Introduction to IASI-NG Level 1D and Level 2 IPP (In-house Prototype Processor) and the user familiarisation data

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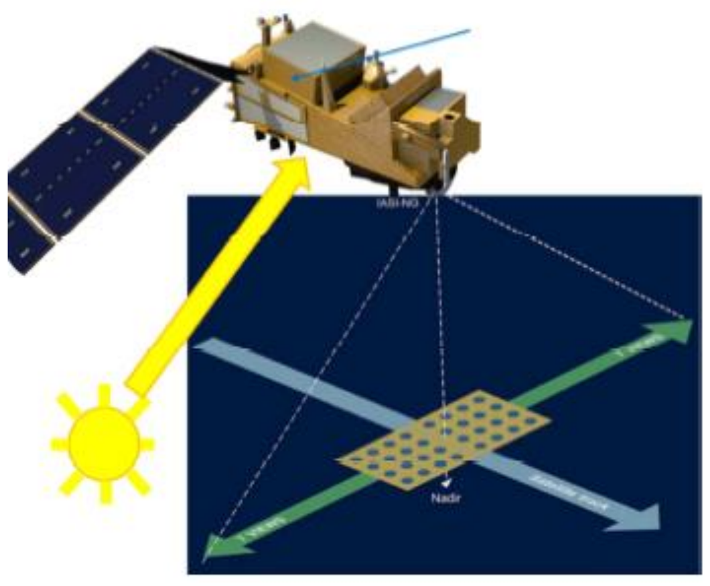


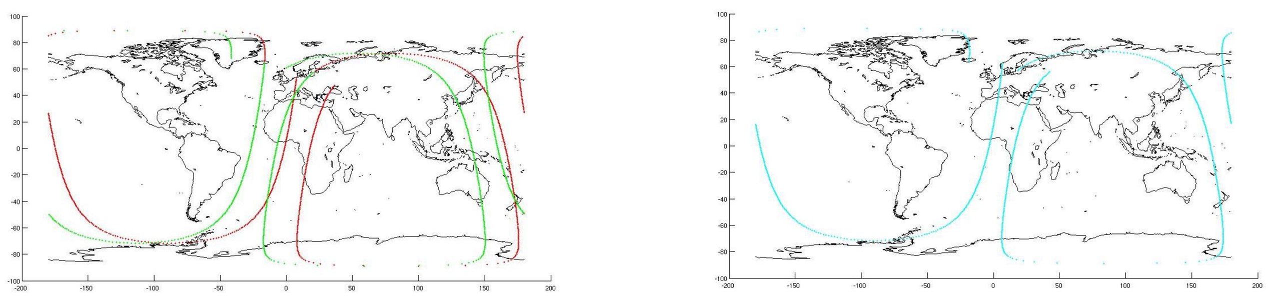
The EPS-SG, EUMETSAT Polar System Second Generation, will provide continuity of observations after EPS in the 2020-2040 time frame. It is Europe's contribution to the future Joint Polar System (JPS), which is agreed to be established together with the National Oceanic and Atmospheric Administration (NOAA) of the United States, following on from the Initial Joint Polar System (IJPS).

The **IASI-NG**, Infrared Atmospheric Sounding Interferometer - New Generation, is the successor instrument of the IASI instruments flown on the EPS/Metop satellites. It will provide hyper-spectral infrared soundings of temperature, water vapour, and trace gases with a spectral resolution of 0.25 cm-1 (twice the spectral resolution of IASI) within the spectral range from 645 to 2760 cm-1. The noise figures of the IASI-NG are half the ones of IASI. As for IASI, the footprint at Nadir is about 12km and the observations will be performed at an average spatial sampling distance of 25 km. Similarly as in EPS, IASI-NG will be accompanied by a microwave sounder (MWS) and a high spatial resolution radiometer (METimage).

Test data is available for three simulated IASI-NG orbits:

1st orbit: 2007/09/12 from 08:43 to 10:21
2nd orbit: 2007/09/12 from 10:21 to 12:02
3rd orbit: 2008/02/23 from 08:46 to 10:28

They cover a variety of scene type for testing purposes (clear, cloudy, land, sea, snow/ice, day and night etc.).



Generated products L1D

Product name	Content	Purpose
PCC	IASI-NG Principal Components	NRT dissemination Archive
Score	Reconstruction score	NRT dissemination Archive
Outliers	Identification of the outliers	NRT dissemination Archive
Residuals	For the outliers, the quantised trailing PC scores	NRT dissemination Archive

Generated products L2

Product name	Content	Purpose
TWV	Temperature profile	NRT dissemination Archive
TWV	Water vapour profile	NRT dissemination Archive
TWV	Water vapour total column from IAS and MWS	NRT dissemination
SFC	Surface temperature (Sea)	NRT dissemination Archive
SFC	Surface temperature (Land, Ice)	NRT dissemination Archive
SFC	Land and ice surface emissivity	NRT dissemination Archive
CLD	Cloud detection and fractional coverage from VII and IAS	NRT dissemination Archive
CLD	Cloud top phase	NRT dissemination Archive
CLD	Cloud top height/pressure	NRT dissemination Archive
CLD	Cloud drop effective radius at cloud top (by product)	NRT dissemination Archive
CO	Carbon monoxide profile	NRT dissemination Archive
CO	Carbon monoxide partial column	NRT dissemination Archive
GHG	Methane partial column	NRT dissemination Archive
NAC	Nitric acid partial column	NRT dissemination Archive
GHG	Nitrous oxide total column	NRT dissemination Archive
O3	Ozone profile	NRT dissemination Archive
O3	Ozone total column	NRT dissemination Archive
SO2	Sulphur dioxide total column	NRT dissemination Archive

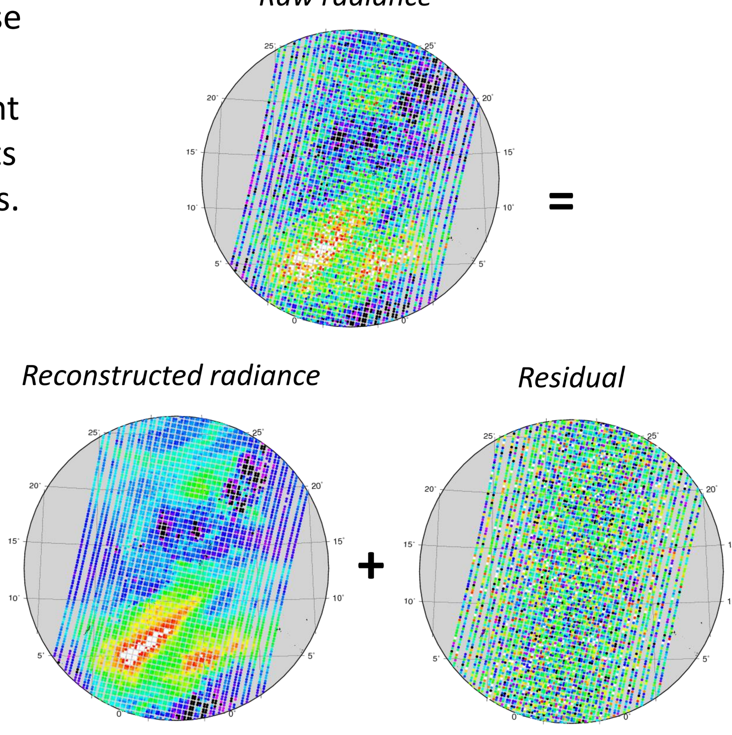
L1D PCC → PREP → PWLR³ → RETRIEVAL → FORLI and BRESCIA

L1D PCC

IASI-NG measurements consist of signal and noise. The IASI-NG L1C measurements are represented as radiances at 16921 wave-numbers, which are spectrally highly correlated. This correlation comes from the signal itself as the noise is spectrally uncorrelated. This redundancy means that the effective rank of the subspace spanned by the signal within the measurements is much lower than the number of channels or in other words, the number of independent pieces of information within the IASI measurements is much smaller than 16921. These are the principal components scores (PCS) computed with the leading eigenvectors representing the variance and covariance of the measurements. Reconstructed radiances can be computed from the PCS, effectively projecting the measurements onto the signal subspace with the result that the signal is preserved while a major part of the noise is suppressed. The difference between the original and the reconstructed radiances is called the reconstruction **residuals** and essentially contain random instrument noise. The residuals are used to compute reconstruction scores. If the reconstruction score for a given spectrum is too high (i.e. exceeds a configurable threshold), there is suspicion that some atmospheric signal could not be represented by the selected leading principal components. An **outlier** flag can be raised for the corresponding pixel. The threshold for the identification of the outliers is different for each detector and depends linearly on the sum of the radiances, to account for the photonic noise.

$$p = E^T N^{-1}(y - \bar{y}) \quad \text{PC scores}$$
$$\tilde{y} = NEp + \bar{y} \quad \text{Reconstructed radiance}$$

E is the eigenvectors matrix, N is the noise normalization matrix and $\bar{y}$ is the mean radiances.

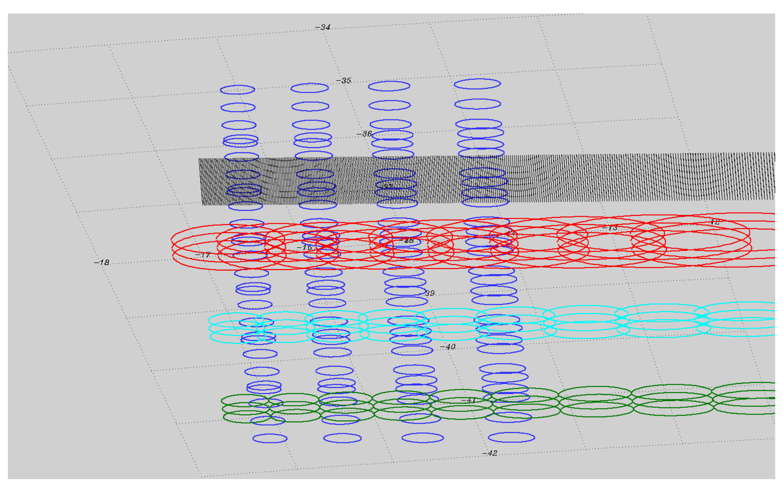


(IASI radiance @1772.75 cm^{-1} 20130717)

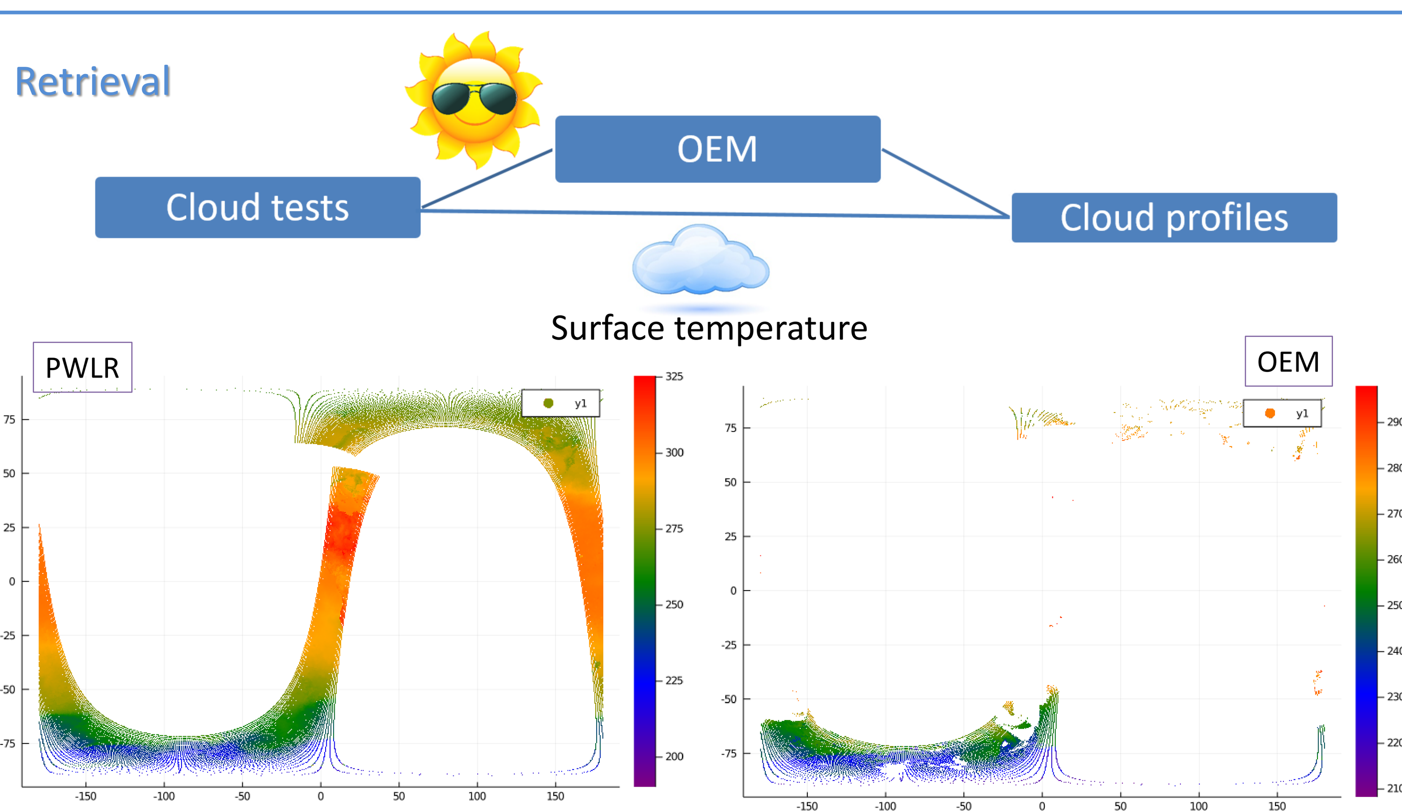
PREP

The purpose of the input data preparation is to gather IASI-NG L1D measurements and relevant collocated data in a common file, which serves as input for the further sub-functions. The collocated data includes METimage cluster radiance mean and standard deviations (already included in the IASI-NG L1C files), MWS radiances, ECMWF forecasts data as well as land fraction and surface elevation mean and standard deviation within each IASI-NG field of view.

IASI-NG, MWS and METimage footprints (swath edge)



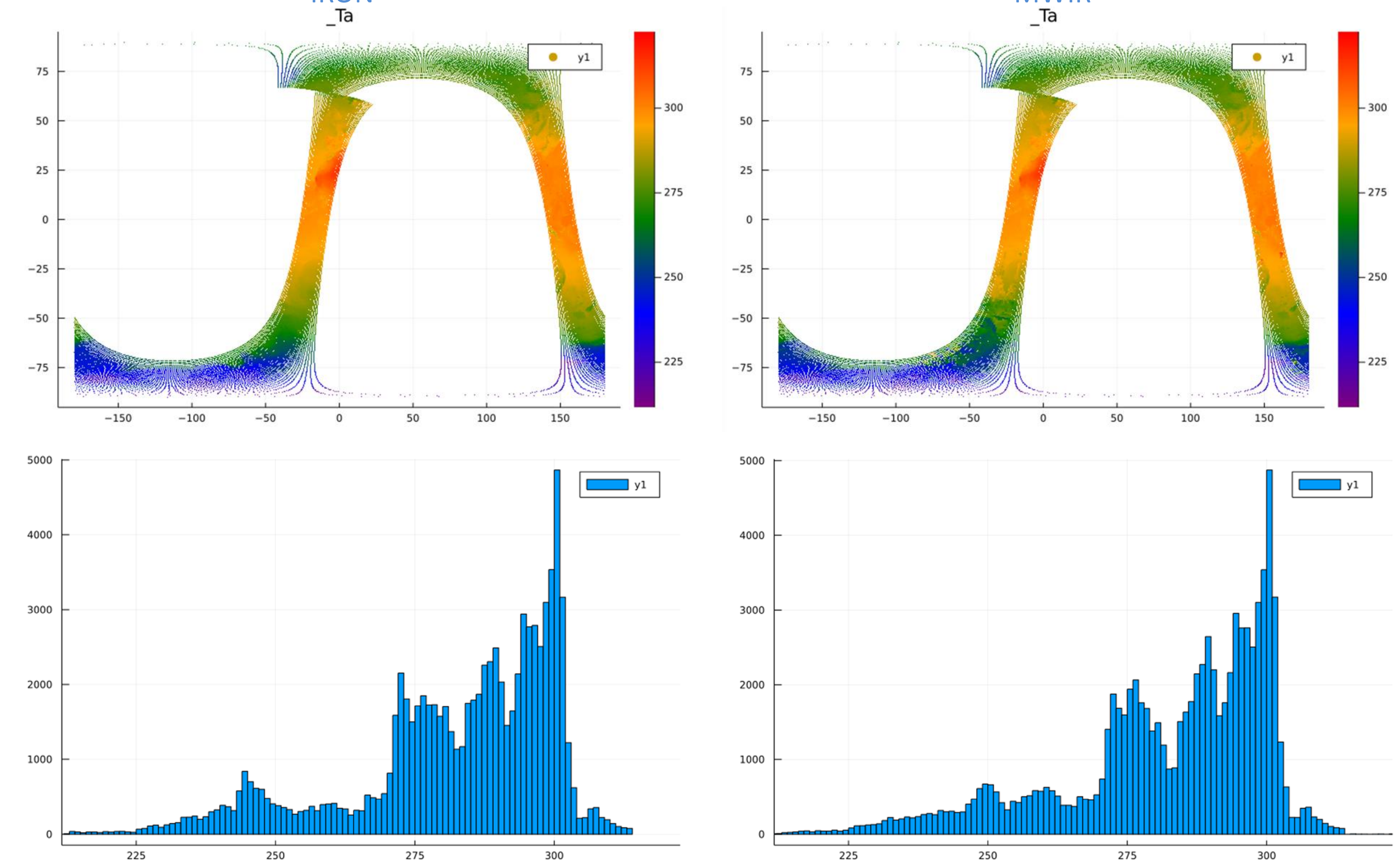
Retrieval



PWLR³

All sky statistical retrieval of temperature, water vapour, ozone, emissivity and green-house gases profiles using IASI-NG with co-located MWS radiances.

PWLR is a fast, accurate and precise, all sky retrieval of temperature, water vapour, ozone, and surface pressure, which was developed for version 6 of EUMETSAT's operational IASI L2 processor, using IASI as well as co-located AMSU and MHS radiances as inputs. The retrieval is based on linear regression, but in order to capture non-linear relationships between the inputs and the outputs better, the input space is divided into several classes.



OEM

Optimal estimation method for clear sky

The optimal estimation retrieval of atmospheric and surface parameters is performed by minimisation of a cost function, J, consisting of two terms, the background (J_x) and the observation (J_y) terms:

$$J = J_x + J_y$$

$$J_x = (x - x_a)^T S_x^{-1}(x - x_a)$$

$$J_y = (F(x) - y)^T S_y^{-1}(F(x) - y)$$

Where

- x is the state vectors to be retrieved in PC scores:

$$x = \left(t_1, \dots, t_{n_t}, o_1, \dots, o_{n_o}, c_1, \dots, c_{n_c}, e_1, \dots, e_{n_e}, e_{MW_1}, \dots, e_{MW_{n_{MW}}}\right)$$

- x_a is the a priori state vector (PWLR³)
- y is the observation vectors and it is a subset of reconstructed radiance (e.g. IASI-NG and MWS radiances) ;
- F(x) is the simulated observations vectors using the forward model (RTTOV) ;
- S_x and S_y are the background error and observation error matrices, respectively. The full matrix S_y is the combined measurement and forward model error.

The iterative minimization method is the **Newton descent algorithm.**

FORLI and BRESCIA

Profiles of CO, HNO3 and O3 are retrieved by the FORLI library.

The SO2 columnar amount is retrieved by the BRESCIA library.

These two libraries are provided by the ***EUMETSAT AC SAF*** and take raw radiance from the L1C as input, rather than the reconstructed radiances from L1D and are built for IASI spectra rather than IASI-NG spectra.

In order to invoke them it is therefore necessary to convert the IASI-NG spectra to IASI-like spectra. After this transformation, the FORLI and BRESCIA libraries has to be applied.

The input profiles of temperature and water vapor are taken from the optimal estimation retrieval (or PWLR).

EUMETSAT Polar System-Second Generation (EPS-SG) simulated IASI-NG Level 1D ad Level 2 test data are available for user familiarization and system testing from February 2020.

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