IRS L1 Status and open points

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Outline

1) MTG IRS L1 scheme based on the ATBD

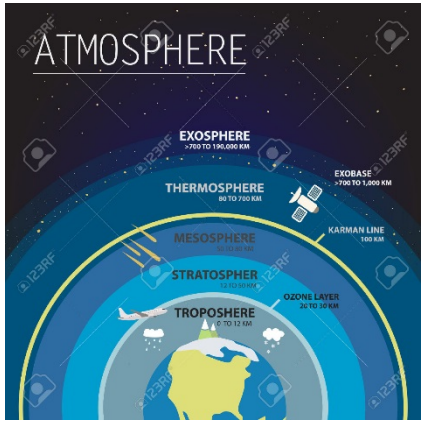
- ✓ On-board processing – overview and open points
- ✓ On-ground processing – overview and open points

2) Main open points and improvements:

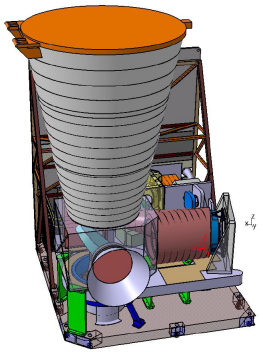
2a) Uniformisation
2b) Apodisation
2c) IRS spectral grid: different possibilities
2d) Information of the scene heterogeneity
2e) Meta data needed by the users community

3) Feedbacks needed from the MAG members

1) MTG IRS L1 scheme – On-Board processing



Atmospheric components



Raw measurements

Main On-Board processing steps

Correction tables → **Non-Linearity correction**

Thresholds → **Spike detection and correction**

Pixels position → **Interferogram resampling** (Corner Cube movement correction + first spectral calibration)

Decimation Filter → **Decimation and compression**

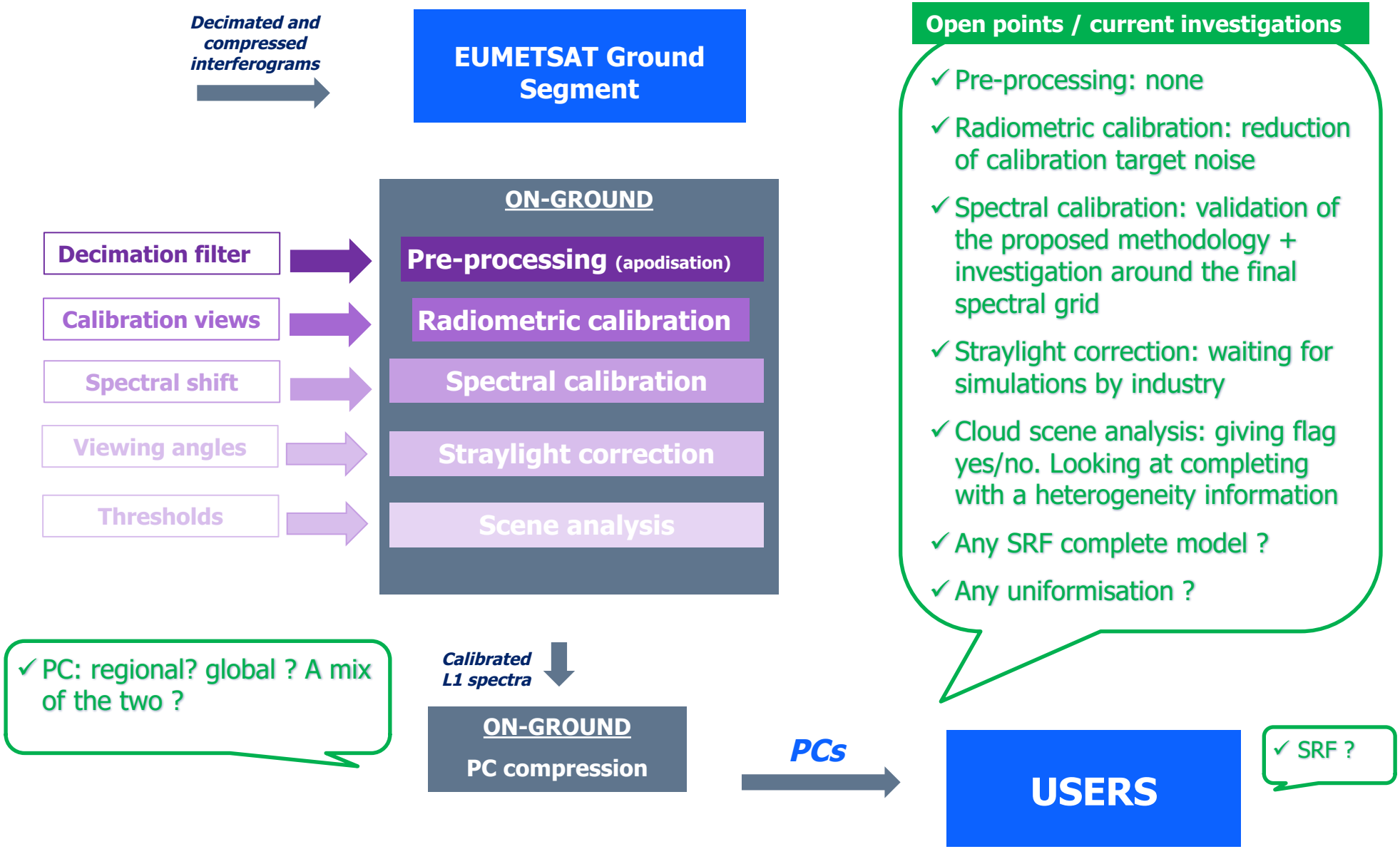
Decimated and compressed interferograms

EUMETSAT Ground Segment

Open points / current investigations

- ✓ NL correction: take advantage of recent improvement on IASI ?
- ✓ Spike correction to be checked with IRASS performance tool
- ✓ Resampling strategy: are all corner cube movement flaws corrected ? Sweep direction dependency well removed?
- ✓ Decimation and compression: waiting for latest decimation filter from industry.

1) MTG IRS L1 scheme – On-Ground processing



2) IRS L1 processing: open points and improvements

Following five points will be addressed today:

2a) Uniformisation, currently a place holder in the IDPF-S
- ✓ The proposed methodology has been finalized and is fully validated
- ✓ Some improvement is terms of timeliness is on-going

2b) Apodisation
- ✓ Impact on the spectral resolution, specified better than 0.754 cm^{-1}

2c) Spectral grid is currently 0.625 cm^{-1}
- ✓ The instrument has better performances than the specification

2d) Cloud/heterogeneity analysis
- ✓ Current algorithm proposed provide a cloud flag yes/no
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2e) Meta data needed by the users community

2a) Principle of the uniformisation

Objectives: To uniformise the Spectral Response Function across the detector array, in the spectral range and in time ⟷ To remove the SRF from the measurements.

Measured spectrum:

$$S_{mes} = (S.R) \otimes ILS$$

S: Infinite spectrum
R: is the Radiometric response
ILS: Instrument Line Shape
(including the apodisation function)

Methodology:

$$I_{1B}(x) = FT[S_{mes}(v)]$$

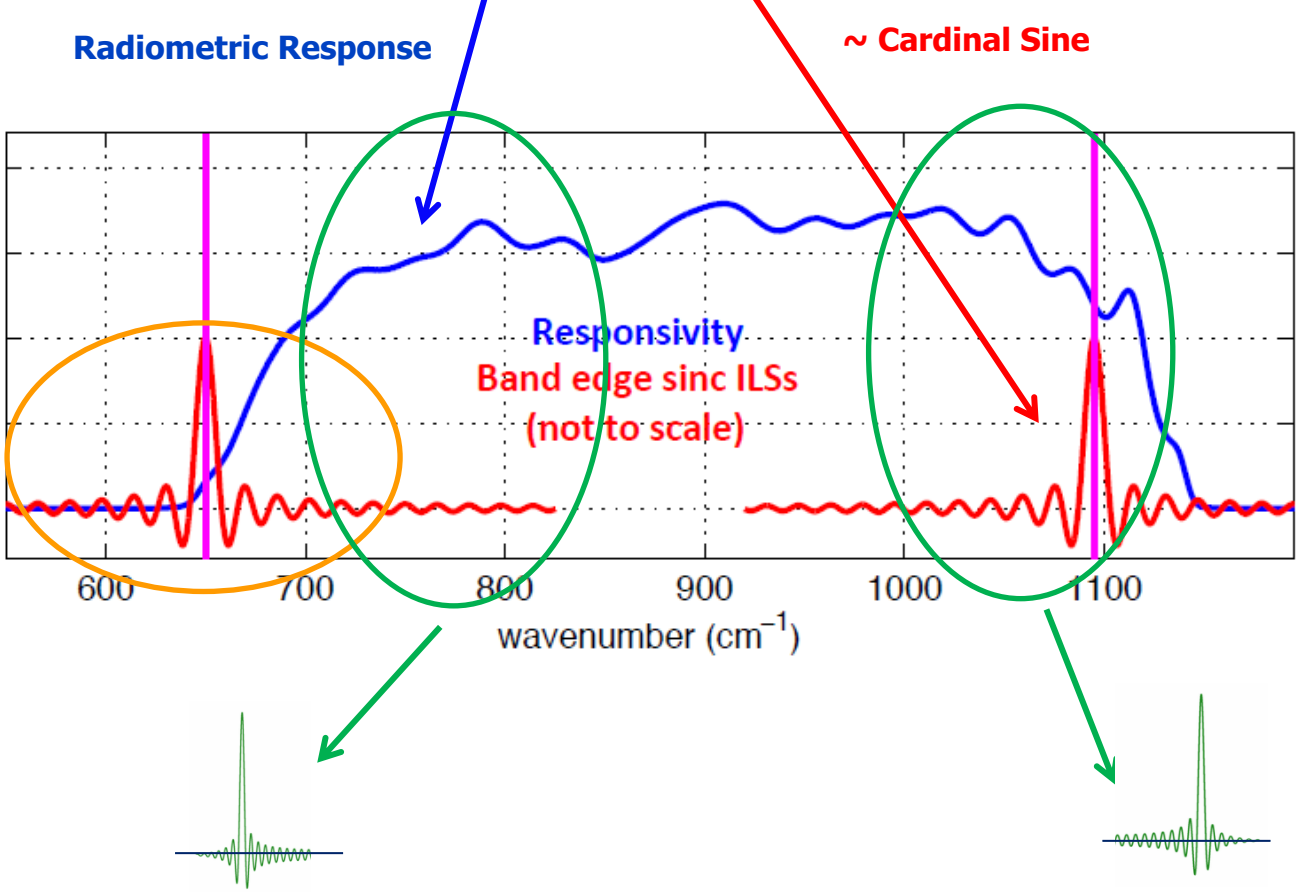
$$S_{1C}(v) = FT^{-1}\left[\frac{I_{1B}(x)}{SAF_{1B\_est}(v,x)}\right]$$

SRF

with $$SAF_{1B\_est}(v,x) = FT\left[ILS_{1B\_est}(v_0 - v).R(v).\right]$$

2a) Spectral Response Function variability

$$SRF_{\nu_0}(\nu) = Re\left[\frac{R(\nu)}{R(\nu_0)} \times ILS_{\nu}(\nu_0)\right]$$



Missing information in the band edge is a problem

SRF more spectrally dependent

Radiometric Response is pixel dependent (25600 pixels for a dwell)

2a) Spectral Response Function variability

$$SRF_{\nu_0}(\nu) = Re\left[\frac{R(\nu)}{R(\nu_0)} \times ILS_{\nu}(\nu_0)\right]$$

The Spectral Responsivity is:

- ✓ Pixel dependant → 25600 SRF
- ✓ Spectral dependant → 1800 SRF
- ✓ Instrument dependant → Regular update: every year? Month? Day?

Current situation of today:

- → To reduce that number in grouping spatially – no information on reduction
- → Since the spectral variation is small, we can reduce to 5 functions per band
- → No information

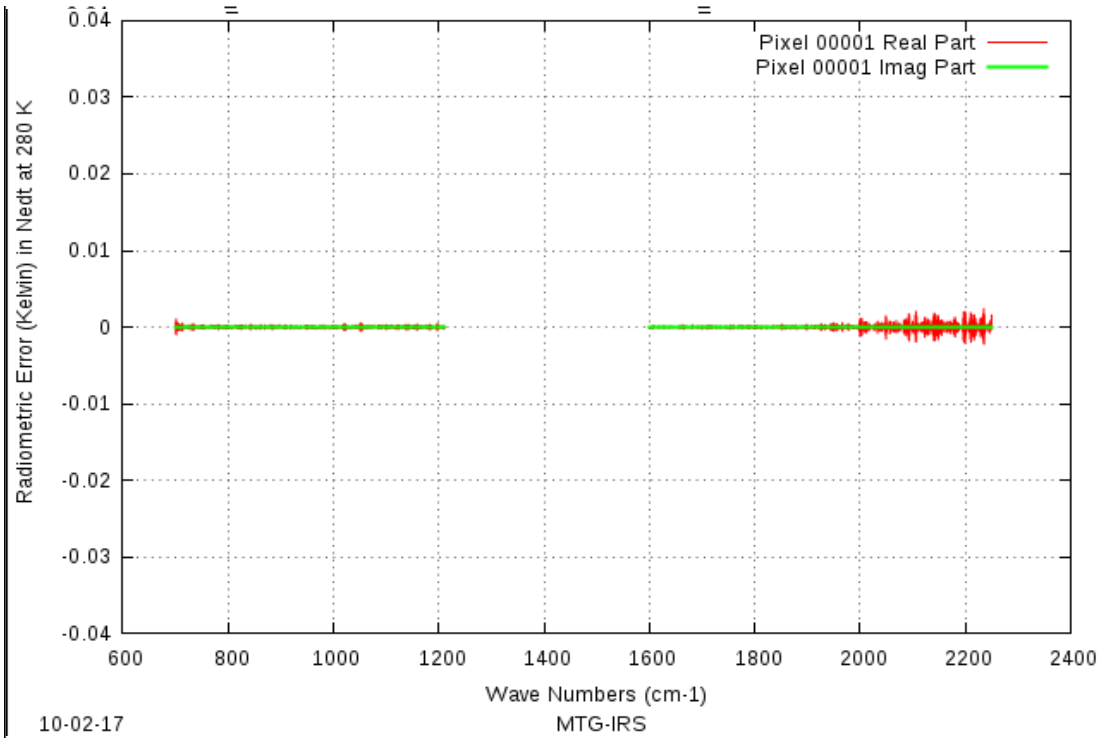
→ **Update of ~~1800~~ 10 x 25600 SRF, every year, month or day**

2a) Uniformisation of the ILS

Difference between Corner and Center pixels

No Uniformisation

With Uniformisation



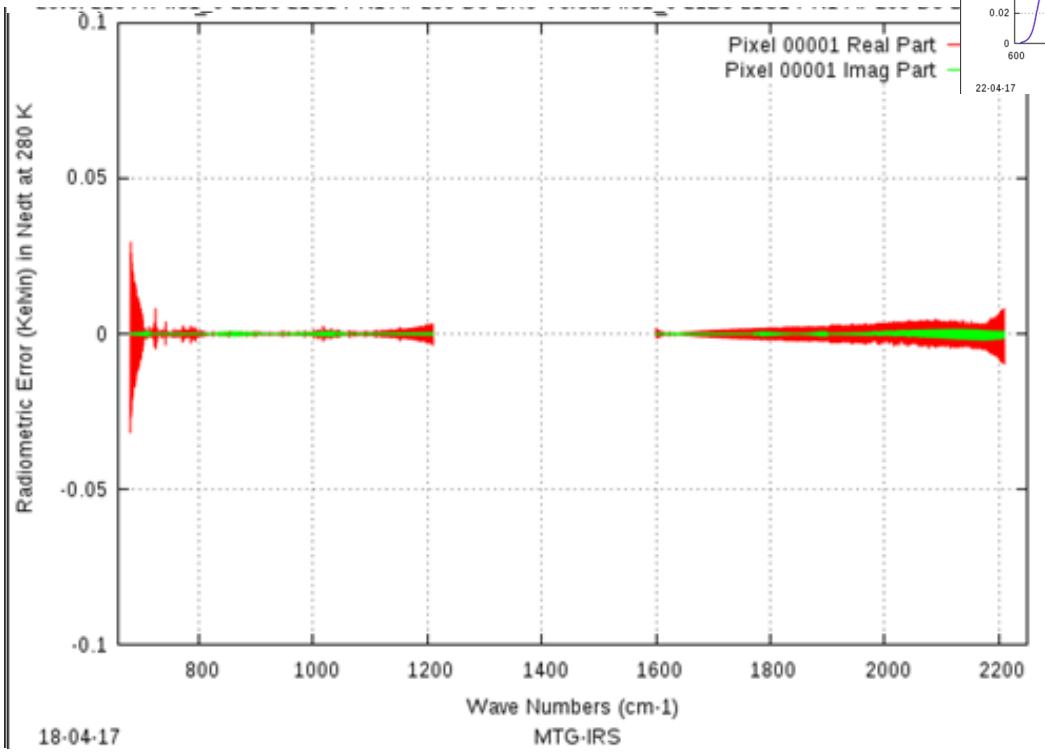
2a) Uniformisation of the Radiometric Response

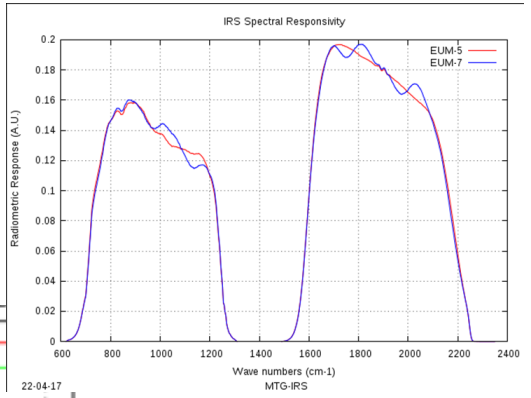
Effect on different Radiometric Response

Extreme Case

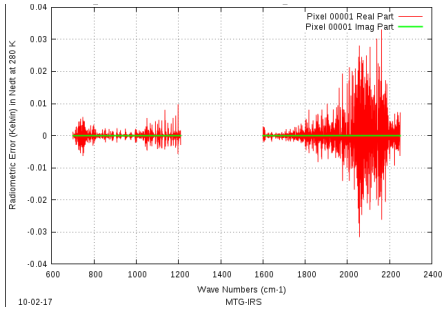
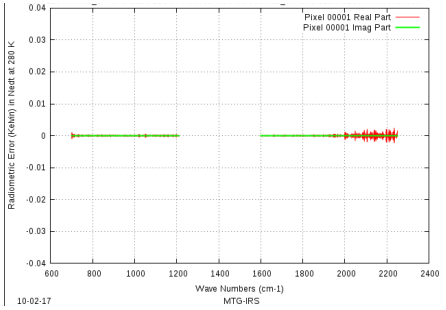
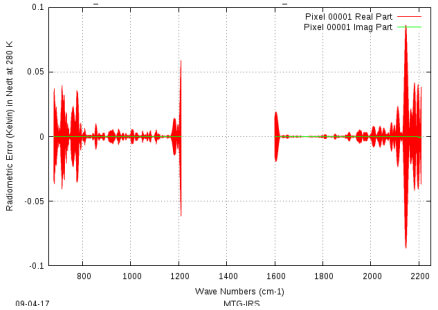
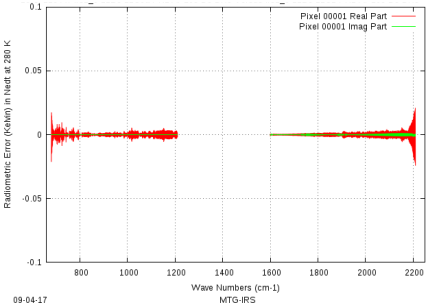
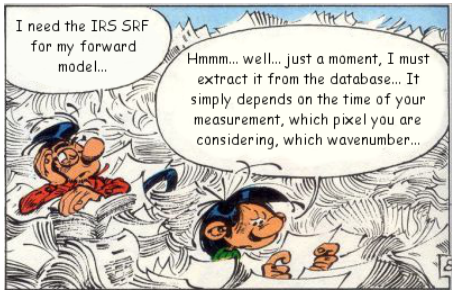
No Uniformisation

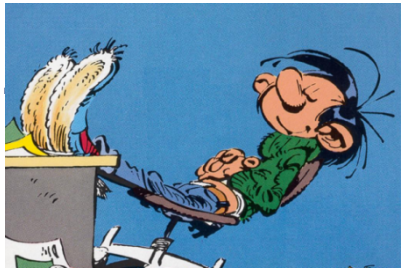
With Uniformisation





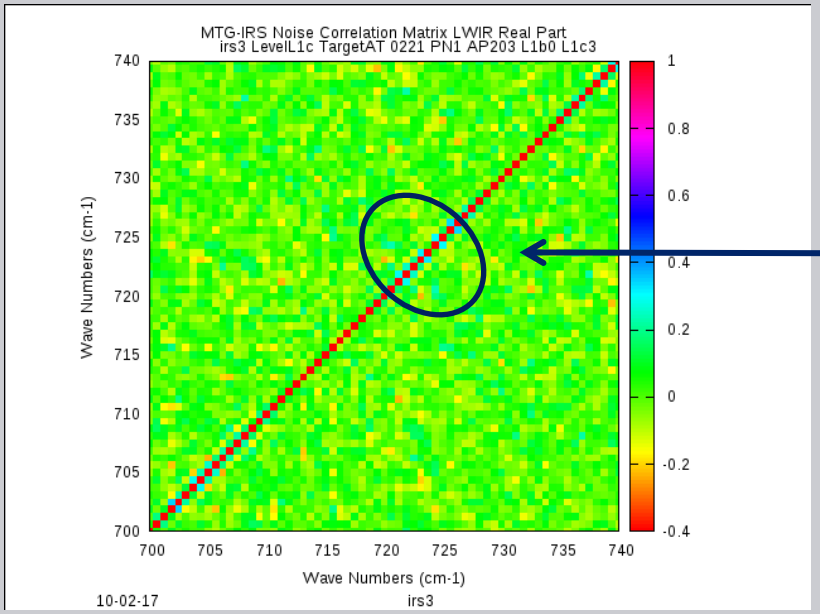
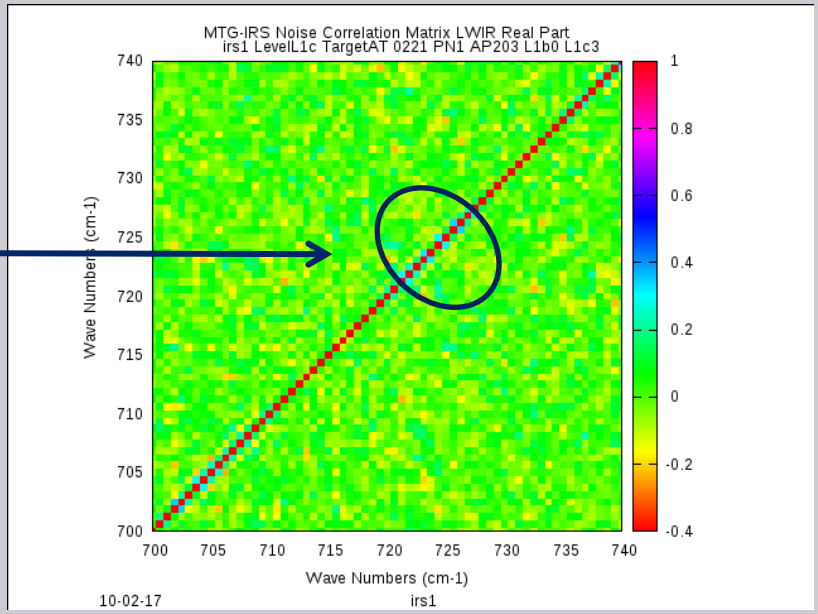
2a) Uniformisation of the full SRF

	Simulated error to be corrected		Residual error after uniformisation
ILS (corner-center pixel)		+	
Radiometric response (EUM5-Flat)		=	
USERS	= noise for 1 pixel by 25600 pixels = 256000 SRF to be updated regularly		= <u>Negligeable noise</u> for all pixels, and no evolution in time



2a) Impact on the noise correlation

Effect of the **uniformisation** on the noise correlation

Without shape removal	With shape removal
	

Uniformisation = No impact on the noise correlation

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2b) Apodisation

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2c) Spectral grid is currently 0.625 cm^{-1}

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2e) Meta data needed by the users community

2b) IRS Instrument Line Shape

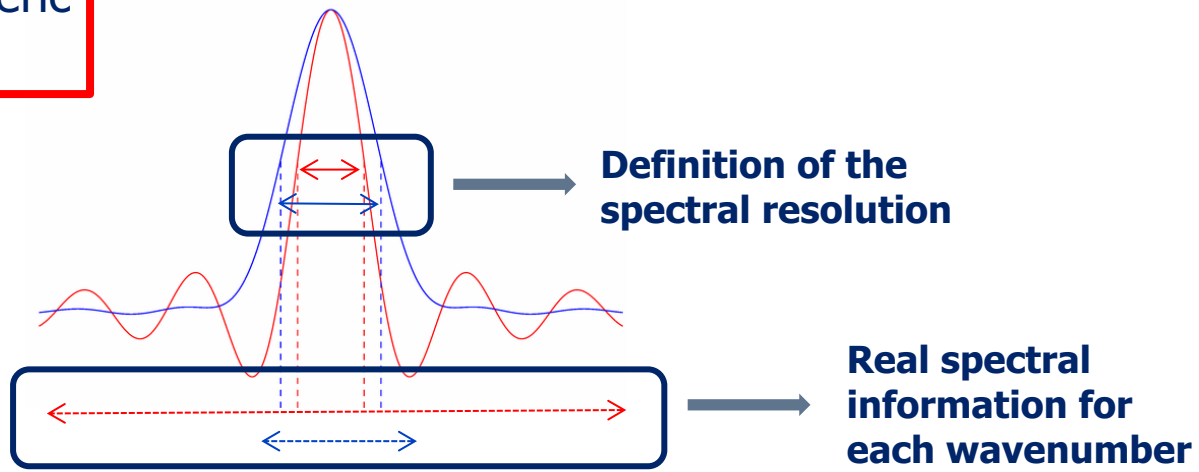
It is possible to improve the situation regarding the ILS with an apodisation (which respects the mission requirement)

Measured ILS:

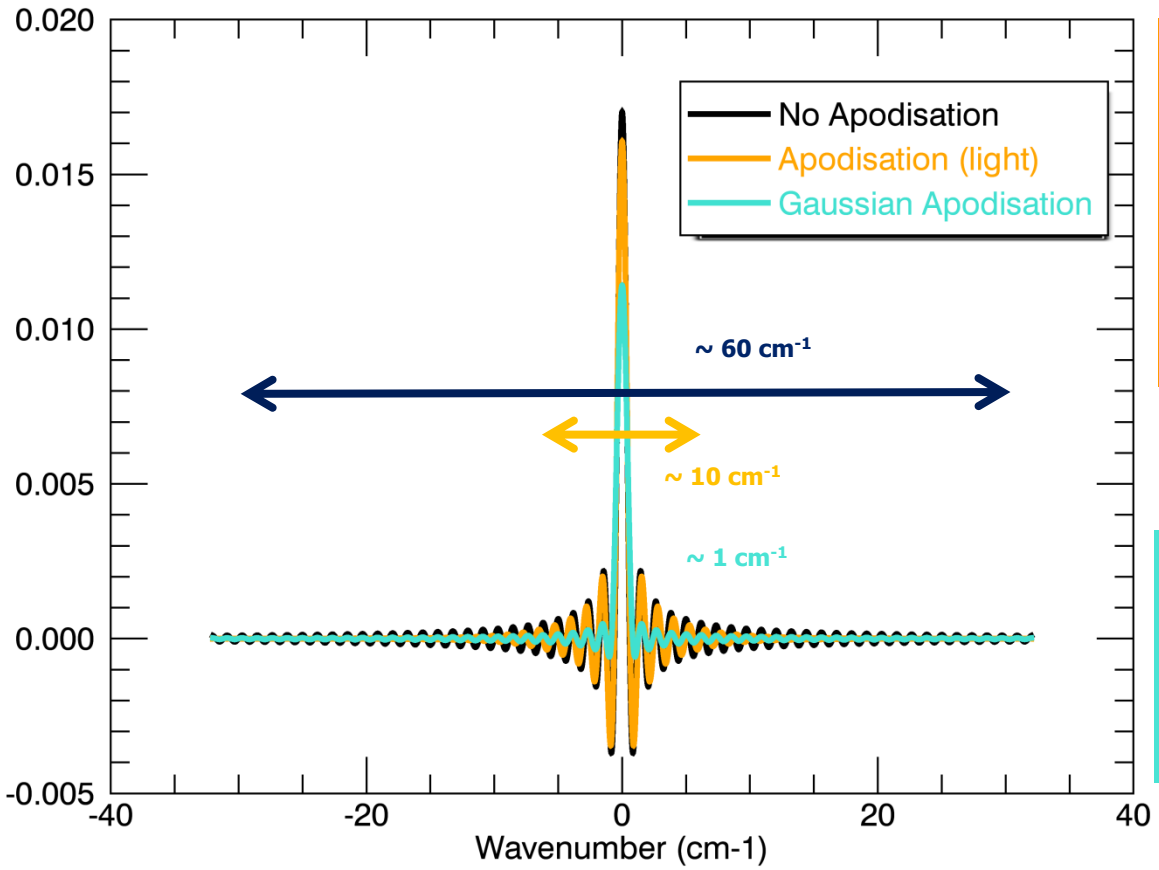
- ✓ It respects the spectral resolution of 0.754 cm^{-1} (mission requirement)
- ✓ Defined on a larger spectral area, each wavenumber represents the information coming from a spectra covering (at least) 60 cm^{-1} → kind of "polluted" by different atmospheric component (spectral cross-talk)

Gaussian apodisation (IASI type)

- ✓ It degrades the spectral resolution by 0.1 cm^{-1} (TBC)
- ✓ Each wavenumber are independent in terms of integrated information (no spectral cross-talk)



2b) Possible apodisations



SELECTED

1) Light apodisation (gate slig… apodised) which:
- ✓ respect the spectral resolution of 0.754 cm^{-1}
- ✓ reduce the spectral cross-talk
- ✓ Does not remove the first lobes

2) Apodisation type Gaussian would:
- ✓ remove the spectral cross-talk
- ✓ degrade the spectral resolution by 0.1 cm^{-1} (at first estimation)

2b) Other apodisations – "Stronger ones"

Advantages:

- ✓ Reduced the spectral cross-talk covering ~10 cm^{-1} → ~1cm^{-1}
- ✓ Does not remove information from the original signal
- ✓ Is reversible – always possible to go back to the original SRF
- ✓ Doesn't put any constrain on the choice of the RT Models

Drawbacks:

- ✓ Enlarge the central pick, linked to the definition of the Spectral resolution
- ✓ Does not respect the mission requirement written ONLY in the System Requirement Document (SRD)

Proposition to:

➔ **To change in the SRD (in blue):**

[SRD] IRS-10540 - Level 1b pre *spectral resampling*
The full width half maximum (FWHM) of the IRS *spectral sample spectral response function* (SRF) shall be less than or equal to 0.754 cm^{-1} for unapodised spectra. In case of apodisation, the apodisation should be reversible.

➔ **To add the same information in the EURD**

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2e) Meta data needed by the users community

2c) IRS L1b spectral sampling

Mission specification: L1b sampling ≤ 0.625 cm^{-1}

Communication to users: L1b sampling of 0.625 cm^{-1}

Current situation:

- ✓ The mission specification is with a maximum OPD (Optical Path Difference) of 0.8 cm ➔ Spectral sampling of 0.625 cm^{-1}
- ✓ The interferograms received from the instrument are with a max OPD of 0.828 cm ➔ Spectral sampling of 0.6038… cm^{-1}

Impacts:

- ✓ Keeping 0.6038… is not a round number ➔ acceptable?

2c) IRS L1b spectral sampling

Three options:

- ✓ Under-sampling to 0.625 cm^{-1}
  - ✓ Information loss:
    - ✓ Sampling of 0.625 cm^{-1} → 816 channels in B1, 920 channels in B2
    - ✓ Sampling of 0.6038 cm^{-1} → 844 channels in B1, 951 channels in B2
      - ➔ Loss of 28 channels in band 1, 31 in band 2
  - ✓ Introduction of artefacts

- ✓ Keep the L0 sampling of 0.6038… cm^{-1}
  - ✓ Artefact minimization if L0 and L1B grids are identical
  - ✓ sampling step is an irrational number (→ acceptable?)

- ✓ Oversampling of the L0 grid (eg. 0.6 cm^{-1})
  - ✓ Increase of channel number in the useful bands (→ acceptable?)
  - ✓ No artefact introduced

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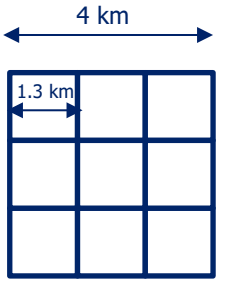
2d) Cloud Information

Goal of the study:

- ✓ To review the current cloud flag retrieval specification
- ✓ To recommend approaches to potential improvements

To do so:

- ✓ Use of IRS imager mode data
  - IRS detector arrays have 480x480 elements
  - For each 4km-pixel resolution, 9 pixels of 1.3 km resolution



- ✓ Study the potential synergy with FCI
  - Use of 4 pixels of 2 km-resolution in the infrared domain, 8 bands from 3.8 to 13.3 microns
  - Use of 16 pixels of 1 km-resolution, 8 bands from 0.4 to 2.2 microns
  - Depends on co-registration and possible synchronization in time

2d) Cloud mask

Current baseline of the Cloud mask scheme mainly is based on:

- ✓ Comparison of radiances in a transparent spectral channel with NWP short term forecast
- ✓ Test based on the auto-correlation functions in the region of 800-950 cm^{-1}
- ✓ Spatial correlation test to detect cloud edges

Comparison with AVHRR:

✓ AVHRR cloud mask

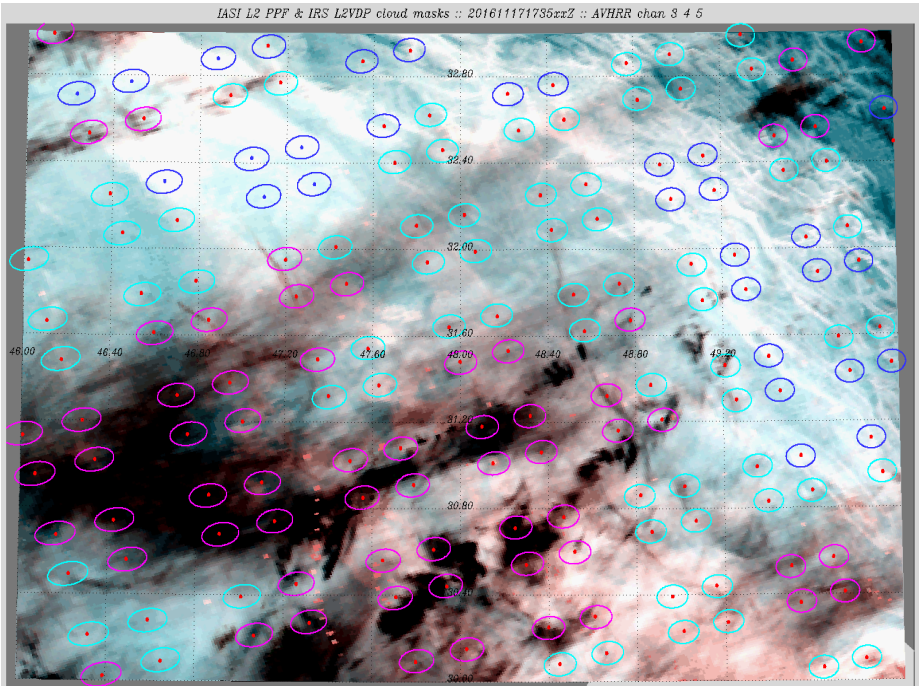
Clear | Partly cloudy | Cloud

✓ IASI L2 PPF cloud mask

✓ IRS L2VDP cloud mask

Clear | Clear enough | Partly cloudy | Fully cloudy

Saudia AVHRR [3 4 5]
201611171735Z

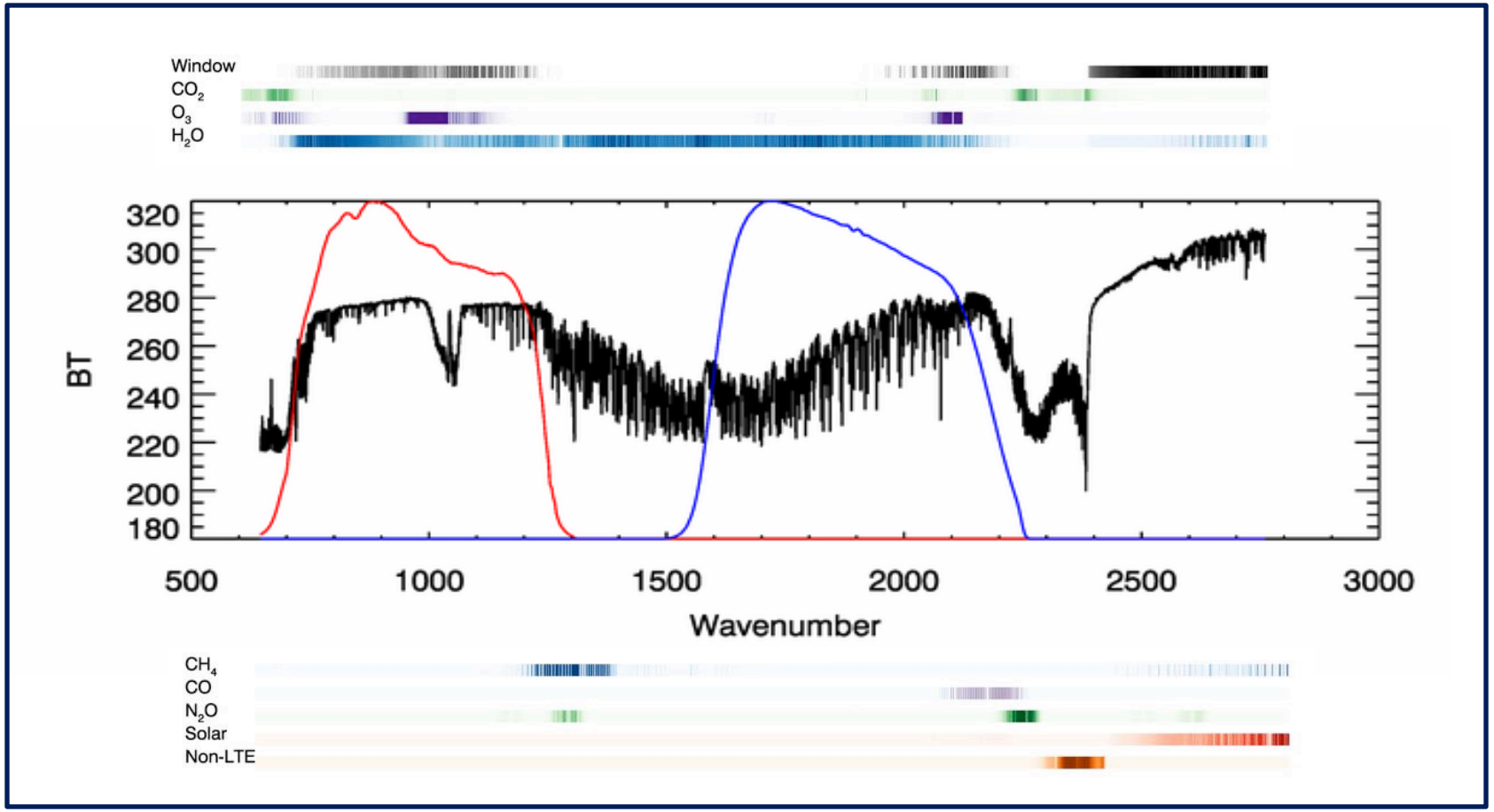


IRS L2VDP systematically cloudy, regardless of actual cloudiness

2d) Use of the IRS imager mode

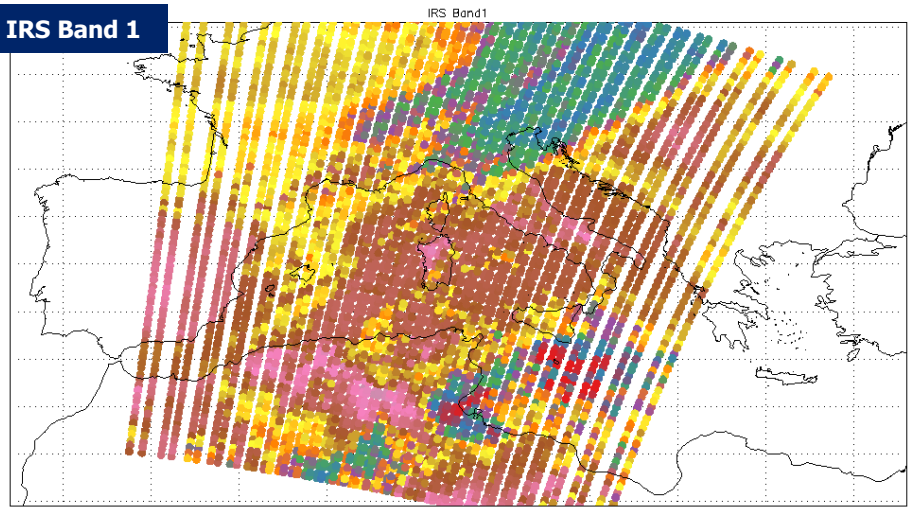
Cloud/Heterogeneity analysis:

- ✓ To take advantage on the IRS imager mode (9 sub-pixels of 1.3 km)
- ✓ Later to exploit the synergy between IRS and FCI

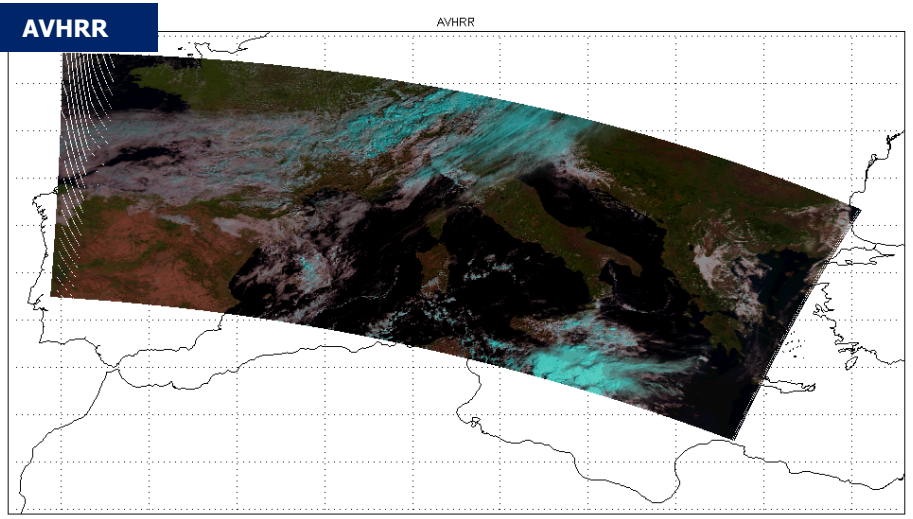


2d) Simulated IRS band 1&2 radiances vs. AVHRR

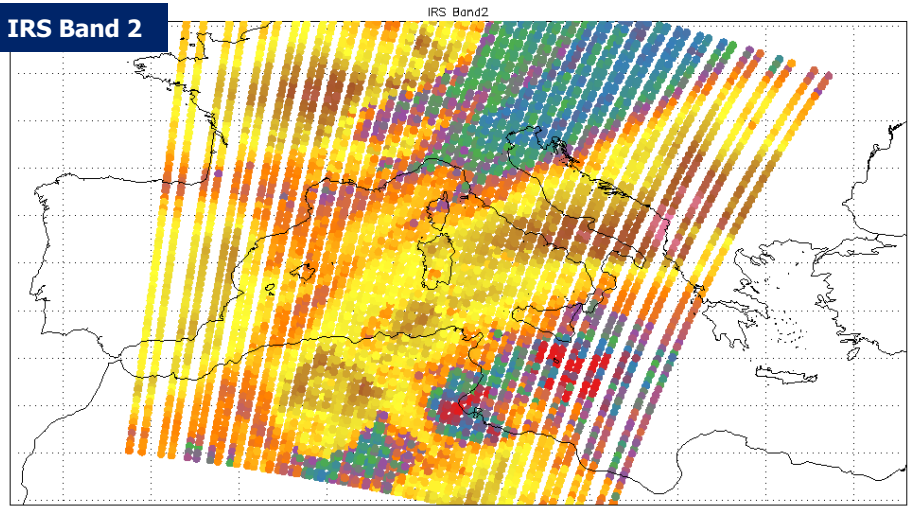
IRS Band 1



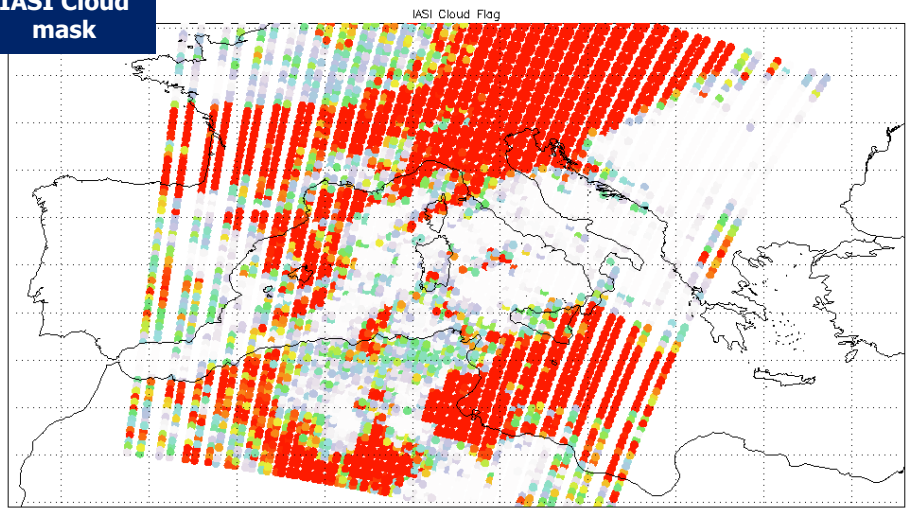
AVHRR



IRS Band 2

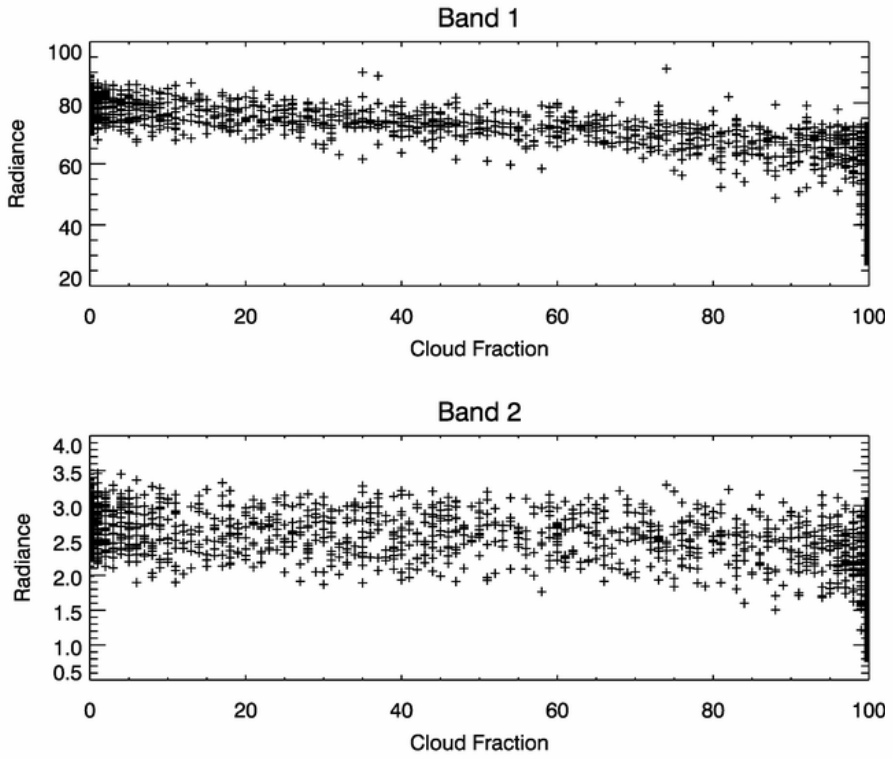


IASI Cloud mask

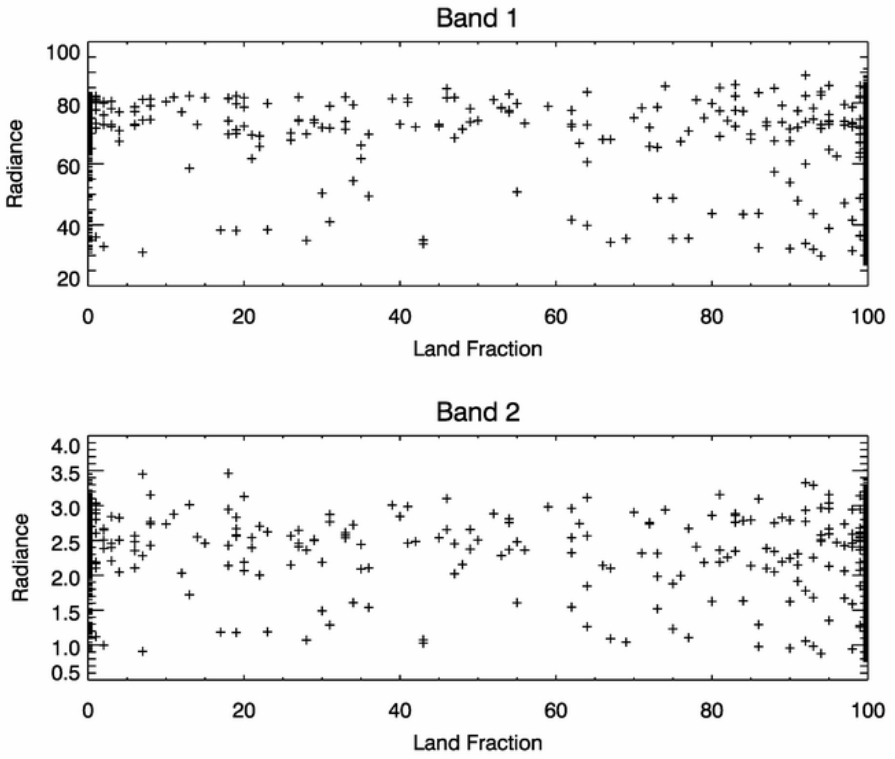


2d) Correlation IRS band radiance vs. cloud & land

Cloud Fraction



Land Fraction



- ✓ Only a slight correlation between radiance in band 1 and cloud fraction
- ✓ No correlation in band 2

No clear correlation in both band

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2e) IRS Meta data

From IRS level 1 format specification:

- ✓ Information on the state of the satellite (e.g. attitude, orbit, OBT to UTC correlation, etc.)
- ✓ Instrument (e.g. instrument mode and operations, etc.)
- ✓ Geolocation of spatial sample (lat, lon) and Subsatellite (lat, lon)
- ✓ Satellite and solar azimuth/zenith angles
- ✓ Scene type (clear/cloudy, sea/land/mixed)
- ✓ Eclipse information: Sun eclipse by Earth, Sun eclipse by Moon,…
- ✓ Spatial sampling distance (default 4km)
- ✓ Limb view information

➔ **Any specific need ?**

3) Feedbacks needed from the MAG members

5 main points have been presented:

- ✓ **Uniformisation** → MAG to give a recommendation
- ✓ **Spectral grid** → MAG to give a recommendation
- ✓ **Apodisation** → MAG to test and give feedback by next MAG
- ✓ **Cloud mask** → MAG members to comment on their needs
- ✓ **Meta data** → MAG to give a feedback by next MAG