MTG-IRS L2 data assimilation into the ECMWF model

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Core phase of the project

1. Technical developments
2. Quality assessment
   - Understand the data characteristics
   - Design quality control
   - Estimate realistic observation errors and error correlations
3. Data assimilation experiments
   - Depleted observing system: degraded quality but easy to demonstrate impact
   - Full observing system: operational quality, more difficult to demonstrate impact

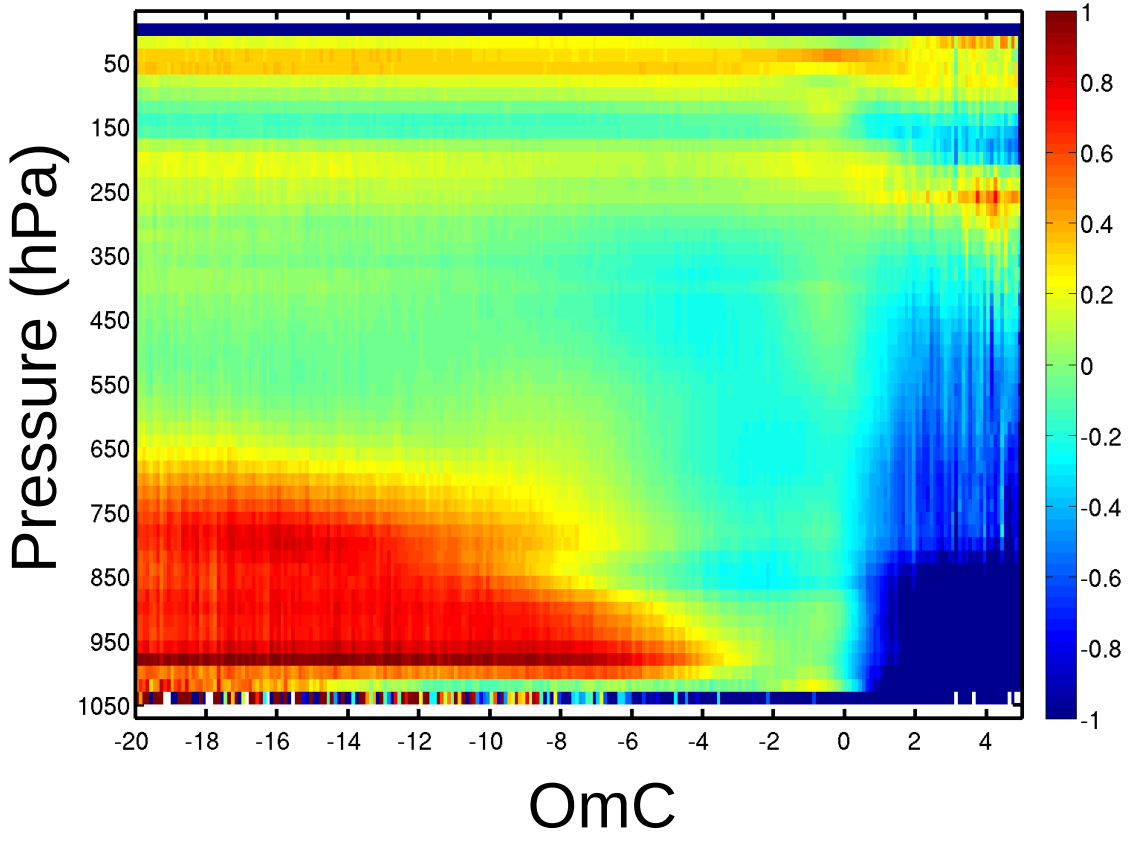
In the core phase of the project the main focus has been on “best of the best” T and q clear sky retrievals over sea.

Quality assessment

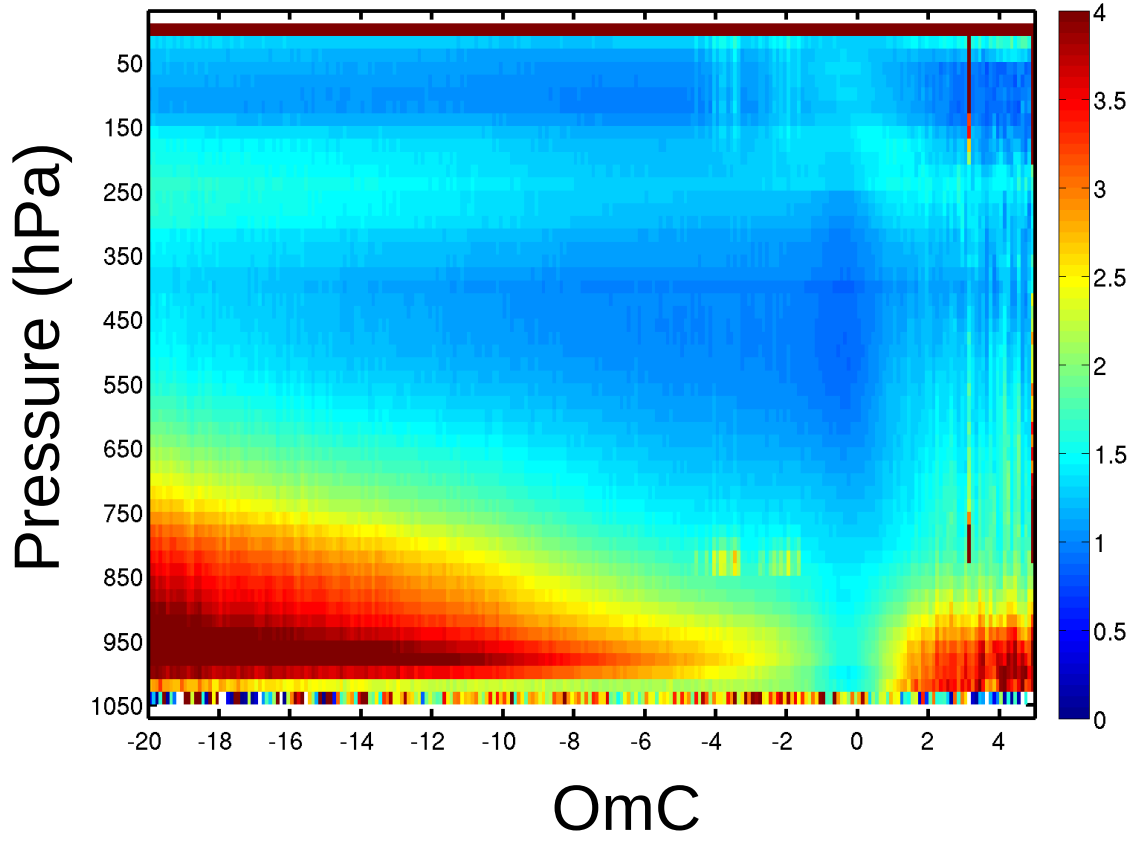
Measure of cloudiness OmC

- OmC: observed window channel brightness temperature minus the corresponding brightness temperature computed by a forward model with clear-sky assumption
- Criterion used to select cloud free data |OmC| < 1

Temperature OmB bias, sea

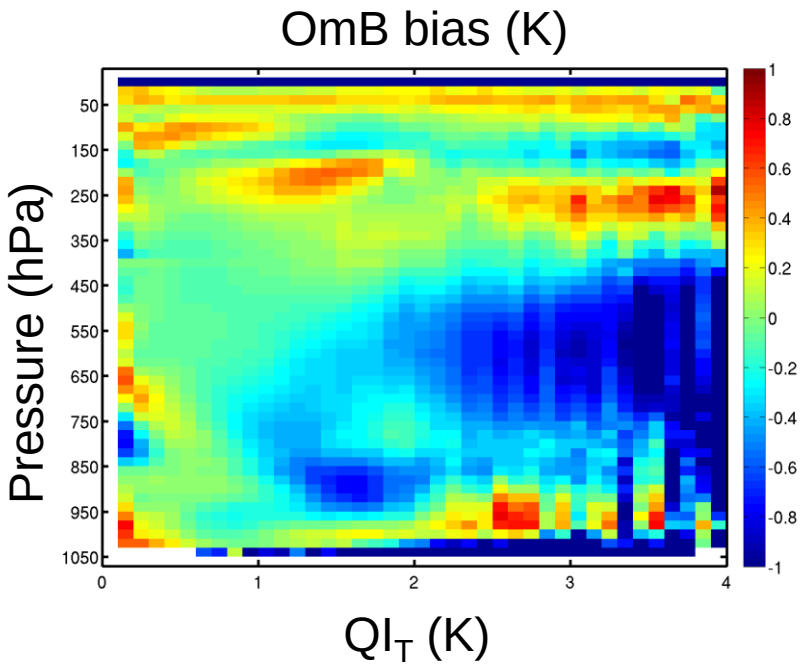


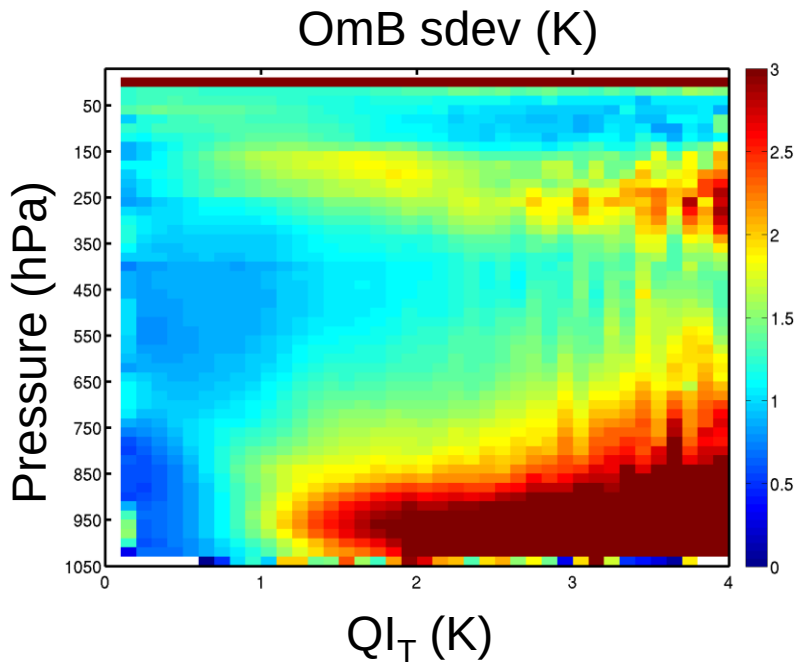
Temperature OmB sdev, sea

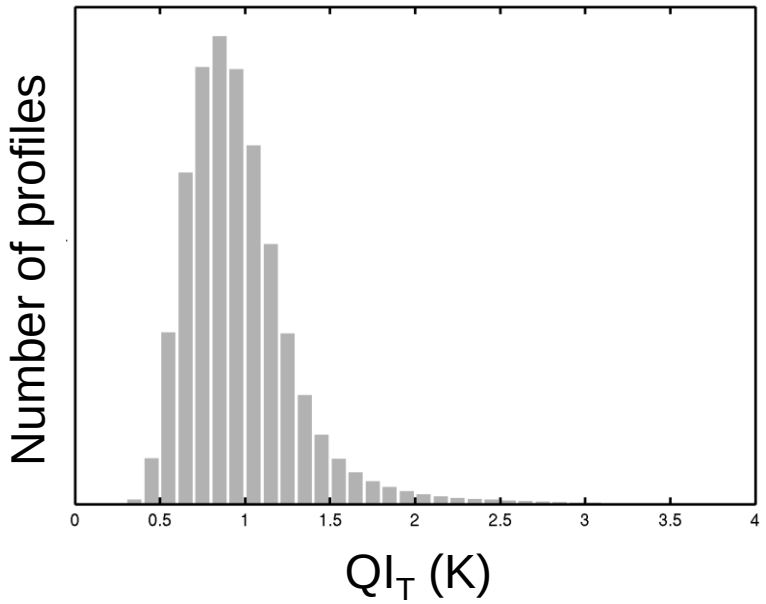


Quality indicator QI_T

- QI_T: uncertainty estimate of the low tropospheric temperature
- Additional screening for high quality data, $QI_T < 1.5$
  - Over sea majority of the data fulfil the criterion





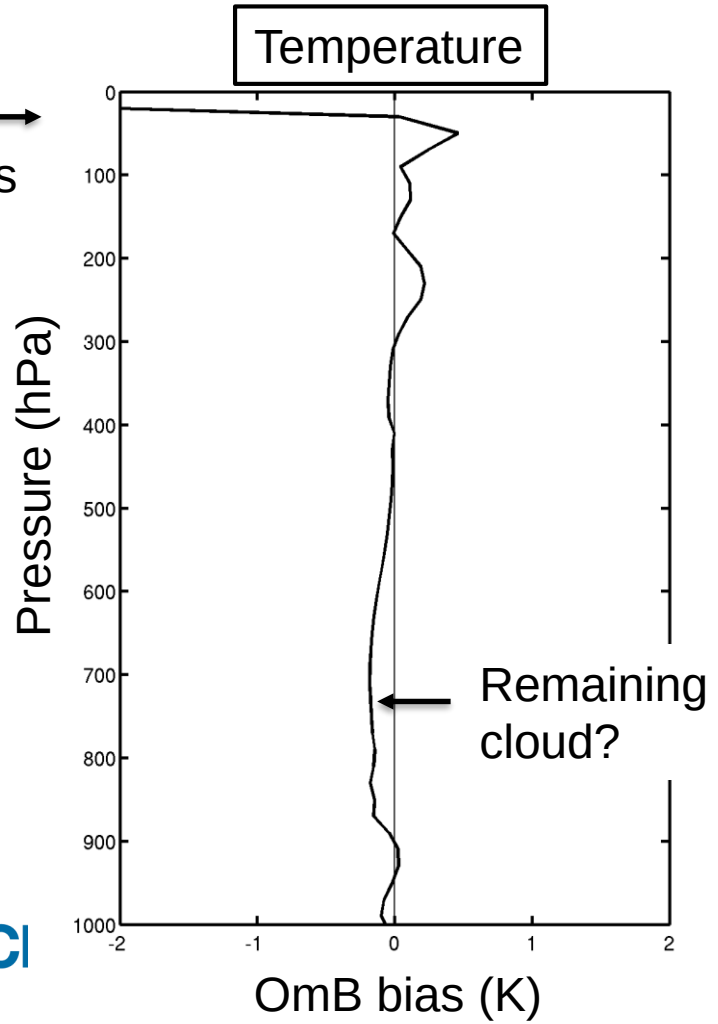


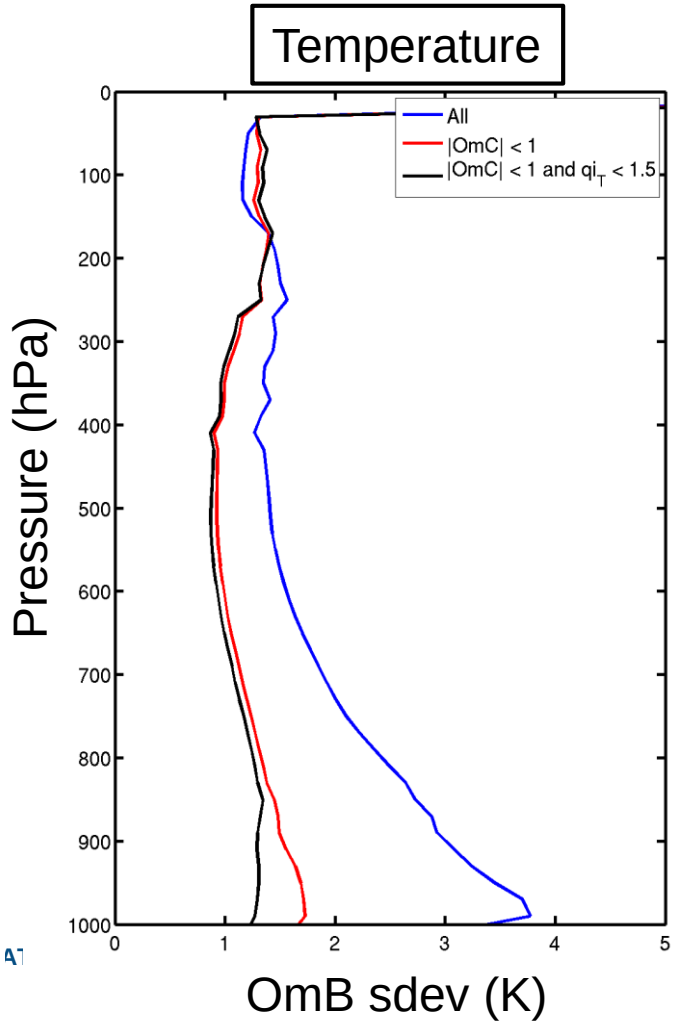
Applying quality criteria

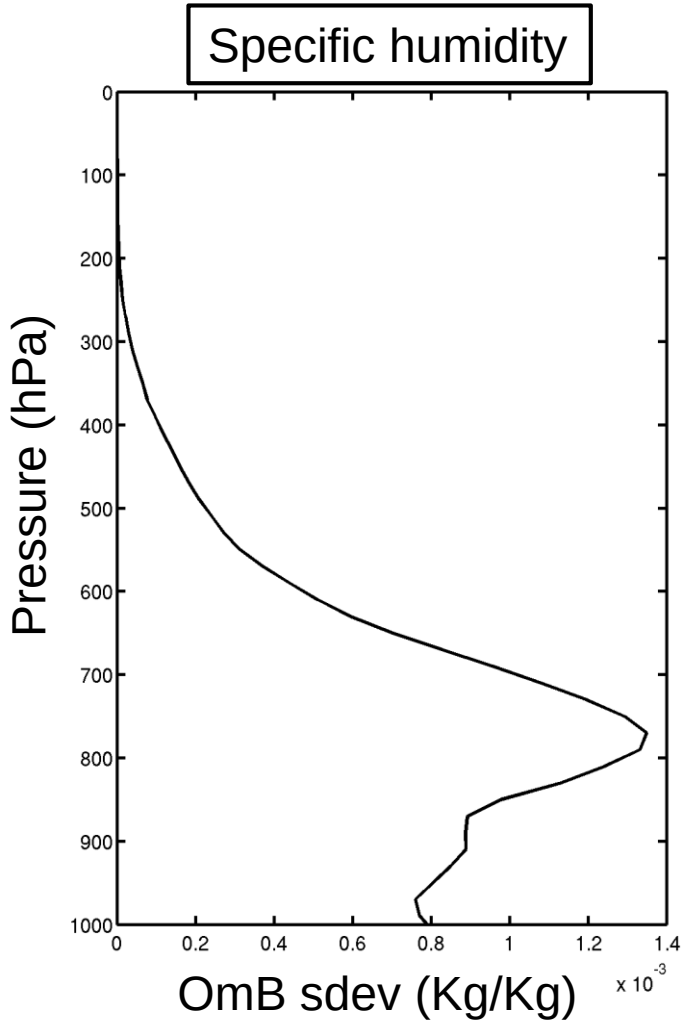
- The overall quality of the retrievals is relatively good as long as strict quality criteria are applied to exclude cloudy scenes. (Focus on data over sea only.)
- All, cloud free retrievals |OmC| < 1, additional quality screening for cloud free retrievals $QI_T < 1.5$

Error characteristics from ERA5

Remaining cloud?

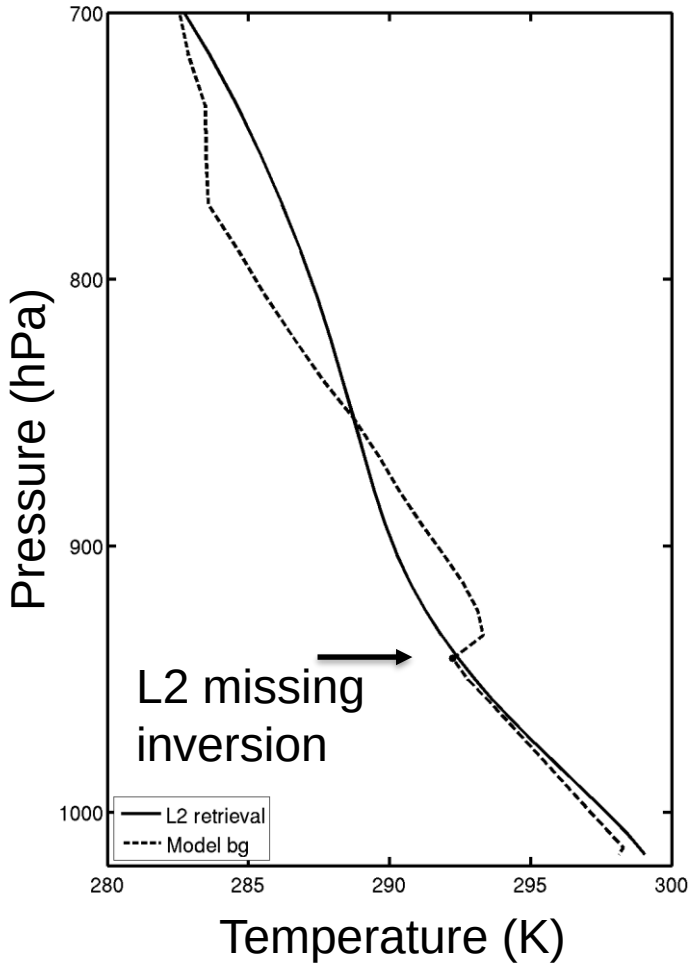


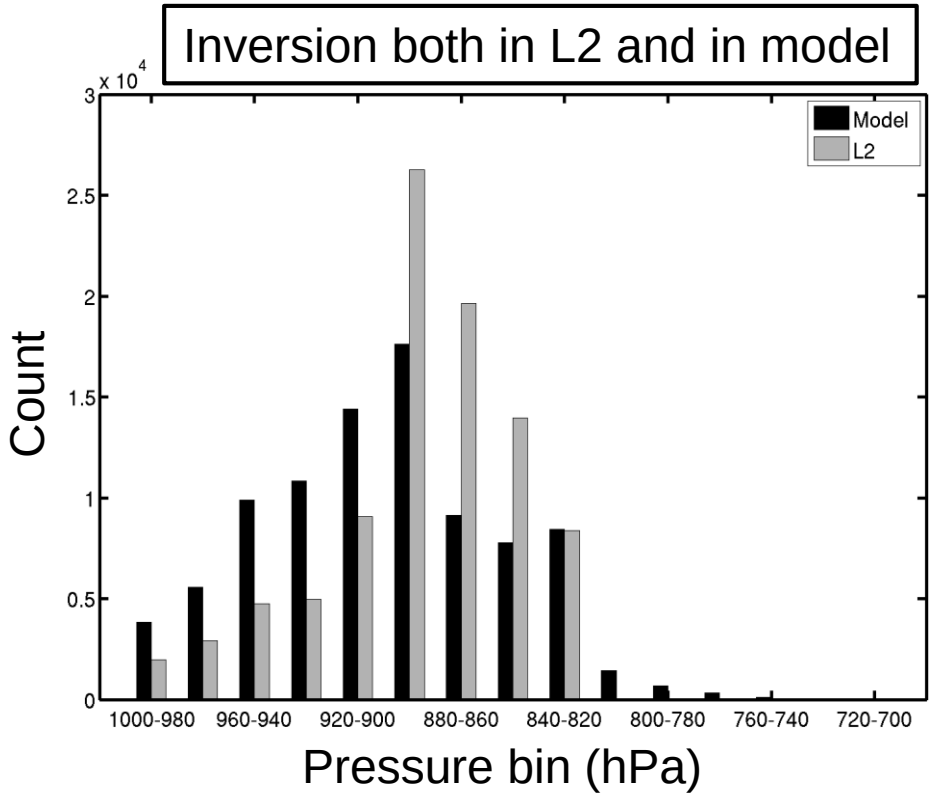




L2 has challenges to capture low level inversions

- Model is capturing the low level temperature inversions much more frequently than L2.
- L2 inversions are smooth, and on average found from higher altitudes than the model inversions.

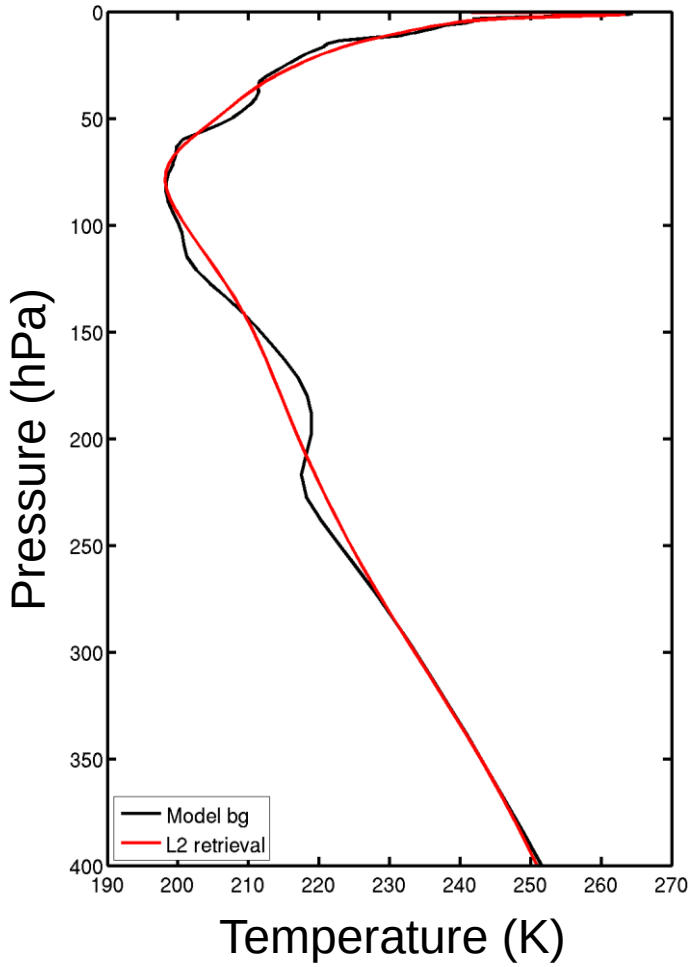


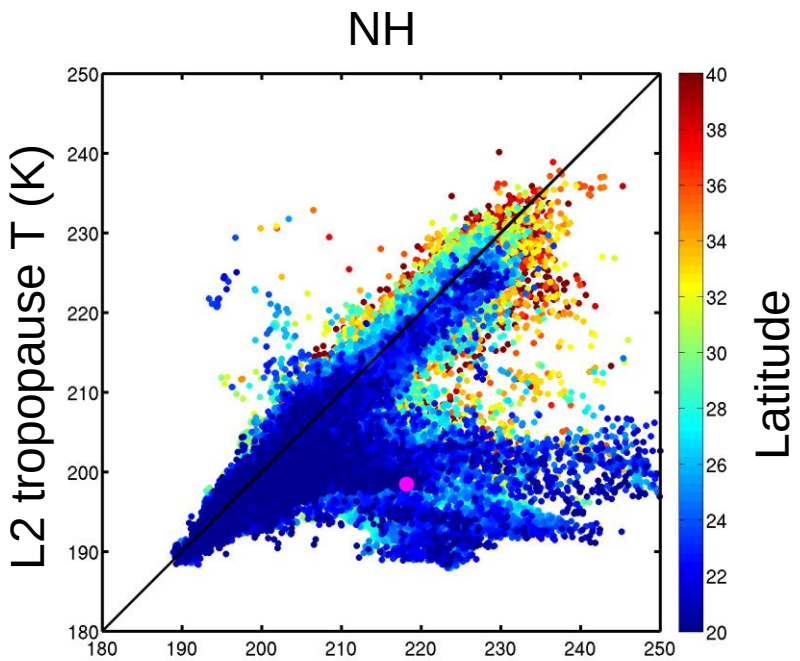


	Model: % of low level inversions 1.1-31.3.2017	L2 profiles: % of low level inversions 1.1-31.3.2017	Model: % of low level inversions 1.6-31.8.2017	L2 profiles: % of low level inversions 1.6-31.8.2017
Geodisc NH	64.6	10.8	79.3	33.4
Geodisc TR	67.3	17.6	67.0	18.2
Geodisc SH	67.6	19.4	68.5	14.0

Tropopause structure

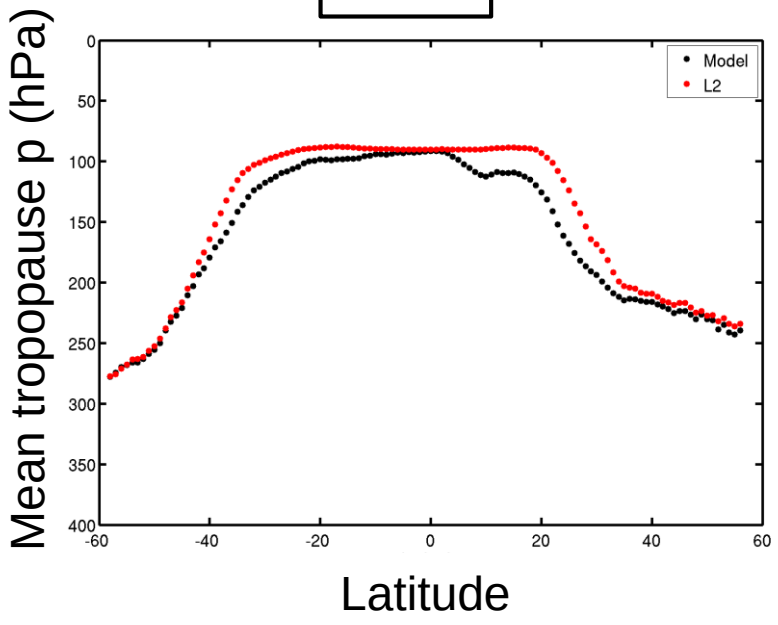
- The model tropopause is on average warmer and at lower altitude than the L2 tropopause.
- Model captures more often the double tropopause structure in the midlatitudes

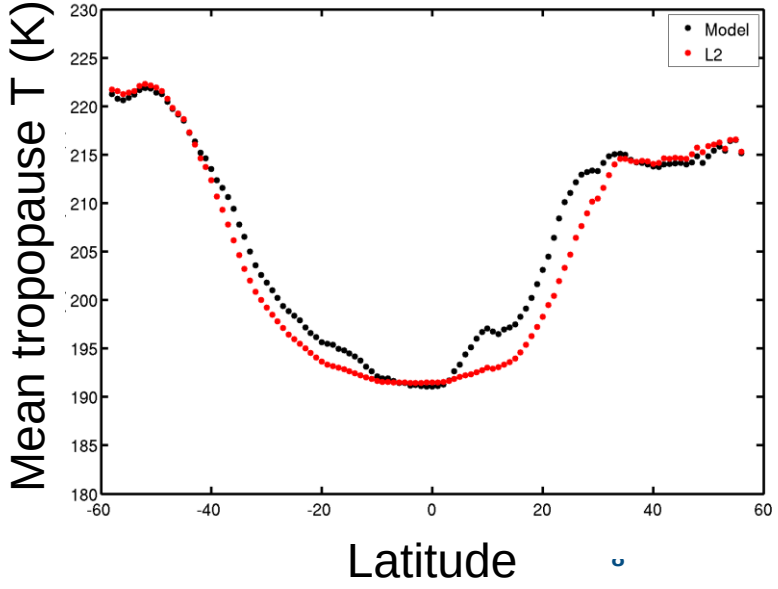




- Example profile

Model
L2





Summary of the quality assessment

- Quality of the retrievals is highly situation and location dependent
  - Cloud free profiles have the best quality
  - Errors increase rapidly for cloud affected data
  - Generally the data quality is better over sea than over land
- QI_T is useful for filtering good quality data especially over land
  - |OmC| < 1, 11% of all data
  - QI_T < 1.5 K, 35% of all data
  - |OmC| < 1 and QI_T < 1.5 K 9 % of all data
- Model is capturing the low level inversions much more frequently than L2
  - L2 inversions are smooth, and on average found from higher altitudes than the model inversions
- The model tropopause is on average warmer and at lower altitude than the L2 tropopause.
  - Model has more often the double tropopause structure in the midlatitudes

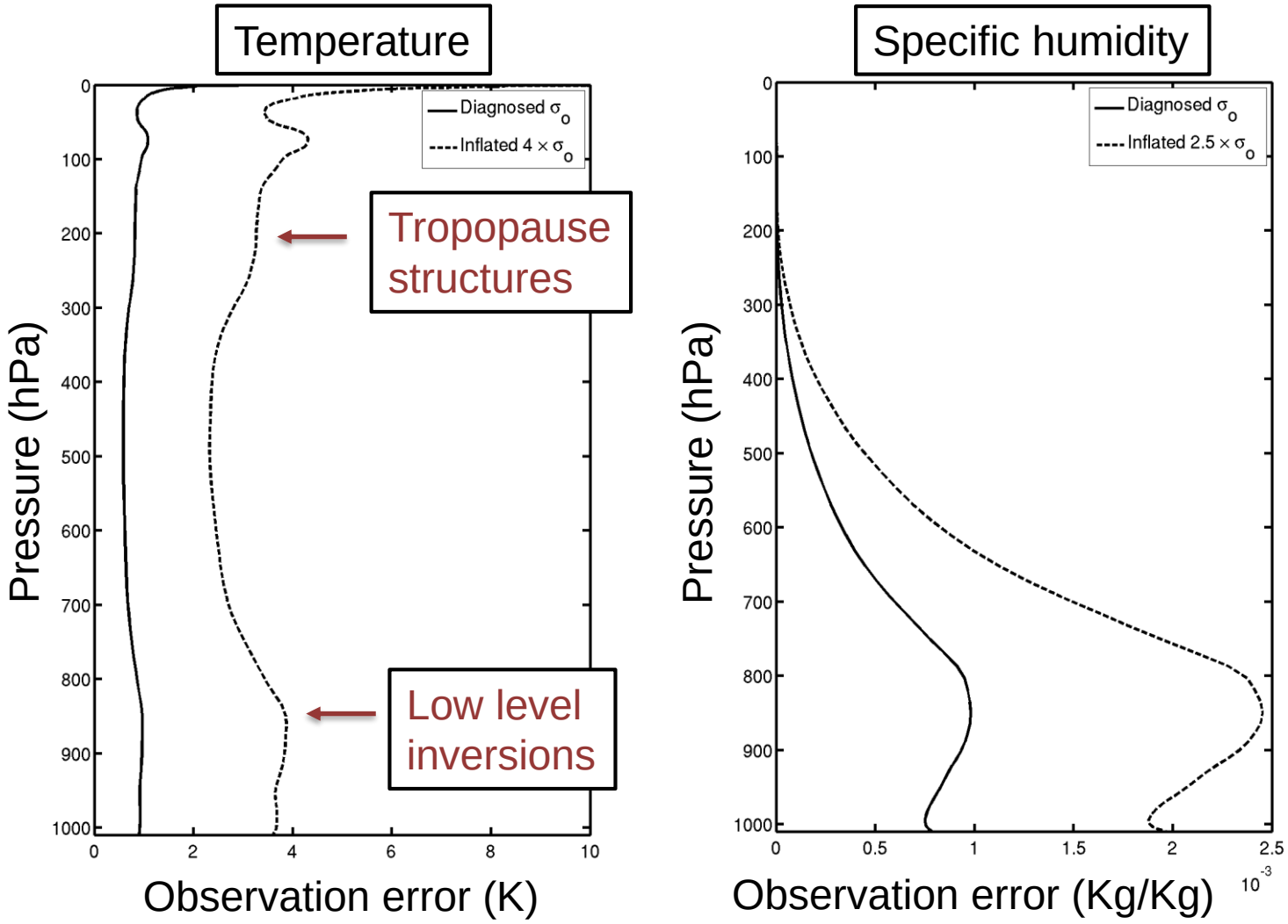
Impact assessment

Estimating observation errors

- Observation errors diagnosed with Desroziers method.

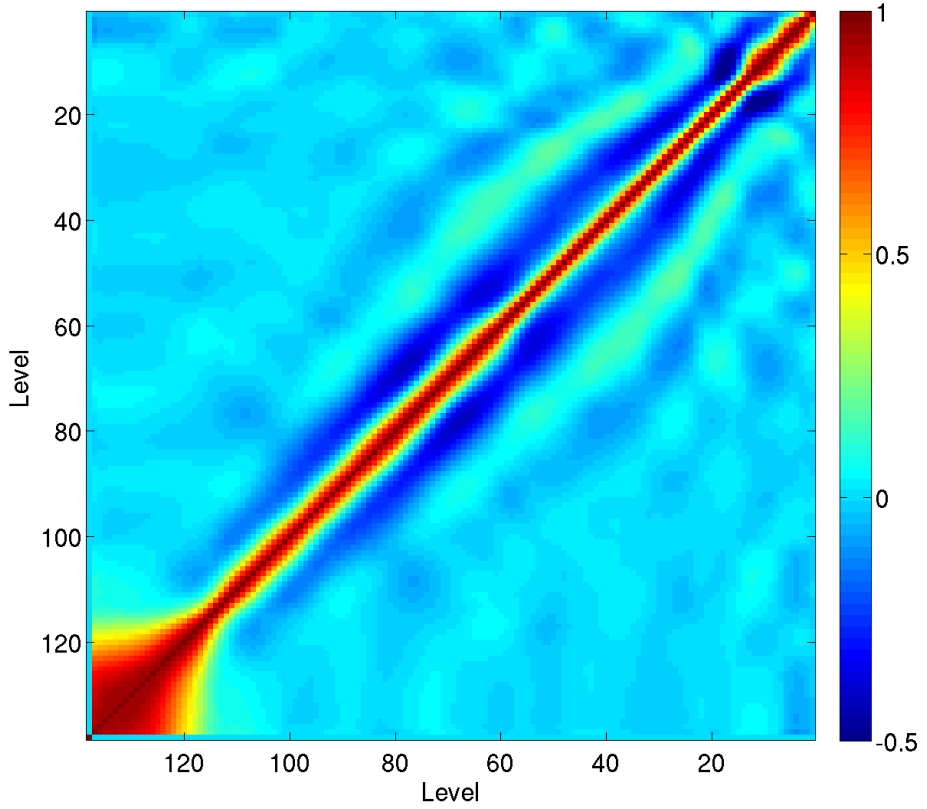
- Temperature errors require significant inflation, $4*\sigma_{oT}$ used in the assimilation experiments.
  - Increased errors at low level inversion and tropopause levels.

- Inflation for humidity errors moderate, $2.5*\sigma_{oq}$

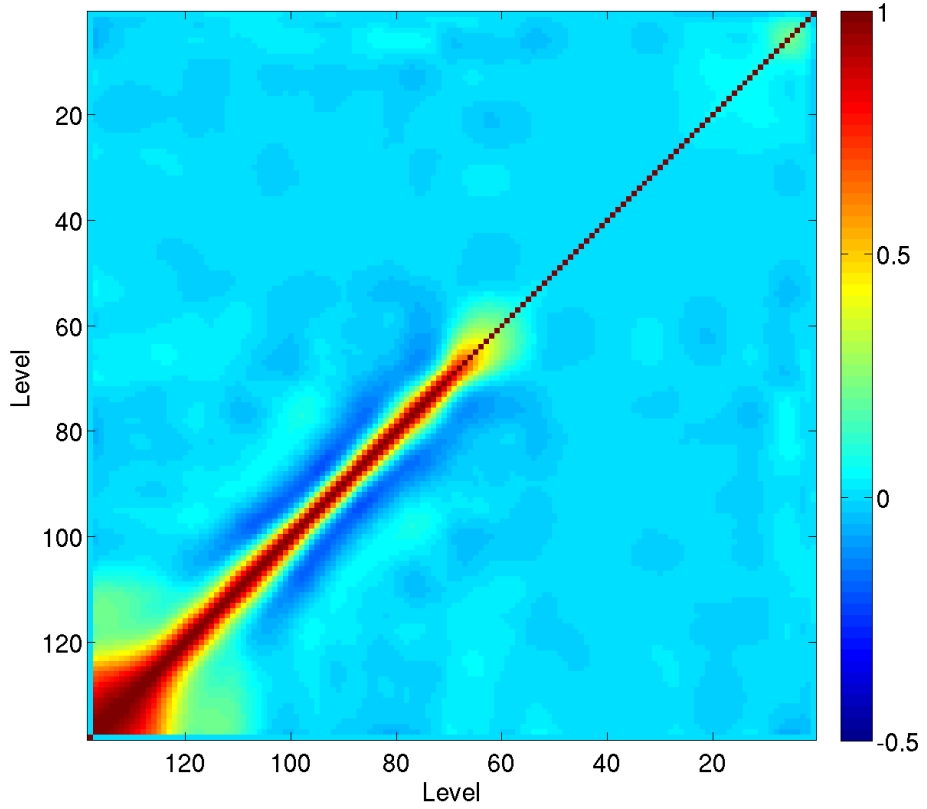


Observation error correlations in clear sky

IASI L2 temperature



IASI L2 specific humidity

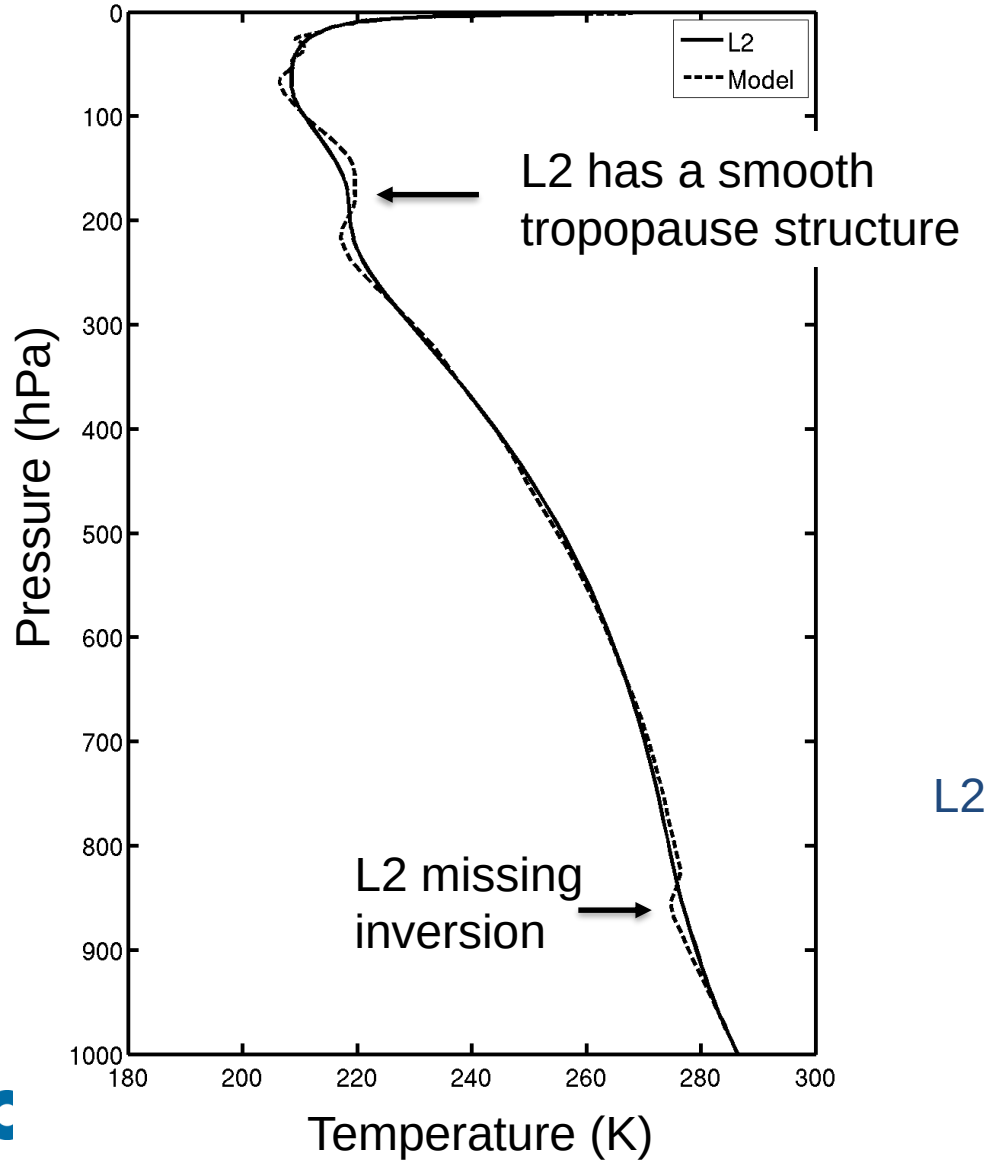


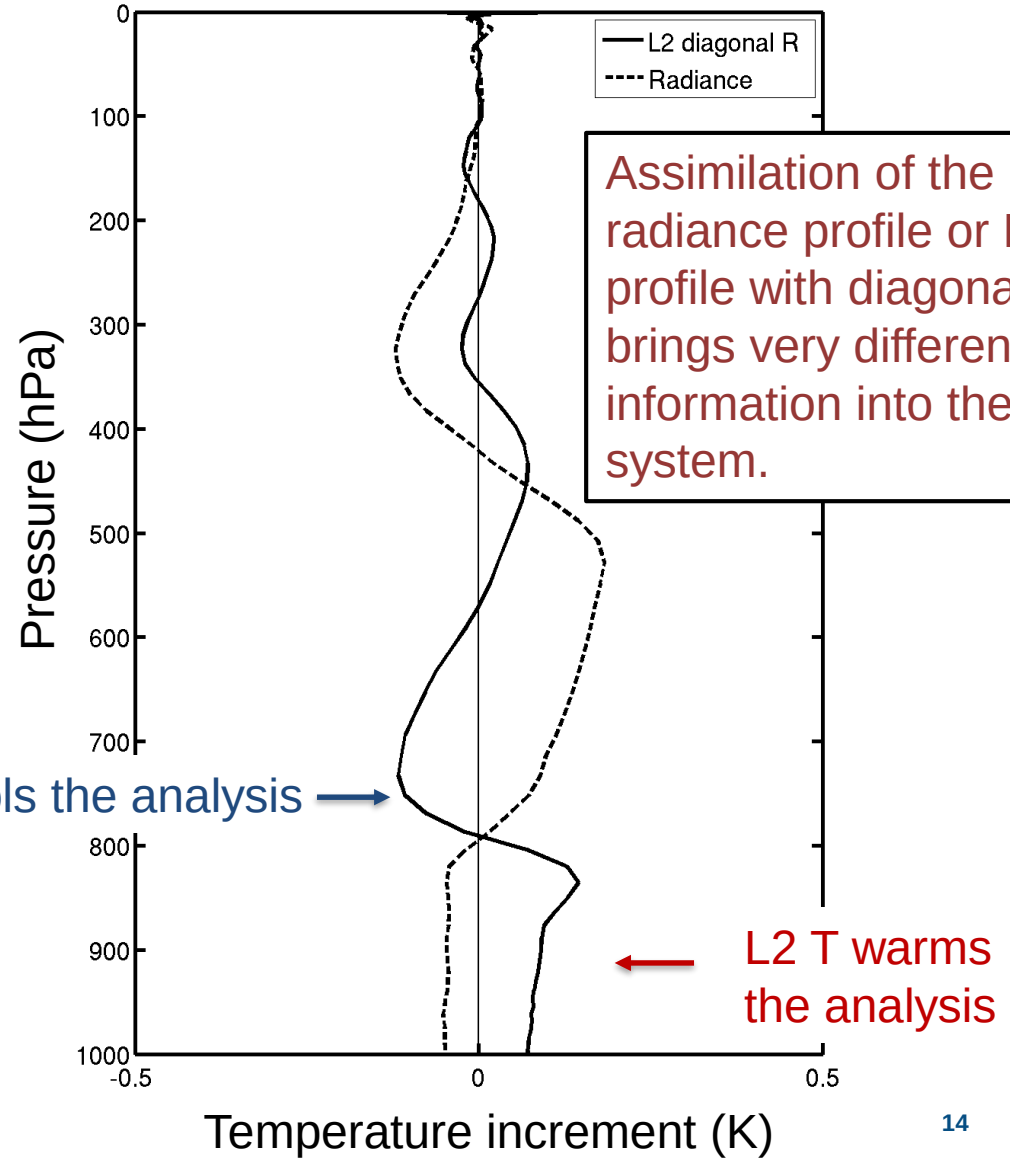
Reconditioning required, especially for the humidity **R**

Single observation experiment, temperature

- 1.1.2017, 12.38 UTC
- 39.26 N, 33.41 W
- All IASI channels are cloud free according to ECMWF cloud detection scheme
- High quality clear sky L2 temperature profile
  - OmC = 0.36
  - QI_T = 0.75

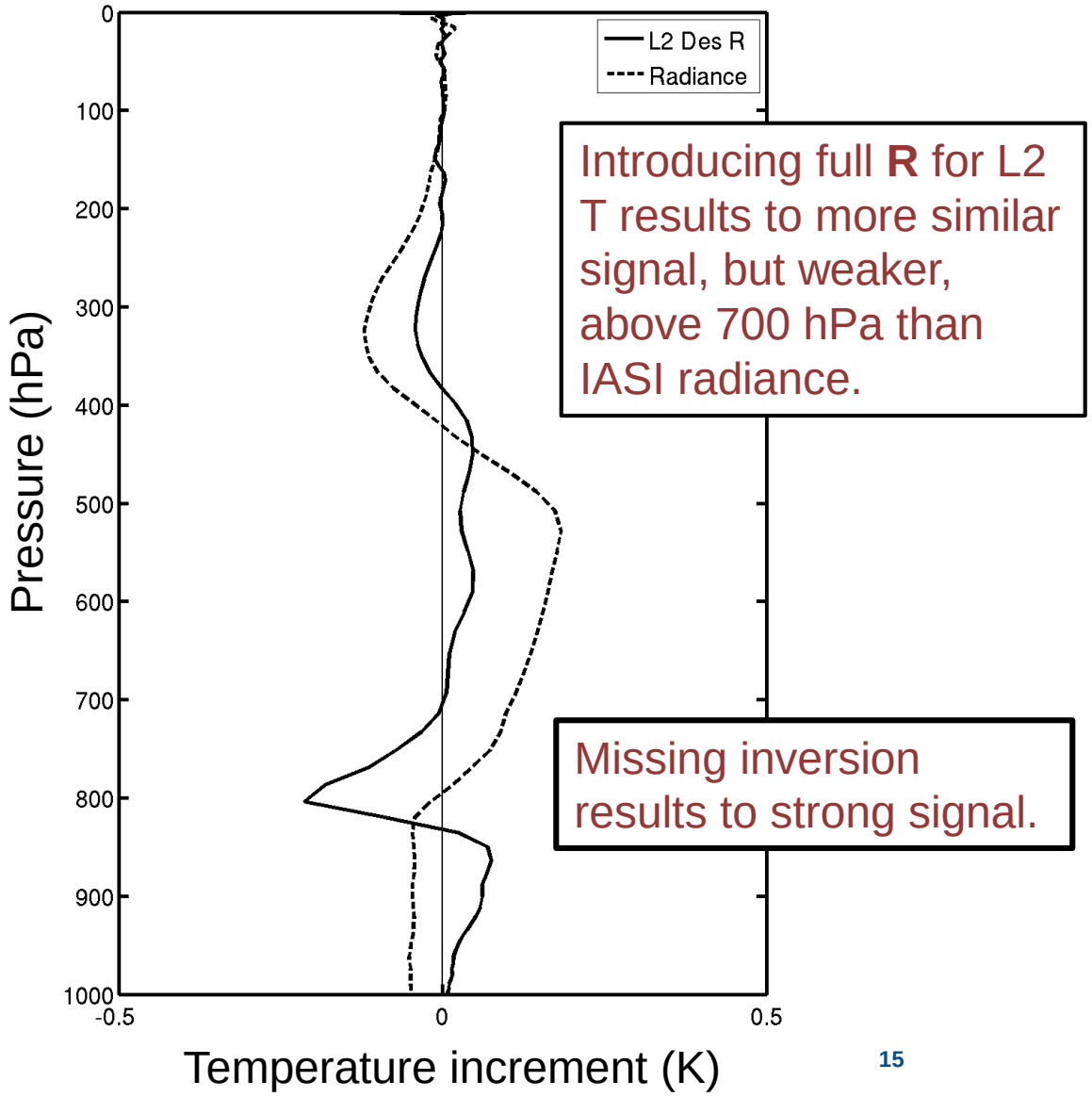
Single observation experiment, using diagonal **R**





Single observation experiment, using full **R**

- It is very important to take the vertical error correlations into account.
- Missing inversion results to strong signal in the analysis increment despite significantly inflated σ_{oT}.



Data assimilation experiments, Jan – Feb and Jun – Jul 2017

- Depleted observing system

  CTL: Conventional observations + AMSU-A

  L2: **CTL** + L2 temperature and specific humidity

  IASI: **CTL** + IASI radiances

- Full observing system

  CTL: Full observing system without IASI

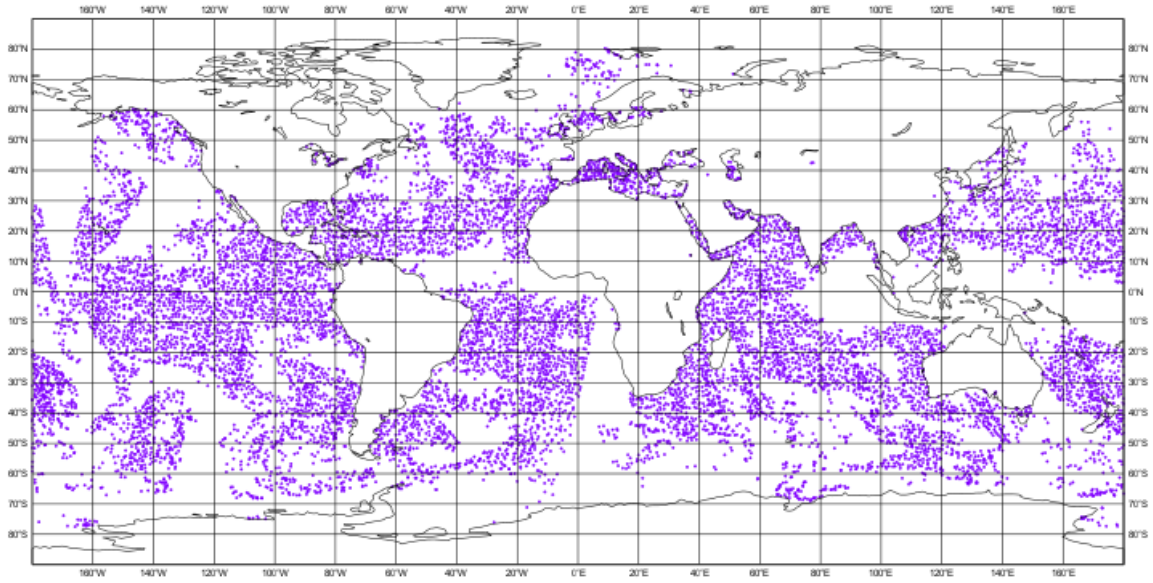
  L2: **CTL** + L2 temperature and specific humidity

  IASI: **CTL** + IASI radiances

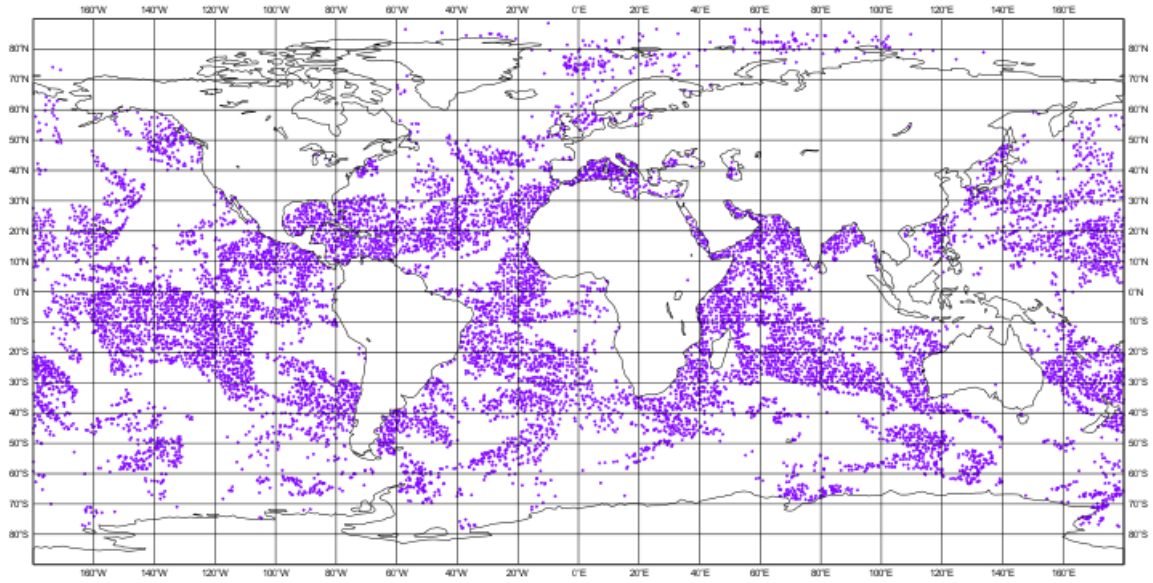
12-hour sample coverage for active data

- Data selection as similar as possible for L2 profiles and radiances
  - Horizontal thinning 125 km
  - Clear sky data over sea only
  - IASI radiances blacklisted at the edges of the swath
  - L2 data blacklisted above ~30 hPa due to large temperature errors

IASI radiances, channel 3049 (~11700 obs)

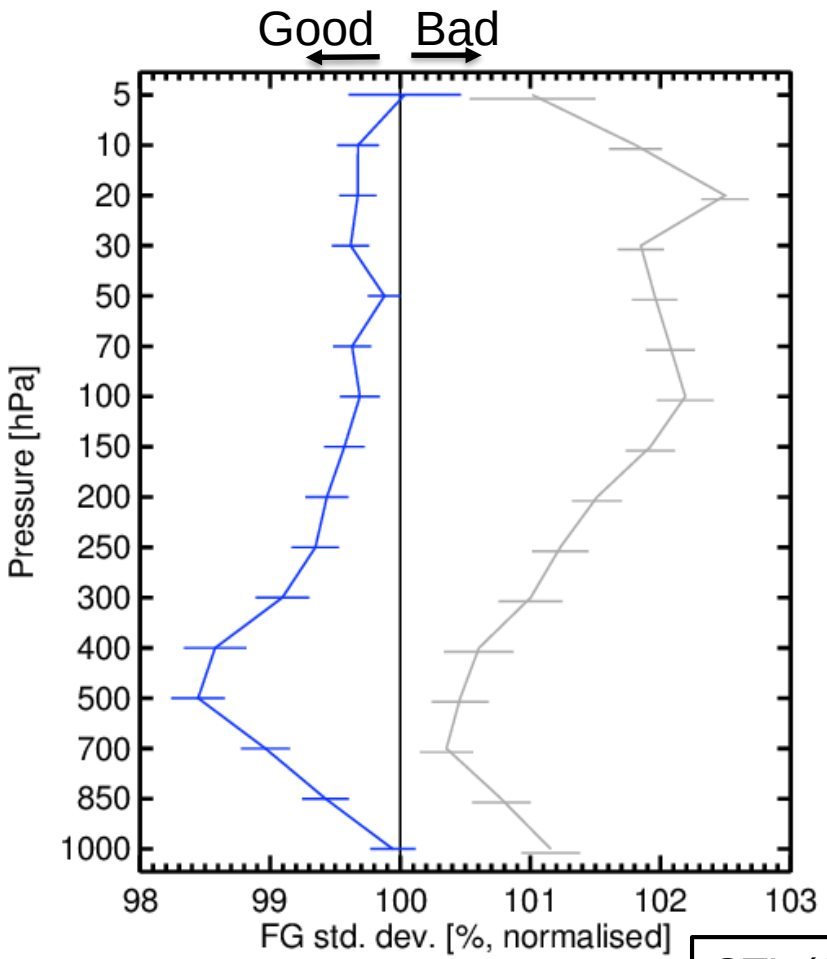


L2 humidity profiles (~12400 obs)

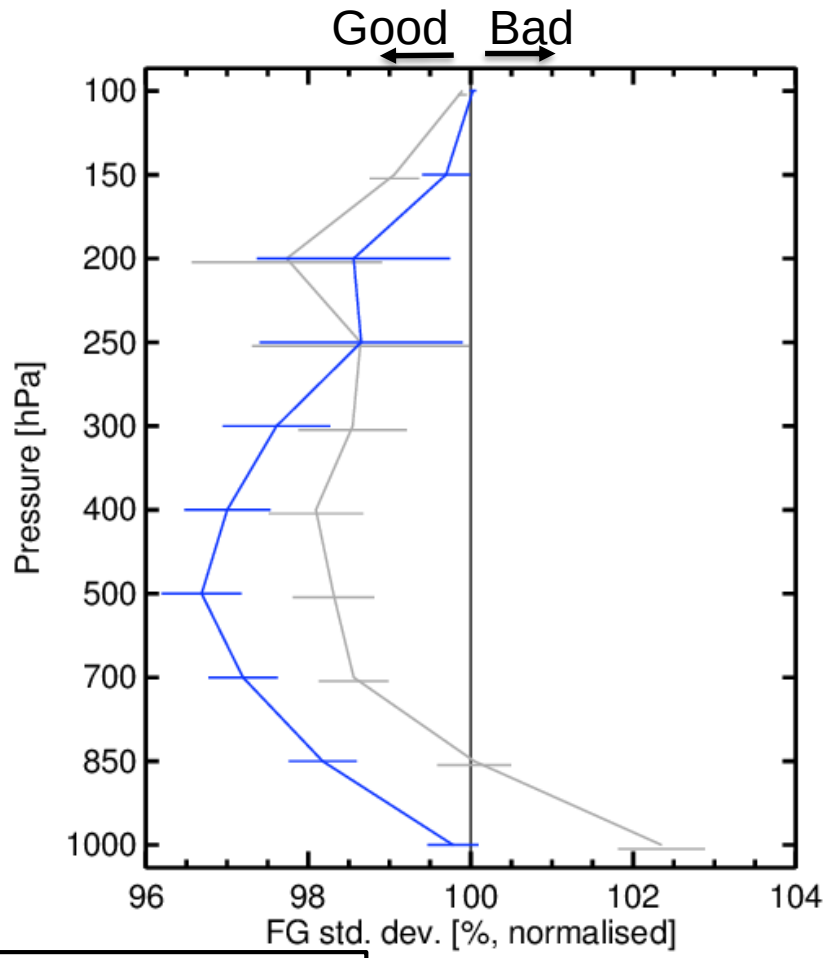


Short range forecast impact, depleted observing system

Radiosonde temperature



Radiosonde humidity



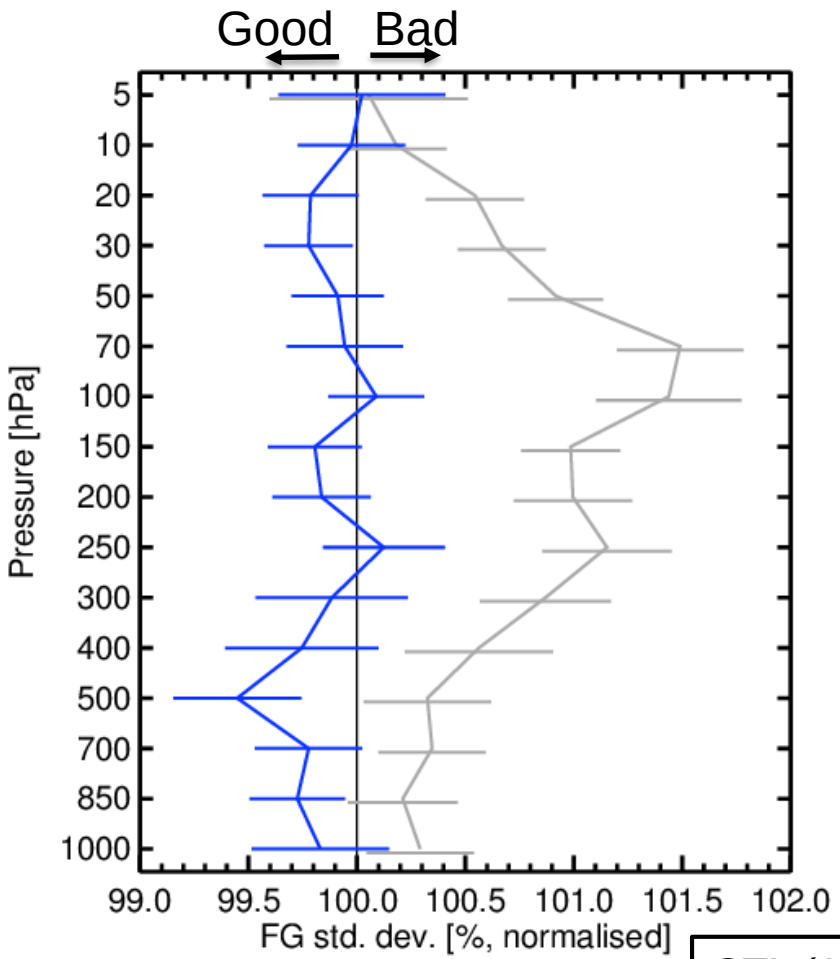
CTL (100%): Conv + AMSU-A

CTL + IASI L2 T and q with full **R**

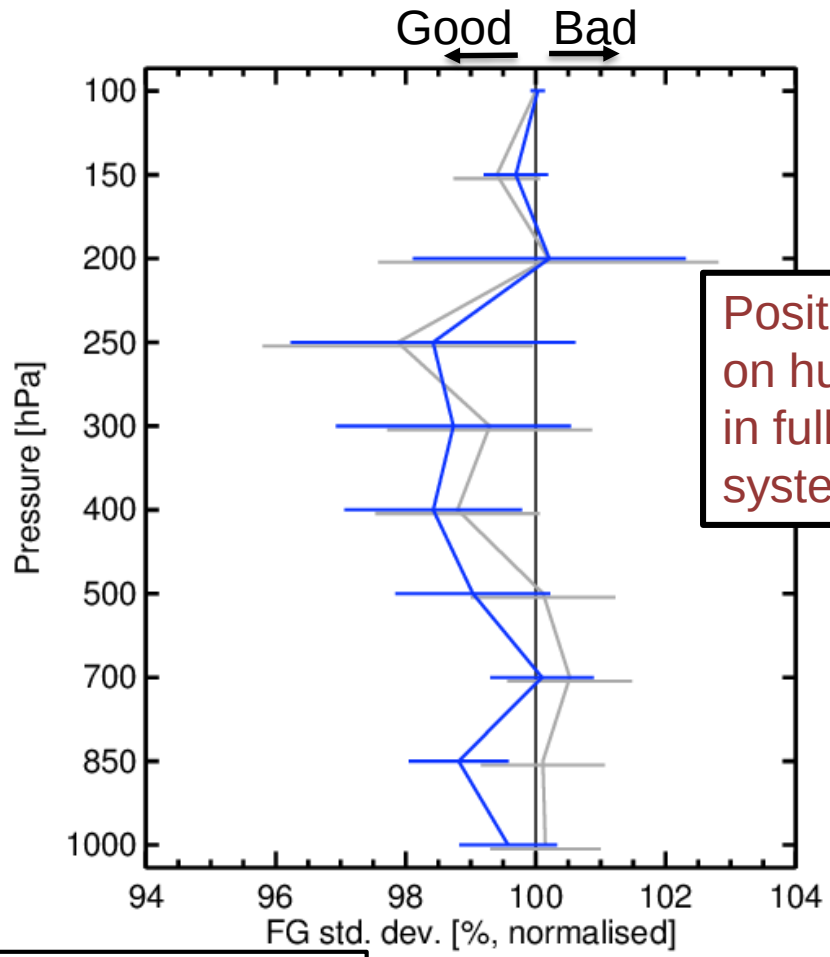
CTL + IASI radiances

Short range forecast impact, full observing system

Radiosonde temperature



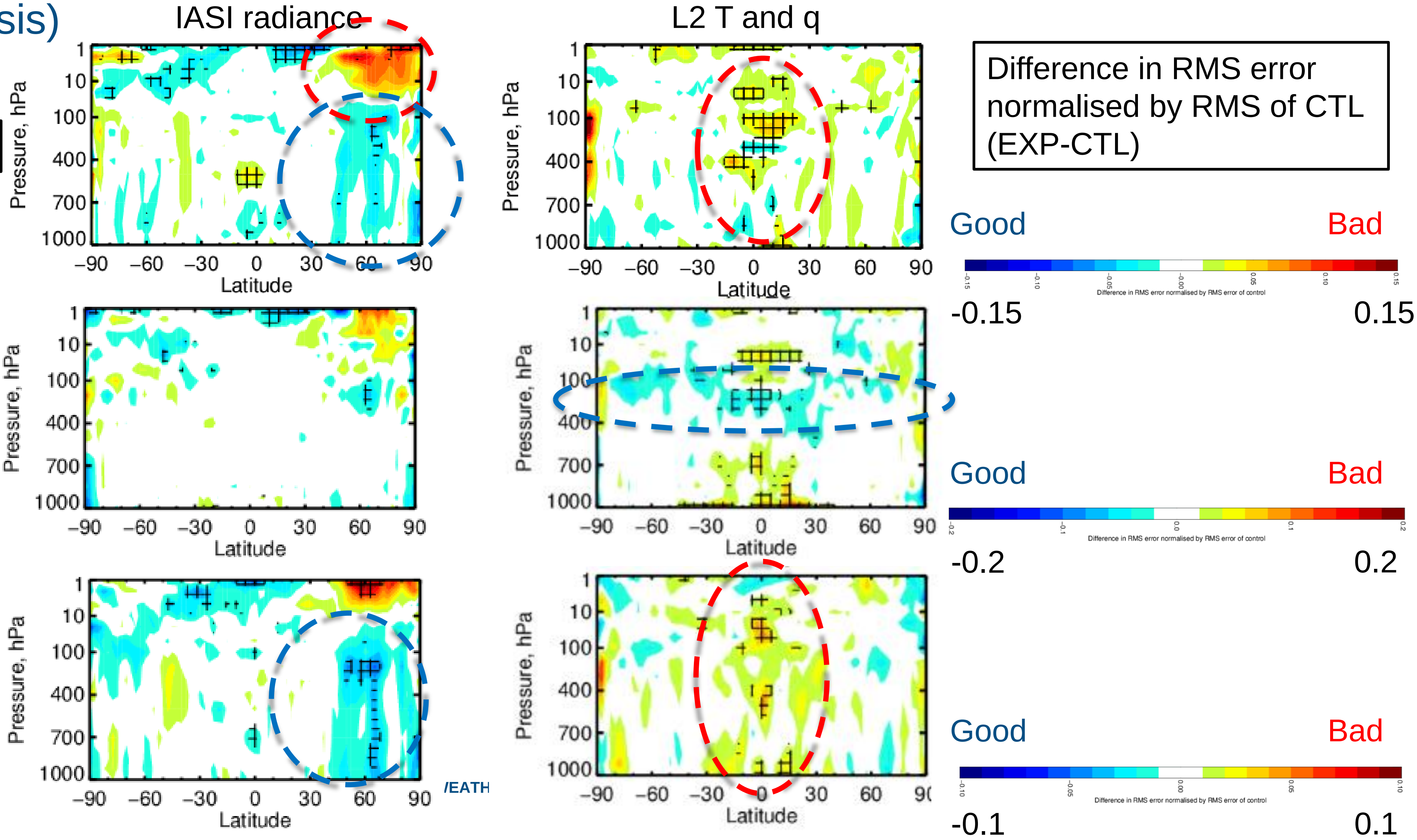
Radiosonde humidity



Positive impact on humidity even in full observing system!

CTL (100%): Full observing system without IASI
CTL + IASI L2 T and q with full **R**
CTL + IASI radiances

Forecast impact day 5, full observing system (verification against own analysis)



Temperature

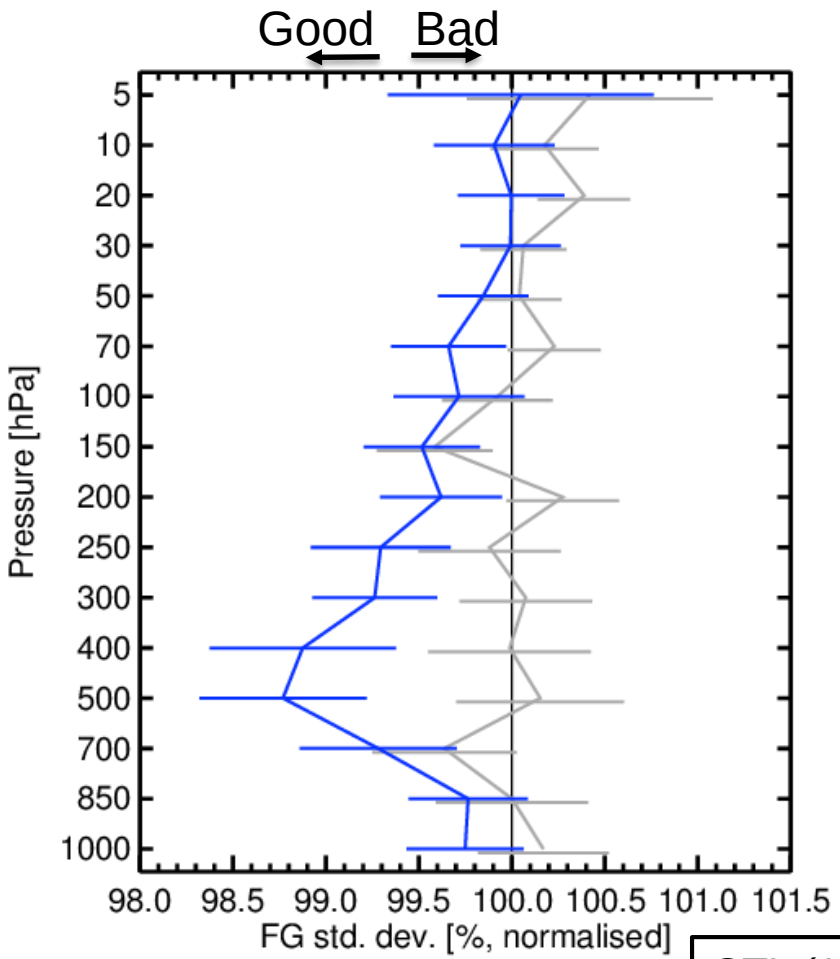
Relative humidity

Wind

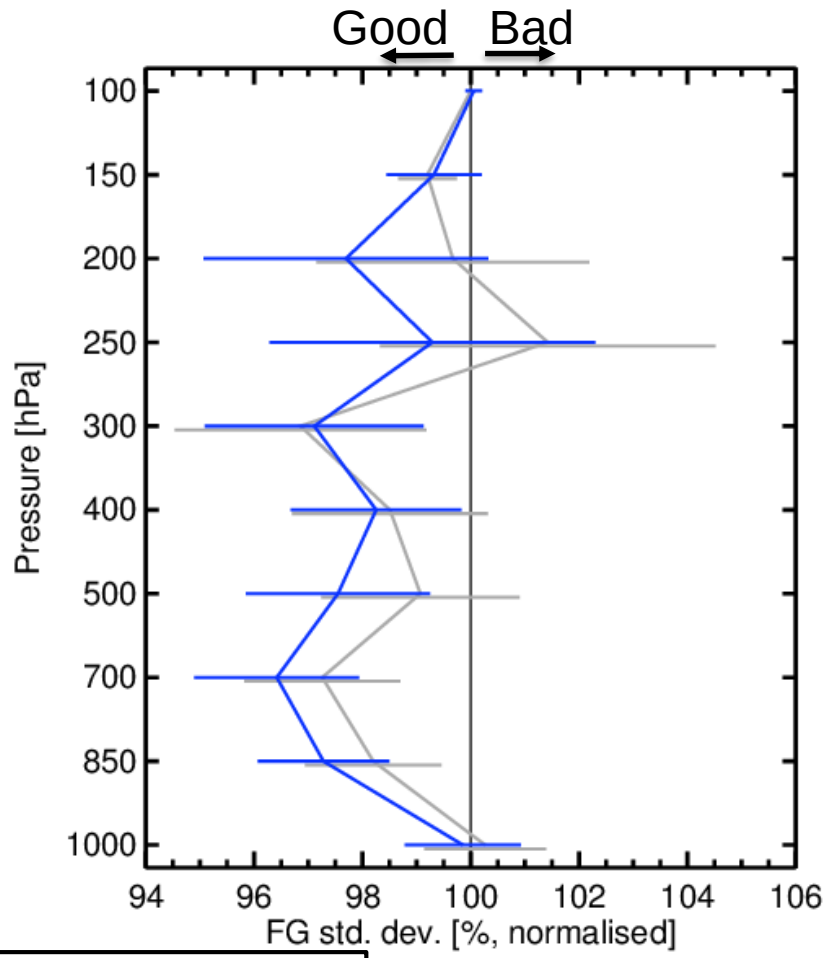
Difference in RMS error normalised by RMS of CTL (EXP-CTL)

Assimilation experiments with q only, depleted observing system

Radiosonde temperature



Radiosonde humidity



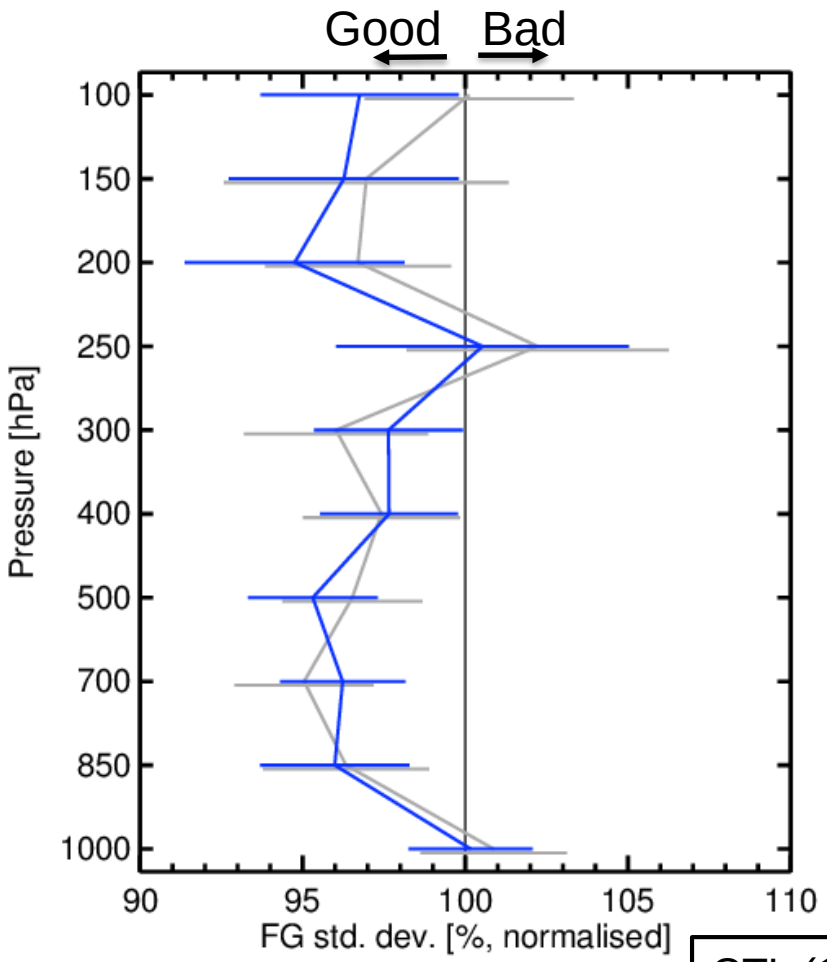
CTL (100%): Conv + AMSU-A

CTL + IASI L2 q with full **R**

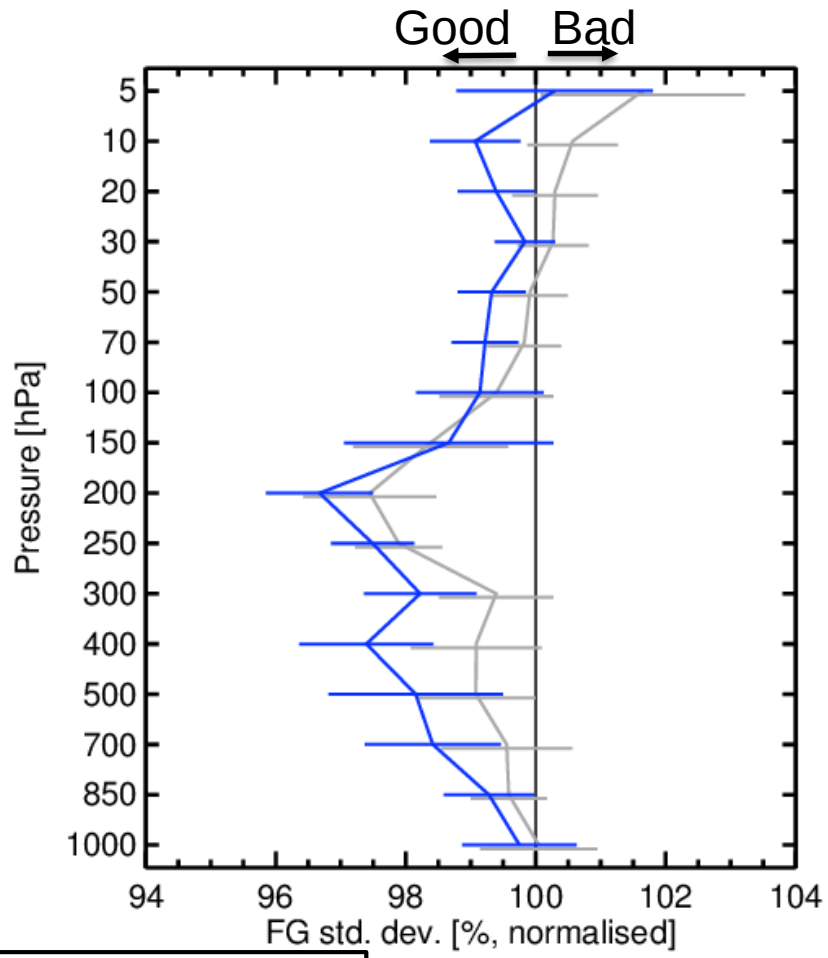
CTL + IASI radiances

Impact in tropics, depleted observing system

Radiosonde humidity



Radiosonde wind



CTL (100%): Conv + AMSU-A
CTL + IASI L2 q with full **R**
CTL + IASI radiances

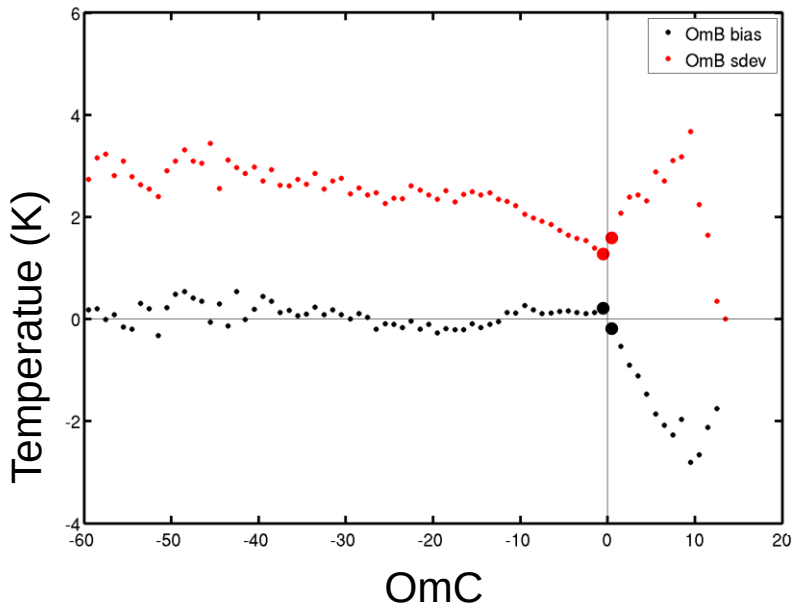
Summary of the L2 impact in clear sky conditions

- Positive impact from L2 humidity
  - Benefit comparable to IASI radiances
- Negative impact from L2 temperature
  - Most likely due to smoothing of inversions and tropopause structures
- Results are consistent in depleted and full NWP systems
  - Smaller impact in full system
- L2 impact is very sensitive to the diagnosed error correlations

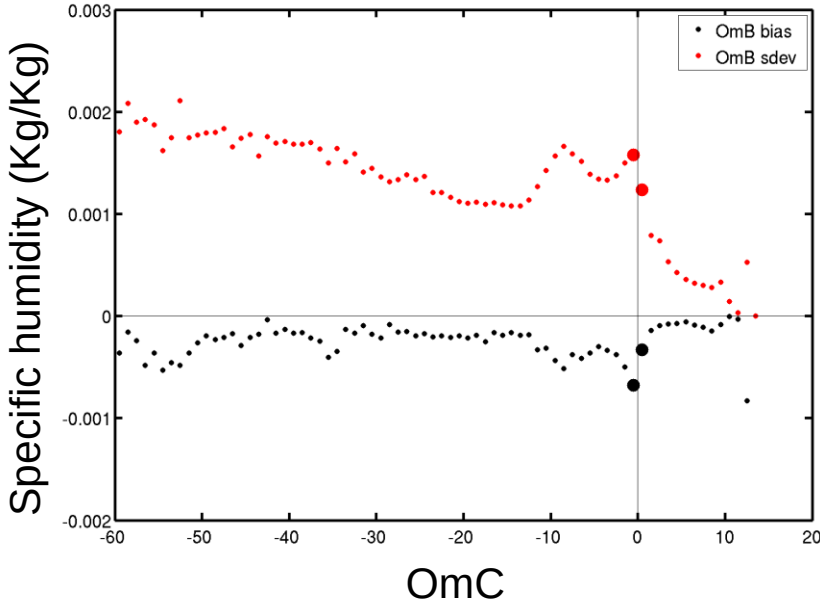
6 month extension phase, focus on cloud affected data

- In the L2 assimilation experiments only “best of the best” clear sky data is used, |OmC| < 1. This represents a very small fraction of the available data (large dots, blue bars in the figures below).
- Errors are highly situation dependent and grow rapidly for cloud affected data.
- Suggestion: focus next only on humidity to get realistic understanding of the potential of the cloud affected humidity retrievals.

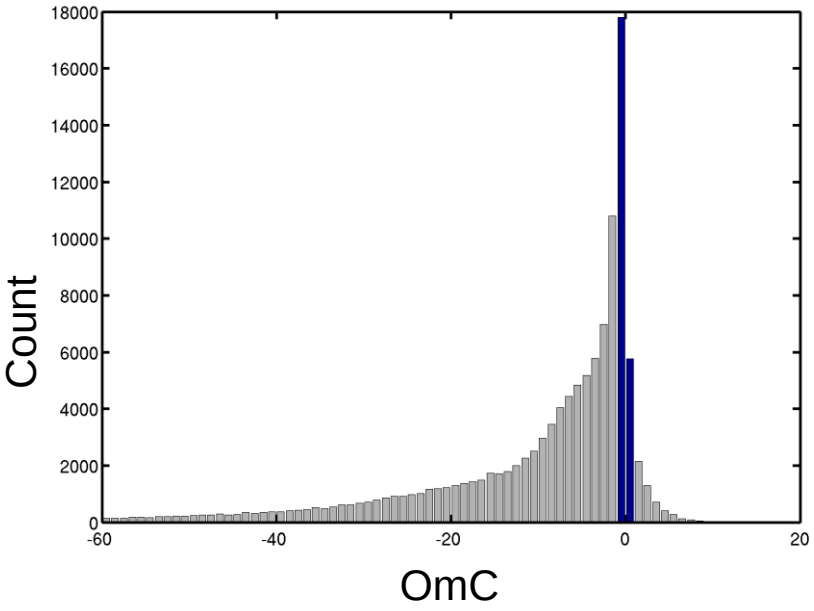
850 hPa



850 hPa

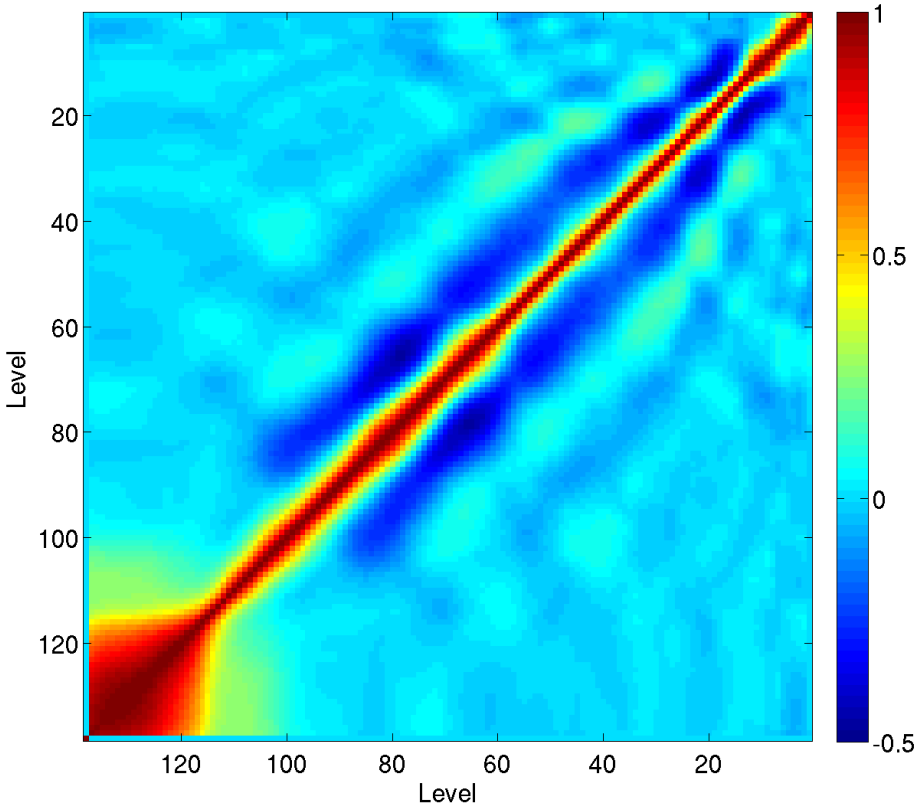


850 hPa

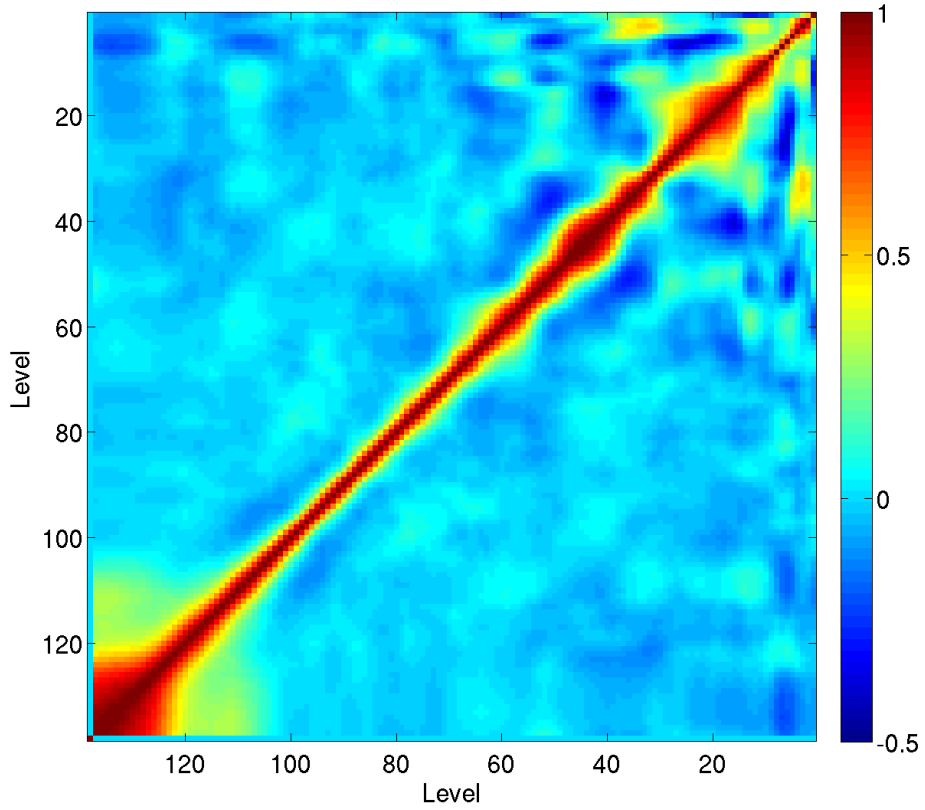


Clear sky error correlations

IASI L2 temperature

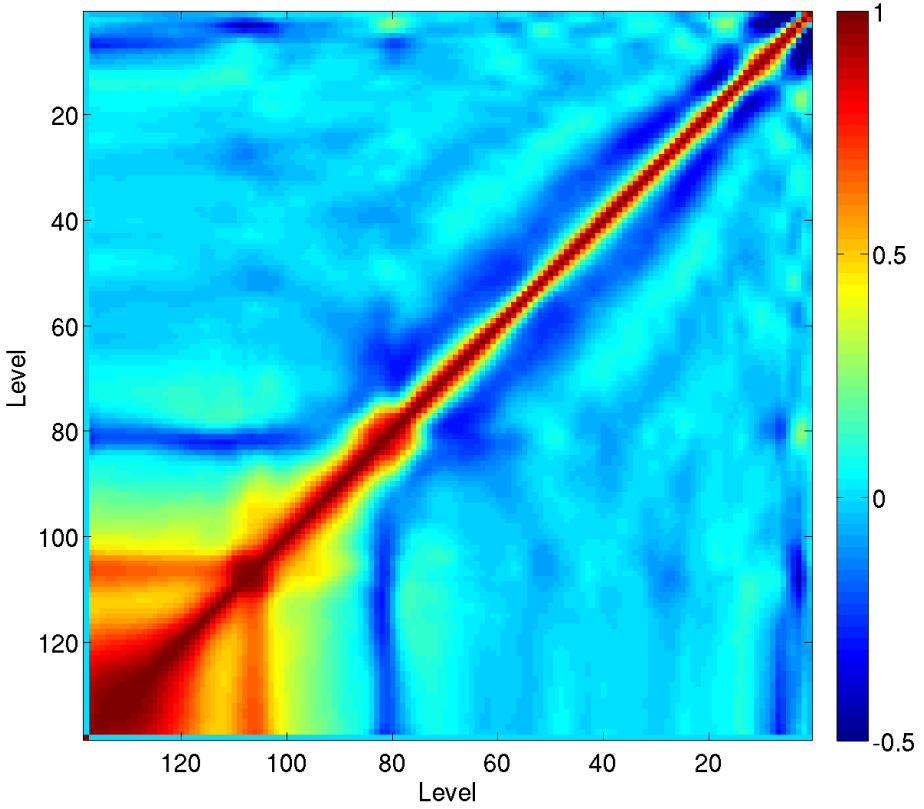


IASI L2 specific humidity

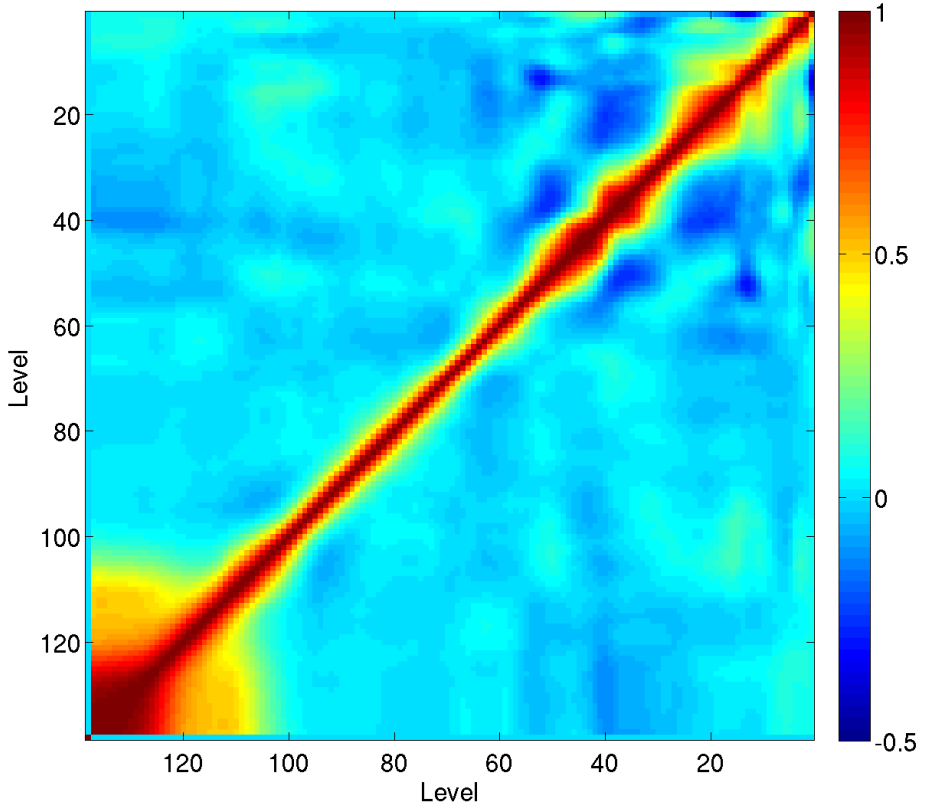


Cloudy error correlations

IASI L2 temperature



IASI L2 specific humidity



Error correlations become increasingly stronger for cloudy data