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Wetter und Klima aus einer Hand

Radar-based Precipitation Nowcast at Deutscher Wetterdienst (DWD)

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Quantitative precipitation forecasting with high temporal and spatial resolution is essential for the meteorological warning management as well as for hydrological applications in the context of flood risk management. DWD operates a radar-based nowcast suite covering a lead time of two hours with an update frequency of 15 minutes focusing on high-resolution forecasts of precipitation quantity, aggregate state, and type. The predicted amounts of precipitation are quantified making use of the results of the latest gauge-adjustment. Combining the radar-based precipitation nowcasts with data from complementary observations and numerical modelling allows an estimation of the precipitation phase, while the concurrency of high reflectivity values in the radar signal and the occurrence of strong lightning intensity points to an enhanced probability of hail within a thunderstorm event.

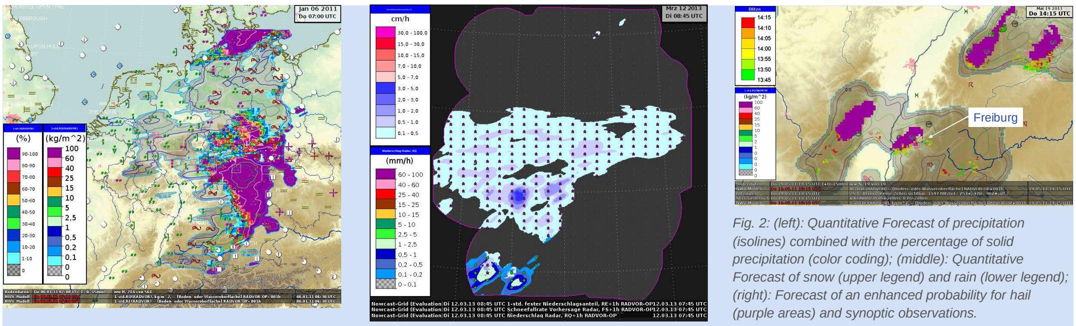

Fig. 2: (left): Quantitative Forecast of precipitation (isolines) combined with the percentage of solid precipitation (color coding); (middle): Quantitative Forecast of snow (upper legend) and rain (lower legend); (right): Forecast of an enhanced probability for hail (purple areas) and synoptic observations.

Quantitative Precipitation Nowcast

The operational weather radar network of DWD currently comprises 17 sites (Fig. 1), where precipitation scans are performed every 5 minutes. The radar-based reflectivity fields are combined to a 1 km x 1 km composite covering Germany and are transformed into amounts of precipitation by applying a categorized Z-R relation.
The qualitative-quantitative radar composites serve as input for a radar tracking algorithm providing nowcasts for up to two hours. The tracking algorithm is based on the advection of precipitation elements using the displacement vector field that is derived from the mapping of detected precipitation patterns in successive picture data.
The predicted stratiform precipitation is quantified by making use of the results of the latest gauge-adjustment assuming persistence of the precipitation frequency distribution resulting in the quantitative precipitation forecast for the next two hours with an update frequency of 15 minutes.

Nowcast of Precipitation Phase

For hydrological and meteorological applications not only the quantity but also the type of the precipitation is of paramount importance. Qualitative information on the precipitation phase is derived from the combination of the radar-based nowcast with additional observational and model data. The key components of the algorithm are the spatial interpolation of synoptic weather data according to areas of similar reflectance derived from MSG satellite data, station-based observations, as well as temperature and humidity profiles from numerical weather prediction.
In combination with the underlying orography, the algorithm allows the discrimination between solid and liquid precipitation types at surface level in the quantitative precipitation nowcast. Figure 1 gives an example (note that freezing rain is regarded as liquid by hydrometeorological definition).

➔ See also Paper 48 by Tim Böhme and Paper 65 by Paul James for the application of radar-based nowcasting in DWD operational weather forecasting!

Nowcast of Snow Amount

The combination of the predicted hourly precipitation sum and the percentage of solid precipitation allows the forecast of the expected snow height, however, at this stage neglecting any processes within the snow blanket.
As a first guess a factor of 8.5 was introduced to convert the water equivalent of solid precipitation to snow height that proved to be in the right ballpark for the event shown in the middle panel of Figure 2.

Nowcast of Hail

An additional qualitative information on whether an enhanced probability for hail prevails is predicted based on the combination of intense lightning activity and extremely high radar-derived precipitation intensity.
The right panel of Figure 2 shows a weather situation with several convective cells within the Black Forest region near Freiburg with purple areas indicating a predicted enhanced hail probability. The purple triangle marks the station at which hail has been observed.

German Radar Composite

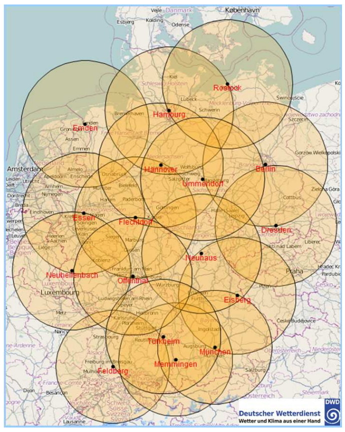

Fig. 1: German radar composite consisting of 17 C-band Doppler radar systems currently being replaced by new dual-polarization systems (effective April 2013).

Multiplicative Bias (Elbe Flood) / Frequency Bias (Elbe Flood); Lead Time [h] vs. Precipitation Threshold [mm/h]

	Lead Time [h]	MB 0.1	MB 1.0	MB 2.5	MB 5.0	MB 10	FB 0.1	FB 1.0	FB 2.5	FB 5.0	FB 10
RS	1–2	0.56	0.56	0.51	0.40	0.20	0.72	0.75	0.55	0.32	0.04
RS	0–1	0.57	0.56	0.53	0.46	0.27	0.74	0.73	0.55	0.35	0.06
RQ	1–2	0.74	0.76	0.77	0.78	0.78	0.68	0.77	0.76	0.75	0.75
RQ	0–1	0.72	0.74	0.76	0.76	0.84	0.68	0.75	0.72	0.70	0.84

Fig. 3: Verification results for the heavy precipitation event causing the flooding of the river Elbe in August 2002; the upper panels give the result for the forecasts before (RS), the lower panels after quantification (RQ).

Verification

The focus of the presented verification study was laid on the effect of the quantification algorithm on the precipitation nowcasts modifying the precipitation frequency distribution, but not altering the location of the predicted precipitation. Figure 3 gives selected results for the 2002 Elbe flood event. Due to strong attenuation, for this event the unadjusted radar-derived product RS strongly underestimated the observed precipitation amounts. The quantification led to a distinct improvement of the precipitation forecast, especially for larger thresholds.
Over all five cases of the verification study (*not shown*), the quantification increases the quality and quantity of the precipitation forecast for stratiform events and has proven to be a valuable tool for the nowcast of strong precipitation events.

Applications and Outlook

Radar-based precipitation forecasts are provided to the risk management authorities of the German federal states for application in flood forecasting.
Within Deutscher Wetterdienst radar-based precipitation forecasts are part of the automatic system for the generation of weather warnings AutoWARN.
The focus of future developments lies on the improvement of the real-time provision and visualization of combined analysis and forecast products for operational forecasting and warning.

References

Winterrath T., Rosenow W., Weigl E., 2012: On the DWD quantitative precipitation analysis and nowcasting system for real-time application in German flood risk management. Weather Radar and Hydrology, IAHS Publ. 351.

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