Recent, current & future work with NorESM-L in Bergen

Thomas Toniazzo, Ingo Bethke, Mats Bentsen,
Francois Counillon, Noel Keenlyside, and others...

AMWG meeting
Boulder, 10/2/2014

Low-resolution Norwegian Earth-System Model (NorESM-L)

Efficient CESM-based coupled GCM to perform:

- s2d ensemble hindcast with data assimilation (NorCPM)
- Ensemble palaeoclimate, historical, and scenario integrations

MICOM on tripolar 2ºx(2º-1/2º) grid, sigma L53

MCT coupler

CAM4 -L26

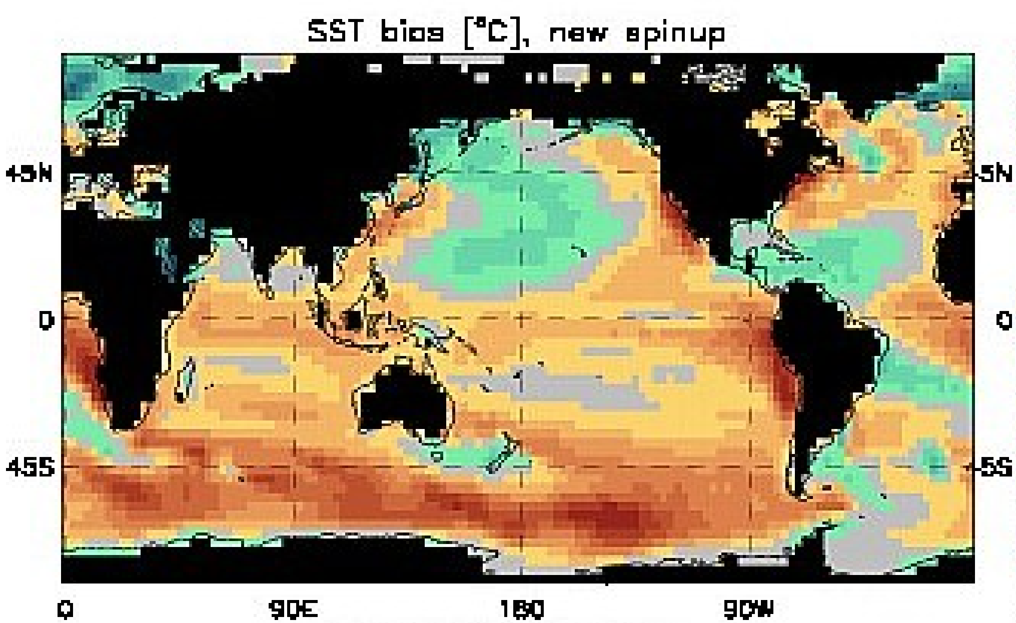
spectral dyn. core @T42 | **finite-volume @2.5ºx1.9º**

Performance on hexagon.bccs.uib.no:

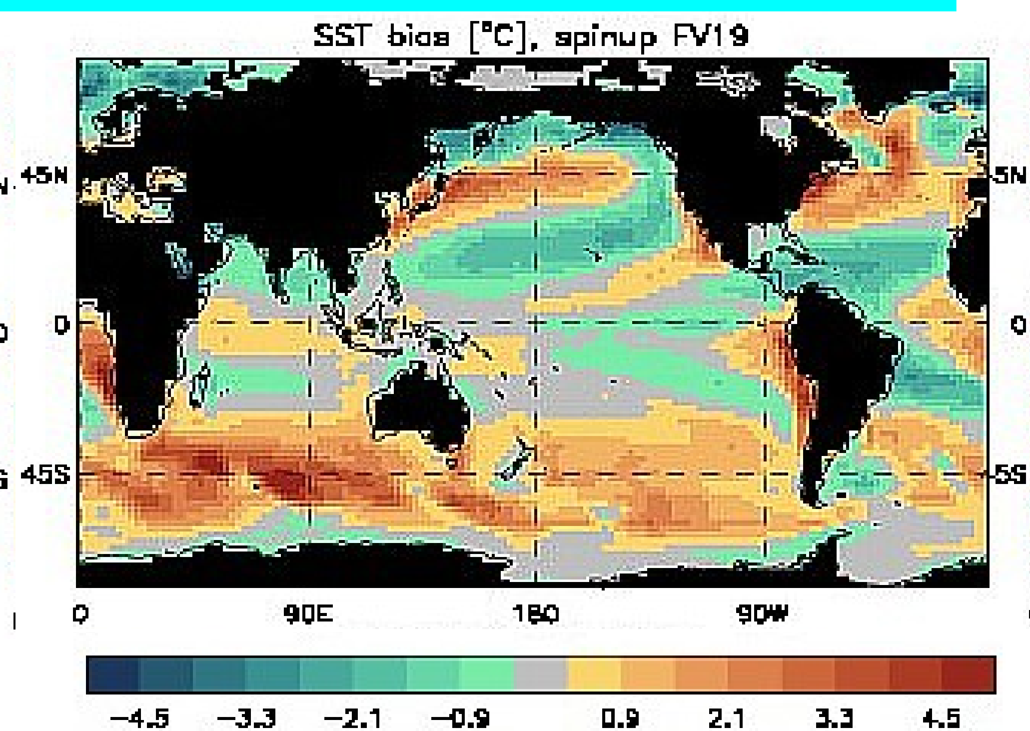
Configuration	cpus	throughput	cost
F19 TN2	256	29.9 m-y/d	0.56 cpu-h/m-d
T42 TN2	320	45.5 m-y/d	0.46 cpu-h/m-d
T31 TN2	192	50.7 m-y/d	0.25 cpu-h/m-d
F19	128	26.9 m-y/d	0.31 cpu-h/m-d
T42	128	40.6 m-y/d	0.21 cpu-h/m-d

Initial task: look for a scientifically useful, validated configuration.

CAM4 T42

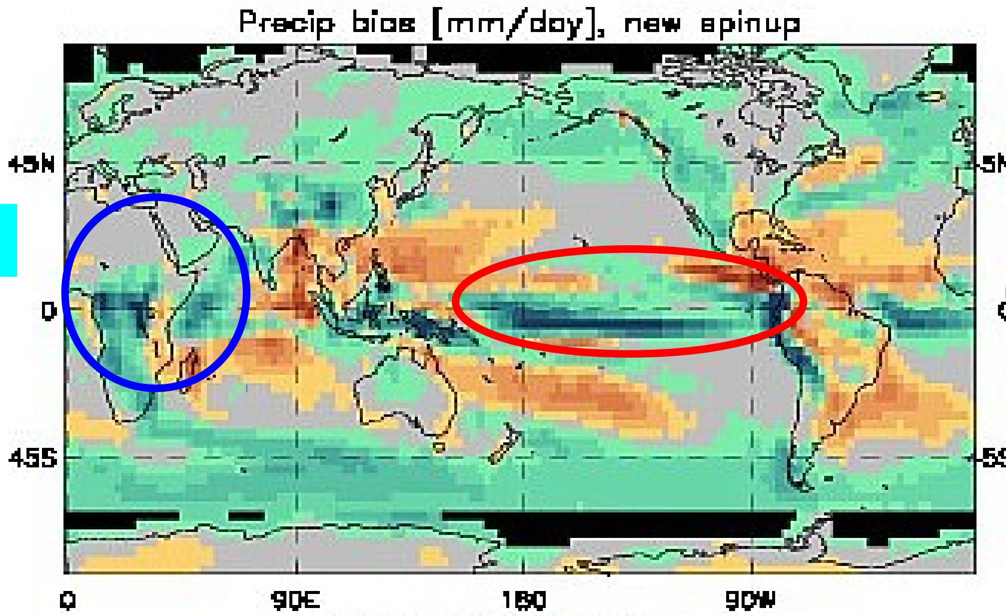


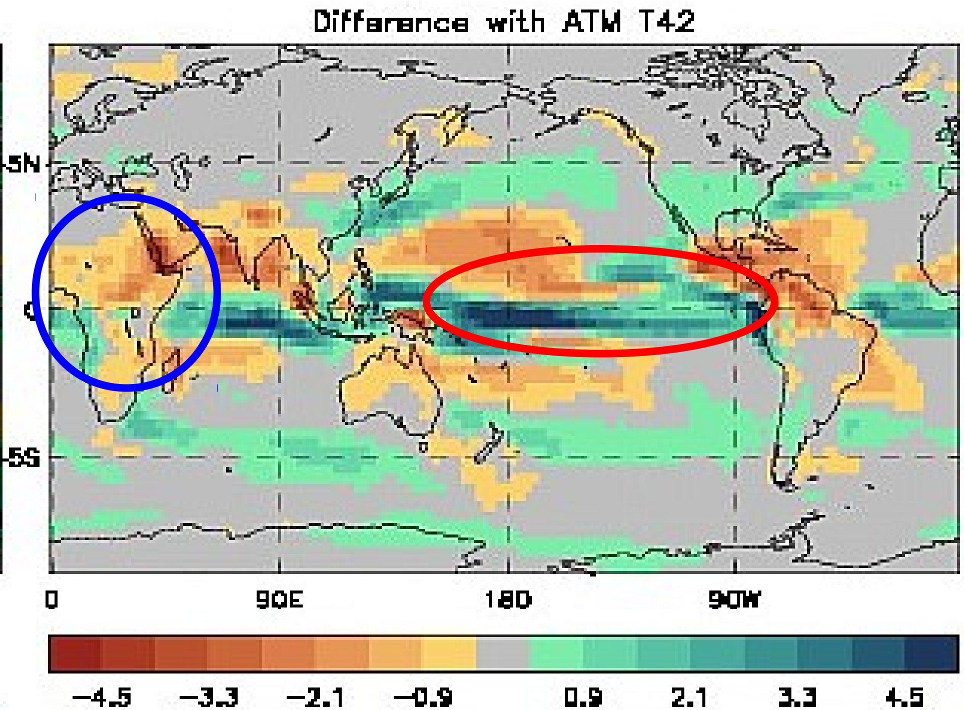
CAM4 F19



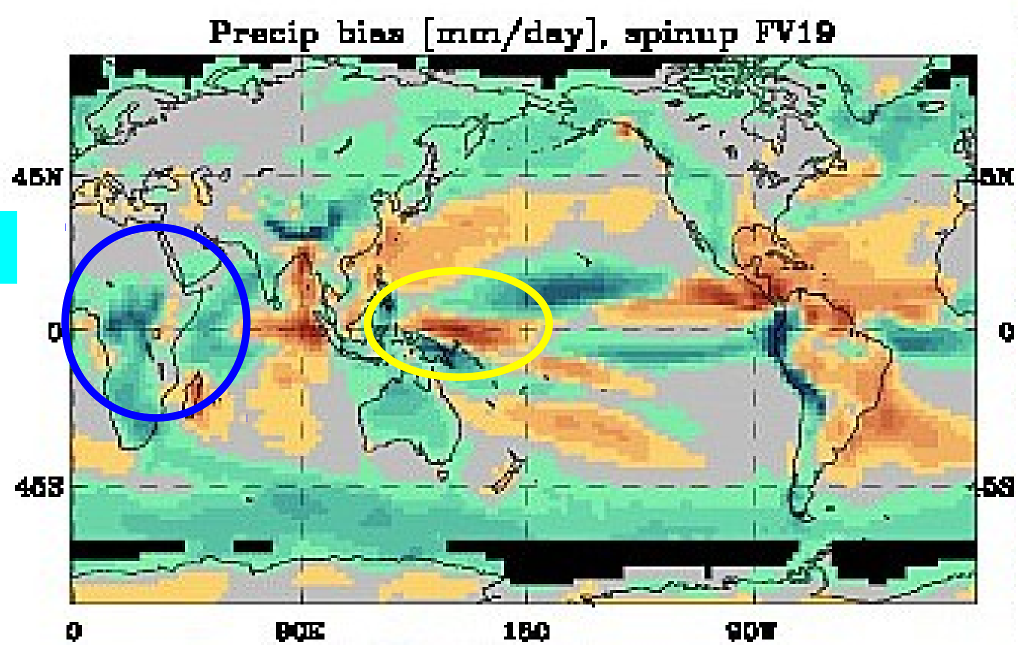
Mean precipitation biases

T42



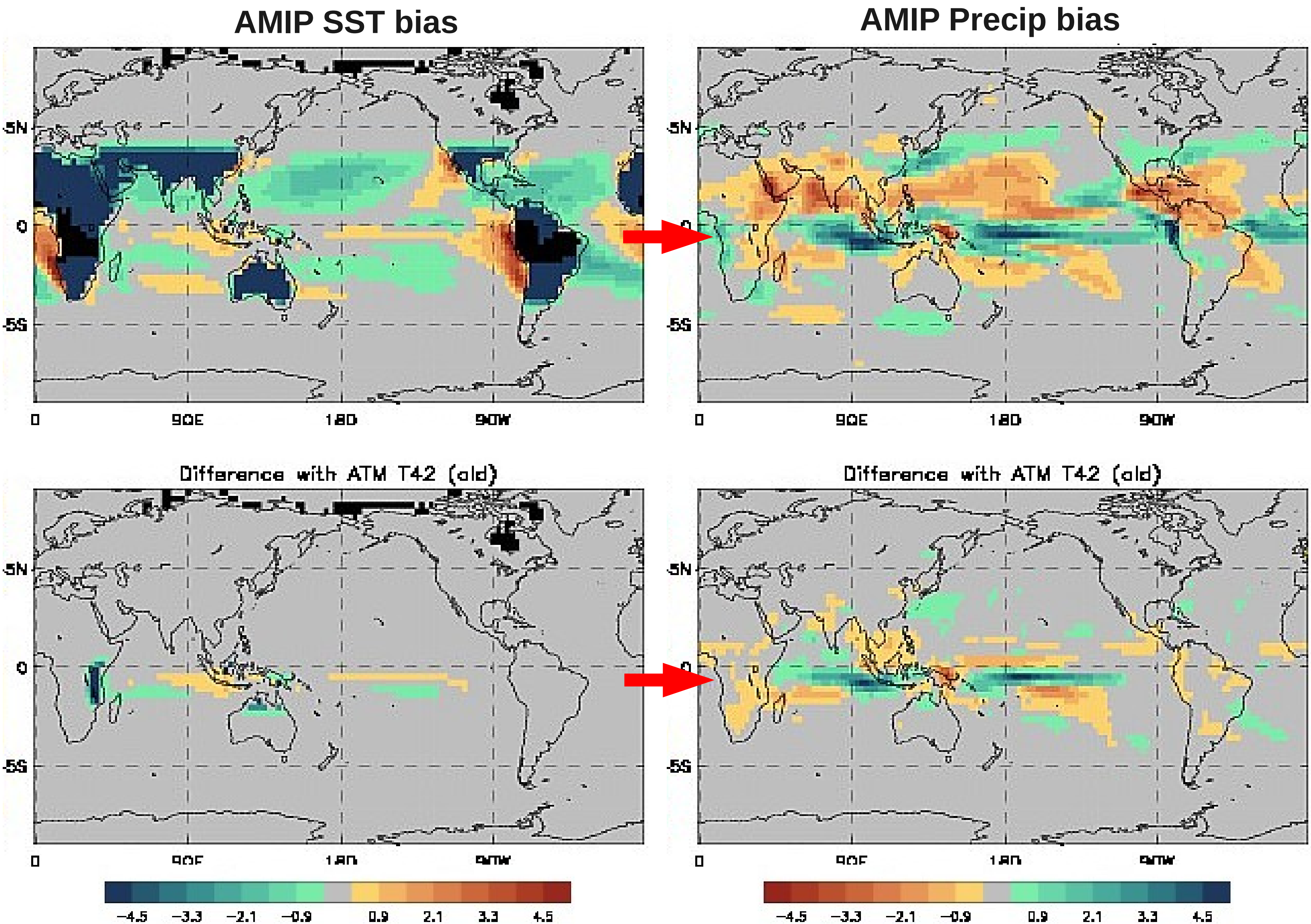


F19

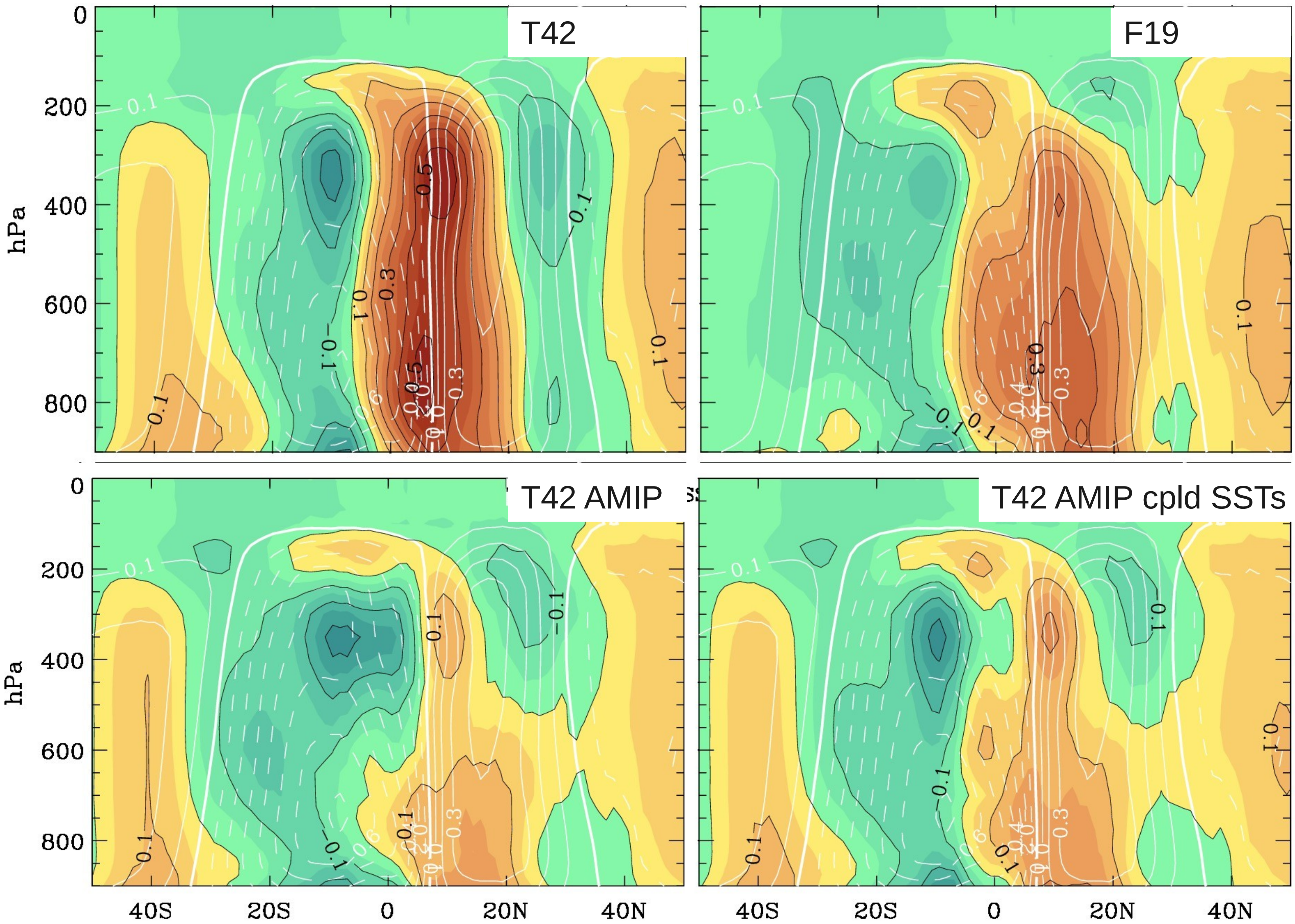


1. Coupled integrations amplify some of the biases of AMIP-mode integrations
2. sensitive to choice of atm. dyn. core
3. not shared with CORE-mode ocean-only integrations

SST sensitivity of precipitation error



Hadley circulation



Summary of main problems

T42

- Warm SH
- Severe double ITCZ
- Circulation too strong and symmetric about Eq
- ENSO active in JJA
- Too little sea-ice
- Atlantic meridional overturning slightly too strong

F19

- Double ITCZ
- Atlantic meridional overturning too strong
- ENSO active predominantly in ASO

Sensitivity tests and main effects

1. Inclusion of orographic drag (do_tms)

   ➔ Better upper-tropospheric circulation, cooler SO, winter ENSO dead

2. Changed surf. flux computation from Large-like to COARE (added option in shr_flux.mod, controlled by namelist entry in *seq_infodata_inparm*)

   ➔ Weaker zonal-mean circulation, less SH rainfall

3. Lowered cloud-formation threshold (cldfrc_RHminl)

   ➔ SH cooling, cloud bias worse

4. Increased albedo of snow on ice (r_snw)

   ➔ Cooler SH, more sea-ice

5. Increase of maximum deep convective plume entrainment rate

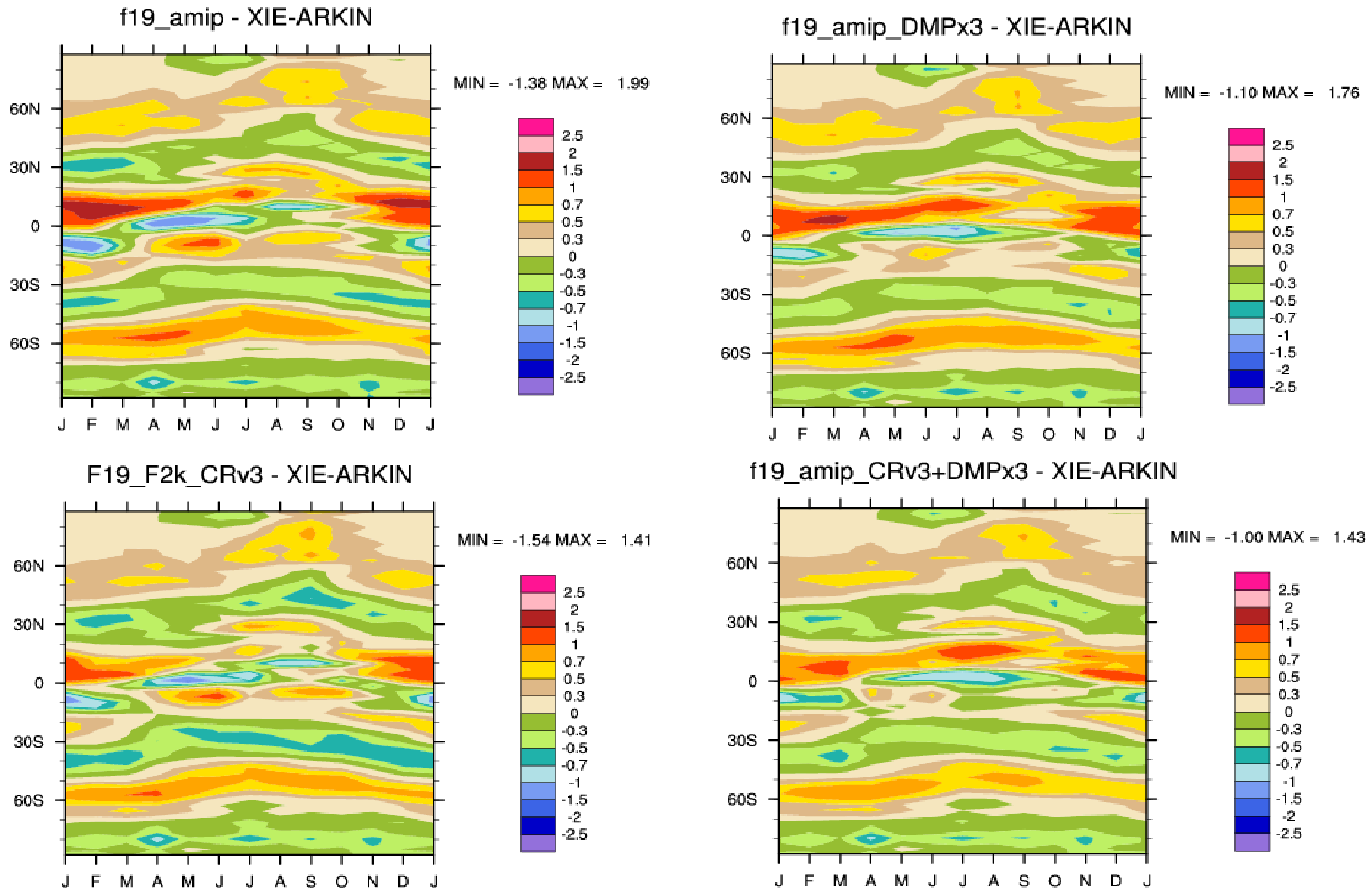
   ➔ Double ITCZ mitigated

Mods in CAM4 with positive impacts

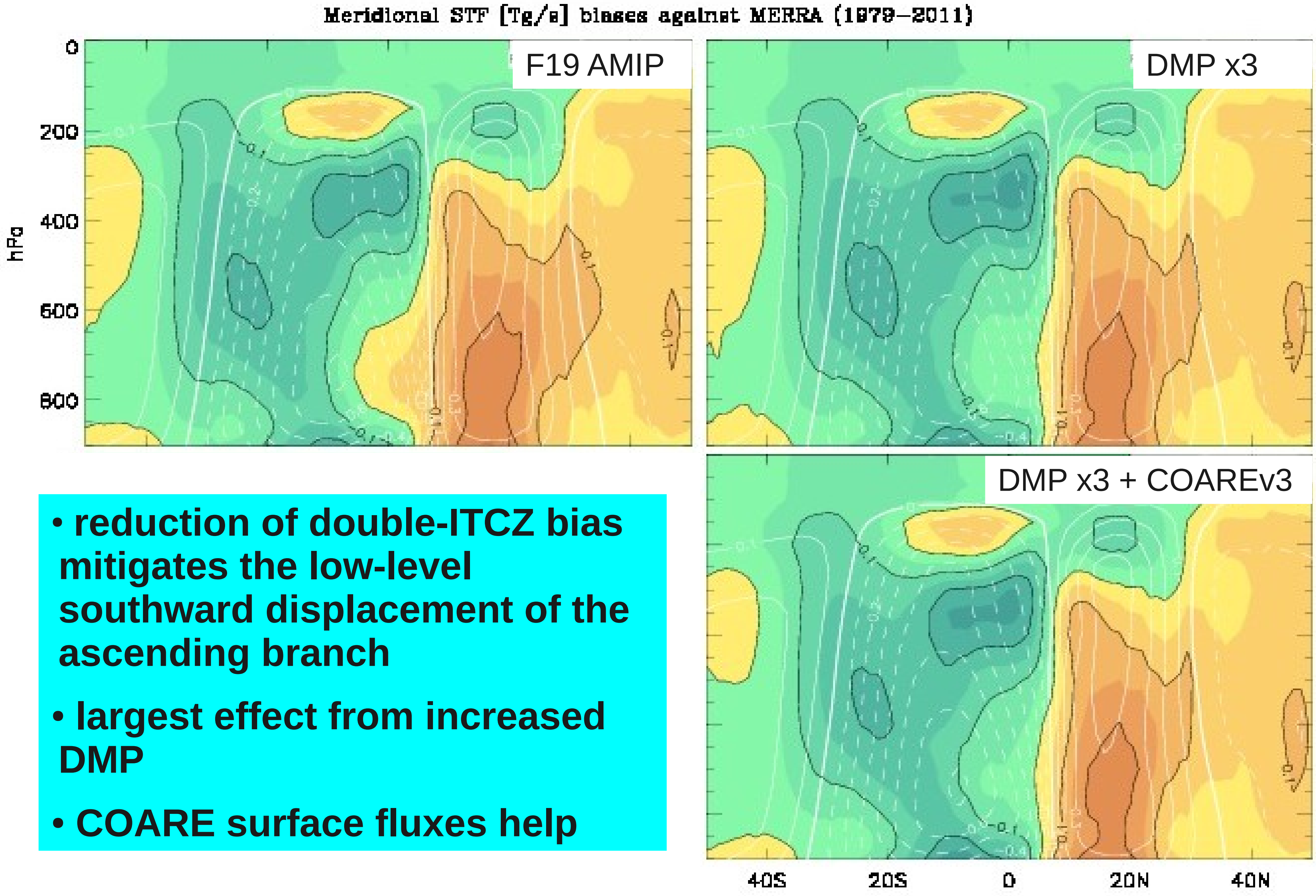
- **Surface flux computation over ocean according to (simplified) COARE v3.0 algorithm (Fairall et al. 2003)**
  - ✓ consistent formulation in terms of parametrised z*
  - ✓ first guess for stability branch, convergence iteration
  - ✓ more commonly used self-similarity functions
  - ✓ less evaporation per stress than Large et al.
    - ➔ Weaker circulation
    - ➔ Better zonal winds
    - ➔ Positive impact on ENSO in F19

- **Increase in Zhang-McFarlane maximum entrainment rate**
  - ✓ deeper cloud, higher heating
  - ✓ more sensitivity to ambient moisture
    - ➔ stronger localisation of ITCZ
    - ➔ better upper-tropospheric temperatures and TOA LW

Zonal-mean precipitation biases CAM4 F19 AMIP tests

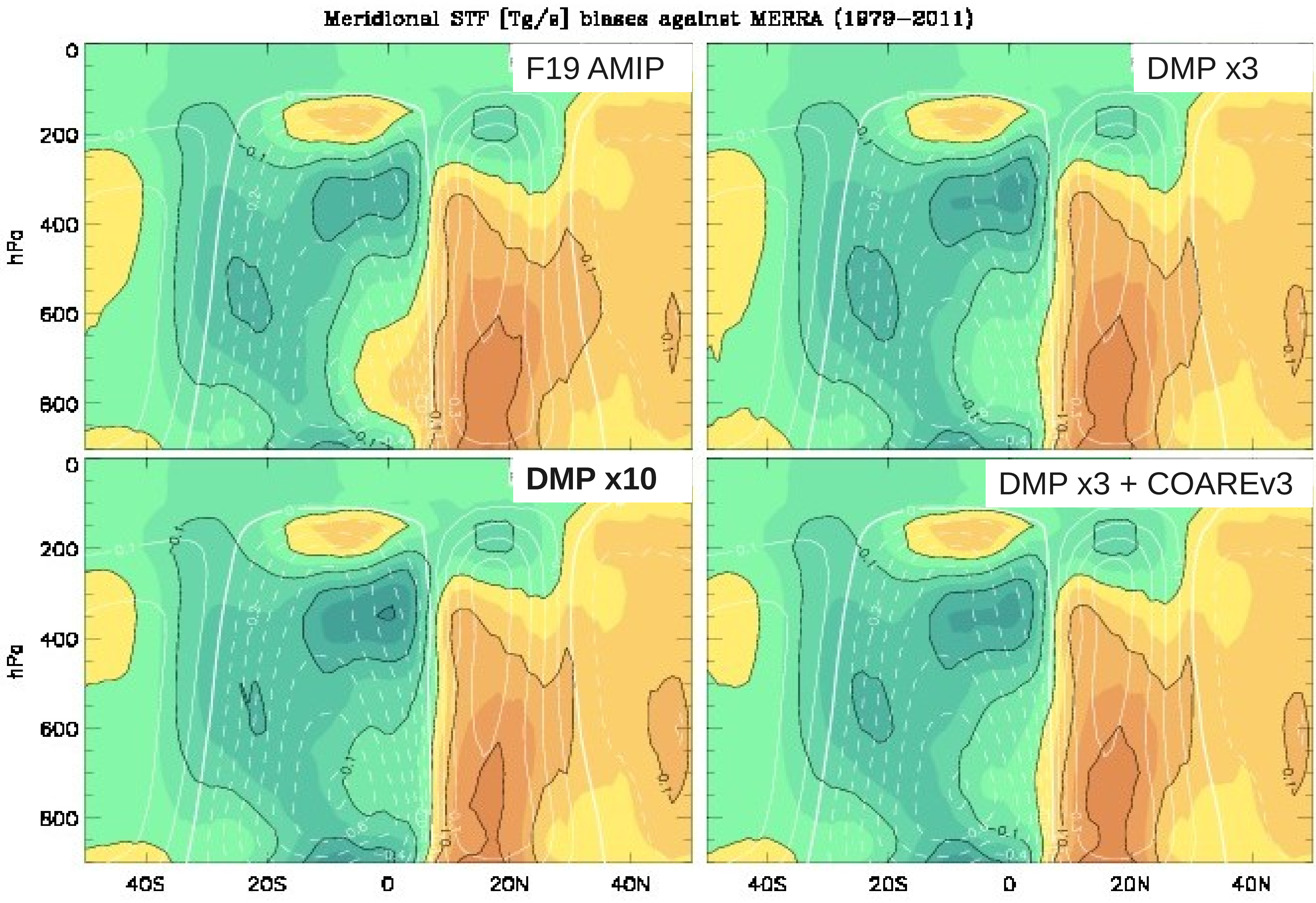


Hadley circulation biases in CAM4 F19 AMIP tests



- **reduction of double-ITCZ bias mitigates the low-level southward displacement of the ascending branch**
- **largest effect from increased DMP**
- **COARE surface fluxes help**

Hadley circulation biases in CAM4 F19 AMIP tests



NorESM integrations in s2d hindcast mode (NorCPM)

- **Coupled data assimilation using ensemble Kalman filter technique**
- **Currently SST anomalies only, + model covariances, window of several month (Counillon et al, 2014)**
- **Studying ways of assimilating full fields**
- **Wind nudging to be included**
- **1979-2005 suite of seasonal hindcasts (EPOCASA)**

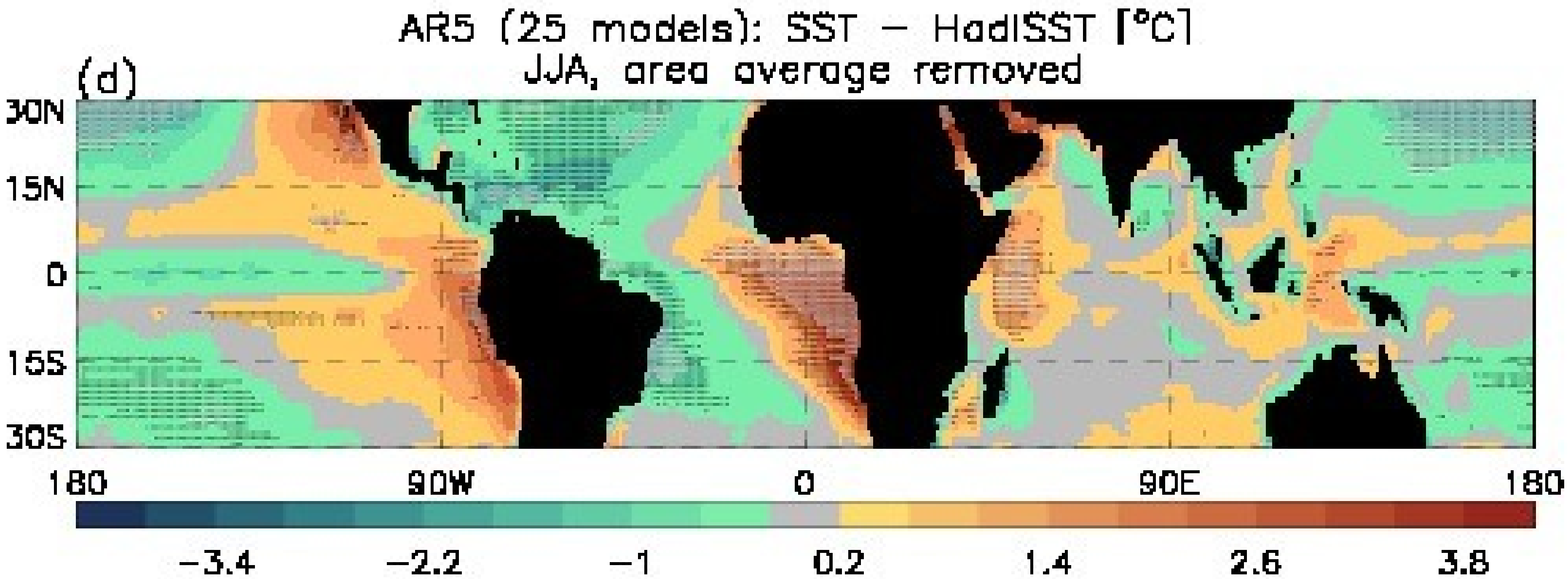
➔ **Will allow study of *origin* of model biases and implications for the simulated variability & sensitivity (PREFACE)**

➔ **Will inform model confidence for historical and projected change and variability**

Persistent model errors

Summer (JJA) Sea Surface temperature bias pattern in CMIP5 ensemble

White stipples indicate model biases that are consistent across all CMIPx models



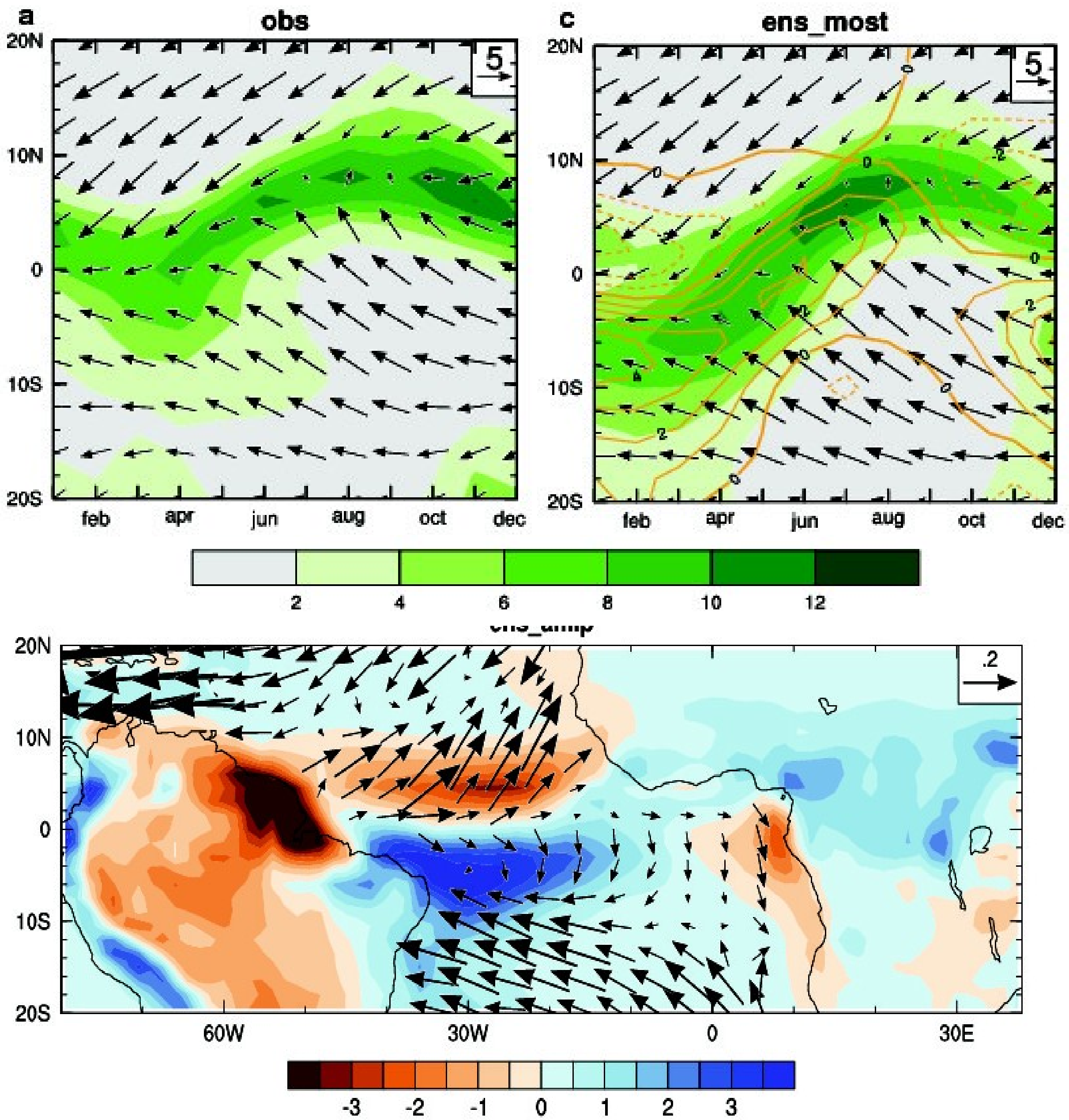
Toniazzo and Woolnough, 2013

Are *all* GCMs *warm* in the SE tropical Atlantic? Why?

Does this have an impact on model predictions?

Seasonal dependence of mean-state biases

Model mean-state and seasonal-cycle biases related to the large-scale distribution of convective precipitation



Richter et al. 2012

Scientific objectives of PREFACE CT3
(area of focus: tropical Atlantic sector)

1. Determine the mechanisms by which GFD model simulations develop systematic biases compared with the observed climatology of the tropical Atlantic via
   a) analysis (coordinated diagnostics) ← SPECS
   b) sensitivity tests (coordinated experiments, 2 sets)

2. Establish the relationship between model systematic biases and simulated variability, including teleconnections

3. Address mechanisms in 1. towards reducing relevant systematic biases, via targeted fluxcorrections and/or changes in model configurations and parametrisations

4. Inform on optimal techniques or strategies towards climate predictions and projections of greater reliability

Envisaged scientific objectives and open questions

I. identify of role stratospheric processes and interactions for s2d variability and climate sensitivity

- ➔ affordable high-top (WA)CAM4/5 configuration ?
- ➔ seamless link to chemistry-climate model ?

II. study the impact of increased resolution

- ➔ cost-effective higher-resolution with CAM4 physics ?
- ➔ vertical grid ??

III. isolate mechanisms responsible for internal variability & their dependence on model formulation and configuration

- ➔ Idealised configurations (AP, mixed-layer) of NorESM/CESM