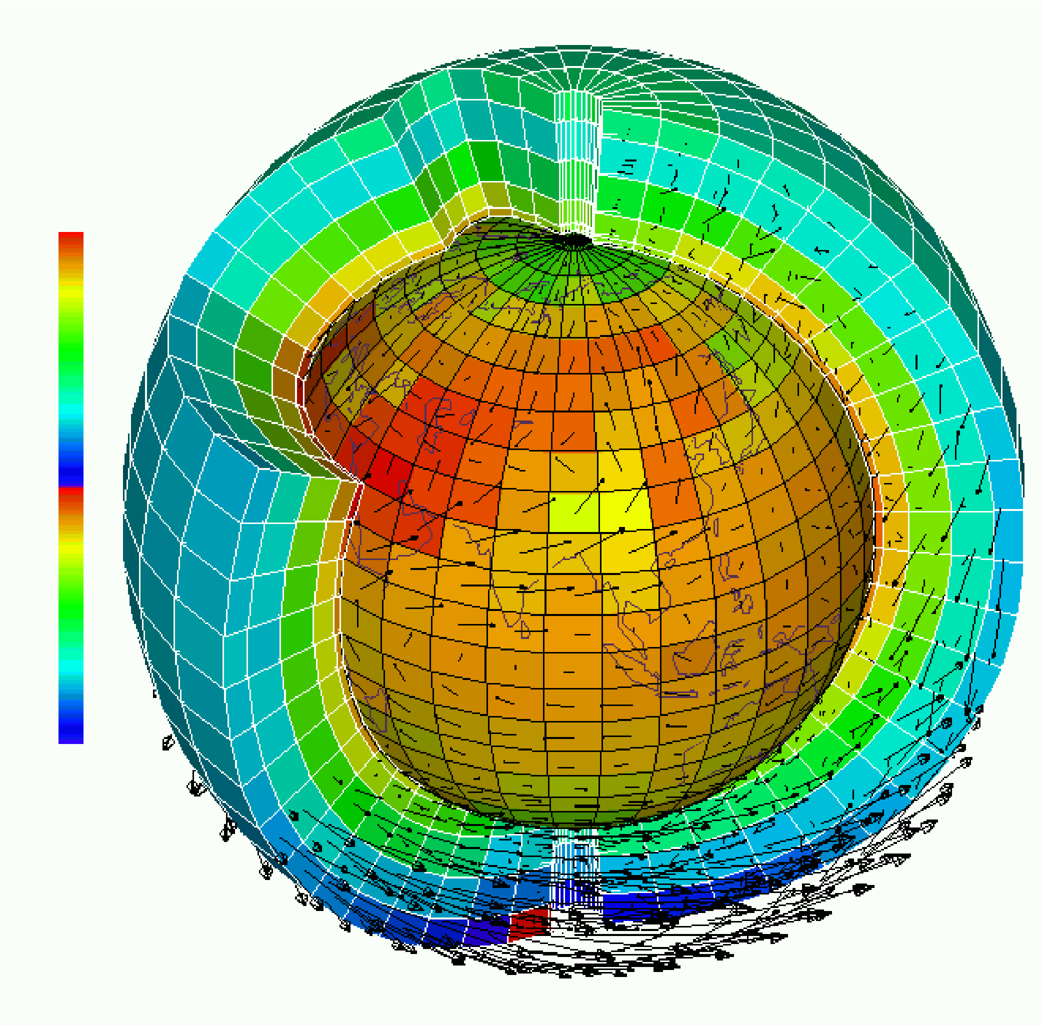
Working Group on Coupled Models (WGCM)
&
the WCRP Modelling Advisory Council (WMAC)



Sandrine Bony & Jerry Meehl
WGCM co-chairs

Beijing, July 2012

WCRP
World Climate Research Programme

Outline :

- WGCM missions
- CMIP5 : overview, first lessons, implications for WCRP
- How may the WMAC help address key challenges ?

  How may WGCM activities contribute to these efforts?

WGCM Missions

- Review and foster the development of coupled climate models (and now ESMs)
- Coordinate model experiments and inter-comparisons
  (in collaboration with many WCRP/IGBP partners) to:

    - better understand natural climate variability and predictability
      on decadal to centennial time scales

    - predict and understand the past and future climate response
      to natural & anthropogenic perturbations

- Promote and facilitate model evaluation using observations
  and diagnosis of shortcomings

Promote a balance between :

Prediction, Evaluation & Understanding

WCRP Coupled Model Intercomparison Project - Phase 5 - CMIP5 -

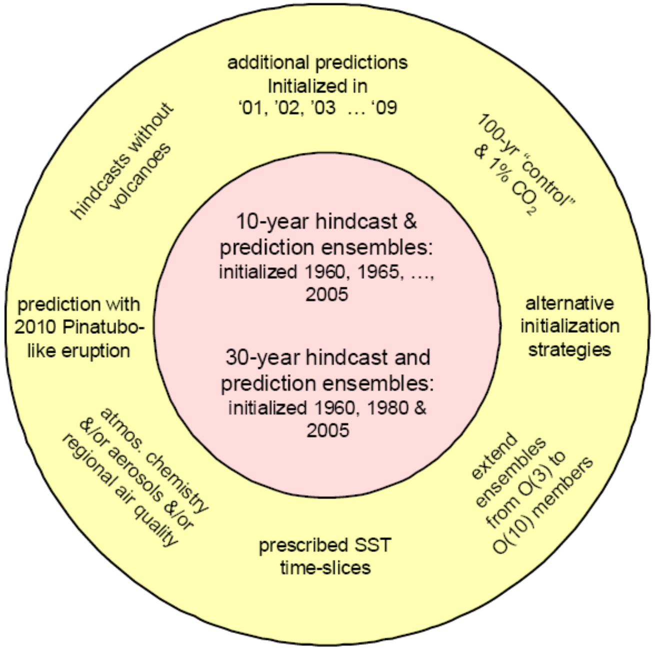
Paleoclimate Modelling PMIP3 Intercomparison Project

CFMIP

Cloud Feedback Model Intercomparison Project

CMIP5 is organized around several sets of simulations

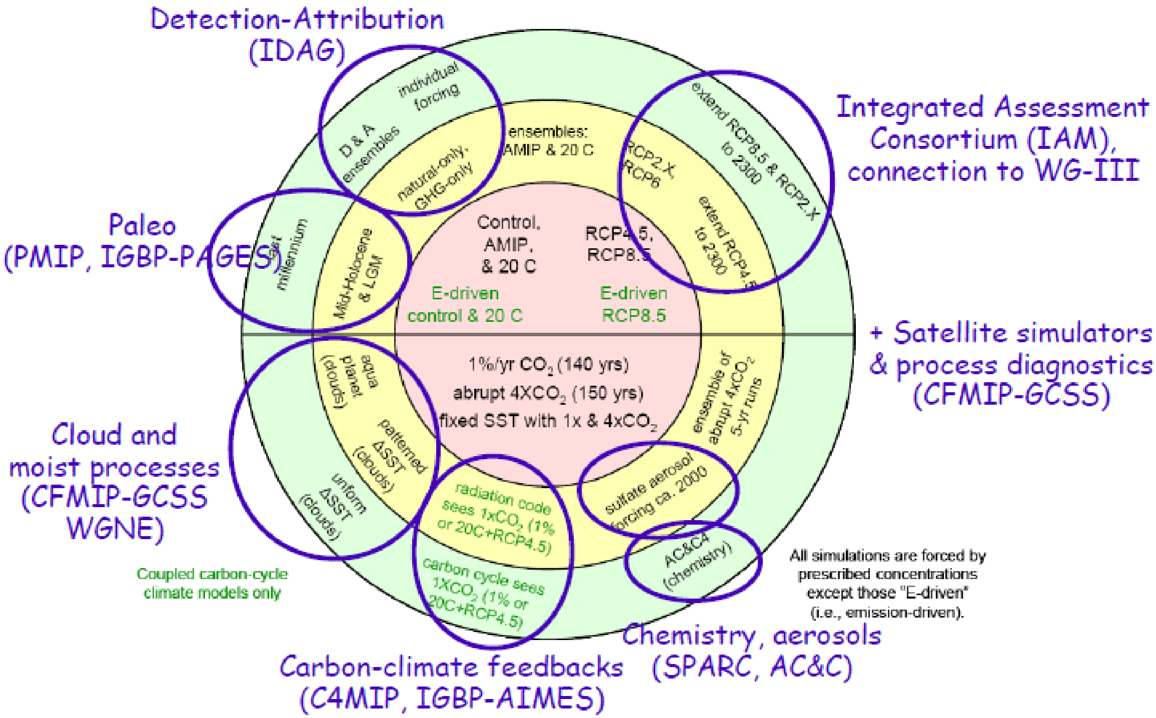
"Near-Term" Experiments
(decadal, up to 2035)



Designed and overseen by the WGCM-WGSIP Decadal Climate Prediction Panel

Up to 26 models (currently)
Mean Resol: 1.3 deg (atm); 0.8 deg (ocean)

"Long-Term" Experiments
(century & longer)



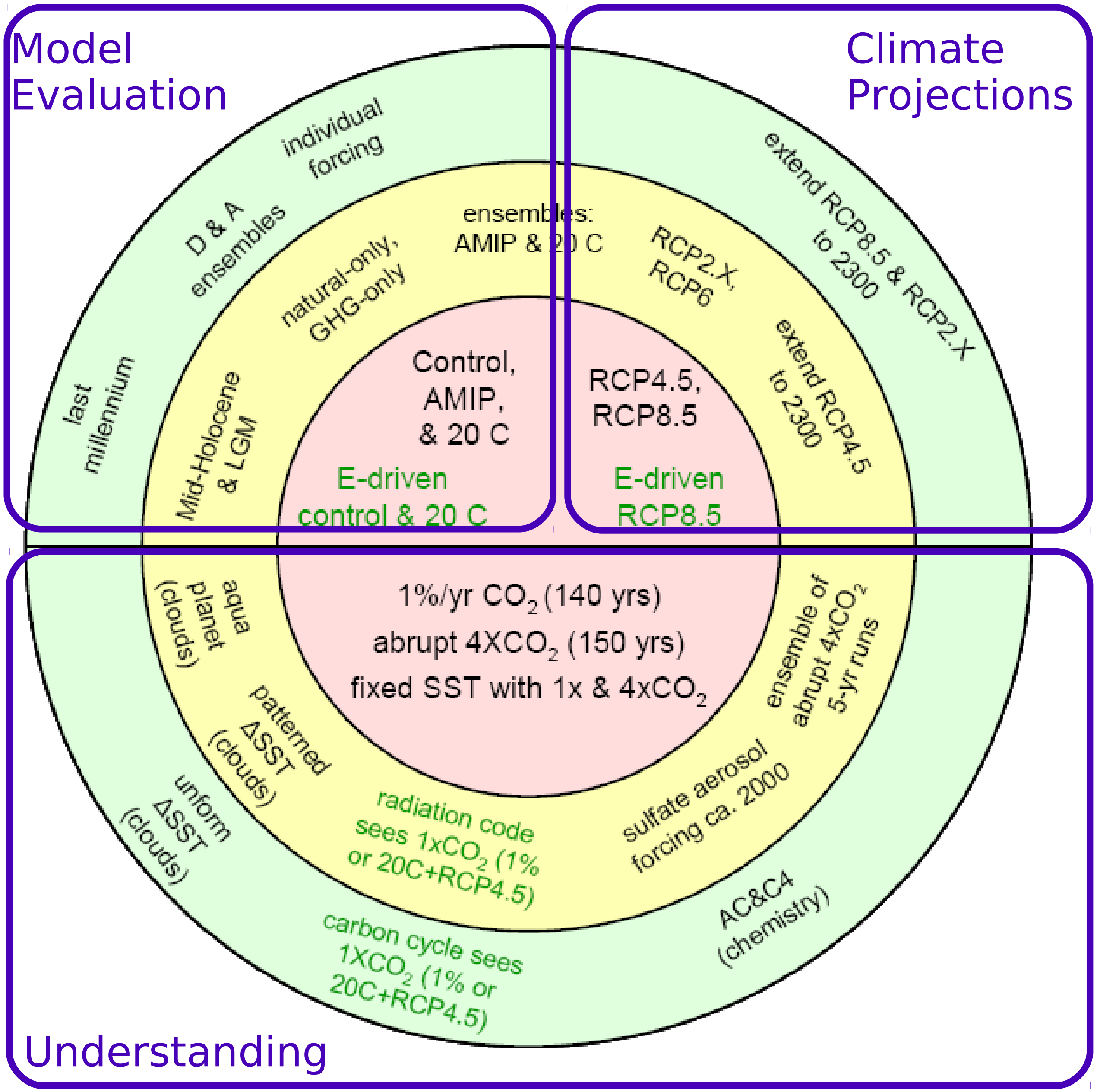
Designed in collaboration with many WCRP/IGBP partners

Up to 42 models (currently)
Mean Resol: 2.1 deg (atm) ; 0.9 deg (ocean)
+ a few high-resol global models (0.2-0.6 deg)

WGCM missions translated into action ...

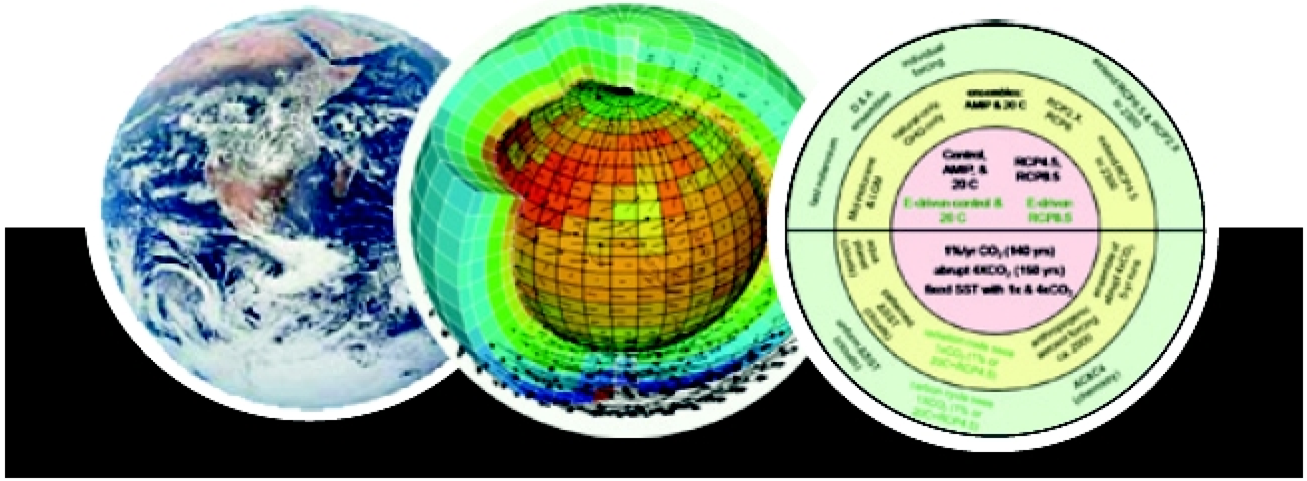
- Satellite simulator
- Process outputs
- Paleoclimates

- Several scenarios
- ESMs
- High-resol time slices



- Idealized expts
- Range of config (OAGCM, AGCM, Aqua-planet)
- New generation of climate models (ESMs, SP-GCM, GCRM)

WCRP Coupled Model Intercomparison Project - Phase 5
- CMIP5 -



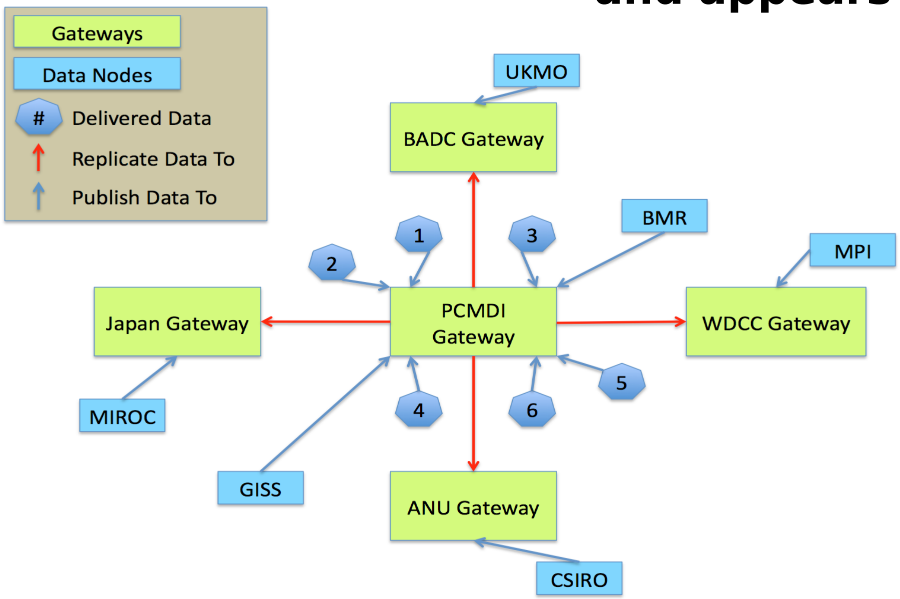
CLIVAR Exchanges, CMIP5 special issue (May 2011)

- The largest and most ambitious model inter-comparison ever organized
  (26 modeling centers, 53 models, many experiments & outputs)

- First lessons and implications for WCRP ?

Governance of the Earth System Grid Federation (ESGF)

CMIP5 model output is served by federated centers around the world and appears to be a single archive :



- Distributed archival and storage capability widely viewed as the future of accessing both model and observed data for a wide variety of applications in climate science

- PCMDI + other partners (BADC, DKRZ, NCAR, etc)

- **Governance structure of the ESGF needs to be improved** (e.g. decision-making framework or procedure accepted by the various ESGF institutions, interface with both our community and other communities)

→ **Role of WCRP in organizing it ? A new ESGF Working Group in WCRP ?**

CMIP5 Model Analysis Workshop

(IPRC, Hawaii, March 5-9 2012)

175 participants (230 abstracts submitted)

CMIP5 Model Analysis Workshop

(IPRC, Hawaii, March 5-9 2012)

First impressions from organizing committee (G. Meehl, S. Bony, K. Taylor)

• In spite of some delays in model availability and challenges in downloading model data, analyses so far usually could include between 15 and 22 AOGCMs, 4 to 8 decadal prediction simulation sets, about 6 high-top models, and 3 to 8 ESMs included in analyses, and there is **considerable interest and excitement in analyzing model data to learn new things** about the climate system.

• The concern that the spread of future projections from the new generation of AOGCMs with more complexity, or from ESMs with coupled carbon cycle, would be wildly greater than from the AOGCMs of CMIP3 appears to have been unfounded —**spread of projections in CMIP5 AOGCMs comparable to CMIP3**, and most first generation ESMs are well-behaved and produce **comparable first order results to AOGCMs**.

• However, CMIP5 offers the opportunity :
  - to study climate change with **many additional capabilities** (carbon and chemistry, short-term climate change, comparison paleo/future, forcings and feedbacks diagnostics, high-resolution, high-frequency outputs, etc)
  - to **better understand the spread and better assess the robustness** of model results and thus our confidence in model results.

• Regarding model performance :
  - **Some quantities show considerable improvement** (e.g. rate of sea ice loss in Arctic) or a decrease in model spread (e.g. AMOC, Nino3 standard deviation)
  - **Others have not significantly improved** (e.g. double ITCZ, Arctic clouds and atmospheric circulation, Antarctic sea ice loss, southern ocean too warm, SPCZ too zonal, humidity in subtropical descent regimes too high)

Synthesis of CMIP5 results

- Hundreds (thousands?) of papers will be based on CMIP5 model output analysis
- **Growing need for community reviews and syntheses of CMIP5 analysis results**

→ An opportunity for WCRP

  - to sollicit a series of review papers from its core panels, WG, expert communities
  - to make its activities highly visible..and more digestable by other communities
  - to facilitate IPCC assessments (ARs are not review papers..)

→ How to organize this activity in practice ?

Functions of the WCRP Modelling Advisory Council

(cf Report from the WCRP Modelling Coordination Meeting)

- Promote the confrontation of models with observations and results of process studies
- Promote application of models to problems of societal relevance, quantifying uncertainties and ensuring they are well communicated and understood.
- Promote model development
- Promote collaboration amongst various climate modeling communities (involved in every other item)

→ ideas & suggestions based on experience
and opportunities offered by WGCM activities

How to promote the confrontation of models with observations and results of process studies ?

1. Obs4MIPs

→ organize governance at the WCRP level, extend the project to in-situ obs, maintain close collab with MIPS

2. Promote the development and use of satellite simulators

- already used in many climate models + a few NWP models (ECMWF, MetOffice..) + CRMs (SPCAM, NICAM)

→ promote its use within WGNE (NWP), CLIC (polar regions), GASS (CRM/LES), WGRC (regional models)

3. Exploit CMIP5/CFMIP model outputs on stations and associated observations

→ communication with GASS, CLIVAR panels, WGNE (NWP)

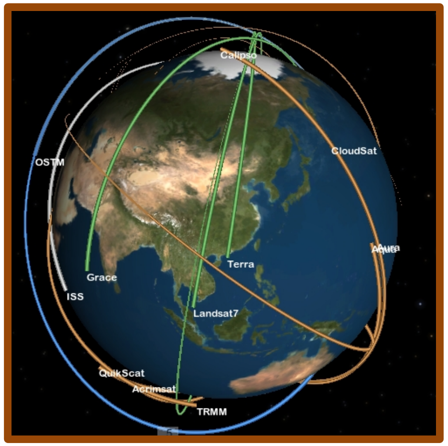
4. Encourage proxy modeling (e.g. water stable isotopes)

- to provide new ways of evaluating models (convection, TTL, sfc-atmosphere interactions, etc) + new obs

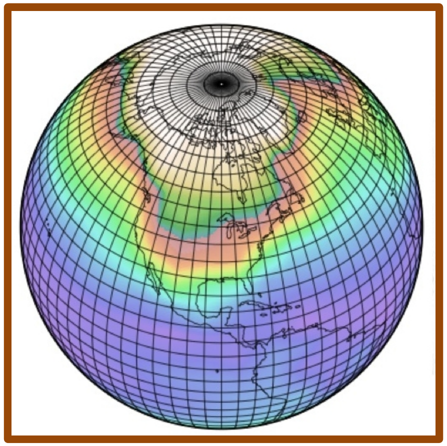
→ promote proxy modeling and its integration into MIPs? (ex: GEWEX isotopic modelling into PMIP & CMIP)

obs4MIPs: An Overview and Update

Duane Waliser et al. (NASA JPL)



Obs4MIPs



Obs4MIPs is a pilot effort to improve the connection between data experts and scientists involved in climate model evaluation. It is closely aligned with CMIP5, with encouragement from the WGCM and WGNE. NASA and the U.S. DOE have initiated the project with significant contributions of appropriate NASA products. An overarching goal is to enable other data communities to contribute data to Obs4MIPs, <u>but guidance and endorsement of this activity is now needed</u>.

for presentation to the
WCRP Data Advisory Group (WDAC)
Prepared June 2012

Some Basic Tenets of the Initial Activity

1. Use the CMIP5 simulation protocol (Taylor et al. 2009) as guideline for deciding which observations to select.
Initial Target was monthly averaged (OMON, AMON) products on 1 x 1 degree grid

2. Convert (Satellite) Observations to CMIP model output format
CMOR output, NetCDF files, CF Convention Metadata, CMIP standard pressure levels, etc.

Not a new product. Independent QC check before release.

3. Includes a 6-8 page Technical Note describing strengths/weaknesses,

uncertainties, caveats regarding comparisons with models.

(at graduate student level)

4. Host side by side on the ESG with CMIP5

Challenges and Questions

Specific areas that present challenges and questions include:

- What observations go into obs4MIPs? *A fundamental criteria is there has to be a 1-to-1 correspondence with a CMIP model output variable. A second criteria is that the product be well documented with peer-reviewed publications, ideally with examples of use for model evaluation.*

- What to do when there is more than one observation product for a given variable – 1) keep it simple for the user and attempt to choose the "best", 2) select the "best" two to account for some observational uncertainty, 3) select more than two if available but run the risk of the offerings become overly complex for the non-expert. For 1) and 2) – by what criteria is this decided?

- What if the data sets don't quite match e.g. product is total column (ozone) but CMIP only requests the vertically resolved profile?

- What guidelines should there be regarding update frequency and process?

- Who provides quality control over the technical documentation and data set content?

- Thus far technical documents were made one per variable, in some cases it may be advantageous to document more than one in the same technical note, how is this decided?

For more details: see Notes/Action Items from recent NASA obs4MIPs Science Working Group Meeting.

Recommendation

What role could WDAC play for Obs4MIPs?

- General oversight on the advancement of Obs4MIPs

e.g., via annual updates to WDAC, similar to AMIP/CMIP panels established by the WGNE and WGCM to guide climate model intercomparisons.

WDAC establish an Obs4MIPS panel to:

- **Ensure that datasets contributed to Obs4MIPs are appropriate for model evaluation**
- Advance guidelines that are used to recommend, select and document the data
- **Identify the highest priority observations for model diagnostics and evaluation**
- Encourage additional contributions to Obs4MIPs and promote activity

WDAC Obs4MIPs panel membership and organization

- NASA volunteer to chair the group and provide some support for annual meetings, PCMDI volunteers continued support, membership and/or co-chair responsibilities
- **Membership should consist of a mix of observation providers and model experts**
- WDAC/WCRP to recommend members
- **Obs4MIPs to report annually to WDAC and WMAC**

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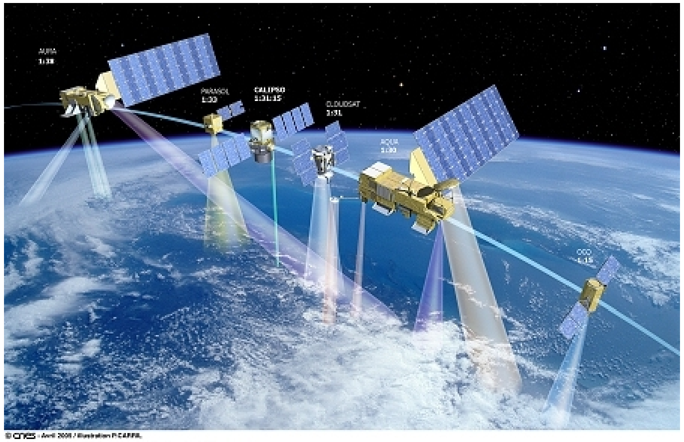
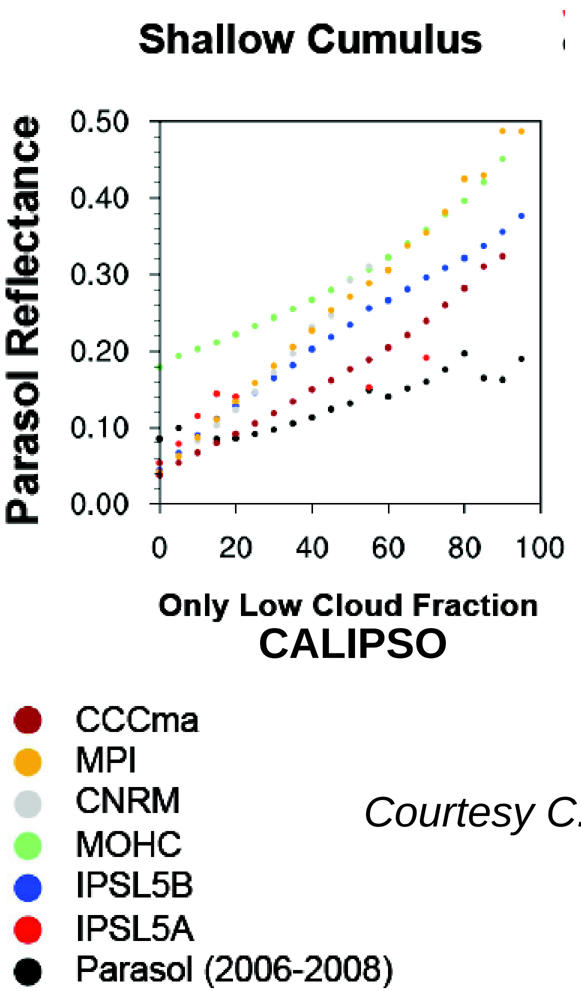
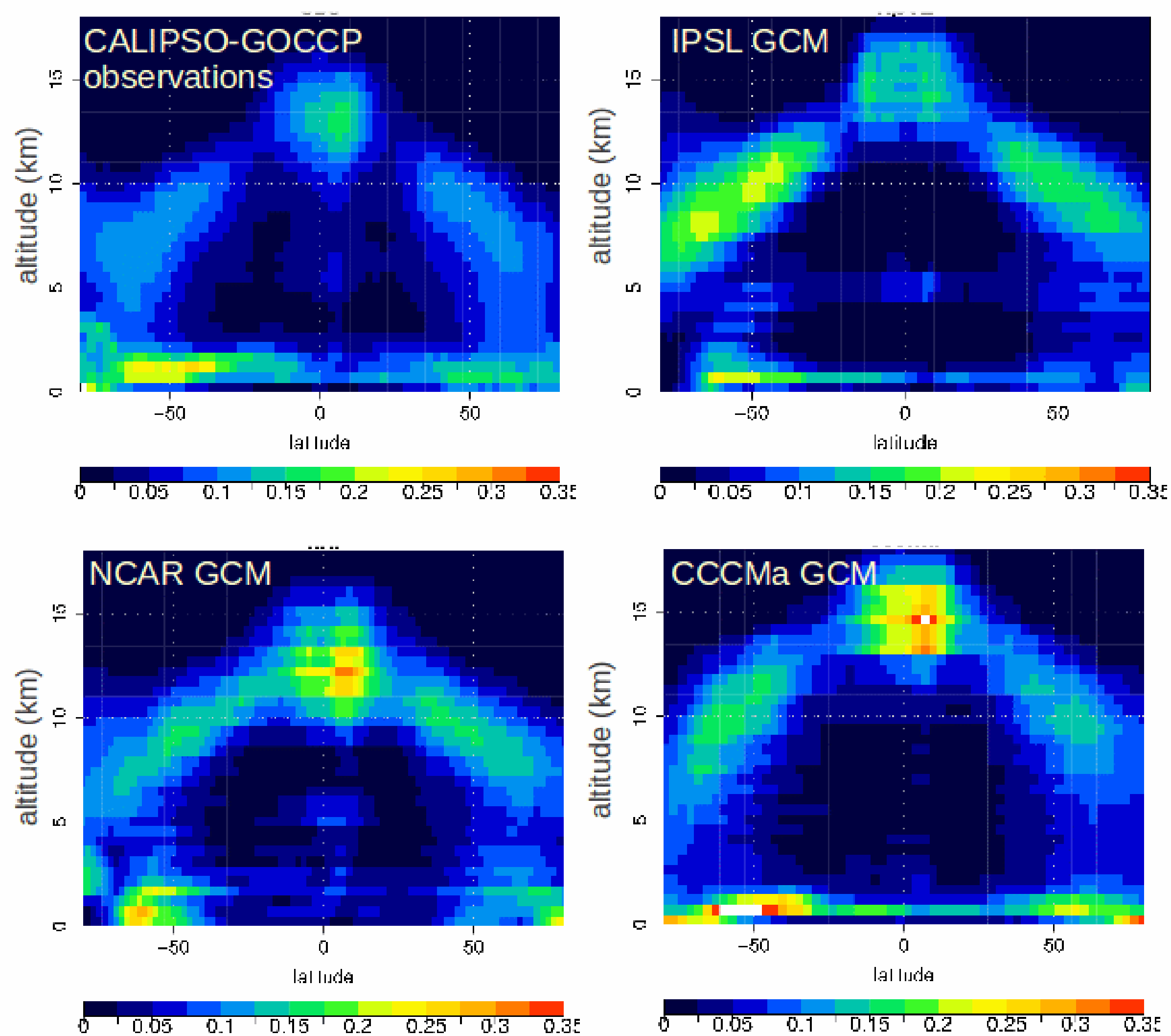


CFMIP / CMIP5

Evaluation of clouds simulated by CMIP5 models using A-Train satellite observations and the CFMIP satellite simulator package (COSP)



Courtesy C. Nam



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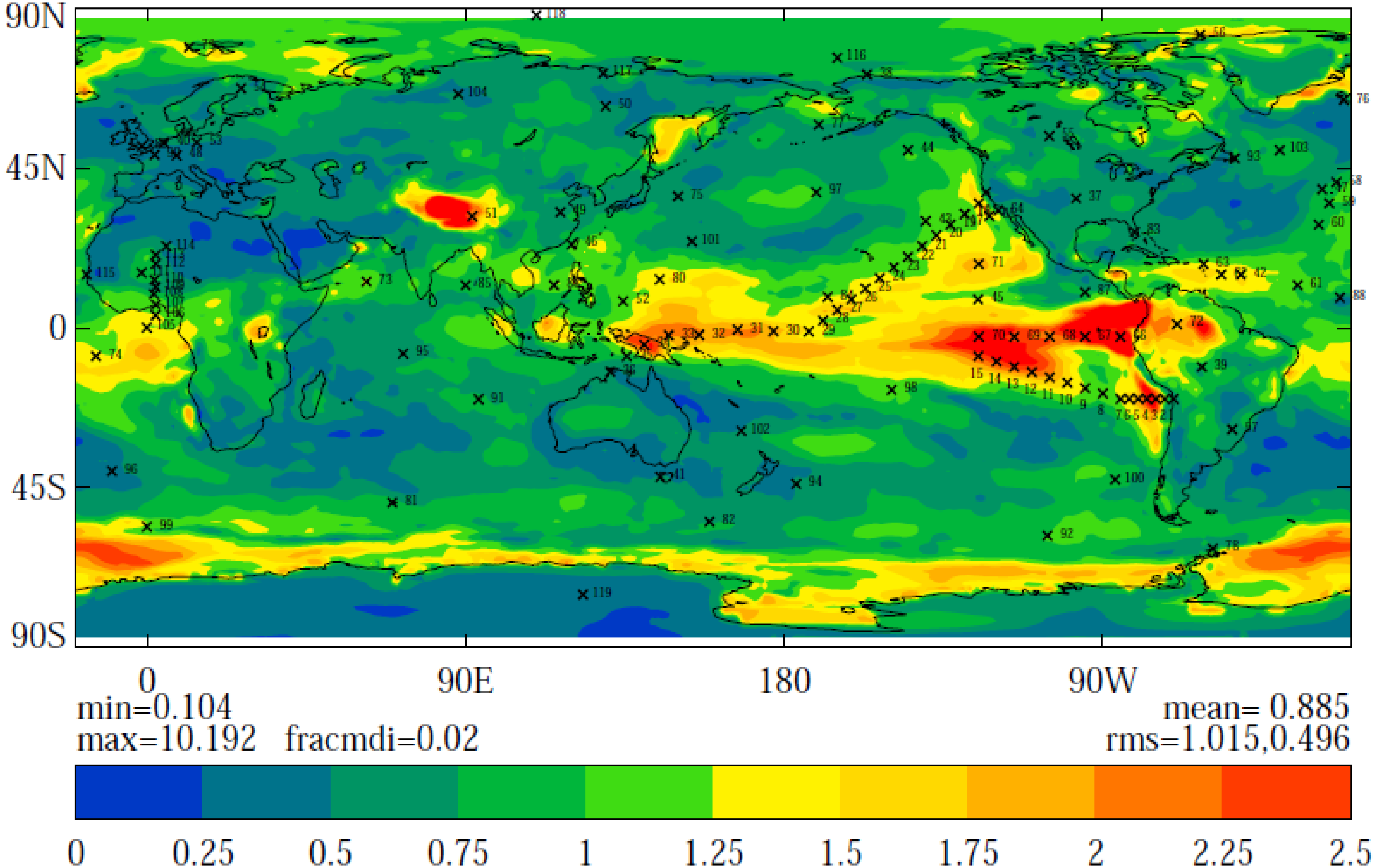
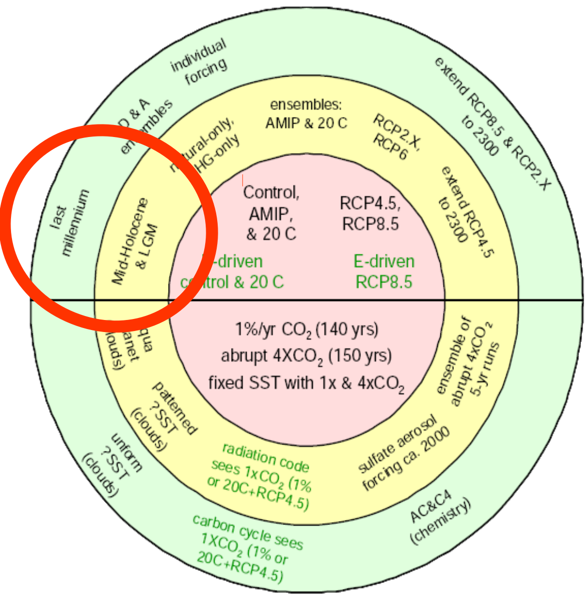
CFMIP/GCSS/CMIP5 model outputs at selected locations
(120 locations, high-frequency, detailed cloud diagnostics)

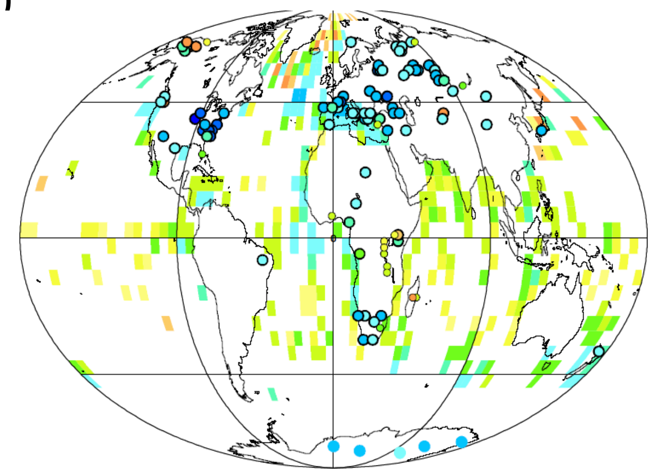


- ARM, CEOP, CloudNet instrumented sites
- GPCI / Tropical West & South East Pacific / AMMA transects
- Field experiments / GCSS case studies
- Locations of large inter-model spread of cloud feedbacks (CMIP3)

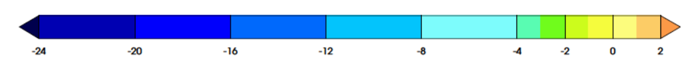
Relationship between Past and Future Climate Changes ? (PMIP)



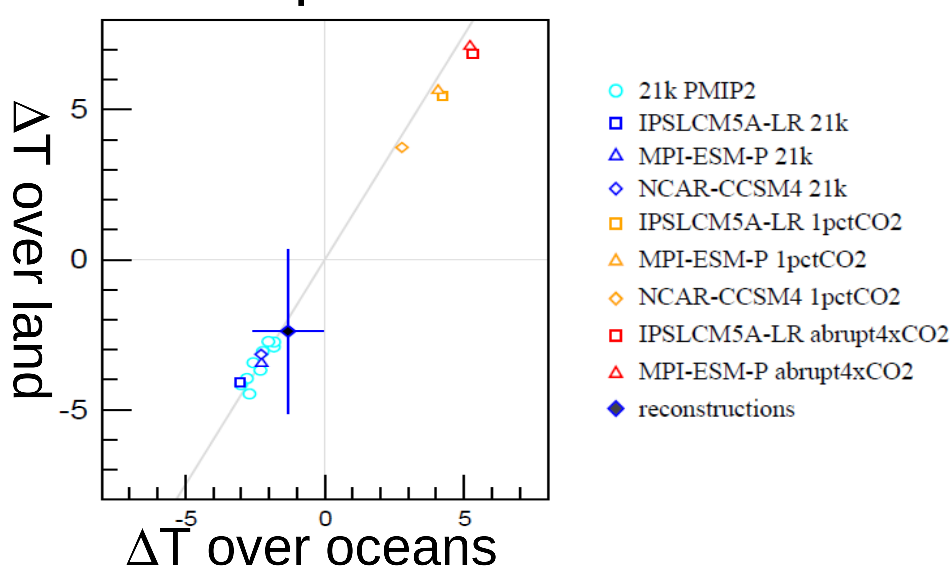
Examples (on-going) :
- Climate sensitivity, tropical SST changes, land-sea constrasts (LGM)
- Carbon-climate feedbacks (LGM)
- ENSO changes (Mid-Holocene)
- High-CO2 climates and high-latitudes warming, link to ice sheets and sea level (Emien, 125-130 ka)



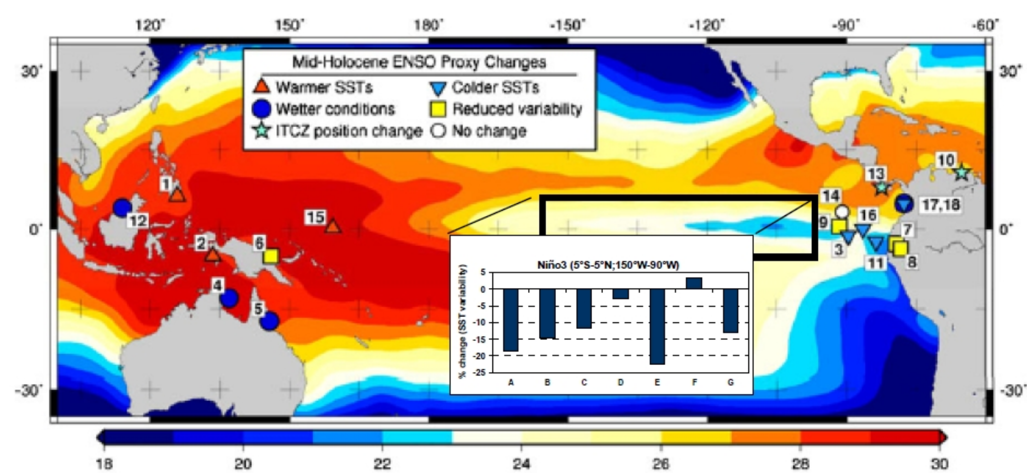
Reconstructions of past climates



Tropics



Courtesy Masa Kageyama



Braconnot et al.(2012), Zheng et al. (2008)

How to promote application of models to problems of societal relevance, quantifying uncertainties and ensuring they are well communicated and understood ?

1. Promote the analysis of the wealth of CMIP5 outputs and experiments

→ do not only quantify uncertainties, also assess robustness

→ physically understand the drivers of societally-important features (ex regional precip changes, extremes)

2. Promote communication between global scale / regional scale modeling

→ encourage CMIP5 / CORDEX comparisons

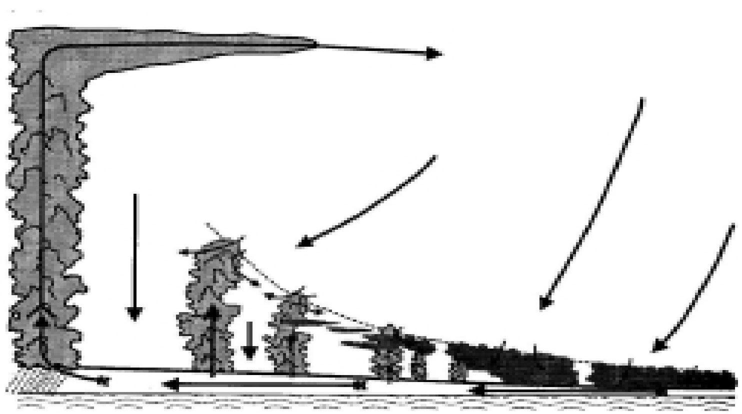
→ communicate about the methodological strengths and limitations of the different downscaling methods

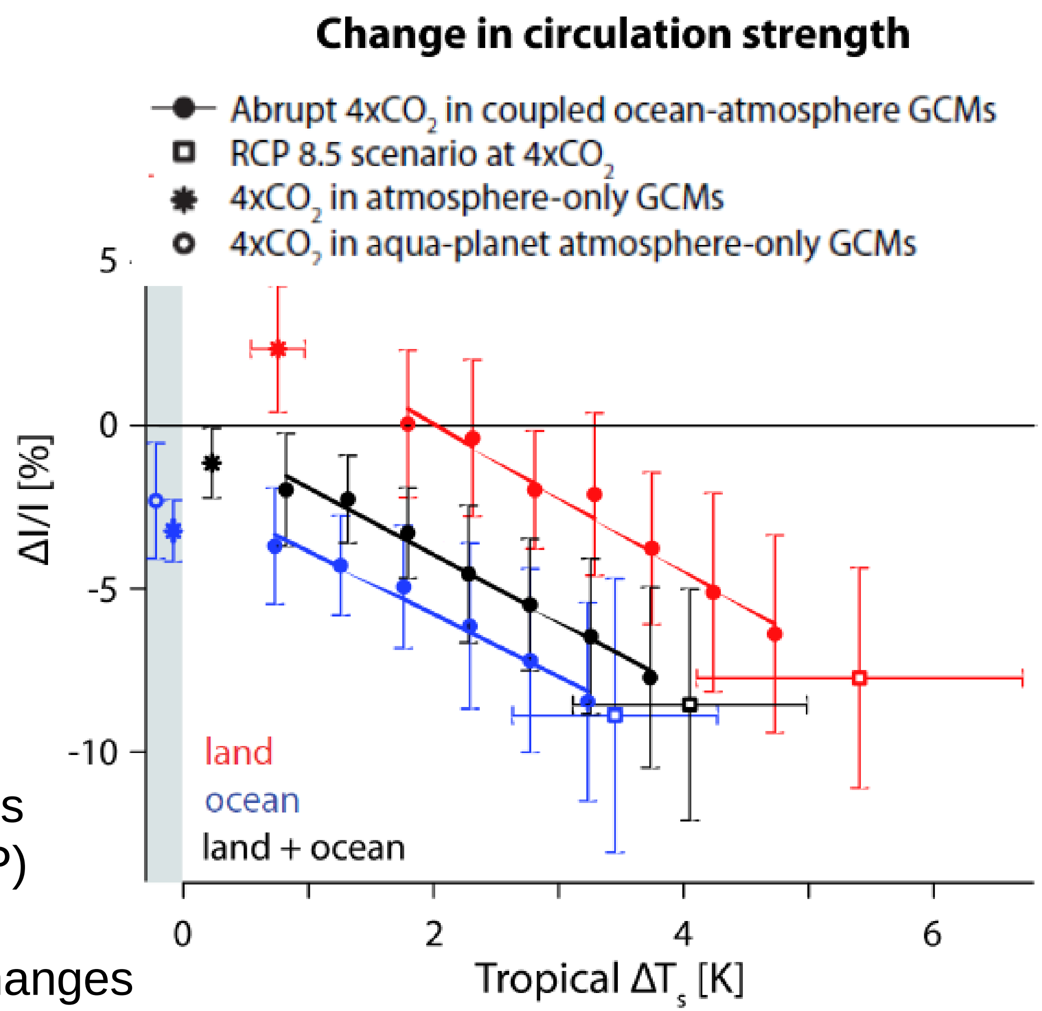
3. Promote interactions among communities

→ interactions among MIPs (e.g. role of physical climate in bio-geochemical feedback uncertainties ?

→interactions climate/NWP on climate issues controled by fast processes (evaluation, climate change)

Response of the tropical overturning circulation to increased CO2 and surface warming





- Direct effect of increased CO2 on the tropical overturning circulation
- Controlled by fast processes
- Robust across models and configurations (OAGCM, AGCM, aqua-planet, 1D, NWP)
- Large impact on regional precipitation changes

Bony et al. (submitted)

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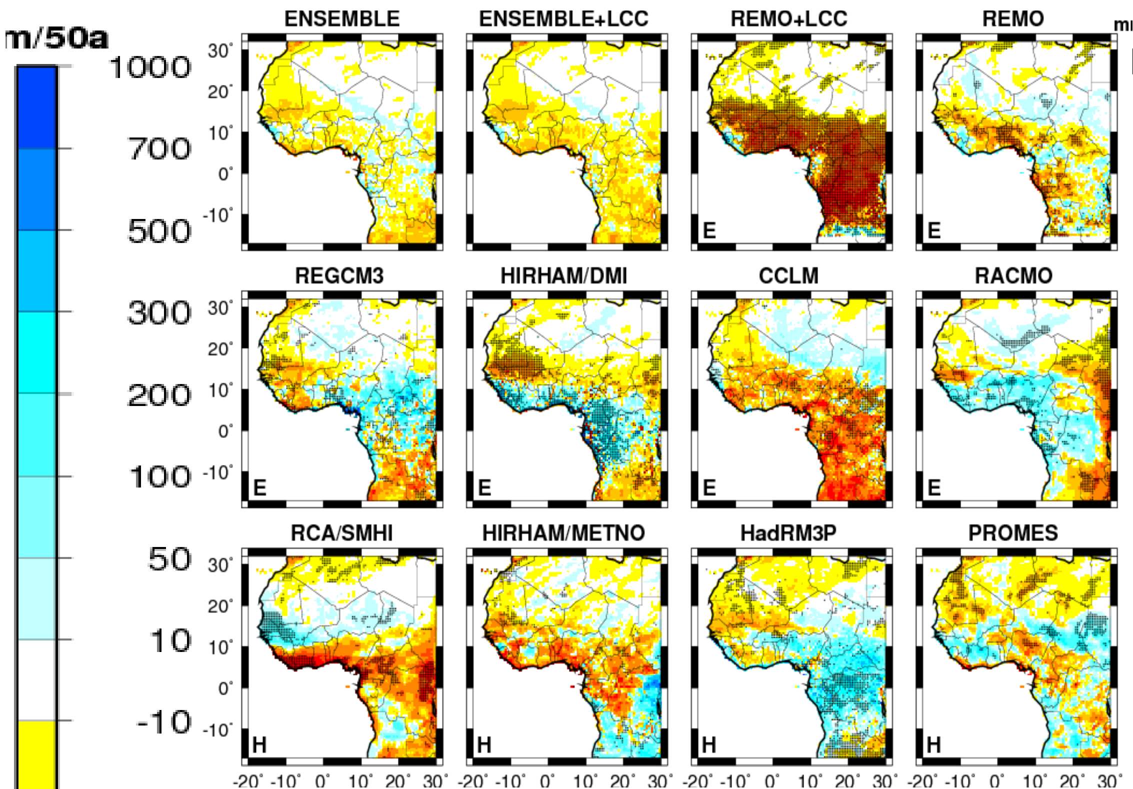
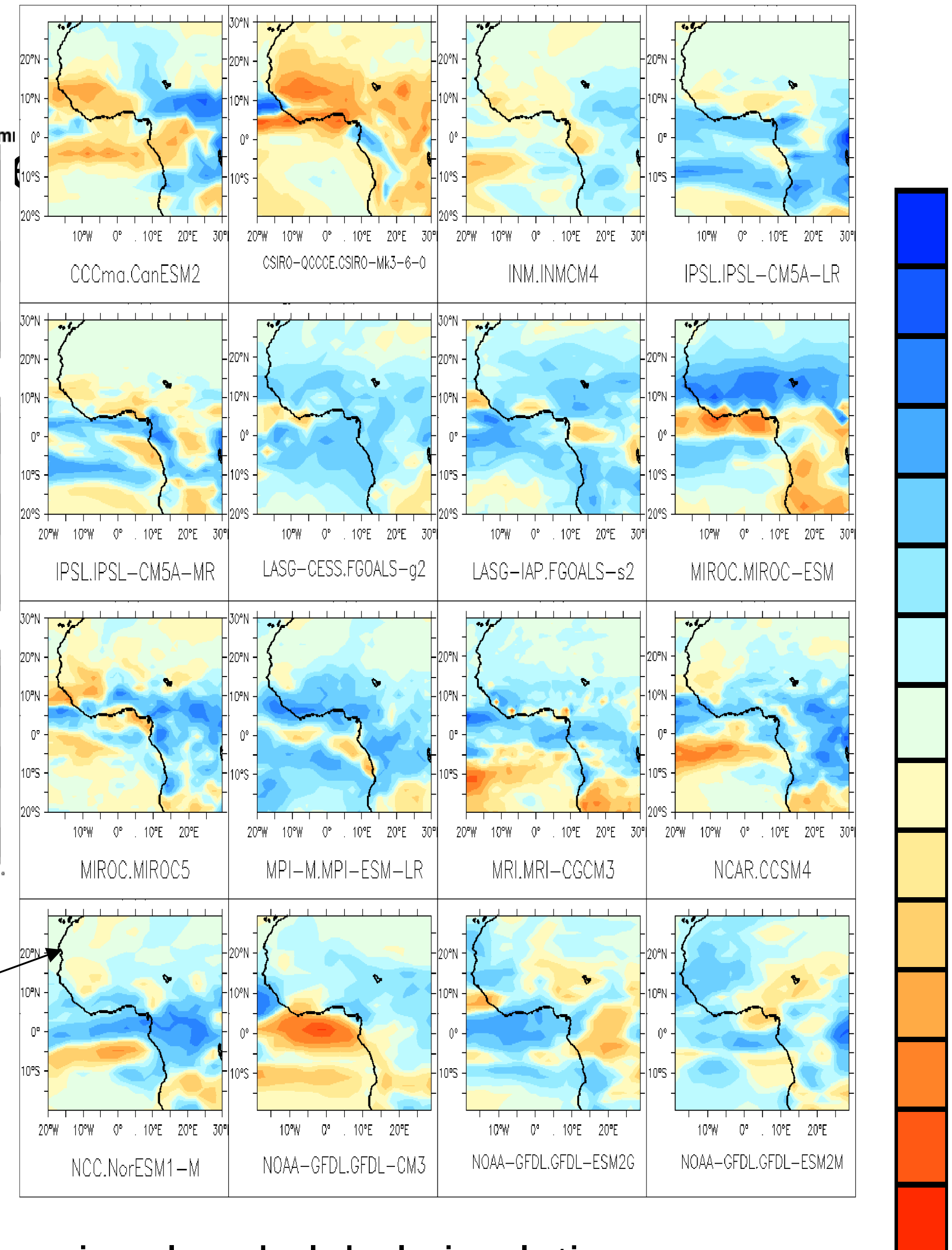
Rainfall projections (trend in mm/50yr)



Regional Ensemble/AMMA simulations (A1B)

Global CMIP5 simulations (RCP 8.5)



- Spread in rainfall projections similar in regional and global simulations
- Mostly in large scale patterns (resolved by both global and regional models)
- Not only due to the large-scale forcing (additional internal feedbaks)

Courtesy F. Hourdin

How to promote model development and improvement ?

Major difficulties or gaps :

- how to convince groups/agencies that making old processes better in a model is at least as important as putting new processes ?
- how may a modeling group benefit from the developments made elsewhere ?
- how do large-scale biases/errors relate to process representations ?

1. Improve communication/exchanges around parameterizations development :

→ depository sites (with documentation of the codes) ?

→ workshop on model errors solved through model development

2. Guide model development :

→ seek feedback from CMIP5 analysts

→ promote approaches that aim at understanding interactions between physics & dynamics (NWP approaches, idealized experiments, CRM/LES simulations on large domains)

3. Facilitate communication and share modeling experience

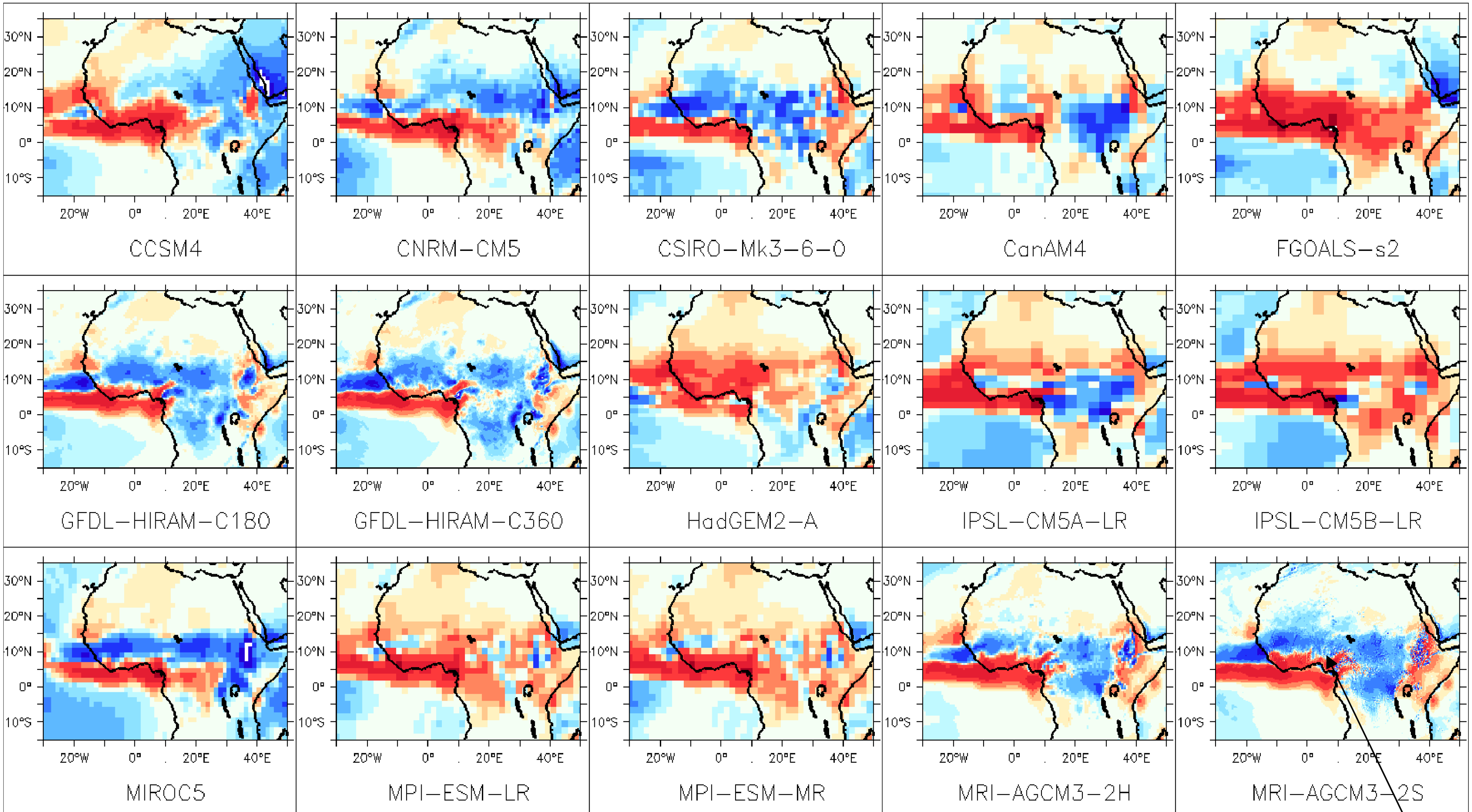
→ organize workshops on topics such as :

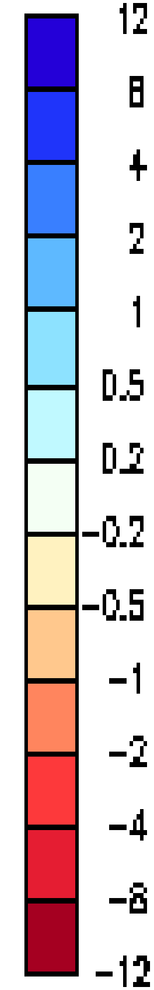
The benefits and limits of higher resolution

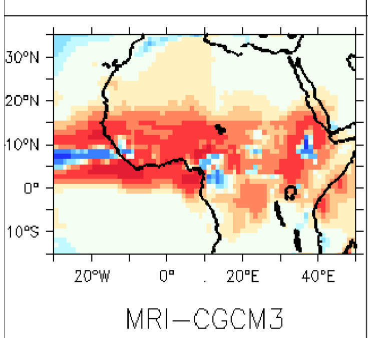
Practice and effects of model tuning

JJAS mean precipitation bias (versus CPC) 1980-1999 (mm/day)

Prescribed (observed) SSTs





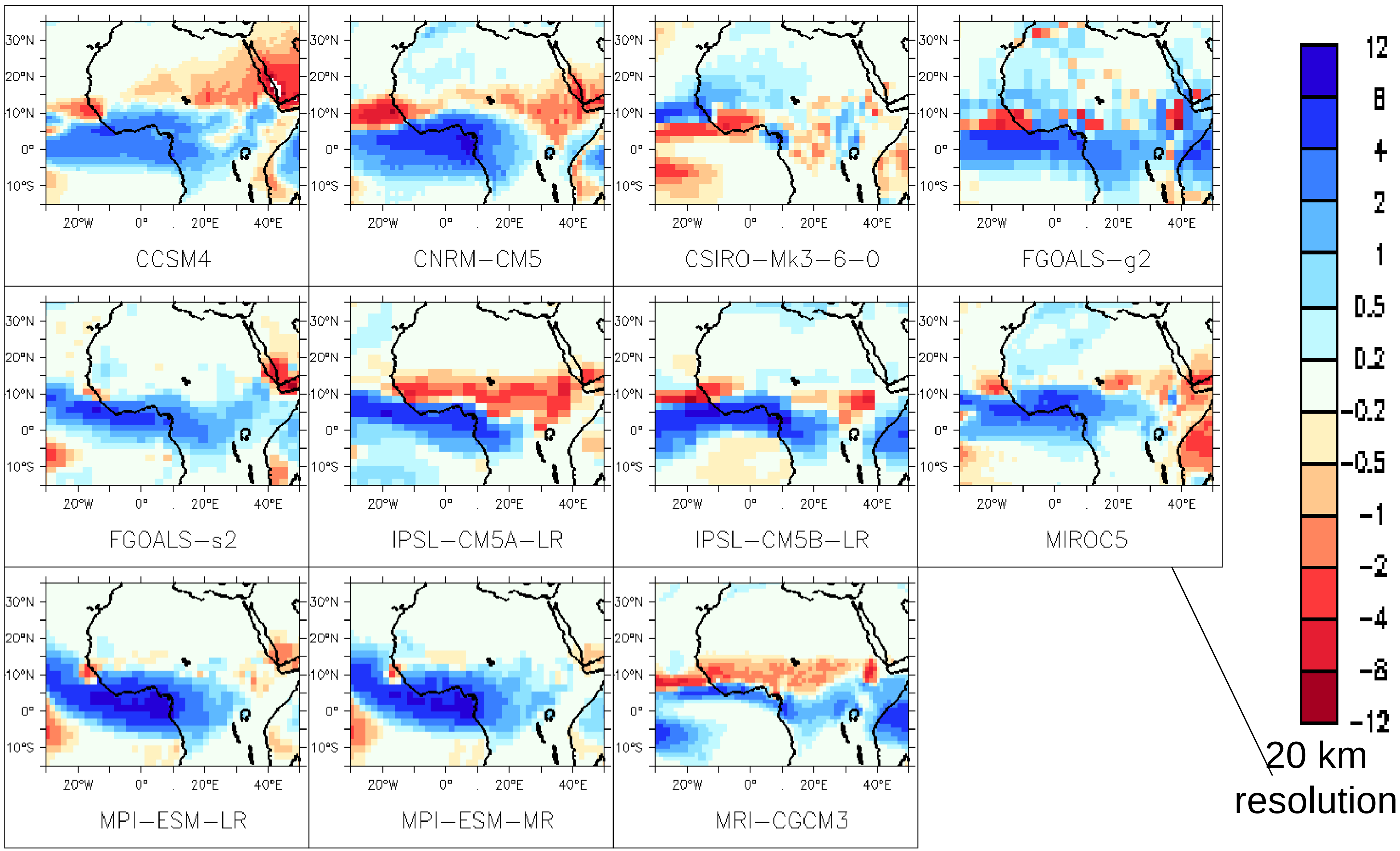


- Larges biases in mean rainfall
- Not systematic
- Not much improvement compared to CMIP3
- No systematic improvement with resolution increase

20 km resolution

Courtesy F. Hourdin

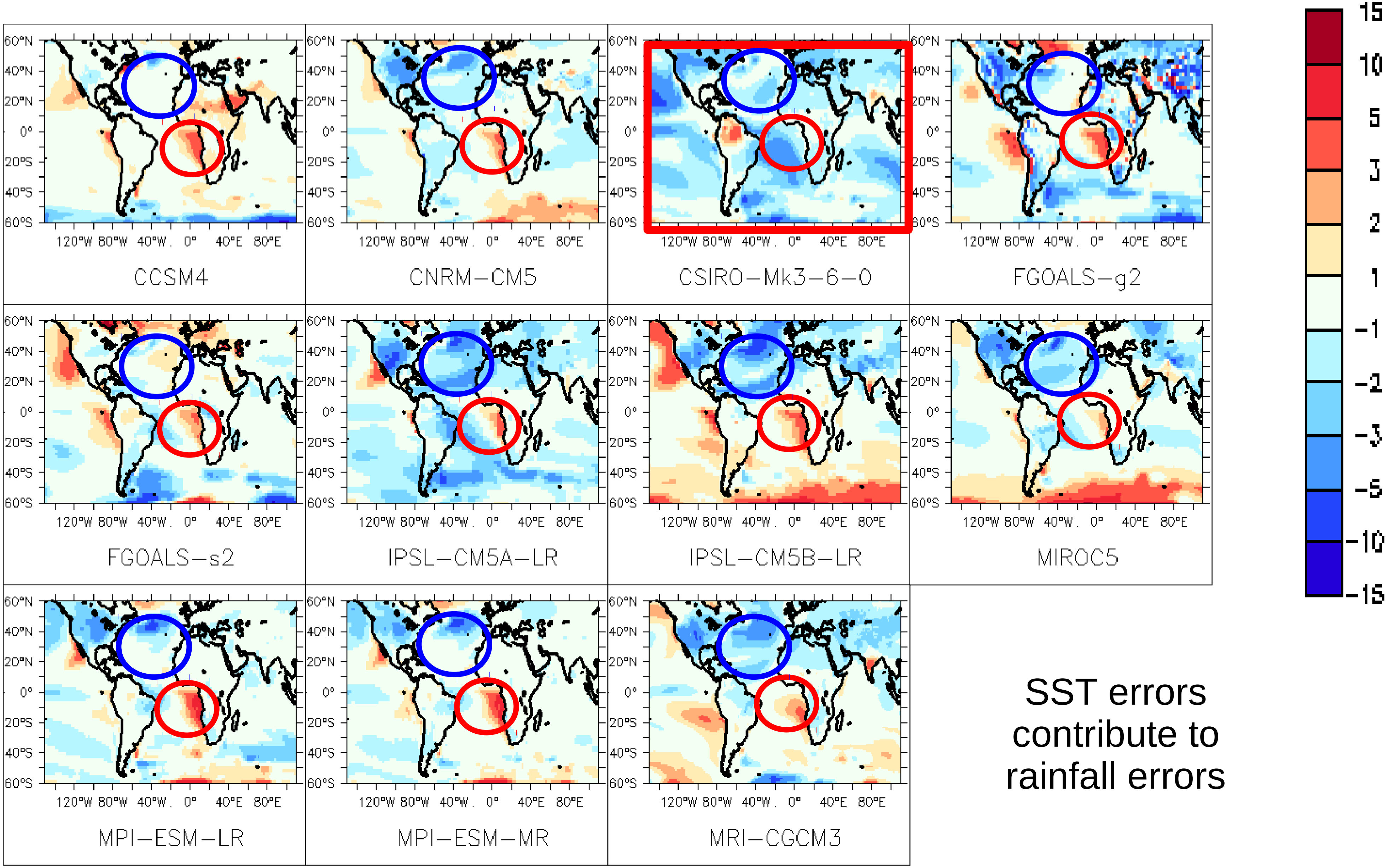
Impact of OA coupling on JJAS precipitation (mm/day)
(difference « historical » CMIP5 OAGCM – «amip» CMIP5 AGCM)



Courtesy F. Hourdin

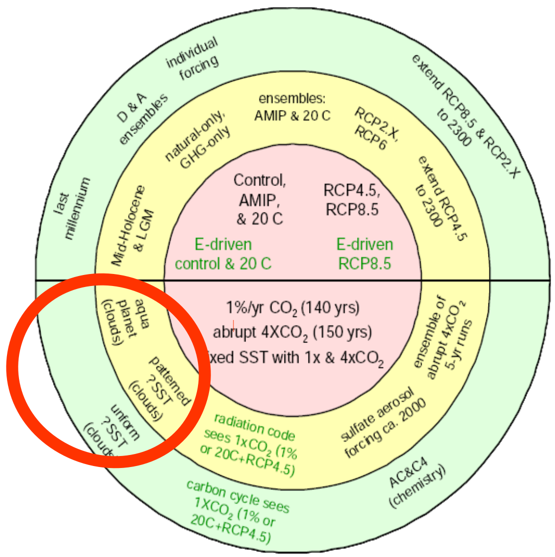
Impact of OA coupling on JJAS surface-air temperature (K)

(difference « historical » OAGCM – «amip» AGCM)



SST errors contribute to rainfall errors

Courtesy F. Hourdin



CMIP5 aqua-planets CTRL, 4xCO2, +4K (AGCMs, GCRM)

Courtesy B. Medeiros