our knowledge, no one has ever attempted to investigate comprehensively to what extent (if any) the occurrence and frequency of heavy precipitation events over the northeastern US are controlled by anomalous large-scale circulation anomalies as measured, for example, by the phase and amplitude of the NAO. We hypothesize that in the northeastern US the negative phase of the NAO will be associated with a higher-than-usual frequency of cutoff cyclones and coastal storminess. In contrast, the positive phase is hypothesized to be associated with episodic occurrences of warm air advection driven precipitation events in the absence of major cyclogenesis. The opportunity exists to develop conceptual models for use by NWS forecasters of characteristic large-scale flow regimes that can be associated with distinctive cyclone structures, evolutions, tracks, and distributions of precipitation over the northeastern US. An awareness of the expected synoptic-scale flow variability as a function of large-scale flow regime can serve as a useful “first alert” to the forecaster.

Avid snowstorm enthusiasts in the northeastern US know that a strong Atlantic jet situated poleward of 50°N in winter (positive phase of the NAO) is the “kiss-of-death” to active weather (defined as frequent coastal storminess) in the northeastern US, especially if a large-scale upper-level ridge covers much of the eastern US. In such situations, the northeastern US tends to lie in the equatorward-entrance region of an anomalously strong North Atlantic jet. Cold air from Canada bypasses the US and is adverted eastward over the western North Atlantic in the confluent jet-entrance region where it is “wasted” on the fish (lots of “fishstorms” are produced) instead of being available to enhance baroclinicity over the northeastern US. Dynamically, disturbances moving toward the northeastern US from the Midwest get sheared off as they approach the confluent jet-entrance region over the North Atlantic. A large-scale environment that favors trough shearing will reduce the likelihood of major coastal storminess. However, the large-scale confluent jet-entrance region pattern can be very favorable for episodic warm-air advection occurrences. Depending upon critical thicknesses, moisture availability; and the presence of a cold surface anticyclone near or poleward of the northeastern US, this flow regime can be conducive to the occurrence of complex mesoscale precipitation patterns accompanying extratropical cyclones in the northeastern US, even for cyclones of weak or moderate intensity.

Proposed Operational Forecasting Product:

Conceptual models will be developed that relate distinctive cyclone structures, evolutions, tracks, and distributions of precipitation over the northeastern US to various large-scale flow regimes as represented, for example, by the phase and amplitude of the NAO. The procedure to be followed will consist of the following steps: 1) identify the phenomena of interest (i.e., slow-moving cutoff lows; synoptic-scale cyclones exhibiting important mesoscale substructure) over a 30+ year period; 2) depict events spatially and temporally with respect to track and stage of life cycle, as well as to the distribution of precipitation; 3) stratify and categorize events with respect to the observed large-scale flow anomalies and to the various indices that objectively define the applicable large-scale flow regimes. The third step will benefit substantially from the horse sense and expertise of the forecasters at NCEP/HPC and the participating WFOs. The resulting conceptual models will be formulated graphically and will be suitable for Web-based display. These conceptual models will provide a welcome “first alert” to the forecaster of the “problem of the week” based upon operational guidance concerning present and expected large-scale flow regimes. Such “first alerts” are even more appreciated when significant, abrupt changes to the large-scale flow regime can be anticipated.

• Improve the prediction of the distribution of precipitation in association with slow-moving cutoff cyclones in the northeastern US, where complex terrain plays a critical role.

WFO Binghamton, New York (BGM), and WFO Burlington, Vermont (BTV)

Quantitative precipitation forecasting in the case of slow-moving cutoff cyclones is very challenging in the northeastern US because the complex terrain plays a critical role in modulating the distribution of precipitation (e.g., LaPenta et al. 1995). A classic example was in December 1992 when upwards of 1 m of snow fell over the northern Catskills and the Berkshires in conjunction with a slow-moving cutoff cyclone, while snowfall amounts in the immediate Albany area were in the 10-20 cm range. The local forecasts reflected the inherent uncertainty and difficulty. Snow was forecast in Albany, but never materialized in the early stages of the storm when the deep easterly flow poleward of the cutoff resulted in downslope flow in the Hudson Valley. Subsequently, significant snow occurred in the Hudson Valley, especially in the highlands to the east of the Hudson River (after forecasters “gave up” on the storm), as low-level winds backed to northerly and northwesterly.
One sees a variety of precipitation distributions that reflect the response of the wind shear and stability profiles in the cutoff cyclone to the complex terrain of the northeastern US. We lack a basic climatology of cutoff-cyclone precipitation and an understanding of how subtle differences in the moisture, stability and lifting profiles affect the precipitation distribution. Although the cutoff cyclone precipitation issue is under consideration from a cool-season perspective, during the warmer half of the year, especially in spring or early summer when the air at midlevels is still relatively cold, deep convective outbreaks may occur in conjunction with slow-moving cold cutoff cyclones (e.g., LaPenta et al. 1995). Even though deep convection occurs preferentially in the warm season over the northeastern US, its effects are felt throughout the year, especially when heavy precipitation is involved.

**Proposed Operational Forecasting Product:**

Given the lack of a basic climatology of cutoff cyclone precipitation in the northeastern US, we propose the following: 1) perform a climatology of all 500 hPa cutoff cyclones that occurred over the northeastern US over a 30+ year period; 2) document the spatial patterns and intensity of significant precipitation associated with individual cutoff cyclones; 3) relate the precipitation distributions to cutoff cyclone track, intensity, and vertical structure, as well as to additional factors such as season, thermodynamic stability, wind shear, and orography; 4) develop a classification scheme that identifies characteristic precipitation patterns associated with cutoff cyclones categorized in terms of the attributes identified in step #3; 5) construct cyclone-relative composite analyses illustrative of the respective categories of the classification scheme developed in step #4. The resulting composites will be used to construct a comprehensive conceptual model for cutoff cyclone precipitation in the northeastern US that is amenable to Web-based graphical displays. These displays will provide forecasters with a heads-up in regard to the detailed characteristics of the expected precipitation distributions in situations where numerical guidance indicates the likelihood of significant precipitation in association with cutoff cyclones over the northeastern US.

- Understand the life cycles of precipitation-producing mesoscale substructures (e.g., banded precipitation features) within extratropical cyclones in the northeastern US.

**WFO Albany, New York (ALY), and WFO Binghamton, New York (BGM)**

The 4 January 1994 cyclone over the northeastern US illustrated many significant operational forecast problems. Although this cyclone may have been a more extreme event than usual, we suspect that almost all synoptic-scale cyclones will be associated with important mesoscale features (defined as ones that the general public will notice) if only we would scrutinize the data carefully enough (e.g. Uccellini and Kocin 1987; Homan and Uccellini 1987; Uccellini 1990; Bosart 1999). Successful numerical circulation forecasts do not guarantee equally successful weather forecasts, because similar looking synoptic-scale flow patterns can still be associated with significantly different precipitation distributions (e.g., Roebber and Bosart 1998). Although this point is sometimes overlooked, as the taxpayers and the voters, who don’t live at the 500 hPa level, will be quick to remind us, it is crucial to anticipate how the details of the lift, instability, and moisture patterns associated with transient disturbances interact to produce mesoscale substructure in extratropical cyclones. For example, mesoscale substructure seems to be especially apparent when warm fronts attempt to move poleward against entrenched shallow cold air dammed up east of the Appalachians (e.g., Bosart and Sanders 1986; Forbes et al. 1987; Bell and Bosart 1988). In such situations, elevated-base thunderstorms (e.g., Colman 1990a,b) can occur ahead of the surface warm front as moist, unstable air is forced to ascend the low-level dome of cold air. Frequently, these cool-season pre-warm frontal thunderstorms are observed to occur with snow, sleet, and/or freezing rain. This observation suggests that a vigorous secondary mesoscale circulation associated with differential cooling induced by melting snow may be important in forcing air parcels to reach their level of free convection.

Other classic examples of difficult-to-forecast cases would include the unforecast heavy snowstorm across parts of northeastern Massachusetts in December 1996 and the April Fool’s Day storm of 1997, the latter of which dumped between 50 and 90 cm of snow across parts of New York and New England. The latter storm featured banded precipitation structure associated with conditional symmetric instability (CSI), deep convection, and orographically enhanced upward motion, all occurring in the presence of lift associated with warm-air advection and frontogenetical forcing. Banded precipitation is frequently observed in cyclones, and arguments have raged as to the