1.4 THE USE OF THE HYDRO-NOWCASTER FOR MESOSCALE CONVECTIVE SYSTEMS AND THE TROPICAL RAINFALL NOWCASTER (TRaN) FOR LANDFALLING TROPICAL SYSTEMS

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1. BACKGROUND

The Satellite Analysis Branch (SAB) of the National Environmental Satellite, Data, and Information Service (NESDIS) provides satellite-derived Geostationary Operational Environmental Satellite (GOES)-based Quantitative Precipitation Estimates (QPEs) for heavy rain or snow (including Lake Effect) over the contiguous U.S. and Puerto Rico. SAB's efforts concentrate primarily on locations where there is a potential for or occurrence of heavy precipitation and/or flash flooding. These estimates are sent in both text and graphic format to National Weather Service (NWS) field forecasters via the Advanced Weather Interactive Processing System (AWIPS) as part of the Satellite-derived Precipitation Estimate (SPENES) message; these products are also available over the Internet at http://www.ssd.noaa.gov/PS/PCPN/precip.html. In addition to QPEs, the SPENES messages often also contain manually produced, text-format guidance on satellite analysis, trends, and short range forecasts (nowcasts).

For a number of years, these satellite-based QPEs were produced using a man-machine technique called the Interactive Flash Flood Analyzer (IFFA; Scofield 1987). The amount of manual effort that was required by the IFFA limited both the spatial coverage and the update frequency of the SPENES so that only those regions of greatest concern were monitored by SAB forecasters and were updated as resources permitted. To make the process more efficient, a fully automated algorithm called the Hydro-Estimator (H-E; Scofield and Kuligowski 2003) has been implemented and has greatly expanded the spatial coverage of satellite-based QPEs to cover the entire continental United States, and has improved their timeliness as well.

In order to extend these benefits to satellite-based nowcasting, an automatic Hydro-Nowcaster (H-N; Scofield et al. 2003a) is under development at NESDIS and hoped to complement and possibly eventually replace the aforementioned manual nowcasts produced by SAB.

2. METHODOLOGY

Successful application of the H-N has the potential to increase the lead time for some types of flash floods. However, this is not an easy task since one of the greatest challenges of an operational meteorologist is the short-term prediction of the direction and speed of movement of Mesoscale Convective Systems (MCSs). Propagation is the controlling influence on the movement of MCSs. At this time, the mechanisms of storm propagation are minimally understood. Any 3-h nowcast algorithm must take into account propagation characteristics of MCSs. Movement of MCSs involve the 0-3 h movement/propagation of existing Meso-Beta Cores (MBCs) of heavy rainfall. MBCs are defined as the coldest cloud top clusters (as determined from the GOES 10.7μm brightness temperatures) embedded within the MCS; MBCs have spatial scales of 10-100 km and time scales of 1-10 h. As a note, satellite-derived MBCs may be relatively conservative features, especially as compared to the rapidly-changing rainfall cores detected in the radar. Thus, satellite-derived MBC may be more reliable to extrapolate in the short time frame of 0-3 h.

The H-N algorithm is a Storm-Mesoscale (Inside-Out) methodology where the speed and direction of movement of the MBC are computed from two consecutive satellite images–preferably separated by 30 min or less. Pattern correlation is used to determine cloud motions, from which a motion vector is assigned to every pixel in the image. The pattern correlation is performed using only coldest 25% of GOES pixels within a 25-pixel radius, in order to isolate the MBCs. Each pixel that is assigned rainfall by the H-E is then driven through the motion vector field for 3 h and the accumulated rainfall at each location is tracked. The trends of the MBCs (as indicated by changes in temperature and

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spatial extent) are also incorporated to enhance the predicted rainfall during growth and diminish it during dissipation.

A natural extension of the H-N algorithm is to apply it to landfalling hurricanes and tropical systems. Therefore, the H-N is being modified into a Tropical Rainfall Nowcaster (TRaN) (Scofield et al. 2003b). TRaN will be tested for those tropical systems that are 6 h or less from making landfall and after the system is over land.

3. EXAMPLES

3.1. A mid-Atlantic cold front

On September 4–5 an active cold front passed through the area that contained a SW-to-NE oriented line of rainfall with embedded meso-beta convective cores. Figure 1 depicts an example of the 1- and 3-h nowcasts from the H-N compared to the corresponding rainfall accumulations from the H-E and Stage IV radar/raingauge products. The spatial patterns of rainfall predicted by the H-N are quite similar to the other analysis products; however, the H-N does appear to overestimate the rainfall in southern NC, especially for the 3-h time frame.

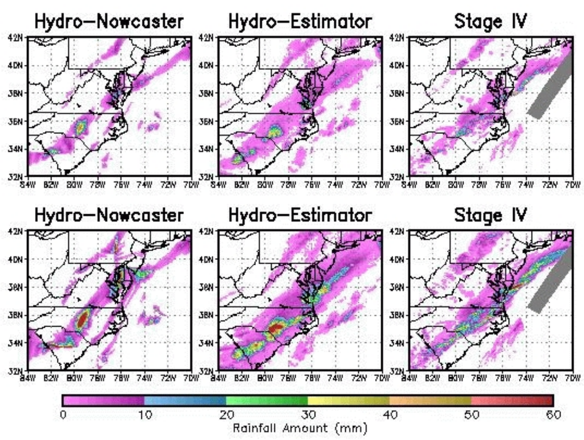

Figure 1. Comparison of the H-N, H-E, and Stage IV for the 1-h nowcast beginning 2100 UTC 4 September 2003 (top) and the 3-h nowcast beginning at the same time (bottom).

A statistical analysis of this event covering 1700 UTC on the 4^{th} to 0300 UTC on the 5^{th} is presented in Table 2. The H-N amounts have less of a wet bias than the H-E for this eveng, but the low correlations between the H-N and Stage IV amounts (at 4-km resolution) show that significant improvements are needed in both the H-N and the H-E algorithm that forms the basis of the H-N.

	1-h Nowcasts			3-h Nowcasts		
	RMSE (mm)	Bias Ratio	Correlation	RMSE (mm)	Bias Ratio	Correlation
H-E	2.3	1.89	0.41	6.7	1.99	0.41
H-N	2.4	1.26	0.27	7.4	1.51	0.20

Table 1. Summary statistics for the H-E and H-N for the period 1700 UTC 4 September to 0300 UTC 5 September 2003. All comparisons are made to the Stage IV radar/raingauge product.

3.2. Landfall of Hurricane Isabel

Hurricane Isabel struck the mid-Atlantic seaboard on 18 September 2003 as a Category 2 hurricane with 85-kt winds. Figure 2 depicts an example of the 1- and 3-h nowcasts compared to the corresponding H-E and Stage IV rainfall accumulations. Although the rainfall patterns between the H-E and Stage IV were similar, the TRaN predictions are relatively poor, including a significant underestimation of the total precipitation as indicated in Table 2. It appears that TRaN has to be modified to better account for cloud features associated with landfalling hurricanes.

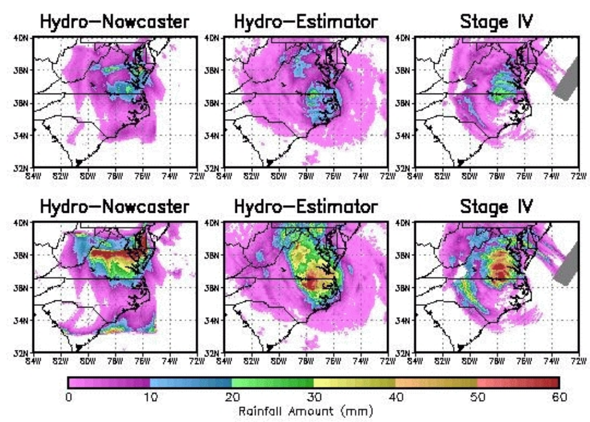

Figure 2. Same as Fig. 1, but for the 1-h nowcast beginning 2100 UTC 18 September 2003 (top) and the 3-h nowcast beginning at the same time (bottom).

	1-h Nowcasts			3-h Nowcasts		
	RMSE (mm)	Bias Ratio	Correlation	RMSE (mm)	Bias Ratio	Correlation
H-E	2.6	1.48	0.48	8.1	1.48	0.43
H-N	2.8	1.17	0.38	10.0	1.28	0.34

Table 2. Same as Table 1, but for the time period 1200-2300 UTC 18 September 2003.

4. PRODUCT ACCESS

Nowcasts from the H-N are produced every 15 minutes for the entire continental United States and are made available via the Internet via the "Hydro-Nowcaster" link on the NESDIS Flash Flood Home Page (http://orbit35i.nesdis.noaa.gov/arad/ht/ff). Fig. 3 contains an example of a 3 hour H-N product from the Web page.

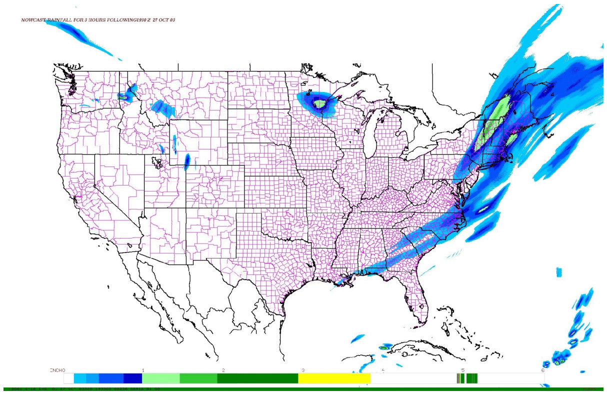

Figure 3. H-N Web page product for the 3 h beginning 1930 UTC 30 October 2003.

5. FUTURE WORK

Areas for improvement of the H-N and TRaN include:

1. Continuing to improve the H-E, since the performances of the H-N and TRaN are based largely on the accuracy of the H-E from which they are derived;
2. Improving the scheme for depicting MBC growth and decay;
3. Developing a non-linear advection scheme for circular storms that have a rotational as well as a translational component of movement;
4. Continue to improve understanding of phenomena associated with heavy rainfall, including MCSs and the various structures within tropical systems such as the Central Dense Overcast (CDO) and banding areas.

5. REFERENCES

Scofield, R. A., 1987: The NESDIS operational convective precipitation estimation technique. Mon. Wea. Rev., 115, 1773-1792.

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