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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 D4.1.4: Assessment of the different contributions of the radiative feedbacks to the mean and spread of global warming estimate in climate models.

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Revision [draft 1]

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
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)	
CO	Confidential, only for members of the Consortium (including the Commission Services)	

Radiative feedbacks are known to have a major contribution on global temperature change in response to an external forcing but how much the different feedback processes contribute to the temperature change estimate and to its spread was not quantified. A method has been proposed to quantify the contribution of the different radiative feedbacks to the equilibrium or transient temperature change and was applied to the simulation results of 12 coupled GCM (Dufresne and Bony, 2008). Results show that the water vapour plus lapse rate (WV+LR) feedback has the largest contribution to the multi-model mean of the temperature increase whereas the cloud feedbacks constitute by far the primary source of spread of both equilibrium and transient climate responses simulated by GCMs (Figure 1). Surprising for such an idealised experiment was the quite large contribution of the forcing to the spread. Another important result is that the ratio between the temperature increase due to each feedback and the global temperature increase is the same for both equilibrium and transient runs.

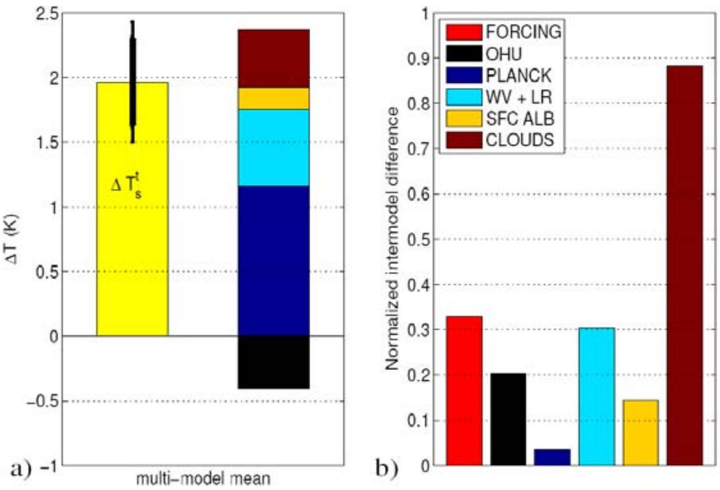

Figure 1: For simulations where the CO2 increases by 1%/year, at the time of CO2 doubling, (a) multi-model mean ±1 standard deviation (thick line) and 5%-95% interval (thin line) of the equilibrium temperature change (ΔTs), and contributions to this temperature change associated with the Planck response, combined water vapor and lapse rate (WV+LR) feedback, surface albedo feedback and cloud feedback. (b) inter-model standard deviation of the temperature change estimates associated with the radiative forcing, the Planck response and the various feedbacks normalized by the inter-model standard deviation of the equilibrium temperature change ΔTs reported in (a).

The origin of the large spread due to cloud feedback has been identified: it is mainly due to low level clouds that cover the largest part of the ocean (Fig. 2) (Bony and Dufresne 2005, Bony et al. 2006, Webb et al., 2007). However, 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.

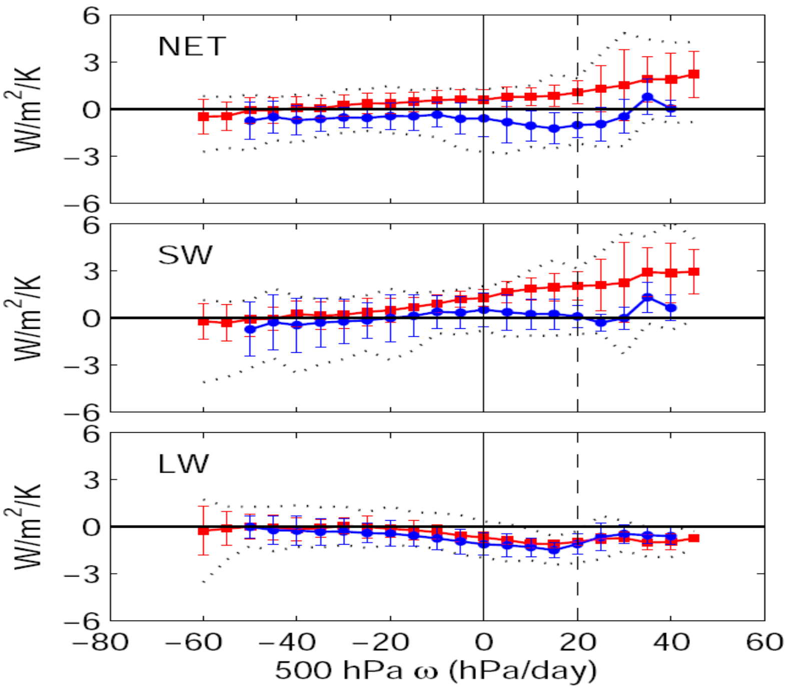

Figure 2: Sensitivity (in Wm-2 K-1) of the tropical (30o S-30o N) NET, SW and LW cloud radiative forcing to sea surface temperature changes associated with climate change (in a scenario in wich the CO2 increases by 1% per year) derived from 15 coupled ocean-atmosphere GCMs participating in the AR4. The sensitivity is computed for different regimes of the large-scale atmospheric circulation (the 500 hPa large-scale vertical pressure velocity is used as a proxy for large-scale motions, negative values corresponding to large-scale ascent and positive values to large-scale subsidence). Results are presented for two groups of GCMs: models that predict a positive anomaly of the tropically averaged NET CRF in climate change (in red, 8 models) and models that predict a negative anomaly (in blue, 7 models). From Bony and Dufresne (2005).

In order to reduce the spread of climate feedback estimate by GCMs, and therefore in climate change projections, a strategy was developed on how to constrain water vapour and cloud feedbacks processes using observations and process studies. This main objective is common with the Cloud Feedback Model Intercomparison Project (from WGCM/WCRP), and the ENSEMBLES project gives significant inputs to the CFMIP phase 2 plans, for instance via the organization of a joint CFMIP/ENSEMBLES workshop held in Paris in April, 2007 (see deliverable D4.1.3 and http://www.cgam.nerc.ac.uk/research/ensembles-rt4/meetings/meetings.html). In this frame, the importance of developing specific tools to make quantitative comparisons between model results and satellite observations was highlighted. A CFMIP Observational Simulator Package (COSP) has been developed that currently includes 5 satellite instruments. The ENSEMBLES project contributes to two of them, the Calipso and Parasol simulators (Chepfer et al., 2008). Compare to previous cloud climatology, such as the ISCCP climatology, the added value is very important (Fig. 5): the low level clouds are much better detected with Calipso, and there is only small changes between the low level cloud cover diagnose by the Calipso simulator and the actual low level cloud cover simulated by the model (compare Fig3-e and Fig3-i).

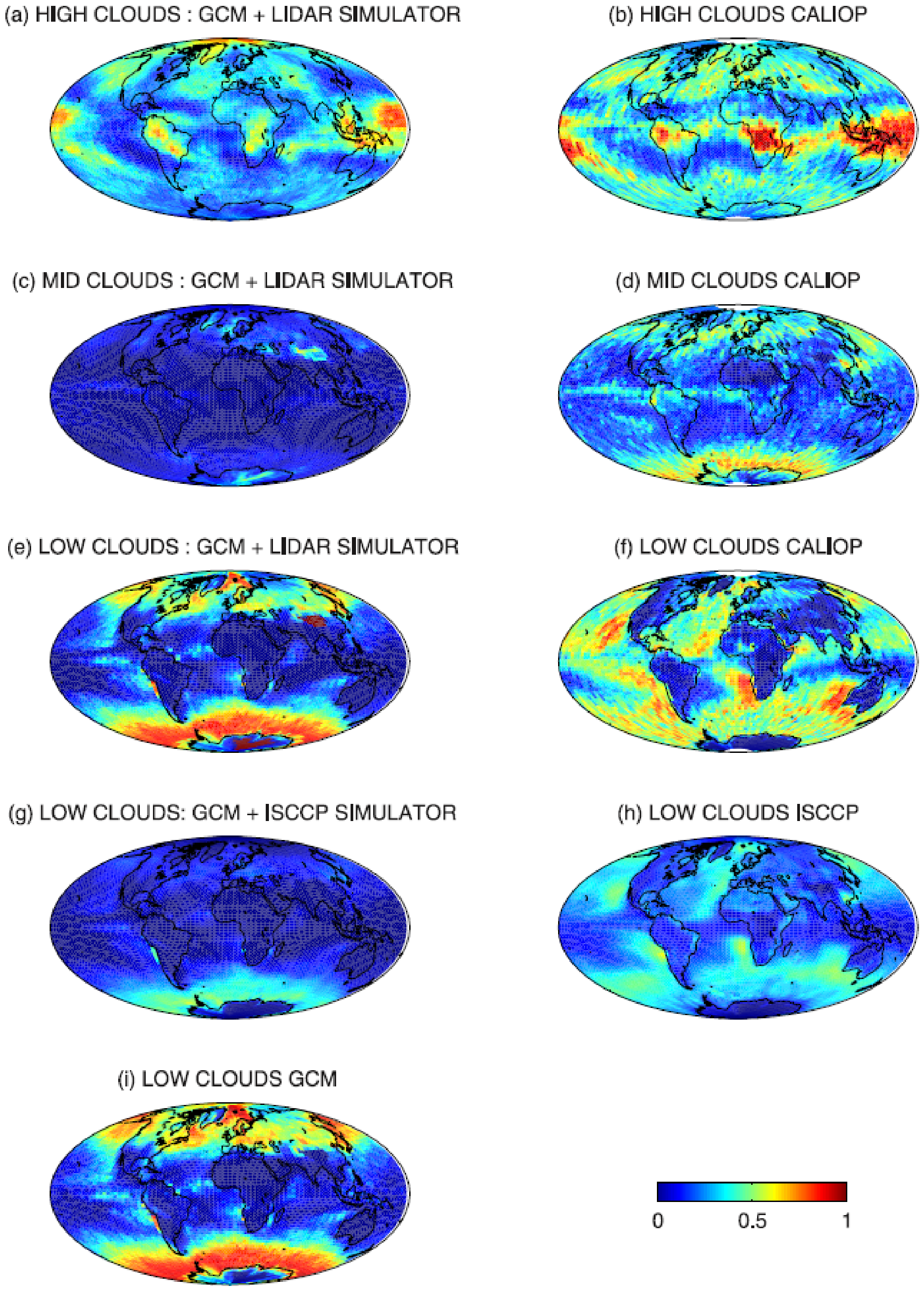

Fig 3: Low-level cloud fractions averaged for the January-February-March season. (a) The cloud fractions actually predicted by the GCM, (b) the cloud fractions derived from the lidar simulator and (d) from CALIOP/CALIPSO observations using similar consistent criteria. Also reported at the bottom is (c) the low-level cloud fraction derived from ISCCP-D2 data and (e) that diagnosed from the ISCCP simulator.

To ensure the consistency between the outputs of the Calipso simulators and the measurements of the Calipso satellite, a specific "GCM Oriented Calipso Cloud Product" (GOCCP) has been developed (Chepfer et al., 2009). This COSP simulator will be used by climate models when running the simulations recommended by the CMIP-5 project to support the preparation of the IPCC fifth assessment report.

The tools and the methods developed within the ENSEMBLES project will therefore be widely used in the next few years to better asses the climate feedbacks, and in particular to better assess the 3D cloud cover as simulated by the various GCMs.

References:

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