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StucK radar composite for Northern Germany

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The German research project StucK (Long term drainage management of tide-influenced

coastal urban areas with consideration of climate change) investigates the increasingly challenging task of mitigating flood risk in coastal urban areas.

Urban waters are often characterized by a growing degree of impervious surfaces causing faster run-off times. This results in flood waves with short rise times and short but high maxima. An additional challenge often met in coastal areas is that drainage can be restricted by tides. In the case of Hamburg many of the smaller waters drain into the river Elbe which is tide influenced and has a mean tidal hub of 3.68 m measured at the level St. Pauli(HAMBURG PORT AUTHORITY 2014). This means that under normal conditions many creeks can only drain during low tide. An increased flood risk results from storm events with unusually high water levels of the Elbe and coinciding heavy local rainfall, e.g. an event associated with the low pressure system “Xaver” in 2013 (GÖNNERT et al. 2014). Under climate change an increasing probability of these events is likely. The goal of the project is to find strategies combining flood risk management with ecologic aspects which are also applicable in other coastal urban areas. For example retention areas can provide a number of important eco system services but are space intensive and therefore have to compete with other uses such as housing. An increased understanding of the hydrological processes will be gained by detailed hydrologic modeling as a prerequisite for improved management strategies. These different strategies for flood risk management and urban planning will be evaluated using economic measures as part of StucK.

For this project rainfall data is necessary for two important aspects. Firstly as an input for hydrologic modeling and secondly rainfall forecasts are essential for a flood warning system. For this reason a number of data from the German weather service are acquired in real time:

1. Rain gauge station data (hourly resolution for Northern Germany and one minute resolution for two stations in Hamburg)

2. Radar data of four radars in Northern Germany (DX-product of radar Boostedt, Rostock, Hannover and Emden; low level scan at 0.8° elevation with a spatial resolution of 1° x 1 km and time resolution of 5 minutes)

3. Numerical weather forecast data from COSMO-DE and COSMO-DE-EPS (BALDAUF et al. 2011).

The forecast strategy for this project is to combine the strength of radar nowcasts for the immediate future and the one of numerical weather predictions for an extended outlook. It was decided to investigate the use of ensemble forecasts for a flood warning system as we believe that a probabilistic forecast can provide crucial information for flood risk management.

In a first step a radar composite has been constructed from the four radars. This requires correcting the radar data. Based on the SCOUT software for analyzing and processing radar data,a number of quality control filters was used. The corrections required can be illustrated on the example of the data from radar Rostock. The data has three mayor shortcomings:

- a hotel close to the radar site is blocking part of the radar beam

- ships frequently cause radar echoes with varying positions but on fixed routes

- wind farms cause radar echoes in fixed locations.

In order to correct for these effects 6 months of radar data was analyzed and based on the findings a twofold clutter map was constructed. The first part of the clutter map contains individual pixels which are part of extended areas which permanently cause echoes not associated with rainfall. These pixels will be deleted from all radar images. This is part of the strategy used for removing the echoes from wind farms. The second part of the clutter map contains pixels from extended artificial echoes which temporarily affect the radar image. For these pixels the subsequent filters are applied under more strict conditions. Subsequent filters, which are applied to the whole image include speckle filter and Gabella filter (Gabella and Notarpietro 2002). The former one removes unrealistically small echoes from the image while the latter one compares individual pixels to their surrounding and replaces their value by interpolating the neighboring pixels. Another important step which is performed for all radars is the interpolation of the radar images in the time domain. This effectively converts the instantaneous reflectivity measured by a radar to a five minute average intensity. One of the benefits of the last step is the improved agreement of interpolated radar data with the 5 minute cumulated precipitation measured by rain gauge stations.

The settings for the correction filters have been optimized for each of the four radars and can be applied in an operational near real time system on a server which was specifically purchased for this project. The operational computation of a composite combining the data from all four radars was also implemented. In this step all radar data are mapped on a 1km by 1 km rectangular grid. In areas where radars overlap the data from individual radars is averaged using distance weighting. Next, the radar data is adjusted by rain gauge stations distributed over the whole area covering the radar composite. The result is an adjusted radar composite image every five minutes with a lag time of about 5 minutes compared to the measurement time.

The adjusted radar composite forms the basis for the derivation of radar nowcast ensembles. Precipitation time series can easily be extracted from the measured and forecasted radar images by scout. These time series will be provided operationally as an input to the hydrologic model. Ensemble nowcast and online model results shall be operational in autumn 2016.

Literature

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