REQUEST FOR ADDITIONAL RESOURCES IN THE CURRENT YEAR FOR AN EXISTING SPECIAL PROJECT

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MEMBER STATE: Germany

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Project title: AGricultural Decision-Tailored (Sub)SEasoNal Drought ForecAsting for Sub-Saharan Africa (AGENDA-SSA)

Project account: **SP DE4L**

Additional computer resources requested for		**2023**
High Performance Computing Facility	(units)	34,000,000
Data storage capacity (total)	(Gbytes)	-

Continue overleaf

[1] The Principal Investigator is the contact person for this Special Project

Technical reasons and scientific justifications why additional resources are needed

WRF setup optimization

The WRF test simulation phase on Atos HPC is now finished. Based on conducted speedup performance tests using different compiler settings, i.e., different domain settings (nested vs single nest simulations) as well as different number of nodes, a reasonable WRF setup has been identified. Scalability on Atos is found to be much higher for a single nest and a big domain and using OpenMPI. Figure 1 is illustrating the speedup performance normalized to 4 nodes of 128 cores each. Speedup performance is close to linear but non-optimal (slope < 1). For instance, the configuration using 40 nodes is showing a speedup performance of about 13.

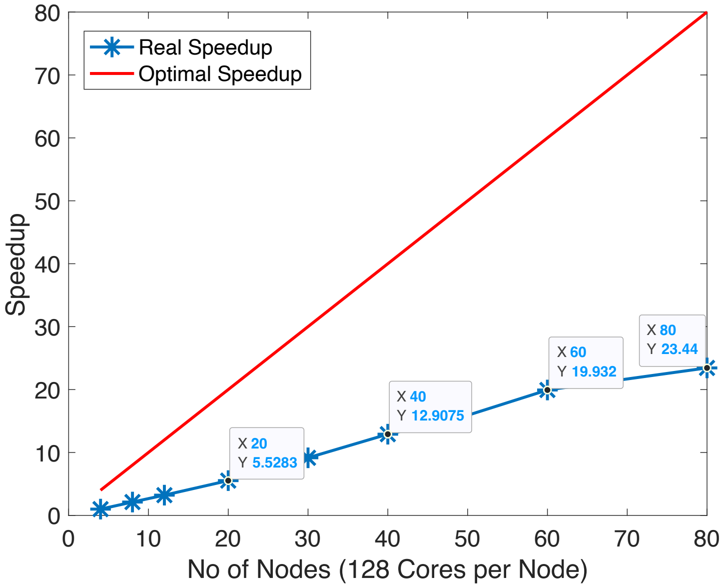

Figure 1: Speedup performance normalized to 4 nodes of 128 cores each.

Taking into account the wall time limitation of 48 hours and the real time needed to conduct the simulations, 40 nodes are considered a good choice. Based on this, a full 7-month seasonal forecast can for the whole of Africa be performed in two cycles. Monthly restart files are written, in case of non-robust simulations. However, test simulations finished without any interruptions.
For scientific reasons, the original work plan (particularly WP 3) has been adopted. It is now aimed at convection-permitting (CP) simulations at 4 km for the whole African continent (see domain setup, Figure 2). Additional physics parameterization settings will be taken from the literature review (e.g., Laux et al., 2021a).

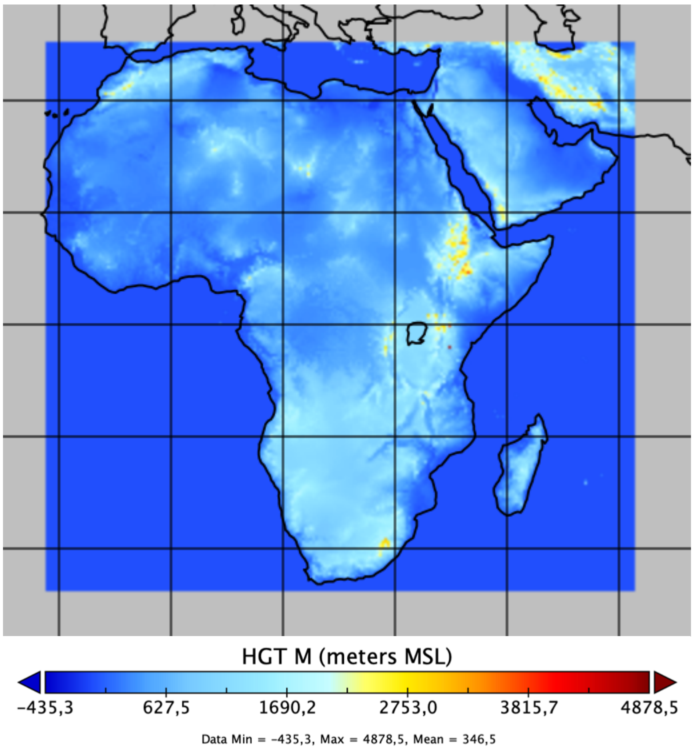

Figure 2: Geographical domain setup of WRF-SEAS5 simulations.

Reasons for changes in the working plan (compared to WP3 of original SP proposal)
While there exist only a few studies of downscaled seasonal predictions for different regions across Africa (Mori et al., 2020; Siegmund et al., 2013), to the best of the PI's knowledge, it is the first time that seasonal CP simulations are being performed for whole Africa. It is expected that the new CP simulations will clearly outperform the simulations based on Cumulus parameterization and that they will raise significant scientific attention.
There is an increasing interest in sub-seasonal to seasonal predictions for various sectors such as water resources management, health, and energy, for which there exist many potential applications and project collaborations. The usage of the generated downscaled seasonal forecasts in future projects has recently been discussed with members of the AgMIP community. In addition, it is planned to apply the generated data in combination with a process-based hydrological model, calibrated for West Africa to evaluate its suitability for flood forecasting.
It is aimed to publish the generated dataset, approaching impact modelers and decision makers mainly in western-, eastern-, and southern Africa.

Both, the higher spatial resolution and larger domain size will also increase the HPC needs tremendously. In order to save computing resources and balance these two effects, it is necessary to reduce the size of the ensemble, obtained by perturbed initial conditions (PICs). In the original proposal, dynamical downscaling of 25 PIC members for two selected years (i.e., the rainy season of a dry and a wet year) from the retroforecasts was suggested. As it is assumed that most members will lead to similar results, the focus will be set on most "extreme situations" and one instance representing "normal" conditions. Based on pre-processing of raw SEAS5 temperature and precipitation fields for the domain of interest, members which represent well the different possible combined wetness and warming states, i.e., dry/hot, wet/hot, dry/cold, wet/ cold, and normal, will be pre-selected from the 25 ensemble members. Laux et al. (2021b) already applied this approach to analyze whether post-processing bias correction will lead to changes in the wetness and warming states of climate simulations. This approach can be applied also to PIC simulations. This will finally reduce the number of PICs for downscaling from 25 to 5.

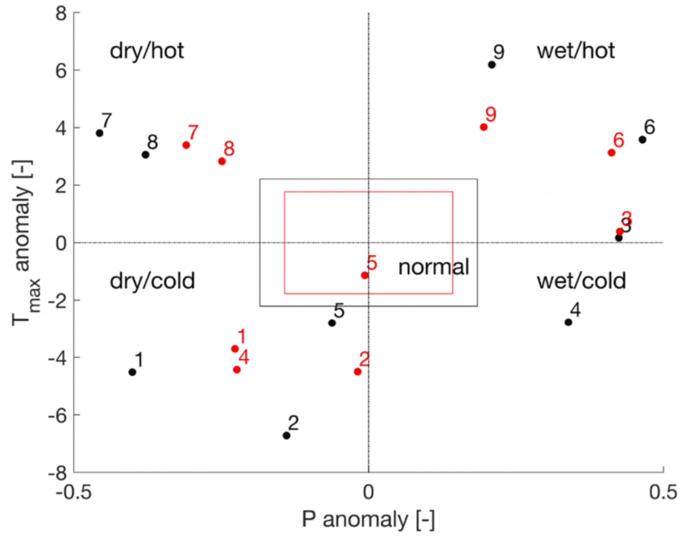

Figure 3: Anomaly plot of temperature (T) and precipitation (P), following the procedure of Ruane et al. (2015). Shown are the uncorrected CTRL run of 1980–2005 (black) vs. the uncorrected RCP4.5 runs (2006–2100) (red). The numbers denote the different CORDEX GCM-RCM combinations. For more information, the reader is referred to Laux et al. (2021b).

Moreover, it has been decided to reduce the seasons from 2 to only 1, a wet season. This will reduce the required resources to 50%.

Updated resources planning and SBU request

In total, 28 Mio SBUs would be needed to run the simulations with the suggested changes in WP3, i.e., for 1 selected season (7 months [*1]) and 5 PIC [*2] simulations (see Table 1). This corresponds to about approximately 16 months (assuming an efficiency of 80%). Based on the test simulations using 40 nodes, this requires **15 Mio SBUs for the pre-processing** steps (note that only the QoS np is calculated here to run the real.exe, additional steps such as retrieving data from MARS as well as the ungrib.exe and the metgrid.exe will be done using the nf) and **54 Mio SBUs for the WRF**. It is suggested to distribute the resource equally for the 2 remaining years of the SP duration. Thus, in 2023 7 Mio SBUs and 28 Mio SBUs will be required for WPS and WRF, respectively. Since 1 Mio SBU is granted for 2023, it is applied for an additional **34 Mio SBUs in 2023**.

Table 1: Overall resources needed to run the WRF simulations for 1 selected season over the remaining 2 years of this Special Project. An efficiency of 80% is assumed for the jobs, i.e., 20% of the real-time the jobs are not running due to queuing, maintenance, or other unforeseen events:

Overall resource needs (2023-2024)	**Absolute time [h] for 1 month**	**Absolute time [h], 80% efficiency (1 month)**	**Absolute time on cluster [days]**	**Needed resources [SBUs]**
WPS (Preprocessing)	2	2.4	7 [*1] x 5 [*2] x 2.4 = 84	7 x 5 x 0.4 Mio = 14
WRF	~11 (variable, adaptive time step option)	13.2	7 x 5 x 13.2 = 460	7 x 5 x 1.6 Mio = 56 Mio
Sum	13	15.6	**544**	**70 Mio**

References:

Mori, P, Schwitalla, T, Ware, MB, Warrach-Sagi, K, Wulfmeyer, V. Downscaling of seasonal ensemble forecasts to the convection-permitting scale over the Horn of Africa using the WRF model. *Int J Climatol*. 2021; 41 (Suppl. 1): E1791–E1811. https://doi.org/10.1002/joc.6809.

Siegmund J, Bliefernicht J, Laux P, Kunstmann H. 2013. Toward a Seasonal Precipitation Prediction System for West Africa: Performance of CFSv2 and High Resolution Dynamical Downscaling. Journal of Geophysical Research Atmospheres 120(15), DOI: 10.1002/2014JD022692.

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