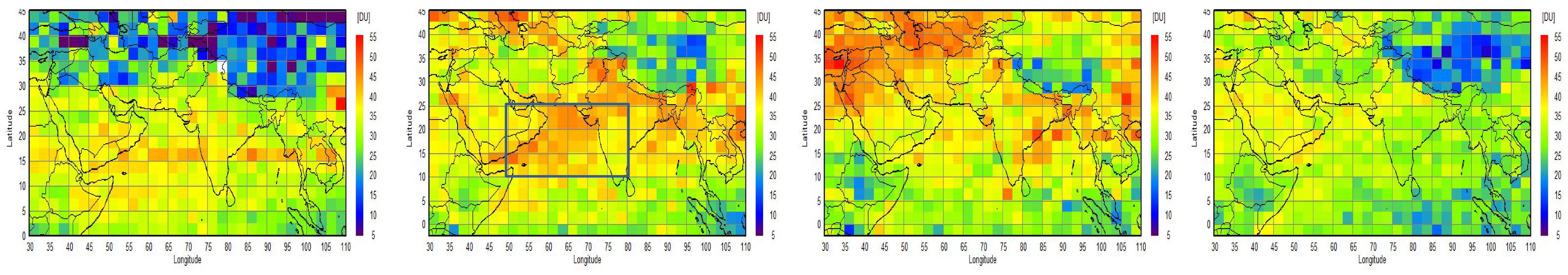
The tropospheric ozone variation over Arabian sea during pre-monsoon

Jia Jia, A. Ladstätter-Weißenmayer, F. Ebojie, A.Rozanov, J. P. Burrows

Institute of Environmental Physics/Remote Sensing, University of Bremen,
Email: jia@iup.physik.uni-bremen.de

I. Motivation



Winter-monsoon | **Pre-monsoon** | **Summer-monsoon** | **Post-monsoon**

Fig. 1 SCIAMACHY LNM tropospheric ozone in 2008. From left to right: DJF, MAM, JJA, SON.

Tropospheric ozone: Tropospheric ozone, unlike the 90% ozone that is located in the stratosphere which protect living beings from harmful UV-b&c radiation, is one of the most important green-house gases and the main component of photochemical smog that threaten the respiratory system. It can be photochemical produced during pollution events from the precursors, e.g. NOx, VOCs, CO. With a longer life time (up to 2-3 months), tropospheric ozone can be transported with a longer distance thus influences larger area.

Arabian Sea (AS) enhancement: The Arabian Sea is a remote area with few local pollutions. However, we observed strong enhancement at this region, especially the pre-monsoon season. Figure 1 shows the seasonal tropospheric ozone data at AS from SCIAMACHY Limb-Nadir-Matching (LNM) retrieval (Please be invited to the talk at 16:45 today in room B9: J.Jia et al, *An improved tropospheric ozone database retrieved from SCIAMACHY Limb-Nadir-Matching method*). In this poster, we will try to answer the follow questions. 1, why the tropospheric ozone 'prefers' pre-monsoon season? 2, Where are the sources and sinks? 3, what are the possible factors that cause pre-monsoon tropospheric ozone variation?

II. Mechanisms part 1: Meteorology

The climate at AS is normally separated into 4 part (shown in Figure 1): the winter-spring monsoon season (Dec-Feb); the pre-monsoon transition season (Mar-May); the summer monsoon season (Jun-Aug); and the post-monsoon transition season (Sep-Nov). Figure 2 shows the averaged wind patterns in these seasons. The wind near sea surface shows the summer Somali jet which brings strong precipitation and increased air humidity at AS region, which cleans tropospheric ozone. However, in pre-monsoon season, the surface winds are westerly at northern AS with an anticyclonic pattern centred over the middle AS. This pattern would possibly cause air been transported from upside down which results in an air mass accumulation.

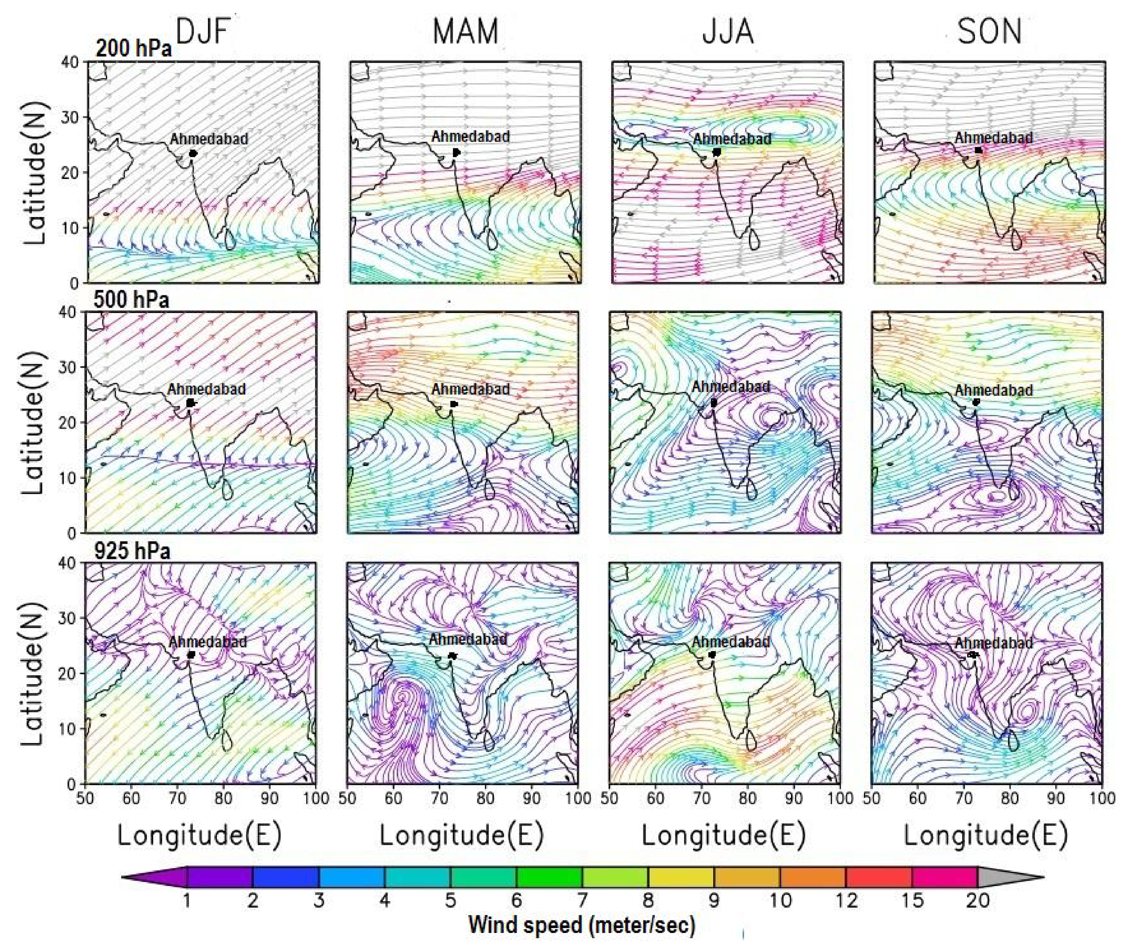


Fig. 2 Average wind for DJF, MAM, JJA and SON on the 925, 500, and 200 hPa surface. (Fig. 1 in Lal, S. et al., 2014).

III. Mechanisms part 2: Possible sources and sinks

As seen in Fig. 3, the sources are Middle East, India, Africa and North America at lower troposphere (0-7km). The higher tropospheric ozone (12-18km) is found mostly uplifted and transported from the North Indian Ocean and Southeast Asia. The air masses at lower troposphere sinks locally with anti-circulation in 10 days. During this time more tropospheric ozone could be photochemically produced from the precursors. The enhanced ozone are most contributed from lower troposphere as seen from MACC model (Fig. 5). These ozone-rich air could be transported back to India. We also observes transportation to Red Sea through Gulf of Aden. The higher troposphere air masses could be transported to the Pacific Ocean through China.

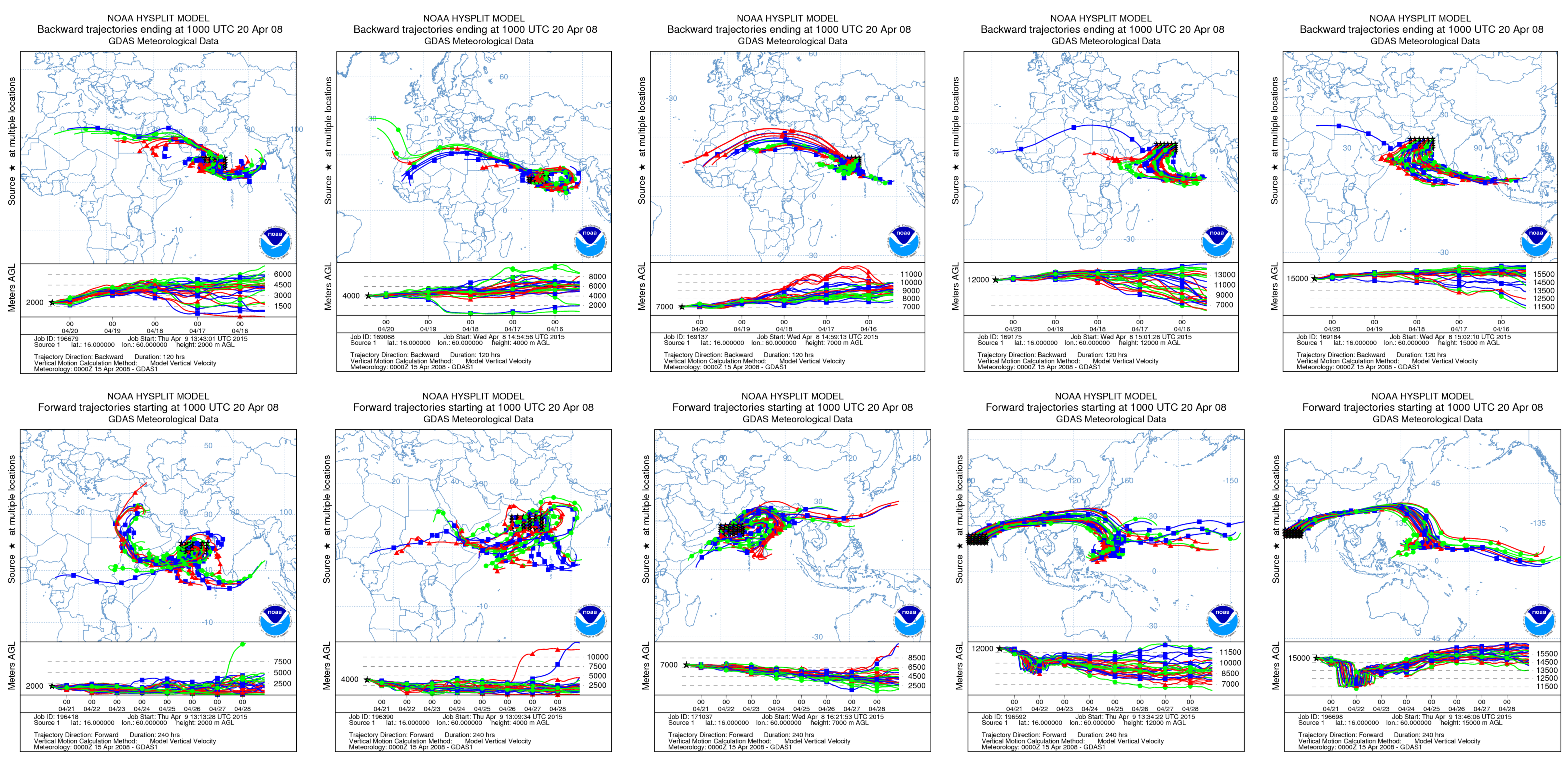


Fig. 3 HYSPLIT trajectory model results for air masses at AS with source location at 2, 4, 7, 12 and 15 km. The upper panels are results from the backward trajectories; the lower panels are results from the forward trajectories.

IV. Tropospheric O_3 variation

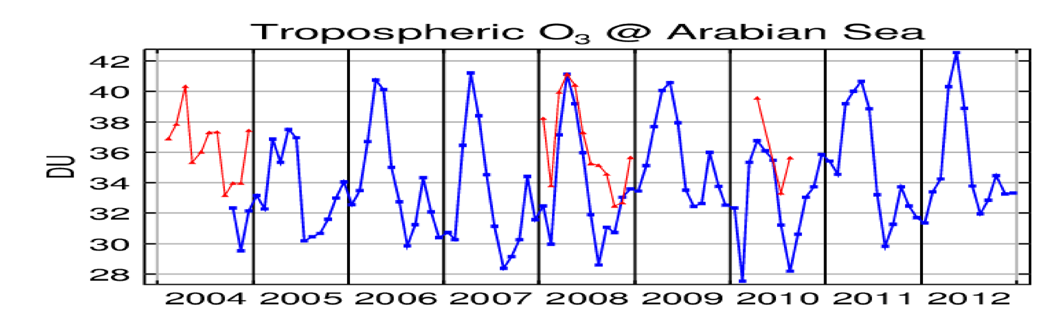


Fig. 4 Time series of the tropospheric ozone volume at AS. Red curve presents data from SCIAMACHY; blue curve presents data from OMI/MLS.

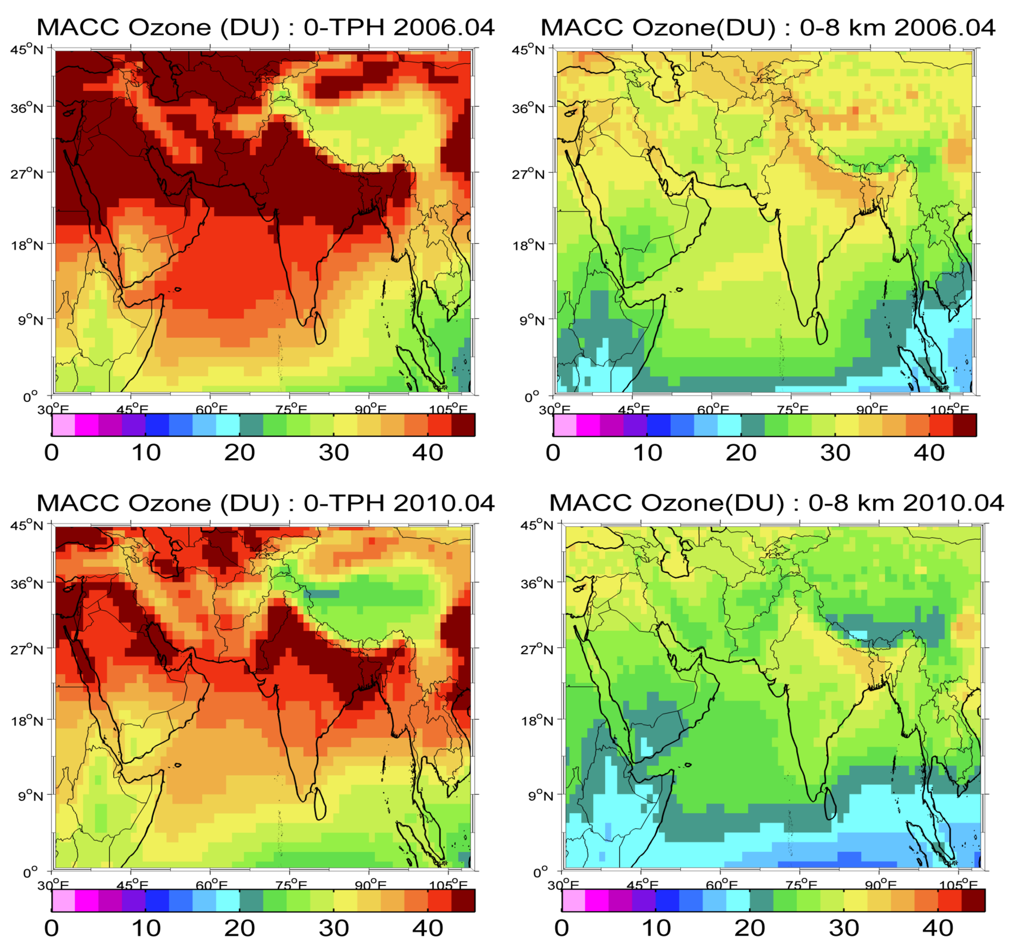


Fig. 5 Ozone partial columns from MACC model. TPH stands for tropopause height

The AS pre-monsoon tropospheric ozone has two minima: 2005 and 2010 (Fig. 4). The differences are entirely contributed from the lower troposphere (Fig. 5). Similar ozone decent is observed at continental surrounding too, which suggest a dynamical anomaly.

V. Conclusions and Outlooks

1. A tropospheric ozone enhancement at AS region in pre-monsoon (season was seen from SCIAMACHY, OMI/MLS observations and MACC model.
2. This enhancement is believed to be a result of ozone accumulation at 0-7/8 km by using HYSPLIT and MACC model.
3. Our study suggested the sources of tropospheric ozone to be mainly long range transport from Middle East, India and Africa which is consistent with the previous studies (Lal, S. et al., 2014).
4. Ozone anomaly is observed in 2005 and 2010. Changes are probably dynamically induced. The dynamical and chemical influences of El Niño will be considered in the next step.

VI. Selected references and Acknowledgements

1. Bovensmann, H., Burrows, J. P., et al.: SCIAMACHY: mission objectives and measurement modes. J. Atmos. Sci., 56, 127–150, 1999.
2. Ebojie, F., von Savigny, C., et al.: Tropospheric column amount of ozone retrieved from SCIAMACHY limb–nadir-matching observations, Atmos. Meas. Tech., 7, 2073-2096, 2014.
3. Lal, S., Venkataramani, S., et al.: Transport effects on the vertical distribution of tropospheric ozone over western India, J. Geophys. Res. Atmos., 119, 10,012–10,026, 2014

1. We acknowledge MACC reanalysis database (http://www.gmes-atmosphere.eu), HYSPLIT trajectory model and OMI/MLS tropospheric ozone data base (http://acd-ext.gsfc.nasa.gov).
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