Multiple Scatterometer Hurricane Winds, Year 2

QuikSCAT complete, OceanSAT-2 begun

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Outline

- Background
- QuikSCAT Hurricane Winds
  - 10 year, global data set
  - Validated vs. H*WINDS, Best Track, and SFMR
- Analysis of wind speed statistics
  - High speed GMF
  - Effect of rain on retrievals
  - Location of maximum speed
- Preliminary OceanSAT-2 Hurricane Winds
- Summary

Background

- Goal: To optimize, produce, validate, and utilize ocean surface wind speed fields around all tropical cyclones (TCs) observed by QuikSCAT, and OceanSAT-2, and ASCAT.
- Why are scatterometer winds useful for studying tropical cyclones?

Why ocean surface winds?

Single Storm Modeling

- Models of single storms include the effect of the atmosphere on the ocean surface.
  - The outputs of these models include surface level winds and related quantities such as storm surge.
  - Surface winds are needed to validate these models.
- Feedback from the ocean to the atmosphere in TCs is of great interest.
  - The place to look for such feedback is in the portion of the atmosphere closest to the surface.

Seasonal, Regional and Long-Term TC Studies

- These studies seek to correlate trends in size and intensity of storms with ocean current events and cycles (e.g. ENSO).
  - A global distribution of TC surface winds over years or decades is needed to further such research.
  - QuikSCAT data was used for this by [Chan and Chan, 2012] and [Chavas and Emmanuel, 2010]

Why scatterometer winds?

Comparison with other data

- Currently the most common sources of surface winds in TCs are:
  - Best track data.
    - Typically a point estimate.
    - Inconsistently defined due to production by different international agencies.
  - Models and Data Assimulations (e.g. H*WINDS)
    - May have systematic errors .
    - Are infrequently produced.
  - Aircraft data (e.g. SFMR)
    - Only available when overflights are performed
    - Consist of a handful of 1-D linear profiles
- Scatterometer winds have the advantages of
  - Frequent observations of storms.
  - Global coverage
  - Whole fields rather than point or line measurement.
  - Data not models

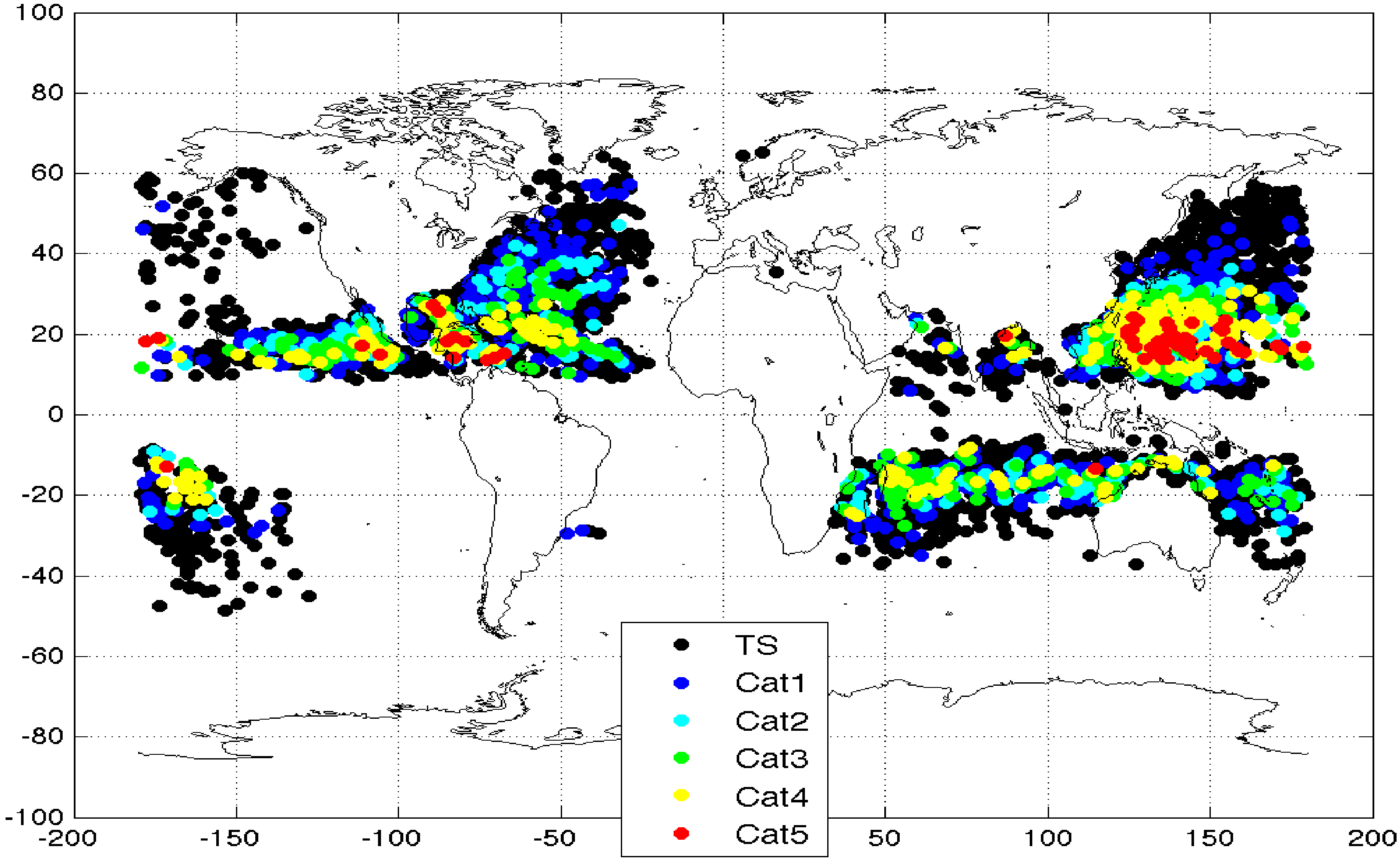
Improvements Performed

- Previously available scatterometer winds are inaccurate.
  - Rain contamination [Yueh and Stiles,2002] [Nie and Long, 2007].
  - Decreased sensitivity at high winds.[Fernandez et al, 2006],[Donelan et al, 2004]
- We produce speeds that are corrected for rain contamination and make optimal use of the available wind sensitivity.
- Toward this end we fit a mapping (simple neural network[Stiles and Dunbar, 2010]) from 9 scatterometer measurements to wind speed.
  - Inputs are 8 sets of backscatter values
    - 2 different azimuths,
    - 2 different polarizations,
    - 2 different spatial scales (12.5 and 87.5 km)
    - a rain rate from the scatterometer noise channel [Ahmad et al, 2005].
  - The ground truth speeds are from H*WINDS data from 2005 Atlantic hurricanes.
- Attempt to correct wind direction in rain is left for future work.
  - Nominal direction retrievals from JPL QuikSCAT L2B products are maintained.

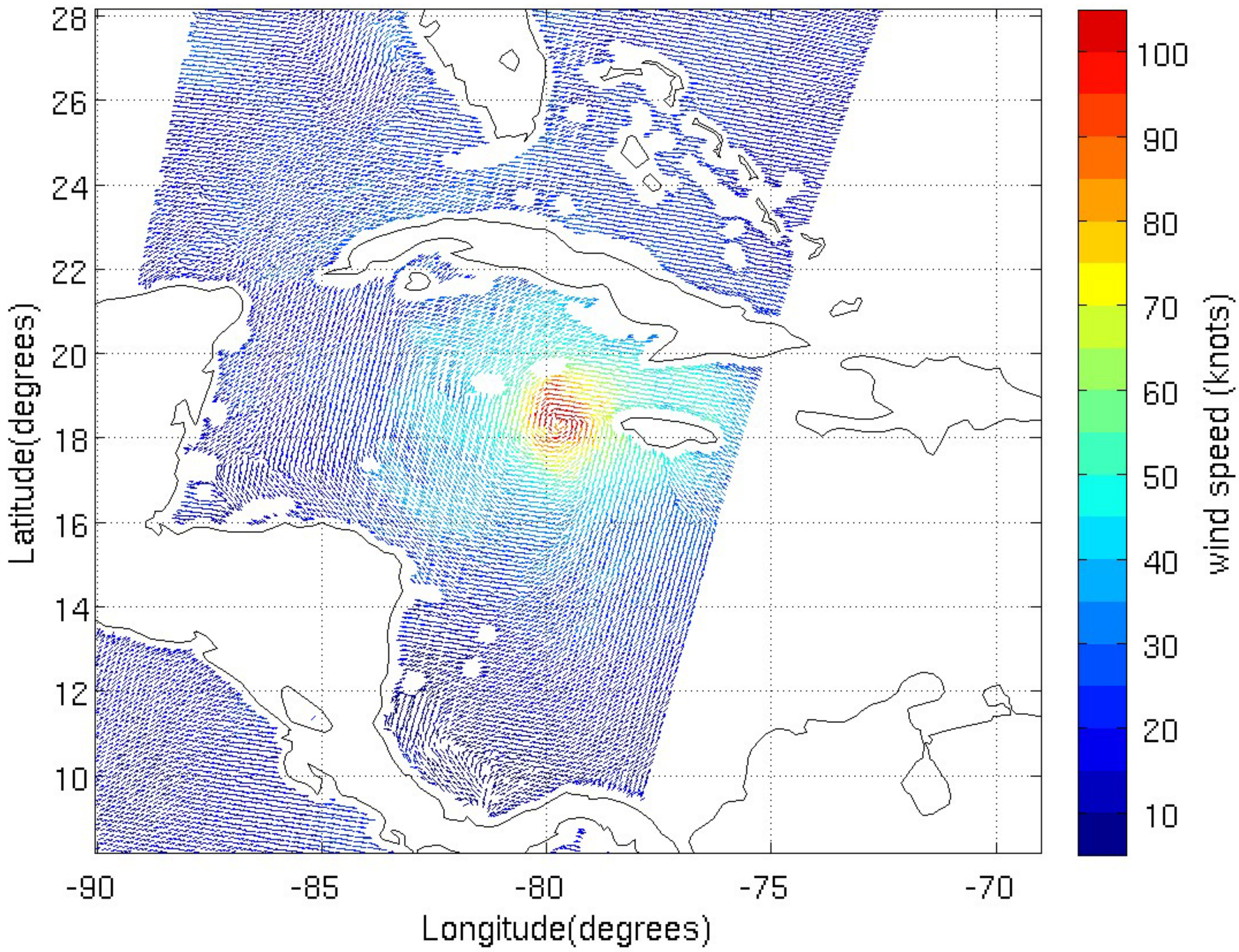
QuikSCAT Data Set

- http://tropicalcyclone.jpl.nasa.gov
- 21600 total storm scenes from October 1999 to November 2009
- 11435 scenes with best track center within the image, including:
  - 3295 TS, 788 CAT-1, 367 CAT-2, 330 CAT-3, 289 CAT-4, 55 CAT-5
- Data on the site includes:
  - JPEG Images of tropical cyclone optimized winds and two versions of the JPL global wind product.
  - Netcdf files containing, all three wind sets, SRAD rain rates, all 8 backscatter sets, and SSM/I co-locations
  - A comprehensive set of best track data from a variety of sources.

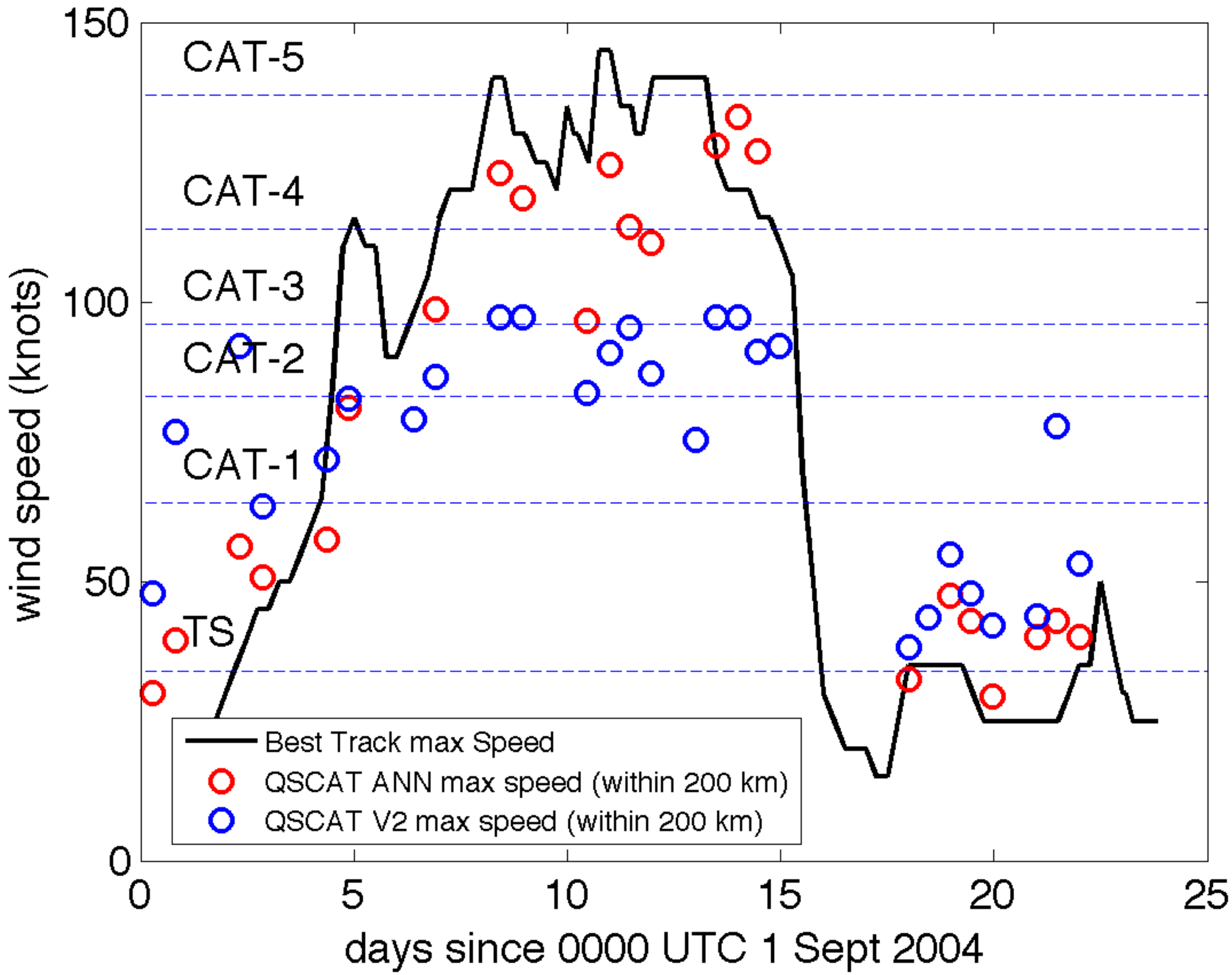
QuikSCAT 1999-2009 Data Set

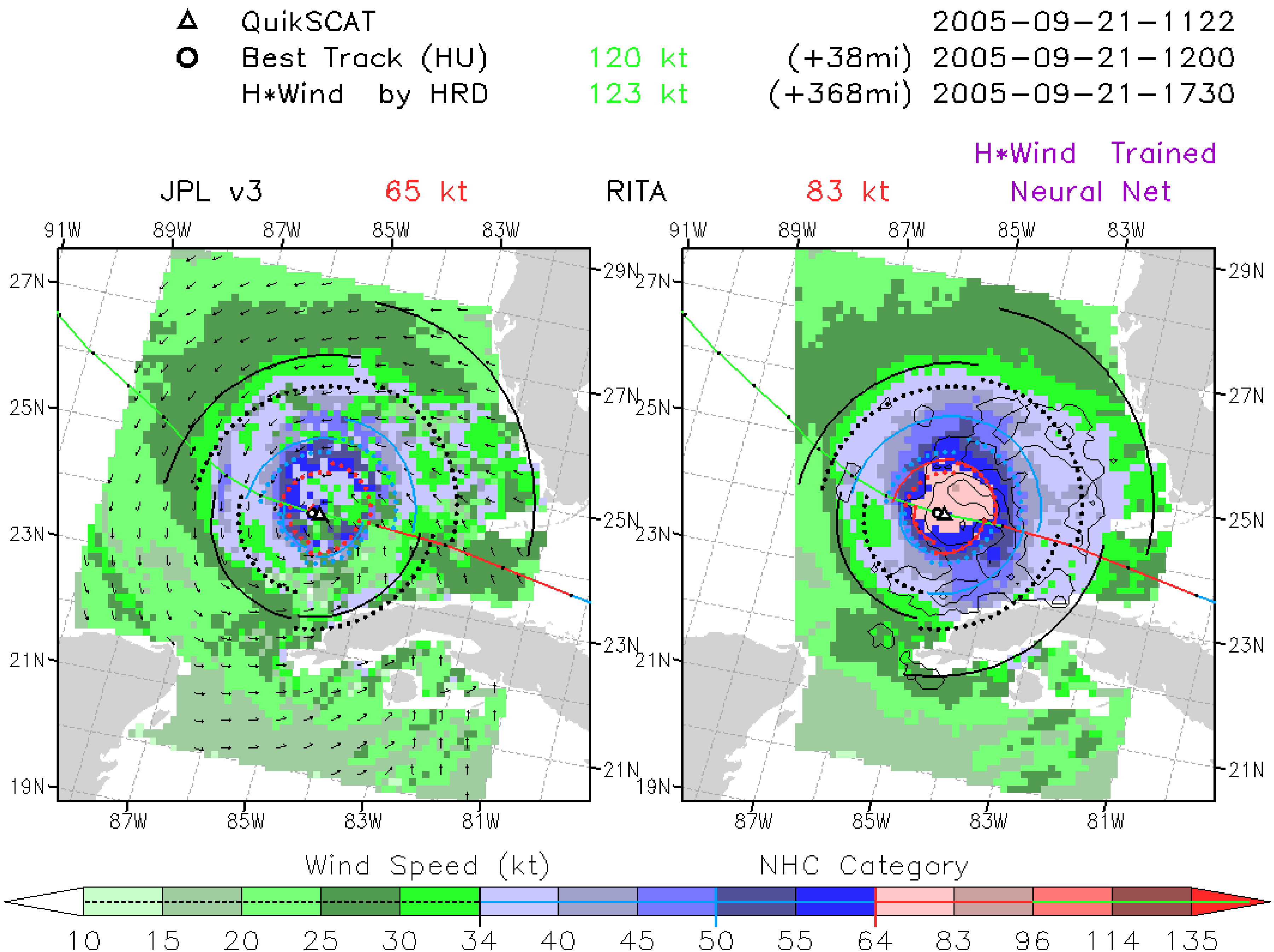


Hurricane Ivan 23:37 UTC 11 Sept. 2004

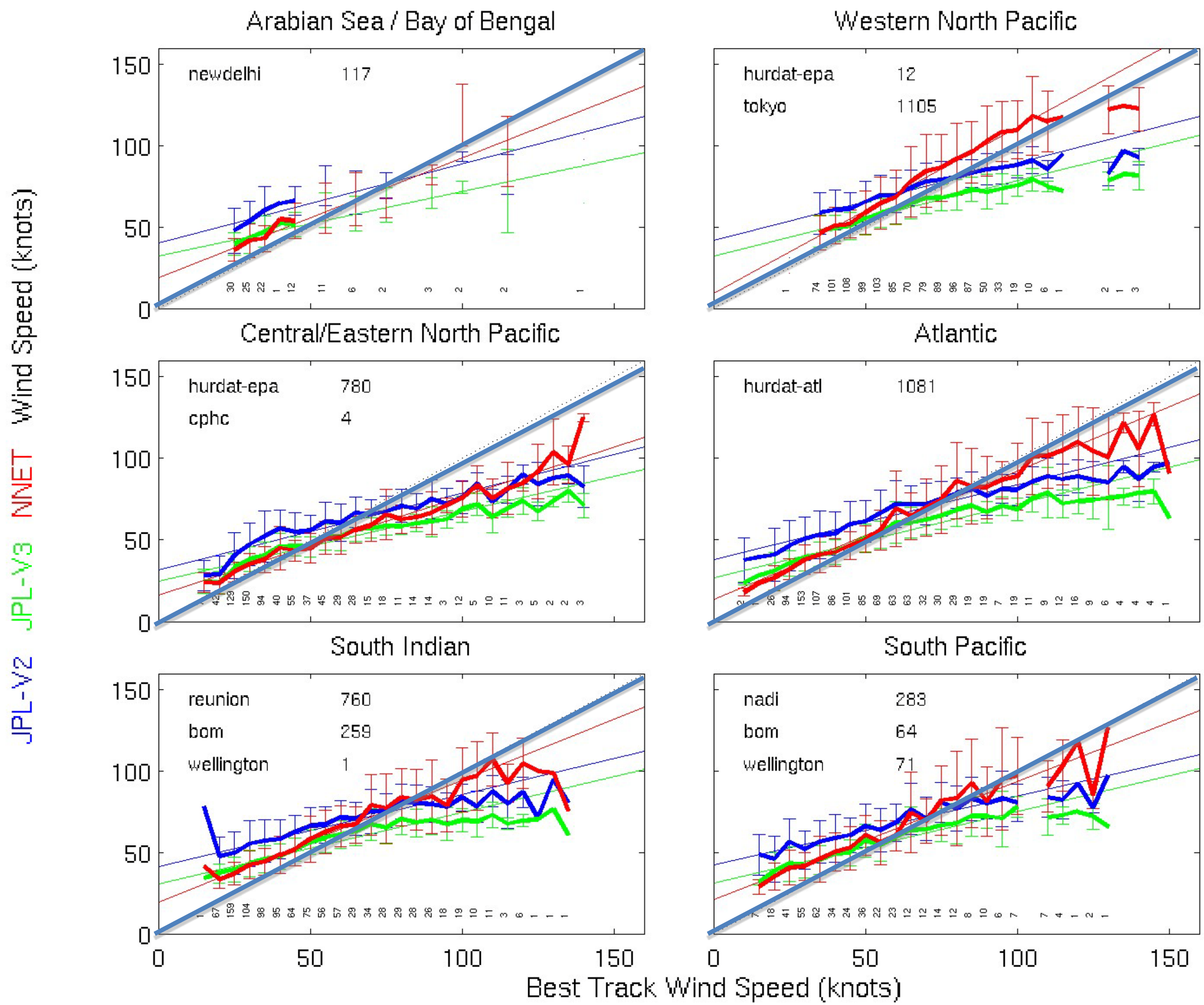


Examples Maximum Speed Tracks – Ivan 2004

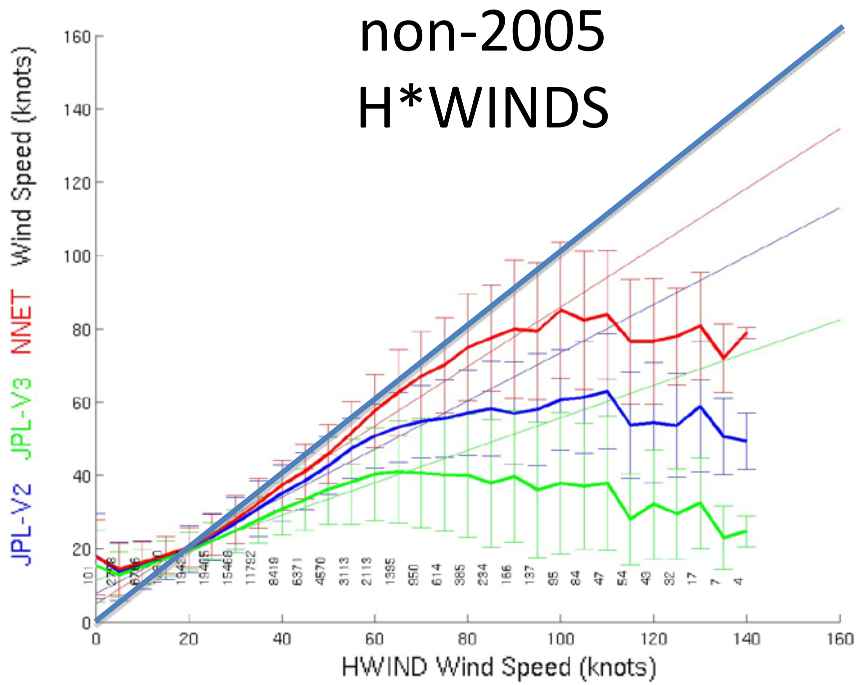


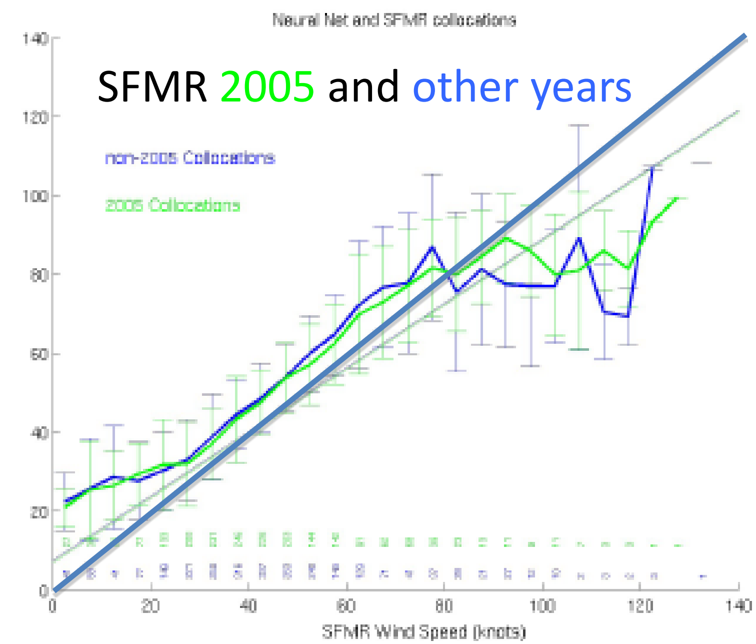

QuikSCAT
2005-09-21-1122
Best Track (HU)
120 kt
(+38mi)
2005-09-21-1200
H*Wind by HRD
123 kt
(+368mi)
2005-09-21-1730
H*Wind Trained Neural Net
JPL v3
65 kt
RITA
83 kt
91W
89W
87W
85W
83W
81W
29N
27N
25N
23N
21N
19N
Wind Speed (kt)
NHC Category
10
15
20
25
30
34
40
45
50
55
64
83
96
114
135

Max Wind Speed Statistics



Validation vs. H*WINDS and SFMR speeds





- NNET winds slight negative bias vs. H*WINDS up to 80 knots.
- JPL-V2 winds start to saturate at 40 knots.

- NNET winds trend with SFMR up to 80 knots.
- Have a positive bias vs. SFMR in training year 2005 and other years.

Validation: QuikSCAT–NHC Best Track

Max. Wind (kt)

	N	AVG	STD	FSP
HWind	39	-3.1	9.9	18%
N Net	**132**	**-1.2**	**18.9**	**35%**
JPL v3	132	-10.1	23.5	23%
JPL v2	132	1.5	23.3	24%

34-kt Radii (nm)

	N	AVG	STD	FSP
HWind	127	11.9	36.5	11%
N Net	329	22.7	40.5	23%
JPL v3	**329**	**8.3**	**37.4**	**30%**
JPL v2	329	31.9	47.2	18%

50-kt Radii (nm)

	N	AVG	STD	FSP
HWind	127	6.6	20.5	13%
N Net	**339**	**4.7**	**26.1**	**21%**
JPL v3	339	-4.9	27.5	20%
JPL v2	339	26.2	45.9	11%

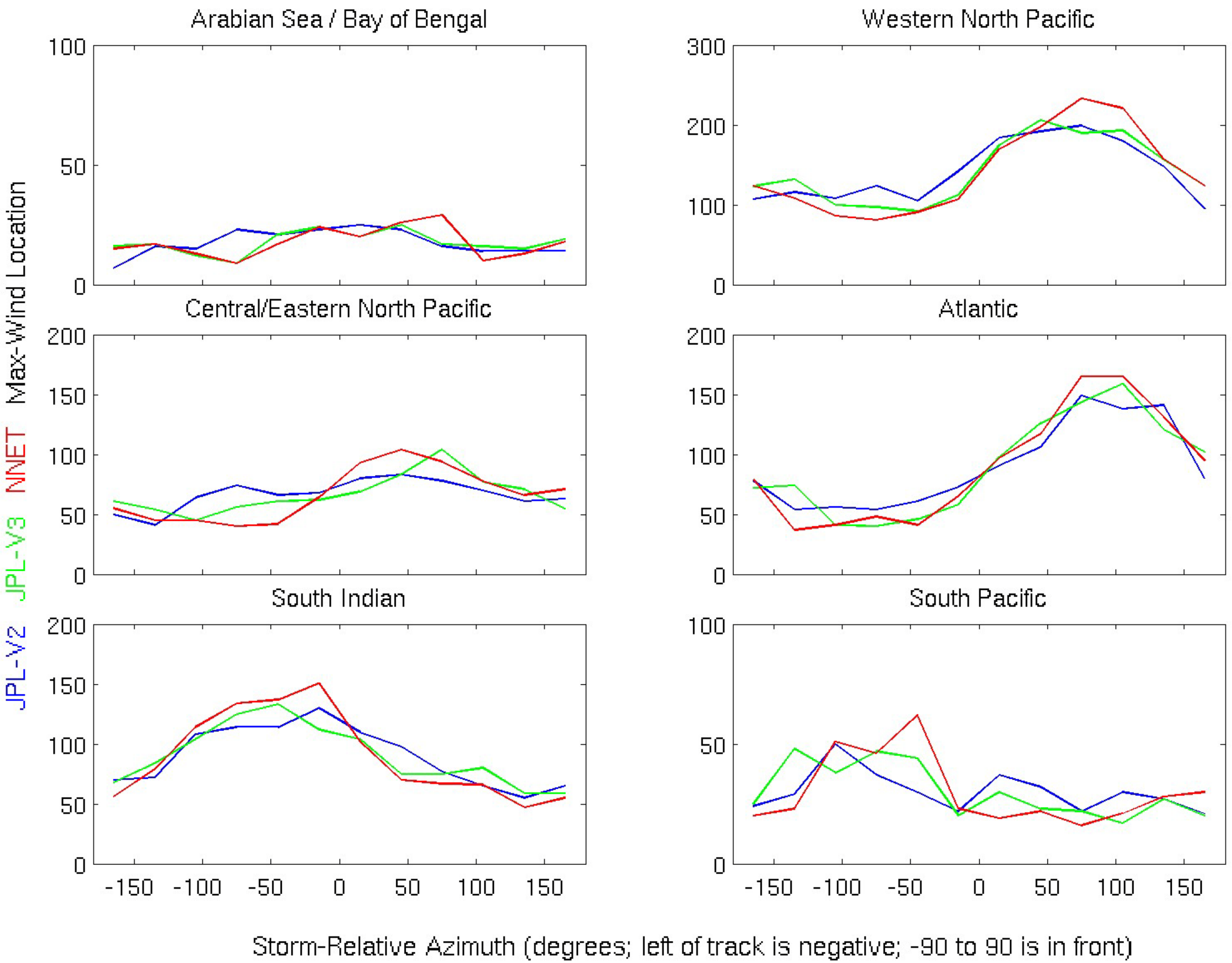
64-kt Radii (nm)

	N	AVG	STD	FSP
HWind	127	4.7	13.7	13%
N Net	**338**	**1.8**	**18.7**	**15%**
JPL v3	338	-8.6	19.3	12%
JPL v2	338	11.6	36.1	10%

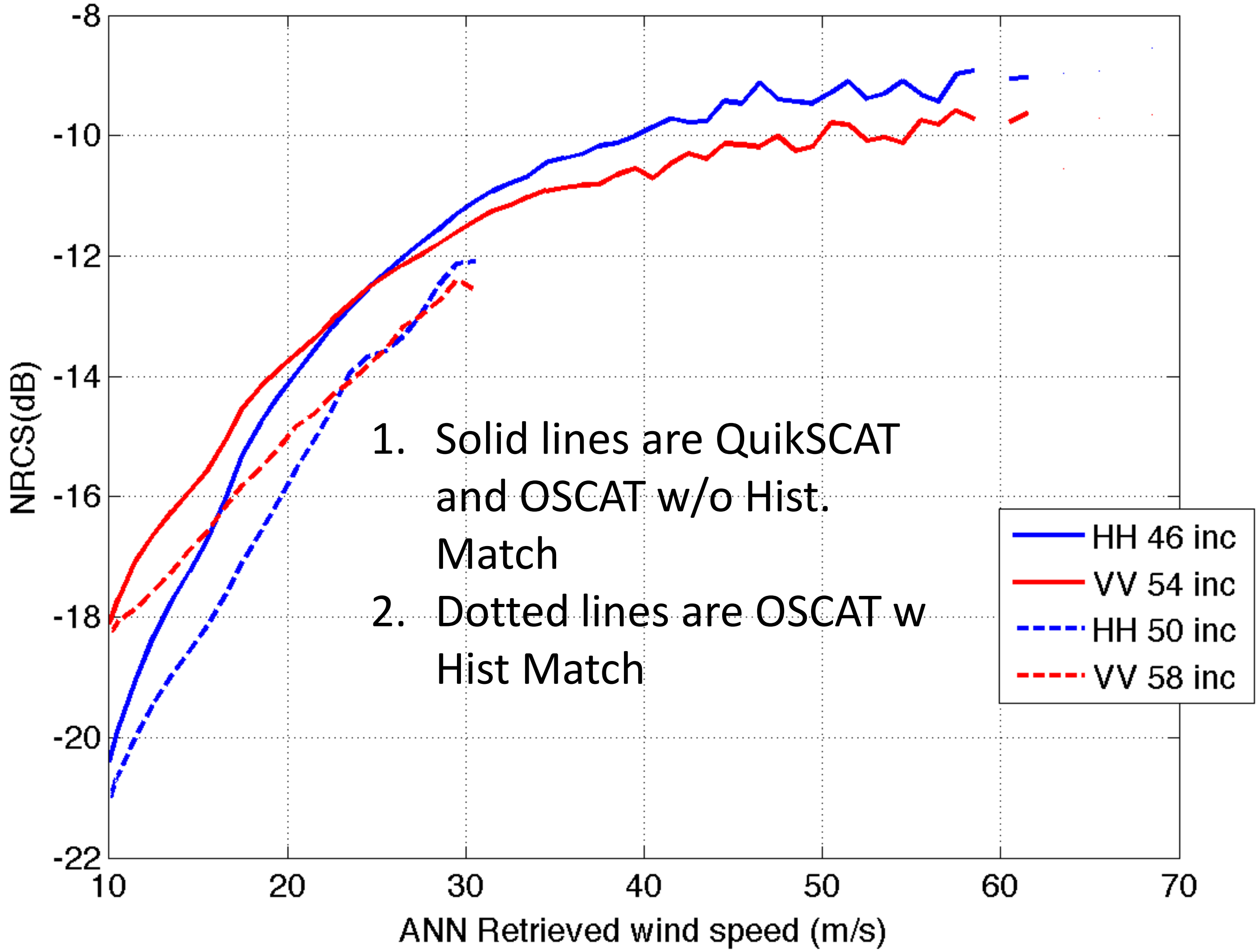
Green denotes superior QuikSCAT-only retrieval

Max Winds Location Statistics

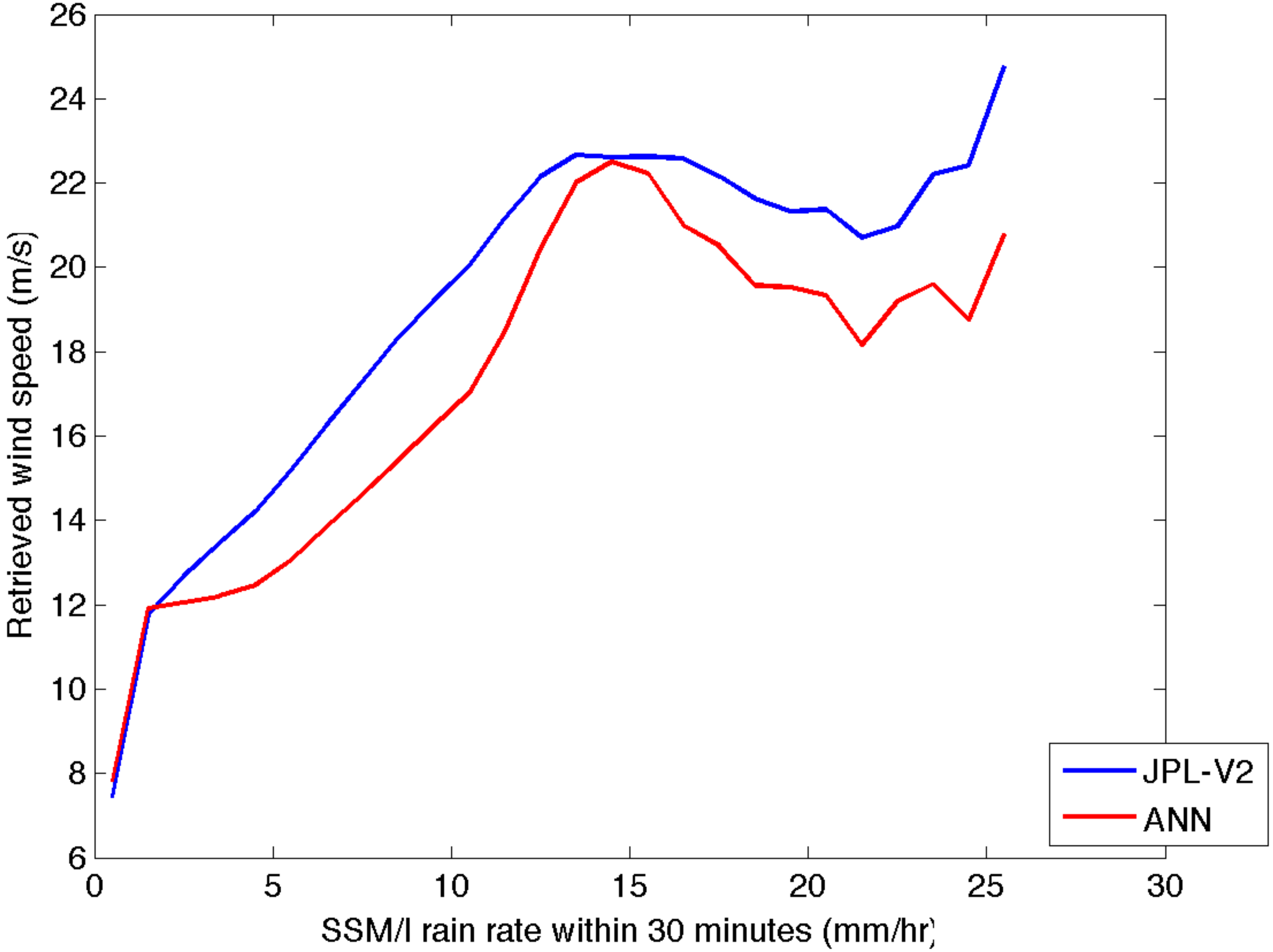
(compare to [Ulhorn and Black, 2007])



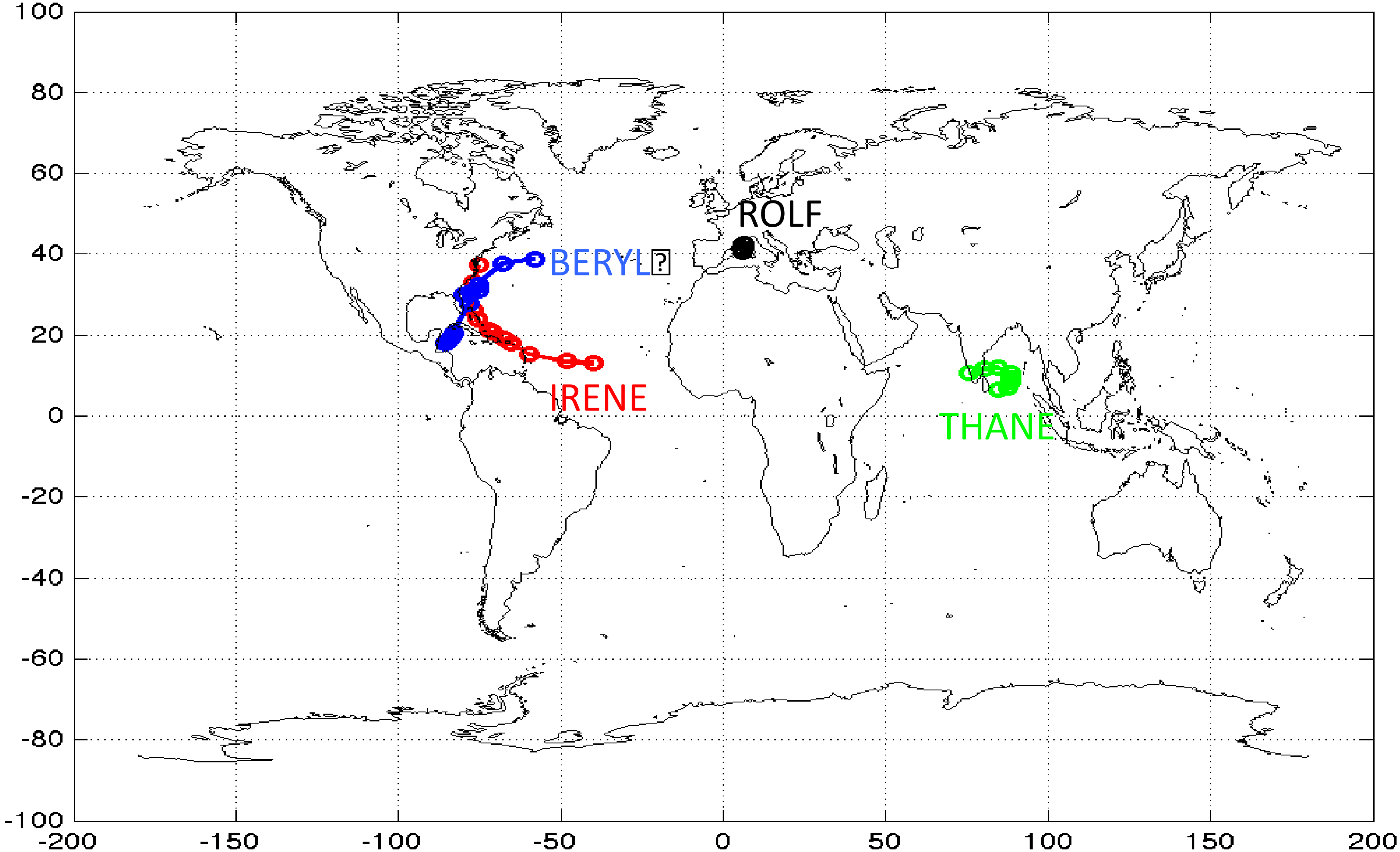
Rainfree NRCS vs Wind Speed



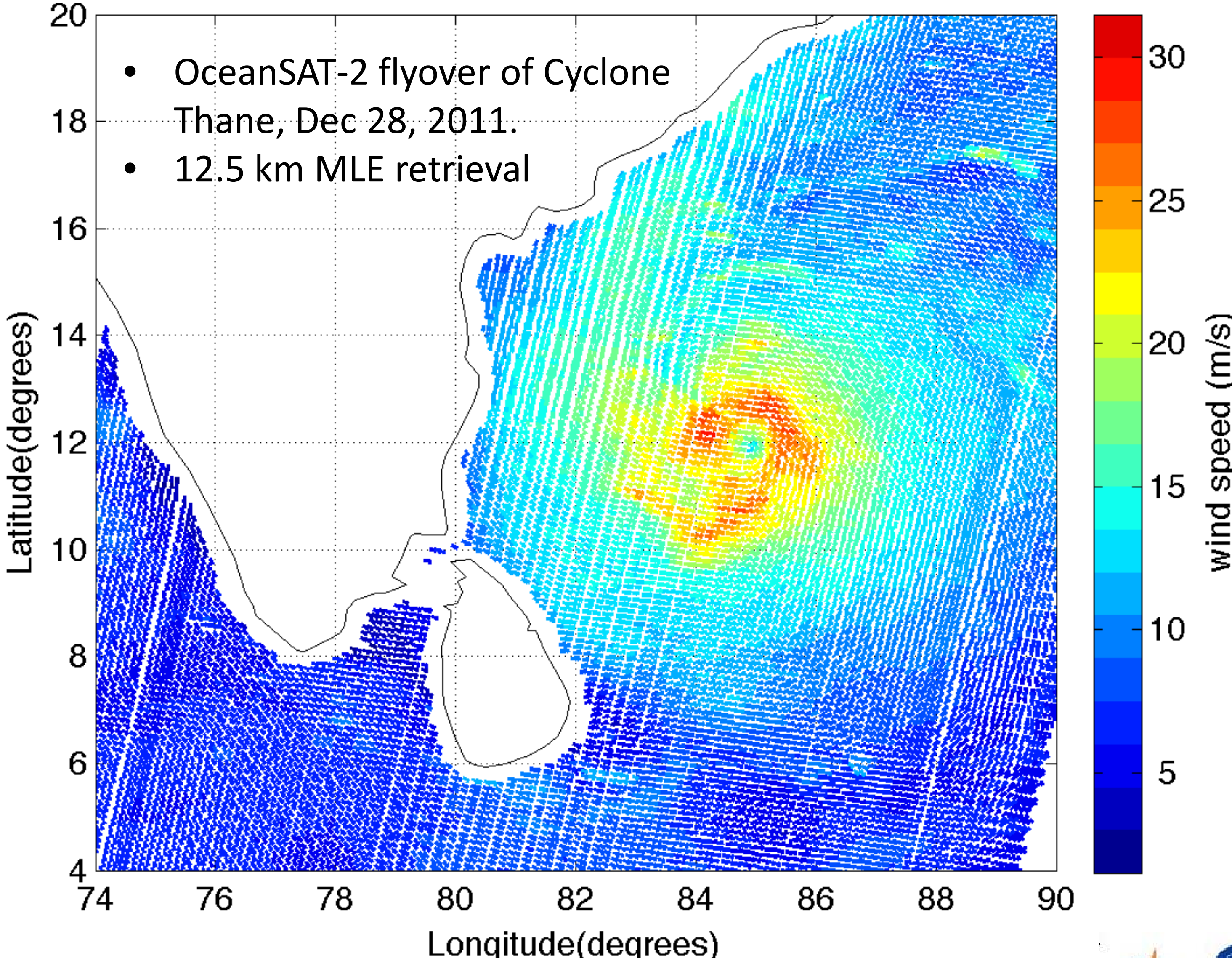
Average Wind Speed Vs. Rain Rate



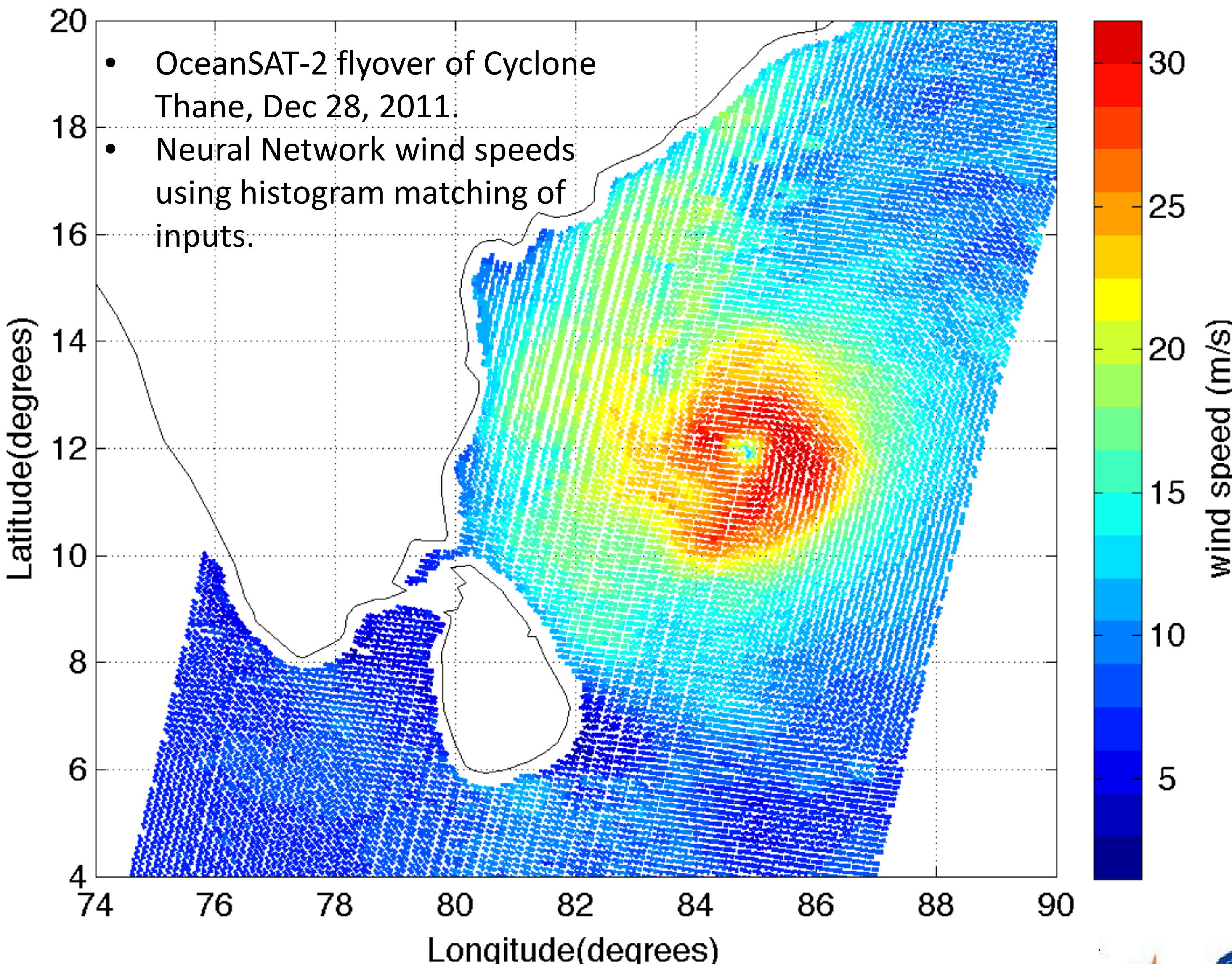
OceanSAT-2 Retrievals



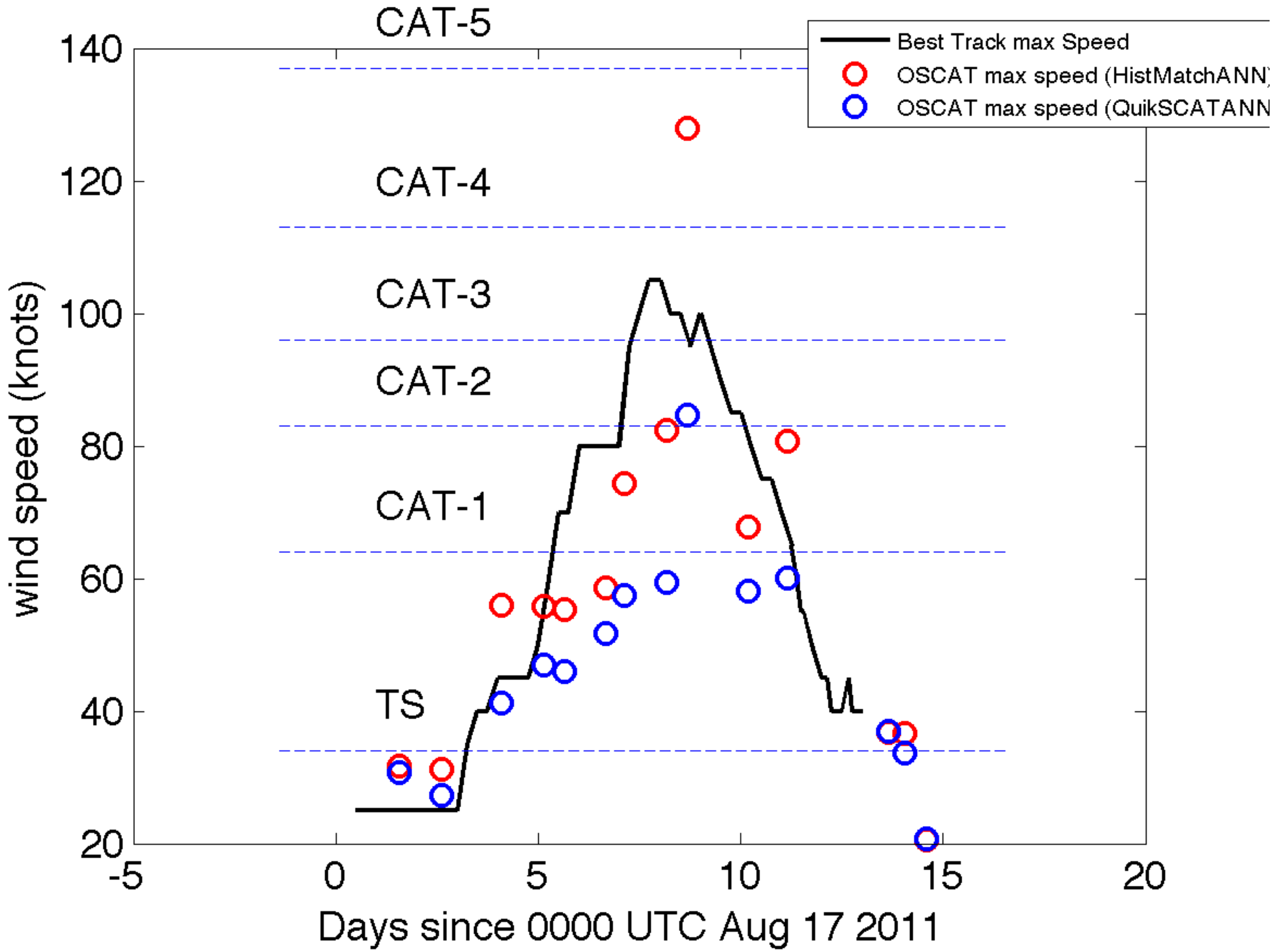
OceanSAT-2 Tropical Cyclone Winds



OceanSAT-2 Tropical Cyclone Winds



Example Max Speed Track Irene 2011



Summary

- Wind tropical cyclones speed fields have been
  - Optimized for accuracy
  - Produced for all ten years of the QuikSCAT mission including over 5,000 observations of tropical storms and above.
  - Validated vs. H*WINDS, SFMR, and best track wind speeds.
  - Made available online to the community at large in a browsable data base.
    - Ancilary data such as backscatter imagery and co-located rain information are also included.
- We now begin the scientific exploitation of the QuikSCAT TC dataset.
  - Initial investigations will include:
    - Distribution of max winds as a function of storm movement and geographic location
    - Correlation of storm features with rapid intensification and de-intensification events
    - Storm size estimation and trend analysis
- We also plan to produce similar datasets for OceanSAT-2 and ASCAT
  - Sample OceanSAT-2 fields have been produced and we are currently validating and optimizing them.
  - ASCAT fields are planned for the following year.
- A paper describing the production and validation of the QuikSCAT data set is in prep.

Acknowledgements

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- The website portal used to distribute the data set is part of a program funded by NASA’s Hurricane Science Research program.

References

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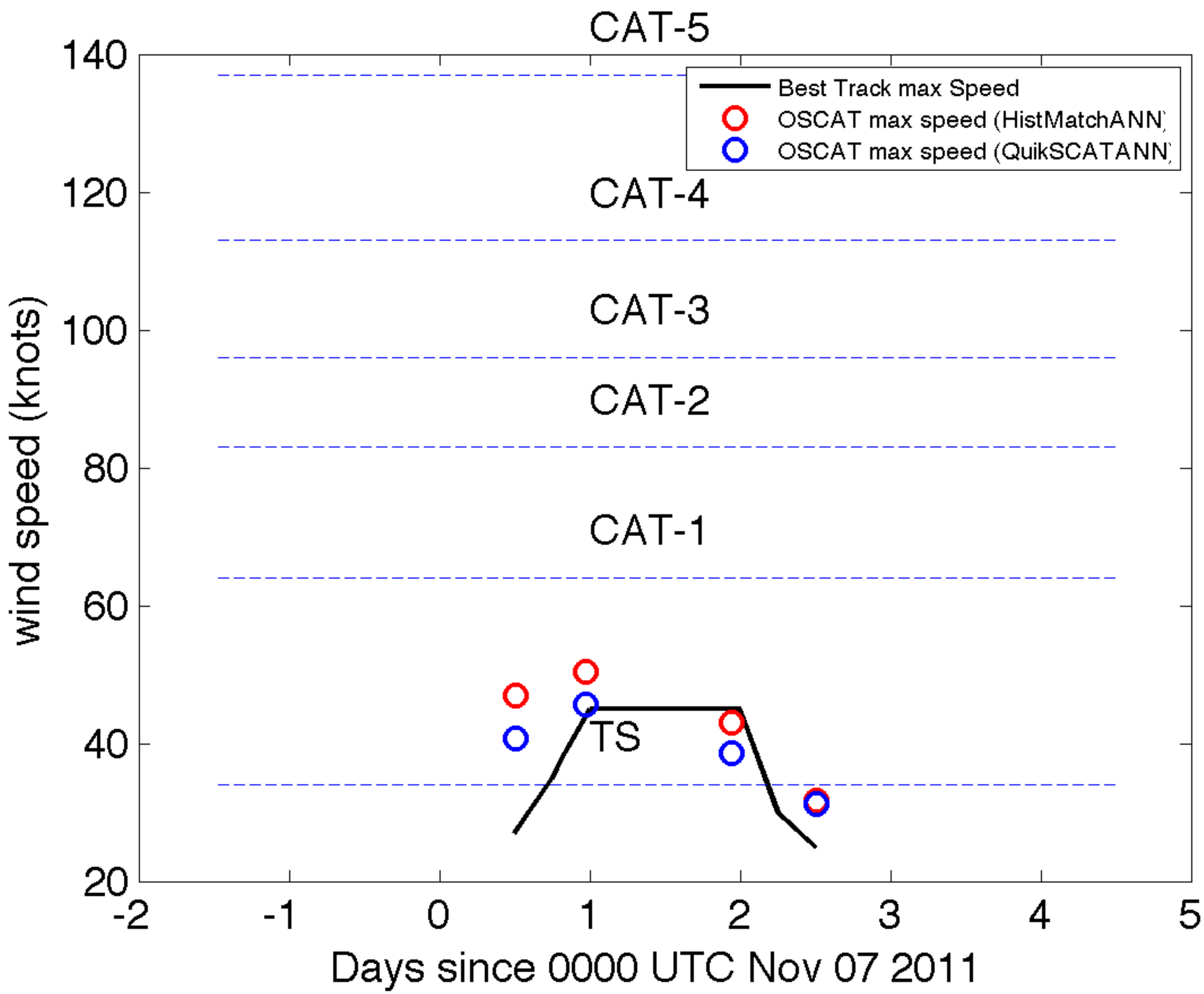
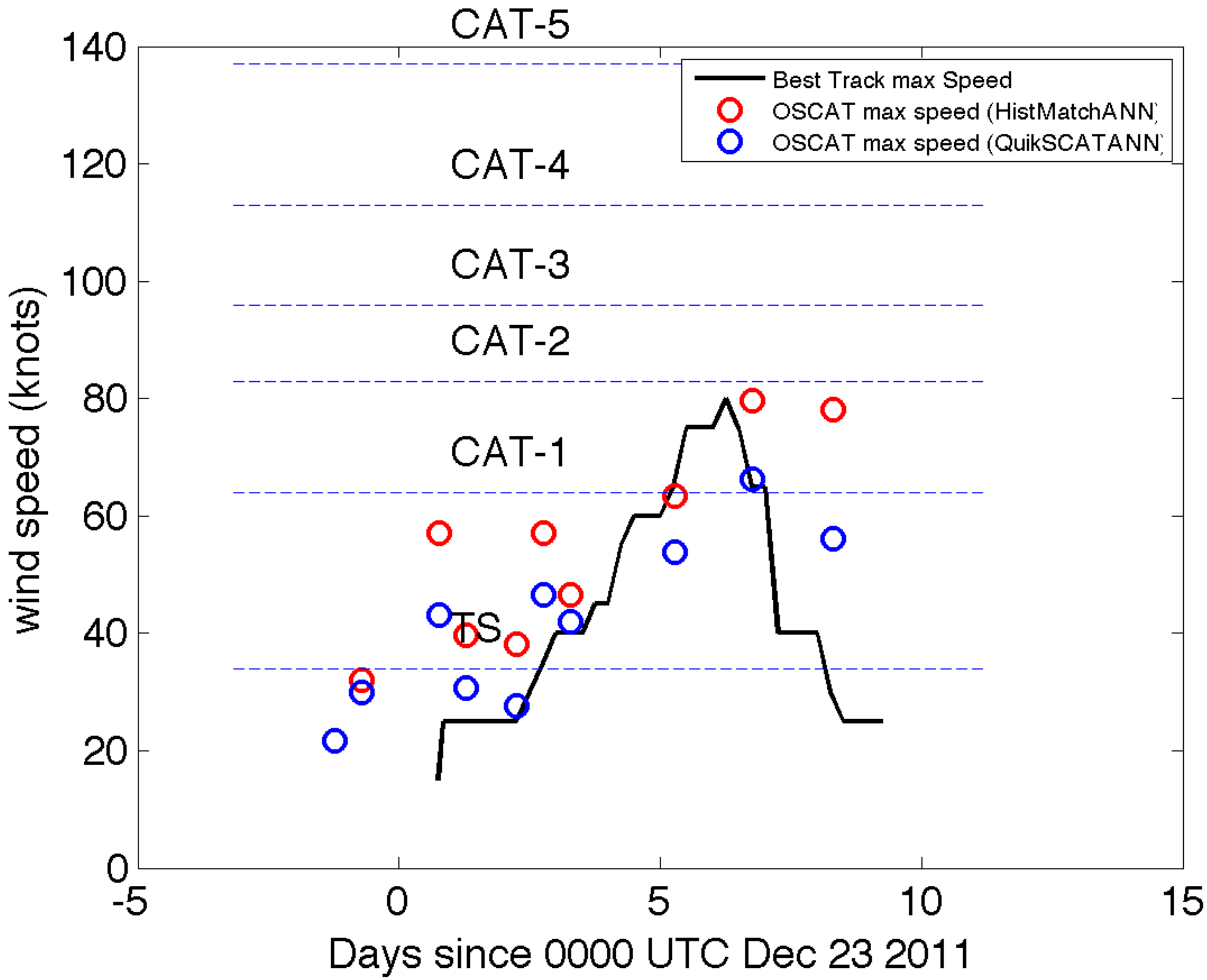
Backups

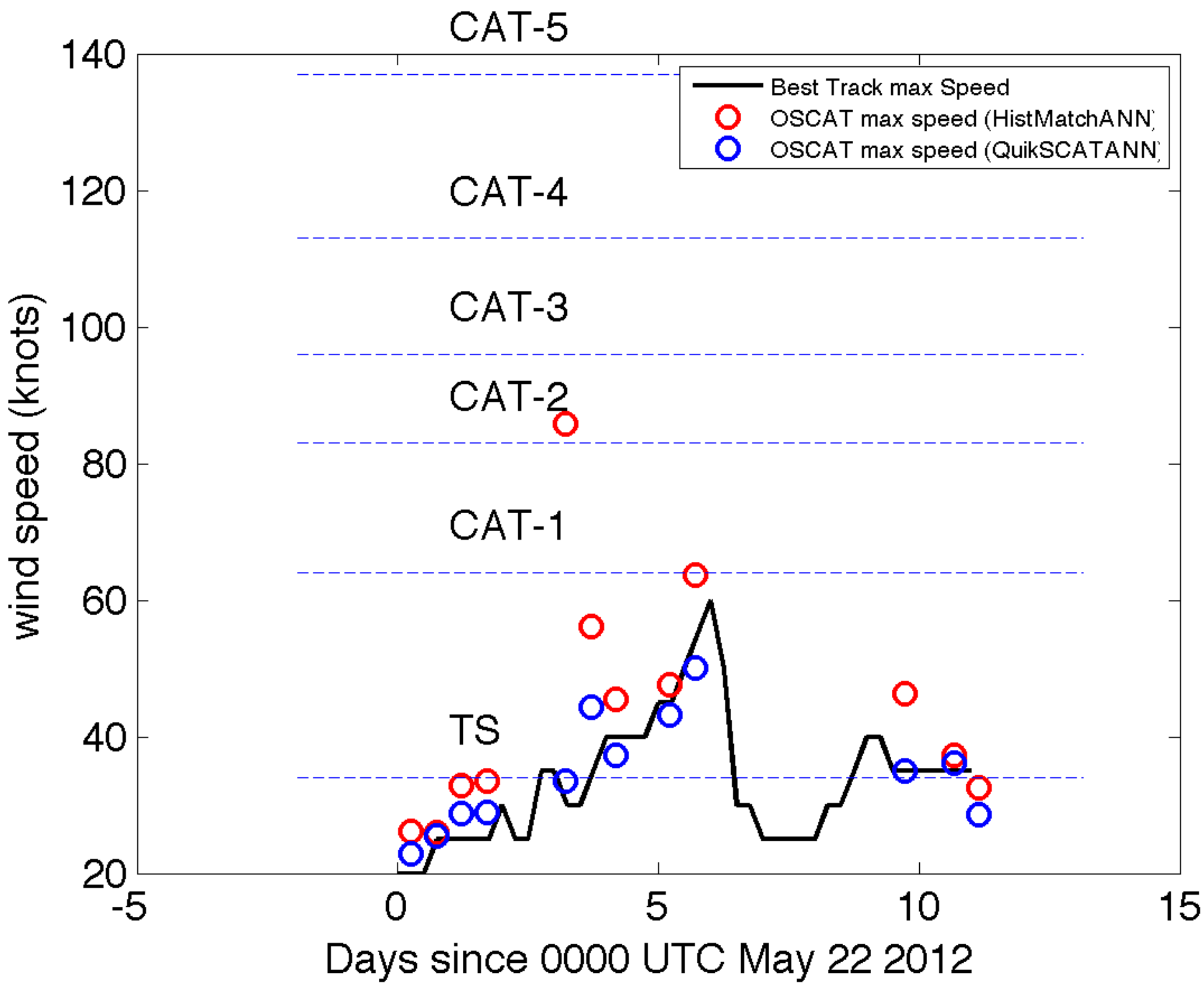
Example Max Speed Track Rolf 2011



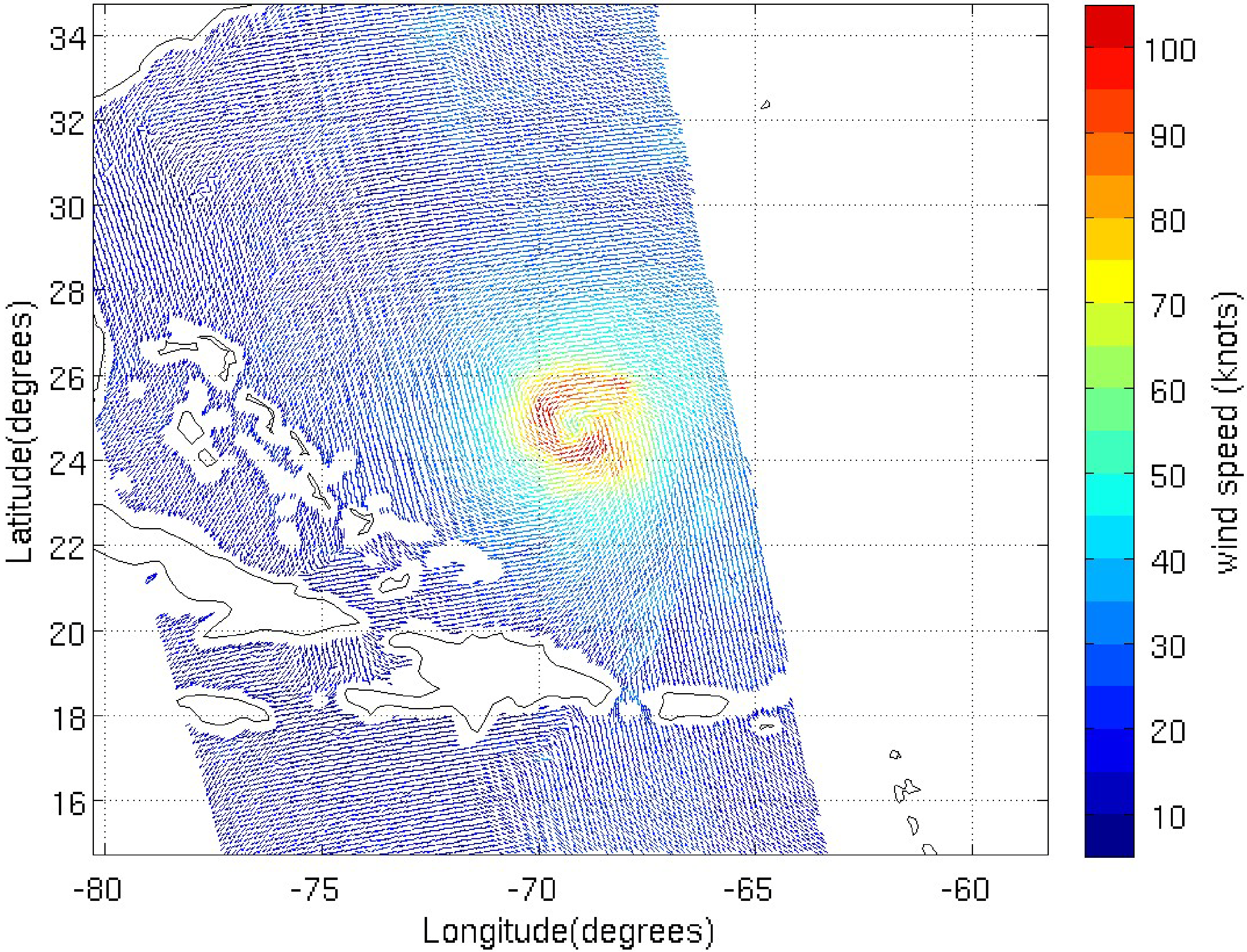
Example Max Speed Track Thane 2011-2012



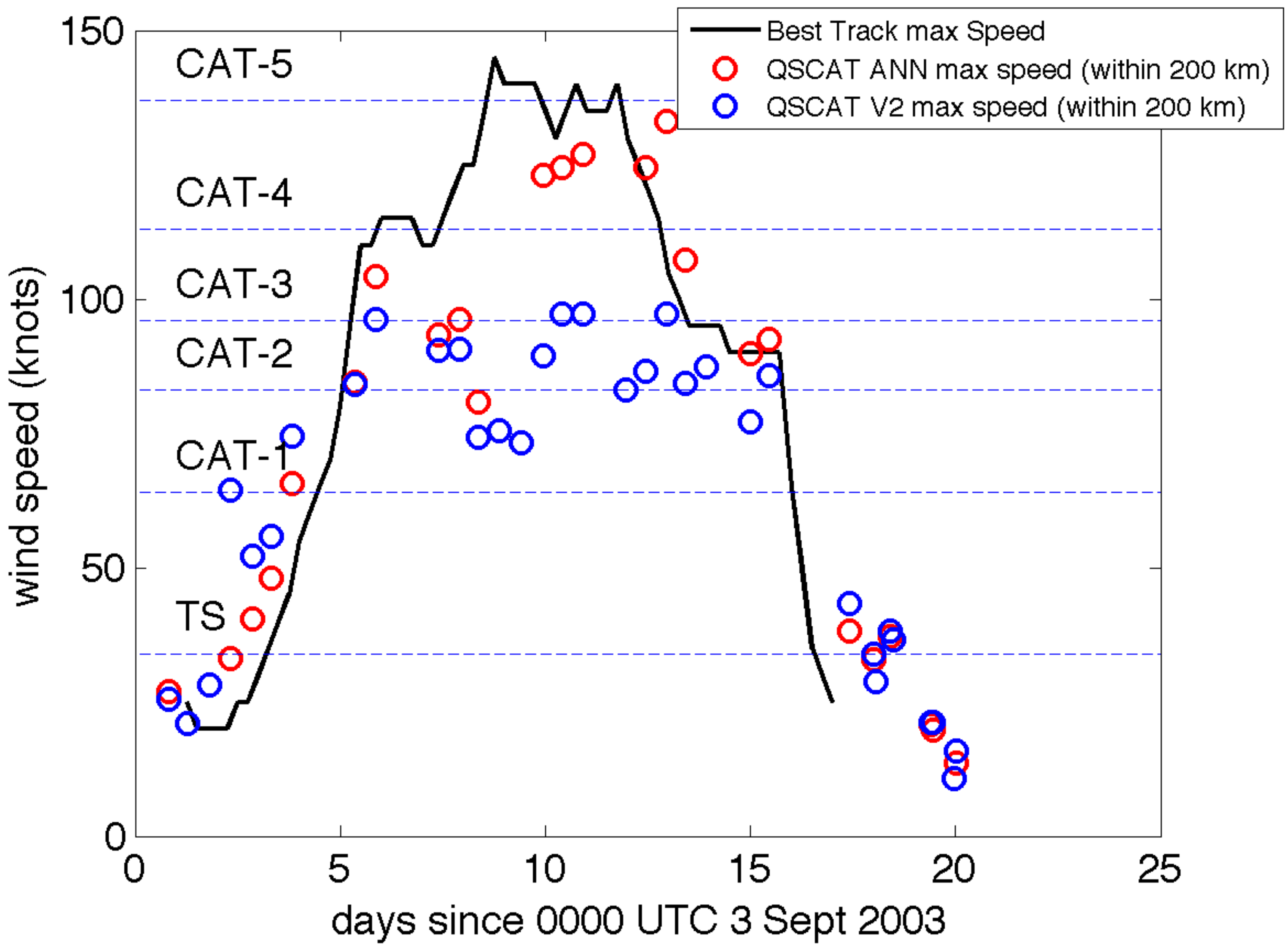
Example Max Speed Track Beryl 2012



Hurricane Isabel, 1028 UTC 15 Sept 2003



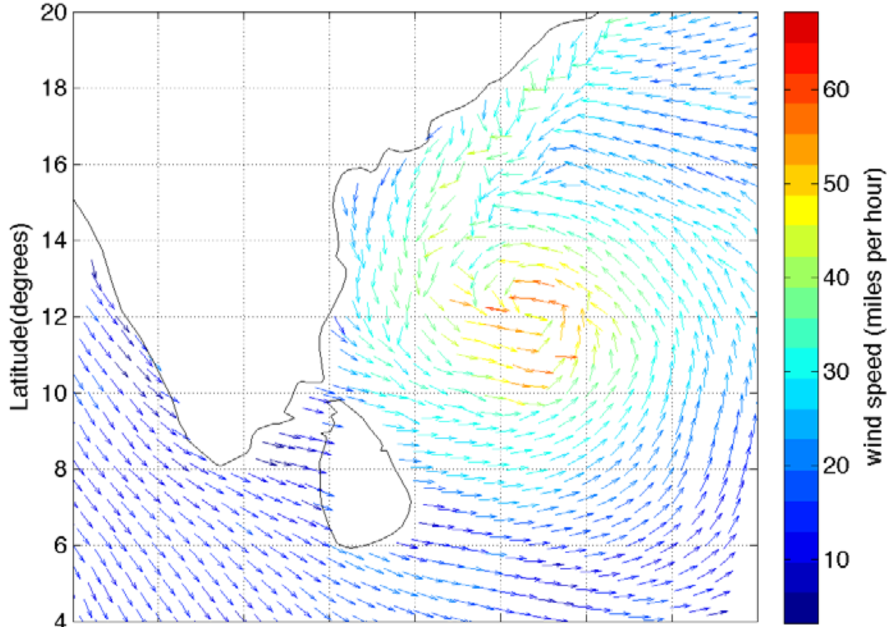
Examples Maximum Speed Tracks – Isabel 2003

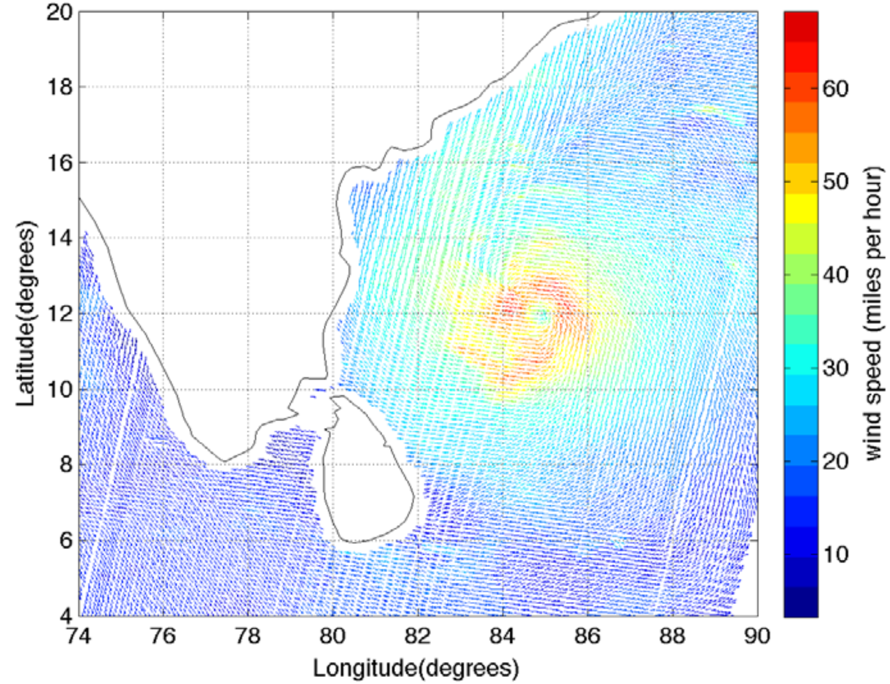


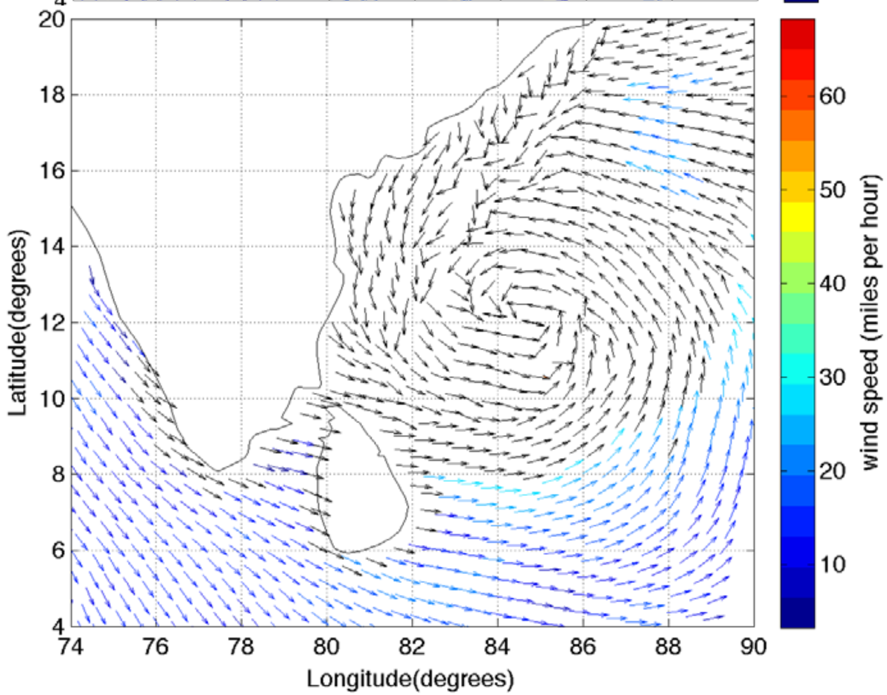
OceanSAT-2 Tropical Cyclone Winds

- OceanSAT-2 is a 13.4 GHz ocean wind scatterometer operated by the Indian Space Research Organization (ISRO).
- For the past two years ISRO has been collaborating with NASA/JPL and NOAA to refine the calibration of the OceanSAT-2 backscatter data.
- The goal of the collaboration is to extend the Ku-band scatterometer wind data record initiated by QuikSCAT.
- A crucial element of this effort has been the repointing of the QuikSCAT instrument to match the OceanSAT-2 viewing geometry.
- Although QuikSCAT ceased nominal operations in November 2009, its precisely calibrated backscatter measurements remain useful for cross-platform calibration.
- To date the ISRO/NASA/NOAA collaboration has resulted in:
  - More robust wind retrieval in low wind areas.
  - Absolute backscatter calibration tuned to match QuikSCAT data within 0.1 dB.
  - Improved wind accuracy as compared to numerical wind products and buoys.
  - Ongoing monitoring of calibration drift by comparison between QuikSCAT and OceanSAT-2 backscatter values.
- The fruitfulness of the collaboration is further illustrated by the tropical cyclone winds on the next slide.
  - The OceanSAT-2 operational wind product is binned at 50 km with a conservative land mask employed to insure accurate winds.
  - JPL has retrieved winds at higher resolutions and closer to the coast.
  - Cases are shown before and after calibration improvements.

OceanSAT-2 flyover of Thane, 28 Dec 2011.







- Upper Right: Winds retrieved by NASA JPL at 12.5 km resolution.
- Upper Left: ISRO NRT Winds (50 km)
- Lower Left: ISRO NRT Winds (rain flagged vectors set to black)