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Teleconnections in the Presence of Climate Change: A Case Study of the Annular Modes

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Long model integrations of future and past climates present a problem for defining teleconnection patterns through Empirical Orthogonal Function (EOF) or correlation analysis when trends in the underlying climate begin to dominate the covariance structure. Similar issues may soon appear in observations as the record becomes longer, especially if climate trends accelerate. The Northern and Southern Annular Modes provide a prime example, because the poleward shift of the jet streams strongly projects onto these patterns, particularly in the Southern Hemisphere. Climate forecasts of the 21st century by chemistry climate models provide a case study. Computation of the annular modes in these long data sets with secular trends requires refinement of the standard definition of the annular mode, and a more robust procedure that allows for slowly varying trends is established and verified.

The new procedure involves two key changes. First, the global mean geopotential height is removed at each time step before computing anomalies. This is particularly important high in the atmosphere, where seasonal variations in geopotential height become significant, and filters out trends due to changes in the temperature structure of the atmosphere. Pattern definition can be very sensitive near the tropopause, as regions of the atmosphere that used to be more of stratospheric character begin to take on tropospheric characteristics as the tropopause rises. The second change is to define anomalies relative to a slowly evolving seasonal climatology, so that the covariance structure reflects internal variability. Once these changes are accounted for, it is found that the zonal mean variability of the atmosphere stays remarkably constant, despite significant changes in the baseline climate forecast for the rest of the century. This stability of the internal variability makes it possible to relate trends in climate to teleconnections.