



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

**SUMMARY 2010**

*Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection  
Collaborative Project & Large-scale Integrating Project - Grant Agreement No. 226520*

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The general goal of the COMBINE project is to advance the capabilities of climate prediction and projection by including critical physical and biogeochemical processes (“new components”) into Earth system models (ESMs) and by using observation based analyses of the ocean and sea ice states, to benefit from the predictability of the climate system.

At the start of the project the consortium had available climate and impact models, as used to contribute to the 4<sup>th</sup> Assessment Report of IPCC. The protocol for the Coupled Model Intercomparison Project phase 5 (CMIP5) for new climate projections and climate predictions was published, though important data sets needed for CMIP5 were not yet available to the community. Prototypes of component models in some cases were also available to the consortium, although the knowledge and experience in the coupling between the component models and the ESMs were generally not available.

During the reporting period, the COMBINE partners have advanced significantly on two main tasks: develop the scientific and technical foundations for incorporating new components in ESMs; and prepare and test the ESMs to be used for CMIP5.

Main results achieved so far:

- Implementation in relevant ESMs and first testing of new processes related to the carbon cycle, such as land use changes, terrestrial and oceanic nitrogen cycles, and wildfire; and processes related to methane emissions from changes in permafrost and wetlands.
- Improvements in the description of sub-grid-scale cloud-radiation and aerosol-cloud interactions, first evaluations of cloud-radiation effects and of aerosol-cloud relationships; and land use impacts on tropospheric chemistry.
- Significant improvement in the representation of stratospheric variability both in the tropics and in the extra-tropics in the relevant ESMs.
- Extensive evaluation of the processes regulating ice-sheet surface energy and mass balances; and increased realism of the representation of surface snow processes in both ice-sheet and sea-ice models.
- New ocean re-analyses conducted using the most up-to-date quality-controlled ocean observation data sets and forcing fluxes from improved atmospheric re-analyses; significant progress in the area of sea-ice assimilation.
- Provision of initial states for decadal hindcasts and forecasts; preliminary assessment of the impact of different ocean re-analyses and initialization strategies on the simulated ocean variability and predictability.
- Decadal prediction and centennial projection simulations following the CMIP5 protocols have started with the relevant COMBINE modeling systems. Following the project plan, 4 modeling systems are employed for the decadal experiments. These experiments have been initialized using observation based ocean state

estimates to benefit from the predictability of the climate system. All the COMBINE modeling systems are involved in the centennial CMIP5 simulations.

Some non-critical delay in the project work is reported. A major reason for this delay is the fact that convergence, within the international climate research community, in delineating and constructing the CMIP5 radiative forcing data was reached only toward the end of 2009 (and in some cases beginning of 2010). This situation has been exploited for further advancing the status of the ESMs, but it has delayed the actual running of the simulations and in some cases also the work on the incorporation of the new components in some ESMs.

Neither the expected results nor the intentions for use and impact of the project results have changed. The COMBINE model-data; the quantifications of impacts and scenarios and the scientific knowledge emerging from the improved ESMs will substantially contribute to the next IPCC assessment. The project work will strengthen the scientific base for environmental policies of the EU for climate negotiations.