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A zonal wavenumber-3 pattern of the North winter circulation: Linking interannual variability and trend

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Interannual variability and trend in the northern winter large-scale circulation over the last 50 years or so are often interpreted in terms of the Northern Hemisphere Annular Mode (NAM). However, NAM corresponds to co-variations in North Pacific and North Atlantic high latitude surface pressure of the same sign, while observed trends have been of opposite sign in these regions. In this study, we find a better correspondence between modal behavior and trend if we use 300hPa meridional wind (v300), rather than surface pressure, as the key variable. This variable accentuates the zonally asymmetric component of the circulation, which is important for regional climate. Based onto December-February means from the 1958-2011 NCEP/NCAR reanalysis, we find that the linear trend of v300 resembles the second Empirical Orthogonal Function (EOF) of v300 detrended interannual fluctuations; both show a distinct zonal wavenumber-3 (Wave 3) structure at 50-70N. Both at and above the surface, the structure of fields associated with this pattern, which in its positive phase corresponds to an eastward shift in the climatological stationary waves, are much closer to observed trends than are fields associated with the NAM. In particular, the associated surface pressure field corresponds to fluctuations of the same sign in North Pacific and North Atlantic high latitudes. Given the importance of this mode, especially in the context of climate change, we have examined a number of CMIP3 models to determine how well they represent its properties. Using both historical runs for 1950-1999 and the A1B scenario in the 21st century we find that of the total interannual variance the Wave 3 pattern represents from 5% to 14% depending on the model, while in nature it represents 13% of the variance. In both periods, depending on the model examined, we find trends of both signs. Clearly understanding the properties and dynamical origins of the Wave 3 mode and improving the representation of this pattern in models used for climate change should be a research priority.