Progress in Latent Heat Nudging

Real Case Studies

RADVOR-OP, supported by LAWA

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Real Case Studies

Radar Data

Humidity Adjustment

Filtering of Vertical Profiles

Real Case Studies

Results and Future Work

Radar Data

Input data currently used

- radar reflectivity at the ground (int. Composite: Germany and surrounding countries)
- pixel size: 4km $\times$ 4km
- time resolution: 15 minutes (data from volume scan)
- conversion: reflectivity to precipitation rate by simple Z-R-relation
- problems: clutter, only 7 reflectivity classes

Radar Data

„new“ radar data

- preliminary product of the project RADOLAN
- input data: reflectivities from precipitation scan, mesh: 1km $\times$ 1°, time resolution: 5 minutes
  - correction of orographic attenuation
  - variable Z-R-relation
  - compositing
- interpolation to the LM grid
- access: offline
- still incomplete clutter correction

Humidity Adjustment

- Increased heating
  $\Rightarrow$ increase q to reach f=100% over nudging timescale τ

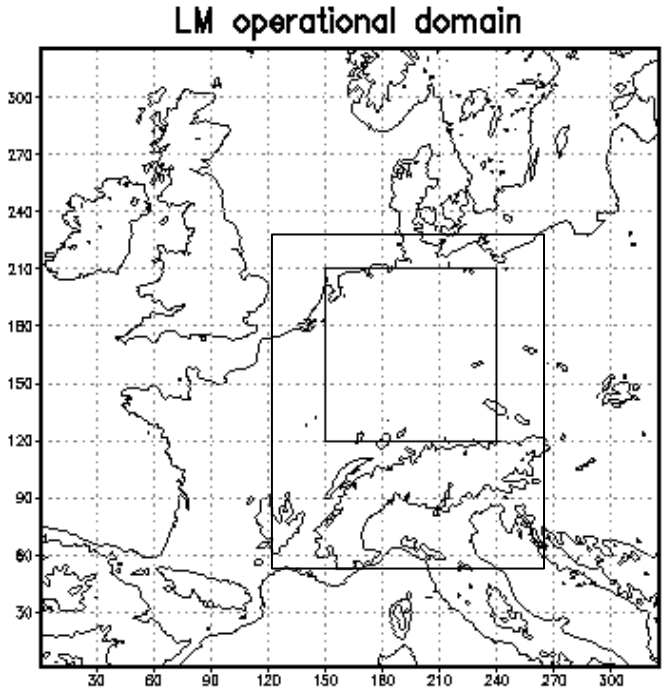
- Reduced heating
  $\Rightarrow$ decrease q (maintain f)

Humidity Adjustment

- Convective event on 28. Aug. 2002 over western Germany

- LM run on a domain:
  - with 361 x 441 grid points
  - covering almost Germany
  - with mesh size 2.8 km

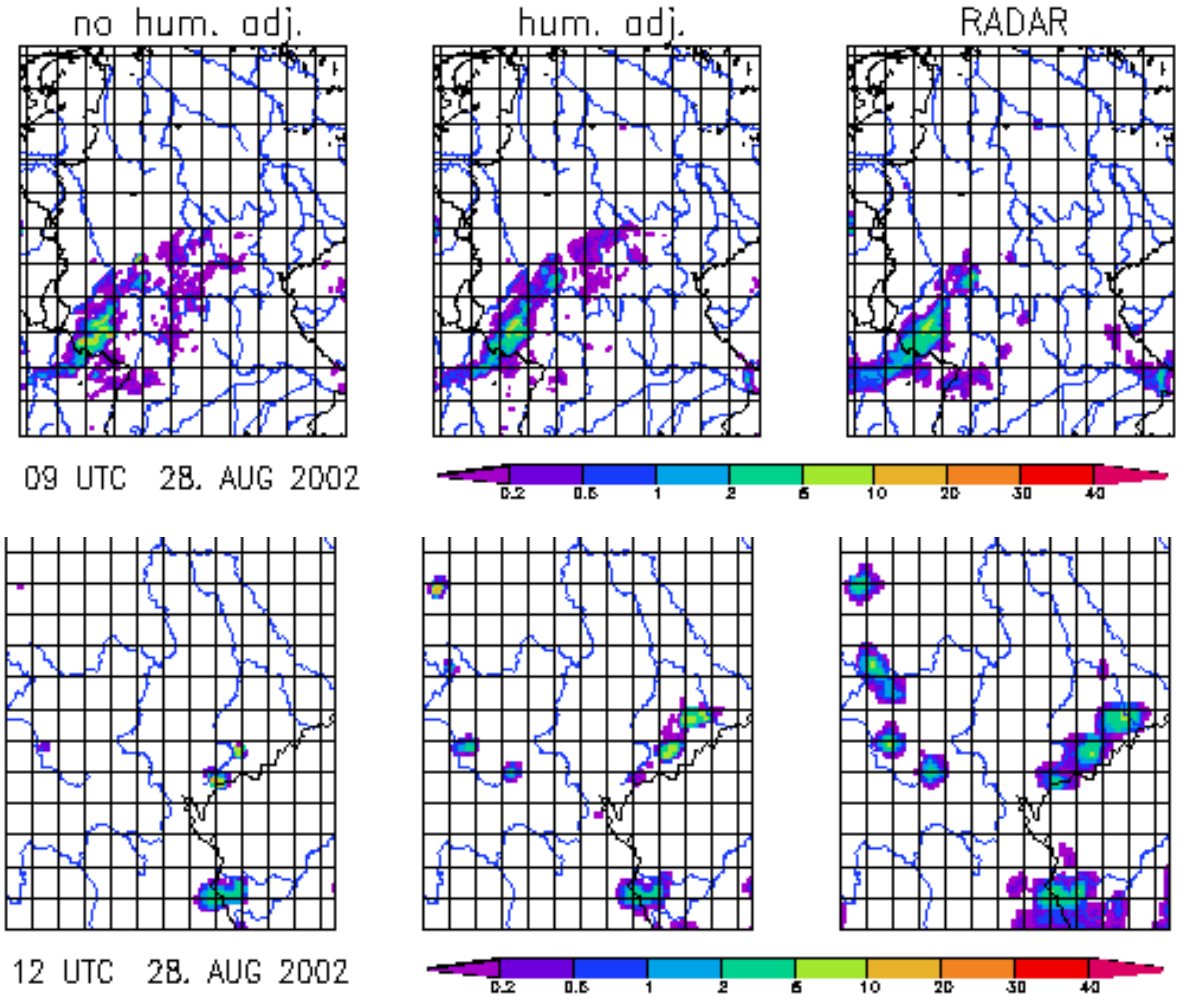
  - convective parameterisation scheme switched off
  - laterally driven by GME
  - 6h Nudging + LHN
    - adjustment of humidity during LHN
  - 6h free forecast



Humidity Adjustment

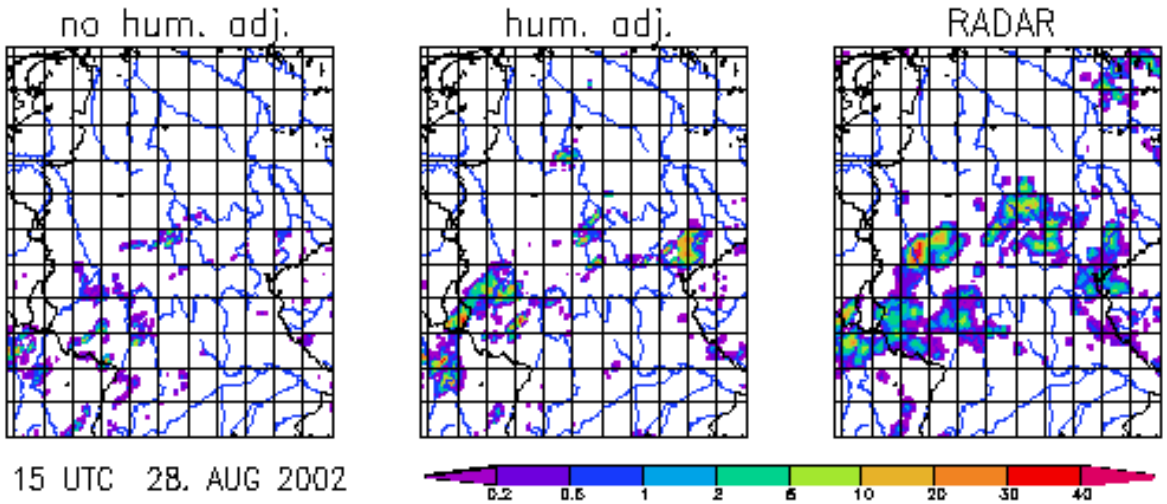
Hourly sums of modeled and radar-observed precipitation in mm/h

- Nudging 08-09 UTC
- Nudging 11-12 UTC



Humidity Adjustment

- free forecast
  14-15 UTC



Filtering of Vertical Profiles

- Frontal case on July 10th 2002 (Berlin thunderstorm)
- LM run (operational domain):
  - mesh size 7 km
  - convective parameterisation scheme switched off

- 3h Nudging + LHN starting at 9 UTC

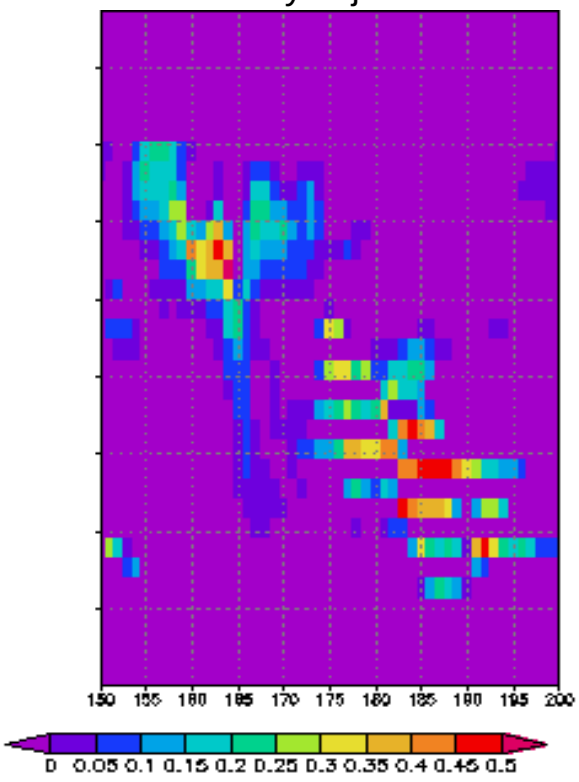
  - no filtering of T-increments:
    - humidity adjustment
    - no humidity adjustment

  - filtering of T-increments:
    - humidity adjustment
    - no humidity adjustment

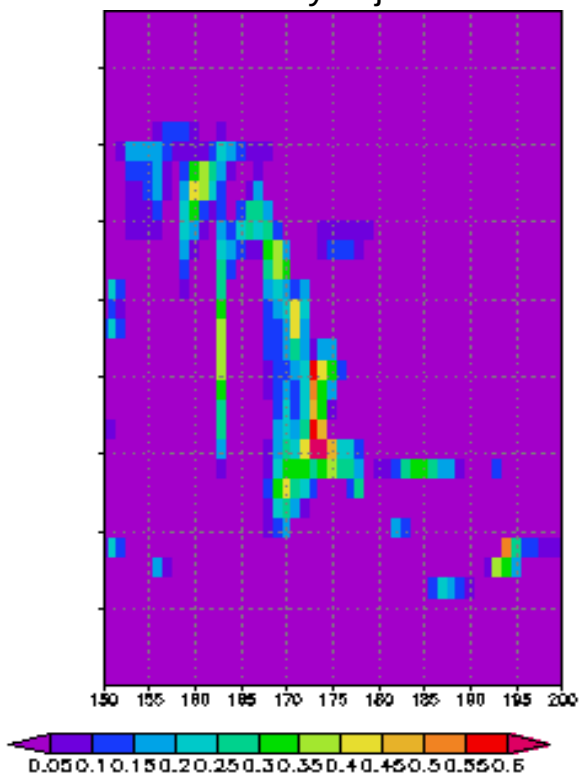
Filtering of Vertical Profiles

No filtering of T-increments, vertical cross section W-E, t = 11 UTC
specific cloud liquid water content in g/kg

humidity adjustment



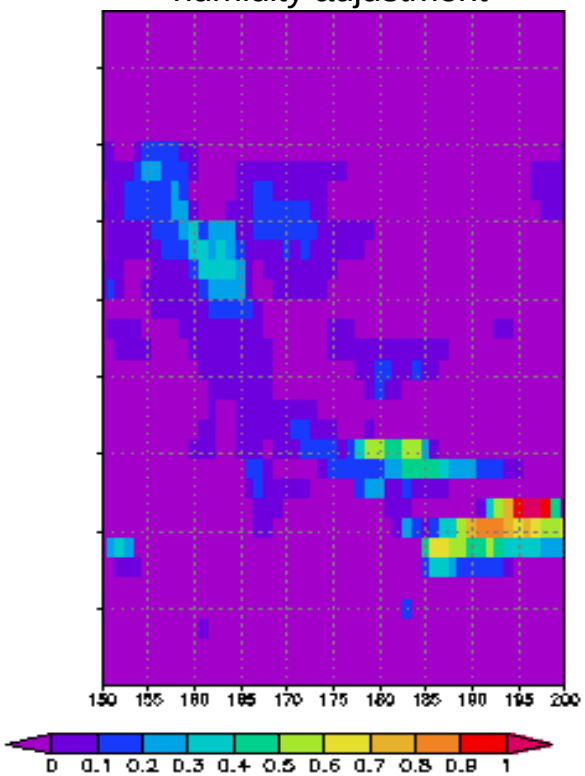
no humidity adjustment



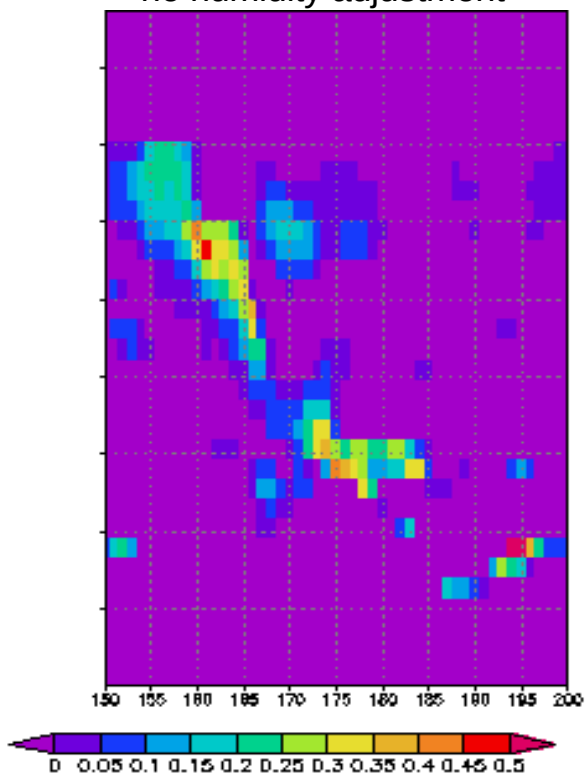
Filtering of Vertical Profiles

Filtering of T-increments, vertical cross section W-E, t = 11 UTC
specific cloud liquid water content in g/kg

humidity adjustment

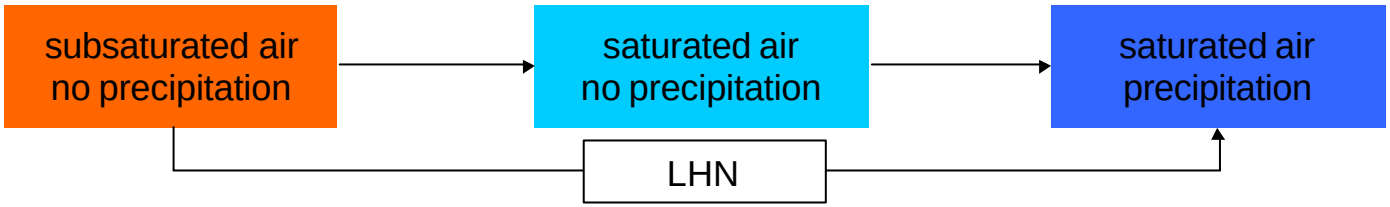


no humidity adjustment

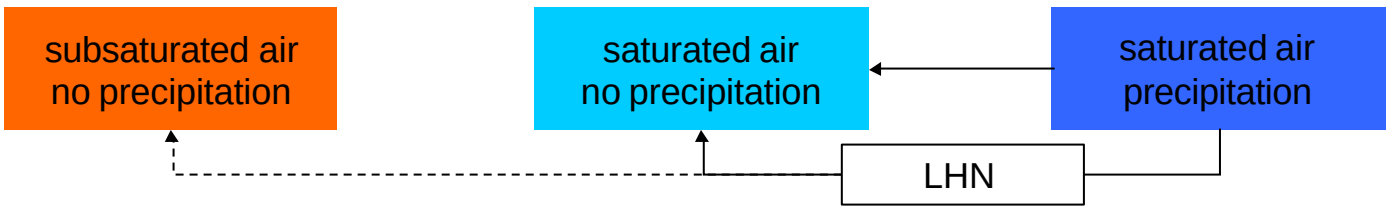


Filtering of Vertical Profiles

- Increased heating
  ⇒ increase q to reach f=100% over nudging timescale τ



- Reduced heating
  ⇒ decrease q (maintain f)



- Need for additional humidity information, e.g. satellite cloud data

Case Studies: convective event

- Deep convection on the afternoon of 28.Aug. 2002 over western Germany
- LM run on the operational domain:
  - mesh size 7 km
  - convective parameterisation scheme switched off

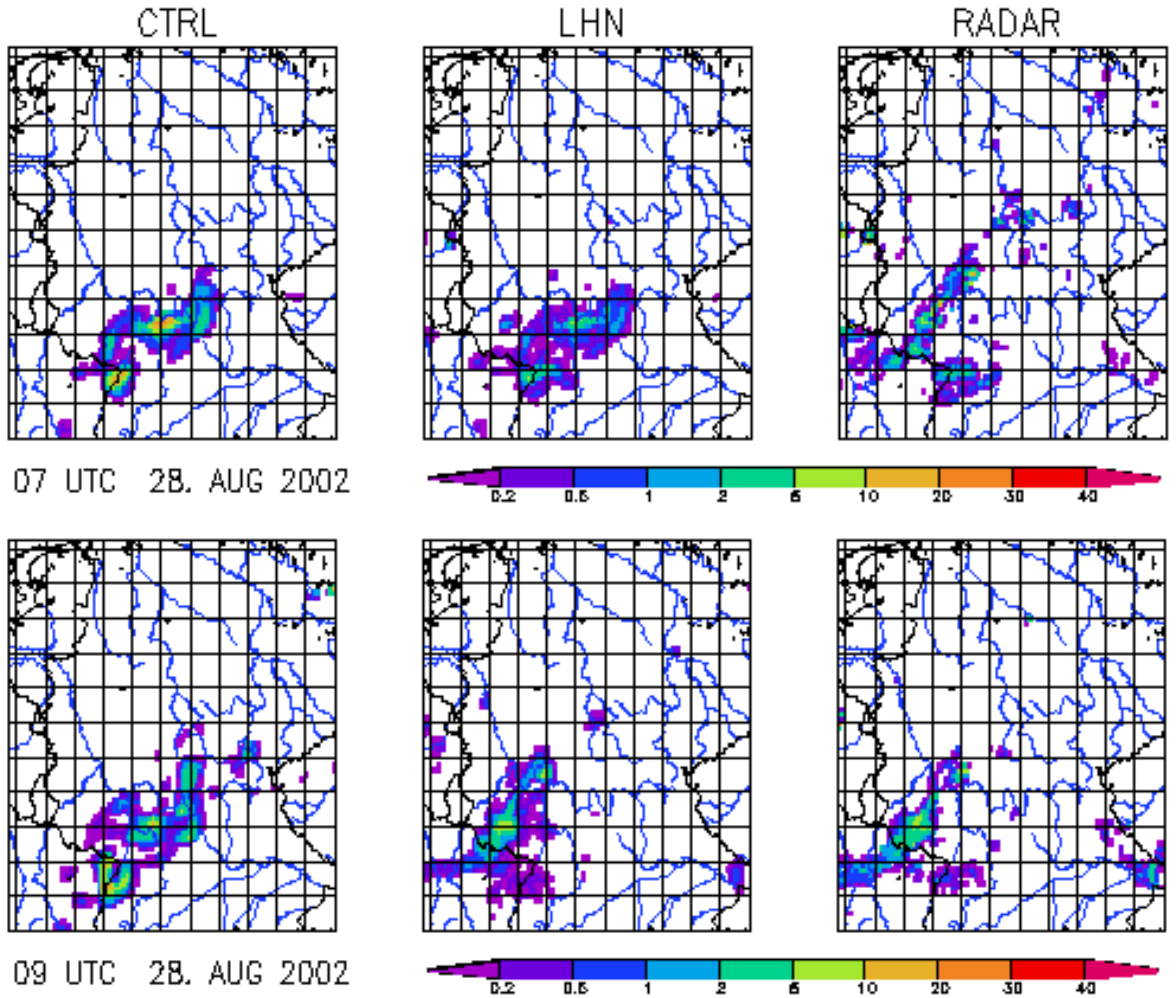
- CTRL:
  - 6h Nudging starting at 6 UTC
  - 6h free forecast
  - laterally driven by GME

- LHN:
  - 6h Nudging + LHN
  - 6h free forecast
  - laterally driven by GME

Case Studies: convective event

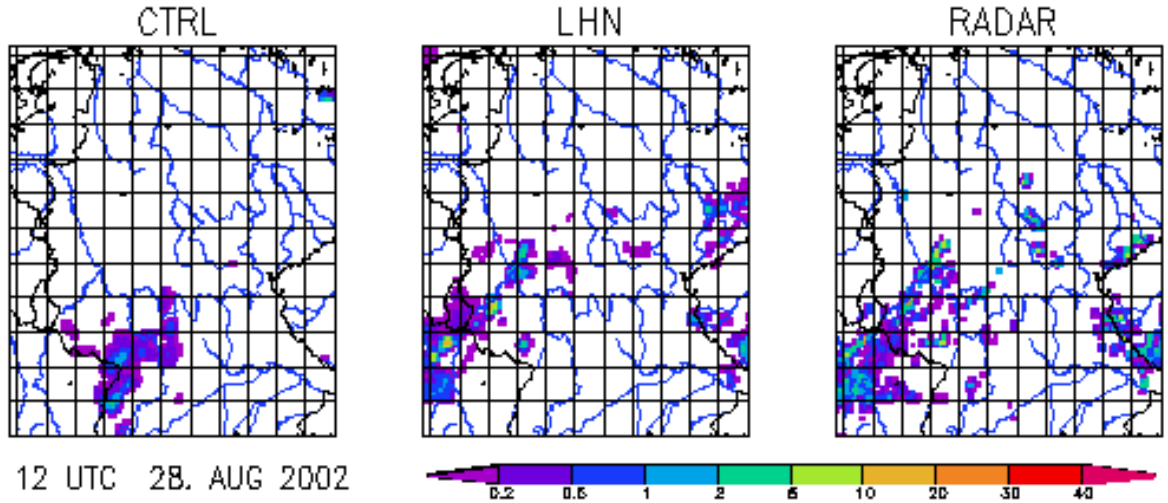
Hourly sums of modeled and radar-observed precipitation in mm/h

- Nudging 06-07 UTC
- Nudging 08-09 UTC

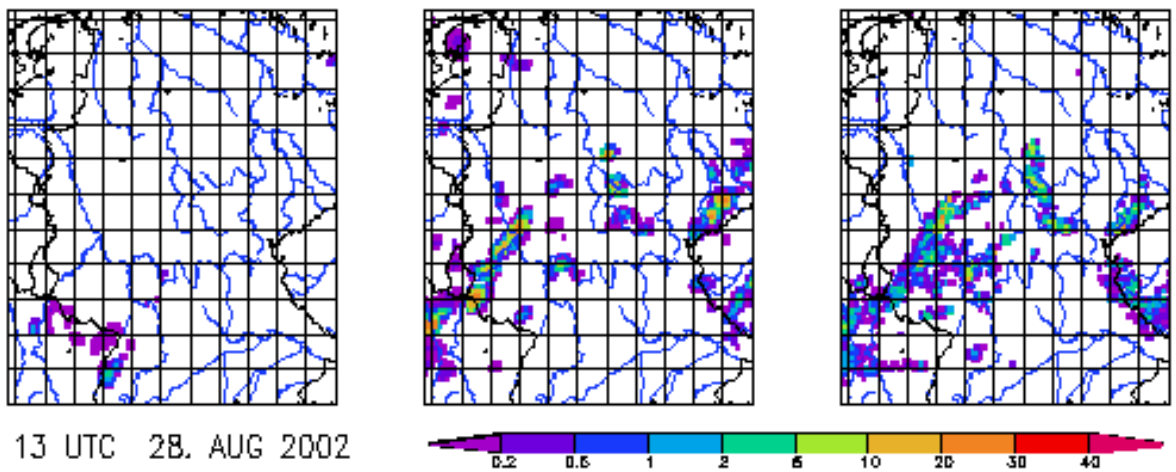


Case Studies: convective event

- Nudging
  11-12 UTC

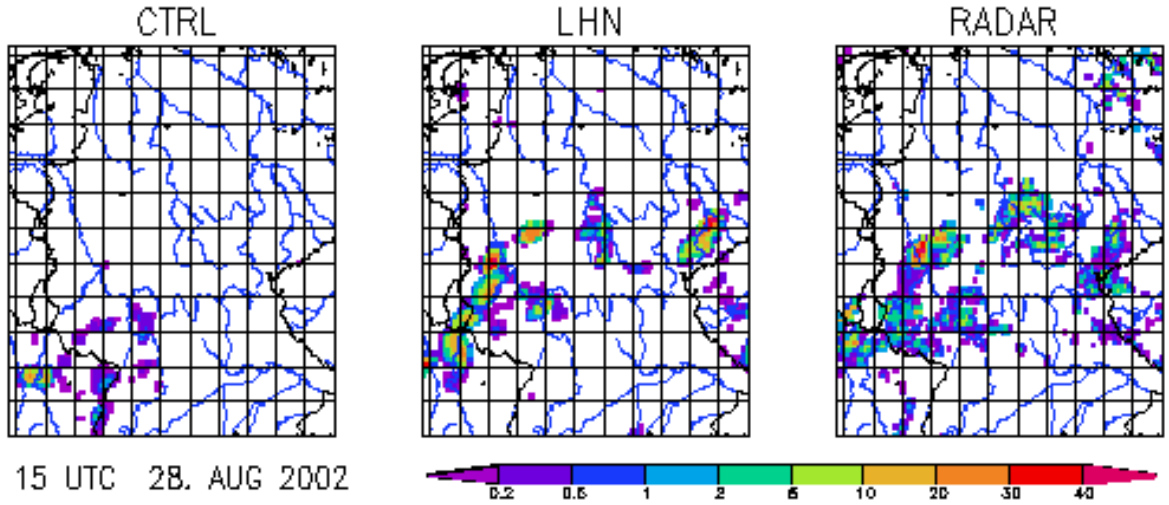


- free forecast
  12-13 UTC

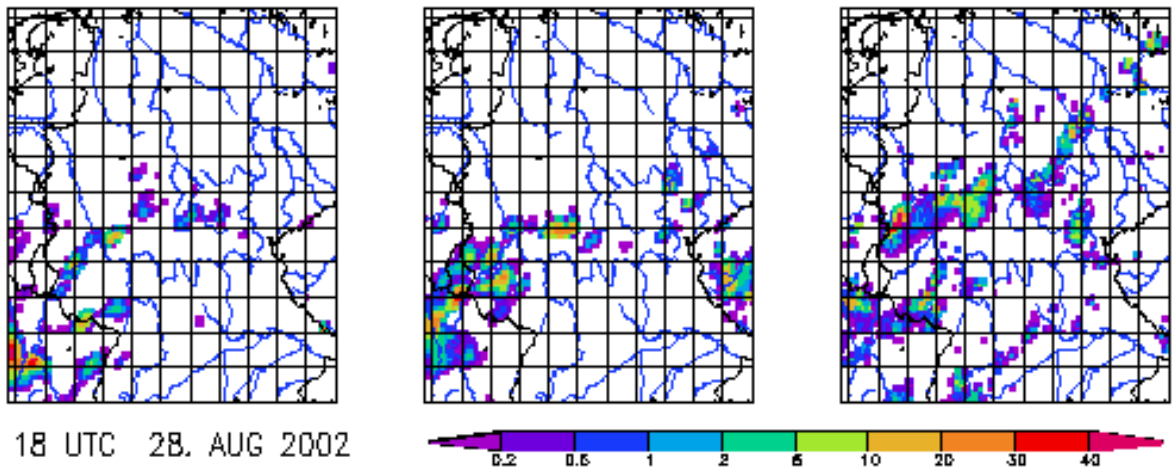


Case Studies: convective event

- free forecast
  14-15 UTC



- free forecast
  17-18 UTC



Case Studies: comparison: convective precipitation with and without convective parameterisation scheme

- Convective event on 28. Aug. 2002 over western Germany
- LM run on the operational domain:
  - mesh size 7 km

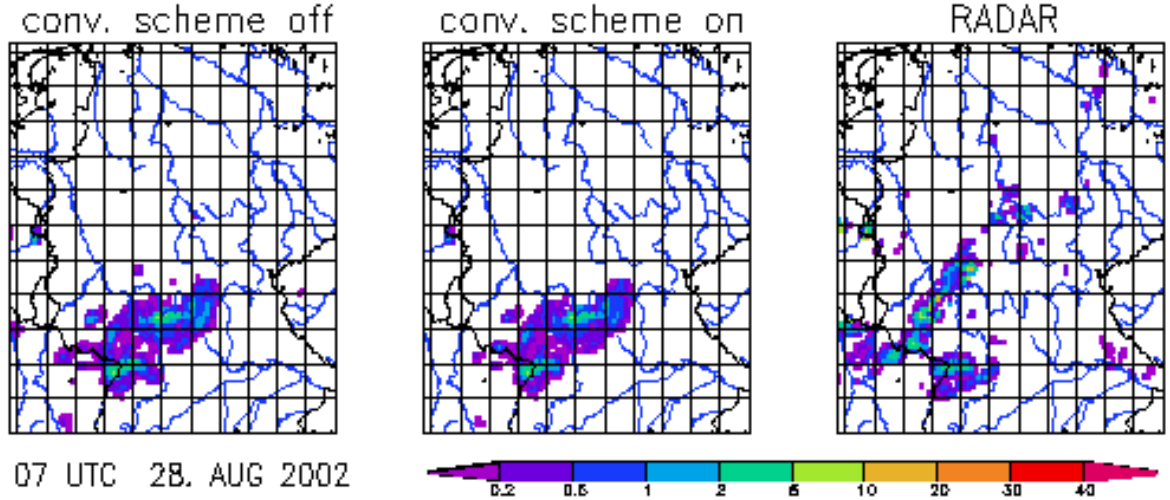
- with convective parameterisation scheme: (middle column)
  - 6h Nudging + LHN starting at 6 UTC
    - no adjustment of humidity during LHN
  - 6h free forecast
  - laterally driven by GME
  - convective parameterisation scheme **switched on**

- without convective parameterisation scheme: (left column)
  - the same as above,
    but convective parameterisation scheme **switched off**

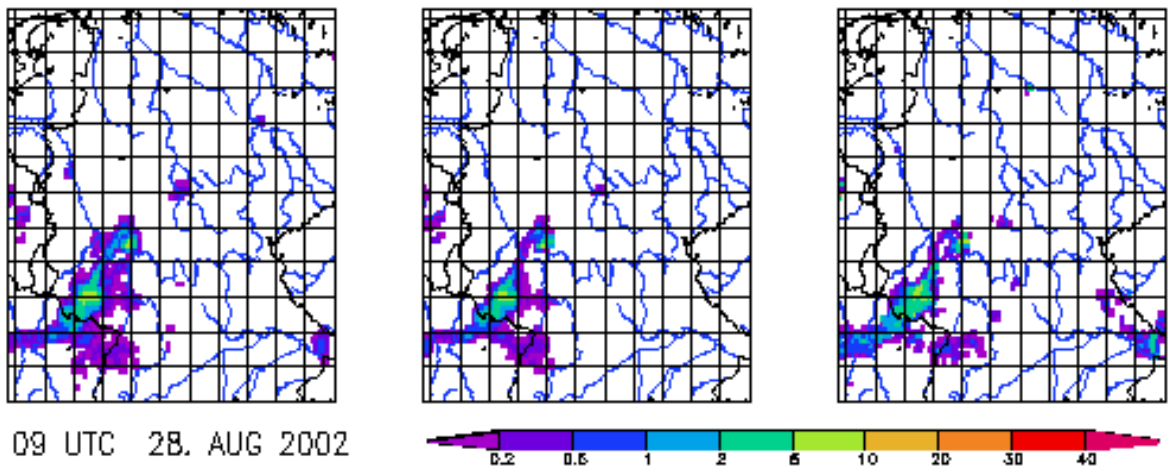
Case Studies: comparison: convective parameterisation scheme

Hourly sums of modeled and radar-observed precipitation in mm/h

- Nudging 06-07 UTC

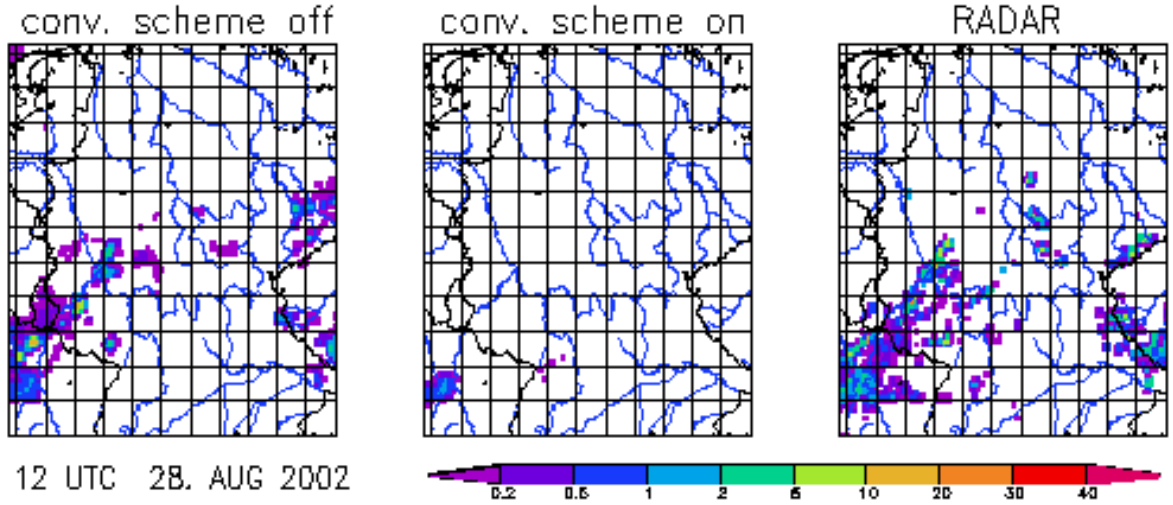


- Nudging 08-09 UTC

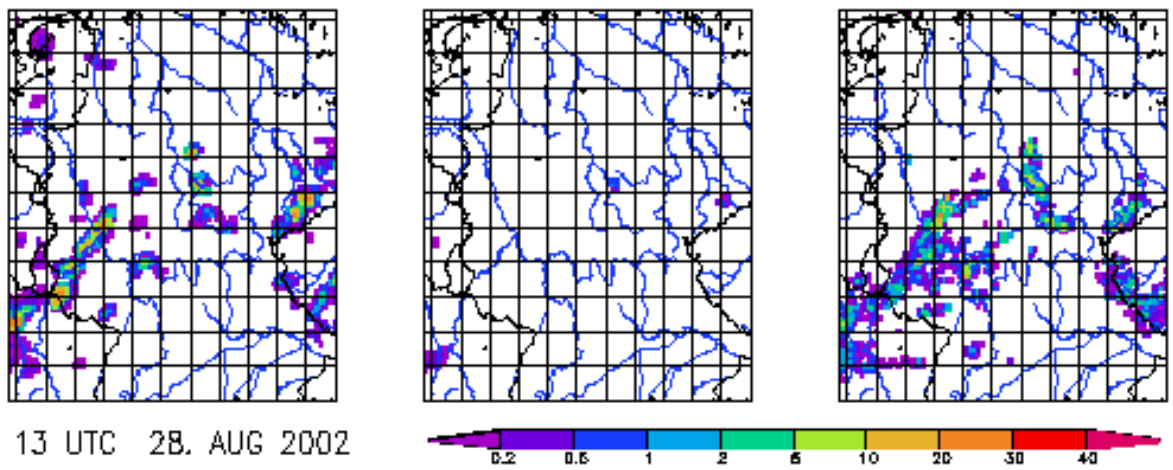


Case Studies: comparison: convective parameterisation scheme

- Nudging
  11-12 UTC

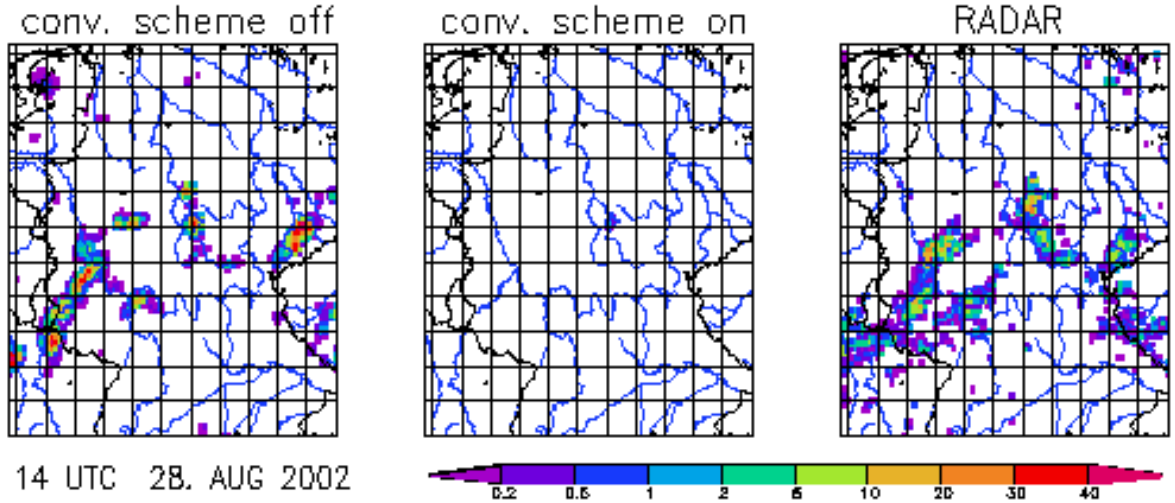


- free forecast
  12-13 UTC

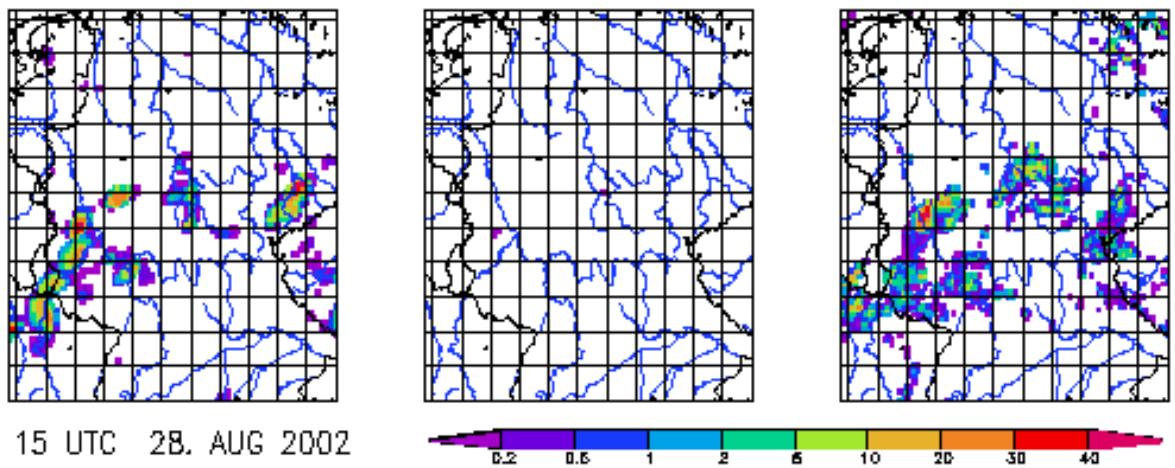


Case Studies: comparison: convective parameterisation scheme

- free forecast
  13-14 UTC



- free forecast
  14-15



Case Studies: comparison: mesh sizes 7 km and 2.8 km

- Convective event on 28. Aug. 2002 over western Germany
- LM run on the operational domain:
  - convective parameterisation scheme switched off

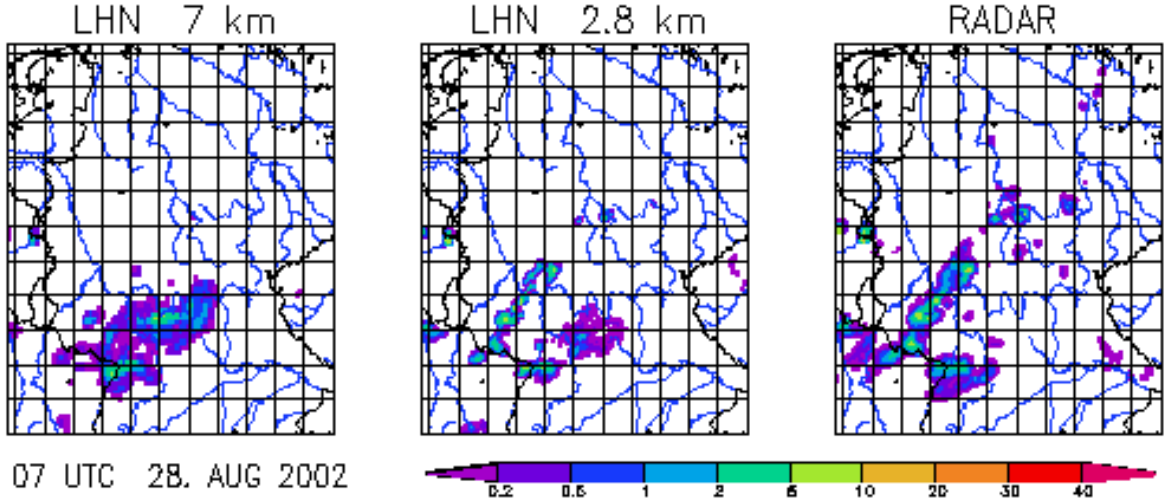
- LHN 7 km:
  - 6h Nudging + LHN
    - adjustment of humidity during LHN
  - 6h free forecast
  - laterally driven by GME
  - mesh size **7 km**

- LHN 2.8 km:
  - the same as above, but mesh size **2.8 km** (smaller model domain)

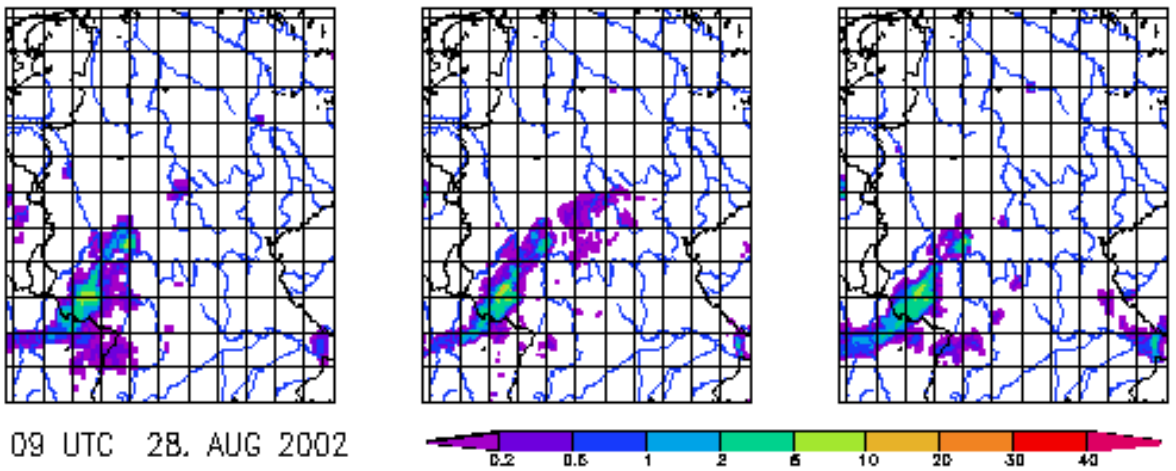
Case Studies: comparison: mesh sizes 7 km and 2.8 km

Hourly sums of modeled and radar-observed precipitation in mm/h

- Nudging 06- 07 UTC

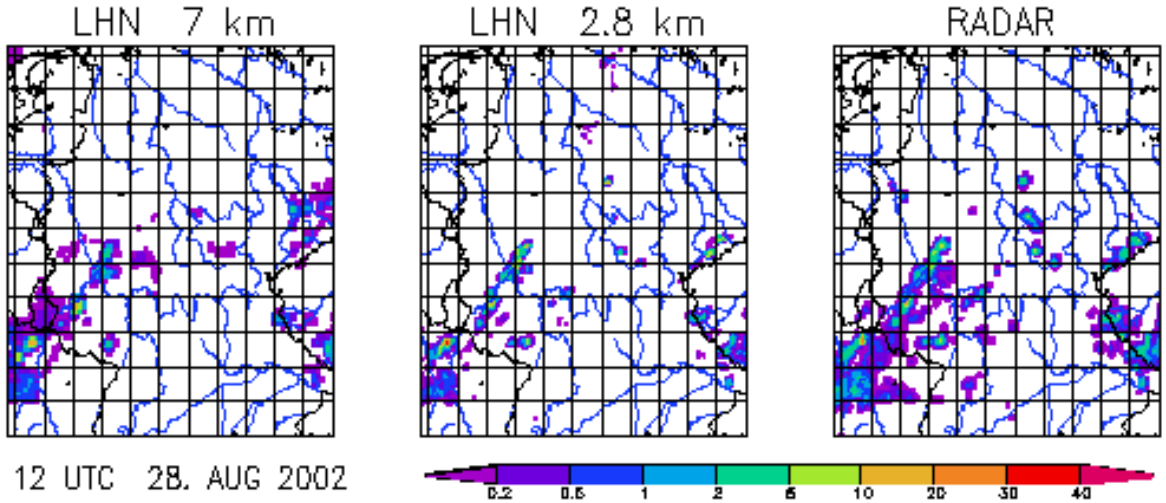


- Nudging 08-09 UTC

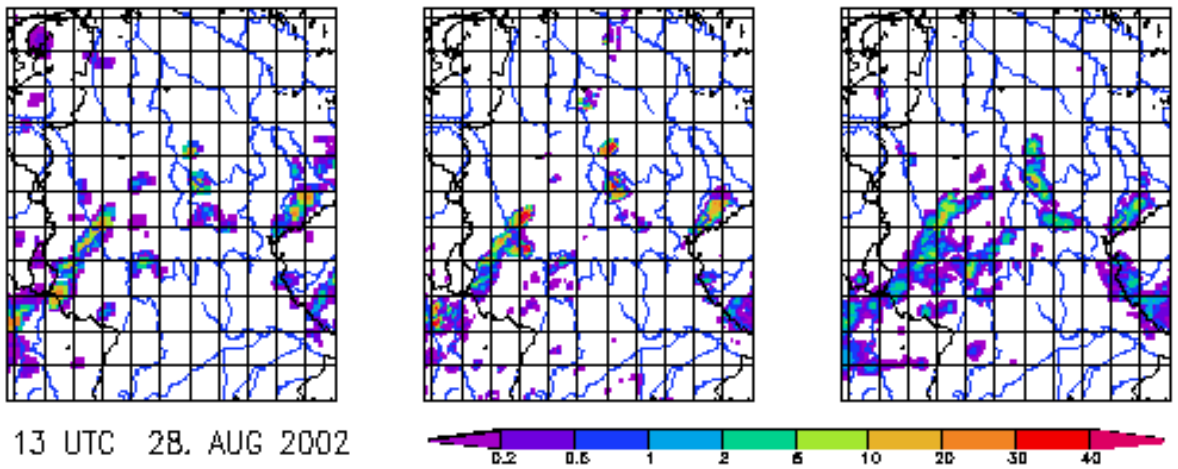


Case Studies: comparison: mesh sizes 7 km and 2.8 km

- Nudging
  11-12 UTC

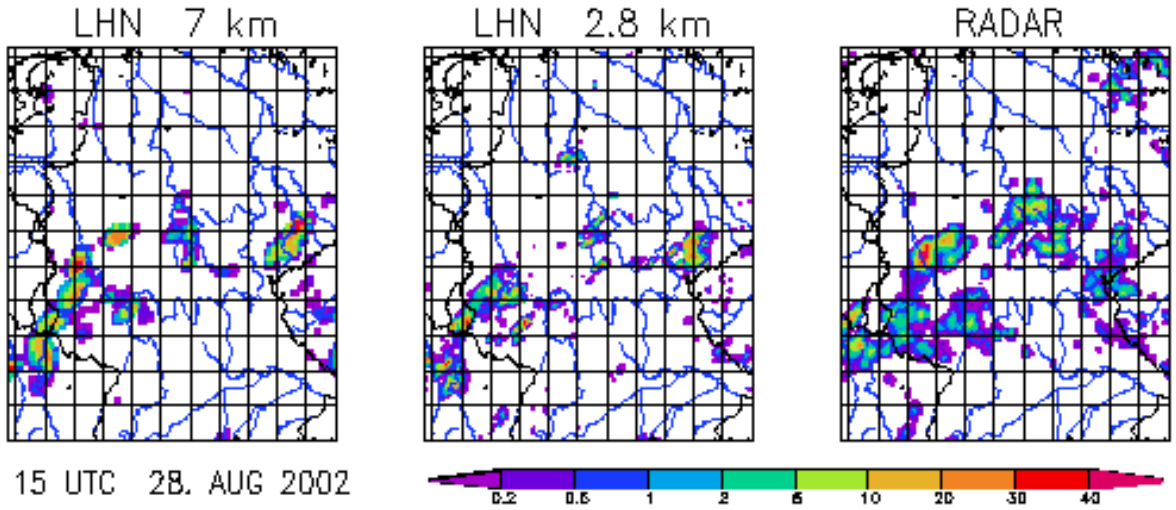


- free forecast
  12-13 UTC

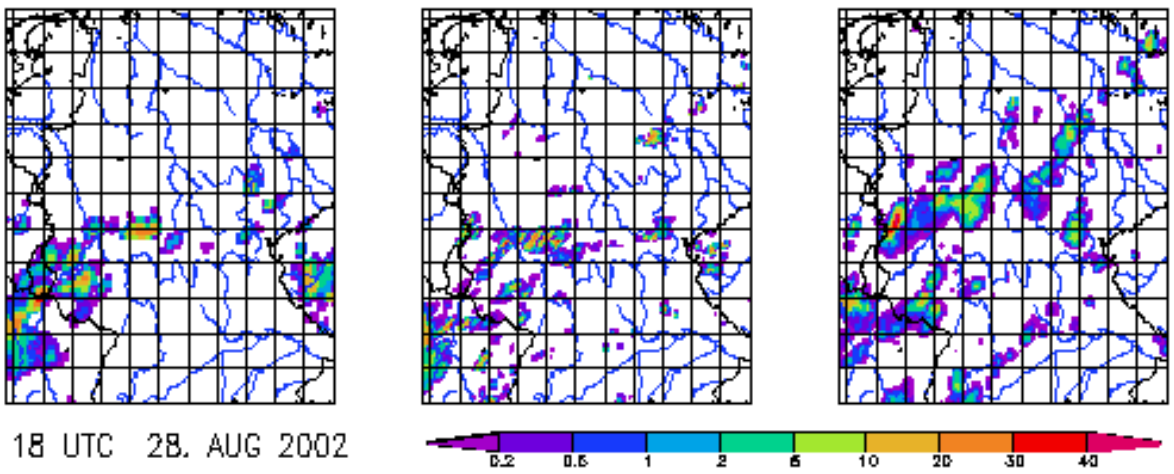


Case Studies: comparison: mesh sizes 7 km and 2.8 km

- free forecast
  14-15 UTC



- free forecast
  17-18 UTC



Results and Future Work

- **Results:**
  - explicit simulation of convection produces more realistic patterns and amounts of precipitation than the corresponding model run with a parameterisation scheme
  - adjustment of humidity supports the assimilation of precipitation and leads to more exact free forecasts
  - model with 2.8 km mesh size shows potential for further improvements of precipitation forecast
  - sporadical occurrence of spurious precipitation
  - influence of the assimilation lasts for several hours

Results and Future Work

- **Problems concerning LHN:**
  - numerical problems with noisy profiles of latent heat (2 Δz-structures)
  - adjustment of humidity during LHN
  - quality of radar data
  - improvements to extend the influence of assimilation during free model run

Results and Future Work

- **Outlook:**
  - investigations concerning:
    - changes of stability of the T-profile caused by LHN
    - humidity adjustment
  - use of radar data with time resolution of 5 minutes
  - prognostic precipitation
  - two further scientists in the Aktionsprogramm 2003:
    tasks:
    - preparation of radar data for assimilation
    - investigation of latent heat nudging