Investigations on scene dependent observation errors to account for residual cloud contamination

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Motivation

- Hyper-spectral infrared data is used in completely clear and clear above cloud scenes.

- Completely clear scenes represent only ~ 10% of the data

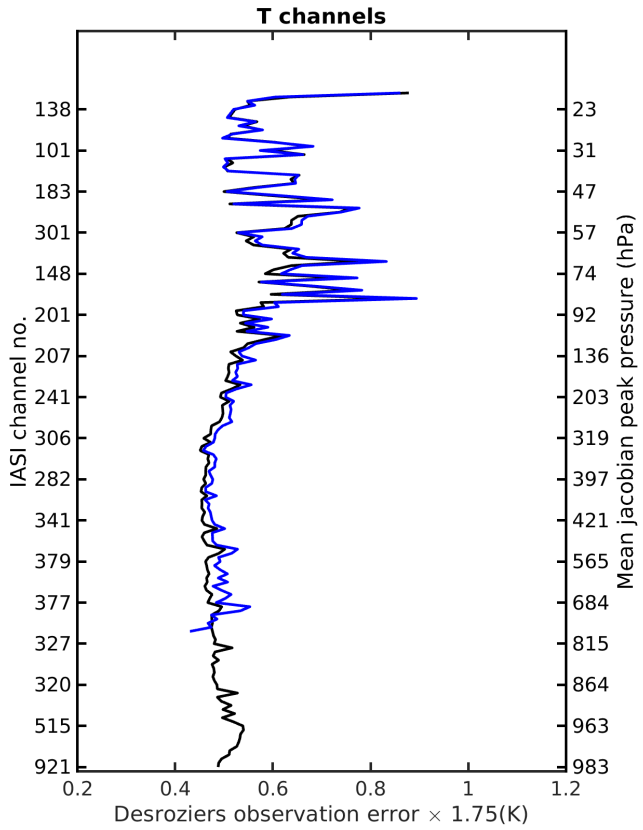
- Cloud detection must be
  - Conservative to avoid significant cloud contamination
  - But relaxed enough to avoid false detection to maximise data coverage

- Thus, part of the actively used data will include some residual cloud contamination and this is likely to introduce highly correlated errors in the affected radiances

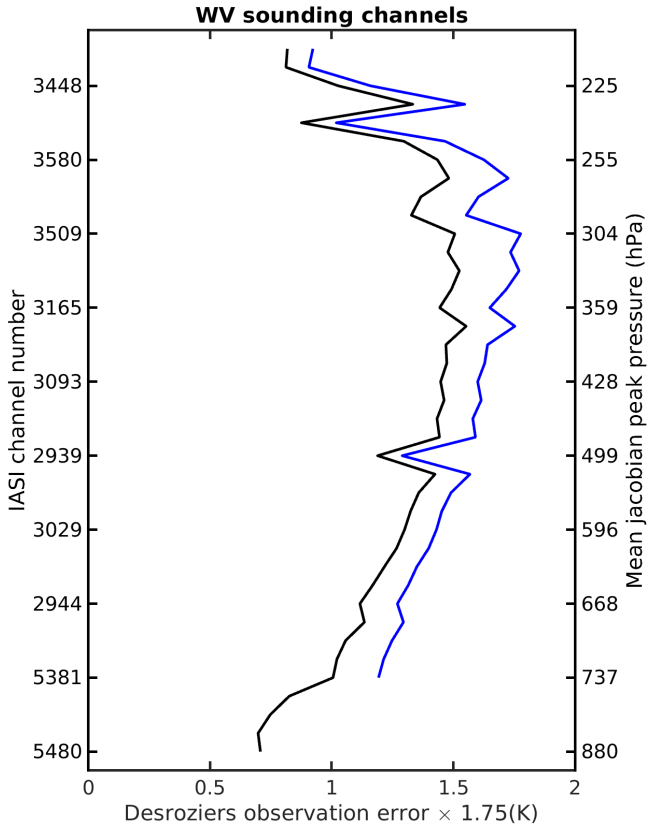
- Errors are typically diagnosed in clear scenes only and an empirical inflation factor is needed to compensate the non-diagnosed errors.

Increased errors diagnosed for channels diagnosed clear above cloud

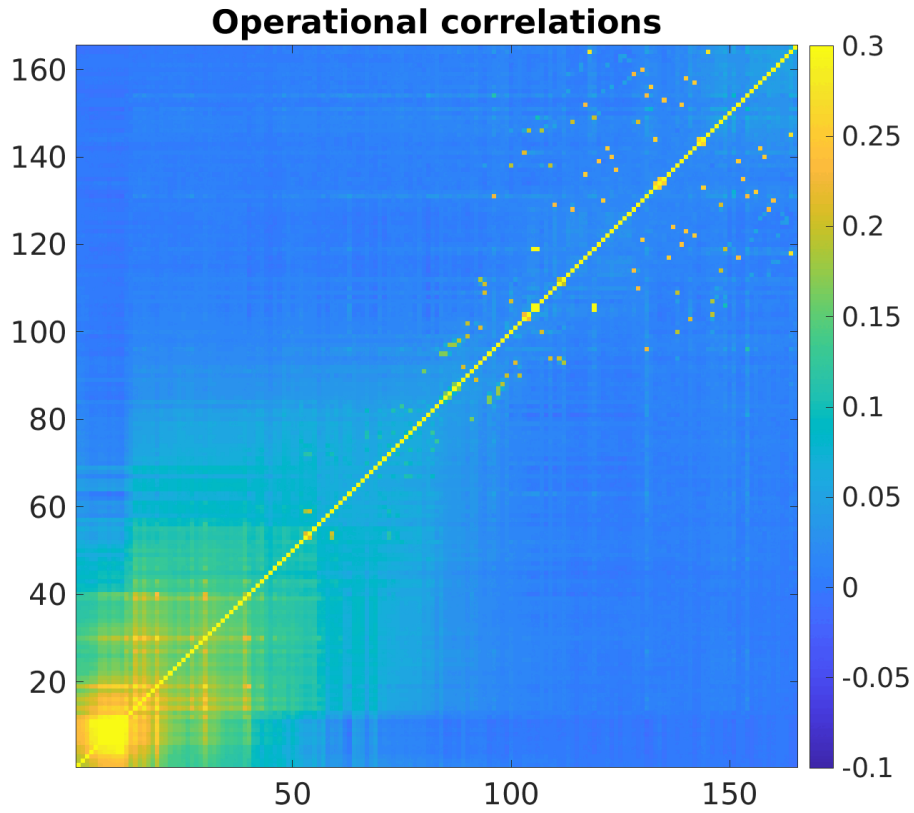
Diagnosed erros for T



Diagnosed erros for WV



Diagnosed error correlations for T sounding channels



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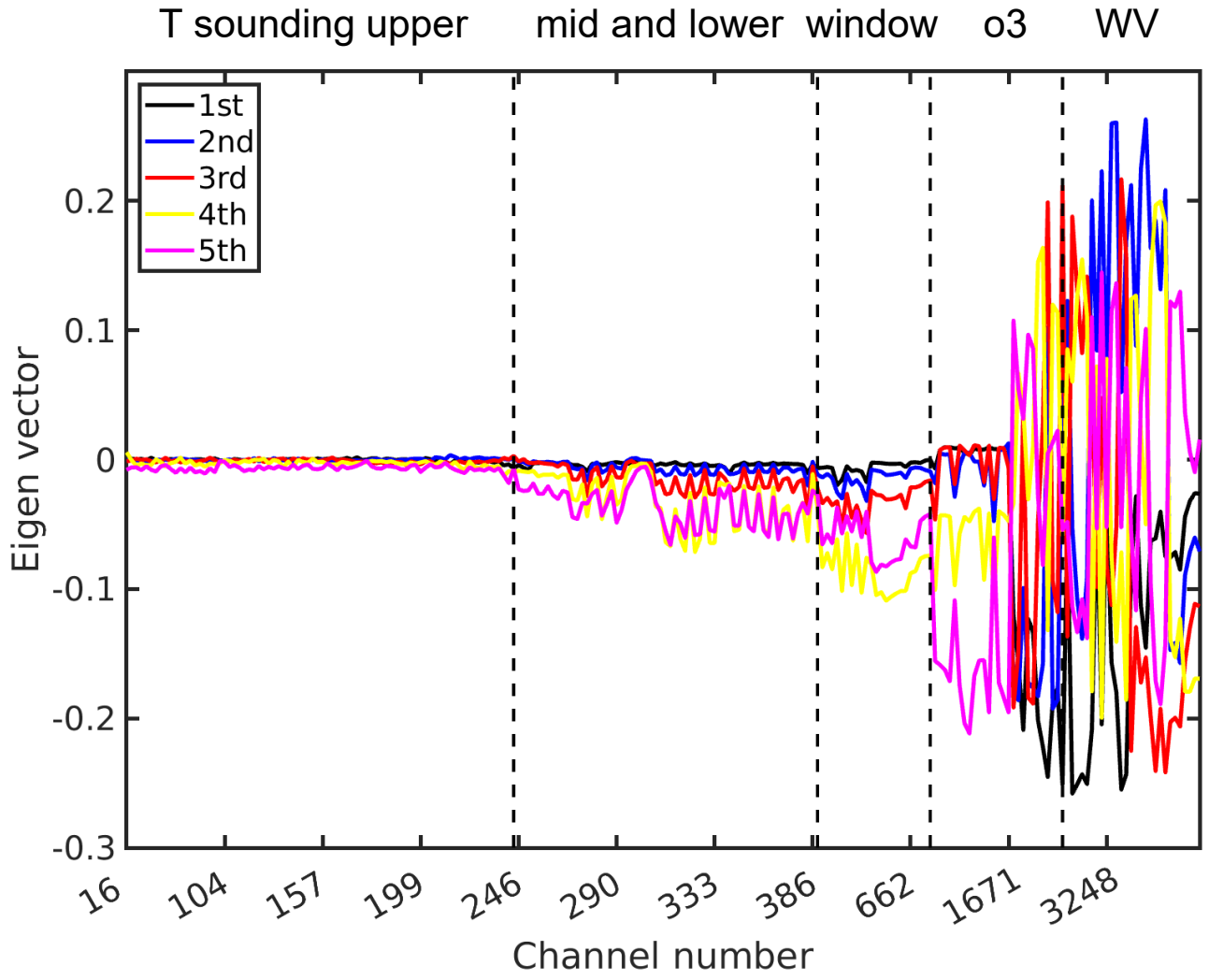
Clear scenes
Clear above cloud

First 5 eigenvectors of operationally used covariance (R) for IASI

- The leading eigenvectors of R represent structures with broad spectral features expected from residual cloud contamination.

- Strongest signal in the humidity sensitive channels.

- Clear signal in eigenvectors 3 - 5 for tropospheric temperature sensitive channels.



Comparing eigenvalues for clear and clear above cloud covariances (R)

- R diagnosed from clear channels above cloud has larger eigenvalues than the operationally used R which is diagnosed in clear scenes.
  - For eigenvalues 1-4: factor ~1.3
  - For the 5th eigenvalue: factor ~2.3

- Idea under testing: inflate the eigenvalues of operational R to take into account the errors from residual cloud contamination.

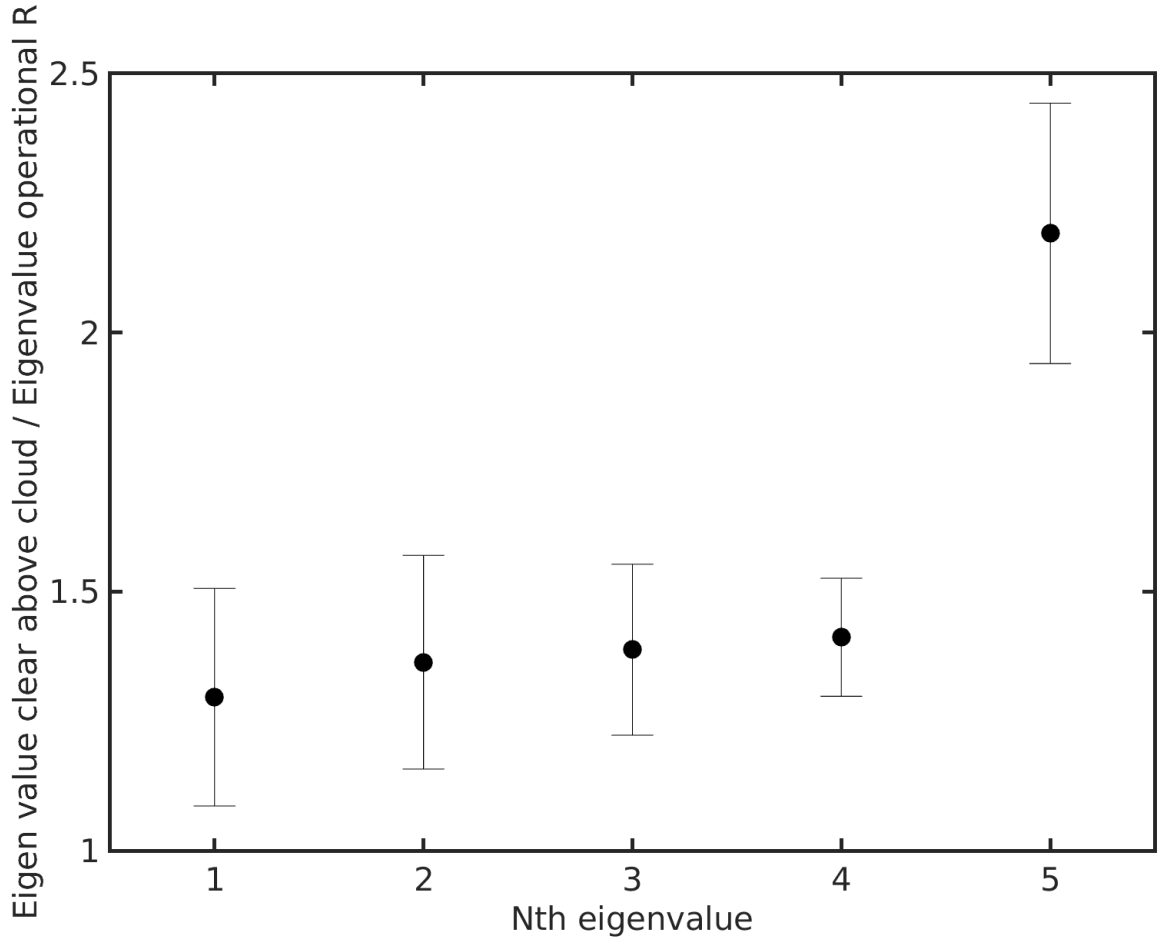
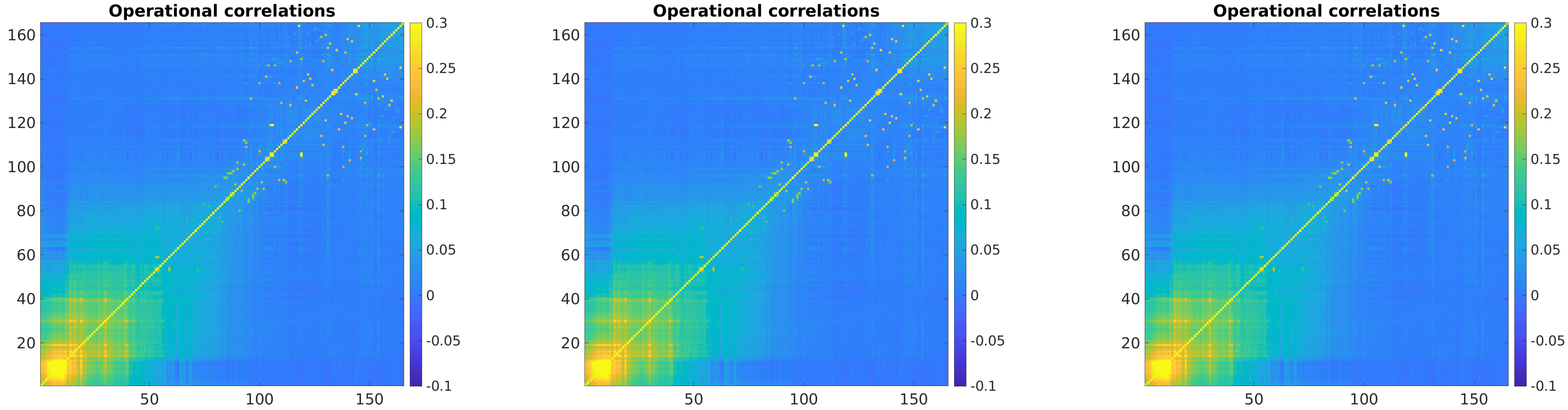


Illustration of scene dependent error correlations produced with the method

- The method under testing produces stronger correlation structures for channels sensitive just above the cloud top (right) and mimics well the behaviour of correlations diagnosed for clear channels above cloud (middle). In operations the correlations stay unchanged (left).



Experimenting with scene dependent observation errors for IASI

- ECMWF cycle 48r1, summer 2.6-31.8.2020 and winter 2.12.2020-28.2.2021 periods

- Control: all observations used as in operations

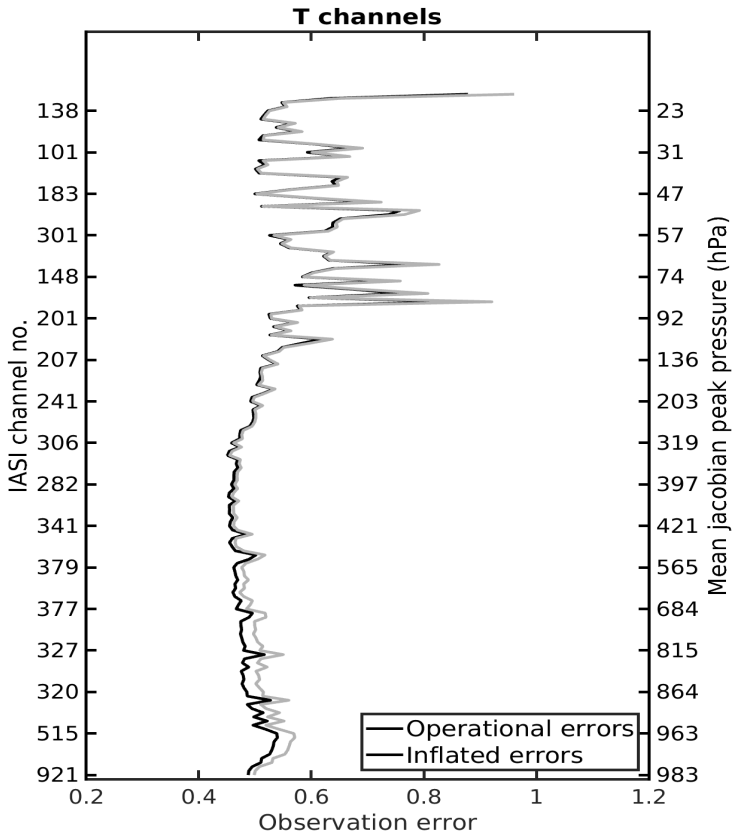
- Experiments focusing on:
  - What happens if the error inflation is applied on top of the operational errors?
  - Can more weight be given for clear scenes and channels sensitive high above the cloud top?

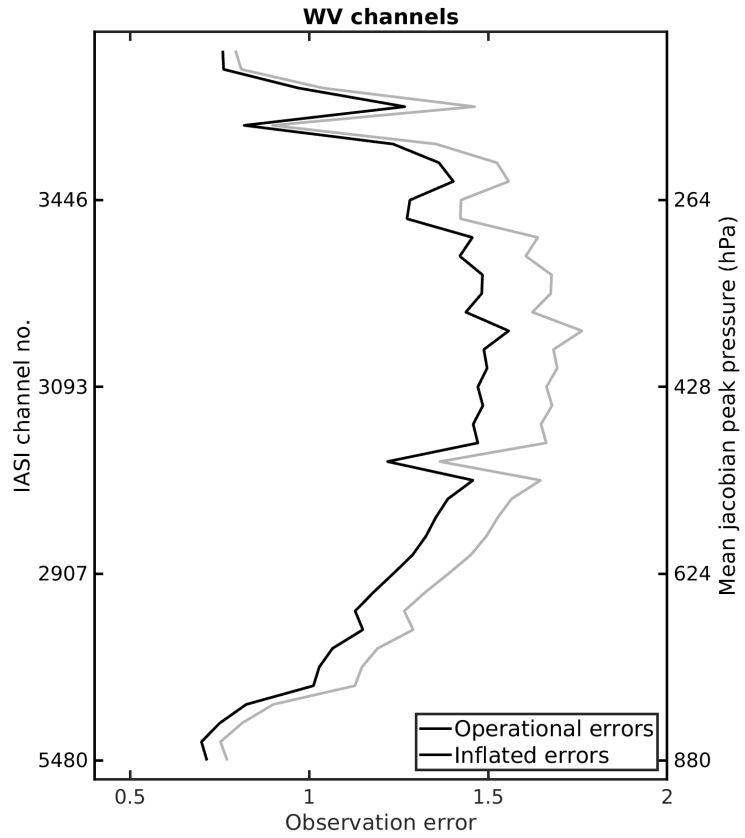
- In the following test experiments errors are inflated for channels just above the cloud top and also made more correlated by inflating the first 5 eigenvalues of R.

Errors are inflated in a similar manner than seen in diagnosed errors

Average observation errors in clear scenes vs clear above cloud

- Black line: operational errors for IASI, now used for clear scenes
- Grey line: average inflated errors for channels diagnosed clear above cloud

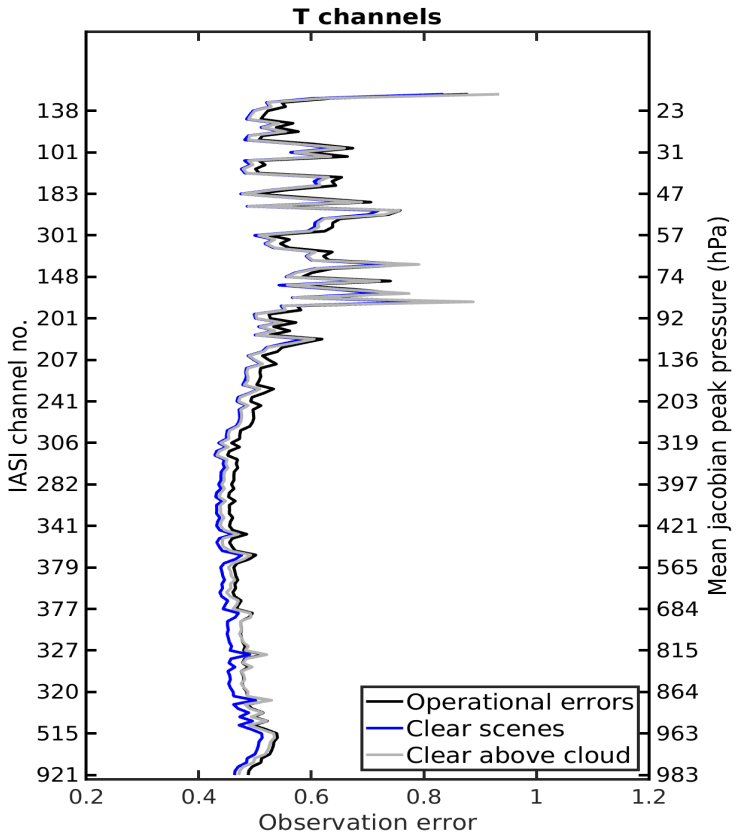


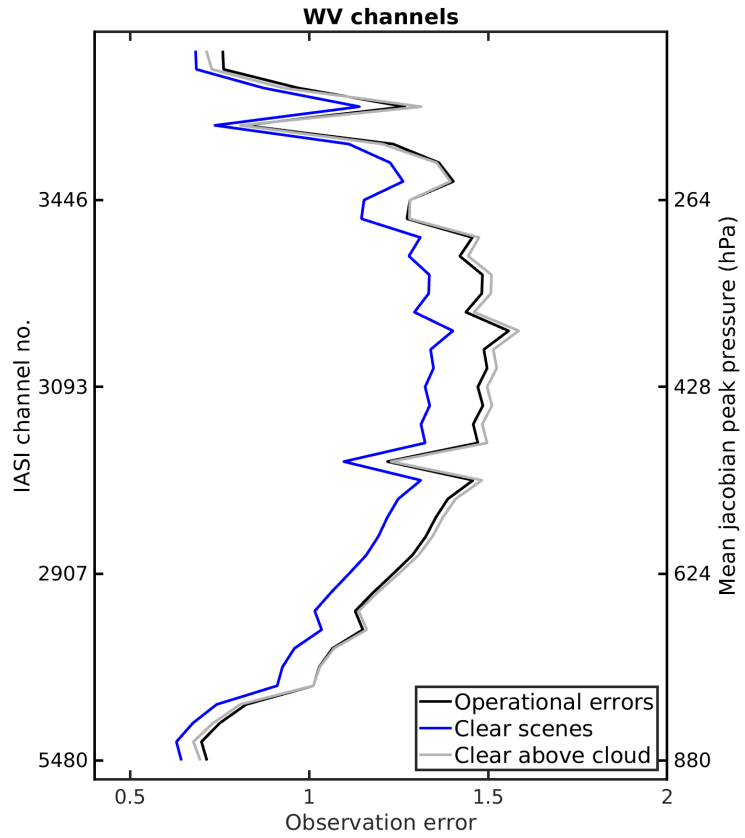


Can more weight be given for clear scenes

Average observation errors in clear scenes vs clear above cloud

- Black line: operational errors for IASI
- Blue line: 0.95 x operational errors for T channels and 0.9 x operational errors for WV channels for clear scenes
- Grey line: average inflated errors for channels diagnosed clear above cloud

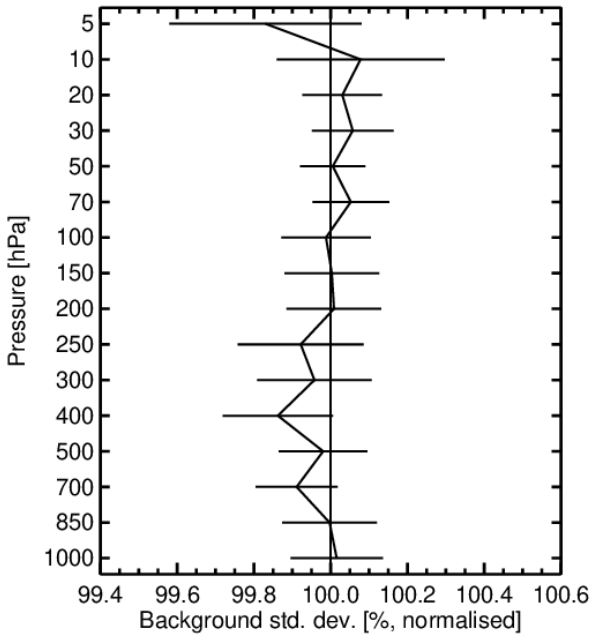




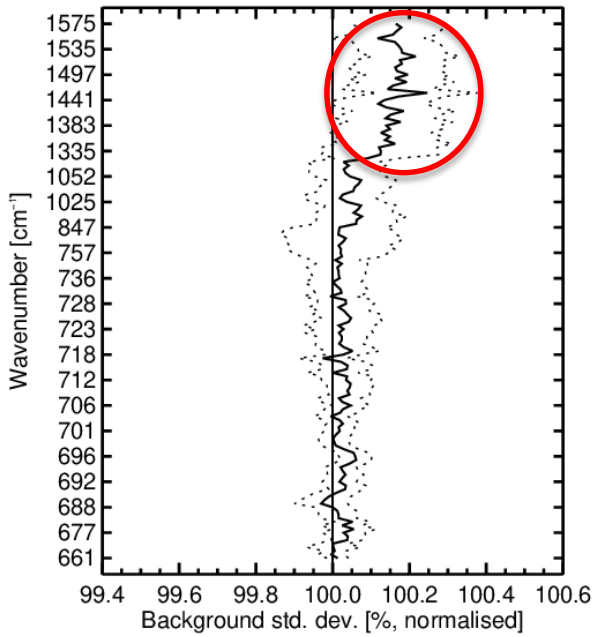
Applying the error inflation on top of the operational errors

- Negative impact on humidity
- Mainly neutral impact on temperature

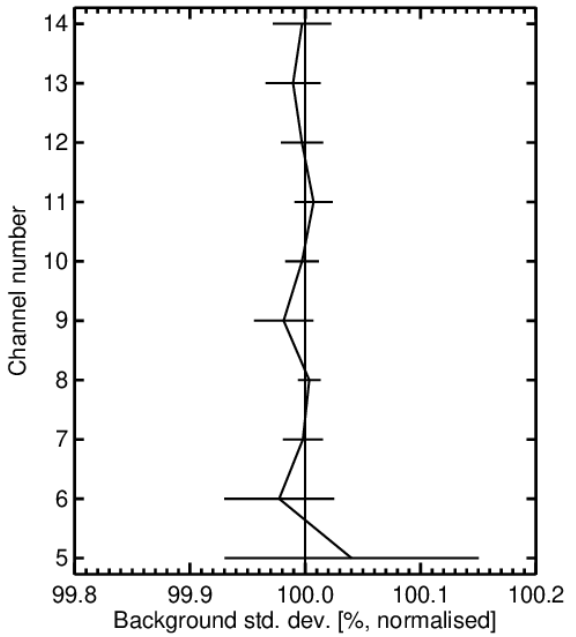
Radiosonde temperature



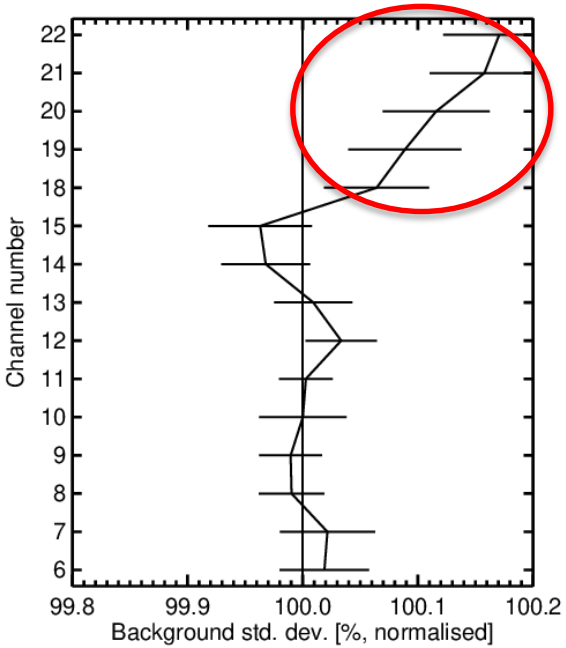
CrIS



AMSU-A



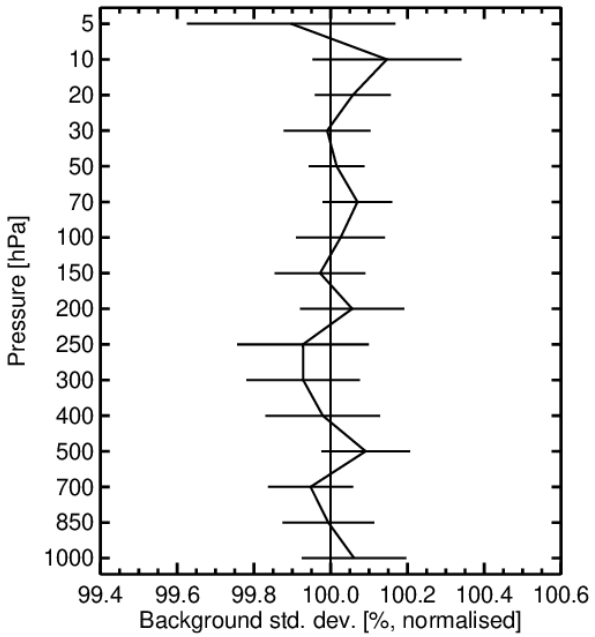
ATMS



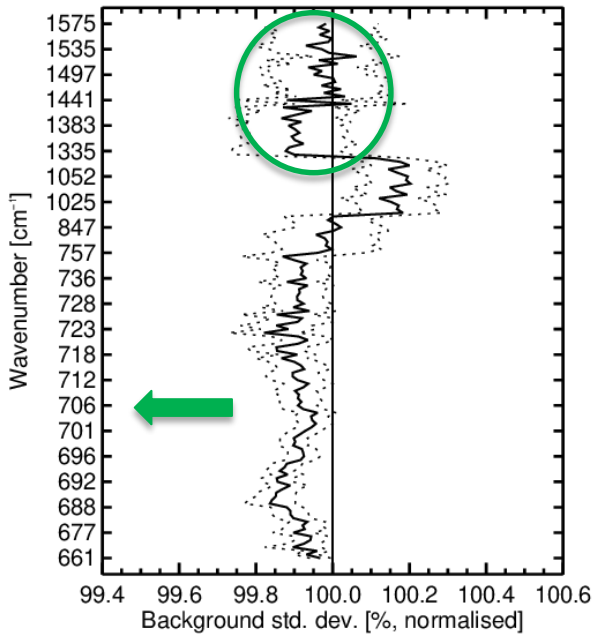
Giving more weight to clear scenes and channels peaking high above the cloud

- Neutral to positive impact, strongest improvements seen against other hyperspectral IR instruments
- ATMS indicating some degradation for temperature while the fit to humidity sensitive channels indicates now more neutral impact.

Radiosonde temperature



CrIS



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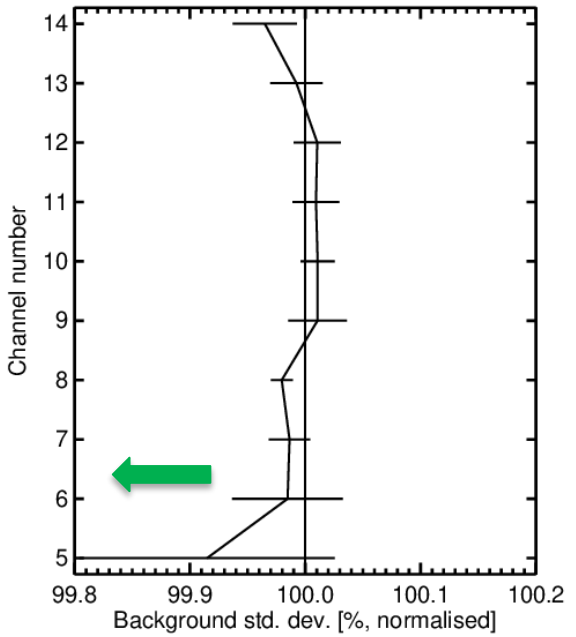
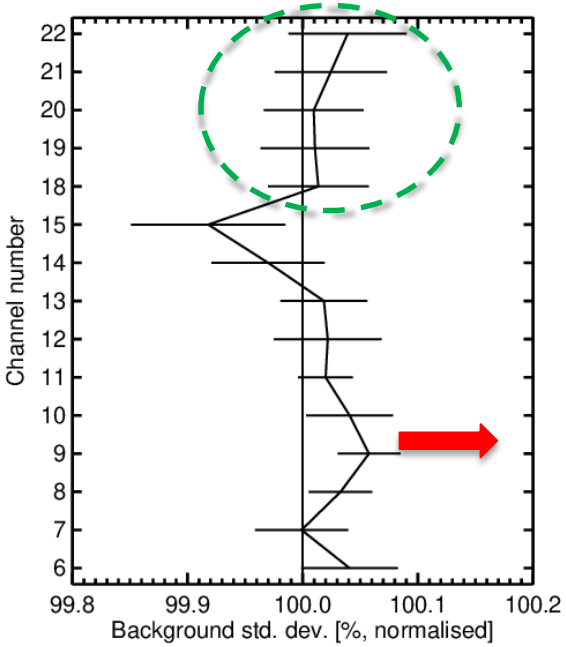


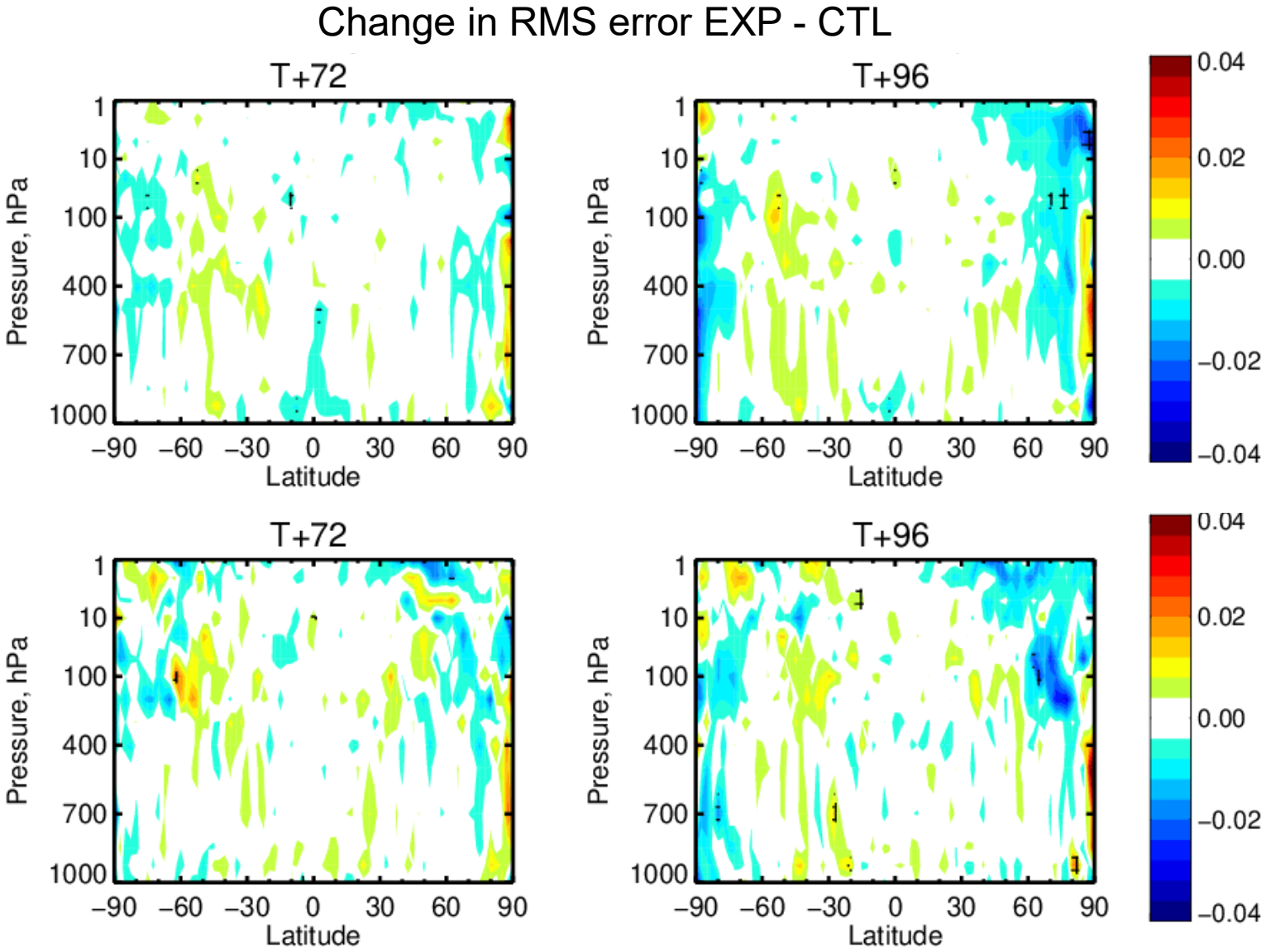
ATMS



Impact on longer range forecasts is neutral (more weight given for the clear scenes)

Temperature

Relative humidity



Conclusions

- Residual cloud contamination leads to stronger errors and error correlations for clear channels used above cloud.
  - A method to take this into account for hyperspectral IR is being developed and tested with IASI data. Method is based on modifying first few eigenvalues of the error covariance diagnosed in clear scenes.

- What happens if the error inflation is applied on top of the operational errors?
  - Degradation for short range humidity forecasts, mainly neutral impact on temperature.

- Can more weight be given for clear scenes and channels sensitive high above the cloud top?
  - For humidity sensitive channels yes, for temperature sounding channels results are more mixed
  - Empirical inflation factor for the diagnosed errors is still required.

- Experimenting how sensitive the results are to the used eigenvalue inflation factors is ongoing. The approach will also be tested for other hyperspectral IR instruments.