Testing Recent and Future GCM Expressions of Antarctic Surface Melting Conditions

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GCM skill in the climate change-sensitive polar regions is key to using them to predict future changes in the ice sheet environment, as is knowing why a GCM is wrong (or right) versus observed climate. We evaluate GCM skill and variability for modern (1981-2000) and future (2081-2100) melt-season surface climates in Antarctica with a nonlinear data analysis tool, self-organizing maps (SOMs). Intermodel variability is evaluated via 19 CMIP5 models with sub-daily data needed for regional-scale modeling and intramodel (i.e., internal) variability with the 30-member CESM1.0-CAM5-BGC Large Ensemble.

Three scenarios test modern GCM skill: placing models in the context of the variability of our reference dataset (the ERA-Interim reanalysis, ERAI); locating GCMs in a “universal” data space covering all models plus ERAI; and comparing GCM patterns to those associated with extensive ice sheet melt events. In each case, SOMs abstract complex datasets (e.g., daily near-surface air temperature) into a relatively small set of generalized patterns representing dataset variability and pattern frequency analyses help us understand skill.

The ERAI SOM provides a summary of variability in the reanalysis and a test of how well each GCM reproduces ERAI variability. Mismatches in pattern frequencies indicate shortcomings in GCM skill with pattern over/underoccurence potentially providing insights to mechanisms.

The “universal” SOM analyzes ERAI and CMIP5 models together and thus both summarizes the variability of multiple realizations of climate (the GCMs) and helps to place each GCM in a common context with the other models. Because of the joint data analysis, intercomparisons are now done against patterns drawn from all the models.

The universal SOM also provides a framework for examining model conditions during melting events. For example, frequency mapping of data stratified to those days with notable melt on the Ross Ice Shelf helps to identify related circulation patterns potentially driving the melting. GCM skill in reproducing ERAI pattern frequencies for the melt subset tells us about GCM strengths and weaknesses under melting conditions and and can inform our analyses of GCM-based predictions of future melting.