Eastern Tropical Oceans Synthesis (ETOS) Working Group

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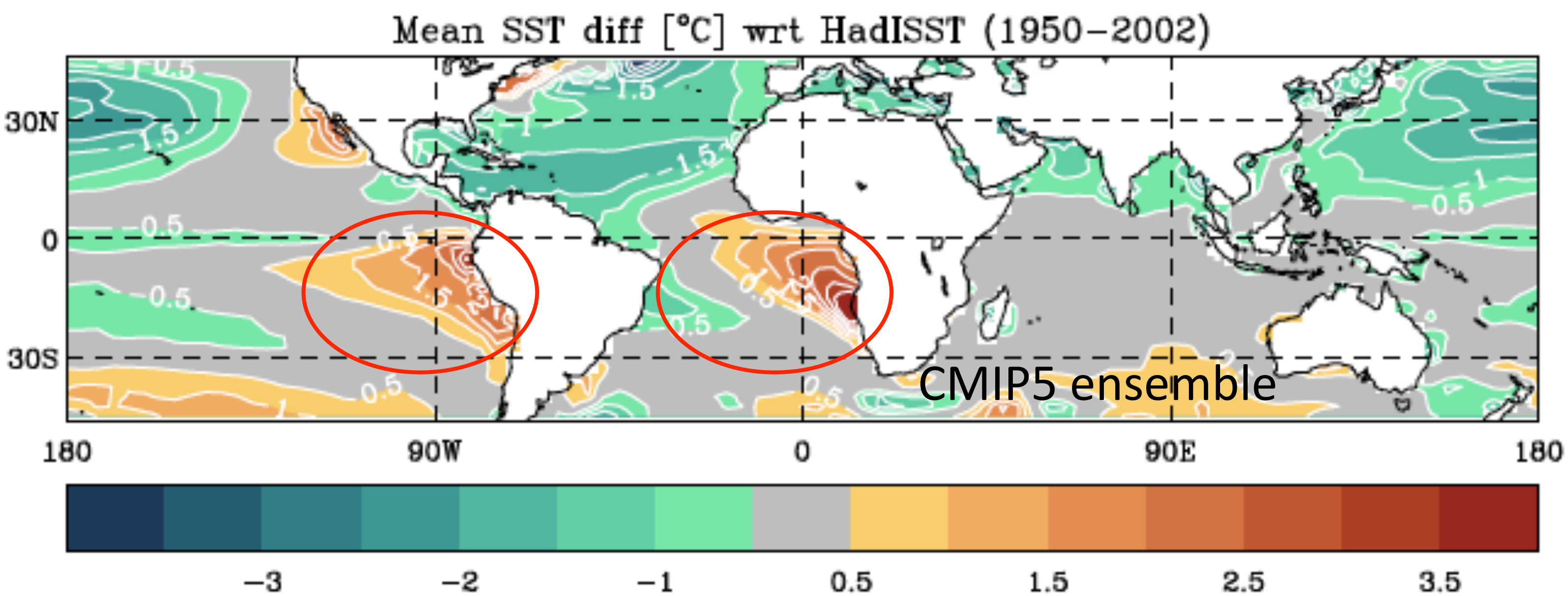
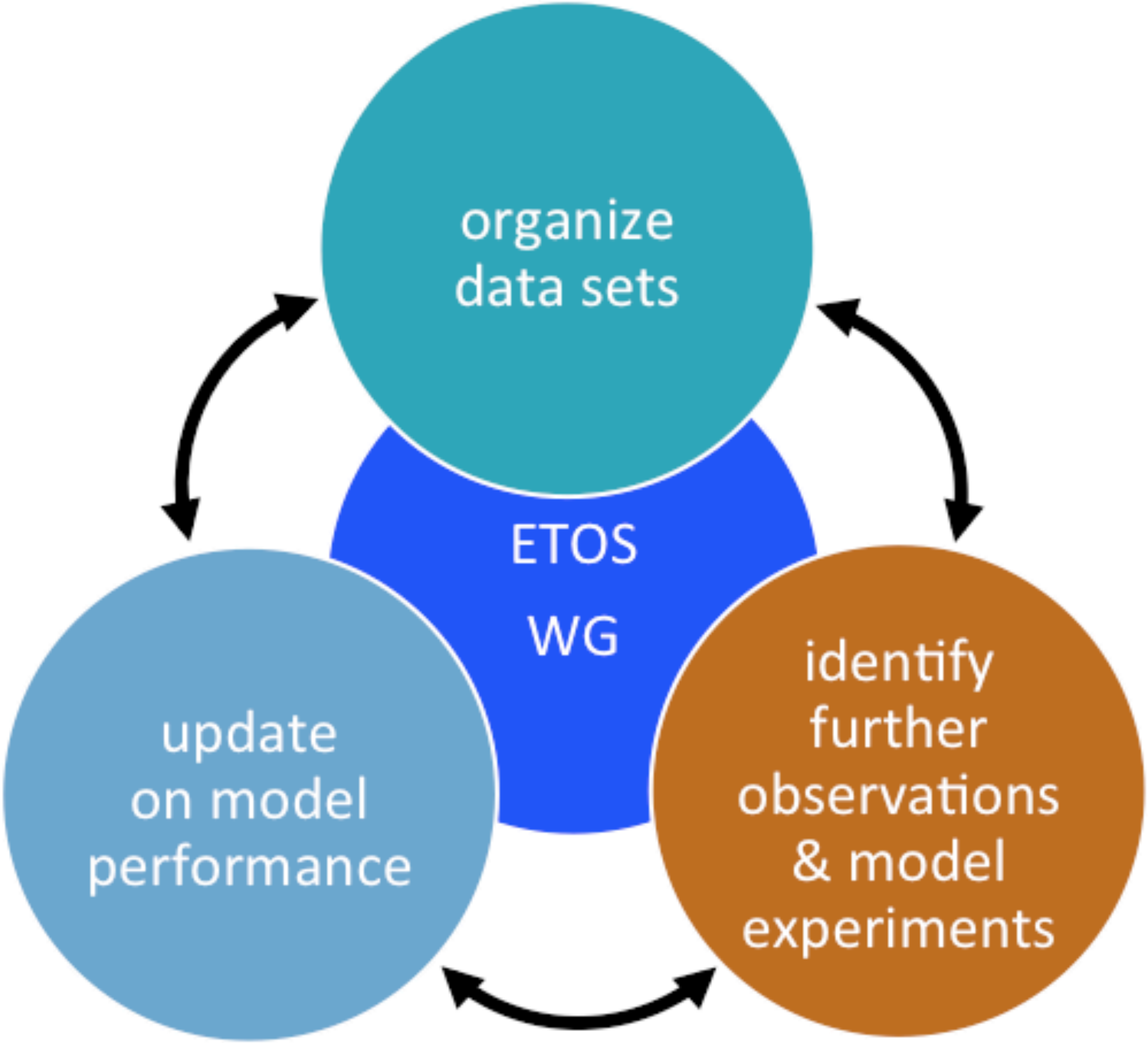
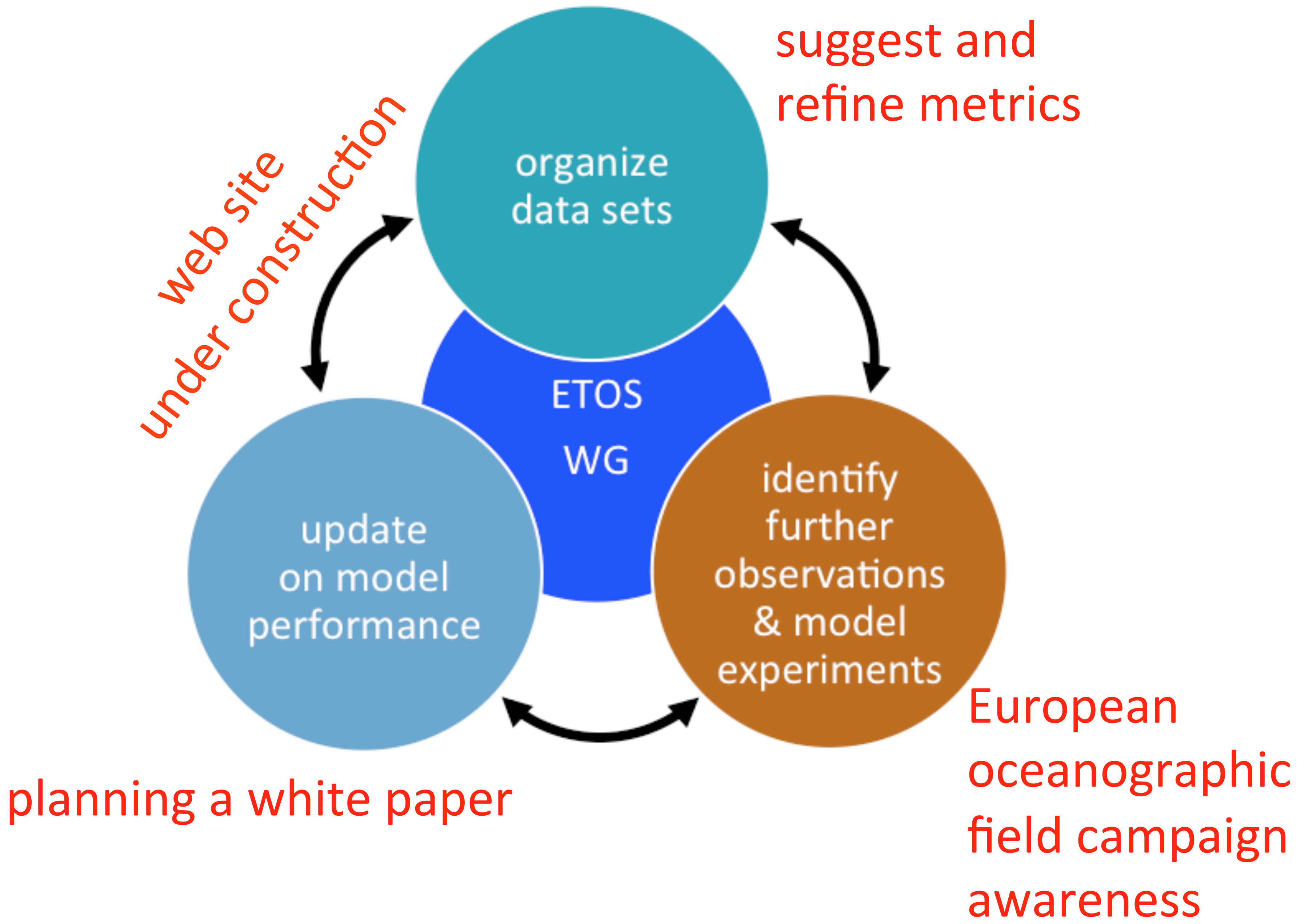
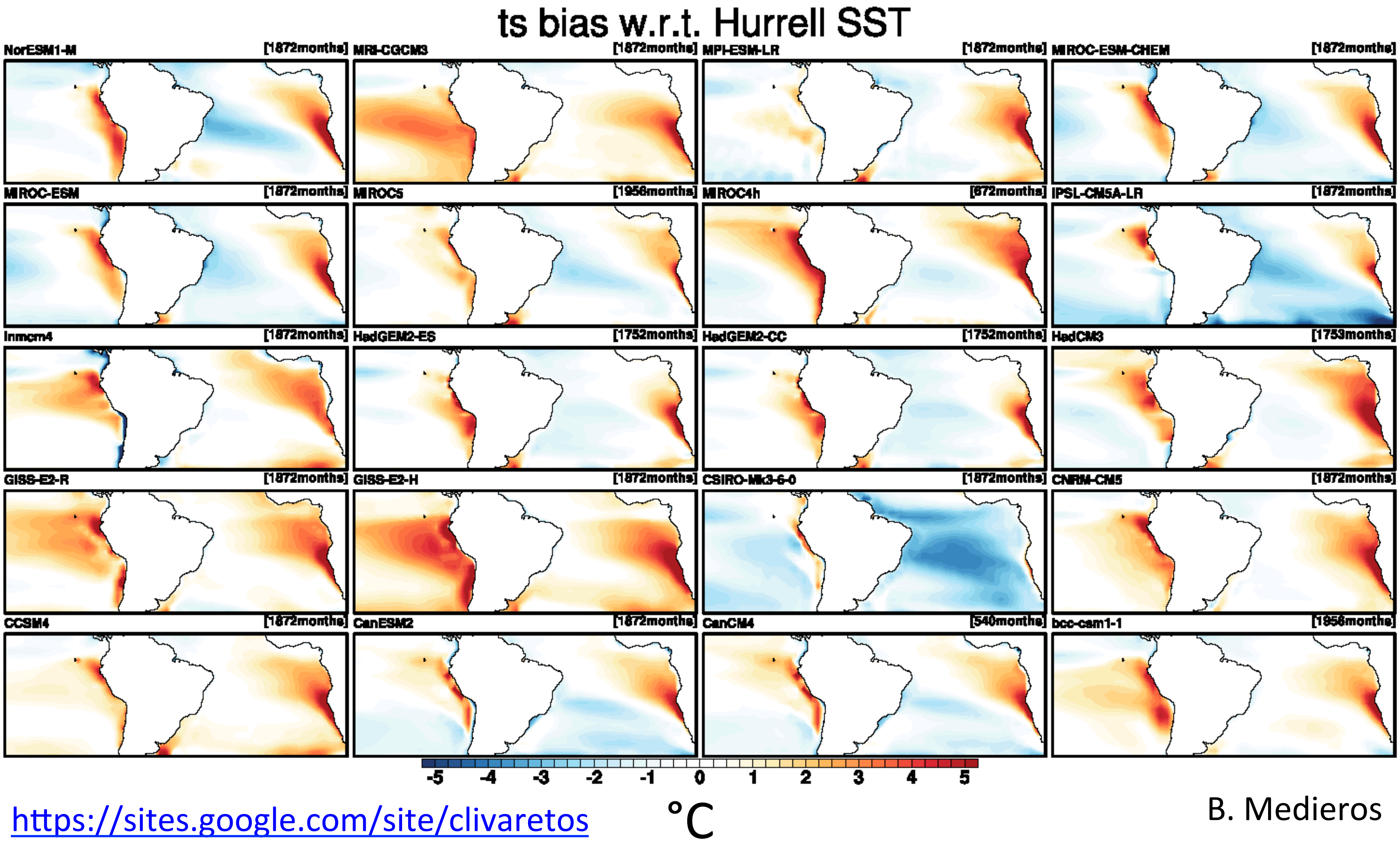


Toniazzo and Woolnough 2013


organize
data sets
ETOS
WG
update
on model
performance
identify
further
observations
& model
experiments


organize
data sets
suggest and
refine metrics
web site
under construction
ETOS
WG
update
on model
performance
identify
further
observations
& model
experiments
planning a white paper
European
oceanographic
field campaign
awareness

CMIP5 model performance update: mediocre improvement in Atlantic



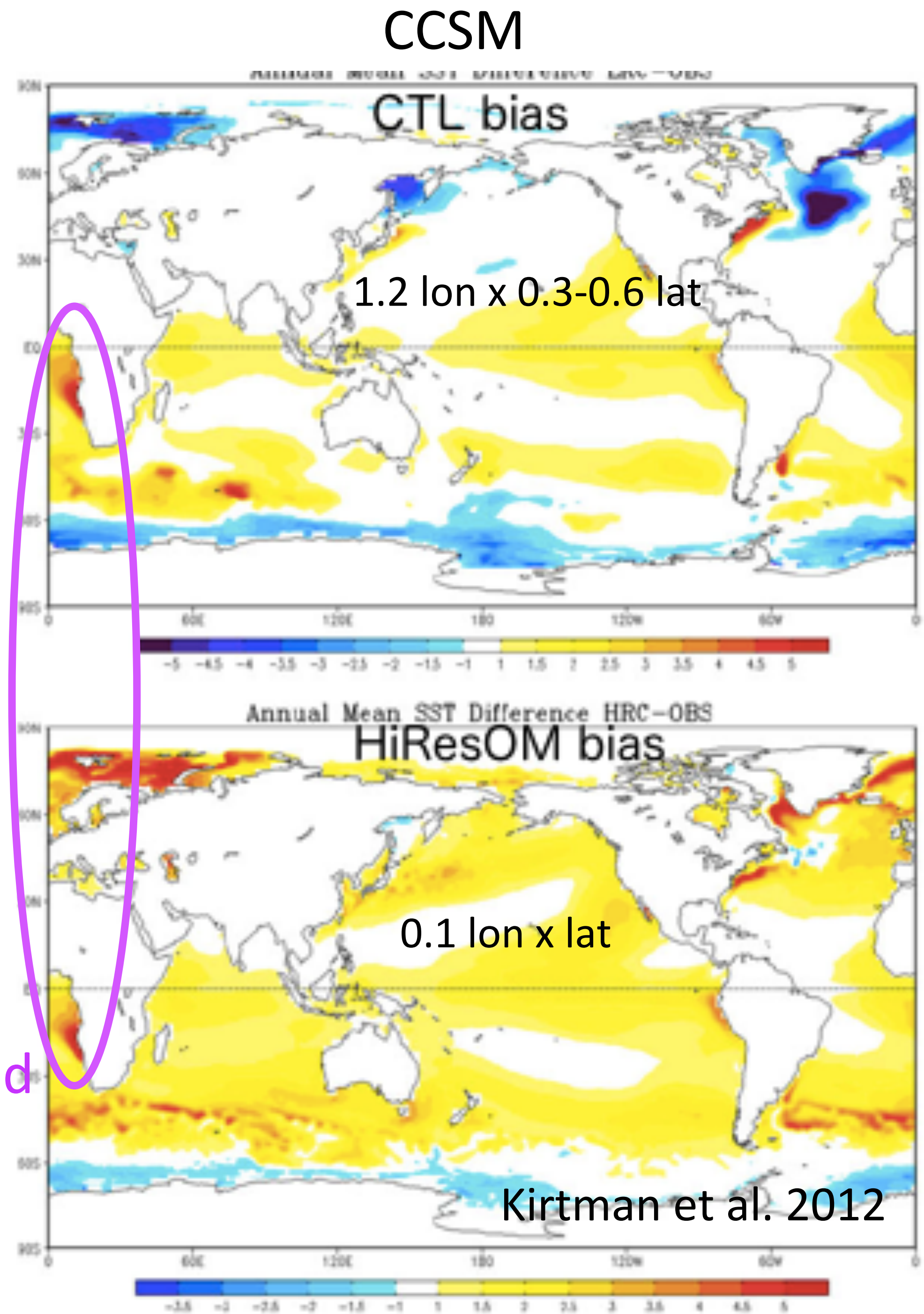
https://sites.google.com/site/clivaretos

B. Medieros

Is resolution the solution?

No

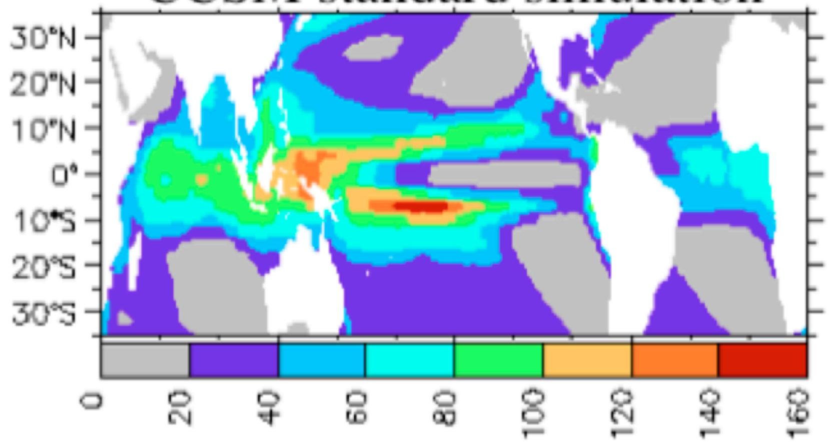
- resolving mountains helps in Pacific, less so in Atlantic (Doi)
- shorter convection time scale reduces circulation (Schneider, Williamson)



little improved

UPSCALING EFFECTS FROM SUBTROPICAL EASTERN BOUNDARY OCEANS

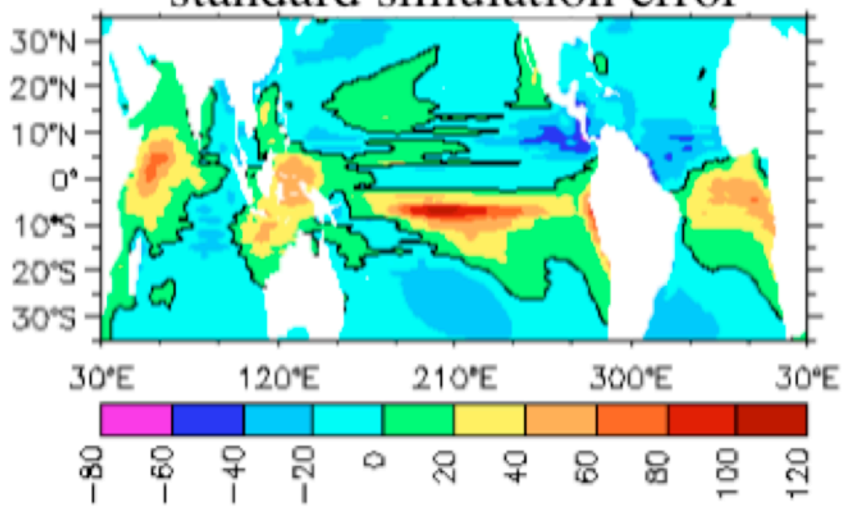
CCSM standard simulation



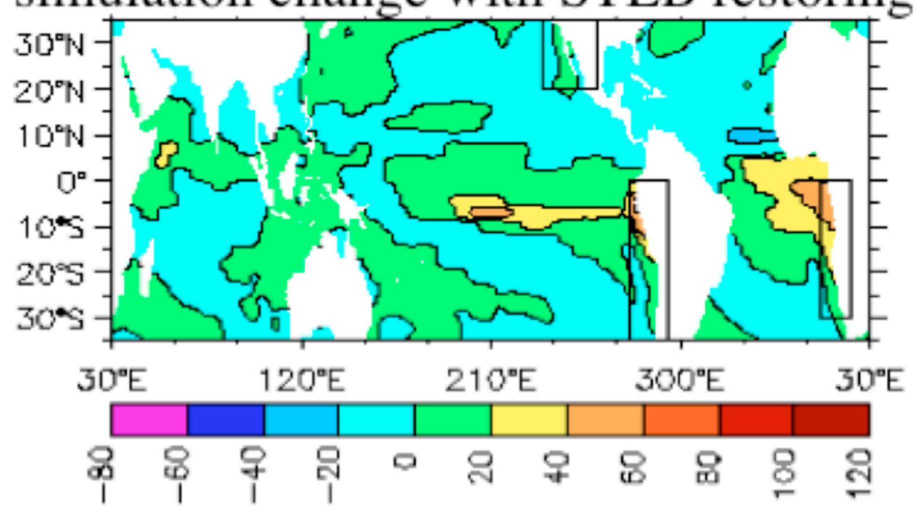
Mean precipitation [mg/m^2/s] in coupled model and its change with restoring of T & S in upper subtropical Eastern Boundary regions in N. & S. Pacific and S. Atlantic.

(Large & Danabasoglu, 2006)

standard simulation error

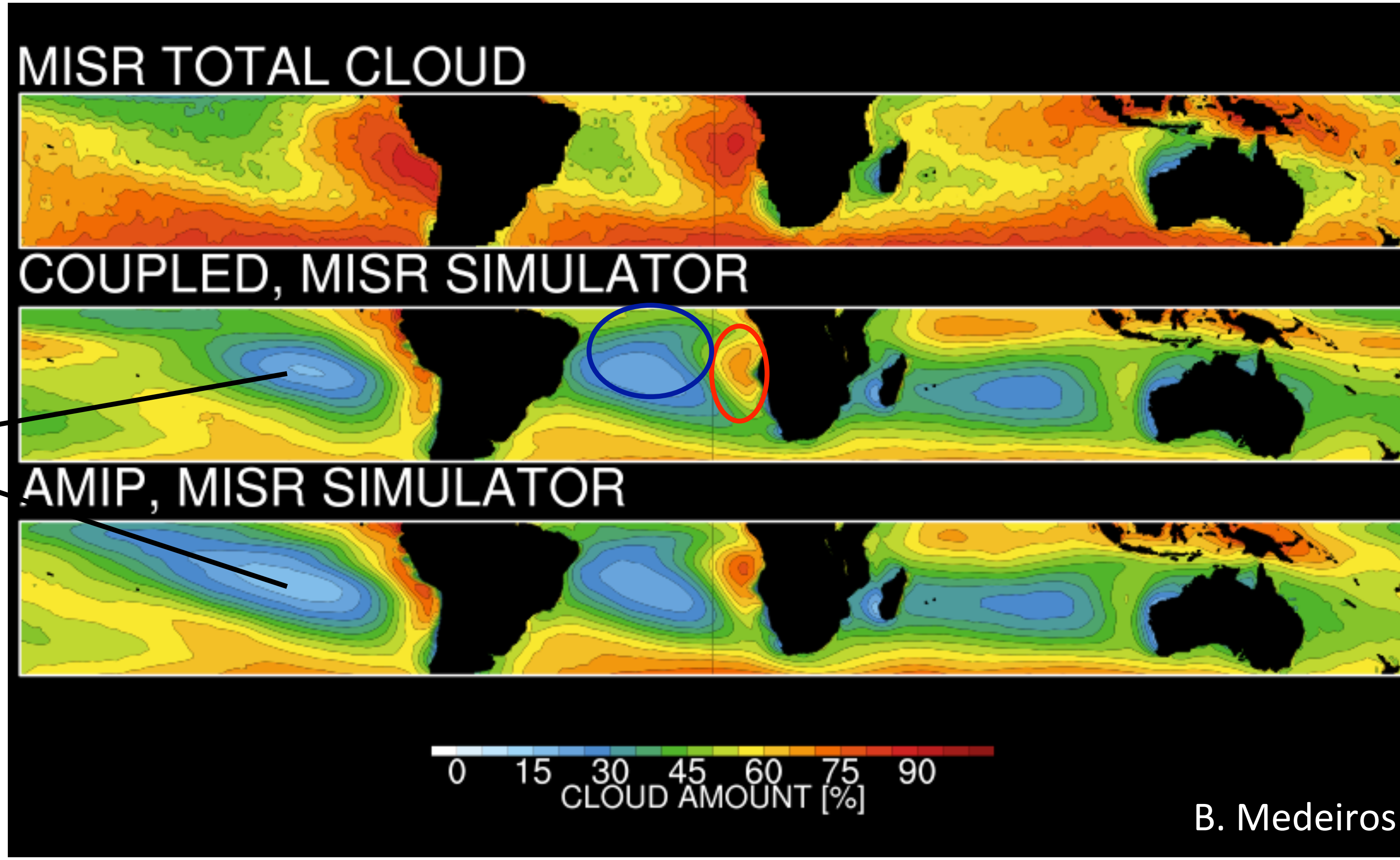


simulation change with STEB restoring



Cloud amount errors

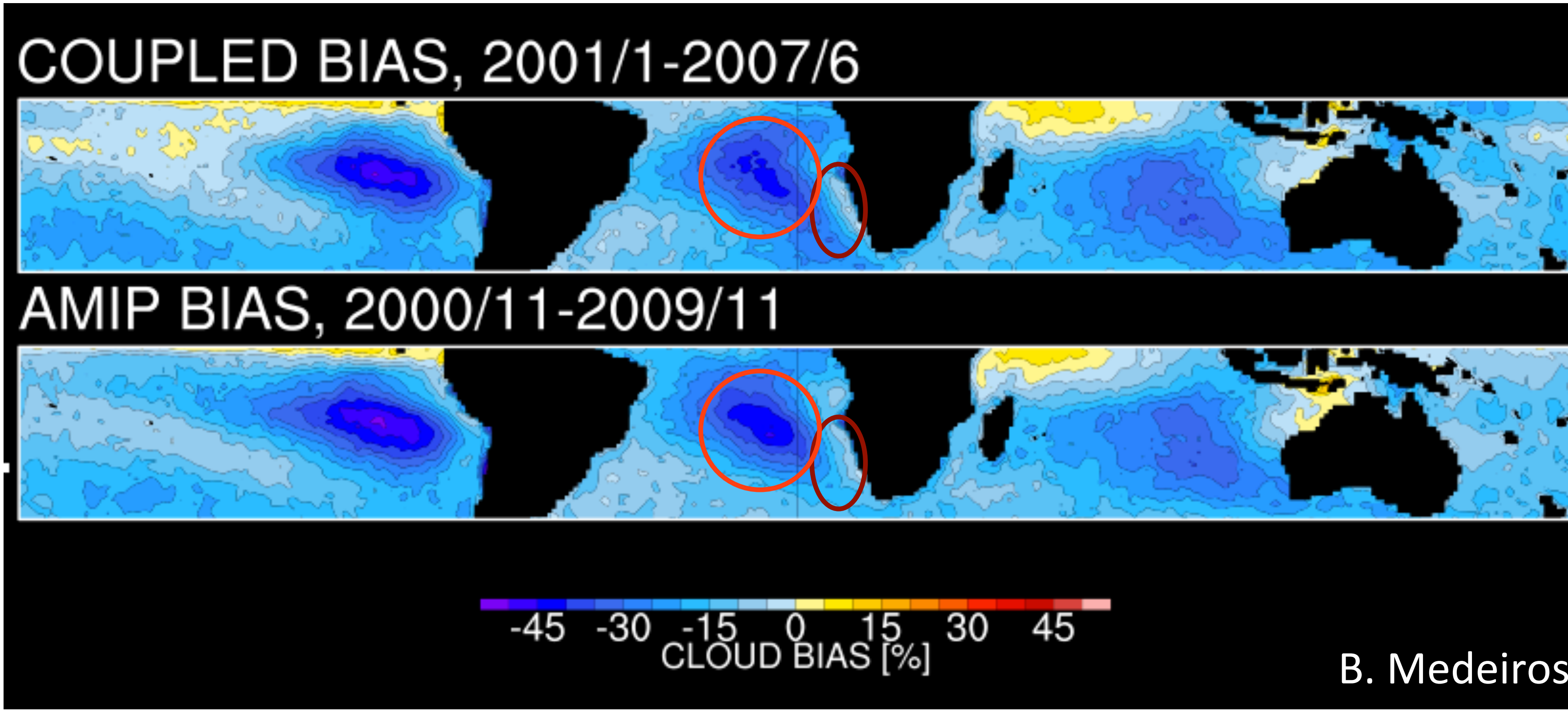
cloud deficit: transition region too-coastal



- Similar cloud amount in NCAR coupled (CESM1) and atmospheric (CAM5) models.
- SST-cloud feedback does not explain too-low offshore cloud.
- Cloud bias offshore of SST bias

cloud biases in CAM5 & CESM

cloud 30% too low   SST 3°C too warm



- SST bias more coastal than cloud bias
- cloud errors don't depend only on SST

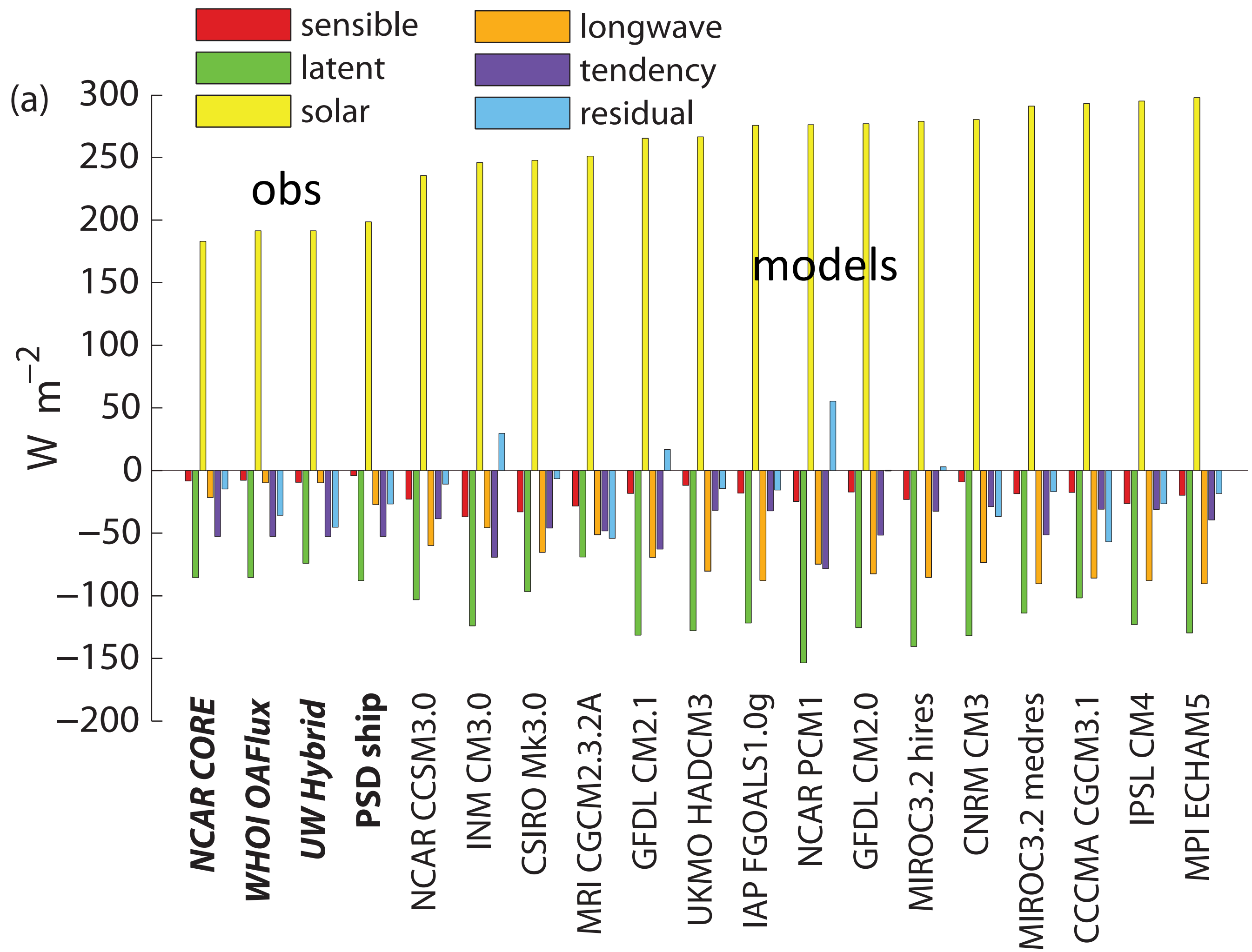
Model update summary

1. CMIP5 SST biases have improved relative to CMIP3 in both Pacific & Atlantic.
2. Improved models show less improvement in Atlantic SST biases than in Pacific
3. SST biases in the Atlantic have a critical oceanographic contribution
4. Cloud-SST feedbacks are evident, but not enough to explain/remove biases.

ETOS is preparing a white paper.

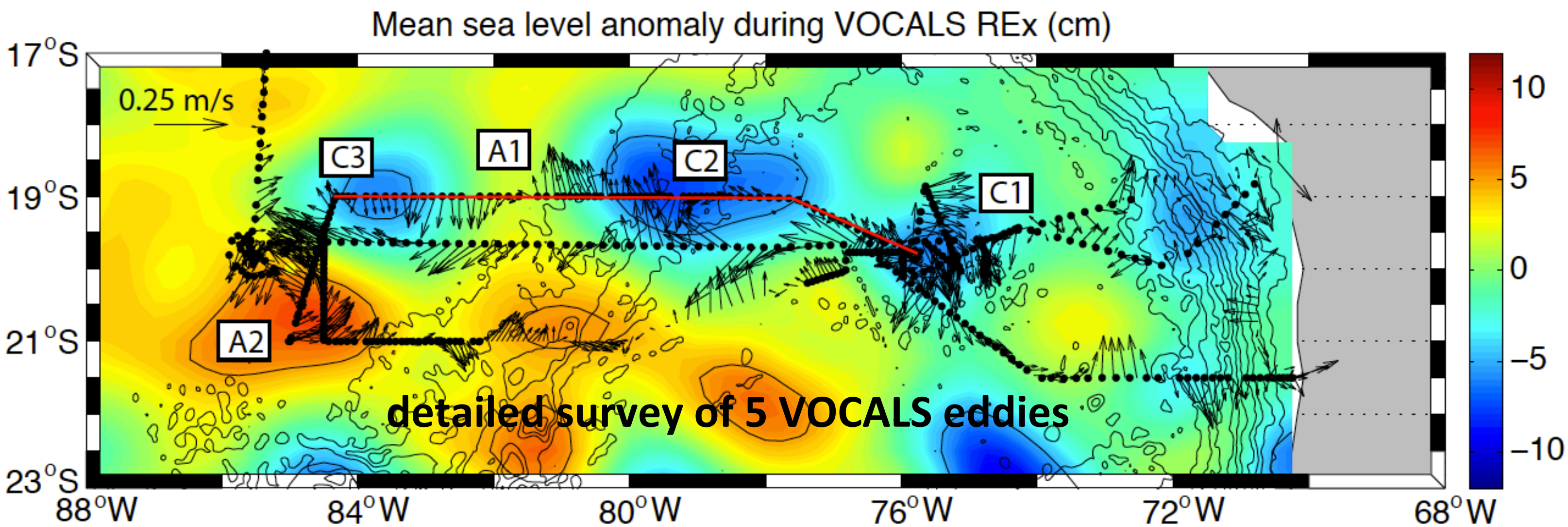
Pacific model SST bias hypotheses

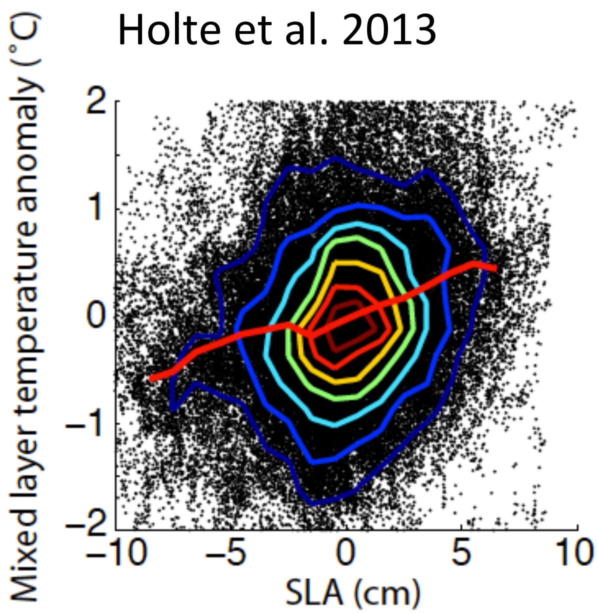
- Cloud amount deficit warms SST
- Ocean subsurface cooling
  - mean currents & upwelling
  - eddies
- SST warms so surface fluxes balance excess warming



de Szoeke et al. 2011; Mechoso et al. 2013, *BAMS*

Eddies in the Southeastern Pacific Ocean





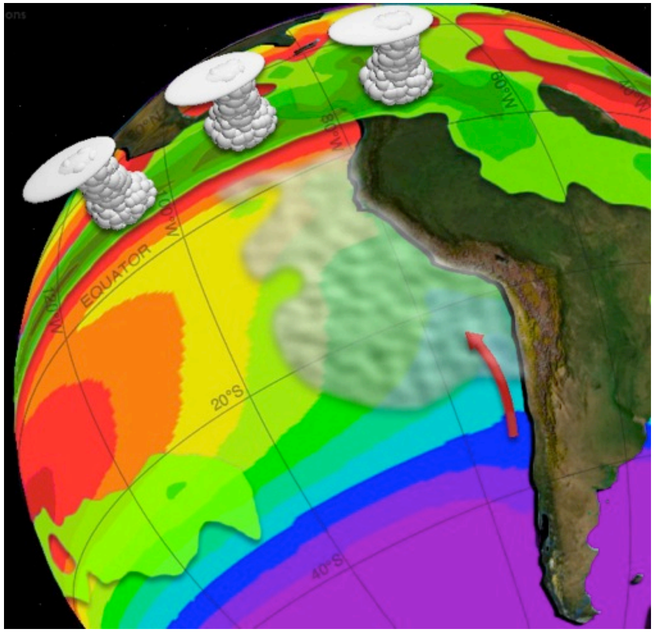
ARGO drifters

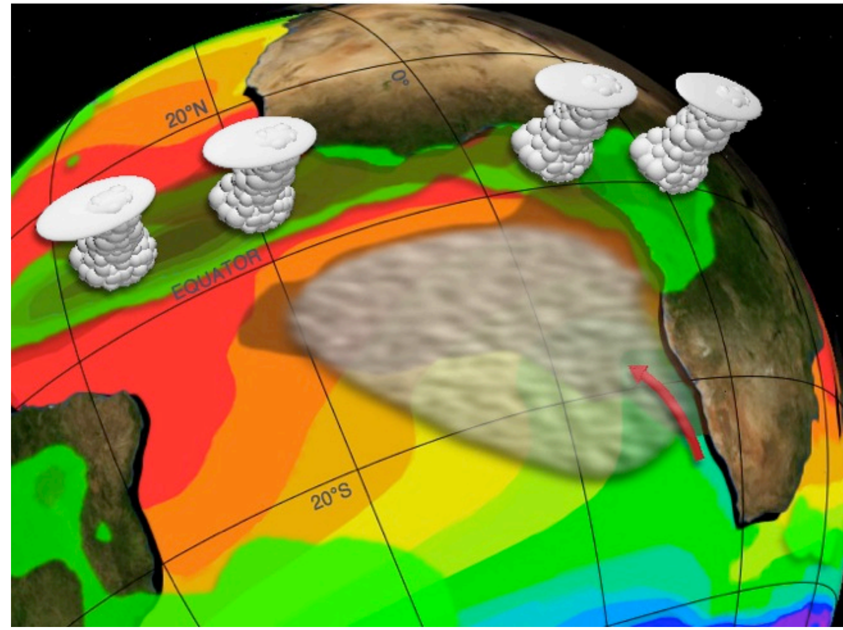
Satellite & drifters: cyclones and anticyclones are equally frequent.
➔ Eddy heat flux divergence = 0 at Stratus mooring (80°W, 20°S).

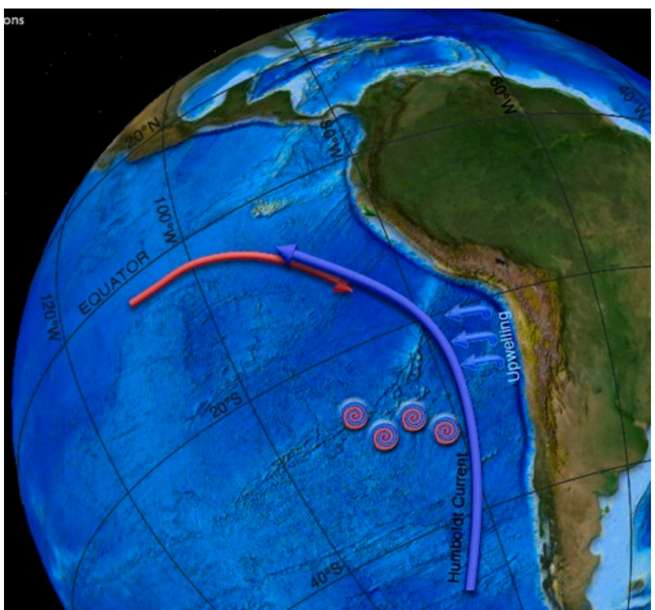
Mean currents & fluxes explain ocean cooling at Stratus mooring.

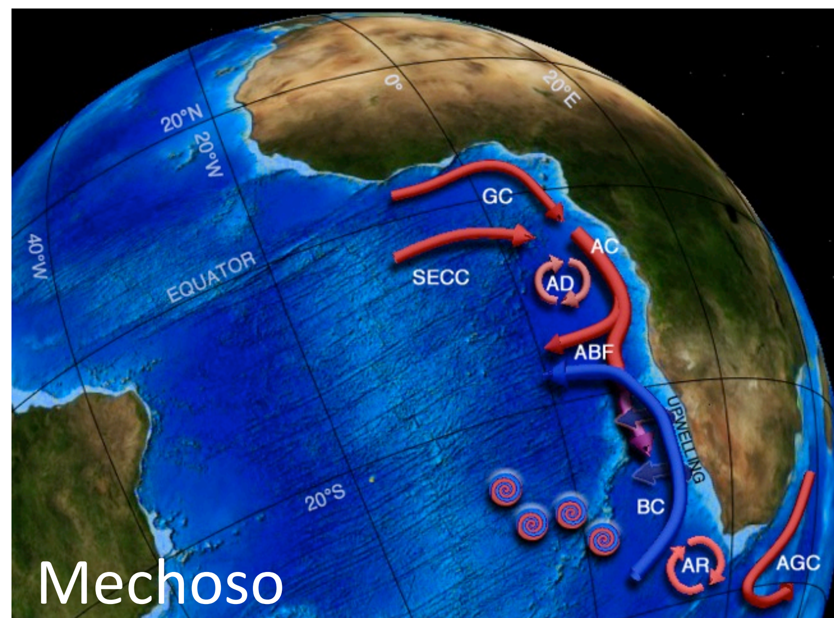
Eddies may be important near shore.

Pacific and Atlantic processes





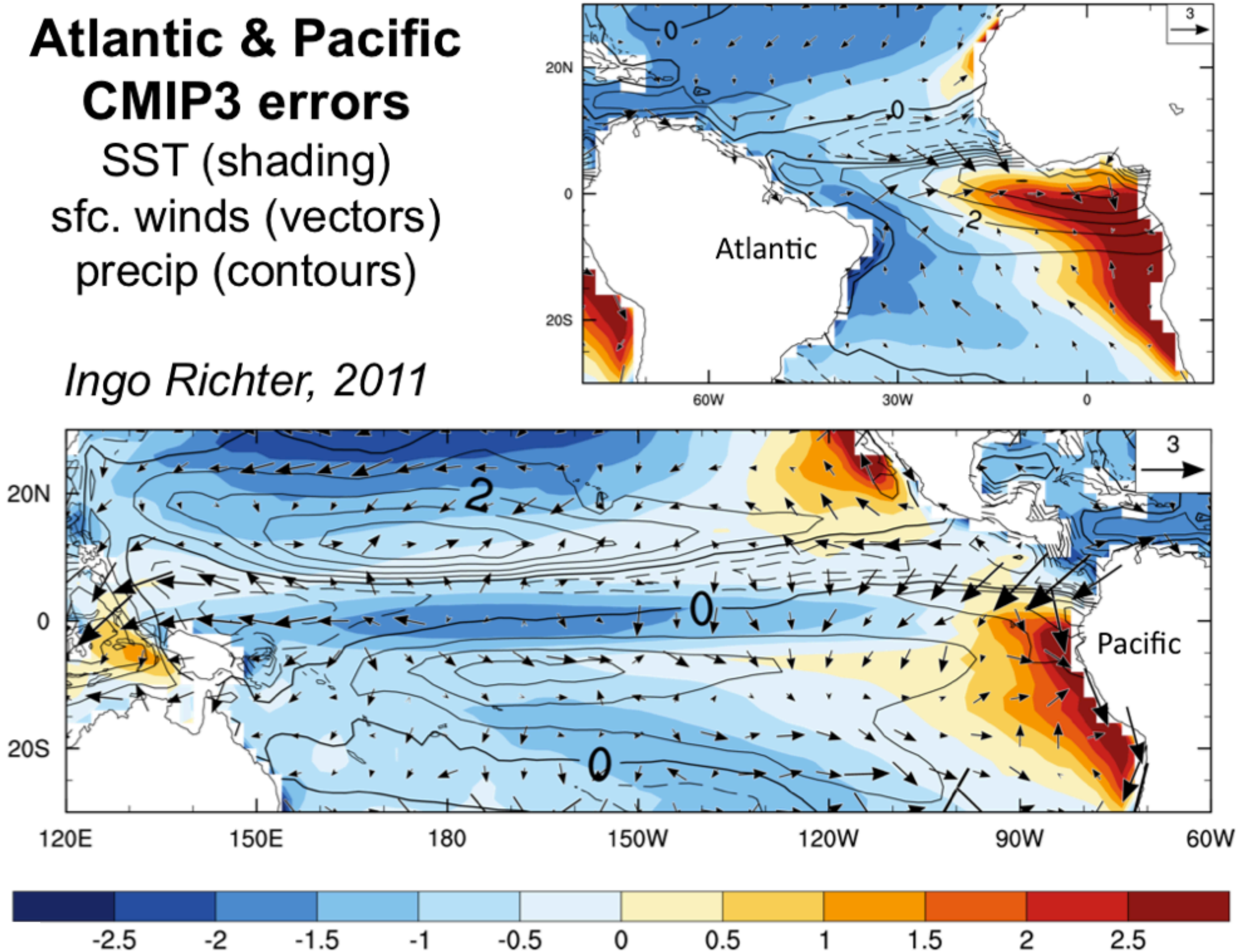




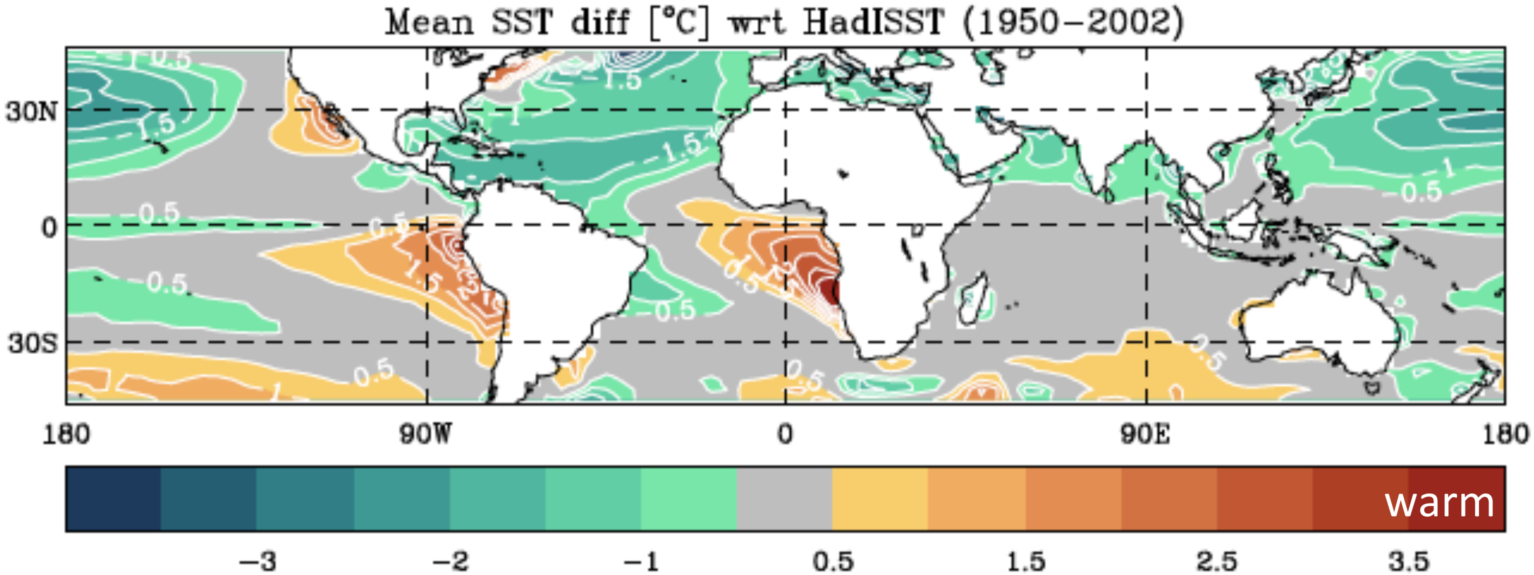
Atlantic & Pacific CMIP3 errors

SST (shading)
sfc. winds (vectors)
precip (contours)

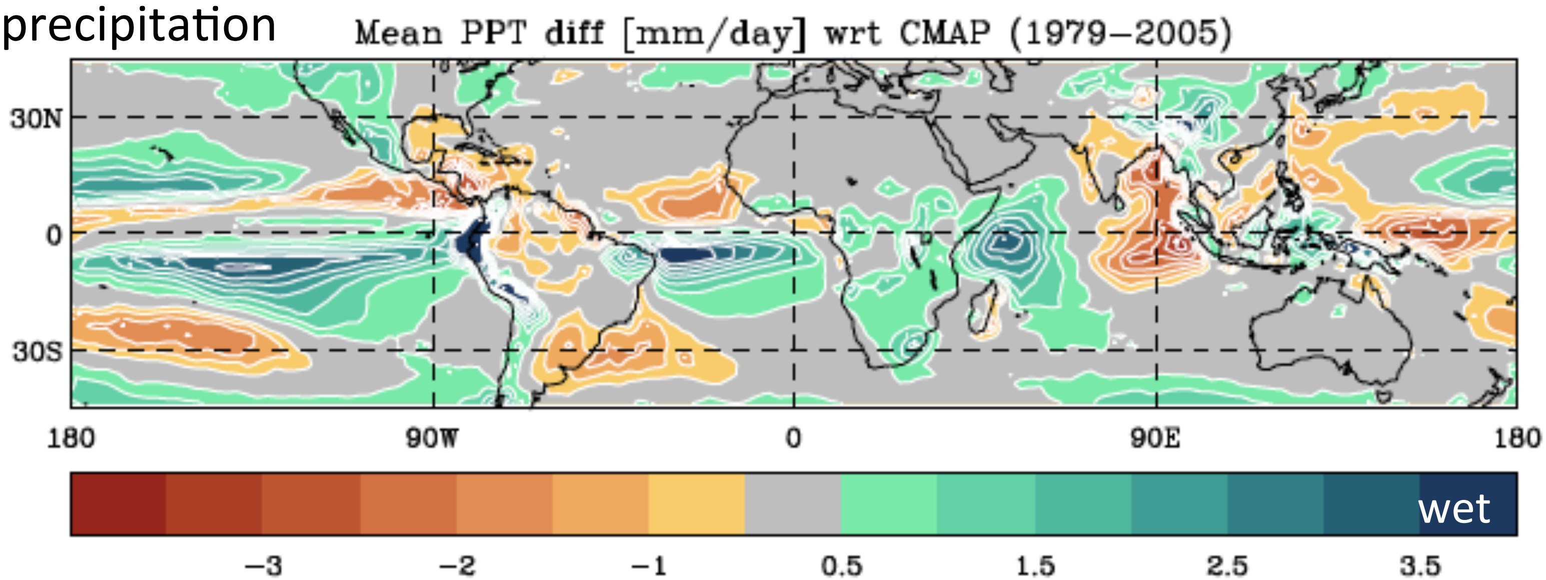
Ingo Richter, 2011



Attention turns to the Atlantic



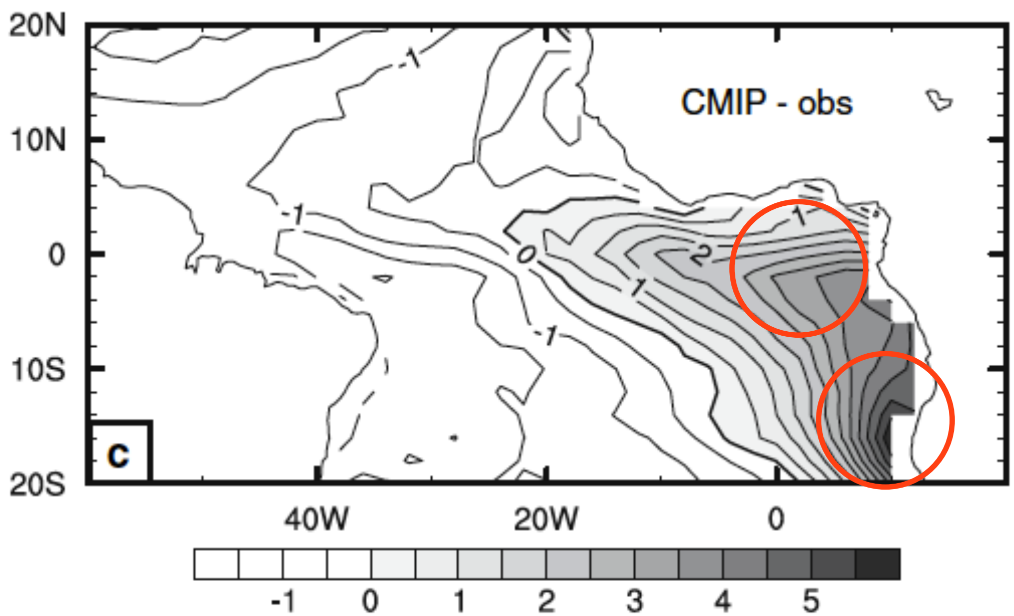
precipitation



Toniazzo and Woolnough 2013

Two Atlantic SST errors

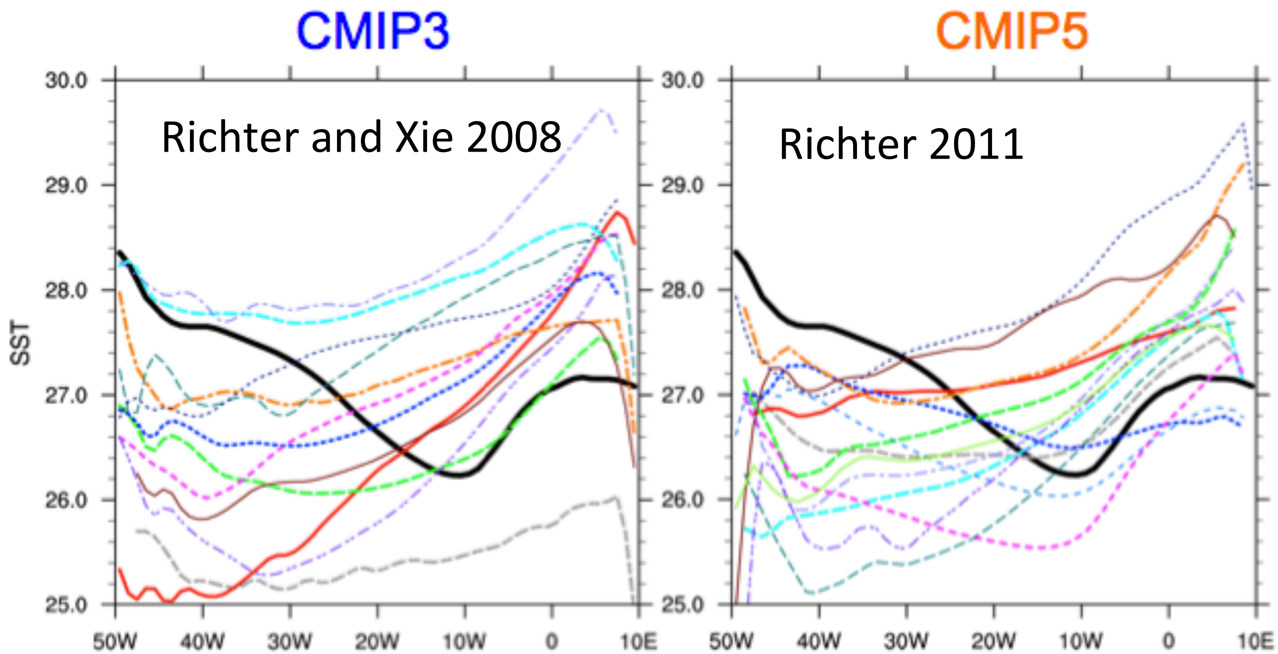
1. Equatorial SST and thermocline zonal gradient reversed along equator
   (Richter and Xie 2008, Richter 2011)
2. Strong SST errors near 18°S, Angola-Benguela front
   (Ping Chang)



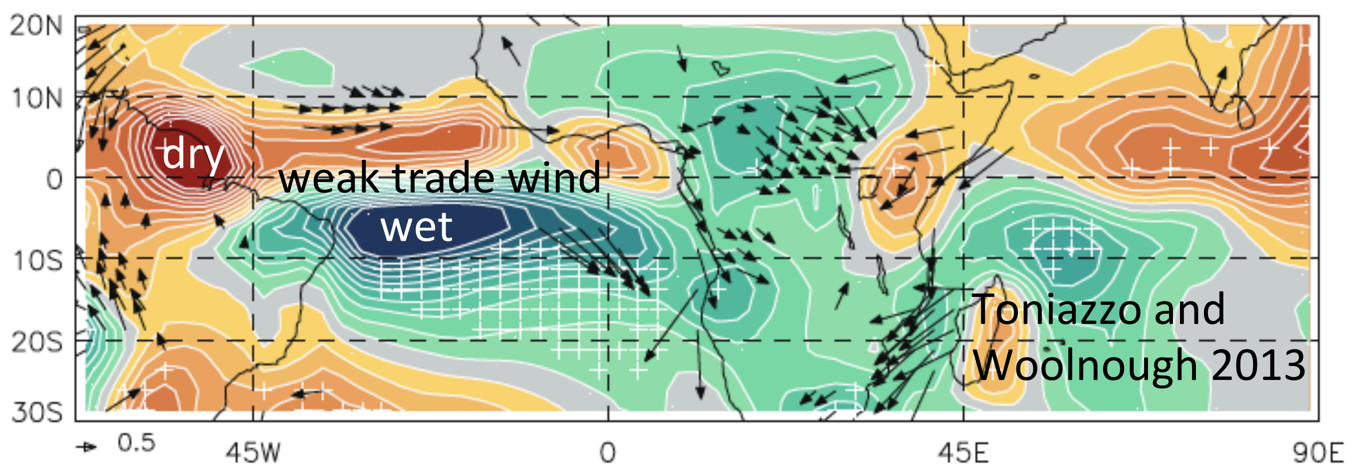
Richer and Xie 2008

How are southeastern errors related to equatorial errors?

Reversed zonal Atlantic SST gradient along equator remains



precipitation bias, CMIP5, MAM 1979-2004

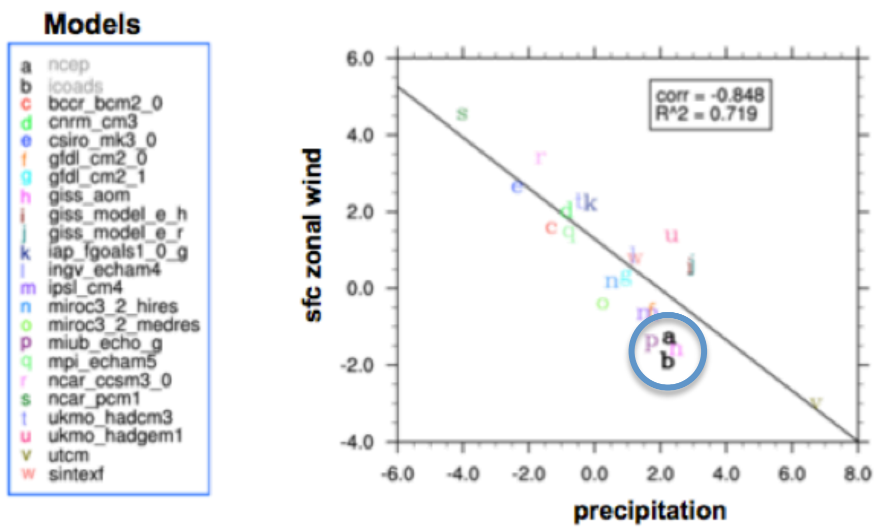


Zonal SST error related to precipitation and wind stress

MAM precip vs. sfc zonal wind at the equator

x-axis: gradient of precip, 80W-50W minus 0-30E, 5S-5N, MAM

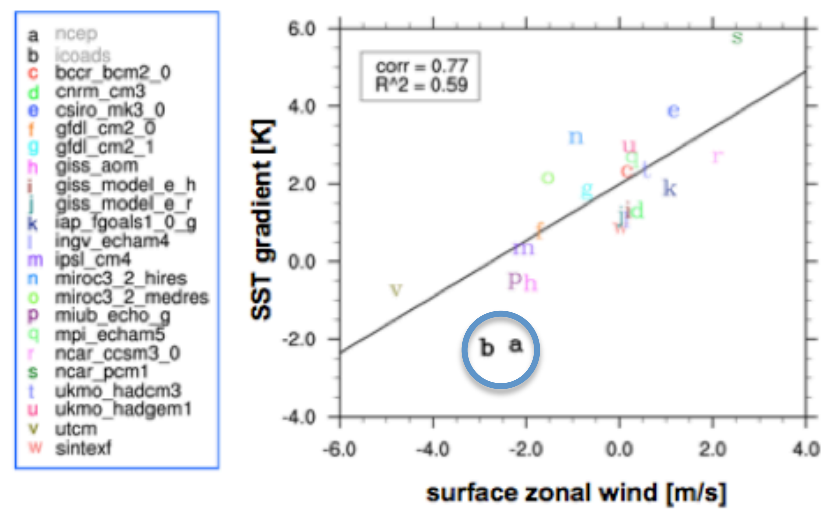
y-axis: avg of sfc zonal wind 30W-0, avg 2S-2N, MAM



MAM sfc zonal wind vs. JJA SST at the equator

x-axis: avg of zonal wind, 40W-10W, 2S-2N, MAM

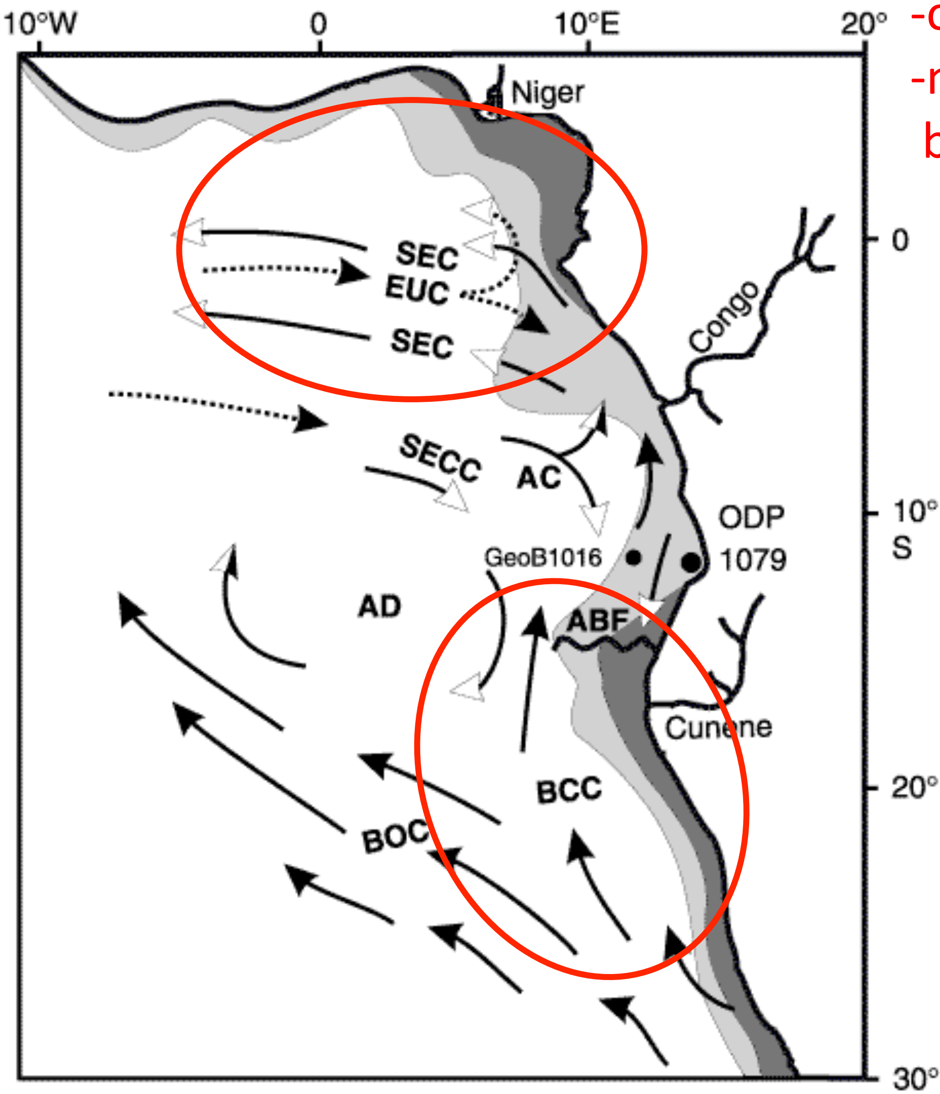
y-axis: gradient of SST 40W-8E, avg 2S, 2N, JJA



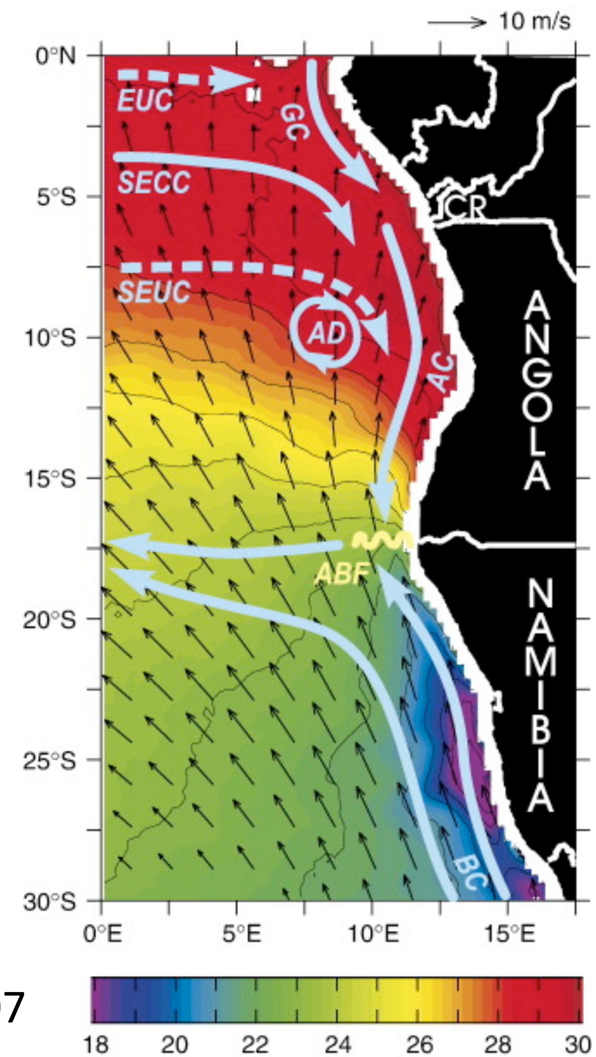
Richter and Xie 2008

- weak Amazon precipitation → weak trade wind → wrong equatorial SST gradient
- model experiments show errors in the east are also locally forced (Chang, Patricola)

Locally-forced errors in Eastern Atlantic

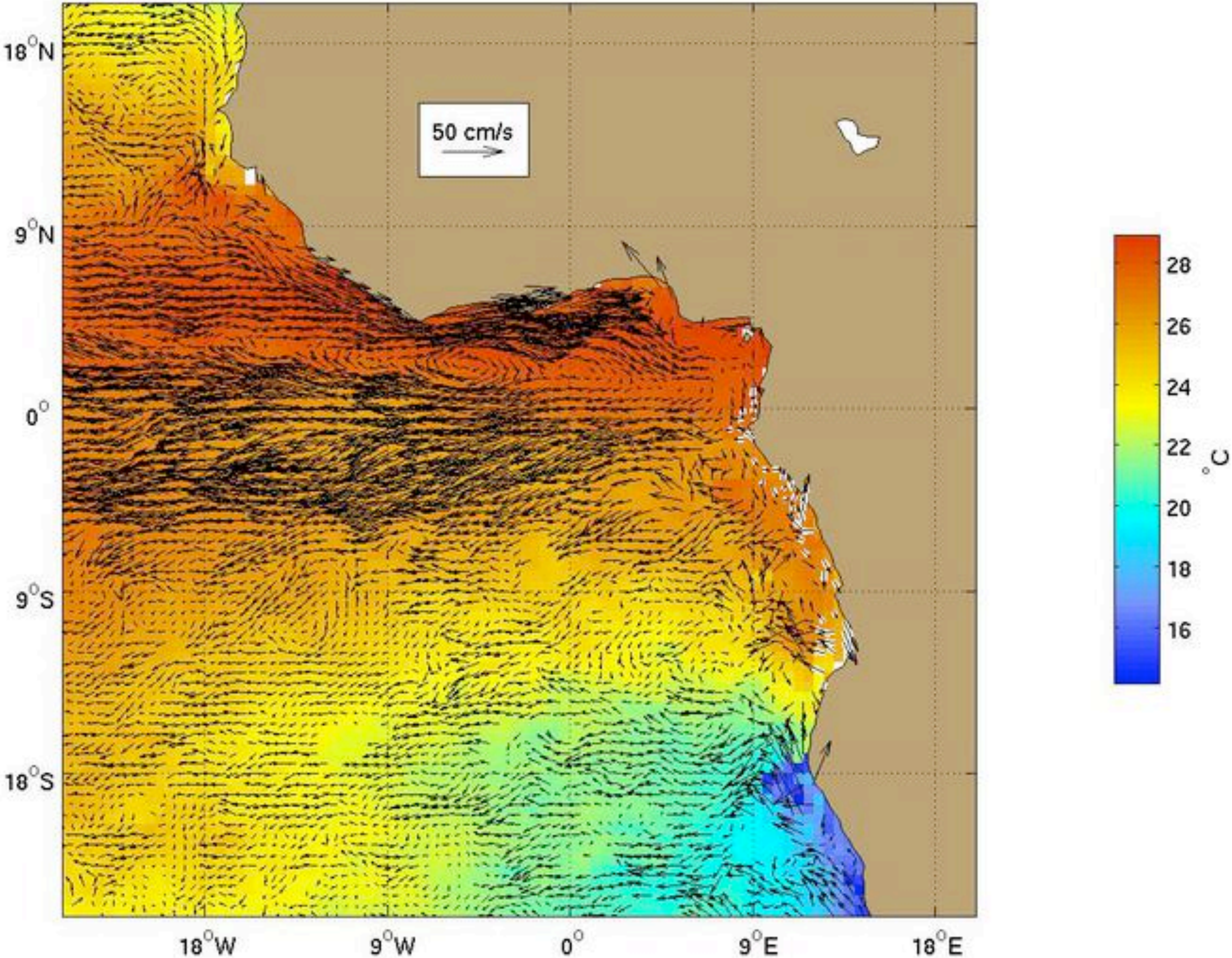


-on equator
-near Angola-Benguela Front (ABF)
by wind stress (Colberg and Reason 2006)



Schneider et al 2006

Rouault 2007



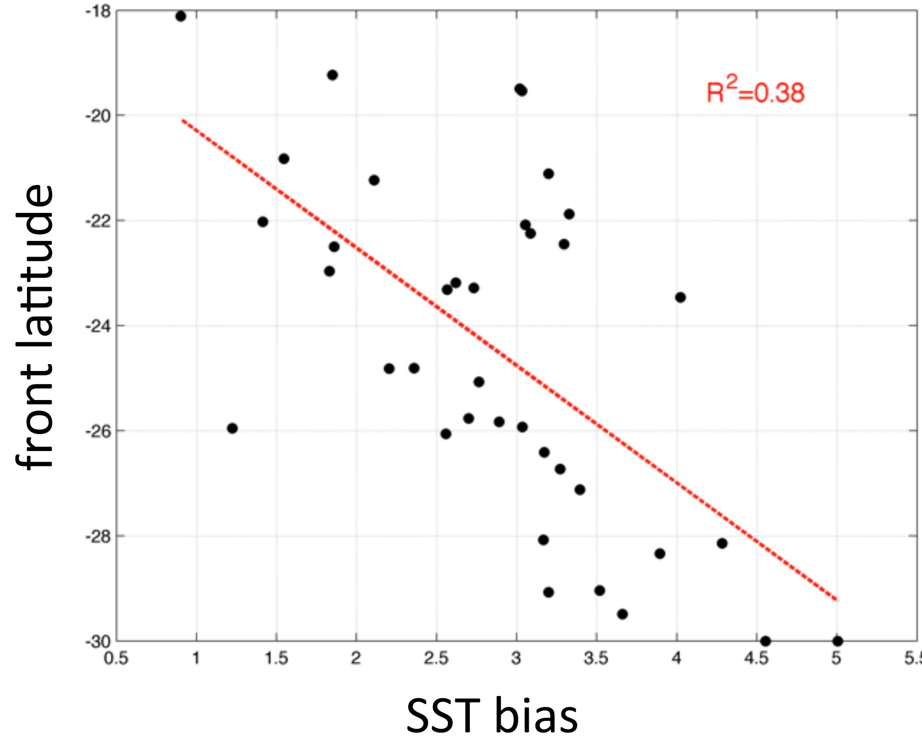
18°N
9°N
0°
9°S
18°S
18°W
9°W
0°
9°E
18°E
50 cm/s
28
26
24
22
20
18
16
°C

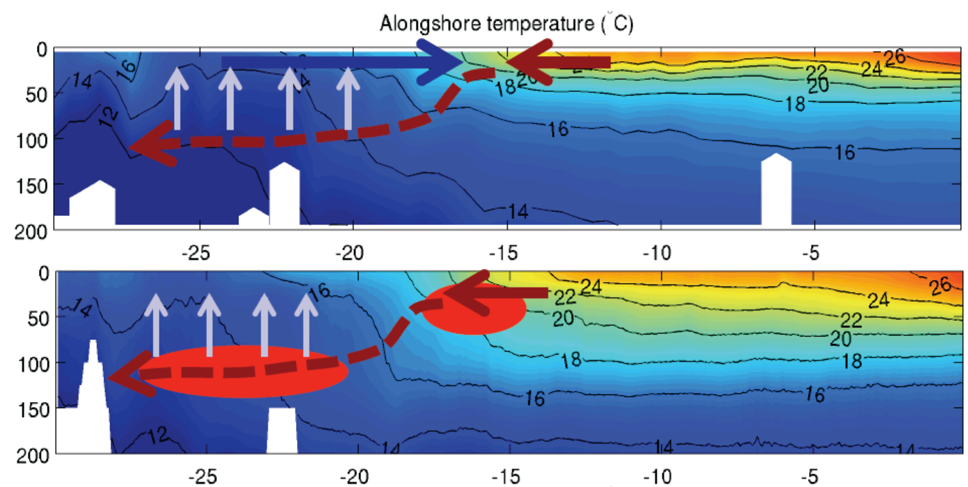
SST error near Angola-Benguela Front

<u>hypotheses:</u>

- Coastal wind stress (curl) is too weak south of the ABF, and the front is too weak and too far south.
- Angola current advects south underneath ABF, and the thermocline is too diffuse warming the surface.
- Is there variability from Coastal Kelvin waves?

CMIP5 models





south

P. Chang

Atlantic Meridional Mode

- Meridional mode

Metrics for model performance

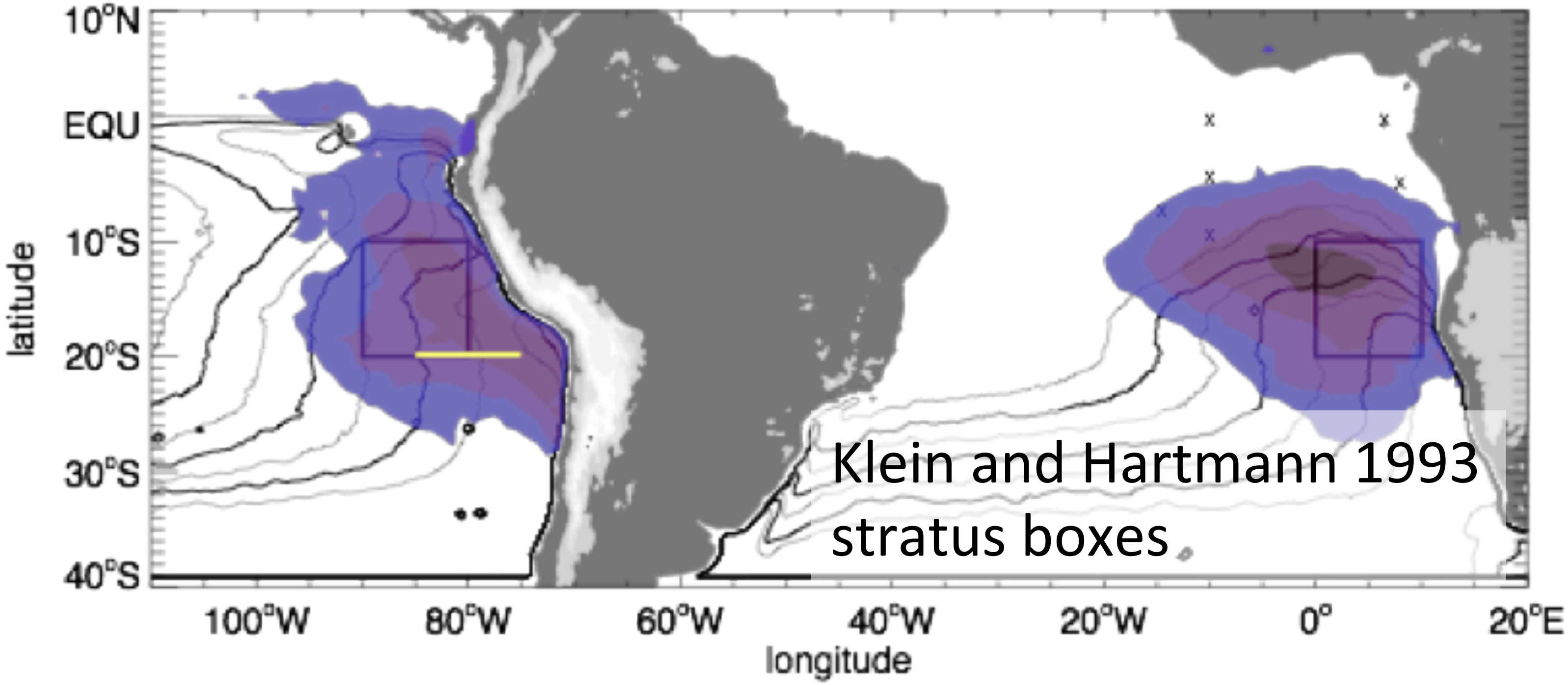
- SST is central to atmosphere/ocean coupling
- Cloud amount and cloud radiative forcing
  - TOA radiative forcing & feedback → climate
  - surface radiative forcing → SST

- Metrics indicating *mechanisms* are important and useful.

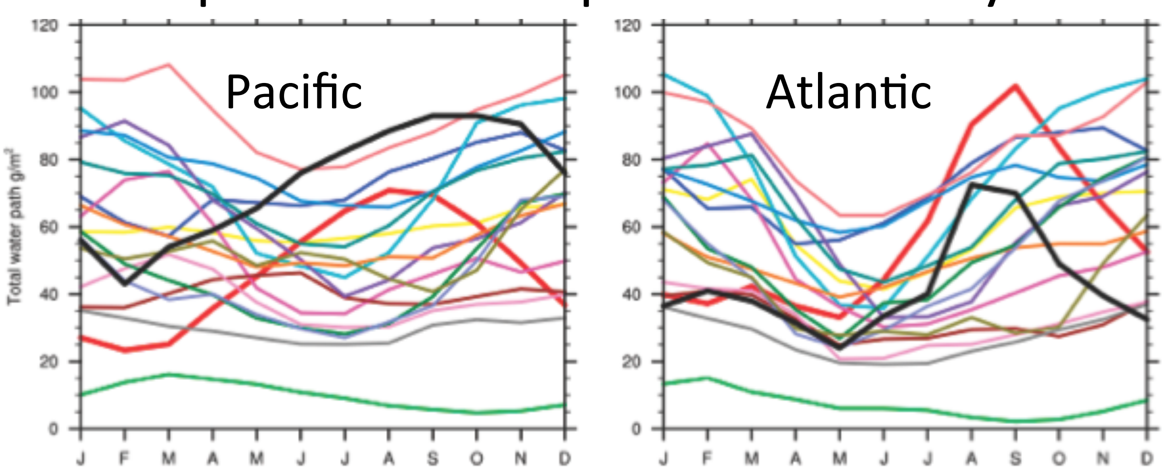
Metrics for mechanisms

- Seasonal cycle
- Zonal and meridional gradients
- Ocean mixed layer heat budgets
- Satellite cloud simulators (ISCCP, MISR, CALYPSO, MODIS-underutilized)
- Multi-model ensembles probe the climate parameter space
  - correlated biases suggest physical processes
- Decadal hindcast evolution away from observed state (Toniazzo and Woolnough 2013)
  - indicates errors, processes, and timescales

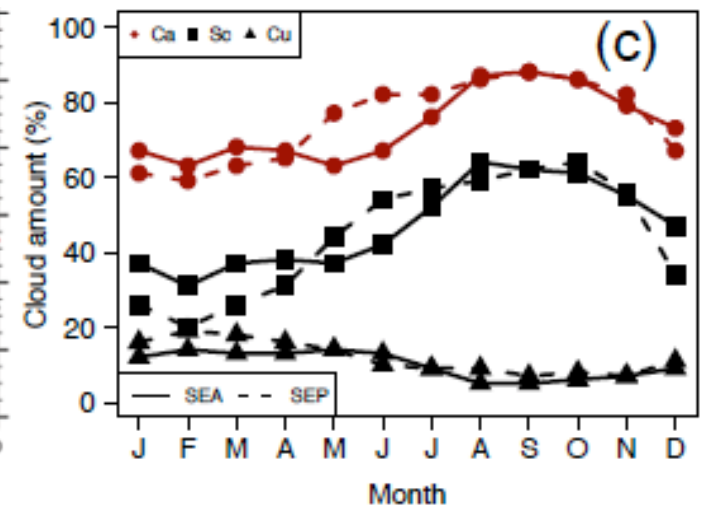
Cloud seasonal cycle metrics



liquid+ice water path seasonal cycle



Cloud amount

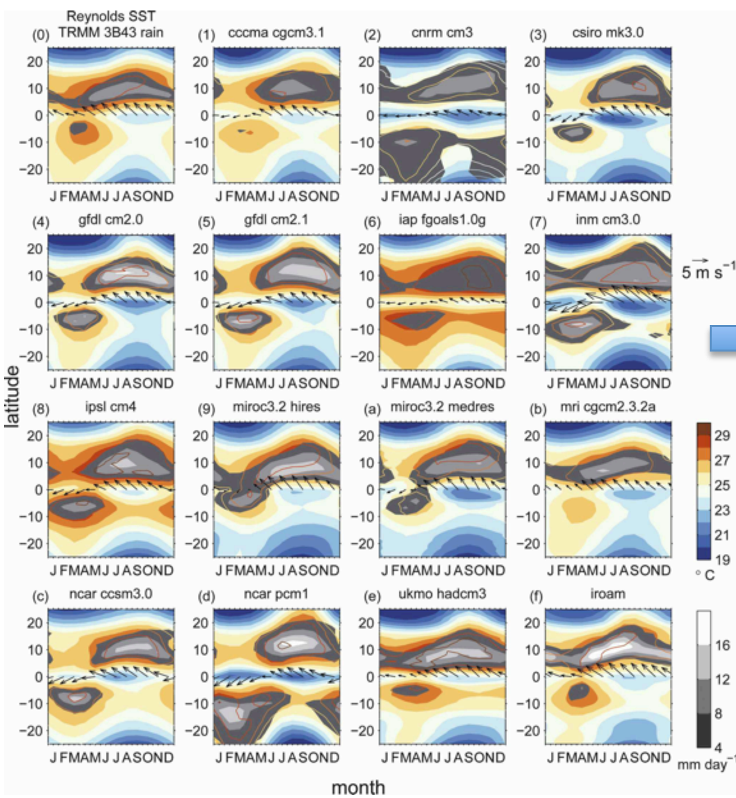


Zuidema and Bellomo

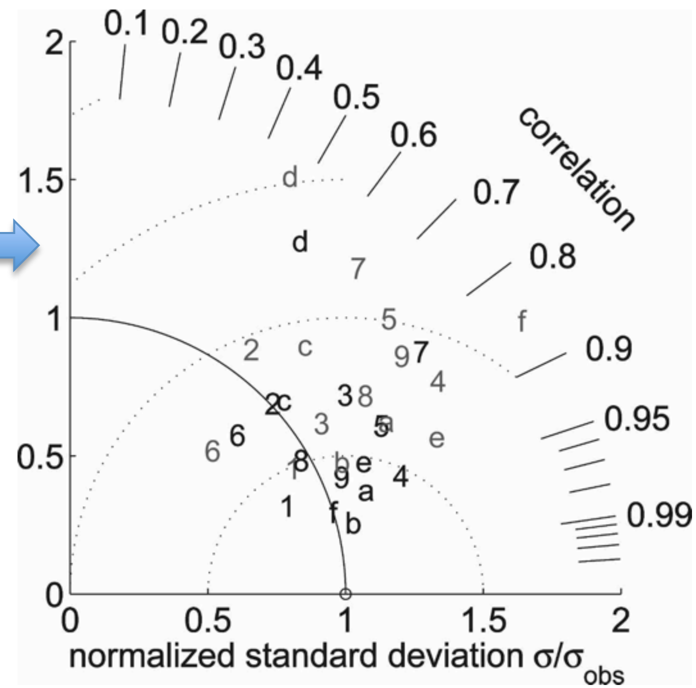
CMIP meridional-seasonal cycle

- Wallace and Mitchell (1992) equatorial seasonal cycle
  Atlantic: Okumura and Xie 2004
  Pacific: de Szoeke and Xie 2008
- Meridional interannual mode: Chiang and Vimont 2004

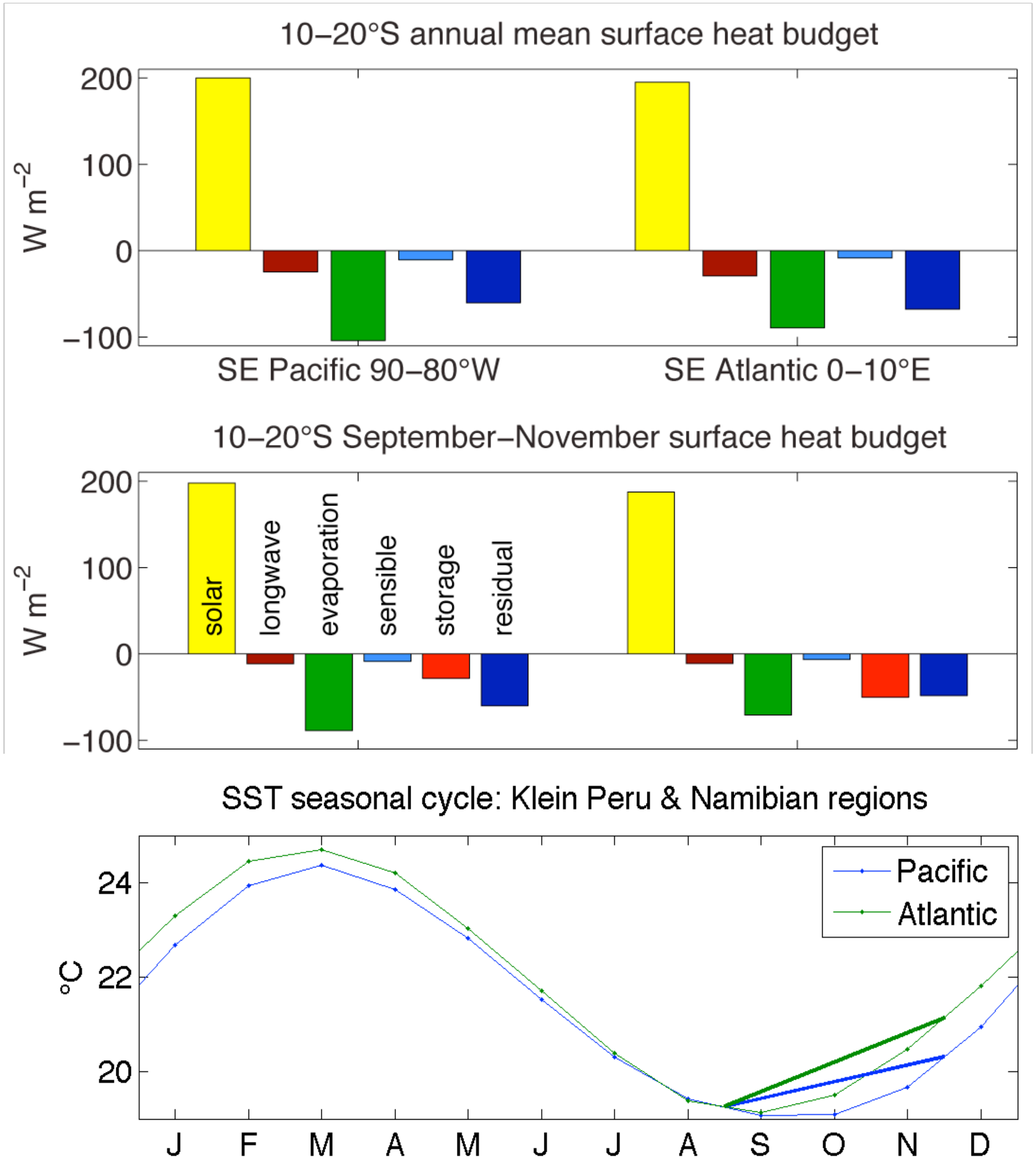
SST and precipitation



de Szoeke and Xie (2008)
Taylor (2001) diagram



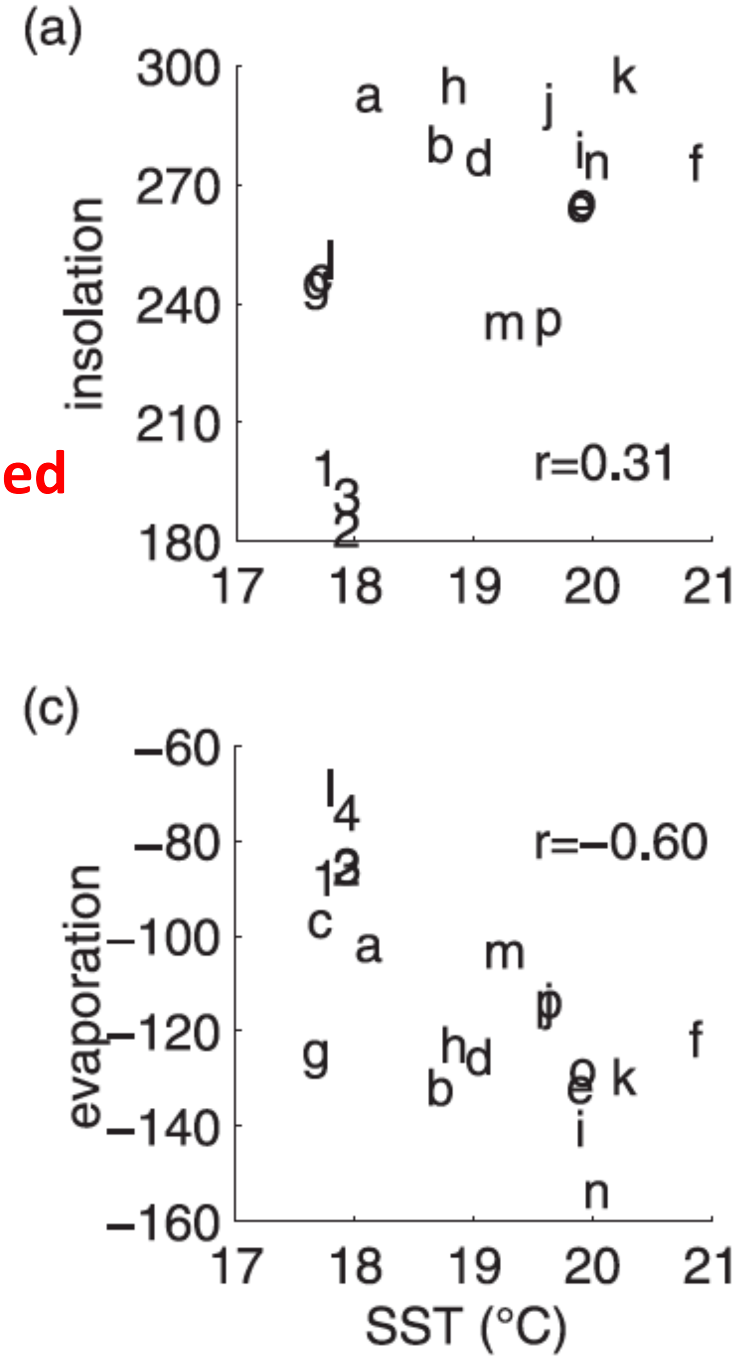
Peruvian and Namibian stratus heat budgets



Klein and Hartmann stratus regions

similar seasonal cycle
Atlantic warms earlier

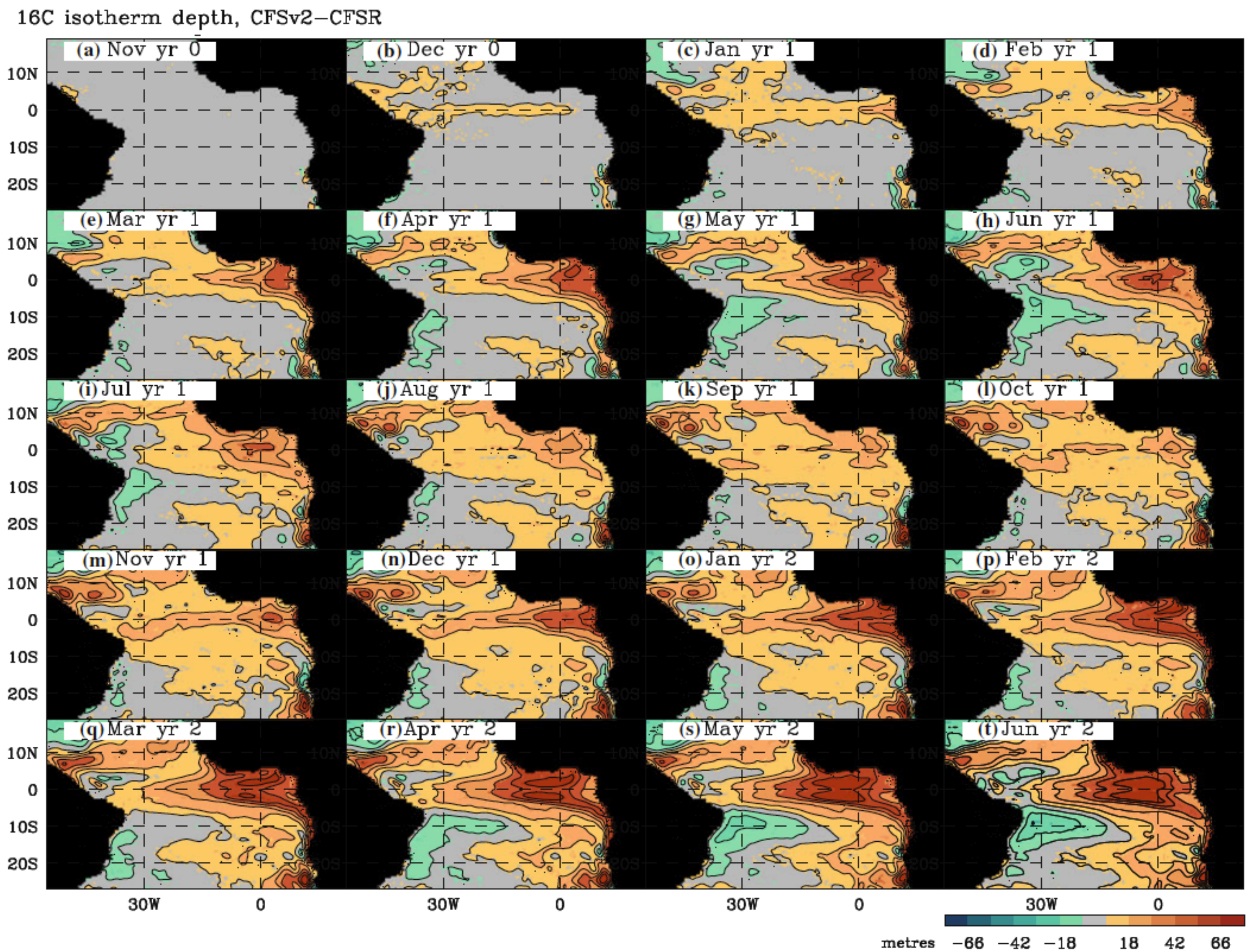
Pacific heat budget model ensemble



SST only weakly correlated to insolation

while evaporation responds to SST

CFS hindcast monthly SST error growth



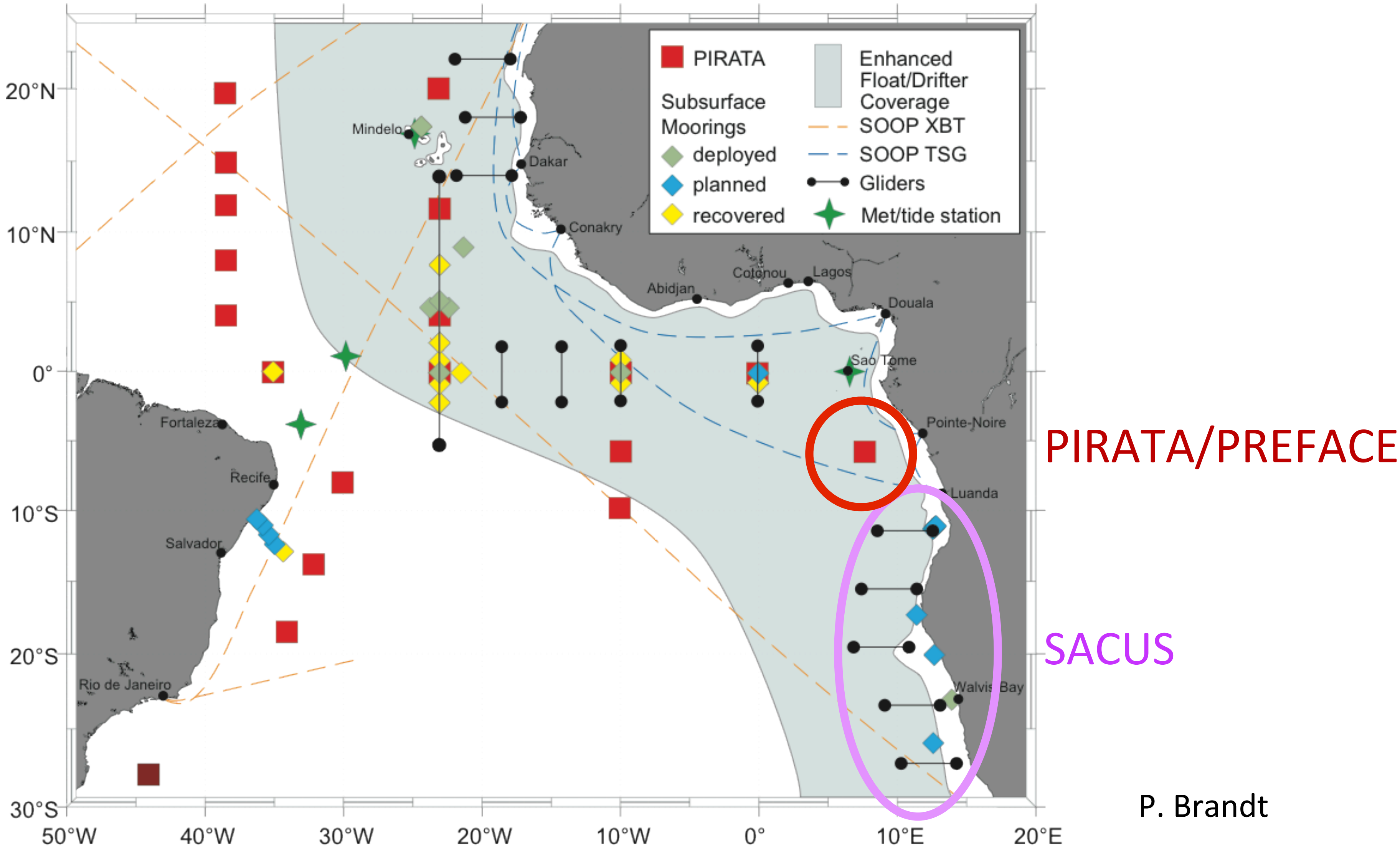
Toniazzo and Woolnough 2013

Observations in the near future: European oceanographic field campaigns

- PREFACE (Enhancing PREdiction oF tropical Atlantic ClimatE and its impact, 2013-2019)
  – redeploy 6°S, 8°E mooring
- SACUS (Southwest African Coastal Upwelling System and Benguela Niños, 2013-2015)
  BMBF, German Federal Ministry of Education and Research
  – 4 cruises, east Atlantic coastal glider sections 10-28°S
    - southeast upwelling connection to equatorial undercurrent
    - coastal current variability

What science can US contribute?

European Oceanographic Experiments



P. Brandt

Euro/US opportunity

- SACUS and PREFACE objectives are primarily oceanographic, yet could sample atmosphere on existing deployments "of opportunity."

One might propose:

- 4-6 soundings per day on research cruises
- 6°S, 8°E PIRATA buoy enhancements
  - multispectral solar radiometer for column aerosol
- Other science?

Atlantic atmospheric field campaign proposals developing

due late 2013/early 2014

ORACLES (NASA, Jens Redemann-PI)

CLARIFY (UK, Jim Haywood)

ONFIRE (NSF, Zuidema)

- Document & understand smoke-stratus interactions.
- Cloud structure and surface radiation budget is a common interest w/ oceanographic campaigns.
- Surface aerosol forcing most pronounced near coast, of secondary relevance to equatorial SST biases.

ETOS year 1.5 summary

- Eastern tropical oceans model assessment
  - white paper in preparation
- Identify available and expected observations
- Identify the gaps
  - model experiments
  - needed observations
- Hypotheses
- Metrics
  - model assessment
  - physical processes