MTG-IRS L2 data assimilation into the ECMWF model

Progress report 14th March 2019

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Update since the last progress meeting

- Assimilation experiments with depleted observing system focusing on
    1. Impact from moving from Hollingsworth-Lönnberg **R** to Desroziers **R**
    2. How the observation errors should be inflated
    3. Blacklisting data above level 40
    4. Single observation experiments to better understand the results
    5. Test with NH midlatitude **R** and observations
- Example of the results from full observing system (using Hollingsworth-Lönnberg **R**)

Assimilation experiments in depleted observing system

- January – February 2017 (some of the experiments are still running, results will be updated accordingly)
- Thinning 125 km
- Blacklisting decisions (accept only): |OmC| < 1, $qi_T < 1.5$, data over sea

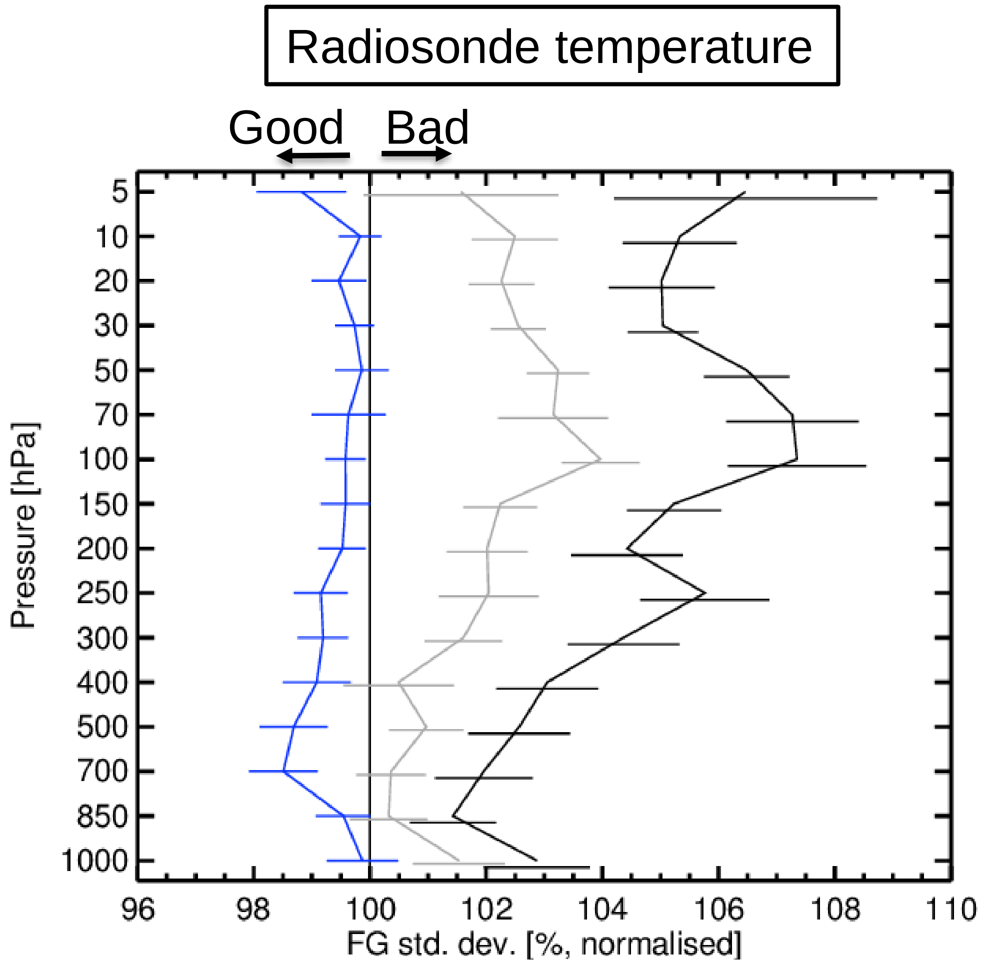
Ctl: Conventional observations + AMSU-A

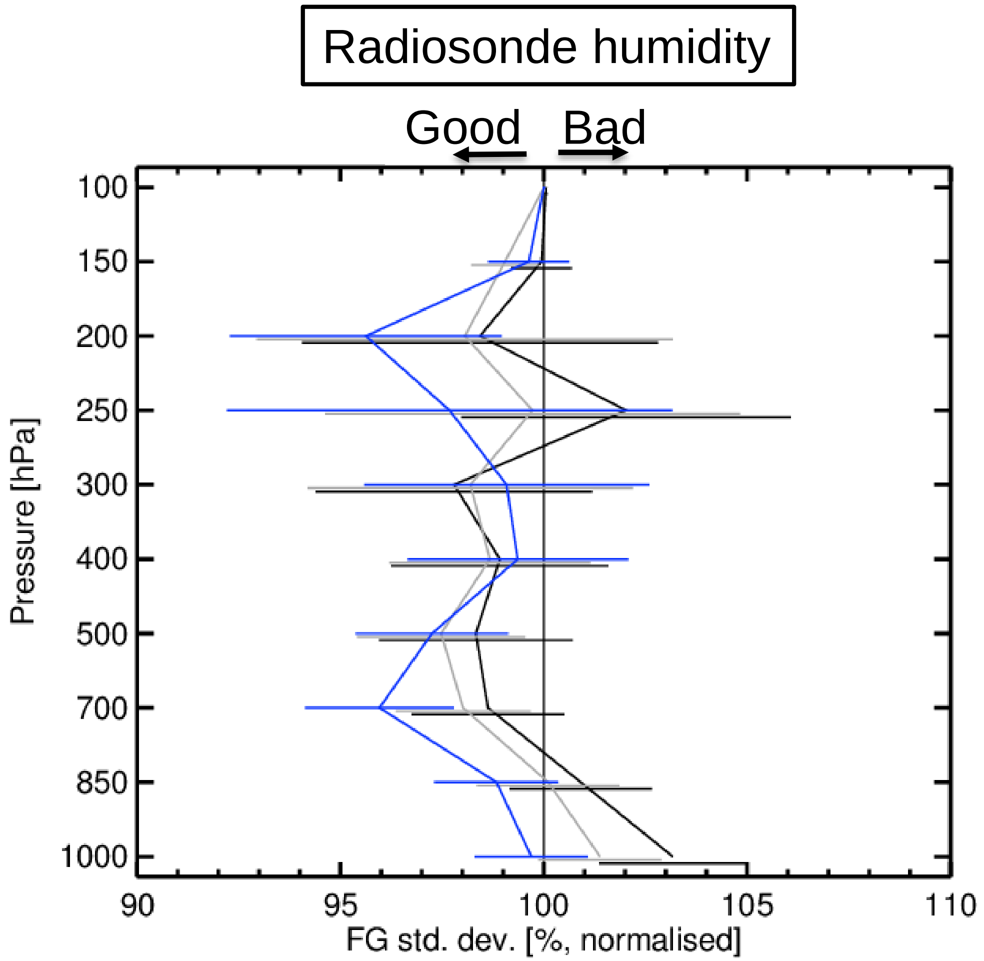
L2: Ctl + L2 T and q, various configurations

IASI: Ctl + IASI as in operations but only over sea

Impact assessment in terms of the fit of conventional observations to the model first guess (short range forecast).

Impact of using Hollingsworth-Lönnberg **R** compared to diagonal **R**



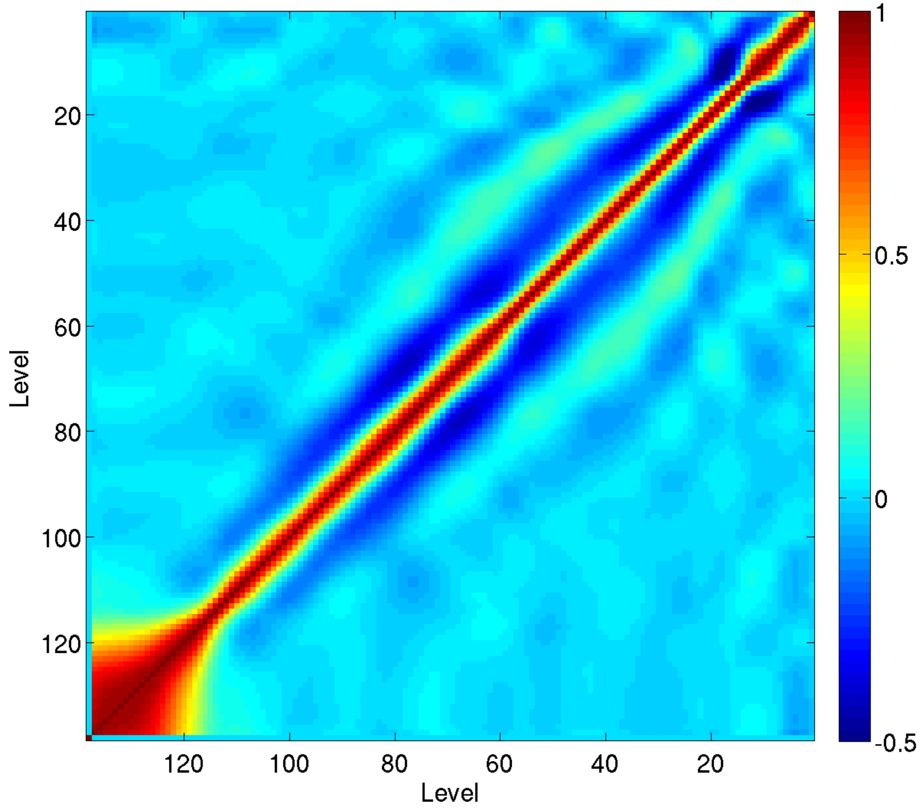


Significantly less degradation when using full **R** for temperature. It is essential to take the error correlations into account.

CTL (100%): Conv + AMSU-A
IASI: CTL + IASI radiances over sea
L2 diagonal R: CTL + IASI L2 T and q with diagonal **R**
L2: CTL + IASI L2 T and q with Hollingsworth-Lönnberg **R**

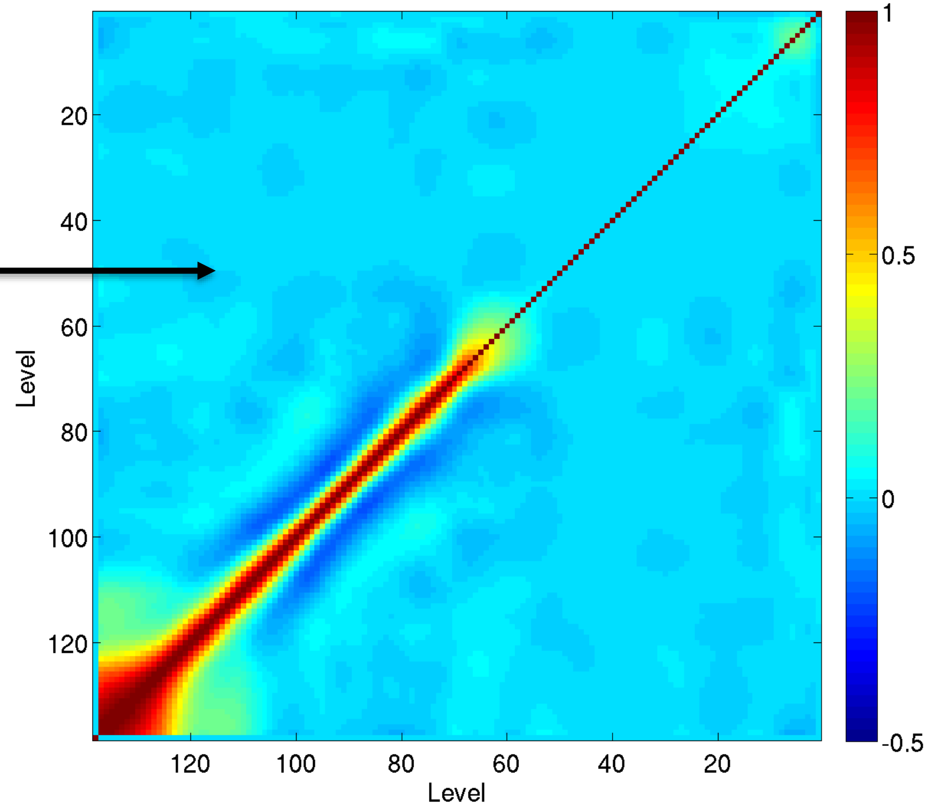
1. Desroziers **R** reconditioned with the eigen value method

IASI L2 temperature



~210 hPa

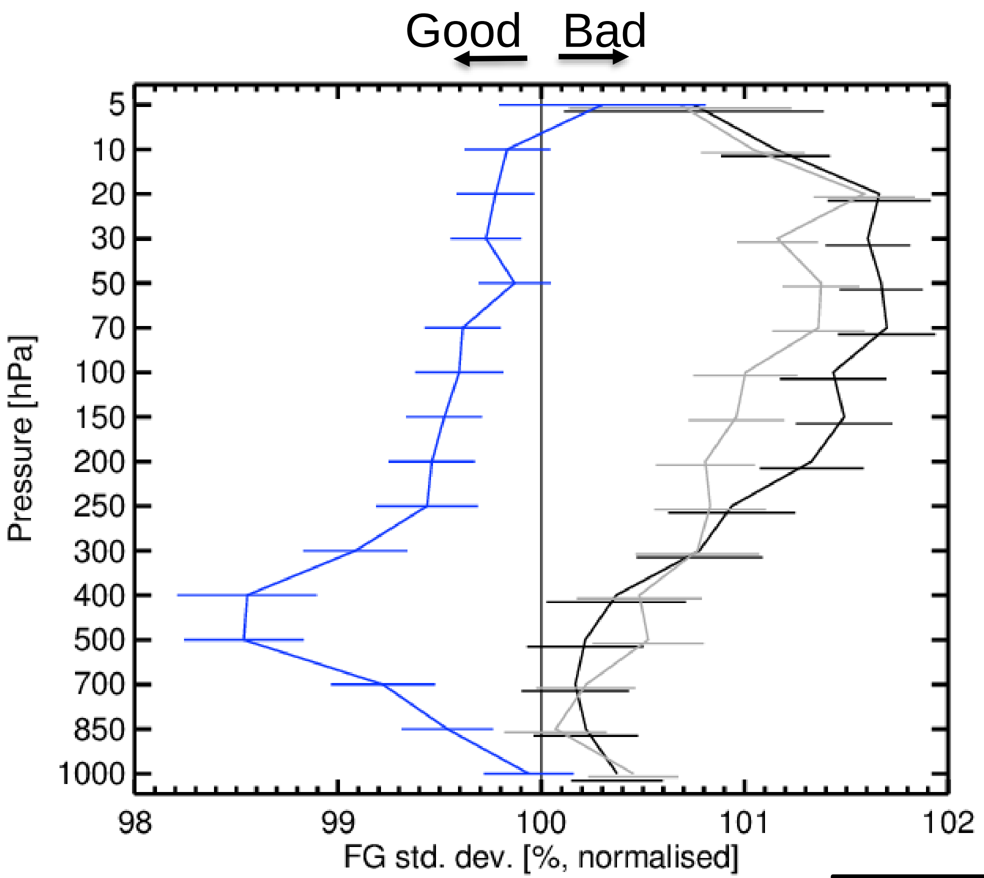
IASI L2 specific humidity



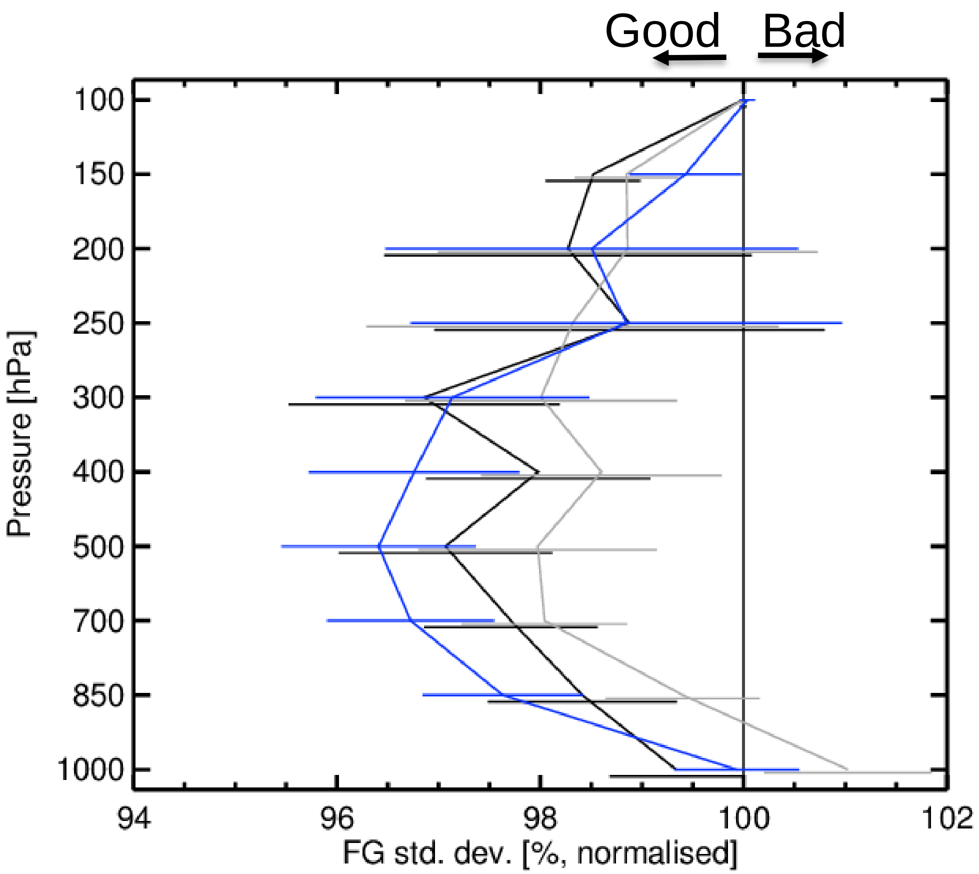
Set 67 smallest eigen values to the value of the 70th eigenvalue.

1. Impact of using Desroziers **R** compared to Hollingsworth-Lönnberg **R**

Radiosonde temperature



Radiosonde humidity

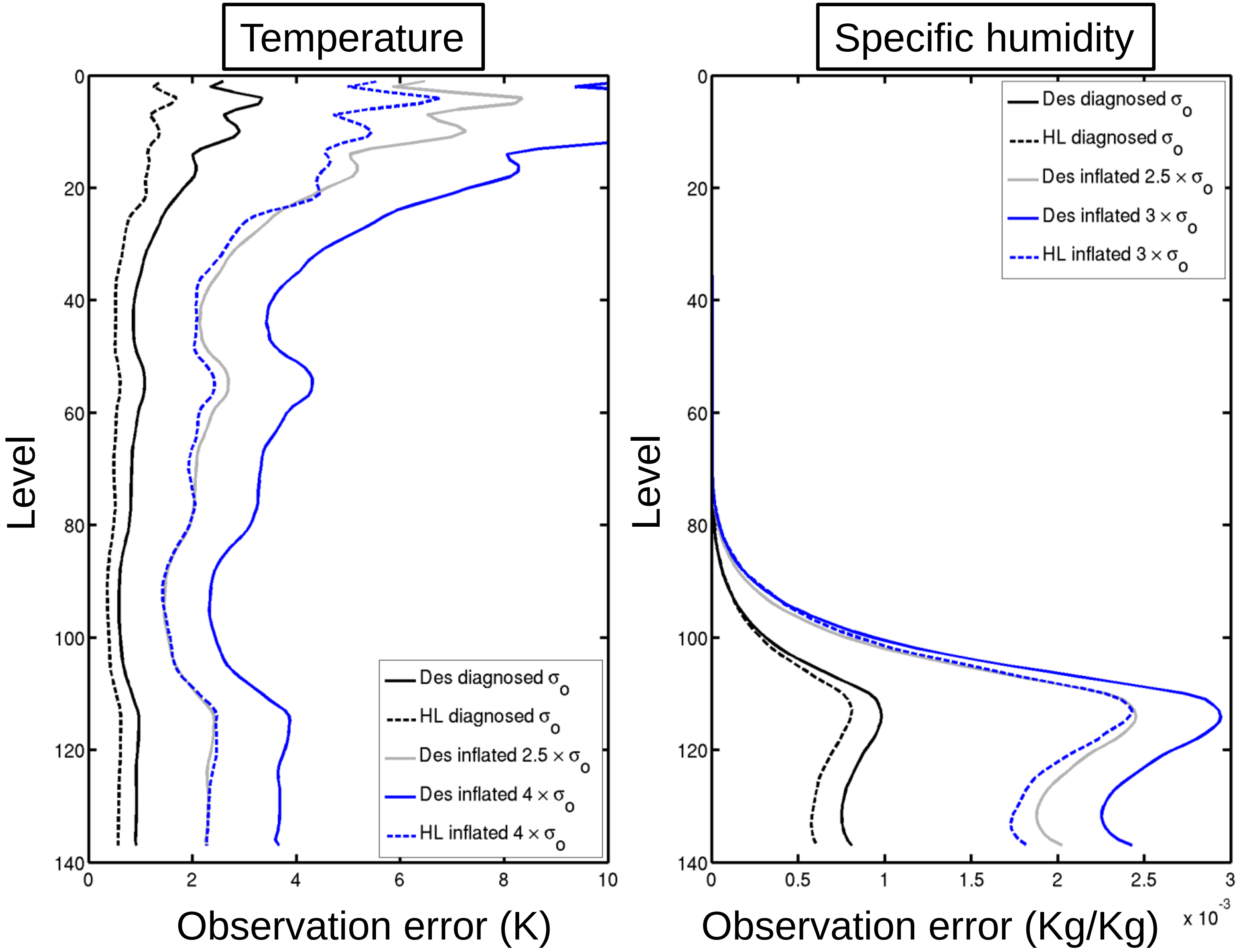


Some advantage from using Desroziers **R** for temperature at high levels.

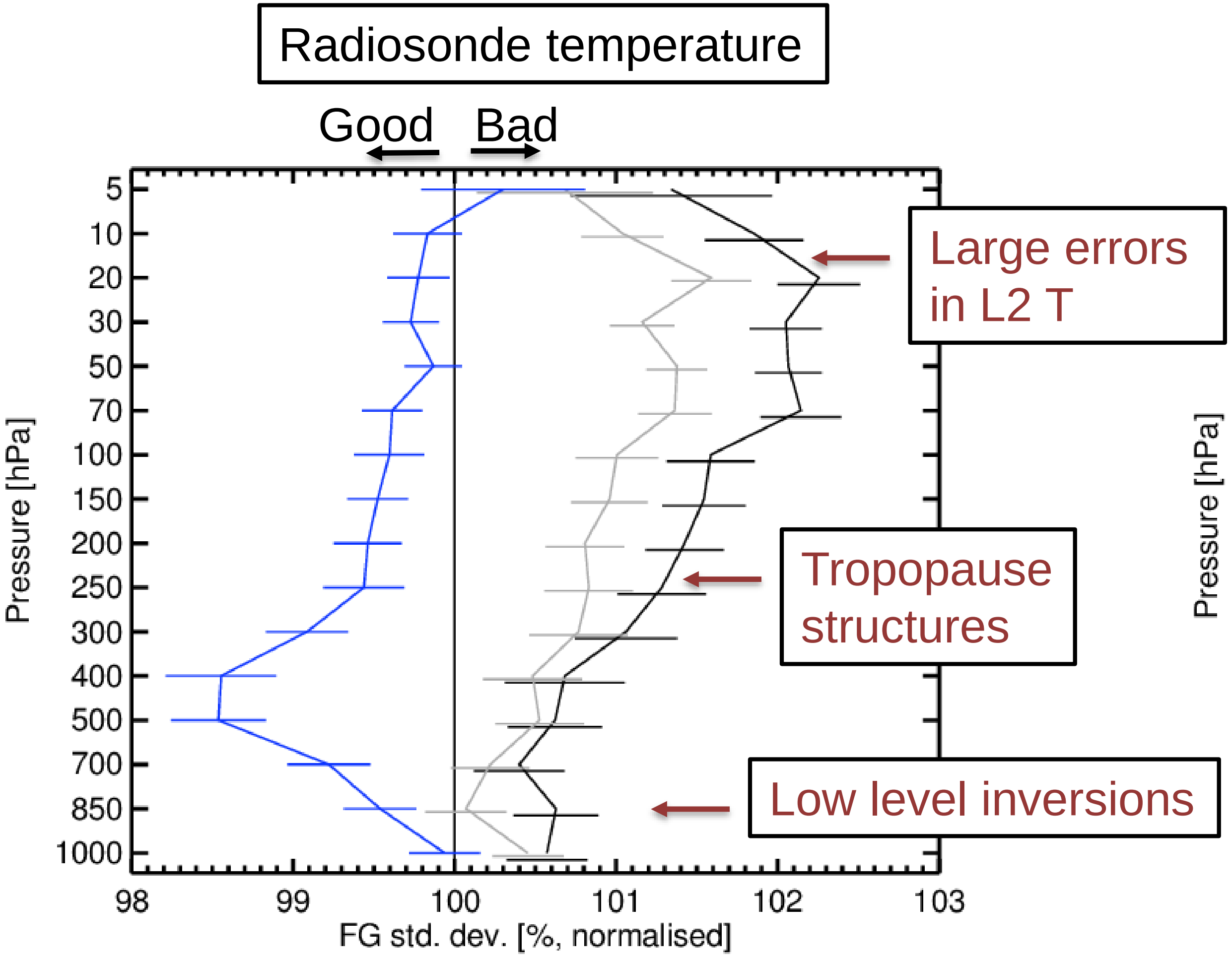
CTL (100%): Conv + AMSU-A
IASI: CTL + IASI radiances over sea
L2 HL: CTL + IASI L2 T and q with Hollingsworth-Lönnberg **R**
L2 Des: CTL + IASI L2 T and q with Desroziers **R**

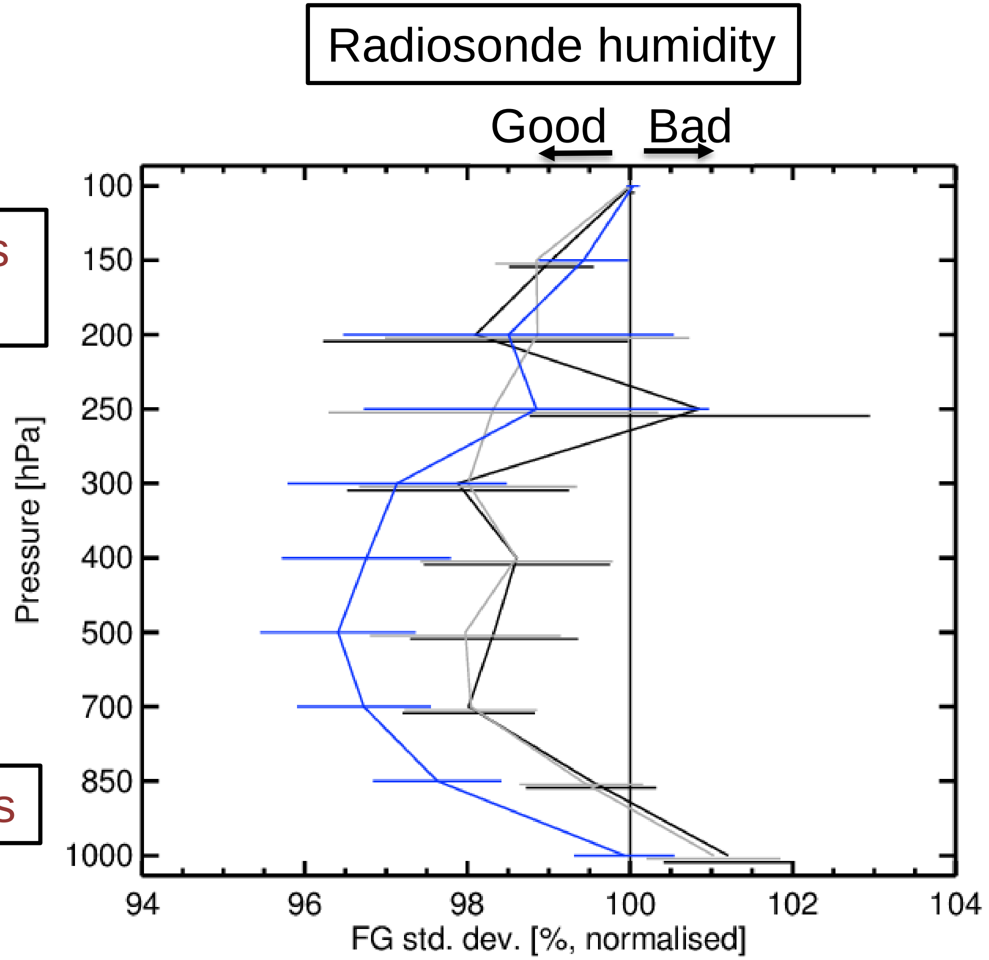
2. Inflating observation errors σ_o

- Observation errors diagnosed with Desroziers method are higher in magnitude than observation errors diagnosed with Hollingsworth-Lönnberg method.
- Inflation factors $4^*\sigma_{oT}$ and $3^*\sigma_{oq}$ have been used for observation errors in experiments using Hollingsworth-Lönnberg **R**.
- For Desroziers **R** experiments different inflation factors are tested.



2. Impact of using different inflation factors

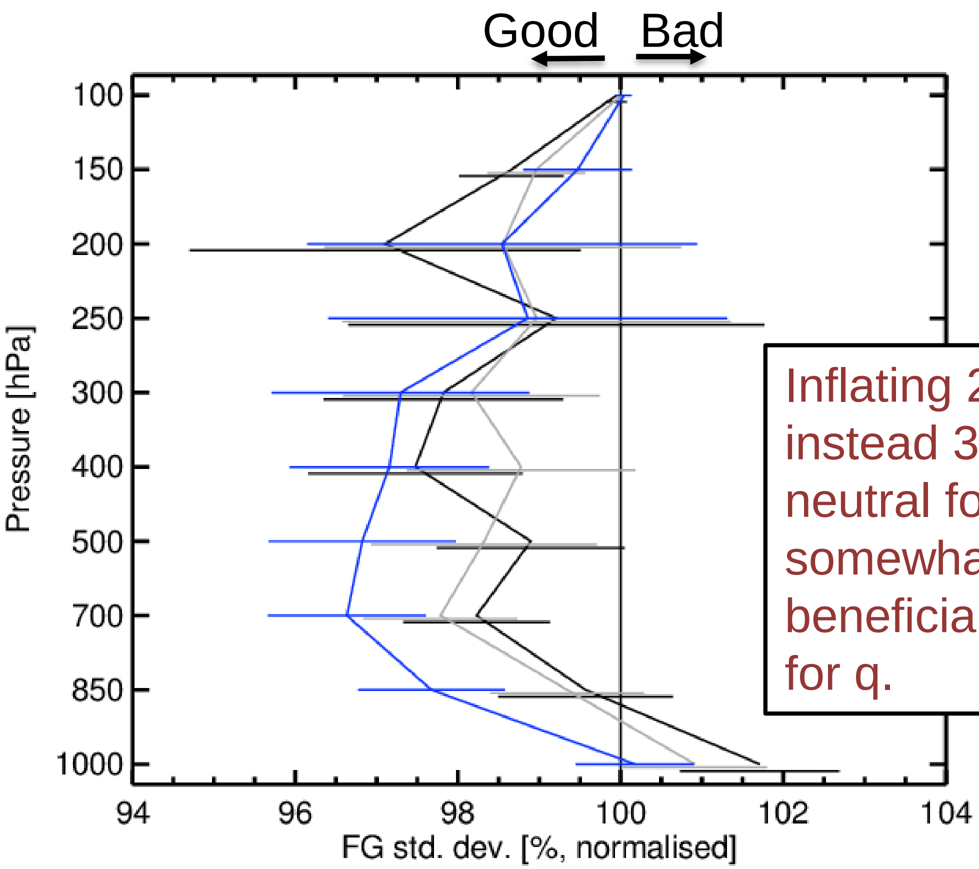




CTL (100%): Conv + AMSU-A
IASI: CTL + IASI radiances over sea
L2 Des1: CTL + IASI L2 Desroziers **R**, inflating factors $2.5^*\sigma_{oT}$ and $2.5^*\sigma_{oq}$
L2 Des2: CTL + IASI L2 Desroziers **R**, inflating factors $4^*\sigma_{oT}$ and $3^*\sigma_{oq}$

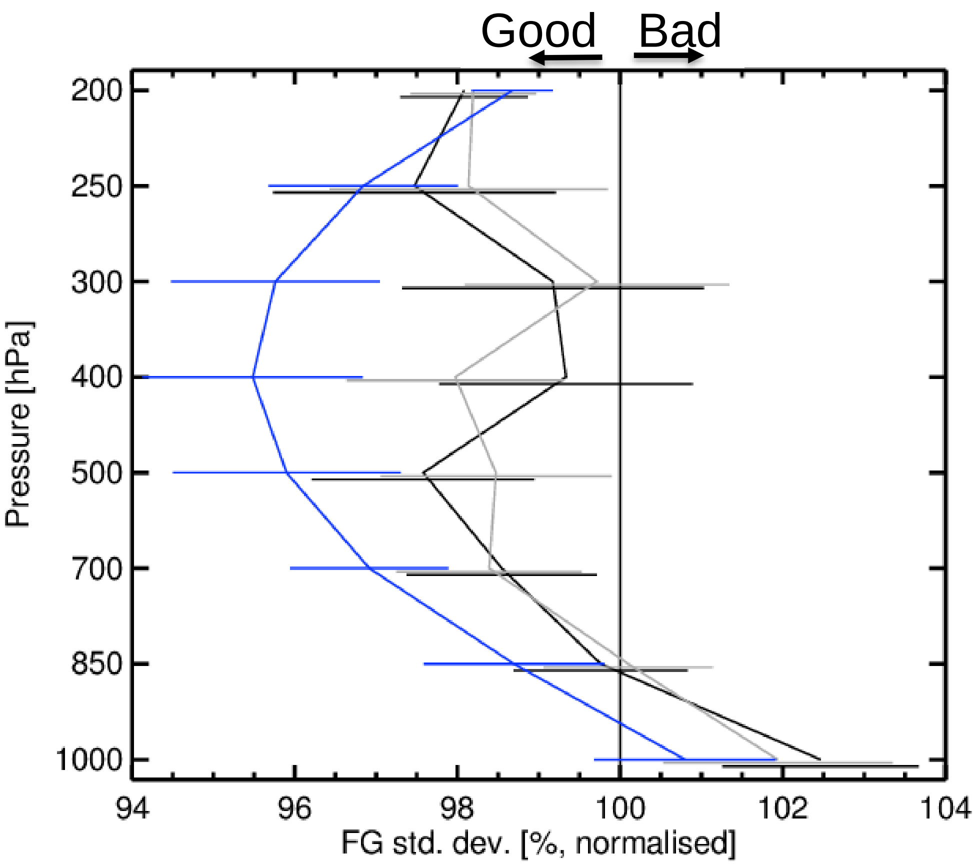
2. Impact of using different inflation factors

Radiosonde humidity



Inflating 2.5*σ_{oq} instead 3*σ_{oq} is neutral for T and somewhat beneficial for q.

Aircraft humidity

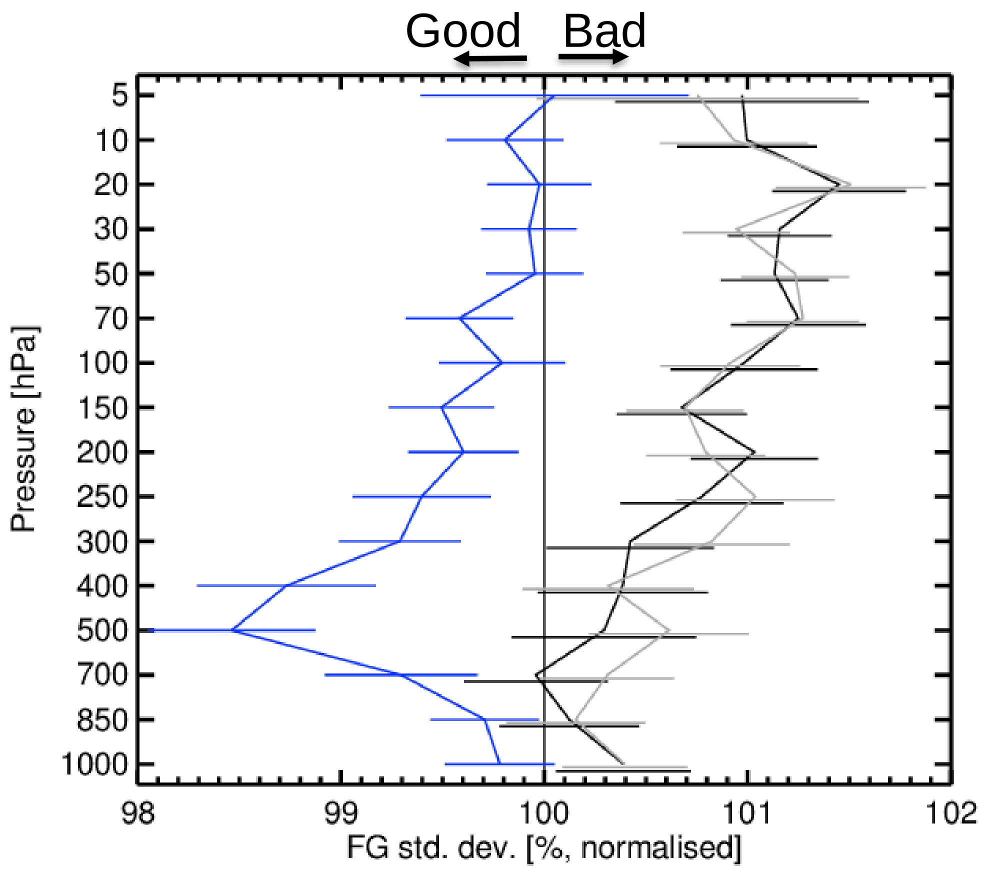


CTL (100%): Conv + AMSU-A
IASI: CTL + IASI radiances over sea
L2 Des1: CTL + IASI L2 Desroziers **R**, inflating factors 4*σ_{oT} and 2.5*σ_{oq}
L2 Des2: CTL + IASI L2 Desroziers **R**, inflating factors 4*σ_{oT} and 3*σ_{oq}

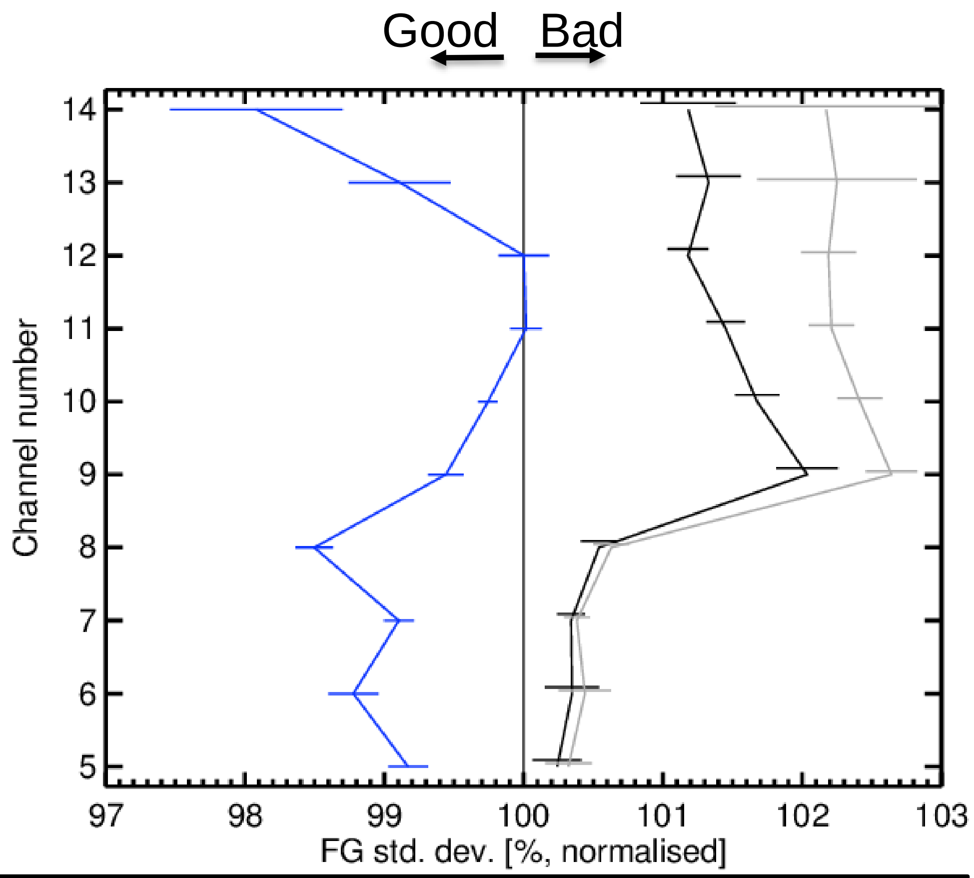
3. Impact of blacklisting data above level 40 (~30 hPa)

Blacklisting data above level 40 beneficial for satellite data.

Radiosonde temperature



AMSU-A



CTL (100%): Conv + AMSU-A
IASI: CTL + IASI radiances over sea
L2 Des1: CTL + IASI L2 T and q with Desroziers **R**, data above level 40 blacklisted
L2 Des2: CTL + IASI L2 T and q with Desroziers **R**, all levels active

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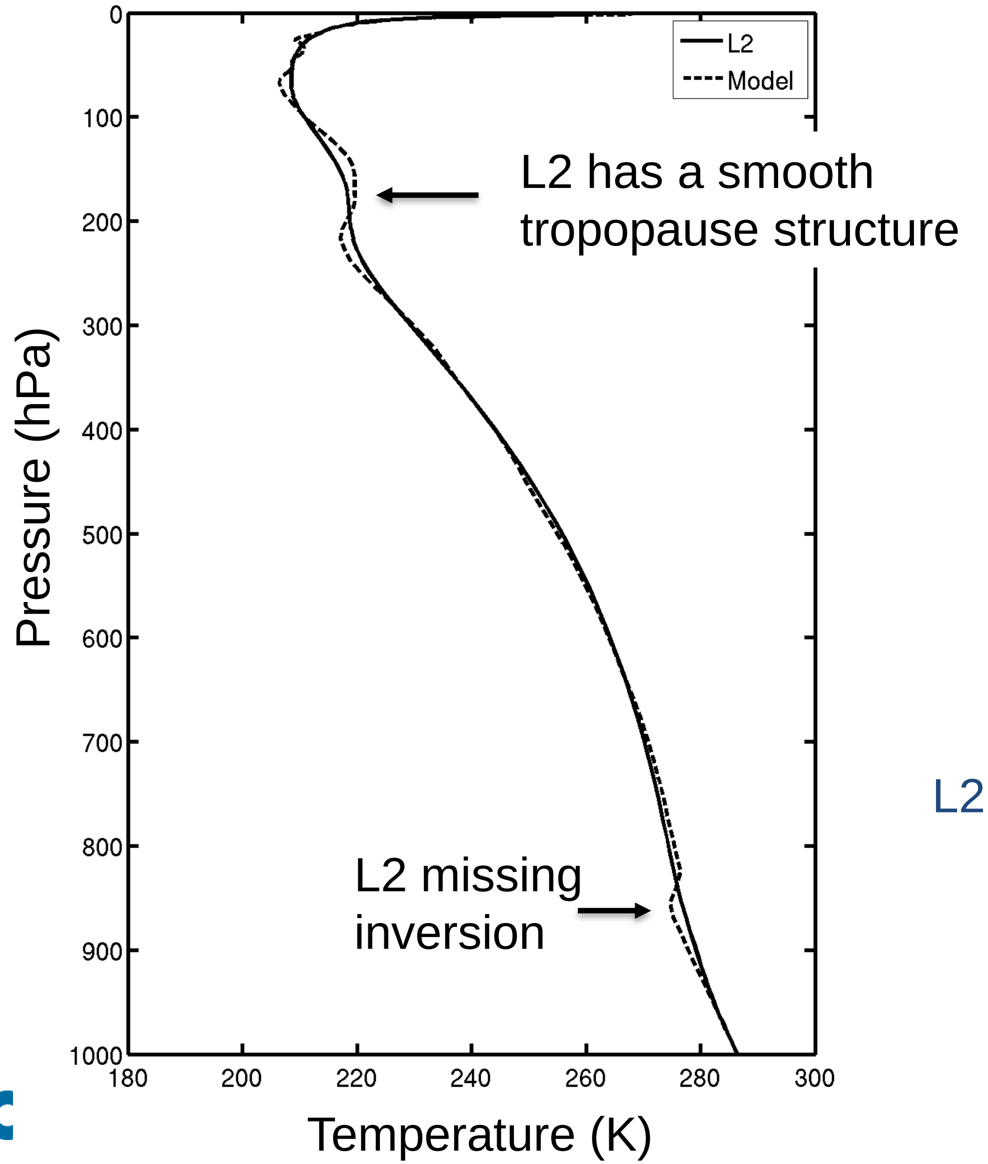
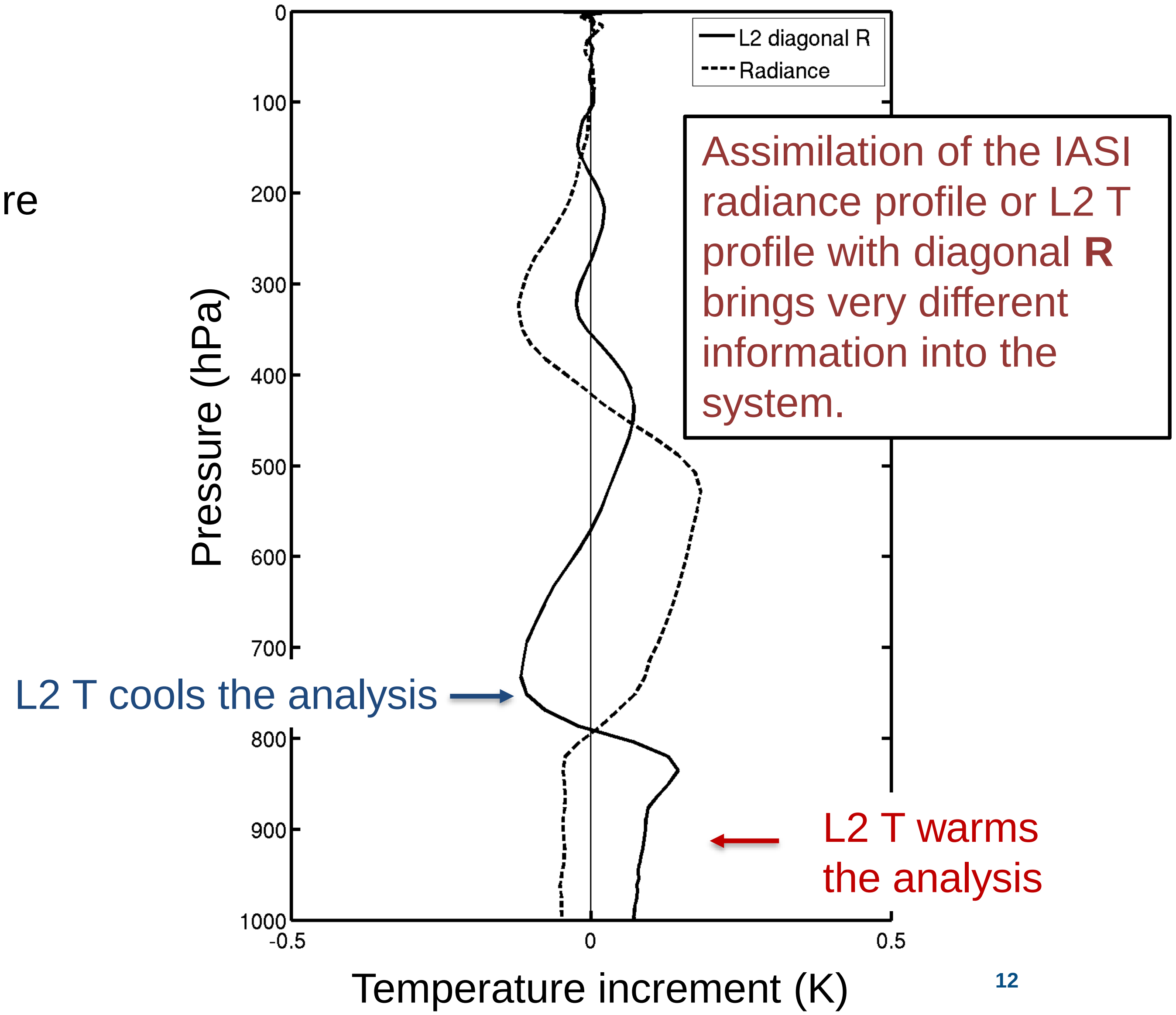
4. Single observation experiment (case 1 from October progress report presentation)

- 1.1.2017, 12.38 UTC
- 39.26 N, 33.41 W
- All IASI channels are cloud free according to ECMWF cloud detection scheme
- OmC = 0.36
- $QI_T = 0.75$

4. Analysis increments, diagonal **R**, $4^*\sigma_{oT}$

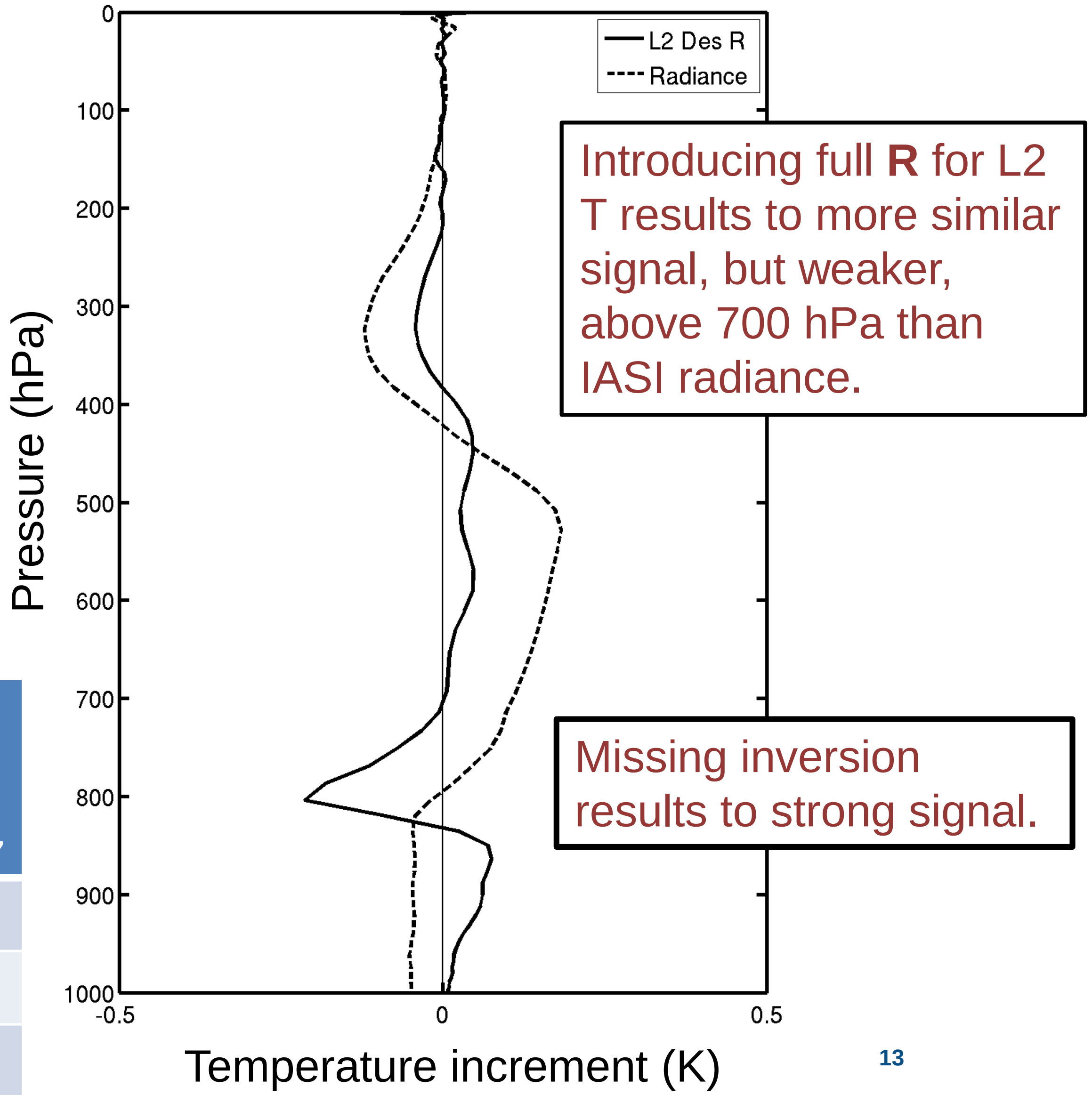




4. Analysis increments, full Desroziers **R**, $4^*\sigma_{oT}$

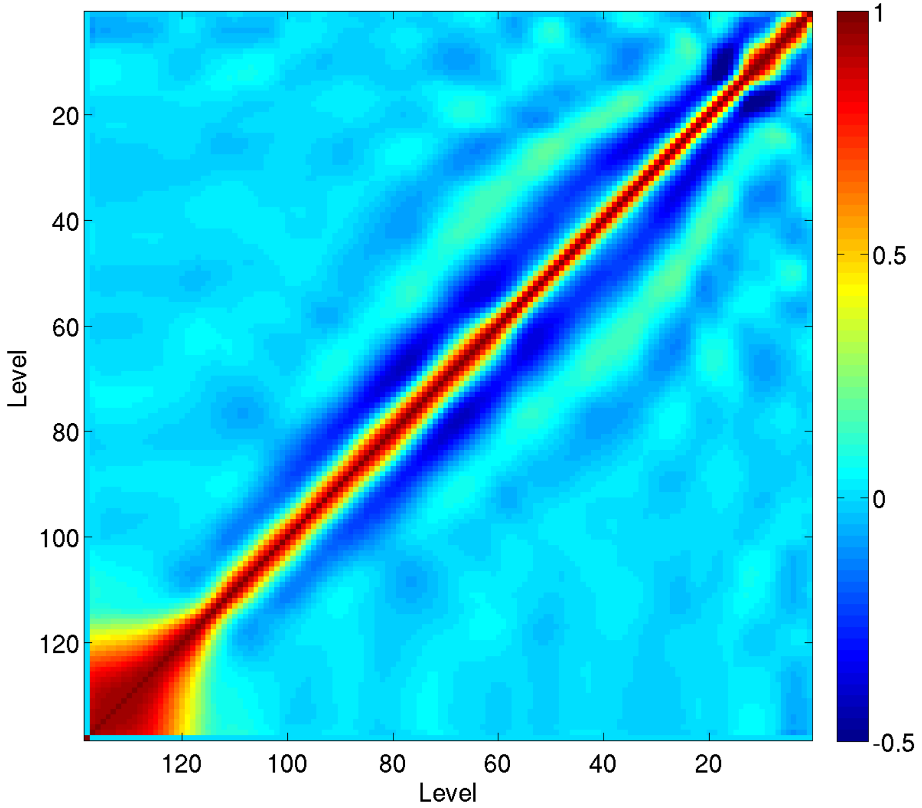
- Model is capturing the low level inversions much more frequently than L2.
- L2 inversions are smooth, and on average found from higher altitudes than the model inversions.
- Missing inversion results to strong signal in the analysis increment despite inflated σ_{oT}.

	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

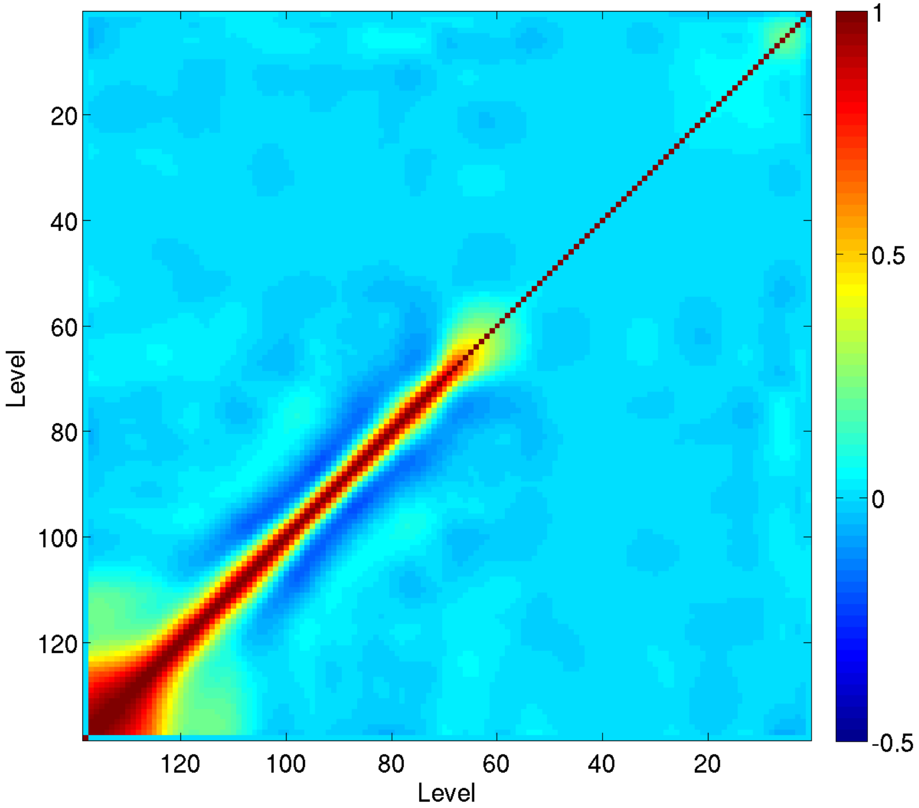


5. Global Desroziers **R** reconditioned with the eigen value method

IASI L2 temperature

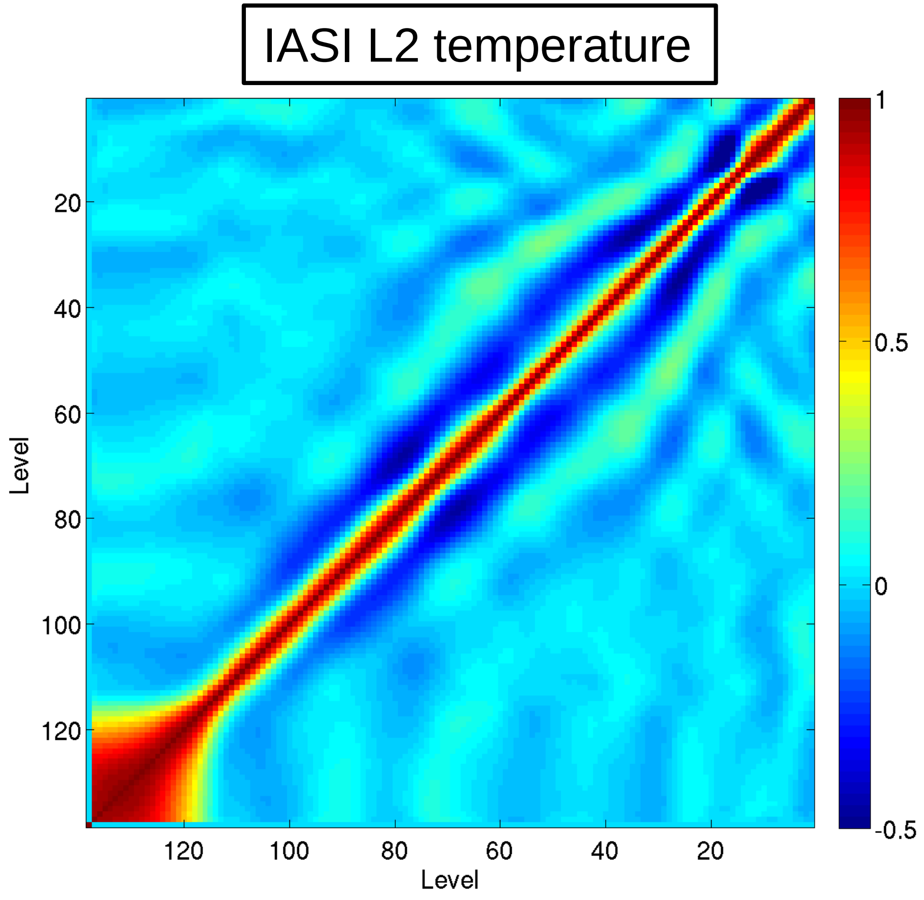


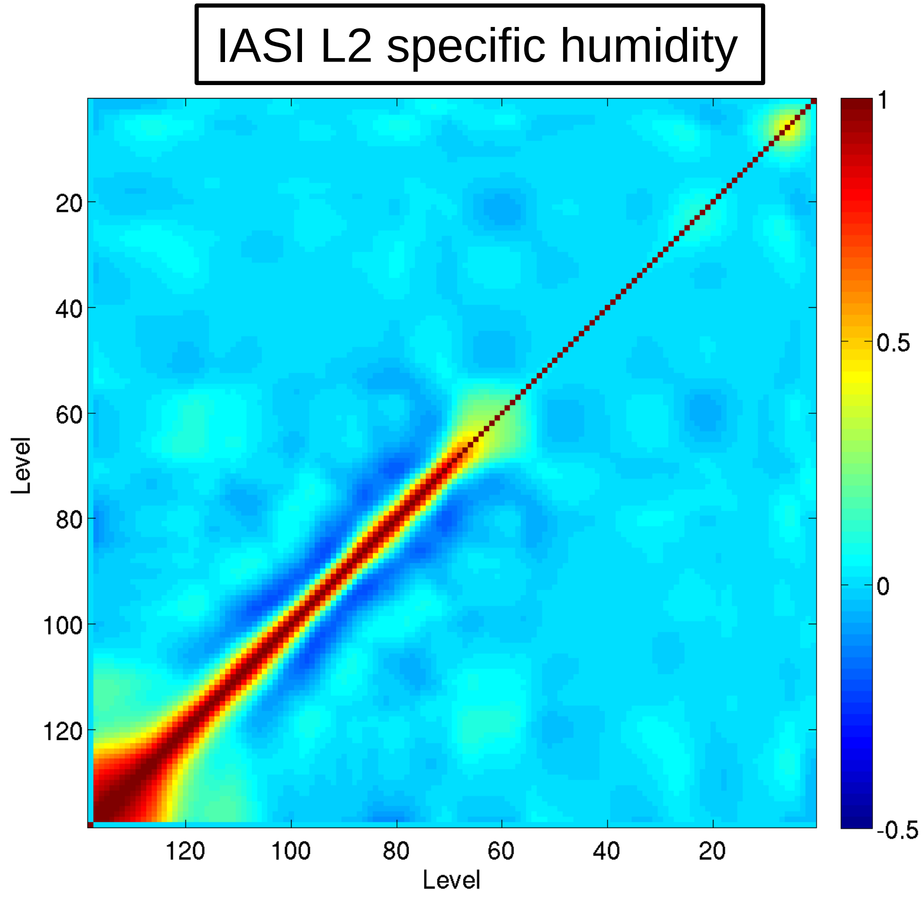
IASI L2 specific humidity



Global **R** is a rough generalisation of the error structures

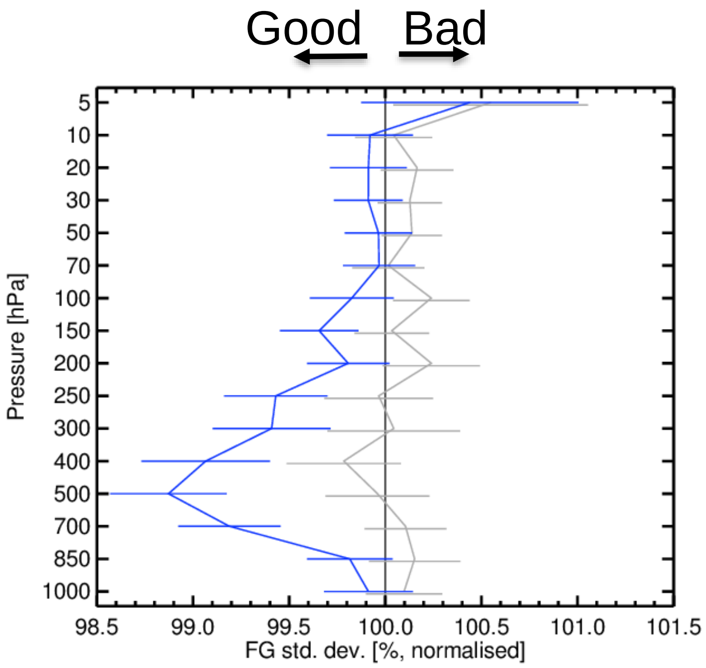
5. NH midlatitudes (20-60N) reconditioned Desroziers **R**



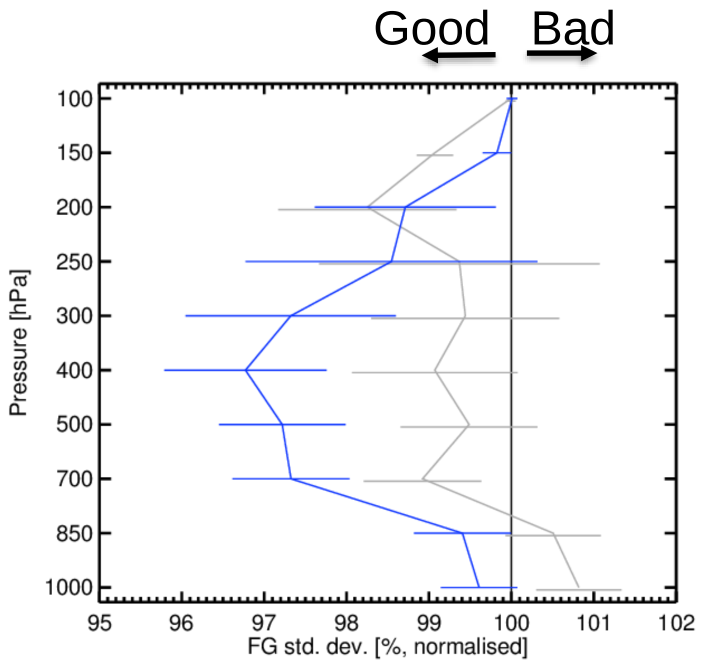


5. IASI radiances and L2 active only 20-60N

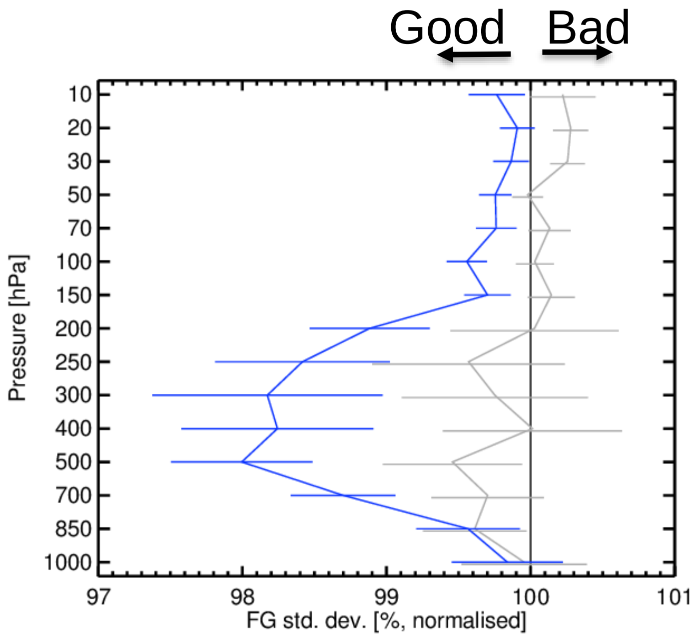
Radiosonde temperature



Radiosonde humidity



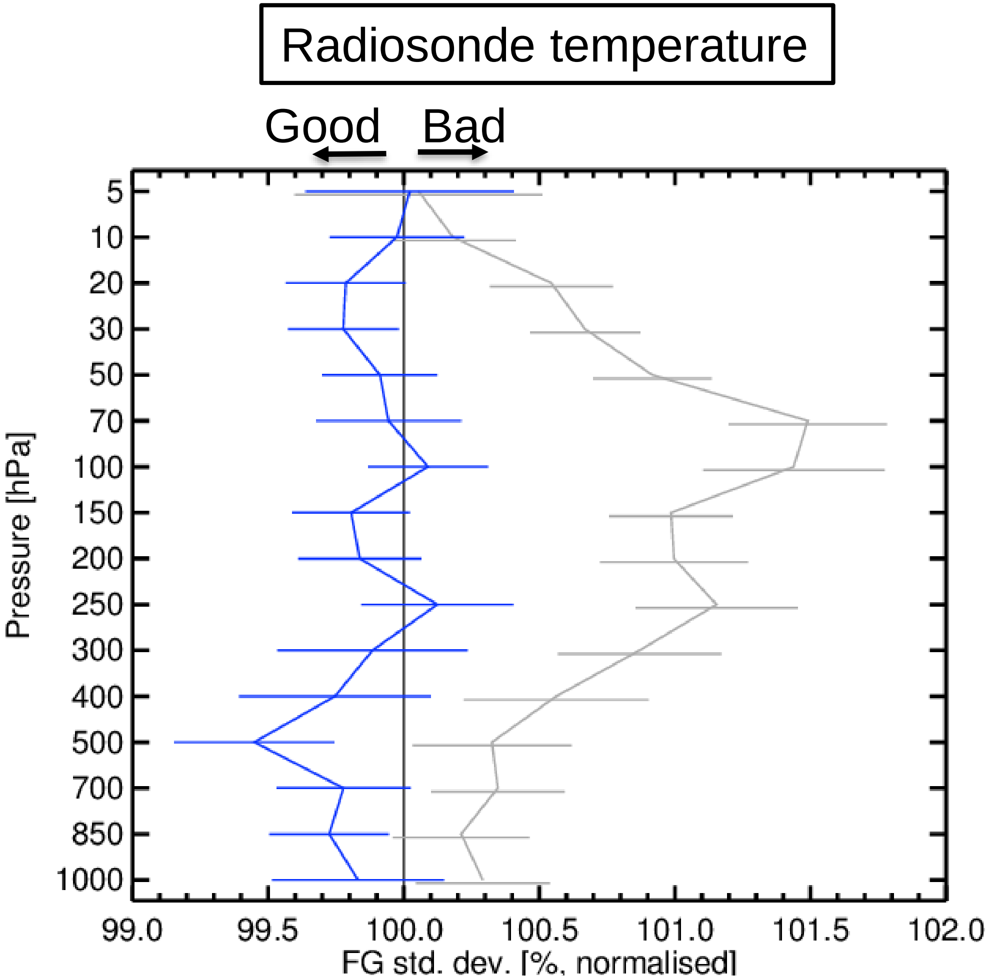
Conventional wind

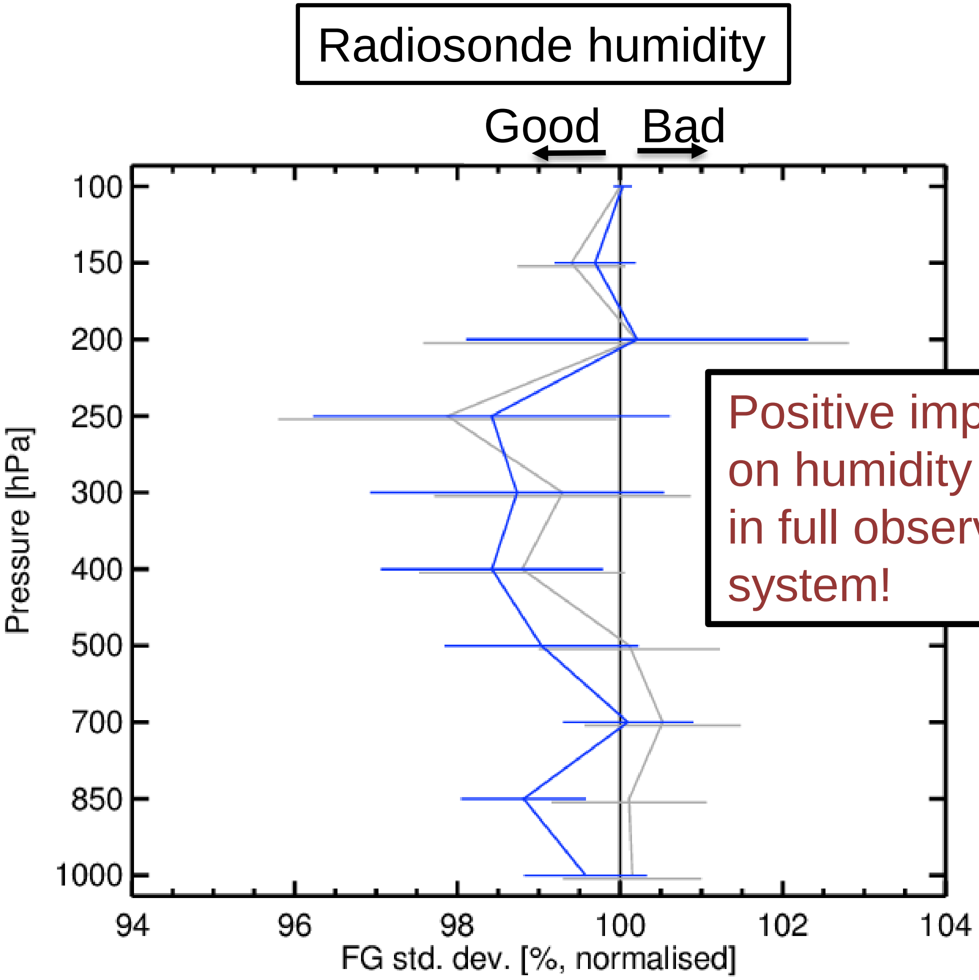


Using more ‘local’ **R** is beneficial

CTL (100%): Conv + AMSU-A
IASI: CTL + IASI radiances over sea NH midlatitudes only
L2 Des: CTL + IASI L2 T and q with Desroziers **R**, inflating factors $4*\sigma_{oT}$ and $3*\sigma_{oq}$ NH midlatitudes only (inflation factor for humidity could be smaller)

Experiments in full observing system (HL **R**, data blacklisted above level 40)





Positive impact on humidity even in full observing system!

CTL (100%): Full observing system without IASI

IASI: CTL + IASI radiances over sea

L2 Des: CTL + IASI L2 T and q over sea with HL **R**, inflating factors 4*σ_{oT} and 3*σ_{oq}, Data above level 40 blacklisted

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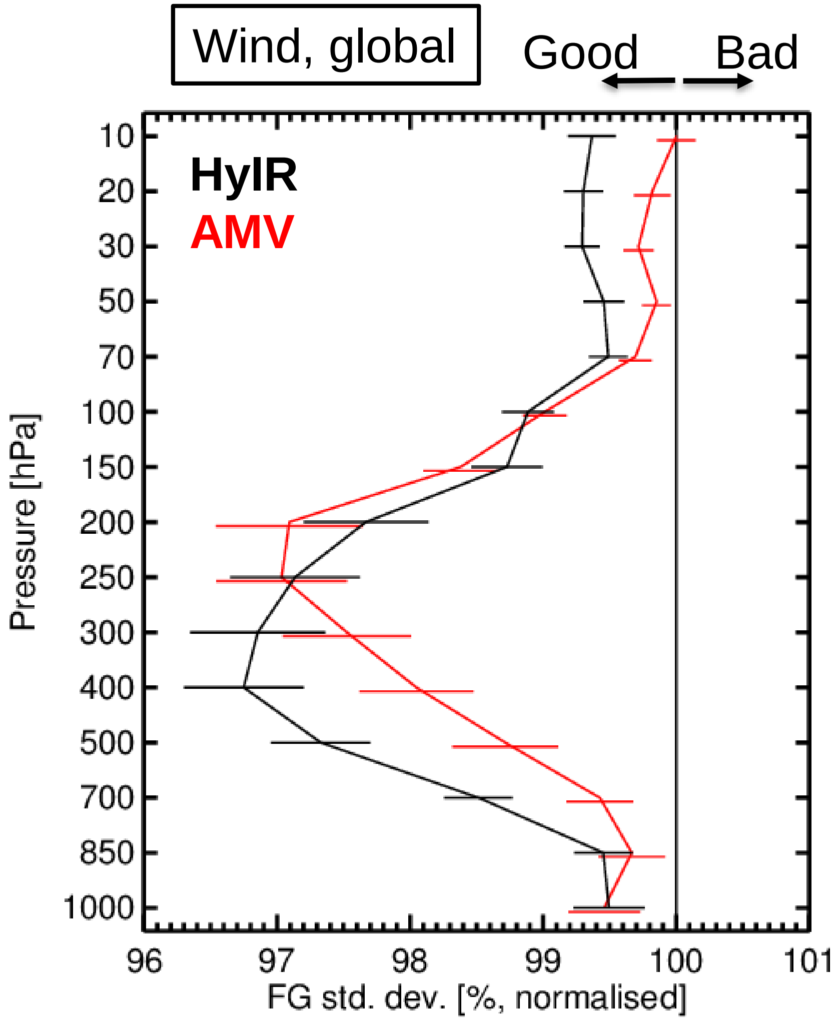
Conclusions from the data assimilation experiments so far

- Assimilation experiments indicate negative impact for temperature
  - Information about missing/smooth low level inversions and smooth tropopause structures spreads widely in vertical if diagonal **R** is used.
  - Using full **R** is important but observation errors require still strong inflation. Thus, the weight given to observations on altitudes without problems is modest but for example missing inversion results still in strong (unrealistic) analysis increment.
  - Global **R** is a very rough estimation, in reality the errors are strongly situation and location dependent.
  - Improving the L2 product to have better representation of the vertical structures would be beneficial.

- Encouraging results for humidity, also in full observing system
  - Indication of positive impact in all experiments so far.
  - Moderate inflation of the observation errors.
  - So far only clear sky data has been investigated. For wind tracing, cloud affected data would be interesting. Expected complex and very situation dependent error characteristics.

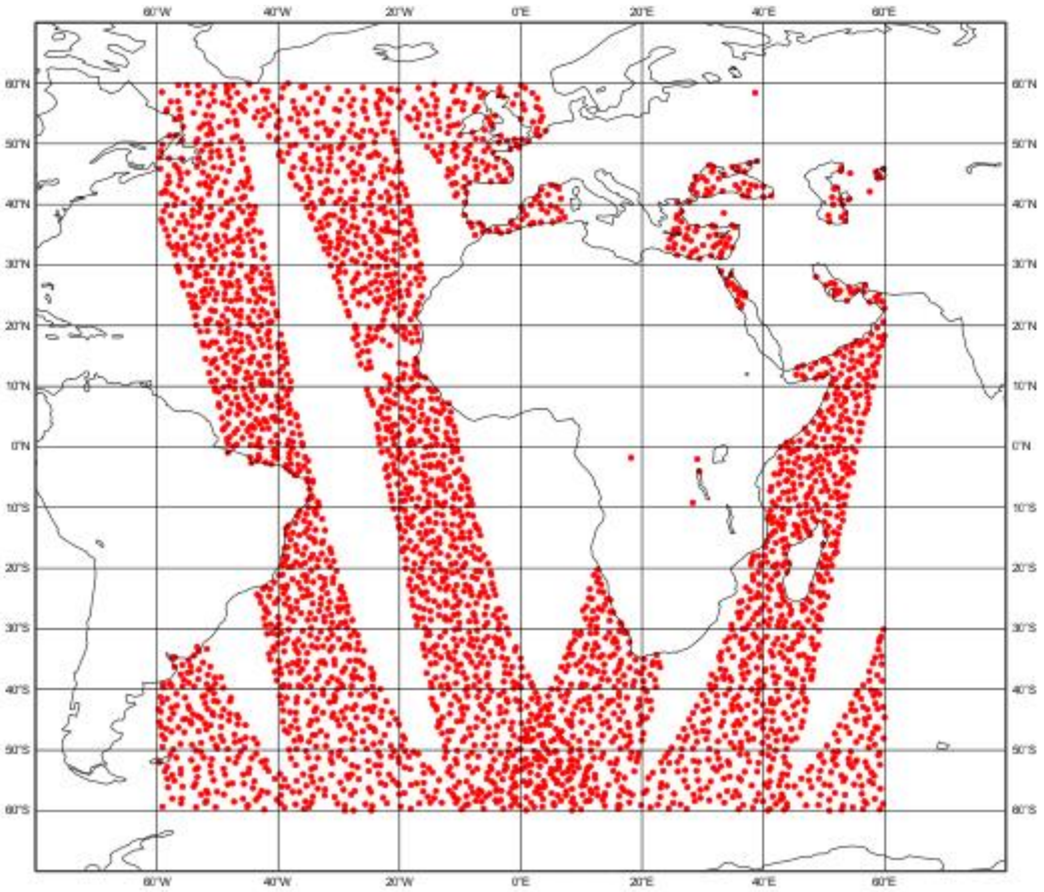
Future MTG-IRS impact on wind is expected to be very significant

- Radiance information from the current hyperspectral sounders provide comparable or even more information on wind than the AMVs.
- Majority of this wind information comes from wind tracing in 4D-Var, i.e tracing the movement of the humidity structures in the radiance data.
- MTG-IRS is expected to provide even bigger wind impact wind with its rapid time sampling.

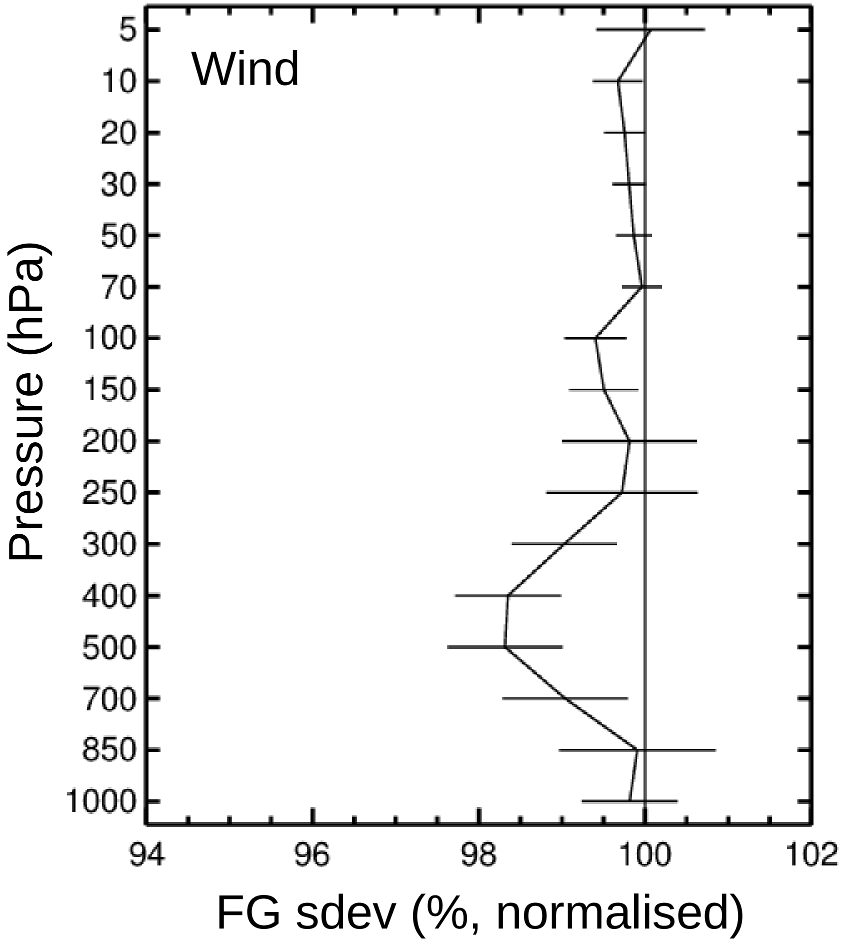


Wind impact improves with better time and spatial sampling

CTL: Conv + AMSU-A
EXP: CTL + Metop-A IASI

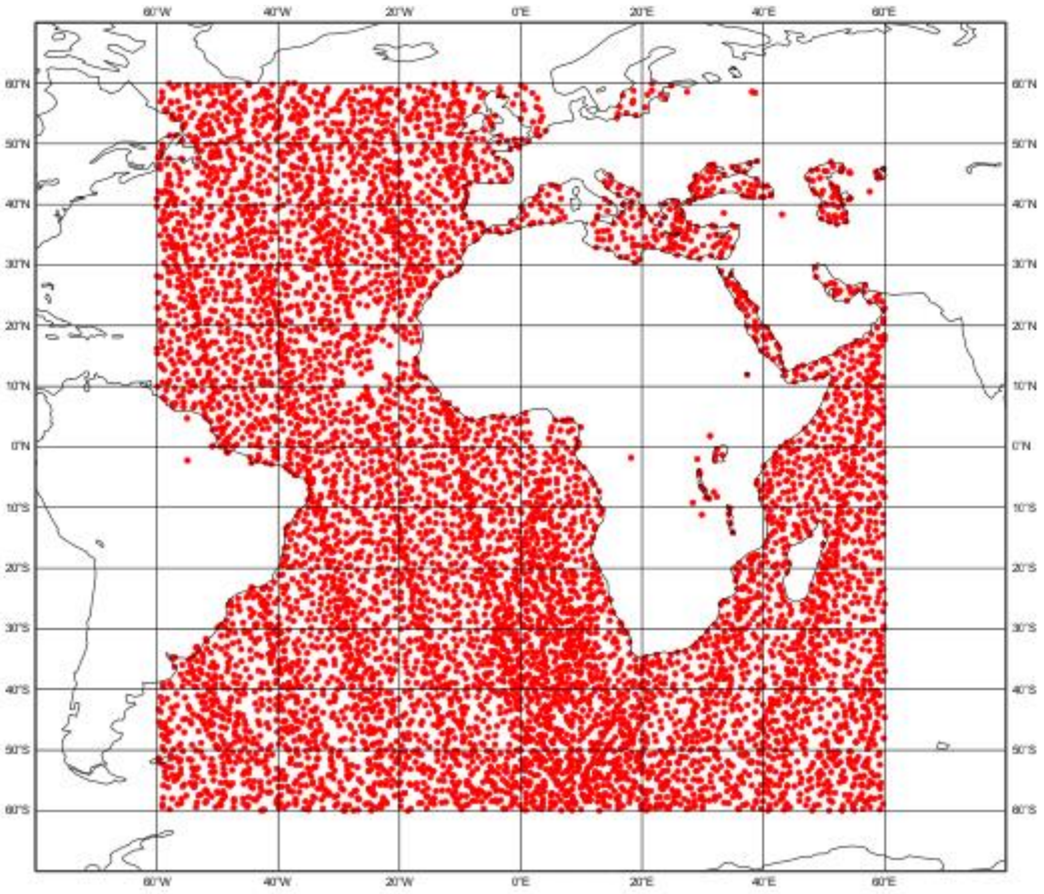


Metop-A



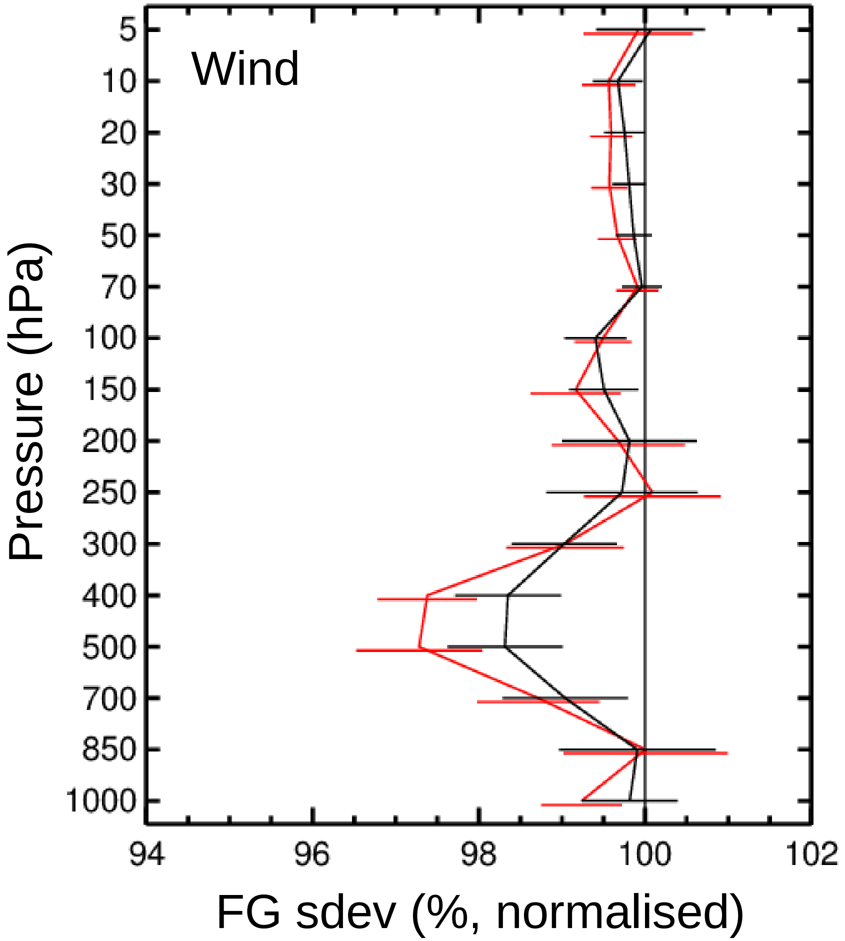
Verification over Meteosat-11 disc

Wind impact improves with better time and spatial sampling



Metop-A Metop-B

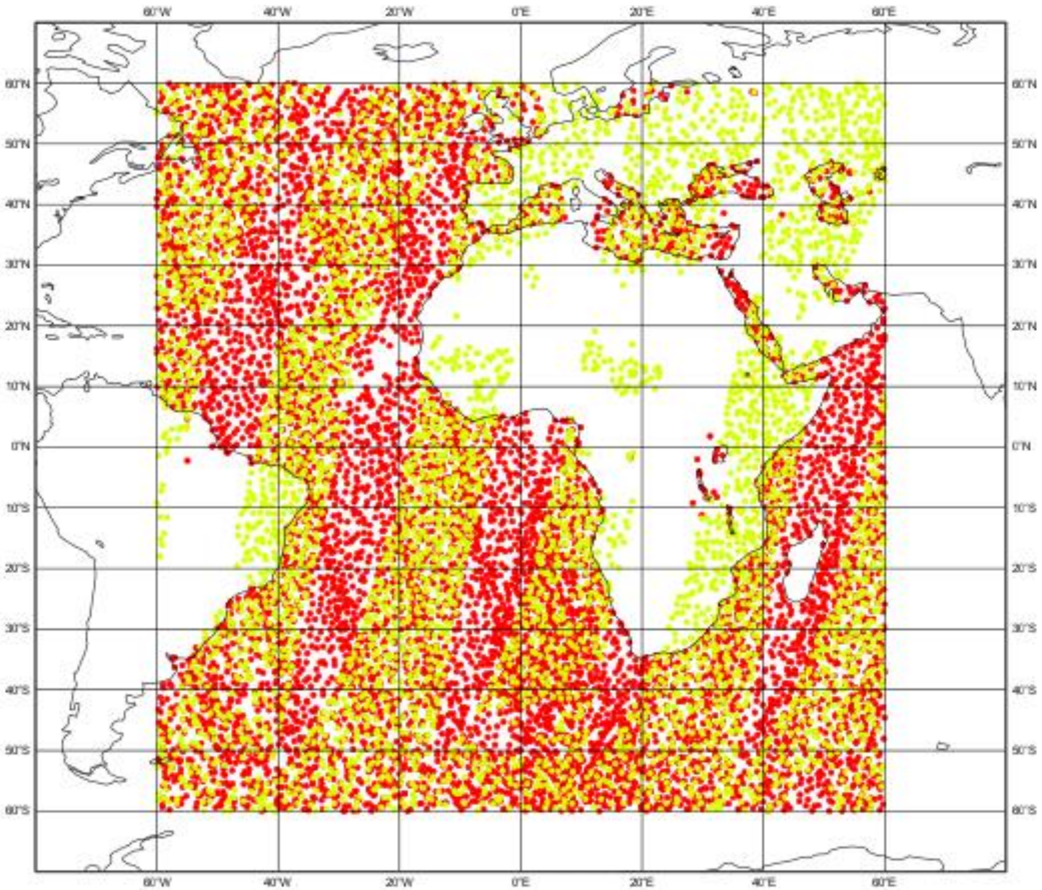
CTL: Conv + AMSU-A
EXP: CTL + 2 IASI



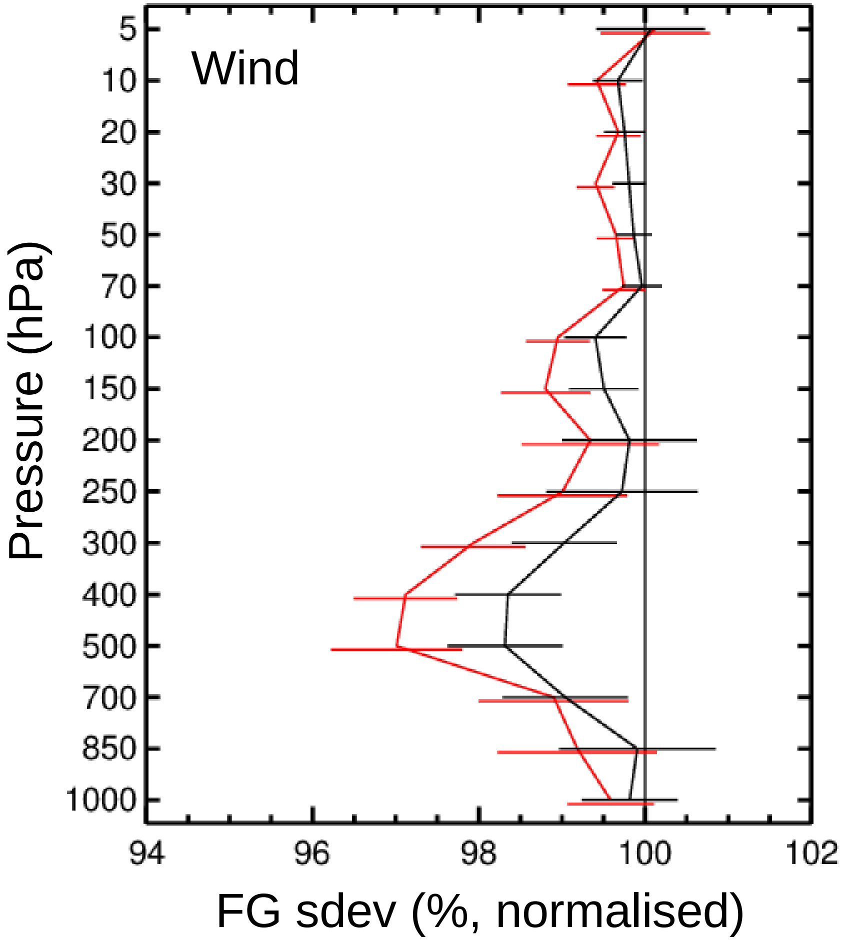
Verification over Meteosat-11 disc

Wind impact improves with better time and spatial sampling

CTL: Conv + AMSU-A
EXP: CTL + 2 IASI + CrIS



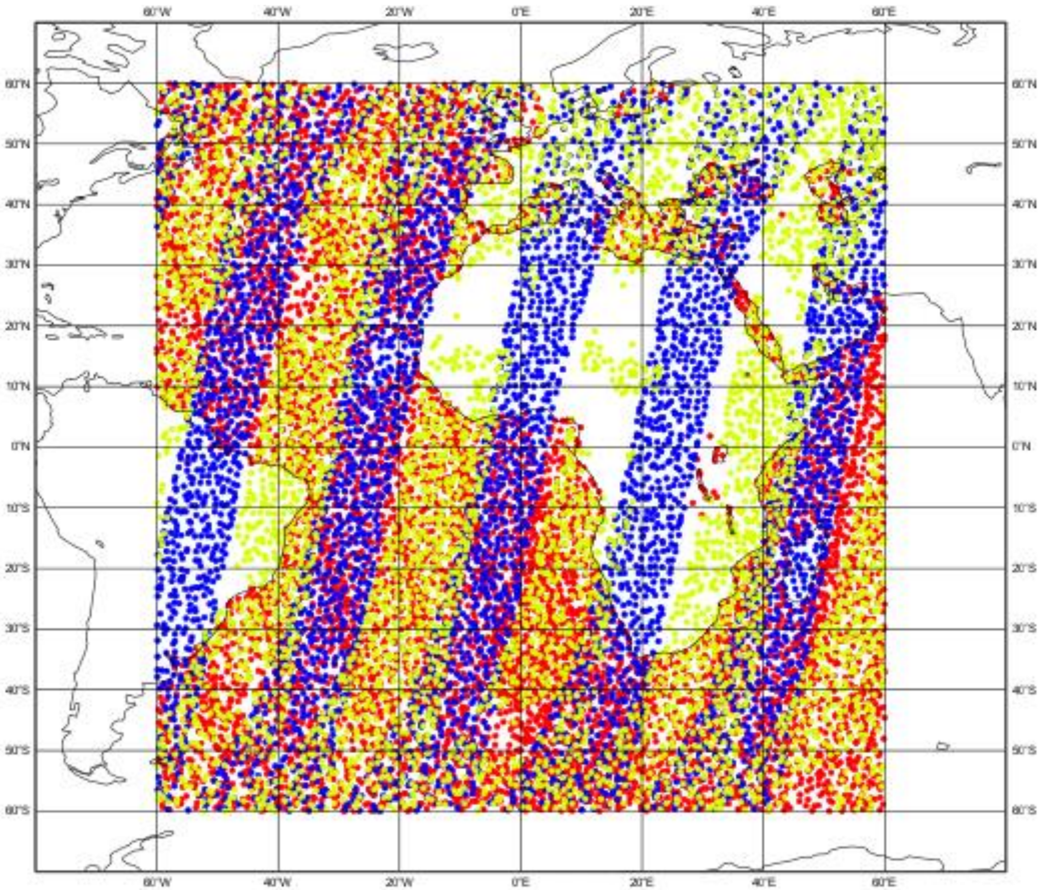
Metop-A Metop-B CrIS



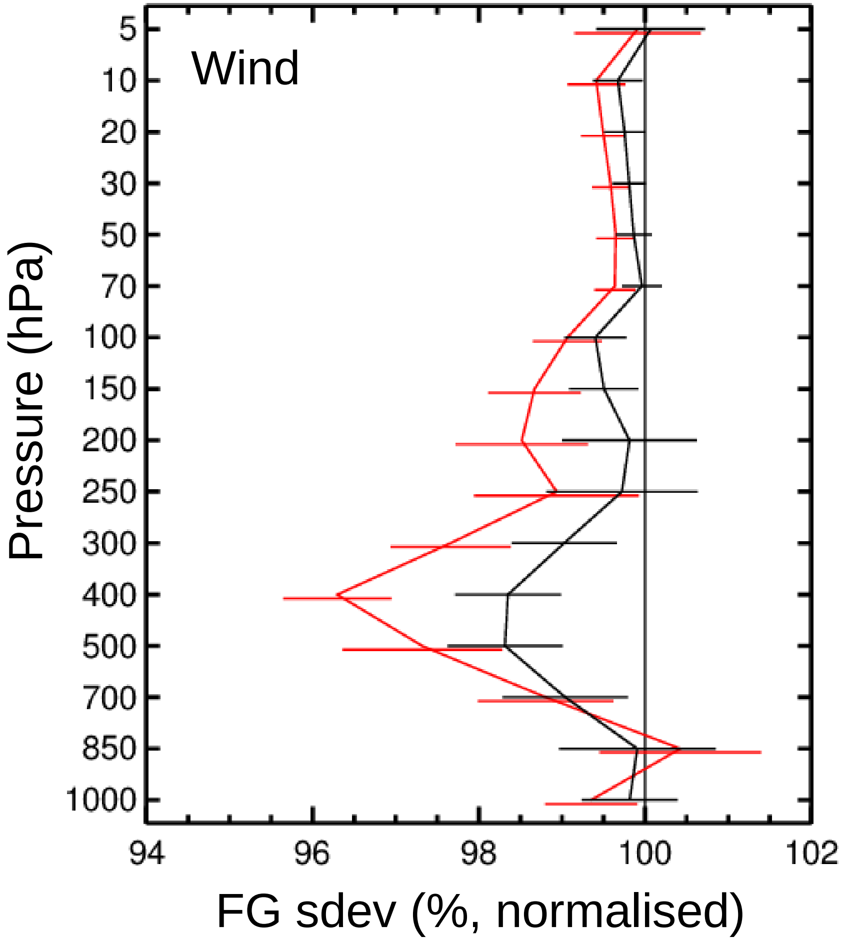
Verification over Meteosat-11 disc

Wind impact improves with better time and spatial sampling

CTL: Conv + AMSU-A
EXP: CTL + 2 IASI + CrIS + AIRS



Metop-A Metop-B CrIS AIRS



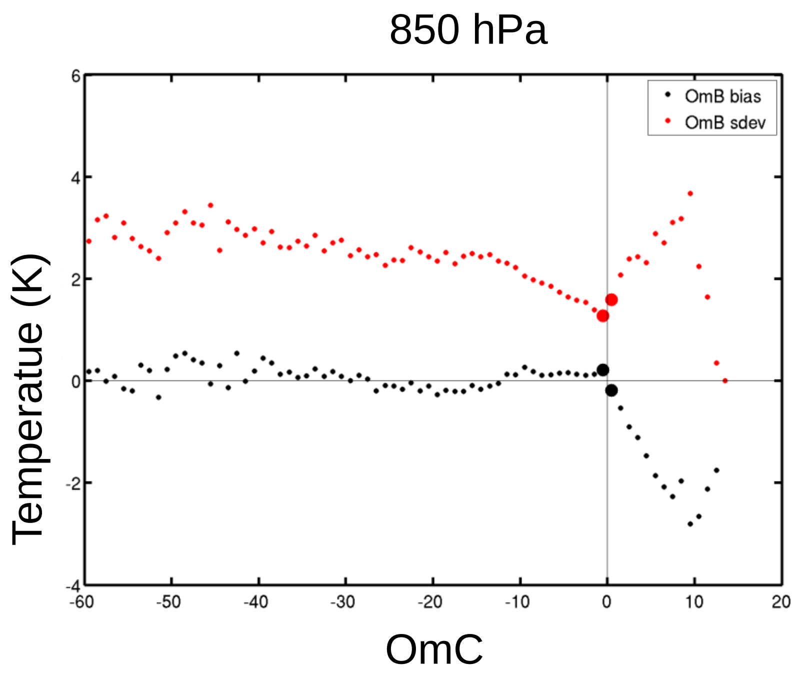
Verification over Meteosat-11 disc

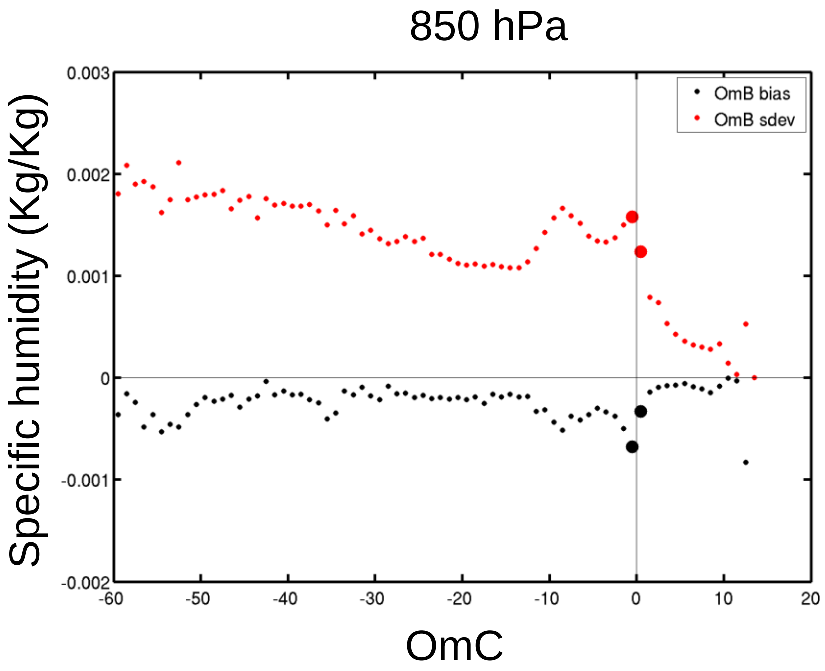
How this information can enter NWP systems

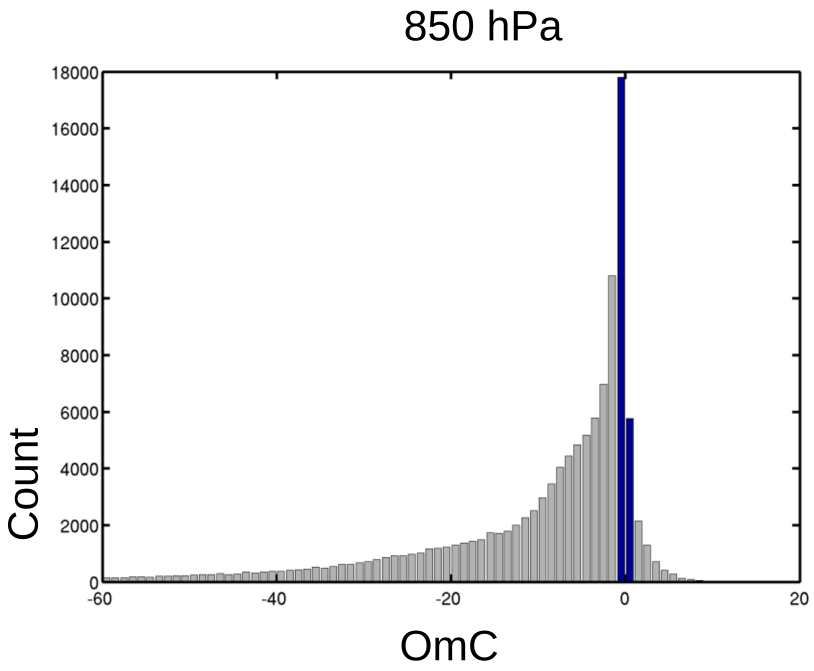
1. Direct assimilation of humidity sensitive radiances in 4D-Var
2. L2 humidity assimilation in 4D-Var
3. Assimilation of L2 humidity/o_3 based 3D winds

L2 error characteristics

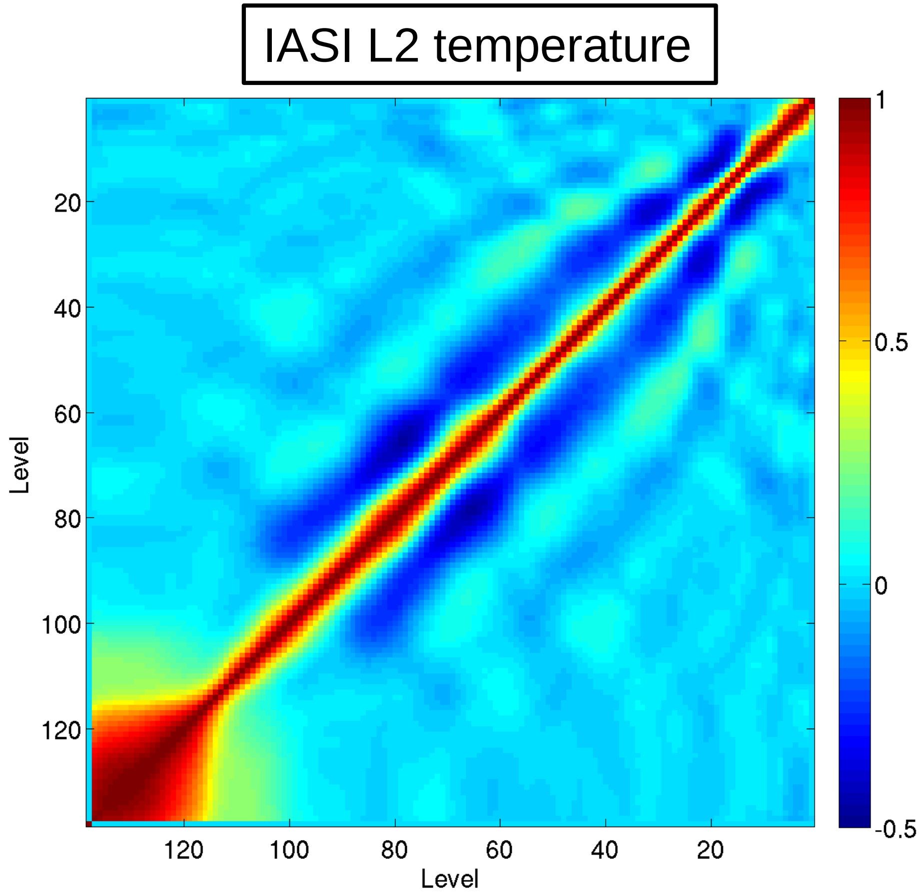
- In the L2 assimilation experiments only “best of the best” clear sky data is used, |OmC| < 1. This represents a very small fraction of the available data (large dots, blue bars in the figures below).
- Errors are highly situation dependent and grow rapidly for cloudy data.
- Error characteristics need to be understood and if possible improved to get most out of the data.

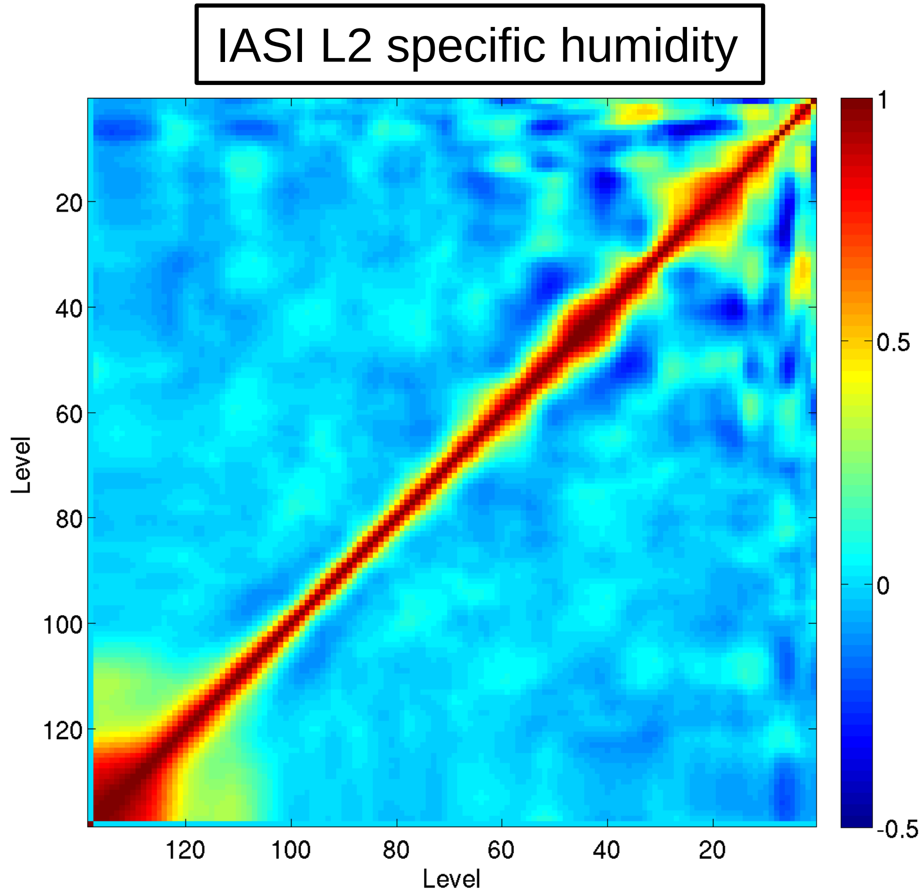




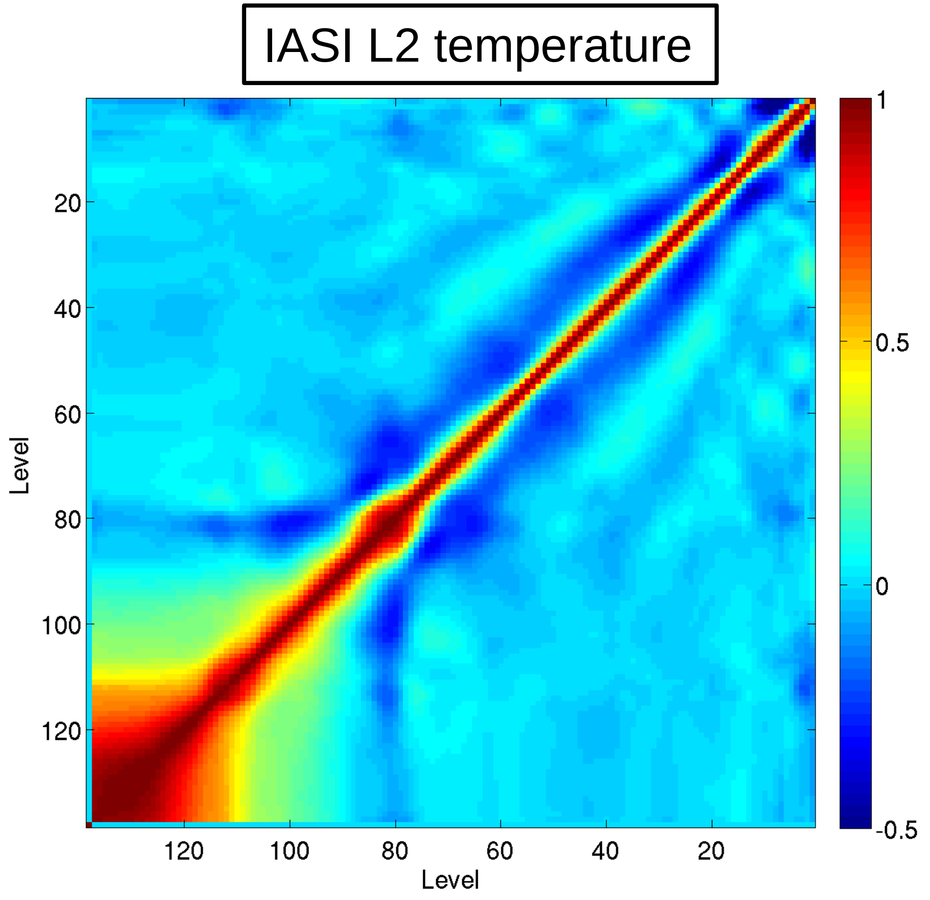


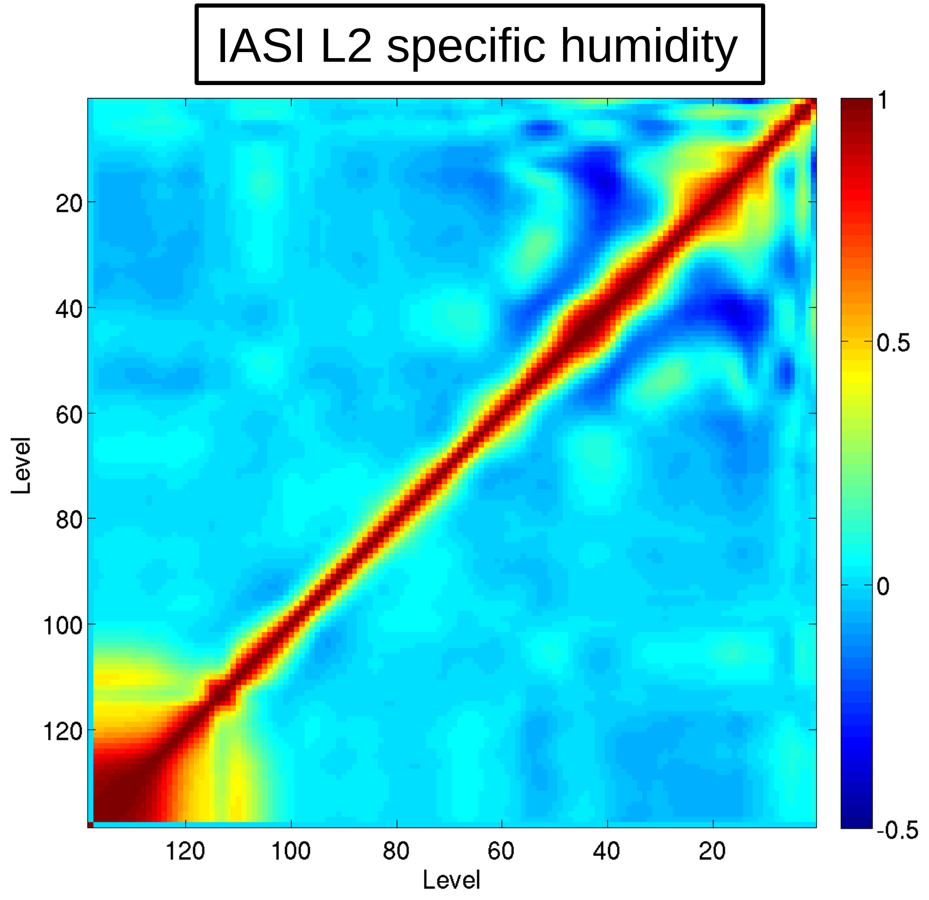
Global Hollingsworth-Lönnberg **R**, |OmC| < 1





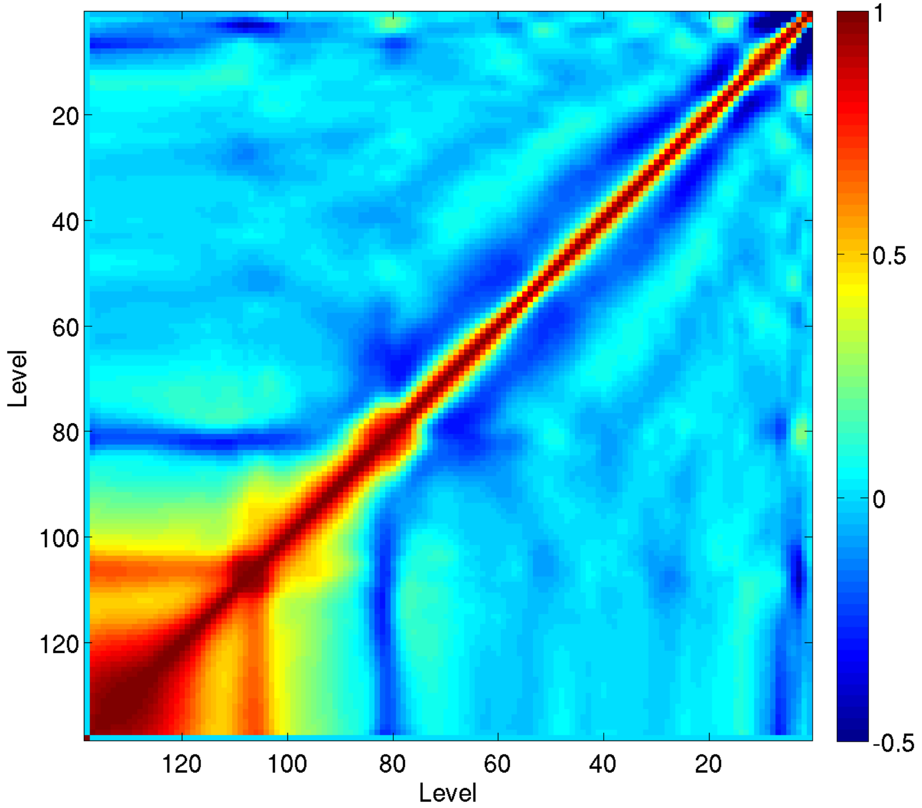
Global Hollingsworth-Lönnberg **R**, -15 < OmC < -10



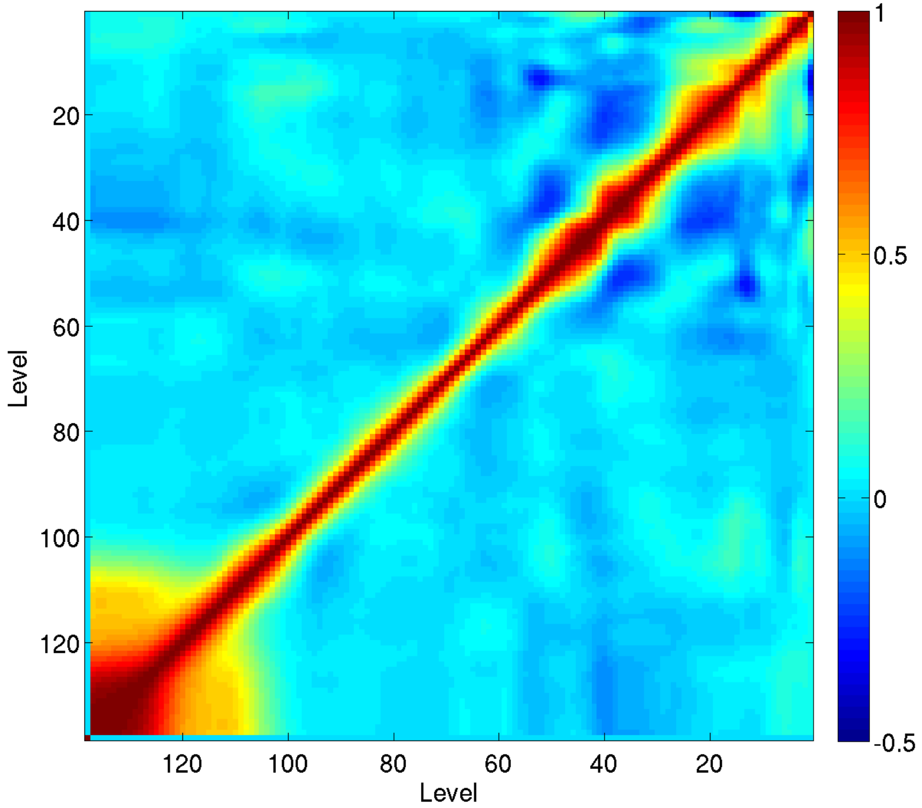


Global Hollingsworth-Lönnberg **R**, -25 < OmC < -20

IASI L2 temperature



IASI L2 specific humidity



Error correlations become increasingly stronger for cloudy data