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surface.ocean solas lower.atmosphere.study

The Surface Ocean-Lower Atmosphere Study (SOLAS): Contributing to our understanding of air/sea exchange in the Atlantic

- Tom Bell, Mingxi Yang , Tim Smyth (PML)
- Parv Suntharalingham (UEA)
- Christa Marandino, Arne Körtzinger (GEOMAR)
- Jessica Gier and Lisa Miller (SOLAS)

Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports

Western Channel Observatory

ACSIS

MOYA

esa

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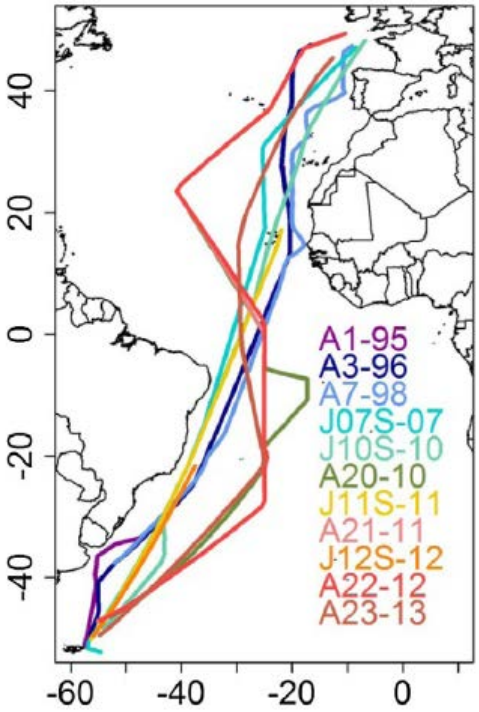
SOLAS is an international research initiative aiming "*to achieve quantitative understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and atmosphere, and of how this coupled system affects and is affected by climate and global change*."

Core Themes:

1. Greenhouse gases and the oceans
2. Air-sea interface and fluxes of mass and energy
3. Atmospheric deposition and ocean biogeochemistry
4. Interconnections between aerosols, clouds, and marine ecosystems
5. Ocean biogeochemical controls on atmospheric chemistry

- Integrated topics (e.g., upwelling systems, polar oceans, coastal waters, Indian Ocean)
- Evaluating the environmental efficacy and impacts of geoengineering
- Science & Society: impacts of ship-plume emissions on ocean biogeochemistry, blue carbon, open-ocean stewardship

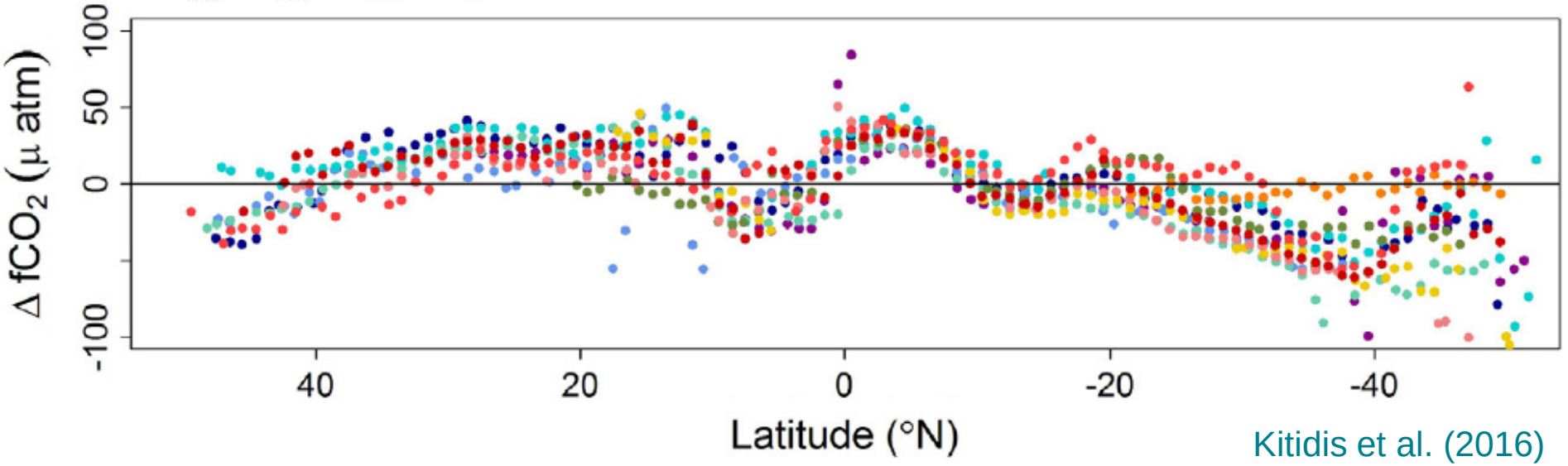
Quantifying air/sea CO_2 exchange in the Atlantic



- Atlantic Meridional Transect (AMT) program
- Decade of ocean and atmosphere CO_2 measurements

Air/sea CO_2 Flux = $K\Delta fCO_2$

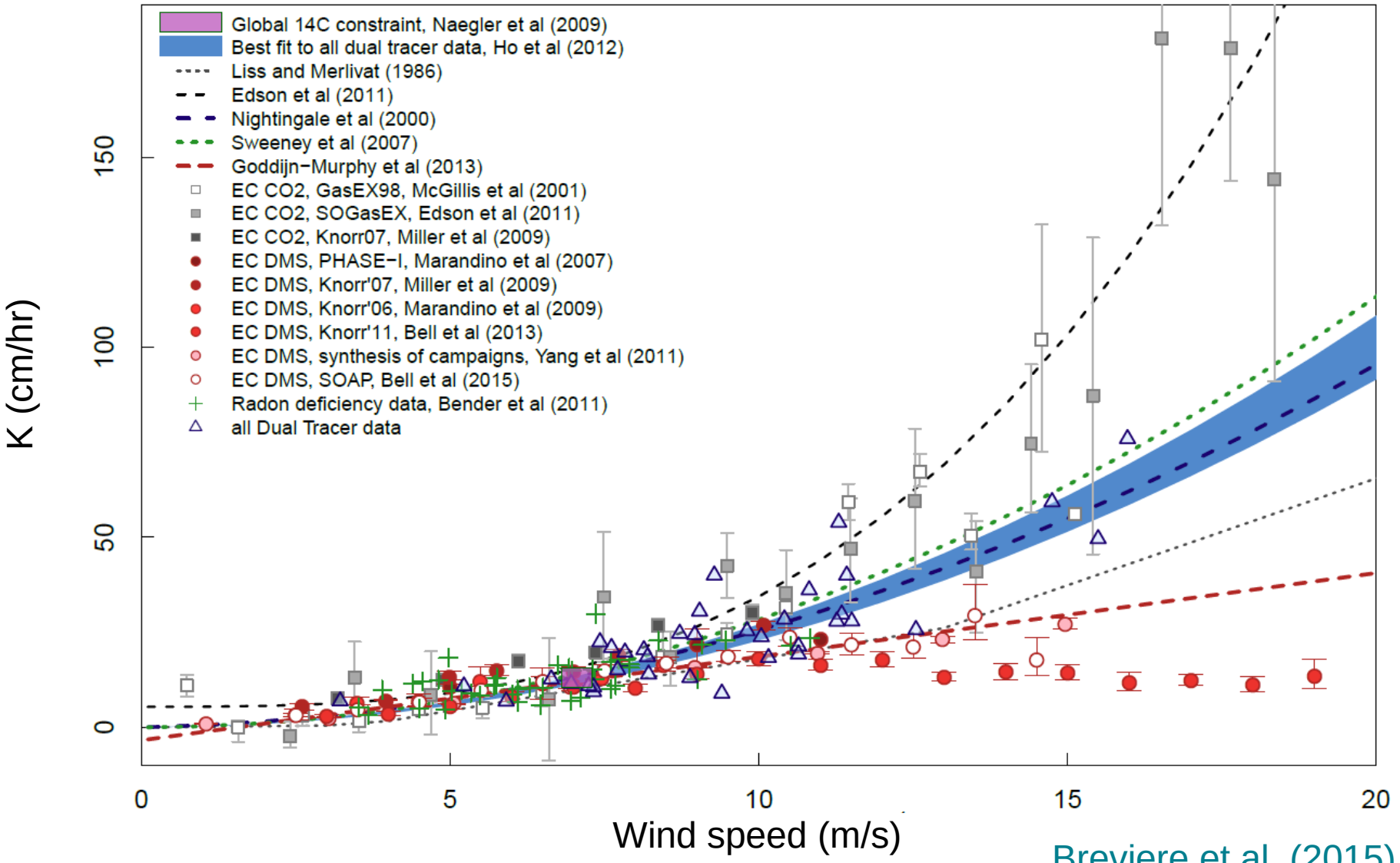
K = Gas Transfer Velocity



Kitidis et al. (2016)

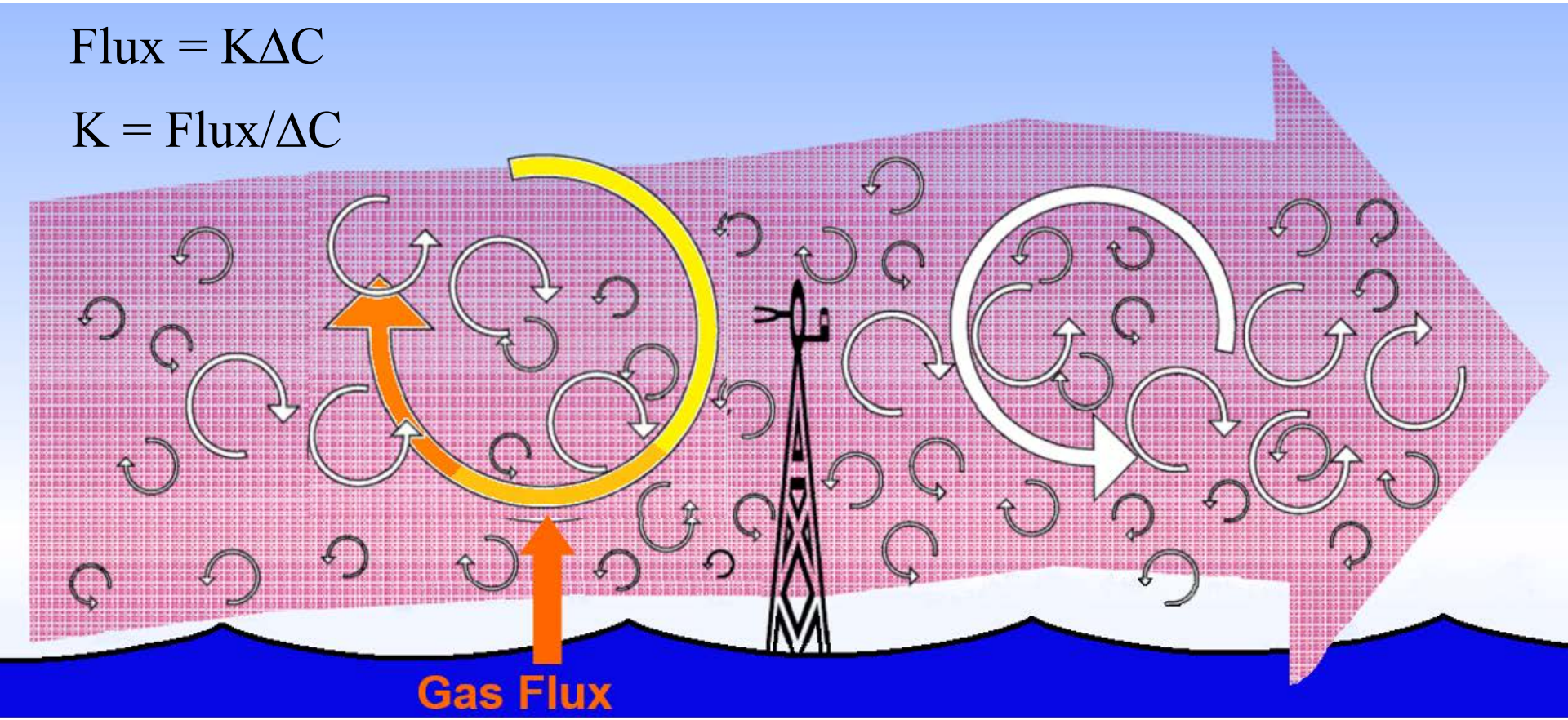
Wind speed control of gas transfer?

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



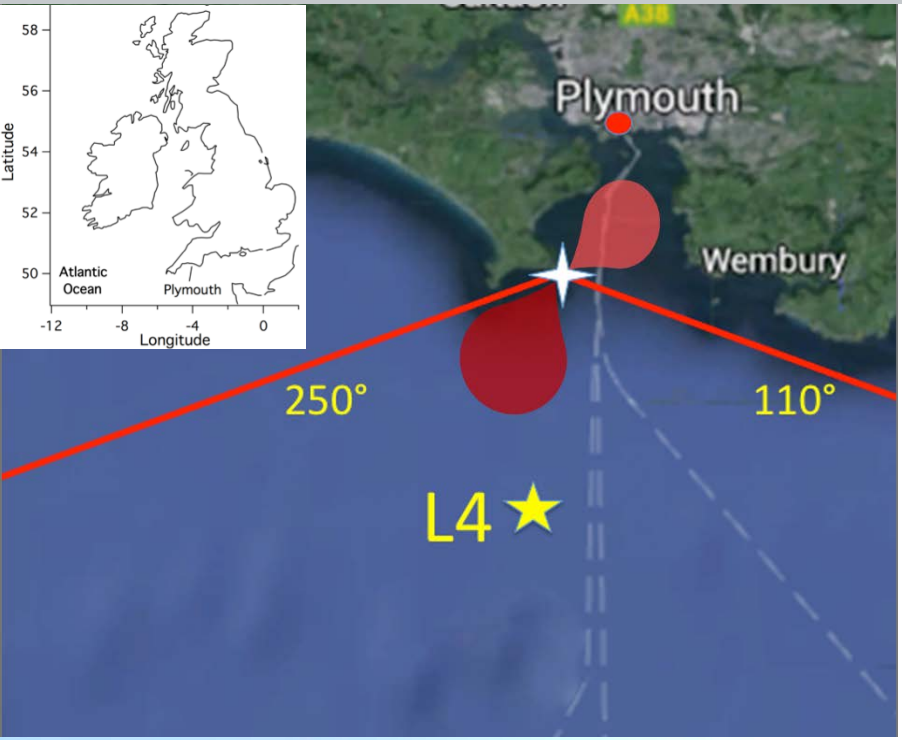
Breviere et al. (2015)

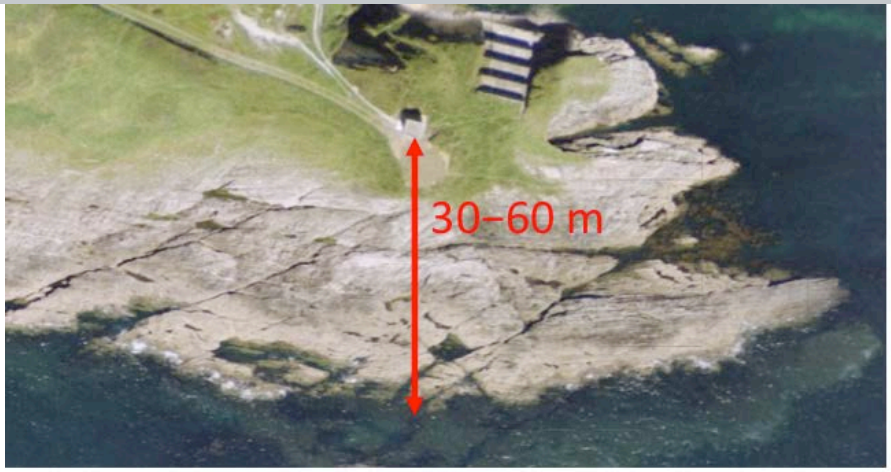
Eddy covariance flux measurements



- Direct measure of flux using covariation in vertical winds and gas concentrations
- Tool for understanding processes controlling K
- Validation of other flux estimates (e.g. from satellite)

Penlee Point Atmospheric Observatory (PPAO)





- Meteorology and air/sea CO_2 and CH_4 fluxes
- Gases (SO_2, O_3, CO_2, CH_4)
- Periodic aerosol number and size distribution
- Aerosol composition
- Rainwater collection

http://www.westernchannelobservatory.org.uk/penlee/

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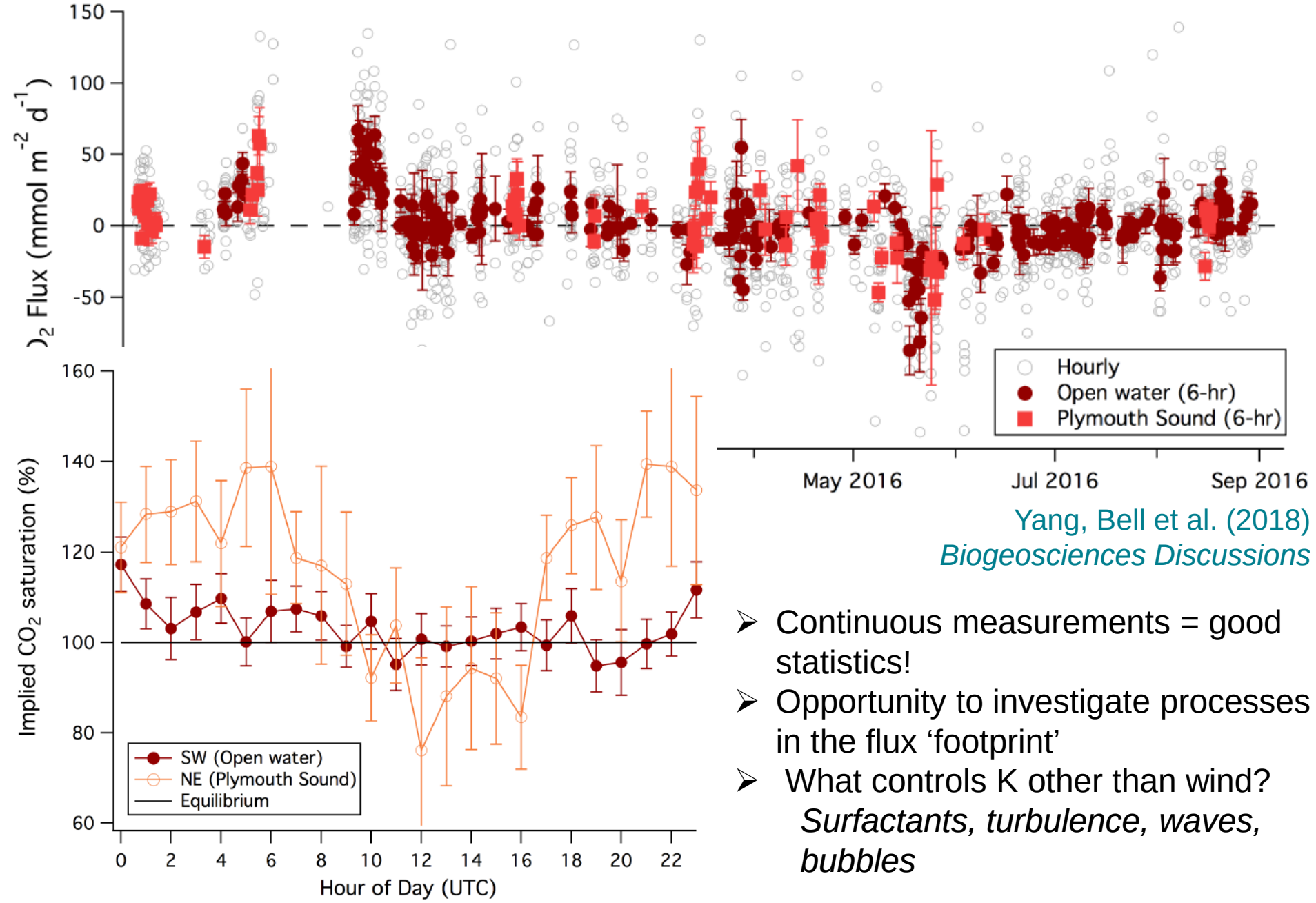
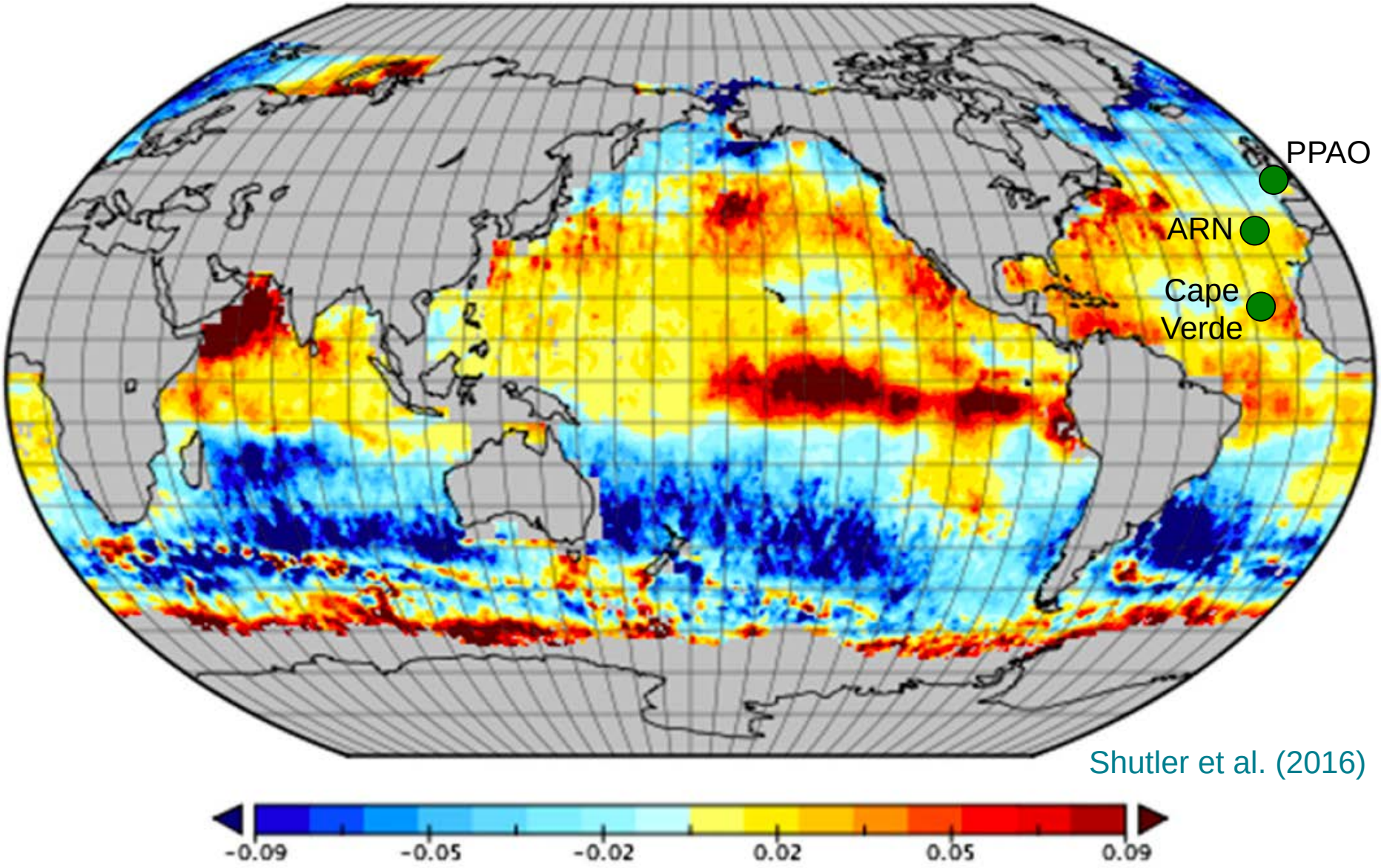
Seasonal uptake and outgassing of CO_2



Yang, Bell et al. (2018)
Biogeosciences Discussions

- Continuous measurements = good statistics!
- Opportunity to investigate processes in the flux 'footprint'
- What controls K other than wind?
  Surfactants, turbulence, waves, bubbles

Timeseries process understanding vs. spatial coverage



Shutler et al. (2016)

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

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Back to AMT: Installation of CO_2 flux system on JCR

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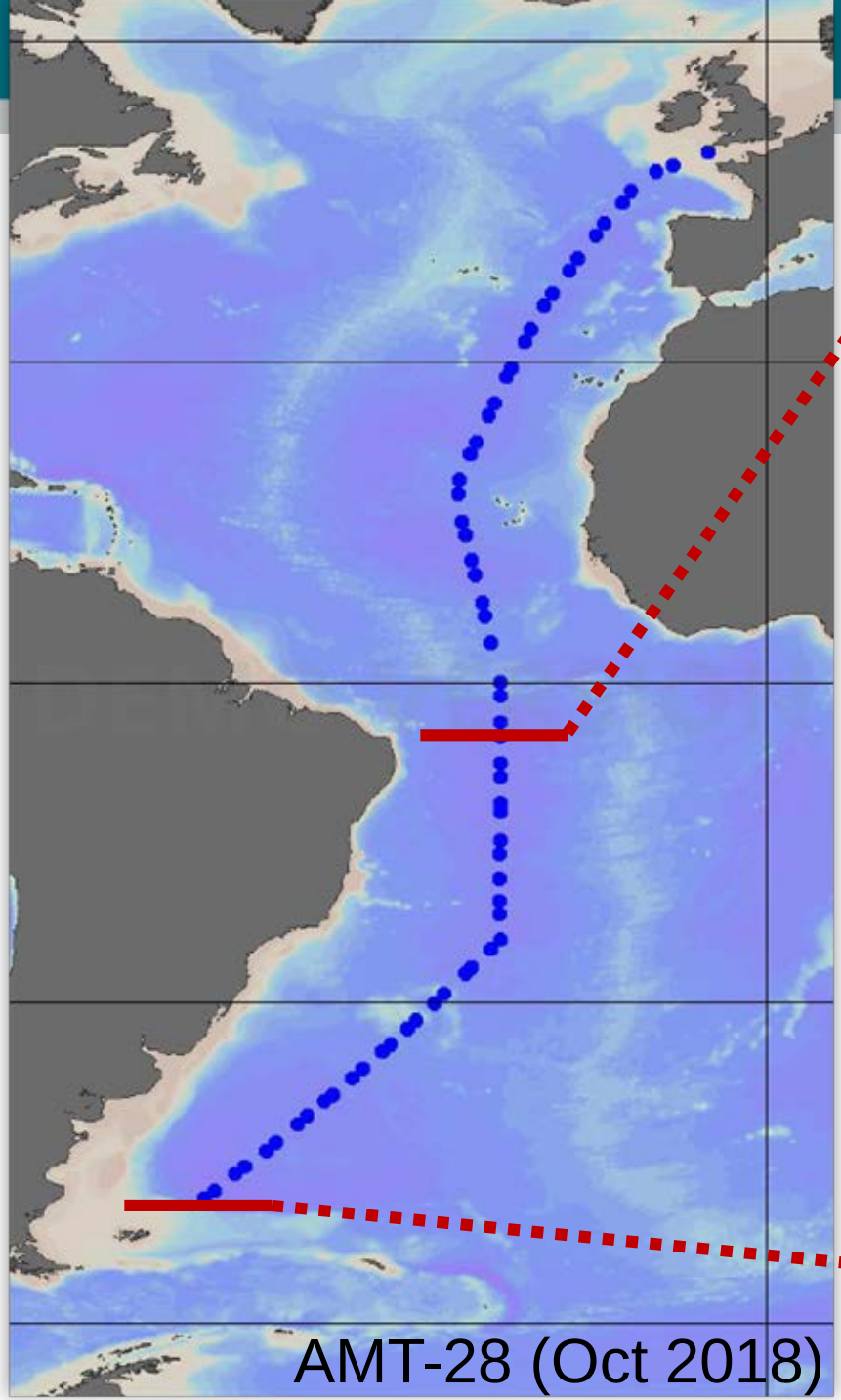
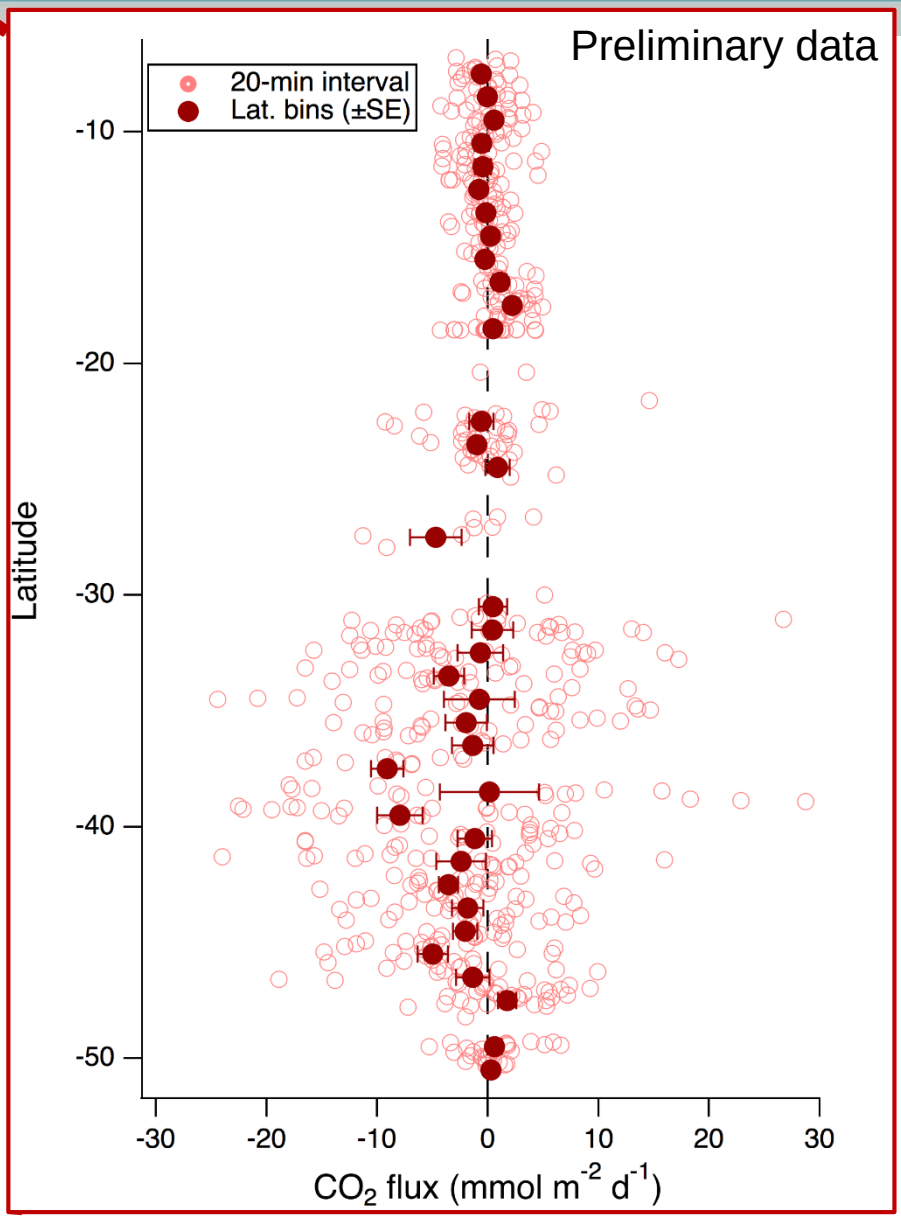
September 2018

CO_2 fluxes hot off the press (ship)!





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Conclusions and Recommendations

- Conclusions:

  Long-term continuous eddy covariance measurements offer opportunity to:

  1. Investigate processes controlling CO_2 air/sea fluxes
  2. Validate satellite products and test inversion model estimates

- Recommendations:

  CO_2 / Gas Exchange:

  Distributed network of continuous flux measurements?

  Atmospheric CO_2 retrievals (XCO_2) – use with inverse models?

  Make use of other satellite data products to interpret gas flux measurements (waves, bubbles, surfactants)

  Application of geostationary satellites to timeseries stations?

  Can we decouple retrievals of wind speed from retrievals of waves/sea surface scattering?

  Other 'SOLAS-topic' recommendations:

  Improve satellite retrievals of concentrations and fluxes of other gases (e.g. DMS)

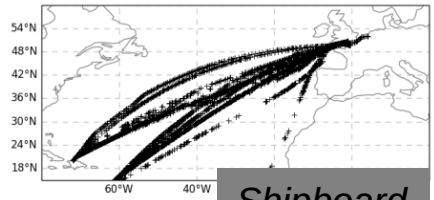
  Assessment of ship emissions (particles, SOx, NOx) and impacts on ocean biogeochemistry – new global IMO regulation in 2020

  Links between ocean ecosystems, aerosols and clouds (e.g. NASA NAAMES)

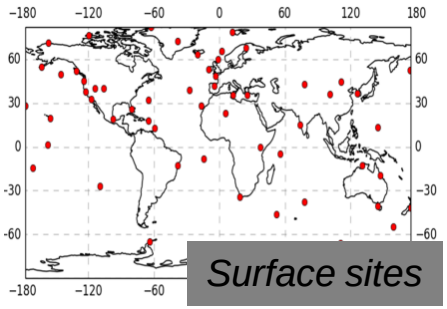
Air-sea CO_2 fluxes from atmospheric inverse analysis

Parv Suntharalingam, Zhaohui Chen (P.Suntharalingam@uea.ac.uk)

CO_2 Observations



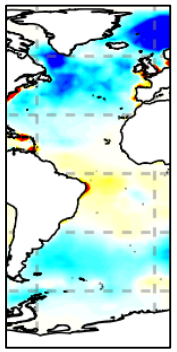
Shipboard

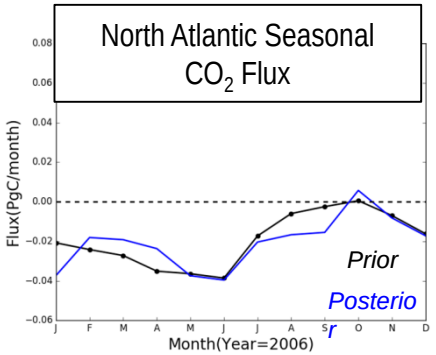


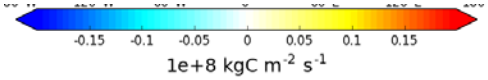
Surface sites

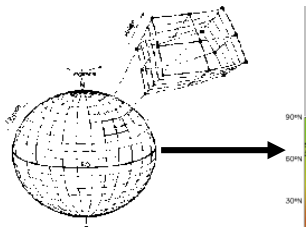
INVERSE MODEL
LETKF-GEOSChem
Local Ensemble Transform Kalman Filter

Optimized Flux Estimates



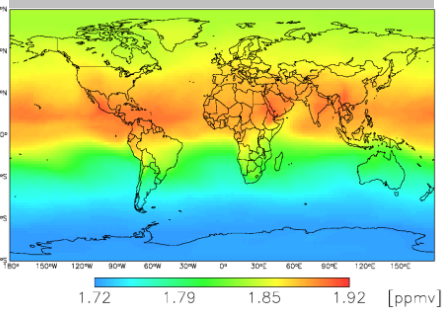






Prior Fluxes

Model Concentrations



Atmospheric Model
GEOS-Chem v9.02

- Use of shipboard CO_2 measurements provide improved North Atlantic flux estimates in comparison to use of surface site data alone
- Could satellite XCO_2 data constrain estimates further?

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SOLAS International Project Office

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Executive Director: Jessica Gier; Project Officer: Esther Rickert

Nodal Office

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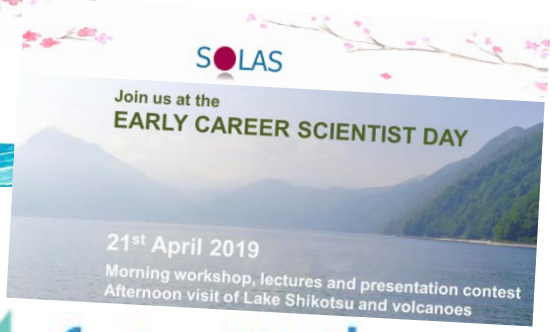

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State Key Laboratory of Marine Environmental Science (Xiamen University)

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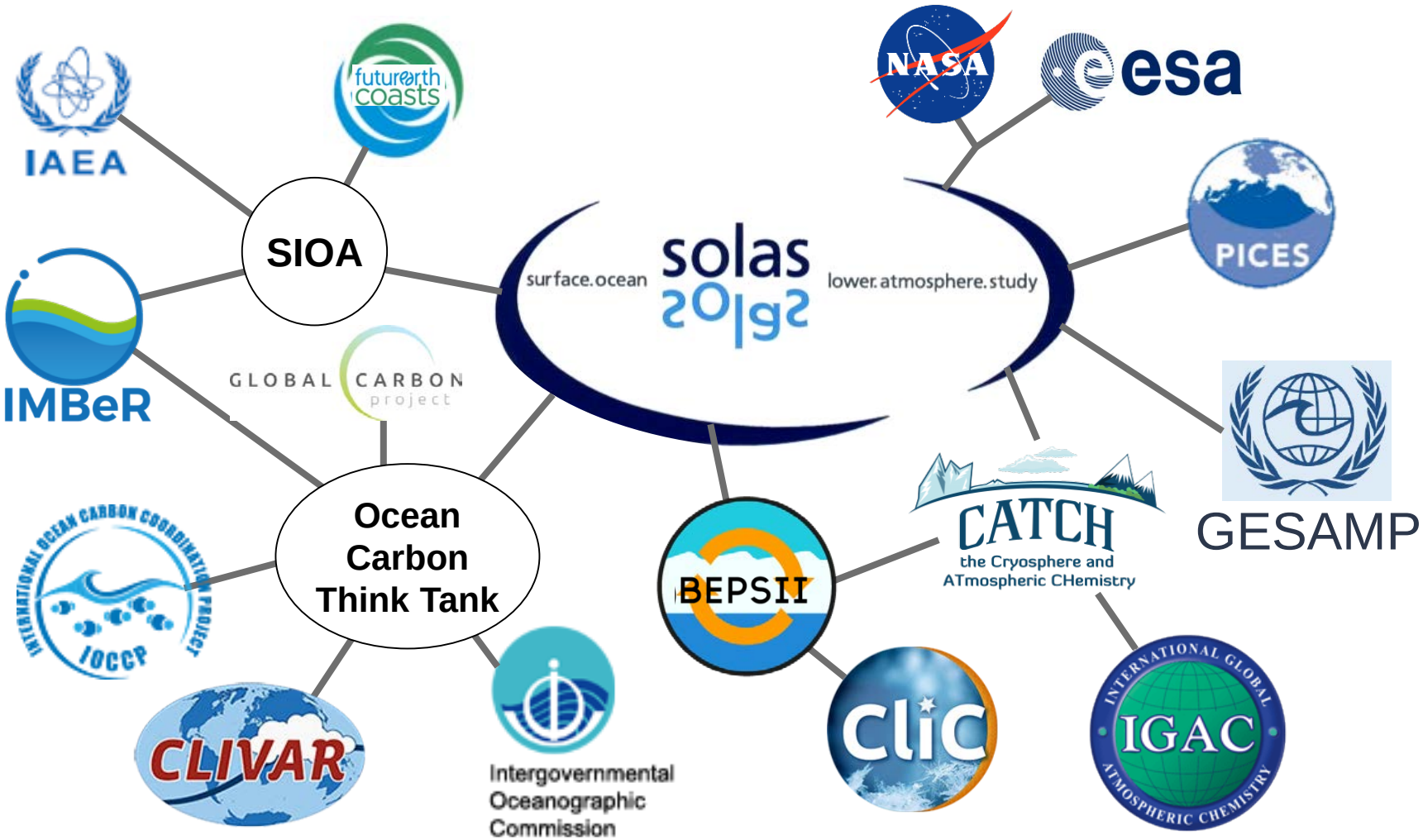
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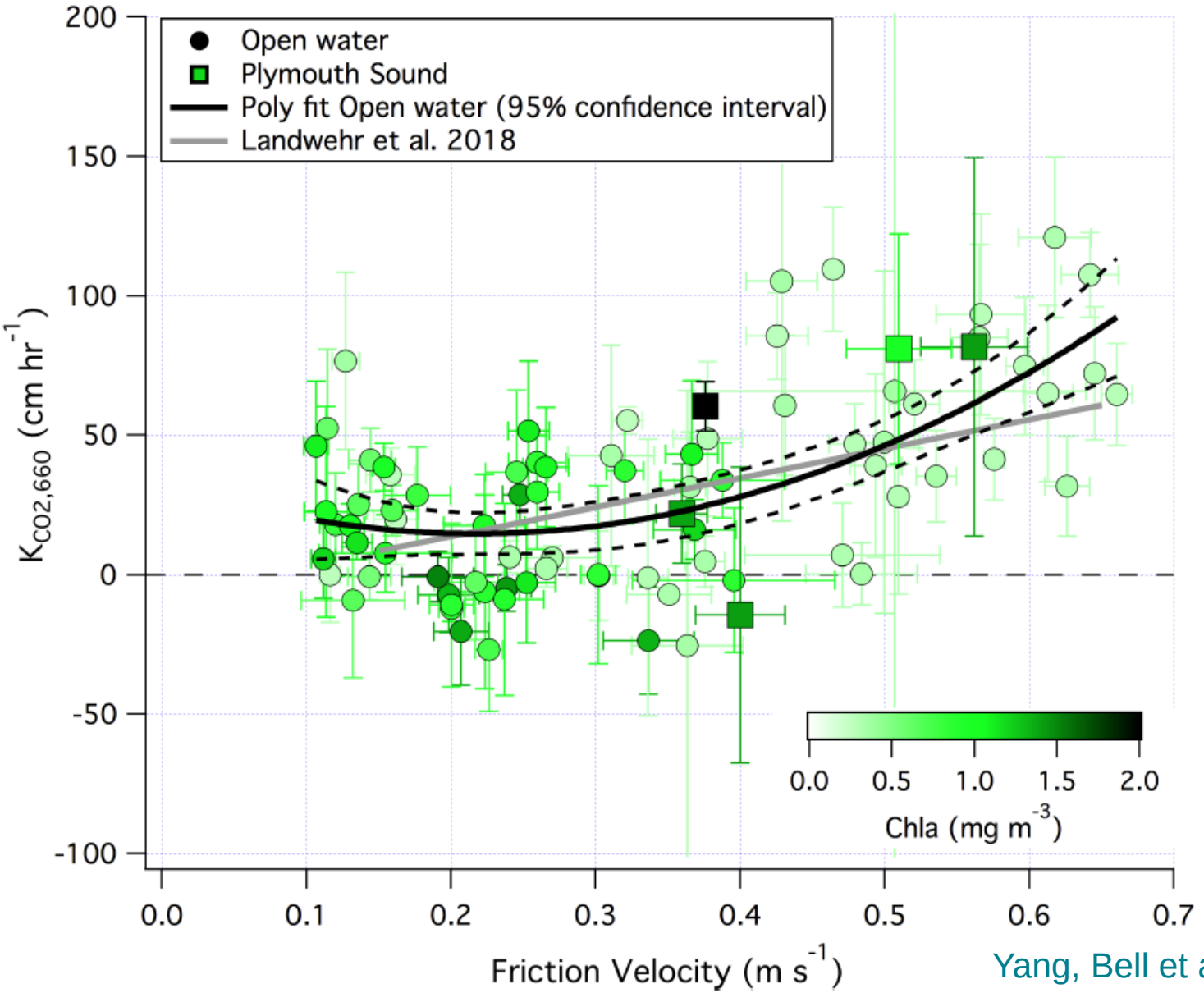
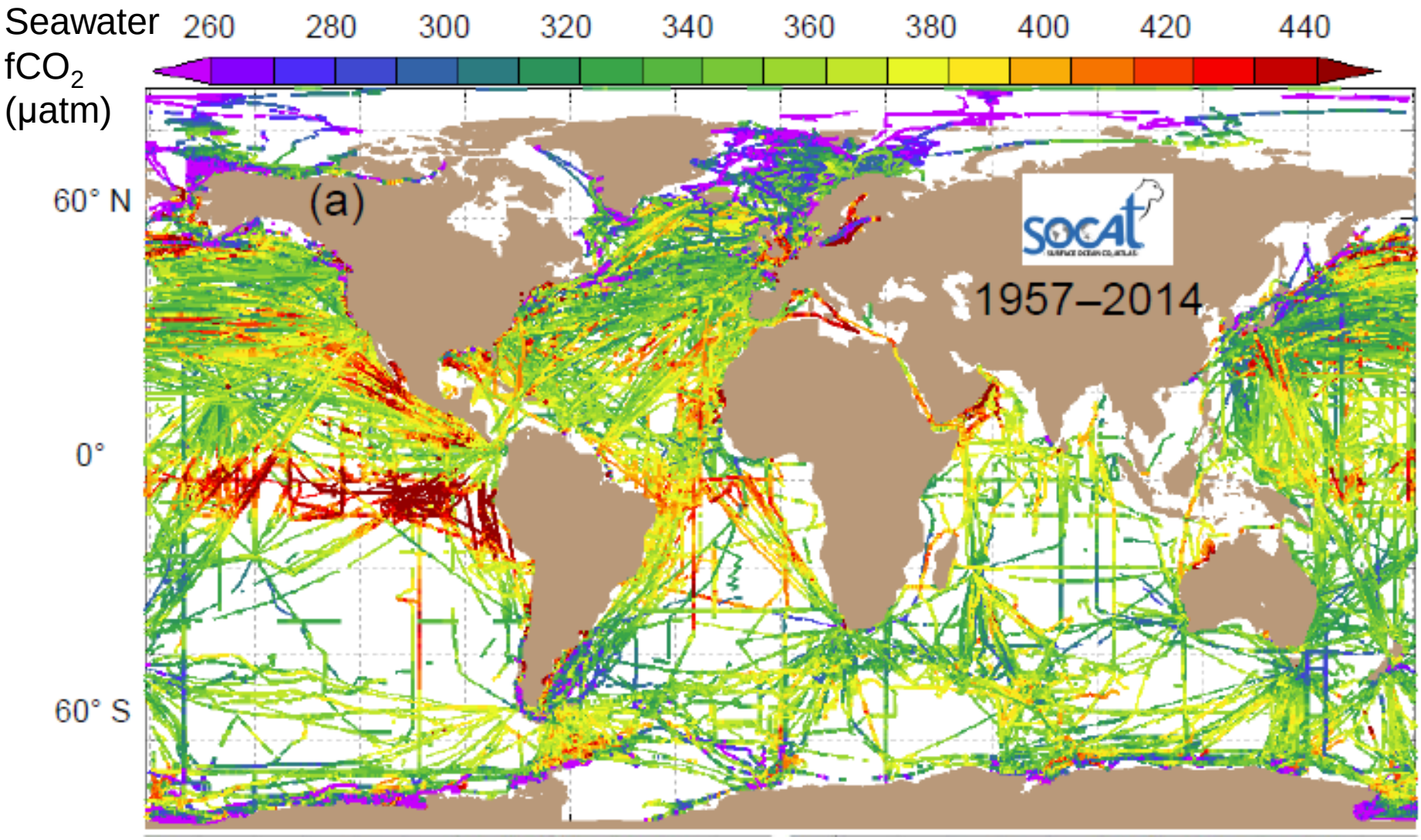
CliC
IGAC



Yang, Bell et al. (2018)
Biogeosciences Discussions

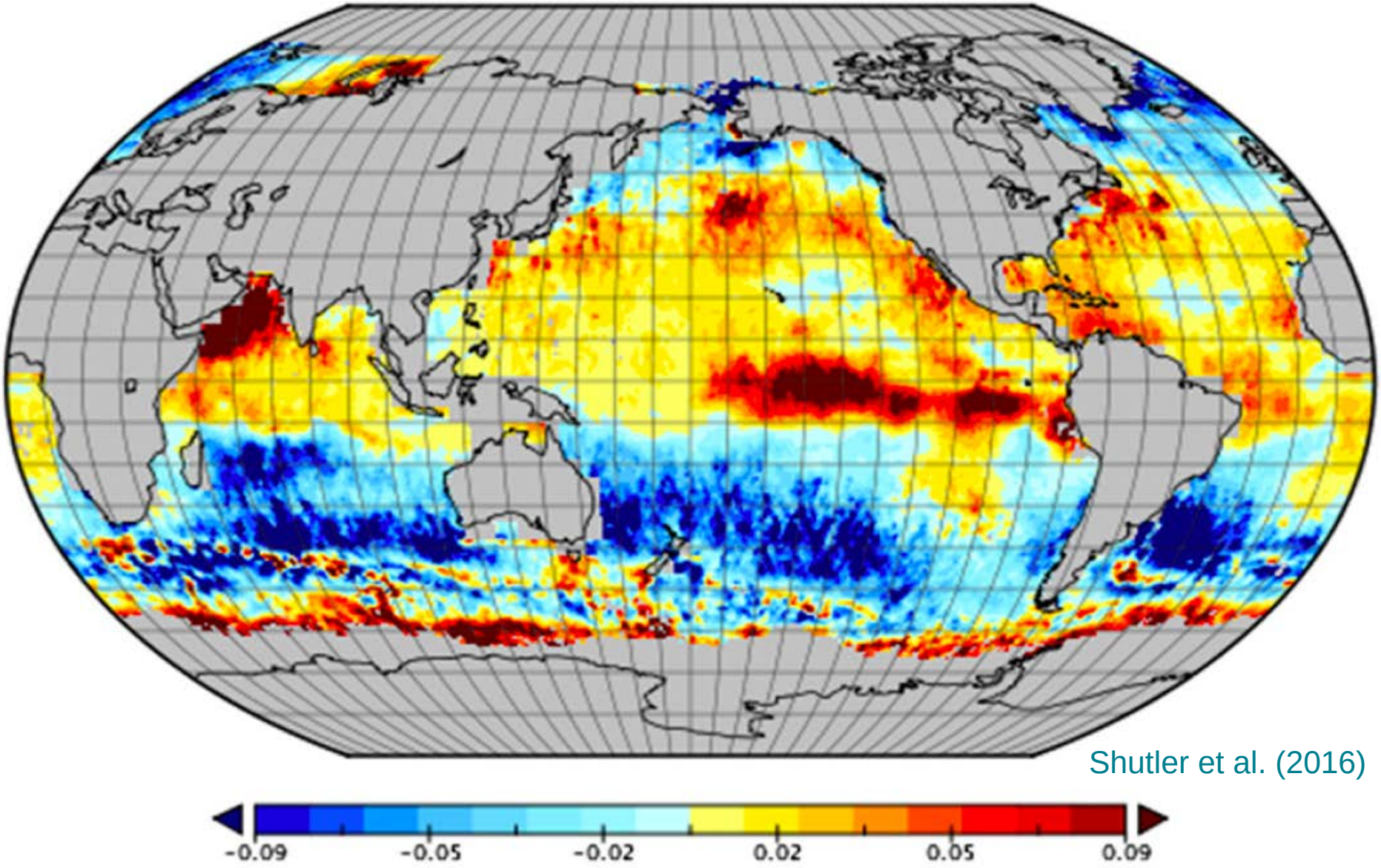
Seawater fCO_2 database (SOCAT)



Bakker et al. (2016)

Air/sea CO_2 Flux = KΔfCO_2

CO_2 air/sea exchange estimates from satellite



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