4.089 What controls interannual variability and long-term trends in global tropospheric chemistry and aerosols in past and future? .

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Abstract:

Global distributions and abundances of tropospheric constituents (O_3, CH_4, NOy, CO, VOCs, NHx, SOx and aerosols) inter-annually change under the influences of meteorology (transport, temperature, water vapor, clouds, rain, etc.) and emissions from anthropogenic/natural sources and biomass burning. Since chemistry climate models are generally used for future projection of individual constituents, model validation against the observations and precise interpretation/understanding of changing processes in a model are essentially needed. In this study, we investigate the inter-annual variability and long-term trend of tropospheric constituents in a chemistry-aerosol coupled climate model CHASER (MIROC-ESM) focusing on the past reproduction (1960 to 2016) and future projection (2010-2100). In this study, we basically use our CHASER simulations for the CCMI multi-model experiment. Our results show that temporal variability (anomaly) in surface and lower tropospheric ozone and PM($PM_{2.5}$) very clearly correlates with that in CO, especially in NH (r>0.8), indicating the principal importance of biomass burning emissions in determining near-surface O_3 and $PM_{2.5}$ variabilities. Changes in middle to upper tropospheric O_3 for the past decades and future, on the other hand, respond principally to variabilities/trends in water vapor, transport from the stratosphere (STE), and lightning NOx production associated with climate trend (i.e., warming) and variability (inc. ENSO, PDO, etc.) and/or stratospheric O_3 change. It is also demonstrated that the inter-annual variability and long-term trend in tropospheric mean OH concentration (and hence CH_4 concentration) is largely controlled by tropospheric abundances of O_3, NOx, and water vapor. In the simulations, the emission-driven long-term increase in global mean CH_4 (~350 ppbv for 1980-2010) is nearly halved (~170 ppbv) by OH increases due to changes in climate and NOx emission. Our simulations further suggest that this kind of complex interaction among O_3-OH-CH_4 and climate plays key roles in future changes and radiative forcing of tropospheric constituents including aerosols (sulfate and nitrate).