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Better Validating Stratospheric Transport in Climate Models: The Case for Long-Term Profile Measurements of a Specific Suite of Trace Gases

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We use a modified version of the tropical leaky pipe (TLP) model of the stratosphere to explore how well an idealized model can (1) reproduce global chemistry-climate model (CCM) output and (2) constrain transport characteristics necessary to replicate measurements of long-lived trace gases. The version of the TLP model we use includes the simulation of long-lived trace gases, such as SF6 and CO2, as well as photochemically active trace gases such as CFC-11, CFC-12 and N2O. The TLP model was found to accurately replicate trace gas output from the Canadian Middle Atmosphere Model (CMAM) for time-averaged profiles in the tropics and each extratropical region. Given confidence that the TLP model represents the basic transport features in CMAM we then used the TLP model to interpret differences between CMAM output and measurements from the Atmospheric Chemistry Experiment (ACE) and balloons. The TLP model is shown to uniquely determine mean circulation and recirculation (mixing between the extratropics and tropics) changes necessary for CMAM to more accurately simulate the measurements. Such guidance on transport changes is novel, and cannot readily be obtained from direct comparison of CCM output with measurements. The TLP model can thus be used as a bridge between measurements and CCMs to allow more targeted modification of the CCMs than would otherwise be possible. This study points out the importance of a specific suite of trace gas measurements with unique sensitivities to the mean stratospheric circulation and mixing. Future measurement programs should prioritize profiles of these trace gases in order to evaluate modeled stratospheric transport.