Large-Scale Tropospheric Transport: Connections with Dynamics and New Observational Constraints

Clara Orbe, NASA Goddard Institute for Space Studies, New York, NY

The transport of trace gases and aerosols is a major uncertainty in the modeling of tropospheric composition. Here I present an overview of recent studies oriented toward an improved understanding of the large-scale dynamical processes controlling transport from the Northern Hemisphere (NH) midlatitude surface to the Arctic and to the Southern Hemisphere (SH).

First, results are presented using a hierarchy of numerical models, ranging from a dry dynamical core to the fully comprehensive models participating in the Chemistry Climate Modeling Initiative (CCMI). In particular, historical integrations of idealized tracers reveal that there are substantial (~30-45%) differences in simulated transport to the Arctic free troposphere and that the spread among tracers with predominantly land- and ocean-based sources is correlated with the spread in the location of the Hadley Cell edge and differences in (parameterized) convection, respectively. Large differences are also reported in the strength of interhemispheric transport into the SH and are shown to originate within the northern subtropical transport barrier. Idealized abrupt-CO_2 simulations using the NASA Goddard Institute for Space Studies (GISS) ModelE are further used to examine the link between projected changes in large-scale transport and the response of the Hadley Cell edge/(parameterized) convection. Finally, the model-based results are placed in the context of new observational constraints on the mean time (or mean age) since air was last at the NH midlatitude surface. These new estimates, derived from a network of new surface and in-situ aircraft measurements of SF_6, reveal that the SF_6 age has been decreasing nearly uniformly by ~0.16 yr/dec over the period 1997-2018. Quite importantly, these decreases are not due to underlying changes in dynamics but, rather, are associated with a southward shift in SF_6 emissions from northern midlatitudes into the northern subtropics.