# ALERT - Towards a Save Landing

**A new LES-based system for short-range forecasting of near-surface high-impact weather at airports**

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## In Short

- Severe weather conditions like dense fog and strong gusts impose high risks onto airport environments.
- The parallelized large-eddy simulation model PALM will be used to explicitly resolve fog and gust risks.
- An operational LES-based forecasting system for airport environments will be developed.

The quality of weather forecast and warning products strongly relies on the quality of parametrization of all those processes that cannot be resolved by operational numerical weather prediction (NWP) models due to their coarse grid resolution. Particularly, turbulent processes in the atmospheric boundary layer (ABL) are still parameterized in state-of-the-art NWP models. However, turbulent processes are the key factor for various high-impact weather conditions relevant for the operation of airports. The stable boundary layer (SBL) regime for example is closely linked to the formation of fog. Dense fog usually forms in the nighttime ABL and can have a strong impact on the economy and also on personal safety. Low visibility is a major issue for the operation of airports. The life cycle of fog, from formation after sunset to dissipation in the morning hours, and its microstructure, however, are not well understood and the quality of operational fog forecast is still a weak point of NWP models. Recently, it has been shown that small-scale surface heterogeneities and airport buildings can significantly modify the formation time of fog, which clearly point out that the surface properties are essential for an accurate forecast of critical atmospheric conditions at airports and that traditional forecast systems are often inadequate in such conditions. In the neutral boundary layer, severe wind gusts associated with strong-wind events like winter storms are regarded as the most expensive natural disaster in Germany. Small spatial and temporal scales of gusts lead to a lack of observational studies and hence verification data to improve wind gust estimation (WGE) models used in NWP models. A comparison of different approaches for WGE in the COSMO-CLM model of the german weather service (DWD) showed that empirical gust estimation models still have advantages over a physically based approach. However, a deeper understanding of the shape and life cycle of wind gusts is needed to improve current WGE models. A major task for the operation of airports is a good prediction of wind gust effects on airplanes during final approach. Airport environments in Germany are commonly characterized by relatively flat terrain, accompanied by airport buildings of varying shape and size. Such topography elements have the potential of modifying the local flow conditions significantly and are thus suspect to be an important factor for wind gusts on the runway, particularly in strong-wind conditions.

The operation of airports during such foggy or strong-wind conditions currently relies on operational NWP and regional model data. These models can neither resolve the relevant near-surface processes that lead to fog or wind gusts, nor can they account for small-scale surface heterogeneity, such as airport buildings or vegetation and soil heterogeneity. A logical approach to achieve a more reliable forecast for airport areas would be the use of an LES model, coupled to or forced by an NWP model. This LES model can resolve the turbulence in the ABL as well as the interactions with airport buildings and the surface.

In the course of the DWD project 2015EMF-13 (codename ALERT) a tested and evaluated LES-based forecasting system for airport environments will be developed. The system will act as a magnifying lens and will be suitable for the forecast of high-impact weather conditions related to the turbulent processes in the near-surface ABL that cannot be adequately represented in state-of-the-art NWP models. The system eventually will allow the operational forecast of critical conditions relevant for aviation and airport operation, namely the forecast of dense fog ad severe wind gusts in stormy weather. It will be driven by NWP model data and shall run fast enough at operational level with reasonable (limited) computational resources.

Unlike current NWP models, the LES-based system aims at explicitly resolving the effects of the actual airport buildings and other surface properties, such as vegeation, impervious surfaces and soil on the boundary layer turbulence. This will allow to explicitly predict e.g. effects of wake turbulence generated by airport buildings on aircraft during final approach or the hazard of low visibility due to radiation fog at the airport.

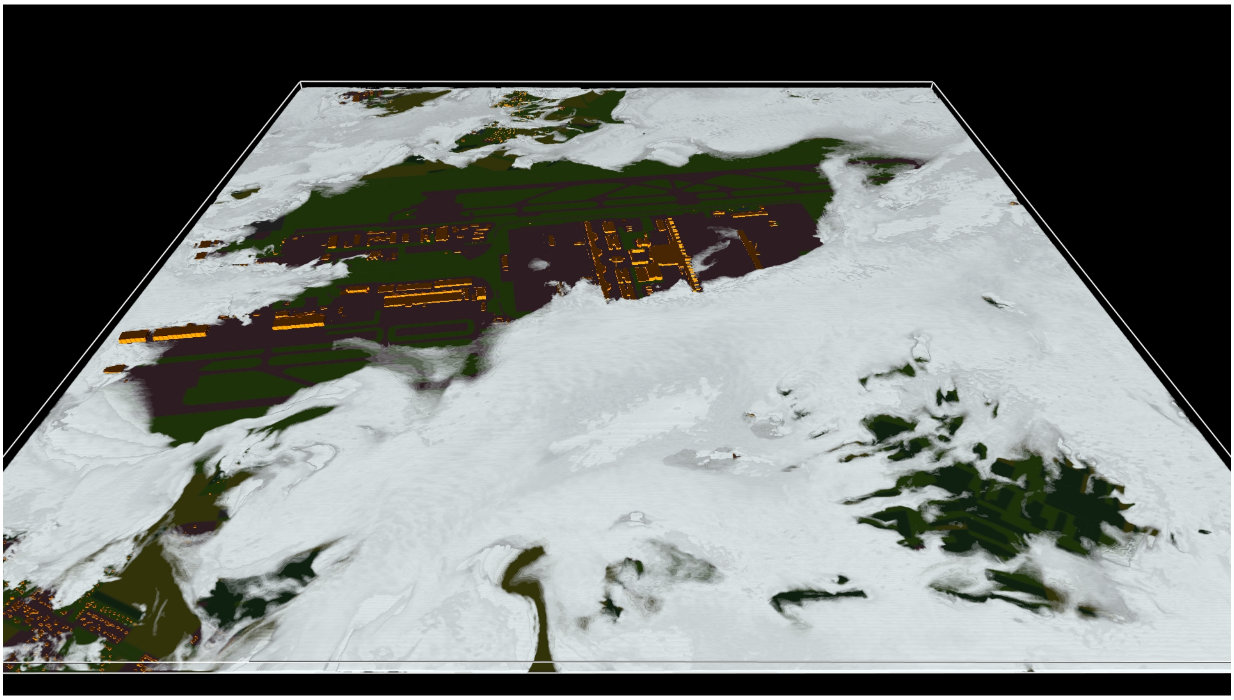

***Figure 1:*** *Three dimensional rendering of the Munich airport environment showing radiation fog (in white) as the fog develops throughout the night and slowly encloses the airport. The fog delaying effect of the airport buildings and the largely sealed pavement surface of the airfield can clearly be seen via the hole in the cloud cover close to the the middle of the rendering. The animated data was generated with PALM [1,2]*

As the project is in its third year of development we have already successfully simulated complete airport environments in full detail. The forecasting system considers the airport vicinity including the orography and all buildings as well as highly detailed surface and vegetation properties. Even forest canopies can be resolved with their heterogeneous distribution of tree trunks and leafs.

Figure 1 shows a three-dimensional data rendering of fog as it develops throughout the Munich airport during the night. While the systems own radiation model computes the dynamic radiative cooling of all surfaces on the complex topography, the air moist air flow above these surfaces gradually cools and slowly reaches its dew point. At that point the also included bulk cloud microphysics model starts computing how much water is condensed into cloud droplets. This so called liquid water content in the air flow slowly builds up as the radiative cooling continues and the fog develops. Figure 1 clearly shows the fog delaying effect of the airport buildings and the largely sealed pavement surface of the airfield as the fog leaves a hole in the cloud cover close to the middle of the airport. This hole shrinks in size as the night progresses. In the morning the suns short-wave radiation reverses that process and starting from the middle of the airport the fog slowly dissolves and convection starts. Equally detailed simulations can be performed in order to provide gust predictions for aircraft during final approach.

The forecasting systems boundary conditions can be driven by lower resolution NWP model data and, once validated and optimized, can be applied to any airport in order to serve as a magnifying glas in the NWP model chain of the German Weather service (DWD). Currently the system undergoes rigorous testing and validation in order to assess the reliability and accuracy of the produced fog and gust forecasts.

## WWW

https://www.muk.uni-hannover.de

## More Information


[1] B. Maronga et al. (2015): The Parallelized Large-Eddy Simulation Model (PALM) version 4.0 for Atmospheric and Oceanic Flows: Model Formulation, Recent Developments, and Future Perspectives *Geosci. Model Dev.* 8.8 pp. 2515-2551. doi:10.5194/gmd-8-2515-2015

[2] See also: https://palm.muk.uni-hannover.de


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