Assimilation of Infrared Radiances Into the HIRLAM Model

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Outline

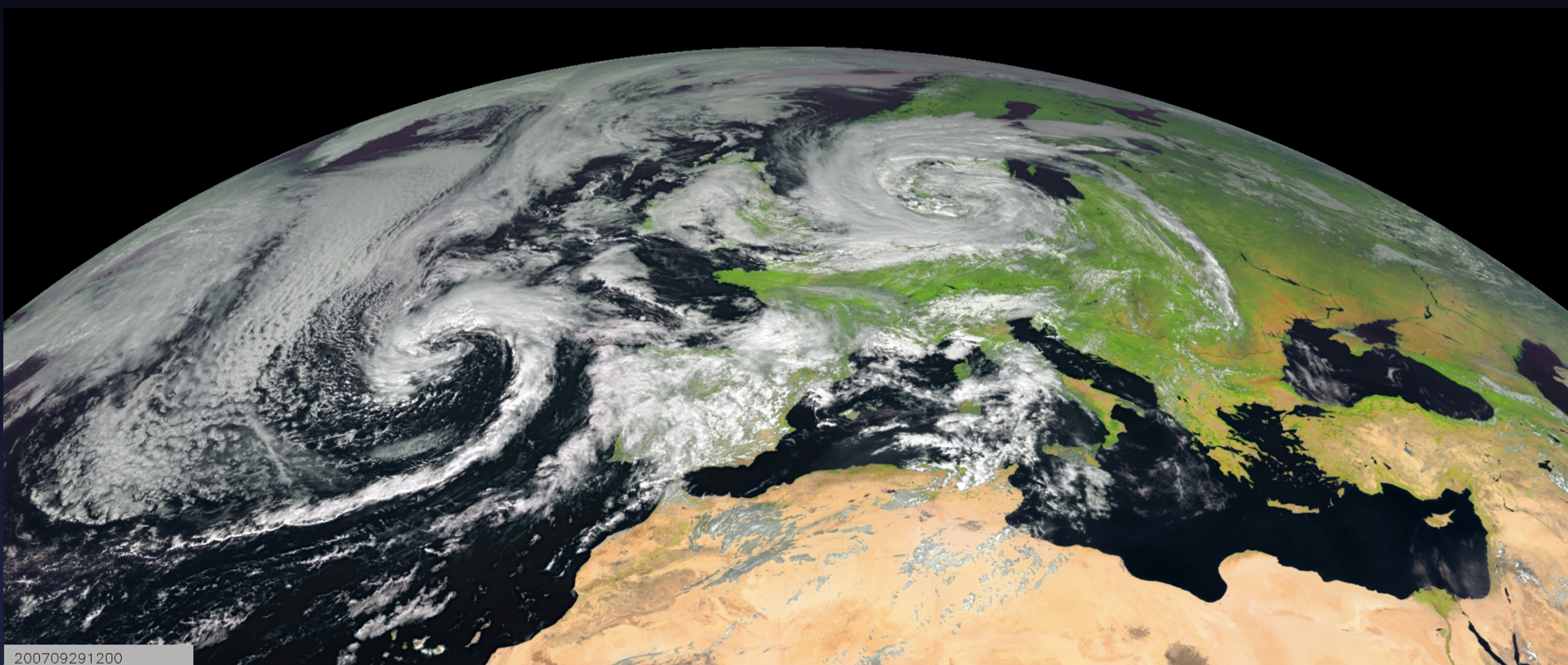
- Assimilation of IR radiances in clear-sky condition
  - Data preparation steps (SEVIRI radiances)
  - Example impact on analysis
  - Results of impact studies
- Assimilation of IR radiances in the presence of clouds
  - Observations above low-level clouds (not radiance-affecting)
  - Observations slightly affected by clouds
  - Exdenting the observation operator with a simplified moist physics scheme

SEVIRI data

- Resolution in space and time:

Imaging cycle of 15 minutes | 60 minutes res. used in 4D-Var

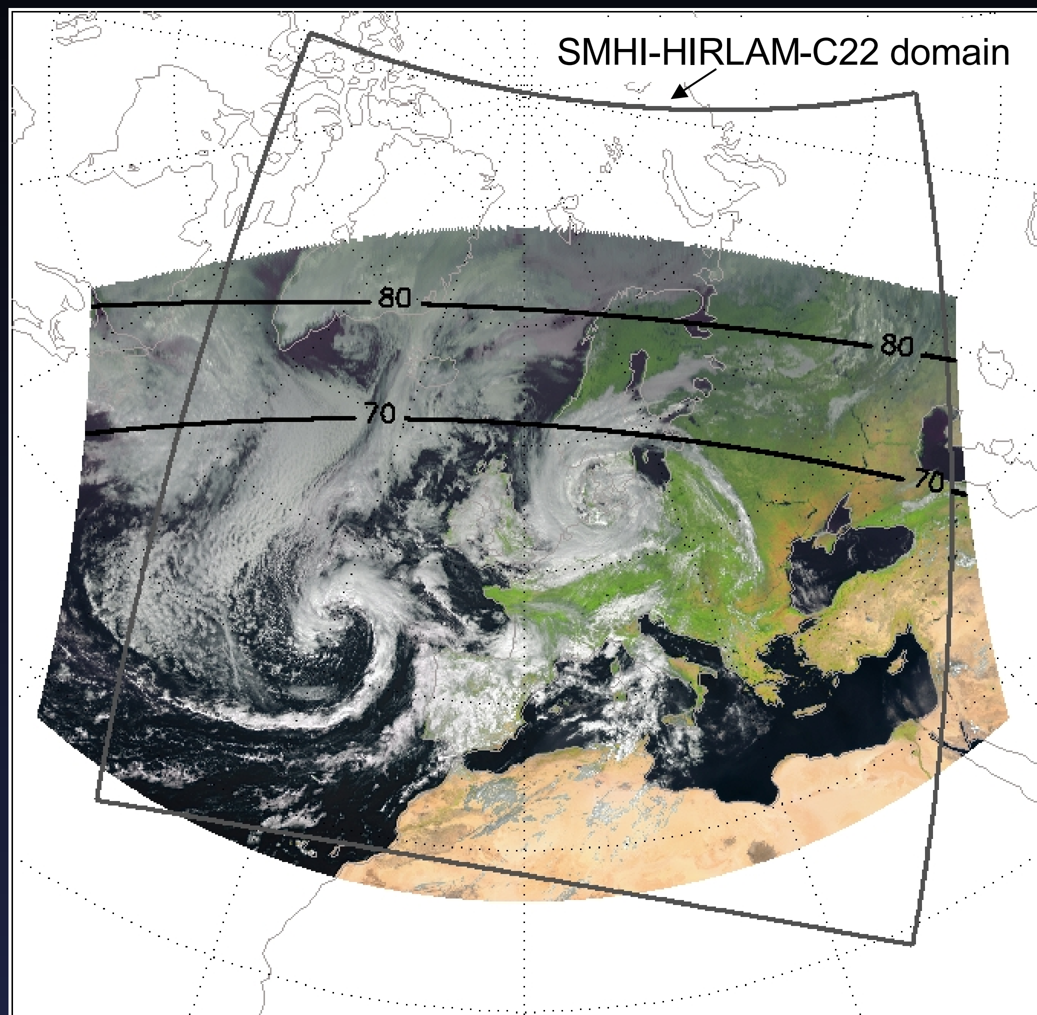
5km (IR) over central Europe | Spatial thinning applied (~90km)



SEVIRI data

- <u>Data coverage:</u>

Covers 2/3 of the HIRLAM-C22 domain

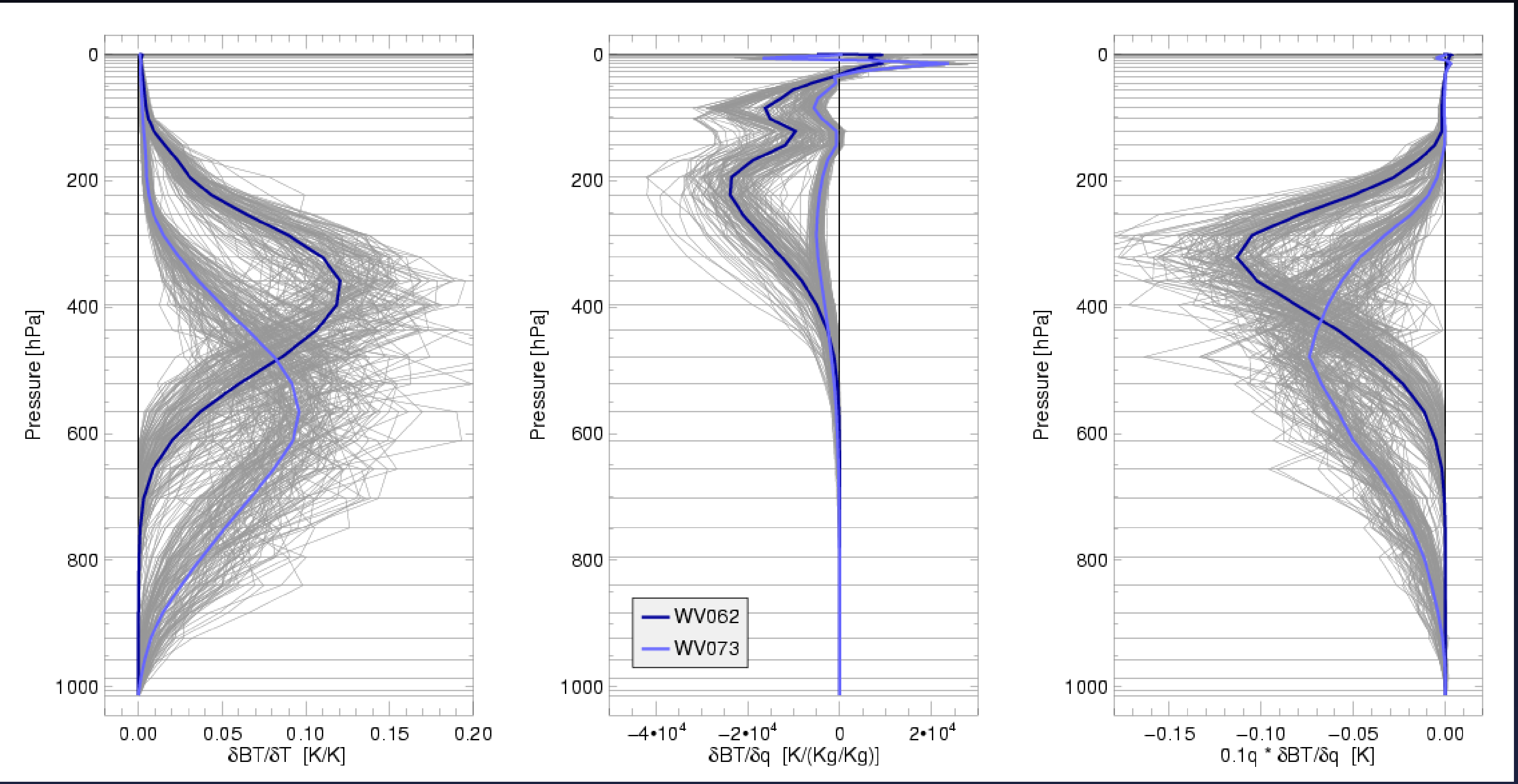


SEVIRI data

- Spectral resolution:

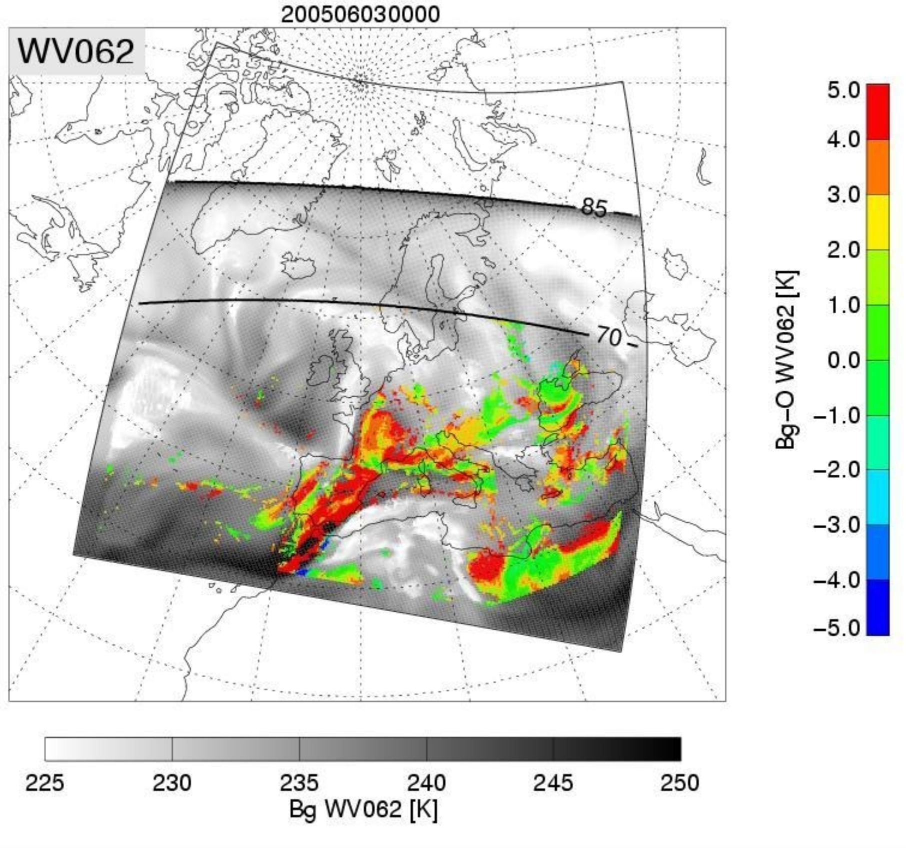
12 channels (8IR,1NIR,2VIS,1HRVIS) | Using water vapour channels only

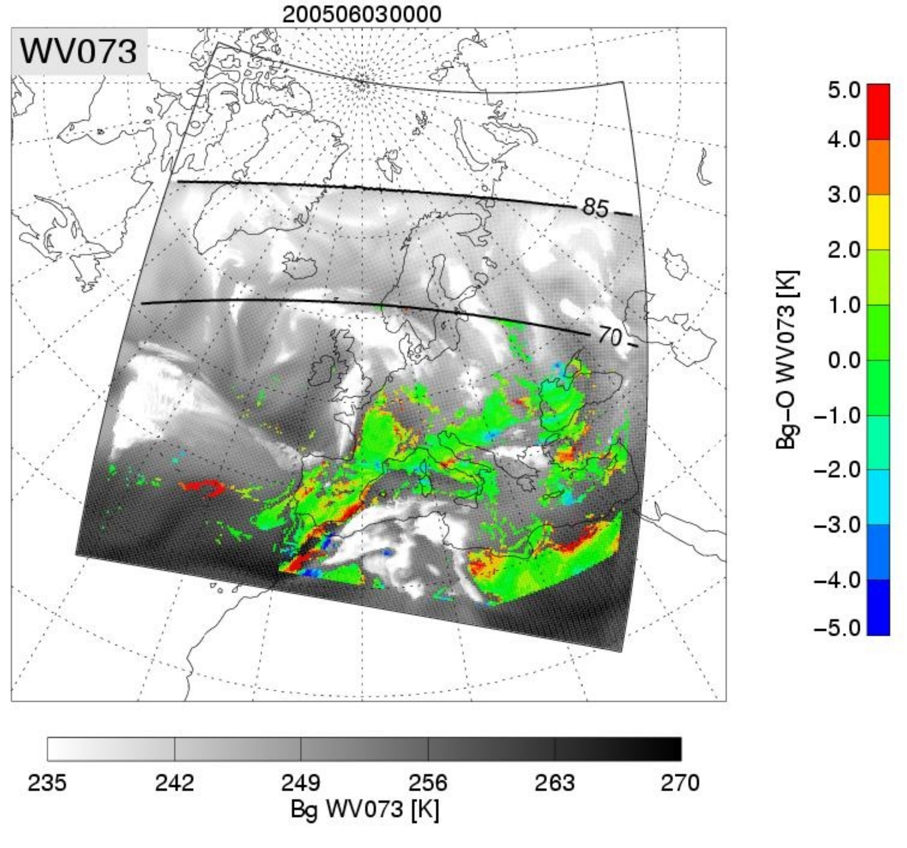
Ensemble and mean of WV062 and WV073 T- and q-'Jacobians' (RTTOV):



Background statistics

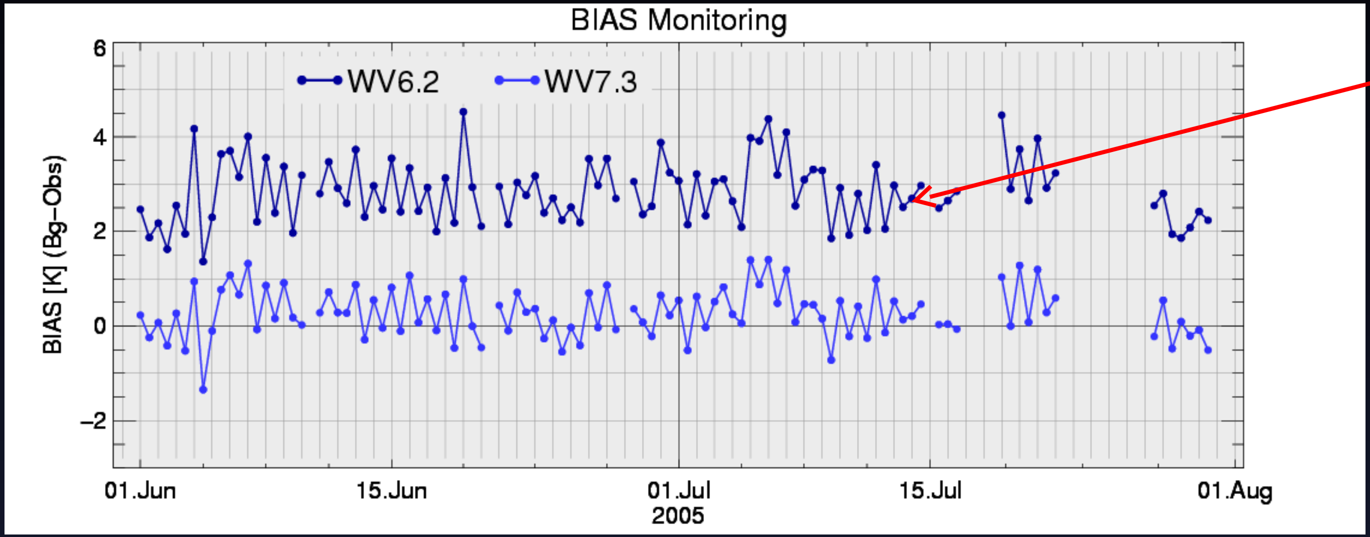
- Simulated radiances minus observed radiances
  (6h forecast fields)





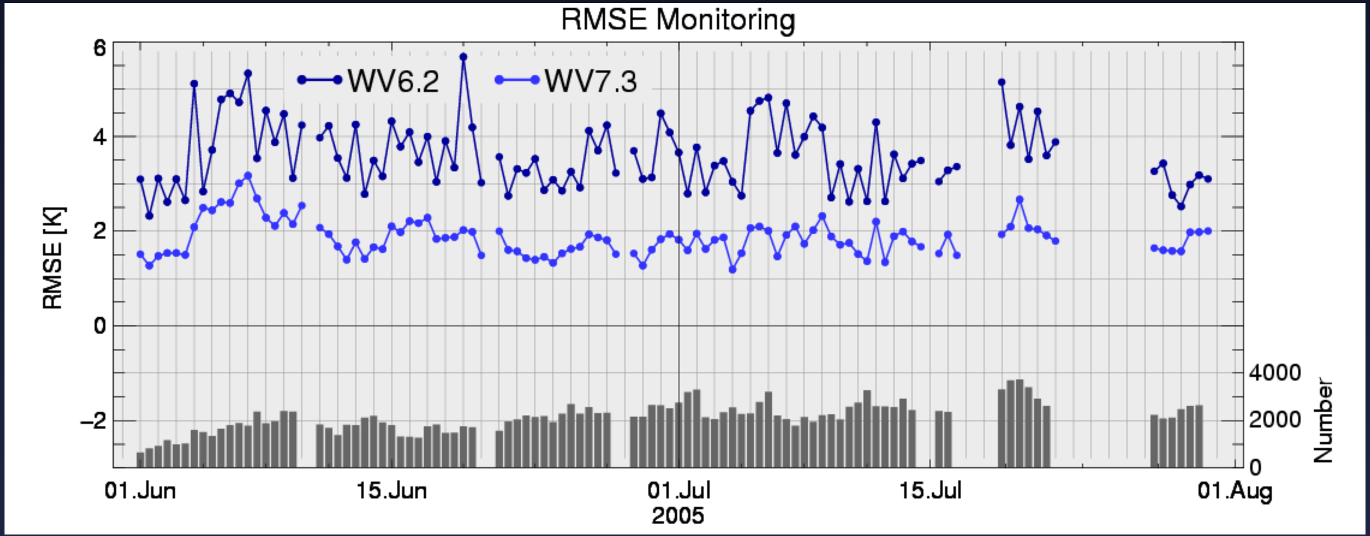
Background statistics

- <u>Monitoring of RMSE and Bias</u>
  (Operational HIRLAM 6h-forecast fields used)



large BIAS found (2.6K)

Systematic error in:
- NWP?
- Observation?
- Observation operator? (RTTOV)

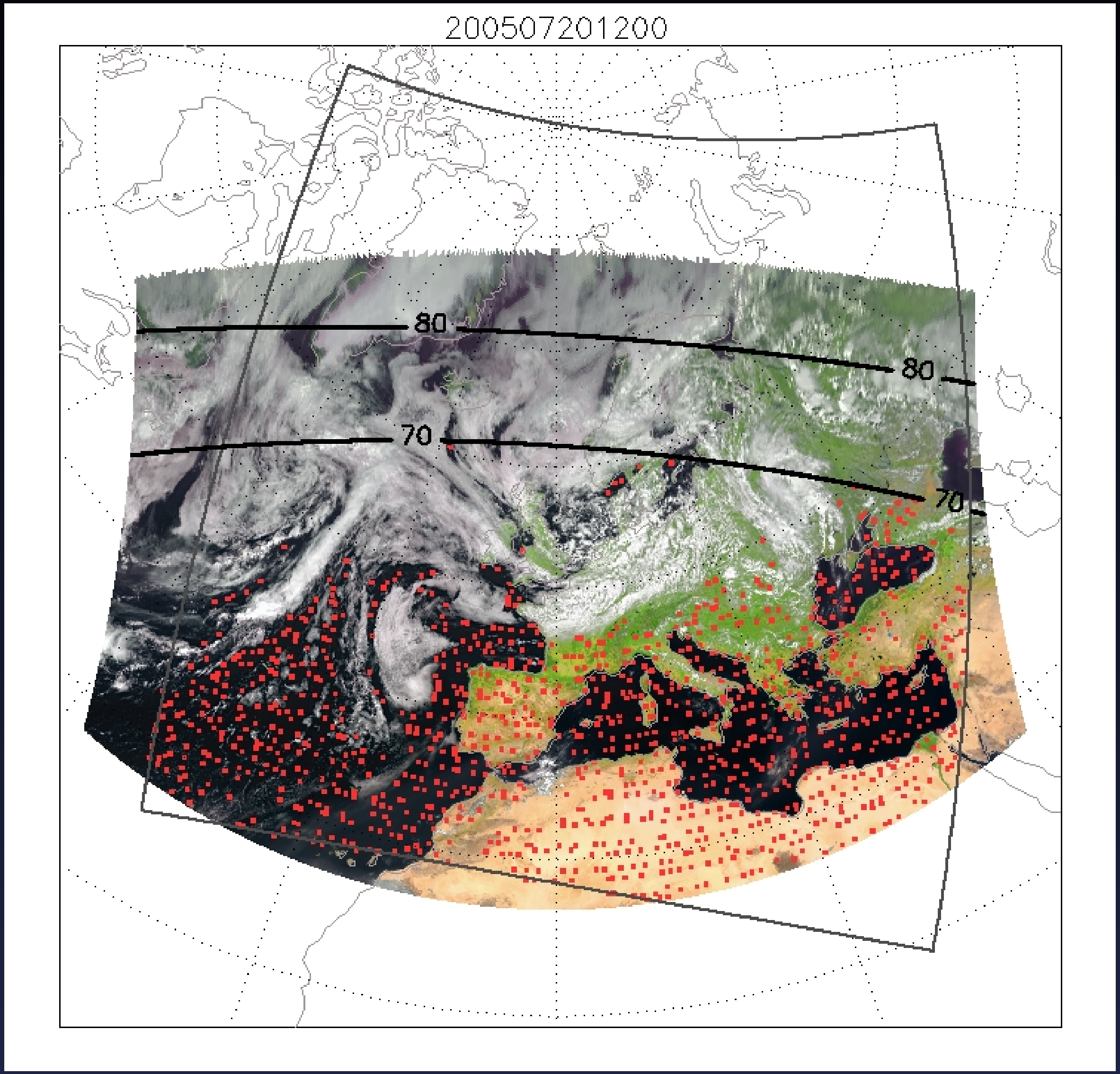


SEVIRI data preparation

- <u>Data preparation steps</u>
  - Processing of BTs and PGEs employing the SAF NWC software (for SEVIRI-segments 7 and 8)
  - Rejecting out-of-domain pixels
  - Rejecting cloudy pixels (PGE01/CMa, cloud mask)
  - Rejecting pixel which cover mountain areas
  - Selecting 1 pixel out of a 10x10 pixel box
  - BIAS correction applied to observations – WV062 (flat, 2.6K)
  - First guess check
  - Spatial thinning (thinning box size = 90km)
  - 500 to 1200 pixels are then used in minimization

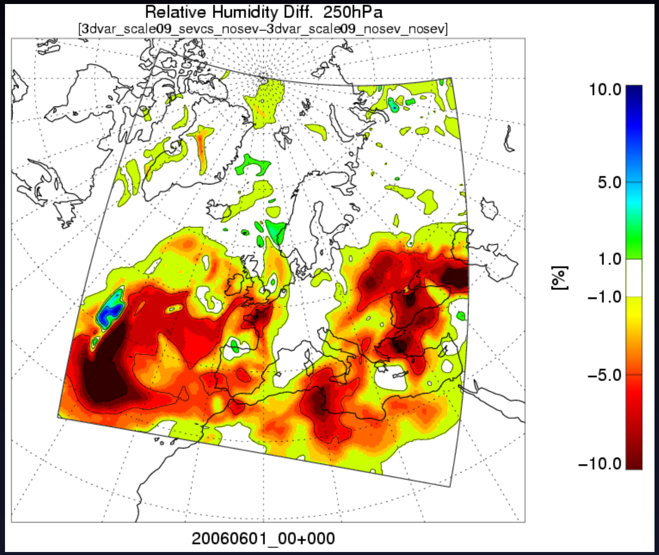
SEVIRI data preparation

- Example:



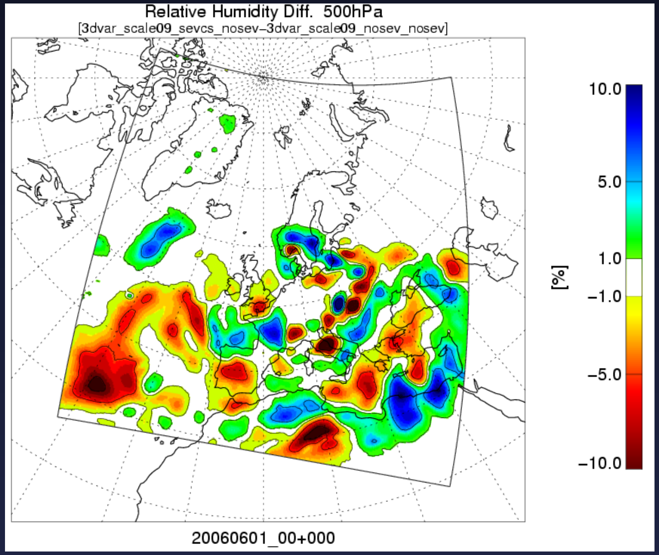
Impact on analysis

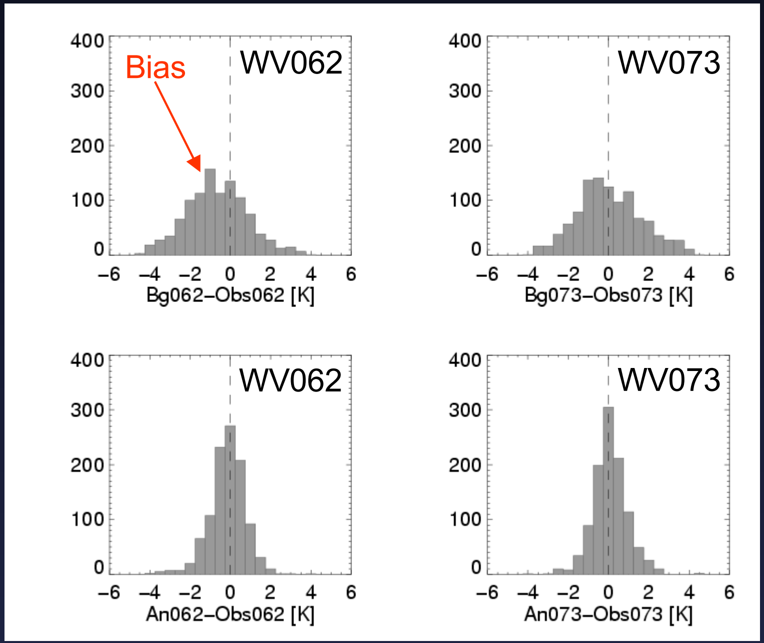
- Case study, 3D-Var:



Relative Humidity increment, 250 hPa

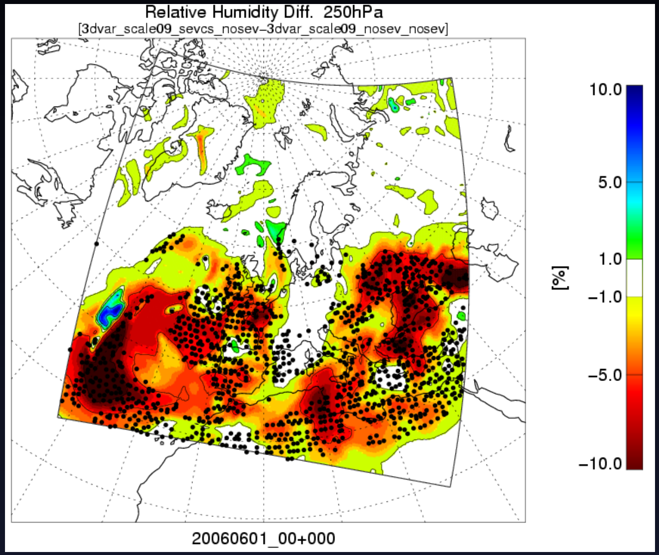
Relative Humidity increment, 500 hPa





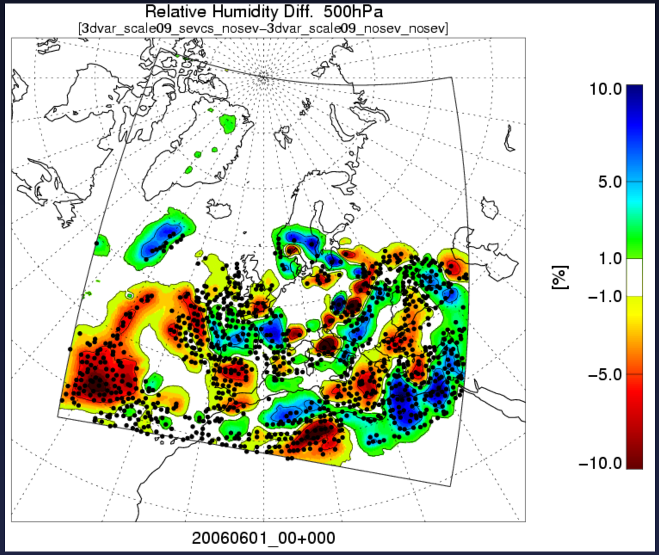
Impact on analysis

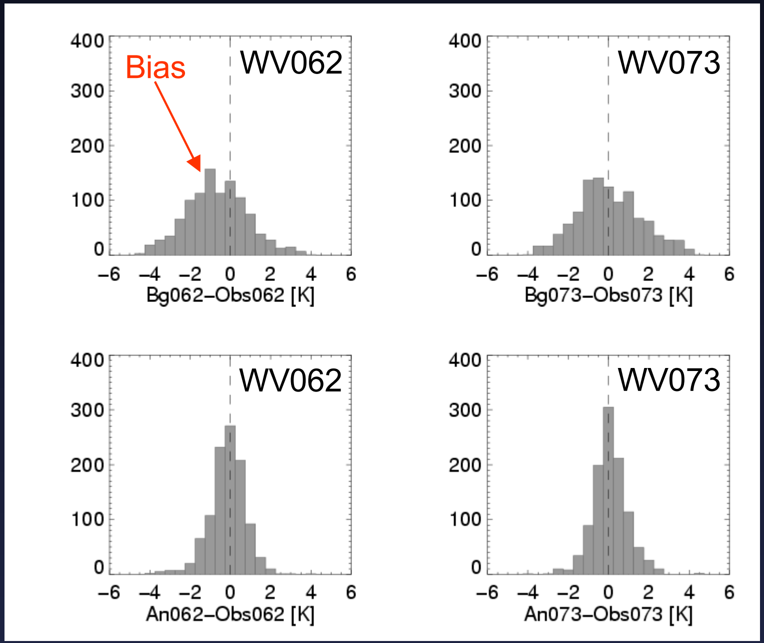
- Case study, 3D-Var:



Relative Humidity increment, 250 hPa

Relative Humidity increment, 500 hPa





Impact on analysis and forecast

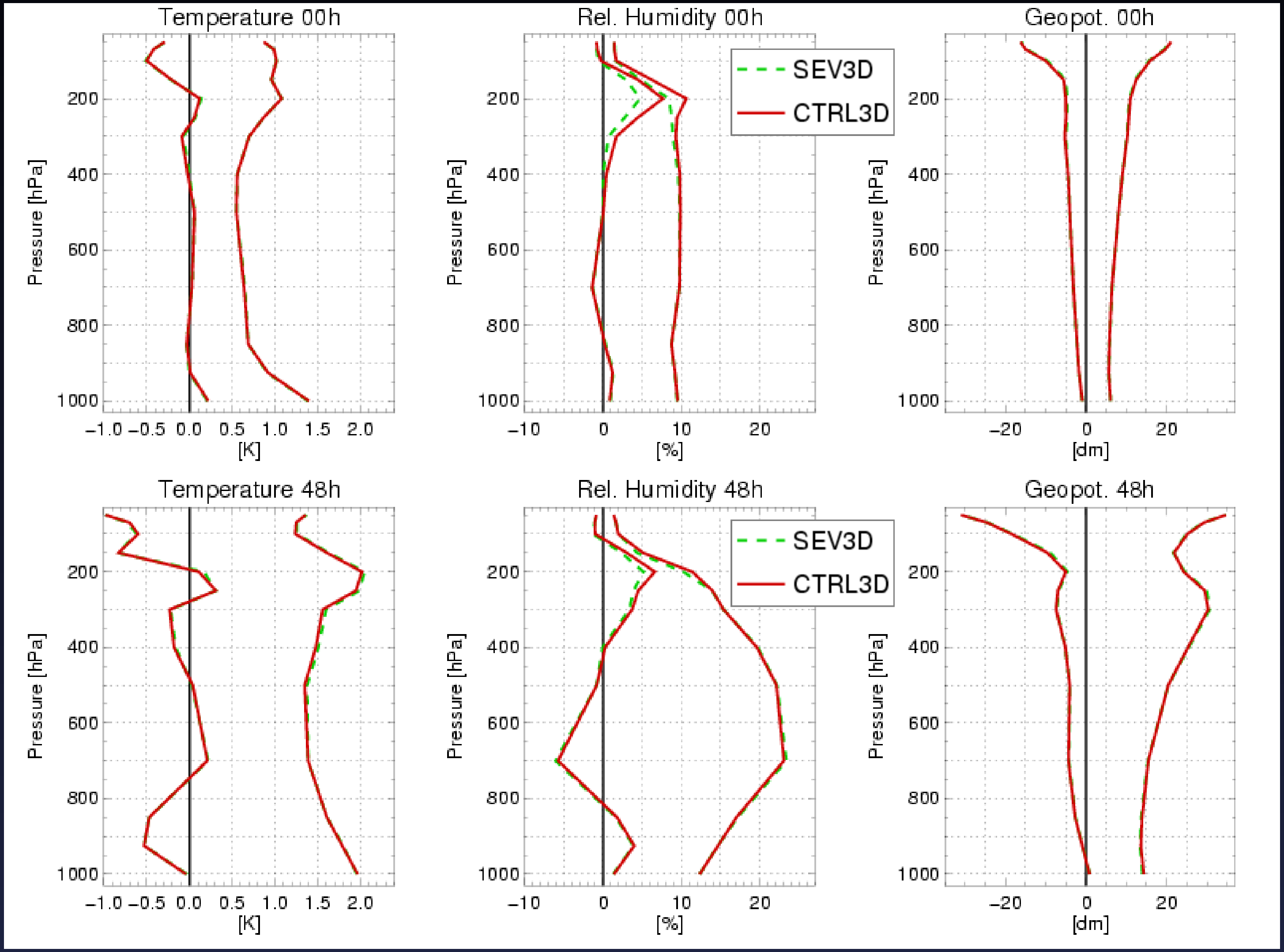
- Observing system experiments

CTRL3D	3D-Var analysis with conventional observation only
SEV3D	3D-Var analysis with conventional and SEVIRI observation SEVIRI; SEVIRI observation are taken only from one time slot, the one closest to analysis time is chosen.
CTRL4D	4D-Var analysis with conventional observation only
SEV4D	4D-Var analysis with conventional and SEVIRI observation SEVIRI; SEVIRI observation are taken from six time slots, where each is the one closest to the respective observation window centre
SigmaO	2K for both channels (observation error)
Period	Summer month (24/06/2005 - 21/07/2005) Winter month (02/12/2005 - 31/12/2005)
Cycle	6 hour assimilation cycle
Forecast	0-48 hours

HIRLAM C22 domain, 22km, 40 vertical levels, statistical balance

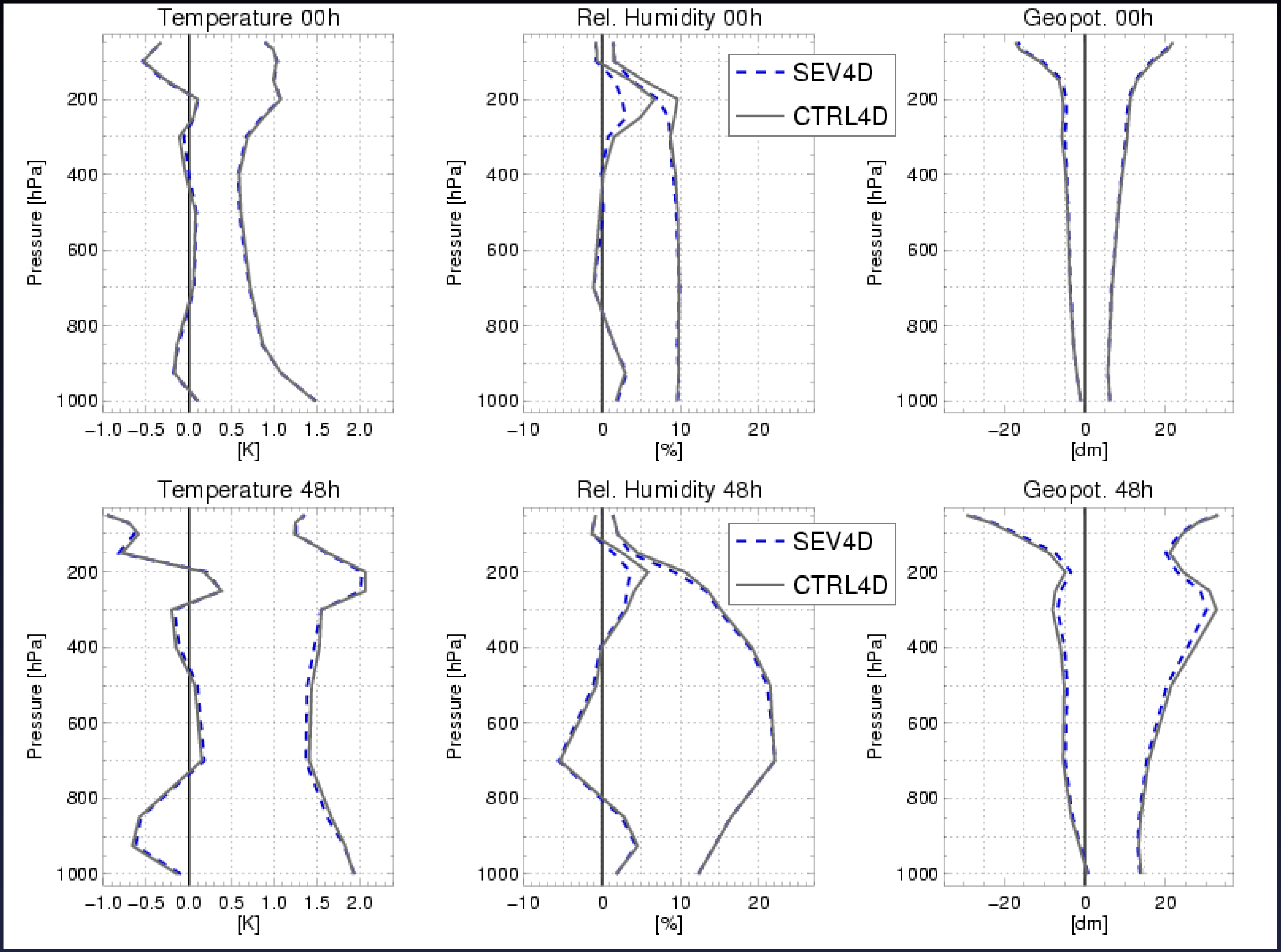
Impact on analysis and forecast

- Summer month / 3D-Var



Impact on analysis and forecast

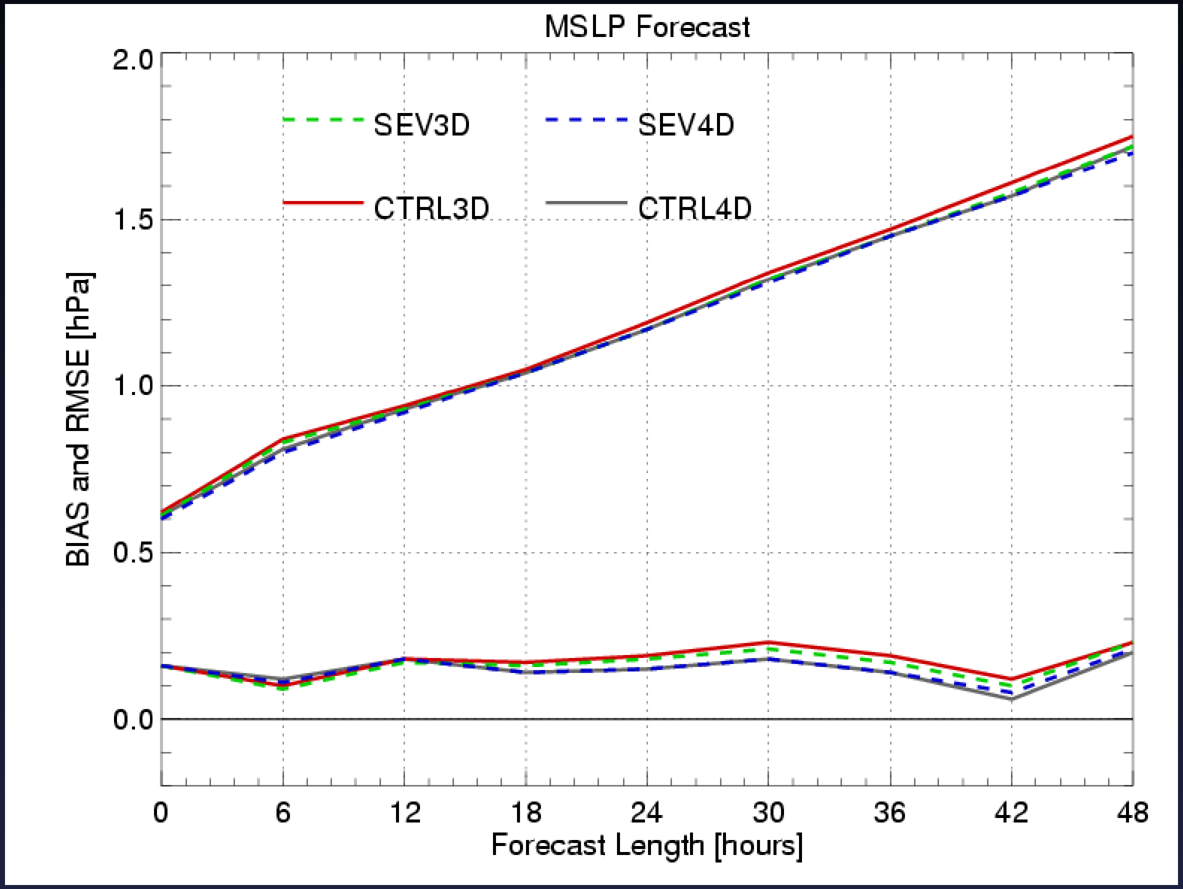
- Summer month / 4D-Var



Impact on analysis and forecast

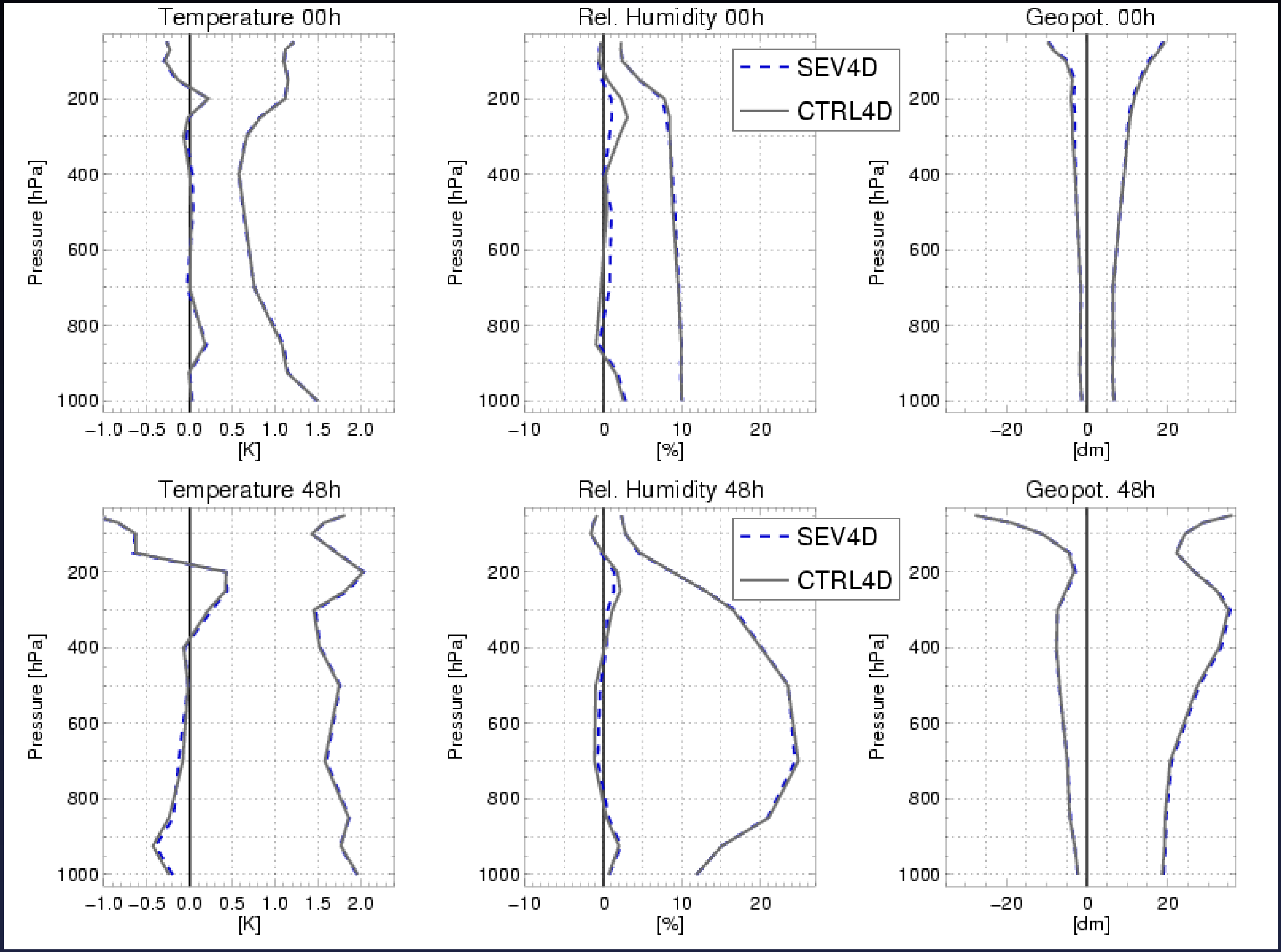
- Summer month / 3D-Var, 4D-Var

Mean sea level pressure forecast:

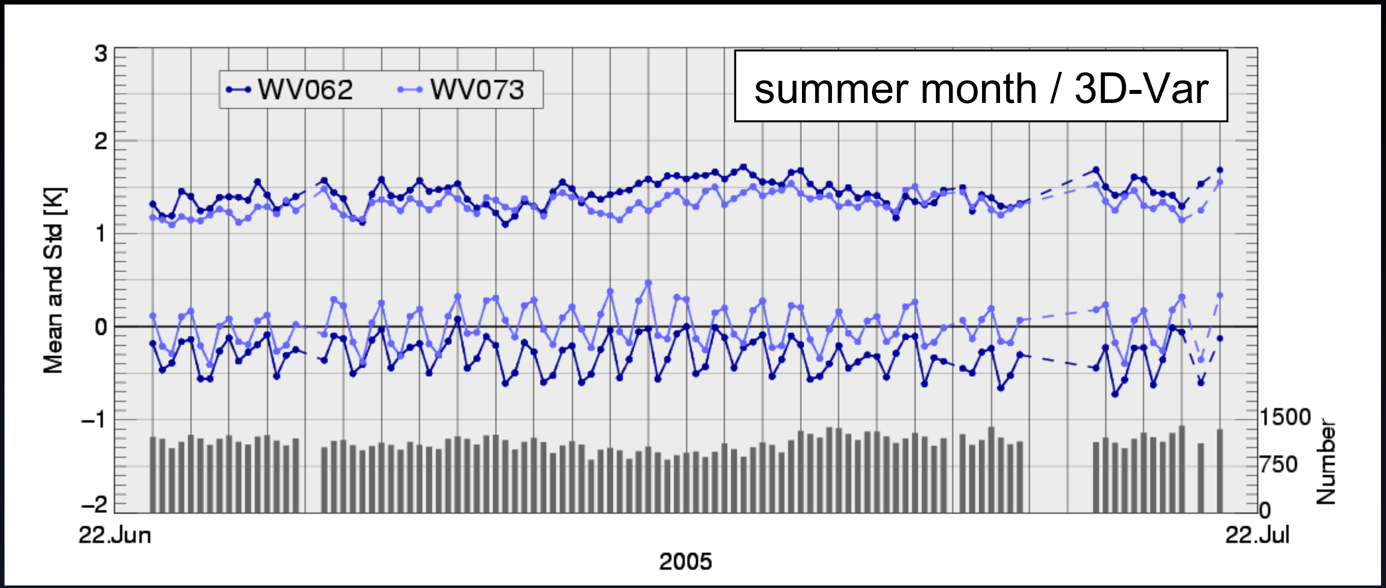


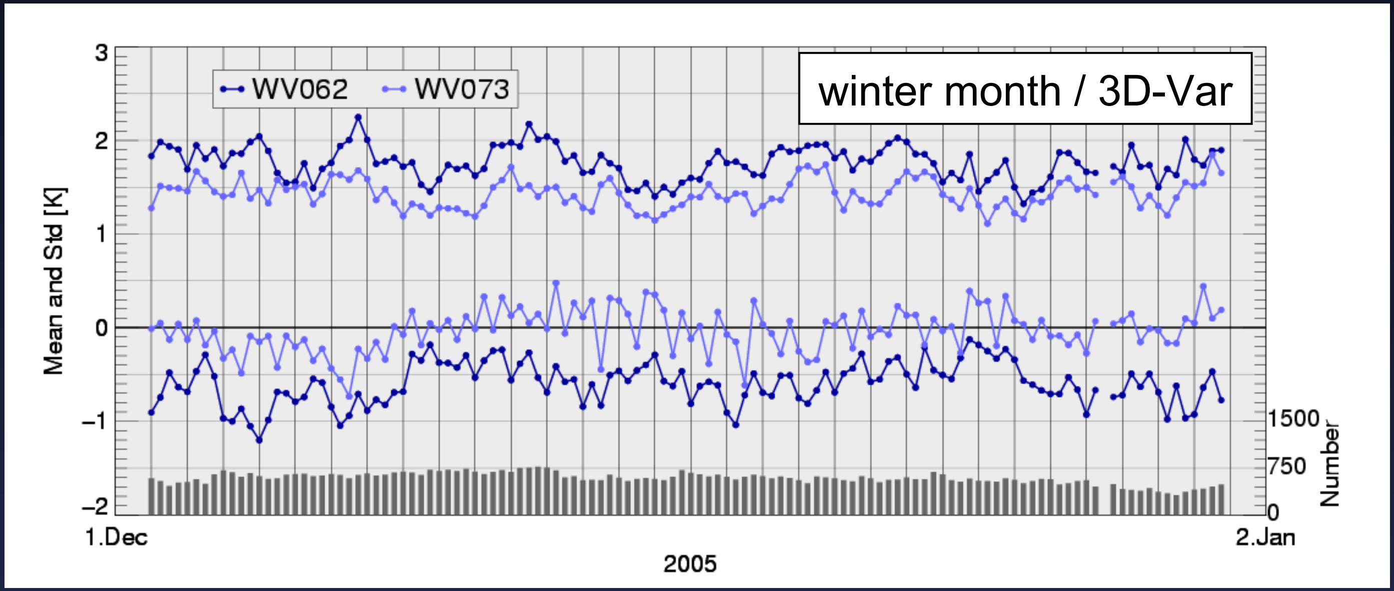
Impact on analysis and forecast

- Winter month / 4D-Var



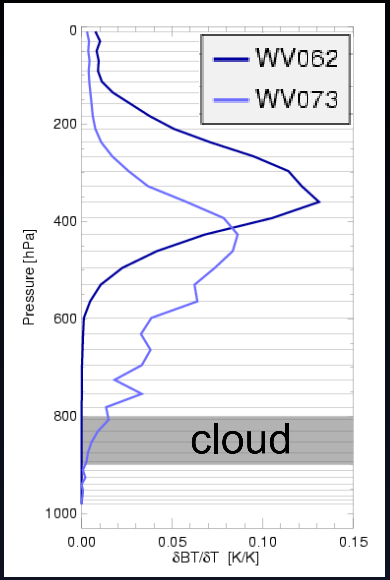
Impact on analysis and forecast

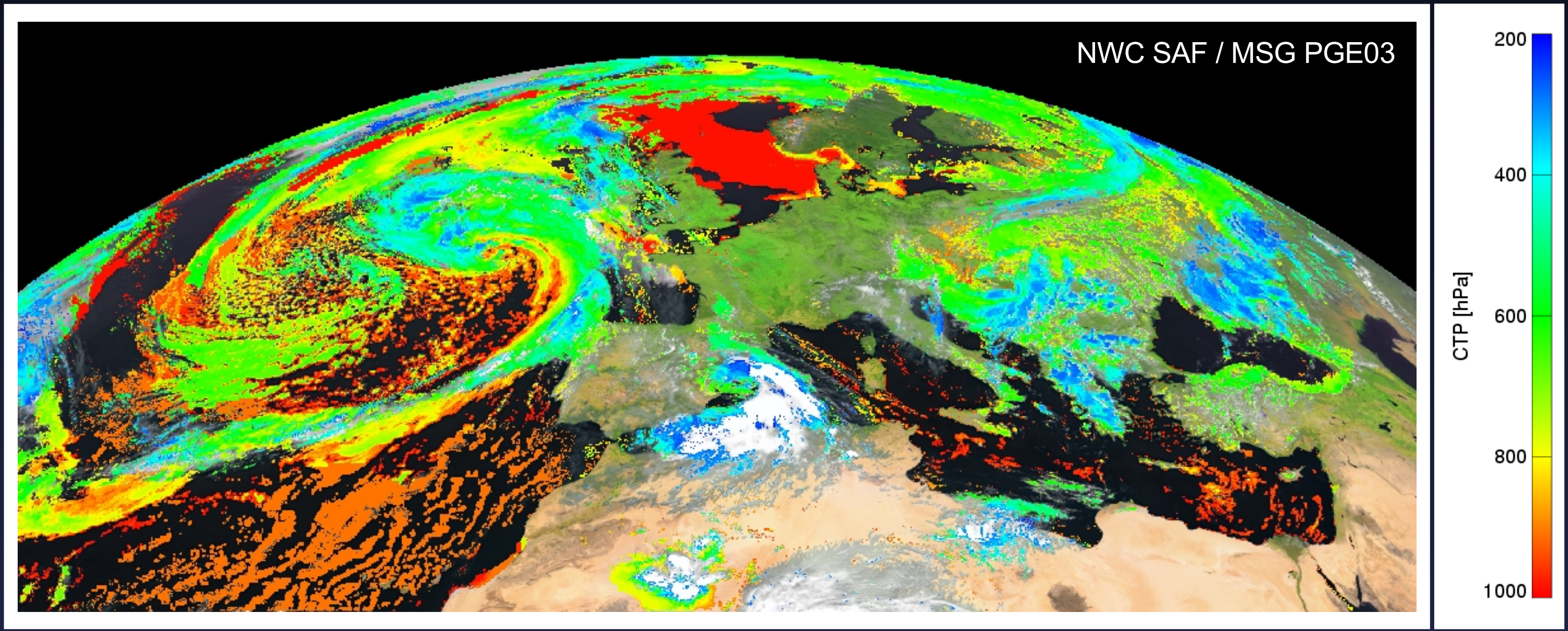




Observations above low-level clouds

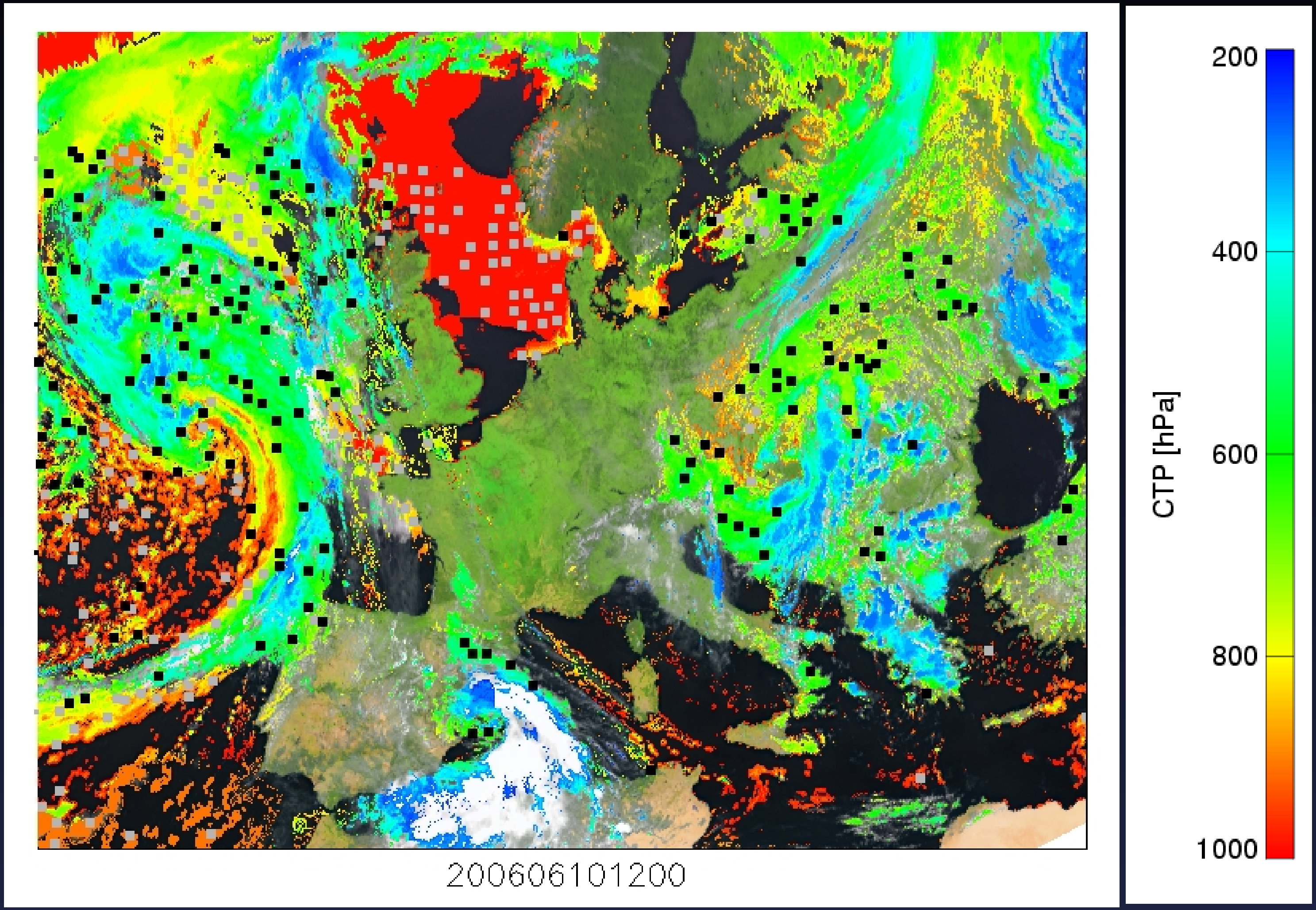
- Identifying not-radiance-affecting clouds:
  - Using a cloud top pressure/height information
  - Identify not-radiance-affecting clouds using local Jacobians or CTP threshold
  - Assimilation as in clear sky conditions
  - (Blacklisting only one channel for some cases)





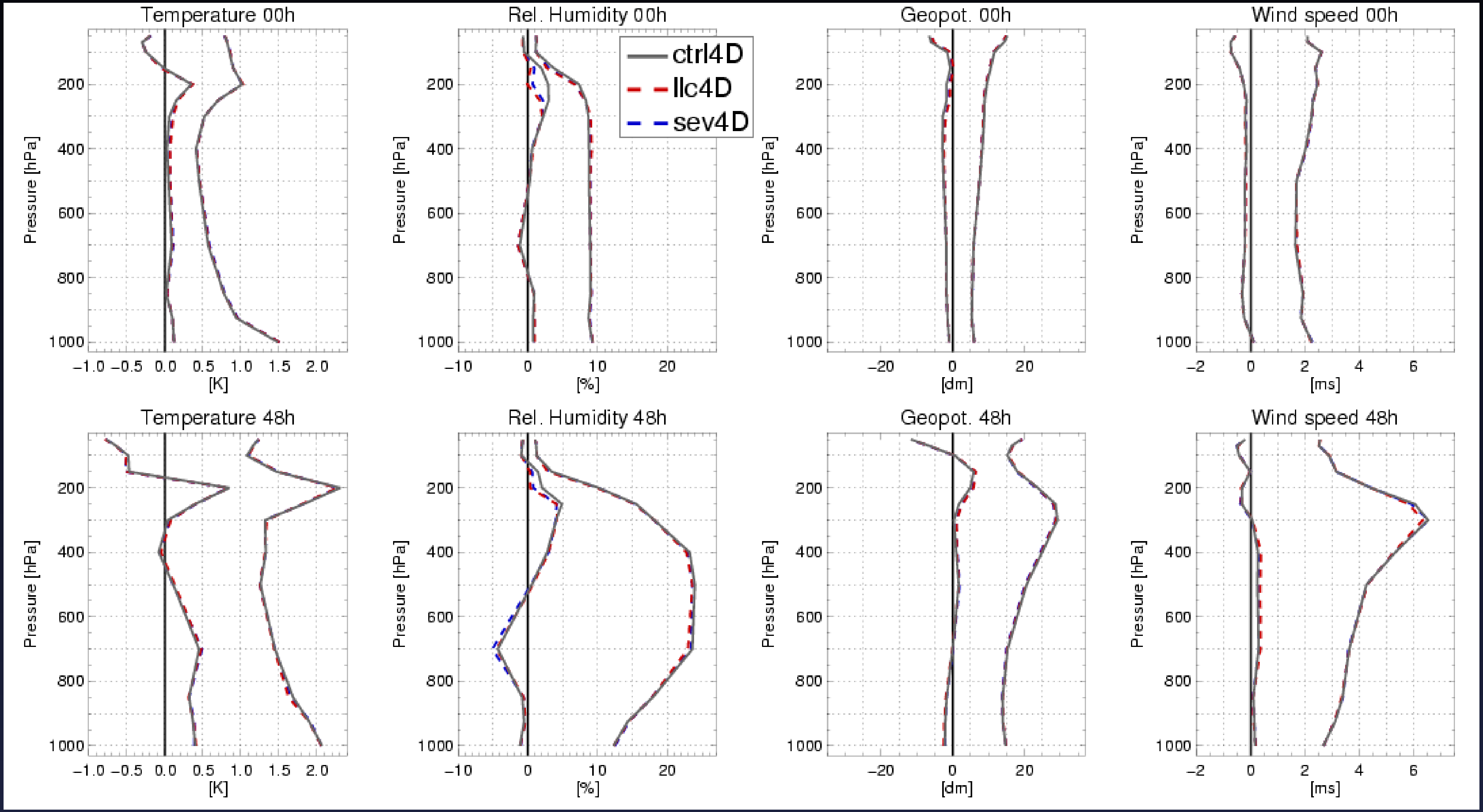
Observations above low-level clouds

- <u>Example (after screening):</u>



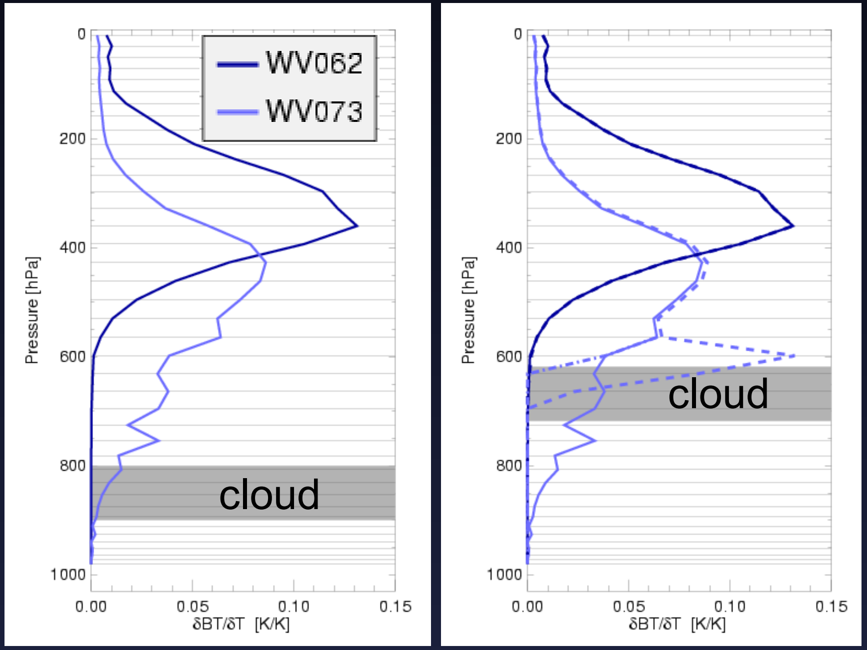
Observations above low-level clouds

- Summer month / 4D-Var

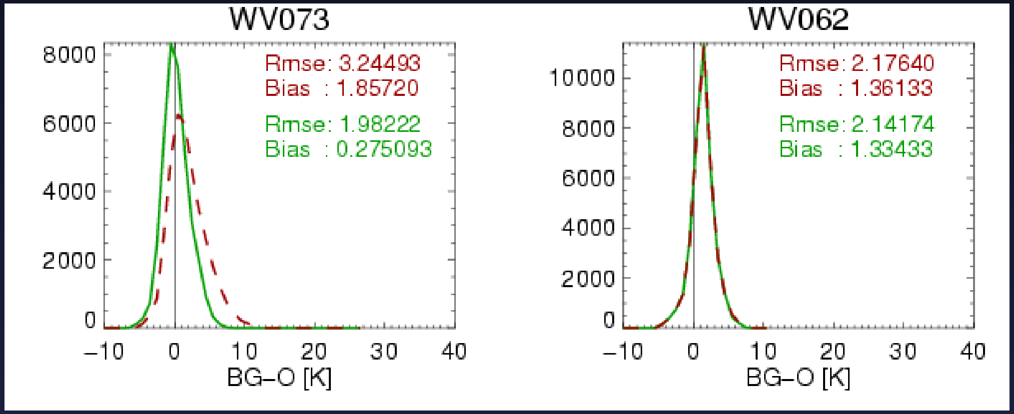


Observations above mid-level clouds

- <u>Strategy:</u>
  - Identify slightly-radiance-affecting clouds using local Jacobians
  - Using properties to constrain a cloud in RTTOV



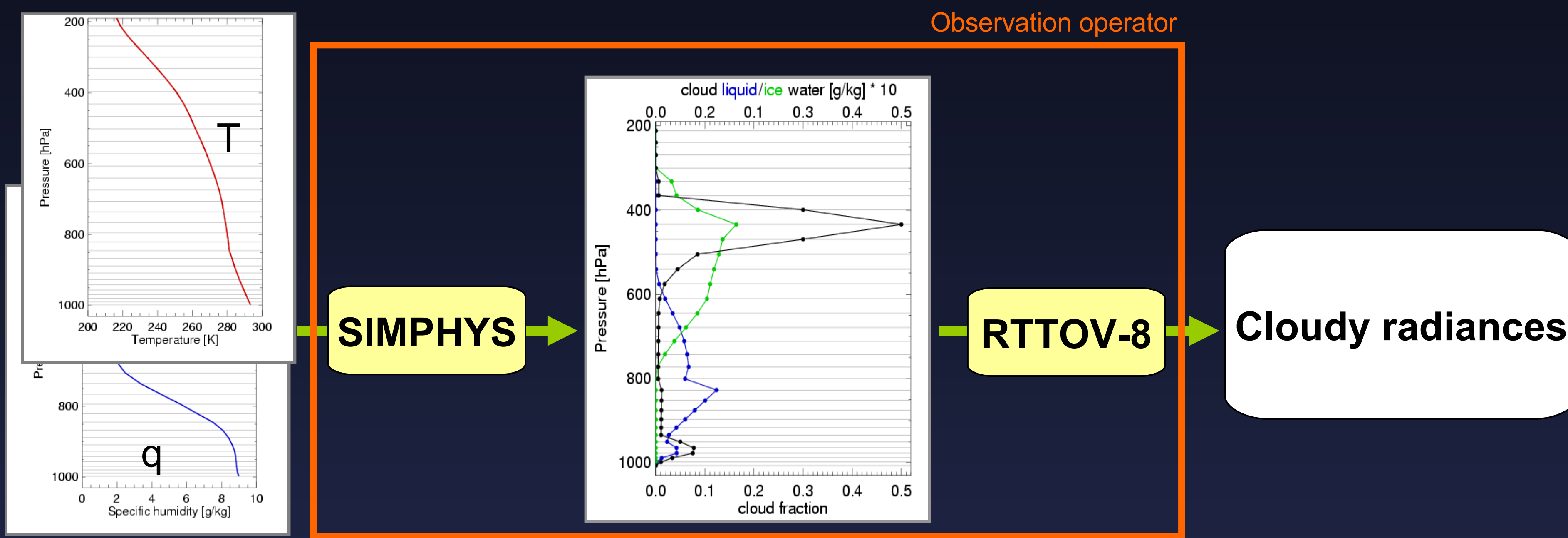
500<CTP<600hPa



Cloudy radiances / Extending the obs. operator

- Strategy:
  - “Next-Generation” Simplified Moist Physics Package (SIMPHYS), (ECMWF)
  - Simplified parameterization for convection
  - Simplified parameterization for large scale cloud and precipitation processes
  - Using sensitivity of modelled cloud to model fields of T and q

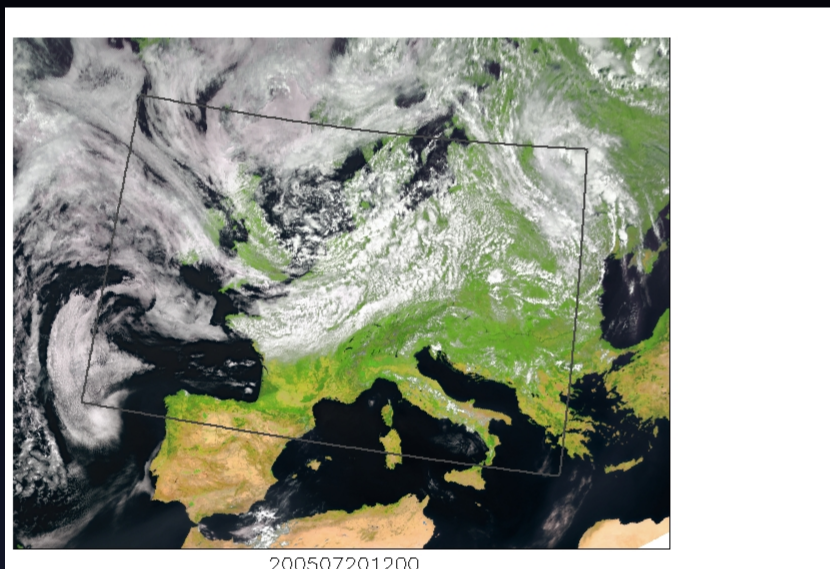
  → sensitivity of modelled cloudy radiances to T and q
  - Provide sensitivity to assimilation system
  - Goal: Mapping cloudy BG-O via cloud scheme sensitivities to T and q increments

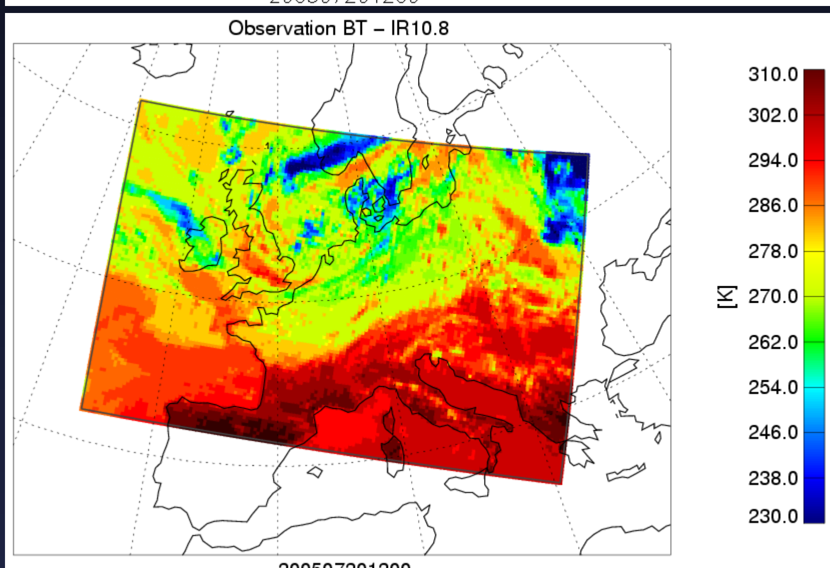


……

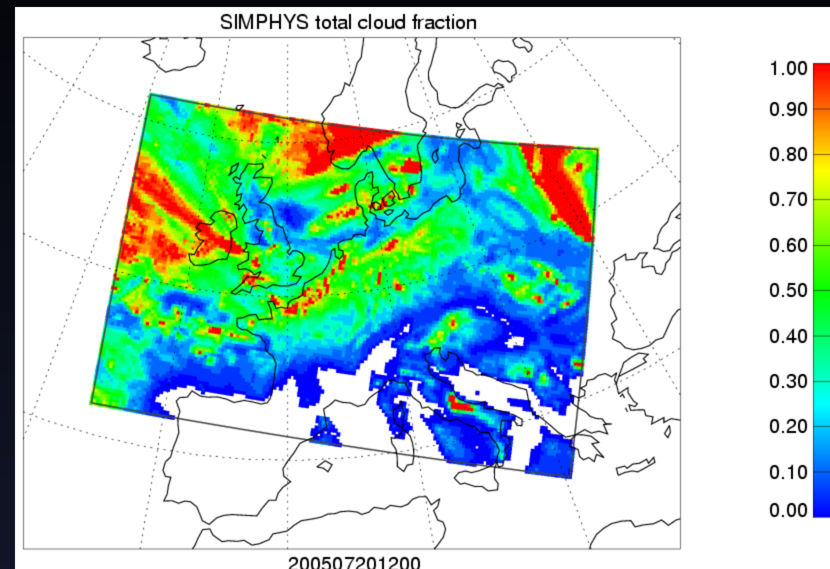
Cloudy radiances / Extending the obs. operator

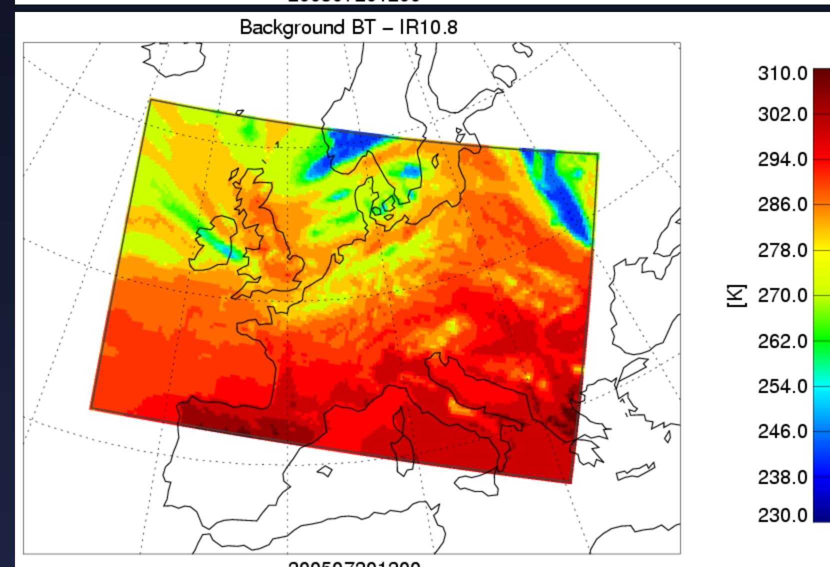
MSG1-SEVIRI





SIMPHYS





Cloudy radiances / Problems

- First comparisons show: SIMPHYS underestimates clouds (cloud cover,……)
- Performance of RTTOV?
  (ok for low levels water clouds?)
- Matching observations and model in space and time
- Identifying when the cloud scheme models ‘realistic’ clouds
- On/Off processes
- Errors in modelled land surface temperatures lead to errors in modelled IR window channel radiances

Summary / Future work

- Clear-sky radiance assimilation
  - Neutral to positive impact of SEVIRI radiances during the summer trial
  - Neutral to slightly negative impact during winter; probably due to the inefficient Bias correction
  - More impact studies needed
  - Improve Bias correction, to take into account medium- and long-term trends of systematic errors
  - Improve spatial data thinning (maybe ‘supperobbing’?)

- Cloudy radiance assimilation
  - Strategies as described on previous slides
  - First statistics of extended observation operator performance (not shown)
  - First 1D-Var studies (not shown)
  - Use in HIRVDA (long term goal)

Thank you!