Summary

The number and intensity of severe weather events is increasing, leading to loss of goods, property, and human lives. Improved weather forecasting, especially for severe weather events expected less than 6 hours in the future, also known as *nowcasting*, is expected to help mitigate the outcome of such events. The WeaMyL project aims to improve nowcasting accuracy through deep learning methods and Big Data approaches able to manage the large volume of meteorological data that is constantly being produced. National Meteorological Institutes are the project's direct beneficiaries, while the public at large is the most important, indirect beneficiary. Both Romanian and Norwegian populations will benefit by having more time to prepare and, with a reduced risk of false alarms, more confidence in meteorological alerts.

The project team includes researchers from the Babeș-Bolyai University (BBU), who contribute their expertise in machine learning (ML). Meteorology experts from the Romanian National Meteorological Administration (NMA) provide the data and interpretation for Romania, while their colleagues at the Norwegian Meteorological Institute (MET) do the same for Norway. The Norwegian team includes software development specialists (MET-IT subteam) who are responsible for the development of the WeaMyL platform front-end, the integration layer between weather data and the software platform, as well as integration with national warning systems. The MET team also includes a team of meteorology operatives (MET-MT) who will extensively test and evaluate WeaMyL.

After three years of sustained work, by the end of the WeaMyL project, consistent scientific progress has been achieved. The WeaMyL system, which has been deployed to both meteorological partners, benefits from enhanced machine learning models that are able to predict radar values 60-120 minutes in the future, an annotated Atlas providing intelligent information retrieval, a forecasting platform that produces forecasts, offering the meteorological products to be consumed by the other components in the WeaMyL system for visualization, analyses, and nowcasting, all these being integrated with the national warning systems in Romania and Norway. Last, but not least, awareness has been properly raised in the community with respect to both the importance of the problem at hand and to the challenging interdisciplinary aspects of the employment of machine learning approaches towards solving problems such as meteorological nowcasting.

Scientific and Technical Achievements

The main objectives set for 2023 were completely fulfilled. According to the project plan, the main technical objectives of the fourth project phase (Phase 4, 2023) – entitled Meteorological evaluation, interpretation, and analysis– were: (O1) Extract, annotate and validate meteorological data to be used for training from NMA and MET databases. (O2) Define conceptual methods for filtering relevant data (O3) Test the Atlas and the Forecasting Platform within the operational environment and (O4) Evaluate and offer feedback on the WeaMyL platform to continuously improve the embedded deep learning-based nowcasting model. These objectives were fulfilled by the final WeaMyL prototype, which consists of the following high-level components: *Machine learning-based Forecasting Platform*, *Annotated Atlas of Meteorological Observations* and *Integration Module* which integrates the previous components with the software systems already deployed at MET Norway and NMA Romania.

In the following we describe the work that was achieved by project partners for fulfilling the scientific and technical objectives during 2023.

The **activities carried out by the BBU team** are summarized as follows. The deep learning regression models integrated in the forecasting platform (trained on both radar and satellite data) were continuously improved based on feedback provided by NMA and MET meteorologists. The BBU team coordinated the development of the methodology for validating the ML models. The experimental evaluation of the ML models, comparisons, and statistical analyses of the obtained results were carried out for selecting the most performant supervised learning models embedded in the final prototype of the forecasting platform. The feedback received from the meteorological partners regarding the performance of the nowcasting models was used for deciding the most appropriate performance metrics for evaluating the models' accuracy. BBU assisted MET-IT with software development activities. The team offered support to MET-IT in integrating the deep learning module into the final prototype of the Forecasting Platform. In addition, team members contributed to integrating historical and real-time data obtained from the meteorological partners into the deep learning module of the Forecasting Platform. The BBU team members continuously improved the computational models developed for nowcasting, according to the feedback received from the operational meteorologists from NMA and MET-MT regarding the performance of the forecasting platform.

The **NMA team's activities for 2023** can be summarized as follows. NMA team members provided meteorological insight concerning the data used and the results of the experiments conducted by BBU and evaluated the performance of the implemented ML techniques based on nowcasting quality criteria. The NMA team assisted MET in the process of integrating the Forecasting Platform with national warning systems, by providing specifications about the communication protocols employed in Romania, to set up efficient data transfer and integration. NMA team members continued an activity started in 2022 by extracting, annotating, and validating radar data from the NMA's database. The meteorological data sets were used by the BBU team for training the forecasting platform's ML models. NMA's operational meteorologists analysed the functionalities of the Annotated Atlas of Meteorological Observations, the integration with existing software and hardware infrastructure, as well as the quality and performance of the Atlas. During this activity, MET-IT provided technical support and monitoring for NMA's operational meteorologists. The NMA team members also analysed the performance of the Forecasting Platform with that of established techniques with respect to quality thresholds related to spatial, temporal, and quantitative accuracy. The work was carried out in an operational environment using real time data. Technical support was provided by MET-IT, who used the feedback for development of the final prototype. NMA team members participated in the activity regarding post-project exploitation, an activity coordinated by MET.

The work carried out by the MET teams (MT and IT subteams) is summarized in the following. MET-MT provided meteorological insight concerning the data used and the results of the experiments conducted by BBU and evaluated the performance of the implemented ML techniques based on nowcasting quality criteria. MET-IT continued the development and testing of the Forecasting Platform front-end. The ML components developed by BBU were continuously integrated into the platform. The activity led to the first functional prototype of the forecasting platform. The improved ML model embedded in the final prototype of the Forecasting Platform incorporated feedback received during the platform piloting. The Data Acquisition component was improved according to feedback received from the meteorological teams and integrated the meteorological data sets required to build the initial and final prototypes of the Annotated Atlas semantic data bank. The final Atlas prototype was tested by NMA and MET meteorologists in an operational environment. The MET-MT team members analysed the performance of

the annotations, the search and filter functionalities and their relevance for data retrieval and nowcasting. MET team members were involved in deploying the final prototype of the Forecasting Platform. The total length of the deployment was 12 months, thus allowing the pilot to encompass an entire calendar year, providing the research team valuable data regarding the platform's behaviour in various weather conditions, both during the summer and winter. MET also coordinated the activity regarding the project exploitation. Post-project prototype exploitation will be unrolled at both NMA and MET and the pilot is planned to be used for an undetermined period of time.

Dissemination

As the project promoter, BBU was in charge of administrative, scientific and technical project coordination. This involved coordinating the communication and collaboration between partners, identifying and monitoring risks and taking corrective measures when required. The project promoter coordinated work on deliverables and relevant artefacts to ensure the project progressed in accordance with time and budgetary constraints towards meeting its defined objectives. All consortium partners worked on disseminating the results to relevant authorities and scientific organizations. In this regard, they contributed in publishing the results of the technical and scientific activities in high-quality open access journals and conference proceedings. These efforts materialized in the publication of **4** peer-reviewed scientific papers and **1** other publication in a software magazine **2** are Web of Science (WoS) indexed journals (one situated in **Q1** and one in **Q2**) and **2** are WoS indexed conferences, published in a Scopus indexed journal. Among them, one is a joint publication between all three project partners.

One of the most important dissemination activities during 2023 was the second edition of the **WeADL workshop** organized on June 9, 2023. Its main goal was to raise awareness in the scientific community regarding the challenges of deep learning, machine learning or broadly artificial intelligence-based scientific research in highly interdisciplinary domains. Emphasis was placed on the purposes of the current project - employing deep learning techniques for improving meteorological nowcasting based on historical satellite, radar and other meteorological products. The event took place over Zoom, with the programme and talks recorded and made available on the website. The event had more than 40 registrations, among which 20 participated actively in the online event. Participants included fellow researchers in the field, PhD, and Master students, as well as scientists from the project partners.

The project partners have worked towards making their research known within the scientific community and added original content to the project **website**. The website illustrates the system's operation using short, descriptive videos and it represents a key vehicle for dissemination. Social media was used to engage the scientific community, various stakeholders, and the public at large. The results obtained within the WeaMyL project were also disseminated to the public at large in a public event, **Artificial Intelligence 4.0 @UBB, Cluj-Napoca**, an on-site conference held by UBB, attended by over 200 guests, event in which our team members Iuliana Bocicor (UBB) and Eugen Mihulet (ANM) presented the WeaMyL project outcomes. Other important activities for project dissemination include events for the popularisation of science, to which the project members participated and articles and interviews provided by the project members for the audio-visual and print media.