Project: **1234**

Project title: **Air Quality: Worldwide Analysis and Forecasting of Atmospheric Composition for Health (AQ-WATCH): High-resolution air quality multi-model forecast system for focus regions in Asia and the Americas**

Principal investigator: **Cathy Li**

Report period: **2023-11-01 to 2024-10-31**

Over the last report period, this project has contributed to two key publications, one on model comparisons of air quality models across Latin America (Pachon et al., 2024), and another on multi-scale modelling across South America (Lichtig et al, 2024).

In Pachon et al. (2024), the study presents the development of a multi-scale modelling ensemble chain as a preliminary step towards creating an air quality forecasting system for Latin America. Two global and three regional models were tested, focusing on simulations for January and July of 2015. Observations from air quality monitoring networks in six Latin American countries were used for evaluation. The models generally performed well in large cities like Mexico City and São Paulo but had more difficulty representing smaller cities like Bogotá and Santiago, particularly during Santiago's winter. While no single model consistently outperformed the others across pollutants and locations, ozone (O_3) and nitrogen dioxide (NO_2) were modelled more accurately than other pollutants, with sulphur dioxide (SO_2) being the most challenging. The ensemble model, based on the median values of the individual models, often performed better than the standalone models, particularly in reducing extreme errors. This highlights the potential of ensemble modelling for air quality forecasting in Latin America, although improvements are needed in model capabilities and emissions data, with local expertise playing a key role in addressing these challenges. The DKRZ project provided computational hours to perform some of the air quality models in the ensemble and hosts the ensemble data for the model comparison. An example of the comparison between the different models in the ensemble in major Latin American cities is illustrated in Figure 1.

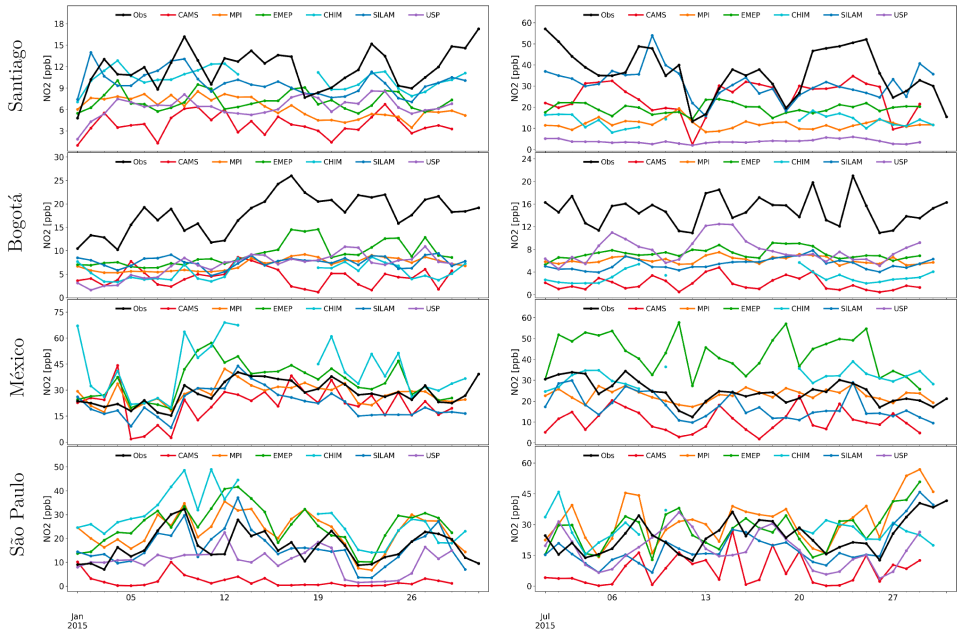

Figure 1: Observed (black) and simulated NO_2 daily mean concentrations in Santiago, (top) Bogotá, México City, São Paulo (bottom) for January (left) and July (right) 2015.

Lichtig et al. (2024) focuses on the atmospheric chemistry of South America, a region with complex topography and diverse emission sources that has been historically understudied. Using the Multi-Scale Infrastructure for Chemistry and Aerosols model (MUSICA), the study analyzed the sources and distribution of carbon monoxide (CO) in the South American troposphere during 2019. It also examined how South American emissions affect global CO levels. The study found that most CO in South America

originates from secondary chemical production linked to non-methane volatile organic compounds (NMVOCs) and biomass burning, with the latter being the primary driver of CO variability. Biomass burning in Central Africa also contributes significantly to CO levels across the continent, including in southern regions. Biogenic emissions play a dual role by both contributing to CO production and limiting its destruction by reducing hydroxyl radical (OH) levels. This dual effect extends the CO lifetime to approximately 120 days over the Amazon, compared to 30–60 days in other parts of South America. The findings emphasize the importance of biomass burning and biogenic emissions in shaping CO distribution and persistence in South America. The DKRZ project provided computational hours to perform the MUSICA simulations for analysis of this study, which is computationally expensive given the large extent of the zoomed model domain over the whole South America continent and the relatively high resolution at 28 km. An intercomparison of the MUSICA simulation performed in this study against the MOPITT satellite is illustrated in Figure 2.

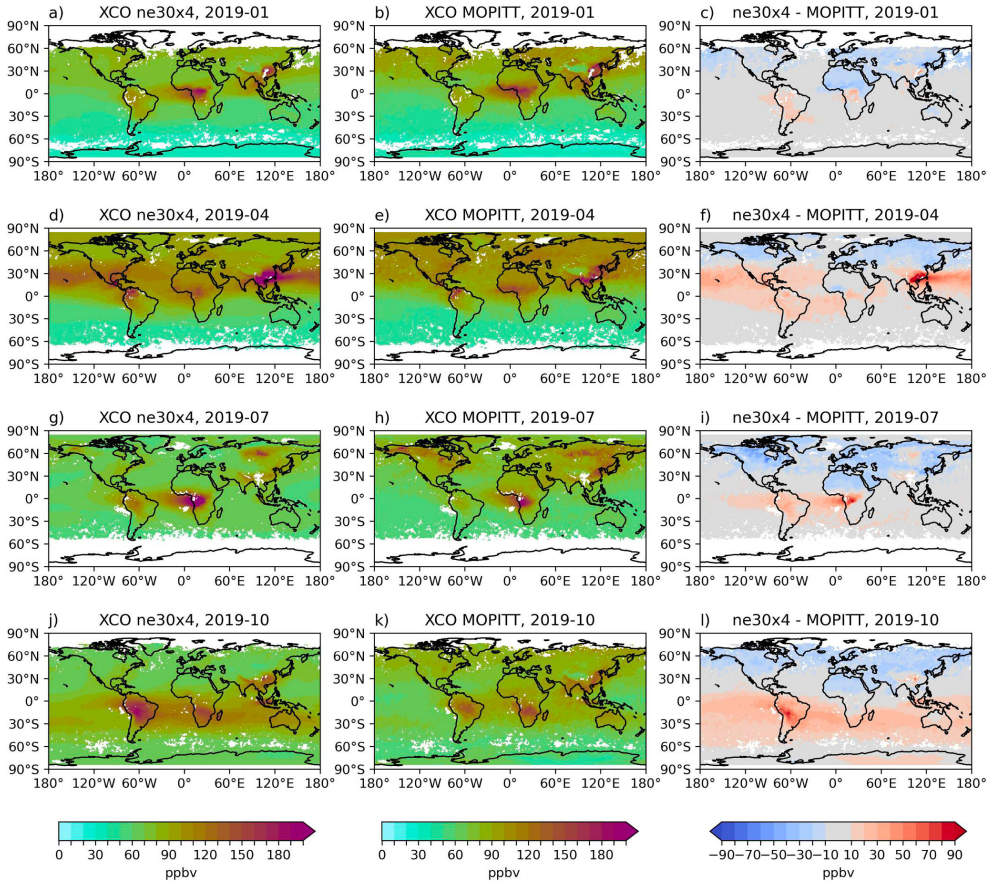

Figure 2: Model evaluation of MUSICA simulation with MOPITT for the months of Jan, Apr, Jul, and Oct.

References:

Pachon, J. E., Opazo, M., Lichtig, P., Hunneus, N., Bouarar, I., Brasseur, G., Li, C. W. Y., Flemming, J., Menut, L., Menares, C., Gallardo, L., Gauss, M., Sofiev, M., Kouznetsov, R., Palamarchuk, J., Dawidowski, L., Rojas, N. Y., Andrade, M. D. F., Gavidia-Calderón, M. E., Delgado Peralta, A. H., and Schuch, D.: Air quality modeling intercomparison and multi-scale ensemble chain for Latin America, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-815, 2024.

Lichtig, P., Gaubert, B., Emmons, L. K., Jo, D. S., Callaghan, P., Ibarra-Espinosa, S., et al.: Multiscale CO budget estimates across South America: Quantifying local sources and long range transport. Journal of Geophysical Research: Atmospheres, 129, e2023JD040434. https://doi.org/10.1029/2023JD040434, 2024.