ESSL Expert Workshop on Severe Weather Warnings: from Expectations via Physical Ingredients to Impact-based Warnings and Beyond

16 – 18 October 2023

ESSL Research and Training Centre Wiener Neustadt, Austria

Workshop Summary

ESSL Report 2024-01

published on ESSL webpage www.essl.org on 22 January 2024

DOI: 10.13140/RG.2.2.25944.06402

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The report authors are thankful to all workshop participants (see list) for their contributions and for the high involvement during the discussions.

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Executive summary

From 16 – 18 October 2023, the European Severe Storms Laboratory (ESSL) organized a workshop on weather warnings, bringing together 20 experts from various backgrounds, including weather forecasters, meteorology researchers, geo risk experts, a judge, and a philosopher. The primary challenges discussed related to the need for accurate, timely, and well-understood weather warnings.

Operational weather services consider the impacts of the adverse weather when issuing warnings, but this complexity can sometimes delay the warning process. In extreme events, a rudimentary impacts consideration based on default assumptions may be necessary to ensure timeliness. A presented study highlighted that while economic impacts are correlated with population density, human impacts are not, with most fatal severe weather-related events occurring in low-populated rural areas, possibly due to higher vulnerability, which has repercussions for warning decision making.

Besides such considerations, the workshop identified several hurdles in the warning process, including the need for approval from higher management in some countries and time-consuming consultations with stakeholders in others, the necessity of which should be considered, especially for the most time-critical warnings.

A key conclusion was that different warning types are required for various timescales, where particularly rapid ones using cell-broadcast push-messages or public sirens may be considered for the most severe and fast developing hazards.

Regarding understanding, probabilistic information can lead to confusion, especially between area-related and pointwise probabilities. It was suggested that social science play an important role in improving warning communication clarity, emphasizing the use of well-understood language rather than technical terms or jargon.

The workshop proposed creating a document describing various warning types and their names to enhance international discussions. The question of whether the most impactful events should be warned at lower probability thresholds requires further discussion.

Workshop program

Monday, 16 October 2023	
13:30 – 13:45	Alois M. Holzer, ESSL Welcome and introduction round
13:45 – 14:00 14:00 – 14:10 discussion	Tanja Renko, DHMZ DHMZ is the only organization responsible for issuing official weather warnings in Croatia. To fulfill its task of informing the public, DHMZ must communicate and cooperate with all services and partners responsible for the security of Croatia's citizens. This presentation intends to provide an overview of the DHMZ Weather Warning System, from the Standard Operating Procedures, development of the system that has been extensively upgraded in the last few years. Also, this summer, a new project started at the level of the Republic of Croatia - system for early warning and crisis management (SRUUK) with which, for the first time in Croatia, citizens will be quickly and efficiently informed about threats by messages via mobile phones.
14:10 – 14:30 14:30 – 14:40 discussion	Stefan Kienberger, GeoSphere Austria Impact-based forecasts and warnings are currently at the centre of attention of Met Services globally. The aim is to improve the uptake of warnings by individuals as well as to support informed decisions of specialised users, such as civil protection agencies. GeoSphere Austria has implemented and is currently developing a number of services, which include impact-based forecasts and warning for the public as well as for dedicated users in a co-design process. This presentation will provide an overview of current developments and will reflect on opportunities and challenges.
14:40 – 14:55 14:55 – 15:10	Alois M. Holzer, ESSL: Where do people die in severe weather? A comparison with population density. Some concepts of impact-based forecasting strongly rely on the population density as a determining factor. The talk will present ESWD fatalities data stratified to different categories of population density.

15:10 – 15:45	Coffee break
15:45 – 16:00 16:00 – 16:30 16:30 – 17:00	Tomas Pucik, ESSL: Introduction of warm-up case In breakout groups: Analysis of the case with emphasis on different lead times and correlated possibilities or requirements for warning philosophy, content, format and means. What is present, what is missing for an integral warning process? Where is the most pressing need for improvement?
Tuesday, 17 October 2023	
09:00 – 10:00 (including discussion)	Rahim Taghizadegan, economist and philosopher, Vienna, Austria: Warnings from a historical, societal, economic, ethical and philosophical perspective. This exploration navigates the history and ethical quandaries of warnings, tracing their evolution from religious admonitions to modern risk-based alerts. Central to the discussion are the profound ethical responsibilities inherent in issuing warnings, particularly in the context of catastrophic risks. The complexities heighten when dealing with risks in societies where trust has been eroded. A deep analysis of these circumstances offers critical insights and a nuanced understanding of how to ensure warnings are both effective and ethically sound in a world increasingly laden with uncertainties.
10:00 – 10:45	Coffee break
10:45 – 12:30	Joint work on a recent case study (meteorological data provided in ESSL Testbed Displayer), discussion of all aspects of the integral warning process.
12:30 – 14:00	Lunch break
14:00 – 14:10	Leonie Villiger, ETHZ, Switzerland A prototype of a hail impact assessment platform for multiple sectors in Switzerland The platform provides both post-event assessment and forecasts of hail impacts. To assess hail damages from the previous day, the models rely on daily radar-based estimates of

14:10 – 14:20 discussion	the maximum expected severe hail size (MESHS) or crowd-sourced hail reports gathered through a mobile application. To forecast hail damages in the upcoming day, the models utilize the output generated by the HAILCAST hail growth model, which is integrated into the numerical weather forecasting model COSMO. In the next version of the prototype, we plan to implement an impact-based warning functionality. Through this ongoing collaboration, we aim to create a comprehensive platform that addresses the various needs of stakeholders and enables them to make informed decisions when facing hail risks.
14:20 – 15:00 15:00 – 15:30 discussion	Michaela Valachová and Martin Adamovsky, CHMI, Czechia The warning concept at CHMI.
15:30 – 16:00	Coffee break
16:00 – 16:30 16:30 – 17:00 discussion	Dalia Tanczos, judge, Austria: Basic principles of liability – an international review and real examples
17:00	End of Tuesday program
Wednesday, 18 October 2023	
09:00 – 09:20 09:20 – 09:30 discussion	Kathrin Feige, Benedikt März, Renate Hagedorn, DWD: Timely, comprehensible and individualizable: Towards a new warning system at the German Meteorological Service With the overarching goal to tailor weather warnings more strongly towards the needs of end-users, the German Meteorological Service (DWD) is renewing their warning system in a program called RainBoW ("**R**isk-based, **a**pplication-oriented and **in**dividualiza**b**le delivery of **o**ptimized **w**eather warnings"). The main fields of action within this program include increasing the temporal horizon of weather warnings up to seven days, improving their comprehensibility, and providing individualizable warnings for users with specific requirements. This talk will elaborate on RainBoW's concepts and present some preliminary results, touching upon various workshop topics along the way.
09:30 – 09:50	Benedikt März, Stefan Bach, Sebastian Altnau, Kathrin Feige (DWD): Tailoring and harmonising DWD's severe weather warnings for public, aviation and the maritime sector towards a future-approved warning system

09:50 – 10:00 discussion	Within the German Meteorological Service (DWD) program RainBoW ("Risk-based, application-oriented and individualizable delivery of optimized weather warnings"), the standardised warnings for public, aviation and the maritime sector are subjected to a renewal process. Aligned with broader strategic goals within DWD's weather forecasting department, one of the main aims of this process is to harmonise between these three fields of meteorology to make the warning management more effective and to generate consistent and coordinated warnings. Simultaneously, the warnings should be tailored to the user's needs and meteorological risks has to be more comparable between each of the warning elements. This talk will give a glimpse about concepts and challenges in developing new tailored warning threshold and a harmonised warning generation process.
10:00 – 12:30 Including flexible coffee break	Joint analysis of recent case, breakout groups possible.
14:00 – 16:00	Discussion and wrapup of the workshop. Joint effort on writing down the most important findings of the workshop in the form of a draft summary.

Participants

Barbara Turato, ARPA Liguria, Italy
Mateusz Barczyk, IMGW, Poland
Tanja Renko, DHMZ, Croatia
Kathrin Feige, DWD, Germany
Benedikt März, DWD, Germany
Alexander Radlherr, GeoSphere, Austria
Jordi Toda Savall, Servei Meteorològic de Catalunya, Spain
Leonie Villiger, ETH Zürich, Switzerland
Michaela Valachova, CHMI, Czechia
Martin Adamovsky, CHMI, Czechia
Stefan Kienberger, GeoSphere, Austria
Raphael Spiekermann, GeoSphere, Austria
Pieter Groenemeijer, ESSL, Netherlands
Thilo Kühne, ESSL, Germany
Tomáš Púčik, ESSL, Slovakia
Alois M. Holzer, ESSL, Austria

Invited speakers

Dalia Tanczos, judge at District Court of Weiz, Austria
Rahim Taghizadegan, philosopher at scholarium in Vienna, Austria

Concept of the workshop

The organizers of the workshop intended to create an open working atmosphere supportive for fresh ideas and solutions. The workshop was organized as an in-person on-site-only event. Different formats were offered:

Classic talks by participants provided basic content and presented the state-of-the-art in different countries.

Invited talks from a judge and from a philosopher widened the horizon and laid down the history of ideas with respect to warnings as well as legal aspects, especially regarding liability of those who issue warnings.

Several workshop slots were reserved for group analysis of **selected recent cases**. These case discussions offered room to include operational aspects and practical issues and were held in **breakout groups** of about 5 persons each.

Finally, sufficient time was spent on **plenary discussions**. Discussion slots were vital to collect the inputs from the breakout groups and to develop a common idea of the main challenges. Also, valuable feedback was provided to the presenters of the classical talks.

Focus of the report

Written records of the key discussions points and individual take-home messages were provided to the participants after the workshop. All collected presentations were offered to the participants via a cloud storage service.

This summary report is intended to provide an overview of the main lines of discussion and identified challenges. For details on the single presentations that go beyond the basic information provided in the programme, we refer the reader to the single authors.

The purpose of this summary is mainly to draw the attention to critical issues and unresolved questions, only to a lesser extent to provide definite answers.

Main lines of discussion

The following topics were most discussed during the workshop:

1) The role and optimal deployment of the (meteorological) forecaster in the context of impact-related warnings.

Examples of setups were discussed that expect from the meteorologist to not only be an expert in weather forecasting but also active in the identification of possible or probable impacts. As a result, a share of the working time of the met forecaster is spent on impact forecast assessment. While the output quantity is expected to remain unchanged, time for the sound meteorological assessment is shortened. Other examples described a team setup where meteorologists, impact experts and representatives of the civil protection services work together and jointly develop the final impact-related warning. Further examples showed a step-after-step setup where the warning that is produced by a meteorologist undergoes a formal acceptance process of senior officials or civil-protection agencies.

2) Identified critical issues for a successful and timely warning procedure - removal of delaying hurdles for events with imminent threat

For the cases of forecast events with a very short lead time, procedures need to be in place that eliminate all retarding steps. Most often, this relates to convective events with timespans of typically less or even much less than one hour between identification of the meteorological hazard and impact. For this reason, every minute counts in the case of convective events. In the case of tornado warnings, any warning attempt that requires more time than very few minutes between identification of the hazard and receipt of the warning by the endangered people, will most likely be useless. Similarly, this holds for flashfloods in small catchment areas.

The reason of delaying hurdles can be, for example, of formal nature (e.g. requirement for green light from superiors not present in the situation room), of organizational nature (sequential instead of parallel assessment processes: first, the met warning is defined, second, impact experts start their assessment, third, superiors or even external instances need to unlock the warning, followed by the technical process of issuing the warning), or of technical nature (production system not able to process a one-click-for-GO warning, instead copy-and-paste actions or even emails or phone calls are needed).

3) Less time pressure for warnings with better lead-times: more room for impact assessment

For events with longer lead-times (or more concretely: timespans of at least several hours between identification of a meteorological hazard and impacts), procedures could be shaped differently. Small delays (on the order of minutes or maybe up to one hour) are less critical in such situations. Team solutions to include impacts-related know-how instead of pre-defined default texts should be given plenty of room in such situations.

4) Time of the day- a logistics factor

Based on a concrete case, it was found that the time of a day of both hazard identification and impacts can be of importance. The worst-case scenario is identification of the hazard in the middle of the night (when most people do sleep) and (expected or real) impacts starting in the early morning hours and into the morning rush-hours (when many people are commuting or outdoors for other reason). In addition, procedures that require more than the decision of the warning meteorologist or the closely collaborating and co-located warning team on shift will result in even longer delays than during daytime or regular office hours (it might be difficult to reach superiors or external decision-makers, it might need long time for them to be briefed and understand the situation).

5) Time of the day- a human response factor

The time of the day should also be considered for the choice of warning means and lead-time when it comes to push-messages via cell-broadcast. People will have more and better options to respond to cell-broadcast warnings received before 8 pm in comparison to such received at 1 am. Warners should have some flexibility to issue foreseeable warnings a few hours earlier than foreseen by general rules to avoid unnecessary and hard-to-respond nighttime alarms. In no way this should limit the use of nighttime push messages via cell-broadcast in the case of unexpected or very short-term events of high magnitude, as such warning and alarm capability is one of the main advantages of cell-broadcast push-messages.

6) When to use cell-broadcast push-messages and public sirens?

The pointwise (user-centric) frequency of receiving such a warning needs to be in balance with the user-centric experience of hazardous events in its vicinity. Push-messages and sirens as a means of warning should be used for unusual and/or highly impactful events, i.e. a threat to health or even life that clearly exceeds acceptable threat-levels under the assumption of a behaviour that is adapted to regional climatology and experience.

Cell broadcast can be either …

… a call for risk-reducing preparatory measures or evacuations in the case of a high-probability and high-magnitude event that is expected on a timescale of 1 to 3 days ahead of expected impact time. An example would be hurricane warnings based on the predicted hurricane track and intensity. For many other events, the required high probability is hard to reach.

… or, most commonly, a call for very soon or even immediate response action in the case of high-intensity (impacts) and high-probability (confidence) events on a timescale of minutes to about 12 hours (less than a day) ahead.

7) Clear communication in understandable language

Plain language, avoiding bureaucratic or technical terminology, should be used to communicate with the general public. It was discussed whether standard texts for impact descriptions should be used.

8) Default impact information

As a default, standard impact text should be used to speed up and simplify the production process. Whenever more specific impact information is available, this should be included and communicated. This can be done in a second step (i.e. an update) in order not to delay the issuance of the first warning.

9) Probabilistic information

Modern model output more and more offers probabilistic information to the forecaster and warner. A professional and user-centric communication strategy will seek to incorporate such information into the warning information. It is critical to use easy-to-understand numbers and wording when directed to the general public. To some extent, this is also a process of lay persons getting used to probabilistic information. An accompanying education concept can help to improve this process.

The ideal communication style is a trade-off between the fact that warning information is never sure and often far away from 100 % local probability of occurrence (point-wise, user-centric) and the need to keep the warning text as short and simple as possible. Automated, accompanying, graphics-based and frequently updated probabilistic warning-content can help to mitigate this problem, as it was shown in some examples.

Social science studies are needed to find out whether descriptive wording or numbers-based wording of probabilities is better understood by the general public.

10) Point-wise probabilities?

While some meteorological agencies and experts prefer to communicate the probability of events for areas, i.e. a probability that the event will take place somewhere in a defined area, the reference frame for potentially affected persons is their point-wise probability, i.e. the probability of personally being hit by certain conditions or impacts. As an example, a nearly 100 % probability for a severe thunderstorm to materialize somewhere in a forecast area (based on nowcasting techniques) might translate into a 10 % probability for a given person to be hit in a given place. In case of a certain threshold to be passed (for example gusts of 32 m/s), the point-wise probability might even drop to something like 1 %.

As a bottom line, communication of area-related probabilities, to the general public or other users, will often lead to misinterpretation or wrong expectations regarding the local occurrence, which is very understandable from the user-perspective. Clear explanation will be required. For some users, like civil protection authorities, an area-related probability might be of value but needs to be labelled.

11) Accept lower warning probability for the deadliest events?

A somewhat related question is difficult to answer. How to deal with very extreme events with high potential danger to life that, typically even in the nowcasting time-range, can only be forecast with a very low point-wise probability? Should the required probability threshold for such events (emblematic example: tornado) be lower than for less intense phenomena? Because if it hits, the consequences are that bad? I.e. allow for a worse FAR in favour of a better POD? In practice, this is done outside of Europe in the USA, especially for tornado warnings.

12) Distinguishing types or modes of warnings, confusing terminology

Workshop discussion has shown that Europe is lacking a commonly accepted and well-defined warning terminology in English language. This makes it difficult to compare concepts in a multi-national discussion. On a national basis and for the national languages, warning terminology is based on the legal framework or on historically grown national terms. Some reported examples even showed wording inconsistencies between different institutions on the national level.

When asked about warning terms, the workshop participants named the following vocabulary in the context of warnings (unranked):

warning trend
alert
alarm
warning
early warning
watch
outlook
advisory
pre-warning

The workshop participants consider it important to make progress towards a common English language terminology (other languages can refer to). This should be further discussed and taken up again at a follow-up workshop.

<u>Ideally, a number of criteria and aspects should be reflected by the warning terms:</u>

- Most intuitive wording with relation to threat level (possible magnitude of event and expected impacts).
- Indication of imminence in terms of lead time (urgency).
- Link to probability (or confidence). There can be significant jumps in the probability in the course of the forecasting process. How to reflect this in the communication?
  In addition:
  What about events with very low point-wise probability and very high potential impact, given that the actual probability is much higher than the climatological one?
  Examples:
  1) A single (for a forecaster often "random") local flashflood in a small catchment area in a typical situation with a lot of convective events (high coverage of non-severe events) in a low-shear environment ("hopeless warning distinction").
  2) Compared to background climatology: high likelihood of a significant tornado somewhere in a large area but still very low point-wise probability (before the first confirmation is received).
- Link to the different required response stages of
  1) timely preparation (including re-planning of activities and stock-up on supplies, energy and healthcare),

2) timely sheltering or evacuation action,
3) last-minute sheltering or escape action.

- Distinction of insidious events on long timescales:
  Long heatwaves with impacts increasing by duration (buildings heat up more and more while the measured outdoor temperatures may not increase further), droughts, extended winter periods, gradual build-up of avalanche danger, …:
  It is not so much a sudden or quick response that is sought but a longer lasting adaptation of behaviour to mitigate the negative consequences and fatalities. Which term would best express this situation and requirement? The terminology should ideally express that a long breath is needed in terms of individual behavioural and public safety response.

13) System flexibility and user-tailored warnings

An ideal warning system offers both stable and reliable standard procedures, and flexibility and ability to quickly react to extraordinary situations.

This can be due to sudden and totally unexpected turns of the situation (for example a sudden jump in the threat level due to observational nowcasting-data well outside of the latest model-envelope).

Also, this can be a very unusual combination of factors (that leads to strong impacts while the classical categories separately wouldn't cause serious impacts).

A system that is able to deal with such highly life-threatening situations needs to foresee a special emergency and quick-mode procedure. It needs to be designed to push cell-broadcasts and siren-activation out on very short time scales (acceptable timespan on the order of a few minutes between identification by the warner and receipt by the affected people).

For special user groups, individualized and customizable alerts can complement the public warnings.

14) Impact-related warnings: to focus on economic impact or on threat to life?

A data analysis by the ESSL found that, based on ESWD data of the past 20 years, the largest share of severe weather cases with fatalities occurred in rural areas, i.e. is counter-correlated with population density.

As forecasters in impact-related warning systems frequently take population density into account for the choice of threat-levels, this finding needs to be further considered.

Economic damage is clearly correlated with population density. If in severe weather situations the threat for health and life is highest in areas with low population density, what does that mean for our warnings?

15) Aviation tornado warnings

Currently no procedures or aviation protocols are in place to handle warnings in the case of a tornado in close proximity to departing or landing aircraft, as an example has shown. This should be discussed with the agencies in charge of the aviation warning procedures.

16) The use of historical impact examples

Cases of extreme flashflood impacts from the pre-instrument/-data era show that certain geographic areas can be at high risk despite more modest statistical estimates from the recent instrument-based data periods. Such examples allow lay people to understand their potential exposure. Where possible, collections of such events should be given to local communities, to civil protection agencies on the regional level but also to forecasters and experts doing the impact assessments in the warning process. Historical impact examples can help to illustrate the damage potential of extreme weather conditions in certain areas.

Expressed desire for follow-up workshops

The participants of the workshop indicated a high interest in a continued process to further discuss the listed issues. A similar workshop format should revisit the identified problems and formulate more concrete recommendations.

A living document that defines the state-of-the-art can help professionals in different countries to improve their warning procedures. One of the main goals is to identify and remove hurdles from the production process of warnings.

ESSL announced its willingness to organize a follow-up workshop within one or two years after the first edition.

Summary of findings and identified challenges

- In the production of impact-related warnings it is important to secure sufficient human capacity for the assessment of impacts. In the interest of lead time, the "translation into impacts" needs to be organized in a parallel, not sequential teamwork process.
- A clear need was identified to remove delaying hurdles for the warning issuance, especially for events with imminent threat (most often convective events).
- Considerations on when to use cell-broadcast push-messages and public sirens were made. In general, different warning types might be needed for different timescales.
- Something to take into account for guidelines: How to deal with the issuance of warnings when the regular issuance time would fall into the middle of the night, a time when most people sleep.
- Important: Clear communication in understandable language. Social science can help to avoid bureaucratic or technical terms within warning messages.
- Under high time pressure: Use default impact information for quick warning production. Especially in cases of extreme meteorological magnitude, it needs to be warranted that detailed impact considerations do not delay the issuance of the initial warning.
- Probabilistic information: There is a risk to create confusion between area-related and pointwise probabilities. Point-wise probabilities are easier to understand and verify for users of the wider public but might sound low or unimportant if communicated without context.
- The question whether the most impactful events should be warned at lower probability thresholds than less impactful events needs to be further discussed.
- There is a lack of well-defined English language warning terminology in Europe. This is seen as a hurdle for international discussions. A draft collection of criteria and aspects to be reflected by the warning terms was proposed.
- Warning systems should be flexible enough to allow the issuance of appropriate warnings for very unusual or very short-term and high-impact events.
- Economic impacts are well-correlated with population density. In contrast, most fatal events occur in rural areas, according to a new study based on ESWD events of the past 20 years. As forecasters in impact-related warning systems frequently take population density into account for the choice of threat-levels, required consequences from this finding need to be further considered.
- Discuss tornado aviation warnings with the agencies in charge of such protocols.
- Collect and use historical impact examples to illustrate the damage potential of extreme weather conditions in certain areas.

Attachment 1: Key Discussion Points- as seen during the last workshop session

Communication: understandable language needed

Distinguish types/modes of warnings

Differentiate between probabilistic and deterministic information

Cell broadcast should be used for very extreme cases only. You should receive such a message max a few times per year and only in case of threat of life.

There can be significant jumps in probability.

We need a warning system that allows for flexibility in case of sudden changes or extreme events on very short time scales (hours or even minutes before the expected impact).

Intensity and level of confidence matter for the decision for push messages (cell broadcast).

Cell broadcast needs to be call for immediate action. Required:

high intensity (impacts) and

high probability (confidence)

close in time to the expected event

(minutes to hours, maybe max. 12 to 18 hours ahead or so).

For special user groups: individualized and customizable alerts to complement regular warnings and cell broadcasts are desirable.

We should define or use a point-wise (user-centered) probability. A forecaster-centered probability (like a 100 % probability for a given region) might lead to misunderstandings.

For very extreme events (impacts), the probability threshold might be set lower than for less intense phenomena.

Attachment 2: Individual take-home messages at the end of the workshop

Leonie: Can be different interpretation of impacts. What is the responsibility of a forecaster?

Alex: Important to having possibility for short time and high impact scenario warning means.

Raphael: Challenging to go from forecasting to warning. Unclear how far forecasters should go towards impacts.

Barbara: Importance to correctly identify the stakeholder of the warning dissemination related to different lead times.

Stefan: Important to have insights from forecaster perspective. It was important to talk openly about challenges. Impact-based forecasting: reluctancy from forecasters. Maybe paradigm shift needed.

Michaela: Two kinds of users. Public needs to understand warnings and message needs to be pushed towards them on time. Other stakeholders have special needs.

Martin: Stuck in meteorologist perspective. Would be good to have lay persons in the room. More data from ordinary people needed.

Tanja: Important to share best practice. Can be inspiring for own services. Important to define the role of the forecasters or the weather service in general. Would be good to hear communication experts and social behaviour experts.

Kathrin: Important is the timing of the messages being sent out. For example, what about night-time? Can we risk more uncertainty in the favour of sending it out before the night?

Benedikt: Warning can be seen as process and not only as a text product. Forecaster main benefit is to forecast meteorology rather than the impacts.

Jordi: Technical aspects and psychological as well as social aspects need to be taken into account. Vocabulary needs to be understood.

Mateusz: Should stop thinking about a warning as a monolith. Needs to be differentiated, for example depending on lead time. Importance to distinguish between prewarning and nowcasting from forecasting perspective but should be seamless for users.

Thilo: Easy language should be used for general public. Important to connect to the daily life. Explain high-end examples with historical examples from the past.

Tomas: Would like to continue a process of thinking about the warnings. Important to also think about how to acquire the best-possible warning from the meteorological data. Assess what are the current capabilities to forecast different phenomena at different timescales.

Pieter: Important to distinguish between general public and stakeholders or special user groups. As a forecaster, need to focus foremost to the general public. There are so many reasons of delays in the process: consultations, too much administration, no easy issuance, thinking about complicated impacts, not enough personnel to do nowcasting-type of warnings. State of the art should be defined. Is there a liability for those who delay?

Alois: Important to put focus on using forecaster capacity for the right things to do: nowcasting. There, as of now, the human forecaster can still add a lot of value.

Addendum

A. Citation and reference for the "Doswell principles for greatest warning value":

"Meteorological forecasts and warnings have their greatest value when the users of the information contained within them
– receive the information,
– understand the information, including its uncertainties,
– know what to do based on that information, and
– take the appropriate action."

From: C. A. Doswell III, Progress toward developing a practical societal response to severe convection (2005 EGU Sergei Soloviev Medal Lecture), Natural Hazards and Earth System Sciences, 5, 1–12, 2005.

B. Raw, unverified notes taken by A. Holzer from oral talk by Rahim Taghizadegan on "Warnings from a historical, societal, economic, ethical and philosophic perspective":

Warn: be aware, be cautious about – see animal colours and natural warning sounds

Primate studies show that this (warnings) is where language develops: cooperation by communication, leading to a human behaviour.

Mesopotamia: warnings as institutional service: admonitions, stabilizing a society, predetermined world outlook (no word for choice), legitimisation of rituals and hierarchies, warnings as protective means.

Similar in ancient Rome with elite role of warner clergy (omnia, prodigia as fear of the displeasure of gods).

Ancient Greece: content of warnings gets less theological, less centralized, more advice.

In Israelite history theological warning: prophecy as subversive force. Deborah in bible: foster identities. Whole group emerges: prophets as a media for national identity.

Paulus: Shut down warners unless there is someone who can interpret it. Competition in warnings.

Elija: Warning for worship of Baal. The first time a prophet challenges the ruling class and threatens an order with apocalyptic warnings.

This became important for Christianity and modern ideas but has a subversive element: gnosis, gnostic (knows something that no one sees). Nearly all modern ideologies have their roots in Christianity. Guilt is very personal (guilty for millenianism). Gnostic approaches in the west: Who is responsible? The saints can protect you.

Such ideas still played a role in modernity: in the 17th century the word warning was increasingly used and peaked around 1707 to be only surpassed in usage frequency in the 21st century. In 1707 it was the expectation that everything would be going down: catastrophism, death drive.

It is a threatening sign if such a dynamic increases in society. Polarizations in history, interventions needed, can diminish the capability to react, no learning effect, fatalism.

Forecast: in Roman tradition a coping mechanism with uncertainty to take a decision. If you do not know which choice is right beforehand, augurs and oracles are used: randomized to reduce bias in decision-making when fear, eagerness, blindness are spreading in a collective.

Causality: Historical forecasting was mostly based on wrong causality.

Heuristics: All about patterns. Still used in farmer's calendars.

Warnings on forecasts. Example from South Africa: girl forecasts that a disease will go away if all cattle are killed. Just a few people refused to kill their cattle. Warnings that are not based on good causal connections can be very dangerous.

Wealth leads to lower fatalities: helps you to cope better, lowers your time preference, thinking, mitigation structures. Decentralized mitigation approaches: protection societies, guilds, insurances try to bear it collectively.

In the 15th century a causal understanding started to develop. Instruments. In 1870 the first influential work on tornado prediction. But still it was for a long time forbidden to use the word tornado. The military perspective hampered the use outside. Panic idea if lots of lay persons are involved. Usually there is too little reaction to warnings instead of panic.

In some cases, reaction to warnings can be worse than the original impact: evacuation can, depending on context, lead to transport accidents, elderly people are under high stress with a risk of early death.

Trust in the warning is important.

Preference for risk (especially appealing for young males) is a problem for warnings, can lead to substitute behaviour. Woman with children can best deal with probabilistic warning information.

"Dosing" of warnings over time needs to be considered.

C. Raw, unverified notes taken by A. Holzer from oral talk by Dalia Tanczos "Basic principles of liability – an international review and real examples":

Liability: stand up for misconduct. Experts are connected to a high level of liability. Where does the personal liability begin and end? One can only be held liable if doing something legally wrong.

It is decisive if one only does forecast quantity or decides on concrete actions (for example evacuation). Moving into the field of advice and action increases the liability.

Negligence: disregards care, according to the law, reasonable in mental/physical condition.

Comparison: the average weather forecaster who knows existing standards and works according to the state-of-the-art. Therefore, it is important to know the current standard. If the standard is not met, there can be a problem with criminal liability. What was foreseeable, almost probable?

Standard: up to date knowledge through continuous training and further education.

To proof this: document (and keep/store) request for further training sent to the employer.

Civil liability: Someone or something has been damaged. Proof needed that the wrong forecast was causal and legally wrong if the standard was not met.

If you act as an expert, the liability is very strict. It even counts if you do not take money for the service. Whenever there is a contract, you are already liable for slight negligence. The burden of proof is on the side of the expert.

When is a prediction wrong?

A judge does not ask for the perfect outcome, but you are liable, if the professional process was not state-of-the-art. How did you arrive at your forecast? A judge must call experts to assess what is the standard.

How to prevent myself from liability:
As a doctor does not owe the patient the cure, the meteorologist does not owe the perfectly verified forecast. Important: An expert opinion is correct if recognized universities or institutes confirm it. If a method in a single case (or region) is questionable or not, a judge would look to the whole country or to the whole of Europe to compare with the state-of-the-art.

Important: Draw the attention of the client to the fact that there can be other expert opinions and that the given advice is based on the available and used data. Since an expert opinion is not the reflection of an absolute truth but the result and human communication message that reaches the public in an understandable fashion. How is it understood by fair-minded people with an interest to not misunderstand it? (Not driven by my own interest.) Experts need to mark subjective opinions.

A judge will check from the ex-ante perspective. This is the only perspective that counts, not the outcome.