Spatial and inter-channel observation error characteristics for AMSU-A and IASI and applications in the ECMWF system

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Outline

1) **Estimation of observation errors**
   - **AMSU-A**
   - **IASI**
2) **Applications in 4DVAR**
3) **Summary**

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Background

- **Current observation errors (O+F) for radiances are specified largely in an ad-hoc way, loosely based on FG-departures and other considerations.**

- **Any error correlations are neglected (spatial/inter-channel).**

- **Likely sources of error correlations:**

    ♦ **Radiative transfer (spectroscopy, assumed gas concentrations,…)**

    ♦ **Representativeness**

    ♦ **Instrument design; calibration practices; etc**

    ♦ **Quality control**

- **Thinning/error inflation is used to reduce the impact of spatial error correlations; choices largely based on intuition.**

- **Observation error correlations could be accounted for in the assimilation.**

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Methods

- **Estimating observation errors is not straightforward.**

- **Estimation methods rely on a range of (questionable) assumptions or have other problems.**

- **Use three methods, based on bias-corrected assimilated FG/AN-departures:**

  ♦ **Hollingsworth/Lönnberg (Hollingsworth & Lönnberg 1986)**

  ♦ **"Background error method"**

  ♦ **Desroziers diagnostic (Desroziers et al. 2005)**

- **Used for ATOVS instruments, AIRS, and IASI; see Bormann and Bauer (2010) and Bormann et al. (2010), both QJ.**

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Methods: "Background error method"

- **Based on covariances calculated from pairs of FG departures, binned by separation distance.**

- **Subtract a scaled version of the assumed background error, mapped to radiance space.**

Assumed background error, mapped to radiance space

Scaled assumed background error, mapped to radiance space

Difference to FG-departure covariance → obs. error
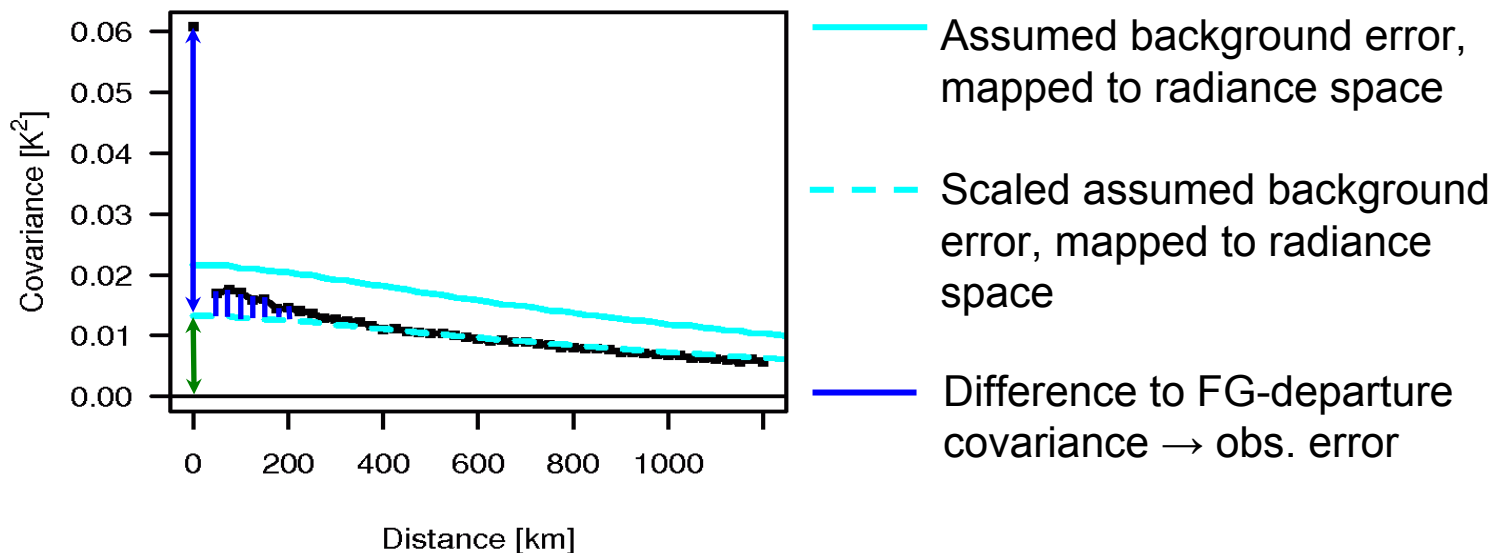
- ◆ **Scaling such that FG-departure covariances match scaled assumed background errors for separations > threshold (scaling ≤ 1).**

- ◆ **Relies on adequate background error covariance; problems for T_{skin} error.**

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N-18 AMSU-A: Estimated observation errors (σ_O)
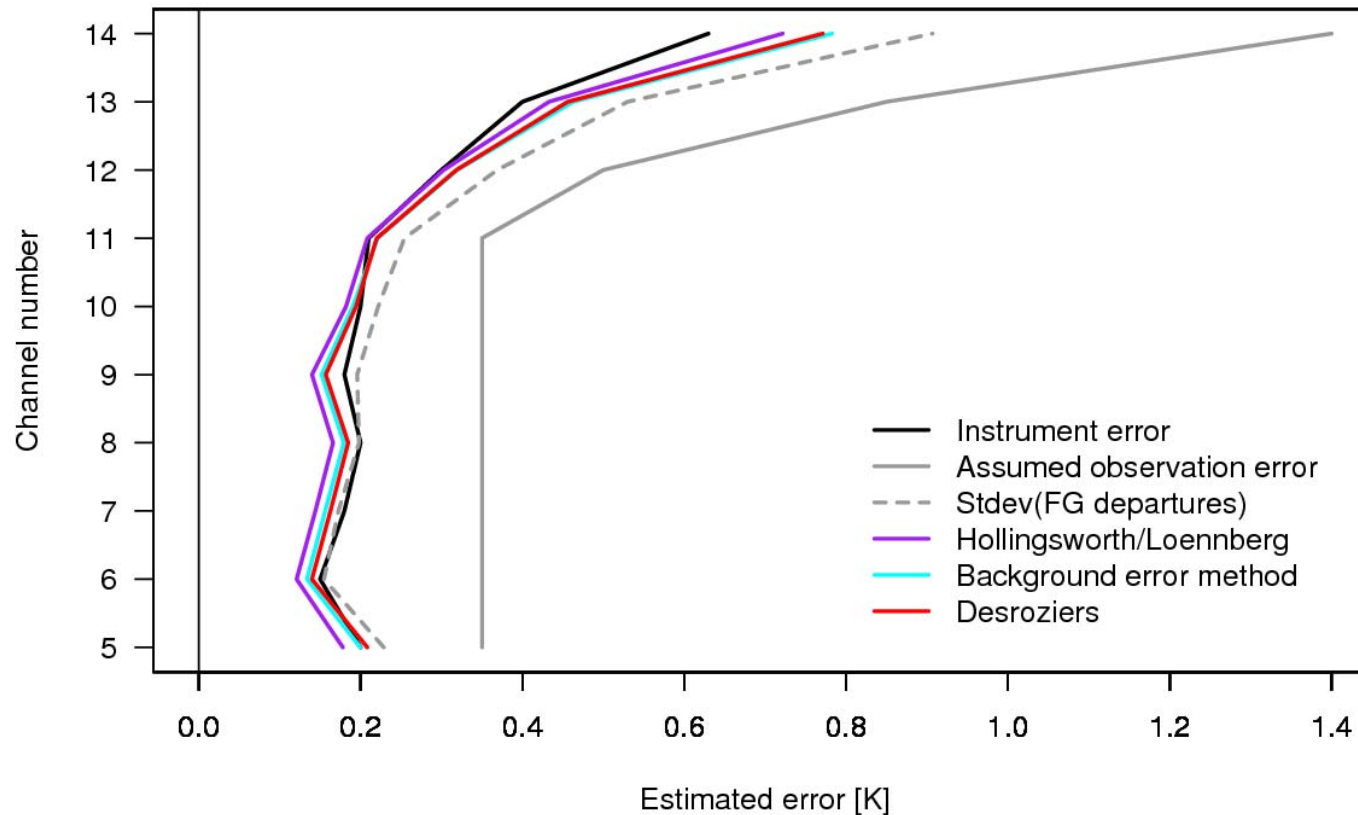
- Good agreement between different methods.

- Estimated errors close to instrument noise – RT error largely taken out by bias correction?

- Estimated errors lower than errors currently used in the assimilation (~half).

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AMSU-A: Spatial observation error correlations by separation distance
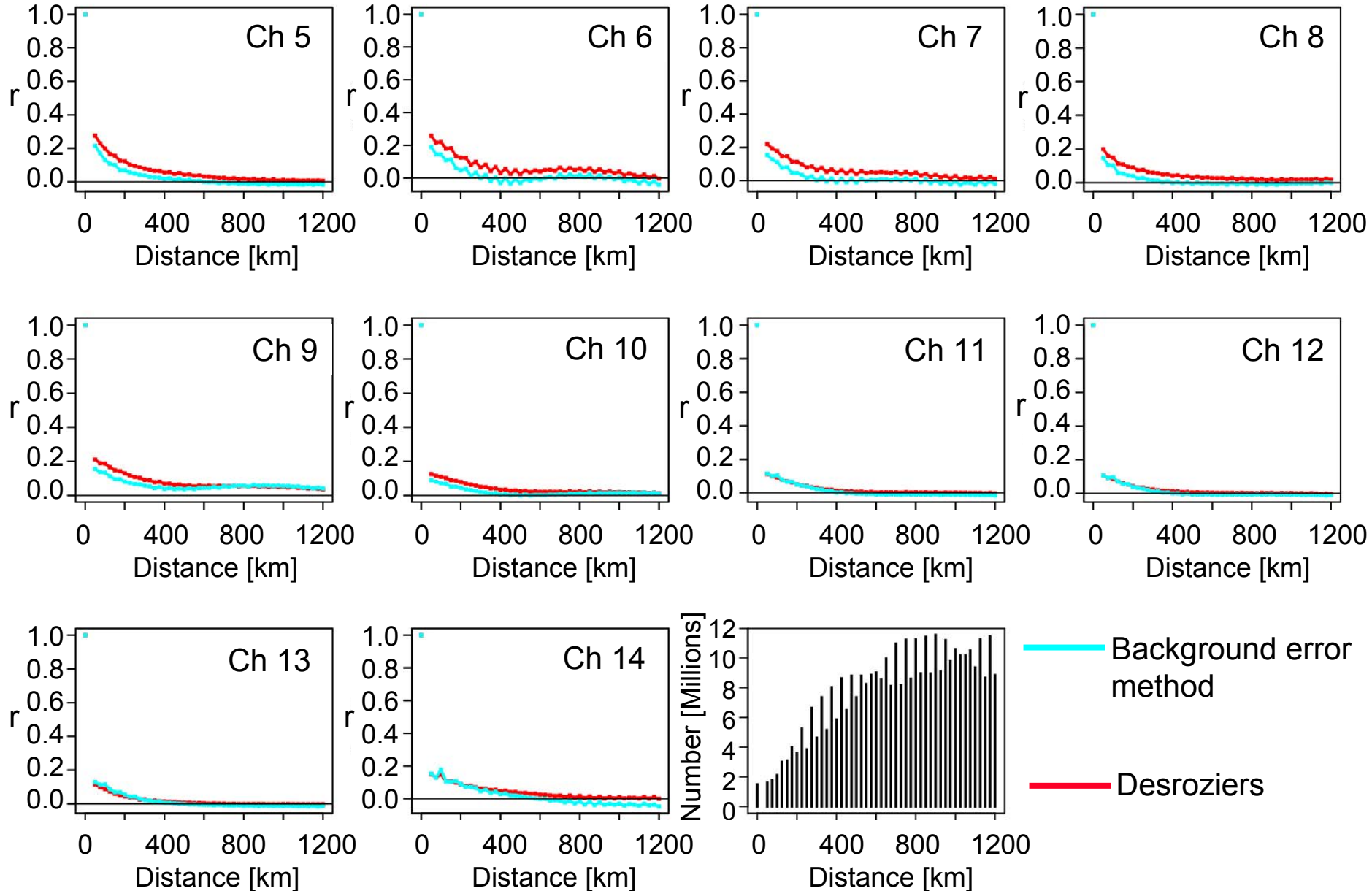
AMSU-A:
Inter-channel observation error correlations

Hollingsworth/Lönnberg
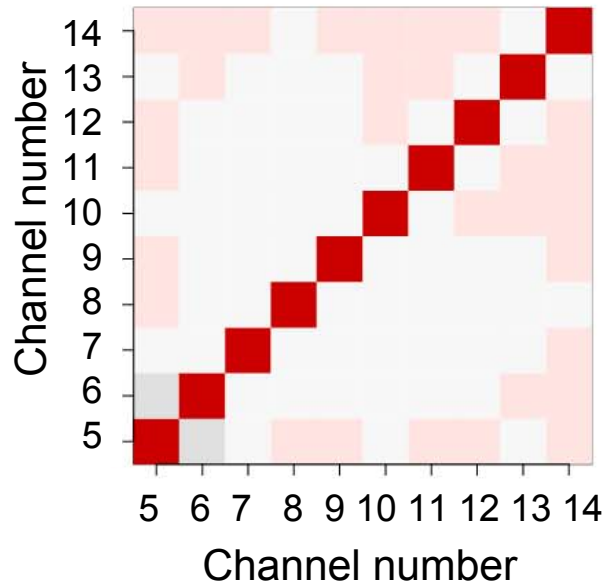
Background error method
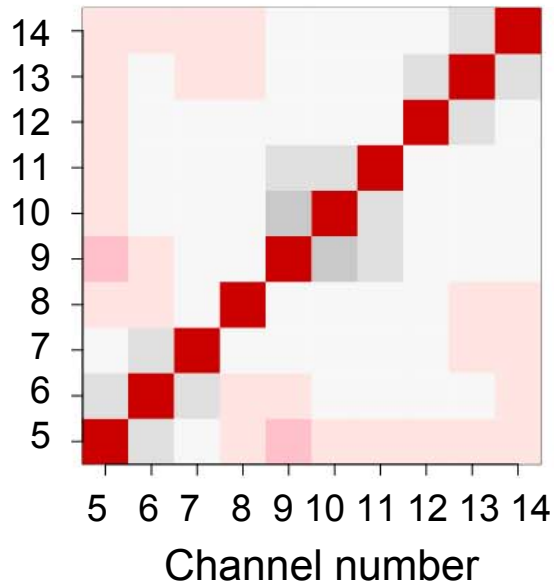
Desroziers

IASI: Observation errors (σ_o)

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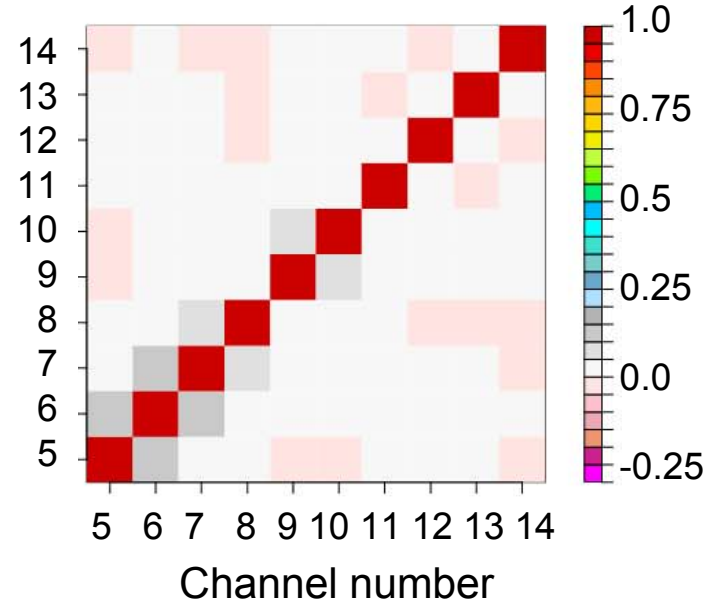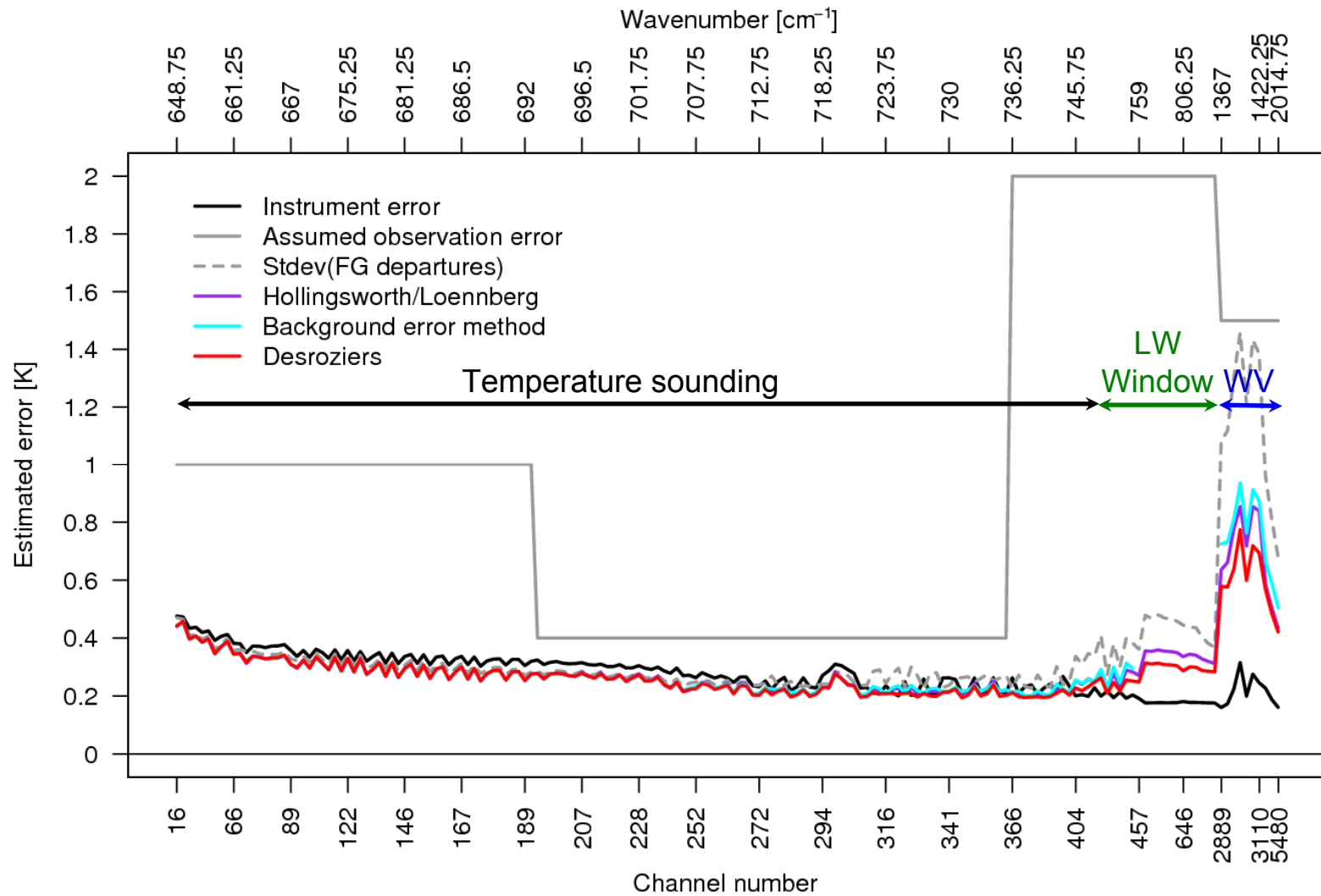
IASI:
Spatial error correlations
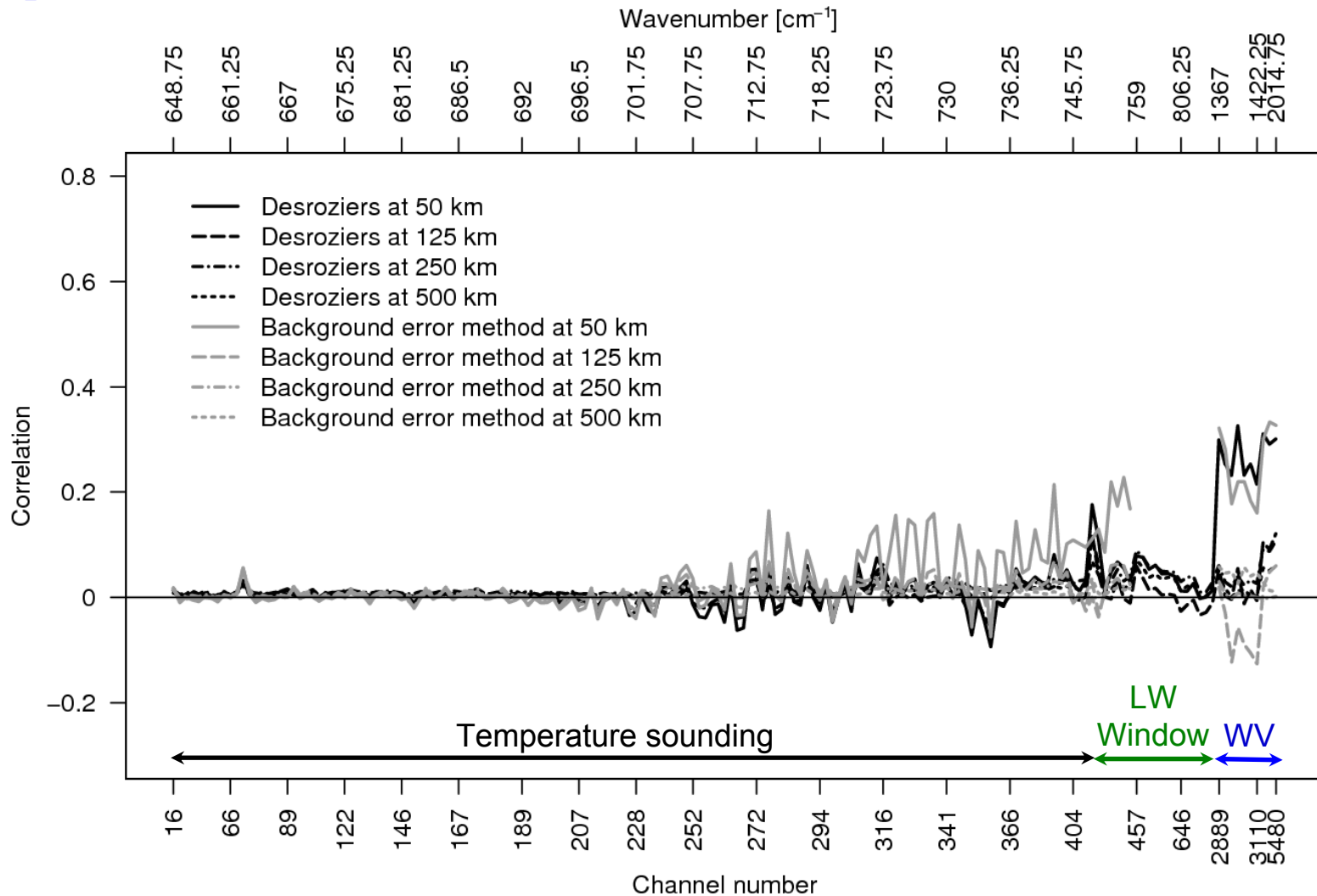
IASI:
Inter-channel
error correlations

Desroziers

Hollingsworth/
Lönnberg

Background error
method
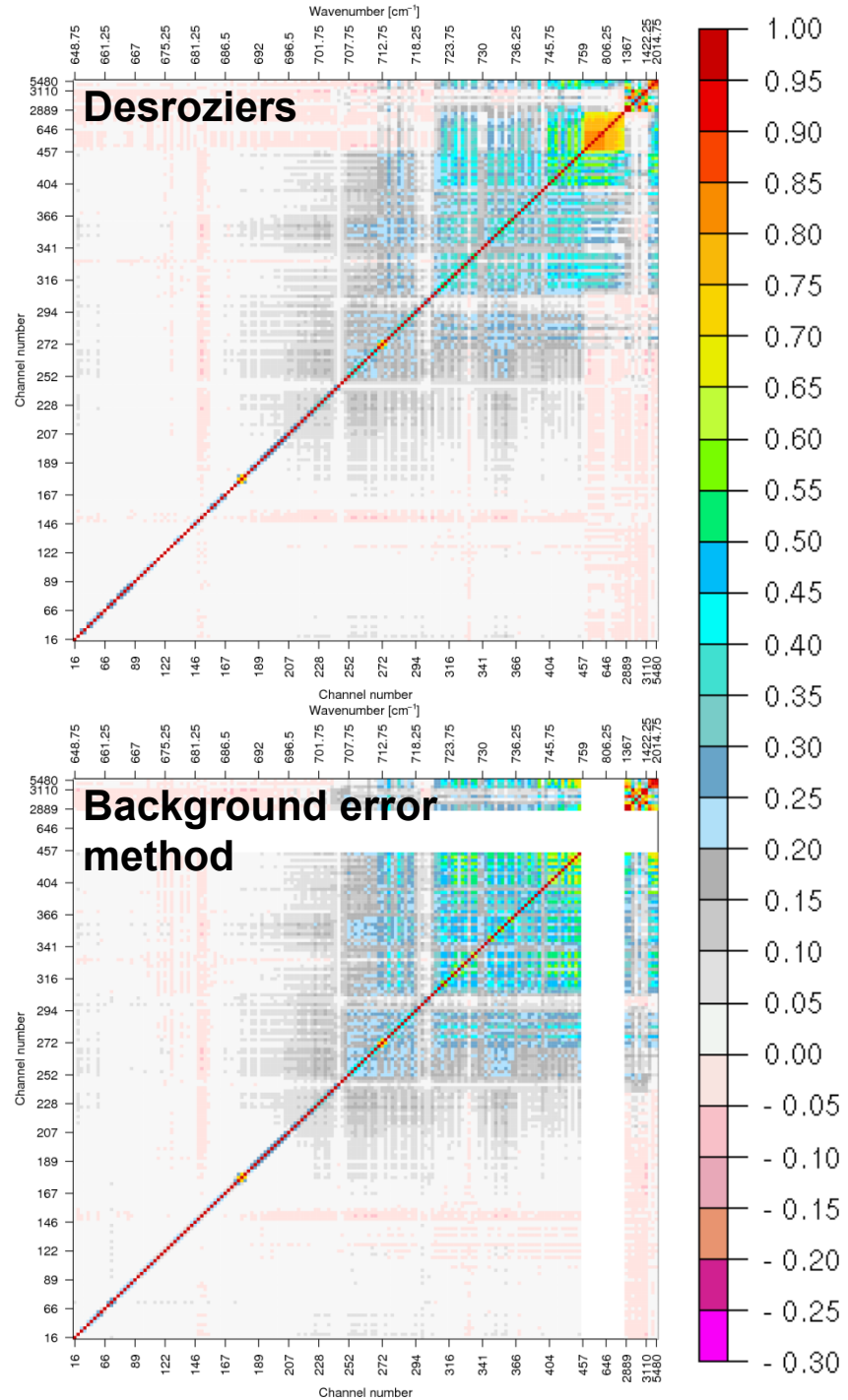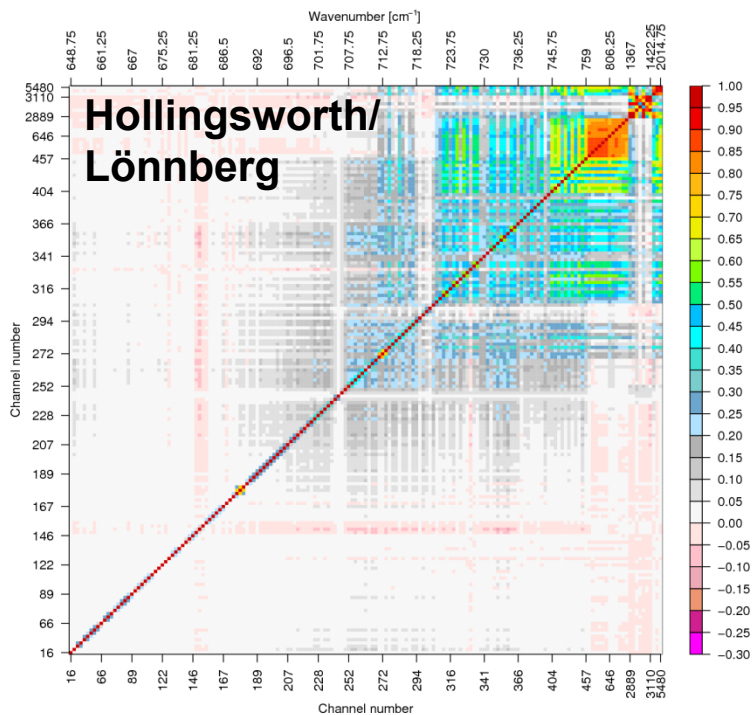
IASI: Inter-channel error correlations (Desroziers)

Outline

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Forecast impact: Less thinning for AMSU-A

CTL: 125 km thinning for AMSU-A
EXP: 62.5 km thinning for AMSU-A

T511 experiments:
   NH Winter: Dec 2008/Jan 2009
   NH Summer: June/July 2009

• Impact larger for summer hemisphere
• Some degradation for Z in the stratosphere for the winter hemisphere

Normalised RMSE differences (123 cases):
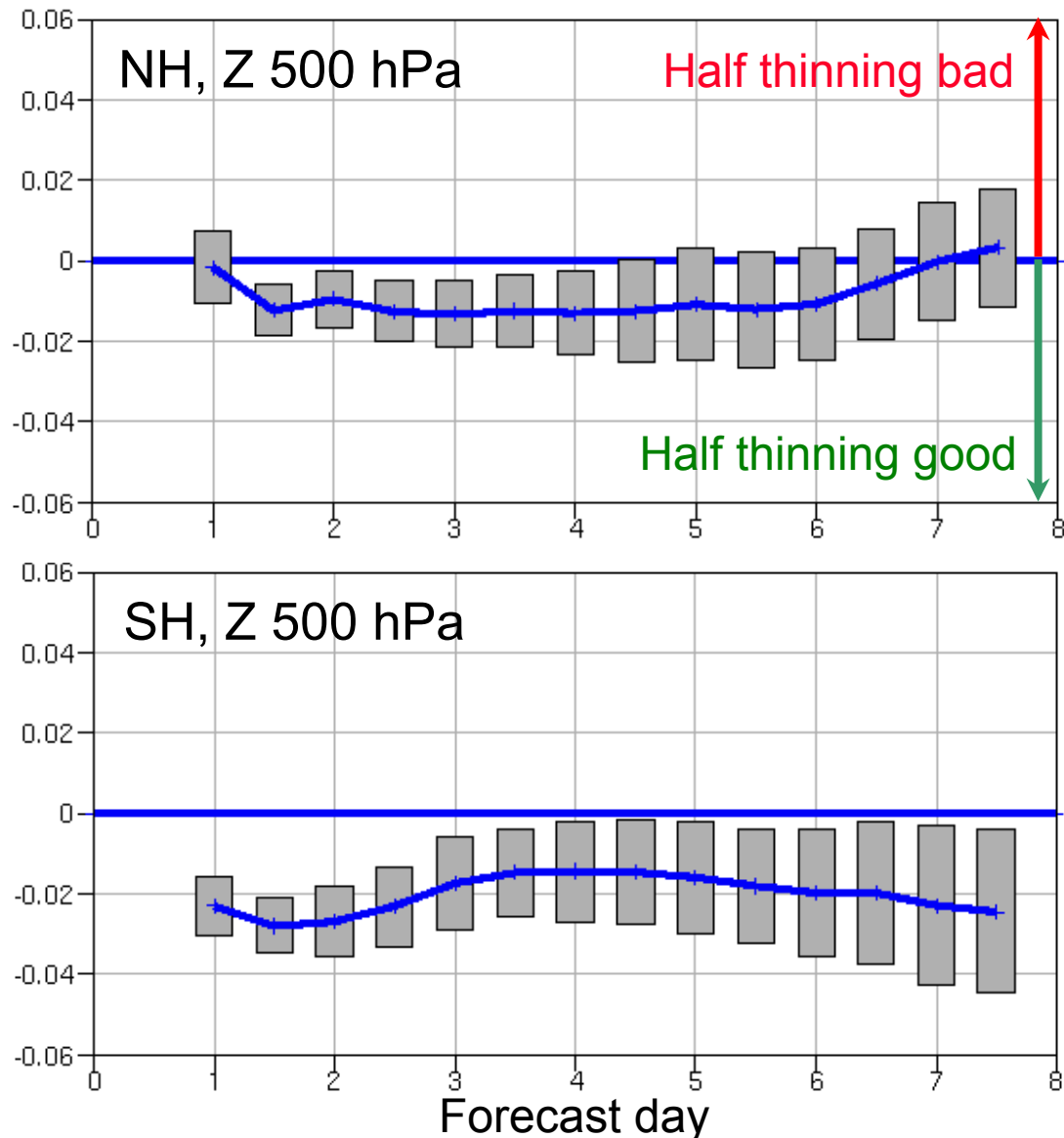
NH, Z 500 hPa

Half thinning bad

Half thinning good

SH, Z 500 hPa

Forecast day

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Modifying IASI observation errors: Forecast impact

Experiments with modified IASI observation errors (July/August 2009):
- **CTL**: Old (diagonal) observation errors
- **EXP1**: Updated diagonal observation errors for T-sounding channels (factor 2.5)
- **EXP2**: As EXP1, but with error correlations for all channels

Normalised difference in the RMSE, EXP1 vs CTL, (54 cases):
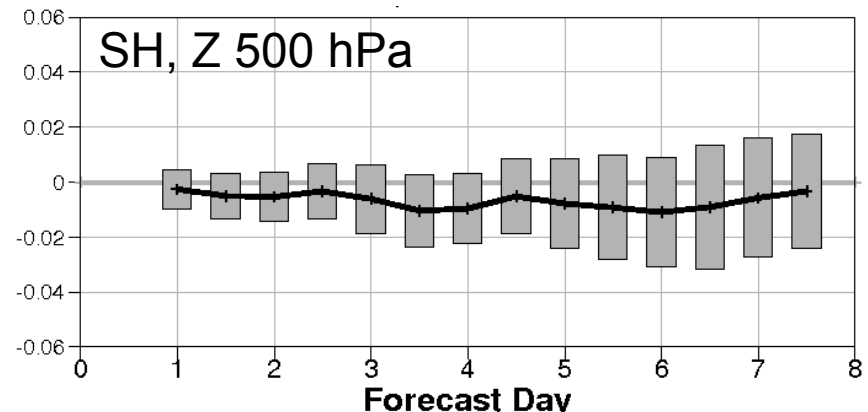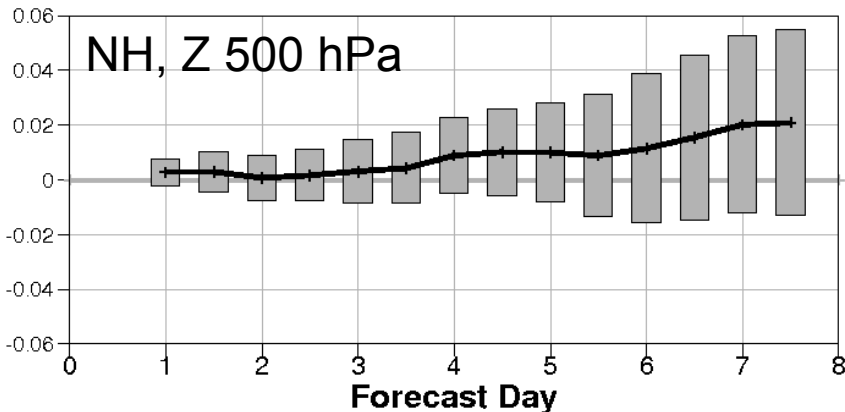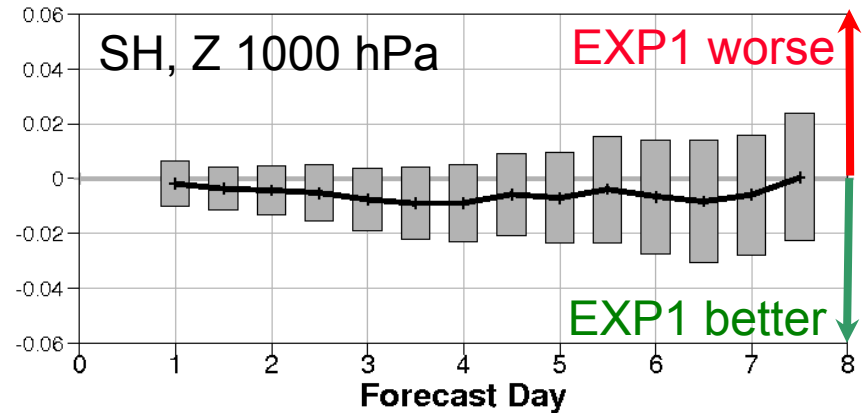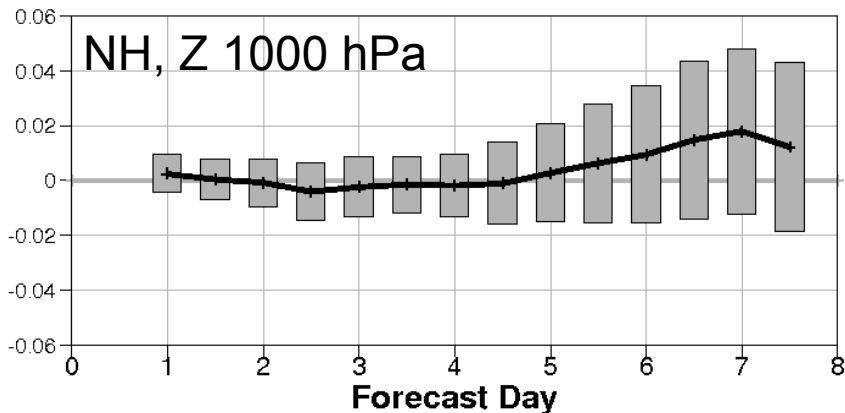
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Modifying IASI observation errors: Forecast impact

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Normalised difference in the RMSE, EXP2 vs CTL, (54 cases):
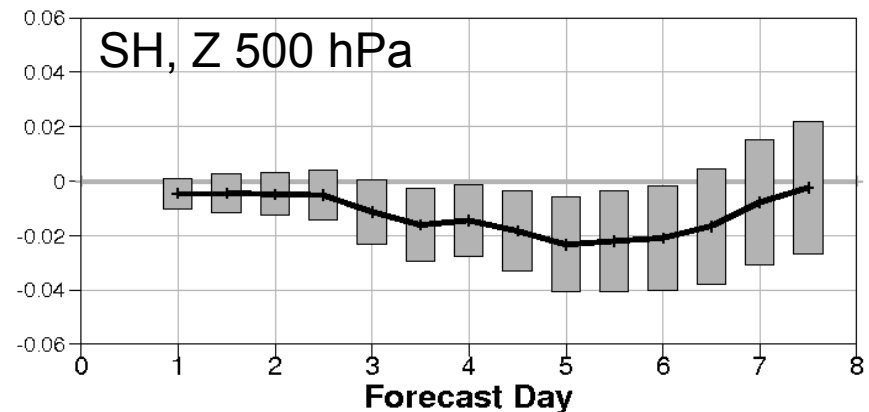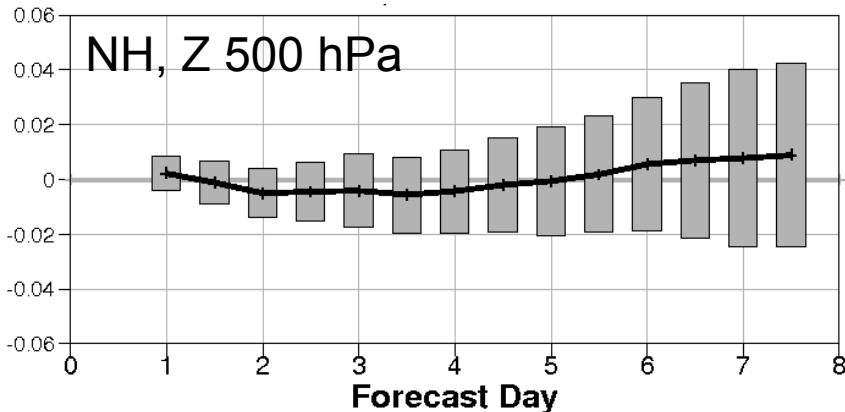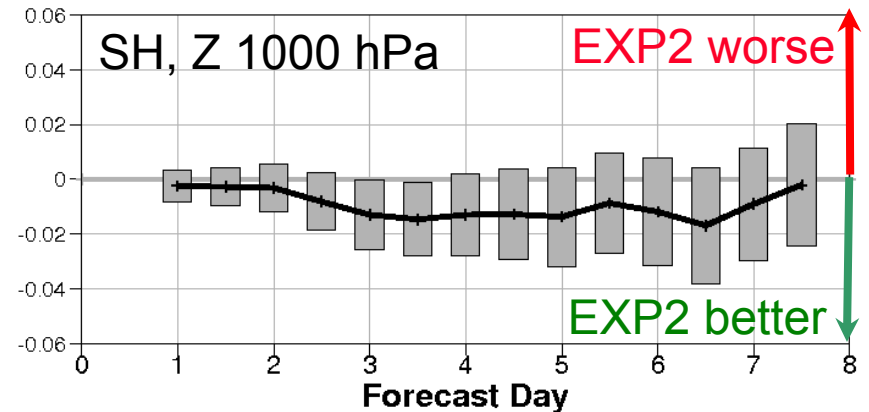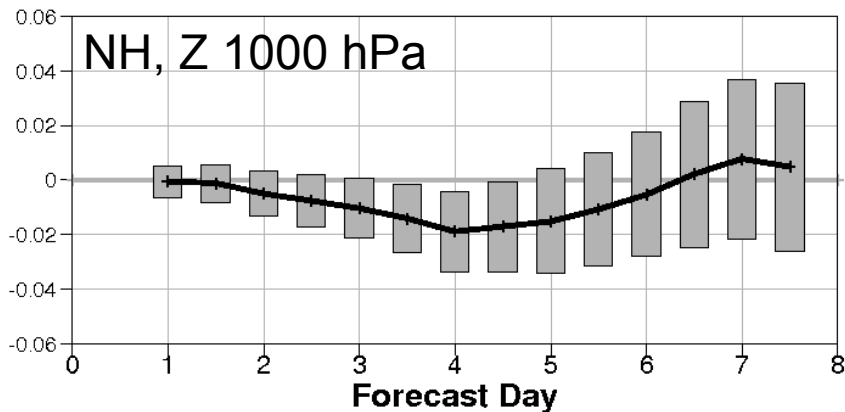
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Summary

- **Small observation error correlations (<0.2) for surface-insensitive temperature-sounding channels at current thinning scales.**

- Some inter-channel error correlations for:
  - ◆ **IASI water-vapour channels**
  - ◆ **IASI long-wave window channels**
  - ◆ **Neighbouring IASI channels (apodisation)**

- Some spatial error correlations for:
  - ◆ **Water-vapour channels at small scales**

- Role of RT errors and bias correction?

- **See Bormann and Bauer (2010) and Bormann et al. (2010), soon in QJ.**

- Application in 4DVAR:
  - ◆ **Improved forecast impact from assimilating AMSU-A more densely.**
  - ◆ **Encouraging results from taking IASI inter-channel observation error correlations into account, but scaling of errors required.**

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Modifying IASI observation errors

- Use Desroziers-estimated observation errors in 4DVAR, with correlations, and scaling factor (July/August 2009).

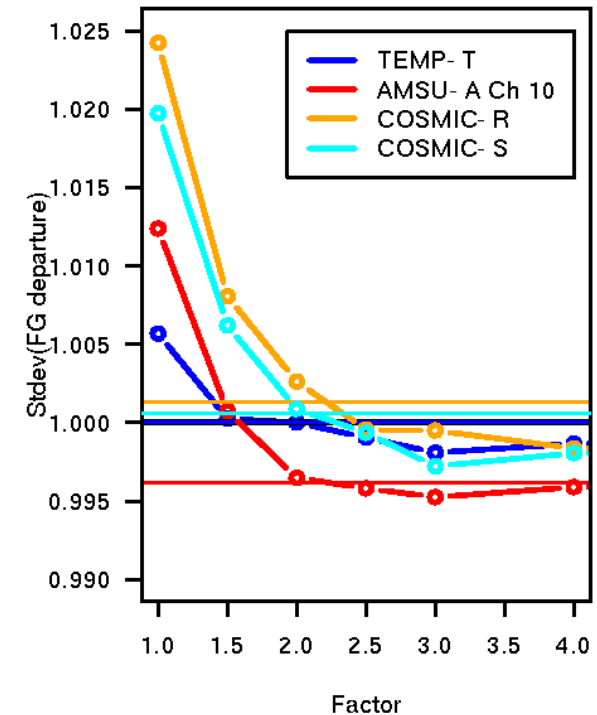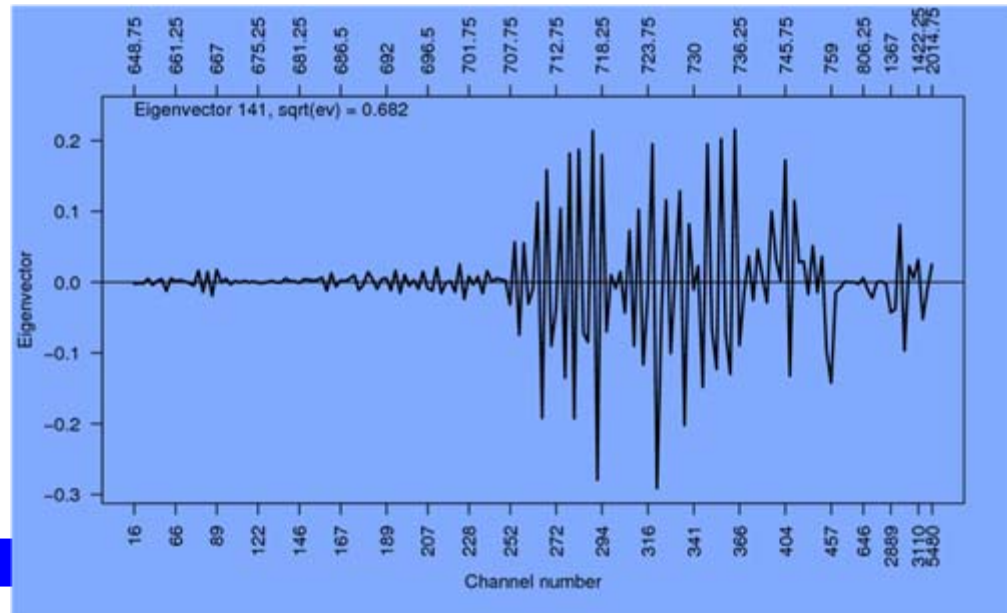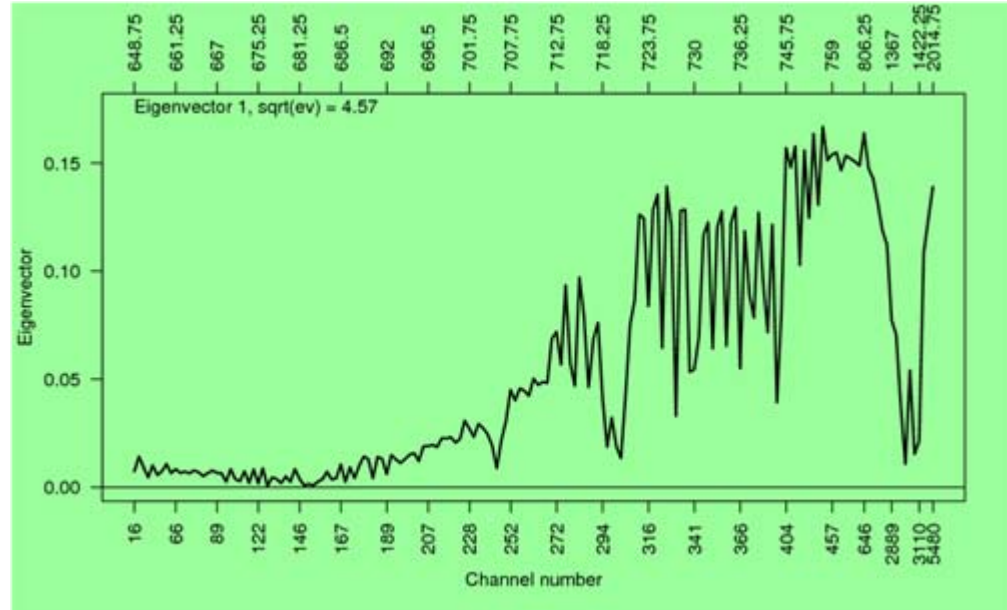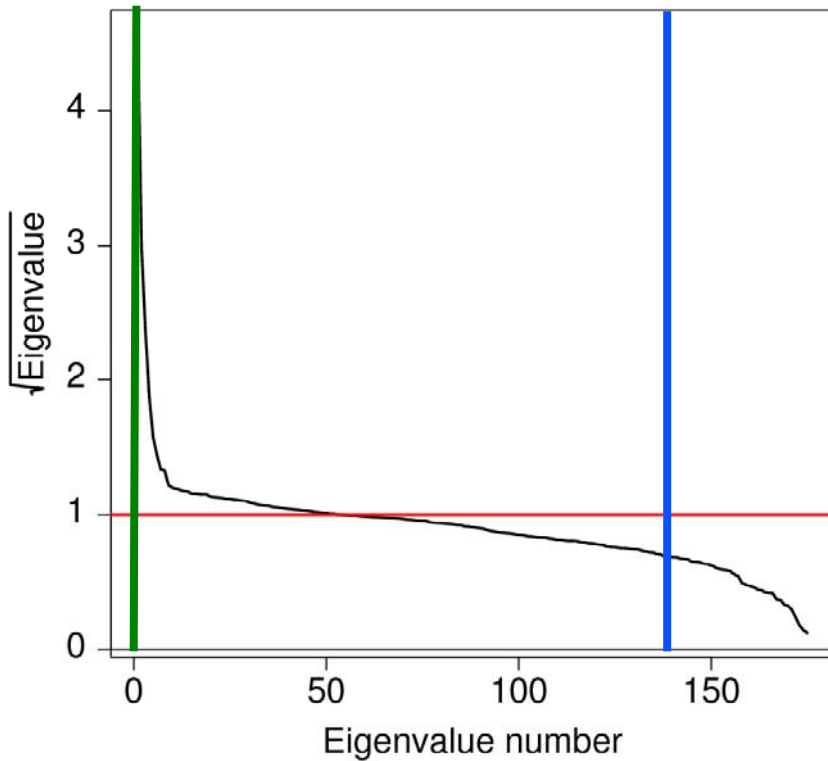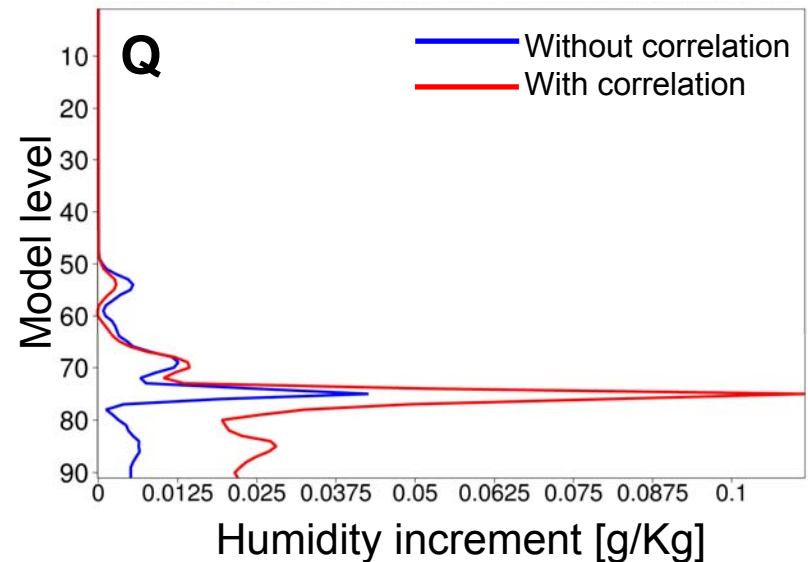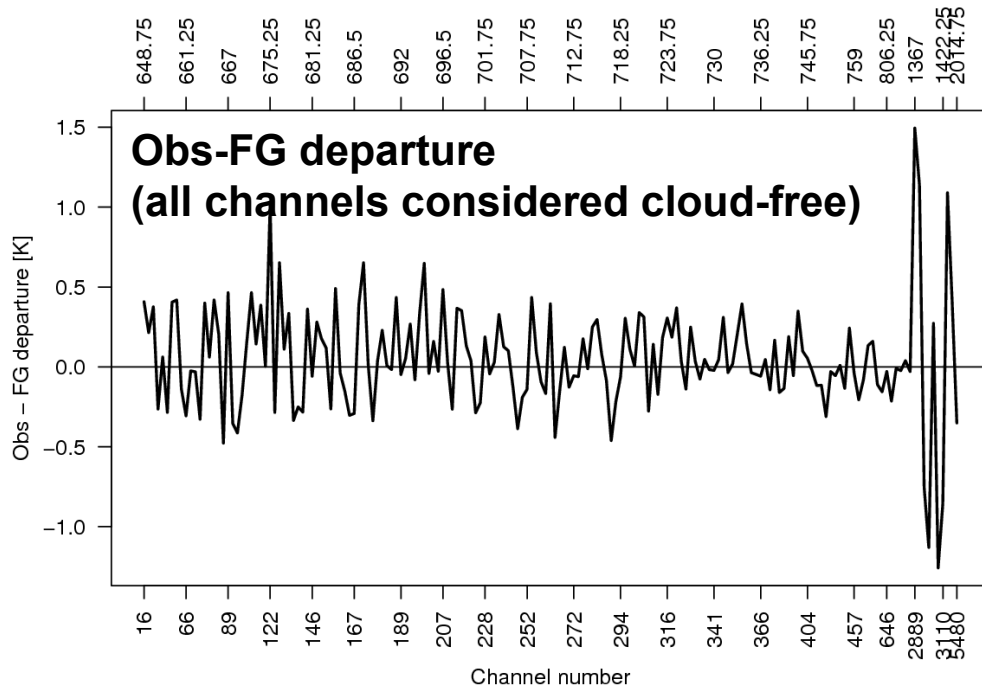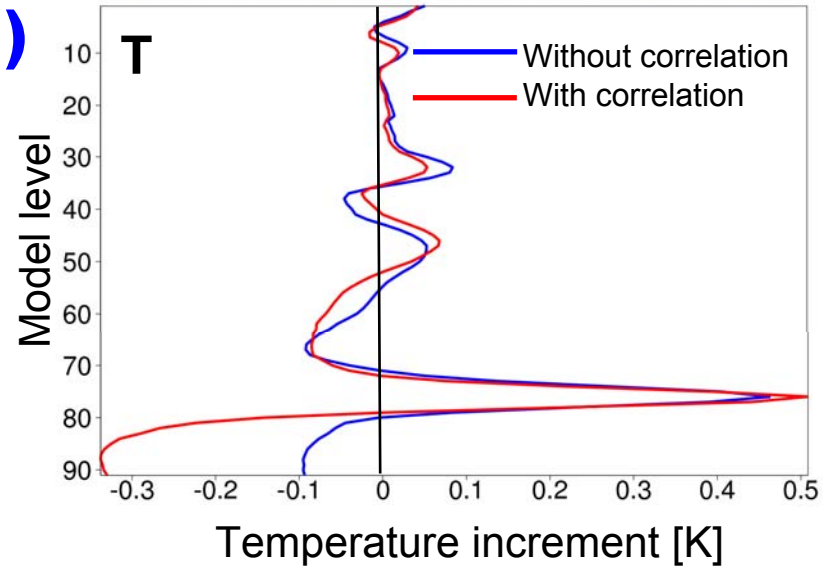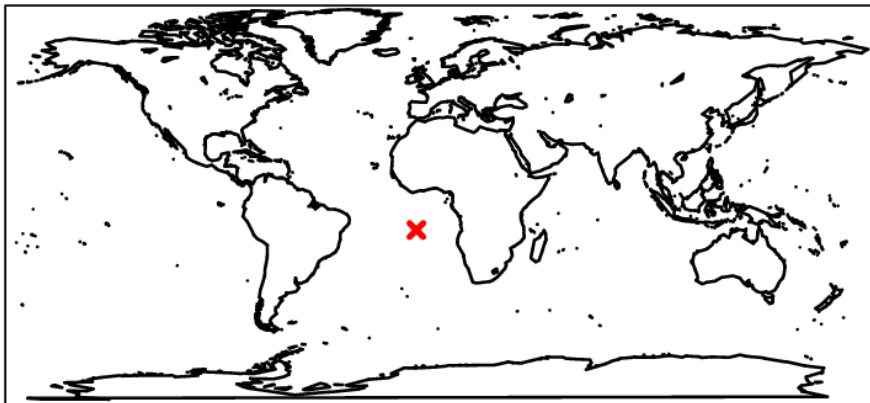- Standard deviations of Obs-FG, normalised to 1 for no-IASI experiment:

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Modifying IASI observation errors

• Use Desroziers-estimated observation errors in 4DVAR, with correlations, and scaling factor (July/August 2009).

• Standard deviations of Obs-FG, normalised to 1 for no-IASI experiment:

Horizontal lines: Values using old (diagonal) observation errors.

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Modifying IASI observation errors

• Use Desroziers-estimated observation errors in 4DVAR, with correlations, and scaling factor (July/August 2009).

• Standard deviations of Obs-FG, normalised to 1 for no-IASI experiment:

Horizontal lines: Values using old (diagonal) observation errors.
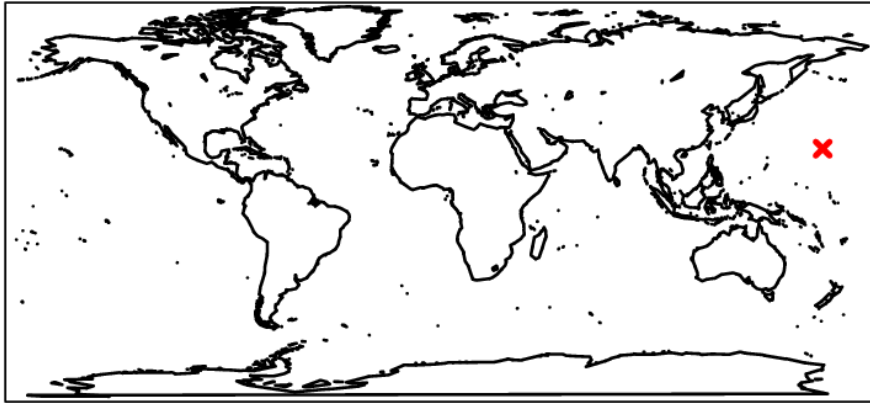
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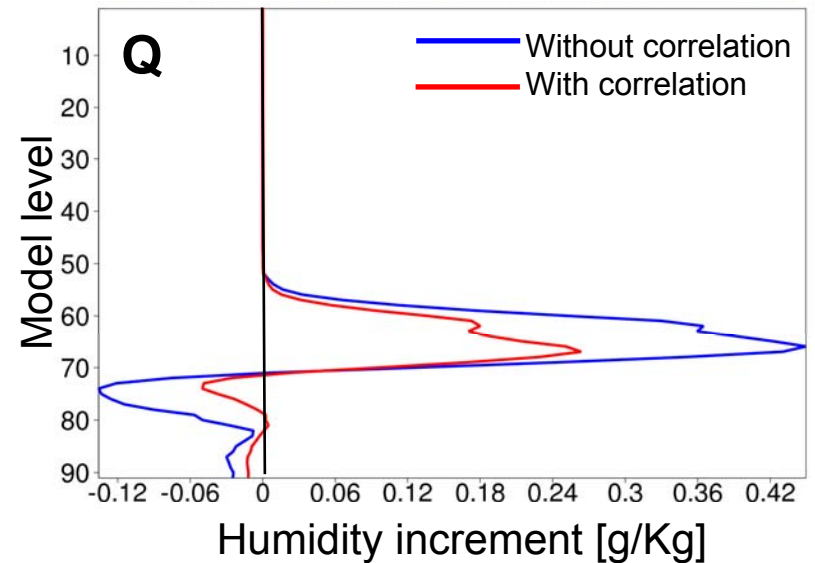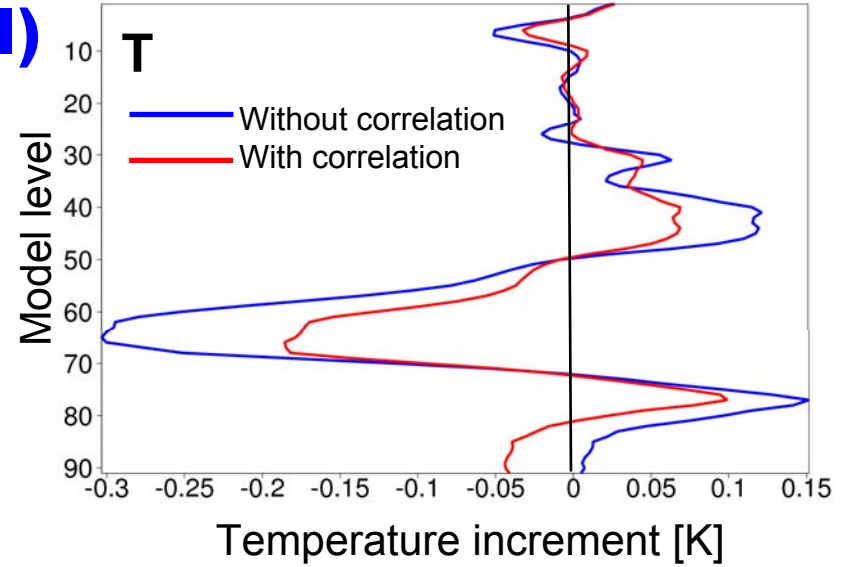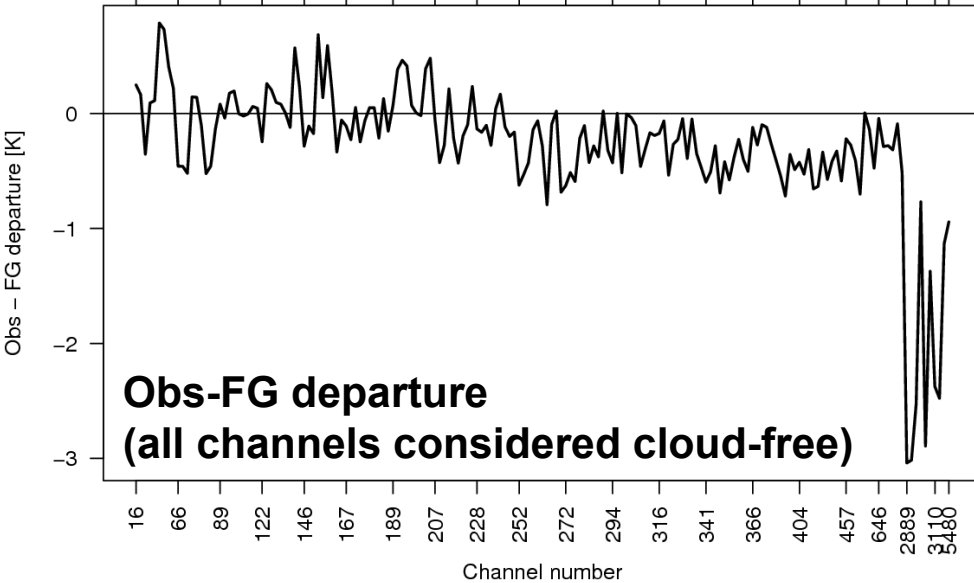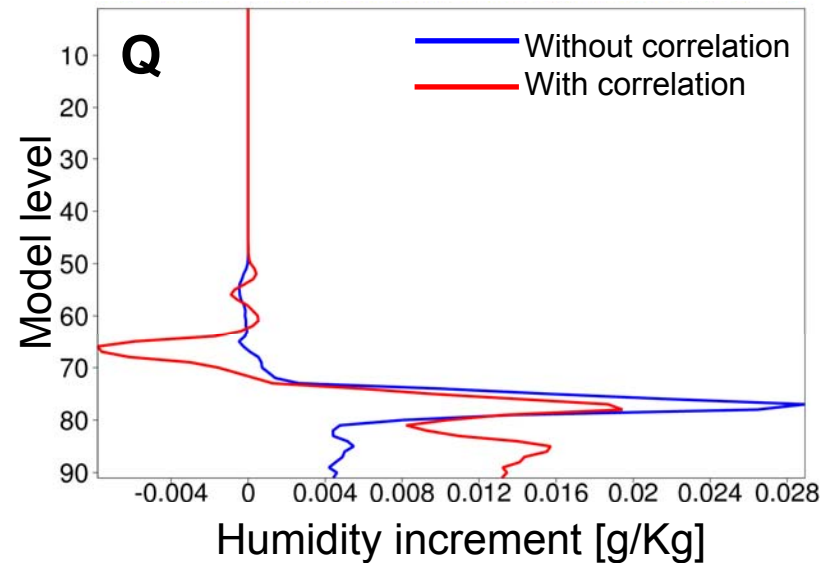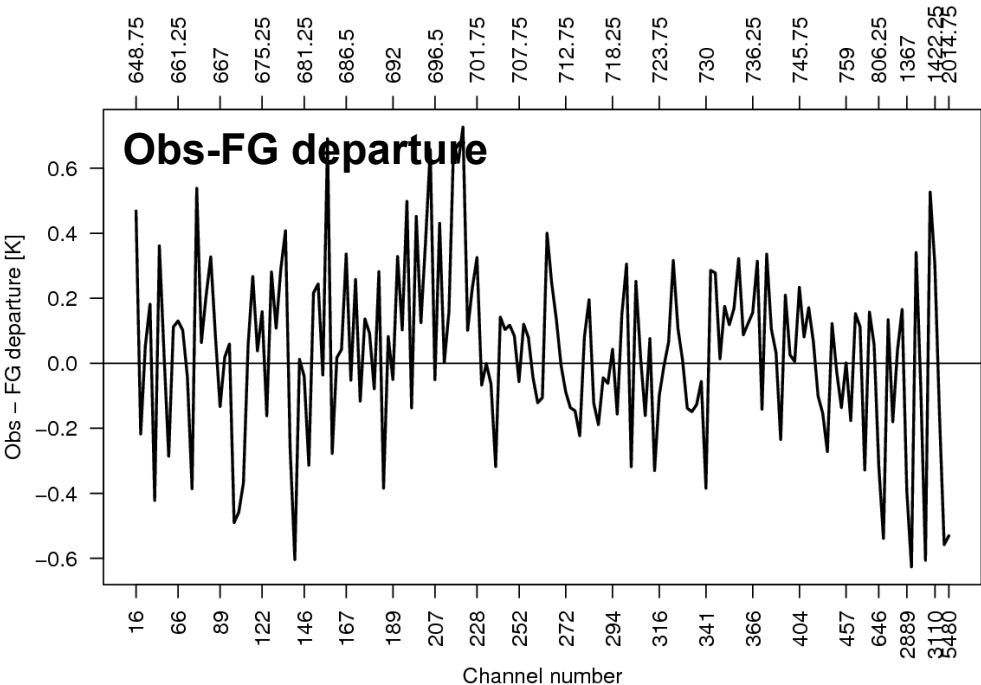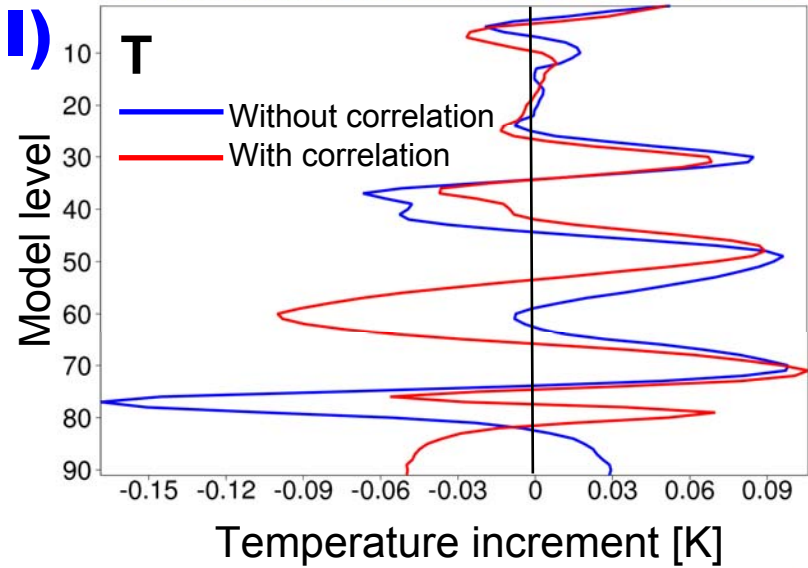# IASI inter-channel error correlations

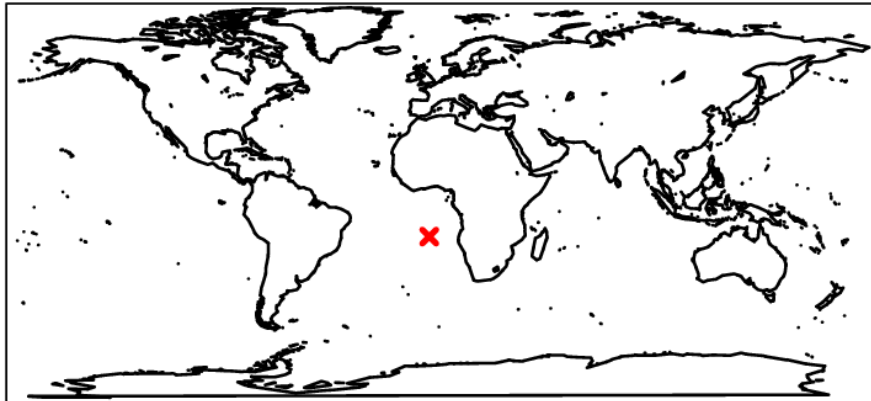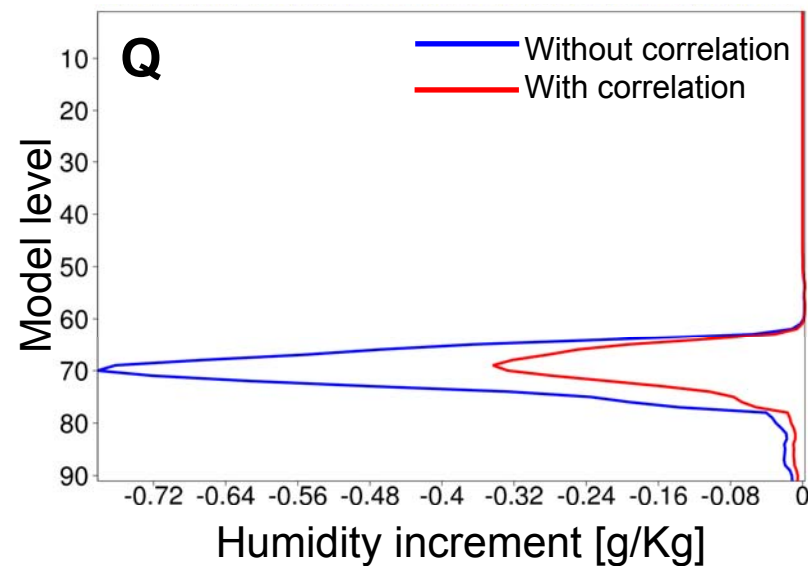Eigenvalues of the error correlation matrix:

Single IASI spectrum assimilation experiments (I)

Obs-FG departure
(all channels considered cloud-free)

T — Without correlation / With correlation

Temperature increment [K]

Q — Without correlation / With correlation

Humidity increment [g/Kg]

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Single IASI spectrum assimilation experiments (II)

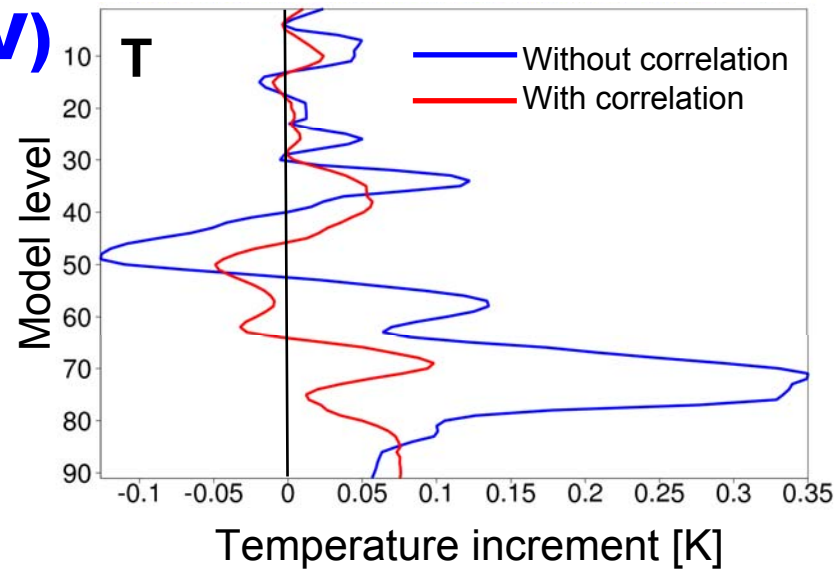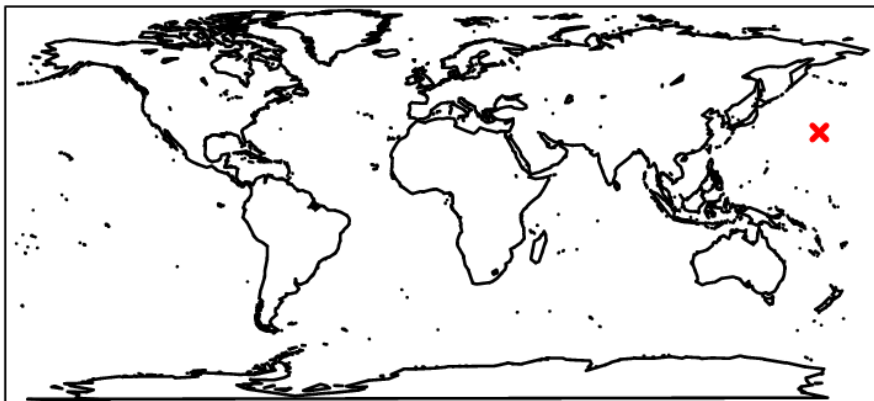

Obs-FG departure
(all channels considered cloud-free)

Single IASI spectrum assimilation experiments (III)

Single IASI spectrum assimilation experiments (IV)