Assessing the uncertainties in Atmospheric Reanalyzed Surface Freshwater Budgets using satellite-based freshwater products and ocean salinity observations

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MAPP Climate Reanalysis Task Force (CRTF)
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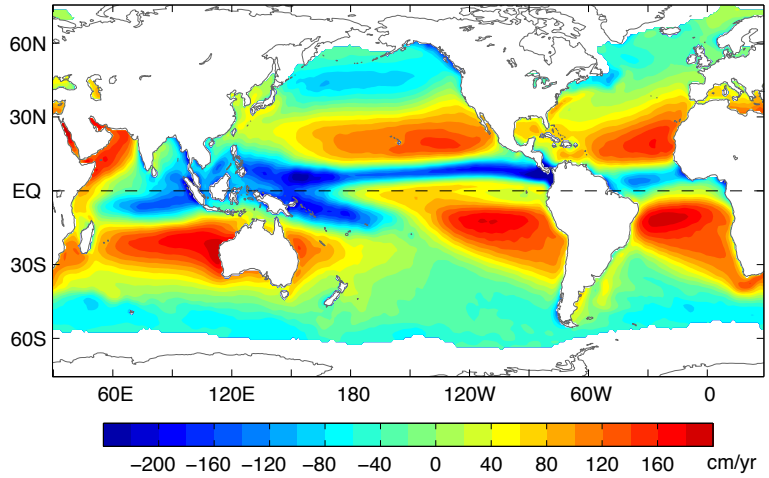
Main issues:

- Uncertainties in the surface freshwater flux products from the reanalysis.
  - Mean
  - Seasonal cycle
  - Variability of interannual and long timescale
  - Trend
- Using ocean salinity observations evaluate the uncertainties.
  - develop salinity-based metrics for validation (preliminary results)

9 E – P Products:
- NCEP1
- NCEP2
- CFSR
- ERA-interim
- MERRA
- JRA55
- 20CRv2
- OAFlux - GPCP
- OAFlux - CMAP

Freshwater fluxes: Evaporation – Precipitation (E – P)

Mean (9 Products) 1979-2014

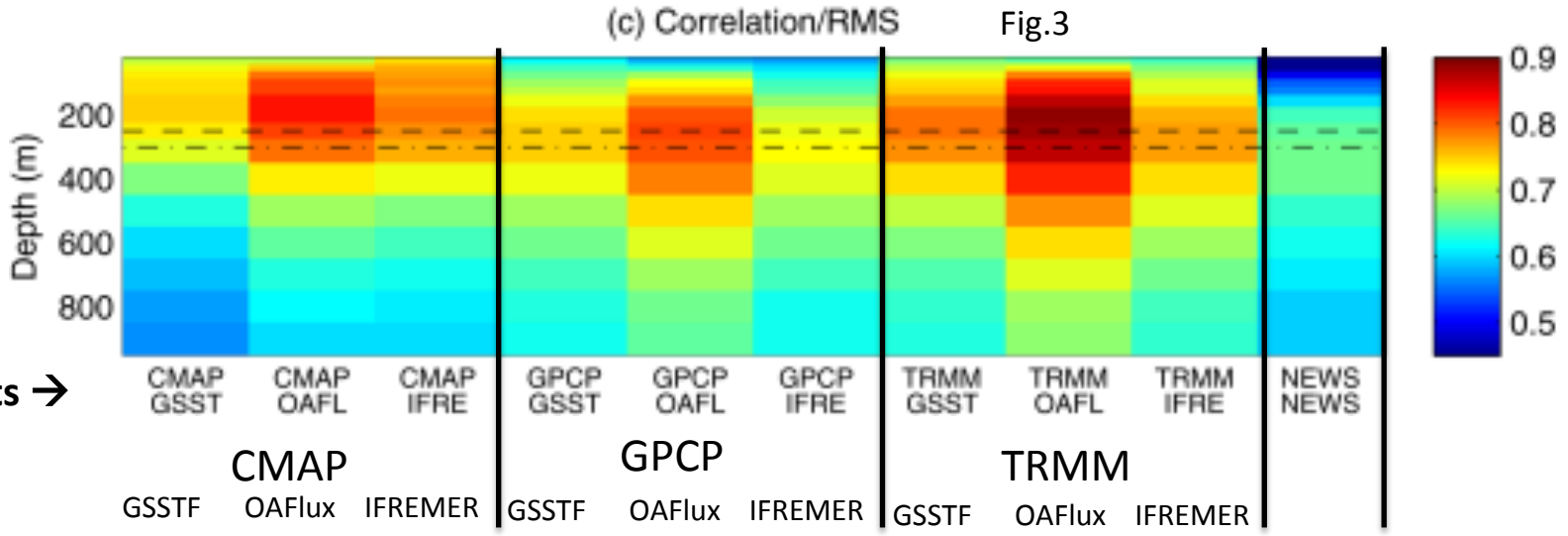


OAFlux: WHOI Evaporation product (Yu et al. 2008)
GPCP: NASA precipitation product (Adler et al. 2003)
CMAP: NOAA CPC precipitation product (Xie and Arkin, 1997).

Selecting OAFlux-GPCP as base E-P reference

Mean pattern of OAFlux-GPCP shows good consistency with the salinity-derived E-P.

One most recent data-based assessment is conducted by L. Ren, E. Hackert, P. Arkin, and A. Busalacchi : "**Estimating the global oceanic net freshwater flux from Argo and comparing it with satellite-based freshwater flux products**" (JRG-Oceans, 2014)



Evaporation products:

(i) OAFlux

(ii) GSSTF3 (Goddard Satellite-Based Surface Turbulent Fluxes v3, Shie et al. 2009)

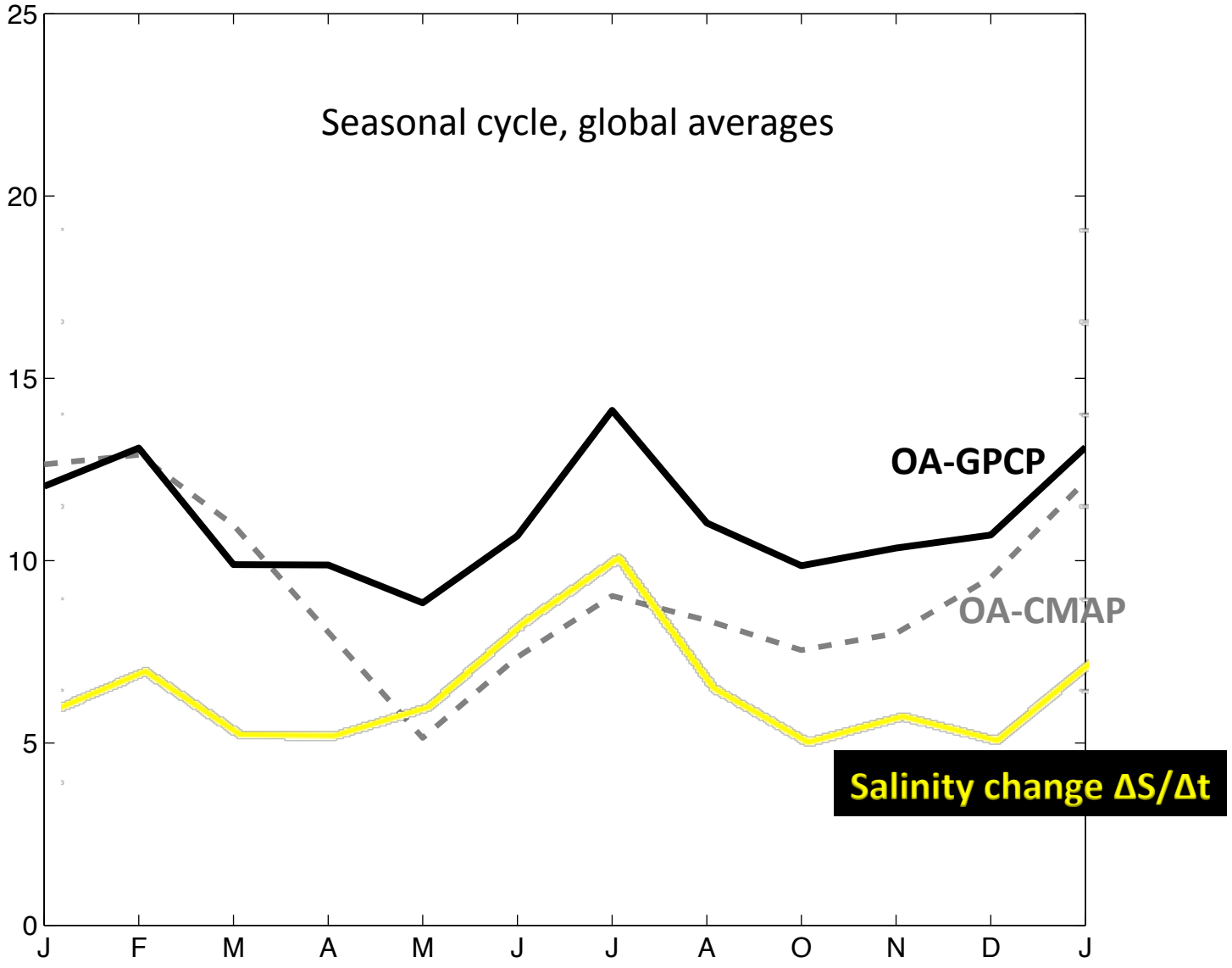
(iii) IFREMER (France, Bentamy et al. 2013)

Precipitation products:

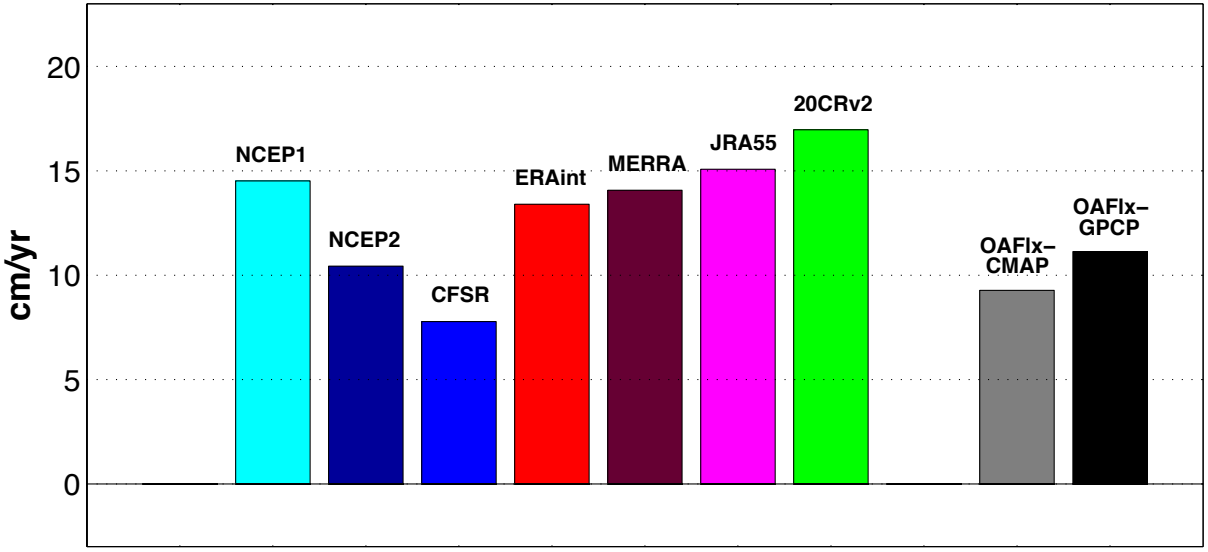
(i) CMAP, (ii) GPCP, (iii) TRMM (40S-40N).

E-P product: NEWS - RSS (Remote Sensing Systems)

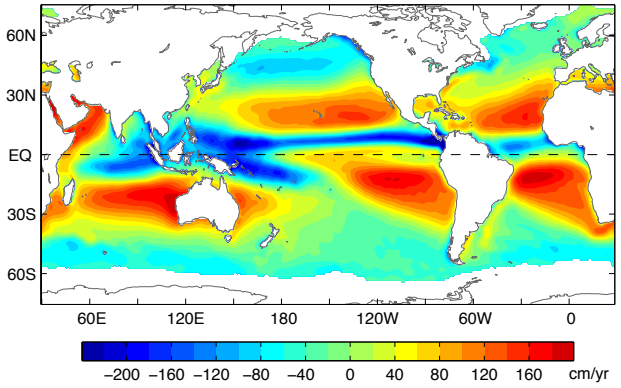
OAFlux - GPCP shows good consistency with the seasonal cycle of ocean salinity.



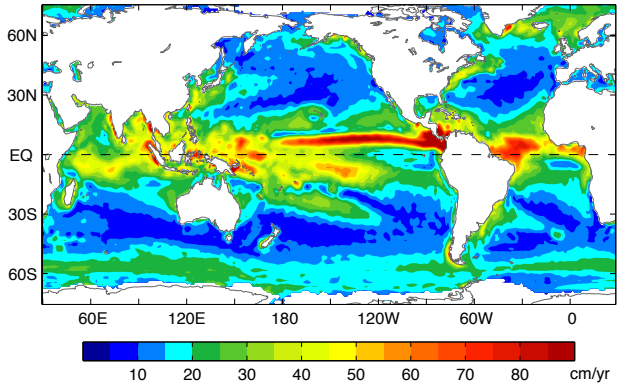
Estimates of the E-P Budget over the global oceans



Mean (9 Products) 1979-2014

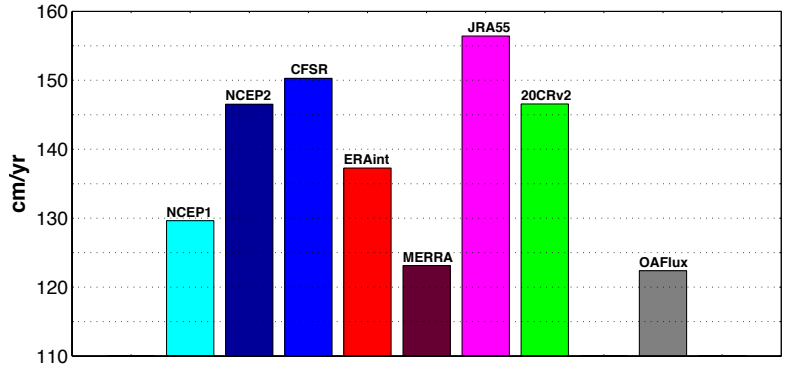


STD E – P (9 Products)

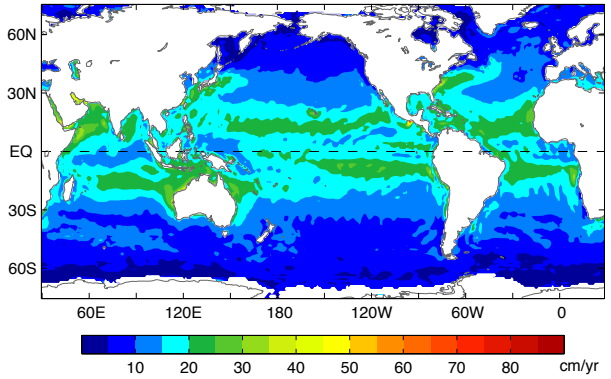


Estimates of the E and P Budget over the global oceans

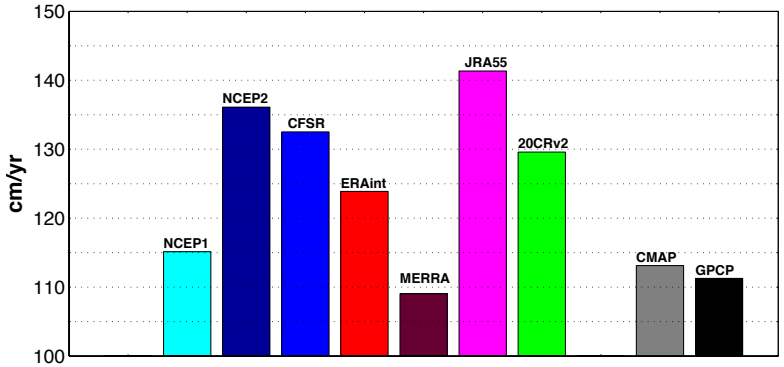
Global average: E



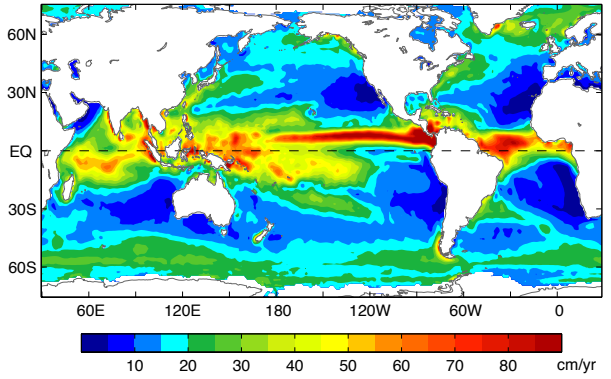
STD E (8 Products)



Global average: P

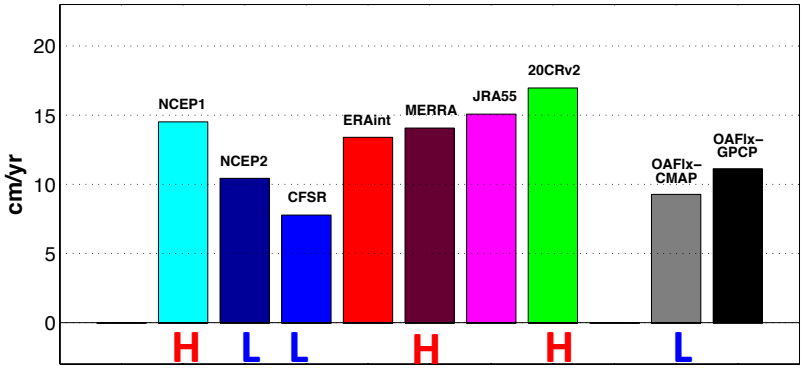


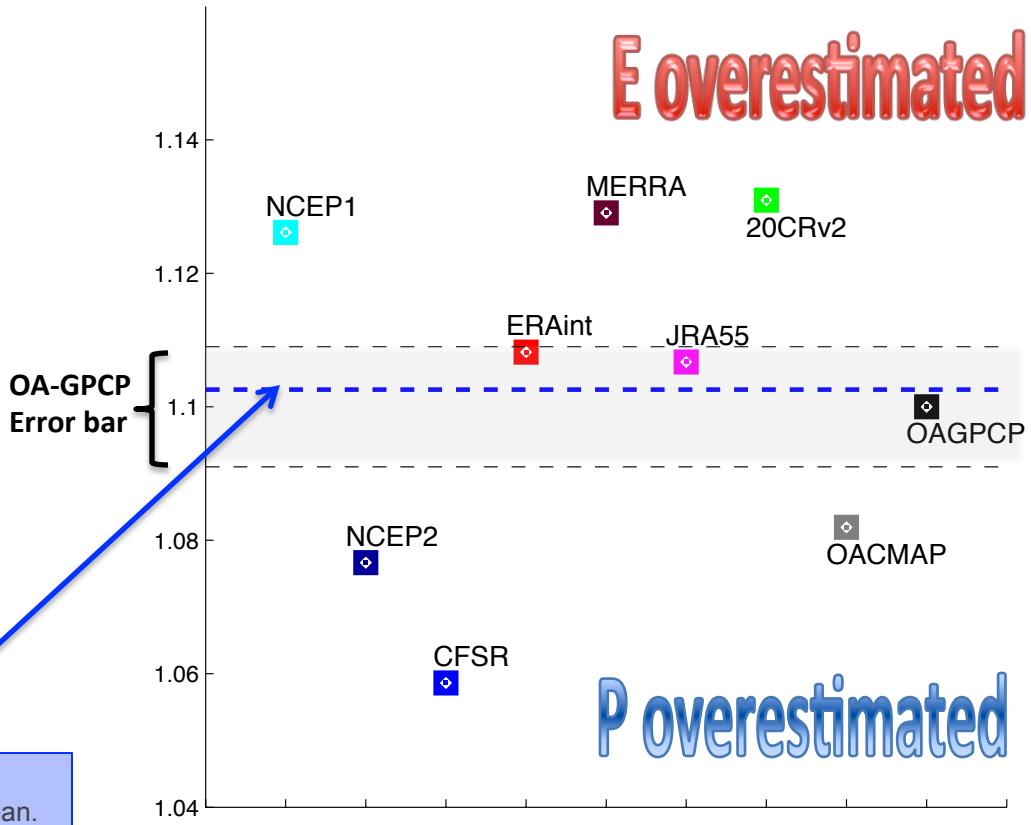
STD P (9 Products)



Estimates of the E and P Budget over the global oceans

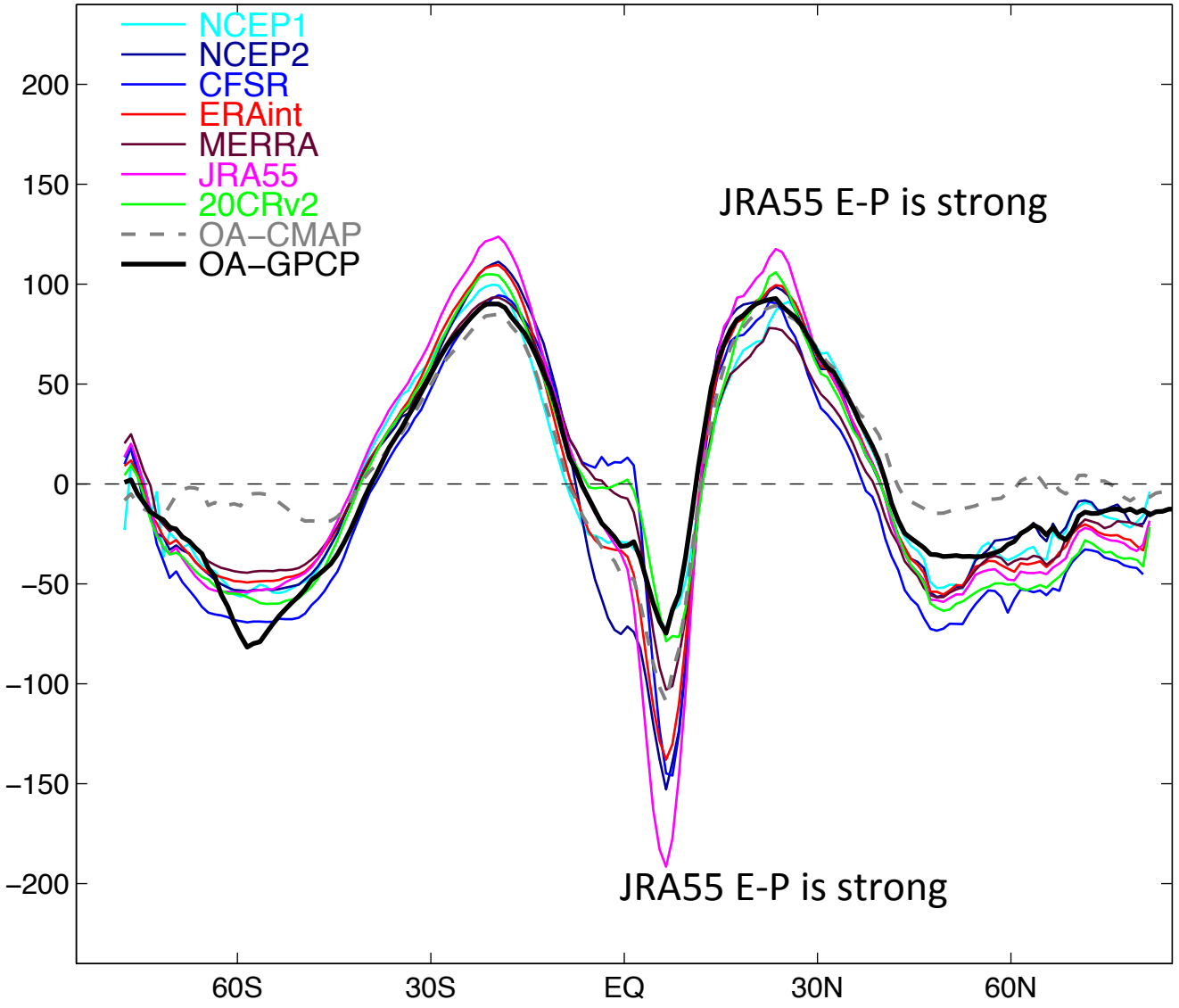
Global average: E-P





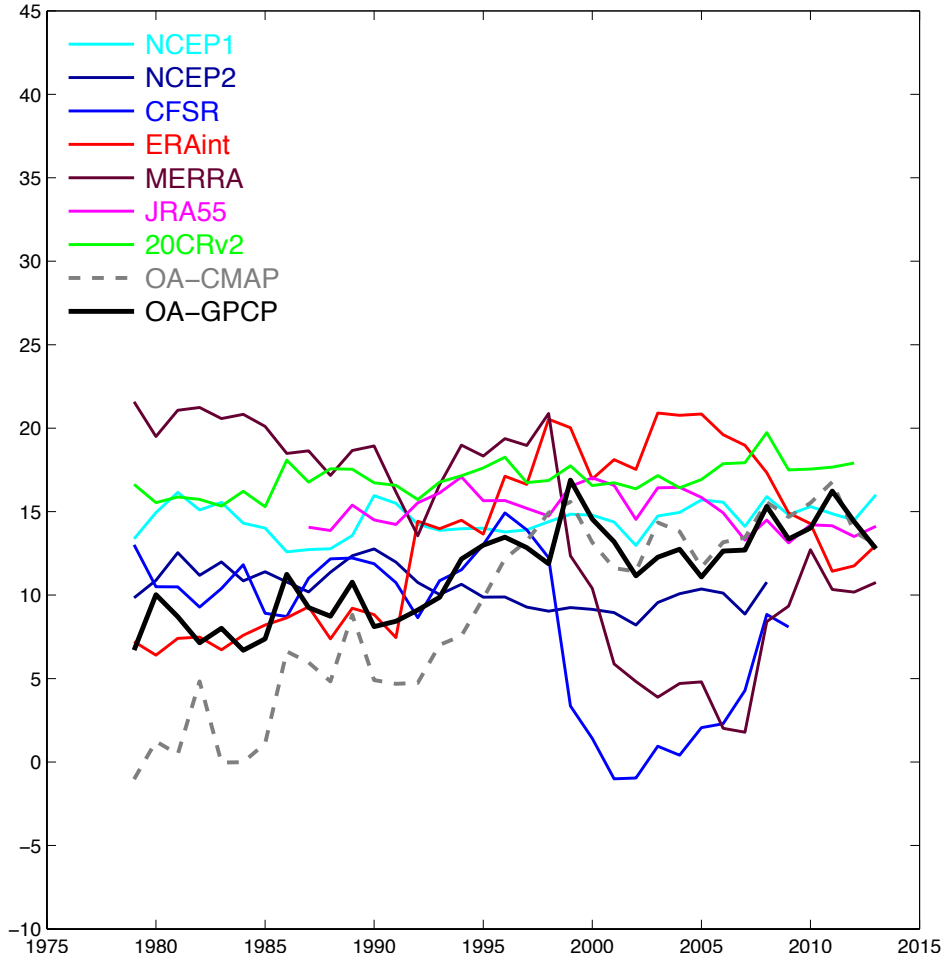
Textbook:
globally, **86% of E and 78% of P** occur over the ocean.

Zonal averages

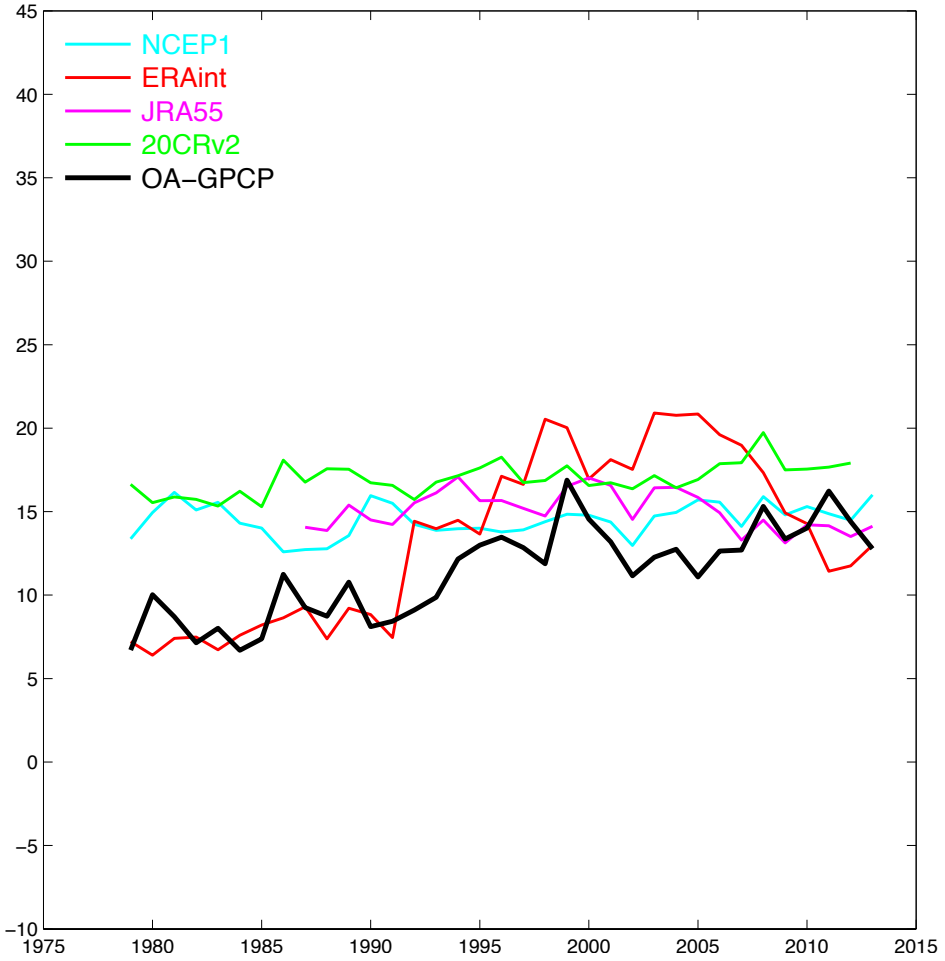


Time series of E-P averaged over the global oceans

All 9 products

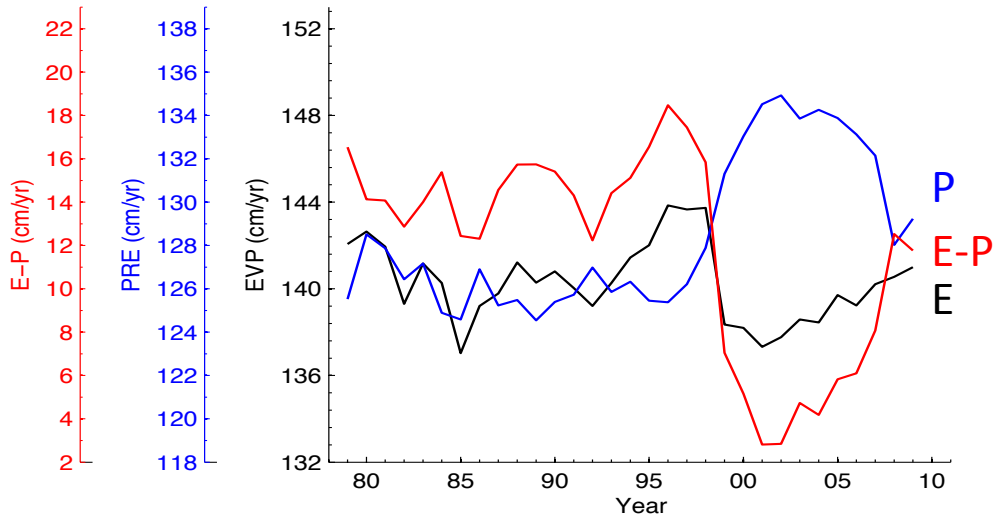


Remove NCEP2, CFSR, MERRA, OACMAP

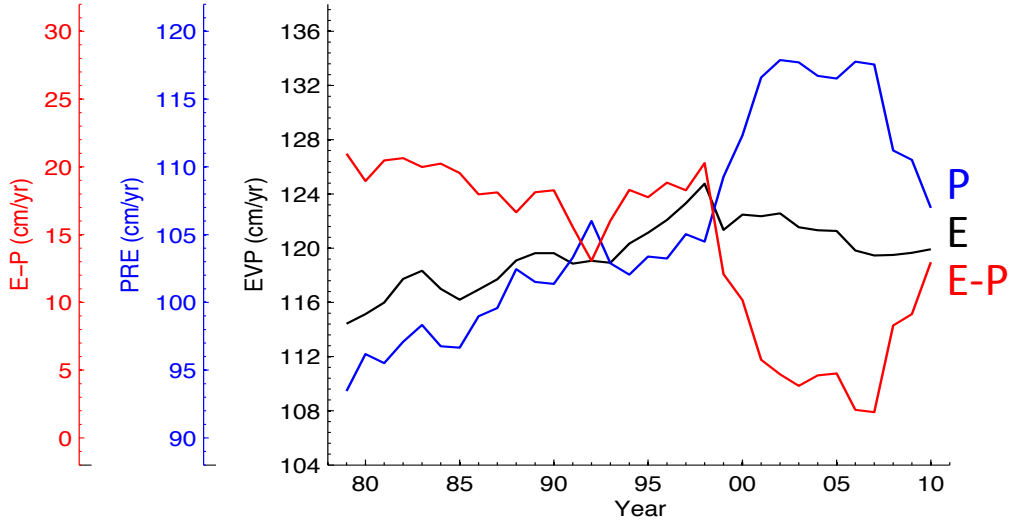


What is the problem in CFSR and MERRA?

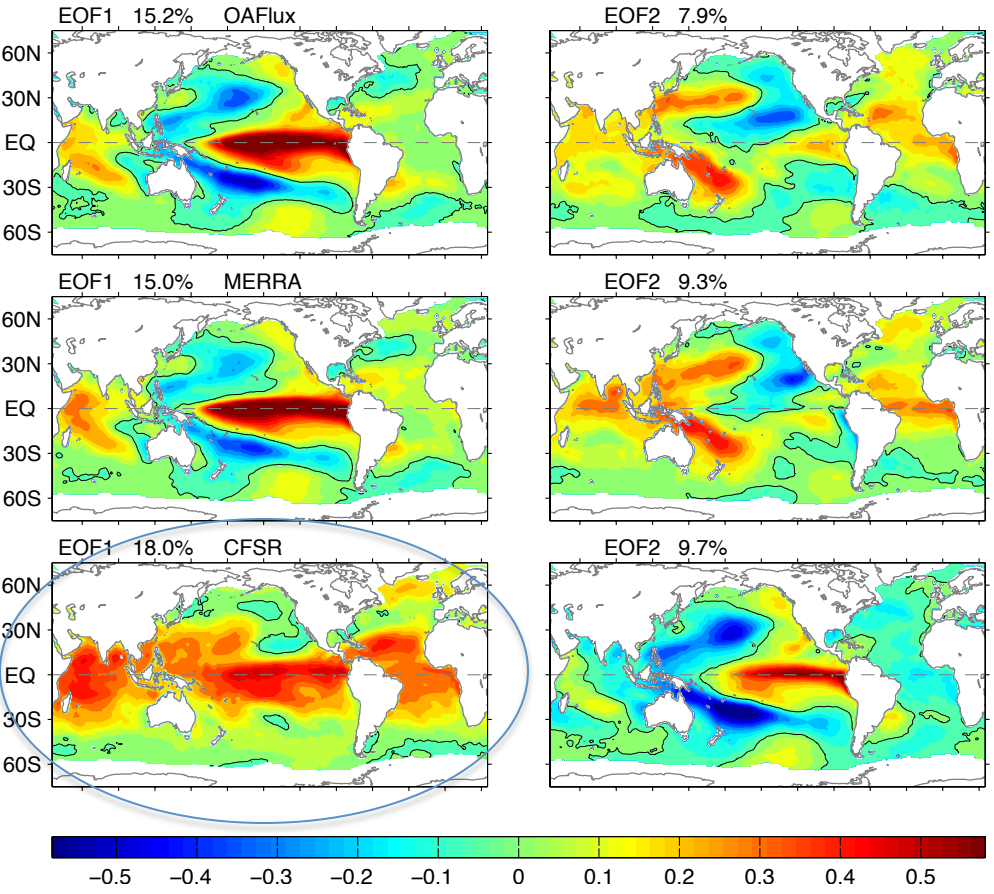
CFSR, Artificial jump occurred around 1997-98in both E and P

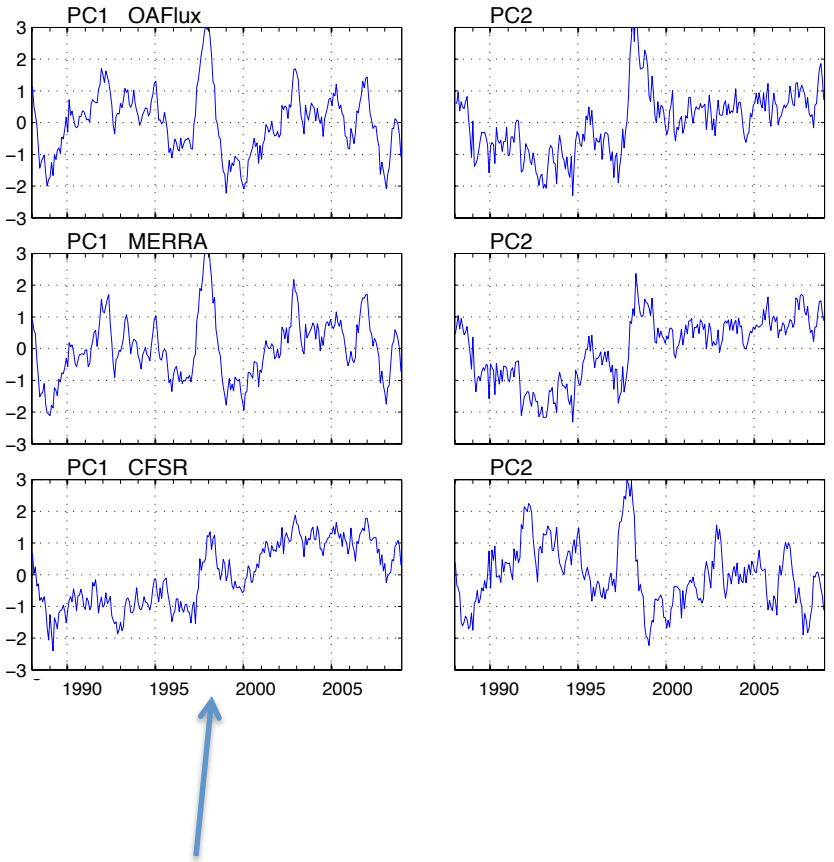


MERRA, Artificial jump occurred around the similar time, more on P.

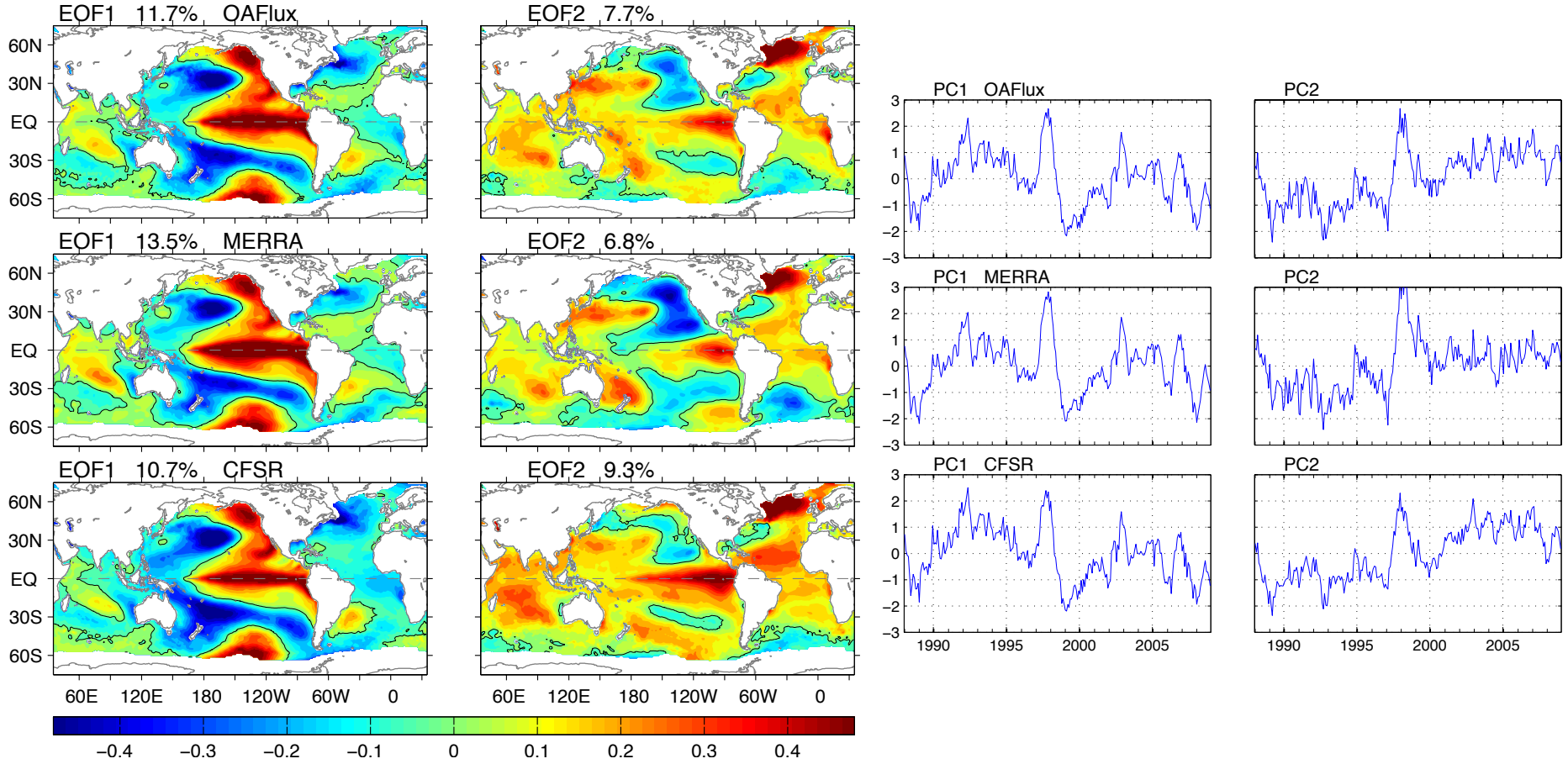


EOF mode 1: CFSR air-humidity shows a jump in the mean state

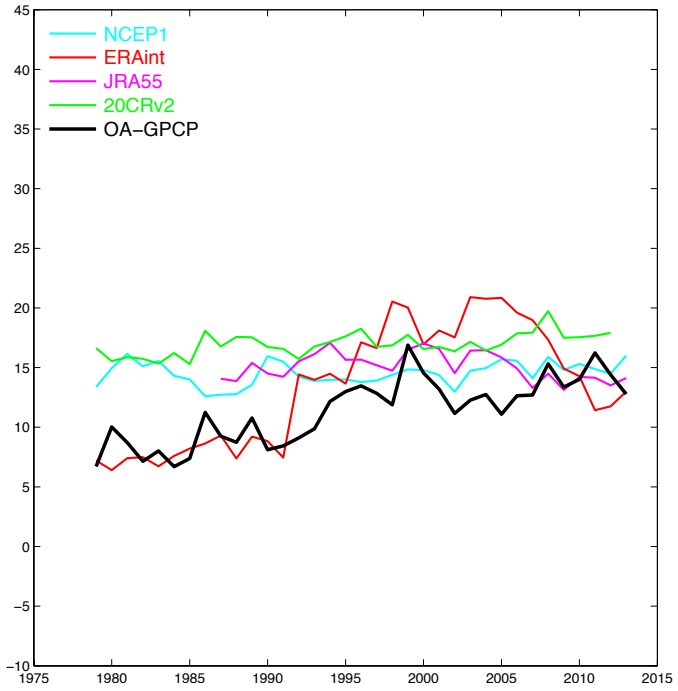


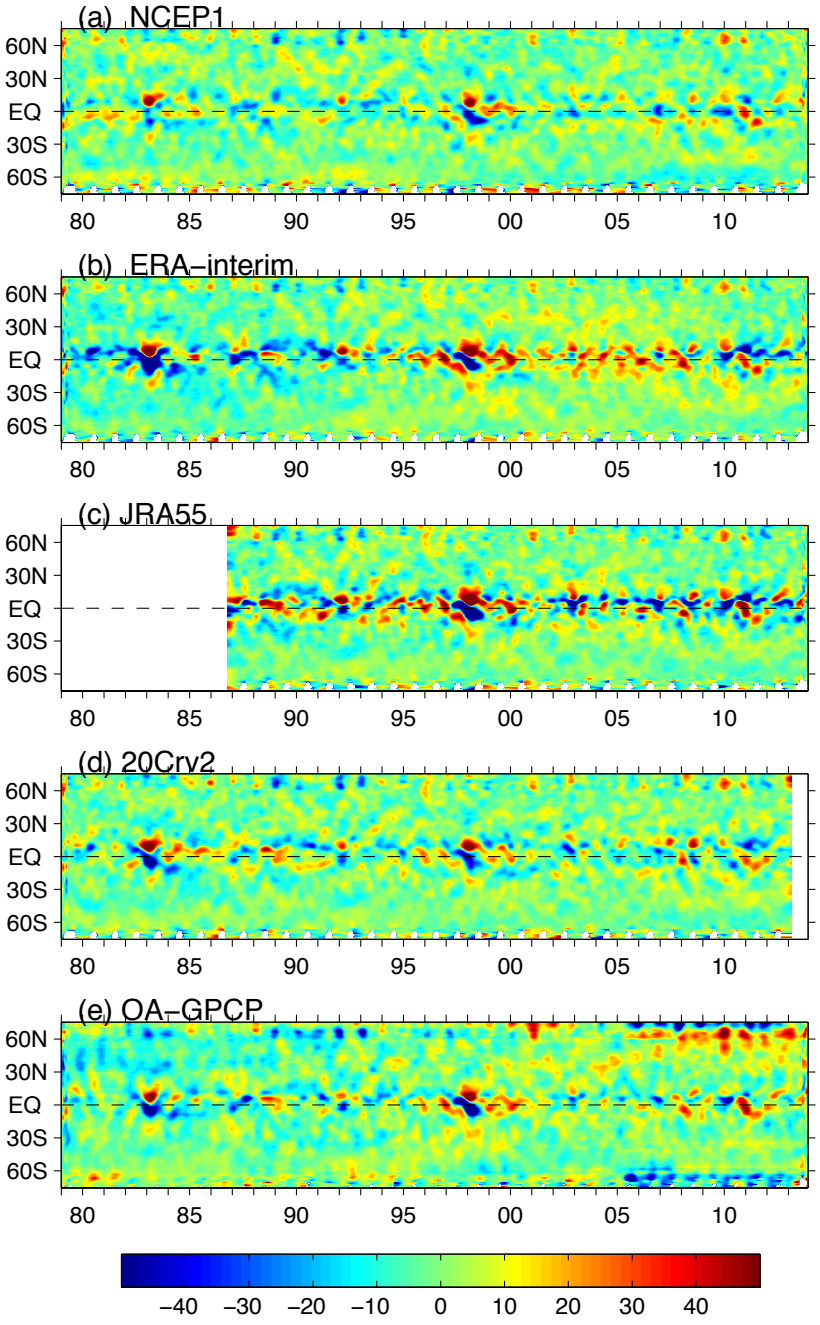


CFSR air-temperature is less affected.

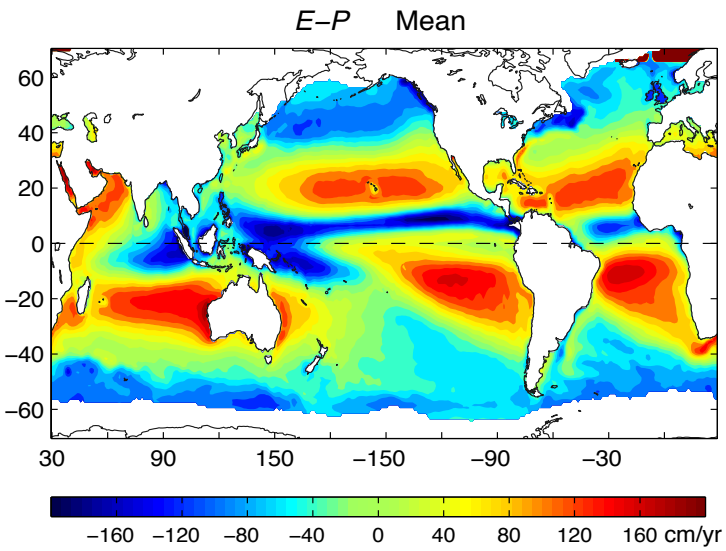


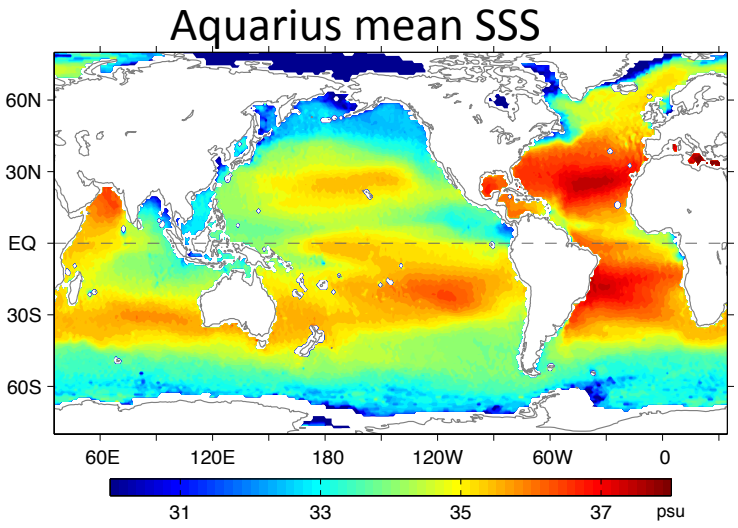
Which time series has the right trend?





Mean patterns of E-P and salinity are related.





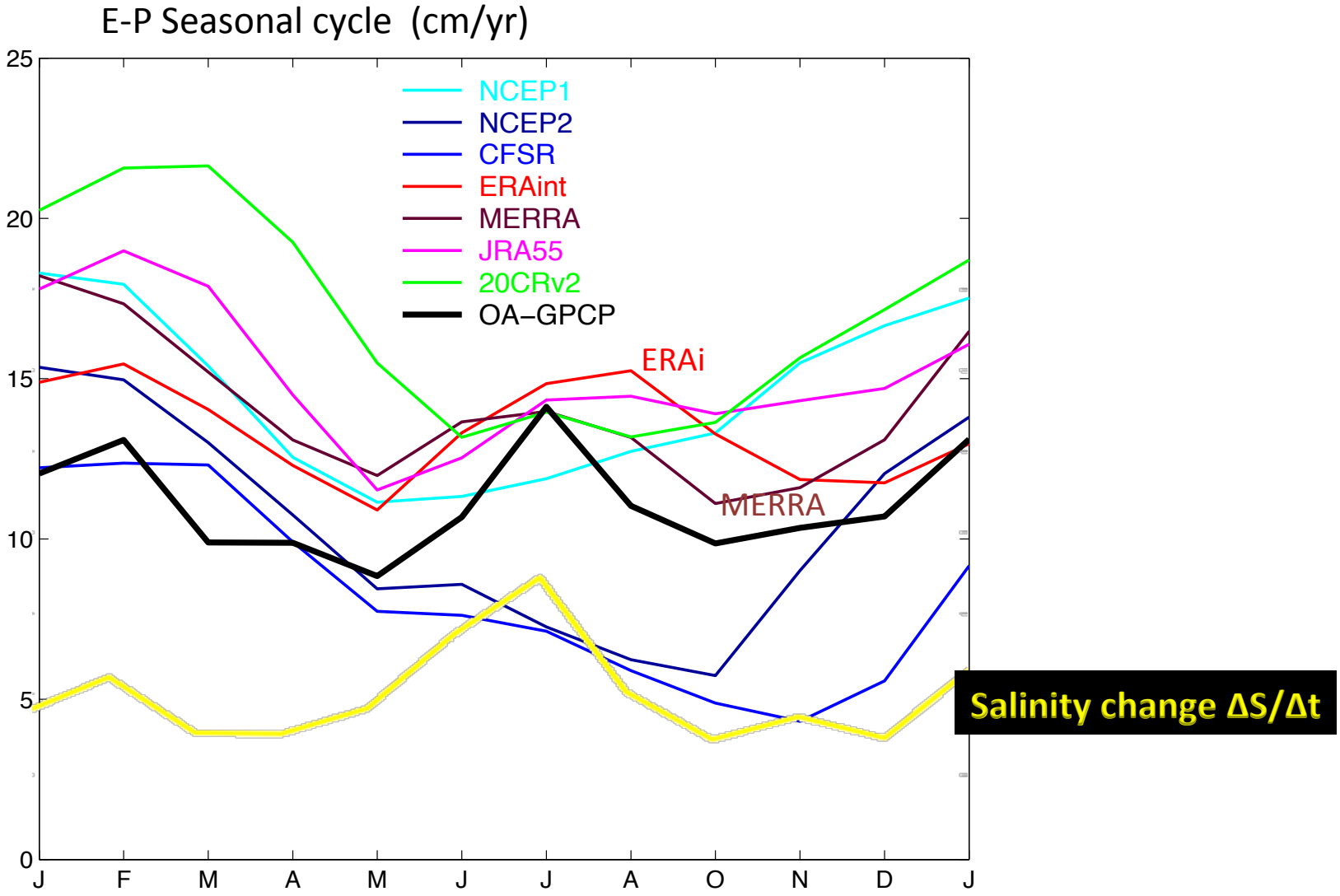
The observation record is too short to validate the long-term trend pattern in the surface freshwater fluxes.
They may be useful for validating the seasonal variability

$$\frac{\partial S'}{\partial t} \approx \frac{S_0\left(E' - P'\right)}{\bar{h}} - \bar{\mathbf{U}}_{\boldsymbol{EK}} \cdot \nabla S' - \mathbf{U}'_{\boldsymbol{EK}} \cdot \nabla \bar{S} - \bar{\mathbf{U}}_{\boldsymbol{g}} \cdot \nabla S' - \mathbf{U}'_{\boldsymbol{g}} \cdot \nabla \bar{S} - \frac{(\Gamma(w_e)(S - S_b))'}{\bar{h}} + R$$

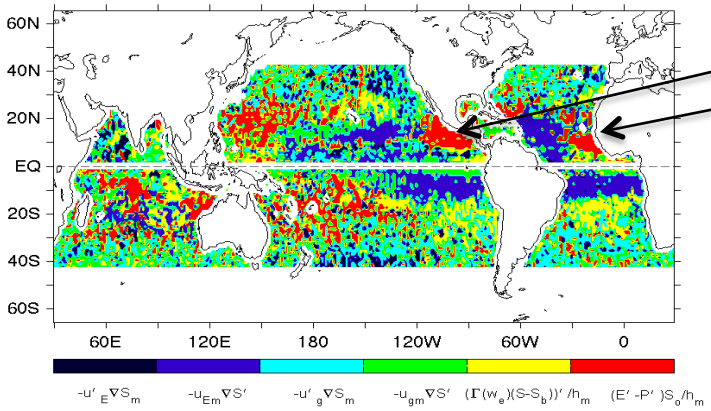
Salinity change E-P Ocean processes

Salinity-based evaluation

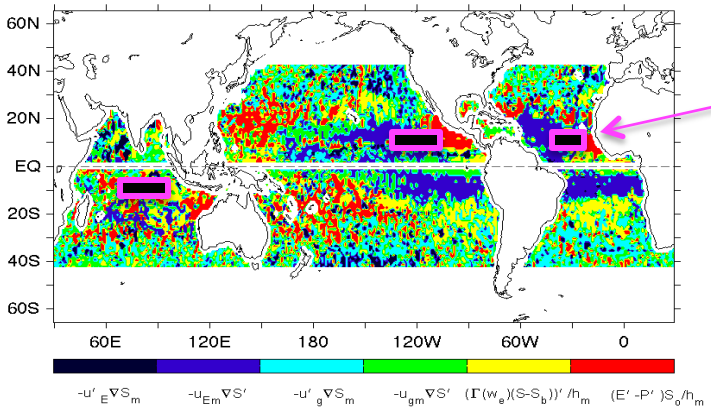
Seasonal cycle, global average



Regionally, where does the E-P contribute most to the salinity change?



E-P dominance



Three boxed areas are selected

$$\frac{\partial S'}{\partial t} \approx \frac{S_0\left(E' - P'\right)}{\bar{h}} - \bar{\mathbf{U}}_{EK} \cdot \nabla S' - \mathbf{U}'_{EK} \cdot \nabla \bar{S} - \bar{\mathbf{U}}_g \cdot \nabla S' - \mathbf{U}'_g \cdot \nabla \bar{S} - \frac{(\Gamma(w_e)(S - S_b))'}{\bar{h}} + R$$

Salinity change

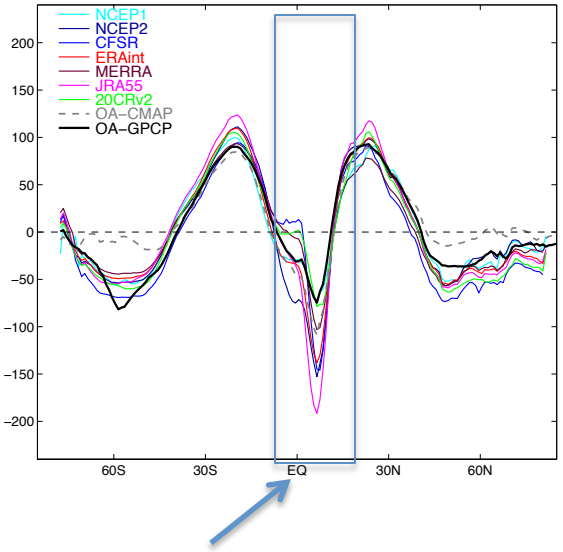
E-P

Ocean processes

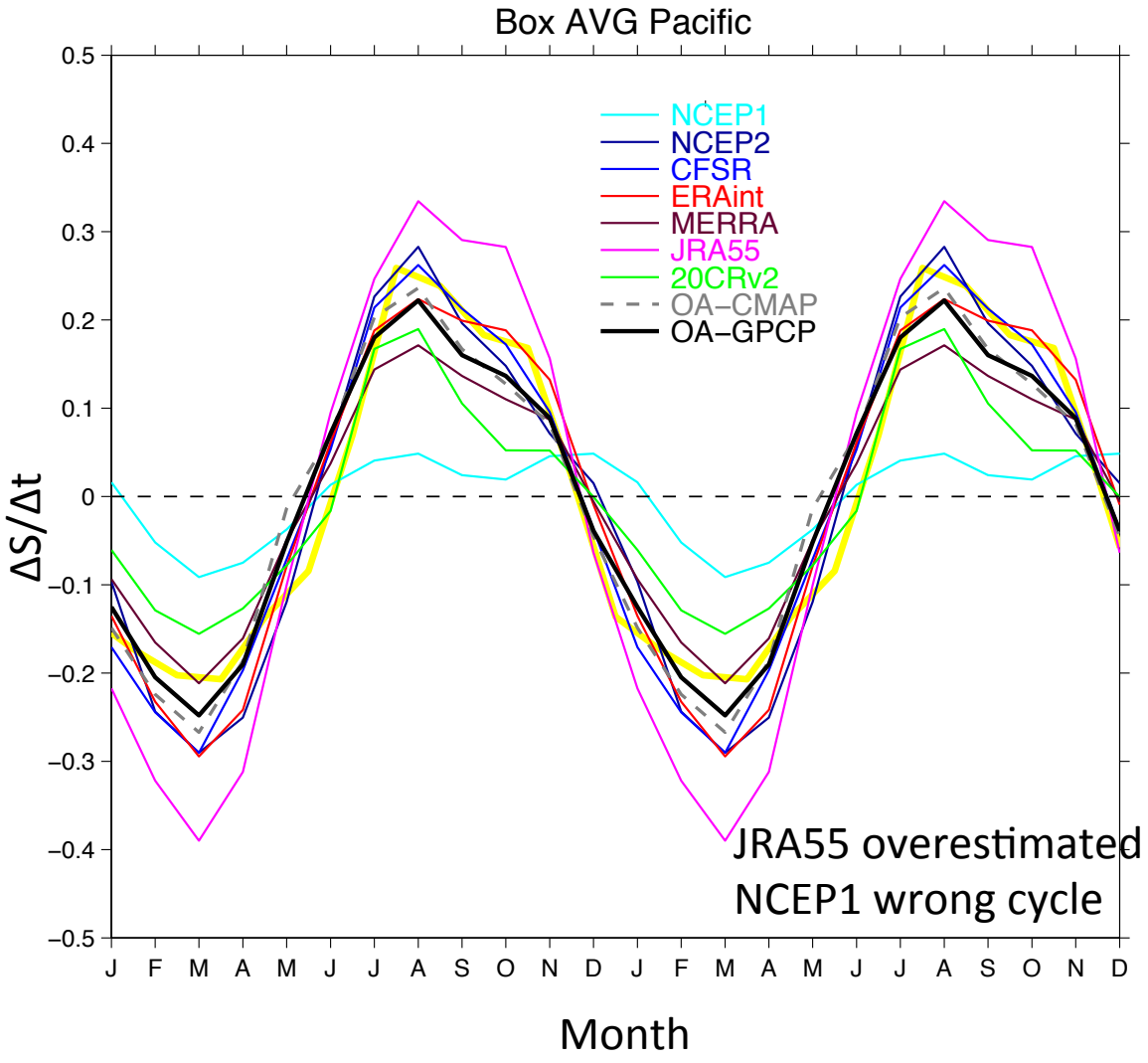
Salinity-based evaluation

Seasonal cycle, box average: the eastern Pacific

Zonal Average

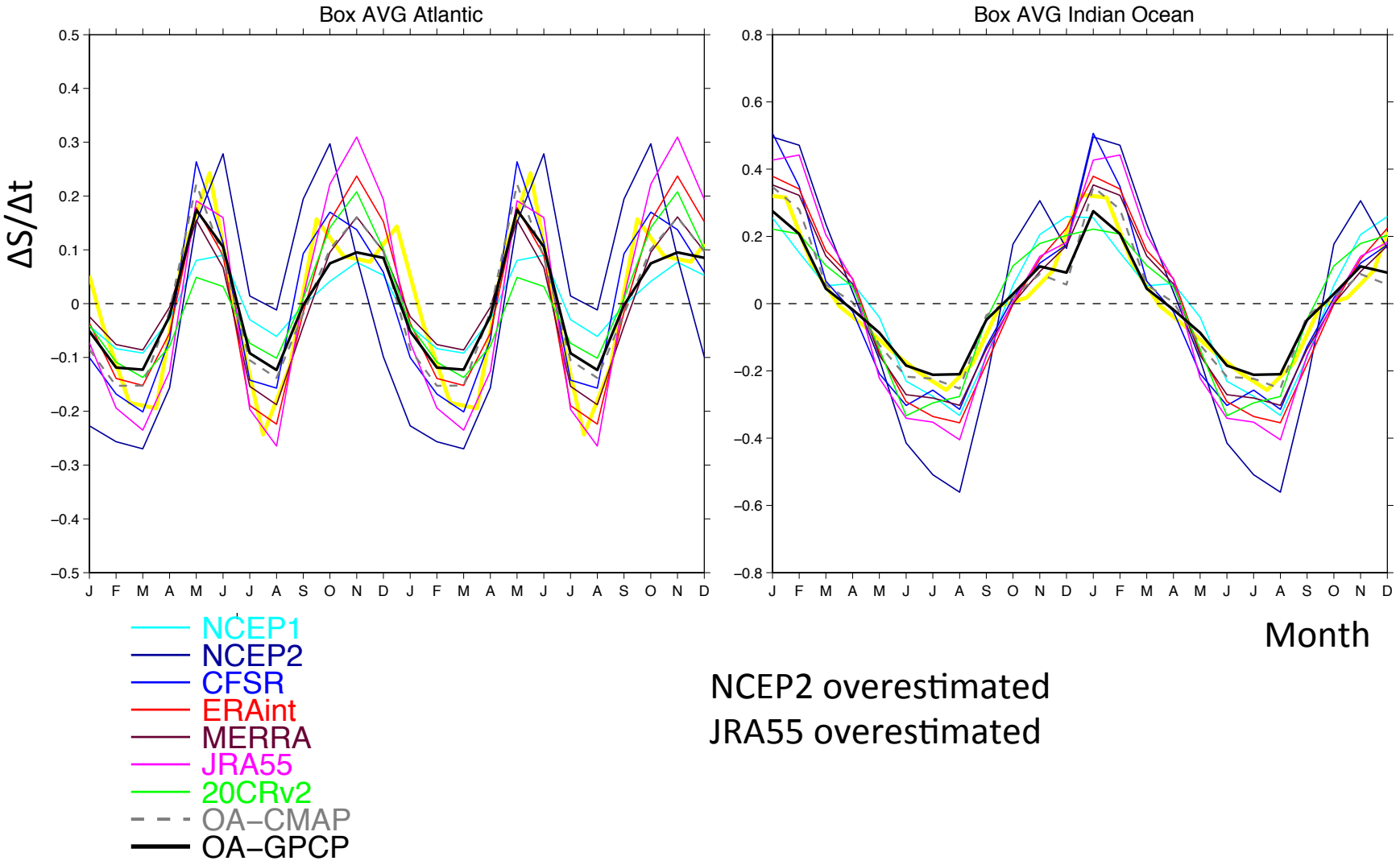


Box-averaged salinity metrics examine the E-P in the tropical ocean.



Salinity-based evaluation

Seasonal cycle, box average: the tropical Atlantic and Indian Oceans

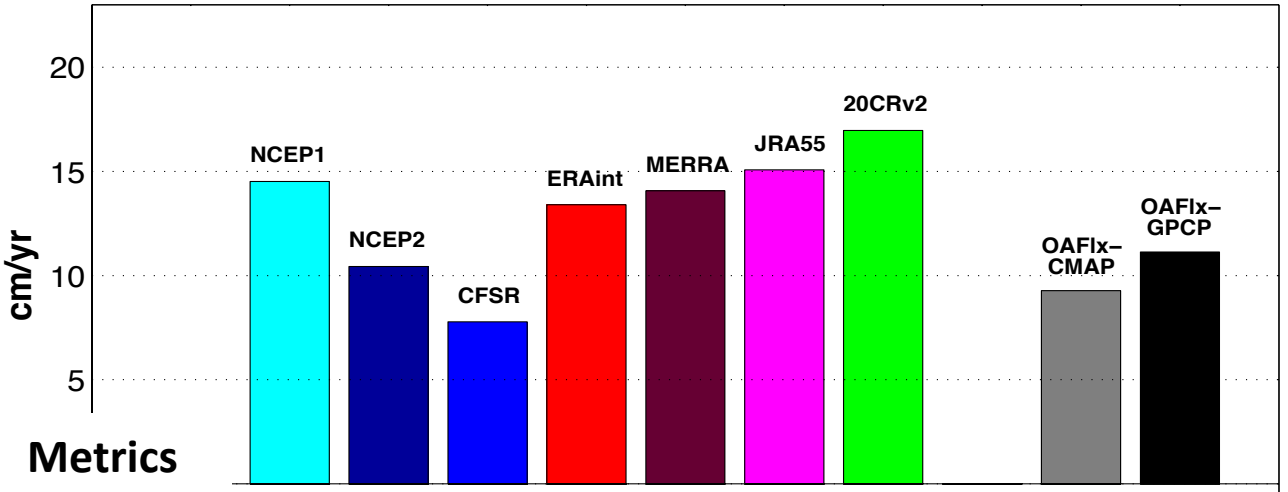


NCEP2 overestimated

JRA55 overestimated

Summary

Global average: E-P



Metrics	NCEP1	NCEP2	CFSR	ERAint	MERRA	JRA55	20CRv2	OAFlx–CMAP	OAFlx–GPCP
Ratio of E/P				**x**		**x**			**x**
Time series	x			x		x	x		x
Global avg				x	x				x
Box avg			x	x	x		x	x	x

Preliminary results:

- Uncertainties in 7 reanalysis products are analyzed.
- Compared to OA-GPCP and salinity based metrics, ERA-interim is an overall better E-P product.