VALIASI: IASI OZONE TOTAL COLUMN AMOUNTS AND VERTICAL PROFILES VALIDATED AT SUBTROPICAL, MID-LATITUDE AND POLAR LATITUDE

E. Sepúlveda[1,2], O.E. García[2], M. Schneider[3], T. August[4], F. Hase[3], T. Blumenstock[3], M.E. Sanromá[2], T. Hultberg[4], A. Redondas[2], E. Cuevas[2], N. Peinado[5], X. Calbet[6], E. López-Baeza[5], A. M. de Frutos[1]

(1) Atmospheric Optics Group (GOA). University of Valladolid. E-mail contact: esepulvedah@goa.uva.es

(2) Izaña Atmospheric Research Centre, Agencia Estatal de Meteorología (AEMET), SC de Tenerife, Spain. (3) Institute for Meteorology and Climate Research (IMK-ASF), Karlsruhe Institute of Technology, Germany; (4) EUMETSAT, Germany; (5) University of Valencia, Spain; (6) Agencia Estatal de Meteorología (AEMET), Madrid, Spain.

Satellite-based sensors can give a complete overview of the ozone (O3) global distribution, and, therefore, contribute fundamental observations for monitoring the atmosphere and for climate research studies. In this context, the IASI (Infrared Atmospheric Sounding Interferometer) is a very relevant sensor as it combines long-term data availability, high quality, global coverage, and good measurement frequency. However, a comprehensive documentation of the IASI data quality and consistency has to be carried out prior to any scientific study.

In this context and within the project VALIASI (VALidation of IASI level 2 products), an EUMETSAT research fellowship, we present this study. The IASI-A O3 Level 2 (L2) operational products (total column amounts and vertical profiles), generated by the EUMETSAT Polar System (EPS) with processor version 4, 5 and 6 (-v4, -v5 and –v6), are validated by using the ground-based FTS (Fourier Transform Spectrometer) at the subtropical Izaña Observatory (28°N, 17°E). The validation at mid- and polar latitudes is on-going.

VALIASI fellowship

Motivation

To date: Validation activities only for short periods, for a specific gas and using as reference different techniques.

Valiasi proposes: Validation for long periods, all trace gases and using as reference one single measurement technique.

Aim

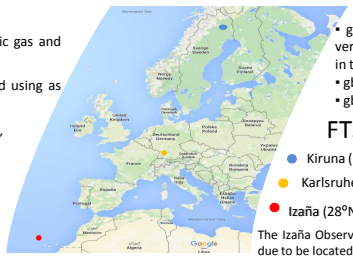
Comprehensive validation of IASI level 2 humidity and trace gas (O3, CO, CO2, CH4 and N2O) products by means of ground-based high-quality Fourier Transform Infrared (FTS) spectrometry.

Benefits

· Empirically assessment and documentation of the overall quality of the IASI L2 humidity and trace gas products.

· New insights in the importance of different error sources: latitude dependency, viewing geometry, surface emissivity, aerosols,...

· Conclusions for further improvements.



Ground-based FTS as validation reference

- gb FTS produces precise total column amounts (precision better than 0.5%) and low-resolution vertical profiles (4 partial columns, DOF≈4), with precision better than 6% in the troposphere and 3% in the lower, middle and upper stratosphere (Schneider et al., 2008; García et al., 2012).
- gb FTS and IASI vertical sensitivity (given by the averaging kernels) overlap.
- gb FTS measures quasi continuosly during daytime and weather permits.

FTS Sites for validation

- Kiruna (67°N, 20°E; 419m a.s.l). The NDACC FTS is located at the Swedish Institute of Space Physics.
- Karlsruhe (49°N, 8°E; 110 m a.s.l.). The TCCON FTS is located at the Karlsruhe Institure of Technology.
- Izaña (28°N, 16°W; 2.37km a.s.l.)

The Izaña Observatory (IZO) is well representative for atmospheric background conditions at the subtropical North Atlantic due to be located above a trade-wind temperature inversion layer. The FTS is part of NDACC and TCCON networks

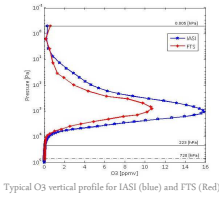
TOTAL & TROPOSPHERIC PARTIAL COLUMN AMOUNTS

The period covered by this work goes from 01/01/2007 to 31/12/2012 and includes the three coexisting versions of the IASI L2 processor at EUMETSAT Data Center. Note that IASI L2 version 6 is a re-evaluated time series (private communication T. August)

The validation exercise is performed comparing the variabilities observed for each instrument at different time scales: intraday and annual cycle. For that, coincident criteria were established. This work shows an example for IZO: ±1° validation box around IZO and FTS observations within ± 1 hour from the IASI overpass.

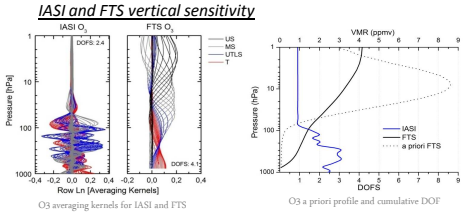
	IZO FTS (hPa)	IASI (hPa)
OZONE TOTAL COLUMN AMOUNT (OTC)	720 - 0.005	1050 - 0.005
OZONE PARTIAL COLUMN AMOUNT (OPC)	720-223	1050-223

First right panel shows two typical observed O3 profiles for IASI (blue) and FTS (red). Horizontal lines display the pressure limits defining the OTC and OPC for both instruments.



Typical O3 vertical profile for IASI (blue) and FTS (Red)

IASI and FTS vertical sensitivity



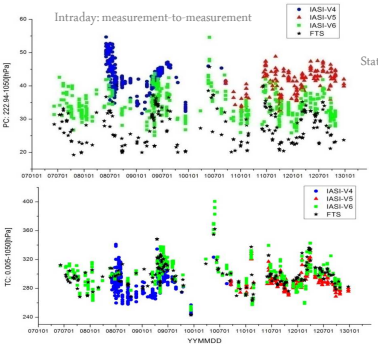
O3 averaging kernels for IASI and FTS

O3 a priori profile and cumulative DOF

The middle two panels show the O3 averaging kernels for IASI and FTS (being, T, troposphere; UTLS, Upper troposphere/lower stratosphere; MS, middle stratosphere and US, upper stratosphere. The third panel shows the O3 a priori profiles for FTS (dashed line) and the cumulative DOF (Degree Of Freedom for signal) for IASI (blue) and FTS (black)

Partial column missed by FTS is not crucial since IASI has a weak sensitivity below IZO!!
But, the different sensitivities make IASI-FTS comparison difficult.

Comparison of the O3 variabilities as observed by IASI (-v4, -v5 & -v6) and FTS



Left panels show the comparison of the intraday variablities as oberved by the FTS and IASI (all versions) for the OTC (bottom) and OPC (top). Right panel shown the same as left panel, but for the annual cycle.

Statistic summary for O3 total column (OTC) and O3 partial column (OPC) comparison for the three version of IASI L2 processor.

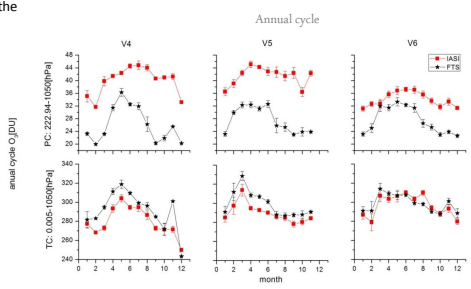
Time Scale	IASI L2 Version	OTC M	OTC IP68 / vN	OTC R	OPC M	OPC IP68 / vN	OPC R	N
Single Measurements	V4	-13.9	0.15 (0.43)	0.21	12.8	0.32 (0.11)	0.40	398
	V5	-9.1	0.11 (0.26)	0.67	13.2	0.51 (0.17)	0.38	237
	V6	1.6	0.10 (0.32)	0.78	6.6	0.32 (0.10)	0.76	578
Annual Cycle	V4	-13.6	1.22 (1.13)	0.83	12.9	4.30 (2.60)	0.85	12
	V5	-9.4	0.60 (1.15)	0.87	13.1	4.46 (1.86)	0.71	11
	V6	-2.3	0.62 (0.74)	0.71	7.8	3.06 (1.79)	0.82	12

· M: median of the absolute differences (IASI-FTS) in D.U. , i.e., from the observed time series. $IP68 = 0.5[Q_{84}(\Delta p) - Q_{16}(\Delta p)]$

· R: Spearman correlation coefficient.

· IP68: semi 68% inter-percentile of the relative differences [Δp=(IASI – FTS)/FTS] (%); i.e., from the deseasonalized time series.

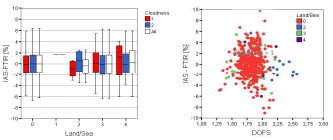
The statistics in brackets are given in D.U.



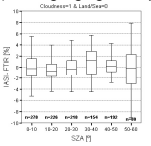
Sources of dependency

We study the dependency of the O3 total column amounts obtained with the IASI L2 ***version 6*** processor wrt cloud conditions, land or sea pixel and viewing angle geometry. There is no significant differences for cloud conditions for the land/sea flag. Higher DOFS values are obtained for land/sea flag (2). For solar zenith angles (SZA) higher than 50° the IASI-FTS differences show more dispersion.

1) Land or Sea and Cloud free or partly cloudy



2) Viewing angle geometry



Flag characterisation based on EUMETSAT L2 product guide

Land/sea Flag

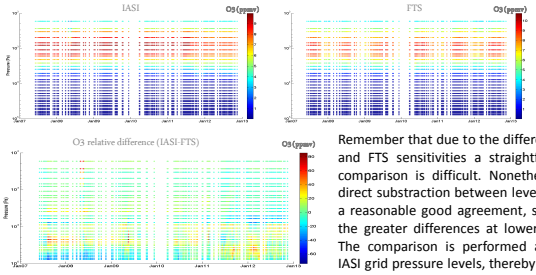
0 - The IASI IFOV is completely covered by water
1 - The IASI IFOV is completely covered by land, the variability of the surface topography is low
2 - The IASI IFOV is completely covered by land, the variability of the surface topography is high
3 - The IASI IFOV covers land and water, the variability of the surface topography is low
4 - The IASI IFOV covers land and water, the variability of the surface topography is high
5 - The IASI IFOV contains sea-ice

Cloud Flag

1 - The IASI IFOV is clear
2 -The IASI IFOV is processed as cloud-free but small cloud contamination possible
3 - The IASI IFOV is partially covered by clouds
4 - High or full cloud coverage

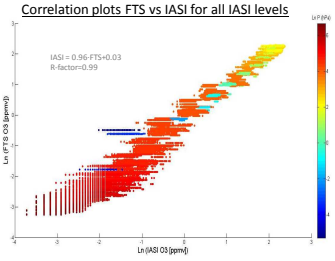
VERTICAL PROFILES

O3 vertical profiles as observed by FTS and IASI -v6

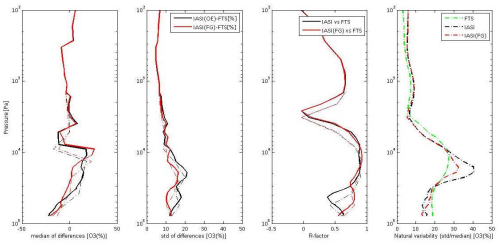


Remember that due to the different IASI and FTS sensitivities a straightforward comparison is difficult. Nonetheless, a direct substraction between levels show a reasonable good agreement, showing the greater differences at lower levels. The comparison is performed at the IASI grid pressure levels, thereby FTS O3 profiles was interpolated to those grid.

Correlation plots FTS vs IASI for all IASI levels



Vertical profiles of the differences between IASI-FTS



The above right panels show the differences applying IASI First Guess (FG) in red and IASI Optimal Estimation retrieval (OE) in black level-to-level (dashed lines correspond to 3km averaged layer). Left first panel shows the median and the second panel the standard devatiation (1σ) of the differences. Third panel shows the vertical profiles of the correlation coefficient. Fourth panel shows the observed actual variability considering the coincident observations for the revaluated 2007-2012 time series of the IASI L2 version 6.

CONCLUSIONS

- Ground-based FTS ozone (O3) products are a powerfull tool for satellite-based validation.
- The O3 products of IASI L2 version 6 show better agreement wrt FTS than previous versions, specially the tropospheric partial columns, likely due to the improvements in the temperature and humidity profiles in the lower troposphere introduced in V6. The exception is the annual cycle of the total column amounts, where versions 4 and 5 show better correlation.
- From the OTC dependcy study for IASI L2 version 6 we conclude that the highest DOF are obtained for pixels over land likely due to the improved thermal contrast. Over sea there is no significant difference in considering cloud free or partly free pixels. The highest dispersion for the difference IASI-FTS is obtained for solar zenith angle higher than 50º.
-IASI L2 version 6 provides, for the first time, O3 vertical profiles and averaging kernels, which allow us to analyse the IASI vertical sensitivity and evaluate how IASI reproduces the actual O3 variability at different altitudes.
-The O3 IASI-FTS profile comparison suggests that there are two wide layers well correlated, in the tropopause region (200-80 [hPa]) and in the middle stratosphere (15-7 [hPa]) showing correlation factor of R ≈ 0.90 and R≈0.68, respectively, in agreement with the number of independent layers detected by IASI (DOFS around 2). Note that a higher agreement is observed for the IASI first guess O3 profiles in the lower troposphere, but further analysis are needed. .

ACKNOWLEDGMENTS

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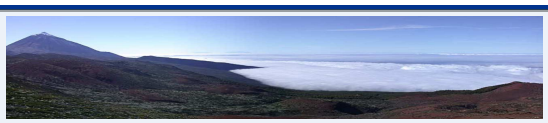

REFERENCES

-García et al., Atmos. Meas. Tech., 5, 2917-2931, 2012.
- IASI L2 product guide V6: EUM/OPS-EPS/MAN/04/0033 v3B, 15 October 2012.
- Schneider et al., Atmos. Chem. Phys., 8, 5579–5588, 2008.