



Solar and stratospheric influences on the Northern Atlantic Oscillation and the Southern Annular Mode: Nonlinear interaction

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The current view about the Northern Atlantic Oscillation (NAO) and the Southern Annular Mode (SAM) is that they are the properties of system internal variability and cannot be predicted. We show, at the seasonal time scale, that the 3-yr running correlation coefficient between the winter-time NAO and geomagnetic Ap index is well correlated to the 11-yr sunspot cycle. Using dynamic linear regression (DLR), an approach to modelling nonstationary time series, we find that both the NAO and the SAM can be successfully simulated using a simple non-linear equation at annual to biennial time scales. A quasi-22-year cycle is identified by the DLR model and shown to modulate the influence of both the 11-yr solar cycle and the upper stratospheric quasi-biennial oscillation (QBO). These results suggest that the NAO and the SAM may not be a result of purely internal variability but rather a combination of internal system dynamics and external forcing. In addition, the Sun may affect the NAO and the SAM by multiple means in a non-linear and indirect fashion. The significance of the non-linearity is that the cyclic resonance may result in a mismatch in dominant time scales between forcing and response variables. This can obscure the controlling processes for a particular time scale or time period. This explains why previous one-to-one linear correlations often exhibit confusing evidence with the correlation appearing and disappearing with time.