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Exploitation of greenhouse gas observations at Ile de la Réunion using WRF-Chem simulations

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Réunion is a French island in the Indian Ocean, which holds one of the very few atmospheric observatories in the tropical Southern Hemisphere. Moreover, it hosts experiments providing both ground-based in situ and column Fourier Transform InfraRed spectrometer (FTIR) observations of CO_2, CH_4 and CO atmospheric concentrations, contributing to the Integrated Carbon Observation System (ICOS), the Network for the Detection of Atmospheric Composition Change (NDACC) and the Total Carbon Column Observing Network (TCCON). This work presents a comprehensive study of these observations made in the capital Saint-Denis and at the high-altitude Maïdo Observatory. We used simulations of the Weather Research and Forecasting model coupled with chemistry (WRF-Chem), in its passive tracer option (WRF-GHG), to gain more insight in the factors that determine these concentrations. Additionally, this study provides an evaluation of the WRF-GHG performance in a region where it has not yet been applied.

This presentation discusses the model set-up and the main findings from the comparisons between the observations and the model simulations, as summarized hereafter.

A comparison of the meteorology near the surface and along atmospheric profiles showed that WRF-GHG has decent skill in reproducing these measurements, especially temperature. Surface CO_2 in Saint-Denis follows a distinct diurnal cycle with values up to 450 ppm at night, driven by local anthropogenic emissions, boundary layer dynamics and accumulation due to low wind speeds. Due to an overestimation of local wind speeds, WRF-GHG underestimates this nocturnal buildup. At Maïdo, a similar diurnal cycle is found but with much smaller amplitude. There, surface CO_2 is essentially driven by the surrounding vegetation. A high correlation was found between the hourly XCO_2 of WRF-GHG and the corresponding TCCON observations. These represent different air masses than those near the surface. They are influenced by processes from distant areas such as Africa and Madagascar. The model shows contributions from fires during the biomass burning (BB) season, but also positive biogenic enhancements associated with the dry season. WRF-GHG fails to reproduce the CH_4 observations at Réunion accurately due to a seasonal bias in the background arising from the CAMS reanalysis boundary conditions. Further, local anthropogenic fluxes are the largest source influencing the surface observations at Réunion. However in Saint-

Denis, and even more so at Maïdo, the anthropogenic CH_4 emissions from EDGAR are likely overestimated. WRF-GHG is able to simulate the CO levels at Réunion with a relative high degree of accuracy. As to the observed XCO, the importance of BB plumes from Africa and elsewhere for explaining the observed variability is confirmed. The surface observations at Maïdo can detect anthropogenic signals from the coastlands during the day and BB enhancements from afar at night, when the Observatory is located in the boundary layer and the free troposphere, respectively.

The high model resolution of 2km is needed to accurately represent the surface observations. Because of the complex topography and local dynamics, an even higher resolution might be needed at Maïdo. To simulate the column observations on the other hand, a model resolution of 50km might already be sufficient.