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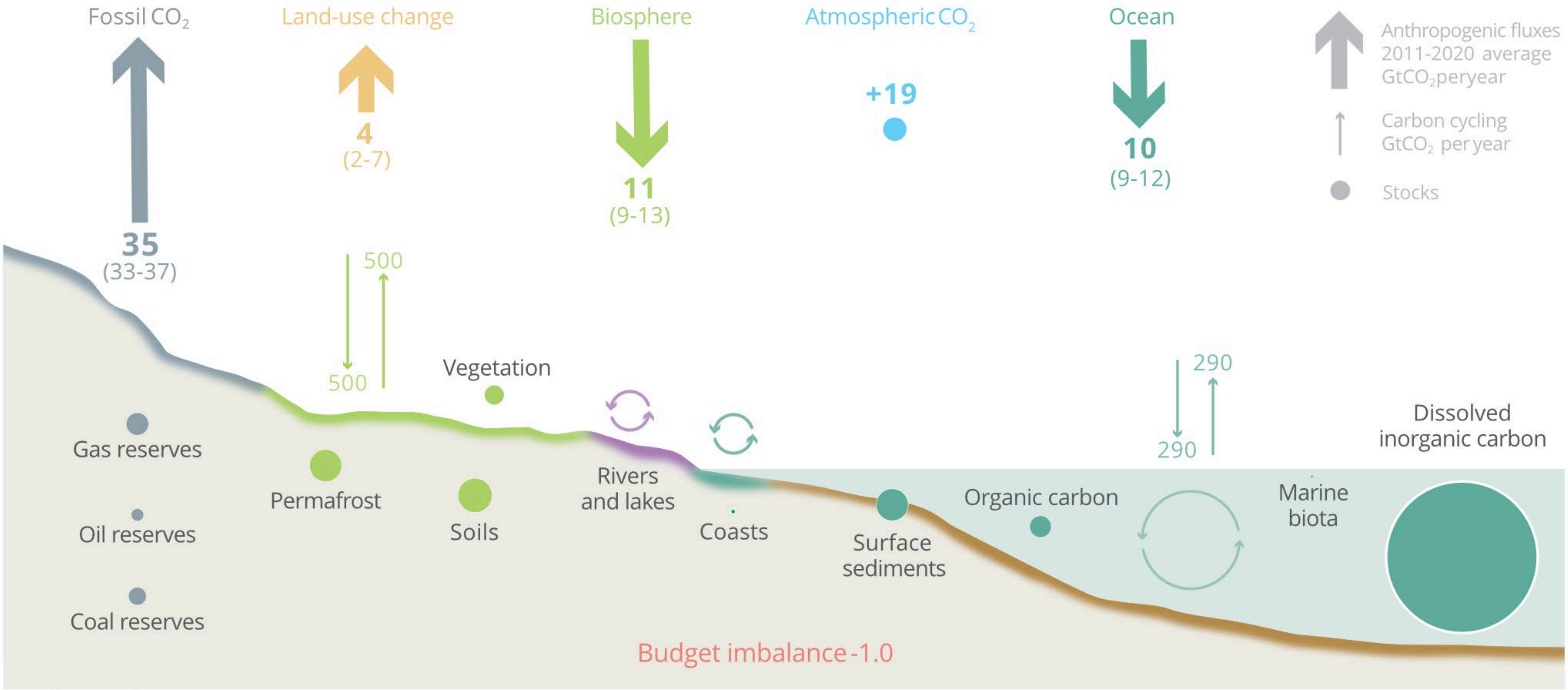
esa

In situ observations to improve satellite estimates of global ocean-atmosphere CO_2 exchange

T.G. Bell, M. Yang, L. Marie, Y. Dong, T. Smyth, V. Kitidis, I. Brown, J. Shutler, G. Tilstone

amt4oceansatflux

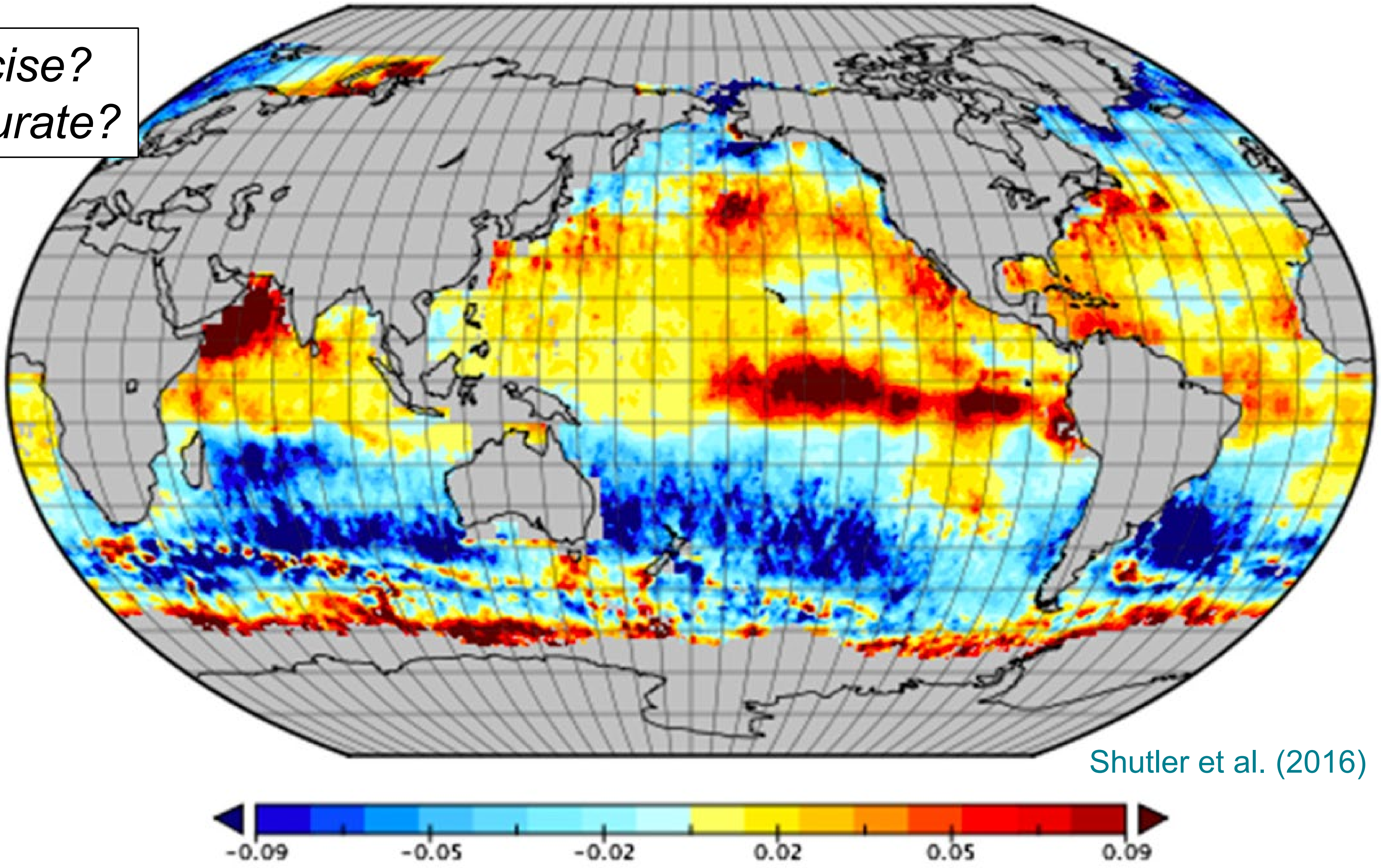
Why measure air-sea CO_2 fluxes?



Friedlingstein et al. (2021)

Satellite-based estimates of air-sea CO_2 flux

How precise?
How accurate?



Shutler et al. (2016)

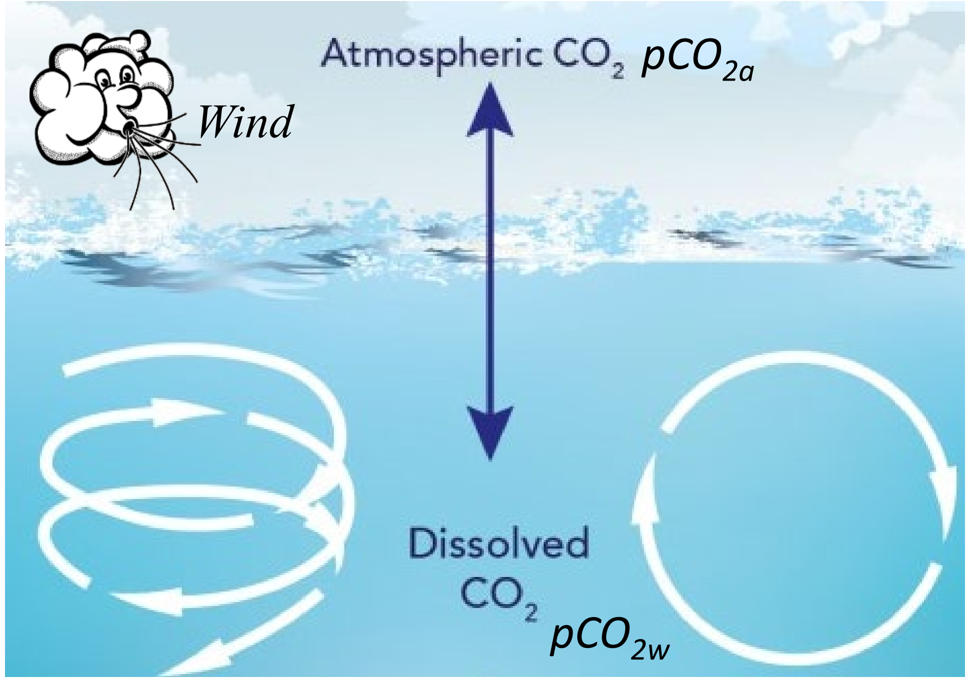
Air-sea CO_2 flux (gC m^{-2} day^{-1}) for August 2000

Measuring air-sea CO_2 fluxes

Indirect measurements of oceanic/atmospheric variables to calculate flux

$$\text{Flux} = K(\alpha_w pCO_{2w} - \alpha_i pCO_{2a})$$

α (solubility), function of temperature



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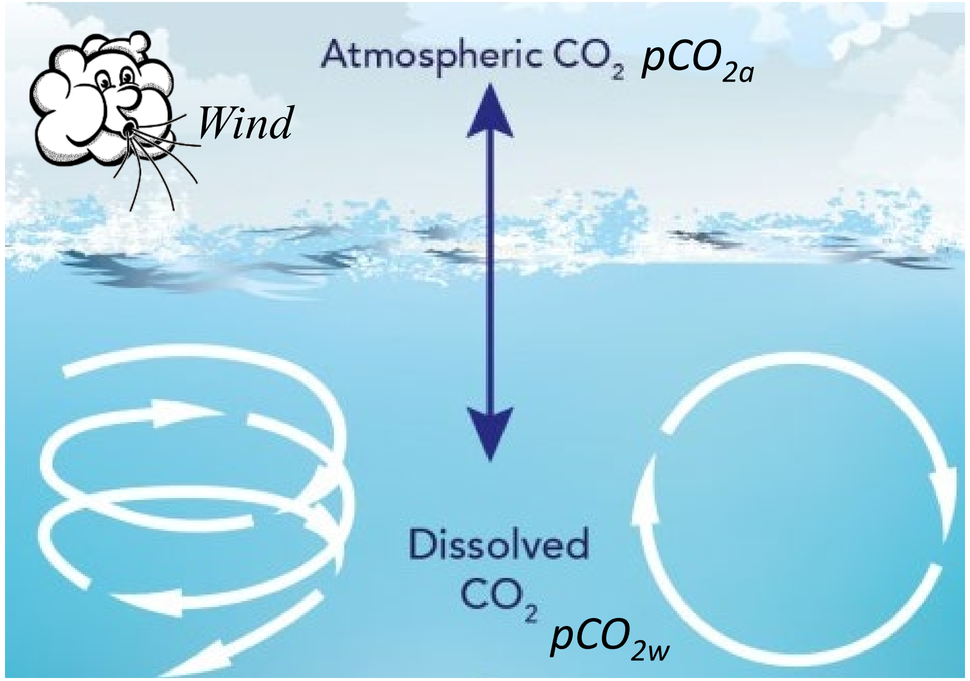
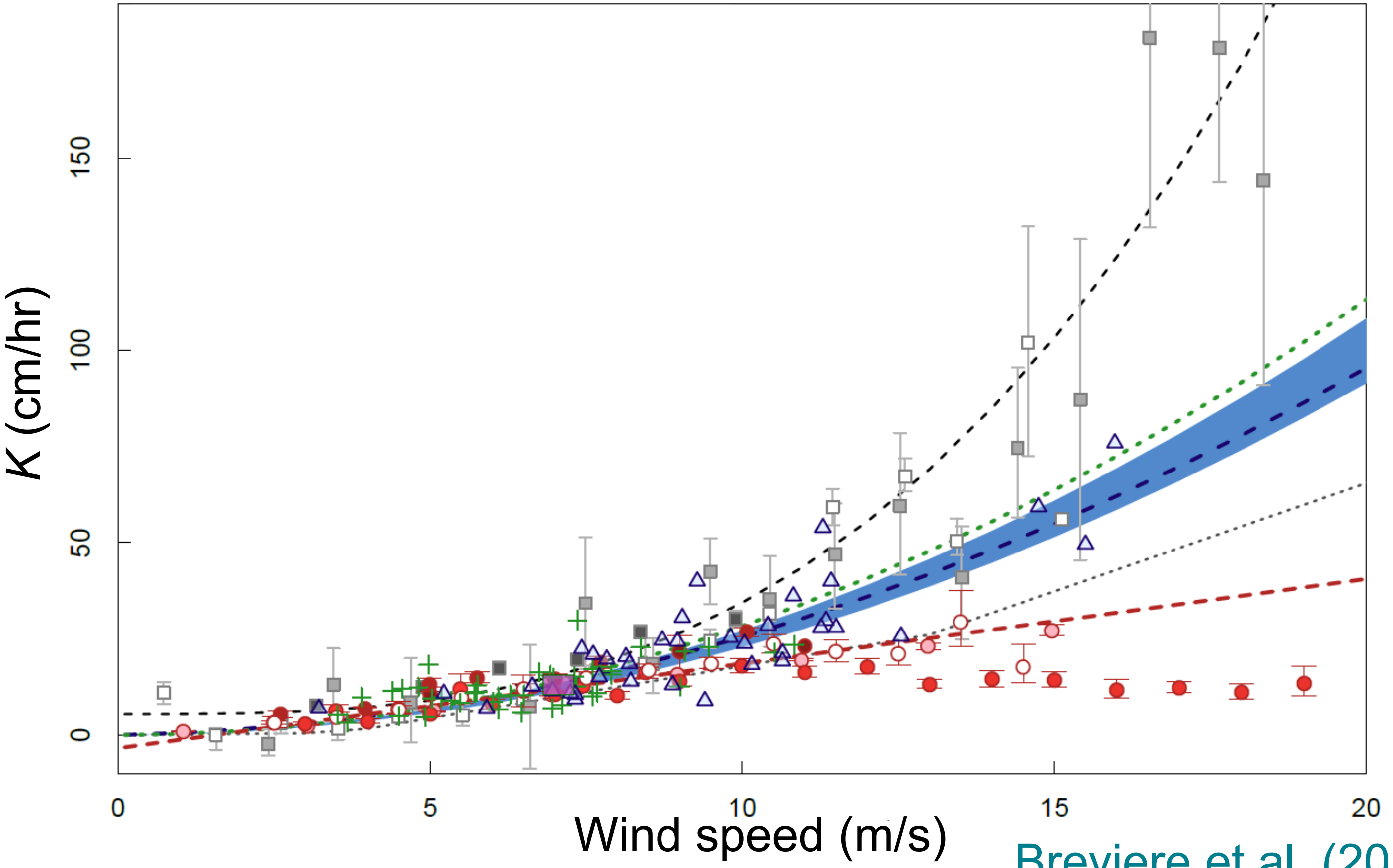


K (gas transfer velocity) uncertainty



Breviere et al. (2015)

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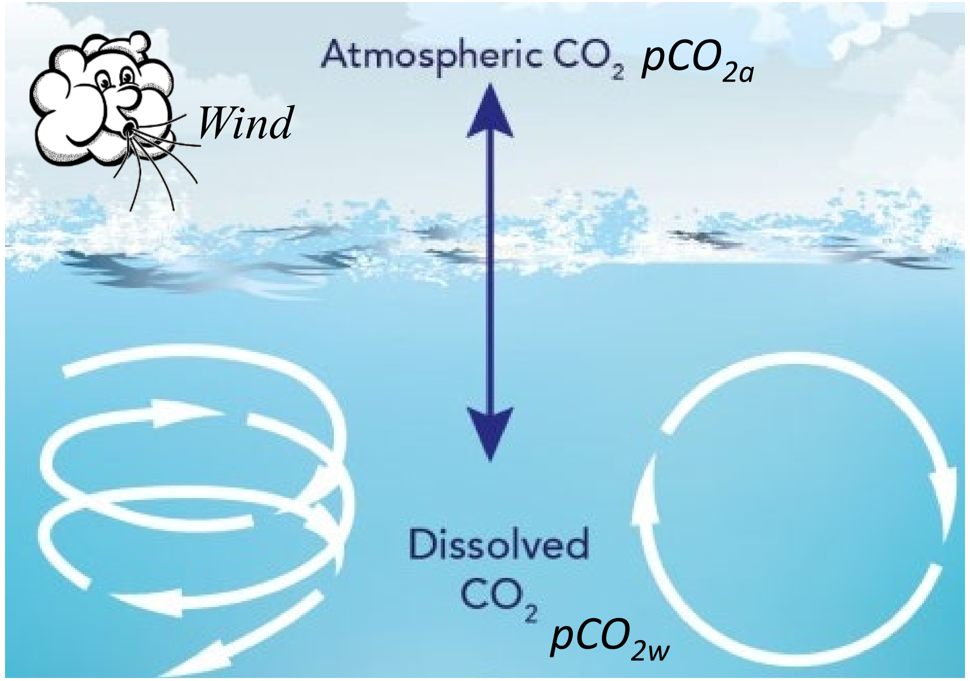
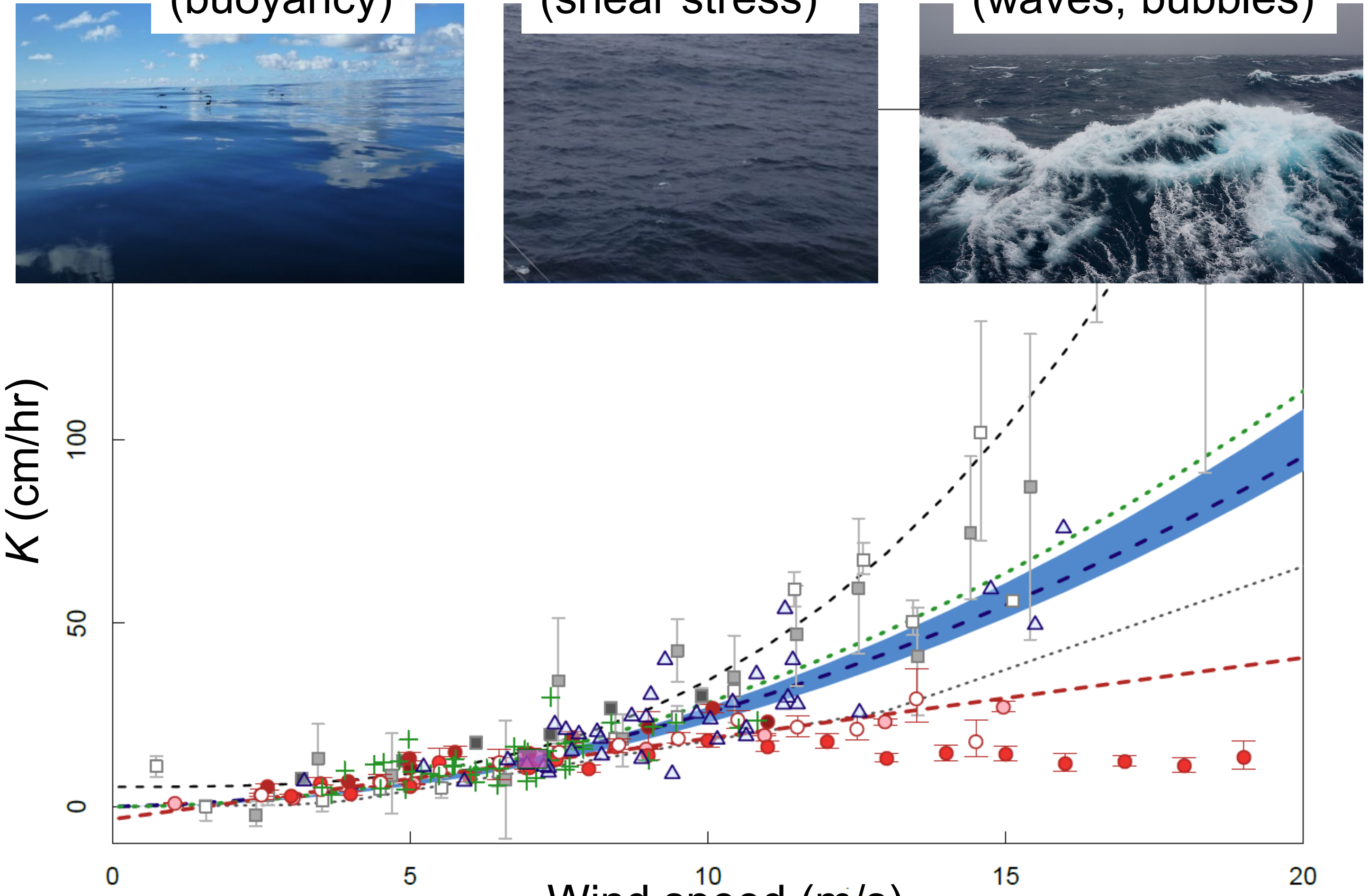


K (gas transfer velocity) uncertainty

calm (buoyancy) → moderate wind (shear stress) → rough (waves, bubbles)



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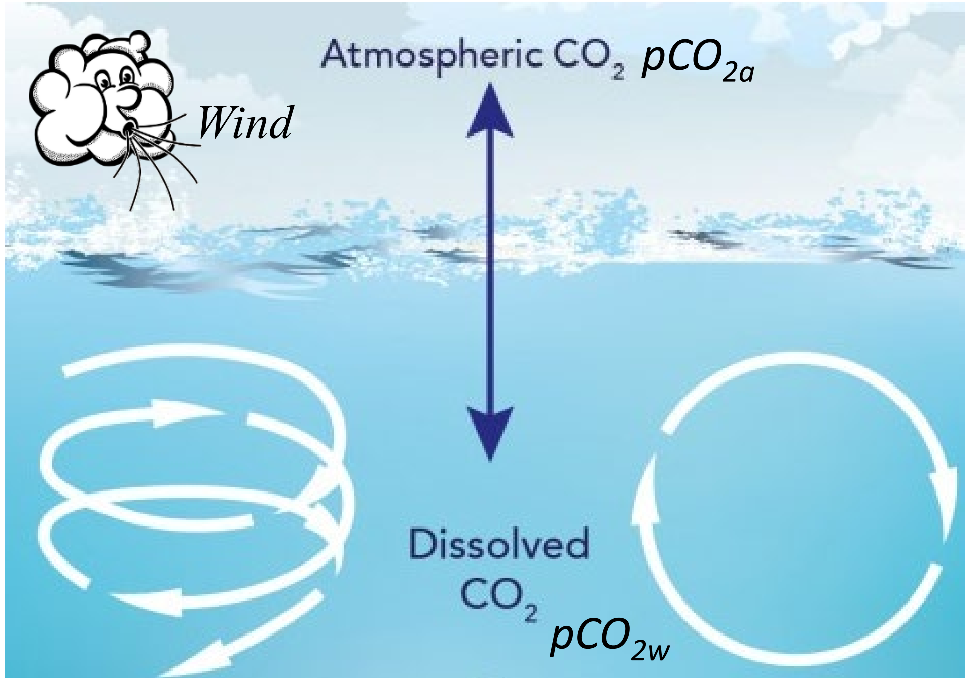
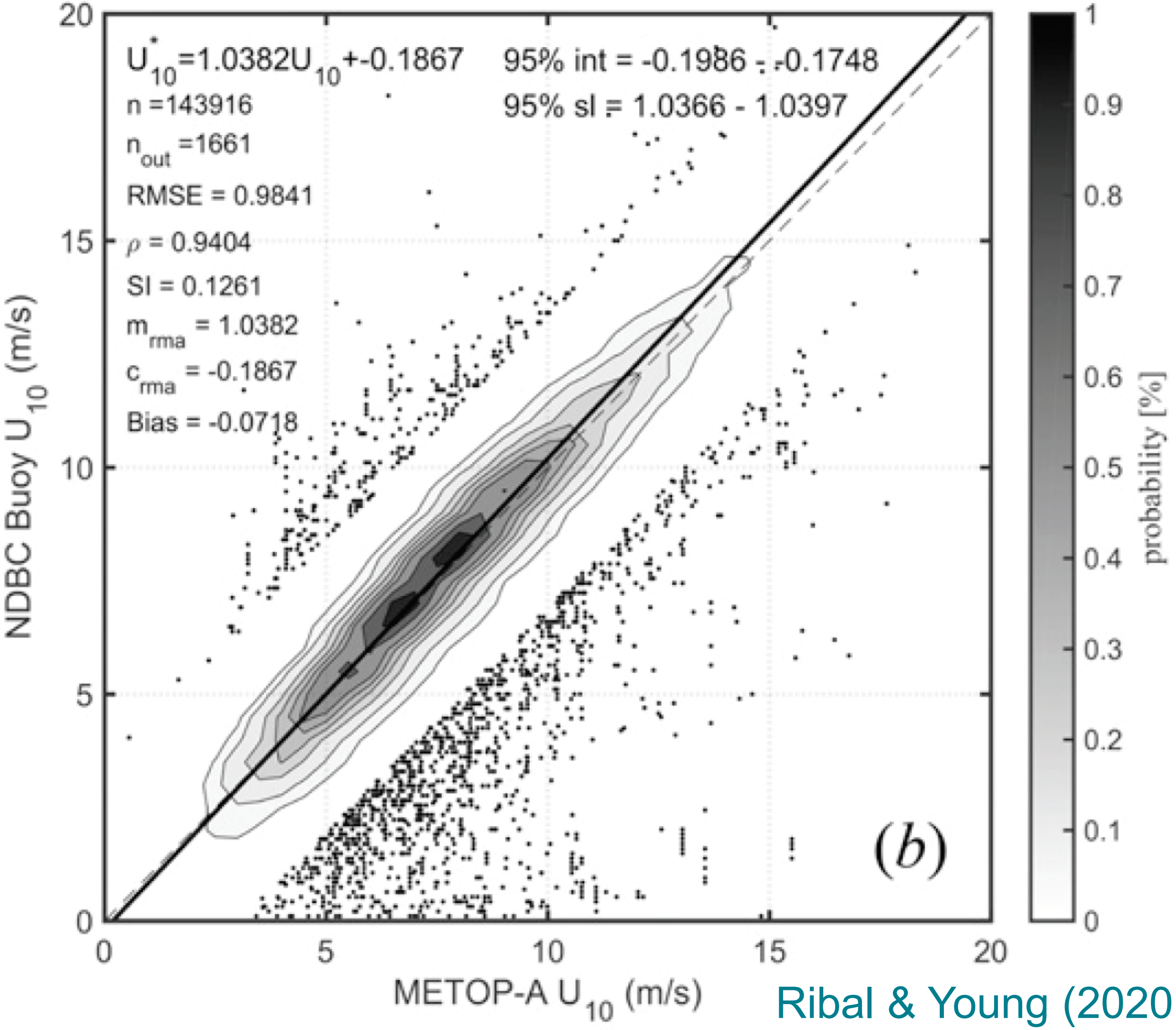
$$\text{Flux} = K(\alpha_w pCO_{2w} - \alpha_i pCO_{2a})$$

- α (solubility), function of temperature
- K (gas transfer velocity), function of physical forcing(s) but uncertain



Satellite wind speed (U_{10}) uncertainty



Ribal & Young (2020)

Measuring air-sea CO_2 fluxes

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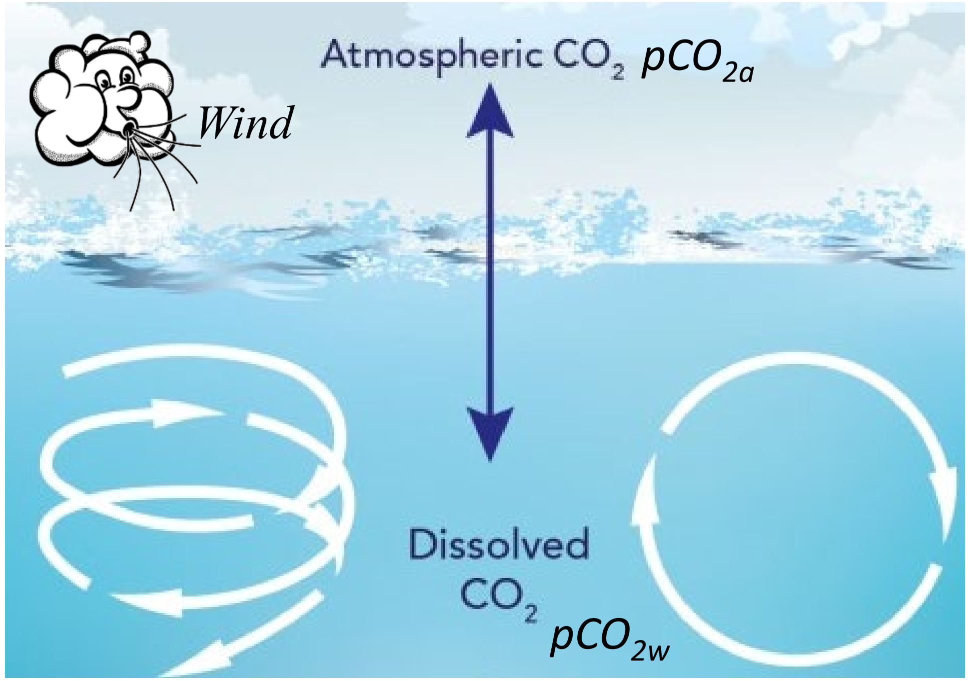
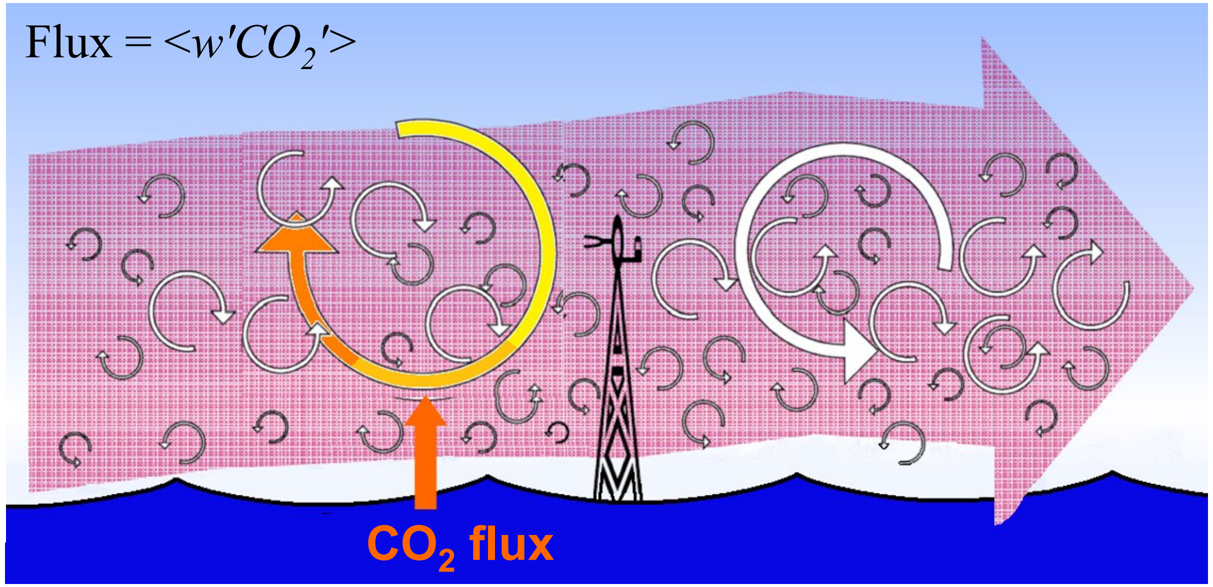
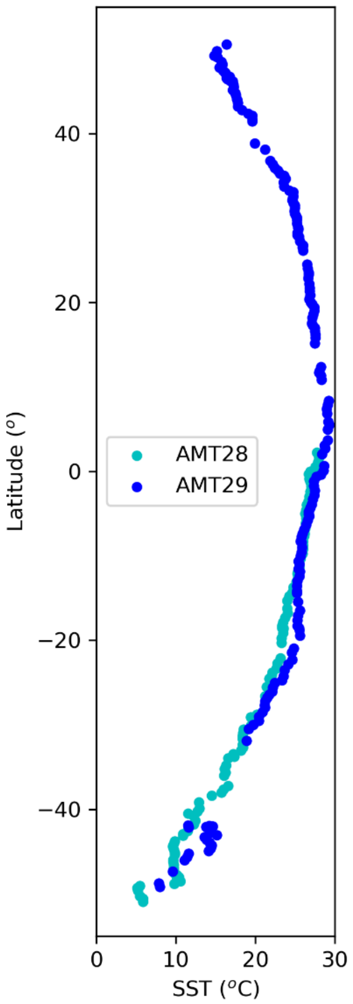


Direct measurements (eddy covariance) – independent estimate of flux

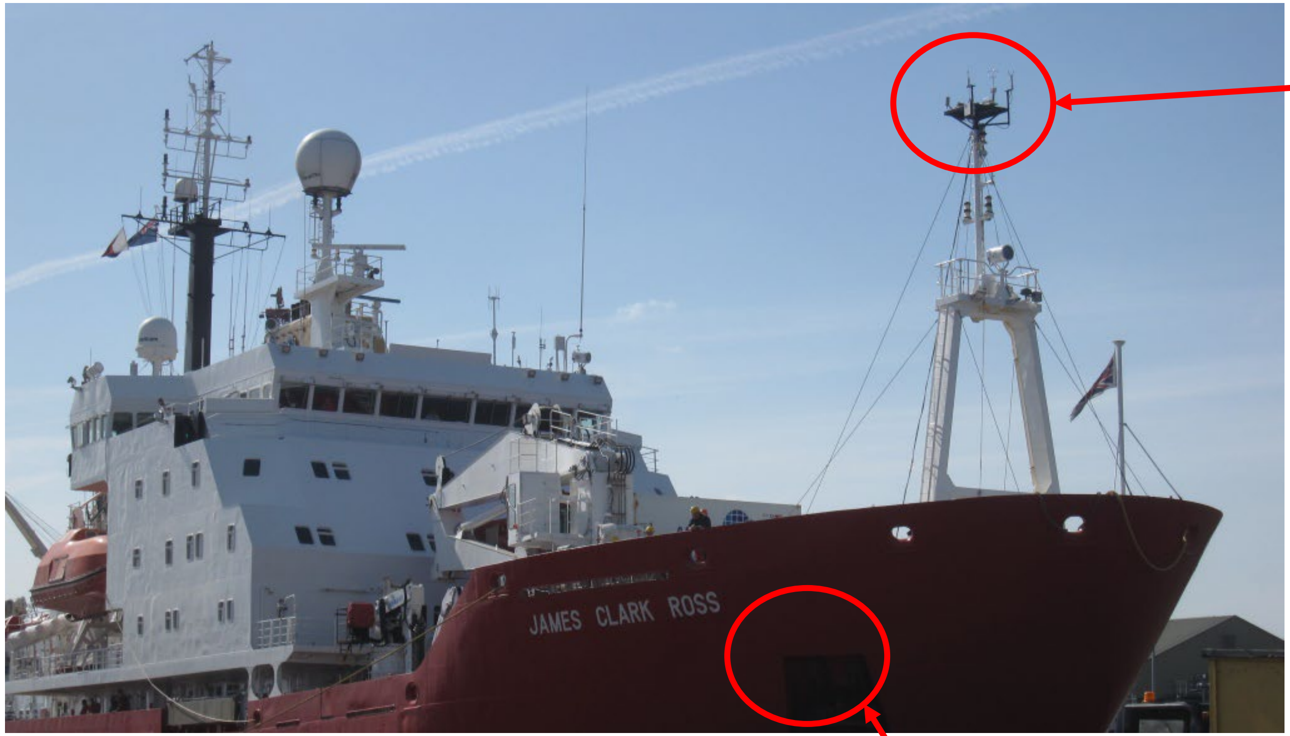


Combined observations are a tool to investigate processes: $K = \text{Flux} / (\alpha_w pCO_{2w} - \alpha_i pCO_{2a})$

Atlantic Meridional Transect (AMT)



Autonomous air-sea CO_2 flux systems



Direct CO_2 fluxes

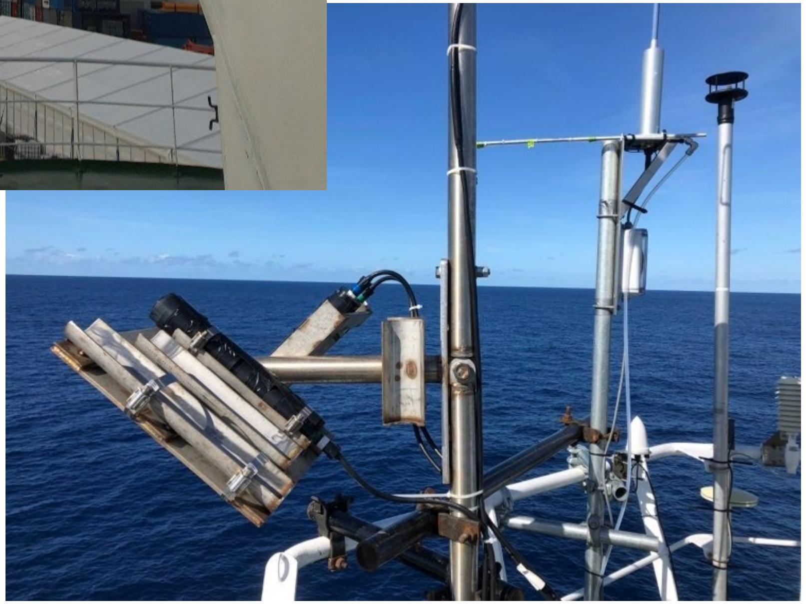
$$K = \text{Flux} / \Delta CO_2$$

ΔCO_2

Sea surface scattering observations

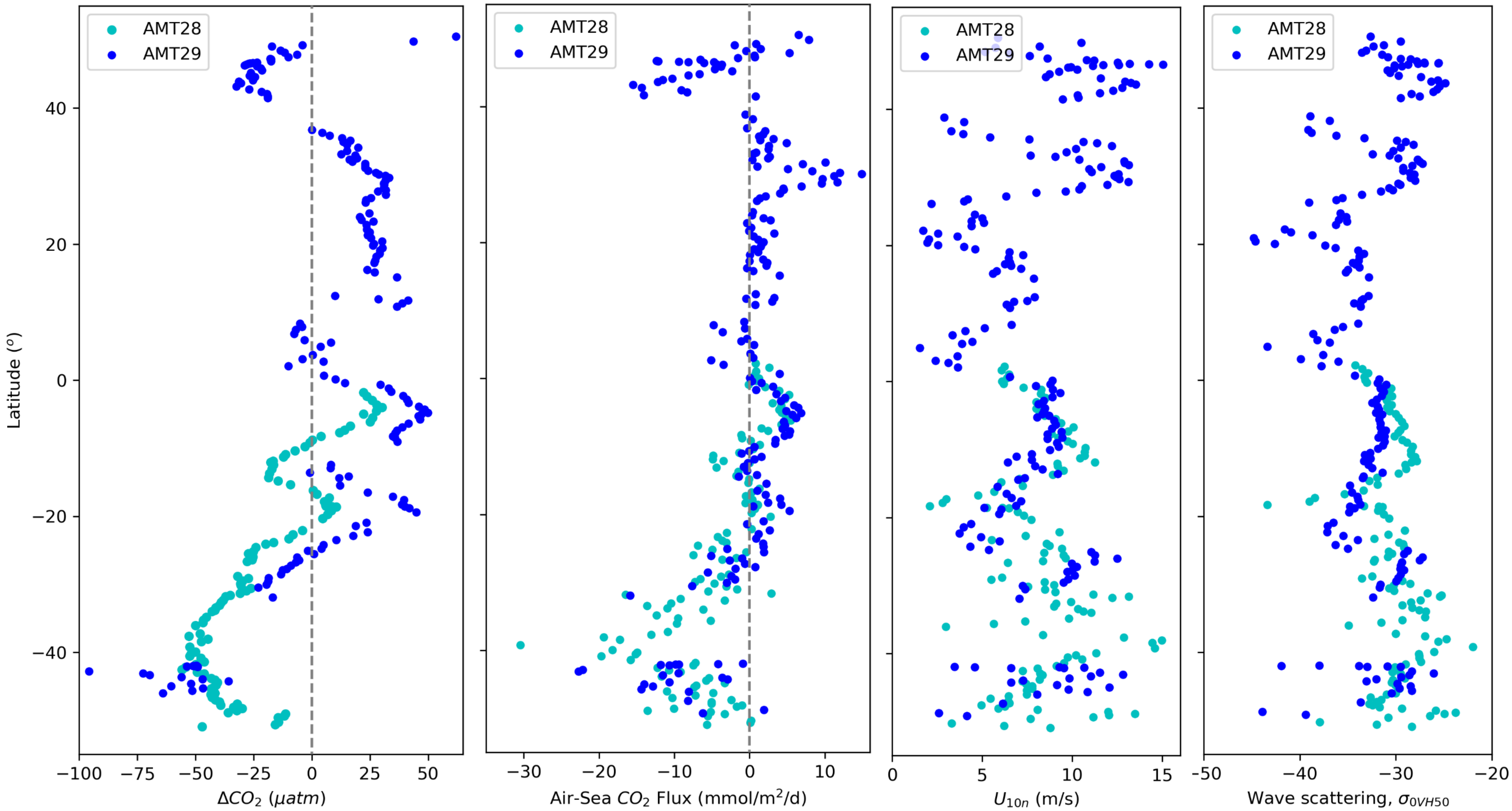
Sentinel 1

Kudryavtsev et al. (2014)



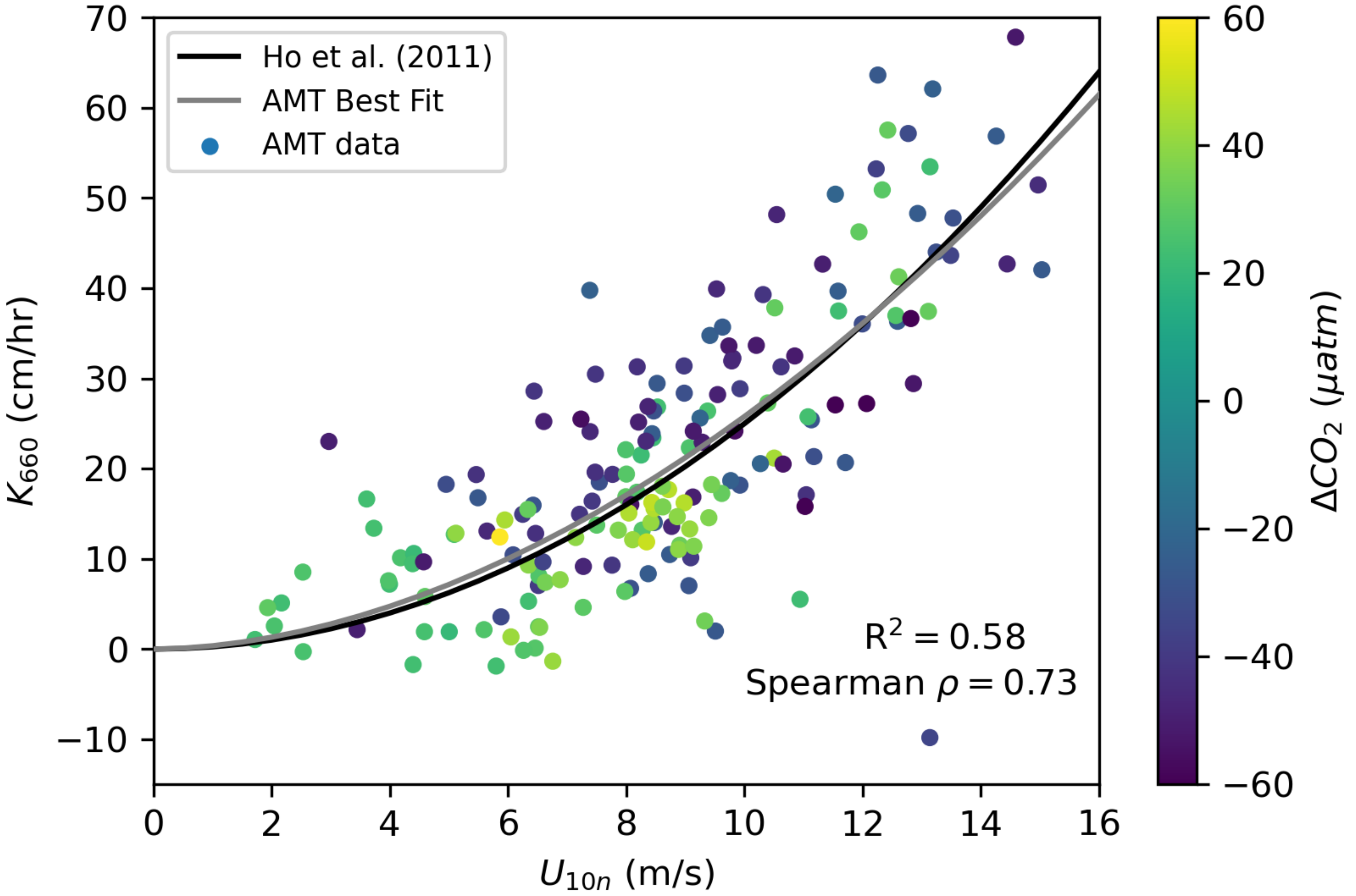
- ICBR (C-band radar scattering)
- Cross Polarisation (Horizontal/Vertical)
- Angles: 30º-50º
- Small scale waves and breaking waves/foam

Latitudinal trends



K vs Wind Speed (U_{10n})

K = Flux / ΔCO_2

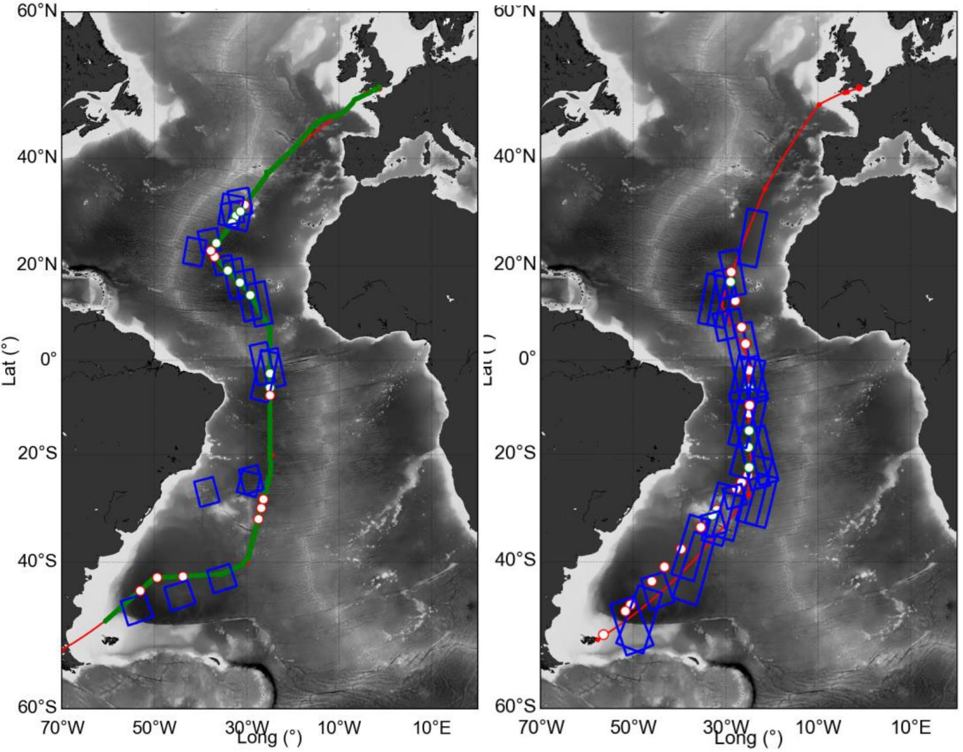


K vs Scattering (σ_0)

Polarization	Angle(°)	Spearman ρ
VV	30	0.72
VV	40	0.74
VV	50	0.74
VH	30	0.68
VH	40	0.77
VH	50	0.78
HV	30	0.77
HV	40	0.77
HV	50	0.77
HH	30	0.75
HH	40	0.75
HH	50	0.75

U_{10} Spearman ρ = 0.73

Satellite matchups of scattering (σ_0)



Summary and Outlook

- Relationship of *K* with *in situ* radar backscatter is as good as (better than?) relationship with wind speed
- Cross polarization (VH) and 50^0 angle is optimal (marginally)
- In situ scattering observations compare well with satellite match ups (Sentinel 1A/B, ASCAT)
- Potential to estimate *K* directly from satellite rather using estimate of wind speed (reduction in uncertainty)

Future: - More data (next cruise left last week)
- Higher wind speeds / rougher seas

Thanks for your attention