COMBINE Quarterly Newsletter 4 – April 2011

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

This issue:

- Report on the ILAMB Benchmarking Meeting by Jones and Friedlingstein
- Report on the Stream 1 Decadal Prediction Experiments by Haarsma et al

Project News:

- Dr Claus Brüning is the new European Commission Project Officer for COMBINE. We welcome Dr Brüning and look forward to collaborate with him.
- University of Exeter, UK, has joined the COMBINE partnership. We welcome the University of Exeter and the continuing collaboration with Dr Friedlingstein.

ILAMB Benchmarking meeting

Jones, C (Met Office, UK) and P Friedlingstein (University of Exeter, UK)

The International Land Model Benchmarking (ILAMB; www.ilamb.org) project held an international meeting hosted at University of California, Irvine, near Los Angeles from 24th-26th January, 2011 thanks to support from the US Department of Energy and IGBP-AIMES. It involved 45 participants from around the world and featured sumptuous, but very early, breakfasts.

ILAMB is a model-data intercomparison and integration project designed to improve our understanding of the performance of land models, to guide their development and to improve the design of new measurement campaigns to reduce uncertainties associated with key land surface processes. ILAMB grew out of several activities – the US land model evaluation activity, C-LAMP (Randerson et al. 2009; http://www.climatemodeling.org/c-lamp/), benchmarking of the JULES land-surface model in the UK (Blyth et al. 2010), and coupled carbon-cycle GCM evaluation (Cadule et al. 2010).

The goals of ILAMB are to:

1. Develop internationally accepted benchmarks for land model performance,
2. Promote the use of these benchmarks by the international community for model intercomparison,
3. Strengthen linkages between experimental, remote sensing and climate modeling communities in the design of new model tests and new measurement programs,
4. Support the design and development of a new, open source, benchmarking software system for use by the international community.

Over the last decade or so, a growing number of climate models have been developed to investigate the coupling between the climate system and the global carbon cycle and increasingly other components of the Earth System. Such Earth System Models (ESMs) have the ability to tell us more and more about the future climate and its interactions with ecosystems. They are also finding more and more applications across more and more space and timescales from weather forecasting to climate predictions, and from site level to global scale simulations. However, as they become more complex they also have the potential to become less and less constrained and more difficult to analyse or understand. Therefore there is a growing requirement for systematic and targeted evaluation of these models against relevant observational datasets to ground-truth their behaviour at a process level, and constrain their projections at an integrated level. Seductive as it may be to add ever more processes to the models it is important that we do so in a way that brings benefit rather than loss of skill. ILAMB aims to define and facilitate systematic and comprehensive benchmarking of land-surface models.

Past data-model intercomparisons have strengthened the representation of key processes in land models, but often this information has not been easily accessible for use by other modeling teams or in future intercomparisons. Often modellers don't appreciate data limitations and data providers don't appreciate modellers' requirements. ILAMB aims to bring together experts from around the world in processes, models and observations to enable optimal model-data integration and aims to alleviate the large cost in developing the infrastructure to make meaningful model-data comparisons, through pre-defined and programmed evaluation metrics against pre-assembled datasets. Such an open-source infrastructure can be centrally maintained but constantly developed by the community. In the same way that model development can benefit from a community approach, so can model benchmarking.

The workshop included general discussion of what the community means by benchmarking which can have several definitions, commonly but misleadingly used to mean simply “evaluation”, it can legitimately be used to refer to a standardised evaluation or test of models. Benchmarking could also be seen to involve *a prior* setting of a performance standard, which must be reached before a model is seen as “fit for purpose”. As well as the philosophical aspects, the meeting addressed practical questions such as key model outputs to benchmark and which datasets to use. The workshop was very focused on achieving a tangible output in the near-term with particular emphasis on developing a 1st ILAMB product release in time to perform useful evaluation of both offline (TRENDY, http://dgvm.ceh.ac.uk/trendy-gcp) and coupled (CMIP5, http://cmip-pcmdi.llnl.gov/cmip5/index.html) land surface simulations: both key activities contributing to AR5. Simultaneous evaluation of models against carbon, water and energy fluxes across a range of timescales will present a genuine challenge for current generation land-surface models.

Many challenges still exist such as determining which metrics should be used for which application? What observations provide a constraint rather than simply an evaluation? Can benchmarking be used to weight multi-model output to form a pdf of projections? Should performance levels for models be pre-defined? This is an exciting and rapidly moving field of modelling and one in which COMBINE can bring valuable expertise.

ILAMB will bring benefit to the land-surface and ESM community through: increased availability of relevant and standardised data; standardised metrics by which to evaluate the comparison quantitatively; standardised simulation protocols to facilitate comparison of new developments and hence track progress. COMBINE will contribute to ILAMB through evaluation data assembled and used in WP1, and will benefit from ILAMB through constraints on simulations under WPs 6, 7 and 8. ILAMB represents an excellent opportunity for COMBINE to interact with and contribute to the wider international ESM community.

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The COMBINE Stream 1 Decadal Prediction Experiments

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Half way the COMBINE project, a first set of decadal prediction experiments has been completed. First analysis of the results reveals that the observed trend and variability up to 2-5 years can be successfully simulated. These promising results provide a basis for further analysis and will serve as a benchmark for a second set of decadal predictions with the improved model systems and initialization techniques developed within the project.

Motivation for decadal predictions

Within the wide range of temporal scales affecting the spectrum of climate variability, the decadal (10 to 30 years) timescale plays a particularly relevant role for human societies, as this is a temporal horizon of major interest for decision and policy makers. Over this temporal scale, natural fluctuations and anthropogenic change induced by increasing greenhouse gas concentrations are competing factors in shaping the climate signal. Disentangling the relative influence of these factors is particularly crucial at the regional scale where the internal variability may eventually offset the trend associated with an increasing radiative forcing. The concern for the environmental and socio-economic impact of near-term climatic changes led to the development of decadal predictions. This novel field of investigation lies somewhat in between the seasonal-to-interannual predictions and the longer-term century-scale climate projections. In particular, the initial state of the system and the time evolution of the radiative forcing both play a role over the decadal range, making decadal predictions a “hybrid” initial/boundary value problem. Due to its large heat capacity the ocean is strongly affecting the decadal variability signal. For reliable decadal forecasts the initial state of the ocean as well as its coupling with the atmosphere need to be adequately represented. Leading variability modes characterizing the slow ocean evolution and involving the Meridional Overturning Circulation (MOC), particularly active in the Atlantic region, and the Pacific Decadal Oscillation (PDO) are likely to drive a considerable fraction of the overall decadal predictability. Fluctuations in external forcings such as aerosols and in internal variability in the cryosphere and soil moisture may also play a role.

Review of status of decadal predictions

Pioneering studies on climate predictability performed with AOGCMs using “perfect model” experimental setup (Griffies and Bryan 1997; Boer 2000) revealed the existence of potential predictability at decadal timescales, particularly over the oceans, and most notably in the North Atlantic. These idealized studies set the basis for “real” decadal predictions, leading to investigate the effects of realistic ocean initializations, based on available syntheses of the time-varying three-dimensional ocean state, on the predictive skill of climate models. Substantial developments of the global ocean observing system and improvements of ocean data assimilation techniques have recently fostered the development of decadal prediction systems (Smith et al. 2007, Keenlyside et al. 2007; Pohlmann et al. 2009).

Similarly to the well established practices developed for seasonal scale and weather predictions, sampling the uncertainties associated with imperfect knowledge of the initial state of the coupled system requires the design of ensemble simulations starting from perturbed initial conditions for the atmosphere and ocean. No “best practice” has emerged yet concerning the initialization and perturbation procedures to be used when constructing the ensembles of decadal simulations. Full-value and anomaly initializations for the ocean feature both advantages and disadvantages. Other pending issues concern the initialization of sea-ice and land surface. The scarcity of direct observations of sea-ice and soil parameters makes the initial state of these components of the climate system largely unconstrained, with potentially relevant implications for the reliability of the decadal predictions.

COMBINE WP6

The overall goal of COMBINE WP6 is the assessment of the impact of new model components, (developed in WP1-4) and new initialization strategies (developed in WP5) on the Decadal Prediction Experiments (DPEs) performed with a multi-model ensemble of global coupled atmosphere-ocean-seaice models. To this aim, two streams of DPEs have been planned within WP6. In a first stream of experiments (Stream 1), state-of-the-art coupled models, initialized using existing initialization techniques, are used to perform ensembles of DPEs. A second stream of DPEs (Stream 2), where the climate models and the initialization techniques will be appropriately improved according to the results and the findings obtained during the first three years of the project, will be then performed during the last part of the project. The Stream 1 DPEs thereafter serves as a benchmark to evaluate the impact of the new initialization schemes and the new model components that will be implemented in the COMBINE models, on the decadal predictions. Finally, the DPE results are going to be used in WP8, a work package specifically devoted to impact studies.

Within WP6, five model systems (CMCC, MPI, EC-EARTH, HadGEM and CNRM-CM) are used by 7 partners (CMCC, MPG, KNMI, DMI, SMHI, METO and CERFACS). Two partners (UCL and MF-CNRM) are mainly involved with sea-ice modeling. Different decadal prediction strategies have been explored. The GECCO, INGV-ODA and/or NEMOVAR ocean initialisation data have been used. Full as well as anomaly coupling is done. For one model system (EC-EARTH) both strategies are followed enabling a more direct comparison. Some partners have applied nudging whereas others did not use constraints. Sea-ice initialisation is still in its infancy and various methods have been used, varying from climatology to data from an ocean-atmosphere model forced with atmospheric fields. For the perturbations of the initial state to obtain ensembles different options have been chosen: Atmospheric only perturbations or ocean perturbations as well. Evaluations of these procedures are underway and will guide the experimental set-up for Stream 2.

Contribution of COMBINE WP6 to CMIP5

The COMBINE project, specifically WP6, is providing a framework for the coordination of the European contribution to the decadal prediction experiments of the Coupled Model Intercomparison Project Phase-5 (CMIP5, http://cmip-pcmdi.llnl.gov/cmip5/index.html). The Stream 1 of the COMBINE DPEs has been designed so that it follows the CMIP5 protocols and radiative forcings. The start dates of the DPEs are from 1960 to 2005 with an interval of 5 years, and the length of the simulations is 10 years, although some partners performed longer 30-years experiments. The forcing includes historical greenhouse forcings, ozone and aerosol concentrations for the 1960-2005 period, while after 2005 the RCP4.5 is used. Stream 1 model-outputs, and possibly also Stream 2 model-outputs, are being and/or will be included in the CMIP5 database.

Preliminary Results & Discussion

Figure 1 shows the observed global mean 2-metre temperature (T2M) for the period 1950 to present together with simulated T2M after bias correction. This bias correction is applied because of model drift toward its own climate after the initialization. The procedure of the applied bias correction is outlined in a CLIVAR publication (2011). Figure 1 shows that the observed T2M increases over the time period considered and that it stays within the multi-model ensemble, revealing to first order the success of the bias correction and the ability of the models to simulate the trend. The correlation between the observed and simulated multi-model mean T2M for the 2-5 lead year period, averaged over all the initial start dates is 0.98. This high correlation is mainly due to a correct simulation of the trend, which is caused by the change in the radiative forcing. After removing this trend the correlation is, however, still significant as shown in Figure 2. For the multi-model mean it is 0.79.

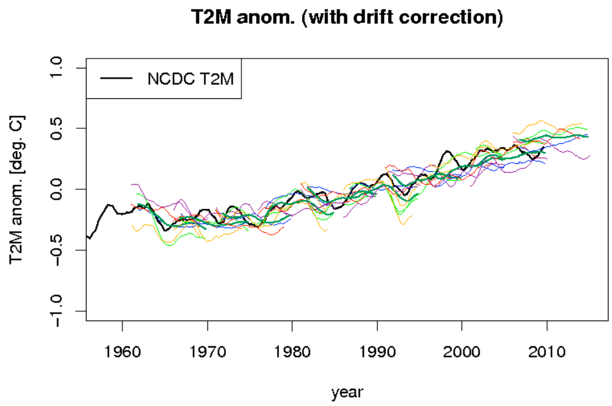

Figure 1: *Anomalous global mean T2M. Black observed. Thin coloured lines ensemble mean of the different models of COMBINE (blue: EC-EARTH, green: HadGEM, red: CMCC, magenta: MPI, orange: CERFACS). The thick green line denotes the multi-model mean ensemble.*

The results for the global mean T2M display significant skill even after detrending. The preliminary analysis confirms the added value of using an ensemble of model systems. The skill of the multi-model mean appears to be larger than of the individual models and the multi-model spread incorporates most of the time the observations, as shown in Figure 1. This is well known from seasonal predictions but appears also to apply for decadal predictions, underscoring the importance of a coordinated effort as in the COMBINE project. The promising results of the Stream 1 decadal prediction runs provide a basis for further analysis, in order to identify what are the main processes that are responsible for skilful predictions at various lead times and climate conditions.

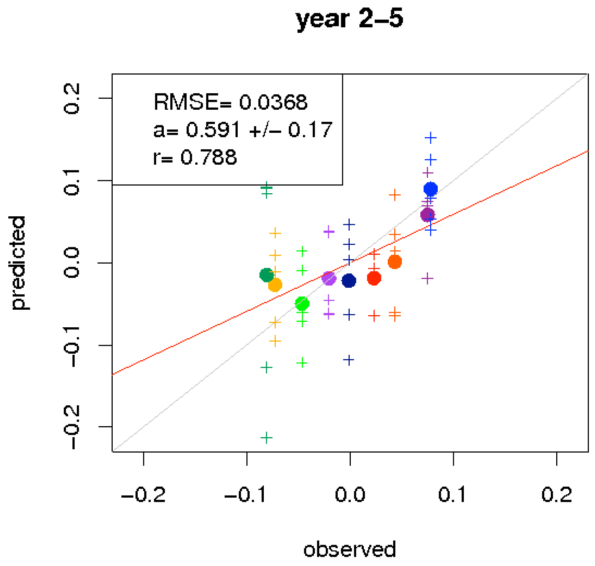

Figure 2: Observed and simulated global mean T2M for the 2-5 year lead period. The different colours indicate the different start dates of the decadal prediction runs. The solid circles denote the multi-model mean and the crosses the ensemble mean of the individual COMBINE models. a is the slope of the relationship indicated by the solid red line. r is the correlation coefficient, and rmse the root mean square error.

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

EVENTS of interest:

16-19 May 2011 **YOTC International Science Symposium and 8th AMY International Workshop**, Beijing, CHINA

24-27 May 2011 **2nd COMBINE General Assembly**, Exeter, UK

27-30 June 2011 **3rd Advances in Marine Ecosystem Modelling Symposium (AMEMR III) The Next Generation,** Plymouth, UK

27 June – 8 July 2011 **IUGG XXV General Assembly: Earth on the Edge: Science for a sustainable Planet**, Melbourne, Australia

12-15 July 2011 **Past Present and Future Change in the Atlantic Meridional Overturning Circulation, International Science Meeting**, Bristol, UK

18-23 September 2011 **3rd iLEAPS Science Conference**, Garmisch-Partenkirchen, Germany

24-28 October 2011 **WCRP OSC: Climate Research in Service to Society,** Denver CO, USA

26-29 March 2012 **Planet Under Pressure: New knowledge towards solutions**, London, UK

4-6 June 2012 **'Rio+20': United Nations Conference on Sustainable Development**, Rio de Janeiro, Brazil