Project: **1245**

Project title: **Weather and climate modules of the AI-based early warning system DAKI-FWS**

Principal investigator: **Elena Xoplaki**

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1. Brief overview of the project results acquired until now

The project DAKI-FWS (Data and AI-supported Early Warning System to stabilize the German Economy), funded by the Federal Ministry of Economic Affairs and Climate Action (Germany), develops an innovative early warning system with a seasonal time horizon to protect and support lives, jobs, land and infrastructure.

The first phase of the project has been focused on collecting the large datasets, the preparation of algorithms and models, training and testing, and the preparation of LISFLOOD.

The first at least 5 months of the project, ***Levante was not available*** at all and after that with several interruptions and problems that prevented a stable work progress of the data collection and models preparation. Therefore, the node hours usage in Levante until now has been either affected by expired node hours that were impossible to be used anyway due to the unavailability of the system or could not be fully taken advantage of due to the nature of the work that had to be undertaken and due to the long delays has not proceeded as it could and should.

2. Bias-correction & downscaling of the seasonal forecast models

The study of extreme events, their characteristics and evolution, requires bias correction of the model output and downscaling to appropriate spatial scales. In this project, we combine the two methodologies in a holistic approach and have designed and implemented high-skilled, innovative time and space-dependent bias correction and high resolution downscaling artificial intelligence approaches, such as deep learning and reinforcement learning techniques. The work has been based on pairs of predictors and predictands with the large scale atmospheric circulation elements, the seasonal forecast fields and the high resolution observational grids, respectively. Examples of precipitation downscaling and bias correction with some of the developed AI-based systems and the ECMWF SEAS5 system are depicted in Figure 1. The first results of the bias-correction/downscaling approaches have been presented at the European Meteorological Society Annual Meeting 2022 (Heidari et al., 2022; Lin et al., 2022).

The work is continuing with the remaining of the other seven models increasing the input data and the training pool.

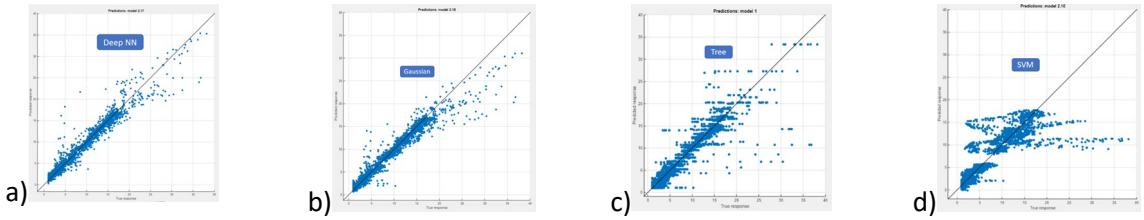

Figure 1. Comparison of downscaled and bias corrected precipitation data using: a) deep neural network, b) Gaussian mixture model, c) random tree, d) support vector machine

3. Hydrological modelling

The LISFLOOD model of the EC's Joint Research Centre (JRC) is prepared for Germany. The model and associated tools have been installed to Levante and the calibration and validation processes for initial river basins are running. These procedures are conducted on the basis of the static maps and the meteorological forcing provided by the European Flood Awareness System (EFAS), and streamflow from the hydrological service of Germany and the neighboring countries, prior to the generation of the streamflow simulations for the seasonal forecast (Figure 2).

For the calibration process, a settings file is implemented containing in total of 14 parameters. In the pre-calibration phase, calibration and validation periods of analysis are calculated based on the available streamflow and meteorological data. Subsequently, the station and catchment list is updated and the corresponding maps are generated with the locations of the gauging stations, and the interstation regions. Since the computational workload would be too large, parallelization concepts are used. For the calibration process, a map with the calibrated parameter values is created for each parameter and assigned to the corresponding regions.

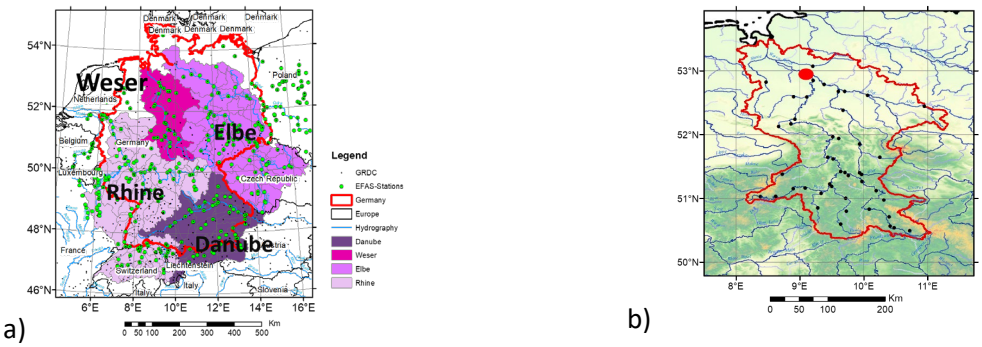

Figure 2. a) Major catchments of study. b) Testing area: Weser Catchment at Intschede hydrological station (area = 37720 km^2).

Current work continues with the collection of the meteorological forcing data from EFAS, HYRAS, and TRY-Project, and the static maps for the major catchments in Germany. As a first test has been used the Weser catchment as seen in Figure 3.

Further we are now pre-processing (checking for anomalous and suspicious data) the meteorological inputs, and computing the potential evaporation and evapotranspiration terms/fields. The implementation of the LISFLOOD-calibration tool is on-going as well as the upgrade of the source code to the newest state.

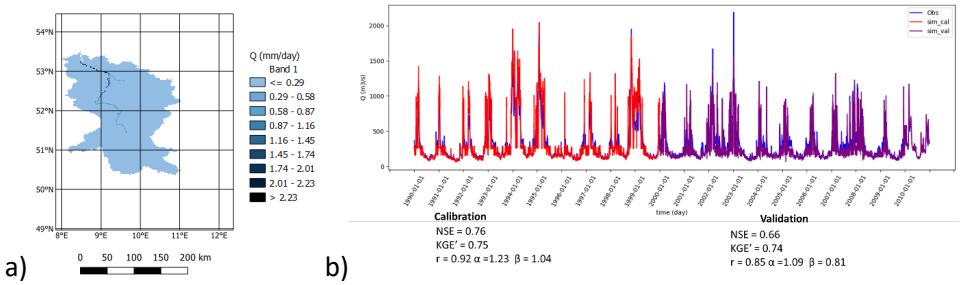

Figure 3. LISFLOOD outputs: a) Surface streamflow over Waser catchment. b) Streamflow at Intschede station (Preliminary results).

The research work has also focused in parallel on the performance of Long Short-Term Memory (LSTM) Networks for rainfall-runoff modelling in large catchments. The first results of this work have been presented to the European Meteorological Society Annual Meeting 2022 (Espitia et al., 2022).

4. Summary and outlook

In summary, we downloaded and continue downloading the seasonal forecast models ensembles, the observational data. We have developed, tested the AI-algorithms for bias-correction and downscaling and assessed their performance. We have installed the LISFLOOD hydrological model and commenced with the preparation for Germany with various river catchments, we calibrate and validate the model for the catchments. This project continues with:

- The bias-correction and downscaling for all eight seasonal forecast models and variables.
- Detection of extreme events, heatwaves, wind storms, droughts based on AI approaches.
- Further preparation of the LISFLOOD model for the remaining river catchments in Germany. AI-enhancement of the forecast tool.