Surface Stress and Drag Coefficient in Tropical Cyclones with Scatterometers

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Strong wind of TC causes destruction, but it is stress that drags down TC.
Practically no stress measurements; stress were almost entirely derived from wind through a drag coefficient.

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Number of collocated pairs is around $10^5$ for 10 m/s bin, decreases to around 10 at > 50 m/s bin.
Our hypothesis and method

- Physics of Bragg Scattering or relation between backscatter and surface roughness applies to solid and liquid surface; it does not distinguish different weather systems. The same retrieval algorithm may apply in TC.

- The change of wind retrieval algorithm in TC is explained through the relation between wind and roughness (drag coefficient).

- We will establish an algorithm to retrieve stress over moderate winds, where data are more abundant and the drag coefficient is established, and then apply it to the high wind regime in TC.
Relation between scatterometer sigma0 and stress

$$\log_{10} t_p = a + b s_p(dB)$$

a & b coefficient obtained by linear fitting for each polarization using data in medium wind

$10 \text{ m/s}$  $20 \text{ m/s}$  $30 \text{ m/s}$
\[ C_D = a + bW + cW^2 + dW^3 \]

- \( a = 0.000186986 \)
- \( b = 0.201764 \)
- \( c = -0.00538577 \)
- \( d = 3.97605 \times 10^{-5} \)
Caveats
° We focus only in the main signal of backscatter and not the full dependence on frequency, polarization, incident angle, and azimuth angle
° We brush aside secondary effects of air-sea interaction, stability, sea-states, swell, breaking waves, surfactant, density etc.
° These are preliminary results of a feasibility study. Continuous work includes
1 revise our stress algorithm by incorporated WindSAT, buoy, ship, model data over moderate range of wind speed
2 sub-divide our algorithm according to azimuth angle
3 expand high wind data set with dropsonde data
backup
\[ \tau = \rho C_D (U - U_S)^2 \]

\[ \frac{U - U_S}{U_*} = 2.5(\ln \frac{z}{z_0} - \psi_U) = \frac{1}{\sqrt{C_D}} \]

\[ H = \rho c_p C_H (T - T_s)(U - U_S) \]

\[ \frac{T - T_s}{T_*} = 2.5(\ln \frac{Z}{Z_T} - \psi_T) = \frac{\sqrt{C_D}}{C_H} \]

\[ E = \rho C_E (Q - Q_s)(U - U_S) \]

\[ \frac{Q - Q_s}{Q_*} = 2.5(\ln \frac{Z}{Z_Q} - \psi_Q) = \frac{\sqrt{C_D}}{C_E} \]

\[ U_* = \sqrt{ \frac{H}{U} } \]

\[ T_* = \frac{H}{U_*} \]

\[ Q_* = \frac{E}{U_*} \]

\[ Z_o = 0.11 \frac{\nu}{U_*} + 0.011 \frac{U_*^2}{g} \]

Liu et al. (1979) account for stability and surface constraints by solving similarity profiles.
Emanuel (1995) argued that to attain the strong wind of TC, drag cannot keep increasing while supplies of sensible and latent do not increase.