REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBER STATE: France

Principal Investigator[1]: Lauriane Batté

Affiliation: CNRM-GAME/GMGEC

Address: 42 avenue G. Coriolis
31057 Toulouse
France

E-mail: lauriane.batte@meteo.fr

Other researchers:
Constantin Ardilouze (CNRM-GAME)
Matthieu Chevallier (CNRM-GAME)

Project Title:

Impact of land surface and ocean initial conditions on sub-seasonal to seasonal forecasts

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** _____	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2016	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2016-2018: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2017.)		**2016**	**2017**	**2018**
High Performance Computing Facility	(units)	10 million	12 million	12 million
Data storage capacity (total archive volume)	(gigabytes)	20000	35000	43000

*An electronic copy of this form **must be sent** via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):

09 June 2015

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

Principal Investigator: Lauriane Batté

Project Title: Impact of land surface and ocean initial conditions on sub-seasonal to seasonal forecasts

Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

Scientific background

The land surface and ocean-sea ice components of the climate system provide sources of predictability at the sub-seasonal to seasonal time scales (see e.g. Prodhomme et al. 2015, Koster et al. 2010, Palmer et al. 2004, Guemas et al. 2014, as well as Doblas-Reyes et al. 2013 for a review on seasonal predictions). Meteo-France now routinely runs seasonal forecasts as part of the EUROSIP consortium, and since May 2015 participates in the WWRP/WCRP S2S project, using the CNRM-CM coupled model (Voldoire et al. 2013, Batté and Déqué 2012). Ongoing research on sub-seasonal to seasonal prediction at CNRM aims not only at developing the operational system, but at improving knowledge on what is predictable at these time scales using a GCM.

Over the last decades the observation systems for the ocean and land surface components have undergone considerable developments, thanks to satellite data, field campaigns and an increasing effort to monitor the climate system. The most straightforward way of using these additional data for a better knowledge of the initial state of the climate in a forecasting framework is to assimilate them directly into the coupled system, as done routinely at centres such as ECMWF (Balmaseda and Anderson 2009). Incoherences between the initial conditions of the separate model components can lead to initialization shocks, and in a re-forecasting framework another solution is to initialize the model from a coupled run of the same model, nudged towards reanalysis datasets.

The aim of this special project is to further assess the impact of the initialization of the different components of the CNRM-CM coupled climate model in sub-seasonal to seasonal runs. Our focus will be on the first month and months 2-4 of seasonal re-forecast runs. We wish to address the following key questions:

- What is the extent of initial condition information needed to properly initialize the components of model?

- Can improvements in model initialization impact the predictability of specific events with our model?

Aspects of these questions have been addressed as part of the CNRM contribution to the FP7-SPECS project. For instance, a re-forecast ensemble using ERA-land initial conditions for the land surface model SURFEX used in CNRM exhibited a significant increase in correlation skill in near-surface temperature over parts of Europe, with respect to a reference run (Constantin Ardilouze, work yet to be published). The impact of sea ice initialization has also been investigated in FP7-SPECS through a comparison between hindcasts initialized with a realistic sea ice cover and hindcasts with sea ice initialized with a climatology. Additionally, CNRM took part to the WCRP/WGSIP Sea Ice Historical Forecast Project (Ice-HFP, Peterson et al., 2015), which investigated the impact of sea ice initialization in seasonal forecasting systems on predictions starting close to anomalously high (1996) and low (2007) sea ice extents.

The first part of the project will focus on a limited number of case studies, and we will then run a comprehensive set of re-forecast experiments.

Work plan

The main goal of this special project is to investigate and document in the CNRM-CM model the impact of the initialization of the sea ice and land surface components.

In a first stage of the project, we will build our surface and sea ice initial conditions and climatologies using CNRM-CM land surface and ocean-sea ice components in forced mode. A new development in the SURFEX model to constrain the model towards reference data could be used. The ocean-sea ice component of CNRM-CM, NEMO coupled to GELATO sea ice model (NEMO-GELATO), will be run over the period 1979-2013 forced using meteorological fields, radiative fluxes and precipitation from the ERA-Interim reanalysis, with some corrections based on satellite and in-situ measurements as in Chevallier et al. (2013). An analysis of the land surface and sea ice conditions over the 1979-2013 period will determine "extreme" years in terms of initial conditions for these variables. For sea ice, the focus will be on Arctic sea ice extent and concentration. For land surface, snow cover in the Northern Hemisphere will be considered, as well as soil moisture for the boreal summer case, but these criteria still need to be defined precisely.

Once this analysis on the land surface and sea ice conditions is complete, we wish to run re-forecast ensembles for two specific test cases: boreal winter 2009/2010 and summer 2003. Both cases have already been thoroughly studied in the literature (e.g. Weisheimer et al. 2011 and Prodhomme et al. 2015 for the 2003 heatwave over Europe) and our results would therefore be assessed in the light of previous work with other coupled seasonal forecasting systems. The ensemble size for these test cases will be of 15 members, using initial perturbations of the atmosphere initial condition to generate the ensemble. Each test case will be run with several combinations of initial conditions for sea ice and land surface, following table 1. The stand-alone runs 1979-2013 climatologies will be used for the "Clim" initial conditions for the test cases restart dates. In the table, Ext+ and Ext- will be the initial conditions for the "extreme" years for the surface conditions studied in the first step. For land surface initialization we plan to test both snow and soil moisture conditions, so two sets of Ext+ and Ext- initial conditions are planned. It is possible that some sets coincide in which case additional ensemble members would be run.

		Sea ice initialization			
		Clim	Init	Ext+	Ext-
Land surface initialization	Clim	X	X		
	Init	X	X	X	X
	HumExt+		X		
	HumExt-		X		
	SnowExt+		X		
	SnowExt-		X		

Table 1: Case study experiments planned (marked with X) with the different sets of land surface and sea ice initial conditions

The final stage of the project consists in running a full re-forecast experiment with the best initial conditions possible for land surface and sea ice. Currently, the routine re-forecast runs with CNRM-CM generally use climatology for sea ice initial conditions, and ERA-Interim for land surface variables. The initialized re-forecast ensembles will be compared to these more standard re-forecasts, in the light of impacts found in the case studies.

We request resources for a three-year project. During Year 1 (2016) the initial conditions will be derived and Ext+ and Ext- years defined for sea ice and land surface, and a restricted ensemble (10 members) will be run for the test cases. These cases will be extended to 15 member ensembles in Year 2 (2017), and the re-forecast run will be started for one season. The re-forecast will be completed during Year 3 (2018) with the remaining resources.

Justification of computer resources

SBU and storage costs estimations are summarized in table 2. More details are given below.

Estimation of SBU needed on HPCF:

Currently, running a single member hindcast for one month with CNRM-CM using a T255L91 resolution for ARPEGE-SURFEX for the atmosphere and land surface, coupled (using the OASIS coupler) with NEMO on the ORCA 1° grid (292 x 362 points) with 42 vertical levels (10 in the upper 100m) including GELATO for sea ice (using 4 thickness categories) requires approximately 2.5k SBU on the Cray HPCF at ECMWF.

Based on table 1, for the test cases we will run 10 seasonal runs to test the initial conditions combinations for each test case. We wish to run 4-month lead times and 15 members for the test cases, and initialize in April, May and June for the summer case and October, November and December for the winter case in order to test for sensitivity to the lead time, for a total of 60 runs.

For the re-forecast experiments we wish to extend the configuration with “Init” conditions for both sea ice and land surface to 35 years (1979-2013), for both May and November startdates, with a 30 member ensemble size.

An additional 4M SBU is requested to run the stand-alone SURFEX and NEMO-GELATO runs to derive the initial condition data for the “Init”, “Clim” and “Ext” experiments.

	1 month (SBU)	1 month (storage)	Ensemble size	Startdates	Lead time	Total (months)	Total cost (SBU)	Total cost (storage)
Initial conditions		1.50 GB	-	128	-	128	~4 M	192 GB
Test cases	2500	6.75 GB	15	60	4	3600	9 M	24.3 TB
Hindcasts	2500	2.10 GB	30	70	4	8400	21 M	17.64 TB
Total	-	-	-	-	-	-	**34 M**	42.132 TB

Table 2: Breakdown of the estimation of computation and storage costs for the project

Estimation of archive capacity needed:

For initial conditions, restart files for ARPEGE-Climate, GELATO, NEMO, atmosphere and ocean fluxes for OASIS, SURFEX and river routing model TRIP amount to an estimated total of 1.35 GB of data for one start date. We wish to use a total of 128 initial conditions (combining dates and initialization methods).

The most part of the archive capacity needed is for the seasonal re-forecast outputs. For the test cases we wish to archive atmospheric and surface fields as well as ocean outputs at a daily time step, which represents an estimated cost of 6.75 GB per month of re-forecast at the resolution used.

For the re-forecasts, we will restrict the output fields at a daily time step to typical atmospheric and surface fields. The total amount of storage needed for the entire project is approximately 42 TB, to which we add a small margin.

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