Observations, Reanalyses and Ice Cores: Early Results from a Synthesis of Antarctic Climate

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Understanding of Antarctic climate relies heavily on four main sources of data: direct meteorological observations, numerical modeling of the atmosphere, satellite-based remote sensing, and indirect measurements from ice-core-based proxies. Various limitations (e.g., missing or limited data, uncertainties in dating or interpretation, computing resources) often challenge the straightforward application of these data to climate questions. The goal of this project is to apply new tools to try to circumvent these limitations and create a new synthesis of Antarctic climate. Here we present early results from a pilot study of July surface temperatures. Self-organizing maps (SOMs) are a nonlinear, artificial neural networks-based approach to the analysis of complex datasets. SOMs provide an unsupervised classification of complex geophysical data sets, e.g., time series of the atmospheric circulation or sea-ice extent, into a fixed number of distinct generalized patterns, or modes, representing the probability density function (PDF) of the input data. These patterns collectively provide a nonlinear classification of the continuum of the PDF into a two-dimensional, spatially organized grid form. In contrast to principal component analysis, SOMs do not force orthogonality or require subjective rotations to produce interpretable patterns. As a preliminary, pathfinding step in this project, July daily 2-m temperatures were extracted from a ~24-year (1979-2002) dataset of ERA-40-based Polar MM5 runs at 60 km-resolution (Monaghan et al, 2006). A number of climatologies of these data have been developed using SOM analysis at different resolutions (4x3 and 6x5 grids) and considering the complete dataset versus the land-only subset. Having fewer patterns (12), a 4x3 grid better summarizes the big picture while the larger 6x5 grid, with 30 patterns, provides a higher resolution picture of variability. As an example of changes over the 24-year period, pattern frequency analysis was done using the first and last five years of data. In the 3x2 pattern set, for the full dataset, there is a shift from mostly warm/cold East Antarctic patterns (30% and 34%, respectively) to a higher occurrence of warm West Antarctic patterns (10% versus 30% in the early record). For the warm (cold) East Antarctic patterns, anomalies exceed 8 K (-4 K) over substantial areas. Similarly, warm anomalies in West Antarctica exceed 4 K. A similar, land-only analysis shows comparable frequency changes and anomaly magnitudes. Interannual variability of the patterns (e.g., most common patterns) and other aspects of variability within these climatologies (e.g., trajectories between patterns) are also being investigated. When combined with ongoing and future stages of this project, such as artificial neural network-based interpolations of instrumental records, we anticipate that these SOM-based analyses will bring new insights into the complex climate of this region.