Seasonal and interannual variabilities of tropospheric Ozone and CO over the Indian Ocean with IASI-SOFRID 2008-2013 data

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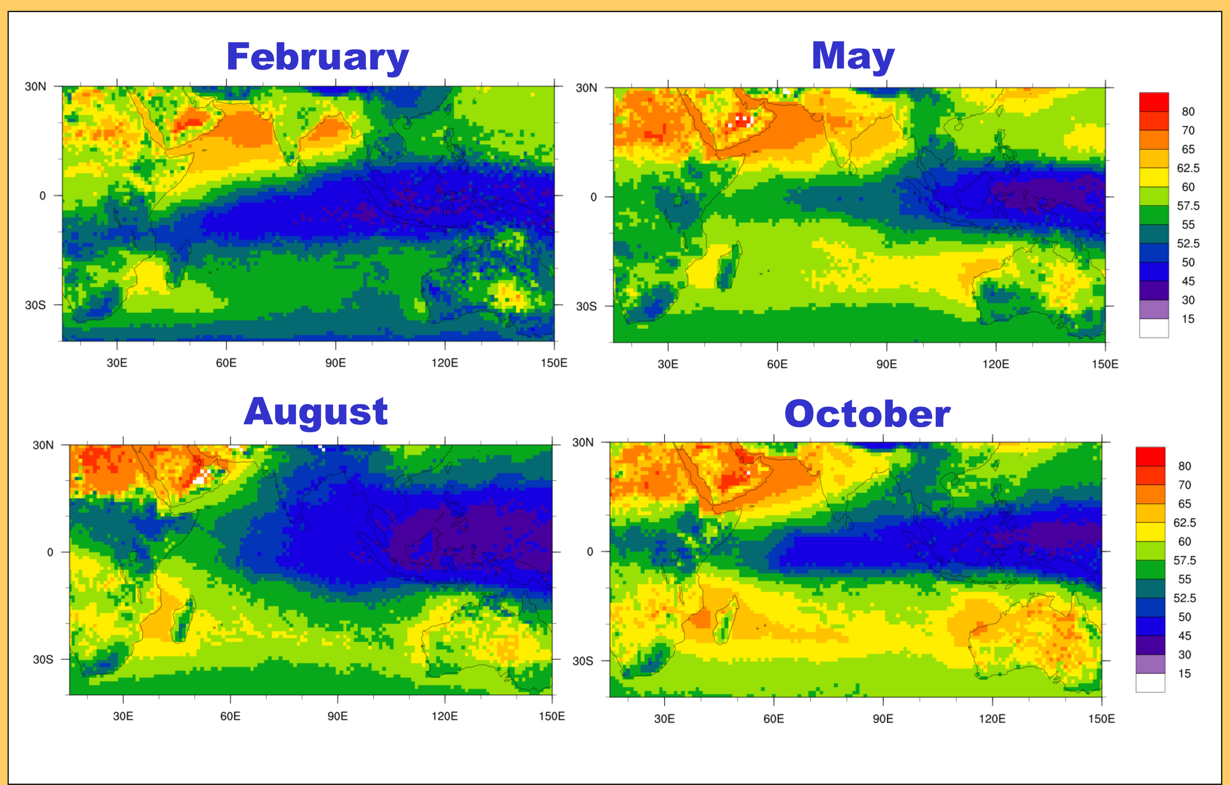
Rationale and Objectives

Tropospheric O3 over the Southern Indian Ocean is controlled by a number of sources such as Stratosphere to Troposphere Exchanges (STE), LiNOx and Biomass Burning (BB) from Africai. From multi annual (2005-2009) observations from the TES space borne sensor, Zhang et al. (2012) recently highlighted an O3 maximum in May. This maximum was shown to be caused by the production of LiNOx from Africa. Important interranual variability was observed with larger maxima in 2006 and 2008 related to anomalous anti-cyclonic circulation over central Africa. Nevertheless, many aspects concerning the factors controlling the variability and evolution of O3 over the Southern Indian Ocean region remain unclear. In this study we use 6 years (2008-2013) of O3 (Barret et al., 2011) and CO (De Wachter et al., 2012) data retrieved from the Metop-A/IASI sensor with the SOftware for a Fast Retrievals of IASI Data (SOFRID) to document the seasonal and interannual variability of tropospheric O3 and CO over the Indian Ocean region. In order to understand the observed seasonal and interannual variabilities, we have performed simulations with the GEOS-Chem chemistry transport model. We present comparisons between the simulated and observed O3 and CO distributions and a preliminary discussion concerning the source regions and transport processes responsible for the observed variabilities.

2008-2013 IASI Climatology

O_3 at 521 hPa



Northern Indian Ocean :

O3 is high all year long except during the Asian Summer Monsoon (ASM).

Southern Indian Ocean :

O3 has higher concentrations in the tropical band (10-30°S) and a bimodal seasonal variations with peak concentrations in May and October and lowest concentrations in February and August.

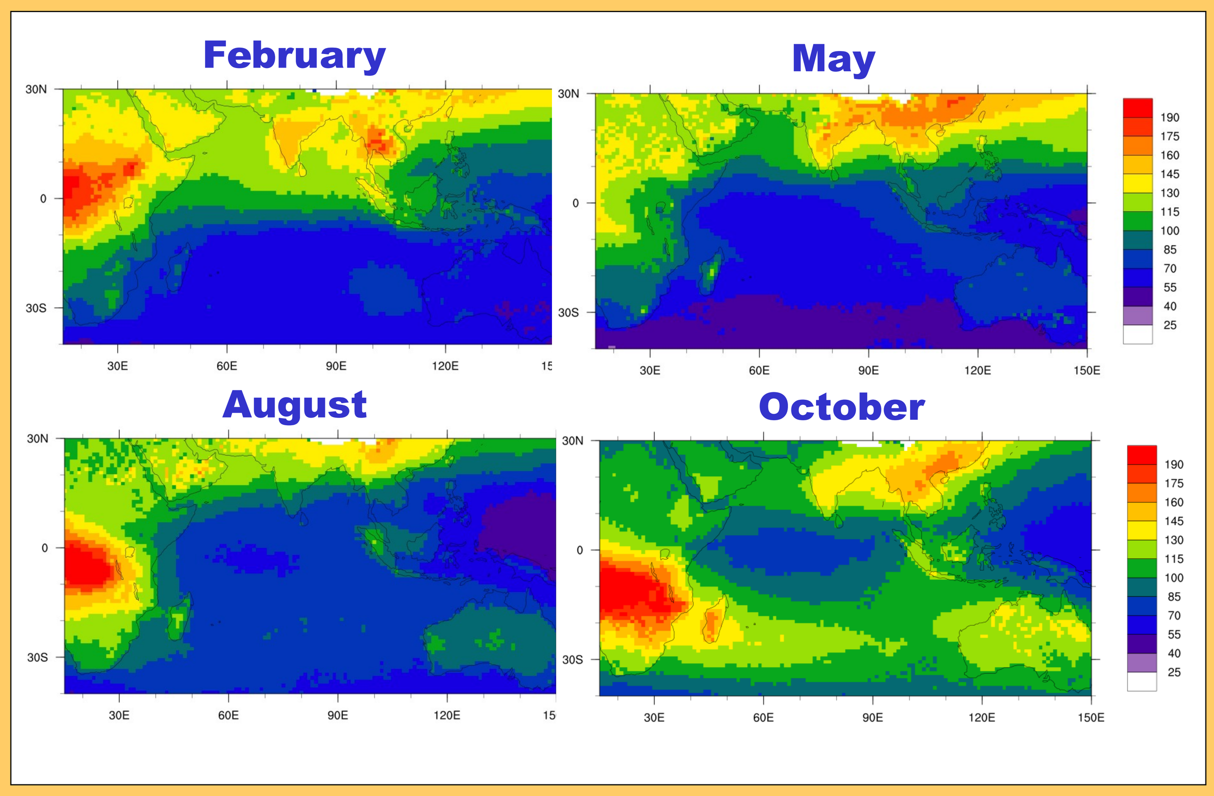
CO at 749 hPa

Northern Indian Ocean :

CO is high north of the ITCZ which extends most to the South in boreal winter. CO is the highest both over populated (India) and fire (Africa, South-East Asia) regions. CO is low during the ASM.

Southern Indian Ocean :

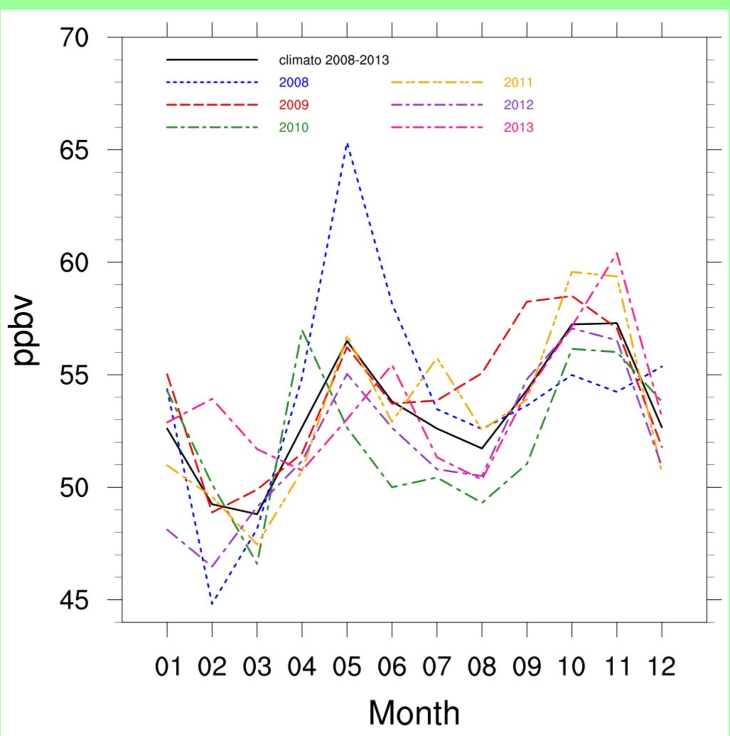
CO is low most of the year except during Southern Africa BB period (austral spring). The BB plume is transported accross the Indian Ocean.



Interannual variations

IASI O_3 at 521 hPa

10°x10° averages at [15S , 85E]



The climatological mean clearly shows the two seasonal O3 maxima in May and October-November.

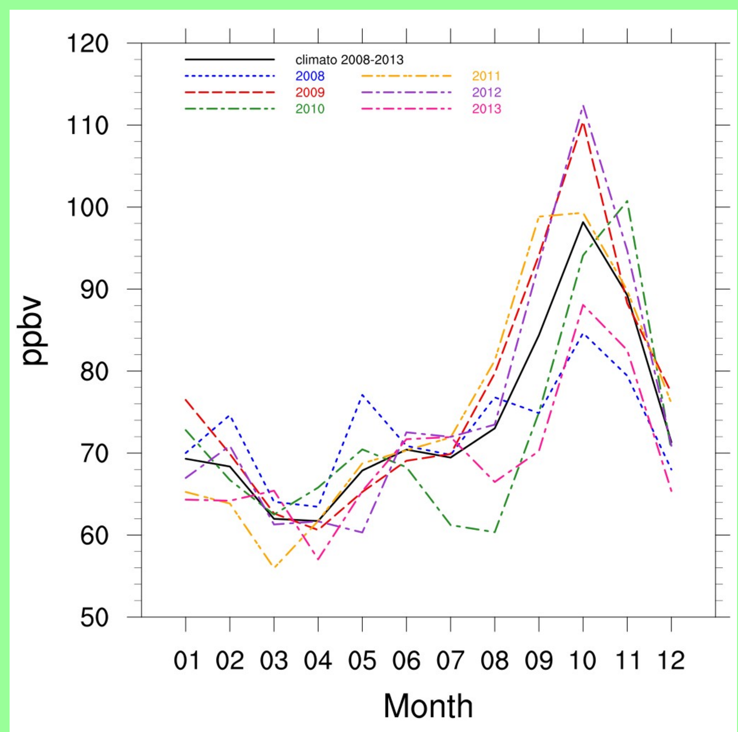
The May O3 peak is characterised by a strong interanual variabilty with maximum of 65 ppbv in 2008 and minimum of 55 in 2012. This austral automn maximum is in fact occuring in April in 2010 and June in 2013.

The October (November in 2013) peak has a much lower variability with values comprised between 55 to 60 ppbv.

The real variability is probably higher because of the IASI low resolution (about 6-8 km) which causes the smoothing of the O3 true profile and to a lower variability.

IASI CO at 749 hPa

10°x10° averages at [15S , 85E]



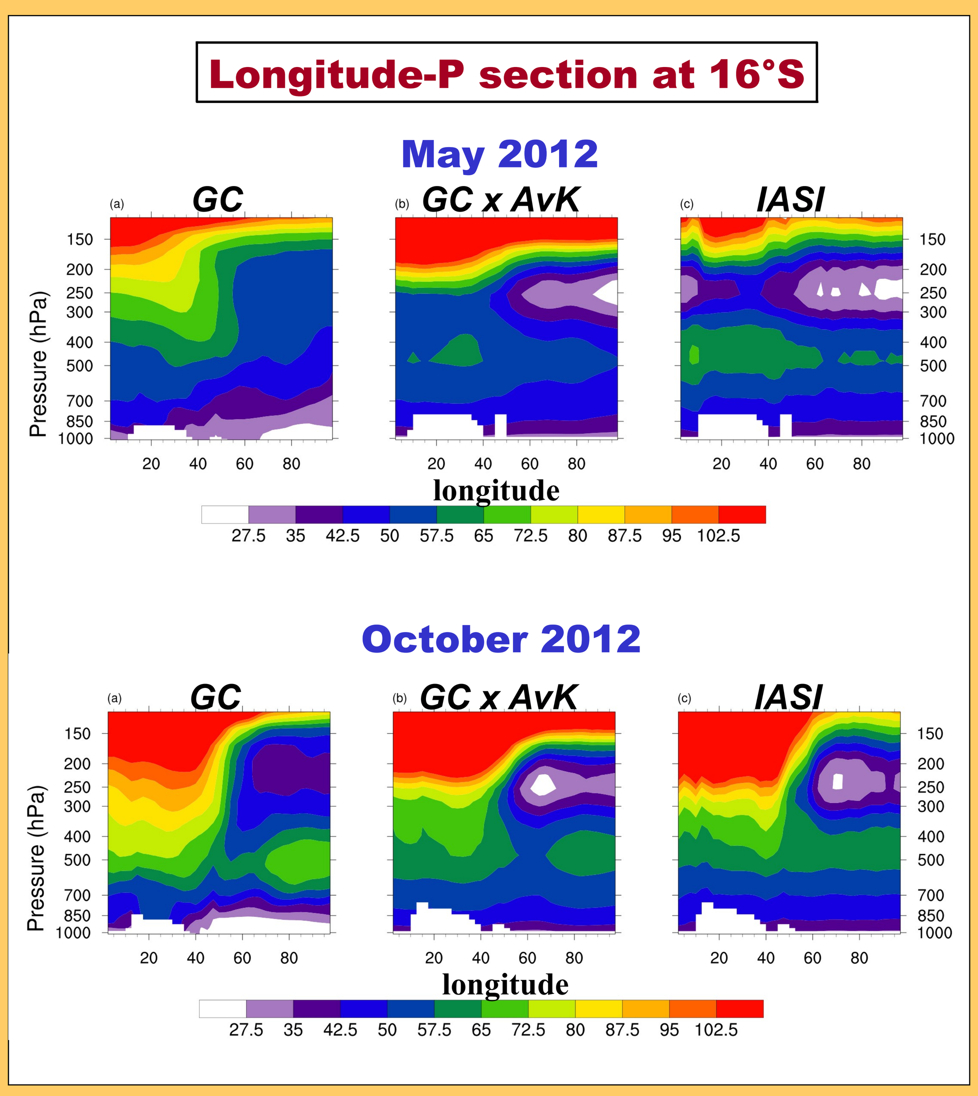
From December to August, IASI climatological lower tropospheric CO mixing ratios are between 60 and 70 ppbv. CO is high between September and November with an October maximum of 98 ppbv.

Interanual variations of the October maximum are rather high with lowest values around 86 ppbv in 2008/2013 and highest values of ~111 ppbv in 2009 and 2012. This maximum is shifted to November in 2010.

The relationship between CO and O3 interannual varibility is not straighforward even for the BB plume in October. Nevertheless, the lowest CO and O3 October concentrations are observed in 2008.

GEOS-Chem versus IASI

O_3 at 521 hPa



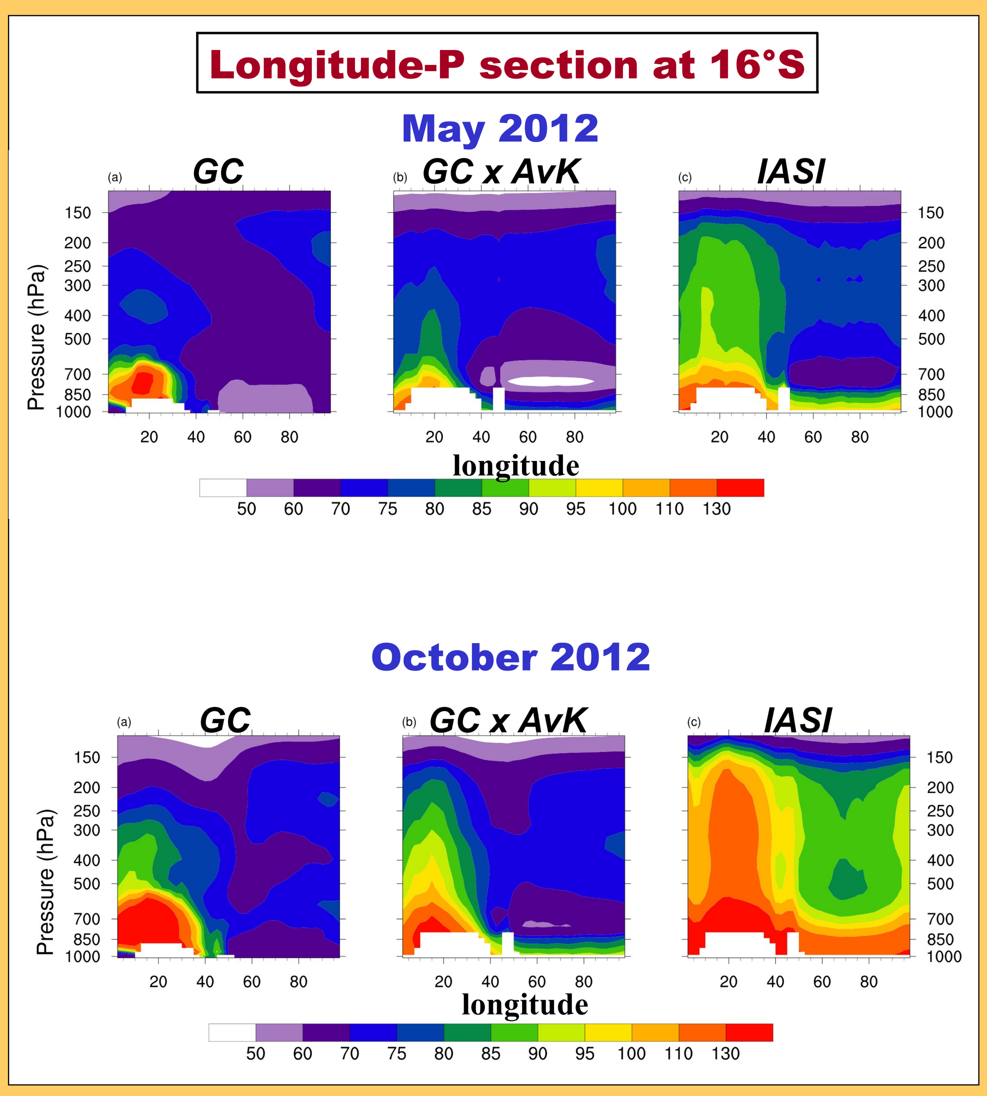
In order to make sound comparisons, GEOS-Chem (GC) profiles are smoothed with the IASI averaging kernels taking the a priori into account.

The smoothing decreases the level of the « chemical tropopause », reduces the mid-tropospheric O3 peaks and accentuates the UT O3 minimum.

For both months, GC and IASI show a very good agreement about the vertical and longitudinal structure of O3 with :

- The typical S-shape of O3 tropical oceanic profiles with UT minima over the eastern Indian Ocean.
- The larger O3 concentrations are observed and modeled over the source region i.e. Africa.
- O3 concentrations in the middle troposphere are larger in October than in May.

CO at 749 hPa



- The smoothing of the modeled profiles has the effect of contaminating the upper troposphere with CO emitted in the lower and middle tropopshere by fire emissions over Africa.
- The efffect of smoothing improves the agreement with IASI observations.
- CO concentrations in the lower and middle tropospehere over the source regions are in good agreement.
- Obsereved and modeled CO are larger in October than in May in agreement with the seasonality of fires in southern Africa.
- CO from IASI is higher in the UT maybe indicating an injection level for fire emissions too low in the model.
- Lower tropospheric CO over the Ocean is also lower in the model indicating either insufficient emissions or advetion.

Conclusions

- **The SOFRID-IASI CO an O3 database enables to document the seasonal and interannual variability of CO and O3 over the Indian Ocean.**
- **Over the southern Indian Ocean O3 is characterized by a bimodal seasonal variability with maxima in May and October. The CO seasonal variability presents a single maximum in October, clearly related with fire emissions from southern Africa.**
- **Both CO and O3 maxima are characterized by large interannual variabilities. In 2008 IASI observations show the largest O3 peak in May and the absence of O3 peak in October such as reported in Zhang et al. (2012) from TES observations. The low CO October peak also observed in 2008 probably indicates a low fire activity that could be responsible for the lower observed O3.**
- **The next step will be to make GEOS-Chem sensitivity simulations to establish the importance of the different sources (fire, lightning's, stratosphere…) in the O3 and CO budget and to determine the role of source and dynamics variabilities in modulating the southern Indian Ocean composition.**

References

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E. De Wachter et al., Retrieval of MetOp-A/IASI CO profiles and validation with MOZAIC data, Atmos. Meas. Tech., 5, 5, 2843-2857, 2012.

Acknowledgments:

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