Interactive comment on “Evaluating the potential of IASI ozone observations to constrain simulated surface ozone concentrations” by G. Foret et al.

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Referee

This study evaluates the potential use of IASI satellite measurements of tropospheric ozone to constrain surface ozone in a regional data assimilation scheme, here applied over Europe. Most IR sounders like IASI and TES have very limited sensitivity to the PBL layer, so the question arises how free tropospheric ozone, well measured by IR sounders like IASI, can help in constraining modeled surface ozone. This study uses passive tracers in a regional model to investigate how much ozone from a given level in the free troposphere subsides into the planetary boundary layer and to the surface.

Authors

We thank the reviewer for fruitful remarks. They have been conducted us to add additional material to the paper, and thus hopefully to improve it significantly. In our comments, some clarifications are also given.

Referee

The idea promoted here is: the higher the fraction that reaches the surface, the more effective the constraint from satellite observations will be. On the other hand, one could argue that models that assimilate satellite observations will anyhow force model results towards observations, and errors due to the limited sensitivity to PBL ozone will be effectively incorporated into the model as well. That leaves the question how surface ozone in the model can be indeed improved using thermal IR nadir sounders like IASI. This discussion is central to this paper given the paper title but, however, is absent here.

Authors

If we understand well the reviewer’s remark, he doubts that IASI could be useful to constrain boundary layer ozone, because of a large error on observed boundary layer ozone due to to lacking sensitivity.
Indeed, thermal IR nadir sounders are not sensitive to near surface concentrations. But this fact is expressed in the averaging kernel (given in the paper’s figure 10 for IAS1 ozone retrieval). In an assimilation algorithm (Parrington et al.2008) or when comparing IASI ozone observations to simulated or observed profiles (Keim et al., 2009), the averaging kernel, expressing the measurement’s sensitivity, is always used to make both types of information comparable (as in the paper’s equation 2). By this way, the so called smoothing error (Rodgers, 2000) related to a lack of an instrument’s sensitivity for a specific height range, can be avoided.

This (current) use of IASI profiles is anticipated here when constructing the tracer to mimic additional information delivered by the IASI observations. It is explained, how the knowledge of the instruments sensitivity (averaging kernel) allows to select “useful” information from the instrument.
In conclusion, the reviewer’s fear of a major flaw in the papers fundamental reasoning is in our opinion not justified, because the smoothing error is explicitly taken into account, and avoided, by the way IASI observations are in general used as a model constraint and in the way the “IASI like” tracer is constructed.

To make this clearer in the revised version of section 4.1, it is stated:

“In particular, this information [given by the IASI-like tracer] will be exempt of the smoothing error, defined by Rodgers (2000).”

And

“It is this transformation [given by Eq. 2 in the text], which allows to avoid the smoothing error related to the observation, by making the simulated profile coherent with the observed one.”

Referee

In another study, also cited in this paper, Parrington et al. (2008) have assimilated TES observations (which are similar to IASI) and claim improvements in modelling surface ozone in the US. This study should be critically evaluated and discussed in this paper and implications for/from this study indicated. IASI is also operating since 2006, so data assimilation with IASI ozone profiles is possible, but not done here.

Authors

The discussion of the study made by Parrington et al (2008) has been extended in the corrected version of the paper. Concerning the assimilation itself, our study aims at identifying the transfer of the free tropospheric information (about ozone) to the PBL. Having this transfer made evident and assessed is clearly a prerequisite for a successful assimilation of observations from IASI or more generally from thermal IR nadir sounders, which might be undertaken by our or by other groups with a European scale CTM. For instance, in light of our results, assimilation of IASI is expected to correct boundary layer ozone over the Mediteranean basin, but much less over North-Western Europe, which will limit the potential of IASI data assimilation over this area. These are important results future papers can rely on, when discussing success of data assimilation. Otherwise, distinguishing different factors contributing to the success or limitations of data assimilation will be difficult.

Referee

This paper solely focuses on subsidence of ozone from the free troposphere to the surface above Europe using passive tracer experiments. In the first part passive ozone tracers are initialised at

different altitude levels and their evolution over successive four day periods during two European summers are followed, and secondly, a passive tracer profile mimicking the averaging kernels from IASI is used. The major results are that
1) only free tropospheric ozone below the 500 hPa level subside to the surface and 2) subsidence is strongest in the southeastern part of Europe. This second result was also confirmed by the IASI passive tracer experiment. The methodology is sound, but processes other than subsidence (convection, chemistry, horizontal transport etc.) are not covered here. It seems that the paper promises less than what the reader may expect when reading the title of this paper.

Authors

In fact, all dynamical processes (at least processes that can be handled by a chemistry transport model coupled to a meteorological model) are implicitly included in the study. This includes vertical advection, turbulent mixing within the boundary layer, convection, but also horizontal transport. More detailed explanations and analysis about these aspects have been included in the revised version of the paper. The major process identified as responsible for enhanced free tropospheric tracer levels at surface is advective subsident motion. Independently of the Eulerian simulations, this has been made evident very clearly by trajectory analysis, which has been added to the revised version of the paper. Also evidence for entrainment of initially free tropospheric tracers into the growing convective boundary layer has been made evident for some cases (but depending on the tracer release height). Also the effect of horizontal transport, advecting free tropospheric tracers to mountainous areas is clearly mentioned. Also chemical aspects (chemical loss of ozone like tracer) have been included in a more detailed way.

Referee

With regard to the passive tracer experiment, some additional major issues remain.
1.) The handling of boundary conditions is not well explained. What happens if the major wind direction comes from outside the model domain of Europe. This may lead to underestimation of subsidence in certain regions of Europe. This may put a question mark to the 2nd result of this study. In the hot summer of 2003, I would have expected that strong subsidence may occur over a more extended region in Europe than in 2004, but yet the results look very similar for both years.
2.) It would be nice to describe the mean European summer meteorology by adding wind maps and pressure maps for 2003 and 2004 to the paper.

Authors

Aspects linked to boundary conditions and especially the fact that no tracers were used outside the simulation domain has been addressed in the revised papers version. The fact that the big majority of the trajectories (originating from free troposphere and reaching the surface) stays within the model domain during the last four days indicates, that results of tracer transport at the time scale are not much influenced by boundary conditions;

Moreover, the specific questions about the year 2003 and its differences with the year 2004 have been inspected. Both years are, on average, very similar because the heat wave of year 2003 and the associated unusual anticyclonic conditions mainly occurs (but with a very strong signature) on a short period (around 10 days) at the beginning of August. Examples of the tracer distribution during this period have been included in the paper.

Several meteorological maps (geopotential and vertical winds) have been added, in addition to trajectory analysis, to more clearly describe the meteorological situation and to strengthen the analysis of the results. Also, some more references to papers (and figures included in these papers) have been added to describe the meteorological situation more extensively without lengthen the paper too much.

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