Project Name	Land-Surface Initialization in High-resolution seasonal Prediction (LSIHP)	
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1 Significance of the Research
1.1 Purpose of the Research

LSIHP is a proposal for the “General Projects of the K computer use” call that aims at enhancing seasonal climate forecast capability as a general purpose. Its specific purpose is to leverage the land surface sources of predictability through the highest resolution used up-to-date in a seasonal forecasting context.

1) <u>Scientific background for the research</u>

The Earth's climate undergoes natural variability at interannual-to-decadal timescales. Informing public sectors that are vulnerable to its variations is a key societal and economical challenge. Prediction of climate variability tackles this challenge to support stakeholders in sectors such as agricultural production (Challinor et al., 2005), energy production (García-Morales et al., 2007) and human health (Thomson et al., 2006). Due to the reality that the climate is changing as a response to increasing levels of greenhouse gases (GHG) according to the Fifth Assessment Report from the Intergovernmental Panel on Climate Change, a growing demand in predictions of the climate variability is emerging and shaping a new scientific challenge: climate forecasting.

Climate forecasting bridges the gap between weather prediction and climate change projections (Doblas-Reyes et al., 2013). Weather prediction is an initial value problem that is limited to a few days due to the chaotic nature of the atmosphere. Climate projection is by contrast driven by external radiative forcings that requires long timescales to detect a signal emerging from natural variabilities of the climate system. Climate forecasting aims at predicting both, the natural variability and the climate change signal of the near-term climate. It thus shares the requirements of both approaches, accurate information of observed initial conditions of the ocean, atmosphere and land (Balmaseda et al, 2013) and knowledge about the changes in the external forcings such as the atmospheric composition (Doblas-Reyes et al., 2006). Both sources of predictability need to be prescribed in a numerical climate model that integrates our current understanding of the climate system.

Current climate forecast systems can provide accurate predictions of the tropical Sea Surface Temperatures (SST) anomalies associated with El Niño Southern Oscillation (ENSO) with forecast times of several months (Saha et al., 2006; Stockdale et al., 2011), although the spread among different forecast systems is substantial, sometimes even differing in the sign of the tropical Pacific SST anomaly (Weisheimer et al., 2009; Alessandri et al., 2010). Over the extra-tropics, the skill of current seasonal forecast systems is very limited (Rodwell and Doblas-Reyes, 2006; Frías et al., 2010). Recent results suggest however that initializing the land surface from observed soil moisture conditions could increase substantially the forecast quality over Europe for surface temperature and precipitation, in particular during heat waves (Prodhomme et al, 2015) and that an increase of resolution in climate forecast systems is one of the necessary factors to reach a useful level of skill over Europe (Scaife et al., 2014).

In an early study, Schär et al. (1999) had shown the existence of a soil-precipitation feedback over Europe. Later on, soil has been shown to influence precipitations, mean temperature and extreme temperature over Europe (Fischer et al. 2007a,b; Douville 2010; Seneviratne et al. 2006, 2010, 2013; Quesada et al. 2012; Bellprat et al. 2013). For instance, Seneviratne et al. (2010) described the soil moisture-temperature coupling feedback loop in which, when an anticyclonic anomaly is present over Europe the soil moisture content will either amplify or moderate the surface temperature response. If the soil is moist (energy limited regime) the available surface energy will preferentially dissipate into latent heat fluxes and dampen surface heating. Conversely, when the soil is dry (soil moisture limited regime) more energy is available for sensible heating, inducing an increase of near-surface air temperature (Seneviratne et al. 2010; Hirschi et al. 2011). As soil moisture partly controls the occurrence of warm events over Europe, a correct initialization of soil moisture content might be essential to correctly forecast summer extreme temperatures. This problem was studied by the global land-atmosphere coupling experiment (GLACE) intercomparison project (http://gmao.gsfc.nasa.gov/research/GLACE). The first phase (GLACE-1) focused on predictability that arises from soil moisture anomalies and determined the geographical regions where soil moisture exerts a significant influence on surface air temperature and precipitation (hot spots) of land-atmosphere coupling (Koster et al. 2004). The second phase (GLACE-2) focused on forecast quality, and assessed the impact of accurate soil-moisture initialization on actual skill using a multimodel approach (Koster et al. 2011). The multimodel mean in GLACE-2 indicates a significant soil-moisture contribution to surface temperature forecast skill in summer with forecast times of up to two months over North and South America (Koster et al. 2010, 2011). While Europe was not then found as a main region of improvement when soil moisture is initialized during the GLACE project, numerous other studies (using coupled ocean-atmosphere models instead of atmospheric models with prescribed ocean boundary conditions) have found an impact of soil moisture initialization in Europe (Douville 2010; van den Hurk et al. 2010; Materia et al. 2014; Prodhomme et al, 2015).

The EC-Earth model (Hazeleger et al. 2012, https://dev.ec-earth.org) contributed to the projection and prediction protocols of the Coupled Model Intercomparison Project Fifth Phase (CMIP5, Taylor et al 2012) and is regularly used to perform seasonal predictions, using resolutions of ~0.7° and ~1° in the atmosphere and ocean, respectively. While such resolution compares favourably with other CMIP5 models, it is poor in terms of the resolution required for an accurate simulation of important modes of climate and weather variability. Higher model resolution has been suggested to significantly improve the representation various climate processes. Jung et al. (2012) and Kinter et al. (2013) found significant improvements in the simulation of many atmospheric features such as tropical precipitation and the frequency/intensity of both tropical and mid-latitude cyclones in IFS-only simulations (the atmospheric component of EC-Earth). Recently, several studies reported the use of coupled climate models in the resolution range ~50 km (atmosphere) and ~10-30 km (ocean), identifying large improvements in a number of systematic errors seen in lower resolution versions of the same models such as an improved structure of the North Atlantic Ocean circulation (Delworth et al., 2012). Running seasonal predictions at higher resolution than the usual ~1° should allow for a maximal benefit from the land sources of predictability on seasonal timescales.

We plan to use EC-Earth3, which is one of the few available coupled models that is tuned at different resolutions, including a T511 (~39 km), 91 levels for the atmosphere (IFS) and 0.25° horizontal resolution, 75 vertical levels (T511L91-ORCA025L75) for the ocean (NEMO). Compared to the resolution of the model used in CMIP5 simulations, the horizontal resolution is increased by a factor of up to 4, with an increased number of vertical levels in both ocean and atmosphere by factors of 1.5 to 2. With this high-resolution version, our objective is to reproduce the second phase of the GLACE-2 project, but with a forecasting period of 17 years instead of 10 years. Two retrospective seasonal forecasting exercises will be conducted over the 1993-2009 period: one exercise using the best possible estimate from observed land surface initial conditions and another one using a simple climatology of these land surface conditions. The rest of the experimental setup will be exactly the same for both exercises. Their comparison will allow for the most robust identification performed up-to-date of the added-value from land-surface initialisation from observations on seasonal forecast quality.

2) What will be elucidated and to what extent will it be pursued during the research period?

LISHP will allow for the most robust identification performed up-to-date of the role of land sources of predictability on seasonal forecast quality, thanks to seasonal forecasts ran at the highest resolution ever used in a seasonal forecasting context, and over a exceptionally long reforecasting period. LISHP will deliver crucial information about seasonal forecast quality and enhance our predictive capability over Europe, in particular for extreme events such as heat waves and droughts. The final results will be of utmost interest for climate services in a wide range of sectors (health, agriculture, energy …) and therefore of key *societal significance*. For example, seasonal climate forecasts are routinely to forecasting wind energy production as well as viticulture yield by the Earth Services group within our department.

3) Scientific characteristics and originality of the research in the area

LISHP proposes the use of groundbreaking resolution to leverage the benefits from the key source of climate predictability on seasonal timescales that are the land surface conditions. This project is therefore of *scientific excellence* and could lead to a *breakthrough*, through a substantial increase in seasonal forecast skill and the robust identification of the land surface as a key source of climate forecast predictability. Its execution requires the use of the K computer because of the exceptionally large amount of computing resources required to carry out successfully such project.

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1.2 Expected achievements and Ripple effects

LSIHP will enhance our seasonal climate forecast capability over continental areas. Through close collaboration with the Earth Services Group from the Earth Department of the BSC, we will ensure that the resulting progress feeds the climate services team and is exploited to generate user-relevant climate information in sectors such as the wind energy or the viticulture, as a *contribution to society*. The results of the project will be of the research type and, hence, will not be the subject of commercial use. Instead, the results will be widely presented in scientific conferences, as in the EGU (European Geosciences Union) annual meeting for example and in courses. Furthermore, the results of the project will feature at the meetings of the Scientific Steering Group (SSG) CLIVAR (Climate and Ocean Variability Predictability and Change) project, of which Virginie Guemas is a member, as well as the meeting of CLIVAR's WGSIP Working Group on Seasonal-to-Interannual Prediction of which Francisco Doblas-Reyes is a member. These results will contribute to the SPECS, IMPREX and PRIMAVERA projects funded by the European Commission in which the applying team participates, the first one focusing on improving seasonal forecast quality, the second one on a better understanding of hydrological extremes and the third one on the added-value from increasing climate model resolution, as well as the RCOF (Regional Climate Outlook Forum) organised by the World Meteorological Organisation (WMO). These results will benefit the wider seasonal forecasting and climate community and therefore contribute to the state-of-the-art knowledge on sources of predictability and on the development of seasonal forecasting systems. At least one paper will be published in a peer-reviewed journal to summarize and disseminate the main results of this project. A press release will be prepared at the time of publishing this article to ensure an optimal media outreach. Being of *scientific excellence and social significance*, this project could lead to a *breakthrough*, i.e. a substantial increase in seasonal forecasting performance and the robust identification of the land surface as a key source of climate forecast predictability. Its execution requires the use of the K computer because of the exceptionally large amount of computing resources required to carry out successfully such project.

2 Research Plan and Method

2.1 Research Plan and Method

1) Porting, performance analysis and speed up of the EC-Earth climate model code

EC-Earth model is a fully Earth System coupled model using the following components:

- IFS: The atmosphere model (http://www.ecmwf.int/en/research/modelling-and-prediction/atmospheric-dynamics)
- NEMO: The ocean model (http://www.nemo-ocean.eu/)
- OASIS: The coupler (https://verc.enes.org/oasis)

In its high resolution configuration, EC-Earth3.1 uses a spectral truncation of the atmospheric model (IFS) at T511 (approx. 40 km globally) and 91 vertical levels and a grid resolution of the ocean model (NEMO3.3) of 0.25° globally (approximately 25 km) with 75 vertical levels which thickness increases from 1m below surface up to 500m in the deep ocean. The sea ice model (LIM3) is embedded into NEMO and runs at the same resolution while the vegetation (LPG) and chemistry (TM5) model are embedded into IFS and run at the same resolution.

These components are written in Fortran and are parallelized through MPI . The compilation of each component (IFS, NEMO and OASIS) generates a different executable, so to run the model the three executables will run at the same time.

Although K compilers have not been tested to run EC-Earth model, the building process of each component is fully configurable and allows to use a wide range of compilers and libraries. Having deployed the model in many different HPC facilities, we can demonstrate a large experience in using different environments.

Besides, some developments could be necessary to adapt Autosubmit workflow manager to use K computer scheduler.

Once the model has been compiled and runs successfully, a scaling analysis will be carried out in order to set up the optimum configuration for the case to simulate. Here, the number of cores assigned to each component will have a great impact on the performance of the model. Even if there exists a generic optimal configuration, their values have to be tuned for each HPC platform. In order to do so, a set of cutting edge performance tools will be used to carry out the necessary studies and analyse how each one of the model's components manage its assigned resources.

Finally, optimizations based on compilation flags or K system administrator's indication will be applied.

2) Seasonal forecasting experiments

The period for the retrospective forecast exercise will be 1993 to 2013 with ten-member ensembles and two start dates per year (first of May and November) that will be run for four forecast months. The ten members are generated by introducing perturbations of the atmospheric initial conditions using singular vectors. This makes a total of 1680 (21 years, 2 start months, 4 forecast months, 10 members) months of simulation for each experiment. Such a large number of start dates and members is essential for a robust assessment of the seasonal forecast quality. In both experiments, the atmosphere will be initialised with the ERA-Interim atmospheric reanalysis (Dee et al., 2011) interpolated to the T511L91 resolution, the ocean with the GLORYS2v1 ocean reanalysis (Ferry et al., 2010) in its original resolution (ORCA025L75) and the sea ice will be initialised following the methodology of Guemas et al (2014) where the sea-ice model is forced by fluxes from reanalyses at the resolution of interest.

In a sensitivity experiment referred to as ***LandInit*** in the following, the initialisation of the land surface is tested using realistic initialisation with observationally constrained conditions. The land surface scheme uses data from an offline simulation performed with the ERA-Land system (Balsamo et al., 2014) at the T511 resolution as initial conditions for the retrospective forecasts. In a control experiment referred to as ***LandClim*** in the following, climatological conditions are used for the land-surface initialisation. The climatology is computed for a window of 10 days around the starting month of the predictions.

3) Analyses

The forecast quality will be assessed in terms of amplitude and characteristic timescales of the climate forecast drift (the climate model develops its own biases/systematic error when initialised from observations), as well as in terms skill after bias correction under a deterministic (anomaly correlation and root mean square skill score) and probabilistic framework (Brier score and reliability diagram). Various bias correction techniques will be tested. The forecast quality assessment will be carried out using the most complete framework available at the time of finishing the simulations and will be based on the new verification packages developed by the BSC in the SPECS project (e.g. s2dverification). The forecast quality assessment will focus, in particular, on climate modes such as the North Atlantic Oscillation, and its potential teleconnections, as well as extreme temperature and precipitation events (through metrics based on daily data such as quantiles). The predictability mechanisms linking the land surface initialisation with the European climate will be identified through water budget and analyses of the large-scale dynamics. A particular emphasis will be put on preconditioning by the soil moisture conditions via regression analyses and classification of start dates and prediction members. Case studies such as the 2003, 2010 and 2012 European heat waves will be investigated in detail.

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2.2 Utilization plan of computational resources

2.2.1 The requested computational resources (for each computational resource)

Provider name/Resource name: RIKEN/K computer

Program name	Task	Data size (GB)	#time steps	Normal execution confirmed?
EC-Earth3.1	Porting	1		Yes
EC-Earth3.1	Speed-up	1		Yes
EC-Earth3.1	LandInit	16		Yes
EC-Earth3.1	ClimInit	16		Yes

The Autosubmit software (Asif et al., 2014), briefly described below, will be used to manage the workflow and ensure a uniform and optimal use of the resources. Our two seasonal prediction experiments offer a large computing flexibility as each one is a set of 420 simulations (21 years, 2 start dates per year, 10 members) that can be run independently and therefore in parallel for an optimal use of the computing resources on the K computer. They will be managed, and packed in groups in a single large executable, if required, by Autosubmit to optimize the use of the machine and avoid collapsing the I/O system. The data storage and data transfer can be organized with a disk space of 10 TB in the “scratch” file system. This required scratch space is motivated by the requirement to perform many independent simulations at the same time each producing up to 80 GB of raw data. These data will be held in the workspace before being post-processed to reduce the data volume to less than a fifth of their original size, which will then be transferred to the “archive” file system and finally locally, by Autosubmit which allows to make an efficient use of the scratch space. Around 500 GB of “home” space will be required to host the code and its modified versions.

(Utilization plan for the first half-year)

(1) Porting and testing of the EC-Earth3.1 climate model code (April)

To port and test the model version chosen for LSIHP (e.g. EC-Earth3.1), very few computing resources will be required. The plan is: 1) To install or get installed essential tools like SZIP, HDF5, NETCDF4, GRIB_API and GRIBEX with respect to the available compiler and MPI environment, 2) To compile the model components, 3) Perform a few trivial modifications of the available testing scripts that have been used on other HPC environments to adapt them to the KComputer environment, 4) To make a test run of the T511L91-ORCA025L75 configuration required for this project. Porting and testing the model on the KComputer will require three to fours weeks in total.

(2) Performance analysis and speed-up of EC-Earth3.1 (May-September)

In this phase of the utilization plan, performance analyses and speed-up assessments will be performed, with the aim of using the resources in the most efficient way. For the performance analyses it will be necessary to generate traces for the model runs to study them afterwards.

Speed-up evaluation: 50 nodes * 2000 sec * 50 times = 1,389 node * hours
Speed-up evaluation: 100 nodes * 1000 sec * 50 times = 1,389 node * hours
Speed-up evaluation: 150 nodes * 750 sec * 50 times = 1,389 node * hours
Speed-up evaluation: 200 nodes * 500 sec * 50 times = 1,389 node * hours
Performance analysis: 200 nodes * 600 sec * 50 times = 1,667 node * hours

In anticipation of 2778 node * hours as spare computing resources, we request **10,000 node * hours** for the first half-year.

(Utilization plan for the second half-year)

The experiments planned during this second half-year period are the LandInit and LandClim experiments described in details in section 2.1.2, which each counts 1680 years of simulation. That makes a total of 3360 years of simulation for the second half-year period. Based on the model performance at the Marenostrum 3 platform on which the model has already been tested, we estimate a need of 3,665,088 node hours to complete these 3360 years of simulation. Adding a small buffer to account for failing jobs that will need to be restarted, we estimate a total need of 4,000,000 node hours for this second half-year.

	October	November	December	January	March	April
LandInit						
LandClim						

Table 1: Approximate schedule of the experiments to be performed during the second half-year.

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Requested resource amount
Provider name / Resource name: RIKEN / K-computer
First half-year (Apr. 2016-Sep. 2016): 10,000 node-hours
Second half-year (Oct. 2016-Mar. 2017): 4,000,000 node-hours
Total (Apr. 2016-Mar. 2017): 4,010,000 node-hours
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2.2.2 HPCI shared storage (Please fill out only if you request.)

Requested resource amount: GB
Basis of the estimate:

References:

Asif, M., A. Cencerrado, O. Mula-Valls, D. Manubens, F.J. Doblas-Reyes and A. Cortés (2014). Impact of I/O and data management in ensemble large scale climate forecasting using EC-Earth3. Procedia Computer Science, 29, 2370-2379, doi:10.1016/j.procs.2014.05.221.

2.3 Preparatory status of the application program

Application program name: EC-Earth

1) Has the development of the program been finished?
Have you verified that the calculation results of the program are correct, irrespective of the computer and the kind of data?

The development of the EC-Earth3.1 model code has finished and this model is routinely used by the applying institute, BSC. It has already been well deployed on MareNostrum III (a tier-0 system;

having 2x Intel SandyBridge-EP E5-2670/1600 8-core processor at 2.6 GHz, 8x4GB DDR3-1600 DIMMS (2GB/core) and Infiniband FDR10 network). Previous versions of EC-Earth made extensive contributions to the climate prediction protocols in CMIP5. The BSC has been involved in the IS-ENES/PRACE-1IP working group focusing on the EC-Earth3 adaptation to Tier-0 machines. It has tested a range of EC-Earth3 configurations, in the atmospheric resolutions T255/511/799 on several HPC systems: SGI Altix 3500, NEC-SX6, Linux cluster with Intel Xeon, Dell PowerEdge 2900, IBM pSeries 575 Power6 and IBM Power PC. The BSC leads the development of Autosubmit, a python-based wrapper software that can manage any type of climate simulation workflow. It can also bundle numerous jobs into a single big job for performing job-control on parallel sets of simulations throughout the execution. The BSC has also expertise in analyzing parallel programming model codes using cutting-edge tools. This allows continuously carrying out performance analyses to reach the optimum configurations for EC-Earth and NEMO. A solid collaboration has been established with the NEMO developers for sharing the performance reports and code optimization tools and techniques. A similar collaboration is being established with the OpenIFS developers at ECMWF.

2) Have you verified that the calculation results of the program are correct on the requested computers?

EC-Earth has never run on the K-computer. Hence, six months of this one-year project will be dedicated to porting the model code and scaling it up to optimize the run time as described in section 2.2.1. Afterwards, a short test will run at the K computer will be compared to an equivalent run at Marenostrum 3, briefly described in the table under section 2.4, to verify that the differences between the two tests arise only from the machine precision. If not, a thorough analyses of the model code and the compilation option that could lead to such differences will be carried out during the first half-year period of the project to sort this out.

3) Have you verified that the calculation results of the program are correct on the requested computers using the similar kind and scale of input data to those for the target?

We have already verified that the calculation results of EC-Earth are correct on Marenostrum 3 machine which is briefly described in the table under section 2.4.

4) Is the estimated parallel efficiency for the target value of the number of nodes sufficient in carrying out the project? (The value of the guideline is about 50% or more.)

The target value of the number of nodes: 201
Estimated parallel efficiency: 51.094152 %

The estimated parallel efficiency for the target value of the number of nudes is sufficient to carry out this project.

2.4 The necessity of the requested computational resources

Given the large amount of simulation years and the groundbreaking high resolution of these simulations, such a project would only be feasible with a HPC machine such as the K computer.

	ECMWF-CCA	**MareNostrum3**	**KComputer**
Motherboard	Cray XC30 system	IBM dx360 M4	Fujitsu
Processor	Dual 12-core E5-2697 v2 (Ivy Bridge) series processors (2.7 GHz), 24 cores per node	Intel SandyBridge-EP E5-2670 (2.6 GHz), 16 cores per node	SPARC64 VIIIfx 8C (2GHz), 8 cores per node

Main memory	64 GB per node	32 GB per node	16 GB per node
Interconnect	Cray Aries interconnect links all compute nodes in a Dragonfly topology	Infiniband (IB)	Tofu Interconnect (6D Mesh/Torus)
Operating system	Cray Linux Environment (CLE)	Linux - SuSe Distribution 11 SP2	Linux
EC-Earth3.1 (one month test run with T511-ORCA025 configuration)	0.7 wall-clock hours using 1735 procs	0.9 wall-clock hours using 1616 procs	?

2.5 Organizational plan of the project execution and staffing plan

(Organization Chart)

Organization	Roles
BSC	Central implementation of the project
JAMSTEC	Cooperation : Scientific advising

(Project Members)

Project member	Affiliation	Specialization	Whether to use the resource s	Roles
Virginie Guemas	BSC	Climate prediction	Use	Project representative, analyses
Swadhin Behera	JAMSTEC	Climate variability	Use	Scientific advising
Muhammad Asif	BSC	High Performance Computing	Use	EC-Earth porting
Oriol Tinto	BSC	High Performance Computing	Use	Performance analysis and speed-up
Miguel Castrillo	BSC	High Performance Computing	Use	Performance analysis and speed-up
Chloe Prodhomme	BSC	Soil Moisture	Use	Running LandInit/LandClim and analyses
Omar Bellprat	BSC	Soil Moisture	Use	Running LandInit/LandClim and analyses
Francisco Doblas-Reyes	BSC	Earth Sciences	No use	Scientific advising

(Experience and Achievement)

Dr Virginie Guemas is currently Head of the Climate Prediction Group within the Earth Sciences department at BSC. She is member of the WCRP (World Climate Research Program) CLIVAR (Climate and Ocean Variability, Predictability, and Change) SSG (Scientific Steering Group), principal investigator (PI) of the nationally funded PICA-ICE project focused on Arctic climate predictions (2013-2015) and Work Package leader within the EU H2020-funded PRIMAVERA project focused on high-resolution and model development to be started in November 2015. She has contributed to the IPCC (Fifth Assessment Report) and is participating in several EU FP7 and H2020 projects. She is author of 32 articles published in international peer-reviewed journals, among which 16 as first author, 1 in Nature Climate Change and 2 in Bulletin of the American Meteorology Society.

Dr. Swadhin K. Behera is a principal scientist and a group leader in the Application Laboratory of JAMSTEC. After obtaining his Ph. D. degree from India and working for about 10 years in Indian Institute of Tropical Meteorology, he moved to JAMSTEC in 1998. Since then he has been associated with various centers and programs of JAMSTEC. He also serves as an adjunct professor for the Department of Ocean Technology, Policy and Environment at the University of Tokyo and as a guest professor at the Graduate School of Global Environmental Studies in Sophia University. He has published 80 articles in refereed journals with an average citation of 26 and an h-factor of 21, over 200 scientific articles, newspaper reports, presented many invited talks and several key-note speeches. He has also appeared in several radio and television programs.

Mr Muhammad Asif is a software research engineer for deploying and maintaining the EC-Earth on different available supercomputing platforms/infrastructures. He is currently part of the development team of EC-Earth version 3.

Mr Oriol Tinto is currently carrying out a PhD on computational performance profiling and optimization applied to NEMO ocean model.

Mr Miguel Castrillo is an expert on performance profiling and optimization applied to EC-Earth with a strong experience in software development. He is part of the Technical Issue Working Group for EC-Earth and the NEMO model HPC Working Group.

Dr Chloe Prodhomme is a research scientist expert on the climate modeling and coupling processes. She did a PhD on the role of Sea Surface Temperature on the the modelisation of the Indian Summer Monsoon in the LOCEAN with a collaboration with the Tokyo University, which has lead to the publication of four peer-review journal articles (two as first author). Two years ago she joined the Climate Forecasting Unit to work on the impact soil moisture on the development of extreme events such as heat waves and droughts and also to assess the impact of resolution increase on the forecast quality. Two peer-review journal articles have been published on this work and three more are in preparation.

Dr Omar Bellprat is a research scientist specialized into attribution of climate extremes and identification of sources of predictability such as soil moisture.

Prof Francisco J. Doblas-Reyes is an expert in the development of seasonal-to-decadal climate prediction systems and the head of the Earth Sciences Department at BSC. He is involved in the development of the EC-Earth Earth System Model since its inception. Prof Doblas-Reyes serves in several panels of the World Climate Research Programme (WCRP) and the World Weather Research Programme (WWRP) of the World Meteorological Organisation (WMO) and is a member of the European Network for Earth System modelling HPC Task Force. Currently, Prof Doblas-Reyes is the principal investigator (PI) or co-investigator in six FP7 and H2020 European projects, is coordinator of the FP7 collaborative SPECS project and supervises numerous postdoctoral scientists and software engineers. He is a lead author of the chapter 11, "Near-term Climate Change: Projections and Predictability", in the UN IPCC AR5 Working Group I – The Physical Sciences Basis report. Overall, Prof. Doblas-Reyes has authored and co-authored more than 100 peer-reviewed papers and other publications on climate modeling and prediction, as well as climate services.

(Staffing plan & training)

April : Muhammad Asif will be given the "K-computer users' Lecture"
May : Oriol Tinto and Miguel Castrillo will be given the "K-computer users' Lecture"
July : Virginie Guemas will be given the "K-computer users' Lecture"
September : Chloe Prodhomme and Omar Bellprat will be given the "K-computer users' Lecture"

3 Research information relevant to this proposal

The applying team has currently access to the European Center for Medium Range Weather Forecast HPC facilities through the SPESICCF special project (http://old.ecmwf.int/archive/about/special_projects/index.html).

Collaborating Facility Name: ECMWF
Project No.:
Project Name: High resolution climate prediction with EC-Earth
Summary: SPESICCF plan to address the impact of an increase in resolution through experiments based on standard seasonal prediction protocols. It will concentrate on the role of the ocean initialisation by using initial conditions from two different ocean reanalyses: GLOSEA5, the new initialization product released by the UK Met Office, and ORAS5, the latest reanalysis performed by ECMWF. The project will use EC-Earth3, which is one of the few coupled models available that is tuned at different resolutions, including a T511 (~39 km), 91 levels and 0.25° horizontal resolution, 75 vertical levels (HR, T511L91-ORCA025L75) for the atmosphere (IFS) and ocean (NEMO) components. This configuration will be compared to the configuration at standard resolution (SR) T255L91-ORCA1L46.

4 Research achievements

Referee reading publications:

Prodhomme, C., Doblas-Reyes, F, Bellprat, O, Dutra, E. (2015) Impact of land-surface initialization on sub-seasonal to seasonal forecasts over Europe. Climate Dynamics, doi:10.1007/s00382-015-0094-3.

Bellprat, O., F.C. Lott, C. Gulizia, H.R. Parker, L. Pampuch, I. Pinto, A. Ciavarella and P.A. Stott (2015). Unusual past dry and wet rainy seasons over Southern Africa and South America from a climate perspective. Weather and Climate Extremes, doi:10.1016/j.wace.2015.07.001.

Asif, M., A. Cencerrado, O. Mula-Valls, D. Manubens, F.J. Doblas-Reyes and A. Cortés (2014). Impact of I/O and data management in ensemble large scale climate forecasting using EC-Earth3. Procedia Computer Science, 29, 2370-2379, doi:10.1016/j.procs.2014.05.221.

Guemas V, Auger L, Doblas-Reyes FJ, Rust H, Ribes A, 2014, Dependencies in Statistical Hypothesis Tests for Climate Time Series. Bulletin of the American Meteorological Society, 95 (11), 1666-1667.

Guemas V, Blanchard-Wrigglesworth E, Chevallier M, Day J J, Déqué M, Doblas-Reyes F J, Fučkar N, Germe A, Hawkins E, Keeley S, Koenigk T, Salas y Mélia D, Tietsche S, 2014, A review on Arctic sea ice predictability and prediction on seasonal-to-decadal timescales, Quarterly Journal of the Royal Meteorology Society, doi:10.1002/qj.2401.

Guemas V., Doblas-Reyes F., Germe A., Chevallier M., Salas y Mélia D., 2013, September 2012 Arctic sea ice minimum: Discriminating between sea ice memory, the August 2012 extreme storm and prevailing warm conditions [in "Explaining Extreme Events of 2012 from a Climate Perspective"], Bull. Amer. Meteor. Soc., 94 (9), S20-S22.

Guemas V. , Doblas-Reyes F. J., Andreu-Burillo I., Asif M., 2013, Retrospective prediction of the global warming slowdown in the past decade. Nature Climate Change, 3, 649-653, doi : 10.1038/nclimate1863.

Doblas-Reyes F. J., Andreu-Burillo I., Chikamoto Y., García-Serrano J., Guemas V., Kimoto M., Mochizuki T., Rodrigues L. R. L. and van Oldenborgh G. J., 2013, Initialized near-term regional climate change prediction. Nature Communications, 4, 1715, doi:10.1038/ncomms2704.

5 Validity to perform the project

We confirm that the execution of the project and utilization of the results will be limited to peaceful purposes and proper in terms of Basic Act on Science and Technology and social standards. LSIHP is a research project which results are not intended to commercial use but rather intended to contributing to society through the provision of user-relevant climate information.

Eligibility confirmation of Junior Researcher Promotion Project Applicant ※ To apply for the junior researcher promotion project, it must be less than or equal to 39 years of age at the time April 1, 2016 (born on and after April 2 1976). Only if you want to apply to it, please fill in the age of the project representative.	
Age	(as of April 1, 2016)