Implications of observation error correlation on the assimilation of interferometric radiances

Reima Eresmaa, Niels Bormann and Tony McNally

Outline

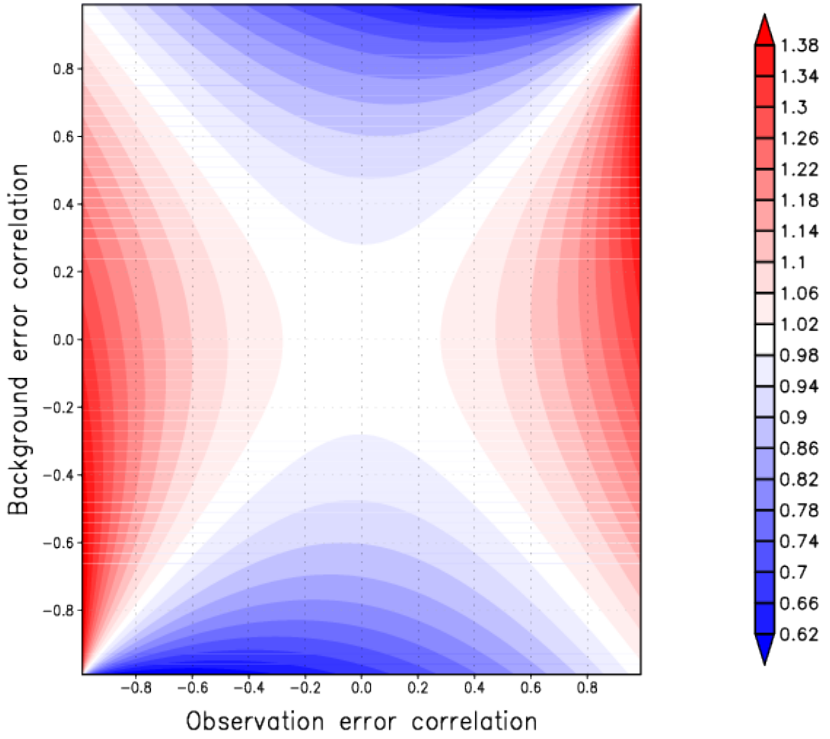
- Theoretical effect of observation error correlation (OEC) on information content in linear analysis framework
- Derivation of OEC-based and reference channel selections for the assimilation of IASI radiances

  → Effect of OEC on channel selection in a realistic framework
- Performance comparison in theory and practice
- Summary

Degrees of Freedom for the Signal (DFS)

in a two-parameter / two observation system

*DFS **decreases** with increasing BG error correlation …*



*… but **increases** with increasing OEC.*

Current approach for the assimilation of IASI radiances at ECMWF

- Normally no OEC assumed at all
- Experimental assimilation with explicitly accounting for (inter-channel) OEC in the **4D-Var** step
- Most optimally, both inter-channel and spatial OEC would be explicitly taken into account in **pre-screening**, **channel filtering**, and **4D-Var** steps

What do we know about OEC (in the framework of infrared sounders)?

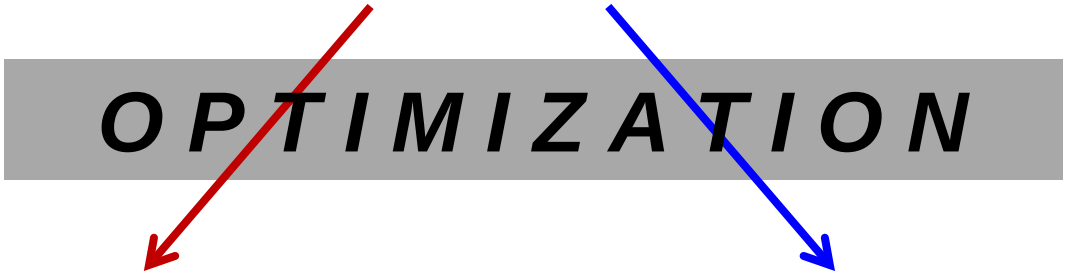
- Errors related to representativeness and forward modelling are likely correlated, but these are difficult to quantify for all channel pairs
- Diagnostic tools provide some information but are subject to validity of certain assumptions
- Signal processing theory provides accurate knowledge of OEC associated to signal apodization
  - Strong OEC between channels adjacent to each other (0.70 in the case of IASI)
  - Weaker (but non-zero) OEC between alternate channels (0.25 in the case of IASI)

  → Only a few pairs of adjacent channels are included in the operationally-assimilated subset of IASI channels

Are there implications on channel selection?

Operational list:

- 191 channels
- Practically optimized



Reference list:

- Optimized assuming no OEC
- Pairs of adjacent channels not allowed

OEC-based list:

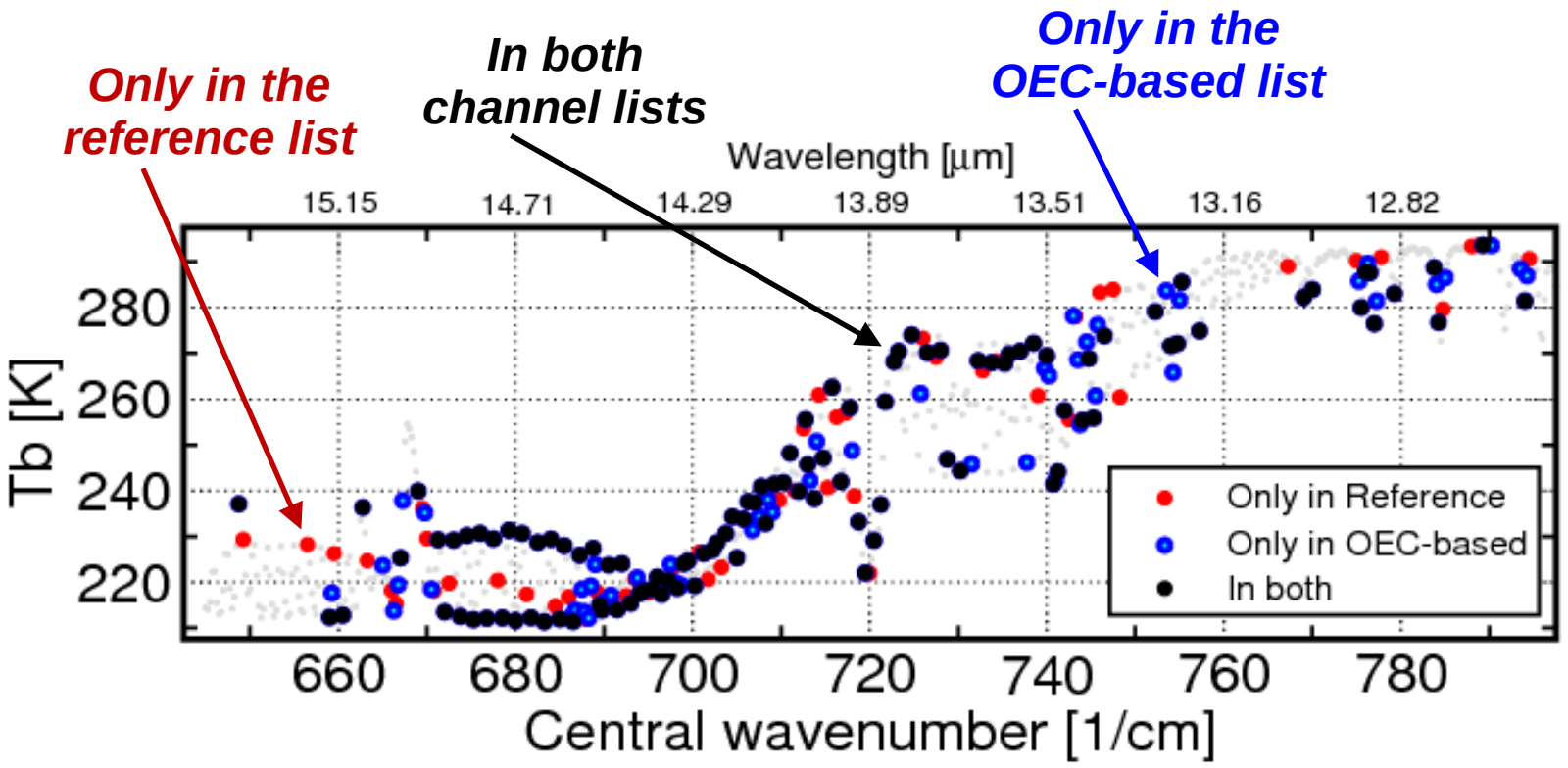
- Optimized assuming the signal apodization to be the only source of OEC
- Pairs of adjacent channels allowed

Optimization algorithm

- The idea is to repeatedly replace the least useful channel contained in the list by the most useful channel not yet included
- Usefulness of a channel is measured in terms of its contribution to the overall DFS
- Only the first 600 IASI channels are considered

- Observation error variances set using a polynomial fit on background departure statistics on operationally-used channels
- A representative description used for background error covariance
- Consider analysis state vector consisting of surface temperature and 43-level profiles of temperature, humidity and ozone
- Two reference profiles representing mid-latitude summer and winter

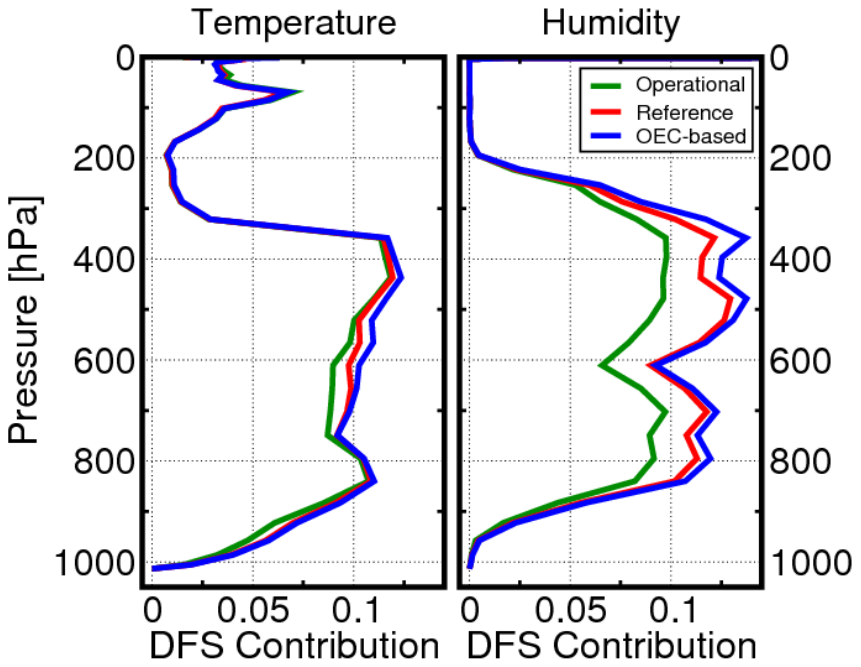
The effect of OEC on channel selection



→ The OEC-based list contains fewer stratospheric- and upper-tropospheric sounding channels, but more lower-tropospheric and humidity-sensitive window channels

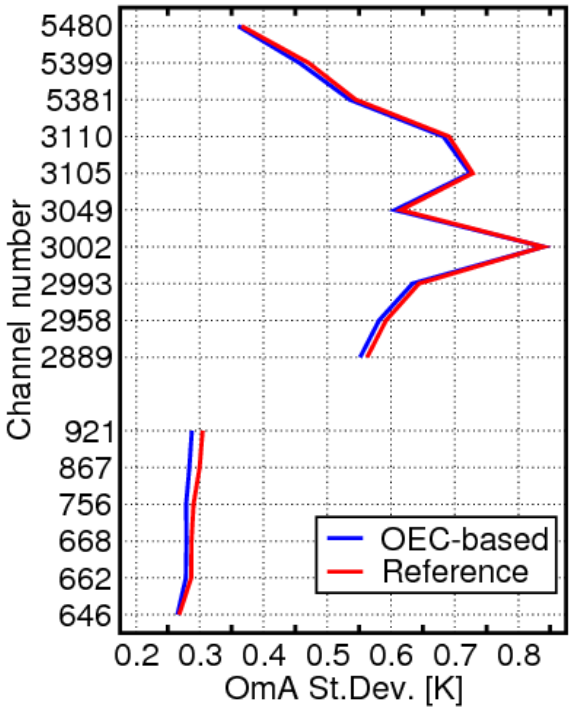
Theoretical performance comparison

	Reference	OEC-based
Iterations	38	76
DFS @ start	11.02	10.73
DFS @ end	11.84	12.14
% of maximum available	76.7	83.7

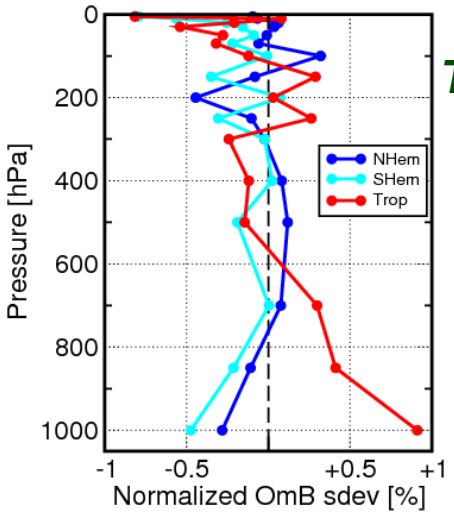


→OEC-based list performs better in retrieving mid-tropospheric temperature and tropospheric humidity information

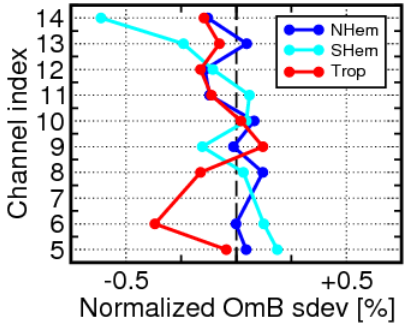
Practical performance comparison:
Observation departure statistics



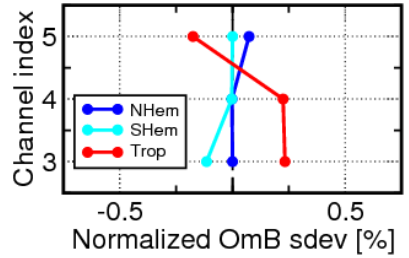
IASI analysis fits (tropics)



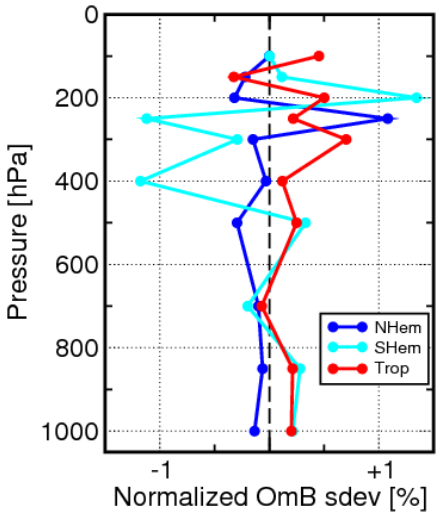
TEMP-T background fits



Metop-A AMSU-A



Metop-A MHS

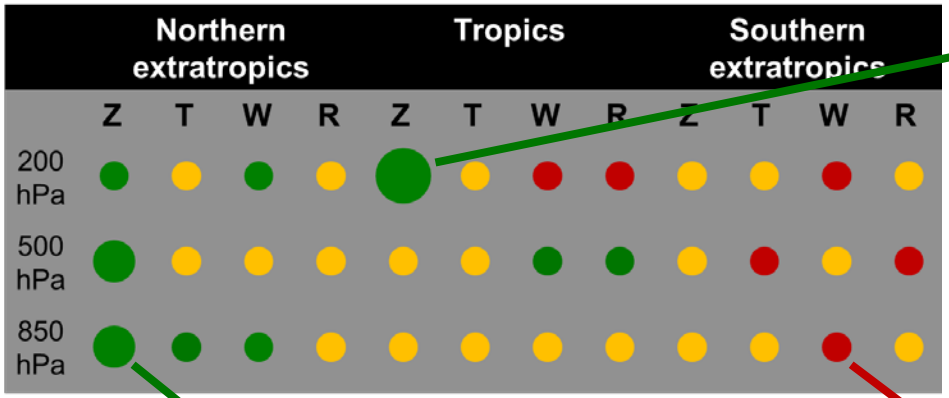


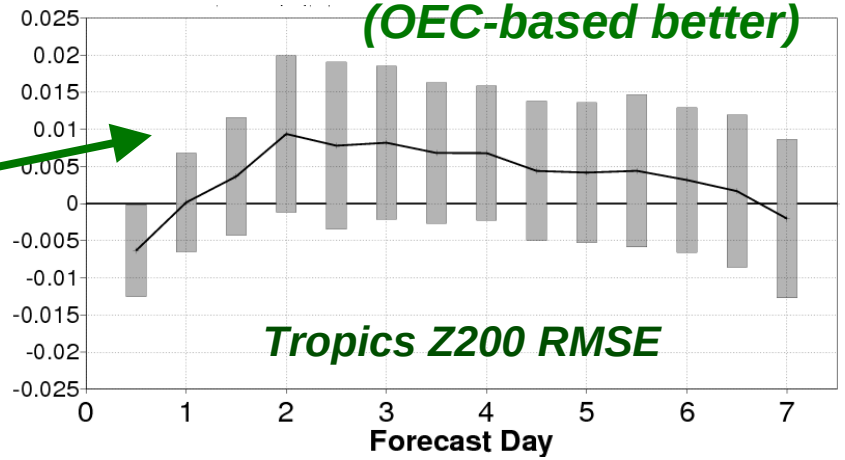
TEMP-Q

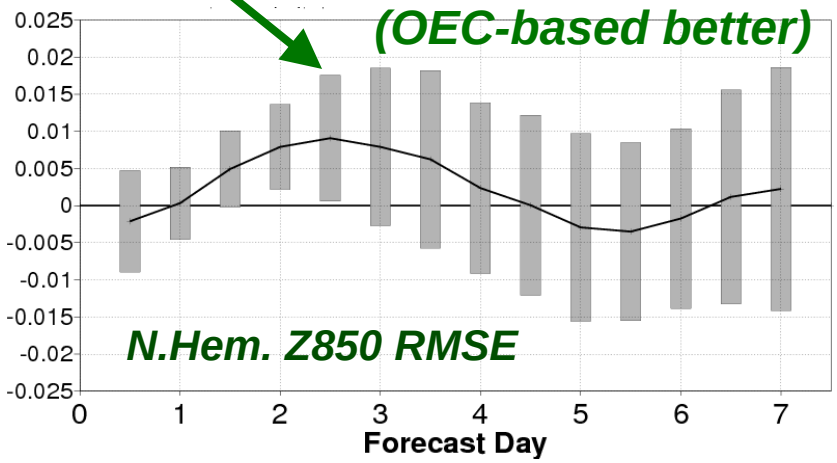
83 days in 38r2 / T511 / L91
(OEC-based – Reference) / Reference

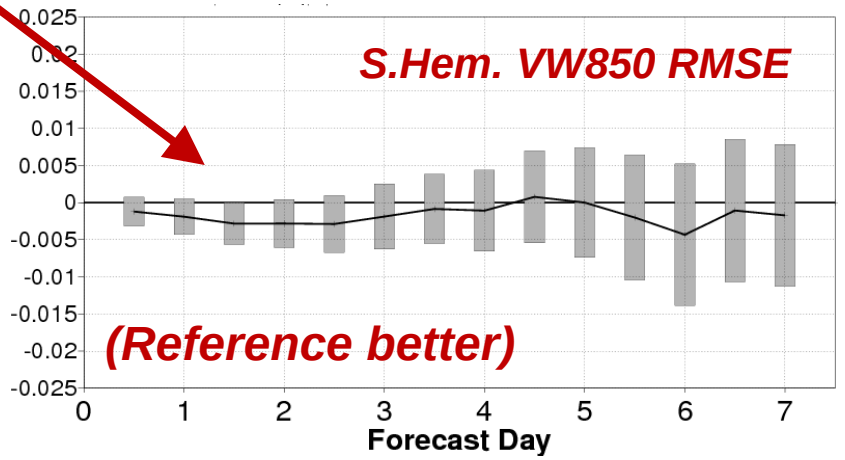
Practical performance comparison:

Medium-range forecast scores









Summary

- Inter-channel OEC is shown to have implications on the optimization of interferometric channel selections

  → Assimilation of IASI radiances could potentially be improved by making deliberate use of spectrally-adjacent channel pairs

- Theoretical analysis benefits from improved capability to distinguish between temperature and humidity errors, when OEC is taken into account in the channel selection

- Assimilation experiments show little benefit from accounting for OEC already in the channel selection

  → It continues to be difficult to fully resolve the temperature-humidity-ambiguity in practical 4D-Var assimilation