PRINCIPAL COMPONENT ANALYSIS OF IASI MEASUREMENTS FOR THE ANALYSIS OF PERFORMANCES OF L0 & L1 PROCESSING

SPASCIA

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OBJECTIVES

A Principal Component Analysis (PCA) method has been implemented and tested for the detection and characterization of extreme events from IASI L1 measurements.

The ability of the presented method to efficiently identify rare or unexpected atmospheric signatures in the IASI spectra has been exploited to evaluate the performances of two different aspects of the IASI data processing :

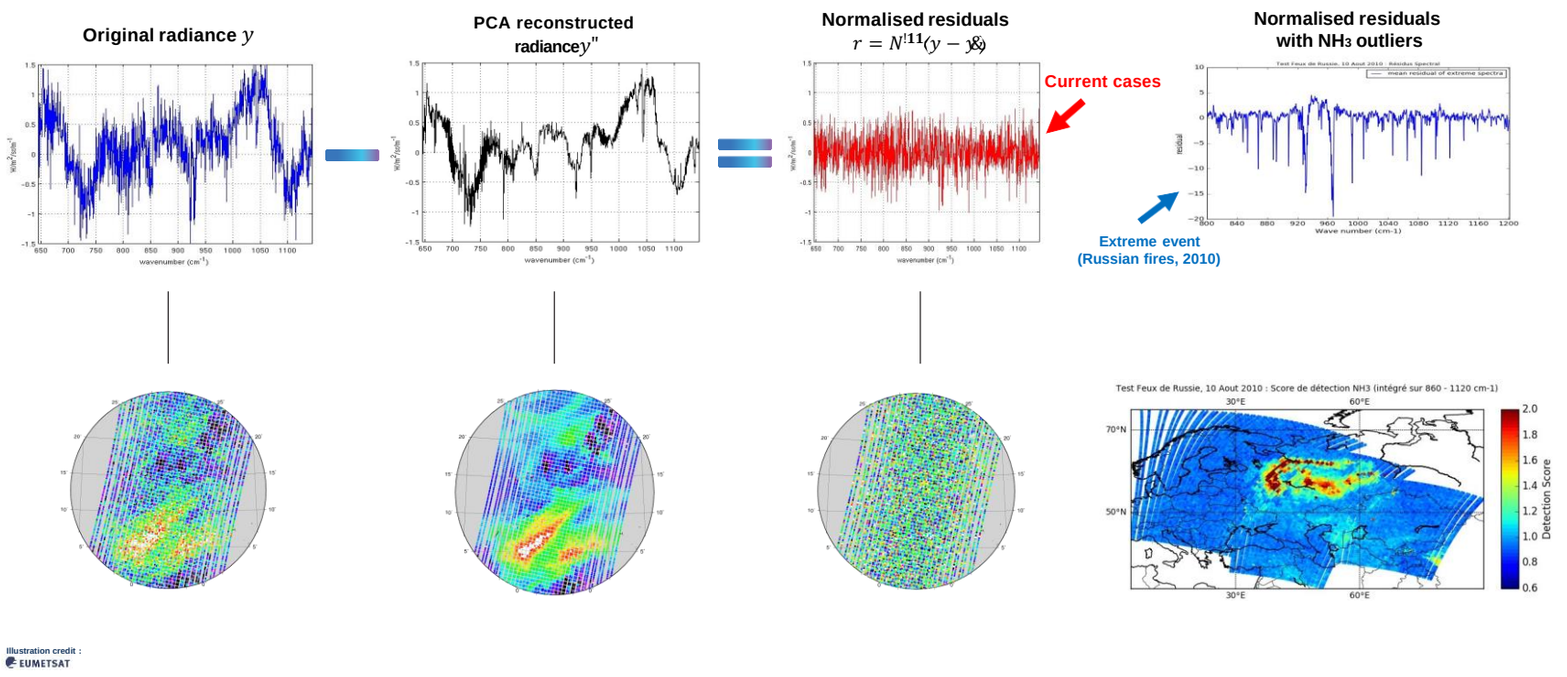
1) The EUMETSAT Principal Component (PC) compression of IASI L1C data,

2) The IASI L0 processing (CNES, TEC = Technical Expertise Centre for IASI).

The IASI-PCA approach has proven to be a powerful technique for targeting air chemistry (AC) situations to be tested with the EUMETSAT PC compression tool.
The IASI-PCA method also allowed us to associate L0 monitoring anomalies detected by CNES, with extreme geophysical situations.

METHOD : IASI-PCA DETECTION APPROACH

The method is based on the Principal Component Analysis (PCA) of the L1C spectra. The detected extreme events are defined as data outliers with respect to the representative global (and non perturbed) variability of IASI spectra. These outliers are obtained from the analysis of **residual differences between measured spectra and spectra reconstructed from PCA decomposition**.



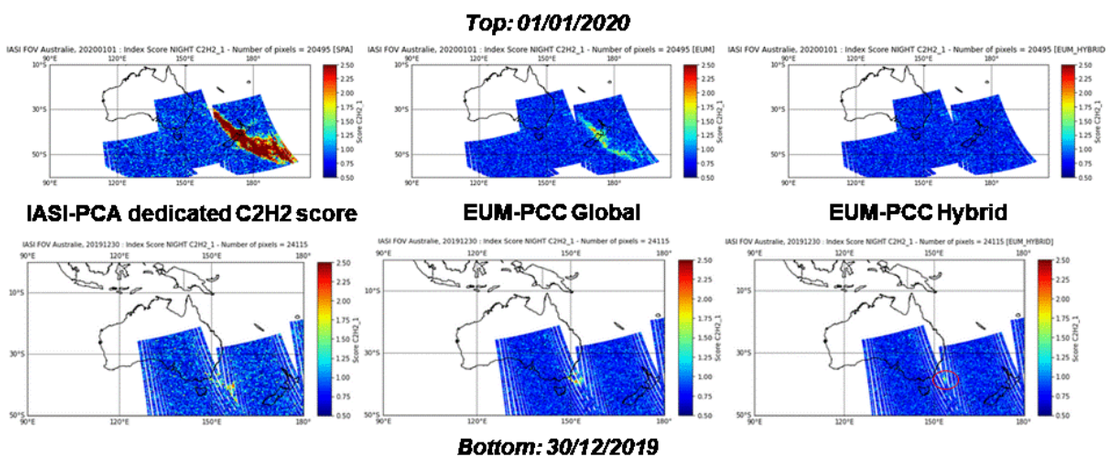
RESULTS

EUMETSAT PC COMPRESSION EVALUATION FOR ATMOSPHERIC COMPOSITION

As part of a study supported by EUMETSAT, the IASI-PCA detection is used to explore the performances of the EUMESAT Principal Component Compression (EUM-PCC) of IASI L1C for atmospheric chemistry applications. IASI-PCA detection identifies rare spectral signatures in the IASI measurements not captured by the static approach of EUM-PCC, but well reconstructed by a local (or hybrid) implementation of the EUM-PCC.

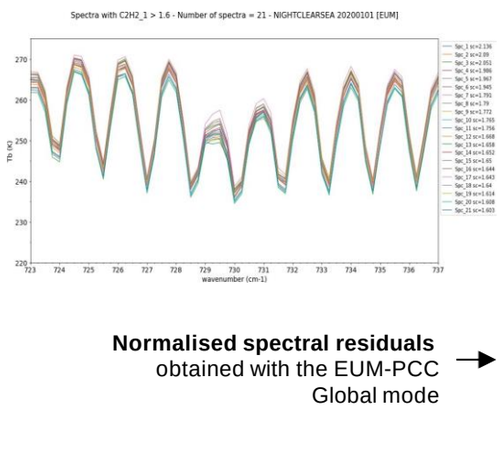
How well EUMETSAT PC compression retains relevant AC signal ?

Example with the Australian fires for which C_2H_2 signal information has been detected. The figure below shows the dedicated C_2H_2 reconstruction score map computed over the reduced spectral domain [728.0 ; 732.0] cm^{-1}.



The EUM-PCC Global mode fails to reconstruct the signal for both dates (middle panel) where the IASI-PCA method detects C_2H_2 outliers (left panel). However, the Hybrid mode is efficient to capture such rare spectral signature (right panel).

From the detected spectra associated to outliers, it is possible to alert on rare signals, to be potentially included upfront in the global basis used by EUM-PCC to improve the compression processing.



Observed spectra
A drop is seen in the comb of CO_2 lines (usually of a stable amplitude) due to the additional absorption by C_2H_2

Normalised spectral residuals obtained with the EUM-PCC Global mode

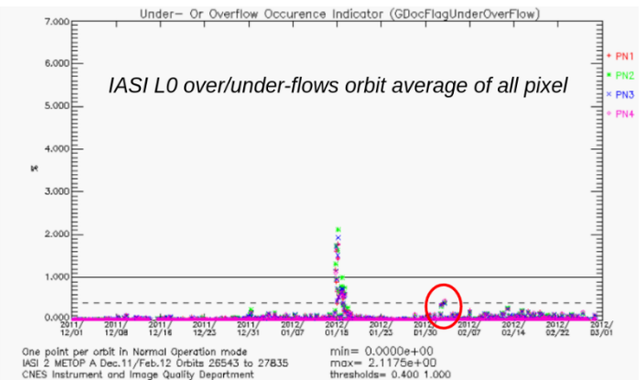
CNES TEC MONITORING OF IASI ANOMALIES

As part of an ongoing project supported by CNES, the IASI-PCA detection is used to analyse and identify possible geophysical events associated to extreme IASI spectra leading to under/overflow of the coding tables needed to encode measured spectrum transmitted to the ground in the L0 IASI processing. Specific cases possibly associated with volcanic eruptions or with other anomalous atmospheric composition events have been identified.

Coding tables are constructed from spectra covering the natural atmospheric variability. Some particularly extreme atmospheric conditions can lead to an overrun of the coding tables, raising the flag "GDocFlagUnderOverFlow".

Can the IASI-PCA analysis make it possible to better identify and understand certain extreme atmospheric events that cause coding table exceedances?

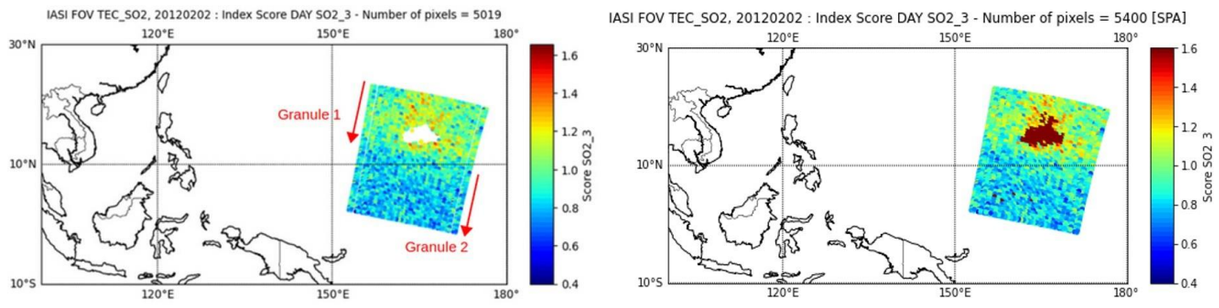
- Analyse several tenths of IASI TEC alerts from 2007 and check if unknown events causing table overflows are detected with IASI-PCA processing (outliers),
- Study the possible correlations between the risk alerts of exceeding the coding table and the outliers identified by IASI-PCA,
- Identify the geophysical origin of the events causing TEC alerts and correlate them with detected outliers.



Date yyyymmdd	conditions	TEC alert time (UT)	IASI-PCA outlier indicator
20120202	jour clair nuit clair	22:35:10 → 22:37:50 10:04:31 → 10:08:30	SO2_3

TEC under/overFlow flag monitoring, and date/time of a TEC alert anlysed by IASI-PCA

IASI-PCA Analysis of the days associated with TEC alerts: Outliers SO_2 - 02/02/2012
2 night granules : without (left) and with (right) flagged overflow IFOVS



CONCLUSIONS

IASI-PCA approach allowed to target efficiently situations of interest for challenging EUM-PCC. The global + hybrid approach appeared to be very robust for most of the targeted situations. In addition, spectrally-focused reconstruction scores (associated to spectral structures of geophysical interest), that are used by IASI-PCA for the detection of geophysical events, could be exploited for characterizing and flagging the rare cases where EUM-PCC compression process potentially fails to fully capture spectral features of geophysical interest.

IASI-PCA allows us to clearly associate an SO_2 event with the coding table overflow and the quality-flagged IFOVS. The geophysical nature of this event is still to be investigated, as well as the demonstration that this event is at the origin of the overflow.