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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Application of X-band Radar and Lidar Measurement at Frankfurt and Munich Airports for Air Traffic Management (ATM)

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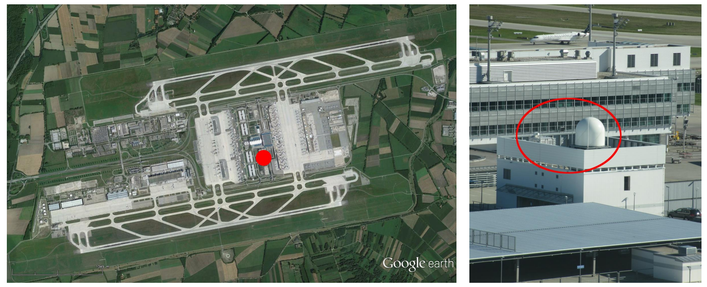

Figure 1: Location of lidar and radar at MUC.

In order to detect and quantify on the presence of low-level wind shear a novel system (LLWAS) based on a SELEX Meteor 50DX polarimetric radar and a Lockheed Martin WTX WindTracer lidar have been installed at the international airports of Munich (MUC; Figure 1) and Frankfurt (FRA). However, the high-resolution measurements can also be used as back-up of operational systems and as input for analyzing systems and models as well as for precise time based separation of aircrafts.

ICAO recommendation

As a consequence of numerous aircraft accidents due to wind shear ICAO recommends that wind shear information between runway level and 1600 ft AGL shall be updated at least every minute.

Scan strategy

For the purpose of monitoring wind shear along the glide paths both sensors radar and lidar perform a 3° PPI scan every minute. A volume scan using several elevations is performed every 5 minutes to detect wind at different heights.

Wind shear

Following wind shear techniques are used on lidar and on radar velocity data after suppression of non-meteorological and ambiguous radar echoes by different filter techniques: (1) Runway-Oriented Shear (ROSHEAR) which essentially provides information on loss and gain of aircraft lift when approaching to or departing from the airport, (2) Gust Front (GF) is based on horizontal velocity convergence, (3) Microburst (MB) which uses reflectivity as well as radial shear segments of different heights, (4) Volume Velocity Processing (VVP) in order to derive vertical wind profiles.

Figure 2: Left panel: Radar radial velocity and ROSHEAR. Right panel: LLWAS wind barbs depending on height.

In general, horizontal wind shear alerts from ROSHEAR are referred mostly of X-band radar data at FRA and MUC since a large amount of horizontal wind shear is related to precipitation (Figure 2, left panel); vertical wind shear events are mostly obtained from VVP wind profiles based on lidar velocity data as a fact of low-level temperature inversions (Figure 2, right panel).

Back-up and hydrometeors

However, meteorological radar systems usually are located in some distance of airports; as a consequence there are measurement gaps of the lower atmosphere of the TMA. By using the dual polarized X-band radar measurements at FRA and MUC atmospheric phenomena which influence aerospace management significantly like low stratus clouds connected with snow as well as precipitation types are able to be detected.

3D wind prototype

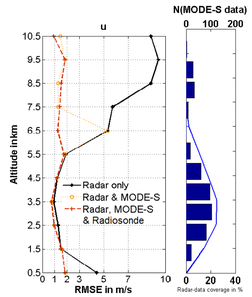

Figure 3: Influence of observations on u wind RMSE.

In order to summarize all available wind data in the vicinity of airports within one domain for MUC a 3D wind prototype is under development (domain: 100 km x 100 km x 10 km, resolution: 1 km x 1 km x 0.5 km). Basically, X-band radar and lidar measurements are merged by a 3DVAR scheme with additional measurements from C-band radar and radiosondes as well as wind retrievals from aircrafts (Mode-S; KNMI). Comparison studies by model results show a high benefit (Figure 3).

COSMO-MUC model

For MUC a highly regionalized version of the German numerical weather forecast model COSMO-DE has been developed the so-called COSMO-MUC model (1.4 km, 1h update cycle). In general the skill of now-cast and short range forecasts is enhanced particularly by including the new data from radar and lidar as well as from Mode-S (Figure 4).

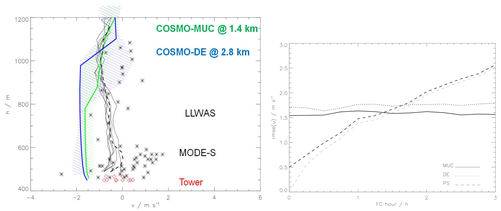

Figure 4: Left panel: V wind of observations and model results; as a function of height. Right panel: U wind RMSE of 15 minutes COSMO-DE, COSMO-MUC and nowcast outputs for a lead time of 3 h.

Time-based separation

According to EC regulations distance based aircraft separation shall be replaced by time based aircraft separation for example at FRA and MUC. The replacement aims on enhancement of airport capacities by reduction of distances between aircrafts when wind speed thresholds are reached. Since the X-band radar and lidar at FRA and MUC are located in such a way that scanning directions are rather parallel of all runways head and tail wind can be approximated precisely (1 min, 100 – 150 m radial).

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