

Deciphering the variability in air-sea gas transfer due to sea state and wind history

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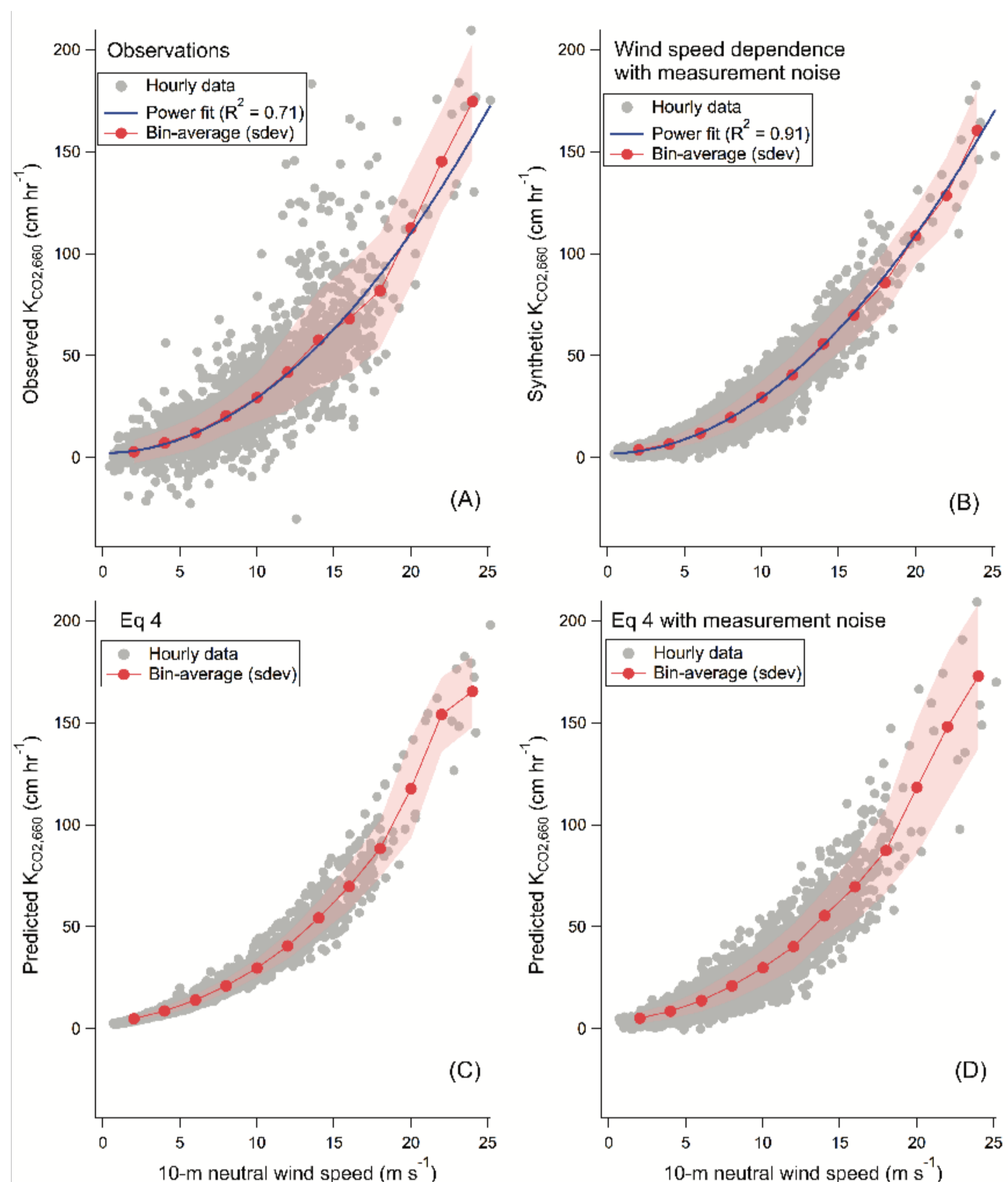
1. Motivation:

$$\text{Flux} = K \Delta C$$

- Air-sea transfer velocity (K) of sparing soluble gases such as CO₂ is governed by processes in water, but almost universally parametrized as function of wind speed (U) only → *simplistic and uncertain*
- Mechanistically, K is the sum of diffusive transfer (k_d , approximated by DMS transfer) & bubble-mediated transfer (k_b)
- Effects of waves on K not well understood, which we investigate using the largest observational K dataset to date (~2600 h)

U dependence explains R^2 of 0.71 in obs.

New wind-wave dependent parametrization (see Box 5)

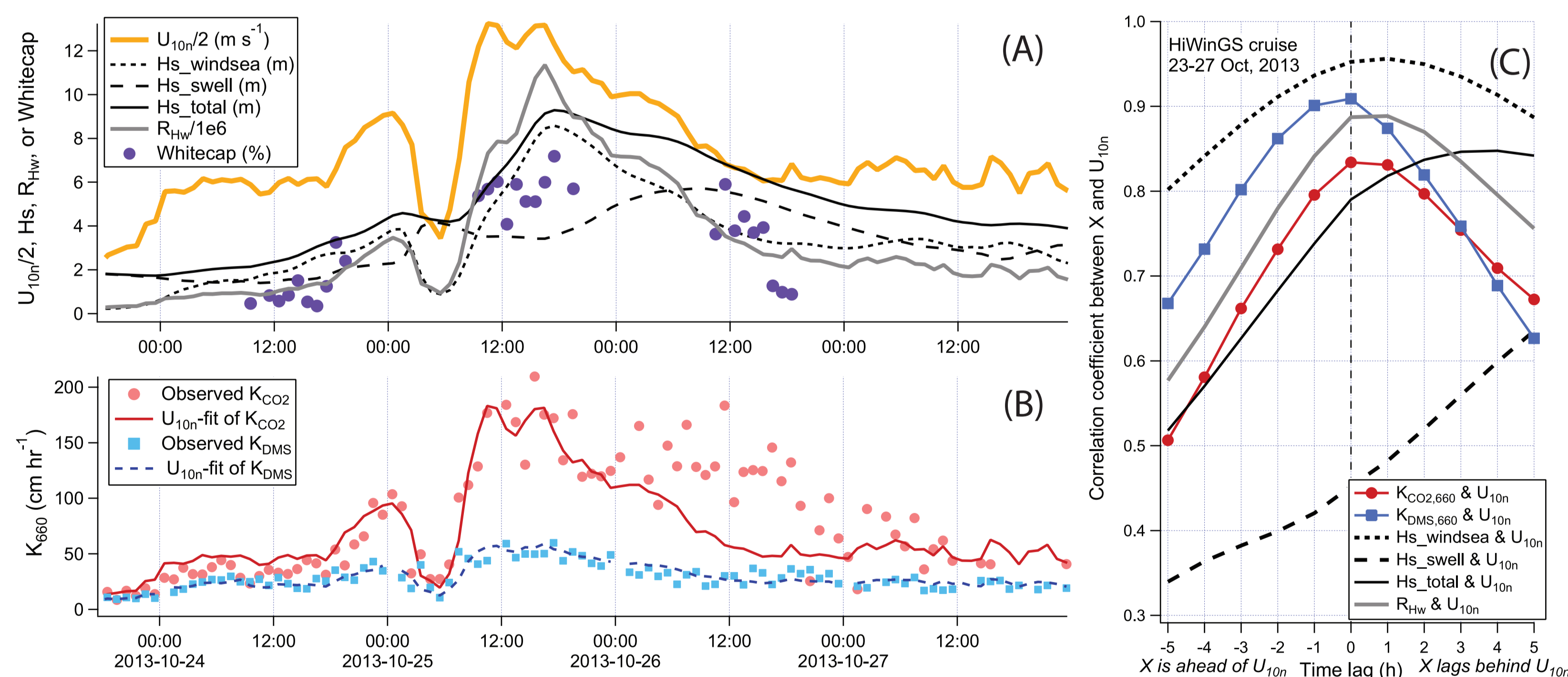


A synthetic K dataset based on U dependence with measurement noise (Dong et al. 2021) yields R^2 of 0.91

New wind-wave dependent parametrization with measurement noise resembles obs.

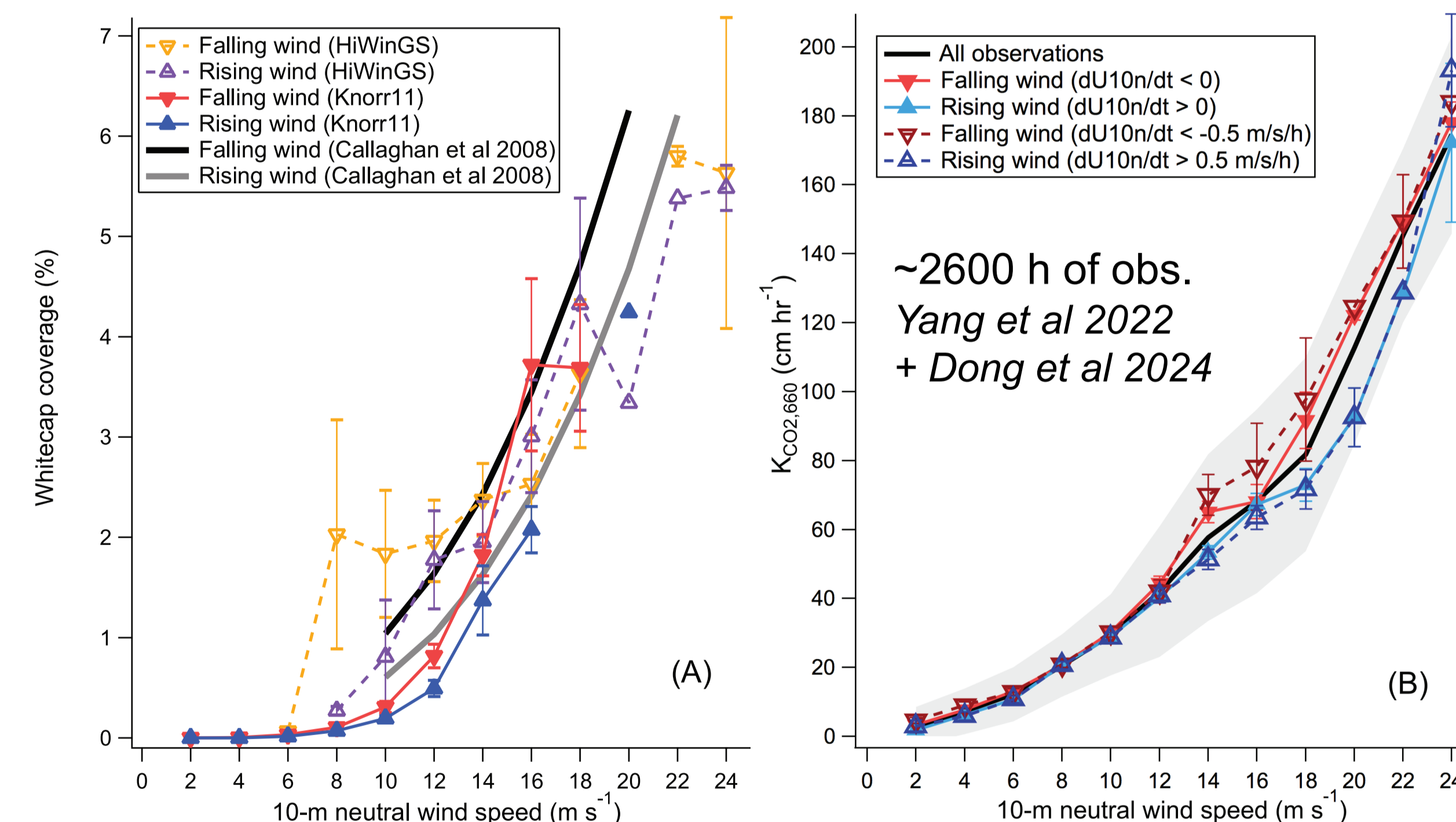
2. Examples of wave effects on K during HiWinGS cruise

- K_{CO_2} elevated following peak of storm — poorly represented by U dependence
- Similar hysteresis absent in K_{DMS} , suggesting that k_b important for CO₂



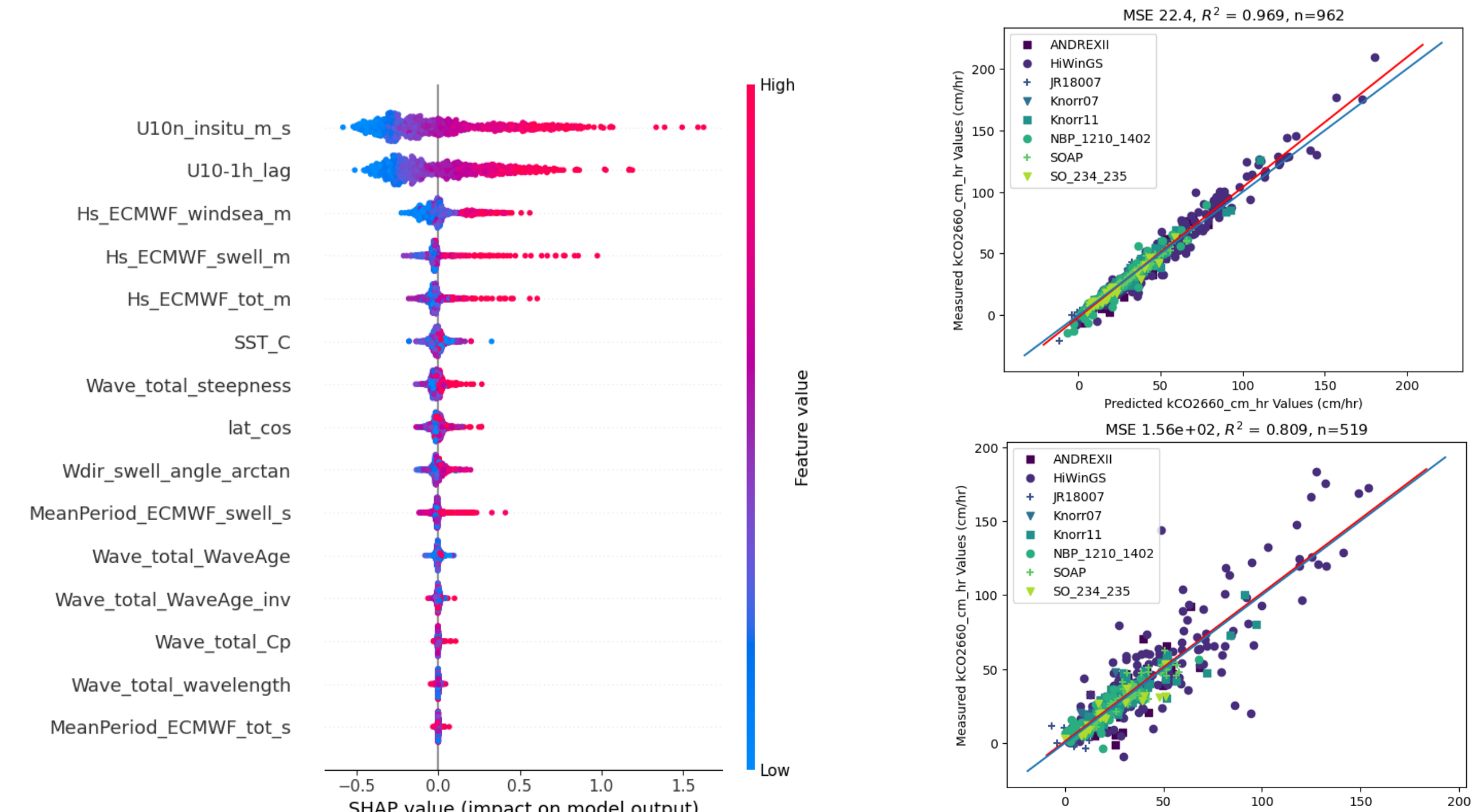
3. Mean wind history dependence

- Both whitecap coverage (A) and K_{CO_2} (B) tend to be greater during falling winds (when waves are larger) than during rising winds
- Effect most pronounced at high wind speeds



4. Machine learning analysis of wave effects on K

- Random forest model explains 14% more variance than U
- Significant wave (height) key, not wave direction or age



5. Developing a new wind/wave parametrization of K

$$K_{CO_2,660} = k_d + k_b = A u_* + B u_* H_s$$

$A = 1.52e-4$; $B = 2.90e-5$

