LINKING INFORMATION FROM SSS TO OCEANIC FRESHWATER FLUXES USING NEAR-SURFACE SALINITY BUDGETS

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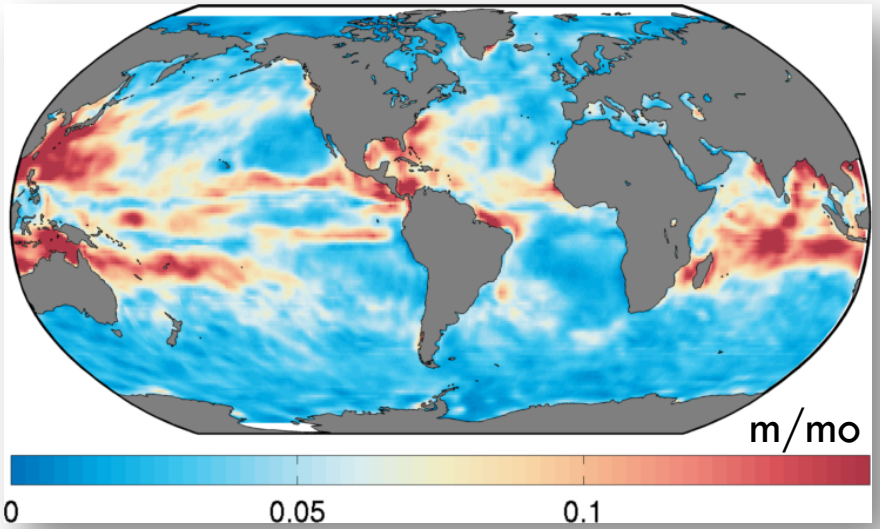
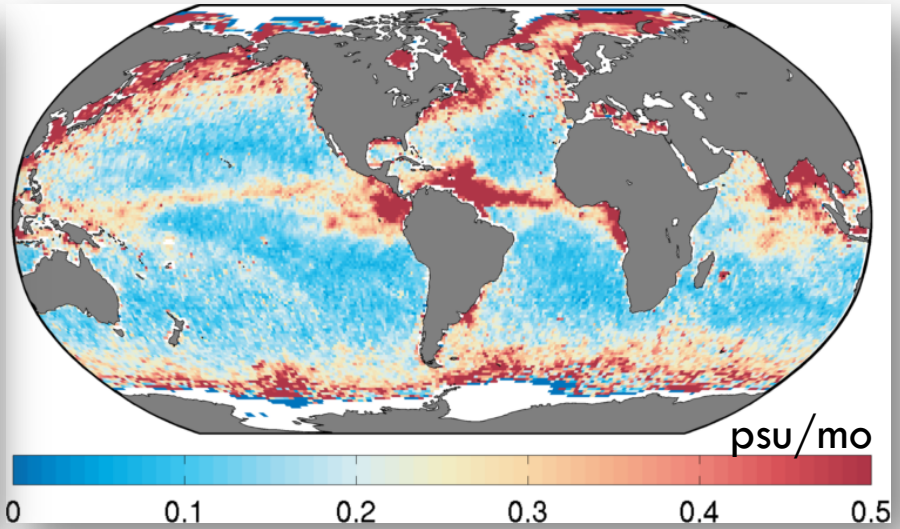
CHANGES IN SSS AS INDICATOR OF E-P?

STD E-P (NCEP)



STD SSS-TENDENCY (AQUARIUS, v3.0)

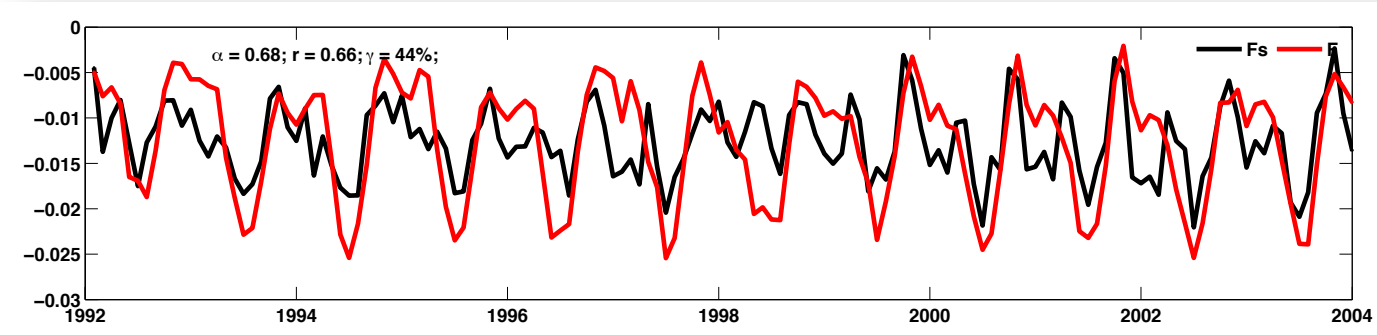


Linking surface salinity to freshwater flux is an important subject (e.g., *Durack et al. 2012; Pierce et al., 2012; Terray et al., 2011; Bingham et al., 2011; Yu 2011*), but is difficult in practice (*Vinogradova and Ponte 2013*)

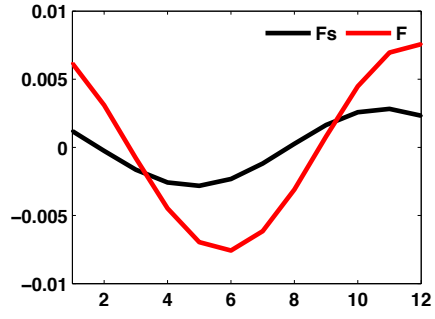
EXAMPLE

- Can net freshwater flux be inferred from globally-averaged SSS from an ocean estimate?
- Salinity-derived freshwater flux = $\alpha \bullet \bar{S}'$
- Non-linear relationship confirms the importance of ocean fluxes in regulating global-mean changes in SSS.

Net freshwater flux: SSS-derived (black) vs Observed (red)



Annual cycle



Vinogradova and Ponte, JGR 2013

SALINITY BUDGET FRAMEWORK

- Salinity budget : $S' = \mathcal{F} + O$
- Differences between S' and $\mathcal{F}$ related to O affect regression (*Vinogradova and Ponte 2013*).
- Inclusion of information about O from data can improve estimates of $\mathcal{F}$.
- Objectives:
  - Where, when can $\mathcal{F}$ be inferred from partial knowledge of the budget terms?
  - Develop practical methodologies on how to use Aquarius measurements to infer meaningful values of $\mathcal{F}$

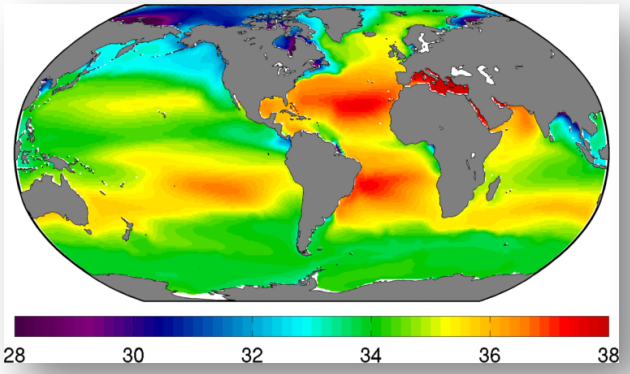
BASIC APPROACH

- Explore salinity budgets within the constrained estimation of the oceanic state:
  - Guaranteed budget closure
  - Solutions are close to observations (including salinity)
  - Dynamical consistency with all the forcing fields

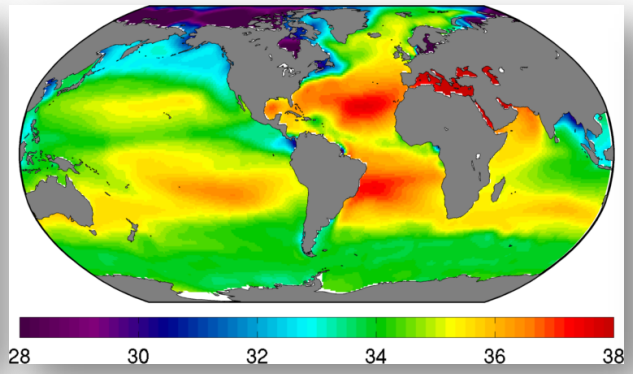
ECCO SOLUTION

- Ocean state estimate is obtained from model/data synthesis produced by the ECCO consortium [1], [2]
- ECCO solution is close to observations within prescribed data errors
- Future ECCO solutions will include Aquarius/SMOS SSS constraints (*Vinogradova et al., 2014*)

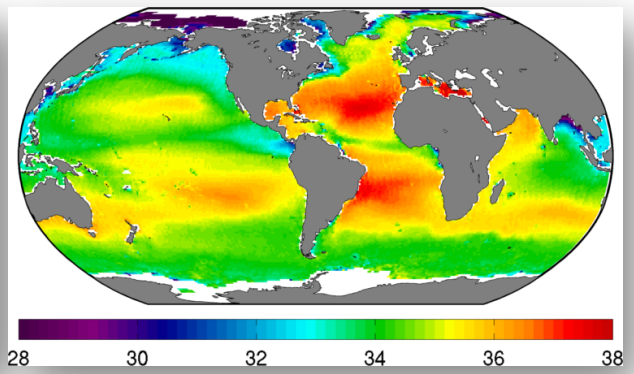
ECCO



IN SITU



AQUARIUS



Estimating the Circulation and Climate of the Ocean (ECCO)

[1] *Wunsch et al., 2009;* [2] *Speer and Forget 2013*

ECCO SOLUTION

- It is important to accurately represent the effects of freshwater fluxes
  - "Virtual" salt flux (previous versions)
  - Real freshwater flux (current analysis)
- Freshwater flux modifies tracer concentration and ocean volume:

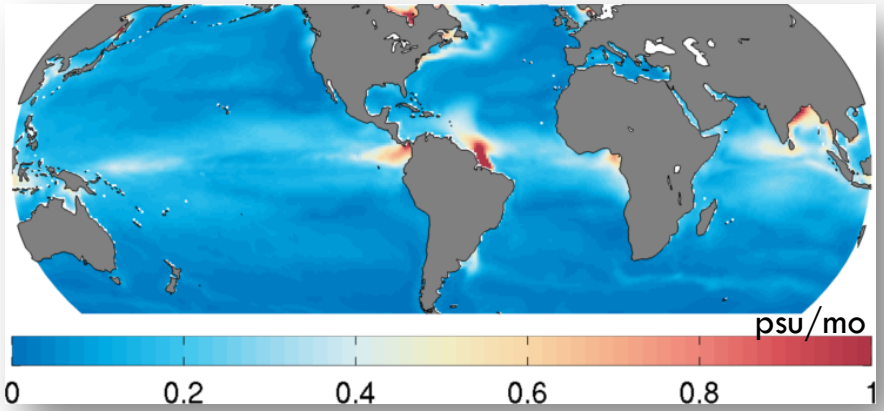
$$\frac{\partial (hS)}{\partial t} = -\nabla \cdot (hS\boldsymbol{u}) + \nabla \cdot (\boldsymbol{K}\nabla S)$$

$$\frac{\partial h}{\partial t} = -(E - P - R) - \nabla \cdot (h\boldsymbol{u}) \qquad h = H + \eta$$

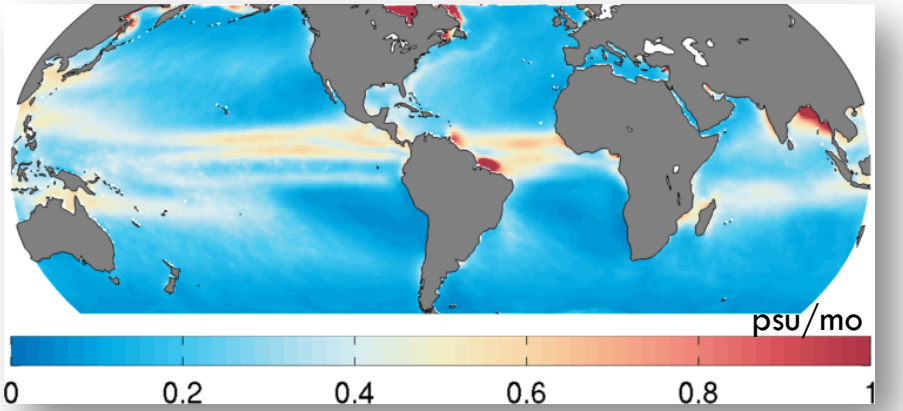
$$h\frac{\partial S}{\partial t} = S(E - P - R) - \nabla \cdot (\boldsymbol{u}S) + \nabla \cdot (\boldsymbol{K}\nabla S)$$

ECCO SALINITY BUDGET: STD

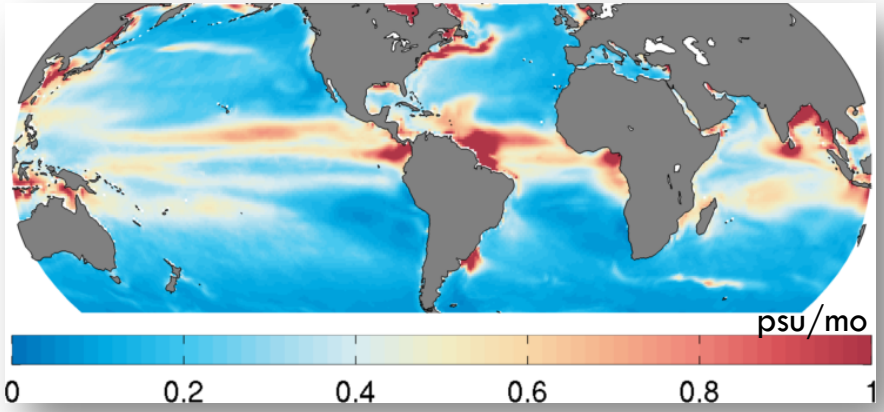
SALINITY TENDENCY



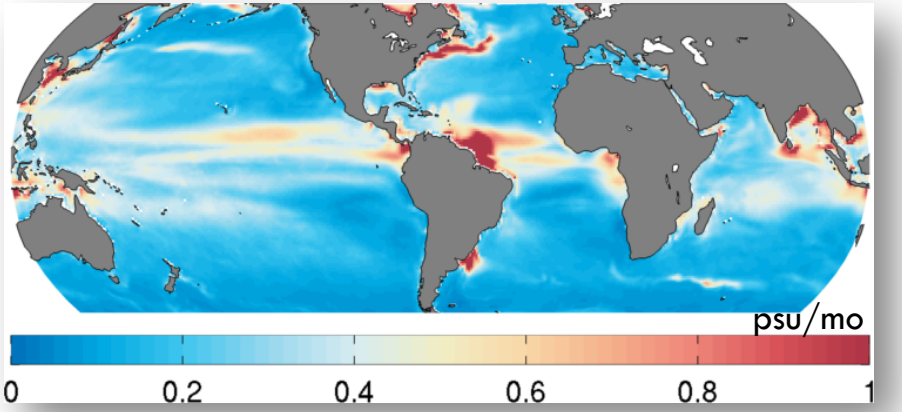
DILUTION DUE TO FRESHWATER FLUXES



ADVECTIVE SALINITY FLUX

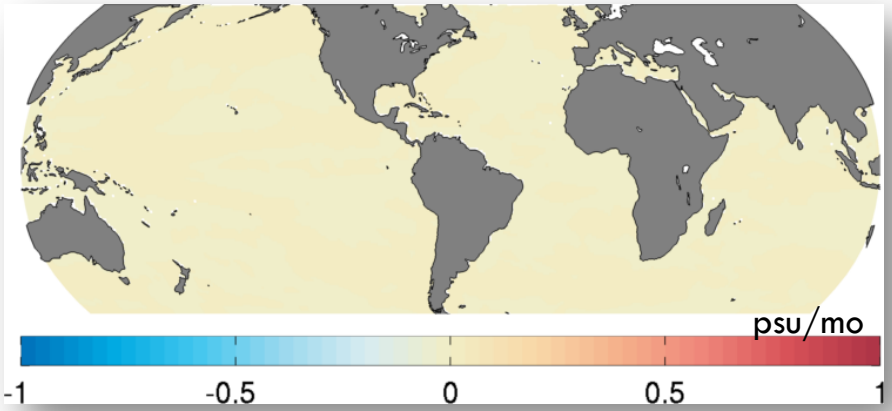


DIFFUSIVE SALINITY FLUX



ECCO SALINITY BUDGET: TIME MEAN

SALINITY TENDENCY



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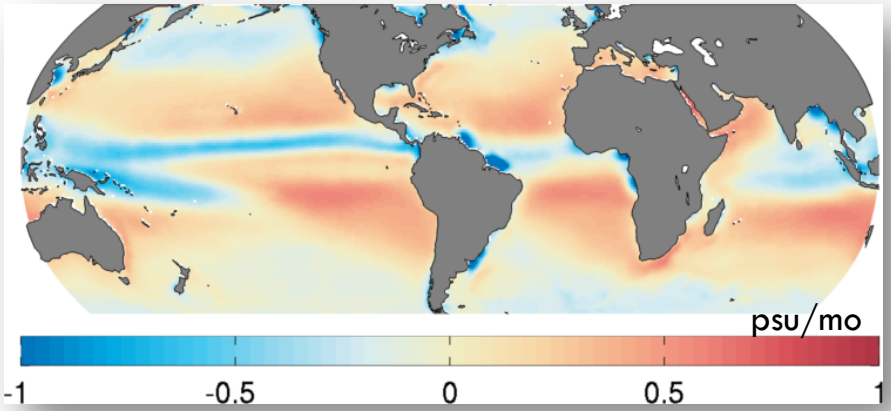

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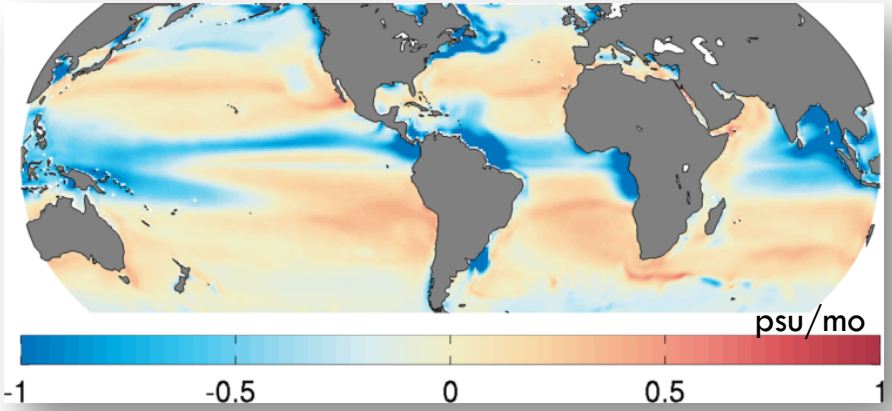

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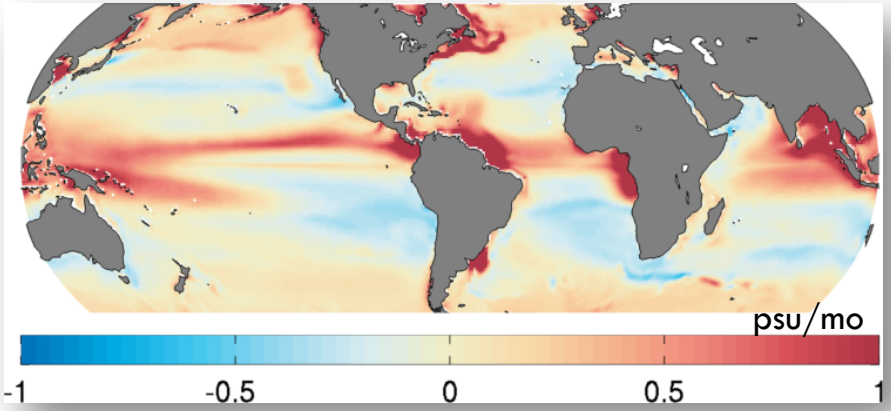

FUTURE PLANS

- Preliminary results show that ocean contribution to salinity variations is particular important in the tropics and many coastal regions, which may complicate the use of salinity observations as a direct proxy of freshwater flux, at least on timescales from months to years

- Future analysis of the mixed-layer salinity budget and decomposition of oceanic fluxes will be used to explore how freshwater fluxes can be expressed as a combination of ocean variables, including SSS:
  - E.g., do Ekman advection and surface fluxes dominate in any region or time scale?
  - What is the impact of Aquarius data constraints on the upper ocean salinity and surface freshwater fluxes?