

# Surface freshening and salinification: decadal fluctuations vs secular trends

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NADYA T. VINOGRADOVA

MARTHA W. BUCKLEY

CHRISTOPHER G. PIECUCH

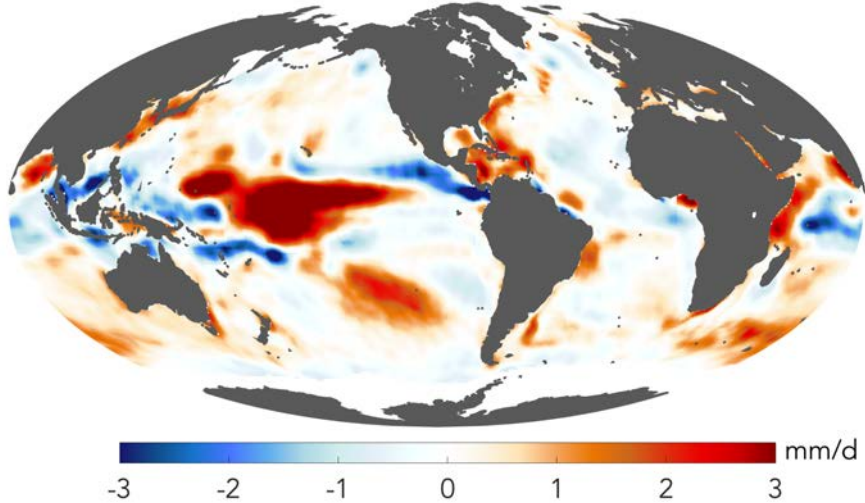
RUI M. PONTE

**CAMBRIDGE CLIMATE INSTITUTE**



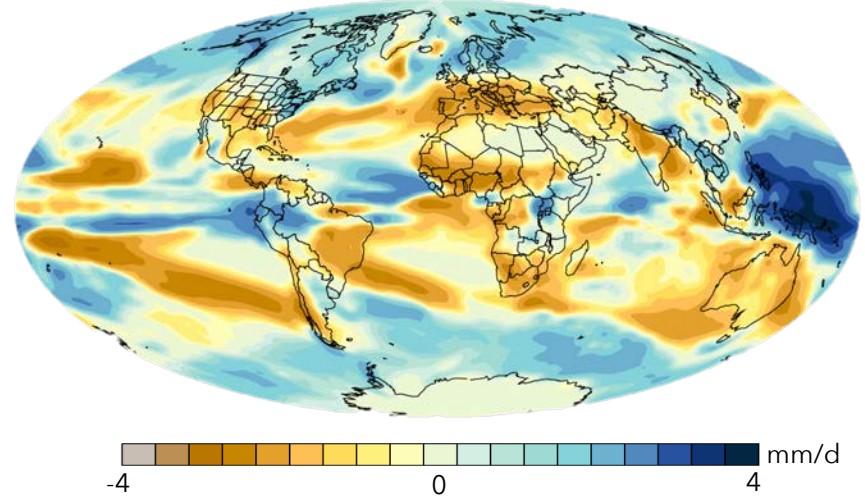
# Trends in the ocean water cycle

Observed trend in E-P: 50 years



Observations: *E* - OAFflux (Yu & Weller, 2007)  
*P* - NCEP (Kalnay et al., 1996)

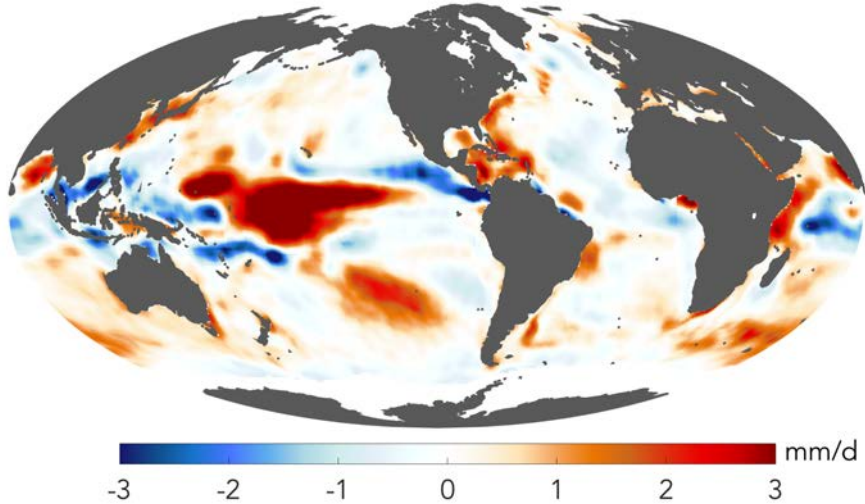
Projected trend in P: 100 years



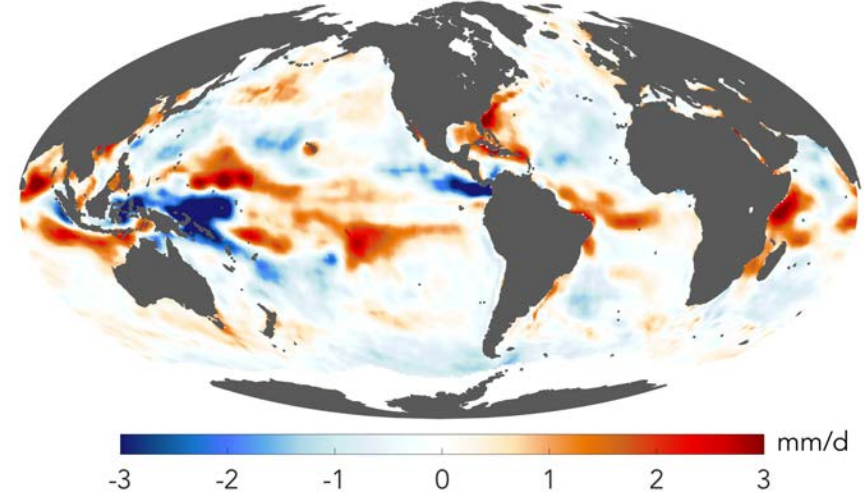
Projections: GFDL CM2.1 (IPCC, WG1, 2007)

# Trends in the ocean water cycle

Observed trend in E-P: 50 years



Observed trend in E-P: 20 years

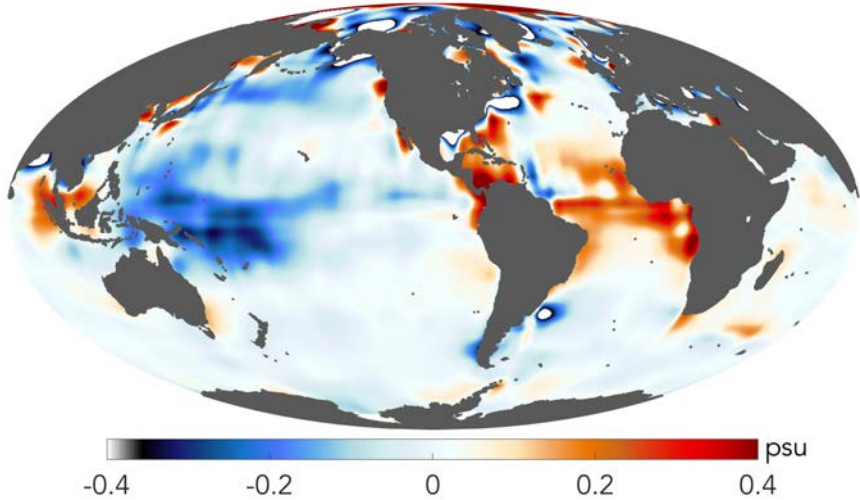


*Pattern amplification: 2% - 5% since 1993  
(Vinogradova & Ponte, 2017)*

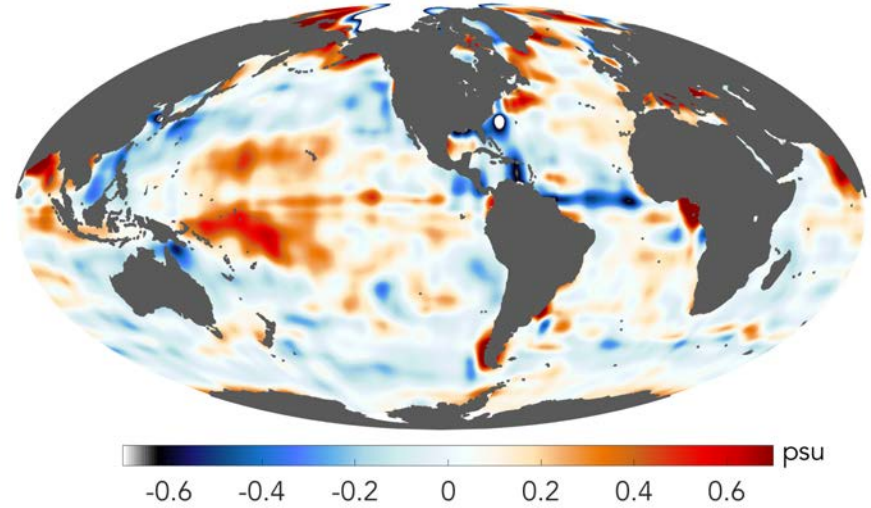
*See also Yu et al., 2017 for product review and uncertainties*

# Trends in surface salinity

Observed trend in SSS: 50-years



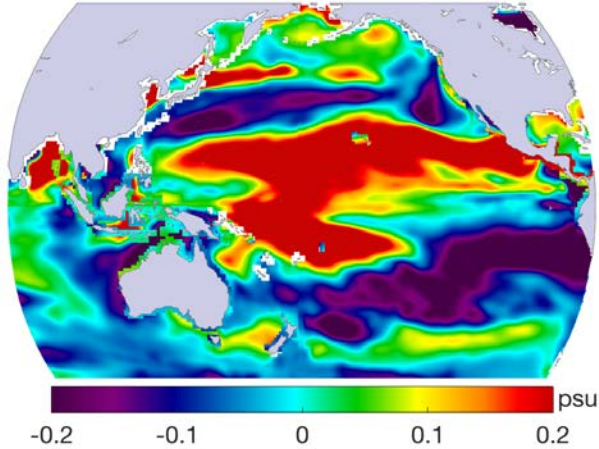
Observed trend in SSS: 20 years



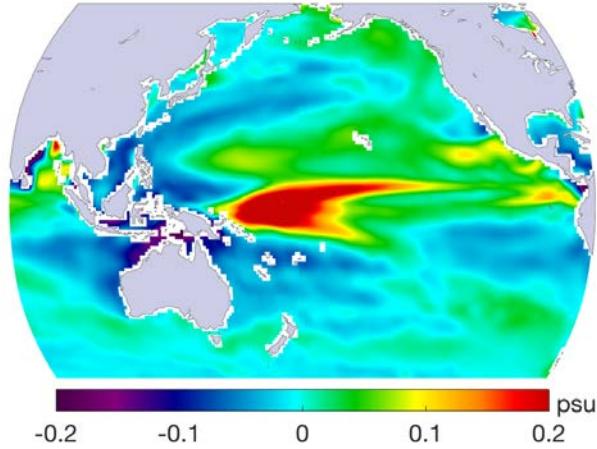
*Observation: SSS - EN4 (Good et al., 2013)*

# Role of natural variability in modulating SSS trends

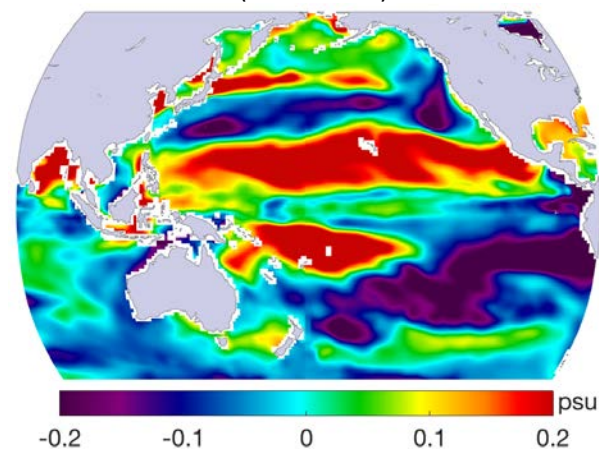
Total SSS trend since 1993



SSS trend explained by IPO

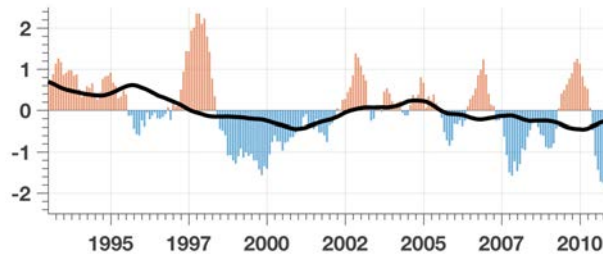


Residual (non-IPO) SSS trend



SSS - ECCO v4.r2 (Forget et al., 2015)

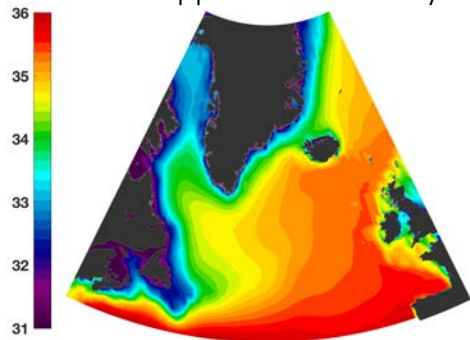
IPO - NOAA (Hanley et al., 2015)



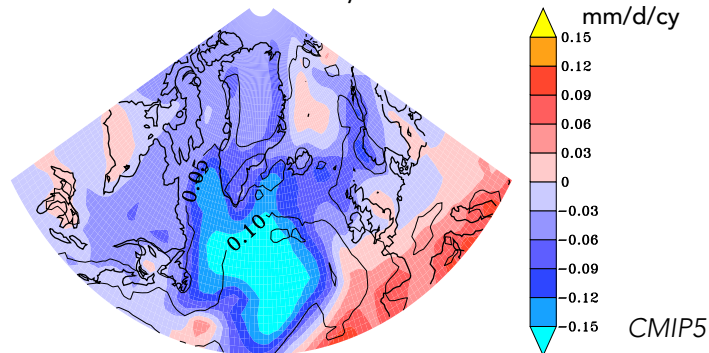
Vinogradova & Ponte, 2017, JCLim  
(Julian's idea)

# Decadal fluctuations opposing secular trends: example - subpolar North Atlantic

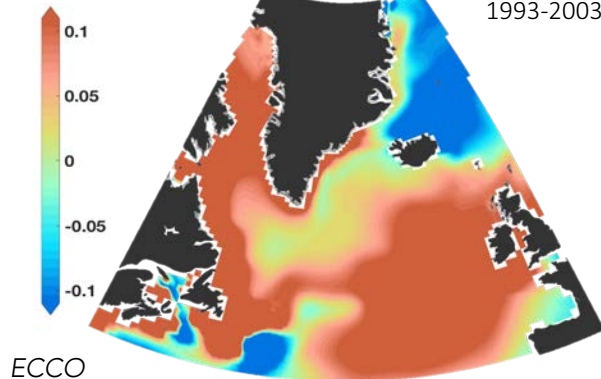
Mean upper-ocean salinity



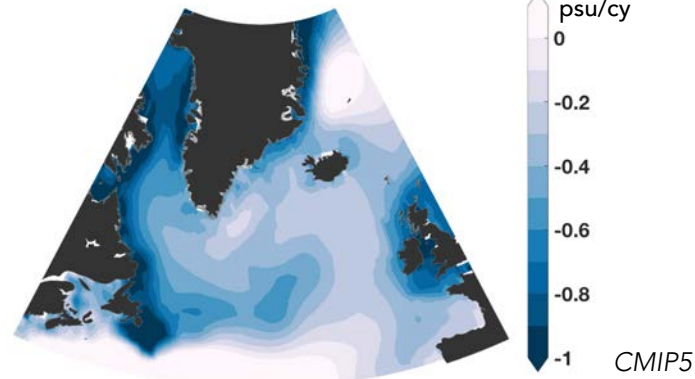
Trend in E-P: 100 years



Trend in upper-ocean salinity: 10 years  
1993-2003

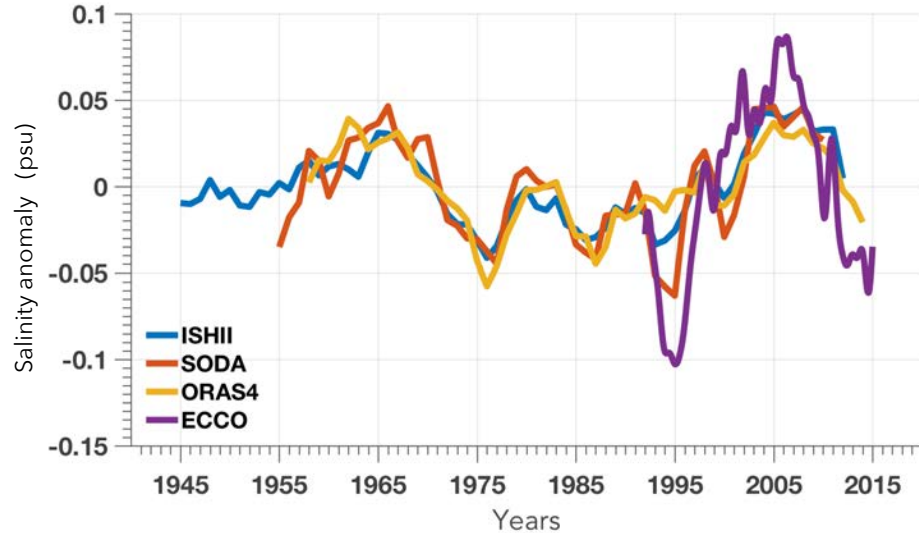


Trend in upper-ocean salinity: 100 years

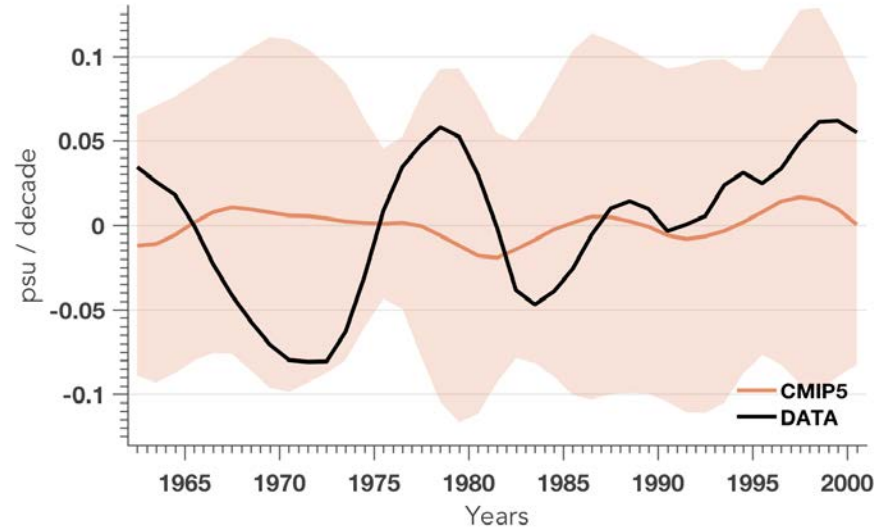


# Decadal salinification event in the context of historical changes

Historical data: time series

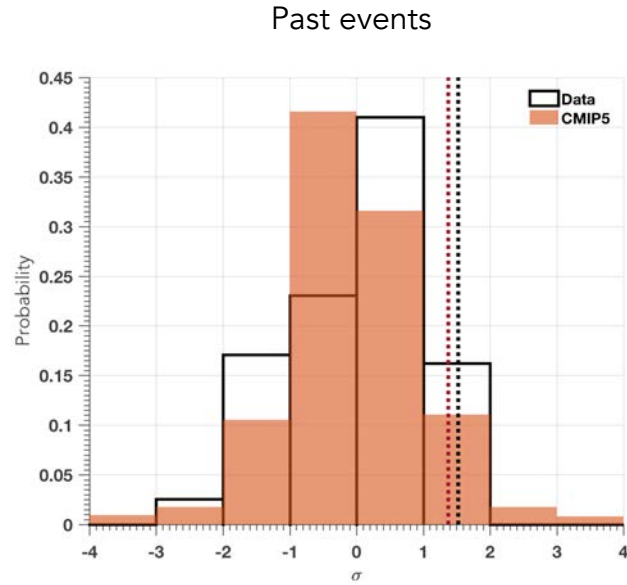


Historical data and models: decadal trends



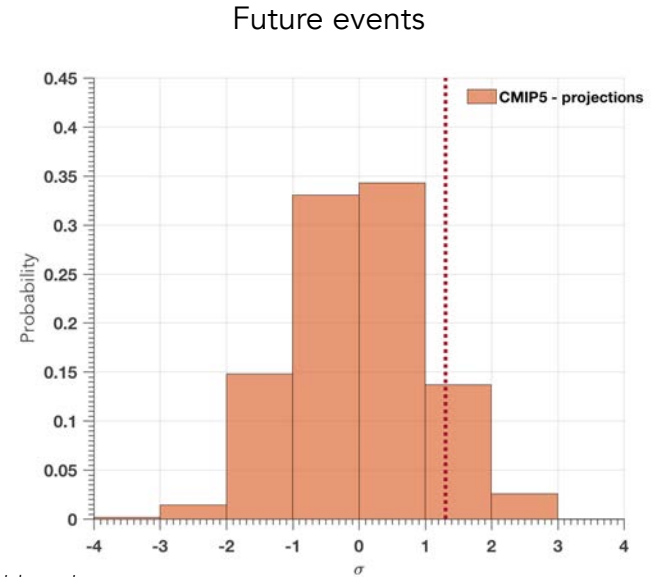
*Anomalies in the upper-ocean salinity are averaged over the subpolar North Atlantic [45-65N, 0-70W] and over the top 700 m*

# Likelihood of a strong, decade-long salinification in the presence of background freshening



$$z = \frac{X - \mu}{\sigma}$$

Probability of all possible decadal trends



*Under the influence of internal variability, strong salinification is plausible (although rare):  $p \sim 0.1$*



# Conclusions

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1. The time of emergence for anthropogenic trends in the ocean water cycle might be substantially earlier than that for surface salinity.
2. While plausible under the influence of internal variability, strong decadal salinification in the presence of background freshening are rare events.