Geophysical Research Abstracts
Vol. 19, EGU2017-14394, 2017
EGU General Assembly 2017

Unravelling the Sources of Climate Model Errors in Subpolar Gyre Sea-Surface Temperatures

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Climate model biases are systematic errors affecting geophysical quantities simulated by coupled general circulation models and Earth system models against observational targets. To this regard, biases affecting sea-surface temperatures (SSTs) are a major concern due to the crucial role of SST in the dynamical coupling between the atmosphere and the ocean, and for the associated variability. Strong SST biases can be detrimental for the overall quality of historical climate simulations, they contribute to uncertainty in simulated features of climate scenarios and complicate initialization and assessment of decadal climate prediction experiments.

We use a dynamic linear model developed within a Bayesian hierarchical framework for a probabilistic assessment of spatial and temporal characteristics of SST errors in ensemble climate simulations. In our formulation, the statistical model distinguishes between local and regional errors, further separated into seasonal and non-seasonal components.

This contribution, based on a framework developed for the study of biases in the Tropical Atlantic in the frame of the European project PREFACE, focuses on the subpolar gyre region in the North Atlantic Ocean, where climate models are typically affected by a strong cold SST bias. We will use results from an application of our statistical model to an ensemble of hindcasts with the MiKlip prototype system for decadal climate predictions to demonstrate how the decadal evolution of model errors toward the subpolar gyre cold bias is substantially shaped by a seasonal signal. We will demonstrate that such seasonal signal stems from the superposition of propagating large-scale seasonal errors originated in the Labrador Sea and of large-scale as well as mesoscale seasonal errors originated along the Gulf Stream. Based on these results, we will discuss how pronounced distinctive characteristics of the different error components distinguished by our model allow for a clearer connection between error dynamics and the physics of the simulated climate, a more reliable identification of error sources and propagation pathways, and a clearer separation between error phases, including shock, drift and bias.