Tropical Cyclone Wind Validation of the JPL OSCAT Artificial Neural Network (ANN) Wind Product

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NOAA/NESDIS/STAR

Abstract – The Oceansat-2 scatterometer (OSCAT) is a Ku-band dual-polarized rotating pencil beam scatterometer. It was developed by the Indian Space Research Organization (ISRO) and was launched on September 23, 2009 on board the Oceansat-2 satellite. A specialized OSCAT wind product known as the artificial neural network (ANN) winds, produced by the Jet Propulsion Laboratory (JPL), was developed for retrieving the ocean surface winds in tropical cyclone conditions. A database of tropical cyclone winds from OSCAT ANN for 2010 to 2011 can be obtained at http://tropicalcyclone.jpl.nasa.gov.

In this work we evaluate the OSCAT ANN tropical cyclone winds in four ocean basins: the North Atlantic, East Pacific, West Pacific and North Indian. An analysis of the wind radii with respect to the hurricane best track is presented. The validation of OSCAT ANN winds is presented with respect to a variety of high wind data sources including the Stepped-Frequency Microwave Radiometer (SMFR), GPS dropwindsondes, H*WIND analysis and the Advanced Scatterometer (ASCAT) using CMOD5.H GMF. Finally we present a comparison of the maximum wind measurement with respect to the best track maximum wind for each of the four basins.

We found that the OSCAT ANN wind radii perform well for the 34-knot wind speed but are larger than best track by about 6% for the 50-kt radii and about 16% for the 64-kt radii in the first quadrant. The wind speeds compare well to GPS dropsonde winds but exhibit a slightly high bias with respect to SFMR and HWIND from wind speed ~ > 30 m/s. The maximum wind speed of OSCAT ANN compare relatively well with the best track.

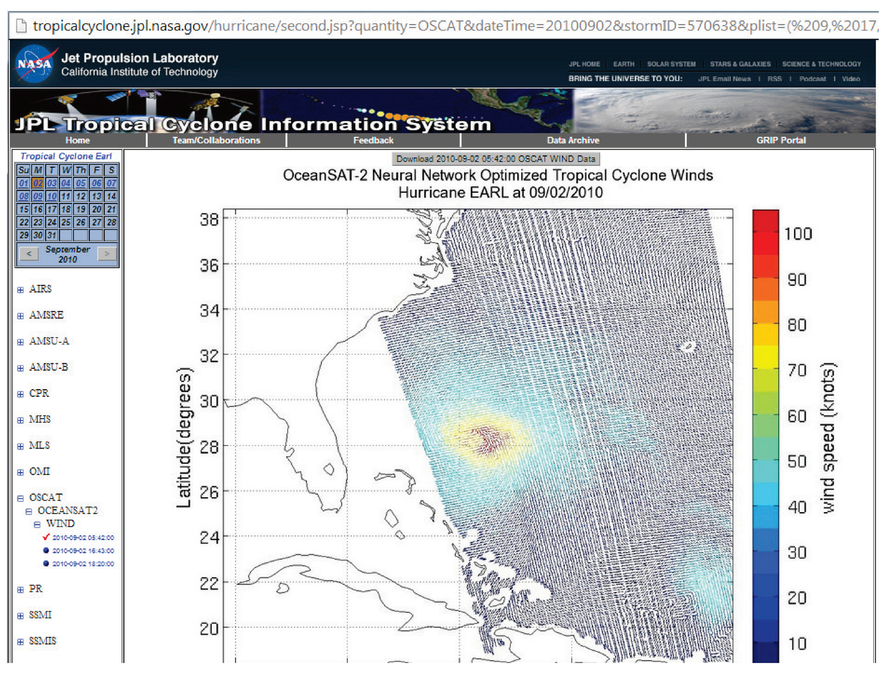

Fig. 1. A screen snap shot of JPL Tropical Cyclone Information System webpage displaying OSCAT Neural Network Winds for Hurricane Earl.

In this study we evaluate and validate the performance of the OSCAT artificial neutral network (ANN) processing technique [1] for retrieving 12.5-km resolution winds in the tropical cyclone environment. These data were produced for all the tropical cyclone overpasses from 2010 to 2011.The OSCAT ANN data is available for download from the JPL webpage at http://tropicalcyclone.jpl.nasa.gov. An example of a screen snapshot of the OSCAT ANN overpass Hurricane Earl is shown in Fig. 1. We evaluated the OSCAT ANN winds in North Atlantic, East Pacific, West Pacific and North Indian basins. The results are presented for wind radii performance with respect to those from the best track, wind speed comparisons with HWIND, SFMR, dropwindsonde, and ASCAT and finally the maximum wind speeds retrieved.

[1]. B. W. Stiles, R. E. Danielson, W. L. Poulsen, M. J. Brennan, S. Hristova-Veleva, T.-P. Shen and A. G. Fore, "Optimized Tropical Cyclone Winds From QuikSCAT: A Neural Network Approach," *IEEE Trans. Geosci. Remote Sens., Issue: 99, Pages 1-17, Apr. 2014*

Data Sources

- Tropical Cyclone best tracks (contain maximum wind speed, and 34-, 50- and 64-knot wind radii of four quadrant)
  - North Atlantic and East Pacific basin best track data were obtained from Nation Hurricane Center (NHC)
  - West Pacific and North Indian basin best track data were obtained from the Joint Typhoon Warning Center (JTWC)
- SFMR:
  - SFMR surface wind data available from Hurricane Research Division (HRD) ftp site
    - flag SFMR data based on the following conditions: Pitch angles: < 0 or > 5 degree, Roll angle: < -2 or > 2 degree, and |SFMR-HWIND| wind speed > 16 m/s
- Dropsonde
  - Utilized TEMP DROP message available on HRD
  - Compute surface wind speed by applying wind reduction factor to the last 150m averaged wind speed
  - Quality control by flag data when |Sonde-HWIND| wind speed > 16 m/s
- HWIND
  - Available through Dr. Mark Powell (Private Communication)
- ASCAT
  - Wind retrievals using CMOD5.H GMF available from NOAA

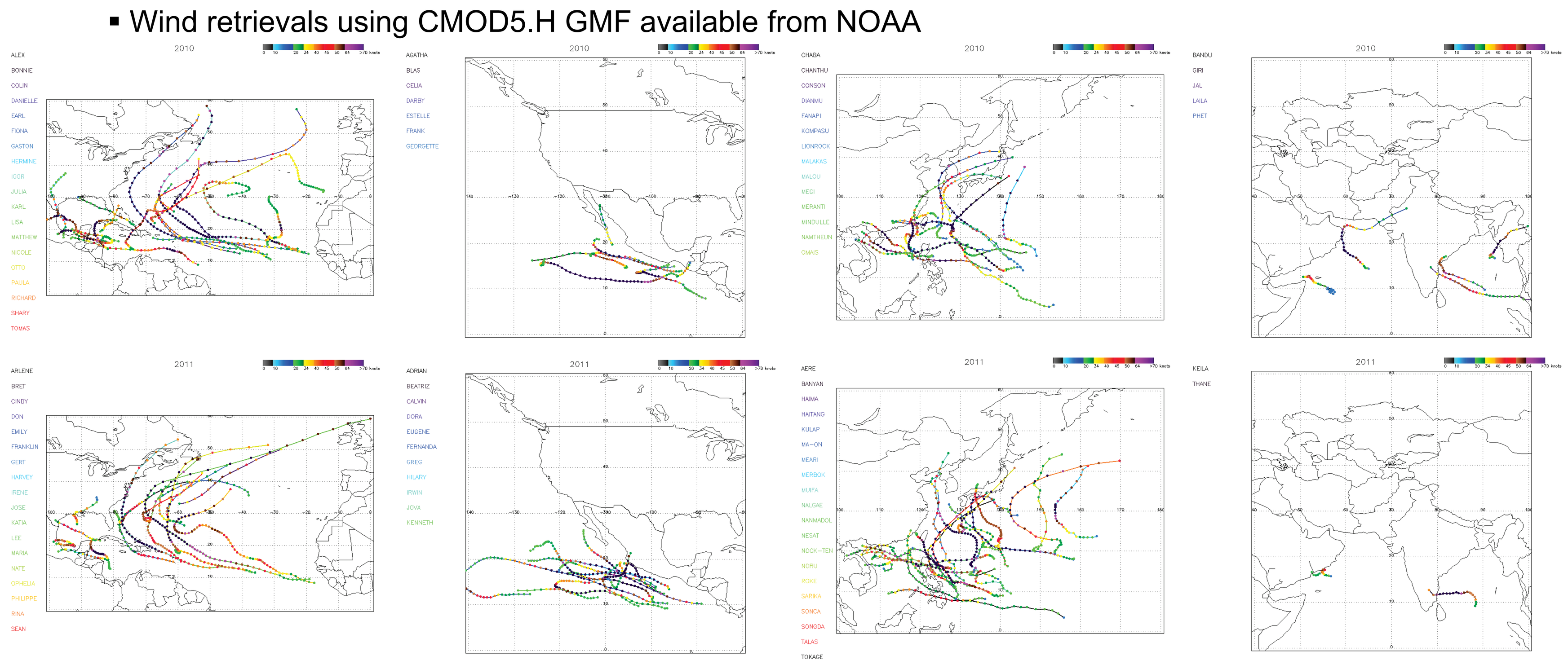

Fig. 2. Tropical cyclone best tracks from storms in 2010 and 2011. From left to right column: North Atlantic basin, East Pacific basin, West Pacific basin and North Indian basin. The colored lines matched the storm name on the left of each panel. The colored dots represent the strength of the wind in knots (color code shown on top).

Wind Radii Analysis

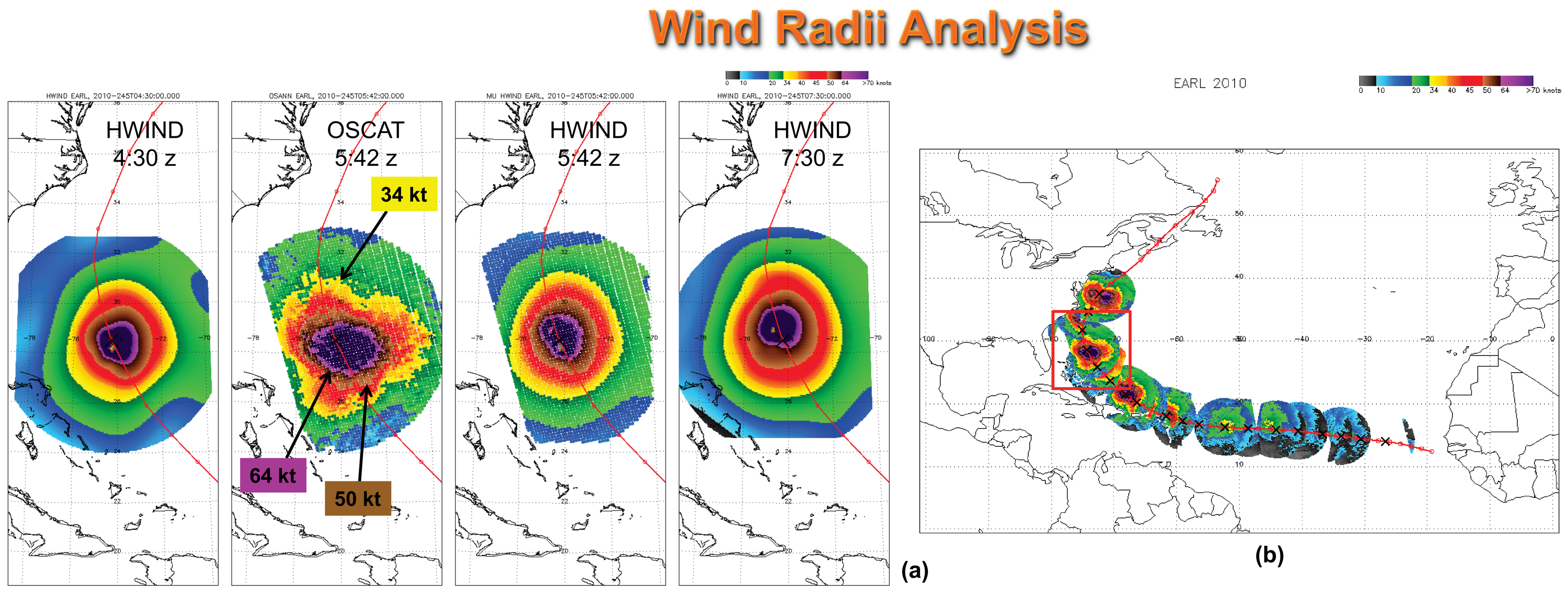

Fig. 3. (a) A snapshot of OSCAT overpass within 1000 km diameter of Hurricane Earl best track and corresponding HWIND field within 3 hour of OSCAT time (b) Snapshot of OSCAT overpass best track during the entire life of Hurricane Earl. The snapshot is shown in red square box.

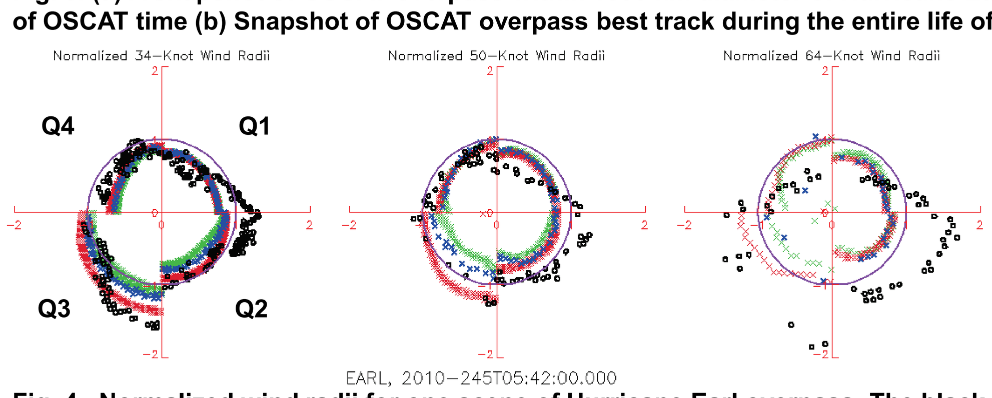

Fig. 4. Normalized wind radii for one scene of Hurricane Earl overpass. The black circle represent OSCAT, the blue X represent interpolated HWIND field, and red and green X represent HWIND field before and after OSCAT time respectively.

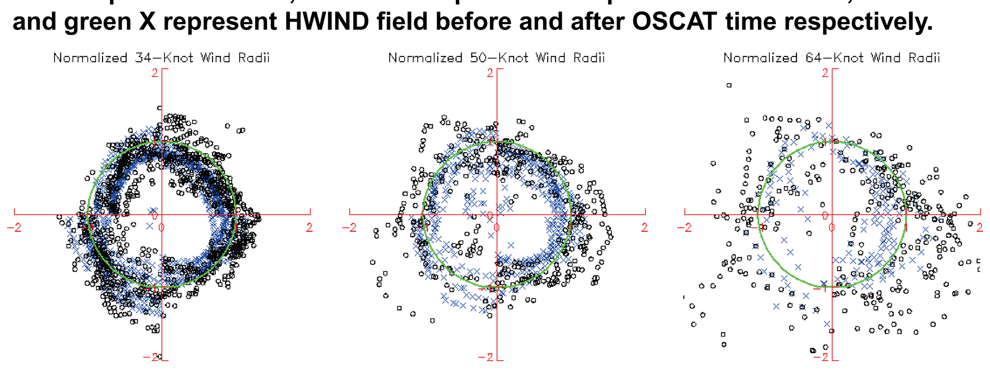

Fig. 5. Normalized wind radii for all scene of OSCAT overpass Hurricane Earl. The black circles represent OSCAT and blue X represent interpolated HWIND.

OSCAT retrievals were collocated with the hurricane best track by interpolating the best track 34-, 50- and 64-knot wind radii to the OSCAT time for every OSCAT overpass. A snapshot (scene) of an OSCAT overpass is shown in Fig. 3a second column. At this specific time we search for HWIND analysis before and after this time which are not more than 6 hours apart (column 1 and column 4 in Fig. 3a) and then linearly interpolate in time the closest samples for the two HWIND to each of OSCAT wind vector cell. The result is shown in Fig. 3a column 3.

The wind radii is computed by searching for wind speeds within ±1 knot of 34, 50, and 64 knots and calculating the distance and angle from the best track center. Then for each quadrant we normalized the radial distance with the best track's radii and plot the normalized radii for each wind speed. This results are shown in Fig. 4 for one scene and the entire storm in Fig. 5.

Wind Radii Analysis

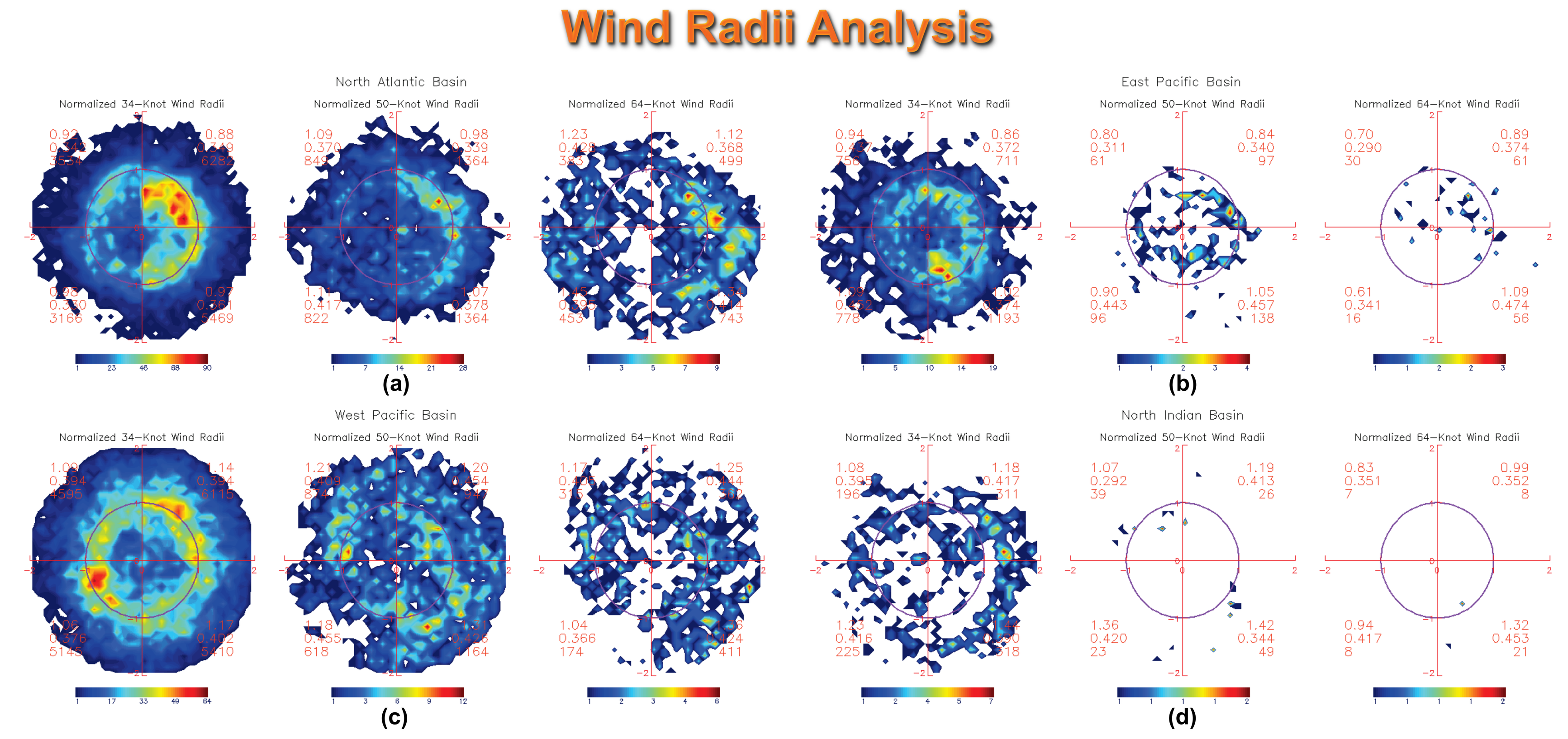

Fig. 6. A composite distribution of 34-, 50-, and 64-knot normalized OSCAT wind radii of all storms for (a) North Atlantic basin, (b) East Pacific Basin, (c) West Pacific basin and (d) North Indian Basin. The color code represent number of points. The red number in each quadrant represent mean and standard deviation radii relative to best track's radii and total number of points within each quadrant.

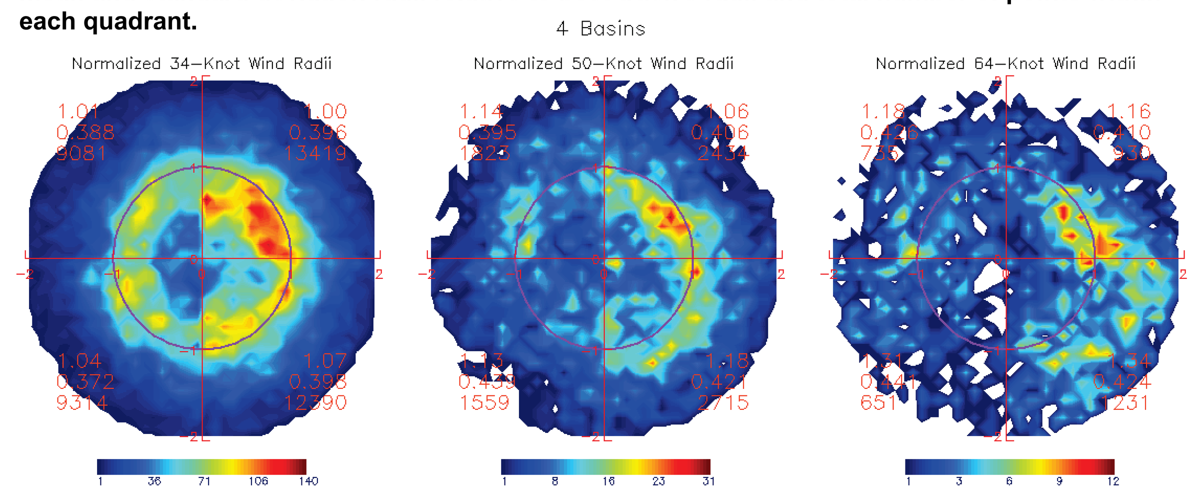

Fig. 7. A composite distribution of 34-, 50-, and 64-knot OSCAT normalized wind radii of all storms for all four basins. The color code represent number of points. The red number in each quadrant represent mean and standard deviation radii relative to best track's radii and total number of points within each quadrant.

By computing a normalized wind radii from individual storms, we are be able to make a composite plot showing the distribution of 34-, 50- and 64-knot normalized OSCAT wind radii for each basin as shown in Fig. 6. As a quality control measure, any normalized wind radii greater than 2 were not included. Fig. 7 displays the composite wind radii for all four basins combined. For example, on average, Q1 shows that the 34-kt radii matches best track radii, 50-kt radii is 6% larger than the best track radii and the 64-kt radii is 16% larger than the best track radii.

Wind Speeds Validation

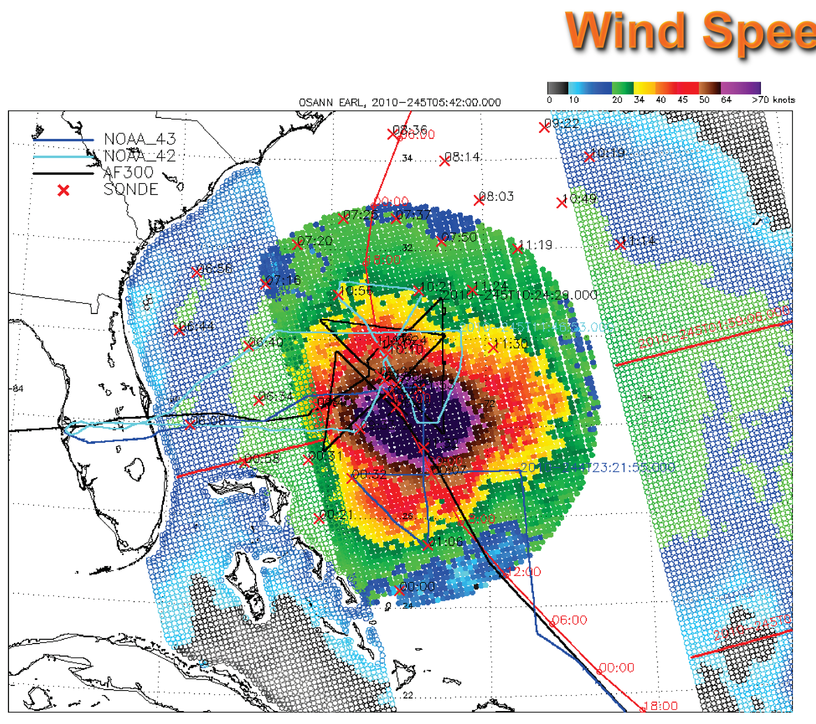

Fig. 8. Graphic displaying various observations within ±6 hr of OSCAT overpass Hurricane Earl. The red X represent sonde, "4-figure" pattern represents P-3 SFMR flight paths and dual swath represents ASCAT. Each observation is marked with their corresponding time.

The OSCAT ANN winds are collocated with HWIND, SFMR, dropwindsonde, and ASCAT winds. Due to the sampling characteristics of OSCAT and the relatively scarce observations from SFMR and dropsondes, a time window of ±6 hr. was utilized to increase the number of matchups. Collocated data points for HWIND, SFMR and dropsondes are primarily found in the North Atlantic basin. For ASCAT collocations a time constraint of ±3 hr. was utilized in all four basins.

The results of comparisons of the OSCAT ANN wind speeds with the other observational data is shown in Fig. 9. This is shown as the cumulative distribution function (CDF) curves for each pair of matchups. From these curves, we can create unbiased bin averages that compare OSCAT with other observations of the same distribution function for each wind speed bin as shown in Fig. 10. From examination of these curves, OSCAT compares relatively well with dropsonde winds for all wind speeds, while exhibiting a high bias for wind speed ~ >30m/s compared to the HWIND and SFMR wind speeds.

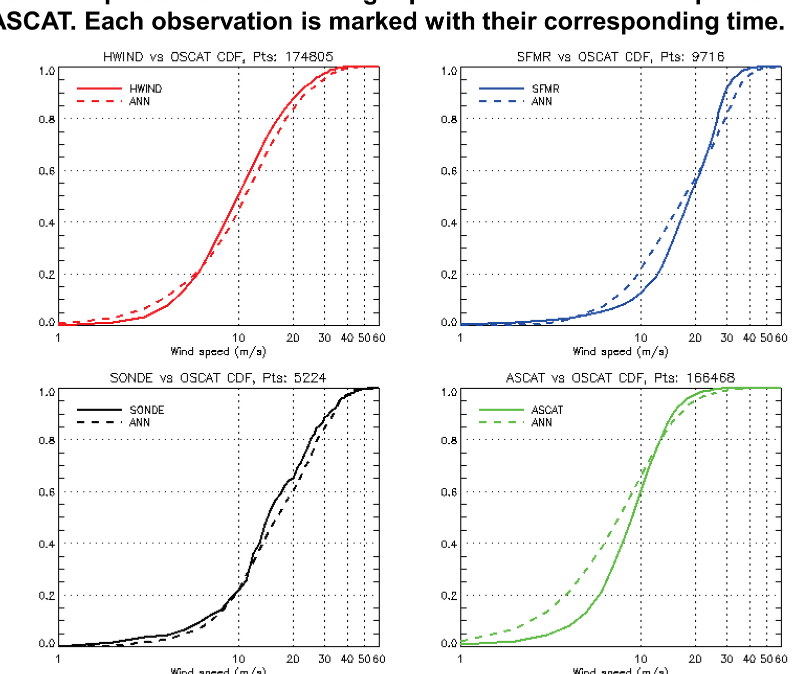

Fig. 9. Comparison of cumulative distribution function (CDF) of HWIND, SFMR, SONDE and ASCAT vs OSCAT ANN winds CDF.

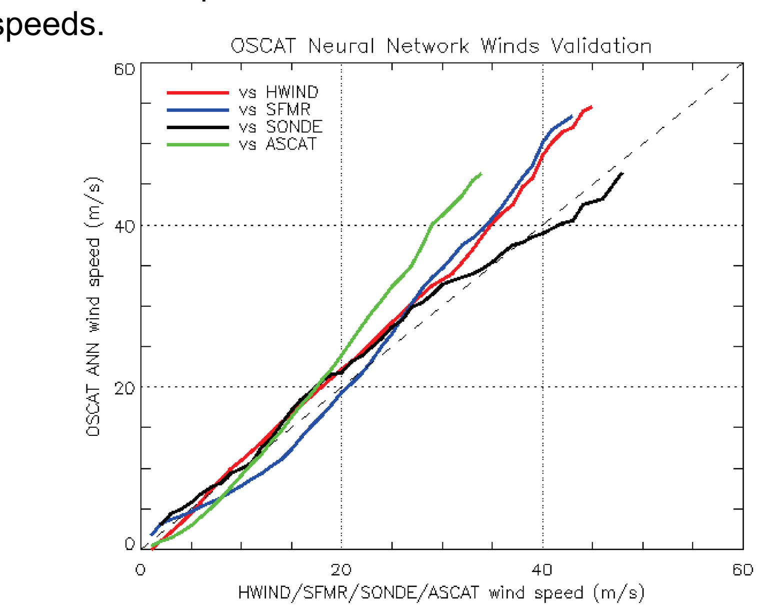

Fig. 10. A comparison of OSCAT ANN wind speeds with respect to HWIND, SMFR, SONDE and ASCAT winds

Maximum Wind Speed

The maximum wind speed from the OSCAT ANN wind retrievals was computed by searching for the maximum wind speed within a 200 km radius from the best track center location. As a quality control measure, we reject OSCAT scenes that covered less than 40% of full circular shape and have maximum wind difference larger than 10 m/s. The resulting time series of maximum OSCAT ANN wind speeds of selected storms compared to the best track maximum wind speeds are shown in Fig. 12.

Scatter plots of the maximum wind speed for all storms from the North Atlantic, East Pacific, West Pacific and North Indian basins are shown in Fig. 13. The red curves represent the cumulative distribution curves. Finally, Fig. 14 shows a density plot of maximum wind from all four basins combined with the cumulative distribution curve (magenta line). These results indicate that the OSCAT ANN maximum wind speeds compare relatively well to the best track maximum wind speeds for full range of wind speeds.

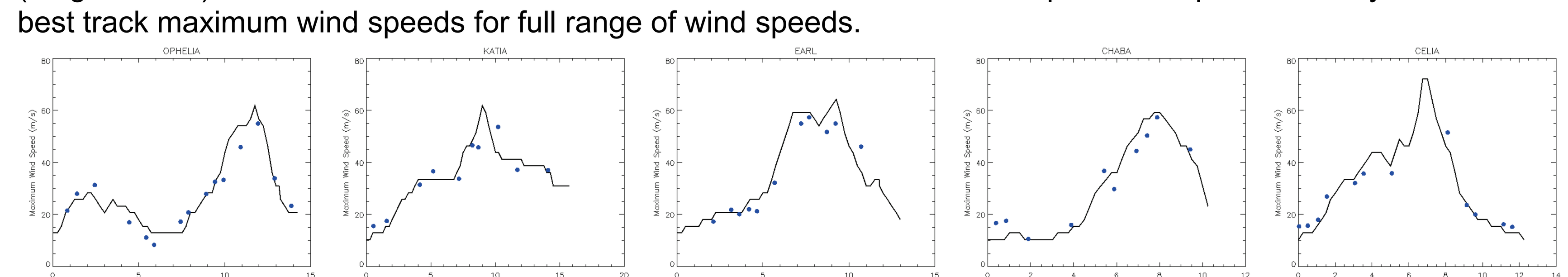

Fig. 11. Time series of maximum wind of selected storms. The solid line represent maximum wind speed from best track. The blue dots represent maximum wind of OSCAT ANN within 200 km radius of best track.

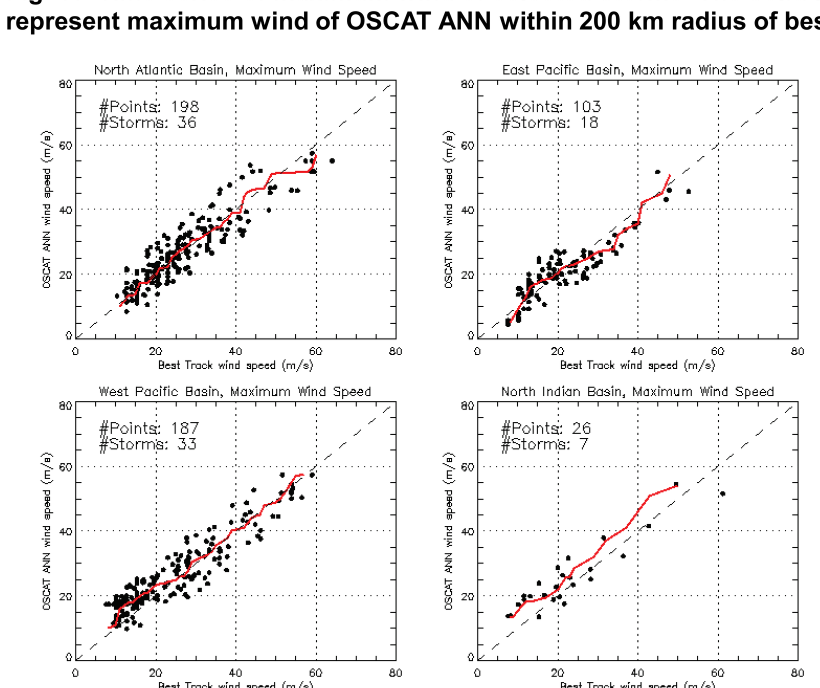

Fig. 12. Maximum wind speed of OSCAT vs best track from North Atlantic, East Pacific, West Pacific and North Indian basins.

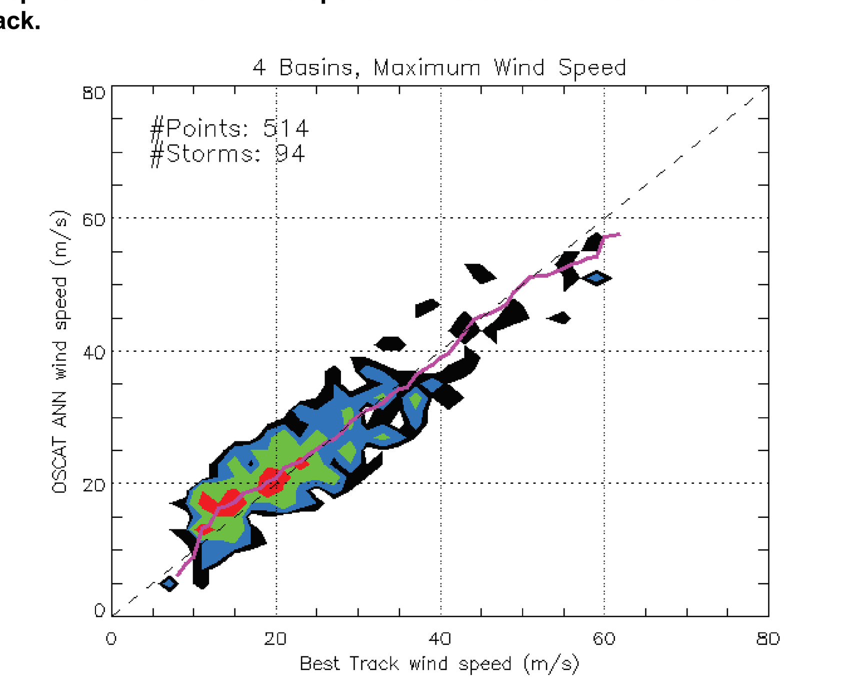

Fig. 13. Maximum wind speed of OSCAT vs best track from four basins. Color code is 1(black), 2(blue), 4(green) and 8(red) points