DYNAMICS AND FORCING OF SSS AND THE POTENTIAL OF SATELLITE-DERIVED SSS TO CONSTRAIN AIR-SEA FRESHWATER FLUXES

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OBJECTIVES

1. To examine the relationship between SSS, air-sea freshwater fluxes and ocean transports on time scales from months to years.

2. To analyze the potential of satellite-derived salinity measurements to constrain surface freshwater flux.

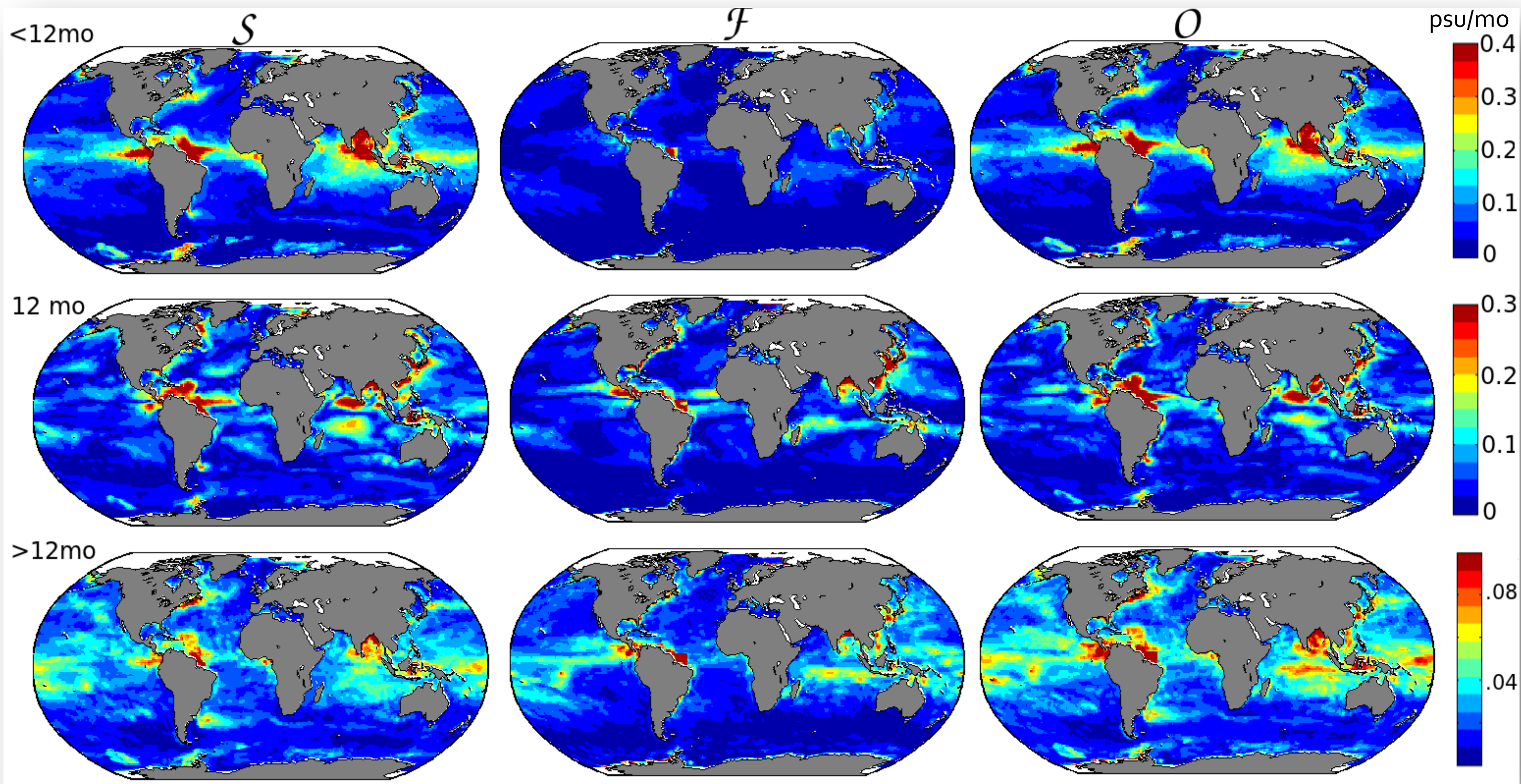
TOOLS

- Ocean state estimate is obtained from model/data synthesis produced by the ECCO consortium (Wunsch et al., 2007; 2009)
- Fields are computed on a 1° horizontal grid and are diagnosed as monthly averages during 1992-2004
- SSS refers to salinity averaged over the mixed-layer*

**Considering top-layer salinity as a measure of SSS did not change our main conclusions*

SALINITY BUDGET*

$$\frac{\partial [S]}{\partial t} = \frac{(E-P)}{h}[S] - [\nabla \cdot (\vec{\boldsymbol{u}} S)] + \left[\nabla \cdot (\vec{\boldsymbol{K}})\right] - \frac{1}{h}\Delta S \frac{\partial h}{\partial t} \quad \Rightarrow \quad \mathcal{S} = \mathcal{F} + \mathcal{A} + \mathcal{M} + \mathcal{E} = \mathcal{F} + \mathcal{O}$$



- Both $\mathcal{F}$ and $\mathcal{O}$ give rise to variability in $\mathcal{S}$ with $\mathcal{O}$≠o in many ocean regions
- See poster by Vinogradova and Ponte for more discussion

Budget formulation follows Kim et al. (2006)

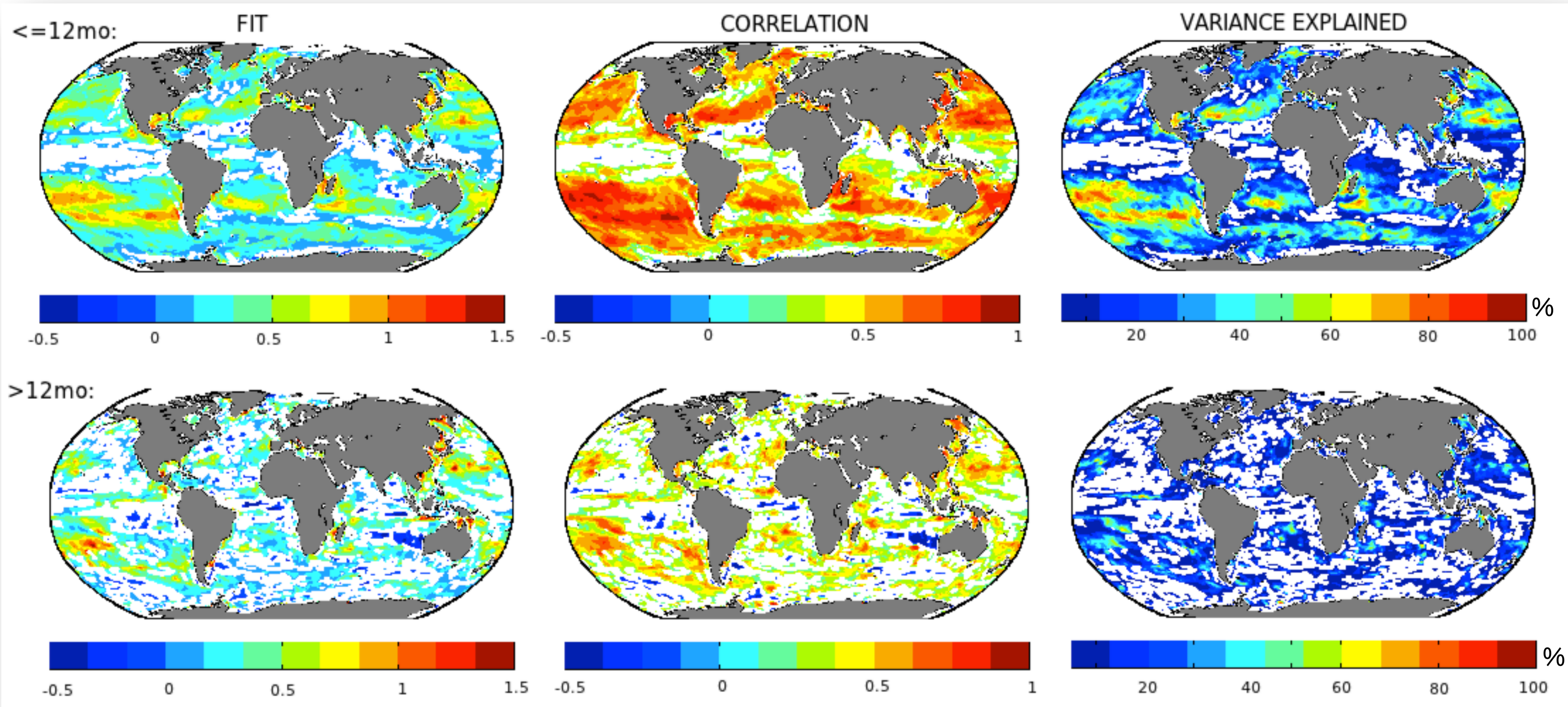
SALINITY-DERIVED FLUX

- Parameterizing $\mathcal{O}$ and $\mathcal{F}$ as a linear function of $\mathcal{S}$:

$$\begin{cases} \mathcal{O} = \beta \cdot \mathcal{F} + \varepsilon_{\mathcal{O}} \\ \mathcal{S} = \mathcal{F} + \mathcal{O} \end{cases} \longrightarrow \quad \mathcal{F} = \alpha \cdot \mathcal{S} + \varepsilon = \mathcal{F}_{\mathcal{S}} + \varepsilon \qquad (1)$$

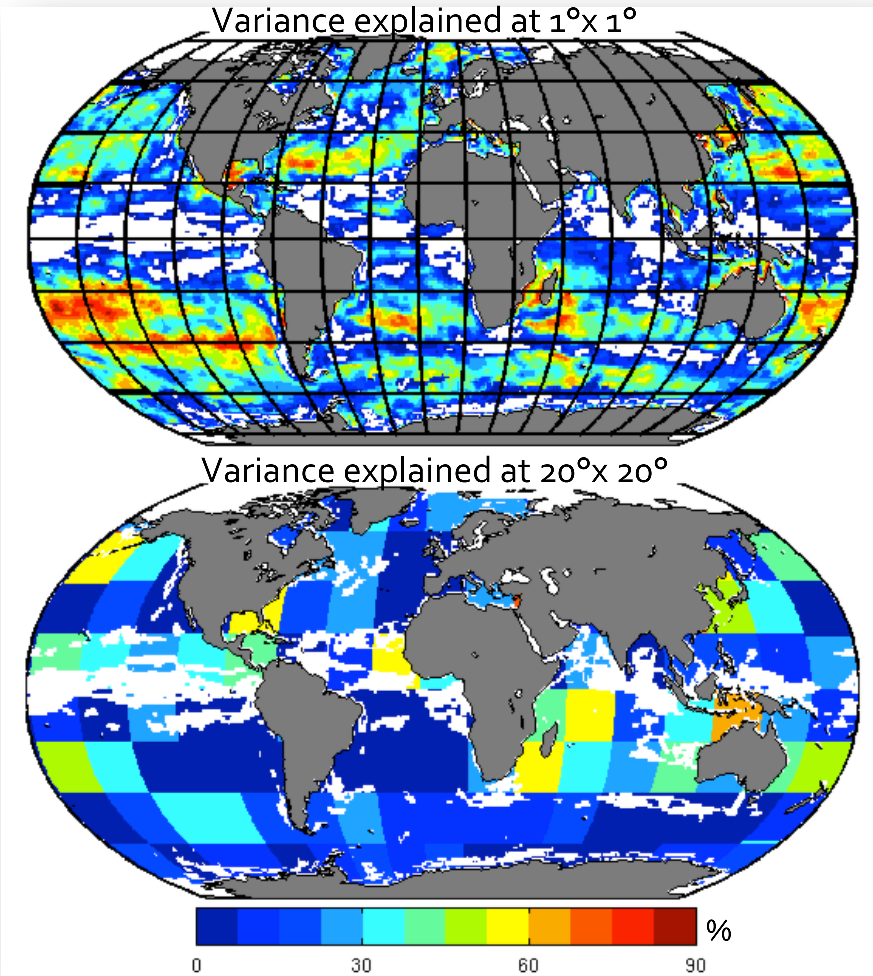
- For linear model (1) to be adequate: $\sigma^2(\varepsilon) << \sigma^2(\mathcal{F})$
  - If $\mathcal{O} \sim 0$ (as previously assumed, e.g., Bingham et al. 2011), then $\mathcal{S} = \mathcal{F}$
  - If $\mathcal{O} \neq 0$ (a more general approach), then (1) is valid if $\mathcal{O}$ and $\mathcal{F}$ are correlated

SALINITY-DERIVED $\mathcal{F}s$: 1°x1°



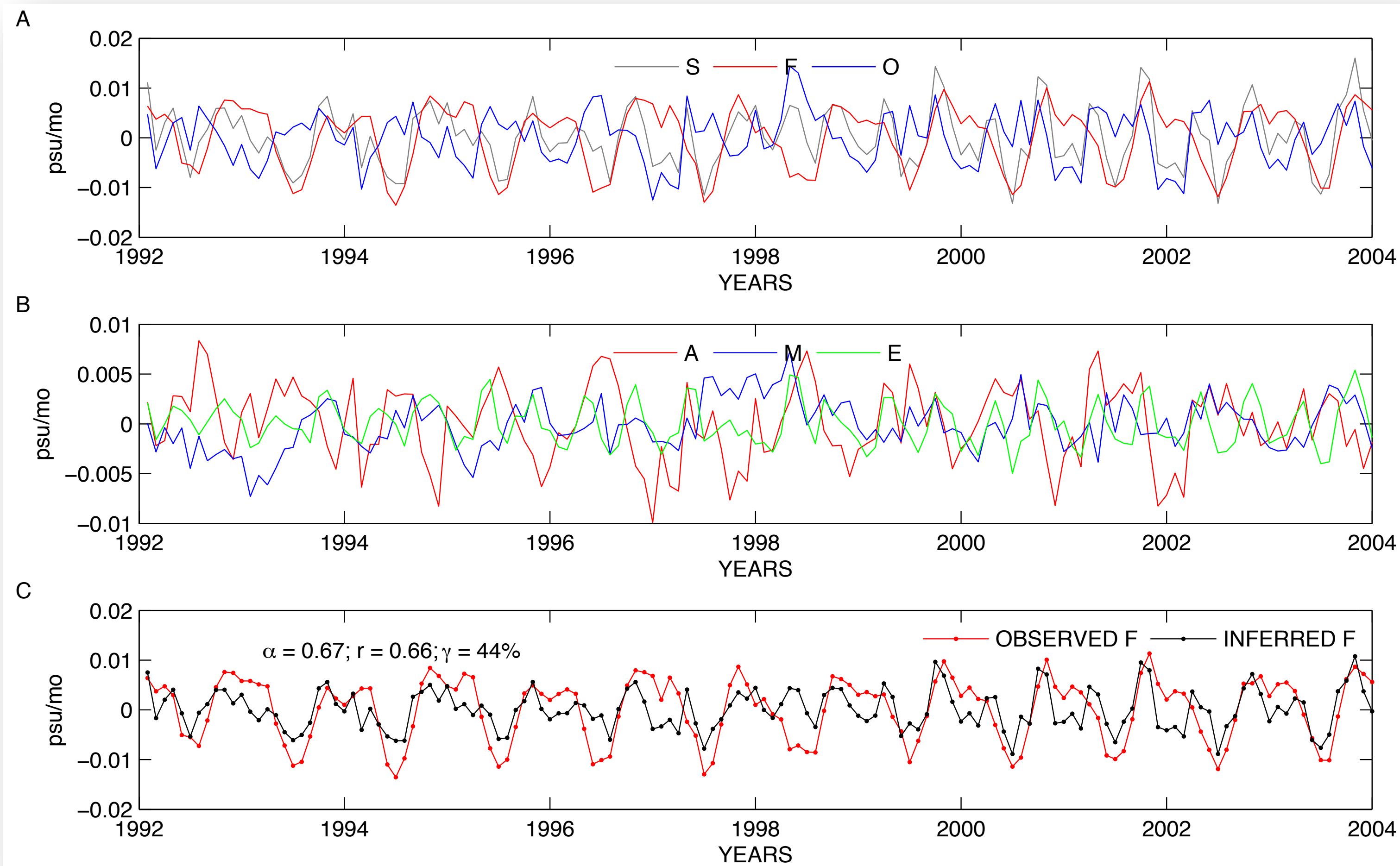
- Inter-annual time scales: linear relation is non-existent.
- Annual and shorter timescales: $\mathcal{F}$ can be inferred from $\mathcal{S}$ using linear model at several regions.

SALINITY-DERIVED $\mathcal{F}s$: 20°x20°



- For larger spatial scales, we compute $\mathcal{F}s$ based on S and $\mathcal{F}$ volume-averaged within 20°x20° box
- Considering larger spatial scales did not change the results

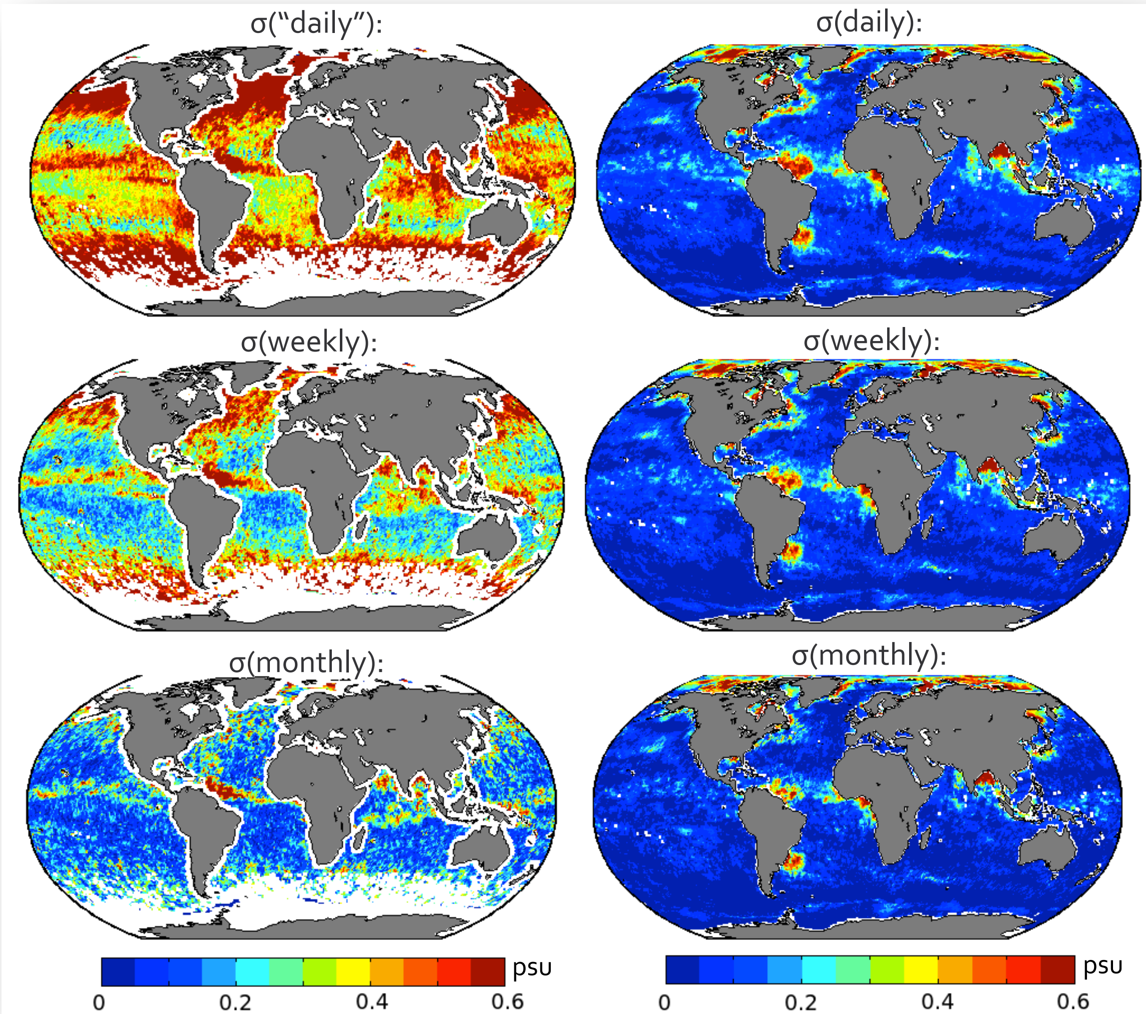
SALINITY-DERIVED $\mathcal{F}$s: GLOBAL-MEAN



- Apart from the forcing surface fluxes, ocean fluxes greatly affect the evolution of SSS
- $\mathcal{S}$ cannot be used as a proxy for global-mean fluxes of $\mathcal{F}$ (and $\mathcal{O}$) using linear model.

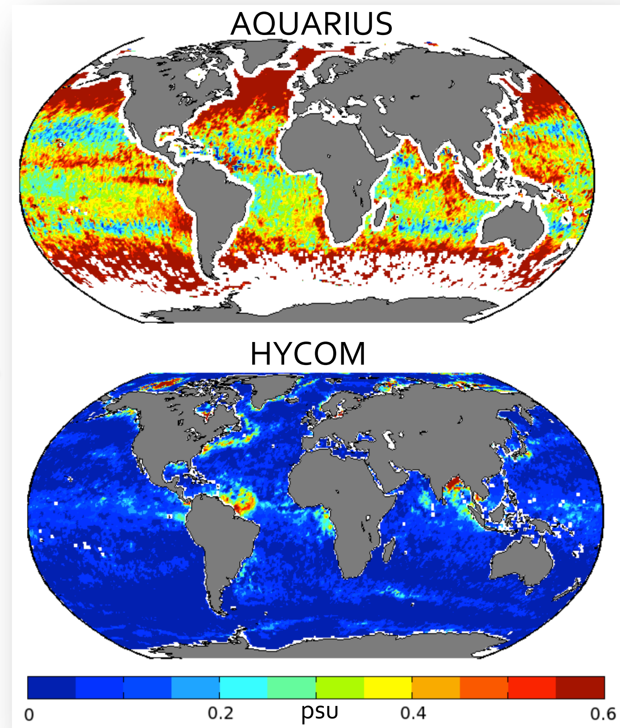
APPLICATION TO DATA?

AQUARIUS HYCOM



SUB-MONTHLY VARIABILITY:

$(\sigma^2(\text{daily})-\sigma^2(\text{monthly}))^{1/2}$



Aquarius variability at sub-monthly time periods is contaminated by noise

CONCLUSIONS

- Salt budget analysis show that variability in $\mathcal{S}$ can be attributed to both $\mathcal{F}$ and $\mathcal{O}$, demonstrating the importance of the ocean's role in evolution of SSS in many regions, particularly through advective fluxes of salt.
- There are only a few regions where SSS can be used as a proxy for $\mathcal{F}$ and $\mathcal{O}$ using linear model, and only at $T \leq 12$ months.
- Notice that the relationship can be different at higher temporal and spatial scales.
- Estimates of $\mathcal{S}$ and $\mathcal{F}$ can be also sensitive to model numerics (mixing schemes, etc).
- More sophisticated analysis (e.g., systems like ECCO) might offer a more meaningful estimation of $\mathcal{F}$ by assimilation of SSS observations.