Quality Assessment of the IASI Operational Trace Gas Products by using ground-based Fourier Transform Spectrometry at the Izaña Atmospheric Observatory

O.E. García[(1)], M. Schneider[(2)], T. August[(3)], F. Hase[(2)], T. Blumenstock[(2)], E. Sepúlveda[(1)], T. Hultberg[(3)], S. Barthlott[(2)], A. Wiegele[(2)], M.E. Sanromá[(1)], A. Gómez-Peláez[(1)], A. Redondas[(1)], E. Cuevas[(1)], P.M. Romero-Campos[(1)], Y. González[(1,4)]

(1) Izaña Atmospheric Research Centre, Agencia Estatal de Meteorología (AEMET), Spain. E-mail contact: ogarciar@aemet.es

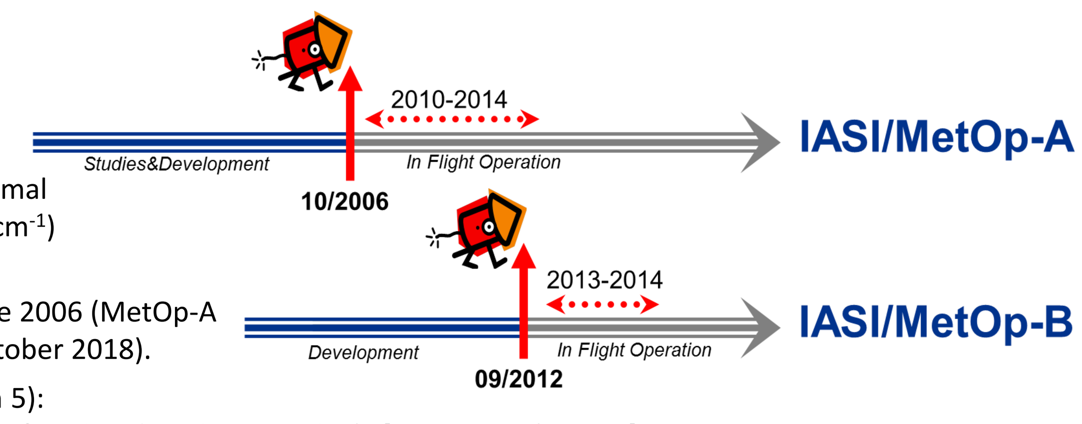
(2) Institute for Meteorology and Climate Research (IMK-ASF), Karlsruhe Institute of Technology, Germany; (3) EUMETSAT, Germany; (4) Sieltec Canarias, S.L., Spain.

This work exploits the large potential of the Spanish atmospheric super-site Izaña Atmospheric Observatory (IZO, Tenerife), as a ground-based reference site, to perform a comprehensive and quasi near-real time validation of the EUMETSAT operational level 2 trace gas products (ozone, methane, nitrous oxide, carbon monoxide and carbon dioxide) of the remote sensor IASI (Infrared Atmospheric Sounding Interferometer). By using the IZO's ground-based FTS (Fourier Transform Spectrometer) experiment we document the quality of the IASI-A and IASI-B Version 5 time series (2010-2014 and 2013-2014, respectively). Moreover, we establish the methodology to perform this validation exercise shortly after the measurements. Such near operational validation of satellite sensor products is strongly requested by the satellite operators and the climate research community.

EUMETSAT/IASI

IASI remote sensor is a nadir-viewing atmospheric sounder based on a Fourier Transform Spectrometer (FTS) recording thermal infrared emission spectra of the Earth-atmosphere system in the 645-2760 cm^{-1} region (apodized spectral resolution of 0.5 cm^{-1}) on a surface swath width of about 2200 km twice per day.

They are onboard the meteorological satellites MetOp in the framework of EUMETSAT Polar System (EPS) since 2006 (MetOp-A launched in October 2006, MetOp-B launched in September 2012 and MetOp-C with launch scheduled for October 2018).



Status and expected uncertainties of EUMETSAT Operational Level 2 Total Columns (TC) (Version 5):

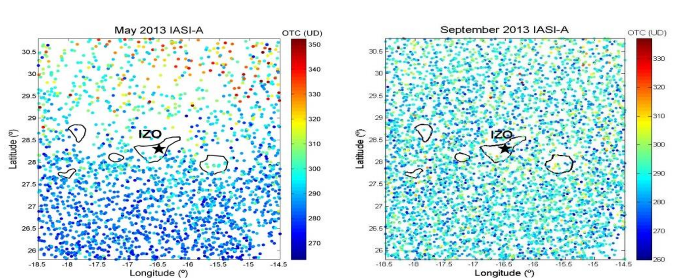
- O_3 and CO TCs are operatively disseminated in operational mode with an expected uncertainty of <5% and 15%, respectively [August et al., 2012].
- N_2O, CH_4 and CO_2 TCs are operatively disseminated, but they are produced in an experimenal mode with expected uncertainties <20% ["IASI Level 2 Product Guide", EUM/OPS-EPS/MAN/04/0033].

COLOCATION STRATEGY

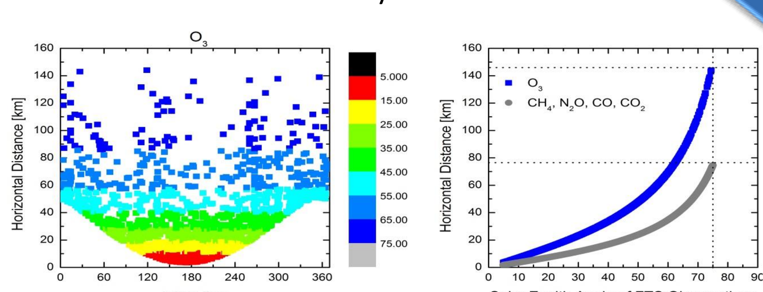
SPATIAL COLOCATION

- 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 FTS observations is between 80 km (CH_4, N_2O, CO and CO_2) and 150 km (O_3) → **± 1º centred at IZO location for all the trace gases considered**

Latitudinal/longitudinal O_3 TC distributions

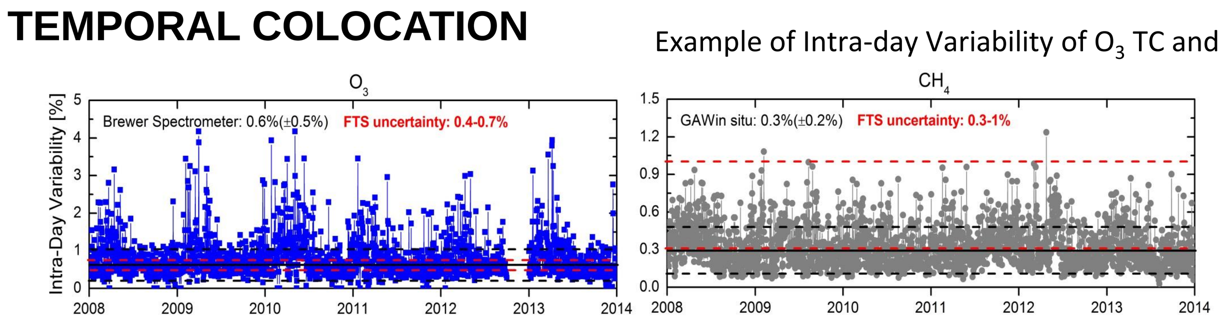


Horizontal Distance covered by FTS TC observations



TEMPORAL COLOCATION

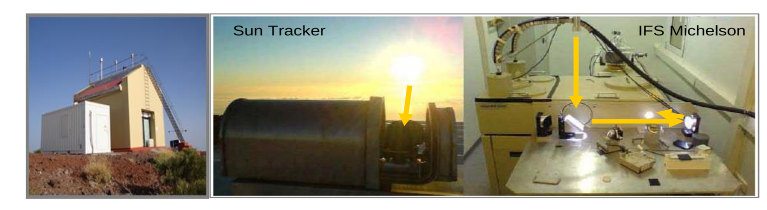
Example of Intra-day Variability of O_3 TC and tropospheric CH_4 at IZO



Intra-day Variability > Theoretical Uncertainty FTS → **±1h IASI overpass for O_3 and CO**

Intra-day Variability < Theoretical Uncertainty FTS → **Daytime medians for CH_4, N_2O and CO_2**

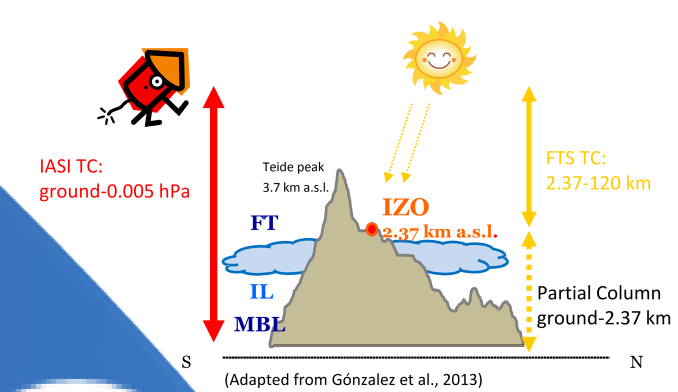
GROUND-BASED FTS



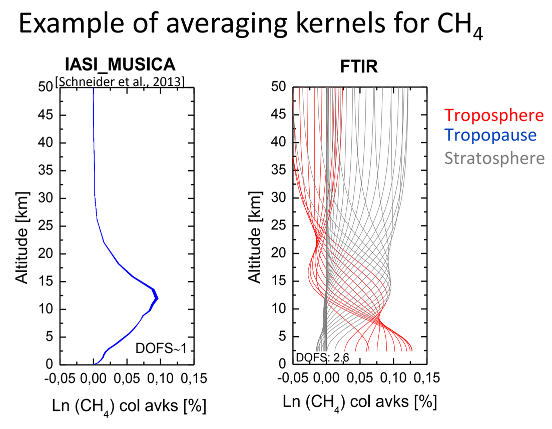
IZO FTS activities started in 1999 and continue until present, contributing to the international networks NDACC (Network for Detection of Atmospheric Composition Change) and TCCON (Total Carbon Column Observing Network) since 1999 and 2007, respectively.

FTS Volume Mixing Ratio (VMR) profiles are retrieved with PROFFIT [Hase et al., 2004] from middle infrared solar absorption spectra (from 700 to 9000 cm^{-1} at 0.005 cm^{-1} of apodized spectral resolution).

Then, FTS TC are integrated from 2.37 km to Top of Atmosphere, with a theoretical and experimental precision of better than 1% for all the trace gases considered here [García et al., 2015].



Example of averaging kernels for CH_4



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

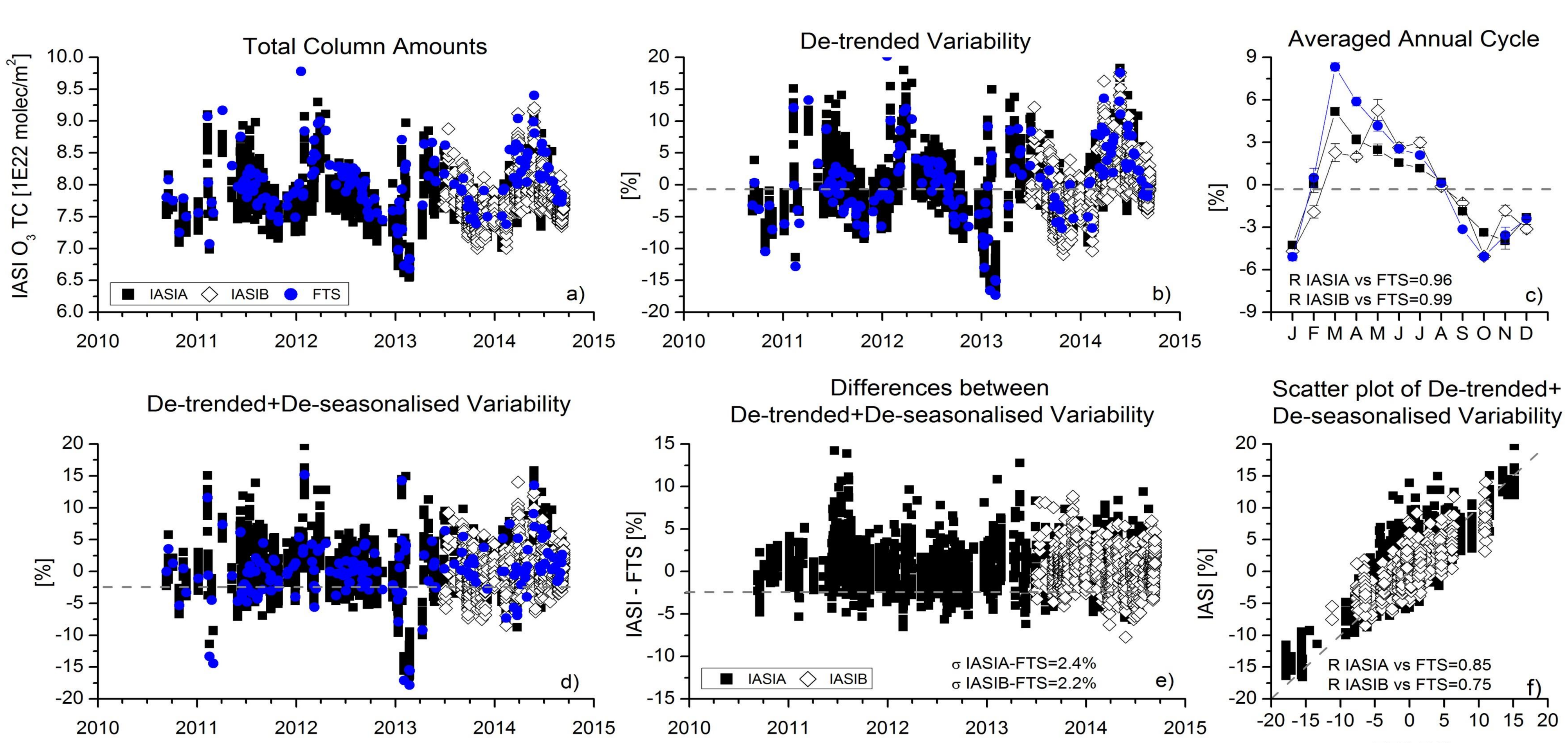
DISSEMINATION

The continuous comparison of IASI and FTS products at IZO is publicly available through the Spanish project NOVIA at www.novia.aemet.es.

This webpage updates the quality assessment of IASI-A and IASI-B level 2 trace gas products on a monthly basis.

COMPARISON BETWEEN IASI-A/IASI-B AND GROUND-BASED FTS

EXAMPLE OF IASI-FTS INTERCOMPARISON FOR O_3



The quality assessment of IASI-A and IASI-B products is addressed at different time scales: single measurements, daily, annual , and and long-term trends.

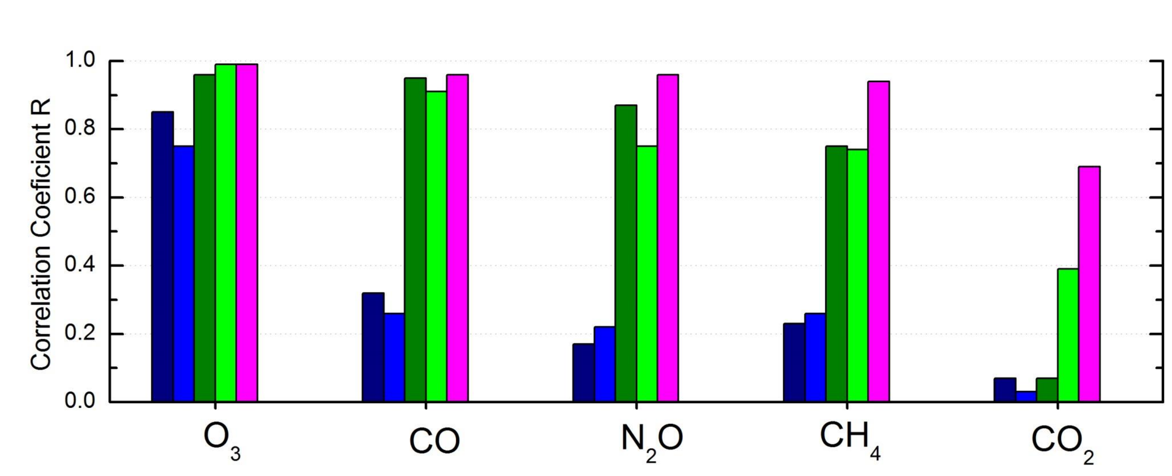
De-trended Variability= Observations - Long-term linear trend

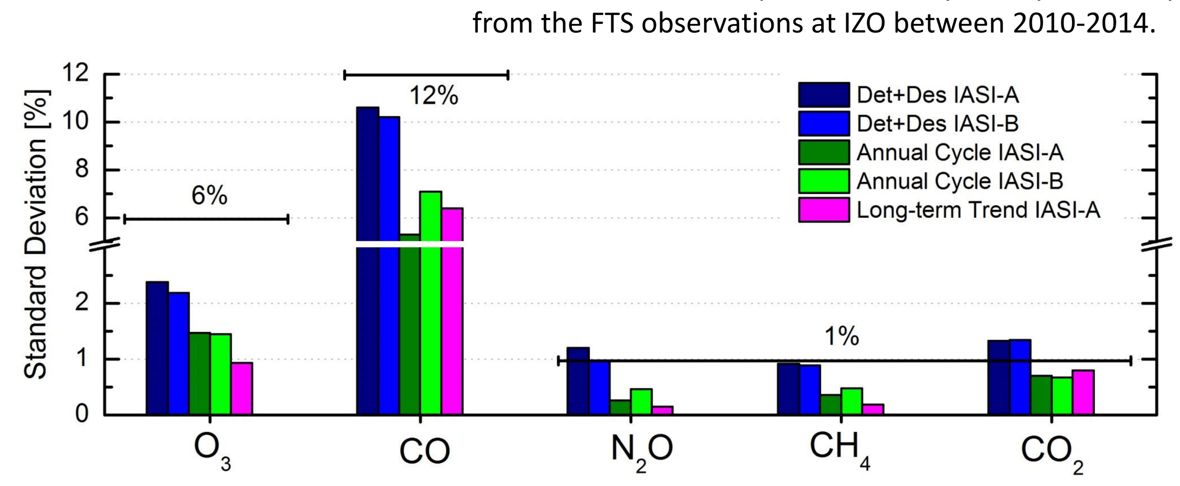
De-trended+De-seasonalised Variability (Det+Des)= Observations – Annual Cycle – Long-term linear trend

Quasi Near-Real Time IASI Validation

SUMMARY OF IASI-FTS INTERCOMPARISON FOR O_3, CO, N_2O, CH_4 AND CO_2

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





- ✓ Ground-based FTS experiments are a powerful tool to validate all the IASI trace gas products due to their high precision and high measurement frequency. Also, this technique allows a comprehensive validation for IASI products using one single measurement technique as reference, thereby the validation results are directly comparable among trace gases.
- ✓ The quality assessment of IASI-A and IASI-B products is addressed at different time scales (single measurements, daily, annual, and long-term trends). This temporal decomposition provides an added value for validating trace gases with a rather small variability, like N_2O or CO_2. For such gases the uncertainty is often larger than the day-to-day variability and, then, a validation at longer temporal scales is more meaningful than a validation only limited to a comparison of individual coincidences. Moreover, this analysis allows us quickly to detect instrumental issues or inconsistencies.
- ✓ EUMETSAT IASI operational level 2 products well reproduce the ground-based FTS observations at the longest temporal scales, i.e., annual cycles and long-term trends for the all trace gases considered except for CO_2 (correlation coefficient, R, larger than 0.95 and 0.75 for long-term trends and annual cycles, respectively). The remaining differences observed can in part be accounted for the different vertical sensitivities of the two remote sensing instruments. Regarding very short-term variabilities, only the operational O_3 product seems to be well sensitive to actual atmospheric variations (R~0.80), while CO products are moderately sensitive (R~0.50). For the rest of the trace gases, still disseminated as demonstrational products, further improvements might be recommendable to capture the day-to-day real atmospheric variability.

ACKNOWLEDGEMENTS

The research leading to these results has received funding from the Ministerio de Economía and Competitividad from Spain for the project CGL2012-37505 (NOVIA projectand from EUMETSAT under the Fellowship Programme (VALIASI project). Furthermore, M. Schneider and Y. González are supported by the European Research Council under FP7/(2007-2013)/ERC Grant agreement nº256961 (MUSICA project).

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