A modelling study of large-scale flow variability from warm to cold climates

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The extratropical atmosphere exhibits variability on a wide range of time scales. The large-scale flow of the Northern Hemisphere has month-to-month variability that is dominated by well-known fundamental modes such as the North Atlantic Oscillation (NAO) / Northern Annular Mode (NAM). In recent years, there has been growing interest in how this large-scale flow variability is related to synoptic-scale activity (storminesss). There is observational evidence that the fundamental modes of large-scale variability are in fact driven by momentum fluxes associated with modes of storm track variability within an ocean sector (see abstract submitted by Wettstein et al.). However, the mean state of the large-scale flow and the storm tracks also depends on external factors, such as topographic and thermal forcing. Thus, we may ask whether the relationship between large-scale flow variability and storminess changes in different climates.

We analyze simulations by a coupled climate model (CCSM3) spanning a range of climate states, including cold (Last Glacial Maximum, 21 ka), warm (mid-Holocene, 6 ka) and future global warming scenarios as well as simulations representing the present day and pre-industrial climates. We examine variables at the jet-level in order to focus on the essential dynamics of extratropical variability. In general, warmer climates exhibit increased storminess; increased interannual variability of the large-scale flow; and a slight increase in the fraction of total variance explained by the leading mode of large-scale flow variability (i.e., the “dominance” of the leading mode). The changes in storminess appear to be linked to a tendency for the atmospheric jets to become more eddy-driven (like the Atlantic jet today) in warmer climates and more subtropical (like the Pacific jet today) in colder climates.