



The release to the atmosphere of different anthropogenic gases and aerosols are provoking undoubtedly the change in the Earth-Atmosphere system. The greenhouse gases and CFCs are provoking the global warming and the destruction of the Ozone layer, respectively.

Monitoring the atmosphere is crucial in order to reverse, mitigate or prevent future climate change. In this context, satellite-based remote sensing platforms are an extremely valuable tool, as they can screen the atmosphere at a global scale. On the other hand, ground-based remote instruments can only map the atmosphere at specific location; however they are indispensable to validate the satellite measurements.

This work summarizes the methodology followed and the main results obtained within the Spanish project NOVIA aiming on performing a quasi-near-real time validation of the operational level 2 products (O3, CO, CH4, N2O & CO2) of the IASI sensor onboard the MetOp satellite series, produced and delivered by EUMETSAT Polar System EPS Core Ground Segment. The ground-based high-quality Fourier Transform Infrared spectrometer (FTS), located at the Izaña Observatory in the subtropical North Atlantic region, has been used as the reference instrument.

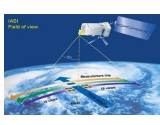


## G-b Fourier Transform Infrared Spectrometer (FTS)



• Izaña Observatory (IZO: 28.3°N, 16.5°W, 2.4 km a.s.l.) at the Tenerife island is a subtropical high-mountain super-site observatory, located above a trade-wind temperature inversion layer acting as a barrier for local pollution. So, it offers excellent conditions for remote sensing of the atmosphere.

	FTS	IASI
Type of Observation	Direct solar absorption	Thermal infrared emission
Spectral range [cm <sup>-1</sup> ]	700 - 9000	645 - 2760
Spectral resolution [cm <sup>-1</sup> ]	0.005	0.5
Field of view	0.2° (< solar disc)	At nadir 4 pixels of 12 km
Frequency of Observation	weather permit, ~3 days/week	twice per day, at IZO region around 10 am / pm
Sample length	6-8 min	8s (30x4 pixels)
Data availability	Since 1999 (@IZO)	Since 2007 IASI A Since 2012 IASI B

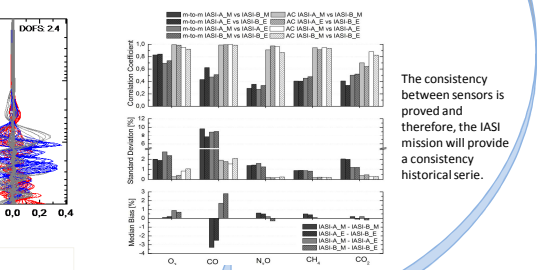
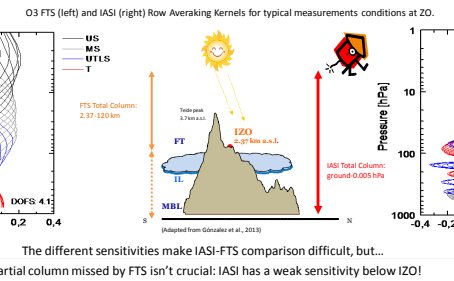


## Infrared Atmospheric Sounding Interferometer (IASI)

- The IASI sensor flies onboard the MetOp satellite series in a polar sun-synchronous orbit (about 800 km altitude), crossing the equatorial plane twice per day (at 9:30 am & pm). MetOp-A launched in 2006, MetOp-B launched in 2012 and MetOp-C expected to be in orbit in 2018.
- Different versions of the IASI L2 Product Processing Facility have been used to produce the EUMETSAT IASI L2 operational trace gas products: V4 (06/08-09/10), V5 (09/10-09/14) and V6 (09/14-onwards). [IASI L2 product guide V6; August et al., 2012]
- IASI -A / IASI -B consistency study for measurement-to-measurement and annual cycle. It distinguishes between Morning and Evening overpass.

The FTS at IZO takes part of the Network for the Detection of Atmospheric Composition Change (NDACC) and the Total Carbon Column Observing Network (TCCON) since 1999 and 2007, respectively. The FTS can measure quasi continuously (during daytime and weather permit).

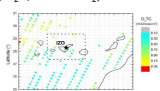
• FTS Volume Mixing Ratio (VMR) vertical profiles of different trace gases are retrieved with PROFFIT [Hase et al., 2004], and then, the total columns are integrated from the IZO altitude to the top of atmosphere. The FTS products considered here have been extensively validated throughout different measurement techniques, such as: Brewer spectrometer, Radiosonde, GPS, ... (Schneider et al., 2005; García et al., 2012; Sepúlveda et al., 2014).



## VALIDATION STRATEGY

### SPATIAL CRITERIA

- IZO is far away from the sources/sinks of the trace gases considered. Also, the latitudinal and longitudinal gradients of these gases are rather smooth at oceanic subtropical latitudes.
- The projected horizontal distance covered by IZO FTS observations is between 80 km (CH<sub>4</sub>, N<sub>2</sub>O, CO and CO<sub>2</sub>) and 150 km (O<sub>3</sub>)

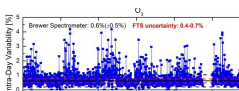


Validation box of ±1° around IZO

### TEMPORAL CRITERIA

Intra-day Variability > Theoretical Uncertainty FTS → ±1h IASI overpass for O<sub>3</sub> and CO

Intra-day Variability < Theoretical Uncertainty FTS → Daytime medians for CH<sub>4</sub>, N<sub>2</sub>O and CO<sub>2</sub>



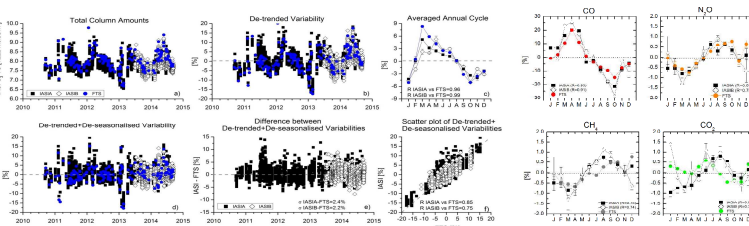
Intra-day variability for O<sub>3</sub>

### TEMPORAL DECOMPOSITION

- The quality assessment of IASI-A and IASI-B products is addressed at different time scales:
  - Short time scale: measurement-to-measurement and day-to-day
  - Long time scale: Annual cycle and long-term trend
- The IASI L2 products are fitted to a Fourier time series model accounting for trend and intra-annual variations:
 
$$f(t) = a_0 + a_1 t + \sum_{j=1}^n [d_j \cos(k_j t) + e_j \sin(k_j t)]$$
 being, t the time in days, a<sub>0</sub> a cte value, a<sub>1</sub> the parameter of linear trend and d<sub>j</sub> and e<sub>j</sub> the parameters of the annual cycle. k<sub>j</sub>=2π/T with T=365.25days
- The seasonal variations are obtained by subtracting the fitted trends from the measured time series and the averaged annual cycle is computed by averaging these de-trended time series on a monthly basis.
- The remaining variability, corresponding to the variations among individual observations, is obtained by subtracting the multi-annual averaged annual cycle from the de-trended time series, resulting in the de-trended and de-seasonalised time series (Det+Des).

## IASI vs FTS

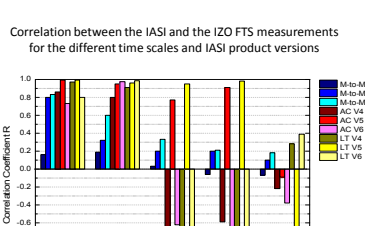
### Example for IASI L2 product version 5



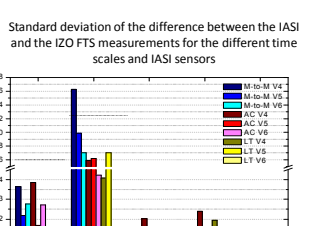
Example for the decomposition of O<sub>3</sub> time series in measurement-to-measurement and annual cycle (in blue circles FTS, in black squares IASI-A and in white circles IASI-B).

Agreement between the annual cycles obtained for IASI-A, IASI-B and FTS for the rest of gases.

### Summary for all versions



Correlation between the IASI and the IZO FTS measurements for the different time scales and IASI product versions



Standard deviation of the difference between the IASI and the IZO FTS measurements for the different time scales and IASI sensors

The solid black lines represent the day-to-day variability from the FTS observations at IZO between 2010-2014.

## CONCLUSIONS

## DATA DISSEMINATION

-G-b FTS produces high-quality and precise total column amounts and VMR vertical profiles. Therefore, FTS is placed as an excellent reference instrument to validate satellite-based sensors.

-The validation assessment is performed at different time scales. Trace gases with rather small variability, such as N<sub>2</sub>O or CH<sub>4</sub> (uncertainty larger than the day-to-day variability) are comparable only at long time scales while O<sub>3</sub> and CO can be compared also at short time scale (uncertainty smaller than the day-to-day variability). These time scales decomposition allows us to detect quickly inconsistencies or instrumental issues.

-EUMETSAT IASI operational level 2 products reproduce well the ground-based FTS observations at the longest temporal scales, i.e., annual cycles and long-term trends for all trace gases considered except for CO<sub>2</sub>. The remaining differences observed may in part be accounted for the different vertical sensitivities of the two remote sensing instruments. Regarding very short-term variabilities, only the operational O<sub>3</sub> product seems to be well sensitive to actual atmospheric variations (R=0.80), while CO products are moderately sensitive (R=0.50 on a daily basis).

-For the rest of the trace gases, still disseminated as demonstrational products, further improvements might be recommendable to capture the real day-to-day atmospheric variability.

The continuous comparison of IASI and FTS products at IZO is publicly available through the Spanish project NOVIA at [www.novia.aemet.es](http://www.novia.aemet.es). And publication (e.g. García et al., 2015, García et al., 2013)

