Stage de recherche au LACy
Laboratoire de l'Atmosphère et des Cyclones

UMR8105 - Université de La Réunion, 97400 Saint-Denis de La Réunion

Titre du stage : **Ozone distribution in the troposphere/UTLS in the tropics/subtropics and the effect of dynamics and chemistry.**

Nom et statut du (des) responsable (s) de stage : Stéphanie Evan (CR, CNRS)

Coordonnées (téléphone et email) du (des) responsable (s) de stage :, **+262 262 93 82 53,**
stephanie.evan@univ-reunion.fr

Sujet du stage :

Why do we care about Ozone in the troposphere and UTLS?

As a greenhouse gas, ozone affects climate and its presence in the upper atmosphere (stratosphere) is key to plant and human life via its ability to block the Earth's surface from harmful ultraviolet radiation from the Sun. Atmospheric ozone has two effects on the temperature balance of the Earth. It absorbs solar ultraviolet radiation, which heats the stratosphere. It also absorbs infrared radiation emitted by the Earth's surface, effectively trapping heat in the troposphere. Therefore, the climate impact of changes in ozone concentrations varies with the altitude at which these ozone changes occur.

Ozone near Earth's surface in excess of natural amounts is considered a pollutant. Surface ozone in excess of natural levels is formed by reactions involving air pollutants emitted from human activities, such as nitrogen oxides (NOx), carbon monoxide (CO), and various hydrocarbons (gases containing hydrogen, carbon, and often oxygen). Exposure to surface ozone above natural levels is harmful to humans, plants, and other living systems because ozone reacts strongly to destroy or alter many biological molecules. In addition, increases in tropospheric ozone lead to a warming of Earth's surface because ozone is a greenhouse gas.

The variability of ozone in the tropical upper troposphere (10–16 km in altitude) is important for the climate as it influences the radiative budget (Lacis et al., 1990; Thuburn and Craig, 2002; Riese et al., 2012) and modifies the oxidizing capacity of the atmosphere and the lifetime of other chemical species and greenhouse gases. The tropical ozone budget in the upper troposphere is influenced, on a short timescale, by transport processes such as stratosphere-to-troposphere exchange (STE; Lin, Fiore, Cooper, et al., 2012; Ott et al., 2016), biomass burning, convective activity and chemistry (Thompson et al., 2008, Héron et al., 2020). On greater timescales, seasonal and interannual variations of O3 is affected by the El Niño–Southern Oscillation (ENSO; Chandra et al., 2002), the Madden-Julian oscillation (MJO), or the quasi-biennial oscillation. However, the tropical upper troposphere is a remote region and difficult to measure with high vertical precision and accuracy.

In this internship we will use observational datasets from ozone soundings in the subtropics to investigate the ozone variability in the upper troposphere and UTLS. Ozonesondes provide high vertical resolution (~150 m) ozone measurements from the surface to the mid-stratosphere with excellent precision and accuracy (Witte et al., 2017); several records from around the globe span multiple decades. Because of their high vertical resolution, ozonesondes are able to capture fine details in the geophysical features that control the variability in ozone.

The objectives are

1) Characterize the impact of in situ formation, transport of stratospheric and lower tropospheric air on the ozone budget in the subtropical troposphere using 20 years of ozone sonde data, CAMS reanalysis chemical products and ERA5 thermodynamic parameters.
2) Quantitatively estimate the role of surface sources (biogenic, biomass burning, anthropogenic, oceanic), long range transport and inter-hemispheric transport over 2 years using the FLEXPART Lagrangian model output. Assess the

impact of transport and mixing on the ozone budget in the UTLS through the identification of each air mass with a distinct origin and composition

Methodology:

The CAMS copernicus reanalysis and near real time datasets time coverage starts from 2003 to 2020. Chemical tracers (CO, NOx, hydrocarbons) and thermodynamics variables from ERA5 will be used along with ozone sonde measurements to segregate the impact of chemistry and dynamics on ozone variability. Different statistical tools (principal component analysis, self organizing map) will be used to clusterize (following Stauffer et al., 2018) the dataset according to specific chemical and dynamical regimes .

In addition, the FLEXPART Lagrangian particle dispersion model (Stohl et al., 2005) will be used to quantify the atmospheric transport and dispersion, backward in time, of individual air parcels at a resolution of 150m over 2 years of ozone sonde datasets. The input meteorological fields of the model will be the ERA5 reanalysis that have 137 vertical levels up to 0.01 hPa and a spatial resolution of 0.25 degrees. The impact of long range transport, interhemispheric transport and major surface sources of chemical species will be quantified using the FLEXPART backtrajectory products. The impact of convection will be evaluated by combining FLEXPART backward with maps of convective clouds measured by geostationnary satellites (Héron et al., 2020, https://geosur.osureunion.fr/public_html/cgi-bin/web/display_image_vapeurdo.py). In addition, NOx formed by lightning (LiNOx) will be taken into account using lightning detection datasets.