PROJECT PERIODIC REPORT

Grant Agreement number: 244067

Project acronym: EUCLIPSE

Project title: EU Cloud Intercomparison, Process Study & Evaluation Project

Funding Scheme: FP7

Date of latest version of Annex I against which the assessment will be made:

Periodic report: 1st X 2nd ☐ 3rd ☐ 4th ☐

Period covered: from 1 February 2010 to 31 July 2011

Name, title and organisation of the scientific representative of the project's coordinator[1]:

Prof. Dr. A.P. Siebesma, KNMI

Tel: +31 30 2206760

Fax: +31 30 2210407

E-mail: siebesma@knmi.nl

Project website[2] address: http://www.euclipse.eu

---

[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement .

[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate) [3]:

  ☐ has fully achieved its objectives and technical goals for the period;

  X has achieved most of its objectives and technical goals for the period with relatively minor deviations.

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable

  X is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Prof. Dr. A.P. Siebesma

Date: September 29, 2011

For most of the projects, the signature of this declaration could be done directly via the IT reporting tool through an adapted IT mechanism.

[3] If either of these boxes below is ticked, the report should reflect these and any remedial actions taken.

3.1 Publishable summary

Objectives:
Cloud Feedbacks in Earth System Models (ESMs) remain the largest source of uncertainty in projections of future climate. Consequently, the central challenge of EUCLIPSE is:

to determine, understand and reduce the uncertainty due to cloud-climate feedback.

In order to respond to this challenge, EUCLIPSE represents a focused multi-disciplinary by fostering coordinated research in the area of cloud processes in relation to climate change. The specific objectives of EUCLIPSE to achieve this challenge are:

- Evaluation of cloud processes in Earth System Models.
- Development of physical understanding of how cloud processes respond and feedback to climate change.
- Development of a metric to measure the relative credibility of the cloud feedbacks by different Earth System Models.
- Improvement of the parameterization of cloud related processes in current Earth System Models.

Context:
Earth system models (ESMs) are our major modelling tools used to address how our climate will respond to increasing greenhouse gases such as atmospheric carbon dioxide. Nevertheless, the global warming of the various ESM's that participated in the World Climate Research Programme's (WCRP) third phase of the Coupled Model Intercomparison Project (CMIP3) in support of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) exhibit a large spread of global equilibrium temperature ranging from 2.3 to 4.2 K as a response of carbon dioxide doubling (see Figure 1).

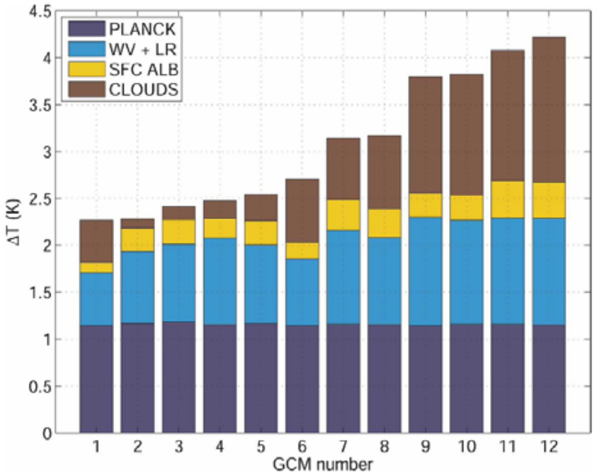

Figure 1*. (source Dufresne and Bony, J. of Climate 2008)*

The global warming of each ESM can be broken down into different contributions: i) direct warming due to doubling of carbon dioxide (dark blue) only, ii) enhanced warming due to an increase of water vapour in the atmosphere, the so called water vapour feedback (light blue), iii) enhanced warming due to an decrease of the Earth's surface albedo as an result of decreasing ice coverage (yellow) and iv) an enhanced warming due changes in cloud amount and cloud properties, also known as the cloud feedback (brown). This analysis illustrates one of the main conclusions of the latest IPCC report (IPCC AR4 SPM 2007):

"Cloud effects remain the largest source of uncertainty in model based estimates of climate sensitivity."

Clouds are also a major contributor to uncertainty in other feedbacks (e.g., surface albedo, carbon cycle) in the Earth System. Through interactions with the large-scale circulation, cloud processes also contribute to synoptic circulations and regional climate. They are therefore critical to the prediction of future changes in precipitation patterns, climate variability and extreme events.

In EUCLIPSE, four distinct communities will work together across a set of integrated work packages over a four-year period: the observational community will provide state-of-the-art measurements from ground- and space-based active and passive remote sensing; the numerical weather prediction community will provide analyses of short timescale model biases induced by cloud processes; the cloud modeling community will provide fine-scale models as an additional tool for understanding cloud behavior in a changing climate; finally, the climate modeling community will synthesize the physical understanding and observational constraints identified by the other communities to improve the representation and assessment of cloud processes in ESMs and so improve the predictive skill of ESMs.

Main Results Achieved So far

During the first 18 months period of the project the majority of the foreseen deliverables have been achieved. This work has taken place mostly in Work Package 1 (WP1) and Work Package 3 (WP3) during this period.

The activities in WP1 of EUCLIPSE focuses on three main objectives:

The first one was to prepare and implement into EUCLIPSE ESMs the latest versions of the CFMIP Observational Simulator Package (COSP). This objective has been accomplished: a final operational version of COSP has been finalised and this COSP version has been implemented in all 5 ESMs that participate within EUCLIPSE. This will be a key tool that allows for the first time an objective evaluation of the vertical structure of clouds using the satellite products of the A-train

The second objective was to collect, improve and make available to the ESM groups, evaluation tools and packages that will facilitate the process-based evaluation of the model output. Also this objective has been accomplished. On the EUCLIPSE website (www.euclipse.eu/downloads/ESM_Evaluation_Toolkit.htm) a simple portal has been created with links to the various tools and a description document.

The third objective was to execute the global model and to produce the and store the output of the simulations such as required by CMIP5 . All ESMs have implemented the required diagnostics and the majority of the required ESM runs have been finished (see Table 1 in the scientific report). It is expected that the remaining runs are completed November 2011 well before the time limit set by CMIP5 so that all the output of the ESM simulations will be available and ready for the analyses that will go into the next IPCC report.

WP3 aims to evaluate how large-scale forcing conditions control cloud cover, cloud amount, precipitation, how these cloud properties influence the radiative budget and to what extend this is faithfully reproduced by the ESMs. The focus will be on the subgrid processes of boundary layer clouds that act on the grid scales of ESM (of the order of 100 km).

To this purpose we have created 5 representative cases. Three of those represent equilibrium states of distinct regimes: stratocumulus (S12), stratocumulus close to the transition to shallow cumulus (S11) and a shallow cumulus case (S6) . These three equilibrium cases are idealisations of observations over the North Pacific Ocean. In addition EUCLIPSE designed two so called transition cases that describe the transition from stratocumulus to shallow cumulus in a Lagrangian setting following the trade winds from the subtropical ocean toward the equator. One of the transition cases is based on observations over the Atlantic Ocean and the other on observations over the Pacific Ocean. All these cases have been successfully simulated with 3 high resolution Large Eddy Simulation (LES) models from the EUCLIPSE project and with 2 LES models from American institutes . The intermodel spread and deviations from observations are small enough so that this suite of LES results can be used as a critical benchmark for the Single Column Model (SCM) versions of the ESMs. All the 5 institutes that participate in EUCLIPSE with ESMs have run the same cases with SCM versions of their ESMs. Preliminary analyses indicate a large spread in the parameterized cloud properties for most of the SCMs. Further in depth analysis of these cases will provide insight in the physical mechanisms of the parameterizations used in these SCMs.

As a proxy of how the boundary layer cloud types will respond in a future climate we have repeated the 3 equilibrium runs forced with a higher sea surface temperature (SST) and with a lower subsidence. These are both robust changes that are believed to occur in the (sub)-tropical regions over the oceans in a warming climate.

The Large Eddy Simulations results suggest that i) the equilibrium results of the shallow cumulus clouds for the perturbed climate are almost identical to the control case indicating that these clouds do not contribute to a strong cloud feedback signal ii) for the stratocumulus cases the situation is more subtle: the LES models indicate a cloud feedback strength ranging from -10W/m^2 to +10W/m^2. If no weakening of the subsidence is assumed so that only a warming of the SST is assumed, all LES models predict a small positive cloud feedback. This shows how subtle the cloud response depends on the change of the large scale forcing (i.e. subsidence strength) in a warming climate. So in conclusion it appears that the for the equilibrium cases of interest show no (shallow cumulus) to a small cloud feedback strength (stratocumulus) though the sign of the latter is still unknown. Further research will be concentrated of extending this research by exploring a whole phase space of equilibrium cases rather than just 3 isolated cases and perturbing all these cases with different SST and subsidence changes. The SCM results on the other hand give a much wider spread in cloud feedback ranging from +20 to -20 W/m2 for all three cases, evidently much larger than suggested by LES results which are our most accurate tool to investigate the cloud feedback as a response to a perturbed climate.

These results suggest that the largest impact might be expected from a change in probability of occurrence of shallow cumulus and stratocumulus rather than changes in the regimes themselves. This reinforces the importance of investigating the transition from stratocumulus to cumulus as is one of the main interests of WP3. The LES results show a good agreement for both transition cases in the timing of the transition, indicating that the transition might be a simpler problem than the equilibrium solutions.

Probably the most important intermediate conclusions at this point is therefore that:

shallow cumulus clouds (the dominant cloud type in our atmosphere) appear to be rather insensitive to realistic SST and subsidence perturbations suggesting a low cloud feedback for this cloud type which appear to be in clear contradiction with the behaviour of these clouds such as parameterised in many ESMs.

A final achievement is the creation of a comprehensive observational data set of the atmospheric column for three European Atmospheric Profiling Stations for a 2 year period. In the next phase of EUCLIPSE these data sets will be used to evaluate the ESMs. This will happen for the free climate model runs but also in a more constraint mode by running them in a numerical weather forecast mode and in a SCM mode. This way it will be possible to separate model errors due to the large scale dynamics from errors due to the physical (cloud) parameterizations.

Project Consortium:
EUCLIPSE is a collaborative effort of 12 European partners. The Management Board of the EUCLIPSE project is made up of the following persons: A. Pier Siebesma (Royal Netherlands Meteorological Institute, coordinator), Sandrine Bony (Institute Pierre Simon Laplace), Bjorn Stevens (Max Planck Institute for Meteorology), George Tselioudis (Academy of Athens), Stephan de Roode (Delft University of Technology),. The EU project officer is Dr. Claus Brüning (European Commission, DG Research). The principle investigators of the other project partners are: Mark Webb, Mark Ringer Alejandro Bodas (Met Office), Frank Selten, Roel Neggers (KNMI), Johannes Quaas (MPI-Hamburg), Helene Chepfer, Frederique Cheruy, Jean-Louis Dufresne, Eric Guilyardi, Frederic Hourdin (CNRS-IPSL), Anastasia Romanou (Academy of Athens), Tim Palmer, Mark Rodwell (ECMWF), Harm Jonker (TU Delft), Hervé Douville, Isabelle Beau, Gilles Bellon, Dominique Bouniol, Francois Bouyssel, Michel Déqué, Françoise Guichard (Météo France), Gunilla Svensson, Michael Tjernstrom (Stockholm University), Ulrike Lohmann (ETHZ), Hanna Pawlowska (University of Warsaw), Michael Lautenschlager (DKRZ).The Advisory Board of EUCLIPSE is made up of the following persons: Christian Jakob (Monash University, Australia), Graeme Stephens (JPL NASA, USA), Ghassem Asrar (WCRP, Switzerland), Susanne Crewell (Cologne University). The Project Office at KNMI (The Netherlands) which is responsible for the routine administration of the project and the scientific direction, is staffed by Karin van der Schaft and A. Pier Siebesma.

Project Website:
http://www.euclipse.eu

3.2 Core of the report for the period: Project objectives, work progress and achievements, project management

3.2.1 Project objectives for the period

The EUCLIPSE Objectives are

Project Management:

- Manage efficiently the project.
- Communication between the European Commission and EUCLIPSE, including all forms of reporting specified in the consortium contract agreement.
- Provide the communication tools for the project: public and internal web sites.
- Organise annual general assemblies and project meetings.
- Ensure promotion of clustering and cooperation with related projects (both in FP7 and other international and national projects).

WP1

- Complete the development of the CFMIP Observation Simulator Package (COSP) and implement the package in the code of the ESMs that are participating in CMIP-5 and CFMIP-2.
- Collect existing model evaluation techniques and assess them in terms of their ability to resolve atmospheric processes responsible for cloud formation and water cycling. Improve existing techniques and make them available for application to observational retrievals and to EM output.
- Execute a suite of ESM simulations that include current-climate conditions, perturbed climate warming conditions, and idealised aqua-planet simulations. Implement model diagnostics packages that facilitate the application of process-based model evaluation techniques. Ensure cooperation with related projects, both in FP7 and in other international and national projects.

WP3

- To conduct dedicated high resolution simulations with Large Eddy Simulation (LES) models and SCMs that will provide further insight in the cloud dynamical processes
- To evaluate ESMs experiments with observations for key cloud regimes on selected locations for present climate
- To analyse the response of boundary layer clouds in idealised and future climate conditions through the use of LES models and SCMs

3.2.2 Work progress and achievements during the period

<u>WP1: Evaluation Techniques and Climate Model Experiments</u>

Introduction

The work in WP1 of EUCLIPSE focused on addressing three main objectives. The first was to prepare and implement to EUCLIPSE ESMs the latest versions of the CFMIP Observation Simulator Package (COSP), the second to collect, improve, and make available to the ESM groups model evaluation tools and packages that will facilitate the process-based evaluation of the model output, and the third, to execute the global model runs implementing the diagnostics that are necessary to better perform model analysis and evaluation studies. In other words, WP1 work was meant to produce a suite of tools and model output that can be subsequently used by the other Work Packages to study cloud feedbacks processes and their climate effects.

It is important to note here that, despite the well-defined time limits that were set for the completion of the different WP1 tasks, improvements and refinements of the work reported here will continue throughout the duration of the project. As will be detailed in this report, the basic foundation of both the model runs and the tools and diagnostics was completed in the predetermined limits. This enables the other work packages to begin their work in the scheduled timelines. However, both the suite of model simulations and that of the evaluation tools and observations will continue to be updated as the program progresses. It is also crucial to report that WP1 established a close collaboration between the modelling groups that participate in EUCLIPSE through the establishment of a monthly teleconference session that has been taking place on the first Friday of each month. This session fosters a close collaboration between the groups and allows the transfer of know-how in difficult technical issues such as the implementation of the simulators in the climate model code.

The report that follows will be structured along the three main tasks outlined in the beginning paragraph. For each task, an outline of the work performed will be provided and some representative examples of that work will be illustrated. Emphasis will be given on the completion of the deliverables that were detailed in the proposal. It must be noted, however, that all work performed in the work package is stored in the EUCLIPSE web page in the form of reports, software packages, and databases. This makes the work easily accessible by any interested parties.

WP1.1. Development and Implementation of the Satellite Simulator Software

The CFMIP Observation Simulator Package (COSP) includes currently simulators for several A-Train instruments as well as ISCCP retrievals. Small changes to remove bugs were made to the software and Version 1.3 of COSP was posted on the CFMIP web site (http://cfmip.metoffice.com/COSP.html) in May 2010, thus fulfilling on time *Deliverable 1.1*. This new production version was designed for implementation in CMIP5 experiments (inline and offline). It contained several bug fixes and changes to make it work with the MIP tables released by PCMDI. An updated version of the user's manual was also included. Since the original posting, two new versions of the software package were introduced in order to deal with bugs discovered in the implementation phase. The latest version (1.3.2) can be run in two different configurations. In-line, implemented within the numerical model, and off-line as stand alone software. In the in-line implementation, COSP is called from within the model in run-time, and the outputs are passed to the model’s standard output system. For the off-line version, instantaneous COSP inputs have to be generated from the model, and then COSP is run independently.

The latest version of COSP was implemented in the GCMs participating in EUCLIPSE, in fulfilment of *Deliverable 1.3*. These are the institutes that participated in this task:

- UK Met Office (UKMO),
- Laboratoire de Météorologie Dynamique/Institut Pierre Simon Laplace (LMD/IPSL),
- Max-Planck Institut für Meteorologie (MPI-M),
- Météo-France Centre National de Recherches Météorologiques (MF-CNRM),
- Koninklijk Nederlands Meteorologisch Instituut (KNMI).

These centres are running the following models as part of EUCLIPSE:

- UKMO: HadGEM2
- LMD/IPSL: LMDZ5
- MPI-M: ECHAM6
- MF-CNRM: CNRM-CM5
- KNMI: EC-Earth

COSP was implemented both off- and in-line at UKMO, in line at KNMI, and off-line in the other three modelling centers. The technical work of the implementation was aided significantly by the monthly teleconferences established by WP1, which enabled the group at UKMO (Bojas, Webb) to provide technical assistance to the rest of the modelling groups. A full report, entitled 'Report on the implementation of ESM versions with COSP software, was posted on the EUCLIPSE web site (http://www.euclipse.eu/products.html) in April of 2011, fulfilling the requirement for Deliverable 1.3. The report shows examples of the COSP outputs for the different models, with figures showing outputs from the three instrument simulators (ISCCP, CALIPSO and CloudSat) from which outputs are requested for the EUCLIPSE experiments. They show global and tropical (15° S-15° N) averages of the following variables:

- ISCCP: histograms of cloud top pressure versus optical depth
- CALIPSO: histograms of scattering ratio as a function of height
- CloudSat: histograms of radar reflectivity as a function of height

Here an example is shown of representative COSP output from a run of HadGEM2. Figure 2 shows COSP outputs from one July of an atmosphere-ocean coupled simulation of HadGEM2 with preindustrial forcings. The left-hand side column shows globally-averaged results, and the right-hand side column shows averages over the tropical belt (15° S-15° N): (a,b) ISCCP histograms, (c,d) CALIPSO histograms, and (e,f) CloudSat histograms.

In addition to the more complex COSP package, a simpler simulator of MODIS products was constructed by MPI (Quaas). The simulator allows for a comparison of climate-model simulated cloud and aerosol fields with retrievals by MODIS and other space borne passive radiometers. The tool considers three steps: (i) the sampling of cloud-top quantities using the model's cloud overlap hypothesis, (ii) the satellite instrument sensitivity by discarding clouds with little cloud fraction or optical depth, and (iii) the diurnal sampling by taking into account the satellite overpass time for polar-orbiting satellites. The tool is easy to implement and easy to use, and has been tested widely.

A report entitled 'MODIS-simulator for process-oriented climate model evaluation' was posted on the EUCLIPSE web site (http://www.euclipse.eu/products.html) in January of 2011, in partial fulfilment of *Deliverable 1.2*. The report explains the structure and functionality of the simulator and provides the simulator code.

In addition to the COSP and MODIS simulator packages, a CALIPSO-PARASOL observational analysis product was created by LMD. The GCM Oriented Cloud Calipso Product (CALIPSO-GOCCP) is designed to evaluate GCM cloudiness. CALIPSO-GOCCP contains observational cloud diagnostics fully consistent with the ones simulated by the ensemble "GCM+ CALIPSO simulator" (COSP-CAPSIM): same spatial resolution for the lidar profile before the cloud detection, and same cloud detection threshold. CALIPSO-GOCCP is derived from CALIPSO Level 1 NASA product. A report entitled 'CALIPSO-GOCCP product' was posted on the EUCLIPSE web site (http://www.euclipse.eu/products.html) in January of 2011, that completes the fulfilment of *Deliverable 1.2*. The report explains the structure and character of the data and provides the link to the full dataset.

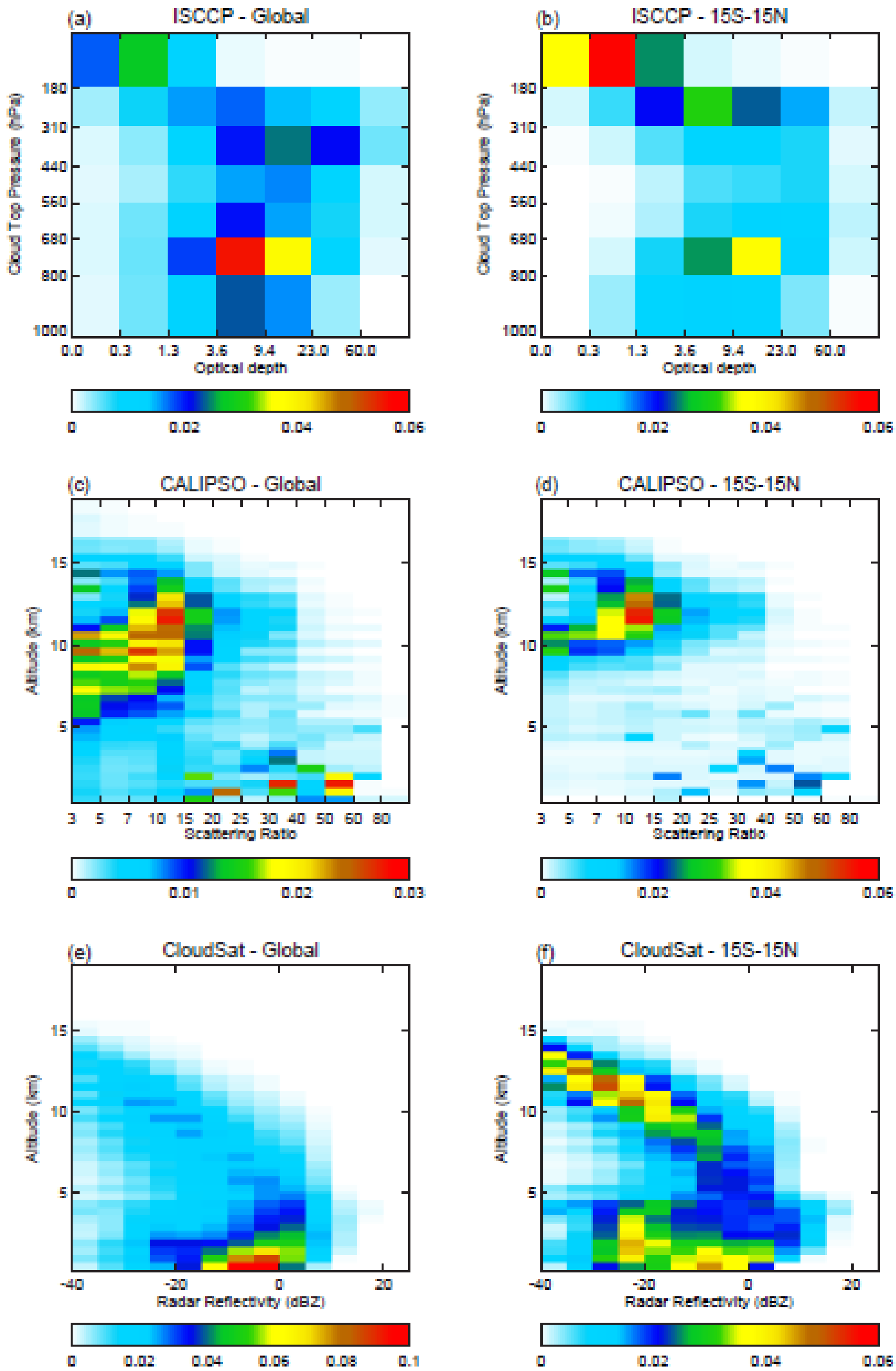

Figure 2. *COSP outputs from one July month of an atmosphere-ocean coupled simulation of HadGEM2 with preindustrial forcings. The left-hand side column shows globally-averaged results, and the right-hand side column shows averages over the tropical belt (15^{o}S-15^{o}N): (a,b) ISCCP histograms, (c,d) CALIPSO histograms, and (e,f) CloudSat histograms.*

WP1.2 Development of Diagnostic Techniques

In addition to the use of simulators to create model outputs comparable to the observational retrievals, the process-based evaluation of models requires the application of methodologies that divide model and observational outputs into regimes that have physical meaning. This way, model deficiencies in a particular regime can be better attributed to the physical processes that are dominant in that regime. Several methods have been used lately to examine cloud and precipitation variability in the context of such regimes. The methods include compositing, where one or more atmospheric properties are used to define regimes and composite cloud and precipitation properties in them, and clustering, where multiple cloud properties are used to define cloud structures corresponding to particular regimes. In the context of WP1 an effort was undertaken to first create a survey of existing model evaluation techniques that put emphasis in resolving the processes involved in cloud formation and water cycling. A report entitled 'Survey of Model Evaluation Techniques' was compiled and is stored on the EUCLIPSE web site in fulfillment of *Deliverable 1.5.*

Since several of the compositing and clustering techniques have been developed by participants in EUCLIPSE, improvements and tunings were applied to some of those techniques by participating groups. An improved version of the method to identify midlatitude storms and their area of influence was created that includes better attribution of the grid points affected by more than one storm centers (AA). In addition, techniques were developed that correlate cloud properties derived from PARASOL and CALIPSO retrievals (LMD). Finally, a toolkit with model evaluation methodologies was created and posted on the EUCLIPSE web site, in order to complete fulfilment of *Deliverable 1.5*. A list of the collected process-based methods along with links to the sites hosting them is provided below.

Correlation between cloud properties

- 2D histogram of instantaneous cloud reflectance (PARASOL) and cloud fraction (CALIPSO):
  ftp://ftp.climserv.ipsl.polytechnique.fr/cfmip/goccp/MULTI-SENSORS/CRef/ref_cf.m

- Relationship between instantaneous cloud reflectance (PARASOL) and vertical profile of cloud fraction (CALIPSO):
  ftp://ftp.climserv.ipsl.polytechnique.fr/cfmip/goccp/MULTI-SENSORS/CRef/cf3d_ref.m

- Joint height-SR histogram of Scattering Ratio (CALIPSO):
  ftp://ftp.climserv.ipsl.polytechnique.fr/cfmip/goccp/SR_histo/SR_histo.m

Clustering methods

- Mean Cloud Top Pressure (CTP) - Cloud Optical Depth (τ) clusters (ISCCP):
  http://isccp.giss.nasa.gov/climanal5.html

- Cloud Regime Error Metric describing the ability of models to simulate the correct radiative properties and frequency of occurrence of large-scale cloud regimes:
  http://cfmip.metoffice.com/codes.html

Compositing methods
- Climatology of Midlatitude Storminess, allowing to composite cloud properties in the area of influence of midlatitude storms
http://gcss-dime.giss.nasa.gov/mcms/mcms.html

– Tropical El Niño Southern Oscillation Anomaly Database:
http://gcss-dime.giss.nasa.gov/ARRA/arra.html

It must be noted here that the evaluation toolkit will be continuously updated during the lifetime of the project, as corrections to the existing methods will be applied and new methods will be created.

WP1.3. Planning, Organization, and Archival of ESM simulations

EUCLIPSE ESMs have been performing a hierarchy of experiments, in particular those proposed by CFMIP-2 as part of the CMIP-5 coordinated experiments. The initial suite of EUCLIPSE climate experiments was performed in the context of WP1. Models are been run with atmosphere-only configurations and with prescribed Sea Surface Temperature (SST) patterns. The experiments include: a) Control AMIP simulations using interannually varying observed SSTs, b) 'Hansen' CO2 forcing experiments with SSTs from the control run and 4xCO2, c) SST perturbation experiments using a pattern based on a composite of CMIP3 AOGCM CO2 quadrupling experiments, d) uniform +4K SST perturbations e) Aqua-planet experiments using an idealised zonal mean climatology for the control, with 4xCO2 and uniform +4K perturbation experiments. In addition to those runs that are the focus of the CFMIP and EUCLIPSE programs, WP1 participants coordinated and monitored the progress of the rest of the CMIP-5 experiments performed by the participating modelling groups.

Additional diagnostics have been implemented within EUCLIPSE ESM model runs. One primary set of such diagnostics is the output from the COSP simulator. The set of simulator output variables for short periods (1-3 years) includes a lightweight set of basic simulator diagnostics, but in addition requires joint height-reflectivity distribution of CloudSat radar outputs, joint height-lidar scattering ratio distribution of lidar outputs, as well as cloud frequency of occurrence as seen by CALIPSO but not CloudSat, required for studies making combined use of CloudSat/CALIPSO simulator output.

For a 1-year period of the AMIP control experiment, 3-hourly global instantaneous outputs are produced. These experiments will allow the process modelling groups in WP3 to examine the representation of cloud processes by GCMs in the current climate in any climate regime or meteorological situations without imposing *a priori* geographical constraints. In addition, for several years of the AMIP control run, 3-hourly outputs are produced along a few transects (e.g. GCSS/WGNE-Pacific Cross-section Intercomparison - GPCI, VOCALS) or locations for which a large number of observations will be available (satellite data for GPCI, field campaign for VOCALS, long-time series of ground-based observations for ARM or CloudNet instrumented sites).

WP1 has been closely monitoring the progress of both CFMIP-specific and CMIP-5 runs through regular submissions of progress reports by the different partners. As a result, a complete inventory of model run progress was created and has been continuously updated. This inventory is posted on-line at: cfmip.metoffice.com/cfmip2_status.html, and includes the progress both in terms of the runs and the produces sets of diagnostics. In order to summarize some aspects of those extensive reports, Table 1 shows progress of the different modelling groups in the four core experiments of the CFMIP/EUCLIPSE projects.

It can be seen that the vast majority of the diagnostics from the four core simulations have either been already posted in the DKRZ data portal or are completed and in the process of been submitted to the portal. Below, a brief summary of progress of the CMIP-5 simulations for all WP1 participating group is presented.

UKMO. All of the EUCLIPSE experiments which were marked as high priority are completed, and basic outputs from these were made available on the ESG in May 2011. We are working our way through the remaining data conversions, and delivered all of the monthly CFMIP outputs from these experiments to the BADC ESG node in August. We expect to complete the process by the end of 2012.

CNRM. All CFMIP2 experiments have been completed and most basic outputs, including COSP, have been published on the CNRM ESG data node (table cfOff is still missing). All CMIP5 simulations have been also completed and all land surface and atmospheric outputs have been also published on ESG. No COSP outputs will be produced for these coupled simulations.

At the **DKRZ** the storage area of 50 TByte space for storing model output data was implemented. The access is possible by sftp. For all participants a user account was created within the appropriate DKRZ project. Beyond the CMIP5 project there will be some extra output done by extra post processing. The objectives for this post processing are developed by Euclipse WP2. All participants are able to transfer their data into the institutes' directory space, all other users are able to read and download them using sftp. There are two DELL blades (Quad Core Opteron) available as storage and computing resources for the Euclipse project. Their actual urls are EUCLIPSE1.dkrz.de (available) and EUCLIPSE2.dkrz.de (can be made available on demand in the near future).

LMD. All EUCLIPSE simulations have been run with the IPSL-CM5A-LR GCM, and many CFMIP outputs are already available on the ESG. We had to re-run some of the simulations to extract some particular diagnostics that were either not computed the first time (e.g. 4xCO2 2D and 3D radiation diagnostics, station data) or not archived within the first ensemble of outputs (e.g. some 3D physical tendencies). Some of these simulations are now completed (e.g. AMIP), others are running. As soon as these additional outputs will be CMORized, they will be made available on the ESG. What also remains to be done is to run COSP offline for the year 2008, with all simulators activated (for the moment, only daily and monthly COSP outputs computed in-line for CALIPSO, PARASOL and ISCCP are available on the ESG) and the outputs in orbital format. We are currently working on this, and we plan to make the outputs available on the ESG by the end of 2011 or early 2012.

Experiment Name and Description	Experiment number	CFMIP monthly 3D (A1c_cfmip)	CFMIP monthly 4xCO2 2D	CFMIP monthly 4xCO2 3D	CFMIP monthly inline (A1d,f,g)	CFMIP monthly offline (A1e)	CFMIP daily 2D (A2a,c,f)	CFMIP daily 3D (A2b,d,g)	CFMIP 3-hourly orbital offline (A2e)	CFMIP 3-hourly inline (A4)	CFMIP time-step station data (A3)
AMIP (1979-at least 2008)	**3.3**	KNMI	KNMI	KNMI	KNMI	KNMI	KNMI	KNMI	KNMI	KNMI	KNMI
		CNRM	CNRM	CNRM	CNRM	CNRM	CNRM	CNRM	CNRM	CNRM	CNRM
		IPSL	IPSL	IPSL	IPSL	IPSL	IPSL	IPSL	IPSL	IPSL	IPSL
		MPI	MPI	MPI	MPI	MPI	MPI	MPI	MPI	MPI	MPI
		UKMO	UKMO	UKMO	UKMO	UKMO	UKMO	UKMO	UKMO	UKMO	UKMO
4xCO2 AMIP AMIP (1979-2008) conditions (expt. 3.3) but with 4xCO2	**6.5**	KNMI			KNMI	KNMI	KNMI	KNMI	KNMI		KNMI
		CNRM			CNRM	CNRM	CNRM	CNRM	CNRM		CNRM
		IPSL			IPSL	IPSL	IPSL	IPSL	IPSL		IPSL
		MPI			MPI	MPI	MPI	MPI	MPI		MPI
		UKMO			UKMO	UKMO	UKMO	UKMO	UKMO		UKMO
AMIP plus patterned anomaly consistent with CFMIP, patterned SST anomalies added to AMIP conditions (expt. 3.3)	**6.6**	KNMI			KNMI	KNMI	KNMI	KNMI	KNMI		KNMI
		CNRM			CNRM	CNRM	CNRM	CNRM	CNRM		CNRM
		IPSL			IPSL	IPSL	IPSL	IPSL	IPSL		IPSL
		MPI			MPI	MPI	MPI	MPI	MPI		MPI
		UKMO			UKMO	UKMO	UKMO	UKMO	UKMO		UKMO
AMIP plus 4K anomaly as in expt. 3.3, but with a uniform 4K increase in SST	**6.8**	KNMI			KNMI	KNMI	KNMI	KNMI	KNMI		KNMI
		CNRM			CNRM	CNRM	CNRM	CNRM	CNRM		CNRM
		IPSL			IPSL	IPSL	IPSL	IPSL	IPSL		IPSL
		MPI			MPI	MPI	MPI	MPI	MPI		MPI
		UKMO			UKMO	UKMO	UKMO	UKMO	UKMO		UKMO

Not planned	
Planned	second half october
Run	finished by half october
Available	

Table 1 : Overview of the progress of the different modelling groups in the four core experiments of the CFMIP/EUCLIPSE project

EC-Earth. History and scenario runs with the coupled configuration of EC-Earth version 2.3 for CMIP5 have just been completed. Now the post-processing of the standard output files using CMOR is done. Meanwhile the modifications to the code for the EUCLIPSE runs with version 2.3 have been merged and the group is verifying the results before starting the actual runs.

It must be emphasized here that CMIP-5 has been a unique exercise, unprecedented in both the number of model runs as well as the size of the saved diagnostics. As a result, delays have been occurring with all modelling groups around the world participating in the program. Coordination through EUCLIPSE has allowed the European program partners to coordinate their efforts and facilitate the running of the experiments, particularly those in the core of the CFMIP/EUCLIPSE programs.

WP2 : Climate Model Evaluation and Analysis

Introduction

The WP2 of EUCLIPSE entitled "Climate Model Evaluation and Analysis" has three main objectives: (1) to evaluate the climate models that will participate in the CMIP5 model intercomparison project, focusing on the representation of cloud processes, (2) to better understand the role of clouds in climate, both in present-day and in climate change, and (3) to better interpret inter-model differences in climate projections.

Although this WP has officially started on month 13 (February 2011), many EUCLIPSE participants have already started to work on it before the official start. The range of analyses undertaken, as well as promising preliminary results, have been presented during the EUCLIPSE/CFMIP/GCSS workshop held at the UK MetOffice (Exeter, GB) in June 2011. This report presents a synthesis and a short selection of these results, and discuss their relevance for the next Deliverables due on January and July 2012.

WP2.I. Evaluation of the representation of clouds in CMIP5 climate models (Task 2.1)

Thanks to the availability of new satellite data from space (CALIPSO, CloudSat, Parasol), and to the implementation of the CFMIP Observations Simulator Package (COSP) in EUCLIPSE climate models (cf WP1), it is now possible to compare model outputs with observations in a consistent way. Several presentations were given on this matter at the last General Assembly of EUCLIPSE in June 2011.

Alejandro Bodas-Salcedo (UK MetOfice) compared several EUCLIPSE models with CALIPSO, CloudSat, ISCCP, MISR and MODIS observations for the North Pacific region and suggested several common biases across models (lack of non-drizzling clouds, lack of supercooled clouds, etc; article accepted; see Figure 3). Christine Nam (LMD/IPSL) showed that several EUCLIPSE models were exhibiting compensating errors in the simulation of low-level cloud radiative effects owing to an underestimate of the low-cloud fraction and an overestimate of the cloud optical thickness, and tended to overestimate the occurrence of high-level clouds over boundary-layer clouds. Helene Chepfer (LMD/IPSL) presented a novel methodology aiming at characterizing and evaluating the optical thickness of clouds in climate models using a combination of PARASOL and CALIPSO observations (article in preparation). Yoko Tsushima (MetOffice) discussed how ISCCP and radiation budget satellite data could be used together with COSP outputs to develop cloud metrics for climate models. Richard Forbes (ECMWF) showed how CloudSat observations and COSP could be used to assess cloud processes in a weather forecast model, and discussed also the limitations. Romain Roehrig (LMD/IPSL) showed how a combination of space observations could be used to assess the influence of the vertical structure of large-scale dynamics on the clouds distribution and cloud radiative effects (article in preparation). Georges Tselioudis (University of Athens) presented a study where the influence of storm strength on precipitation and radiation budget at the top of the atmosphere is quantified in observations and in climate models using a clustering methodology. On-going studies focusing on the evaluation of polar clouds were not presented at the meeting but are on-going (Gunilla Svensson, MISU)

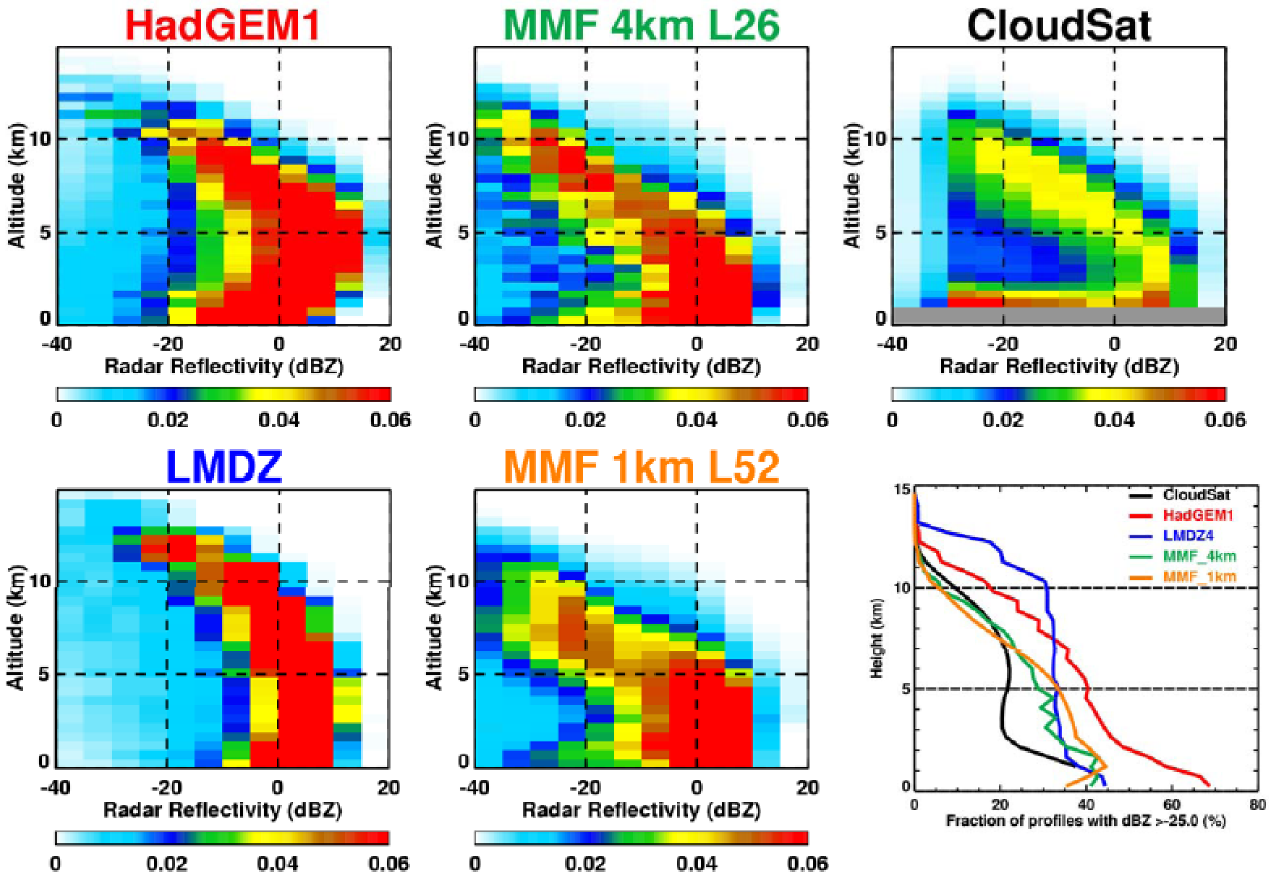

Figure 3. *Comparison of radar reflectivity-height histograms derived from CloudSat satellite observations and different climate models (using outputs from the COSP simulator) over North-Pacific. The lower-right panel shows the corresponding vertical profiles of hydrometeors. After Bodas-Salcedo et al. (2011).*

Deliverable D2.1 (due at month 30, i.e. July 2012) will synthesize the outcome of these different studies. The work (by J. Quaas and U. Lohmann) on cloud-aerosol interactions associated with Deliverable D2.2 (also due at month 30) has just started.

WP2.2 Investigation of the influence of the representation of cloud and moist processes in the simulation of prominent features of the current climate (Task 2.2)

Several on-going studies aim at unravelling the role of cloud processes in the simulation of the Inter-tropical convergence zone (ITCZ), in natural modes of variability of the tropical climate (intra-seasonal oscillations, ENSO..) and in temperature extremes over Europe.

Boutheina Oueslati (Meteo-France) presented an analysis of the reasons why some general circulation models run with similar boundary conditions predict either a single or several maxima of precipitation and mass convergence in the tropics (manuscript submitted). Eric Guilyardi (LOCEAN/IPSL) showed the role of atmospheric processes and cloud feedbacks in the simulation of ENSO in coupled ocean-atmosphere models. Julien Cattiaux (Meteo-France) presented a new methodology to quantify the relative role of dynamical and thermodynamical influences on the frequency of occurrence and the severity of heat waves in Europe. When applying this methodology to two

EUCLIPSE models and considering intraseasonal variations of weather regimes, he pointed out the predominant role of thermodynamical processes, suggesting an important role of cloud and radiative processes in the characteristics of European heat waves simulated by climate models (see Figure 4). Sandrine Bony (LMD/IPSL) showed that cloud radiative effects have a large influence on the strength of the tropical overturning circulation in the current climate, and proposed that the different EUCLIPSE modelling groups investigate this influence in a coordinated manner (to be discussed in 2011).

The advancement of these studies make us confident that Deliverable D2.4 (due at Month 24 or January 2012) will be delivered on time

WP2.3. Analysis and interpretation of the diversity of cloud-radiative feedbacks and precipitation responses produced by climate models in climate change simulations (Task 2.3)

The physical mechanisms underlying cloud-radiative feedbacks in climate change were investigated in several EUCLIPSE models, based on the wide range of model simulations , configurations (atmospheric, coupled ocean-atmosphere, aqua-planet, uni-column) and outputs (stations data, global outputs, COSP outputs) prepared for CMIP5 and CFMIP2 as part of WP1. CGILS simulations (i.e. climate change simulations performed in a uni-column, idealized framework using the same physical parameterizations as in CMIP5 climate simulations, cf WP3) were also used in several groups to explore these mechanisms in more depth and to assess the influence of the model tuning procedure on cloud feedbacks.

Mark Webb (MetOffice) discussed the importance of relative humidity changes above the trade inversion in the control of low-cloud feedbacks in the Hadley Centre model (manuscript in preparation), and analyzed the fast response of clouds to CO2 radiative forcing in several EUCLIPSE models. Florent Brient (LMD/IPSL) presented an interpretation of the positive low-cloud feedback predicted by the IPSL climate model, highlighting the importance of changes in the vertical advection of moist static energy in the control of boundary-layer clouds (manuscript submitted, Figure 5). Suvarchal Kumar (MPI) presented an analysis of low-cloud feedbacks in the ECHAM6 climate models using the CGILS framework. Bjorn Stevens (MPI) presented a physical mechanisms (supported by LES simulations) through which a positive cloud feedback may arise in a constant relative humidity atmosphere (manuscript submitted). The role of this mechanism in CMIP5 climate model simulations will be assessed later in the project. Mark Ringer (MetOffice) analyzed the timescales and reversibility of the cloud response to different external forcings. Sandrine Bony presented a new methodology to interpret the response of tropical precipitation to climate change, and the role of cloud radiative effects in this response (manuscript in preparation).

The diagnostic of cloud feedbacks and precipitation responses to climate change in ESMs being already on-going, we are confident that Deliverable D2.6 (due at month 24, i.e. January 2012) will be delivered on time.

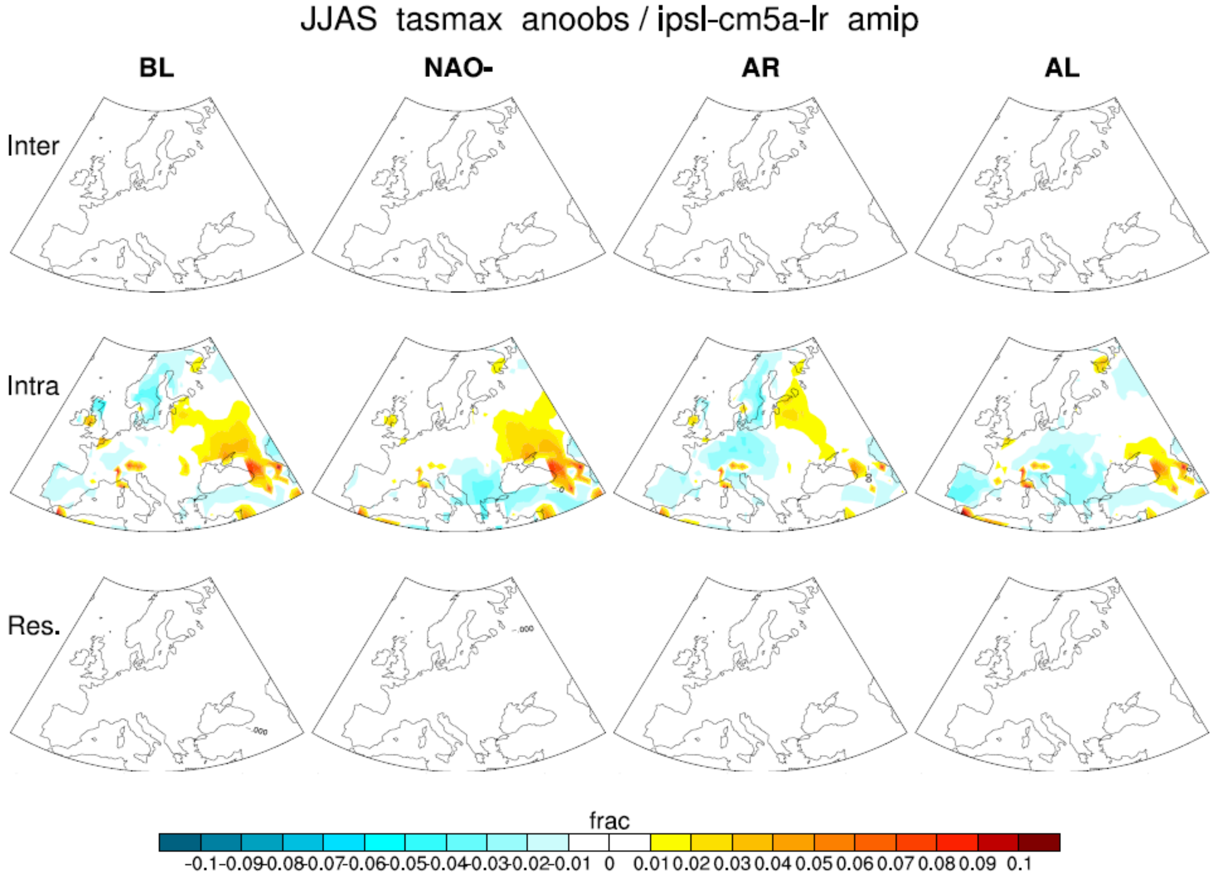

Figure 4. *Evaluation and analysis of the occurrence of temperature extremes during summer predicted by the IPSL-CM5A-LR climate model over Europe: the difference between the frequency of temperature extremes predicted by the model and that derived from observations (E-OBS) is shown for four predominant weather regimes (Blocking or BL, NAO-, Atlantic Ridge or AR, and Atlantic Low -or AL), and decomposed in two main contributions: one related to differences in the occurrence of the weather regimes themselves ("Inter"), one related to differences in the physical conditions associated with each regime ("Intra"). The second-order residuals are indicated by "Res". The figure shows that the model tends to overestimate the severity of heat waves over central Europe and to underestimate it elsewhere, and that most of the difference with observations comes from the physical conditions (e.g. the cloud cover) predicted by the model under specified weather regimes rather than from differences in the occurrence of the weather regimes themselves. Preliminary study from Cattiaux et al. (personal communication).*

.

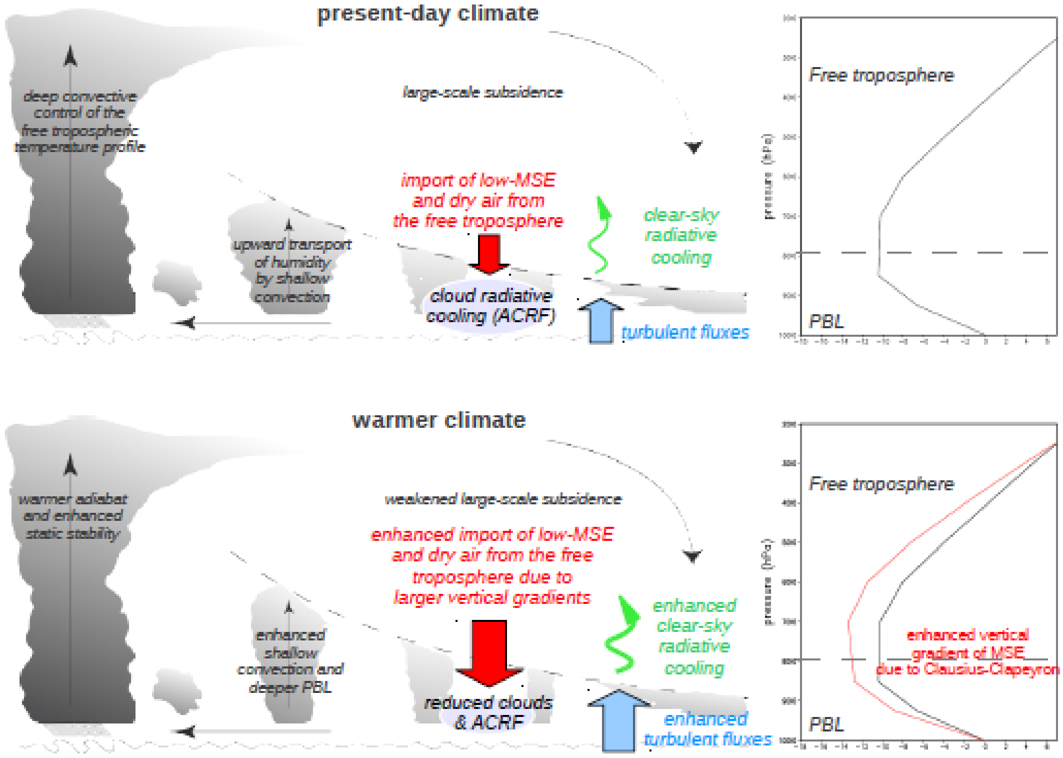

Figure 5. *Schematic of the physical mechanism explaining the positive low-cloud feedback of the IPSL-CM5A-LR ESM in climate change. The key role of changes in the vertical deficit of the atmospheric moist static energy (shown on the right of the figure) in the energy budget of the planetary boundary layer and the low-level cloudiness is highlighted. After Brient and Bony (2011).*

WP2 Conclusions, link to other WPs, and future plans :

As illustrated by this short report, WP2 activities are well on track. EUCLIPSE participants have started to work on the different tasks of WP2, and progress is expected on a number of issues:

- the evaluation of cloud processes in EUCLIPSE models
- the understanding of the influence of cloud processes on the tropical atmospheric circulation and natural variability, and in European heat waves.
- the physical understanding of low-cloud feedbacks in EUCLIPSE models
- the development of new and original approaches to interpret inter-model differences in cloud feedbacks and precipitation responses in climate change (these approaches are currently being applied to CMIP5 models)

Most of the work done in WP2 is based on coordinated numerical experiments and output diagnostics prepared in WP1 (global simulations from ESMs, OAGCM, atmospheric and aqua-planet models; COSP outputs; high-frequency model outputs over an ensemble of selected sites) and in WP3 (CGILS uni-column simulations, which turn out to be very helpful to understand 3D cloud feedbacks). Thanks to the analysis work carried out so far in WP2, several physical mechanisms have been identified as playing a key role in the control of low-cloud feedbacks. In WP3 it will be possible to assess these processes, and in WP4 it will be possible to design specific numerical experiments to assess the actual role of these processes in cloud feedbacks uncertainty, to investigate the dependence of these processes on model formulation, and to use observational constraints to revise uncertainty bounds of climate sensitivity.

In coordination among the different partners, several topics of joint analysis will be proposed for the next year:

1. the development of cloud-oriented metrics by selecting, among the many observational tests developed as part of WP2, the diagnostics that seem the most relevant for the evaluation of clouds in climate models (in particular to unravel compensating errors in models) or for constraining some components of climate change cloud feedbacks. It will contribute to Deliverable D2.3.
2. the assessment of the spread of radiative forcing and cloud feedback estimates among CMIP5 models, using different methodologies or different types of simulations. It will directly contribute to Deliverable D2.6.
3. the investigation of the impact of model tuning parameters on climate change cloud feedbacks using CGILS and/or CFMIP2 idealized climate change experiments (in collaboration with WP4). It will contribute to Deliverables D2.7 and D2.8
4. the study of the role of cloud radiative effects in the large-scale atmospheric circulation. It will contribute to Deliverables D2.7 and D2.8.

Publications published or submitted as part of EUCLIPSE:

Bodas-Salcedo, A., M.J. Webb, S. Bony, H. Chepfer, J.-L. Dufresne, S.A. Klein, Y. Zhang, R. Marchand, J.M. Haynes, R. Pincus, and V.O. John, 2011: COSP: satellite simulation software for model assessment. *Bull. Amer. Meteor. Soc.*, in press.

Brient F. and S. Bony: Interpretation of the positive low-cloud feedback predicted by a climate model under global warming. *Climate Dynamics*, submitted (July 2011).

Konsta, D., H. Chepfer, J-L Dufresne: A process oriented description of tropical oceanic clouds for climate model evaluation, based on a statistical analysis of daytime A-train high spatial resolution observations. *Climate Dynamics*, submitted (May 2011).

Rieck, M., L. Nuijens, and B. Stevens: cloud feedbacks in a constant relative humidity atmosphere. *J. Atmos. Sci.*, submitted (July 2011).

Oueslati B. and G. Bellon: Tropical precipitation regimes and mechanisms of regime transitions : contrasting two aquaplanet general circulation models, *Climate Dynamics*, submitted (June 2011).

WP3 : Process-Level Evaluation

Introduction

WP3 aims to evaluate how the large-scale forcing conditions control cloud cover, cloud amount, precipitation, and how these cloud properties influence the radiative budget and to what extend this is faithfully reproduced by the ESMs. The focus will be on the subgrid processes of boundary layer clouds that act on the grid scales of ESM (of the order of 100 km). To this purpose WP3 will use a bottom up approach and will concentrate on 3 themes:

1. on the shortest time scales of days, WP3 will conduct dedicated high resolution simulations and analyses with Large Eddy Simulation (LES) models and use the results to evaluate Single Column Model (SCM) versions of ESMs for stratocumulus, cumulus and transitions between these cloud types.
2. on the time scale of months ESMs will be evaluated with respect to key cloud regimes on selected locations for present climate.
3. to understand the cloud response in a perturbed future climate, SCMs and LES experiments will be done on selected cases in which the sea surface temperature is increased and the large scale subsidence is weakened as suggested by perturbed future climate model runs.

WP3.1 - Description of the set-up for the ASTEX and composite Lagrangian stratocumulus to cumulus transition cases, and the CGILS equilibrium state study (Month 12)

We will consider a transition case based on observations collected during the First Lagrangian experiment of the Atlantic Stratocumulus to Cumulus Transition Experiment (ASTEX) (Albrecht et al., 1995; Bretherton et al., 1995; De Roode and Duynkerke, 1997) Figure 6 shows a schematic of the observed transition during ASTEX. The observed breakup of the stratocumulus cloud can either be attributed to a weakening of the large-scale subsidence rate, or a gradual decrease in the inversion stability and a subsequent increase in the entrainment rate.

In addition to the ASTEX Lagrangian, we also consider a slow, intermediate and a fast transition based on composite observations as reported in Sandu and Stevens (2010). The initial conditions of the latter three cases differ mainly in terms of temperature and humidity jumps across the inversion layer. The availability of aircraft observations and satellite retrievals allows for a detailed verification of model results.

The CGILS (CFMIP-GCSS Intercomparison of Large-Eddy and Single-Column Models) project is dedicated to study the response of equilibrium boundary-layer clouds for Stratus, Stratocumulus and Cumulus such as observed in the Northern Pacific Ocean along the GEWEX Pacific Cross-section Intercomparison (GPCI) (see Figure 11). These 3 cases are also subjected to idealized future climate conditions. To this end SCMs and LES models are run towards equilibrium states for the same three selected locations in the GEWEX Pacific Cross Section (GPCI). To determine the cloud-radiative feedback perturbed future climate conditions are enforced by increasing the SST by 2K and by weakening the subsidence.

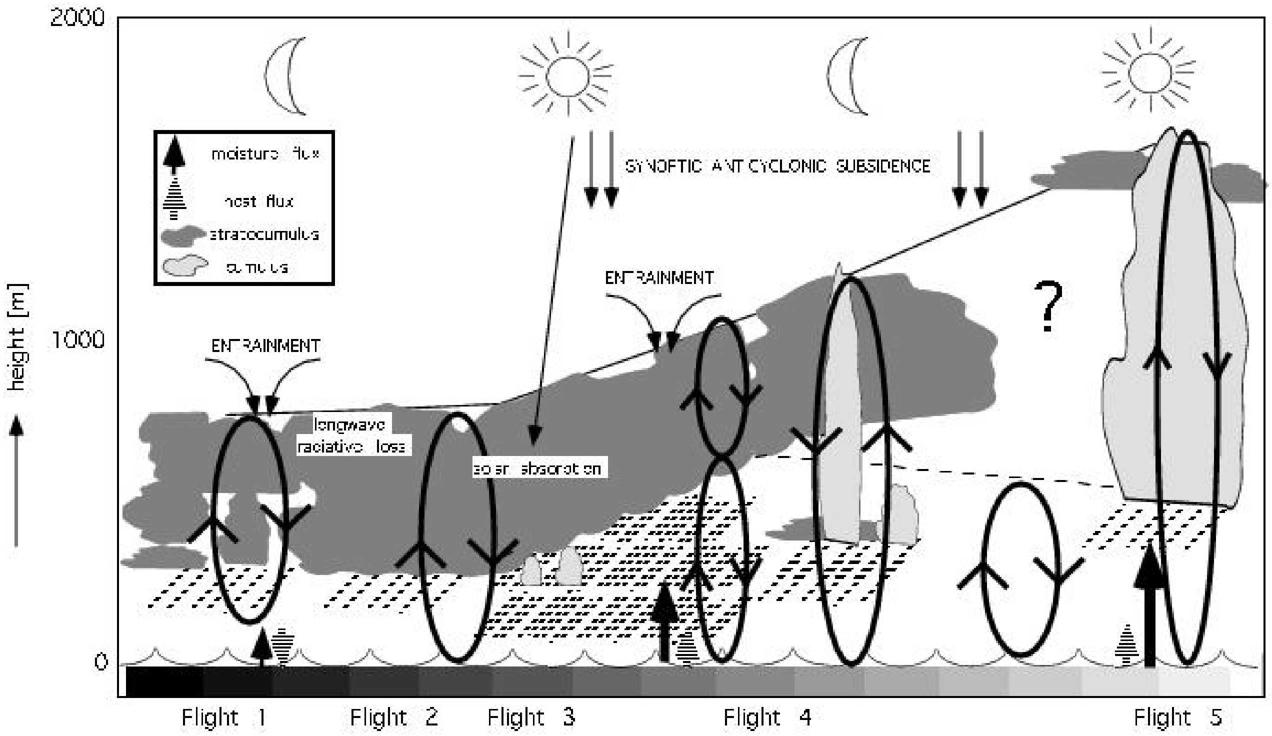

Figure 6. *Schematic of the stratocumulus to cumulus transitions as observed during the First Lagrangian of ASTEX. Five aircraft flights were performed between 12-14 June 1992.*

a. Set up of the ASTEX transition case

For a model intercomparison case the time-dependent large-scale divergence rate, the sea surface temperature (SST), and the geostrophic wind components need to be prescribed. Because a Lagrangian trajectory is modelled the horizontal advection terms can be neglected.

The SST is taken from Bretherton et al. (1999), who provide a best estimate of the time-varying SST along the ASTEX First Lagrangian trajectory on the basis of ECWMF SST fields that were obtained with a data assimilation procedure, direct measurements from the ship R/V Oceanus and radiometric observations from aircraft.

In the subtropical parts over the oceans, the large-scale divergence of the horizontal winds is characterized by positive values in the lower part of the atmosphere, which is associated with a large-scale descending motion, which is often referred to as large-scale subsidence. For the ASTEX area, there is a considerable uncertainty not only in the magnitude but also in the sign of the large-scale divergence. Bretherton et al. analysed ERA-40 data and found that the large-scale divergence in the column changed sign after approximately 15 hours (see Figure 7). By contrast, Ciesielski et al. (1999) calculated the large-scale divergence directly from radiosonde observations and found no change in the sign. Sigg and Svensson (2004) applied a spectral analysis to examine the oscillating behaviour of the large-scale divergence at the boundary-layer top. Their analysis showed that the large-scale divergence is influenced by cumulus clouds on time-scales up to 15 h with a peak at 9 h. After filtering out these scales, they concluded that the large-scale divergence remains positive all along the first Lagrangian.

Temporal changes in the thermodynamic properties of the lower part of the free atmosphere are due only to advection and radiation. A suite of test runs with different time series for the large-scale divergence were performed with DALES. The large-scale divergence as shown in Figure 7 is found to provide the best agreement between the modelled and observed temperature and humidity in the free atmosphere. This time-varying large-scale divergence is therefore prescribed in the model intercomparison study. Furthermore, the DALES results showed that changing the sign of the large-scale divergence rate during the Lagrangian causes a stratocumulus cloud layer that is too deep and too persistent (De Roode and van der Dussen, 2010). Similar results are reported by Sandu and Stevens (2010).

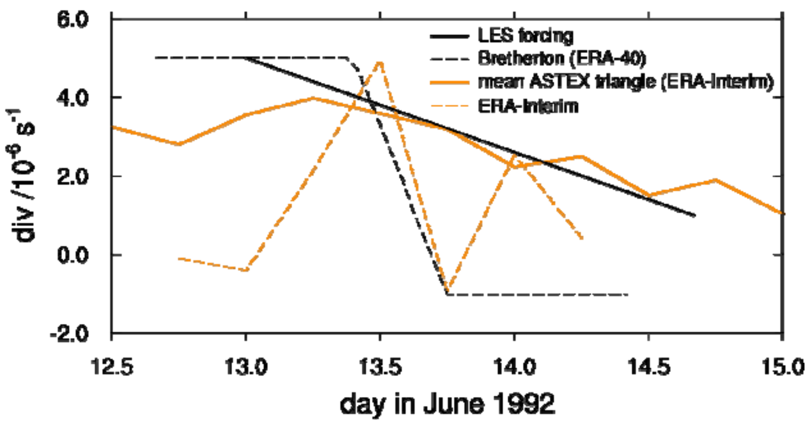

Figure 7. *The large-scale divergence along the trajectory of the First Lagrangian of ASTEX according to ERA-40 and ERA-Interim data, its mean value over the ASTEX triangle as obtained from ERA-Interim data, and the time series used for the model intercomparison study.*

The prescribed geostrophic winds are time-dependent and force the modelled wind velocities in the free atmosphere towards the observed values. The reference pressure p_0 = 1000 hPa and the surface pressure p_s = 1029.0 hPa is set to a constant value during the Lagrangian. Constant values for the latitude=34^{0}N and longitude=25^{0}W are used. Small effects on the coriolis force and the shortwave forcing due the gradual southwards advection of the modelled air mass are thus neglected.
The simulations start on 13 June 00 UTC. Figure 8 shows the initial vertical profiles for the temperature, total specific humidity and liquid water content and the results from aircraft observations collected during Flight A209. The profiles are identical to the set up of the GCSS A209 stratocumulus intercomparison study.

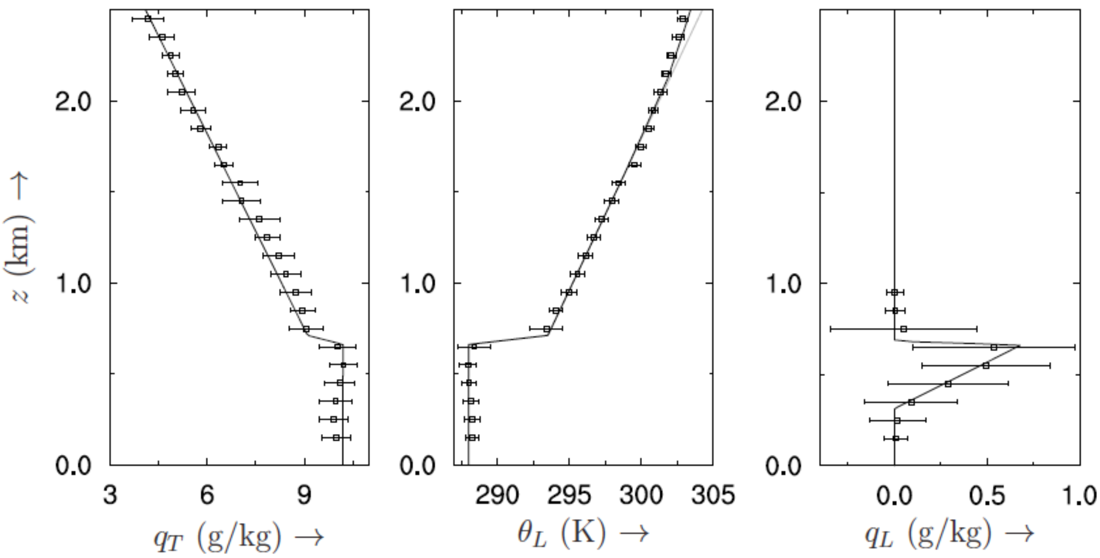

Figure 8. *Initial profiles of the total specific humidity q_T, the liquid water potential temperature θ_L and the liquid water content q_L. Squares denote bin-averaged observations over equal height intervals collected during flight A209. Error bars show ± one standard deviation from the mean.*

b. Composite Lagrangian intercomparison cases (MPI contribution)

In addition to the ASTEX Lagrangian, three other transition cases are set up by Irina Sandu (MPI), which are based on satellite observations and ECMWF-INTERIM data in four of the eastern subtropical oceans where the stratocumulus to cumulus transitions typically occur, i.e. northeast, southeast, Atlantic and Pacific (Sandu et al., 2010). The data covers a six month period centered around the month with the highest mean cloud fraction in each area (i.e. May to October for the Northern Atmosphere and July to December for the southern one), spanning the period 2002-2007. A data selection was applied on the basis of environmental conditions, in order to obtain cases that are most likely to experience a transition. For each region a total number of 3000 trajectories were used for statistical analysis.
Sandu et al. divided the observed transitions in three categories, i.e. fast, intermediate and slow. They examined the differences between the fast and the slow transitions, and noticed only a little difference in the initial conditions of the clouds, including the median cloud fractions and optical thickness. They also found that environments in which the fast and the slow conditions occur are mainly distinguished by their values of SST and the lower tropospheric stability (LTS). Figure 9 shows the observed cloud fraction for the slow, intermediate and fast transitions and the SST, LTS and Div as obtained from the ECMWF-INTERIM data set. These results are used as large-scale forcing conditions for the three composite Lagrangian intercomparison cases. The observed cloud cover from the satellite data provides an excellent opportunity to verify model results. The ASTEX case mainly differs from the composite case in the sense that it has smaller jumps of humidity and temperature across the inversion layer compared to the composite cases (see Figure 10).

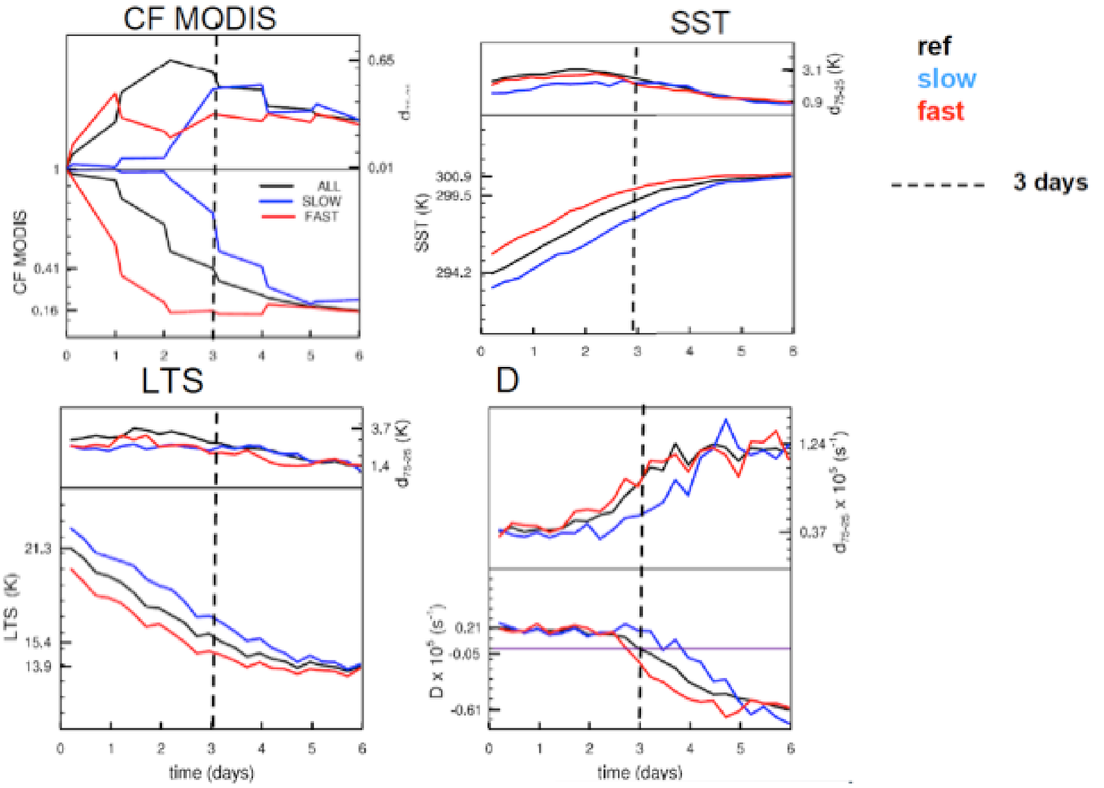

Figure 9. *(a) The MODIS liquid cloud fraction (b) the SST, (c) the LTS and (d) the large-scale divergence D along the trajectories for the slow, intermediate and fast transitions, respectively. The lower panel shows the evolution of the median and the upper panel illustrates the interquartile spread (i.e. the distance between the third and first quartile) of the distribution of the cloud fraction for the sets of trajectories analyzed in each of the four subtropical oceans. In the lower panel, the y-axis labels the values at the initial time, after 3 days and respectively at the end of the median trajectory for the North Eastern Pacific; in the upper panel it labels the minimum and the maximum values of the interquartile spread for the same region.*

The details of the case set up can be found at http://www.mpimet.mpg.de/en/mitarbeiter/irina-sandu/transition-cases.html.

The simulations last at least 40 hours. The SCM versions should be taken from the host ESM version. The LES models all use a full radiative transfer scheme. In the LES models a stretched vertical grid is used, with a spacing of 5 m near the inversion zone in order to resolve the sharp vertical gradients present in this layer. In total 128 number of grid points are used in each horizontal direction, and the 50 m horizontal resolution constitutes a domain size of 4.48 x 4.48 km^2.

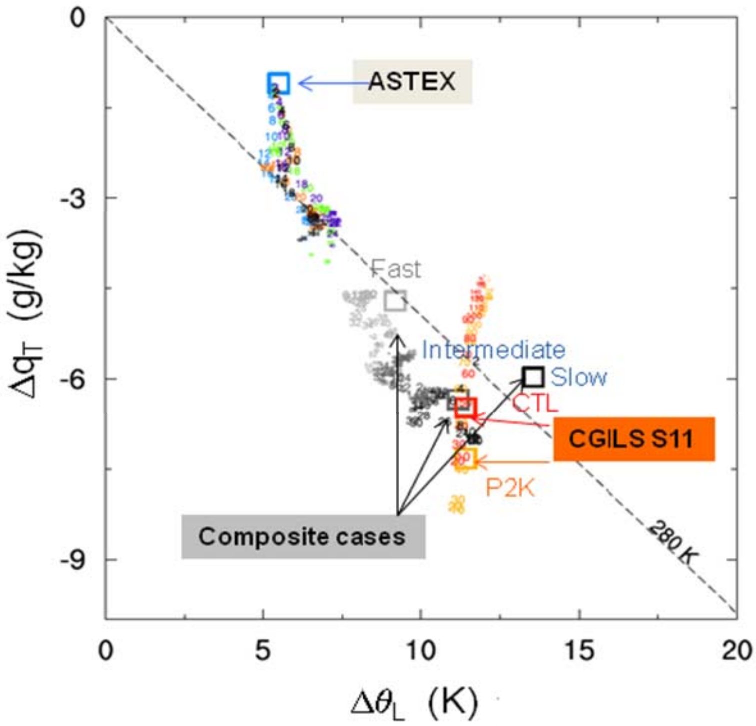

Figure 10. *Inversion jumps of the liquid water potential temperature and the total water content for ASTEX, the slow, intermediate and fast transitions, and the CGILS S11 stratocumulus column. The coloured squares show the initial jumps. The coloured numbers sprawling from the ASTEX square indicate the inversion jumps as a function of time (hours after start up) for five different LES models. For CGILS and the composite cases only the DALES inversion jump evolutions are shown.*

C. CGILS equilibrium state studies

CFMIP and the GCSS WG1 initiated the CGILS project to use idealized large-scale dynamical conditions to evaluate cloud feedback processes in GCMs. In particular, the GPCI (GEWEX Pacific Cross Section Intercomparison) cross section (Siebesma et al. 2004) is described by 13 grid boxes starting from (1°S, 173°W), with increments of 3 degrees in latitude and 4 degrees in longitude in the north eastward to the California coast at (35°N, 125°W). CGILS considers three grid points (see Figure 11):

(1) S6 — at (17°N, 149°W), the middle point of the GPCI cross section, to represent the shallow cumulus regime;
(2) S11 — at (32°N, 129°W), near the California coast, to represent the stratocumulus regime;
(3) S12 — at (35°N, 125°W), immediately off the California coast, to represent the stratus regime

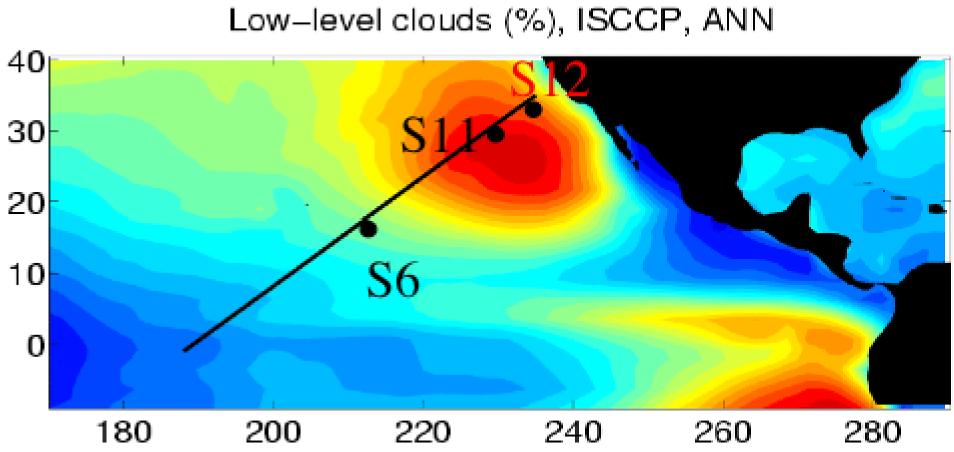

Figure 11. *ISCCP annual mean low-level cloudiness in the GCPI cross section area. Also shown are the three CGILS grid points S6, S11 and S12 (courtesy Minghua Zhang).*

The models carry out six simulations, one for a control climate and one for a perturbed climate which is mimicked by a SST increase of 2K along with a weakened subsidence, at each of the three grid points. It is assumed that the vertical velocity and horizontal advective tendencies of temperature and water vapour do not change with time. Preliminary experimentation has indicated that the constant forcing can be used to obtain similar cloud responses as those from transient forcing within a GCM over the eastern Pacific. The development of the forcing data follows Zhang and Bretherton (2008) and is representative for July conditions. The design is guided by emulating the large-scale forcing in the control and warmer climate in various GCMs that is independent of any physical parameterizations.

EUCLIPSE takes advantage of the CGILS set up proposed by Zhang and Bretherton (see http://atmgcm.msrc.sunysb.edu/cfmip_figs/Case_specification.html) and fully participates in this project. The SCMs simulations are run towards a quasi-equilibrium, which in practice takes about 20 to 30 days. As this length is computationally too expensive for the high-resolution LES models, they are run for a limited period of 10 days.

D3.2 Storage of instantaneous 3D LES fields and key statistical variables in a public archive (Month 24)

Five LES models and twelve SCMs (see Tables 2 and 3 for a list of participating models) have submitted the results of the Lagrangian transitions. The University of Warsaw LES model experienced some difficulties and has submitted some preliminary results.

Investigator	Affiliation	Model	ASTEX	Composite cases
Johan van der Dussen	**TUD**	**DALES**	✓	✓
Irina Sandu Thijs Heus	**MPI**	**UCLA**	✓	✓
Adrian Lock	**UK Met Office**	**MOLEM**	✓	✓
Marcin Kurowski	**U Warsaw**	**EULAG**	*Expected soon*	*Expected soon*
Peter Blossey	U Washington	SAM	✓	×
Andy Ackerman	NASA	DHARMA	✓	✓

Table 2. *Summary of participating LES models in the Lagrangian transition intercomparison cases. The participating EUCLIPSE models are written with bold face letters. The '✓' symbol indicates that the simulation results have been submitted.*

Investigator	Affiliation	Model	ASTEX	Composite cases
Eric Basile	**Meteo France**	**AROME**	✓	✓
		ARPEGE-NWP	✓	✓
Isabelle Beau	**Meteo France**	**ARPEGE-CLIMAT**	✓	✓
Sara dal Gesso Roel Neggers	**KNMI**	**EC-Earth**	✓	✓
		RACMO	✓	✓
Suvarchal Kumar	**MPI**	**ECHAM6**	*Expected soon*	*Expected soon*
Ian Boutle	**UK Met Office**	**UKMO**	✓	✓
Irina Sandu Martin Köhler	**ECMWF** DWD	**IFS cy36r1**	✓	✓
Suvarchal Kumar	**MPI**	**ECHAM6**	*Expected soon*	*Expected soon*
Vincent Larson	UWM	CLUBB	✓	×
Hideaki Kawai	JMA	JMA	✓	✓
Anning Cheng	NASA LaRC	LaRC	✓	✓
Heng Xiao	UCLA	UCLA-AGCM	✓	✓

Table 3. *Summary of participating SCMs in the Lagrangian transition intercomparison cases. The participating EUCLIPSE models are written with bold face letters. The '✓' symbol indicates that the simulation results have been submitted.*

The model results are stored and can be viewed at the KNMI Parameterization Testbed (KPT) web site (http://www.knmi.nl/samenw/rico/RICO) The purpose of the test bed project is to comprehensively evaluate existing and new parameterizations for general circulation models (GCMs) against atmospheric measurements from various permanent meteorological "supersites" on a continuous, daily basis. In addition, the site also hosts a suite of model intercomparison cases, including ASTEX and the three composite Lagrangian cases.

The user-friendly test-bed web interface allows for an easy visualization of any arbitrary variable that has been requested for data submission. Figure 12 displays an example of a plot produced from the test-bed web interface, and shows the cloud cover for the ASTEX First Lagrangian as obtained from the LES and SCM models. If available, results from aircraft measurements may also be added to the plots. The data of the instantaneous 3D LES fields will be made publicly available soon.

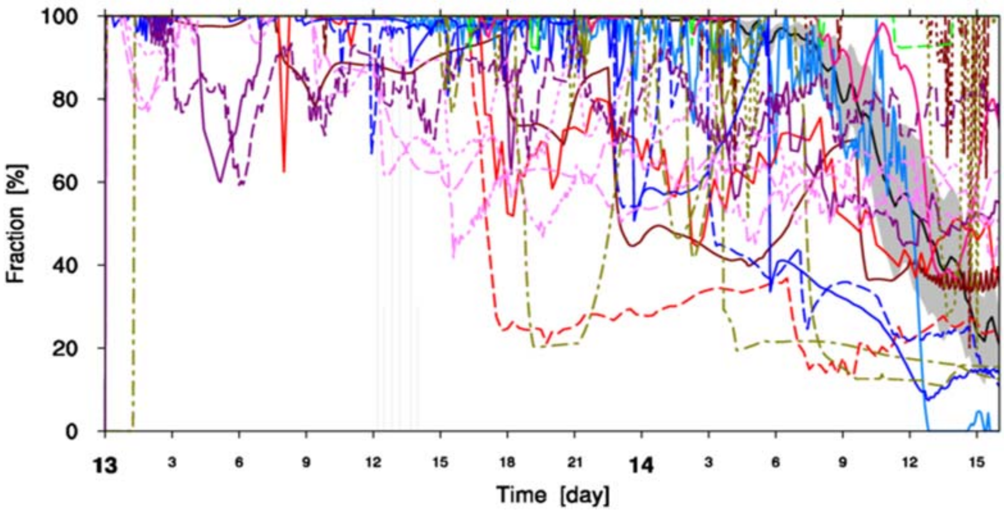

Figure 12. *Cloud cover results of twenty-four SCM simulations of the ASTEX Lagrangian. The grey band show the LES results, where the width of the band the standard deviation from the mean. The lines represent different models, and also display results obtained with modified set-ups of the model in order to test the effects of vertical resolution and changes in the parameterization scheme.*

D3.3 Detailed analyses of the LES and SCM results for the Lagrangian transitions and the three GPCI columns (Month 30)

a) Lagrangian transitions

The LES models all give a remarkably similar evolution of the cloud boundaries for ASTEX (see Figure 13) and they are in qualitative agreement with the schematic presented in Figure 6. The lowest cloud base height varies between 300 and 500 m, and actually represents the height of the lowest cumulus cloud base. The cumuli penetrate into the stratocumulus cloud layer above. There is some difference in the modelled timing of the break up of the stratocumulus cloud, which occurs between 28 and 36 hours after the start of the simulations.

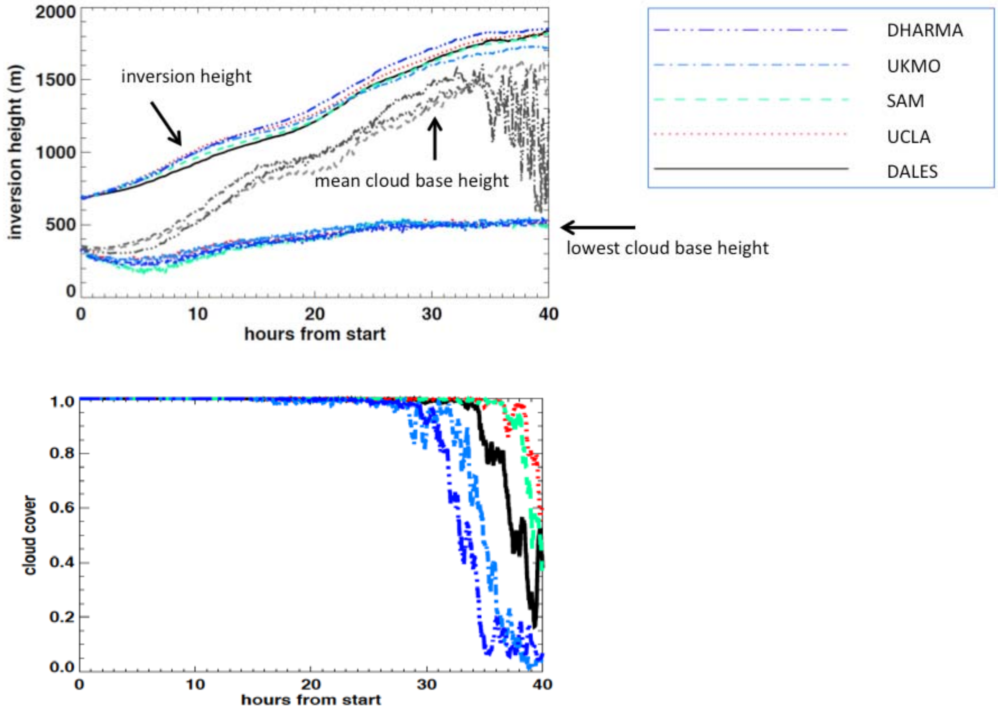

Figure 13. *Time series of the inversion height, mean cloud base height, and lowest cloud base height (upper panel), and the cloud cover (lower panel) from five large-eddy simulations of ASTEX. MPI and TUD operates the UCLA LES and DALES model, respectively, and the NASA and the University of Washington have contributed to the EUCLIPSE Lagrangian transitions with DHARMA and SAM, respectively. Line styles are according to the legend.*

The SCM cloud cover results shown in Figure 12 exhibit a larger spread than the LES results. A preliminary analysis indicates that the most advanced parameterization schemes like the Eddy-Diffusivity Massflux approach (Neggers et al. 2009) or the University of Wisconsin model CLUBB appear to have the best agreement with the observations and LES results.
As a next step a detailed comparison of turbulent fluxes and variances from LES results with the ASTEX aircraft observations will be made. In addition, the LES results of the transitions will be exploited to diagnose the degree of the decoupling as measured by mean differences of thermodynamic quantities between the subcloud and cloud layer and the vertical turbulent transport across their interface. In addition, quantities that constitute the main ingredients of boundary-layer cloud parameterization schemes like the eddy-diffusivity and mass-flux profiles which are otherwise difficult to obtain from field measurements will be determined. Although their vertical profiles have been reported for either stratocumulus or shallow cumulus topped boundary layers, it is not yet well understood how they should be treated when the cloud layer is decoupled and contains both cloud types simultaneously.

b) CGILS

Figure 14 shows SCM results of the diagnosed cloud radiative feedback (ΔCRF) for the three selected CGILS grid points (courtesy Minghua Zhang). Models which apply parameterizations that yield rather vertically well mixed boundary layers (non-local diffusion, counter-gradient transport, some TKE and higher order closure) tend to produce negative feedback. On the other hand, models with explicit cloud-top entrainment tend to produce positive feedback.

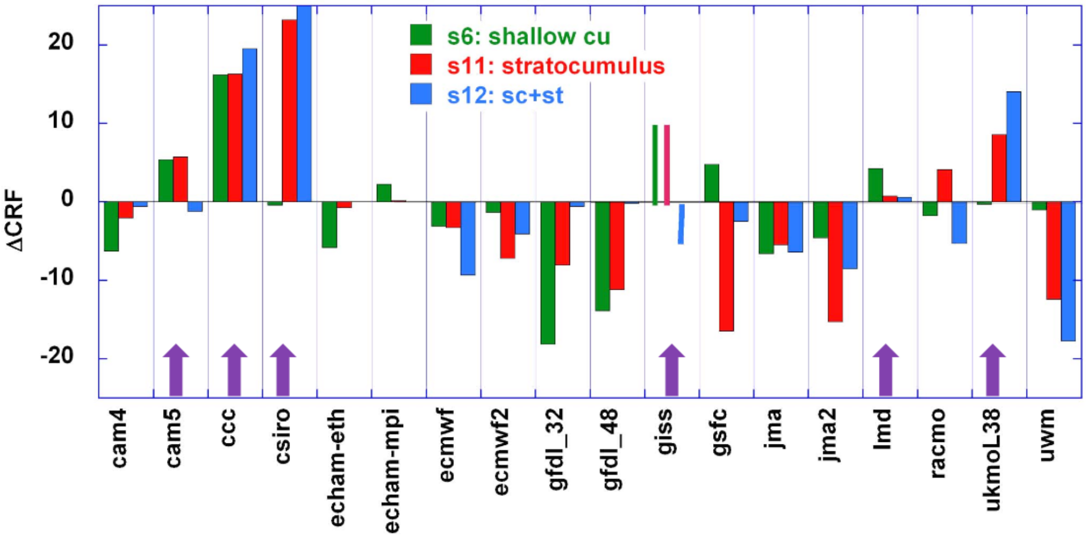

Figure 14. *Cloud feedback ΔCRF (W/m^2) at the three CGILS grid points (courtesy Minghua Zhang). The vertically pointing purple arrows indicate models that have a positive cloud feedback. EUCLIPSE has contributed to these results with two versions of ECHAM, ECMWF, LMD, RACMO, UKMO.*

The three grid points have also been simulated with LES models operated by EUCLIPSE partners (TUD, KNMI, MPI). The Large Eddy Simulations results suggest that i) the equilibrium results of the shallow cumulus clouds for the perturbed climate are almost identical to the control case indicating that these clouds do not contribute to a strong cloud feedback signal ii) for the stratocumulus cases the situation is more subtle: the LES models indicate a cloud feedback strength ranging from -10W/m^2 to +10W/m^2. If no weakening of the subsidence is assumed so that only a warming of the SST is assumed, all LES models predict a small positive cloud feedback. This shows how subtle the cloud response depends on the change of the large large scale forcing (i.e. subsidence strength) in a warming climate. There is also a strong sensitivity to the vertical resolution. Especially the S11 stratocumulus case calls for a fine vertical resolution of the LES models, Δz=5m. Despite the fact that for S11 the boundary layer structures are similar for the reference and perturbed case, small differences nevertheless yield considerable differences in the cloud LWP.

So in conclusion it appears that the for the CGILS equilibrium cases of interest show no (shallow cumulus) to a small cloud feedback strength (stratocumulus) though the sign of the latter is still unknown. Further research will be concentrated of extending this research by exploring a whole phase space of equilibrium cases rather than just 3 isolated cases and perturbing all these cases with different SST and subsidence changes. The SCM results on the other hand give a much wider spread in cloud feedback ranging from +20 to -20 W/m2 for all three cases, evidently much larger than suggested by LES results which are our most accurate tool to investigate the cloud feedback as a response to a perturbed climate.

D3.4 and D3.5 Equilibrium Solutions of SCMs for boundary layer clouds and identification and comparison of the key quantities used in ESM parameterization schemes that control the cloud properties (Month 30).

KNMI (Sara Dal Gesso) has been working on generalizing the equilibrium cases of CGILS for the equilibrium stratocumulus and shallow cumulus case. This generalisation is accomplished by varying the strength of the inversion jumps and investigating how the equilibrium solutions of the atmospheric state depend on this. These inversion jumps are represented as the difference of $\phi \in \{\theta_l, q_t\}$ between 3000 m and the sea surface, where θ_l denotes the potential liquid water temperature and q_t denotes the total water specific humidity. The reason for this is that the inversion strength is an important parameter that largely determines the cloud amount of the equilibrium solution. As an example we show in Figure 15 for a SCM version of EC-Earth how the liquid water path of the equilibrium solutions varies with the inversion strength.

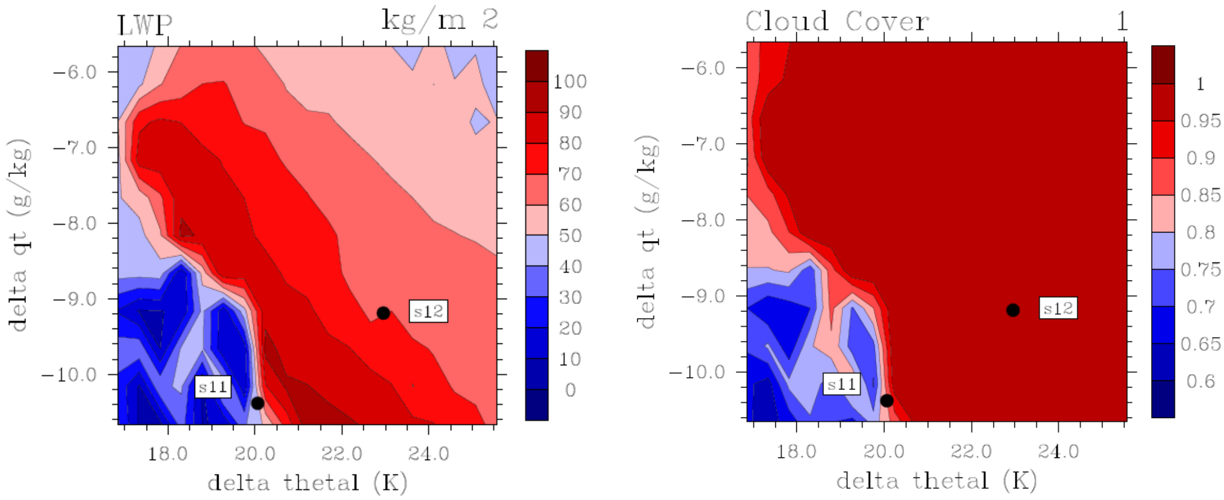

Figure 15: The liquid water path(left panel) and the cloud fraction (right panel) for 100 equilibrium runswith a SCM version of EC-Earth are shown in which the inversion strengths of the humidity and the temperature is varied. The S11 and the S12 case are indicated as special cases.

It can be seen in Figure 15 that if the temperature jump is decreased the cloud fraction and the liquid water path is decreasing and a transition from Stratocumulus to cumulus can be observed. Such a result can be viewed as fingerprint of which boundary clouds a parameterization scheme produces as a function the inversion strength. This exercise will be repeated for all SCM version of the ESMs that participate within EUCLIPSE and benchmarked with LES results that can serve as a benchmark. Also the sensitivity for the used entrainment formulation will be addressed as well as the response of an increased SST thereby generalizing the CGILS philosophy to a more complete phase space.

D3.6 Compilation of ESM results at selected grid points (Month 18).

All the ESMs have implemented the appropriate software to have dedicated output at selected grid points in all the present and future climate ESM runs described in WP1.

These selected grid points are displayed in Figure 16 and include points along the Pacific Cross Section (GPCI), a cross section across the AMMA area, the ARM sites and the so called Cloudnet sites including Cabauw, SIRTA and Chilbolton which are 3 main European atmospheric profiling stations. In addition for the year 2008 the selected grid point output will be delivered at a high-temporal 3 hour frequency which will allow a detailed evaluation on a process level with observational data.

Since the ESM runs have not finished (see report WP1) the results are not yet compiled. This will be done as soon as the runs have been completed which is expected to be in November 2011.

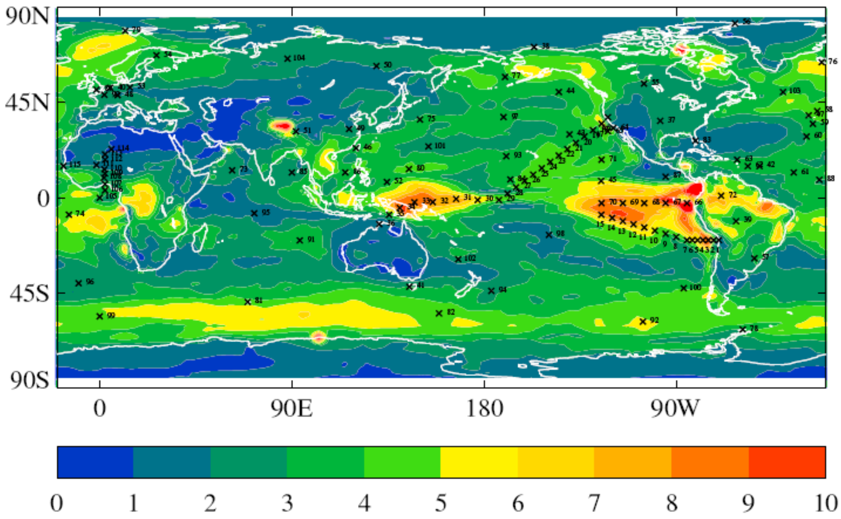

Figure 16. *119 Locations at which enhanced ESM output will be available at a high 3 hourly temporal resolution. The background displays the variability in cloud climate feedback strength as computed from the CMIP3 climate model runs in units of W/m2.*

D3.7 A comparison of the hydrological and energy balance and the cloud amount as computed by ESMs with field observations and satellite retrievals (Month 36)

As a preparation of this deliverable we would like to report on 2 activities:

i) Creation of observational data sets based on three European atmospheric profiling stations.

ii) Preliminary evaluation of one of the EUCLIPSE ESMs (Arpege) at the selected grid points in West Africa using observations such as performed during AMMA. The other EUCLIPSE ESMs will be evaluated in depth with the AMMA observations, once the CMIP5 runs from Deliverable 1.4 are ready.

A dedicated EUCLIPSE meeting is planned in October 2011 in order to discuss in more detail how these observational data from both set will be employed to evaluate the ESM runs of the present climate.

i) Synthesis of ground-based atmospheric measurements from 3 European observatories.

M. Chiriaco, J-C. Dupont, M Haeffelin, F. Cheruy (IPSL, France), P. Siebesma, H. Klein Baltink, F. Bosveld (KNMI), E. O'Connor (Reading University)

In order to evaluate the EUCLIPSE present day climate runs in their ability to simulate clouds, a homogeneous hourly averaged data set for the atmospheric profiling stations at Cabauw (Netherlands), Chilbolton (UK) and SIRTA (France) has been created (see Figure 17).
This was achieved in several steps. First based on the required CMIP5 ESM model output a list of observables was created that can be directly used to compare model output with observations. These observables include; radiative fluxes both at the surface and at the top of the atmosphere, latent and surface heat fluxes, 2 meter values of wind, temperature and humidity and cloud parameters such as cloud base height, cloud fraction, liquid water content. A complete list of these observables can be found at http://climserv.ipsl.polytechnique.fr/fr/cfmip-observations-5.html (click on "table EUCLIPSE CONTENTS 01.pdf"). For all 3 sites 1-hour averages were derived, the retrieval algorithms were harmonized and subjected to the same quality control. Whenever possible the spatial variability has been calculated from neighbouring meteorological stations. Finally netcdf files have been produced with the same metadata and definition of the attributes. This has resulted in 3 data files for each atmospheric profiling station for the period January 2008-April 2010 overlapping with the agreed period for the ESM present day climate runs with the high frequency 3-hourly output. In addition a data file with a longer time interval 2002-2010 for the SIRTA observational data has been created as well. The data files can be found at the website mentioned above.
As more data will be added during the course of the EUCLIPSE project these data files will be updated regularly. More information on this data set can be found at http://www.euclipse.eu/downloads/PresentationsExeter2011/AgendaExeterJune2011_latest.htm in the presentation of Martial Haeffelin

Figure 17. *Locations of the three atmospheric profiling stations in Europe for which observational data sets have been created for the period Jan 2008 – April 2010*

ii) Simulation of clouds and cloud radiative forcing over West Africa with ARPEGE

Françoise Guichard, Dominique Bouniol, Fleur Couvreux, Amanda Gounou, Sophie Tyteca, Boutheina Oueslati, Gilles Bellon and Hervé Douville

CNRM-GAME (CNRS and Météo-France), Toulouse, France

Over land In the Tropics, the cloud cover has a strong impact on the radiative budget, both at the top of the atmosphere (TOA) and at the surface. Furthermore, the cloud cover affects interactions among processes down to small scales and are likely to plays a role in land surface-atmosphere feedbacks occurring within the diurnal cycle. Here, we focus on an evaluation of cloud modelling over West Africa, from the wet Guinean coast to the Sahara desert. The study relies on AMMA observations and observational products which are further used to assess simulations performed with the ARPEGE GCM, especially regarding its ability to reproduce the observed annual and diurnal cycles.

First, satellite data and products (CloudSat, CALIPSO, ISCCP, CERES) emphasize marked meridional contrasts in the clouds observed over West Africa, in terms of amount, but also vertical structure (Bouniol et al. 2011). They also point to distinct cloud radiative signatures in the long-wave and short-wave budgets, leading to a very well-defined maximum of TOA net radiation in the Sahel during the monsoon. Finally, the observations point to the significance of the population of mid-level clouds.

We have started to make use of ground-based data collected in several sites along this climatological meridional gradient, all within the list of 119 locations around the world for which high-frequency process-oriented outputs were defined for CFMIP-2 (illustrated below for Niamey, in the Sahel). Data provide estimates of cloud radiative forcing at the surface (AMMA-Catch; e.g. Guichard et al. 2009, and ARM mobile facility (AMF) data). They are further complemented by sounding data and NWP analyses (notably ECMWF AMMA reanalysis).

Figure 18 : time series of incoming short-wave flux at the surface in 2006 at selected point along the West African climatological gradient, from a wet Soudanian site (Djougou, bottom) to the Southern (Niamey, middle) and Northern Sahel (Bamba, top). A 15-day running mean has been applied.

Note that the cloud radiative impact increases and extends in time from the northern to southern locations and is the largest during the monsoon period, from June to September.

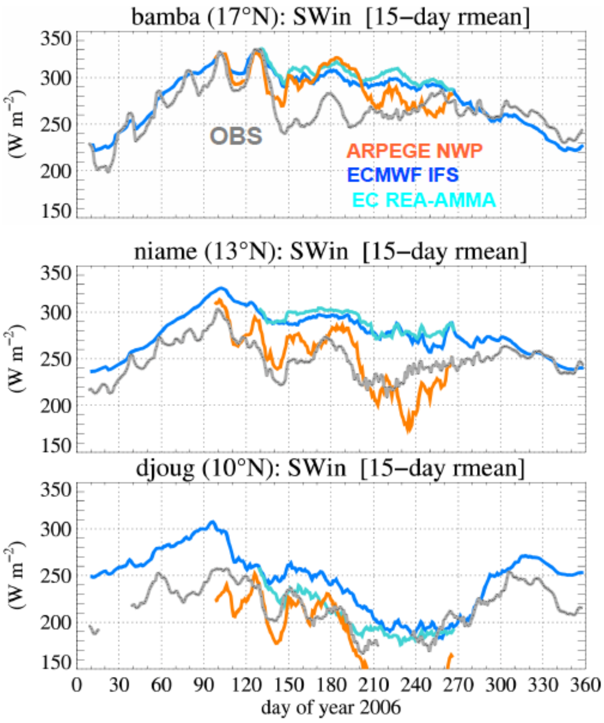

***Figure 18**. shows a comparison of the annual cycle of the incoming solar radiation in models and observations at selected locations. It illustrates the structure of the observed meridional gradient of the cloud radiative impact (reaching more than 50 W/m2 within 7° of latitude during the monsoon). This feature is at best qualitatively captured by NWPs, indeed, the gradient is largely underestimated by the ECMWF models and much too strong in ARPEGE.*

First examination of ARPEGE results show that these biases involve a too approximate modelling of different cloud types, and notably mid-level clouds in the Sahel. These clouds develop within an atmosphere characterized by a relatively weak stability up to 4 km (above the top of the boundary layer) – Fig.19 (left). The significance of such a thermodynamic-cloud coupling was pointed out by Johnson (JAS 1999) albeit in the very distinct moister climate of the Pacific warm pool and involved congestus clouds. As illustrated in Fig. 19 (left), the model reproduces reasonably well the low-level atmospheric structures, including the diurnal cycle of the boundary layer which is only somewhat too cold. However, it fails to capture the weak stability layer above. Similarly, it is able to capture the seasonal changes of the cloud cover vertical structure, with an increase of the low cloud cover during the monsoon (Fig. 19 right). Simulated mid-level clouds remains too few though.

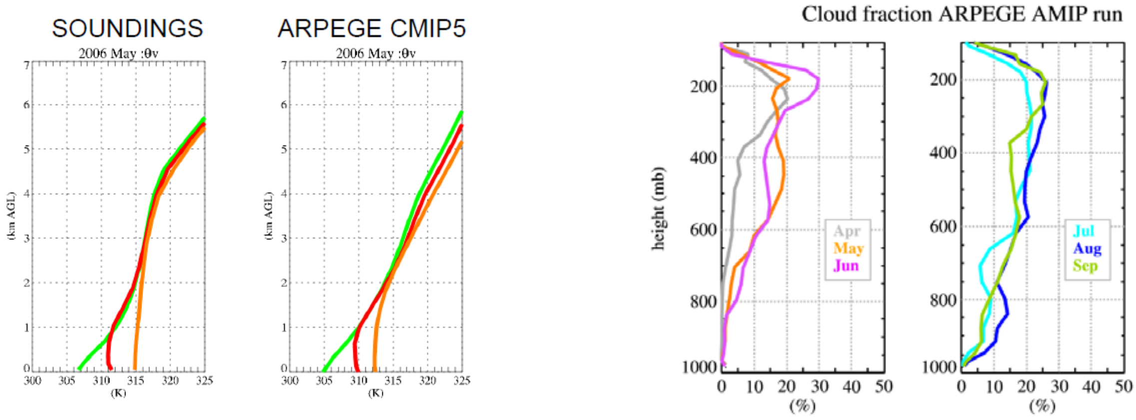

Figure 19. *Monthly mean profiles of (left) virtual potential temperature in May, from sounding data and in ARPEGE, at 0000 (green), 1200 (red) and 1800 (orange) UTC and (right) cloud cover prior to and during the monsoon -Niamey point.*

An analysis of the budgets indicate that outside of the core monsoon season, the variations of the cloud cover are dominated by a diurnal mode associated with the occurrence of daytime deep convection (Fig 20). This behaviour does not coincide with observations, as the occurrence of daytime deep convection is much less systematic. In the model, this process acts to warm the free troposphere, and therefore to stabilize it. Thus, this too frequent daytime deep convective activity does not favour the simulation of atmospheric conditions associated with mid-level clouds, and it could be argued that this mechanism is responsible for the lack of this cloud type in the model. However, we carried out a similar analysis with ARPEGE NWP runs, and it appears that, even though the thermal structures closely follow the observations in these short daily runs, mid level clouds are still too few. Therefore, it is likely that a proper modelling of these clouds is relying first on an improvement of physical parameterizations. Furthermore, because this cloud type is present outside of the monsoon season when deep convection is rare, it seems reasonable to conclude that an improvement of the modelling of shallow convection and clouds is also necessary if one is to more accurately simulate mid-level clouds.

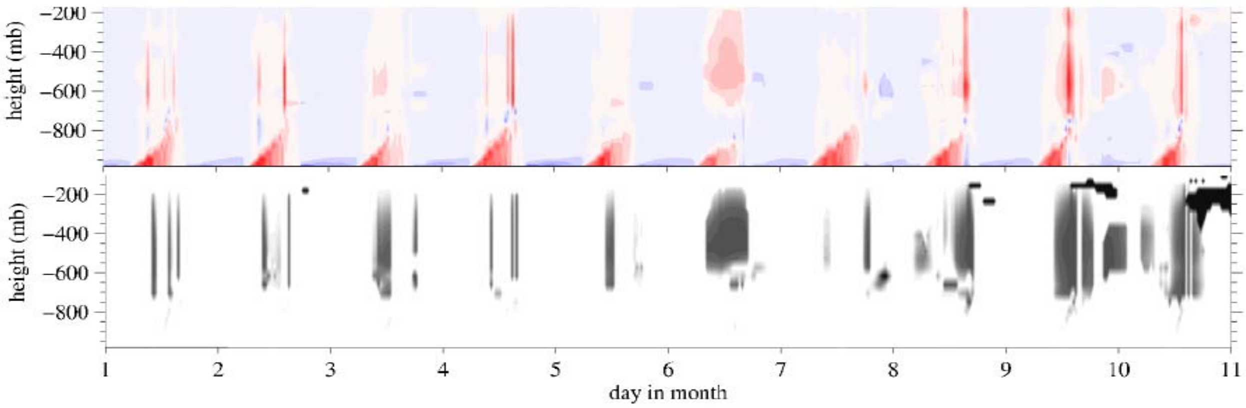

Figure 20. *an example of simulated time-height series showing the diabatic heating rate (top) and cloud cover (bottom). Niamey point, 1-h sampling, outside of the monsoon core season.*

Extra Activities

Sara Dal Gesso (KNMI/TUD) has set up a radiation intercomparison study to determine the consistency of radiation schemes applied in climate models for given vertical profiles of temperature and total specific humidity. The vertical profiles constrain the cloud liquid water path (LWP). A considerable scatter in the calculated cloud albedo is found for identical values of the LWP. As radiative transfer schemes need the cloud optical depth as an input parameter, the variation in the results can be mainly attributed to different values used for the cloud droplet effective radius, or differences in the applied relations between the optical depth and the liquid water content. These findings prove to be useful for further constraining the CGILS set up for LES models, which now requests all LES models to use the mean volume radius for calculating the cloud optical depth.

References

Albrecht, B.A., C.S. Bretherton, D. Johnson, W. Schubert and A.S. Frisch, 1995: The Atlantic Stratocumulus Transition Experiment (ASTEX). *Bull. Amer. Meteor. Soc.*, **76**, 889-903.

Bouniol et al., 2011: Diurnal and seasonal cycles of cloud occurrences, types and radiative impact over West Africa. *J. Appl. Met. Clim*., to appear.

Bretherton, C.S., Austin, P., and S.T. Siems, 1995: Cloudiness and marine boundary layer dynamics in the ASTEX Lagrangian experiments. Part II: Cloudiness, drizzle, surface fluxes and entrainment. *J. Atmos. Sci.*, **52**, 2724-2735.

Bretherton, C.S., S. K. Krueger, M.C. Wyant, P. Bechtold, E. Van Meijgaard, B. Stevens, and J. Teixeira, 1999: A GCSS boundary-layer cloud model intercomparison study of the first ASTEX Lagrangian experiment. *Bound.-Lay. Meteor.*, **93**, 341-380.

Ciesielski, P.E., W.H. Schubert, and R.H. Johnson, 1999: Large-scale heat and moisture budgets over the ASTEX region. *J. Atmos. Sci.*, **56**, 3241-3261.

Guichard et al. 2009: Surface thermodynamics and radiative budget in the Sahelian Gourma: seasonal and diurnal cycles, J. Hydrology, 375, 161-177.

Neggers, R.A.J., M. Koehler and A.A.M. Beljaars, 2009: A dual mass flux framework for boundary layer convection. Part I: Transport. J. Atmos. Sci., **66**, 1465-1487.

De Roode, S.R. and P.G. Duynkerke, 1997: Observed Lagrangian transition of stratocumulus into cumulus during ASTEX: Mean state and Turbulence structure. *J. Atmos. Sci.*, **54**, 2157-2173.

De Roode, S.R. and J. van der Dussen, 2010: Large-eddy simulation of a stratocumulus to cumulus cloud transition as observed during ASTEX. *AMS 19th Symposium on Boundary Layers and Turbulence*, August 2–6, 2010, Keystone, CO, USA.

Sandu, I., B. Stevens, and R. Pincus, 2010: On the transitions in marine boundary layer cloudiness. *Atmos. Chem. Phys.*, **10,** 2377-2391

Sandu, I. and B. Stevens, 2010: On the factors modulating the stratocumulus to cumulus transitions. *J. Atm. Sci., submitted*.

Siebesma, A.P., C. Jakob, G. Lenderink, R.A.J. Neggers, J. Teixeira, E. van Meijgaard, J. Calvo, A. Chlond, H. Grenier, C. Jones, M. Koehler, H. Kitagawa, P. Marquet, A.P. Lock, F. Mueller, D.C. Olmeda, C. Severijns, 2004: Cloud representation in general-circulation models over the northern Pacific Ocean: A EUROCS intercomparison study. *Quart. J. Roy. Meteor. Soc.*, **130**, 3245-3267.

Sigg, R. and G. Svensson, 2004: Three-dimensional simulation of the ASTEX Lagrangian 1 field experiment with a regional numerical weather prediction model. *Quart. J. Roy. Met. Soc.*, **130**, 707-724.

Zhang, M. and C.S. Bretherton, 2008: Mechanisms of low cloud-climate feedback in idealized single-column simulations with the Community Atmospheric Model, version 3 (CAM3). *J. Clim*, **21**, 4859-4878.

WP4 : Sensitivity Experiments and Hypothesis Testing

In this WP we will integrate results from other work-packages to develop numerical experiments designed to both test our developing understanding and identify observables that can help further constrain cloud feedbacks. The work proposed in this package is broken into three tasks:

1. Evaluate unusual behavior
2. Developing and Testing Parameterization Improvements
3. Establishing Observational Metrics

This WP officially started only in Month 13 and since many of the tasks depend on the results of the other WP's it is in a preparing stage. A meeting in the autumn of 2011 is planned to discuss the practical implementation of the tasks in WP4 in relation to the other 3 WP's. As a preparation of the use from numerical weather prediction for the evaluation of fast processes in climate models, ECMWF has started in setting up a testing framework to evaluate climate models in weather prediction mode. A report can be found below

A study identifying the utility of NWP based methods for identifying and narrowing sources of divergent behaviour in cloud-feedbacks in models (Month 36)

Deliverable D4.3

Daniel Klocke, Mark Rodwell

ECMWF

The work for the EUCLIPSE project at ECMWF started on June 1st 2011. The aim is to utilize and compare different techniques from numerical weather prediction for the evaluation of fast processes in climate models. Such processes include, for example, clouds and convection.

Two methods are proposed in the literature to evaluate climate models in weather prediction mode. The diagnostic of initial physical tendencies (Rodwell and Palmer, 2007) allows evaluation closest to the process level. However, this technique requires data assimilation capabilities of the used model, which are not always available for climate models that are used to solve boundary condition problems. Alternatively transpose-AMIP experiments were proposed by Phillips et al., (2004), where a short forecast with a climate model is initialized with an analysis produced by an 'alien' model. The advantage is that no data assimilation capabilities are required. However, the analysis from the alien model is not entirely consistent with the physics of the evaluated climate model and this can lead to spurious tendencies at the beginning of each forecast. This could potentially lead to wrongly diagnosed model error. Therefore errors in the transpose-AMIP framework are diagnosed after a few forecast days in the hope that the initial shock has decayed sufficiently. At these longer lead times, there is more scope for processes to interact and for local errors to be overwhelmed by remote effects.

In Figure 21 we propose a framework to identify the ideal diagnostics window for transpose-AMIP experiments. On the one hand, the lead-time should be long enough that the initialization shock has decayed sufficiently for the true physics errors (or physics differences) to dominate. On the other hand, the lead-time should be short enough that 'noise' associated with chaotic interactions with the resolved flow do not necessitate an unfeasibly large sample size.

To test this framework, two forecast models and two sets of climate-resolution analyses are required. Here, T159 analyses using 4D Var data assimilation with a 6-hour window have been made for two models for the month of April 2011. The first model is the control version of ECMWF's integrated forecasting system (IFS). The second model differs from this in that it has a reduced entrainment rate for deep convection. Climate-resolution weather forecasts using each model are then initiated from each set of analyses (2x2=4 sets of forecasts started 4 times a day for 30 days).

Figure 22 shows first results for the zonal mean forecast temperature differences following the approach proposed in Figure 21. The left-hand column shows mean forecast differences between the two models initiated from the same (control) analysis (corresponding to the blue and red models started from the blue analysis in Figure 21). The forecast differences are strongest in the convection dominated tropics during the first few forecast days while, at longer lead times, differences in the extra tropics start to dominate. The right-hand column of Figure 22 shows the mean forecast differences when the control model is initialized from the control analysis and from the analysis obtained using the perturbed model version (i.e. blue model started from the blue and red analyses in Figure 21). Forecast differences due to differences in the initial conditions (right-hand column) are larger than the differences due to model differences (left-hand column) for the first forecast days. The appropriate lead-time window for Transpose AMIP experiments will depend on the variable, the degree of inconsistency between the analysis and the forecast model, and the process of interest. In some cases, e.g. when the influence of the initialization becomes too large and errors are strongly dominated even after several forecast days by the initial shock, such a window might not exist, and the transpose-AMIP diagnostics might be uninformative.

In such a case, the initial tendency approach can give deeper insights into errors of parameterizations of fast physical processes. A big advantage is that departures from the analysis for different variables can be split into contributions of different processes. Figure 23 shows the zonal mean temperature analysis increments for the two model versions, the difference in the increments, and the difference in temperature tendency from the convection parameterization over the six hour forecast period. The largest part of the difference in the assimilation increments can be explained by differences in the temperature tendencies coming from the deep convection. In this case the larger error of in the perturbed model could be identified directly.

Both approaches will be analysed further and the feasibility for their utilization in the EUCLIPSE project will be assessed. Once a suitable test case is identified, results will be compared between the cooperating climate modelling centres.

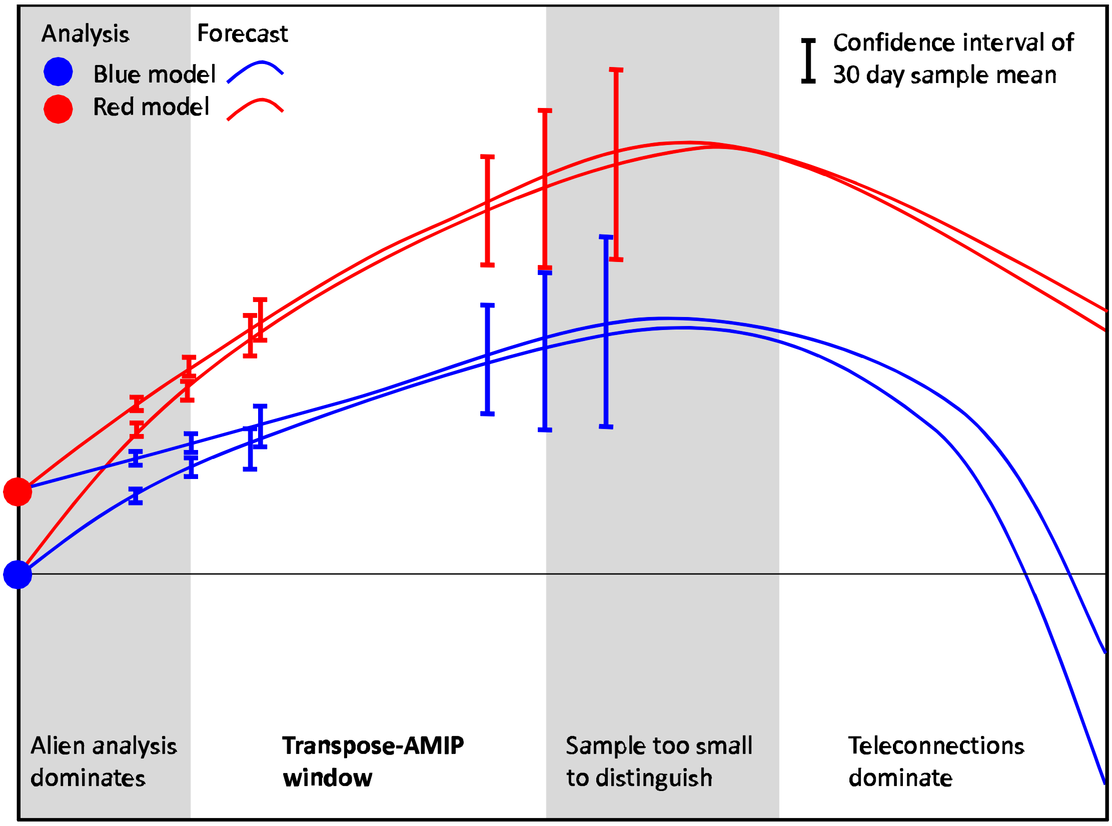

Figure 21: *Schematic framework to determine the optimal time window for transpose-AMIP climate model evaluation.*

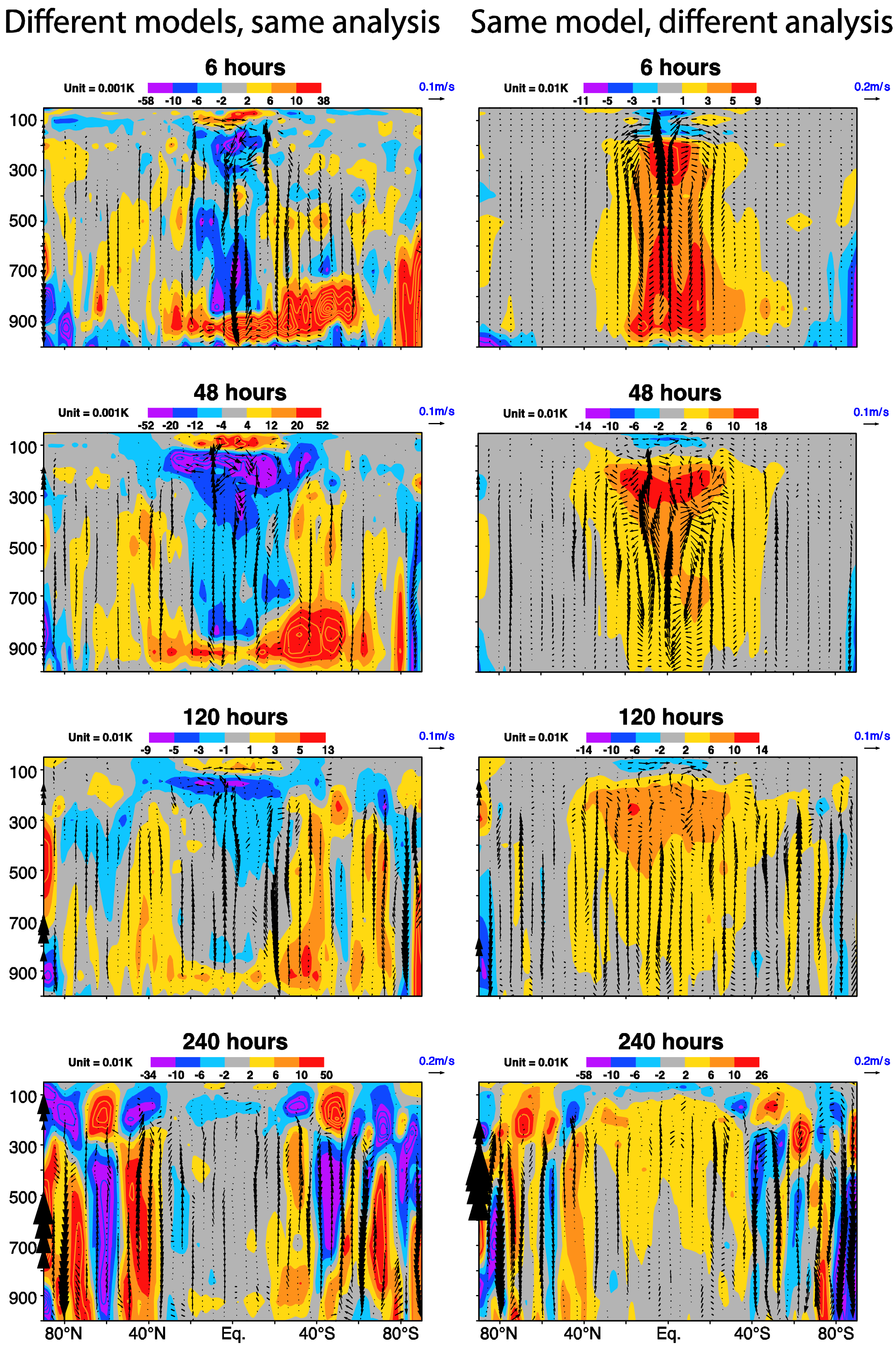

Figure 22. *Assimilation increments and forecast errors the control and the model with reduced entrainment rate in the parameterization of deep convection as a function of forecast time. The left column shows the difference in the zonal mean temperature error for the two different models initialized with the same analysis and the right column shows the error difference for the identical model initialized from the analysis created using the two different models*

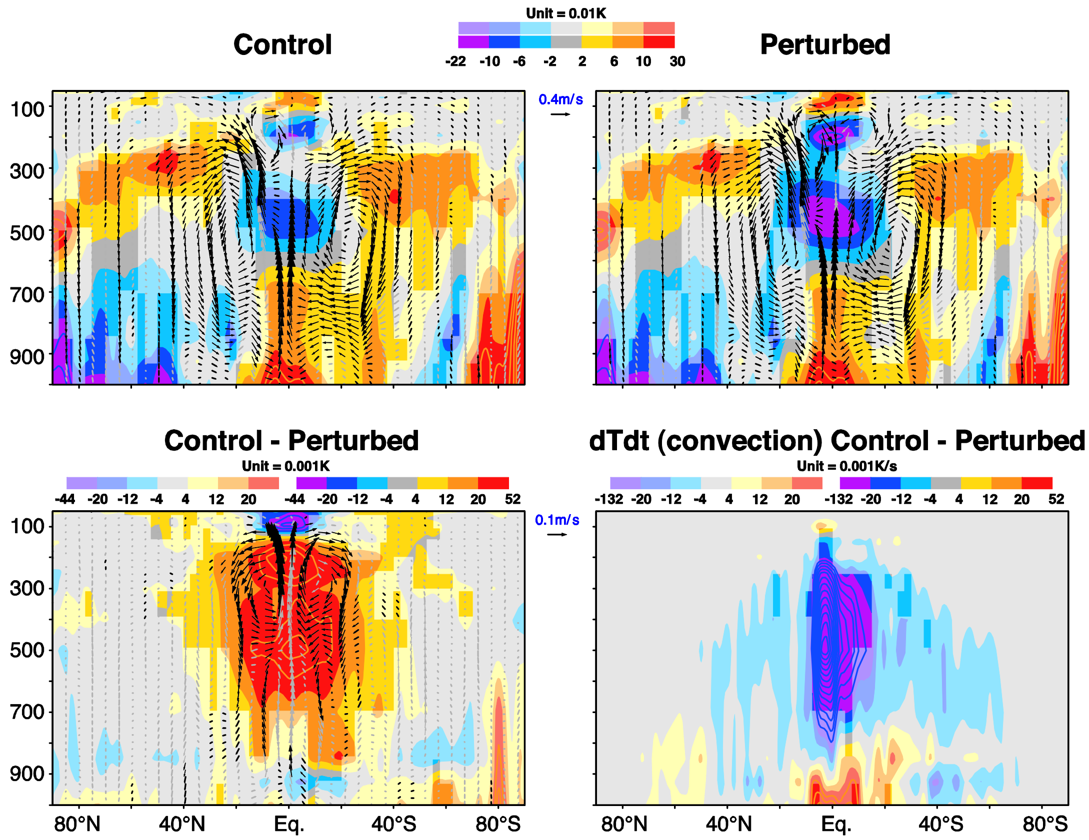

Figure. 23. *Zonal mean temperature assimilation increments in April 2011, for a control and an experiment with reduced entrainment rate in the parameterization of deep convection (top). On the bottom the difference in temperature assimilation increments between the two experiments is shown (left) and the mean difference in temperature tendencies accumulated over the first six forecast hours due convection, explaining most of the model differences.*

References

Rodwell, M. J., and T. N. Palmer, 2007: Using numerical weather prediction to assess climate models. *Quart. J. Roy. Meteor. Soc.*, **133**, 129-146.

Phillips, T. J. , G. L. Potter, D. L. Williamson, R. T. Cederwall, J. S. Boyle, M. Fiorino, J. J. Hnilo, J. G. Olson, S. Xie, and J. John Yio, 2004: Evaluating parameterizations in General Circulation Models: Climate simulation meets weather prediction. *Bull. Am. Met. Soc.*, **85**, 1903-1915.

3.2.3 Project management during the period

- *Consortium management tasks and achievements;*

i) set up of the management consortium

The agreed management structure for the project such as proposed in the DOW has been implemented.
The Project Office: the coordinator (Pier Siebesma, KNMI) responsible for the overall coordination of the project, a project assistant manager (Karin van der Schaft, KNMI) assisting the coordinator with the external and internal communication of the project, a financial officer (Jeroen Sassen, KNMI), responsible for the financial administration of the project
The Work Package Leaders: (Sandrine Bony, Bjorn Stevens, George Tselioudis, Stephan de Roode) are together with the coordinator responsible for the efficient running and the progress of the WPs and oversee the collaborations between the WPs.
The Management Board: consists of the WP leaders and representatives of all partners and is chaired by the coordinator.
The General Assembly: consists of all representatives of all institutions such as presented in the DOW and which has been enhanced through additional contractors that have entered the project.

ii) Project Flyer (Deliverable D0.1)

A project flyer has been produced and is distributed to all partners and to external organisations and institutes. (see www.euclipse.eu)

iii) Website (Deliverable D0.1, D0.4)

A project public website can be found at http:/www.EUCLIPSE.eu where all information of the project can be found. It includes news on the project, information on the deliverables, the data sets, software products, outreach activities, information on the meetings, including agenda, minutes and presentations. As there was no real need for an internal website these deliverables have been merged.

iv) Kick-off meeting (Deliverable D0.2)

After being postponed in April because the eruption of the volcano Eyjafjallajökull that had a big impact on flight traffic from, to and within Europe, the kick-off meeting took place Monday 27th - Tuesday 28th of September 2010 at the Pietershof in Utrecht, Netherlands. The purpose of the meeting has been: to meet all the EUCLIPSE participants, teambuilding and providing an overview of the planned project-activities and the progress in the first months in WP1 and WP3 were discussed.

v) International Summer School on the achievements of EUCLIPSE (Deliverable D0.9, Month 40)

A location has been found in the Les Houches Physics School in France (http://houches.ujf-grenoble.fr/) . An application to organise a EUCLIPSE summer school at this prestigious location has been approved and a reservation has been made for the second half of June 2013.

vi) *Edited book with lectures from the summer school (Deliverable D0.10, Month 48)*

The possibility of an edited book was discussed during the general assembly in June in Exeter (UK). The general feeling was that there is a need for a comprehensive textbook on the topic "Clouds & Climate". As EUCLIPSE consists of an excellent group of experts on this theme we feel that this is a unique opportunity to write a standard text book. The expected audience will be advanced graduate students, PhD candidates with a background in one of the disciplinary areas the book will cover. A breakdown in 13 chapters has been made. Each chapter will be written by 2 authors from the EUCLIPSE consortium. A preliminary version of the book is expected to be ready during the Summer school in 2013 and the final release date is expected in early 2014.

- *Problems which have occurred and how they were solved or envisaged solutions;*

Due to administrative reasons that were beyond control of the EUCLIPSE project office the final contracts and the money transfer was only arranged in May 2010. As a result numerous partners could start advertising for personal only after this date. There have been discussions with the EU officer whether EUCLIPSE should postpone the starting date. It was advised to keep the starting date fixed and to consider an extension of the project if this appears to be necessary. The effects of this have been minor the only mild delay of a few months in the delivery of the output of the ESM simulations (deliverable D1.4).

- *Changes in the consortium, if any;*

The consortium is unchanged with respect to the start of the project.

- *List of project meetings, dates and venues;*

An up-to-date list of project meetings (including meeting agendas, presentations and reports) is maintained on the project website (www.euclipse.eu). It therefore suffices here to give a list with the EUCLIPSE project meetings:

i) Kick-off Meeting EUCLIPSE, September 27-28, 2010 Pietershof, Utrecht, the Netherlands.
ii) WP3 meeting on the various intercomparison cases jointly with the GEWEX Cloud System Studies (GCSS) Boundary Layer Clouds Working Group, September 29-30, 2010, KNMI, De Bilt, The Netherlands.
iii) Technical Meeting on the construction of a EUCLIPSE observational database for European Atmospheric Profiling Stations, December 2, 2010, IPSL, Paris France.
iv) 2nd General Assembly (combined with CFMIP and GCSS), June 6-10, 2011, Met Office, Exeter, UK.

Besides the EUCLIPSE project meetings EUCLIPSE partners have been invited to various meetings to inform other international projects on the progress and content of the EUCLIPSE project:

i) R. Neggers: "European SCM-testbed and the EUCLIPSE project", FASTER Project Kickoff Meeting, Brookhaven National Lab, November 23-24, 2009
ii) G. Tselioudis: EUCLIPSE overview talk. IS-ENES General Assembly, Barcelona, May 26-28, 2010
iii) A. P. Siebesma: EUCLIPSE activities relevant for WGNE. 26th session of the CAS/JSC Working Group on Numerical Experimentation, JMA, Tokyo, Japan, 18-22 October, 2010,
iv) A.P. Siebesma: Evaluation of cloud related processes in climate models with observations from advanced atmospheric profiling stations: A Euclipse perspective. COST Action ES0702, Konigswinter/Koln November 16-18, 2010

- *Project planning and status*

Del. no.	Deliverable name	WP	Lead Benef.	Del Date
D0.6	Year 2 report	0	KNMI	26
D0.8	Brochure	0	KNMI	36
D1.6	Reprocessed version of EUCLIPSE model data products for long-term archiving within WDCC beyond the runtime of the project	1	DKRZ	36
D2.1.	Evaluation of clouds, radiation and precipitation in ESMs using COSP, clustering and compositing techniques.	2	METO	30
D2.2	Report on the evaluation of cloud-aerosols-radiation interactions in ESMs	2	MPG	30
D2.3	Design and application of a set of metrics that synthesises the ability of climate and weather prediction models to simulate clouds, precipitation and radiation	2	METO	36
D2.4	ESM evaluation of the ITCZ, the intra-seasonal and inter-annual variability of the tropical atmosphere, and temperature extremes over Europe	2	MF-CNRM	24
D2.6	Diagnostic of the climate feedbacks, including global and regional spreads, produced ESMs and of cloud and precipitation responses to climate change for CMIP5 runs; comparisons with estimates from the CMIP3 models	2	CNRS-IPSL	24
D2.7	Identification of the processes or cloud types most responsible for the spread in climate change cloud feedbacks and precipitation responses	2	CNRS-IPSL	36
D3.2	Storage of instantaneous 3D LES fields and key statistical variables in a public archive	3	TUD	24
D3.3	Detailed analyses of the LES and SCM results for ASTEX and the two GPCI columns	3	TUD	30

D3.4	Identification and comparison of the key quantities used in ESM parameterization schemes with LES results and observations	3	TUD	30
D3.5	SCM equilibrium states in the Hadley circulation	3	TUD	30
D3.6	Results at selected grid points (GCPI/CloudNet/ ARM/AMMA)	3	KNMI	18
D3.7	Comparison of the hydrological and energy balance and the cloud amount as computed by ESMs	3	MF-CNRM	36
D3.8	Development and application of methods to exploit high frequency for understanding cloud feedbacks	3	METO	36
D3.9	Quantification of the cloud-climate feedback and its uncertainty for prescribed large-scale conditions	3	MPG	36
D4.1	A developing database and protocol for parameter and structural (numerical) sensitivity studies	4	MPG	24
D4.2	Comparison study of the model sensitivity to the numerical structure of the computations (grid and time step) with the parameter sensitivity of the model.	4	MPG	36
D4.3	Report on a study identifying the utility of NWP based methods for identifying and narrowing sources of divergent behaviour in cloud-climate feedbacks in ESMs	4	ECMWF	36

- *Impact of possible deviations from the planned milestones and deliverables, if any;*

The delay of a few months of the output of the ESM simulations of a few months has impacted the deliverable of the results on the selected grid points (D3.6) by also a few months. No further impact on these delays is foreseen.

- *Any changes to the legal status of any of the beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs;*

none

- *Development of the Project website, if applicable;*

See http://www.euclipse.eu

- *short comments and information on co-ordination activities during the period in question, such as communication between beneficiaries, possible co-operation with other projects/programmes etc.*

The internal communication within the EUCLIPSE project has taken place through the Generally Assembly meetings, smaller dedicated subproject meetings. For the more practical issues such as the tasks in WP1 monthly teleconferences has been held throughout the first 18 months of the project. Exchange of information has also occurred through visits of EUCLIPSE participants to other institutes that are part of EUCLIPSE. Frank Selten of KNMI has been visiting Max Planck Institute in Hamburg for assistance of

the COSP simulator in EC-Earth. Stephan de Roode (TU Delft) has visited Warsaw University to assist in helping to set up the LES intercomparison case.
Externally, EUCLIPSE works closely together with the Cloud Feedback Intercomparison Project (CFMIP) which is part of the Working Group of Coupled Climate Models (WGCM) in order to make sure that the evaluation of ESMs is well coordinated with ESMs from outside Europe. For the same reason EUCLIPSE also works closely together with GEWEX Cloud System Studies (GCSS) to coordinate the more process oriented studies with institutes outside Europe. In order to foster these collaborations the 2nd Assembly of EUCLIPSE was organised together with CFMIP and GCSS last June 2011 in Exeter. As a result many institutes outside Europe participate in the intercomparison studies set up by EUCLIPSE and vice versa allow this close collaboration that EUCLIPSE can profit from activities set up by GCSS and CFMIP. There is also close collaboration with the Working Group on Numerical Experimentation (WGNE) in which all the centers that operate Numerical Weather Prediction (NWP) models are represented. Several members of EUCLIPSE (Bony, Siebesma) visit the annual meetings of WGNE so that a close collaboration between the activities of WGNE is assured. The Transpose-Amip project which is initiated through WGNE being is a good example of this collaboration.

There are also numerous contacts with present FP7 projects and links with past FP projects. Through DKRZ there is collaboration with IS-ENES through the use of a data portal of the dissemination of the ESM output, the database for observations from the European atmospheric profiling stations is being build up in collaboration with the COST action ES0702 and through links of the previous FP5 project Cloudnet. AMMA observational data will be used for analysing clouds in West Africa. Also close collaboration with the upcoming FP7 project is foreseen especially on the topic of convection. Finally there are close links with the US project FASTER, which has similar objectives as EUCLIPSE.

Finally there have been a number of activities to promote and communicate the findings of the EUCLIPSE project to stakeholders and the public at large:

i) A mini-documentary was made about EUCLIPSE in February 2011. This documentary has been broadcasted by EURONEWS television, the Futuris magazine story, entitled: "The Cloudbusters" on 10th March at 18.45 and was online for one week at EURONEWS. EURONEWS television is on the cable in most of the European countries. This documentary can be viewed at YouTube at http://www.youtube.com/watch?v=5UCb38WzkII

ii) An article about EUCLIPSE, titled "Watching the skies" is published in the August 2011 edition of the magazine "International Innovation". A copy of the article can be found at http://www.euclipse.eu/downloads/p13-15_EUCLIPSE.pdf .

List of acronyms

- AA - Academy of Athens (http://www.academyofathens.gr)
- AMMA – African Monsoon Multi-disciplinary analyses (http://www.amma-international.org/)
- AMIP – Atmosphere Model Intercomparison Project (http://www-pcmdi.llnl.gov/projects/amip)
- AMS – American Meteorological Society
- AOGCM – Atmosphere Ocean General Circulation Model
- AR4 – Fourth Assessment Report (http://www.ipcc.ch/ipccreports/assessments-reports.htm)
- ARCMIP – Arctic Regional Climate Model Intercomparison (http://curry.eas.gatech.edu/ARCMIP/)
- ARM – Atmospheric Radiation Measurement program (http://www.arm.gov/)
- AROME – Applications of Research to Operations at MEsocale (the Meteo-France mesoscale model)
- ARPEGE - Action de Recherche Petite Echelle Grande Echelle (the MF-CNRM
- atmospheric GCM)
- ASTEX - Atlantic Stratocumulus Transition Experiment (http://kiwi.atmos.colostate.edu/scm/astex.html)
- CALIPSO - Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (http://www-calipso.larc.nasa.gov/)
- CERES – Clouds and the Earth's Radiant Energy System (http://science.larc.nasa.gov/ceres/index.html)
- CFMIP – Cloud Feedback Model Intercomparison Project (http://www.cfmip.net)
- CGILS - CFMIP-GCSS Intercomparison of Large-Eddy and Single-Column Models (http://atmgcm.msrc.sunysb.edu/cfmip_figs/Case_specification.html)
- CLUBB – Cloud Layers Unified by Binormals (parameterization) (http://club.larson-group.com/about.php/)
- CloudNet - Development of a European pilot network of stations for observing cloud profiles (http://www.cloud-net.org/index.html)
- CloudSat – NASA Earth observation satellite that uses radar to measure cloud properties (http://cloudsat.atmos.colostate.edu/)
- CMIP – Coupled Model Intercomparison Project (http://www-pcmdi.llnl.gov/projects/cmip/)
- CMOR= Climate Model Output Rewriter
- CNRM - Centre National de Recherches Météorologiques (http://www.cnrm.meteo.fr/)
- CNRM-GAME – CNRM Mesoscale Modelling Group
- CNRS - IPSL Centre National de la Recherche Scientifique - Institut Pierre Simon Laplace (http://www.ipsl.jussieu.fr/)
- COSP – CFMIP Observation Simulator Package (http://cfmip.metoffice.com/COSP.html)
- DALES – Dutch Atmospheric Large Eddy Simulation (http://www.knmi.nl/~siebesma/LES/)
- DKRZ – Deutsche Klimarechenzentrum (http://www.dkrz.de)
- EC - European Commission (http://ec.europa.eu/index_en.htm)
- EC-EARTH – Earth System Model based on the ECMWF integrated forecasting system (http://ecearth.knmi.nl)
- ECHAM – General Circulation Model of MPI Hamburg (http://www.mpimet.mpg.de/en/wissenschaft/modelle/echam.html)
- ECMWF – European Centre for Medium Range Weather Forecasts

(http://ecmwf.int)

- ENSEMBLES - European project supported by the EC 6th Framework Programme as a 5 year Integrated Project from 2004-2009 (http://ensembles-eu.metoffice.com/index.html)
- ENSO – El Niño Southern Oscillation
- ERA40 – ECMWF reanalysis project 1957-2002 (http://www.ecmwf.int/products/data/archive/descriptions/e4/index.html)
- ESM – Earth System Model
- ETHZ - Eidgenössische Technische Hochschule Zürich (http://www.ethz.ch/)
- EU – European Union (http://europa.eu)
- EUCLIPSE – European Union CLoud Intercomparison, Process Study & Evaluation project
- EULAG – Eulerian LAGrangian (http://www.mmm.ucar.edu/eulag/)
- EUROCS – European Cloud Systems (http://www.cnrm.meteo.fr/gcss/EUROCS/EUROCS.html)
- FASTER - Fast-Physics System Testbed and Research Project (http://www.bnl.gov/esm/)
- FP – Framework Program
- GCM – General Circulation Model
- GCSS – GEWEX Cloud System Studies (http://www.gewex.org/gcss.html)
- GEWEX – Global Energy and Water cycle Experiment (http://www.gewex.org)
- GPCI - GCSS/WGNE Pacific Cross-section Intercomparison (http://www.igidl.ul.pt/cgul/projects/gpci.htm)
- GOCCP – GCM-Oriented Cloud CALIPSO Product (http://climserv.ipsl.polytechnique.fr/cfmip-atrain.html)
- GPCI : GEWEX Pacific Cross section Intercomparison
- HADGEM2-ES – Hadley Centre Global Environmental Model 2 (Earth System)
- IFS - Integrated Forecasting System
- IPCC - Intergovernmental Panel on Climate Change (http://www.ipcc.ch/)
- IPSL – Institut Pierre-Simon Laplace (http://www.ipsl.jussieu.fr/)
- ISCCP - International Satellite Cloud Climatology Project (http://isccp.giss.nasa.gov/)
- IS-ENES - INFRA-2008-1.1.2.21: establishing an European e-Infrastructure for earth system's understanding and modeling
- ITCZ – Inter Tropical Convergence Zone
- JMA – Japan Meteorological Agency (http://www.jma.go.jp/jma/indexe.html)
- JPL - Jet Propulsion Laboratory (http://www.jpl.nasa.gov/)
- KNMI - Royal Netherlands Meteorological Institute (http://www.knmi.nl)
- LES – Large Eddy Simulation
- LOCEAN – Laboratoire d'Océanographie et du Climat : Expérimentations et Approches Numériques (https://www.locean-ipsl.upmc.fr/index.php)
- LMD – Laboratoire de Météorologie Dynamique (http://www.lmd.jussieu.fr/)
- LMDz - Laboratoire de Météorologie Dynamique general circulation model
- LTS Lower Tropical Stability
- LWP – Liquid Water Path
- MB – Management Board
- METO - Met Office (http://www.metoffice.gov.uk/)
- MF-CNRM[4] - Météo-France - Centre National de Recherches Météorologiques (http://www.cnrm.meteo.fr/)

[4] CNRM is also affiliated to the Centre National de la recherché Scientifique (CNRS) under the name of Groupe d'Etude de l'Atmosphère Météorologique (GAME)

- MISR - Multi-angle Imaging SpectroRadiometer (http://www-misr.jpl.nasa.gov/)
- MISU – Department of Meteorology Stockholm University (http://www.misu.su.se/)
- MODIS - Moderate Resolution Imaging Spectroradiometer (http://modis.gsfc.nasa.gov/)
- MPG - Max Planck Gesellschaft (http://www.mpg.de)
- MOLEM – Met Office Large Eddy Model
- MPI-M – Max Planck Institute for Meteorology (http://www.mpimet.mpg.de/)
- NASA – National Aeronautics and Space Administration (http://www.nasa.gov/)
- NAO – North Atlantic Oscillation
- NWP – Numerical Weather Prediction
- OAGCM - Ocean-Atmosphere Global Climate Model
- PARASOL - Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (http://smsc.cnes.fr/PARASOL/)
- PC – Project Coordinator
- PCMDI – Program for Climate Model Diagnosis and Intercomparison (http://www-pcmdi.llnl.gov/)
- RACMO - Regional Atmospheric Climate Model
- SAM – System for Atmospheric Modeling (http://rossby.msrc.sunysb.edu/~marat/SAM.html)
- SCM – Single Column Model
- SIRTA - Site Instrumental de Recherche par Télédétection Atmosphérique (http://sirta.ipsl.polytechnique.fr/)
- SPM – Summary for Policy Makers
- SST – Sea Surface Temperature
- SU - University of Stockholm (http://www.bbcc.su.se/)
- TKE – Turbulent Kinetic Energy
- TOA – Top Of Atmosphere
- TUD - Delft University of Technology (http://www.ws.tn.tudelft.nl)
- UCLA – University of California, Los Angeles (http://www.ucla.edu/)
- UKMO – United Kingdom Meteorological Office (http://www.metoffice.gov.uk/)
- UW - University of Warsaw (http://www.uw.edu.pl/en/)
- VOCALS – VAMOS Ocean-Cloud-Atmosphere-Land Study (http://www.eol.ucar.edu/projects/vocals/)
- WCRP – World Climate Research Program (http://wcrp.wmo.int)
- WGNE – Working Group on Numerical Experimentation
- WMO – World Meteorological Organisation (http://www.wmo.int)
- WP – Workpackage
- WU – Uniwersytet Warszawski (http://www.uw.edu.pl/)

-

3.3 Deliverables and milestones tables

Deliverables

The deliverables due in this reporting period, as indicated in Annex I to the Grant Agreement have to be uploaded by the responsible participants (as indicated in Annex I), and then approved and submitted by the Coordinator. Deliverables are of a nature other than periodic or final reports (ex: "prototypes", "demonstrators" or "others"). If the deliverables are not well explained in the periodic and/or final reports, then, a short descriptive report should be submitted, so that the Commission has a record of their existence.

If a deliverable has been cancelled or regrouped with another one, please indicate this in the column "Comments".
If a new deliverable is proposed, please indicate this in the column "Comments".

This table is cumulative, that is, it should always show all deliverables from the beginning of the project.

TABLE 1. DELIVERABLES

Del. no.	Deliverable name	Version	WP no.	Lead beneficiary	Nature	Dissemination level[5]	Delivery date from Annex I (proj month)	Actual / Forecast delivery date Dd/mm/ yyyy	Status No submitted/ Submitted	Contractual Yes/No	Comments
D0.1	Project Flyer	1.0	999	KNMI	Other	PU	3	16/9/11	submitted		
D0.2	Internal web site	1.0	999	KNMI	Other		3	--	--		Because the external website was available right at the start of the project an internal website was considered not useful
D0.3	Kick-off Meeting	1.0	999	KNMI	Other	PU	3	19/4/11	Submitted		
D0.4	Public web site	1.0	999	KNMI	Other	PU	6	19/4/11	Submitted		
D1.1	Final version of COSP software	1.0	1	MET OFFICE	Other	PU	3	4/7/11	Submitted		
D1.2	Final version of CALIPSO-PARASOL	1.0	1	MPG	Other	PU	3	19/4/11	Submitted		

5 **PU** = Public
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).
Make sure that you are using the correct following label when your project has classified deliverables.
EU restricted = Classified with the mention of the classification level restricted "EU Restricted"
EU confidential = Classified with the mention of the classification level confidential " EU Confidential "
EU secret = Classified with the mention of the classification level secret "EU Secret "

	observational analysis product and of MODIS simulator										
D1.3	ESM versions with COSP software	1.0	1	MET OFFICE	Other	PU	6	19/4/11	Submitted		
D1.4	Final output of ESM simulations	1.0	1	MET OFFICE	Other	PU	12	23/9/11	Submitted		
D1.5	Final versions of model evaluation packages	1.0	1	AA	Other	PU	18	20/9/11	Submitted		
D3.1	Description of the set-up for the ASTEX, the GPCI stratocumulus and shallow cumulus and the SCM equilibrium state cases	1.0	3	TUD	Other	PU	12	14/7/11	Submitted		

Milestones

Please complete this table if milestones are specified in Annex I to the Grant Agreement. Milestones will be assessed against the specific criteria and performance indicators as defined in Annex I.

This table is cumulative, which means that it should always show all milestones from the beginning of the project.

TABLE 2. MILESTONES							
Mile stone no.	Milestone name	WP no	Lead	Delivery date	Achieved Yes/No	Actual / Forecast achievement date dd/mm/yyyy	Comments
M1.1	**Completion of COSP and MODIS software and CALIPSO-PARASOL observational products**	**1**	**METO**	**3**	**Yes**	**April-June 2011**	**Prototype Models and Observational data sets**
M1.2	**Completion of the model evaluation packages**	**1**	**AA**	**18**	**Yes**	**Sept. 2011**	**Prototype Model**
M1.3	**Delivery of the ESM simulation output**	**1**	**DKRZ**	**18**			**Model data**