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Impact of uncertainties in atmospheric mixing on simulated UTLS composition and related radiative effects

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The composition and dynamic structure of the upper troposphere/lower stratosphere (UTLS) have a significant impact on surface climate and its variability, through radiative and dynamic coupling. Changes in the chemical composition of this region result in particularly large changes in the radiative forcing of the atmosphere. In addition, there is growing evidence that dynamic coupling between the troposphere and stratosphere has a significant impact on regional weather and climate. Improvements of forecasts by chemistry-climate models (CCMs) therefore rely on a quantitative representation of radiative and dynamic couplings and the underlying physical and chemical processes.

We will give a brief overview on physical and chemical processes, determining UTLS composition (e.g., stratosphere-troposphere exchange) and influencing the dynamical coupling with the troposphere (e.g., gravity waves). In the second part, we present results of an analysis of the influence of uncertainties of one particular process, mixing of air masses, on global UTLS distributions of greenhouse gases (water vapor, ozone, methane, and nitrous oxide) and associated radiative effects. The study is based on multi-annual simulations with the Chemical Lagrangian Model of the Stratosphere (CLaMS) driven by ERA-Interim meteorological data and on a state-of-the-art radiance code. It is shown that radiative effects of of water vapor and ozone, both characterized by steep gradients in the UTLS, are particularly sensitive to uncertainties of the atmospheric mixing strength. Globally averaged radiative effects are about 0.72 and 0.17 W/m2 for water vapor and ozone, respectively.