Accounting for correlated observation error in the assimilation of ATMS

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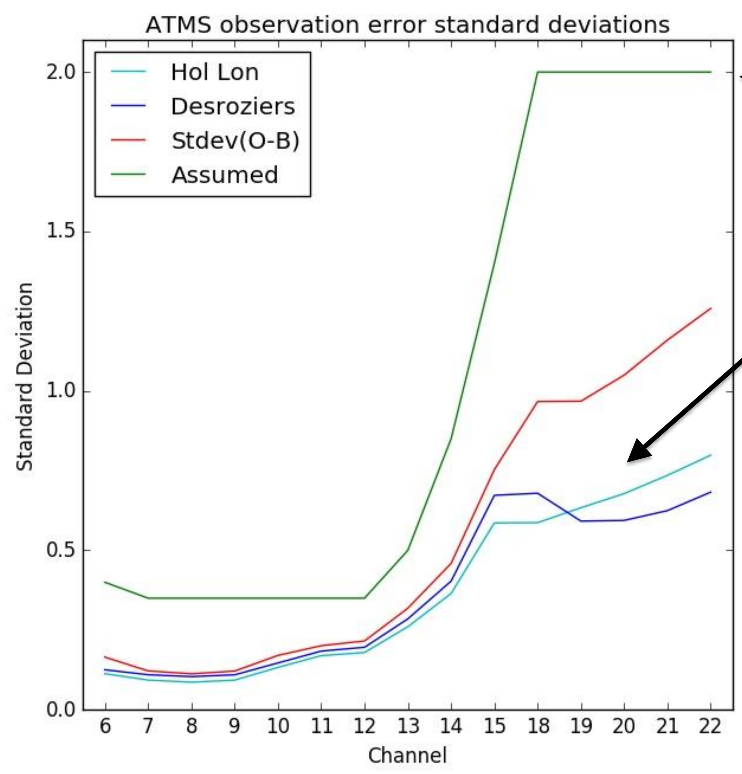
1) Introduction

In recent years a number of NWP centres have started taking account of inter-channel observation error correlations for hyperspectral IR data in their assimilation systems (Weston et al., 2014; Bormann et al., 2016). In addition, NRL have recently begun taking account of correlated error in the assimilation of ATMS data (Campbell et al., 2017). ATMS on Suomi-NPP is a single instrument which combines channels similar to those from AMSU-A and MHS. One of the main differences between the ATMS temperature sounding channels and the corresponding AMSU-A channels is stronger correlated instrument noise which is caused by a low-noise amplifier present on ATMS but not AMSU-A. This causes striping effects to be visible in first guess departure maps of ATMS data. Initially when ATMS was assimilated the assigned observation errors were inflated to indirectly account for the stronger correlations. The work on this poster investigates instead assimilating ATMS with smaller error variances and non-zero inter-channel error correlations.

2) Error diagnosis method

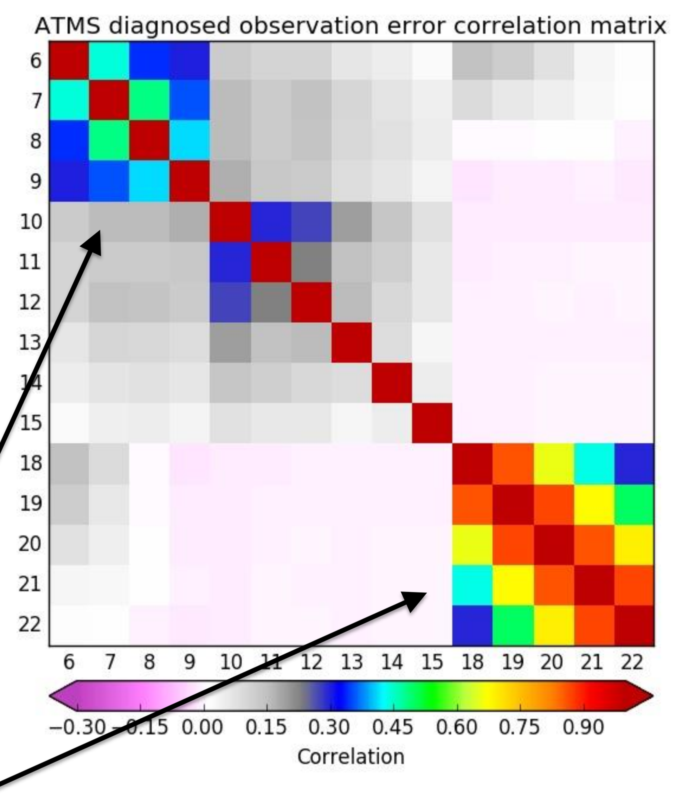
A combination of a posteriori diagnostic methods are used to estimate the observation errors and correlations in line with Bormann et al. (2016). Firstly the method of Hollingsworth and Lönnberg (1986) is used where the innovation covariances are calculated at various separation distances. The observation errors are assumed to be spatially uncorrelated so they are estimated by subtracting the covariances at the shortest separation distance from the covariances at zero separation. The estimate produced is modified by making the matrix symmetric and inflating the error standard deviations by a factor of 1.5. This matrix is then used in the assimilation system for a period of a month and the first guess and analysis departures from this experiment are used to estimate the observation error covariance matrix via the method of Desroziers et al. (2005).

3) Error diagnosis results



Currently used operationally assigned errors are significantly larger than diagnosed values using both methods

Figure 1: Standard deviations of operationally assigned observation errors, diagnosed observation errors and first guess departures for assimilated ATMS channels



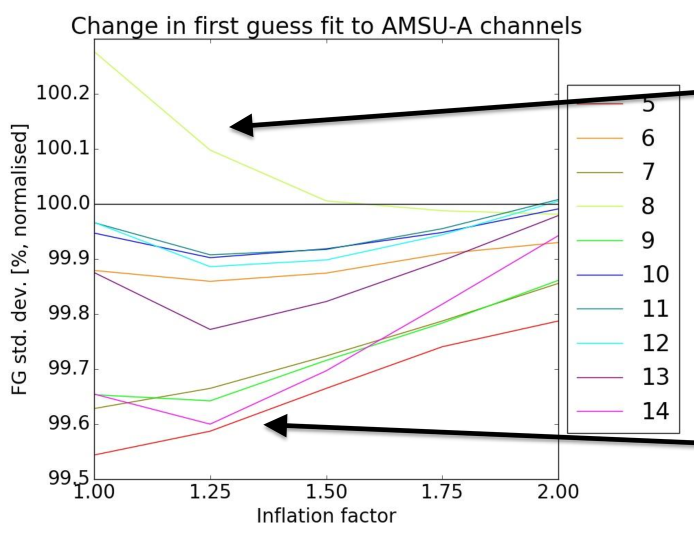
Strongest blocks of correlations for tropospheric temperature sounding and humidity sounding channels

Figure 2: Diagnosed observation error correlations for assimilated ATMS channels

4) Experiment results

Table 1: ATMS correlated error experiments summary

Exp no.	Control	1	2	3	4	5
Inflation	Current	1.0	1.25	1.5	1.75	2.0
Correlated	No	Yes	Yes	Yes	Yes	Yes



Degraded first guess fit to AMSU-A channel 8 for lowest inflation factors suggests tropopause degradation

Improved first guess fits to all other AMSU-A channels using any inflation factor tested

Optimal inflation appears to be 1.25 for most channels

Figure 3: Change in first guess fits to AMSU-A channels for ATMS correlated error experiments using various different inflation factors for error standard deviations

However, longer range forecast scores show significant degradations in the tropics when using inflation factors of 1.5 or less.

With an inflation factor of 1.75 the majority of benefits in the extra-tropics are preserved

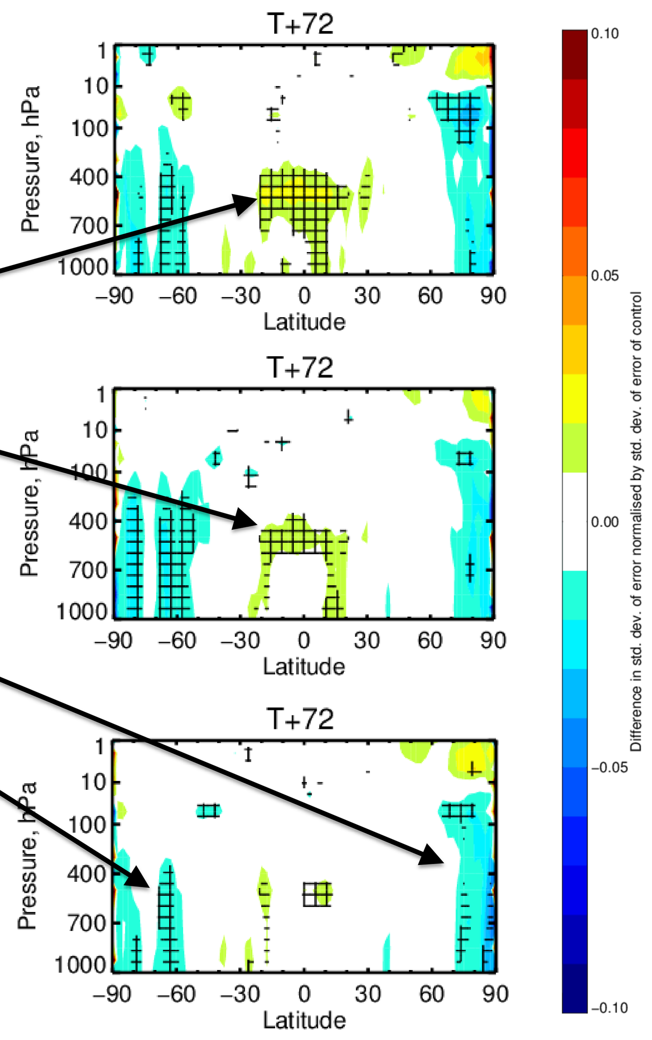
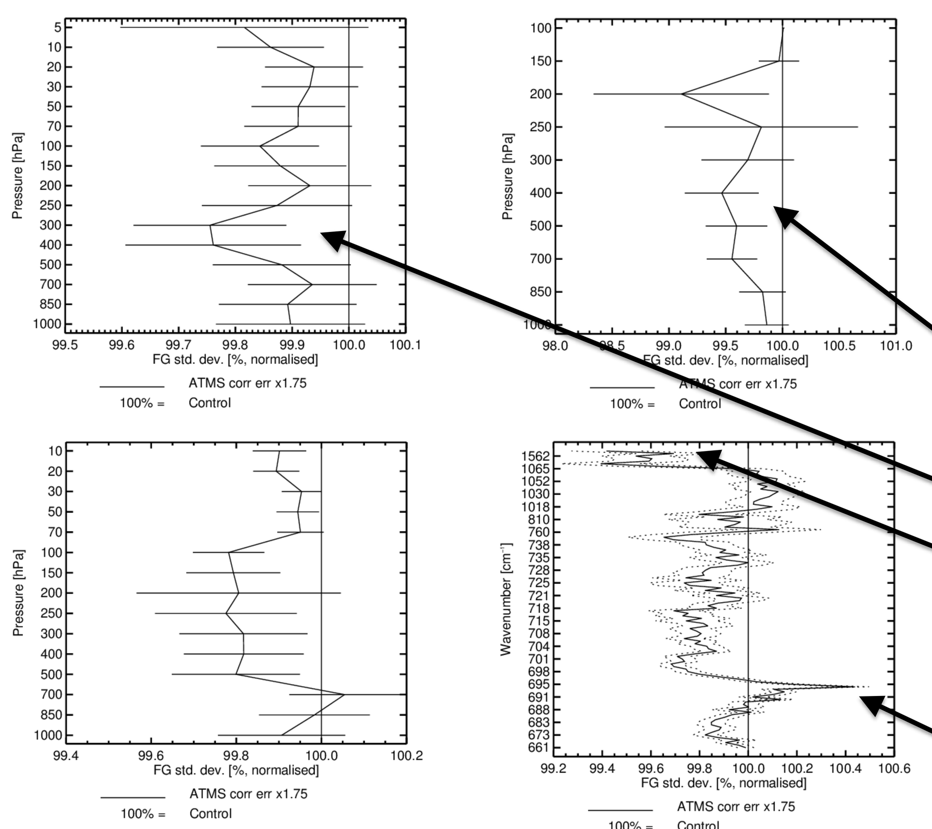


Figure 4: Zonal change in standard deviation of T+72 geopotential height forecast errors when accounting for ATMS correlated errors using an inflation factors of 1.25 (upper), 1.5 (middle) and 1.75 (lower)



Improved first guess fits to temperature, humidity and wind observations

Degradation to CrIS channels peaking around tropopause

Figure 5: Change in first guess fits to sonde temperature (upper left), sonde humidity (upper right), conventional wind (lower left), and CrIS (lower right) observations for ATMS correlated error experiments using an inflation factor of 1.75

5) Conclusions and future work

There are significant inter-channel error correlations between ATMS humidity channels and temperature sounding channels. Previously these were indirectly accounted for by inflating the error standard deviations. Experiments have shown that directly accounting for the error correlations and using significantly smaller error standard deviations lead to more aggressive use of the ATMS data and modest improvements to short to medium range forecast skill.

There are degradations to forecasts at the tropopause. A second round of experiments where the error standard deviations for stratospheric channels have been relaxed to the currently used values aims to address this while investigations into the cause are ongoing.

Depending on results from these latest experiments it is planned that correlated errors for ATMS will be implemented operationally from the next ECMWF upgrade cycle 45r2 aimed for implementation in 2018.

References

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Acknowledgements

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