



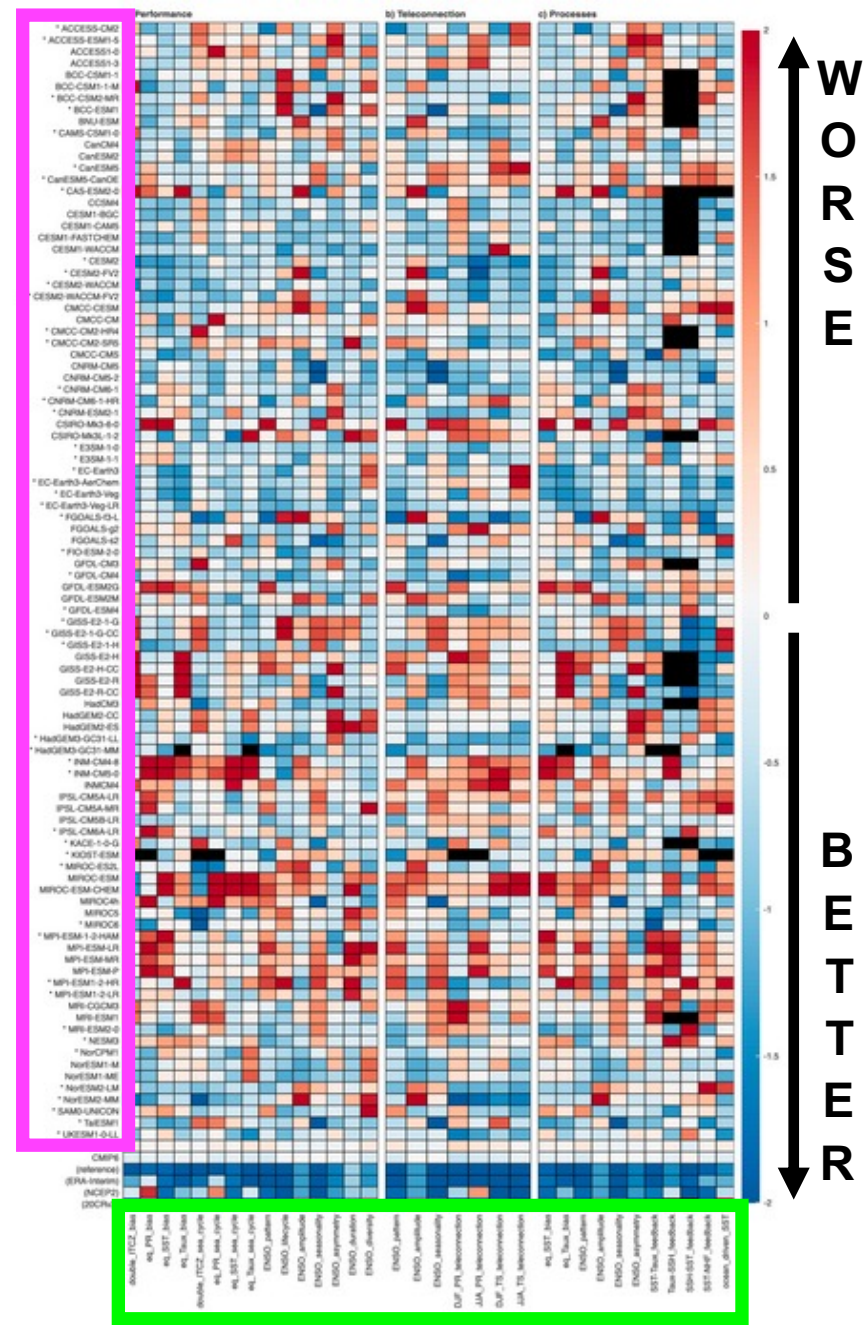
ENSO metrics

A tool for model evaluation, model selection, benchmarking model performance, detection of changes with climate change, analysis of the relationships between mean state and variability, analysis of the evolution of the relationships with climate change...

Yann Y. Planton

Eric Guilyardi, Andrew T. Wittenberg, Jiwoo Lee, Peter J. Gleckler, Tobias Bayr, Shayne McGregor, Michael J. McPhaden, Scott Power

climate models



metrics

Accessibility and computation



CMIP >20 Petabytes

Reproducibility and comparison

New model:

Presentation and Evaluation of the IPSL-CM6A-LR Climate Model

Olivier Boucher¹ , Jérôme Servonnat² , Anna Lea Albright³ , Olivier Aumont⁴ 

New CMIP:

ENSO representation in climate models: from CMIP3 to CMIP5

H. Bellenger · E. Guilyardi · J. Leloup ·
M. Lengaigne · J. Vialard

Better understanding of ENSO dynamics:

The Asymmetric Influence of Ocean Heat Content on ENSO Predictability in the CNRM-CM5 Coupled General Circulation Model

YANN Y. PLANTON,^a JÉRÔME VIALARD,^a ERIC GUILYARDI,^{a,b} MATHIEU LENGaigne,^{a,c}
AND MICHAEL J. MCPHADEN^d

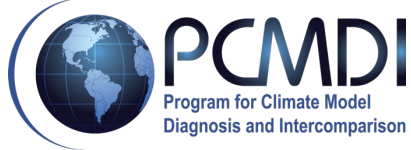
Evolution of ENSO with climate change:

ENSO Change in Climate Projections: Forced Response or Internal Variability?

N. Maher^{1,2} , D. Matei¹, S. Milinski^{1,3} , and J. Marotzke¹ 

Accessibility and computation

Reproducibility and comparison

CMIP data analyzed by  using the CLIVAR ENSO metrics
<https://cmec.inl.gov/results/enso/>

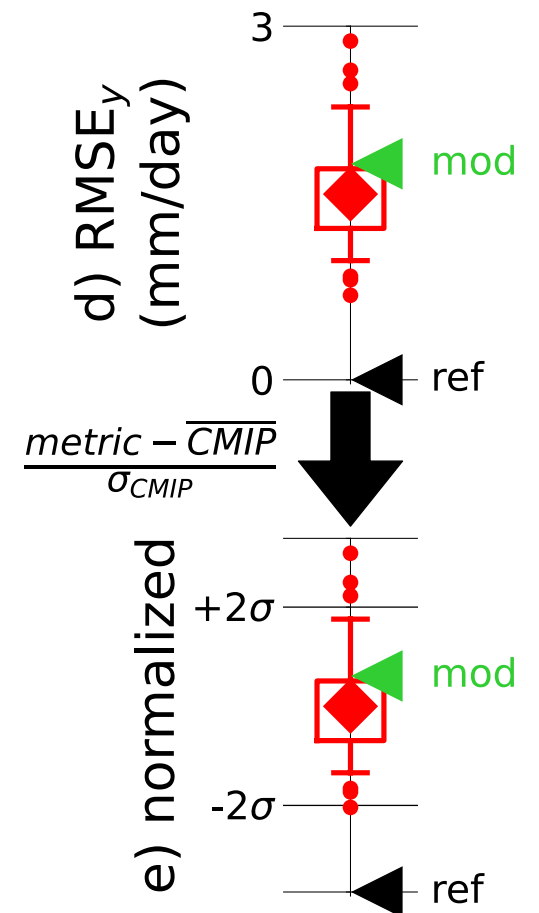
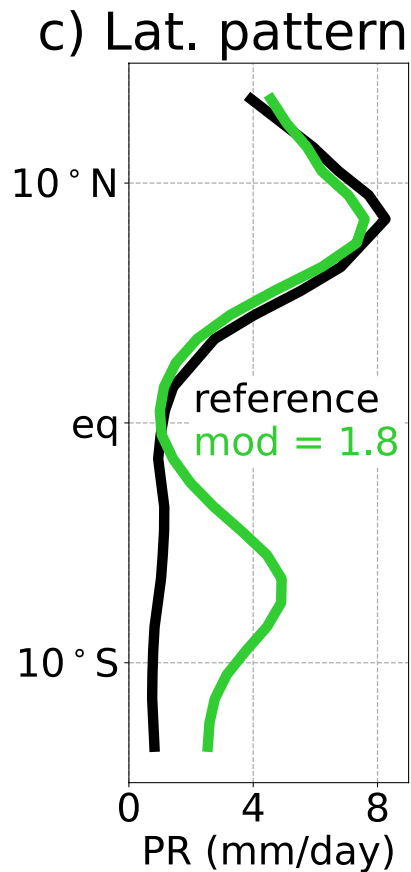
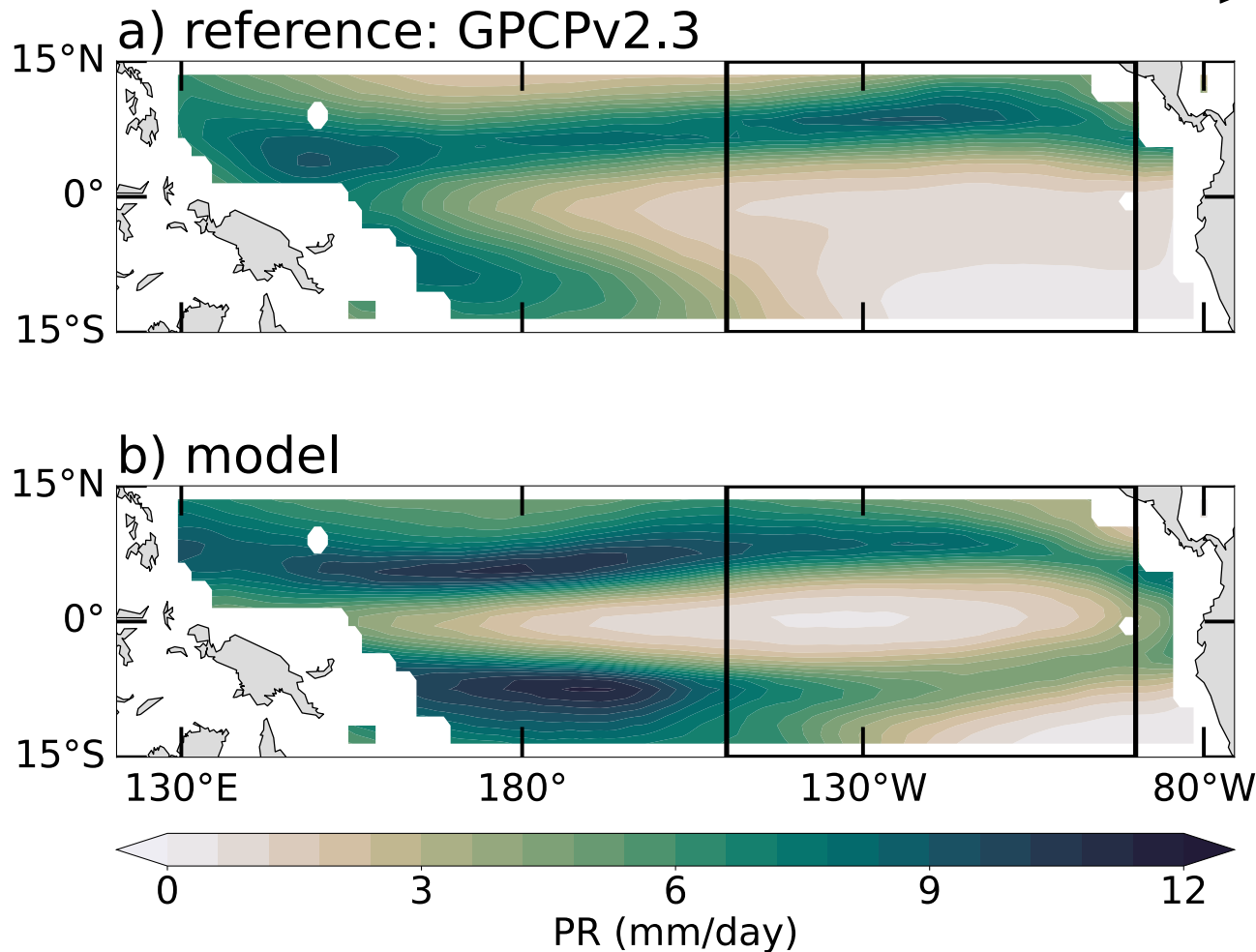
 CLIVAR ENSO metrics code available:
https://github.com/CLIVAR-PRP/ENSO_metrics

~20 Petabytes of CMIP data

Evolution of ENSO with climate change:
ENSO Change in Climate Projections: Forced Response
or Internal Variability?

Metric = nbr comparing mod to a ref

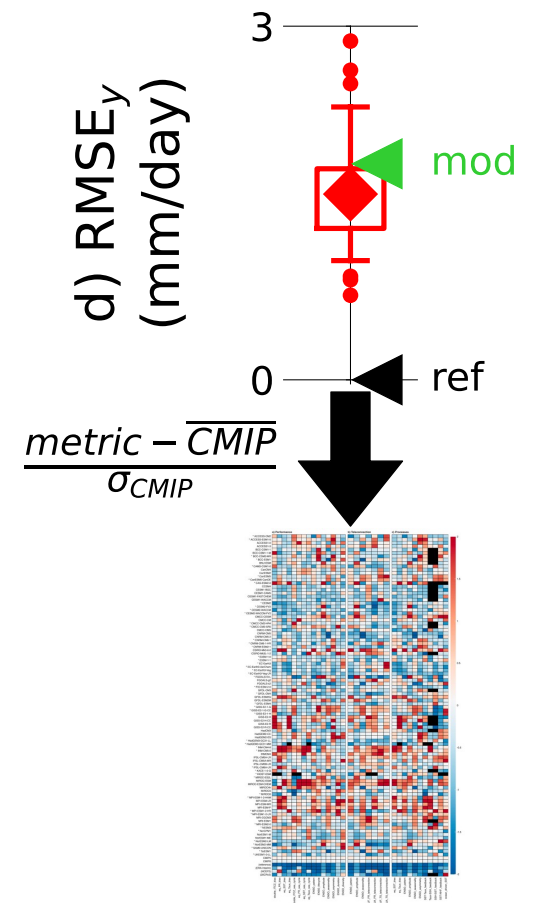
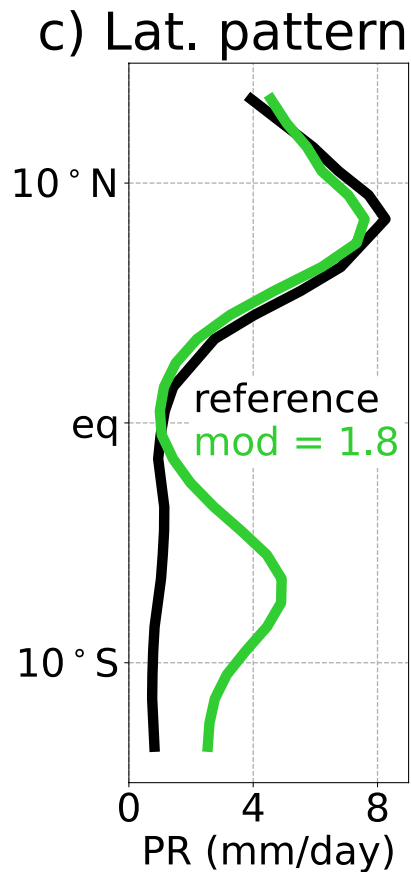
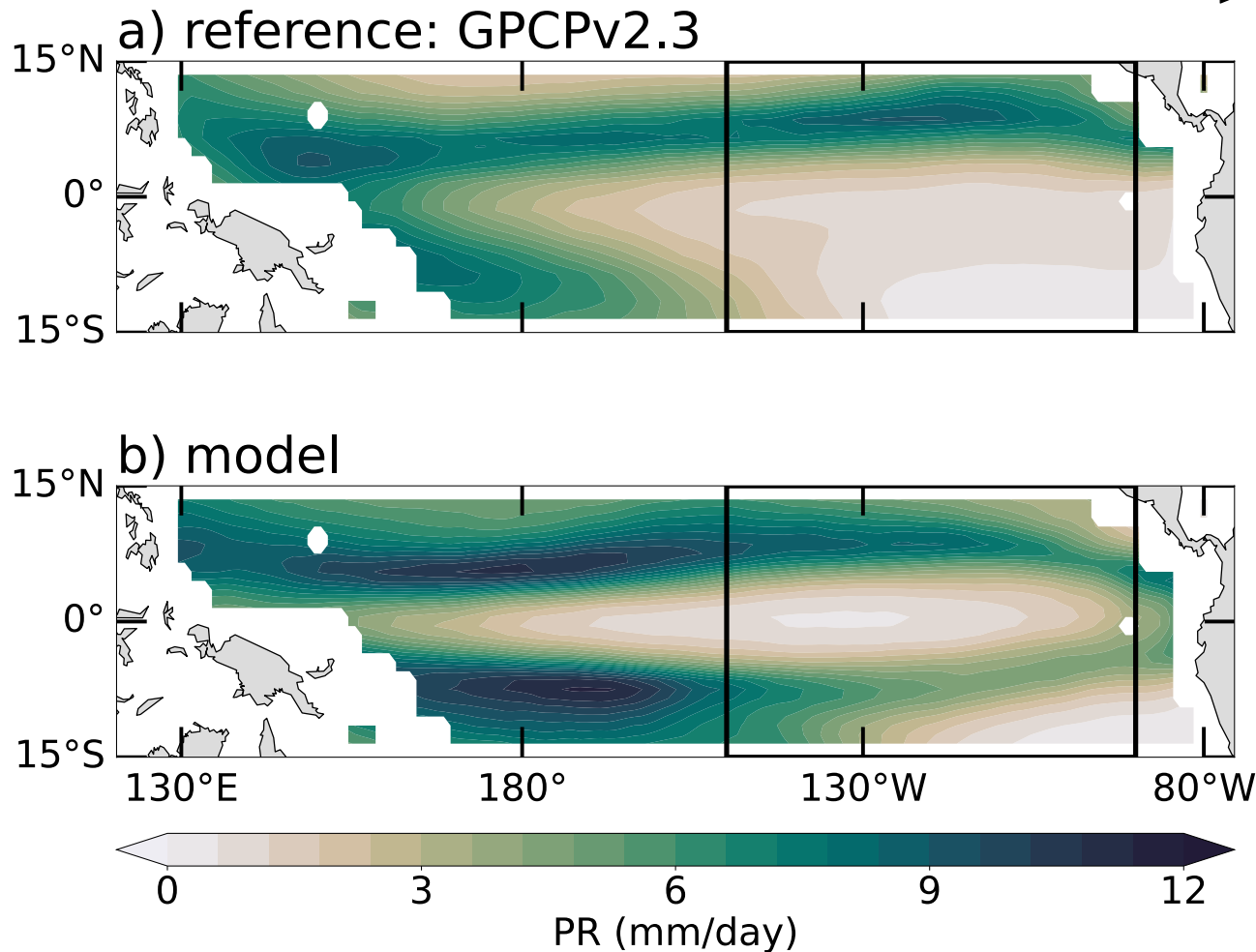
Diagnostic 1 → **Diag. 2** → **Metric**



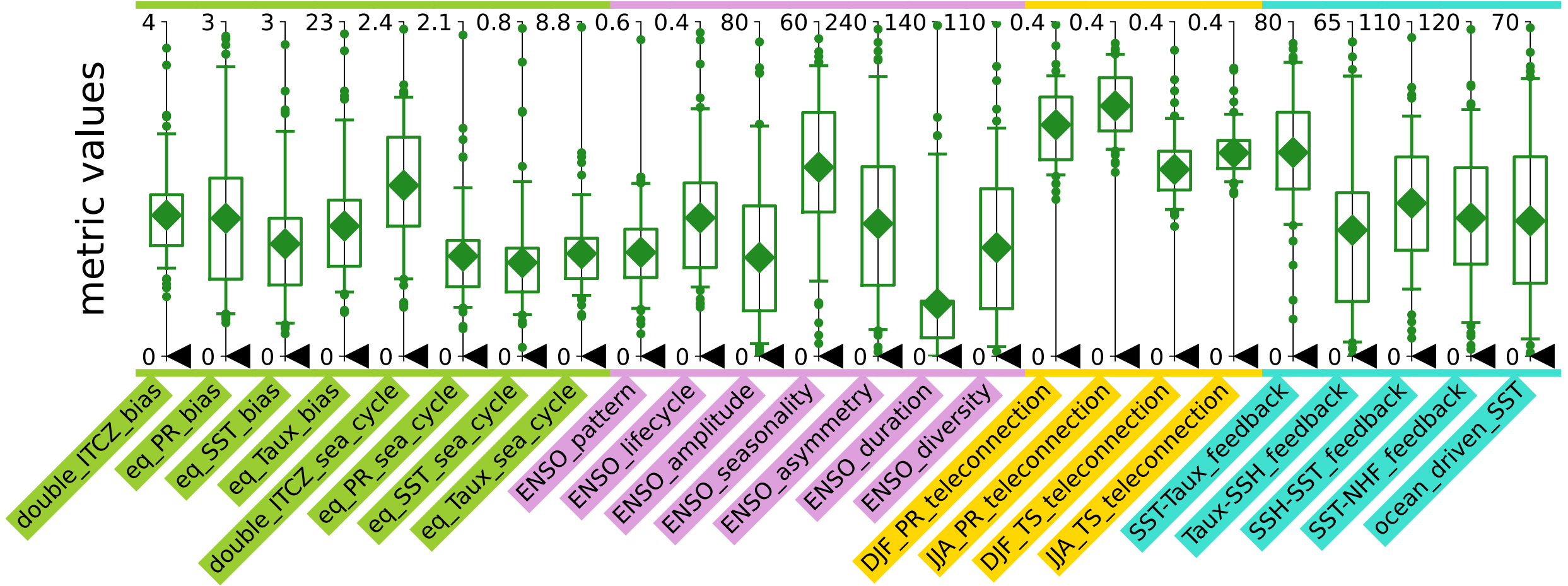
Planton et al. (2021)

Metric = nbr comparing mod to a ref

Diagnostic 1 → **Diag. 2** → **Metric**



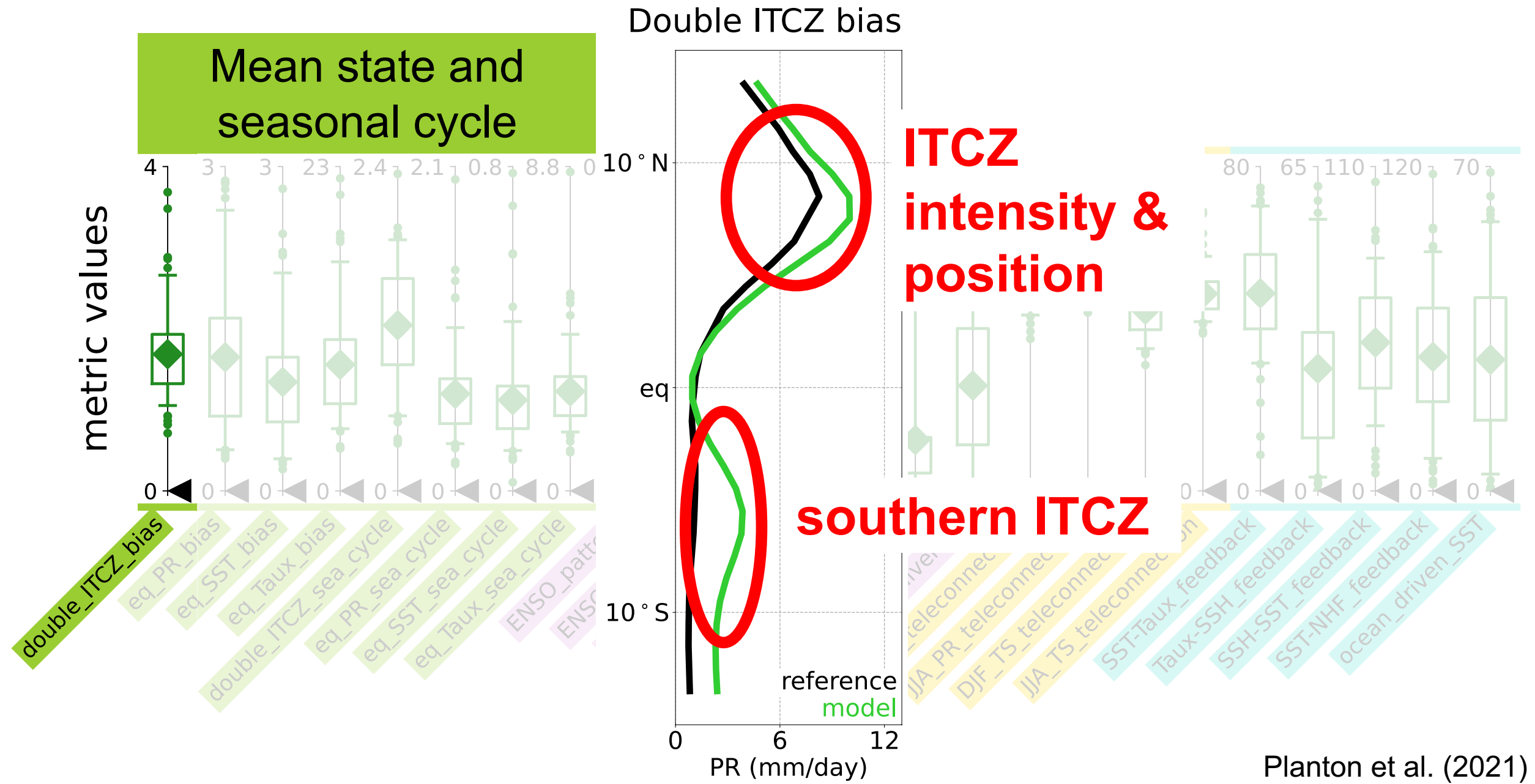
4 categories of metrics



obs CMIP

Planton et al. (2021)

PR, SST, Taux mean and seasonal cycles

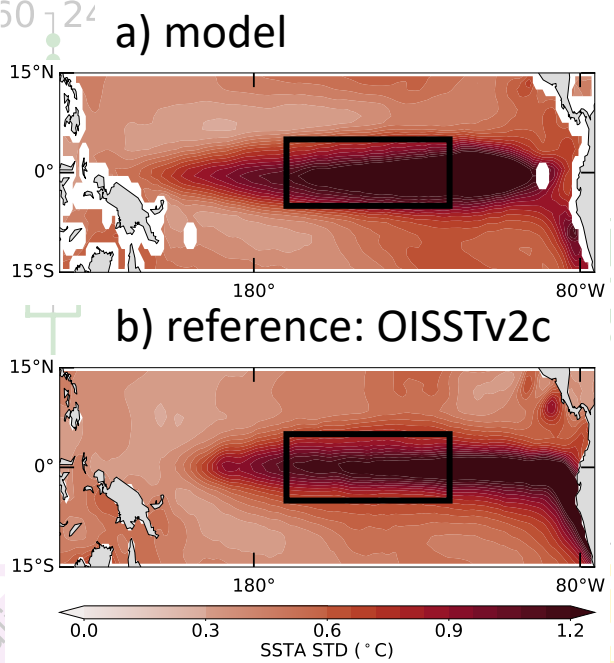
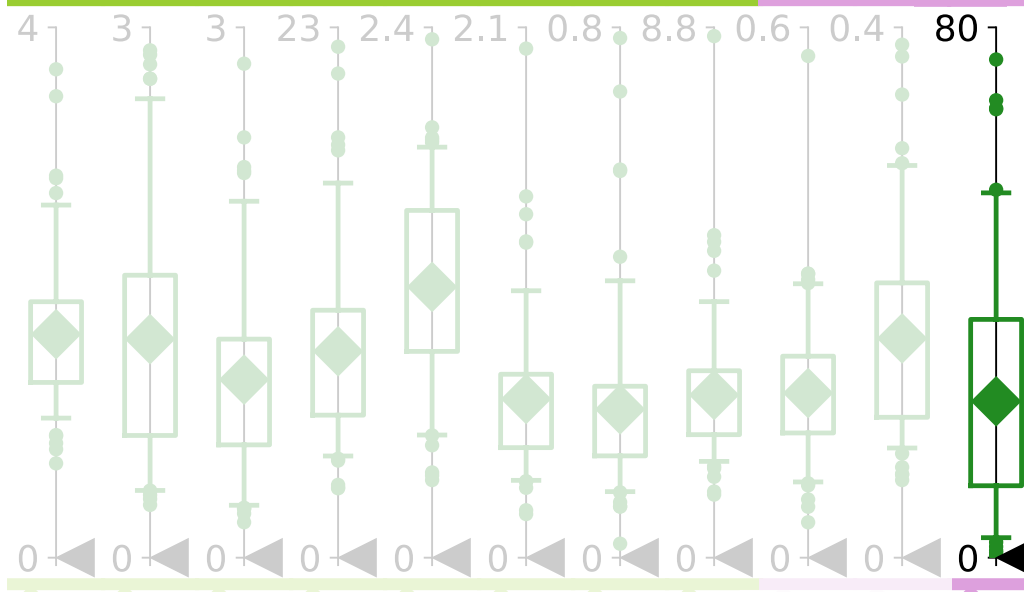


SST variability (pattern, amplitude...)

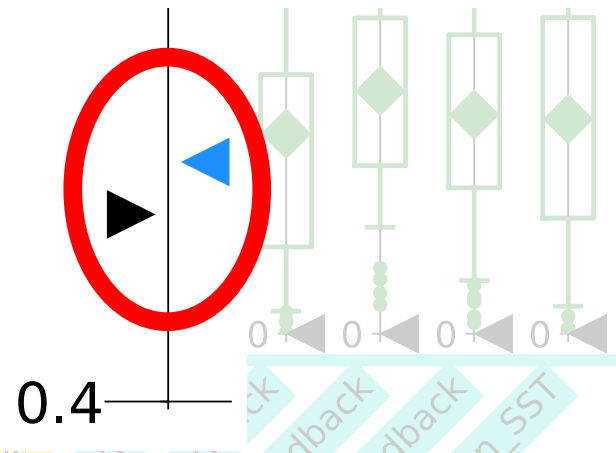
Mean state and seasonal cycle

ENSO (SST variability)

metric values



large ENSO amplitude



double_ITCZ_bias eq_PR_bias eq_SST_bias eq_Taux_bias double_ITCZ_sea_cycle eq_PR_sea_cycle eq_SST_sea_cycle eq_Taux_sea_cycle ENSO_pattern ENSO_lifecycle ENSO_amplitude ENSO_seasonal ENSO_asym ENSO_du ENSO_div DJF_PR_teleconn JJA_PR_teleconn DJF_TS_teleconn JJA_TS_teleconn SST-Taux_fee Taux-SSH_fee SSH-SST_feeback SST-NHF_feeback ocean_driven_SST

obs CMIP

Planton et al. (2021)

T. and PR patterns related to ENSO

Mean state and seasonal cycle

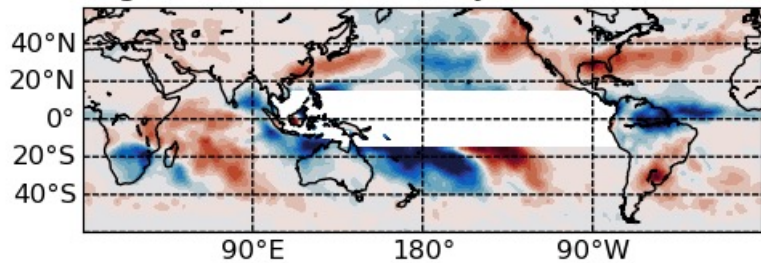
ENSO (SST variability)

T. and PR Telecon.

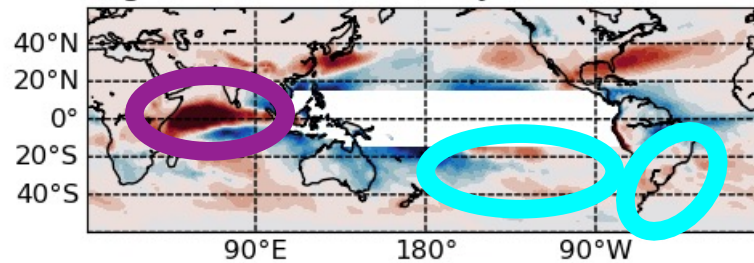
ref: Tropflux_GPCPv2.3

model

reg(ENSO SSTA, PRA) DJF

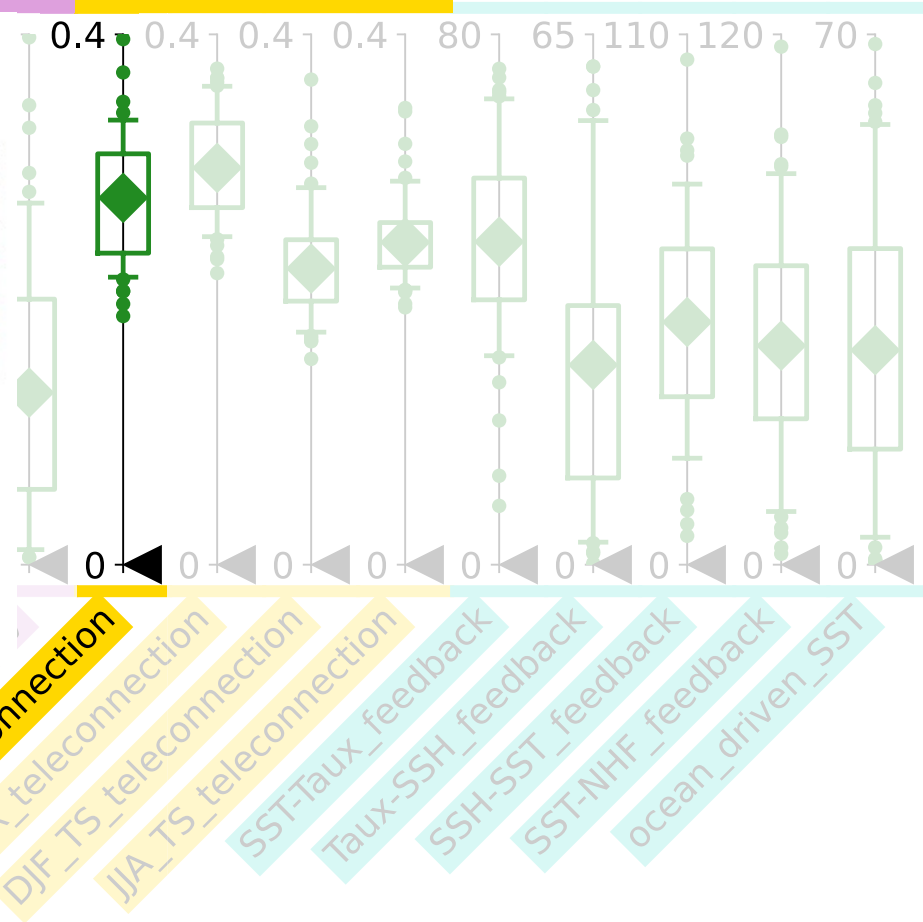


reg(ENSO SSTA, PRA) DJF



CORR: 0.62
RMSE: 0.24 mm/day/°C

strong / weak PRA response to SSTA

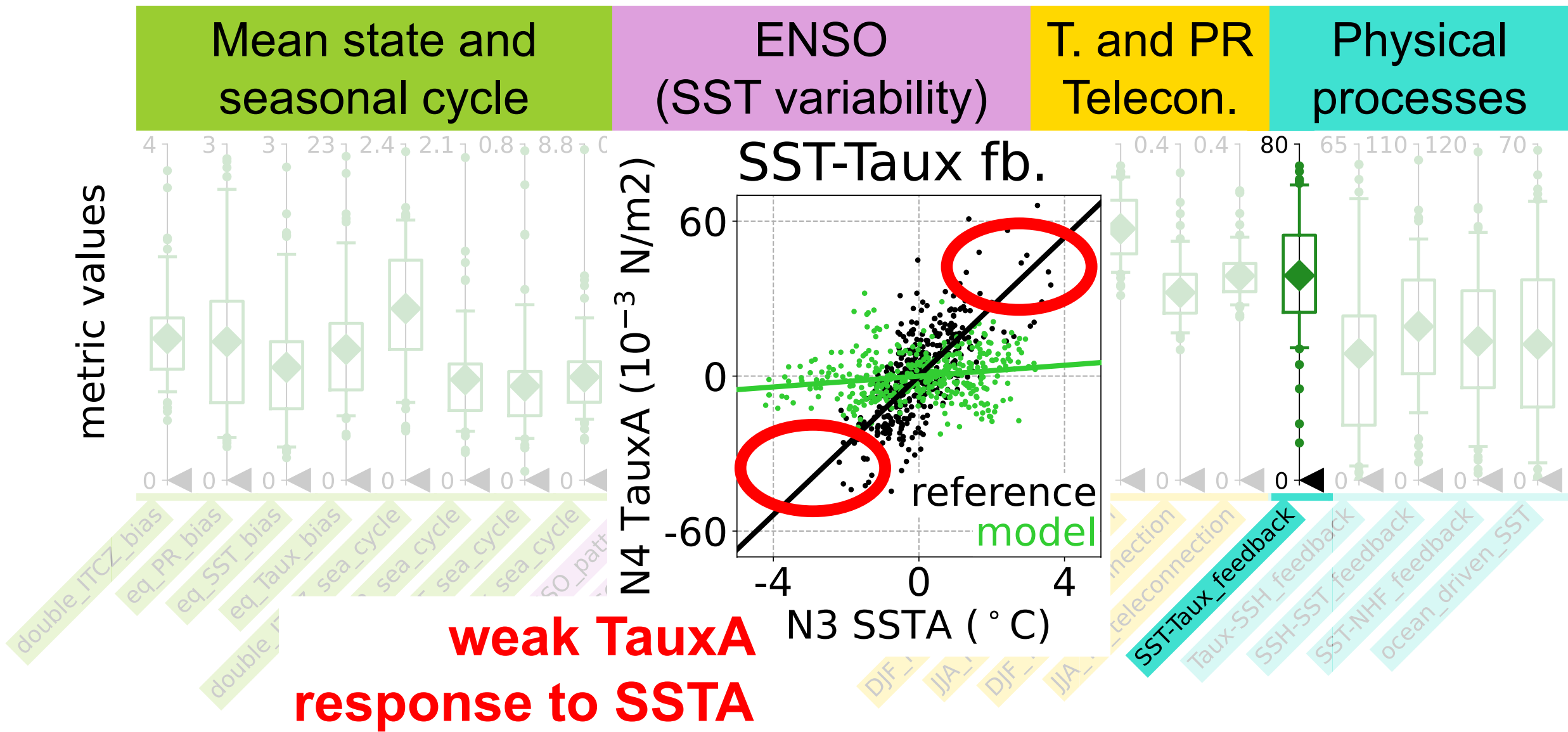


double_ITCZ_ eq_PR_ eq_SST_ eq_Taux_ double_ITCZ_sea_C_ eq_PR_sea_C_ eq_SST_sea_C_ eq_Taux_sea_C_ ENSO_pat_ ENSO_lifec_ ENSO_ampli_ ENSO_season_ ENSO_asymm_ ENSO_dura_ ENSO_diver_ DJF_PR_teleconnection JJA_PR_teleconnection DJF_TS_teleconnection JJA_TS_teleconnection SSTA-Taux_feedback Taux-SSH_feedback SSH-SSTA_feedback SSTA-NHF_feedback ocean_driven_SST

obs CMIP

Planton et al. (2021)

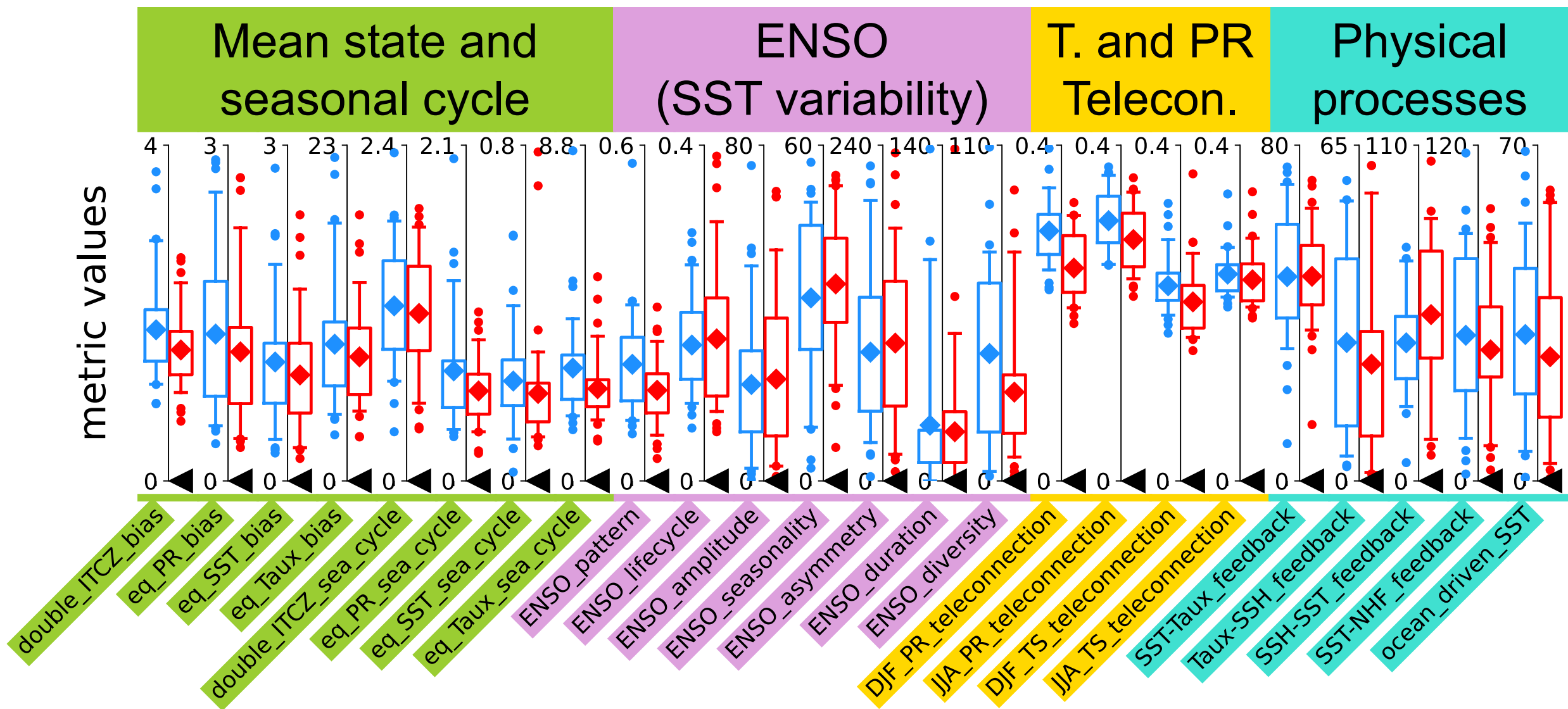
Main feedbacks



**weak TauxA
response to SSTA**

obs CMIP

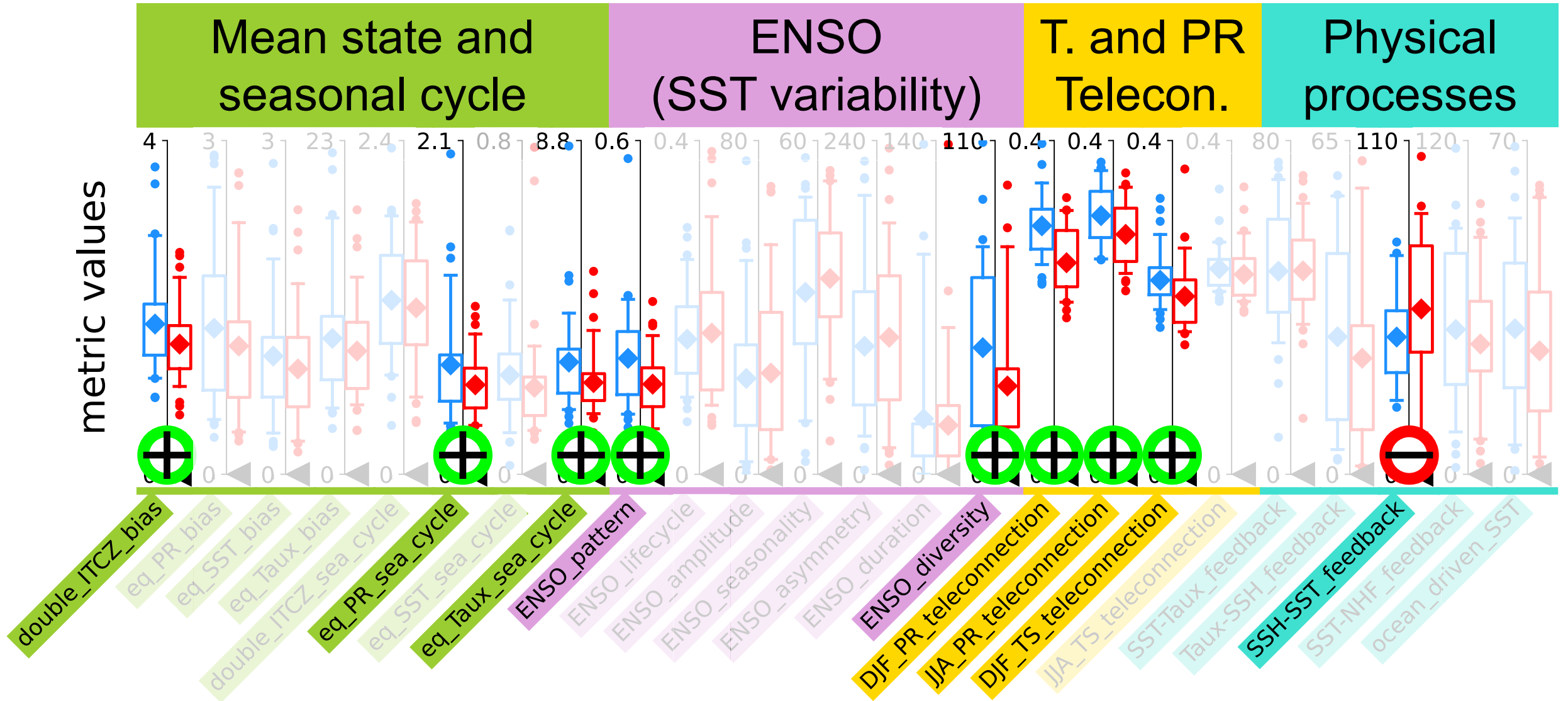
Metrics can be used to detect improvement



obs CMIP5 CMIP6

Planton et al. (2021)

8 metrics significantly improved, 1 worsened

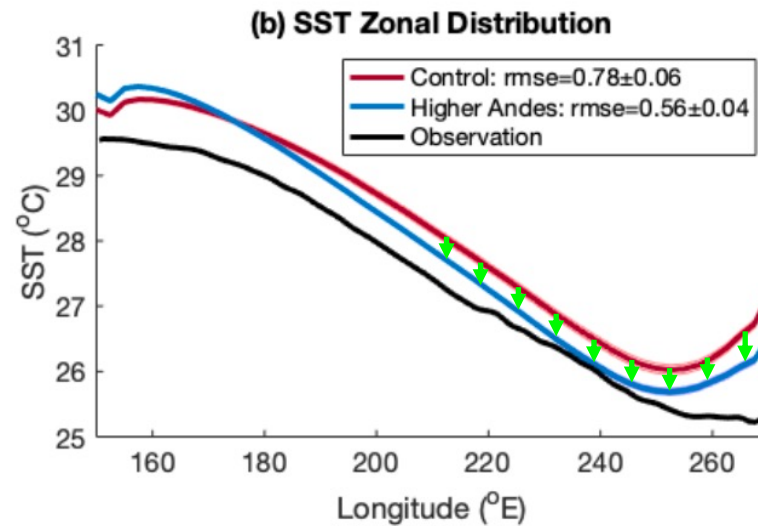
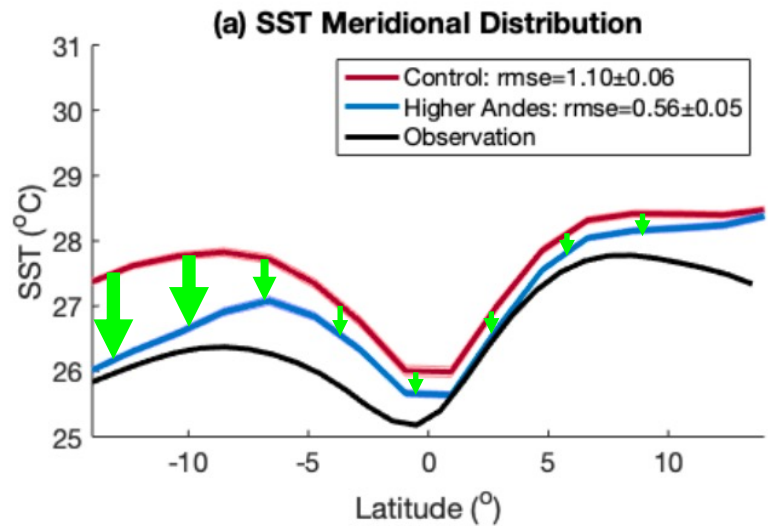


obs CMIP5 CMIP6

Planton et al. (2021)

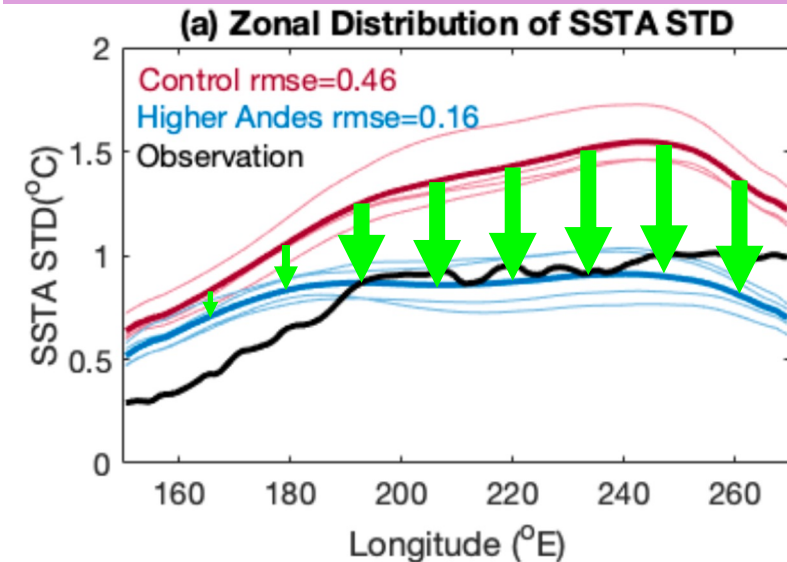
New model config. improves simulation

Mean state: SST



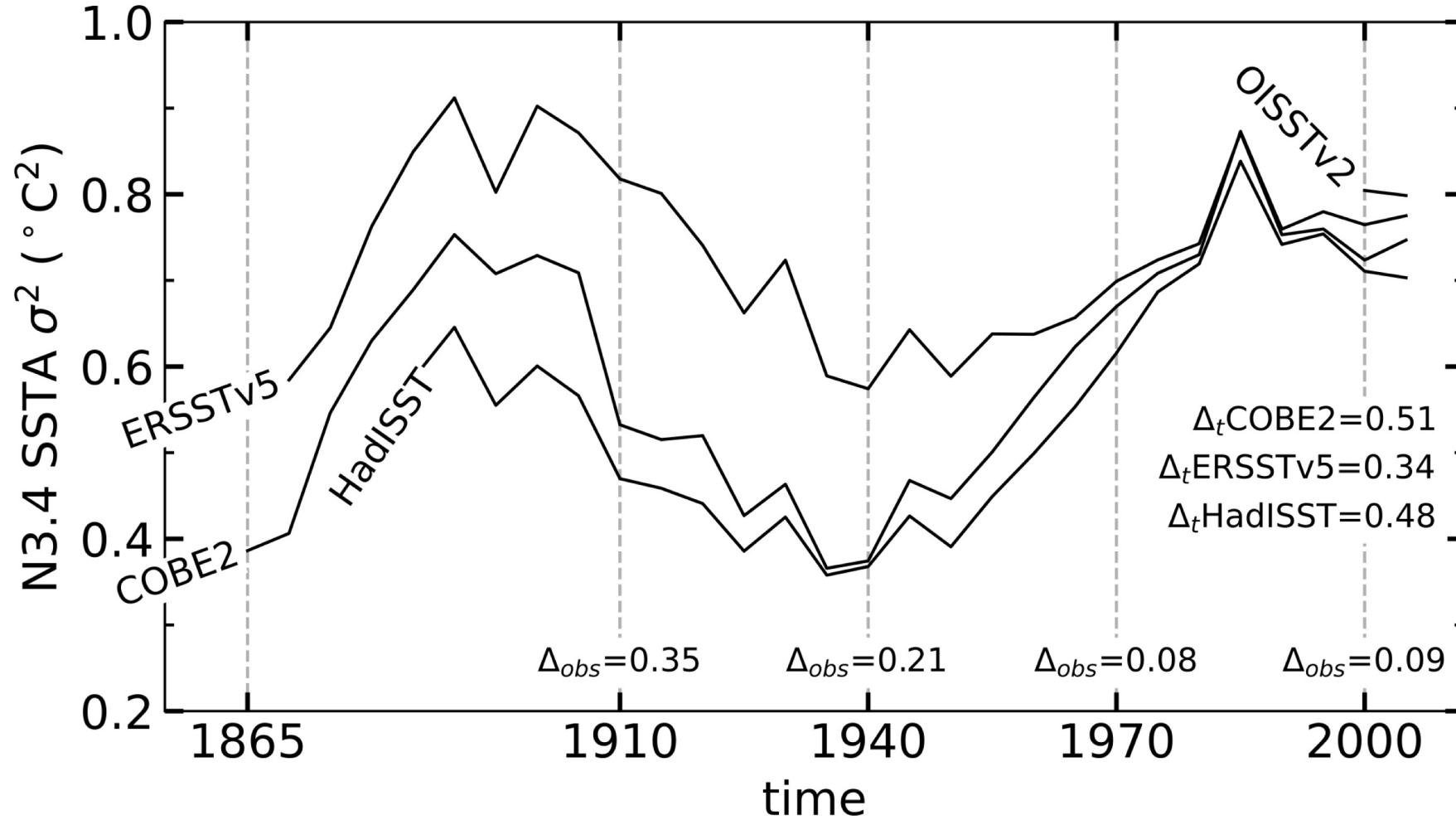
old model config.
new model config.
obs

Variability: amplitude

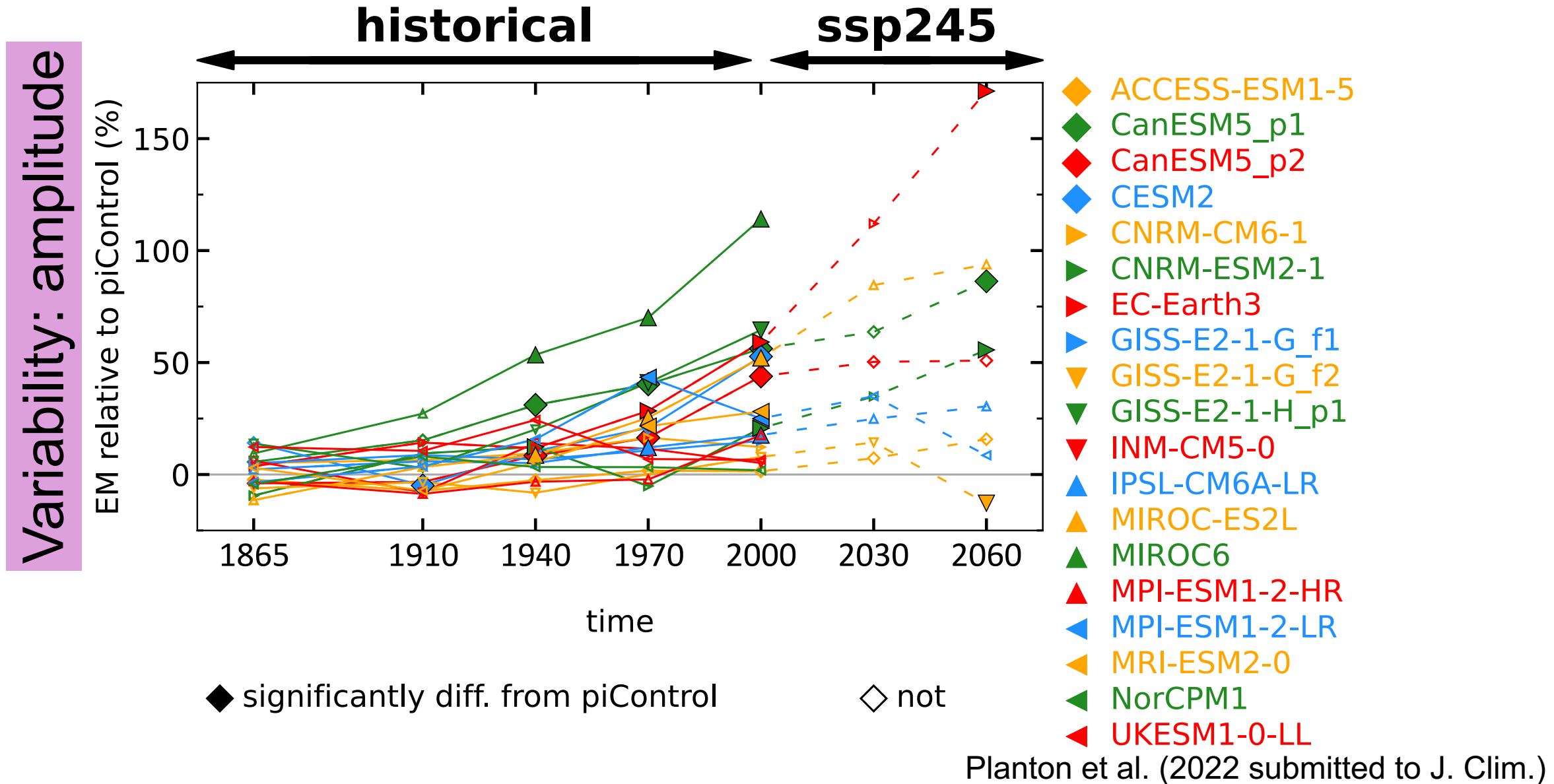


Metrics can be used to detect changes

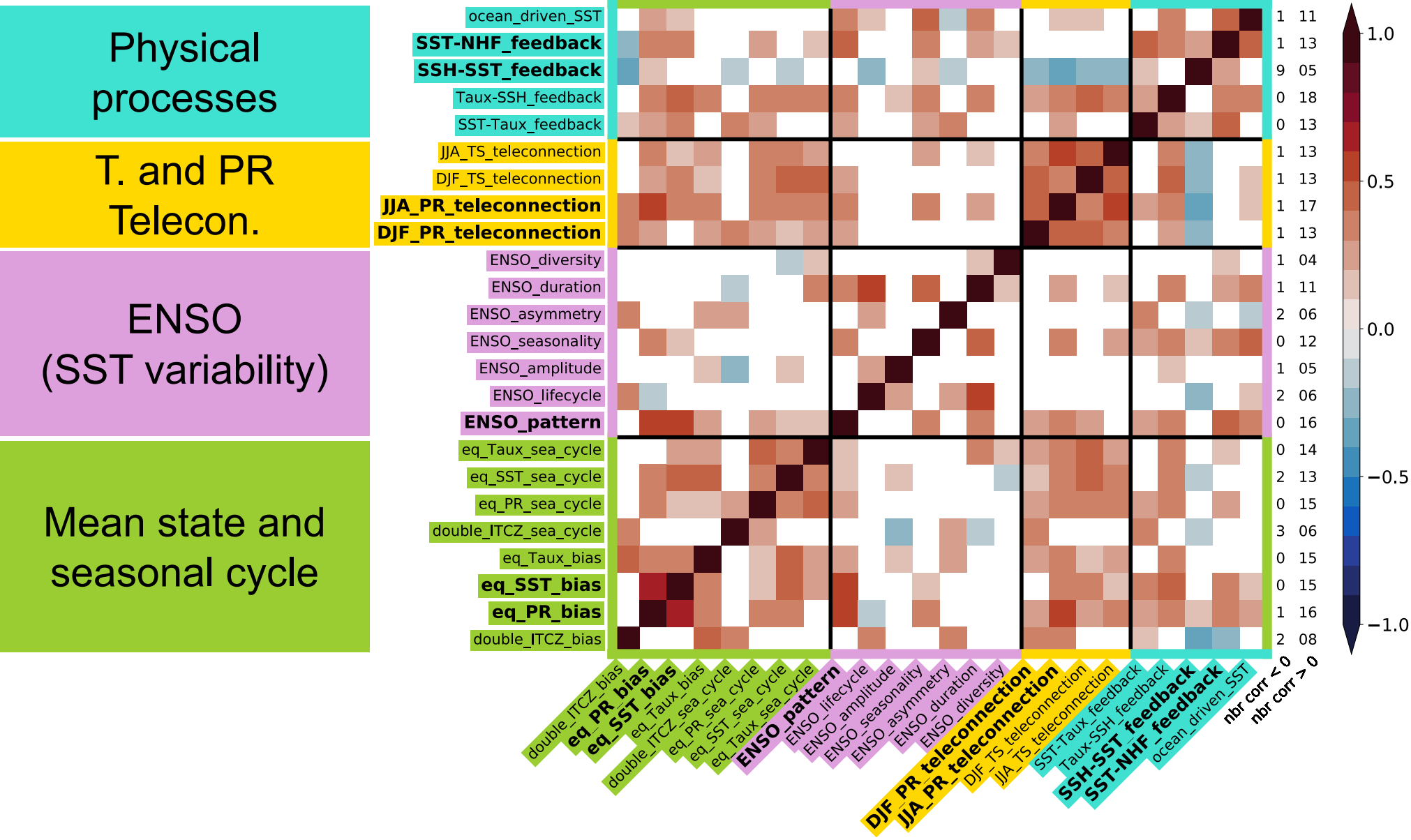
Variability: amplitude



ENSO is getting stronger in 60% of the LE



Metrics can be used to study relationships



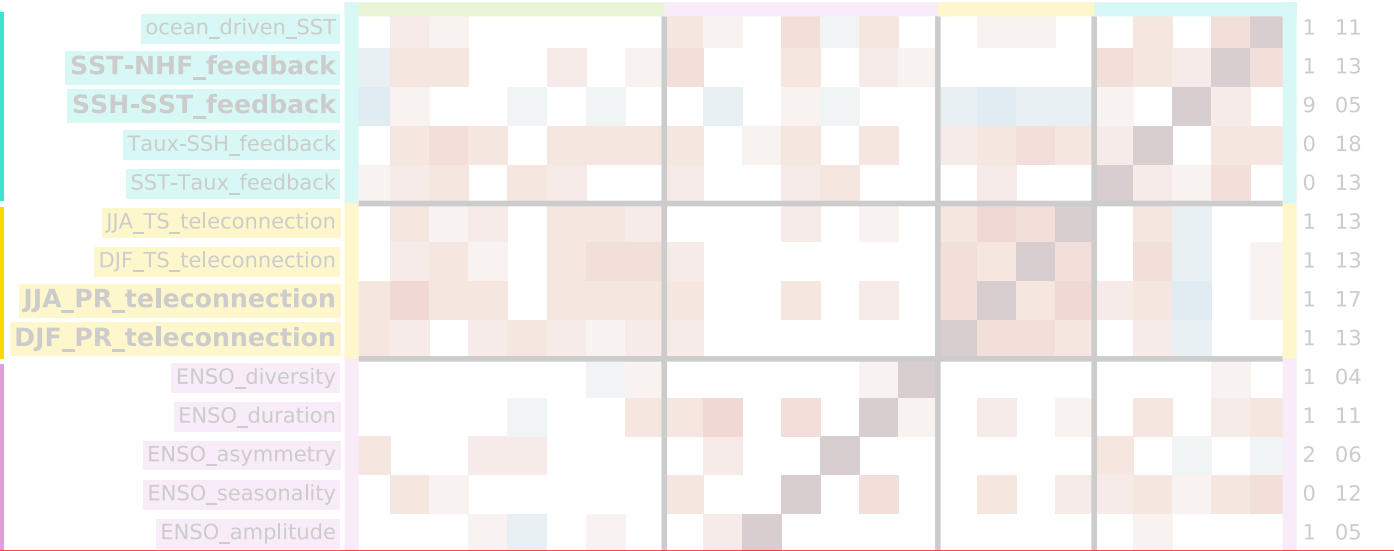
Confirm previous findings

Physical processes

T. and PR Telecon.

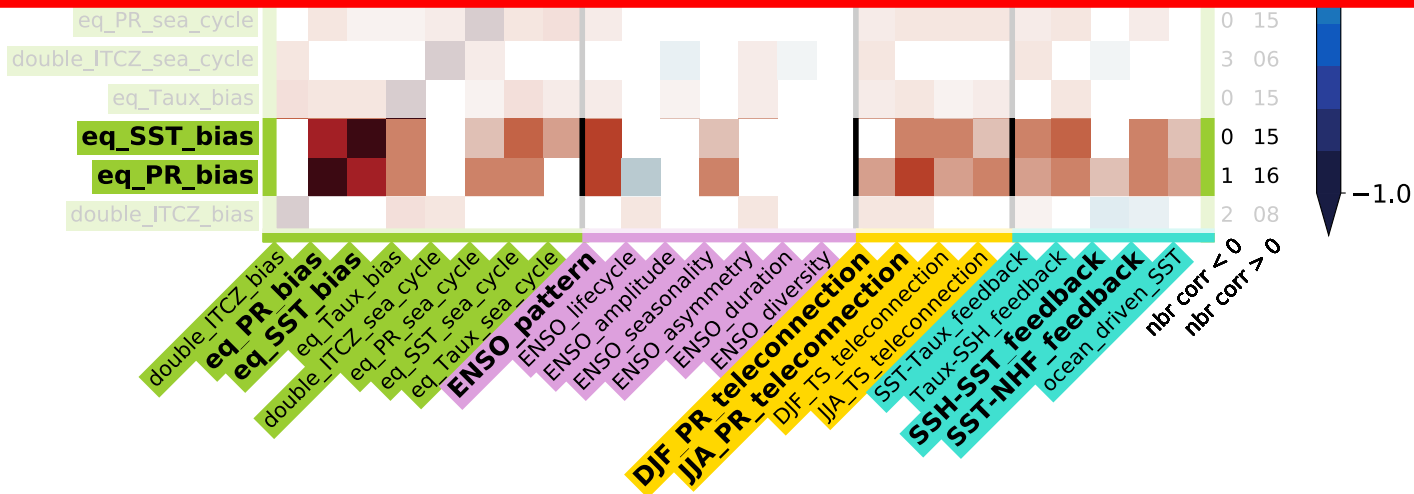
ENSO (SST variability)

Mean state and seasonal cycle



Consistent with previous studies (e.g., Bellenger et al. 2014; Bayr et al. 2019; Brown et al. 2020)

SST and PR biases correlated with most metrics



Highlight interesting relationships

Physical processes



Thermocline feedback **anticorrelated** with half of the metrics

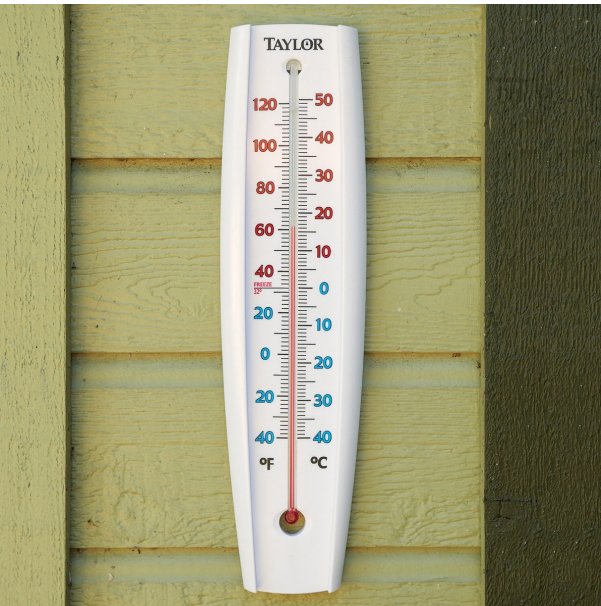
ENSO (SST variability)



Mean state and seasonal cycle

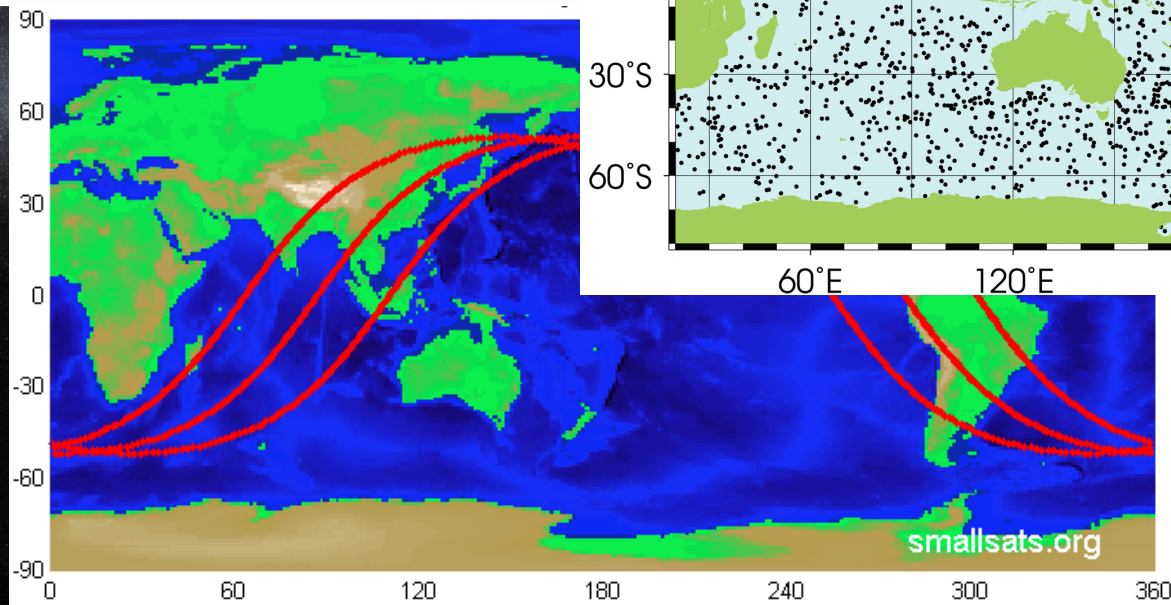
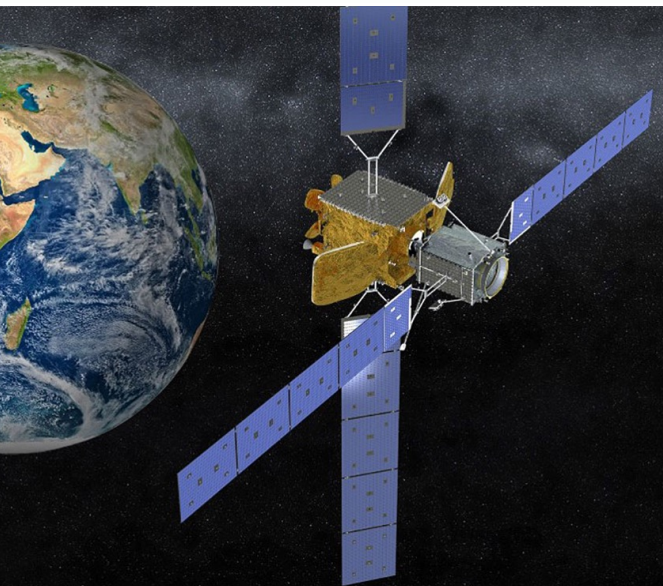
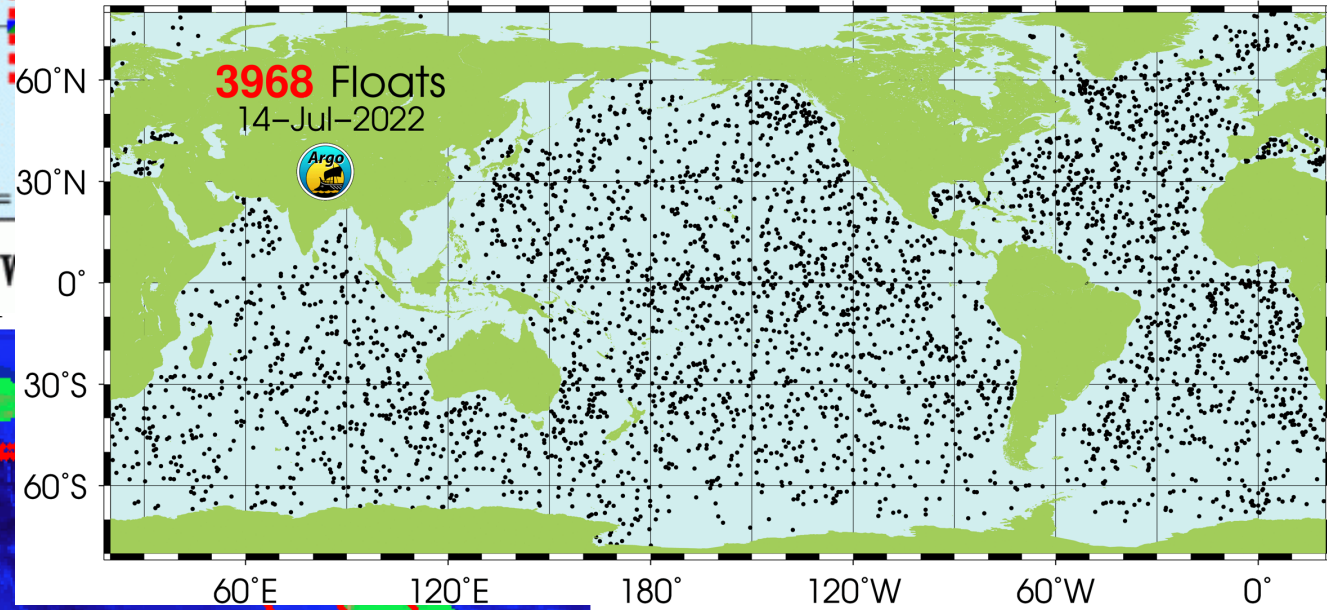
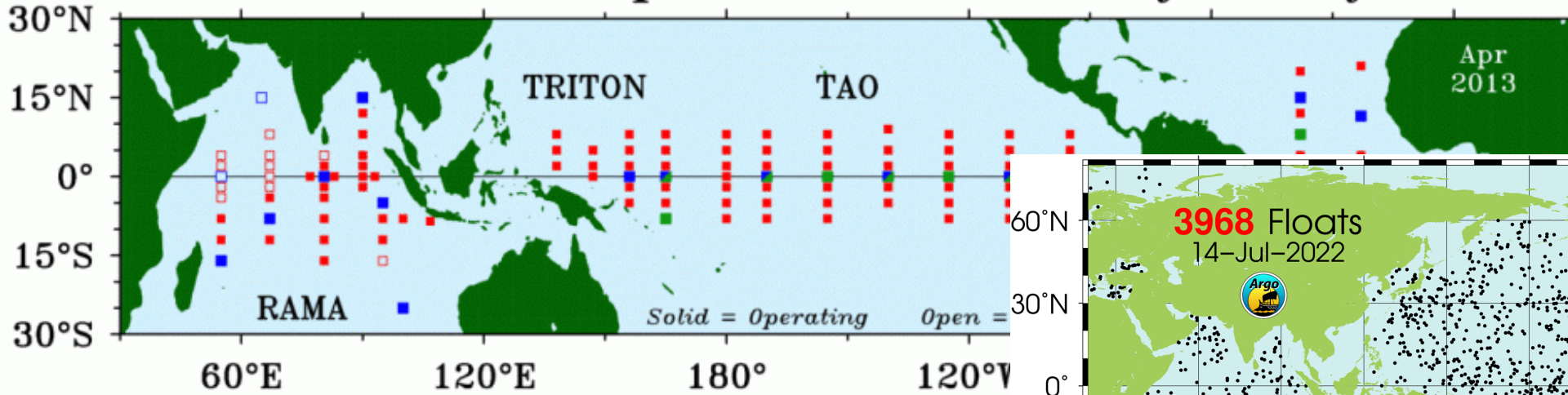


Reference dataset? Observation?

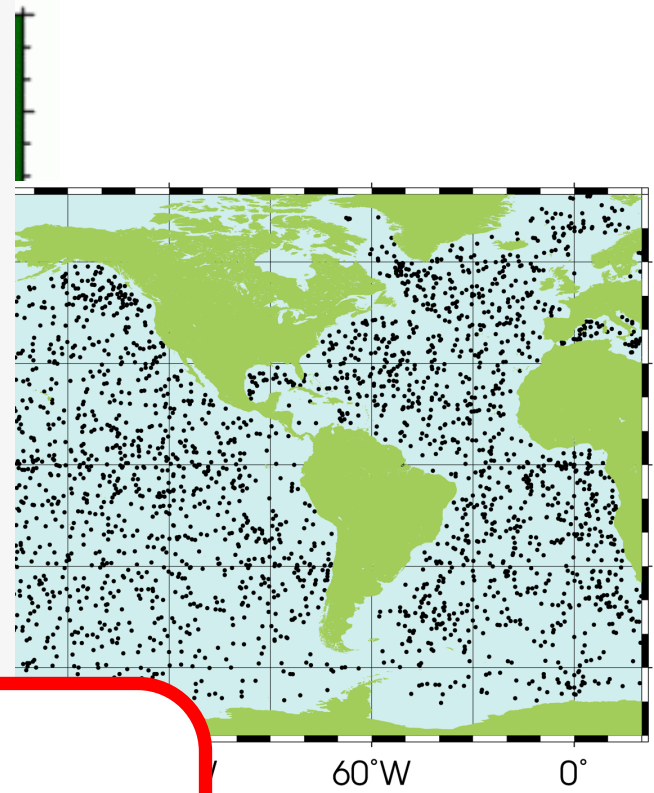
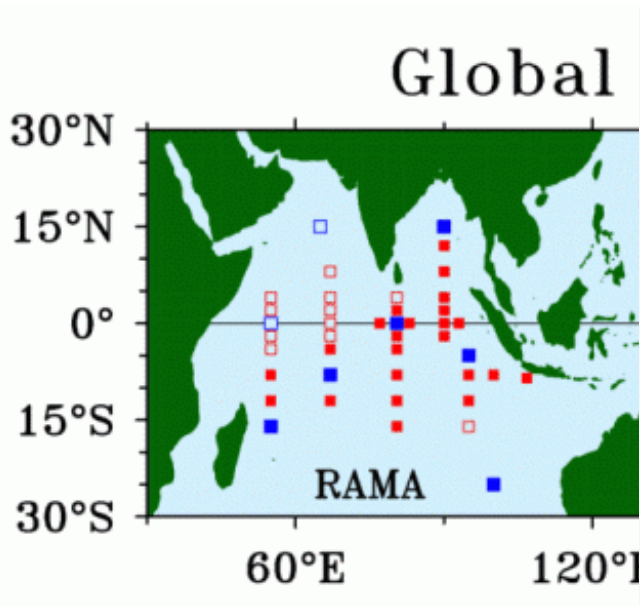


Reference dataset? Observation?

Global Tropical Moored Buoy Array



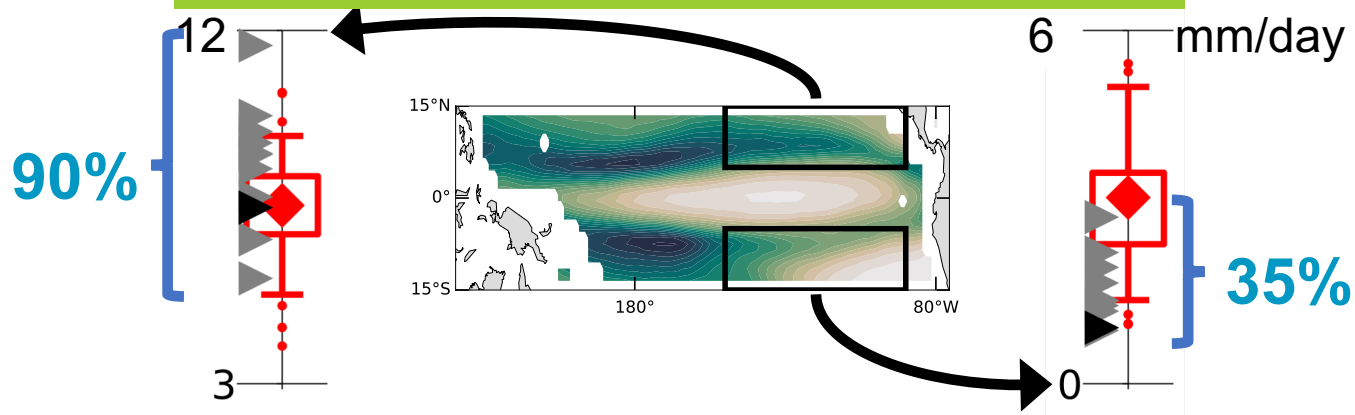
Gridded observational datasets needed



Interpolation
Statistical methods (EOTs, EOFs...)
Climate models

How good are our observational datasets?

Mean state: precipitation

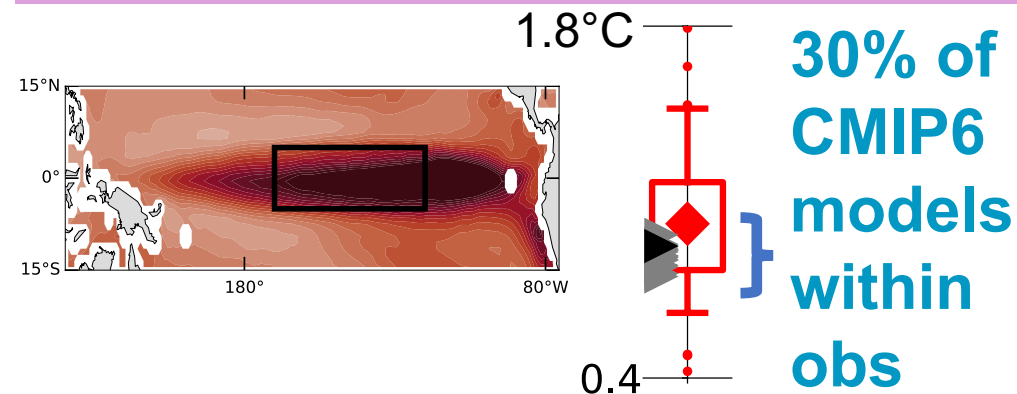


CMIP6 models

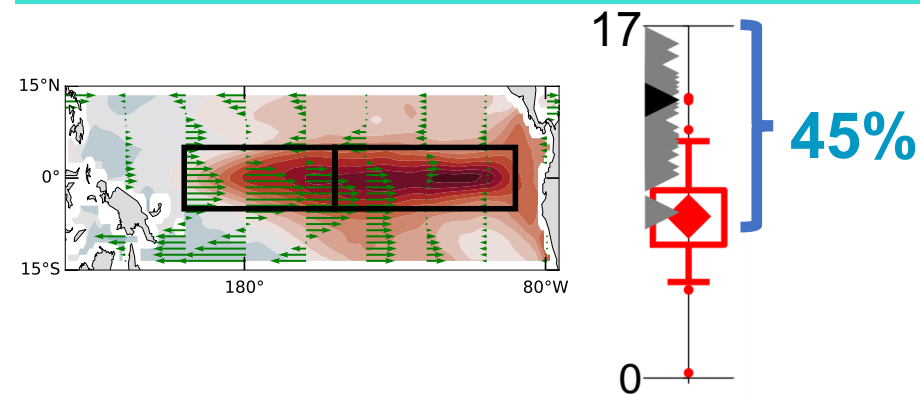
Reference dataset

Other datasets

Variability: amplitude



Processes: wind stress fb.



Which one(s) should we use?

	model	HF	PR	SSH	SST	Tau
20CR	Atm	X	X		X	X
AVISO				X		
CERA-20C	Atm-Oce	X	X		X	X
CFSR	Atm-Oce	X	X	X	X	X
C-GLORS	Oce	X		X	X	X
CMAP			X			
COBE					X	
CSIRO_SSH				X		
ERA-20C	Atm				X	X
ERA-I	Atm	X	X		X	X
ERA5	Atm	X	X		X	X
ERSST					X	

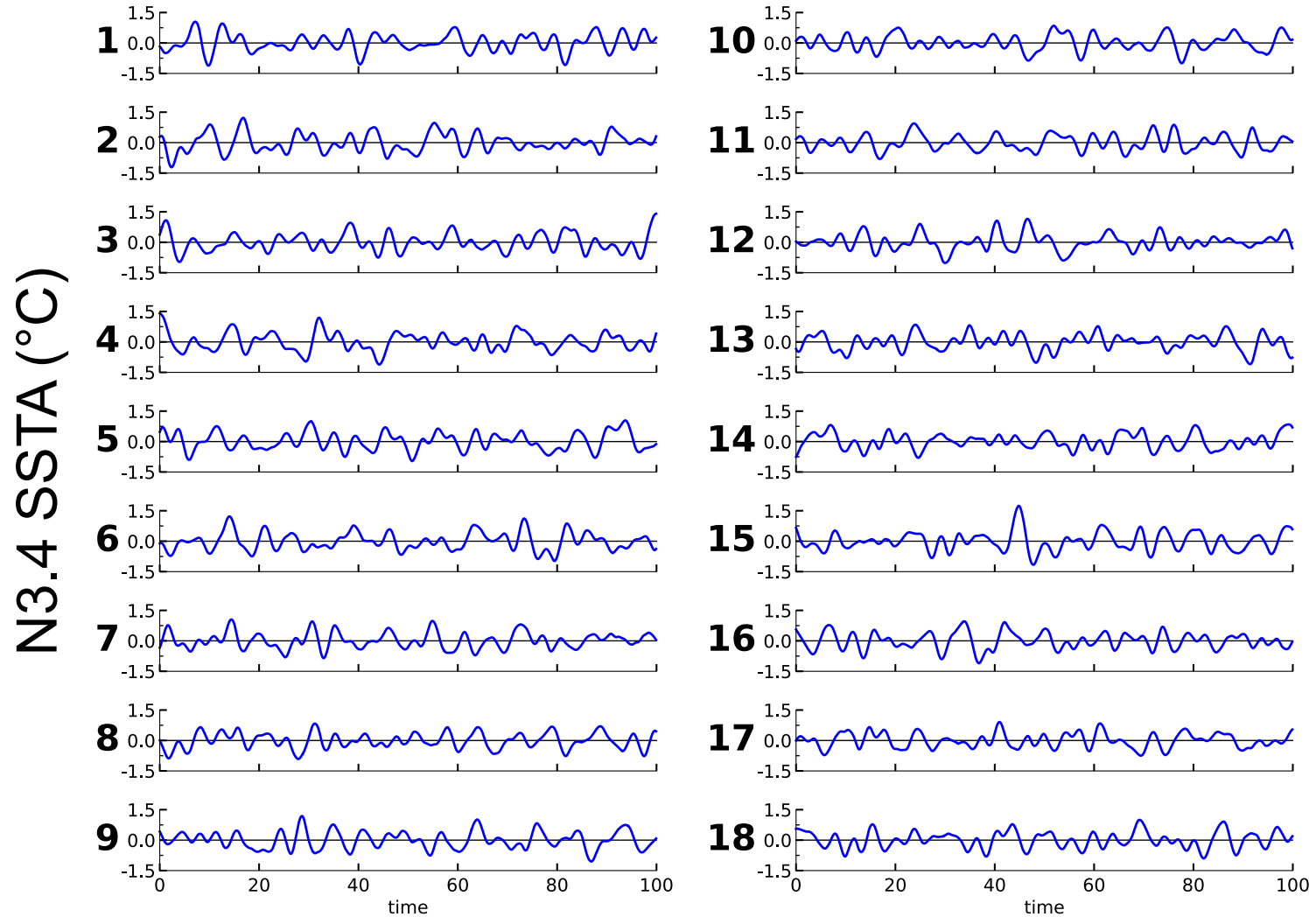
	model	HF	PR	SSH	SST	Tau
GFDL-ECDA	Atm-Oce	X		X	X	X
GODAS	Oce	X		X	X	X
GPCP			X			
HadISST					X	
JPL_SSH				X		
JRA-55	Atm		X		X	
MERRA	Atm	X	X		X	X
NCEP	Atm	X	X		X	X
OISST					X	
ORAS	Oce	X		X	X	X
SODA	Oce	X		X	X	X
Tropflux	Atm	X			X	X

Earth's climate naturally fluctuates on due to processes intrinsic to the climate system

unforced climate in a piControl simulation

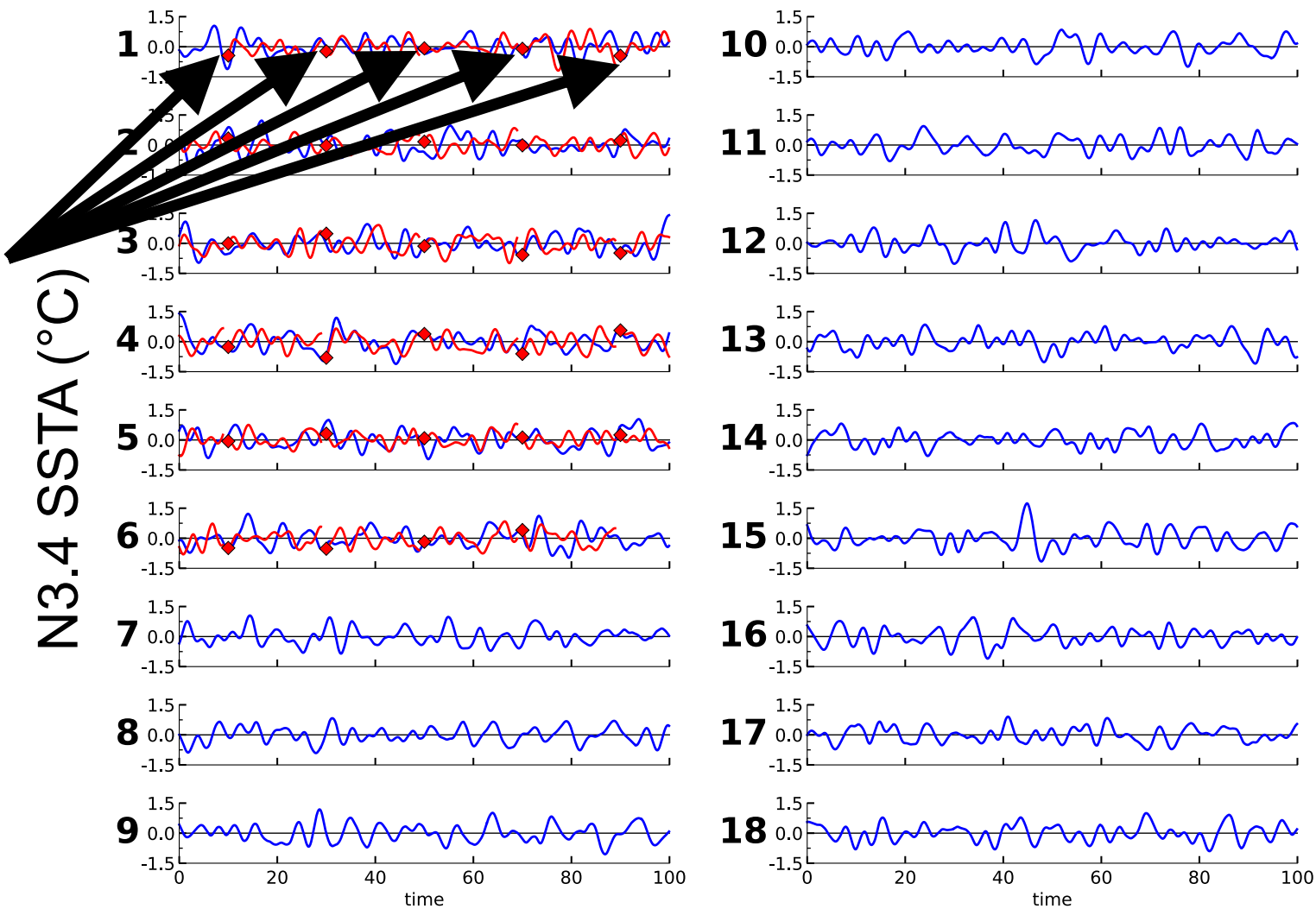
Fixed:

- greenhouse gas
- ozone
- orbital parameters
- solar irradiance
- land use



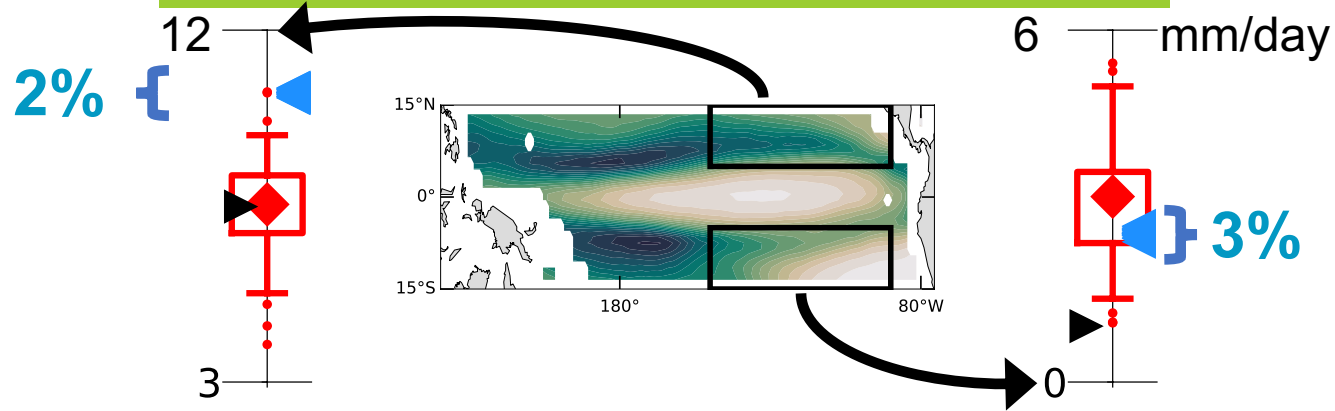
Initial conditions influence the evolution of the Earth climate: ensemble simulations

historical members branched from piControl at regular intervals



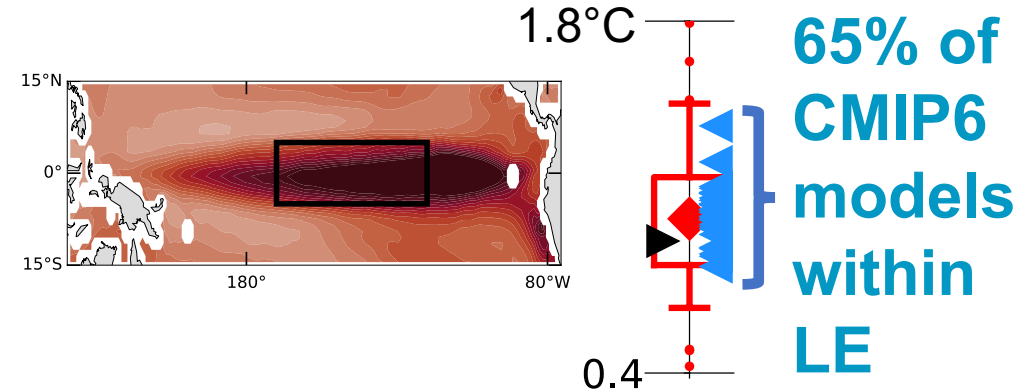
How distinct are the ensemble member?

Mean state: precipitation

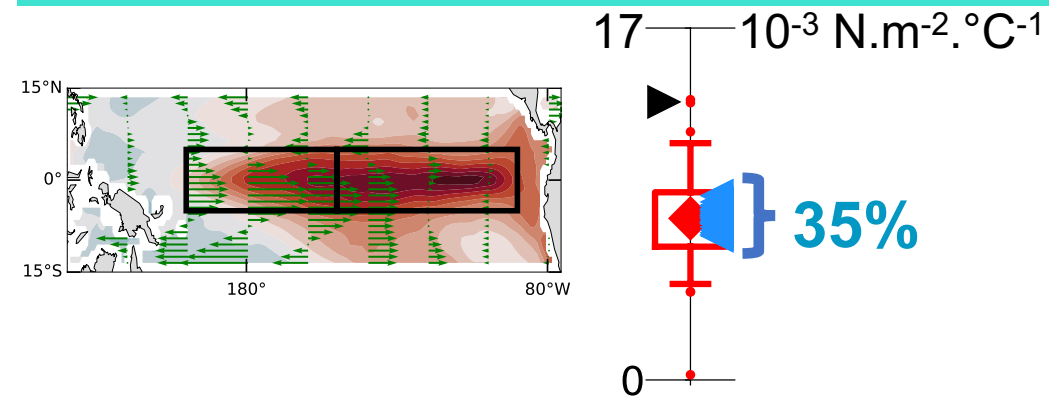


CMIP6 models
Reference dataset
32 members

Variability: amplitude



Processes: wind stress fb.



Lab work: Wed. and Thur. afternoons

Use results from CLIVAR ENSO metrics to:

- evaluate climate models**
- analyze co-variability of model errors**
- analyze co-variability of climate variables**
- ...**

Learn:

- How the package can help you**
- Use many observations**
- Use many models and if possible LE**