Reduction of systematic errors in climate models : model improvement versus tuning of free parameters

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The reduction of systematic errors in climate models is driving the development of new parameterizations and concepts. This development is often done in a single column version of the climate models (SCM) using, as a reference, Large Eddy Simulations (LES). When going from 1D to 3D however, the model free parameters must be re-tuned. Whatever the sophistication of the cloud parameterizations, the uncertainty of the simulated radiation is much larger than the accuracy of 1W/m2 required to obtain a global surface temperature that does not depart from observation by more than 1K in coupled models. Tuning can be pushed forward to better represent other key aspects of the climate engine such as the latitudinal distribution of radiation, that drives the global circulation. For the tuning of the CMIP6 version of the IPSL model, we targeted as well the systematic warm biases observed on the eastern tropical oceans, and to a lesser extent in high southern latitudes, relying on correlations observed in CMIP5 between anomalies in the surface energy balance in forced-by-SST simulations and SST anomalies in coupled simulations.
We present this tuning strategy and some related issues. Tuning may in some cases slow down the process of model improvement: too strong a tuning (over-fitting) on end-users metrics, may make it difficult to demonstrate the improvement of a new development (Hourdin et al., BAMS, 2017). We finally discuss strategies to try to make model improvement (in terms of physical content) and tuning “more in tune”. This includes the use of Uncertainty Quantification (UQ) methods to explore more efficiently and objectively the space of acceptable parameters, the fact of privileging process oriented rather than end-users metrics, or the application of UQ approaches to determine the range of acceptable parameters at process level, in the SCM / LES comparison.