GC#4 Clouds, Circulation & Climate Sensitivity

Lead Coordinators: S Bony & B Stevens

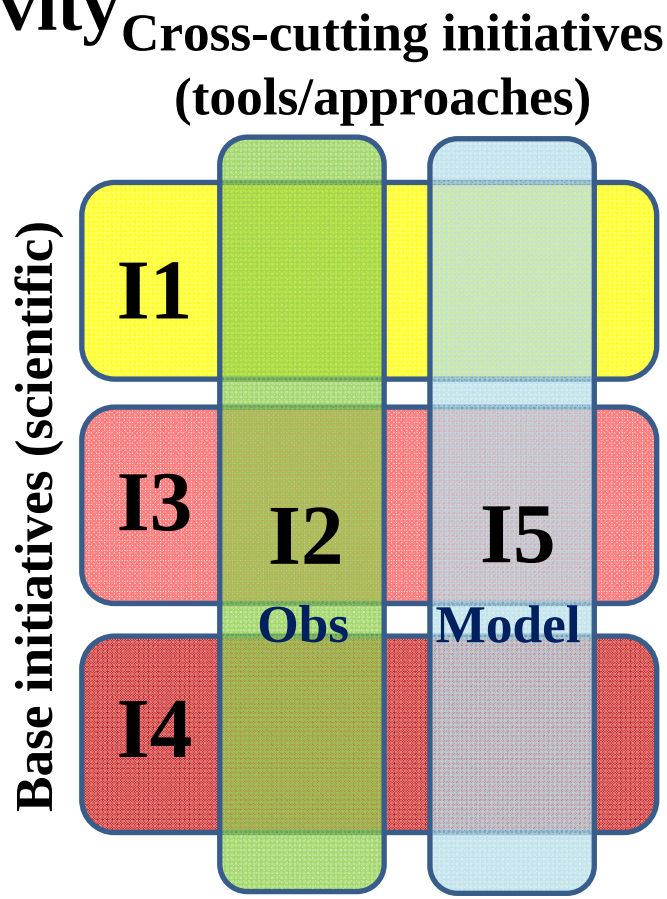
I1: Climate and Hydrological Sensitivity
(S Sherwood & M Webb)

I2: Leveraging the Past Record
(M Kageyama & R Pincus)

I3: Coupling Clouds to Circulations
(P Siebesma & TBD)

I4: Changing Patterns
(T Shepherd & A Sobel)

I5: Towards More Reliable Models
(C Jacob & M Watanabe)



GC#4 Clouds, Circulation & Climate Sensitivity

WCRP-WWRP-THORPEX Model Evaluation & Development Survey

(Thanks to Anna Pirani)

Key issues:

- **Identifying uncertainties/deficiencies/problems of current GCMs**
- **Opportunities across communities useful for progress**
- **Suggestions for new initiatives**

To provide input to the strategic planning for model improvement activities coordinated thru various WG and panels of WCRP

Summary of the survey will soon be available at the CLIVAR website

WCRP World Climate Research Programme

WWRP WORLD WEATHER RESEARCH PROGRAMME

THORPEX A World Weather Research Programme

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(Thanks to Anna Pirani)

Key issues:

☐Identifying uncertainties/deficiencies/problems of current GCMs

•Systematic errors in tropical states (low clouds, ITCZ, Walker Circulation, ENSO, etc)

•Mechanisms by which parameterization schemes (unresolved processes) determine the equilibrium CS

•Cloud and convective processes (coupling with BL, microphysics, entrainment, diurnal cycle)

•Resolution issues

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Key issues:

☐Opportunities across communities useful for progress

•More thorough intercomparison of particular aspects (states, processes) of climate models

•Modularized and open source model coding

•Joint working group (or climate process team) for diagnostics combining people working on development/ diagnosis/assimilation

"… but the analysis results are obtained once the model versions are frozen so less efficient for making progress in model development"

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WCRP-WWRP-THORPEX Model Evaluation & Development Survey

(Thanks to Anna Pirani)

Key issues:

☐Suggestions for new initiatives

•So many comments mentioning ‘disconnection’

•Enhancing connection between

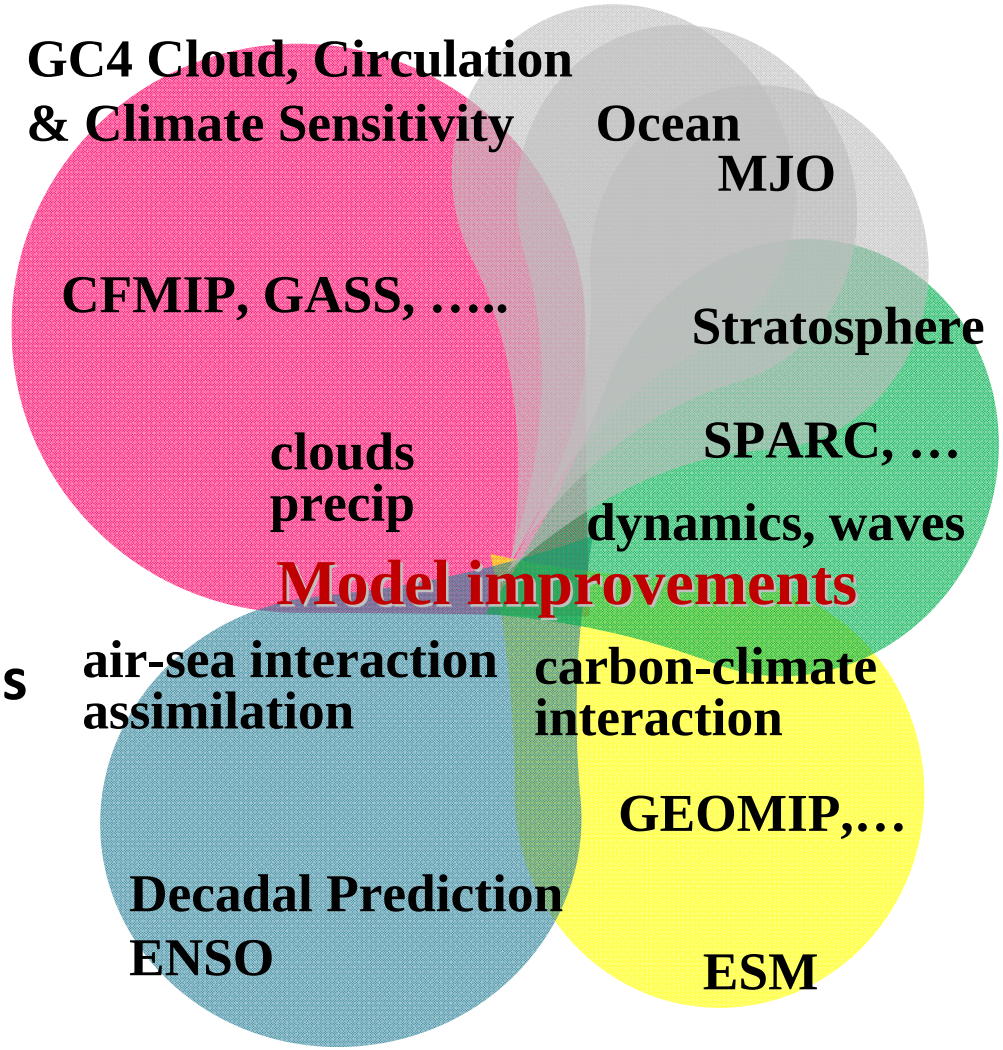
- **diagnostics & modeling groups**
- **NWP & climate modeling groups**
- **measurement (incl. satellite) group & parameterization developers**
- **LES/CRM & GCM groups (as led by GCSS)**

Need to keep in mind

- Model improvement has to be activated in a larger framework

- GCMs may only be incrementally improved during a few years (as we've seen from CMIP3 to CMIP5)

$\Rightarrow$ Should we have two timelines for model improvements?
short: one CMIP cycle
long: beyond (up to 10yrs)



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What to do for us:

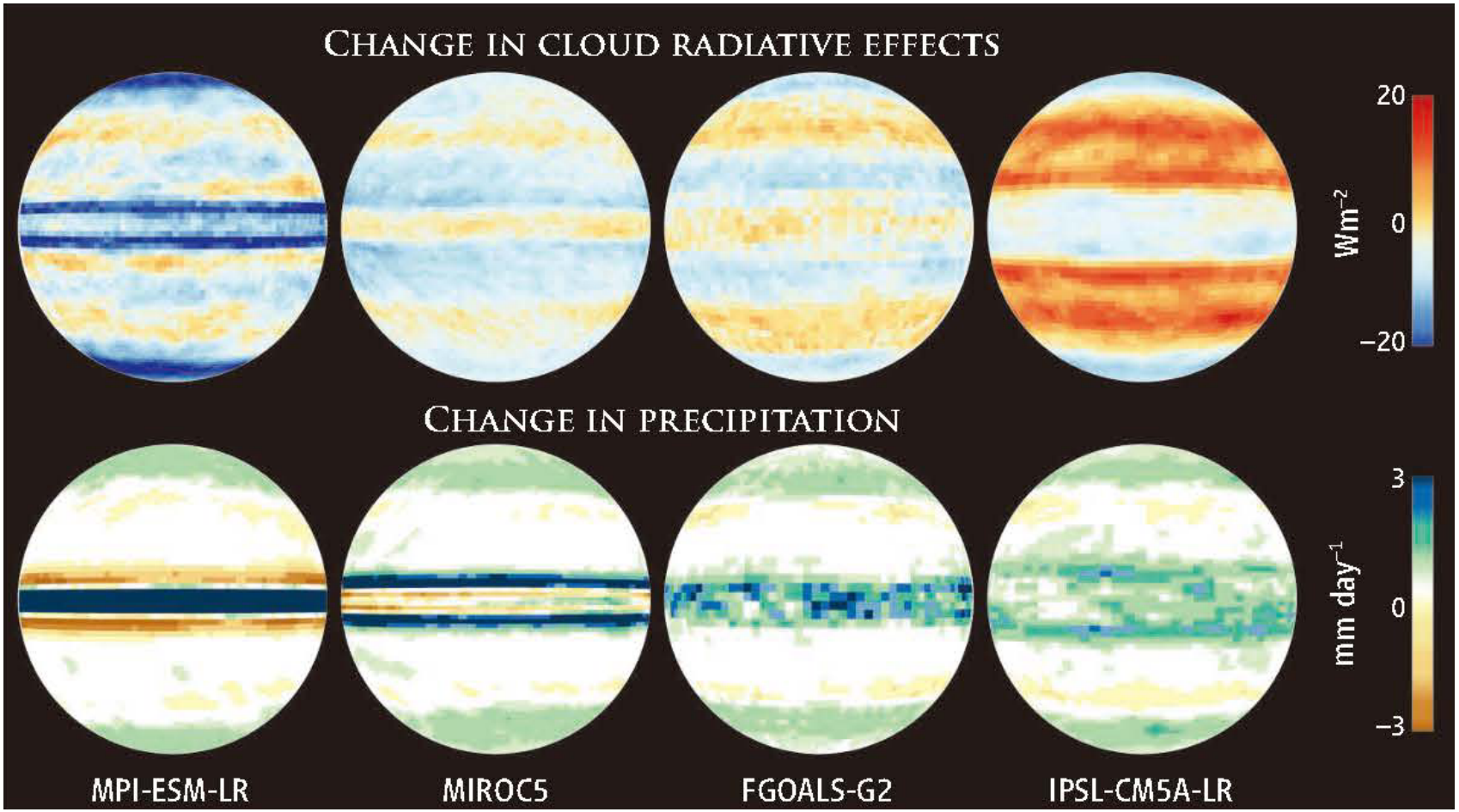
•Importance of providing 'cloud metrics' (in parameter space: EIS, SST, Div, q_{FT}, E, τ, …)
to modeling groups

•Further ideas of coordinated experiments for understanding model diversity (could help possible CMIP6/CFMIP-3 exp design)

- **COOKIE-type sensitivity runs?**
- **Advanced hierarchical modeling approach (CGCM => AGCM => aqua / SCM / RCE)?**
- **More extensive use of Transpose-type runs?**

•More

‘Back to Basics’



Convection OFF, Simplifying cloud scheme, …
=> Let models go back to1980s for future modeling?

Stevens & Bony (2013, Science)

Aerosols-Clouds-Radiation

WGNE meeting in Apr 2013

Courtesy of Leo Donner

Clouds-Aerosols-Radiation, I

- Context provided by WCRP Grand Challenge on clouds, including improving reliability of climate models, learning from historical record of observations, clouds and circulations
- Long-standing strategic question: Build-up vs. Top-down, Reductionist vs Emergent view: both perspectives valid and important, process realism key but balance critical, rate-limiting process improvements may obscure progress, scale awareness and better representation of subgrid variability in parameterizations essential

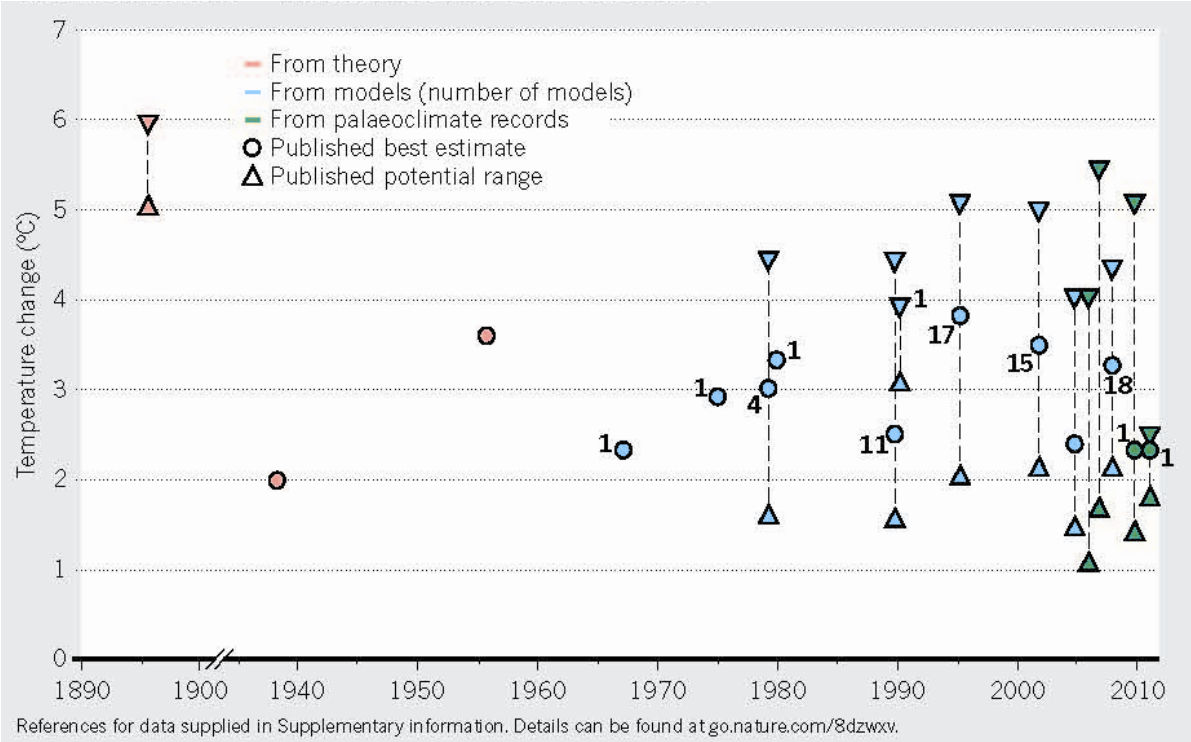
Clouds-Aerosols-Radiation II

- Cloud-aerosol interactions for climate and NWP: significant improvements in process realism required, especially precipitation/water budget/cloud dynamics-research underway on these. Convection and dust transport also discussed.
- Diagnostic and parameter perturbation studies strongly suggest long-standing biases, e.g., double ITCZ are related to cloud biases, which can generate erroneous inter-hemispheric heating asymmetries. Structural errors in parameterizations persist.

Clouds-Aerosols-Radiation III

- T-AMIP paradigm vs long-term statistics: what errors do not develop in in the first few days?
- Observations: are we exploiting them to their full potential? Not only for evaluating models, but for developing parameterisations (e.g subgrid scale) and hypotheses. Need of observational campaigns that help understanding processes behind some of the long-standing errors (e.g. Southern Ocean)?Need to use observations to evaluate process models (LES,CRM) being used to guide parameterization development

WCRP Grand Challenges



Maslin & Austin (2012, Nature)

WCRP Grand Challenges

http://www.wcrp-climate.org/grandcha.shtml

The WCRP intends to promote Grand Science Challenges that will continue to be both highly specific and highly focused identifying a specific barrier preventing progress in a critical area of climate science enable the development of targeted research efforts with the likelihood of significant progress ***over 5-10 years***

- **Regional Climate Information**
- **Sea-Level Rise and Regional Impacts**
- **Cryosphere in a Changing Climate**
- **Clouds, Circulation and Climate Sensitivity**
- **Changes in Water Availability**
- **Science Underpinning the Prediction and Attribution of Extreme Events**

GC#4 Clouds, Circulation & Climate Sensitivity

Inability to constrain the effects of clouds on CS estimate

What are the origins of inter-model differences in CS?
What is the relative importance of feedbacks on versus adjustments to radiative forcing?
What are the physical processes responsible for cloud feedbacks and adjustments in GCMs?
Can critical tests be designed to assess the relative reliability of model-based representations of such processes? …..

Understanding of regional circulation and precipitation changes

What are the primary factors that control the modes of circulation variability?
What is the role of clouds and the coupling between aerosols and clouds?
How do these factors link to large-scale patterns of precipitation?
Can projections of future precipitation changes at the regional scale be made more robust?
How can paleoclimate reconstructions help assess the ability of climate models?

Representation of the cloud-dynamical coupled processes

Can the physical origin of major model biases be identified?
How much do the biases hinge on the representation of cloud processes?
What is their dependence on model resolution?
How do model biases at the process level translate into model biases at the larger scale?
How can we represent cloud-scale dynamics and their coupling with larger scales?
How do they affect simulations of past and future climate changes?