LATE REQUEST FOR A SPECIAL PROJECT 2015–2017

MEMBER STATE: Germany

Principal Investigator[1]**:** Dr. Joel Arnault

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Other researchers:

Prof. Harald Kunstmann, Dr. Kirstin Kober

Project Title:

The role of soil moisture and surface- and subsurface water flows on predictability of convection

Would you accept support for 1 year only, if necessary?	YES ☐	NO ☒

Computer resources required for 2015-2017: (The project duration is limited to a maximum of 3 years, agreed at the beginning of the project. For late requests the project will start in the current year.)	**2015**	**2016**	**2017**
High Performance Computing Facility (units)	1,000,000	2,000,000	2,000,000
Data storage capacity (total archive volume) (gigabytes)	1,500	1,500	1,500

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):

June, 23, 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: Joel Arnault

Project Title: The role of soil moisture and surface- and subsurface water flows on predictability of convection

Extended abstract

This project is part of the newly established DFG (German Research Foundation) Collaborative Research Center 165/1 “Wave to Weather”, funded for the period 07/2015 – 06/2019.

Research plan:

Moist convection is an atmospheric process whose initiation depends both on the synoptic-scale weather situation and local forcing. In weather situations characterized by weak synoptic-scale forcing, local characteristics, e. g., land surface variability, are more likely to be significant in the initiation of convective precipitation. Current state of the art numerical weather prediction (NWP) models still have a limited representation of terrestrial hydrological processes, particularly with respect to soil moisture and lateral terrestrial water flows. In the same time these NWP models are known for their limited forecast quality during weak synoptic-scale forcing conditions, which could be related to a larger contribution of unresolved land-atmosphere coupling processes in such weather situations.

In this project we will investigate which improvements in convective precipitation predictability can be achieved by a more sophisticated treatment of terrestrial hydrological processes in NWP models.

To reach this objective we will simulate a panel of case-studies in Germany and West Africa using the Weather Research and Forecasting (WRF) model, a hydrologically enhanced version of WRF, namely WRF-Hydro, and the Consortium of Small-scale Modeling (COSMO) model. We will then develop methods to quantify the physical processes at stake in soil moisture – precipitation feedback mechanisms, especially for the cases where more complex descriptions of surface and subsurface lateral water flows improve precipitation predictability.

A further focus will be set on the description of uncertainties by adopting and applying a stochastic boundary layer parameterization. This parameterization scheme aims to represent subgrid-scale variability caused by specific processes important for convective initiation. Such a parameterization is developed for the COSMO model and will be transferred and implemented in the WRF/WRF-Hydro modeling system. The ability of this approach to account for the land-atmosphere exchange variability originating from surface and subsurface lateral water flows will be assessed.

Ensembles of soil moisture fields will be produced with WRF-Hydro, and used to investigate the sensitivity of cloud microphysical and boundary layer processes to a physically-enhanced description of soil moisture initial and boundary condition in the COSMO model. We will finally assess the role of lateral water flows at the surface and subsurface for improved soil moisture initialization in weather forecasting.

Need for high performance computing and ECMWF operational analyses/forecast

A typical WRF-Hydro simulation uses a horizontal grid of 300x300 points at 5 km resolution and 35 vertical levels for the atmosphere, and a horizontal grid of 1500x1500 points at 1 km resolution with four soil layers for the terrestrial hydrology. It is noted that in WRF-Hydro the interactions between the vadose and saturated zones are computed with a 2-D ground water model.

The determination of the initial conditions of terrestrial hydrological variables in WRF-Hydro is a key issue. It requires a model spinup time of at least one year, in order to account for the full range of hydrological processes potentially playing a role in land-atmosphere feedback mechanisms and convection initiation. The computing time for a one-year WRF-Hydro simulation using the above setup is estimated at 85000 SBU.

With the requested computed time of 2,000,000 units (half of it for 2015), a panel of such WRF-Hydro simulations for multi-year periods will be done (a total of about 11, 23 and 23 years of simulation for 2015, 2016 and 2017, respectively). This will allow investigating how to use WRF-Hydro in order to prepare the initial condition of terrestrial hydrological variables for short term forecast runs. The first 18-month period will be devoted to the German region, while the second 18-month period will deal with the West African region.

These WRF-Hydro outputs will finally be used to investigate the impact of a multiyear spinup time of terrestrial hydrological variables in COSMO, WRF and WRF-Hydro model case-studies of convection initiation. Access to the atmospheric model operational analyses/forecast data from the archive is therefore required.

For the multi-year WRF-Hydro simulations it is planned to save only the soil variables that are needed for the initialization of a forecast run. Also, the produced data won't be stored at the ECMWF for more than a one-year period. Storage of 1,500 gigabytes for the whole project's duration should therefore be sufficient.