Hurricane Studies with Altimeter Data

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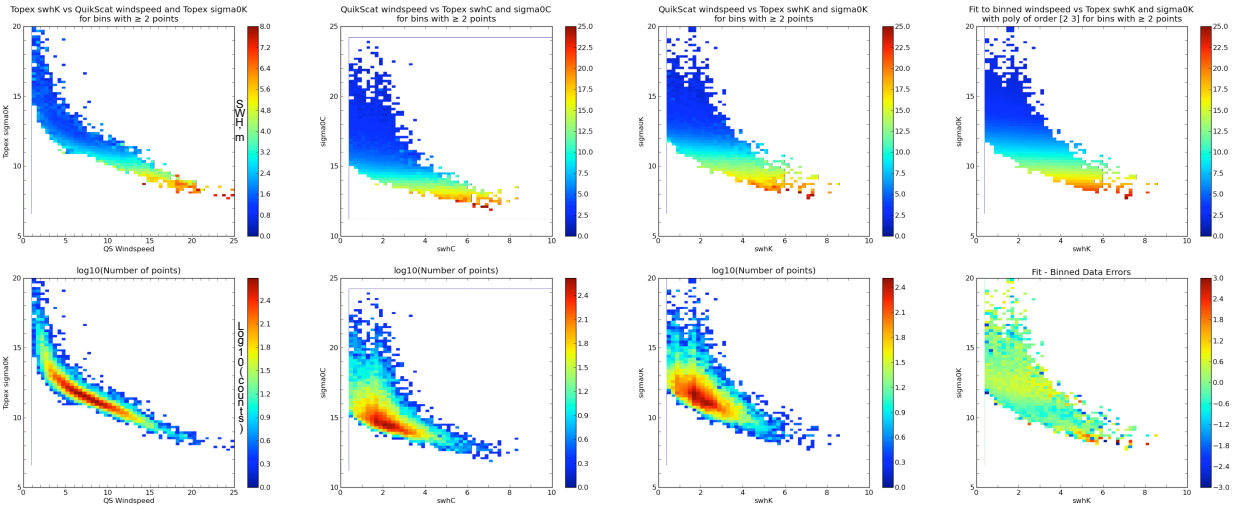
Copyright 2010, California Institute of Technology. Government sponsorship is acknowledged. This work was supported by the NASA Physical Oceanography program.

Abstract

We have used data where TOPEX and QuikScat come within 1000 km of the center of tropical storms within 1 hour of one another to determine the relationship between altimeter sigma0 at both Ku and C band, Ku band and significant wave height (SWH), and wind speed as determined by QuikScat – wind speed model functions. We have used only data that were not rain flagged by either instrument. The model functions are determined as purely empirical tables giving wind speed for increments of both sigma0 and SWH. In spite of being near storms up to strong hurricanes, the highest wind speeds found are about 27 m/s corresponding to a Ku/C band sigma0 of ~ 7/12 dB and an SWH of ~7 m. Altimeter measured SWH increases rapidly for QuikScat speeds above 15 m/s.

We have also examined the properties of the TOPEX and QuikScat rain flags as a function of time separation and wind speed. As might be expected, the amount of disagreement of the two flags increases with time separation (values checked = 5, 15, 30, 60 min). The flags agree better for wind speeds above 10 m/s. The QuikScat data include a numerical weather model wind speed as well as the scatterometer value. The difference between the model and measured values increases dramatically for rain. The "truth tables" comparing flags suggest that TOPEX is over-flagging rain. Wind images from QuikScat with overlays of TOPEX and Jason quantities are shown for illustration.

The research described here was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.



TOPEX Sigma0_K vs QuikScat Wind Speed.
Top: Bins colored by SWH.
Bottom: Counts in bins.
This result is similar to that found by Vandmark et al from global data.

Two Center Panels: Graphical representations of Ku and C band wind speed model function – wind speed in color as a function of SWH_Ku and sigma0 at Ku or C band. **Bottom plots** are counts in bins; bins are 0.2 dB and 0.2 m.

Right Panel: Fit to binned Ku band model function – third order in sigma0_Ku, second order in SWH_Ku. **Bottom plot:** Residuals of binned data from fit. **Fit:** -0.010*swh^2 -0.148*swh -0.023*sigK^3 + 1.25*sigK^2 -22.2*sigK +66.78
C band results are similar. Second order fit in sigma0 has much larger residuals, while third order in SWH_KU does not significantly reduce the residuals.

Rain Flagging

Rain is a significant problem for Ku band scatterometers such as QuikScat. For other than the lightest rain the backscatter from the rain drops dominates absorption resulting in erroneously high wind speeds. The effect is more pronounced for low wind speeds for which the surface backscatter is lower. Direction determination is also adversely affected, tending to become "cross-track". These features can be seen in the overpass images at the right. Hurricanes tend to have strong rain bands, so the above model functions were derived from only rain-free data as indicted by both the QuikScat and TOPEX rain flags. Here we compare the rain flags as a function of the time separation of the TOPEX and QuikScat overpasses of the hurricanes. The TOPEX rain flag based on the Ku-C band sigma0 difference as well as the liquid water amount from the TMR was expected to be more reliable than the autonomous QuikScat rain flag based on internal consistency of the various sigma0 measurements. The first two tables show the results for a 5 minute observation separation – short enough that the rain might be constant – for low and high wind speed. The rain flags disagree about as muchas they agree. Based on the wind speed difference, it appears that the QuikScat rain flag is at least a good predictor of increased error in the wind speed. The second set of tables shows the results for 30 minute separation (the results are similar for 15 minute separation). Surprisingly, the relative agreement of the flags and wind speed errors are similar.

Rain Flag Truth Table – 5 min Separation, WS = [0:10]: Number of Cases and Avg Diff QS – Model Wind Speed (m/s)	QuikScat Clear	QuikScat Rain
TOPEX Clear	1002 / 0.27	20 / 2.27
TOPEX Rain	31 / 0.44	5 / 4.71

Rain Flag Truth Table – 5 min Separation, WS = [10:30]: Number of Cases and Avg Diff QS – Model Wind Speed (m/s)	QuikScat Clear	QuikScat Rain
TOPEX Clear	258 / 1.35	26 / 4.22
TOPEX Rain	35 / 3.11	76 / 6.76

Rain Flag Truth Table – 30 min Separation, WS = [0:10]: Number of Cases and Avg Diff QS – Model Wind Speed (m/s)	QuikScat Clear	QuikScat Rain
TOPEX Clear	8316 / 0.30	121 / 1.94
TOPEX Rain	199 / 0.41	75 / 2.06

Rain Flag Truth Table – 30 min Separation, WS = [10:30]: Number of Cases and Avg Diff QS – Model Wind Speed (m/s)	QuikScat Clear	QuikScat Rain
TOPEX Clear	1837 / 1.69	177 / 4.32
TOPEX Rain	297 / 3.38	450 / 6.68

Overpass Images

Isabel, Cat 2, dt =03:35, c405p152

Nida, Cat 5, dt = 12:30, c429p240