Observations and Modeling of Shelf-Slope Front Seasonal Variability Between 75° and 50° W

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ABSTRACT

The shelf-slope front (SSF) located off the northeastern United States and Canada is an oceanographic front separating colder and less-saline continental shelf waters from generally warmer and more-saline slope waters over the continental slope. The surface expression of the SSF is visible year-round using sea surface temperature (SST) data obtained from satellite-based infrared radiometers. Availability of 20 years (1973-1992) of SSF positions, digitized from weekly satellite-derived SST charts between 75°-50°W longitude, allows a detailed spatial analysis of the seasonal variability of the SSF position between Cape Hatteras and the Tail of the Grand Banks. Results show an overall maximum seaward (shoreward) extent during winter (summer), consistent with earlier work. However, our more detailed spatial analysis shows that the eastern-most and western-most monthly SSF anomalies, relative to the long-term (1973-1992) mean are 180° out of phase, with maximum seasonal SSF variability of O(±50 km) occurring generally east of 58°W. Furthermore, seasonal westward meander propagation of the seaward-most (landward-most) SSF position is evident between 50° and 58° W from November to April (May to October), decreasing in amplitude towards the west. A simple Ekman coastal plume model incorporating gridded wind stress anomalies and a constant plume depth (h_c=25 m) reproduces the general seasonal cycle of the SSF along with the east-west phase shift, except in easternmost regions where SSF positional variability is maximal. The east-west phase shift results from interaction between the slowly varying (in space) wind-stress anomalies and the abrupt change in orientation of the mean along-SSF direction, from a mean of 81.8°±14.3° T between 50.5° and 70.5°W, to a mean of 51.3°±24.0° T) between 70.5° and 74.5°W. A more complex Ekman coastal plume model that allows the upper layer to evolve to a uniform thickness through shear-induced mixing and a critical Richardson number criterion (h_c=variable), overestimates onshore movement of the SSF south of Nantucket Shoals by a factor of 2-3 compared to August-October observations. While clearly not locally wind-forced, we speculate that a possible source of the seasonal, westward-propagating SSF meander is due to seasonal variability in the volume of shelf waters within this eastern-most region resulting from Labrador Current transport that is maximum (minimum) during fall (spring) upstream of the Tail of the Grand Banks and within the Labrador Sea. Comparisons of the seasonal movements of the satellite-derived surface SSF position with previously-published sub-surface expressions of the SSF and shelf water volumes derived from hydrographic data collected within the Middle Atlantic Bight section of our domain, demonstrate decoupling of the surface wind-forced SSF from the sub-surface thermohaline-forced SSF over seasonal timescales for this westernmost region.