EMS Annual Meeting 2023
Bratislava, 3 to 8 September 2023

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Analysis of suitable weather conditions for the operation of HAPS (High Altitude Pseudo Satellites)

Jürgen Lang[1], Ulrike Gelhardt[1], Falk Anger[2], Thomas Wetter[2] and Björn-Rüdiger Beckmann[2]

Acknowledgement: We thank the Leichtwerk AG for information on suitable weather conditions for HAPS.

High Altitude Pseudo Satellites (HAPS) are lightweight aircraft-like vehicles with very large wingspans. They fly very slowly, are powered by hydrogen and can remain in the stratosphere for several days to several weeks. The OBeLiSk project, an R&D project funded by the German Federal Aeronautical Research Programme is currently developing an operational concept for safe and efficient airspace integration of such HAPS. Due to the structural limitations imposed by the lightweight design, HAPS can reach their limits very quickly in certain weather conditions. In the analysis presented here, frequencies of "potential operating hours", i.e. hours during which the weather situation at an airport allows HAPS to take off or land safely, were determined.

Definition of potential operating hours and data base

Wind speed (FF), especially wind gusts (FX), icing and precipitation (RR) are limiting factors during take-off and landing of HAPS. Since ground-based measurements of these variables are available at major German airports with hourly resolution over the period from 2001 to 2020, they were used to investigate the frequency of suitable weather conditions for HAPS. Weather conditions are considered suitable exactly when applies FF < 6 kt, FX < 10 kt and neither precipitation nor icing occurs. Icing potential is determined as a function of temperature and relative humidity.

Diurnal and annual variation of potential operating hours

The diurnal variation of operating hours (Fig. 1) shows basically the same pattern for all airports with a maximum during the night hours and a minimum during the day. However, there is a clear difference between airports located in the north and those located in the south of Germany.

While for the northern airports the maximum of the potential operating hours is between 30 and 40 %, the maximum in Munich and Nuremberg rises to about 50 %. Stuttgart airport seems to be the most suitable for HAPS.
A seasonal analysis of the diurnal variation using Cologne/Bonn Airport as an example (Fig. 2) shows further significant differences. As expected, the weather conditions for HAPS are significantly better in summer than in winter. The diurnal variation is most pronounced in summer. In winter, the maximum of potential operating hours falls in the late afternoon.
When considering multi-year mean annual cycles, a minimum of potential operating hours can be observed in the winter months.

Fig. 1: Diurnal variation of potential operating hours for different German airports

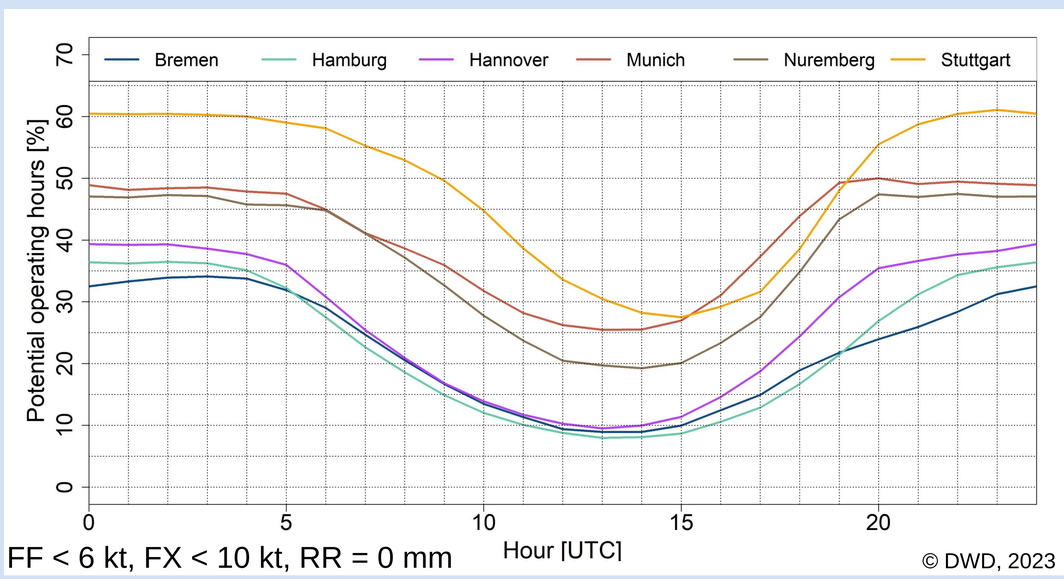
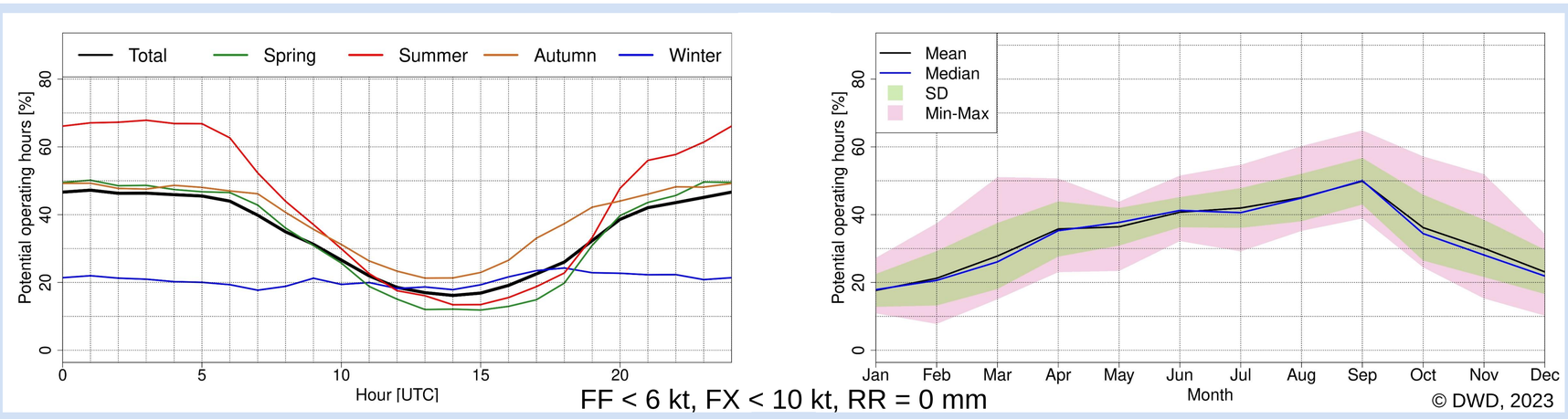
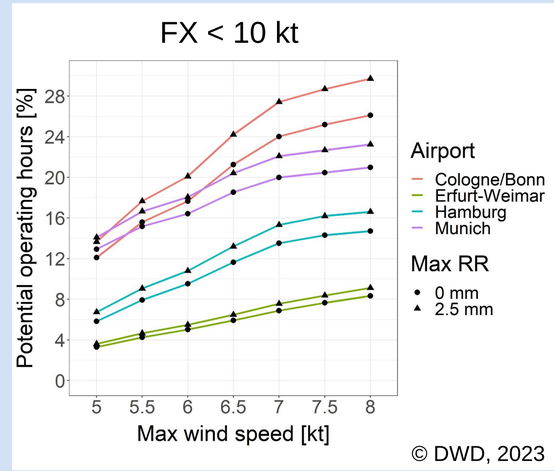


Fig. 2: Airport Cologne / Bonn: Diurnal seasonal and annual variation of potential operating hours



The results presented here were produced as part of the project OBeLiSk by MeteoSolutions GmbH on behalf of the Deutscher Wetterdienst (DWD).

Fig. 3: Sensitivity of potential operating hours to the maximum permissible wind speed



Percentage of potential operating hours at four airports studied as a function of maximum permissible wind speed for two different assumptions of precipitation (0 mm and 2.5 mm) in each case.

Sensitivity of potential operating hours

For all four selected airports, there is a significant increase in potential operating hours if higher wind speeds are permitted (Fig. 3). This is particularly evident at Cologne/Bonn Airport. While at a maximum permissible wind speed of 5 kt and assuming that no precipitation may fall during operation, the share of potential operating hours is only 12 %, the share doubles to 24 % at a maximum permitted wind speed of 7 kt. A further increase in the maximum permissible wind speed causes a smaller increase in potential operating hours due to the underlying wind statistics. In principle, this flattening of the curve can also be observed at the other three airports.

Outlook

While climatologies of operating hours can be derived for selected sites based on measurements, a Germany-wide operating hour climatology can be created using model data and radar data. In this way, arbitrary sites could be evaluated in the resolution of the underlying data with respect to their suitability for HAPS operation.

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Contact
[1] MeteoSolutions GmbH, Darmstadt, Germany: juergen.lang@meteosolutions.de
[2] Deutscher Wetterdienst, Offenbach a.M., Germany: falk.anger@dwd.de