Assimilation of radar reflectivity into the LM model with a high horizontal resolution

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Motivation: Flash flooding in the CR

4.5.2001 Ostrovce
http://www.chmi.cz/poboc/PL/

13.7.2002 Chocerady foto
ÚFAAVČR

15.7.2002 Olešnice
http://www.chmi.cz/poboc/BR/

extreme event in July 1998, Orlice (202mm)

Data, NWP model

Data set :

- CZRAD-CHMI, 2 radars
- ~ 800 gauges measure daily rainfalls

LM COSMO

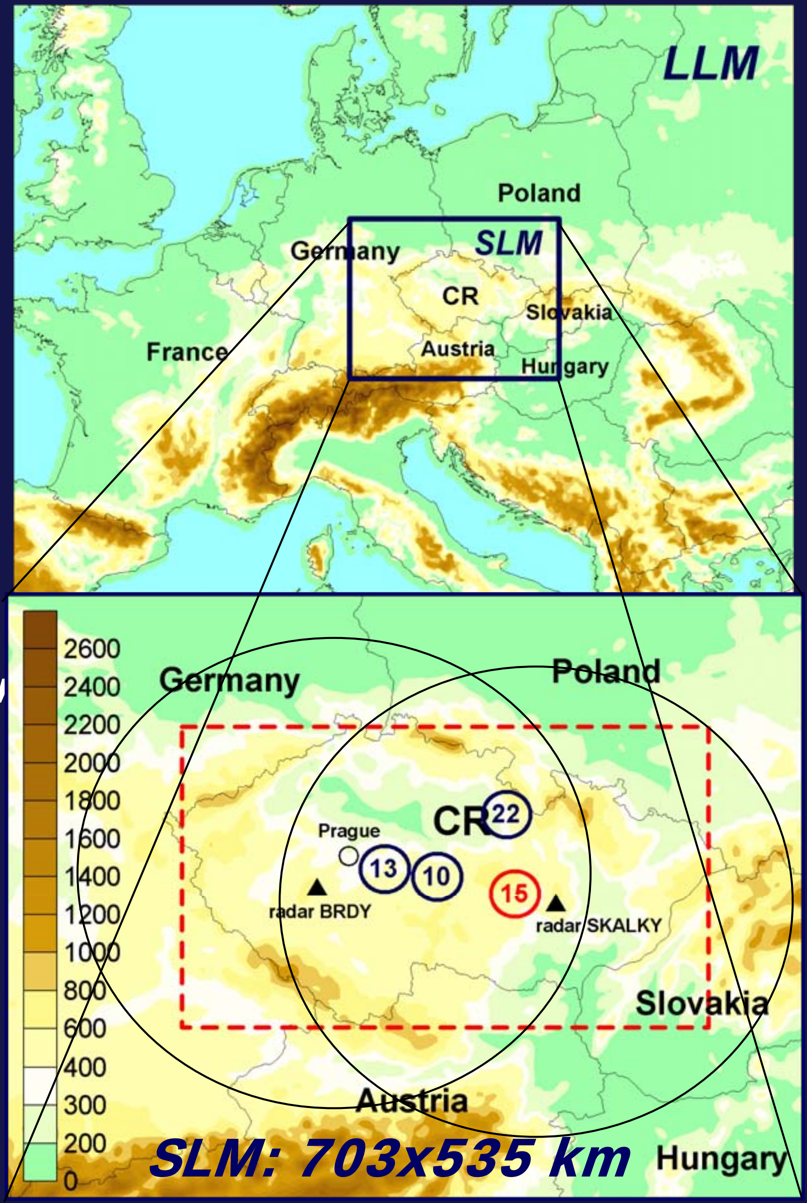
(i) v3.09 with diagnostic precipitation

(ii) v3.16 with prognostic precipitation

LM: LLM → SLM

- **LLM :** 231x175 g.p., **<u>11km</u>**, 00UTC+24h, init.cond. ECMWF
- **SLM** : 251x191 g.p., **<u>2.8 km</u>**, 06UTC+18h, init.con. LLM
- CZRAD - 2 radars

- Local flash flood storm 150702



Assimilation of radar data

- Data: radar reflectivity
  - Δt=10 min.,
  - Area resolution Δh=1km x 1km
  - Vertical levels: 1000, 1500,..., 14000m
  - Relations used (Hagen, Yuter, 2003):

$$Z = 200R^{1.6}$$

$$W = 3.4Z^{4/7}$$

$$Q = \frac{W}{\rho}$$

Z	reflectivity [dBZ]
R	rain rate R [mm/h]
W	liquid water content [mm^3/m^3]
Q	water vapour mixing ratio [kg/kg]
ρ	air density [kg/m^3]

Assimilation method

- Based on: Falkovich et al. (2000), Davolio and Buzzi (2004)
- Modifications $\mathbf{q_v}$ (water vapour mixing ratio)
- Modifications are made in each time step (30s) in each gridpoint
- Changes depend on:

$$D_k = Q(R^{RAD}_{ground}) - Q(R^{NWP}_{ground})$$

or

$$D_k = Q(R^{RAD}_{k}) - Q(R^{NWP}_{ground})$$

(A)
If **D > 0** … actual rain rate is higher than model rain rate

$q_{v,k}^{new} = q_{v,k} + DIF$

$DIF = MIN(\alpha D, \delta)$

$D = Q(R^{RAD}_{ground}) – Q(R^{NWP}_{ground})$

$\delta = MAX(\varepsilon^{+} q_{sv,k}(T_k) – q_{v,k}, 0)$

$q_{sv,k}(T_k)$ – saturated q_v for T_k

Parameters: $\alpha=0.001$ $\varepsilon^{+}=1.02$

(B)
If **D < 0** … actual rain rate is lower than model rain rate

$q_{v,k}^{new} = q_{v,k} - DIF$

$DIF = MIN(\alpha D, \delta)$

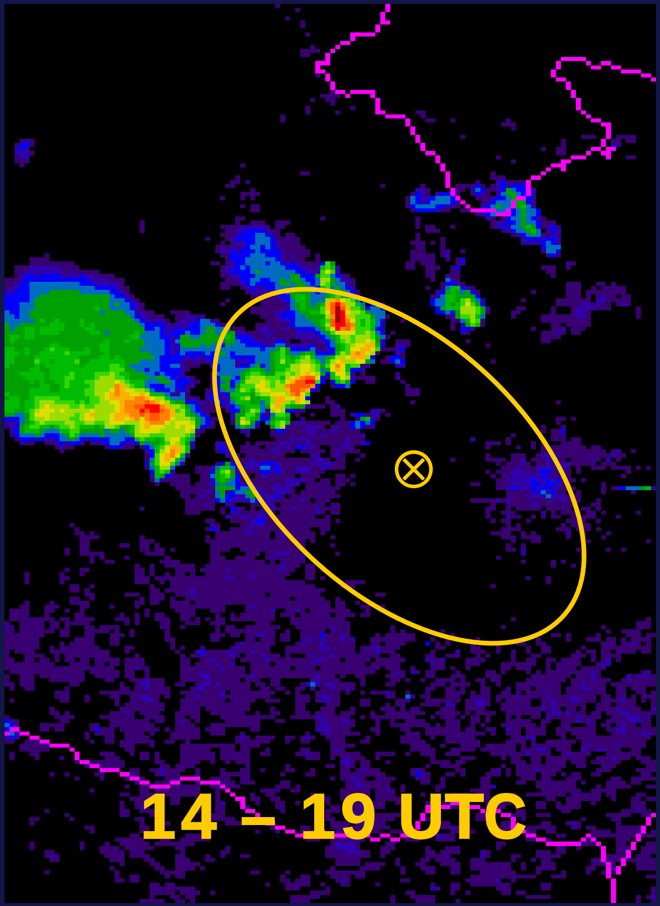
$D = -\{Q(R^{RAD}_{ground}) - Q(R^{NWP}_{ground})\}$

$\delta = MAX(\varepsilon^{-} q_{sv,k}(T_k) - q_{v,k}, 0)$

$q_{sv,k}(T_k)$ – saturated q_v for T_k

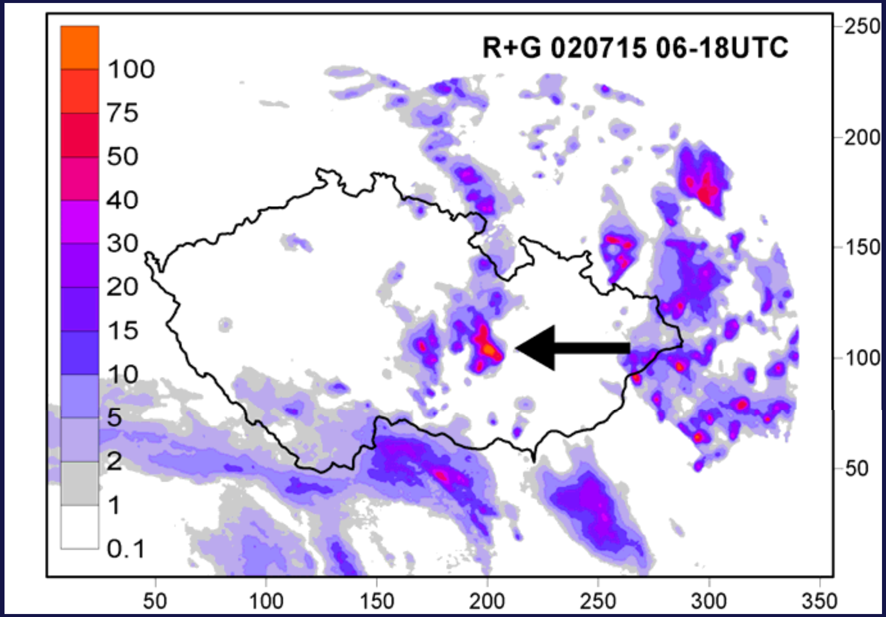
Parameters: $\alpha = 0.001$ $\varepsilon^{-} = 0.95$

Convective event 150702

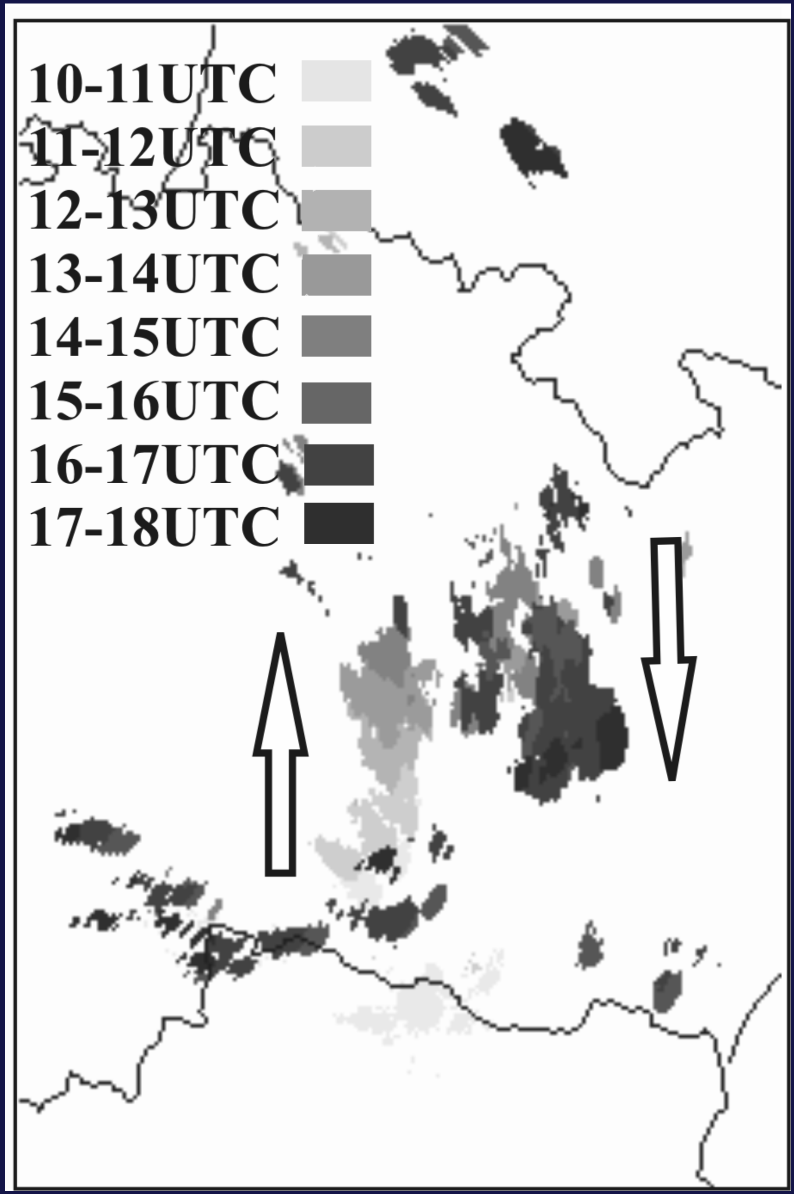


- 15/7/2002 multicellular convection
- 15-17UTC: convective storm in nearly steady position
- ⊗ daily max. rainfall of <u>171 mm</u>
- local flash flood, local damage

150702



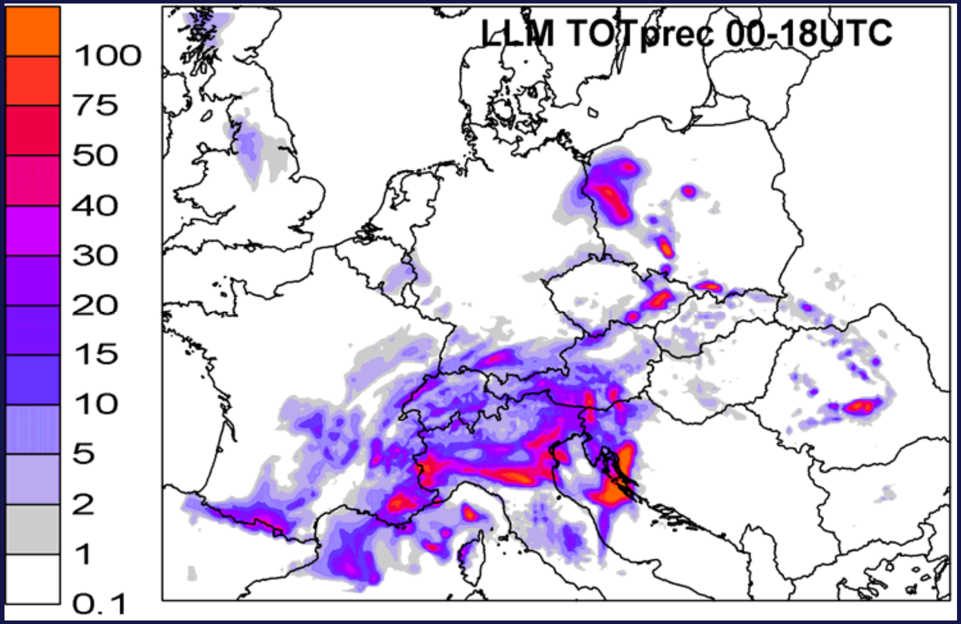
Radar+gauges 06-18 UTC
Max. observation 171 mm



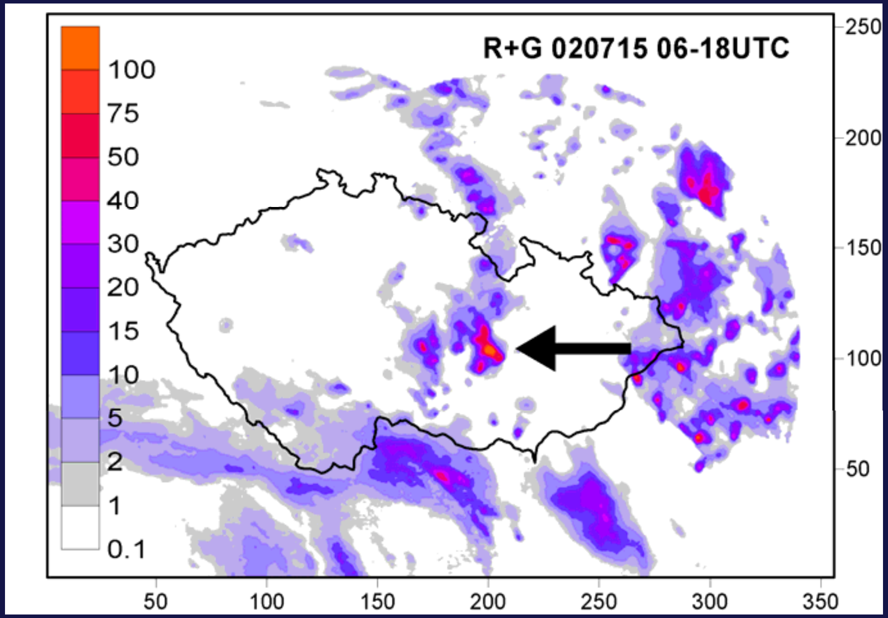
Time development of Z_{max}

Rainfall 1507 06-18UTC

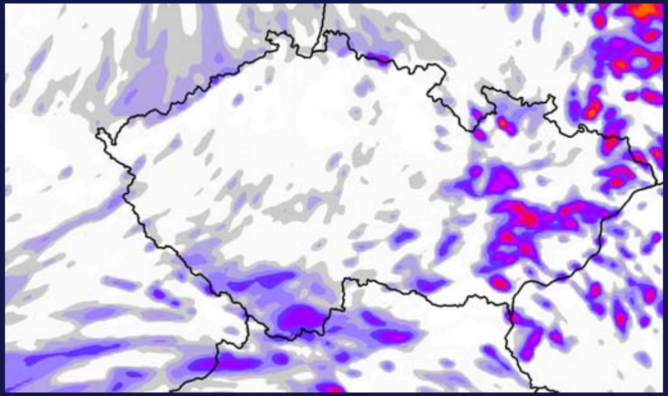
LM 3.09, h=11km, 06-18 UTC



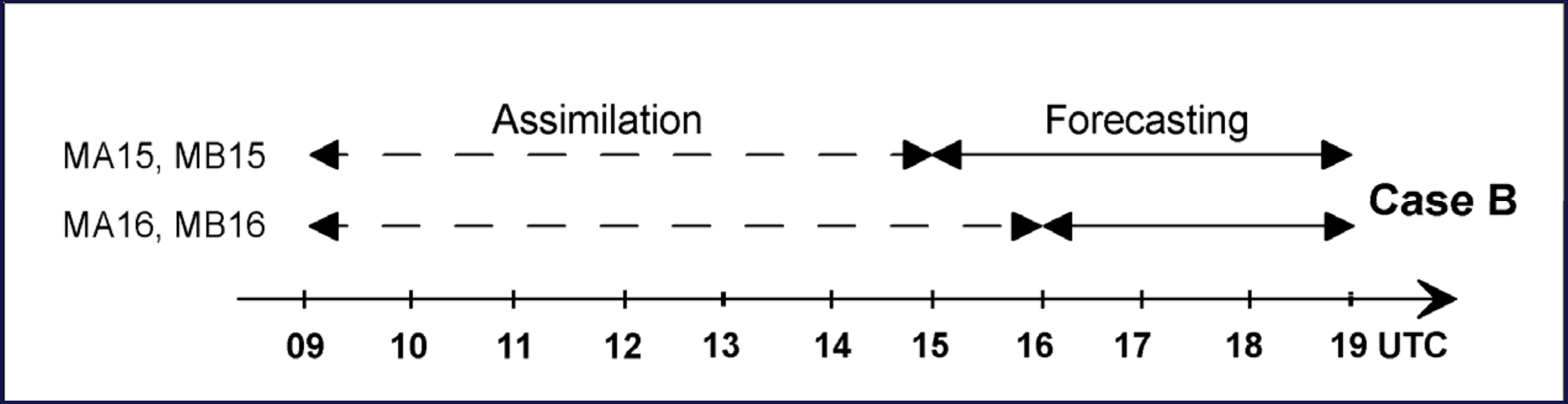
Estimated precipitation



LM 3.09, h=2.8km 06-18 UTC



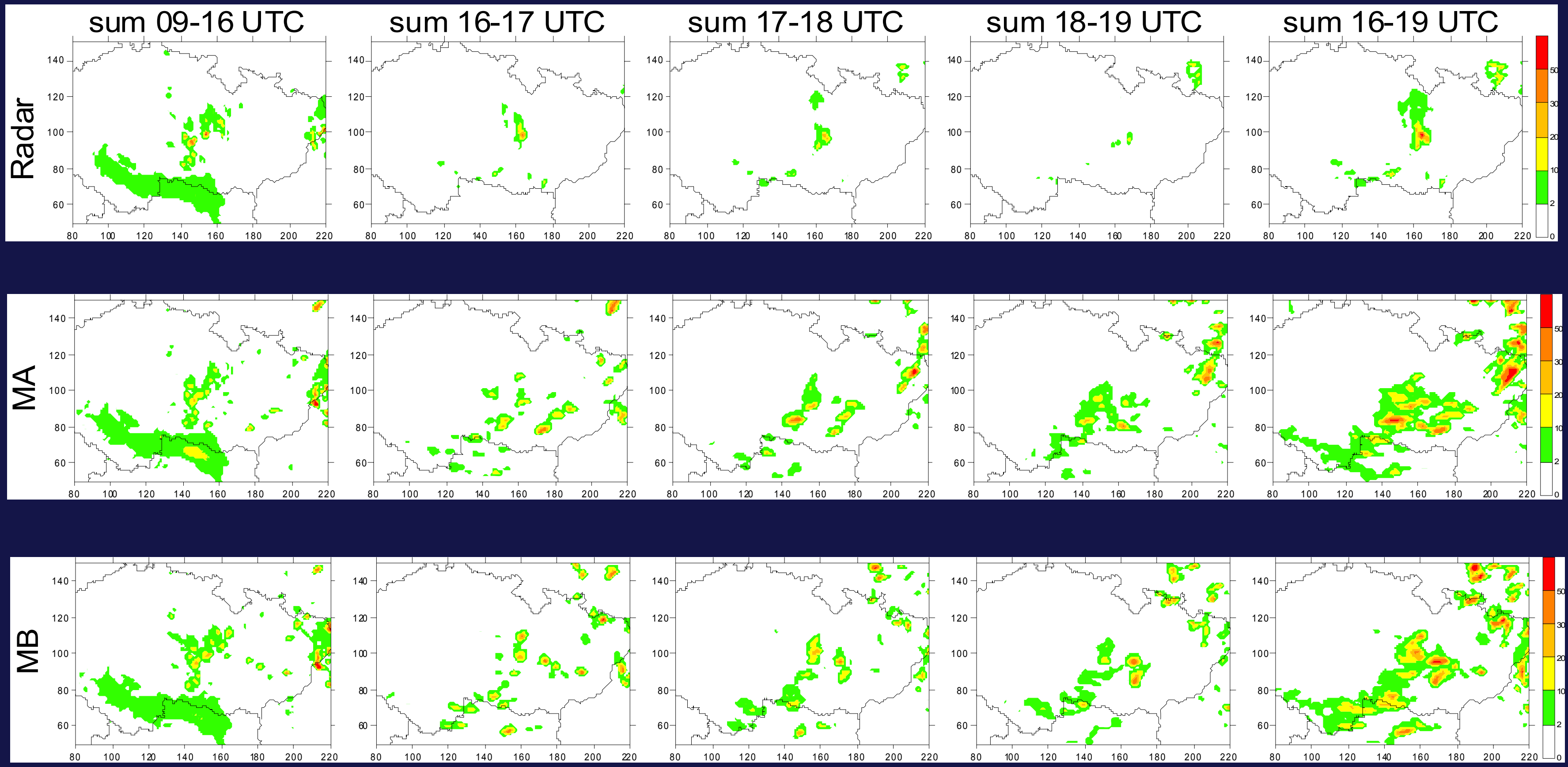
Assimilation of radar data



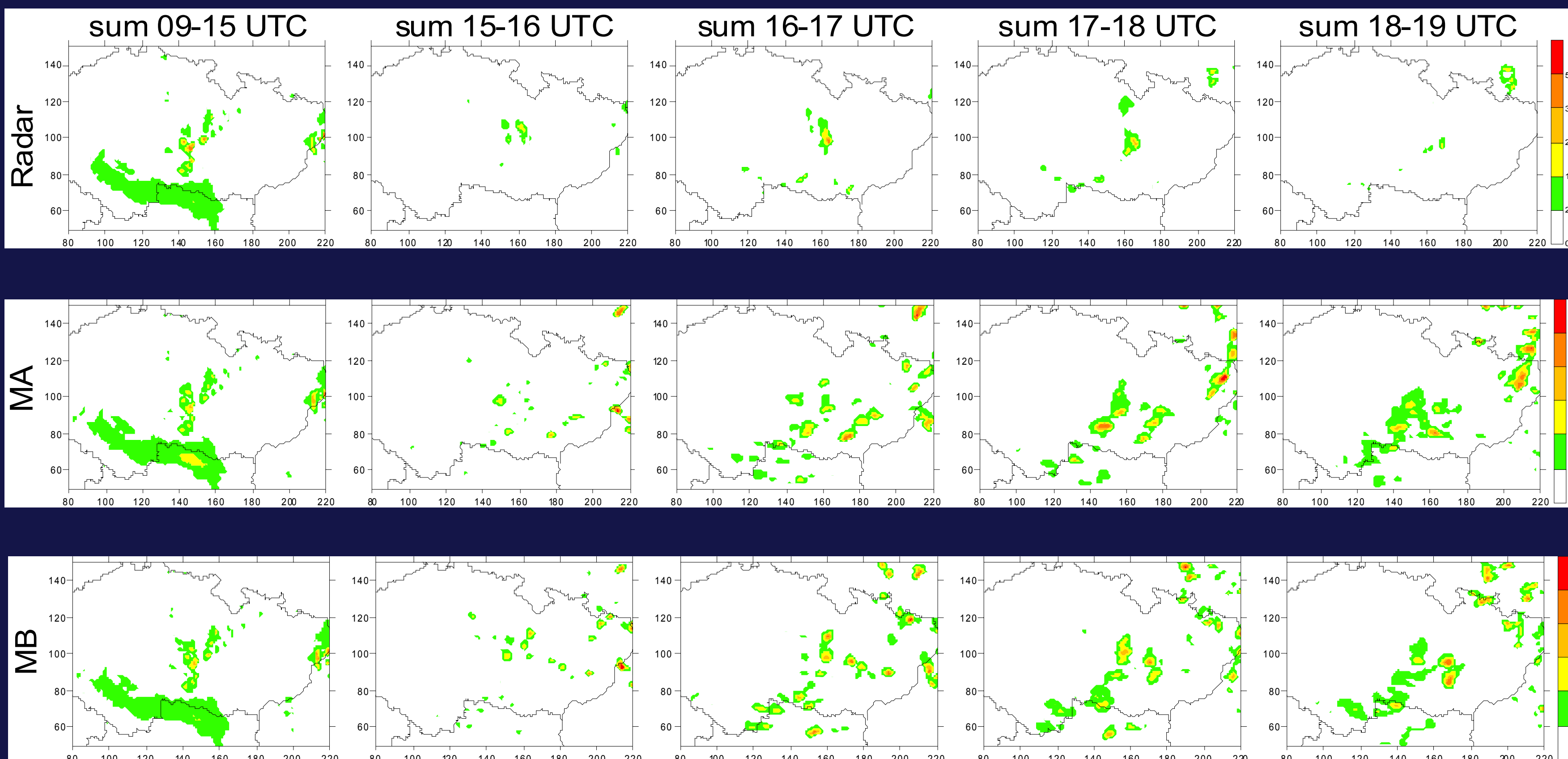
MA: $D_k = Q(R^{RAD}_{ground}) - Q(R^{NWP}_{ground})$

MB: $D_k = Q(R^{RAD}_{k}) - Q(R^{NWP}_{ground})$

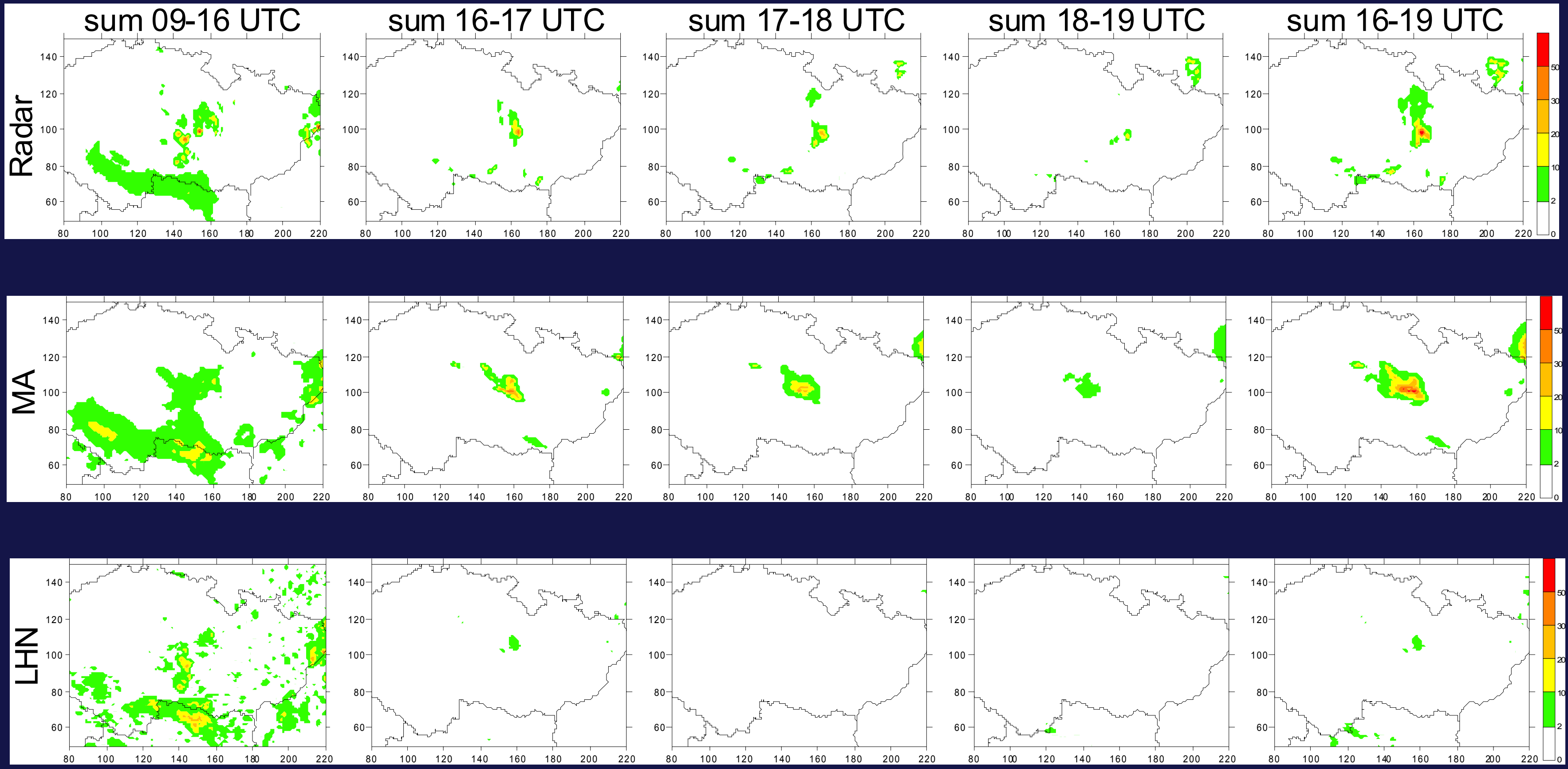
LM 3.09: Assimilation 09-16 UTC
Forecast 16-19 UTC



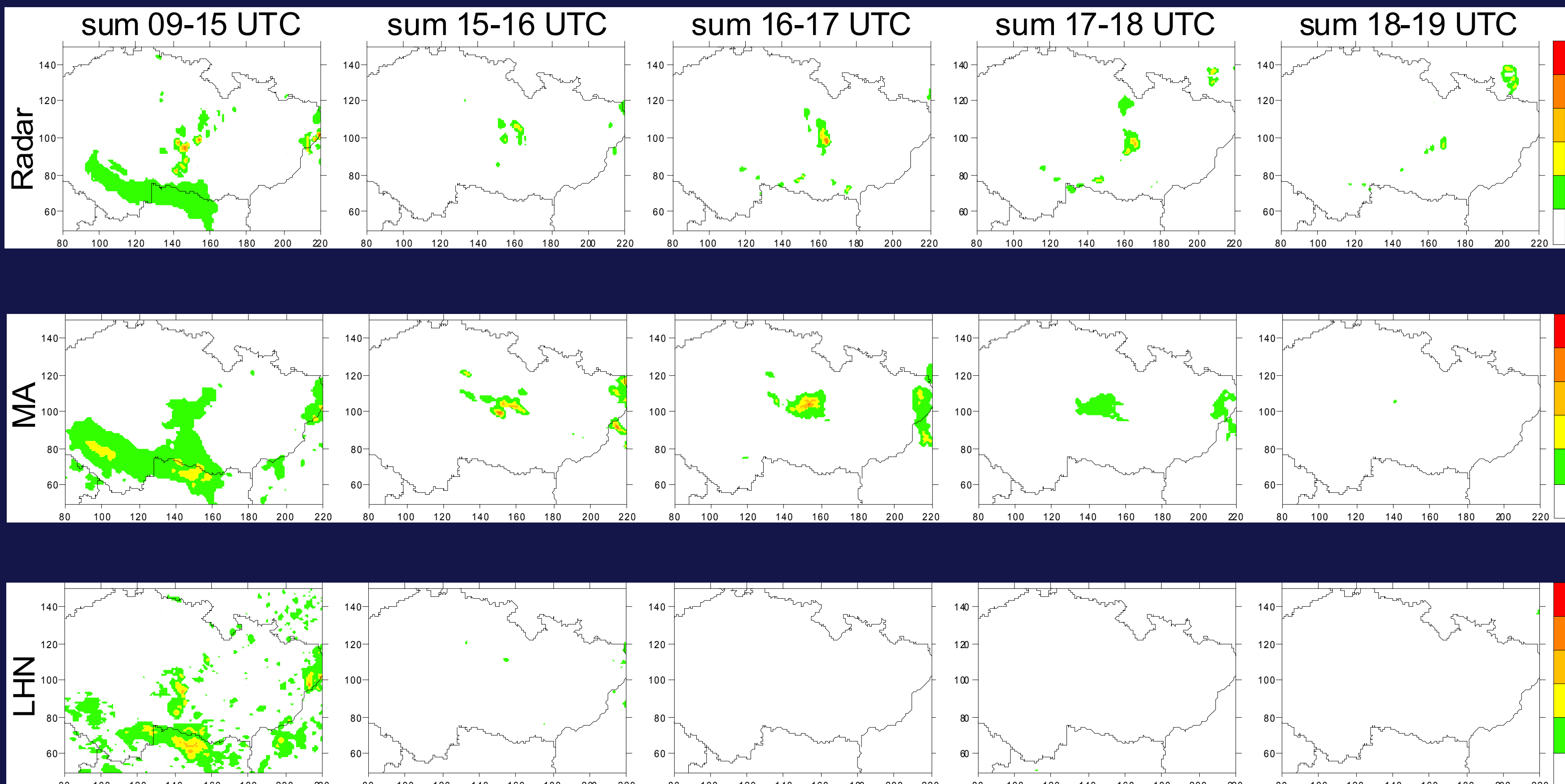
LM 3.09: Assimilation 09-15 UTC
Forecast 15-19 UTC



LM 3.16: Assimilation 09-16 UTC
Forecast 16-19 UTC



LM 3.16: Assimilation 09-15 UTC
Forecast 15-19 UTC



Conclusions - 1

Assimilation:

- Assimilation of radar reflectivity apparently improves the precipitation forecast of convective storms
- The improvement is visible 2-4 hours after finishing the assimilation
- The proposed method is an alternative to the LHN method

Conclusions - 2

LM model (our experience):

- The diagnostic precipitation scheme in LM3.09 and LM3.16 yields different forecasts
- The precipitation forecast by LM3.16 with the prognostic precipitation scheme seems to be smoother than the forecasts by LM3.09 with the diagnostic scheme

Acknowledgement:

DWD (LM COSMO)

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Thank you