Assimilation of 3D radar reflectivity into the Local model

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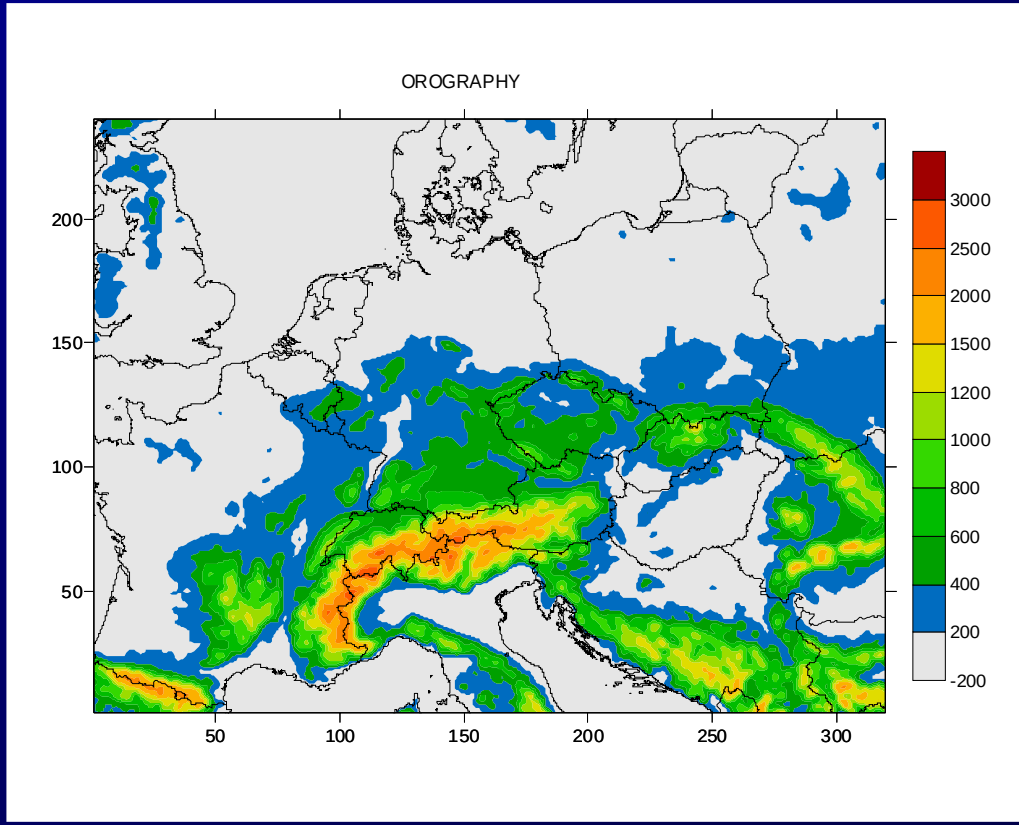
Content

- LM model
- Radar data
- Assimilation methods: 2D and 3D
- Case studies
- Conclusions

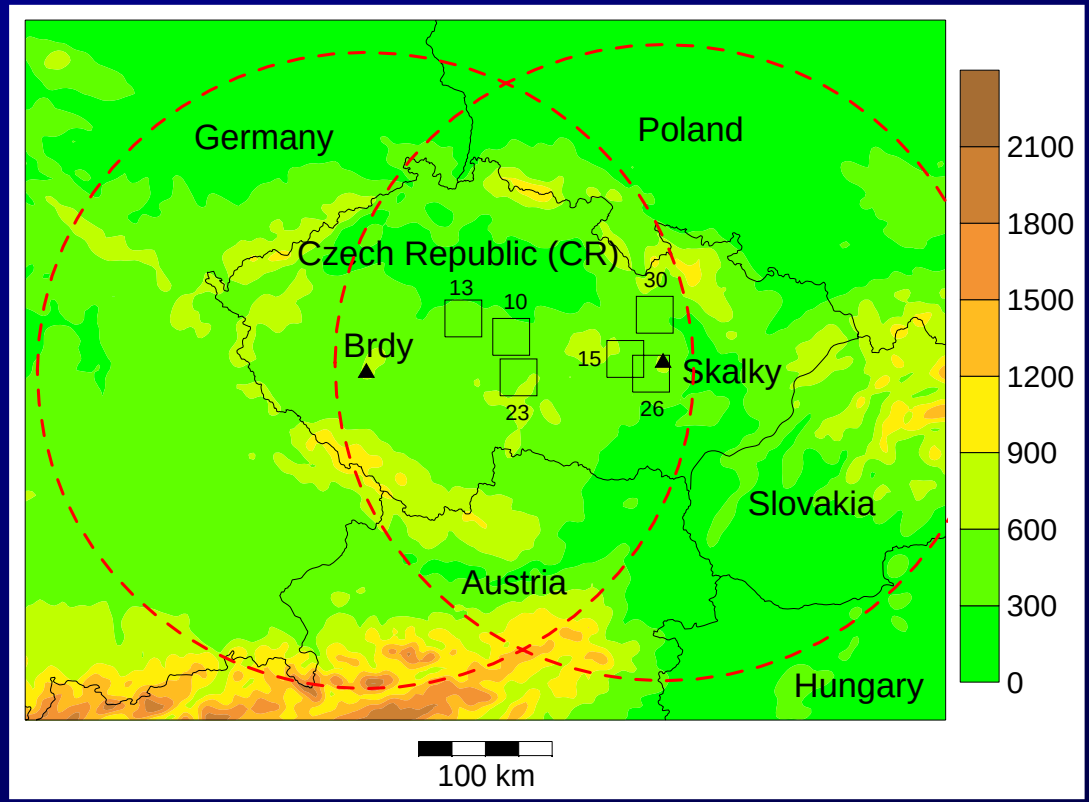
Implementation of the LM (version 3.18)

- Δh = 11 km
- 35 vertical levels
- ECMWF analyses
- Tiedtke's cumulus parameterization
- Prognostic variables:
  - rain water
  - ice



SLM

- Δh = 2.8 km
- 35 vertical levels
- Explicit precipitation
- Prognostic variables:
  - rain water
  - ice
  - graupels

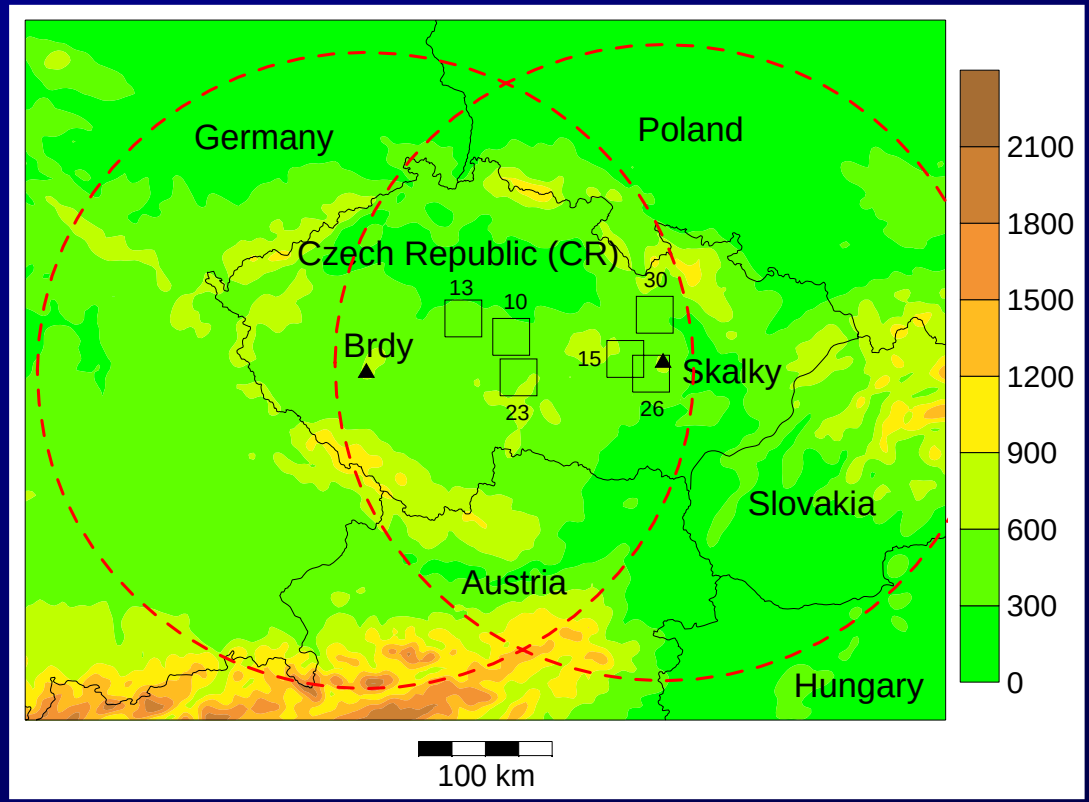


Radar data

- Brdy, Skalky
  C-band
- Resolution 1km x 1km
- Δt=10 min.
- Z-R α=200, β=1.6

$$Z = \alpha R^{\beta}$$

- CAPPI 2km (ground precipitation)
- CAPPI at 1, 1.5, 2, …,
  14 km



Assimilation of radar reflectivity

WVC: Correction of q_V is based on the difference
D = "model precipitation" – "observed precipitation"
unit: [kg/kg]
(Falkovich et al., 2000) and (Sokol and Rezacova, 2006)

IF(D > 0)

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

$DIF = w(z)*MIN(\alpha*D, \delta)$

$\delta = MAX(\varepsilon^+ * q^s_{v,k}(T_k) - q_{v,k}, 0)$

ELSE

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

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

ε^+, ε^-, α … constants, k … vertical index, z … elevation
w(z) is weighting function

Types of assimilation methods

- WVC 2D

  D = "model prec." – "observed prec."

  at the ground
- WVC 3D

  D = "model prec." – "observed prec."

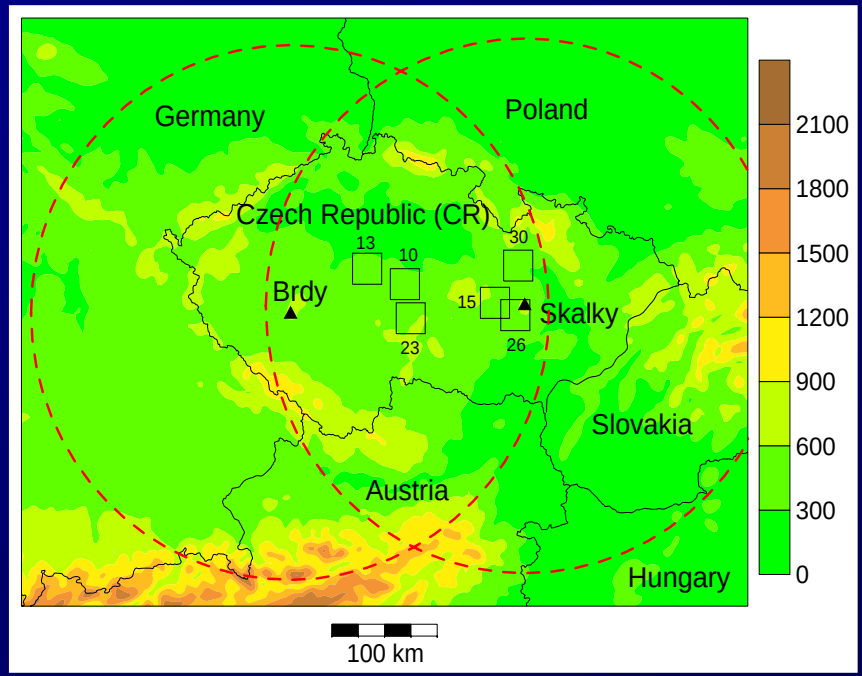
  at single model levels
- WVC VIL (3D)

  D = "model VIL" – "observed VIL"

  VIL – vertically integrated water vapour content
- LHN (2D)

Case studies

- Six convective storms from the CR
  (10 June 2004 14UTC, 13 July 2002 14UTC, 15 July 2002 15UTC,
  23 May 2005 14UTC, 26 May 2003 12UTC, 30 May 2005 14UTC)
- Duration approx. 3 hr, [T,T+3]
- Local storms
- Observed precipitation
  by rain gauges: 50 – 170 mm
- The centres of the events
  (g_1,g_2) – max. precip. [T,T+3]



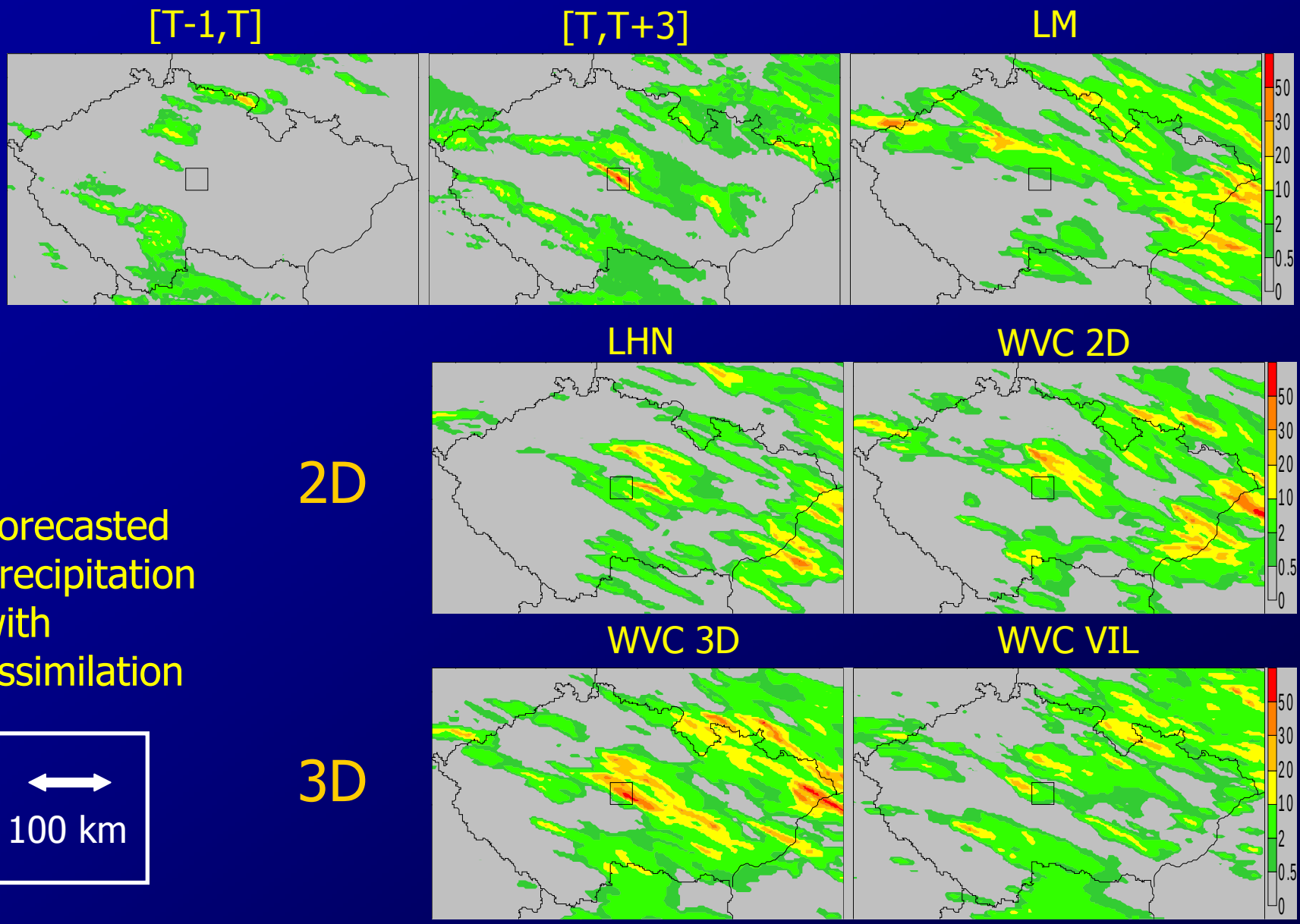
- Only radar data are
  assimilated and used in the verification
- Radar underestimates precipitation

Verification - evaluation

- Event oriented
- 3h precipitation [T,T+3]
- Methods of verifications
  - "by eye"
  - "objective evaluation" (using subjective criterions)

(i) Verification "by eye"

10 June 2004 - Observed precipitation T=14 UTC



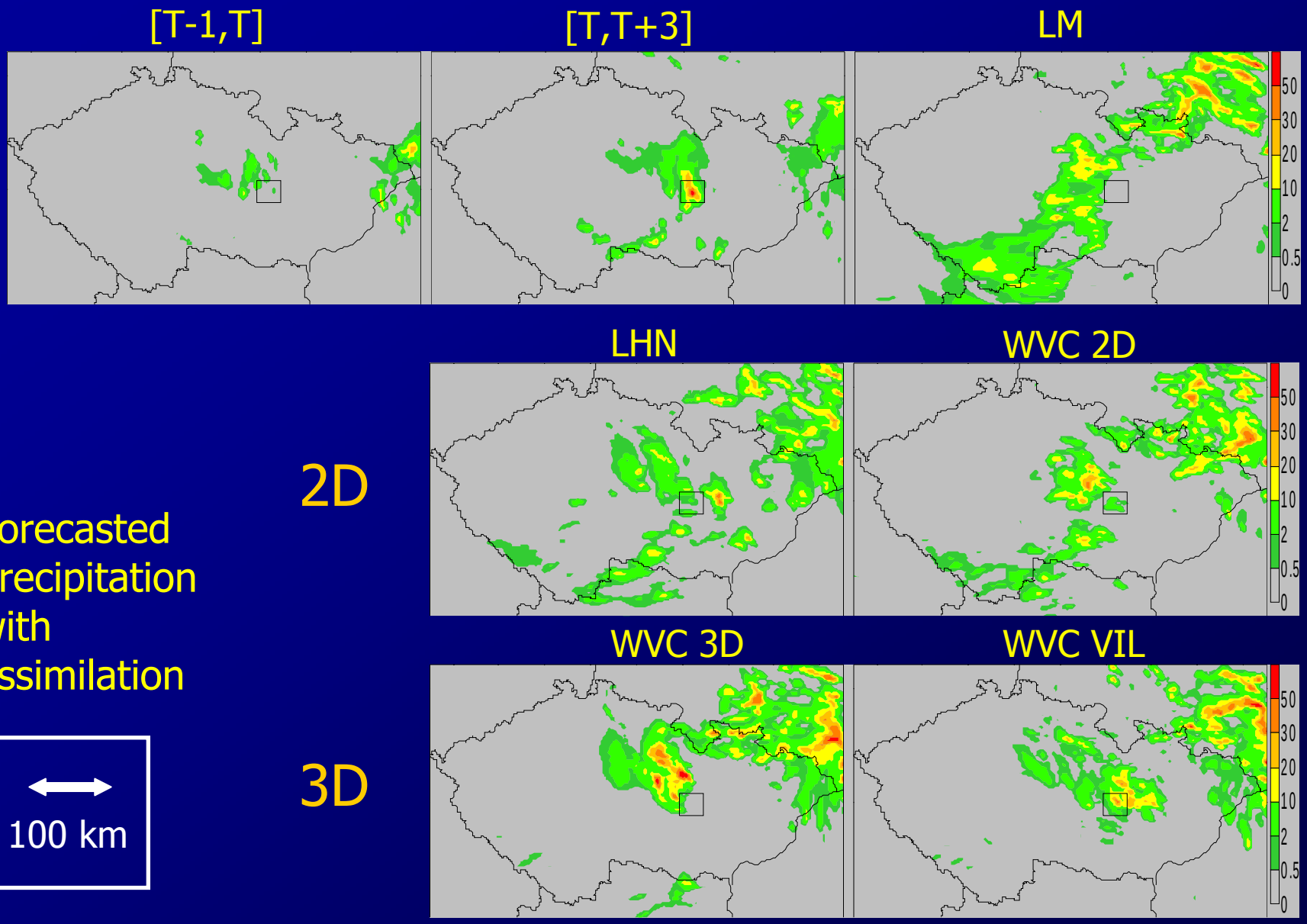
Forecasted precipitation with assimilation

2D

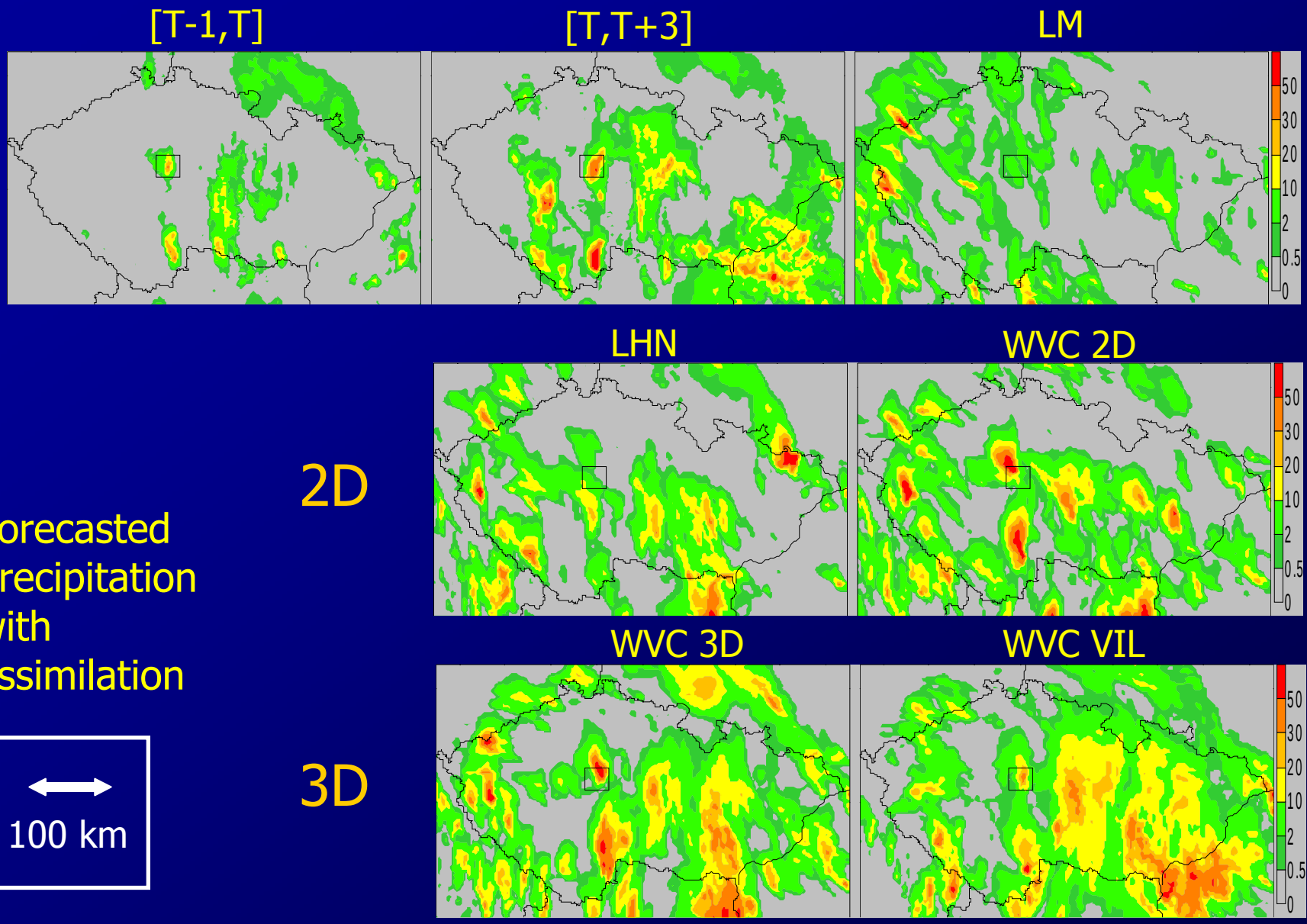
3D

100 km

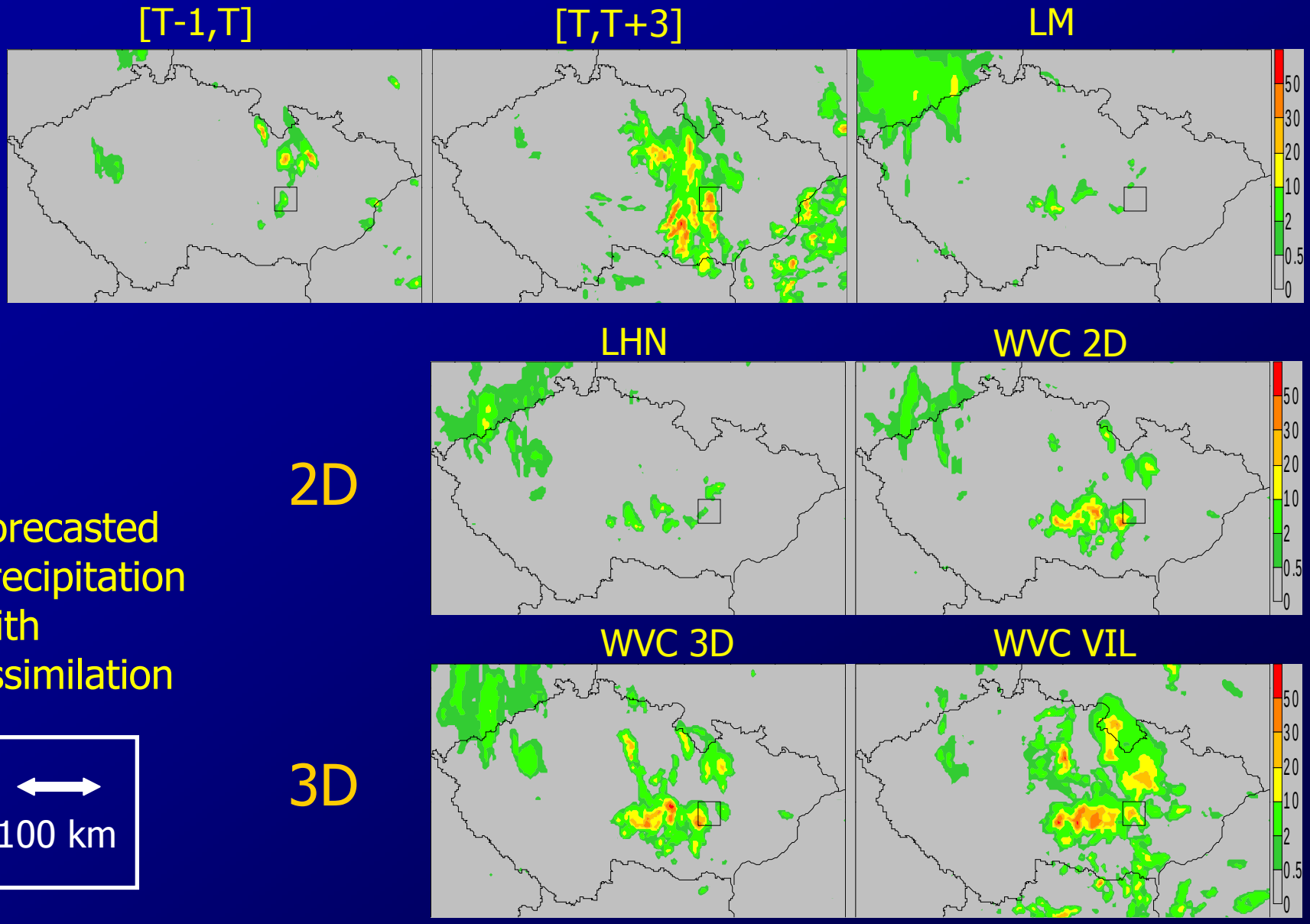
15 July 2002 - Observed precipitation T=15 UTC



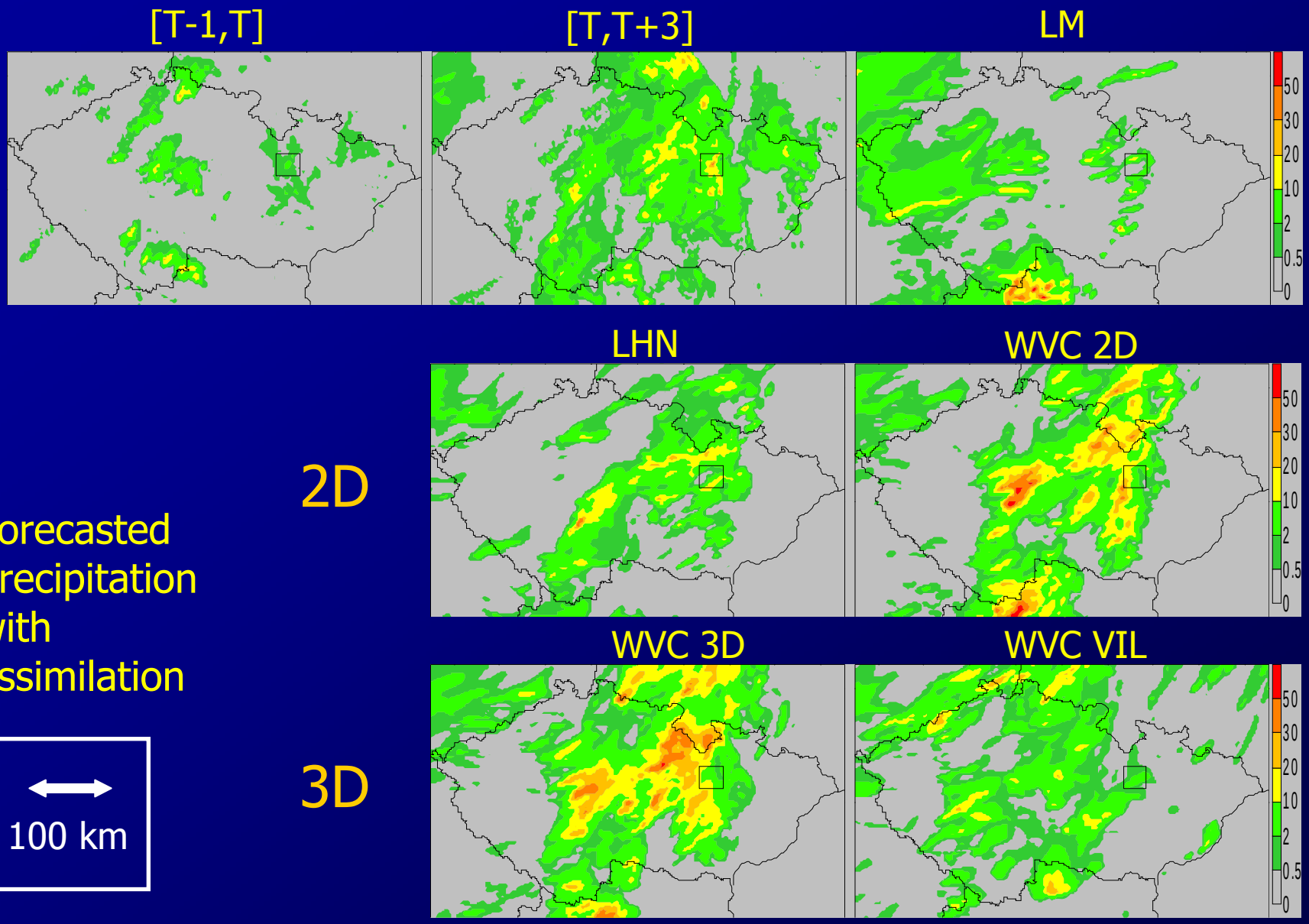
13 July 2002 - Observed precipitation T=14 UTC



26 May 2003 - Observed precipitation T=12 UTC

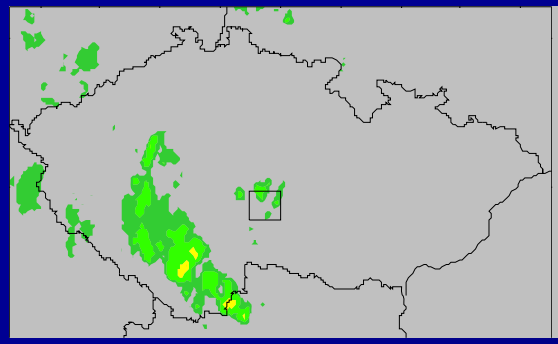


30 May 2005 - Observed precipitation T=14 UTC

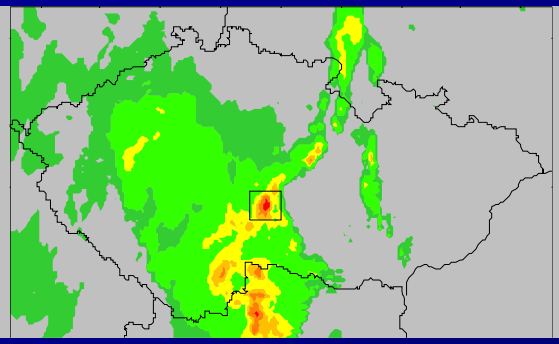


23 May 2005 - Observed precipitation T=14 UTC

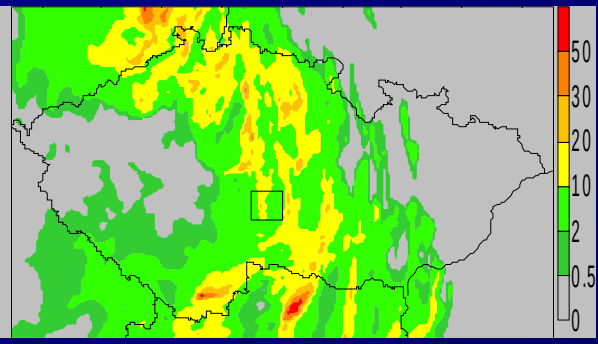
[T-1,T]



[T,T+3]

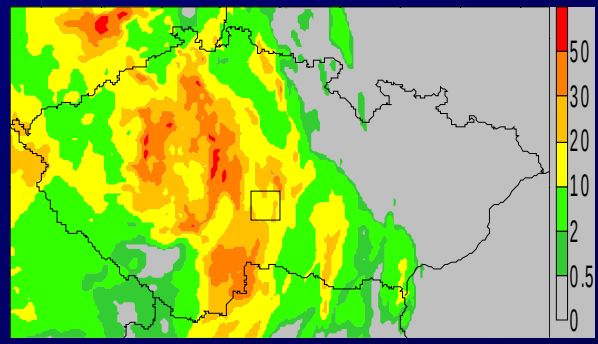


LM



LHN

WVC 2D

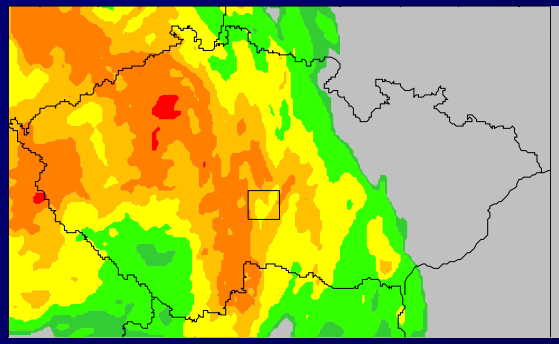


2D

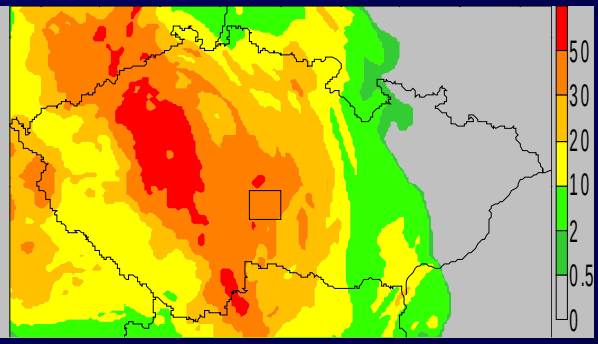
Forecasted precipitation with assimilation

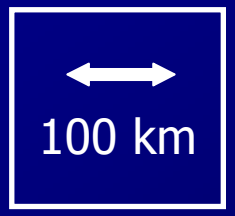
3D

WVC 3D



WVC VIL





(ii) “Objective approach”

SRMSE

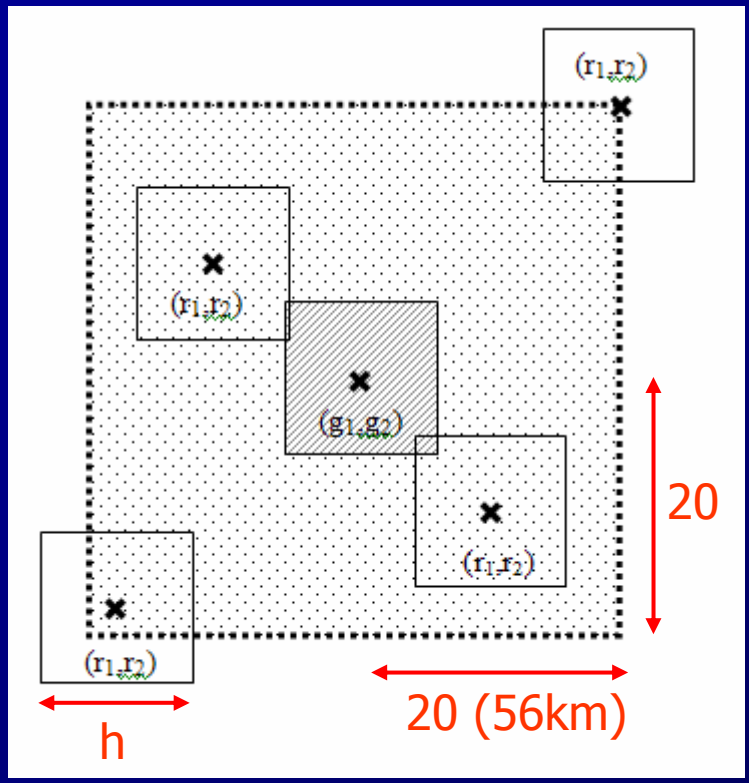
Assumptions:

The storm position as well as the structure are not expected to be forecasted accurately.

But we want:

a) The forecasted storm should be close to the observed one.

b) Distribution of precipitation values should be similar.



Verification method

- Observed $\{o_i\}$ and forecasted $\{f_i\}$ grid values from squares h x h are compared:

  $o_1 \le o_2 \le \ldots$

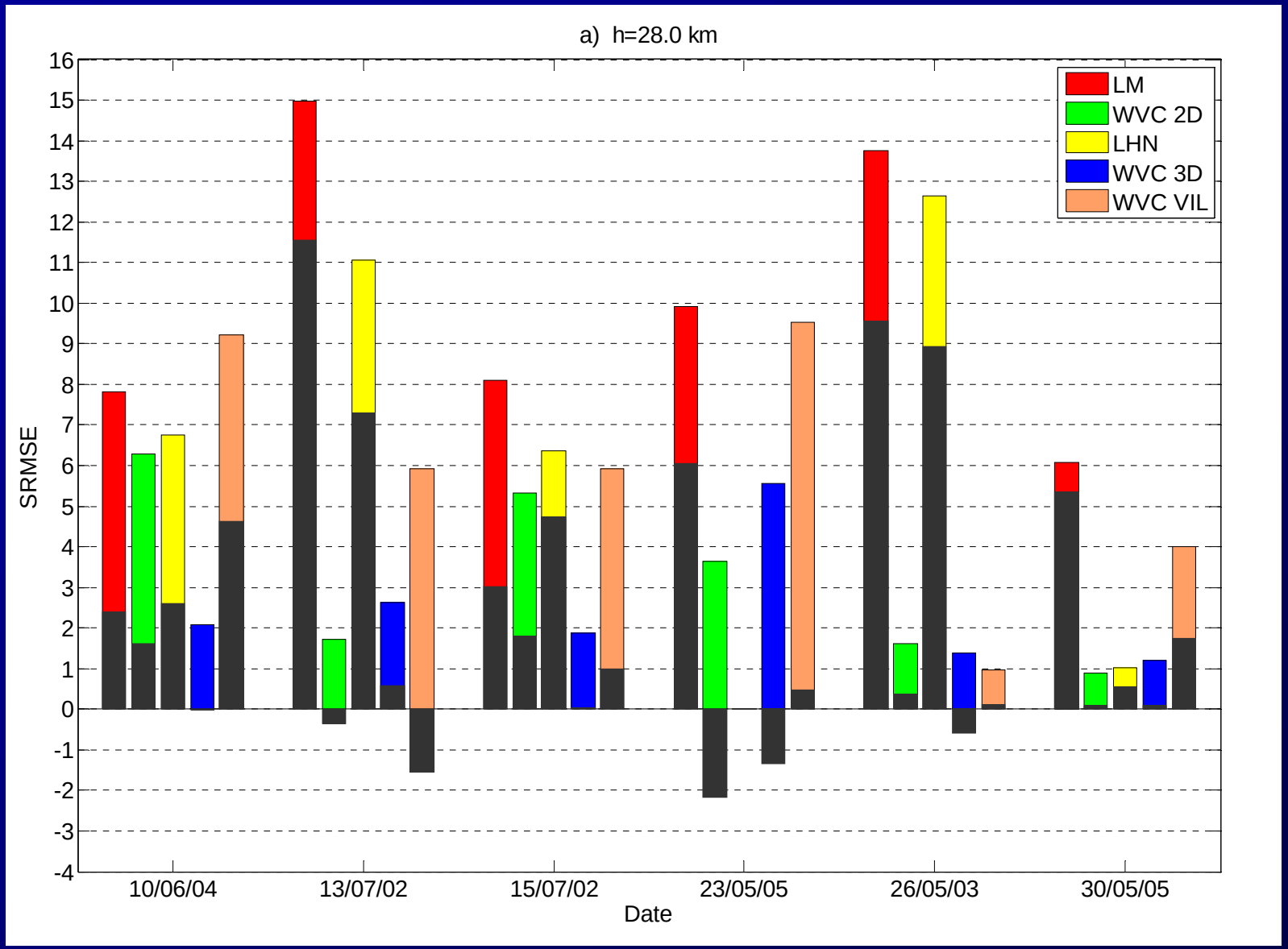
  $f_1 \le f_2 \le \ldots$

  RMSE(o,f)

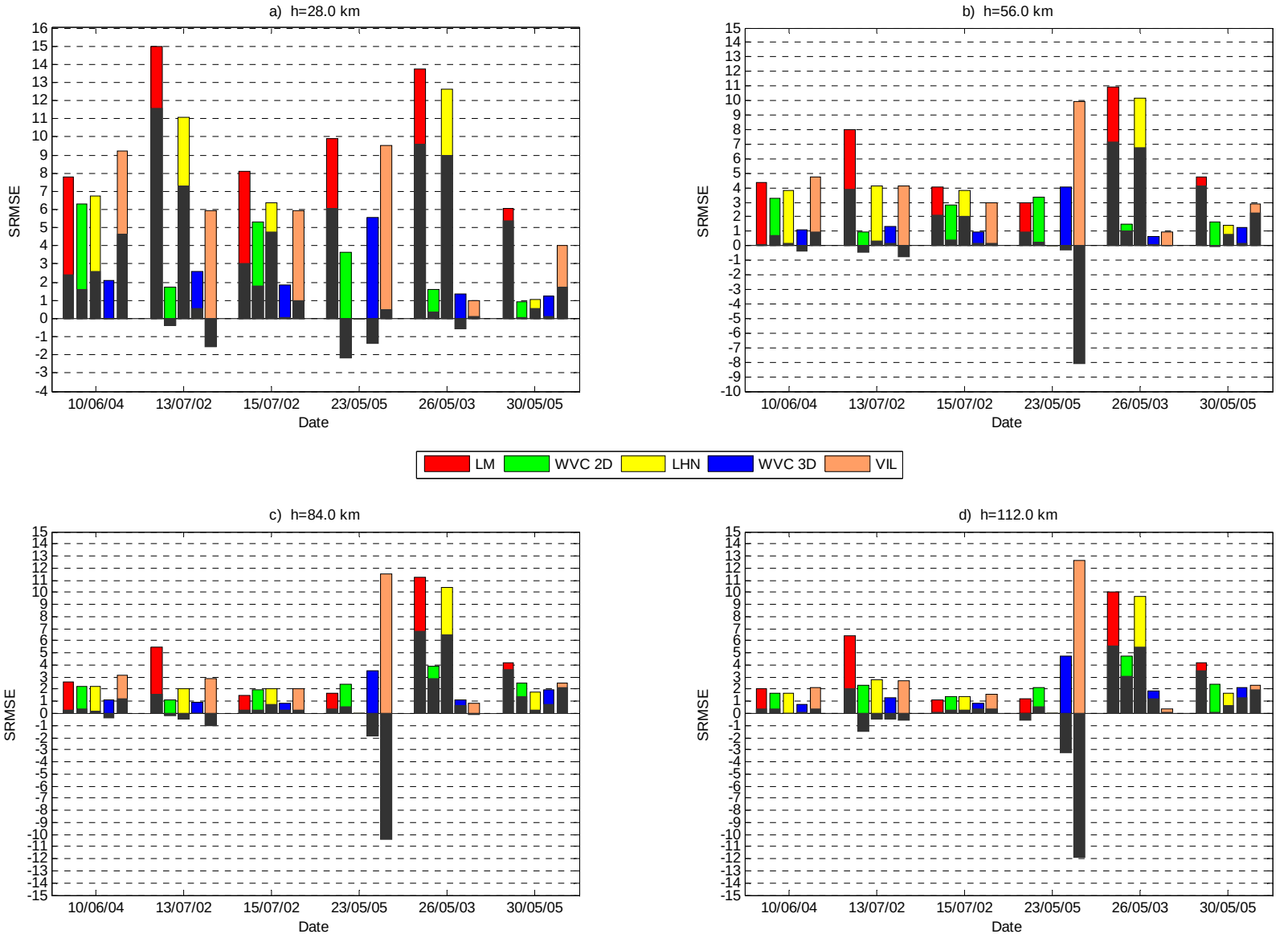
2. Observed values are from the fixed squared in the centre (g_1,g_2)
3. Forecasted values are from various squares (r_1,r_2)
4. SRMSE = min { RMSE(o,f) }

   $abs(r_1-g_1) \le 20$, $abs(r_2-g_2) \le 20$

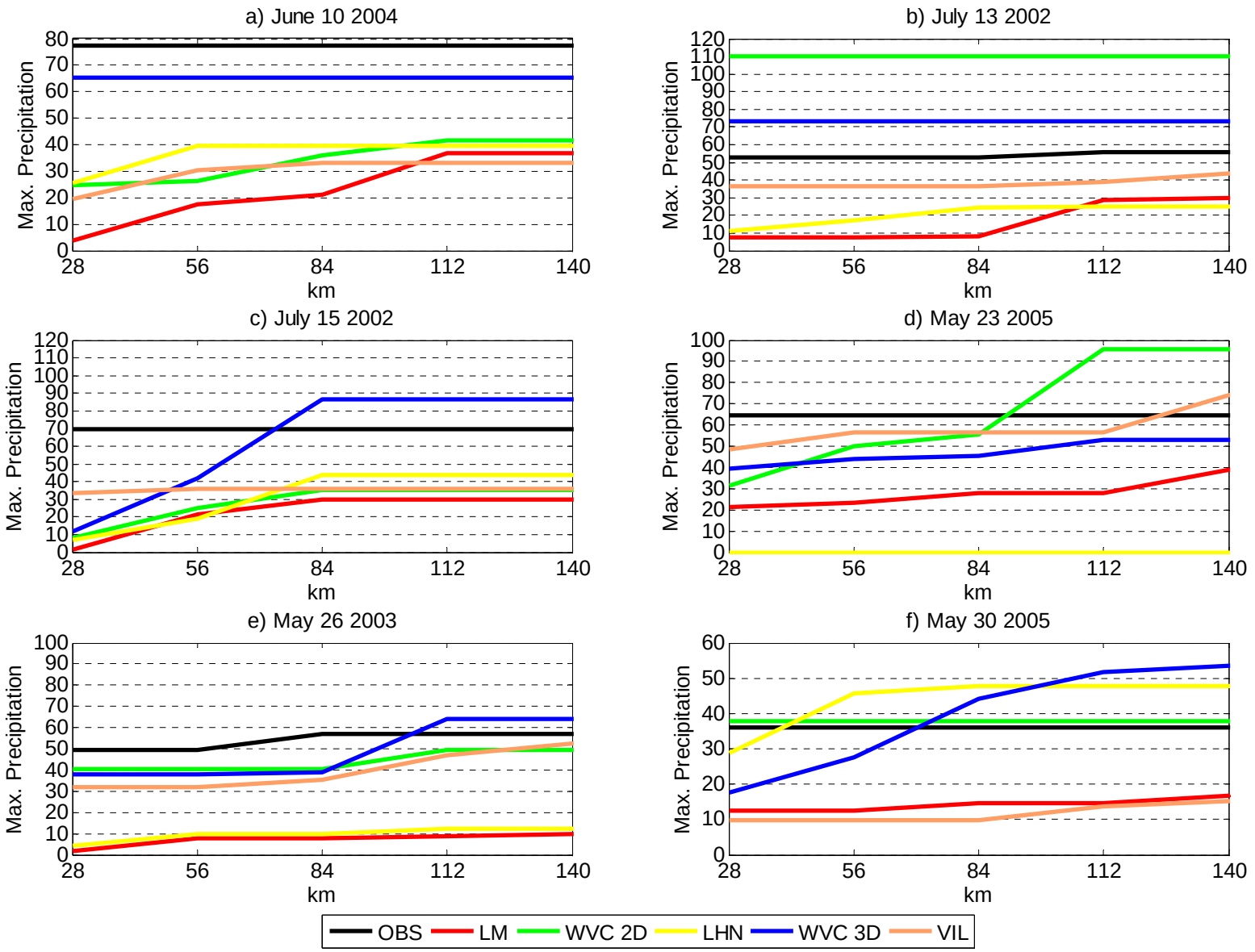
SRMSE 28km x 28km



SRMSE


a) h=28.0 km
b) h=56.0 km
c) h=84.0 km
d) h=112.0 km
SRMSE
Date
10/06/04
13/07/02
15/07/02
23/05/05
26/05/03
30/05/05
LM
WVC 2D
LHN
WVC 3D
VIL

Maximum in squares h=28, 56, 84, 112, 140 km



Conclusions

- The assimilation significantly improves the forecast.
- 2D methods:
  - LHN and CWV methods are comparable when LM forecast is good
  - If LM does not forecast precipitation and observed precipitation during the assimilation period is small then the LHN has problems to develop precipitation.
- 2D versus 3D methods:
  - Preliminary results
  - VIL is not good
  - WVC 3D seems slightly better
- The forecast is successful if first indications of the storm are observed by radars.
- Nowcasting of precipitation

Thank you

Acknowledgement:
DWD (LM COSMO)
CHMI (radar and gauge data)