

Assimilation of spectrally-adjacent pairs of IASI channels

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Motivation

The use of IASI radiances at ECMWF is built upon the assumption of uncorrelated observation errors. As for any interferometer, signal apodization makes observation errors correlated in spectrally-adjacent channel pairs. Such pairs are therefore avoided in commonly-used channel selections. Applicable tools for dealing with correlated error have been introduced by now (Bormann *et al.*, 2015; Weston *et al.*, 2014).

According to the linear estimation theory, analysis can benefit from properly-modelled error correlations, but only if observations sharing the correlated error measure different things (Miyoshi *et al.*, 2013). We are attempting to make practical use of the theoretical concept in the special case of IASI.

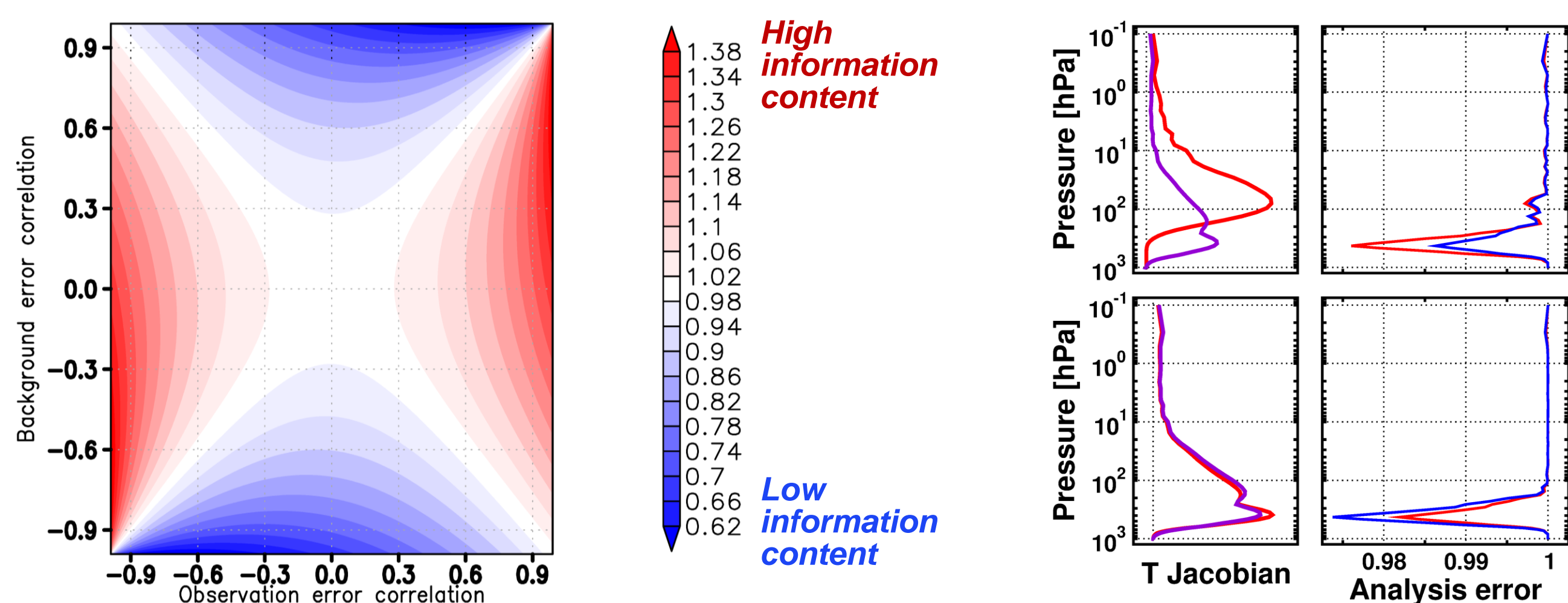


Figure 1. Theoretical Degrees of Freedom for the Signal as a function of observation and background error correlations in a two-parameter system.

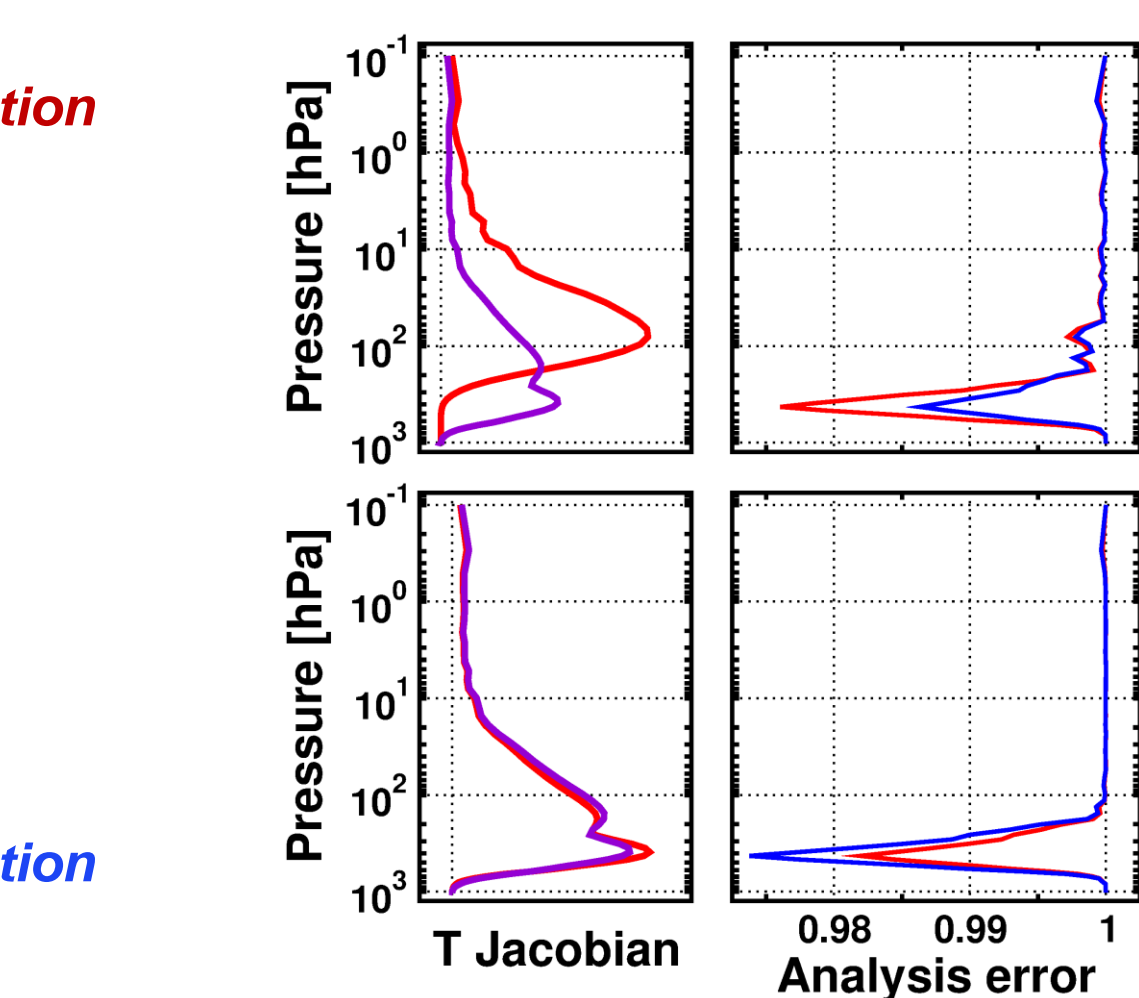


Figure 2. Analysis error in two systems, each consisting of two channels with either correlated (red) or uncorrelated (blue) observation errors.

Identification

The currently operational setup at ECMWF makes active use of 191 channels. To take advantage of the well-characterized error correlation effect of the apodization, we have derived an alternative selection of 191 channels such that several spectrally-adjacent channel pairs are included.

We have chosen the channel pairs on the basis of observed brightness temperature (T_B) correlation in a global sample of clear channels over sea. We identify useful channel pairs as those where observed T_B is the least correlated. The alternative list includes channel pairs with T_B correlation falling below 0.96 (a subjective threshold). Changes in the channel list are restricted to the wavenumber range 645–895 cm^{-1} .

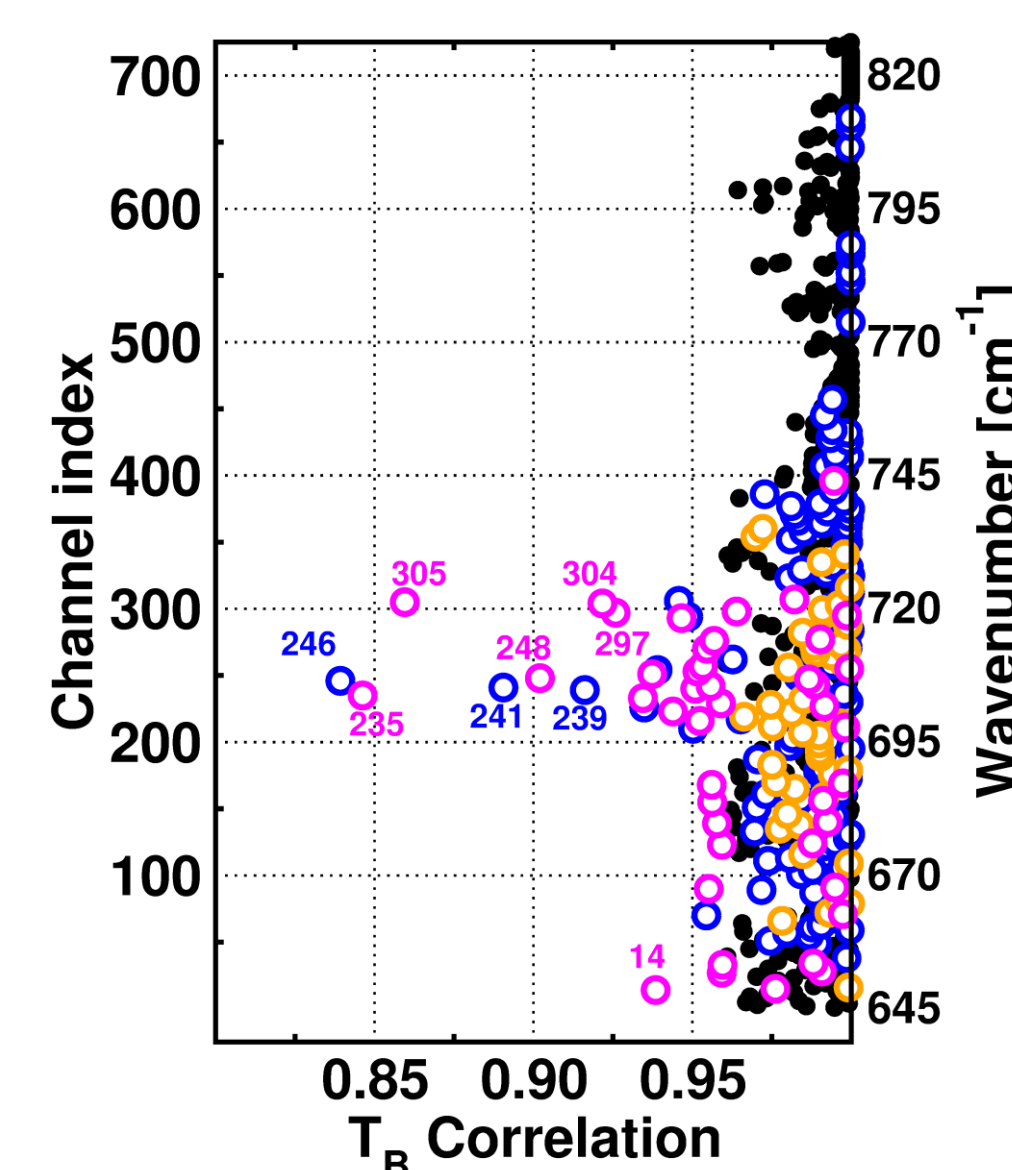


Figure 3. Observed T_B correlation in pairs of spectrally-adjacent channels. Those included in the operational list, alternative list, or both are highlighted.

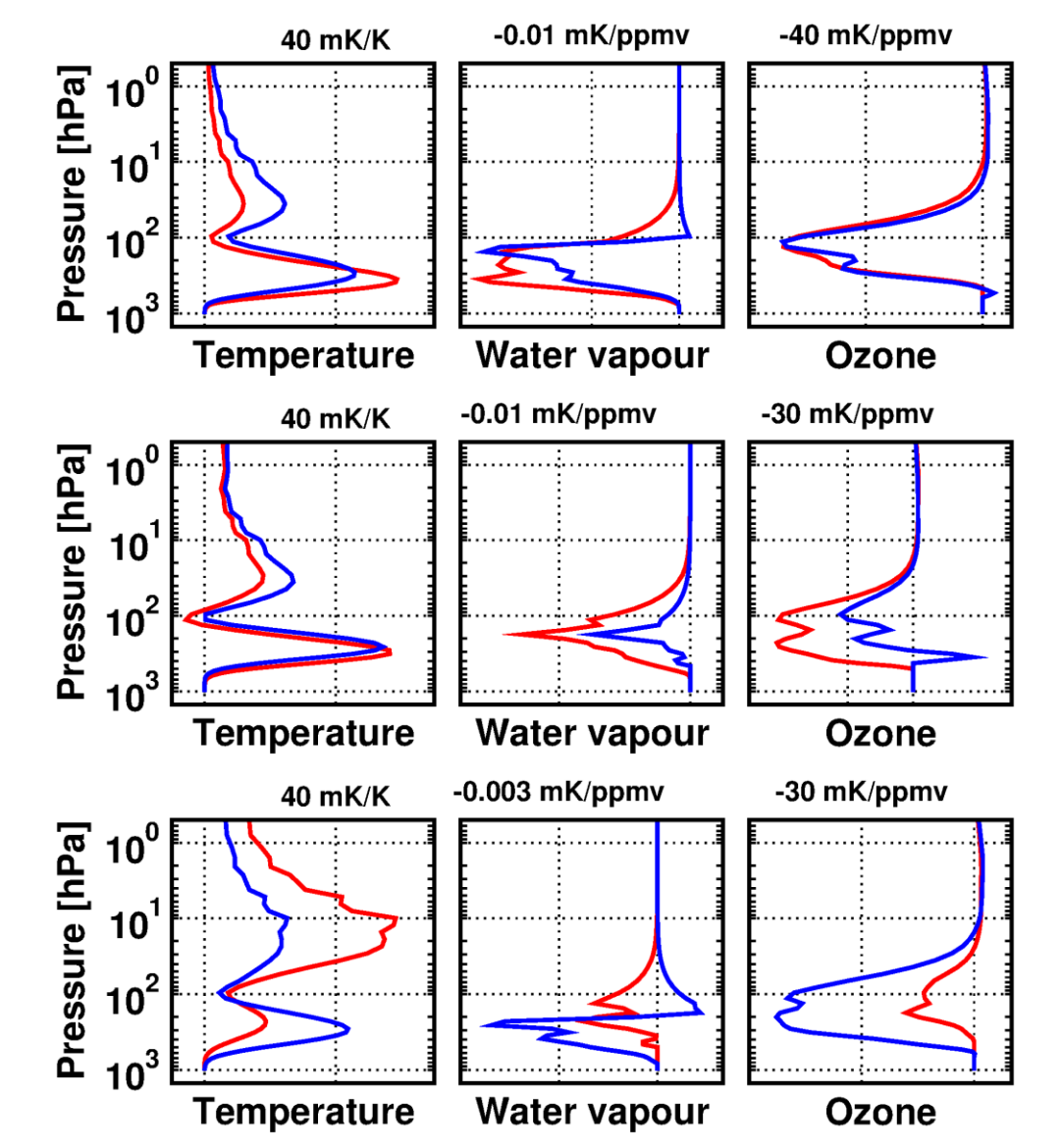


Figure 4. Atmospheric sensitivities of selected channel pairs in a tropical reference profile. From top to bottom: 246/247; 297/298; 304/305.

Evaluation

We have evaluated performance of the alternative channel list using the Integrated Forecasting System (version Cy41r1). Starting on 1 January 2015, we have produced a 4-month control run with the operational channel list and another run with the alternative channel list. Apart from the channel lists, the two runs are similar to each other. We account for inter-channel error correlations, but assume that they are due to the signal apodization only. Consistently with the ECMWF operational system, we have set observation error standard deviations to either 0.4 K, 1.0 K or 2.0 K.

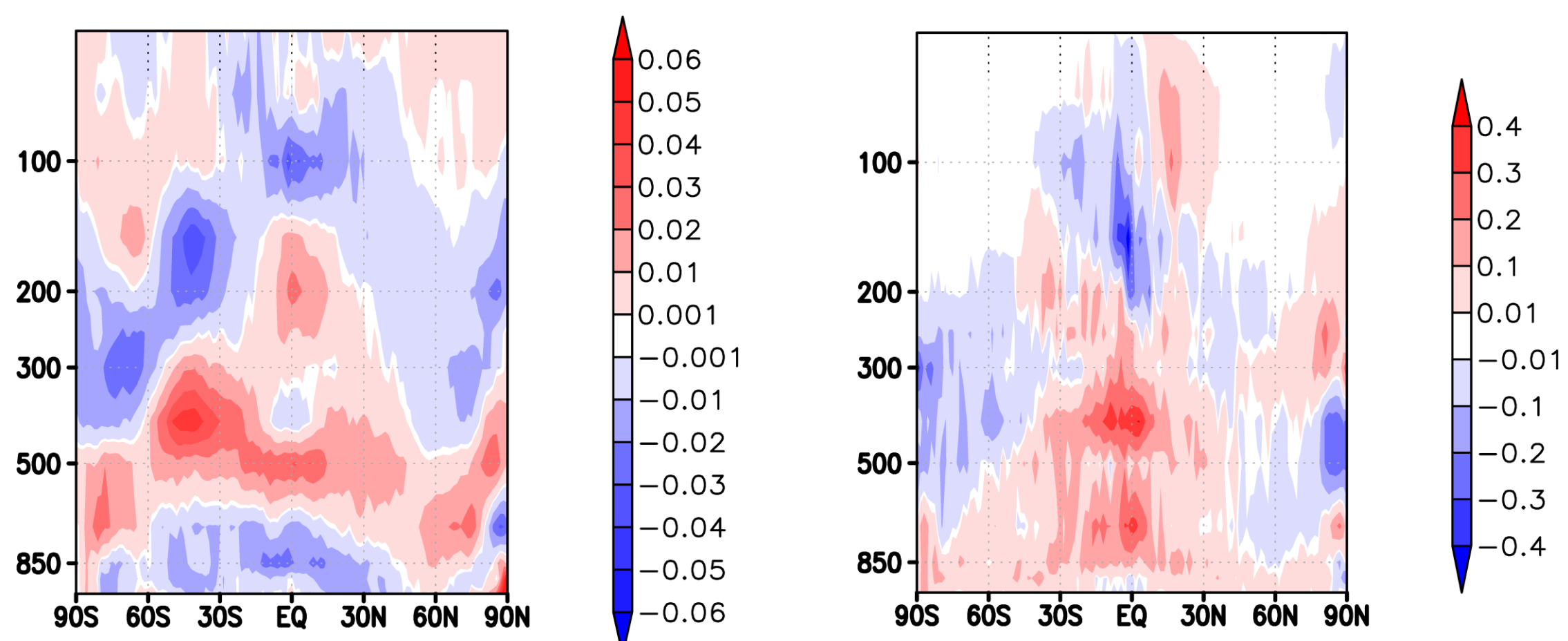


Figure 5. Impact of switching to the alternative channel list on temperature (left; unit K) and relative humidity (right; unit %) analysis. Red shades indicate warming or moistening.

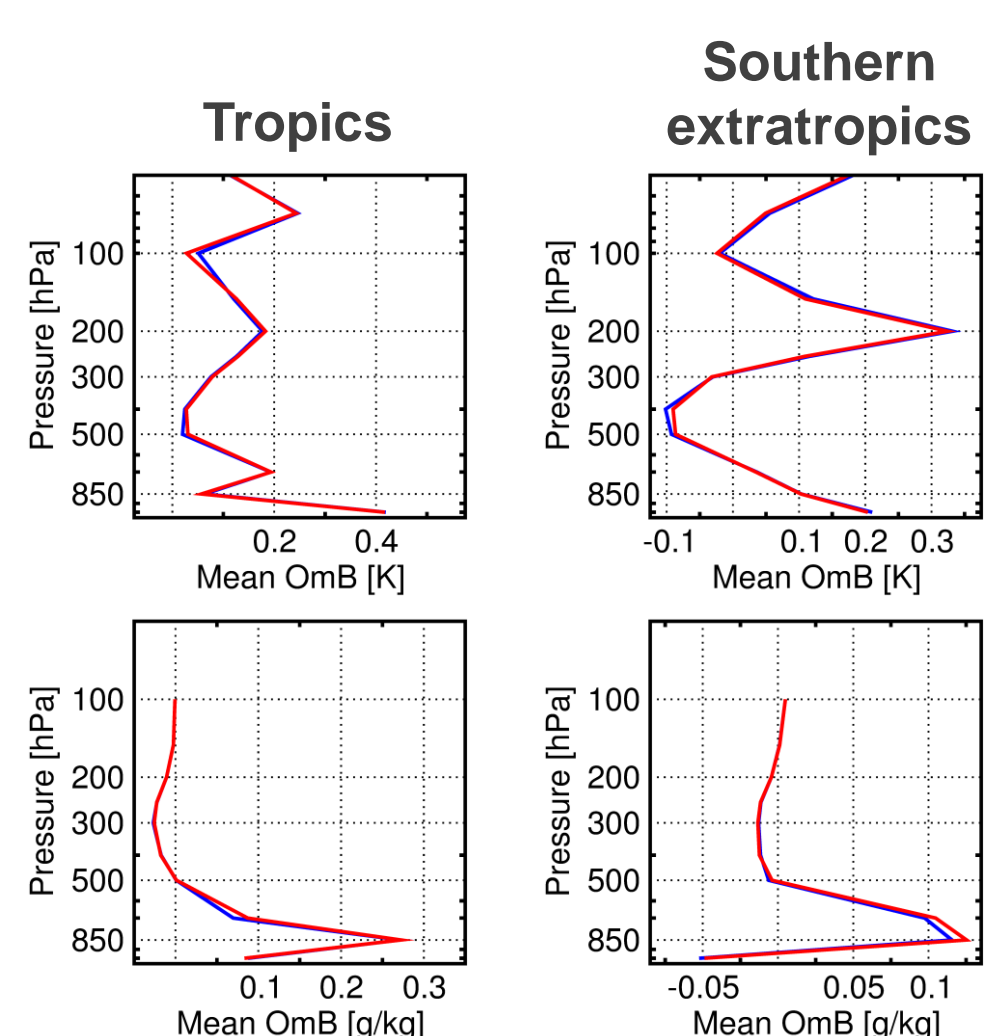


Figure 6. Mean background departure for conventional temperature (top) and specific humidity (bottom) data in the Tropics (left) and Southern extratropics (right) when using either alternative or operational channel list.

Switching to the alternative channel list introduces a systematic pattern dominated by mid-tropospheric warming and lower- to mid-tropospheric moistening in the numerical analysis. Tropopause region experiences cooling and drying. Conventional data confirm these changes. The mean humidity impact is towards improving the background fit, but the temperature impact is mixed.

Conclusion

We have demonstrated that assimilation of a large number of spectrally-adjacent channel pairs is feasible and results in performance similar to, and in some respects even better than, when using a reference system that contains the same number of channels but only few spectrally-adjacent pairs.

Optimizing the channel list for presence of correlated error is found to improve the assimilation system's capability to produce realistic humidity and ozone increments in the vicinity of tropopause. There is also a beneficial moistening impact on mean tropospheric humidity field.

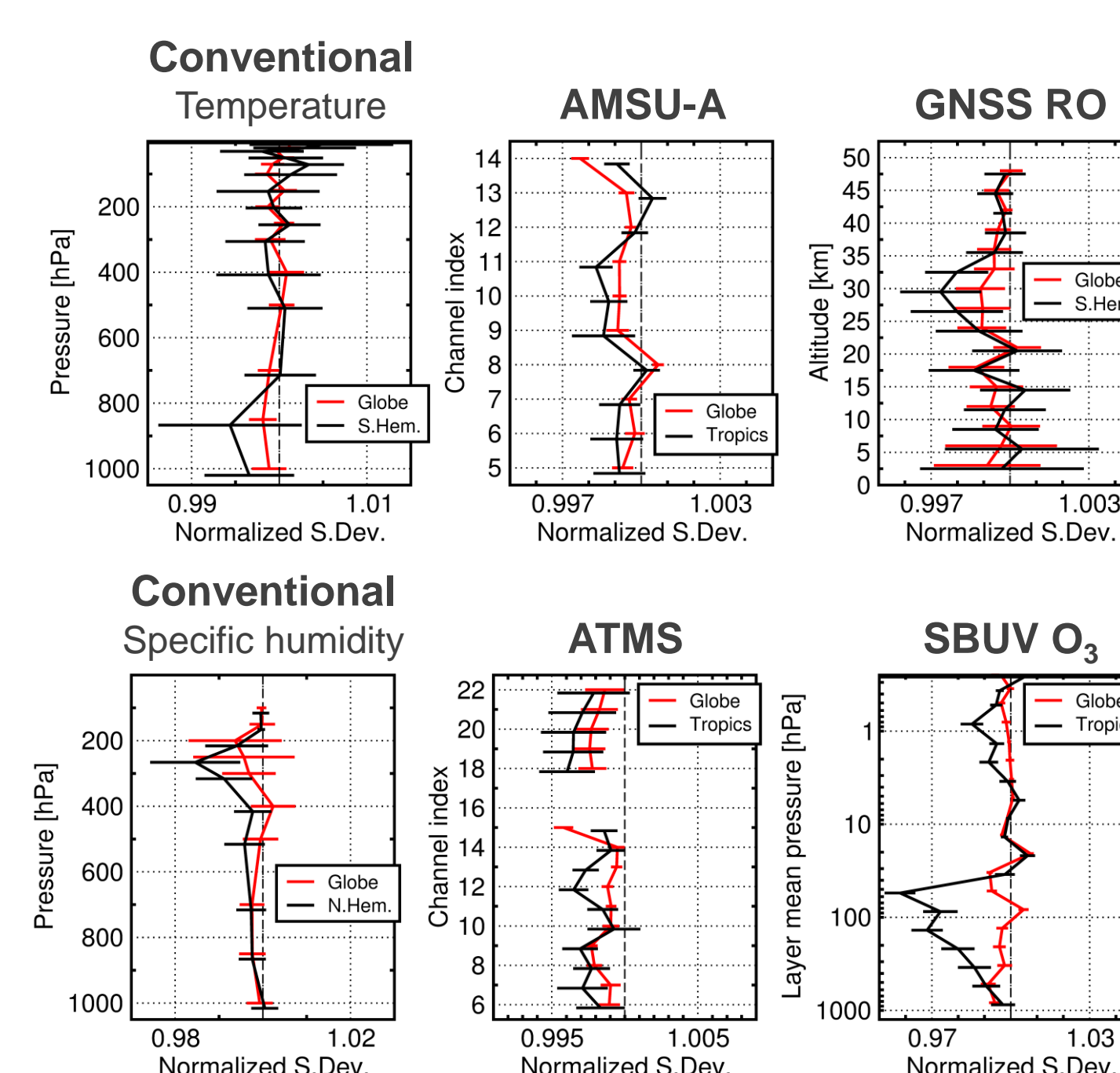


Figure 7. Control-normalized standard deviation of background departure for selected observation types. Bars indicate the 95% confidence intervals.

Short-range forecast verification is based on the impact on standard deviation of background departure on independent observations. The largest improvements are seen on near-tropopause-level humidity in the extratropics and on ozone-sensitive data in the Tropics. Microwave sounders and radio occultation data suggest a small positive temperature impact.

In contrast to the short-range, there is no evidence of a positive forecast impact in the medium range.

References

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- Miyoshi T, E Kalnay and H Li, 2013: Estimating and including observation-error correlations in data assimilation. *Inv. Prob. Sci. Eng.*, 21: 387–398.
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