P3.45 IMPROVEMENTS TO THE EXPERIMENTAL TROPICAL RAINFALL POTENTIAL (TRaP) TECHNIQUE

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1. INTRODUCTION

As discussed by Kidder et al. (2001), heavy rainfall from landfalling tropical cyclones is a major threat to life and property. Rappaport (2000) found that in the contiguous United States during the period 1970–1999, freshwater floods accounted for more than half of the 600 deaths directly associated with tropical cyclones.

Forecasting rainfall from landfalling tropical cyclones is a difficult task. While the storm is offshore, few rainfall observations are possible, and initializing NWP models with sufficient details of the storm so that accurate rainfall forecasts can be made is extremely difficult. Radar observations of storm rain rate and rain area are valuable, but only when the storm is within radar range of the coast.

Since 1992, the Satellite Services Division (SSD) of the National Environmental Satellite, Data and Information Service (NESDIS) has experimentally used the operational Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) rain rate product (Ferraro 1997) to produce a rainfall potential for tropical disturbances expected to make landfall within 24 hours. The launch in 1998 of the first Advanced Microwave Sounding Unit (AMSU) on the NOAA-15 satellite provided an additional rainfall data source.

The NESDIS/SSD technique (Kidder et al. 2000) was performed manually by an analyst and resulted in a single number called the tropical rainfall potential, defined as

$$\text{TRaP} = R_{\text{av}} D V^{-1}, \tag{1}$$

where R_{av} is the average rainfall rate of the storm, D is the diameter of the storm, and V is the speed of the storm. Kidder et al. (2001) attempted to improve the technique by automating it and by calculating the rainfall at every point in an image, so that the location as well as the amount of the precipitation could be estimated. A similar but not identical method is now initiated by NESDIS/SSD analysts to calculate TRaP images.

The TRaP technique of Kidder et al. (2001) is described in Section 2. For the 2001 western hemisphere hurricane season, the TRaP technique has been further improved. These improvements are described in Section 3. The results of the improved technique for the one case which has occurred as of this writing (Tropical Storm Allison) are presented in Section 4. Conclusions are the subject of Section 5.

2. 2000-SEASON TRaP TECHNIQUE

The TRaP technique starts with a satellite-based observation of rain rate. The Cooperative Institute for Research in the Atmosphere (CIRA) uses rain rates from the AMSU instrument produced by the NESDIS Atmospheric Research and Applications Division Hydrology Team (Ferraro et al. 2000). SSD also uses the technique with rain rates from the DMSP SSM/I and the operational NESDIS Auto-Estimator (Vicente et al. 1998).

To make the technique work properly, the time of observation of the storm must be known. CIRA uses the Tropical Prediction Center (TPC) track forecast, together with the observed storm positions and the satellite ephemeris calculated from the orbital elements, to precisely calculate the time when the satellite observed the center of the storm. Next, a cubic spline interpolation of the position of the storm center every 15 min throughout the 6-h or 24-h forecast period is calculated as well as the cubic spline position of the storm at the time of the satellite observation. At every point in the output image, the rainfall is calculated as

$$\text{accumulated rainfall} = \int_{t_1}^{t_2} R(t)dt \tag{2}$$

It is assumed (1) that everything in the rain rate image is accurate, invariant in time and moves with the storm center and (2) that the forecast track does a reasonably good job of depicting the

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future track of the cyclone. *R*(*t*) is calculated by picking out in the rain rate image the point which will be over the station at time *t*. All calculations are performed on a Mercator map grid with 8 km resolution at the equator. Since everything moves with the storm, the calculation simplifies to applying a set of *x-y* offsets for each 15 min time period.

The TRaP calculation has been entirely automated at CIRA. Triggered by receipt of a track forecast fom TPC's Automated Tropical Forecasting System (ATCF; Sampson and Schrader 2000), the AMSU rain rate data are accessed, and the TRaP forecasts are made.

As reported by Kidder et al. (2001) the automated TRaP technique appeared promising.

3. 2001-SEASON IMPROVEMENTS

The TRaP technique has been improved in three important ways. First, a second satellite (NOAA-16) carrying the AMSU instruments has been launched. This approximately doubles the number of observations of a particular storm.

Second, the AMSU-B rain rates have been substituted for the AMSU-A rain rates used last year. Since the spatial resolution of the AMSU-B is three times as fine as that of the AMSU-A (16 vs. 48 km) and the same rain rate algorithm is used over land and ocean, TRaPs generated this year have better spatial information.

Third, we are attempting to receive track forecasts from all the world's oceans by accessing both the TPC and the Navy version of the ATCF so that more storms can be studied.

4. RESULTS

As of this writing, one landfalling tropical cyclone has occurred in the western hemisphere during the 2001 season: Allison, the most costly tropical storm in United States history (Fig. 1). Figure 2 shows the NOAA-16 AMSU-B rain rates at 0812 UTC on 5 June 2001 while the storm was in the western Gulf of Mexico. The storm was traveling toward the north-northwest at 8 kt. Figure 3 shows the results of the TRaP calculation for the 24-h period ending at 1200 UTC 6 June 2001.

The TRaP rainfall amounts were validated against Stage III raingauge-adjusted radar data (Fulton et al. 1998) that are produced operationally by the River Forecast Centers (RFCs), in particular, the West Gulf RFC and the Lower Mississippi RFC. The 24-h estimates corresponding to Fig.3 are shown in Fig. 4.

A comparison of Figs. 3 and 4 shows that even though the TRaP technique misplaced the location of the maximum rainfall, it did a credible job both of indicating the general location of the heavy rain threat area and of estimating the peak rainfall amount. (Note that CNN reported on 6 June 2001 that "a National Weather Service employee recorded 12 inches (30 centimeters) of rainfall in about six hours at his home in the western Galveston County city of Santa Fe," Texas.) As Allison came ashore, rain developed to the east of the storm, which accounts for the heavy rain that fell in southeast Louisiana.

5. CONCLUSIONS

The experimental TRaP estimates for Allison were transmitted by NESDIS/SSD to the National Weather Service's River Forecast Center at Fort Worth and the National Center for Environmental Prediction's Hydrometeorological Prediction Center and Tropical Prediction Center hours before the storm's landfall. We conclude that the improved TRaP technique could be of significant value to forecasters concerned with landfalling tropical cyclones. We continue to collect cases, and we will have further results at the conference in October.

Acknowledgments

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Figure 1. The Interstate 45/Interstate 10 interchange north of downtown Houston on Saturday, 9 June 2001, after Tropical Storm Allison. [Courtesy of DallasNews.com.]

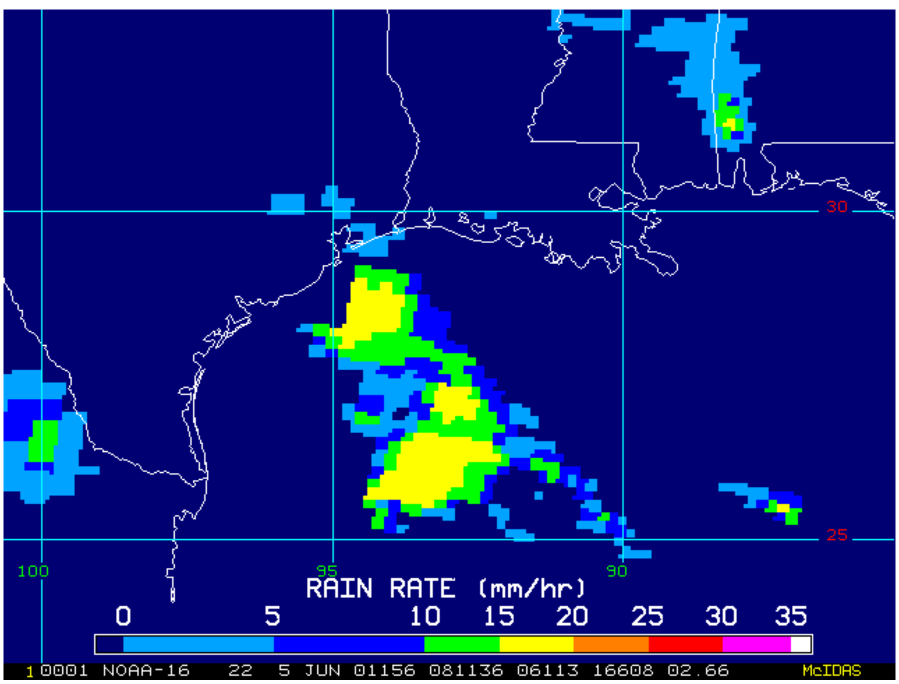

Figure 2. NOAA-16 AMSU-B rain rates for Tropical Storm Allison at 0812 UTC on 5 June 2001.

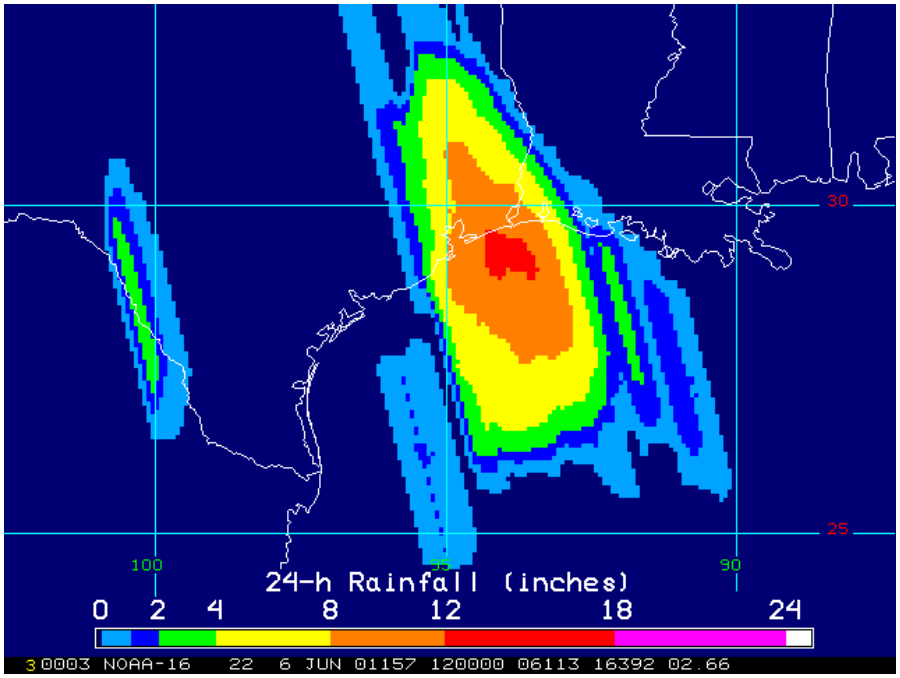

Figure 3. The 24-h TRaP for the period ending 1200 UTC on 6 June 2001. This image was created using the rain rates in Fig. 2. The peak 24-h rain amount is 12+ inches.

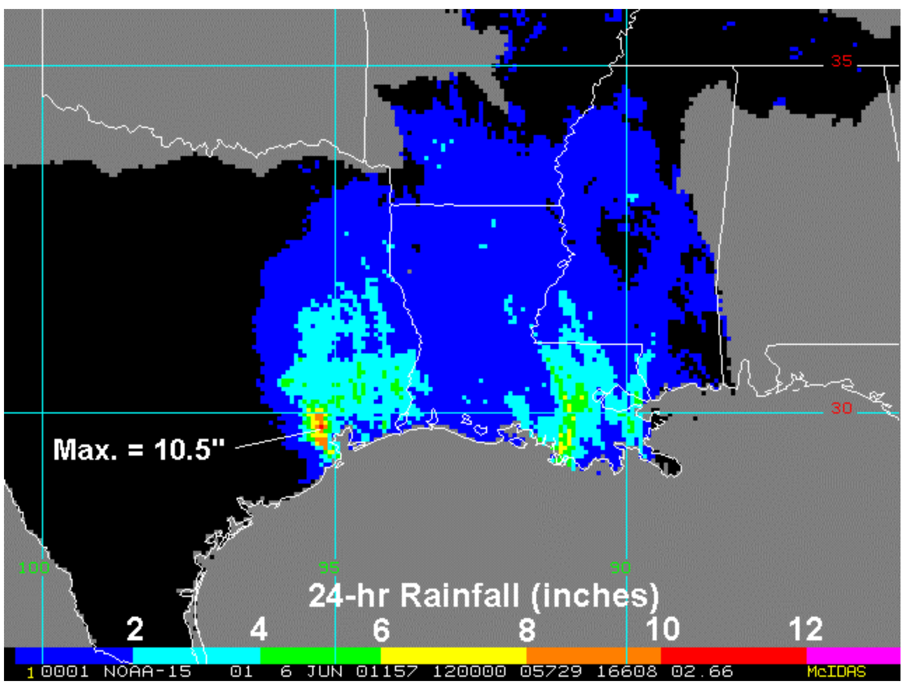

Figure 4. Stage III raingauge-adjusted radar rainfall estimates for the 24-h period corresponding to Fig. 3. Note that a NWS employee measured 12 inches at his home in Galveston County, Texas.