Analysis of the WRF-HAILCAST model applied to the Croatian area

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Aim & Motivation

- **Knowledge about hail characteristics** in the continental part of Croatia, in comparison to the coastal parts, **is extremely disproportionate**.
- **Hailpads** are placed → **at main meteorological stations**, as well as **on a specially designed polygon in north-western Croatia**
- Highest frequency of intense hail → **western and central Croatia**
- Aim → **to examine processes leading to hailstone growth and to provide guidance for hailcast results tuning**

Model & Simulation specifications

- **WRF-ARW 3D nonhydrostatic mesoscale model**
- A one-way nested configuration with grid spacing of **9 km**, **3 km** and **1 km** and **66** eta **levels**
- Initial and boundary conditions → ECMWF analysis
- WRF physics options for all domains:
  - **Mellor-Yamada Nakanishi and Niino Level 2.5 PBL**
  - longwave radiation → **RRTM**, shortwave radiation → **Dudhia scheme**
  - microphysics → **Morrison double-moment scheme**
  - surface layer → **MYNN** surface layer
  - surface physics → **Noah Land-Surface Model**

Episode A : 30 July 2014

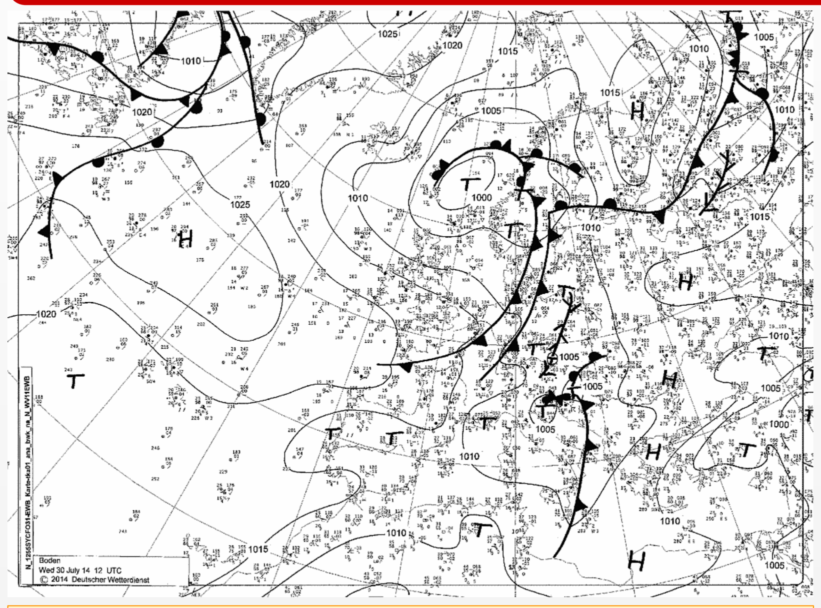

Figure 1: **Surface diagnostic chart at 12 UTC on 30.7.2014** for Europe (Source: wetter3.de). Croatia is under influence of low pressure system. Winds are moderate and from E to SE directions.

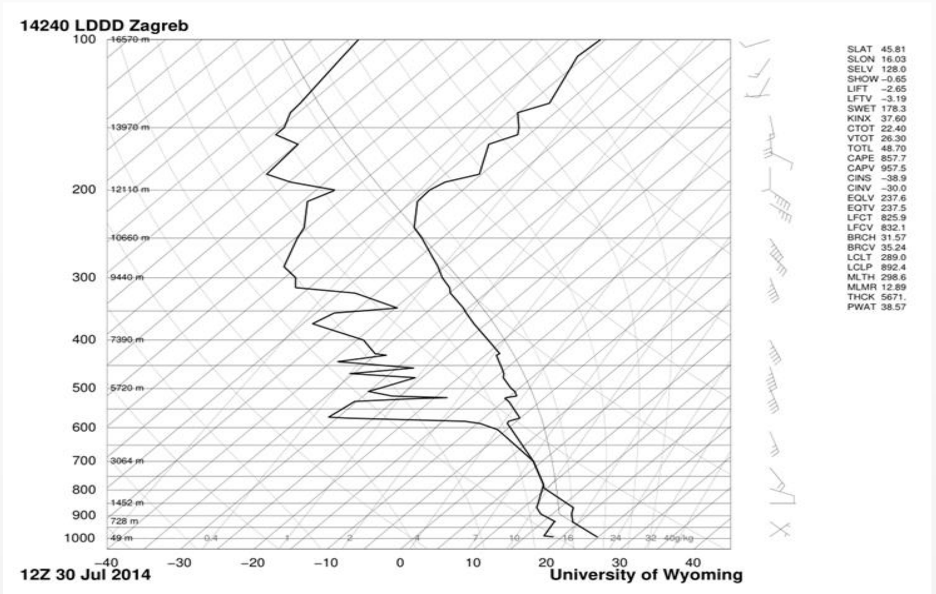

Figure 2: **Sounding from Zagreb, Croatia (30.7.2014, 12 UTC)**. CAPE = 857.7 J kg-1, LI = -2.65, K = 37,60 indicate a strong potential for convective activity. Freezing level is at 650 hPa and cloud base at 800 hPa. Strong dew point depression begins above 600 hPa.

Episode A Results

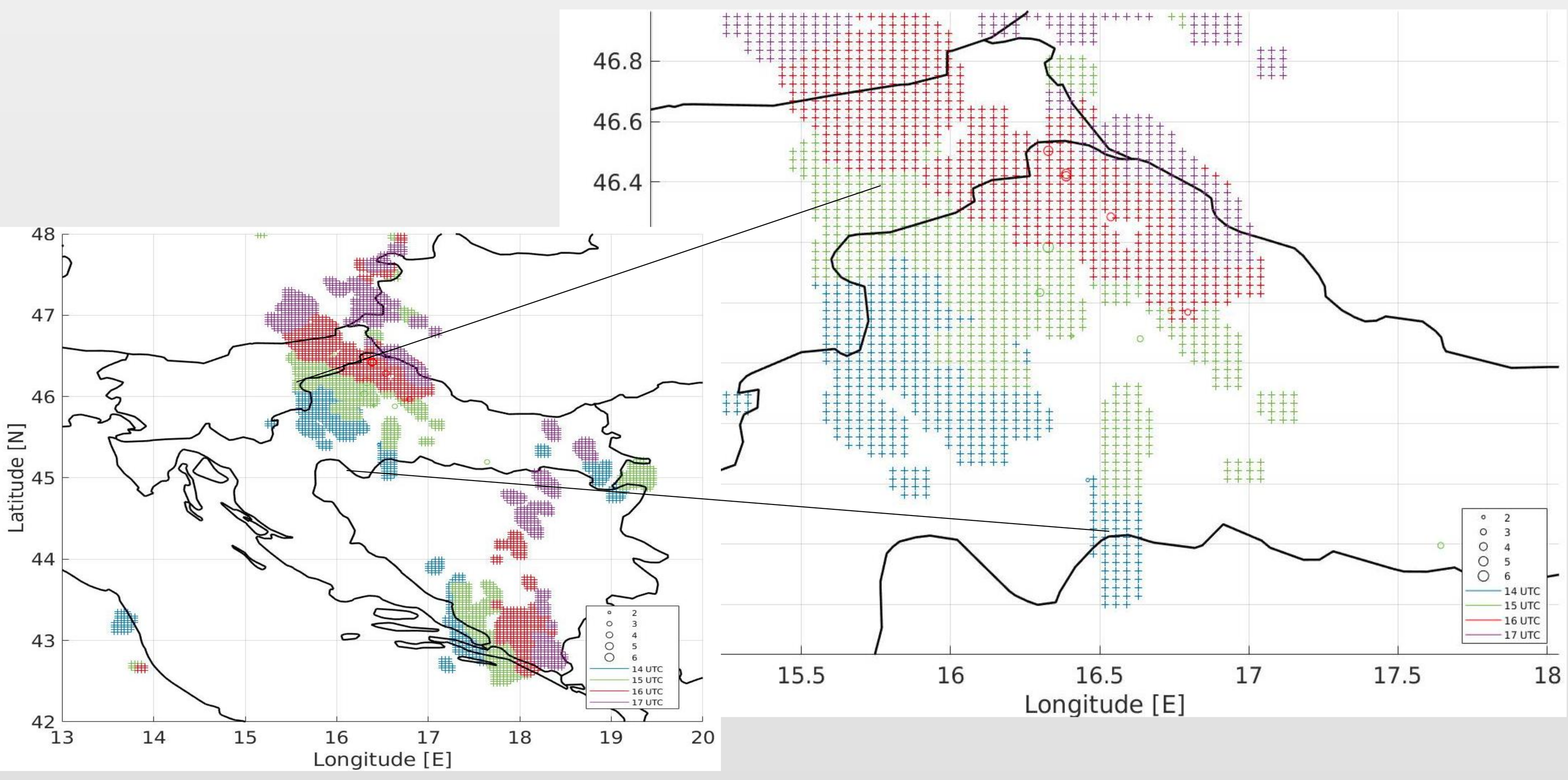

Figure 5: **Modelled and measured maximum hail diameter**. Colours represent UTC time, size of the crosses and circles modelled, i.e. measured max hail diameter classified into hail categories. The analysed region is covered with many hailpads but only few of them registered hail. The model simulated the events very well, but took into account too large an area.

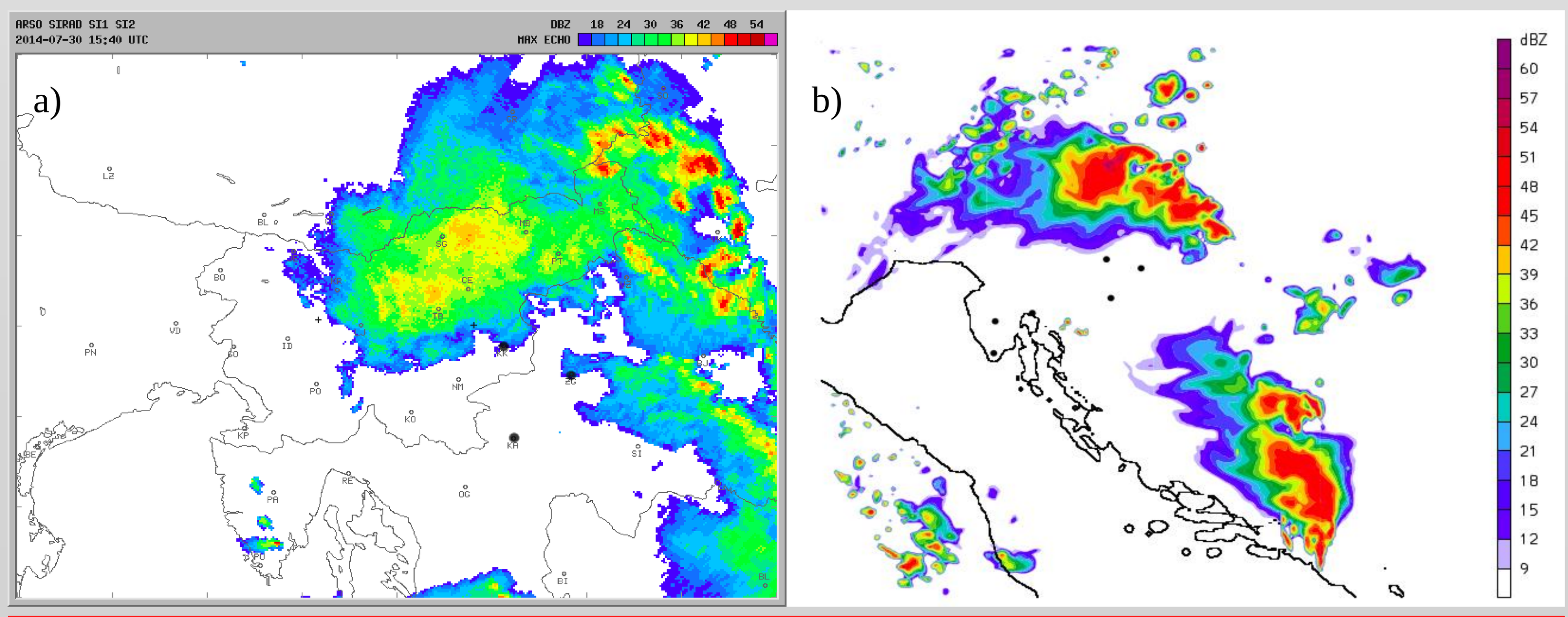

Figure 7: (a) **Measured** (15:40 UTC) **and** (b) **modelled** (16:00 UTC) **maximum radar reflectivity** (dBZ). In northern Croatia, spots with maximum radar reflectivity above 40 dBZ occur. We can link some of these areas with observed hail (fig 5). The modelled maximum radar reflectivity affects much larger area and has slightly higher values. It consequently predicts widespread hail.

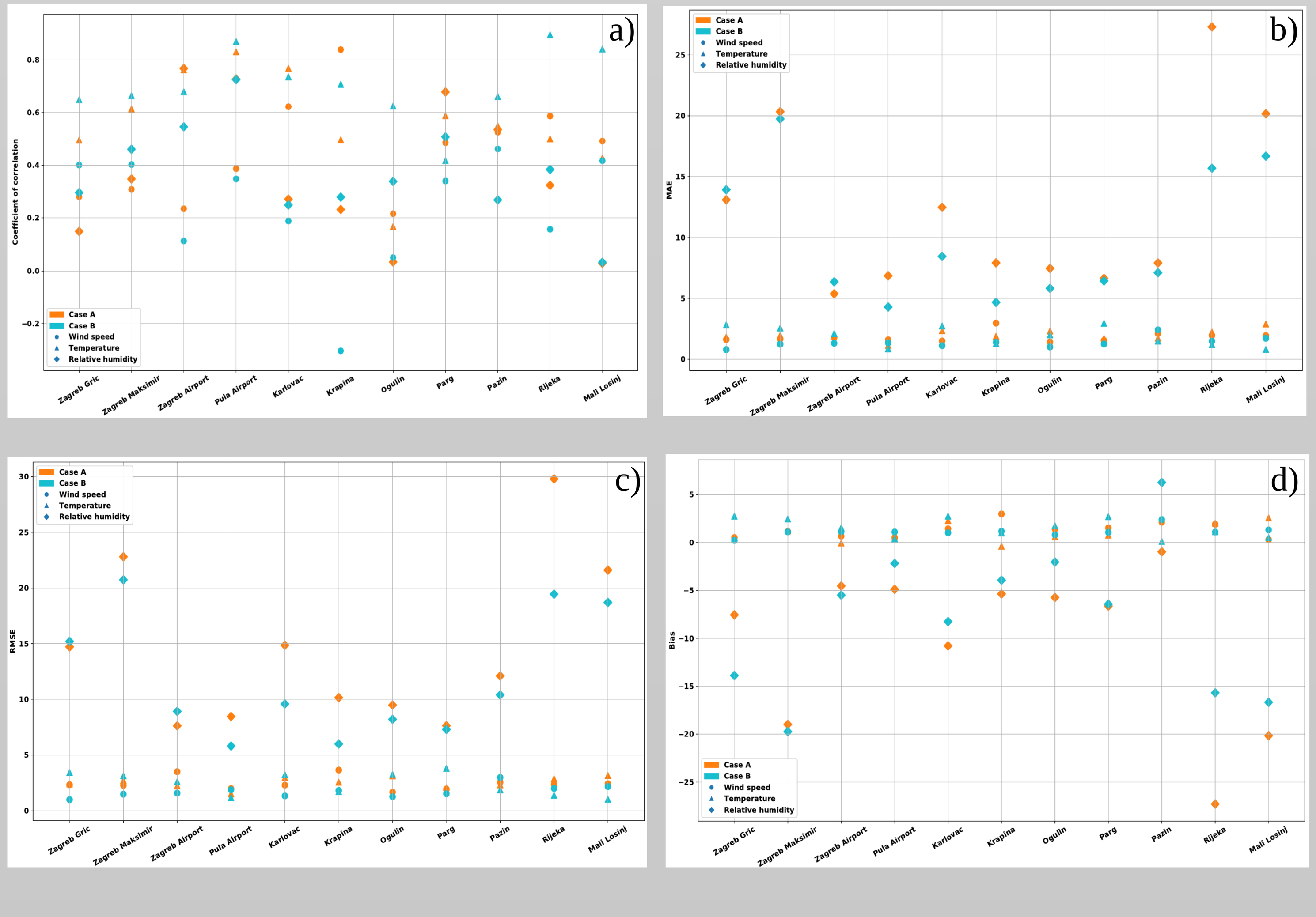

Figure 9: **Statistical parameters** for wind speed, temperature and relative humidity, a) **Correlation coefficient** b) **MAE** c) **RMSE** d) **Bias**.

The model shows satisfying results, but their precision spatially fluctuates. The deviation of temperature and wind speed (RMSE) for both episodes does not exceed 5 °C, i.e. 5 m/s. Wind speed and temperature are overestimated at all stations (except one) in both episodes (Bias). The deviation of relative humidity varied from around 5% to 30%; it is underestimated at all but one station.

Episode B : 16 - 17 September 2017

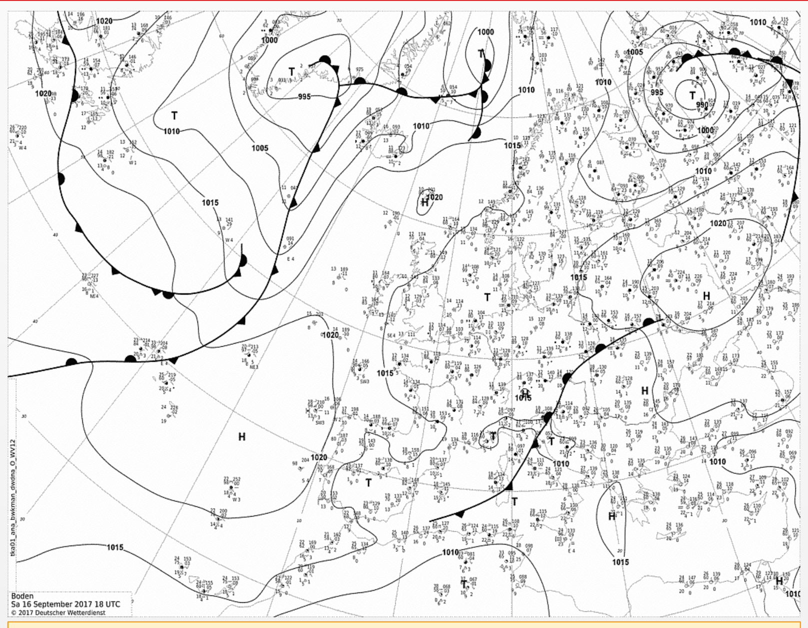

Figure 3: **Surface diagnostic chart at 18 UTC on 16.9.2017** for Europe (Source: wetter3.de). Target area is under influence of low pressure system. Winds are weak from S to SW directions.

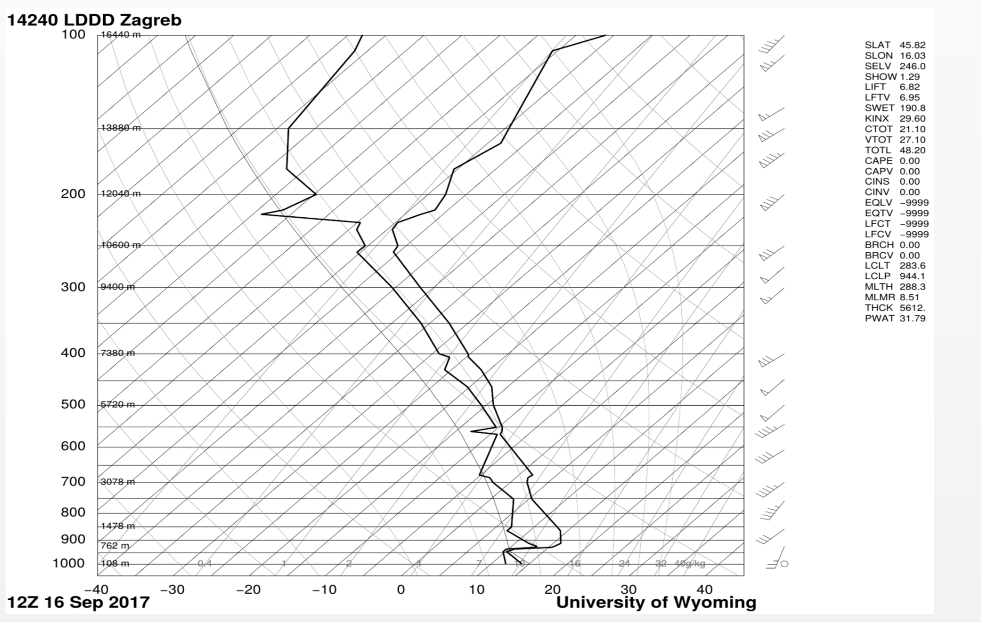

Figure 4: **Sounding from Zagreb, Croatia (30.7.2014, 12 UTC)**. CAPE = 0.0 J kg-1, LI = 6.82 indicate stable and K = 29.6 and TT = 48.2 °C marginally unstable conditions. Freezing level is at 660 hPa.

Episode B Results

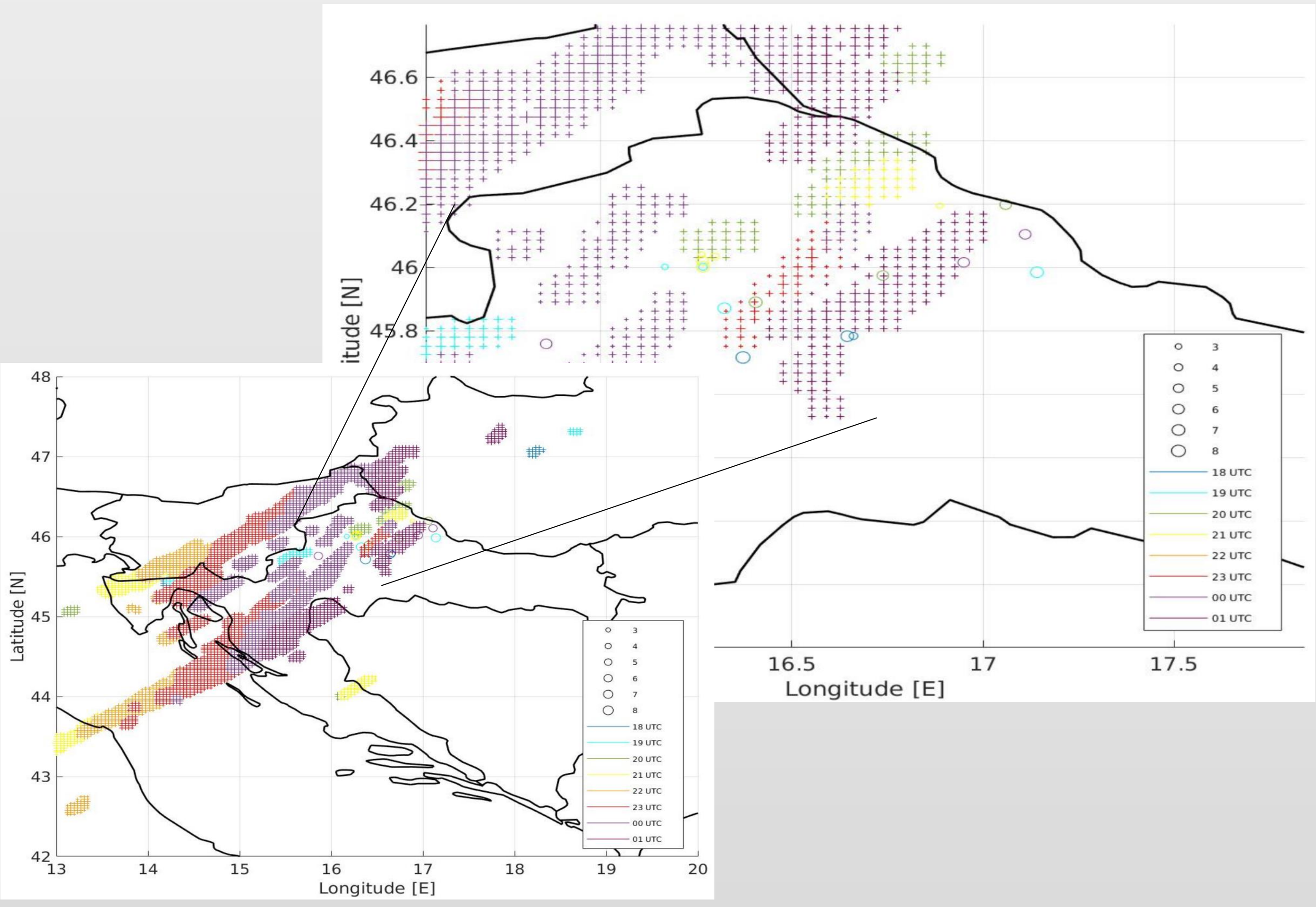

Figure 6: **Modelled and measured maximum hail diameter**. Colours represent UTC time, size of the crosses and circles modelled, i.e. measured max hail diameter classified into hail categories. Model didn't capture temporal characteristics of the observed hail and took into account too large an area.

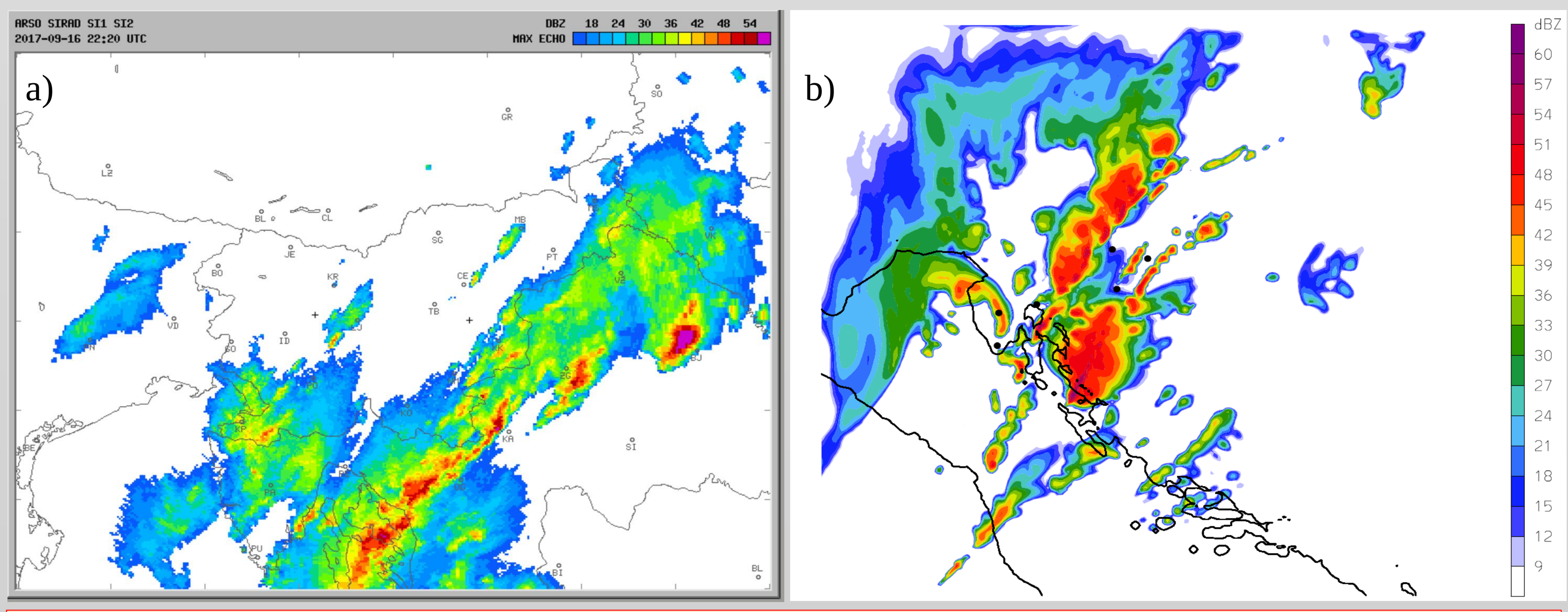

Figure 8: (a) **Measured** (22:20 UTC) **and** (b) **modelled** (23:00 UTC) **maximum radar reflectivity** (dBZ). Spots with maximum radar reflectivity above 40 dBZ occur; some of these areas can be linked with observed hail (fig 6). The modelled maximum radar reflectivity has slightly higher values and affects an area that is larger and NW from the observed area. It consequently predicts widespread hail.

Summary & Conclusions

- WRF - HAILCAST overestimated the values of analysed parameters, but in general, synoptic conditions favourable for developing stormy weather over northern Croatia are successfully reproduced in both analysed episodes.
- Target area is overestimated in both episodes.
- Model successfully captured measured maximum hail diameter in episode A both spatially and temporally. However, in episode B measured maximum hail diameter was not captured temporally.

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