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MTG-IRS processing overview and performances

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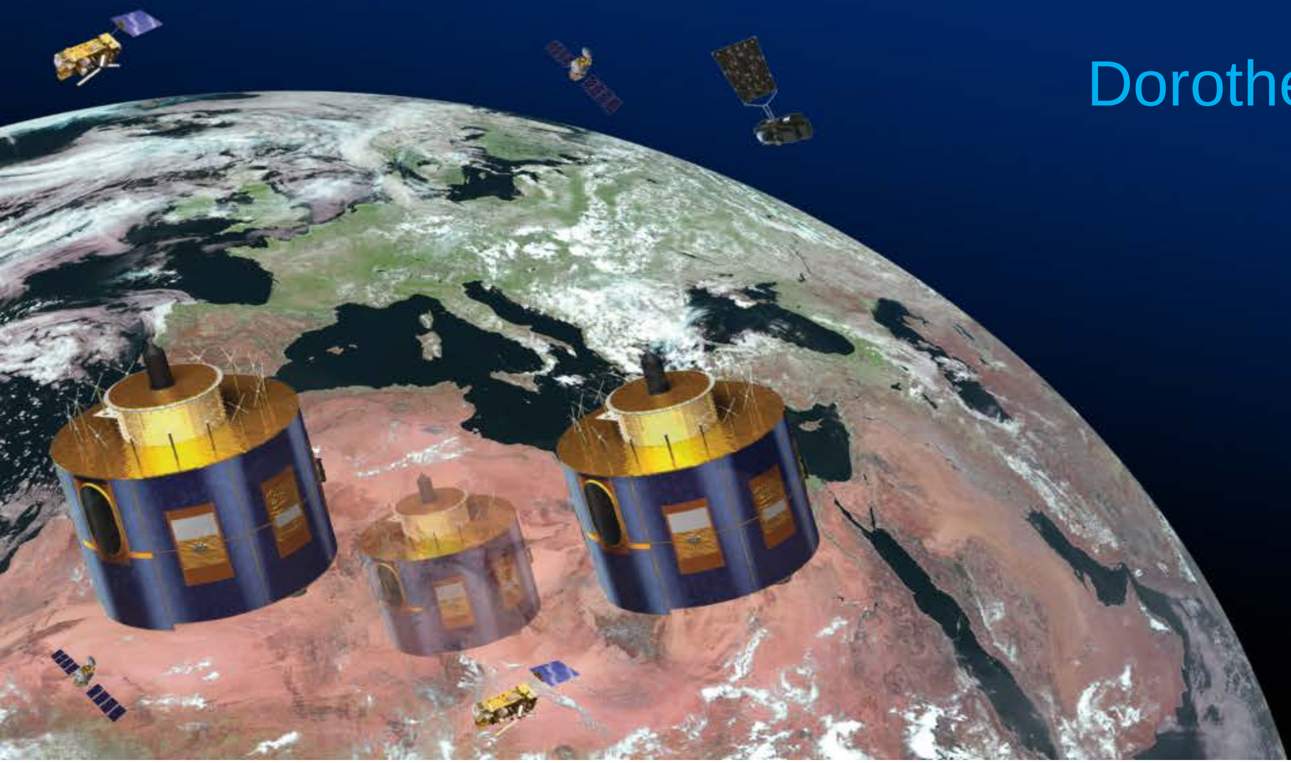


Outlines

1) Overview of MTG mission and IRS instrument

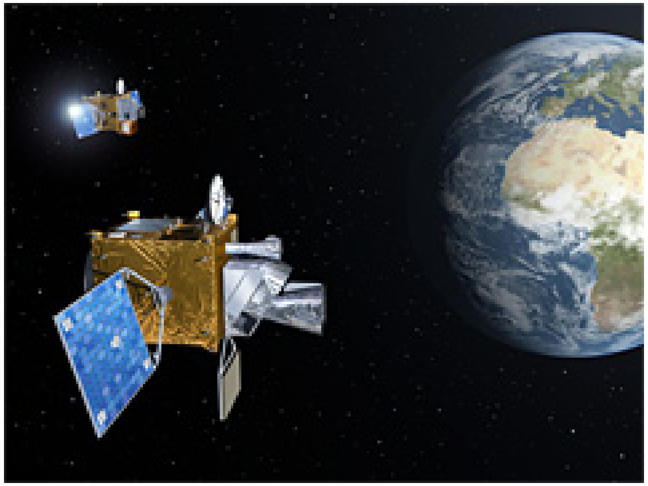
2) Overview of L1 processing for MTG-IRS

3) IRS Spectral Response Function (SRF) and impact for the users community:
   a) Variablility of the Radiometric Response → Uniformisation
   b) Status of the apodisation

4) Conclusion

1) MTG mission

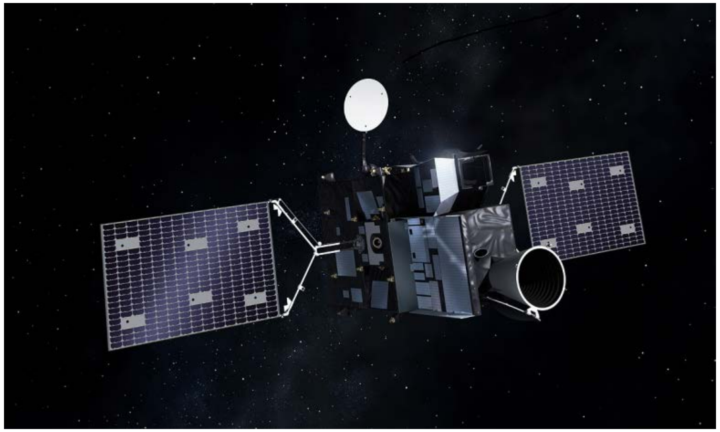
- ✓ The Meteosat Third Generation is based on twin satellite concept, based on 3-axis platforms:
  - ✓ Four Imaging Satellites (MTG-I), expected to provide 20 years of operational services
  - ✓ Two Sounding Satellites (MTG-S), expected to provide 16 years of operational services



- ✓ MTG-I satellites:
  - ✓ Flexible Combined Imager (FCI)
  - ✓ Lightning Imager (LI)
  - ✓ Data Collection System (DCS) and Search and Rescue (GEOSAR)

- ✓ MTG-S satellites:
  - ✓ Infrared Sounder (IRS)
  - ✓ Ultra-violet, Visible and Near-infrared Sounder (UVN)

1) IRS mission



in courtesy of ESA

The main performances can be summarized as follows:

- Spatial sampling : 4km at Sub-Satellite Point
- Spectral sampling : Better than 0.625 cm^{-1}
- Spectral Resolution : Better than 0.754 cm^{-1}
- Radiometric stability and noise : around 0.1-0.2K
- Spectral accuracy : 0.1K equivalent noise
- Repeat cycle : 30 min Europe
  6h repeat cycle for the Whole Earth

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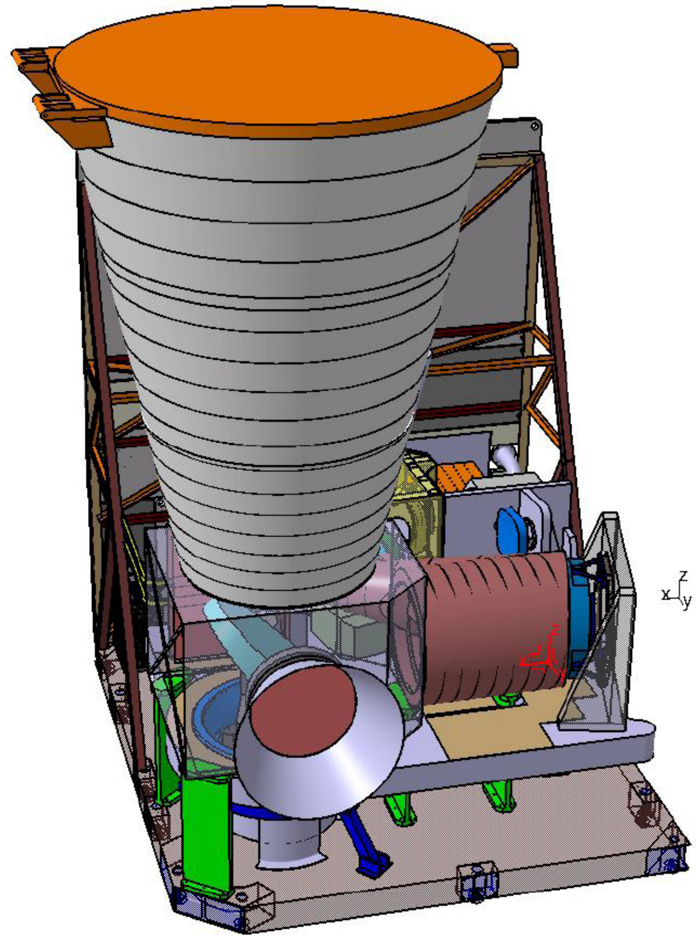
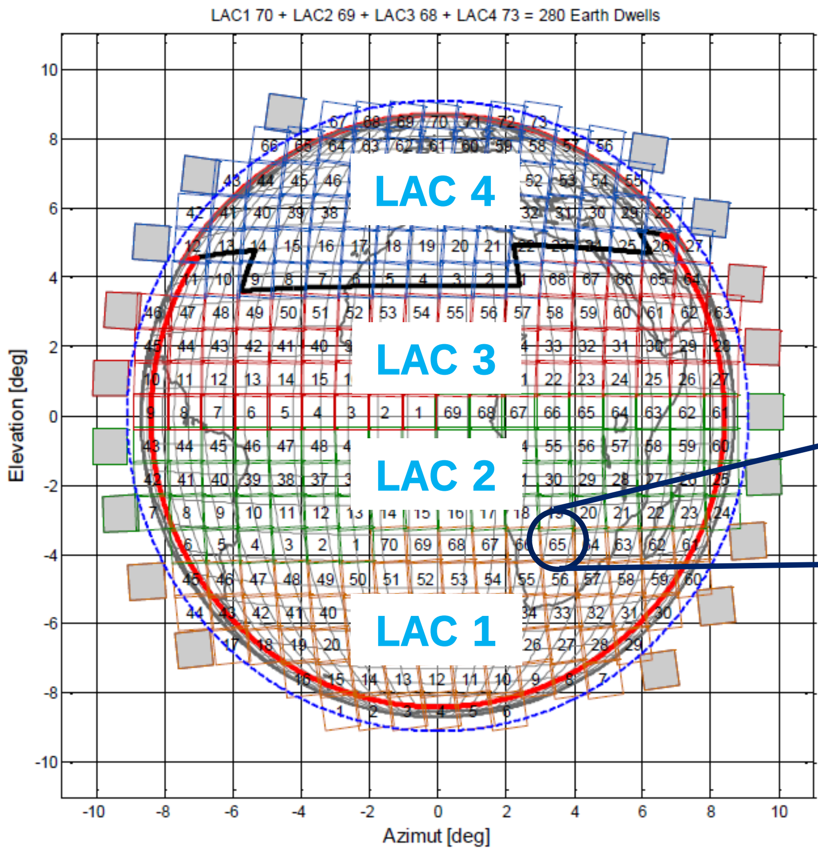
1) IRS instrument

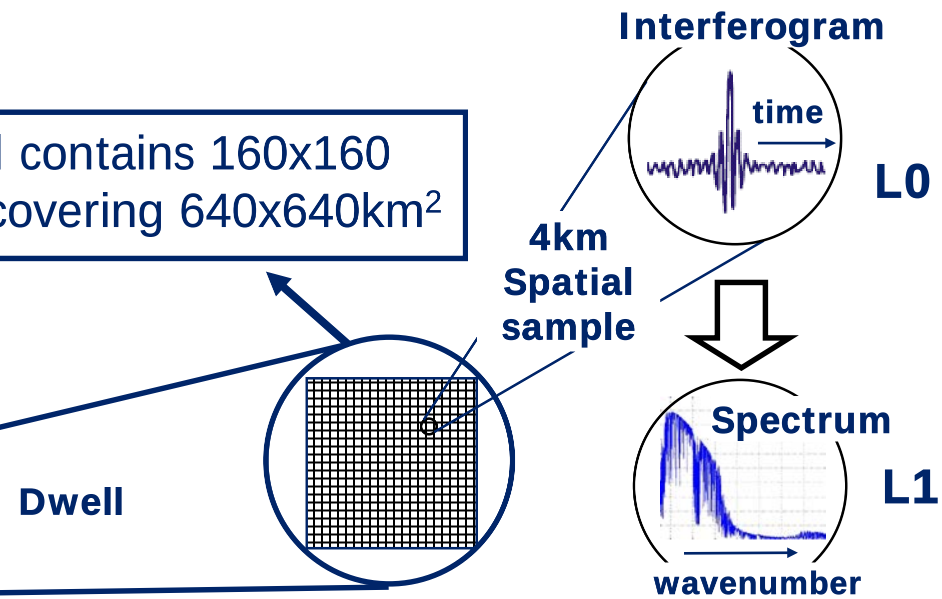
- ✓ Imaging Fourier Transform Spectrometer, based on a Michelson interferometer
- ✓ 2 spectral bands: LWIR (700 to 1210 cm-1) and MWIR (1600 to 2175 cm-1)
- ✓ CCM mechanism similar to IASI
- ✓ 3 laser beams allowing monitoring the CCM speed variations as well as apex vector offset and slope
- ✓ Maximum OPD on-ground: 0.8 cm (specification)
- ✓ Detector: 160x160 pixels (a “dwell”) measured in 10 sec, with the pixel size of 4 km.



1) IRS scanning sequence

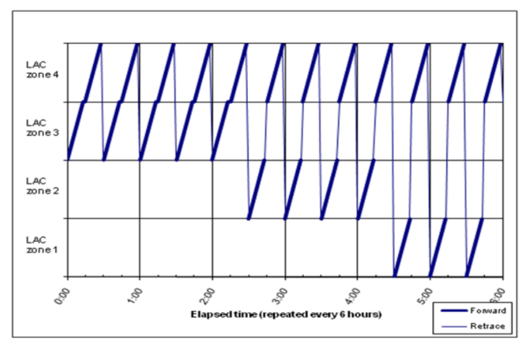


A dwell contains 160x160 pixels covering 640x640km^2



- ✓ The GEO disk is split in **4 Local Area Coverage** (LAC) zones, covered in 15 min each
- ✓ The measurement sequence is the following:

5 times (3-4)
4 times (2-4)
3 times (1-4)



➔The Earth is covered in 280 steps

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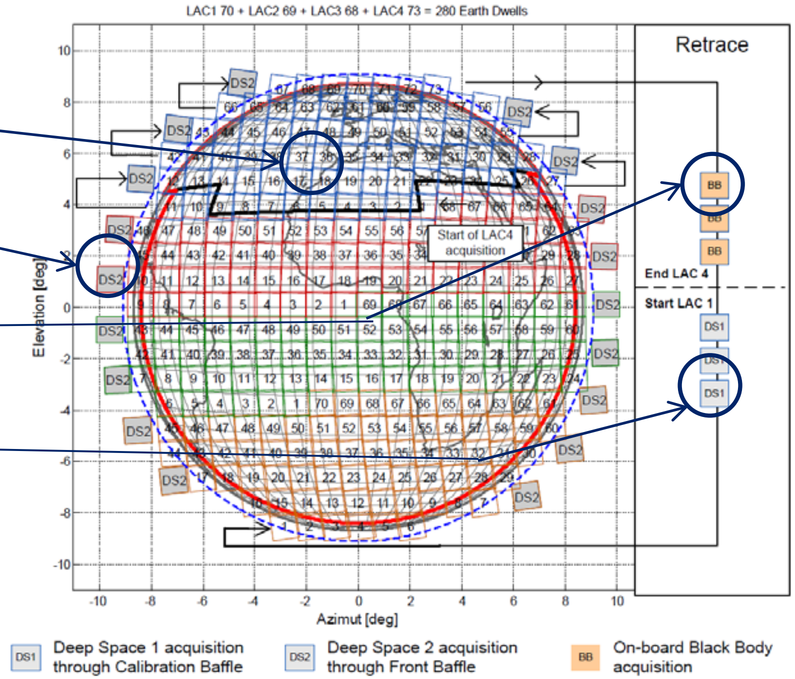
1) IRS measurements

✓ L0 data (interferograms, images and auxiliary data) from the instrument, collected and packed by the on-board processing

✓ 4 different kinds of measurements within an L0 dataset, one Earth View and three radiometric Calibration Views:

- Earth View (EV): actual Earth scene
- Deep Space 2 (DS2): a deep space observation at the beginning of a row
- Blackbody (BB): direct observation of the internal blackbody
- Deep Space 1 (DS1): a deep space observation through the BB path



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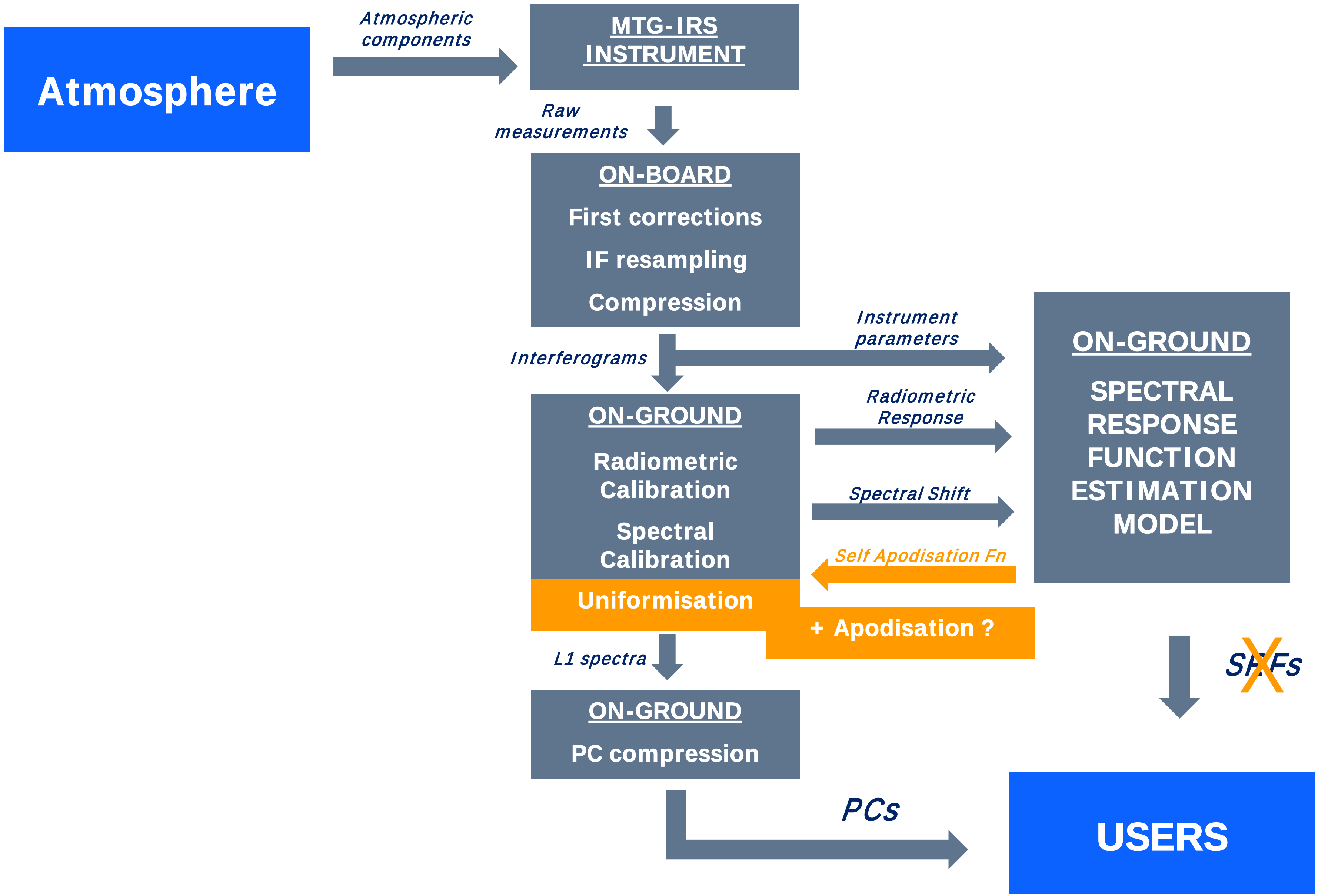
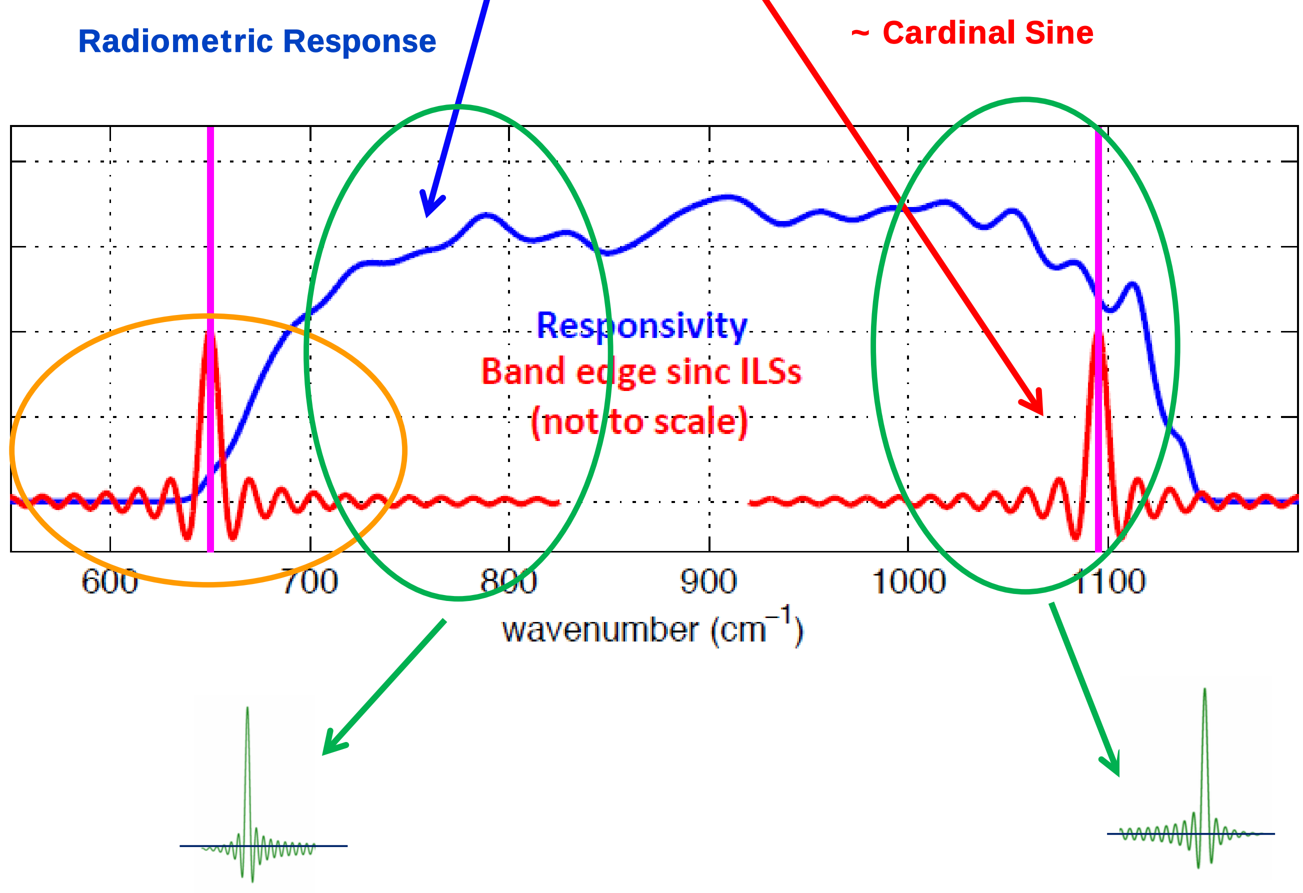
2) Quick overview of the IRS L1 data processing



3-a) Radiometric Response in the SRF estimation

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



Missing information in the band edge is a problem

SRF more spectrally dependent

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

3-a) Situation for the users regarding the SRF

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

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

→ Possible Optimisation with 10 SRF

→ No recent information

→ **Update of 10 x 25600 SRF, probably every month**

3-a) 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:

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

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

SRF

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

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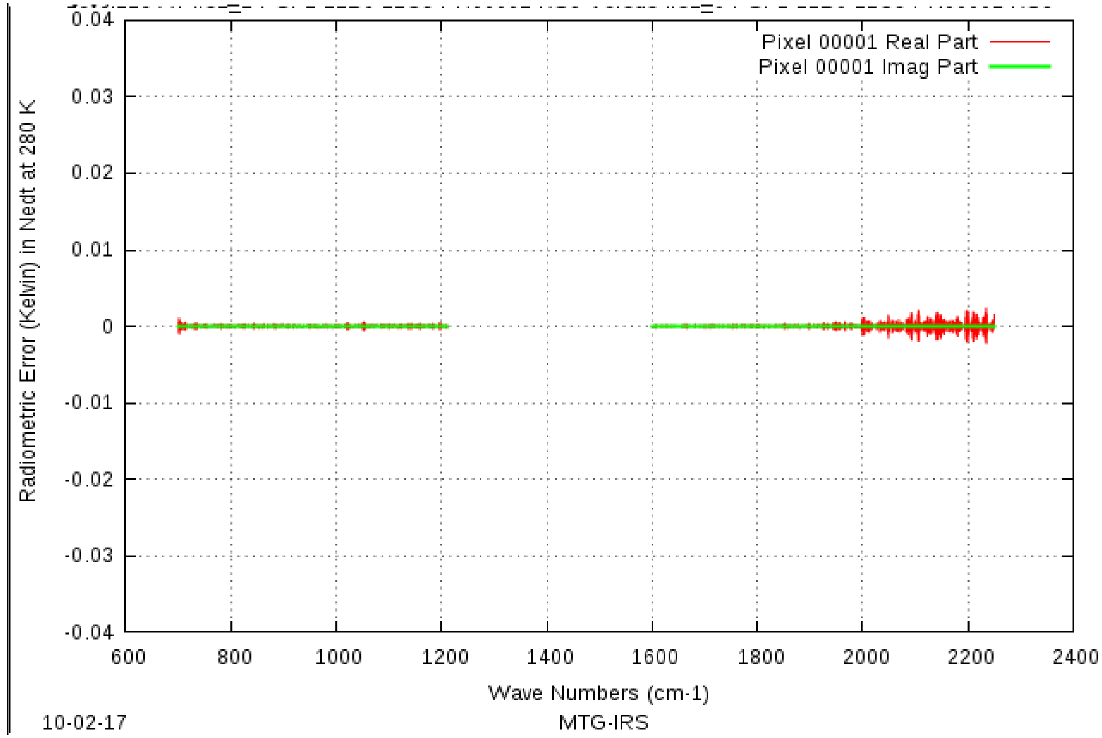
3-a) Uniformisation - ILS

Difference between Corner and Center pixels

With Uniformisation



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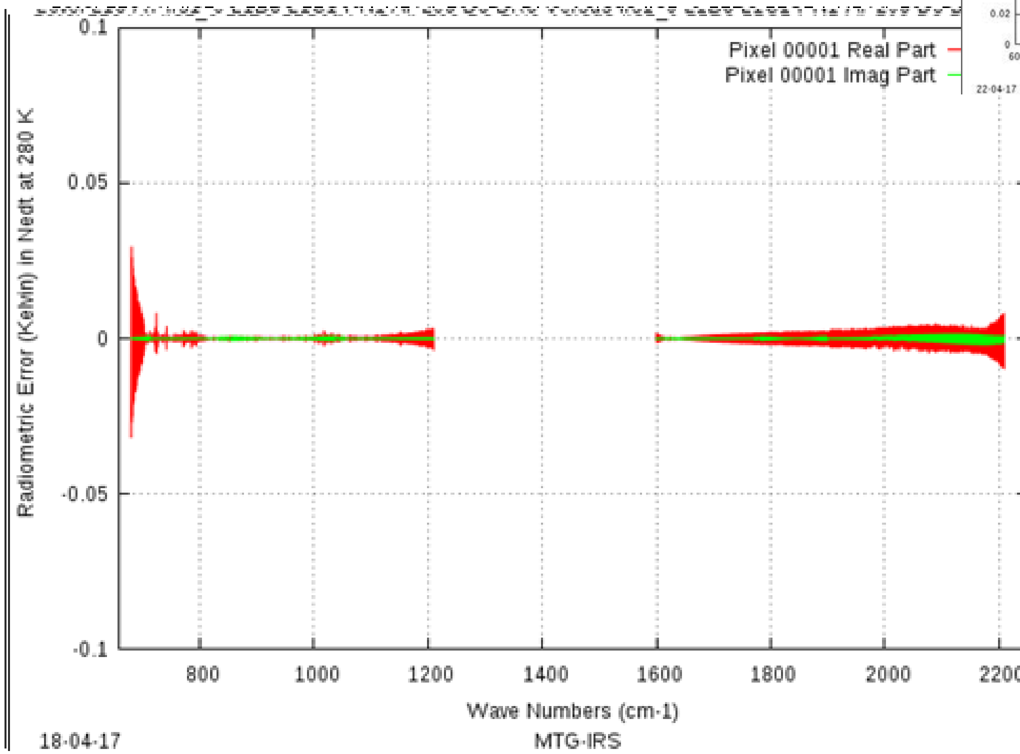
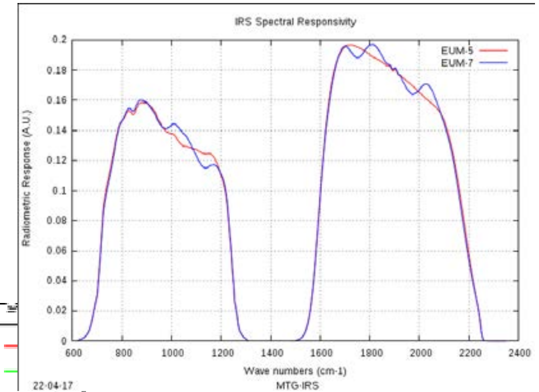
3-a) Uniformisation – Radiometric Response

Effect on different Radiometric Response

Extreme Case

With Uniformisation





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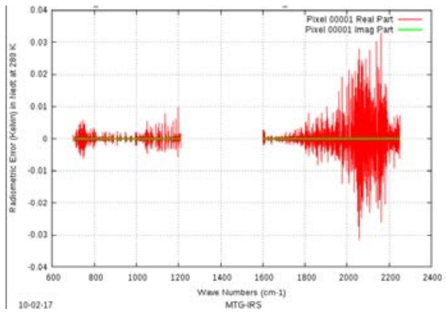
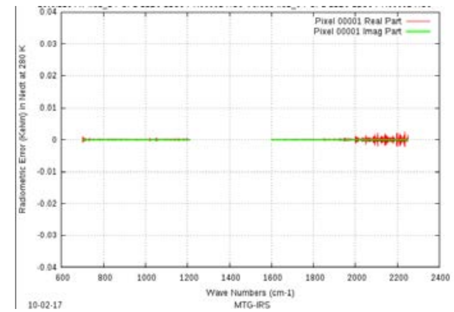
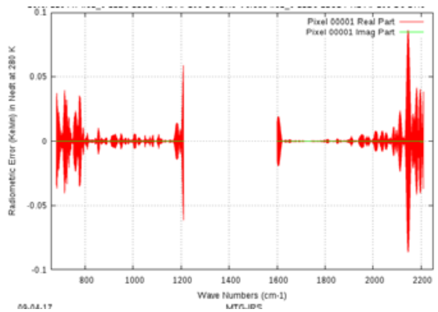
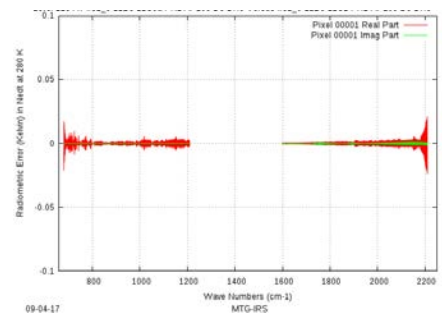
3-a) Situation for the users regarding the SRF

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

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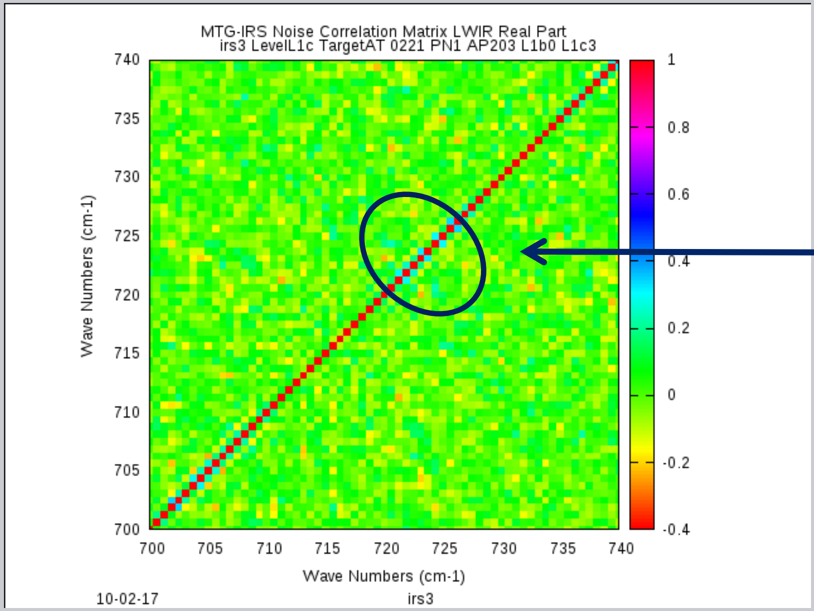
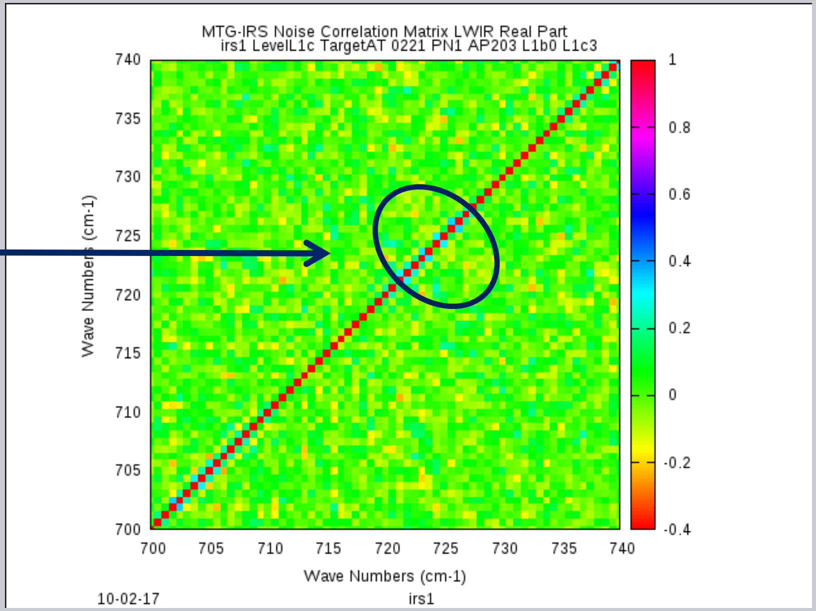
3-a) Impact on the noise correlation

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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3-b) IRS Instrument Line Shape

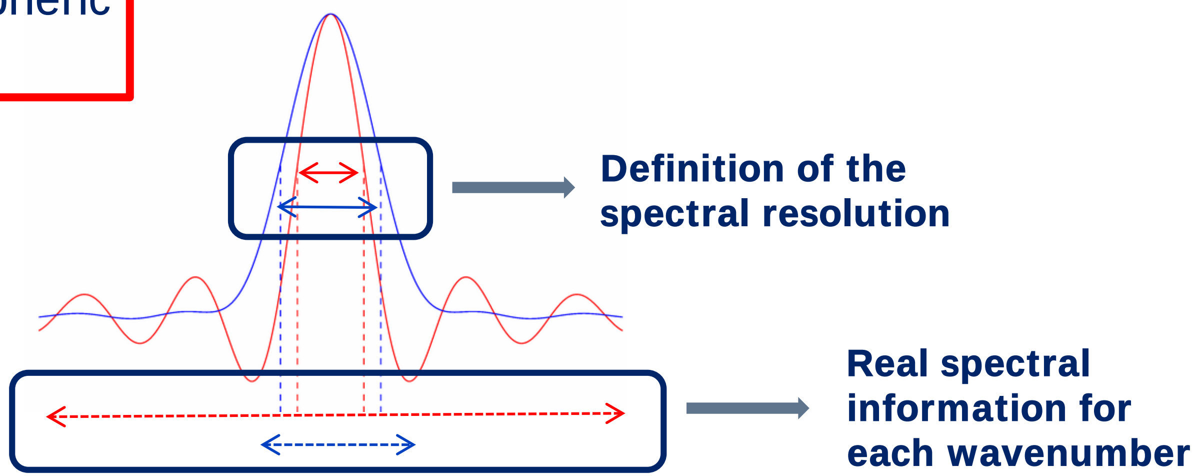
It is possible to improve the situation regarding the ILS with an apodisation (which respects the mission requirement)

Current 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)

Case of Gaussian apodisation

- ✓ It enlarges the spectral resolution
- ✓ Each wavenumber are independent in terms of integrated information (no spectral cross-talk)



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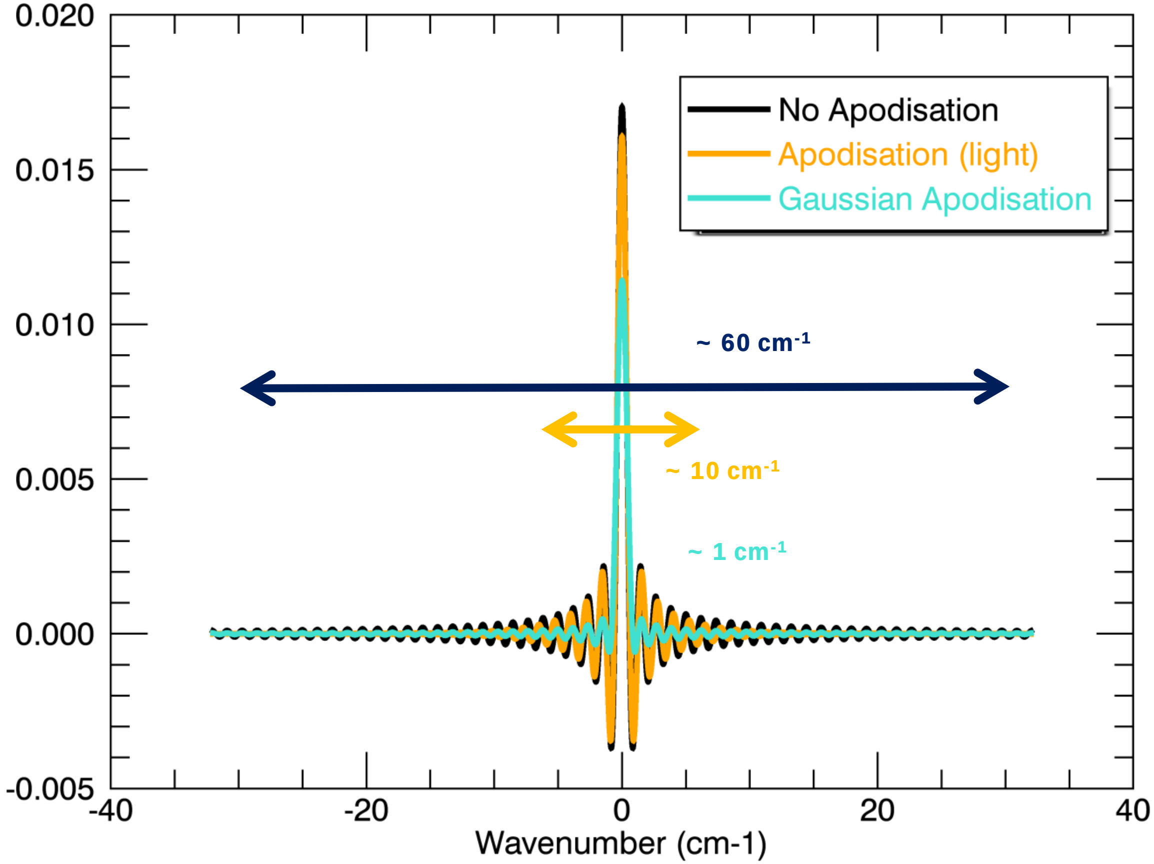
3-b) Possible apodisations



Selected apodisation:

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

Considered apodisation for users:

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

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Conclusion and next steps

Conclusion:

- ✓ The MTG IRS level 1 processing is being consolidated

➡ The operational processing development will start beginning of 2018

- ✓ Some open issues have been addressed:
  - ✓ The light apodisation has been selected for the operational processing
  - ✓ Strong apodisation is being considered
  - ✓ The uniformisation has been consolidated and is fully validated.

Next steps:

- ✓ To take advantage of better instrument performances ➔ change the spectral sampling from 0.625 cm^{-1} ➔ 0.6 cm^{-1}
- ✓ To apply a stronger (reversible) apodisation, like a Gaussian apodisation