The Atlantic Hurricane Database Reanalysis

October 2012

NOAA Climate Diagnostics and Prediction Workshop

Chris Landsea, *National Hurricane Center*, Miami, USA

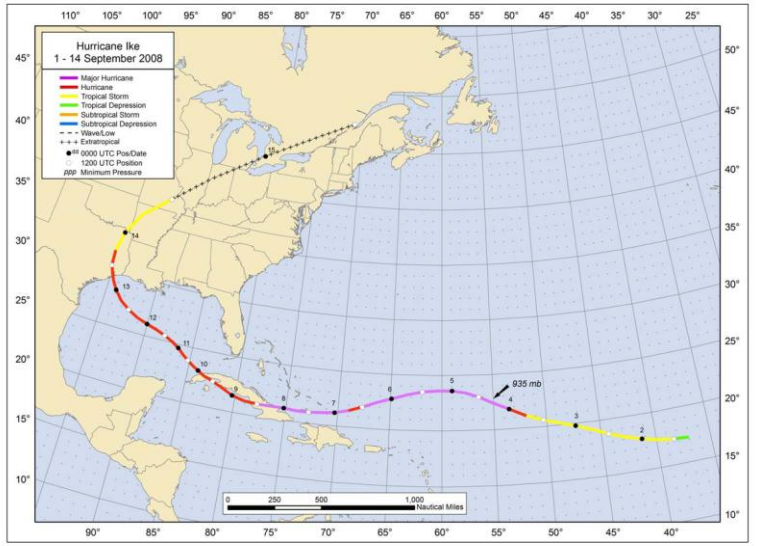
Supported by the NOAA Climate Program Office

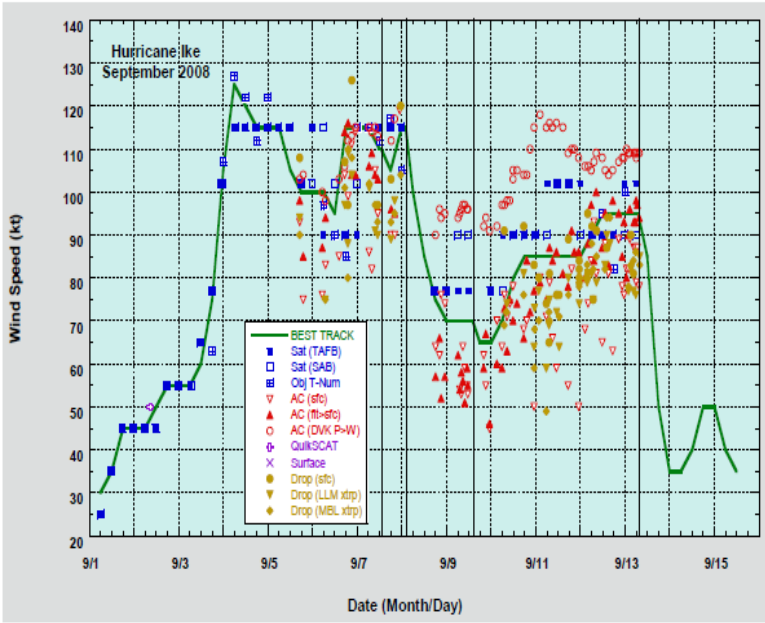
HURDAT

The National Hurricane Center maintains and updates annually the North Atlantic Basin's Hurricane Database (HURDAT)

HURDAT provides from 1851 to 2011 for all tropical storms, subtropical storms, and hurricanes every 6 hours:

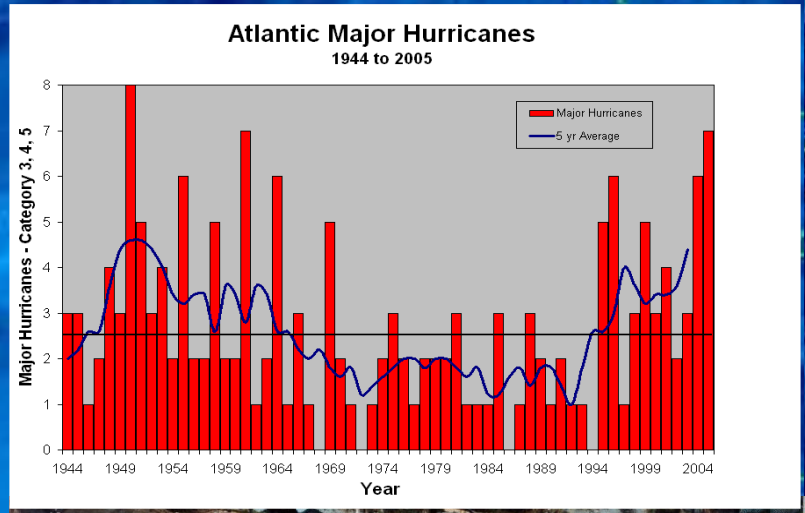
- **Positions** (to nearest 0.1 degree latitude/longitude)
- **Intensity** (1 min surface winds to nearest 10 kt from 1851-1885, 5 kt from 1886 onward)
- **Central pressure** (to nearest 1 mb, when observed)
- **34, 50, and 64 kt wind radii maximum extent** since 2004 (by quadrant, to nearest 10 nmi)

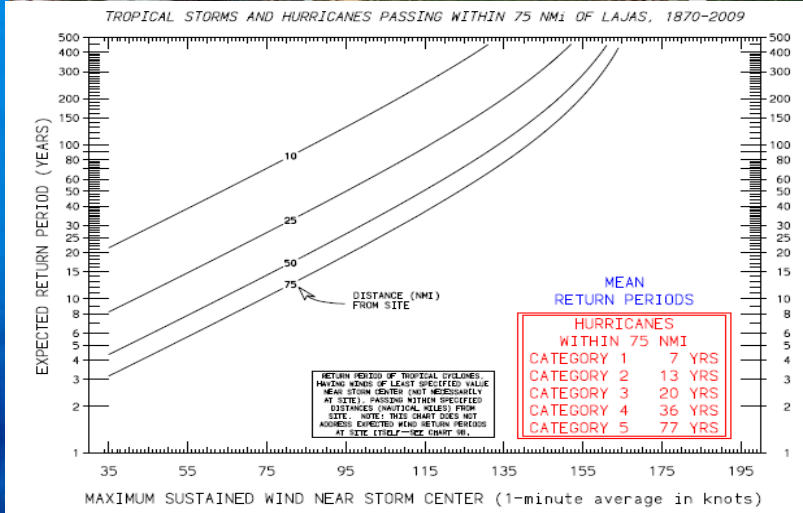




HURDAT applications:

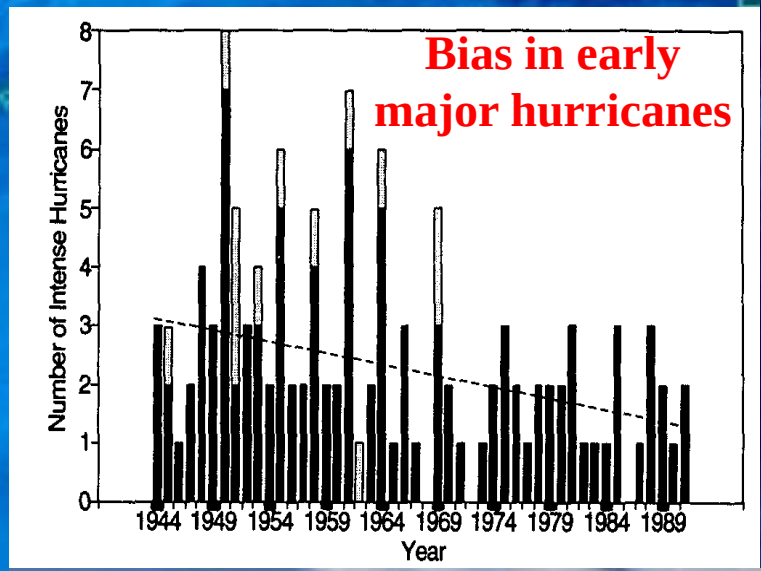
- Validation of official and model predictions
- Climate trend assessment – long term trends, seasonal forecasts, etc.
- Building code standards and insurance rates for coastal communities
- Risk assessment for emergency managers (recurrence intervals)

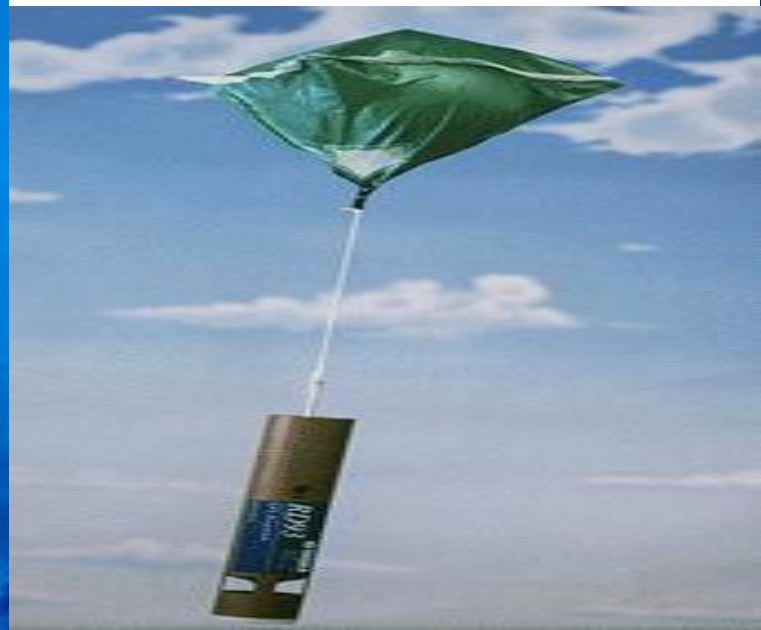




Why revise HURDAT?

- HURDAT contains many systematic and random errors
  - 1938 Hurricane: Cat 3 at landfall, but 85kts at last offshore position
- "Missing storms"
- Lack of exact hurricane landfall parameters
- Advances in the understanding of hurricanes and analysis techniques

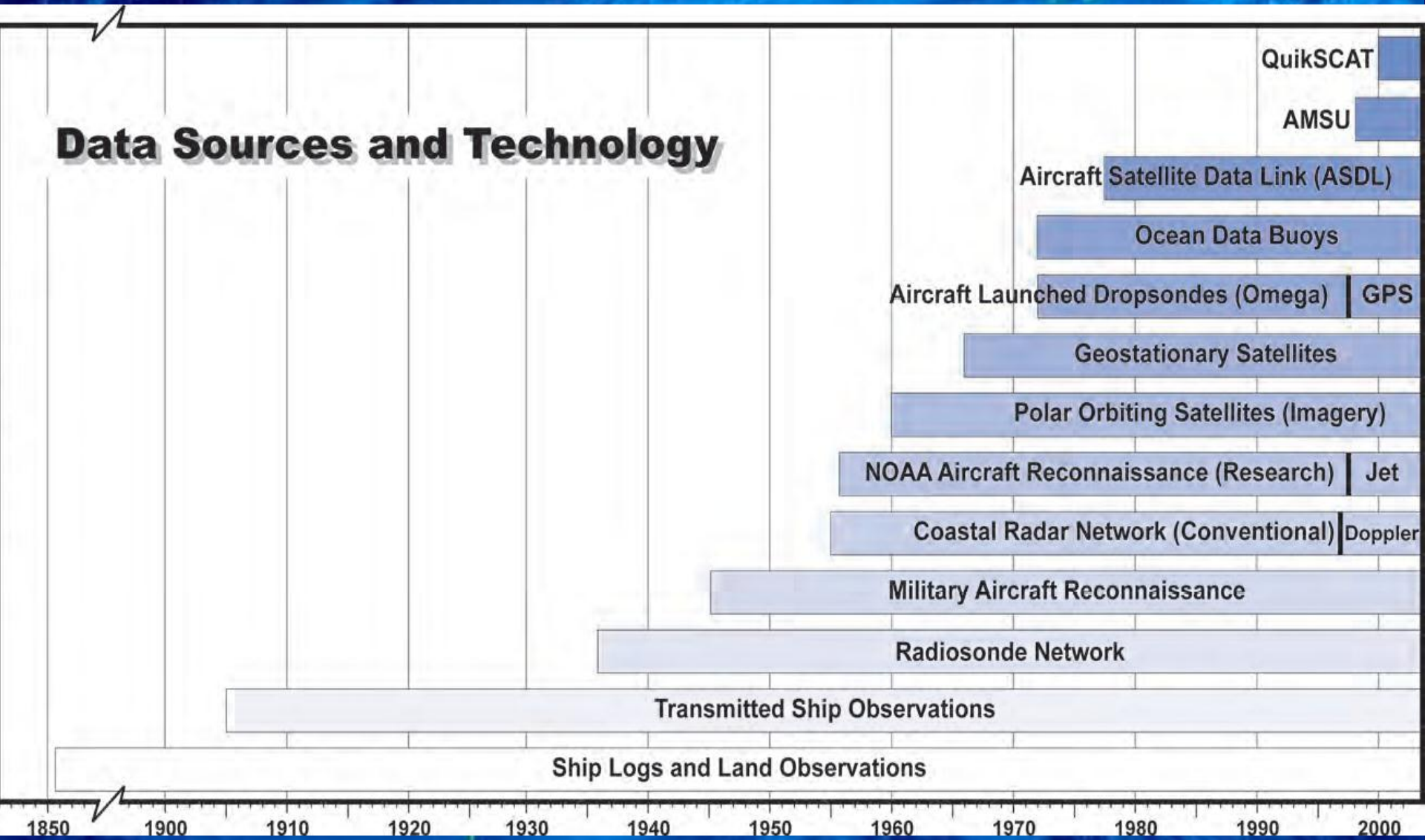




How is the reanalysis conducted?

- Search through all data sources to find all info/data that exist on storms
- Place all raw data into a single database
- Conduct synoptic analyses 1 to 4 times daily by plotting all observations (i.e. wind, pressure, etc.) on surface maps
- Determine track and intensity
- Document revisions (metadata file)
- After TCs for a year are reanalyzed, a search is conducted for missing storms

Observation Capabilities: Huge Improvements over Time



Work of Jose Partagas: Historical Reconstruction from 1851-1910

Researcher's ashes tossed in storm's eye

By CURTIS MORGAM
Herald Staff Writer

As the P-3 Orion research plane bumped and rolled through one last circle inside Hurricane Danielle, Peter Black placed a simple cloth sack into a chute and sent its contents swirling into the atmosphere.

And at 10:05 p.m. Sunday, latitude 28.0 north, longitude 74.2 west, 400 miles east-northeast of Miami, Jose Fernandez Partagas finally got a send-off fellow weather scientists know he would have appreciated: His ashes were scattered into the howling heart of an Atlantic hurricane.

"I found it quite a moving experience," Black, a National Oceanographic and Atmospheric Administration research meteorologist, said Tuesday. "It just seemed very appropriate to do it in the eye of a hurricane."

The ceremony, a rare honor, was a gesture of respect for an eccentric but affable researcher who lived to study hurricanes and died, nearly destitute, doing just that. It also rescued Partagas from an obscure burial. After his death a year ago in August at age 62, police found no relatives. His father had died in Cuba, his mother in Miami and he had never married.

When no one claimed the body, the National Hurricane Center did.

"They didn't want Jose to go to a pauper's grave," said Jim Gross, a center research meteorologist. Gross stored the ashes, awaiting a scheduled storm flight with the right conditions for the brief ceremony, attended by six scientists and most of the 11 crew members.

"We think Jose would have been honored, happy to have it done this way," Gross said.

Partagas was born and schooled in Cuba, receiving a degree in meteorology from Havana University and working at the national observatory, said friend Luciano Blanco, a retired physicist in Miami who went to school

PLEASE SEE PARTAGAS, 4B

A EULOGY ALOFT

Peter Black, lead National Oceanographic Administration scientist aboard the P-3 Orion research plane, recorded this in the plane's official log for 10:05 p.m., Aug. 30, 1998:

"The crew and the scientists of NOAA aircraft 43RF gathered for a brief ceremony in which the ashes of Jose Fernandez Partagas were scattered into the eye of Hurricane Danielle at latitude 28.0 north, 74.2 west, thus returning Jose to the hurricanes he loved and which formed his life's work."

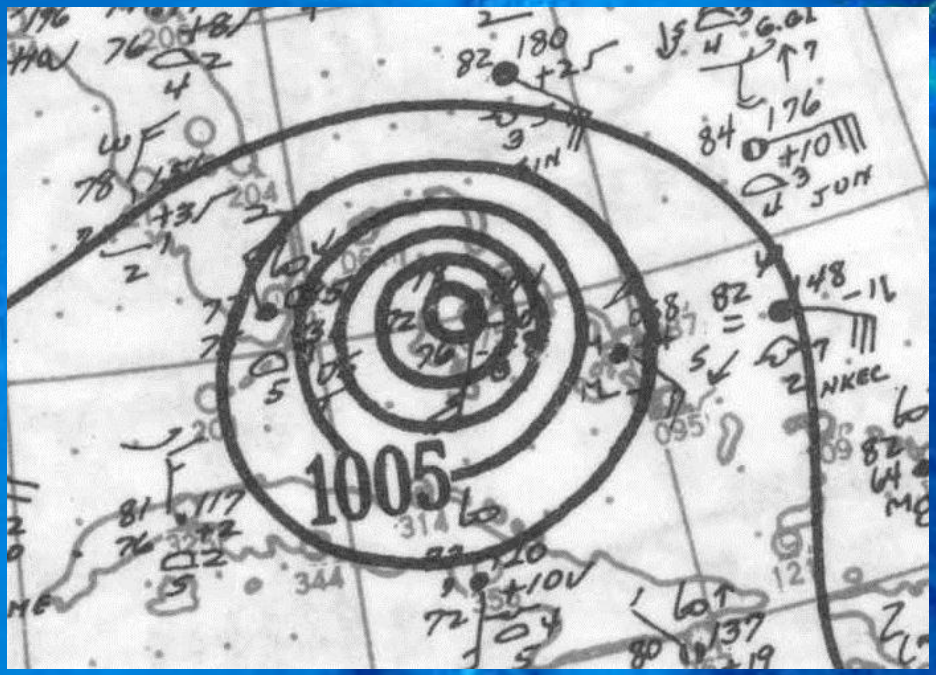
Partagas

Data Sources

Microfilm

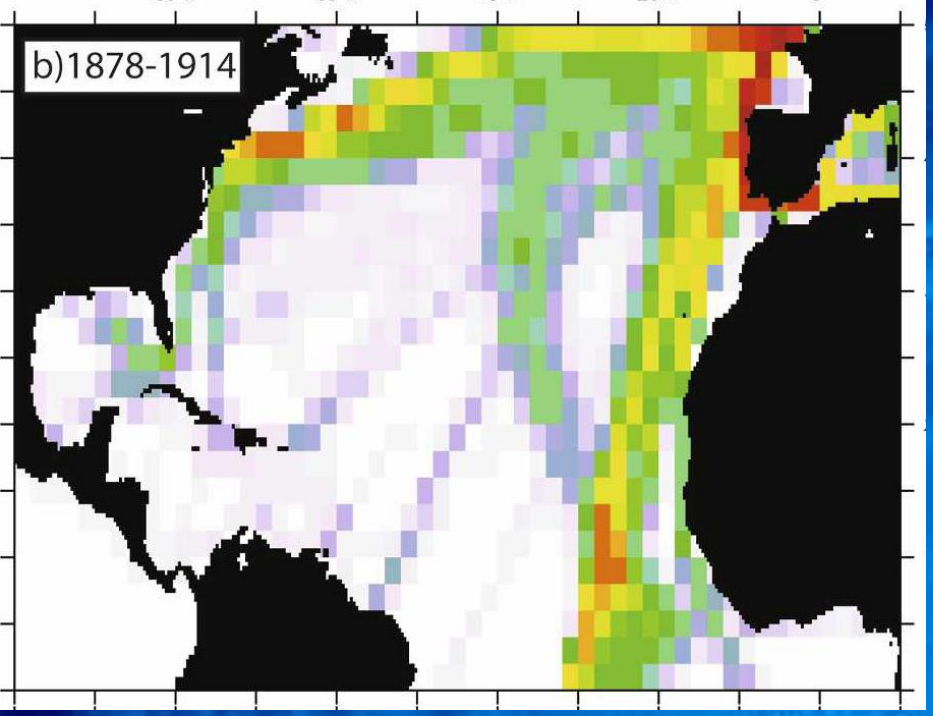
1947 Storm 8

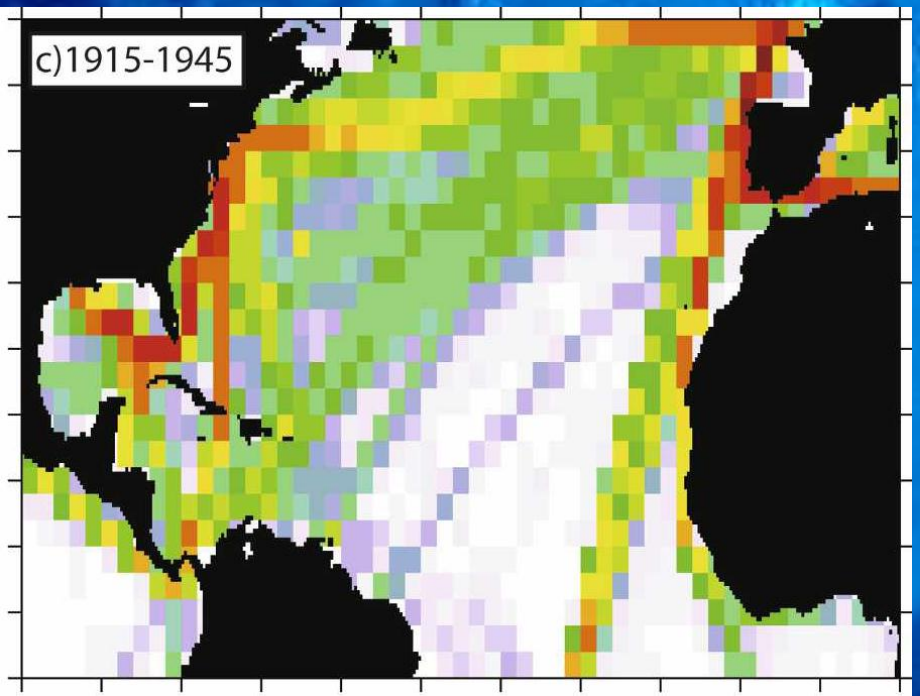
Historical Weather Maps

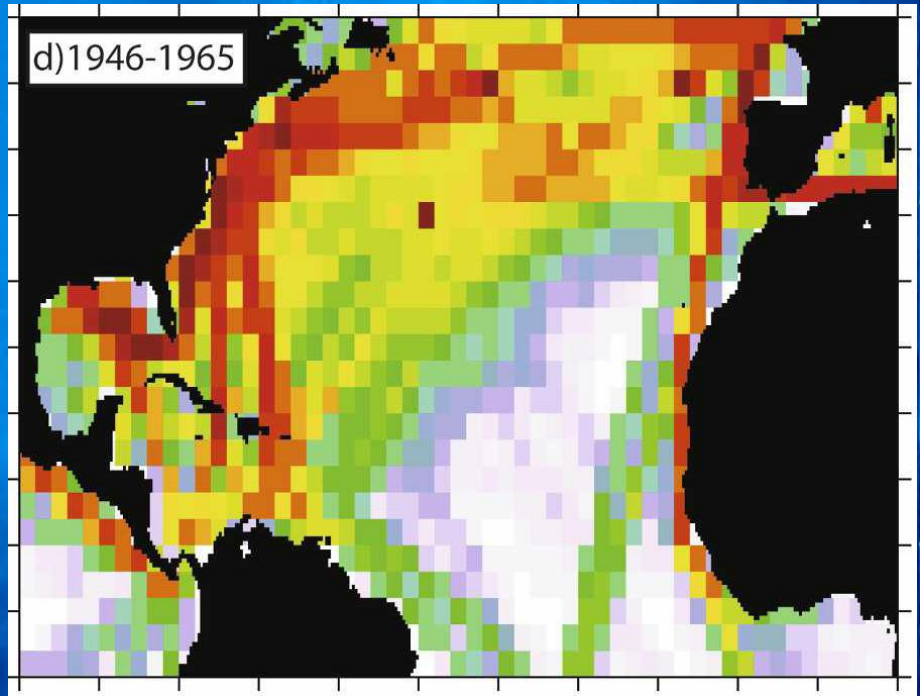


1949 Storm 2

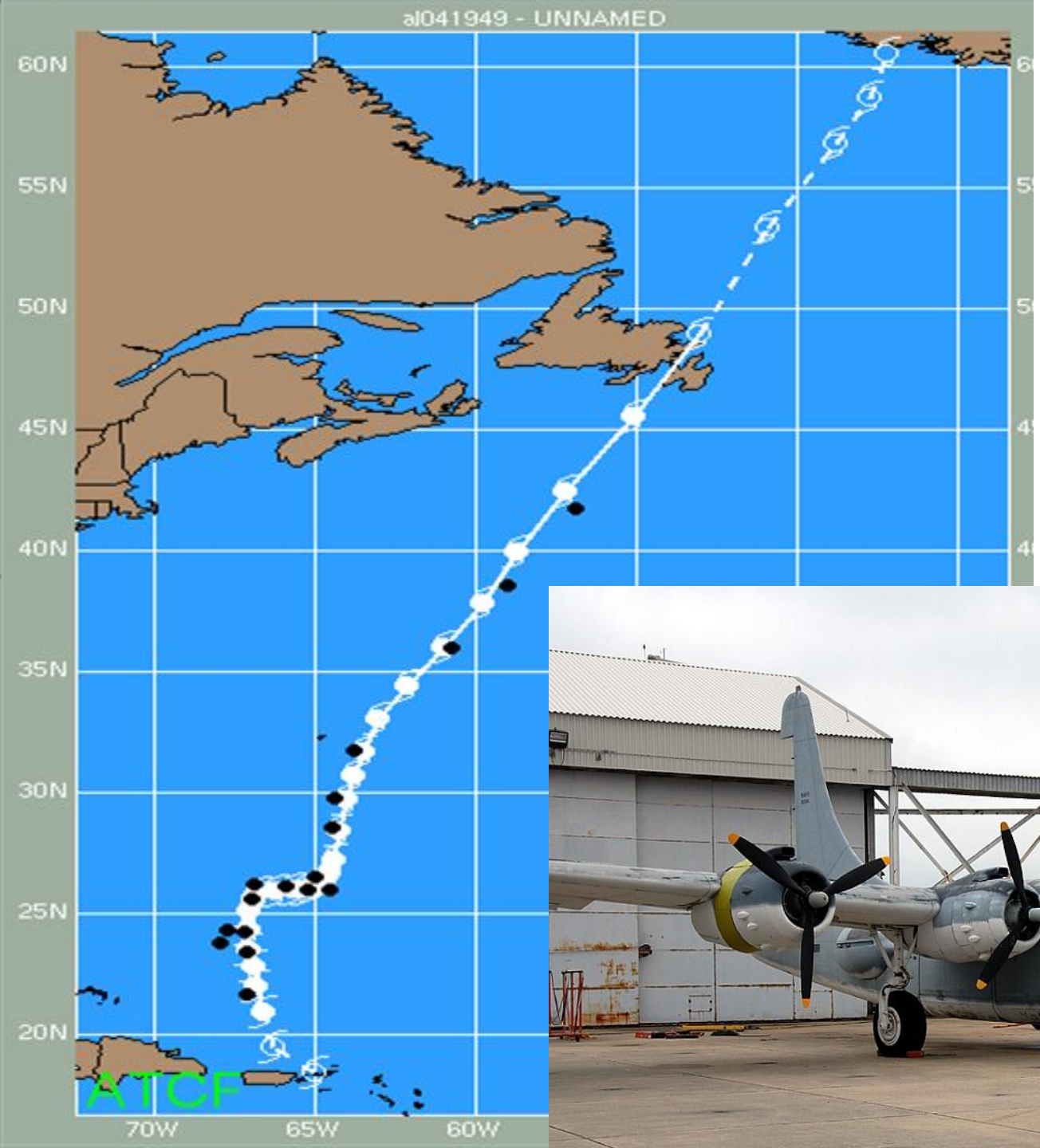
International Comprehensive Ocean-Atmosphere Dataset (ICOADS)

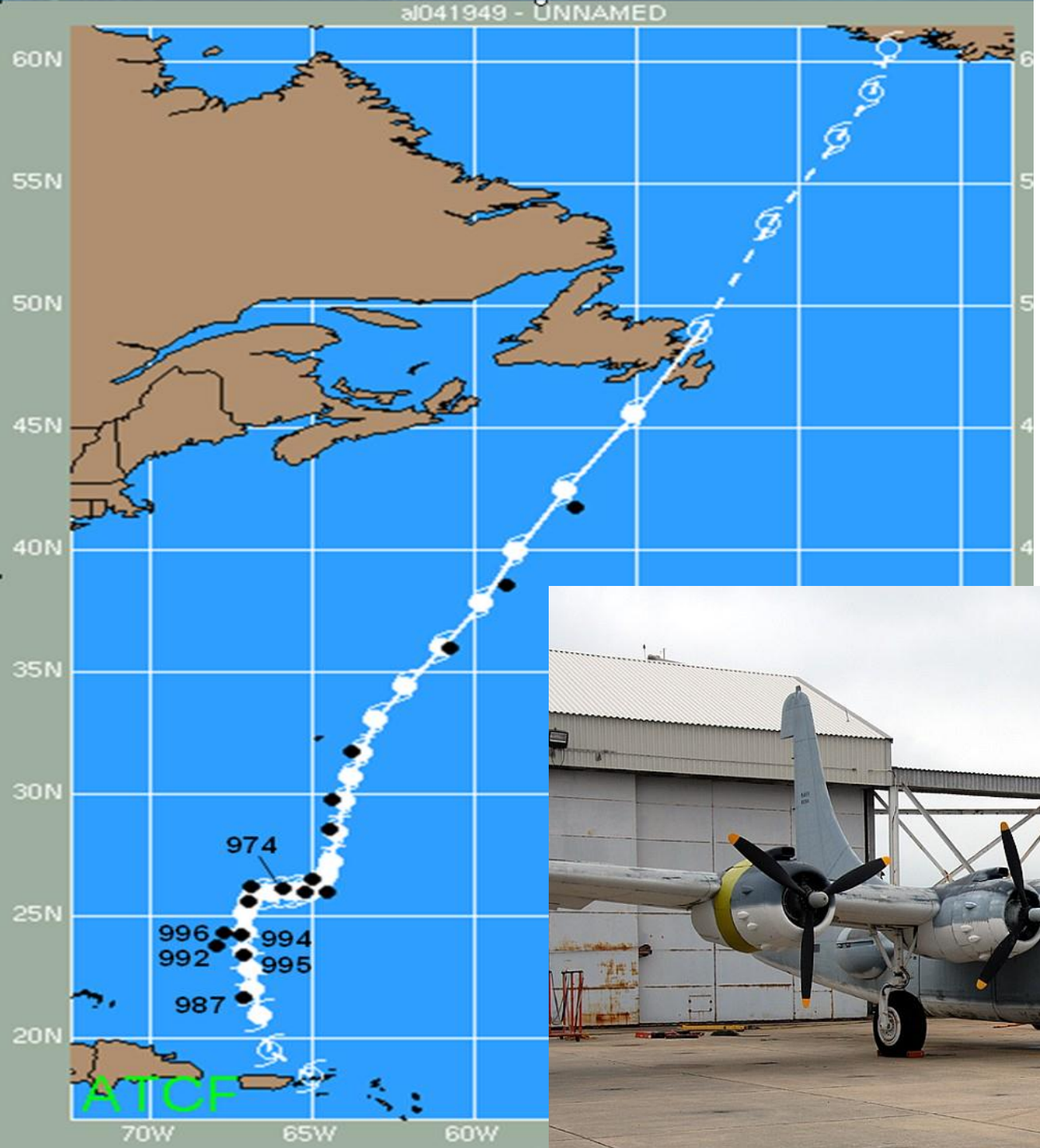






Hurricane Aircraft Reconnaissance in late 1940s and early 1950s: U.S. Navy's PB4Y2

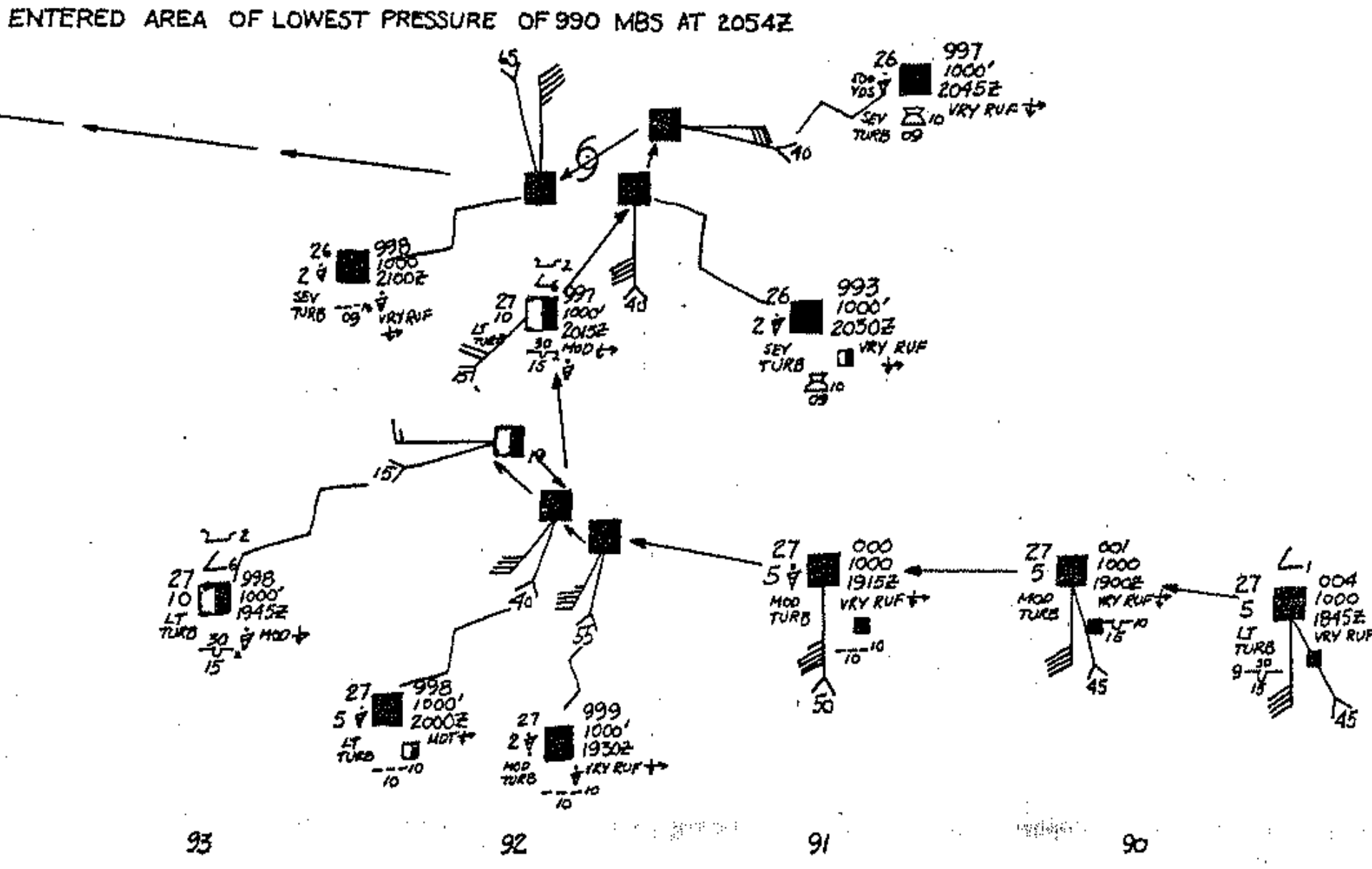




U.S. Navy's PB4Y2:

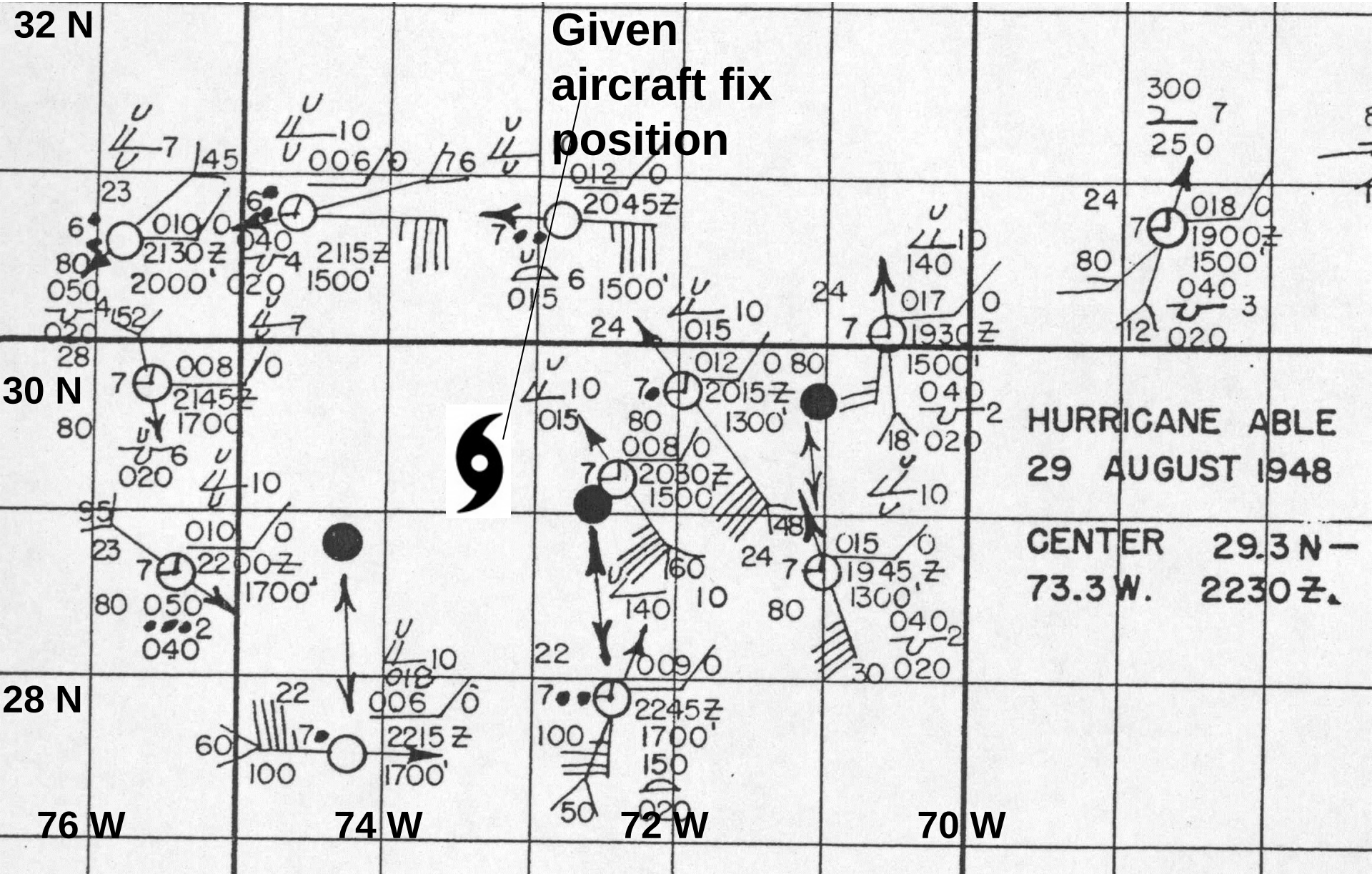
- No night flights
- No central pressure for major hurricanes

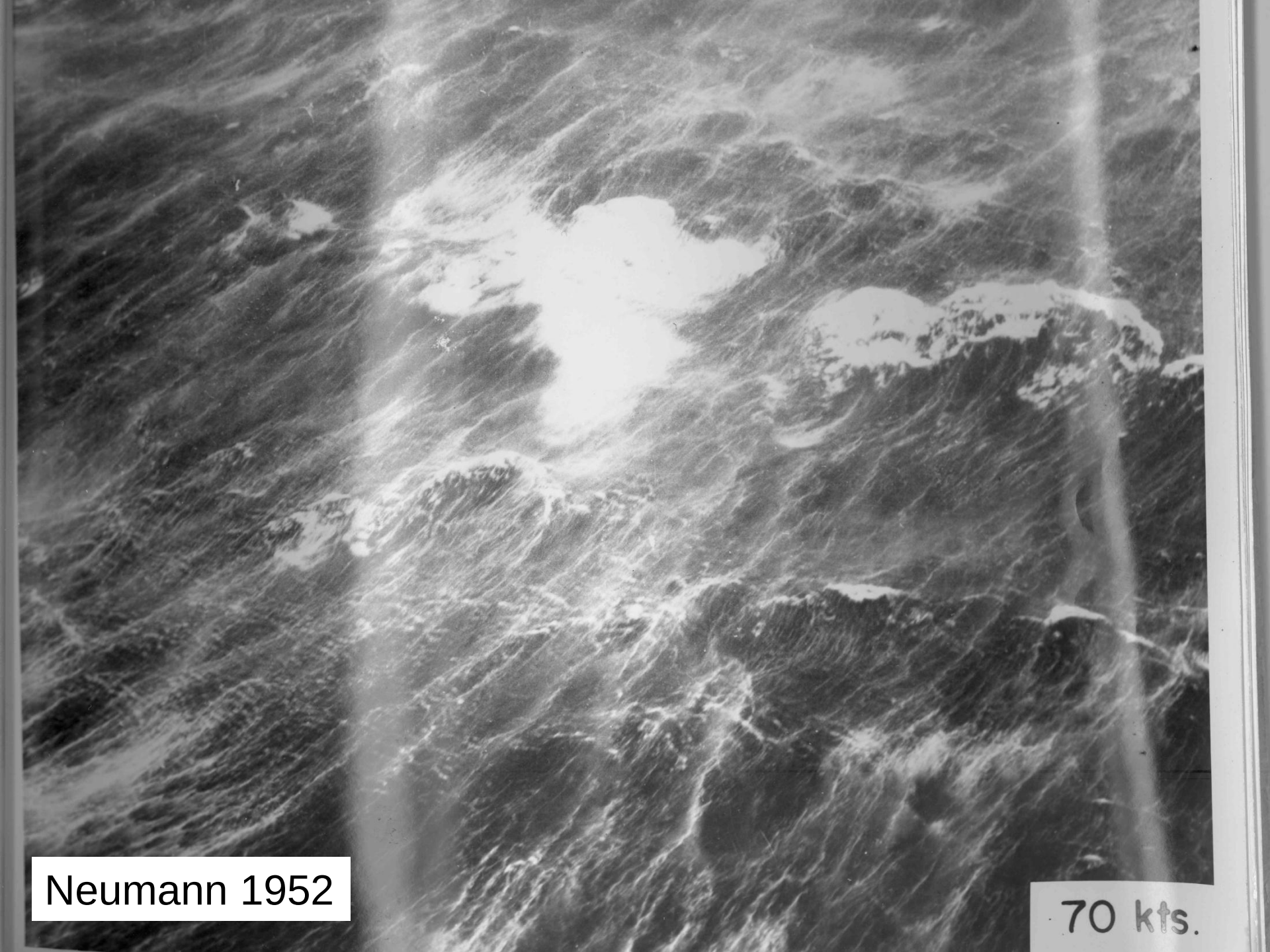
Aircraft Reconnaissance Penetration: 1948 Storm 5



Flight track 1948 Storm 3 – August 29th

Circumnavigation - typical technique for intense hurricanes




Neumann 1952
70 kts.

Reanalysis Products

Raw Data

22-Oct ~16Z	989		SWAN IS.	175 842
22-Oct ~20Z		70 SW	SWAN IS.	175 842
23-Oct ~22Z	941 EYE		SHIP	215 855
24-Oct 8Z	959	70 E	SHIP	240 852

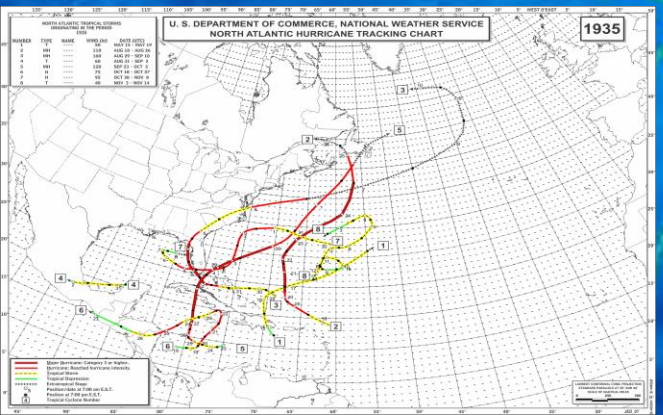
"Best Track" Data

```
22590 10/20*123 801   35     0*131 804   35
0*137 806   35     0*143 809   40     0
```

Metadata

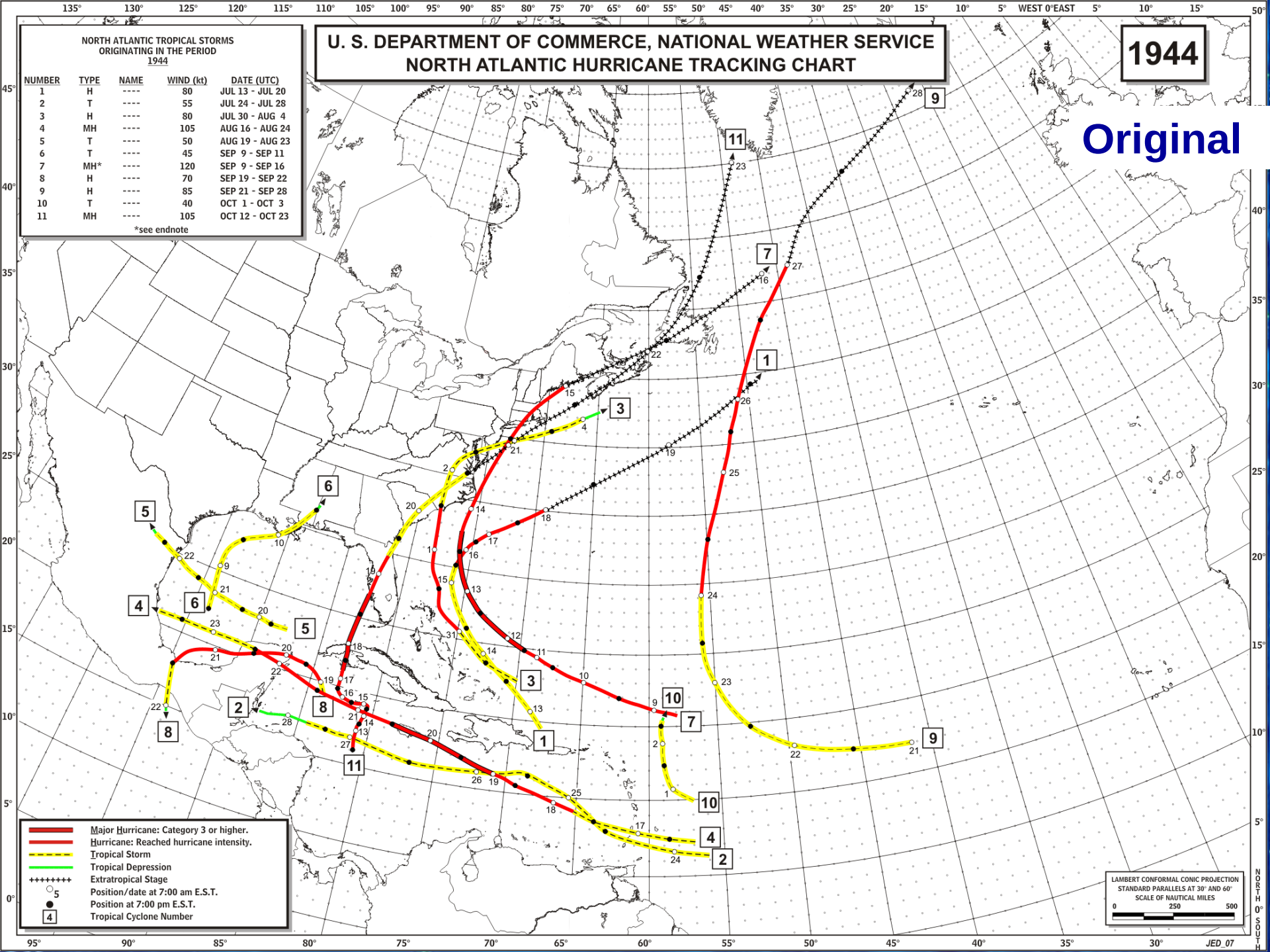
The hurricane made landfall in southwest Florida with a central pressure of 952 mb measured in Tarpon Springs at 1940-2040 UTC on the 25th. 952 mb suggests winds of 108 kt from the Gulf of Mexico pressure-wind relationship. The new Brown et al. (2006) pressure-wind relationship suggests 103 kt from the north of 25N associations. Schwerdt et al. (1979) suggested an

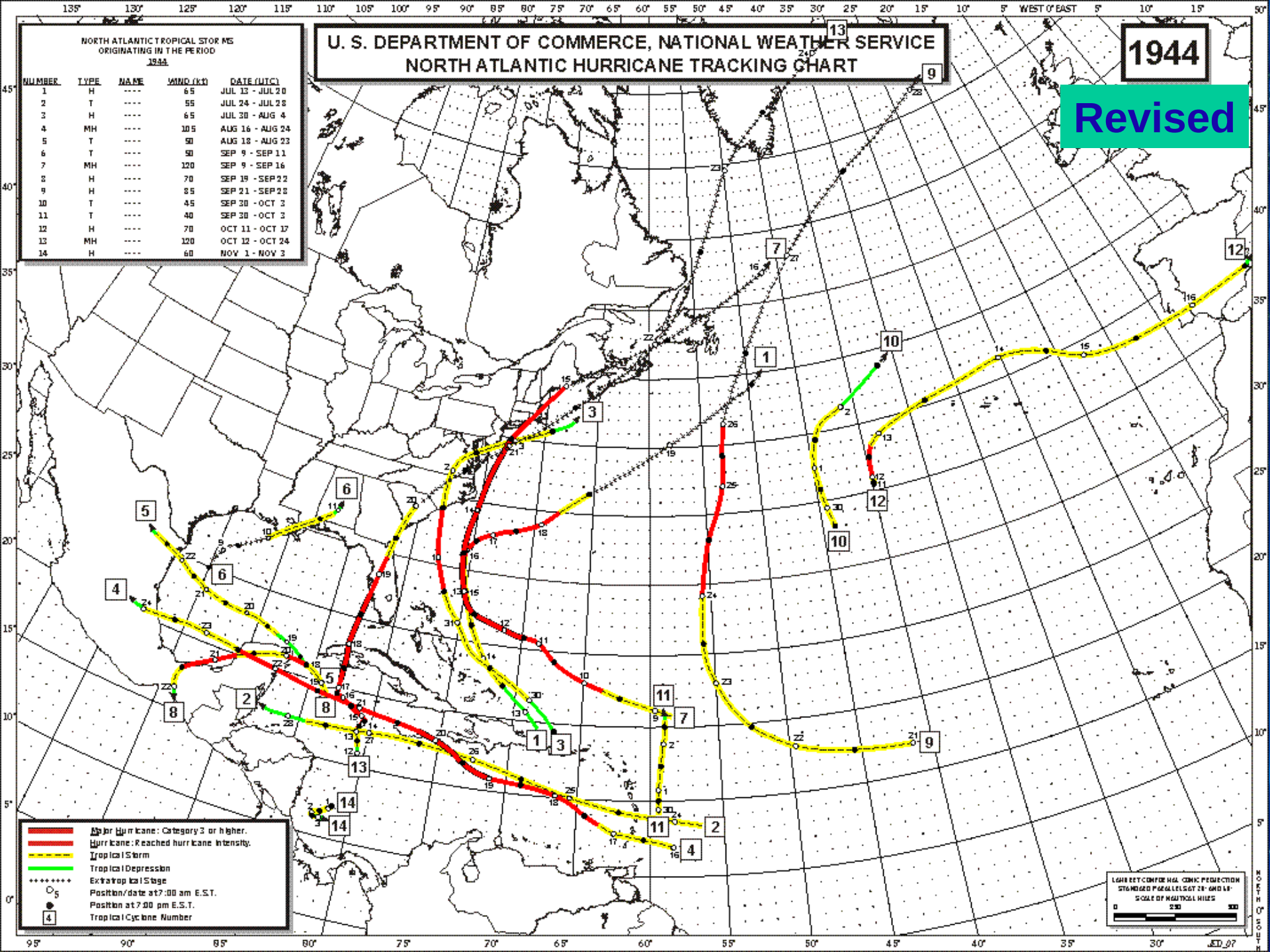
Track Maps



Comments by/Replies to Best Track Change Committee

1921 #8: Given the west wind of 20 kt found in the HWM, it is suggested that the wind at 12Z on 10/20 be maintained at 35 kt. Please note that the observation cited in the metadata for 10/23 (27.5, 85.6) appears to be either for some other day, or the latitude is incorrect (21.5?). A major


U. S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE
NORTH ATLANTIC HURRICANE TRACKING CHART
1944
Original
NORTH ATLANTIC TROPICAL STORMS
ORIGINATING IN THE PERIOD
1944
NUMBER TYPE NAME WIND (kt) DATE (UTC)
1 H ---- 80 JUL 13 - JUL 20
2 T ---- 55 JUL 24 - JUL 28
3 H ---- 80 JUL 30 - AUG 4
4 MH ---- 105 AUG 16 - AUG 24
5 T ---- 50 AUG 19 - AUG 23
6 T ---- 45 SEP 9 - SEP 11
7 MH* ---- 120 SEP 9 - SEP 16
8 H ---- 70 SEP 19 - SEP 22
9 H ---- 85 SEP 21 - SEP 28
10 T ---- 40 OCT 1 - OCT 3
11 MH ---- 105 OCT 12 - OCT 23
*see endnote
Major Hurricane: Category 3 or higher.
Hurricane: Reached hurricane intensity.
Tropical Storm
Tropical Depression
Extratropical Stage
Position/date at 7:00 am E.S.T.
Position at 7:00 pm E.S.T.
Tropical Cyclone Number
LAMBERT CONFORMAL CONIC PROJECTION
STANDARD PARALLELS AT 30° AND 60°
SCALE OF NAUTICAL MILES
0 250 500
JED_07


U. S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE
NORTH ATLANTIC HURRICANE TRACKING CHART
1944
Revised
NORTH ATLANTIC TROPICAL STORMS ORIGINATING IN THE PERIOD 1944
NUMBER TYPE NAME WIND (kt) DATE (UTC)
1 H ---- 65 JUL 13 - JUL 20
2 T ---- 55 JUL 24 - JUL 28
3 H ---- 65 JUL 30 - AUG 4
4 MH ---- 105 AUG 16 - AUG 24
5 T ---- 50 AUG 18 - AUG 23
6 T ---- 50 SEP 9 - SEP 11
7 MH ---- 120 SEP 9 - SEP 16
8 H ---- 70 SEP 19 - SEP 22
9 H ---- 85 SEP 21 - SEP 28
10 T ---- 45 SEP 30 - OCT 3
11 T ---- 40 SEP 30 - OCT 3
12 H ---- 70 OCT 11 - OCT 17
13 MH ---- 120 OCT 12 - OCT 24
14 H ---- 60 NOV 1 - NOV 3
Major Hurricane: Category 3 or higher.
Hurricane: Reached hurricane intensity.
Tropical Storm
Tropical Depression
Extratropical Stage
Position/date at 7:00 am E.S.T.
Position at 7:00 pm E.S.T.
Tropical Cyclone Number
WEST OF EAST
NORTH OF SOUTH

1944 missing hurricane found

New to HURDAT:

31895 10/11/1944 M= 7 12 SNBR= 707 NOT NAMED XING=0

31896 10/11*355 400 35 0*355 400 35 0*355 400 40 0*355 400 45 0*

31897 10/12*356 400 50 0*357 400 60 0*360 400 70 0*366 400 70 0*

31898 10/13*375 399 70 0*383 395 60 0*390 385 50 0*397 365 50 0*

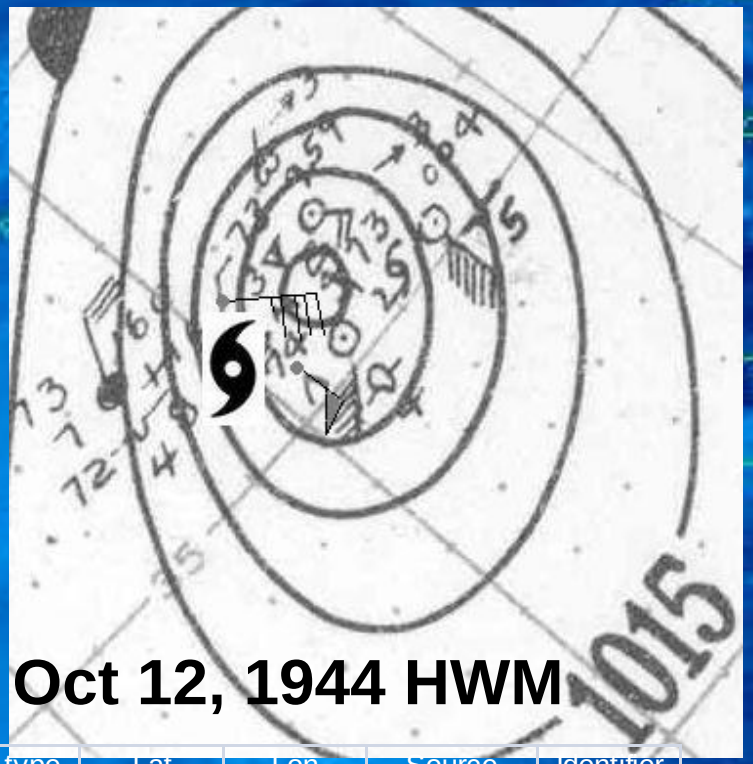
31899 10/14*404 335 45 0*410 295 45 0*415 255 45 0*412 230 45 0*

31899 10/15*405 210 45 0*397 195 50 0*390 180 55 0*385 160 55 0*

31899 10/16*382 130 50 0*381 100 50 0*380 70 45 0*380 40 35 0*

31899 10/17*380 10 30 0* 0 0 0 0* 0 0 0 0* 0 0 0 0*

31960 HR

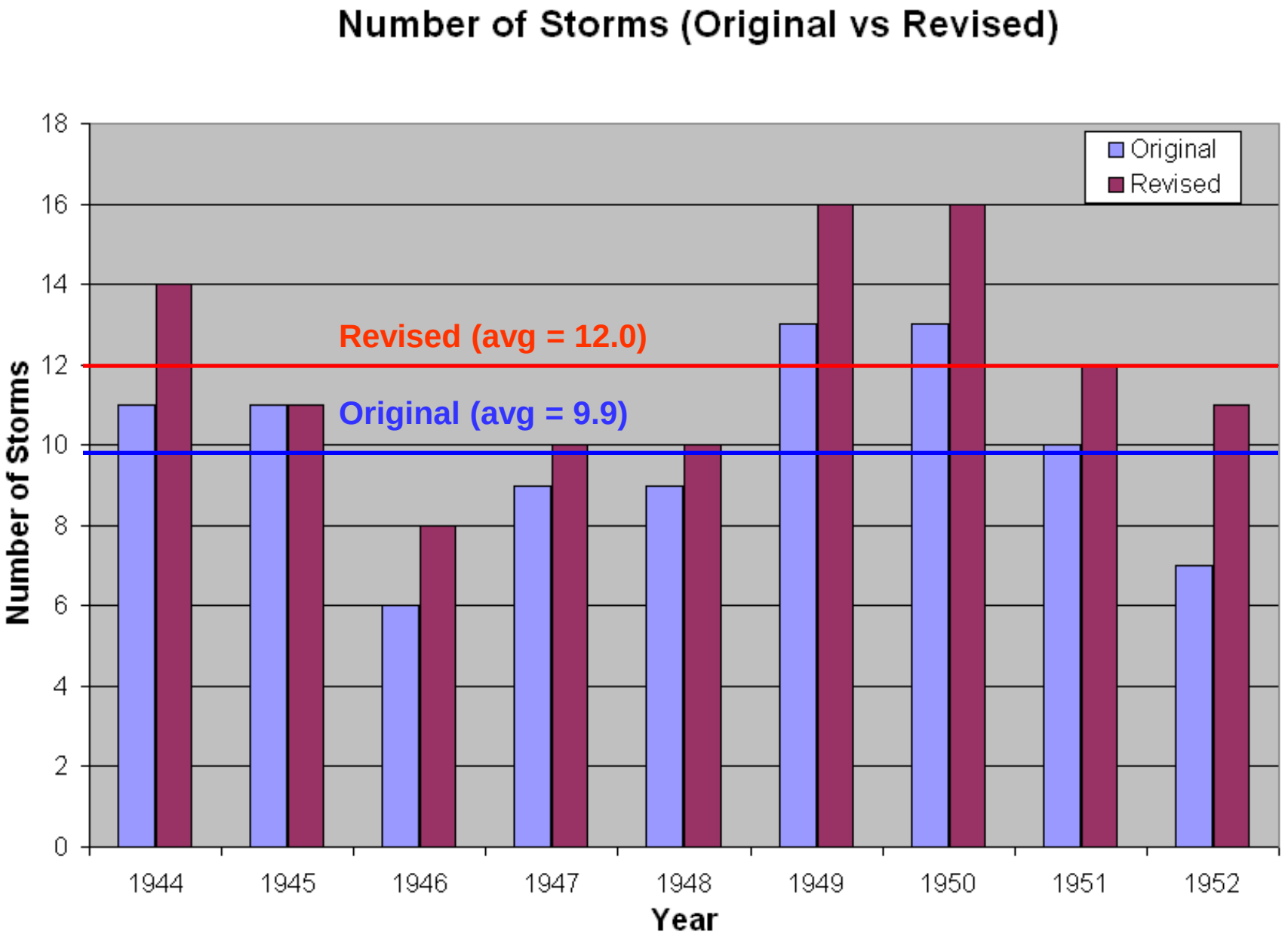


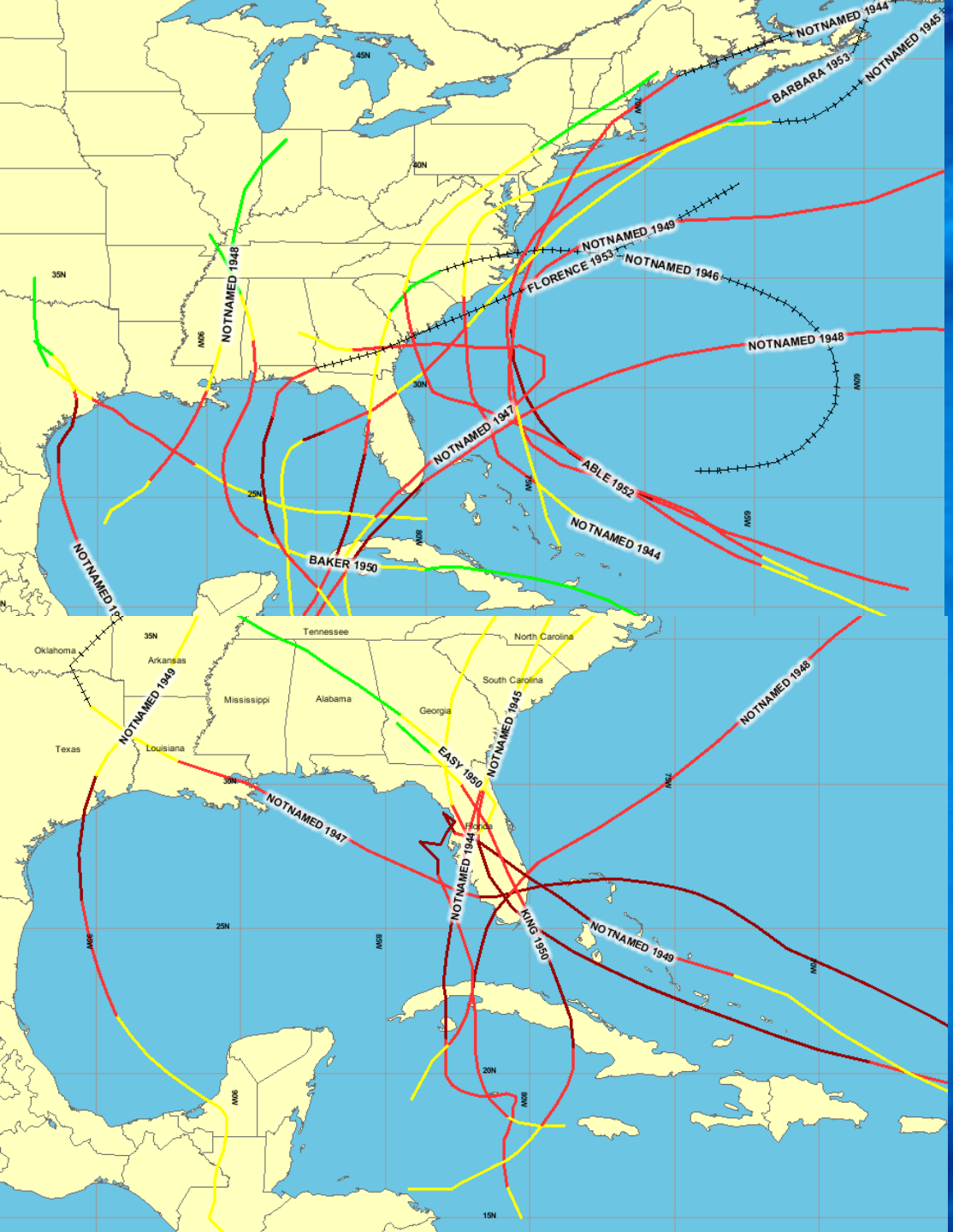
Oct 12, 1944 HWM

Key observations:

Date	Time	Pressure	Wind (kt)	Dir	Air Temp	SST	Ob type	Lat	Lon	Source	Identifier
11-Oct	15Z	**1005**	25	NE	75		SHIP	375	415	COA	37016
11-Oct	19Z	1011	**40**	NNE	74		SHIP	365	405	COA	
11-Oct	23Z		**45**	N	76	74	SHIP	365	415	COA	61132
11-Oct	23Z	1012	**35**	NE	74	75	SHIP	365	405	COA	14352
11-Oct	23Z	1011	**35**	NNE	75	76	SHIP	365	405	COA	61061
12-Oct	10Z	**1000**	**65**	S	73	73	SHIP	355	375	COA, HWM	14352
12-Oct	11Z		**50**	S	74	72	SHIP	355	395	COA	61132
12-Oct	11Z	**998**	**45**	SE	72		SHIP	365	395	COA	
12-Oct	11Z	**996**	10	SE	73	74	SHIP	365	385	COA, HWM	61061
12-Oct	12Z		**50**	SW	74		SHIP	352	389	HWM	
12-Oct	14Z	1010	**70**	S	74	74	SHIP	355	375	COA	14352
12-Oct	14Z	1006	**45**	S	75	74	SHIP	355	375	COA	61061
12-Oct	15Z		**60**	S	73	74	SHIP	355	395	COA	61132
12-Oct	15Z	1008	**45**	S	73		SHIP	365	385	COA	

Tropical storms and hurricanes





US Cat 1&2 Hurricanes (1944-1953)

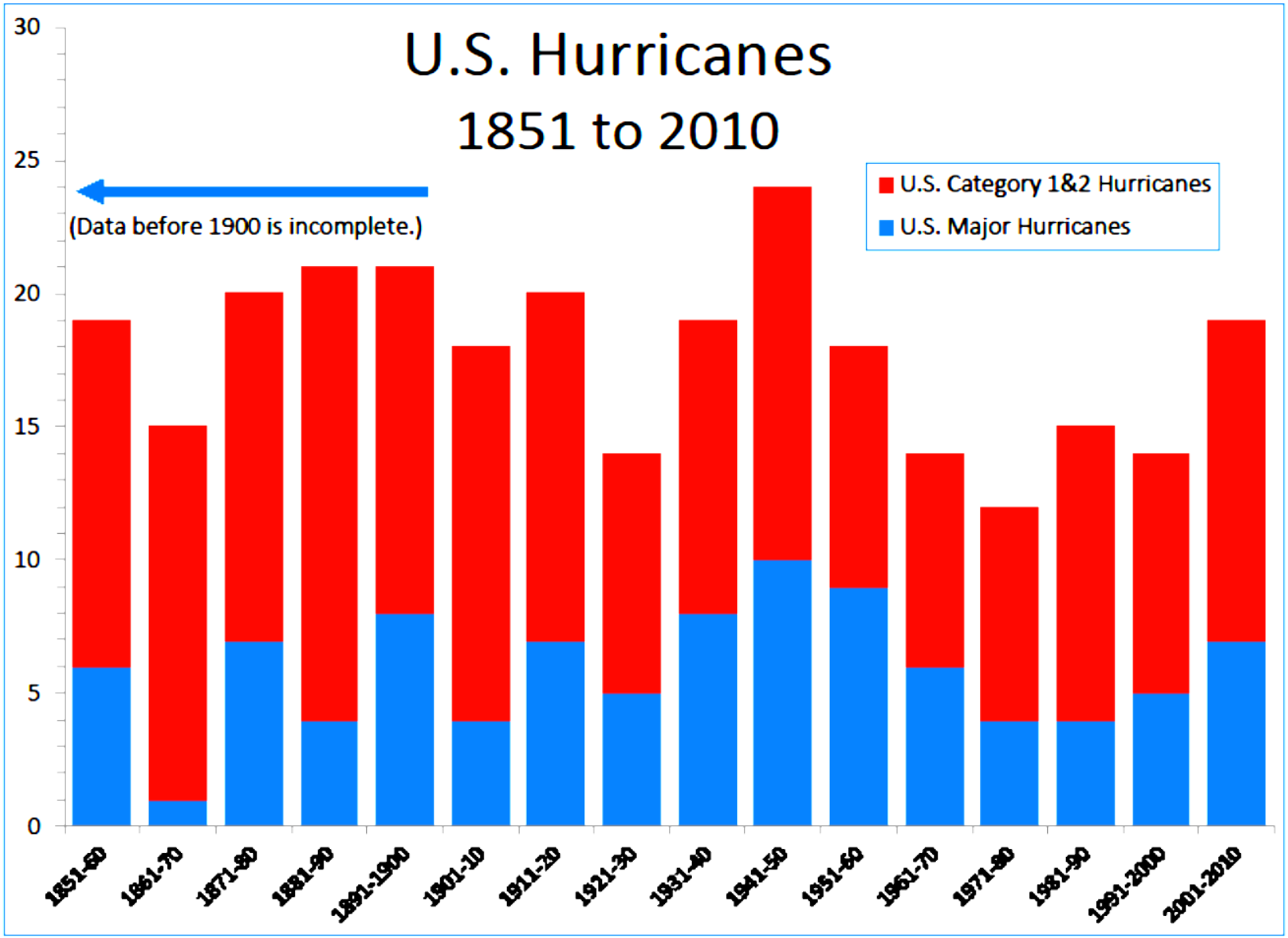
1944-1953:

6 up 1 Category

2 down 1 Category

15 unchanged

US Major Hurricanes (1944-1953)


U.S. Hurricanes
1851 to 2010
(Data before 1900 is incomplete.)
U.S. Category 1&2 Hurricanes
U.S. Major Hurricanes
30
25
20
15
10
5
0
1851-60
1861-70
1871-80
1881-90
1891-1900
1901-10
1911-20
1921-30
1931-40
1941-50
1951-60
1961-70
1971-80
1981-90
1991-2000
2001-2010

Accomplishments:

2000 – Added in 241 new TCs for 1851 to 1885

2002 – Reanalyzed 1992's Hurricane Andrew

2003 – Reanalyzed 1886 to 1910 – Revised all existing 194 TCs, added 23 new TCs, removing one TC

2005 – Reanalyzed 1911 to 1914 – Revised all 15 existing TCs, added 5 new TCs.

2008 – Reanalyzed 1915 to 1920 – Revised all 34 existing TCs, added 8 new TCs, removed one TC

2009 – Reanalyzed 1921 to 1925 – Revised all 27 existing TCs, added in 10 new TCs, removed one TC

2010 – Reanalyzed 1926 to 1930 – All 29 TCs revised, 4 new TCs

2012 – Reanalyzed 1931 to 1935 – All 58 TCs revised, 15 new TCs, 4 removed TCs

2012 – Have submitted 1936 to 1954 reanalyses for consideration

Overall: Revised 357 existing tropical cyclones, added 316 new systems, removed 8 tropical cyclones

http://www.aoml.noaa.gov/hrd/data_sub/re_anal.html

The Atlantic Hurricane Database Reanalysis

October 2012

NOAA Climate Diagnostics and Prediction Workshop

Chris Landsea, *National Hurricane Center*, Miami, USA

Supported by the NOAA Climate Program Office

Reanalysis of NW Pacific Typhoon Database

- Shifts in Typhoon Tracks over the western North Pacific during the 20th century based on the recovery of historical data
  Hisayuki Kubota, Research Institute for Global Change/ Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan; and J. C. L. Chan, J. Matsumoto, and E. Ginn – American Meteorological Society Hurricanes and Tropical Meteorology Conference, April 2012

Revised HURDAT average position errors

Year	US Landfalling (settled)	Open ocean w/ AC	Open ocean w/ no AC
1851-85	60 nmi	N/A	120 nmi
1886-1920	60 nmi	N/A	100 nmi
1944-1953	20 nmi	35 nmi	80 nmi
Late 1990s	12 nmi	15 nmi	25 nmi
Late 2000s	12 nmi	15 nmi	25 nmi

1851-1920 numbers from Landsea et al. 2004, Landsea et al. 2008. Late 1990s and late 2000s estimates from Landsea 2012

Revised HURDAT average intensity errors

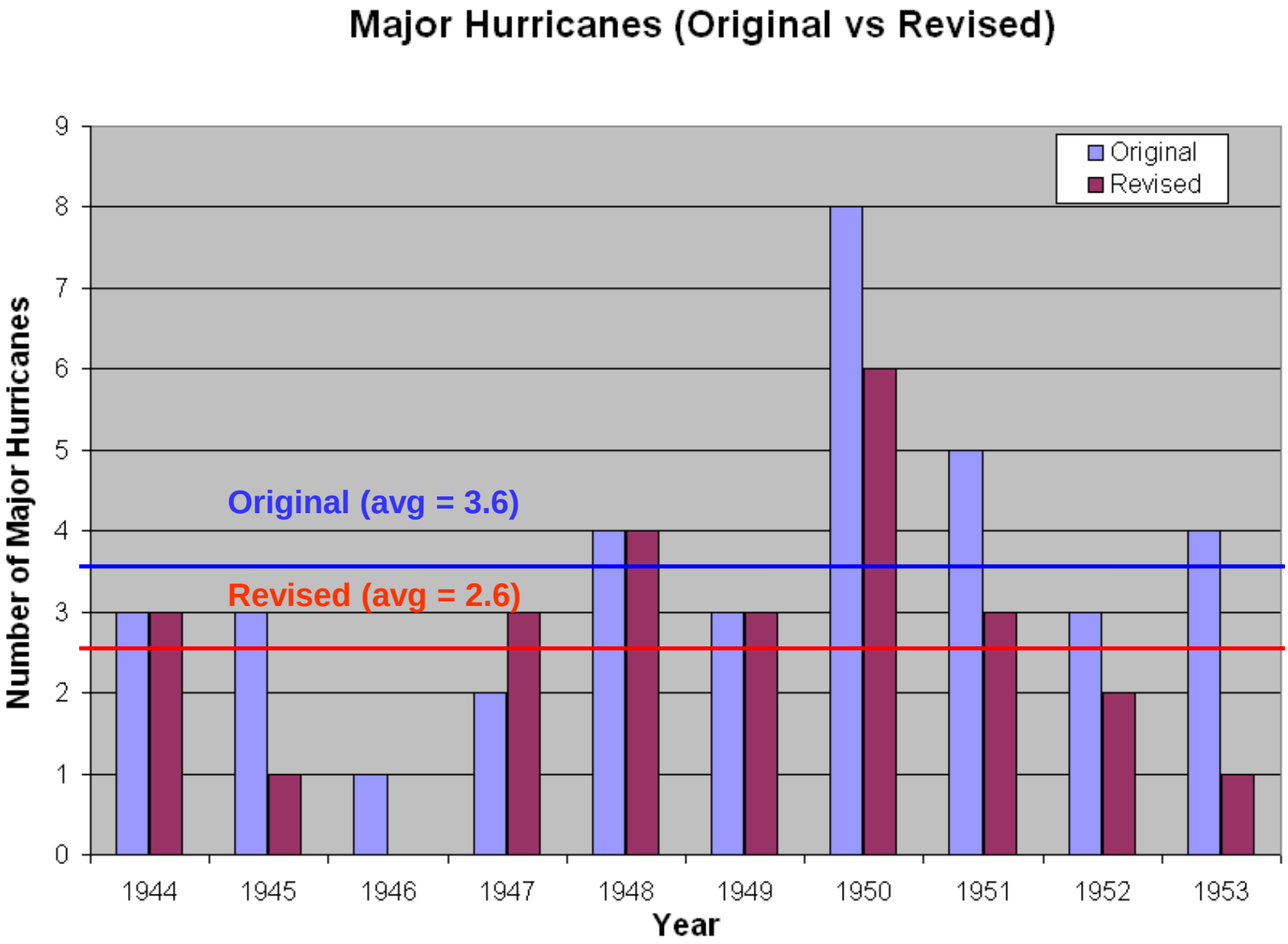
Year	US Landfalling (settled)	Open ocean w/ AC central pressure	Open ocean w/ AC; no central pressure	Open ocean w/ no AC
1851-85	15 kt	N/A	N/A	25 kt
1886-1920	12 kt	N/A	N/A	20 kt
1944-1953	11 kt	13 kt	15 kt	20 kt
Late 1990s	10 kt	12 kt	N/A	15 kt
Late 2000s	9 kt	10 kt	N/A	12 kt

Revised HURDAT intensity biases

Year	1851-85	1886-1920	1944-53	Late 2000s
US Landfalling (settled)	0 kt	0 kt	0 kt	0 kt
Open ocean w/ AC cp	N/A	N/A	0 kt	0 kt
Open ocean w/ AC; no cp (30-95 kt)	N/A	N/A	+5 kt	N/A
Open ocean w/ AC; no cp (100-115 kt)	N/A	N/A	0 kt	N/A
Open ocean w/ AC; no cp (120+ kt)	N/A	N/A	-10 kt	N/A
Open ocean w/ no AC	-15 kt	-10 kt	-10 kt	0 kt

1851-1920 numbers from Landsea et al. 2004, Landsea et al. 2008. Late 1990s and late 2000s estimates from Landsea 2012

Major hurricanes



More data Sources

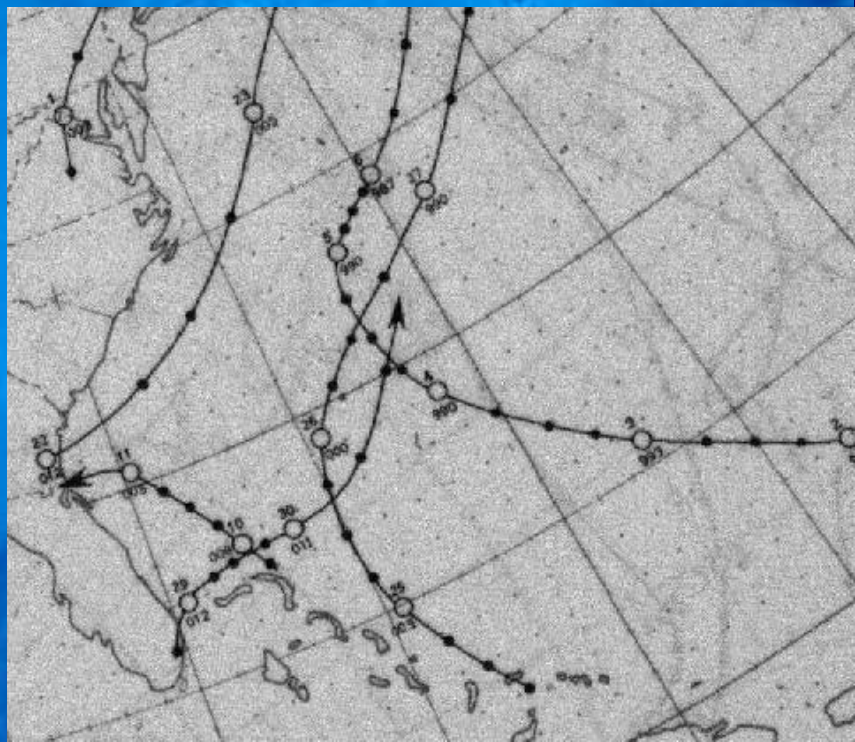
COADS Ship Observations

date	time	pres	wind (kt)	dir	T	S	type/place	lat	lon	source	ship #
18-Oct	13Z	1009	35	E	81		SHIP	265	805	COA	97082
18-Oct	14Z	999	35	NNE	79	80	SHIP	255	855	COA, HWM	89009
18-Oct	17Z	1009	35	E	85	82	SHIP	265	805	COA	97082
18-Oct	18Z	995	35	NNE	77	80	SHIP	255	855	COA	89009
19-Oct	1Z	1005	35	E	82	82	SHIP	265	805	COA	97082
19-Oct	2Z	986			77	80	SHIP	265	855	COA	89009
19-Oct	13Z	998	60	SE	81	82	SHIP	285	805	COA	97082
19-Oct	14Z	998	50	NW	79	80	SHIP	265	855	COA	89009
19-Oct	17Z	998	60	SE	82	82	SHIP	285	805	COA	97082

Other useful data sources

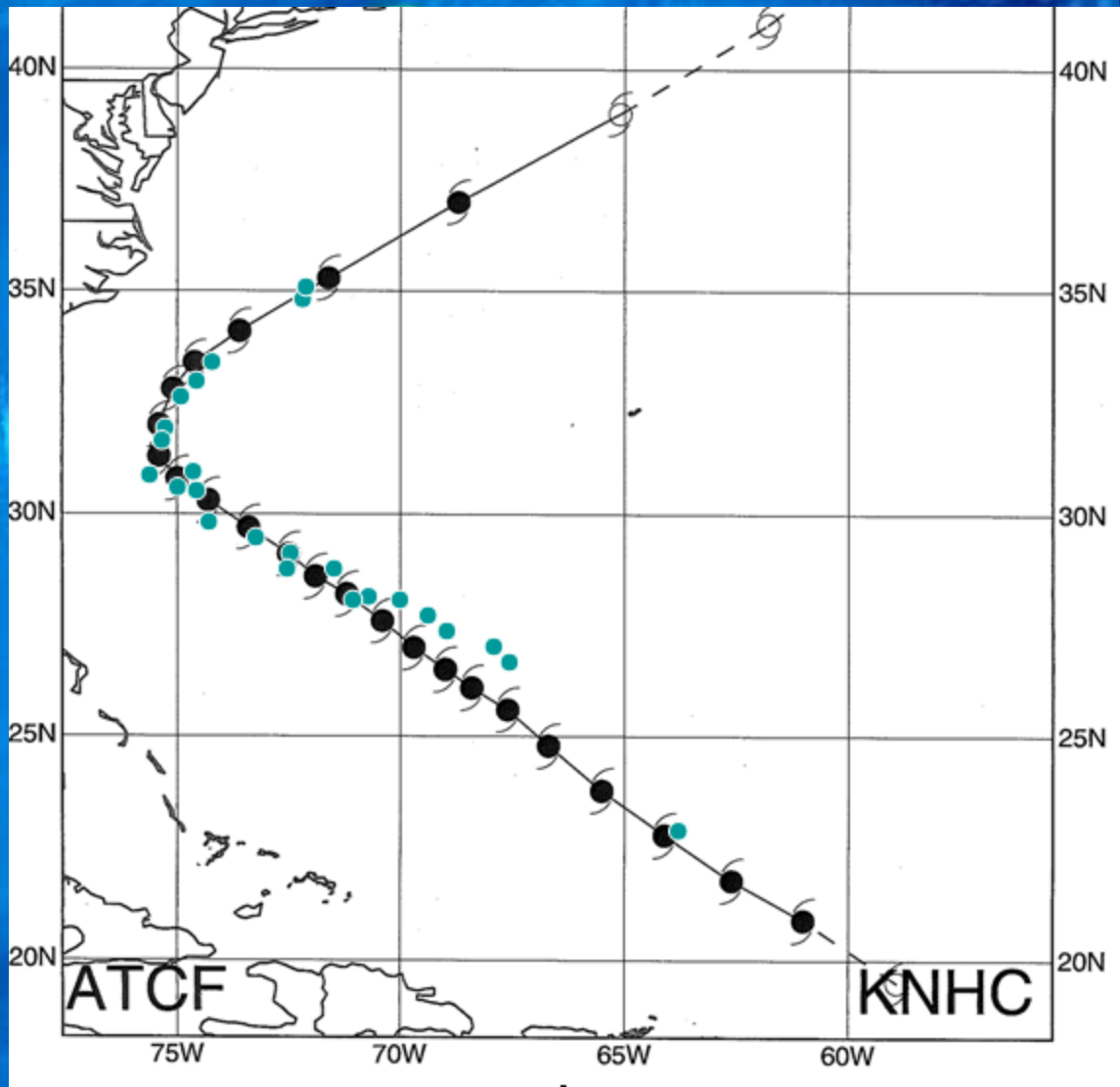
- Monthly Weather Review (MWR) post-season summary articles
- Navy, Army-Air Force, and Air Weather Service post-season hurricane summaries: These focus on aircraft reconnaissance
- Original Monthly Records and Climatological Data Summaries of U.S. coastal station observations
- Several publications on case studies of Atlantic hurricanes

MWR Tracks of Lows



Track analysis methodology (with abundant recon fixes)

- All center fixes compiled
- Fixes plotted and interpolated to 6-hourly positions
- Ship and station data plotted against aircraft data
- Final revised positions are a consensus of all data
- When lack of data, significant changes are not implemented



Intensity analysis tools

- Ship, coastal stations, aircraft reconnaissance data
- Brown et al. (2006) pressure-wind relationships
- Vickery et al. (2000) climatological RMW values
- Kaplan and DeMaria (1995) inland decay model
- Schloemer (1954) equation
  - Calculates central pressure given a peripheral pressure measurement
- Ho et al. (1987) inland pressure decay model
  - Estimates landfall central pressure based on a post-landfall central pressure measurement
- Neumann model from Schwerdt et al. (1979)
  - Calculates extent of hurricane force winds
- Franklin et al. (2003) flight-level to sfc wind