Simulation of severe convective storms with hail occurrence by the COSMO NWP model

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Introduction

In this poster we applied the COSMO NWP model to nowcasting of convective precipitation and hail occurrence. We used COSMO 4.18, which was complemented by:

- two-moment microphysics of Seifert-Beheng (2006), (hydrometeors: rain water, cloud water, snow, ice, graupel and hail)
- assimilation of radar reflectivity by the water vapour correction method (Sokol, 2011)

Two nested model runs were performed. The first run was with the horizontal resolution of Δh=2.8 km (50 vertical levels) and the initial and lateral boundary conditions were interpolated from the prognostic fields of the COSMO-EU model (horizontal resolution is 7 km). The second run was one-way nested into the first one and the horizontal resolution was 1.1 km with 70 vertical levels (Fig. 1). The model was run in a nowcasting mode which means that the models started integration every hour (and also with the step of 30 min., not shown here) and lead time was 1-4 h.

We selected 6 events with heavy convective storms accompanied by observed large hail (diameter>3cm) and evaluated COSMO forecasts with the lead time 1-4h. The occurrence of hail was determined using the algorithm based on radar data and vertical profiles of atmosphere (Skripniková et al., 2014).

The results for two events are shown:

- 2nd July 2012 – severe hailstorms in Central Bohemia with maximum 7cm diameter hails
- 9th June 2013 – hailstorms in Central and Northern Bohemia – 5 cm hails

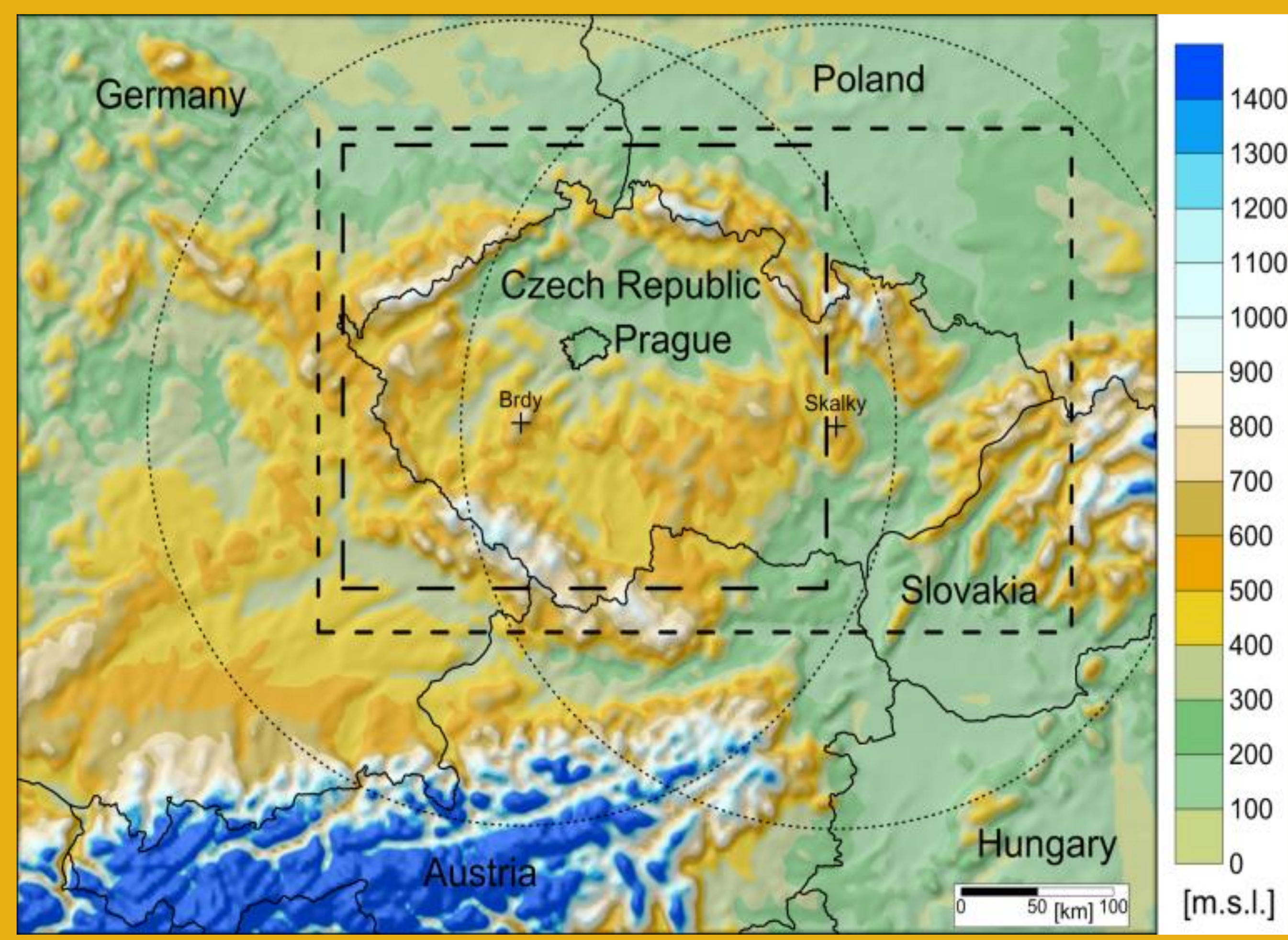

Fig. 1. The model domains with the resolution of 2.8 km (larger) and 1.1 km with topography above sea level in m (see legend). The positions of the Brdy and Skalky radars (black triangles) and the areas covered by the radar data assimilated into the model (dashed circles) are marked.

2nd July 2012

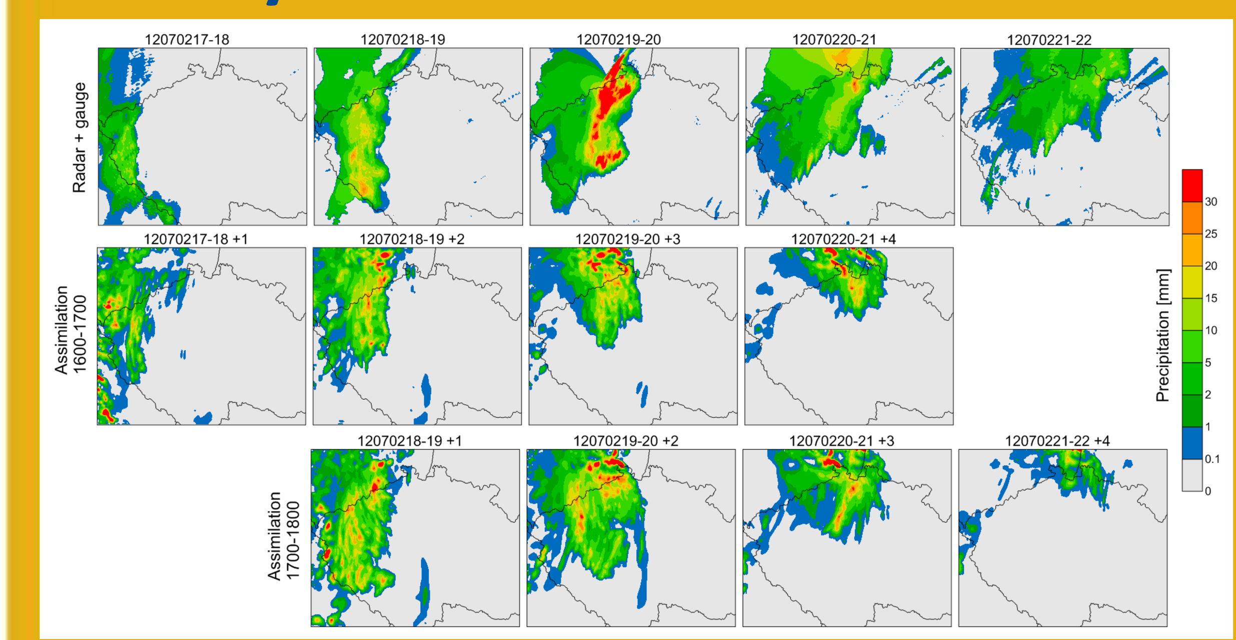

Fig. 2. Observed (upper row) and forecasted hourly precipitation for 2nd July, 2012. Sequence of forecasts differs in the assimilation period.

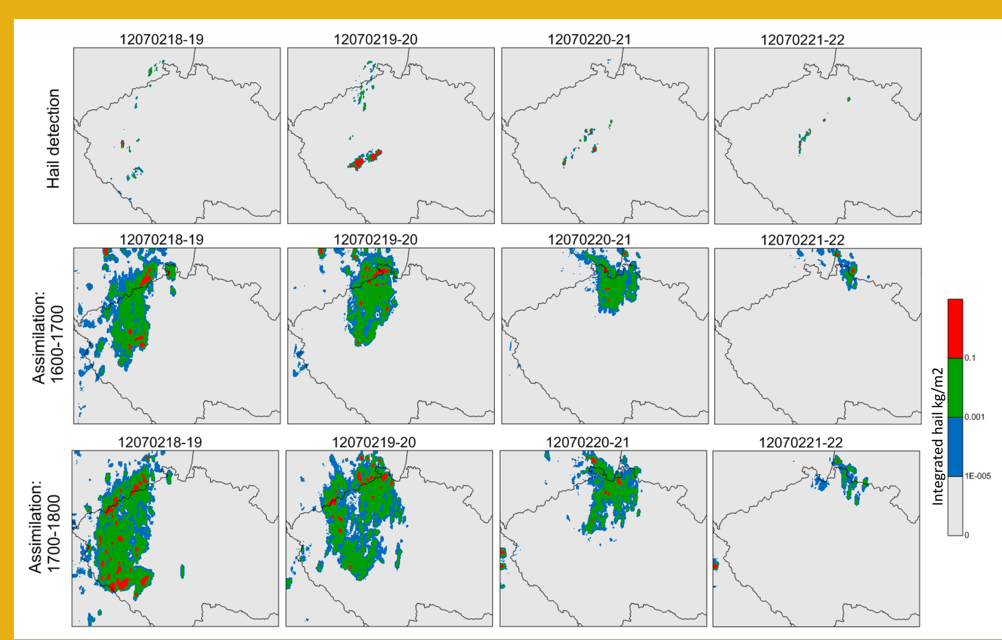

Fig. 3. "Observed" (upper row) and forecasted hail accumulated over an hour. Three levels of forecasted hail expressed in integrated ice content [kg/m^2] are shown. "Observed" hail are determined by the algorithm described in Skripniková et al. (2014) and blue, green and red points are places where hail was indicated by the algorithm.

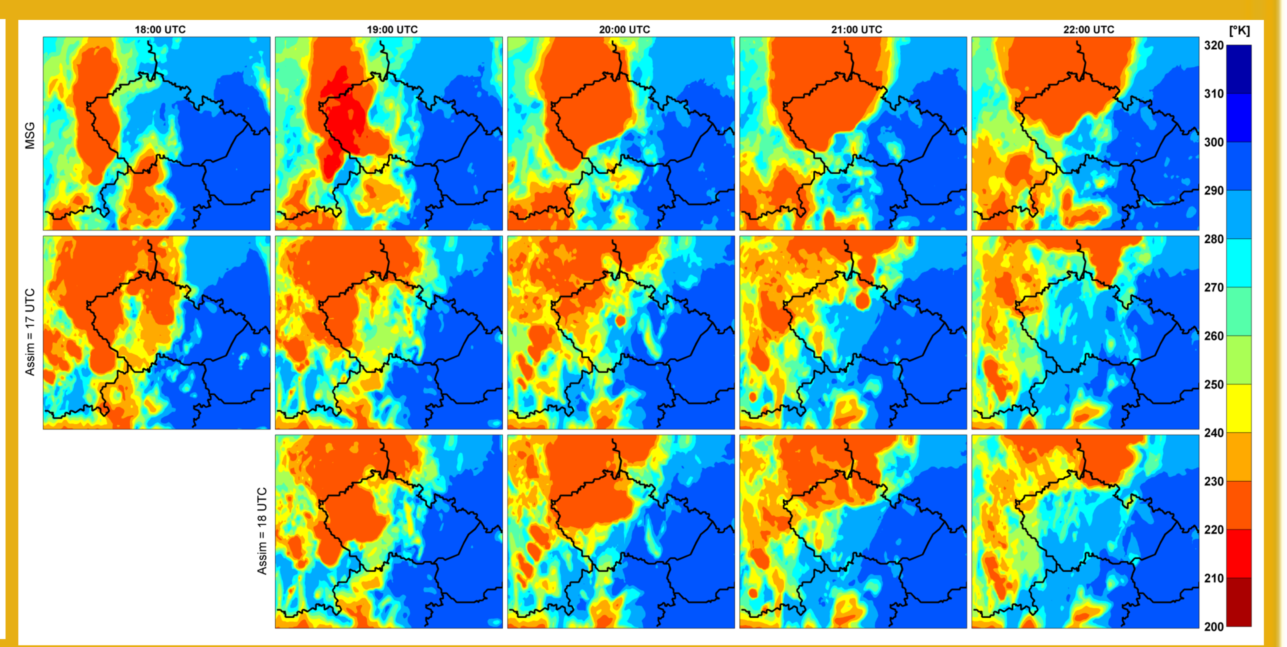

Fig. 4. Verification of cloudiness by comparing the synthetic satellite images with real MSG imagery.

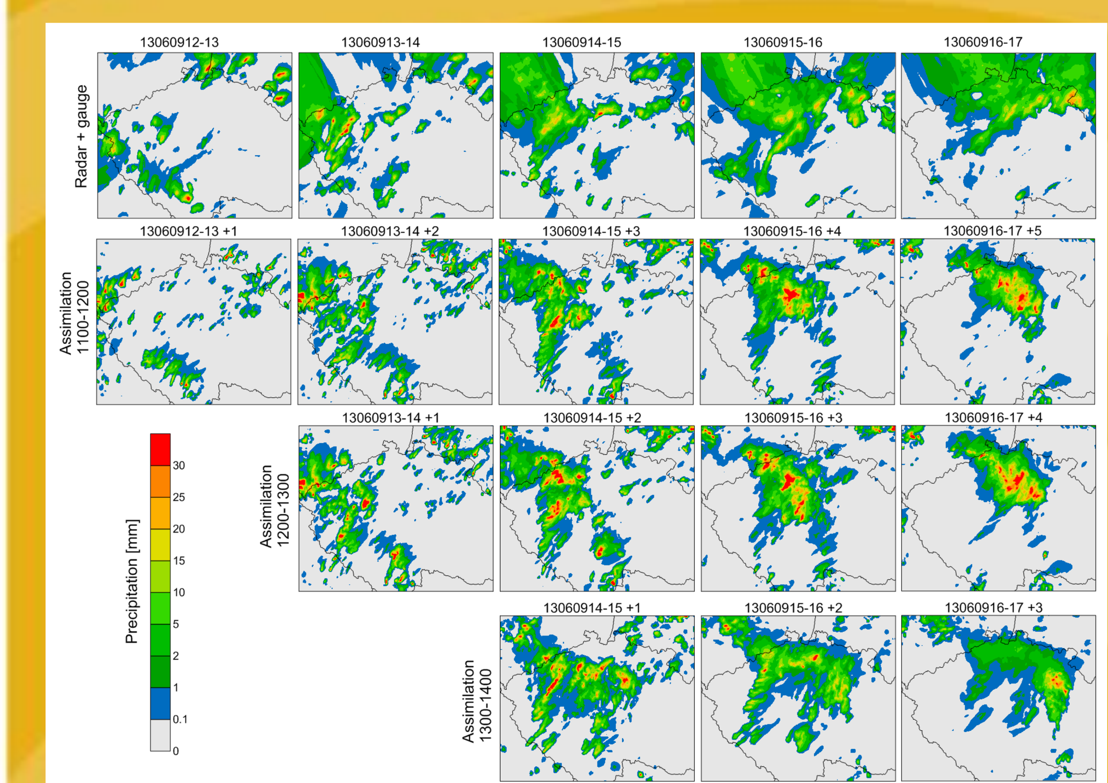

Fig. 5. The same as Fig. 2 for 9th June, 2013.

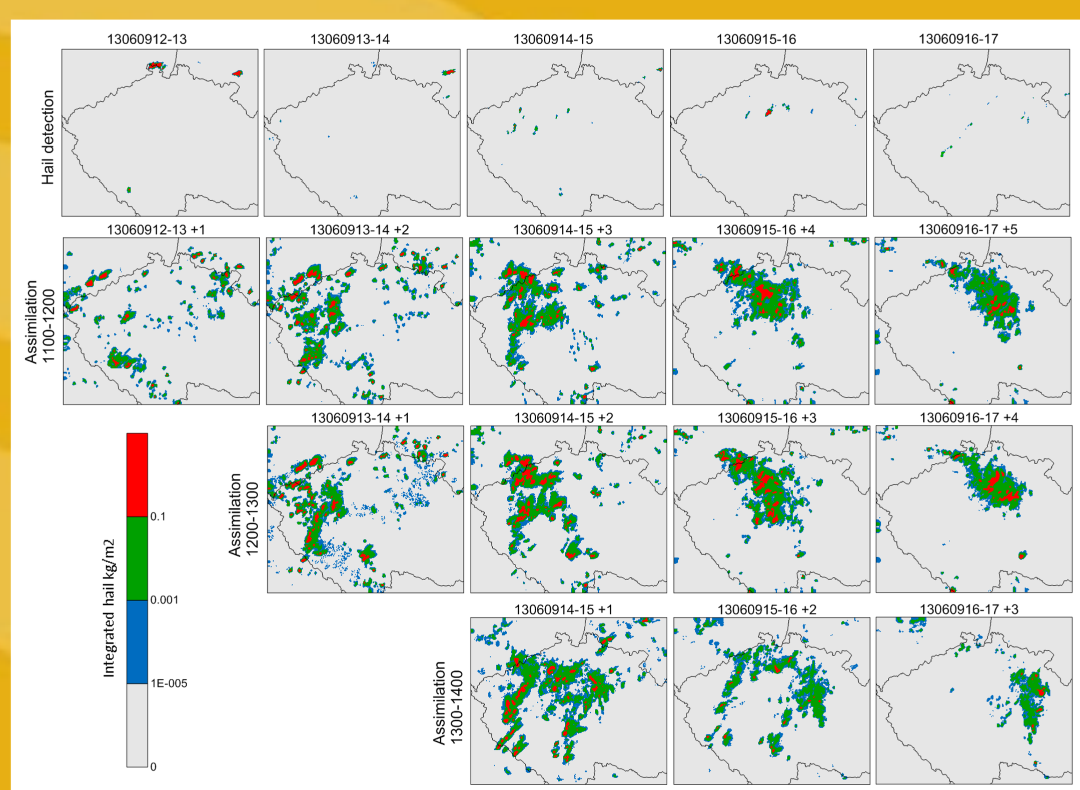

Fig. 6. The same as Fig. 3 for 9th June, 2013.

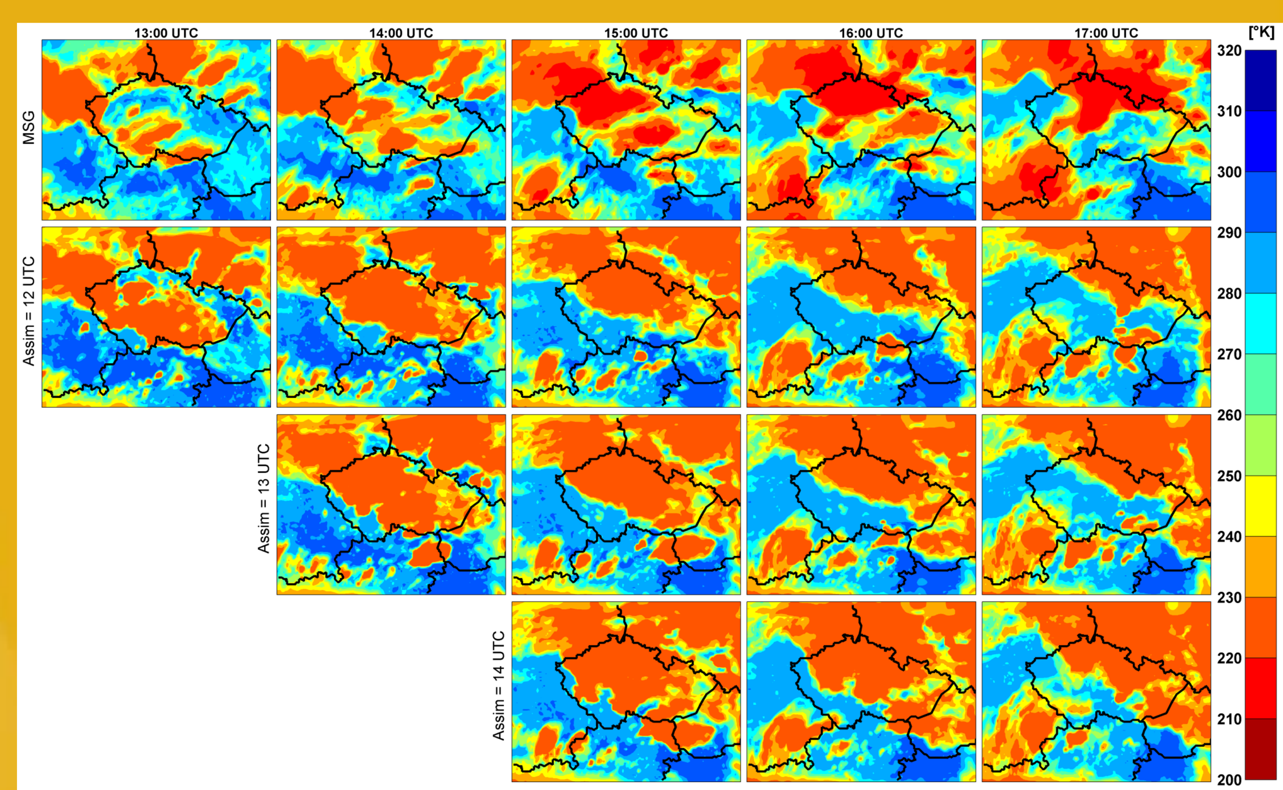

Fig. 7. The same as Fig. 4 for 9th June, 2013.

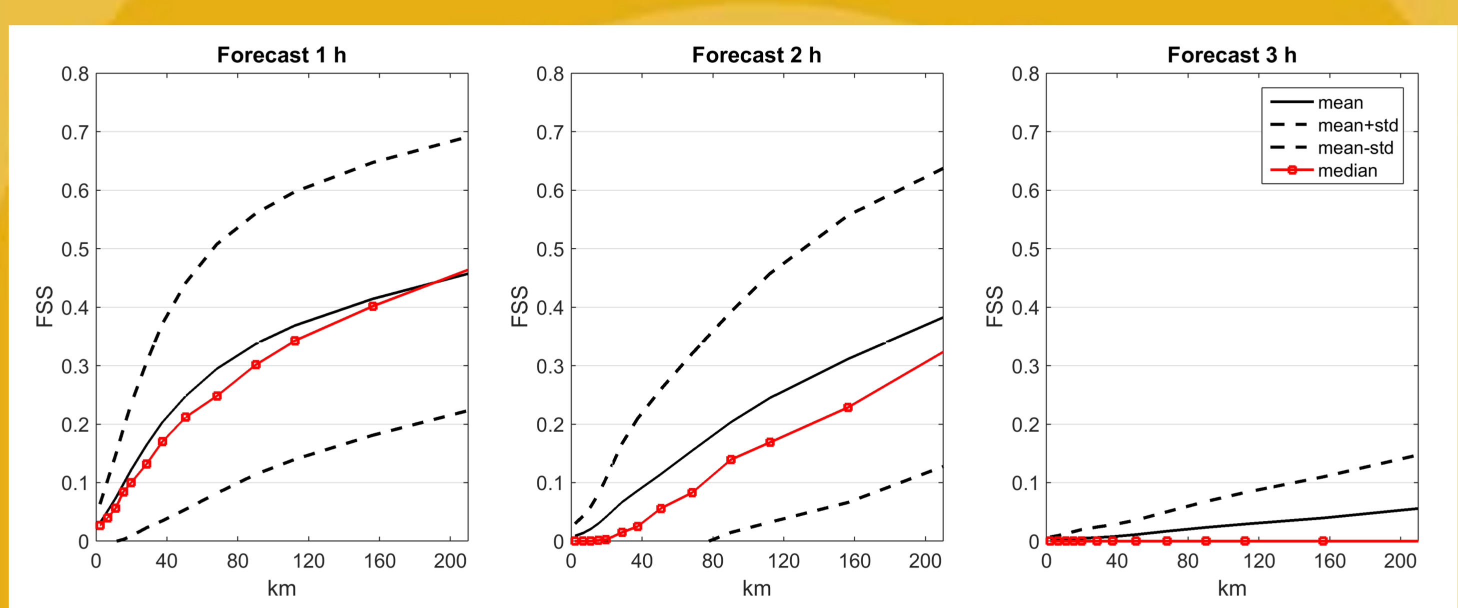

Fig. 8. Evaluation of hail forecasts by FSS (Roberts et al., 2008) for lead times 1, 2 and 3 hours for six events (19 forecasts). The curves show mean, median and mean +/- standard deviation of FSS. Sizes of squares, used to calculate FSS, are shown in x axis.

Conclusions

- Assimilation is crucial for both precipitation and hail forecast (not shown in figures).
- In case of organized convection the COSMO model provides useful precipitation forecasts for lead times up to 3-4 hours. The model partly overestimates maximum "observed" precipitation derived by merging radar and gauge data. This overestimation is not crucial because the "observed" values might be underestimated due to attenuation of radar measurements in centers of convective storms.
- Hail forecast is difficult to verify because reliable observations are not available. The applied technique was developed using hail events causing damage (data from insurance companies were used) and it may be inaccurate. COSMO outputs contain integrated amount of hail on the ground, which does not contain information on hail diameter. Therefore using various contour levels we can determine regions with probable hail occurrence and the higher level the higher probability of devastating hail. From this viewpoint COSMO can forecast areas endangered by hail for lead time up to 2 h. On the other hand COSMO identifies much larger areas than are "observed".
- Verification of COSMO by comparing simulated and observed radiances (temperatures) by MSG confirms that the model reasonable well develops convective storms.

References

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