DKT-12-47
https://doi.org/10.5194/dkt-12-47
12. Deutsche Klimatagung

Assessing spatio-temporal variability and biases of climate models

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Atmospheric spatial and temporal variability are closely related with the former being relatively well observed compared to the latter. The former is also regularly assessed in the validation of numerical weather prediction models while the latter is more difficult to estimate. Likewise, thermodynamical fields and circulation are closely coupled calling for an approach that considers them simultaneously.

In this contribution, spatio-temporal variability spectra of the four major reanalysis datasets are discussed and applied for the validation of a climate model prototype. A relationship between deficiencies in simulated variability and model biases is derived. The underlying method includes dynamical regime decomposition thereby providing a better understanding of the role of tropical variability in global circulation.

Results of numerical simulations are validated by a 20th century reanalysis. A climate model was forced either with the prescribed SST or with a slab ocean model that updates SST in each forecast step. Scale-dependent validation shows that missing temporal variance in the model relative to verifying reanalysis increases as the spatial scale reduces that appears associated with an increasing lack of spatial variance at smaller scales. Similar to variability, bias is strongly scale dependent; the larger the scale, the greater the bias. Biases present in the SST-forced simulation increase in the simulation using the slab ocean. The comparison of biases computed as a systematic difference between the model and reanalysis and between the SST-forced model and slab-ocean model (a perfect-model scenario) suggests that improving the atmospheric model increases the variance in the model on synoptic and subsynoptic scales but large biases associated with a poor SST remain at planetary scales.