Global trends in air-water CO_2 exchange over seagrass meadows revealed by atmospheric Eddy Covariance

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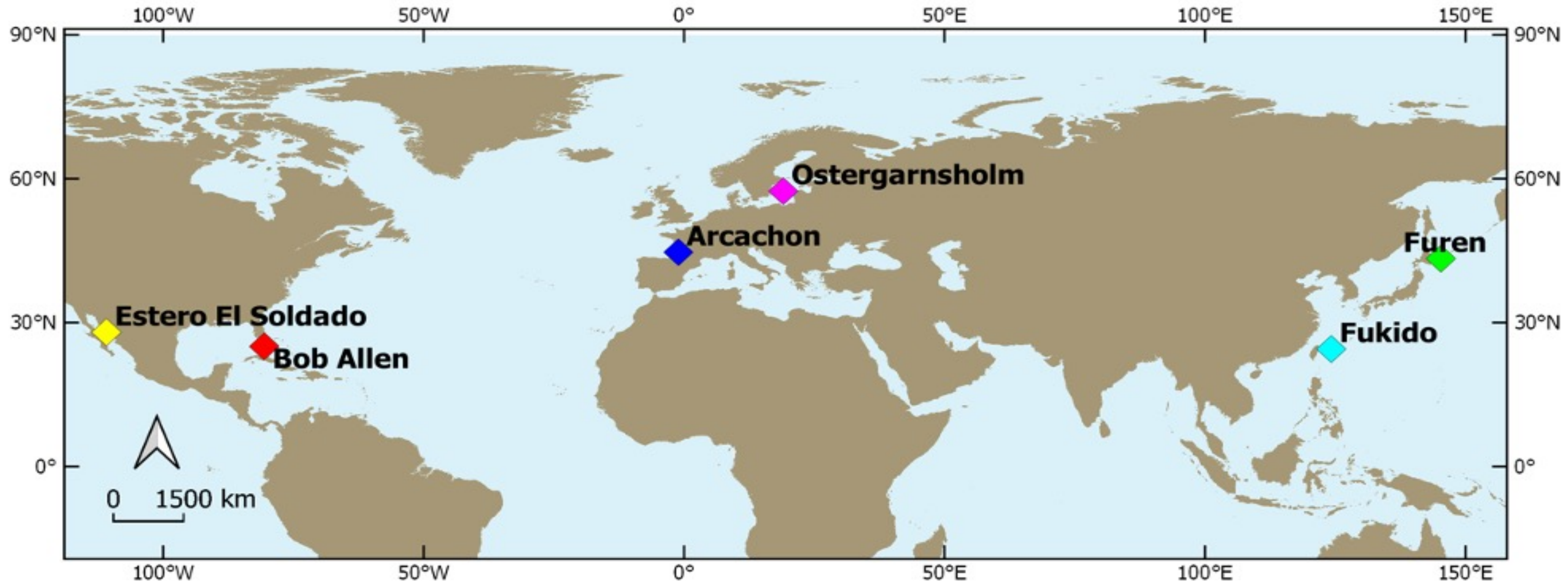
Motivation:

- Organic C storage in seagrass sediments considered as a "blue carbon" approach for C mitigation
- However, this C sink may be complicated by net CO_2 exchange with the atmosphere
- We compiled all available direct measurements of air-water CO_2 flux (FCO_2) over seagrass meadows using atmospheric Eddy Covariance (EC).
- EC provides pseudo-continuous and direct measurements of FCO_2



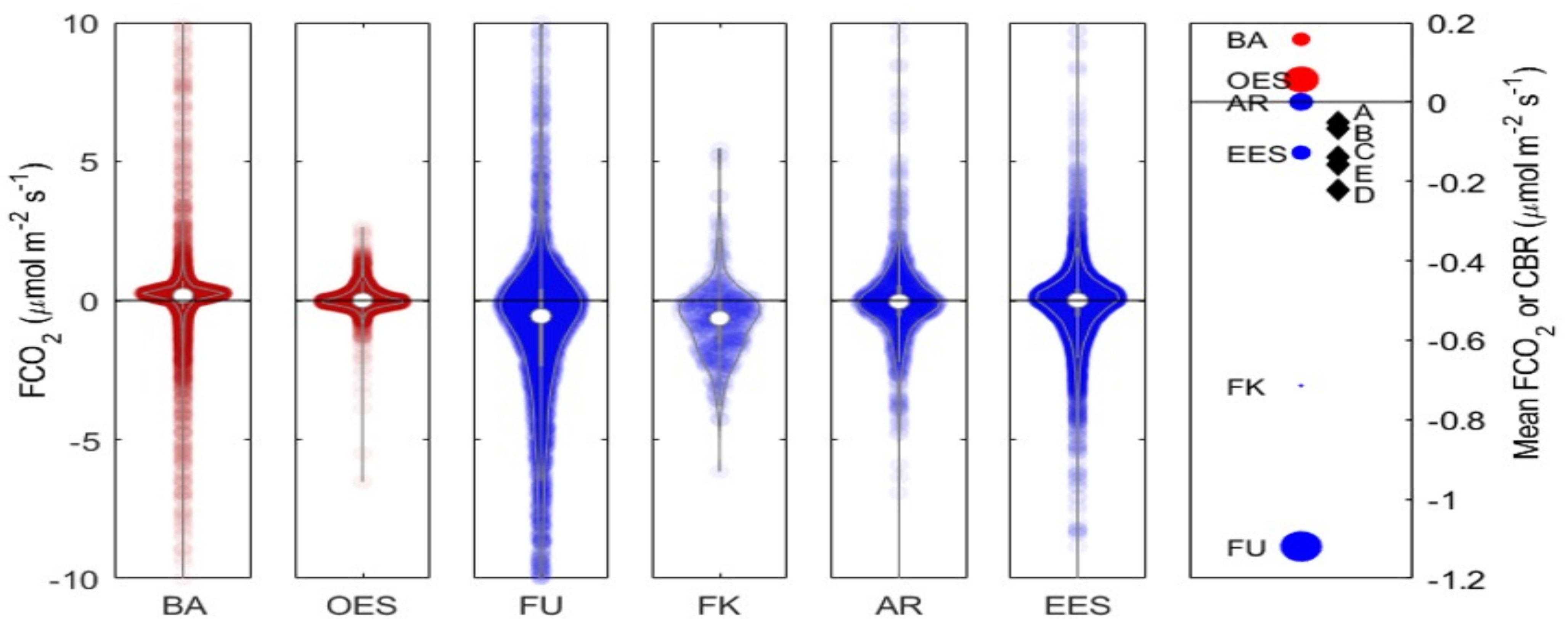


Figure 1: FCO_2 violin plots for tidal (blue) and non-tidal (red) sites. To the right, literature values of carbon burial rates (CBR; black diamonds) are shown alongside average FCO_2 values (blue and red circles), on the same scale. CBR averages are from Samper-Villarreal et al., 2018 (A), Prentice et al., 2020 (B), Duarte et al., 2005 (C), Kennedy et al., 2010 (D), Sanders et al., 2019 (E).

Key Findings:

- All sites varied between CO_2 source and sink with time (Figure 1)
- CO_2 emissions at non-tidal sites may offset potential C burial
- Sites with greater CO_2 uptake are more often tidally-influenced

Summary:

- Global FCO_2 trends are complex, but key drivers include:
  1. **Enhanced physical forcing of air-water exchange:** Drag coefficients were greater than prediction, suggesting universal gas transfer enhancement (Figure 2)
  2. **Tidal forcing:** Complex interaction between: lateral carbon exchange, bottom-driven turbulence, and pore-water pumping (Figure 3)
- Future "Blue carbon" assessments will be incomplete if they do not consider air-water CO_2 exchange

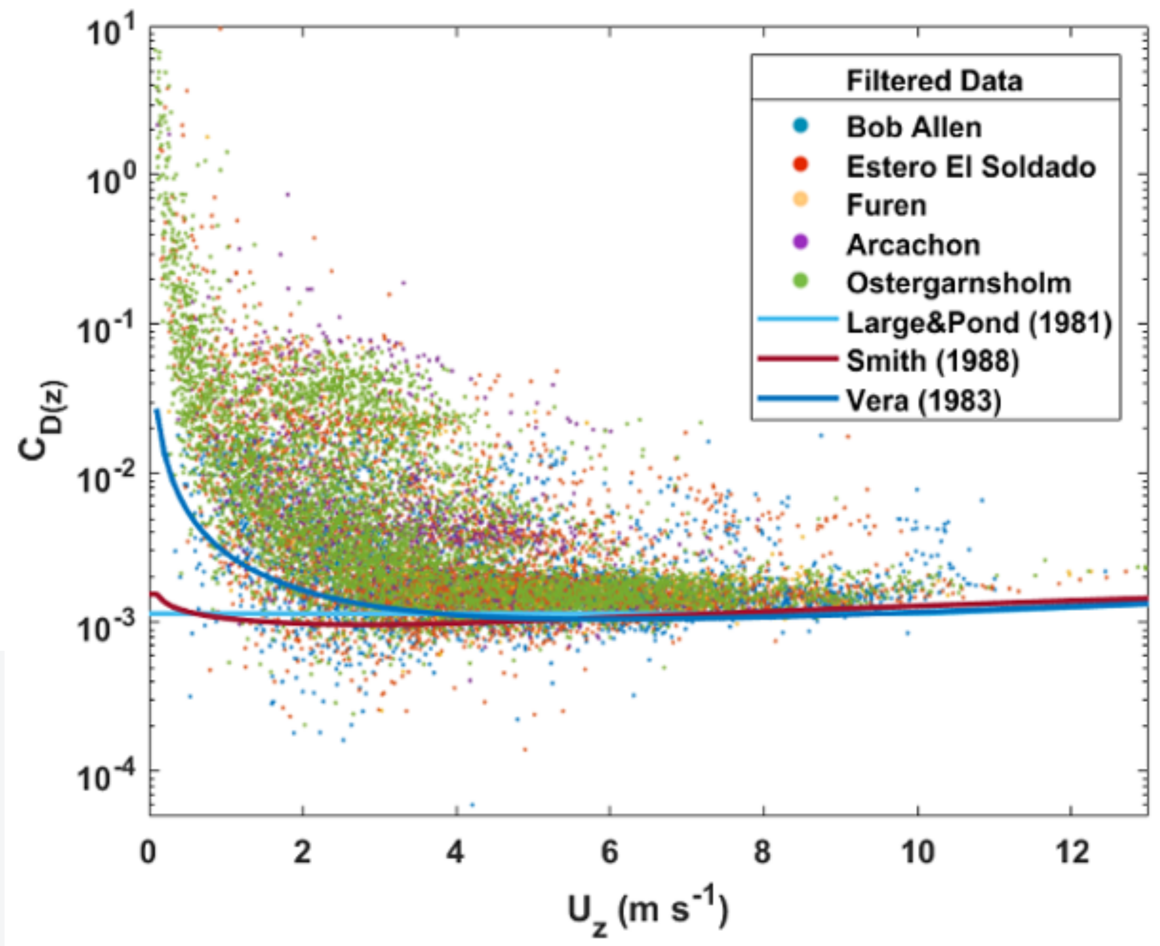


Figure 2: Relationship between Uz and $C_{D(z)}$, compared with a selection of open-ocean relationships from the literature in the solid lines.

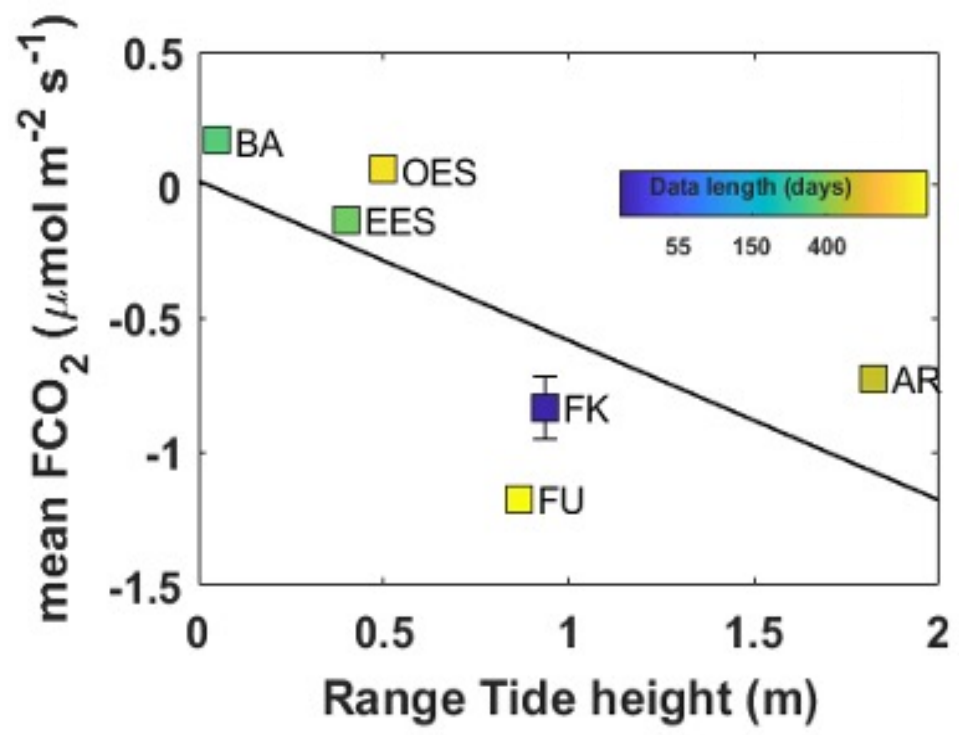


Figure 3: Mean FCO_2 against tidal range; points colored by dataset length ($R^2 = 0.504$, $p < 0.01$)

Next Steps:

- Explore more deeply the physical underpinning for our observed gas transfer enhancement
- Better constrain biogeochemical drivers of CO_2 variability in the water, especially tidal and thermal forcing
- Future targeted studies combining EC and geochemical techniques, allowing us to quantify biogeochemical processes governing CO_2 production/consumption and the physical factors driving air-water CO_2 exchange

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Global Biogeochemical Cycles AGU
https://doi.org/10.1029/2020GB006848

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