Ozone pollution : What do we see from space ? A case study

G. Foret (LISA), M. Eremenko (LISA), J. Cuesta (LISA), P. Sellitto (LISA), J. Barré (CNRM), B. Gaubert (LISA), A. Coman (LISA), P. Dauphin (LISA), M. Beekmann (LISA), G. Dufour (LISA)

LISA, Laboratoire Inter-universitaire des Systèmes Atmosphériques , UMR7583, Universités Paris-Est et Paris Diderot, CNRS, Créteil, France
CNRM-GAME, Météo-France and CNRS URA1357, Toulouse, France.

Introduction

The use of satellite observations for pollution monitoring and model evaluation is becoming stronger. In the case of ozone, the last generation of space-borne sounder is offering increased opportunities to observe **tropospheric ozone** (**GOME-2** or **OMI** in the UV and **TES** or **IASI** using TIR). Several studies have already shown the potential of these instruments to monitor tropospheric ozone. Nevertheless, **the ability of satellite ozone observations to detect photochemical pollution event has not been clearly demonstrated and quantified**. In spite of their lower sensitivity to boundary layer ozone concentrations, it is interesting to evaluate their skill in the context of a **photochemical pollution event** (supposed to be more favourable in term of sensitivity of these instruments to boundary layer concentrations): pixel number is higher due to low cloud, ozone concentrations are high, thermal contrast at the surface is enhanced, BDL are more developed. To investigate this, we have chosen to study a moderate ozone pollution event (August 2009) using a multi-instrumental approach. The ability of satellite based instrument to "see" this pollution event is evaluated using surface observations and model simulations. Satellite observations are directly compared to model simulation that are catching the event fairly well. To do so, 2 state of the art rCTM are used (MOCAGE and CHIMERE). Moreover, the most skilled satellite data are assimilated in these models to assess potential improvement.

Objectives: 1) Evaluate the ability of satellite observations to detect BDL ozone.
2) Quantify the potential gain for monitoring/forecasting systems.

Case study description : a moderate ozone pollution event

■ An **anticlonic situation dominates Europe the 2009/08/19** and is swept eastward by an Atlantic cyclonic circulation the 2009/08/20 with **a clear frontal area separating both systems**. High 2m temperature are observed during the anticyclonic episodes.

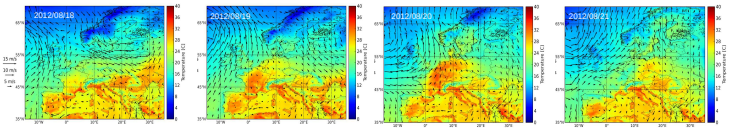


Figure 1. 2m temperature and surface wind field from the IFS system between the 2009/08/18 and the 2009/08/21 at 10 a.m

■ Surface ozone concentrations (background stations from AIRBASE database) « folllows » the temperature pattern showing **high concentrations associated to the anticyclonic situation**. 300 hourly values up to 180 µg;m^{-3} are observed during the 3 days episodes. Also **strong spatial gradients** are observed along the frontal areas

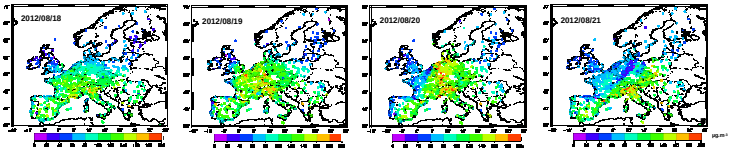


Figure 2. Surface ozone concentrations (ppb) measured at European ground stations at 3 pm between the 2009/08/18 and the 2009/08/21

Model (CHIMERE) Analysis

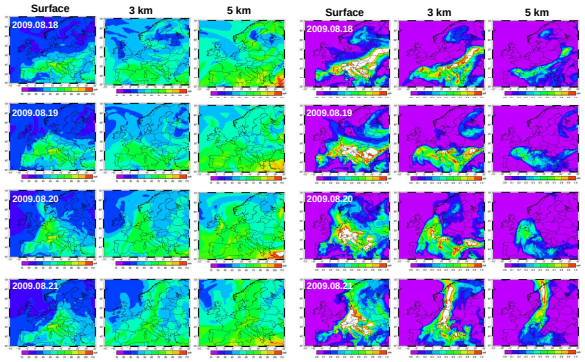


Figure 3. Simulated Ozone (Left panel) and PAN (Right Panel) using CHIMERE model.

■ Simulated Ozone concentrations catch the episode and the frontal pattern at surface
■ Surface pattern is still present @ 3 km but less clear at 6 km height
■ PAN (produced only at surface) shows that BDL air masses are significantly transported upward along the frontal area.

→ **Surface pollution episode with a significant vertical extension**

Satellite view of the case study

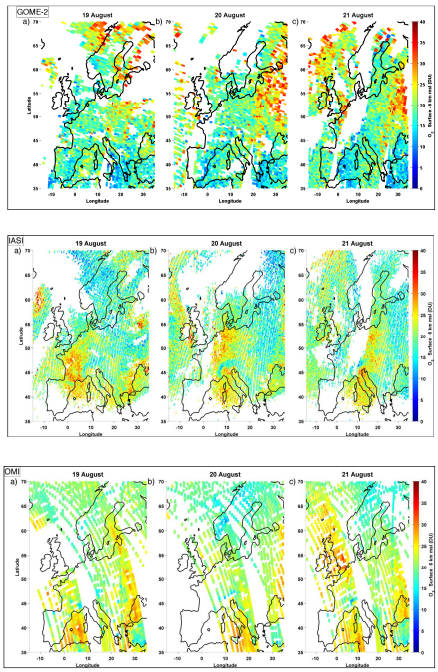


Figure 4. 0-6 km ozone columns from GOME2 (Cai et al, 2012, JGR); OMI (KNMI); IASI (Eremenko et al, 2008)

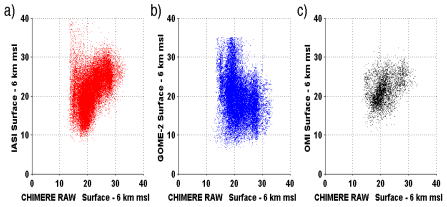
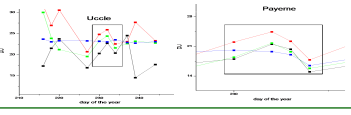


Figure 5. Scatter plot of the 0-6 km ozone colonnes for (a) IASI/ CHIMERE; (b) GOME-2/CHIMERE and (c) OMI/CHIMERE (2009.08.19/20/21)

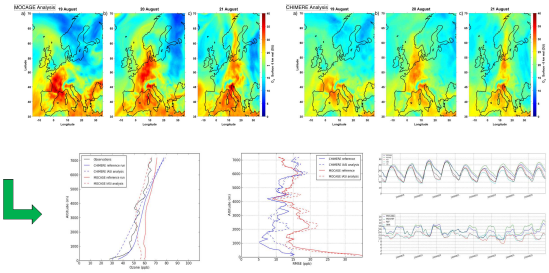
■ **GOME2/IASI/OMI** 0-6km ozone columns are shown for the 2009.08.19, 20 and 21 (Figure 4). Sampling of TES is too weak and is not shown.
■ IASI is detecting the event fairly well as shown by correponding simulations by CHIMERE and MOCAGE models. OMI is better than GOME-2 but with a much weaker sampling than IASI for the event (cf Figure 5).

■ Comparisons of IASI with sondes (Uccle, Payerne) and MOZAIC (Frankfurt) measurements also shows the ability of the satellite to follow the pollution event



Assimilation

■ IASI observations have been assimilated within MOCAGE-PALM (Barré et al, 2012) and CHIMERE-EnKF (Coman et al, 2012) for a 10 days period (15-25 august 2009).



■ Analysis are evaluated against MOZAIC profiles (~20) and surface stations → weak improvement in general in term of RMSE
■ Not yet clear if IASI observations can improve the models in such pollution case.

Conclusion

■ The **capability of satellite to observe ozone pollution is assessed**.: GOME2 (UV), OMI (UV), IASI (TIR) and TES (TIR) observations (0-6 km partial columns) have been retrieved for **a moderate ozone pollution event** occuring over Europe during summer 2009.

■ **IASI observations allows catching the pollution event** qualitatively but also quantitatively as shown by comparisons with rCTM (MOCAGE & CHIMERE) and also vertical profiles.

■ IASI observations are assimilated within MOCAGE-PALM and CHIMERE EnKF → preliminary results do not indicate clear improvement.

■ More case study are needed to strenghen first conclusions

■ New products/algorith may improve retrieval performance

■ Synergy between UV and TIR products is also very promising (Cuesta et al, 2013)