Showcasing the compact Earth system model OSCAR v3.1 with CMIP6 simulations

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While Earth system models (ESM) provide spatially detailed process-based outputs, they present heavy computational costs. Reduced complexity models such as OSCAR are calibrated on those complex models and provide an alternative with faster calculations but lower resolutions. Yet, reduced-complexity models need to be evaluated and validated. We diagnose the newest version of OSCAR (v3.1) using observations and results from ESMs and the current Coupled Model Intercomparison Project 6. A total of 99 experiments are selected for simulation with OSCAR v3.1 in a probabilistic framework, reaching a total of 567,700,000 simulated years. Here, we showcase these results. A first highlight of this exercise is the unstability of the model for high-warming scenarios, which we attribute to the ocean carbon cycle module. The diverging runs caused by this unstability were discarded in the post-processing. The ensuing main results were further obtained by weighting each physical parametrizations based on their performance to replicate a set of observations. Overall, OSCAR v3.1 qualitively behaves like complex ESMs, for all aspects of the Earth system, although we observe a number of quantitative differences with state-of-the-art models. Some specific features of OSCAR contribute in these differences, such as its fully interactive atmospheric chemistry and endogenous calculations of biomass burning, wetlands and permafrost emissions. Nevertheless, the low sensitivity of the land carbon cycle to climate change, the unstability of the ocean carbon cycle, the seemingly over-constrained climate module, and the strong climate feedback over short-lived species, all call for an improvement of these aspects in OSCAR. Beyond providing a key diagnosis of the model in the context of the reduced-complexity models intercomparison project (RCMIP), this work is also meant to help with the upcoming calibration of OSCAR on CMIP6 results, and to provide a large set of CMIP6 simulations all run consistently with a probabilistic model.