Toward a probabilistic assessment of the global ocean response to fully-varying runoffs

Work in progress

The IMHOTEP OST-ST project

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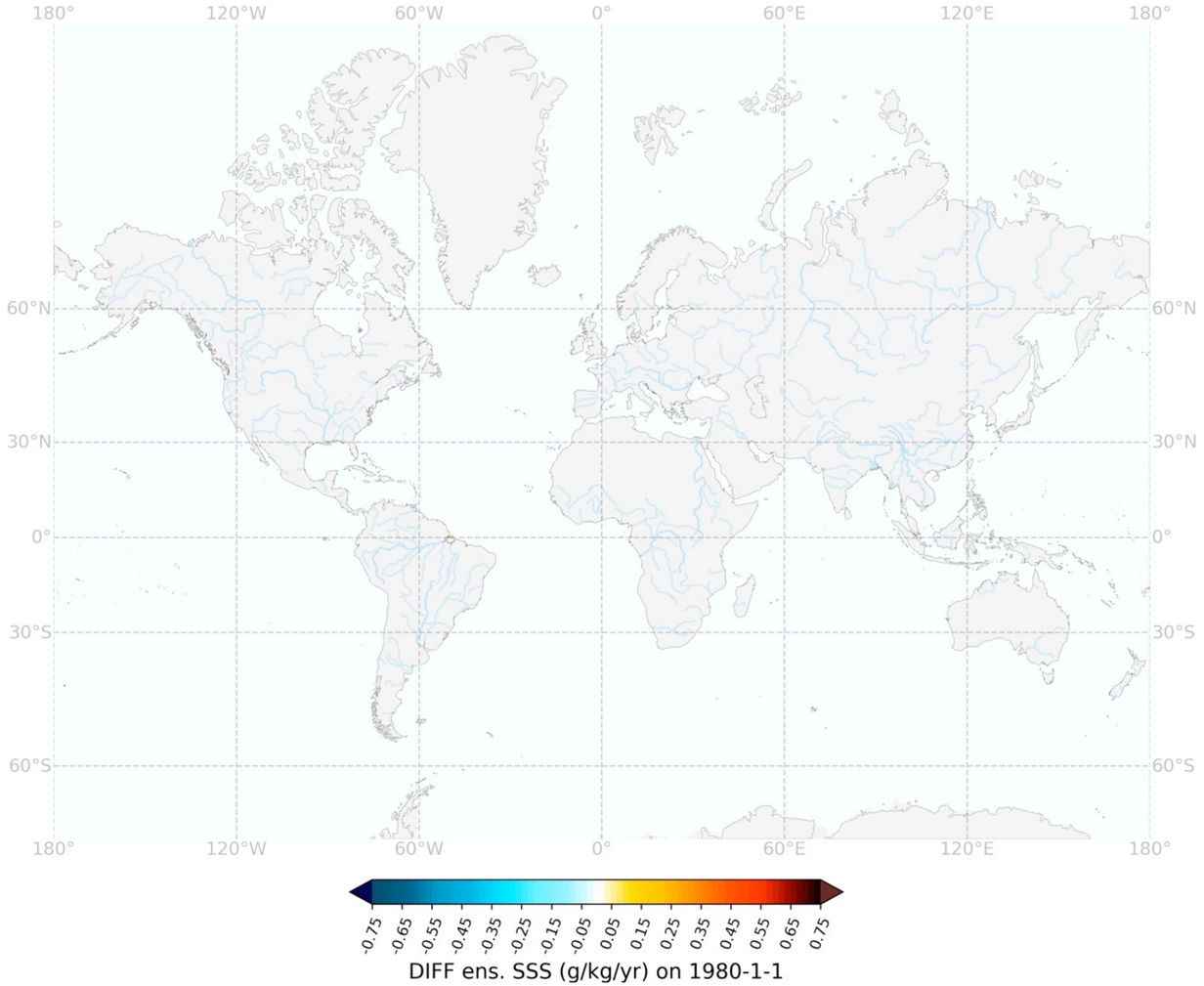
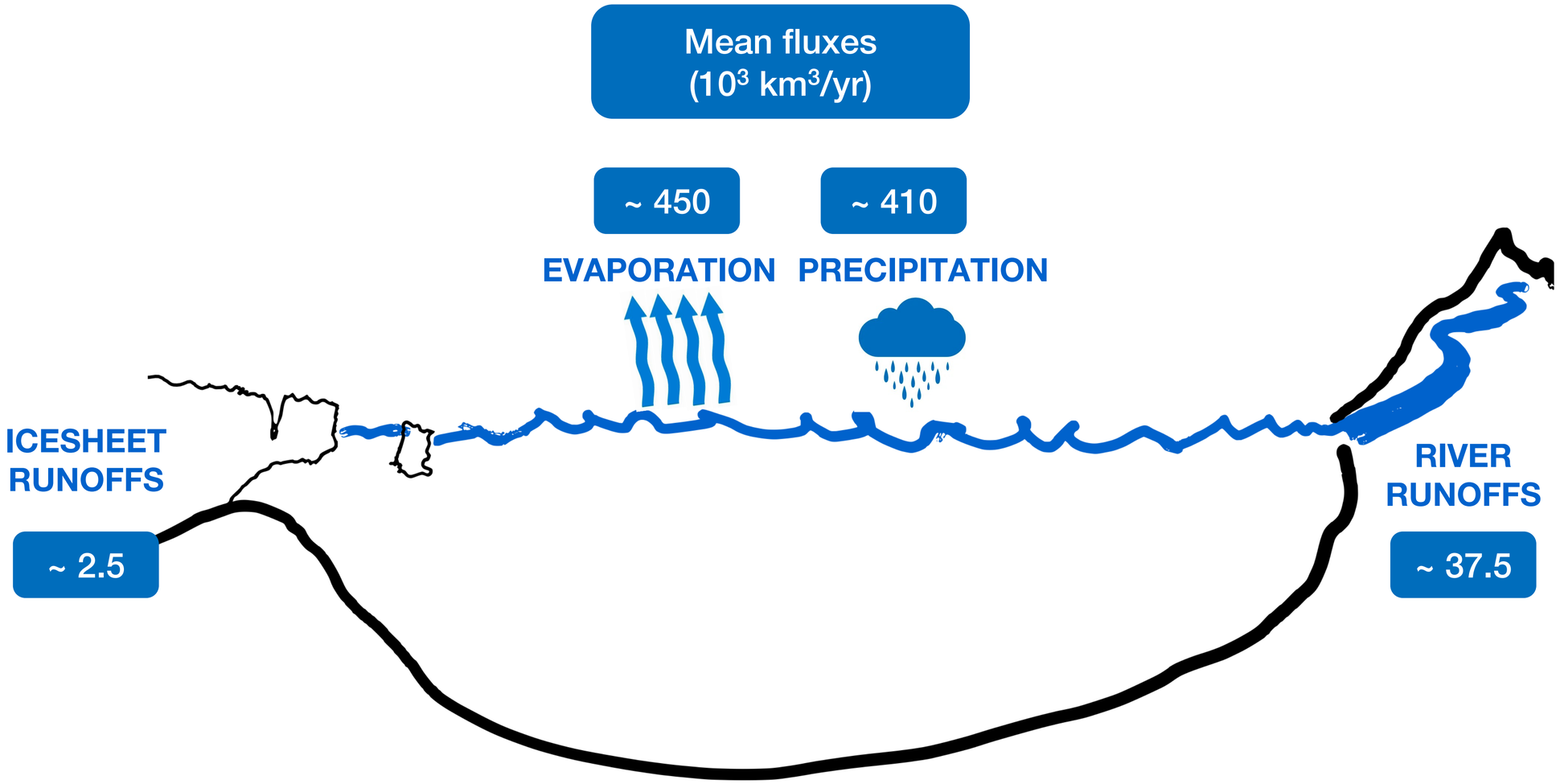
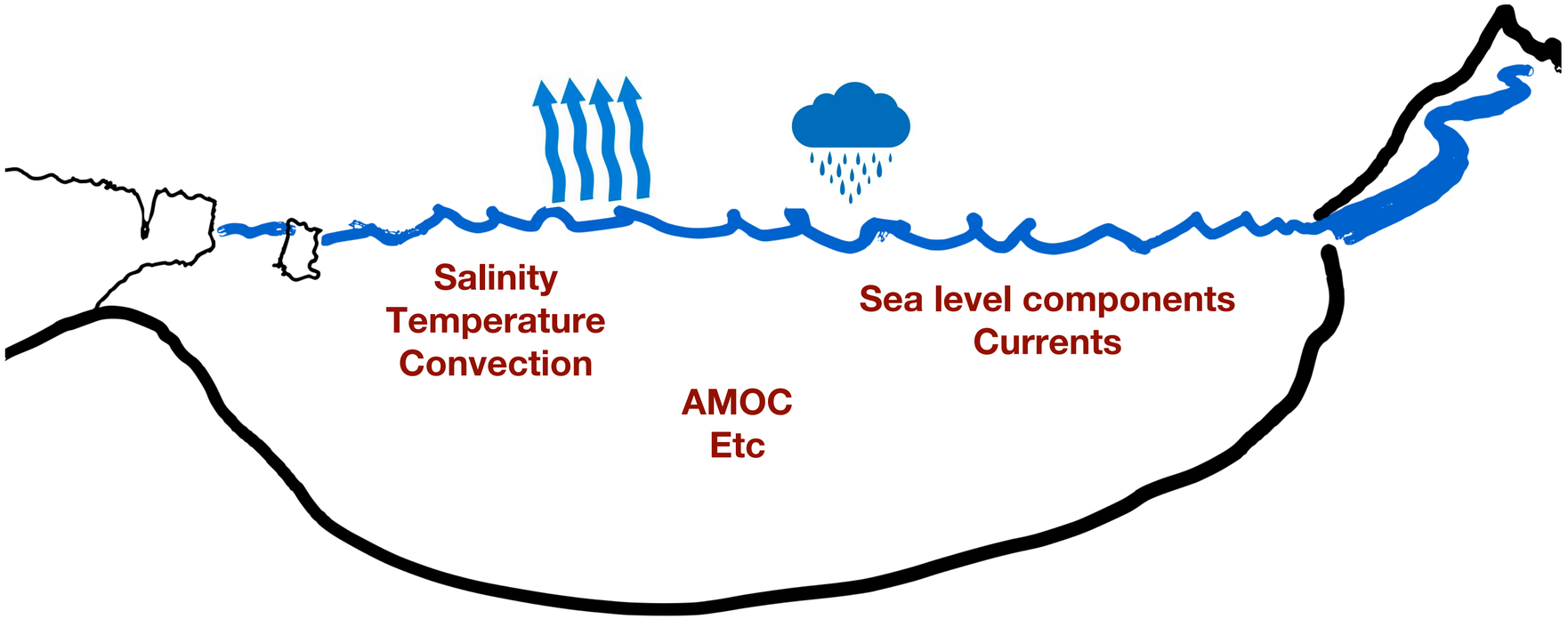


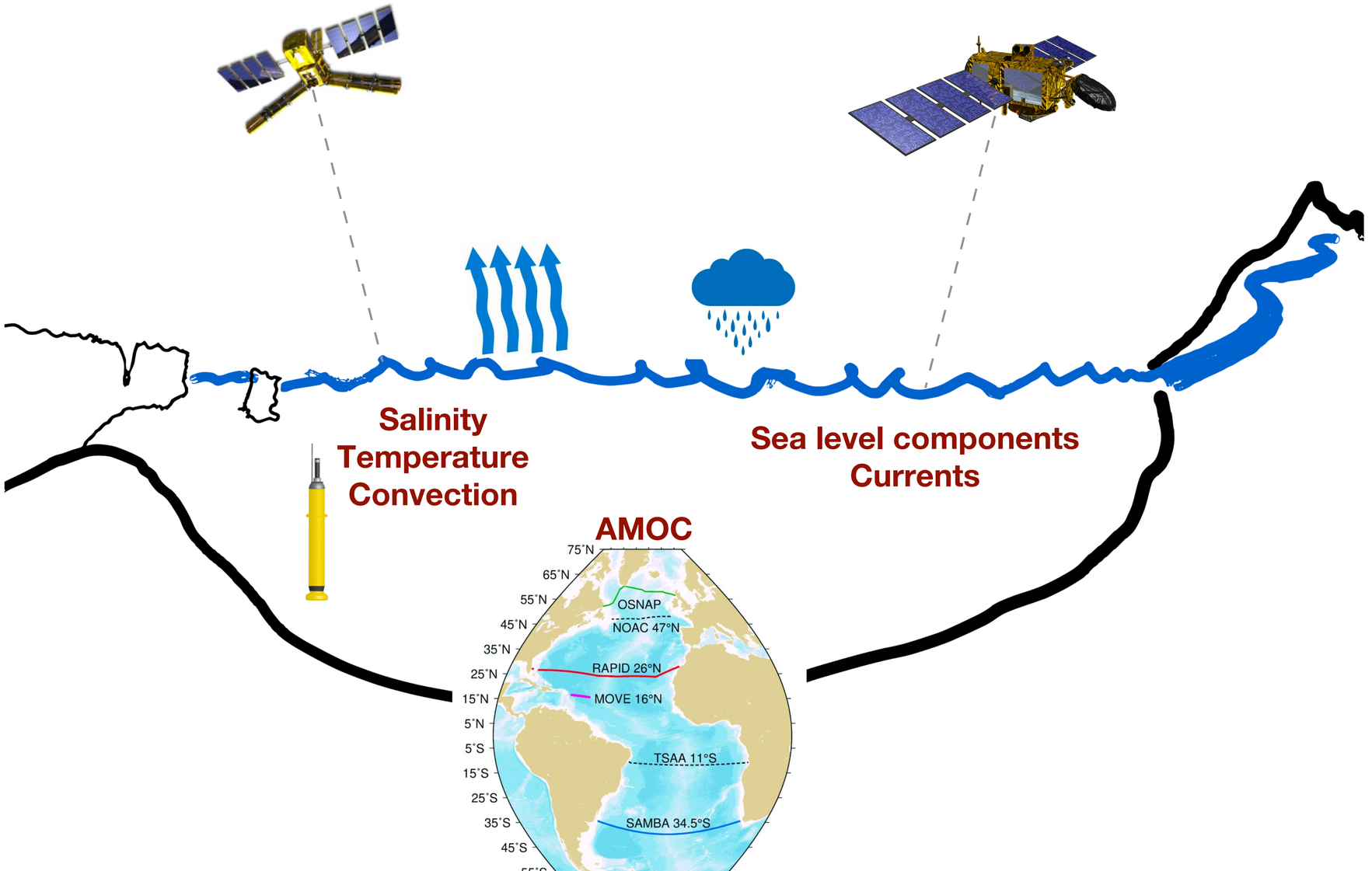
ocean freshwater budget



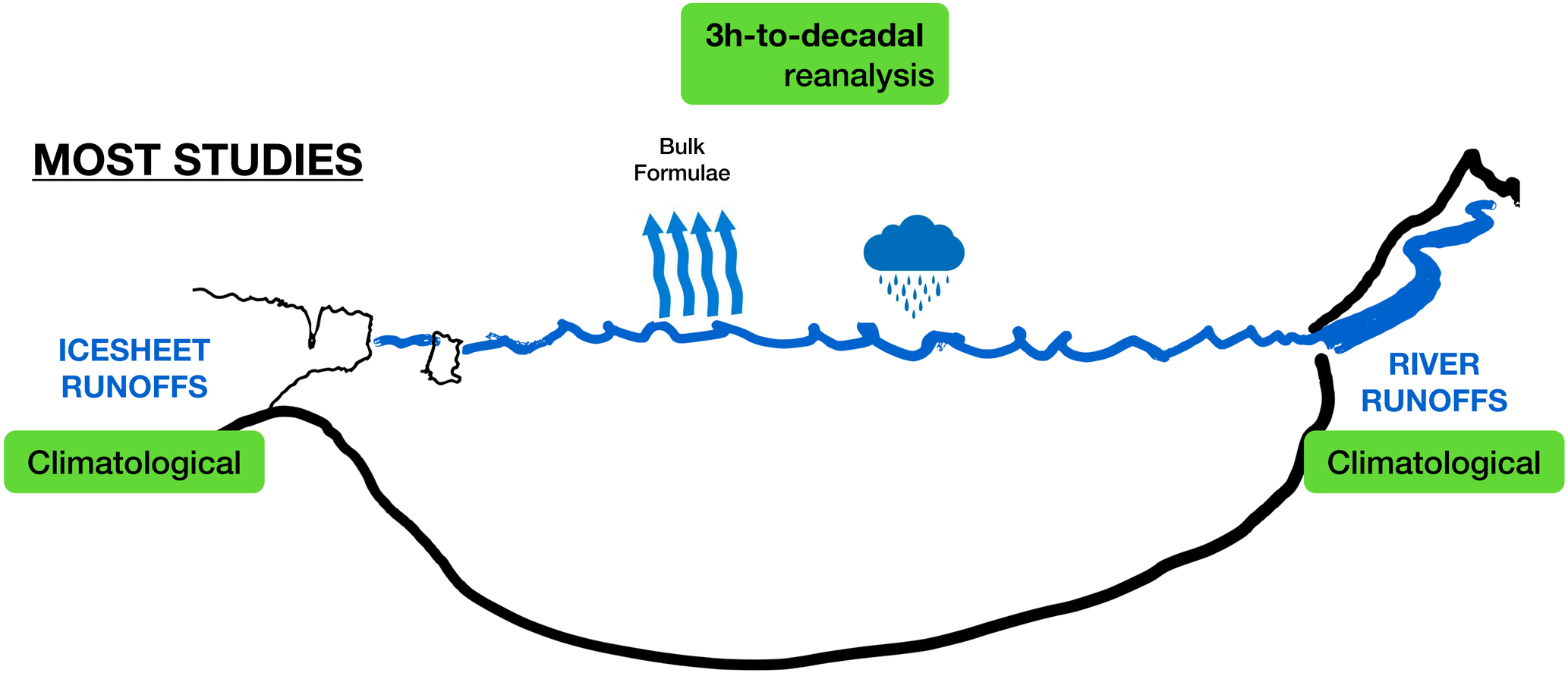
impacts of ocean freshwater budget



Observed impacts of ocean freshwater budget



Modeled impacts of ocean freshwater budget fluctuations



Modeled impacts of ocean freshwater budget fluctuations

IMHOTEP

3h-to-decadal
JRA reanalysis

Bulk
Formulae

GREENLAND ICESHEET RUNOFFS

local bedrock depth

Explicit iceberg advection+melting

10m

RIVER RUNOFFS

A **Climatological**

B **monthly-to-decadal**
(GRACE+altimetry+RCMs, Mouginot et al 2019)

A **Climatological**

B **daily-to-decadal**
(ISBA reanalysis Decharme et al 2019)

Modeled impacts of ocean freshwater budget fluctuations

Runs A vs B: ocean response to fully-varying runoffs?

IMHOTEP

NEMO model
1/4° resolution

~~SSS restoring~~:
Flux correction

Explicit iceberg
advection+melting

5
additional
runs

Ensemble versions
of runs A and B
in production

GREENLAND
ICESHEET
RUNOFFS

A Climatological

B monthly-to-decadal
(GRACE+altimetry+RCMs, Mouginot et al 2019)

RIVER
RUNOFFS

A Climatological

B daily-to-decadal
(ISBA reanalysis Decharme et al 2019)

This talk:
river runoffs → sea surface salinity (SSS)

See Poster by Llovel et al:
Greenland discharge→ Arctic sea level

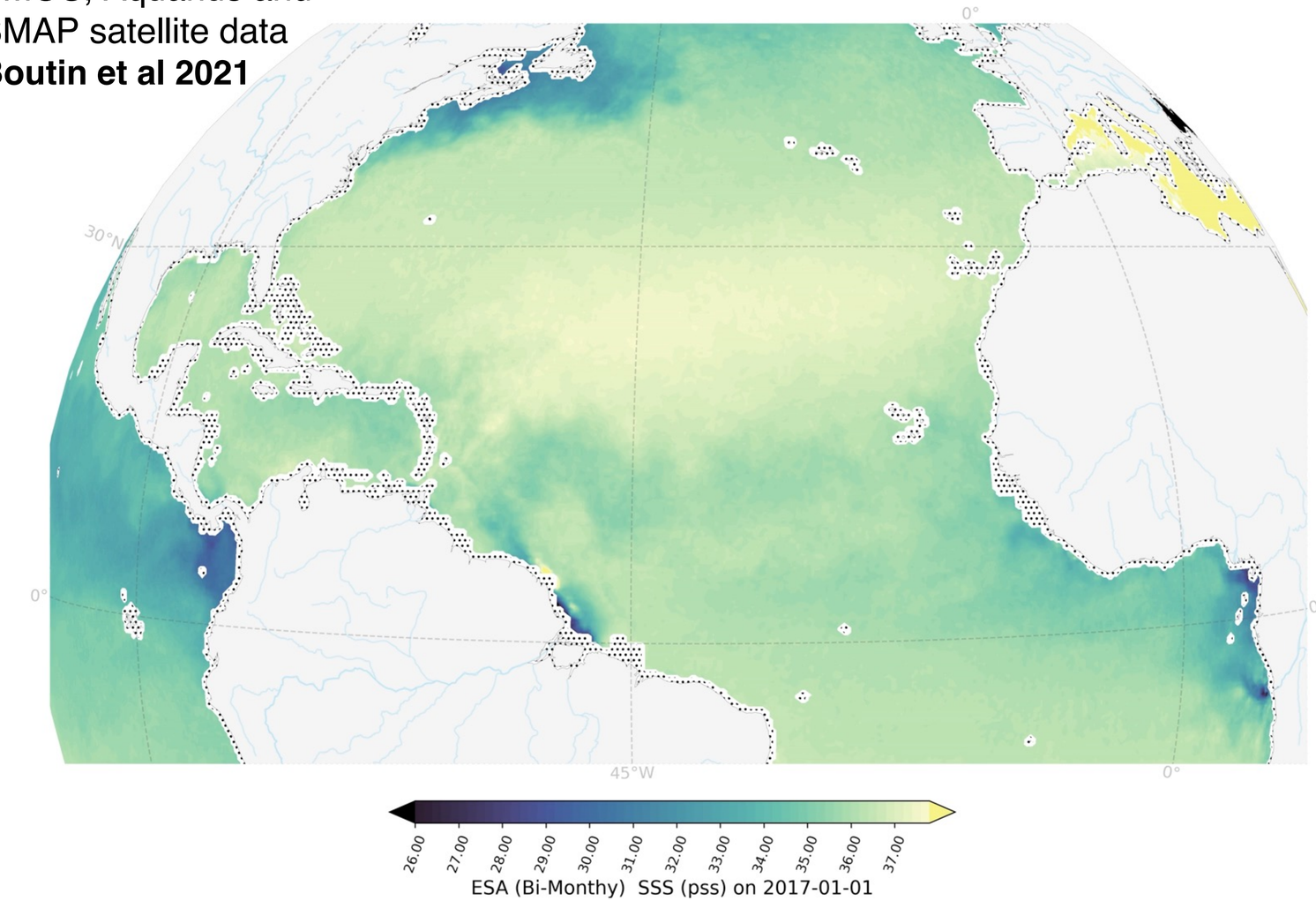
Model SSS vs CCI product (2010-2018)

CCI product

Compare SSS

IMHOTEP run B (fully-variable runoffs)

SSS L4 product merging SMOS, Aquarius and SMAP satellite data
Boutin et al 2021



in terms of

Time mean
Interannual STD

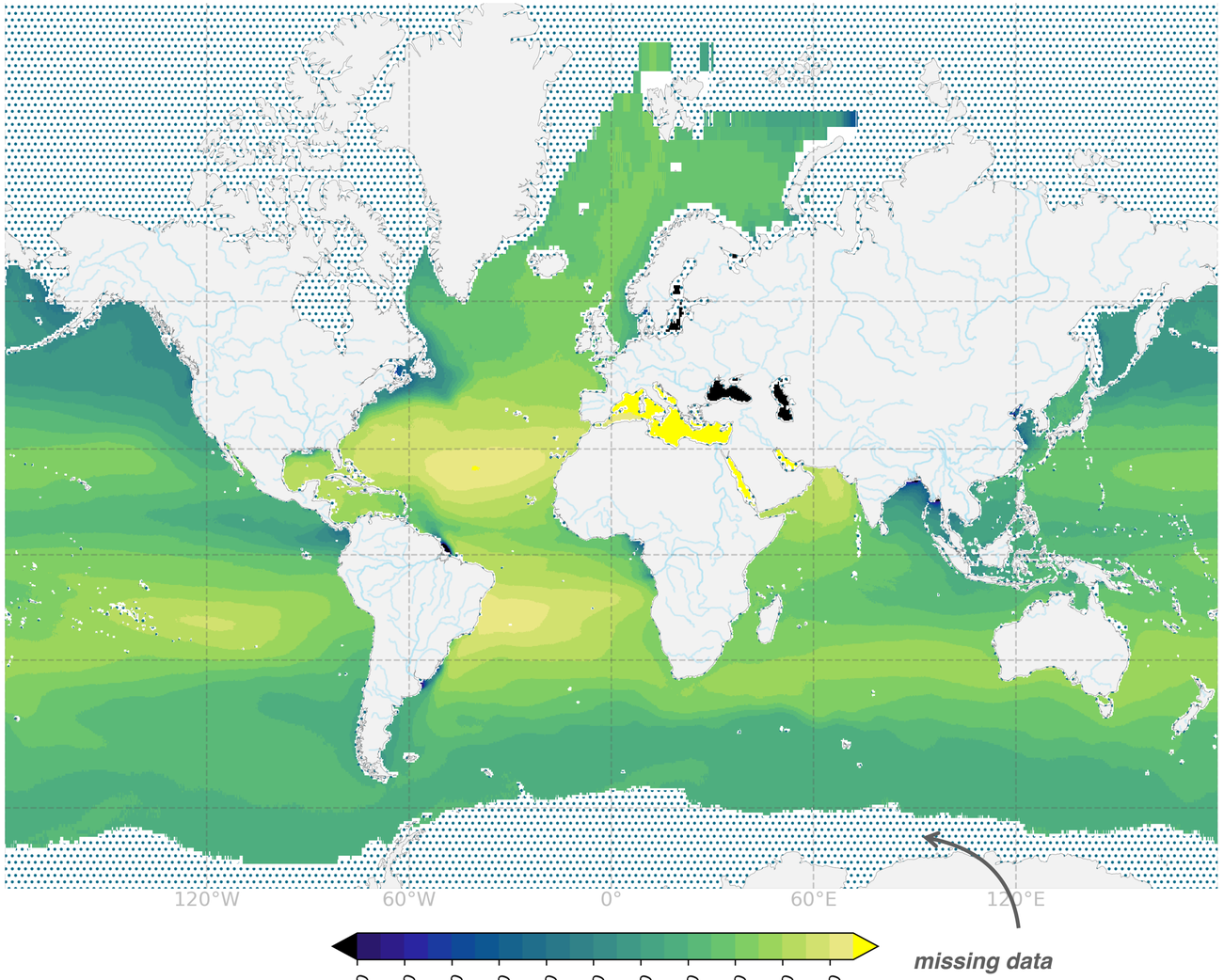
Salinity response:
max near the surface,
small below ~100 m.

Additional responses are expected at depth.

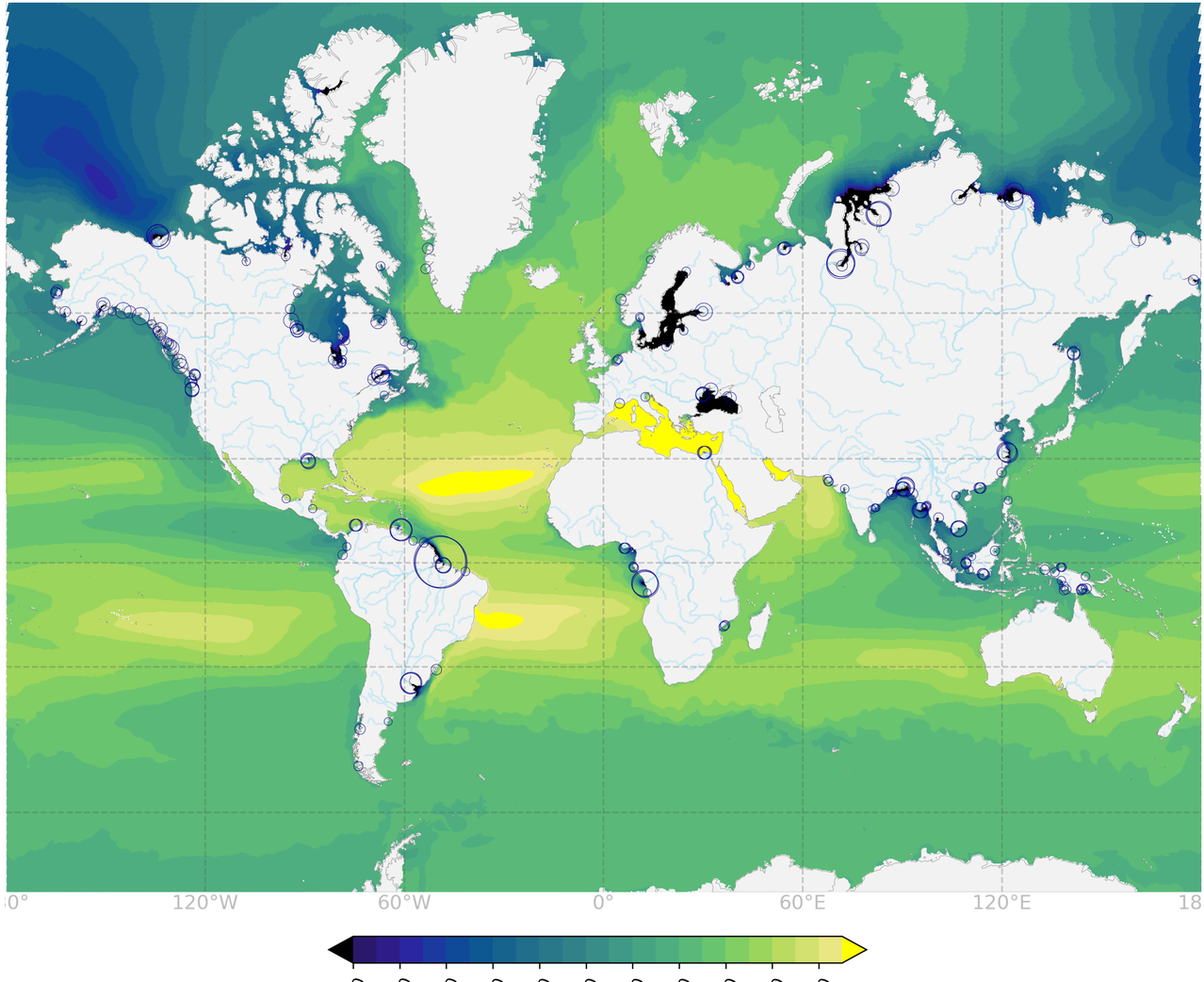
Model SSS vs CCI product (2010-2018)

Time mean

CCI product



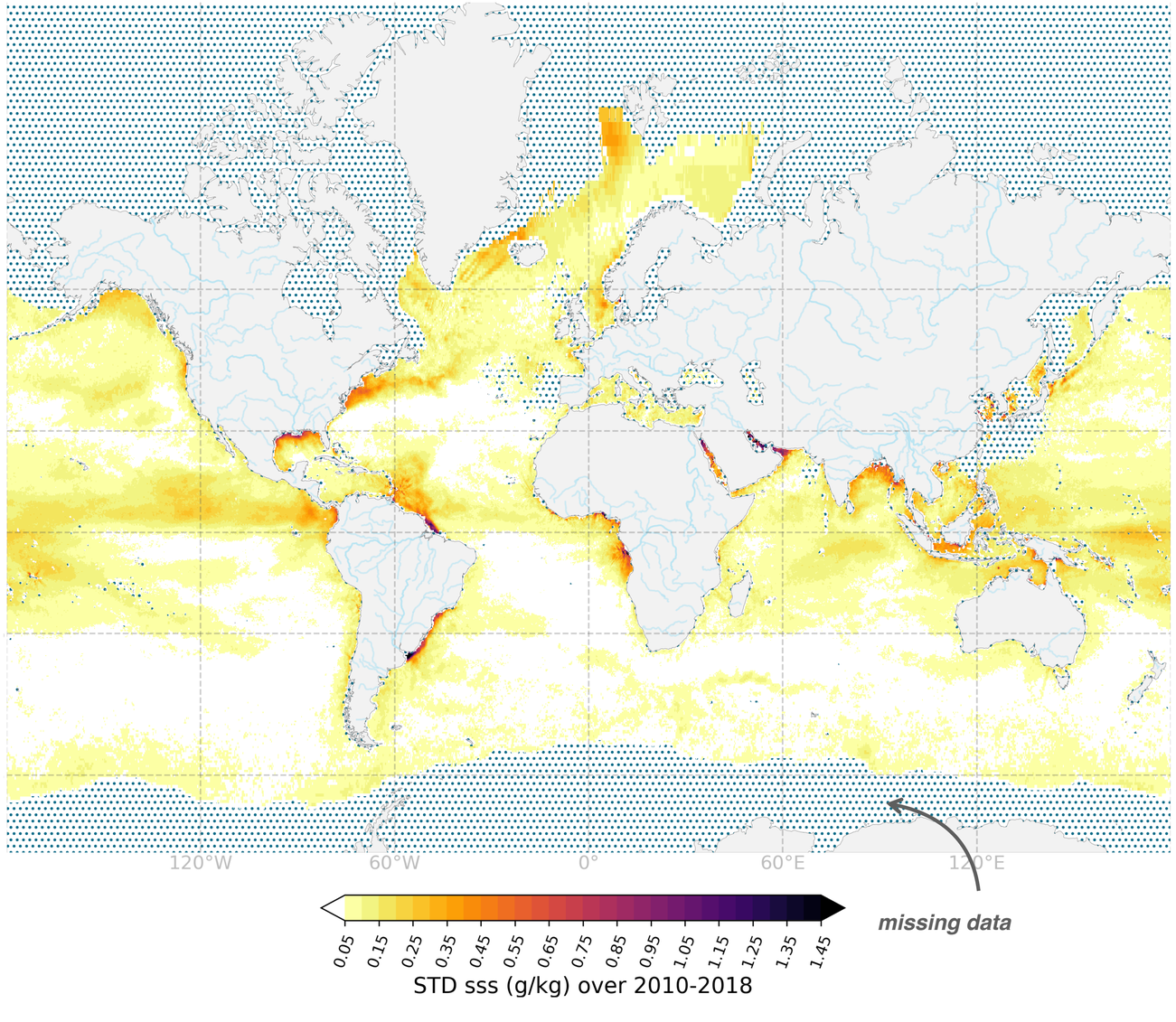
IMHOTEP run B



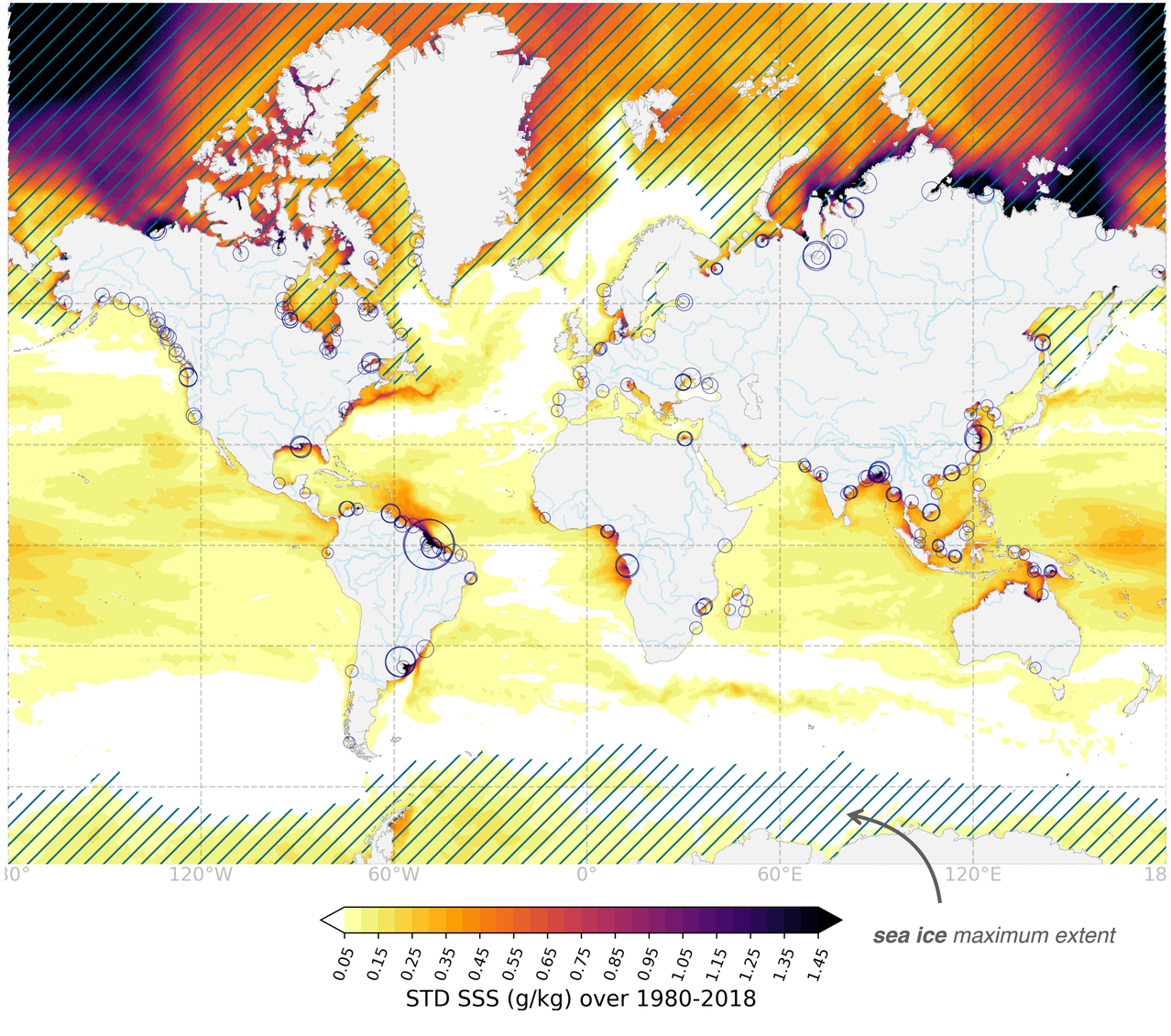
Model SSS vs CCI product (2010-2018)

Interannual STD

CCI product



IMHOTEP run B



Model SSS: impact of fully-varying runoffs (1980-2018)

IMHOTEP run A (climatological runoffs)

Compare SSS in terms of

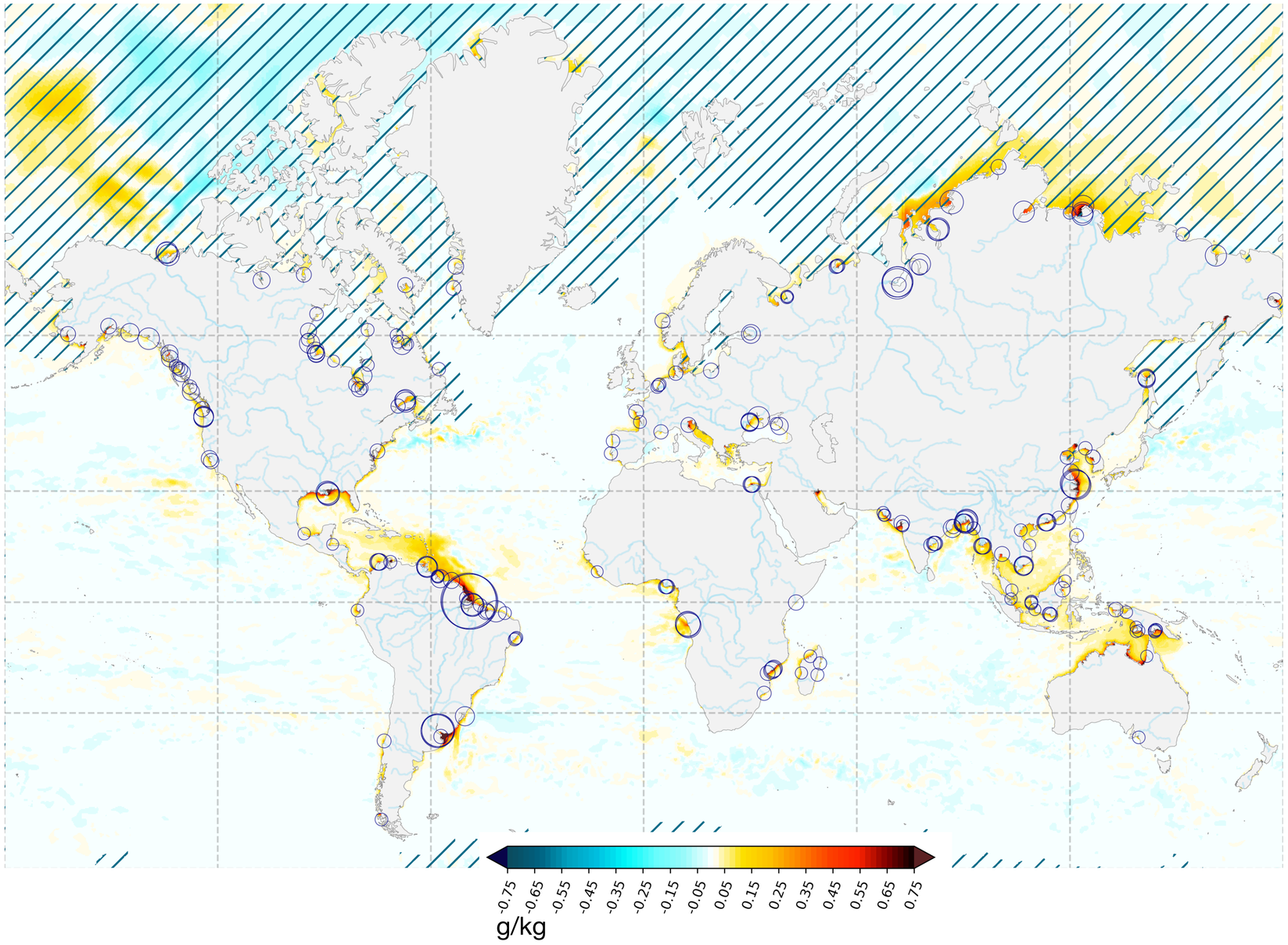
Interannual STD
40-year trend

IMHOTEP run B (Fully-varying runoffs)

Model SSS: impact of fully-varying runoffs (1980-2018)

Interannual STD

STD(run B) - STD(run A)



Circles:

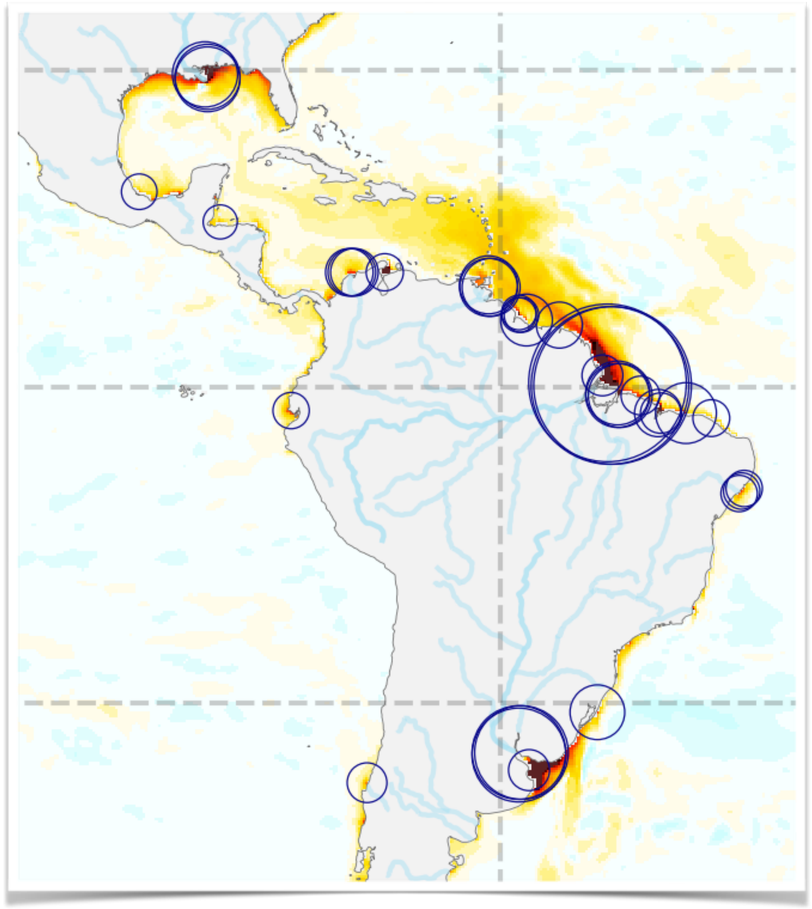
5% largest runoff

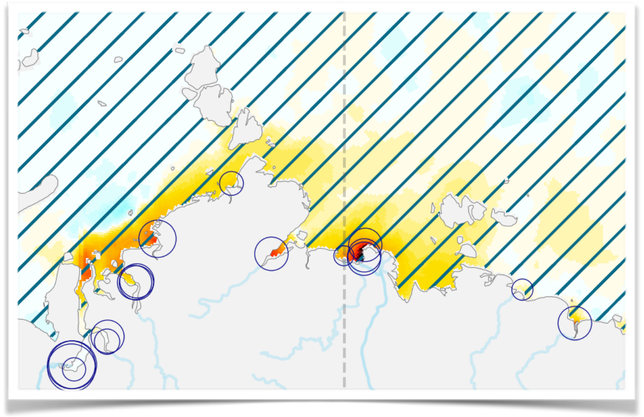
interannual STDs

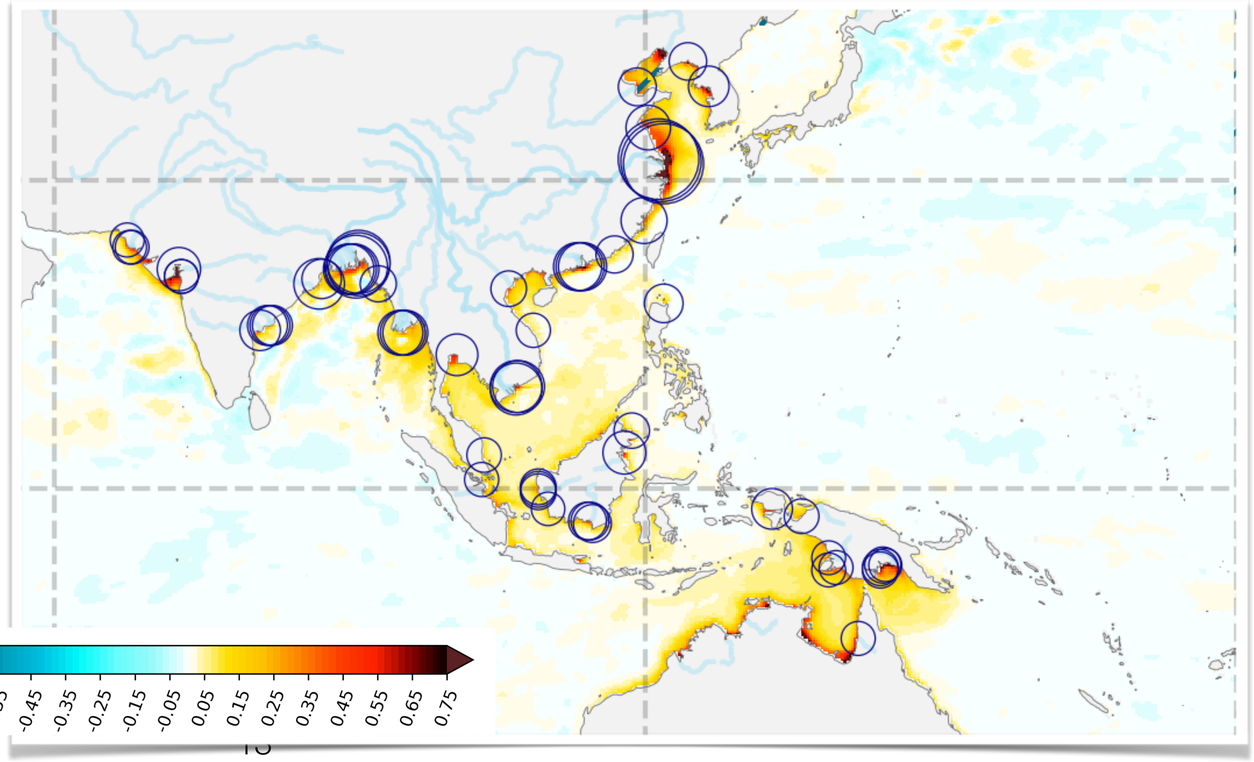
Model SSS: impact of fully-varying runoffs (1980-2018)

Interannual STD

STD(run B) - STD(run A)







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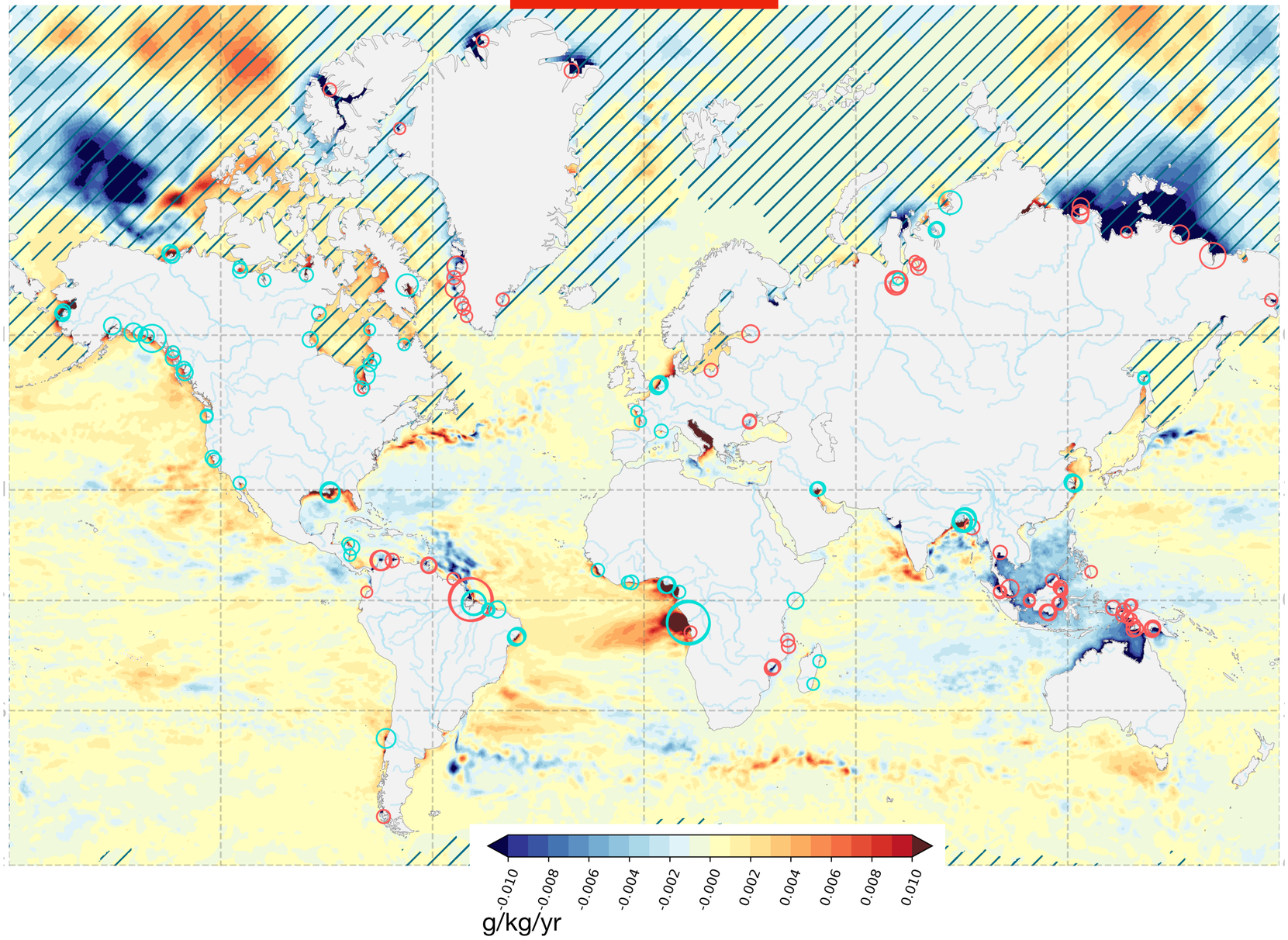
interannual STDs

Model SSS: impact of fully-varying runoffs (1980-2018)

Linear trend

Trend(run B) - Trend(run A)



Circles:

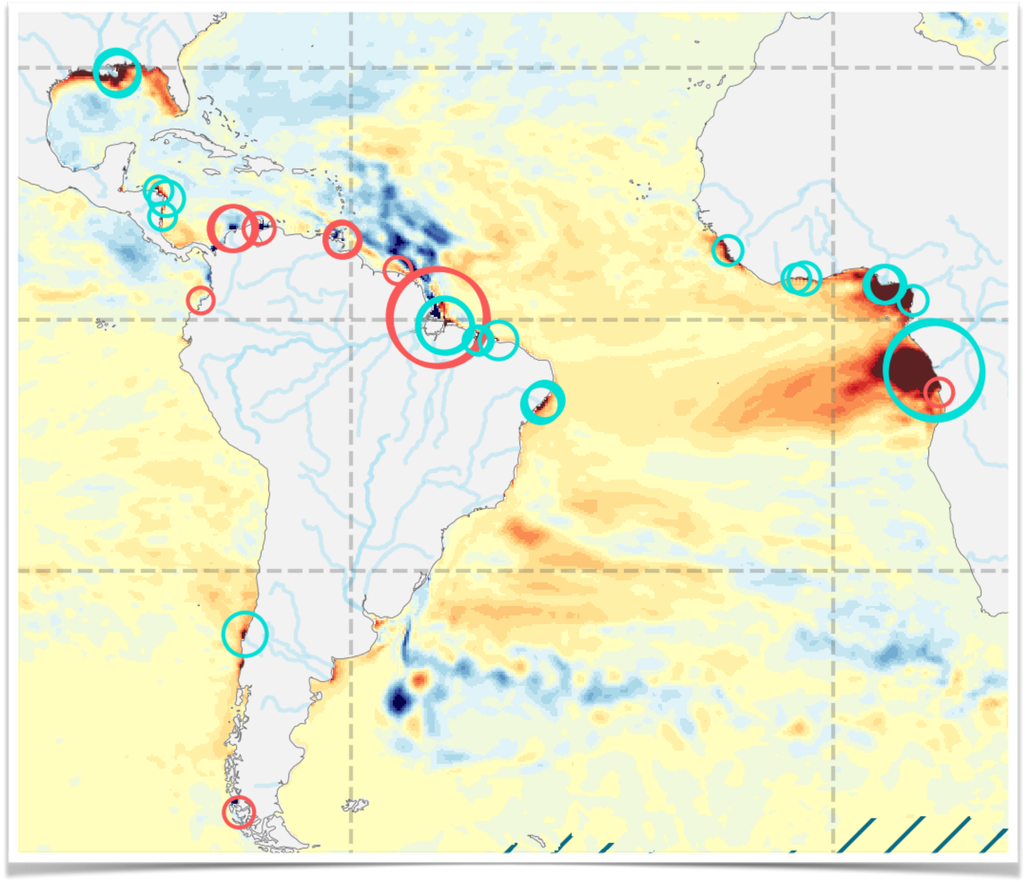
10% largest runoff

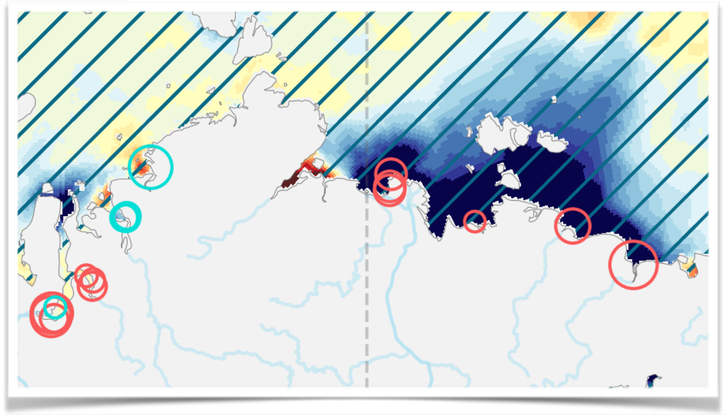
positive/negative trends

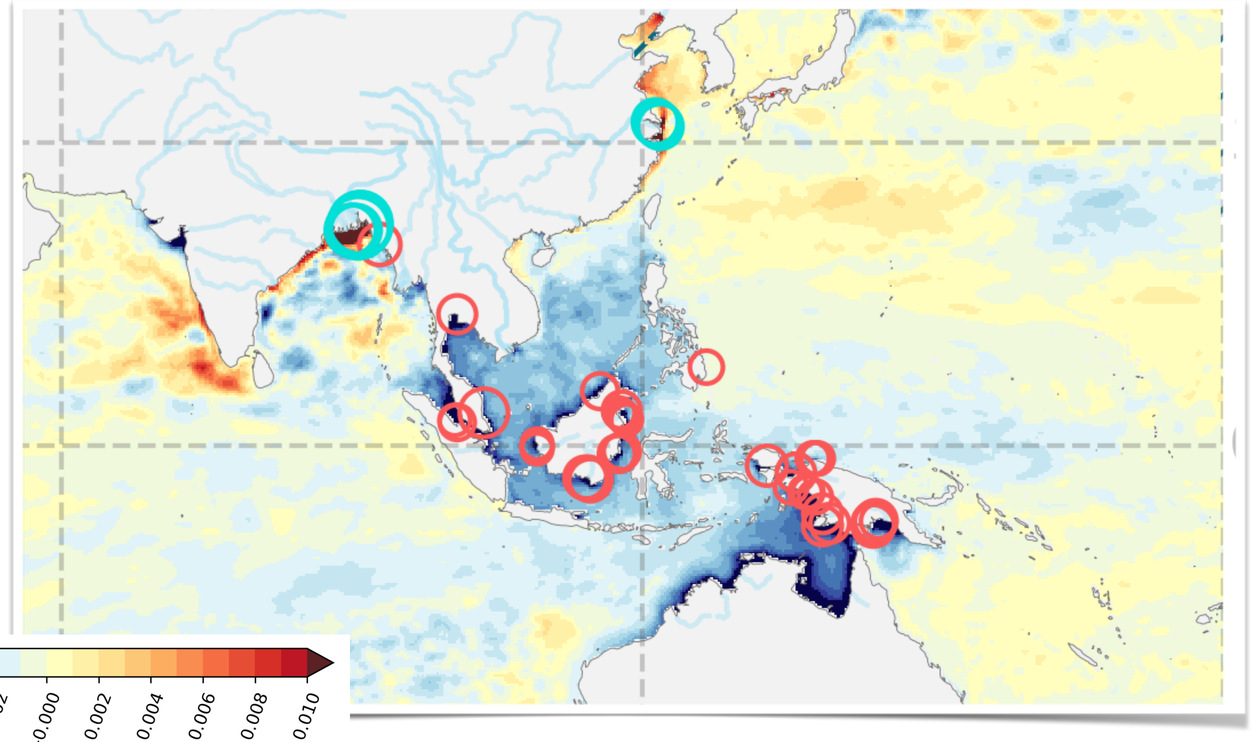
Model SSS: impact of fully-varying runoffs (1980-2018)

Linear trend

Trend(run B) - Trend(run A)







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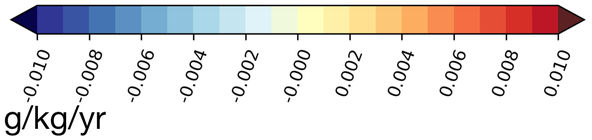


Summary

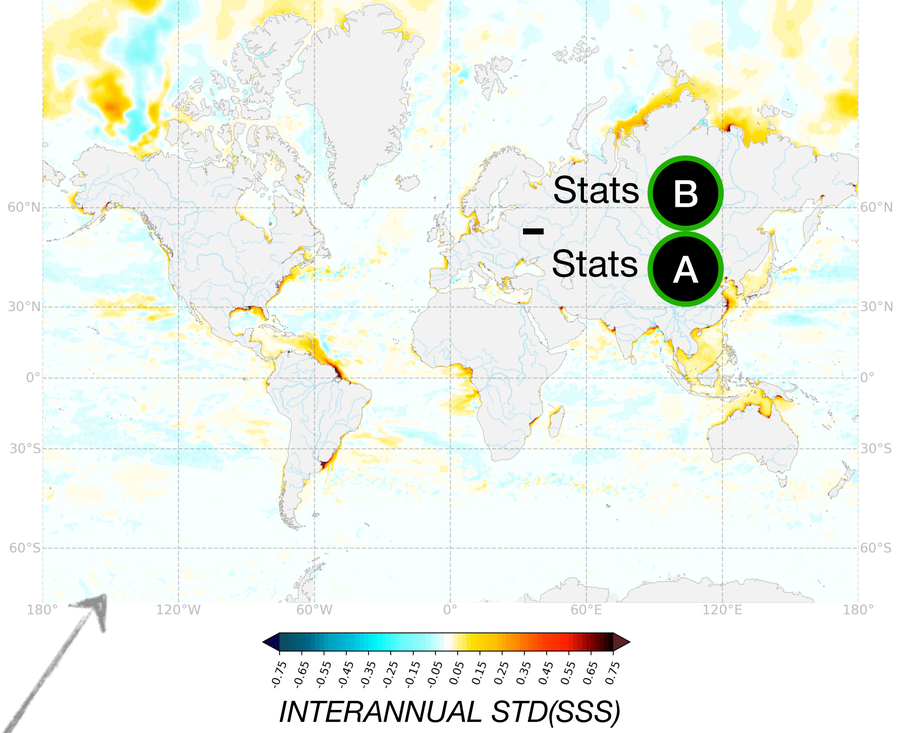
- Global ocean impacts of fluctuating runoffs
- Recent runoff data (world rivers, Greenland melt)
- Careful NEMO setup (~~SSS restoring~~, liquid/solid runoffs, explicit icebergs, etc)

Modeled SSS

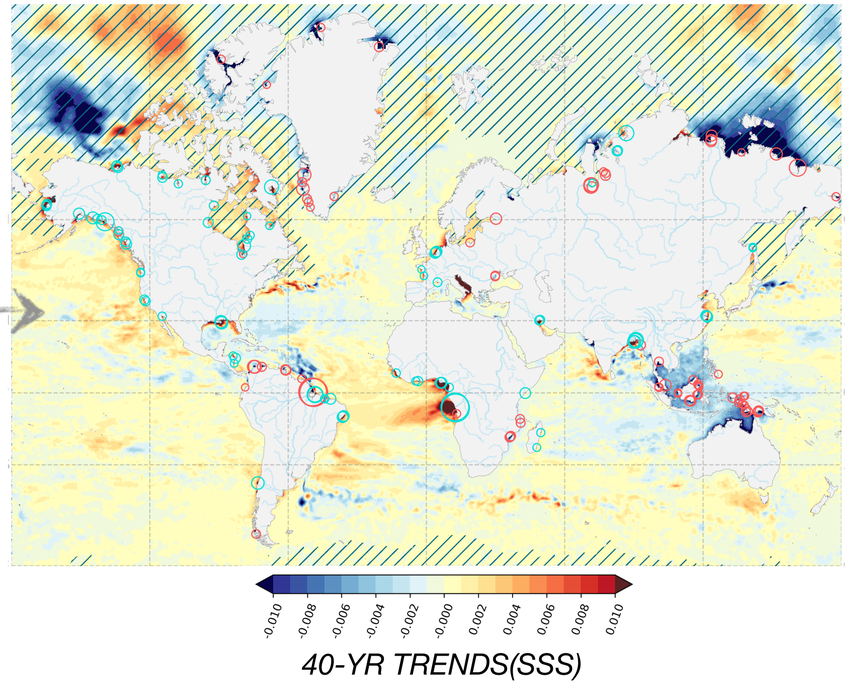
- Interannual STD(SSS) matches CCI satellite product
- River fluctuations (1980-2018):
  - Salinity impact over 0-100m depth
  - Tropical Atlantic, Maritime continent, Siberian coast
  - Strongly enhance SSS STD (river plumes up to ~3000km)
  - Strongly impacts +/- SSS trends (up to gyre scale)

Ongoing

- Other variables (SSH, SST, water masses, transports, AMOC, etc)



INTERANNUAL STD(SSS)



40-YR TRENDS(SSS)

Penduff, Llovel, et al, in preparation

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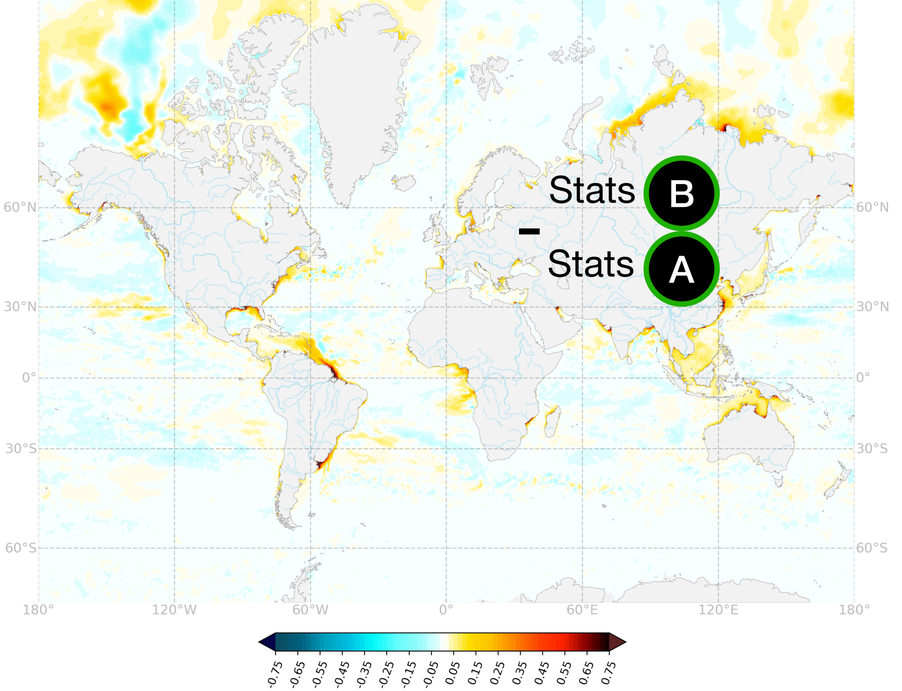
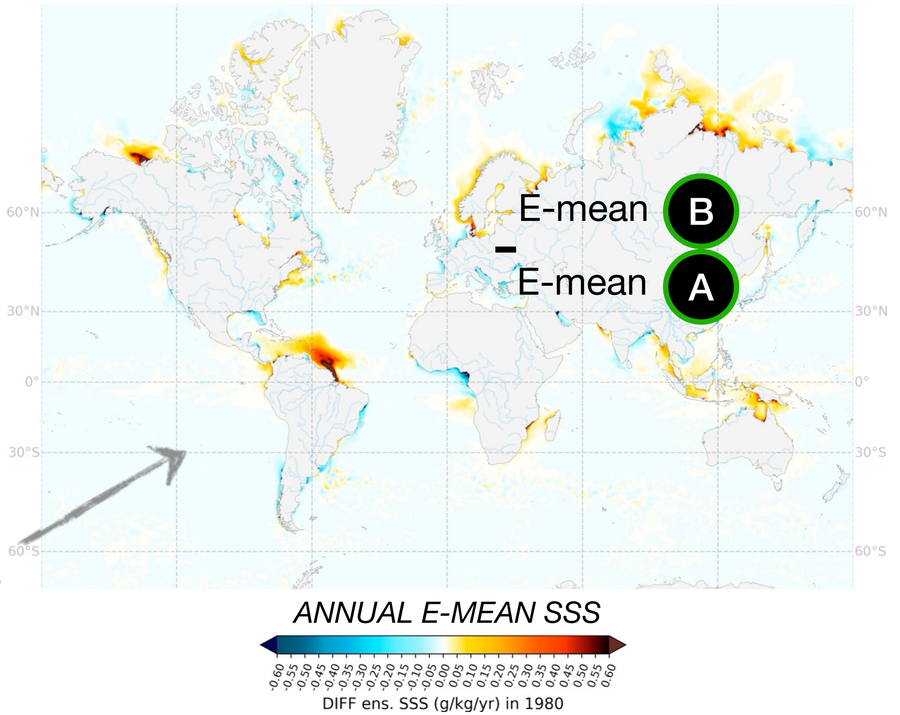
Ongoing

- Other variables (SSH, SST, water masses, transports, AMOC, etc)
- Ensemble runs: attenuate intrinsic variability, follow individual signals



INTERANNUAL STD(SSS)



ANNUAL E-MEAN SSS

Penduff, Llovel, et al, in preparation

Integration in progress

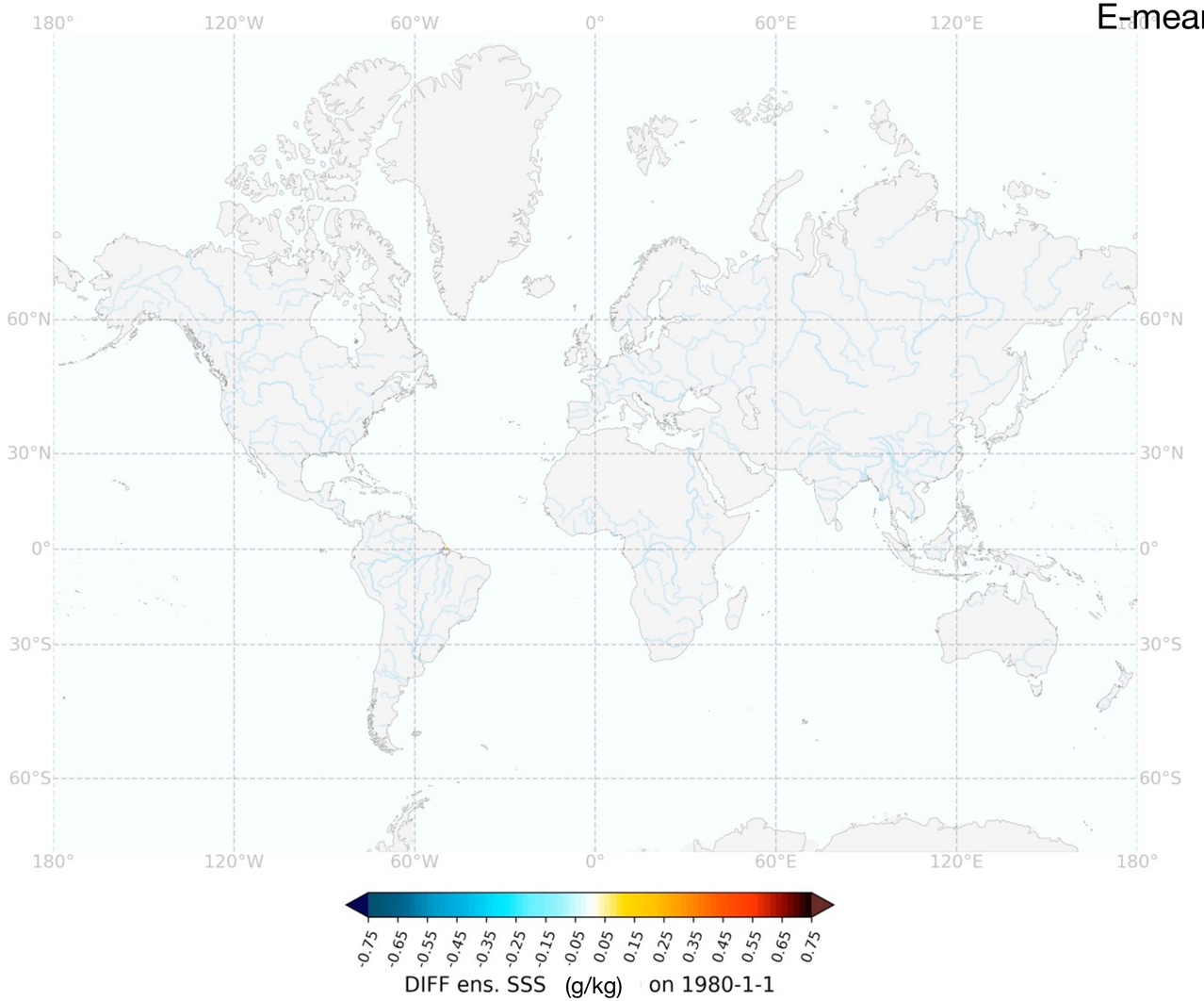
Ensemble-mean SSS differences

E-mean B

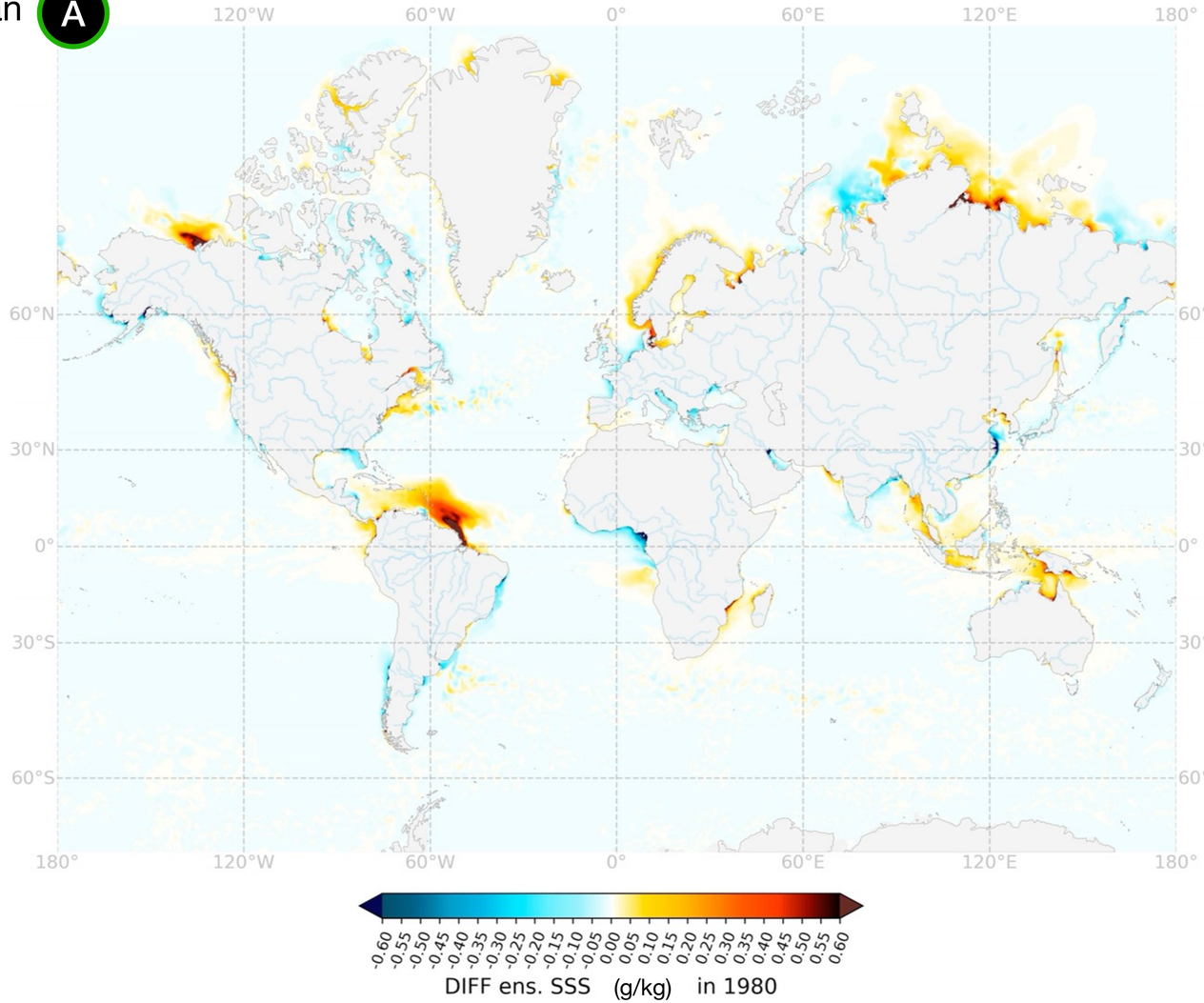
_

E-mean A

Daily differences (every 4 day: 1980-1982)



Yearly differences (every year: 1980-2003)



Penduff, Llovel, et al, in preparation

2. recap of the IMHOTEP experiments (WP1)

Spin-up

Test flux correction

Freshwater runoff sensitivity

Experiment	02	GAIa	SC	S	GAI	GA	AI	GI
Time period of the run	1968-2018	1997-2007	1980-2018	1980-2018				
Atmospheric Forcing	JRA55		JRA55 (clim)	JRA55				
Surface salinity restoring	yes	no	no	no				
FW air-sea flux correction	no	yes (clim)	yes (clim)	yes (interannual)				
.				**Forcing by FRESHWATER RUNOFFS:**				
Greenland melt	climatological	interannual	climatological	climatological	interannual	interannual	climatological	interannual
North Atlantic rivers	climatological	interannual	climatological	climatological	interannual	interannual	interannual	climatological
North Indian rivers	climatological	interannual	climatological	climatological	interannual	climatological	interannual	interannual

(*) "Climatological" = seasonal cycle repeating identically every year

Nomenclature:

G : **Greenland**

A : **Atlantic**

I : **Indian**

S : Seasonal (clim).