An assessment of data from the GIIRS instrument

ITSC-22

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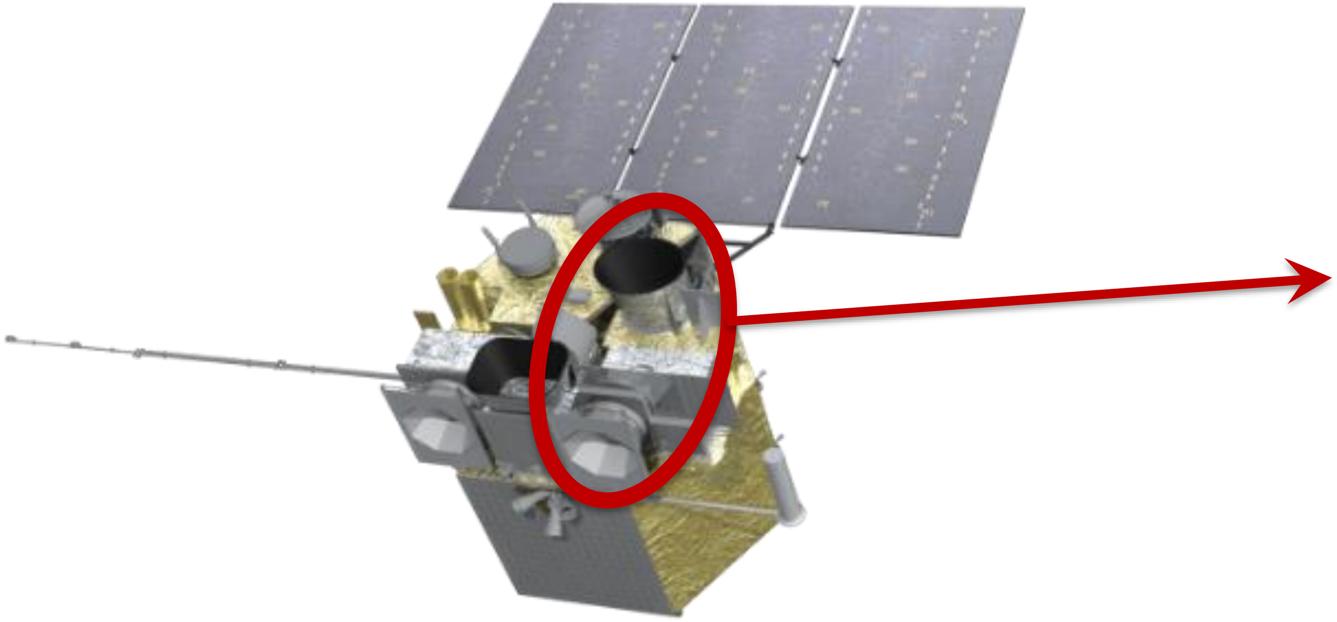
Thanks to Peter Lean and, for providing the data, NSMC/CMA.

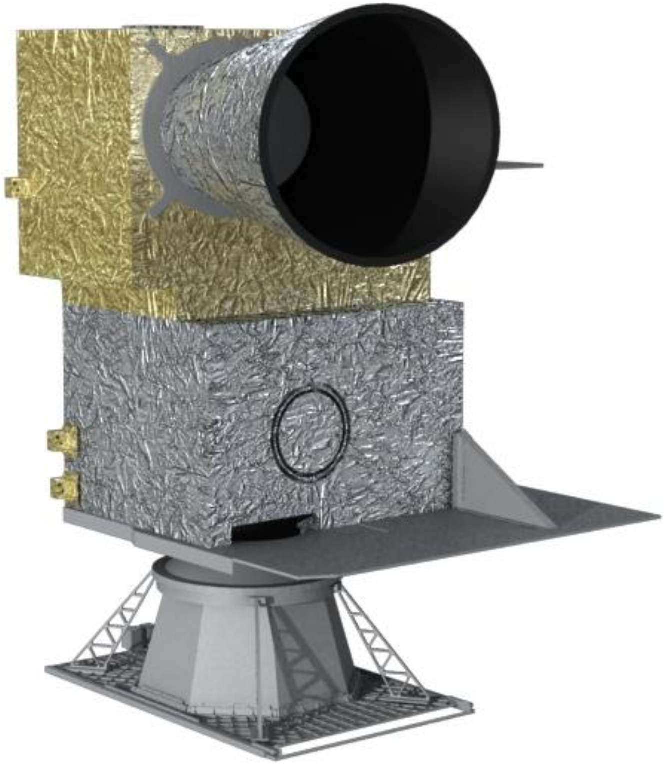
ECMWF

What is FY-4A / GIIRS?

The Chinese geostationary satellite FengYun-4A (**FY-4A**) was launched in December 2016.

Geostationary Interferometric Infrared Sounder (**GIIRS**) is the first hyperspectral infrared instrument in a geostationary orbit.

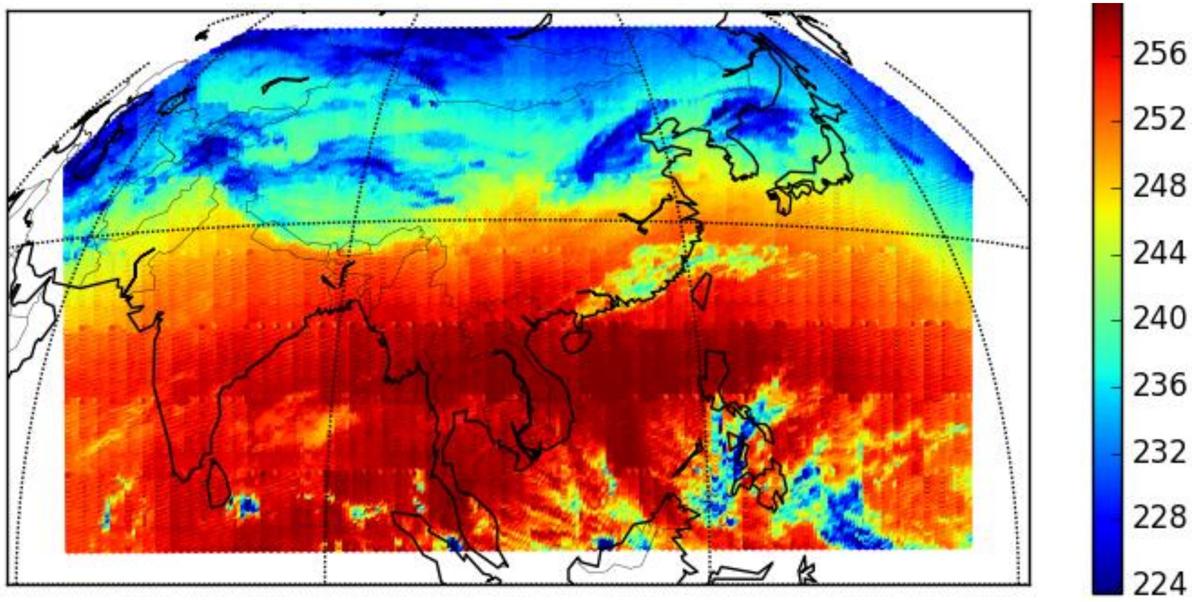




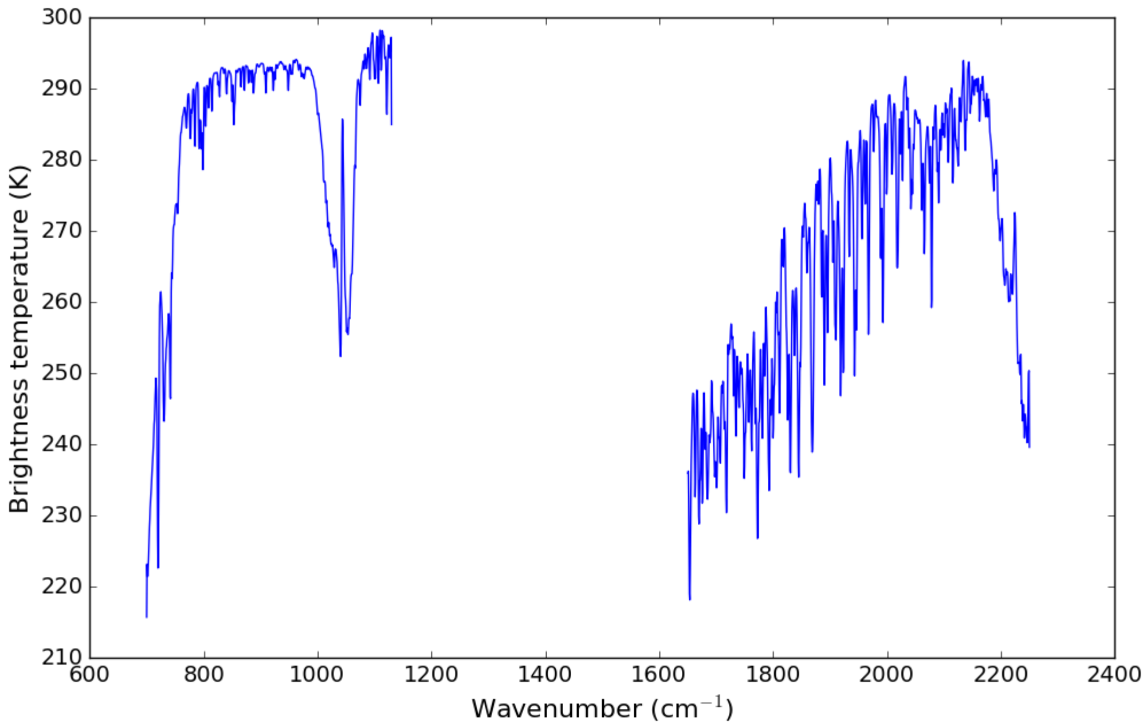
Spatial coverage and spectral range

This area is scanned **every 2 hours**.

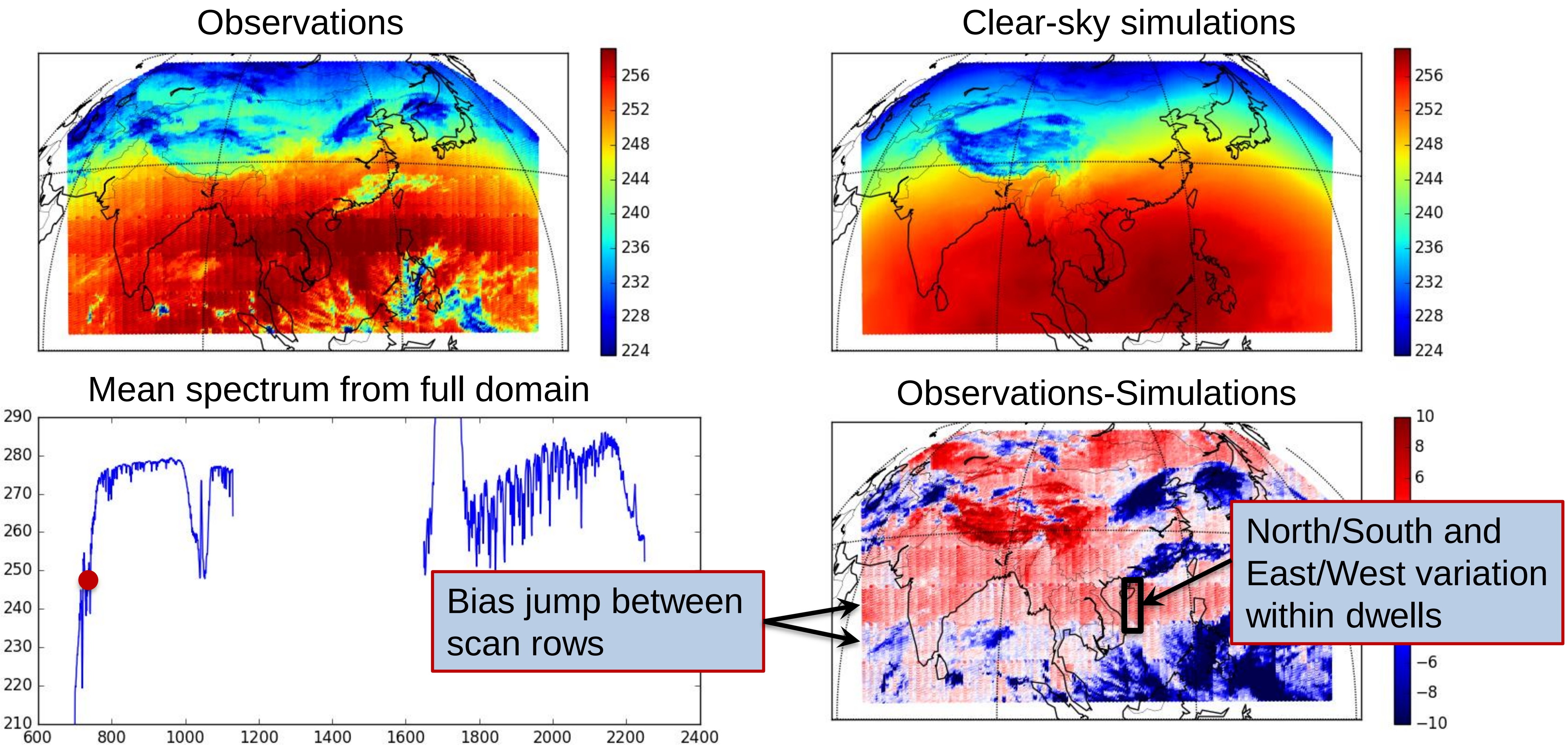
Region comprises 240x224 pixels.



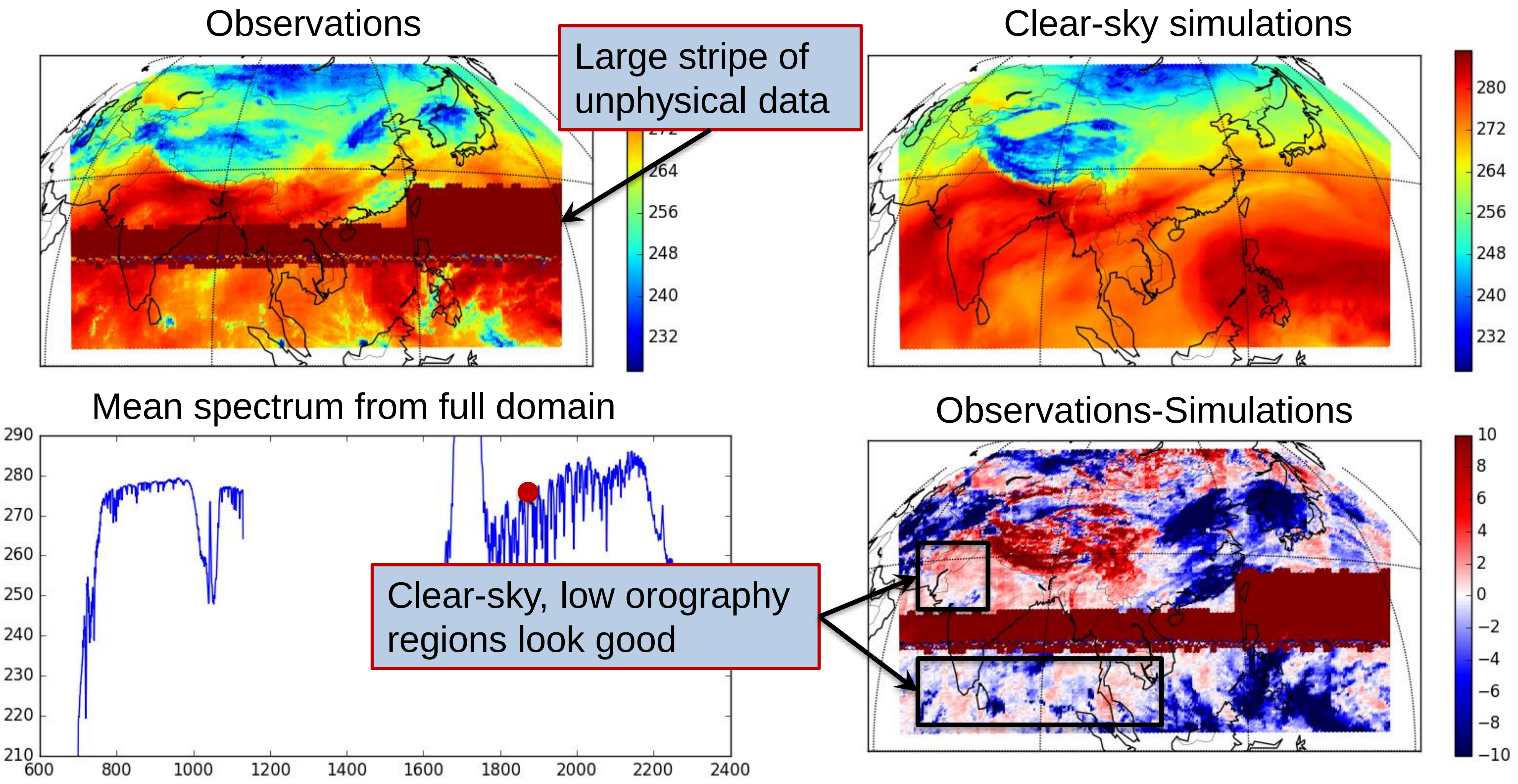
For each pixel, radiances from **1650 channels** are measured.



O-Bs: 736.25 cm^{-1}: systematic errors are present.



O-Bs: 1875 cm^{-1}: Ignoring unphysical band, data look good.



Apodisation

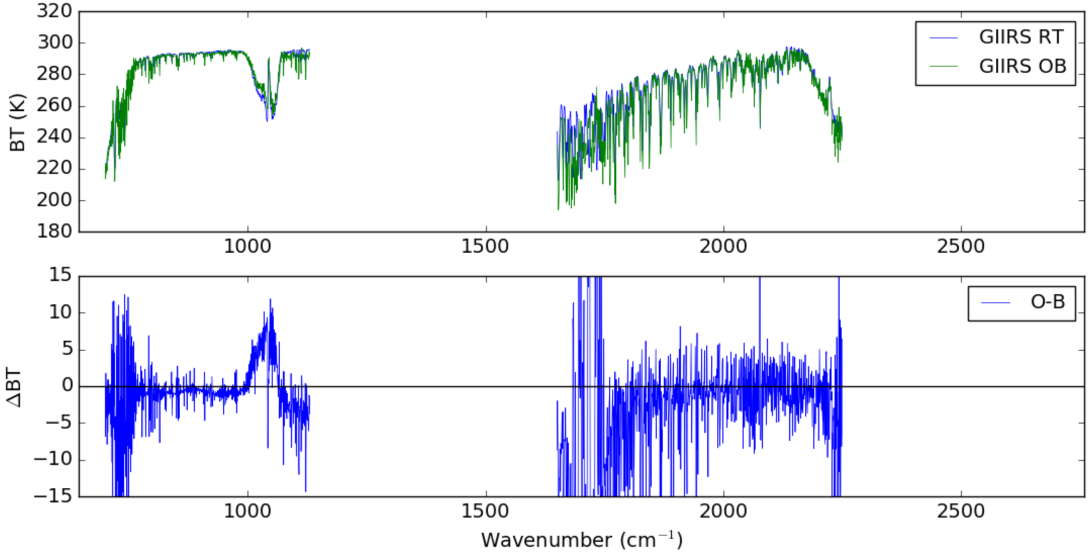
Date	Apodised?
... until Aug 12 2019	Unapodised
Aug 13 2019 to Aug 28 2019	Apodised
Since Aug 29 2019 ...	Unapodised
Later in 2019…?	Apodised?

The RTTOV coefficients we have access to (from SSEC/CMA) assume Hamming-apodisation.

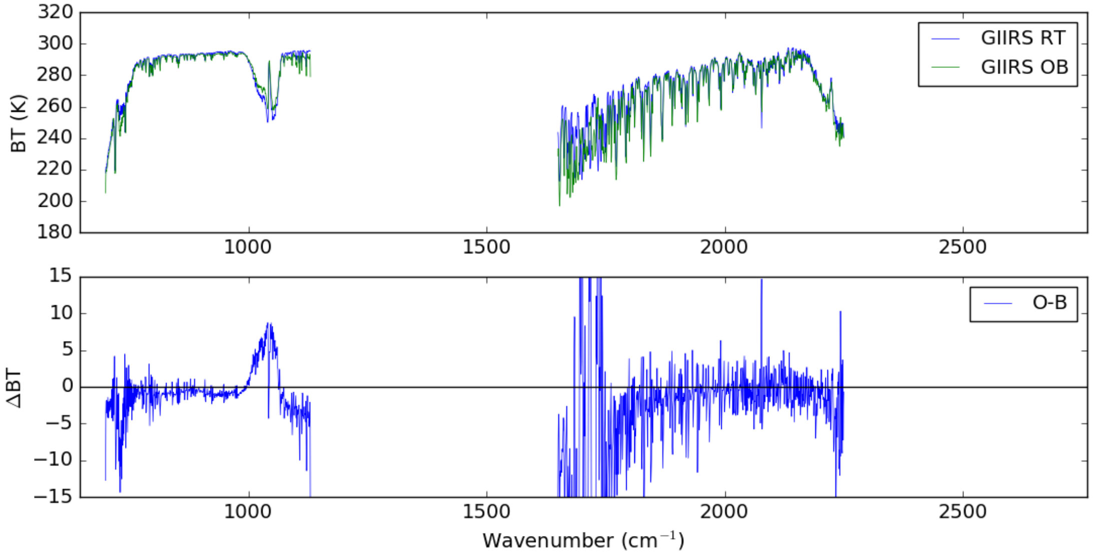
When the observations are unapodised, Hamming-apodisation is easy to apply in spectral space:

$$L_{apod}[i] = 0.23L[i-1] + 0.54L[i] + 0.23L[i+1]$$

Unapodised observations as received (single spectrum):

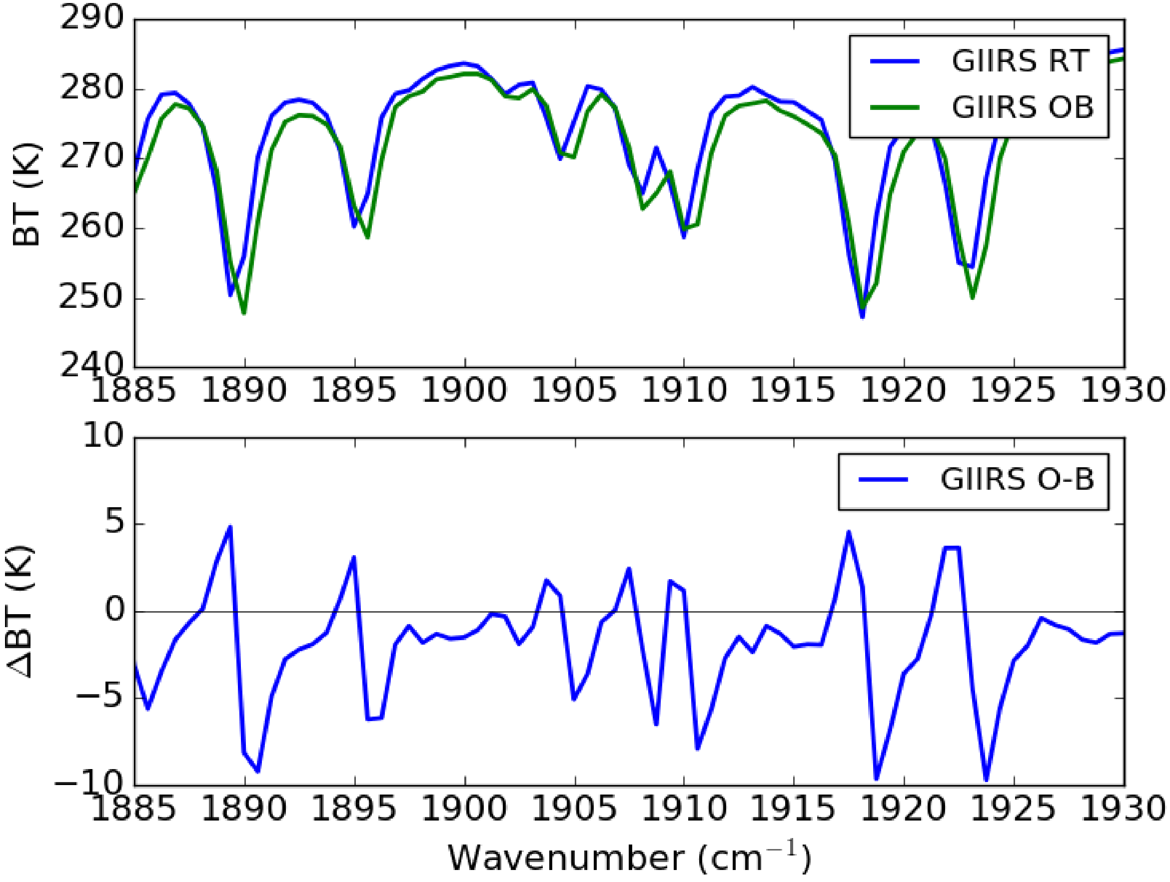


After apodisation has been applied:

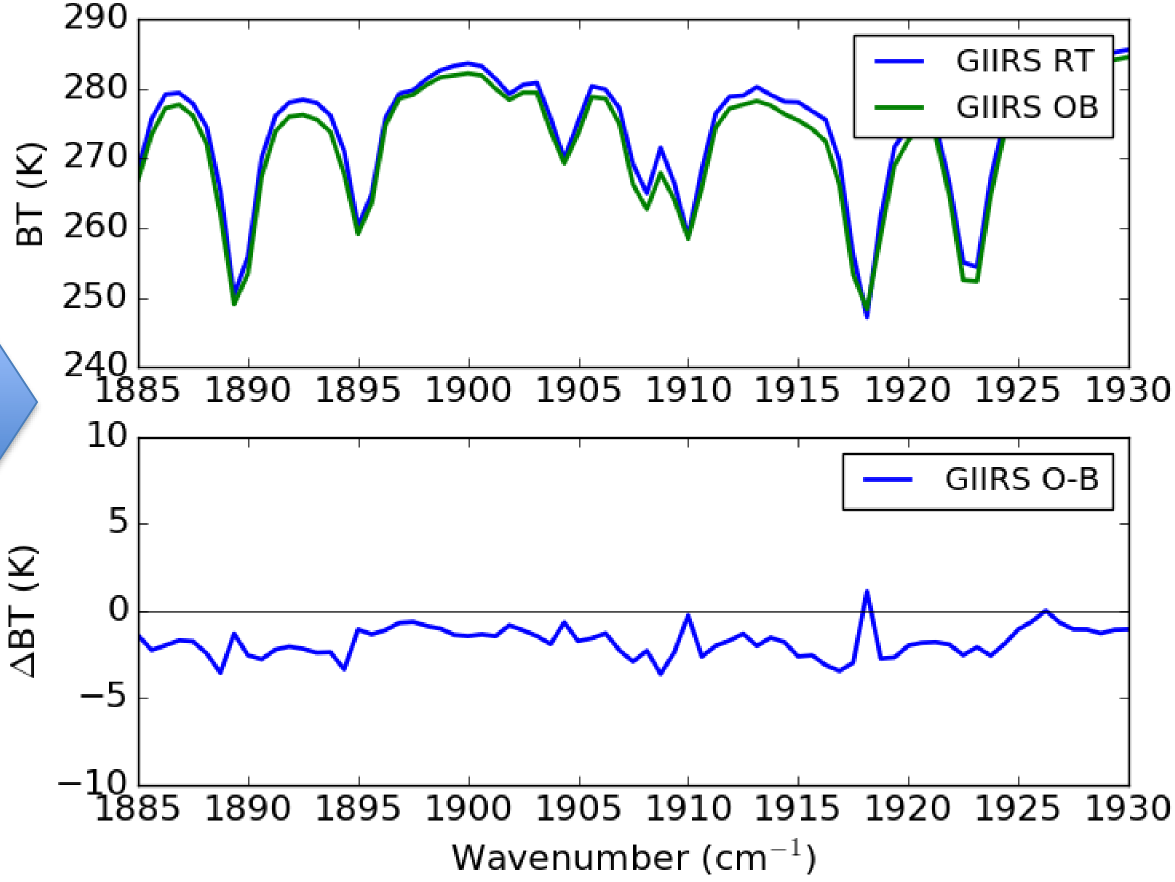


Zooming in, a spectral shift is seen when comparing observations with RT simulations

Before correction



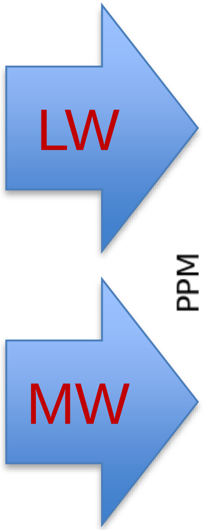
After correction

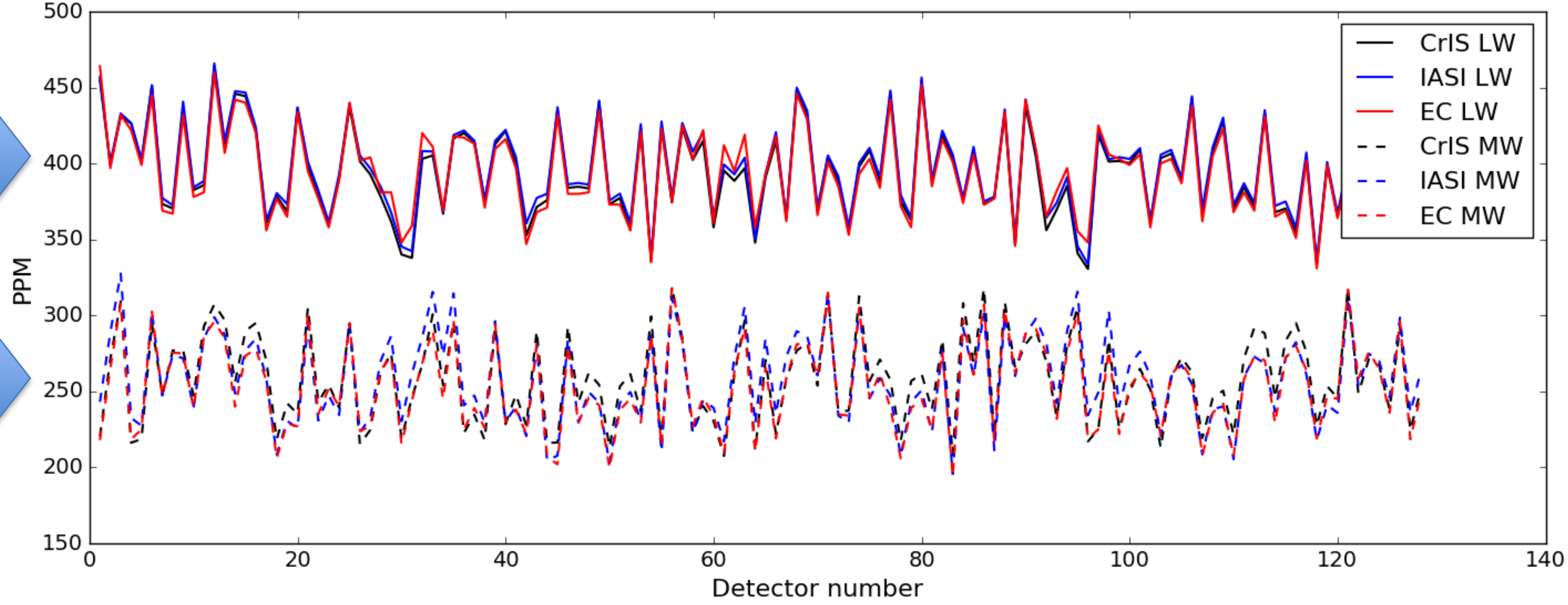


Diagnosed shift for each of the 128 detectors (version 2 processing)

The shift is defined by the parameter 'PPM' which scales the wavenumber axis.

$$\nu_{new} = (1 + PPM \times 10^{-6})\, \nu_{orig}$$





Detector array numbering

1	33	65	97
2	34	66	98
3	35	67	99
4	36	68	100
.	.	.	.
.	.	.	.
.	.	.	.
32	64	96	128

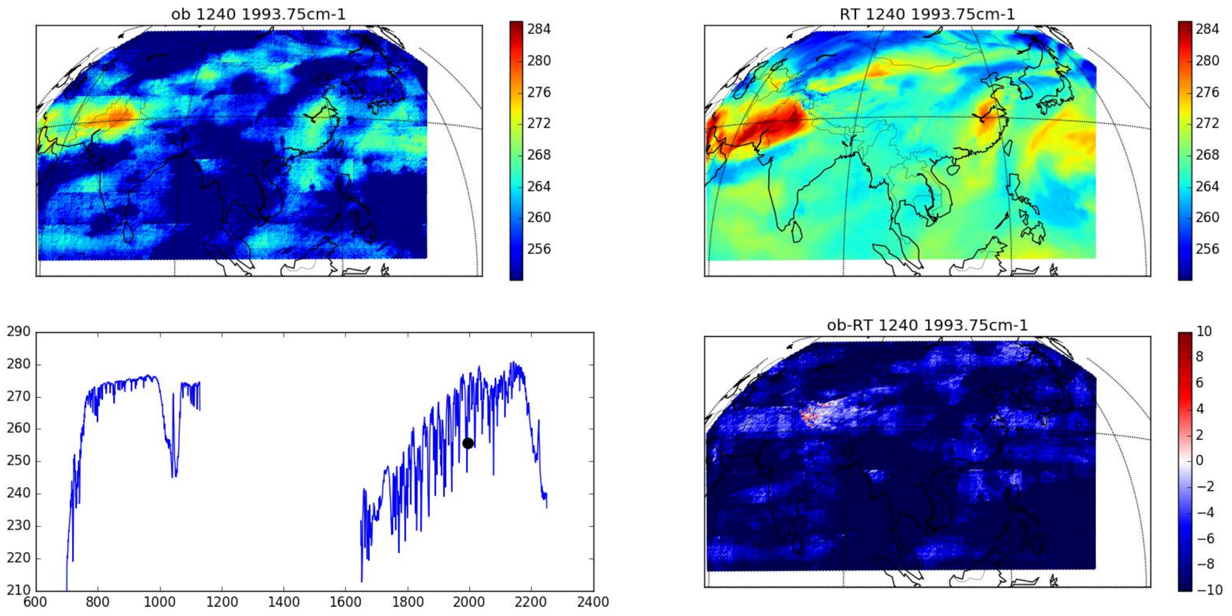
These PPM values were derived independently using CrIS/IASI SNOs (by Bob Knuteson at SSEC) and also using O-Bs from the ECMWF model.

Many thanks to Bob Knuteson for sharing his resampling algorithm.

The importance of correcting the shift

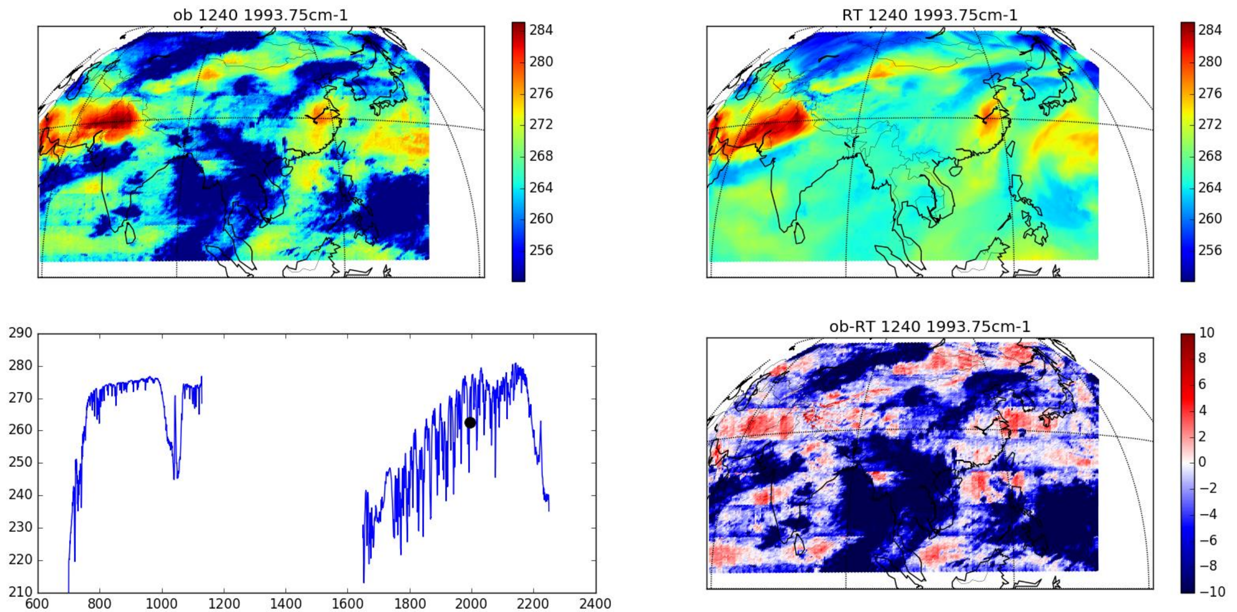
Before:

Compared to the RT simulations, the observed brightness temperatures are systematically cold by up to 10K.



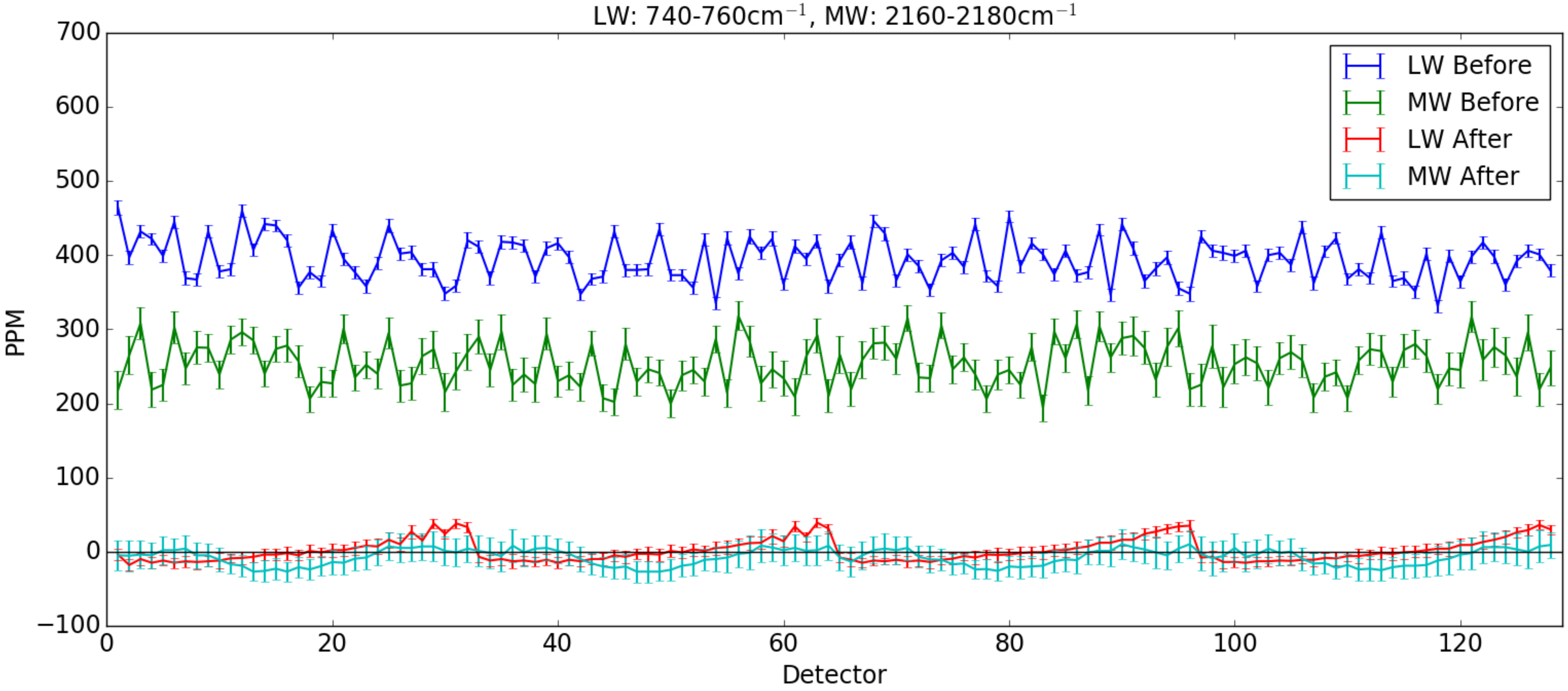
After:

The systematic bias is largely removed (ignoring cloudy regions).



Latest progress!

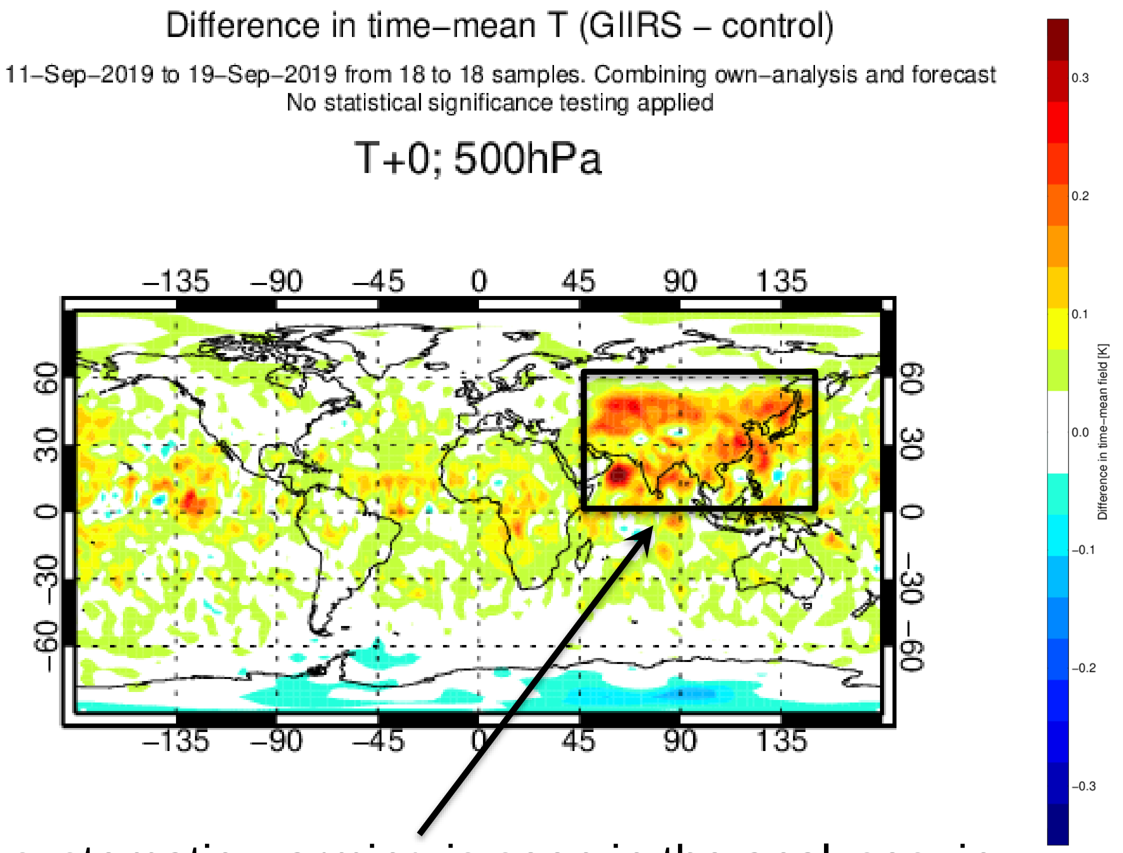
- A few days ago, Qiang Guo at CMA has improved the algorithms, thus resulting in significantly smaller spectral shifts.



- This should be implemented in V3 of the processing on 8th Nov 2019.

Preliminary 4D-Var radiance assimilation experiment

- A subset of long-wave channels has been assimilated for ~3 weeks.
- Still to be optimised:
  - Observation errors.
  - Channel selection.
  - Cloud screening parameters.
  - Aerosol detection.
  - VarBC predictors.
  - Thinning.
- Until these are refined, it is impossible to make a conclusive statement about the impact.



A systematic warming is seen in the analyses, in the vicinity of the GIIRS domain.

It is anticipated that the most significant impact will arise from wind-tracing of water vapour information within the 4D-Var.

Summary

- GIIRS observations show a number of systematic issues when compared to model simulations, although some channels look good.

- Spectral shifts have been diagnosed using model simulations, and are fairly consistent with those produced using CrIS/IASI co-locations.

- Correcting the spectral shift is currently an essential processing step (should be fixed in V3).

- An initial 4D-Var assimilation experiment has demonstrated that analysis increments are being applied where they are expected, although several factors of the assimilation methodology require further refinement.

- Gaining experience in the use of GIIRS data will prepare us well for MTG-IRS.