Analyzing the Pacific-North American teleconnection pattern and its relationship to climate using RegCM3, a high resolution regional climate model

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Introduction
The Pacific-North American (PNA) teleconnection pattern is widely recognized as a robust feature of Northern Hemisphere atmospheric circulation, and more specifically represents the structure of the quasi-stationary wave field over the North Pacific and North America. The PNA is a strong control of inter- and intra-annual climate variability over North America. This study presents an assessment of the influence of the PNA on past, present, and future climate and surface hydrology in North America.

The Models
The GCM output used here is from the ECHAM5/MPI present climate (20C) and IPCC A2 SRES runs, which span the years 1860-2100. Here we use the output from ECHAM5 to analyze the PNA and to drive the regional model, RegCM3, which is run on a much finer 50-km grid. This study presents results from both ECHAM5 and RegCM3 for the entire 240 year period.

Methods
We examine spatial and temporal changes in the PNA pattern and index over the length of the 240 year model runs for the DJF winter season. The PNA index and spatial pattern are based on the modified linear pointwise method from Wallace and Gutzler (1981) and “modified” by NCEP/CPC, and a rotated principle component analysis (RPCA) (Barnston and Livezey, 1987).

We apply a modified linear pointwise method to compute a monthly index value based on a linear combination of standardized 500-hPa geopotential height anomalies:

$$PNA = \frac{1}{2} \left( z^{+}(15-25^\circ N,180-140^\circ W) - z^{-}(40-50^\circ N,180-140^\circ W) + z^{-}(45-60^\circ N,125-105^\circ W) - z^{+}(25-35^\circ N,90-70^\circ W) \right)$$

where $z^+$ is the mean standardized height anomaly in the specified region. The index value is a measure of the spatial structure of the PNA pattern: a positive index value corresponds to more meridional flow at 500 hPa, whereas a negative index indicates more zonal flow (Fig. 1 above). The PNA index is computed using the ECHAM5 global simulation, and the computed index is used to analyze patterns and changes in North American climate in the RegCM3 simulations.

Results

Figure 4 Correlations between the PNA index and selected surface field anomalies for present (1950-2000, "1x") and future (2050-2099, "2x") scenarios as simulated by the RegCM3. The variables shown are a) 2 m air temperature, b) precipitation, c) soil moisture, and d) snow water equivalent (SWE). The plotted values are the temporal correlation between the PNA index and the anomaly value at each grid point for the given time period. The anomalies are departures from the 1950-2000 climatological base period.

Discussion
The Pacific-North American teleconnection is expressed as a robust pattern in both the ECHAM5 global and RegCM3 regional climate models. Figure 2 displays a PNA index time series of a similar frequency and magnitude to that calculated from observations. The spatial pattern emerges as a leading mode in a rotated EOF analysis, also consistent with observations (Fig. 3). The PNA index is highly correlated with North American climate, notably temperature and precipitation. Positive and negative PNA patterns tend to distinct changes in the anomalies of these and other climate variables. The effects of global warming are evident, particularly in Figures 5a-b where the geopotential heights and temperatures both increase in the A2 plots, however the spatial patterns remain in tact. Soil moisture and SWE (Figs. 5c,d) show a complete reversal in sign between the 20C and A2 scenarios under a negative PNA pattern, indicating that the effects of global warming outweigh the effects of the PNA on North American climate.

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References