Automated Quality Control of Tropical Cyclone Winds Through Data Mining

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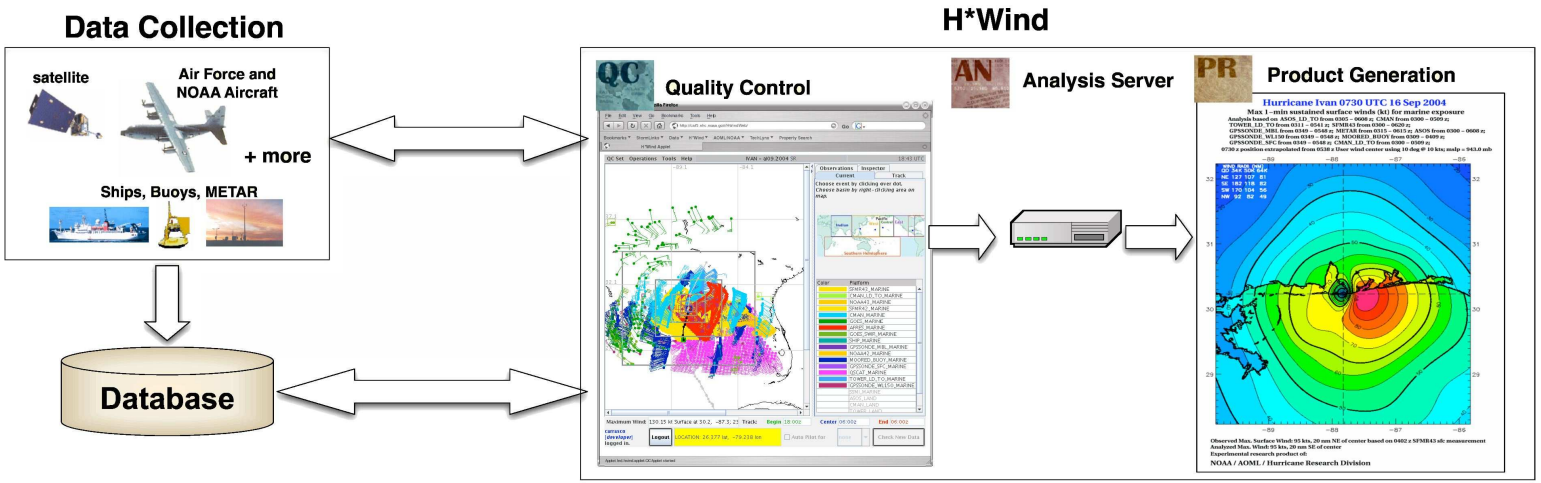
Aug. 16, 2005

Overview

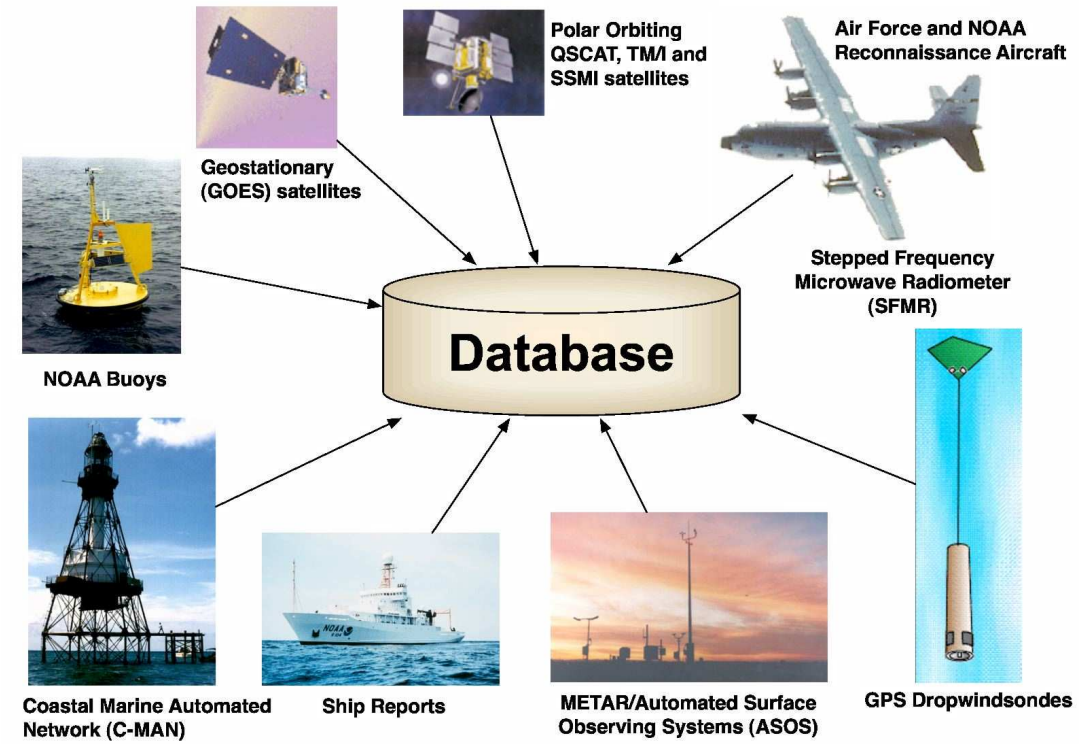
- Brief Introduction to H∗Wind
- Tropical Cyclone Data
- QC of Tropical Cyclone Data
- Clustering and DBSCAN
- Coordinate Systems
- Results
- Conclusion
- References

A Brief Description of what H∗Wind is



- A Complete System
  - Data Collection Suite
  - An Interactive User Interface
  - Tropical Cyclone Analysis Engine
  - Product Generation Suite

Tropical Cyclone Data

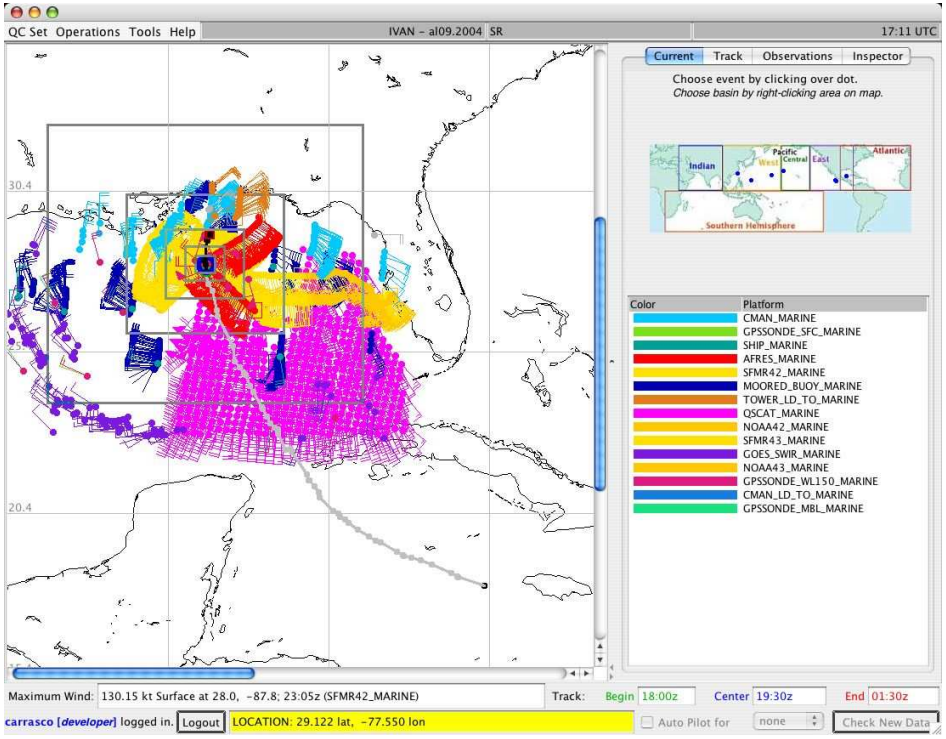


Wind data is adjusted to a common framework of a 1minute sustained wind at 10meter open exposure

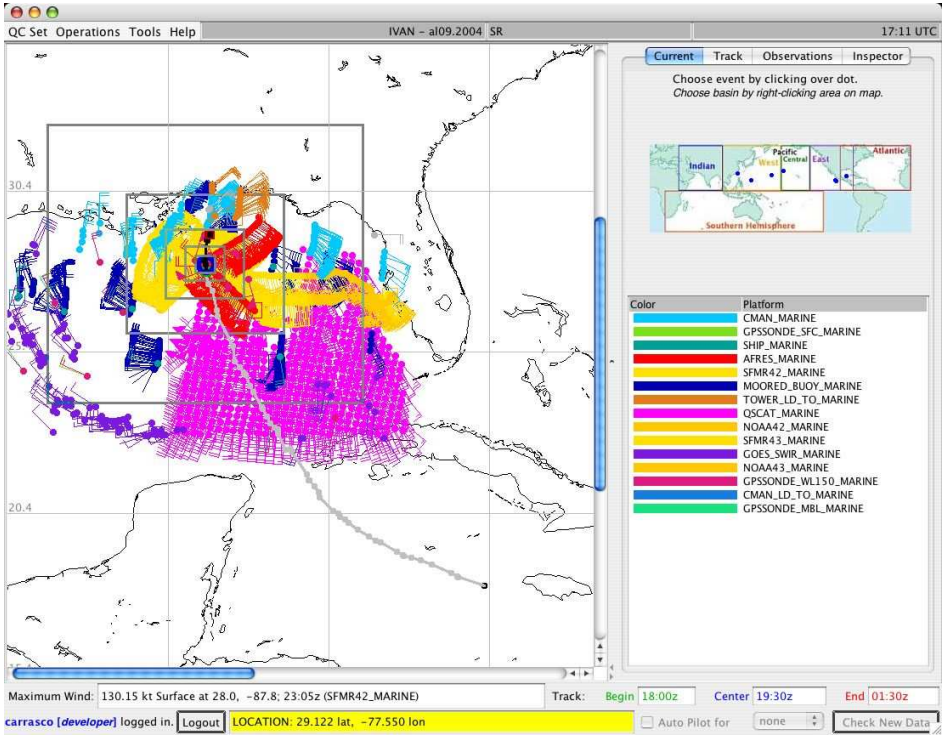
Common Attributes:

- data & time
- location
- wind speed & direction
- pressure
- temperature
- humidity

QC of Tropical Cyclone Data

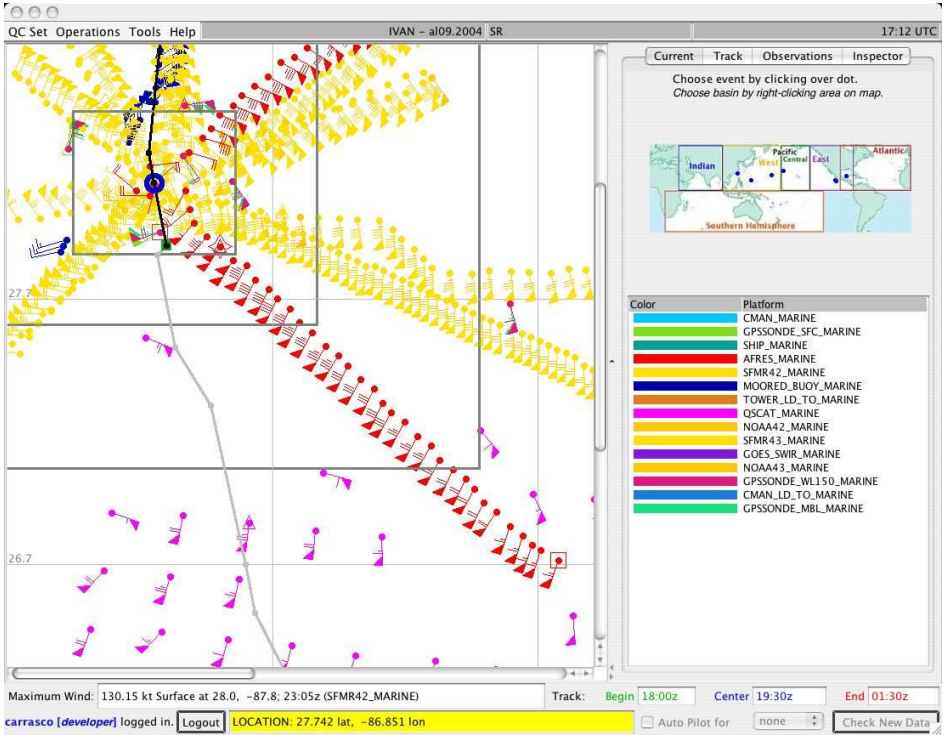


QC of Tropical Cyclone Data



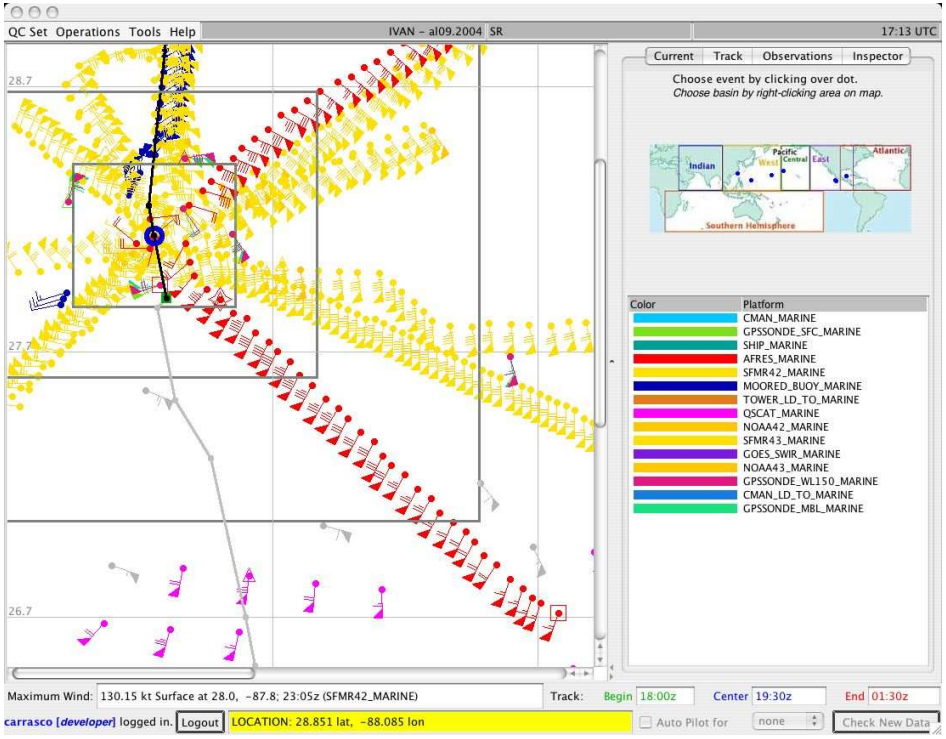
- Data Coverage

QC of Tropical Cyclone Data



- Data Coverage
- Erroneous Data

QC of Tropical Cyclone Data



- Data Coverage
- Erroneous Data
- Flagged Data

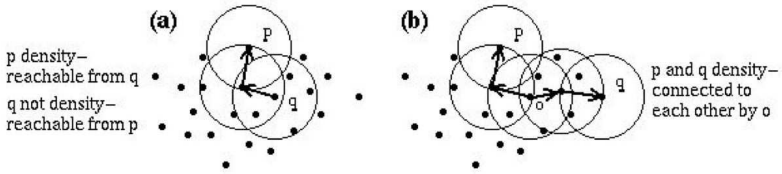
Clustering and DBSCAN (Ester et.al. 1996)

Clustering and DBSCAN (Ester et.al. 1996)

- FindCluster(. . .)

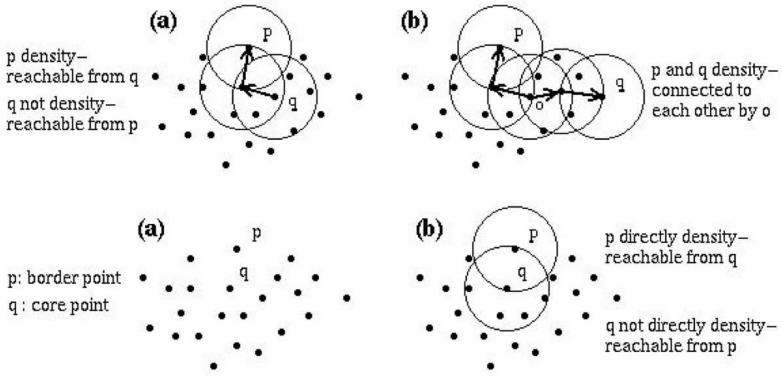
Clustering and DBSCAN (Ester et.al. 1996)

- FindCluster(. . .)
  - *GetEpsNeighbors(. . .)*



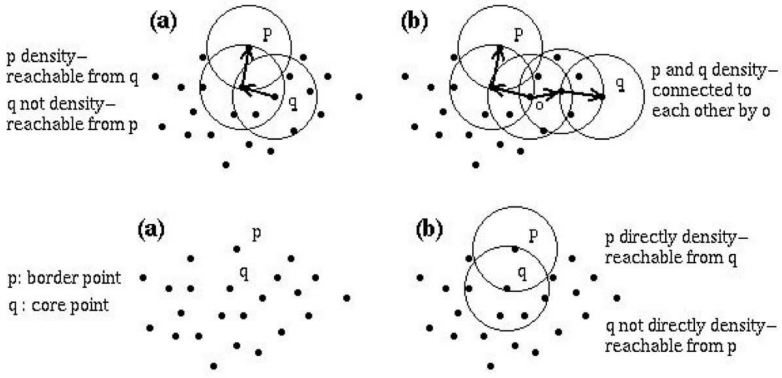
Clustering and DBSCAN (Ester et.al. 1996)

- FindCluster(. . .)
  - *GetEpsNeighbors(. . .)*
    - *core points*
    - *border points*



Clustering and DBSCAN (Ester et.al. 1996)

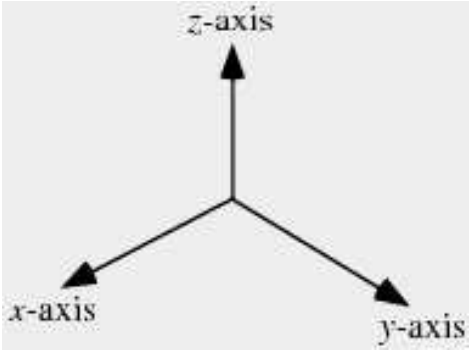
- FindCluster(. . .)
  - *GetEpsNeighbors(. . .)*
    - *core points*
    - *border points*
  - *isNeighbor(. . .)*



Coordinate Systems (Mathworld)

Coordinate Systems (Mathworld)

- Cartesian



Coordinate Systems (Mathworld)

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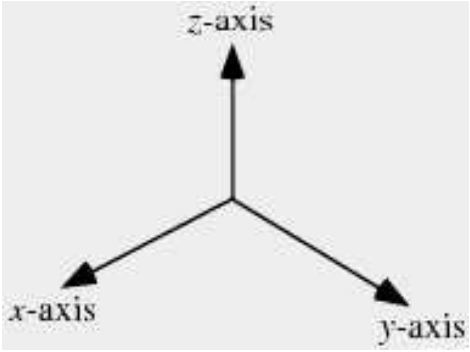
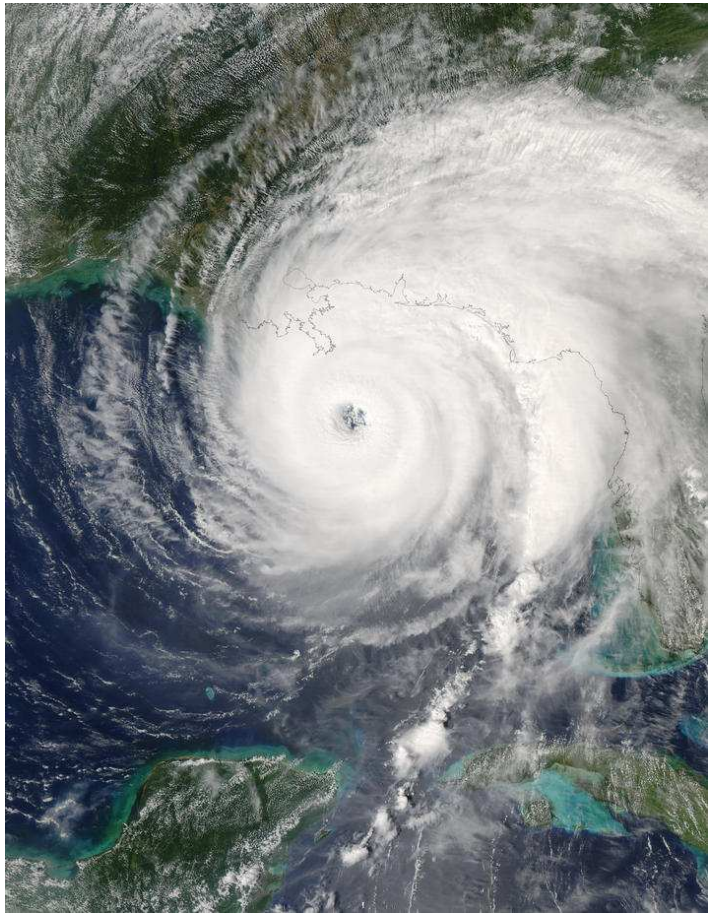
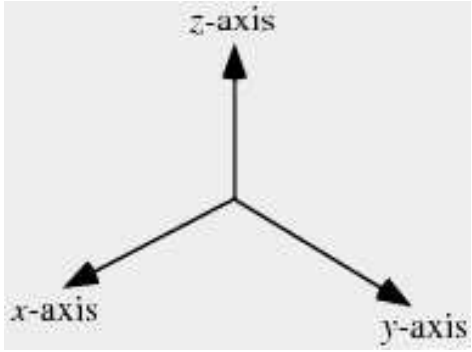




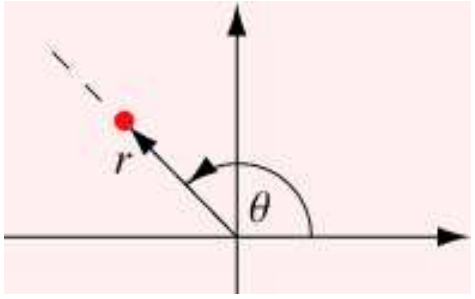
courtesy of CIMSS-WISC http://cimss.ssec.wisc.edu/tropic/tropic.html

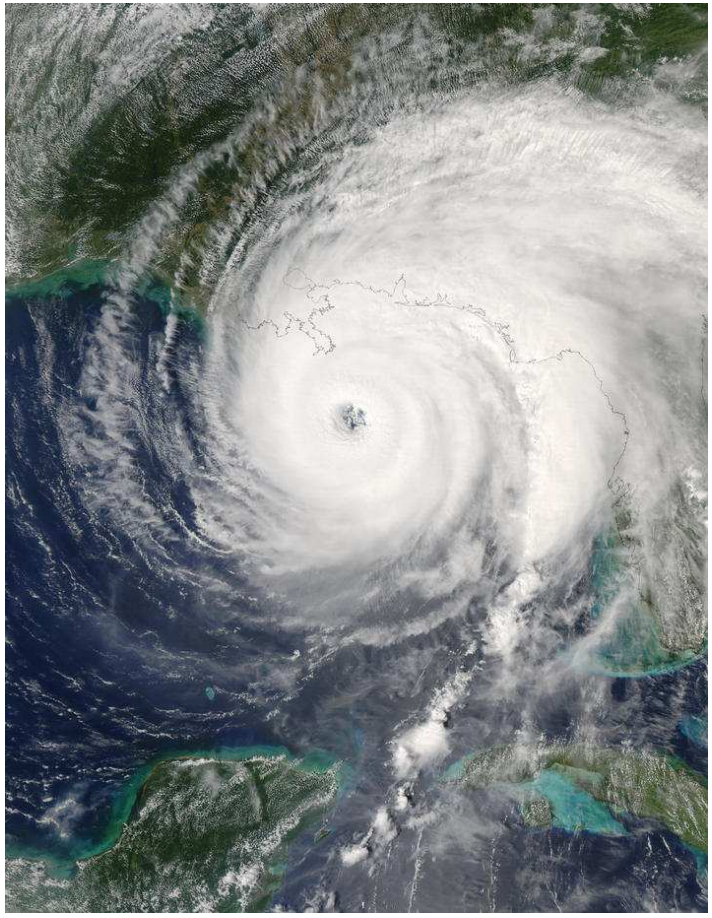
Coordinate Systems (Mathworld)

- Cartesian



- Polar/Cylindrical





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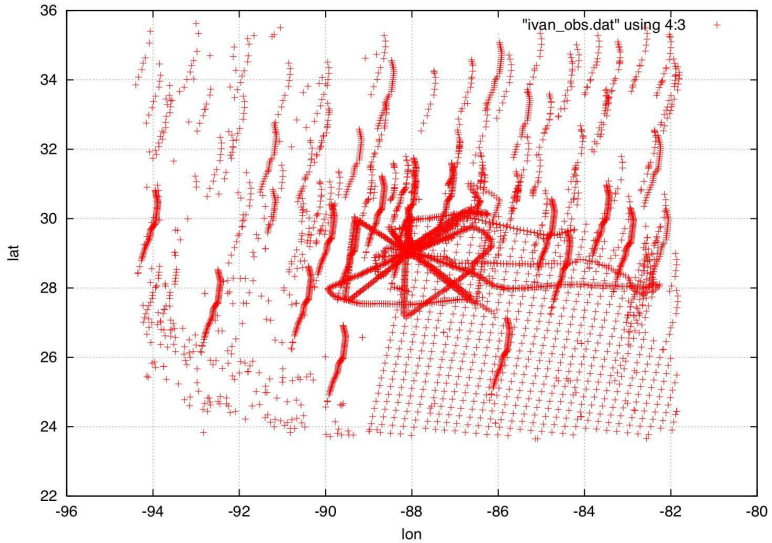
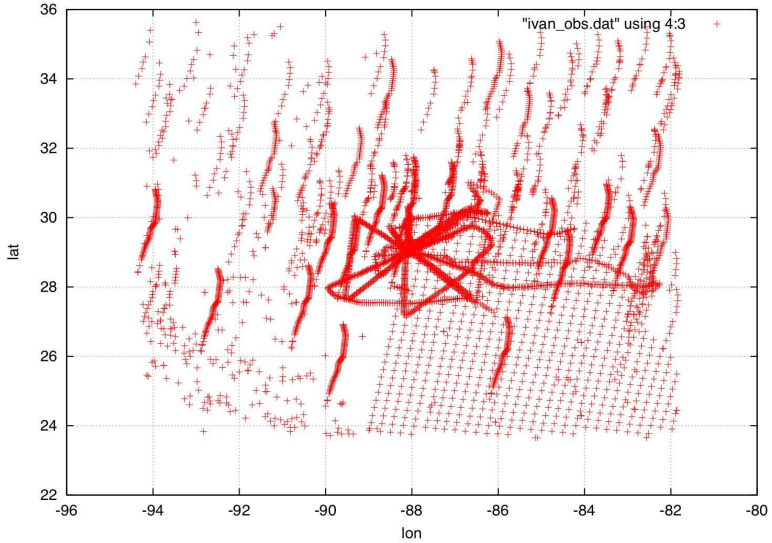
Coordinate Systems

Cartesian

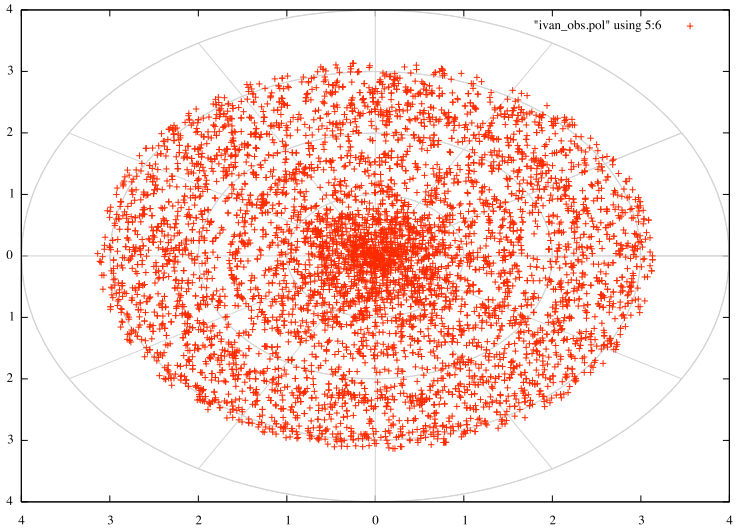


Coordinate Systems

Cartesian



Polar



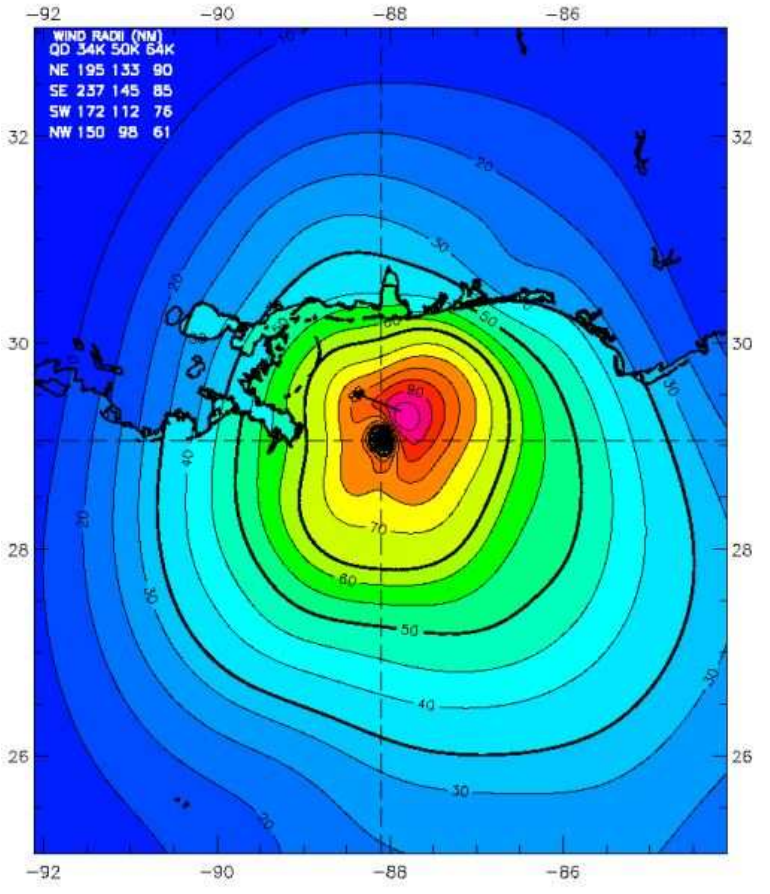
Eps and MinPts values

- Cartesian distance = 26km
- Radial difference = 10km
- Angular = 45deg
- Wind speed = 5kt 2.5m/s
- Wind direction = 90deg

Minimum number of neighbors to construct a valid cluster = 4

Hurricane Ivan 2004 Sept. 16 0130z

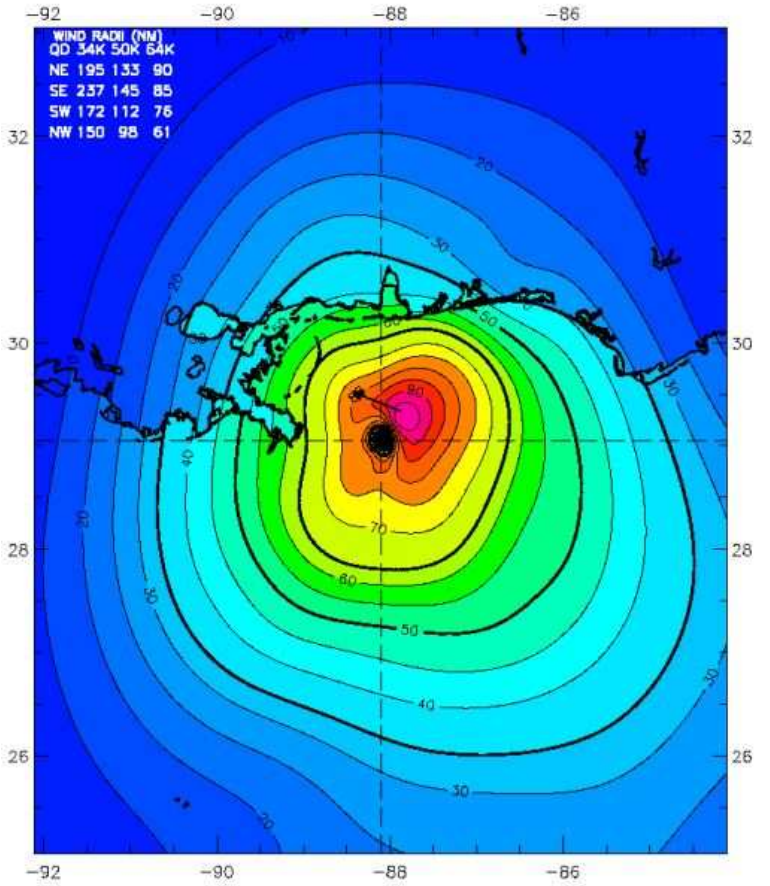
Operational



Observed Max. Surface Wind: 99 kts, 21 nm NE of center based on 0135 z SFMR43 sfc measurement
Analyzed Max. Wind: 99 kts, 21 nm NE of center

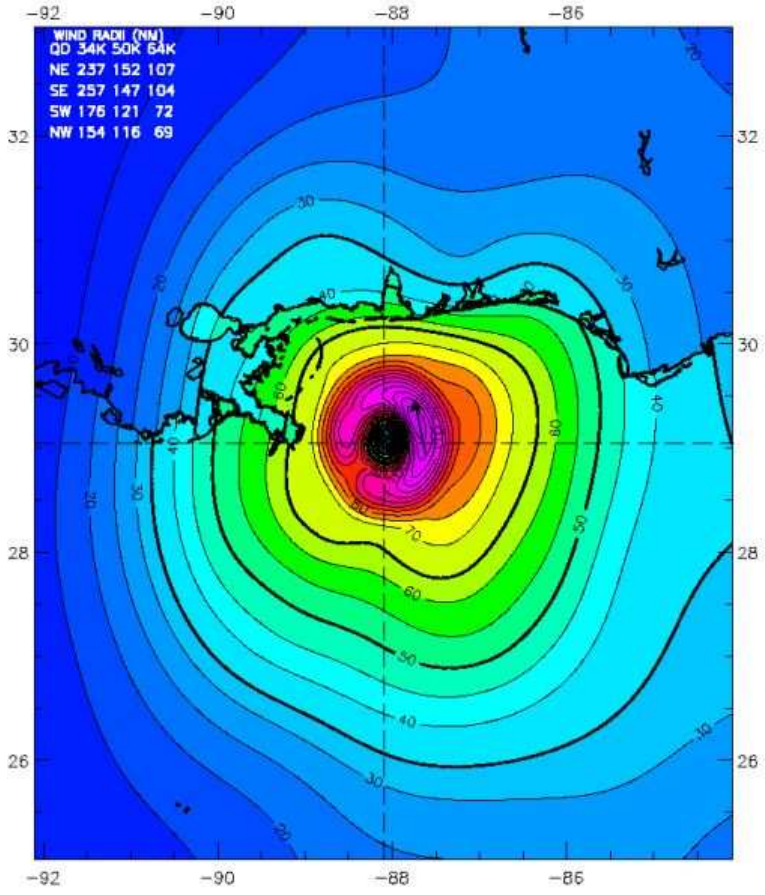
Hurricane Ivan 2004 Sept. 16 0130z

Operational



Observed Max. Surface Wind: 99 kts, 21 nm NE of center based on 0135 z SFMR43 sfc measurement
Analyzed Max. Wind: 99 kts, 21 nm NE of center

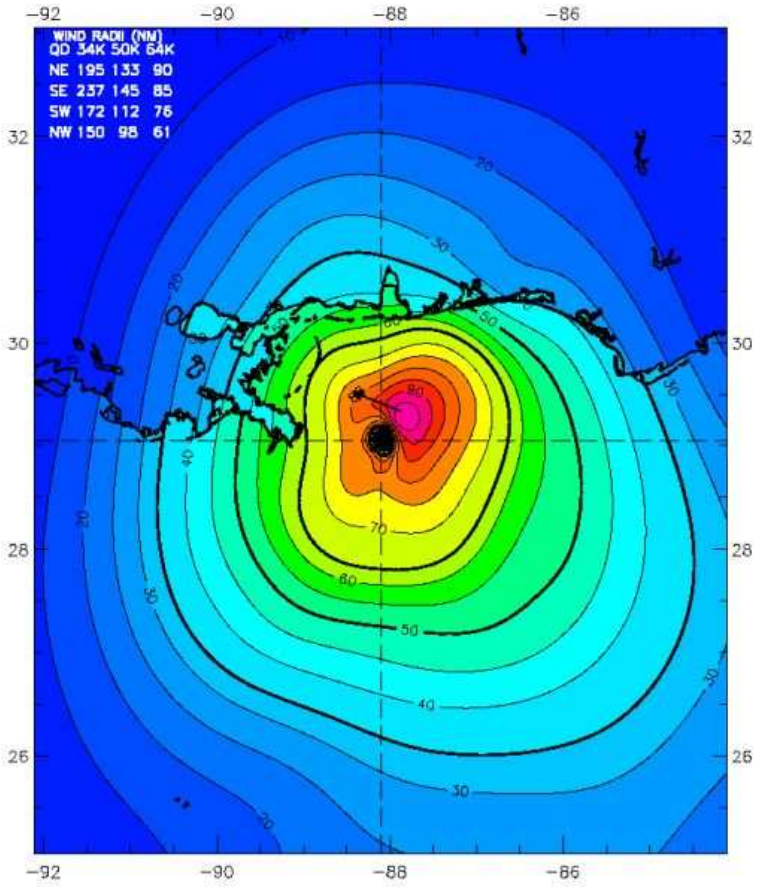
No QC



Observed Max. Surface Wind: 130 kts, 26 nm SE of center based on 2305 z SFMR42 sfc measurement
Analyzed Max. Wind: 130 kts, 26 nm NE of center

Hurricane Ivan 2004 Sept. 16 0130z

Operational



Observed Max. Surface Wind: 99 kts, 21 nm NE of center based on 0135 z SFMR43 sfc measurement
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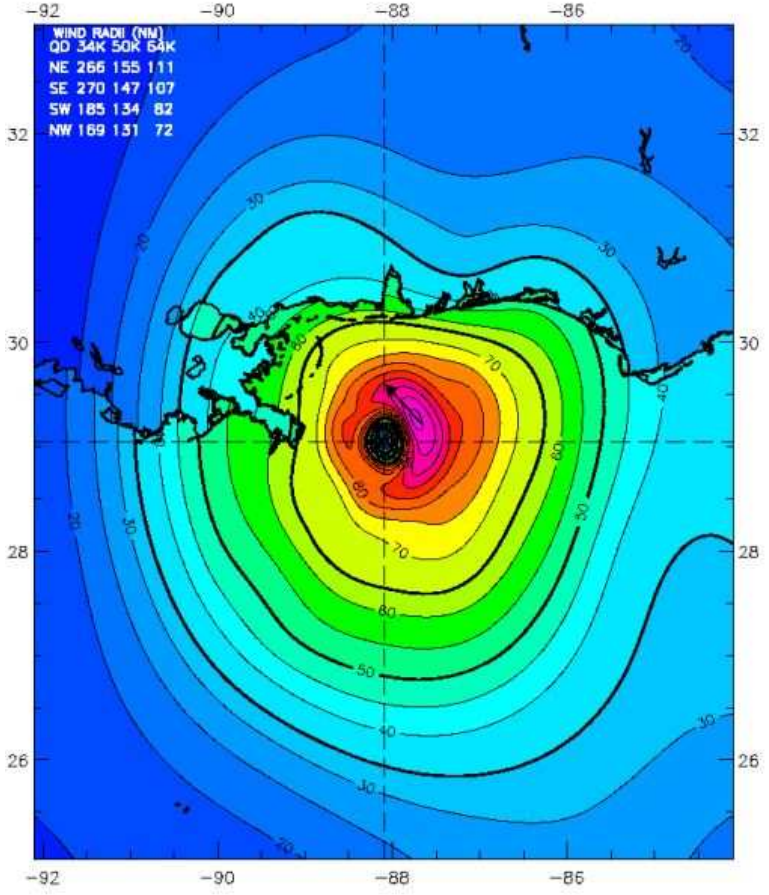
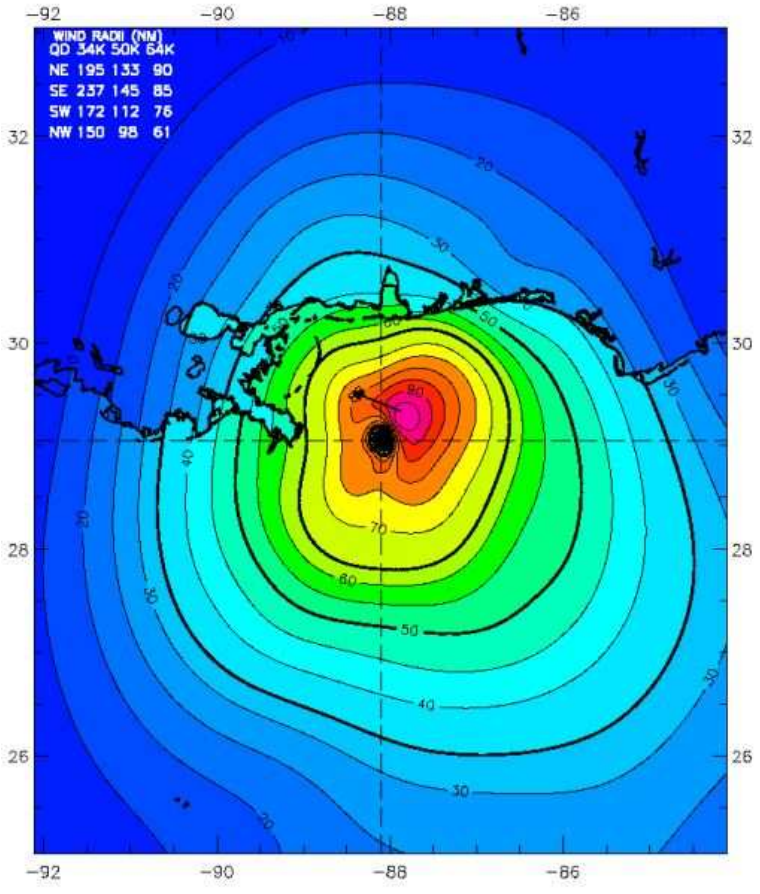
Cartesian



Observed Max. Surface Wind: 107 kts, 25 nm NE of center based on 2015 z NOAA42 sfc measurement
Analyzed Max. Wind: 107 kts, 26 nm NE of center

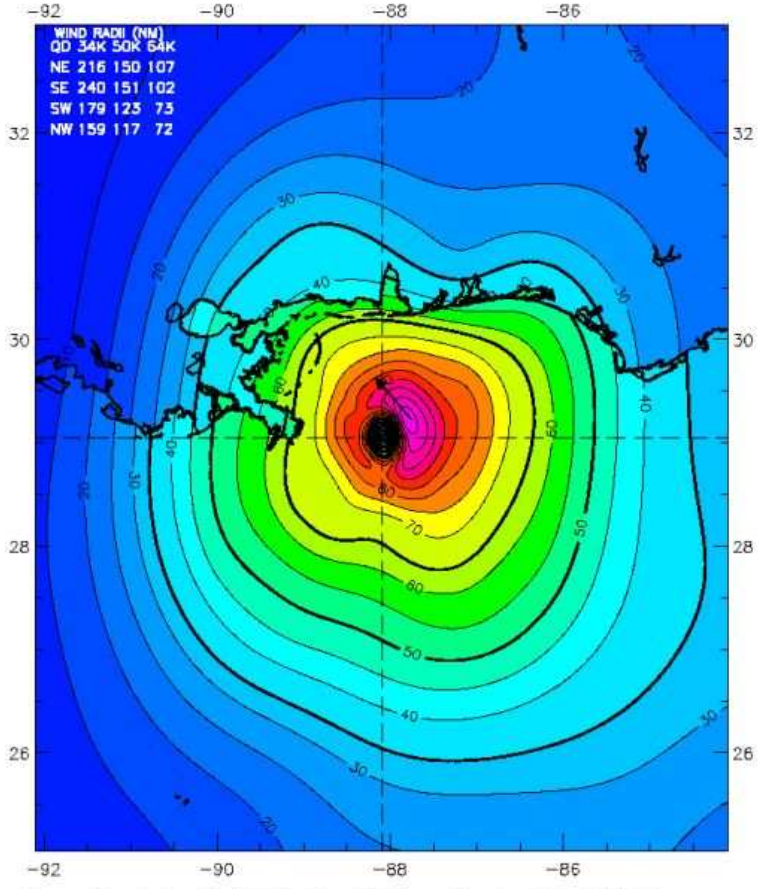
Hurricane Ivan 2004 Sept. 16 0130z

Operational



Observed Max. Surface Wind: 99 kts, 21 nm NE of center based on 0135 z SFMR43 sfc measurement
Analyzed Max. Wind: 99 kts, 21 nm NE of center

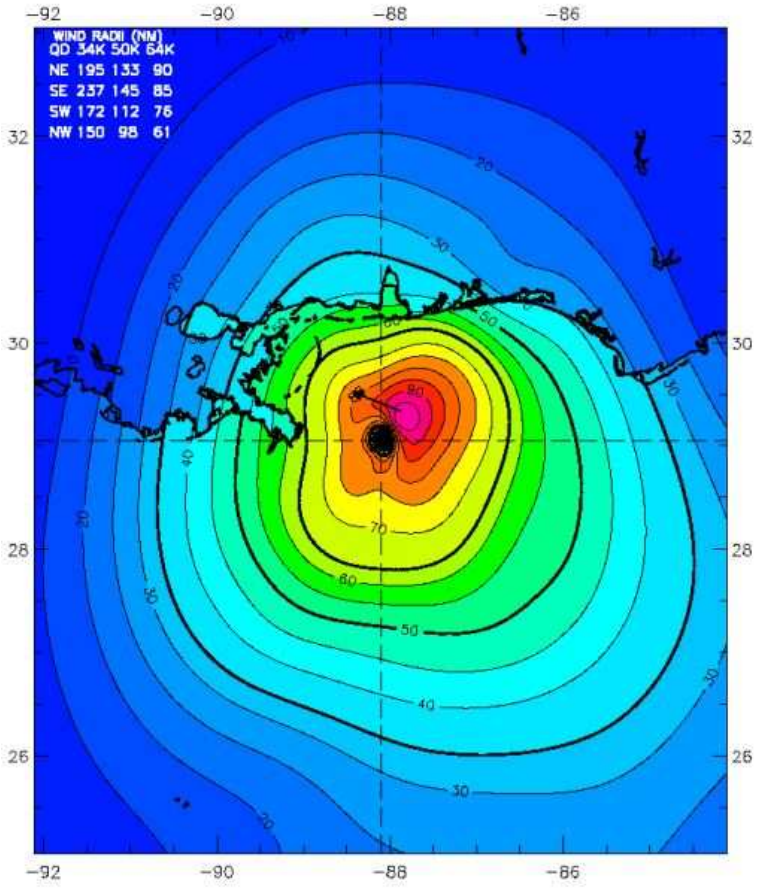
Radial



Observed Max. Surface Wind: 109 kts, 21 nm NE of center based on 2125 z NOAA42 sfc measurement
Analyzed Max. Wind: 109 kts, 22 nm NE of center

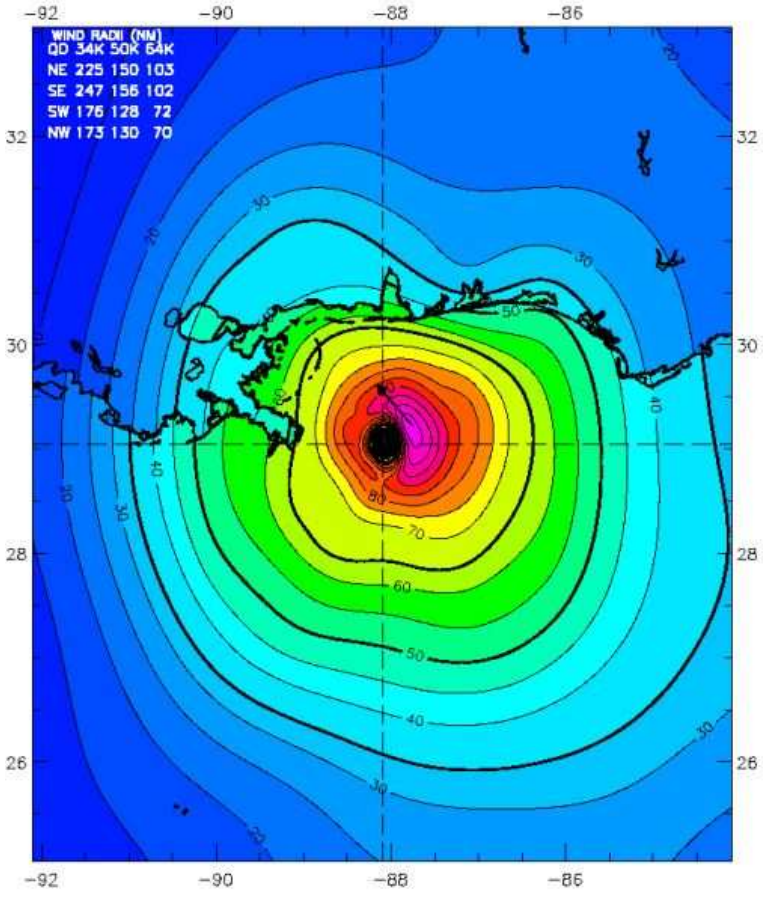
Hurricane Ivan 2004 Sept. 16 0130z

Operational



Observed Max. Surface Wind: 99 kts, 21 nm NE of center based on 0135 z SFMR43 sfc measurement
Analyzed Max. Wind: 99 kts, 21 nm NE of center

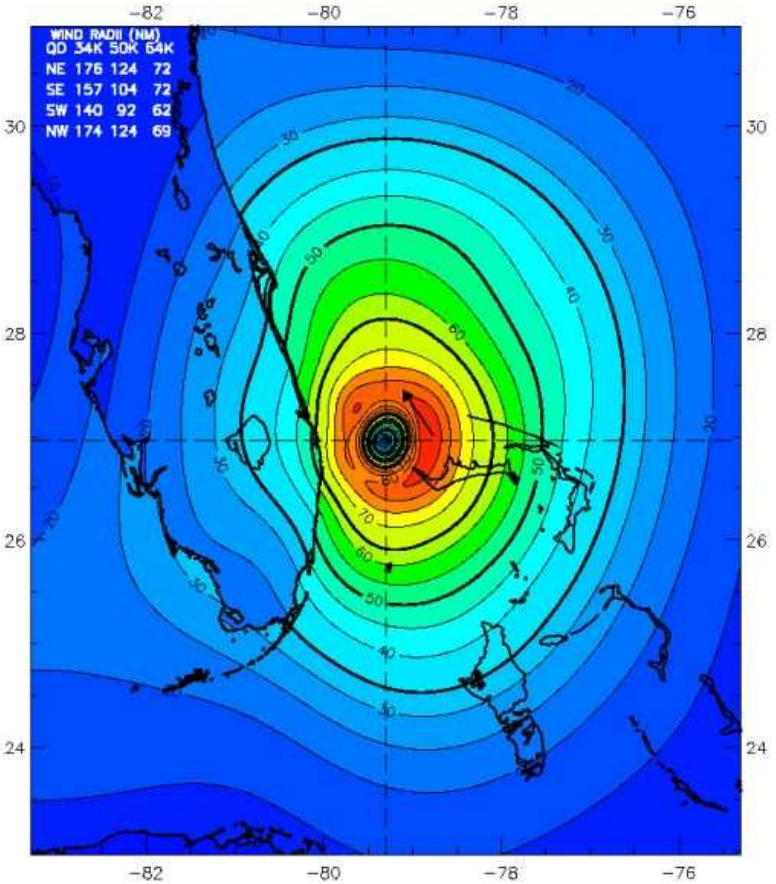
Polar



Observed Max. Surface Wind: 109 kts, 21 nm NE of center based on 2125 z NOAA42 sfc measurement
Analyzed Max. Wind: 109 kts, 22 nm NE of center

Hurricane Frances 2004 Sept. 04 2230z

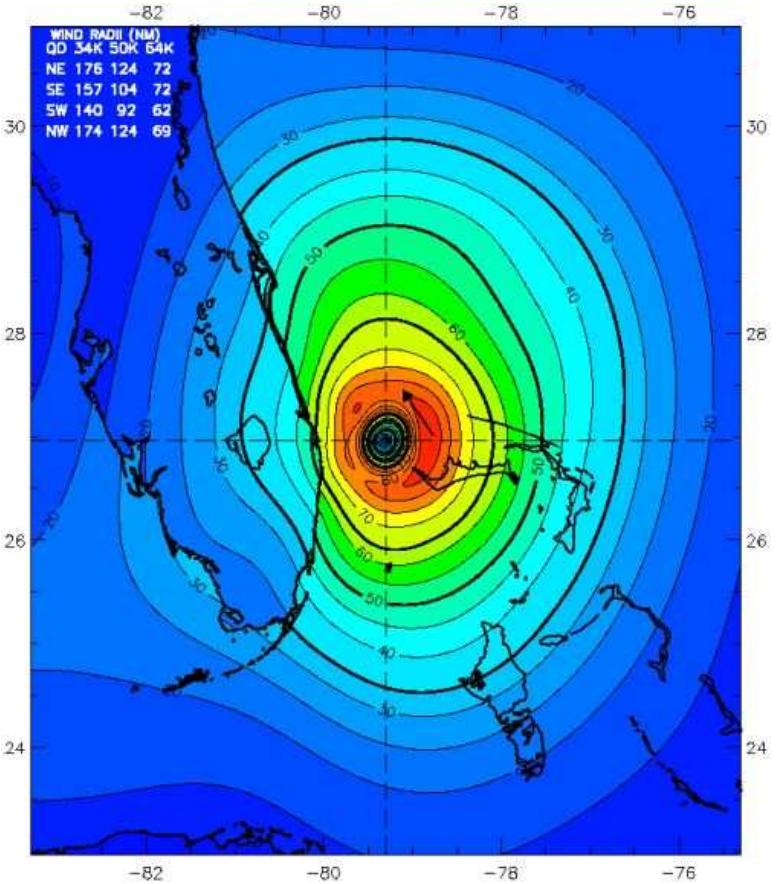
Operational



Observed Max. Surface Wind: 90 kts, 29 nm NE of center based on 2044 z GPSSONDE_MBL sfc measurement
Analyzed Max. Wind: 90 kts, 29 nm NE of center

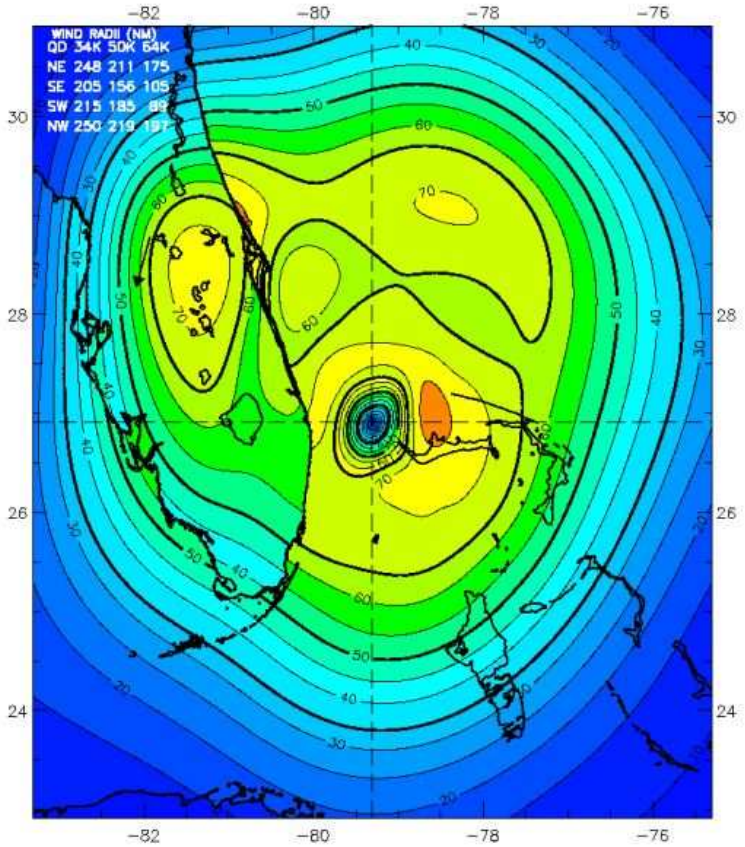
Hurricane Frances 2004 Sept. 04 2230z

Operational



Observed Max. Surface Wind: 90 kts, 29 nm NE of center based on 2044 z GPSSONDE_MBL sfc measurement
Analyzed Max. Wind: 90 kts, 29 nm NE of center

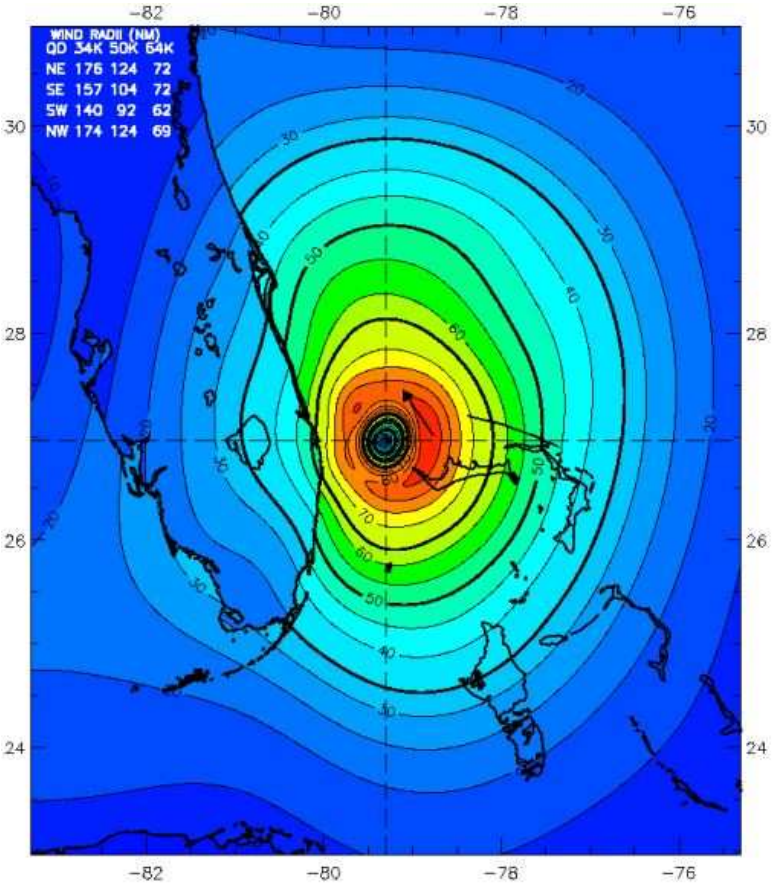
No QC



Observed Max. Surface Wind: 160 kts, 179 nm NW of center based on 1813 z SFMR43 sfc measurement
Analyzed Max. Wind: 78 kts, 42 nm NE of center

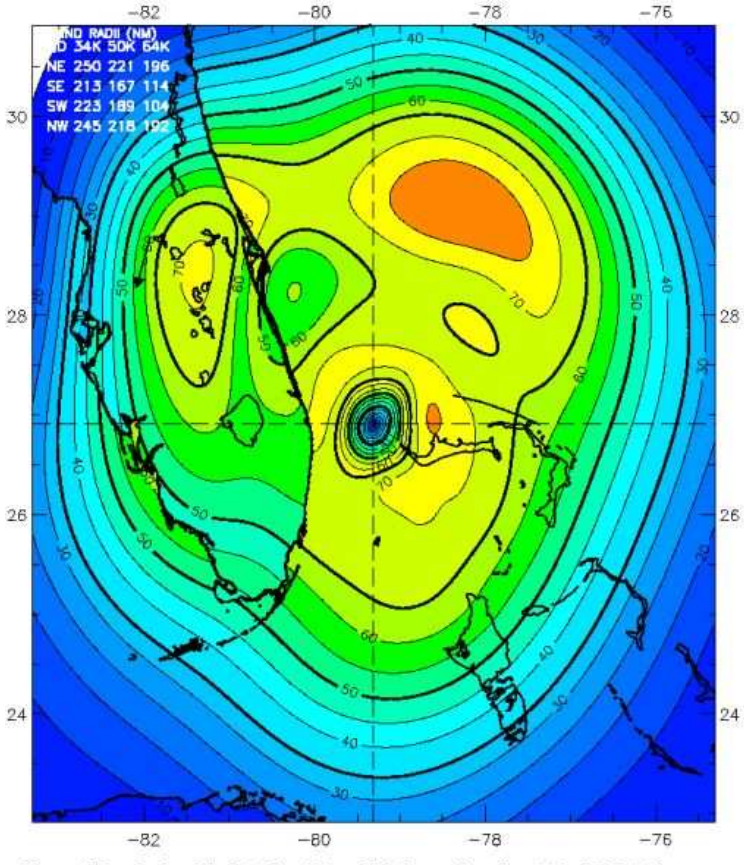
Hurricane Frances 2004 Sept. 04 2230z

Operational



Observed Max. Surface Wind: 90 kts, 29 nm NE of center based on 2044 z GPSSONDE_MBL sfc measurement
Analyzed Max. Wind: 90 kts, 29 nm NE of center

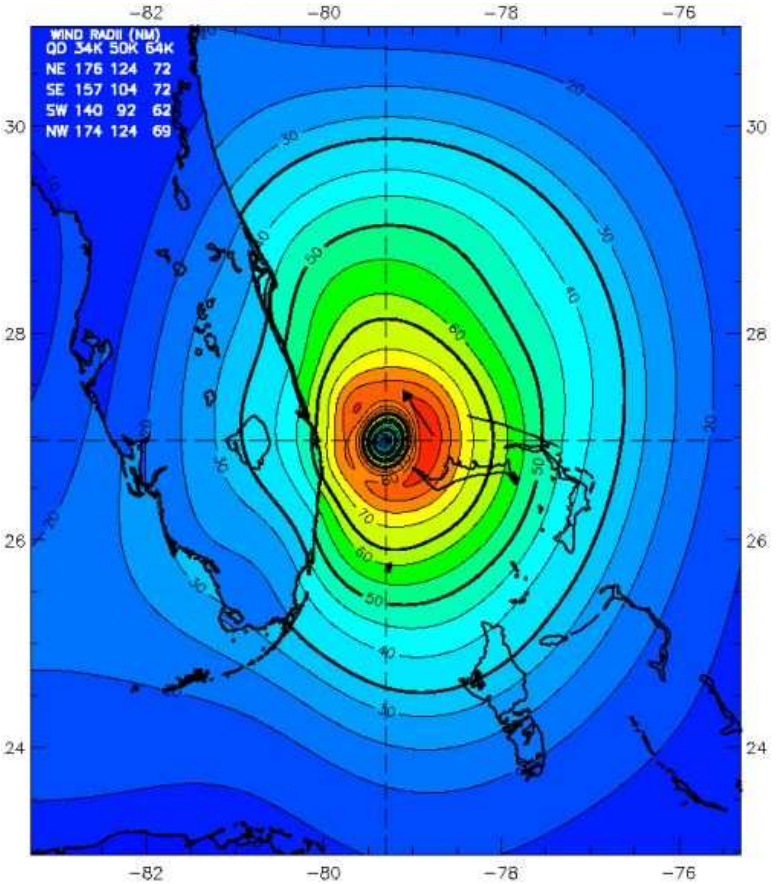
Cartesian



Observed Max. Surface Wind: 160 kts, 179 nm NW of center based on 1813 z SFMR43 sfc measurement
Analyzed Max. Wind: 80 kts, 144 nm NE of center

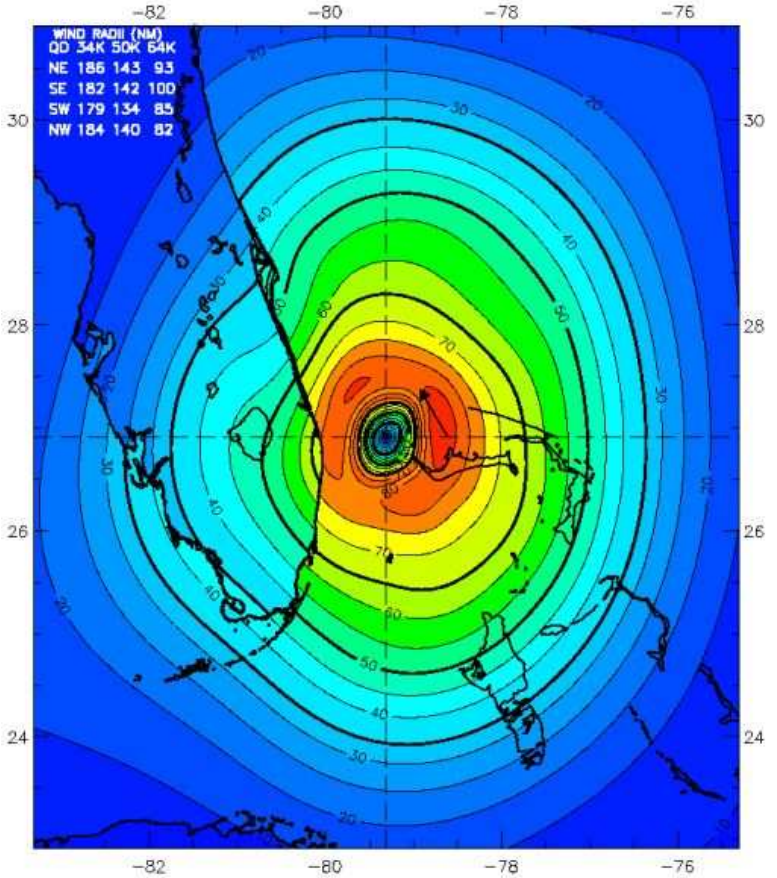
Hurricane Frances 2004 Sept. 04 2230z

Operational



Observed Max. Surface Wind: 90 kts, 29 nm NE of center based on 2044 z GPSSONDE_MBL sfc measurement
Analyzed Max. Wind: 90 kts, 29 nm NE of center

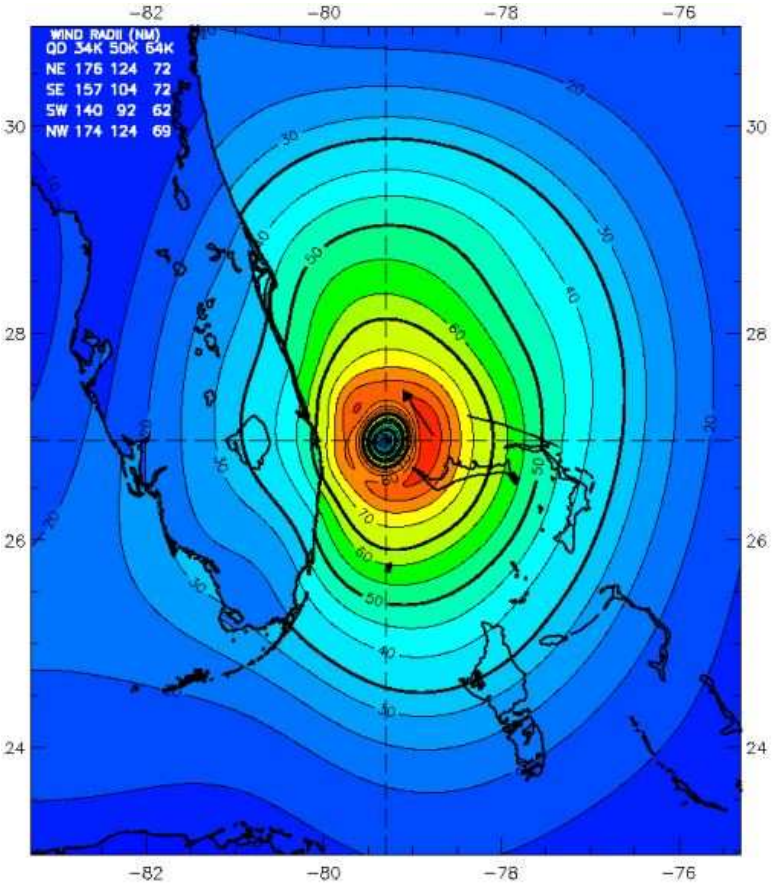
Radial



Observed Max. Surface Wind: 90 kts, 29 nm NE of center based on 2046 z GPSSONDE_MBL sfc measurement
Analyzed Max. Wind: 90 kts, 36 nm NE of center

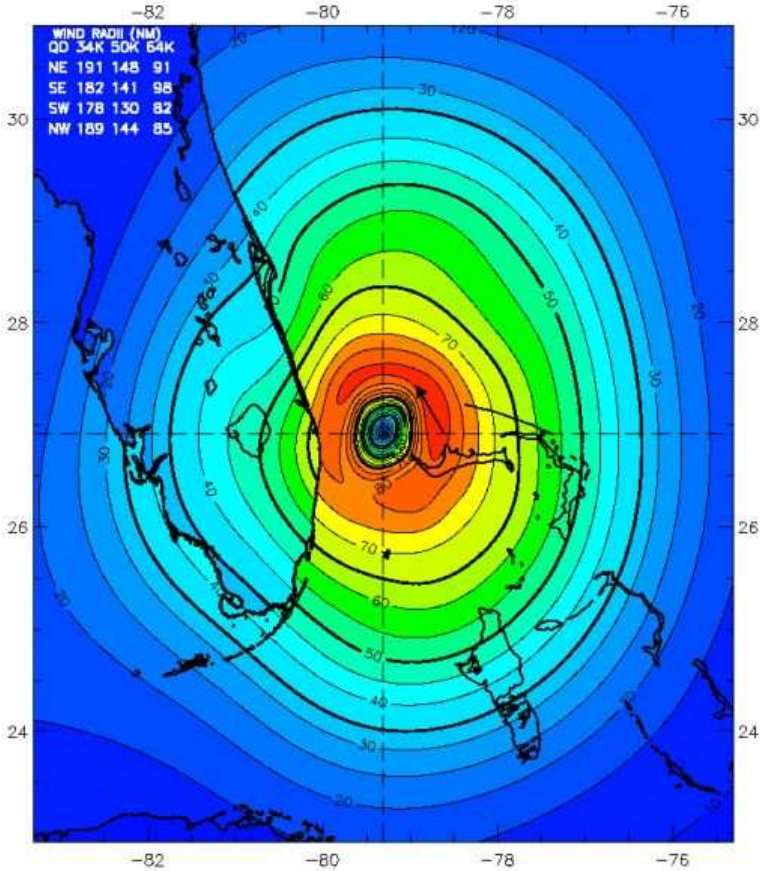
Hurricane Frances 2004 Sept. 04 2230z

Operational



Observed Max. Surface Wind: 90 kts, 29 nm NE of center based on 2044 z GPSSONDE_MBL sfc measurement
Analyzed Max. Wind: 90 kts, 29 nm NE of center

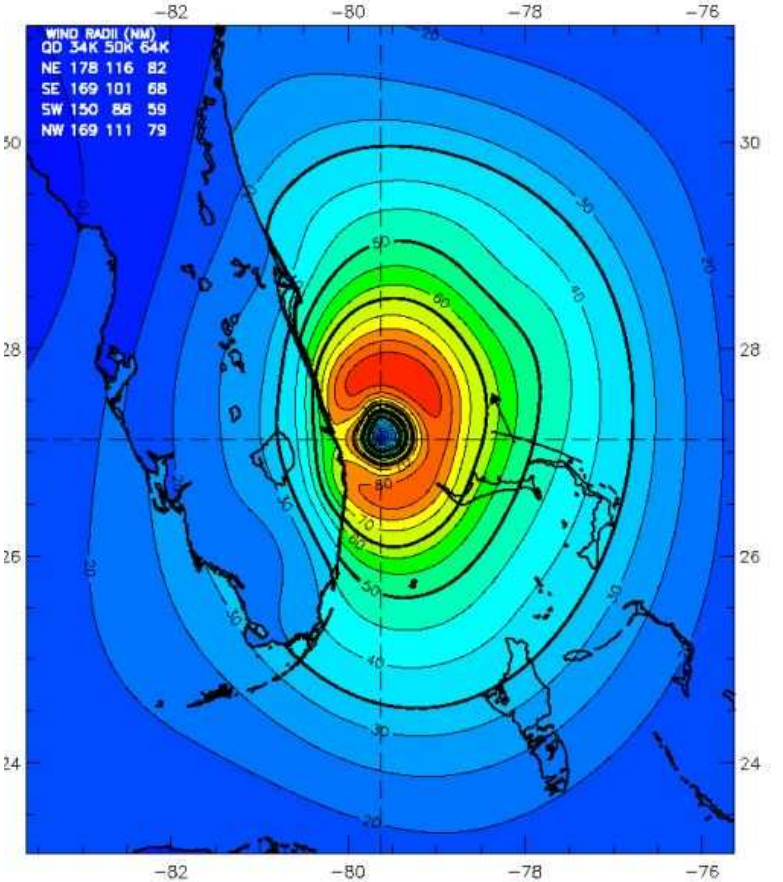
Polar



Observed Max. Surface Wind: 90 kts, 29 nm NE of center based on 2046 z GPSSONDE_MBL sfc measurement
Analyzed Max. Wind: 90 kts, 37 nm NE of center

Hurricane Jeanne 2004 Sept. 26 0130z

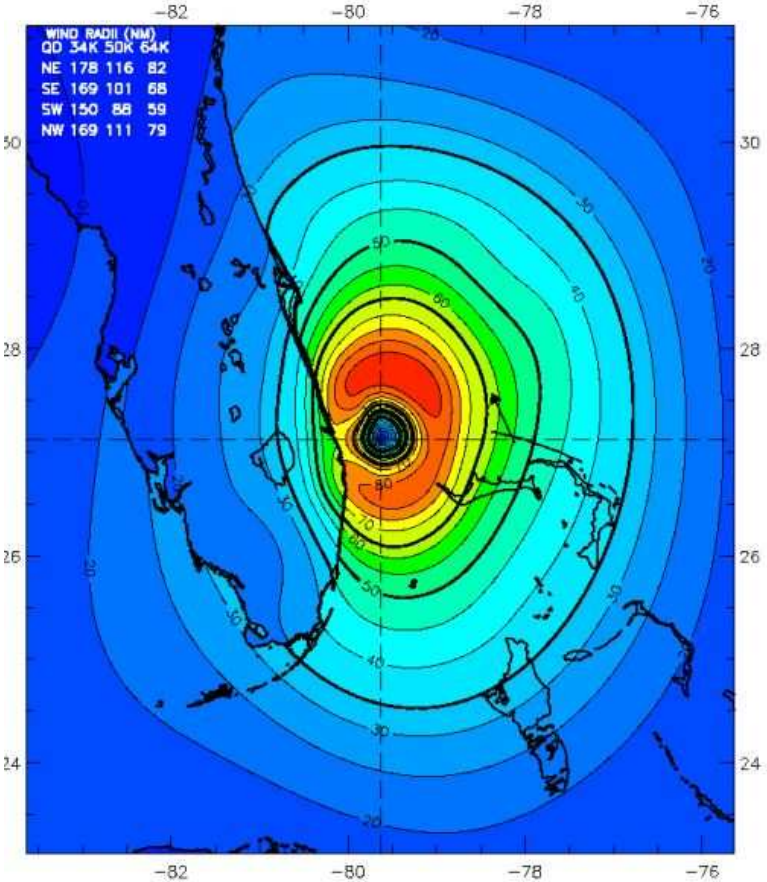
Operational



Observed Max. Surface Wind: 90 kts, 34 nm NW of center based on 0020 z SFMR43 sfc measurement
Analyzed Max. Wind: 90 kts, 41 nm NE of center

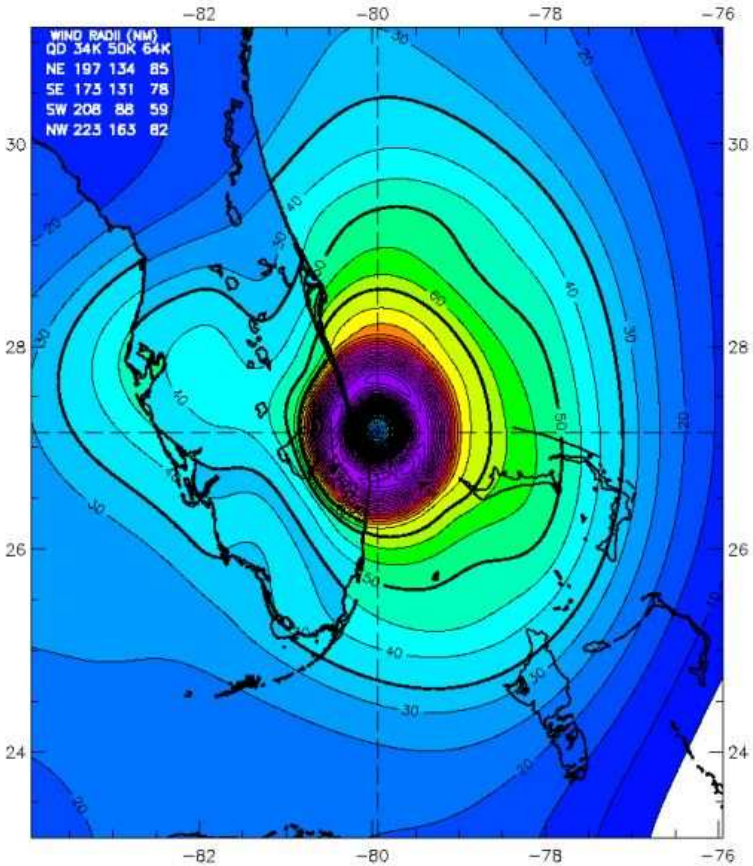
Hurricane Jeanne 2004 Sept. 26 0130z

Operational



Observed Max. Surface Wind: 90 kts, 34 nm NW of center based on 0020 z SFMR43 sfc measurement
Analyzed Max. Wind: 90 kts, 41 nm NE of center

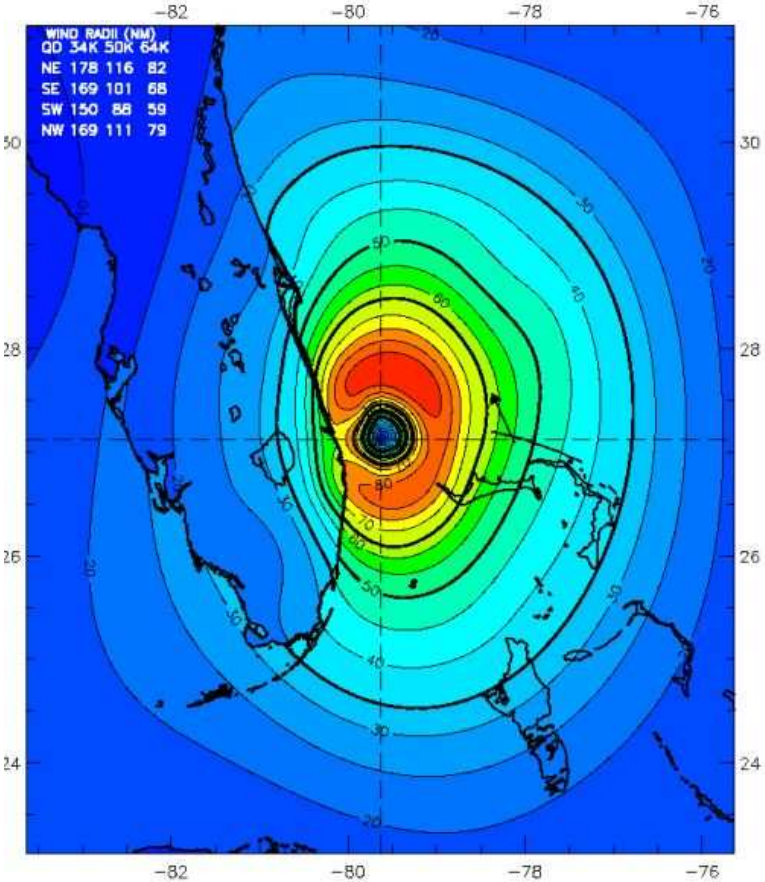
No QC



Observed Max. Surface Wind: 168 kts, 30 nm NW of center based on 2042 z SFMR42 sfc measurement
Analyzed Max. Wind: 168 kts, 30 nm SE of center

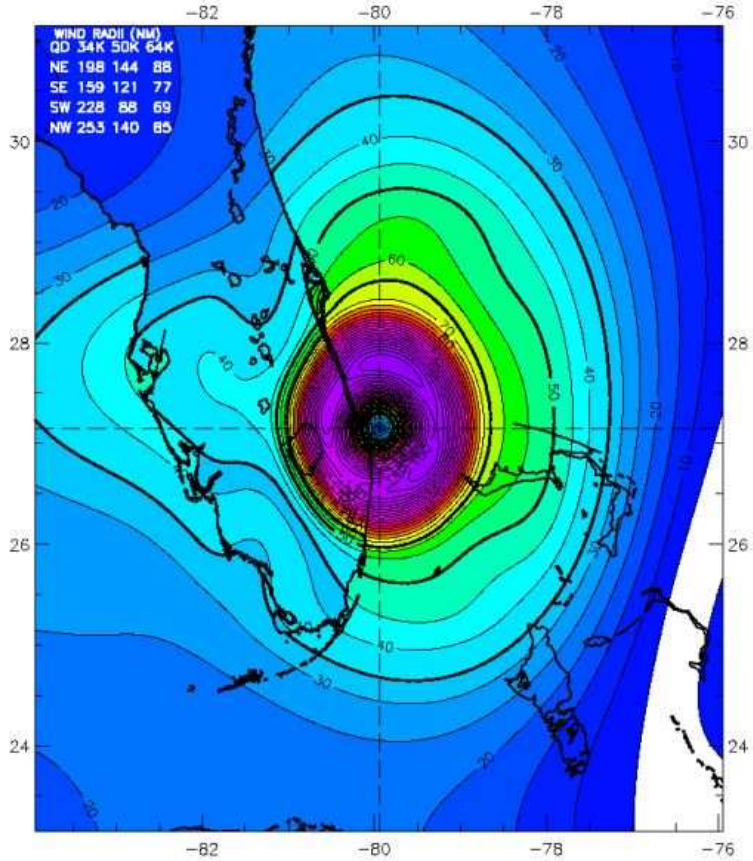
Hurricane Jeanne 2004 Sept. 26 0130z

Operational



Observed Max. Surface Wind: 90 kts, 34 nm NW of center based on 0020 z SFMR43 sfc measurement
Analyzed Max. Wind: 90 kts, 41 nm NE of center

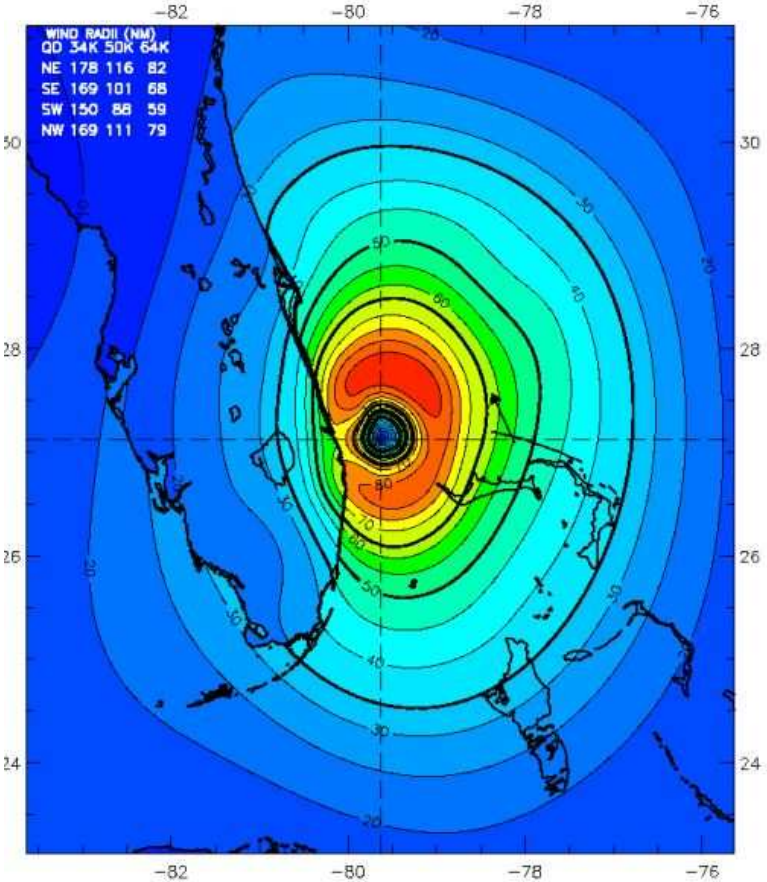
Cartesian



Observed Max. Surface Wind: 160 kts, 145 nm NW of center based on 1946 z SFMR43 sfc measurement
Analyzed Max. Wind: 160 kts, 39 nm NE of center

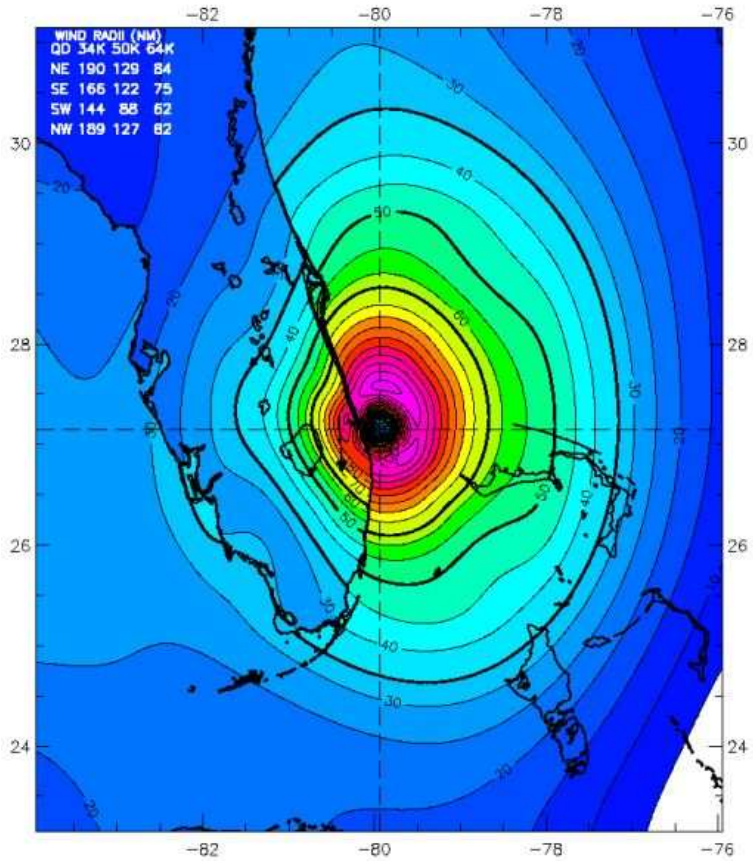
Hurricane Jeanne 2004 Sept. 26 0130z

Operational



Observed Max. Surface Wind: 90 kts, 34 nm NW of center based on 0020 z SFMR43 sfc measurement
Analyzed Max. Wind: 90 kts, 41 nm NE of center

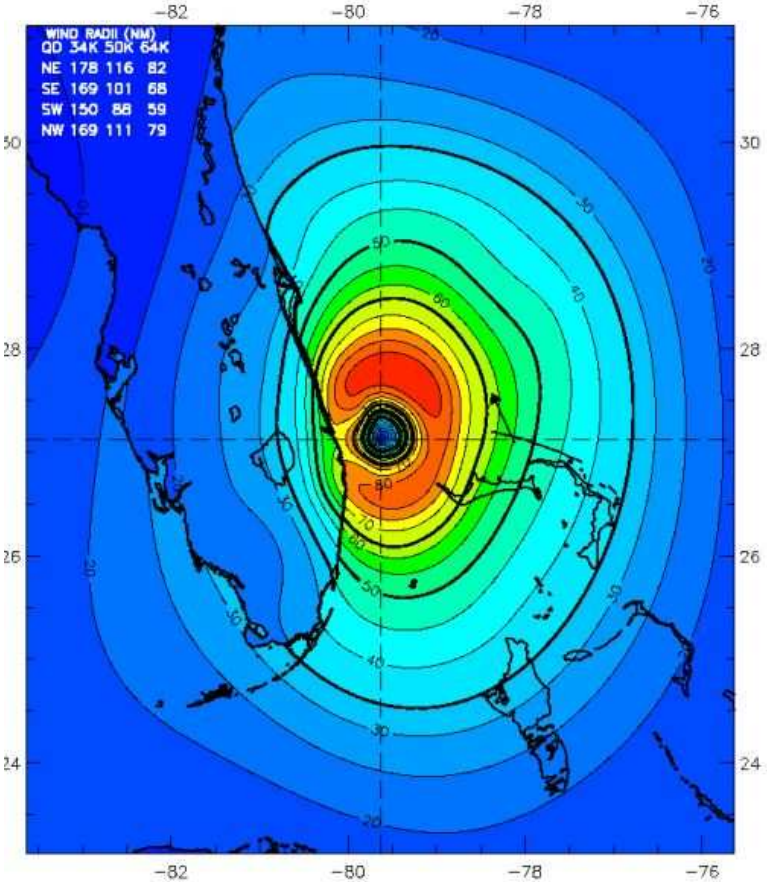
Radial



Observed Max. Surface Wind: 112 kts, 26 nm NW of center based on 2041 z SFMR42 sfc measurement
Analyzed Max. Wind: 112 kts, 26 nm NE of center

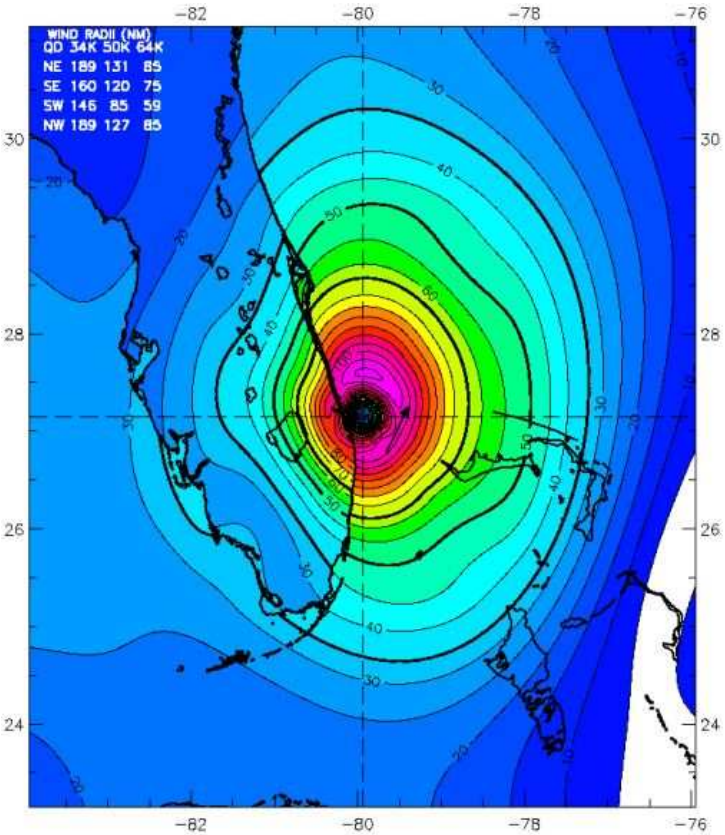
Hurricane Jeanne 2004 Sept. 26 0130z

Operational



Observed Max. Surface Wind: 90 kts, 34 nm NW of center based on 0020 z SFMR43 sfc measurement
Analyzed Max. Wind: 90 kts, 41 nm NE of center

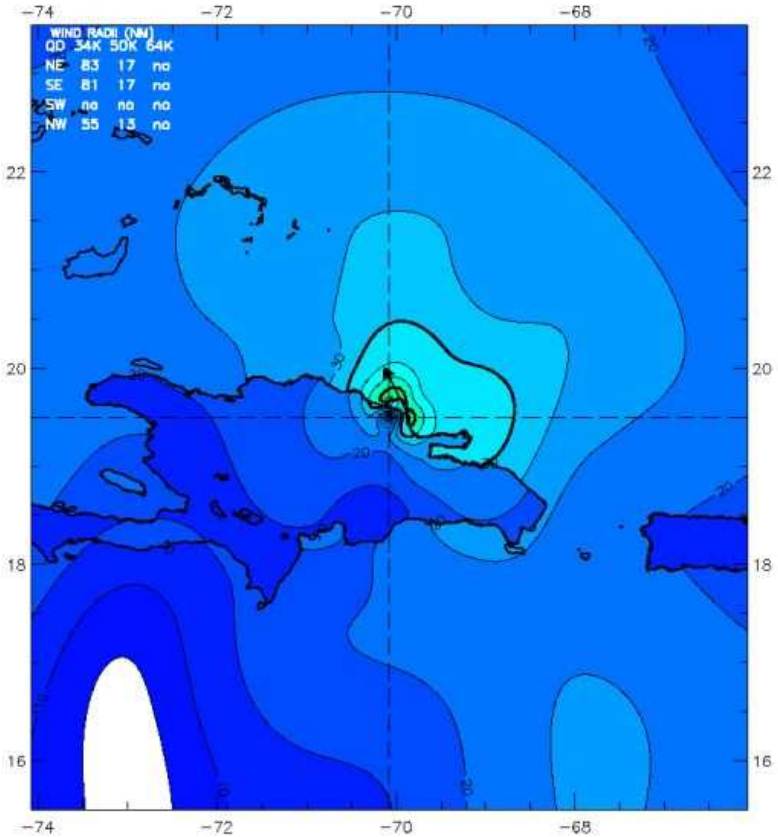
Polar



Observed Max. Surface Wind: 112 kts, 27 nm SE of center based on 2339 z CMAN_LD_TO sfc measurement
Analyzed Max. Wind: 112 kts, 26 nm NE of center

Hurricane Jeanne 2004 Sept. 17 0730z

Operational



Observed Max. Surface Wind: 55 kts, 10 nm NE of center based on 0628 z AFRES sfc measurement
Analyzed Max. Wind: 55 kts, 13 nm NE of center

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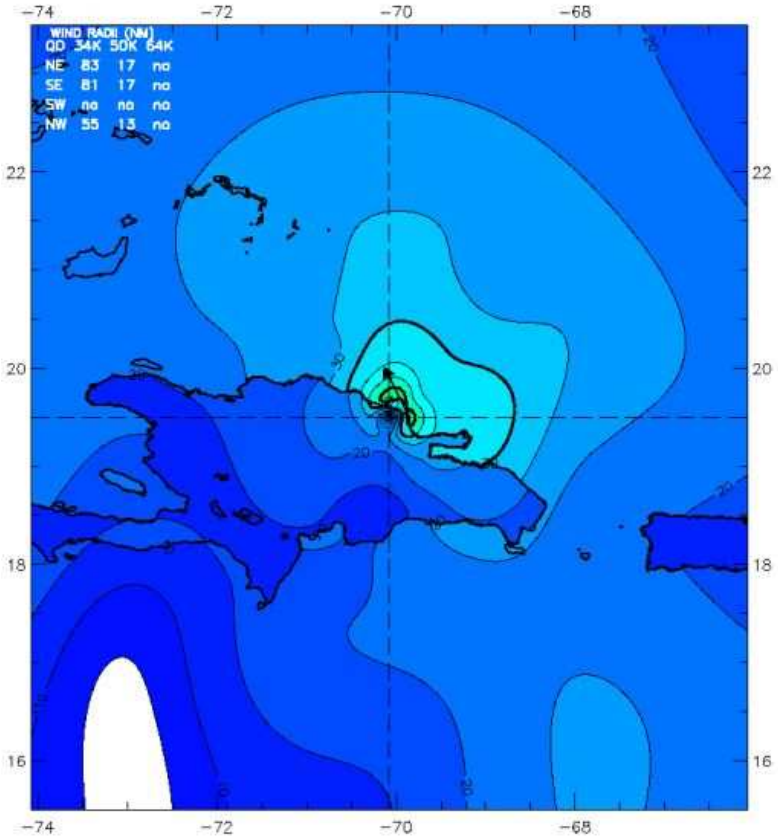
Operational



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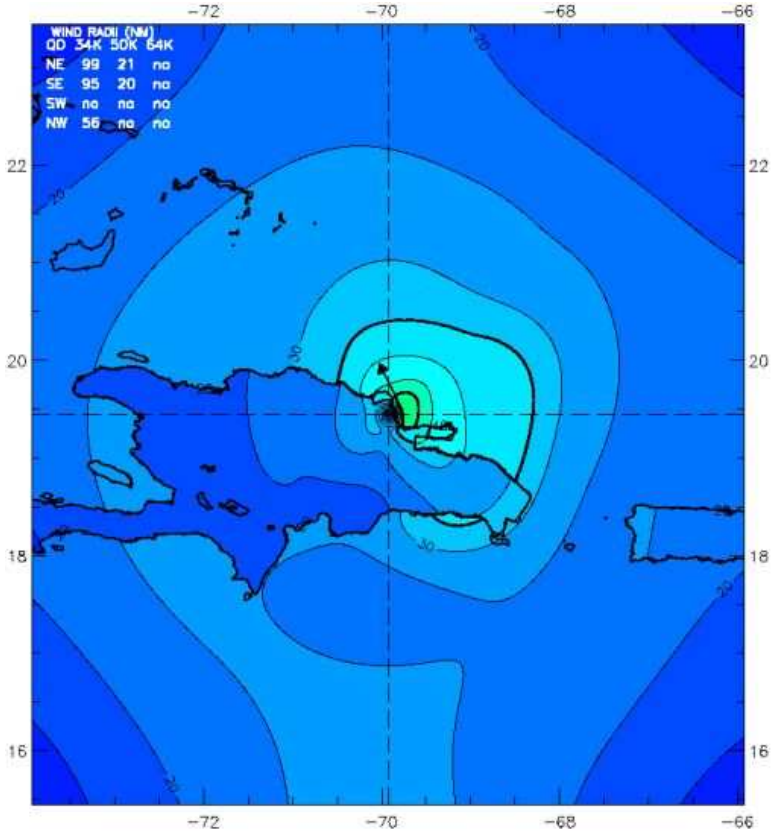
No QC



Observed Max. Surface Wind: 55 kts, 7 nm NE of center based on 0628 z AFRES sfc measurement
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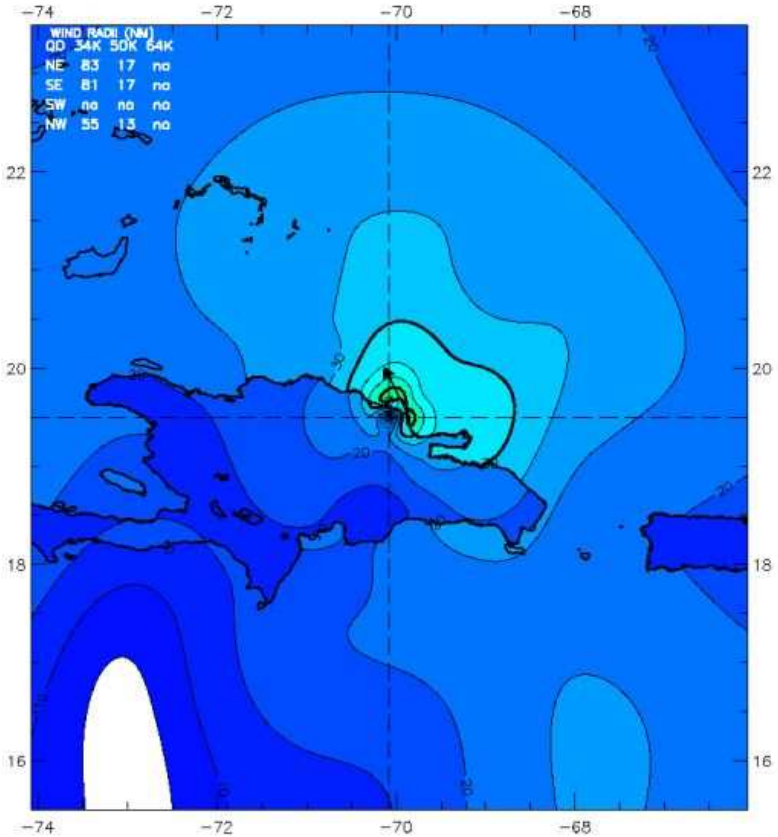

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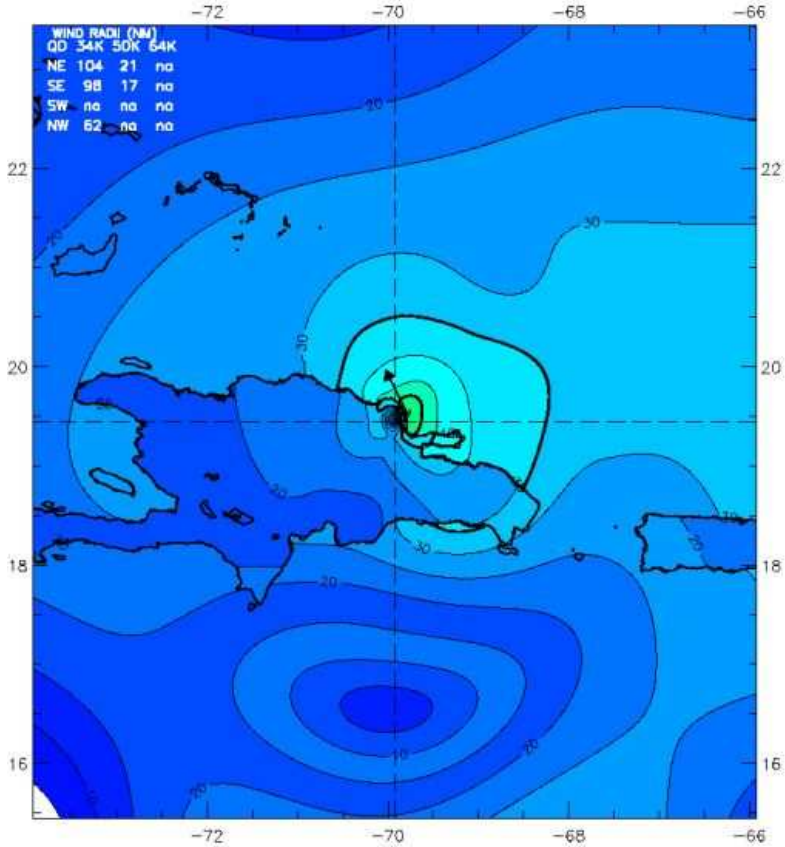
Cartesian



Observed Max. Surface Wind: 55 kts, 7 nm NE of center based on 0628 z AFRES sfc measurement
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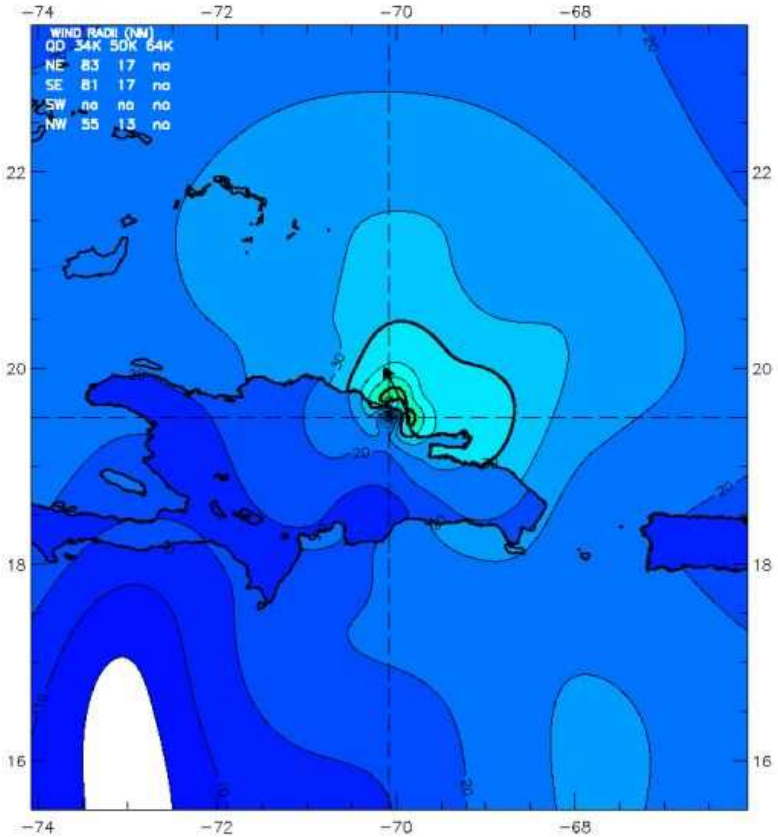
Operational



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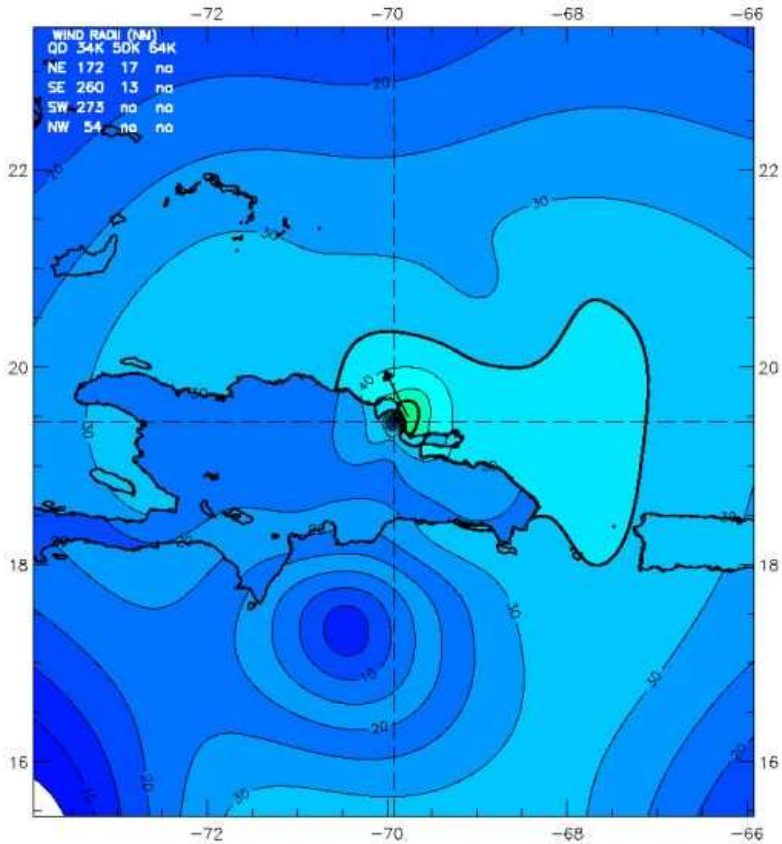
Radial



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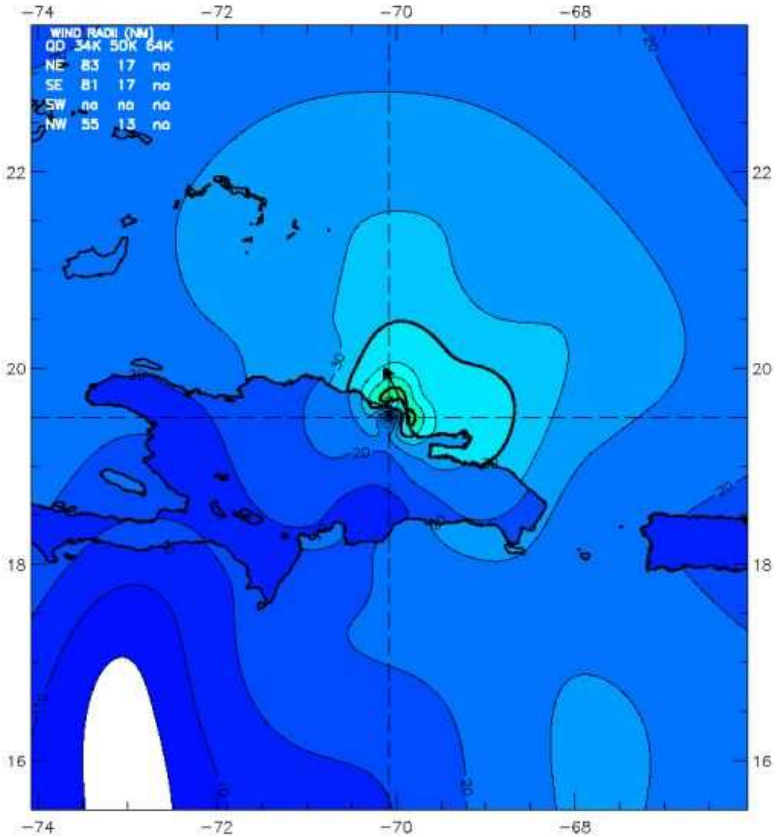
Hurricane Jeanne 2004 Sept. 17 0730z

Operational



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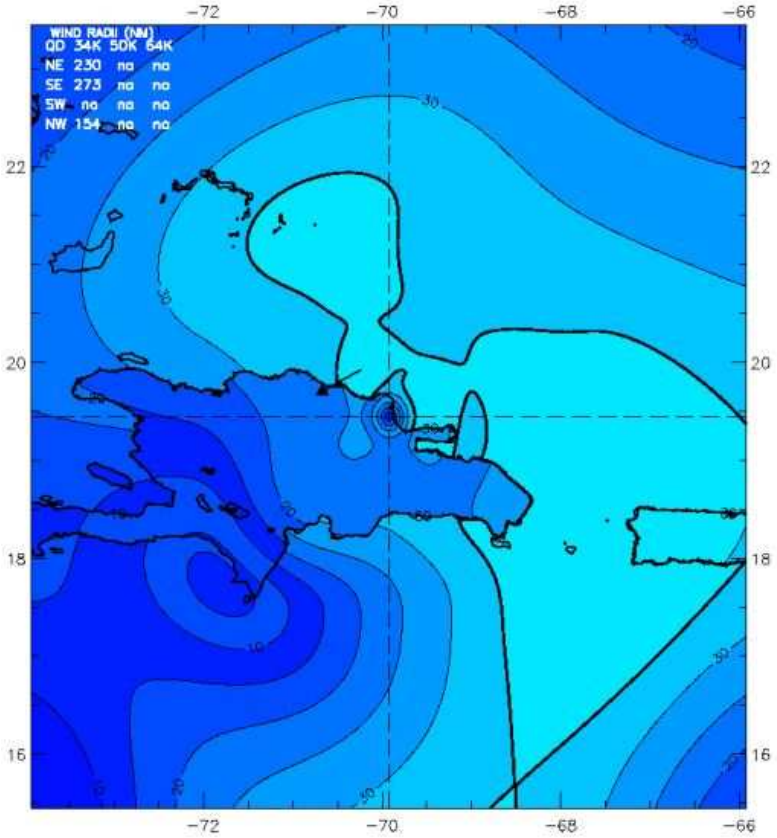
Polar



Observed Max. Surface Wind: 46 kts, 35 nm NW of center based on 0613 z AFRES sfc measurement
Analyzed Max. Wind: 38 kts, 164 nm SE of center

Result Table(1)

Hurricane Ivan 2004 Sept. 16 0130z					
	Operational	No QC	Cartesian	Radial	Polar
max observed(kt)	99	130	107	109	109
location	21nm NE	26nm SE	25nm NE	21nm NE	21nm NE
Obs Passed		2494	1468	2045	1765
64kt(NE)	90	107	111	107	103
64kt(SE)	85	104	107	102	102
64kt(SW)	76	72	82	73	72
64kt(NW)	61	69	72	72	70
50kt(NE)	133	152	155	150	150
50kt(SE)	145	147	147	151	156
50kt(SW)	112	121	134	123	128
50kt(NW)	98	116	131	117	130
34kt(NE)	195	237	266	216	225
34kt(SE)	237	257	280	240	247
34kt(SW)	172	176	185	179	176
34kt(NW)	150	154	169	159	173

Result Table(2)

Hurricane Frances 2004 Sept. 04 2230z					
	Operational	No QC	Cartesian	Radial	Polar
max observed(kt)	90	160	160	90	90
location	29nm NE	179nm NW	179nm NW	29nm NE	29nm NE
Obs Passed		2024	1405	1744	1549
64kt(NE)	72	175	196	93	91
64kt(SE)	72	105	114	100	98
64kt(SW)	62	89	104	85	82
64kt(NW)	69	197	102	82	85
50kt(NE)	124	211	221	143	148
50kt(SE)	104	156	167	142	141
50kt(SW)	92	185	189	134	130
50kt(NW)	124	219	218	140	144
34kt(NE)	176	248	250	186	191
34kt(SE)	157	205	213	182	182
34kt(SW)	140	215	223	179	178
34kt(NW)	174	250	245	184	189

Result Table(3)

Hurricane Jeanne 2004 Sept. 26 0130z					
	Operational	No QC	Cartesian	Radial	Polar
max observed(kt)	90	168	160	112	112
location	34nm NW	30nm NW	145nm NW	26nm NE	27nm SE
Obs Passed		5762	4098	4653	4248
64kt(NE)	82	85	88	84	85
64kt(SE)	68	78	77	75	75
64kt(SW)	59	59	69	62	59
64kt(NW)	79	82	85	82	85
50kt(NE)	116	134	144	129	131
50kt(SE)	101	131	121	122	120
50kt(SW)	88	88	88	88	85
50kt(NW)	111	163	140	127	127
34kt(NE)	178	197	198	190	189
34kt(SE)	169	173	159	166	160
34kt(SW)	150	208	228	144	145
34kt(NW)	169	223	140	189	189

%Error

%error = abs(x-y)/y				
	No QC	Cartesian	Radial	Polar
Mean %error	0.34	0.34	**0.20**	0.30
64kt(NE)	0.55	0.68	0.17	**0.15**
64kt(SE)	0.28	0.32	0.23	**0.22**
64kt(SW)	0.16	0.31	0.15	**0.13**
64kt(NW)	0.67	0.24	**0.14**	0.15
50kt(NE)	0.31	0.36	**0.10**	0.36
50kt(SE)	0.25	**0.20**	0.21	0.40
50kt(SW)	0.36	0.42	**0.18**	0.20
50kt(NW)	0.60	0.45	**0.16**	0.21
34kt(NE)	**0.23**	0.29	0.33	0.52
34kt(SE)	**0.15**	0.20	0.60	0.66
34kt(SW)	0.32	0.40	0.12	**0.11**
34kt(NW)	0.20	0.21	**0.06**	0.54

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- Coordinate systems play a large role in spatial environments.
- Both distance measures and coordinate systems should be tailored to the environment.
- For tropical cyclones it may be necessary to mix coordinate systems based on some threshold setting.
  - Vary how far out from the center of a storm the polar coordinates are used.
  - Change how the wind data is represented.

Acknowledgments

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