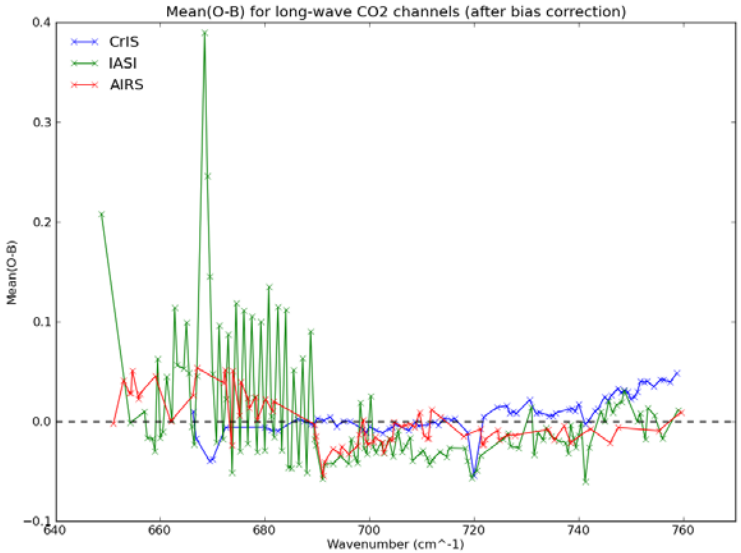
CrIS Assimilation at the Met Office

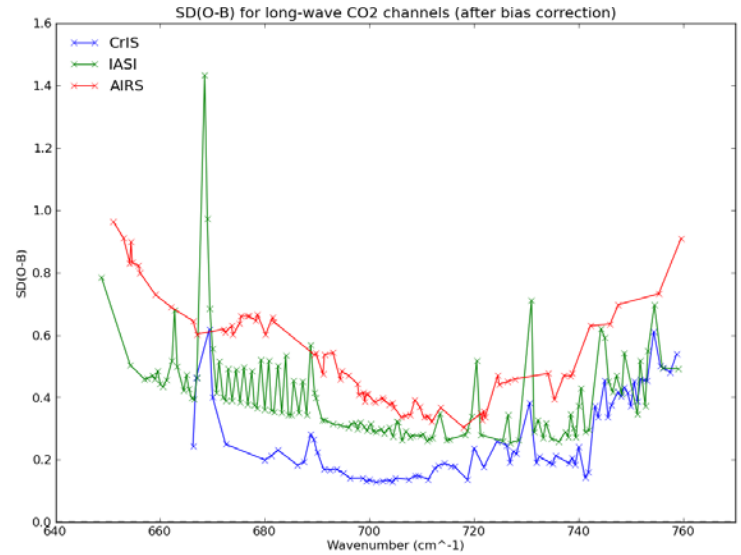
Andrew Smith (presented by Fiona Smith)

SA Science Meeting 20/12/2012

Acknowledgements: Nigel Atkinson, Amy Doherty, Fiona Smith, Bill Bell

Data quality comparison – LW CO_2/Temperature channels

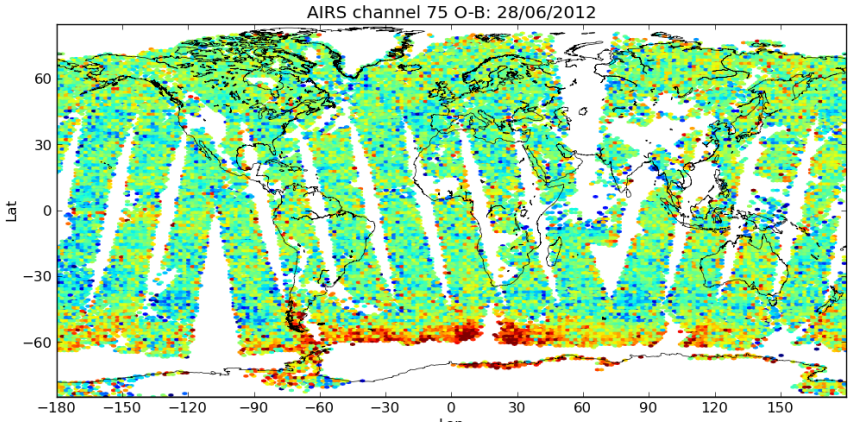


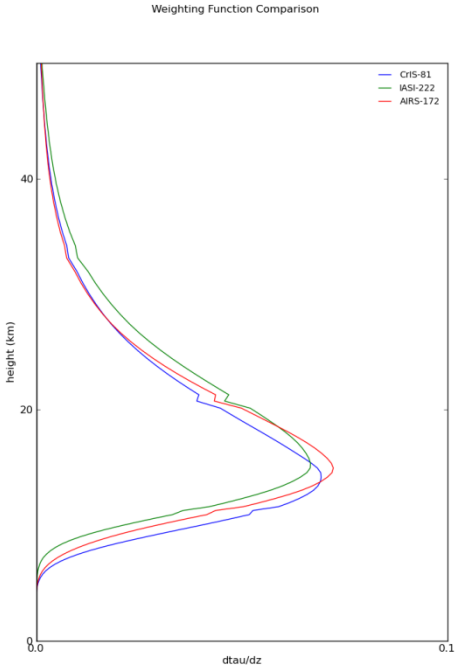


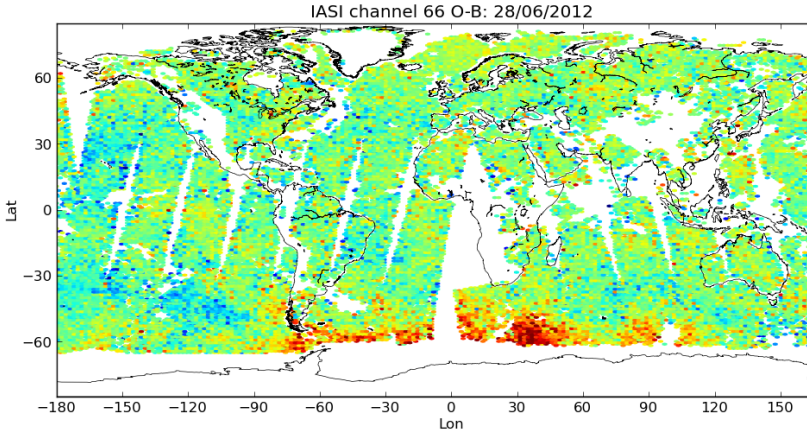
- Very small biases
- Slight increase at the SW end
  - Surface and water vapour

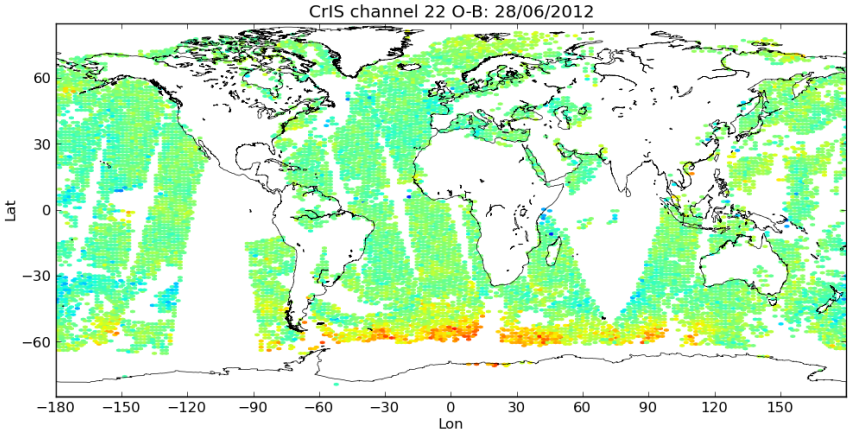
- Instrument noise very low
- O-B down to 0.15 K in some channels, half that of IASI

Data Quality comparison – lower stratosphere



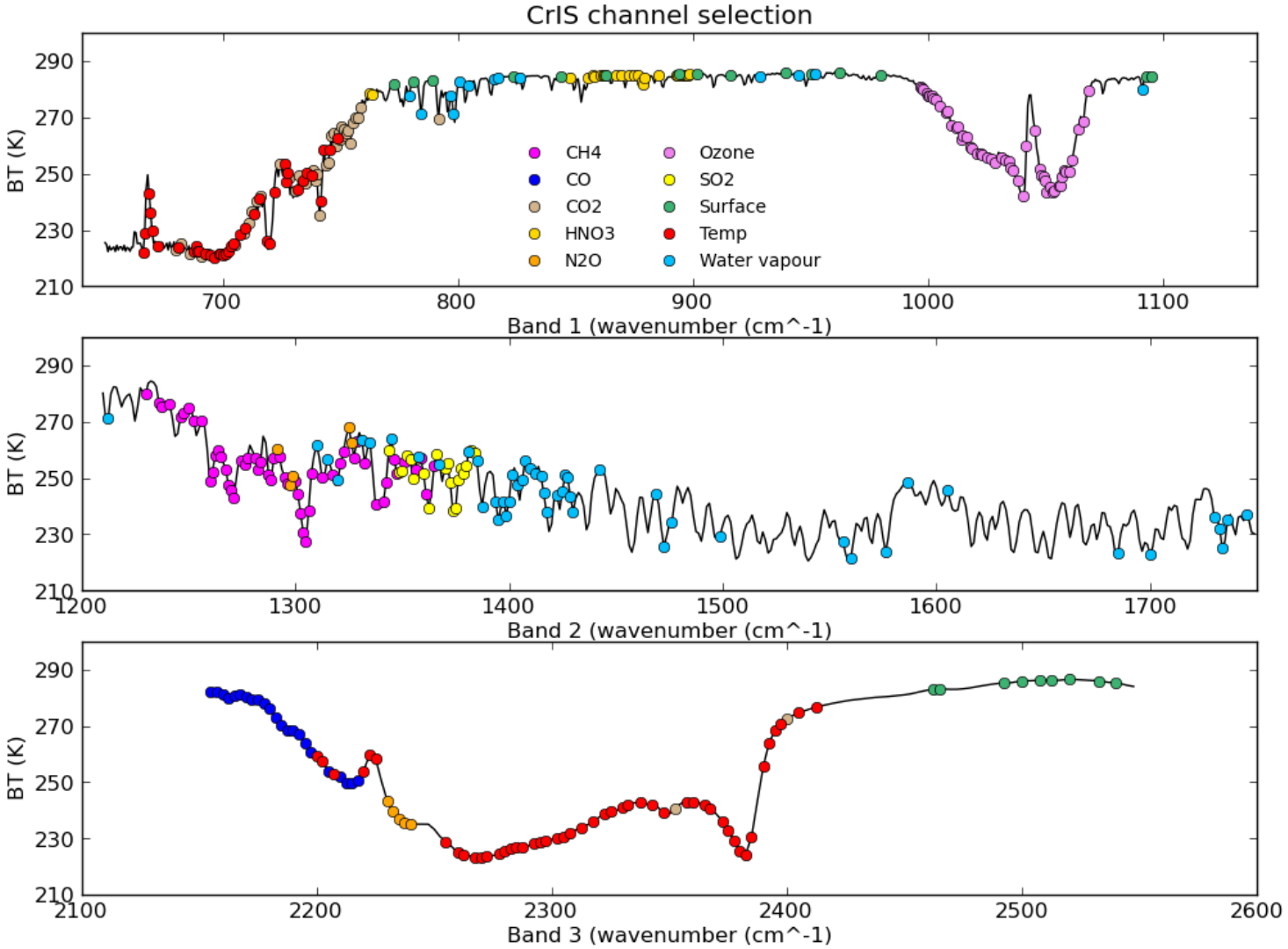


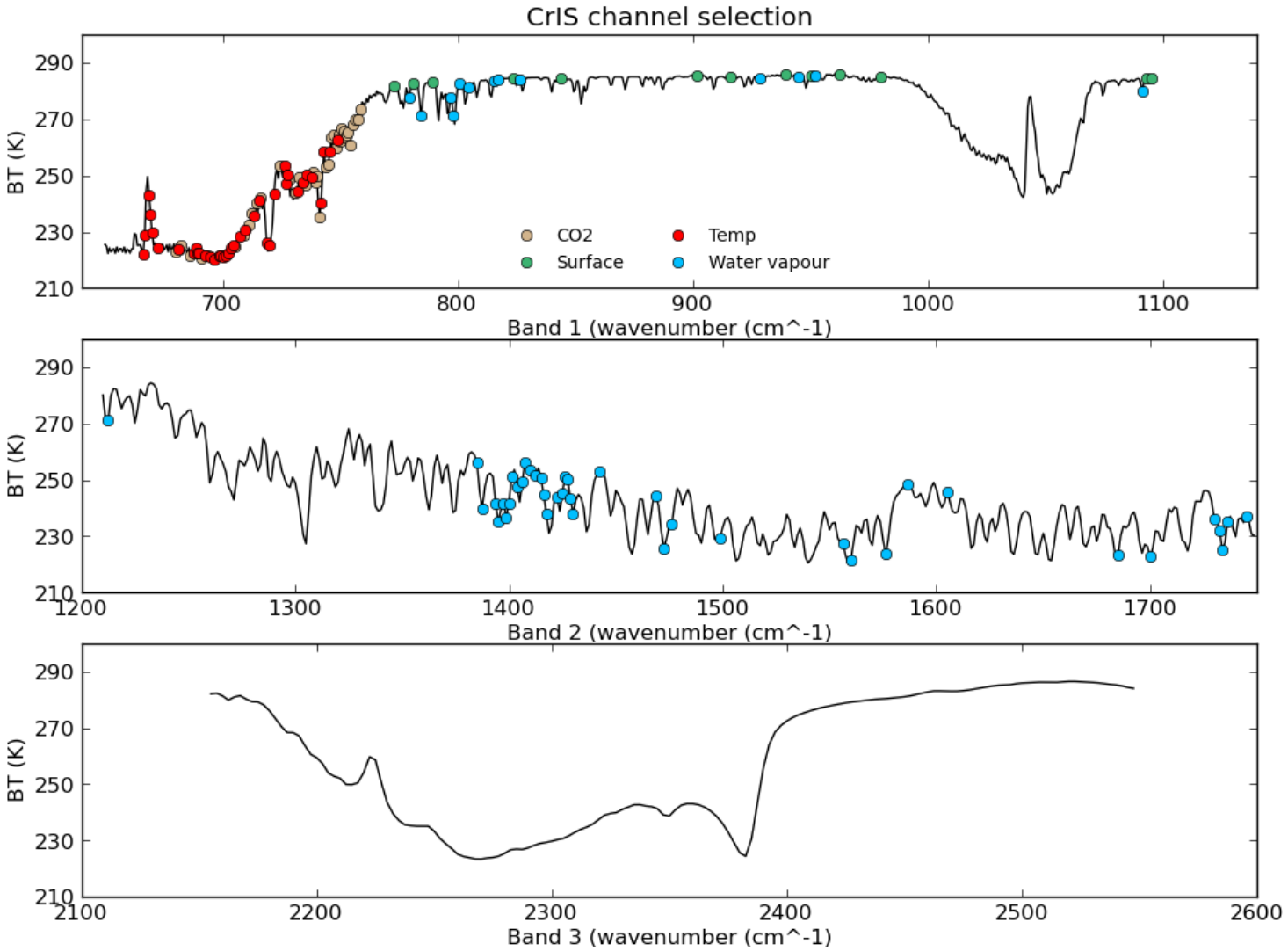


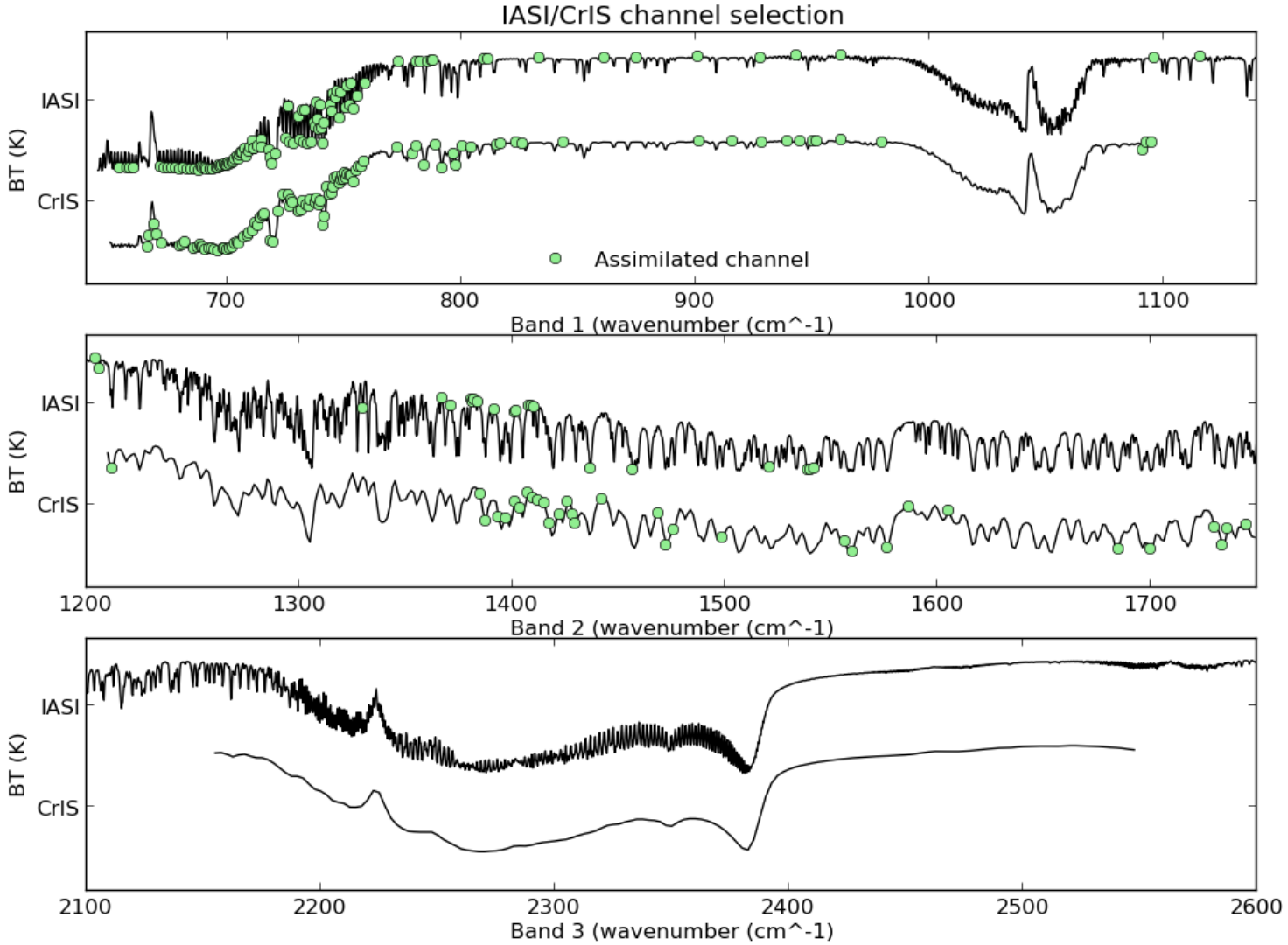


What channels should we use?

- NESDIS channel selection
  - 399 from a total of 1305 channels, selected using an information content study.
  - Far too many! (Expensive to process and a fair amount of redundancy)
  - One size fits all - categorised by principal sensitivity, the selection includes
    - 173 NWP channels: 24 surface, 87 temperature, 62 water vapour (WV)
    - 226 Other: 53 ozone, 173 other gases (but includes CO_2).
- Compare with IASI
  - The IASI MetDB selection (314 channels) is more NWP focussed – trace gas channels removed as are highly correlated channels.
  - For IASI we assimilate only 138, including 87 temperature, 21 surface, 30 water vapour.
  - ‘Difficult’ channels removed (large O-B, peculiar Jacobians, noisy, large forward model errors).


CrIS channel selection
BT (K)
290
270
250
230
210
700
800
900
1000
1100
Band 1 (wavenumber (cm^-1)
CH4
CO
CO2
HNO3
N2O
Ozone
SO2
Surface
Temp
Water vapour
BT (K)
290
270
250
230
210
1200
1300
1400
1500
1600
1700
Band 2 (wavenumber (cm^-1)
BT (K)
290
270
250
230
210
2100
2200
2300
2400
2500
2600
Band 3 (wavenumber (cm^-1)


CrIS channel selection
BT (K)
290
270
250
230
210
700
800
900
1000
1100
Band 1 (wavenumber (cm^-1)
CO2
Surface
Temp
Water vapour
BT (K)
290
270
250
230
210
1200
1300
1400
1500
1600
1700
Band 2 (wavenumber (cm^-1)
BT (K)
290
270
250
230
210
2100
2200
2300
2400
2500
2600
Band 3 (wavenumber (cm^-1)


IASI/CrIS channel selection
IASI
CrIS
BT (K)
Assimilated channel
700
800
900
1000
1100
Band 1 (wavenumber (cm^-1)
IASI
CrIS
BT (K)
1200
1300
1400
1500
1600
1700
Band 2 (wavenumber (cm^-1)
IASI
CrIS
BT (K)
2100
2200
2300
2400
2500
2600
Band 3 (wavenumber (cm^-1)

Channel selection for assimilation

- Like IASI
  - Reject ozone and other trace-gas channels
  - Reject short-wave (band 3) channels
  - Reject low-peaking channels over land
    - Land emissivity retrieval not yet included
  - Reject very high-peaking channels?
    - Not such an issue for CrIS because the lower spectral resolution means there is only one ‘problematic’ channel.
  - Reject over sea/ice?
    - May not be necessary but do it for initial implementation to keep the trial ‘clean’.

Obs. errors

- 1D-Var matrix
  - Diagonal
  - Combine NeΔT with flat 0.2 K RT error
    - Estimate NeΔT from NeΔN instrument spec
    - NeΔT varies considerably with scene temperature - rescale for a standard atmosphere scene
    - Apply apodisation noise reduction ~ 1.5

4D-Var errors – not so scientific!

- Need inflating for
  - Representativeness error
  - Correlations between channels
    - Highly correlated channels removed for IASI
    - Apodisation
      - Noise in adjacent channels highly correlated (theoretically ~0.63)
      - Alternate channels weakly correlated (~0.13)
- ‘Rounded’ values of 0.5 K (main temperature channels), 1.0 K (surface, high-peaking), 4.0 K (water vapour) for IASI.
- CrIS is low noise – may benefit from lower obs. errors.
  - But large error estimate may compensate for lack of correlations.
- Can treat correlated error better with a statistical analysis (e.g. Desroziers as implemented for IASI in Jan 13)

Trials

- Summer season only (28th Jun – 23rd Aug 2012)
- Original trial
  - 129 channels (87 T, 44 WV, 13 surface)
  - Biases from early monitoring data
  - Similar errors to IASI (0.5 K, 1.0 K, 4.0 K)
- Variants
  - Reduce number water vapour channels
  - Recalculate biases
  - More aggressive obs. errors

Trial results 1

- Trial with biases version 0 is the baseline configuration
- Effect of changing biases
  - Little effect on forecasts but significant changes in the analysis
  - Usually affects humidity fields the most

Biases version	Index change *vs* obs.	Index change *vs* analysis
0	+0.146	+0.008
1	+0.159	-0.273
2	+0.152	+0.081

Trial results 2

- Effect of changing the channel selection
  - Conventional wisdom is that water vapour channels can be problematic - it's usually best to be careful with these.
  - Trials run with about half the original set of WV channels, carefully selected for nice looking Jacobians; and one with no water vapour.
  - A surprise! There were no signs of 4D-Var convergence problems and the water vapour channels had more of an impact than the others in this configuration!

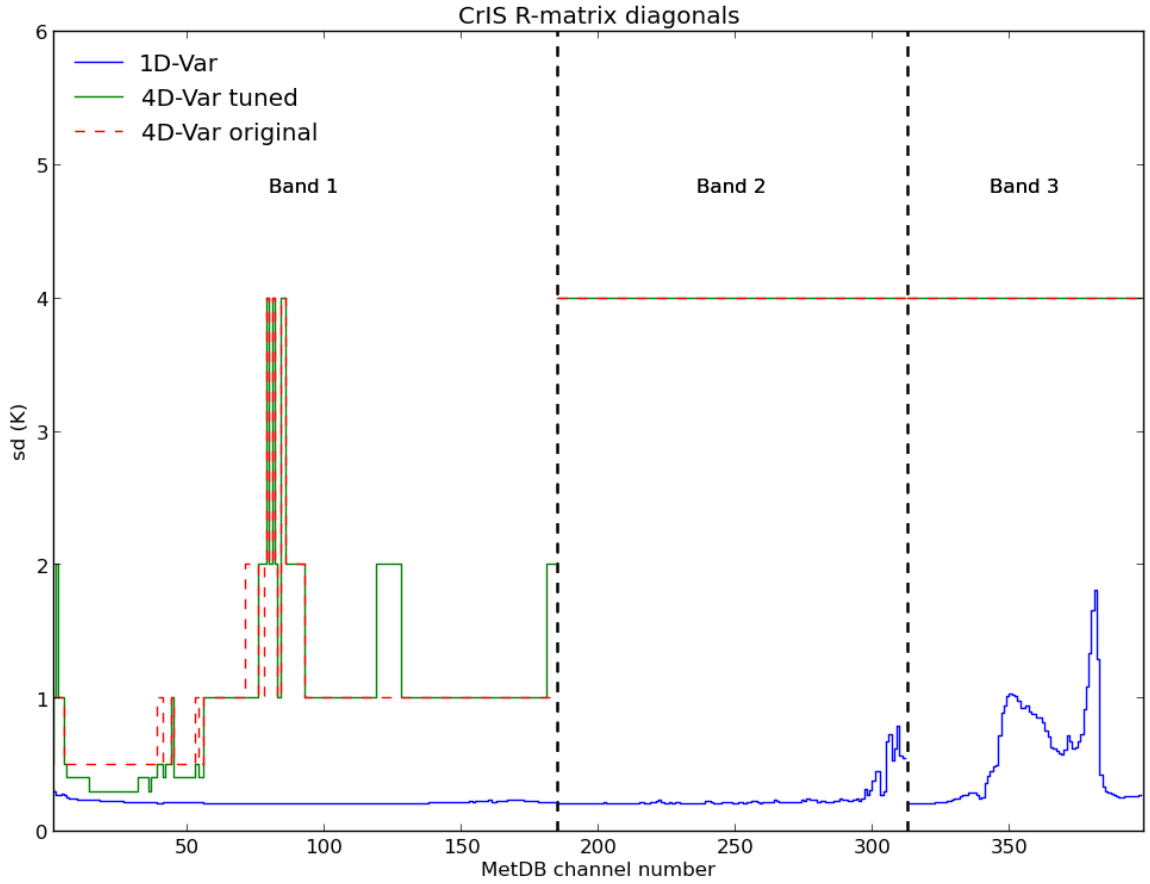
Channels	Index change *vs* obs.	Index change *vs* analysis
129 (original)	+0.146	-0.273
111 (reduced WV)	+0.064	-0.268
85 (no WV)	+0.047	-0.266

Trial results 3

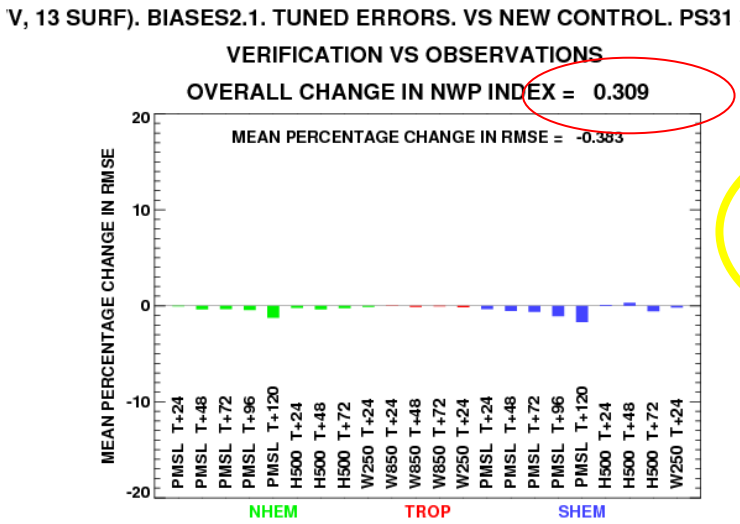
- Effect of tuning the obs. errors
  - Can justify reducing the obs. errors for temperature channels because the O-B values are very small.
  - Doubles the impact!

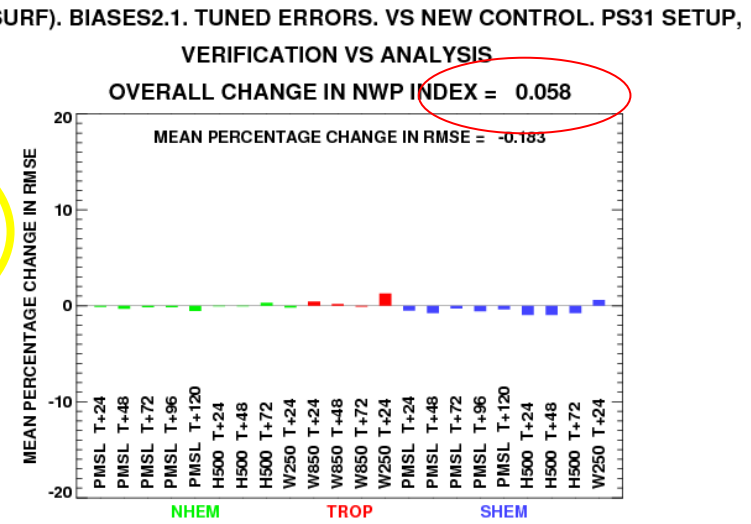
Channels	Errors	Index change *vs* obs.	Index change *vs* analysis
85 (no WV)	Original	+0.047	-0.266
85	Tuned	+0.108	-0.205
129	Original	+0.159	-0.273
129	Tuned	+0.274	-0.086

Obs. errors

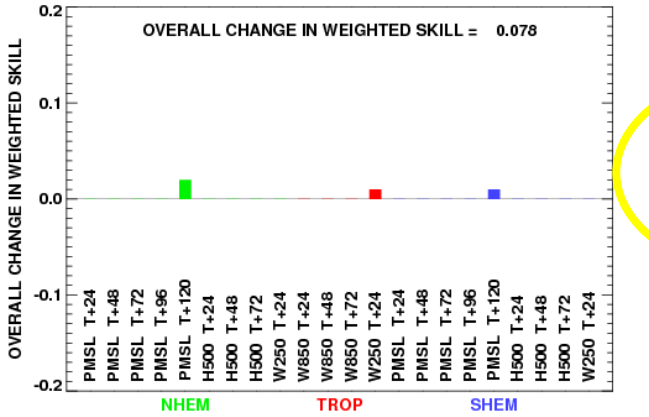

CrIS R-matrix diagonals
1D-Var
4D-Var tuned
4D-Var original
Band 1
Band 2
Band 3
sd (K)
MetDB channel number
0
1
2
3
4
5
6
50
100
150
200
250
300
350

Trial results - final configuration

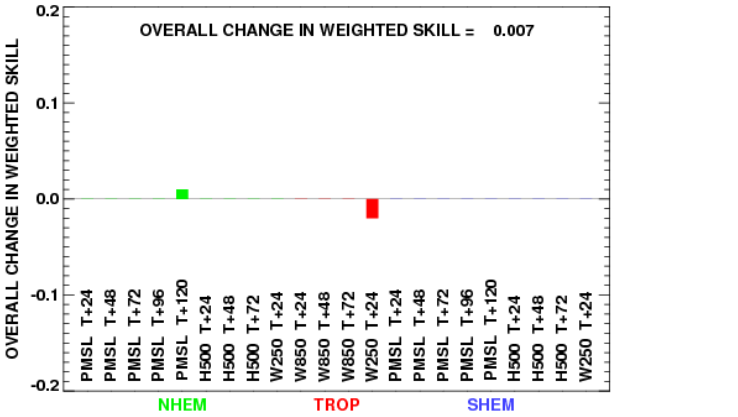




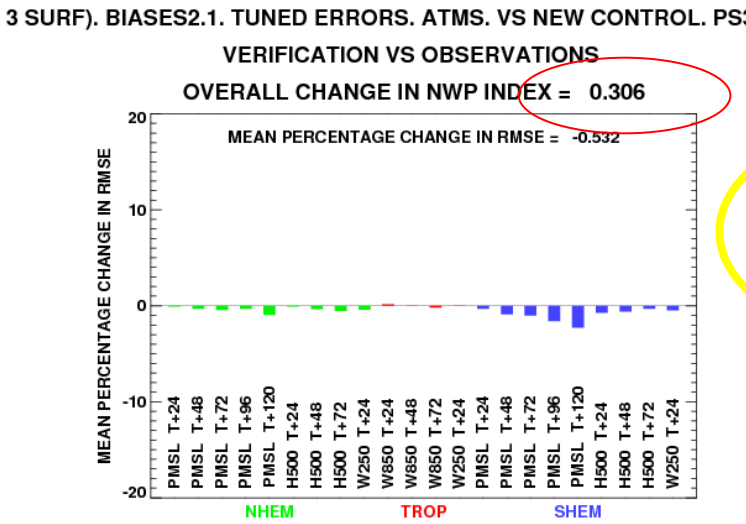
Down is good!

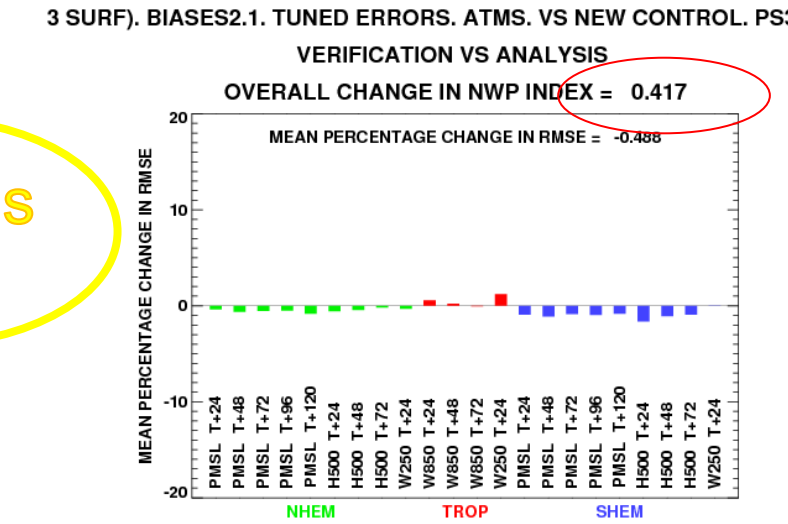


Up is good!

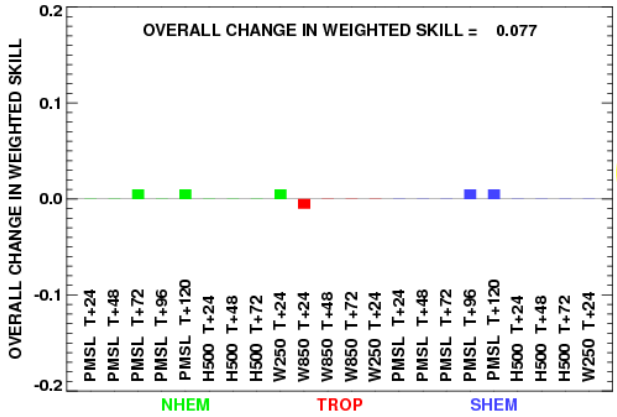


CrIS+ATMS trial results

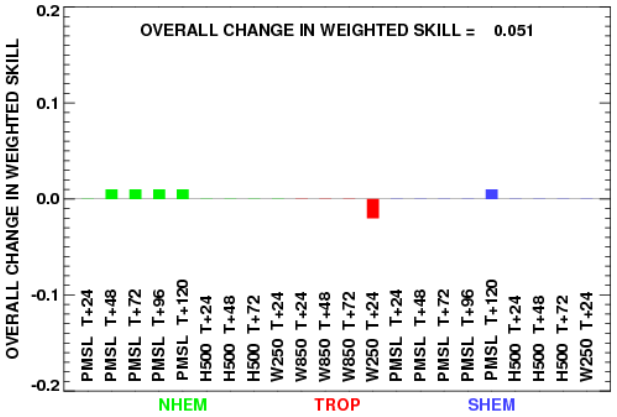




Down is good!



Up is good!



Conclusions

- Data quality is excellent
- Forecast impact positive but quite modest
  - Assimilation on top of AIRS and IASI?
  - May improve with ‘Day 2’ upgrades
    - Correlated error
    - Land emissivity
- Should be operational in April 2013