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Conference Report

Conference Report: Fourth European Nowcasting Conference

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Abstract
The fourth European Nowcasting Conference took place as an online event from 21 to 24 March 2022, organized by the EUMETNET (European National Meteorological and Hydrological Services Network) Nowcasting Program (E-NWC), and kindly supported by EUMETCAL (EUMETNET Education and Training Collaborative Network of the National Meteorological Services within Europe). More than 110 participants attended the conference. 46 conference's presentations were given within the 0) opening session, a session on 1) observation as a basis for nowcasting, 2) seamless prediction with a special focus on Artificial Intelligence (AI), 3) nowcasting systems, products, and techniques and 4) verification, impacts on society, as well as applications and aspects of users. This report summarizes the scientific contributions presented and the discussed scientific questions.

Keywords: nowcasting, seamless prediction, observations, ensemble, machine learning, user requirements

1 Introduction

A European wide cooperation on nowcasting within EUMETNET exists since 2013, with the aim of exchanging information about nowcasting systems, observations, verification and applications. In the beginning, the focus was predominantly on the nowcasting range (lead times from 0 to +2 hours), which was extended to very short range forecasts (lead times from 0 to +6 hours), and finally to seamless prediction (lead times from minutes up to a few days ahead). The latter integrates several elements including observation-based nowcasting and numerical weather prediction (NWP) to provide smooth forecasts which are presented in a consistent way. Nowcasts are especially important for high-impact events and should compensate for NWP deficiencies.

Since 2014, a conference dedicated to nowcasting is organized under the umbrella of the E-NWC Program every two to three years. The goal of the conference is to promote recent advances in the theory and practice of nowcasting in Europe and other parts of the world. It welcomes participants from operational as well as research centres and forecast users to discuss methods for improving the quality of nowcasting in Europe.

The first European Nowcasting Conference (ENC) was held in Vienna, Austria, in 2014 (http://www.zamg.ac.at/ENC2014/). The results of the second ENC, which was held in Offenbach, Germany, in 2017, are summarized in Wapler et al. (2017), see also https://www.dwd.de/EN/specialusers/research_education/seminar/2017/enc/enc_en.html. The third ENC took place in Madrid, Spain, in 2019 (see http://eumetnet.eu/european-nowcasting-conference-enc-2019/, and Schmid et al., 2019).

The fourth ENC was held as an online event in March 2022. In total, more than 110 participants connected to the different sessions of the conference, representing mostly National Meteorological and Hydrological Services (NMHS) and universities/research institutes. The detailed program of the conference, all abstracts, and PDFs of most of the presentations are available online at the following webpage: https://eumetcal.eu/en/ui#/page/ENC2022%20. Within the opening session, EUMETNET's role, functioning and ongoing projects were presented, highlighting the role of the E-NWC Program (Kraai). The impact on lives of the absence of adverse early weather warning systems was underlined, and the importance of nowcas-

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ting products obtained by satellites in Africa was highlighted (de Coning). The hierarchy of elements within the landscape of Artificial Intelligence (AI) applications was described by Bartholomew: i) AI is a technique that allows machines to mimic human behaviour, ii) machine learning (ML) is a subset of AI that uses statistical methods to enable machines to improve with experience, and iii) deep learning (DL) is a subset of ML that enables the calculus of multi-layered neural networks (NN). The use of these methods in different processes of nowcasting was highlighted, since they allow the combination of data from different sources, being able to capture non-linear patterns. The aforementioned advantages in developing a DL method to nowcast electrical storm activity was presented by Leinonen et al.

ENC2022 showed again (similar to previous ENCs) that similar systems are being developed in parallel at different research institutes or NMHS. Modelling consortia, such as those for NWP, do not exist yet for nowcasting. Such cooperation is difficult due to different national observation systems and their specific characteristics as well as the user focused nature of nowcasting. In this heterogeneous and interdisciplinary setting, it is important that E-NWC continues to support the cooperation between nowcasting researchers and practitioners among NMHS, and to provide a platform such as ENC for exchanging information and know how on a regular basis.

2 Observations as basis for nowcasting

2.1 Presentation summary

Nowcasting is closely related to observations, and especially to remote sensing data. Regarding radar-based observations, the extra information obtained from the phase and shape of precipitation by the Doppler-effect was shown in radar scans towards the zenith (Gergely et al.). Another study showed the results on mini supercells with high-resolution phased-array X-band radars (Dai et al.). The analysis of the characteristics of storms causing tornadoes F2 (on Fujita scale) or higher was studied with a combination of radar reflectivity, radar radial wind, lightning information and report data (Wapler). The potential for automatically detecting the presence of rain showers and storms was analysed based on radar data together with lightning and NWP data (Feger).

Information derived from satellites plays a crucial role in nowcasting too. In this regard, the following was shown: the usefulness of the 0.9-micron channel to describe atmospheric humidity and radiation that will be measured from the FCI (Flexible Combined Imager) instrument of the MTG (Meteosat Third Generation) (Groenemeijer et al.), and the difficulties in the assimilation in LAPS (Local Analysis and Prediction System) of wind data measured from a Doppler Laser in the Aeolus satellite (Katsafados). There were some improvements in prediction after the assimilation of extra observations into NWP models, such as wind and temperature measured in wind turbines in Austria (Meier et al.), or so-called crowd-sourced data gathered through the Met Office's Weather Observations Website (WOW) network with ensemble-like assimilation (Pavelin et al.).

The visualization of observations plays an important role in a correct diagnosis. A system was presented to provide operational data from the Nowcasting Satellite Application Facility (NWCSAF) and other sources that, after formatting, disseminate them through the ADAGUC system (Lliso et al.) – a geographical information system dedicated to visualize meteorological, climatological and atmospheric datasets via web services.

2.2 Discussion summary

Within the discussion session, NMHS mentioned that several experiments are undertaken with similar feedback to crowd-sourced data (cars' sensor data, meteorological data from citizens using smartphone data, citizen campaigns based on mainly Twitter and Instagram but not in real time): The main issue is the poor quality of the data. Thus, data are so far mainly used in experiments and/or for validation of individual cases but not operationally yet. Quality control (QC) of crowd-sourced data is a big issue (e.g. auto control mechanism for every observation coming in; filter to compare). In general, the quality of such observations is not yet determined, however it is assumed that it might be quite reliable for several events (although sometimes it is exaggerated with the size of hail, for example); false observations are in some situations relatively easy to filter which is quite useful. In other cases, there might be problems in QC for representativeness issues (on some occasions, significant differences arise within a few kilometres). A consistency check of neighbouring observations is planned, therefore, a high density of data is needed, which is not large enough at the moment. In addition, observations for other countries would be useful. The Met Office is involved in a project using Twitter and impact reports with promising results, however, mainly for post-event analyses. Moreover, the European Severe Weather (ESW) database is a crowd-sourced database that is used e.g. for extreme events validation, and which is easily accessible.

3 Seamless prediction

Several European NMHS have developed so-called seamless forecasting systems by combining extrapolations from observation fields (which start from observations and have good skill in the first one or two hours) to predictions of an NWP model (which start from model analysis and have good skill from several hours onwards). These systems will be probabilistic in the near future as uncertainty is present in the models.

3.1 Presentation summary

For the combination of observation-based nowcasts with the predictions of NWP models, different techniques were presented using AI: e.g., NN, for the prediction of storms (Kann et al.); or DL, for the prediction of lightning (Zhou et al.). One of the modules of the SINFONY (Seamless Integrated Forecasting System) project of Deutscher Wetterdienst (DWD) combines object-based probabilistic nowcasting and NWP ensemble: the convective cell detection and tracking algorithm KONRAD3D is applied on observed as well as simulated radar reflectivity (Ulbrich et al.).

An example of a probabilistic seamless system is a product that combines the extrapolation of the radar field using pySTEPS with a time-lagged ensemble of an NWP model (Casellas et al.). To add a pseudo-probabilistic information to the PIAF system (a deterministic tool of Météo-France that blends the radar field with the precipitation of the NWP model), spatial perturbations were applied on a time-lagged ensemble (Warnan et al.).

3.2 Discussion summary

Within the discussion part of the seamless session, the importance that the model output looks realistic was pointed out, and that forecasters know how to use probabilistic information (ensemble forecast). It is crucial to evaluate seamless prediction models on a long period to make sure they behave well on average, as well as with a special focus on high impact events to make sure they predict well when it matters most. Many verification scores encourage “smoothing” behaviour. The first version of PIAF (Météo-France) lead to weights often around 0.5. Nowadays, the weight changes fast from 0 to 1 leading to more realistic looking output.

On open question during discussion was whether seamless results need to look meteorologically realistic, or whether it is more important that the results are statistically sound, e.g.: spatio-temporal correlation, intensity, duration. One major challenge is the interpretation of weather measurements which is not always possible in a deterministic way. Forecasters and developers have to communicate the uncertainty and probability of events. Work is done on an easy, fast and comprehensive visualisation of ensemble forecasts to improve users' understanding of them, which is very challenging. Forecasters have limited time to issue warnings thus the manner in which data are presented to the forecasters/users is a critical component. Examples of good and bad practices can be useful in training forecasters to know when they can (still) add value.

Linking the developed tools to impacts is also important as more and more forecasters have to communicate what the impacts of a severe weather event are.

4 Nowcasting techniques, systems, and products with focus on AI

4.1 Presentation summary

Improvements were presented in some already operational systems, e.g. Integrated Nowcasting through Comprehensive Analysis (INCA with annex CH for Switzerland, Buzzi et al.) predicting several surface variables in a seamless way, and in the NowPrecip system which is a seamless system with focus on precipitation, with stochastic noise that gives it a probabilistic character (Sideris et al.), and in the Hungarian seamless system named MEANDER for precipitation (Horváth et al.). Improvements were also presented for some of the convective-objects-oriented systems, such as the German KONRAD3D, which is based on 3D radar data and was extended to include lighting data, with warnings of a sudden increase, Lightning Jump (LJ), and a polarimetric radar based hydrometeor classification (Josepovic et al.), and a review of the adaptive scheme of detection of cells in radar, commenting on the progress in the probabilistic version (Werner et al.). Also oriented to objects, but detected from satellite images, a method based on the infrared IR10.8 and water vapour WV6.2 channels, and NWP model data (Barbosa et al.) was presented.

To improve the performance of the Lagrangian based approach of nowcasting, statistical studies are necessary to obtain conceptual models of the life cycle of precipitating systems. From a study of the characteristics of storms in the TITAN system (Thunderstorm Identification Tracking Analysis and Nowcasting), storm life cycle curves were obtained to improve the forecast (Viteri et al.); and from the analysis of the results of A-TNT (Austrian Thunderstorm Nowcasting Tool), the usefulness of vertically integrated ice according to radar and LJ as precursors of lightning and hail, respectively, was analysed (Meyer et al.).

Similar to the session on seamless systems, several AI models were presented as part of the nowcasting techniques and systems: ML applied to the analysis of stationary convective cells to predict their life cycles (Berndt et al.); NN applied to radar field extrapolation for precipitation nowcasting (Choma et al.); comparisons between NN and radar field extrapolations based on optical flow (Quintero). AI techniques have also been used to post-process the output of NWP models, e.g. using ML methods for radiation nowcasting for photovoltaic plants (Papazek et al.), and using NN for wind nowcasting (Schicker et al.).

Concerning automatic severe weather warnings a system based on LJ and extrapolations of the centroids of convective cells (Rigo et al.) was presented; as well as a data assimilation method for an NWP model, including radar data and radar field extrapolation techniques (Gelpi et al.).

From the NWCSAF of EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites), the latest update of the software package was presented. It extends the coverage of a large part of its products to the entire globe, furthermore, improvements of the products are underway (García-Pereda et al.). In addition, the NWCSAF team presented a method based on ML using proxy data from the IASI-MetOP (Infrared Atmospheric Sounding Interferometer for operational and scientific applications) for the retrieval of data from the future infrared sounding interferometer that will be embarked on the MTG-Sounding mission satellite – MTG-S (Peinado-Galán et al.).

4.2 Discussion summary

A broad overview was presented within this session on nowcasting systems and methods, cell tracking and modern techniques using AI components. AI is complementing the traditional approaches. ML is used in many research fields, which makes it attractive. One possible approach could also be the use of ML as an enhancement to techniques such as Optical Flow, not as replacement. However, extremes are often difficult to capture with ML (they have to be in the training data). Further sources of limitation are due to false analogues and unphysical evolution of features. ML should not be used blindly. Nowcasting in tropical latitudes is seeing more success with optical flow than with ML. The poor performance of ML in some examples might also be due to the complex orography, but this could potentially be addressed by including orographic data into the ML input and allowing for non-locality.

ML approaches are inherently probabilistic, but current ML attempts are often tuned to produce deterministic results, so possibly ML should be trained with loss functions that avoid the double-penalty function. As noted earlier, forecasts of precipitation extremes are critical for nowcasting because of the high impacts they cause. There are probabilistic loss functions aiming at predicting extremes and the behaviour of the distribution tail. A recent technique divided precipitation fields into a histogram (several bins of data) which were then used to train the ML – and reached better results for threshold exceedance. The actual model remains a black box. To assess, understand and communicate uncertainties, which may be case-dependent (if the highest impact events reside in the extreme ends of the distributions, where training data is typically sparse), forecasters would need good understanding of the behaviour of the ML near the limits. In general, forecasting with confidence requires a large amount of hands-on experience with the different data products, which may not be available since high-impact weather is somewhat rare.

Within the discussion, some specialized examples of Generative Adversarial Network (GAN) approaches were mentioned. Generally speaking, an open-source GAN approach that is easy to adapt would certainly be useful for the community (just compare the situation to pySTEPS – open source program – or rainymotion). However, it would take time to improve forecast capabilities and uncertainties, when applying the novel tools like GAN.

5 Verification and application

Verifying user products is very important. The use of just Mean Absolute Error (MAE) and Mean Squared Error (MSE) are not useful to most users. Local vulnerability is also important. Forecasting and verifying localised weather phenomena is challenging. While a shift of an event by only 1 km may mean that only trees are impacted, instead of inhabited property, it could be argued that a forecast with a dislocation of 1 km is still a good forecast. It might be challenging to communicate the value of the product to the user.

5.1 Presentation summary

To improve forecast and warning of severe convective events, the NMHS of the Czech Republic installed the so-called Convective Group, composed of ten experts who support forecasters in convective situations (Valachová et al.).

Two WMO projects (World Meteorological Organization) were shown at the conference: the SEE-MHEWS project (South-East European Multi-Hazard Early Warning Advisory System), for the forecast of precipitation in basins of Bosnia and Herzegovina with the system INCA (Bica et al.); and the HIGHWAY project (High Impact Weather Lake System), for the issuance of nowcasting and severe weather warnings in Lake Victoria (Roberts et al.). HIGHWAY included the deployment of observation networks, storm analysis, training of local staff, with a significant reduction in the number of drownings in the lake (Roberts et al.).

Moreover, the results of four surveys were presented: one among NMHS in South America on access to radar, satellite and lightning data as well as nowcasting techniques and warnings, and more (Stoll et al.); another among EUMETNET members and their users on probabilistic predictions and warnings (Agersten et al.); and two others among the participants of the conference, on training needs in nowcasting topics (Bañón et al.) as well as verification and evaluation practices (Wapler et al.). The latter survey showed that often some verification results are provided to forecasters along with the implementation of nowcasting techniques but often not on a regular basis. Also, evaluation of products by the forecasters and the discussion with developers is typically not done in a structured way but rather individually. More exchange should be supported.

5.2 Discussion summary

Different verification metrics can give different results and someone should not cherry-pick just one or two. The choice of a suitable verification method should reflect the purpose of a nowcast product in a way the verification results can best support the user in understanding, interpreting and using the product. The link from verification to system tuning is not often seen in presentations.

The question was asked why verification is an issue with nowcasting systems. And if methods developed for NWP verification can also be applied for nowcasting. One answer was that "Nowcasting is supposed to answer the questions that NWP cannot." It is often asked for in high impact weather events, for which suitable observations are incomplete. Furthermore, nowcasting methods are directly linked with applications and more difficult to verify.

6 Summary

Complementing the exchange of nowcasting experts with more participants from the user community would be of high interest. The WMO Weather & Society platform (https://www.weatherandsociety.de/) is open for different application areas, probably another group can be reached through this platform. One aim of upcoming ENC is to try to foster the communication with the application side.

It is important to identify where best to add value in the chain: better observation / better model / better communication with limited resources. Moreover, the importance of providing impact information along with meteorological forecast and warning is a current topic in NMHS. A more collaborative decision-making procedure might be one future approach (with increased stakeholder communication: e.g. external and internal stakeholders, as undertaken at KNMI – Royal Netherlands Meteorological Institute). The issued warning level could then be dependent on impact assessment.

Another important trend in recent years is the potential of crowd-sourced data in nowcasting, from a pure experimental or research setting to an important extra source of input data in operational nowcasting schemes.

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