Skill in nowcasting high-impact heavy precipitation events

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1 Introduction

The objective of this study is to assess the skill of a precipitation nowcasting (very short range forecasting) system, with particular emphasis on hig-impact Heavy Precipitation Events (HPE). A threshold amount of 20 mm in 30 minutes is adopted, according to the first warning level issued for high rainfall rates by the Meteorological Service of Catalonia (NE Spain). These type of events are relatively frequent during autumn in the Mediterranean area and may produce flash-floods and substantial socio-economic losses when affecting densely populated areas in small catchments near the coast. Moreover, they can also produce local damage due to severe weather induced by winds of convective origin such as tornadoes or microbursts. Therefore, under these circumstances nowcasting systems producing very-short range (<3h) quantitative precipitation forecasts (QPF) are particularly necessary.

Recent studies have pointed out the benefits of combining or blending the information from radar-based nowcasting systems and high resolution Numerical Weather Prediction (NWP) models to fill the gap between the lead-times of forecasts provided by each type of system - see for example Atencia et al. (2010), Berenguer et al. (2012) or the review by Pierce et al. (2012). Here we focus on assessing the quality of precipitation forecasts to examine realistic lead-times provided in four selected cases (see *Table 1*) for different precipitation amounts. The evaluation is done in two ways. Firstly forecasts are compared against radar based Quantitative Precipitation Estimates (QPE). Secondly the QPF fields are compared against actual raingauge data. Results are presented for all events together and for individual cases.

Table 1: Maximum rainfall depths for 30 minutes and 24h from raingauge observations and collocated weather radar estimates (in parentheses and italics) in the area of study. Details and references about the case studies are also given for further information.

EVENT	30'[mm]	24h[mm]	Comments	References
2005/09/07	44.6 *(32.4)*	87.9 *(89.2)*	Tornado outbreak (4 tornadoes, 1 F2). Multicells and MCS	Bech et al. (2007)
2006/09/13	57.6 *(41.0)*	216.0 *(154.4)*	Tornado outbreak (3 tornadoes, 2 F1 tornadoes). Multicells and MCS	Mateo et al. (2009)
2006/10/18	40.2 *(52.1)*	93.6 *(114.3)*	F2 tornado, microburst. Multicells	Aran et al. (2009) Bech et al. (2009)
2008/11/02	40.0 *(29.4)*	130.2 *(88.2)*	F2 tornado, microburst. Supercells and MCS. Orographic effects.	Bech et al. (2011) Trapero et al. (2013)

2 Data and Methodology

2.1 Raingauge and radar QPE data

Raingauge data was provided by the Catalan Water Agency and the Meteorological Service of Catalonia (SMC) -about 200 stations-, which also provided weather radar observations from the Creu del Vent C-band Doppler radar. Quantitative Precipitation Estimates (QPE) data from this radar were derived using the EHIMI system (Sánchez-Diezma et al. 2002, Bech et al. 2005) which performs a set of corrections over polar data volumes, including beam blockage correction and elimination of non-precipitating echoes (Berenguer et al. 2006). Raingauge data were available in 10 and 30 intervals from the hour and QPE were produced every 6 minutes from the hour for short range radar data (approximately 130 km from the radar) - see daily accumulations in *Figure 1* and comparisons between collocated gauge and radar QPE values in *Figure 2*.

2.2 Nowcasting system

QPF data was obtained from the deterministic component of the probabilistic ensemble system SBMcast based on a Lagrangian extrapolation approach of the radar QPE. This system was developed for hydrometeorological applications (Berenguer et al 2005, 2011) and was partly developed an earlier high-resolution precipitation modelling system proposed by

Pegram and Clothier (2001). QPF forecasts were developed every 6' with lead times up to 180' (3 h). An example of forecast is shown in *Figure 3*.
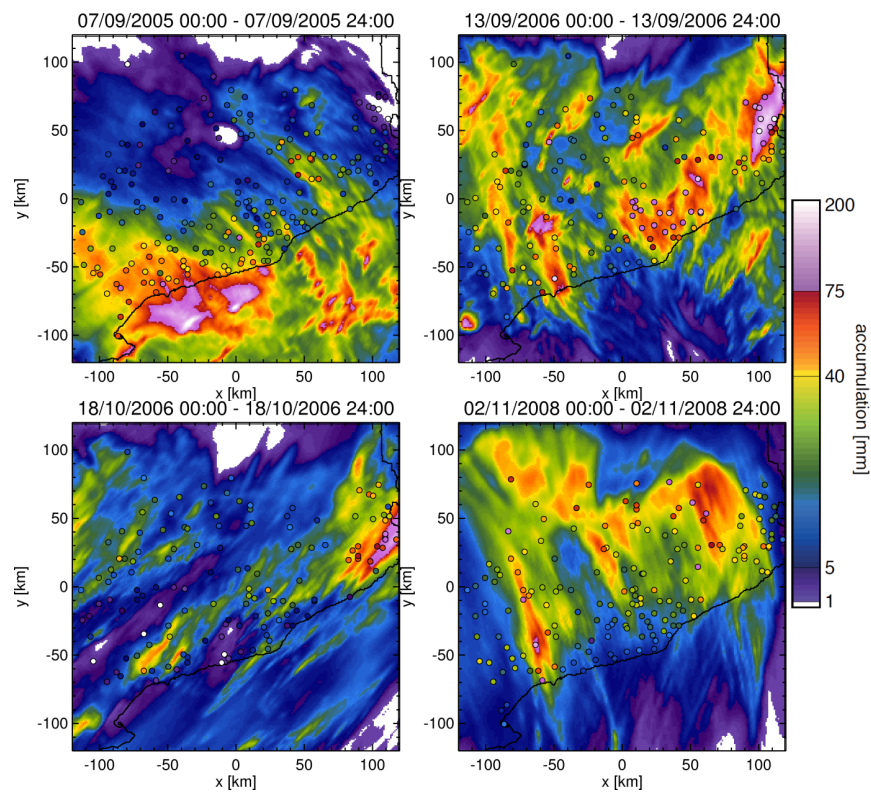

Figure 1: *Weather radar derived 24h quantitative precipitation estimates (shaded colours) and raingauge observations (circles) for the case studies. The domain analysis is centred at the CDV radar site.*
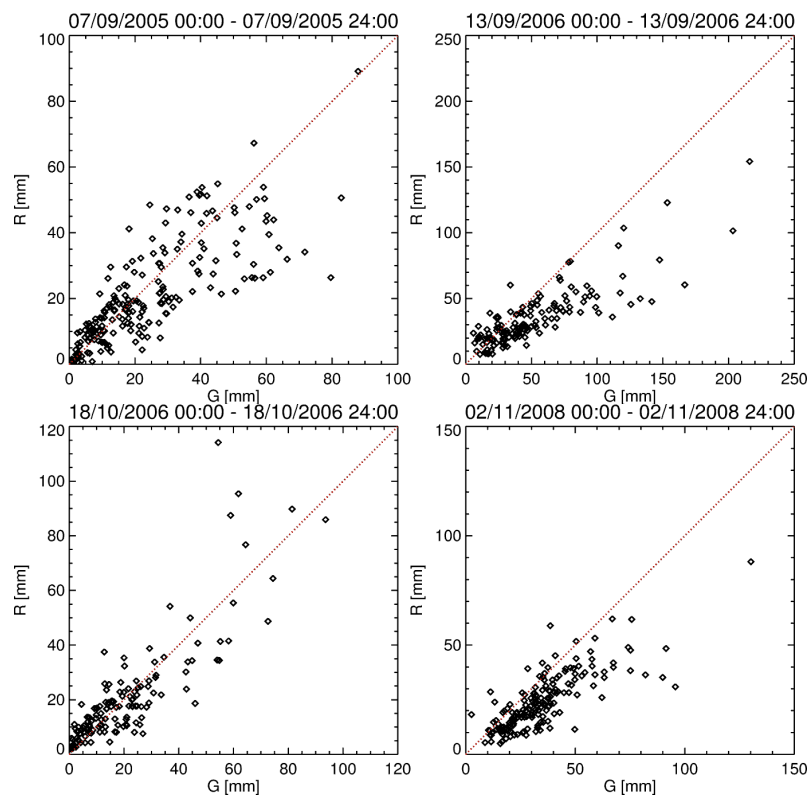

Figure 2: *Scatter plots of 24h weather radar precipitation estimates vs collocated raingauge observations shown in Figure 1.*
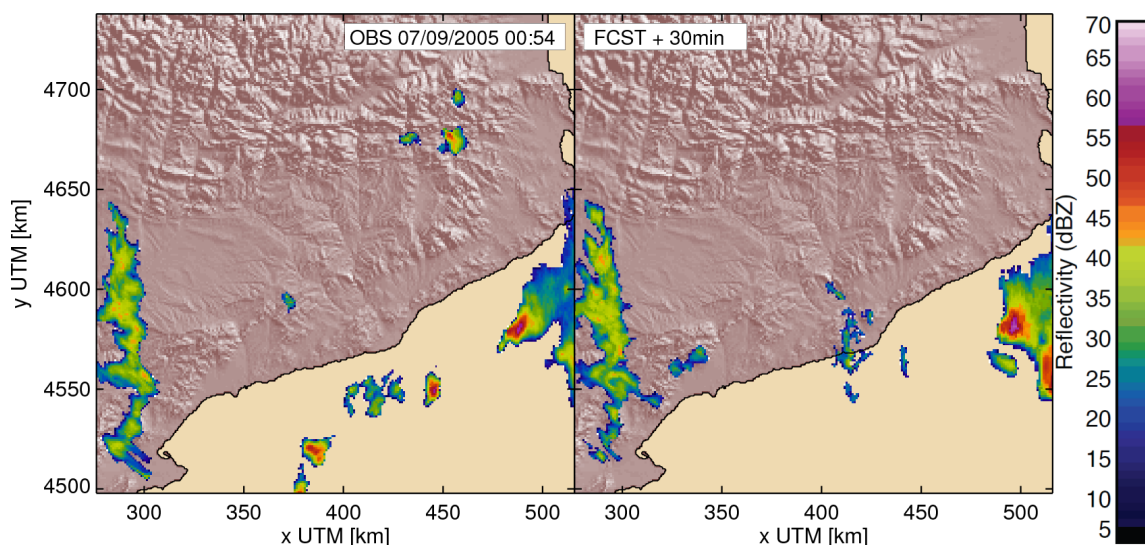
Figure3*: Example of quality controlled radar reflectivity field from case study 2005/09/07 at 00:54 UTC and the corresponding forecast produced with observations recorded 30 minutes before.*

3 Results

An analysis in terms of the Gilbert skill score, or GSS (also called Equitable Threat Score), is presented in this section. GSS ranges from -1/3 to 1 (worst to best forecast) and 0 indicates no skill. It takes into account the occurrence of hits due to random chance and it is frequently used for verification of rainfall forecasts.

3.1   All data

Results are shown considering the whole data set of four events listed in Table 1. This allows for a more complete analysis as more data are available, and for example higher precipitation amounts used as thresholds can be examined. **Figure 4** shows GSS values up to 3h for 30 minute rainfall values exceeding thresholds from 0.1 mm to 20 mm, comparing forecasts with radar QPE (left panel) and collocated raingauges (right panel) - so the number of sites verified are the same in both plots. As expected as rainfall intensity and lead times increase the quality of the forecast decrease. For example 0.1 mm GSS forecasts compared to radar QPE at 2h (GSS about 0.4) are comparable to 5 mm forecasts at 30'. The limitations for high intensities are well illustrated - for example the right panel shows that after 60' the skill is nearly negligible (nearly 0).
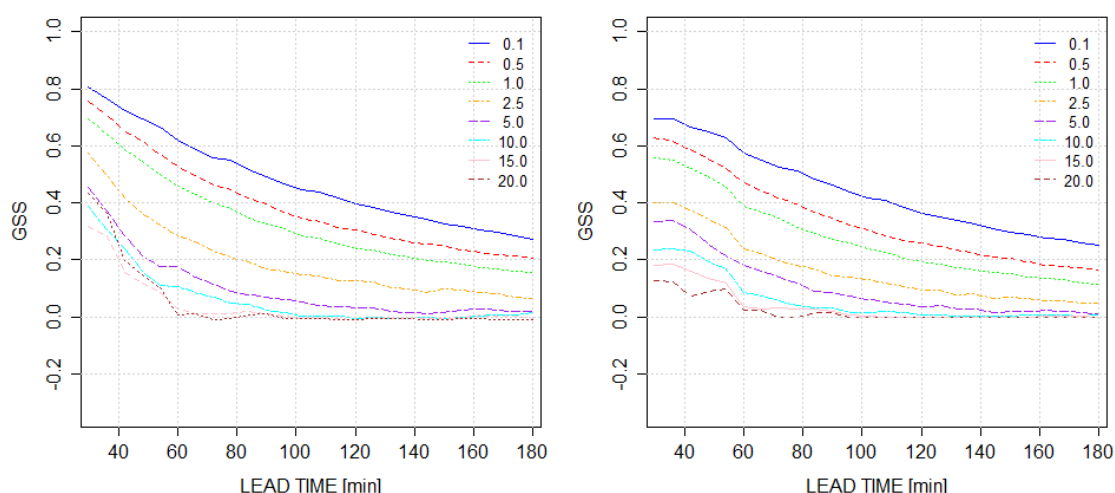

Figure 4. *Gilbert skill score comparing 30 minute QPF vs radar QPE (left column) and QPF vs raingauge data (right column).Different rain amounts considered for each forecast and lead time range from 0.1 mm to 20 mm in 30 minutes.*
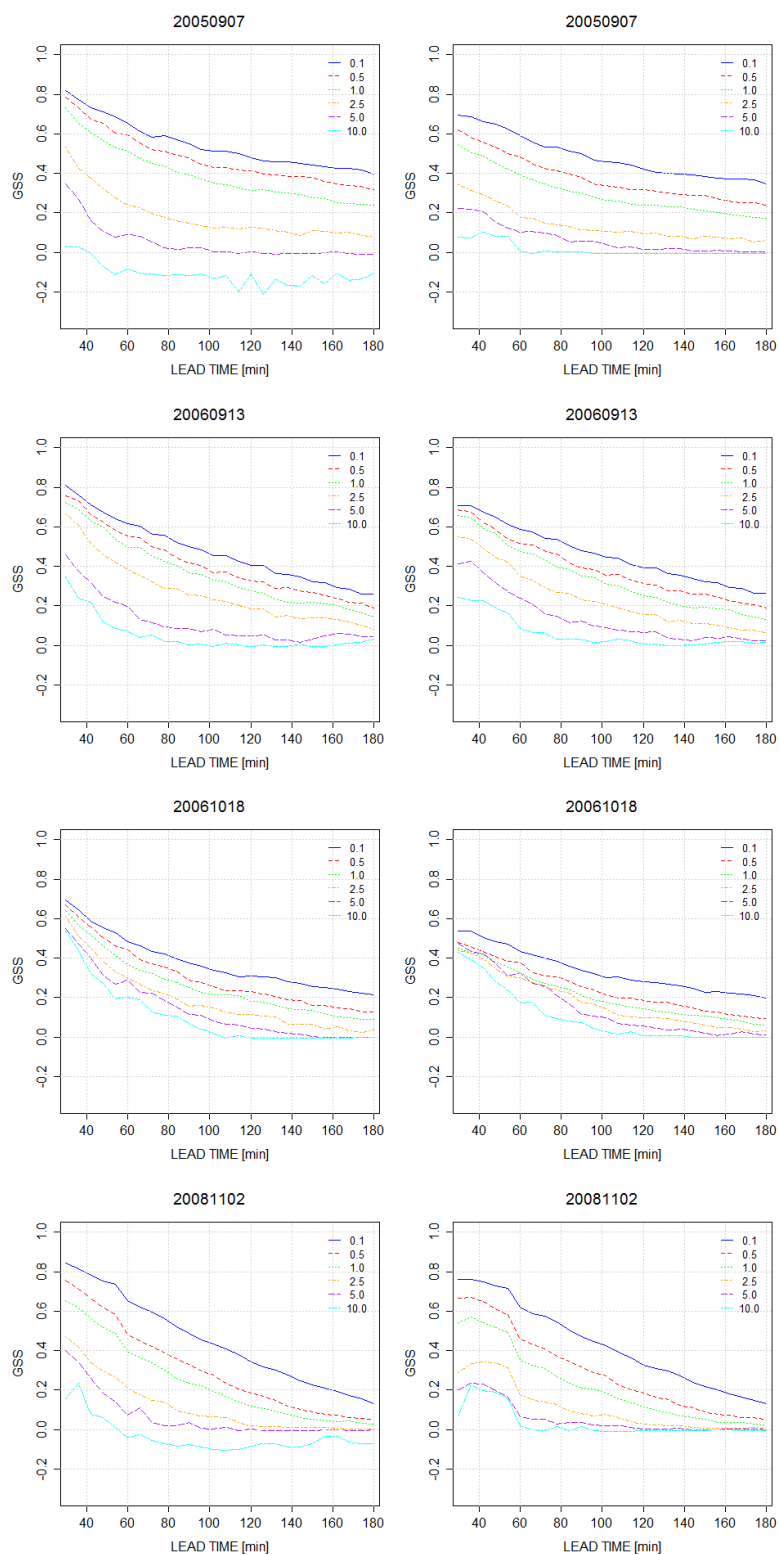
Figure 5. *As Figure 4 (left column QPF vs radar QPE and right column QPF vs raingauge) but now each row corresponds to a different event.*

3.2 Case studies

Figure 5 shows similar plots but group by the different case studies, thus illustrating the variability found among the different events. Maximum intensity considered was 10 mm as higher values provided meaningless results due to the limited number of data available.

4 Final remarks

Further work is progress considers comparison of results with those comparing Eulerian persistence of observations (both radar QPE and raingauges) and more in depth analysis of different features in each event, considering verification scores computed over the whole precipitation field (not only over raingauge sites).

Acknowledgement

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