TROPOSPHERIC OZONE FROM IASI MEASUREMENTS IN THE INFRARED USING ALTITUDE-DEPENDENT TIKHONOV REGULARIZATION

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Algorithm

KOPRA

KOPRA (The Karlsruhe Optimized and Precise Radiative transfer Algorithm) is a layer by layer line by line radiative transfer code for calculation of atmospheric transmission and radiance spectra along with the partial derivatives of the spectra with respect to atmospheric state parameters. The KOPRA forward model has been developed in particular for analysis of data from MIPAS instrument on Envisat and has been used for different feasibility and sensitivity studies in this context.

The forward model was compared to other models and validated by IASI Sounder Science working group.

The retrieval tool KOPRAFIT based on this model applied the Tikhonov-Philips Regularization with one adjustable parameter to constrain the solution vector.

Both the forward model and the inversion method were adopted for the purposes of nadir sounding analysis (IASI measurements).

Method

Regularization methods in contrast with probabilistic approach (optimal estimation methods) use analytically defined constrains in the ill-posed problems solution.

The optimized value here is not only the a posteriori Error of the retrieval, but also the Degree Of Freedom for the solution.

The main reason for which we use the Regularization is that this method is less dependent on the ozone statistics. Available statistics may have following problems:

- Available statistics on the ozone profiles are uncertain, especially in the troposphere
- Available climatological covariances can have unwanted correlations
- Available climatological covariances are not always invertible

The standard case of regularization is the Tikhonov-Philips method with the diagonal constraint matrix and one adjustable parameter called the strength of regularization. We use a more sophisticated form which consists in applying an altitude dependent constraint to constrain the different parts of the atmosphere with different strengths. Regularization method may retain an enlarged freedom for the solution in spite of known low variability and therefore may be more adapted for unexpected climatological conditions.

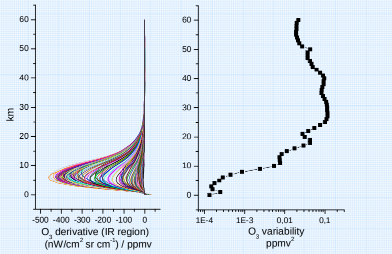
Simulated retrievals

IR → information comes from the free troposphere (max. 6-7 km)

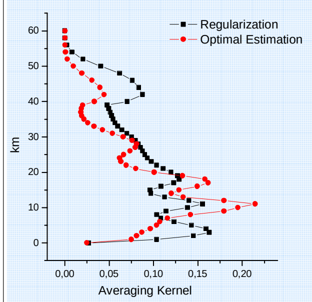
ozone climatological variability usually used to constrain the retrieval (Optimal estimation method) is not adapted to possible unusual situations

Regularization permits to constrain the solution with a function which would be less dependent of the covariances and would take into account as much information coming from the measurement as possible.

Atmospheric ozone variability for middle latitudes region at the summer period (right part) and partial derivatives from IR signal with respect to ozone concentration



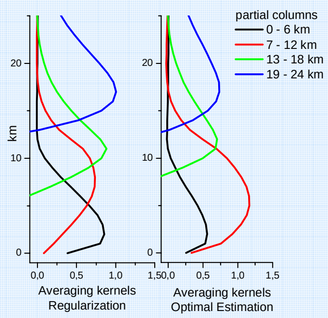
Diagonal of Averaging Kernel matrix (degrees of freedom by altitude) for the OE and Regularization methods



Averaging Kernels for IASI ozone retrieval were calculated using simulated measurement vector obtained from the standard atmospheric state (Europe, June, Noon).

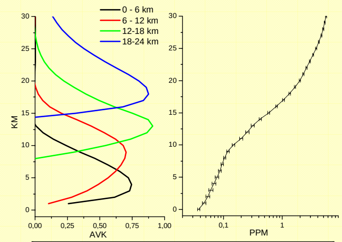
Regularization type of constrain gives more degrees of freedom and allows to separate the information on the two parts of the free troposphere:
- 0 to 6 km
- 6 to 12km

Averaging Kernel in partial column space



Retrieval example

Typical averaging kernels and an typical example of the retrieved ozone profile



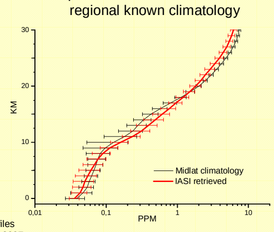
	Total Err (%)	DOF
Lower tropospheric column (0-6 km)	22.9	0.7
Total tropospheric column (0-12 km)	23.5	1.3
Total column (0-60 km)	4.15	3.7

The number of cloudfree scenes obtained is about 60% of the total measurements number which makes 4000 – 5000 retrieved profiles by day.

Mean ozone profile and its variability obtained for these IASI measurements have been compared to the tropospheric ozone climatology from the ozone sondes for the summer midlatitudes [McPeters et al. 2007]

Comparison shows that obtained results are realistic and of the same order that known ozone climatological data.

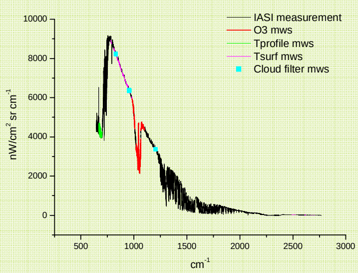
Comparaison of retrieves results with regional known climatology



R.D.McPeters, G.J. Labow and J.A. Logan, Ozone climatological profiles for satellite retrieval algorithms, *J. Geophys. Research*. 112, D05308, 2007

IASI data analysis
Preliminary results for the 2007 European heat wave

Ozone and Auxiliary data retrieval domains

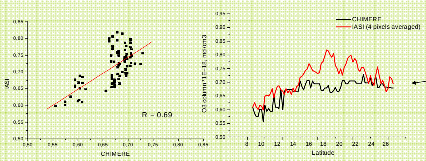


In the absence of the Level2 data (water vapor, vertical atmospheric temperature, cloud information) for the measurements, these auxillary data are retrieved from IASI spectra for each measurement before the ozone retrieval.

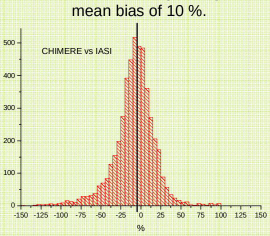
Up to now no information about the cloud mask is available. We developed our own method to identify clear scenes. This method consists of two parts:

- Rejection of unreasonably cold (for the analyzed season and location) spectra allows filtering opaque clouds that are seen in IR as cold surfaces.
- Analysis of the spectrum's baseline: the presence of clouds in the field of view may be detected by their broad band signal which becomes apparent in the baseline of the measured spectrum and could be interpreted in the retrieved ozone concentration.

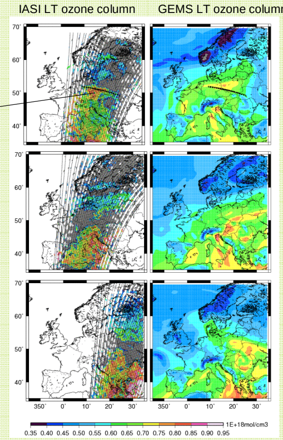
Example of swath crossing a simulated ozone maximum



Global statistics : overall good agreement - mean bias of 10 %.



IASI LT ozone column | GEMS LT ozone column



Three representative days were chosen to follow the ozone field evolution during the July 2007 heat wave.

Model data provided by the CHIMERE regional CTM working in forecast mode (top = 500 hPa).

Simulated tropospheric ozone columns (about 0-5.5 km) are compared with retrieved from IASI data partial columns (0-6km)

Comparisons are encouraging and confirm the utility of satellite measurements for air quality modeling.

CONCLUSION – IMPROVEMENTS – FUTURE WORK

Preliminary results shows the capabilities of the method to retrieve ozone information from the lower tropospheric layers and the utility of these data to air quality CTM .

In order to perform more consistent comparison, following works should be done:

- The free-tropospheric version of CHIMERE (up to the tropopause) will be used.
- IASI averaging kernels will be applied to smooth the model profiles to the vertical resolution of measurement