COMBINE **Quarterly Newsletter 12 – October 2013**
Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection

COMBINE INTEGRATING PROJECT (May 2009 – October 2013)

FINAL REPORT EXECUTIVE SUMMARY

The European integrating project COMBINE brought together research groups to advance the capabilities of Earth system models (ESMs) for more accurate climate projections and climate prediction. COMBINE improved ESMs by including (1) key physical and biogeochemical processes, which were missing in predecessor models, but known to influence the variability of climate and the feedbacks determining climate change; and (2) analyses of the ocean and sea ice in prediction systems.

The overall carbon cycle feedback to climate change was confirmed to be positive. Models without nitrogen limitation simulate an excess uptake of carbon, which is not supportable by the available nitrogen. If nitrogen limitation is considered, then the overall carbon cycle feedback to climate change becomes more positive, and the allowable carbon emissions for a given CO_2 concentration pathway are smaller than if nitrogen limitation of the carbon cycle is neglected. Generally, however, it remains a challenge to properly include the fully coupled carbon/nitrogen cycle in models.

The Greenland ice sheet was found to shrink substantially for high CO_2 forcings, while the amount of melting still differs significantly among models, due to difficulties in parameterizing the albedo of snow on ice. Modeling the coupling to the Antarctica ice sheet in ESMs remains an open challenge. Improvements in the representation of the sea-ice have demonstrated a larger susceptibility of sea-ice associated with the coupling of atmosphere/ocean and sea-ice processes.

COMBINE developed and tested new ocean initialization techniques. Advancements in ocean re-analysis made also possible to diagnose the role of the ocean circulation for heat absorption variability, providing a plausible explanation for the recent hiatus in surface warming. Sea-ice assimilation and initialization techniques were developed and implemented for the first time in climate prediction systems.

Through COMBINE the European contribution to the projection experiments of the Coupled Model Intercomparison Project – phase 5 (CMIP5) was accomplished. CMIP5 is the latest set of climate projections and predictions, done in support to the Intergovernmental Panel on Climate Change (IPCC). In addition, the feedback analysis on radiative (aerosols), nitrogen & carbon, and cryospheric processes carried out on new COMBINE projections will contribute to the next cycle of CMIP.

European modeling groups lead by the COMBINE project were effective in advancing climate prediction by contributing to the first internationally coordinated set of decadal hindcacts and

forecasts (under CMIP5). This set was and is currently investigated to assess its reliability and potentials, including decadal prediction of extreme events. Decadal forecasts showed that Atlantic sea surface temperatures appears to have considerable predictive capability up to ~10 years. Similarly, long-term predictability was found for near-surface air temperature over Northern Africa and the adjacent Mediterranean and Middle East. Improvements in climate variability resulted from the incorporation of the stratosphere.

Results from the COMBINE projection runs were used to assess impacts of climate change. These analysis confirmed significant consequences on hydrological extremes. Despite a global increase of water availability, in regions such as Central America, the Mediterranean and Northern Africa renewable water resources are assessed to diminish. Analyses showed that feedbacks could have a considerable impact on the strategy of climate policies and related costs, with mitigation costs varying by a factor of 8 depending on assumptions on climate sensitivity.

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