LATE REQUEST FOR A SPECIAL PROJECT 2025–2027

MEMBER STATE: Germany

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Project Title: **AGRO-CAST** – AGricultural RObust Climate and Seasonal Tools: Enhanced Agricultural Decision-Tailored (Sub)Seasonal Drought Forecasting for Sub-Saharan Africa with Operational Implementation, Model Sensitivity Analysis, and Validation Using In-Situ Observations

To make changes to an existing project please submit an amended version of the original form.)

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** de4l	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2025	
Would you accept support for 1 year only, if necessary?	YES X	NO ☐

Computer resources required for project year:		**2025**	**2026**	**2027**
High Performance Computing Facility	[SBU]	10,000,000	20,000,000	20,000,000
Accumulated data storage (total archive volume)[2]	[GB]	15,000	15,000	15,000

EWC resources required for project year:		**2025**	**2026**	**2027**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.
[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.
[3]The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

Principal Investigator: Dr. Patrick Laux

Project Title: AGRO-CAST

1. Abstract

AGRO-CAST will deliver an operational framework for agricultural decision-tailored (sub)seasonal drought forecasting in the Greater Horn of Africa (GHAF). Building on the ECMWF Special Project *AGENDA-SSA* (2022–2024), which demonstrated skilful prediction of the OND rainy season via an IOD–EAR index approach, AGRO-CAST will complete and extend high-resolution WRF sensitivity experiments for selected SEAS5 perturbed initial condition (PIC) members. Using a newly available, dense in-situ observation network for Ethiopia and Sudan, forecasts will be comprehensively validated and integrated into agricultural decision-support tools. The project will produce valuable high-resolution datasets for the scientific community and likely contribute to operational workflows in water resources management, thereby strengthening climate-resilient agricultural planning in Sub-Saharan Africa. In addition, two peer-reviewed publications are expected as a project outcome.

2. Description of the project

Background and Rationale

Agricultural productivity and food security in Sub-Saharan Africa, especially in the GHAF, are highly sensitive to rainfall variability. *AGENDA-SSA* demonstrated that SEAS5 forecasts, when filtered via an Indian Ocean Dipole (IOD) and East African Rainfall (EAR) index approach, achieve strong predictive skill for the OND season (r = 0.75 at a four-month lead time). This provides a robust basis for targeted dynamical downscaling to support agricultural management. Such targeted downscaling may support the selection of suitable crops as well as other management options considering intraseasonal rainfall distribution and amount. However, the original AGENDA-SSA project's final year was constrained by reduced personnel and data loss, leaving planned WRF parameterization experiments, validation, and agricultural integration incomplete.

AGRO-CAST addresses these gaps and adds a significant new asset: **in-situ station data from the SPS Blue Nile project** (Fig. 1), which will enable unprecedented forecast validation for the GHAF:

- *Ethiopia*: Daily precipitation, Tmin, Tmax for ~75 stations; partial wind speed (2 m), relative humidity, and sunshine hours.
- *Sudan*: Daily precipitation, Tmin, Tmax from 8 stations in the Sudanese Blue Nile basin.

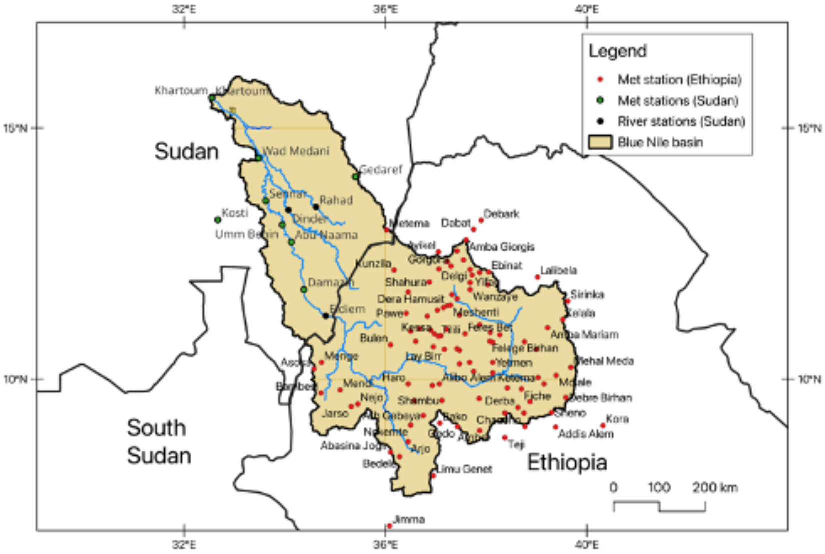

Figure 1: Meteorological observation data for the GHAF, available through the SPS project.

Project objectives

1. Complete and extend WRF sensitivity experiments (microphysics, radiation, and PBL schemes) for selected SEAS5 PIC members and seasons.
2. Validate forecasts using dense in-situ station data, satellite products, and reanalysis.
3. Integrate SEAS5 forecasts into agricultural and hydrological decision-support tools for the GHAF.

3. Methodology

SEAS5 ensemble member selection:

- Use the IOD–EAR approach developed in AGENDA-SSA to identify dry, wet, and neutral PIC members for OND seasons.

Downscaling (WRF):

- Dynamical downscaling will be conducted using the **Weather Research and Forecasting (WRF) model**, leveraging extensive experience from both *AGENDA-SSA*.
- WRF will be configured in a **single large-domain nest** at convection-permitting resolution,. This setup was identified in *AGENDA-SSA* through systematic scalability and performance tests on Atos HPC, showing optimal efficiency when combined with **OpenMPI parallelization** and I/O optimization strategies. Due to resources limitations the geographical domain will be restricted to Central and Eastern Africa covering the GHAF. Covering the whole of SSA would exceed available resources.
- The single-nest configuration was found to outperform nested domains for our spatial and computational requirements, enabling efficient large-scale simulations.
- Parameterization sensitivity experiments will follow the ensemble approach of Laux et al. (2021), varying:
    - **Microphysics**: WSM6, Thompson, Morrison.
    - **Planetary Boundary Layer (PBL)**: YSU, MYNN.
    - **Radiation Schemes**: RRTMG, CAM.

- Output will be post-processed to a standardized grid for inter-comparison and agricultural model coupling.
- Prior WRF experience from *AGRI-SSP* ensures rapid and robust deployment for both hindcast validation and real-time forecast applications.

Validation:

- Multi-source validation framework combining:
  - SPS in-situ data for Ethiopia and Sudan.
  - Satellite datasets (CHIRPS, TRMM, GPM).
  - ERA5 reanalysis.
- Metrics: RMSE, correlation, Brier scores, categorical accuracy, drought indicators.

Agricultural Integration and Operational Trials:

- Couple forecasts to crop and water management models.
- Run real-time forecasts for OND seasons in the final project year.

4. Work Plan and Timeline

Year 1 (Oct 2025 – Sep 2026):

- Reduced geographical Setup of WRF for Central and Eastern Africa
- Reproduce and complete WRF sensitivity experiments.
- Begin validation with in-situ and satellite/reanalysis datasets.

Year 2 (Oct 2026 – Sep 2027):

- Expand validation across additional seasons/PICs.
- Begin agricultural model coupling.

Year 3 (Oct 2027 – Sep 2028):

- Conduct operational trials.
- Finalize agricultural model integration.
- Publish results.

Optional Year 4 (Oct 2028 – Sep 2029):

- Consolidate operational workflow.

5. Anticipated results and potential benefits

- Fully validated, high-resolution seasonal drought forecasts for the GHAF.
- First large-scale evaluation using dense in-situ datasets from Ethiopia and Sudan.
- Operational pipeline for agricultural decision support.
- Contribution to strengthened resilience of agricultural systems to climate variability.
- At least two peer-reviewed publications.

6. Justification of the computer resources requested

The project requires high-resolution seasonal downscaling (WRF) of selected SEAS5 PIC members for multiple years and sensitivity runs. Each experiment will use a single large-domain nest at convection-permitting resolution. HPC scalability tests from *AGENDA-SSA* indicate high efficiency under OpenMPI. The computational request will cover:

- WRF parameterization experiments for selected OND seasons using ERA5 Reanalysis and 7 different parameterization settings
- Dynamical downscaling of the OND season with different lead times (3) per year × 3 PIC members (9 simulations per analysed season).
- Storage for raw and post-processed data (~ 15 TB).
- Re-runs for operational trials in Year 3.

An exact Service Unit (SU) and storage request will be calculated separately, based on the final WRF domain configuration, horizontal and vertical resolution, number of simulation years, number of selected SEAS5 PIC members, and the planned ensemble of physical parameterization experiments.

7. Justification for late submission

This late request stems from unforeseen constraints in *AGENDA-SSA*'s final year—namely loss of simulation data and lack of personnel—which prevented completion of planned work. The newly available in-situ dataset from the ongoing SPS Blue Nile project now enables robust, independent validation which was not possible before. AGRO-CAST builds directly on completed work and ensures prior investments translate into operational tools for climate-resilient water agriculture.

P. Laux, D. Dieng, T. C. Portele, J. Wei, and S. Shang. A High-Resolution Regional Climate Model Physics Ensemble for Northern Sub-Saharan Africa. Frontiers in Earth Science, 9(September):1–16, 2021b. doi: 10.3389/feart.2021.700249.