8.5 Deliverables list

Continue the deliverable numbers on from the numbers given in the first 18 months detailed implementation plan, and remember to include the deliverables that we originally set from months 13-18 (using the same numbers as in the first DIP)

Del. No.	Deliverable name	WP no.	Lead participant	Estimated indicative person-months	Nature [1]	Dissemi-nation level[2]	Delivery date[3]
1.3	Advanced ocean data assimilations systems, based on improved optimal interpolation, Ensemble Kalman Filter, and variational methods, developed in the ENACT project, adapted to the OGCMs to be used in the ENSEMBLES system.	1.3	CERFACS	42	O	PU	18
1.4	A new multi-model coupled model ensemble system for seasonal to decadal forecasts will be created and installed at ECMWF, with capabilities to run, in addition, perturbed parametrisations, and stochastic physics.	1.4	ECMWF	39	O	PP	18
1.5	WP1.1 workshop	1.1	MPIMET	1	O	PP	21
1.6	Report on the developed and tested ESMs	1.1	MPIMET	60	O	PU	24
1.7	Interim probability distributions of transient climate change over Europe will be produced, for use by other RTs in testing methodologies for prediction of climate change impacts.	1.6	METO-HC	12	O	PP	24

[1] Please indicate the nature of the deliverable (**R**=report, **P**=prototype, **D**=demonstrator, **O**=other)
[2] Please indicate the dissemination level (**PU**=public, **PP**=restricted to other programme participants including the Commission Services, **RE**=restricted to a group specified by the consortium including the Commission Services, **CO**=confidential, only for member of the consortium including the Commission Services
[3] Month in which deliverables will be available. Month 1 marking the start of the project, and all delivery dates being relative to this start date.

Del. No.	Deliverable name	WP no.	Lead participant	Estimated indicative person-months	Nature [1]	Dissemi-nation level[2]	Delivery date[3]
1.8	Updated assessment in terms of forecast quality and potential economic value of the relative merits of the multi-model approach, the perturbed parameter approach, and the stochastic physics approach, to representation of model uncertainty in seasonal to decadal forecasts.	1.5	ECMWF	10	R	PU	30

8.6 Work package description (18 months period, month 13-30)

Work package number	1.0	**Start date or starting event:**	Month 13
Activity Type[4]	RTD		
Participant id	1 (METO-HC), 5 (ECMWF), 70 (UOXFDC), 10 (MPIMET)		
Funded/unfunded Person-months	METO-HC (2/2), ECMWF (0/0), UOXFDC (0.5/0), MPIMET (1/0)		

Objectives

Provide management and coordination of activities within RT1.

Description of work

WP1.0: Management of RT1

Task 1.0.2: The RT1 website will be maintained and developed, containing information such as location of model documentation, model output data, contact details, progress reports, summaries of meetings and key scientific developments etc.

Task 1.0.3: Timely delivery of milestones, deliverables and progress reports and representation of RT1 at ENSEMBLES management meetings will be ensured.

Task 1.0.4: A second meeting of RT1 participants will be held between months 18 and 24 to review progress and finalise contributions to Major Milestones 1.1 and 1.2, "Provision of a set of tested Earth System Models", and "Provision of a "first generation" ensemble prediction system (Version 1) for use in RT2.

Deliverables

Milestones[5] **and expected result**

Work package number	1.1	**Start date or starting event:**	Month 13
Activity Type[6]	RTD		
Participant id	1 (METO-HC), 3 (CNRS-IPSL), 10 (MPIMET), 7 (INGV), 4 (DMI)		
Funded/unfunded Person-months	METO-HC (4.5/4.5), CNRS-IPSL (16/16), MPIMET (18/6), INGV (5/2), DMI (9/6)		

[4] For Integrated Projects each workpackage must relate to one (and only one) of the following four possible Activity Types: RTD/Innovation activities, Demonstration activities, Training activities, Management activities

[5] Milestones are points where major results have successfully been achieved as the basis for the next phase of work, or are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

[6] For Integrated Projects each workpackage must relate to one (and only one) of the following four possible Activity Types: RTD/Innovation activities, Demonstration activities, Training activities, Management activities

Objectives

Provision of Earth System models constructed from available component modules and available for ensemble prediction system.

Description of work

WP1.1: Construction of Earth System Models for ensemble climate prediction.

The WP1.1 activities will proceed with the aim of providing a set of tested ESMs at month 24 (Major Milestone 1.1). Based on results of the first 12 months, as described in Deliverable D1.1, the further development will produce ESMs for the physical system, the carbon cycle system and the aerosol system for multi model ensemble simulations. A physical system model will be developed and tested for employment at high resolution. Further parameters will be identified in the METO-HC model to be used for the perturbed parameter ensemble. The possibility to extend this approach to other parameter subspaces, for example relevant for aerosols, will be tested. Together these works will allow investigation of the role of the carbon cycle and the aerosol components in climate simulations using the multi model ensemble and possibly the perturbed parameter ensemble.

Task 1.1.4: ESMs for multi model ensembles
Continuation of the activities of the WP1.1 partners in year 1. Assembly and testing of ESMs for the physical system, the aerosol system and the carbon cycle system. Investigation and improvement of identified performance problems.

Task 1.1.5: ES parameters for perturbed parameter ensembles
Further parameters will be identified, possibly in parameterisations external to the physical system. This work will extend the existing studies performed at the METO-HC.

Deliverables

D1.5: WP1.1 workshop

D1.6: Report on the developed and tested ESMs

Milestones[7] and expected result

Work package number	1.2	**Start date or starting event:**	Month 13
Activity Type[8]	RTD		
Participant id	1 (METO-HC), 5 (ECMWF), 70 (UOXFDC), 38 (FUB), 49 (LSE), 8 (KNMI), 4 (DMI), 45 (IRI)		

[7] Milestones are points where major results have successfully been achieved as the basis for the next phase of work, or are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

[8] For Integrated Projects each workpackage must relate to one (and only one) of the following four possible Activity Types: RTD/Innovation activities, Demonstration activities, Training activities, Management activities

Funded/unfunded Person-months	METO-HC (3/3), ECMWF (6/2), UOXFDC (4.5/0), FUB (2.5/2.5), LSE (8/2), DMI (0/3), IRI (0/1)	

Objectives

Develop techniques for the representation of modelling uncertainties in ensemble predictions.

Description of work

WP1.2: Developing and testing schemes to represent model uncertainty in seasonal to centennial prediction.

WP1.2 activities will proceed with the aims of further developing alternative methods of sampling modelling uncertainties in ensemble climate prediction, and of weighting members of ensembles through comparison with the present climate state and/or historical climate changes, building on work carried out during months 1-12 (see D 1.2). Methods of combining different approaches (e.g. multi-model, perturbed parameter and stochastic parameterisation ensembles) will also be developed, since these may outperform any individual approach.

Task 1.2.4 The Hadley Centre will collaborate with statistical experts in probabilistic inference from complex simulators develop a general methodology for generating probabilistic climate change predictions from small ensembles of simulations. The method will use a Bayesian framework to generate a joint probability distribution that measures the probability of all combinations of values for all uncertain objects in the problem. Key components are; ensembles of model simulations in which key parameters are varied, an emulator which uses statistical and reduced-complexity physical models to sample parts of parameter space for which no simulation exists, and a discrepancy term to account for imperfections in the climate model arising from "structural" deficiencies, which add uncertainty to probabilistic inferences about real world changes derived from models, but have yet to be accounted for in climate prediction. During months 13-30 implementation of the Bayesian prediction algorithm will start by developing the emulator and testing methods for assessing discrepancy by using results from the ENSEMBLES multi-model simulations.

Task 1.2.5 Oxford will continue development of a methodology for probabilistic climate forecasting which seeks to minimise model bias and maximise the dependence of the forecast distribution on the data used to constrain it. Such “stable inferences from data” (STAID) forecasts are set up to minimise the effect on the forecast of the prior beliefs of the experimenter.

Task 1.2.6 Development of methods of comparing alternative methodologies (1.2.4, 1.2.5) so as to maximise the useful information in forecasts will be undertaken by the Hadley Centre and Oxford.

Task 1.2.7 The FUB will develop and test schemes to represent model uncertainties by perturbing selected parameters (cloud parametrization, stratospheric representation) of the EGMAM-model and by variations in the model components.

Task 1.2.8 FUB plan to implement a stochastic physics scheme to generate ensembles with the EGMAM model. This gives the possibility to produce multi-model stochastic physics ensembles (see Task1.2.9). The effects of stochastic physics schemes in centennial model runs will be investigated. Different methods of weighting members of ensembles generated with the multi-model approach will be tested. The aim is to adapt the weighting methods commonly applied on the seasonal time scale for centennial forecasts. In the project month 13 to 30 we will provide an evaluation of methods for model weighting in multi-model centennial predictions.

Task 1.2.9 ECMWF propose to carry out additional integrations with updated versions of the stochastic physics scheme developed at ECMWF for medium range weather forecasting.

Task 1.2.10: A simple weighting of models used for climate change experiments will be set up by DMI. This will be based on the ability of the individual Earth system models (in un-flux-corrected

mode) to simulate different aspects of the climatological annual cycle which is the most simple example of a forced climate signal where both the forcing and response is well known.

Deliverables

Milestones[9] and expected result

Work package number	1.3	**Start date or starting event:**	Month 13
Activity Type[10]	RTD		
Participant id	1 (METO-HC), 5 (ECMWF), 43 (IfM) , 8 (KNMI), 3 (CNRS-IPSL), 20 (CERFACS), 7 (INGV)		
Funded/unfunded Person-months	METO-HC(3/3), ECMWF (2/0), IfM (5/5), KNMI (3/3), CNRS-IPSL (5/5), CERFACS (3/3), INGV (4/1)		

Objectives

Techniques for representation of initial condition uncertainties in ensemble predictions.
Improved methods of initialising the ocean module for seasonal to decadal predictions.

Description of work

WP1.3: Initialisation procedures for ocean components based on observed states.

Ocean initialisation procedures for ENSEMBLES will be developed in two stages.
Task 1.3.1: In stage one (months 1-18) advanced data assimilation systems developed in the ENACT project will be adapted to OGCMs to be used in the ENSEMBLES system. The assimilation systems will be based on improved optimal interpolation, Ensemble Kalman Filter (EnKF) and variational methods. The EnKF and variational assimilation systems will be adapted to a common OGCM configuration so that methods for combining the two approaches and exploiting their relative strengths can be explored in stage two (beyond month 18). Methods for estimating and modelling background-error covariances will be improved in order to enable effective exploitation of observational data.
Task 1.3.2: The ENACT quality-controlled oceanographic database will be continued and improved. An updated version of the quality controlled ocean observations for the ERA40 period will be produced by month 20 to include new delayed mode data sources and better tuning of the QC after feedback from phase 1.
Task 1.3.3: Strategies for representing uncertainty in ensembles of ocean analyses will be defined. Perturbations derived from the statistics of independent analyses will provide a starting point. More

[9] Milestones are points where major results have successfully been achieved as the basis for the next phase of work, or are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.
[10] For Integrated Projects each workpackage must relate to one (and only one) of the following four possible Activity Types: RTD/Innovation activities, Demonstration activities, Training activities, Management activities

sophisticated strategies reliant on perturbations derived from objective estimates of analysis error covariances will be investigated.
Task 1.3.4: based on task 1.3.1 and on WP1.5 results, a process will be designed for production of ensembles of ocean analyses suitable for seasonal to decadal hindcasts over the full ERA40 period. This design will feed the production of ocean analyses ensembles in WP1.3 and WP2A.1.

Deliverables

D1.3: Advanced ocean data assimilations systems, based on improved optimal interpolation, Ensemble Kalman Filter, and variational methods, developed in the ENACT project, adapted to the OGCMs to be used in the ENSEMBLES system.

Milestones[11] and expected result

M1.3: Completion of the technical development needed to adapt the ENACT-based assimilation systems to the ENSEMBLES OGCMs, Month 18.

M1.4: Updated quality-controlled oceanographic database, Month 20.

Work package number	1.4	**Start date or starting event:**	Month 13
Activity Type[12]	RTD		
Participant id	1 (METO-HC), 5 (ECMWF), 2 (CNRM), 43 (IfM), 3 (CNRS-IPSL), 20 (CERFACS), 7 (INGV)		
Funded/unfunded Person-months	METO-HC (3/3), ECMWF (13/1), CNRM(0/1), IfM (6/0), CNRS-IPSL (5/5), CERFACS (2/2), INGV (5/2)		

Objectives

Assembly of a multi-model prediction system.

Description of work

WP1.4: Assembly of a multi-model ensemble system, with common output, with installation on a single supercomputer, where appropriate.

Task 1.4.1: The latest versions of the ECMWF, Met Office, CNRM, CNRS-IPSL and MPI global coupled climate models will be installed on the IBM supercomputer at ECMWF. The latest version of the INGV coupled model will be installed on the NEC supercomputer at INGV. Initialisation procedures will be taken from the FP5 ENACT programme and developments from WP1.3 and RT2A (5-year Task 1.4a).

[11] Milestones are points where major results have successfully been achieved as the basis for the next phase of work, or are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.
[12] For Integrated Projects each workpackage must relate to one (and only one) of the following four possible Activity Types: RTD/Innovation activities, Demonstration activities, Training activities, Management activities

Task 1.4.2: In addition, the METO-HC seasonal and decadal versions of the coupled model will be installed with perturbed parameterisation schemes, and the ECMWF model will be installed with stochastic physics (5-year Task 1.4a).

Task 1.4.3: Unified output and archival routines will be developed, so that atmosphere and ocean data can be output into ECMWF MARS archival (5-year Task 1.4b).

Task 1.4.4: Additional development of the stochastic physics scheme and sets of experiments as in WP1.5 will be carried out by ECMWF. The design of the experiments will depend on the results of the preliminary assessment of the pre-production simulations (5-year Task 1.4a).

Task 1.4.5: METO-HC will port and test the next generation ESM (HadGEM), with improved forecast initialisation. The initialisation process may upset physical or dynamical balances between the components of the model, e.g. between the ocean or land and the atmosphere. The adjustment of the model to the initialisation will be explored with the aim of reducing such imbalances and hence improving retention of anomalies present in the initial conditions.

Deliverables

D1.4: A new multi-model coupled model ensemble forecast system created and installed at ECMWF, with capabilities to run, in addition, perturbed parameters and stochastic physics ensembles. Month 18.

Milestones[13] and expected result

Work package number	1.5	**Start date or starting event:**	Month 13
Activity Type[14]	RTD		
Participant id	1 (METO-HC), 5 (ECMWF), 2 (CNRM), 43 (IfM), 20 (CERFACS)		
Funded/unfunded Person-months	METO-HC (8/8), ECMWF (1/0), CNRM (2/2), IfM (2/0), INGV(5/2) CERFACS (0/0)		

Objectives

Test methodologies for probabilistic climate prediction on seasonal to decadal time scales accounting for modelling and initial condition uncertainties in ensemble predictions.

Description of work

[13] Milestones are points where major results have successfully been achieved as the basis for the next phase of work, or are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

[14] For Integrated Projects each workpackage must relate to one (and only one) of the following four possible Activity Types: RTD/Innovation activities, Demonstration activities, Training activities, Management activities

WP1.5: Generation of pre-production ensemble predictions of climate on the seasonal to decadal timescale, initialised from observations.

Task 1.5.1: Seasonal and decadal-timescale ensemble integrations will be made using a) the multi-model ensemble system, b) the perturbed parameter system, c) the stochastic physics system. The seasonal integrations will be at least 7 months long, and made over a number of start dates at different times of year, and for ENSO and non-ENSO periods. The decadal integrations will be 10 years long and made over two contrasting decades from the 20th century (e.g. 1960s and 1990s). ECMWF ERA-40 data will be used to provide atmospheric initial conditions and atmospheric verification (5-year Task 1.5a).

Task 1.5.2: Forecast quality will be estimated for each system and for a simple combination of them using a set of deterministic and probabilistic scores (5-year Tasks 1.5b and 1.5c).

Task 1.5.3: METO-HC will commence production of further decadal integrations with their perturbed physics system, covering a wider range of initial dates taken from the 1960s, 70s and 80s and 90s. The choice of dates will be coordinated with the "stream 2" multi-model simulations made in RT2A.

Deliverables

D1.8 Updated assessment in terms of forecast quality and potential economic value of the relative merits of the multi-model approach, the perturbed parameter approach, and the stochastic physics approach, to representation of model uncertainty in seasonal to decadal forecasts. Month 30.

Milestones[15] and expected result

M1.2: Preliminary assessment of the relative merits of the multi-model approach, the perturbed parameter approach, and the stochastic physics approach, to representing model uncertainty in seasonal to decadal forecasts. Recommendations to the ENSEMBLES project concerning the design of the production ensemble system, Month 18.

Work package number	1.6	**Start date or starting event:**	Month 13
Activity Type[16]	RTD		
Participant id	1 (METO-HC), 70 (UOXFDC), 38 (FUB), 2 (CNRM)		
Funded/unfunded Person-months	METO-HC(6/6), UOXFDC (13/0), FUB (4/4), CNRM (1.5/1.5)		

Objectives

Test methodologies for probabilistic climate prediction on centennial time scales accounting for uncertainties in different Earth System modules and variations in model reliability.

[15] Milestones are points where major results have successfully been achieved as the basis for the next phase of work, or are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

[16] For Integrated Projects each workpackage must relate to one (and only one) of the following four possible Activity Types: RTD/Innovation activities, Demonstration activities, Training activities, Management activities

Description of work

WP1.6: Generation of pre-production ensemble predictions of climate on the century timescale, initialised from model initial conditions.

Task 1.6.1: Further ensemble experiments to quantify the sensitivity of time-dependent climate change to atmospheric parameter perturbations will be undertaken using the Hadley Centre coupled model HadCM3. In addition, parameter ranges which control the behaviour of other components of the model, specifically the ocean, the sulphur cycle and the terrestrial carbon cycle will be quantified. Experiments will be initiated to test the spin-up of model versions with perturbed ocean parameters. Frequency distributions (interim PDFs) of transient regional change will be produced.
Task 1.6.2: Ensemble sizes in Task 1.6.1 will be limited by the availability of computer resources. During months 12-30 a version of the fully-coupled HadCM3 model will be prepared for release to the general public under the climateprediction.net project. This will involve solving a large number of both technical and scientific issues but will allow further assessment of perturbation techniques. In addition, a climateprediction.net experiment in which perturbations are made to sulphur-cycle parameters in the atmospheric-mixed-layer version of the model will be started.
Task 1.6.3: Tests of the sensitivity of time-dependent climate change to parameter perturbations in the EGMAM model will be continued. This will allow comparison of the EGMAM and the HadCM3 models and to give recommendations to the ENSEMBLES project concerning the design of the production ensemble system at month 18 (Milestone M1.3). Additionally, the most promising perturbation methods developed in RT1.2 will be used to start centennial forecast ensembles. The results of these ensemble runs will provide the basis for statistical analysis to document the performance of the methods. CNRM will start using its new Earth-System model in a pre-production mode to generate a small ensemble of climate simulations in order to explore the sensitivity of the climate response to different ocean initial conditions.

Deliverables

D1.7: Interim probability distributions of transient climate change over Europe will be produced, for use by other RTs in testing methodologies for prediction of climate change impacts, Month 24.

Milestones[17] and expected result

M1.3: Preliminary assessment of the perturbed parameter approach to representing model uncertainty in centennial climate predictions. Recommendations to the ENSEMBLES project concerning the design of the production ensemble system, Month 18.

[17] Milestones are points where major results have successfully been achieved as the basis for the next phase of work, or are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.