COSMO General Meeting, Milano, 22 - 24 Sept. 2004

Recent Developments on Latent Heat Nudging and the Use of Wind Profiler Data

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Assimilation of Wind Profiler Data ***(Buchhold)***

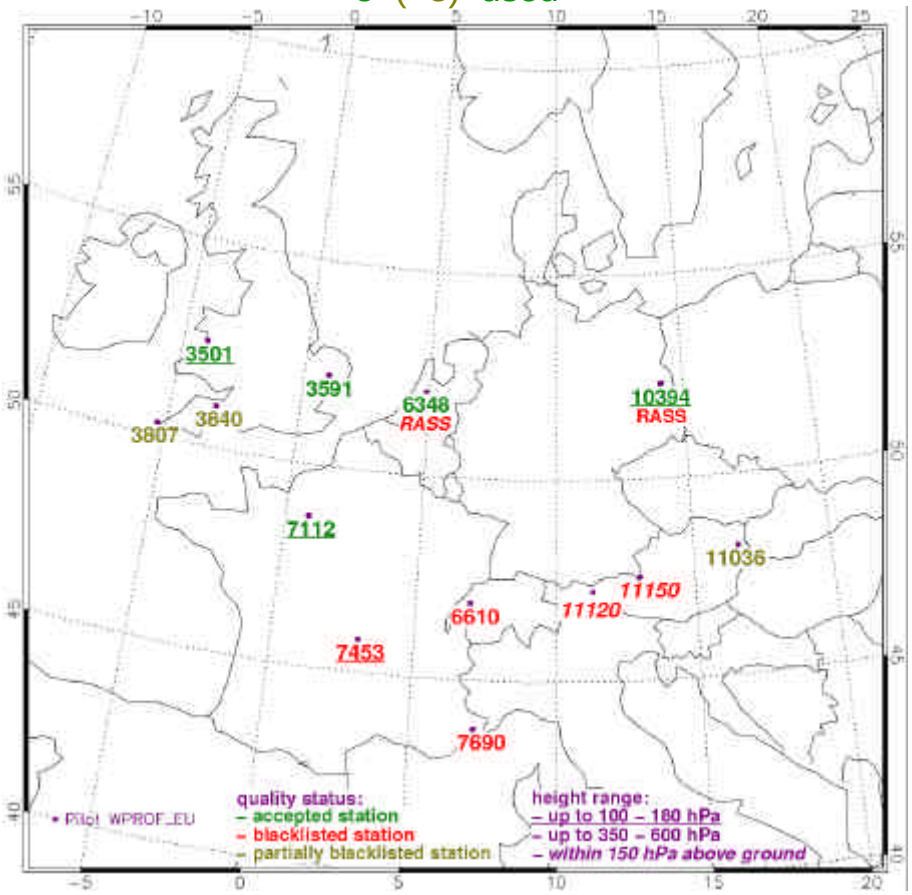
Latent Heat Nudging ***(Klink, Stephan)***

- **Review and Early Results**
- **Diagnostics and Filtering**
- **Influence of Prognostic Precipitation**
- **Results and Future Work**

Wind Profiler : Monitoring

Wind Profiler stations in April 2002

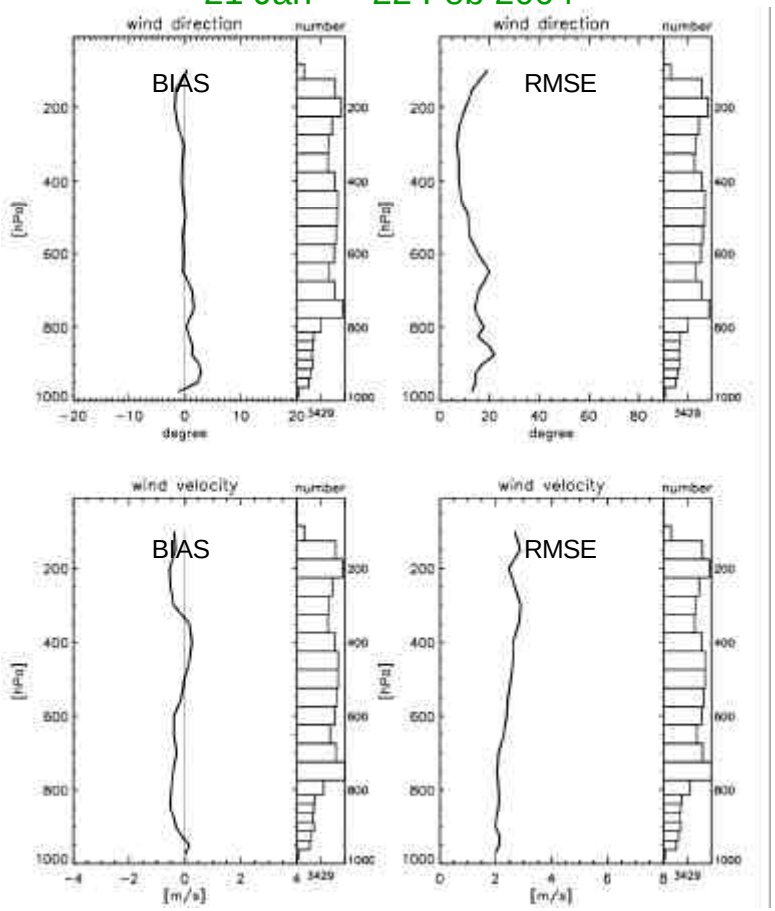
5 (+3) used



Wind Profiler : Monitoring

monitoring of wind profiler Ziegendorf (10266) against LM analyses

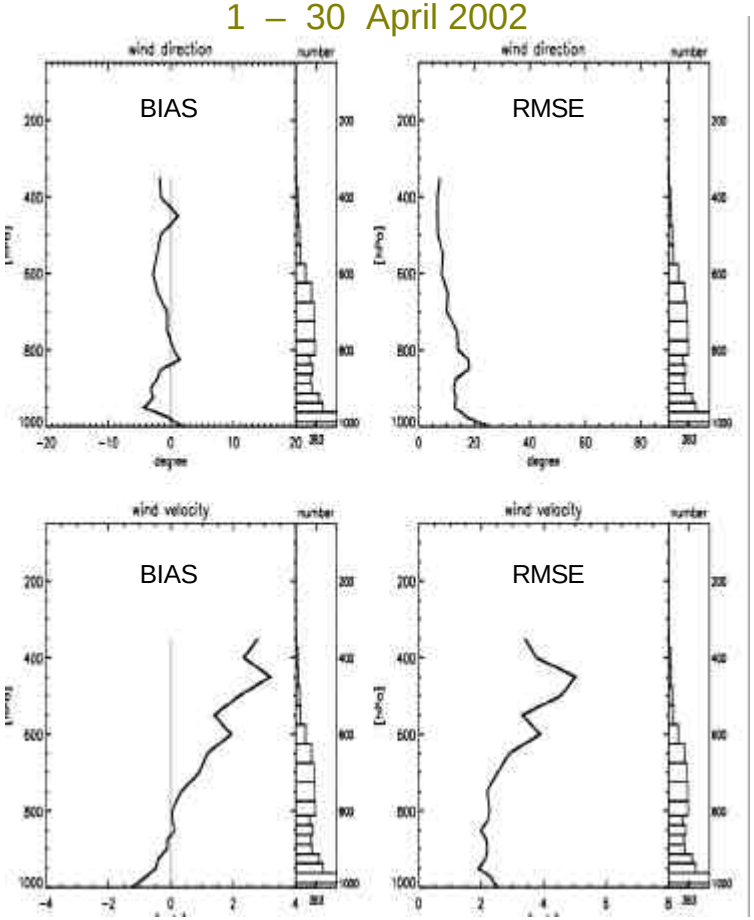
21 Jan – 22 Feb 2004



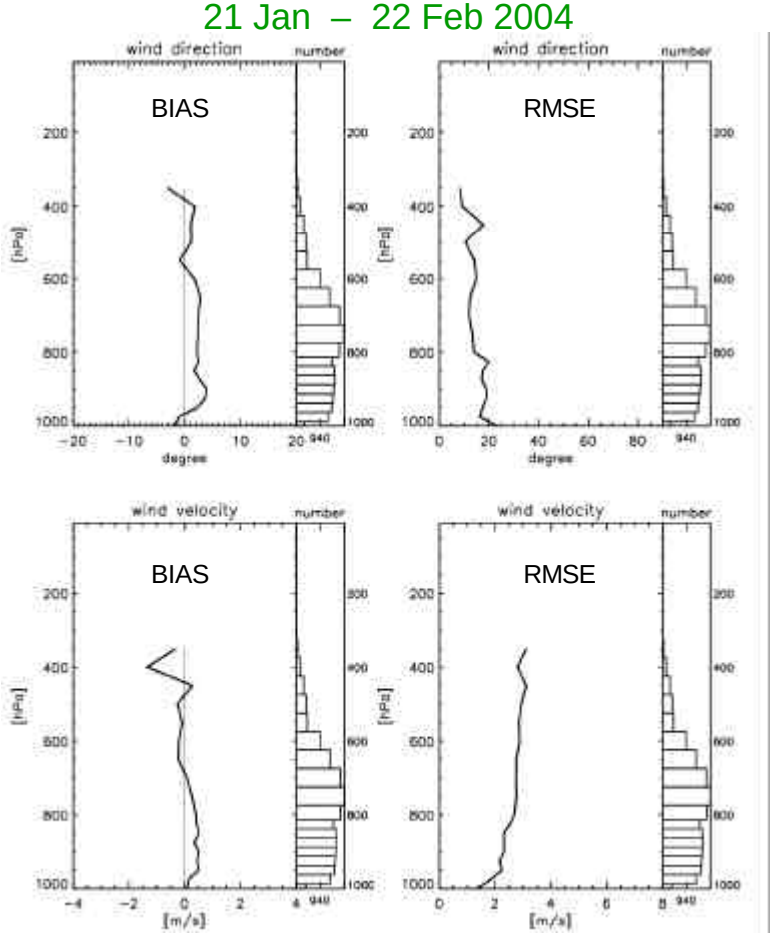
Wind Profiler : Monitoring

monitoring of wind profiler Camborne (03807) against LM analyses

1 – 30 April 2002



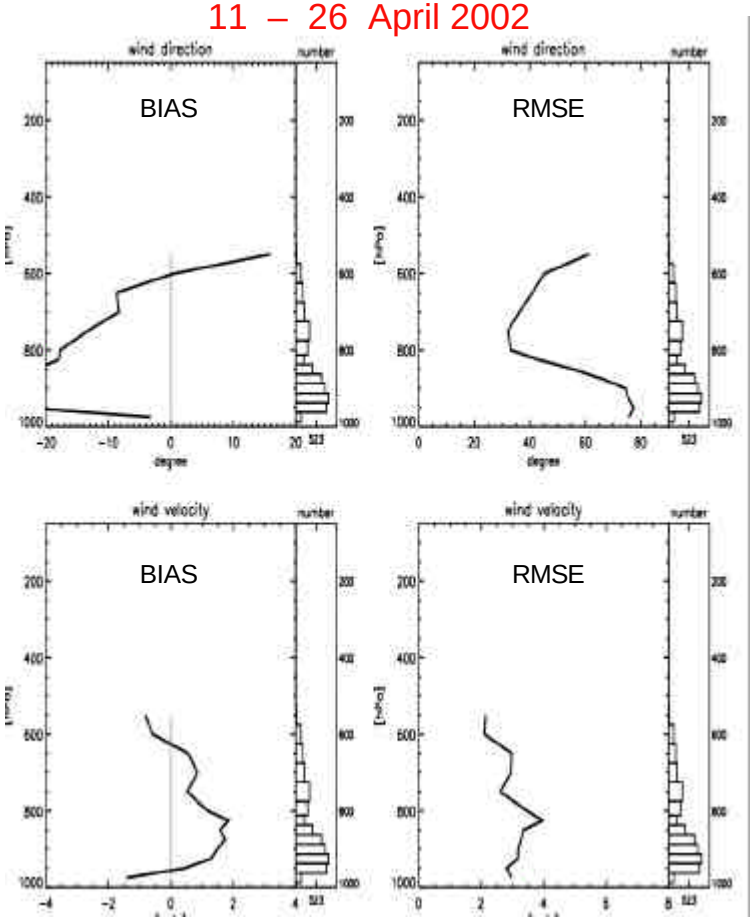
21 Jan – 22 Feb 2004



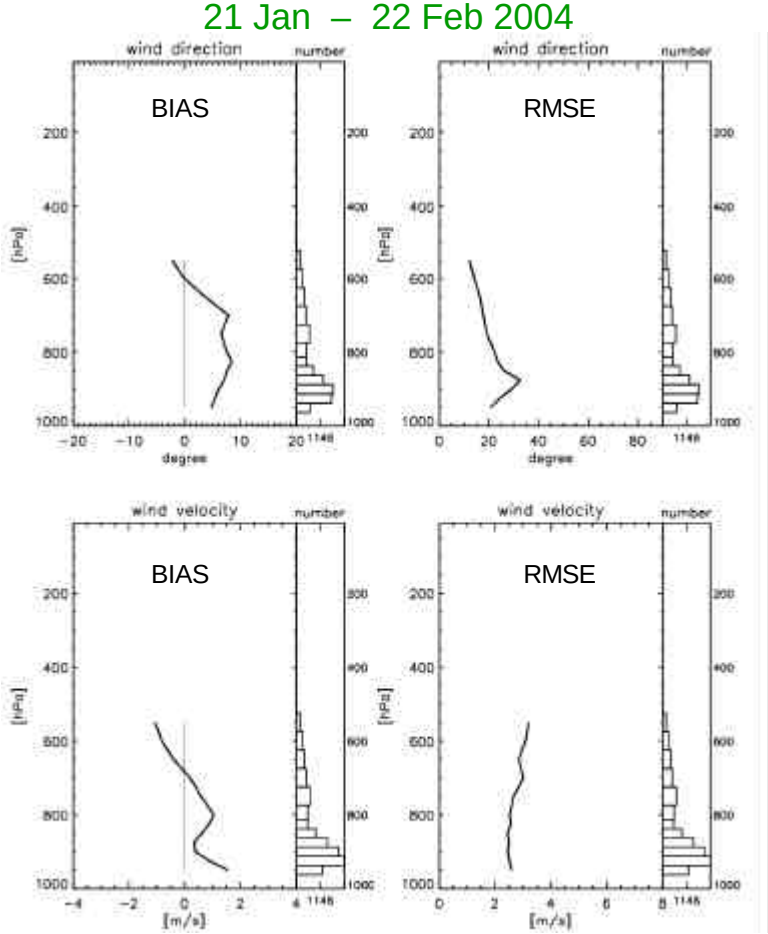
Wind Profiler : Monitoring

monitoring of wind profiler Payerne (06610) against LM analyses

11 – 26 April 2002



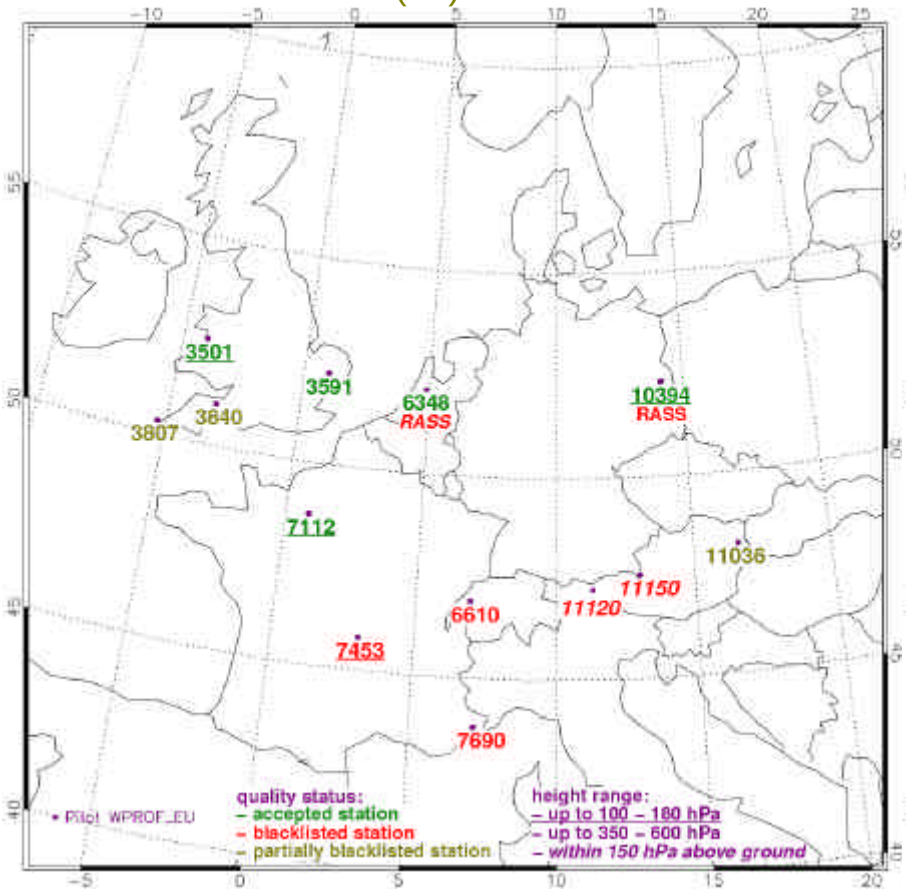
21 Jan – 22 Feb 2004



Wind Profiler : Monitoring

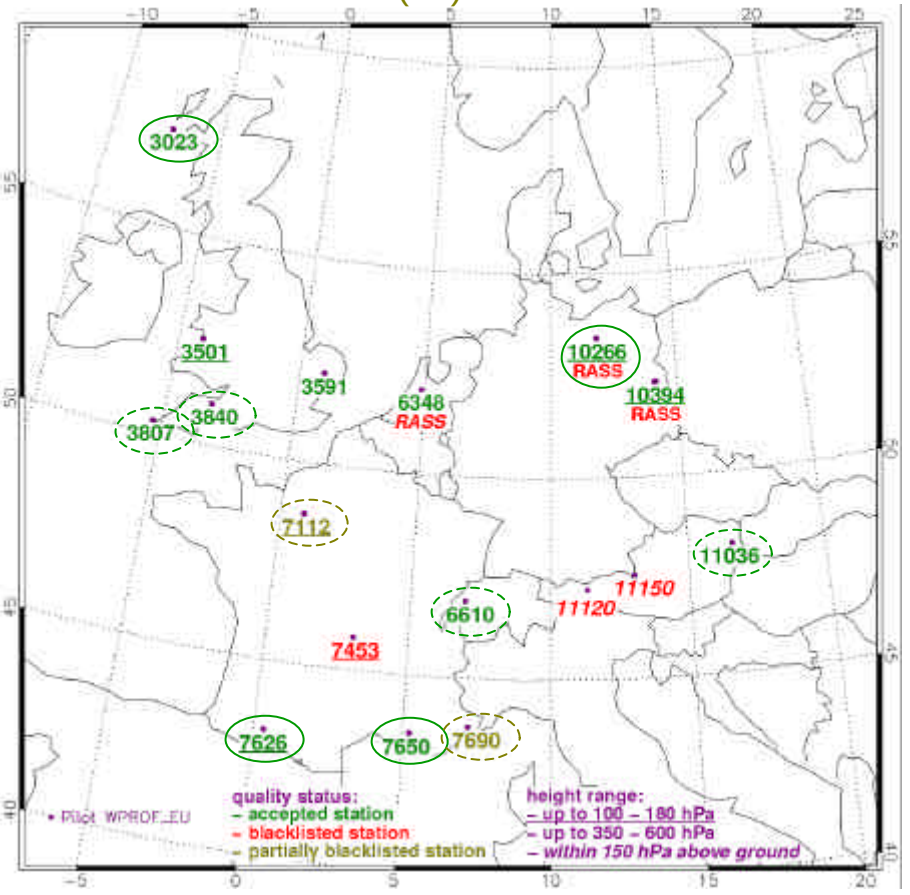
Wind Profiler stations in April 2002

5 (+3) used

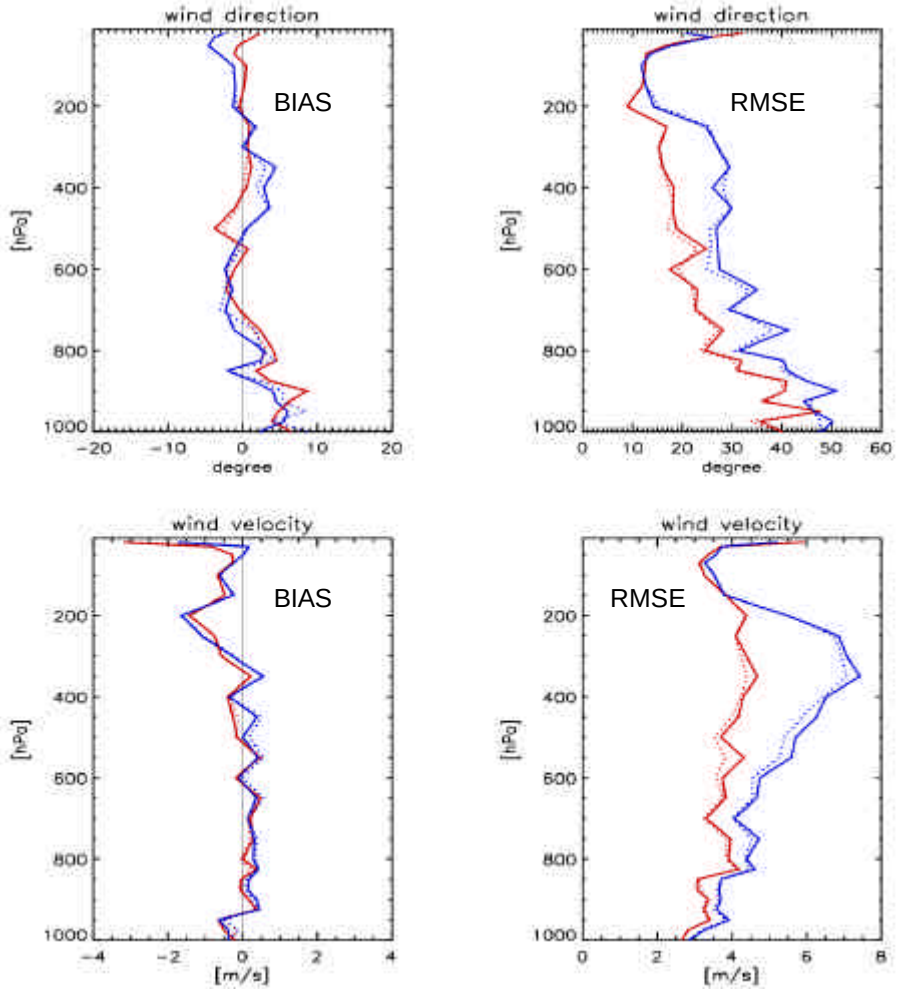


Wind Profiler stations in February 2004

12 (+2) used



Wind Profiler : Impact Study and Conclusion



verification against radiosonde data

23 Jan – 24 Feb 2004 , 18 UTC

operational: *without* use of wind profilers	experiment: *with* use of wind profilers
+ 42 H	+ 42 H
+ 18 H	+ 18 H

→ positive impact on upper-air wind forecasts

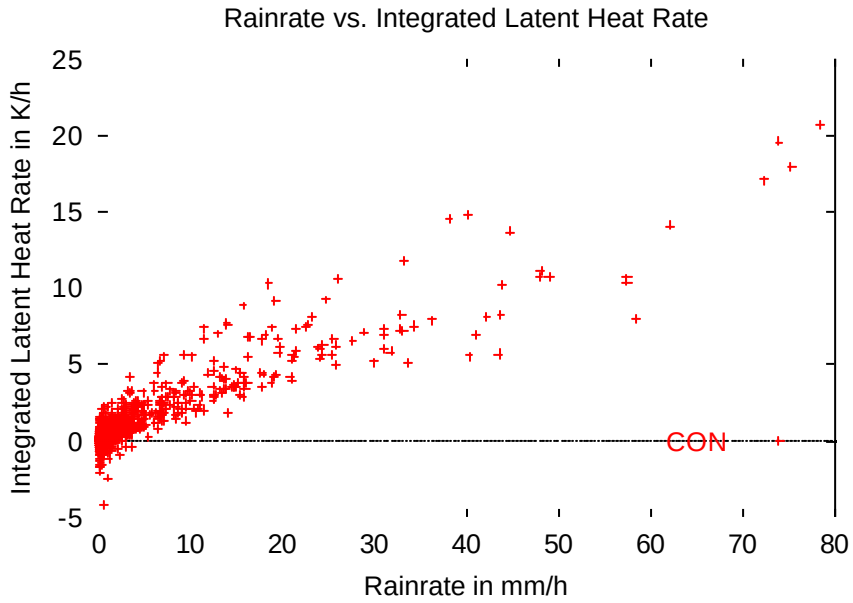
→ neutral impact on precipitation and weather, slightly positive at SYNOP verification

→ wind profiler observations used operationally since 14 July 2004 !

LHN : Approach + Basic Assumption

- **Required:** relation: precipitation rate ↔ model variables
  (observed) (info required by nudging)
  precipitation ↔ condensation ↔ release of latent heat

- **Assumption:** vertically integrated latent heat release ∝ precipitation rate



- **Approach:** modification of latent heating rates, in order to simulate the observed precipitation rates → Latent Heat Nudging

LHN : Method + Implementation

- **Method:** adding the nudging increment to the temperature tendency

$$T_{new} = T_{old} + \Delta T_{micro} + \Delta T_{satad} + \Delta T_{non\text{-}LH} + \Delta T_{nudg} + \Delta T_{LHN}$$

- scaling of the latent heat profile given by the model temperature increment :

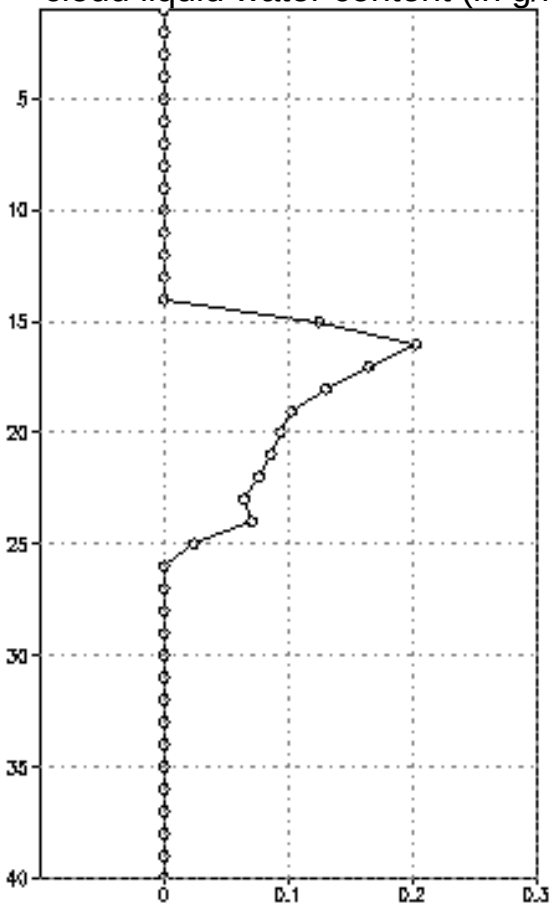
$$\Delta T_{LHN} = \left(\frac{RR_{obs}}{RR_{mo}} - 1 \right) \cdot \Delta T_{LHmo}$$

- sources + sinks for latent heat:
  - condensation/evaporation in clouds
  - evaporation of precipitation below clouds
  - melting of snow/ice and freezing of rain
- model precipitation below threshold: LH profile search / idealised profiles
- vertical + horizontal filtering of LHN temperature increments
- adjustment of specific humidity q in order to maintain relative humidity f

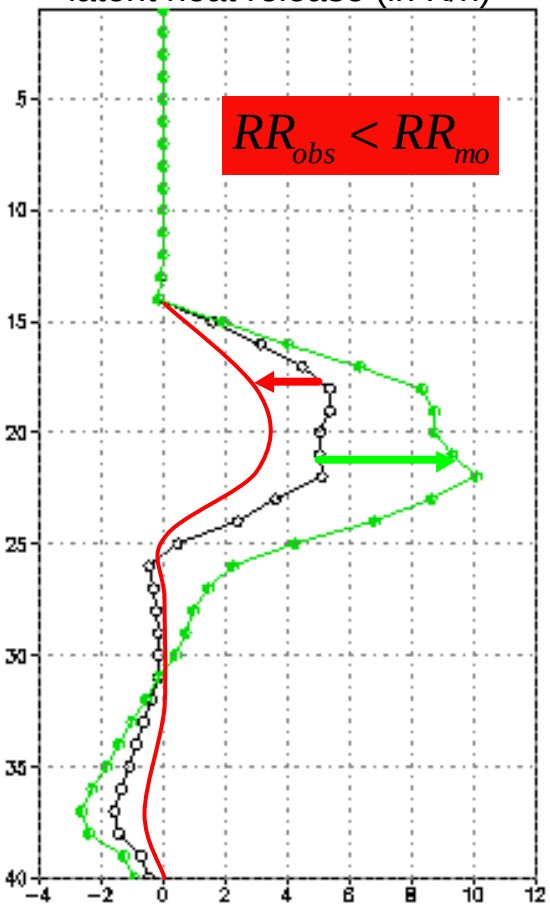
$\Delta_{LHN} T > 0$
$RR_{obs} > RR_{mo}$ $\Rightarrow$ increase q to reach f =100% over nudging time scale τ

LHN : Implementation

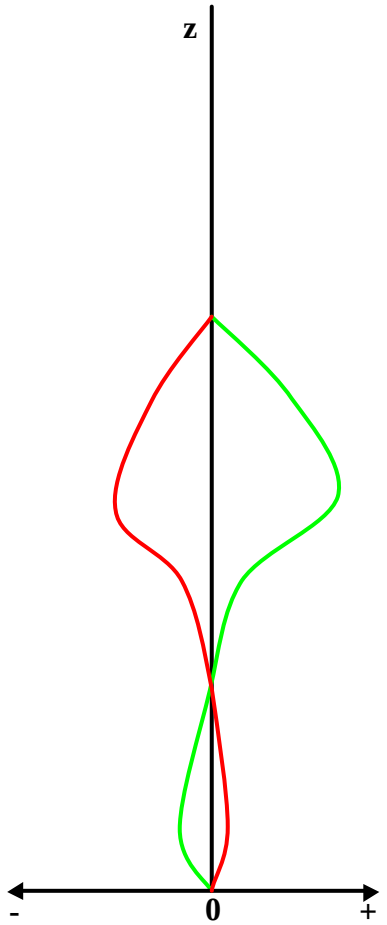
Vertical profiles:
cloud liquid water content (in g/kg)



latent heat release (in K/h)

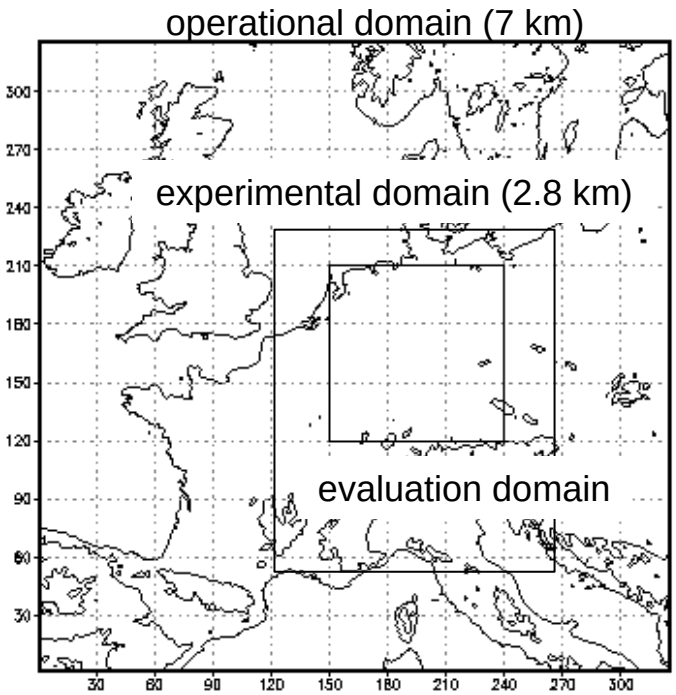


LHN - temperature increment



LHN : Impact Study

Δx = 2.8 km , no convection parameterisation , LHN with humidity adjustment



LHN : Impact Study

Δx = 2.8 km , no convection parameterisation , LHN with humidity adjustment

28 August 2002

1-hour sum of precipitation

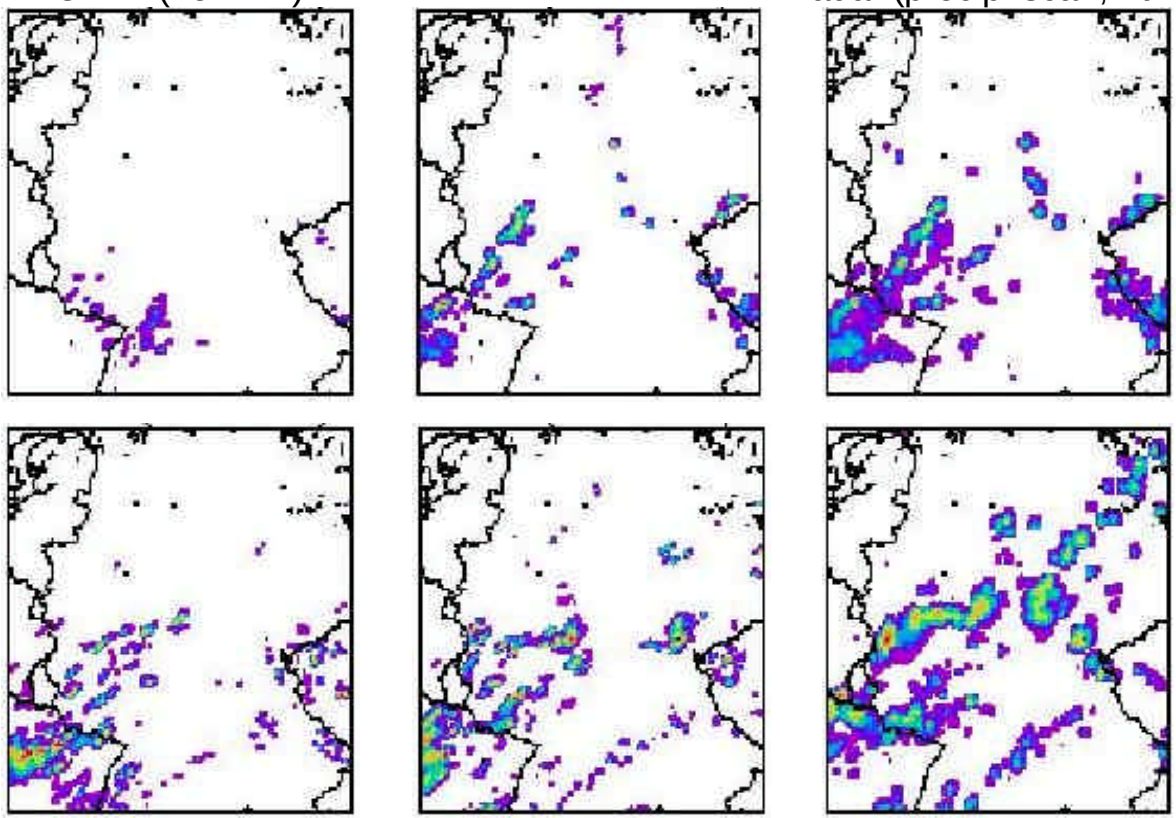
CTRL (no LHN) | LHN | radar (precip. scan, Δt=5')

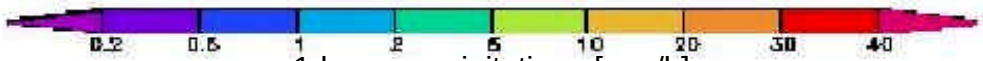
valid for 12 UTC:

end of 6-hour data assimilation period

valid for 17 UTC:

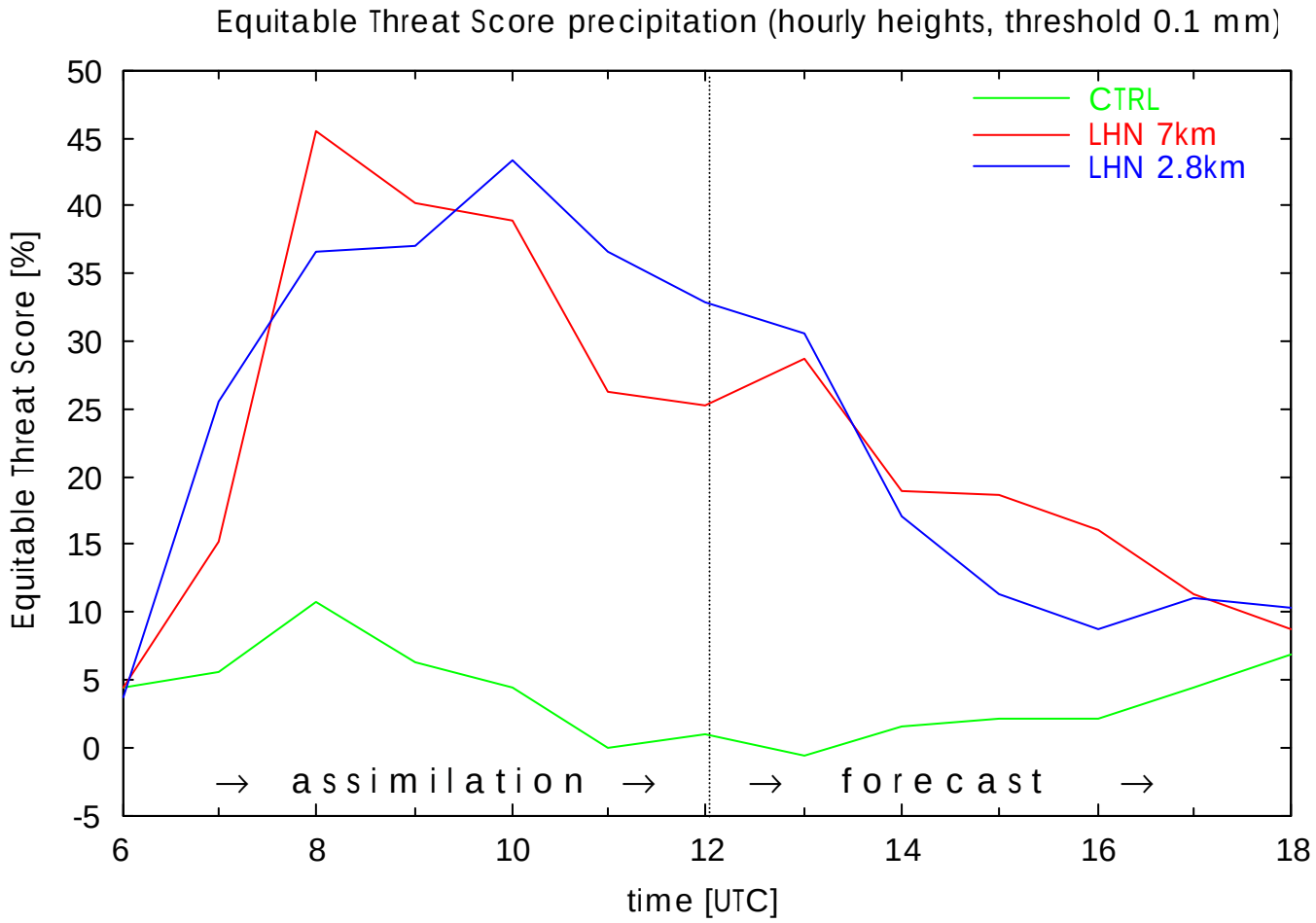
5th hour of free forecast





1-hour precipitation [mm/h]

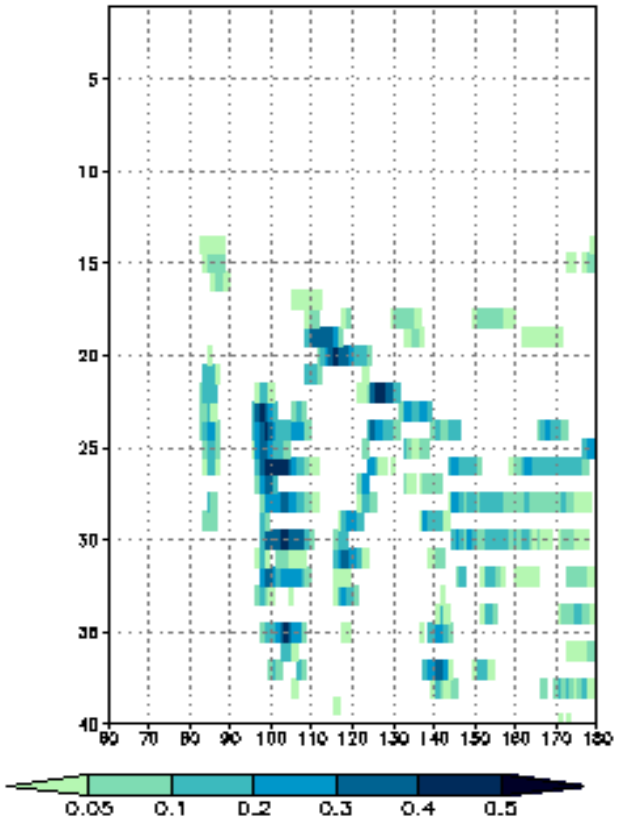
LHN : Impact Study



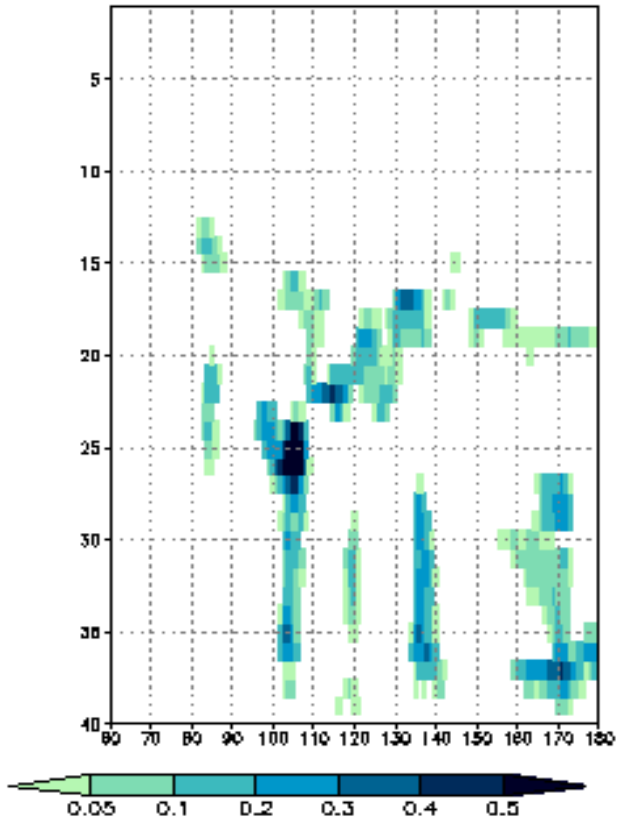
LHN : Vertical Filtering

vertical cross section: cloud liquid water content (in g/kg)

preliminary filter



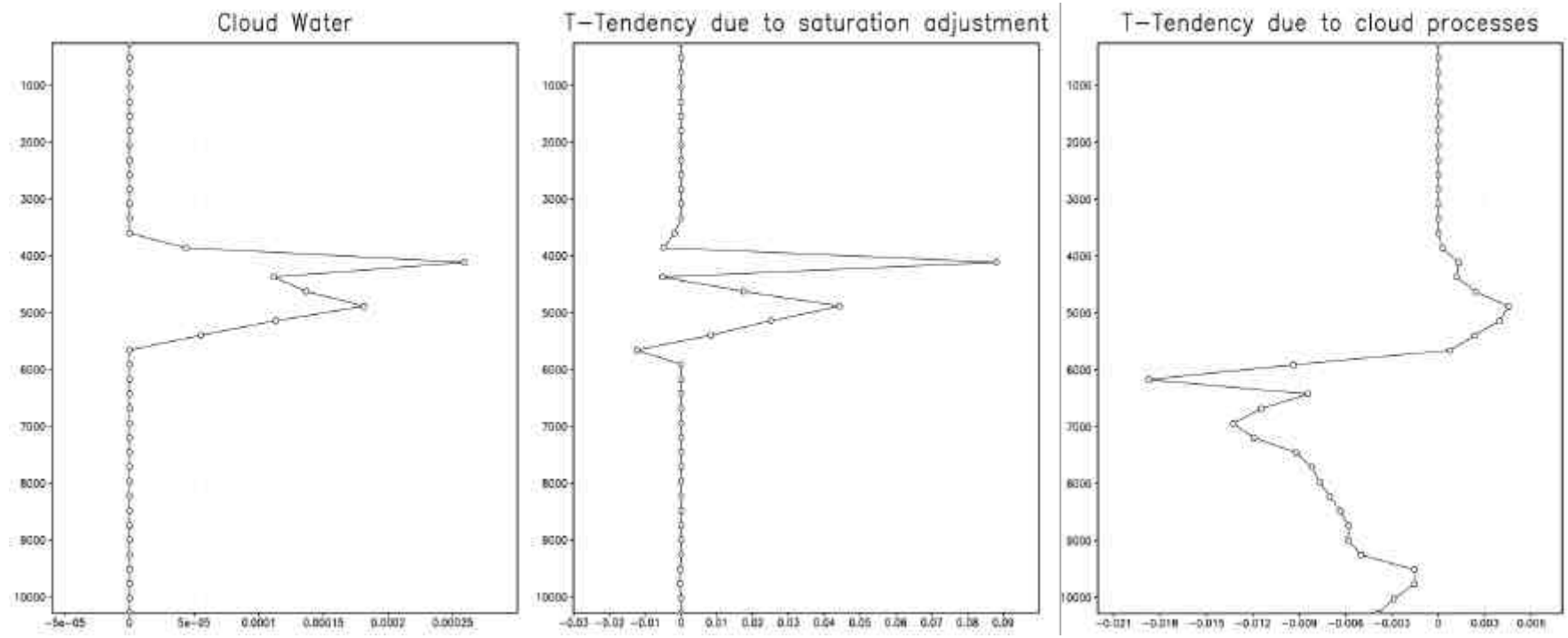
vertical filter applied



LHN : Diagnostics, Impact of Turbulence Scheme

→ investigation on processes contributing to the model temperature tendency, i.e. advection, diffusion, radiation, turbulence, etc:

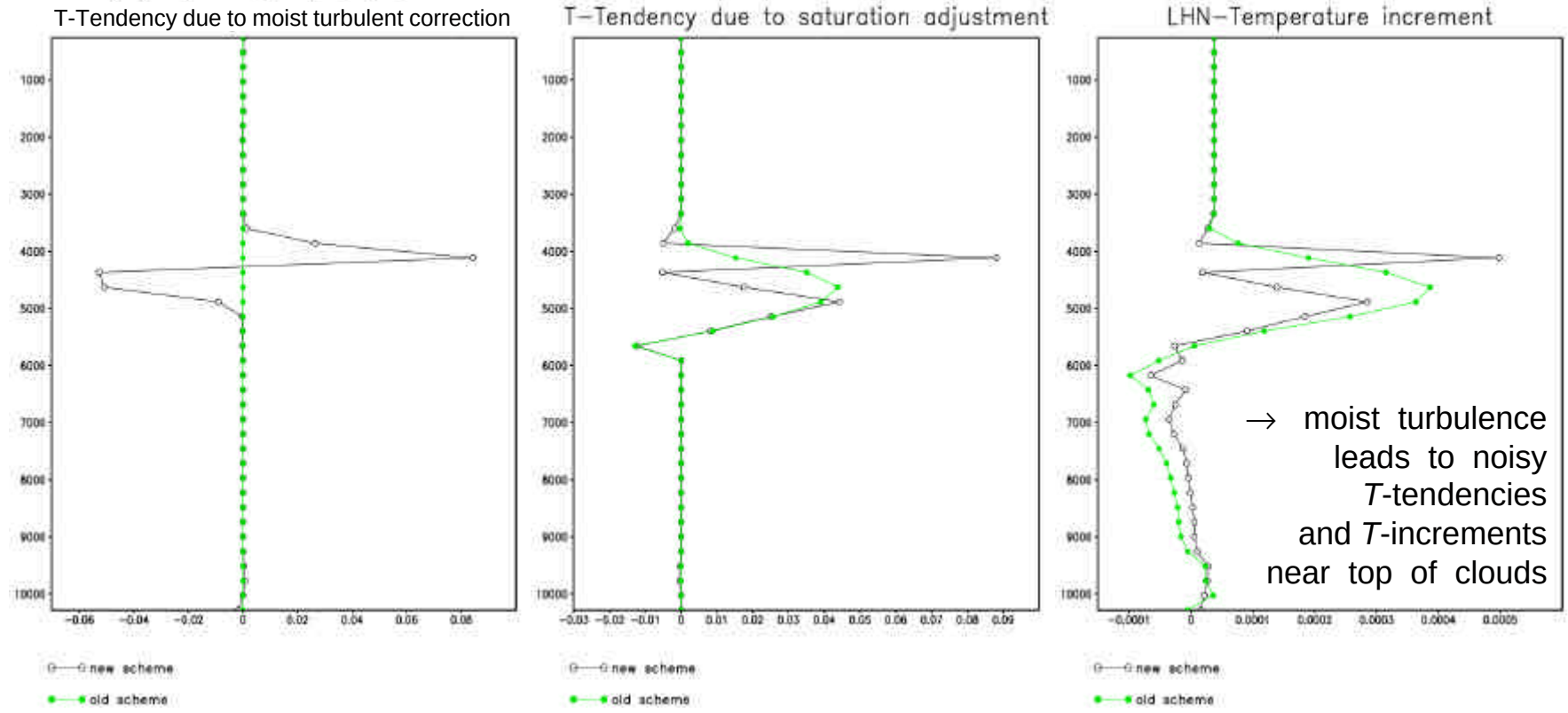
→ e.g. at a grid point with observed > model precipitation



LHN : Diagnostics, Impact of Turbulence Scheme

→ investigation on processes contributing to the model temperature tendency, i.e. advection, diffusion, radiation, turbulence, etc:

→ e.g. vertical profiles at a grid point with observed > model precipitation

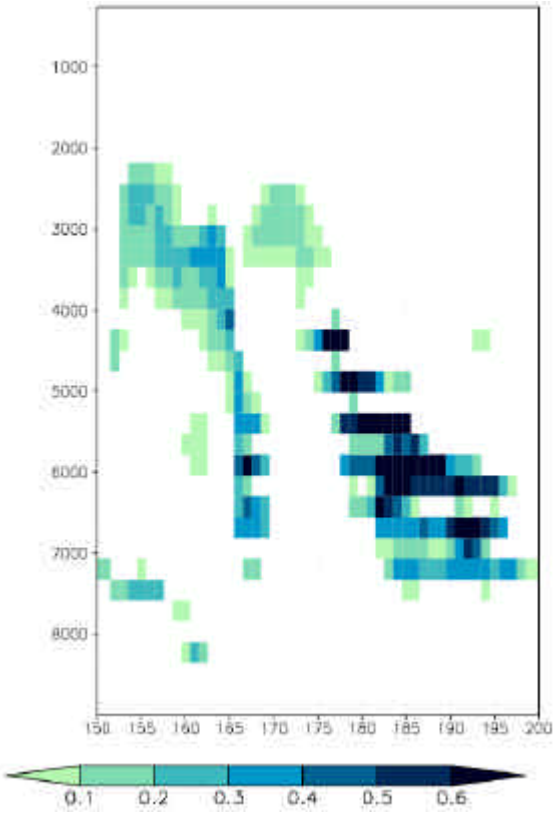


→ moist turbulence leads to noisy *T*-tendencies and *T*-increments near top of clouds

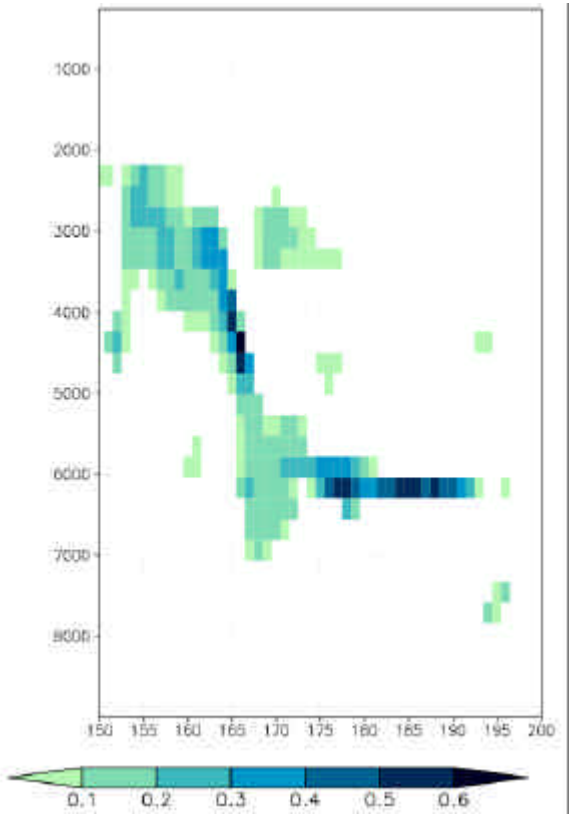
LHN : Diagnostics, Impact of Turbulence Scheme

vertical cross section: cloud liquid water content (in g/kg)

new turbulence (prognostic TKE)



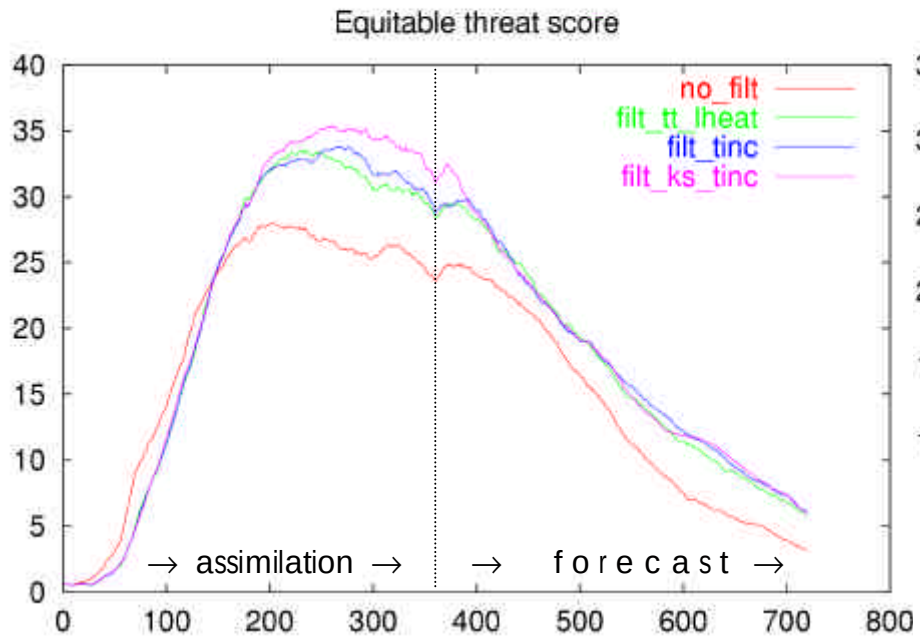
old diagnostic turbulence scheme



→ noisy *T*- and *q*- increments excite computational mode of Lorenz grid

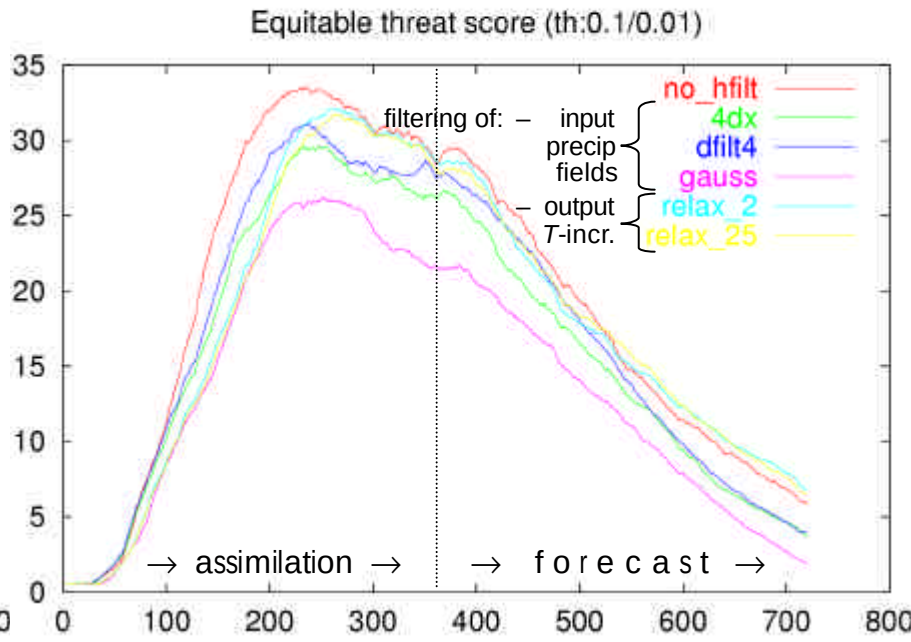
LHN : Filtering

vertical filtering



→ vertical filtering of temperature increments should be applied

horizontal filtering

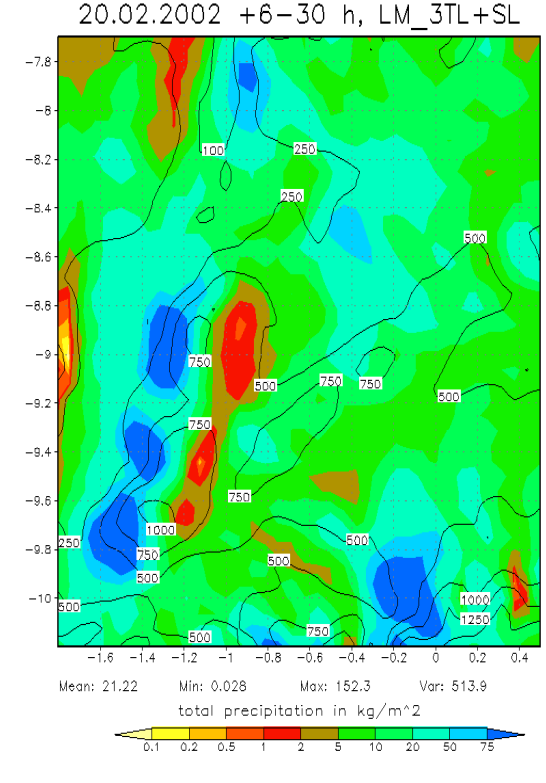


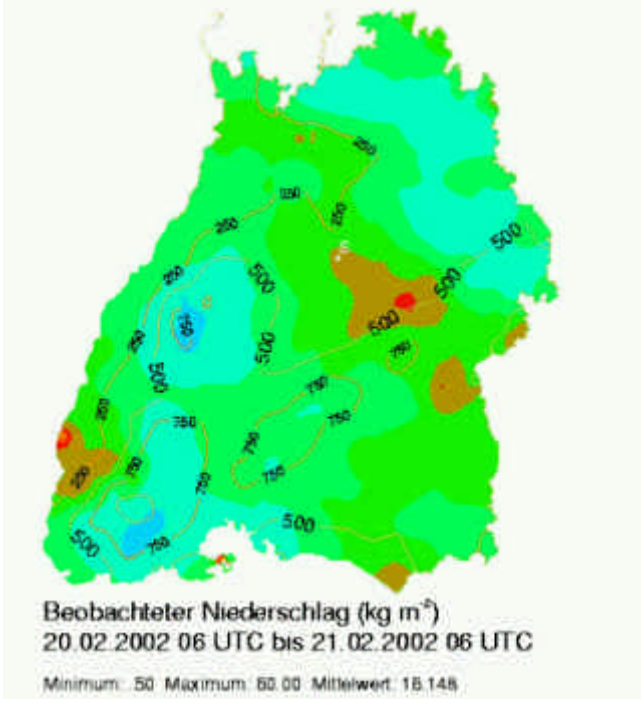
→ better to apply filter to resulting temperature increments than to input precipitation fields

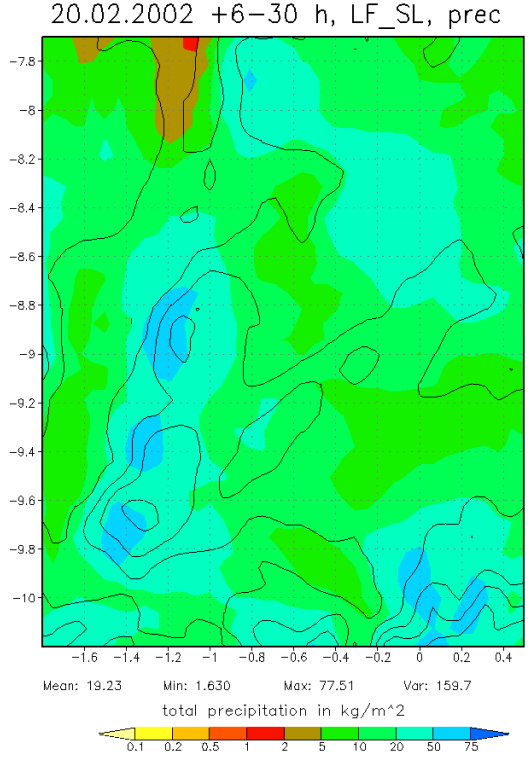
Prognostic Precipitation: Model Improvement

Case Study: 20. February 2002, +06 – 30-h forecasts : 24-hour sum of precipitation

diagnostic precipitation scheme | observation | prognostic precipitation scheme

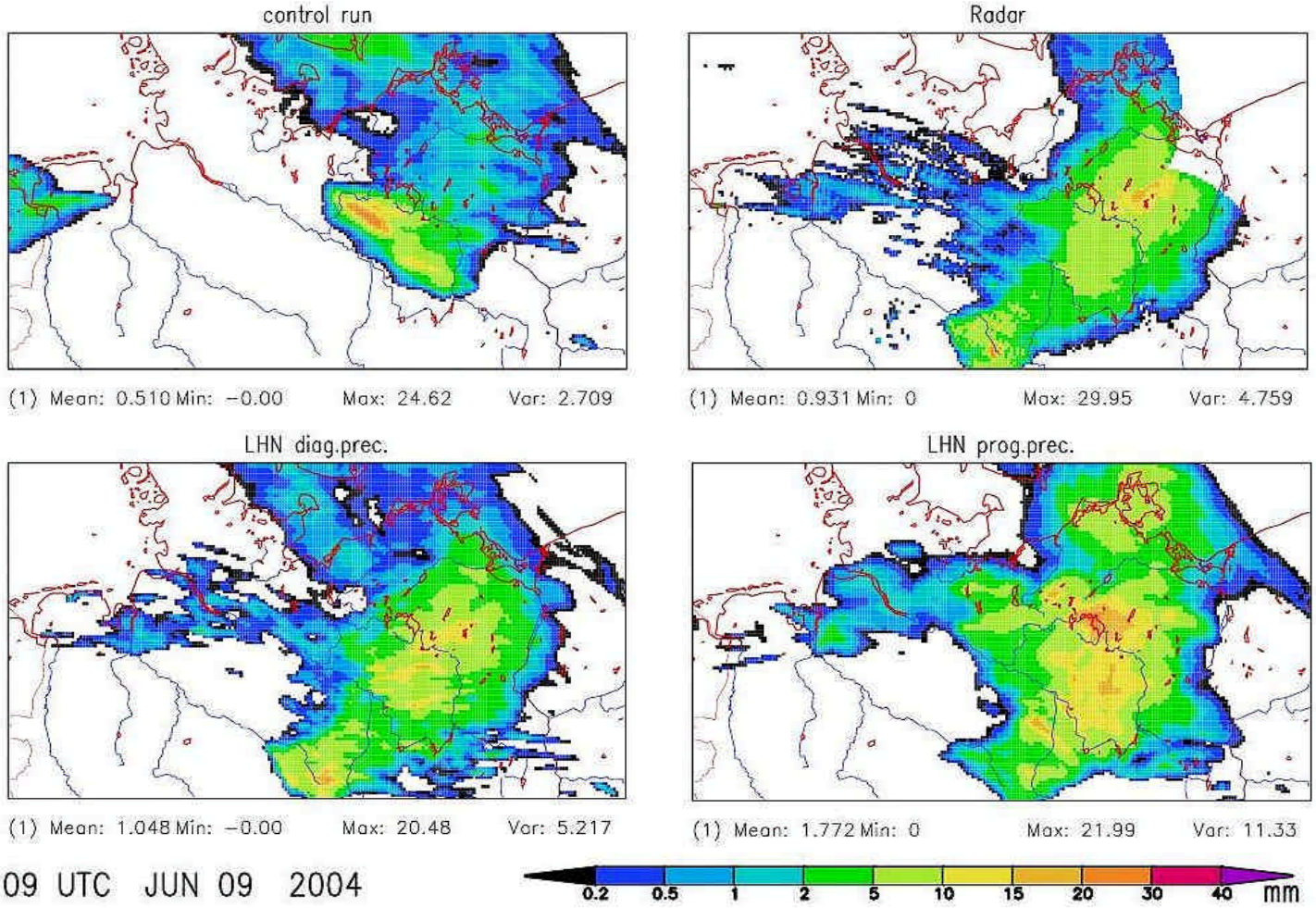




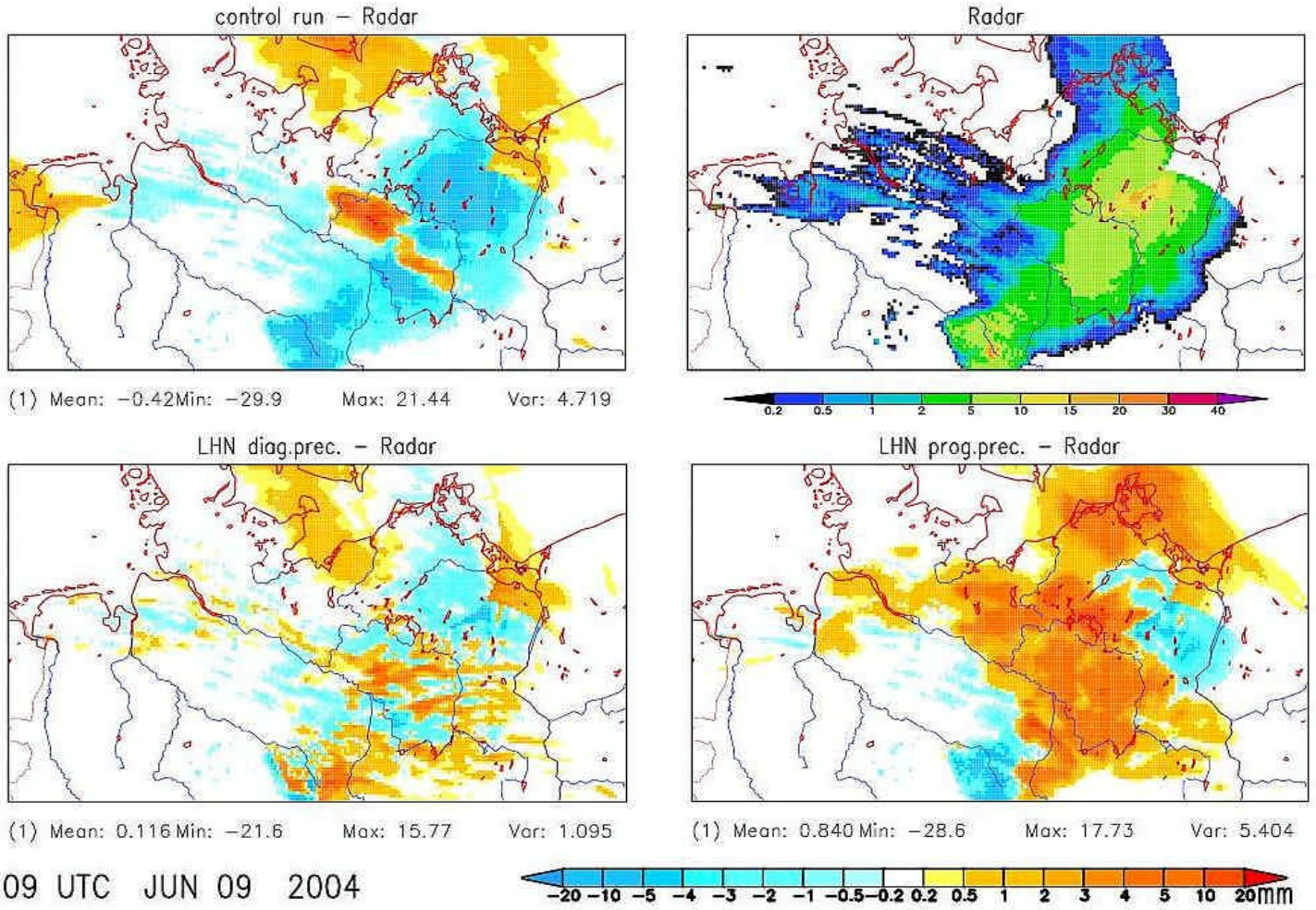


DS: COLA/IGES 2003-12-23-13:32 GrADS: COLA/IGES 2004-02-09-0

LHN : Influence of Prognostic Precipitation



LHN : Influence of Prognostic Precipitation



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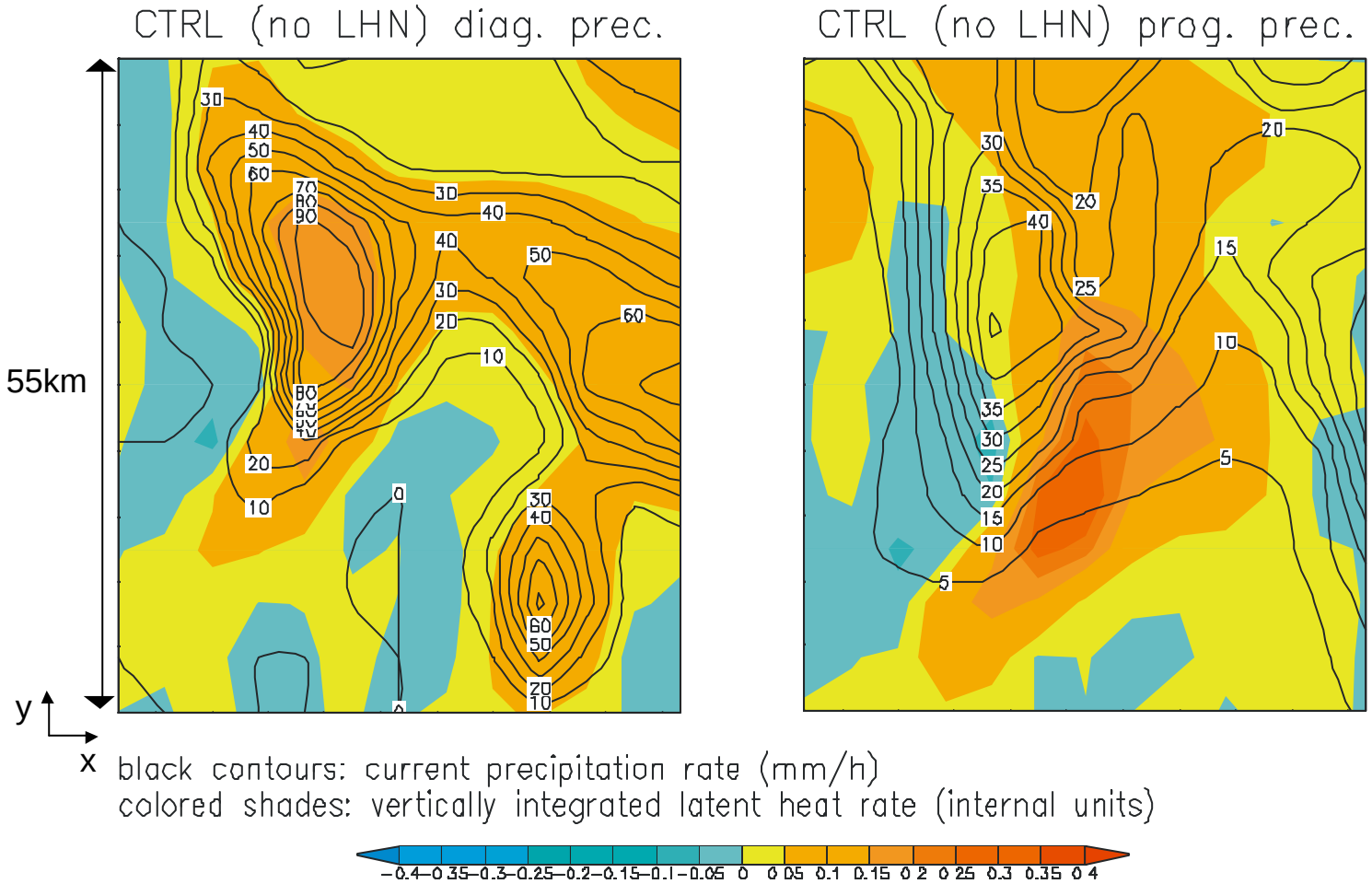

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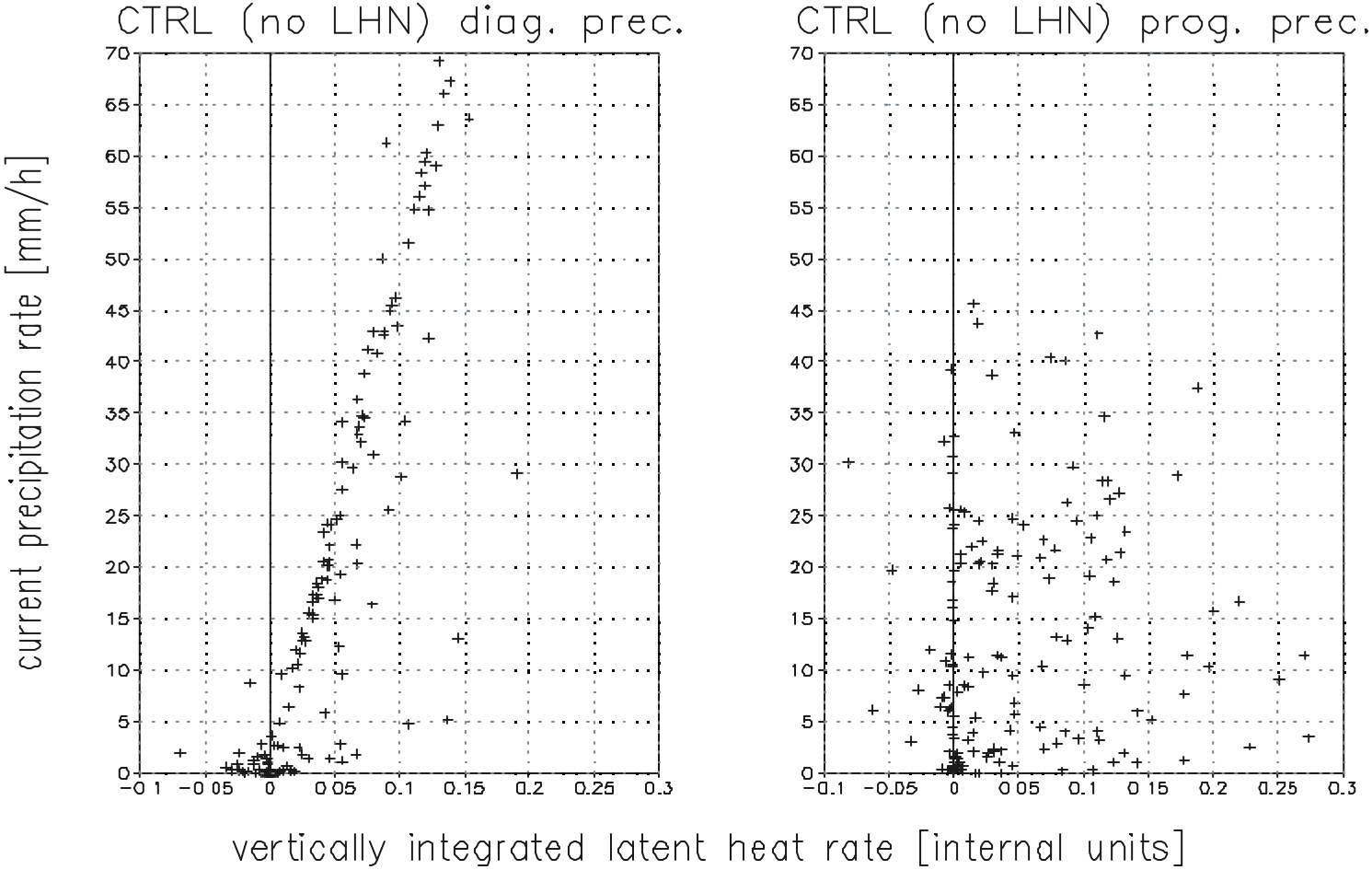

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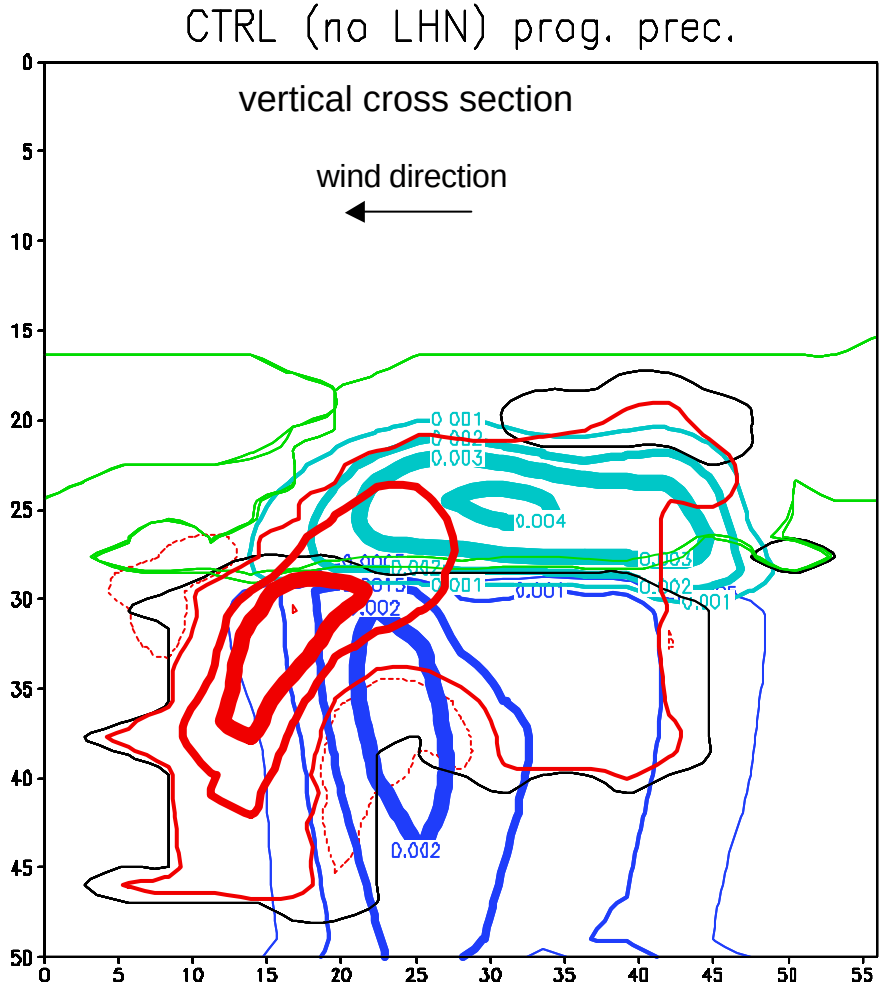

spec. cloud water

spec. cloud ice

latent heat rate

spec. **rain** content

spec. **snow** content

LHN : Results and Future Work

- **Results:**
  - positive impact of LHN assimilation on forecasts lasts for several hours
  - moist turbulence correction plays a role in excitation of computational mode
    → vertical filtering of increments beneficial
  - prognostic treatment of precipitation (drifting) limits the validity of the basic assumption of the LHN algorithm

- **Future Work:**
  - consideration of drifting of precipitation (in time and space) in order to re-establish a relation between latent heat release and precipitation amount
  - improvements to extend the influence of assimilation during free forecast
    → analysis of moisture convergence

Questions ?

Remarks ?