Tropical Cyclone Report
Hurricane Frances
25 August – 8 September 2004

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Frances was a Cape Verde-type hurricane that reached a peak intensity of category 4 on the Saffir-Simpson Hurricane Scale. It affected the Bahamas as a category 3 hurricane and the Florida east coast as a category 2 hurricane.

a. Synoptic History

Frances developed from a vigorous tropical wave that moved westward from the coast of Africa on 21 August. Convection associated with the wave gradually became better organized, and the first Dvorak satellite intensity estimates were made on 24 August. A tropical depression formed from the wave near 0000 UTC 25 August about 655 n mi west-southwest of the southern Cape Verde Islands. The "best track" chart of the tropical 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.

The depression moved westward on the south side of the Bermuda-Azores high and intensified, becoming a tropical storm later on 24 September. Frances turned west-northwestward on 26 August as it became a hurricane, and that heading and the intensification continued until 28 August, when Frances reached a first peak intensity estimated at 115 kt. The hurricane turned westward late on 29 August while it slowly weakened during a concentric eyewall cycle. Re-intensification began on 30 August, and Frances reached a second peak intensity of 125 kt (category 4) late on 31 August as it passed north of the Leeward and Virgin Islands. The hurricane moved west-northwestward on 1-2 September, which brought the center just north of the Turks and Caicos Islands and the southeastern Bahama Islands. The maximum winds remained 120-125 kt during this time while the hurricane underwent a series of concentric eyewall cycles. Moderate westerly vertical shear developed later on 2 September, and Frances weakened notably during the next two days. It was a category 3 hurricane, with winds of 100-110 kt, over the central Bahama Islands on 2-3 September and a category 2 hurricane, with winds of 85-90 kt, over the northwestern Bahamas on 3-4 September.

Steering currents weakened as Frances reached the northwestern Bahamas due to a high pressure ridge building west of the cyclone. This caused storm moved slowly westward across the Gulf Stream on 4 September. The shear weakened, which allowed slight re-intensification over the Gulf Stream, followed by slight weakening just before Frances made landfall over the southern end of Hutchinson Island, Florida near 0430 UTC 5 September as a Category 2 hurricane. Frances gradually weakened as it moved slowly west-northwestward across the

Florida Peninsula, and became a tropical storm just before emerging into the northeastern Gulf of Mexico near New Port Richey early on 6 September.

Frances did not strengthen over the Gulf, with maximum sustained winds remaining 50-55 kt with a pressure near 982 mb. It moved northwestward and made a final landfall near the mouth of the Aucilla River in the Florida Big Bend region about 1800 UTC 6 September. The northwestward motion continued until 7 September, when Frances re-curved northeastward into the westerlies over eastern Alabama and western Georgia. Frances weakened to a tropical depression early on 7 September and then became extratropical over West Virginia early on 9 September. As an extratropical cyclone, Frances briefly had gale-force winds as it accelerated northeastward across New York later on 9 September. The cyclone turned eastward across northern New England and southeastern Canada, dissipating over the Gulf of St. Lawrence late on 10 September.

b. Meteorological Statistics

Observations in Frances (Figs. 2 and 3) include satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB) and the U. S. Air Force Weather Agency (AFWA), as well as flight-level and dropwindsonde observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Microwave satellite imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM), the NASA QuikSCAT, the NASA Aqua, and Defense Meteorological Satellite Program (DMSP) satellites were also useful in tracking Frances. Additionally, WSR-88D Doppler radars in Puerto Rico and the southeastern United States provided detailed data on Frances, as did a U. S. Department of Defense radar located in the Bahamas.

The Air Force Reserve and NOAA Hurricane Hunters flew 34 operational missions for Frances, including standard reconnaissance and synoptic surveillance. The aircraft made a total of 59 formal fixes of Frances – 56 from the Air Force and 3 from NOAA. A NOAA aircraft reported winds of 144 kt at a flight level of 8000 ft at 1726 UTC 31 August, while Air Force aircraft measured winds of 138 kt at 700 mb at 1114 UTC 31 August and again at 0543 UTC 2 September. A dropwindsonde in the northern eyewall reported winds peak of 166 kt at a level of 904 mb near 0539 UTC 2 September. The lowest aircraft-measured pressure was 935 mb at 0712 UTC 1 September, with a 936 mb pressure reported at 0718 UTC 2 September. Several research flights also occurred, with one such mission deploying a series of drifting buoys that reported useful pressure and sea surface temperature data from Frances as well as the subsequent Hurricane Jeanne.

Frances brought hurricane conditions to much of the central and northwestern Bahamas, southeastern Florida, and the adjacent Atlantic. Ship reports of winds of tropical storm force associated with Frances are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3. The maximum sustained wind reported from a land station was 87 kt at North Eleuthera in the northwestern Bahamas at 1000 UTC 3 September. The Coastal Marine Automated Network (C-MAN) station at Settlement Point on Grand Bahama

Island reported a 10-minute mean wind of 73 kt at 2320 UTC 4 September and a peak gust of 96 kt. San Salvador in the Central Bahamas reported a peak gust of 104 kt at 1900 UTC 2 September. In Florida, an Army Corps of Engineers (USACE) station at Port Mayaca reported sustained winds of 74 kt at 0500 UTC 5 September, while a portable instrumented tower run by the Florida Coastal Monitoring Program (FCMP) at Ft. Pierce reported 70 kt sustained winds at 0402 UTC 5 September along with a peak gust of 94 kt. Unofficial reports include a sustained wind of 70 kt from the Jupiter police department and a gust to 94 kt in Martin County. It should be noted that a gust of 108 kt at Port Canaveral that was reported operationally was found to be unreliable in post-analysis.

Shipping mostly avoided Frances as it crossed the Atlantic. The highest winds reported by a ship were 43 kt from a ship with the call sign C6FV9 at 1200 UTC 5 September. Two drifting buoys reported sustained winds of 78 kt, although the reliability of these reports is uncertain.

The lowest reported pressure from a land station was 948.1 mb at San Salvador in the Bahamas at 2000 UTC 2 September. North Eleuthera reported a minimum pressure of 958.6 mb at 1400 UTC 3 September, while Settlement Point reported a minimum pressure of 963.2 mb at 1600 UTC 4 September. In Florida, the USACE station at St. Lucie lock reported a minimum pressure of 962.1 mb at 0600 UTC 5 September, while the FCMP tower at Port Salerno reported a minimum pressure of 962.8 mb at 0550 UTC that day. A storm chaser on southern Hutchinson Island reported an unofficial pressure of 959.0 mb at 0525 UTC that day, while a second storm chaser at Sewall's Point reported a pressure of 962.0 mb at 0345 UTC that day. Additionally, a drifting buoy measured a pressure of 955.2 mb at 0307 UTC 2 September.

Frances produced notable storm surges along both the Atlantic and Gulf coasts of Florida. The highest measured storm surge was 5.89 ft above mean sea level on the Florida east coast at the St. Lucie Lock. The National Weather Service Melbourne Weather Forecast Office (WFO) estimated storm surge at 8 ft near Vero Beach and 6 ft around Cocoa Beach. Lesser storm surge values were estimated elsewhere along the Florida east coast, while storm surges of 1-2 ft above normal tide levels were reported as far north as the Georgia coast. Along the Gulf coast, a storm tide of 6 ft was estimated in Pinellas County, FL, while storm tides of 3-5 ft were estimated in the Florida Big Bend area.

Frances also produced significant storm surge on several of the Bahama Islands, which the inundated the airports at Freeport, Grand Bahama, and Marsh Harbor, Abaco. However, exact surge values are not available.

Frances caused widespread heavy rains and associated freshwater flooding over much of the eastern United States (Figure 4). The maximum reported rainfall was 18.07 in at Linville Falls, North Carolina (Table 4). This was part of a swath of rains in excess of 10 in along the Appalachian Mountains in western North Carolina and northeastern Georgia. Rainfalls in excess of 10 in also occurred over large portions of the central and northern Florida Peninsula and southeastern Georgia, with storm totals of 15.84 in at High Springs, FL, 15.81 in near Chassahowitzka, FL, and an unofficial total of 15.08 in at Port Orange, FL (Table 3). Storm-

total rainfalls of 5-10 in were common elsewhere along Frances' track as a tropical cyclone, with reports of 3-6 in totals along the extratropical portion of the track.

A total of 101 tornadoes have been reported in association with Frances – 23 in Florida, 7 in Georgia, 45 in South Carolina, 11 in North Carolina, and 15 in Virginia. Many of the tornadoes occurred in an outbreak over South and North Carolina on 7 September.

c. Casualty and Damage Statistics

Frances is directly responsible for seven deaths - five in Florida, one in the Bahamas, and one in Ohio. Three deaths were caused by wind, two by storm surge, one by freshwater flooding, and one by lightning. The hurricane is indirectly responsible for 42 deaths – 32 in Florida, 8 in Georgia, 1 in the Bahamas, and 1 in Ohio.

The American Insurances Service Group reports that Frances causes $4.43 billion in damage to insured property in the United States, with $4.11 billion occurring in Florida. Applying a two-to-one ratio to this figure to account for damage to uninsured property yields a damage estimate of $8.86 billion. Additionally, space and military facilities in the Cape Canaveral area reported over $100 million dollars in property damage. Therefore, the best estimate of the total property damage from Frances is $9 billion, which in terms of unadjusted damage makes Frances the fourth most costly hurricane in United States history behind Andrew of 1992, and Charley and Ivan of 2004. This total does not include agricultural or economic losses. Widespread property damage also occurred in the central and northwestern Bahama Islands. However, no monetary damage figures are available at this time. *Note – as of 2011 the U.S. damage estimate has been revised to $9.507 billion, which makes Frances the eighth-costliest U.S. hurricane.*

d. Forecast and Warning Critique

The overall track forecast errors for Frances were exceptionally good. Average official track errors (with the number of cases in parentheses) were 20 (53), 36 (53), 52 (53), 66 (52), 80 (48), 100 (44), and 128 (40) n mi for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively. These errors are 50-70% lower than the average official track errors for the 10-yr period 1994-2003[1] (44, 78, 112, 146, 217, 248, and 319 n mi, respectively), (Table 5). Not only are the average track forecast errors outstanding, but only five of the individual track forecasts at any time exceeded the long-term average errors – two 12-h forecasts, one 36-h forecast, and two 96-h forecasts. As good as the official track forecasts were, they were bettered by some of the numerical guidance. The lowest track forecast errors amongst the guidance were from the Florida State University Superensemble (FSSE), which on average outperformed the official forecast at all times.

[1] Errors given for the 96 and 120 h periods are averages over the three-year period 2001-3.

Some of the low track forecast errors can be attributed to Frances' long track south of the subtropical ridge and the occasionally slow motion, both of which favor low track forecast errors. However, the forecast errors stayed relatively low through the time where Frances slowed near the Bahamas and turned northwestward across Florida – which were tougher forecast scenarios.

The average intensity forecast errors were also smaller than normal. Average official intensity errors were 2, 7, 10, 13, 15, 14, 14, and 16 kt for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively. For comparison, the average official intensity errors over the 10-yr period 1994-2003 are 6, 10, 12, 15, 19, 20, and 21 kt, respectively. While the average errors were low, there were two periods of rather large forecast errors. The first was early in Frances' life when the amount of intensification was underforecast. The second was as Frances approached the Bahamas when the impact of the vertical shear was underestimated, resulting in a series of forecast intensities that were too strong.

Table 6 shows the watches and warnings issued for Frances. A hurricane watch was issued for the southeastern Bahamas and the Turks and Caicos Islands at 0900 UTC 31 August, with a hurricane warning issued 6 h later. These were 33 and 27 h respectively before the closest approach of the center to the Turks and Caicos. A hurricane watch was issued for the central Bahamas at 1500 UTC 31 August, while a hurricane warning was issued at 1500 UTC 1 September. These were 52 and 28 h respectively before the arrival of the center at San Salvador Island. A hurricane watch was issued for the northwestern Bahamas at 1500 UTC 1 September, with a hurricane warning issued at 0000 UTC 2 September. These were 43 and 34 h respectively before the arrival of the center at Eleuthera Island.

In the United States, a hurricane watch was issued for the east coast of Florida at 0300 UTC 2 September, with a hurricane warning following at 1500 UTC that day. These were 73 and 61 h respectively before the center reached Hutchinson Island. Along the Gulf coast, a tropical storm watch was issued for the eventual landfall area at 1500 UTC 4 September, with a tropical storm warning following 6 h later. These were 51 and 45 h respectively before the center reached the Aucilla River.

A series of watches and warnings were issued for the islands of the northeastern Caribbean in anticipation that Frances would come close enough to produce tropical storm conditions. Also, a hurricane warning was issued for portions of the Florida Gulf coast in anticipation that Frances would maintain hurricane strength all the way across the Florida Peninsula, or re-intensify over the Gulf of Mexico. These watches and warnings did not verify.

Acknowledgements

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Service. Remote Automated Weather Stations (RAWS) data were provided by the National Interagency Fire Center. United States Geological Survey (USGS) data were provided by the NWISWeb web site. The rainfall map and much of the supplementary rainfall data was provided by David Roth of the Hydrometeorological Prediction Center. Much of the tornado data was provided by the Storm Prediction Center. Several of the unofficial observations were obtained from the Weather Underground web site.

Table 1. Best track for Hurricane Frances, 25 August – 8 September 2004.

Date/Time (UTC)	Latitude (^{o}N)	Longitude (^{o}W)	Pressure (mb)	Wind Speed (kt)	Stage
25 / 0000	11.1	35.2	1009	25	tropical depression
25 / 0600	11.2	36.8	1008	30	“
25 / 1200	11.3	38.3	1007	30	“
25 / 1800	11.5	39.8	1005	35	tropical storm
26 / 0000	11.9	41.5	1003	40	“
26 / 0600	12.3	42.9	1000	45	“
26 / 1200	12.8	44.5	994	55	“
26 / 1800	13.3	45.8	987	65	hurricane
27 / 0000	13.7	46.8	984	70	“
27 / 0600	14.2	47.8	980	75	“
27 / 1200	14.7	48.5	970	90	“
27 / 1800	15.4	49.3	962	100	“
28 / 0000	15.9	50.0	962	100	“
28 / 0600	16.6	50.9	962	100	“
28 / 1200	17.2	51.6	958	105	“
28 / 1800	17.7	52.3	948	115	“
29 / 0000	18.1	52.9	948	115	“
29 / 0600	18.4	53.6	948	115	“
29 / 1200	18.6	54.4	948	115	“
29 / 1800	18.8	55.0	948	110	“
30 / 0000	18.9	55.8	954	105	“
30 / 0600	19.0	56.8	958	100	“
30 / 1200	19.2	58.1	956	100	“
30 / 1800	19.4	59.3	948	110	“
31 / 0000	19.6	60.7	946	110	“
31 / 0600	19.8	62.1	950	115	“
31 / 1200	20.0	63.5	949	120	“
31 / 1800	20.3	65.0	942	125	“
01 / 0000	20.6	66.4	941	120	“
01 / 0600	21.0	67.9	939	120	“
01 / 1200	21.4	69.1	937	120	“
01 / 1800	21.8	70.4	941	120	“
02 / 0000	22.2	71.4	939	120	“
02 / 0600	22.7	72.5	937	125	“
02 / 1200	23.2	73.5	939	120	“
02 / 1800	23.8	74.3	948	115	“
03 / 0000	24.2	75.0	948	105	“
03 / 0600	24.7	75.7	954	100	“
03 / 1200	25.3	76.3	958	95	“
03 / 1800	25.7	77.1	960	90	“
04 / 0000	26.0	77.5	960	85	“
04 / 0600	26.4	77.9	960	85	“
04 / 1200	26.8	78.5	962	90	“

Date/Time (UTC)	Latitude (^{o}N)	Longitude (^{o}W)	Pressure (mb)	Wind Speed (kt)	Stage
04 / 1800	26.8	79.1	962	90	“
05 / 0000	27.0	79.4	958	95	“
05 / 0600	27.2	80.2	960	90	“
05 / 1200	27.4	80.7	969	80	“
05 / 1800	27.8	81.7	975	60	tropical storm
06 / 0000	28.1	82.3	978	55	“
06 / 0600	28.6	83.3	981	55	“
06 / 1200	29.2	83.7	982	55	“
06 / 1800	30.1	84.0	982	50	“
07 / 0000	31.0	84.6	984	35	“
07 / 0600	31.5	85.0	988	30	tropical depression
07 / 1200	32.0	85.2	992	25	“
07 / 1800	32.5	85.1	996	25	“
08 / 0000	33.4	84.7	998	25	“
08 / 0600	34.3	84.3	1000	25	“
08 / 1200	36.1	83.2	1001	25	“
08 / 1800	37.8	82.1	1002	25	“
09 / 0000	38.7	81.3	1001	25	extratropical
09 / 0600	40.5	80.0	1001	30	“
09 / 1200	42.8	77.7	1001	35	“
09 / 1800	44.3	75.7	1002	30	“
10 / 0000	45.3	73.3	1003	25	“
10 / 0600	46.2	70.5	1004	20	“
10 / 1200	46.6	67.3	1005	20	“
10 / 1800	47.2	64.2	1005	20	“
11 / 0000					dissipated
01 / 0700	21.1	68.1	935	120	minimum pressure
31 / 1800	20.3	65.0	942	125	maximum wind
02 / 0730	22.8	72.8	936	125	“
02 / 1930	24.0	74.5	948	110	landfall on San Salvador Island, Bahamas
03 / 0530	24.6	75.6	954	100	landfall on northern end of Cat Island, Bahamas
03 / 1000	25.1	76.1	956	95	landfall on Eleuthera Island, Bahamas
04 / 1000	26.6	78.2	961	90	landfall on Grand Bahama Island, Bahamas
05 / 0430	27.2	80.2	960	90	landfall at southern end of Hutchinson Island, FL
06 / 1800	30.1	84.0	982	50	landfall at mouth of Aucilla River, FL

Table 2. Selected ship and drifting buoy reports with winds of at least 34 kt for Hurricane Frances, 25 August – 8 September 2004

Date/Time (UTC)	Ship call sign/name	Latitude (^{o}N)	Longitude (^{o}W)	Wind dir/speed (kt)	Pressure (mb)
01 / 0700	Buoy 41544	23.0	66.7	090 / 37	1010.4
01 / 1600	Buoy 41544	23.1	66.7	090 / 41	1015.2
01 / 1601	Buoy 41927	23.6	70.1	080 / 93	1010.9
02 / 0000	Buoy 41543	24.0	70.7	100 / 39	1008.1
02 / 0000	Buoy 41539	24.4	69.1	090 / 35	1012.9
02 / 0000	Buoy 41545	24.4	70.4	090 / 39	1011.0
02 / 0307	Buoy 41922	22.2	71.9	N/A / 35	955.2
02 / 0400	Buoy 41543	24.1	70.7	120 / 49	1009.7
02 / 0600	**Anke-Angela**	26.9	72.1	090 / 36	1016.0
02 / 0700	Buoy 41545	24.4	70.4	110 / 37	1010.8
02 / 0727	Buoy 41925	22.9	71.7	130 / 70	989.3
02 / 0906	Buoy 41934	24.6	72.0	N/A / 78	N/A
02 / 0910	Buoy 41939	22.2	71.2	N/A / 52	N/A
02 / 1800	Buoy 41542	27.6	69.6	N/A / 58	1016.0
02 / 1841	Buoy 41927	23.6	70.1	N/A / 41	N/A
03 / 0243	Buoy 41926	23.1	69.1	140 / 35	1014.6
03 / 0700	Buoy 41541	24.6	76.6	320 / 49	986.7
03 / 0700	Buoy 41542	27.6	69.6	130 / 51	1015.2
03 / 1800	Buoy 41541	24.5	76.4	200 / 58	999.0
03 / 2000	Buoy 41540	27.9	78.6	N/A / 78	1009.0
04 / 0227	Buoy 41923	24.1	71.4	N/A / 49	1013.8
04 / 1900	Buoy 41540	28.3	79.2	N/A / 49	998.3
05 / 0000	**Zim California**	29.0	77.6	100 / 35	1012.0
05 / 0600	**Saudi Abha**	26.8	76.4	140 / 37	1005.4
05 / 1200	C6FV9	24.2	81.5	260 / 43	1004.0
05 / 1200	**Galveston Bay**	27.3	73.8	350 / 40	1013.0
05 / 1800	SHIP	25.0	83.4	270 / 39	1004.7
06 / 0000	**Maersk New Orleans**	29.1	78.4	120 / 35	1009.0
06 / 0900	KS004	25.8	80.1	170 / 37	1006.9
06 / 0900	**Chevron Arizona**	27.5	86.1	350 / 37	999.5
06 / 1500	**Heidelberg Express**	28.5	79.6	130 / 39	1011.8
06 / 1800	**Sea-Land Freedom**	30.1	79.7	160 / 36	1010.0
06 / 1800	**Nordon**	31.8	79.3	120 / 35	1013.0
07 / 0000	**Nordon**	31.4	80.4	120 / 37	1009.3
09 / 0300	**Nanticoke**	42.1	81.4	050 / 38	1014.0
09 / 1200	**Canadian Progress**	42.7	80.1	000 / 35	N/A
10 / 0600	3FFL8	43.1	65.1	180 / 35	1018.0

Table 3. Selected surface observations for Hurricane Frances, 25 August – 8 September 2004.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)			
Bahamas								
N. Eleuthera	03/1400	958.6	03/1000	87				
N. Norman Reef (NOAA CREWS)	03/0400	992.0	03/0100	37	53			
San Salvador	02/2000	948.1	02/1900	59	104			5.47
Alabama								
Auburn (KAUO)								
Dothan (KDHN)	07/0359	992.8	06/1937	32	45			1.00
Florida								
Alachua[l]								4.71
Altamonte Springs 7E USGS			05/1334		50			
Anclote			04/ N/A		61			
Apalachicola (KAAF)	06/1823	991.5	06/0232	31	39			1.12
Apalachicola[i]	06/1906	991.8	05/2200		41		2.48	
Astor Bombing Range (KNAE)[f]	05/1556	995.5	05/0535	28	39			
Avalon[l]								5.98
Big Carlos Pass[f]	06/0000	996.0	05/2012	40	51			
Big Cypress[g]	05/0745	990.3	05/0802		40			
Bings Landing[i]	05/2300	999.5					4.17	
Boca Raton (KBCT)			03/2030		50			
Brooksville (KBKV)	06/0147	981.4	05/1755	33	47			
Buffalo Bluff[i]							3.49	
Bunnel (KX47)[f]			07/0544	30	39			
Cache[j]			05/1716		39			
Canal C-38/S65CW[g]	05/1315	972.1	05/1315	35	58			
Canal C-38/S65DWX[g]	05/1230	972.4	05/1115	35	65			
Cape Canaveral (KCCA)[f]			05/1119	31	48			
Cape Canaveral[j]			05/1715		52			
CCUT[i]	05/2133	980.1	06/0615	44	55			

Cent. Miami-Dade[g]	05/0630	995.4	05/0456		59			
Chekika[j]					47			
Citra[l]								6.56
Clearwater Beach[i]	06/0000	984.1	05/1854	54	64		4.35	
Clewiston/CFSW[g]	05/0815	981.7	05/0745	32	56			
Crescent Beach[i]							6.62	
Daytona Beach (KDAB)	05/2000	994.9	05/1000	49	65			9.96
E. Lake Okeechobee/L006[g]	05/0730	975.3	05/0600	54	79			5.87
E. Lake Okeechobee/LZ40[g]	05/0730	972.6	05/0720		80			
Fernandina Beach (K55J)[f]			06/0855		38			
Fernandina Beach[i]	06/0800	1002.7	06/0500		43	1.55	7.73	
Ft. Lauderdale Exe. (KFXE)			04/1848		48			
Ft. Lauderdale Int. (KFLL)	05/0630	990.0	03/1916	36	48			4.26
Ft. Myers (KFMY)	05/1922	992.2	05/1859	32	42			2.89
Ft. Myers (KRSW)	05/1926	992.6	06/1010	31	40			4.44
Ft. Myers[i]	05/1836	991.9	05/0700		37		4.01	
Ft. Pierce (FCMP tower)			05/0402	70	94			
Ft. Pierce[l]			05/0300	50				3.44
Fred Howard			04/ N/A		61			
Gainesville (KGNV)	06/0044	991.0	05/2200	41	56			10.81
Hastings[l]			05/0815	36				8.35
Indian Harbor Beach (FCMP tower)	05/1259	981.9	05/1455	46	68			
Jacksonville Cecil Field (KVQQ)			06/0034	27	39			9.17
Jacksonville Craig Exe. (KCRG)[f]	06/0753	998.6	05/2053	29	52			7.10
Jacksonville I-295[i]							3.68	
Jacksonville Int. (KJAX)	06/0922	998.2	06/0017	38	54			9.13
Jacksonville Main St.[i]							4.50	
Jacksonville NAS (KNIP)	06/0655	997.6	05/2246	42	54			6.37
Kenansville[l]								6.44
Key West Intl. (KEYW)	05/0953	1002.9	05/1640	31	38			1.58
Key West NAS (KNQX)	05/0955	1002.9	05/1033		43			1.65
Key West[i]	05/1000	1003.6	04/2000		43	0.3	2.22	
Lake Apopka[k]			05/1330		43			
Lake City (KLCQ)	06/1439	994.5	06/1909	29	41			
Lake Tohopekaliga[g]	05/1545	976.0	05/1345	48	71			

Lake Wales Ridge[j]			05/1246		43			
Lake Winder[k]			05/1245		52			
Leesburg (KLEE)[f]	05/1859	988.5	05/1949		52			6.46
Live Oak[l]								8.10
Loxahatchee/LXWS[g]	05/0530	979.1	05/0600	49	76			
Marathon (KMTH)	05/0853	1001.7	05/1928		37			1.57
Mariana (KMAI)	06/2323	990.8	06/1424	32	43			1.01
Matanzas River[i]							6.88	
Mayport (KNRB)	06/0955	997.6	06/0144	45	55			5.15
Mayport[i]							6.35	
Mayport (Bar Pilots Dock)[i]	06/0724	1001.7	06/0518	36	49		5.96	
Mayport (Degaussing Structure)[i]	06/0800	1001.4	06/0900	35	51			
McKay Bay[i]			06/1318	38	55			
Melbourne (KMLB)[f]	05/1858	995.9	04/2358		63			7.95
Merrit Island Airport	N/A	984.0	05/0935	64	78			
Miami Int. (KMIA)	05/0807	995.0	05/1932	37	51			3.49
Miami WFO			04/1940		44			3.09
Naples (KAPF)			05/2007	33	47			1.06
Naples[i]	05/0900	996.3	05/1200	36	47		4.30	
NASA Tower 19[h]			05/1040	59	82			
NASA Tower 22[h]			05/1150	55	72			
NASA Tower 110[h]			05/1210	49	78			
N. Lake Okeechobee/L001[g]	05/1000	969.5	05/0715	62	83			5.84
NW Broward[g]	05/0745	986.9	04/2040		53			
NW Collier[g]	05/0900	994.6	05/1810		47			
Oasis[j]			04/2134		41			
Ocala (KOCF)	05/2255	987.8	05/1955		43			10.81
Ochopee[j]			05/0636		39			
Ocklawaha[l]								8.94
Okahumpka[l]								7.35
Opa Locka (KOPF)	05/0548	993.0	05/1730	37	47			3.43
Orlando Int. (KMCO)[f]	05/1052	989.4	05/0848	47	60			6.50
Panama City (KPFN)	06/1835	993.9	05/2241	36	53			0.49
Panama City Beach[i]	06/2200	995.4	07/0700		39			
Pembroke Pines (KHWO)	05/0542	992.0	05/0035	35	47			5.04
Perry (K40J)	06/1615	987.1	06/1701	32	41			3.54

Pierson[l]								9.05
Ponce Inlet[k]			05/2215		36			
Port Manatee[i]							4.63	
Port Mayaca (USACE)	05/0645	964.7	05/0500	74				
Port St. Lucie (Texas Tech tower)			05/0329	67	83			
Port Salerno (FCMP tower)	05/0550	962.8	05/0240	49	71			
Punta Gorda (KPGD)	05/1905	989.2	06/0538	40	50			
Putnam Hall[l]								11.64
Racy Pojnt[i]			05/2100		55			
Red Bay Point[i]							3.28	
St. Augustine (KSGJ)	05/2205	999.0	05/2015	41	53			
St. Lucie Lock (USACE)	05/0600	962.1	05/0330	37		5.89		
St. Petersburg (KPIE)	05/2216	982.4	06/0619	38	49			5.41
St. Petersburg (KSPG)	05/2147	981.4	06/0101	38	50			6.27
St. Petersburg[i]	05/2054	981.7	06/0612	36	47		5.02	
Sanford (KSFB)[f]	05/1457	989.8	04/2313	44	61			4.40
Sarasota (KSRQ)	05/2132	984.4	06/0850	36	46			4.69
Seminole Cnty. Stn. 22	05/1214	988.8	05/1451		51			5.98
Seminole Cnty. Stn. 35	05/1514	989.5	05/1257		50			5.77
Skyway Bridge			05/1418		55			
SW Palm Beach[g]	05/0630	986.9	05/0456		59			
Space Coast Regional Arpt. (Texas Tech tower)			05/1529	60	78			
Summerland Key Marine Lab			05/1710	31	37			2.07
Tallahassee (KTLH)	06/1910	984.4	05/1938	41	52			2.48
Tamiami Exe. (KTMB)	05/0827	996.0	05/2141	41	49			2.33
Tampa (KTPA)	05/2225	980.0	05/1905	39	47			5.74
Tavares[l]								7.37
Tenraw[j]			05/0723		44			
Trident Pier[i]	05/1300	989.1	05/1224	41	57		7.08	
Umatilla[l]								8.86
Vaca Key[i]	05/0900	1001.7	05/0300		36	1.0	2.22	
Vero Beach (FCMP tower)			05/0435	49	71			
Vero Beach (Texas Tech tower)			05/0907	59	73			
Vilano Beach[i]	05/2300	999.5	05/2300	33	53			
Virginia Key[i]	05/0600	994.5	05/0836	38	49		3.01	

Virginia Key AOML	05/0551	992.0	04/2031		53			2.84
W. Cent. Collier[g]	05/1100	996.6	05/0601		41			
W. Lake Okeechobee/L005[g]	05/0915	980.1	05/0845	52	78			3.53
West Palm Beach (KPBI)	05/0508	972.0	05/0656	56	71			13.56
Winter Haven (KGIF)[f]	06/1602	977.3	06/1559	40	50			
WRWX[g]	05/1630	976.1	05/1510		59			
Georgia								
Albany (KABY)	07/0042	991.8	06/1942	38	59			4.53
Alma (KAMG)	07/0002	996.9	07/0237	35	39			6.46
Atlanta Hartsfield Int. (KATL)	07/2151	998.3	07/0800		45			3.02
Bainbridge (KBGE)			06/1620		37			
Brasstown[j]			07/1206		39			
Byromville[j]			07/0005		37			
Brunswick (KBQK)	06/2319	1002.3	06/0221	27	38			
Columbus (KCSG)	07/0751	994.4	07/0251		39			3.53
Cook[j]			06/1804		34			
Douglas (KDQH)	06/2259	995.2	06/2259		35			
Ft. Benning (KLSF)	07/0655	994.1	07/0155		39			3.90
Ft. Pulaski[i]			06/1148	32	39		7.97	
Gainesville (KGVL)	08/0553	1000.1	07/1008		34			4.56
Gannett Lake (USFL)			06/0400		36			
Helen 7N[j]								11.06
Macon (KMCN)	07/0753	998.5	07/0337		44			5.66
Newnan[j]			07/0702		36			
Plains[j]			06/2003		35			6.87
St. Simon's Island (KSSI)	06/2300	1001.9	06/1807	37	47			3.45
St. Simons Island[i]						2.06	8.35	
Savannah (KSAV)	07/2253	1004.8	06/2219		35			2.37
Savannah Hunter USAAF (KSVN)	07/2255	1005.1	06/2155		38			4.51
Valdosta (KVLD)	06/2105	993.2	06/0127	31	45			6.43
Waycross (KAYS)	06/2320	997.3	07/0140		39			
Waycross[j]			06/2304		40			6.64
Waycross 9SE (USFL)			05/0204		45			
NOAA Buoy/C-MAN								

Buoy 41008	07/2250	1004.8	06/0650	33	45			
Buoy 41009[f]	05/1320	990.8	05/1450	52	66			
Buoy 41010	04/2320	1003.6	04/1350	39	52			
Buoy 41012	06/0050	1002.7	06/0100	41[e]	54			
Buoy 42036	06/0850	989.6	06/0220	42[e]	55			
Buoy 42039	06/1950	998.1	06/0450	33	41			
Buoy 45012	09/1500	1002.0	09/1000	35	43			
Cedar Key, FL (CDRF1)	06/1000	987.6	06/1120	43[e]	59			
Duck, NC (DUCN7)	08/2300	1011.9	08/1940	25[e]	34			
Dunkirk, NY (DBLN6)	09/1000	1002.2	09/1100	36	47			
Folly Beach, SC (FBIS1)	08/0700	1008.4	06/1400	33	39			
Fowey Rocks, FL (FWYF1)	05/0600	996.1	04/2000	53[e]	66			
Keaton Beach, FL (KTNF1)	06/1600	985.6	06/1740	35[e]	45			
Lake Worth, FL (LKWF1)	05/0500	972.5	05/0700	54	73			
Long Key, FL (LONF1)	05/0800	1000.7	05/0200	34	45	0.5	1.67	
Molasses Reef, FL (MLRF1)	05/0800	998.4	05/0940	42[e]	59			
St. Augustine, FL (SAUF1)	05/2200	999.0	05/2200	56	71			
Sand Key, FL (SANF1)	05/1000	1002.7	05/1840	37[e]	55			
Settlement Point, GBI (SPGF1)	04/1600	963.2	04/2320	73[e]	96			
Sombrero Key, FL (SMKF1)	05/0800	1002.6	05/1740	46[e]	81		2.23	
Tyndall Tower, Fl (SGOF1)	06/1600	992.2	06/0450	48[e]	58			
USF COMPS Stations								
Buoy NA2	05/2210	989.5	05/1810	39	47			
Aripeka (APK)	06/0212	979.2					4.64	
Egmont Key (EGK)			05/1936	45	54		4.02	
Homosassa (HOM)	06/0318	983.5	06/1724	47	57		4.51	
New Port Richey (PAS)	06/0136	979.6	05/1712	31	44		4.90	
North Florida Bay (NFB)	05/0624	999.6	05/0048	33	42	0.5	4.96	
Shell Point (SHP)	06/1706	992.7					4.92[f]	
Tarpon Springs (TAS)	06/0036	980.7	05/2030		42		4.04	
Skidaway Insitiute Stations								
Tower R2	07/2328	1005.7	06/1028	39	47			

Tower R6	07/2100	1007.6	07/1300	35	47			
Tower R8	07/2132	1006.3	06/0632	33	39			
Unofficial Observations								
Florida								
Alligator Point[m]	06/1719	984.6	05/1920		48			
Arlington[m]	06/0730	1000.6	06/0625		36			
Boca Raton			03/2030		50			
Boca Raton Wtr Treament			03/2054		61			
Boynton Beach	N/A	977.3	04/1420		61			
Boynton Beach			04/1723		66			
Boynton Beach								9.56
Clearwater[m]			06/1445	34	56			
Clermont[m]	05/1835	984.0	05/1600		56			
Delray			04/1835		52			
Deerfield Beach								8.00
Dunedin[m]	05/2315	982.3	05/1515		42			
Flagler Beach FD	05/2300	994.9	04/1730		63			
Golden Beach			04/1743		50			
Holder[m]	06/0030	987.7	06/0700		39			
Jacksonville[m]	06/0700	1000.2	06/0512		40			
Juno Beach[m]	05/0345	963.7	05/0830		55			
Jupiter PD			04/1655	70	78			
Jupiter Inlet			04/1300		79			
Kendall			04/1900		57			
Kendall			04/1940		64			
Largo[m]	05/2100	981.9	05/1700		36			
Lawtey								13.50
MacClenny	06/0840	998.0	06/0010		41			10.25
Martin County			05/1145		92			
Melbourne								7.04
Miami[m]	05/0617	995.1	05/0729		50			
New Port Richey[m]	06/0045	980.2	05/1630		43			
Odessa[m]	06/0000	979.6	05/1830		37			
Orlando Azalea Park[m]	05/1537	988.0	05/1305		50			
Orlando Pine Hills[m]	05/1815	987.7			46			
Ormond Beach PD			05/1620		50			

Oviedo								9.00
Port Orange								15.08
Riviera Beach			04/0510		66			
St. James City[m]	05/1847	993.5	05/1350		37			
St. Petersburg Beach[m]	05/2115	981.6	06/1110		50			
Sebastien[m]	05/1228	974.5	05/1128		71			
Sewall's Point	05/0345	962.0	05/0226	63	85			
S. Hutchinson Island	05/0525	959.0						
S. Lakeland	05/2100	972.3	05/1800		63			12.01
Starke[m]	06/0600	996.8	06/1600		35			
Tampa Bay Crest[m]			06/1230		50			
Tampa University Village[m]	05/2242	977.2	05/1527	37	57			
Taylor								10.00
The Villages[m]	06/0000	987.7	05/1600		37			
Valrico[m]	05/2030	974.5	05/1210		49			
West Pasco	06/0400	990.6						
Georgia								
Harris			07/0245		41			

[a] Date/time is for sustained wind when both sustained and gust are listed.
[b] Except as noted, sustained wind averaging periods for C-MAN and land-based ASOS reports are 2 min; buoy averaging periods are 8 min.
[c] Storm surge is water height above normal astronomical tide level.
[d] Storm tide is water height above National Geodetic Vertical Datum (1929 mean sea level).
[e] 10-min average wind.
[f] Incomplete record.
[g] South Florida Water Management station - 15-min average sustained wind.
[h] NASA towers are at the Kennedy Space Center and Cape Canaveral Air Force Station; elevation 54 ft; all tower records are incomplete.
[i] National Ocean Service station – sustained wind averaging periods are 6 min.
[j] RAWS station.
[k] St. John's River Water Management District station.
[l] FAWN station.
[m] Data from Weather Underground web site.

Table 4. Supplemental storm-total rainfall observations for Hurricane Frances, 25 August – 8 September 2004.

Location	Rainfall (in)		Location	Rainfall (in)
Florida			Fernandina Beach (FRBF1)	3.75
Alapaha Tower (ALAF1)	4.79		Floral City (FLCF1)	9.10
Andytown 2N	4.13		Floral City 1E (FLOF1)	9.20
Antioch (BKRF1)	7.34		Floral City 3E (LESF1)	9.20
Apollo Beach 1SE (APBF1)	6.34		Ft. Lauderdale	4.39
Archbold (ACHF1)	3.21		Ft. Meade (FTMF1)	6.12
Archbold 3S (HCAF1)	4.15		Ft. Ogden 3W (FOGF1)	3.35
Avon Park 2E (APKF1)	6.37		Ft. Ogden 11E (PWTF1)	3.40
Avon Park 2W (AVPF1)	6.57		Ft. White (FWHF1)	7.96
Balm (BLMF1)	7.01		Gardner 1S (MRSF1)	8.57
Bartow (BARF1)	5.98		Gardner 2N (GDRF1)	5.15
Bartow 3N (LKAF1)	5.83		Glen St. Mary 1W (GSMF1)	9.22
Baxter (BAXF1)	7.00		Haines City 3SW (LKEF1)	7.32
Bell 4WNW (BLLF1)	7.96		Haines City 4NNW (LLOF1)	6.15
Benton	8.85		Hastings 4NE (HTGF1)	9.42
Big Pine Key	3.28		Hernando (HERF1)	8.98
Bowling Green 1S (PAYF1)	6.21		Hernando 4NE (HNNF1)	8.91
Bradenton 1S (WCRF1)	4.10		Hernando 6N (JPOF1)	10.55
Bradenton 3SW (PSDF1)	3.89		High Springs (HGHF1)	15.84
Bradenton 11ENE (RYEF1)	4.87		Hildreth 129 Bridge (FTWF1)	7.72
Brandon 2E (BRDF1)	5.99		Hillsboro Canal	7.18
Brooksville (HLKF1)	10.82		Holder (WRHF1)	11.42
Buckingham (OLGF1)	3.77		Hollywood	4.74
Bushnell (BSWF1)	7.70		Homestead (KHST)	3.41
Carrollwood 1N (BALF1)	7.32		Inverness 1E (INRF1)	7.08
Carrollwood 1SW (WITF1)	6.43		Inverness 3SE (INVF1)	4.99
Chassahowitzka 1E (CHSF1)	15.81		Jasper (JASF1)	5.27
Chiefland 5SE (CHIF1)	7.29		Kissimmee (KISF1)	5.65
Clearwater (ALLF1)	4.75		Lake Butler (LKBF1)	14.84
Cooper City	4.22		Lake City 2E (LCTF1)	10.52
Coral Springs (CSSF1)	11.67		Lake Panasoffkee 5NW (LPNF1)	8.67
Coral Springs 11W	4.03		Lake Placid 3WNW (JIWF1)	3.99
Crescent City (CREF1)	4.43		Lake Wales 1N (LKRF1)	5.83
Cross City (KCTY)	4.89		Lake Wales 6S (WSCF1)	6.95
Dade City 2E (DCYF1)	7.54		Lake Ward (LWDF1)	4.23
Deland	11.26		Lakeland 2SE (LKGF1)	7.74
Devils Garden	5.55		Lakeland 3E (SDLF1)	8.70
Dowling Park (DOWF1)	6.23		Lakeland 3NE (LPOF1)	7.06
Dundee 1W (LKHF1)	6.58		Lakeland Linder Field (LLDF1)	8.67
Dunedin (CCKF1)	6.50		Lisbon	8.03
Dunedin 1SE (CRCF1)	5.31		Lithia (LITF1)	6.85
Dunnellon 3N (RASF1)	10.60		Live Oak Tower (LOKF1)	5.64
Dunnellon 5 ESE (DLLF1)	11.30		Lutz 1E (LHAF1)	8.56
Durant 1E (LKMF1)	7.71		Lutz 3N (COMF1)	8.71
Edgeville (EDGF1)	4.71		MacClenny	7.81
Ellenton 2NE (GHMF1)	4.88		Madison (MDSF1)	4.50
Ellenton 3SE (CYSF1)	6.16		Masaryktown 2NNE (SWFF1)	9.77
Ellenton 9E (GCRF1)	5.69		Mayo (MAYF1)	3.25
Federal Point (HASF1)	8.73		McDill AFB	6.86

Location	Rainfall (in)		Location	Rainfall (in)
Melbourne WFO	8.11		Tampa Dam (TMTF1)	6.61
Miami Beach	3.74		Tampa Delaney Creek (DLYF1)	7.03
Middleburg (MDDF1)	8.70		Tampa Delaney Creek (DLNF1)	8.90
Myakka City (MKAF1)	4.80		Tampa Progress Blvd (NACF1)	7.95
Myakka Head 4NE (HORF1)	6.10		Tampa Sweetwater 8NW (SCKF1)	5.79
Myakka Head 8W (MKHF1)	3.95		Tarpon Springs 5E (TSPF1)	7.59
Nocatee 5W (HCKF1)	3.39		Thonotosassa 2SE (LKTF1)	8.96
North Miami Beach	3.71		Thonotosassa 2SW (TBHF1)	8.86
North Port 2N (NPOF1)	3.34		Thonotosassa 3N (MORF1)	11.07
North Port 11NE (MRDF1)	3.37		Three Rivers Estates (TREF1)	6.26
Ocala (OCAF1)	11.05		Titusville	7.00
Odessa 3SSW (ISFF1)	6.85		Town ‘N Country 1W (TOWF1)	5.39
Odessa 4S (CLKF1)	6.21		Union Tower (UNTF1)	9.02
Oldsmar 2W (TBFF1)	5.63		Venice (VNCF1)	3.13
Oldsmar 3NE (OLDF1)	3.97		Verna 7NNE (BTHF1)	4.20
Ona (ONAF1)	5.53		Weston	3.00
Oneco (ONEF1)	4.22		White Springs 7N (WSGF1)	9.11
Oneco 2SE (PDRF1)	4.34		Whitfield 1NW (BCRF1)	3.66
Orlando East	7.91		Wimauma 6NW (WMMF1)	5.95
Orange Springs 2SSW (OSPF1)	13.63		Wimauma 4 SW (WIMF1)	6.08
Osprey 1E (OPRF1)	3.05		Wildwood 2E (WWOF1)	6.93
Palatka (PTKF1)	11.42		Winter Haven (WHVF1)	6.36
Palm Bay	7.27		Withla 3SW (RRDF1)	7.10
Palm Harbor 3NE (TRSF1)	7.57		Yankeetown (BDCF1)	11.02
Palmetto 4NE (RUBF1)	4.90			
Penny Farms (PNYF1)	8.73		**Georgia**	
Pinellas Park (SJOF1)	4.88		Alma (GAEMN)	6.40
Pinellas Park (PNBF1)	4.31		Ashburn (ASHG1)	6.00
Pinellas Park 2SE (SAWF1)	4.43		Athens (KAHN)	3.86
Plant City (PLCF1)	4.00		Atkinson 1WSW (ATKG1)	10.22
Plant City 2S (PCTF1)	7.21		Augusta (KAGS)	3.78
Plymouth	7.95		Augusta Daniel Field (KDNL)	3.44
Polk City (PLKF1)	6.57		Baxely 5NNW (BXEG1)	10.40
Port Salerno	8.68		Baxely 5SW (BXYG1)	7.26
Ridge Manor 2SE (WTRF1)	8.11		Boone (BONN7)	10.85
Ruskin WFO (KTBW)	5.53		Burton Dam (TIGG1)	9.25
Safety Harbor (SHBF1)	4.80		Clayton (NACG1)	11.01
St. Augustine Lighthouse (STAF1)	5.20		Clayton (PIMG1)	10.80
St. Leo (STLF1)	3.22		Cordele (CDLG1)	7.19
San Antonio 3S (SNTF1)	8.14		Cornelia (CORG1)	6.47
Sanford	7.54		Dahlonega (JONG1)	7.89
Sarasota 5E (SRAF1)	3.62		Doctortown (DCTG1)	6.97
Seffner 2E (BKCF1)	8.15		Douglas (DUGG1)	5.73
Starke (SRKF1)	9.97		Fargo 2NE (FARG1)	9.74
Suwannee 6NE (SWNF1)	15.44		Fitzgerald (FTZG1)	6.50
Tampa 2E (TBEF1)	8.44		Folkston 3SW (FLKG1)	9.80
Tampa 4NE (HRIF1)	8.07		Ft. Stewart (KLHW)	6.41
Tampa By. Can. S-155 (TBCF1)	7.92		Hartwell 6E (HRTG1)	7.46
Tampa By. Can. S-159 (TBAF1)	7.17		Hawkinsville 4SW (PREG1)	6.48
Tampa By. Can. S-160 (TBBF1)	6.39		Hazlehurst (HZLG1)	6.83

Location	Rainfall (in)		Location	Rainfall (in)
Homerville (GAEMN)	6.19		Kings Mountain (RAWS)	6.41
Homerville 5N (HMVG1)	7.40		Leeds 4NW (NELS1)	7.83
Jesup 8S (JSUG1)	9.80		Longcreek (LONS1)	9.86
Lakeland (LAKG1)	5.79		McBee 3NE (MBES1)	8.17
Leary 5ENE (LERG1)	6.93		McEntire ANG (KMMT)	3.71
Lumber City (LBRG1)	8.68		Pickens (PICS1)	8.94
Madray Springs 2WNW (MRYG1)	10.78		Rock Hill (KUZA)	3.57
McIntyre 6SW (MCIG1)	7.65		Sandhills NWR (RAWS)	6.62
Metter 1SE (MTFG1)	11.91		Sandy Springs (SSPS1)	6.90
Moody AFB (KVAD)	8.30		Table Rock (TRKS1)	10.02
Mountain City 2N (MTCG1)	8.10		Travelers Rest (TVRS1)	10.89
Mountain City 2SW (MCTG1)	9.34		Travelers Rest 1S (TRAS1)	7.20
Nahunta (GAEMN)	9.22		Walhalla (WALS1)	9.39
Nahunta 6NE (NAHG1)	10.64		Walhalla 2NE (WAHS1)	8.65
Naseville (NSHG1)	6.55		Walhalla 5NW (RAWS)	11.10
Offerman (OFFG1)	9.34		Whitmire 9N (WHIS1)	8.19
Okefenokee 9SW (SWCG1)	7.71			
Patterson (PATG1)	11.94		**North Carolina**	
Peachtree City (KFFC)	3.77		Argura (IARN7)	7.78
Pridgen (PRDG1)	5.58		Asheville (KAVL)	4.64
Redisville (REDG1)	9.80		Banner Elk (BEKN7)	9.65
Statenville (STNG1)	6.68		Bearwallow Mtn. (BWMN7)	12.63
Sterling 3SW (STRG1)	7.25		Beech Mtn. (BCHN7)	9.48
Tallula Falls (TLUG1)	11.28		Black Mountain (MMTN7)	14.62
Tallulah Falls 1NE (TFLG1)	10.03		Blantyre (BLAN7)	7.31
Tugalo Dam (TUGG1)	11.08		Blowing Rock 3SE (BCPN7)	9.56
Warner Robbins AFB (KWRB)	6.45		Boone (BOON7)	7.37
Waycross 4NE (AYSG1)	6.86		Boone (BNKN7)	9.00
Willacoochee 5ENE (WILG1)	6.80		Boone (SDWN7)	8.64
Woodbine (WBNG1)	7.83		Brevard (BVDN7)	7.28
Yonah Dam (YNHG1)	9.93		Canton (BDCN7)	11.08
			Cataloochee (MAGN7)	7.76
Alabama			Chapel Hill (KIPX)	3.01
Bleecker (BLEA1)	3.20		Charlotte (KCLT)	3.41
			Clear Creek (CCGN7)	10.07
South Carolina			Fayetteville (KFAY)	4.38
Anderson (KAND)	6.20		Flat Top (FLAN7)	9.20
Caesars Head (CAES1)	12.14		Forest City (FORN7)	7.37
Calhoun Falls (CALS1)	7.78		Ft. Bragg (KPOB)	3.51
Calhoun Falls 5S (RBRS1)	6.99		Gastonia (KAKH)	4.57
Chesnee 7 WSW (CNES1)	6.58		Grandfather Meadows (GFMN7)	10.40
Clemson (KCEU)	6.34		Greensboro (KGSO)	3.82
Clemson University (CLES1)	7.00		Hickory (KHKY)	6.03
Columbia (KCAE)	3.69		Hawk (HAKN7)	9.40
Columbia Downtown (KCUB)	3.46		Hendersonville (HNDN7)	8.76
Gaffney 6E (GAFS1)	6.61		Highlands (HILN7)	13.00
Greenville-Spartanburg Arpt (KGSP)	5.42		Highlands TVA (HDSN7)	13.02
Greenwood (KGRD)	4.61		Howards Knob (HKWN7)	9.28
Hartsville (HVLS1)	6.33		Lake James (BRWN7)	9.23
Jackson 1S (RAWS)	7.50		Lake Lure (LKLN7)	9.56
Jocassee (JCSS1)	8.08		Lake Toxaway (LKTN7)	17.20

Location	Rainfall (in)		Location	Rainfall (in)
Lake Toxaway (LTYN7)	10.87		Meadows of Dan (MODV2)	7.06
Linville Falls (JSRN7)	18.07		Nelson (BLCV2)	8.31
Mackall USAAF (KHFF)	4.23		Nicholls Knob (NICV2)	9.35
Maxton (KMEB)	5.44		Philpott Dam 2 (PTTV2)	6.27
Monroe (KEQY)	5.49		Richmond (KRIC)	3.17
Morganton (MRGN7)	7.35		Roanoke (KROA)	5.45
Morganton (MGTN7)	11.32		Rocky Mount (RYMV2)	6.17
Mt. Pisgah (MTPN7)	11.40		Upper Sherando (USLV2)	10.48
Nebo 7NE (NCVN7)	11.04		Waynesboro (RBHV2)	10.15
New Bern (KEWN)	5.10		Waynesboro Sewage (WYNV2)	7.00
Old Fort (OLFN7)	9.62			
Pisgah Forest (PISN7)	7.51		**Pennsylvania**	
Pleasant Gardens (PLGN7)	8.67		Altoona (KAOO)	5.81
Plumtree (PLMN7)	8.52		Clearfield (KGIG)	3.63
Rich Mtn. (RCMN7)	12.50		DuBois (KDUJ)	3.19
Roaring Creek (RCAN7)	9.68		Erie (KERI)	3.60
Rosman (RMNN7)	9.62		Meadville (KGKJ)	5.08
Rosman 6E (CFFN7)	12.98		Mt. Pocono (KMPO)	4.61
Rutherfordton 3N (RUTN7)	7.36		Pittsburgh (KPIT)	3.83
Sunburst (SNBN7)	9.86		Pittsburgh Allegheny Cnty (KAGC)	3.28
Triplett (TPHN7)	8.07			
Triplett (TPTN7)	8.68		**New Jersey**	
Tyron (TRYN7)	10.29		Teterboro (KTEB)	3.31
Walker Top (WKTN7)	13.64			
Wilbar (WLBN7)	7.16		**New York**	
Wilmington (KILM)	3.12		Bufflao (KBUF)	4.02
Winston-Salem (KINT)	3.82		Dunkirk (KDKK)	3.46
Wisemans View (WISN7)	10.78		Elmira (KELM)	3.14
Yancy (YNCN7)	7.41		New York City Central Park (KNYC)	4.18
			New York City JFK (KJFK)	3.12
Tennessee			New York City LaGuardia (KLGA)	4.09
Leconte (MTLT1)	3.46		Niagara Falls (KIAG)	3.46
			Oceanside (OCNN6)	3.51
Kentucky			Rochester (KROC)	4.12
Harlan (LYLK2)	4.49		Watertown (KART)	3.02
Jackson (KJKL)	4.26		Wellsville (KELZ)	3.16
			White Plains (KHPN)	6.46
Virginia				
Apple Orchard Mtn. (APEV2)	10.24		**Ohio**	
Big Meadows (BGMV2)	11.50		Lancaster (KLHQ)	4.33
Buena Vista (BUVV2)	5.61		New Philadelphia (KPHD)	3.53
Charlottesville (KCHO)	3.03		Youngstown (KYNG)	4.41
Copper Hill (COHV2)	8.12		Zanesville (KZZV)	5.39
Free Union (FRUV2)	10.00			
Galax Water Plant (GAAV2)	5.83		**West Virginia**	
Glasgow 1SE (GLAV2)	7.13		Bluefield (KBLF)	3.48
Goshen (GOHV2)	10.13		Huntington (KHTS)	4.50
Hot Springs (HSPV2)	5.32		Parkersburg (KPKB)	4.11
Lexington (NOHV2)	6.14			
Mason Cove (MASV2)	7.05		**Maine**	
Mathews Arm (MATV2)	10.00		Frenchville (KFVE)	3.25

Table 5. Preliminary forecast evaluation (heterogeneous sample) for Hurricane Frances, 25 August – 8 September 2004. Forecast errors (n mi) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast (OFCL) are shown in bold-face type. Verification includes the depression stage, but does not include the extratropical stage, if any.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
CLP5	27 (53)	58 (53)	96 (53)	144 (52)	266 (48)	402 (44)	535 (40)
GFDI	**19** (53)	**34** (53)	**50** (53)	68 (52)	108 (48)	156 (44)	222 (40)
GFDL*	22 (51)	**33** (51)	**44** (51)	**61** (51)	101 (48)	145 (44)	200 (40)
GFNI	27 (51)	49 (51)	74 (51)	94 (50)	140 (46)	204 (42)	290 (38)
GFDN*	33 (51)	52 (50)	74 (50)	97 (49)	129 (45)	186 (41)	263 (37)
AF1I	28 (48)	51 (48)	75 (48)	102 (47)	165 (43)		
AFW1*	43 (25)	72 (25)	89 (25)	106 (24)	153 (22)		
COAI	30 (32)	64 (32)	102 (32)	141 (30)	222 (27)		
COAL*	30 (17)	53 (17)	92 (17)	119 (15)	193 (14)		
COEI	34 (26)	74 (26)	119 (26)	165 (25)			
COCE*	30 (14)	62 (14)	101 (13)	145 (13)			
LBAR	**19** (53)	**34** (53)	**45** (53)	**58** (52)	88 (48)	114 (44)	134 (40)
A98E	28 (53)	49 (53)	76 (53)	123 (52)	261 (48)	382 (44)	475 (40)
A9UK	28 (26)	50 (26)	80 (26)	108 (25)	233 (23)		
BAMD	21 (53)	**35** (53)	**49** (53)	**61** (52)	81 (48)	113 (44)	161 (40)
BAMM	24 (53)	43 (53)	64 (53)	81 (52)	104 (48)	126 (44)	159 (40)
BAMS	29 (52)	52 (52)	72 (52)	94 (52)	119 (48)	139 (44)	152 (40)
NGPI	29 (52)	52 (51)	74 (51)	94 (50)	132 (46)	191 (42)	272 (37)
NGPS*	29 (53)	52 (53)	76 (53)	92 (50)	122 (47)	169 (41)	253 (38)
UKMI	28 (52)	53 (52)	77 (52)	92 (51)	120 (47)	160 (43)	221 (39)
UKM*	33 (27)	49 (27)	77 (27)	97 (26)	128 (24)	161 (22)	211 (20)
GFSI	21 (52)	**34** (52)	**48** (52)	**62** (51)	91 (47)	118 (43)	155 (39)
GFSO*	22 (54)	**34** (54)	**49** (54)	**62** (52)	89 (48)	117 (44)	146 (40)
AEMI	24 (52)	38 (52)	**49** (52)	**62** (51)	87 (47)	114 (43)	149 (39)
AEMN*	30 (52)	42 (52)	55 (52)	66 (50)	87 (46)	110 (42)	132 (38)
GUNS	20 (51)	37 (51)	54 (51)	69 (50)	90 (46)	125 (42)	184 (37)
GUNA	**18** (51)	**33** (51)	**45** (51)	**56** (50)	**72** (46)	101 (42)	150 (37)
CONU	20 (53)	**35** (52)	**50** (52)	**63** (51)	85 (47)	120 (43)	172 (39)
FSSE*	**17** (49)	**30** (49)	**40** (49)	**53** (49)	**64** (45)	**75** (38)	**127** (35)
OFCI	22 (53)	40 (53)	53 (53)	**64** (52)	80 (48)	103 (44)	144 (40)
OFCL	20 (53)	36 (53)	52 (53)	66 (52)	80 (48)	100 (44)	128 (40)
NHC Official (1994-2003 mean)	44 (3172)	78 (2894)	112 (2636)	146 (2368)	217 (1929)	248 (421)	319 (341)

* Output from these models was unavailable at forecast time.

Table 6. Watch and warning summary for Hurricane Frances, 25 August – 8 September 2004.

Date/Time (UTC)	Action	Location
29 / 2100	Tropical Storm Watch issued	Anguilla, Antigua, Barbuda, St. Maarten
30 / 0300	Tropical Storm Warning issued	Anguilla, Antigua, Barbuda, Nevis, Saba, St. Kitts, St. Eustatius, St. Maarten
30 / 0300	Hurricane Watch issued	British Virgin Islands, northern U. S. Virgin Islands, Culebra, Vieques
30 / 1500	Tropical Storm Watch issued	Puerto Rico, St. Barthelemy, St. Martin
30 / 1500	Hurricane Watch changed to Tropical Storm Watch	Vieques
30 / 2100	Tropical Storm Warning issued	Puerto Rico, Culebra, Vieques, British Virgin Islands, northern U. S. Virgin Islands
30 / 2100	Tropical Storm Watch issued	St Croix
30 / 2100	Hurricane Watch discontinued	All
31 / 0300	Tropical Storm Watch issued	Northern coast of the Dominican Republic from Manzanillo Bay to Cabo Engano
31 / 0300	Tropical Storm Warning issued	Guadeloupe
31 / 0900	Tropical Storm Warning discontinued	Antigua, Barbuda, Nevis, St. Kitts
31 / 0900	Hurricane Watch issued	Southeastern Bahamas, Turks and Caicos Islands
31 / 1500	Hurricane Warning issued	Southeastern Bahamas, Turks nnd Caicos Islands
31 / 1500	Tropical Storm Warning issued	Northern coast of the Dominican Republic Punta Gorda to Manzanillo Bay
31 / 1500	Hurricane Watch issued	Central Bahamas
31 / 1500	Tropical Storm Warning discontinued	Anguilla, Antigua, Barbuda, Guadeloupe, Nevis, Saba, St. Eustatius, St. Maarten
31 / 1500	Tropical Storm Watch discontinued	St. Barthelemy, St. Croix, St. Martin, and Dominican Republic coast south of Punta Gorda
31 / 2100	Tropical Storm Warning discontinued	Puerto Rico, Culebra, Vieques, U. S. and British Virgin islands
1 / 1500	Hurricane Warning issued	Central Bahamas
1 / 1500	Hurricane Watch issued	Northwestern Bahamas
1 / 2100	Tropical Storm Warning discontinued	Dominican Republic
2 / 0000	Hurricane Warning issued	Northwestern Bahamas
2 / 0300	Hurricane Watch issued	Florida east coast from Florida City to Flagler Beach including Lake Okeechobee
2 / 0300	Tropical Storm Watch issued	Florida Keys from Florida City to Seven Mile Bridge including Florida Bay
2 / 0900	Hurricane Watch extended southward	Florida Keys from Florida City to Craig Key
2 / 1500	Hurricane Warning issued	Florida east coast from Florida City to Flagler Beach including Lake Okeechobee
2 / 1500	Hurricane Watch and Tropical Storm Warning issued	Florida Keys from Florida City to Seven Mile Bridge including Florida Bay
2 / 1500	Hurricane Warning discontinued	Turks and Caicos Islands
3 / 0300	Hurricane Warning discontinued	Southeastern Bahamas

Date/Time (UTC)	Action	Location
3 / 1500	Hurricane Watch extended northward	Florida coast from Flagler Beach to Fernandina Beach
3 / 2100	Tropical Storm Warning issued	Florida coast from Flagler Beach to Fernandina Beach
3 / 2100	Hurricane Warning discontinued	Central Bahamas
4 / 0300	Tropical Storm Warning issued	Florida southwest coast from Bonita Beach to Florida City
4 / 0300	Tropical Storm Watch issued	Florida west coast from Bonita Beach to Suwannee River
4 / 0900	Tropical Storm Warning extended northward	Florida west coast from Bonita Beach to Englewood
4 / 1500	Tropical Storm Warning extended northward	Florida and Georgia coasts from Fernandina Beach to Altamaha Sound
4 / 1500	Tropical Storm Warning extended northward	Florida west coast from Englewood to Anna Maria Island
4 / 1500	Tropical Storm Watch extended northward	Florida west coast from Suwannee River to St Marks
4 / 2100	Tropical Storm Warning extended northward	Florida west coast from Anna Maria Island to St. Marks
4 / 2100	Tropical Storm Watch extended westward	Florida Gulf coast from St. Marks to Panama City
4 / 2100	Hurricane Warning discontinued	Northwestern Bahamas except Grand Bahama, Abaco, Bimini, and the Berry Islands
5 / 0900	Hurricane Warning changed to Tropical Storm Warning	Florida southeast coast from Deerfield Beach to Florida City
5 / 0900	Tropical Storm Warning issued	Florida Keys south of Seven Mile Bridge including the Dry Tortugas
5 / 1500	Hurricane Warning issued	Florida Gulf coast from Suwannee River to Destin
5 / 1500	Hurricane Watch discontinued	Florida east coast from Flagler Beach to Fernandina Beach
5 / 1500	All warnings discontinued	Northwestern Bahamas
5 / 2100	Hurricane Warning extended southward	Florida west coast from Suwannee River to Anna Maria Island
5 / 2100	Hurricane warning changed to tropical storm warning	Florida east coast from Jupiter Inlet to Flagler Beach including Lake Okeechobee
5 / 2100	All warnings discontinued	Florida east coast from Florida City to Jupiter Inlet
6 / 0600	Tropical Storm Warning discontinued	Florida west coast from Bonita Beach to Florida City including the Florida Keys, the Dry Tortugas, and Lake Okeechobee
6 / 0900	All warnings discontinued	Florida west coast south of Englewood and Florida east coast south of Cocoa Beach
6 / 1500	Hurricane Warning changed to Tropical Storm Warning	Florida Gulf coast from Indian Pass to Destin and Florida west coast from Anna Maria Island to Suwannee River
6 / 1500	All warnings discontinued	Georgia coast, Florida east coast, and Florida west coast south of Anna Maria Island

Date/Time (UTC)	Action	Location
6 / 2100	Hurricane Warning changed to Tropical Storm Warning	Florida Gulf coast from Suwannee River to St Marks
6 / 2100	All warnings discontinued	Florida coast west of St. Marks and south of Suwannee River
7 / 0300	All warnings discontinued	Florida coast

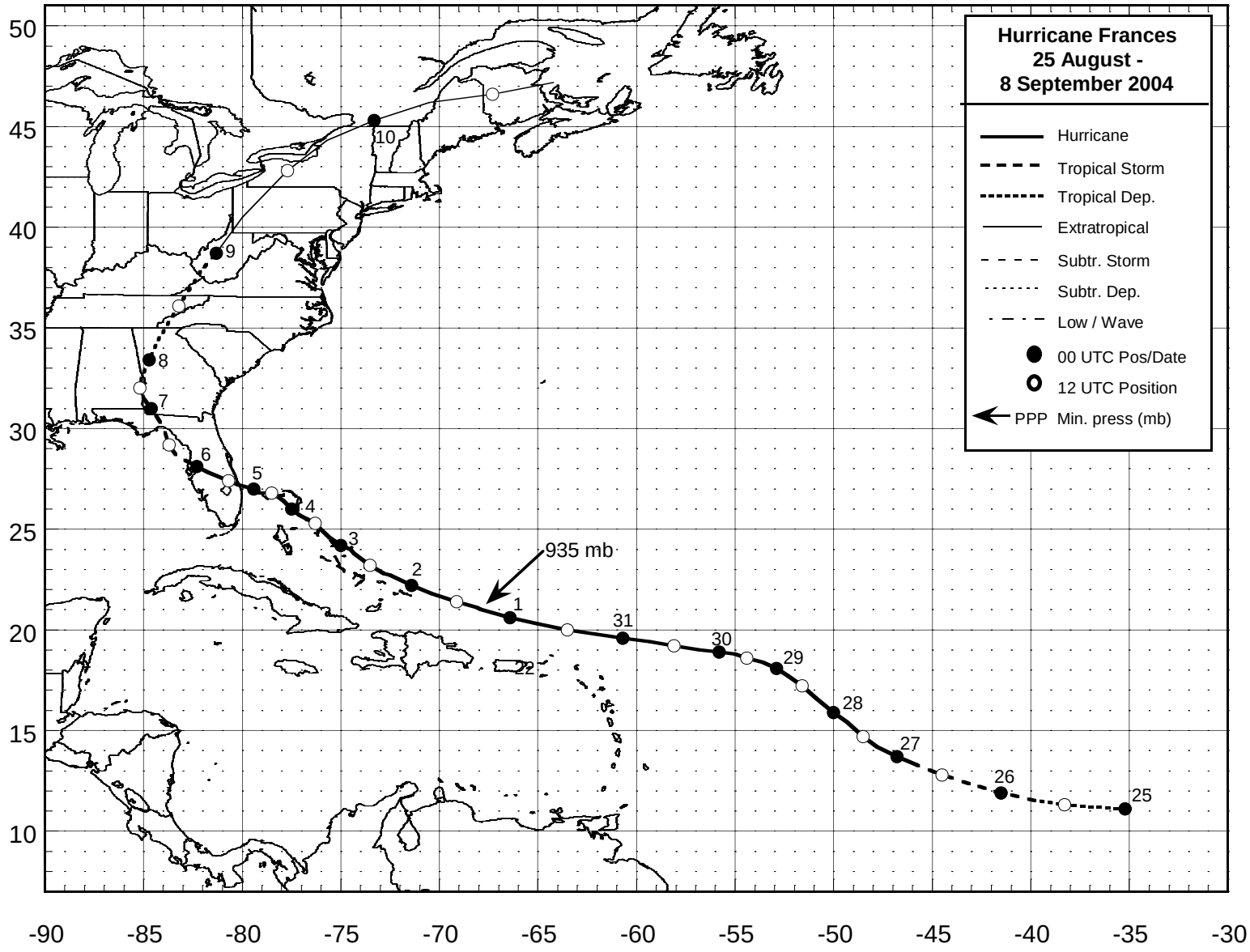

Figure 1. Best track positions for Hurricane Frances, 25 August – 8 September 2004.

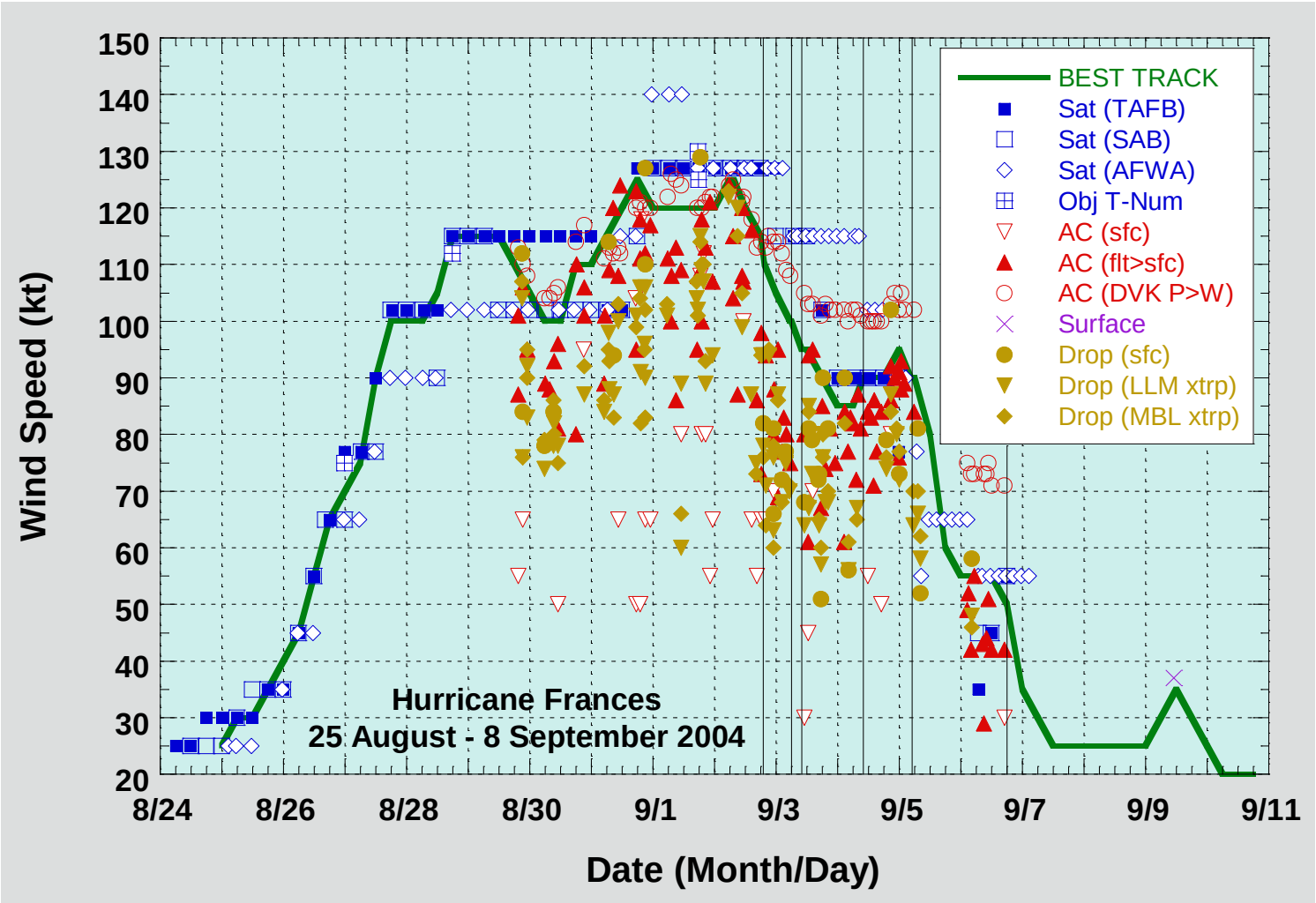

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Frances, 25 August - 8 September 2004. Aircraft observations have been adjusted for elevation using 90% and 80% reduction factors for observations from 700 mb and 850 mb respectively. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM), and from the sounding boundary layer mean (MBL). Objective Dvorak estimates represent linear averages over a three-hour period centered on the nominal observation time. Vertical black lines indicate times of landfalls.

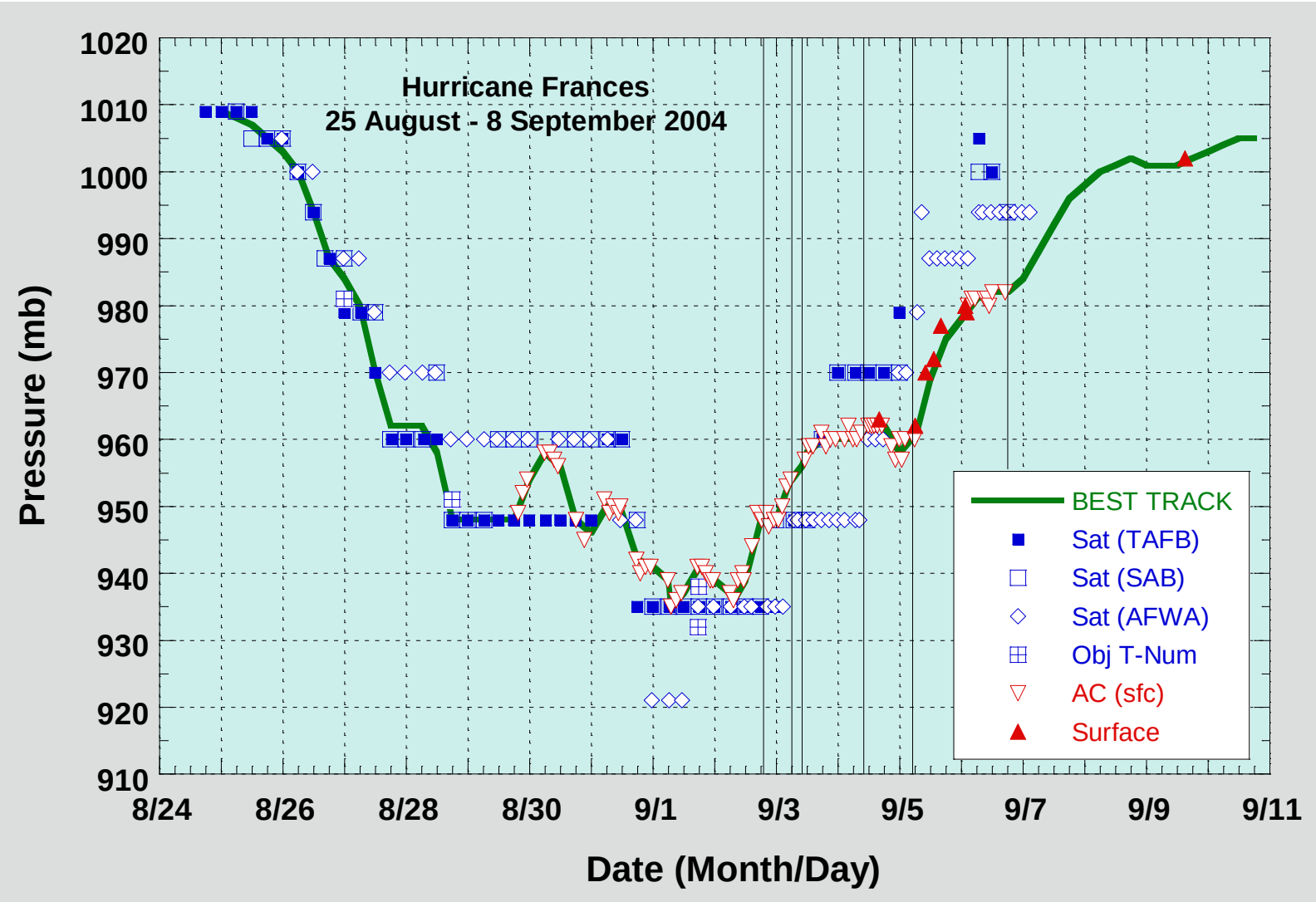

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Frances, 25 August – 8 September 2004. Objective Dvorak estimates represent linear averages over a three-hour period centered on the nominal observation time. Vertical black lines indicate times of landfalls.

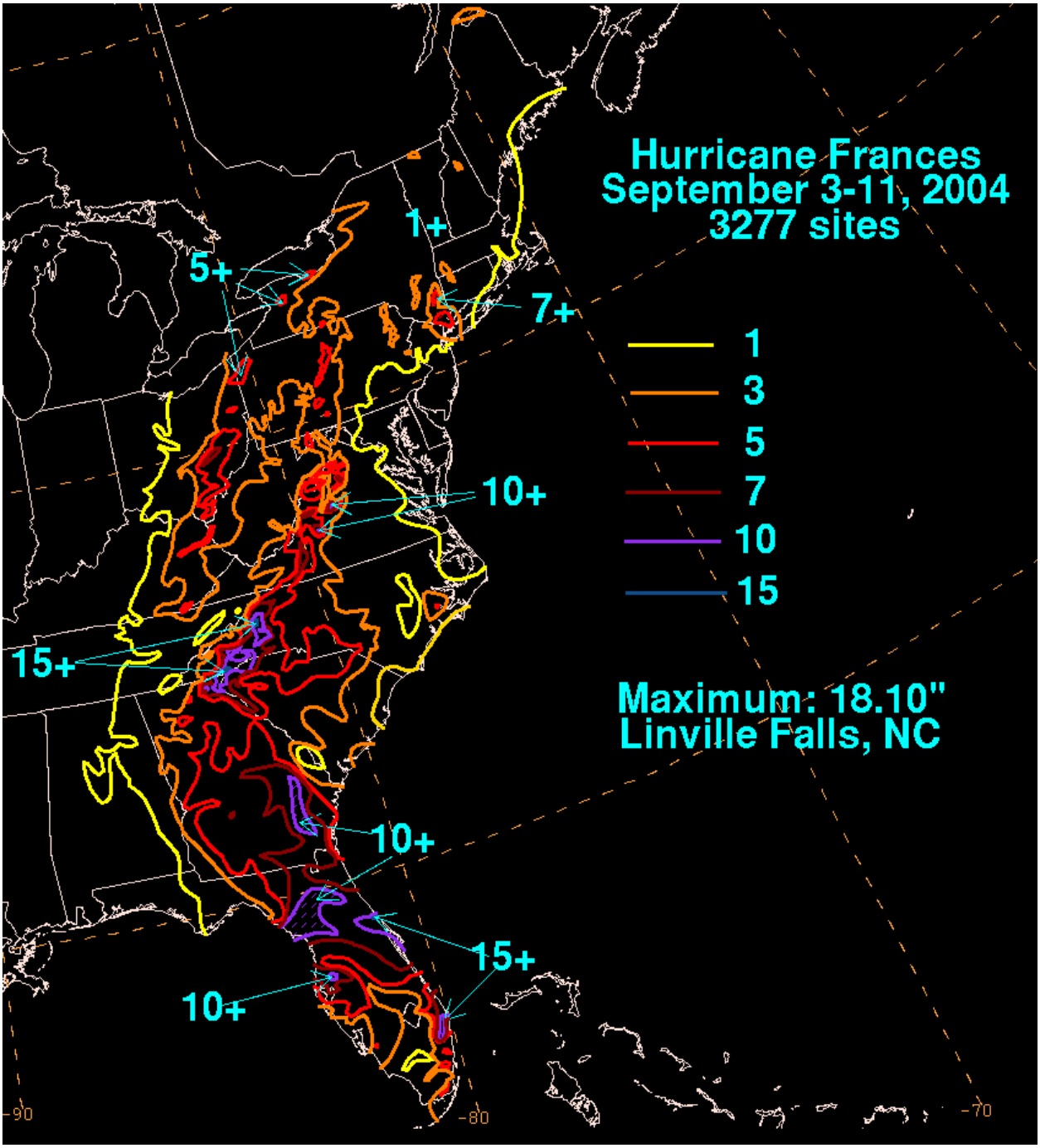

Figure 4. Storm-total rainfalls for Hurricane Frances, 25 August – 8 September 2004. Figure courtesy of David Roth of the Hydrometeorological Prediction Center.