The JSC/CLIVAR Working Group on Coupled Models (WGCM) Report to CLIVAR SSG-18

Sandrine Bony & Jerry Meehl
WGCM co-chairs

Paris, May 2011
Contribuiton of WGCM to CLIVAR Imperatives:

CLIVAR Imperatives:
- Anthropogenic climate change
- Decadal variability, predictability and prediction

CLIVAR Imperative:
- Improved atmosphere and ocean component models of Earth System Models
## CMIP5 Status

At least 21 modelling groups participating

<table>
<thead>
<tr>
<th>Primary Group</th>
<th>Country</th>
<th>Model</th>
<th>Primary contact</th>
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<tr>
<td>CAWCR</td>
<td>Australia</td>
<td>ACCESS</td>
<td>Tony Hirst</td>
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<tr>
<td>BCC</td>
<td>China</td>
<td>BCC-CSM1.1</td>
<td>Tongwen Wu</td>
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<tr>
<td>GCESS</td>
<td>China</td>
<td>BNU-ESM</td>
<td>Duoqing Ji</td>
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<td>CCCMA</td>
<td>Canada</td>
<td>CanESM2, CanCM4, CanAM4</td>
<td>Greg Flato</td>
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<td>CCSM</td>
<td>USA</td>
<td>CESM1, CCSM4</td>
<td>Jim Hurrell</td>
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<td>RSMAS</td>
<td>USA</td>
<td>CCSM4(RSMAS)</td>
<td>Ben Kirtman</td>
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<td>CMCC</td>
<td>Italy</td>
<td>CMCC-ESM, CM, &amp; CMS</td>
<td>S. Gualdi, C. Cagnazzo</td>
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<td>CNRM/CERFACS</td>
<td>France</td>
<td>CNRM-CM5</td>
<td>D. Salas-Melia, L. Terray</td>
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<td>CSIRO/QCCCE</td>
<td>Australia</td>
<td>CSIRO-Mk3.6</td>
<td>Leon Rotstayn</td>
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<td>EC-EARTH</td>
<td>Europe</td>
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<td>Wilco Hazeleger</td>
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<td>MPI-M</td>
<td>Germany</td>
<td>ECHAM6/MPIOM-HR &amp; LR</td>
<td>M. Giorgetta, S. Legutke</td>
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<td>?</td>
<td>China</td>
<td>FGOALS-G2.0, S2.0 &amp; gl</td>
<td>Tianjun Zhou</td>
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<td>GFDL</td>
<td>USA</td>
<td>GFDL-HIRAM-C360, C180, CM2.1, CM3, ESM2G, ESM2M</td>
<td>R. Stouffer, T. Delworth, B. Wyman, L. Horowitz</td>
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<td>MOHC</td>
<td>UK</td>
<td>HadCM3, CM3Q, GEM2-AO, GEM2-ES</td>
<td>Mat Collins, Chris Jones</td>
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<td>NMR/KMA</td>
<td>Korea/UK</td>
<td>HadGEM2-AO</td>
<td>Hyo-Shin Lee</td>
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<td>INM</td>
<td>Russia</td>
<td>incm4</td>
<td>Evgeny Volodin</td>
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<td>IPSL</td>
<td>France</td>
<td>IPSL-CM5A-LR, CM5A-MR, CM5B</td>
<td>Jean-Louis Dufresne</td>
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<tr>
<td>MIROC</td>
<td>Japan</td>
<td>MIROC5, 4m, 4h, ESM, ESM-CHEM</td>
<td>M. Watanabe, S. Emori, M. Ishii, M. Kimoto, A. Abe, M. Kawamiya, T. Nozawa</td>
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<td>MRI</td>
<td>Japan</td>
<td>MRI-AM20km, AM60-km, CGM3, ESM1</td>
<td>Shoji Kusumoki</td>
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<td>NorClim</td>
<td>Norway</td>
<td>NorESM</td>
<td>Trond Iversen / Mats Bentsen</td>
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<td>NASA/GSFC</td>
<td>USA</td>
<td>?</td>
<td>Max Suarez</td>
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</table>

40+ models

K. Taylor (PCMDI)
CMIP5 is organized around several sets of simulations

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

- 10-year & 30-year hindcasts and predictions
- Climate predictability
- Impact of initialization methods
- Impact quality of the ocean initial state

**Long-Term** Experiments (century & longer)

- Current climate, paleo-climates (PMIP)
- Satellite simulator + process outputs (CFMIP)
- RCPs; with/without carbon feedbacks
- Radiative forcings;
- Physical (e.g. clouds) & biogeochemical (carbon, aerosols) feedbacks
- Idealized expts (e.g. aqua-planet)

Overseen by the **WGCM-WGSIP**

**Decadal Climate Prediction Panel**

(chair: George Boer)

→ Nb of models: CORE: 17, Tier1: 3-10
→ Mean Resol: 1.3 deg (atm); 0.8 deg (ocean)

→ Nb of models: CORE: 15-27, Tier1,2: 7-15
→ Mean Resol: 2.1 deg (atm); 0.9 deg (ocean)
CMIP5 is organized around several sets of simulations

"Time Slices" Experiments
(1979-2008 + 2026-2035)

Atmosphere-only experiments:
For models that require enormous computing resources (very high resol, chemistry, etc).

→ explore the impact of higher resolution
→ regional effects of climate change
→ air quality implications of climate change
→ extreme events (e.g. tropical cyclones)

Nb of models: at least 4
Resolution: 0.2 → 0.6 deg (atm)
Access to CMIP5 data: The Earth System Grid (ESG) is up and running!

Model output will be served by federated centers around the world and will appear to be a single archive:

As of May 3rd 2011:
- 8 models have started to publish their CMIP5 outputs on the ESG
- many more models will be available by this summer
- 635 users already registered
- CMIP5 analysis is about to start!
CMIP5 Status

• At least 21 global modeling groups will participate in CMIP5. Likely that about 5 groups will have 50 km class AOGCMs for decadal prediction, at least 10 groups will have ESMs, several groups will have high-resolution time slice AGCMs (<50 km).

• The full sets of forcings (20\textsuperscript{th} and 21\textsuperscript{st} century) for all four RCPs, and the list of model outputs, are available. Simulations or outputs preparation are in progress.

• Model outputs will be accessed via the Earth System Grid (distributed grid technology) for many groups, and some will send their model data directly to PCMDI; all CMIP5 data will be accessed from PCMDI web page with registration; The ESG is now up and running; 635 users (as of Apr 2011) already registered.

• An extensive documentation of the models and of model experiments will be available for CMIP5 through EU Metafor (standardized vocabulary and documentation), and US Earth System Curator projects (web-based tools for ingesting metadata).

• Output from 8 models are now available; Many model runs available by June 2011, but will continue to arrive during 2011; Analyses of model data will begin mid-2011, and will continue through mid-2012 for assessment in the IPCC AR5. (final deadline for papers to be assessed in the AR5: July 31, 2012)

• CMIP5 model simulations and analyses will continue well beyond AR5 deadlines.
Evolution of the global mean surface temperature in 2 CMIP5 climate models

IPSL-CM5A

NCAR-CCSM4

Globally averaged surface air temperature

Courtesy J.-L. Dufresne

Courtesy G. A. Meehl
About 15 ESMs including an interactive carbon cycle will participate in CMIP5.

Evolution of the CO2 concentration (ppm) predicted by the IPSL-CM5A ESM during the historical period.

- Observed
- Predicted from prescribed CO2 emissions
Evaluation of the 3D distribution of clouds simulated by global climate models and observed by CALIPSO
WGCM current events and plans related to CMIP5 (part 1)

• **BAMS article describing CMIP5** submitted (Taylor, Stouffer and Meehl, 2011)

• **Decadal Climate Prediction Panel white paper** on bias correction in decadal predictions completed and posted to PCMDI web page

• **CMIP5 Special Issue of CLIVAR Exchanges** (Thanks to Anna Pirani !)
  - Editorial - Visbeck, Hurrell, Pirani
  - WCRP - Asrar
  - Introduction to CMIP5 - Meehl and Bony
  - Long Terms simulations - Stouffer et al
  - Decadal climate prediction - Doblas-Reyes et al
  - AIMES contribution (RCPs, IAM handshake) - Hibbard et al
  - PMIP - Braconnot et al
  - CFMIP - Bony et al
  - Aerosols - Boucher et al
  - ESMs and C4MIP - Friedlingstein et al
  - Stratosphere-resolving models - Manzini et al
  - Ocean modeling - Griffies et al
  - CORDEX - Jones et al
  - Metafor - Guilyardi et al
  - Satellite observations for CMIP5 - Teixeira et al
  - ESG - TBD
WGCM current events and plans related to CMIP5 (part 2)

- **Encourage/coordinate community groups to write introductory papers** regarding aspects of the CMIP5 dataset (e.g., CFMIP for cloud forcing/response, PMIP for paleo, Metrics panel, etc.) to contribute to IPCC AR5

- **CMIP5 session at WCRP OSC October 2011**
  
  C34: Global Model Evaluation and Projections: CMIP5 and Other Model Intercomparisons
  
  (conveners G. Meehl, D. Waugh, J. Fasullo, K. Williams)
  
  Emphasis is on new CMIP5 analyses, results from CMIP3 and other model intercomparisons also welcome, and could also include results pertaining to, for example, reanalyses, transpose AMIP, and quantitative performance metrics

- **CMIP5 Workshop** hosted by International Pacific Research Center (IPRC), University of Honolulu, Hawaii, **March 5-9, 2012**, comparable to the CMIP3 Workshop held there in 2005, similar “short presentation/poster” format
Contribution of WGCM to CLIVAR Imperatives:

CLIVAR Imperatives:
- Anthropogenic climate change
- Decadal variability, predictability and prediction

CLIVAR Imperative:
- Improved atmosphere and ocean component models of Earth System Models
WCRP-WWRP-THORPEX
Model Evaluation and Development Survey

Idea emerged in parallel at CLIVAR SSG-16
and at WGNE → joint efforts

A. Pirani (CLIVAR)
C. Jakob (WGNE), S. Bony (WGCM), B. van den Hurk (GLACE)

J. Meehl (WGCM), B. Kirtman (WGSIP), S. Griffies (WGOMD)
M. Miller (WGNE), G. Brunet (WWRP), A. Dickinson (THORPEX)
T. Busalacchi, G. Asrar (WCRP)
WCRP-WWRP-THORPEX
Model Evaluation and Development Survey

Questions :

- Given your interest, what would you consider/identify as the KEY uncertainties/deficiencies/problems of current models ?

- Do you see a particular gap (in knowledge, in observations or in practice) that would need to be filled?

- Do you see any particular resource or opportunity within the modeling/process study/observational/theoretical community

Responses :

- More than 120 responses received
  About 20 responses are group or lab-wide responses

- About 30 modeling centers (50% climate modeling center, 50% NWP center) and 44 Universities represented

- Synthesis : on-going
Main outcomes:

1. Key problems of climate models:
   - in the physical climate system
     - convection, clouds, precipitation, land-sfc processes, ocean eddies & mixing
     - errors in mean climate and tropical variability

2. Key obstacles to progress:
   - boundaries between disciplines/communities
   - lack of understanding of process-climate relationships
     and attribution of model errors
   - lack of observations or unsufficient use of avail observations

3. Solutions proposed:
   - encourage integrated research teams (cf Climate Process Teams)
     & facilitate communication/coordination among communities
   - design coordinated model experiments more specifically focused on
     process-climate relationships and on the understanding of
     inter-model differences (resolution, parameterizations, etc)
   - facilitate the use of available observations
Members selected according to their relevant scientific contributions and membership or liaison efforts in key CLIVAR, WCRP and related programs:

- P. Gleckler (PCMDI), Chair – WGNE
- B. Ebert (BMRC) – JWGFVR WWRP/WGNE
- V. Eyring (DLR) – WGCM/SPARC/AC&C
- P. Friedlingstein (Uni. Exeter) – IGBP
- H. Hewitt (Met Office) – WGOMD
- R. Pincus (NOAA) – GEWEX/GCSS
- K. Taylor (PCMDI) – CMIP5/WGCM

Objectives

- identify and promote a limited but diverse set of metrics in an attempt to establish routine community benchmarks for climate models

- facilitate development and adoption of increasingly in-depth metrics via coordination with other CLIVAR/WCRP metrics activities (e.g., CFMIP, MJO task force, CLIVAR AAMP and ocean basin panels)

Contribution of CLIVAR panels and WGs welcome
Facilitating connections between global climate modelling, observations and processes

<table>
<thead>
<tr>
<th>Observations for MIPs evaluation (same format, structure, as CMIP5 output)</th>
<th>WGCM/CFMIP-GCSS process diagnostics on 120 sites (part of CMIP5 output)</th>
<th>WGNE-WGCM “Transpose-AMIP” intercomparison</th>
</tr>
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<tbody>
<tr>
<td>- NASA-PCMDI initiative</td>
<td>- Comparison with data from instrumented sites and past campaigns</td>
<td>- Evaluation of climate models in NWP mode</td>
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<tr>
<td>- to be extended over time (e.g. NOAA)</td>
<td>- High-frequency outputs</td>
<td>- Facilitation of comparisons between models and data from field experiments</td>
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<tr>
<td>- CFMIP-obs initiative</td>
<td>- Opportunity for climate-processes-observations interactions</td>
<td>- Connection to YOTC (tropical convection)</td>
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<td>- archived on the ESG</td>
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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)
WGCM annual meetings

• 14\textsuperscript{th} WGCM meeting held at the UK MetOffice, Exeter, 4-6 October 2010

• First-ever joint meeting between WGCM and WGNE, Boulder, 19-22 October 2011

• 16\textsuperscript{th} WGCM meeting planned on September 2012 in Hamburg, Germany (3rd International Conference on Earth System Modelling, 16-21 September).
Relative Humidity Bias of the IPSL-LMDZ GCM:
Transpose-AMIP simulation (15 Oct 2008) & climatological simulation

Climatological mean (10 years)

Forecast Day + 5

Courtesy S. Fermepin
CFMIP-GCSS Intercomparison of Large Eddy Simulation Models with Single Column Models (CGILS)

A joint activity between CFMIP and the GEWEX Cloud System Study (GCSS) Boundary Layer WG

Led by Minghua Zhang (Stony Brook) & Chris Bretherton (U. Washington)

- Large-scale forcing for 3 types of PBL clouds
- CTRL & +2K experiments
- Same experiments performed by SCMs and LES models

Objectives:

- To understand the physical mechanisms of subtropical low cloud feedbacks in GCMs by using Single-Column Models (SCMs)
- Assess the physical credibility of model physics/cloud feedbacks by comparing SCM results with equivalently forced Large Eddy Simulations (LES) models
Cloud Feedback Model Inter-comparison Project Phase-2
CFMIP-2 (www.cfmip.net)

GCM analysis through
a hierarchy of models

Process studies
(in-situ obs, LES/CRMs)

Satellite observations
& simulators (COSP)

Understanding

Evaluation

Assessment of cloud-climate feedbacks
Observations useful for the evaluation of model clouds through COSP

**CFMIP Observations**

**Observations for COSP, the CFMIP Observations Simulator Package**

The Cloud Feedback Model Intercomparison Program has designed a protocol to evaluate clouds in climate and weather prediction models based on satellite observations [CFMIP2_experiments_March20th2009.pdf](http://cfmip.metoffice.com/CFMIP2_experiments_March20th2009.pdf)

**A-train:**
- CALIPSO
- CLOUDSAT
- CERES
- PARASOL

**Climate Models**

+ ISCCP + MISR
Current priorities for the metrics panel

• Finalize initial set of metrics following feedback from WGCM, WGNE and modeling groups

• Launch website where results will eventually be posted with explanation of the panel objectives, limitations of metrics, etc. This will be a resource pointing to other metrics activities, and will include a repository for code contributions

• Prepare manuscript to document the goals panel, and use its limited set to examine if/how models have improved over time (e.g., CMIP3 to CMIP5)
The panel’s metrics to be presented in a transparent manner

Some of the panel’s selection criteria for metrics:

• easy to calculate, reproduce and interpret, established in the peer-reviewed literature

• must provide all codes/documentation for the limited set of metrics

• Clarity of exactly which observational dataset has been used
  - Example: JPL and PCMDI are currently working to establish guidelines for how selected NASA datasets will be made available specifically for model evaluation. The data will be structurally aligned to facilitate comparison with CMIP5 data and made readily available. There will be specific requirements for documenting each observational product/version. Other major data providers (e.g., NOAA) have expressed interest in following these guidelines.