Sensitivity analysis and application of KLIMA algorithm to GOSAT validation

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The KLIMA-IASI project

KLIMA-IASI is an on-going project supported by ESA-ESRIN and lead by IFAC-CNR in collaboration with IUP, University of Bremen. Final goal is to retrieve CO_2 column values from IASI spectra using the KLIMA inversion algorithm developed by IFAC-CNR and to use this information (averaged over a monthly to seasonal time scale and over a spatial scale compatible with the requirements of a comparison with the CO_2 products of the TANSO-FTS and TANSO-CAI instruments) for GOSAT validation purposes.
The project is organized in two phases:

Phase 1 (March 2008 – July 2009)
- Adaptation of the KLIMA algorithm into a non-operational inversion code optimized for fast and accurate retrieval of CO_2 information from IASI spectra;
-Sensitivity assessment and evaluation of the performances of the optimized KLIMA-IASI code for retrieval of CO_2 information from single IASI spectra.

Phase 2 (December 2009 – August 2011)
- Integration of the optimized KLIMA/IASI CO_2 retrieval code into the ESA G-POD (Grid Processing On-Demand) operational environment;
-Comparison between KLIMA-IASI and GOSAT CO_2 products for cross-validation purposes.

Why this project

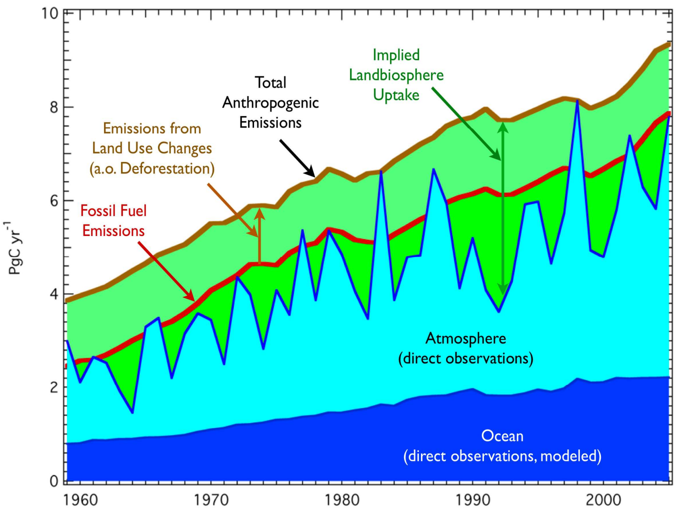
Carbon dioxide is a key constituent of the terrestrial atmosphere with both natural and anthropogenic sources. It’s one of the primary forcing agent of the greenhouse effect, as well as from being the most mobile component of the global carbon cycle that is critically coupled to the Earth’s climate system .

The short-term increase in background concentration of atmospheric CO2, observed in the last two centuries, from a pre-industrial value of 280 ppm to 380 ppm, originates from the steady growth of anthropogenic emissions (mostly due to combustion of fossil fuels (~75%) and to land-use practices (~25%) and increased of about 80% only from 1970 to 2004 (IPCC, 2007)) has been unambiguously related to significant changes in Earth’s climate, particularly the rise of global mean surface temperature.

An effective and potentially valuable source of CO2 data that might become available as an alternative to surface observations (which have limited geographical and temporal coverage) is represented by remote-sensing measurements from spaceborne sensors.

The number of CO2 observation from satellite instruments is order of magnitudes larger than that offered by existing surface networks. Remotely sensed data have in addition the unique features of quasi-global coverage, high temporal sampling and, in some cases, the capability to obtain vertically resolved information about the CO2 distribution.

Currently the most concrete techniques for obtaining global maps of CO2 concentration from spaceborne platforms exploit passive measurements in the Near InfraRed (NIR) and Thermal InfraRed (TIR).



CO2 sources and sinks (http://www.carboscope.eu/img/carbon_cycle_fig2.png)

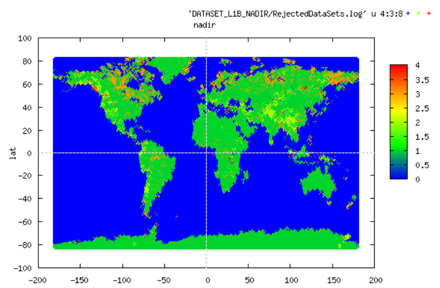
The KLIMA algorithm: basic features

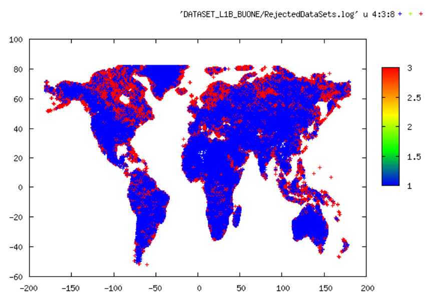
The **KLIMA algorithm c**onsists of two distinct modules.

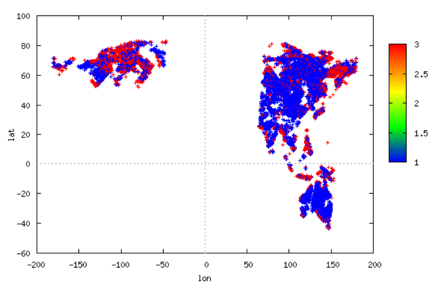
The **Forward Model** (**FM**) simulates wideband nadir radiances measured at the top of the atmosphere using line-by-line Radiative Transfer (RT) calculation. The code computes the radiance that reaches the instrument, and simulates the instrumental effects.

The **Retrieval Model** (**RM**) is designed as a global-fit, multi-target retrieval, based on the constrained Non-linear Least-Square Fit (NLSF) approach: the cost function to be minimized takes into account the a priori information (Optimal Estimation approach) and the Marquardt parameter. The retrieval algorithm enables us to fit the wideband spectrum to find more quantities simultaneously (multi-target retrieval) in order to best account for the errors due to the interfering unknowns. Alternatively, the systematic effects can evaluated using the complete variance-covariance matrix (VCM) defined as the VCM of the measurement errors plus the VCM of the errors in the estimates of the FM parameters.

For more details see http://ga.ifac.cnr.it/klima/klima-iasi-retrieval-code/.







IASI consists of an FTS associated with an imaging instrument. It is designed to measure the spectrum emitted by the Earth-atmosphere system in the TIR spectral range, using nadir geometry. Measurements are performed from the MetOp polar orbit, at an altitude of around 817 km. The satellite is sun-synchronous with a 98.7 inclination to the equator, and the satellite’s ground track is at about 09:30 local time in the morning (and 21:30 in the evening).
The time to complete an orbit is about 101 min, which implies that MetOp makes a little more than 14 orbits a day

Altitude: 817km
Orbit: Polar sun-synchronous
Time for one orbit: 101 min
Repeat cycle: 29 days (421 orbits)
IASI: Fourier transform spectrometer
Spectral range: 645 to 2760 cm^-1
Spectral resolution: 0.3-0.5 cm^-1
Field of view: 50 km at nadir, with 4 simultaneous pixels of 12 km
Lifetime: 5 years

References

Clearbaux et al., 2009: Monitoring of atmospheric composition using the thermal infrared IASI/MetOp sounder. Atmos. Chem. Phys, 9, 6041-6054

Crevoisier et al., 2009: *First year of upper tropospheric integrated content of CO2 from IASI hyperspectral infrared observations*. Atmos. Chem. Phys. 9, 4797-4810