ENC 2019 European Nowcasting Conference

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# Book of Abstract

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## Table of contents

**Advancing the science of nowcasting and mesoscale numerical weather prediction at National Meteorological and Hydrological Services world-wide**

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The role of the WMO World Weather Research Program (WWRP) Nowcasting and Mesoscale Research Working Group (NMRWG) is to advance the science of nowcasting and mesoscale numerical weather prediction modeling. The NMRWG supports the assessment and advancement of new and emerging instrumentation and technologies for nowcasting and mesoscale forecasting, with particular emphasis on the use of high-resolution, very-short-range analysis and forecast models for accurate prediction of high impact weather in urban areas, Polar Regions and in developing countries. Additionally, the NMRWG promotes research and development projects (RDPs) and forecast demonstration projects (FDPs) for increase scientific understanding and predictability of local-scale weather processes and high impact weather. Over the years, the NMRWG has promoted several RDPs. Recent examples include the Aviation Research Demonstration Project (AvRDP) that conducts research in nowcasting and mesoscale modelling at a number of international airports and translates meteorological information into ATM impact products. The Beijing Study of Urban-impacts on Rainfall and Fog/haze (SURF) project collects high-resolution surface observations in the dense urban environment for assimilation into urban models. ICE-POP, an international winter program, was conducted to improve the prediction of winter weather during the 2018 Winter Olympic Games in S. Korea. The motivating factors underscoring any RDP is to use high-resolution observations to understand the evolving weather and to test and improve state-of-the-art nowcasting and NWP systems. Our talk will show examples of RDP programs and highlight some innovative new technologies that allows for the integration of observations with a suite of different NWP modelling approaches. These technologies are the Seamless probabilistic Analysis and Prediction in very HIgh Resolution (SAPHIR) running at ZAMG and SINFONY, a new seamless prediction system for very short-range convective-scale forecasting at DWD.

**The EUMETNET Nowcasting Project**

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For National Meteorological and Hydrological Services (NMHS) it is a key issue to provide consistent forecasting products from nowcasting to short range forecasting together with modern automatic warning tools. Sharing expertise, experiences and best practices of developing and implementing seamless prediction systems will enable NMHSs to develop and provide best possible products to their end users. Therefore, EUMETNET – the European cooperation of national meteorological services – has established a nowcasting cooperation programme that started in 2014. The core activities within this cooperation programme revolve around nowcasting systems, observations used in nowcasting, verification, training and end-user relation.
The focus of this EUMETNET cooperation has transitioned from pure nowcasting (0-6h lead time) to include very short range forecasting (VSRF) systems (up to 12h lead time). Beginning with the EUMETNET phase 2019-2023 it will focus on seamless prediction systems to provide a platform for exchanging know-how and expertise on the optimal combination of forecasting models on different temporal and spatial scales (nowcasting, VSRF, short- and medium range forecasting).
Besides giving a general introduction on the EUMETNET Nowcasting Programme, this contribution will highlight a few results from studies and surveys carried out in the previous phase. Furthermore, an outlook of activities related to the focus of the current phase, including seamless prediction systems, will be given.

## Observation as basis for Nowcasting

### Passenger car data as a new source of real-time weather information for nowcasting, forecasting and road safety

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The demand for higher spatial and temporal resolution of routine weather products is rising. Among key customers is the autonomous driving community, eager to assess environmental conditions for maximum driving safety and convenience. On the other hand, passenger cars collect large amounts of meteorological data such as temperature, precipitation, or visibility, making them suitable for crowdsourcing weather information.
DWD (German National Weather Service) and car manufacturer Audi AG team up in the FloWKar project to explore the potential mutual benefits of data exchange between millions of passenger cars and the weather service to improve nowcasting, forecasting, and driving safety information.
A concept for near real-time weather products focusing on road traffic is established at DWD, with contributions from nowcasting, weather models, and data from passenger cars.
The observations from passenger cars at high spatial and temporal resolution complement established surface observations at weather stations and road weather stations. Provided sufficient car sensor data quality, benefits are expected for the observation-based current weather state and for nowcasting near the ground, where quantitative precipitation estimates and hydrometeor classification based on radar remote sensing alone prove difficult.
Before integrating car passenger data into operational weather products, automated quality checks take place at the car manufacturer as well as at DWD. Campaigns are designed to gauge the car sensor data quality on a level from single sensors to moving cars on highways. Swift data exchange, respecting data protection laws, is the necessary basis for future near real-time weather products delivered back into the vehicles on time.
The presentation gives an overview of the ongoing activities at DWD and Audi AG to establish the system for near real-time weather in the boundary layer.
This work is supported by the mFUND initiative of the German Federal Ministry of Transport and Digital Infrastructure.

### Identification of the life cycle of a Bow echo associated with Tornado – A diagnostic study through Doppler Weather Radar

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The convective arc shaped echo is known as bow echo. Bow echoes are observed near the leading edge of severe thunderstorm outflows that are closely related to damaging winds at the ground and thus, signify great concern in the interest of forecasting of the weather. The aim of the present study is to observe the initiation and development of such a bow echo system associated with tornado occurred over Orissa (26° 00' N, 94° 20' E), India in the late afternoon of March 31, 2009 at about 260 km southwest of the station Kolkata (22.5oN, 88.5oE), India through the Doppler Weather Radar (DWR) located at Kolkata. An intense convective cell developed over Rajakanika block of Kendrapara (20° 30' N, 86° 28' E) district of Orissa causing loss of 15 human lives and left several injured apart from huge loss of properties. Tornado was accompanied with thunderstorm, hailstorm, rainfall and strong wind reaching 250 Km/h. The longevity of the system was near about 4 hours. The results of the present study provide a clear observational evidence that how the system rapidly developed into an intense cell bow echo associated with tornado along with water spout signature. From this study it can be stated that the installation of the DWR over the region has been able to enhance the capabilities to observe and forecast the meso-scale convective weather with high accuracy.

### EO-ALERT – Extreme Weather Scenario: Towards Convective Storm Nowcating Via On-Board Satellite Proccesing

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Fast data availability plays a crucial role in nowcasting applications, where the value of data decreases with time since the moment of acquisition. In Earth Observation (EO) systems, data gathered from a satellite platform is subject to space-to-ground transmission, hence, presenting a relatively large latency between the event and the on-ground observation. The EO-ALERT H2020 project (see, http://eo-alert-h2020.eu/) aims to close this latency gap by implementing processing capabilities on-board the satellite rather than increasing transmission rates, with the goal of producing EO image products on-board that can be quickly and reliably transferred to ground given their relatively low data volume. Two scenarios are considered within the EO-ALERT project: ship detection and a meteorological scenario focused on storm detection in support to nowcasting; the latter will be the focus of this paper.

To achieve on-board storm detection in support to nowcasting, a combination of novel processing techniques and nowcasting domain expertise are being used to develop a data-driven system capable of detecting, tracking and classifying early convective storms on-board the satellite. The objective is to process the acquired data from the satellite payload observation directly on-board the satellite and then send the processed information (the EO product) to ground within 5-minutes of the observation, with a goal to reach latencies down to 1-minute. The system is designed to work on satellites in any orbit (LEO, MEO or GEO), such as upcoming LEO constellations or Meteosat Third Generation GEO satellites, using the satellite payload (imager) as the main source of onboard data. In the project, the proof of concept is performed using existing geostationary EO satellites, in the Meteosat Second Generation satellite. The solution will be calibrated and validated using a specifically created dataset for the application, corresponding to extreme convective weather events occurred over 85 days, composed of MSG images and OPERA weather-radar network composites.
This paper will provide an overview of the overall system, focusing on the algorithmic approaches and the open lines of research. Further advances and the results of the system testing in a satellite avionics test bench, will be presented in future publications, taking into account the feedback received at the conference.

**Wind gusts registered in Zaragoza airport associated to supercellular convection on 1st July 2018 and its spatial variability**

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On Sunday, 1st July 2018, a very complex event of severe weather took place in Aragón Autonomous Community (NW of Spain). Different supercellular convective structures, as a result of splitting storms processes, caused considerable damages in a number of locations in Zaragoza province, being the Zaragoza Airport one of the most affected places by the severity of the thunderstorms.
The most intense wind gusts were recorded with values up to 157 km/h, in one of the aeronautic sensors, and 135 km/h in the synoptic station, which is associated with Zaragoza Airport main observatory. These gusts were among the most intense ever registered in this station. It must be outlined that in Zaragoza Airport several anemometers were available and located in different places along the 7 km length of the airport runaways. All of them worked properly during this event, in this way, data registered by these instruments were useful to characterize the magnitude, significance and the big spatial variability of the impacts associated to convective phenomena.

**Applications of the WMO Solid Precipitation Intercomparison Experiment (WMO-SPICE) results for nowcating activities**

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Undercatch of solid precipitation resulting from wind-induced updrafts at precipitation gauge orifices affects the accuracy of precipitation data recorded in observational networks. This has ramifications for National Weather Services, which issue snowfall warnings based on available real-time data to mitigate impacts on transport and infrastructure in inhabited areas. Automated precipitation gauges with different measurement principles, data processing methods, and shield configurations have been used to measure solid precipitation in national networks, with varying degrees of accuracy.
The World Meteorological Organization (WMO) Solid Precipitation Inter-Comparison Experiment (SPICE) involved extensive field intercomparisons of automated instruments for measuring snowfall. One outcome of SPICE was the development of transfer functions for the wind bias adjustment of snowfall measurements using various precipitation gauge and wind shield configurations. This work will demonstrate the utility of transfer functions for the adjustment of precipitation measurements for nowcasting activities in operational networks.
This work will also highlight a number of challenges for solid precipitation measurements that were identified and/or characterized in WMO-SPICE and must be considered for nowcasting activities. These challenges include: snow capping of gauge orifices, melting delays for snow measurements by heated tipping bucket gauges, noise filtering of data, and blowing snow.
New and emerging snowfall measurement methods based on non-catchment technologies such as disdrometers will be also be discussed. In addition, the advantages and limitations of instruments for the automated measurement of snow on the ground will be discussed within the context of nowcasting.

**The Meteosat Third Generation satellite mission and its future contribution to nowcasting**

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*EUMETSAT - European Organisation for the Exploitation of Meteorological Satellites*

In preparing for the upcoming Meteosat Third Generation (MTG) satellite series, first of which is planned for operations as of 2022, European NMHSs are adding a potentially powerful tool to their nowcasting capability: through a combination of innovative instruments, MTG will for the first time over Europe provide satellite-based atmospheric soundings of temperature and humidity every 30 minutes, derived wind information, continuous observation of lightning activity (cloud-to-cloud and cloud-to-ground) and spectral imagery at least every 10 minutes. All these data streams will be collocated and available at enhanced spatial resolution forming a "4-D weather cube", expected to provide new insights into convective processes, especially instability conditions and convective initiation.
The hyperspectral InfraRed Sounder (IRS) onboard MTG measures in the long-wave infrared (LWIR: 700-1210 cm-1) and mid-wave infrared (MWIR: 1600-2175 cm-1) bands with a spatial sampling distance of around 4 km, at Full Earth Disc and every 30 minutes over Europe. Generation of radiance datasets and sounding products (temperature and humidity profiles) builds on heritage provided by the current polar-orbiting IASI instrument. The Flexible Combined Imager (FCI) onboard MTG will provide continuity with respect to the existing Meteosat Second Generation satellites, data and products of which have been serving European NMHSs reliably since the early 2000s. FCI provides higher spatial and temporal resolution, and has new channels that enable better detection of very thin cirrus clouds, fires, and generation of true colour imagery. Using lightning information is expected to provide additional insight into the development of convective storms, especially in areas outside ground-based lightning detection capacity, such as over the ocean.
The paper describes the current status of MTG development and prospective use of its data in nowcasting and very short-range forecasting applications. It also includes a description of the training approach to MTG.

**A new approach for near-real-time monitoring of atmospheric stability, atmospheric water vapor and liquid water**

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State-of-the-art high-resolution numerical weather prediction models still have large deficits in forecasting the exact temporal and spatial location of severe, locally influenced weather such as summer-time convective storms or cool season lifted stratus or ground fog. More accurate, spatially and temporally more frequent observations of lower-tropospheric water vapor and thermodynamic instability are expected to improve short-term forecasts. While in most of Europe, the thermodynamic state of the atmosphere is well measured close to the surface by in-situ sensors and in the upper troposphere by satellite sounders, the planetary boundary layer remains a largely under-sampled region of the atmosphere where only sporadic information from radiosondes or aircraft observations is available.
This contribution proposes an approach to overcome this gap by the using active and passive ground-based remote sensing (differential absorption lidar DIAL and microwave radiometry MWR) in combination with the Infrared Sounder planned to fly on the geostationary Meteosat Third Generation by 2021. IRS and ground-based remote sensing observations are simulated from the COSMO-DE reanalysis using the radiative transfer model RTTOV. Based on this, we develop a neural-network-based retrieval framework to retrieve typical atmospheric stability indices, integrated water vapor and liquid water path above a hypothetical ground-based remote sensing site. We show the single instrument performance and the benefit of combining ground-based and satellite observations in terms of correlation, uncertainty reduction, probability of detection and other forecast skill scores. Compared to the retrieval based on satellite observations only, the additional ground-based MWR/DIAL measurements were shown to provide valuable improvements not only in the presence of clouds, which represent a limiting factor for infrared IRS, but also under clear sky conditions.
Thus, future nowcasting and seamless prediction may well benefit from a distributed network of ground-based remote sensors combined with future geostationary satellite observations, providing improved temporal and spatial coverage and accuracy of the atmospheric thermodynamic state.

## Seamless prediction with special focus on data assimilation

**NowcRadiation: seamless-nowcasting solar radiation using satellite and high resolution numerical model output**

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NowcRadiation is a project developed by AEMET (the Spanish Meteorological Agency) for the Spanish transmission system operator, Red Eléctrica de España, to improve hourly Global Horizontal Irradiance (GHI) and direct Normal Irradiance (DNI) forecasts in Spanish solar power plants.
Seamless-nowcasting is a technique for very short-range forecasting (normally within 6 hours ahead) covering only a very specific geographic region. This technique is necessary to forecast the availably of solar radiation which is able to predict changes in electricity generation.
We present nowcRadiation a seamless-nowcasting tool developed by AEMET, which provides every 15 minutes the hourly solar radiation accumulated fluxes for the next 4 hours. The meteorological data used for this model are satellite cloud type observations and EXIM outputs a forecasts based on high resolution winds (EUMETSAT SAFNWC/MSG software package

outputs), radiation from high resolution numerical weather prediction model (HARMONIE/AROME radiation outputs) or a combination of both sources of information depending on different forecast time horizons.
The performance of the tool has been evaluated comparing the GHI and DNI forecasts with the ground solar radiation observation measures from seven stations of AEMET network. The verification found in the bibliography are siminar to the results of nowcRadiation in terms of RMSE.
Future work direction will be to apply nowcRadiation to AEMET-γSREPS: the AEMET high resolution 20-member multi-model convection-permitting LAM-EPS. It will allow to have a measure of the uncertainties in the GHI and DNI forecasts and more important, to provide specific probabilistic end-user products related to their own thresholds.

### Seamless approach for precipitations within the 0-3 hours forecast-interval

**Jean-Marc Moisselin**, Philippe Cau; Céline Jauffret
*Météo-France*

Some research on nowcasting systems relies on blending NWP fields and extrapolation data on nowcasting scale. The aim is to take the best of each method to have the most relevant information without break within the 0-3 hours forecast interval.
Several approaches have been investigated at Météo-France. The chosen one, developed since June 2016, is based on a so-called “sequential aggregation of predictors by exponential weights” method. This means blending two predictors:
- The extrapolation of radar QPE (Quantitative Precipitation Estimation);
- The rainfall forecast by highly refreshed numerical model AROME-NWC. The results of blending is a linear compound of products close or better than the best of any of them.

The method, called PIAF (Prévision Immédiate Agrégée Fusionnée), has been extended and improved recently: split of the French domains in 6 sub-areas, new tuning, change of criteria used to estimate the loss (Gerrity score), blending also applied to reflectivity parameter.
PIAF is now implemented at Météo-France and operated every 5 minutes.

### Impact of Bayesian weighting in a probabilistic nowcasting from INCA and C-LAEF

**Aitor Atencia**; Alexander Kann; Yong Wang; Clemens Wastl
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INCA is a deterministic Quantitative Precipitation Nowcasting (QPN) system based on a Lagragian extrapolation of the latest radar observation (merged with rain gauges stations) for several hours. These system are mainly used as deterministic nowcasting techniques in operational and research centers. However, these deterministic approaches does not account for uncertainties and errors due to growth and decay of rainfall system and an ensemble generator is needed to introduce them.
The created ensembles have to reproduce the temporal and spatial statistical properties of a real rainfall field. Mainly, two existing techniques have been combined: Short Space Fast Fourier Transform (ssFFT) to introduce noise with the proper spatial (and local) correlation and a Conditional Auto-regressive Model (CAR) to keep the temporal decorrelation of each ensemble. Other properties of the rainfall field such as the Wetted Area Ratio (WAR) or the Intensity Mean Flux (IMF) are also used to generate realistic rainfall distribution of the ensemble. Consequently, few parameters are needed in this technique: local spatial decorrelation, anisotropy, temporal decorrelation, Probability of Rain, WAR and IMF.
However, these ensemble approaches do not take into account other sources of information such as Ensemble Prediction Systems (EPS) from the Numerical Weather Prediction (NWP) models such as the Convection permitting Limited Area Ensemble Forecasting (C-LAEF) based on the AROME model developed at ZAMG. These systems, even though do not outperform the Lagrangian extrapolation can provide information of the errors in the precipitation field.
This information can be introduced in the probabilistic nowcasting by computing for each ensemble members parameters such as the local spatial decorrelation distance, WAR or Probability of rain. They are merged with the INCA nowcasting parameters by a linear weighting. The main goal of this presentation is to quantify the impact of introducing dependence on the ensemble member merged when computing the weights used in the blending versus the same approach without ensemble member dependence.
The results are two realistic ensembles of different meteorological situations, narrowing the spread among members to the variance provided by C-LAEF. These two final EnQPF are probabilistically verified and compared for the period of July 2016. The comparison will show the benefits, in an hourly update EnQPF, of the Bayesian weighting with dependence on the ensemble member.

### Seamless Nowcasting System Development at the Finnish Meteorological Institute

**Jaakko Nuottokari**; R. Gregow; H. Hohti; J. Kotro; I. Karjalainen; J. Ylhäisi; L. Hieta; M. Partio; J. Jarjalainen

*FMI – Finnish Meteorological Institute, Finland*

Nowcasting at FMI continues to be based on manual work by the forecaster, combining various data sources into a realistic and accurate description of the expected weather in the 0-6h timeframe. As many more users have growing needs for nowcasting information and as data volumes increase, the process needs to be automated and streamlined.
The goal for the development of the FMI Nowcasting System (ULJAS) is a seamless and automated forecast production six hours into the future by the end of 2019 in the current HARMONIE model domain (extended Scandinavian footprint). In this talk, I will present the work ongoing to improve and take into operations weather radar precipitation fields, object-based hazard information, mesoscale weather analysis fields, satellite-based nowcast information, limited area NWP nowcasting model, data blending and quality assurance processes and the development of the supporting production system.
The approach adopted by FMI is to make optimal use of existing research and development work with a focus on operational solutions available to end users in 2020. The project is ambitious both in time and resources, but is essential our ongoing service to our customers

### Development of a new seamless integrated forecasting system (SINFONY) at DWD

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At Deutscher Wetterdienst (DWD), the pilot project SINFONY has been set up to develop a seamless ensemble prediction system for convective-scale forecasting with forecast ranges up to 12 hours, which integrates nowcasting techniques with numerical model prediction (NWP) in a seamless way. The focus is on severe summertime convective events.
So far, the storm-scale forecasting for the first 2 hours and warning rely mostly on observation-based deterministic nowcasting products with frequent updates (5-min intervals) that are available within a few minutes. New NWP forecasts with the convection-allowing ensemble system COSMO-DE-EPS are started only every 3 h and can outperform the quality of nowcasting only at later forecast times. Moreover, nowcasting and ensemble NWP are treated as two separate and independent methods, and there are only few common products available for the forecasters.
The goal of SINFONY is to narrow down this gap and to provide new products for the forecasters from observation time up to +12 h, combining nowcasting and NWP. Therefore, efforts are undertaken on the one hand by enhancements to both nowcasting and NWP separately and on the other hand by mutual information exchange and combination between these two methods.
The nowcasting system is expanded to an ensemble approach and will consider life-cycle information compared to the classical pure advection approach. For the NWP system, a rapid update cycle (RUC) is under development, with hourly updated ensemble forecast on km-scale. The assimilation of further high-resolution observational data (e.g. 3D-radar-data) in the assimilation system is introduced and additional effort is done to further improve the model physics. A thorough comparative verification of nowcasting ensemble and NWP ensemble is another prerequisite for the optimal combination of these systems.
The presentation will give an introduction to the specific forecasting problem, an overview of the concept of the SINFONY project and its current status.

## Nowcasting techniques, systems and products

### Nowcasting mountain waves turbulence on Zagros area by using satellite images and NWP model

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Mountain waves (Lee waves) can produce regional turbulence by creating eddy waves in lee side of mountains ranges, which are very hazardous for aviation operations. Nowcasting and forecasting of turbulence is very important for the pre-operations of air traffic control centers, especially to provide timely alerts to aeronautic user.
In this paper a method is presented that at first using satellite imagery depending on the cloud type and amount detects turbulent region and afterward by analyzing the atmospheric variables derived from the numerical model outputs, the intensity and structure of turbulence is determined. In this paper, a turbulent case on 21 April 2018 on the Zagros mountain range of Iran is investigated. For this purpose, the Meteosat-8 geostationary satellite images that is organized and maintained by the EUMETSAT were used. In addition, outputs of the ARPEG-0.5 numerical weather prediction model were used to consider the three-dimensional structure of the turbulent region.
Results illustrate that formation of long narrow clouds stretched parallel with the mountainous range and perpendicular to the wind currents in the lee side, expresses the existence of turbulence in the region. Besides that the three-dimensional structure of the turbulence were estimated by analyzing vertical profile of dynamic variables of the model including potential temperature and vertical velocity.

**The Nowcasting SAF Products and Services: Recent Improvements in the New SW Packages PPS v2018 and GEO v2018 and Future Plans**

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The Nowcasting SAF is part of the EUMETSAT SAF Network, whose objective is the generation of satellite derived products to ensure the optimal use of the EUMETSAT satellite data. In particular, the Nowcasting SAF (NWC SAF, nwc-saf.eumetsat.int) is specially focused in the Nowcasting applications of the meteorological satellites. It is a Consortium composed by the national meteorological services of Spain, France, Austria, Romania and Sweden.
The Nowcasting SAF develops, distributes and maintains freely distributed software packages that allow the users to generate locally satellite derived products with a direct application to Nowcasting from geostationary and polar satellite data.
In early 2019, the NWC SAF has distributed two new SW packages to the users: GEO v2018 for geostationary satellites and PPS v2018 for polar satellites, including products improvements and also new products.
NWC SAF products for geostationary satellites include:

- Cloud products (Cloud Mask, Cloud Type, Cloud Top Temperature and High, Cloud Microphysics)
- Stability and Humidity products (Precipitable Water and Stability Analysis)
- Precipitation products (Convective Rainfall Rate for geostationary satellites and Precipitation Likelihood)
- Convection products (Convection Initiation and Rapidly Developing Thunderstorm - Convection Warning)
- Wind product (High Resolution Winds and Trajectories)
- Extrapolation Imagery product
- Automatic Satellite Image Interpretation products (Detection of Meteorological features, Tropopause Folding, Gravity Waves)

NWC SAF products for polar satellites include:

- Cloud products (Cloud Mask, Cloud Type, Cloud Top Temperature and High, Cloud Microphysics Cloud Probability)
- Precipitation Likelihood

In the proposed paper, the NWC SAF and its services are presented. A relation of the NWC SAF products and satellites supported is shown, with examples on how to use the products for Nowcasting purposes and highlighting the improvements in the recently distributed new SW packages. Training activities and Testbeds experience and plans will be presented.
Finally, the future plans of the NWC SAF for the next years are highlighted.

**Convective Storm Nowcasting – Capabilities of Remote Sensing in Central Europe**

**Michaela Valachová**; Patrik Benáček; Hana Kyznarová
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Evolution of isolated convective storms, which formed in the Central Europe, is studied by means of multi-sensor observations. According to the reports from the European Severe Weather Database, two categories of storms are classified: severe and non-severe. Based on radar, lightning and satellite measurements, trends of storm characteristics are analysed to ascertain their typical behaviour during whole life-cycles. In order to objectively determine crucial variables for estimating the storm severity, logistic regression models and regularized regressions (elastic net) are employed. Variables from the first 30, 60 and 90 minutes of the monitored storm lifetime are used to show their predictive skill. Results of the models indicate that the essential severe storm predictors of particular remote sensing are: 1) maximum number of strokes per 5 minutes and its sudden increase, 2) radar echo-tops and area of identified reflectivity cores and 3) minimum brightness temperatures in the 10.8 ?m spectral band. Similar variables were also selected by the elastic net, which can handle sparse data and correlated variables. Further training of the models and their operational adaptations have a potential to bring direct use of these results for nowcasting and improve a real-time warning process

**Some algorithmic developments on HARMONIE-AROME for NWP-NWC**

**Carlos Geijo**
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The use of NWP systems in the short and very short forecasting ranges (NWC) is becoming in late times more frequent among LAM-NWP operators, in Europe and beyond. These forecasts constitute a kind of products that Global-NWP systems will always have difficult to provide, no matter how fine becomes the discretization they will use. The main reason

for this argument is that current DA techniques employ by them are not well suited for weather of intrinsically low predictability ranges.
As DA is a fundamental component in the explotation of modern NWP systems, this limitation imposes major constraints.
In the past, many NWC applications have been developed and deployed making use of downstream NWP post-production, and they have demonstrated to be useful. The NWP-NWC concept pursues to go beyond this practice by means of direct assimilation of nearly real-time observations, and in this way to profit from the more complex representations of physical processes encoded in LAM-NWP systems.
In this presentation three developments in the area of DA for short and very short range forecasts carried out at AEMET in the framework of the HIRLAM project and on the HARMONIE-AROME system will be introduced. They intend to be elements eventually integrated in this system as its NWP-NWC component. One is the "Field-Alignment" technique which is able to correct position errors by aligning model wind fields to Doppler radar images. Another one is the application of variational techniques to develop a nudging-like algorithm that takes into account the non-hydrostatic dynamics in the HARMONIE-AROME model to balance and filter noise produced by observation increments shocks. The third is a new method to model flow-dependent covariances using Gaussian Integrals.

### Nowcasting of thunderstorm severity with Artificial Neural Networks in the Alpine Region

**Ulrich Hamann[1]**; J. Zeder1; L. Beusch[2]; L. Clementi[1]; L. Foresti[1]; A. Hering[1]; D. Nerini[12]; L. Nisi[1]; M. Sassi[1]; U Germann[1]
*[1]MeteoSwiss, Switzerland; [2]Institue for Atmospheric and Climate Science, ETH, Zurich*

Today's warning procedures for severe convective storms are often based on nowcasting methods in which, typically, the thunderstorm position is extrapolated with its current motion, while the storm severity is kept constant (Lagrangian persistence assumption). In this presentation, we examine the potential of artificial neural networks (ANNs) for nowcasting the evolution of thunderstorms. In particular, we aim for the short-term forecast of a heuristic severity rank as defined in the TRT algorithm (Hering et al 2008). As predictors we use a comprehensive database of thunderstorm properties in Switzerland and its surroundings for the summer 2018, consisting of satellite, radar and lightning observations, NWP model data, topography, time, and thunderstorm position and movement, in total more than 90 variables. We only consider thunderstorms of severities relevant for operational warnings, resulting in around 10'000 snapshots of single cells in total. For each snapshot, the cell's history of the last 45 min in 5 min time steps was evaluated by deriving the thunderstorm displacement using the open-source library pysteps (https://pysteps.github.io/, Pulkkinen et al 2018). At each location the thunderstorm properties were analyzed in a local surrounding to avoid sensitivities to particular thunderstorm cell boundary definitions, as well as cell splitting and merging. Within the surrounding, several statistics were computed from the predictors, which include the minimum, maximum, standard deviation, and several percentiles. All possible combinations of variables, time steps, and statistics provided a large number of possible predictors. Hence, we apply shallow decision trees (XGBoost, Chen and Guestrin, 2016) as a feature selection algorithm to estimate the importance of the predictors. For the most important ones, we illustrate their physical meaning. In the end, we discuss choices of the neural network design and hyper-parameter selection, as well as the quality of ANN predictions of thunderstorm severity in comparison to Lagrangian persistence

### Lightning-jumps in convective cells tracked by radar as a nowcasting tool in complex orography

**Alessandro Hering**; Luca Nisi; Ulrich Hamann; Urs Germann
*MeteoSwiss, Switzerland*

In intense thunderstorms lightning jumps can occur from few minutes to some tenth of minutes before the onset of severe convection characterized e.g. by hail. In recent years, some algorithms have been developed to exploit the potential of lightning jump for nowcasting severe thunderstorms and to increase the lead-time of real-time warnings. These algorithms were mainly applied on ground-based data of total lightning detection networks over flat or hilly terrain, whereas a study over the complex orography of the Alps was until now missing. A robust, 5-year statistical analysis of thunderstorm cells and total lightning data from an operational ground-based lightning detector network was performed to fill this gap. About 6000 hail storms were automatically detected and tracked by the Thunderstorms Radar Tracking (TRT) algorithm based on volumetric radar data from the MeteoSwiss network, and compared to more than 36'000 non-severe convective storms. Results show an average lead-time of the lightning jumps to hail initiation inside the storm cells of about 20 minutes.
For nowcasting and warning purposes, MeteoSwiss has developed a real-time prototype algorithm for the automatic lightning jump identification and display, based on these findings. It uses the total lightning rate from the operational network to identify the occurrence of lightning jumps based on the classical 2-sigma threshold. In addition for each cell identified automatically by TRT, the continuous value of the sigma-level, a metric of lightning jump strength, is also computed and visualized for the forecasters in real-time with an update of 2.5 minutes.
In this paper the nowcasting potential of lightning jumps is discussed based on a 5-year statistical study, and a first real-time prototype for the use in the complex Alpine orography is presented. The new algorithm will be integrated in the convection nowcasting and warning systems already in use at MeteoSwiss such as TRT, COALITION, NowPAL, NowPrecip and INCA.

**Towards A Nowcasting System for Meteorological Services Singapore**

**Erick Becker**; Xiangming Sun
*CCRS - Centre for Climate Research Singapore, Republic of Singapore*

In Singapore the tropical climate results in year round thunderstorms. These thunderstorms are typically localized and convective in nature and are often characterized with rapid growth and decay, weak environment winds (particularly during inter-monsoon seasons) as well as back-building. As a result, these characteristics can go well beyond the limits of a radar-based nowcasting system that relies on extrapolation methods. Since 2016, a radar-based nowcasting system using a machine-learning (Artificial Neural Network) algorithm has been in development at the Centre for Climate Research Singapore (CCRS); in an attempt to train and predict future one-hour rainfall. The system has been running in real-time since early 2017 and has been verified against radar-observations using data from a 6-month period (Nov 2017 – Apr 2018).
Results show that the radar-based nowcasting system can provide useful forecasts to assist forecasters in issuing heavy rain warnings over a sub-region of Singapore, as long as the dimension of the sub-region is no less than 20 km. However, it proves difficult to produce useful forecasts for events with rain rates exceeding 50 mm/h over the entire simulation domain, yet there is some added value compared to climatology. The predictability gain due to large-scale forcing is only seen in forecasts of small threshold (< 10 mm/h) events.
Future plans include an attempt to extend lead-time through blending the radar-based nowcasts with the SINGV model, a regional version of the UK Met-Office's Unified Model (UM) with a tropical configuration. As well as investigating how to exploit various nowcasting techniques to produce better results in the tropics. Verification results on the radar-based nowcasting system and progress towards a 0 to 6 hour seamless blended nowcasting system will be presented.

**Blended probabilistic nowcasting with the IMPROVER post-processing system**

**Caroline Sandford**; Stephen Mosseley
*Met Office, UK*

The current Met Office post-processing system (UKPP) provides deterministic post-processed forecasts from Met Office UK and global models. With increasing recognition of the value of probabilistic forecasts, a new post-processing system – IMPROVER – is being designed. This will replace the traditional deterministic output and uncertainty estimates with a range of exceedance probabilities, whose distribution provides a more quantitative assessment of the forecast uncertainty at any given location.
The replacement of the UKPP with IMPROVER provides a framework for seamless blended precipitation forecasting, from the very short (nowcast) timescales up to medium range. In this work the implementation of a new nowcasting system is described, which follows the design principles adopted by the IMPROVER project. These principles are based around simple, modular processing chains that are easy to maintain, with the key aim of blending probabilities rather than diagnostic values.
Rather than the complex scale decomposition and blending performed by STEPS, the new system will take a simplified two-stage approach to nowcast generation. Initially, the Met Office Nowcasting (MONOW) system will generate a simple extrapolation nowcast from radar surface precipitation estimates using a model steering flow. This nowcast will be ingested into IMPROVER, to undergo probabilistic post-processing alongside precipitation forecasts from the deterministic UKV and other models. Finally, the nowcast probabilities will be blended with probabilities from the UKV according to the extrapolated radar coverage and the lead time of the forecast, up to a maximum of six hours. Longer range precipitation forecasts are supplied by increasing the weight of Met Office UK ensemble forecasts (MOGREPS-UK) in the continuous blend. This work focuses on the shortest lead times, describing the probabilistic processing to be applied to extrapolation nowcasts, and illustrating performance by comparing the final blended probabilities with radar observations of "true" surface precipitation.

**Nowcasting wind using machine learning: from the stations to the grid**

**Matteo Buzzi**; Matteo Guidicelli; Mark Liniger
*MeteoSwiss, Switzerland*

Current state of the art numerical weather prediction models as COSMO-1 running at very high horizontal resolution (~1km) and using sophisticated assimilation techniques still show substantial biases in wind forecasts, above all in very complex topography such as the Alps.
The INCA-CH system, running at MeteoSwiss, tries to correct the COSMO-1 bias on a 1km grid using the available surface observations. The observed bias at the stations is then interpolated in space using inverse distance weighting (IDW). The

observed limited spatial correlation of the COSMO-1 error and the very low spatial representativeness of weather stations suggest that the spatial interpolation using IDW could result in unwanted effects, and might even deteriorate the raw COSMO field. In addition, the current system is not able to separate the typical systematic bias and the forecast error, related to the predictability during the specific meteorological situation.
Compared to post-processing of wind at individual weather stations, no established methods are available to produce bias corrected gridded fields. Here, we will explore machine learning algorithms to achieve this task. Specifically, we compare the currently operational INCA algorithm with a 2 step machine learning system. The first step consists in the removal of the systematic bias, correcting COSMO-1 wind estimations. An artificial neural network is trained on a complete year of data, considering COSMO-1 variables and several high resolution topographical parameters as predictors. Then, a second step is applied in order to correct the forecast error too. Another machine learning model is trained in real time and on single time steps, using the corrected wind of the first step as additional predictor.
The contribution provided by machine learning methods for post-processing of wind is evident, leading to a consistent reduction of the error with respect to station measurements. But the use of machine learning as spatial interpolation technique remains very challenging, in particular in regions characterized by complex topography.

**Generation of an Object-based Nowcasting Ensemble**

**Robert Feger**; Manuel Werner; Rafael Posada; Kathrin Wapler; Ulrich Blahak
*DWD – Deutscher Wetterdienst, Germany*

The pilot project SINFONY (Seamless INtegrated FOrecastiNg sYstem at the Deutscher Wetterdienst (DWD) aims at integrating numerical weather prediction (NWP) and nowcasting techniques into a new ensemble-based forecasting system. The current focus is on severe summertime convective events with a forecast range up to 12 hours.
The object-based nowcasting system at DWD, called KONRAD3D, is a newly developed deterministic cell detection, tracking and forecasting system operating on observed radar reflectivity, using an adaptive-threshold detection technique as well as a Kalman filter for the cell tracking.
As part of the SINFONY project, the generation of an object-based nowcasting ensemble with KONRAD3D ought to correctly asses the uncertainty of tracking and forecasting cell positions as well as cell evolution in a probabilistic manner. Several possibilities for the ensemble generation are presented as well as a prototype where a variation of procedure parameters is applied, namely the adaptive detection thresholds as well as the Kalman-filter process noise.
The prototype takes the cell life cycle into account by assuming a parabola shape opening down for the cell's covered area over time with the maximum size and the life time as parameter. The life cycle ensemble is Monte-Carlo generated from analysis of historic data.
The presented prototype filters cell positions and life cycle information in an Ensemble Transform Kalman filter for a stable track and forecast including an estimate of the cell evolution and the associated uncertainty. Case studies involving severe convective events in Germany during May and June 2016 are presented.

**VISOR: Real time observations visualizer**

**Cecilia Marcos**; M. Gomez; P. Aguayo; M.T. García; C. Jiménez; C. Perea; J. Riesco; A. Roa; J.I. San Ambrosio
*AEMET, Agencia Estatal de Meteorología, Spain*

Real time observations availability is a key issue for nowcasting tasks. Comparison and superposition of different type of observations can be very useful in order to figure out what is taking place at a particular region. In this sense, VISOR is a tool, developed at AEMET, to make easier the monitoring of any meteorological situation being especially useful for the tracking and surveillance of convective systems.
Among the observations available in VISOR, there are a number of automatic weather stations networks, several radar products, lightning information, MSG satellite imagery including NWCSAF products, web cams, soundings and warnings. All this information is available in layers that can be superimposed. The user can modulate transparency of image layers.
One of the latest products included in VISOR are a couple of experimental parameters derived from radar data named PAD2 and PAD3 (PAD - Potential adversity parameter). These parameters are intended to provide the forecaster with a fast warning of the most dangerous convective cells.
This presentation will show VISOR capabilities focusing on potential adversity parameters.

**Nowcasting lightning using weather radar and a dynamically update ice mass estimator**

**Evan Ruzanski[1]**; V. Chandrasekar[2]
*Vaisala USA[1]; Colorado State University USA[2]*

Short-term automated forecasts (nowcasts) of lightning are important for a number of applications to help save lives and resources. The presence of ice aloft is known to be a key component in the atmospheric electrification process. The measurement range, resolution, and volumetric nature of weather radar observations provide valuable data, which are inherently different from those provided by currently operational lightning detection networks. Weather radar observations can be used to estimate ice mass aloft and are thus favorable for nowcasting lightning.
This presentation describes a new model for estimating ice mass aloft using weather radar data. Previously, a simplified bulk microphysical model with fixed parameters was used to estimate ice mass aloft. The new weather radar-based ice mass estimator uses a novel numerical optimization approach to dynamically update the parameters of this bulk microphysical model to improve lightning nowcasts.
This paper also introduces a new approach to nowcasting lightning activity using weather radar data. The previous methodology used a cell-based approach to lightning nowcasting and verification, where storm cells were first identified, lightning activity was associated with a particular cell, but lead times and lightning locations were not specified in the nowcast. The new method described in this presentation employs a grid-based approach to lightning nowcasting and verification specific in space and time.
The radar data used for this study were collected by the Weather Service Radar-1988 Doppler radar located near Fort Worth, Texas, during a severe convective storm event occurring on 03 Apr 2014 from 000335 to 235741 UTC. The lightning data used for this study were collected by processing detections of lightning discharges from multiple Vaisala remote lightning sensors within the National Lightning Detection Network within approximately 1000 km of the KFWS radar during the same time period.

**Assimilating remote sensing data and its impact in LAPS predictability**

**Petros Katsafados[1]**; C. Spyrou[1]; G. Varlas[2]; M. Anagnostou[3]; J. Kalogiros[3]; A. Papadopoulos[2]
*[1]University of Athens, Greece; [2]HCMR, Greece; [3]IMBRIW, Greece*

NOAA’s Local Analysis and Prediction System (LAPS) is a mesoscale assimilation system that combines diverse observations (in-situ measurements, remote sensing estimations and others) with background data to generate a spatially distributed, three-dimensional representation of atmospheric conditions. LAPS is also able to provide very short-term prediction (nowcasting) through a recently developed forward-advection nowcasting scheme, in order to overcome the 'spin up' period which routinely exists in the conventional numerical weather predictions (NWP). This study assesses the capabilities of LAPS to be used as a forecasting component in a wider early warning system. In order to test the validity of our methodology the model is tested simulating a high impact storm that occurred in the sub-urban area of Mandra, western Attica, Greece. The extreme precipitation rates during the morning of the 15th of November 2017 around Mandra resulted in a flash flood that caused 24 fatalities and extensive damages. LAPS is applied in nowcasting mode for this case study, assimilating regional surface and upper-air observations on gridded model data to produce objective analyses alongside with their nowcasts in a forecast window of 3 hours. The sensitivity of LAPS predictability on the ingestion of high-resolution remote sensing precipitation estimates, including satellite retrievals and ground radar precipitation rates, is also assessed in this study. LAPS nowcasts employing various forcing data are also compared against high-resolution WRF model predictions obtained from previous operational cycles in order to examine the capabilities of the system against conventional NWP procedures.

**Improved motion vectors in rainfall nowcasting using Burgers’ equation**

**GyuWon Lee**; Soorok Ryu
*CARE – Center for Atmospheric Remote Sensing, Republic of Korea*

The most nowcasting of a radar-derived surface precipitation pattern is generated by an algorithm based on advection such as the McGill Algorithm for Precipitation Nowcasting by Lagrangian Extrapolation (MAPLE). This method can produce precipitation forecasting in high spatial and temporal resolution but cannot represent the source-sink of precipitation and non-stationary states of motion vector fields.
In this study, we propose some advection-diffusion equation based on the nowcasting rainfall models with non-stationary motion vectors. The diffusion term of this equation leads to smoother predicted images with lead time and increases some skill scores, and the motion vectors are updated each time step by solving a system of two-dimensional (2D) Burgers equations. The procedure of this forecasting model has the following two steps. First, an initial motion vector field is approximated by the Variational Echo Tracking (VET) algorithm. Second, the forecasting is obtained at each time step by solving a time dependent advection or an advection-diffusion equation. In this step, motion vectors can be updated at each time step by solving Burgers’ equation. High-resolution forecasts are evaluated for lead times from 2:5 min to 3 hr against rain rate observations for 6 events over 250 _ 250 km2 region in southeastern South Korea. To observe the effects of diffusion term and Burgers’ equation, the methods are classified into 4 types, according to the considered equations: advection equation (Type 1), advection equation and Burgers’ equation (Type 2), advection-diffusion equation (Type 3), and advection-diffusion equation and Burgers’ equation (Type 4). The forecasts from the Type 1 method was very similar to those of MAPLE. Whereas the other models (Type 2-4) clearly had better skill scores and correlations on average, up

to 3 hours lead time compared to MAPLE. Especially, we observed that using Berger's equation (type 2 and type 4) has a much better score than other methods using fixed motion vectors when the rate of change of motion vector over time is large.

**iSHAI and PGE00: key tools for preconvective monitoring and for the preparation of the MTG era**

**Miguel Angel Martinez**; Xavier Calbet
*AEMET – Agencia Estatal de Meteorología, Spain*

iSHAI (imaging Satellite Humidity and Instability) is the clear air product of the NWCSAF/GEO software that allows the monitoring in clear pixels of several key ingredients in convection; in addition, it allows to identify the regions where the numerical models used as input do not agree with the observation of the satellite. In version 2018, iSHAI has been adapted to Himawari satellites and it is being adapted for GOES-R class satellites.
The PGE00 program is an AEMET complementary tool that performs first the vertical, temporal and spatial interpolation (4D interpolation) of the profiles from NWP to the projection and time of the satellite images; allowing to generate for all the pixels the same fields that iSHAI. Second, PGE00 can be used to generate synthetic satellite images using RTTOV-12.1 in clear and cloudy conditions with a high degree of realism using the ECMWF model at hybrid levels. In addition to the comparison with real satellite images, synthetic images can be used to generate new developments. As an example, a modified air masses RGB using real and synthetic brightness temperatures to improve the detection of stratosphere's intrusions will be shown.
PGE00 has been is being also used for preparation of MTG era through the generation synthetic MTG-FCI and MTG-IRS images. One of the first application is the use of synthetic images of the new VIS0.9 channel of MTG-FCI to obtain the spatial structure of the total precipitable water content (TPW).
The NWCSAF products and services for the future MTG-IRS will be also briefly presented. As example of the quick-IRS service, together with real and synthetic RGB images from IASI (as proxy of MTG-IRS) it will be presented the use of sequences of real and synthetic IASI images from top to down in the atmosphere.

## Verification and societal impacts & Applications and users aspects

**Use of the radar data for winterly weather warnings at Deutscher Wetterdienst**

**Tim Böhme**; Jörg Steinert
*DWD – Deutscher Wetterdienst, Germany*

A main task for national weather services is to issue weather warnings. These warnings inform about hazardous situations both in winter and summer seasons. In winter, the issue of weather warnings based on remote sensing data can be challenging. In comparison to rain, snow reflects radar signals to a minor degree. Light snowfall leads to radar reflectivities around 0-5 dBZ. In addition, clouds in winter are mostly found in lower heights than in summer. Thus, the radar beam often covers only a part of the clouds and the associated precipitation. But even if the radar can detect and quantify the precipitation entirely, the analysis of the correct precipitation phase and amount at ground level remains a challenge, especially in cases around freezing temperature.
At Deutscher Wetterdienst (DWD), a dual-polarimetric radar network had been installed in the previous years. With the use of dual-polarimetric radar parameters (e.g., Zh, ZDR, ρhv) and numerical weather prediction data (e.g., COSMO-D2 0°C height), the hydrometeors on radar beam height are analysed (algorithm HYMEC – HYdroMEteor Classification). The use of numerical weather prediction vertical profiles of temperature, humidity and pressure enables the vertical extrapolation of the HYMEC analysis data to the ground (algorithm NASMA - Nose Analysis based on Snow Melting Area). With the use of point measurements at ground level, the vertical extrapolation is optimised. In this way, the precipitation phase at the ground can be analysed in the entire radar coverage area.
In the beginning of the winter season 2018/2019 NASMA data were implemented into DWD weather forecast visualisation system NINJO. Afterwards, the data of the NASMA algorithm has been evaluated. Main findings of the evaluation will be presented by the analysis of characteristic case studies. Most of the cases studies (e.g., cold front passages) show good agreement with reference (e.g., weather station) data. Approaches for further algorithm developments (e.g., for complex weather situations) will be discussed, too.

**Aviation operational nowcasting systems**

**Tatiana Bazlova**; Nikolay Bocharnikov; Alexander Solonin
*IRM - Institute of Radar Meteorlogy, Russia*

Nowcasting systems are aimed to give relevant information support to decision-makers and aviation forecasters at airports with heavy traffic and/or many high-impact weather events. Nowcasting systems of IRAM operate 24/7 since 2014 at two airports providing forecasts of most critical parameters for the airport operation. Developed for operational use, numerical model of the atmospheric boundary layer (ABL) is run with a 10-min update cycle, data input from aviation weather observation station (AWOS), high frequency observing additional stations, runway surface analyzers, and AMDAR data. Doppler weather radar data are used to derive weather radar products including precipitation nowcasts.
One of the airports is Irkutsk, whose operations are significantly impacted by low visibility caused by fog. The MeteoExpert nowcasting system has been put into operation at the airport to provide the Aviation Meteorological Center (AMC) with 0-6 h forecasts of weather conditions including fog and visibility.
Another one is Saint-Petersburg (Pulkovo) airport, where more detail information is required in order to ensure the effective maintenance in winter and to improve the airport capacity. The MeteoTrassa system provides the airdrome service with measurements and forecasts, with emphasis on icing at the surface and precipitation onset. This information helps airdrome service to react to hazardous weather in time and to initiate preventive works.
The next MeteoExpert nowcasting system has been operational since 2018 to provide the AMC Pulkovo with 4-h forecasts of visibility and ceiling. The nowcasting system is in the framework of the WMO Aviation Research Demonstration Project (AvRDP). Observation data and forecasts are visualized on the MeteoCube website. Operational thresholds for visibility and ceiling are indicated. Verification option is available on the website. Results of forecast verification are presented.

### European Composite of Convection Nowcasting for SESAR Deployment

**Sandra Turner**; Jean-Marc Moisselin; Stéphanie Desbios
*Météo-France*

The proximity of European countries and the highly temporal variability of convection activity induce multiple weather forecasts over the same area, and possibly may lead to decisions that are not based on the same representation of the weather situation and its evolution. To increase safety in complex scenarios and facilitate collaborative decisions and reactions to hazardous weather events, the Single European Sky ATM Research (SESAR) targets on a common representation of adverse weather situations for all aviation users (pilots, airlines, airports, air traffic management, supporting actors, etc.). At the same time, National Meteorological Services (NMS) developed new nowcasting products, taking advantage of Limited Area Models (LAM), with higher accuracy and frequent update cycle in order to better figure small scale features of convective events out. It is then possible to merge all forecasts from different NMS to produce an harmonised composite of the convective activity over Europe. Météo-France is leading the European harmonisation of the Convection Nowcasting Product by adding to its own product those of the Deutscher Wetterdienst (DWD) and of the UK Met Office. Taking benefits of results of previous research and development activities conducted during the first phase of SESAR, merging technics are studied and tested in order to take advantage of those forecasts and to use them the best way especially in overlapping geographical areas. The goal is to provide rapidly in an operationnal mode a frequently updated (15') convection nowcasting composite to aviation users, in both gridded and vectorial formats, through a unique access point using protocols and governance compatible with System Wide Information Management (SWIM) architecture and principles. (Thanks to SESAR Deployment Project 2015_068_AF5 led by EUMETNET and co-financed by the European Union).

### Precipitation nowcast scenarios for hydrology

**Stephen Moseley**; Caroline Sandford; Nigel Roberts
*Met Office, UK*

The current Met Office post-processing system (UKPP) provides deterministic post-processed forecasts from Met Office UK and global models. With increasing recognition of the value of probabilistic forecasts, a new post-processing system – IMPROVER – is being designed. This will replace the traditional deterministic output and uncertainty estimates with a range of exceedance probabilities, whose distribution provides a more quantitative assessment of the forecast uncertainty at any given location. A new Met Office nowcasting system (MONOW) will initially generate a deterministic radar extrapolation nowcast, which will undergo probabilistic post-processing and blending with the UKV as part of the new IMPROVER system.
The Flood Forecasting Centre (FFC) has the responsibility of warning and managing flooding across the UK. In recognition of forecast uncertainty, the FFC requires realistic scenarios to drive hydrological models to simulate the response of rivers to precipitation.
The replacement of the UKPP with IMPROVER provides a framework for seamless blended precipitation forecasting, from the very short (nowcast) timescales up to medium range. This presentation shows initial ideas for generating scenarios of ""most likely"" and ""reasonable worst case"" from the advection nowcast tools being developed in IMPROVER and seeks feedback from the conference on other techniques that should be considered.

### Experiences in using INCA precipitation nowcasting for Urban Flood Nowcasting

**Frédéric Jordan**[1]; Matteo Buzzi[2]; Lorenza Gianoni[2]; Raphael Mutzner[1]
*[1]Hydrique Ingénierus, Switzerland; [2]MeteoSwiss*

Nowcasting can be of high added-value during storm events in urbanized areas. Indeed, heavy precipitation during thunderstorms can lead to severe damages due to the runoff in the city. A better alarming system up to one hour ahead can help authorities to prepare the population and be better prepared.
The INCA nowcasting system of MeteoSwiss, coupled with a rainfall-runoff simulation by the Routing System model of Hydrique, is able to provide a runoff forecast up to six hours ahead, updated every 10 minutes. This hydro-meteorological coupling is tested on four different basins in Switzerland, ranging from 5 to 200 km2 drainage areas.
The results indicate that for river basins with about 2 to 6 hours response time, the advantage of using Radar-Inca is limited. However, for river basins with 30min to 2 hours response time, the added value of using nowcasting techniques is real. Good forecasts can then be obtained up to 1.5 time the catchment response time ahead.
Finally, it is also highlighted that the most important feature of such a runoff nowcasting system is the ability to update the forecast with no delay, as the storm events happen rapidly. If not, the added-value of the INCA nowcast is reduced for such applications compared to using only real-time observations at rainfall gauges.

### Application of an integrated hydrological nowcasting chain on Liguria Region

**Maria Laura Poletti**[1]; F. Silvestro[1]; S. Davolio[2]; F. Pignone[1]; N. Rebora[1]
*[1]CIMA Research Foundation, Italy; [2]Institute of Atmospheric Sciences and Climate, ISAC-CNR, Italy*

In recent years, the Mediterranean area has been recurrently affected by flash floods events that caused many victims and damages. Liguria Region, facing the Mediterranean Sea in north west Italy, has been the theatre of many flash flood events in the last few years. Forecasting this kind of events is a critical issue for civil protection because of the small spatial and temporal scale characterizing them. To deal with this problem a starting point is to use the best forecast of the rainfall field as input of the hydrological model. In this work, the idea is to take advantage of all the Quantitative Precipitation Forecast available at the time of the forecast. The elements involved are the nowcasting technique PhaSt, a spectral-based nowcasting procedure, the Numerical Weather Prediction System MOLOCH corrected with data assimilation and the hydrological model Continuum, a continuous distributed hydrological model. Within this study, a coupling of these elements has been performed realizing an integrated hydrological nowcasting chain. The combination of the different rainfall input has been achieved through the blending technique, aimed at the linear combination of the rainfall fields according to their reliability varying with lead time. An innovative approach to the blending technique has been done using the information from the NWPS both in terms of location of the precipitation structures and in terms of variation of the total volume on the domain computed. The chain has been tested on some case events of autumn 2014; a distributed analysis, performed on the entire domain on which the hydrological model is computed, led to representative results for all the basins involved in the events.

### Use of conditional probability for short-range visibility forecasting at Zagreb Airport

**Marko Zoldos**; Jadran Jurkovic
*Croatia Control Ltd., Croatia*

Long-lasting fog events at airports can cause significant delays. Therefore, studies of fog are important for aviation meteorology, as improved forecasts can lead to considerable savings. In 2017, a simple statistical model for probabilistic short-range forecasting of visibility at Zagreb Airport was tested in Croatia Control's aviation meteorology division. This approach was originally proposed by Juras and Pasaric in 2006. The simple model should provide operational forecasters with a tool that could be helpful in forecasting low visibility.
The data used consists of METAR half-hourly reports spanning the period from Jan 1, 1994 to Dec 31, 2016. A first-order autocorrelation process is the theoretical foundation of the model, which in essence combines climatology and persistence (hence the amalgam CLIPER). From that, a relatively simple forecast equation for a given meteorological element, such as visibility (developed by Gringorten, 1971), can be defined. It links the correlation between values of the meteorological element at different time steps with conditional probability for onset of pre-defined values. Hourly correlation coefficients, which describe the climatological persistence of visibility, are calculated for each month from cumulative frequencies of visibility. These correlation coefficients are used to forecast visibility 9 hours in advance. In addition to the median forecast of visibility, 50 % and 80 % confidence intervals are calculated as well. These provide a measure of forecast uncertainty. The forecast by percentile, which is assumed to be more suitable for very rare events, is also provided for comparison.
The results for fog dissipation show promise, while visibility forecasts leading to fog formation are quite inaccurate. In these cases, forecasting by percentile appears to be the more suitable approach. Moreover, forecasting by percentile appears

to be useful in rare events. The model presented here is in operational use since late 2017, and first experiences are promising.

### Using lightning data for nowcasting: performance & evaluation

**Stephane Schmitt**
*Meteorage, France*

Few meteorological organizations currently use lightning data to improve their nowcasting techniques.
It may seem paradoxical when this information is certainly the only one accessible in pure real time, unlike the information based on sequenced observation data or images (radar, satellites, ...).
The effectiveness of the warnings provided by the Lightning Locating Systems (LLS) is very high, making it possible to warn a site more than 20 minutes before the storm reaches it, in more than 95% of the cases in western Europe.
These systems are perfectly adapted to security issues on single-site facilities and capable of individually alerting an operator (industry, airport, leisure park, camping, ...) to secure people and assets.
The proposed study consists in analyzing the personal accidents related to lightning during the period 2010-2018 in France and surrounding, to check whether the current techniques, in particular based on weather vigilance, had been sufficient to anticipate the stormy risk, then to calculate the efficiency that a Thunderstorm Warning System (TWS) based on the EUCLID network would have obtained for each case.
The results obtained reveal an ability to alert with a better than 15 minutes lead time for approximatively 90% of the analyzed situations.
They also show that some accidents can certainly be attributed to unsuitable behavior during a storm, rather than a warning fault.
We suggest that improvement of nowcasting techniques, using raw flash data or more advanced algorithm should be combined with an increased awareness of the population, to better mitigate the risk.

### Nowcasting Decalogue: ten essential ideas

**Luis Bañón**
*AEMET – Agencia Estatal de Meteorología, Spain*

The recent revolutions in technology, observation, computing and communication have led to a paradigm shift in how the weather information associated with nowcasting is brought directly from meteorological systems to end users without the intervention of specialized forecasters or nowcasters. However, the surveillance and nowcasting of the most adverse situations with great social echo still rests on the nowcasters, which can be responsible for the prestige of the institution. The NMHSs, by aligning their efforts makes it possible for the nowcaster to solve these situations optimally.
This presentation, organized in the form of a Decalogue for the proper functioning of a nowcasting unit, covers aspects even before the service begins, such as the organization of the work, the training and coaching of the nowcaster and the previous communication with its user. During the practice of nowcasting, it is vital to adapt the work environment and prepare the collaboration with the team, as well as to quickly access to integrating and probabilistic tools that generate automatic messages and seamless forecasts. The end of this basic Decalogue goes through the realization of post-mortem analysis with which to identify and correct weaknesses and reinforce the entire nowcasting process.

### Catastrophic floods on October 9th, 2018 in Mallorca Island

**Gabriela Cuevas**; Ramón Pascual; Alejandro Roa; David Alfonso Esteban
*AEMET - Agencia Estatal de Meteorología, Spain*

Floods produced by high intensity rain are the greatest natural risk in the Mediterranean countries (Llasat et al., 2010). The swelling of, often dry, streams are especially violent in environments of complex orography, which are very widespread in this area.
During the afternoon of October 9th, 2018 there was an episode of torrential rain with thunderstorm in the mountainous area of the northeast of Mallorca Island. The flash floods that occurred affected mainly the municipality of Sant Llorenç des Cardassar and, to a lesser extend, those of Artà, Capdepera, Son Servera and Manacor, resulting in the death of 13 people. The total accumulated precipitation during the episode reached 230 mm, with hourly records of up to 90 mm and instantaneous intensities greater than 2 mm per minute. It is known that the Levante and the northeast of Mallorca are areas prone to high intensity rainfall, especially in the autumnal months (Grimalt et al., 2001).
The meteorological situation on a synoptic scale was defined at high levels by a cut-off low centered on the northeast of the Iberian Peninsula. The Balearic archipelago was at the forward (eastern) sector of this low, under a moderate southwesterly, slightly diffluent, flow. At low levels, there was a week easterly flow over the western Mediterranean,

established by a strong European anticyclone. This meteorological environment favored the development of convective cells on the sea east of Mallorca that were successively penetrating the island, giving rise to the so-called "train effect" (Doswell et al., 1996) which resulted in the pernicious combination of very heavy and relatively persistent rains.
In this work, the meteorological causes that led to the very serious impacts recorded are analyzed in depth, especially showing the predictive capabilities of the available operational tools

**MeteoVIAS: Web Application for winter road weather forecasting**

**Pedro García**; Nieves Garrido; Ignacio Villarino; Inmaculada Abia
*AEMET - Agencia Estatal de Meteorología, Spain*

Severe weather conditions such as ice or snow on the road are potential risks to the safety and operation of national transport systems. Keeping roads clear and open can be a challenge in certain places, especially in winter. The optimization of human and material resources for this purpose requires specific and updated meteorological information. As an attempt to make a contribution in this regard, the web application MeteoVIAS for weather road forecast has been developed. As a model for weather road forecasting, METRo (Model of the Environment and Temperature of Roads) has been chosen due to its low complexity and easy implementation. During an initial phase, an observation data collection from road weather information system (RWIS) stations was performed. Afterwards, a first test campaign was run, aiming to evaluate the quality of METRo forecast and its optimal setup. The model was validated based on those results. Higher skill was observed compared to HARMONIE-AROME forecast.
In the following phase, a complete system to collect RWIS observation and HARMONIE-AROME forecast data, to run METRo, to store the results and serve them through a web, was developed. The whole system information was automatically updated every 6 hours, providing a 36-hour-range forecast each time.
The web application (MeteoVIAS) shows the specific forecast of METRo on roads together with HARMONIE-AROME forecast in the places where the former is not available. It allows to visualize the expected severe weather conditions (low minimum surface temperature, water film thickness, ice and snow cover) and its severity on an interactive map. It also includes an evolution chart, a summary table and different filtering options. The result is an automatic product, accessible through any web browser, which provides multiple visual severe weather information applied to roads, with several levels of detail.

## Posters

**P1. Observational Analysis Environmental Factors of Associated with Heavy Snowfall in Youngdong area, Korea**

**Hae-Min Kim**; Chag-Geun Park; Baek-Jo Kim; So-Ra In
*National Institute of Meteorological Sciences, KMA, Republic of Korea*

In this study, 11 cases of heavy snowfall associated with inflow of easterly wind in winter (December, January, and February) for last 5 years (2014 ~ 2018) and its relation to environmental factors were examined using 3-hourly rawinsonde and snowfall data at Youngdong area, which is located the eastern coastal region of Korea. The environmental factors such as wind direction, Total Perceptible Water (TPW), Strom Relative Helicity (SRH), and Total Totals Index (TTI) were analyzed.
As a result, the northwesterly wind was dominant at altitudes less than 0.5 km in all cases. In addition, the heavy snowfall occurred when total perceptible water was more than 5.7 mm. In the cases of more than 5 cm in a day (heavy snow advisory), mean SRH which indicates a dynamical instability by veering wind (warm advection) was 153 m2s-2. Meanwhile, in the cases of more than 20 cm in a day (heavy snow warning), mean TTI, which is thought to be associated with thermal instability was 50 ?. This study will be helpful for better understanding of the mechanism of Youngdong heavy snowfall by explaining the atmospheric environments which causes the characteristics of snowfall difference. Various observational and modeling approaches need as further studies for the atmospheric features associated with snowfall

**P2. Sensitivity Analysis on Characteristics of Snowfall to the Meteorological Conditions in the Yeongdong Region**

**Baek-Jo Kim[1]**; Yoo-Jun Kim[1]; So-Ra In[1]; Hyoung-Gu Nam[1]; Byung-Gon Kim[2]
*[1]National Institute of Meteorological Sciences, KMA, Republic of Korea; [2]Gangneung-Wonju National University, Republic of Korea*

This study investigates the characteristics of snow particles and snowfall with the different meteorological conditions based on the combined integration of numerical modeling and upper-air observations. The high-temporal resolution (3-hourly) dataset of rawinsonde soundings and snow particle photographs for snowfall episode of two-layered cloud structure that occurred on 29-30 January, 2016 were used. We found out that rimed particles tend to turn into dendrite-like particles as 850 hPa temperature decreases with time. Rawinsonde soundings showed well-defined two-layered cloud structure along with distinctive wind directional shear and strong inversion in equivalent potential temperature above the low-level cloud layer. Sensitivity tests were also carried out to investigate the effects of various meteorological factors on snow characteristics using a high resolution cloud resolving model, namely Cloud Resolving Storm Simulator (CReSS). First, temperature (TEMP) experiment showed a significant difference in snow particles such as increase (2.2 times) in proportion of graupel in the first period and increase (22.5 times) in proportion of snow in the second period, compared with the control (CTRL) experiment. In the single-layered cloud (CLD1) experiment, there was no significant difference, while the easterly (EAST) experiment enhanced the precipitation more than 3 times compared with CTRL. The current results could be used as fundamental data for improving predictability of snow particles in the Yeongdong region.

### P3. Using multi-sensor multi-year statistics of convective events to improve nowcasting systems

Kathrin Wapler
*DWD – Deutscher Wetterdienst, Germany*

While the nowcasting of thunderstorms improved, the estimation of the convective development is still challenging. The analysis of a large number of past events supports a better understanding and a better nowcasting of future events. Large datasets are essential to cover a wide spectrum of possible convective developments.
To thoroughly describe convective systems, a multi-sensor approach is desired. Building a multi-year multi-sensor dataset, reflectivity based object attributes were combined with rotation characteristics and lightning activity. These tens of thousands of convective cells were sorted according to their lifetime. Analysing the temporal evolution of various cell attributes for different lifetimes reveals typical cell developments.
Among others, the analysis showed the different evolutions of rotating and non-rotating cells. The large dataset confirmed that convective cells with mesocyclone (supercells) are longer-living compared to non-rotating cells. Furthermore, the importance of lightning data to characterise convective cells was demonstrated.
The results of the life-cycle analysis and the analysis of lifetimes in dependence of cell attributes can be used as input for nowcasting systems for probabilistic forecasts of cell lifetimes and further convective development (strengthening or weakening). The temporal evolution of the median of a cell attribute as well as its spread can be used to construct an ensemble.
DWD is currently expanding its nowcasting systems to provide probabilistic information. In a first step, life-cycles of reflectivity-based cell attributes derived from historic events could already be implemented to estimate the remaining lifetime of detected convective cells.
The multi-sensor dataset could also be expanded using reanalyses of environmental atmospheric conditions such as lability or shear. This allows studying e.g. the cell motion relative to environmental wind fields or the relation between mesocyclone severity and shear. The knowledge of convective system characteristics in relation to environmental conditions will allow to better nowcast expected convective developments in the future.

### P4. Utilization of 15-yr characteristics of weather radar and lighting data for improvement of Czech Hydrological Institute's convective storm nowcasting system

Petr Novak; Hana Kyznarová
*Czech Hydrometeorological Institute, Czech Republic*

Since the 90's, the Czech Hydrometeorological Institute (CHMI) has been operating digital Czech weather radar network (CZRAD) covering whole area of the Czech Republic and its neighbourhood. Additionally CHMI has been utilizing lightning data from the Central European Lightning Detection Network (CELDN) over the same domain. Both types of data are operationally used in CHMI meteorological and hydrological forecast offices and they proved to be very useful for operational detection, monitoring and nowcasting of convective storms. Weather radar and lightning products are main inputs of CHMI's convective storm nowcasting system. This system is based on COTREC and CELLTRACK nowcasting algorithm and web-based visualization tool JSMeteoView. Currently, CHMI is running project that includes improvement of this nowcasting system.
Archive of both datasets (volumetric CZRAD measurements and CELDN lightning detections) is available in CHMI. Data from fifteen-year period 2002-2016 have roughly the same quality, therefore this time period was used to calculate long-term spatial and temporal characteristics of various weather radar and lightning products. These long-term characteristics show many quality issues of weather radar and lightning products and are also very useful for definition of decision thresholds of convective storms severity. These findings are valuable for human forecasters as well as for automatic nowcasting systems.
The presentation will present these long-term characteristics and their utilization for improvement of CHMI's convective storms nowcasting system. It will discuss relation between radar and lightning characteristics and will present also long-term characteristics of convective storms identified by the cell-oriented CELLTRACK nowcasting algorithm.

**P5. The CI and RDT NWCSAF Convection Products**

Jean-Marc Moisselin; Michaël Claudon; Frédéric Autonès
*Météo-France*

Météo-France develops and contiuously upgrades CI (Convection Initiation) and RDT (Rapidly Developing Thunderstorm) products. Both have been developed in the framework of NWCSAF. The software is available for all NWCSAF end-users. CI is a pixel-based product that provides the probability for a pixel to develop in thunderstorm. The first delivery of the product is version 2016. The last version, v2018, has reached the ""pre-operational"" in Eumetsat sense status thanks to new developments (e.g. use of microphysics), tuning and validation effort.
RDT is an object-based product that aims to detect, track, characterize and forecast the convective cells. The RDT product is now the fruit of more than 15 years of development. The current delivery, v2018, includes new features like lightning jumps detection and is highly flexible and configurable. RDT is very useful for aviation end users.
Both products are operated by Météo-France, on a global scale (5 satellites) for RDT.

**P6. Combination of object-based probabilistic nowcasting and NWP ensemble**

Rafael Posada; R. Feger; M. Schultze; K. Wapler; M. Werner
*DWD, Deutscher Wetterdienst, Germany*

A pilot project has been set up at Deutscher Wetterdienst (DWD) to develop a Seamless INtegrated FOrecastiNg sYstem (SINFONY). It aims to integrate nowcasting techniques with numerical weather prediction (NWP) to create a seamless forecast from observation time up to, at least, +6 h. To achieve this goal, the project focuses on enhancing both nowcasting and NWP separately and developing more reliable combined products.
Regarding these combined products; SINFONY will provide a probabilistic object-based forecast based on the combination of convective cells detected in probabilistic nowcasting and in NWP-Ensemble. The detection of these cells is carried out with KONRAD3D, a method developed at DWD to detect, tracking and forecast the trajectory and evolution of convective cells based on observed radar reflectivity. This method can also be used to detect cells simulated by the NWP since the model forward operator EMVORADO (Efficient Modular VOlume scanning RADar Operator) is able to provide simulated radar data with the same structure and time resolution as the actual radar observations (each 5 minutes). The use of the same method for object identification facilitates the comparison of the identified objects in both nowcasting and NWP.
In this context, a comparison between simulated and observed cells was made to know to what extent the model can reproduce the cells detected in radar. Additionally, an analysis of different KONRAD3D setups has been carried out to identify which one should be used when combining both datasets. Finally, a first method based on clustering-techniques has been developed to generate the object-based combined product.
The first results concerning the comparison, the KONRAD3D analysis and the combined product are presented here.

**P7. WRF-ARW based systems for nowcasting and very-short range forecasts at the Meteorological Service of Catalonia**

Jordi Moré; Jordi mercader; Abdelmalik Sairouni; Manel Bravo
*Meteorological Service of Catalonia, Spain*

As a first step on the development of a seamless forecast system at the Meteorological Service of Catalonia, we describe two experimental real-time tools which are based on the WRF-ARW model and make use of high resolution observational data in a variational framework.
The first tool consists in three parallel WRF model suites, which are intended for very short range forecasts (VSRF). The simulations are refreshed every 3 h to make use of the latest observations, namely our AWS and radar data (reflectivity and radial velocity). All of them run the same WRF model configuration (3 km grid spacing and length up to 12 h), but differ in its data assimilation system. Thus, one suite uses LAPS/STMAS to perform a sequential variational multigrid analysis which also ingests MSG imagery data. The other two are based on a 3DVAR system (WRFDA), one making use of a climatological B matrix, and the other one considering also flow-dependency information through a hybrid approach (3DEnVAR) based on a time-lagged ensemble. In a near future, this set of VSRF could provide probabilistic forecasts for the range 0-6h in the framework of a time-lagged ensemble.
The second tool consists of a three dimensional high resolution real time analysis based on the LAPS/STMAS system. In this one, a higher frequency assimilation cycle is performed combining observational data (AWS, radar data, and satellite imagery) with the latest WRF forecast at 3 km available from the rapid update cycle previously mentioned. As a result, a high resolution analysis (1 km grid spacing) is obtained every 30 minutes as a surveillance tool and information

for any meteorological parameter can be derived and eventually used for the nowcasting observational systems that might require them.

### P8. Radar-Based Nowcasting by Combining Centroid Tracking and Motion Vector of Convective Storm

Youn Choi; Kwang-Ho Kim; Sung-Hwa Jung; Kun-Il Jang
*Korea Meteorological Administration, Republic of Korea*

Radar-based nowcasting system of precipitation is generally categorized into centroid tracking method and area-based tracking technique. While the centroid method can provide physical properties of individual convective cells such as top height, area, volume of storm and liquid water contents within a storm, area-tracking method provide motion vectors over entire precipitation fields. We aim to combine both methods by utilizing complementary characteristics in this study. Two approaches were examined by combination of two methods for determination of future position of convective cells. First, convective cell was forecasted by using motion vector over pre-identified storm cell area. Second, the future position of storm cell was determined by re-identification of cell in reflectivity field advected by motion vector. Here, FAST(Fuzzy logic Approach for Storm Tracking) was used as centroid tracking method and MAPLE(McGill Algorithm for Precipitation nowcasting by Lagrangian Extrapolation) was utilized as area-based technique. several cases of the isolated thunderstorm and mid-latitude cyclones were separately analyzed.

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### P9. Very Short-Term Forecasting of Precipitation Based on Hybrid Surface Rainfall Technique in Korea

MyoungJae Son; Young-A Oh; Ji-Won Kim; Kyung-Yeub Nam; Kun-Il Jang; JeungWhan Lee
*Korea Meteorological Administration, Republic of Korea*

McGill Algorithm for Precipitation Nowcasting by Lagrangian Extrapolation (MAPLE) model was applied for use in nowcasting of precipitation, predicting the lightning frequency and forecasting probability of lightning strikes over the Korean Peninsula including its islands. The limitation of forecasts data from the MAPLE model is that it does not predict the growth or dissipation of precipitation echoes. For that reason, the difference between forecasts and observation become biased not only as forecast time increases but also as depending on the quality of initial data. Initial rainfall estimation is the key of accurate Quantitative Precipitation Estimation (QPE) and very short-term quantitative forecasts (QPF). To improve radar rainfall estimation, Hybrid Surface Rainfall (HSR) technique have developed, which is radar rainfall estimation at the two-dimensional hybrid surface choosing the lowest radar bins that is minimization of contamination from significant beam blockage and ground clutter, to enlarge rainfall region and to prevent contaminations from blockage, ground clutter, and chaff echo. Meteorological object analysis using multi-quadric interpolation was implemented in QPE with Automatic Weather Station (AWS) data and HSR estimation data. By using this method, a better quality of QPE data with improving QPF prediction is made. The service delay time of process and forecast is reduced from 15 minutes to 8 minutes by removing the quality control process of satellite data, software optimization, and setting optimal production time. The nowcasting products of HSR rainfall, the lightning frequency, and probability of lightning strikes using MAPLE were serviced to forecasters of the Korea Meteorological Administration (KMA) every 10 minutes up to 6 hours.

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The research is supported by “Development and application of cross governmental dual-pol radar harmonization (WRC-2013-A-1)” project of the Weather Radar Center, Korea Meteorological Administration

### P10. Improvements of Motion Vector in Variational Echo Tracking Technique by Correction of Initial Guess

Kwang-Ho Kim[1]; Jong-Hoon Jeong[2]; Sung-Hwa Jung[1]; Mi-Kyung Suk1; Kun-Il Jang[1]
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Nowcasting performance of the McGill Algorithm for Precipitation nowcasting by Lagrangian Extrapolation (MAPLE) technique is significantly subjected of the echo motion field derived from Variational Echo Tracking (VET) technique. VET is based on a scaling-guessing method to reduce the risk that minimization converges towards secondary minima. However, since the scaling-guessing method uses one initial guess as a constant, it is difficult to estimate the motion vector in the beam blockage or weak echo area. Because MAPLE predict the location of precipitation echo by Lagrangian

extrapolation using motion vectors, the accuracy of the motion vector directly affects prediction accuracy of MAPLE. In order to improve the accuracy of motion vectors of VET in this study, initial guess was corrected by using analysis field of numerical model. The motion vectors are calculated over 25*25 sub-area using a constant as initial guess by scaling-guessing method. A motion vector at each grid point is then derived by bilinear interpolation using the 25*25 motion vector to apply the semi-Lagrangian advection. We applied 700 hPa wind field of numerical model analysis instead of a constant as initial guess of VET. Correction of initial guess of VET using numerical model solved the problem of underestimation of motion vectors in the beam blockage and ground echo area. As a result of applying the improved motion vector to semi-Lagrangian advection, prediction accuracy of MAPLE was improved by 22% for 3-h forecast and the distortion of the precipitation shape is also reduced.

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### P11. Shaping the future portfolio of the “Extrapolated Imagery” product of the Nowcasting-SAF

Alexander Jann
*ZAMG - Zentralanstalt für Meteorologie und Geodynamik, Austria*

„Extrapolated Imagery“ (abbr. EXIM) has been a component of the Nowcasting-SAF package for geostationary satellite imagery (NWC/GEO) since its version 2016. Using atmospheric motion vectors provided by another NWC/GEO component, “High-resolution Winds”, EXIM performs kinematic extrapolation on NWC/GEO products or geostationary satellites' images. Its current portfolio comprises infrared, water vapour and visible imagery from SEVIRI (and Himawari and GOES-N) and the cloud and precipitation products of NWC/GEO.
Issues of both scientific and technical nature concerning the optimum product design and development priorities have been identified in internal discussions on the first (pre-)releases. With the goal of gaining first feedback on the preferences of actual and/or potential users, the options will be presented and illustrated by means of example output imagery, evaluation statistics,… The addressed topics include:

- Appropriateness of the current parameter portfolio
- User expectations on output design (such as: “full images” vs. “only-cloud”; acceptance of gaps in case of unavailability of suitable displacement vectors (where “suitable” means: near the affected pixel, both horizontally and vertically))

### P12. A comparison between advection nowcasting using Optical Flow velocities and NWP modelled wind fields

Stephen Moseley; Caroline Sandford
*Met Office, UK*

The replacement of the Met Office UK post-processing system (UKPP) in 2021 will include the retirement of the Met Office Short Term Ensemble Prediction System (STEPS) nowcasting system. A new Met Office nowcasting system (MONOW) will initially generate a deterministic radar extrapolation nowcast, which will undergo probabilistic post-processing and blending with the UKV as part of the new IMPROVER system.
STEPS generates precipitation nowcasts by a complex system of scale decomposition and blending. This includes an extrapolated radar field created using advection velocities based on an Optical Flow method. Optical Flow has a few drawbacks when used to advect precipitation data. Where there is no precipitation present, the Optical Flow advection velocities tend to zero meaning that precipitation will move more slowly or even stop when it reaches these regions. To overcome this, smoothing is used which can remove useful small-scale features. The Optical Flow advection velocities also do not vary in time.
Numerical Weather Prediction (NWP) models can predict changes in wind fields and here we present comparisons between extrapolation using advection from Optical Flow and an NWP simulation.

### P13. Development of a probabilistic precipitation-nowcasting approach at DWD

Markus Schultze; Martin Rempel; Robert Feger; Manuel Wener; Kathrin Wapler; Ulrich Blahak
*DWD, Deutscher Wetterdienst, Germany*

At Deutscher Wetterdienst (DWD) a pilot project has been set up to start the development of its future seamless INtegrated FOrecastiNg sYstem (SINFONY). One aspect of the project concerns the improvement of the existing nowcasting system and the extension to an ensemble approach.

The operational radar-based precipitation nowcasting at DWD employs the so-called optical flow technique. It uses composites of terrain-following low elevation radar reflectivity measurements. With this approach the motion vector of individual reflectivity pixel in the composite is estimated from previous observations and the position is linearly extrapolated into the future. The intensity of advected pixels is kept constant during the whole forecast. Deterministic predictions are provided in time steps of 5 minutes with forecast periods of 2 hours and updates every 5 minutes.
To account for the limited predictability of precipitation, especially in convective situations, a transition from deterministic to probabilistic nowcast is necessary. Two different types of inherent forecast uncertainties are addressed: the uncertainty in the propagation of precipitation structures (advection uncertainty), and the uncertainty regarding strengthening and weakening of precipitation during the forecast (dynamic uncertainty). One possibility to assess the advection uncertainty is the variation of parameters within the optical-flow approach, for example the weighting of the motion of individual pixels in comparison to the large-scale motion. The dynamic uncertainty is considered with a scale-dependent auto-regressive extrapolation of precipitation intensity that is perturbed by correlated stochastic noise in the course of the forecast. With this approach, large-scale precipitation (e.g. frontal rain) is predicted to be more persistent than small-scale precipitation (e.g. thunderstorm). An ensemble is generated by different realizations of stochastic perturbations.
First results for different case studies from Germany during May and June 2016 are presented. This period is characterized by a variety of severe convective events in particular with respect to heavy precipitation.

### P14. On the impact of machine learning for nowcasting applications

Alexander Kann; Irene Schicker; Petrina Papazek; Linye Song; Yong Wang
*ZAMG - Zentralanstalt für Meteorologie und Geodynamik, Austria*

Precise very short range forecasts of the spatial and temporal distribution of temperature, wind and precipitation are of vital interest in many modern applications, e.g. weather warning, flood forecasting. Traditionally, observation based methods such as extrapolation of consecutive radar images are bridging the gap between analysis and NWP forecasts. Although modern NWP systems (i.e. RUC, Rapid Refresh) are more and more capable to meet the nowcasting requirements, they still exhibit deficiencies within the first few hours (mainly due to spin-up effects or higher latency due to computational costs).
During the past years, the scientific enthusiasm for artificial intelligence and machine learning has reached the meteorological community. Classical statistical post-processing methods (MOS) are complemented by machine learning algorithms like artificial neural networks (ANN), Support Vector Machine (SVM), Random Forests (RF), among many others. For nowcasting purposes, the present paper discusses the capability of machine learning methods to add skill to classical approaches. Considering the example of precipitation and wind nowcasting, possible implementations that make extensive use of available real-time data are examined. Pros and cons as well as potential operational implementations will complete the presentation.

### P15. Assessment of satellite rainfall nowcasting based on extrapolation technique

Seon-Young Jeong; Ki-Hong Park; Geun-Hyeok Ryu; Jae-Dong Jang
*KMA – Korea Meteorological Agency, Republic of Korea*

The National Meteorological Satellite Center (NMSC)/Korea Meteorological Agency (KMA) produce extrapolated images based on satellite data for nowcasting. THE MAPLE (McGill Algorithm for Precipitation Nowcasting and Lagrangian Extrapolation) algorithm is a technique to predict echo after several hours by Lagrangian extrapolation using motion vectors generated by VET. It is used for radar - based precipitation prediction, but it is also applied to satellite images. However, the VET technique used in MAPLE has the problem of moving the coastline or the land because it generates vectors in the clear regions and predicts them based on images. To solve these problems, the NMSC uses the EXIM (Extrapolated Imagery) algorithm to produce a prediction image. The EXIM algorithm is an algorithm developed by NWCSAF, which uses an atmospheric motion vector containing altitude information. The EXIM technique solves the previously mentioned problem by applying cloud detection and land / sea mask.
Since the NWP prediction of rapidly developing storm has limitation, the usability of the precipitation prediction information based on the real-time observation is enhanced. The application of rainfall information based on real time observations is increasing. We use MAPLE and EXIM to produce precipitation forecasts. MAPLE-based precipitation prediction is predicted by using the vector generated in the infrared channel, and EXIM is predicted using AMV of higher than IR / VIS 400hpa. In order to verify the accuracy of the rainfall prediction information, we compared the MAPLE motion vector and the AMV used in EXIM then, the proper motion vector for rainfall nowcasting.

### P16. Current Status of Convective Clouds Discrimination in NMSC/KMA

Ki-Hong Park; Geun-Hyeok Ryu; Jae-Dong Jang

*KMA – Korea Meteorological Agency, Republic of Korea*

Nowcasting is the science of anticipating the extraordinary and severe weather events such as heavy rainfall, lightning, hail in the next few hours (0~6 h). Geostationary satellite observation can provide a nowcast of the location and timing of developing storms. Occasionally, The Korean Peninsula has been influenced by heavy rain of rapidly developing convective cells in the summer season. Also, convective cloud system flows into inland from the west coast over the Yellow Sea. Sometimes, locally developed convective cell often occurs over the Korean Peninsula due to unstable atmosphere condition. Thus, the National Meteorological Satellite Center (NMSC) of KMA has the Rapid Development Thunderstorms (RDT) module developed by NWCSAF/EUMETSAT. The RDT algorithm consists of three parts: detection, tracking, and discrimination which provide information on clouds related to significant convective systems using geostationary satellite data. In order to optimize the use of satellite data, we adapted Himawari-8/AHI data to RDT module and performed the tuning of discrimination model by an ensemble of logistic regression over the Korean Peninsula. In addition, it improved the detection of convective clouds by adjusting the stability index mask based on the NWP data. As a result, discrimination skill of RDT algorithm was improved (POD ~75%, severe lightning). However, the RDT product still overestimates convective cells compare to radar and lighting data. For the future work, we plan to improve the RDT algorithm using rapid scan data of GK-2A. Also, we want to apply various machine learning methods using radar reflectivity data and visible channel data.

### P17. **Nowcasting support using satellite imagery extrapolation technique**

Heeyong Lee[1]; In-Chul Shin[1]; Chu-Yong Chung[1]; Seong-Hoon Cheong[1]; Gyu-Won Lee[2]
*[1]KMA, Korea; [2]Kyungpook National University, Republic of Korea*

The Korea Meteorological Administration successfully launched the GEO-KOMSAT-2A in December 2018, and plans to service its data in July 2019. Many product retrieval and application algorithms are under developing, and satellite forecast image processing for nowcasting application is one of them. . This technology uses simple image extrapolation based on the motion vectors generated from MAPLE developed by McGill University of Canada. In this study, Himawari-8/AHI data was used, which is similar to GK-2A/AMI, the target sensor of this study. Considering the processing time, the domain was set to 2400 × 2400(East Asia) and the 9 hour extrapolation forecast fields were produced with a 10-minute interval. For the longer time forecast, we introduced the merged motion vector using numerical weather prediction (NWP) model. In the earlier forecast time period, the motion vector determined by MAPLE is dominantly used, but NWP based motion vector weighing is became larger depending on the forecast time. In this presentation, we will introduce the satellite forecast image processing technology, we are developing. Some case results and discussion will be presented.

### P18. **Pysteps - a Community-Driven Open-Source Library for Precipitation Nowcasting**

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Pysteps is a community-driven effort to implement an open-source Python library for probabilistic radar-based precipitation nowcasting. Currently the project has contributors from Finland, Switzerland, Canada and Australia. Being hosted on GitHub and published under the GNU GPL license, it is easily accessible to researchers and practitioners. Pysteps aims to be a modular library with interchangeable components, thus making it an easy-to-use platform for research purposes. On the other hand, the public availability makes it an easily accessible tool for a wide range of practitioners from weather forecasters to hydrologists. This is facilitated by support of standard input and output file formats (e.g. HDF5 and NetCDF) commonly used in meteorological agencies.
The theoretical framework of pysteps is built on the Short-Term Ensemble Prediction System (STEPS) originally developed in the Australian Bureau of Meteorology. In this approach, a deterministic nowcast is computed by using optical flow techniques and a semi-Lagrangian advection scheme. The input precipitation field is decomposed into multiple spatial scales, and an the temporal evolution of precipitation intensities is modeled based on scale-dependence of predictability. Stochastic perturbations are added to precipitation intensities and to the advection field in order to simulate uncertainties. Pysteps implements a collection of modules aimed at the above tasks. Several optical flow techniques as well as advanced stochastic generators have been implemented. In addition, pysteps contains statistical post-processing, visualization and extensive set of verification metrics for both deterministic and probabilistic nowcasts. New features not implemented in the present operational nowcasting systems include localization of the nowcasting model. Our results show that this offers improved forecast skill particularly in large domains, where different types of precipitation can coexist due to different meteorological and geographical conditions.

### P19. **Detection, tracking, and nowcasting of convective cells using KONRAD3D**

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In the recent years, a new tool for the automated detection, tracking and nowcasting of convective cells, called KONRAD3D, has been developed at Deutscher Wetterdienst (DWD). Its main goal is to further improve the performance of DWD's automated warning decision support system AutoWARN and to equip other internal and external customers and follow-up applications with an improved scheme based on three-dimensional quality-controlled radar data, complemented by lightning and satellite data.
KONRAD3D was initially designed and planned as a deterministic scheme. However, in the course of DWD's project SINFONY (Seamless INtegrated FOrecastiNg sYstem), the scope was extended to probabilistic ensemble nowcasting. On the one hand, this was done to be able to assess uncertainties of generated detections and nowcasts. On the other hand, the probabilistic setting seems more adequate for the design of seamless products derived from nowcasting and NWP. Moreover, it allows for a convenient incorporation of cell lifecycle models by which we intend to better predict reinforcement or mitigation tendencies.
The deterministic core of KONRAD3D uses state of the art techniques for detection, tracking and forecasting of convective cells. For instance, we resort to adaptive thresholding schemes for cell detection and apply Hungarian matching and classical Kalman filtering of cell centroids and velocity within the tracking and forecasting component. In addition, cell tracking is supported by standard optical flow methods imported from the widely used OPENCV (Open Source Computer Vision) software library. A variety of cell attributes is derived capturing the three-dimensional geometry and the intensity of the cell.
The present work focuses on this deterministic radar-based core of KONRAD3D. We present the basic design and internal workflow and give an overview on the various cell attributes and how they are computed. We also illustrate the basic functionalities for prominent example cases.

**P20**. **First verification results from an analysis-forecast smoother applied at FMI**

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In order to provide real-time seamless forecast for operative forecasting purposes, an analysis-forecast smoother has been applied over the Scandinavian domain at FMI since July 2018. The method takes the latest analysis field from LAPS analysis system and the four-hour forecast field from the operative weather forecast. Any forecast model could be used, though. Then, the one-to-three hour forecast fields are interpolated in between of these using an OpenCV-based optical flow interpolation method. The smoother is run once an hour whenever a new LAPS analysis has been produced. Currently smoothed variables are temperature, dewpoint, wind speed and pressure. Total cloud cover and 1h accumulated precipitation are following soon.
The method is able to nicely preserve well-behaving features in the animations, especially for the pressure which typically has smooth spatial characteristics. The behaviour of the other variables often is considerably more complex and they have a smaller spatial scale. This sometimes results in an apparent discontinuity on the field motion at the four-hour forecast length - The ""frozen-turbulence"" approximation is the better the more similar the characteristics in the analysis and model fields are. Often, either field is missing some visible feature present in the other field.
There are several ways to improve the existing scheme: Four-hour ""predictability"" could be dynamically adjusted, the two input fields should be smoothed to have the same spatial characteristics and the interpolated fields in the between often behave too linearly. However, the feedback from the forecasters has in general been encouraging and our verification statistics also show that the minimum requirement of the interpolated fields is met: The RMSE of the interpolated values outperform both DMO and persistence in one to three hour forecast range. The results also reveal interesting differences on the predictability between the used variables.

**P21**. **Convection-induced severe winds over Menorca Island on 28 October 2018. Under the watch of a forecaster**

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In the morning of 28 October 2019 a severe thunderstorm crossed Menorca Island from south to north producing very strong winds and tornado-strength damage including the collapse of four high voltage towers and a subsequent wide blackout which last for 72 hours. Wind gusts up to 140 km/h were estimated through a comprehensive field study, which concluded that both microburst and tornado phenomena could be responsible for the observed damage. The affected areas were located beside the convective cell path along 20 km. A detailed report on the impact of severe winds will be presented here.
The present study explores this event of severe weather under the perspective of an operational forecaster, from the diagnosis and short range forecast using NWP systems, to the monitoring of the meteorological situation. An assessment

of past and current weather conditions is accomplished by monitoring data from automatic weather stations and satellite images, but lightning and radar products are the main tools to fulfil surveillance and nowcasting.
Beyond the rushed operational analysis, a more thorough study has been carried out on the dynamics and environmental instability that allowed deep convection. The event occurred during a strong cold outbreak that took place over Western Europe from 26 October. On the 28th an upper-level through was deepening over Iberia, pushed southwards by a 150 kt upstream jet streak, and cyclogenesis in Balearic surroundings took place in response to high dynamical forcing. Severe convection developed just ahead the cold front, inside the mass of subtropical air characterized by moderate to high conditional instability.
We discuss the nature of the thunderstorm that produced high-impact winds, which exhibit characteristics in common with supercels, and analyse the predictability of such a phenomenon with the current nowcasting tools.

**P22. Construction of a krigged precipitation field based on surface observations and remote sensing tools. Application to the flash-flood event of October 9, 2018, over the east part of Majorca**

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Torrential precipitation events in small river basins can produce flash-floods with high impact and associated damage. In this contribution we focus on the precipitation field during the tragic event of October 9, 2018, which caused 13 deaths and losses close to 100 millions of euros in the municipality of Sant Llorenç (Majorca, Spain). Starting with ten-minute precipitation data measured by a number of rain gauges which are distributed over the east part of Majorca we analyze how different remote sensing tools and model fields can provide added value to the constructed field by means of interpolation or ordinary kriging. The ancillary information for the kriging is obtained from the radar-based estimation of rain and from the NWC SAF Convective Rainfall Rate product. High-resolution model fields like orography or humid advection are also taken into account. The preliminary results could give rise a product to be used by forecasters in future events of this nature.

**P23. A new severe weather warnings system to very short term, based on the lightning jump technique**

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The Severe Weather Warning Project of the Meteorological Service of Catalonia (SMC) aims to develop and put into operation a warning system for forecasting severe weather phenomena in the very short term (large hail, severe gusts wind, downbursts or tornadoes). This new method, which will complement the existing system of Hazard Weather Warnings of SMC, will be deployed jointly with Civil Protection, who will inform local administrations and other end-users to manage the necessary actions and thus minimize the possible effects of the severe weather phenomena.
The severe weather warning system is based on the study of Lightning Jump method. This nowcasting technique provides an indicator of the sudden increases in the total intensity of lightning inside a convective system before a severe weather phenomenon occurs (between 30 minutes and 2 hours in advance).
On the other hand, the SMC has developed specific software that shows LJ alerts, as well as the evolution of convective systems. Storm tracking is estimated with weather radar data of the SMC network, and provides a cone of probability of its future movement in the very short term (2 hours view). Nowadays, from the SMC a pilot test is underway. When an LJ alert is detected a short term warning is issued for the possible areas affected. This warning system is expected to be operational in the near future in coordination with Civil Protection.

**P24. Radar Nowcasting for the German Air Traffic Control**

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The DWD (German National Meterological Service) is the designated air navigation service provider for the DFS (German Air Control Service). The project IRADAR was created to develop innovative radar based products for the DFS. Key among the products that the DWD already provides are radar composites for the German airspace. They consist of radar station and composite data provided by DWD and its European partners. The contributions differ in their quality, validity times, production timings (e.g. 2.5,5,10 minutes) as well as the delay time between production and delivery.
One goal of the project is to deal with these sources of inhomogeneity to improve the resulting composite. This will be the basis to produce nowcasts up to 25 minutes, with a stepping size of one minute, updated every five minutes. A fast production cycle is mandatory to provide the air traffic controllers with optimal information.

The production cycle of the composite and the nowcasts is organized along a time grid with a stepping size of five minutes. Each contribution is casted with optical flow techniques to the time of the next composite that will be produced and to the time step thereafter. The composite at target time consists of the freshest available data. Contributions with timings of 10 minutes (or more) as well as missing contributions do not show as holes in the composite since forecasts are available as backup. Next, the composite is forecasted by means of the POLARA software developed at DWD. Finally, the available motion information is used to cast the contributions for the next composite.
The presentation gives an overview of the new production of radar nowcasts for the DFS and the challenges of the combination of temporal inhomogeneous radar data from European partners.

Project IRADAR is funded by BMVI (Federal Ministry of Transport and Digital Infrastructure).

### P25. **Comparing observed and modeled radar reflectivities at different spatial scales**

Chiara Marsigli
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In the framework of the SINFONY Project of the Deutscher Wetterdienst, seamless ensemble predictions will be generated, by combining nowcasting and short-range forecasting ensembles. A calibration will be developed for the resulting combined ensemble products. With a focus on the prediction of convective events, this will require to perform a matching between reflectivity fields derived from radar data with reflectivity fields generated by a radar operator elaborating the NWP model output.
Tough the two fields to be compared and combined, the observed and the modeled one, are expressed in term of the same variable (reflectivity), they have different characteristic, since they are derived from very different sources, and with different spatial resolution. Therefore, aiming at their calibration and verification, a study is performed in order to assess their different characteristics. In this work, this is performed by analyzing the frequency distribution of the two fields, over a set of cases of convection. The spatial characteristics of the two fields are also studied. In order to improve their degree of matching, spatial aggregation is performed, following a neighbourhood approach. Based on spatial verification methods (e.g. FSS), it is studied at which scale the spatial aggregation permits to reach a good level of matching between them.

97

### P26. **Thunderstorms and the public perception of risks**

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Extreme meteorological events are the cause of major loss both to values and lives even in a highly developed country as Germany. While enormous progress was made in the field of weather forecasting, this was less so in transforming such forecasts into successful warnings. However, there are multiple factors underlying the communication and use of weather forecast information. In an inter- and transdisciplinary approach involving meteorology, social sciences, and psychology, the project WEXICOM investigates the optimal use of weather forecasts and warnings to the benefit of the society. A basic understanding of weather risks is essential for the public to anticipate risks and respond appropriately. A representative study was performed to test the knowledge of the German public regarding weather risks.
As shown by many contributors during the last European Nowcasting conference, thunderstorms are still one of the major themes in nowcasting. We present a multi-year analysis (using measurements from the German weather radar network and a lightning location system) of thunderstorm occurrence and characteristics, and contrast it with the perception of thunderstorms by the German public tested as part of the representative study.
While stationary cells might lead to excessive rain on small spatial scales, supercells (which often produce hail or even tornados) tend to propagate faster than ordinary thunderstorms. Thus, people may be caught by surprise if they underestimate the speed of thunderstorms or the time a presumable “harmless” cumulus cloud needs to evolve into a deep convective thunderstorm. Although almost 80% of the study respondents were aware that thunderstorms can travel and evolve fast, about 50% were unaware that lightning can strike even 10 km away from the storm. Moreover, about 40% overestimated the distance to a thunderstorm based on the gap between lightning and thunder, and may not seek shelter in time in critical situations.

### P27. **Nowcasting for the road maintenance during winter in CHMI**

Tereza Uhlíková; Lenka Musilová
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The road meteorology is an important application of the operational weather forecasting. In the Central Europe, especially winter weather creates many challenges for the road maintenance authorities, who ensure fluent and safe traffic. Potentially dangerous weather phenomena during this season include decreased visibility (due to fog or heavy snowfall), icy road conditions (black ice, frost deposit) or snow drifts. Regarding the high impact of these phenomena on traffic, Forecasting Offices of the Czech Hydrometeorological Institute (CHMI) issue new road weather forecasts every 4-7 hours during the winter period (1st November to 31st March). Crucial information is provided by regional NWP models (ALADIN, ICON, UM) with a six hour update cycle and atmospheric sounding. However, to increase the accuracy of forecasts, several nowcasting techniques are employed as well. We present strengths and weaknesses of these techniques used in CHMI operational nowcasting during winter (e.g. extrapolation, optical flow, blending of NWP model outputs with observations). Furthermore, we give an overview of surface observation network in the Czech Republic and suggest possible improvements for the road meteorology nowcasting.

### P28. Improving OPERA radar data for nowcasting

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Radar data is an essential element in nowcasting by extrapolation. Edges of your radar image dictate the maximum length of your nowcasts. So it is natural to look for international radar composites, such as the Pan-European composite by OPERA programme of EUMETNET, the European Meteorological Services' Network. Park & al. (projects ERICHA, SMUFF) have used the OPERA composite for European-scale forecasting because of its superior coverage, but they noticed the quantitative accuracy is not good enough for hydrological purposes. On the other hand, those running nowcasting models in national scale have not always been happy in timeliness of the product.
Because of the disparate needs of different users, OPERA is now developing three separate production lines: for the good, for the fast and for the independent ones. We will also utilize the large investments made in national networks in 2010-2018 by shifting the focus of quality control to national level.
Further reading:
Huuskonen, Saltikoff and Holleman (2014), The Operational Weather Radar Network in Europe BAMS 95, No. 6 pp. 897-907
Park, S., Berenguer, M., and Sempere-Torres, D.,(2019): Long-term analysis of gauge-adjusted radar rainfall accumulations at European scale, J. Hydrol, under revision (as of February 2019).

### P29. Current status of the predicted satellite imagery generation in NMSC/KMA

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National Meteorological Satellite Center of Korea Meteorological Administration (NMSC/KMA) launched successfully the second geostationary meteorological satellite, Geo-KOMPSAT-2A(GK-2A) on 5 December 2018. NMSC/KMA has developed the algorithm for extracting 52 meteorological and geophysical products from GK-2A Advanced Meteorological Imager (AMI) observations. These products include scene analysis, cloud, precipitation, aerosol, radiation, atmospheric condition, and surface parameters. In addition, we developed the predicted satellite imagery production algorithm for nowcasting application. This algorithm has two methods of producing forecast field using McGill algorithm for Precipitation Nowcasting by Lagrangian Extrapolation (MAPLE) and using NWP model. The first method is a technique to produce the satellite prediction data by calculating the motion vector using variational echo tracking (VET) method in satellite observation data and applying the extrapolation method. The second method uses NWP model to produce a satellite forecast field. The predicted motion vector is calculated using simulated brightness temperature calculated through the fast Radiative transfer model (RTM). As a result, the calculated motion vector is merged with the motion vector obtained through NWP model. In this study, we used the radiative transfer for TOVs (RTTOV) model with meteorological data provided by the NWP model in KMA to simulate the brightness temperature of the infrared channels of Himawari-8 like GK-2A satellite under cloud conditions. In this talk, we present the predicted satellite imagery generation algorithm and the prediction performance verification in detail.

### P30. Postprocessing at MeteoSwiss to provide local forecasts

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Weather forecasts for arbitrary user-defined locations are increasingly sought after by end-users and professional customers. In parallel, decision support systems and impact modelling rely more and more on an adequate quantification of forecast uncertainty. Even though numerical weather prediction (NWP) models are run at ever increasing resolution and in ensemble mode, raw ensemble forecasts still tend to be biased and underdispersed. Furthermore, the information is ideally merged from several NWPs models and nearby observations are taken into account as far as possible. Hence, statistical postprocessing is expected to improve forecast quality and may help to condense the forecast information. At MeteoSwiss a project on postprocessing of the most relevant parameters for public weather forecasts, i.e. near-surface temperature, precipitation, wind speed, and cloud cover, has recently been launched. The project's goal is the introduction of an operational suite providing probabilistic spatial fields of postprocessed predictions integrating observations and available NWPs from global (ECMWF IFS) and limited-area models (COSMO-E). The project aims at optimally combining published approaches and tailoring these to the existing forecast production environment and the challenging topography.