NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM IVO

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22 – 25 August 2013

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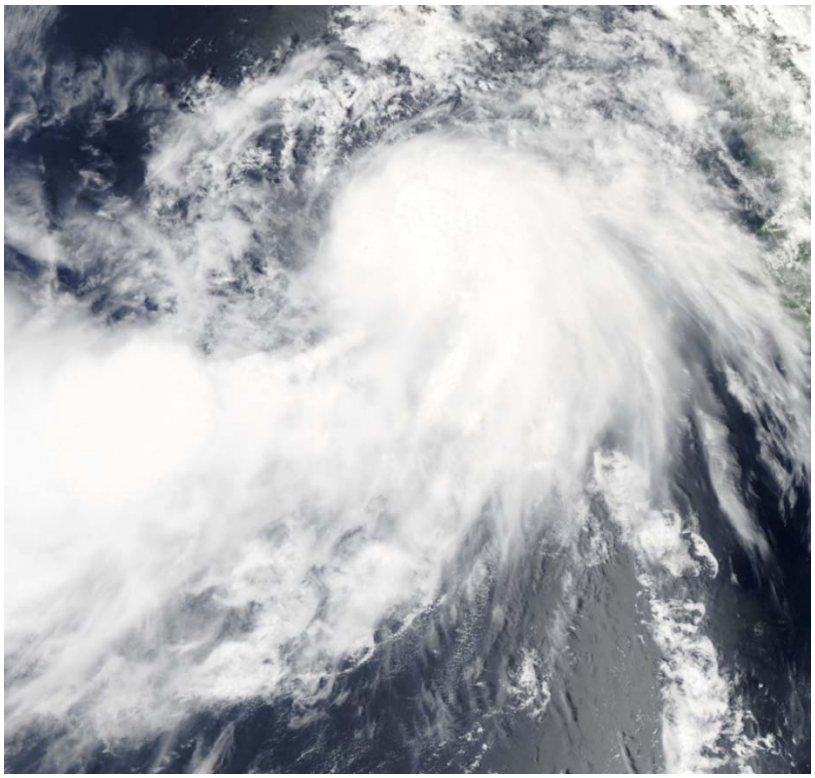

NASA MODIS VISIBLE IMAGE OF TROPICAL STORM IVO AT 2015 UTC 23 AUGUST 2013.

Ivo was a weak tropical storm that formed well west of southwestern Mexico, and moved generally north-northwestward parallel to but offshore of the southern and central Baja California peninsula. The cyclone produced heavy rains and near tropical-storm-force winds in the southern Baja California peninsula, and moisture associated with Ivo contributed to floods in the southwestern United States.

Tropical Storm Ivo

22 – 25 AUGUST 2013

SYNOPTIC HISTORY

The southern end of a tropical wave moved into the eastern Pacific south of Central America on 15 August. Little convection accompanied this disturbance during the next day or two while it moved westward to the south of Mexico. Disorganized deep convection increased on 17 and 18 August, and a broad low- to mid-level cyclonic circulation formed several hundred n mi south-southwest of Manzanillo, Mexico. Even though the system's deep convection was disorganized and intermittent, satellite data suggested that a well-defined surface low pressure area formed about 560 n mi south of the southern tip of the Baja California peninsula by 20 August. The low turned northwestward around this time, with northeasterly shear limiting the organization of the convection. The shear finally decreased early on 22 August, and a tropical depression formed around 1200 UTC that day about 430 n mi west-southwest of Manzanillo. The "best track" chart of the cyclone's path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1[1].

The depression moved slowly north-northwestward on 22 August just southwest of Socorro Island around the western side of a mid-level ridge oriented north to south over the central United States and Mexico. Meanwhile, a disturbance associated with the next tropical wave was near the coast of south-central Mexico on 20 August, well to the east of the depression. This disturbance moved slowly northwestward, parallel to but just offshore of the southwestern coast of Mexico during the next couple of days while the distance between the two systems gradually lessened. On 22 August, when the two were separated by about 350 n mi, a convergence line developed between the the depression and the other disturbance, with the most vigorous convection occurring along this line about 150 n mi to the east of the depression's center. This convection became the focus for further development, and the center of the depression reformed in this convection by early on 23 August (Fig. 4) (resulting in abrupt apparent turn to the northeast shown in Fig. 1). It was during this interaction that data from the European Space Agency's Advanced Scatterometer (ASCAT) showed tropical-storm-force winds, and it is estimated that the depression became a tropical storm around 0000 UTC 23 August.

After the interaction with the disturbance was concluded, Ivo moved northwestward around the same mid-level ridge, reaching a peak intensity of 40 kt around 0000 UTC August and moved across a strong gradient in sea surface temperatures during the next 12 h. By 0000 UTC 25 August, Ivo had turned north-northwestward, reached sub-24°C waters, and weakened to a tropical depression while gradually losing its deep convection. The cyclone became a

[1] A digital record of the complete best track, including wind radii, can be found on line at ftp://ftp.nhc.noaa.gov/atcf. Data for the current year's storms are located in the *btk* directory, while previous years' data are located in the *archive* directory.

remnant low less than a 100 n mi west of the west-central coast of the Baja California peninsula later that day. The forward motion of the circulation slowed considerably, and the post-tropical cyclone then drifted south-southwestward in the low-level flow before dissipating a couple of days later.

METEOROLOGICAL STATISTICS

Observations in Ivo (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM), the European Space Agency's ASCAT, and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Ivo.

There was only one ship report of winds of tropical storm force. The Danish ship **Sally Maersk** (OZHS2) reported winds of 35 to 40 kt between 0000 and 0300 UTC 24 August, more than 100 n mi east-northeast of the center. Socorro Island reported tropical-storm-force wind gusts late on 23 August and a minimum pressure of 997.0 mb around 1300 UTC that day when the center of the depression made its closest approach. However, post-analysis suggests that the pressure measured on Socorro Island may be a couple of millibars too low. Stronger winds could have occurred after that time since the island was in the southeastern semicircle of the cyclone where most of the strong winds were located; however, these observations are unavailable. Cabo San Lucas recorded peak 1-minute winds of 34 kt with gusts to 51 kt at 1500 UTC 23 August in outer bands associated with the cyclone. Wind gusts to near tropical-storm-force also occurred at Puerto Cortes, Mexico, early on 25 August, when the center of Ivo passed within a couple of hundred n mi of the southern Baja California peninsula.

Rainfall and Flooding

Moisture associated with Ivo was drawn into the central and northern Baja California, far northwestern Mexico, and the southwestern United States on 25 and 26 August. Although this increase in moisture caused heavy rains in Mexico, there are no observations available at this time. The increase in moisture over the southwestern United States, in combination with the forcing associated with a mid-latitude trough, triggered locally heavy rains primarily over portions of southern California, extreme southern Nevada, and Arizona. The highest rainfall totals were of 4.42 inches (112 mm) and 4.26 inches (108 mm) near Julian, California, and Grapevine Springs, Nevada, respectively.

CASUALTY AND DAMAGE STATISTICS

There were no reports of casualties directly associated with Ivo.

In the southern Baja California peninsula, heavy rains associated with Ivo caused Arroyo San Telmo (San Telmo Creek) to overflow its banks, which resulted in the flooding of 200 homes in Loreto. A total of 400 residents were evacuated with the anticipation that the rising water would affect them. Six people were reported injured. Several roadways near Loreto were damaged, and six people were injured in a car accident related to the weather in this region. The water supply to the city of Loreto was also cut off temporarily. There is no monetary estimate of damage in the areas affected.

One indirect death is attributed to the remnants of Ivo. A 77-year old woman died in San Bernandino County, California, when flash flooding associated with moisture from the former tropical cyclone swept away her vehicle near the California-Nevada state line. Mud slides and debris flows also stranded vehicles on roadways across portions of the southwestern United States. The flooding was particularly severe in the northwestern suburbs of Las Vegas, where city officials estimated the damage to be at least $300,000. Several inches of rain fell on 25 August in a short period of time, flooding streets and businesses. Flash flooding also led to 18 swift water rescues in the southwestern United States on that same date.

FORECAST AND WARNING CRITIQUE

The genesis of Ivo was well forecast. The disturbed weather from which Ivo formed was introduced into the 48-hour Tropical Weather Outlook 102 h prior to genesis (1200 UTC 22 August). The 48-hour genesis probability was then raised to the medium category (30% to 50% chance) 60 h and to the high category (60% or greater) 24 h prior to genesis, respectively. The extended-range forecasts of the genesis of Ivo were also successful thanks in part to the good model agreement in the global models. The system was introduced into the 5-day outlook for genesis nearly a week before tropical cyclone formation and placed into the high category four days before genesis.

A verification of NHC official track forecasts for Ivo is given in Table 2a. Official forecast track errors were greater than the mean official errors for the previous 5-yr period through 36 h but lower than the long-term errors at 48 h and 72 h. The initial position error, partially a result of the interaction of Tropical Depression Nine-E with another disturbance, accounted for much of the greater-than-average errors seen in the short-term portion of the official forecasts. A homogeneous comparison of the official track errors with selected guidance models is given in Table 2b. The fixed consensus model (TCON) and the variable model consensus (TVCE) consistently outperformed the official forecast, while the GFSI and HWFI models bested the official forecast at 12 and 24 h.

A verification of NHC official intensity forecasts for Ivo is given in Table 3a. Official forecast intensity errors were considerably lower than the mean official errors for the previous 5-yr period at all times through 72 h. The official forecasts correctly anticipated that Ivo would struggle to intensify due to moderately strong northeasterly shear and the large size of the tropical cyclone. A homogeneous comparison of the official intensity errors with selected

guidance models is given in Table 3b. All of the intensity guidance had errors well below the 5-yr mean errors of the official forecast, with the multi-model consensus (ICON) superior to the official forecast beyond 24 h.

Watches and warnings associated with Ivo are given in Table 4. Even though the center of Ivo was expected to remain offshore of the Mexican coast, the government of Mexico issued a tropical storm watch and warning for portions of the southwestern coast of the Baja California peninsula late on 23 August due to the large size of the cyclone's wind field.

Table 1. Best track of Tropical Storm Ivo, 22-25 August 2013.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
20 / 0600	13.6	108.2	1008	20	low
20 / 1200	13.8	108.9	1008	20	"
20 / 1800	14.2	109.6	1007	25	"
21 / 0000	14.5	110.0	1007	25	"
21 / 0600	14.8	110.3	1007	25	"
21 / 1200	15.2	110.7	1006	25	"
21 / 1800	15.7	111.0	1006	30	"
22 / 0000	16.2	111.2	1005	30	"
22 / 0600	16.6	111.4	1004	30	"
22 / 1200	17.0	111.6	1003	30	tropical depression
22 / 1800	17.4	112.0	1002	30	"
23 / 0000	17.8	112.5	1001	35	tropical storm
23 / 0600	18.3	112.5	1000	35	"
23 / 1200	18.9	112.0	999	35	"
23 / 1800	19.6	111.4	998	35	"
24 / 0000	20.5	111.8	997	40	"
24 / 0600	21.4	112.6	997	40	"
24 / 1200	22.0	113.3	998	40	"
24 / 1800	22.5	113.8	999	35	"
25 / 0000	23.1	114.1	1001	30	tropical depression
25 / 0600	23.9	114.5	1002	30	"
25 / 1200	24.7	114.9	1003	30	"
25 / 1800	25.7	115.2	1004	25	low

26 / 0000	26.7	115.6	1005	25	"
26 / 0600	27.0	115.8	1006	20	"
26 / 1200	27.0	116.0	1007	20	"
26 / 1800	26.9	116.1	1007	20	"
27 / 0000	26.7	116.2	1007	20	"
27 / 0600	26.3	116.3	1007	20	"
27 / 1200	25.5	116.4	1008	15	"
27 / 1800	24.5	116.6	1008	15	"
28 / 0000					dissipated
24 / 0000	20.5	111.8	997	40	Maximum wind and minimum pressure

Table 2a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Ivo, 22-25 August 2013. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	47.4	69.1	61.9	**49.0**	**62.5**		
OCD5	59.3	106.7	146.4	170.5	224.4		
Forecasts	11	9	7	5	1		
OFCL (2008-12)	27.0	43.1	57.8	71.9	101.7		
OCD5 (2008-12)	37.4	73.0	114.9	158.3	238.4		

Table 2b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Ivo, 22-25 August 2013. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 2a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	48.9	72.1	52.8	43.1			
OCD5	60.6	114.0	149.0	179.2			
GFSI	**40.1**	**71.7**	66.2	79.3			
GHMI	51.6	87.7	96.1	76.2			
HWFI	**45.6**	**63.1**	67.0	74.1			
EGRI	54.4	99.0	111.7	140.4			
EMXI	52.1	84.5	75.9	66.6			
CMCI	52.0	80.0	80.1	70.4			
TCON	**44.7**	**65.1**	**52.1**	46.8			
TVCE	**45.5**	**67.2**	**50.6**	**41.6**			
AEMI	**43.2**	74.4	67.2	68.8			
LBAR	64.3	112.2	92.3	108.4			
BAMS	50.5	84.5	106.0	119.4			
BAMM	54.0	93.5	106.7	103.4			
BAMD	60.3	99.4	88.3	79.0			
Forecasts	9	7	5	4			

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Ivo, 22-25 August 2013. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**3.2**	**3.9**	**5.0**	**2.0**	**5.0**		
OCD5	4.1	6.8	5.3	6.2	19.0		
Forecasts	11	9	7	5	1		
OFCL (2008-12)	6.3	10.5	13.4	14.5	15.3		
OCD5 (2008-12)	7.6	12.5	16.5	18.8	20.4		

Table 3b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Ivo, 22-25 August 2013. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	3.2	3.9	5.0	2.0	5.0		
OCD5	4.1	6.8	5.3	6.2	19.0		
GHMI	5.0	7.1	6.7	4.8	**3.0**		
HWFI	**2.8**	5.4	6.3	3.6	**1.0**		
DSHP	5.0	7.1	7.3	6.2	8.0		
LGEM	5.2	8.1	6.6	2.0	**1.0**		
ICON	4.3	5.7	**4.1**	**1.2**	**2.0**		
Forecasts	11	9	7	5	1		

Table 4. Watch and warning summary for Tropical Storm Ivo, 22-25 August 2013.

Date/Time (UTC)	Action	Location
23 / 2100	Tropical Storm Watch issued	Punta Abreojos to Punta Eugenia
23 / 2100	Tropical Storm Warning issued	Loreto to Punta Abreojos
24 / 2100	Tropical Storm Watch discontinued	All
24 / 2100	Tropical Storm Warning discontinued	All

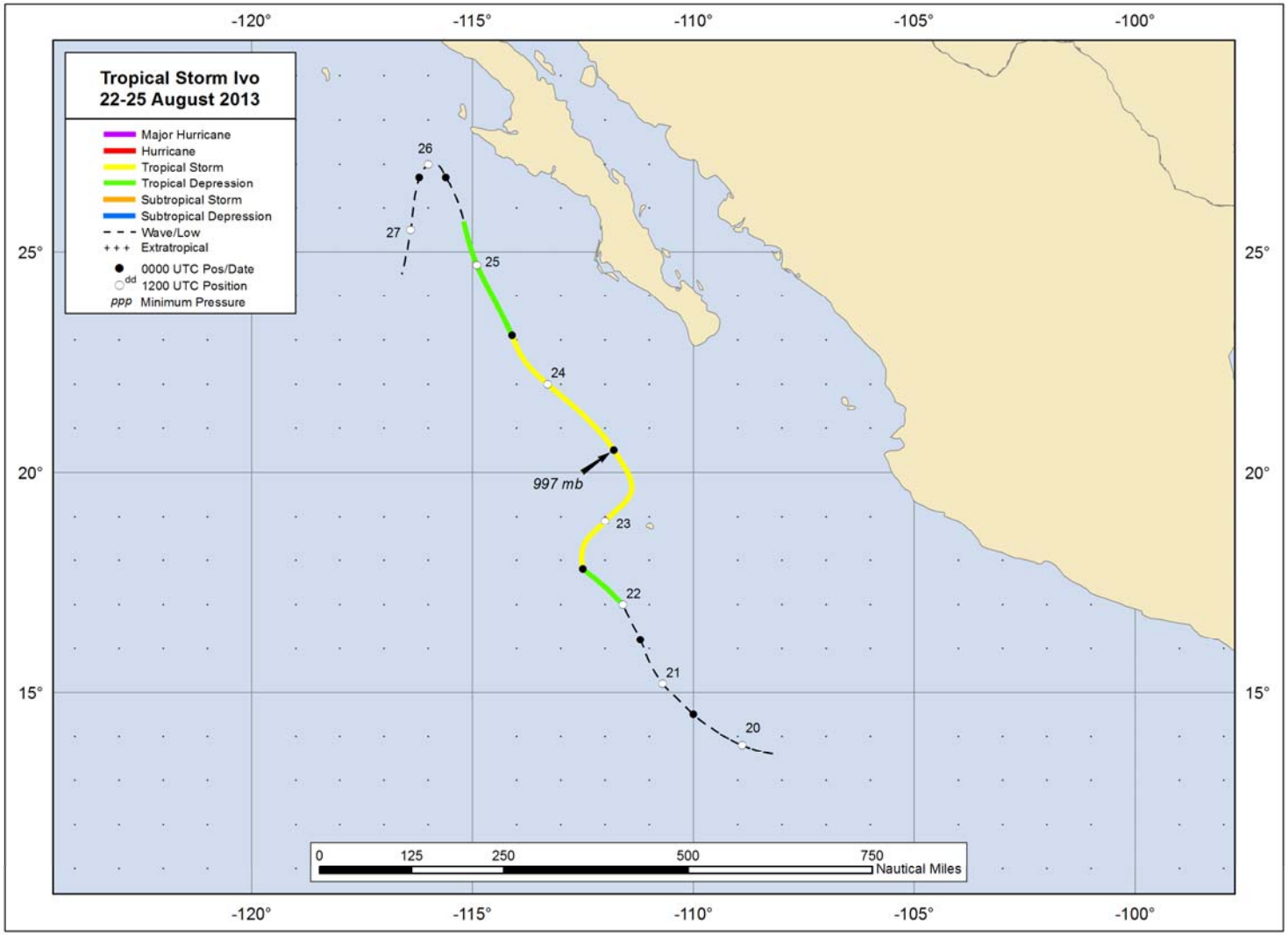

Figure 1. Best track positions for Tropical Storm Ivo, 22-25 August 2013.

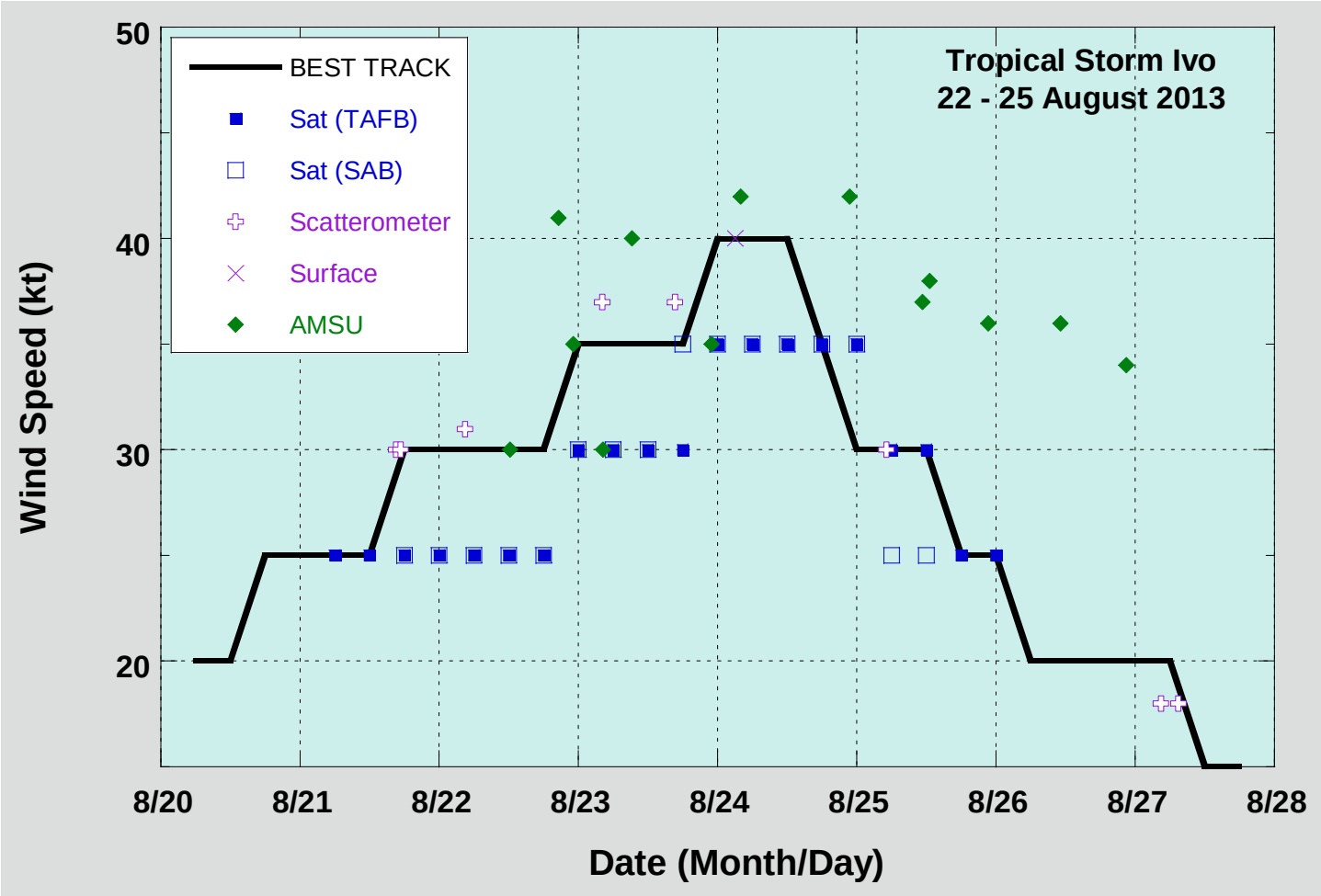

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Ivo, 22-25 August 2013. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

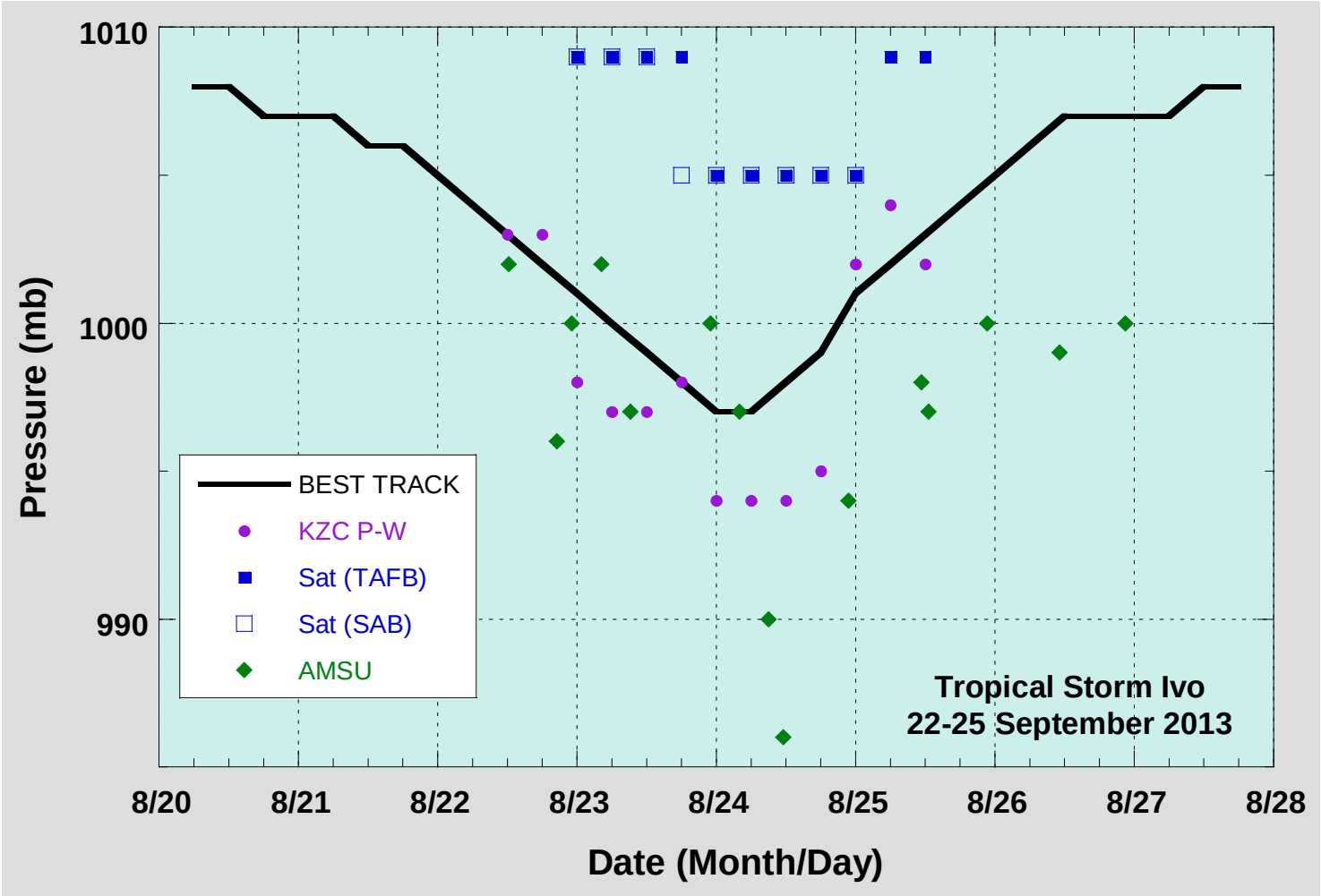

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Ivo, 22-25 August. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

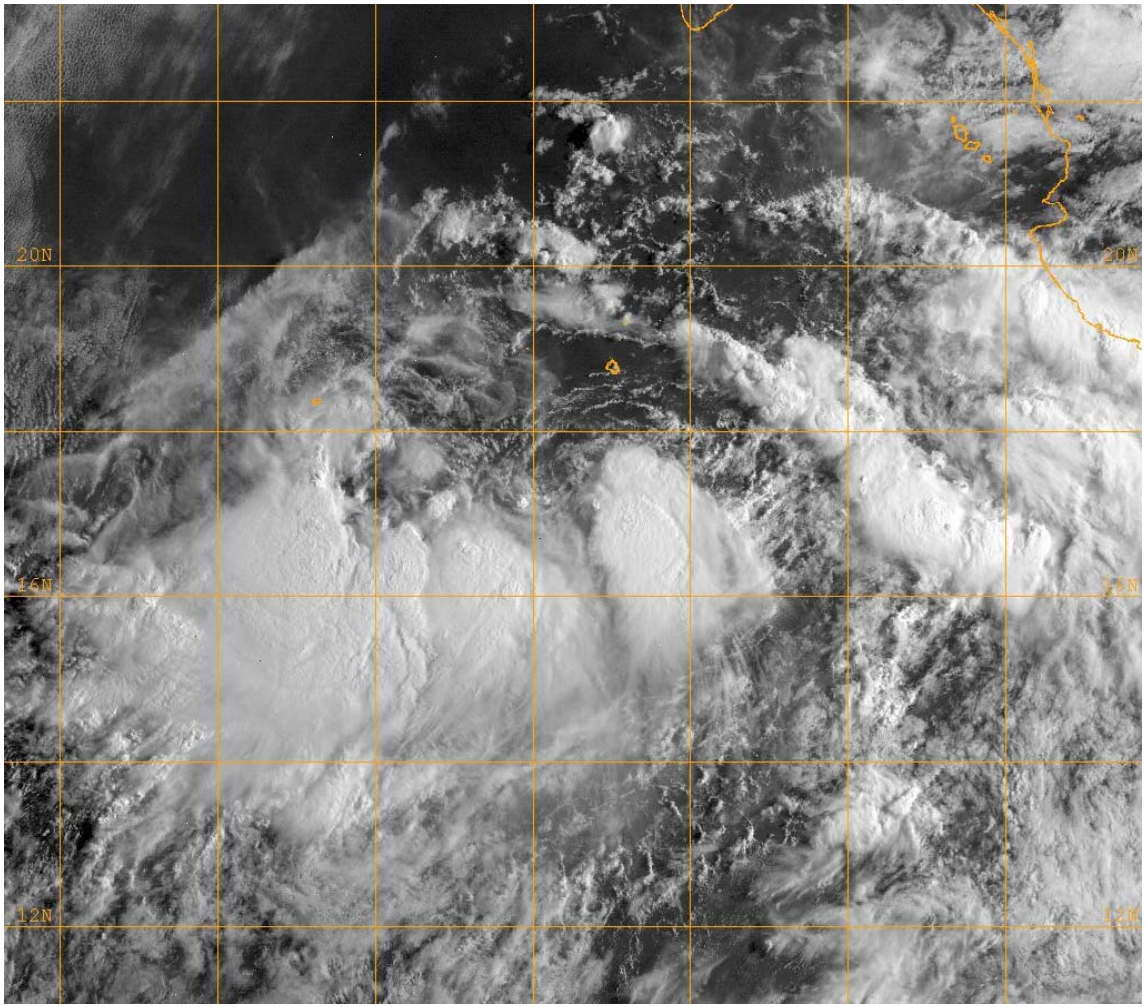

Figure 4. GOES-15 visible satellite image at 1500 UTC 22 August 2013, showing the beginning of the reformation of the center of Tropical Depression Nine-E along a line of convergence to the east of Socorro Island.