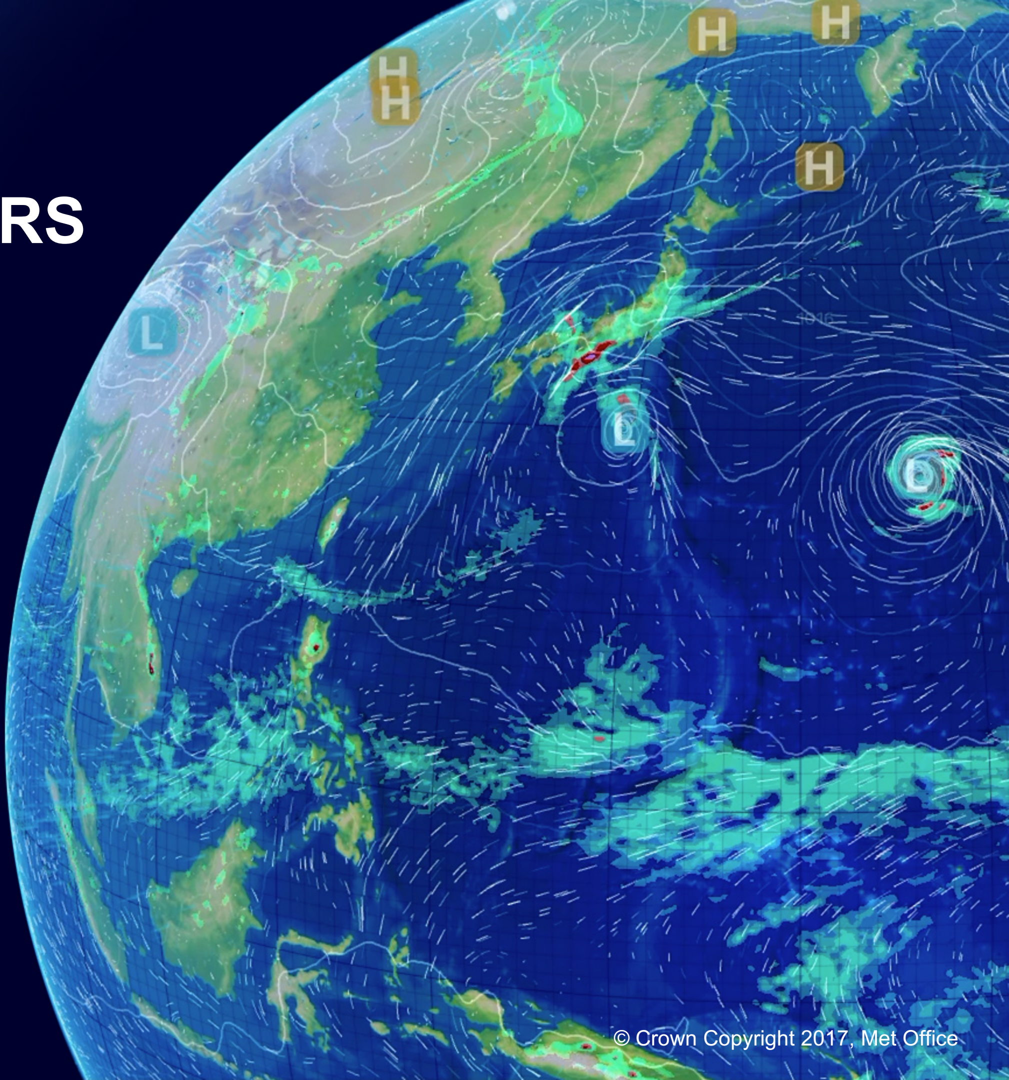
On the reversibility of MTG-IRS apodisation conversions



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Introduction

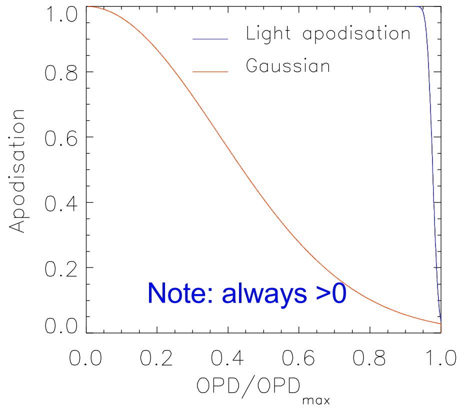
MTG-IRS current baseline is to generate *lightly-apodised spectra*

This is advantageous for the PC product because it greatly simplifies the process of noise-normalisation (the noise is nearly diagonal)

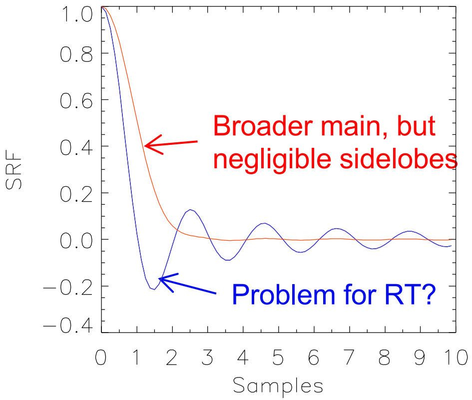
Some users would like more heavily-apodised spectra, to avoid problems with radiative transfer (see below)

This presentation addresses the question … ***are the apodisation manipulations accurate and reversible?***

For users of the PC product, the focus shifts from apodising the spectra to apodising the eigenvectors … but the principles are the same



Interferogram domain



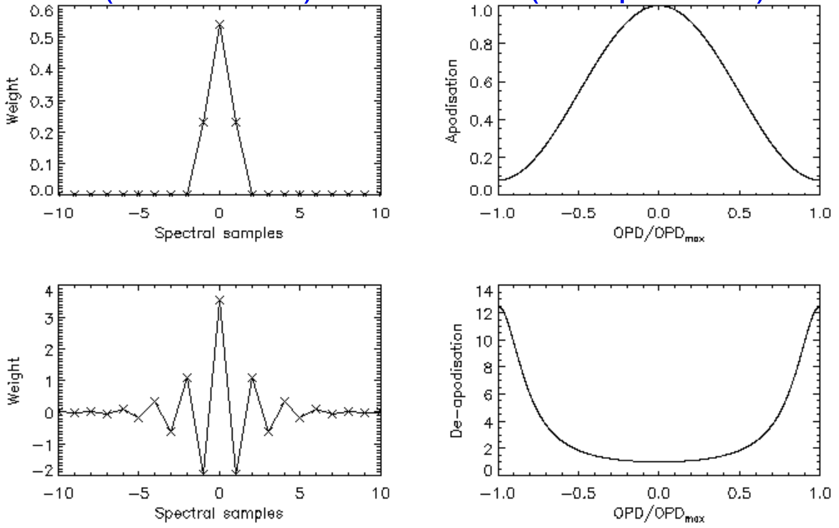
Spectral Response Function

Why is it normally easier to apodise than to de-apodise?

Spectral domain (convolution) | Interferogram domain (multiplication)

Apodise →

De-apodise →



Example:

Hamming

(as used for CrIS)

Apodisation is a simple convolution of the spectrum with a 3-point array – but de-apodisation requires many more than 3!

MTG-IRS assumptions / method

- Band 1 coverage is 680 to 1210 cm^{-1} (have not looked at band 2)
- Spectral sampling 0.625 cm^{-1} for IRS (users will actually get 0.6 cm^{-1} but it probably makes no difference to the conclusions of this study)
- Simulate IRS using IASI (sampling 0.25 cm^{-1}) – use the same 9-minute dataset that has been used in other studies
- Using the apodisation set out in the Level 1 ATBD – integral of a Gaussian. *The original coscar is not reversible because it falls to zero at* OPD_{max}

To change the apodisation, simply multiply the *interferogram* by the new/old apodisation ratio

- This is exact, in principle, since neither of the apodisations go to zero.

BUT if we are starting from *spectra*, we know nothing about the spectral regions <680 or >1210 cm^{-1}

Concern that band-edge effects could cause errors

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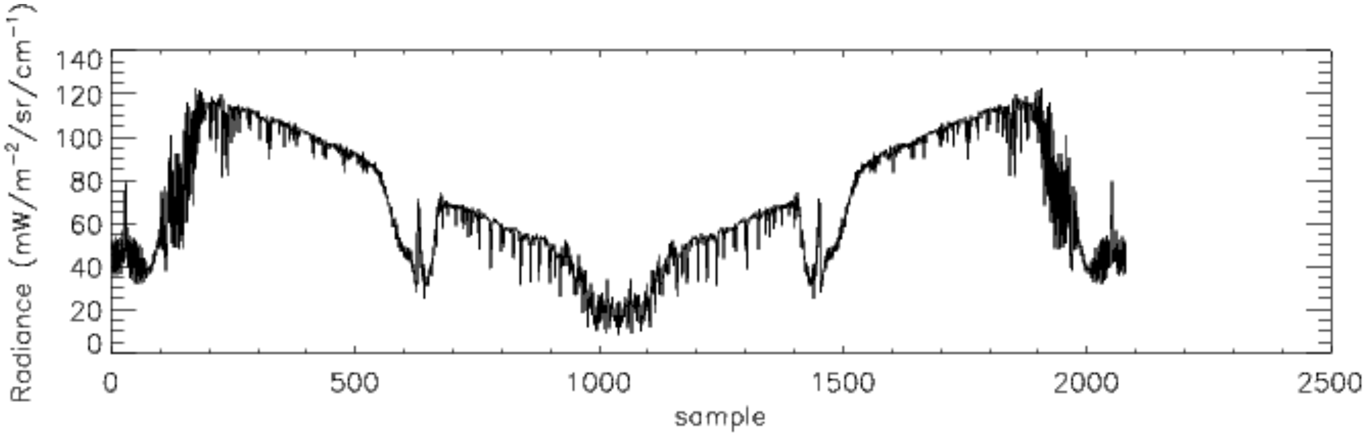
How to go from spectrum to "interferogram"

To carry out the required FFT, spectrum *must repeat*

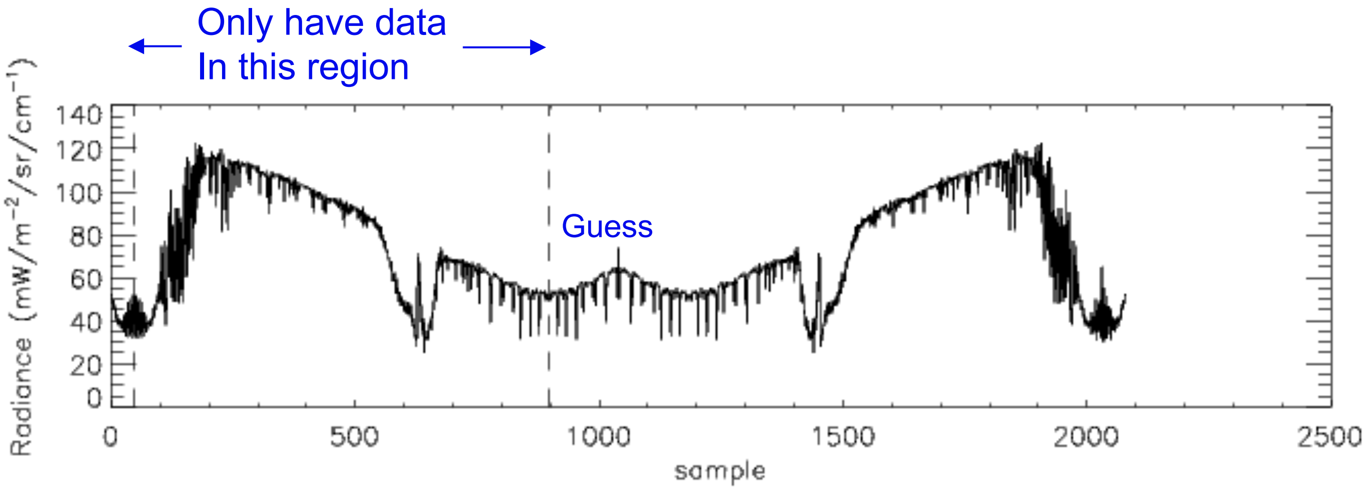
A common way is to *reverse* the spectrum before carrying out FFT:



This is generated from IASI, covering an extended range: 650 to 1300 cm^{-1}

Spectrum to “interferogram” (cont.)

In the absence of extended spectral range, we have to do something like this:



It’s a reasonable approach – achieves repeating spectrum with no discontinuities

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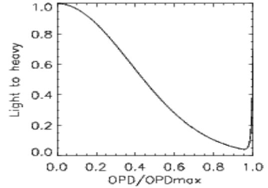
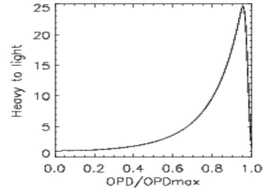
Procedure followed in this study

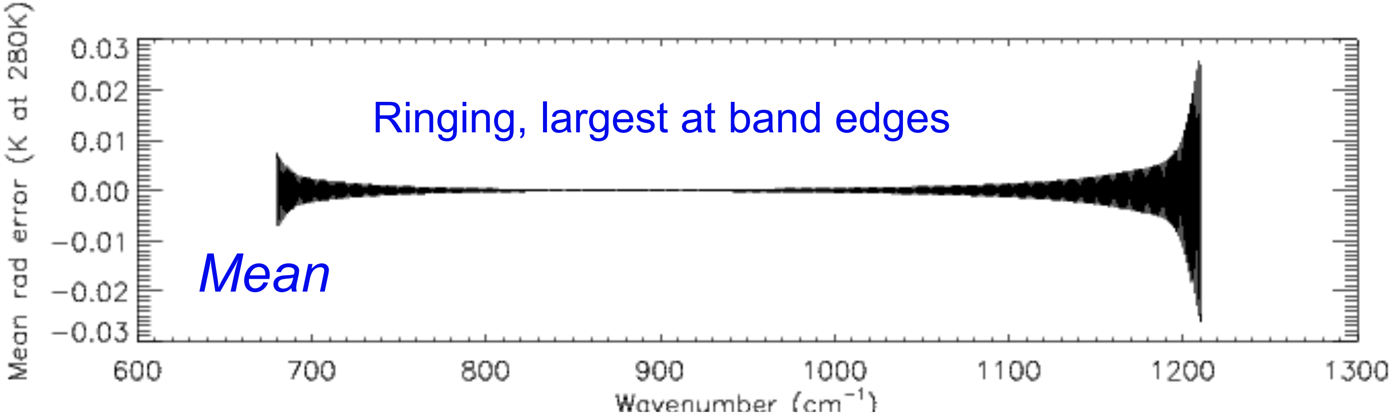
1. Generate the ideal lightly-apodised IRS spectrum (from IASI)
2. Truncate at the band edges and fill in the missing regions as in previous slide *[optional]*
3. FFT to interferogram domain
4. Multiply by *heavy / light* apodisation ratio
5. Inverse FFT to spectral domain – *this is the heavily-apodised spectrum*
6. Truncate at the band edges and fill in the missing regions (again)
7. FFT to interferogram domain
8. Multiply by *light / heavy* apodisation ratio
9. Inverse FFT to spectral domain – *this is the reconstructed lightly-apodised spectrum*

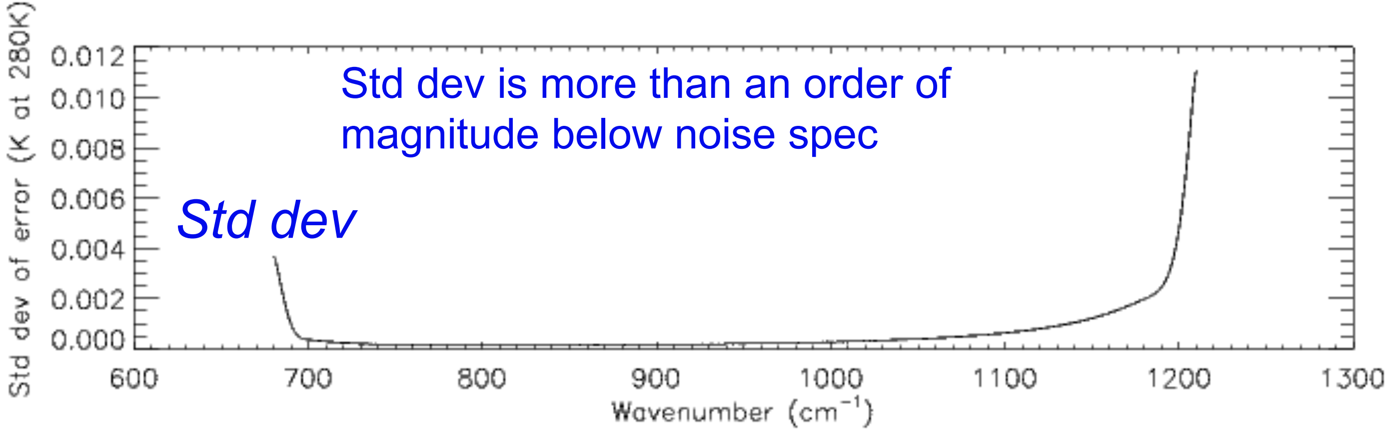


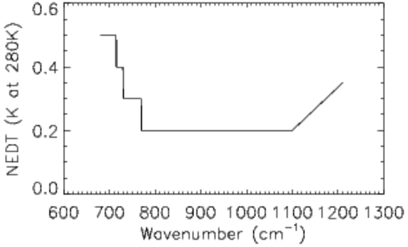


Repeat for each spectrum, comparing output of step 9 with step 1

Results







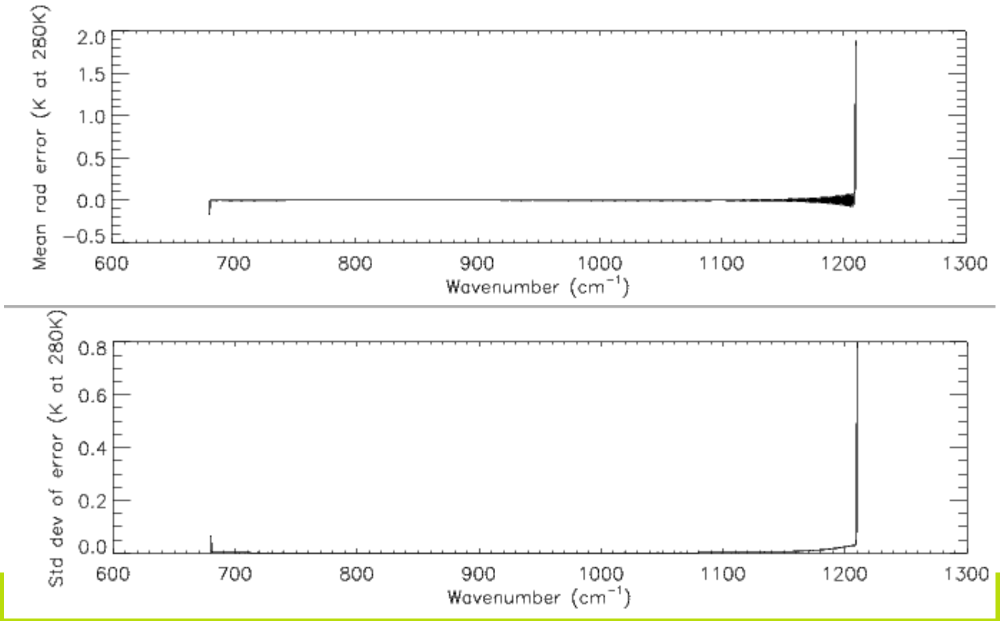
Noise specification

Comment

This result suggests that there is no problem with reversibility

However,

- The strongly-apodised spectra have been generated using artificial margins – does this matter?
- Compare real margin with artificial in the strongly-apodised spectra:



Significant error at RH edge of band

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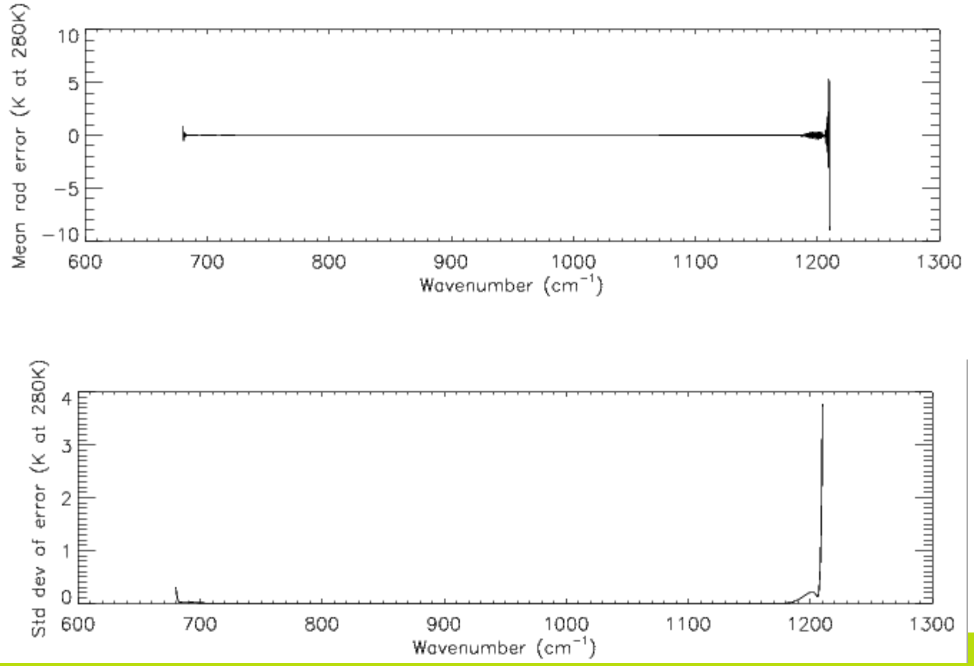
and if we then convert the "true" strongly-apodised spectrum back to weakly-apodised, using artificial margin, …



Error is increased

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Conclusions

- To achieve reversibility and maintain accuracy of spectra, some spectral margin is needed (a EUMETSAT study reached a similar conclusion)
- How much margin depends on the accuracy requirements and the chosen apodisation functions
- Of order 20 cm^{-1} ?
- Margin also desirable in the eigenvectors distributed to users – *is this feasible?*
- Obviously we also have to take care not to damage the spectra by numerical rounding (conversion to integer, to aid data compression), especially if working with the heavily-apodised spectra. But assume that is taken into account in dataset design.