Using ECMWF-forecasts (UEF2018)
ECMWF, Reading, UK
05 - 08 June 2018

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

How the uncertainty of a forecast or warning could be communicated

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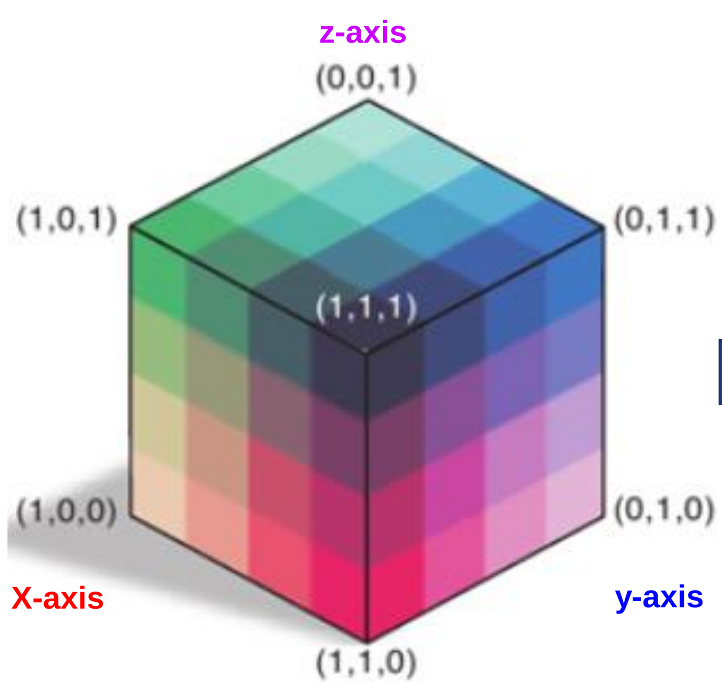
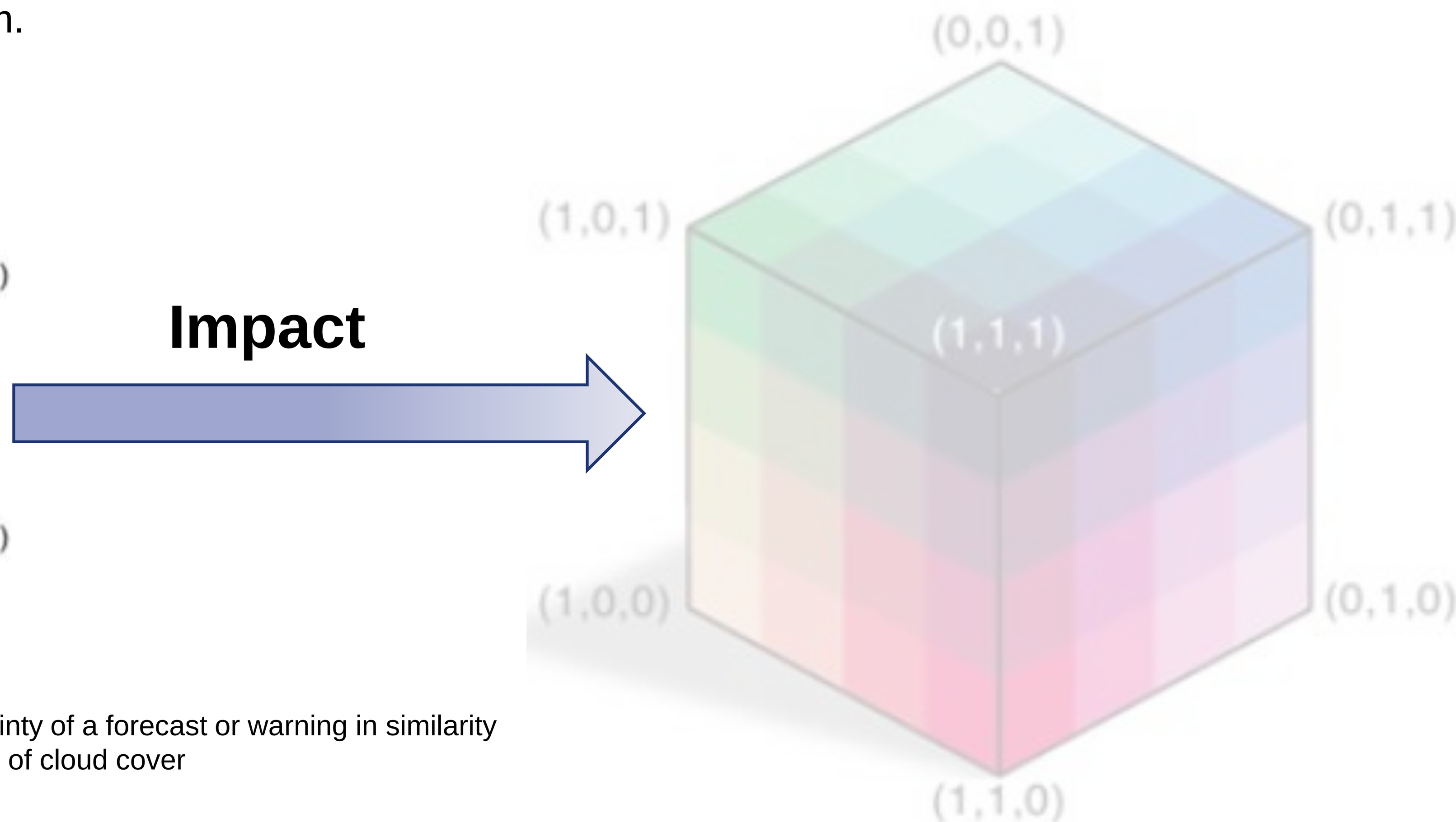
An accurate prediction of severe and high-impact weather events is the core task of the DWD. From the point of the forecaster´s view it is obvious that warnings as a forecast product are uncertain in some aspects. For a rapid developing wind storm it may be the exact swath with the highest wind gusts, mostly the period and the intensity of damaging winds could be specified earlier. In situations with freezing rain forecasters have to keep an eye on the predicted and observed type and intensity of the precipitation but the affected region and the time of the onset of the event considerably well predictable. Therefore a forecast or warning is intrinsically uncertain in fact that some aspects (period, intensity or affected area and impact) rather accurate and others are poor predictable.
In cooperation with the users of our predictions and warnings estimates of the uncertainty and the impact will be requested by general public as well as by authorities. A challenging task is to communicate not only the level of the per se uncertainness but much more what related to the upcoming severe weather event is almost certainly and what not. A possible idea could be to split the assessed uncertainty for each forecast or warning into four sections (affected area, period, intensity and impact) and to express it by a number consists of four digits. This method may contain more valuable information for the end-users than a common probability for the entire event.

Idea and introduction

After issuing of forecasts or warnings the communication of uncertainty is one of the main topics of the subsequent consultations and expert advices. One method is to publish facts like pros and cons for a warning decision by a detailed synoptical guidance as a textual product. This will be issued twice per day for the short-range and once per day for medium-range forecast. The advantage of this forecast product for specialists is that the forecaster could go there deep into synoptical details. On the other side the user has to read sometimes a lot what is difficult to understand without of any or with only poor meteorological background. Therefore some additional consultancy by phone is essential to explain which aspects of the forecast or warning are certain and which not.
The idea is to represent the uncertainty by a diagram where the abscissa is the time, thy y-axis is the spatial arrangement (horizontal pattern) and the intensity or amplitude will be represented by the z-coordinate. All variables should be scaled between 0 and 1 (or 0 and 100%) similar to probabilities where 0 is the minimum (certain) and 1 means that the uncertainty reaches a maximum.



Rubic´s cube, as an **idea** to visualize the uncertainty of a forecast or warning in similarity to the color table used for the different categories of cloud cover



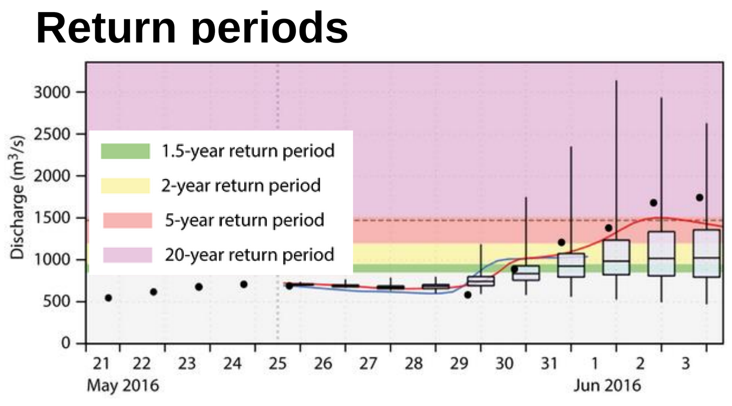
Related to a severe weather event additionally the impact has to be considered as a fourth dimension.
Less severe events may have a strong impact and vice versa. It is not the same whether a severe thunderstorm producing large hail and torrential rain in excess of 100 mm/hour hit a large town or an almost unpopulated area. Freezing rain may cause dependent from its intensity a blocking of some minor roads and paths up to a complete break down of essential infrastructure (failure of electrical power supply…) if the totals of freezing rain are high enough. The assessment of the impact of an upcoming severe weather event is a challenge in the process of the preparation of warnings because some non-meteorological parameters has to be taken into account. The smaller the area the less in known.

(1,0,0) means the x-axis reaches a maximum I don´t know ***when*** the severe event will happen. This is typically for the ***onset*** of deep convection after a longer dry period.
(0,1,0) is the expression for the y-axis reaches maximal values. Here severe weather that could affect in a wide-spread area comparatively small regions only. For most of deep convection is this the norm.
(0,0,1) will tell the user that the ***intensity*** is absolutely uncertain. This will be often observed in severe weather situations with freezing rain.
(1,1,1) is the expression for "it is known what severe weather will occur" but the time, the area that will be affected by the event and it´s intensity are incalculable. In this situation the predictability goes down. A typical case for this scenario was the heavy rain event in the surroundings of Berlin end of June 2017 (see https://software.ecmwf.int/wiki/display/FCST/201706+-+Rainfall+-+Germany).
And **(0,0,0)** on the opposite side of the cube stands for e certain forecast or warning well in advance. For this rare situation a typical example was the windstorm „Kyrill" in January 2007.
To compress these values an adequate scaling between 1 and 9 is acceptably. By a 3-digit or impact-including 4-digit number it could be expressed how certain a forecast or warning might be.
To visualize the uncertainty the "Rubik's cube" representation of the colour table for the different categories of the cloud cover visualisation from the ECMWF web page has been used.
In most cases a prewarning ("Watch") for a greater area could be issued up to 48 hours in advance. These watches will include all aspects of uncertainty, currently expressed by a text statement and will be updated closer to the event.

Approaches to consider the impact of a severe weather

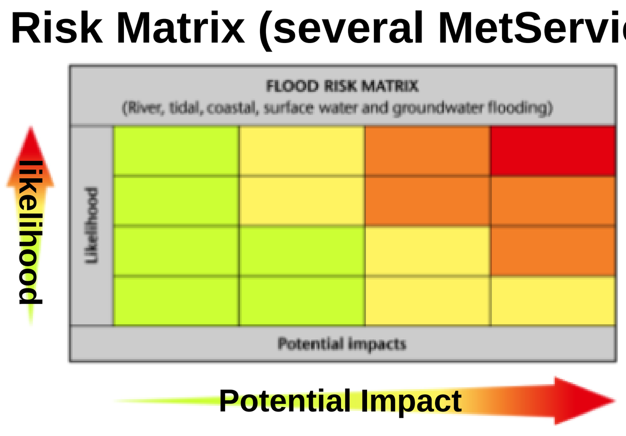
Hazard impact modelling
UK Met Office: Vehicle OverTurning / Surface Water Flooding Impact Model

Return periods



Used to illustrate the severity of an event, applied for large floodings by flood control authorities

Risk Matrix (several MetServices)



The DWD´s approach
A fixed set of warning criteria, for yellow, amber, red and magenta alerts has been established, harmonized over whole Germany and all regions. Criteria has been coordinated with civil protection and emergency management authorities.
The Supervisor of the forecast and advisory center hast to decide finally in cooperation with the staff of the center and regional offices which color code the warning has to be.
In situations if the expected intensity of the event is between two color states the "higher" color will be chosen **(impact-based thinking):**

- A very high-populated area will be affected
- Past weather (last days…weeks) will implicate much more impact than "usual"
- Season (leafy trees more windstorm-sensitive)
- If the risk for repairing and cleaning teams (fire brigades, traffic way clearance) is too high the color state will remain severe even if already the event starts to weaken

If the severe weather situation may produce a danger for life and a wide-spread break-down of essential infrastructure (mainly magenta alerts) the supervisor may initiate an alert to authorities and nationwide media to warn the general public directly by a separate communication system.

References

1. B. Hemingway, Met Office: From Hazards to Impact: Experiences from the Hazard Impact Modelling project, ECMWF UEF 2017
2. L. Magnusson, F. Wetterhall, F. Pappenberger: Forecasts showed Paris flood risk well in advance, ECMWF Newsletter, No. 148, 4,5
3. T. Kratzsch, Personal communication, April 2017

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