AQUARIUS AND SMOS SALINITY ERRORS FOR ASSIMILATION INTO CLIMATE MODELS

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SATELLITE SSS AS NEW CONSTRAINTS

- Data assimilation involves minimizing the "distance" between model and data
- E.g.:

$$J(X) = \sum (\mathbf{I}X - D)^T \mathbf{W_D} (\mathbf{I}X - D) \rightarrow \mathrm{MIN}$$

- Weights W_D determine how important D become in the optimization
- Question:
  - What are appropriate weights for assimilation of Aquarius and SMOS into dynamical systems?

ESTIMATING WEIGHTS

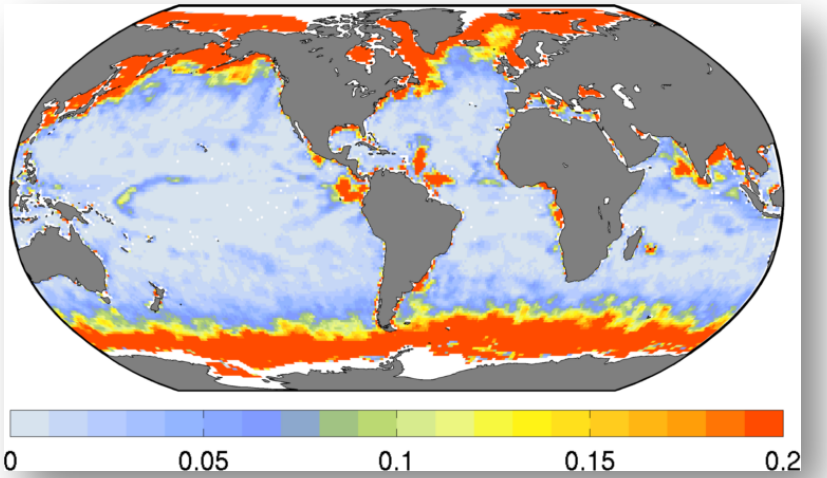
- Model (M) and Data (D) represent the Truth (T) as
  - $D = T + err_D$
  - $M = T + err_M$
- Then,
  - $var(err_D) = var(D) - cov(D, M) + cov(T, err_M) - cov(T, err_D) + cov(err_D, err_M)$ (0)
- $$\varepsilon_D^2 = \begin{cases} var(D) - cov(D, M) & \text{if } var(err_D) >= 0 \\ 10\ \%\ var(D\text{-}M) & \text{if } var(err_D) < 0 \end{cases}$$
- $W_D = 1 / \varepsilon_D^2$

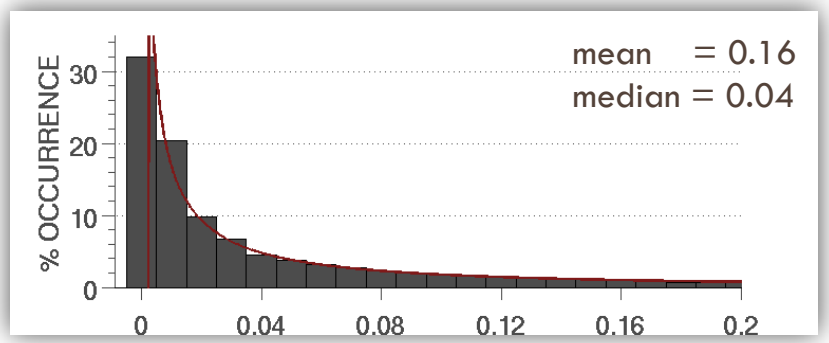
MODEL AND DATA

- DATA:
  - AQUARIUS L3 v2.0
  - SMOS L3 OI
- MODEL:
  - ECCO configuration state estimation
  - Forward run, no data constraints
- TIME PERIOD:
  - 16 months (Sep 2011 – Dec 2012)
  - Monthly output
  - All fields are on Aquarius 1deg grid

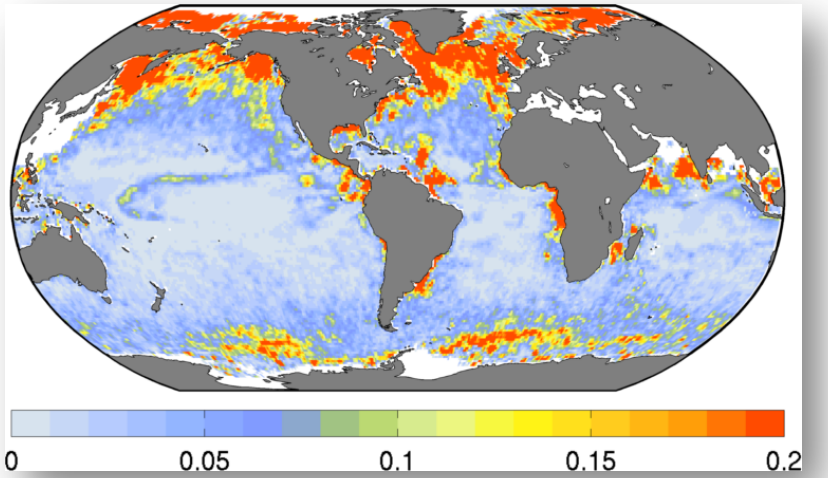
DATA ERROR VARIANCE, ε_D^2

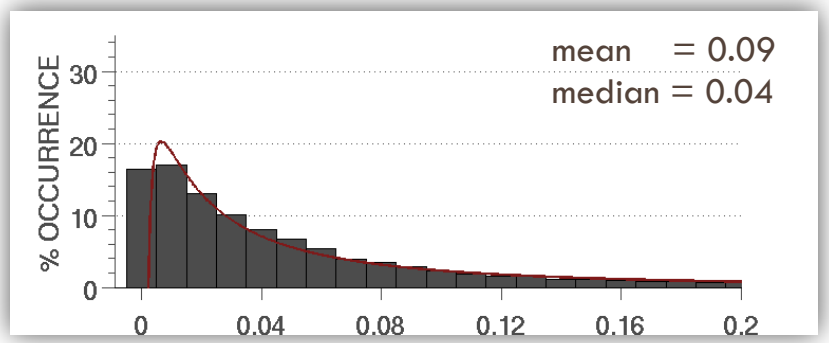
AQUARIUS





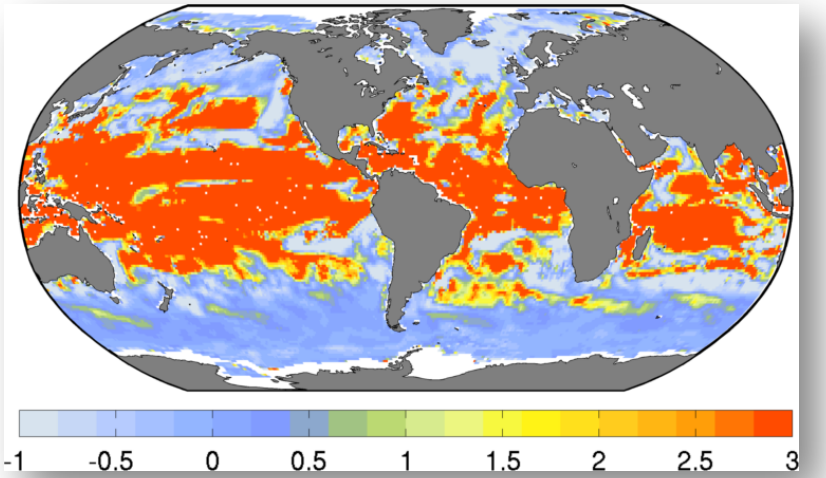
SMOS



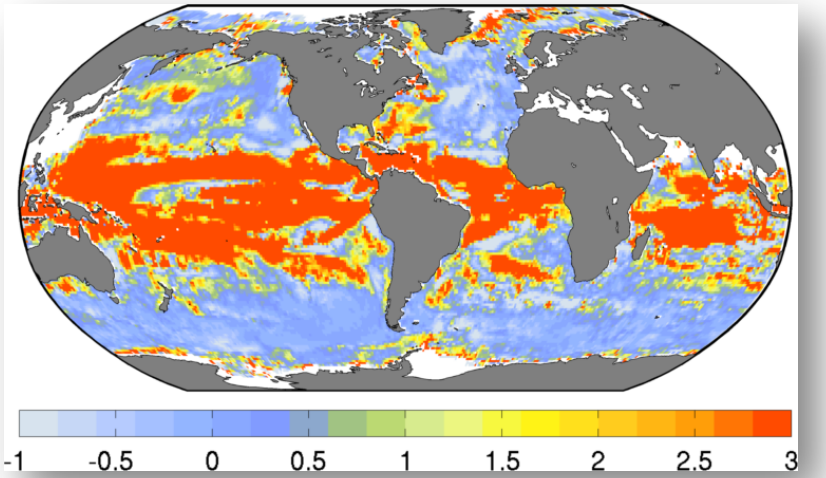


SIGNAL-TO-NOISE RATIO

AQUARIUS



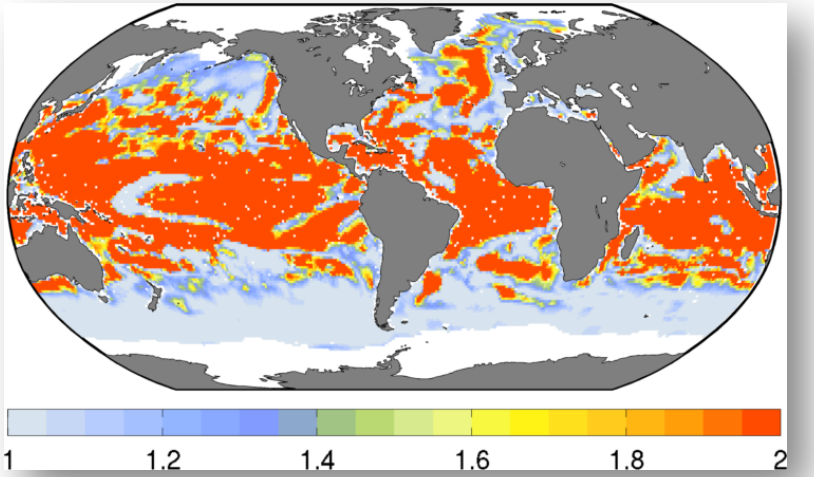
SMOS



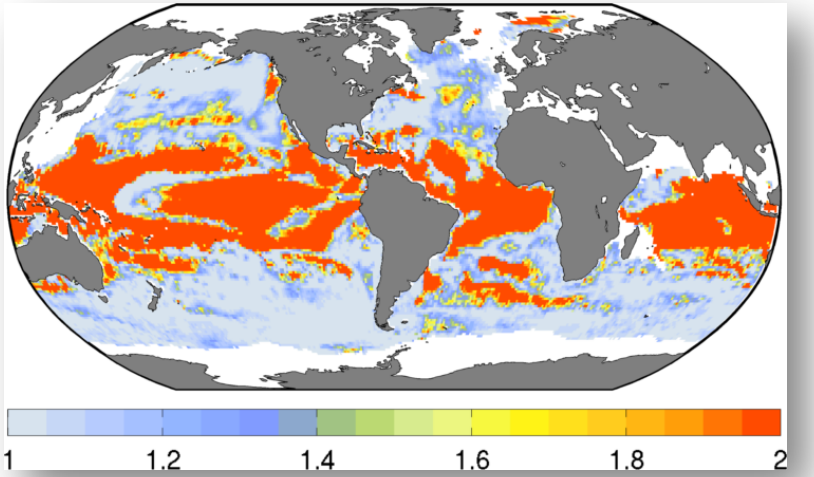
$$\text{SNR (dB)} = 10 \log_{10} (\text{var (D)} / \varepsilon_D^2)$$

COST

AQUARIUS

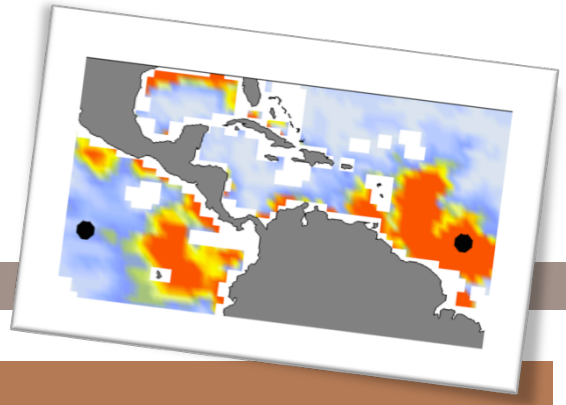


SMOS

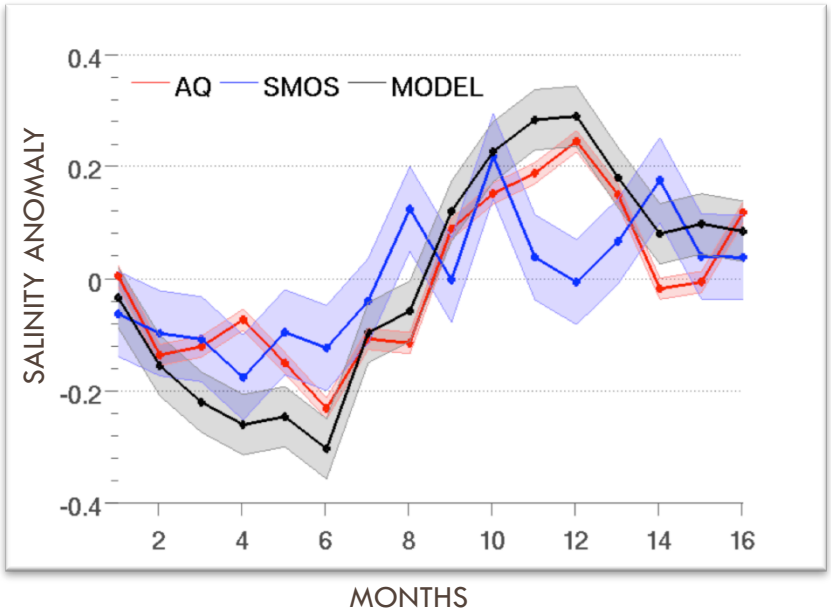


$$\text{cost} = \text{var}\,(D\text{-}M)/\,\varepsilon_D^{\,2}$$

EXAMPLES

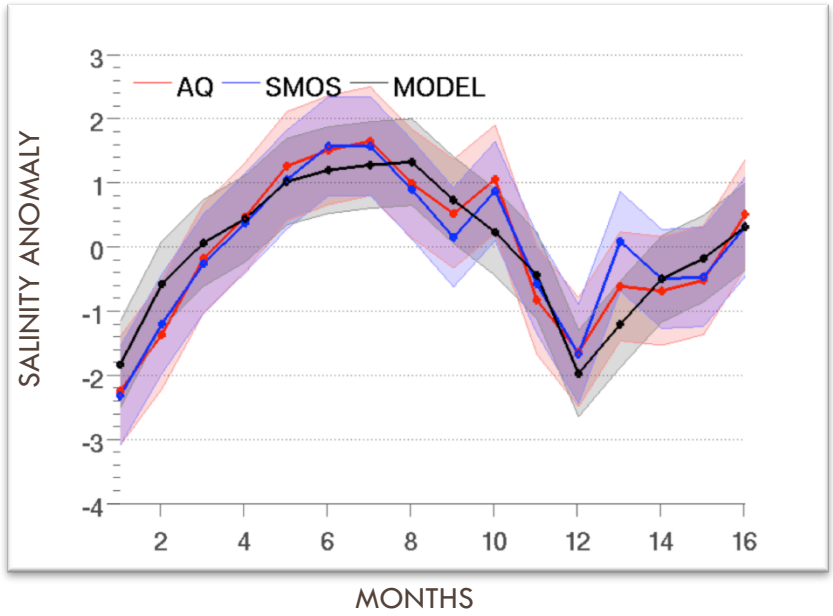


EQUATORIAL PACIFIC



	ε_D	cost
AQ	0.04	29
SMOS	0.2	1.2

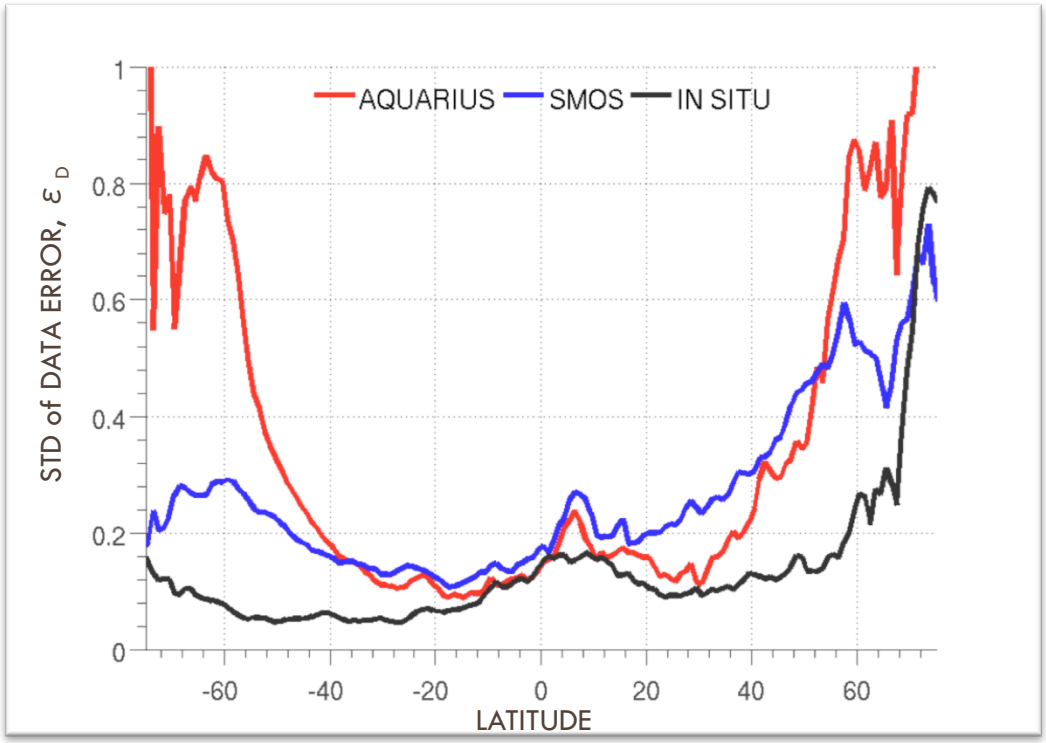
OFF AMAZON RIVER



	ε_D	cost
AQ	0.5	1.2
SMOS	0.4	1.1

ERROR BUDGET

STD OF DATA ERRORS, ε_D



LAT	AQ	SMOS	ALLC[1]
0° - 10°	.16	.19	.15
11°- 20°	.13	.16	.16
21°- 30°	.12	.18	.16
31°- 40°	.16	.21	.18
41°- 50°	.28	.28	.21
51°- 60°	.55	.38	.24
61°- 70°	.79	.39	.26
71°- 80°	.89	.47	.26
AVE	**.36**	**.28**	**.20**

[1] *Lagerloef et al., Oceanogr., 2008*

SOURCES OF ERRORS

EQUATORIAL BAND:
10°S – 10°N

$\varepsilon_{InSitu} = 0.15$

$\varepsilon_{AQ} = 0.16$

- $\varepsilon_D^2 =$ instrument + sampling + representation error
- Sources of sampling/representation errors:
  - Small-scale noise [1]
  - Temporal aliasing [2]
  - Near-surface vertical stratification [3]
- In situ:
  - $\varepsilon_{InSitu}^2 \approx \varepsilon_{instr}^2 + \varepsilon_{aliasing}^2 + \varepsilon_{vert}^2 + \varepsilon_{small\text{-}scale}^2$
  - $\varepsilon_{instr} \approx \sqrt{0.15^2 - (0.09^2 + 0.06^2 + 0.12^2)} \approx 0.02$
- AQ:
  - $\varepsilon_{AQ}^2 \approx \varepsilon_{instr}^2 + \varepsilon_{aliasing}^2 + \varepsilon_{vert}^2$
  - $\varepsilon_{instr} \approx \sqrt{0.16^2 - (0.09^2 + 0.06^2)} \approx 0.12$

[1] Vinogradova & Ponte, JTECH, 2013; [2] Vinogradova & Ponte, JTECH, 2012; [3] Vinogradova & Ponte, in prep;

CONCLUSIONS

1. Aquarius and SMOS constraints could measurably affect estimated SSS values in several ocean regions (e.g., WB, ITCZ, EQ).

2. Derived errors are comparable to mission accuracy requirements in low and mid latitudes, but considerably larger at high latitudes.