Nowcasting

Nowcasting, or ultra-short-term forecast, offers a current forecast of local weather features for a period of up to 6 hours, including a detailed description of the meteorological situation. It is based on methods of processing and extrapolation of radar or satellite data. The expected movement of the precipitation zone and/or storm cells can be obtained at the highest temporal and spatial resolution. This is especially important and applicable for airports and regions with unstable weather.

Nowcasting plays an increasingly important role in crisis management and risk prevention systems; however, its implementation is a complex task that requires a special approach.

The weather forecast for the next few hours is relevant for many sectors of the economy - agriculture, construction, transport, production, distribution of electricity, tourism - as well as for authorities and the population.

Unlike the development of numerical models, which requires deep knowledge of the dynamics of atmospheric processes based on the laws of physics and mathematical approximations, the development of nowcasting systems is focused on the specific needs of various consumers of meteorological information.

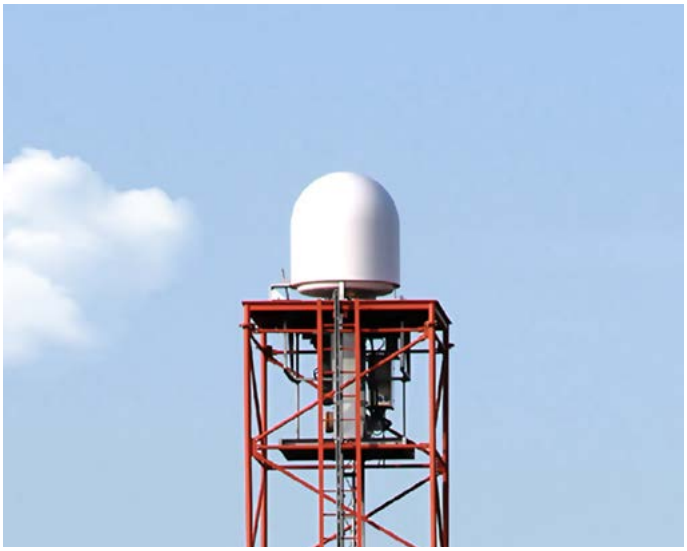
An essential aspect of nowcasting is the early detection of hazardous weather events (e.g., thunderstorms, hail, altitude icing in aviation), including the issuing of warnings and the rapid transmission of this information to the end users of the system.

The performance of nowcasting highly depends on the quality of the observational information. In the case of an ultra-short-term forecast of precipitation and storm events, the observational information is predominantly the data of atmospheric radar sounding. Meteorological radars make it possible to obtain a three-dimensional picture of the precipitation field and thunderstorms in real-time. For these purposes, MicroStep-MIS has developed a compact meteorological radar MMR-116 - a unique portable X-band meteorological radar, which is capable to detect precipitation with a reflectivity of 10 dBZ at a distance of up to 200 km.

By default, the observational information from the radar contains many inaccuracies of different types, caused by both technical and meteorological features. These include the appearance of false, non-meteorological signals on the images, or distortion of the output signal values. The task of radar image correction becomes even more difficult when these two factors overlap.

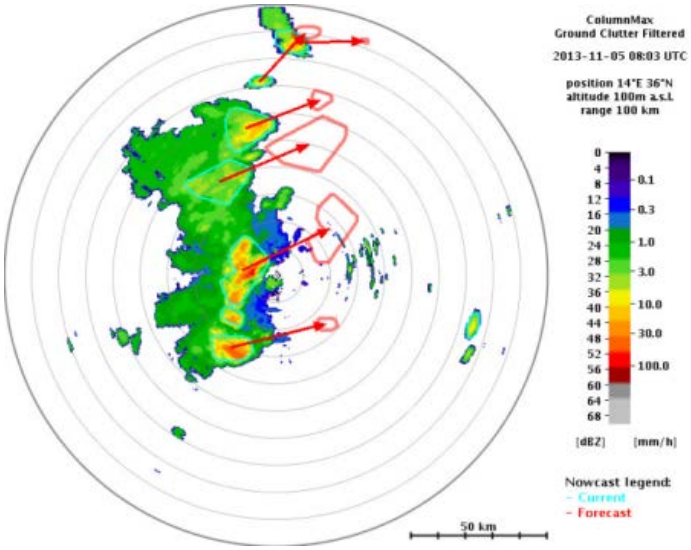
The IMS4 Radar Studio software package automatically corrects the data using an image filtering procedure (filter parameters are individually set up and fine-tuned for each radar). Following the filtering, standard radar products are generated, such as:

- PPI (Plan Position Indicator) - one radar elevation;
- CAPPI (Constant Altitude PPI) - horizontal cross-section;
- RHI (Range-Height Indicator) - vertical cross-section; echo top/base;
- Composite Reflectivity (Column max) - reflectivity maxima in individual columns;
- VIL (Vertically Integrated Liquid) – the amount of precipitable water in individual columns.



Mini Meteorological Radar MMR-116

Nowcasting of precipitation and thunderstorms is an advanced radar product. In the IMS4 Radar Studio system, the nowcasting of precipitation is carried out by various algorithms. First, it is the COTREC (COntinuity of TREC vectors) method, which is a modern analog of the TREC (Tracking Radar Echoes by Correlation) algorithm. The idea of both approaches is to determine the displacement vectors from two radar images, related to the previous and the current time. The images are divided into small squares, and for each of them, the resulting displacement vector is determined. The COTREC method also allows for estimating the displacement vectors in the empty parts of the image, to smooth the displacements in the image points. Due to these techniques, which are not available in original TREC approach, the noise and inconsistencies are corrected and the divergence of the resulting vector field is reduced.



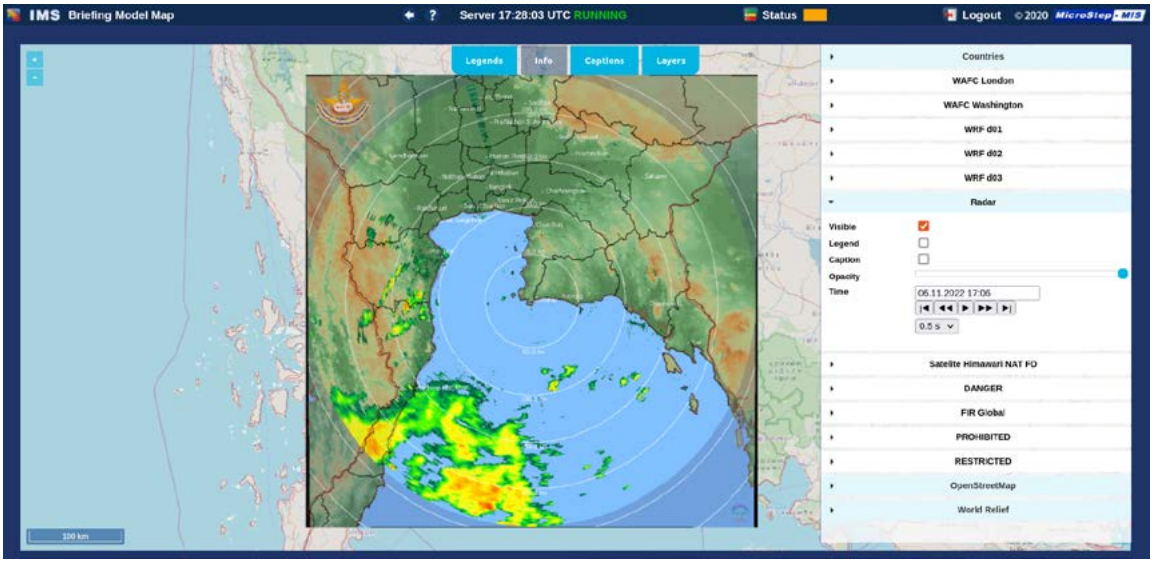
Nowcasting of thunderstorm cells

The second algorithm is TITAN (Thunderstorm Identification, Tracking, Analysis, and Nowcasting), which is used for nowcasting the movement of thunderstorm structures. For each time step, the algorithm identifies a "storm cell". This is done using configurable radar reflectivity thresholds (e.g., 20 dBZ) and cell size (dimensions can be specified in both 2D and 3D planes). An optimization scheme is then applied to match the location and size of storm cells over two time steps to avoid unrealistic cell mergers and decays. Finally, the forecast of the thunderstorm movement is based on several provisions, such as a thunderstorm tends to move in a straight line; the growth or decay of a thunderstorm cell follows a linear trend; and the trajectory of the thunderstorm structure has a random component.

The IMS4 Radar Studio software package also includes a forecast verification module, which compares the predicted and the observed values of radar reflectivity in images. The forecast success is evaluated according to the widely used indicators CSI (Critical Success Index), FAR (False Alarm Ratio), and POD (Probability Of Detection).

The high quality of the input information, achieved through the preprocessing of the IMS4 Radar Studio system, also allows

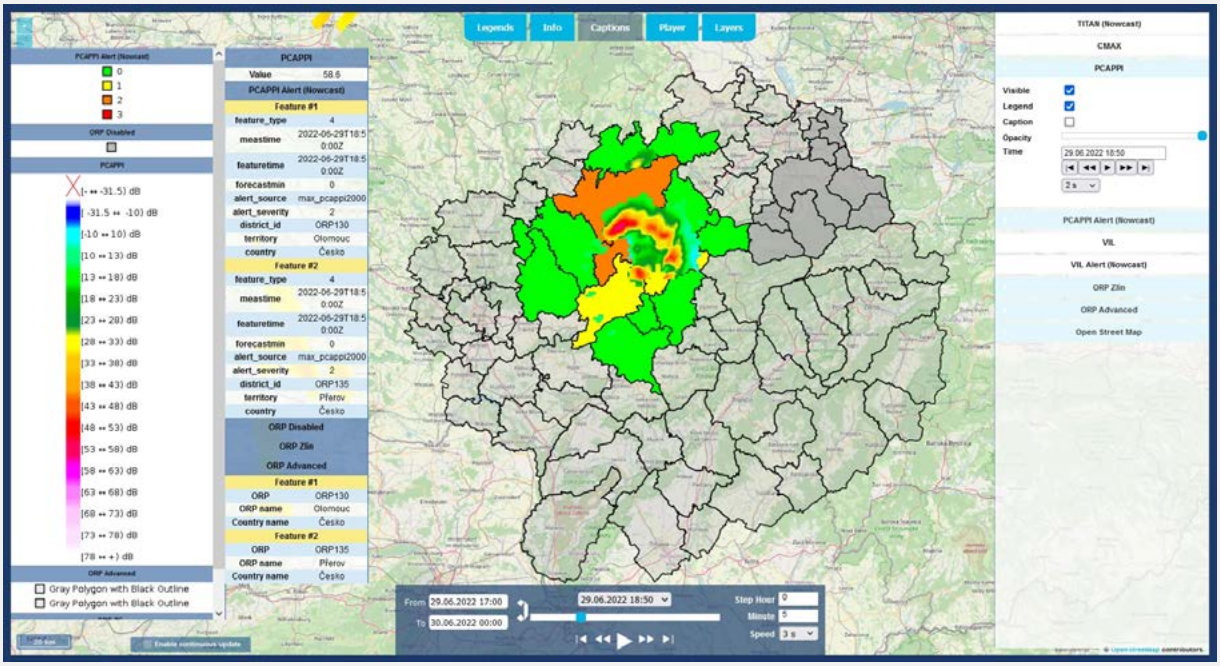
- to integrate additional nowcasting algorithms into the IMS4 Radar Studio system (for example, local Lagrangian methods);
- to obtain a probabilistic pattern of precipitation distribution for several hours ahead by integrating a stochastic algorithm into the IMS4 Radar Studio module.



IMS4 Briefing Model Map

WMO recommends placing the information needed for nowcasting on a web-based display in a form of an integrated meteorological system (IMS). It allows the forecaster to access relevant information quickly and manage the system easily. In MicroStep-MIS, these capabilities are implemented in the IMS4 Radar Studio module, which allows processing, analysis, visualization, and back-up of both actual and forecast radar products.

An example of such a web-based display is the graphical user interface, which has recently been developed in MicroStep-MIS for the purposes of the research project with the focus on nowcasting convective precipitation in the Zlín region (Czech Republic). Here, the relevant meteorological and/or geographical information can be displayed by switching on/off a number of available layers with the traditional radar products (CAPPI, VIL, CMAX) and their derivatives (CAPPI Alert / VIL Alert, which are specific transformation of CAPPI and VIL data into a 4-class qualitative classification system, valid for the pre-defined administrative districts instead of individual pixels). The user can preview the history (15 days by default), the current weather as well as the nowcasting of CAPPI Alert / VIL Alert characteristics for the lead times of 5, 10, 15 … 60 minutes ahead.



A screenshot from the web-based nowcasting application developed for the Zlín region (Czech Republic)