Ozone Total and Partial Column Amounts Comparison between satellite-based METOP-IASI and ground-based NDACC FTS

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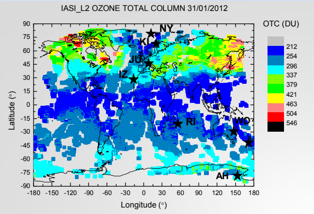
Satellite-based (s-b) sensors have the advantage of monitoring the Earth's atmosphere at global scale and at high frequency and, therefore, increasing the temporal and spatial coverage of the ground-based (g-b) sensors networks. However, the quality and consistency of the satellite-sensor datasets have to be assessed prior to any scientific use. In this context, the g-b high-quality Fourier Transform Infrared spectrometers (FTS) that take part in the NDACC (Network for the Detection of Atmospheric Composition Change) have proved to be suitable to perform this task.

This study analyzes the capability of the s-b MetOp-A IASI (Infrared Atmospheric Sounding Interferometer) sensor of monitoring global ozone distributions (total and partial column amounts) by comparing with eight globally distributed g-b NDACC-FTS sites. From the s-b IASI observations two retrieval codes are considered: the EUMETSAT IASI level 2 (L2) generated by the EPS Core Ground Segment (version 5 and version 6) and the Fast Optimal Retrievals on Layers for IASI (FORLI) from LATMOS.

Reference: ground-based NDACC -FTS

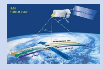
Site (Acronym)
Ny-Ålesund (NY)
Kiruna (KI)
Jungfraujoch (JU)
Izaña (IZ)
Reunion Island-Maido (RI)
Wollongong (WO)
Lauder (LA)
Arrival Height (AH)



Satellite-based Metop IASI (Infrared Atmospheric Sounding Interferometer)

The IASI sensor flies onboard the MetOp satellite series in a polar sun-synchronous orbit (Low Earth Orbit, about 800 km altitude), crossing the equatorial plane twice per day (at 9:30 am & 21:30 pm local time). Its mission is guaranteed for several years with the launch of three sensors (-A in 2006, -B in 2012 and –C expected in 2018). IASI provides atmospheric emission spectra to derive vertical structure of temperature and humidity profiles with an accuracy of 1 K and vertical resolution of 1km. Moreover, from the spectra measured different trace gases can be retrieved, such as, O3, CO, CO2, CH4 and N2O.

FTIR & IASI features



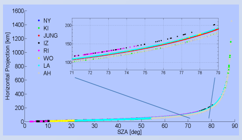
	FTS	IASI
Type of Observation	Direct solar absorption	Thermal infrared emission
Spectral Range [cm^{-1}]	700 – 9000	645 – 2760
Spectral Resolution [cm^{-1}]	0.005	0.5
Field of View	0.2 º (< solar disc)	At nadir 4 pixels of 12 km
Frequency of Observation	weather permit, ~3 days/week	twice per day, at IZO region around 10 am / pm
Sample Duration	6-8 min	8s (30x4 pixels)
Data Availability	Station dependent	Since 2007 MetOp-A/IASI Since 2012 MetOp-B/IASI

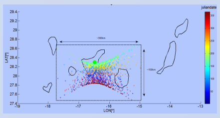
VALIDATION STRATEGY

Spatial and Temporal colocation

Spatial colocation: Validation box → NDACC site-dependent.

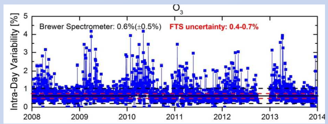
The NDACC site is centered in a box, whose dimensions are defined according to the effective column observed by the FTIR instruments.





Example for Izaña station

Temporal colocation: It depends on natural variability of target gas and the FTIR theoretical uncertainty. For O3 we have established **±1h** from the IASI daytime overpass.



Temporal descomposition: The validation exercise is performed comparing the variabilities observed for each instrument at different time scales: intraday and annual cycle.

Annual Cycle Variability -> Original O3 Time Series – Fitted Linear Trend

Intra-day Variability -> Original O3 Time Series – (Annual Cycle + Linear Trend)

IASI and FTS O3 Products:

IASI: We analyse the MetOp-A/IASI O3 total and partial column amounts obtained by two retrieval algorithms: (1) the operational O3 products generated by the EUMETSAT Polar System (EPS) with processor version 5 (09/2010-09/2014) and version 6 (10/2014-12/2015) (August et al., 2012; IASI Guide, 2014); (2) the Fast Optimal Retrievals on Layers for IASI (FORLI) from LATMOS (Hurtmans et al., 2012)

FTS: g-b FTIR produces precise total column amounts (precision better than 0.5%) and low-resolution vertical profiles (4 partial columns, DOFs≈4), with precision better than 6% in the troposphere and 3% in the lower, middle and upper stratosphere (Schneider and Hase, 2008; García et al., 2012). From the g-b FTS observations a common retrieval strategy for all sites involved in this study is carried out.

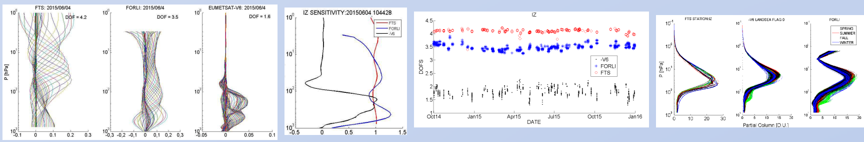
	O3 FTS	O3 IASI (*version v5/v6*)	O3 IASI (*FORLI*)
Microwindow [cm^{-1}]	780 - 1015	1001 - 1065	1025 - 1075
Retrieval Method	TP	OEM	OEM
a-priori	Constant site dependent obtained from WACCM	Constant global apriori obtained from collection of ECMWF. First-guess from PWLR method.	Constant global apriori obtained from the McPeters/Labow/ Logan ozone profile climatology
Pressure grid	~42 levels (site dependent)	90 level grid/101 levels	41 levels

TP: Tikkonov Phillip; OEM: Optimal Estimation Method

VERTICAL SENSITIVITY

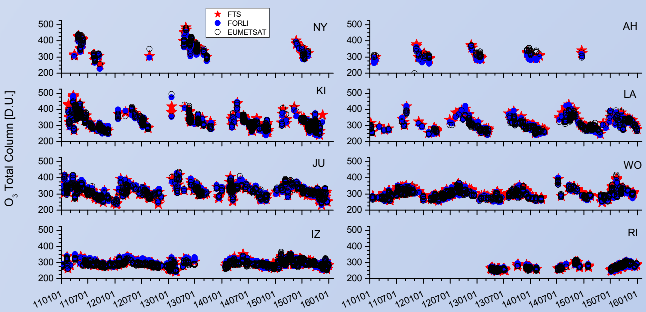
s-b IASI and g-b FTS have different vertical sensitivities, making the IASI-FTS comparison difficult.

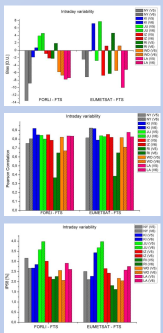
Example for Izaña site (from left to right): typical ozone averaging kernels and vertical sensitivity, DOFs time series and vertical Partial Column profiles.



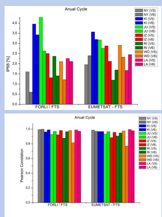
TOTAL COLUMN AMOUNTS

INTRADAY VARIABILITY





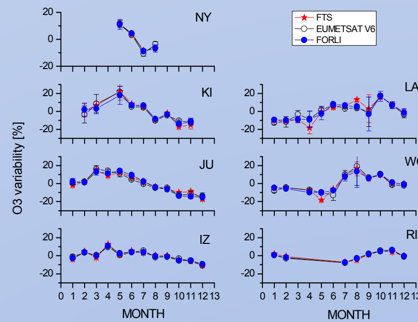
ANNUAL CYCLES



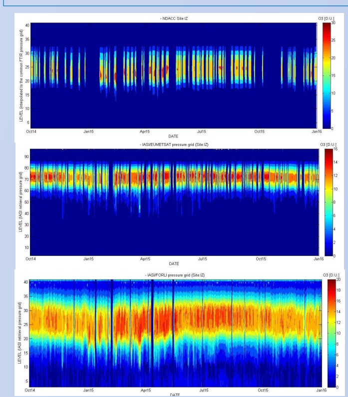
IP68: semi 68% inter-percentile :

$$IP68 = 0.5\ [\ Q_{84}(\Delta X) - Q_{16}(\Delta X)]$$

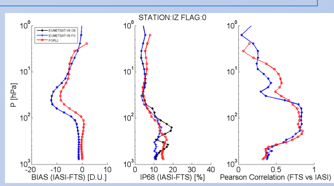
where Q_{84} and Q_{16} are the 84 and 16% percentiles of the difference distributions: (FORLI-FTS) and (EUMETSAT-FTS)



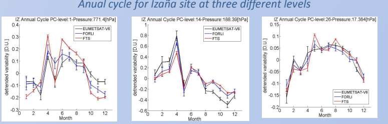
VERTICAL PROFILES OF PARTIAL COLUMN AMOUNTS



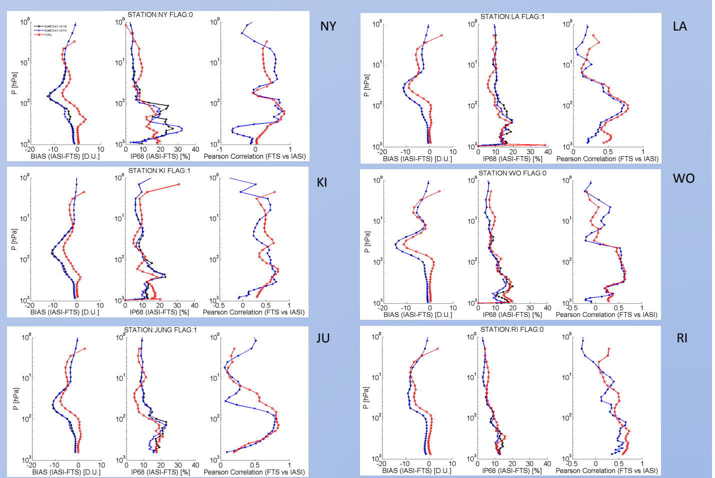
Example for Izaña (from top to bottom): FTS, EUMETSAT V6 & FORLI.



Anual cycle for Izaña site at three different levels



	771.4 [hPa]	*188.39 [hPa]*	*17.38 [hPa]*
Pearson Correlation			
FORLI - FTS	0.92	0.98	0.96
EUMETSAT - FTS	0.84	0.95	0.88
IP68 [%]			
FORLI - FTS	10.19	5.90	2.68
EUMETSAT - FTS	14.04	21.02	3.31



CONCLUSIONS

- G-b FTS produces high-quality and precise total and partial column amounts and vertical profiles. Therefore, FTS is placed as an excellent reference instrument to validate satellite-based sensors.
- Spatial and Temporal colocation criteria has to be established for each site.
- Vertical sensitivity has to be carefully addressed for the intercomparison / validation study.
- The EUMETSAT L2 O3 operational products obtained with processor version 5 and version 6 and the FORLI O3 products are compared with the FTS O3 products obtained at different NDACC sites. The comparison is performed at two different time scales (intra-day and anual cycle).
- The scatter observed by EUMETSAT and FORLI O3 Total Colum is consistent with respect to the FTS (showing no latitudinal dependence). The IASI precision is between (2.5-3)% , conservative values.
- For the Partial Column Amounts, the IASI precision is below 7% for the stratosphere and below 13% for the troposphere, conservative value.

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ACKNOWLEDGMENTS

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