Aviation

Overview

Weather radar is the most important tool for monitoring weather for aviation and military aviation, for flight planning and air traffic control. The most hazardous phenomena for aviation are: thunderstorms, heavy rain and hails, wind shear etc. These phenomena can be monitored by weather radar in real-time mode with high time and space resolution.

Air traffic control (ATC) and Air traffic management (ATM) are services provided by ground-based controllers who direct aircraft on the ground and in the air. The primary purpose of used ATC and ATM systems is to separate aircraft to prevent collisions, to organize and expedite the flow of traffic, and to provide information and other support for pilots when possible.

An air traffic controller uses weather radar to give pilots information about heavy rains, thunderstorms and all other hazardous phenomena. As a result the radar data and air traffic data are combined. Especially military pilots use weather radar data very actively since its role is very important.

There are three facilities of air traffic control: ACC – Area Control Centre controlling high-level en-route aircraft, APP – Approach Control, TWR – Tower (local control at medium levels climbing and descending). They differs significantly in required meteorological data in terms of their sources, resolution and range The facilities of control are held by particular national air traffic control authorities.

In the ATC and ATM systems meteorological data can be visualized in 8 levels using ASTERIX CAT008 or CAT009 format. Weather radar reflectivity generalized within the six classes is a standard meteorological information used in ATC. The common practice is connecting the ASTERIX levels with weather radar reflectivity, so that so called "hazard index" map (8 levels in ASTERIX format) with attached short text description is used instead of standard meteorological map.. The "hazard index" can be computed from multi-source data, but mainly radar reflectivity data, taking into amount maximum of radar reflectivity, echo top, wind shear, etc.

However on other auxiliary displays the data can be presented in more detailed way using any operating system and data format.

Data usefulness

The radar data should be of high-resolution for ATC, i.e. at least 1 km, and generated about every 60 sec. Important expectation is that the data must be available in "really real-time" (that means practically: nowcasted). The following kinds of data are the most desirable:

- Volume of radar reflectivity (or on selected altitudes).
- Volume of precipitation rate and type.
- Volume of wind, especially for detection of related small-scale phenomena such as shears, turbulences, microbursts, however wind profilers are most effective for this purpose.

– Other sources of data are desirable as well, especially data from wind profiler, lidar, lightning detection systems and other systems.

Examples of implementations

Area Control Centre (ACC) area

Size of controlled area of ACC usually equals over 500 km. Radar data especially useful for this areas is composite of MAX (Maximum Display) radar product to visualize hazard areas within upper air area (altitude about 10 km). Product named FL MAX (Flight Level Maximum Product), in which minimum and maximum of flight level are configurable, is a product dedicated to aviation.

The radar data can be presented in main displays of air traffic control (Fig. 1).

Fig. 1. Example of ACC display with radar MAX data (ATRAK system).

Approach Control (APP) area

a) b)

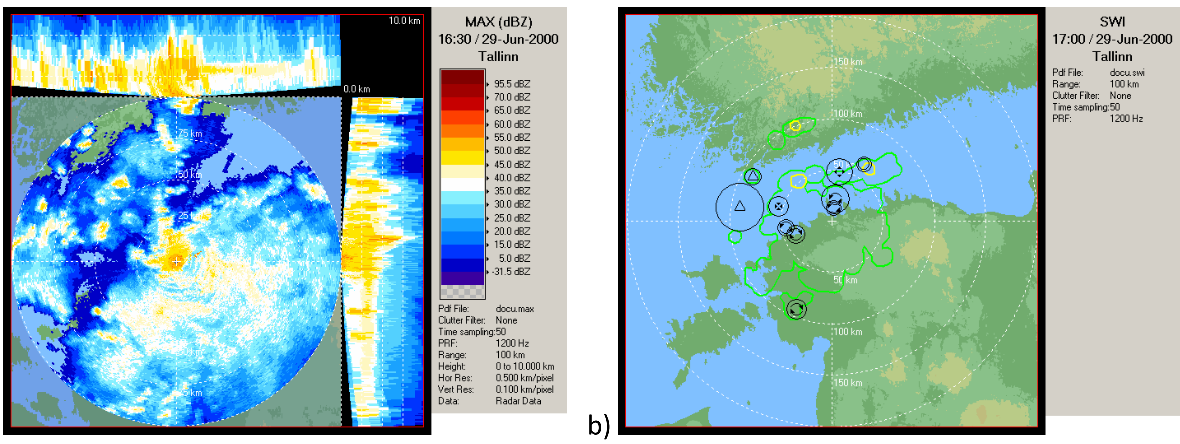

Fig. 2. Examples of single radar products useful for APP areas:
a) MAX, b) SWI (Selex SI Gematronik).

APP areas cover about 100-150-km areas of responsibility, where hazard phenomena are visualized using radar products MAX or SWI (Severe Weather Indicator) from single radar or composite map (Fig. 2).

Tower (TWR) area

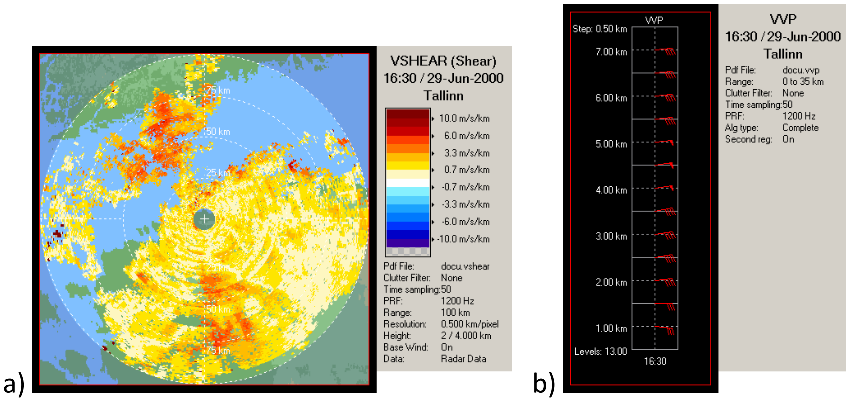

Fig. 3. Examples of single radar products useful for TWR areas:
a) VSHEAR, b) VVP (Selex SI Gematronik).

Within TWR areas, where responsibility reaches 10-30 km around the airport, phenomena are detected and visualized using radar products like SWI, MAX, wind shears (e.g. VSHEAR, HSHEAR – Vertical and Horizontal Shear), wind profile (e.g. VVP – Volume velocity Processing), etc. (Fig. 3). Moreover, data from other sources are desirable, like wind profilers, lightning detection, etc., as well.

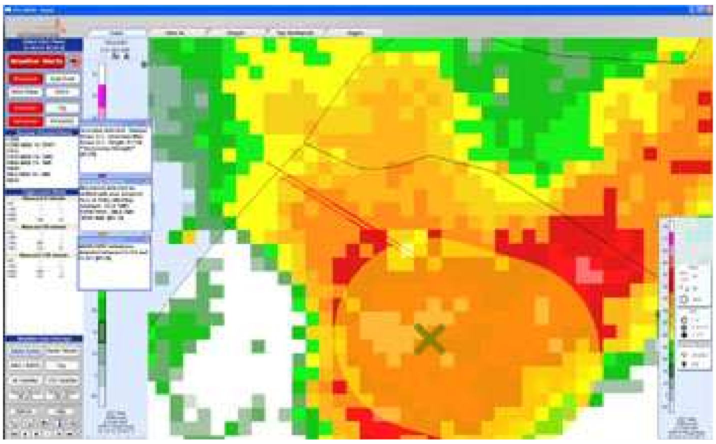

Fig. 4. Example of display showing a microburst affecting an airport using a dedicated aviation weather decision support system (Barrere et al., 2008).

The weather phenomena can have great impact on operations at the airport. Thus, having the ability to detect, nowcast, and forecast these phenomena precisely and with high accuracy is of great value. Providing that information to both the meteorologists and air traffic controllers, in a manner they can use it operationally, is also of great importance. The aviation weather decision support systems collect meteorological data from several sources, integrates the data, runs a suite of detection and nowcasting algorithms and provides enduser interfaces (Figs. 4 and 5) for real-time air traffic control operations as well as the support of operational meteorologists' work flow.

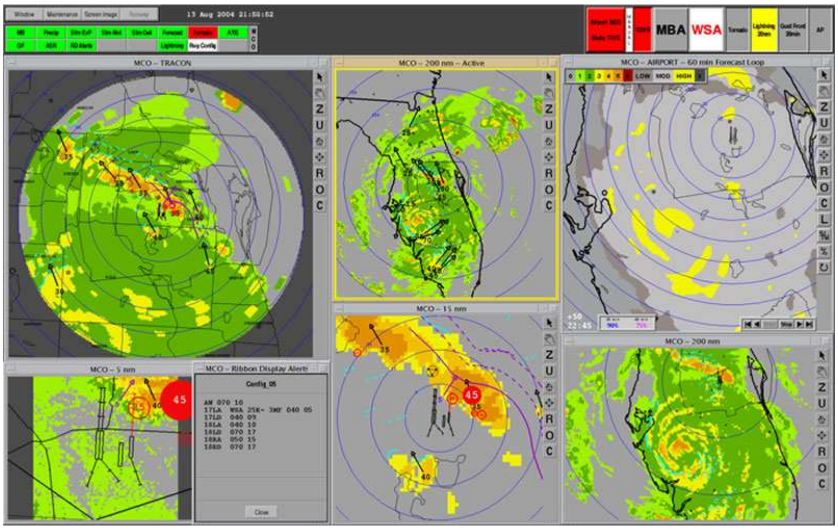

Fig. 5. Display of ITWS system that provides multiple views of weather round an airport (http://www.ll.mit.edu/mission/aviation/).

Meteorological hazard index

Weather hazard index (WHI) has been introduced as a metric describing meteorological hazards to analyse weather conditions for needs of air traffic control (Ośródka et al., 2010). Eight classes of the WHI are distinguished that are assigned to no hazard situation (WHI = 0) and hazard ones with different levels of severity (from 1 to 7) (Fig. 6).

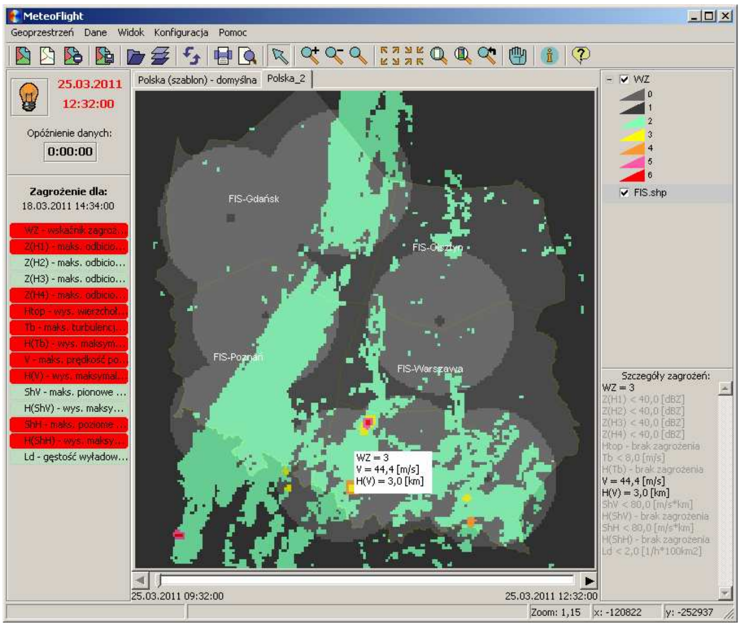

Fig. 6. Weather hazard index displayed by MeteoFlight application.

The system MeteoFlight is being developed by Institute of Meteorology and Water Management (IMGW) for Polish Air Navigation Services Agency, where input for ATC system

PEGASUS 21 (Polish Enhanced Generation ATC System for Unified Solutions of 21st Century) of Indra (Madrid) is generated in the form of meteorological overlay. Independently, the MeteoFlight application is running on MS Windows computers as GIS-based software enabling to visualize detailed information about the severe phenomena and also carry out advanced analyses by means of graphical user's interface.

The input data for the MeteoFlight come from remote sensing meteorological systems operated by IMGW, such as weather radar network (Doppler C-Band radars) and lightning detection system. At present, the following radar products generated by radar software are employed: maximum reflectivity (MAX), echo top (ETOP), horizontal wind field (HWIND), horizontal and vertical wind shears (HSHEAR and VSHEAR), turbulences (LTB), and lightning reports. As the real time information is essential for ATC, the data have to be nowcasted up to current time because of time necessary for the data processing and transmission.

Literature

Air traffic control, Lincoln Laboratory, Massachusetts Institute of Technology (http://www.ll.mit.edu/mission/aviation/).

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Ośródka, K., Jurczyk, A., Dziewit, Z., Szturc, J., and Korpus, L., 2010. MeteoFlight: System of weather hazard monitoring for air traffic control. 6th European Conference on Radar in Meteorology and Hydrology, ERAD 2010 (http://www.erad2010.org/pdf/POSTER/Thursday/06_Operational/11_ERAD2010_0081_extended.pdf).