



European Commission's 7<sup>th</sup> Framework Programme  
Grant Agreement No. **226520**

Project acronym: **COMBINE**

Project full title: **Comprehensive Modelling of the Earth System for Better  
Climate Prediction and Projection**

Instrument: Collaborative Project & Large-scale Integrating Project

Theme 6: *Environment*

Area 6.1.1.4: *Future Climate*

ENV.2008.1.1.4.1: *New components in Earth System modelling  
for better climate projections*

Start date of project: 1 May 2009

Duration: 48 Months

**Milestone Reference Number and Title:  
M1.3 Complete coupled system of ESM with carbon nitrogen  
and methane models.**

**Lead work package for this milestone:  
WP1**

**Organization name of lead contractor for this milestone:  
University of Exeter**

**Due date of milestone: 31/10/2011  
Actual submission date: 15/05/2012**

As detailed in deliverable “D1.2: Each ESM run with multiple new components fully coupled, and performance in control state evaluated”, completion of coupled models with new components has experienced some delays. Main reasons being the high priority put on every group to perform the CMIP5 simulations in time of inclusion in the IPCC AR5. The CMIP5 deadline slipped, as did the opening of the PCMDI database, COMBINE partners prioritised completing the CMIP5 simulations under WP7.

Offline model developments have nevertheless been proceeding by all groups, but the inclusion of the new elements in the coupled model is notoriously hard to plan, and very often slips compared with original timetable. All groups have made good progress, and generally have been successful coupling new components offline. Work is in progress to couple them online as summarised in the table below

Table 1: Summary of coupling status of the components. In the Table, LU=Land Use; PF=Permafrost

<b>partner/model</b>	<b>component</b>	<b>Coupled offline</b>	<b>Coupled in GCM</b>
<b>MetO / HadGEM2-ES</b>	LU	Y	Y
	fire	Ongoing	Ongoing
	N-cycle	Y	N
	Wetlands / PF	Improved physics, biogeochemistry	Wetlands, Y PF, N
	ALL together	ongoing	N
<b>IPSL / IPSL CM</b>	LU and fire	Y	N
	N-cycle	Y	N
	Wetlands / PF	Y	Y
	ALL together	N	N
<b>MPG / MPI-ESM</b>	LU	Y	Y
	N-cycle	Y	Y
	ALL together	Y	N
<b>KNMI / EC-Earth</b>	LU	Y	Y
	Wetlands / PF	Y	N
	ALL together	N	N
<b>Bergen / NorESM</b>	LU	Y	Y
	N-cycle	Y	Y
	ALL together	Y	Y (except river transport of nutrients)

The nitrogen cycle is now fully part of the JULES and ORCHIDEE offline models, respectively of the Hadley and IPSL ESMs. JULES is currently being tested while ORCHIDEE (OCN) had been tested, evaluated and published. NorESM has the NCAR CLM

land surface model, this model already includes a nitrogen cycle, which has been tested, evaluated and published as part of the NCAR ESM. NorESM CMIP5 simulations are hence fully interactive in term of nitrogen cycle. The MPI ESM has a full nitrogen cycle, although it hasn't been fully evaluated within the ESM because of the important CPU overhead involved.

Methane models are in a similar stage, ORCHIDEE has a wetlands and permafrost model now, it has been implemented, tested and published, however this is a different version from the nitrogen cycle version. Merging of the two versions is planned, although the priority has been given to methane in term of coupling with the ESM. A fully coupled run with carbon, nitrogen and methane is not envisaged in the near future. The Hadley Centre model already has a wetland emission model as well as a permafrost scheme that, at the moment, account for the physical mechanisms only (no biogeochemistry). The biogeochemistry module is still under development.