SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2016………………………………………………………………
Project Title:	Go Beyond Current Limitations of Climate Simulation and Projection over Land
Computer Project Account:	spitales ……………………………………………….……
Principal Investigator(s):	Alessandri Andrea ……………………………………..……
	……………………………………………………………..……
Affiliation:	ENEA …………………………………………………..……
Name of ECMWF scientist(s) collaborating to the project (if applicable)	……………………………………………………………..…… ……………………………………………………………..……
Start date of the project:	1 January 2016……………………………………
Expected end date:	31 December 2018………………………………..

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	NA	NA	4 million	250615
Data storage capacity	(Gbytes)	NA	NA	50000	350

Summary of project objectives
(10 lines max)

The objectives of this special projects are (i) develop a process-based albedo parameterization in EC-Earth, (ii) validate and assess the effects of the new albedo scheme on the simulated climate during the last Century historical period and (iii) evaluate the interactions and feedbacks of the interactive albedo in the future climate projections (CMIP6).
The couplings and feedbacks of the newly introduced interactive albedo will be assessed together with the interactions with the changes of water availability (soil moisture and snow) as well as changes in land cover/land use types.

Summary of problems encountered (if any)
(20 lines max)

The current version of EC-Earth 3.2beta experiences numerical instabilities, which makes it impossible to run multi-decade experiments, as committed for CMIP6. This affects the atmosphere-only and the coupled configurations. Work is undergoing in the EC-Earth community to identify and correct any bugs in the code, configuration, or intitial files that cause instabilities and make sure that the model can be run for at least some decades without regular crashes.

Summary of results of the current year (from July of previous year to June of current year)
This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

The preliminary phase of the project has been devoted to the installation and testing of the upgraded Earth System Model (ESM) developed by the EC-Earth consortium (hereinafter EC-Earth ESM; Hazeleger et al. 2012; Weiss et al., 2012; 2014) for the participation in the Climate Model Intercomparison Project Phase 6 (CMIP6). The installation and testing of the latest version of the EC-Earth ESM (v3.2beta) has been accomplished in the new ECMWF high performance computing system (Cray XC30, cca). The released standard resolution is T255 with 91 vertical levels for the atmospheric model IFS and $1°\times1°$ horizontal grid for the ocean model NEMO. Two configurations have been considered: the first one with IFS+NEMO and the second one also including the LPJ-GUESS model for the simulation of dynamical vegetation.
Preliminary scalability tests performed with v3.2 beta on the cca system, indicated that the best configuration for the fully coupled model (atmosphere+ocean+vegetation) was 372 tasks on 18 nodes distributed on: 1 proc XIOS (input/output server for NEMO) and OASIS3-MCT (coupler) + 1 proc runoff-mapper + 72 procs NEMO (Ocean model) + 288 procs IFS Atmospheric model) + 10 proc LPJ-GUESS (dynamical vegetation). Large scalability is not an issue for our experiments since we can run different experiments at the same time. More thorough scaling tests will be performed if project needs would require an improvement of model performances.
A modified version of the land-surface model included in IFS (HTESSEL; Balsamo et al., 2009) has been recently developed to represent a Lambert-Beer formulation for the computation of vegetation fractions (Alessandri et al., 2016). This parameterization, which constitutes a major improvement in comparison with the CMIP5 version of the model, was developed at ENEA for the previous version of EC-Earth (v2.4), and has been ported and tested on version 3.2 during the first months of SPITALES. Consistently to what reported for EC-Earth v2.4 (Alessandri et al., 2016), the analysis conducted (not shown) has confirmed the enhanced sensitivity of the modeled surface

climate of EC-Earth v3.2 to the vegetation variability introduced by the new Lambert-Beer parameterization. In addition, the analysis identified an underestimation of albedo over subtropical dry regions leading to an inverted south-north albedo gradient over (e.g.) north-west Africa (Figure 1) that would imply unrealistic local and large-scale impacts on model climatology.

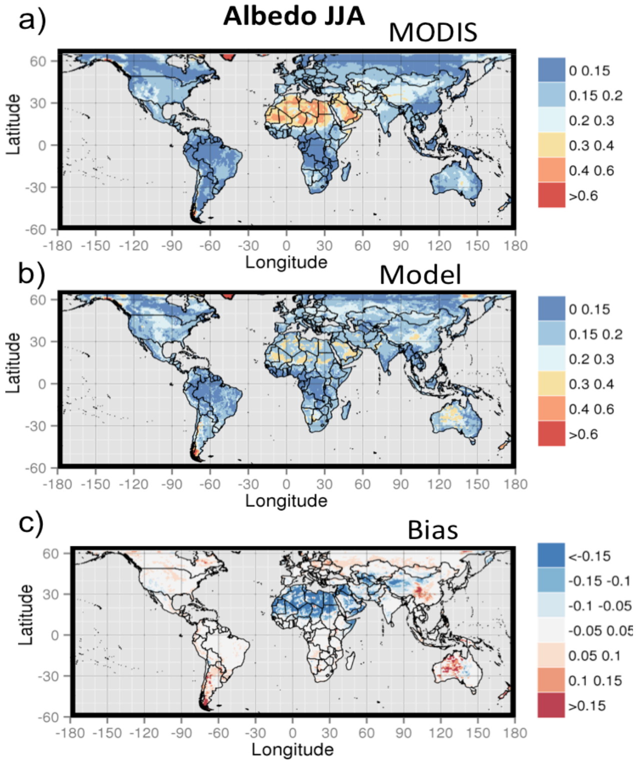

Figure 1: Boreal summer (June-July-August) climatology of surface albedo for (a) MODIS observation and (b) model. (c) difference between Model and MODIS.

This motivated us to develop a revised albedo parameterization over deserts in HTESSEL to overcome the substantial underestimation of albedo over subtropical dry regions such as Sahara affecting the original IFS model (Control; Figure 1c). A realistic representation of albedo over desert surface has been implemented in IFS-HTESSEL based on satellite-derived albedo from the MODIS dataset. Specifically, realistic albedo values for the four radiation bands considered in IFS is obtained by averaging observed albedo over deserts and then prescribed over each desert grid point in the model. Our analysis indicates that indeed this parameterization allows to overcome major underestimation of albedo over desert regions of the world such as Sahara (Figure 2b). The improved albedo over Sahara is shown to have a considerable impact on rainfall pattern over subtropics and tropics (Figure 2c) that considerably corrects the bias affecting the Control experiment (Figure 2a).

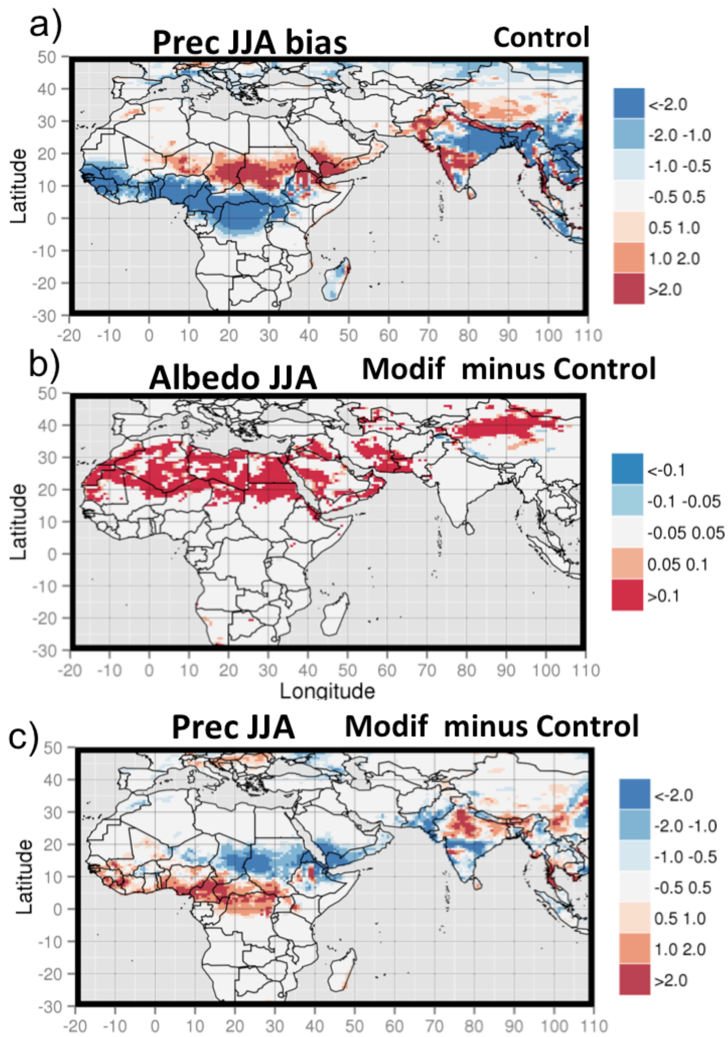

Figure 2: Boreal summer (June-July-August) (a) bias of precipitation (b) Modif minus Control surface albedo and (c) Modif minus Control precipitation.

References:

Alessandri, F. Catalano, M. De Felice, B. Van Den Hurk, F. Doblas Reyes, S. Boussetta, G. Balsamo, P. Miller (2016), "Multi-scale enhancement of climate prediction over land by increasing the model sensitivity to vegetation variability in EC-Earth", In Press. Climate Dynamics.

Balsamo, G., A. Beljaars, K. Scipal, P. Viterbo, B. van den Hurk, M. Hirschi, and A. K. Betts, 2009: A revised hydrology for the ECMWF model: Verification from field site to terrestrial water storage and impact in the integrated forecast system. J. Hydrometeor. , 10 , 623–643, doi:10.1175/2008JHM1068.1.

Hazeleger W., and Coauthors, 2012: EC-Earth v2.2: Description and validation of a new seamless Earth system prediction model. Climate Dyn., 39, 2611–2629, doi:10.1007/s00382-011-1228-5.

Weiss, M., B. van den Hurk, R. Haarsma, and W. Hazeleger, 2012: Impact of vegetation variability on potential predictability and skill of EC-Earth simulations. Clim. Dyn., 39, 2733-2746.

Weiss, M., Miller, P., van den Hurk, B., van Noije, T., Stefanescu, S., Haarsma, R., van Ulft, L. H.,Hazeleger, W., Le Sager, P., Smith, B., and Schurges, G., 2014: Contribution of dynamic vegetation phenology to decadal climate predictability; J. Clim. , doi:10.1175/JCLI-D-13-00684.1.

List of publications/reports from the project with complete references

A. Alessandri, F. Catalano, M. De Felice, B. Van Den Hurk, F. Doblas Reyes, S. Boussetta, G. Balsamo, P. Miller (2016), "Multi-scale enhancement of climate prediction over land by increasing the model sensitivity to vegetation variability in EC-Earth", In Press. Climate Dynamics.

Summary of plans for the continuation of the project

(10 lines max)

Based on the testing and early analysis performed during the first months of the project, we plan to go on with the planned activity of (i) developing a process-based albedo parameterization in EC-Earth that will be subsequently (ii) validated to assess the effects on the simulated climate during the last Century historical period and used to (iii) evaluate the interactions and feedbacks of the interactive albedo in the future climate projections (CMIP6).

The couplings and feedbacks of the newly introduced interactive albedo will be possibly evaluated together with the interactions with the changes of water availability and the changes in land cover/land use types.