REQUEST FOR A SPECIAL PROJECT 2014–2016

MEMBER STATE: Germany

Principal Investigator[1]: Dr. Patrick Laux.

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Other researchers: Prof. Harald Kunstmann

Project Title: Tailor-made seasonal forecasts for sub-Saharan Africa

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.)	2014	
Would you accept support for 1 year only, if necessary?	YES X	NO ☐

Computer resources required for 2014-2016: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2016.)		**2014**	**2015**	**2016**
High Performance Computing Facility	(units)	1,000,000	1,000,000	1,000,000
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):

…………………………………………

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.

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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.

Agricultural productivity and food security in sub-Saharan Africa (SSA) heavily depend on uncertain rainfall. The exposure to climate risk characterizes the livelihood of the majority of the region's population: High rainfall variability impedes the farmers' efforts to intensify agricultural production and negatively affects the level of food security.

The goal of the special project "Tailor-made seasonal forecasts for sub-Saharan Africa" if the development of improved and regionally adapted and optimized seasonal drought forecast products that integrate technical and climatic limitations and farmers' needs in the context of delivery institutions. The seasonal (retro)forecasts will be analyzed and evaluated for two different catchments in West and East Africa, the Volta basin as well as the Tana River Basin.

This goal will be achieved by:

i) Statistical Analysis of the raw (uncorrected) global seasonal forecasting system of ECMWF (S4) in terms of precipitation amounts and its intra-(seasonal) rainfall distribution such as onset, cessation of the rainy season (Laux et al., 2008,2009), and various droucht indices (SPI, EDI, etc.). The performance will be assessed for all ensemble members using different lead times and verification techniques.

ii) Bias correction of the global seasonal forecasting system of ECMWF using different bias correction methods such as historgram matching or a Copula-based approach (Laux et al., 2011; Vogl et al., 2012).

iii) Spatiotemporal refinement applying dynamical downscaling of selected ensemble members based on i) and different clustering methods such as e.g. EOF-based methods (Harr et al., 2008). Only the first 5 ensemble members of the re-forecasts have the required model level data and are suitable for dynamical downscaling procedures. A throughout evaluation of different physical parameterization schemes such as cumulus schemes and microphysics schemes will be performed (Laux et al., 2012). The results of the dynamical downscaling will be validated using gridded precipitation observations such as GPCC.

Need for high performance computing

WRF is a next-generation mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. The WRF Software Framework (WSF) provides the infrastructure that accommodates the dynamics solvers, physics packages that interface with the solvers, programs for initialization, WRF-Var, and WRF-Chem. There are two dynamics solvers in the WSF. The one applied in this project is the Advanced Research WRF (ARW) solver which was primarily developed at NCAR (National Centre for Atmospheric Research, USA). The ARW dynamics solver integrates the compressible, non-hydrostatic Euler equations. The equations are cast in flux form using variables that have conservation properties. The equations are formulated using a terrain-following mass vertical coordinate. The flux form equations in Cartesian space are extended to include the effects of moisture in the atmosphere and projections to the sphere.

For the temporal model discretization the ARW solver uses a time-split integration scheme. Generally speaking, slow or low-frequency (meteorologically significant) modes are integrated using a third-order Runge-Kutta (RK3) time integration scheme, while the high-frequency acoustic modes are integrated over smaller time steps to maintain numerical stability. The horizontally propagating acoustic modes (including the external mode present in the mass-coordinate equations using a constant-pressure upper boundary condition) and gravity waves are integrated using a forward-backward time integration scheme, and vertically propagating acoustic modes and buoyancy oscillations are integrated using a vertically implicit scheme (using the acoustic time step). The time-split integration for the flux-form equations is described and analyzed in Klemp et al. (2007). The spatial discretization in the ARW solver uses a C grid staggering for the variables. That is, normal velocities are staggered one-half grid length from the thermodynamic variables. The grid lengths Δx and Δy are constants in the model formulation; changes in the physical grid lengths associated with the various projections to the sphere are accounted for using map factors. The vertical grid length $\Delta\eta$ is not a fixed constant; it is specified in the initialization. The user is free to specify the η values of the model levels subject to the constraint that $\eta = 1$ at the surface, $\eta = 0$ at the model top, and η decreases monotonically between the surface and model top.

The requested computing time will be used for dynamical downscaling using the regional climate model WRF. A mimimum data storage capacity of 1,500 GB will required to storage the WRF outputs before archieving them at a data server at KIT, IMK-IFU. The PI of the special project is familiar with performing regional climate simulations on HPC environment (project LUCCi, Laux et al., 2012).

Additionally, access to the seasonal forecast product S4 of ECMWF, namely the re-forecasts as well as operational forecasts is required.

Laux P., Kunstmann, H., Bárdossy, A. (2008) Predicting the Regional Onset of the Rainy Season in West Africa, International Journal of Climatology, 20(3), 329–342, doi:10.1002/joc.1542.

Laux, P., Wagner, S., Wagner, A.Bárdossy, A., Jacobeit, J., Kunstmann, H. (2009) Modelling Daily Precipitation Features in the Volta Basin of West Africa, International Journal of Climatology,29(7): 937–954, doi:10.1002/joc.1852.

Laux, P., Vogl, S., Qiu, W., Knoche, H. R., and Kunstmann, H. (2011) Copula-based statistical refinement of precipitation in RCM simulations over complex terrain, Hydrol.Earth Syst. Sci., 15, 2401–2419, 2011. www.hydrol-earth-syst-sci.net 2/15/2401/2011/, doi:10.5194/hess-15-2401-2011.

Vogl, S., Laux, P., Qiu, W., Ganquan M., and Kunstmann, H. (2012) Copula-based assimilation of radar and gauge information to derive bias corrected precipitation fields, Hydrol. Earth Syst. Sci., 16, 2311–2328, 2012. www.hydrol-earth-syst-sci.net /16/2311/2012/, doi:10.5194/hess-16-2311-2012.

Laux, P., Phan, V.T., Lorenz, Ch., Thuc, T., Ribbe, L., Kunstmann, H. (2012) Setting up Regional Climate Simulations for Southeast Asia. High Performance Computing in Science and Engineering ’12, Conference Proceedings, Wolfgang E. Nagel, Dietmar B. Kröner, Michael M. Resch (Eds.), Springer, pp 391–406.