Project: **1478**

Project title: **Mediterranean and pan-European forecast and Early Warning System against natural hazards - MedEWSa**

Principal investigator: **Elena Xoplaki**

Report period: **2025-11-01 to 2026-10-31**

MedEWSa is building a multi-hazard, impact-based Early Warning System for floods, heatwaves, droughts and compound events across Europe, the Mediterranean and Africa. The system starts from AI-downscaled and bias-corrected SEAS5.1 seasonal forecasts and translates them into probabilistic hazard forecasts for the MedEWSa Decision Support Dissemination System (DSDS). By the time of this report, 6078 of the 8018 CPU node-hours allocated for 2026 had been used, as the production had to continue under the deadlines of the project, in particular for the hazard products required by the DSDS. At the same time, verification continued, with very interesting results, towards the publication of the results.

Most of the year went into turning the model-development phase into production. A Deep Residual–Convolutional Neural Network with Channel and Spatial Attention Blocks (Díaz Esteban et al., 2024; Lin et al., 2024; Woo et al., 2018) was trained on GPUs and applied from 1° to 1 arcminute (about 1.5 km) over the whole pan-European, Mediterranean and North African domain, for the full SEAS5.1 ensemble (25-member reforecasts 1993–2016, 51-member forecasts 2017–2025) and 7 lead times. This was the most resource-intensive step of the project so far, and the full pipeline was tested and validated against observed extreme events. Handling packed and compressed NetCDF files, harmonising time axes, merging domains and repeating quality-control loops over large ensembles took a large share of the computing time, and the codes are being optimised continuously to reduce the required computation time. Output of this research has been presented by Iakovidis et al. (2026), Corrado et al. (2026) at the MedCLIVAR2026 Conference.

For Ethiopia, the post-processing from 1° to 0.1° was completed for precipitation and for minimum and maximum temperature. The model was trained on 1993–2016, with further model development and one annual model per variable on the full pool of 25 ensemble members and seasonal sine and cosine inputs, and production was carried out up to 2024 for 7 lead times. The downscaled fields represent the cooler highlands and the localised rainfall over the Ethiopian highlands much better than the coarse input (Figures 1 and 2), although differences in intensity and extent remain.

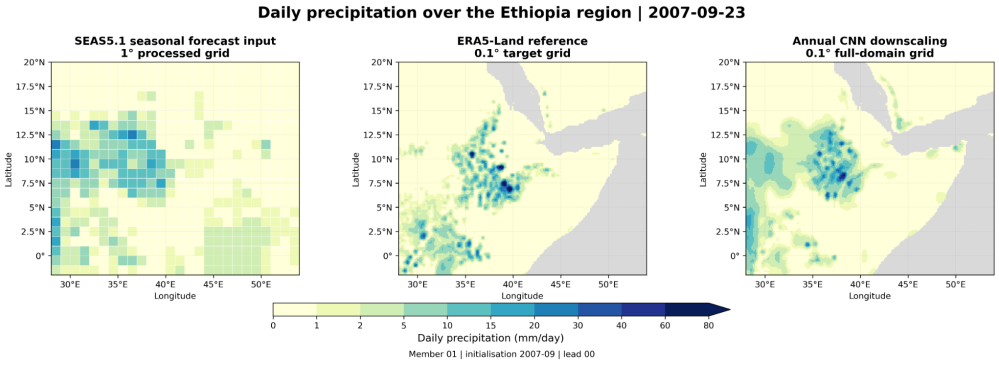


Fig. 1. Ethiopia daily precipitation, 23 September 2007, member 01, lead 00: SEAS5.1 (1°), ERA5-Land (0.1°) and the DRCNN output (0.1°).

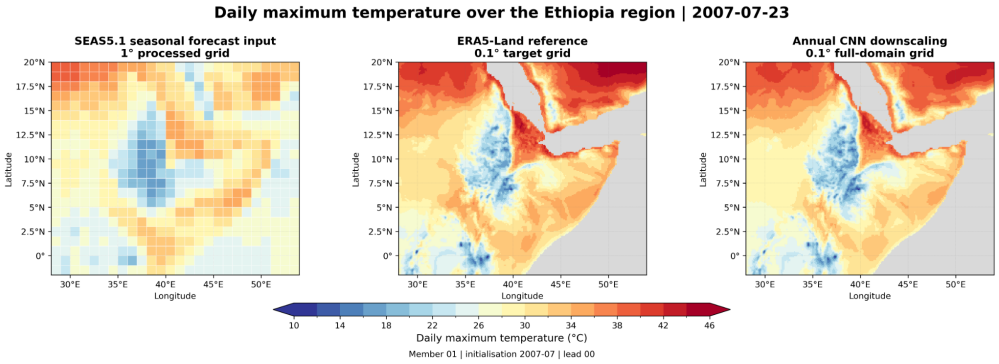


Fig. 2. Ethiopia daily maximum temperature, 23 July 2007, member 01, lead 00: SEAS5.1 (1°), ERA5-Land (0.1°) and the CNN output (0.1°).

On top of the downscaled fields we computed for the pan-European-Northern African domain the climatological reference fields, the non-parametric SPEI (NPSPEI, monthly), the Heat Magnitude Day and Bivariate Heat Magnitude Day (BVHMD) indices (daily) and the Non-linear Combined Stress Index (NLCSI) for compound

events, across ensemble members and temporal scales. Heatwaves, droughts, anomalously wet conditions and compound heatwave–drought events were detected, their drivers were analysed, and probabilistic hazard forecasts were produced for the DSDS. On the hydrological side, LISFLOOD was set up, calibrated and tested, and run for Slovakia and the upper Danube basins at a first step with a 1-month lead time. The outputs have been compared with EFAS output and presented by Gazzotti et al. (2026) at the MedCLIVAR2026 conference.

The work over Ethiopia and the verification with the LISFLOOD simulations showed clearer what is still required for the further improvement of the approach and improvement of the seasonal forecast outputs. Over the Danube region the European products resolve fine-scale temperature contrasts, but the spatial and temporal pattern of the downscaled precipitation differs from the observations in the location and extent of the wet area (Figure 3), and this propagates into the LISFLOOD simulations. Seasonal rainfall forecasts are inherently less skilful than temperature (Johnson et al., 2019), and seasonal streamflow skill varies with season, region and lead time (Arnal et al., 2018), so these limits have to be separated from the deficiencies of the downscaling. Training on all 25 members, as done for Ethiopia, improved the results considerably and gives a practical basis for the Danube.

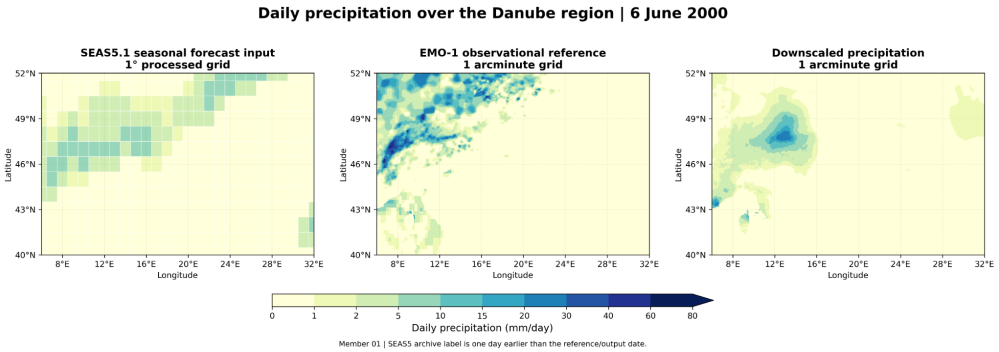


Figure 3. Danube-region daily precipitation, 6 June 2000, member 01: SEAS5.1 (1°), EMO-1 (1 arcminute) and the existing European downscaling. Differences in rainfall location and extent motivate the revision.

For this reason, the precipitation downscaling over the Danube catchment must be redone, and the LISFLOOD ensemble simulations rerun with the revised input. This is not a repetition of finished work. A downscaling-to-flood chain can only be published in international peer-reviewed journals if the revised precipitation is independently verified and the discharge simulations are based on it, and these results are the core of the publications planned for 2027. The revised downscaling is scheduled for the end of 2026. In 2027 the project will verify it against observations and run about 8,400 LISFLOOD simulations (25 and 51 members, a 33-year reforecast/forecast period, lead times up to 7 months, including 1,000 calibration and test runs, initialised with long-term warm-start runs), and deliver probabilistic flood products to the DSDS. LISFLOOD closes the chain from climate forcing to river discharge and flood hazard, which is the information impact-based warnings require. MedEWSa builds on DAKI-FWS (bb1245) and CLINT (bb1318), and its downscaled forecasts, hazard indices and flood products would then provide inputs to the work of Horizon Europe project ARTEmis (GA 101225852).

References

Arnal, L. et al., 2018: Skilful seasonal forecasts of streamflow over Europe? Hydrol. Earth Syst. Sci., 22, 2057–2072, doi:10.5194/hess-22-2057-2018.

Corrado, S. et al., 2026: A comparative assessment of drought, heatwave and compound event indicators for multi-hazard early warning. MedCLIVAR2026, https://medclivar2026.eu/

Díaz Esteban, Y. et al., 2024: Statistical downscaling of seasonal forecast temperature using a climate-informed AI approach. EGU24-19311, doi:10.5194/egusphere-egu24-19311.

Gazzotti, P. et al., 2026: Assessing seasonal hydrological forecasts with LISFLOOD in the Danube basin: sensitivity to forcings downscaling for the Slovak twin region. MedCLIVAR2026, https://medclivar2026.eu/

Iakovidis, I. et al., 2026: High-resolution seasonal forecast of compound extreme events in Cyprus using AI-based downscaling and hazard indicators. MedCLIVAR2026, https://medclivar2026.eu/

Johnson, S. J. et al., 2019: SEAS5: the new ECMWF seasonal forecast system. Geosci. Model Dev., 12, 1087–1117, doi:10.5194/gmd-12-1087-2019.

Lin, Q. et al., 2024: A CNN-based downscaling method of C3S seasonal forecast: temperature and precipitation. EGU24-12988, doi:10.5194/egusphere-egu24-12988.

Woo, S. et al., 2018: CBAM: Convolutional Block Attention Module. arXiv:1807.06521.