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Can Single-Column Models be used for climate feedback studies?

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The Single-Column Model (SCM) has proven a useful tool for the development, evaluation and improvement of the representation of boundary-layer clouds in large-scale models. Recently, the parameterization of such clouds have been identified as a major contributor to uncertainty in future climate predictions. However, much remains to be understood about the reponse processes of the boundary-layer clouds. One then wonders if, and if so how, the SCM can be used to make progress. A first step is to assess how representative long-term SCM simulations on climate timescales are of the model climate of their native General Circulation Model (GCM). To this purpose, 30-year simulations are performed with the SCM version of EC-EARTH GCM, that are forced by high-frequency cfSites output of the CFMIP5 simulations of the EC-EARTH GCM. The 30-year SCM simulations are performed at two cfSites of interest, each site representing a different climate regime. The Barbados Cloud Observatory (BCO) reflects subtropical marine Tradewind conditions, while the Cabauw site (CESAR) in the Netherlands frequently features mid-latitude continental boundary layer clouds. A key novelty compared to previous SCM climate studies such as CGILS is that the prescribed large-scale forcings are non-idealized as well as highly variable in time. As a result, articifical grid-locking effects are automatically avoided; in addition, the forcings can be made representative of different scenarios of future climate. This enables the targeted use of SCM simulation as a laboratory for investigating the response of boundary layer clouds in GCM. The results of this study provide support for such use of long-term SCM as a climate feedback testbed, and provide some guidance on how large-eddy simulations and high-frequency observations can be integrated into this framework.