SELECTING SUITABLE VARIABLES FOR NUMERICAL PREDICTION MODELS OF NEW ENGLAND WINTER HYDROCLIMATE

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To provide a basis for future winter hydroclimatic forecasting, New England (NE) regional precipitation, snowfall, temperature and streamflow records have been compared with indices for the North Atlantic Oscillation (NAO), El Nino/ Southern Oscillation (ENSO), and NE regional sea surface temperatures (SSTs). Results revealed a complex array of interrelationships on several spatial and temporal scales (Bradbury et al. 2002a; 2002b); initial results from a lead-lag study suggest that all three variables could be useful for forecasting regional winter climate. Also, analyses of regional storm tracking (in progress) and tropospheric airflow patterns (Bradbury et al. 2002b) provide evidence for physical mechanisms responsible for some of the observed statistical links. Thus, the process of developing a winter climate prediction model begins with a plausible conceptual model for past changes in low-frequency (monthly to interannual) regional climatic behavior.

In winter, the US East Coast marks the boundary between a cold (often snow-covered) continent and the warmer Atlantic Ocean, as well as the dramatic meridional SST gradient at the northern edge of the Gulf Stream, where atmospheric circulation is characterized by strong eddy activity (Lau 1988), frequent baroclinicity, and widespread regional cyclogenesis (Colucci 1976; Zishka and Smith 1980). While these fixed geographical features largely determine the mean location of the East Coast trough and associated storm tracking, intraseasonal to interdecadal variability in East Coast surface climate is evidently also related to slow-to-change global- and regional-scale climatic boundary conditions.

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In general, low frequency variability in the neighboring North Atlantic region (NAO and regional SSTs) is broadly consistent with decadal-scale trends in NE winter hydroclimate (Fig. 1). In

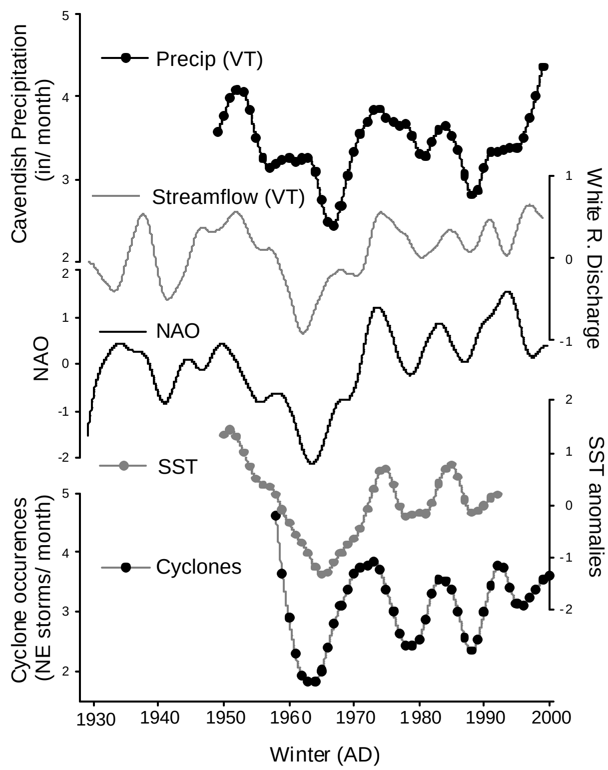

FIG. 1. Winter (Dec. – Mar.) Precipitation and Streamflow records from Vermont (VT) compared with the winter NAO, NE regional SST anomalies and an index for the frequency of regional winter storminess (cyclone occurrences). Less-than-decadal-scale variability was removed from each record objectively using a robust spline smoothing filter and spectral analysis.

addition, results from Bradbury et al. (2002b) suggest that both the NAO and NE regional SSTs are related to variability in the mean longitude of the East Coast trough (at 500-hPa), such that negative NAO and cool SSTs are associated with an eastward-displaced trough, greater upper-level convergence and drier winters in the NE region. Earlier work shows that SST anomalies in the Atlantic, east of NE and north of the Gulf Stream, are well correlated with the current and previous winter's NAO phase (Fig. 2a; Rogers and Van Loon 1979; Hartley 1996). Given the prominent link observed between regional SSTs and NE winter climate (Bradbury et al. 2002b) the strong intraseasonal persistence of this variable is also of interest (Fig. 2b). While large-scale patterns of

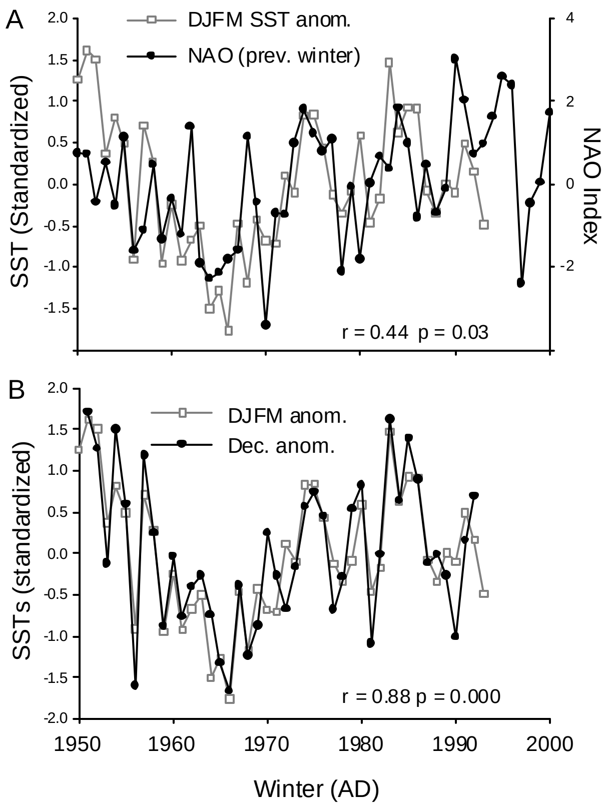

FIG. 2. a) Winter season (Dec. – Mar.) SST anomalies compared with the previous winter's NAO. b) NE regional SST anomalies for December compared with SST anomalies for the entire winter season (Dec. – Mar.).

Atlantic SST anomalies are evidently driven by surface wind anomalies associated with the NAO, there is a growing body of evidence that suggests the atmosphere can, in turn, respond thermodynamically to underlying SST anomalies, in some cases driving changes in the strength and position of regional storm tracks (Kushnir et al. 2002). Ongoing work by the authors will test the hypothesis that persistent regional SST anomalies may provide a viable seasonal predictor for regional winter storm tracking behavior.

Due to the immense inertia of the tropical Pacific Ocean, the predictive value of ENSO has been well documented in several tropical and extratropical regions. Unfortunately, ENSO's signature in NE winter climate is subtle, making it (alone) of little use as a basis for seasonal forecasting. However, ENSO's association with East Coast winter storminess has been established (Hirsh et al. 2001); ENSO indices have recently been incorporated into seasonal prediction models for frequencies of East Coast winter storms (DeGaetano et al. 2002).

Ultimately, it is evident that our ability to produce reliable forecasts for NE winter hydroclimate is dependent on the predictability of the variables included in our model. Clearly, the existence of reliable medium- to long-lead forecasts for ENSO makes this variable appealing for use in our model. Also, recent reassessments of the predictive value of the NAO (Gamiz-Fortis et al. 2002) and the related Northern Hemisphere Annular Mode (Thompson et al. 2002), via lagged associations between stratospheric and surface weather patterns (Baldwin and Dunkerton 2001), indicate that similar progress in being made in the North Atlantic. Finally, our growing understanding of factors that may influence patterns of NE regional storm tracking (i.e., SSTs) coupled with improving prediction models for the frequency of East Coast winter storms (DeGaetano et al. 2002) will undoubtedly contribute to seasonal forecasting capabilities for NE winter hydroclimate.

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