Identification of CO sources and transport processes driving O3 and CO distributions in the upper troposphere over Africa

B. Sauvage1, A. Fontaine1, J.-P. Cammas2, B. Barret1, P. Nédélec1, H.G.J. Smit3, V. Thouret1

1Laboratoire d’Aérologie, Université de Toulouse, CNRS; France; 2OSU-R, UMS3365, La Réunion, France; 3Forschungszentrum Juelich GmbH, IEK-8, Juelich, Germany / contact: basile.sauvage@laero.obs-mip.fr

Context and Objectives

Tropical upper troposphere (UT) is a key area in atmospheric sciences, with active photochemistry and multiple transport processes that act in modifying tropospheric chemistry composition. Indeed pollutants are emitted from biomass burning (South America, Africa, Asia) and anthropogenic activities (with some of the highest world cities in the Tropics). Distribution of key tropospheric trace gases such as ozone (O3) and carbon monoxide (CO) are still poorly understood in these regions because of limited spatial and temporal coverage of current observational systems (satellite or campaigns). Pollution origin remains uncertain with multiple regional and synoptic dynamical processes involved in the long range transport of air masses.

We use daily aircraft observations of O3, CO and relative humidity (RH) to describe the seasonal distribution variations of these species between Dec. 2005 and Oct. 2013 in the African UT. Attribution of the sources and regions driving the meridional CO distributions is realized through a lagrangian modeling / emissions coupling system that we developed.

1-Methdology: MOZAIc observations and SOFT-IO modeling

From Dec. 2005 to Oct. 2013, one Air Namibia aircraft carried MOZAIc instruments, allowing daily observations of O3, CO and RH between Frankfurt and Windhoek around 9-12 km, and with an unprecedented spatio-temporal coverage and accuracy.

We use modeled CO calculations from the SOFT-IO scientific tool (shortly implemented as added-value products in the IGOS database). It consists in coupling backward transport calculations of particles initialized every 0.5° along aircraft observations (from the FLEXPART lagrangian model), with global and regional emission inventories (anthropogenic and fires).

2-Dynamical context

Lower tropospheric circulation is driven by the trade winds (lower branch of Hadley cells) that convergence towards the low pressure zone (ITCZ).

In the upper troposphere, meridional transport is driven by the upper branch of the Hadley cells, from the ITCZ up to the sub-tropics.

- Easterly circulation (TEJ, Asian monsoon Anticyclone) links Asia to Africa in the northern hemisphere, whereas westerly circulation (South Atlantic anticyclone) dominates in the southern hemisphere linking South America and Africa.

3-Tropospheric trace gases seasonal distributions

4-UT CO seasonal origins: sources and regions

5-CO (ppb) time series (monthly means)

6- Conclusions

- For the first time, O3, CO & RH seasonal distribution variations over Africa, are described in details thanks to daily aircraft observations.
- Negative CO & RH gradients are observed south and north of the ITCZ winds divergence zone.
- First estimation on the origin of the CO distributions thanks to SOFT-IO modeling.
- Tropical UT CO is related to the transport process scheme described in Sauvage et al. (2007); African emissions (anthropogenic and fires) are mostly influencing UT CO gradients through Hadley cells circulation.
- Anthropogenic emissions have the highest influence on the UT CO tropical gradients, except in DJF.

References

2 Sauvage et al., Science attributing using FLEXPART and carbon monoxide emissions inventories for the IGOS In-situ Observation database (SOFT-IO), GMD, to be submitted 2016.