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The variable link between PNA and NAO in observations and in multi-century ECHAM CGCM simulations

Joaquim G. Pinto (1), Mark Reyers (1), and Uwe Ulbrich (2)

(1) Institute for Geophysics and Meteorology, University of Cologne, Germany (jpinto@meteo.uni-koeln.de), (2) Institute for Meteorology, Freie Universität Berlin, Germany

The link between the Pacific/North American pattern (PNA) and the North Atlantic Oscillation (NAO) is investigated in reanalysis data and multi-century CGCM runs for present day climate using 3 versions of the ECHAM model. PNA and NAO patterns and indices are determined via rotated principal component analysis on monthly mean 500hPa geopotential height fields. The multi-century CGCM simulations show on average a significant anti-correlation between PNA and NAO. Further, multi-decadal periods with significantly enhanced (high anti-correlation, active phase) or weakened (low correlations, inactive phase) coupling are found in all CGCMs. In the simulated active phases, the storm track activity near Newfoundland has a stronger link with the PNA variability than during the inactive phases. On average, the reanalysis datasets show no significant anti-correlation between PNA and NAO indices, but during the sub-period 1973 - 1994 a significant anti-correlation is detected, suggesting that the present climate could correspond to an inactive period as detected in the CGCMs.
An analysis of possible physical mechanisms suggests that the link between the patterns is established by the baroclinic waves forming the North Atlantic storm track. The geopotential height anomalies associated with negative PNA phases induce an increased advection of warm and moist air from the Gulf of Mexico and cold air from Canada. Both types of advection contribute to increase baroclinicity over eastern North America and also to increase the low level latent heat content of the warm air masses. Thus, growth conditions for eddies at the entrance of the North Atlantic storm track are enhanced. In terms of average temporal development, an enhanced Newfoundland storm track maximum is found in the early winter for negative PNA, followed by a downstream enhancement of the Atlantic storm track in the subsequent months. In active (passive) phases, this seasonal development is enhanced (suppressed). As the storm track over the central and eastern Atlantic is closely related to the NAO variability, this development can be explained by the shift of the NAO index to more positive values.