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PREDICTION OF TROPICAL CYCLONE TRACK FORECAST ERROR FOR HURRICANES KATRINA, RITA, AND WILMA

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1. INTRODUCTION

Consensus tropical cyclone (TC) track forecast aids formed using TC track forecasts from regional and global numerical weather prediction models have become increasingly important in recent years as guidance to TC forecasters at both the National Hurricane Center (NHC) and the Joint Typhoon Warning Center (JTWC). Forecasters at NHC routinely use forecasts from CONU, a consensus forecast aid formed using the interpolated TC track forecasts from the GFDL model (GFDI; Kurihara et al. 1993, 1995, 1998) and the Global Forecast System (AVNI; Lord 1993) run at NCEP; the Navy Operational Global Atmospheric Prediction System (NGPI; Hogan and Rosmond 1991, Goerss and Jeffries 1994) and the GFDL model (GFNI; Rennick 1999) run at FNMOC; and the UK Meteorological Office global model (UKMI; Cullen 1993, Heming et al. 1995). Goerss (2004) found that the TC track forecast performance of CONU was comparable to that for GUNA (a consensus model formed when the tracks from GFDI, AVNI, NGPI, and UKMI are all available), and that the forecast availability for CONU was decidedly superior to that for GUNA.

To provide the forecasters with some measure of confidence in the consensus forecasts, a predicted consensus error product (GPCE; Goerss 2004, 2006) was developed and installed on the Automated Tropical Cyclone Forecasting System (ATCF; Sampson and Schrader 2000) at both centers. Using stepwise linear regression and a pool of predictors from the 2001-2004 seasons, regression models were found to predict consensus TC track forecast error for each combination of forecast length, consensus model, and basin. These regression models were then used to determine the radii of circular areas drawn around the consensus model forecast positions within which the verifying TC position was expected to be contained approximately 75% of the time. These circular areas were graphically displayed on the ATCF for use by the forecasters at both NHC and JTWC.

In this study, the performance of GPCE for Hurricanes Katrina, Rita, and Wilma is examined by determining the percent of time the verifying TC position was contained within the circular area drawn around the CONU forecast position. Then its performance is more closely examined for various forecast lengths verifying at landfall for the three hurricanes.

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2. RESULTS

First, the performance of GPCE was examined by determining the percent of time the verifying TC position was contained within the circular area drawn around the CONU forecast position for the three hurricanes. For Hurricane Katrina, the area contained the verifying position 88%, 85%, 88%, 75%, and 100% of the time at 24h, 48h, 72h, 96h, and 120h, respectively. The CONU forecast errors (number of verifying forecasts) were 36 nm (24), 79 nm (20), 144 nm (16), 201 nm (12), and 267 nm (8), respectively (cf., 56 nm, 101 nm, 153 nm, 230 nm, and 312 nm for the entire season). For Hurricane Rita, GPCE verified 67%, 70%, 69%, 83%, and 100% of the time at 24h, 48h, 72h, 96h, and 120h, respectively. The respective CONU forecast errors (number of verifying forecasts) were 46 nm (24), 80 nm (20), 140 nm (16), 194 nm (12), and 188 nm (8). For Hurricane Wilma, the area contained the verifying position 74%, 76%, 62%, 52%, and 57% of the time at 24h, 48h, 72h, 96h, and 120h, respectively. The CONU forecast errors (number of verifying forecasts) were 48 nm (38), 93 nm (33), 148 nm (29), 270 nm (25), and 371 nm (21), respectively. For the three hurricanes, GPCE performed about as expected, verifying 76%, 77%, 70%, 65%, and 76% of the time at the respective forecast lengths (cf., 76%, 77%, 77%, 75%, and 75% for the entire season). For the 24-h to 72-h forecasts, GPCE verified about as expected for Rita and Wilma but overestimated the CONU forecast error for Katrina. For the 96-h forecasts, GPCE verified about as expected for Katrina, overestimated the CONU forecast error for Rita, and underestimated the CONU forecast error for Wilma. For the 120-h forecasts, GPCE overestimated the CONU forecast error for Katrina and Rita and underestimated the error for Wilma.

GPCE displays, similar to what the NHC forecasters would see on the ATCF, are shown in Figs. 1-4. In these figures the verifying TC position is denoted by a large red-orange circle. The CONU forecast position is located at the center of the red circle that encloses the area expected to contain the verifying TC position approximately 75% of the time.

The displays for various length forecasts for Hurricane Katrina verifying at 12Z and 18Z, 29 August 2005 are shown in Figs. 1 and 2, respectively. In Figs. 1a and 2a, we see that the verifying position for Katrina is located just within the circles about the position of the 120-h CONU forecasts from 12Z and 18Z, 24 August. Spread is defined to be the average of the distances between the individual forecast positions and the CONU forecast position and is a leading predictor of CONU forecast error. As one would expect, with 120-h model forecasts ranging from Louisiana to South Carolina, the

GPCE circular areas are large, indicating considerable uncertainty in the CONU forecasts. Comparing Figs. 1b and 2b, we see that, while the model 96-h forecast guidance still shows considerable spread, the model tracks and CONU 96-h forecast position from 18Z, 25 August have shifted to the west. When we compare Figs. 1c and 2c, we see a dramatic decrease in the spread of the 72-h model guidance from 18Z, 26 August. The GPCE circular area (Fig. 2c) has decreased significantly, indicating less uncertainty in the CONU 72-h forecast position. As the forecast length gets smaller, we see a continuous reduction in the size of the GPCE circular areas, indicating increasing confidence in the CONU forecast positions (Figs. 1d-f and 2d-f). With the exception of the 96-h forecasts from 12Z, 25 August (Fig. 1b), all of the GPCE circular areas contained the verifying landfall positions for Katrina.

For the Katrina landfall forecasts valid at 12Z, 29 August (Fig. 1), the CONU forecast errors were, 19 nm, 52 nm, 91 nm, 296 nm, and 252 nm at 24h, 48h, 72h, 96h and 120h, respectively. The respective forecast errors were 36 nm, 94 nm, 66 nm, 161 nm, and 252 nm for the landfall forecasts valid at 18Z, 29 August (Fig. 2). While the landfall forecast errors are for the most part smaller than the CONU forecast errors for the entire storm (and season) making it more likely that the GPCE circular areas would contain the verifying position, it is interesting to note that many of the verifying positions are close to the edge of the area. This would indicate that there was good correlation between the GPCE predicted radius and the CONU forecast error.

The GPCE displays for various length forecasts for Hurricane Rita verifying at 06Z and 12Z, 24 September 2005 are shown in Fig. 3. For the 72-h forecasts from 21 September (Fig. 3a-b), all of the models were in good agreement but their tracks were too far to the west. As a result of the small spread, the GPCE circular areas were relatively small, indicating high confidence in the CONU forecast, but the verifying landfall positions were not contained within them. For the 48-h and 24-h forecasts from 22 and 23 September (Fig. 3c-f), the models were in excellent agreement and their tracks were shifted to the east. The GPCE circular areas were very small indicating very high confidence in the CONU forecasts. With the exception of a near miss for the 24-h forecast from 12Z, 23 September (Fig. 3f), the verifying positions were contained within the circles. For the landfall forecasts valid at 06Z, 24 September, the CONU forecast errors were 34 nm, 34 nm, and 159 nm at 24h, 48h, and 72h, respectively. The respective errors for the landfall forecasts valid at 12Z, 24 September were 50 nm, 36 nm, and 170 nm.

Finally, the GPCE displays for various length forecasts for Hurricane Wilma verifying at 06Z and 12Z, 24 October 2005 are shown in Fig. 4. For the 72-h forecasts from 21 October (Fig. 4a-b), almost all of the models failed to forecast the acceleration of Wilma to the northeast. The verifying positions are to the northeast of the CONU forecast positions and fall outside the GPCE circular areas. The models do a better job for the 48-h forecasts from 22 October (Fig. 4c-d) but most are still slow with the acceleration of Wilma. The GPCE circular areas are nearly four times larger than those for Rita (Fig. 3c-d) and contain one of the verifying positions, which are to the northeast of the CONU forecast positions. For the 24-h forecasts from 23 October (Fig. 4e-f), the GPCE circular areas are nearly three times larger than those for Rita (Fig. 3e-f) and just contain the verifying positions, which are still northeast of the CONU forecast positions. For the landfall forecasts valid at 06Z, 24 October, the CONU forecast errors were 69 nm, 72 nm, and 313 nm at 24h, 48h, and 72h, respectively. The respective errors for the landfall forecasts valid at 12Z, 24 October were 72 nm, 124 nm, and 300 nm.

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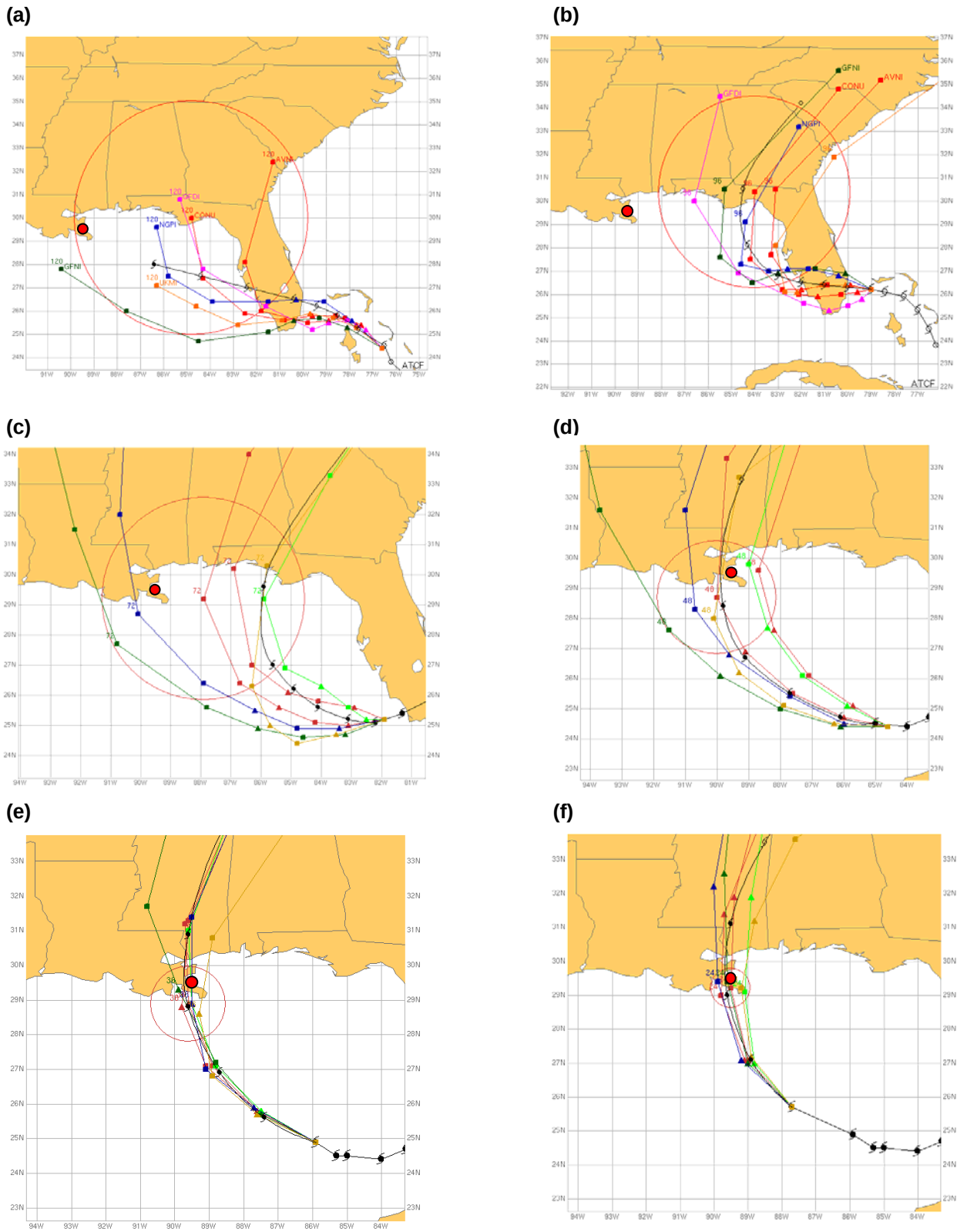

Fig.1. GPCE displays for Hurricane Katrina for (a) 120-h, (b) 96-h, (c) 72-h, (d) 48-h, (e) 36-h, and (f) 24-h forecasts valid at 12Z, 29 August 2005.

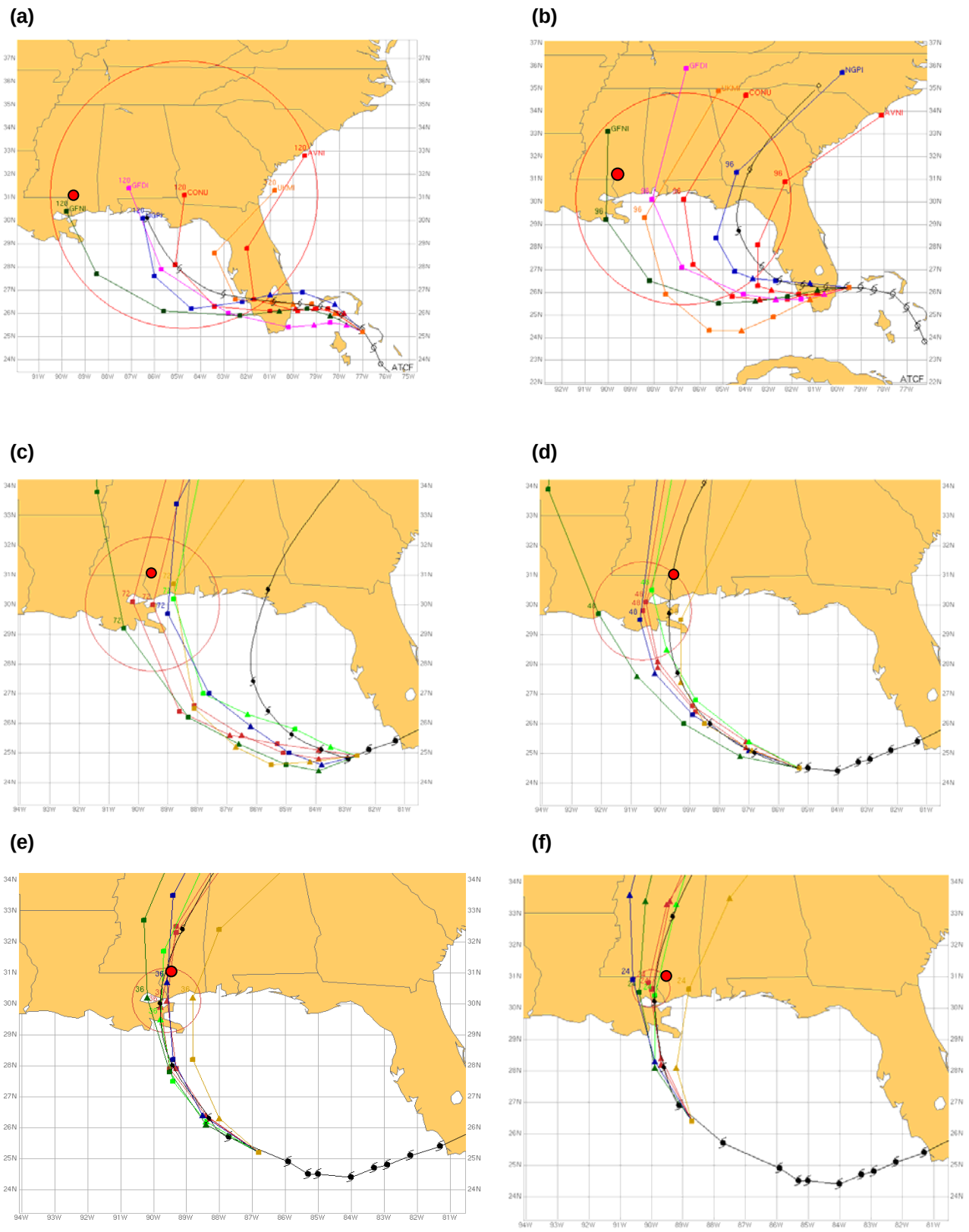

Fig.2. GPCE displays for Hurricane Katrina for (a) 120-h, (b) 96-h, (c) 72-h, (d) 48-h, (e) 36-h, and (f) 24-h forecasts valid at 18Z, 29 August 2005.

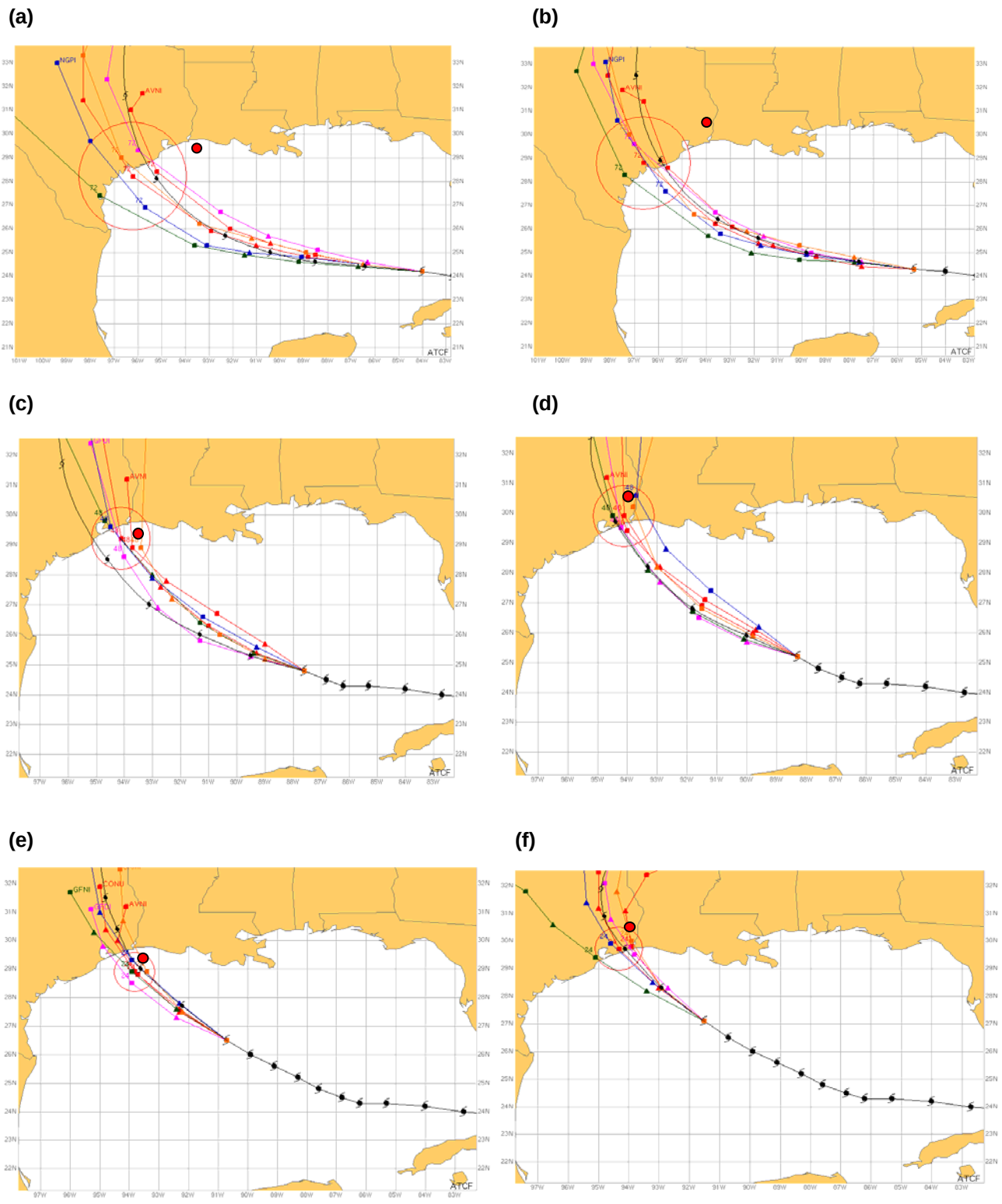

Fig.3. GPCE displays for Hurricane Rita for (a) 72-h, (b) 48-h, and (c) 24-h forecasts valid at 06Z, 24 September 2005 and for (d) 72-h, (e) 48-h, and (f) 24-h forecasts valid at 12Z, 24 September 2005.

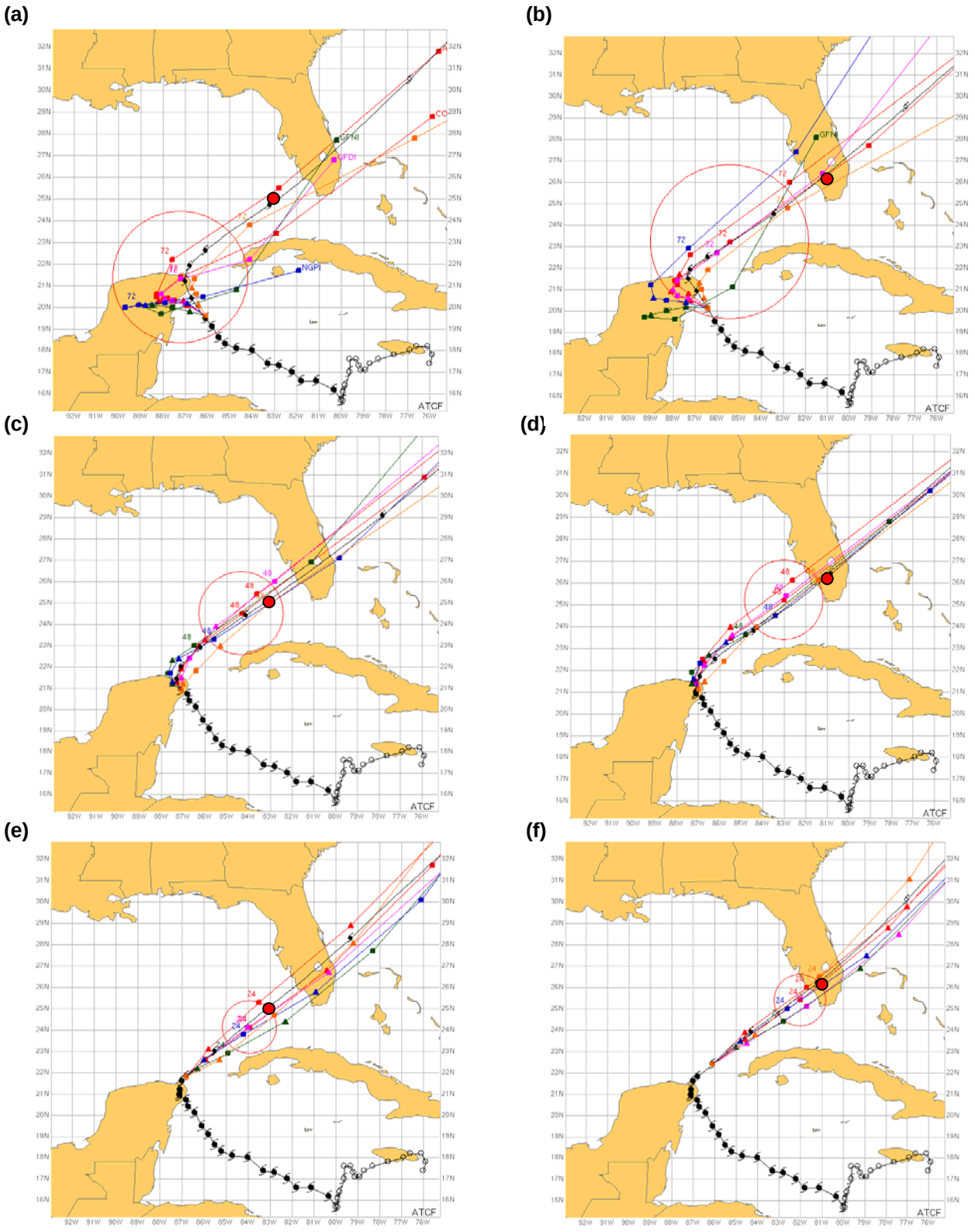

Fig.4. GPCE displays for Hurricane Wilma for (a) 72-h, (b) 48-h, and (c) 24-h forecasts valid at 06Z, 24 October 2005 and for (d) 72-h, (e) 48-h, and (f) 24-h forecasts valid at 12Z, 24 October 2005.