Strategy for the validation of IASI-NG Level 1 processing

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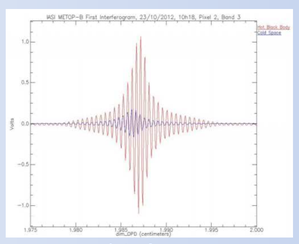
The IASI-NG mission

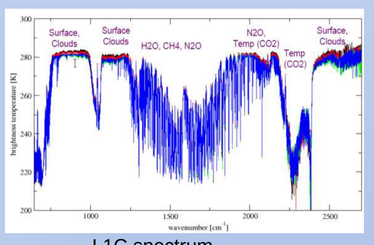
After the success story of IASI, CNES and EUMETSAT have decided to develop the next generation of atmospheric sounder, in the frame of the EPS-SG program. IASI-NG is an interferometer, that will scan the atmosphere in the infrared wavelengths with a radiometric noise and a spectral resolution twice smaller than for IASI.


IASI-NG on Metop-SG

See F. Bermudo's poster for IASI-NG program overview

In this collaboration, CNES is in charge of the development of the IASI-NG system, including the instrument but also the processing chain (in the space and ground segments). This Level 1 processing enables the transformation of raw interferograms to fully calibrated spectra (level 1C), correcting various instrument effect.


interferogram

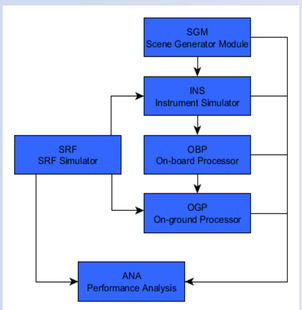


L1C spectrum

The System Performance Simulator

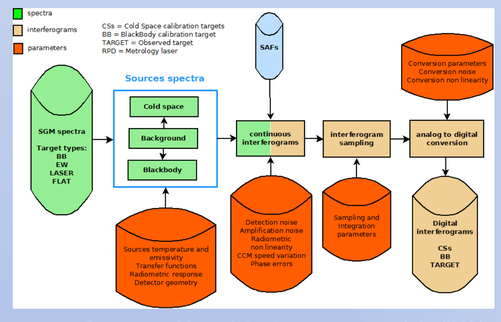
In order to validate the IASI-NG L1 processing chain, a simulation tool has been developed by Noveltis, named System Performance Simulator (SPS). It enables the simulation of interferograms from radiances coming from radiative transfer calculations, and the estimation of the level 1C spectra after the different steps of correction, on board and on ground.

Moreover, the SPS includes a generator of Spectral Response Function (SRF), used by the INS module for the interferograms simulation as well as the OGP module, for the correction of the instrumental SRF.

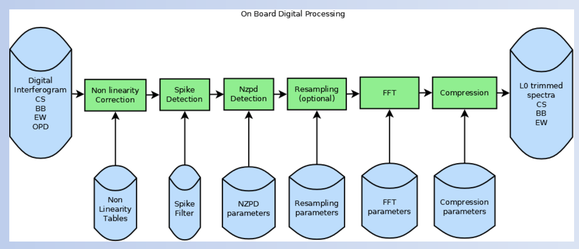


SPS overview

All these modules are divided into several operators, as described in the following schemes, showing the decomposition of the Instrument and the On-Board Processing (OBP) modules:



Decomposition of the Instrument module (INS)



Decomposition of the On-Board Processing module (OBP)

Validation of the Level 1 processing chain

Three degrees of validation have been defined:

1) Unit testing

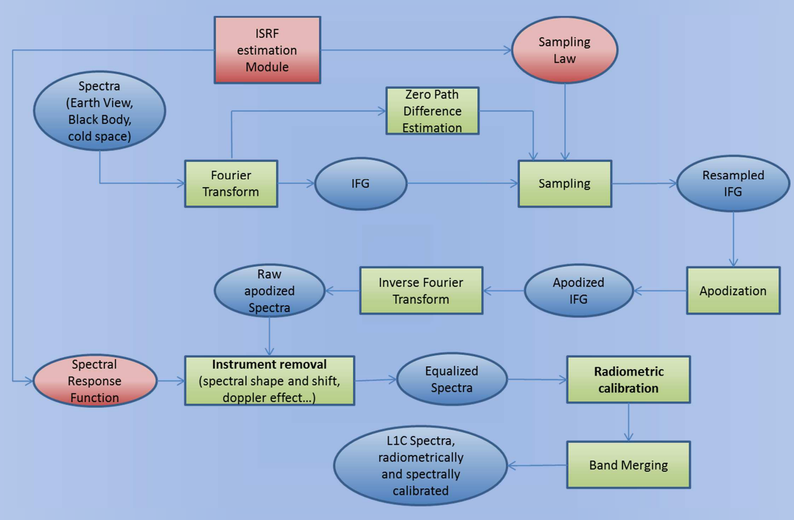
Each operator implemented in the SPS software has been tested separately, before being integrated in the whole processing chain. This stage is the first degree of validation and is made only from a "computing" point of view.
For each operator, reference inputs and parameters have been defined and are used to compare the outputs computed by the SPS operators to the reference ones.

2) Validation of a module

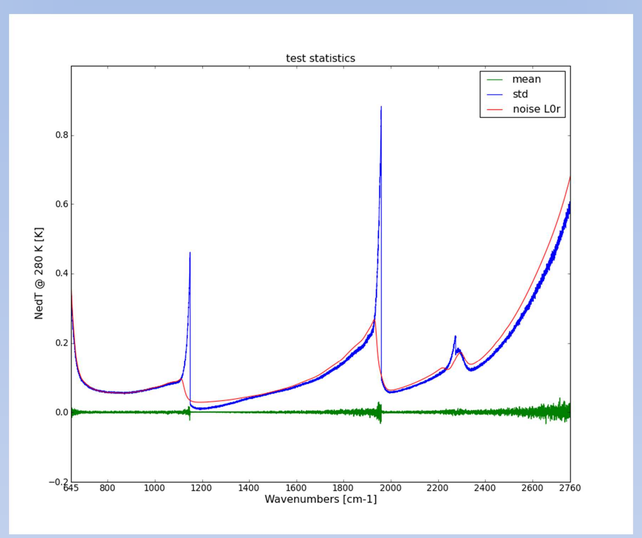
The second step of the validation is performed at the scale of a module, *i.e*. a group of several operators. The goal is to validate functionally and scientifically the different algorithms implemented in the on-board and on-ground processing, as well as their sequencing.
Here, the objective is to assess the performance of the correction algorithms, designed for the IASI-NG L1 processing. Simulated spectra or interferograms are used, perturbed by several defaults due to the instrument optics, the acquisition chain, or the platform.

Capitalize on the IASI's heritage…

The effort made to validate a module of the IASI-NG L1 processing chain depends whether this module has changed compared to the IASI processing. As an example, the figures opposite represents the On-Ground Processing (OGP) module. The "elementary" operators such as the Fourier Transform calculations, the sampler or the apodization do not require individually scientific validation. Moreover, the radiometric Zero Path Difference Estimation uses an algorithm already validated in the IASI context (the Connes method).In this case, the validation consists only in checking that this algorithm has the expected performances with the simulated IASI-NG data as inputs.



Decomposition of the On-Ground Processing module



Mean and standard deviation of the difference between spectra simulated with and without noise, after the instrument removal algorithm (assuming that the Spectral Response Function is perfectly known). The level of the blue curve is similar to the red one, showing that the instrument removal algorithm does not induce additive noise.

Adaptations especially made for IASI-NG

Some other modules have been defined especially to be suited for the IASI-NG design and to reach the level 0r performances needed for the mission. This is the case for the "instrument removal" module, which aims at correcting in one operation several artefacts such as the spectral shift, the shape and the Doppler effect. It is based on using of a pre-calculated Instrument Spectral Response Function (from metrology data). To validate this module, and particularly the "instrument removal" algorithm, several spectra (generated for EUMETSAT IASI-NG data tests) have been tested as inputs, coming from different simulations with different imperfections at the instrument level (microvibrations, wave front errors, spectral shift…). Firstly, the instrument removal has been tested using similar hypothesis to compute the input spectrum and to remove the instrumental effect (same ISRF). The calculations have been made with and without noise. The results are shown, in terms of NedT at 280K, in the figure opposite.

Then, different values of the instrument errors have been used for the spectrum simulation on the one hand, and for the computation of the ISRF used in the OGP processing on the other hand. This last step in the validation of the instrument removal algorithm aims at simulating the differences which will occur in flight between the estimated ISRF (calculated from the metrology and stored in tables) and the actual ISRF for the current spectrum.

3) End-to-end simulations

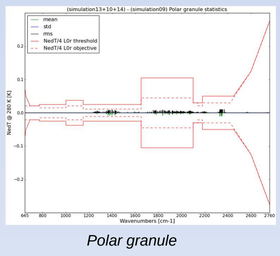
After testing each module of the OBP and OGP separately, the third and last step consists in validating the whole processing chain, comparing simulated spectra (calculated from test orbits using a radiative transfer code in the Scene Generator Module) and level 1C spectra, given by the simulator as outputs.
Whereas the end-to-end simulations are needed to validate the level 1 processing, at this stage of the IASI-NG system development, this macroscopic validation has not been performed yet.

Latest results and future work

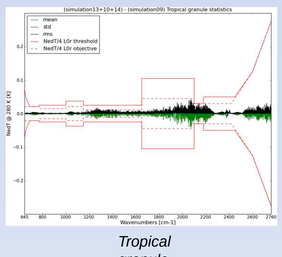
Latest results

The validation of the IASI-NG Level 1 processing is still in progress and will continue to evolve with the modifications of the instrument design and performances, which will occur during the space segment development.
The System Performance Simulator, conceived to draw up performance budgets is now consolidated. The recent studies concerning the validation show that the instrumental removal algorithm is robust when errors are added in the ISRF knowledge. This is the last step of the validation of this module and the next one will be the end to end simulation.

Verification of the robustness to the micro-vibration defects



Polar granule



Tropical granule

Level 1c NedT@280K bias (in green), standard deviation (in blue) and rms (in black) IASI-NG error spectrum induced by micro-vibration defect as a function of the wavenumber.

Future work : end-to-end simulations and atmospheric profiles comparison

Additionally to the comparison of spectra at level 1C during the end-to-end simulations, it is possible to add an inversion code (4ARTIC, based on optimal estimation) to the SPS, in order to obtain level 2 products, such as temperature or water vapor profiles. If needed, it enables a direct comparison between atmospheric profiles used to simulate the spectra given in the SPS as inputs and the ones estimated in the level 2 products.

The validation process is a long term endeavor to ensure the IASI-NG performances, with the objective that next generation of IASI will be even better calibrated as the first generation. In a sense, we contribute to prepare the future references for the IR atmospheric sounders !