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A simple model of Arctic freshwater flux and its connection to the Northern Annular Model

B. Newton (1) B. Tremblay (1)
(1) Lamont Doherty Earth Observatory

Temporal variability in the outflow of relatively fresh water from the surface Arctic Ocean to the Greenland Sea is studied in a two-layer, wind driven model with highly idealized geometry. The simplifications of basin geometry allow for an analytic solution that predicts anomalies of sea-surface height and pycnocline depth resulting from large-scale changes in sea-level pressure. The sea-surface height predictions are compared with time series of tide gauge measurements along the Eurasian coastline, and yield a surprising degree of consistency, given the simplicity of the model. Using NCEP sea-level pressure gradients and geostrophic balance across Fram Strait, the model predicts freshwater fluxes to the Greenland Sea that are roughly of the same size as the salinity anomalies that have been observed in the Nordic seas over the last several decades. Impacts of changes in salinity gradient across the strait are combined with the pycnocline depth anomalies to study the dynamic range of freshwater anomalies through the strait. The model thus provides a mechanism connecting changes in the principal mode of Northern Hemisphere sea-level pressure with changes in freshwater flux to the Nordic Seas and estimates the dynamic range of such anomalies.