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Analysis of the detector responsivity correction method presented by UW at ITSC-21: application to MTG-IRS

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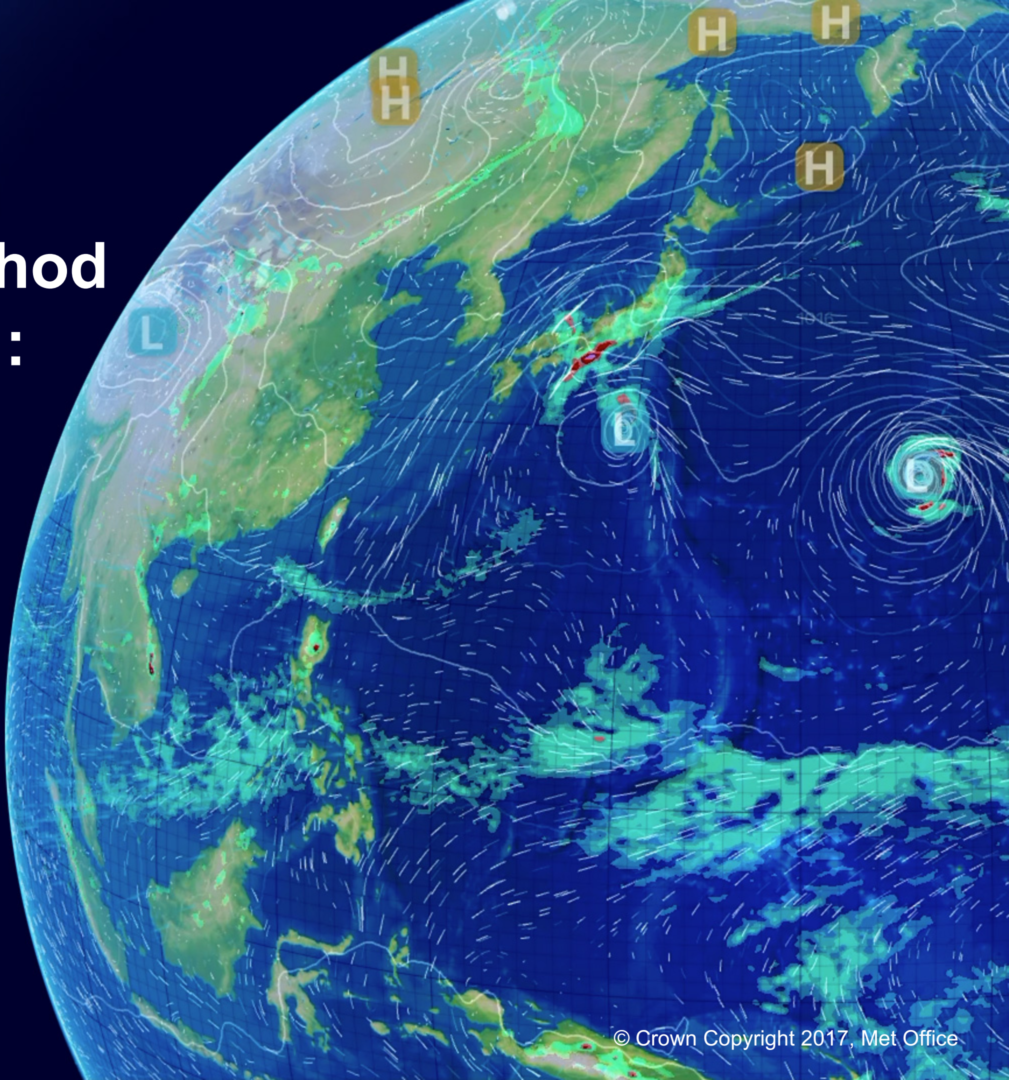

Background

Talk presented at ITSC-21:

Friday, 1 December 2017		
8:30 – 9:45 Session 8a: Hyperspectral IR (oral presentations - 12 minutes) Chairs: Nigel Atkinson and Thomas August		
8.02	Hank Revercomb	Correction to Remove the Residual Responsivity Dependence of Spectral Instrument-Line-Shapes for Fourier Transform Spectrometers

- Deals with the issue of detector responsivity / uniformisation, discussed in previous MAG meetings
- The method presented by Hank differs from that outlined in the IRS Level 1 ATBD
- I will try to outline it and give some results on how well it performs
- Written up in a *Met Office Satellite Applications Technical Memo*

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Method

Measured Spectrum (before calibration) — High res spectrum — Responsivity — Line shape

$$S(\nu) = [N(\nu).R(\nu)] \otimes ILS(\nu)$$
$$= \int N(\nu')R(\nu')ILS(\nu-\nu')\,\mathrm{d}\nu'$$

Expand $R(\nu')$ as a Taylor expansion in $(\nu - \nu')$ to take it outside the integral, giving (eventually)

Asymmetric — *Symmetric*

$$S(\nu) = R(\nu)[N(\nu)\otimes ILS(\nu)] - R'(\nu)\{N(\nu)\otimes[\nu.ILS(\nu)]\} + \frac{R''(\nu)}{2!}\{N(\nu)\otimes[\nu^2.ILS(\nu)]\} - \ldots$$

Measured (before calibration) — Ideal spectrum — Correction terms

Radiometric calibration is equivalent to division by $R(\nu')$, then re-arrange to put the ideal spectrum on the left …

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Method (cont.)

$$N_{cor}(\nu) = N_{meas}(\nu) + \frac{R'(\nu)}{R(\nu)}\{N(\nu)\otimes[\nu.ILS(\nu)]\} - \frac{R''(\nu)}{2!R(\nu)}\{N(\nu)\otimes[\nu^2.ILS(\nu)]\} + \ldots$$

Note that the correction terms involve $N(\nu)$ (high resolution spectrum) which is in general not known. Approximate using the *measured* spectrum (lower resolution).

This formula is very easy to compute. If we ignore self-apodisation (which is small for IRS) we can do the whole band at once, with a very small number of FFTs (only 2 for a first-order correction)

Correction terms involve the responsivity derivatives. The first term does most of the work.

Results (1)

First experiments used an analytical function for R. It was immediately apparent that

- In the unapodised case (i.e. when ILS is a sinc function), ***no correction is possible***
- i.e. correction is only possible when we have information from $>OPD_{max}$
- which is consistent with other studies

In the apodised case (weak apodisation), an improvement is obtained

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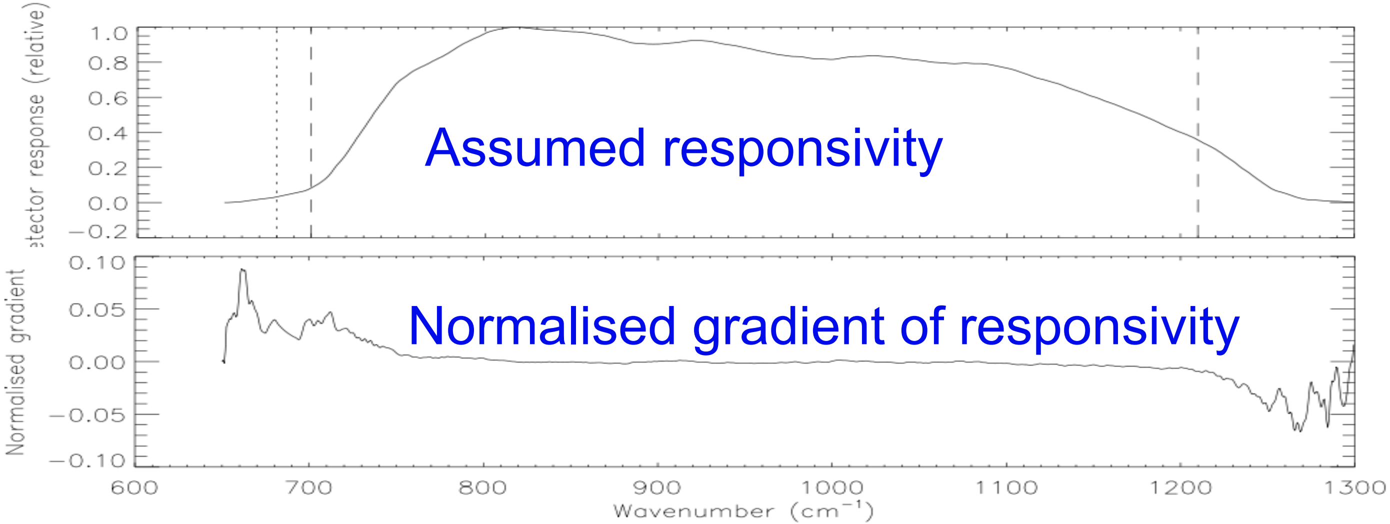
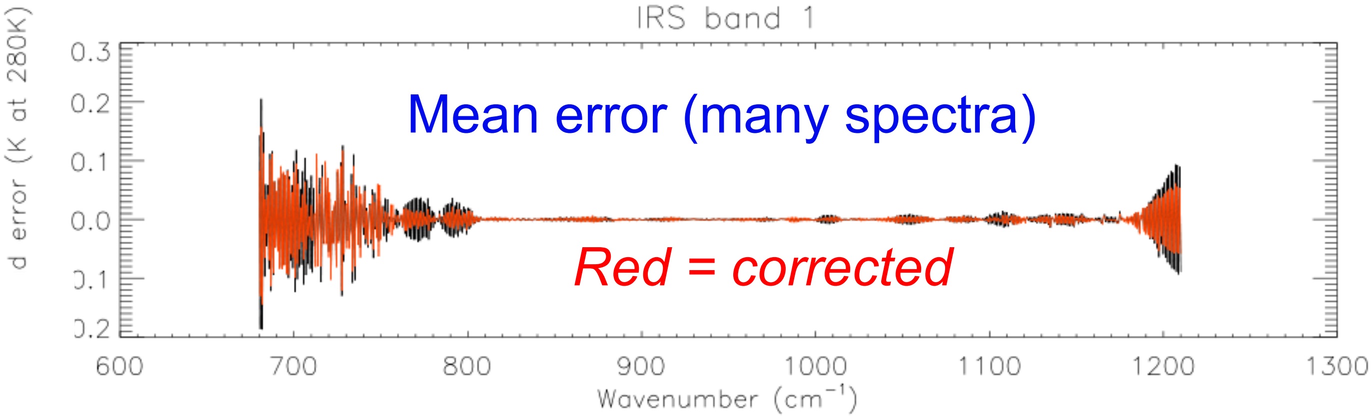
Results (2) for realistic IRS simulation



Simulating IRS from IASI



Error is relative to ideal apodised spectrum

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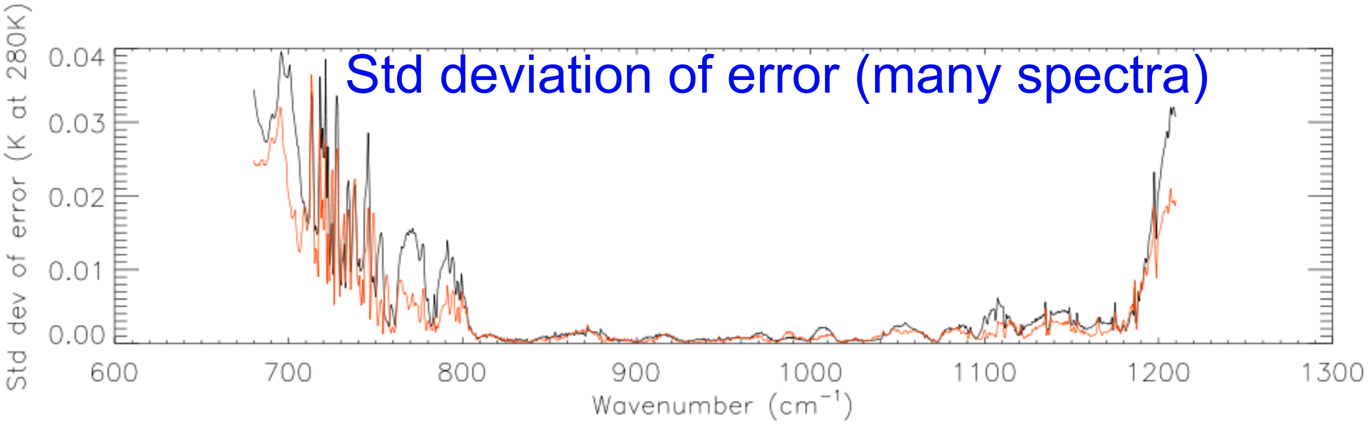
Results (cont.)



The correction is not perfect (and cannot be, without knowledge of the high-resolution spectrum), but there is a significant improvement in some spectral regions

I've assumed the processor has access to spectral regions outside the nominal band. If not, expect larger errors at band edges

Conclusions

- The UW method is theoretically sound, and easy to compute
- Recommend to compare results with EUMETSAT's method outlined in the Level 1 ATBD
  - EUMETSAT would be in the best position to do this study because they already have simulator tools
- For more details, see Met Office SA Tech Memo 79. It can be circulated to the MAG if you would like.