Accounting for correlated observation error in the assimilation of IASI observations

Peter Weston, 3rd IASI Conference, 05/02/2013

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- Error Diagnosis

- Using Correlated Errors

- Assimilation Trial Results

- Conclusions & Future Work

- Acknowledgements: Laura Stewart, James Cameron, Brett Candy, John Eyre, Fiona Smith, Ed Pavelin, Bill Bell, Niels Bormann

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Introduction

- Inter-channel error correlations can be caused by:

  - Representativeness errors

  - Forward model errors

  - Apodisation

- Currently these are ignored by using a diagonal **R** matrix with inflated error values

- Accounting for them means using a full **R** matrix with non-zero off diagonal elements

- Should lead to improved use of IASI data by:

  - Giving the correct weight to these observations

- First step: Need to know what the correlations look like

Desroziers Diagnostic

- Initially intended as a consistency diagnostic

- Can be used to estimate the true structure of the **R** matrix

- The method assumes that the **R** and **B** matrices used in the original assimilation are correct

- The method derives the following formula for **R** which includes both 'O-A' and 'O-B' statistics

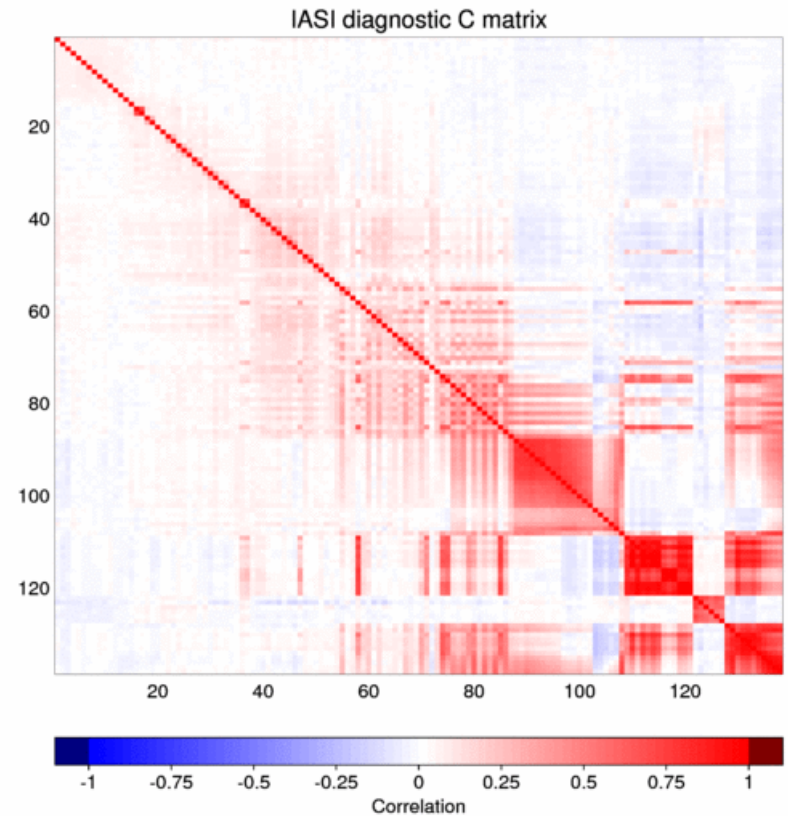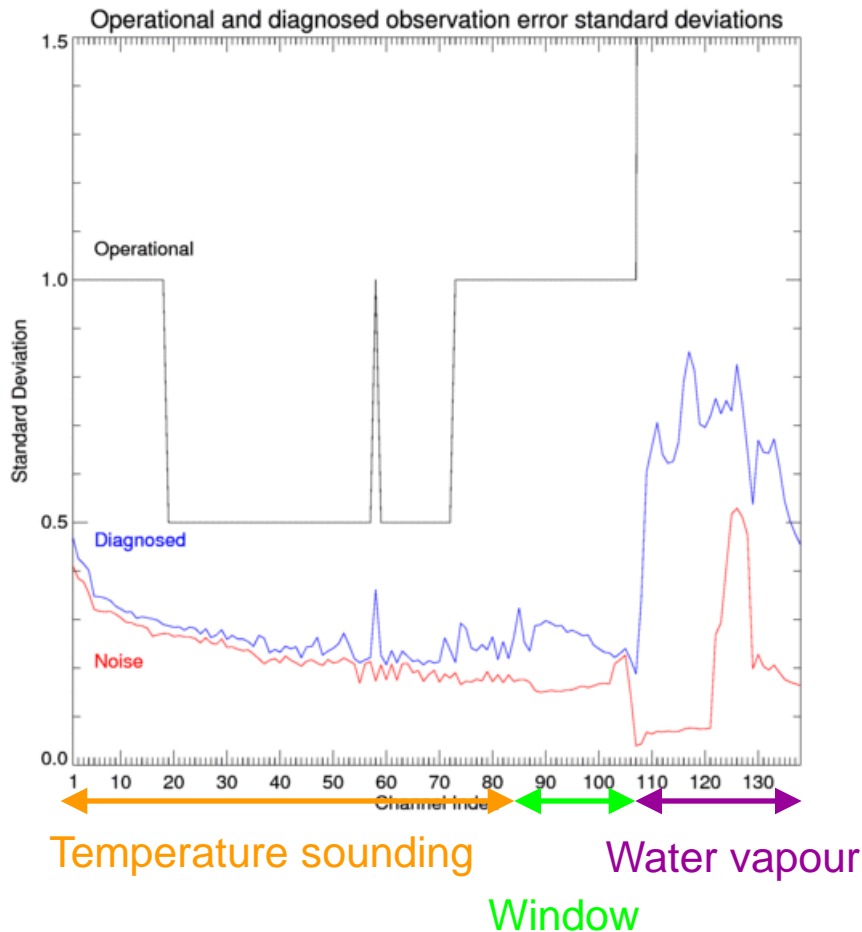$$R(i, j) = \frac{1}{N} \sum_{k=1}^{k=N} \{(y - H[x_a])_i (y - H[x_b])_j\}_k$$

- Where *i* and *j* are channel numbers and *N* is the number of observations where both channels *i* and *j* are selected
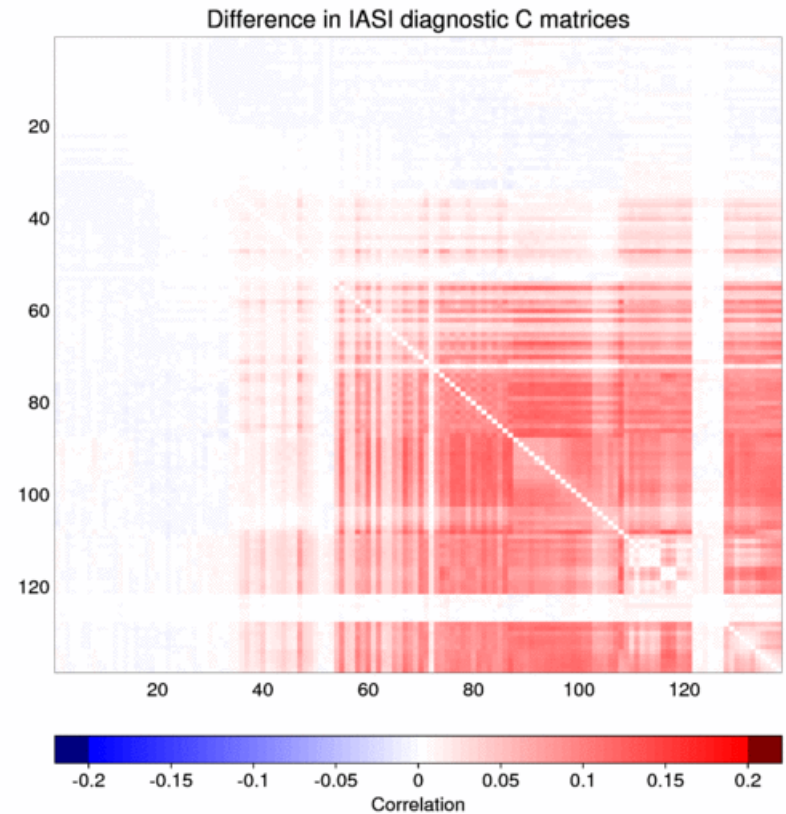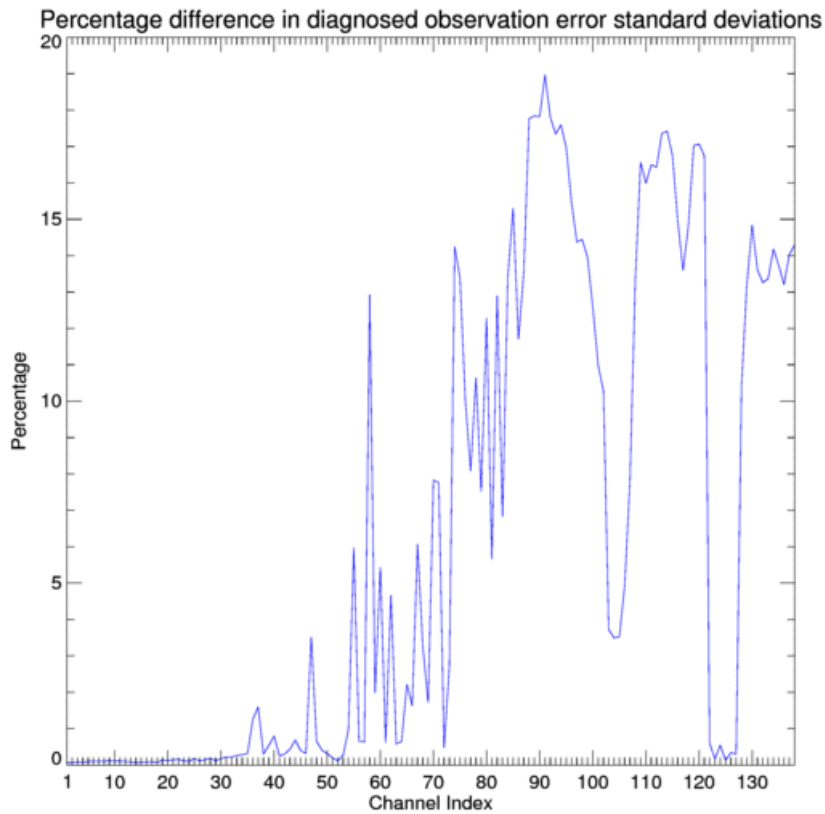
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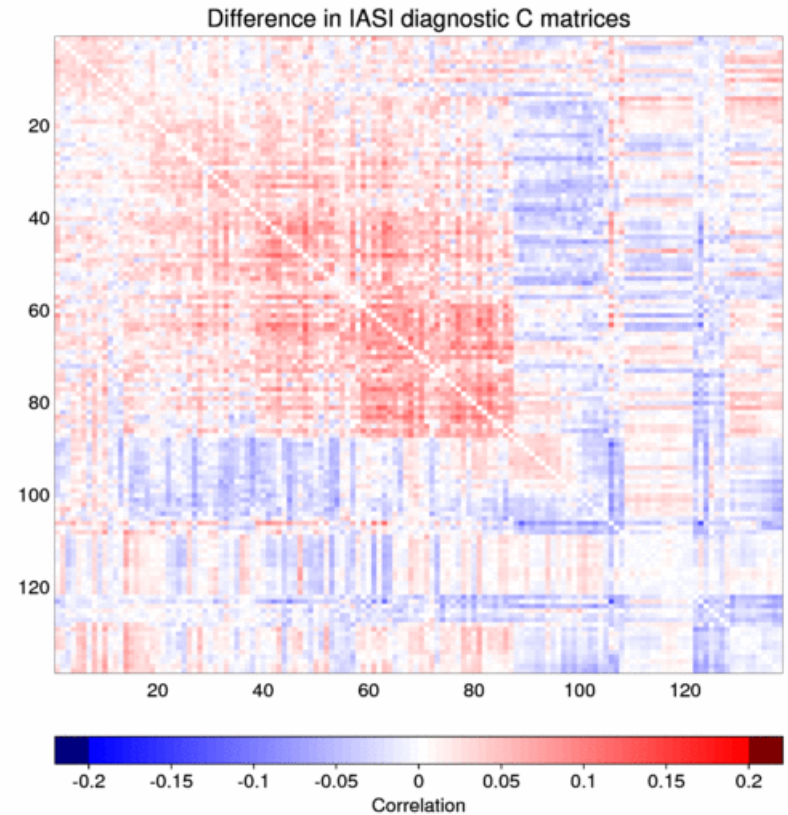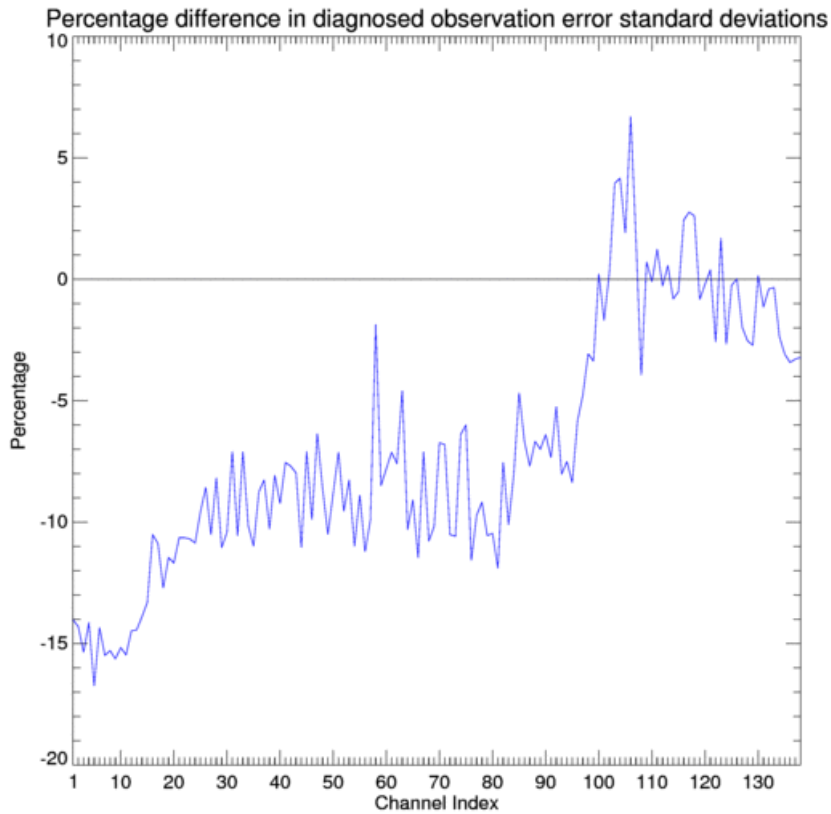- Conclusions & Future Work

Diagnosed IASI errors from 4D-Var

Operational and diagnosed observation error standard deviations

IASI diagnostic C matrix

Temperature sounding

Window

Water vapour

Different 4D-Var Resolutions

Percentage difference in diagnosed observation error standard deviations

Difference in IASI diagnostic C matrices

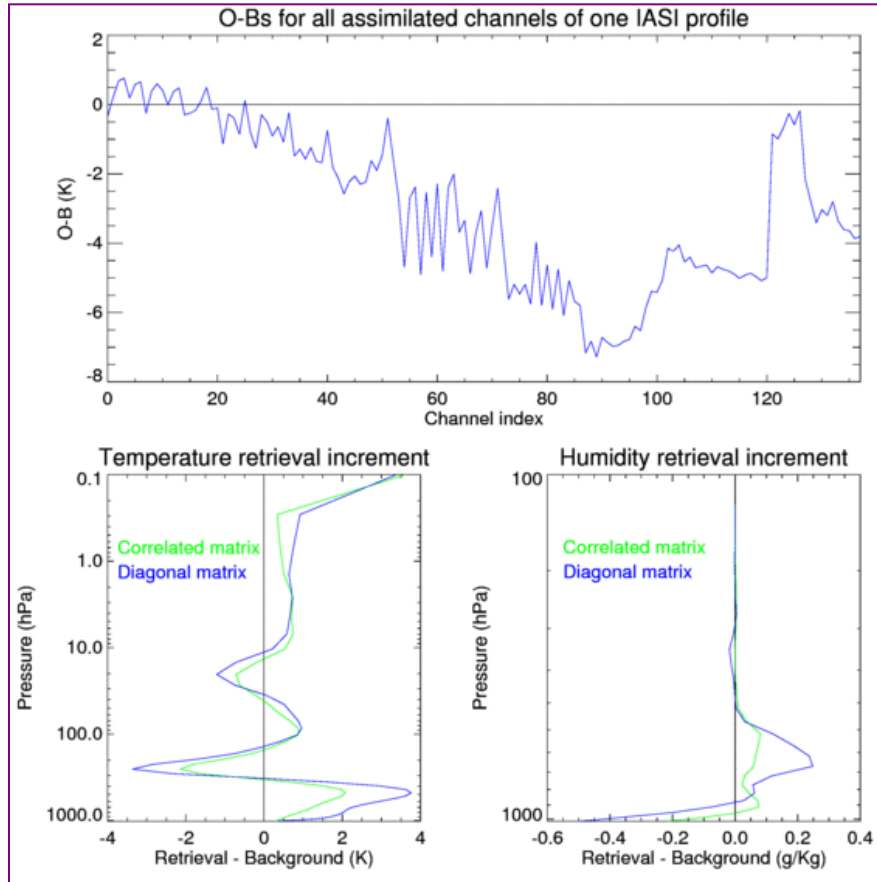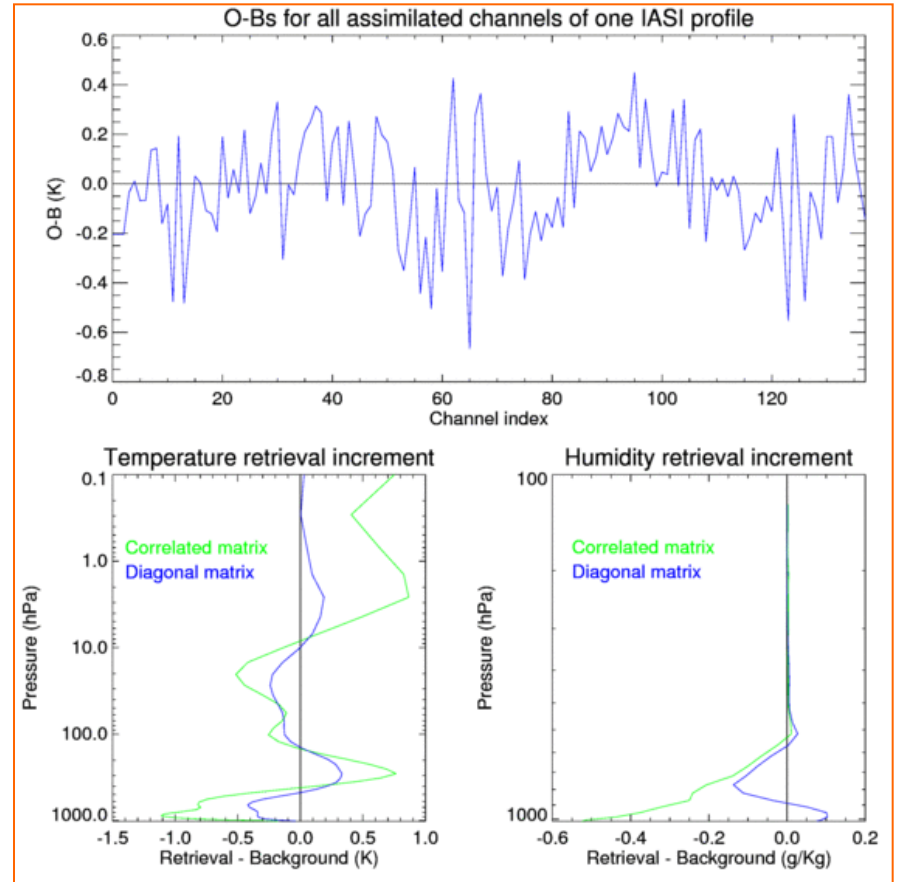# MetOp-B IASI v MetOp-A IASI

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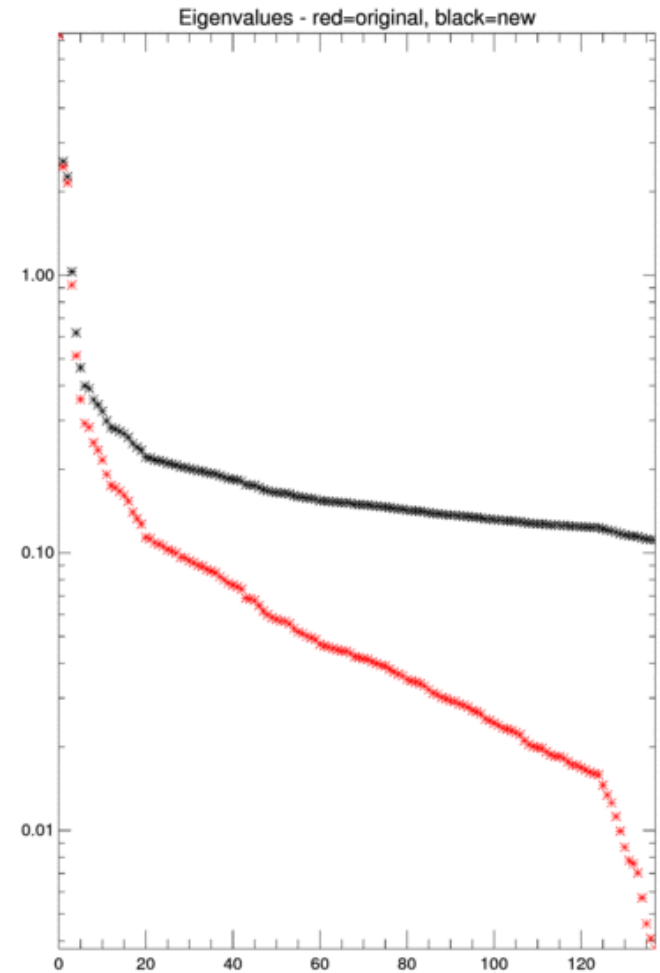# Effect of accounting for correlated errors
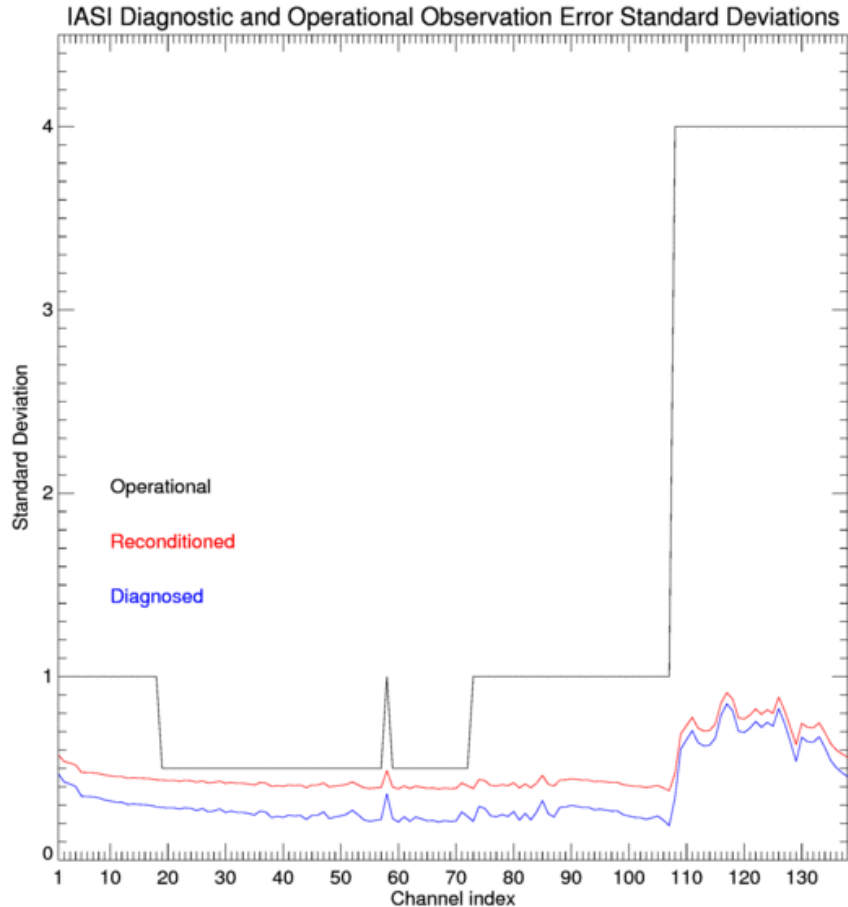

Down-weighted observation

Up-weighted observation

Testing the matrix in 4D-Var

- The extra time required to invert the matrix was negligible
- The minimisation took over double the number of iterations to converge as with the diagonal matrices
- Fixing the number of iterations caused the assimilation to fail
- Problems with convergence related to the conditioning
- The condition number of a matrix is:

$$\kappa = \lambda_{max} / \lambda_{min}$$

- I tried reconditioning the matrix to improve the stability of the minimisation…

Reconditioning

Eigenvalues - red=original, black=new

IASI Diagnostic and Operational Observation Error Standard Deviations

Operational
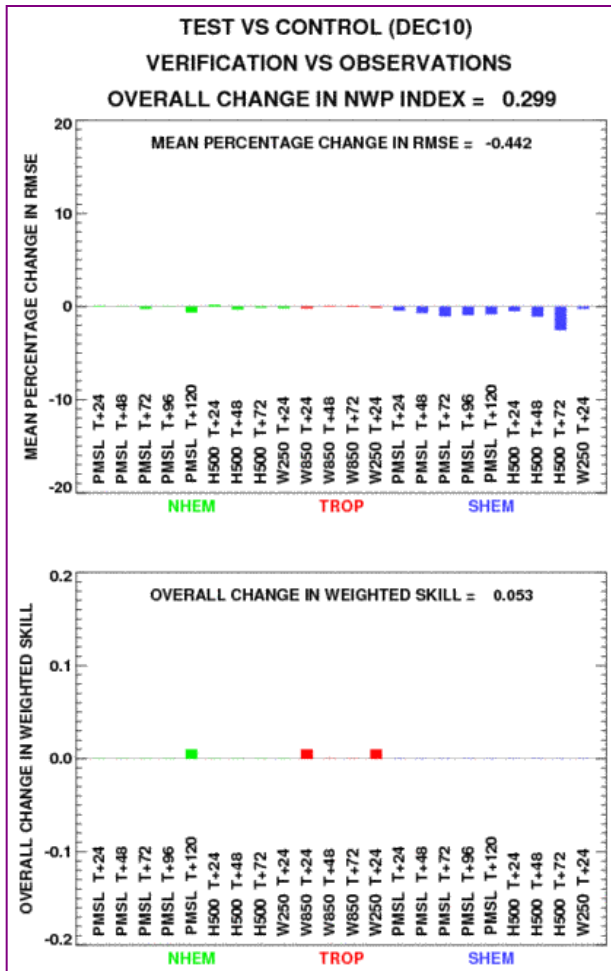
Reconditioned

Diagnosed

- Using reconditioned matrix results in:
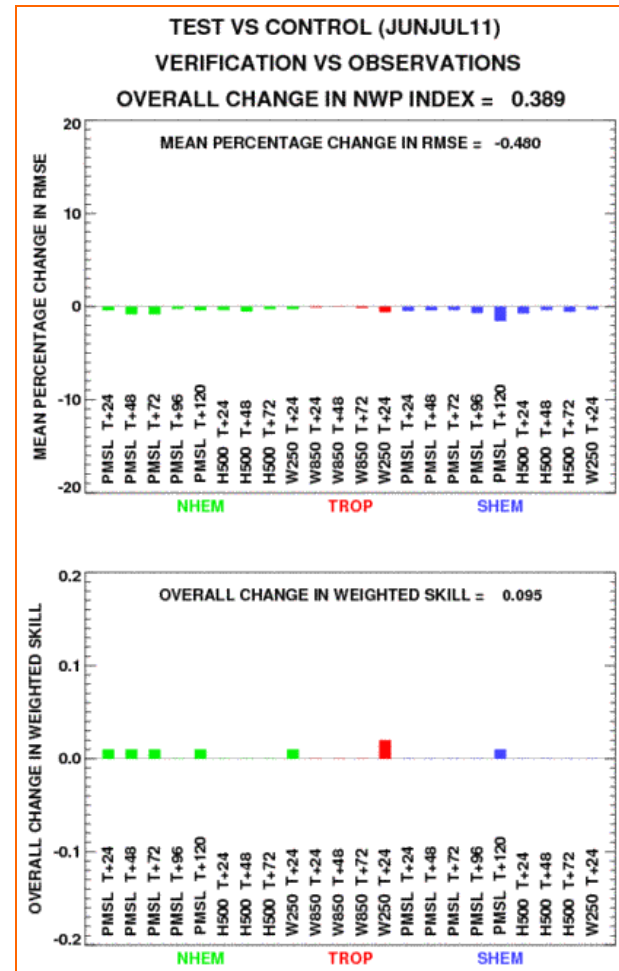 - Reduced weight given to IASI obs
  - Good convergence

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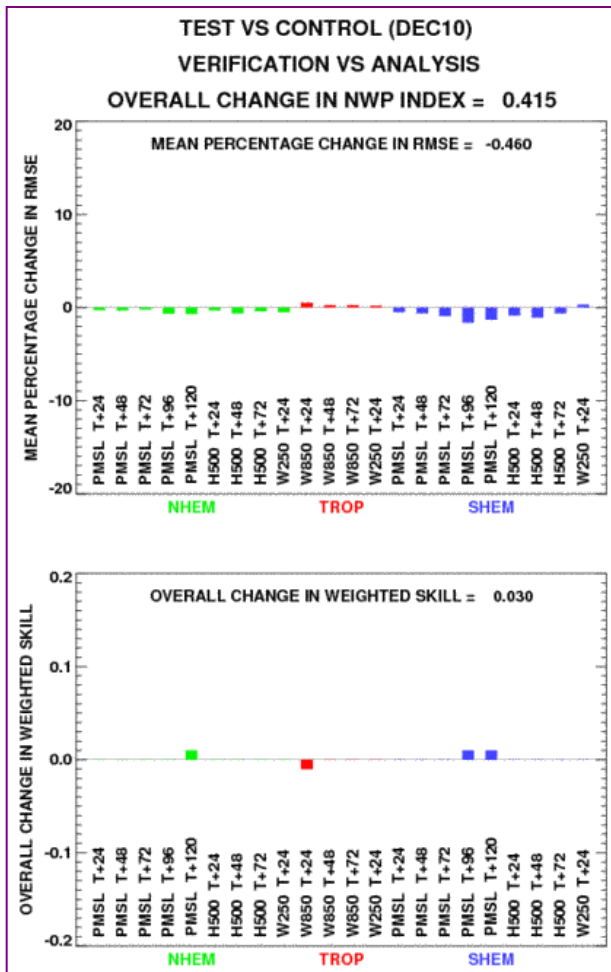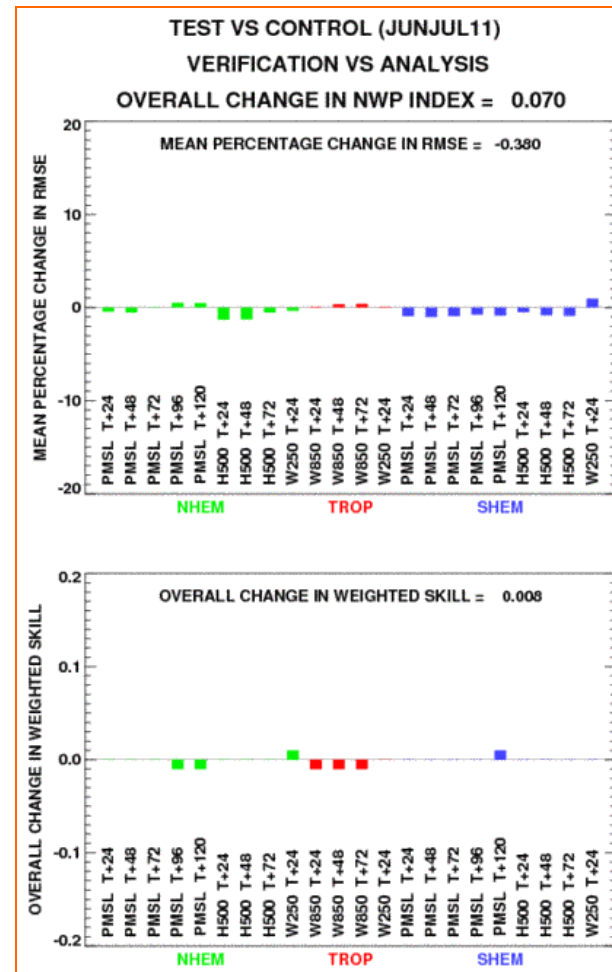- Conclusions & Future Work

Trial results – Impact vs Obs

Winter

Summer
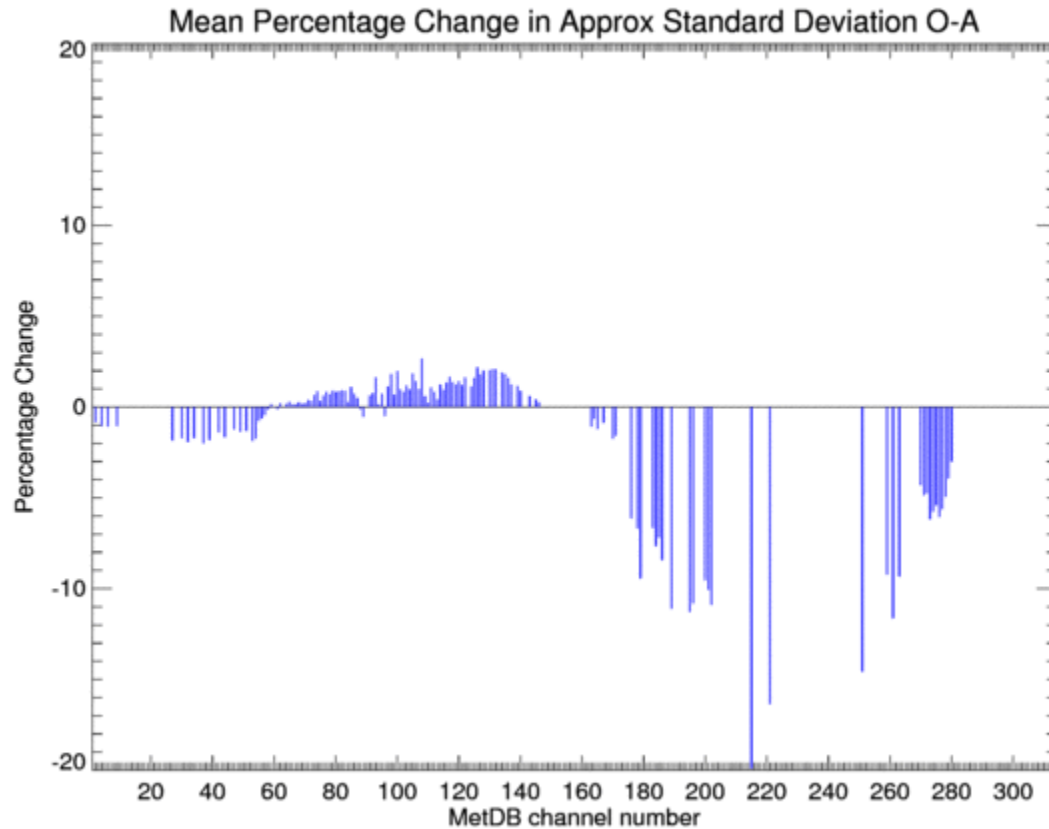
Trial results – Impact vs Analysis

Winter

Summer
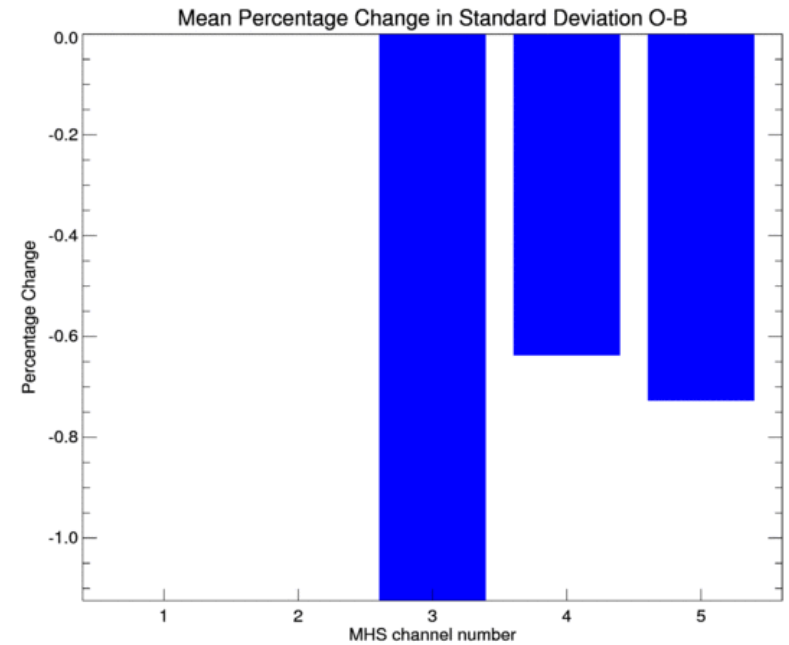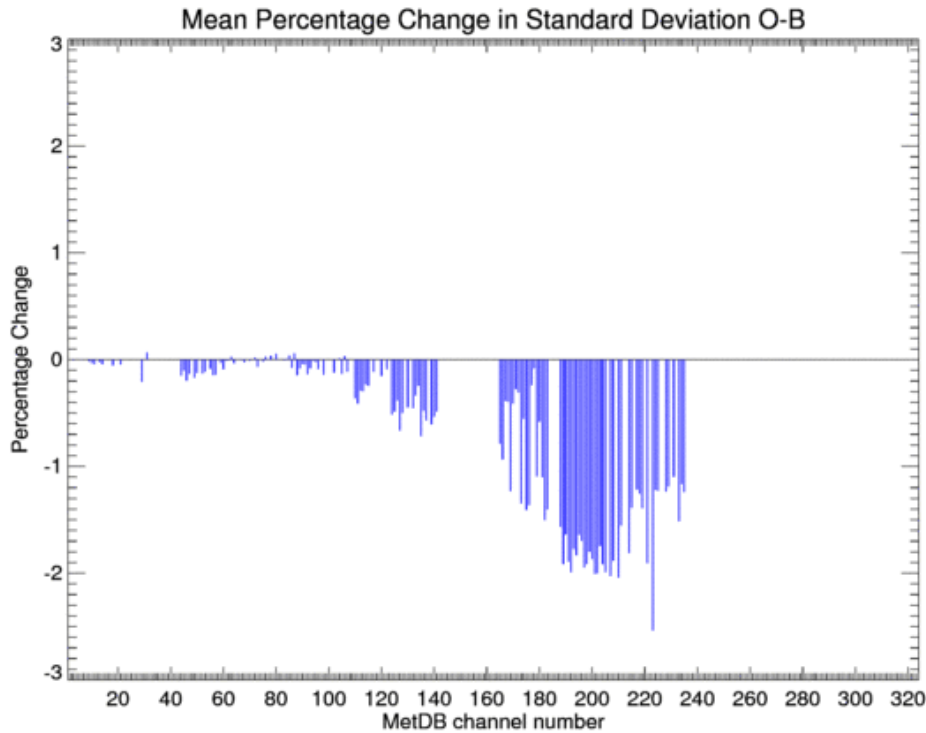
Analysis fit to IASI observations

Mean Percentage Change in Approx Standard Deviation O-A

Background fit to AIRS & MHS

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Conclusions

- The Desroziers diagnostic produces matrices which have:
  - Weak correlations between temperature sounding channels
  - Strong correlations between window and water vapour sensitive channels
  - Smaller diagonal values than are currently used operationally
- Using the diagnosed matrices causes convergence problems which are solved by reconditioning
- Using the full matrix in assimilation trials results in
  - **Reduction in forecast errors**
  - More weight being given to IASI observations
  - Improved background fit to other observations
- Error correlations are now accounted for in the Met Office 4D-Var scheme for IASI (from 16th January 2013)

Future Work

- Work on implementation for AIRS and CrIS
- Investigate the benefits of using correlated observation errors in the operational 1D-Var pre-processor
- Isolate how much forecast impact is coming from modelling the correlations
- Research whether using a full matrix affects the optimal channel selection for IR sounders
- Extend work to other instruments: ATOVS, SSMIS, ATMS, SEVIRI?

Thanks for listening

Any questions?