VALIDATION OF IASI CO RETRIEVALS USING SATELLITE AND AIRCRAFT MEASUREMENTS

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ABSTRACT

To validate the IASI carbon monoxide observations, we propose to compare them to aircraft measurements using the IASI resolution in one hand and in other hand to satellite data via assimilation in a chemistry transport model. The different methods are presented in this paper.

Key words: Validation, carbon monoxide, IASI, MOPITT, MOZAIAC.

1. INTRODUCTION

The Infrared Atmospheric Sounding Interferometer (IASI) will be launched in July 2006 onboard the first MetOp satellite. This instrument primarily dedicated to measure meteorological parameters, will also enable the determination of tropospheric chemical species such as greenhouse effect gases, nitric acid or carbon monoxide (CO). Our proposal focuses on the validation of different IASI level-2 CO products. The level-2 satellite data validation is important to ensure a satisfactory scientific use of the observations. For example, this exercise has been done for other satellite instruments such as the Measurements Of Pollution In The Troposphere (MOPITT) (Drummond and Mand, 1996) dedicated to measure tropospheric CO (Emmons et al, 2004). Tropospheric satellite observations have the possibility to be compared with a wealth of multiplatform data (satellite, aircraft, ground-based, balloons).

For comparisons between in situ data and satellite observations, it is necessary to select coinciding observations and to take into account the vertical sensitivity of the satellite observations in order to make a sound comparison.

Conversely, comparison between observations from two satellite instruments with different vertical sensitivities, horizontal resolutions and samplings and time/location of measurements is not straightforward. Assimilating each dataset in a 3D Chemistry Transport Model (CTM) taking into account those differences is one of the ways to achieve this goal. In this project, we propose to validate IASI CO :
-First, with aircraft measurements from the MOZAIAC (Measurements of Ozone aboard Airbus in-service aircraft) programme, which are considered as the truth regarding the tropospheric CO concentrations
-Second, with satellite observations from the MOPITT instrument using assimilation in the CTM MOCAGE (MOdèle de Chimie Atmosphérique à Grande Echelle) developed at Météo France (Peuch et al, 1999).

2. THE MOZAIAC DATA

The goal of the MOZAIAC programme (Marenco et al., 1998; see Web site http://www.aero.obs-mip.fr/mozaiac/) is to collect in situ data on atmospheric composition changing under the influence of human activity. In MOZAIAC, regular measurements of ozone (O3), water vapor (H2O), CO and nitrogen oxides (NOy) are made by autonomous instruments aboard 5 long range commercial Airbus airliners (A340-300). CO concentration measurements are performed since 2002 and details can be found in Nédélec et al (2003). The large database including profiles (take-offs and landings) of measurements collected in the course of MOZAIAC allows detailed studies of chemical and physical processes in the atmosphere, and hence the validation of global chemistry transport models and of course retrievals from satellite instruments.

Figure 1 gives an idea of the global coverage own by the aircraft. More than 3000 flights were performed during the year 2005 with most of them between EU and US.

Figure 2 shows an example of MOZAIAC data (CO and O3) measured at the cruise altitude between US and EU during summer 2004.

3. THE MOPITT DATA

The MOPITT instrument onboard the Terra platform has been monitoring tropospheric CO profiles since March 2000. Those profiles are characterized by 1 to 2 independent pieces of information. Moreover, MOPITT with a
pixel size of 22 km x 22 km covers the Earth in about 3 days. These data have been intensively validated by comparison with aircraft in situ observations (Emmons et al, 2004). The maximum likelihood method, used to retrieve the MOPITT CO, is a statistical combination of the measurements and a priori information ($X_a$). The retrieved profiles ($X_{ret}$) are characterized by their averaging kernels (defined by a matrix $A$) which give information on the vertical resolution of the measurements. The relationship between the retrieved profile and the true profile is given by the following equation:

$$X_{ret} = X_a + A(X_a - X_{true})$$  \hspace{1cm} (1)

where $X_{true}$ represents the CO profile representative of the atmosphere. For more details about MOPITT see Deeter et al, 2003; Deeter et al, 2004. An example of MOPITT CO is shown on Figure 3 which presents daytime MOPITT CO at 500 hPa during the third week of July 2004.

4. VALIDATION APPROACH

We describe two methods of comparison for validating the CO retrievals from the IASI instrument. The first one is the comparison between IASI CO retrievals and in situ measurements, e.g. aircraft data (MOZAIC) and the second one is more sophisticated and based on the assimilation of satellite data (MOPITT) in a CTM.

Concerning the validation of IASI CO with MOZAIC data, the use of profiles (take-offs and landings) is necessary in order to make meaningful comparisons. Aircraft take-offs and landings are numerous make possible to have a significant number of profiles coinciding with IASI pixels location in terms of time and space. In order to make a meaningful comparison the vertical sensitivity of IASI measurements has to be taken into account. This is achieved by smoothing the in situ profiles with the function representative of the IASI instrument resolution. In the case of maximum likelihood retrievals, equation 1 is applied with the corresponding MOZAIC profile considered as the true profile ($X_{true}$) (Fig. 3). The biases will be evaluated statistically at the different locations (airports) over a significant period of time covering at least a seasonal cycle.

The second method of validation is based on the comparison between separate assimilation of IASI and MOPITT CO observations in the same CTM. We propose to assimilate in the MOCAGE CTM the different satellite data on a common period over the globe. The data assimilation technique is described in Khattatov et al. (2000). It consists of a sub-optimal Kalman filter that uses the model forecast at the beginning of a one-hour assimilation window as the background field, with an explicit calculation of the forecast error variance. By using this technique, we could take into account the different errors, resolution and samplings regarding the two satellite instruments.
and the comparisons will be consistent on a common 3-D global grid. In the same way as the first method, biases and statistics will be analysed.

5. CONCLUSIONS

In this paper, we propose two ways for validating IASI CO. The first one is the comparison between IASI CO profiles with aircraft measurements (MOZAIC data) considered as the true data. For this, we will use the formalism of the retrieval algorithm to obtain meaningful comparisons. On the other hand, we propose to compare results of assimilation of IASI and MOPITT CO in the MOCAGE CTM. These comparisons will provide statistics crucial to determine biases or discrepancies in the first sets of level-2 IASI CO retrievals. The information obtained will help updating/improving the level 1 and level 2 data processing ground segment.

REFERENCES