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Perception and use of uncertainty in severe weather warnings by emergency services in Germany

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ABSTRACT

In the course of the WEXICOM project at the Hans-Ertel-Centre for Weather Research of the Deutscher Wetterdienst (DWD), a survey was conducted in autumn 2012 to question how weather warnings are communicated to professional end-users in the emergency community and how the warnings are converted into mitigation measures.

161 members of emergency services (e.g. fire fighters, police officers and civil servants) across Germany answered an online questionnaire. Questions included user's confidence in forecasts, their understanding of probabilistic information and their perception and use of uncertainty in forecasts and warnings. A large number of open questions were selected to identify new topics of interest, unknown problems, and research gaps in the field of communicating weather information in Germany.

Results show that the emergency service personnel who participated in this survey generally have a good appreciation of the uncertainty of weather forecasts. Although no single probability threshold could be identified for organisations to start with preparatory mitigation measures, it became clear that emergency services tend to avoid forecast based on low probabilities as basis for their decisions.

This paper suggests that when trying to enhance weather communication by reducing the uncertainty in forecasts, the focus should not only be on improving computer models and observation tools, but also on the communication aspect, as uncertainty also arises from linguistic origins. Here, improvements are also possible and thus uncertainty might be reducible.

1. Introduction

Severe weather warnings are, as weather forecasts in general, uncertain (NRC, 2006). Uncertainties in weather warnings arise from the chaotic character of the atmosphere, incomplete knowledge and inaccuracy in weather observations and computer models (NRC, 2006; Steinhorst, 2009).

Although widely used, the term uncertainty is generally not well defined and meanings differ between scientific disciplines and authors. Especially in interdisciplinary research, as social scientists and natural scientists often have a different understanding of the calculability of uncertainty: while social scientists argue that uncertainty is always connected to an unknown lack of knowledge, natural scientists tend to see uncertainty as probabilistic and assessable (Banse, 1996; Weichert, 2007).

Altogether, uncertainty is an often misunderstood and therefore confusing expression for forecast users, and communicating uncertain weather warnings is a difficult task even to experienced users such as emergency service personnel.

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A first step to define uncertainty is to distinguish between these perspectives by differentiating knowledge and randomness. With respect to the latter, uncertainty arises from the stochastic variability in known and observable phenomena (and is called aleatory uncertainty) (NRC, 2006; Pate-Cornell, 1996). In this way, uncertainty can be understood by the aspect of probability of occurrence and would thus be seen as generally quantifiable (Weichert, 2007).

Secondly, uncertainty arises from the lack of knowledge or incomplete observations (and is called epistemic uncertainty). As the entirety cannot be completely known, it is generally not quantifiable (Pate-Cornell, 1996: 96–97). Since some rare events happen unexpectedly, e.g. because there is no observed record of events, incalculable epistemic uncertainty is always part of aleatory uncertainty. This missing knowledge leads to uncertainty about the uncertainty or "*second-order uncertainty*" (NRC, 2006) and is called ambiguity (Ellsberg, 1961) or vagueness (Colyvan, 2008).

Ensemble-Prediction-Systems (EPS) are one way to make estimates about the (aleatory) uncertainty of a weather forecast. However, while a weather forecast can be enhanced by quantifying this uncertainty, the ambiguity associated with the interpretation and communication of the forecast remains (Handmer and Proudley, 2007).

So far the topic of perception and use of uncertainty in weather information has mainly been addressed in the US and UK, maybe due to a wider use of probabilistic information in weather forecasts in these countries (Gigerenzer et al., 2005).

Some of the early studies (e.g. Murphy et al., 1980; Sink, 1995) came to the conclusion that more emphasis should be put into meteorological education to enhance people's knowledge about numerical weather prediction. Other studies (e.g. Gigerenzer et al., 2005) demand more emphasis on improving the communication of statistics. However, some more recent studies (e.g. Frick and Hegg, 2011; Morss et al., 2008) concluded that understanding meteorological definitions correctly is not of preferential importance, as ultimately users have to infer the information to their subjective preferences and make their individual assessment of the situation.

The general perception of probabilities and uncertainties by the public has been addressed in several studies (e.g. Kahneman and Tversky, 1979). Most studies in the context of communication of weather forecasts and warnings are conducted with laypersons (ABM, 2009; CFI, 2005; Joslyn and Savelli, 2010; Morss et al., 2008; Sink, 1995) or based on psychological experiments amongst university students (e.g. Joslyn and Nichols, 2009). Little is known, however, about how emergency service personnel perceive this information and make use of it (Frick and Hegg, 2011; Handmer and Proudley, 2007; Steinhorst, 2009). The question how to communicate weather warnings, especially to emergency services, has to be addressed separately from the communication to the general public, because this user group differs from other groups and the general public regarding its needs and requirements (Demeritt et al., 2007; Visschers et al., 2009). Only a few studies address emergency management experts (e.g. Demeritt, 2012; Punkka and Rauhala, 2011; Frick and Hegg, 2011) or show a sampling mixture of both laypersons and experts (e.g. Handmer and Proudley, 2007). While surveys with laypersons usually have big samples consisting of several hundred (e.g. Sink, 1995) or thousand (e.g. CFI, 2005) participants, expert surveys usually have smaller samples consisting of several dozen (e.g. Frick and Hegg, 2011) or a few hundred (e.g. Demeritt, 2012; Punkka and Rauhala, 2011) persons.

Based on these studies, research gaps include the topics of understanding, interpretation and use of weather warnings (e.g. Morss et al., 2008). Visschers et al. (2009) point out that only little research has focused on user specific tailored information, while Morss et al. (2008) criticise that most study designs have experimental character and miss out real-world settings. Whereas almost all studies come from the US, with some exception of Switzerland, Scandinavia and the UK, no scientific study addressing emergency services has been conducted in Germany so far.

This paper starts with a methodological overview, presenting the survey procedure and the questionnaire design. Then survey results regarding the communication of weather forecasts and warnings will be discussed. A special focus is on the perception of uncertainty and the use of probabilistic information by emergency services in Germany.

2. Methods

An explorative approach was chosen to gain new knowledge about perception and use of uncertainty amongst the emergency management community in Germany. Thus, an online survey was conducted between September and October 2012. An online approach was chosen to enable the participation of a broad range of experts within Germany in short time. In this study experts are defined as professional users of weather information in emergency services, civil protection or affiliated fields.

In preparation of the survey qualitative expert interviews took place mainly with representatives from Deutscher Wetterdienst (DWD) and Fire Brigades in order to identify the key questions and to identify potential experts.

2.1. Sample and survey procedure

Since most experts could be identified within administrative agencies, a snowball sampling technique was used to recruit participants starting with existing administrative contacts of DWD: Users of the FeWIS tool – a DWD weather warning tool especially designed for emergency services – and other professional warning users of DWD were provided with a link to the online questionnaire via email and were asked to forward it to their colleagues. The survey took place between September 17th and October 12th 2012 and all contributions were kept anonymous.

In total 161 experts completed the questionnaire. 89 participants were fire fighters, with 40 of them being professional fire fighters, 13 voluntary fire fighters, 5 plant fire fighters and 30 working in an emergency service command centre.

6 participants represented various federal agencies, 9 participants represented a state agency (Environmental Ministries and Interior Ministries), and 34 participants represented a communal or regional agency (District Government, City Council or likewise). The remaining 23 were either policemen, paramedics, or other emergency managers from e.g. transport or relief organisations.

The high number of participants from fire departments and communal administrative well reflect the German emergency management system which is mainly organised on that level.

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