Impact of reducing climatological bias on seasonal prediction skill

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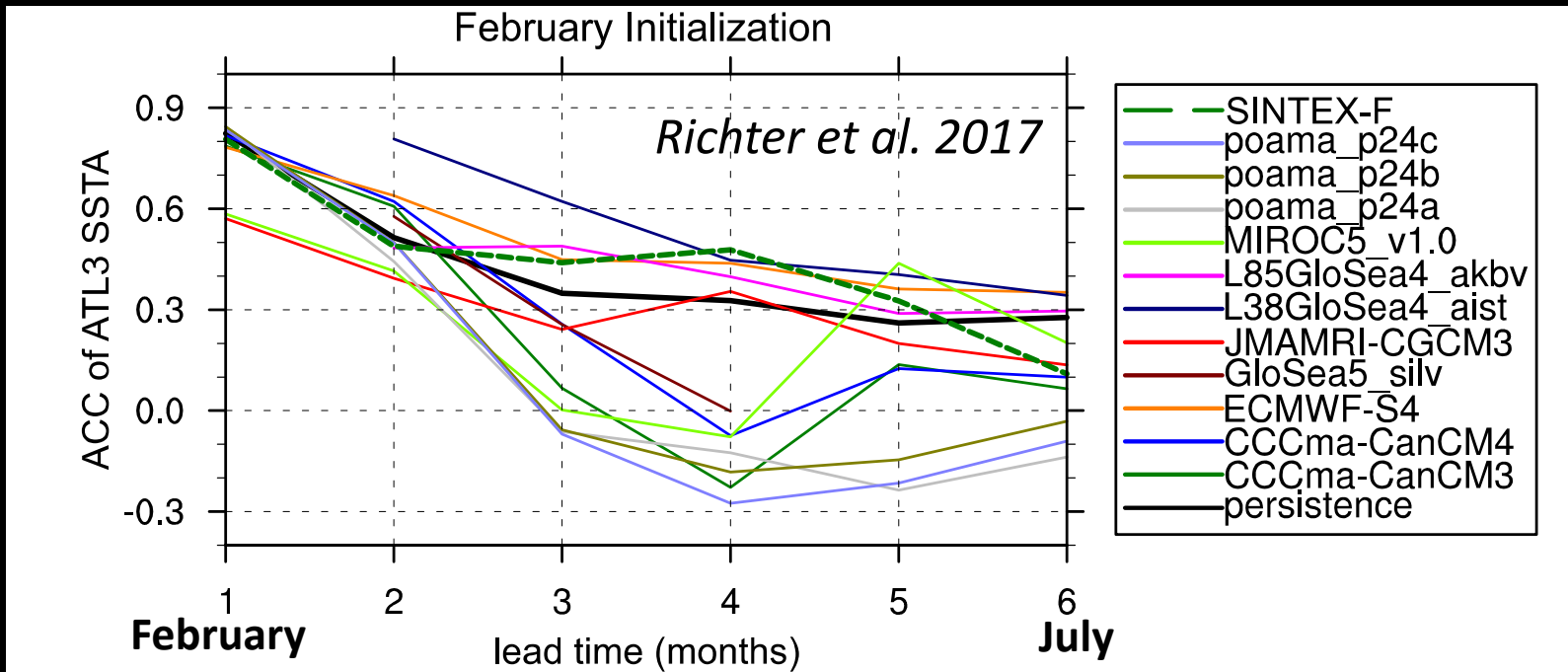T. Demissie, T. Toniazzo, Y. Wang

www.preface-project.eu

Atlantic Niño poorly forecast

Anomaly Correlation, Atl3 SST, Climate Historical Forecast Project Models

February Initialization

Richter et al. 2017

Legend: SINTEX-F, poama_p24c, poama_p24b, poama_p24a, MIROC5_v1.0, L85GloSea4_akbv, L38GloSea4_aist, JMAMRI-CGCM3, GloSea5_silv, ECMWF-S4, CCCma-CanCM4, CCCma-CanCM3, persistence

- ## Intrinsically low predictability?

  – Dominance of atmospheric noise, low-memory, weak coupled variability (Richter et al. 2014, Jansen et al. 2009)

- ## Model error?

The Atlantic Niño

The Bjerknes Positive feedback and delayed negative feedbacks underlie the Atlantic Niño
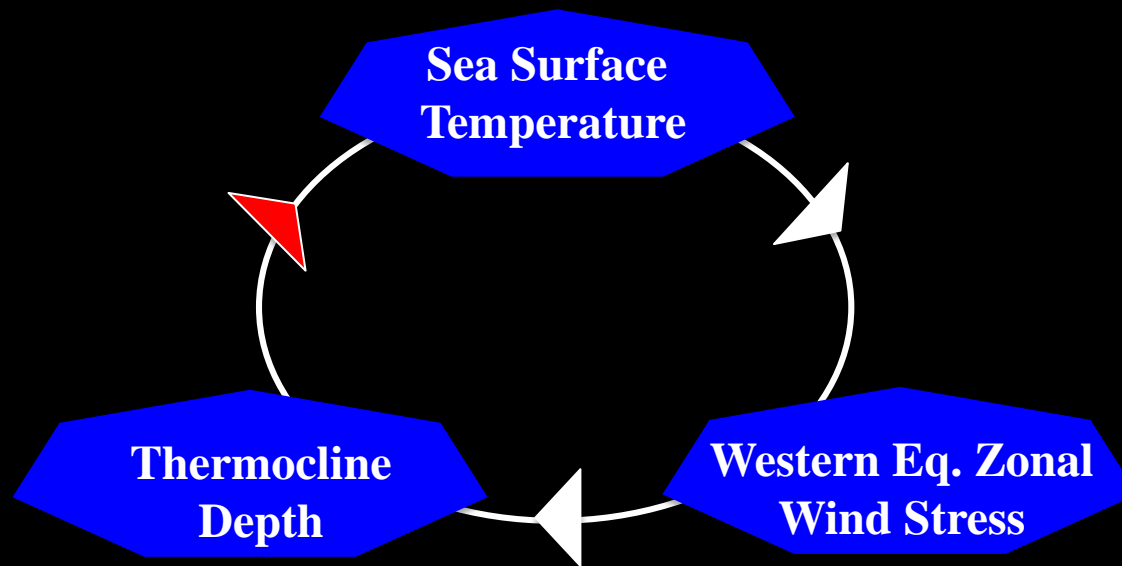*[e.g., Zebiak 1993, Keenlyside & Latif, 2007, Ding et al. 2010]*

Sea Surface Temperature

Thermocline Depth

Western Eq. Zonal Wind Stress
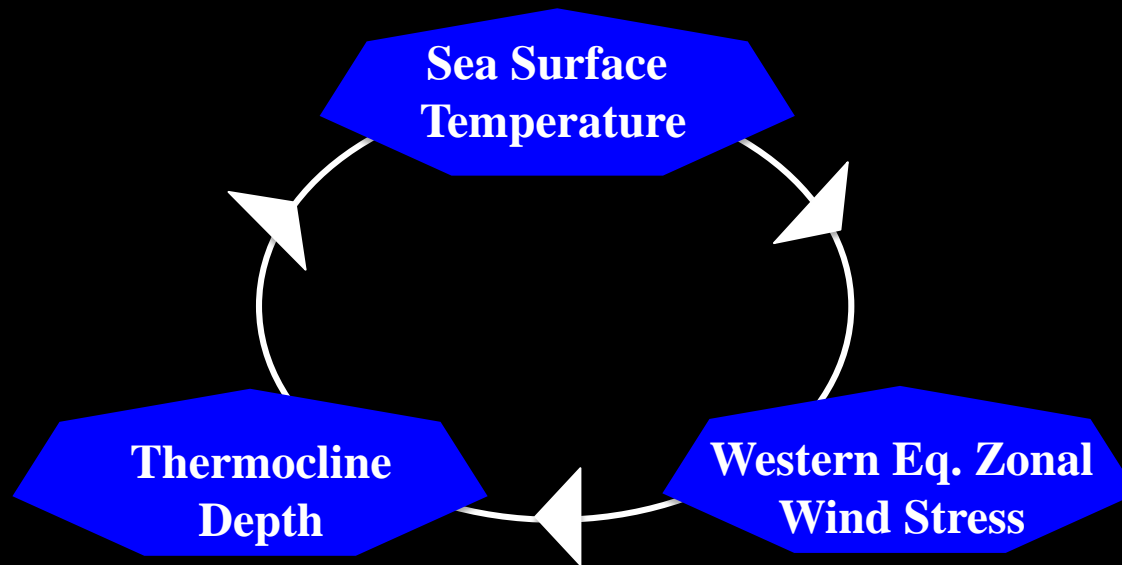
The Atlantic Niño

*Consistently with the warm bias, coupled models underestimate the thermocline feedback*
[e.g., Nnamchi et al. 2015, Deppenmeier et al. 2015, Ding et al. 2015a,b; Jouanno et al. 2017]

Assessing the consequences of tropical Atlantic model biases

- Norwegian Earth System model (NorESM)
  - CAM4-MICOM; CMIP5 version; 2°atm; 1°ocn

- Standard and anomaly coupled configurations

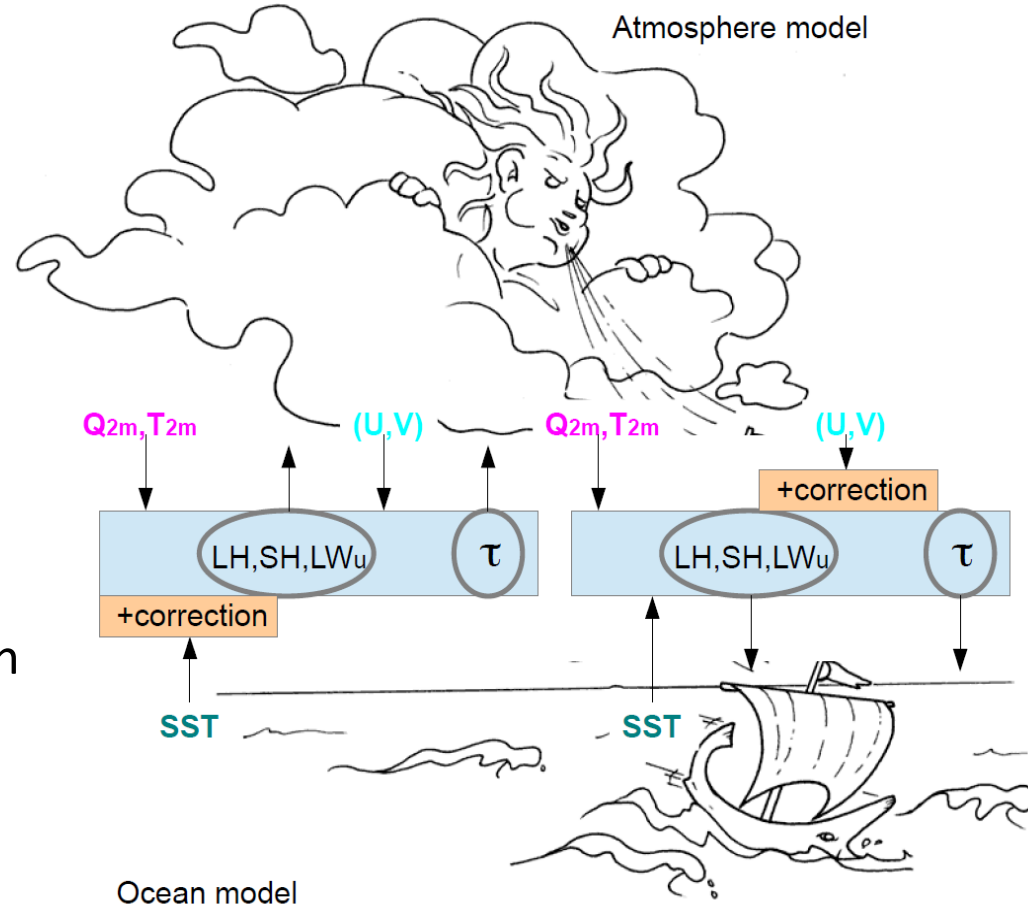- Analysis of control and prediction experiments

Standard coupled model

Quantities exchanged between atmosphere and ocean
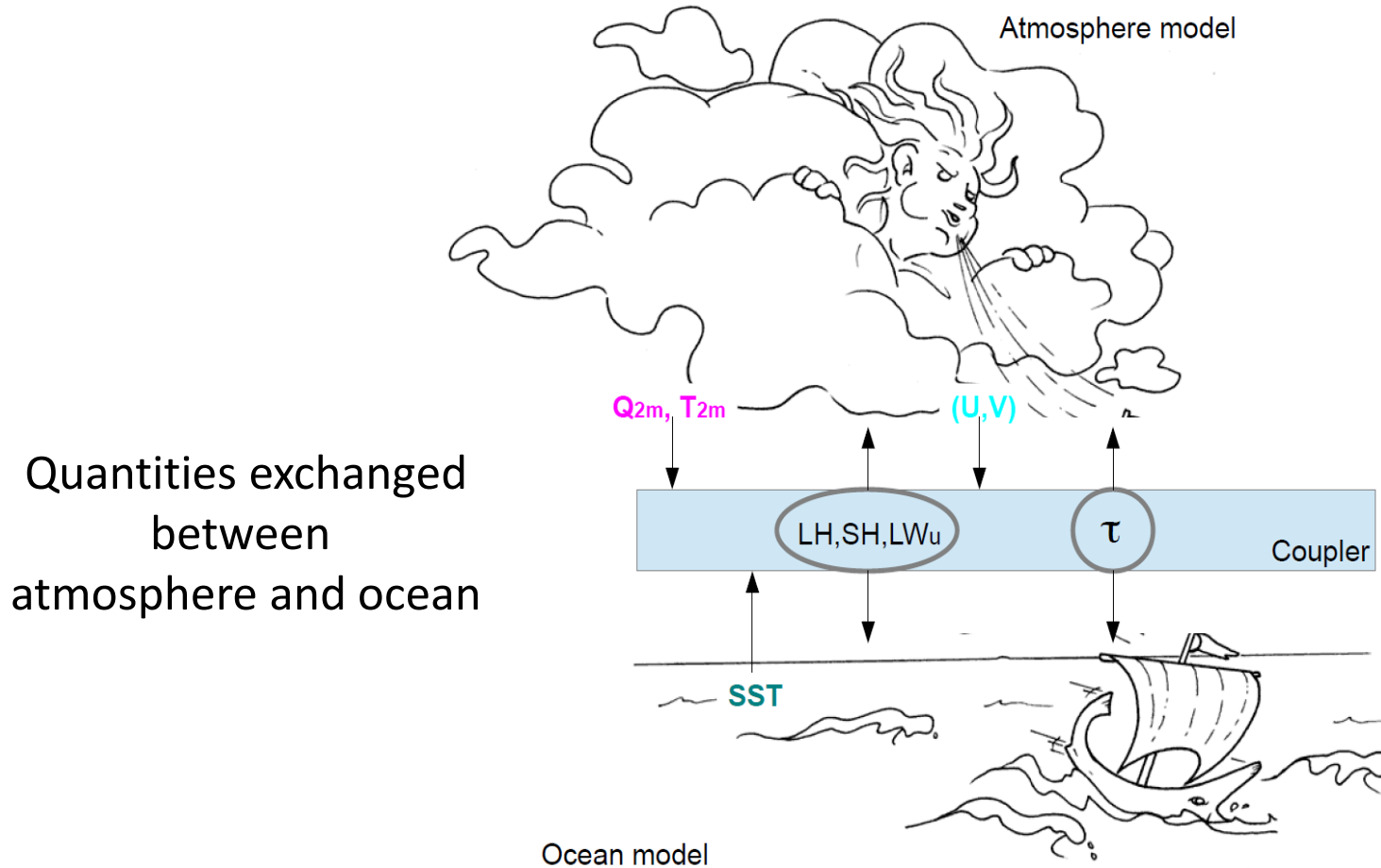
Courtesy: Thomas Toniazzo

A methodology to correct mean state biases: Anomaly coupled model

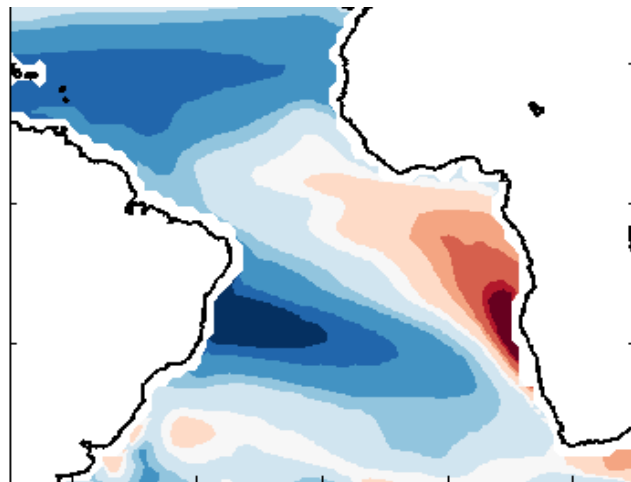Correction added to quantities exchanged between atmosphere and ocean

Courtesy: Thomas Toniazzo

Toniazzo and Koseki, 2018

Anomaly coupling captures Atlantic cold tongue

NorESM annual mean SST (ocean model) bias, 1980-2000

Standard

Anomaly coupled

Difference of bias(1980-20
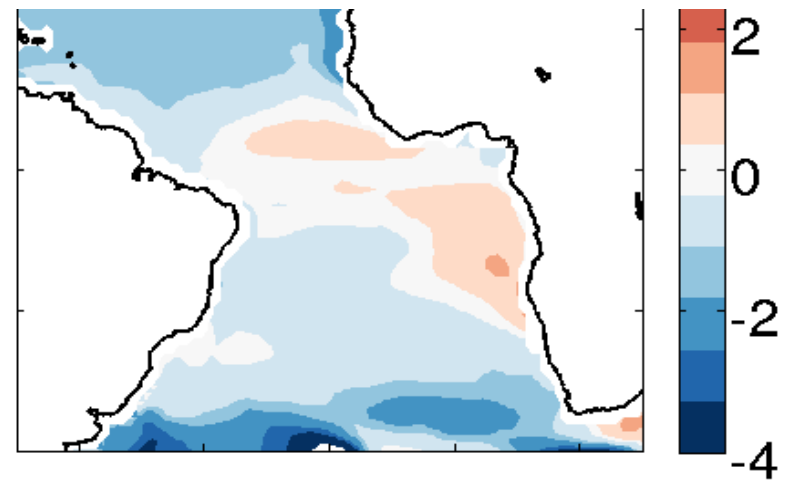
SST. CTR-AC(1980-2000)

Courtesy: Teferi Demissie

Anomaly coupling captures cold tongue onset
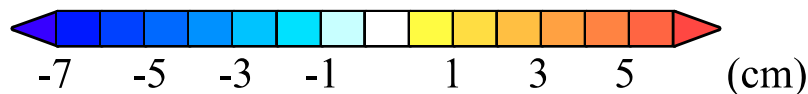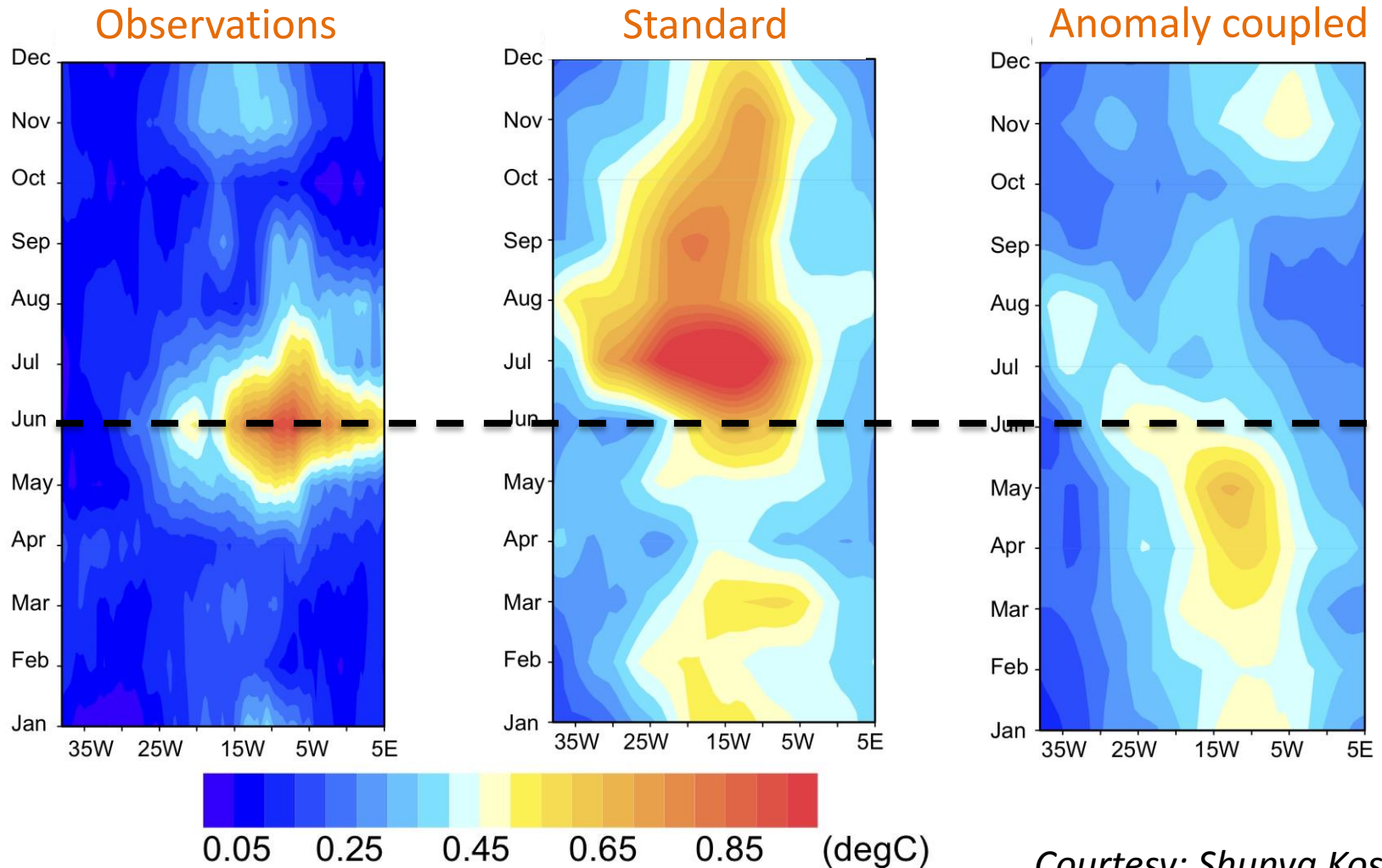
Standard
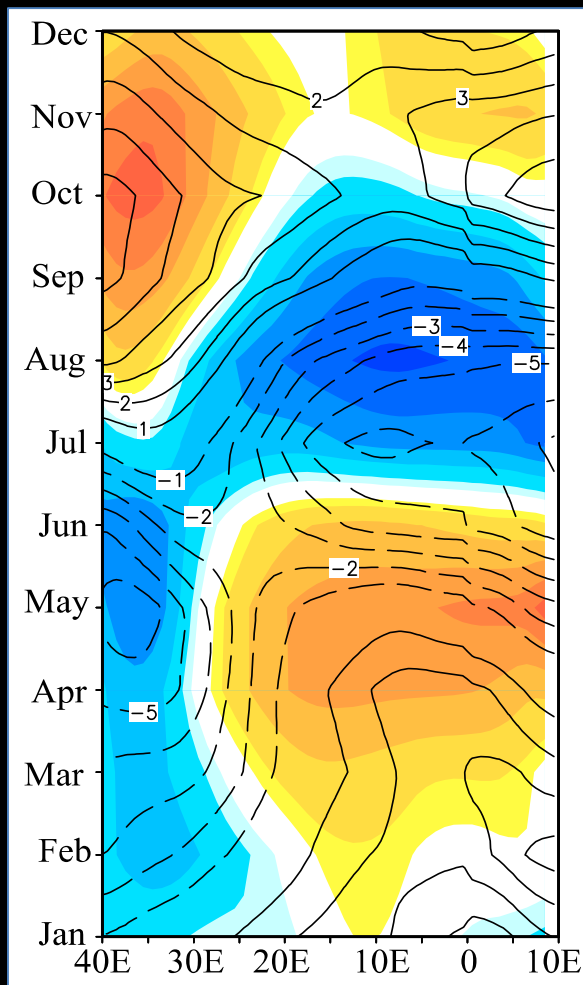
Anomaly coupled
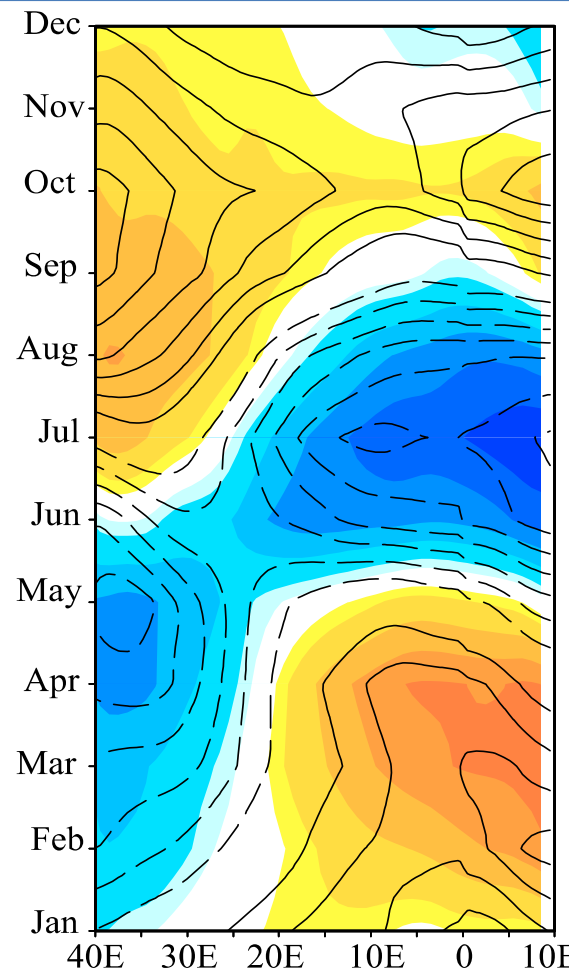
Courtesy: Shunya Koseki

Reduced bias -> better equatorial variability

Standard deviation of SST along the equator, January - December

Observations   Standard   Anomaly coupled

0.05   0.25   0.45   0.65   0.85   (degC)

Courtesy: Shunya Koseki

Better simulated Bjerknes Feedback

Correlation: ATL3 SST and equatorial zonal wind (contours)
Equatorial SST and sea surface height (shaded)

Observations

Courtesy: Shunya Koseki

Better simulated Bjerknes Feedback

Correlation: ATL3 SST and equatorial zonal wind (contours)
Equatorial SST and sea surface height (shaded)

Observations
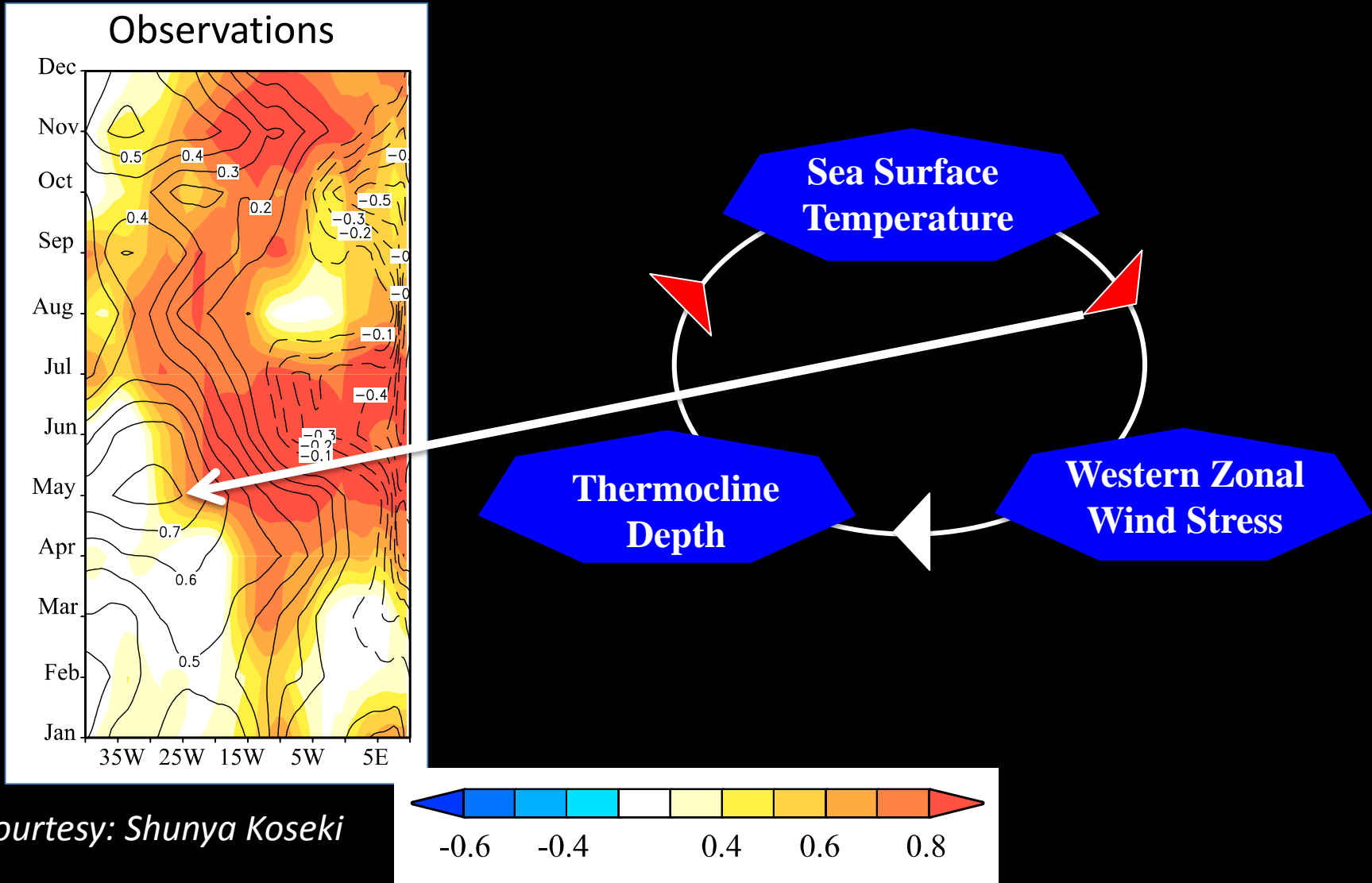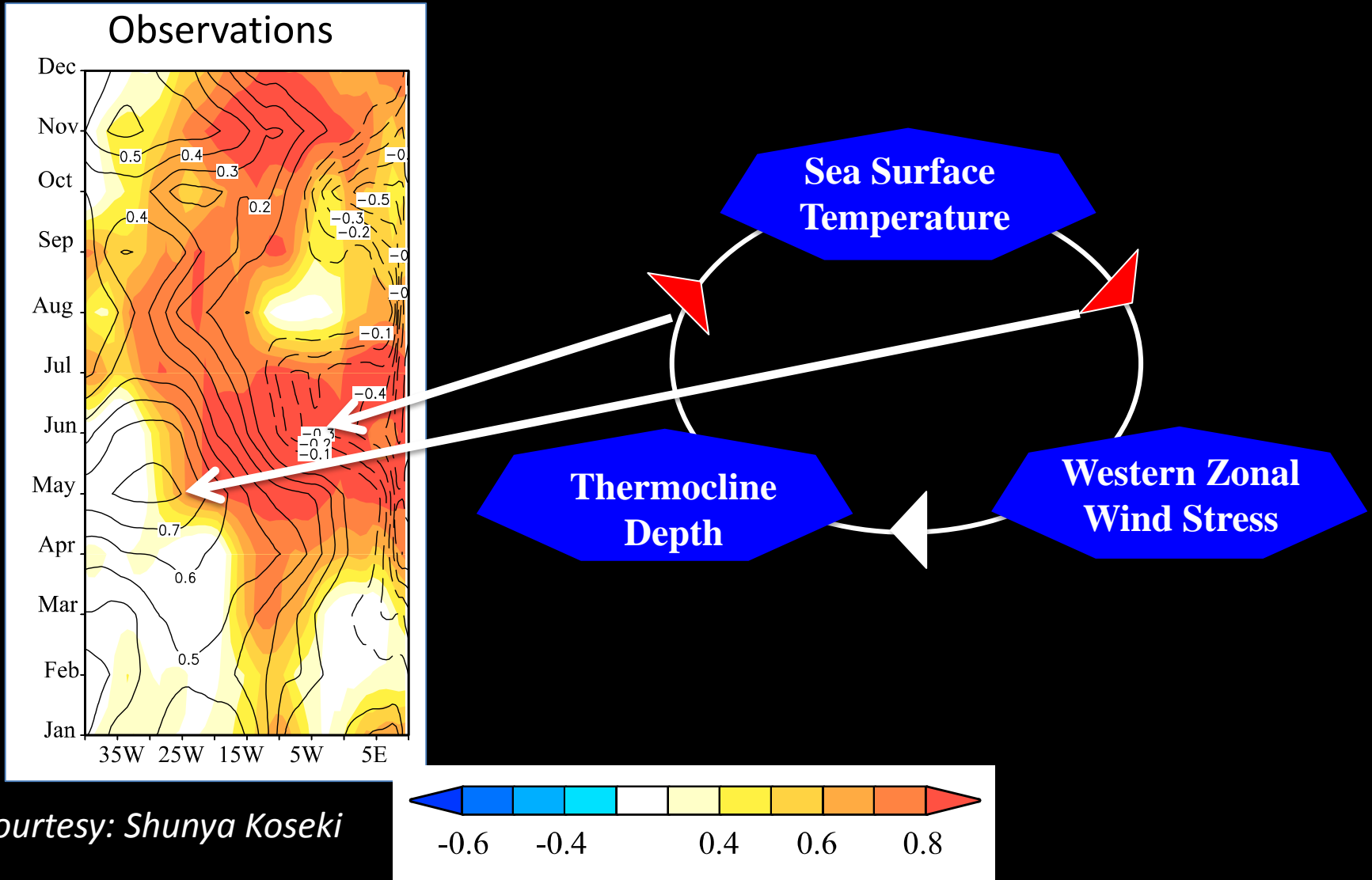
Courtesy: Shunya Koseki

Better simulated Bjerknes Feedback
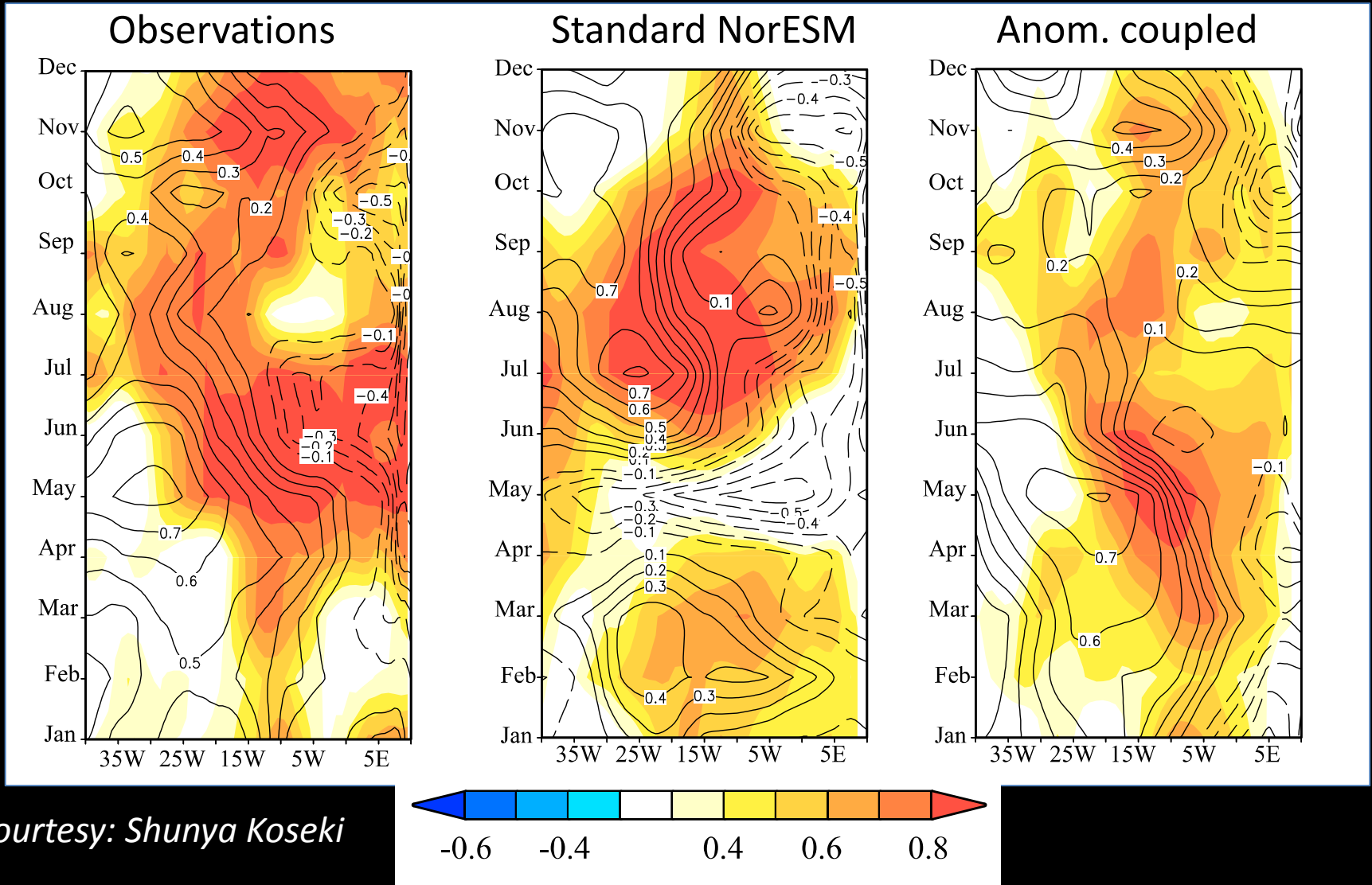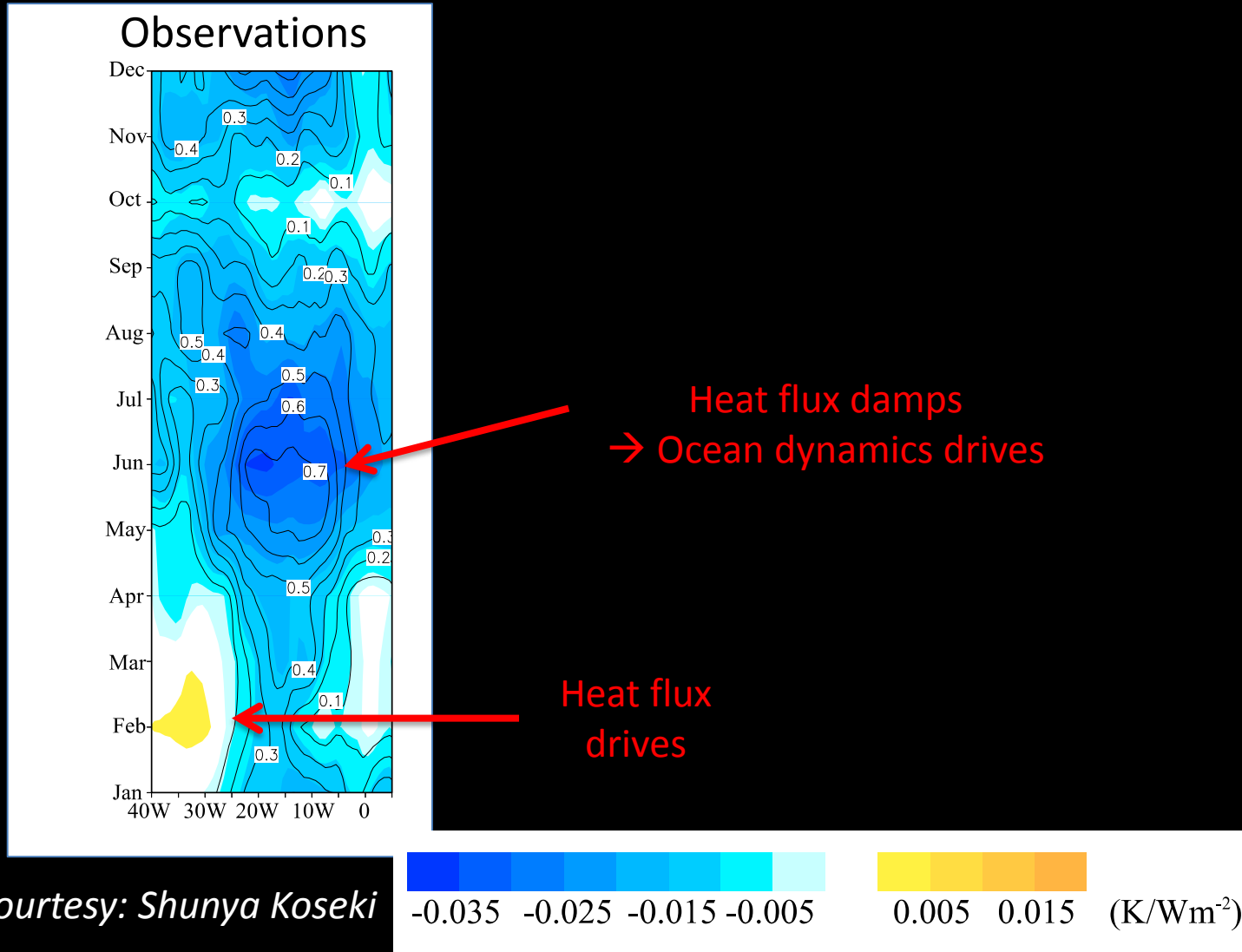
Correlation: ATL3 SST and equatorial zonal wind (contours)
Equatorial SST and sea surface height (shaded)

Courtesy: Shunya Koseki

Dynamical Ocean-atmosphere interaction enhanced

Regression of equatorial SST and net surface heat flux
(contours: explained variance)

Observations

Heat flux damps
→ Ocean dynamics drives

Heat flux
drives

Courtesy: Shunya Koseki

Dynamical Ocean-atmosphere interaction enhanced

Regression of equatorial SST and net surface heat flux (contours: explained variance)
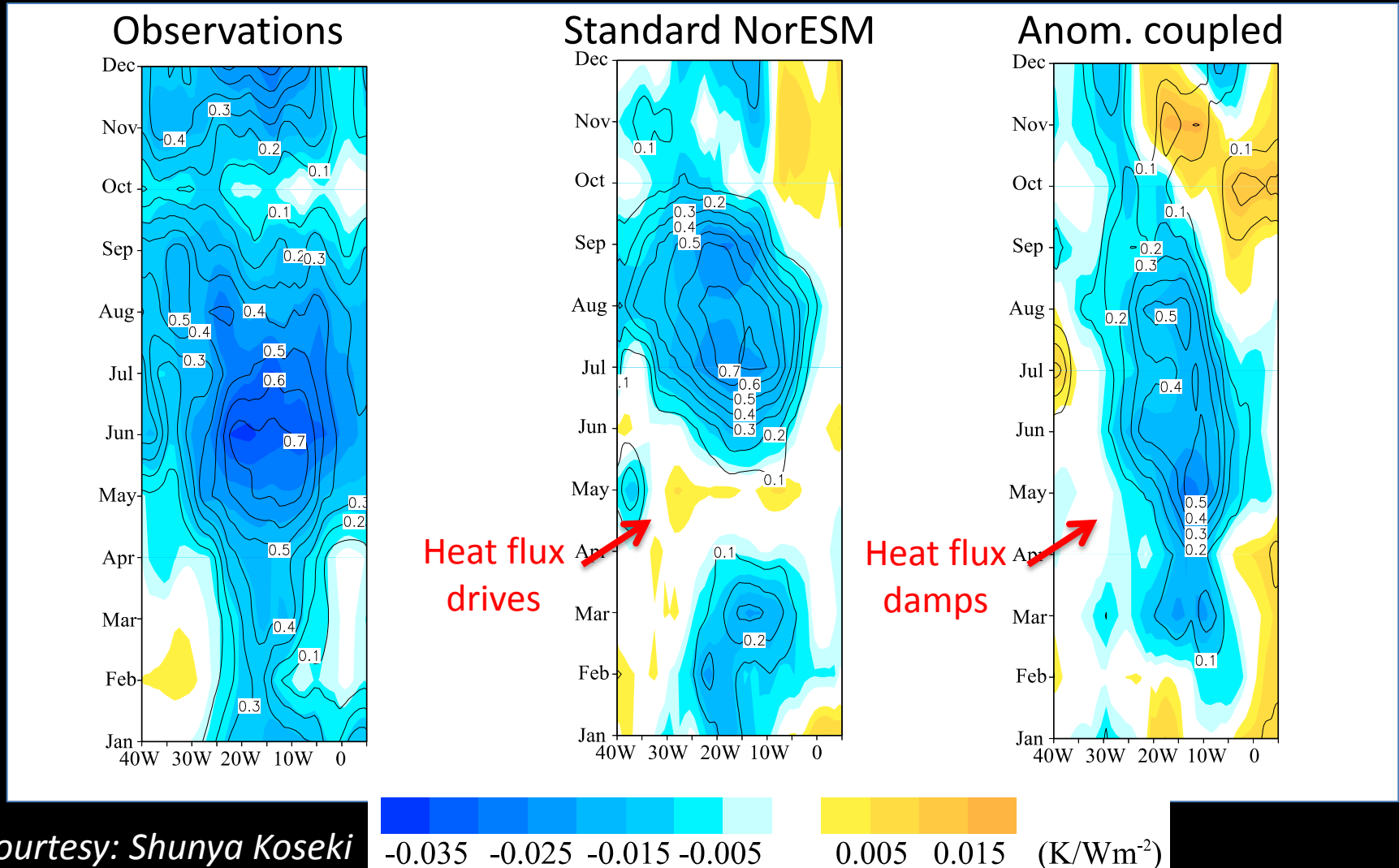
Courtesy: Shunya Koseki

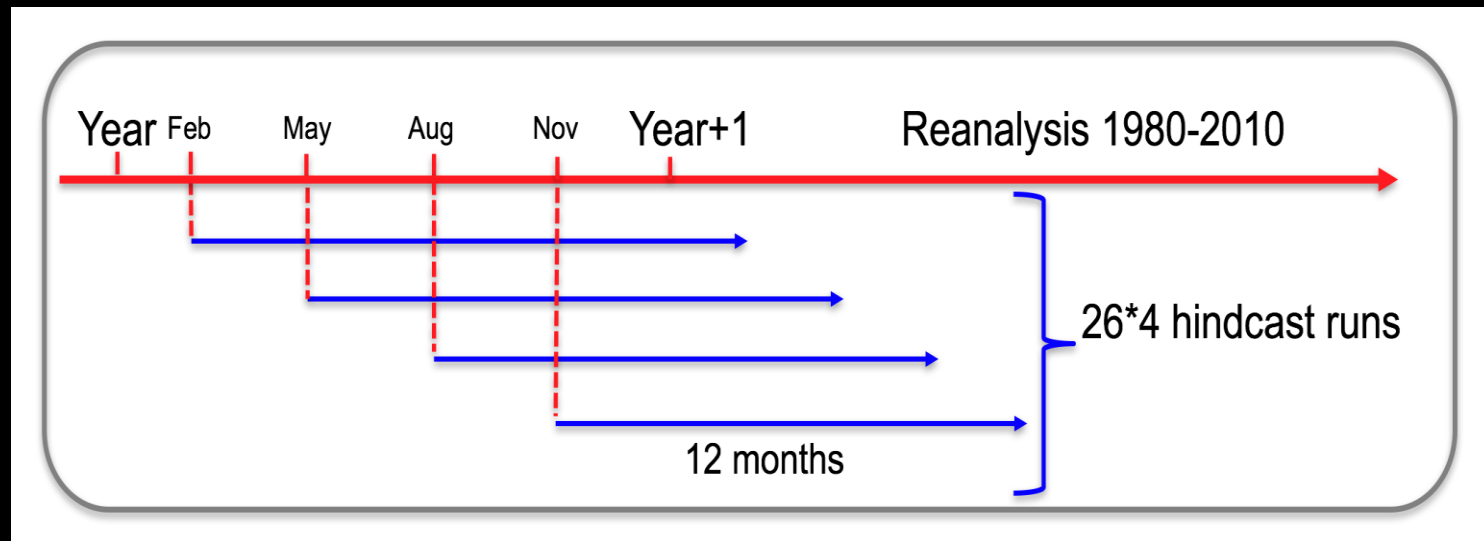# Seasonal predictions – With and without mean state bias

Norwegian Earths System Model *with and without anomaly coupling* *(Toniazzo & Kosseki 2018)*

Reanalysis

- 30 member ensemble
- Assimilation of anomaly SST, and T,S profiles , 1980-2010
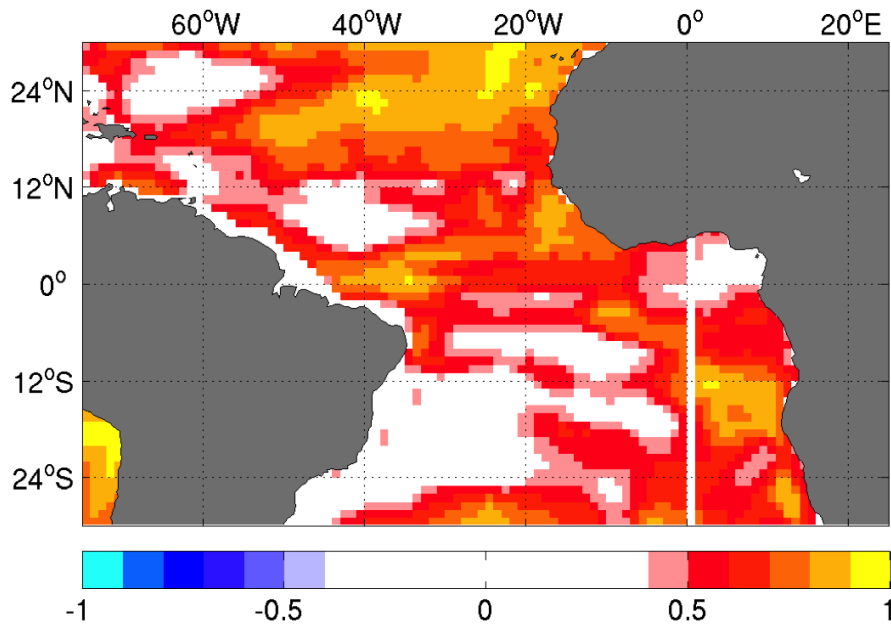
Retrospective forecasts

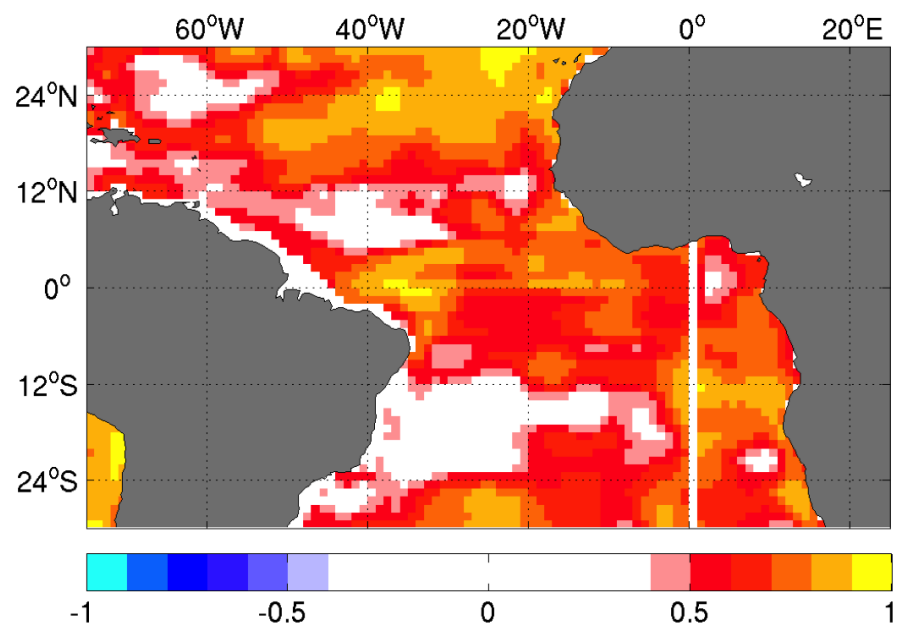- 1985 to 2010 with 9 members and 4 start date per year

Reduced bias -> Better Initial Conditions

Correlation (1980-2010), 200m heat content
EN4 objective analysis with
Norwegian Climate Prediction Model ocean reanalysis
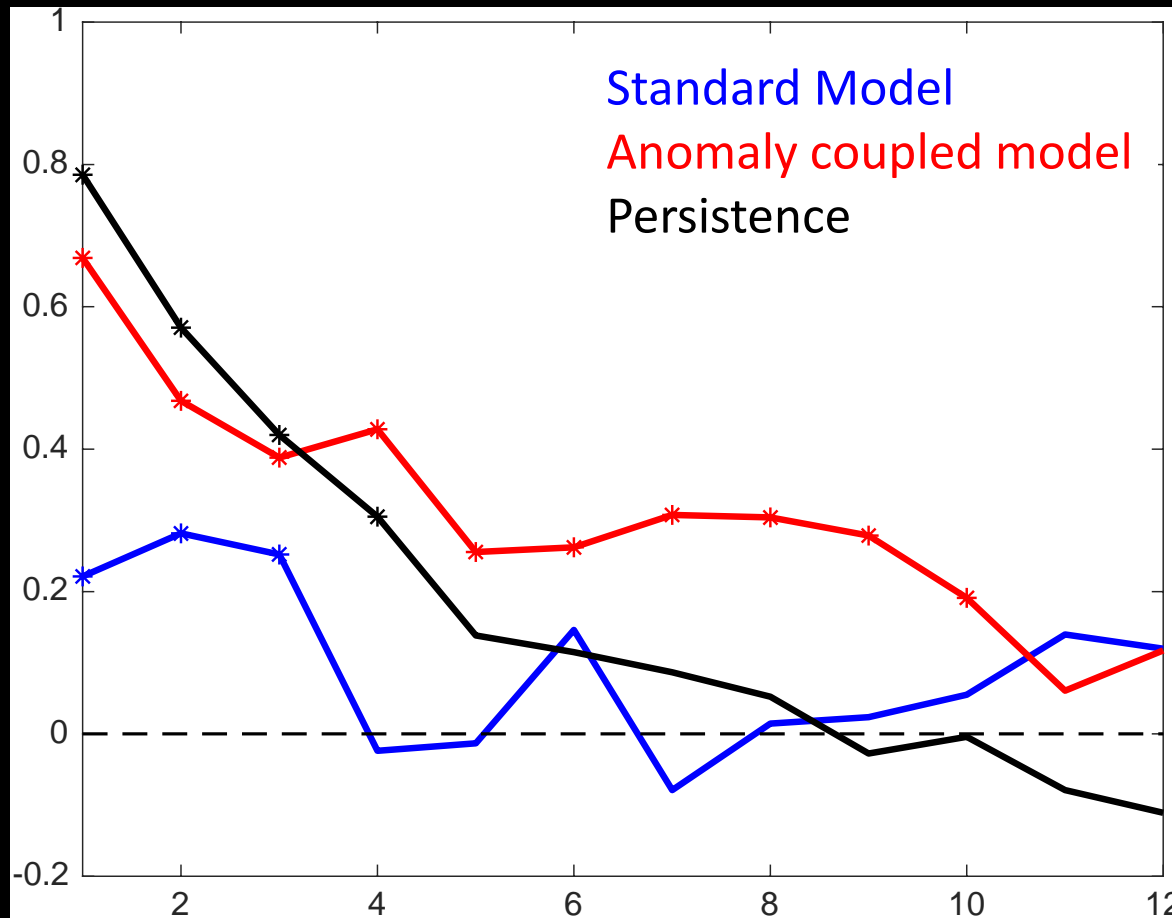

Standard (biased) model

Anomaly coupled model

Courtesy: Francois Counillon

Reduced biases enhances seasonal prediction skill for the Atlantic Niño

Norwegian Climate prediction Model, Correlation skill for ATL3 region
1985-2010, 4 starts per year (Feb. May, Aug. Nov.), 9 ensemble members

Courtesy: Francois Counillon

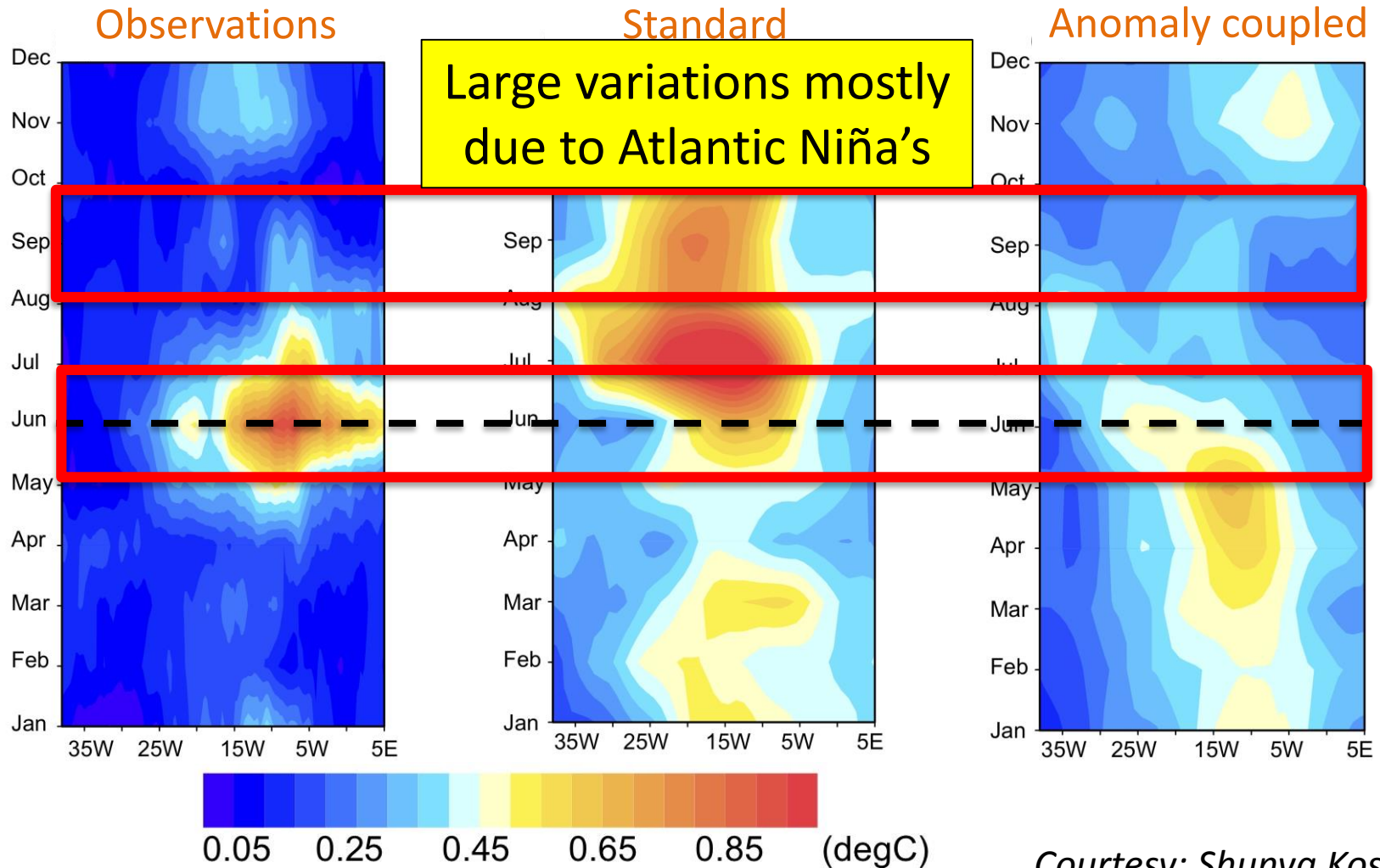# Improvement is not from predicting Atlantic Niño/Niña variability

Norwegian Climate prediction Model, Correlation skill for ATL3 region
1985-2010, 9 ensemble members
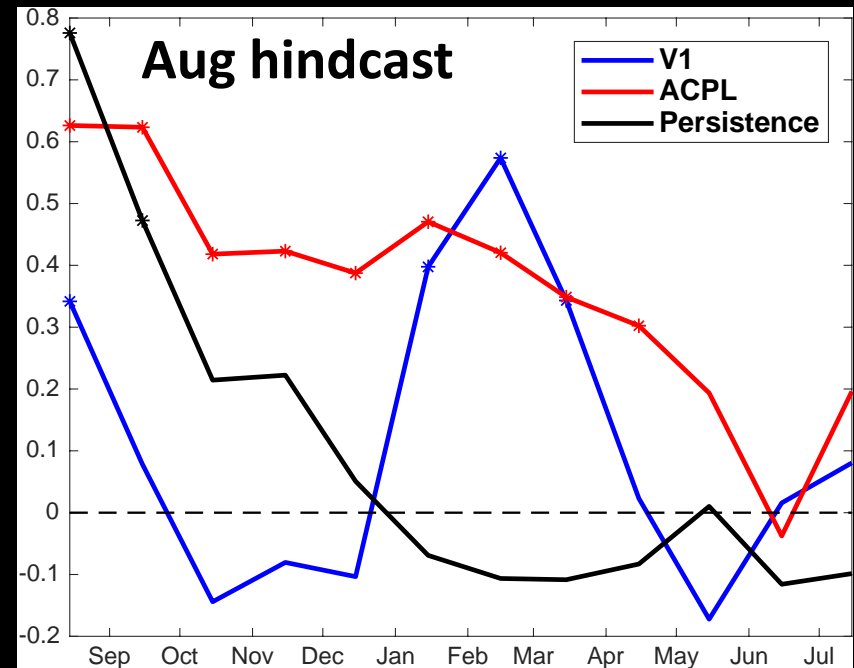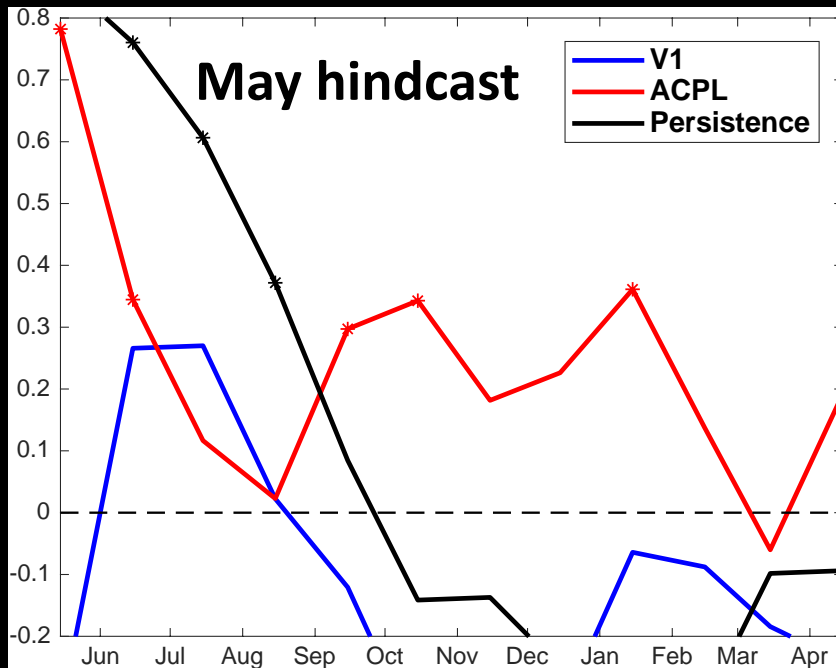
Standard Model
Anomaly coupled model
Persistence

Courtesy: Francois Counillon

Reduced bias -> better equatorial variability

Standard deviation of SST along the equator, January - December

Observations   Standard   Anomaly coupled

Large variations mostly due to Atlantic Niña's

Courtesy: Shunya Koseki

… but skill remains poor, and not better than other models

Correlation skill for ATL3 region, NorCPM anomaly coupled
and North American Multi-Model Ensemble
1985-2010, 4 starts per year (Feb. May, Aug. Nov.), 9 ensemble members

Courtesy: Francois Counillon
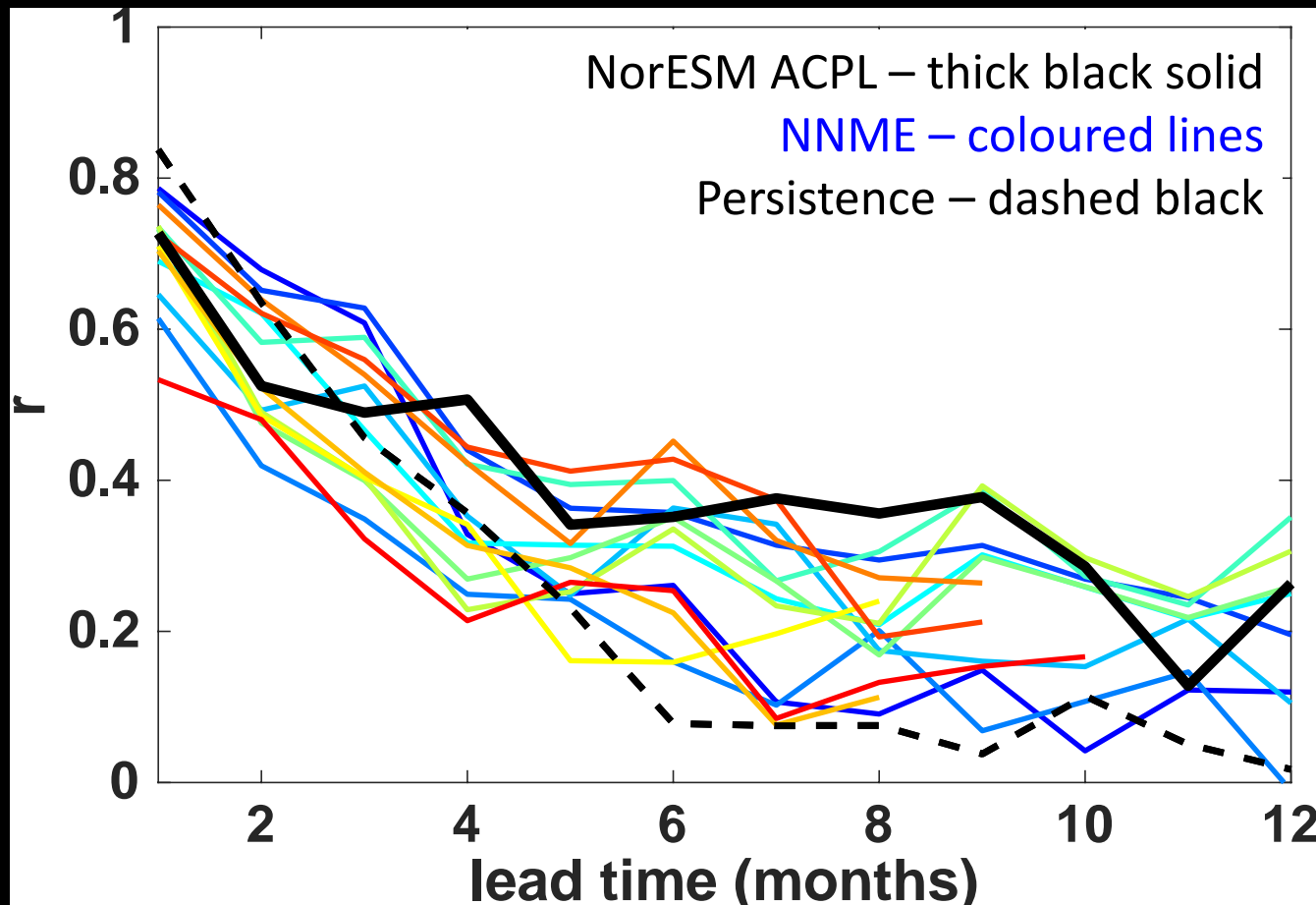
Model biases do impact simulated Atlantic Niño/Niña variability and prediction skill

Experiments with anomaly coupled and uncoupled variability showed reducing bias:

- Improved mechanisms for equatorial SST variability
- Improved for boreal fall, but not for summer

Can a better model improve prediction skill for boreal summer also?

Thank you for your attention