



COMBINE

Quarterly Newsletter 9 – July 2012

Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection

May and June of 2012 have been dedicated to writing and synthesizing the 2nd Period report. The report is available to the partners via the internal protected web site (<http://www.combine-project.eu/Reporting.790.0.html>). We are grateful to everybody for the enjoyable collaboration during the report preparation.

This issue:

- 2nd Periodic Report Publishable Summary
- Report on the Euro-PISM meeting

Announcements:

- To provide for an opportunity to report on the scientific and technical work produced within the project, we have the **COMBINE Technical Report Series**. Possible topics for the series include documentations of scientific and technological development of new model components, analysis tools for evaluation of model outputs, support datasets for running experiments, new observations and analysis datasets, for initializing and evaluating model performance, and methodologies for model evaluations. Please consider the COMBINE technical report series (<http://www.combine-project.eu/Technical-Reports.1668.0.html>) as an avenue to publish and disseminate your technical oriented work.

Project News:

- **COMBINE Technical Report No. 2: Bellucci et al. 2012, *An assessment of a multi-model ensemble of decadal climate predictions performed within the framework of the COMBINE project*.** (http://www.combine-project.eu/fileadmin/user_upload/combine/tech_report/COMBINE_Tech_REP_n02.pdf)
- The project welcomes a new associate partner: Istituto di Scienze dell' Atmosfera e del Clima (ISAC-CNR), in Roma, Italy, and represented by Chiara Cagnazzo.

2nd Periodic Report Publishable Summary

1. Project context and main objectives

The general goal of the COMBINE project is to advance the capabilities of climate prediction and projection based on comprehensive Earth system models. The project brings together the leading European centres in Earth system modeling thus making use of an ensemble of seven Earth system models.

The general goal has three major foci: Firstly COMBINE includes research on critical dynamical, physical and biogeochemical processes in the Earth system and the related feedbacks, which eventually determine the amplitude of natural climate variability and anthropogenic climate change. For this goal the COMBINE project develops new model components for selected processes and assesses the sensitivity of feedbacks and climate change in Earth System models to such added processes, using standardized Coupled Model Intercomparison Project Phase 5 (CMIP5) experiments. The processes selected for this project represent: C- and N-cycle; aerosols coupled with clouds and chemistry; stratospheric dynamics; and ice sheets, sea ice and permafrost for the cryosphere.

Secondly COMBINE investigates the potential predictability of climate on time scales up to a decade and the development of initializations and correction methods to practically realize this potential. This research aims at a better quantification of the potential predictability based on an ensemble of Earth system models and standardized CMIP5 experiments, and at the development of procedures to exploit this potential in current Earth system models, using ocean and sea ice analyses and accounting for systematic biases of models. The project assesses the sensitivity of decadal predictions to the choice of the initialization and correction

methods, as well as to adding selected new components to the Earth system models.

Thirdly COMBINE aims at linking Earth system simulations for the past and future to global and regional impacts with focus on water availability, and to feed the climate change simulations back to the development of new scenarios, thus closing the circle between the development of socio economic scenarios and the projection of climate change by comprehensive Earth system models. The latter is of particular interest as Earth system models, as used in COMBINE for the CMIP5 scenarios, include the carbon cycle and thus can simulate simultaneously the evolution of temperature and alternatively CO₂ concentration or implied anthropogenic CO₂ emissions.

Overall the COMBINE project addresses current research questions related to climate change, making use of an ensemble of comprehensive Earth system models developed in Europe. The research goals are well aligned with the international research activities, in particular the simulations made in this project have been selected from the CMIP5 protocol, and a major part of these simulations will be disseminated to the international scientific community through the CMIP5 Earth System Grid. Thus the project will not only generate results from its own analysis of the Earth system model simulations, but it will also broadly support international climate research, and thus the climate change assessment conducted under Intergovernmental Panel on Climate Change (IPCC).

2. Work performed and main results achieved

The work performed since the beginning of the project and the main results achieved so far is summarized as follows:

New components for the representation of carbon and nitrogen cycle, aerosols, clouds and chemistry, stratospheric dynamics, cryosphere: ice shields, sea ice, permafrost, have been developed and tested by means of new methodologies. Main results include: reduction in methane lifetime with global warming; reduction in ocean denitrification in response to reduced productivity of the marine ecosystem; stronger troposphere-stratosphere coupling; more accurate simulation of the Arctic sea ice cover; Greenland ice-sheet simulation for a pre-

industrial control run, for which the ice-sheet volume remains stable, compared to an abrupt 4xCO₂ simulation in which this volume is clearly decreasing. The construction of “new” Earth system models based on the “new components” is in an advanced state. For some models the production of stream 2 simulations has begun.

Ocean initialization: New ocean re-analyses have been conducted, with improved methodology and observational datasets. These new analyses are used in decadal predications. Major advances are reported on sea-ice initialization and predictability, a novel research field.

Stream 1 simulations: The CMIP5 experiments planned in COMBINE are completed and disseminated. The data can be accessed through the Earth system grid. These simulations are analyzed with regard to decadal predictability, predictive skill, and climate feedback parameters related to physical and carbon cycle processes.

Predictions: Predictive skill of surface temperature is largely driven by trends in radiative forcing, but significant residual skill is found in the North Atlantic area. The Atlantic Multidecadal Oscillation (AMO) appears to be predictable in the near-term (2-5 yrs) as well as in the longer (6-9 yrs) term. A near-term forecast initialized on year 2005 shows a general consensus across models on the AMO persisting in a positive (warm) phase. Predictive skill is generally low over most of the continental areas in the 2-5 years range, with notable exceptions for Scandinavia, Northern Europe and parts of Australia and North America.

Climate feedbacks: A model inter-comparison based on the partial radiative perturbation method applied to idealized 1% per year CO₂ increase experiments, has been carried out. For the model considered, it is found that the inter-model spread in cloud radiative feedbacks is not substantially larger than in other feedbacks like the water vapor or the lapse rate feedback, in contrast to previous works. The diagnostic of radiative fluxes against changes in near surface temperatures in an experiment where CO₂ is instantaneously quadrupled from pre-industrial levels suggests that the strength of fast tropospheric adjustment processes in different CMIP5 models varies significantly. This could

substantially contribute to differences in the climate sensitivity of the models. The sensitivity of the Earth system models with respect to physical and biogeochemical forcing was assessed. For the COMBINE models, about the same sensitivities were obtained for both categories of forcing as previously found. Partially coupled experiments were also made, to assess the linearity in the physical and biogeochemical feedbacks. It turns out that linearity is not valid for every model, hence it is not a general assumption and the derivation of the carbon cycle climate feedbacks using separate runs is not fully adequate.

Impacts and Scenarios: Contribution to the development of the Representative Concentration Pathways (RCPs); developing a modeling framework for the impact assessment; preliminary results indicate a clear acceleration of the hydrological cycle as a consequence of climate change.

3. Expected final results and their potential impacts and use

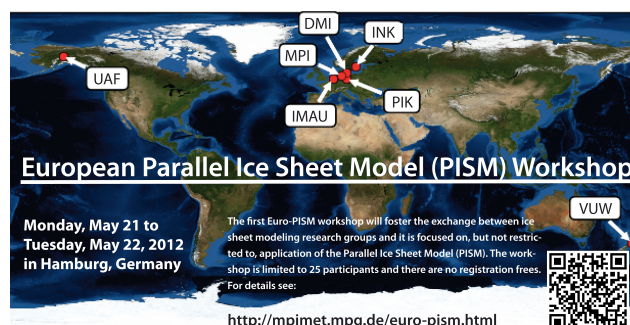
The COMBINE project generates new knowledge in the field of fundamental climate research through the development and use of an ensemble of European Earth system models. The final results will consist in advanced understanding of the role of selected processes for feedbacks in the climate system. The project analyses the changes in climate feedbacks and climate related to the addition of new process models to Earth system models. The final outcome of the project will consist of two kinds of products:

Simulations: The project generates a substantial number of climate simulations for its own research. As these experiments were chosen to follow the CMIP5 protocol, the simulations have been disseminated to the CMIP5 archive, which is accessible to climate researchers worldwide through the Earth System Grid. These data contribute significantly to a broad multi model ensemble that will be analyzed by a large number of scientists for many aspects of climate variability, climate change and climate predictability, beyond the lifetime of the COMBINE project. These data will not only be analyzed with regard to the physical and biogeochemical functioning of the Earth system, but will also be invaluable for the investigation of

socio-economic impact and the wider societal implications of different climate change scenarios.

Publications: Scientific results from the research pursued in the COMBINE project are mainly disseminated to the international research community by peer-reviewed articles. Those articles submitted and published before the cut-off dates for the 5th assessment report (AR5) of the IPCC (31.7.2012 and 15.3.2013, respectively) can be reflected and assessed for the AR5. Through the provision of the AR5 authors with most up-to-date knowledge on the functioning of the Earth system and climate change studies, the COMBINE researchers support indirectly the decision makers, who base their decisions on the IPCC assessments.

Euro-PISM: First European meeting of the Parallel Ice Sheet Modeling community.



Organizer: Christian Rodehacke (MPI, DE)

From 21 to 22 May 2012 ice sheet modelers from diverse European research groups came together at the Max Planck Institute for Meteorology in Hamburg, Germany, to exchange ideas and latest research results during the first "Euro-PISM"-Workshop dedicated to ice sheet modeling. Ice sheets and ice caps have the potential to bring the climate system into a state that differs sharply from the current one. Greenland and Antarctica, for instance, interact with the climate system through numerous processes. These operate predominantly on longer timescale if we do not take fast catastrophic events into account here. Large-scale disintegration of ice sheets would raise the sea level drastically, which could flood

densely populated coastal areas globally. Melt water released into the ocean poses also a threat for the meridional overturning circulation, which is a backbone for the global redistribution of heat and sequestration of greenhouse gases. These impacts have far reaching consequences and, therefore, put ice sheets in the focus of climate research and public discussion.

The 25 ice sheet modelers from six countries focused their discussion on the *Parallel Ice Sheet Model* (PISM, <http://www.pism-docs.org>). PISM is used by two COMBINE partners, the Danish Meteorological Institute (DMI) and the Max Planck Institute for Meteorology (MPI), to perform coupled ice sheet - Earth system simulations. During the first day, oral and poster presentations spanned a width range of topics such as parameterization development of essential processes (e.g., ice shelf calving); paleo-studies (standalone and coupled simulations of the Last Glacial Maximum); and fully coupled ice sheet - Earth system studies of the present and future climate. During the second day, essential and pressing topics have been presented by invited speakers. The workshop then evolved into working groups, which focused on deepening the topics introduced by the invited speakers. The invited speakers and the working groups addressed the following four topics:

- *Introduction to PISM*, by Ed Bueler (University of Fairbanks, Alaska, USA)
- *The Calving Law and related topics*, by Anders Levermann (Potsdam Institute for Climate Impact Research, DE)
- *Ocean-Ice sheet/shelf interaction*, by Klaus Grosfeld (Alfred Wegener Institute for Polar and Marine Research, DE)
- *Coupling between Earth system models and ice sheet models*, by Gudfinna Adalgeirsdottir (Danish Meteorological Institute, Dk).

During the final discussion, key elements (like the exchange of properties) to enable a smooth integration of the PISM ice sheet model into Earth system models have been identified and specified. This workshop has been a very fruitful meeting and has clearly highlighted the challenges of coupling Earth system models with ice sheet/shelf models, which, ultimately, can only be met by close international collaborations.

COMBINE Web Site:

<http://www.combine-project.eu/>

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UNIVBRIS, UK	Uni Kassel, DE	TUC, GR
CYI, CY	INPE, BR	UNEXE, UK

EVENTS of interest:

27-31 August 2012 **Quadrennial Ozone Symposium**, Toronto, Canada

17-21 September 2012 **3rd International Conference on Earth System Modelling and COMBINE GA 2012**, Hamburg, Germany

24-27 September 2012 **Third Symposium - The Ocean in a High-CO2 World, Ocean Acidification**, Monterey, CA, USA

24-26 October 2012 **Worlds within reach. From science to policy. IIASA 40th Anniversary Conference**. Vienna, Austria

3-7 December 2012 **AGU Fall Meeting**, San Francisco, CA, USA

18-20 March 2013 **European Climate Change Adaptation Conference 2013**, Hamburg, Germany

15-19 April 2013 **4th WGNE workshop on systematic errors in weather and climate models**, Exeter, UK

22-26 April 2013 **SPARC/DynVar & SNAP Workshop**, Reading, UK

3-7 June 2013 **9th International Carbon Dioxide Conference**, Beijing, China