Long-term Monitoring of Greenhouse Gases at the Izaña Atmospheric Observatory

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Izaña Atmospheric Observatory

The Izaña Atmospheric Observatory (IZO, 28.39N, 16.59W, 2367 m a.s.l., Tenerife, Spain) is a sub-tropical high-mountain observatory, run by the Izaña Atmospheric Research Center (IARC, http://izaña.aemet.es), belonging to the State Meteorological Agency of Spain (AEMET). The IARC conducts monitoring and research related to atmospheric constituents that are capable of forcing changes in the climate and quality of the Earth. IZO is normally above a temperature inversion layer and below the descending branch of the Hadley cell. Consequently, it offers excellent conditions for trace gas and aerosol in situ measurements under “free troposphere” conditions, and for atmospheric observations by remote sensing techniques. The environmental conditions and pristine skies are optimal for calibration and validation activities of both ground-based and space-based sensors.

Regarding greenhouse gases (GHGs), IZO has been a Global WMO-GAW (World Meteorological Organization-Global Atmospheric Watch) station since 1984, recording continuous in-situ concentrations of the main GHGs. In addition, since 1999 total column amounts and low-resolution vertical profiles of many different atmospheric trace gases. GHG among them, are retrieved by using Fourier Transform Infrared Spectrometer (FTS) in the framework of NDACC (Network for the Detection of Atmospheric Composition Change) and TCCON (Tropospheric Carbon Column Observing Network).

In this context, this work gives an overview about the IZO capabilities and activities for monitoring of atmospheric GHGs, especially focusing on the validation of space-based observations.

GAW In Situ

Ground-level in situ atmospheric continuous measurements of CO (since 1984), CH₄ (since 1994), N₂O (since 2007), SF₆ (since 2004) for NDACC products and GFIT (Wunch et al., 2015) for TCCON products. The IZO continuous trace gas measurements are external quality assured by (1) periodic audits (the participation in WMO Round Robin intercomparisons; and (2) the continuous comparison to simultaneously collected flask samples, within the NOAA/ESRL/GMD CCGG cooperative air sampling network. The expected uncertainties in these IZO continuous measurements are ±0.1 ppm for CO₂, 2 ‰ for CH₄, 0.2 ppm for N₂O, and 0.025 ‰ for SF₆. Refer to Gómez-Peláez et al. (2012) and Gómez-Peláez et al. (2013) for more details. Figure below displays the time series of CH₄, CH₃O, N₂O and CO as observed by in situ GAW analysers and high-resolution FTS at IZO, showing the high agreement between both datasets.

FTS

The high-quality IZO data has been extensively applied since many years for the validation of trace gases measured by different satellite instruments (ILAS, MIPAS, ACE-FTS, GOME, OCIO, TROPOMI, …). Currently, our activities are focused on the IASI sensor through the European projects MUSICA and VALIASI, the German project MOVIT and the Spanish projects NOVIA and INMENSE. By means of these projects the validation of all IASI operational atmospheric trace gases being carried out as well as the development of the new IASI retrieval strategies.

Here, we present an example of the capability of the IZO GHGs observations (GAW in situ and FTS) to validate the CH₄ and N₂O products generated by the IASI processor developed during the project MUSICA (Multi-platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water, Schneider and Hase, 2011; Wegele et al., 2014; Schneider et al., 2016). Figures on the right show the global distributions of the MUSICA IASI CH₄, products retrieved at the Upper Troposphere/Lower Stratosphere (ULTS, ~12 km) and averaged for a latitude-longitude area of 2ºx2º (the maps are shown separately for mid February 2014 and mid August 2014).

The comparison studies demonstrate that the MUSICA (IASI) data capture signals well that are larger than 1-2‰, like the latitudinal gradients, the long-term increase and the seasonal cycles in the ULTS region. The MUSICA IASI CH₄ data offer a better sensitivity than N₂O data. While for the latter the sensitivity is mainly limited to the ULTS region, for CH₄ we are able to proof that at low latitudes the MUSICA (IASI) processor can detect variations that take place in the free troposphere independently from the variations in the ULTS region (case figures below). This validation exercise is also extended to two a posteriori corrected CH₄ products (CH₄⁰ and CH₄¹), based on the a posteriori calculated logarithmic scale difference of the CH₄ and N₂O retrieval estimates. Refer to García et al. (2017) for more details.

Validation of Space-based Greenhouse Observations

The FTS programme at IZO is the result of the collaboration between the IARC-AEMET and the IRK-ASF-KIT. Within NDACC activities, the IZO high-resolution FTS records direct solar spectra in the middle infrared between 740-4200 cm⁻¹ (β(0-60°) cm⁻¹), while for TCCON the spectral range covers the near infrared from 3500-9000 cm⁻¹ (β(0-20°) cm⁻¹). By evaluating the measured solar absorption spectra, the FTS systems can derive total column amounts and low-resolution vertical profiles of different atmospheric trace gases with high precision. To do so, two retrieval codes are used at IZO: PROFIT (Hase et al., 2004) for NDACC products and GFT (Wunch et al., 2015) for TCCON products. The IZO FTS have routinely contributed to NDACC with CH₄, CO₂, CO, CH₄, COF₂, HCl, HCN, HF, H₂O, HDO, NH₃, N₂O, NO₂, CO, and OCS observations (total column amounts and volume mixing ratio profiles) since 1999. While total column-averaged abundances of CO₂, N₂O, CH₄, H₂O, CO, HDO and HDO are measured within TCCON since 2007. The IZO FTS programme is complemented by a EMCS/UN portable FTS. It measures in the near infrared (β(0.5°) cm⁻¹) providing total columns of CO₂, CH₄, CO₂ and H₂O.

Global distribution of MUSICA IASI CH₄ products at UTS (12 km)

Seasonal cycle relative to long-term background [%]