Transport Pathways of Carbon Monoxide in the Upper Troposphere-Lower Stratosphere Over the Asian Summer Monsoon Region

THE EARTH INSTITUTE
COLUMBIA UNIVERSITY

Steven Gutterman[1] and Yutian Wu[2]

1. Columbia University, Department of Applied Physics and Applied Mathematics 2. Lamont-Doherty Earth Observatory, Ocean and Climate Physics Division

Introduction

- The Asian Summer Monsoon (ASM) region is a region of Asia that experiences heavy rainfall and strong winds in June-July-August (JJA), characterized by the upper-level high-pressure anticyclone at the upper troposphere-lower stratosphere (UTLS)
- High concentrations of trace pollutants in the UTLS over the ASM region in JJA are thought to come from anticyclonic trapping of surface emissions
- CO is a pollutant that contributes to ground-level ozone and smog in the troposphere and breaks down ozone in the stratosphere
- Goal is to address how the anticyclone affects CO transport, with specific note of the UTLS, where the role of CO changes by comparing atmospheric chemistry models and observations

Data/Methods

- Data from various sources (see below) were studied using Jupyter Notebook to visualize and understand the transport pathways, using metrics such as geopotential height, zonal/meridional wind components, and regional CO emissions
- NASA Aura Microwave Limb Sounder (MLS): satellite data with gridded latitude-longitude (35 latitude points by 72 longitude points) and 37 vertical pressure levels
- Community Atmosphere Model with Chemistry (CAM-Chem): simulations of global troposphere/stratosphere atmospheric composition developed by the National Center for Atmospheric Research (NCAR) with gridded latitude-longitude (192x288), 32 pressure levels, and regional tags (East Asia, South Asia, Europe, North America, etc.) which track CO from specific surface origins
- Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA): NCAR's newest modeling infrastructure designed to replace CAM-Chem with gridded latitude-longitude (192x288), 58 vertical pressure levels, also with regional tags. Notable regions include the Tibetan Plateau (PlateauSFlank), East Asia, North Africa, West Asia, Europe, North America, among others

Results

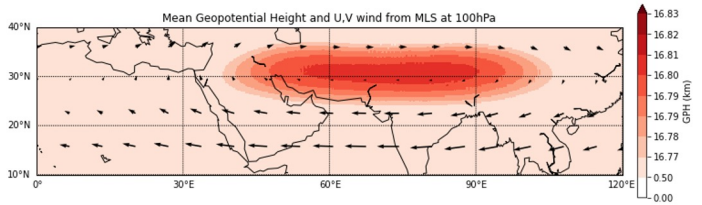
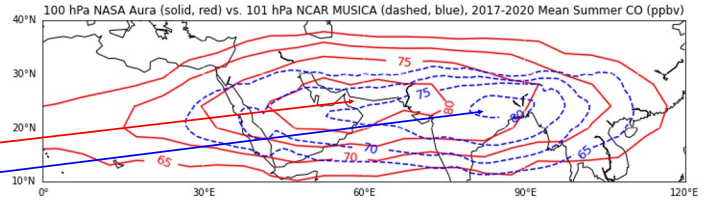


Figure 1: The ASM anticyclone is characterized by high GPH near the UTLS. Depicted is the 2005-2020 Mean JJA GPH from Aura satellite data at 100hPa

Figure 2: Mean climatological CO contour plots of MUSICA model output and NASA Aura observations from 2017-2020 at 100hPa, highlighting their different centers (red arrow = Aura center, blue arrow = MUSICA center)



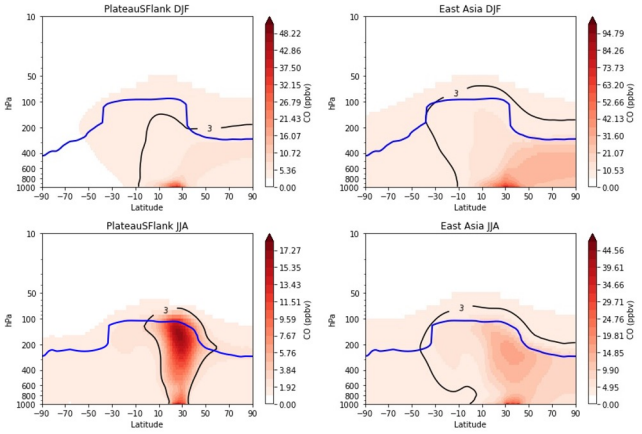
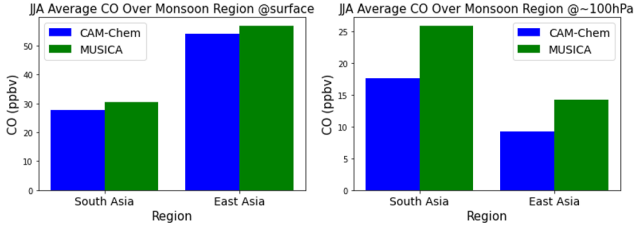


Figure 3: Zonal mean climatological CO plots of MUSICA model output from 2017-2020 for the Tibetan Plateau (PlateauSFlank) and East Asia tagged regions with thermal tropopause (blue line) and 3 ppbv CO contour in DJF (December-January-February) and JJA

Figure 4: Bar plots depicting average CO concentration per grid point from 10-40N/0-120E for South Asia and East Asia tagged regions at the surface and at 100hPa, comparing CAM-Chem and MUSICA output



Discussion

- Figure 1 highlights the anticyclone, yet Figure 2 showcases how CO concentration at 100hPa does not directly match the anticyclone's position but does match the general shape for both MUSICA output and satellite observations
- Notably, MUSICA and the satellite observations have different CO maxima locations, and each center appears to be within a different part of the anticyclone. In future work exploring these differences, it may be helpful to better understand the bimodality of the ASM anticyclone, which has one mode near Iran and another mode at the southwestern flank of the Himalaya, and how these two modes may influence transport pathways
- Figure 3 highlights the clear vertical column in the JJA zonal mean plot over the Tibetan Plateau, with a high CO concentration that penetrates the tropopause, suggesting major influence from the summer anticyclone. East Asia also has signs of this vertical column, although not to the same degree, suggesting that its emission pathways may be less influenced by the ASM
- DJF zonal mean plots in Figure 3 suggest transport primarily towards the Arctic, leading to a build-up of CO in Arctic latitudes, agreeing with general atmospheric circulation dynamics
- Figure 4 supports the idea that South Asian emissions are more impacted by the ASM since both the CAM-Chem and MUSICA models agree that East Asia has higher surface emissions in the boxed 10-40N/0-120E region but notably lower concentrations at 100hPa

Acknowledgements

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References

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