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**Bundesamt für Meteorologie und Klimatologie MeteoSchweiz**

# Assimilation of Radar Rainfall in COSMO-2 and Use of Humidity Profiles from GPS Tomography

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Thanks for contributions of Felix Ament, MeteoSwiss

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# Outline

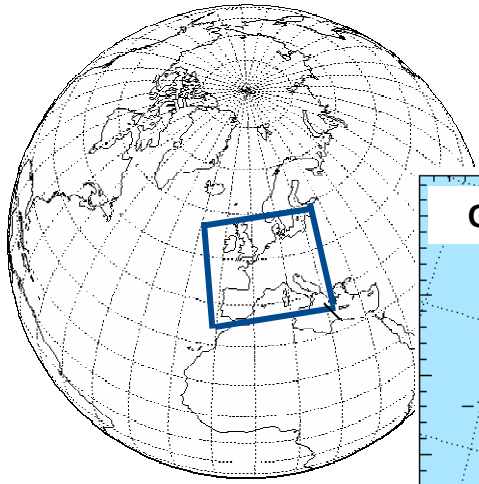
- Motivation
- Model Setup
- Radar Rainfall Assimilation
- GPS Tomography
- Summary and Outlook

# Motivation

- Poor QPF performance in summer
- Partly due to initial conditions
- Need for high-resolution observations
- Radar
  - Reflectivity, wind
  - 5min temporal, 1km spatial
- GPS
  - Humidity
  - <1h temporal, ~50km spatial

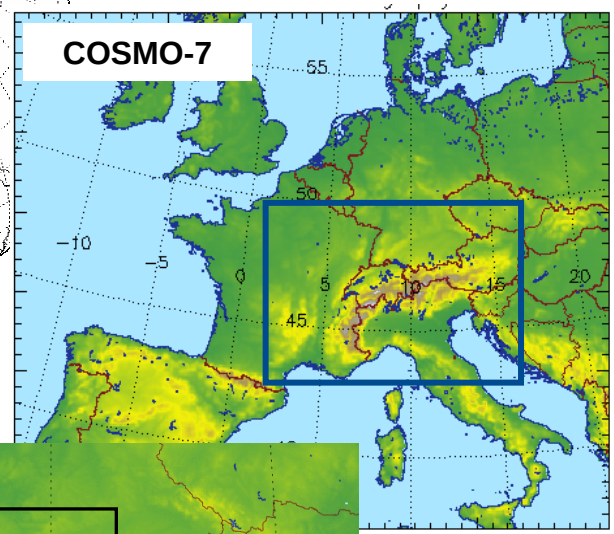
# Model Setup

IFS (ECMWF)



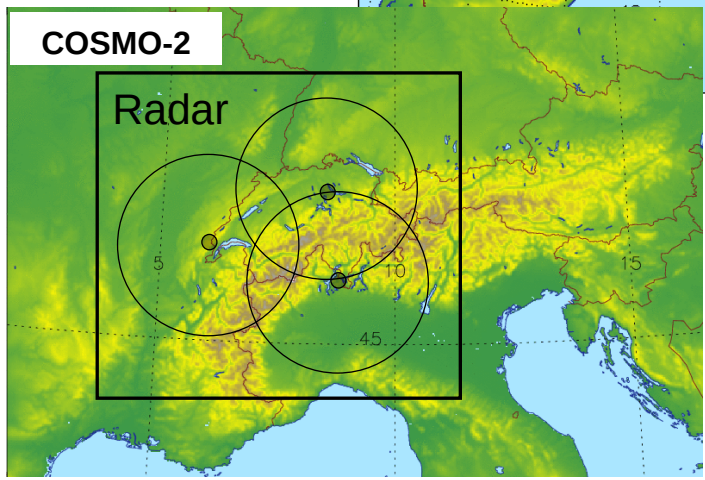
COSMO-7

- 7km, 45 levels
- Tiedke conv. scheme




COSMO-2

- 2.2km, 60 levels
- Shallow conv. scheme



# Radar Rainfall Assimilation

- Latent Heat Nudging (LHN)

  Jones and Macpherson, 1997, Leuenberger and Rossa, 2007

- Adjusts model temperature and moisture to match radar rainfall

- Modifications for advection of precipitation (DWD)

- More details in Klaus Stephan‘s presentation

Jones, C. D. and B. Macpherson, 1997: A Latent Heat Nudging Scheme for the Assimilation of Precipitation Data into an Operational Mesoscale Model, *Meteorol. Appl*., **4**, 269-277

Leuenberger, D. and A. Rossa, 2007: Revisiting the latent heat nudging scheme for the rainfall assimilation of a simulated convective storm, Meteorol. Atmos. Phys., online first, DOI 10.1007/s00703-007-0260-9

# Radar Data

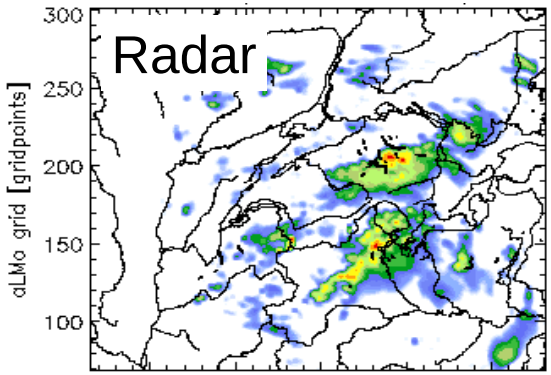
- High-quality rainfall information derived from Swiss radar composite (3 C-Band Radar)
- Best estimate of surface precipitation
- Clutter suppression, vertical profile correction, gauge adjustment on long time scale
- 5 min update frequency

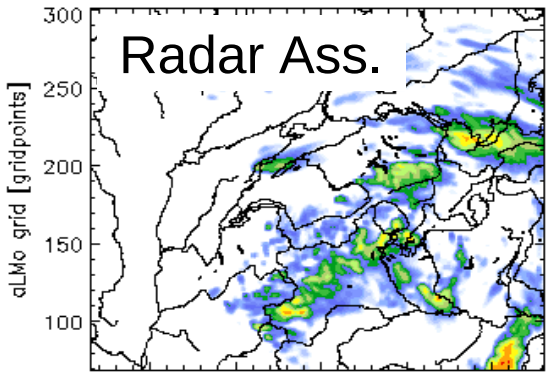
# Setup of Experiments

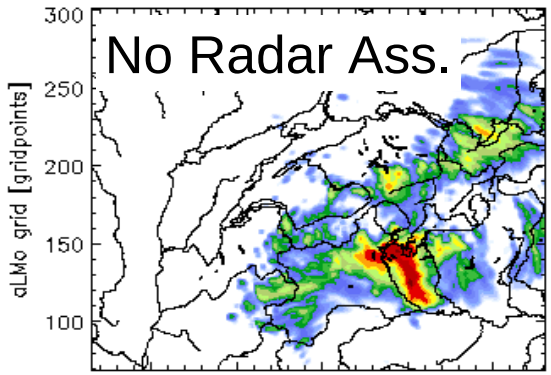
- 2.2km assimilation cycle with/without LHN
- Forecasts out to 12h started from the analyses
- Parallel test suite running currently at MeteoSwiss
- Two summer months (11. Jun - 23. Aug 2007)
  - 8 forecasts per day
- One autumn month (15. Sep – 18. Oct 2007)
  - 3 forecasts per day (00, 12, 18 UTC)

# Examples of forecast improvement

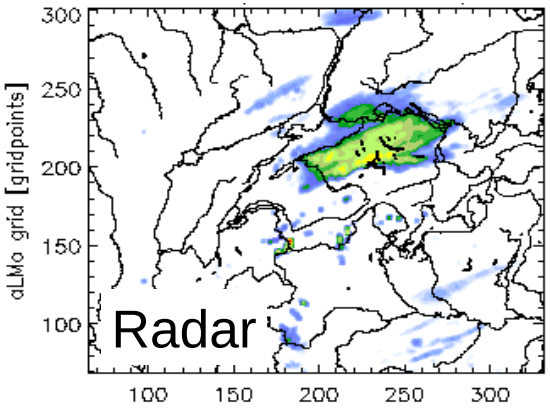
## **0-6h** Precipitation Forecast (12.06.2007, 18-24UTC)

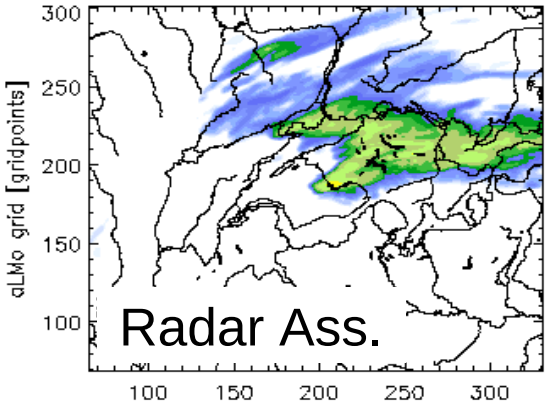


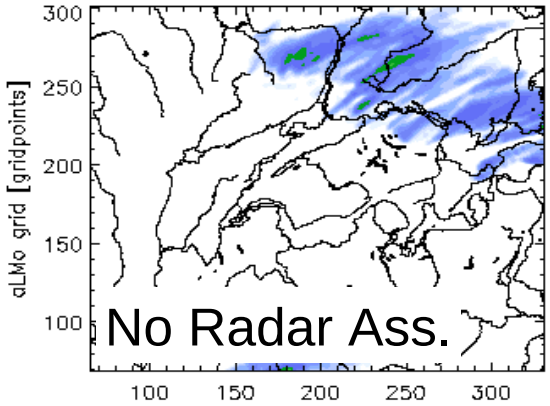




## **6-12h** Precipitation Forecast (19.06.2007, 00-06UTC)



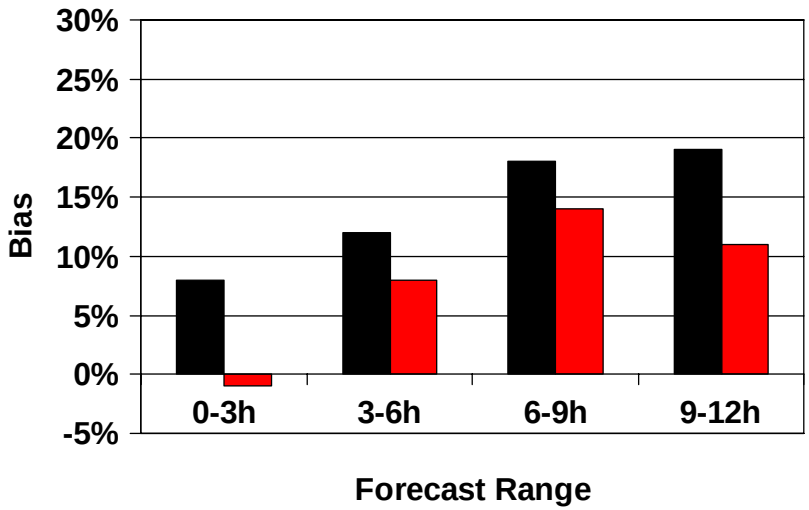



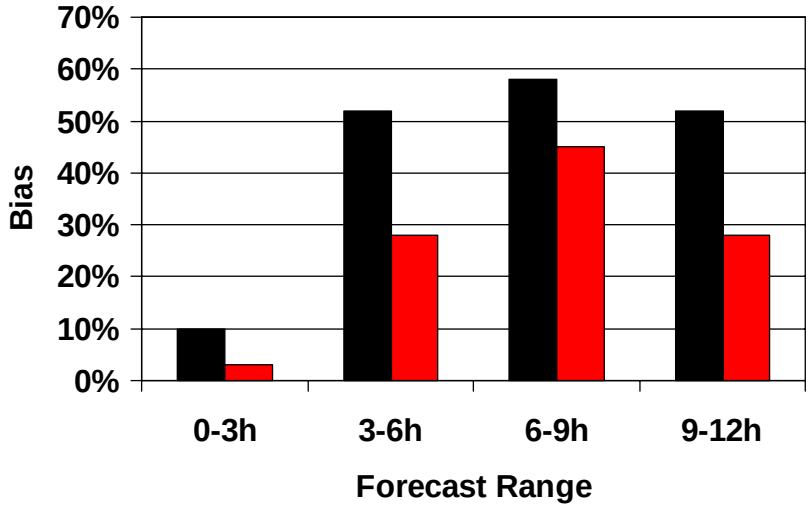
# Statistical Evaluation against Radar

Precipitation forecast bias over Switzerland

Summer (344 forecasts)



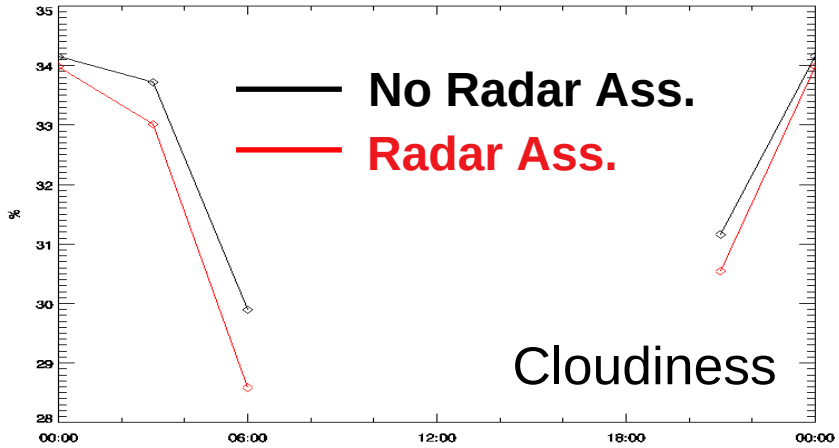

Autumn (102 forecasts)

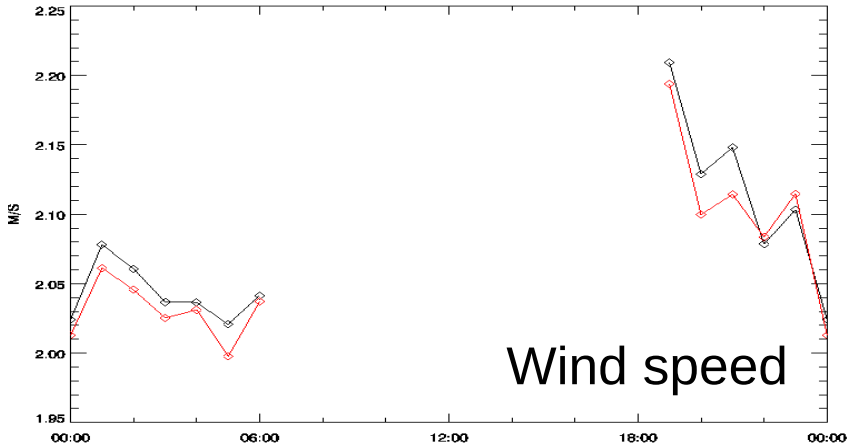


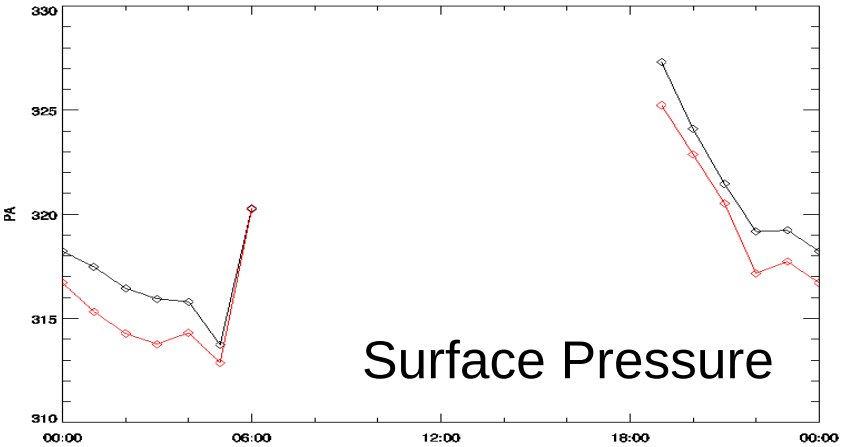

LHN No LHN

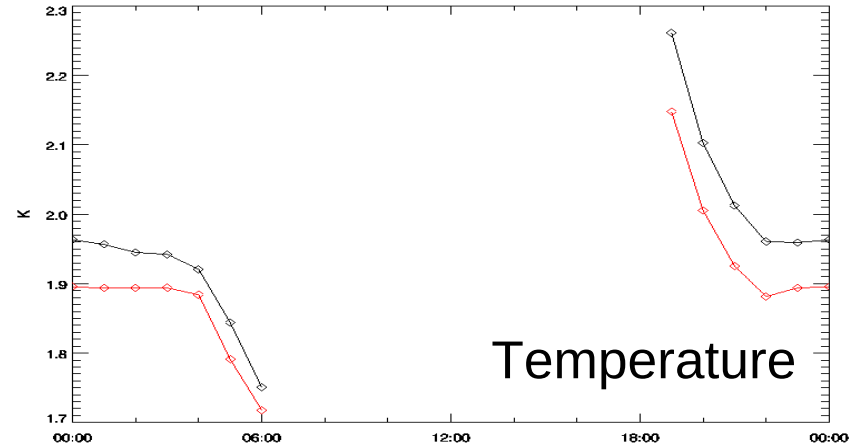
# Summer Evaluation (Surface Obs.)

RMS of 74 18UTC Forecasts (Reference: ca. 60 Swiss Sfc. Stations)



# Summary Radar Assimilation

- Improvement of precipitation bias out to 12h

- Surface obs
  - Small but consistent improvement of T, U/V, clouds and $P_s$ out to 12h in summer (up to 3% reduction of RMSE)
  - Mixed results in autumn

- Radiosondes
  - Small impact at +6h (+ in summer, +/- in autumn)
  - Neutral impact at 12h

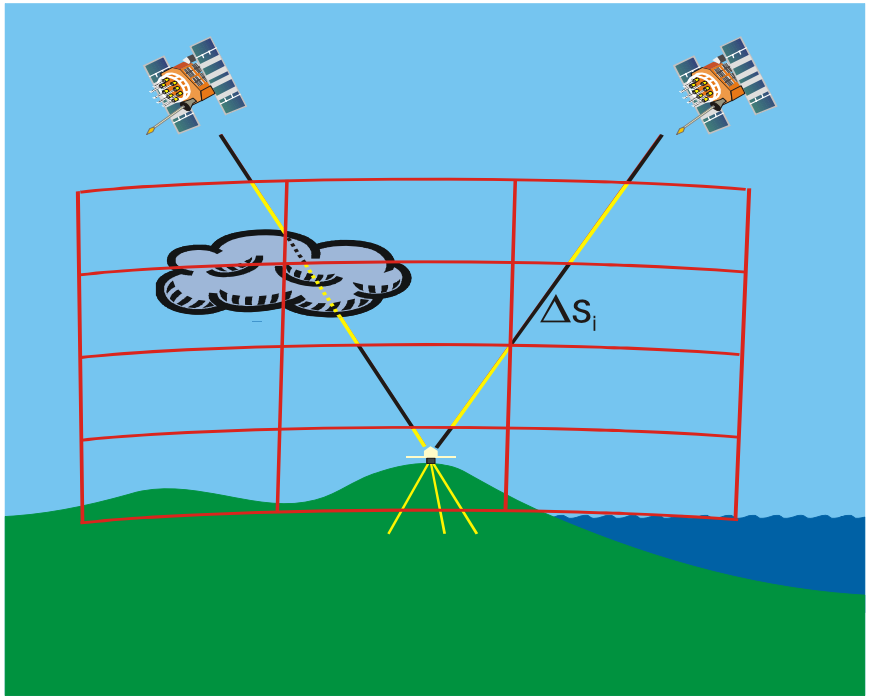
- Mesoscale environment important for success of radar assimilation

# GPS Tomography - Motivation

- Atmospheric moisture important for QPF
- Highly variable in time and space
- Currently: very sparse observations
  - Radiosondes (200km x 12h)
  - Surface stations (50km x 6h for SYNOP, locally higher), representativity problems
  - Satellites: problems over land, lower atmosphere and in cloudy regions
- => Large uncertainty in NWP humidity

# GPS Tomography - Method

- New method to retrieve humidity **profiles** from GPS
- High-resolution **in time and space**




Distance between satellite and receiver:

$$\rho = \int_{receiver}^{satellite} n \cdot ds$$

$\rho$: length of signal path
$n = c/v$: refractivity index

Making use of a voxel model:

$$\rho = \sum_{i=1}^{k} n_i \cdot \Delta s_i$$

$n_i$: constant refractivity index inside voxel i
$\Delta s_i$: path in voxel i
$k$: number of voxels

# Comparison with Temps and COSMO-7

- Wet refractivity from Payerne radiosonde

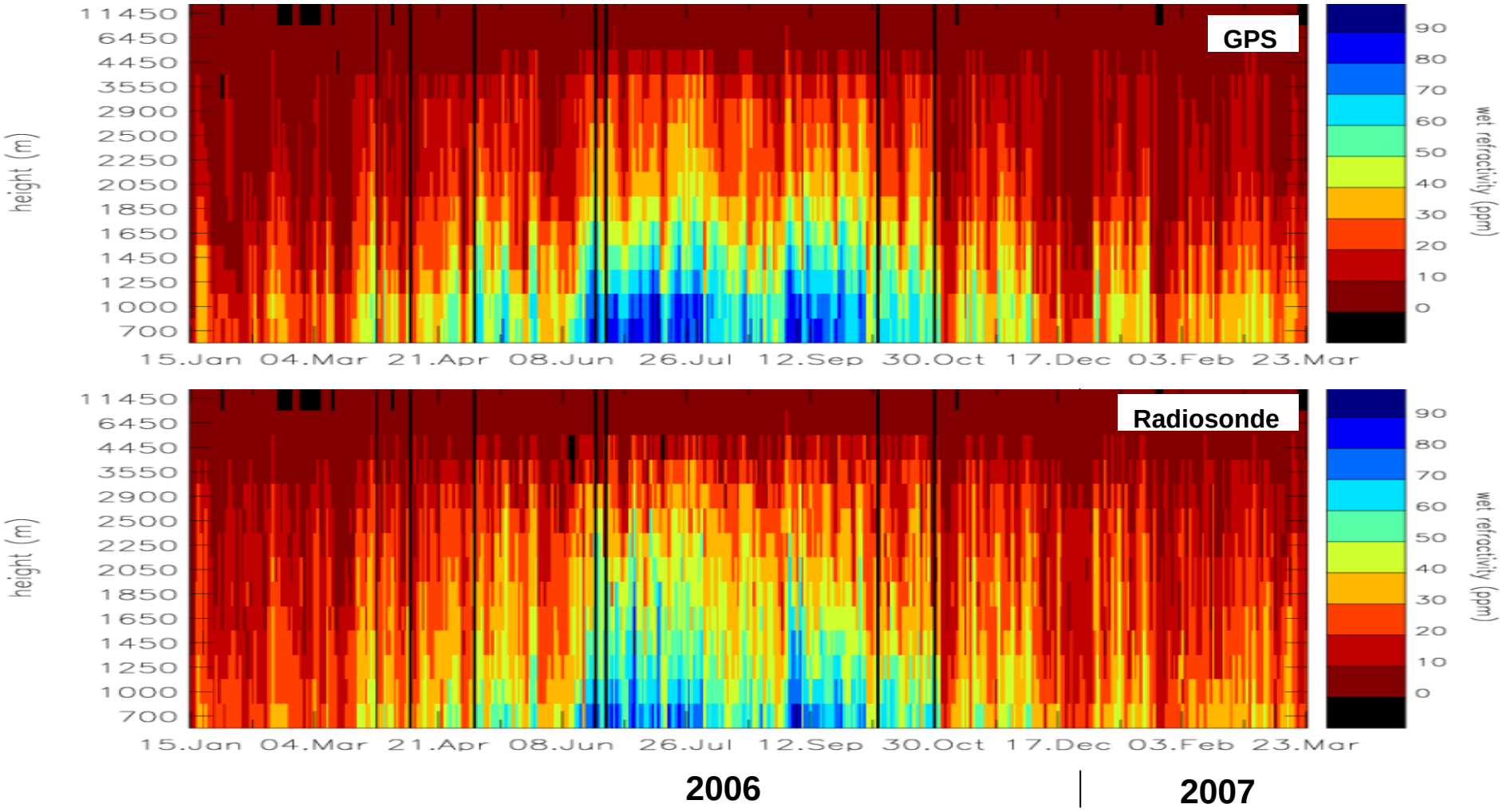
$$N_{wet} = k_2 \frac{e}{T} + k_3 \frac{e}{T^2} \qquad \varepsilon = R_d/R_{v,}$$

$k_2$= 64.8 K/hPa, $k_3$= 3.776e5 $K^2$/hPa

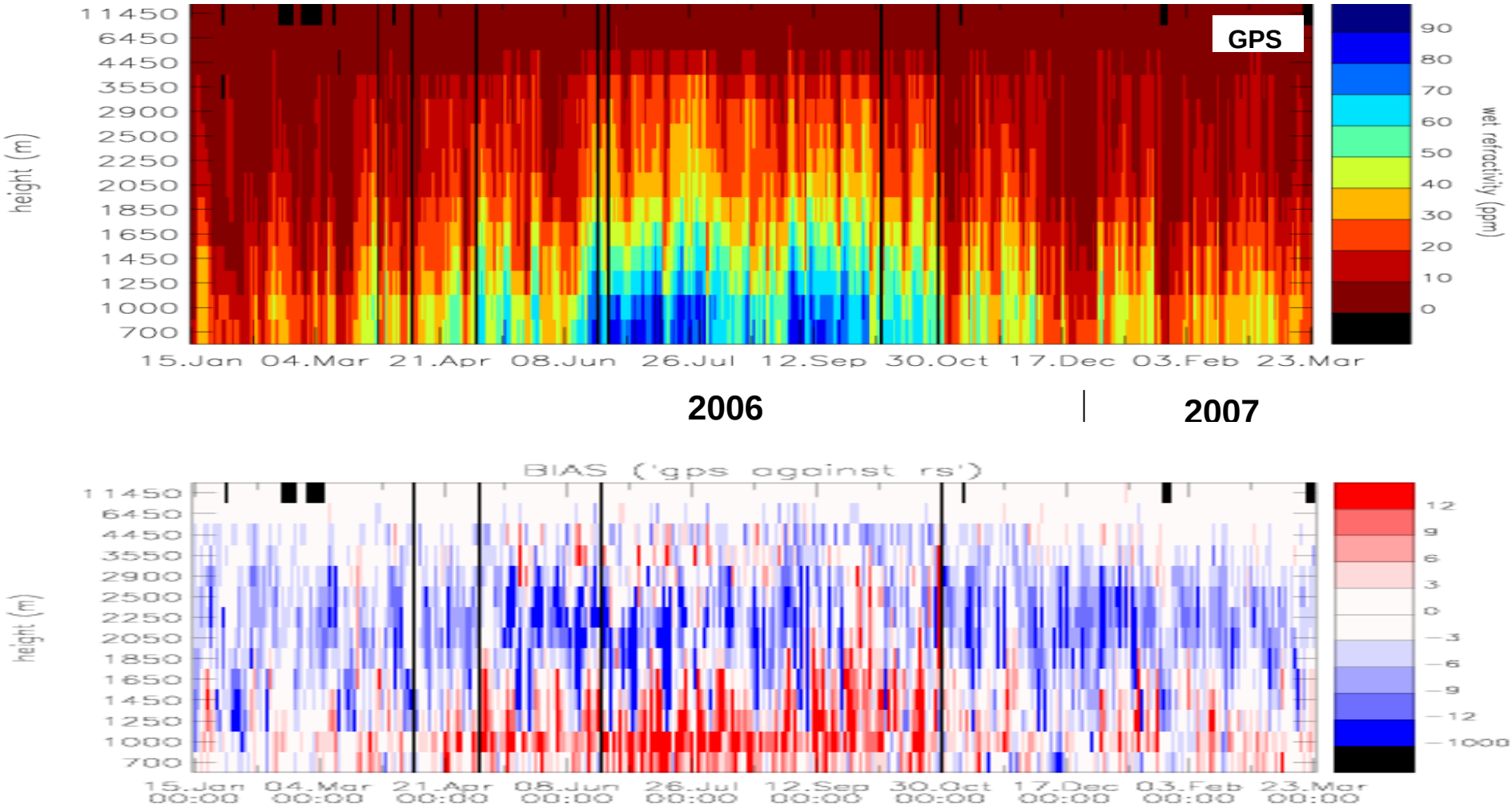
- Wet refractivity from COSMO-7 analyses and forecasts

$$N_{wet} = \frac{q_v p}{T\left(\varepsilon + q_v(\varepsilon - 1)\right)}\left(k_2 + \frac{k_3}{T}\right)$$

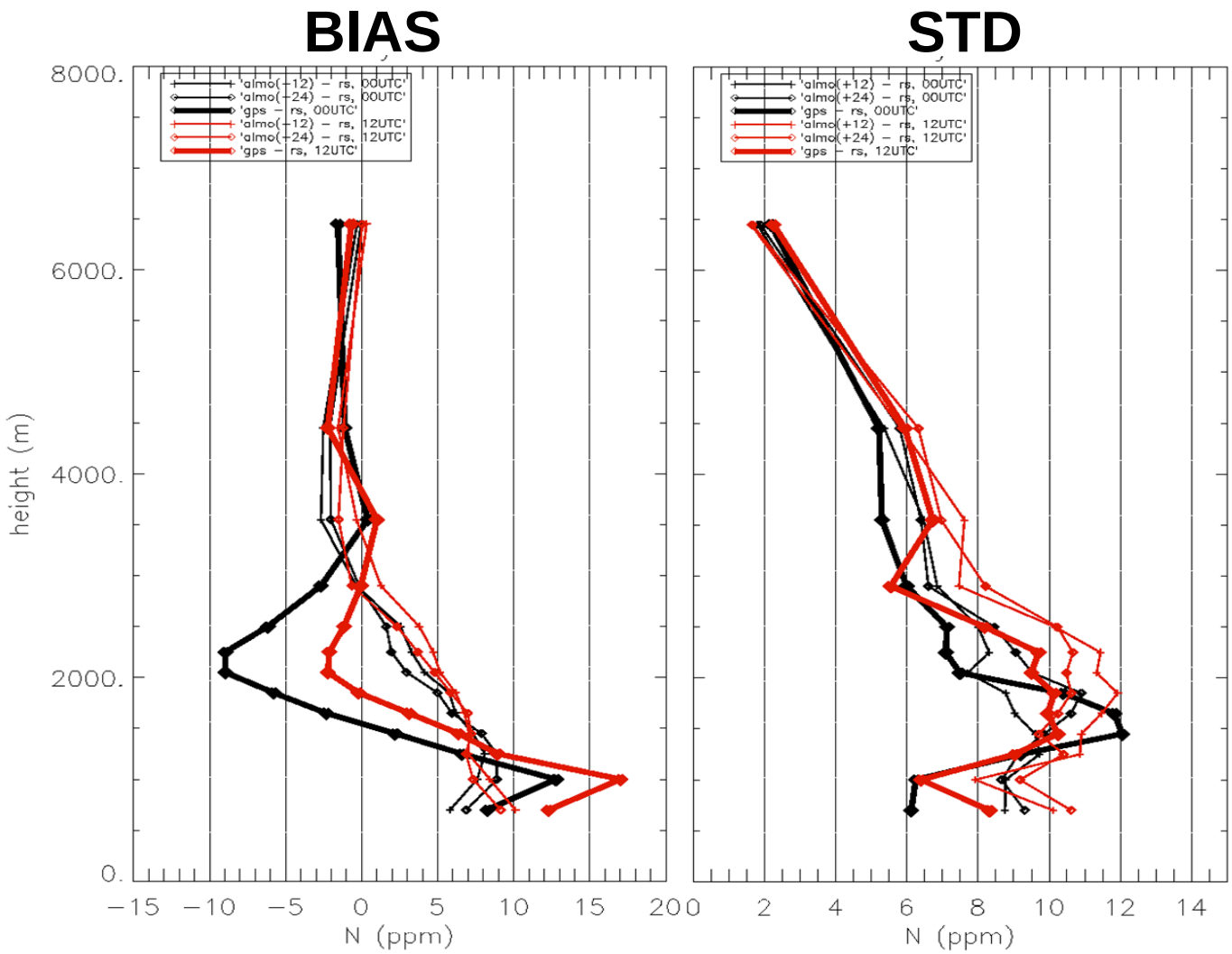
# Yearly Humidity Distribution



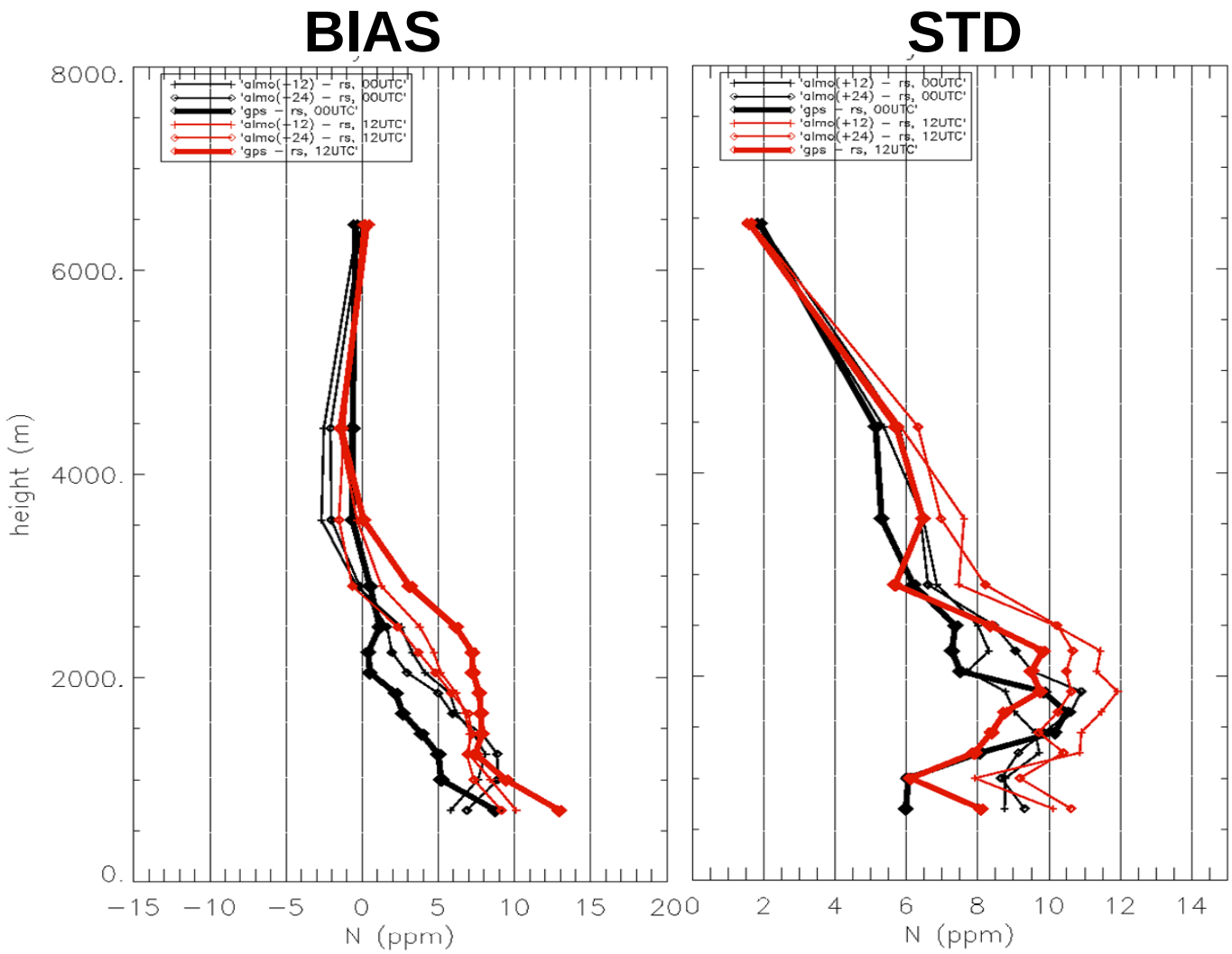
# Yearly Humidity Distribution



# Statistics of July/August 2006



# Statistics with Bias Correction



# Summary GPS Tomography

- Potentially valuable src of humidity information
- Currently, the quality is insufficient for assimilation
- Problem: equation system is under-determined
  - Lower BC (interpolation of sfc stations)
  - Spatial and temporal neighbour constraints
- GLONASS and GALILEO should help
- Efforts for improvements at ETH Zürich

# Outlook

- Parallel LHN test suite continues into winter
- Introduce LHN in COSMO-2 (Q1 2008)
- Add more foreign radar stations
- Improve GPS Tomography retrieval
- Assimilate humidity profiles

# Thank you for your attention !