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.

The main objectives set for 2022 were completely fulfilled. The third phase of the project (which extended during 2022) was marked by consistent scientific and technical progress. The WeaMyL system, which was deployed to MET Norway, benefits from enhanced deep learning models able to accurately predict radar product values up to 1 hour in the future and an Annotated Atlas providing intelligent information retrieval. The Forecasting Platform provides realtime and near real-time meteorological data for the embedded machine learning model, using this model to generate short term predictions for meteorological products of interest, both automatically and on demand.

Scientific and Technical Achievements

The third project phase took place during 2022 and was entitled ***Software development, testing and integration***. It continued the work carried out in 2021 and added the following new objectives: development and scientific validation of novel ML computational models and techniques specially tailored for accurate nowcasting; development and user evaluation of the Annotated Atlas of Meteorological Observations - a large database containing meteorological data; development of the open-source WeaMyL platform for early forecast of severe weather phenomena. All planned activities were carried out and completed successfully within existing time and budgetary constraints.

In the following we describe the work that was achieved by project partners for fulfilling the scientific and technical objectives during 2022.

The **activities carried out by the BBU team** are summarized as follows. During 2022 team members continued the previous work on modeling the nowcasting problem as a supervised learning task and improving the performance of the Xception Deep Learning architecture proposed for nowcasting. The next step was to establish a scientific methodology for validating the ML models and further

experimentally evaluating these models. Numerous comparisons and statistical analyses of the obtained results were carried through for selecting the most performant supervised learning models to be embedded in the initial/advanced 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. The BBU team offered support to the MET-IT team in integrating the deep learning module into the initial and advanced prototypes of the forecasting platform. In addition, BBU team members contributed to integrating historical and real-time data obtained from the meteorological partners into the Xception deep learning module of the forecasting platform. They also continuously incorporated new data annotated by meteorologists in the online learning component of the forecasting module. The team members continuously improved the computational models 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 2022 can be summarized as follows**. First, the team 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. Team members supported the development of the Annotated Atlas of Meteorological Observations and provided continuous assistance to MET-IT regarding the integration of relevant meteorological data into the data bank. They also 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 continued their work with regard to extracting, annotating, and validating radar data from their database and provided these data to 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. NMA team members have also analysed the performance of the Forecasting Platform using 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 will use the received feedback for final prototype development.

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. The MET-IT team continued the development of the Annotated Atlas of Meteorological Observations (work started in April 2021 and finalised with the initial prototype of the Atlas in spring 2022). In parallel, MET-IT continued the incremental development in prototype versions (initial - started in 2021, advanced, and final) and testing of the Forecasting Platform, continuously integrating the ML components developed by the BBU team. The advanced prototype of the forecasting platform was ready by August 2022 and piloting started at MET in September 2022. The MET team also coordinates the integration of the final prototype of the forecasting platform within the Romanian and Norwegian national warning systems. The MET-IT subteam members improved the Data acquisition component according to the 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 Pilot deployment of the Annotated Atlas of Meteorological Observations started in March 2022, after the initial prototype was finalised in February 2022. During the next phase, in 2023, the two Atlas prototypes (initial and final) will be tested by NMA and MET meteorologists in an operational environment. The MET-MT team members will analyse the performance of the annotations, the search

and filter functionalities and their relevance for data retrieval and nowcasting. MET-IT is responsible with coordinating the deployment of the advanced and final prototypes of the forecasting platform, an activity which started in September 2022 and which involves all project partners. The total length of the deployment is 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.

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 3 scientific papers, 2 of which in Web of Science indexed journals and 1 in Web of Science conference, 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 2022 was the second edition of the **WeADL workshop** organized on June 3, 2022. 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 50 registrations, among which 30 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.

Other important activities for project dissemination include:

- events for the popularisation of science, to which the project members participated;
- articles and interviews provided by the project members for the audio-visual and print media;
- Andrei Mihai's (BBU team member) presentation, entitled "An innovative machine learning model for short term weather prediction based on radar data", at the ITDays 2022 event in Cluj-Napoca. The presentation aimed to raise awareness on the challenges of deep learning-based weather nowcasting with emphasis on the project's scientific achievements.