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Project acronym: ENSEMBLES

Project title: ENSEMBLE-based Predictions of Climate Changes and their Impacts

Instrument: Integrated Project

Thematic Priority: Global Change and Ecosystems

Deliverable D4.1.3: Meeting and report on how to constrain water vapour and cloud feedbacks processes produced by GCMs under climate change using observations and process studies

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Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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The spread of climate model projections for a given economic "scenario" is mainly due to radiative feedbacks. The water-vapor feedback has the strongest impact on the multi-model mean of the temperature increase and the cloud feedback has the largest contribution to the inter-model spread. It is therefore of key importance to assess these two feedbacks.

CNRS-IPSL and METO-HC have organized a joint CFMIP/ENSEMBLES Workshop on assessment of cloud and water vapour feedback processes in GCMs, Paris, 11th-13th April, 2007

(see http://www.cgam.nerc.ac.uk/research/ensembles-rt4/meetings/meetings.html). CFMIP is the Cloud Feedback Model Inter-comparison Project lunched in 2003 by the Working Group on Coupled Modelling (WGCM) of the World Climate Research Program (WCRP). The workshop took place at the "Pierre & Marie Curie University", 60 persons participated and key partners of RT1, RT2A and RT5 where present. See appendix 1 for the program of this workshop. Only a few people worldwide are working on the assessment of cloud and water feedback, and this joint CFMIP - ENSEMBLES workshop as a good opportunity to bring together most of the current scientists working in this field. The motivation of this workshop was to address the following questions:

- what is the current knowledge worldwide?
- how can we used it to constrain current GCMs (especially for ENSEMBLES)?
- how can we progress in the future?

During this workshop, three beak-out groups made discussions on the three following topics:

- Experimental design to better understand physical mechanisms underlying the different cloud-climate feedbacks in climate model
- diagnostic requirements for future runs
- collaboration between GCSS and CFMIP to assess the credibility of cloud-climate feedbacks.

The recommendations made by these groups are given in appendix 2 to 4. For the ENSEMBLES project, a strong recommendation was to use, if possible, the ISCCP simulator for the stream 2 runs of RT2A.

Since the CFMIP/ENSEMBLES Workshop, CFMIP has defined its plans for the second phase of the project, CFMIP-2. These plans may be found at the following url http://cfmip.metoffice.com/cfmip2/cfmip2_20070822.pdf and contains many points that have been addressed in the joint CFMIP/ENSEMBLES meeting. Here we presented some of them that are directly relevant for the ENSEMBLES project.

Evaluation of clouds simulated by climate models

Current output from climate model simulations, as for ENSEMBLES stream 1 simulations, do not include a sufficient number of variables to allow a quantitative assessment of the characteristics of

clouds. With the existing variables, quantitative evaluation of model clouds can only be done using two-dimensional satellite observations of radiative fluxes and total cloud fraction, and this is insufficient as many compensating errors may occur.
The ISCCP simulator can be used to quantify errors in the prevalence of difference cloud types, the heights of their tops and their optical properties, which remain as compensating errors in models control simulations after tuning, undermining their credibility. It is therefore recommended to use ISCCP simulator for the ENSEMBLES stream 2 simulations. More generally, recommendations to improve the diagnostics are given in appendix 3.

Evaluation of multi-level information on clouds and precipitation (with more information on low level clouds previously obscured by those above) will be also possible in the near future with the arrival of new observations from space-borne radar and lidar (CloudSat and CALIPSO) in synergy with other instruments from the A-Train constellation of satellites. Until simulators become widely used to quantify errors in models' clouds (both in the assessment and development process), compensating errors will continue to undermine the credibility of models. Therefore CFMIP-2 will continue to develop techniques and tools for evaluating modelled cloud-climate feedbacks using satellite products. Current efforts in this area are mainly focused on development of the CFMIP ISCCP/CloudSat /CALIPSO Simulator (CICCS), some minor enhancements to the ISCCP simulator, and the development and application of cloud-climate feedback evaluation techniques and metrics based on comparisons with ISCCP and CloudSat/CALIPSO data using these simulators.

Development of metrics relevant to cloud-climate feedback.

In recent years, metrics have been proposed for assessing the relative quality of different climate models compared to observational datasets. Many of these (e.g. Murphy et al (2004), Reichler and Kim (submitted), Sexton et al (in preparation)) are based on climatological variables, and do not take advantage of new compositing techniques. In this framework, it is possible to develop cloud-climate metrics which use monthly and daily cloud diagnostics to more effectively target the cloud feedback processes understood to contribute most to current uncertainties climate model sensitivity. An example of this approach is illustrated by Williams et al (2006) who show that present day spatiotemporal composites can capture some aspects of the cloud-climate feedback/response pattern in climate models. Results show that a metric based on this compositing method tends to favour higher sensitivity models (consistent with the findings of Bony and Dufresne (2005).) However, metrics based on 2D radiative fluxes will not penalise models that get plausible values of cloud radiative forcing with compensating errors in cloud fraction, cloud optical depth, etc. Newer approaches based on simulator output show the potential to provide stronger constraints on cloud-climate feedbacks in models. Williams and Tselioudis (2007) argue that metrics based on the clustering approach have the potential to reduce the inter-model spread in climate sensitivity by a third. However, a necessary pre-requisite for this is the inclusion of the ISCCP simulator as standard in a wide range of models. This not only supports the calculation of metrics, but gives a wealth of information that can be used in the model development process to remove compensating errors and improve the credibility of the models' cloud simulations in the longer term.

The development of cloud-climate feedback metrics is one part of a wider activity to develop metrics to assess all aspects of climate models performance. This topic was discussed at the Paris meeting in a presentation by Robert Pincus and a plenary discussion chaired by Karl Taylor and Robert Pincus. A session on metrics is planned for the PAN-GCSS meeting in Toulouse, June 2008.

Assessing the credibility of model feedbacks – CFMIP-GCSS collaboration

In recent years the aims of CFMIP and the GEWEX Cloud System Study (GCSS) have shown increasing overlap. As CFMIP-2 focuses more on understanding and assessing the credibility of cloud feedback mechanisms in climate models, there are benefits to comparing with models that resolve cloud feedback processes more explicitly. CRMs and LES models can give more consistently plausible simulations than Single Column Model (SCM) versions of NWP and climate models given the same forcings (e.g. Brown et al (2002) cf Lenderink et al (2004).) These have been routinely used by GCSS Working Groups to simulate cloud systems in present day case study mode, for comparison with SCMs and field observations. However, despite the explicit mandate of GCSS to improve cloud representation in climate models, GCSS case studies do not routinely examine the large-scale context and the climate model relevance of the simulated cloud systems. This context can be provided by CFMIP, which not only documents climate model cloud-type deficiencies but also assesses their impact on model climate sensitivity and its inter-model spread. This synergy led to the decision to organize a working group at the Paris meeting to explore practical routes for a CFMIP/GCSS collaboration (led by Pier Siebesma and George Tselioudis.)
The outcome of the session was a set of recommendations to CFMIP and GCSS on future collaboration that both extends the scope of existing CFMIP and GCSS initiatives to better address common issues, and proposes new initiatives to integrate research components of the two projects (see appendix 4 for more details).

Output recommendations

The CFMIP-2 diagnostic recommendations for CMIP4 and CFMIP-2 experiments are summarized in Table of appendix 3. The requested outputs are organized into four diagnostics packages combined with a number of temporal and spatial sampling options to support a range of analytical techniques in the published literature. Each package builds upon the previous one so that studies using Package 3 tend to also require Packages 1 and 2. The packages are:

- Package 1: CFMIP-1 2D fields. This is the same as the CMIP3 table A1a except with the addition of 3 x 2D ISCCP simulator fields, 500hPa vertical velocity and temperature and humidity at 700hPa (to calculate lower tropospheric stability).
- Package 2: CFMIP-1 3D fields. This is the same as the CMIP3 table A1c except with the addition of the full 4D ISCCP simulator diagnostics as standard, 3D cloud amount, liquid water and ice (total or stratiform and convective) and convective mass flux (separated into shallow and deep if possible). Most of the non-cloud fields in CMIP3 table A1c (in which the vertical profile is fairly smooth in the monthly mean) were requested on pressure levels. However, to see the relationships between cloud and environmental variables (temperature, humidity, etc) it is necessary to save all 3D fields at daily and higher temporal resolution on model levels. Saving these on standard pressure levels only would lose information on

humidity/temperature inversions which can have a significant impact on the simulation of low level cloudiness (e.g. Lock et al (2000).) We therefore request that 3D fields being collected by CMIP4 at daily and higher temporal resolution are saved on model levels. A post processing tool to convert the daily fields to pressure levels for some users may also be necessary.

- Package 3: CloudSat/CALIPSO simulator diagnostics. The exact nature of these is still being discussed, however they are likely to include statistical summaries similar to the 4D ISCCP simulator diagnostics.
- Package 4: Cloud tendency diagnostics. These give insight into the processes responsible for the different cloud responses in GCMs. However, as they will vary from model to model the proposal is for these diagnostics not to form part of the CMIP4 request and will instead be conned to the additional CFMIP-2 experiments

Appendix 1:

Program of the CFMIP / ENSEMBLES Workshop (April 11-13 2007)
LMD / IPSL, Université Pierre et Marie Curie, Paris, France

<u>Wednesday 11 April :</u>

09:00-09:30: REGISTRATION AND COFFEE

Opening / Overview (Chair: Rob Colman) :
09:30-09:50: Jean-Louis Dufresne (LMD/IPSL) : Welcome and objectives of the workshop.
09:50-10:10: Chris Hewitt (Met Office): the ENSEMBLES project
10:10-10:30: Sandrine Bony (LMD/IPSL): Cloud feedbacks in GCMs: Progress and prospects
10:30-10:50: Mark Webb (Met Office): From CFMIP-1 to CFMIP-2
10:50-11:10: BREAK

Definition / Estimate forcings and feedbacks (Chair: Mark Webb) :
11:10-11:30: Eigil Kaas (GFY): Estimates of fixed SST climate forcings during the 20th Century in the ENSEMBLES models
11:30-11:50: Rob Colman (BMRC): Diagnosing and comparing water vapour and lapse rate feedbacks in models.
11:50-12:10: Tokuta Yokohata (NIES): Climate feedback analysis by an approximate PRP method.
12:10-12:30: Karl Taylor (PCMDI): Cloud feedback analysis in Earth System Models (to be confirmed)
12:30-14:00: LUNCH (13:30 Coffee)

Understanding feedbacks (Chair: Sandrine Bony) :
14:00-14:20: William Ingram (Oxford): A physical explanation for the size of the water vapour feedback and a new way of quantifying & attributing GCMs' water vapour feedback
14:20-14:40: Tomoo Ogura (NIES): Response of cloud condensate budget to CO2 increase in GCMs
14:40-15:00: Brian Soden (RSMAS): Cloud feedback and the weakening of the tropical circulation
15:00-15:20: Brian Medeiros (UCLA): Using aquaplanets to understand GCM climate sensitivity
15:20-15:40: Minghua Zhang (SONY): Stratus and stratocumulus clouds over the Eastern Pacific in GCMs, SCMs and Satellite Data
15:40-16:00: BREAK

What do CRMs/MMF tell us ? (Chair: Pier Siebesna)
16:00-16:20: Wojtek Grabowski (NCAR): Moisture-convection and convection-SST feedbacks in the tropics.
16:20-16:40: Marat Khairoutdinov (CSU): Cloud feedbacks as simulated by the CSU MMF
16:40-17:00: Hirofumi Tomita (JAMSTEC): The global cloud resolving model NICAM : model introduction and cloud-feedback tests from the view point of the radiation-convection equilibrium
17:00-17:20: Shin-ichi Iga (JAMSTEC): A perpetual July experiment by NICAM : preliminary results from the global CRM.
17:20-17:40: Yoko Tsushima (JAMSTEC): Toward improvement of GCM's cloud feedback through the comparative analysis with global cloud resolving model NICAM

Thursday 12 April :

Use of satellites to evaluate models (Chair: Brian Soden) :
09:00-09:20: Kuan-Man Xu (NASA Langley): Overview of CERES data products for model evaluation
09:20-09:40: Tony Del Genio (NASA GISS): What observed cloud objects tell us about processes that influence cloud feedbacks ?
09:40-10:00: George Tselioudis (NASA GISS): Using dynamic regime compositesto examine midlatitude cloud, radiation and precipitation feedbacks in observations and climate model simulations.
10:00-10:20: Keith Williams (Met Office): Constraining the range of climate sensitivity through the diagnosis of cloud regimes
10:20-10:40: Alejandro Bodas-Salcedo (MetOffice) and Marjolaine Chiriaco (SA/IPSL): The CFMIP CloudSat/CALIPSO simulator

10:40-11:00: BREAK

Other strategies of validation (Chair: Yoko Tsushima) :
11:00-11:20: Jason Cole (Univ. Brit. Columbia): Evaluation of clouds and radiative fluxes in the CCCma GCM
11:20-11:40: Leo Donner (GFDL): Strategies for Evaluating Aerosol-Cloud Interactions in GCMs.
11:40-12:00: Keith Williams (Met Office): Initial tendencies of cloud regimes in the Met Office Unified Model
12:00-12:20: Mark Rodwell (ECMWF): The use of NWP in climate model assessment.

12:20-13:30: LUNCH

Future / Ongoing collaborative projects (Chair: George Tselioudis) :
13:30-13:50: Robert Pincus (NOAA CDC): GCSS metrics efforts
13:50-14:10: Pier Siebesma: GCSS and its future link with CFMIP
14:10-14:30: Joao Teixeira (NRL): GEWEX Pacific Cross-Section Intercomparison (GPCI)
14:30-14:50: Bjorn Stevens (UCLA): An LES perspectives on cloud feedback.
14:50-15:10: Adrian Lock (Met Office): The GCSS PBL working group

15:10-15:30: BREAK

15:30-17:10 : Discussion (Chairs: workshop organizers + chairmen indicated below)
- What particular aspects of cloud and water feedbacks need to be understood/evaluated ?
  (Chairs: Tony Del Genio & Joao Teixeira)
- What role for CRMs and LES in the cloud feedback problem ?
  (Chairs: Bjorn Stevens & Adrian Lock)
- How may we constrain climate sensitivity estimates from understanding+evaluation ?
  (Chairs: Karl Taylor and Robert Pincus)

Friday 13 April :

Ensembles - CFMIP2 sub-projects (Chair: Keith Williams) :
09:00-09:20: Mark Webb (Mett Office): CFMIP-2 plans
09:20-09:40: Brian Soden (RSMAS): CFMIP -2 CO_2 forcing subproject

09:40-10:00: Johannes Quaas (MPI): CFMIP-2 idealised physics sub-project.
10:00-10:20: Mark Ringer (Met Office): CFMIP-2 experimental design options

10:20-10:40: BREAK

Ensembles – CFMIP – AR5 (Chair: Jean-Louis Dufresne) :
10:40-11:00: Matthew Collins (Met Office): Perturbed physics approaches in ENSEMBLES and plans for applying CFMIP process based constraints.
11:00-11:20: Eigil Kaas (Copenhagen Univ) and Heike Huebener (Berlin Univ): Presentation of ENSEMBLES climate simulations.
11:20-11:40: Karl Taylor (PCMDI): Process for determining standard output and experiments for AR5
11:40-12:00: Definition of working groups (e.g: Experimental designs for CFMIP2, ENSEMBLES-CFMIP interactions, GCSS-CFMIP interactions).

12:00-13:30: LUNCH

Working Group Discussions:
13:30-15:30 : “Brainstorming” of the different working groups
15:30-15:50 : BREAK

Conclusions :
15:50-16:20 : Report from the Working Groups to the Plenary
16:20-17:00 : Discussion / concluding remarks

17:00 : End of the workshop

Appendix 2:

CFMIP/ENSEMBLES workshop – IPSL, Paris, 11-13th April 2007
Break-out group 1 – Experimental design
Chairs: Mark Ringer and Brian Soden

Mark Ringer – 23rd April 2007

1. Primary experiments for CFMIP2

Mixed-layer ("slab") ocean experiments

Although these were the principal experiments in CFMIP1 it was not thought that we should pursue the slab model approach in CFMIP2. A key reason for doing this would be to retain continuity with past IPCC assessments, in particular the calculation of equilibrium climate sensitivity and an estimate of its range of uncertainty. It could be argued that we will be unable to demonstrate that this range has been reduced (if indeed it has) unless we follow a similar methodology. In addition, if slab experiments are not included as part of the AR5 protocol we might consider that it is our role to continue them. However, it was felt that transient climate response (TCR) was now becoming the climate sensitivity metric of choice, as it is considered more relevant to climate change over the coming century, and this greatly reduces the need for performing slab experiments. Slab models also present certain technical issues (e.g. inclusion of a sea-ice model) which make some centres reluctant to commit resources to their development and could thus restrict participation in the project.

Patterned SST experiments

These involve forcing an atmospheric model with a realistic (relevant) projected SST distribution such as a mean pattern derived from a multi-model ensemble of fully coupled runs. For example, Wyant et al. (2006) used the SST distribution at time of CO_2 doubling from CMIP 1%/year increasing CO_2 simulations. The recommendation from the group was that we should pursue this approach. These experiments have the advantage that the models begin from the same control SST distribution and respond to the same climate change perturbation, thus reducing the degrees of freedom in the problem. With no unknowns in the forcing, they are also amenable to the "feedback kernels" method of Soden and Held (2006). It should be noted, of course, that these experiments will not allow us to examine how the SSTs respond to changes in cloud.
On the practical side, the following recommendations were made:

- The control experiment should use the climatological seasonal cycle of SST rather than varying (AMIP) SSTs. This helps to keep the experiments as simple as possible, eliminating potential complications such as the models' different responses to ENSO. The AMIP runs will be present in AR5, in which case we need to ensure that the diagnostics we consider important are included as part of that experimental set-up, as these runs will undoubtedly be of great interest to CFMIP (e.g. cloud responses to ENSO, comparison with observations, etc.).
- The climate change SST distribution used should be constructed from as wide a range of models as possible, with a "mean pattern" derived by averaging the models' SST change normalised by their global mean SST increase. This mean pattern can then be scaled up, for example by the average global mean SST increase across all the models or even by some arbitrary factor.
- The origin of the climate change SST distribution needs to be settled. Following the Wyant et al. (2006) approach links to already published work and helps to maintain relevance to 21st century climate change, which is likely to be highlighted in AR5. However, a mean pattern could also be derived from the AR4 slab models, maintaining a link to the equilibrium climate change

experiments.

- Including a sea-ice perturbation pattern (using a simple algorithm) should be an optional experiment in addition to the SST-only forcing runs. This ensures that any technical difficulties centres might have doing this would not prevent them from participating in the project.

2. Other experiments

Forcing experiments

We should do 2×CO_2 fixed SST (Hansen) experiment but other types of forcing experiment do not really fall within the remit of CFMIP. One additional experiment that was proposed involved re-running the perturbed SST simulations with doubled CO_2 (in practise this will probably be some factor, f×CO_2, to maintain TOA balance). This experiment is "complete" in the sense that it includes tropospheric adjustment (fast forcing/feedbacks), is as inexpensive to run as the others and can be analysed in the same way.

Physics perturbation experiments

It was felt that these should be driven by individual researchers or pilot studies rather than imposed across the project. Some pilot studies have, in fact, already begun. Publicising the results to the rest of the CFMIP community would then allow participants to pursue ideas and experiments they thought interesting

Aquaplanet experiments

If aquaplanet models are able to provide insights into processes relevant to the cloud feedbacks we see in full GCMs then they could potentially make a valuable contribution to CFMIP. The recommendation was that these be optional but we should certainly agree a common experimental design: the APE experimental design (see http://www.met.reading.ac.uk/~mike/APE/ape_spec.html for details) might provide a good starting point, which we could adapt to our own requirements as necessary. This would make a very good CFMIP/GCSS project which, given the links to LES studies, could be led by the GCSS participants to CFMIP. Note that although some concern was expressed about aquaplanet models' inability to generate stratocumulus cloud it is possible to envisage an experimental design which would allow this, a zonally asymmetric boundary condition with a warm and cold pool, for example.

Appendix 3:

Summary of breakout group on diagnostic requirements

(Chair: Keith Williams and Karl Taylor)

The purpose of the group was to identify diagnostics which would be required for phase 2 of CFMIP, which experiments they would be needed in, what temporal frequency is required and over what period of the simulation should they be saved.

The starting point for identifying the diagnostics were the CFMIP I lists (available from www.cfmip.net). The following questions were then addressed:

- Are all the CFMIP I diagnostics required in future experiments?
- Are there any other diagnostics (in addition to those from CFMIP I) which would help with understanding/evaluating cloud feedback?
- What temporal resolution is required?
- Which experiments are they needed in (e.g. what do we need in the AMIP, 20C, 1%/ye, earth system model/scenario expts; what is needed in ENSEMBLES)?
- Over what period of the run?
- All of the above to be addressed baring in mind data volumes.

Due to time constraints and the fact that experiments to be specifically conducted as part of CFMIP II were being discussed in parallel, the focus of the discussion was on diagnostic requirements for CMIP 4 (AR5) and ENSEMBLES.

The principle outcomes from the discussion were:

- CFMIP I output should be requested for CMIP4/ENSEMBLES since most fields have already been used to good effect in published literature
- 3D field on model levels vs. pressure levels. The group felt that, with the exception of cloud amount/water, 3D fields were most suitable on pressure levels for monthly data (as was requested by CMIP3/AR4). However for understanding cloud processes using daily and higher temporal resolution data, it was agreed to be important to have all 3D atmospheric fields on model levels (not just the cloud fields), in order to understand the interaction with the meteorology which can be vertically inhomogeneous at high temporal resolution. It is recognised that some users will still require fields on pressure levels (although most of these will only use the monthly data), so additional code will be required on the data portal to convert onto pressure levels if required. (All of the data required to do this conversion must therefore be in the netCDF file).

- Cloud output is an integrated package. Most studies on understanding and evaluating cloud feedback use a variety of diagnostics (both cloud and other meteorological fields). The study cannot be performed if one of these is missing. The CFMIP I lists were developed with diagnostic packages in mind so it is important to encourage modelling groups to include ALL of the requested diagnostics.
- CloudSat/CALIPSO simulator diagnostics. These are new diagnostics to CFMIP II and were believed to be very important for inclusion in the CMIP4 request. (It was recognized that the simulator would not be ready for ENSEMBLES). It will take some effort from modelling groups to include these diagnostics, hence those involved with CFMIP must continue to 'sell' the importance of these to modelling groups. Discussion in plenary highlighted that we do not necessarily know the best way to use these data, hence exactly what is collected may need further discussion, but it is likely to include statistical summaries similar to the ISCCP simulator histograms.
- Cloud/T/q tendencies. It was agreed that these were extremely valuable for understanding the response of a GCM and they should be included in future dedicated CFMIP experiments, however it was felt that it would be difficult to persuade modelling groups to save these for AR5 or ENSEMBLES.
- Support for "complete" set of variables at limited number of points. High temporal resolution data (at least 3 hourly) are required for detailed process understanding and are a key requirement for collaboration between CFMIP and GCSS. Data volumes preclude saving such high temporal resolution data globally for a large number of diagnostics, so there was support in the group for saving a handful of point diagnostics and the GPCI. It was again noted that this is likely to require post processing or different output setups by modelling groups to extract these points and so a case again needs to be made to modelling groups regarding why these are necessary.
- High temporal resolution global fields. A few high temporal resolution fields are desirable globally (e.g. for studying cloud evolution during storm tracking). It was felt that CFMIP would be able to request these on its own, however the requirement may overlap with other groups (e.g. those investigating the diurnal cycle), and between these groups a case might be made.
- Not all output needed from all experiments. This is key to controlling data volumes. As a first priority, the diagnostics are required from: climate of the 20th century (coupled runs), AMIP, pre-industrial control, 1%/yr increasing CO2. Monthly CFMIP I fields are probably sufficient for the other experiments (scenarios and earth system experiments) since these are generally analysed less for mechanistic understanding of feedbacks. These criteria also apply to ENSEMBLES, hence the breakout group encouraged a 1%/yr experiment to be requested in ENSEMBLES stream 2.

The proposal for the diagnostics to be saved in each experiment is summarized in the table below in which the number represents the number of years of simulation over which the data should be saved.

	Time Sampling Frequency	CFMIP I 2D fields incl. 2D ISCCP simulator, fluxes, water paths, clt, stability, w500	CFMIP I 3D fields incl. ISCCP, cl,clw, omega, u,v,t,q	CloudSat /CALIPSO Simulator (not ENSEMBLES)	Cloud/T/q tendencies
1) Present day experiments (AMIP, 20C)					
	Monthly	All	All	All	
16 yr daily = 85-90 & 98-07	Daily	All	16	16	
23 year sub-period 85-07	3hr/daily Point	23	23	23	
2) All Coupled model pre-industrial control and 1%/yr simulations					
	Monthly	All	All	All	
(Sub-periods centred on time of	Daily	All	10	10	
CO2 doubling and equiv in ctrl)	3hr/daily Point	20	20	20	
3) Scenarios					
SRES/ESM scenarios	Monthly	All	All		
4) CFMIP II sensitivity tests					
	Monthly	All	All	All	All
	Daily	All	10	10	
	3hr/daily Point	20	20	20	

Appendix 4:

Summary of the discussion on collaboration between GCSS and CFMIP during the CFMIP-ENSEMBLES Workshop April 11-13 2007

First Draft, 26 April 2007
A. Pier Siebesma, and others.

Introduction

Clouds still form the largest source of uncertainty with respect to climate feedbacks processes and are therefore the primary sources of climate sensitivity uncertainty. .More detailed CFMIP studies indicate that both the feedback magnitude as well as its uncertainty is mainly due to shortwave effects of low level clouds in subsidence (suppressed) regions. Within these suppressed regions one can distinguish roughly two type of climate models: High sensitivity climate models that do show a strong positive cloud climate feedback and low sensitivity models that show a low (but positive) cloud climate feedback. Further analyses of how the cloud radiative forcing responds to interannual variations in the SST do suggest that the high sensitivity models are more realistic than the low sensitivity models.

In the 2nd phase of CFMIP there will be a strong focus on cloud process studies in order to answer key question such as:

- What makes a climate model a high or a low sensitivity model w.r.t. cloud climate feedback.
- What determines the cloud climate feedback: thinner clouds, lesser clouds, different clouds, etc ?
- Which are the key processes that determine the sensitivity for cloud climate feedback: top-entrainment , lateral entrainment, precipitation efficiency, detrainment processes, etc?
- (How) can we use high resolution models such as Large Eddy Simulation (LES) and Cloud Resolving Models (CRM's)

To address these questions, a GCSS-CFMIP collaboration has been proposed in order to jointly tackle these questions. One of the objectives of the CFMIP-ENSEMBLES workshop was to have extensive discussion of how to set up joint GCSS/CFMIP research activities that address the above mentioned points. The outcome of these discussions is summarized in the next section.

2. Outcome of the discussion

a) Data Analysis

It was generally agreed to focus on the GCSS Pacific Cross Section Intercomparison Project (GPCI) since this transect spans up all the important (sub)-tropical cloud regimes in a well geographically separated way. In addition to these GPCI related activities, there will an effort to host model and observational output for specific point locations such as: ARM sites , Cloudnet sites and BSRN sites and locations where past GCSS intercomparison studies have been conducted.

Specific planned activities:

- To determine which are the minimal amount of climate model grid points in the vicinity of the GPCI transect that are needed to recreate the shortwave cloud feedback such as demonstrated in Bony and Dufresne (2006). It might very well be that the GPCI transect needs to be widened in order to have a better sampling statistics. (action: S. Bony and M. Webb)
- Supply of additional coordinates of additional field campaign location in order to extract CFMIP model output. (action A. P. Siebesma)
- Saving and Storing state variables and advective tendencies at the GPCI grid points in order to set up isolated LES/CRM/SCM studies. This should be 3 hourly data as a minimum temporal resolution (action: CFMIP). Remark: for the present required summer periods (1998 and 2003) the advection and profile data have been kindly supplied by Martin Kohler. These will be hosted on the DIME site (action Teixeira, Sambingo)
- Cloud cluster analysis for the GPCI grid points (action: George Tselioudis)

b) Modelling activities

Individual Activities:

- Single Column Model (SCM) studies with idealized mean state and forcings for present and future climate (Minghua Zhang).
- Cloud feedback model studies using an idealized aquaplanet with the GFDL-models and NCAR CAM3 model. Preliminary studies show that the cloud climate sensitivity for these 2 models are quite different but that those differences persist in a simplified Aquaplanet setting. This allows to investigate the different feedback of the 2 models in a simpler setting that has substantial advantages: better statistics, no seasonality , fast equilibration, etc. (Brain Medeiros, Bjorn Stevens).
- Cloud Resolving Model (CRM) studies in a Eulerian setting for a number of locations on the GPCI-crossection fed by ECMWF model fields and advection tendencies. (Kuan-Man Xu)

GCSS group activity:

The design of a Lagrangian case study across the GPCI cross section, starting at the SCu region to the trade wind cu region. This will be set up for both LES/CRM studies as well as for SCM's. Such a study serves at least purposes:

- To assess the capability of these LES/CRM models and SCM's to realistically simulate and parameterize the break up of Scu into shallow cumulus. (action: Lock?, Teixeira?, Siebesma?).
- Anticipating that this first step can be achieved successfully such a Langrangian run will be repeated in a future climate setting. This will allow to assess the cloud climate feedback process using more realistic high resolution models (i.e. LES models and CRM's) and in a SCM context. This will facilitate the opportunity to assess the physical mechanisms that are responsible for the cloud climate feedback along the same lines as in Bony and Dufresne (2006).

Appendix 5

CFMIP / ENSEMBLES Workshop, April 11-13 2007
LMD/IPSL, Université Pierre et Marie Curie, Paris, France
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