Surface Stress and Drag Coefficient in Tropical Cyclones with Scatterometers

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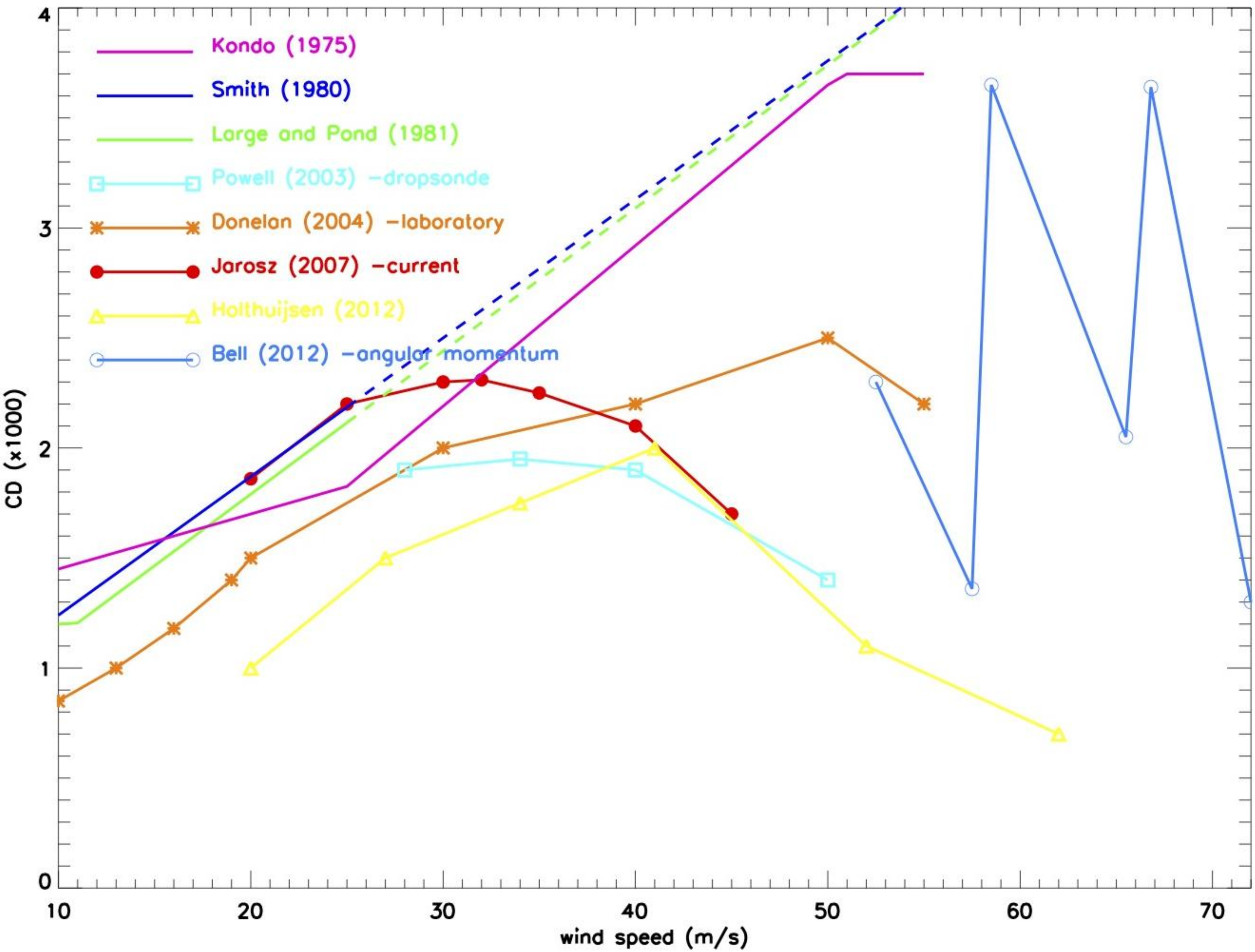
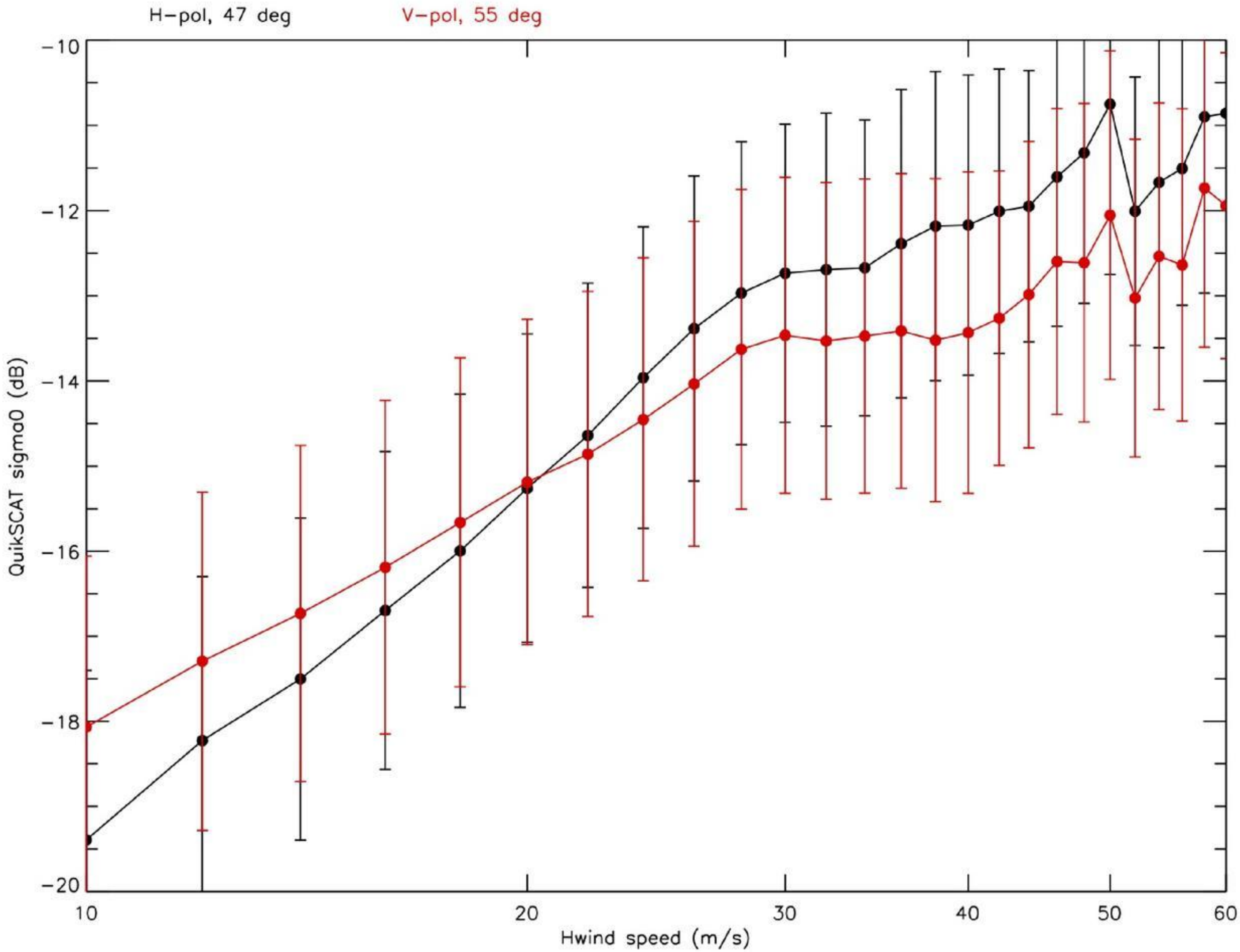
Strong wind of TC causes destruction,but it is stress that drags down TC

Practically no stress measurements; stress were almost entirely derived from wind through a drag coefficient

IOVWST 2015, Portland, OR


Kondo (1975)
Smith (1980)
Large and Pond (1981)
Powell (2003) -dropsonde
Donelan (2004) -laboratory
Jarosz (2007) -current
Holthuijsen (2012)
Bell (2012) -angular momentum
CD (×1000)
wind speed (m/s)
0
1
2
3
4
10
20
30
40
50
60
70

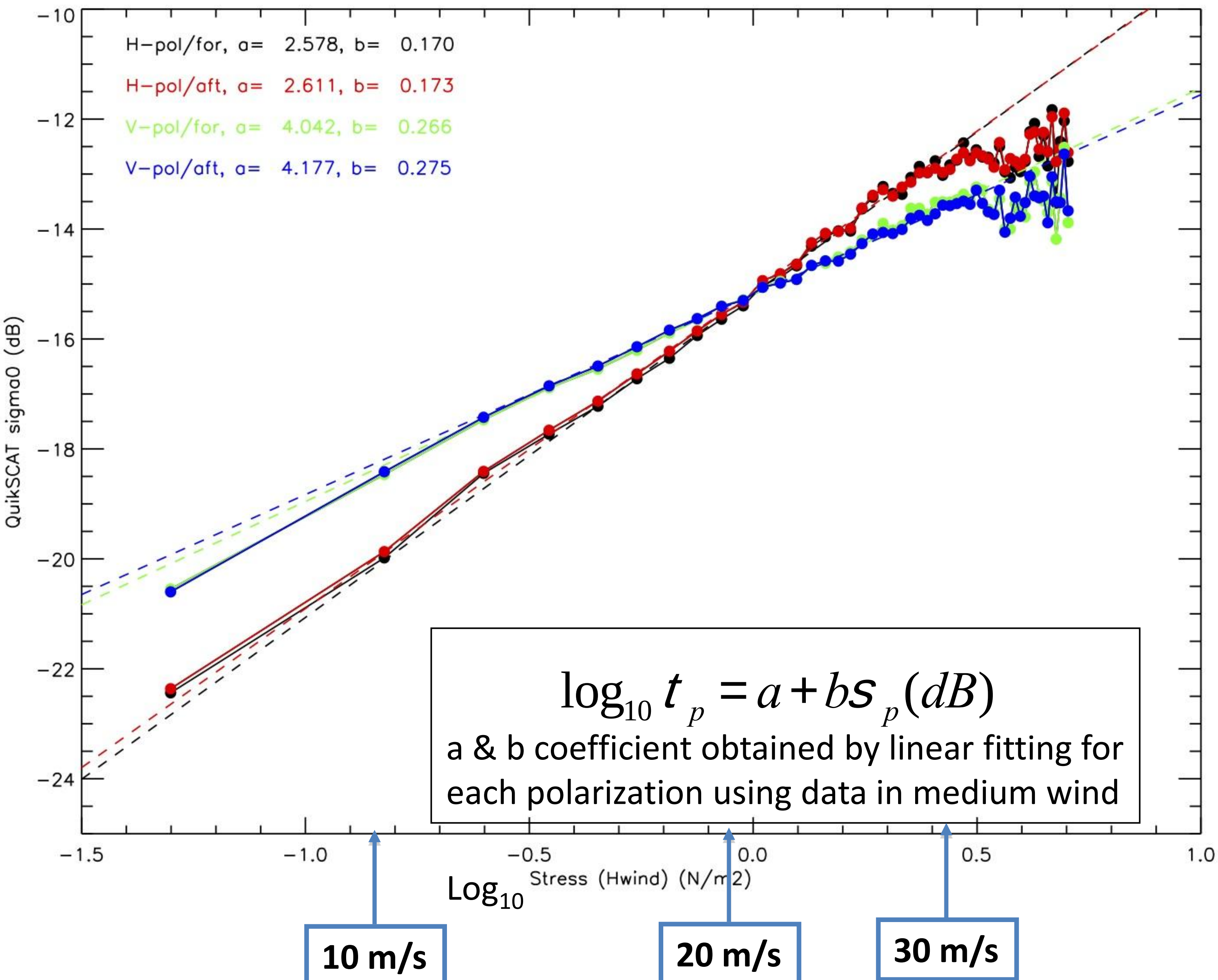


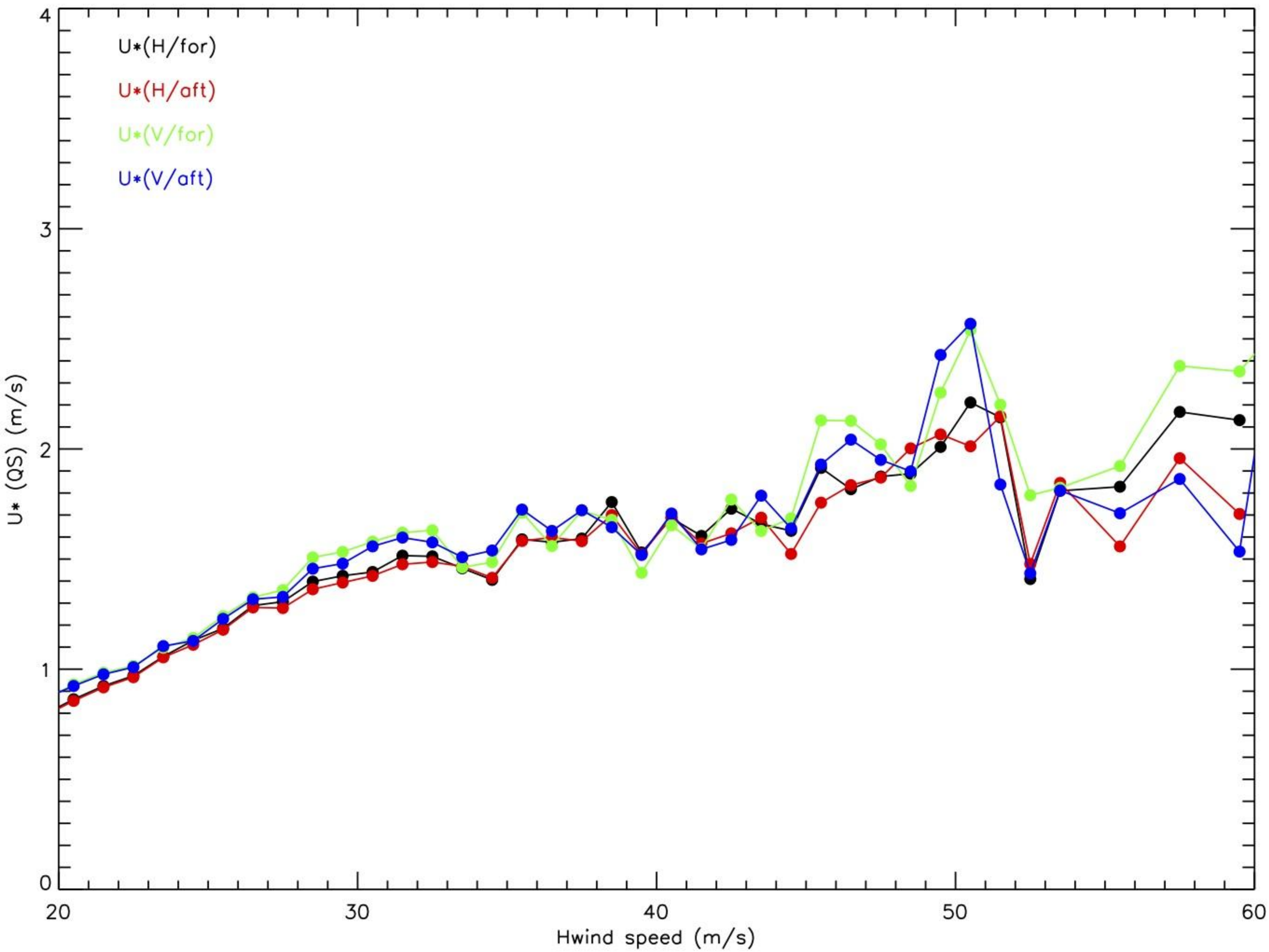
Number of collocated pairs is around 10^5 for 10 m/s bin, decreases to around 10 at > 50 m/s bin.

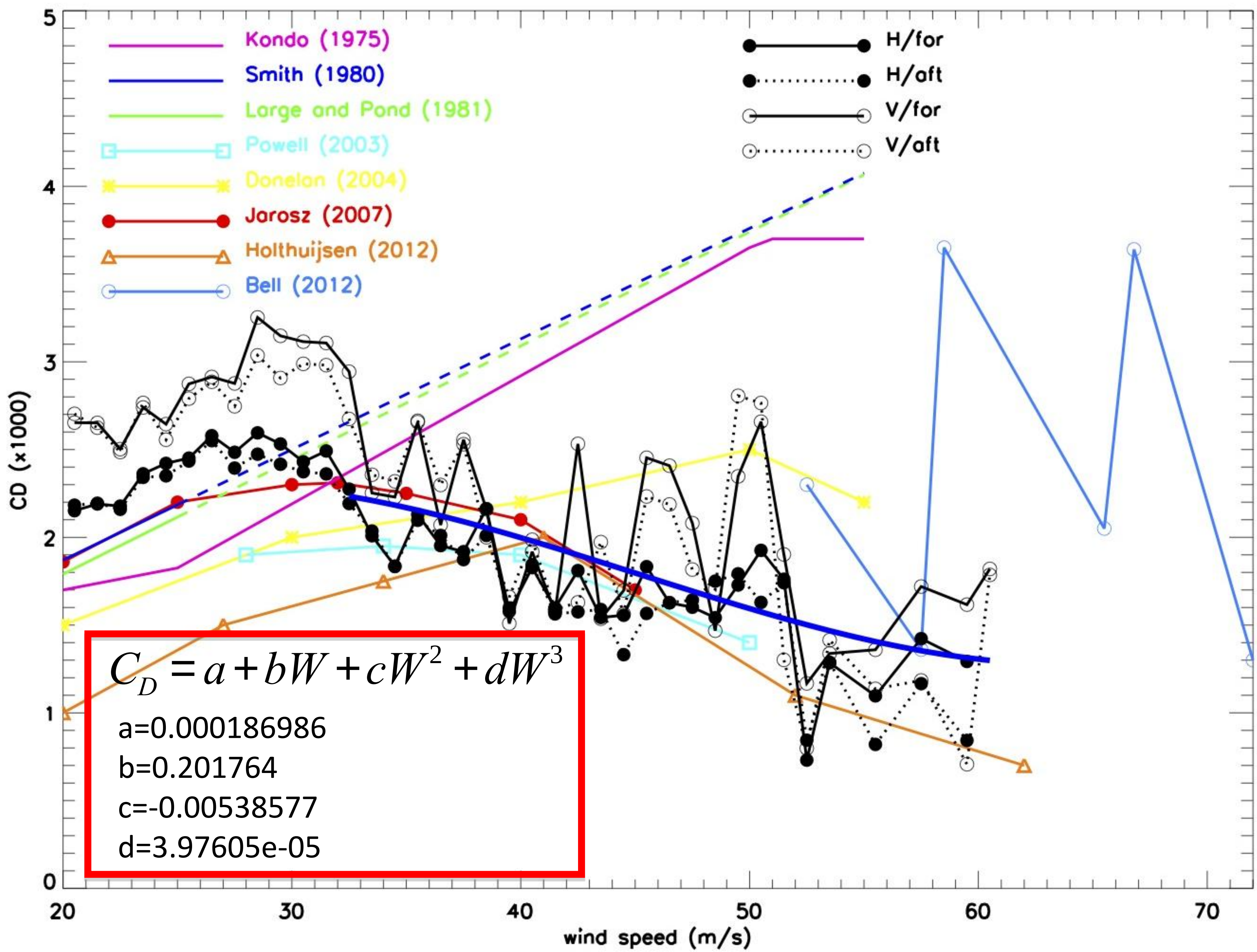
Our hypothesis and method

- **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




U∗(H/for)
U∗(H/aft)
U∗(V/for)
U∗(V/aft)
U∗ (QS) (m/s)
Hwind speed (m/s)
0
1
2
3
4
20
30
40
50
60


Kondo (1975)
Smith (1980)
Large and Pond (1981)
Powell (2003)
Donelan (2004)
Jarosz (2007)
Holthuijsen (2012)
Bell (2012)
H/for
H/oft
V/for
V/oft
CD (×1000)
wind speed (m/s)
$C_D = a + bW + cW^2 + dW^3$
a=0.000186986
b=0.201764
c=-0.00538577
d=3.97605e-05

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 interation, stability, sea-states, swell, breaking waves, surfectant, 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

$$\boxed{\tau = \rho C_D (U - U_S)^2}$$

$$\boxed{\frac{U - U_s}{U_*} = 2.5(\ln\frac{z}{z_0} - \psi_U) = \frac{1}{\sqrt{C_D}}}$$

$$H = \rho c_P C_H (T - T_s)(U - U_S)$$

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

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

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

$$\boxed{U_* = \sqrt{\frac{t}{r}}}$$

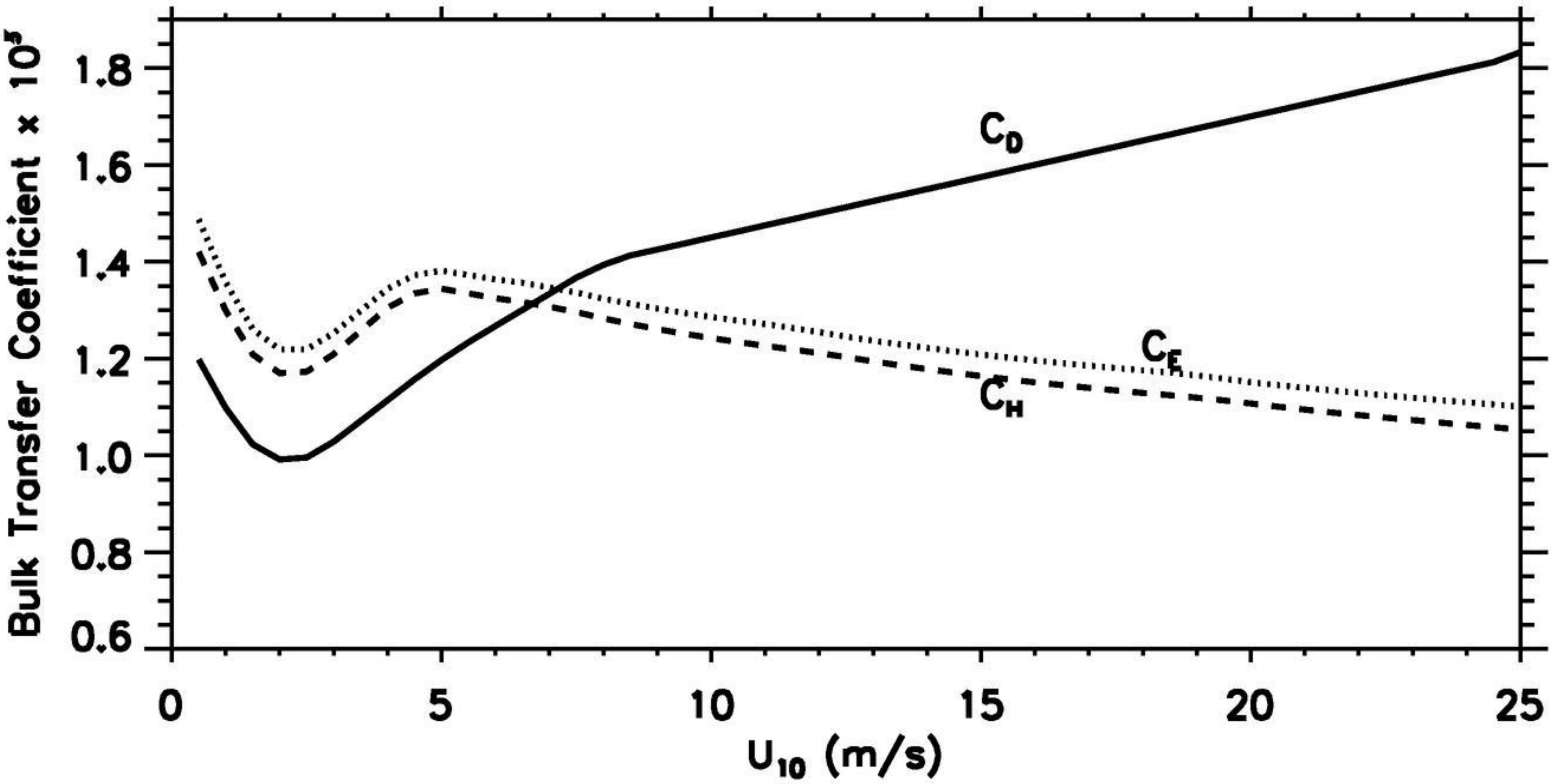
$$T_* = -\frac{H}{rU_*}$$

$$Q_* = -\frac{E}{rU_*}$$

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

Liu et al.(1979) account for stability and surface constaints by solving similarity profiles

Liu, Katsaros, and Businger, 1979



Emanuel (1995) argued that to attain the strong wind of TC, drag cannot keep Increasing while supplies of sensible and latent do not increase