Analyses of the capabilities of carbon cycle and energy model of simple Earth system models for analyzing aviation effects on climate

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Aviation emissions can impact climate both directly e.g., through radiative effects from emitted carbon dioxide (CO2), soot, and water vapor (H2O), as well as indirectly through effects on complex gaseous and aerosol processes affecting ozone, methane and clouds. Lee et al. (2009) estimates that aviation contributed approximately 4.9% percent of the total anthropogenic RF for the year 2005, including the highly uncertain aviation induced effects on cirrus clouds. Scientifically based evaluation of the future effects of aviation on climate under proposed policy considerations is necessary for policymakers to evaluate the tradeoffs and costs associated with potential responses to different environmental effects. To do so, it is important to develop scientifically well-grounded models that are easy to use for policy considerations to facilitate analyses of optimum aviation climate impact mitigation actions, policy options and tradeoffs. Towards understanding their current capabilities and limitations, we are evaluating aviation-induced and other climate effects determined from available simple models. In this presentation, results from four models are evaluated: the Aviation Environmental Portfolio Management Tool (APMT), the CICERO1 2-box model, the CICERO2 efficient carbon cycle model, the Integrated Science Assessment Model (ISAM) model and MAGICC model. The capabilities and limitations of the carbon cycle and energy balance representations in these simple models to project the future CO2 concentration and future temperature change induced by aviation for a series of different emission scenarios are analyzed. The results reveal that due to the nonlinearities in the ocean chemistry and the terrestrial fertilization by elevated CO2 level, the projected CO2 concentration is different for CO2 pulses with different size emitted into the different background holding different level of CO2. MAGICC, ISAM and CICERO2, due to having more complex treatments of the carbon cycle that account for nonlinearities in the ocean chemistry and the terrestrial fertilization by elevated CO2 level, provide the most realistic projections of future CO2 concentration. Moreover, the results related to evaluation of the energy balance representation in these models reveal that the derived temperature changes are substantially affected by the processes and the ocean parameterization considered in the temperature derivation. These results suggest that a multi-box ocean model gives the best results.