7.2 EARLY DETECTION OF TROPICAL CYCLONES USING SEAWINDS-DERIVED VORTICITY

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Prior to the advent of scatterometer-based ocean surface vector-wind observations, routine surface wind observations near a TC were found only by ships of opportunity, buoys, reconnaissance airplane dropsondes, or by coastline observation stations and their Doppler radar systems (Tuttle and Gall 1999). Satellite-borne scatterometers have been useful in monitoring the location and intensity of TCs (Hsu and Liu 1996; Katsaros et al. 2000). With the advent of ERS-1, spatial and temporal resolution of surface vector-wind observations were much better than before, but they were still impractical for use as an early detection tool because of the swath width and frequency of coverage. The NASA Scatterometer (NSCAT) had sufficient accuracy (Bourassa et al. 1997); however, NSCAT coverage was insufficient for the task. The SeaWinds scatterometer has improved spatial coverage and temporal resolution, and we will show that it can be used as an early detection tool.

A vorticity-based detection tool should account for the size and magnitude of vorticity features in tropical cyclones. SeaWinds observations of the 1999 Atlantic hurricane season are used to develop an objective technique for detection of TCs. This technique applies mean vorticity thresholds on two spatial scales. Vorticity is calculated within the SeaWinds swaths, rather than from a regularly gridded product in anticipation of using the technique operationally with the near-realtime data. The existence of a TC is confirmed by visual inspection using images made with and without removing rain-contaminated data.

The first spatial scale for averaging vorticity is a 3-point (75 km) by 3-point box centered on the swath points. The circulation theorem is used to calculate vorticity values from each 2 by 2 set of wind observations; a minimum of 3 wind vectors out of 4 in a square is required for the calculation. This approach allows the vorticity to be calculated at the same spatial density as the wind observations. For the second spatial scale vorticity is averaged over a 7-point (175 km) by 7-point box. All wind vector data are used in these calculations (i.e., the rain-contaminated data are not removed). If the average vorticity in the boxes exceeds the minimum threshold vorticity (23×10^{-5} s^{-1} for the small box and 10×10^{-5} s^{-1} for the large box) and if the maximum rain-free wind speed within the boxes exceeds a certain minimum wind speed (8.9 m s^{-1} for the small box and 10.0 m s^{-1} for the large box), then a potential TC is identified. These threshold numbers are subjectively determined using the research quality SeaWinds data for the 1999 Atlantic hurricane season (the near-realtime product was not available at that time). Storms from that season had to be directly ‘hit’ by the QuikSCAT swath (i.e., the storm center could not be at the edge of the swath) and their central circulation pattern had to be clear of any landmasses to be considered in our determination of a threshold. Due to the small sample of storms that fit this criteria, the thresholds might be too large, but are ideal for lowering 1999's false alarm rate.

The domain used to develop this technique is the Gulf of Mexico, the Caribbean Sea, and the tropical Atlantic in the latitude band from 10°N to 25°N. Points north and south of this band are excluded because they are climatologically unfavorable origin points for TCs, and TCs did not develop there in the 1999 season. Test runs farther north are also susceptible to mis-identifying mid-latitude frontal systems in the latter months of the hurricane season.

Our vorticity-based test is applied to research-quality QuikSCAT data for the 1999 Atlantic hurricane season (available starting 20 July 1999). Of the over 1100 swaths that passed through the domain during that period, the test identifies a total of 151 overpasses containing potential systems (e.g., TC Lenny (Fig. 1) had 6 overpasses). Most of the identified systems are NHC-classified TCs (41.1%). Of the 14 TCs that occurred during the 1999 season, 9 are identified before the NHC classified them as TCs. The average early detection time for these nine storms is 36 hours before the NHC classified them as TCs.

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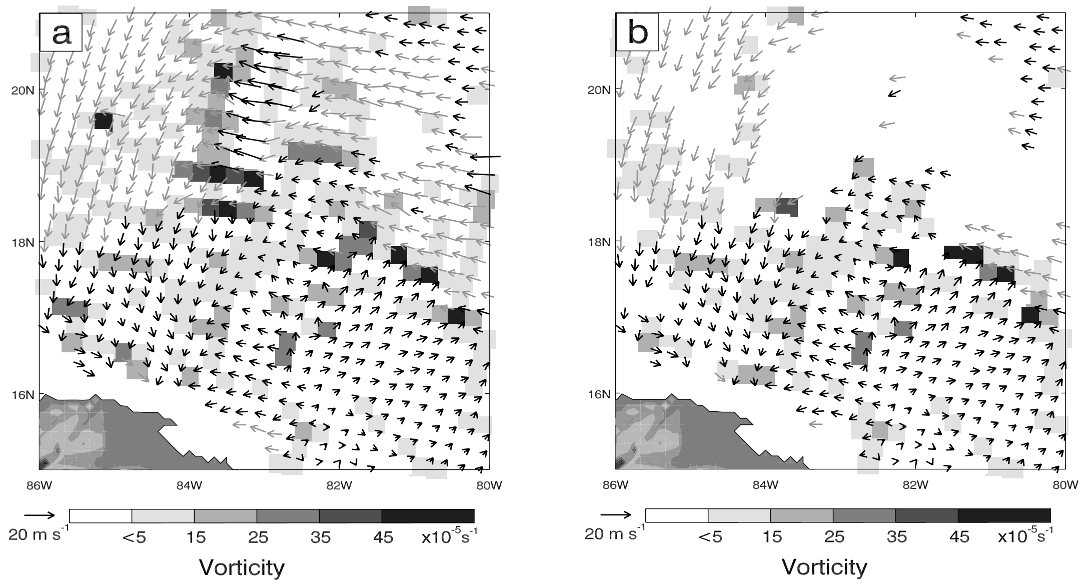

Fig. 1. Lenny, as viewed by SeaWinds, 46 hours before the NHC classified it as a 2334 UTC 11 November 1999). The gray scale represents in-swath vorticity. Wind speed is proportional to arrow length. Small black arrows represent wind speeds less than 8.9 m s^{-1} (20 mph). Gray arrows represent wind speeds between 8.9 and 17.3 m s^{-1} (39 mph), and long black arrows represent wind speeds greater than 17.3 m s^{-1}. The left figure (a) displays all wind vectors, whereas the right figure (b) does not display the rain-contaminated wind vectors.

The threshold values derived from the 1999 Atlantic hurricane season are applied to the available data for the 2000 season. Most of the detected systems have closed circulations (61.6%). The detection technique finds ten of the storms an average of 23 hours before the NHC classified them. This reduction in early warning is probably due to the inclusion of QuikSCAT data in the NHC's determination of a closed circulation.

The near-realtime data set used in this study became available on 18 August 2000. Compared to the research-quality data, a smaller percentage of the detected systems are closed circulations (46.5%). Despite this decreased accuracy, the vorticity-based test still detects five of the TCs before the NHC times, which is two less than found in the research-quality data for the same time period.

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