Tropospheric O_3 and CO seasonal variability over South Asia: *IASI observations and GEOS-Chem simulations*

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Rationale and Objectives

South-Asia is one of the most heavily populated and polluted region. Tropospheric pollution over there is controlled by both large scale transport and local sources. During most of the year, stable and dry conditions promote high pollution levels. During summer, the monsoon flux brings clean oceanic air over the region and precipitations that clean the troposphere. Changing weather conditions also drive large intra-seasonal variability of the O_3 concentrations [1]. Many studies based on local ozonesonde observations [3] and large scale observation campaigns [4] have allowed to better understand the seasonal variations of the O_3 distribution over this region. Nevertheless, global observations are necessary to document the O_3 and CO distributions and to validate models over the whole region.

Since 2006 the Infrared Atmospheric Sounding Interferometer (IASI) measures tropospheric O_3 [1] and CO [2] from space with an unprecedented spatio-temporal coverage (overpass twice daily). Here we use the IASI data to document the seasonal variations of these species over the whole South-Asian region. MOZAIC airborne observations are used to validate IASI over central India at Hyderabad. Chemistry transport simulations are performed to understand the sources driving O_3 over South Asia at the seasonal scale. Here we show preliminary results of comparisons between the O_3 and CO distributions observed by IASI and modeled by the GEOS-Chem model.

1-Observations and modeling

The **GEOS-Chem** global chemistry transport model is used with full chemistry and through sensitivity studies by reducing NO_x sources (at global and local scale).

O_3 and CO profiles were retrieved from **IASI** with the **S**oftware for a **F**ast **R**etrieval of **I**ASI **D**ata (**SOFRID**) [1,2], based on the RTTOV radiative transfer code and on a 1D-Var retrieval scheme. The retrieved profiles contain about 2 independent pieces of information in the tropical troposphere corresponding roughly to the 565 hPa (750 hPa for CO) and 170 hPa levels. The estimated random errors are below 20% [1,2].

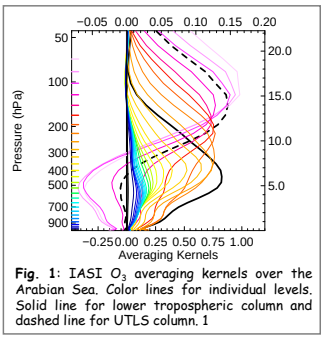
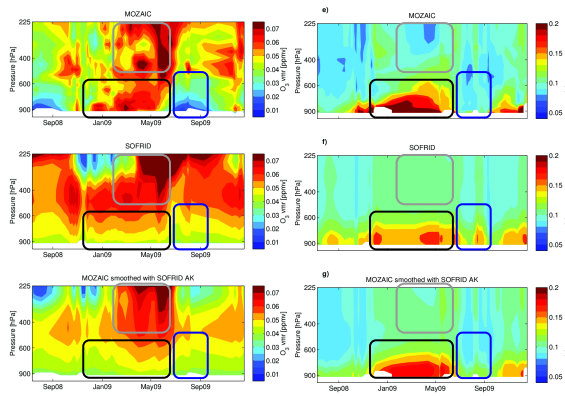


Fig. 1: IASI O_3 averaging kernels over the Arabian Sea. Color lines for individual levels. Solid line for lower tropospheric column and dashed line for UTLS column. 1

2-MOZAIC and IASI O_3 and CO profiles over Hyderabad, India



•**Lower tropospheric pollution** associated with stable anticyclonic circulation is observed in winter and spring.

•Between March and May the **upper troposphere is characterized by high/low O_3/CO** associated with strong undulation of the subtropical westerly jet.

•During the monsoon season **O_3 and CO reach their minima in the lower troposphere.**

•**IASI captures the variations of CO and O_3 observed by MOZAIC**. Below 700 hPa IASI underestimates the O_3 variations because of a lower sensitivity.

3-Distributions of tropospheric O_3 and CO over South Asia during the monsoon period

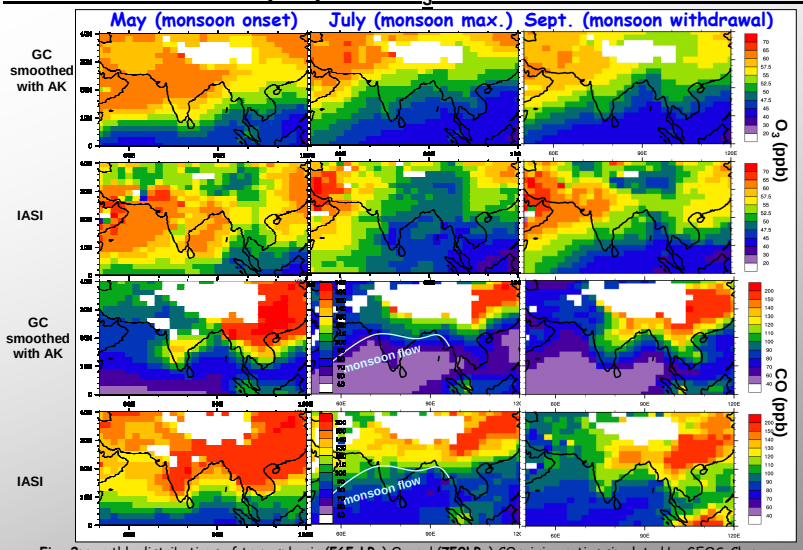


Fig. 2: monthly distributions of tropospheric (**565 hPa**) O_3 and (**750hPa**) CO mixing ratios simulated by GEOS-Chem (smoothed with averaging kernels) and observed by IASI from May to September 2009.

Low and middle tropospheric CO and O_3 distributions are mostly impacted by the monsoon flow between April/May and September/October:

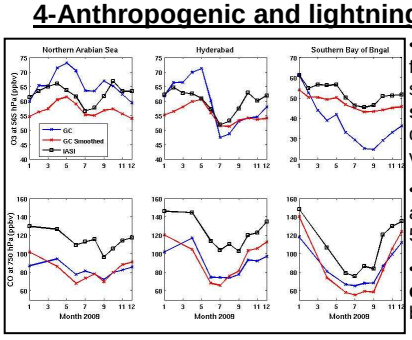
•**In May**, most of the **Indian region** (Western India & the Arabian Sea) is characterized by **high tropospheric O_3** (at 565hPa) resulting from long range transport from Europe and the Middle East as documented in [3]. Over the **Bay of Bengal** high ozone is mostly influenced by the pollution outflow from the Indo Gangetic Plain [5]. CO anomaly seems to be locally-related and located mainly over **central India** at 750hPa.

•**In July**, **O_3 and CO are lower** over most of the south Asian region. The south-western monsoon flux is bringing clean marine air over this region decreasing pollutant concentrations.

•**In September**, **high O_3** related to regional pollution is observed and modeled over the **Northern Arabian Sea and Northern India** while the monsoon flux is withdrawing southwards, [3]. **High CO** is located over **North-East India and Nepal** downwind of regional pollution from South East Asia.

•**GEOS-Chem and IASI are in good agreement** in the localization of the O_3 and CO extrema over South Asia. Some biases appear in the distributions of these species (see part.4)

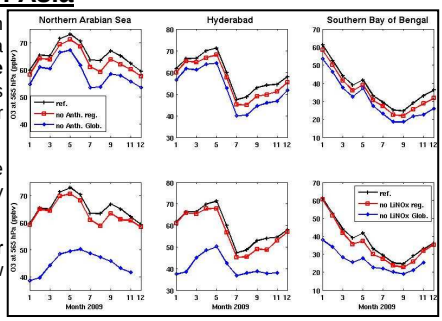
4-Anthropogenic and lightning NOx influence over South Asia



•**Model vs IASI O_3 and CO** comparison for 3 different regions of South Asia shows a **good agreement in the seasonal variations**, with lower values during the monsoon season and higher values in winter and spring.

•GEOS-Chem O_3 smoothed with the averaging kernels is lower than IASI by 5 to 10ppbv.

•**Simulated CO presents larger discrepancies**, with 20 to 40 ppb low bias relative to IASI.



•Sensitivity tests on lightning and anthropogenic NO_x sources have been realized at global scale and for regional sources.

•**Anthropogenic NO_x sources have low influence on O_3** for the 3 regions with 5 ppb maximum for global sources. Bay of Bengal is the most affected region.

•**Lightning NO_x sources seem to drive O_3 in South Asia**, mostly with sources located outside of the region with 5 to 20 ppb of O_3 related to global lightnings. Without Lightning NOx, the spring O_3 max remains, indicating a likely stratospheric influence.

5- Conclusions

- IASI enables the characterization of the seasonal variations of O_3 and CO in the troposphere over South Asia, with however a low sensitivity to O_3 in the lowermost troposphere leading to an underestimation of the winter-spring O_3 pollution-related near the surface compared to MOZAIC.
- The main features of the seasonal variations of O_3 and CO, i.e. a broad winter-spring maximum and a summer minimum, are captured by the GEOS-Chem model. O_3 is slightly underestimated by the model while the low bias is larger for CO.
- A large fraction of tropospheric O_3 is driven by lightning NOx emissions. Regional sources have a low impact on the regional O_3 budget. Anthropogenic emissions have the largest influence over the Bay of Bengal. The springtime O_3 maximum is likely to be related with stratospheric intrusions.

References

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