

Fateful Episode

On Spaces of Responsibility in the Algorithmic Risk Assessment
of Skitourenguru

Master Thesis
M.Sc. Organization Studies
Department of Organisation and Learning
University of Innsbruck

Submitted to
Univ. Prof. Dr. Richard Weiskopf

Written by
Lukas Nagel

Innsbruck, March 2020

Abstract

The increasing prevalence of algorithmic decision systems in both public and private realms demands for ethical and political considerations. However, the often-postulated claims for fair, transparent, and accountable algorithms lack conceptual ground. Particularly, the relation of accountability and transparency is revealed as a self-contradictory figure. As a counter proposal, an ethics of responsible interaction with algorithms is proposed. Drawing from a deconstructive understanding of ethics, a responsibility of translation is developed. The resulting concept is further elaborated by an empirical account of the algorithmic risk assessment of Skitourenguru. For this end, the algorithm of Skitourenguru is examined as a socio-material arrangement linking up temporarily and spatially distinct events. It is shown that human decisions require formally undecidable value judgments. These value judgments it is further argued exceed the limitations of formal systems and must be inscribed into algorithms a priori. Finally, the concept of responsibility is extended towards a democratic duty to participate in the development of value standards for algorithms. Further research is needed to fully understand and differentiate the performative mechanisms of algorithms.

Table of Contents

Abstract	I
Table of Contents	II
Acknowledgments.....	IV
Preface	V
Exposition.....	1
Problematizing Algorithmic Decision Making	1
Initiating a Research Trajectory	2
Developing an Empirical Research Proposition.....	4
Facing Research Limitations and Significance	6
Theoretical Exploration	8
The Historical Development of Algorithms	8
Thinking of Algorithms as Assemblages	11
Translating Algorithms to Responsible Decision-Making.....	15
Decision Making – Explanans or Explanandum	16
Spaces of Responsibility in Algorithmic Decision Making	20
Methodological Considerations.....	26
Discovering Performativity in Critical Algorithm Studies	26
Researching Algorithms as a Performative Practice	31
Assembling the Author.....	34
Second Order Process Analysis.....	37
Second Order Data Analysis	39
Empirical Investigation.....	42

Fateful Episode.....	42
Tracing the Development of Skitourenguru.....	43
Interacting with Skitourenguru.....	49
Unfolding the Algorithm.....	53
Enacting the Risk Assessment.....	55
Asking for Responsibility.....	57
Discussion	62
Summarizing the Empirical Findings.....	62
Reassessing the Theoretical Model	65
Contributing to the Critical Algorithm Studies	70
Limitations of the Study	73
An Ending a Beginning	75
References	VI
Appendix	XIX
Statutory Declaration.....	XXXIV

Acknowledgments

This work would not have been possible without the fabulous support of my parents. I would like to take this opportunity to express my sincere thanks for your unconditional and timeless encouragement. Even if I took a detour or two, you have always stood behind me and strengthened my back. For the opportunities you have opened up for me I want to express my greatest gratitude. With the completion of this thesis, I hope to be on a good way and make the best out of it. In this work I have tried to approach the question of responsibility. And yet I believe that I still have no idea of responsibility. When I look at how much trust and responsibility you placed in me, I have no choice but to express my utmost respect. Even if we see each other only rarely I wish that we continue to maintain this great and responsible relationship with each other.

The fact that I am thinking about responsibility is not least due to the inspiring efforts of Professor Richard Weiskopf. After stumbling out of my bachelor's degree somewhat disoriented, studying Organization Studies in Innsbruck was one of the luckiest coincidences. Whether cybernetic systems, discourse analysis, or rhizomatic networks, your lectures awakened a curiosity in me that I have rarely experienced before. It is a pity that it should be over now, there would be still so much to discover. But you have also helped me methodically. Above all, I have grown in terms of self-organized and self-motivated work. Ultimately, you nourished a flame in me that was about to fade after 16 years of classical schooling. Namely, my critical spirit. This is certainly one of the most valuable gifts for my further development. I would like to express my sincere thanks for this.

Not to forget the many people who took their time and introduced me to their worlds. Weather software developers, decision researchers or mountain guides. I would like to express my gratitude for your time and patience. Above all, I would like to mention Günter S. who, met me with trust and attention. Günter's contribution goes far beyond this master thesis and positively effects the entire ski touring community. Your contribution is trendsetting and will hopefully inspire many more. I also want to thank people like Jochen K., Rita C., Ulrich R., and Luca I. for providing me their time and becoming forks in the pathway of this work. Finally, also friends have contributed to this work. Of course, Lutz and Hansi must be mentioned here. But also, the tireless support of Sophia M., which lifted me out of the valley of despair time and again, must be mentioned. Last but not least, this work owes some interesting lines of thought to my fellow student Ajla N. and Leon K.

Preface

“The thesis will explore the role of algorithmic decision-making in contemporary organizations and discuss its impact on the ‘space of responsibility’ within organizations. In particular, the focus will be on how (managerial) decisions are influenced by algorithmic procedures.” These were the first sentences of a topic proposition, advanced by Professor Richard Weiskopf in October 2019. As it turned out this proposition would keep me busy for the next year. More than that, its very wording induced the trajectory this study would take. Pointing to a certain hemisphere, but leaving me the freedom to wander around, get lost and take detours prepared a fertile ground for the explorative endeavor of this study. Head over heels I stumbled into the work and soon realized that algorithmic decisions were not as tangible and clear cut as expected, but crumble like sand between the fingers. How to identify the origin of a decision? How to draw a line around interactive and recursive computer systems? And how does my own mode of thinking and organizing affect those questions?

I suppose that these questions cannot be answered straight away, but must be exposed to different approaches, views, and relations. Ultimately, it is not about finding the right answers to those question but about exploring modes of operation that allow certain answers to entrench, iterate and sustain. In this respect, the exploration of algorithmic decisions is not a purely technical but a profoundly philosophical endeavor. Consequently, this study did not turn out to be a linear research, but an attempt to trace multiple branches in the fine-meshed network of algorithmic decision-making. Thereby, it became a recurring figure, to lead the diverging branches of this study back to themselves. The resulting, self-referential iterations do not only serve as orientation aids but progressively coalesce the theoretical, methodological, and empirical concerns of this study. My hope is that the reader will find access to participate in the processual unfolding of this study. In this regard, I cannot promise any straightforward answers, but I can invite the reader to stray around with me. The hemisphere is set, but the path still needs to be traced. By doing so I hope that the thesis will explore the role of algorithmic decision-making in contemporary organizations and discuss its impact on the ‘space of responsibility’ within organizations.

Exposition

Problematizing Algorithmic Decision Making

In February 2020, the European Commission has published a white paper on artificial intelligence. This white paper identifies the opacity of artificial intelligence systems as a potential risk to fundamental human rights. More precisely the complex and partially autonomous nature of artificial intelligence systems makes it difficult to trace back problematic decisions (European Commission, 2020). Despite its potential risks, algorithmic decision-making is being applied in a range of contexts such as healthcare, legal or banking (Agrawal et al., 2018). Moreover algorithmic decisions are increasingly being applied in sensitive areas such as national security or police work (Zweig et al., 2018). Along with the increasing proliferation of algorithmic decision-making comes a demand for ethical considerations. Thereby particular attention is given to algorithmic fairness, accountability and transparency (Lepri et al., 2018; Shin & Park, 2019).

In the debate about fair, accountable and transparent algorithms it becomes apparent that it is not the algorithm per se, but its interaction with people that raises ethical issues. For instance, fairness is a social construct with multiple, sometimes mutually exclusive, definitions. However computer programmers must decide for one particular definition of fairness to be implemented in the program (Martin, 2019; Shrestha & Yang, 2019). If such a decision is distributed within a team or organization, the accountability for this decision can be obscured. This issue is long known as the “problem of many hands” (Nissenbaum, 1996). But there is even more that obscures the accountability of algorithmic decisions. The accuracy of modern machine learning algorithms relies on the quality and quantity of training data (Adadi & Berrada, 2018). How such training data is obtained, how the data is filtered and structured has a significant impact on the functionality of the algorithm.

In order to illuminate the complex functionality of algorithms, voices for more transparency are being raised. Transparency is understood as step towards intelligibility (Pasquale, 2015), or as a means to restore accountability (Diakopoulos, 2016). However full transparency might not only be inefficient but also imply negative consequences, such as gaming the system or privacy issues. Hence tradeoffs between functionality and transparency are likely to occur (Laat, 2018). Nevertheless, the discourse on transparency reveals, a common assumption about algorithmic decision-making. If an algorithm’s functionality is sufficiently known, the algorithm is considered as governable or accountable. In this regard transparency is a form of control that

seeks to uncover the truth or the essence of an algorithm (Ananny & Crawford, 2018). What falls short in such approaches is the respective social context in which the algorithm is situated.

To sum this up, it becomes apparent that algorithmic decision-making has a significant and increasing impact on our conduct of life. At the same time, modern machine learning algorithms are complex and opaque (Burrell, 2016). Consequently, ethical considerations stress the importance of fair, accountable, and transparent algorithms. Along with that comes a body of literature that focuses on the technical implementation of ethical algorithms. However, if we want to better understand the social and ethical impact of algorithms we need to consider more than mere functionality (Beer, 2017; Gillespie, 2014b; Kitchin, 2017). Therefore, we need to better understand the interrelation between human and algorithmic actors. We need to investigate beyond the algorithmic black box and broaden our view to the entire network of human algorithm interaction (Crawford, 2016). Such an approach would help us to better understand the actual impact of algorithms on our daily lives and vice versa. Furthermore, it would allow us to depart from the recursive debate of accountability and transparency and develop a responsible interaction between human and algorithm.

Initiating a Research Trajectory

Algorithmic decision-making is notably been studied in the tradition of Science and Technology Studies. Building on the notion of attachment, it is studied how an algorithm affects the involvement of call center employees in decision-making processes (Bader & Kaiser, 2019). Applying a media theoretical perspective, this case study locates the main interaction of human and algorithm at the user interface. What is not addressed is the development side of the algorithm. Also, ethical issues or responsible decision-making are not further addressed. In contrast, Kristen Martin (2019) stresses the corporate responsibility of software development firms. Using the notion of inscription, it is argued that moral responsibility is attached to the very design of algorithms. Furthermore, due to their moral consequence's algorithms are considered as value laden techniques. Martin's study is illustrated with the often-cited COMPAS case. COMPAS is an algorithm that turned out to be race biased in the recidivism risk analyses of defendants (Larson et al., 2016). Interestingly none of the three articles cited above develops a clear-cut definition for algorithm or decision-making.

Another study that refers to the COMPAS case stresses the potential control problem arising from human algorithm interaction. The control problem describes the human tendency to become complacent or incautious when supervising an autonomous system. Consequently,

having a human in the loop does not automatically guarantees reliable decision-making (Zerilli et al., 2019). A proposed solution is to distribute decisions according to the respective strengths of human and algorithm. This notion aligns with the symbiotic perspective on human algorithm interaction. According to it, algorithms have the biggest leverage when used complementarily and not competitively to human intelligence (Lichtenthaler, 2018). Interestingly, responsible decision-making and ethical judgements are likely to remain in the human domain (Agrawal et al., 2017). At this point it becomes apparent that ethical judgment and responsible decision-making exceed the formal rationality of algorithms.

However, the role of rationality plays a decisive role for our understanding of algorithmic decision-making and its social stance. Drawing from Max Weber's notion of formal and substantive rationality, Lindenbaum et al. (2020) identify artificial intelligence based algorithms as 'supercarriers of formal rationality'. Formal rationality follows a means ends calculus. Hence it is particularly compatible with organizations that strive for efficiency and profit maximization. In contrast, substantive rationality has a normative, value-oriented dimension. It allows explorative thinking, visions, or skepticism. Substantive rationality embraces the messy and unpredictable plurality of value propositions in the world. It is this plurality of value propositions which sets the basis for ethico-political judgments and responsible decision-making. A similar notion can be found from Louise Amoore (2019). According to her, doubt plays an essential role for an ethical interaction with machine learning algorithms. Such algorithms should not be understood as single entities, but rather as decentered composites of stakeholders such as designers, engineers, data sets and users. The interaction within such composites is inherently doubtful in the sense, that multiple, ambiguous perspectives interfere throughout the development and application process. The output of an algorithm, however, appears to be beyond doubt and grounded on the 'truth of data'. This inconsistency between the inside and the outside of an algorithmic decisions must be addressed to develop a responsible stance towards algorithmic decisions. Interestingly both Amoore (2019) and Lindenbaum et al. (2020), highlight the importance of an unpredictable, unknown future for a deliberated and pluralistic social order. Similarly, other critical scholars warn of the emergence of a new regime of truth (Weiskopf, 2020a), or the rise of an algocracy (Danaher, 2016). Such a critical point of view does not necessarily correspond with the current Silicon Valley spirit, framing the technology as mere prediction machines (Agrawal et al., 2018). What this gold-digger mentality however reveals, is how value-laden and simultaneously purpose oriented this technology is.

To bring full circle this first iteration of analysis. It has been shown that in order to study the ethical implications of algorithmic decision-making, investigation beyond mere technical functionality is required. Instead, a promising approach is to study the interaction between the numerous actors involved in algorithmic decision-making. Looking at existing interaction approaches many studies lack a reliable concept of what a decision is. Furthermore, the notion of responsibility is not sufficiently differentiated. Looking from a methods perspective, a growing body of literature provides theoretical frameworks for algorithmic decision-making. However underrepresented are field investigations and reliable case studies (Ella Glikson & Anita Williams Woolley, 2020). Another issue that becomes apparent is the abstract and intangible nature of algorithmic decisions. Many studies stress the life changing impact of algorithmic decisions. However, these decisions remain remote, intangible, and out of personal control. A worthwhile study would go one step further and investigate how algorithmic decisions are enacted. Finally, in Amoore's work (2019) a tension arises from the always partial and incomplete image that both people and algorithms gain from their embodied senses or sensors. Considering this, it would be desirable to study how even the most rational, algorithmic decision might be haunted by ambiguities and arbitrariness, when facing real life uncertainty.

Taking these insights together, a potential trajectory for this study becomes apparent. Thereby the interaction between human and algorithm should be explored empirically. To carve out the gap between cognitive and embodied action, the analyzed decisions should have a tangible and bodily dimension. Furthermore, to disentangle the notions of prediction, judgment, and decision-making the final decision should not be calculable by formal rationality. Throughout the analysis, special emphasize should be put on the role of responsibility. To achieve this, the study will provide a theoretical framework for the analysis of human-algorithm interaction within a broader socio-technical assemblage. It will further elaborate a definition for decision-making in relation to uncertainty. Finally, the study will apply an ethical perspective to discuss the spaces of responsibility within the identified assemblage.

Developing an Empirical Research Proposition

In order to explore the human-algorithm interaction in decision-making, I propose to study the case of Skitourenguru. Skitourenguru is a Swiss organization that aims to steer the ski touring community towards ski tours that have a low avalanche risk (Schmudlach, 2020). Therefore, Skitourenguru provides a daily, algorithmic risk assessment of more than 1200 ski touring

routes in the Swiss Alps. Both the swiss alpine club (SAC) and the swiss council of accident prevention (bfu) recommend using Skitouren guru (Ibid.).

Skitouren guru is particularly suitable for this study for several reasons. First, its functionality is openly accessible. Although the source code is not available, the input factors, their weighting and the validation procedures of the algorithm are disclosed. Second, the algorithm requires interaction. Skitouren guru provides a risk assessment and a recommended behavior. However, the ultimate decision must be enacted by a human. Third, the decisions made with Skitouren guru have tangible and potentially fateful consequences. People who enter avalanche terrain are exposed to a risk threatening their health and possibly their lives. Fourth, avalanches cannot be predicted by means of formal rationality. The complexity of snow mechanics makes it impossible to predict avalanches (Munter, 2009). Hence, even algorithmic procedures cannot eliminate a certain degree of uncertainty. Fifth, ski tourers bear responsibility. Such responsibility can be directed towards their own lives, their families, their group members, or their clients. Consequently, the case allows to discuss different manifestations of responsibility.

According to Kitchin (2017) it is a legitimate research approach to unpack the socio-technical assemblage of algorithms. In line with that, this study seeks to analyze the interaction within the socio-technical assemblage of Skitouren guru. More precisely this study seeks to deconstruct and trace back the numerous human and algorithmic factors that influence the decision-making in avalanche terrain. Therefore, this study cannot take the existence of Skitouren guru for granted. Rather, this study should start by asking: For what reason, based on which desires and for what purpose was Skitouren guru developed? Potentially, multiple motives can be identified, dwelling beneath the layer of formal representation. Second, to influence the decision-making of ski tourers, there must be interaction or communication between Skitouren guru and its users. The study will address this by asking: How does the interaction between Skitouren guru and its users look like? This is important because the appearance of the algorithm shapes the way users make sense of it. Accordingly, the algorithm could be understood as an infallible “guru” or as an error-prone tool. Third, to become tangible, the algorithmic recommendation must be enacted and implemented by the user. The study addresses this by asking: How, where and when does the algorithmic recommendation of Skitouren guru influence the decision-making of users? Including this temporal and spatial dimension opens the respective decision context. Throughout this analysis two issues should be focused. First, where do irrational, arbitrary, or random decisions shape the outcome of the algorithmic recommendation? And second, where

within the identified assemblage does responsibility reside and how does this responsibility look like?

Facing Research Limitations and Significance

At first glance, this study focus may seem to lose touch with the field of organization studies. Ultimately, ski touring is a leisure activity and the algorithm of Skitourenguru is a computer technology. However, the study of decision-making has a long-standing tradition in the field of organization studies. Interestingly, recent publications about algorithmic decision-making hardly refer to classic concepts such as bounded rationality (March et al., 1994), political dimensions of decisions (Pettigrew, 2014) or the garbage can model (Cohen et al., 1972). Perhaps this is due to the lethargy in organizational decision-making, which arose around the turn of the millennium (Langley et al., 1995). However, the field of organization studies has developed adequate concepts for decision analysis. Even if this study cannot review this bulk of literature, it should contribute by incorporating the lessons learned from these scholars.

Looking at the technology side of Skitourenguru this study faces a balancing act. In line with Latour (2007), exploring a socio-technical assemblages requires a technical inquiry without being overly technology focused. Hence, the analysis of the operating principle of Skitourenguru will be restricted to a qualitative account. This also sets the boundaries for further related research fields. Both the fields of Decision Theory and Risk Analysis seek to quantitatively describe decision behavior (Borgonovo et al., 2018). This is also of interest when implementing prescribed decision behavior into computer code. However, this exceeds the study focus. The same holds true for the sub field of Distributed Decision-Making (Schneeweiss, 2003). While the object of investigation is comparable, Distributed Decision-Making differs from this study in its quantitative methodology.

Regarding ski-touring, this study touches the fields of avalanche heuristics and human factors. Both professional and recreational ski tourers partly rely on probabilistic, decision-making frameworks, that seek to estimate the respective avalanche risk (Landrø et al., 2020). Often, and similarly to algorithmic procedures, these heuristics follow a simple if-then logic. Even if it is not the scope of this study to judge these decision-making frameworks, discussing them in comparison to algorithmic decision-making could be insightful. On the other hand, the domain of human factors deals with both individual and group factors that influence the decision-making of ski-tourers. Relatively well studied are decision-biases and heuristic traps such as for example expert halos. But also, leadership attribution and group communication play a

decisive role in the domain of human factors (Cierco & Debouck, 2013). To reduce such limitations and biases is the promise of many algorithmic decision systems. However, in the case of Skitourenguru the human factor is likely to remain. Instead, an interference between algorithmic recommendation, avalanche heuristics, personal desires, intuition, and group dynamics is likely to occur. This study seeks to address this interference rather than to reduce the decision to an algorithmic output. Ultimately, allowing a broader perspective reveals a paradox that might hold true to both ski touring and organizational behavior of our time: We are applying super rational technologies to inherently irrational activities.

In summary, this case study explores the multiple factors, that influence the decision-making of ski tourers who apply the risk assessment algorithm of Skitourenguru. Therefore, theoretical inspiration should be drawn from actor-network theory and assemblage thinking. Furthermore, and beyond mere materiality this study stresses the spaces of responsibility within the identified assemblage. Hence this study contributes to the literature of algorithmic decision-making and its ethical implications. In contrast to entirely digital applications, the analyzed decisions are not fully automated. Instead, human interpretation, judgement and action are required to enact the algorithmic recommendation. Such an interaction approach can also be found in strategy formulation and complex organizational decisions (Jarrahi, 2018). However, this study does not seek to produce a how-to guideline for responsible human-algorithm interaction. Rather, the context bound manifestations of responsibility should be explored. Nevertheless, the case might serve as a role model or inspiration for upcoming human-algorithm based decision systems.

Theoretical Exploration

So far, the study has touched on recent work on algorithmic decision-making and its ethical implications. Yet, the terms algorithm, decision-making and responsibility remained unspecified. The following section seeks to develop a theoretical framework which enables this study to analyze the case of Skitouenguru.

The Historical Development of Algorithms

At the first glance, the term algorithm seems to have little in common with the life-changing machines analyzed above. According to the dictionary, an algorithm is “a procedure, or a set of rules used in calculation and problem-solving” (OED Online, 2020). This rather general definition allows to draw parallels with project charts, business processes or bureaucratic organizations. What these procedures have in common is that they decompose given tasks into basic sub-tasks. It should be noted that neither the step-by-step instructions nor the predefined purpose are altered through the operation of these algorithms. Despite these parallels, the word algorithm carries a rather mathematical connotation. In fact, the etymological origin of the term algorithm leads to the Persian mathematician Muhammad ibn Musa al-Khwarizmi from the ninth century. When his work on the Arabic numeral system was translated, his name was altered to the Latin equivalent *Algoritmi* (Mehri, 2017). At that time, the word *algoritmi* referred to the practice of calculating with the Arabic numeral system. However, procedures that correspond to our contemporary definition of algorithm are even older than this work. For example, the Euclidean algorithm was developed in the ancient Greece around 300 BC. The Euclidean algorithm computes the greatest common divisor of two given numbers within a finite number of steps. Thereby the output of the prior step serves as the input of the next step (Chabert, 1999).

Without labelling it as such the mathematicians and logicians from the 18th and 19th century have set the basis for our contemporary understanding of the term algorithm. For example, Gottfried Leibnitz tried to conceptualize a universal, symbolic language (*characteristica universalis*) that combines reasoning and calculation. Similarly to computer algorithms, this language sought to decompose sophisticated concepts into a combination of basic signs (Chabert, 1999). While Leibnitz envisioned a system of multiple signs, it was George Boole who developed a binary sign system in the late 19th century. This system was composed of a

set of logical operations and the values of true and false. The resulting Boolean algebra is the basis of the contemporary computer logic based on 0 and 1 (Nahin, 2013).

Yet at the turn to the 20th century, it was not computer technology that drove the development of algorithms, but the further formalization of mathematics. Attempting to represent arithmetic through logical operations, David Hilbert formulated his influential decision problem (Entscheidungsproblem). According to it, a mathematical statement would be decidable if a mechanical procedure, such as an algorithm, could calculate this statement within a finite number of steps. Later, in 1932 Hilbert's attempt was proven impossible by Kurt Gödel's incompleteness theorem. The theorem shows that any formal system has "formally undecidable propositions" (Gödel, 2012, p. 1). These are statements that can neither be proven true nor false. The work of Hilbert and Gödel was further refined by Alan Turing in 1936. To formalize the process of calculation, Turing envisioned a mechanical model called the Turing machine. A Turing machine converts a given input into an output by reading and writing a chain of symbols. Since then an algorithm could be defined as a procedure that can be implemented on a Turing machine (Krämer, 1988). Consequently, the work on Turing machines has laid the foundation for the field of computer science. At the same time the mechanical apparatus of the Turing machine reveals that also algorithms are subject to mechanical or electronical operations (Kittler, 1993).

Whilst Alan Turing was working on sequential, step-by-step procedures, nowadays we are facing an increasing plurality of algorithms. Looking at this plurality Microsoft researcher Yuri Gurevich argues that "[...] the notion of algorithm cannot be rigorously defined in full generality" (Gurevich, 2012, p. 32). Similarly the computer scientist Paul Dourish argues that "[...] the limits of the term algorithm are determined by social engagements rather than by technological or material constraints" (Dourish, 2016, p. 3). To better understand the notion of algorithm, Dourish (2016) distinguishes between algorithm, computer code and computer program. Accordingly, an algorithm must be transformed into computer code to be implemented in a computer program. A computer program, however, is more than a mere algorithm. Instead, a computer program is an arrangement of elements such as data sets, software modules and interfaces. The crucial point is that the initial algorithm might neither be localizable in a single module, nor in a specific line of code. Instead, the algorithm is entangled within a network of ongoing computational operations. In line with that Lucas Introna argues that algorithms are "temporally unfolding processes" (Introna, 2016, p. 22). Like the flow of a melody their operations are always situated between previous and subsequent operations. What

we retrospectively call an algorithm is, according to Introna, a performative cut. This cut opens the unfolding process for examination by punctuating certain moments and relations within in the network. The cut is performative in the sense that the act of punctuation constitutes the very object being found. Consequently, an algorithm can be related to both technical and social dimensions.

Here the examination of algorithms departs from a mere technical conceptualization and enters an interpretative sphere. Indeed, the term algorithm is increasingly being used by social scientist, too. For example the anthropologist Nick Seaver proposes to study algorithms as “[...] sociotechnical systems, rather than rigidly constrained and procedural formulas” (Seaver, 2017, p. 1). This approach does not seek to give a technical correct definition of the term algorithm. Instead, it seeks to discover how communities of practice make sense of and enact algorithms. Similarly, Malte Ziewitz concludes that algorithms are not only computational procedures but also “[...] sensitizing concept that can help us rethink entrenched assumptions about the politics of computation, automation, and control” (Ziewitz, 2016, p. 4). From this perspective the notion of algorithm offers an opportunity to explore new socio-technical practices and arrangements. Thereby Ziewitz (Ibid.) identifies two salient motives in the social analysis of algorithms. First, algorithms are treated as powerful actors operating in a range of different domains. These powerful actors are assigned a certain degree of agency, autonomy, and potential faultiness. Second, algorithms are perceived as inscrutable, opaque, and unintelligible entities. Accordingly, algorithms are treated as black boxes or complex systems. Interestingly, both Seaver (2017) and Ziewitz (2016) conclude that the initially precise and deterministic figure of algorithm dissolves into new concepts as soon as it is analyzed in terms of its social and political dimensions.

It remains the question why algorithms have only recently become an object of interest in the social sciences. Looking at the reading list for critical algorithm studies of the Social Media Collective (2016), it becomes apparent that the term algorithm is increasingly being used since the early 2010s. It was also at that time when so-called "machine learning" applications were revolutionizing the capabilities of computing. For instance, advances in the field of image recognition were heavily discussed in both scientific and mainstream media (Markoff, 2012), (Marcus, 2018). Other than conventional algorithms, machine learning algorithms do not only consist of predefined instructions. Instead, machine learning algorithms modify their inner logic by experimentally engaging with training data. Referring to this self-learning characteristic it is noted that machine learning algorithms “[...] blur the distinction between code and data”

(Lindenbaum et al., 2020, p. 248). It is this incorporation of external data which seems to be of interest to the social sciences. Accordingly, Louise Amoore treats the output signals of machine learning algorithms not as “mathematical abstractions”, but as “actionable propositions” (Amoore, 2020, p. 12). From this perspective algorithms become “generative agents” which are ascribed the ability to interpret the world and act in it. At this point, the historical development of algorithms touches on the ethical and socio-political concerns outlined in the introduction of this thesis. Modern machine learning algorithms are perceived as powerful but opaque agents with potential biases and flaws.

To conclude this section, it should be said that neither the euphoria about artificial intelligence, nor concerns about logocentrism are new motives. Indeed, already Horkheimer and Adorno write that with Leibnitz’ idea of a universal language “[t]he multiplicity of forms is reduced to position and arrangement, history to fact [and] things to matter” (Adorno & Horkheimer, 2009, p. 4). Nevertheless, the new technology brings new issues. And so nowadays multiplicity might no longer be reduced to matter but to data. An issue that goes together with the debate about algorithms and should not be neglected.

Thinking of Algorithms as Assemblages

What the preceding discussion reveals, is that algorithms can be analyzed by different facets. These facets range from neutral mathematical procedures to value laden technologies. Furthermore, these facets range from inputs to outputs, from hardware to software and from interfaces to data sets. At the same time, algorithms are cultural products. Both software developers, users and observers make sense of and enact algorithms from their very specific point of view. At this point the notion of assemblage comes into play.

Indeed, several researchers have identified algorithms as part of socio-technical assemblages. For example, Rob Kitchin states that algorithms should be analyzed “[...] within the wider context of their socio-technical assemblage” (Kitchin, 2017, p. 18). This point of view stresses the conditions under which algorithms are developed and employed. Consequently, algorithms are no neutral, step-by-step procedures, but part of personal, economic, or political interest. Similarly, Mike Ananny defines algorithms as “[...] an assemblage of institutionally situated computational code, human practices, and normative logics [...]” (Ananny, 2016, p. 99). This definition allows to think of algorithms as contingent to external forces like norms, laws, or professional ideals. Furthermore, Ananny emphasizes the role of the end users. Ultimately, end users contribute to the functionality of machine learning algorithms by providing their user data.

The relation between end-user and algorithm is especially focused by Bader and Kaiser. They argue that in “[...] an assemblage of human and algorithmic intelligence, the user takes on an active part in what the medium becomes” (Bader & Kaiser, 2019, p. 658). What these studies have in common is that they use the notion of assemblage to describe an arrangement or a constellation of actors. Often these studies seek to embrace the multiple facets of algorithms instead of cutting them into abstract pieces. However, none of these studies further examines the concept or the origin of the term assemblage. Therefore, it requires some elaboration at this point.

The notion of assemblage can be traced back to the poststructuralist philosophers Gilles Deleuze and Félix Guattari. The term assemblage is the English translation for the French word *agencement*. An *agencement* describes an arrangement or layout of heterogeneous objects. These heterogeneous objects, however, are not just unrelated multiplicities but gain unity by working together as a functional whole. Yet, such unity does not derive from a predetermined logic or organizing principle. Instead, the unity of an assemblage is a momentary effect created by the current relationships between its parts. Deleuze and Guattari call these relationships the “abstract machine”. The abstract machine is abstract in the sense that it does not “[...] signify or represent anything beyond the arrangement of concrete elements” (Nail, 2017, p. 25). However, the concrete elements and the abstract machine are in a reciprocal relation, a “coadaptation” that codetermines the two (Ibid.).

An assemblage has two faces. On the one hand it resembles an organism that appears as an attributable unity. On the other hand, it resembles a “body without organs” that dismantles the unity, rearranges and recombines its elements (Patton, 1994). In this sense an assemblage is like a mechanism. An emergent and productive interaction that does not affect the nature of its parts. Accordingly, it is argued that an assemblage is “neither a part nor a whole” (Nail, 2017, p. 23). Others argue that assemblages are a means to describe “unity within difference” (Patton, 1994, p. 159). Taken together these definitions stress that assemblages are relational arrangements of heterogeneous elements that form new productive wholes. It should be said that despite its mechanic character the notion of assemblage does not end with machines. Instead the term comprises “[...] animate and inanimate bodies, individual or collective bodies, biological or social bodies” alike (Patton, 1994, p. 158).

Assemblages are not of eternal duration but are subject to deterritorialization. Deterritorialization describes an ongoing movement of transformation and change. For example

the Facebook news feed algorithm got recently changed towards more person to person interaction (Mosseri, 2018). In the terminology of Deleuze and Guattari this can be understood as a “relative negative deterritorialization”. A process of change that maintains the established assemblage after voices against the commercialization of the news feed had been raised. A second type of change is the “relative positive deterritorialization”. Thereby, neither established assemblages are reproduced nor are new assemblages formatted. Two more types of change are the “absolute negative” and the “absolute positive deterritorialization”. Thereby new assemblages are formatted either by undermining established assemblages (absolute negative) or by incorporating new, still uncaptured elements (absolute positive). Looking at this steady movement, assemblage thinking does no longer search for essence but asks how different arrangements interact with and affect the world (Nail, 2017).

The often abstract and philosophical nature of assemblage thinking was picked up and modified for empirical concerns by actor-network theory (ANT). Actor-network theory has its origins in the Science and Technology Studies and was pioneered by scholars such Michel Callon (1984), Bruno Latour (1988) and John Law (1994). Despite its name the actor-network theory is not a coherent theory, but a toolbox for dismantling socio-material relations (Müller, 2015). Like assemblage thinking, these socio-material relations are not seen as consistent, but as provisory and preliminary orders. So, does for example John Law state: “There is no social order. Rather, there are endless attempts at ordering” (Law, 1994, p. 101). In line with that, the ANT approach does not seek to stabilize established terms but seeks to introduce new perspectives, variations, and shifts. Consequently, actor-network theory is itself an assemblage of ever-increasing explorative texts and sensitizing terms. These sensitizing terms allow researchers to focus on issues that would otherwise be neglected or overseen (Mol, 2010).

According to Annemarie Mol (2010), actor-network theory is concerned with the consequences of action, rather than the intentions to act. Accordingly, anything which makes a difference in the world, is considered as an actor. Here a simple but famous example is an automated door closer. If the automated door closer would be removed it would require work to replace its actions (Latour, 2010). However, the door closer is not the sole origin of action but is itself enacted by further actions. These actions could be the engineering of the door closer, the maintenance of the house or the act of opening the door. What the term “door closer” does is to reduce this web of actions to an accountable object. In the terminology of actor-network theory, the door closer is “black boxing” its underlying network (Law, 2007). This underlying network consists of potentially endless associations. The resulting web of associations resembles the

semiotic understanding of language. Other than traditional semiotics, actor-network theory now shifts this understanding from language to materiality (Mol, 2010).

A consequence of this is that former reference points, such as social class, micro and macro, nation state or power, lose their significance as explanatory concepts. Instead these concepts become relational products that must themselves be explained through constellations of both human and material action (Law, 2007). At this point Latour argues that studies in the tradition actor-network theory should not seek to introduce new explanations but rather seek to “[...] describe the state of affairs at hand” (Latour, 2007, p. 144). This descriptive character of actor-network theory has been subject to numerous controversies. For example Whittle and Spicer (2008) argue that the positivist and apolitical nature of ANT is ill suited for critical organization studies. On the contrary Alcadipani und Hassard (2010) reply that the very process of ordering becomes political in actor-network theory. Furthermore, ANT should not be understood as a positivist science but rather as a performative practice that produces both itself and its object of inquiry. Postponing this debate to the methods sections, the discussion should now focus the spatial logic of ANT and assemblage thinking.

Indeed, both actor-network theory and assemblage thinking have an unconventional understanding of space. For example, Latour (1987) considers two forms of spatiality. On the one hand there is the Euclidean space, which comprises the three-dimensional coordinates that are commonly referred to as space. On the other hand, there is the network space, which comprises the network of associations. An object, such as for example a boat, remains stable if it does not move within the network space. In other words, a stable object is “immutable” in network space. At the same time, it is this stability, that renders the boat mobile in the Euclidean space. Here Latour speaks of “immutable mobiles” (Law & Mol, 2001). Another issue that can be found in both assemblage thinking and actor-network theory is the topological understanding of time and space. Accordingly, both time and space are not understood as linear or plane, but as potentially folded or crumpled (Serres & Latour, 2008). Thereby, the metric distance between two objects does not necessarily represent their distance in the association network. Bruno Latour puts it this way: “I can be one meter away from someone in the next telephone booth and nevertheless be more closely connected to my mother 6000 miles away” (Latour, 1996, p. 371). Following this rationale, the study should now draw together the insights gained in the last two chapters.

Translating Algorithms to Responsible Decision-Making

It has been shown that in a technical sense, algorithms are sets of rules that decompose given tasks to subtasks. Initially algorithms were used to explore the limits of formal logic systems. However, these limitations receive little attention in today's public and social scientific discourse. Next it has been shown that algorithms need to be translated to computer code to be implemented in computer programs. The ongoing sophistication of computer programs has led this study to an assemblage understanding of algorithms. When algorithms are described as assemblages, they are understood as arrangements of heterogenous elements that work together as a functional whole. The assembled character of algorithms had already been identified at the turn of the millennium as the “problem of many hands”. Today the accountability of computer systems is further obscured by developments in the field of machine learning. Machine learning algorithms blur the boundaries between data and code and engage with their environment experimentally. Consequently, these algorithms are assigned a degree of agency and autonomy. Along with the increasing proliferation of machine learning application comes a growing interest for algorithms in the social sciences. Thereby the term algorithm serves as a sensitizing concept which helps make sense of and rethink the implications of automated and partially autonomous computer systems. In the actor-network theory sensitizing concepts help researchers to focus on issues that would otherwise be neglected or overseen.

A reoccurring issue in the recent debate is the inscrutability of algorithms. Consequently, algorithms are labeled as opaque black boxes and voices for opening those black boxes are being raised. Looking at studies of actor-network theory, it has been shown that black boxing is a process which assigns agency to otherwise endless networks of associations. From this perspective algorithms are not so much black boxes per se but are enacted as black boxes by the very action of labelling them. Accordingly, in the tradition of ANT, black boxes cannot be opened without dissolving them simultaneously. In that light, it is not surprising that both Seaver (2017) and Ziewitz (2016) conclude that the initially precise and deterministic figure of algorithm dissolves into new concepts as soon as it is analyzed in terms of its social and political dimensions. At this point a tension between description and explanation has been identified. The ANT approach seeks to react on this by describing the affairs at hand, rather than introducing new explanations. Concerning algorithms, such descriptions should seek to trace the numerous interactions and associations within the assemblage, identified as algorithm. Such a material semiotic approach seems especially well suited to computer technology which is itself a system of sign. Another issue that has been identified is the processual ontology of both

actor-network theory and assemblage thinking. Interestingly this issue is often neglected when talking about algorithms as assemblages. Furthermore, and important for the remainder of the study is the topological understanding of time and space, which has been identified in assemblage thinking and actor-network theory. Algorithms, this should be the working model for now, fold time and space to an otherwise unattainable density of associations. The crumpled network can then later unfold through decisions in the Euclidean space.

Before continuing the analysis, it seems worthwhile to zoom out and look at the current trajectory of the study. It has been identified that with their increasing proliferation, algorithms gain on ethical and sociopolitical momentum. To address the ethical impact of algorithms, this study seeks to stress algorithms beyond mere functionality and broaden its analysis to the network of human algorithm interaction. Therefore, this study seeks to depart from the reoccurring debate of fairness, accountability and transparency and emphasize the role of responsibility in algorithmic decision-making. So far, a basic understanding of algorithms and their recent manifestations has been developed. Ideas from actor-network theory have been identified as helpful tools to make sense of algorithms beyond mere functionality. In fact, it has been argued that it is precisely the functionality, which covers or black boxes the underlying network of human algorithm interaction. Also drawing from actor-network-theory, a topological understanding of time and space has been introduced. Accordingly, it has been argued that algorithms fold time and space to an otherwise unattainable density of associations. In the following sections this motive should be further developed towards spaces of responsibility in algorithmic decision-making. Therefore, the notion of decision-making should be deconstructed theoretically. Furthermore, responsibility should be explored as an act of translation.

Decision Making – Explanans or Explanandum

Recent manifestations of algorithms have been identified as opaque and autonomous agents. Consequently, algorithmic outputs are no longer perceived as predetermined results but as actionable propositions. At this point the notion of decision comes into play. Indeed, the classic notion of decision carries aspects of consciousness and intentionality. For example, in the traditional management and organization literature, decision-making is understood as an intentional choice which seeks to optimize towards pre-given goals (March, 1988). Since, the human capabilities to process information are limited, the notion of bounded rationality has become prevalent in organizational decision-theory. Bounded rationality implies that decision

makers decide on the basis of sufficient, rather than complete knowledge. As a result, decision makers often rely on decision rules and heuristics that satisfy rather than maximize the given goals. At this point Langley et al. (1995) differentiate the literature on organizational decision-theory along a continuum between two distinct poles. One end of the continuum is represented by “sequential theories” which highlight the rational and intentional aspect of decision-making. As an example serves Simon’s “intelligence-design-choice” model (Simon, 1960, p. 2). Thereby decision-making is understood as a cognitive, well-structured process which chooses the best among different solutions to a given problem. The other end of the continuum is represented by “anarchical theories” which bring the boundedness to its logic conclusion. As an example serves the garbage can model proposed by Cohen et al. (1972). Thereby decisions are understood as inconsistent and unstructured processes, which originate from ambiguous goals and random constellations of participants, problems, and solutions. As an example for the mid ground serve Minzberg et al. (1976), who describe strategic decision processes as an iterative interplay of both dynamic and structural factors.

Langley et al. (1995) continue to argue that organizational decision theory suffers from three major limitations. Namely the reification, dehumanization, and isolation of decision processes. Reification describes how ongoing action is frozen into an abstract state by the very concept of decision. Accordingly, a decision might not be localizable at a specific point or place. Instead, it might well be the researcher who constructs the point of decision to explain the observed action. Dehumanization describes the issue that, human decision makers are subject to insight, inspiration and affect. However, the administrative man, who is solely guided by bounded rationality bears little resemblance to real-life decision-makers. Finally, the isolation of decision processes might disconnect issues that would otherwise influence each other. As a solution Langley et al. propose to speak of entangled issue networks rather than distinct decision processes.

Whilst Langley et al. (1995) seek to open up organizational-decision theory, others depart from the classic concept of decision-making. So does for example Robert Chia (1994) stress the processual ontology of decision-making. Applying a deconstructive perspective Chia argues, that western logic gives priority to discrete entities and events. Consequently, western logic suppresses “[...] the primarily dynamic and processual nature of reality” (Chia, 1994, p. 786). Drawing from Derrida, Chia traces this issue back to the strong dualities present in western language. Accordingly, dualities such as “is/is not”, reduce human experiences into static states and cause a gap between the phenomenal experience and the articulated language. It is further

argued that these dualities are the result of constructed folds which mark differences in otherwise non-referential and relational texts. Since the very concept of decision derives from this logic, it is necessarily imbued with contradictions and paradoxes. Furthermore, the classic decision concept falls short in explaining group dynamics and spontaneous action.

But Chia (1994) goes even further and argues that attempts to replace the notion of decision are mere substitutes that do not affect the underlying assumptions of organizational decision theory. To change this assumption Chia proposes to think of decisions as explanatory principles which help to rationalize actions retrospectively. This approach departs from the traditional assumption, that decisions offer a causal explanation for action. Instead, Chia understands decisions as plausible punctuations that help to make sense in an otherwise ambiguous world. Consequently, the concept of decision is no longer a neutral explanation but a performative act. It produces the very affair being analyzed. Chia calls this the “the actionality of decision” (Chia, 1994, p. 789). This is further exemplified on Pettigrew’s (1990) attempt to study decisions as processes of change in context. For Chia (1994) the very attempt to study “processes of change in context” already detaches the analyzed affair from its context.

Chia introduces a fresh and stimulating critique into the well-established field of organizational decision-making. Nevertheless, it should be noted that his conclusion has also been contested. For example, Clegg et al. note that “[...] Derrida’s own discussions of decision-making, [...] many of which were published after Chia’s paper, appear quite contrary to Chia’s conclusions” (Clegg et al., 2007, p. 407). Keeping this discussion for later, it must further be said that Chia (1994) does not provide a strong counter-draft when it comes to alternative methods of organizational analysis. Certainly, this is due to his deconstructivist approach, which would inevitably further decompose any suggested method. Nevertheless, he suggests a “symmetrically naïve” approach to study human activities. Such an approach, Chia states, would be free of prior orders or distinctions. Instead it would use an “innocent” perspective to show how “[...] actions, happenings, and relational configurations emerge, come together, coalesce and then take on stabilized appearances” (Chia, 1994, pp. 801–802). Bringing this thought to its natural conclusion, this approach cannot rely on given entities or events but must focus on relations and actions. In this light it is not surprising that Chia’s smallest unit of analysis is not an object or atom, but the action of distinction. Referring to Spencer Brown, Chia argues that the very act of drawing a distinction is enough to generate the logical structures our reasoning is based on. Such distinctions, however, are “linguistic interventions” that fold meaning into an otherwise “meaningless moving mass” (Chia, 1994, p. 799) referring to

(Whitehead, 1985). Interestingly, the two resulting sides of Spencer Brown's primary distinction resemble a binary logic. Indeed it has even been argued, that Spencer Brown's system is "Boolean algebra in an obscure notation" (Cull & Frank, 1979, p. 201).

At this point some of the gained insights should be drawn together. Looking at the classic literature on organizational decision theory it does not surprise why Lindenbaum et al. (2020) warn of the compatibility between organizational and algorithmic decision-making. In both fields, decisions are understood as rational choices that optimize towards pre-given goals. Furthermore, both fields maintain the underlying assumption that decisions precede action and explain it causally. Indeed, the underlying assumption, that decisions determine action is still present in recent studies on algorithmic decision-making in organizations, as for example in the case study of Bader and Kaiser (2019).

However, recent manifestations of machine learning algorithms are no deterministic technologies. Instead they have been identified as uncertain and probabilistic technologies (Amoore, 2019). Drawing from the insights of Chia (1994) it now becomes apparent why transparency and accountability play such central roles in the recent debates on algorithmic decision-making. Both transparency and accountability are required to uphold the deterministic assumptions embedded in an ontology of being. More than this, the very introduction of the term algorithm into the social sciences can be read as an attempt to maintain agency in an otherwise complex and opaque web of associations. Here, Nick Seaver's description of the development of critical algorithm studies serves as a good example. He states:

Where "Big Data" was vague—originating in an overheated marketing discourse—algorithms were precise. They were the core stuff of computer science, definitionally straightforward and, for many humanists, as distilled a case of rationalizing, quantifying, procedural logics as it was possible to find. [...] Yet, just as critical scholars picked them up, algorithms seemed to break apart. (Seaver, 2017, pp. 1-2)

At this point a parallel to the history of organizational decision theory can be drawn. Originally the notion of decision seemed to provide an adequate means to connect both the realms of reason and action. However, organizational action proved to be only loosely coupled to the realm of reason. Consequently, non-deterministic metaphors, such as the garbage can model, were introduced to the field of organizational decision theory. It seems not too far-fetched to compare the garbage can model of organizational decision-making with assemblage approaches to algorithmic decision-making. In both cases decisions are contingent to constellations of heterogeneous aspects. Furthermore, it is the spatial and temporal simultaneity of actions that

renders a decision to appear as a functional whole. However, like the garbage can model, recent assemblage approaches on algorithmic decision-making do not bring the assemblage thinking to its natural conclusion. Namely that it is not just the material actors which form an assemblage but that the very notion of decision is an assemblage itself.

To conclude this section, it has been shown that in the field of organization studies the notion of decision served to connect reason and action. However, the lines between these two realms are blurry and were later dismantled as artificial folds. Indeed, the very notion of decision has been revealed to be such a fold. From this perspective the attempt to distinguish reason, decision and action is a pointless endeavor since the terms mutually produce each other. A similar mechanism can now be found in debates on algorithmic decision-making. Thereby the notion of decision serves as a determining connection between the Boolean computer logic and its material consequences. To maintain this framework voices for accountable and transparent algorithms are being raised. But the framework is self-referential and the very attempt to make an algorithm accountable authorizes its further actions as decisions. Thus, to gain new insights about the ethical implications of algorithms, this study must depart from this recursive debate. Instead, an ethics of responsible translation should now be introduced.

Spaces of Responsibility in Algorithmic Decision Making

A stimulating counter perspective can currently be found in the work of Louise Amoore. Amoore states that her cloud ethics approach “[...] does not belong to an episteme of accountability, transparency, and legibility, but on the contrary begins with the opacity, partiality, and illegibility of all forms of giving account, human and algorithmic” (Amoore, 2020, p. 8). Since machine learning algorithms incorporate their environment through data, Amoore perceives the writing of algorithms as a distributed and collaborative practice. As a result, algorithmic actions have an unidentifiable and ungrounded origin. It is this “ungroundedness” which for Amoore sets the condition of all ethico-political action. Indeed she states that “[t]here is no great origin or source of responsibility without uncertainty and undecidability” (Amoore, 2020, p. 19). To better understand this point of view, it seems useful to shed light on her underlying work.

Louise Amoore draws from Judith Butler (2008) who argues that the issue of an opaque and illegible moral subject is an important figure for the ethics of postmodern discourse. The starting point of Butler’s considerations is that giving an account of oneself is always a partial endeavor since human subjects are unconsciously shaped and influenced by prior structures.

Accordingly, a human subject is no decoupled entity but also incorporates other people. For Butler this is an aspect of responsibility, namely that a human subject already carries the other within itself. Another aspect of responsibility is, for Butler, the opacity of the human subject. Since the subject incorporates the innumerable external forces but can only trace them to a limited extent, a space of indeterminacy remains. From this point of view, ethical responsibility is not a side effect of cause and effect, as it is discussed in the debate of accountable algorithms but is precisely the under determinedness of the human subject.

At this point, another building block of an Amoore's work comes into play, namely the ethics of responsibility in the work Jacques Derrida. When Amoore stresses the relation between responsibility and undecidability, then it is precisely Derrida's work she is referring to. Derrida states: "If there is no 'experience' of the undecidable at the moment of decision, then the decision will be nothing but the mechanical application of a rule" (Derrida & Beardsworth, 1994, p. 38). Interestingly, for Derrida, the very moment of a decision does potentially exist. However, a decision worthy of its name would forever elude itself from knowledge since it is precisely the absence of the predictable that gives the concept of decision its value. Similarly, Derrida says elsewhere that "[t]he instant of decision is a madness [...]" (Derrida, 2016, p. 26). This is a subtle move from Derrida since this notion of decision avoids the realm of deconstruction and thus opens the space for ethical questions. Thereby Derrida's concept of responsibility, like his concept of decision, exceeds the field of knowledge. To quote him at length:

Whoever says that he is responsible, that he has assumed 'his' responsibilities has mistaken the meaning of responsibility. One can never know if one has been responsible or not, one cannot have a good conscience: 'I took the right decision', 'I fulfilled my responsibilities', 'My debts are paid', 'This is where my (or your) responsibility lies', and so on - all such statements are contrary to the essence of responsibility as well as to the essence of a decision. This is why responsibility is infinite. It is infinite because of the finitude of the one who 'decides' or who 'takes responsibility'. (Derrida & Beardsworth, 1994, p. 39)

What becomes apparent here, is that the notions of decision and responsibility are tightly coupled for Derrida. To be truly responsible, for Derrida, means to account for an action that can only be justified through one's decision. Such a decision stands beyond any pregiven order or calculus but faces an aporia of the undecidable. Here Derrida states: "A decision that didn't go through the ordeal of the undecidable would not be a free decision, it would only be the programmable application or unfolding of a calculable process" (Derrida, 2016, p. 24).

Certainly, the now introduced perspectives on responsibility appear counterintuitive and far from user-friendly. In fact it has even been shown that user-friendly moral codes produce the very opposite of what Derrida would call an ethical or responsible conduct (Clegg et al., 2007). Louise Amoore's (2020) cloud ethics seem to face the same issue. Here the notion of responsibility remains equally difficult to handle. Unfortunately, this fosters the tendency for the notion of responsibility to become synonymous with the wider notion of ethics. Concerning responsibility, Amoore concludes that algorithms incorporate human relations, actions, and decisions through data. Accordingly, it is not so much the algorithmic output but already the very input, the "distributed act of writing", which bears responsibility. Consequently, Amoore does not locate responsibility within the algorithm but between us and others. It is a responsibility of shaping and enacting unknown futures. Amoore puts it that way:

Running against the grain of algorithmic logics that show, attend, and tell the meaning of a situation, responsibility means that one cannot see a clear path ahead because the meaning of the situation is undecidable. The multiple branching points of the decision tree or random forest algorithm do in fact carry the risk of exposure to chance and vulnerability. A different kind of responsibility dwells at these forks in the path, bearing the opacity of future consequences of the weighting of one route over another. (Amoore, 2020, pp. 164–165)

With this figure Amoore highlights how troublesome ethical issues are and that neither human nor algorithmic decisions stand outside of this trouble. However, her notion of responsibility might be unhelpful for the empirical concern of this study, namely, to analyze the role of responsibility within human algorithm interaction. This theory section should therefore be concluded by proposing a different model of responsibility. This model should not be imposed on the preceding analysis but is hopefully already inherent in it. I therefore want to summarize some of the gained insights and weave them into a translation model of responsibility.

The chapter "The Historical Development of Algorithms" has shown that algorithms are deeply intertwined with the limits of formal logic systems. Interestingly David Hilbert formulated the limits of formal logic systems as a decision problem. Kurt Gödel and Alan Turing later proved that not any proposition can be decided as true or false through the application of a formal logic. To put this in the language of Jacques Derrida, a formal logical system cannot go through the ordeal of the undecidable. It is instead a "programmable application" an "unfolding of a calculable process". From this perspective algorithms, which are strictly bound to formal logic systems, do neither make decisions nor take responsibility worthy of the name. Does this change with the latest developments of machine learning algorithms? I argue no. Those algorithms

might be unintelligible, uncertain, and opaque but their operating principle remains the same. The operating principle is the binary fold of Boolean algebra, a sign system which is perfectly logic but at the same time inherently bounded.

How then to make sense of the ethical implications of algorithms? Chapter “Thinking of Algorithms as Assemblages” has shown how recent scholars seek to embrace the multiple dimensions interplaying around the algorithm. Taking assemblage thinking seriously one can no longer take the notion of algorithm for granted but needs to ask how the black box of the algorithm is produced and stabilized. This is a refreshing counter perspective to cultural approaches which currently run the risk to overload the concept of algorithm. Unfortunately, many studies do not take full advantage of assemblage thinking. Instead, assemblages tend to be misunderstood as static structures or a deliberate design issues. The opposite is the case. Without labeling it as such, Louise Amoore provides an assemblage understanding of algorithms. Thereby the distributed act of writing algorithms, which exceeds the source code, produces a functional whole, the algorithm. In this sense it is not the single author who is responsible, but the discursive community which produces and gives meaning to its very objects.

To give meaning to action has also been the issue of the chapter “Decision Making – Explanans or Explanandum”. Thereby I have contrasted two different perspectives on decision-making. Does a decision translate reason into action or does a decision translate action into reason? To put it bluntly, I do not know, but certainly a decision stands somewhere between the two realms of reason and action – if they can be separated at all. For Derrida, a decision is neither pure reason, nor deterministic action. And it is precisely this uncertainty which sets the grounds for his ethics of responsibility. To be responsible I must bring something new into the world. It is precisely this point where I see a moment of translation. Since no two words are equivalent, translation always implies to bring forth something new. It is not just the unfolding of a programmable process, but the very struggle with the undecidable. Indeed, it could be conceptualized as a kind of play with the undecidable. Hence, translation is an attempt to give meaning to an otherwise arbitrary array of signs. An attempt to read the material folds as a functional whole. A model of translation has already been introduced to Actor-Network Theory by Michel Callon. He concludes his early work on translation with the following words:

Translation is the mechanism by which the social and natural worlds progressively take form. The result is a situation in which certain entities control others. Understanding what sociologists generally call power relationships means describing the way in which actors are

defined, associated and simultaneously obliged to remain faithful to their alliances. The repertoire of translation is not only designed to give a symmetrical and tolerant description of a complex process which constantly mixes together a variety of social and natural entities. It also permits an explanation of how a few obtain the right to express and to represent the many silent actors of the social and natural worlds they have mobilized. (Callon, 1984, p. 224)

To apply this insight to the field of algorithmic decision-making means that whoever translates algorithmic outputs, who interprets something into them, who ascribes a certain value to them, brings forth something new into the world. Something that is neither inherent, nor emergent of the algorithmic calculus. Hence whoever translates algorithmic outputs bears the responsibility that the translation could have been done differently. In this light it is neither the inputs nor the outputs which bear responsibility. But those who authorize an algorithm to a certain task. To put this more precisely: Algorithms do not take decisions, but there are decisions that bear the responsibility for algorithmic action.

I deliberately do not want to attach the act of translation solely to human subjects but remain with the figure of spaces of responsibility. How such spaces of responsibility could look like, how they translate in networks of associations should be the issue of the empirical part of this study. I hope that a sufficient language has been developed to conduct this endeavor. Certainly, this model runs the risk of stepping into all kinds of traps. To combine notions from actor-network theory with notions from deconstruction has already been claimed as a precarious endeavor (Whittle & Spicer, 2008). But I am willing to bear the responsibility for this since it allows to address the very issue of algorithmic decision-making. Namely the apparent tension between reason and action, between mind and material.

What about organizational aspects in this framework? Certainly, on the first glance this framework seems to lose touch with organization studies. I doubt this. As shown in the chapter “The Historical Development of Algorithms”, algorithms and organizations do have much more in common than expected. Indeed, to study organizations as deep learning algorithms could be a fruitful metaphor for future research. But for now, the field of algorithm studies is still too obscure to build fragile metaphors upon. In this light, the framework of this study should be in the interest of organizational researchers, too. After all, only if we have an adequate understanding of algorithms can we begin to conceptualize them as parts of organizations, as organizers or as organizational products. Ultimately, the field of organization studies has plenty

of models to address some of the current issues in algorithm studies. But to do so it requires translation between the two. A matter this study is willing to address.

Methodological Considerations

So far, this study has outlined the recent debate on ethical issues of algorithmic decision-making and discussed it from a deconstructive perspective. The following section seeks to derive a methodology for the empirical concerns of this study. Thereby theoretical and empirical findings should not be separated but be perceived as intertwined. In this sense the methodology should not be introduced as a neutral instrument but as a condition for the empirical findings. Consequently, it is the notion of performativity that this section revolves around. Finally, the researcher and his connection to Skitourengruru should be discussed as a translating link in the assemblage of this study.

Discovering Performativity in Critical Algorithm Studies

When looking at recent publications in the field of critical algorithm studies, a reoccurring motive is the performativity of algorithms (Amoore, 2020; Beer, 2017; Introna, 2016; Weiskopf, 2020a). Reading closely, however, it becomes apparent that the term is used in different shades. For example, Lucas D. Introna argues:

This temporal flow is what produces the “doing” of algorithms, but, importantly, it is also performative. By this we mean that the doing of algorithms is not simply the execution of instructions (determined by the programmers); rather, their intrarelational actions (Barad 2007) also enact the objects they are supposed to reflect or express. (Introna, 2016, p. 20)

In this work Introna applies a processual and relational ontology. Drawing from Whitehead and Butler, Introna argues that interaction does not link preexisting entities but rather enacts and constitutes them. In this sense actors or entities do not simply exist but must be performed to be recognized. Since Introna perceives algorithms as “temporally unfolding processes”, embedded in “sociomaterial” networks, algorithmic action is necessarily performative. Introna puts it that way: “In performativity every (en)action, within the flow of sociomaterial assemblages, is constitutive of what that assemblage is becoming” (Introna, 2016, p. 24). The underlying ontology, as Introna rightly points out, is closely related to relational frameworks such as actor-network theory. In this regard the algorithm is just as performative as the automated door-closer discussed by Latour (2010). Since its actions make a difference in an actor-network, it also participates in its constitution. But Introna highlights the difference of algorithms arguing that “[...] these technologies of governance are linked to regimes of knowledge and are constitutive of particular subjectivities” (Introna, 2016, p. 30). This is the

crucial point since now algorithmic outputs might serve as normative benchmarks that can be internalized and reenacted. From this perspective, to say that an algorithm is performative is to say that a certain constellation of human and non-human actors produces a feedback loop. A very similar figure can be found in the work of Richard Weiskopf. He states:

In Hacking's terms, it is not just an "engine of discovery"—as the term "Knowledge Discovery in Data Base" (KDD) suggests—but also at the same time an "engine of making up people." Algorithms are thus performative. They generate objects of knowledge that loop back and shape the world. (Weiskopf, 2020a, pp. 9–10)

Interestingly Weiskopf derives this statement from a different theoretical point of departure. Drawing from Derrida's (1992) notion of the undecidability, it is argued that algorithmic outputs produce categories and distinctions that haunt the world. Within this framework, the algorithmic acts of selecting, sorting, and ordering are closely tied to "value judgments" and hence inherently ethico-political activities. Once a category is established it can be reenacted, shaping future events and human conduct. Interestingly, both Weiskopf and Introna leave their initial theoretical framework at this point and introduce the notion of governmentality. Reading closely, it becomes apparent that both scholars describe a circular interaction between algorithmic outputs and human conduct. This is a crucial insight for the question of ethical implications of algorithmic decision-making since it reveals that both technological and normative spheres touch on and affect each other over time. It also reveals that neither sociomaterial nor deconstructivist approaches alone can account for the dynamic and performative interplay of normative and material dimensions. In fact, this iterative and reciprocal mode of production reveals a fundamental social dynamic that did not only begin with the introduction of algorithms. Nevertheless, I am not going to elaborate on the notion of governmentality at this point. Instead, I propose a closer reading on the notion of performativity. An endeavor that is not only missing in the current literature on critical algorithm studies but might also help to develop a critical stance towards the research modes in the empirical part of this study.

The concept of performativity revolves around the central feature of language, to be not only descriptive of but also constitutive of reality. Etymologically, performativity refers to the English verb to perform, which means to execute, act, embody and institute. A performative understanding of language does neither privilege structural nor intentional aspects of language but perceives them as a productive interplay. In this sense performativity stresses the reciprocal and circular production of both institutions and subjects through language. Historically the

origin of performativity is often assigned to John L. Austin. Indeed, Austin coined the philosophical term performative, with his 1955 lecture “Performative Utterances” and his 1962 published lecture series “How to do things with Words”. Nevertheless, the constructive character of language can already be found in the Book of Genesis or in the early ancient Greek philosophy (Hetzel, 2004).

In “How to do things with Words” Austin develops the position that not all speech acts are utterances of true or false but that some sentences also bring about new facts. Examples for these latter, performative utterances are expressions like “I bet you six pence it will rain tomorrow” or “I name this ship *Queen Elizabeth*” (Austin, 1962, p. 5). For Austin, certain conditions must be met for a performative utterance to be successful. These conditions comprise both the context of the speech act and the speaker’s intention. So does a context such as ceremony authorize a certain speaker to name a ship. Furthermore, the speaker must be speaking seriously instead of acting or joking for a performative utterance to be felicitous. Over the course of his lecture series, Austin drops the distinction between constative (true and false) and performative utterances and argues that both types carry aspects of the respective other type. Instead he proposes to analyze speech acts on three different levels, namely locutionary (the meaning of the utterance), illocutionary (the intent of the utterance), and perlocutionary (the actual effect of the utterance) (Gond et al., 2016).

In 1972 Jacques Derrida publishes a critique of Austin’s speech act theory titled “Signature Event Context”. The critique revolves around the intentionality and the closure of context that is essential to Austin’s speech act theory. Derrida pleads for the iterative nature of performative speech acts. In this light, speech acts are understood as citations that can occur in potentially endless contexts. This blurs the distinction between correct and incorrect contexts, central to Austin’s notion of felicitous performatives. Furthermore, what Austin labeled the parasitical performatives, such as acting a play or doing a joke, become a basic part of performatives rather than an exception. Ultimately, Derrida questions the necessity of a self-conscious, intentional speaker, arguing that the intention of the utterance will never be fully transparent to itself (Miller, 2009). Derrida puts it that way:

[...] given that structure of iteration, the intention animating the utterance will never be through and through present to itself and to its content. The iteration structuring it a priori introduces into it a dehiscence and a cleft [brisure] which are essential. The "non-serious," the oratio obliqua will no longer be able to be excluded, as Austin wished, from "ordinary language". (Derrida, 1988, p. 18)

Looking at recent theoretical contributions on the notion of performativity, the work of Judith Butler should be elaborated in more detail. Different to Derrida, Butler puts forward a material conception of performativity. Relating theatrical performances and linguistic speech acts, Butler stresses the material and bodily dimensions of repeated social practices. For Butler gender is an enacted effect produced through a repetitive doing of social norms. In common with Derrida, Butler highlights the iterability of performativity. She states: “In the first instance, performativity must be understood not as a singular or deliberate “act,” but, rather, as the reiterative and citational practice by which discourse produces the effects that it names” (Butler, 2011, p. xii). Other than Austin, Butler turns the aspect of intentionality upside down arguing that intentionality is a product rather than a condition for performative action (Miller, 2009). However, Butler’s notion of performativity is no pre-determined one-way road but sets the very condition for ethical and political decisions. Discussing Hannah Arendt’s fictive death sentence in “Eichmann in Jerusalem”, Butler argues:

So though the speech act is not an efficacious performative, it does something else. It models what a subject might look like, might sound like, who spoke in the name of a diverse humanity and against those who seek to deny or destroy some part of that diversity. (Butler, 2010, p. 156)

The concept of performativity thus refers to a social contingency and allows social modes of reproduction to be changed. In this respect, ethical issues cannot be addressed by prescribed codes of conduct, but only by engaging with the very situation that produces them. In this light Derrida’s notion of responsibility also becomes clearer. To act responsible is to respond to a situation that does not depend on preexisting rules or contexts. Instead, it is to acknowledge, the very singularity of the other and the respective situation. But to do so it requires the utterable to be recontextualizable. Hence the notion of iterability, Derrida’s central claim concerning speech act theory, lies at the very heart of a politics of ethics and responsibility (Barton, 2003). To quote Derrida again:

I am convinced that speech act theory is fundamentally and in its most fecund, most rigorous and most interesting aspects [...] a theory of right or law, of convention, of political ethics or of politics as ethics. It describes [...] the pure conditions of an ethical-political discourse insofar as this discourse involves the relation of intentionality to conventionality or to rules. (Derrida, 1988, p. 97)

Before applying those insights to the current discussion on ethical issues of algorithmic decision-making, I want to take a step back from the realm of deconstruction and take a brief

look at the field of actor-network theory. Indeed in recent years there has been something called the “performative turn” in actor-network theory (Licoppe, 2010). Interestingly, this leads to some profound methodological differences between some scholars of actor-network theory. Looking at the work of Bruno Latour (2007) the notion of performativity can hardly be found. In fact, Latour’s labels his approach of tracing and describing actors as a sort of relativist positivism. In a fictive dialogue he states: “I prefer to break them [the rules of social science training] and follow my actors. As you said, I am, in the end, a naive realist, a positivist” (Latour, 2007, p. 156). This is where the earlier mentioned critique of Whittle and Spicer’s (2008) comes into play, arguing that actor-network theory relativizes scientific knowledge, while being irreflexive of its own methodology and morally blind. As a counter draft, Alcadipani and Hassard (2010) highlight the “political ontology of organizing” in the actor-network theory literature. They state:

Combining ontology with politics thus suggests that ‘the condition of possibilities are not given’ (Mol, 1999: 74), but are in the making. Realities are not immutable—they are shaped, enacted and contested. Ontological politics is connected with the way in which the real is implicated in the political and vice versa, meaning that things could always be otherwise (Law, 2008; Mol, 1999). The concept of ontological politics is based therefore on the notion that things might be ‘different’. (Alcadipani & Hassard, 2010, p. 424)

But Alcadipani and Hassard go one step further and not only apply this insight to their research object, but to their own practice of research. They argue: “In such a view, there is not *a priori* a researcher/object dichotomy; both are produced as outcomes of the practices of research (Law, 1994). The researcher, therefore, is not just observing, s/he is actively constructing what it is being studied” (Alcadipani & Hassard, 2010, p. 428). In this political ontology of organizing, I not only see a strong parallel to the Derridean notion of performativity, but also the opportunity to reflexively engage with my own work. I therefore propose to abandon the fronts between material and abstract realms and invite them to a performative dance for the remainder of this study. To make a start, the insights concerning performativity should now be applied to the debate on ethical issues of algorithmic decision-making.

What do we mean when stating that algorithms are performative? Does it mean that their outputs should be understood as performative speech acts? Does it mean that their categories affect the realm of the utterable and participate in the organization of knowledge? Does it mean that the notion of algorithm shapes our focus of research? Or does it mean that algorithmic applications are driven by a broader demand for instrumental efficiency? Certainly, all those

positions seem feasible. For instance, the outputs of the COMPAS recidivism algorithm could be understood as illocutionary performative speech acts that have the authority to judge and bring forth certain realities. Looking at Introna's (2016) example of the "Turnitin" plagiarism algorithm, we find an example for the organization of knowledge and norms through the algorithmic production of categories. Looking at David Beer's (2017) elaboration on the social power of algorithms, we see that not only the technology but also the notion of algorithm has performative effects. And finally, the work of Lindenbaum et al. (2020) shows that algorithms are produced and embedded in prior, performative value structures.

These insights allow us to loop back on the notion of decision as well. Looking from a performative perspective, algorithmic decisions are no longer deliberate choices or neutral calculations, but 'ontological gestures' that separate, structure and organize certain realities. In this regard, to expect decisions only at the output of algorithmic systems might be fundamentally misleading. Instead the very inputs like sensor points, punctuations and incisions are already archetypal decisions, that bring forth a text/context distinction (Chia, 1996). At this point we begin to grasp that the analysis of algorithmic decisions will not reveal any 'prior mover' but will find itself at the very core of the problematic. How this problematic looks like, and what its implications for the further methodological and empirical realization of this study are, should be further addressed in the next chapter.

Researching Algorithms as a Performative Practice

In the previous chapter the notion of "political ontology of organizing" has been introduced. Along with this comes the claim, that no reality exists outside of description. This has fundamental implications for our understanding of science and the self-concept of this study. To say that there is no reality outside of description implies that science cannot provide a neutral representation of the world but is always entangled in its very production (Chia, 1996). This claim seems to be counterintuitive and obviously hurts the self-esteem of some scientists. But it has the appealing benefit of sensitizing us for the circularity in the production of truth. However, since such post-modern approaches can take ideological qualities too, I propose a modest and carefully considered proceeding (Parker, 1995). Let us exemplify this on a related issue.

Looking at a mountain we find an excellent example for what Chia (1994), calls a "meaningless moving mass". At a narrow timescale we recognize how water flows down the mountain. At a broader timescale we recognize how snow and ice flow down the mountain as well. Whilst at

an even broader timescale we recognize how even the rock flows down into the sea. This game could be played to infinity recognizing ever-new qualities on different scales. What becomes apparent now is that entities and events such as mountains or avalanches are punctuated, abstractions that only work on certain spatial and temporal scales. The argumentation now is that the *thingness* of a rock or the event of an avalanche are linguistic interventions that differentiate and relativize the otherwise meaningless moving mass. Bringing this to its natural conclusion implies that words no longer refer to things in the world but performatively produce these very things through the self-referential system of language. We are now getting a glimpse on what Derrida means when he states that there is nothing outside of text.

Such a processual and relational ontology seems feasible. However, it misses a crucial point, namely our material and embodied condition. An avalanche for example is a life-threatening episode for plants, humans, and animals alike. Any organism that tries to conserve itself must therefore develop functional punctuations that help it to orient itself in the world. What becomes apparent is that even though punctuations can be manifold, they should not be arbitrary. Chia comes to a similar position when he states:

We say a statement is true in so far as it allows us to economically grasp the complexities of a situation expediently and to thereby enable us to act coherently. It is this economy of expression which defines the status of truth. (Chia, 1996, p. 121).

If a meaningless moving mass can be captured economically, or rather in a life sustaining way, it cannot be a randomly moving mass. Rather certain patterns must be identifiable. In this regard to say that there is nothing outside of text seems to profoundly disregard the driving force of text, namely, to give orientation in a pretextual world. Latour makes a similar point when he states:

This is the great paradox of the use of the word construction : it is used by critical sociology to show that things are not simply and naturally there, that they are the product of some human or social ingenuity, but as soon as this metaphor of ‘making’, ‘creating’, or ‘constructing’ barely begins to shine, then the maker, the creator, the constructor has to share its agency with a sea of actants over which they have neither control nor mastery. (Latour, 2003a, p. 33)

In this regard, social constructions are no arbitrary punctuations that can be deconstructed at will, but conventions of multiple, material, and non-material agencies. Latour’s metaphorical use of the word construction relates to the construction of a building. A collaborative and productive process which is subject to path dependencies, as well as material and physical

constrains. In this regard construction requires sensitivity towards the “conflicting agencies” and “exigencies” at work. Here again the idea that heterogeneous elements are assembled to a functional whole resonates in Latour’s work. In what follows, Latour distances his work from critical theory and deconstructivism arguing that “[...] the critical spirit fails since it uses the least realistic definition possible of what it is to create, to construct, to be influenced, to be deluded” (Latour, 2003a, p. 38). Accordingly, to construct should not be understood as a matter of ontology but as a matter of epistemology. In this respect, constructivism is the gradual alignment of scientific perspectives towards objectivity. For Latour, such an alignment of different perspectives is a political process in the sense that it revolves around matters of concern. Thereby Latour’s “political epistemology” comes close to what we have identified as a performative understanding of politics: The establishment of groups, identities and interests through the iterative process of representation and obedience (Latour, 2003b).

We begin to understand that neither algorithmic, nor scientific truth claims are innocent representations, but performative network effects. Recalling some insights from the chapter “The Historical Development of Algorithms” it seems promising to compare prediction algorithms with the methodology of a positivist science. In both cases step by step procedures are imposed on an object of investigation. But instead of problematizing the performative character of such step-by-step procedures, it is precisely their procedural formality that sets the grounds for the authority of the resulting truth claims. In both cases it is the formalization of context that allows explanations to be given and predictions to be made. Thereby the possibility of reproduction allows an iterative stabilization, whereby the methodology becomes an end in itself (Tsoukas, 2017). A similar mechanism has also been identified by Richard Weiskopf. Concluding on the political implications of Cambridge Analytica and its relation to Donald Trump, Weiskopf states: “It seems that post-facticity [...] and hyper-facticity go very well together. Perhaps, post-facticity is even the ghost that haunts hyper-facticity” (Weiskopf, 2020a, p. 30). Looking behind the masquerade of hyper-, or post-facticity we find a common mechanism. Namely the stabilization of truth claims through their iteration in formal (social) networks of reproduction. Gaming this method for personal or economic concerns might be the ghost that haunts our orientation towards hyper-facticity. To add a Latourian objection to this insight, it must be said that not “anything goes”, but that a network of material and non-material agencies constrains what can be held as true.

Let us project these insights onto the further conduct of this study. If this study seeks to analyze the interaction within the socio-technical assemblage of Skitourenguru and trace back the

numerous factors that influence the decision-making in avalanche terrain, it should not limit itself to a mere algorithm. In fact, to cut the analysis along an algorithm would be a performative act highlighting certain information at the expense of others. As a counter draft I propose to follow the respective actors in the tradition of Actor-Network Theory. Latour describes this approach as following:

A good ANT account is a narrative or a description or a proposition where all the actors do something and don't just sit there. Instead of simply transporting effects without transforming them, each of the points in the text may become a bifurcation, an event, or the origin of a new translation. As soon as actors are treated not as intermediaries but as mediators, they render the movement of the social visible to the reader. (Latour, 2007, p. 128)

This approach could be compared with Chia's (1994) organizational analysis in the spirit of "symmetrical naivety". A spirit that does not impose existing categories but rather unfolds the underlying mechanisms and agencies at work. Similarly, also Tsoukas (2017) proposes a conjunctive theorizing style which makes "agency visible to agents". This approach seems promising when it comes to uncovering the assemblage working behind the label of Skitouenguru. However, this approach might tell little about issues of responsibility. Therefore, in a second iteration the uncovered agents are addressed with questions of responsibility. Those questions will be derived from the theoretical iteration of this study, which has outlined a deconstructive understanding of responsibility. Thereby the notion of performativity can serve as a translating link between assemblage thinking and deconstructivism.

Assembling the Author

To start with this analysis, it seems essential to examine the agencies involved in the analysis itself. This issue of reflexivity has already been addressed in chapter "Researching Algorithms as a Performative Practice", whereby the observer claims a reflexive position to himself while denying it to others. However, taking seriously what we have identified as a conjunctive theorizing style, we are now able to solve this issue. In this regard, the author of this text is as much an agent of the analyzed assemblage as any other identifiable agents. To put it in the words of Bruno Latour "The observer – whatever it is – finds itself on a par with all the other frames of reference" (Latour, 1996, p. 377). Further, if the author of this text wishes to observe, account and explain the assemblage of Skitouenguru, he must reveal the interconnecting links

between Skitourenguru and himself. In other words, a reflexive self-analysis cannot be separated from the empirical concern of this study but operates in the same association network.

A reflexive self-analysis might begin with a seemingly naïve question. Namely who is writing this text? The front cover of this thesis seems to provide an intuitive answer. Looking closer however this answer has little explanatory power creating nothing but an additional black box early on in this study. Furthermore, it opens a breach representing the author as both a person and a matriculation number. But although person and matriculation number account for two different sets of information, it is their conjunction which makes possible the writing of this thesis. The matriculation number accounts for a formalized procedure, linking up the person with a formal administrative system. This administrative system is not detached from the world, but grants access to a student insurance, enabling the respective person to focus on questions of responsibility in algorithmic decision-making. But could this person afford this lifestyle without the strong support of his family? Or is this just another indication of the pattern that educational opportunities are unequally distributed and closely correlate with the parental household? Not even to speak about the privileges a white male enjoys in the Austrian society. In any case it seems that the opposite holds true: No grant, no author.

And why again does the author focus on questions of responsibility in algorithmic decision-making? Certainly, the person writing this thesis has a passion for engineering. However, this passion has been neglected after a disenchanting bachelor's degree as an industrial engineer. More than that, questioning responsibility appears to him as a welcome alternation to the ethically questionable contributions he had made to the space and aviation industry at that time. Or would this topic never have come about without the proposal of his professor? Isn't this professor's gaze even inscribed in every single word of this thesis, even though barely looking at it physically? Certainly, the person writing this thesis writes it for himself. But where does this self begin when striving for appreciation and recognition? In any case, the person writing this text would not have expected which personal value this master thesis would once bear. Hasn't this person moved to Innsbruck to become a mountain guide, with a matriculation number in Organization Studies as a mere alibi? Isn't all the enthusiasm, love, and curiosity for the topic of Organization Studies the result of a happy coincidence? Or is this appreciation more than a coincidence and all those efforts, ups, downs, and detours have carved out their specific path dependencies?

Is this person even writing this master thesis by himself, or is this thesis nothing but the sum of institutional forces expressed through an intermediary author? Certainly Creswell (2013), (2014) has an impact, leading this text to its basic research structure. But also, value judgments derive from this source inscribing that good qualitative research should be “self-reflexive”, “rigorous” and “persuasive”. A similar role can be ascribed to Yin’s (2009) case study manifest, imprinting value judgments such as “reliability” or “validity” onto this text. Next, we have formal regulations imposed by the Department of Organisation und Lernen. Those regulations include format, length, and citation style. But even “good sources” such as the journals *Organization* or *Organization Studies* are recommended. Digging deeper those recommendations might not come out of thin air but are the manifestation of a bottomless academic discourse. A mechanism that is so profoundly performative that Google’s search algorithm looks pale in comparison. And what about the theoretical and methodological imprint of this thesis’ supervisor. Looking at the University page of Prof. Richard Weiskopf (2020b), neither the “poststructuralist” approach, nor the “ethico-aesthetic” focus of this work are surprising anymore. More than that, it seems that basic metaphors of this thesis such as the fold, or the network might not only be chosen because of their explanatory value but because they already circulated in the association space of this thesis. It seems that older publications of Prof. Weiskopf (2002) not only manifest in his lectures but also the reasoning mode of this thesis.

These influences, desires and path dependencies become invisible all too quickly once conflated behind the attribution of authorship. And yet we have not even spoken about the process of writing. In the naïve desire this thesis could have an impact the person writing this thesis oscillates between childish curiosity and bare disillusion. Desperately trying to balance the agencies behind this text, he puts the weight of the world on every single formulation. Often enough this pressure results in stagnation, rather than qualitative results. It seems that this process of writing is haunted by a profound undecidability: The sheer impossibility to find a single word that could account for the multiplicity of the situation at hand. And even those rare moments of insight, muse and productiveness come along with this hunch of being preliminary and obsolete as soon as they are embodied in text. Has the author committed himself to a work that can never be finished, or is this just another symptom of our modern condition? In any case this impossible and yet realizable process of writing brings forth more than an *ex post* attributed author. It brings forth a moody and opaque subject who is only able to give a limited and partial account of himself. It brings forth something that will retrospectively be labeled as human agency: The quality of making a difference in both material and abstract realms. Considering

this manifold and emergent process, Latour's agenda of simply describing the states of affair at hand appears all to idealistic.

But what about non-human agencies in the production of this text? How often have I engaged with the translation program DeepL, trying to enact a possible formulation of my thoughts? Neither have I thought about the highly secretive deep learning algorithms operating behind its minimalist user interface. Nor have I thought about its data base being extracted from Linguee or its computation center based in Iceland (Schwan, 2017). And it is even more complicated, since much of the cited literature in this thesis was suggested by the search algorithms such as Researchgate, Google and Google Scholar. How much difference these individualized search engines make became apparent to me, when clearing and disabling the cookies of my browser. Then search results were more diverse, but indeed less compatible with my own interests. Not to mention the further consequences this relation entails, absorbing my behavioral surplus for commercialized prediction products. But also straight forward application like Citavi or Word both constrain and enable this text in their very particular way. How often have I privileged sources that could easily be import via the Citavi picker? How often have I changed my formulation just to align with the next page break? How often have I changed the wording because Word's autocorrection claimed to know better? Certainly, none of these forces have severe or game changing consequences but to neglect their agency would be all to careless.

To summarize this section, it can be said that this text has been inspired, informed, and shaped by a variety of human and non-human agencies. Regarding this multiplicity of forces, the process of writing becomes an impossible yet realizable task. In this light the process of writing can be understood as a translation process, a desperate attempt to link up heterogeneous and autonomous languages. In other words, this text can better be understood as a curation rather than a composition. What exactly is been curated should be further analyzed in the next section.

Second Order Process Analysis

The curation process of this text extends over the period of one year, beginning in spring 2020 and ending in spring 2021. This time frame is preceded by a research proposal which has been developed in Winter 2019/2020. The conceptual part of this thesis is elaborated in the summer of 2020, the empirical part is elaborated in Winter 2020/21. Due to this chronological order, the empirical investigations are informed by the conceptual findings. To still maintain an unfolding and conjunctive theorizing style, these conceptual findings are applied in a second iteration only. Here, the main methodological difficulty becomes apparent. On the one hand, an actor-

network should be unfolded as neutrally as possible. Whilst on the other hand, the issue of responsibility should be traced.

The primary concern of unfolding an actor-network revolves around the research question of how the numerous human and non-human factors of Skitouren guru influence the decision-making in avalanche terrain. This descriptive approach crystalizes from the official website of Skitouren guru. Here, both the involved actors and the respective documentations are listed. These are in total 186 web links by Skitouren guru and 276 web links by external providers. The graph diagram of the underlying link structure can be found below (Appendix 1). In addition to the documentation, Skitouren guru lists 15 direct contributors. Of these 15 contributors, the contact information of ten persons could be found. After contacting those ten contributors closer exchange could be established with six persons. Those persons are Günter S., Jochen K., Ulrich R., Luca I. and Andreas E, and Rosa G. In the case of Andreas E. and Rosa G. the communication took place by email only. In the other four cases personal, semi structured interviews could be conducted. The interviews were informed by the main conceptual themes of this thesis but sought to give space for new links and associations to emerge. In a second, broader association radius, the sponsors, and partners of Skitouren guru are also included. These consist of nine organizations of which contact could be made with six. Thereby the communication took place by email only. Additionally, 20 of the corresponding third-party web links were further explored. A more detailed contact protocol can also be found below (Appendix 2).

The second concern revolves around the question of responsibility and the limits of algorithmic decisions. Therefore, the association radius is further extended to third party stakeholders such as avalanche specialists, alpine clubs, and potential users of Skitouren guru. In the case of Lutz, Hansi, Leon K., Nils B., Renato F. and Rita C and Michael L., semi structured interviews were conducted. In the case of Markus F., Patrick N., and Albert L. the communication took place by email only. Here the investigation changes from an inductive and descriptive emphasis to a deductive and critical emphasis. Thereby the main conceptual themes of responsibility, undecidability, performativity, value-judgment, assemblage, and algorithm are further stressed. For this purpose, the previously collected documents and interviews are analyzed again. Here the focus is not on mere confirmation. Instead, contradictions and weak points of the developed theory are highlighted. Therefore, the main conceptual themes are not simply imposed as a priori codes, but rather exposed to the critical light of the case itself. The knowledge elements of Citavi 6.7 served to organize this process.

To ensure the integrity of the informants, no interview records are being published with this thesis. Furthermore, the informants' last names are abbreviated in the text. In the case of Lutz and Hansi synonymous names were given. To back up both the integrity and the validity of the used quotations all informants had the opportunity to review the passages they are cited in, prior to the publication. Therefore, all interview records were transcribed by edited transcription. In some cases, also conceptual parts were reviewed. Here the contribution of Günter S. must be mentioned who has highlighted interesting links in the conceptual part. A main issue with the quotations was their translation in the text. For a good reading flow the quotations are translated into English. The basic structure of the translation is provided by the translation program DeepL. Technical terms, names and idioms were further edited by the author. To do justice to the wording of the informants, quotes that are taken from interviews or emails can be found in the original language in the appendix. Quotations that originate from German articles are not included since they can be looked up in the respective publications.

Throughout the analysis two actors are hard to distinguish. Namely Günter S., the founder and main developer of Skitouren guru and the Skitouren guru GmbH. To unfold the agencies, of the Skitouren guru GmbH emphasis is put on the person of Günter S. when possible. Nevertheless, contributions on Skitouren guru.ch without an explicit authorship are attributed to the Skitouren guru GmbH. This aligns with an assemblage perspective in so far as that the limited liability has legal and representative agency, too. There is the risk that a strong focus on Günter S. and the Skitouren guru GmbH reproduces a public image without gaining further depth. Therefore, other project members and perspectives are given voice. Thereby, the chairwoman of the Swiss Mountain Guides Association Rita C., the mountain guide Nils B. and the co-developer Joch K. are of particular importance. However, often these voices have little to say about the algorithm of Skitouren guru. Here, a trade off becomes apparent. A narrow focus on the algorithm is more likely to reproduce the public image of the Skitouren guru GmbH. A broader focus however might lose touch with the issue of algorithmic decision-making. To balance these two poles different narrative perspectives are being applied throughout the chapters. These chapters are constructed as follows.

Second Order Data Analysis

The chapter Fateful Episode opens the recurrent question of this analysis, namely which tour is a good choice at all. At the same time, it represents the very beginning of the algorithm, namely a possible data point about prior avalanche accidents. The chapter is based on two individual

interviews with Lutz und Hansi. Whilst Lutz is a friend of the author, no further relation exists between Hansi and the author. Further information about the accident were collected by the Tyrolean as well as the Salzburg Avalanche Service. The written story was reviewed by Lutz and Hansi and approved for publication.

The chapter Tracing the Development makes a temporal cut through the project of Skitouren guru. Based on online publications the sociotechnical development of Skitouren guru is being traced over time. Most of the used publications were already collected on Skitouren guru.ch. In addition, voices from the online conference Skitouren summit, as well as personally conducted interviews are processed. The chapter gives voice to both internal and external stakeholders of Skitouren guru. Accordingly, little spatial differentiation is being done.

The chapter Interacting with Skitouren guru puts emphasis on the interface of Skitouren guru. For this purpose, the appearance of Skitouren guru is being described. This description relies on an in-depth analysis of the underlying hyperlink structure. Therefore 186 weblinks were being protocolled and analyzed. Additionally, visual agencies and symbolic expressions were collected and described. If possible, voices from personally conducted interviews were included to illuminate the underlying thoughts. However little functional differentiation of the underlying model is being done.

The chapter Unfolding the Algorithm stresses the functional aspects of Skitouren guru. Thereby particular attention is being paid to the risk assessment algorithm. The analysis is based on the scientific publications about this risk assessment algorithm. Additionally, clarifying side notes of the main developer Günter S. and Jochen K. are included. The functional aspect is not reduced to mere calculation, but also considers its input parameters. For this purpose, the Tyrol avalanche report is presented in further detail. This is based on personal exchange and online documents.

The chapter Enacting the Risk Assessment leaves the abstract realm and focuses on the material effects of Skitouren guru's risk assessment. To further develop the prior introduced actors, joint ski tours with Lutz were selected for this purpose. Neither the author, nor Lutz were put into danger for this endeavor. However potentially dangerous situations were analyzed for this thesis retrospectively. For this purpose, written notes were made before and after the respective tours.

Finally, the chapter Asking for Responsibility makes an abstract cut again. Here the question of responsibility being traced through the compiled data. This process is further augmented by

a brief discussion of the term risk. For this purpose already identified actors were addressed with questions about responsibility, uncertainty and risks.

To finish this section, it should be said that no funds were received by Skitourengru or its partners. First results of this study were being presented at the OS Conjunction Conference in November 2020.

Empirical Investigation

Fateful Episode

It is six in the morning when Lutz swings out of his bed. First layer, second layer his worn cloths fit like a second skin. A quick coffee, some hot water, a slice of bread. His motions are automated, his mind operates on auto pilot. He slips into his tattered jacket, shoulders his prepacked backpack and steps into the crystal winter air. The plan is clear: Chase the old Skoda to his fellow Hansi, rush through the Bavarian Prealps and approach the Austrian Mitterhorn from the north. Traverse the summit, ski down the prestigious diagonal gully, and reascend the Mitterhorn from the south. After, almost 2500 meters of altitude and 10 kilometers of distance the two fellows would glide back down, documenting their sinus traces left in the fresh north face powder.

Having done 87 ski tours this season Lutz knows the conditions like few other amateur ski tourers around. In the last days he has observed a solid snowpack with a twenty-centimeter layer of fresh powder snow. Last night he felt confirmed by the Salzburg avalanche bulletin, which identified a moderate avalanche risk for the Lofer Alps. The main issue was a strong south foehn, increasing the risk of snow slaps during the day. However, Lutz concluded that the foehn would mainly affect the inner alpine regions, protecting the Mitterhorn from the winds until noon. The assessment of the bordering Tyrolean avalanche forecast (Appendix 3), which identified a considerable avalanche risk, was not further considered.

The plan unfolds and the two fellows find themselves quickly at the end of the road. The small talk fades and turns into a rhythmic ensemble of gliding skies and steady heart beats. Whilst Hansi sets the pace and leads through a slope of mountain pines, Lutz takes some photos every here and there: The steep limestone faces of the Gute Wand. Hansi in front of virgin slopes. The sun peeking behind the Breithorn. Some wind drifts at the Mitterhorn. Surprised about these wind drifts, Lutz compares his impression with the calm air around him. It must be a local wind with only little effects on the snowpack he concludes. Some quick snow tests seem to confirm this impression. Some minor wind sings but an overall stable snowpack. Without further discussing their situation, the two enter a steep gully leading to a pre-summit of the Mitterhorn.

After 150 vertical meters the gully widens up into an open slope. Hansi makes use of the wider terrain and extends the distances between his kick turns. He sets just another step when his

weight triggers a weak layer of snow 50 centimeters beneath the surface. With the speed of sound, the initialized crack extends over a length of 50 meters (Appendix 4). A warning scream echoes through the air. But the ground already drags him away. Desperately fighting against the elements, Hansi can rescue himself to the upper end of the avalanche. But it is Lutz who gets the full load from above. Despite heavy resistance, Lutz gets sucked into the ever-accelerating conglomerate of snow and ice. When he gets spluttered back to the surface, he finds himself sweeping towards a rocky cliff. Lutz gets swept over the cliff; a second cliff follows right away. Blackout.

After a close rescue operation and months of recovery, there remain these questions to Lutz: Could the accident have been avoided? Where could he have decided differently? Should he have been more aware of local signs? Should he have communicated his concerns? Would he do it again? And was the tour a good choice at all?

Tracing the Development of Skitouren guru

Which tour is a good choice at all, is a question that is also been asked by Günter S. Unlike Lutz, however, he does not ask this question retrospectively, but in regard of his next ski tour. In an interview with Lukas Ruetz, he states:

For almost 40 years I have been asking myself before the weekends what would be suitable ski tours in view of the current avalanche warning. To answer this question properly, one would have to meticulously compare the 300 day ski tours accessible from Zurich using a reduction method. This is rather tedious, repetitive work. As a software developer, it quickly became clear to me that the computer could do this much better. On New Year's Eve 2013, I therefore began with the development of version 1.0. (Ruetz, 2018b, p. 3)

Several months had to pass until version 1.0 of Skitouren guru.ch could go online in autumn 2014. In line with the established avalanche doctrine, this version links up slope classes with the current avalanche report. At the Skitouren summit 2020 Günter recalls this version as follows:

So, in the beginning it was more of a joke. I just thought, let us try it. We download the avalanche bulletin as it is, combined it with a simple reduction method and displayed that. It was a very terrible version, version one. Then one thing led to another. (Appendix 5 No. 1)

However, the media presence is still limited. Among other, Skitouren guru shares an article about the avalanche expert Werner Munter in January 2015. In this article Munter does not

preach for safety, but on the contrary, champions risk as a human right. Munter is quoted as follows:

For me, freedom means that you can decide for yourself. You are responsible for what you have decided. Let us imagine a society in which every activity is secured. Then we live in a dictatorship, everything is checked and controlled. Then you no longer decide for yourself, then you are a puppet, an automaton that is controlled. (Knecht, 2015, p. 4)

Skitouren guru describes the article as an "interesting article on the subject of risk", but does not further comment on it. Then in March 2015, further technical improvements are added to the model of Skitouren guru. As the following post indicates:

Since today Skitouren guru is the proud owner of a business license of SwissAlti3D (10 m). SwissAlti3D is a high-resolution, accurate elevation model from Swisstopo. The purchase of this package was made possible by Mammut. Thanks to SwissAlti3D, a new era is dawning for the Skitouren guru. Until now, Skitouren guru had to rely on the third-best elevation model. Accordingly, data analysis was a difficult undertaking. In order to trace discrepancies back to the lack of quality of the elevation model or to the weaknesses of the algorithm, elaborate analyses were necessary. Now finally the milk disk is gone and the Skitouren guru gets a clear view. [...] (Skitouren guru, 2015, p. 1)

Over the course of 2015, further technical improvements follow. Difficulty levels are added to the routes and wildlife rest areas are being considered in route suggestions. But also the risk calculation algorithm, the search function and detail view are further refined. In January 2016, the master thesis of Andreas Eisenhut is presented, on Skitouren guru.ch. His work allows to automatically calculate route corridors for ski tours. In the Swiss Alps, these corridors can now be displayed as an overlay map. It is stated on Skitouren guru:

The future belongs to the corridors. Manual editing of corridors was unthinkable until now. The results would have been too inconsistent, the effort would have been gigantic. Thanks to high-resolution and high-precision geodata, the automatic generation of corridors has become possible today. Skitouren guru dares to predict that in the future every line will be accompanied by a corridor. It is expressed the hope that also the official ski touring maps of the SAC will not be able to escape this development. (Skitouren guru, 2016, p. 1)

It is early in 2016 when the press becomes attentive to Skitouren guru. A cautious attitude towards Skitouren guru is expressed by the two avalanche experts Stephann Harvey and Lukas Dürr. In the swiss alpine club magazine Die Alpen they write:

Although the platform www.skitouren guru.ch is helpful for planning ski, snowboard and snowshoe tours, it cannot replace independent planning. For the planning and independent execution of ski tours, you need a good training. [...] In short: The complete ski tour planning for "dummies" can not be offered by Skitouren guru, but it can make it much easier. (Harvey & Dürr, 2016, p. 20)

And also a comment of the retired avalanche expert Werner Munter is not long in coming. The SRF quotes him as follows:

It will save the lives of many of the 'Generation Selfie'. [But] I will not let a computer take away the pleasure of assessing a risk myself. [...] The most important safety concept on ski tours is to be able to turn back. You can develop hundreds of such programs. Not a single one replaces this important principle. (Heissenbüttel, 2016, p. 1)

Meanwhile, Günter S. and Jochen K. are working on two scientific papers called “Automated Avalanche Risk Rating of Backcountry Ski Routes” and “Method for an Automatized Avalanche Terrain Classification” (Schmudlach & Köhler, 2016a, 2016b). Both papers are presented at the International Snow Science Workshop in Breckenridge, Colorado in October 2016. The latter paper summarizes the model of Skitouren guru as follows:

The platform [[Skitouren guru.ch](http://www.skitouren guru.ch)] evaluates twice a day the avalanche risk on 625 popular backcountry routes in Switzerland. The resulting risk indicator is a decimal value in the range [0..3] and can be split into three basic risk categories: "low", "elevated" and "high risk". The risk indicators are calculated by combining terrain characteristics with up-to-date avalanche forecasting data. The algorithm is essentially based on the well-known Graphical Reduction Method (see Fig. 6). Terrain analysis embraces slope angle evaluation, ridge, and forest detection. The avalanche forecasting data from the "Swiss Snow and Avalanche Research Institute" includes regional information about danger level, critical elevations, and critical aspects. [...] Even though the web presentation of the content is challenging, the approach has the potential to direct the users to routes with low avalanche risk. Such redirection can make an important contribution to the avalanche accident prevention. (Schmudlach & Köhler, 2016b, p. 729)

A similar wording can also be found on the website of Skitouren guru. Concerning the goals of Skitouren guru it is stated:

Skitouren guru wants to direct the community to ski tours that have a low avalanche risk. Such ski tours forgive the one or other mistake on the spot. In addition, Skitouren guru would like to introduce the community to avalanche awareness. The exact description of the desired effects can be found in the goals of Skitouren guru. (Skitouren guru, 2021a, p. 1)

Later in December 2016, Skitourenguru is looking forward to a ski season with 280 additional ski tours, an improvement of the automated route corridors, a single route download, as well as the display of bus stops and deadly avalanche accidents at skitourenguru.ch. The year 2017 then starts with a post on snow height modeling. Thereby the SLF's snow mass map as well as with Nasa's Landsat Program and ESA's Copernicus Program are referenced. However, there is no talk of implementing these layers yet. In April 2017, the mountain guide and lawyer Rita C. explores the question of whether Skitourenguru can change the jurisprudence of avalanche accidents. In the magazine *Die Alpen* she writes:

By all appearances, this digital risk assessment is triggering debate among experts. There is fear that the courts in the event of an avalanche accident, will unilaterally rely on this new tool and in the case of an increased risk indicator will directly conclude that negligence was involved. [...] These concerns are not well founded: If a court must judge an avalanche accident, it always relies on an expert with regard to the avalanche and guidance aspects. As a rule, this is an employee of the SLF or an experienced mountain guide. Such an expert would massively relativize the importance of skitourenguru.ch. [...] However, what is decisive for the legal processing is not the question of the selection of the route, but rather the question of whether the accident slope complied with the current standards of avalanche awareness under the specific circumstances. [...] The platform therefore rightly clarifies that its evaluations are meaningless during phase 2 ("on the spot") and the phase 3 ("single slope"). Decisive for the question whether a responsible person has violated his duty of care is the opinion of the avalanche expert. (Christen, 2017, pp. 36–37)

Later in 2017, Skitourenguru is looking for a volunteer Italian translator. A job that is later taken over by Luca I. Furthermore, Skitourenguru calls to send in GPS tracks. Thereby the motivation is not the commercialization of a behavioral surplus, but the further refinement of the algorithm. It is stated:

The following heatmap is based on GPS tracks recorded between 2006 and 2017. After a complex conversion, filtering and correction process, line segments of a total length of about 48'000 km remain. [...] Of course, the heat map only shows a section of the actual events in the field. The data is subject to bias. Ultimately, little can be said about the nature of this bias at this time. In order for Skitourenguru's algorithm to evolve, Skitourenguru relies on your help: Every GPS track you record and send to Skitourenguru is important! (Skitourenguru, 2017, p. 1)

Besides that, it is rather quiet around Skitourenguru in 2017, which may also be due to Günter's one year collaboration with the SLF, developing an automatic classification of avalanche terrain. In February 2018, the Swiss Council for Accident Prevention (bfu) comes on stage. In

an article, they refer to Skitouren guru as an "excellent planning tool". In a further inquiry, the consultant Monique W. writes:

The BFU Beratungsstelle für Unfallverhütung, has supported Skitouren guru since the beginning because it makes it easier for ski tourers to find and choose a ski tour with a low avalanche risk. The goal of the BFU is to possibly steer tourers to low-risk terrain. Of course, we want ski tourers to choose "green" routes as much as possible, or to be aware of the risks involved in choosing an "orange" tour. (Appendix 5 No. 2)

In July 2018, Skitouren guru version 2.0 is introduced. The improved algorithm allows to quantify the risk of a ski tour. Along with this comes a modified search and display function. However, for the outsider it is not yet evident, how much potential the new development bears. In October 2018, this changes when three papers are being presented at the International Snow Science Workshop in Innsbruck. Central for the further function of Skitouren guru is the now introduced Quantitative Reduction Method (QRM). In the respective paper, Günter S., Kurt W., and Jochen K. write:

In this paper we present the Quantitative Reduction Method (QRM), which allows the estimation of the relative avalanche risk on backcountry ski tours. The method is based upon data: Human involved avalanche accidents (1469), GPS tracks of backcountry ski tours (47'530 km) and avalanche conditions (taken from 4656 avalanche warning forecasts). [...] At the first glance, the QRM resembles earlier strategic methods. However, the QRM shows, that in the orange and red zones the risk increases exponentially with the danger indicator and terrain indicator. On the other hand, the relative risk remains close to zero in the green zone. The new method is suitable for computer applications and separates unambiguously low risk zones from high risk zones. (Schmudlach et al., 2018, p. 1272)

In the other two publications, SLF members investigate in collaboration with Günter S. how experts interpret avalanche terrain from a map and derive an automated avalanche terrain classification. In a later interview with powderguide.com, Günter S. gets more specific about the collaborations and partnerships of Skitouren guru. He is quoted as follows:

A partnership has existed for over three years with the Swiss Council for Accident Prevention (bfu) and with Mammüt. In technical terms, there is a cooperation with Gipfelbuch.ch. Thanks to my collaboration with the SLF on the development of an avalanche hazard map in 2017, there is also a close exchange with the Davos avalanche researchers. Last but not least, I am also in direct contact with the Swiss Alpine Club (SAC). After initial skepticism, the SAC now recommends Skitouren guru for route selection. Since autumn, Achtung Lawine!, a leaflet published by the core team of avalanche education in Switzerland, also refers to Skitouren guru. (Ruetz, 2018a, p. 1)

In winter season 2018/19 the QRM is applied for the first time on Skitourenguru.ch. Furthermore, a test operation of two non-Swiss alpine regions (Eastern Alps and Chaîne de Belledonne) are online. The year 2019 then begins with a statistical validation. Despite skeptical voices, the QRM shows a prevention value of over 60 percent for all avalanche problems. A prevention value of over 80 percent can be achieved if both orange and red routes are avoided. In the conclusion the correct handling of Skitourenguru is emphasized:

Not "against each other", but "one after the other": In the planning phase, use the reduction method, among other things; in the individual slope, also determine the avalanche problem, among other things. The bulletin gives a good indication, but ultimately the avalanche problem on the individual slope must be identified and interpreted on one's own responsibility. (Skitourenguru, 2019, p. 1)

In the next month, the QRM is featured in several articles. For example, the chief executive of the Swiss Alpine Club, and avalanche expert Daniel Marbacher writes in the magazine *Die Alpen*:

When www.skitourenguru.ch first appeared about four years ago, I was skeptical. Or to be more honest, I was a bit afraid that my ability as a mountain guide to do good tour planning would no longer be in demand. And with QRM we can now put a part of the tour planning in the hands of an algorithm, of which we ordinary mortals do not exactly know what it does. However, the results are pleasing from my point of view. [...] I am convinced that the SAC cannot ignore the digital tour planning. We need to think carefully about whether and how we want to cooperate with platforms such as www.skitourenguru.ch [...] (Marbacher, 2019, p. 3)

Also Gipfelbuch.ch reports about the QRM. To the question how Skitourenguru is financed Günter S. answers:

At the moment I run the site full-time. I receive financial support from bfu, Mammüt, Bächli Bergsport and the Petzl Foundation. That is just enough to live on. Apart from me, there is also a network of volunteers who support me in my work. I regularly receive requests from people in the public who would like to contribute to the project. (Cieslik, 2019, p. 1)

A further article appears in the specialist journal *bergundsteigen*. Regarding the prevention value of Skitourenguru Günter S. writes:

Where the threshold of acceptable risk or necessary renunciation lies cannot be answered in a generally valid way and ultimately remains a question of subjective willingness to take risks and social acceptance. The transitions between green (low risk), orange (increased risk)

and red zones (high risk) are usually defined on the basis of accident-avoidance rates. These avoidance rates are arbitrary quantities that need to be discussed in an open process. (Schmudlach, 2019, p. 38)

Later in 2019, the QRM is presented at the 20th European Avalanche Warning Services (EAWS) conference. Furthermore, Skitouren guru commits to IFALP, an initiative for a uniform avalanche forecast throughout the Alps. In December 2019, Skitouren guru is transformed into a limited liability company (GmbH). When asking why this transformation has been done Günter S. replies:

The reason is that I had to urgently separate the activity of Skitouren guru from the private person Günter Schmudlach. A project like Skitouren guru leads to a complex bunch of “legal questions”, like liability, intellectual rights and privacy issues. The risks of these questions are hard to assess and therefor had to be separated from me and my family. (Appendix 5 No. 3)

At the beginning of the winter season 2019/20, Skitouren guru extends its test mode to France, Italy and the Eastern Alps. Furthermore, weather data and data from the Sentinel2 satellite are integrated on the website. The year 2020 then starts with an article about automatically generated ski tours. Later in 2020, Skitouren guru is presented at two conferences. In October, Günter S. contributes at the safety talks of the Bayrisches Kuratorium für alpine Sicherheit. And at the digital Skitouren summit in November 2020. The winter season 2020/21 starts with an expansion of the service to the whole alps, yet France and Italy remain in a test mode. Furthermore, thanks to a cooperation with the startup ExoLabs snow maps can be displayed. Additionally, an algorithm for an automated difficulty assessment has been developed in cooperation with the machine learning specialist Ulrich R. Finally, an improved interface of Skitouren guru.ch is being implemented.

For the future, Skitouren guru plans to make a risk assessment of user generated ski tours. Furthermore, the route network in France and Italy should be further expanded. Finally, a machine learning based model should further improve the avalanche risk calculation. Here, the technical documentation of the underlying dataset can already be assessed. Nevertheless, the dataset is restricted to be used in agreement with Skitouren guru.

Interacting with Skitouren guru

Which tour is a good choice at all? This question was the seed of the development outlined above. But how to achieve a good choice with the help of Skitouren guru? In this chapter this

question is further explored outlining the interaction between Skitouren guru and its users. When entering the website Skitouren guru.ch, the name of guru strikes attention. In an interview, Günter S. refers to this by picking up my research introduction. He says:

[...] according to her doubt plays an essential role for the ethical interaction. So, doubt plays an essential role, and a lot of people ask me why the thing is called Skitouren guru. And basically, it is exactly this point, the name Skitouren guru is supposed to raise doubt. Do you believe in Gurus? (Appendix 5 No. 6)

A similar wording can also be found at info.skitouren guru.ch where it is stated that the name should trigger a “critical-skeptical” reflex in the users. When further browsing the website, a lean design becomes apparent. No cookie settings, paywalls or logins are required to navigate the website. Apart from five static links to the sponsors, the site is free of advertising or external content. Regarding the accessibility of Skitouren guru, Simon W. quotes Günter S. as follows:

You invest a lot of money and a passion in a tool, then put a barrier around it so that people cannot or will not access it. I do not like that. I do not like programming for the trash can. I want people to be able to use the tool. (Welebil, 2020, p. 1)

Once entered, an overview appears. The first sentences refer to the scope of the application and say: “Skitouren guru supports you in planning a suitable ski tour with low avalanche risk”. Below a fixed legend explains the three-colored risk assessment and the three-part crux categorization. A click on the respective categories leads to popup windows, with further explanation. Each popup window contains a link to the respective background information at info.skitouren guru.ch. A dropdown menu at the top right allows to display the website in either German, English, French or Italian. Furthermore, the introduction document, the information page info.skitouren guru.ch, an information page of the bfu and the disclaimer can be accessed. The introduction document explains how to use Skitouren guru and introduces the underlying model. Here both internal and external links are referenced for further explanation. Asking for the manifestation of responsibility, Günter S. describes this information structure as follows:

Clear communication about benefits and limitations. The information is organized hierarchically. Simple, clearly understandable information at the top, lower down complexity, and exactness of the content increases. [...] There is definitely a conflict of goals between comprehensibility and accuracy. Skitouren guru must be easy to understand on the one hand, but on the other hand it must do justice to the complexity of the topics. (Appendix 5 No. 4)

By clicking on the interactive map or in the legend, one of five regions of the Alpine area can be selected. However, before this is displayed, the terms of use must be agreed. These consist of the following 142 words:

Skitouren guru supports you in planning a suitable ski tour with low avalanche risk. For this purpose, Skitouren guru assigns daily an avalanche risk to thousands of ski tours in the alpine region: Green (low risk), orange (elevated risk) or red (high risk). The evaluation is automatized and based on the current avalanche forecast and the terrain. The information presented on Skitouren guru is subject to uncertainties (see Handbook). Therefore, Skitouren guru must not be the only criterion to access a slope. Skitouren guru GmbH does not guarantee the correctness of the information. Any liability for accidents and damages in connection with the use of Skitouren guru is excluded. The planning and execution of your winter sports activities is at your own risk and under your sole responsibility. Skitouren guru uses cookies to improve the service. Do you agree with this exclusion of liability and the use of cookies? (Appendix 6)

Unlike conventional terms of use, the “Yes” and “No” buttons are swapped so that the “No” button is located in the bottom right corner. According to Simon W. (2020) neither Google Analytics nor other trackers, besides a traffic counter, are enabled through this confirmation. The traffic counter is also published on info.skitouren guru.ch and counts roughly 20.000 users until January 2021. Yet the significance of these counts is limited since no login assigns the clicks to its respective users. After confirming the terms of use, the selected region is displayed in more detail. By default, all tours are displayed. However, filters on the right-hand side allow to further refine the displayed routes. A table with the corresponding filter criteria can also be found below. These criteria are travel distance, start elevation, elevation gain, difficulty grade, snow depth at start and avalanche risk (Appendix 11). The default route selection was changed in 2020. Before only green routes were displayed by default. Orange and red routes had to be activated manually. On info.skitouren guru.ch, this modification is commented as follows:

After in-depth discussions with key stakeholders, Skitouren guru has concluded that route prioritization does more harm than helps avalanche accident prevention. Here are three reasons: Accessibility: [...] Optimal accident prevention is only achieved if all information is made available to the user without any hurdles. Transparency: The basic principle of Skitouren guru, namely the assignment of a risk category, only becomes transparent when routes with all three risk categories are displayed on the map and in the table. If at the beginning only "green" routes are displayed, then it is not immediately clear what the "green" color means. If, on the other hand, all three colors are present, then the basic principle can be grasped intuitively without further reading. Respect: A user may have good reasons to choose a "red" or a difficult route. From "recommendations" the way to "commandments" is

not far. Skitourenguru does not "recommend" specific routes, but Skitourenguru "evaluates" all available routes. The users then make their own responsible decisions. Skitourenguru strives to steering towards "green" and easy ski tours. But this must be based on respect. (Skitourenguru, 2021b, p. 1)

Once a route is selected, it is displayed in detail on a slope class map. Depending on the daily risk calculation, individual sections of the route are colored in green, yellow or red. In addition, static cruxes which indicate the most avalanche prone terrain are being displayed. Via a dropdown menu, different map layers can be activated. These layers differ between the Swiss Alps and the remaining regions. Günter S. comments this difference as follows:

[...] in Switzerland it is possible to use professional, official cartography, in the Eastern Alps and in Italy this is not possible. This is related to licenses that would cost several thousand euros per year. Therefore, OpenTopoMap is displayed, which is quite good but actually not optimal to plan ski tours. (Appendix 5 No. 5)

On the right, information about the route is displayed. The information corresponds to the filter criteria with additional information about the length of the routes and the duration of the ascent. Also available are external links for GPS tracks, weather forecast and tour descriptions. Below, the daily avalanche report is displayed. Here Skitourenguru cautions that the summarized danger locations may differ from the original avalanche forecast (Appendix 7). The danger level and textual information however are tightly coupled with the respective avalanche forecast. Links for further information about the respective avalanche warning services are also provided. However, in the Eastern Alps these links do not lead to the avalanche warning services directly, but to a link collection at info.skitourenguru.ch.

Even though the website info.skitourenguru.ch appears in a slim and text-based design, its underlying link structure is far from simple. Also, the implemented algorithms are complex. Concerning this complexity Günter S. write:

All algorithms follow the "white box" approach. This means that anyone who wants to know how the risk indicators are created can understand this in detail. This transparency is not a gift. It has to be developed in strenuous work by actors who are interested in understanding. Transparency always results from the interaction of sender and receiver. Transparency is therefore also a responsibility of the users. (Appendix 5 No. 7)

To get an idea, 793 of the 811 edges in the hyperlink structure are sourced by info.skitourenguru.ch (Appendix 1). As a first approximation, info.skitourenguru.ch consists of 10 categories. The categories Home, News, Media, Links, Disclaimer, Partners and About do

not reveal any further levels and mostly refer to external sources. However, the categories Services, Model and Help reveal several sub-levels each and describe the functionality of Skitouren guru. How this functionality looks like should be explored in the next chapter.

Unfolding the Algorithm

We have seen that Skitouren guru provides several filters, explanations, and assessments to derive a good choice. But what is a good choice at all and how can an algorithm know? This question should be further explored outlining the functionality of Skitouren guru. As we have seen in the chapter “Tracing the Development”, the risk assessment of Skitouren guru is derived by the Quantitative Reduction Method (QRM). Accordingly, this method will also be in the focus of this chapter. However, it must be said that this is not the only algorithm used by Skitouren guru. For example, the automated difficulty rating is based on a distinct algorithm, too.

As the name suggests, the QRM is a so-called reduction method. A procedure that allows to derive a risk classification through the intersection of terrain and avalanche forecast. The first reduction method was developed by Werner Munter in the 1990s and despite initial skepticism, has become part of the general avalanche prevention techniques. Munter writes about his initial reduction method:

When I put forward the provocative thesis 10 years ago that you could assess the single slope risk in minutes with the little 1x1 without looking into the snowpack, it triggered a revolution in avalanche science. The idea of linking the danger level of the LLB with the steepness proved to be extraordinarily fruitful. All decision models propagated today (elementary reduction method, Stop or Go, SnowCard, Limits) build on this basic idea. They differ only in the recommended upper limits. (Munter, 2001, p. 35)

Unlike conventional reduction methods, the QRM is not only able to categorize risk levels but to quantify risk levels. This is because the QRM not only includes accident data but also non-accident data. The accident data is derived from the swiss winter reports and comprises 1469 human-involved accidents with available coordinates and avalanche forecast information. The non-accident data comprises 47 530 kilometers of GPS tracks which are derived from both Gipfelbuch.ch and user feedback. Again, a corresponding avalanche report is available to this data. In a next step a terrain property is assigned to the derived GPS and Accident points. Other than conventional reduction methods, the QRM does not work with slope classes but with an Avalanche Terrain Classification. In the respective publication it is stated:

The algorithm applies for each point in the terrain the following procedure: 1. Pre-processing of the Digital Elevation Model and Land Cover data. 2. Segmentation of a polygon describing the area relevant for the avalanche exposure at the current point. 3. Deduction of geomorphologic properties on the relevant slope area, representative for the hazard at the current point. 4. Calculation of a continuous ATES rating [0..100%] from the geomorphologic properties. (Schmudlach & Köhler, 2016b, p. 729)

Accordingly, both the accident and the non-accident points are assigned with the respective terrain indicator. As a result, both the accident points and the non-accident points can be displayed in a terrain indicator /danger indicator diagram. Dividing the density of the accidents by the density of the non-accidents then produces the relative avalanche risk as a function of the danger indicator and the terrain indicator. For this process, some assumptions must be made. For example, a transition function smooths out the otherwise discrete information about the danger level. But also, assumptions about avalanche trajectories or terrain usage must be made. However, these assumptions are well documented and accessible. In an interview Günter S. replies to my insight, that certain assumptions must be made in advance as follows:

I think there is sometimes a clinch between scientists and engineers. I will put it bluntly, the natural scientist is looking for truth. The engineer is actually looking for good decisions. Often scientists and engineers do not get along very well. We are not looking for the truth, we are looking to make the best out of the available information. We would also like to have truth, but in the field of avalanches truth is just not available. (Appendix 5 No. 8)

So far, the relative risk can be calculated for individual segments in the field. To achieve a prevention effect, the relative risk is further categorized. This categorization is expressed by the color code of green, orange and red. The threshold between the color transition is determined by a priori defined target values. These target values describe a prevention value of 60 percent if the red area is refrained. And a prevention value of 80 percent if both the red and orange areas are refrained. In an interview Jochen K. refers to the thresholds of the color code as follows:

Yes, the traffic light system has a tradition. Here in Norway, it is used for all kinds of weather phenomena, too. There are also different warning levels and always green, yellow and red. The alternative with multiple colors would look a bit strange. [...] You could of course choose different limits for the colors. In the community there is a lot of talk about how much you have to refrain, if you stick to certain heuristics. I think the fixing between green and orange is perhaps a good balance between sacrifice and efficiency in reducing risk. (Appendix 5 No. 9)

In the next step the risk assessment must be applied to the entire ski tour. Therefore, the counter-probabilities of all crossed segments are multiplied. The result then shows the probability not to be caught in an avalanche. However, this probability is not displayed since it is abstract and has little explanatory power. Instead, an overall risk indicator from 0 to 3 is displayed. How this risk indicator relates to the calculated probability is derived by a calibration process. Therefore, the assessment of Skitouren guru is compared with the manual assessment of both expert and recreational ski tourers. Participants had to rate 30 tours at 3 different avalanche forecasts. With a voting weight of 4 to 1 between expert and recreationalists, the mean value is then formed and sets the benchmark for Skitouren guru. Günter S. comments this calibration process as follows:

Skitouren guru's rating is very close to the average of all participants in the two surveys conducted. Since Skitouren guru does not hit the average exactly, it is necessary to add a reserve. This means that Skitouren guru is intentionally calibrated slightly more "defensively" than the average of all participants. (Appendix 5 No. 10)

Looking back, it becomes apparent, which operations are necessary to perform the automated risk assessment of Skitouren guru. It also becomes evident that the risk representation must be calibrated and is only comprehensible in relation to each other. With this knowledge, the largest uncertainty in this model can also be identified. Which is integrated by the daily avalanche report. In total Skitouren guru includes the information of 17 distinct avalanche warning services. Thereby highly generalized indicators are propagated for a large and heterogeneous area. To follow the example of the Tyrolean Avalanche Service. Here an area of 12 534 square kilometers is represented by maximum 29 warning regions. In general, these warning regions are further joined to no more than 5 distinct regions in the avalanche report. Although these uncertainties exist in the model, they allow to reduce the a priori risk in the planning phase. In the next phase further information can be gained (Appendix 12). How the information in the field interacts with the information from the planning phase should be analyzed in the next section.

Enacting the Risk Assessment

It is the 31st of December 2020 when I receive a call from Lutz. As it turns out, we both have planned the same ski tour for that day. After the usual confusion we manage to meet at the well visited Sattelbergalm. We commit to do some common ski tours and even if it is only loosely planned, I already suspect a certain boot camp character for the next days. In fact, it is quite

stormy in the next days and so it is January the 3rd when we finally make a more detailed plan. Lutz suggests the Kesselspitze, a route that is categorized as red by Skitourenguru. I immediately refuse and suggest the green Pfoner Kreuzjöchl instead. Surprisingly, Lutz agrees and so we find ourselves in Ellbögen the next morning. That day the Avalanche Warning Service reports a moderate danger level above the tree line with critical expositions at north facing slopes (Appendix 8). Chatting on the lower forest roads, we miss a turn-off and end up in a dead-end road. We decide to improvise the route finding and struggle up a steep forest slope. Above the tree line, the wind has changed the snowpack dramatically. A fact that was neither visible on the snow maps of the Tyrolean Avalanche Office nor on the snow maps of Skitourenguru. Due to this circumstance, we find ourselves in an alternative, not less dangerous descent. Arrived below I deny the question of whether I want to climb up again and conclude that you can put yourself in unpleasant situations on supposedly green tours as well. Accordingly, I must ask myself whether my route selection was a good choice at all?

For the next day, Lutz had already made a tour proposal, the rather difficult and with a risk classification of 3.0 very dangerous route on the Wilder Freiger. I explain to Lutz that he should use Skitourenguru and that I am not willing to do any red tours. We end up in Seduck, planning to do the Innere Sonnenwand. With a risk indicator of 1.5 we could agree on a yellow route at least. According to the Avalanche Warning Service, the avalanche situation remains similar. Nevertheless, the old snow problem is given priority over the wind slab problem that day. Unfortunately, neither Skitourenguru nor the local ski touring book had pointed out that the trail to the Grundriss Alm is closed in high winter and so we find ourselves on a long valley hike. Finally, the ascent to the Franz Senn hut turns out to be less dangerous than Skitourenguru had predicted. The path is well spurred, and a remote release or spontaneous release of the slopes above seems very unlikely. After a few more bitterly cold hours, we arrive beneath the final slope, the second crux according to Skitourenguru. My worries, however, turned out to be superfluous since the further ascent was more of an easy rock climb rather than an avalanche-prone snow slab. This time I refuse Lutz' alternative decent plans a priori and finish an exhausting, but justifiable ski touring day. Apparently both the routes and terrain estimation of Skitourenguru can deviate from the actual conditions.

The next day we both need a break and so it is January the 7th when we head out again. This time it is my turn to plan the tour and so I choose the Lüsener Villerspitz. Skitourenguru classifies the route in the mid yellow range, which seemed reasonable compared to my last impressions. The Avalanche Warning Service reports the same danger levels as before, however

with slightly improved information in the text (Appendix 9). The tour unfolds according to plan until the track branches off. Lutz follows the track that leads through the direct north face and it takes heavy resistance from my side, to make him turn by. Lutz asks me where such an attitude of pinching out would lead us to and I cannot suppress to say that this would prevent him from ending up in an avalanche again. However, we still not follow the original track but a steep ridge. At the top we argue about the route finding, but quickly settle this with the great view over the Stubai Alps. During the descent, I strictly stick to the route corridor of Skitourengru, which promises a less fancy, but easygoing descent. Lutz, however, descends via the direct north face and so we split up for a stretch. Luckily, except for a few superficial snow slides on Lutz decent everything went well.

How did Skitourengru influence our actions? All three tours were listed on Skitourengru. However, there would have been unlisted, appropriate ski tours, too. Compared to former ski tours, our selection process was changed. Without Skitourengru, we would have selected a tour based on a rough, subjective terrain estimation. Using Skitourengru, I selected the risk first and then evaluated the available tours. The former selection process becomes apparent when looking at Lutz' tour suggestions. Here my disagreement with his suggestions was backed up by the assessment of Skitourengru. Or was my disagreement caused by Skitourengru? In any case, the red category conveys a strong symbolic message. Whether this does justice to the respective routes remains uncertain. But is the exclusion of a certain category already a decision? It seems that this is an early bifurcation in a cascade of decisions. Interestingly, over the course of these three days, I aligned my behavior more and more with the route suggestions of Skitourengru. This correlates with my observation that my spontaneous decisions in the field often turn out to be bad decisions in retrospect. Nevertheless, decisions must be made in situ to align the unique constellation of conditions, terrain, and people. It seems that my personal responsibility starts to crystallize here. How this interferes with the responsibility of Skitourengru should be further illuminated in the next chapter.

Asking for Responsibility

That a unique situation in the field requires personal responsibility seems to align with a performative understanding of responsibility. But how does the responsibility of Skitourengru look like, and how does it differ to other forms of responsibility? These questions should be explored by further engaging with the identified actors. Thinking about the terms of use,

personal responsibility is highlighted early in the appearance of Skitourenguru. To the question of whether responsibility can be bypassed through these terms of use Günter S. answers:

In a legal sense, disclaimers are always meaningless when "life and limb" are at stake. Responsibility (duty of care) therefore applies in any case. However, a disclaimer also has a completely different purpose. It is a chance for the user to deal with the benefits and limitations of the tool. The user becomes aware of the fact that he has at least been given the opportunity to inform himself adequately. A disclaimer thus points out the responsibility of the user to seek for understanding. (Appendix 5 No. 11)

While Skitourenguru clearly refers to the personal responsibility of its users, a mountain guide cannot easily relinquish this responsibility. That this responsibility goes beyond the legal aspect becomes clear when talking to the mountain guide and lawyer Rita C. When asking her whether responsibility is but a formal aspect of her job as a mountain guide, she replies:

Primarily a moral counterpart to the guests. They confide in me. And that triggers a pressure on me that goes beyond this legal responsibility. I feel that this is a heavy burden when I am guiding. In these areas, where you cannot be sure whether your decision is okay or not, I find that very demanding and that leads me to be rather too careful with guests, simply because I find that it weighs so heavily. [...] But basically, I personally feel that the moral responsibility goes further than the legal responsibility, towards a "nothing must happen", which is a conflict with the role and the possibilities. That makes it exhausting to have this activity. (Appendix 5 No. 12)

Similar to the terms of use, Rita C. acknowledges that it is part of her responsibility to educate her guests about the uncertainty of her decisions. Thereby the current conditions must be balanced with the expectations of her guests. She further describes her responsibility as an obligation to apply the current standards and most modern assessment methods to derive her decisions. Standards, however, not only apply for decision-making, but also in the development of Skitourenguru. When asking Jochen K. which standards or norms play a role in the development of Skitourenguru, he refers to methodological standards. He states:

Yes, I have a responsibility in the same area as the responsibility when publishing in general science. So, the bottom line is I am prescribed to document correctly what we do, what assumptions we make, and I am obligated to think well about those assumptions. But that does not mean that all those assumptions will always be considered correct in the future as correct. That is not possible, otherwise we cannot do anything. (Appendix 5 No. 13)

In addition, Jochen K. emphasizes that Skitourenguru is not an automated decision tool, but rather an information tool. Similarly, Günter S. highlights that Skitourenguru is not an

automated decision system and compares it to the daily weather forecast. Nevertheless, Günter S. admits that Skitouren guru is not a neutral tool. When asked about the aims of Skitouren guru and the responsibility for its effects he writes:

Skitouren guru is dedicated to avalanche accident prevention as a project. Avalanche accident prevention is achieved by a steering effect towards routes with "low avalanche risk". We believe such a steering effect is desirable. Skitouren guru is therefore not a neutral technology and does not want to be a neutral technology. Neutral in the sense of "no influence". On the other hand, it is not the primary goal of Skitouren guru to somehow direct ski tourers. Skitouren guru can be used in many ways. For example, search all "red" Routes, because there you are perhaps more lonely. Or look for all "red routes", because possibly there you find better snow. (Appendix 5 No. 14)

Apparently, Skitouren guru is supposed to make a difference in the material world. However, it does make a difference in an abstract realm, too. Looking closer at the risk assessment of Skitouren guru, a Bayesian understanding of risk becomes apparent. Accordingly, the probability of triggering an avalanche is not a property of the respective slope, but a property of my knowledge about the respective slope. Jochen K. formulates this issue as follows:

This sounds a bit alien, but this was just Thomas Bayes, maybe you have heard of him, a pastor and mathematician. And he said probability is actually the degree of our knowledge. That is an extremely interesting definition. [...] And then actually the whole probability would be a subjective quantity, so the probability is an expression of my uncertainty. And no longer the expression of some experiment, and therefore the attribute probability, moves from the thing to the person. So the probability is always connected with you. And not with the thing. (Appendix 5 No. 17)

In this respect, reduction methods such as the QRM, produce a risk estimation rather than reveal the actual risk. A property that can nevertheless be attributed to any other information gain, too. So does for example the daily avalanche report ascribe a certain risk information to the respective slope. Asking Günter S. about the motives behind Skitouren guru a reference to the avalanche services becomes apparent too. Here Günter S. emphasizes that not only the introduction of a new tool bears responsibility, but also its restraint. He writes:

It is not only the actor who bears responsibility, but also the non-actor. Whoever is able to develop a Skitouren guru has to put up with the question of why he does not accept the challenge (e.g. SLF). Yes, there is a responsibility of the one who can swim to jump into the water. (Appendix 5 No. 15)

At this point it seems that responsibility is related to the possible scope of action an actor has. But how does this relate to the individual actors contributing to the development of Skitouren guru? When asking the sponsors of Skitouren guru about their contribution and their responsibility, mainly legal aspects are being stressed. Beyond the legal aspects, some actors highlight their communication when facing this question of responsibility. For example, the consultant of the bfu Monique W. writes:

Only the operator is responsible for the content and functionality of Skitouren guru. The BFU however advises Skitouren guru on the texts (disclaimer, explanations) and always communicates itself, that Skitouren guru primarily serves to select a tour with low risk for subsequent planning. (Appendix 5 No. 16)

Also, Gernot B. from Bächli Bergsport and Moritz H. from Mammut write that they communicate the chances and risks of Skitouren guru adequately. Both companies thereby refer to their safety workshops and avalanche trainings. Similarly, Bernhard S. from ExoLabs highlights that communication and self-responsibility must be combined for a responsible interaction with Skitouren guru. Concerning their own responsibility, Oliver M. from the Petzl foundation refers to the terms of use and compares Skitouren guru with a routing software. Lorenz M. from Geoprävent distances himself even further and leaves it to Skitouren guru, to make recommendations for the use of his platform. Interestingly, even Andreas E., the developer of the route corridors refers to the terms of use. Furthermore, Andreas E. elaborates on his personal responsibility. Asking him whether he considers himself as responsible for the functionality of Skitouren guru he states:

Yes, in the sense that I make my contribution with heart and soul and to the best of my knowledge and belief and declare the work including opportunities and limitations. It is also declared that computer-generated results can never be perfect. The responsibility stops at the point how the users then deal with the information individually. (Appendix 5 No. 18)

Similarly, Luca I. considers his work of digitalizing ski tours a responsible one. He highlights that both Skitouren guru, the user and himself are negatively affected if the routes were not digitalized properly. However, in the same breath he emphasizes that routes might not be perfect from the beginning and require feedback from users in the field. But not only functional aspects but also design aspects might bear responsibility. Asking Rosa G. for her contribution to the new website she states.

My work was content-visual. How do content and structuring inputs help create a better clarity, so that the user can find his/her way better and faster. Of course, as always in the

design, color-typographical-unifying inputs help as well. With the creation of icons, I have also tried to create a more uniform picture so that one can orientate oneself faster. If a little bit of beauty and humor/lightness has been added, I am glad. [...] I always see my work as characterized by responsibility. I deliver good and on time to make the world a little bit clearer, more structured, more beautiful, and therefore better. (Appendix 5 No. 19)

Other than Rosa's work, this thesis cannot be said to be delivered on time. And so Rosa's understanding of responsibility should serve us as a guidepost to lead this work over into its discussion.

Discussion

At this point, the line of thought should be reversed to unroll this work retrogressively. Therefore, the empirical findings will be summarized and discussed on both a substantial and methodological level. Next the empirical findings of this work should be contrasted with the conceptual elaborations. Finally, a refined conceptual model should lead this study to a critical reassessment of the cited literature and a prospect of future steps.

Summarizing the Empirical Findings

Drawing from an assemblage approach, this study sought to trace the numerous agencies involved in algorithmic informed decision-making. To start with, this study brought up the question, for what reason, and based on which desires Skitouren guru was developed? The empirical research has shown that Skitouren guru is not a profit-oriented enterprise. Instead, the development of Skitouren guru is driven by an intrinsic motivation of its developers. Namely, the simplification of the otherwise time-consuming ski tour planning. However, not only its developers have an interest in Skitouren guru. As indicated by the multiple voices in this study, a whole community of actors has an interest in the automated risk assessment of Skitouren guru. This extended interest group is not obligated to blind consumption either but can indirectly contribute to the improvement of the service via feedback and GPS data. A broader view revealed several interests affecting the project of Skitouren guru. Here, institutions such as the alpine clubs or accident prevention institutions (bfu) play important roles. Not least also commercial mountain sports companies do have an interest in being related with positive innovations in the field of accident prevention. Despite this community aspect, Skitouren guru is not a crowd or open-source project. Formally the organization of Skitouren guru is a limited liability company (GmbH) whose sole owner and manager is the main developer and founder Günter S.

Looking at the different parties that have an interest in Skitouren guru, the question of their interaction arises. Early on in this work, the question of how the interaction between Skitouren guru and its users looks like was being raised. The empirical research has shown that Skitouren guru communicates its information in a hierarchical manner. Like the avalanche warning service, the most severe information is communicated early on whilst more elaborate information is communicated later. While basic information is displayed on skitouren guru.ch, more elaborate information is provided through links such as the handbook or

info.skitourengru.ch. This internal reference structure of info.skitourengru.ch, resembles more a small-world network than a hierarchical information tree, nevertheless. How to communicate this complexity adequately is considered as a main challenge by the developers of Skitourengru. So, for example, official training videos were uploaded after the completion of the empirical investigations. At this point it becomes apparent that mere transparency does not solve the issue of public comprehensibility. Instead, a public understanding requires both structured and well accessible information. Furthermore, a critical initiative by the users is required. Skitourengru seeks to trigger this initiative by the terms of use or the unusual name of “guru”. To further simplify the interaction with Skitourengru common symbols such as the traffic light color code are being used. To make the traffic light system comprehensible, both green, yellow, and red ski tours are being displayed by default. A former nudge of hiding the red tours by default has therefor been removed.

So far, this information has little material consequences. Early on in this study it has been highlighted that the algorithmic assessment must be enacted by a user to have tangible effects. Here the question was raised how, where and when the algorithmic recommendation influences the decision-making of its users. Following the recommendation of Skitourengru the risk assessment should be applied in the planning phase of a ski tour. In this sense the algorithmic assessment is a filter that provides reasonable opportunities for further consideration. The advantage in the planning phase is that many alternative opportunities are available. However only limited information about the specific conditions is available in this phase. The auto ethnographic investigations of this study have shown that the exclusion of a certain risk category is a first bifurcation in a cascade of branching points. The investigation also suggests that the decisions in the field are prone to group dynamics and risk blindness. Consequently, decisions in the field serve well as additional “no-go” criteria but not as sole “go” criteria. Neither Skitourengru nor the general avalanche doctrine get explicit about this. Here it is merely stated that decisions must be made on site and on one's own responsibility. Nevertheless, decisions must be made on site to align the unique constellation of conditions, terrain, and people. Thereby several relevant factors such as the risk disposition or abilities of the respective ski tourers can hardly be quantified.

The idea that decisions are not conclusively quantifiable or formally rational has also been introduced at the beginning of this study. Here, the question was raised of where irrational, arbitrary, or random aspects shape the outcome of (algorithmic) decisions. Interestingly, the very commitment to perform a ski tour cannot be explained by formal rationality. However,

asking leading mountain guides it is not irrational either. Rather, ski tours offer the opportunity to experience oneself as an independent and free subject. Whether it is not this irrationality that brings forth the so-called free subject remains to be considered. But not only our own actions, but also the functionality of Skitouren guru is not purely rational. Examining the validation and calibration process of Skitouren guru it became apparent that certain assumptions and value propositions must be made a priori. Where should the thresholds between the risk categories be? How defensive should the algorithm be? How should the reference assessments be weighted? The answers to these questions cannot be derived logically. Rather, they must satisfy certain value propositions. Such value propositions may as well be prescribed institutionally, as the work of Haegeli and Mcammon (2007) shows. While Skitouren guru discloses these assumptions, many other developers do not. An issue that might not least contribute to the perception of algorithms as “supercarriers of formal rationality”.

Whether such a supercarrier of formal rationality can bear responsibility has been a main interest at the beginning of this study. It had been asked, where within the identified assemblage responsibility resides and how this responsibility looks like. Throughout this study the word responsibility has been identified in many different contexts. For example, Hansi has expressed his responsibility as the duty to be honest to his relatives about the tours he does and the risks he takes. Similarly, the mountain guide Rita C. describes her responsibility as the duty to educate her guests about the uncertainty of her decisions. Certainly, this is an aspect of transparency. However, at the same time she acknowledges that her decisions remain opaque to a certain extent and educates her guests about this issue. Here Rita C. also provides a thick description of responsibility. Namely the impossible and heavy weighting burden of nothing must happen.

Looking at Skitouren guru it becomes even more complicated. Asking the founder and main developer Günter S., Skitouren guru has the responsibility to develop and implement the algorithm carefully. At the same time, he highlights his responsibility to communicate the results and limitations of Skitouren guru in an understandable yet technically correct way. Thereby it cannot be answered conclusively what a careful development is or how an appropriate communication looks like. Instead, certain value proposition must be made to validate the avoidance rates of the algorithm or its calibration. These value propositions are documented and published by Skitouren guru. Nevertheless, they might be implicit and require effort to be reconstructed. Here, Günter S. highlight the responsibility of the user to critically engage with the algorithm. The documentation, several articles and videos provide useful

information to do so. Finally, Günter S. highlights the responsibility of non-actors too. Accordingly, institutions that are capable of developing algorithms like Skitouren guru should also be confronted with the question of why they refrain from developing them.

Reassessing the Theoretical Model

Early on in this study the motive has been developed that not the algorithmic calculus bears responsibility but the process of translating this calculus. Accordingly, interpreting the algorithmic calculus or ascribing a certain value to it brings something new to the world. This translation would bear responsibility in the sense that the translation could have been done differently. Accordingly, emphasis should not be put on the algorithmic calculus but on those who authorize an algorithm to certain tasks. Looking at the empirical investigations it becomes apparent that the process of authorizing might not be as clear cut as imagined. Certainly, the developers of Skitouren guru authorize the algorithm when publishing it. Still the agency to authorize the algorithm remains distributed. After all, it requires a broader discourse to define the values and standards against which the algorithm is being measured. For the development and application of avalanche risk assessment algorithms, these standards are not fully developed yet. Accordingly, it remains up to the user to assign a certain value to the risk assessment of the algorithm. The user finds herself in a paradoxical situation then. To use the potentially beneficial algorithm, she must trust in it even though she is officially not allowed to. How the user makes sense of this double bind depends not least on the public account of Skitouren guru by institutions such as alpine clubs or accident prevention institutions.

On a theoretical level, this finding resembles a deconstructive understanding of speech act theory. Accordingly, no prime mover could authorize the algorithm to certain speech acts. Rather, a relational mesh of utterances entrenches over time and ascribes meaning to the otherwise meaningless risk calculation. Stressing this perspective further allows some insights about the interface of Skitouren guru too. The applied color code of Skitouren guru resembles the colors of a traffic light. One could say that a well-entrenched sign system is iterated and recontextualized for the risk assessment of Skitouren guru. This classification allows the user to make a simple stop or go decision. If the results were mere probability fractions, it could hardly be referenced and used for decision-making. At this point it becomes apparent that speech act theory might be quite revealing for the further research of algorithmic decision-making. At the same time, however, the actual algorithm and its representation must be differentiated.

Differentiating between the formal procedure of the algorithm and its representation allows us to pick up the idea of translation again. Since the thresholds between the categories green, yellow and red cannot be derived logically, a translation must be done. Indeed, the current translation of Skitourenguru resembles a Pareto optimality yet the thresholds for these boundaries cannot be set in a generally valid way. Instead, it requires an almost undecidable decision to set the risk thresholds for a whole community of ski tourers. Again, further differentiation must be made. The discussed thresholds apply for the single point evaluation of the algorithm. However, the output of the algorithm is a cumulation of single point evaluations. This accumulated point evaluation must be calibrated, too. Therefore, the assessment of experienced ski tourers is averaged and taken as a reference. Since there is no ultimate answer to the right calibration of the risk assessment, this averaged reference is an assembled benchmark but no final truth. Consequently, Günter S. highlights his openness towards external inputs, ideas, and improvements.

Talking about the construction of benchmarks the performative aspects of risk assessments should be further highlighted. The notion of performativity has been revealed as a main theme in the critical algorithm studies. It describes actions which do not only express but also constitute reality. Nevertheless, it has been criticized throughout this study that the underlying, performative mechanisms are not stressed enough yet. The empirical investigation of this study has identified a Bayesian understanding of risk in the field of engineering. Accordingly, risk is an expression of one's knowledge about an object rather than a trait of the respective object. Hence any further information about the object has an impact on its assigned risk. In other words, the Bayesian risk of a given object is assembled by multiple bits of information. Accordingly, the risk assessment of Skitourenguru is performative in the sense that it gains new knowledge through the automated combination of existing information. Whilst this production of risk can be well described by the notion of performativity, it must be labeled as a weak form of performativity, nevertheless. Ultimately it is an abstract expression of uncertainty which requires further translation to become materially relevant.

Such a translation could be the decision of how to deal with the calculated risk. Throughout this study a deconstructive understand of decision-making has been introduced. Thereby the formal application of a rule is considered as a calculable process but not as a decision. In contrast an archetypal decision would face an ordeal of undecidability. Which is to say that nothing but the decision itself can account for the respective action. Looking at the empirical findings, these archetypal decisions can be found on both the developer side and the user side. On the developer

side, decisions such as the risk categorizations have already been discussed. On the user side, decisions must be made about the risk one is willing to take and the importance the algorithm should get in the planning phase. What becomes apparent at this point is that the term algorithmic decision-making remains ill-suited for the case of Skitourenguru. Instead, decisions are being made before and after the calculation of the algorithm. This is not to say that the algorithm is a mere intermediate, but it has little agency when it comes to decision-making itself.

It remains the question of whether the notion of decision is helpful at all. Throughout this study several concepts of decision-making, and organizational decision-making have been introduced. Thereby the question was raised of whether decisions precede our actions or whether decisions are retrospect punctuations that help us rationalize our actions. As shown in the auto ethnographic section of this study, not any action is preceded by rational consideration. On the contrary, it has been observed that decisions in the field are often biased and ill-considered. Moreover, as the case of Lutz shows, it might not be a single decision that leads to an avalanche accident, but a whole series of cascading micro-decisions. In this case even in retrospect it is hardly possible to identify the one wrong decision. However, the concept of decision should not be discarded at this point. If, for example, the author, unlike his companion, chooses the indirect but safer decent, one can certainly speak of a decision. After all, other than stones rolling down the mountain or algorithms processing their tasks can we choose our path to a certain extent.

Talking about this partial freedom of choice leads us to the question of responsibility again. In this study a deconstructive understanding of responsibility has been proposed. Accordingly, acting responsibly is to respond to a situation free of preexisting rules or contexts. Instead, it means to acknowledge, the very singularity of the other and the respective situation. In this sense responsibility can never be formalized or prescribed but is an unmediated and infinite relation towards the other. In the case of the mountain guide Rita C. this study has observed this form of responsibility. For her, moral responsibility goes beyond legal responsibility. For her, this moral responsibility implies that nothing must happen to her guest. An almost impossible aspiration in the face of uncertain environments such as alpine landscapes. But this concept of responsibility can also be applied to Skitourenguru. Looking at the motives behind Skitourenguru, little financial or economic interests could be identified. Developing and publishing this tool can hence be read as a motive of responsibility. The responsibility to provide one's opportunities for the benefit of others irrespective of external purposes.

Ultimately, the success of the project was by no means certain and produced a unique and unpredictable relation with the ski touring community.

We see that this concept of responsibility can be interpreted broadly. This is both a strength and a weakness of this deconstructive approach. With the attempt to make responsibility an infinite realm it risks becoming a hollow figure. This became apparent in the work of Louise Amoore (2020), too. Thereby the notion of responsibility tends to blur with the wider notion of ethics. For practitioners this has two implications. On the one hand, they must work out their own responsibilities and find ways to do justice to it. This certainly aligns with the spirit of a deconstructive idea of responsibility. On the other hand, however, they can also interpret or downplay their responsibility as they wish. In this regard this notion of responsibility remains surprisingly toothless when faced with practical, real life issues. Here the work of Jochen K. and Rita C. could serve as inspiration. For the work of civil engineers or mountain guides certain standards must be met. These standards are not negotiated individually but the result of conflicting interests. Besides responsibility it might hence be promising to talk of a well-defined and institutionally constructed due diligence of software developers. In which regard the current standards exceed mere best practice approaches remains to be analyzed.

But the deconstructive conception of decision-making and responsibility suffers in yet another aspect. Namely that algorithmic procedures and uncertain decision-making are often intertwined rather than clear cut. Looking at the risk assessment of Skitourenguru this becomes evident. Thereby a well-defined, formal procedure serves as a guideline to estimate the risk for a ski tour. In this case, the algorithmic calculus does not provide a yes or no decision, but a degree of uncertainty. In a next step a decision must be made whether or not one is willing to enact this uncertainty. However, this decision is likely to be informed by prior algorithmic risk assessments, too. What becomes apparent is that algorithmic informed decisions can face an ordeal of the undecidable too. A better suited approach for this issue might be the distinction of formal and substantive rationality. However, while Lindenbaum et al. (2020) focus on formal aspects of algorithmic decision-making, it is the entanglement of formal and substantive rationality that this study has revealed. Not least, have we seen that substantive value propositions are deeply inscribed into algorithms, too.

Leaving the deconstructive realm behind leads us to the material aspects of this study. To speak of spaces of responsibility, this study has outlined a topological understanding of time and space. Inspired by actor-network theory and assemblage approaches, an association space has

been introduced. This association space has proved helpful for the description of Skitourenguru's risk assessment. Since its basic operation is to relate events that would otherwise be separated spatially and temporarily. The proposed metaphor that the algorithm of Skitourenguru folds time and space finds its real-life expression in the graphic display of the Quantitative Reduction Method (Appendix 10). Also crystallizing from this assemblage approach is the processual and relational ontology running through this study. Accordingly, both the study itself and its research field are unfolding processes that link up over time. However, it has turned out that even a supposedly processual study can only provide an excerpt, while the world inevitably continues to turn. One way out of this perpetual obsolescence would be an increased focus on theory building. Which however turned out challenging in the slipstream of the ever-descriptive actor-network theory.

Nevertheless, actor-network theory has proven very helpful for the empirical concern of this study. The idea to give a descriptive and quote driven empirical account of Skitourenguru was strongly inspired by actor-network theory. Ultimately it is the actors themselves and not the author who account for the socio technical assemblage of Skitourenguru. One shortcoming of this approach however was the ethical concern of this study. To combine both ethical and socio technical aspects in this study, a rather unorthodox interplay of deconstructivism and assemblage thinking has been proposed. Thereby the notion of performativity served as the lowest common divisor between the two. Indeed, despite explicit camp fights between the two fields some commonalities could be found. In particular a common political ontology of organizing has been identified. Accordingly, it is the act of categorizing and organizing that brings forth the world as we know it. This insight has allowed the empirical and theoretical concerns of this study to converge. Interestingly, this performative aspect has also affected the self-understanding of this study. After all, this study is an act of organizing that brings forth a particular account of reality, too.

Throughout the study one major organizing principle has been the focus on algorithms and algorithmic decision-making. It has been shown that the social sciences have introduced the notion of algorithm to identify an accountable actor in otherwise intangible and complex network structures. Thereby the often-expressed simultaneous demand for transparency and accountability has turned out to be a double bind. More precisely it has been argued that supposed, accountable black boxes cannot be opened without dissolving them in the same draw. Regarding algorithmic decision-making two contributions could be made. First, algorithms can be executed by human actors, too. Thereby, algorithmic decisions are nothing new as the

prevalence of human decision heuristics shows. While the term algorithm is defined quite broadly here, it is more narrowly defined in computer science. In this regard it has been shown that more differentiation is required in the critical algorithm studies. As a first step, a distinction between algorithm, computer code and computer program has been made. Finally, parallels between algorithmic decision-making and organizational decision-making have been revealed. It has been argued that recent studies on algorithmic decision-making risk missing basic insights from organizational decision theory. For example, the narrow focus on rational decision-making has proven to be too limited for comprehensive organizational analysis. The outlined approach might serve as a possible alternative. Namely to make sense of automated computer systems such as Skitourenguru as value laden, socio-technical arrangements.

Contributing to the Critical Algorithm Studies

This study began with an unsettling observation by the European Commission (2020) identifying the opacity of artificial intelligence systems as potential risk to fundamental human rights. This study has shown that machine learning applications are not necessarily a threat. On the contrary if developed with the right intentions, artificial intelligence applications bear the opportunity to facilitate and improve the lives of many. Nevertheless, it has been shown that a correct handling of the technology, as well as an adequate communication about its strengths and weaknesses, is by no means trivial. In the recent debate on algorithmic decision-making an emphasis on fairness, accountability and transparency has been revealed (Diakopoulos, 2016; Lepri et al., 2018; Pasquale, 2015; Shin & Park, 2019). In this study it has been shown that mere transparency does not necessarily make the algorithm more understandable. On the contrary, the documentation of an openly accessible algorithm such as Skitourenguru must be both technically correct and comprehensible. This study has shown that comprehensibility can be improved through the application of well-established symbolic codes. The resulting proposal to study algorithmic outputs as symbolic, performative speech acts builds on recent studies about performative algorithms (Amoore, 2020; Introna, 2016; Weiskopf, 2020a). However, it has been shown that the underlying, performative mechanisms are not sufficiently investigated and understood, yet. A first step in this direction has been made by attempting to reconcile a Bayesian understanding of probability with the notion of performativity. In this light it turned out that risk is not a property of the examined object, but an expression of one's knowledge about the respective object.

Yet another contribution to the debate on fair, accountable and transparent algorithms could be made. It has been shown that oftentimes algorithms are understood as opaque black boxes and voices for opening those black boxes are being raised (Adadi & Berrada, 2018; Geiger, 2017; Pasquale, 2015). Drawing from studies of actor-network theory, it has been shown that the action of categorizing assigns agency to algorithms and thereby enacts them as black boxes. Accordingly, black boxes cannot be opened without dissolving them in the same draw. In this light a pressing issue in the critical algorithm studies could be addressed. Namely that the initially precise and deterministic figure of the algorithm dissolves as soon as it is analyzed in terms of its social and political dimensions (Seaver, 2017; Ziewitz, 2016). As an alternative to the recursive debate on accountability and transparency, an emphasis on responsible interaction has been proposed. This proposal has been built on the prevalent idea to focus on the interrelation between human and algorithmic actors, rather than mere algorithmic functionality (Beer, 2017; Crawford, 2016; Gillespie, 2014a, 2014b; Kitchen, 2017). The study of Skitourengru has shown that such an interaction approach goes beyond the technical domain of algorithms. Instead, it proved useful to differentiate between algorithm and user interface. Conceptually, this turned out to be a counter movement to cultural approaches, which currently run the risk of overloading the concept of algorithm (Seaver, 2017).

As an alternative it has been proposed to study algorithms as socio-technical assemblages. Such an approach aligns with current studies identifying algorithms as arrangements of heterogeneous actors (Ananny, 2016; Bader & Kaiser, 2019; Kitchen, 2017). However, the etymological study of the word algorithm in combination with the study of Skitourengru has shown that it makes more sense to talk about automated computer systems rather than mere algorithms. This is because computer systems allow to speak of both input and output layers, while an algorithm describes the abstract procedure between the two. However, the assemblage approach has revealed more than this. Inspired by Rob Kitchen's (2017) methodological approach of unpacking the socio-technical assemblage of algorithms, the study has revealed a diverse set of stakeholders interacting with Skitourengru. These stakeholders are by no means just developers and users, but a range of institutionalized actors such as mountain guide associations, alpine clubs, accident prevention agencies and avalanche warning services. The study has shown that these institutions are both affected by Skitourengru and affect the functionality or public representation of Skitourengru. The organization of affected institutions around algorithms seems to be underrepresented in the current literature.

In contrast the notion of decision-making is widely spread in the recent literature of critical algorithm studies (Bader & Kaiser, 2019; Lindenbaum et al., 2020; Weiskopf, 2020a). In this study, algorithmic decision-making has been compared to organizational decision-making. It has been found that basic motifs of organizational decision theory reappear in the research on algorithmic decision-making. In both fields, decisions are understood as rational choices that optimize towards pre-given goals. Furthermore, both fields maintain the underlying assumption that decisions precede action and explain it causally. In particular, the notion of rationality serves as key concept in both fields. So are algorithms referred to as “supercarriers of formal rationality” nowadays (Lindenbaum et al., 2020). The study of Skitourengru has shown that algorithms not only execute formal procedures, but also carry aspects of substantive rationality. For example, value propositions about the risk classification or validation must be inscribed for the algorithm to work. Reducing an algorithm to its formal aspects thus overlooks how value-laden algorithmic action might be. At this point, the deconstructive insights of this study can also be included. Accordingly, a decision is not the formal execution of a rule, but an unmediated intervention in the run of events (Derrida, 2016; Derrida & Beardsworth, 1994). Applied to the rationality debate, this means that there are no purely formal decisions. Rather, decisions are always accompanied by substantial value judgments. When talking about algorithmic decision-making it should hence be well investigated where and how these value propositions are inscribed.

Talking about value proposition leads to the question of responsibility. In contrast to the paradigm of accountability and transparency, an emphasis on responsibility has been derived through the work of recent critical scholars (Amoore, 2020; Weiskopf, 2020a). Accordingly, it is not the algorithmic output but the distributed act of writing, which bears responsibility between us and others. In this study it has been proposed that particular attention should be paid to translation processes which ascribe value to otherwise formal procedures. However, for the study of Skitourengru this deconstructive understanding of responsibility has proven helpful only partially. On the one hand, it has been shown that responsibility cannot simply be attributed but it is an infinite and inexpressible relationship between oneself and the other. It could be shown that such moral responsibility can be perceived as a heavy and haunting burden for embodied decision-makers. Nevertheless, this understanding of responsibility could quickly be misused in practice. Therefore, not only a sense of responsibility, but also an institutionalized duty of care must be enacted in the long term. The development of such standards, however, aligns well with the outlined understanding of responsibility. Accordingly, it is up to each of us

to contribute to the debate of how we want to live and interact with algorithms. Ultimately, both algorithms and responsibility not only address us alone, but us as a community. To illustrate this plurality of responsibility, the term spaces of responsibility has been used throughout this study. Therefore, a topological understanding of time and space has been borrowed from assemblage thinking. The attempt to combine figures from assemblage thinking and deconstructivism turned out to be rather unorthodox (Alcadipani & Hassard, 2010; Whittle & Spicer, 2008). Yet some common ground could be found in the notion of performativity. For future research in the field of critical algorithm studies this might prove as a useful framework to address both material and ethical aspects of algorithmic action.

Finally, the study of Skitourenguru has provided further evidence for a symbiotic interaction with algorithms. Accordingly, algorithms have the biggest leverage when used complementarily and not competitively to human intelligence (Lichtenthaler, 2018). This approach describes well the basic functionality of Skitourenguru providing decision support in the planning phase yet little support in the execution phase of a ski tour. The notion that ethical judgements are likely to remain in the human domain can now be further differentiated (Agrawal et al., 2017). Namely in the inscription of value proposition and the translation of algorithmic outputs. These utterly ethical actions seem to be worth examining in future studies.

Limitations of the Study

The aim of this study was to investigate responsibility in the interaction between the avalanche risk assessment algorithm of Skitourenguru and affected human actors. The algorithm of Skitourenguru was proposed because its functionality is well documented and openly accessible. Furthermore, the bodily and potentially fateful consequences of avalanche decisions seemed promising for the ethical concerns of this study. Ultimately the human enactment of the algorithmic recommendation seemed promising to disentangle the notions of judgment and decision-making. It turned out that the algorithm of Skitourenguru provided revealing insights in the domain of automated risk assessment. However, other than the main concern of the critical algorithm studies, Skitourenguru cannot be considered as an automated decision system. Instead, the resulting decisions are better termed as algorithmically informed decisions. This is a clear limitation of the study since its original purpose was to investigate algorithmic decision-making. The fact that this study identifies algorithmic decision-making as a questionable term loses support in this light. After all there is enough evidence for algorithmic systems whose results directly affect their environment, too (Amoore, 2020).

Conceptually this study was informed by a deconstructive understanding of responsibility. Furthermore, figures from assemblage thinking were incorporated to address the socio-technical dimensions of the studied algorithm. Combining figures from deconstructivism and assemblage thinking has been identified to be a precarious endeavor. To combine the two realms through the notion of performativity must be labelled as an attempt rather than a solidified framework. In this light the proposal of this study to understand responsibility as a form of translation might lack conceptual ground. Respectively, the concept of translational responsibility was not further refined over the course of the study but remained in a prototypical state. As a result, the conceptual contribution of this study shows little coherence but embodies a fragmentary and heterogeneous character. This issue might not least be due to the exploratory method of this study.

Methodologically this study was inspired by studies from actor-network theory (Latour, 2002). The highly descriptive and quote driven empirical account of Skitourengru sought to give voice to the actors interacting with the algorithm of Skitourengru. The resulting, relational approach understood the author as an entangled actor, rather than an opposed observer. Nevertheless, some reflections about the authors background might have fallen short. As for example his personal interest in ski touring and mountain activities. Furthermore, the approach ran the risk of retracing the official representation of Skitourengru whilst introducing little new empirical findings. Here further external voices would have been desirable to gain a more differentiated view on Skitourengru. But also, the user perspective ran the risk of being overly one sided. The autoethnographic sections of this study must be understood as a first approximation rather than a representative user perspective. Future studies could provide much more conclusive results with the help of mixed qualitative and quantitative methods.

Speaking of qualitative studies, the initial skepticism on Skitourengru's part, towards a qualitative single case study, must be expressed. And indeed, a single empirical account runs the risk of reproducing unconscious self-images. Ultimately, however, this study was not written on behalf of Skitourengru. Instead, this study provides an ethical perspective on a recent development in avalanche decision-making. The heterogeneous aspects of this study might, however, make a clear interest allocation difficult. Although both decision-making and avalanches have been addressed, the study does neither contribute to the literature of decision theory (Borgonovo et al., 2018) nor to the field of avalanche heuristics (Landrø et al., 2020). Most closely this study aligns with the focus of the critical algorithm studies (Seaver & Gillespie, 2016). Not least because of the strong focus on algorithms, more traditional aspects

of Organization Studies were barely addressed. Here, for example the organization culture could have been analyzed as a influencing variable of the algorithm.

Finally, a deconstructive study must face the question of what material contribution it makes in the world. Indeed, little tangible contribution could be made throughout this work. Solely a productive understanding of constructivism has been contrasted to the tradition of deconstructivism. And so, the insight that philosophers only interpret the world differently fades in yet another hall of abstraction. However, this deficit must not only be attested to this work but to a large part of the social sciences. Why don't we embody our own insights and perform reality anew? Where is the productive social science that hacks algorithms to gain knowledge and expresses it creatively? Critical theory may have been an attempt, but again we seem overly concerned with yet another idiom or abstract rationalization critique. If the development of Skitourenguru has shown one thing, then the possibility to productively create and shape the world. And so, we too should not hide behind postmodern phrases, but roll up our sleeves and soil our hands with the humus of the future.

[An Ending a Beginning](#)

This thesis initially sought to explore the role of algorithmic decision-making and its impact on the spaces of responsibility within organizations. It turned out that responsibility cannot simply be attributed to a temporal or spatial location. Instead, responsibility proved to be an infinite and unmediated duty towards the other. But not only the notion of responsibility turned out cumbersome but also the notion of decision-making. Do decisions precede our actions, or do we retrospectively make sense of the world through the notion of decision? At this point of the study the latter mechanism should be deployed. Despite these challenges the term “spaces of responsibility in algorithmic decision-making” provided a fertile ground for this study. It could be shown that decisions require more than simple if-then processes, but fundamental value trade-offs. In this regard the term algorithmic decision-making may serve as a buzzword for recent studies, but it runs the risk of overlooking these underlying value trade-offs. In this respect, algorithms must not only be labeled as carriers of formal rationality but also as carriers of substantive rationality.

The empirical account of this study has shown that emerging machine learning techniques bear the opportunity to improve the lives of many. Nevertheless, it has become evident that broad participation is needed to develop a common ground for the application of algorithmic action. This insight is not least due to the unorthodox attempt to combine an ethics of responsibility

with a performative understanding of reality. Ultimately it is not only algorithms that shape and perform reality, but all of us. Consequently, I must ask myself as a graduate student whether the mere analysis and deconstruction of reality does justice to my responsibility as a critical and engaged human being. In this sense, the end of this journey is also a beginning. A beginning that bears the promise to create, shape and perform the future. This in mind I hope that the reader of this study will find themselves within this insight. In any case I hope the reader enjoyed the journey, since I certainly did.

References

- Adadi, A., & Berrada, M. (2018). Peeking Inside the Black-Box: A Survey on Explainable Artificial Intelligence (XAI). *IEEE Access*, 6, 52138–52160.
<https://doi.org/10.1109/ACCESS.2018.2870052>
- Adorno, T. W., & Horkheimer, M. (2009). *Dialectic of enlightenment: Philosophical fragments* [Nachdr.]. *Cultural memory in the present*. Stanford Univ. Press.
- Agrawal, A., Gans, J., & Goldfarb, A. (2017). What to expect from artificial intelligence: To understand how advances in artificial intelligence are likely to change the workplace — and the work of managers — you need to know where AI delivers the most value. *MIT Sloan Management Review*, 58, Article 3, 23–26. <https://sloanreview.mit.edu/article/what-to-expect-from-artificial-intelligence/>
- Agrawal, A., Gans, J., & Goldfarb, A. (2018). *Prediction machines: The simple economics of artificial intelligence*. Harvard Business Review Press.
<http://people.oregonstate.edu/~vanlondp/wgss320/articles/haraway-cyborg-manifesto.pdf>
- Alcadipani, R., & Hassard, J. (2010). Actor-Network Theory, organizations and critique: towards a politics of organizing. *Organization*, 17(4), 419–435.
<https://doi.org/10.1177/1350508410364441>
- Amoore, L. (2019). Doubt and the Algorithm: On the Partial Accounts of Machine Learning. *Theory, Culture & Society*(36), Article 6, 147–169.
http://artsites.ucsc.edu/sdaniel/230/derrida_archivefever.pdf
- Amoore, L. (2020). *Cloud ethics: Algorithms and the attributes of ourselves and others*. Duke University Press. <https://journals.sagepub.com/doi/pdf/10.1177/0162243915606523>
- Ananny, M. (2016). Toward an Ethics of Algorithms. *Science, Technology, & Human Values*, 41(1), 93–117. <https://doi.org/10.1177/0162243915606523>
- Ananny, M., & Crawford, K. (2018). Seeing without knowing: Limitations of the transparency ideal and its application to algorithmic accountability. *New Media & Society*, 20(3), 973–989. <https://doi.org/10.1177/1461444816676645>

- Austin, J. L. (1962). *How to do things with words. The William Hames Lectures*. Oxford University Press.
- Bader, V., & Kaiser, S. (2019). Algorithmic decision-making? The user interface and its role for human involvement in decisions supported by artificial intelligence. *Organization*, 26(5), 655–672. <https://doi.org/10.1177/1350508419855714>
- Barton, J. (2003). Iterability and the Order-Word Plateau: ‘A Politics of the Performative’ in Derrida and Deleuze/Guattari. *Critical Horizons*, 4(2), 227–264. <https://doi.org/10.1163/156851603322398288>
- Beer, D. (2017). The social power of algorithms. *Information, Communication & Society*, 20(1), 1–13. <https://doi.org/10.1080/1369118X.2016.1216147>
- Borgonovo, E., Cappelli, V., Maccheroni, F., & Marinacci, M. (2018). Risk analysis and decision theory: A bridge. *European Journal of Operational Research*, 264(1), 280–293. <https://doi.org/10.1016/j.ejor.2017.06.059>
- Burrell, J. (2016). How the machine ‘thinks’: Understanding opacity in machine learning algorithms. *Big Data & Society*, 3(1), 205395171562251. <https://doi.org/10.1177/2053951715622512>
- Butler, J. (2008). *Giving an account of oneself* (1. ed. [Nachdr.]. Fordham Univ. Press.
- Butler, J. (2010). Performative Agency. *Journal of Cultural Economy*, 3(2), 147–161. <https://doi.org/10.1080/17530350.2010.494117>
- Butler, J. (2011). *Bodies that matter: On the discursive limits of "sex"*. Routledge classics. Routledge. <http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10466496>
- Callon, M. (1984). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *The Sociological Review*, 32, 196–233. <https://doi.org/10.1111/j.1467-954X.1984.tb00113.x>
- Chabert, J.-L. (1999). *A History of Algorithms: From the Pebble to the Microchip*. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-642-18192-4>
- Chia, R. (1994). The Concept of Decision: A Deconstructive Analysis. *Journal of Management Studies*, 31, Article 6, 781–806.

- Chia, R. (1996). *Organizational Analysis as Deconstructive Practice. de Gruyter Studies in Organization: Vol. 77*. De Gruyter.
http://www.degruyter.com/search?f_0=isbnissn&q_0=9783110884494&searchTitles=true
<https://doi.org/10.1515/9783110884494>
- Christen, R. (2017). Verändert skitourenguru.ch die Rechtsprechung? Wie Gerichte mit Lawinen umgehen. *Die Alpen*, 4, 36–37.
https://info.skitourenguru.ch/download/media/DieAlpen_2017_04_S38_39_de.pdf
- Cierco, F.-X., & Debouck, F. (2013). *Human factors in decision making in avalanche terrain*. Grenoble.
- Cieslik, T. (2019). *Interview mit Günter Schmudlach: «Der Computer kann das besser.»*.
<https://www.gipfelbuch.ch/outdoornews/detail/id/620>
- Clegg, S., Kornberg, M., & Rhodes, C. (2007). Organizational ethics, decision making, undecidability. *The Sociological Review*, 55(2), 393–409.
- Cohen, M. D., March, J. G., & Olson, J. P. (1972). A Garbage Can Model of Organizational Choice. *Administrative Science Quarterly*, 17, Article 1, 1–25.
- Crawford, K. (2016). Can an Algorithm be Agonistic? Ten Scenes from Life in Calculated Publics. *Science, Technology, & Human Values*, 41(1), 77–92.
<https://doi.org/10.1177/0162243915589635>
- Creswell, J. W. (2013). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (3rd. ed). SAGE Publications.
- Creswell, J. W. (2014). *Research design qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE Publications.
- Cull, P., & Frank, W. (1979). Flaws of Form. *International Journal of General Systems*, 5(4), 201–211. <https://doi.org/10.1080/03081077908547450>
- Danaher, J. (2016). The Threat of Algocracy: Reality, Resistance and Accommodation. *Philosophy & Technology*, 29, 245–268.
- Derrida, J. (1988). *Limited Inc*. Northwestern University Press.

- Derrida, J. (2016). Force of Law: The "Mystical Foundation of Authority". In M. Rosenfeld, D. G. Carlson, & D. Cornell (Eds.), *Deconstruction and the Possibility of Justice*. Taylor and Francis. <http://lab404.com/misc/ltdinc.pdf>
- Derrida, J., & Beardsworth, R. (1994). Nietzsche and the machine. *Journal of Nietzsche Studies*, 7, 7–66. <https://www.jstor.org/stable/20717600>
- Diakopoulos, N. (2016). Accountability in algorithmic decision making. *Communications of the ACM*, 59(2), 56–62. <https://doi.org/10.1145/2844110>
- Dourish, P. (2016). Algorithms and their others: Algorithmic culture in context. *Big Data & Society*, 3(2), 1-11. <https://doi.org/10.1177/2053951716665128>
- Ella Glikson, & Anita Williams Woolley (2020). Human trust in artificial intelligence: Review of empirical research. Academy of Management Annals (in press). *The Academy of Management Annals*.
https://www.researchgate.net/publication/340605601_Human_trust_in_artificial_intelligence_Review_of_empirical_research_Academy_of_Management_Annals_in_press
- European Commission. (2020). *White Paper on Artificial Intelligence: A European Approach to Excellence and Trust*. Brussels.
- Geiger, R. S. (2017). Beyond opening up the black box: Investigating the role of algorithmic systems in Wikipedian organizational culture. *Big Data & Society*, 4(2), 205395171773073. <https://doi.org/10.1177/2053951717730735>
- Gillespie, T. (Ed.). (2014a). *Inside technology. Media technologies: Essays on communication, materiality, and society*. MIT Press.
<https://doi.org/10.7551/mitpress/9780262525374.001.0001>
- Gillespie, T. (2014b). The Relevance of Algorithms. In T. Gillespie (Ed.), *Inside technology. Media technologies: Essays on communication, materiality, and society* (pp. 167–194). MIT Press. <https://doi.org/10.7551/mitpress/9780262525374.003.0009>
- Gödel, K. (2012). *On Formally Undecidable Propositions of Principia Mathematica and Related Systems. Dover Books on Mathematics*. Dover Publications.

- Gond, J.-P., Cabantous, L., Harding, N., & Learmonth, M. (2016). What Do We Mean by Performativity in Organizational and Management Theory? The Uses and Abuses of Performativity. *International Journal of Management Reviews*, 18(4), 440–463.
<https://doi.org/10.1111/ijmr.12074>
- Gurevich, Y. (2012). What is an Algorithm? In M. Bieliková, G. Friedrich, G. Gottlob, S. Katzenbeisser, & G. Turán (Eds.), *Lecture notes in computer science: Vol. 7147. SOFSEM 2012: theory and practice of computer science: 38th Conference on Current Trends in Theory and Practice of Computer Science, Špindlerův Mlýn, Czech Republic, January 21 - 27, 2012 ; proceedings* (pp. 31–42). Springer.
- Harvey, S., & Dürr, L. (2016). Dei ideale Skitour per Mausklick: Digitale Tourenplanung mit Geländemodell und Lawinenbulletin. *Die Alpen, Februar*, 17–20.
http://info.skitouren guru.ch/download/media/DieAlpen_2016_02_S17_20_de.pdf
- Heissenbüttel, S. (2016). «Das Programm wird der ‹Generation Selfie› das Leben retten». <https://www.srf.ch/news/schweiz/das-programm-wird-der-generation-selfie-das-leben-retten>
- Hetzel, A. (2004). Das Rätsel des Performativen. Sprache, Kunst und Macht. *Philosophische Rundschau*, 51(2), 132–159. <http://ascnetworksnetwork.org/wp-content/uploads/2010/02/IJoC-Network-Theory-2011-ContractorMongeLeonardi.pdf>
- Introna, L. D. (2016). Algorithms, Governance, and Governmentality. *Science, Technology, & Human Values*, 41(1), 17–49. <https://doi.org/10.1177/0162243915587360>
- Jarrahi, M. H. (2018). Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making. *Business Horizons*, 61(4), 577–586.
<https://doi.org/10.1016/j.bushor.2018.03.007>
- Kitchin, R. (2017). Thinking critically about and researching algorithms. *Information, Communication & Society*, 20(1), 14–29. <https://doi.org/10.1080/1369118X.2016.1154087>
- Kittler, F. A. (1993). *Draculas Vermächtnis: Technische Schriften* (1. Aufl.). Reclam-Bibliothek: Vol. 1476. Reclam.
- Knecht, N. (2015, January 28). Risiko ist ein Menschenrecht: Laut Risikoforscher Werner Munter erhöhen Lawinen-Airbags oder Helme die Sicherheit im freien Gelände nicht – im

- Gegenteil. *Tagesanzeiger*. <https://www.tagesanzeiger.ch/reisen/aktiv/risiko-ist-ein-menschenrecht/story/19390762>
- Krämer, S. (1988). *Symbolische Maschinen: D. Idee d. Formalisierung in geschichtl. Abriß*. Wiss. Buchges.
- Laat, P. B. de (2018). Algorithmic Decision-Making Based on Machine Learning from Big Data: Can Transparency Restore Accountability? *Philosophy & Technology*, 31(4), 525–541. <https://doi.org/10.1007/s13347-017-0293-z>
- Landrø, M., Hetland, A., Engeset, R. V., & Pfuhl, G. (2020). Avalanche decision-making frameworks: Factors and methods used by experts. *Cold Regions Science and Technology*, 170, 102897. <https://doi.org/10.1016/j.coldregions.2019.102897>
- Langley, A., Mintzberg, H., Pitcher, P., Posada, E., & Saint-Macary, J. (1995). Opening up Decision Making: The View from the Black Stool. *Organization Science*, 6, 260-279. <https://www.jstor.org/stable/pdf/2392045.pdf?refreqid=excelsior%3A5c9b339908a10dfb8603c26340ae7fe3>
- Larson, J., Angwin, J., Kirchner, L., & Mattu, S. (2016, May 23). How We Analyzed the COMPAS Recidivism Algorithm. *ProPublica*. <https://www.propublica.org/article/how-we-analyzed-the-compas-recidivism-algorithm>
- Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Open Univ. Pr. <https://www.jstor.org/stable/pdf/4320507.pdf>
- Latour, B. (1988). *The pasteurization of France* (First Harvard University Press paperback ed.). Harvard Univ. Press. <https://www.jstor.org/stable/pdf/42572667.pdf>
- Latour, B. (1996). On actor-network theory: A few clarifications. *Soziale Welt*, 47(4), 369–381. <http://www.jstor.org/stable/40878163>
- Latour, B. (2002). *Aramis, or the love of technology* (4. printing). Harvard University Press.
- Latour, B. (2003a). The Promises of Constructivism. In D. Ihde & E. Selinger (Eds.), *Indiana series in the philosophy of technology. Chasing technoscience: Matrix for materiality* (pp. 27–46). Indiana Univ. Press. <http://www.bruno-latour.fr/sites/default/files/32-EXPLANATION-WOOLGAR-GB.pdf>

- Latour, B. (2003b). What if we Talked Politics a Little? *Contemporary Political Theory*, 2(2), 143–164. <https://doi.org/10.1057/palgrave.cpt.9300092>
- Latour, B. (2007). *Reassembling the social: An introduction to Actor-Network-Theory. Clarendon lectures in management studies*. Oxford Univ. Press.
- Latour, B. (2010). Where are the Missing Masses? The Sociology of a Few Mundane Artifacts. In W. E. Bijker (Ed.), *Inside technology. Shaping technology/building society: Studies in sociotechnical change*. MIT Press.
- Law, J. (1994). *Organizing modernity* (1. publ). Blackwell.
- Law, J. (2007). *Actor Network Theory and Material Semiotics*. Lancaster University. <https://journals.sagepub.com/doi/pdf/10.1177/0170840607082223>
- Law, J., & Mol, A. (2001). Situating Technoscience: An Inquiry into Spatialities. *Environment and Planning D: Society and Space*, 19(5), 609–621. <https://doi.org/10.1068/d243t>
- Lepri, B., Oliver, N., Letouzé, E., Pentland, A., & Vinck, P. (2018). Fair, Transparent, and Accountable Algorithmic Decision-making Processes. *Philosophy & Technology*, 31(4), 611–627. <https://doi.org/10.1007/s13347-017-0279-x>
- Lichtenthaler, U. (2018). Substitute or Synthesis: The Interplay between Human and Artificial Intelligence. *Research-Technology Management*, 61(5), 12–14. <https://doi.org/10.1080/08956308.2018.1495962>
- Licoppe, C. (2010). The 'Performative Turn' In Science and Technology Studies. *Journal of Cultural Economy*, 3(2), 181–188. <https://doi.org/10.1080/17530350.2010.494122>
- Lindenbaum, D., Vesa, M., & Den Hond, F. (2020). Insights From "The Machine Stops" to Better Understand Rational Assumptions in Algorithmic Decision Making and Its Implications for Organizations. *Academy of Management Review*, 45(1), 247–263.
- Marbacher, D. (2019). Mitmachen ist besser. *Die Alpen*, Februar, 3. http://info.skitouren guru.ch/download/media/DieAlpen_2019_02_QRM_de.pdf
- March, J. G. (1988). *Decisions and Organizations*. Blackwell. <https://doi.org/10.1177/017084068901000114>

- March, J. G., Simon, H. A [Herbert Alexander], & Guetzkow, H. (1994). *Organizations* (2. ed., reprinted (twice)). Blackwell.
https://fbaum.unc.edu/teaching/articles/Cohen_March_Olsen_1972.pdf
- Marcus, G. (2018). *Deep Learning: A Critical Appraisal*. <https://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks.pdf>
- Markoff, J. (2012). Scientists See Advances in Deep Learning, a Part of Artificial Intelligence. *The New York Times*.
<https://www.nytimes.com/2012/11/24/science/scientists-see-advances-in-deep-learning-a-part-of-artificial-intelligence.html>
- Martin, K. (2019). Ethical Implications and Accountability of Algorithms. *Journal of Business Ethics*, 160(4), 835–850. <https://doi.org/10.1007/s10551-018-3921-3>
- Mccammon, I., & Hägeli, P. (2007). An evaluation of rule-based decision tools for travel in avalanche terrain. *Cold Regions Science and Technology*, 47(1-2), 193–206.
<https://doi.org/10.1016/j.coldregions.2006.08.007>
- Mehri, B. (2017). From Al-Khwarizmi to Algorithm. *OLYMPIADS in INFORMATICS*, 11(2), 71–74.
- Miller, J. H. (2009). *For Derrida*. Fordham University Press.
<http://www.jstor.org/stable/10.2307/j.ctt13x01v0> <https://doi.org/10.2307/j.ctt13x01v0>
- Mintzberg, H., Raisinghani, D., & Théorêt, A. (1976). The Structure of "Unstructured" Decision Processes. *Administrative Science Quarterly*, 21(2), 246–275.
<http://www.jstor.com/stable/2392045>
- Mintzberg, H., & Waters, J. (1990). Studying Deciding: An Exchange of Views Between Mintzberg and Waters, Pettigrew, and Butler. *Organization Studies*, 11(1), 1–6.
<https://doi.org/10.1177/017084069001100101>
- Mol, A. (2010). Actor-Network Theory: sensitive terms and enduring tensions. *Kölner Zeitschrift Für Soziologie Und Sozialpsychologie*, 50, 253–269.
<http://www.heterogeneities.net/publications/Law2007ANTandMaterialSemiotics.pdf>

- Mosseri, A. (2018). *News Feed Aktualisierung: Die Menschen näher zusammenbringen - Über Facebook*. <https://about.fb.com/de/news/2018/01/news-feed-fyi-grosses-update/>
- Müller, M. (2015). Assemblages and Actor-networks: Rethinking Socio-material Power, Politics and Space. *Geography Compass*, 9(1), 27–41. <https://doi.org/10.1111/gec3.12192>
- Munter, W. (2001). Reduktionsmethode: Vom Minutenentscheid zum synthetischen Blick. *Bergundsteigen*, 4, 35–36. <https://www.bergundsteigen.at/file.php/archiv/2001/4/35-36%20%28reduktionsmethode%29.pdf>
- Munter, W. (2009). *3 x 3 Lawinen: Risikomanagement im Wintersport* (4., völlig Neubearb. Aufl.). Pohl & Schellhammer.
- Nahin, P. J. (2013). *The logician and the engineer: How George Boole and Claude Shannon created the information age*. Princeton University Press.
<http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=478992> <https://doi.org/10.1515/9781400844654>
- Nail, T. (2017). What is an Assemblage? *SubStance*, 46(1), 21–37.
- Nissenbaum, H. (1996). Accountability in a computerized society. *Science and Engineering Ethics*, 2(1), 25–42. <https://doi.org/10.1007/BF02639315>
- OED Online. (2020). *Algorithm*, N.
<https://www.oed.com/view/Entry/4959?redirectedFrom=algorithm#eid>
- Parker, M. (1995). Critique in the Name of What? Postmodernism and Critical Approaches to Organization. *Organization Studies*, 16(4), 553–564.
<https://doi.org/10.1177/017084069501600401>
- Pasquale, F. (2015). *The Black Box Society: The Secret Algorithms That Control Money and Information*. Harvard University Press. www.jstor.org/stable/j.ctt13x0hch
- Patton, P. (1994). Metamorpho-Logic: Bodies and Powers in A Thousand Plateaus. *Journal of the British Society for Phenomenology*, 25(2), 157–169.
<https://doi.org/10.1080/00071773.1994.11007058>
- Pettigrew, A. M. (2014). *The Politics of Organizational Decision-Making*. Taylor and Francis. <http://gbv.ebib.com/patron/FullRecord.aspx?p=1639186>

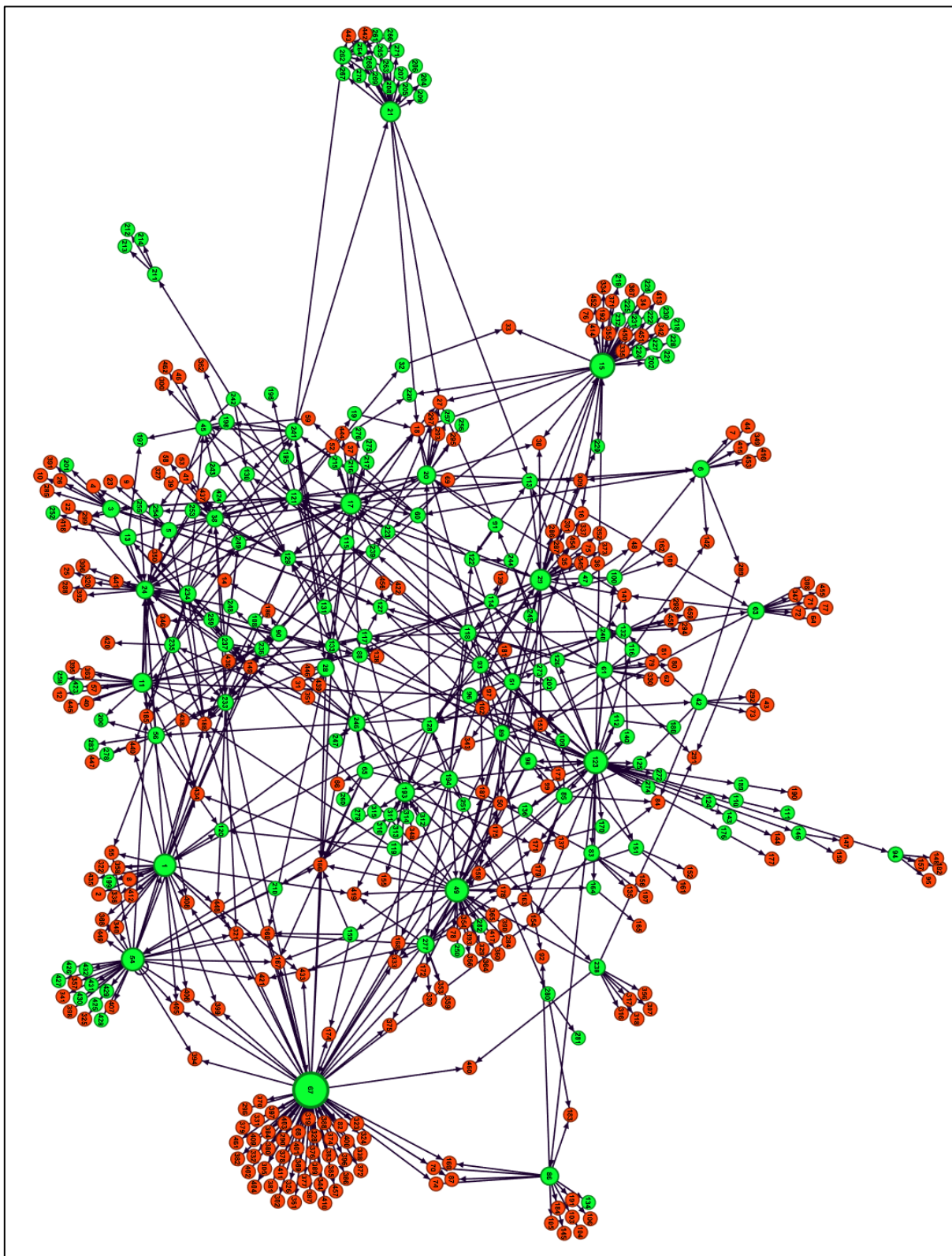
- Ruetz, L. (2018a). *Interview mit Skitouren guru Günter Schmudlach*. Powderguide.
<https://www.powderguide.com/magazin/schneegestoeber/artikel/schneegestoeber-2-201819-interview-mit-skitouren guru-guenter-schmudlach.html>
- Ruetz, L. (2018b). *SchneeGestöber: Interview mit Skitouren guru Günter Schmudlach* [Wie kam es zur automatischen, tagesaktuelle Risikobewertung?].
- Schmudlach, G. (2019). Quantitative Reduktionsmethode: Eine datenbasierte Methode zur Berechnung des Lawinenrisikos für Wintersportler. *Bergundsteigen*(106), 30–42.
<https://www.bergundsteigen.at/file.php/archiv/2019/1/30-42%28quantitative%20reduktionsmethode%29.pdf>
- Schmudlach, G. (2020). *About Guru*. <https://www.skitouren guru.ch/index.php/about>
- Schmudlach, G., & Köhler, J. (2016a). Automated Avalanche Risk Rating of Backcountry Ski Routes. In International Snow Science Workshop (Chair), *Proceedings, International Snow Science Workshop*. Symposium conducted at the meeting of International Snow Science Workshop, Breckenridge. https://arc.lib.montana.edu/snow-science/objects/ISSW16_O19.04.pdf
- Schmudlach, G., & Köhler, J. (2016b). Method for an Automated Avalanche Terrain Classification. In International Snow Science Workshop (Chair), *Proceedings, International Snow Science Workshop*. Symposium conducted at the meeting of International Snow Science Workshop, Breckenridge. https://arc.lib.montana.edu/snow-science/objects/ISSW16_P2.04.pdf
- Schmudlach, G., Winkler, K., & Köhler, J. (2018). Quantitative Risk Reduction Method (QRM): A Data-Driven Avalanche Risk Estimator. In International Snow Science Workshop (Chair), *Proceedings, International Snow Science Workshop*. Symposium conducted at the meeting of International Snow Science Workshop, Innsbruck.
https://arc.lib.montana.edu/snow-science/objects/ISSW16_P2.04.pdf
- Schneeweiss, C. (2003). Distributed decision making—a unified approach. *European Journal of Operational Research*, 150(2), 237–252. [https://doi.org/10.1016/S0377-2217\(02\)00501-5](https://doi.org/10.1016/S0377-2217(02)00501-5)

- Schwan, B. (2017). *Maschinenintelligenz: Der Besserübersetzer: Bei automatischen Übersetzungen im Internet sind bislang Google und Microsoft führend. Ein Kölner Unternehmen will mit verbessertem Deep Learning nun gegenhalten.*
<https://www.heise.de/hintergrund/Maschinenintelligenz-Der-Besseruebersetzer-3814856.html>
- Seaver, N. (2017). Algorithms as culture: Some tactics for the ethnography of algorithmic systems. *Big Data & Society*, 4(2), 1-12. <https://doi.org/10.1177/2053951717738104>
- Seaver, N., & Gillespie, T. (2016). *Critical Algorithm Studies: A Reading List.*
<https://socialmediacollective.org/reading-lists/critical-algorithm-studies/>
- Serres, M., & Latour, B. (2008). *Conversations on science, culture, and time* (5. print). *Studies in literature and science.* Univ. of Michigan Press.
- Shin, D., & Park, Y. J. (2019). Role of fairness, accountability, and transparency in algorithmic affordance. *Computers in Human Behavior*, 98, 277–284.
<https://doi.org/10.1016/j.chb.2019.04.019>
- Shrestha, Y. R., & Yang, Y. (2019). Fairness in Algorithmic Decision-Making: Applications in Multi-Winner Voting, Machine Learning, and Recommender Systems. *Algorithms*, 12(9), 199. <https://doi.org/10.3390/a12090199>
- Simon, H. A [Herbert A.]. (1960). *The new science of management decision.* Harper & Brothers. <https://doi.org/10.1037/13978-000>
- Skitouren guru. (2015). *Skitouren guru erhält SwissAlti3D.*
<http://info.skitouren guru.ch/index.php/news/27-news009>
- Skitouren guru. (2016). *Korridore statt Linien.*
<http://info.skitouren guru.ch/index.php/news/117-korridore-statt-linien>
- Skitouren guru. (2017). *Jeder GPS-Track, den du aufnimmst und an Skitouren guru schickst, ist wichtig!* <https://info.skitouren guru.ch/index.php/news/148-wo-finden-skitouren-statt>
- Skitouren guru. (2019). *Lawinenproblem contra Reduktionsmethode?*
<http://info.skitouren guru.ch/index.php/news/163-lawinenprobleme>
- Skitouren guru. (2021a). *About Guru.* <http://info.skitouren guru.ch/index.php/about>

- Skitouren guru. (2021b). *Grundsatzfragen*. <https://info.skitouren guru.ch/index.php/fragen-und-antworten/93-grundsatzfragen>
- Tsoukas, H. (2017). Don't Simplify, Complexify: From Disjunctive to Conjunctive Theorizing in Organization and Management Studies. *Journal of Management Studies*, 54(2), 132–153. <https://doi.org/10.1111/joms.12219>
- Weiskopf, R. (2002). Deconstructing "The Iron Cage" - towards an Aesthetic of Folding. *Consumption, Markets and Culture*, 5, 79–97.
<https://www.yumpu.com/en/document/read/22014136/deconstructing-the-iron-cage-center-for-research-on->
- Weiskopf, R. (2020a). Algorithmic Decision-Making, Spectrogenic Profiling, and Hyper-Facticity in the Age of Post-Truth. *Le Foucaldien*, 6(1), Article 3, 1–37.
<https://doi.org/10.16995/lefou.62>
- Weiskopf, R. (2020b). *Organizing work and the work of organizing as ethico-aesthetic practice: A theoretical and empirical study of new modes of organizing*. Universität Innsbruck. <https://www.uibk.ac.at/iol/organisation/team/weiskopf/forschung.html>
- Welebil, S. (2020). Skitouren guru: "Tourenplanen kann ein Algorithmus besser". fm4.ORF.at. <https://fm4.orf.at/stories/3009993/>
- Whitehead, A. N. (1985). *Science and the modern world: Lowell Lectures, 1925*. The Free Press.
- Whittle, A., & Spicer, A. (2008). Is Actor Network Theory Critique? *Organization Studies*, 29(4), 611–629. <https://doi.org/10.1177/0170840607082223>
- Yin, R. K. (2009). *Case study research: Design and methods* (4. ed.). *Applied social research methods series*.
- Zerilli, J., Knott, A., Maclaurin, J., & Gavaghan, C. (2019). Algorithmic Decision-Making and the Control Problem. *Minds and Machines*, 29, 555–578.
- Ziewitz, M. (2016). Governing Algorithms: Myth, Mess and Methods. *Science, Technology, & Human Values*, 41(1), 3–16. <https://doi.org/10.1177/0162243915608948>

Zweig, K. A., Wenzelburger, G., & Krafft, T. D. (2018). On Chances and Risks of Security Related Algorithmic Decision Making Systems. *European Journal for Security Research*, 3(2), 181–203. <https://doi.org/10.1007/s41125-018-0031-2>

Appendix



Appendix 1: Hyperlink Structure of Skitourenguru.ch. In total 462 nodes and 811 edges. Green nodes represent internal links, red nodes represent external links. The data has been collected manually and is visualized by a Force Atlas algorithm in Gephi.

Prenome	Name	Organisation	Relation	Participation	Background	Adressed	Replied	Reply	Interview Date	Interview Link	Links	Channel	Record	Transcript	Length
Günter	Schmudlach	SkitourenGuru GmbH	Friends of SkitourenGuru	Founder and Operator	Electrical Engineering and Software Development	02.04.2020; 03.11.2020	03.04.2020; 03.11.2020	Email von Günter Schmudlach Email von Andreas Eisenhut	10.11.2020	Günter Schmudlach	info.skitourenGuru.ch/index.php/about	Zoom Call	Audio	Yes	01:49
Andi	Eisenhut		Friends of SkitourenGuru	Route Corridors	Landscape Architecture and GIS	03.11.2020	04.11.2020				www.aus-sicht.ch				
Baojun	Xu	Joint Research Centre of	Friends of SkitourenGuru	Web Site Development	Environmental Engineering and Statistics	03.11.2020; 26.12.2020					www.researchgate.net/profile/Bart-Degrauwe				
Bart	Degrauwe		Friends of SkitourenGuru	Statistician							www.georgaerni.ch				
Georg	Aerni		Friends of SkitourenGuru	Photographer	Architecture and Photography	26.12.2020	30.12.2020	Email von Georg Aerni			www.ntnu.edu/employees/jochen.kohler				
Jochen	Köhler	Norwegian University of	Friends of SkitourenGuru	Scientific Adviser	Structural Engineering and Risk Based Decision Making	03.11.2020; 16.11.2020	03.11.2020; 24.11.2020	Email von Jochen Köhler	10.12.2020	Jochen Köhler	www.schnitger-film.com/index.php	Zoom Call	Audio	No	01:07
Jörg	Schnitger		Friends of SkitourenGuru	Videographer	Professional Videographer	26.12.2020									
Li	Egli		Friends of SkitourenGuru	Illustrator											
Marius	Huser	Image Lab GmbH	Friends of SkitourenGuru	Software Adviser	Physicist and Software Developer	26.12.2020					www.imagelab.ch/index.html				
Patrick	Mächler		Friends of SkitourenGuru	Server Host											
Luca	Iacometti		Friends of SkitourenGuru	Italy Ambassador	Environmental Science and Technology	07.11.2020	09.11.2020		16.11.2020	Luca Iacometti	www.linkedin.com/in/luca	Zoom Call	Audio	No	00:30
Renata	Grünefelder		Friends of SkitourenGuru	General Adviser											
Rosa	Guggenheim		Friends of SkitourenGuru	Web Site Design	Designer and Illustrator	26.12.2020	05.01.2020	Email von Rosa Guggenheim			guggenheim.li/				
Theres	Eigenmann		Friends of SkitourenGuru	Avalanche Adviser											
Ulrich	Reincke	SAS Institute	Friends of SkitourenGuru	Machine Learning Adviser	Analytic Solution Architect	03.11.2020	04.11.2020	Email von Ulrich Reincke	10.11.2020	Ulrich Reincke	www.linkedin.com/in/ulrich-reincke	MS Teams Call	Audio	No	00:50
Monique	Walter	bfi bpa upl	Partner	Partnership	Swiss centre of competence for accident prevention	07.11.2020; 07.11.2020; 01.01.2021	09.11.2020; 07.11.2020; 01.01.2021	Email von Monique Walter			www.bfi.ch/de				
		Mammut	Partner	Partnership	Mountainsport Manufacturer	07.11.2020; 01.01.2021					www.mammut.com/us/en/#				
		Petzi Foundation Bächli	Partner	Partnership	Mountainsport NGO	07.11.2020; 01.01.2021									
Gernot	Böttinger	Bergsport Schweizer Alpenverein	Partner	Partnership	Mountainsport Retailer	07.11.2020; 07.11.2020; 01.01.2021	11.11.2020	Email von Gernot Böttinger			www.baechli-bergsport.ch/				
Bruno	Hasler		Partner	Partnership	Swiss Alpine Club	07.11.2020; 01.01.2021					www.sac-cas.ch/de/				
Reto	Baur	Bergportal	Partner	Kooperation	Mountain Sport Online Platform	07.11.2020; 01.01.2021	07.11.2020	Email von Reto Baur			www.bergportal.ch/				
Bernhard	Sassik	ExoLabs	Partner	Kooperation	Earth Observation Solutions	07.11.2020; 07.11.2020; 01.01.2021	09.11.2020	Email von Bernhard Sassik			www.exolabs.ch/				
		IGN Institut	Partner	Patronage	National Institute of Geographic and Forest Information						www.ign.fr/institut/identite-card				
Lorenz	Meier	GeoPraevent	Partner	Patronage	Alarm and monitoring systems for natural hazards	07.11.2020	09.11.2020	Email von Lorenz Meier			www.geopraevent.ch/				
Markus	Fleischmann	DAV	External		Training Referent of the German Alpine Club	07.11.2020	10.11.2020	Email von Markus Fleischmann			www.alpenverein.de/				
Leon	Kobinger	Airbus	External		Systems Engineer	17.11.2020	17.11.2020		17.11.2020	Leon Kobinger	www.linkedin.com/in/leon-kobinger	Phone Call	Audio	No	01:22
Lutz			External		Avalanche Experience	23.06.2020	22.06.2020		25.02.2020	Lutz 25.06.2020		Phone Call	Audio	No	00:55
Hansi			External		Avalanche Experience	23.06.2020			01.07.2020			Phone Call	Notes	No	00:59
Nils	Beste	Petzi Tiroler	External		Mountain Guide	03.11.2020; 03.11.2020; 01.12.2020	04.11.2020		09.11.2020	Nils Beste	www.tirol.gv.at/sicherheit/taetiz/ansprechbaer	Phone Call	Audio	No	00:44
Patrick	Nairz	Lawinewartdi	External		Avalanche Prognosticator		07.12.2020	Email von Patrick Nairz							
Renato	Frey	SNSF Center for Cognition and	External		Decision under Risk Researcher	03.11.2020	05.11.2020		10.11.2020	Renato Frey	www.renatofrey.net/	Zoom Call	Audio	No	00:50
Rita	Christin	VBS	External		President of the Swiss Mountain Guide Association	17.11.2020	17.11.2020		02.12.2020	Rita Christin	www.sbg-ssgm.ch/ueber-uns/	Zoom Call	Audio	No	00:44
Albert	Leichtfried	VOBS	External		Training Officer of the Austrian Mountain Guide Association	06.11.2020	13.11.2020	Email von Albert Leichtfried							
Michael	Larcher	OEA	External		Head of the Mountain Sports Department of the Austrian	04.11.2020	05.11.2020		10.11.2020	Michael Larcher	https://www.bergundsteigen.blog/author/mich	Zoom Call	Notes	No	00:25

Appendix 2: Personal contact protocol. Lists date and type of exchange with both internal and external stakeholders of SkitourenGuru.



Lawinenlagebericht des Lawinenwarndienstes Tirol Freitag, den 30.03.2018, um 07:30 Uhr



Regionale Lawinengefahrenstufen

in alpinen Lagen vom 30.03.2018 07:30

GANZTÄGIG



WAS? Problem	WO? Gefahrenstellen
 Nassschnee	 2400m Vorsicht, wo sehr steil
 Tribschnee	 2100m mit Höhe zunehmend
Allg. Stufe Tirol 	Tendenz für morgen gleichbleibend

GEFAHRENMUSTER (GM): [gm.3 - Regen](#) [gm.2 - Gleitschnee](#) [gm.6 - lockerer Schnee und Wind](#)

Verbreitet erhebliche Lawinengefahr - im Süden zunehmend heikle Situation für Wintersportler

BEURTEILUNG DER LAWINENGEFAHR

In Tirol herrscht allgemein erhebliche Lawinengefahr, wobei im Wesentlichen auf zwei Probleme zu achten ist. In tieferen Lagen haben wir ein Nassschneeproblem. Die Schneedecke verliert durch Regen und warme Temperaturen an Festigkeit. Aus extrem steilem Gelände können deshalb - ähnlich wie gestern - wieder nasse Lockerschneelawinen abgehen. Ebenso erhöht sich die Wahrscheinlichkeit von Gleitschneelawinen auf Wiesenhängen. In größeren Höhen spielen der zum Teil schon starke Südwind samt zunehmendem Schneefall - ganz speziell in den südlicheren Regionen - eine immer größere Rolle. Frische Tribschneepakete lassen sich v.a. im schattigen Gelände beginnend von etwa 2400m aufwärts bereits durch das Gewicht eines einzelnen Wintersportlers auslösen. Während der Abend- und Nachtstunden können dann bei erwarteten Neuschneesummen von etwa 30cm in größeren Höhen Schneebrettlawinen bis mittlerer Größe auch von selbst abgehen. Dies betrifft oberhalb etwa 2100m schattiges Gelände, oberhalb etwa 2500m dann zunehmend alle Expositionen.

SCHNEEDECKENAUFBAU

Von gestern auf heute schneite es meist um 10cm, in der Brennergegend und in den Osttiroler Tauern bis zu 20cm, während es in tieferen Lagen regnete. Die Schneedecke ist inzwischen bis 2000m in allen Expositionen bis in tiefere Schichten feucht bzw. nass. In oberflächennahen Schichten reichte die Durchfeuchtung auch schattseitig gebietsweise bereits bis etwa 2700m hinauf. Durch neuerlichen Schneefall, beginnend im Süden, samt starkem Wind entstehen Tribschneepakete, die in der Höhe umfangreich werden können. Brüche in oberflächennahen Schwachschichten (Oberflächenreif und kantige Schichten im Bereich von Schmelzkrusten), beginnend von etwa 2100m schattseitig und ab etwa 2500m in W- und O-Hängen, hochalpin auch in S-Hängen werden in den neuschneereichen Regionen ab den Abendstunden immer wahrscheinlicher.

ALPINWETTERBERICHT DER ZAMG-WETTERDIENSTSTELLE INNSBRUCK

Aufkommende Südföhnlage. Die am Morgen noch starke Bewölkung beginnt aufzulockern und es stellt sich in den Nordalpen und nördlichen Zentralalpen meist eine freundliche Mischung aus Sonne und Wolken ein, wobei die Berge meist wolkenfrei sind und es bleibt trocken. Am Hauptkamm und in den Südalpen dagegen schlechte Sicht durch Wolkenstau und ab 1300-1700m schneit es zumindest zeitweise. Temperatur in 2000m: -2 bis +2 Grad, Temperatur in 3000m: -8 bis -4 Grad, Höhenwind: zunehmender, nachmittags starker bis stürmischer Südwind.

TENDENZ

Im Süden ein für den Wintersportler heikler Tag.

Patrick Nairz

Lawinenabgang Waidringer Nieder, Östliche Nordalpen, 30.03.2018

Sachverhalt

Zwei Skitourengeher befanden sich im Aufstieg in Richtung Mitterhorn, einem Grenzberg zwischen Tirol und Salzburg. Nachdem jene Person, die spurte, einen extrem steilen Abschnitt bereits bewältigt hatte und sich beim sogenannten Waidringer Nieder bereits in etwas flacherem, kammnahen Gelände aufhielt, löste sich eine Schneebrettlawine. Die vordere Person wurde ca. 30 m mitgerissen und kam vor dem Steilabschnitt unverletzt zum Stillstand. Die etwa 50 Höhenmeter unterhalb befindliche Person hingegen wurde bis zum Hangfuß mitgerissen und dort total verschüttet. Der Tourenkamerad setzte sofort einen Notruf ab, fuhr zum Lawinenkegel ab und begann dort mit der LVS-Suche. Bei Eintreffen der Rettungsmannschaft samt Lawinenhunden schaufelte er an der vermeintlichen Verschüttungsstelle. Kurz darauf schlug der Lawinenhund seitlich versetzt dieser Stelle an. Dort konnte der Verschüttete in kritischem Zustand nach ca. 30-minütiger Verschüttungszeit ausgegraben werden. Sein Zustand verbesserte sich während der folgenden Tage zusehends. Der Lawinenhundeführer samt seinem Lawinenhund waren somit lebensrettend!

Kurzanalyse

Wichtig für den Lawinenabgang erscheint an diesem warmen, sonnigen Unfalltag der Südföhn. Im Kammbereich wurde Schnee verfrachtet, der sich im Lee – dem Aufstiegsbereich – ablagerte. Laut Aussagen des Spurenden muss es sich um relativ weichen, jedoch ausreichend gebundenen Schnee gehandelt haben. Da wir nach dem Unfall nicht vor Ort waren, kann über die Schwachschicht nur Vermutungen angestellt werden: Entweder es handelte sich um lockeren, überwehten Pulverschnee, oder aber – und das ist wahrscheinlicher – um eingeschneiter Oberflächenreif (Nigg-Effekt).

Betrachtet man nicht nur die Rettungsaktion, sondern auch das Absturzgelände und den Liegepunkt des Verschütteten so führte eine Verkettung vieler glücklicher Umstände zu einem „happy end“.

relevante(s) Lawinenproblem(e) / Gefahrenmuster

Triebschneeproblem / lockerer Schnee und Wind (gm.6)

Unfalldetails

trockene Schneebrettlawine.jpg

Seehöhe [m]: 2270

Hangneigung [°]: 35

Hangexposition: N

Lawinenlänge [m]: 200

Lawinenbreite [m]: 50

Anrisshöhe [cm]: 50

(Regional gültige) Gefahrenstufe: 3

Beteiligte: 2

Verletzte: 1

Number	Author	Quote	Source
1	Günter S.	Also am Anfang war das ja mehr so ein Witz. Ich habe halt mal befunden, probieren wir es. Wir laden, wie es ist das Lawinenbulletin herunter, kombinieren das mit einer einfach Reduktionsmethode und zeigen das an. Das war eine sehr schreckliche Version die Version eins. Dann hat dann so das eine das andere nach sich gezogen. Also, es gab einen ersten Kontakt mit dem SLF. Im Jahr 2017 konnte ich dann auch ein Jahr lang am SLF arbeiten die haben so Lawinen Gelände Klassifikation haben die Entwickelt.	Günter S. in an Interview with Frank A. at the Skitourensummit, 2020
2	Monique W.	Guten Tag Herr Nagel Die BFU, Beratungsstelle für Unfallverhütung, unterstützt den Skitouren guru seit den Anfängen, weil er den Skitourengeherinnen und -gehern erleichtert, eine Skitour mit tiefem Lawinenrisiko zu finden und zu wählen. Das Ziel der BFU ist es, die Tourengeher in möglichst risikoarmes Gelände zu lenken. Die BFU hatte ein eigenes Projekt, die BFU-Plaisirtouren: Skitourenvorschläge, die bis Gefahrenstufe 2 mit tiefen Risiko begangen werden können (ca. 20 Touren). Mit Skitouren guru hat man viel mehr Möglichkeiten, mehr Tourenbewertungen und dies abhängig von der aktuellen Lawinengefahrenstufe, also auch bei Stufe 3 oder 4. Wir möchten natürlich, dass die Skitüreler möglichst «grüne» Routen wählen oder sich bewusst sind, was die Wahl einer «orange» Tour für Risiken birgt. Man muss nicht die «grünste» Tour wählen, die es gibt, sonst macht man ja immer dieselben Touren ... und es ist klar, dass auch die Schneequalität etc. eine Rolle bei der Wahl spielen.	Monique W. in an email exchange with Lukas N.; 09.11.2020 14:14
3	Günter S.	Der Grund ist, dass ich die Tätigkeit von Skitouren guru dringend von der Privatperson Günter Schudlach trennen musste. Ein Projekt wie Skitouren guru führt zu einem komplexen Bündel von "Rechtsfragen", wie z.B. Haftung, geistige Rechte und Datenschutzfragen. Die Risiken dieser Fragen sind schwer abzuschätzen und mussten daher von mir und meiner Familie getrennt werden..	Günter S. in an interview with Lukas N. via Zoom, 10.11.2020
4	Günter S.	Wie manifestiert sich diese Verantwortung innerhalb der Web-Applikation? <ul style="list-style-type: none"> • Klare Kommunikation über Nutzen und Grenzen. Die Information ist hierarchisch organisiert. Oben einfache, klar verständliche Information, gegen unten nimmt die Komplexität und Exaktheit des Inhalts zu. • Langjährige, zu einem grossen Teil dokumentierte Diskussionen, wie die Resultate in der Web-App den Benutzern unterbreitet werden. Unterschiedliche Stakeholder sind in diesen Prozess involviert (z.B. BFU, Lawinenwarnungen, Grafikerin, Programmierer). • Es gibt durchaus einen Zielkonflikt zw. Verständlichkeit und Exaktheit. Skitouren guru muss auf der einen Seite einfach zu verstehen sein, aber andererseits der Komplexität von Lawinen gerecht werden. • Agile Entwicklung: Skitouren guru kann sehr schnell auf Probleme reagieren, die auftauchen. 	Günter S. in a written reply to Lukas N., 09.11.2020
5	Günter S.	in der Schweiz ist es möglich, professionelle, offizielle Kartografie zu verwenden, in den Ostalpen und in Italien ist dies nicht möglich. Das hängt mit Lizenzen zusammen, die mehrere tausend Euro pro Jahr kosten würden. Daher wird OpenTopoMap angezeigt, dies Karte ist zwar recht gut, aber auch nicht optimal, um Skitouren zu planen..	Günter S. in an Interview with Frank A. at the Skitourensummit, 2020
6	Günter S.	Was ich auch noch interessant fand, According to her doubt plays an essential role fort he ethical interaction. Also der Zweifel spielt eine wichtige Rolle und viele Leute fragen mich warum heißt das Ding Skitouren guru. Und im Grunde genommen ist es genau dieser Punkt, der Name Skitouren guru soll zweifel sähen. Glaubst du an Gurus?	Günter S. in an interview with Lukas N. via Zoom, 10.11.2020

7	Günter S.	Alle Algorithmen folgen dem «WhiteBox» Approach. D.h. wer wissen will, wie die RisikoIndikatoren entstehen, kann das bis ins Detail nachvollziehen. Diese Transparenz ist kein Geschenk, sie muss in anstrengender Arbeit von Akteuren erarbeitet werden, die an Verständnis interessiert sind. Transparenz ergibt sich immer erst aus dem Zusammenspiel von Sender und Empfänger. Transparenz ist also auch eine Verantwortung der Benutzer.	Günter S. in a written reply to Lukas N., 09.11.2020
8	Günter S.	Ich denke, es gibt manchmal einen Clinch zwischen Naturwissenschaftlern und Ingenieuren. Ich will es mal so ausdrücken: Der Naturwissenschaftler sucht nach der Wahrheit. Der Ingenieur ist eigentlich auf der Suche nach guten Entscheidungen. Oft verstehen sich Naturwissenschaftler und Ingenieure nicht besonders gut. Wir sind nicht auf der Suche nach der Wahrheit, wir wollen das Beste aus den verfügbaren Informationen machen. Wir hätten auch gerne die Wahrheit, aber auf dem Gebiet der Lawinen ist die Wahrheit einfach nicht verfügbar.	Günter S. in an interview with Lukas N. via Zoom, 10.11.2020
9	Jochen K.	Ja eben das Ampelsystem hat Tradition, hier in Norwegen verwendet man das auch für alle möglichen Wetterphänomene, es gibt verschiedene Warnstufen also immer rot gelb und grün, also das war wahrscheinlich schon. Die alternative mit Mehrfarben würde ein bisschen komisch aussehen. Und die Farben ganz wegzulassen. Man könnte natürlich die Grenzen für die Farben unterschiedlich wählen, aber das ist ja ein bisschen in der Community wird ja auch immer über den Verzicht geredet, wie viel muss man verzichten, wenn man sich an gewisse Heuristiken hält. Ich denke die Festsetzung zwischen grün und orange entspricht vielleicht einer ganz guten Balance zwischen Verzicht und Effizienz das Risiko zu senken.	Jochen K. in an interview with Lukas N. via Zoom, 10.12.2020
10	Günter S.	Skitouren guru liegt mit der Bewertung sehr nahe am Durchschnitt aller Teilnehmer der zwei durchgeführten Umfragen. Da Skitouren guru den Durchschnitt aber nicht exakt trifft, ist es notwendig eine Reserve einzubauen. Das heisst Skitouren guru ist mit Absicht leicht "defensiver" kalibriert, als der Durchschnitt aller Teilnehmer.	Günter S. in an interview with Lukas N. via Zoom, 10.11.2020
11	Günter S.	In einem juristischen Sinne seien Disclaimer immer dann bedeutungslos, wenn es um «Leib und Leben» geht. Die Verantwortung (Sorgfaltspflicht) gilt also in jedem Fall. Ein Disclaimer hat aber auch noch einen ganz anderen Zweck. Er ist eine Chance für den Benutzer sich mit dem Nutzen und den Grenzen des Tools auseinanderzusetzen. Der Benutzer wird sich wegen dem Disclaimer bewusst, dass er zumindest die Möglichkeit bekommen hat sich angemessen zu informieren. Ein Disclaimer weist also auf die Verantwortung der Benutzer, sich um Verständnis zu bemühen.	Günter S. in a written reply to Lukas N., 09.11.2020
12	Rita C.	<p>L: Das ist doch spannend das heißt für dich ist dann die Verantwortung eher so ein Formaler Aspekt des Bergführers?</p> <p>R: Primär ein moralischer Gegenüber den Gästen, die vertrauen sich mir an und das löst bei mir über diese rechtliche Verantwortung hinaus, wirklich darüber hinaus eine große, auch ein Druck, das ist eine schwere Last, empfinde ich das beim Führen. In diesen Bereichen, wo man nicht sicher sein kann ob das okay ist was man entscheidet oder nicht, das empfinde ich als sehr anspruchsvoll und das führt dazu das ich mit Gästen tendenziell eher zu vorsichtig bin, einfach weil ich finde das wiegt so schwer.</p> <p>L: Das ist spannend, weil eigentlich ist es ja nicht entscheidbar also wie wir ja schon gesagt haben wir können es nicht vorhersehen. Oder sagen wir mal so es muss entschieden werden, es gibt nichts was dir diese Entscheidung irgendwie abnehmen kann. Also du musst es und vielleicht wirkt es deswegen so schwer, weil es keine Checkliste gibt, die dir diese Entscheidung abnehmen kann.</p> <p>R: Ja, Eine gewisse Entlastung gibt die Einwilligung der Gäste in dieses Risiko, das man sie aufklärt und dass sie dann einwilligen. Das finde ich macht die Situation für mich persönlich tragbar. Das ich sage ich gehe mit Menschen in ein Gelände und es kann sein das sie da sterben, das kann sein.</p>	Rita C. in an interview with Lukas N. via Zoom, 02.12.2020

		<p>L: Ja wahnsinn. Vielleicht noch zum Abschluss würdest du zwischen moralischer und juristischer Verantwortung unterscheiden?</p> <p>R: Persönlich merke ich tue ich das. Ich glaube wie soll ich sagen das gefühlt die moralische Verantwortung weitergeht, als die rechtliche. Ich würde enorm drunter Leiden wenn ein gast von mir verunfallen würde, auch wenn ich freigesprochen würde. Weil man als Führer einfach diese Obhutrolle hat und weil man diesen Entscheid getroffen hat. Auch wenn er nach der Lawinenkunde richtig war. Noch schlimmer wäre natürlich, wenn man auch gravierende Fehler gemacht hätte. Das wäre wahrscheinlich eine Situation, die sehr schwer zu ertragen wäre. Aber grundsätzlich gefühlt, geht die moralische Verantwortung für mich weiter als die rechtliche, hin zu einem es darf nichts passieren, was eine, das beißt sich ja mit der Rolle und mit den Möglichkeiten. Das macht es anstrengend diese Tätigkeit zu haben.</p>	
13	Jochen K.	Ja ich habe eine Verantwortung mehr oder weniger im gleichen Bereich wie die Verantwortung, die man hat, wen man allgemein wissenschaftlich publiziert. Also ich bin im Endeffekt verschrieben, das korrekt zu dokumentieren, was wir machen, welche Annahmen wir treffen zu dokumentieren, und ich bin verpflichtet gut über diese Annahmen nachzudenken. Aber das bedeutet nicht das all diese Annahmen in Zukunft immer als richtig angesehen werden. Das geht ja gar nicht sonst können wir ja gar nichts machen.	Jochen K. in an interview with Lukas N. via Zoom, 10.12.2020
14	Günter S.	Skitouren guru hat sich als Projekt der Lawinenunfallprävention verschrieben. Die Lawinenunfallprävention wird durch einen Lenkungseffekt zu Routen mit "tiefem Lawinenrisiko" erreicht. Ein solcher Lenkungseffekt ist durchaus erwünscht. Skitouren guru ist also keine neutrale Technologie und will auch keine neutrale Technologie sein. Neutral im Sinne von «keine Einflussnahme». Andererseits ist es nicht das primäre Ziel von Skitouren guru die Skitouren gänger irgendwie zu lenken. Skitouren guru kann auf vielfältige Weise genutzt werden. Z.b. suche alle «rote» Routen, denn dort ist es vielleicht einsamer. Oder suche alle «rote Routen», denn dort hat es ev. den besseren Schnee.	Günter S. in a written reply to Lukas N., 09.11.2020
15	Günter S.	Wie jede Innovation bringt die Einführung von Skitouren guru (neben den Chancen) Risiken mit sich. Wir können natürlich genüsslich diese Risiken diskutieren. Genauso wichtig ist es aber auch zu diskutieren, welche Risiken die Zurückhaltung von solchen Tools mit sich bringt. Es trägt eben nicht nur der Handelnde eine Verantwortung, sondern auch der Nicht-Handelnde. Wer in der Lage ist einen Skitouren guru zu entwickeln muss sich schon die Frage gefallen lassen, weshalb er die Herausforderung nicht annimmt (z.B. SLF). Ja es gibt eine Verantwortung desjenigen ins Wasser zu springen der schwimmen kann.	Günter S. in a written reply to Lukas N., 09.11.2020
16	Monique W.	Für die Inhalte und Funktionsweise von Skitouren guru ist nur der Betreiber verantwortlich. Die BFU berät aber Skitouren guru bei den Texten (Disclaimer, Erklärungen) und kommuniziert selbst immer, dass Skitouren guru vor allem dazu dient, eine Tour mit tiefem Risiko für die nachfolgende Planung auszuwählen.	Monique W. in an email exchange with Lukas N.; 09.11.2020 14:14
17	Jochen K.	Das hört sich ein bisschen außerirdisch an, aber das war einfach der Thomas Bayes, vielleicht schon mal gehört, ein Pastor und Mathematiker. Und der hat gesagt Wahrscheinlichkeit ist eigentlich der Grad unseres Wissens. Das ist eine extrem interessante Definition. Das würde zum Beispiel bedeuten, das ich das so machen würde wie die Klassiker, ich würde das Kartenspiel haben und ich würde vielleicht annehmen, dass die Karten zufällig verteilt sind, aber ich will, es wäre durchaus möglich auch noch zu testen, ob die wirklich zufällig verteilt sind. Und dann aus der Kombination aus so einem Test und den Spielregeln irgendeine Wahrscheinlichkeiten ausrechnen. Und dann wäre eigentlich die ganze Wahrscheinlichkeit eine subjektive Größe also die Wahrscheinlichkeit ist ein Ausdruck meiner Unsicherheit. Und nicht mehr der Ausdruck von irgendeinem Experiment, und deshalb rückt praktisch das Attribut Wahrscheinlichkeit, rückt von dem Ding von der Sache zu der Person. Also	Jochen K. in an interview with Lukas N. via Zoom, 10.12.2020

		die Wahrscheinlichkeit ist immer mit dir verbunden. Und nicht mir der Sache.	
18	Andreas E.	Sehen Sie sich als Verantwortungsträger für die Funktionsweise von Skitouren guru? Wo beginnt und wo hört diese Verantwortung auf? Ja in dem Sinne, dass ich meinen Beitrag mit Herzblut und bestem Wissen und Gewissen leiste und die Arbeit inklusive Chancen und Grenzen deklariere. Es ist dabei auch deklariert, dass computergenerierte Resultate nie perfekt sein können. Die Verantwortung hört beim Punkt auf, wie die Nutzer dann mit den Informationen individuell umgehen.	Andreas E. in a written reply to Lukas N., 04.11.2020
19	Rosa G.	Wie sieht Ihr Beitrag an dem Projekt Skitouren guru aus? Meine Arbeit war inhaltlich-visuell. Wie helfen inhaltliche sowie strukturierende Inputs eine bessere Übersichtlichkeit zu schaffen, damit sich der/die User*in besser und schneller zurecht findet. Dabei helfen natürlich wie immer in der Gestaltung auch farblich-typografische-vereinheitlichende Inputs weiter. Mit der Erstellung von Icons habe ich ebenfalls versucht ein einheitlicheres Bild zu erschaffen, damit man sich schneller orientieren kann. Wenn noch ein kleines Stück Schönheit und Humor/Leichtigkeit dazu gekommen ist, freut mich das. Inwiefern ist ihr Beitrag von Verantwortung geprägt? Ich sehe meine Arbeit stets von Verantwortung geprägt. Ich liefere gute und termingerechte Arbeit ab, um die Welt ein kleines bisschen übersichtlicher, strukturierter, schöner und damit besser zu machen.	Rosa G. in a written reply to Lukas N., 05.01.2020

Appendix 5: Quotations in original language of non-published documents

Terms of use

Skitouren guru supports you in planning a suitable ski tour with low avalanche risk. For this purpose, Skitouren guru assigns daily an avalanche risk to thousands of ski tours in the alpine region: Green (low risk), orange (elevated risk) or red (high risk). The evaluation is automatized and based on the current avalanche forecast and the terrain.

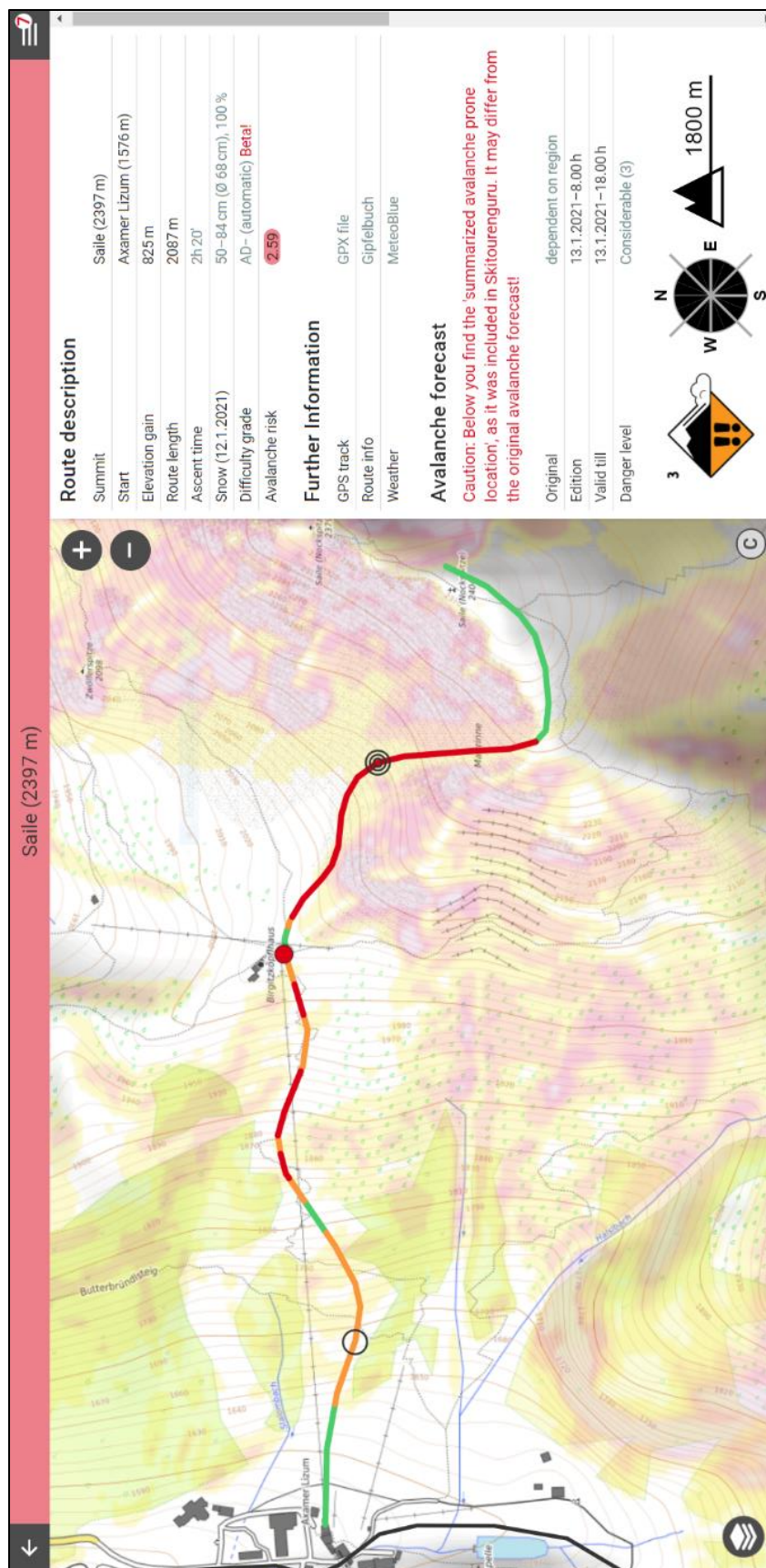
The information presented on Skitouren guru is subject to uncertainties (see **Handbook**). Therefore Skitouren guru must not be the only criterion to access a slope. Skitouren guru GmbH does not guarantee the correctness of the information.

Any liability for accidents and damages in connection with the use of Skitouren guru is excluded. The planning and execution of your winter sports activities is at your own risk and under your sole responsibility.

Skitouren guru uses cookies to improve the service.

Do you agree with this exclusion of liability and the use of cookies?

YES NO



Appendix 7: Skitourenguru Route Display of Saile from the 13th of January 2021

Gefahrenstufe für **Montag, 4.1.2021**

Gefahrenstufe 2 – mäßig



Waldgrenze

Tendenz: Lawinengefahr bleibt gleich →

am Dienstag, 5.1.2021



Waldgrenze



2200m

Triebschnee beachten.

Die frischen und schon etwas älteren Trieb Schneeansammlungen können besonders an steilen Schattenhängen oberhalb der Waldgrenze teilweise von einzelnen Wintersportlern ausgelöst werden, Vorsicht vor allem in Kammlagen, Rinnen und Mulden. Die Lawinen sind meist mittelgroß. Anzahl und Größe der Gefahrenstellen nehmen mit der Höhe zu.

Schwachschichten im unteren Teil der Schneedecke können stellenweise von einzelnen Wintersportlern ausgelöst werden. Vorsicht vor allem an sehr steilen Schattenhängen oberhalb von rund 2200 m, besonders an eher schneearmen Stellen sowie an Übergängen von wenig zu viel Schnee wie z.B. bei der Einfahrt in Rinnen und Mulden.

Schneedecke

Gefahrenmuster

gm.6: lockerer schnee und wind

gm.1: bodennahe schwachschicht

Es fiel lokal etwas Schnee, vor allem im Süden. Der obere Teil der Schneedecke ist hart. Härtere Schneeschichten liegen stellenweise auf weichen Schichten. Die Trieb Schneeansammlungen liegen in mittleren und hohen Lagen teilweise auf Oberflächenreif. Schneeprofile bestätigen diese Situation.

Steile Schattenhänge: Die Altschneedecke ist stellenweise störanfällig. Der untere Teil der Schneedecke ist aufbauend umgewandelt.

Tendenz

Frischen und älteren Trieb Schnee beachten.

Gefahrenstufe für **Donnerstag, 7.1.2021**

Gefahrenstufe 2 – mäßig

● Rechteckiges Ausschneiden



Tendenz: Lawinengefahr bleibt gleich →
am Freitag, 8.1.2021



Einzelne Gefahrenstellen für trockene Lawinen liegen an sehr steilen Schattenhängen oberhalb von rund 2200 m.

Schwachschichten im unteren Teil der Schneedecke können besonders mit großer Zusatzbelastung ausgelöst werden. Dies vor allem an sehr steilen Schattenhängen oberhalb von rund 2200 m sowie an Übergängen von wenig zu viel Schnee wie z.B. bei der Einfahrt in Rinnen und Mulden. Die Lawinen sind teilweise mittelgroß.

Schneedecke

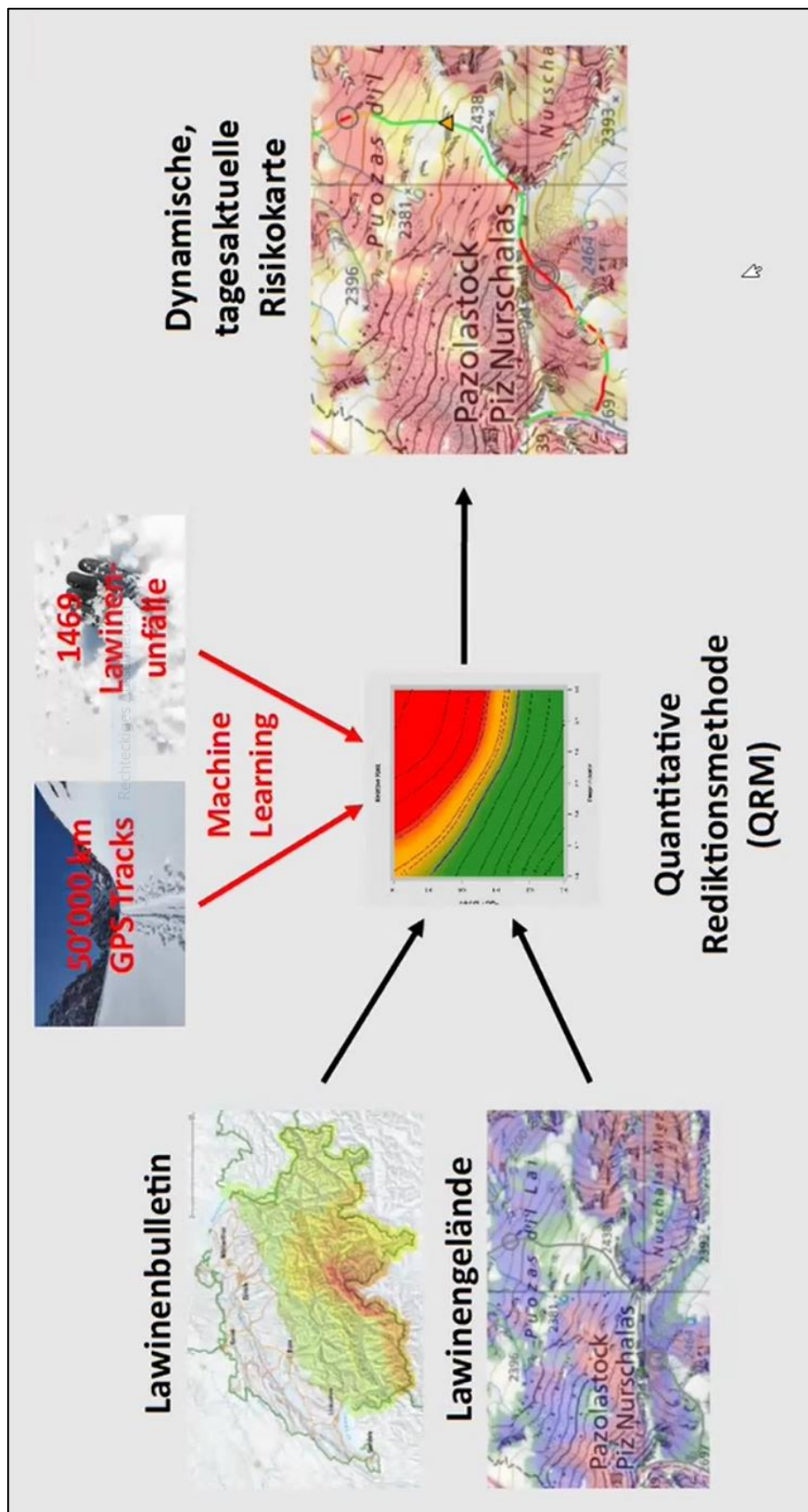
Gefahrenmuster gm.1: bodennahe schwachschicht

Steile Schattenhänge oberhalb von rund 2200 m: Die Altschneedecke ist stellenweise störanfällig. Im unteren Teil der Schneedecke sind kantig aufgebaute Schwachschichten vorhanden. Ältere Triebsschneeanisammlungen liegen teilweise auf Oberflächenreif.

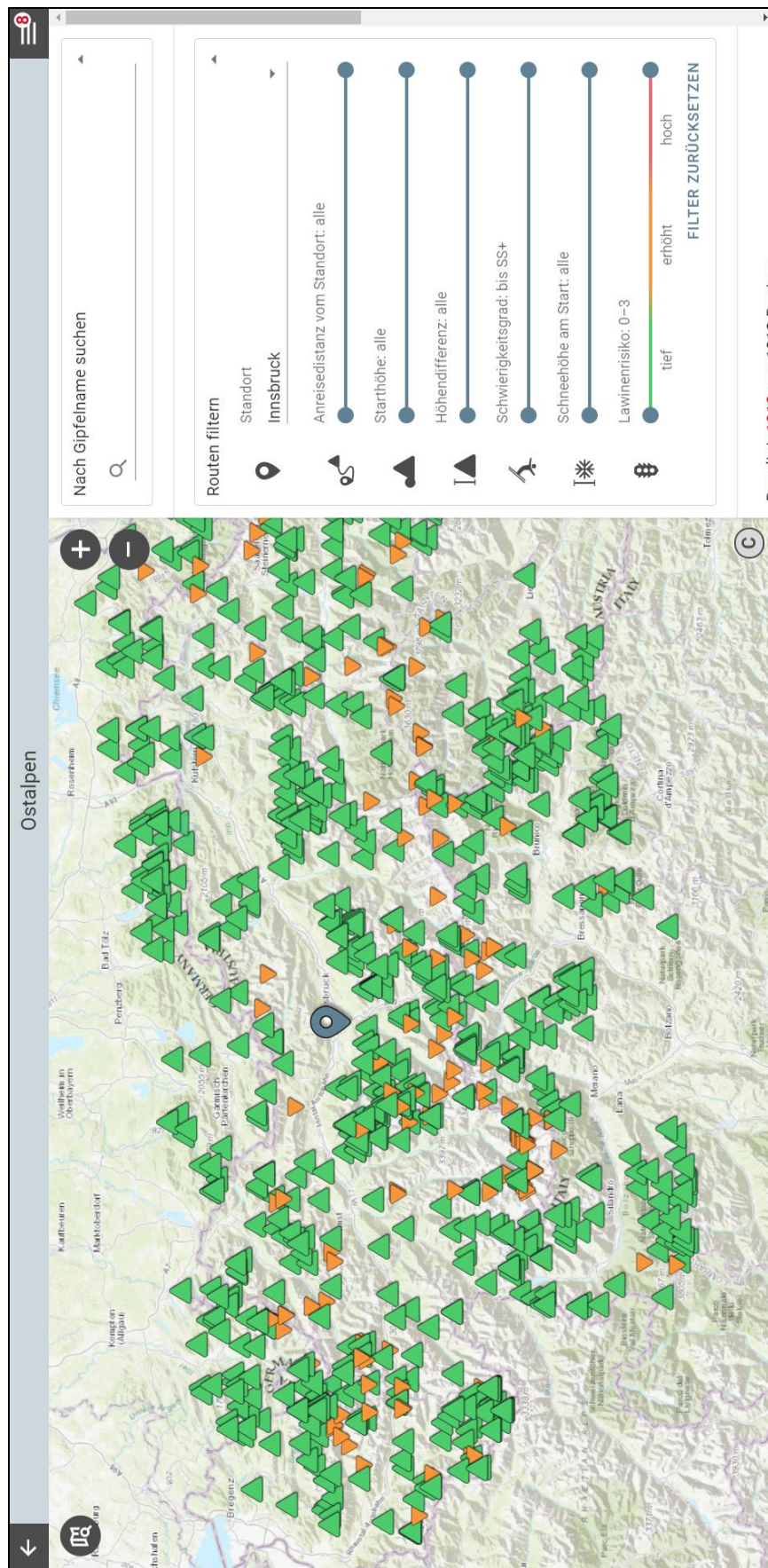
Es fiel etwas Schnee.

Tendenz

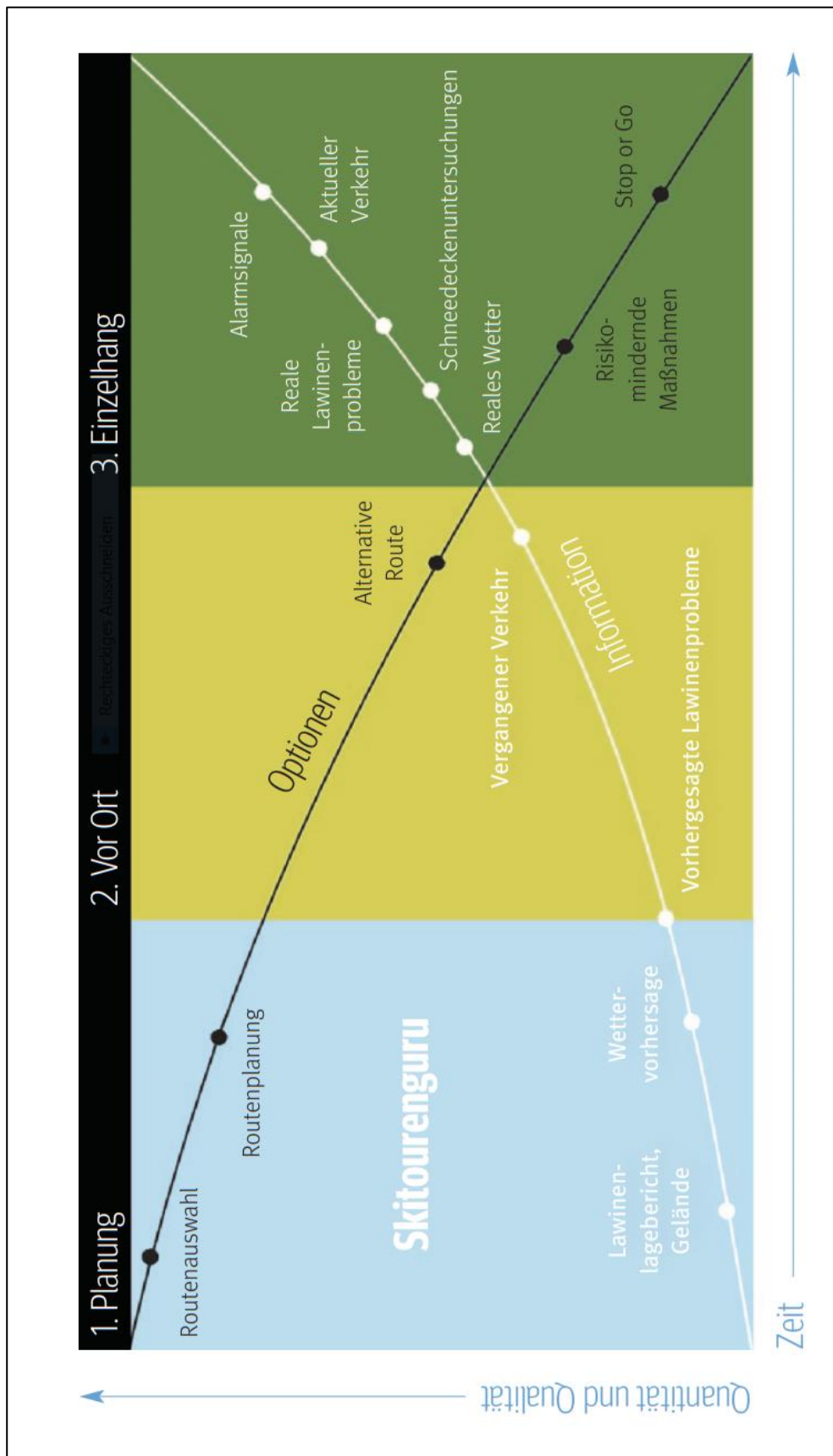
Die Lawinengefahr bleibt bestehen.



Appendix 10: Quantitative Reduktionmethode Partial Screenshot from <https://vimeo.com/showcase/7761681/video/475917002> at the 04.03.2021 15:00



Appendix 11: Interface of Skitouren.guru. Screenshot from <https://skitouren.guru.ch/area-view?area=au> at the 04.03.2021 15:00



Appendix 12: Phases of a skitour. Screenshot from [https://info.skitouren.ch/download/articles/92-100\(quo%20vadis%20lawinenkunde\)%20richtig.pdf](https://info.skitouren.ch/download/articles/92-100(quo%20vadis%20lawinenkunde)%20richtig.pdf), 14th of March 2021 16:00

Statutory Declaration

Ich erkläre hiermit an Eides statt durch meine eigenhändige Unterschrift, dass ich die vorliegende Arbeit selbstständig verfasst und keine anderen als die angegebenen Quelle und Hilfsmittel verwendet habe. Alle Stellen, die wörtlich oder inhaltlich den angegebenen Quellen entnommen wurden, sind als solche kenntlich gemacht.

Die vorliegende Arbeit wurde bisher in gleicher oder ähnlicher Form noch nicht als Magister-/Master-/Diplomarbeit/Dissertation eingereicht.

Datum

Unterschrift