Session: B12 Oral presentation

Analysis of the mechanisms controlling tropical cloud feedbacks in the IPSL-CM5a climate model

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The last IPCC report reaffirms the prominent role of cloud-radiative feedbacks in the inter-model spread of climate sensitivity. Several studies show that the low-cloud response discriminates high and low sensitivity models in the tropics. Understanding the mechanisms that control the behaviour of low-level clouds is thus crucial. However, the complexity of coupled ocean-atmosphere models and the large number of processes potentially involved make the analysis of this response difficult. To simplify this analysis and identify the most critical controls of cloud feedbacks, we analyze the cloud response to climate change simulated by the IPSL-CM5a model in a hierarchy of configurations. As a first step, we compare three model configurations using the same physical parametrizations : the IPSL-CM5a coupled model, its atmospheric component LMDZ and an aqua-planet version. We show that the cloud response to global warming in these models is dominated by a decrease of low clouds in regimes of moderate subsidence (StratoCumulus and Shallow Cumulus). Then, we use a Single Column Model version of LMDZ with the aim of reproducing the cloud profile simulated by the 3D version in weak subsidence areas. The idealized large-scale forcings of the CGILS (CFMIP-GCSS Intercomparison of Large-Eddy and Single-Column Models) S6 case correspond well to weak subsidence regimes. However, we show that it is necessary to add a stochastic forcing on vertical velocity to reproduce the alternance of convective and subsidence situations seen in those regimes, and thus to reproduce the vertical cloud profile predicted in the 3D model, as well as and its response to climate change. As a third step, we analyse the physical mechanisms responsible for the low- cloud decrease. We show that for several external perturbations (SST or CO2 changes), the increase of radiative cooling, especially in the upper troposphere, plays a dominant role in this response. We interpret this finding through an analysis of the tropospheric moist static energy. The implications of these findings for the interpretation of CMIP5 inter-model differences in climate change cloud feedbacks, and for the design of observational tests relevant for the evaluation of these feedbacks will be discussed.