Towards Weather Resilient Innovative Air Mobility Operations Illustrated by the Example of Thunderstorm Nowcasting

Niklas Wartha[1,*], Christoph Metzl[1], Philipp Straub[1], Grigory Rotshteyn[2], Tobias Bölle[1]
*[1] Institut für Physik der Atmosphäre, Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, Germany, * niklas.wartha@dlr.de;*
[2] Unisphere GmbH, Constance, Germany,

Safe, efficient, and reliable drone operations constitute vital components for freight and passenger transport. In civil aviation weather is a major disruptor to operations (re-routings, emergency landings, etc.). Given the smaller scales involved in the innovative air mobility (IAM) and their higher vulnerability, the impact of adverse weather is expected to be one key component to its growth. Appropriate tools for tackling adverse weather in the IAM may also be a contributor to the development of U-space regulations.

In this talk we outline the limitations of currently available aviation weather tools for the IAM and discuss the necessary steps for adapting them appropriately or building new ones. The presentation focuses on thunderstorms as an adverse weather type, which are responsible for great amounts of delay in civil aviation, in particular during the summer months. Furthermore, the lifecycle of thunderstorms intrinsically contains a variety of potentially hazardous effects to drones, including wind, precipitation, hail and lightning strikes. Further adverse weather phenomena may be addressed in an analogous manner.

At present, weather tools for aviation are not built for the spatiotemporal scales involved in the IAM. On the one hand operators have access to numerical weather predictions (NWPs) emerging from sophisticated modelling efforts. However, these lack the spatiotemporal resolution required for the IAM. Furthermore, the extended computations involved with NWPs leads to a major latency in their availability to users. On the other hand, aerodrome weather reports such as METAR and TAF may be utilized, with the limitation of being rather localized data. Equally, alternative crowd data is not sufficient for expanding drone flights and routes. Lastly, sensors installed on drones may aid reactionary maneuvers, but are restricted in their ability for tactical flight planning. Weather resilient operations in the IAM necessitate tactical tools with sufficient spatiotemporal resolution covering a variety of flight paths – facilitating global operations.

In civil aviation, nowcasting (short-term forecasts based on remote sensing data) has shown its added benefit for flight operations. Similarly, the IAM is expected to benefit from nowcasting, given its usage of up-to-date data and low latency to users. However, to our knowledge its applicability in the IAM has been shown only to a limited extent. Particularly within the tactical planning time horizon of drone flights, nowcasting delivers more reliable predictions than NWPs. Our nowcasting approach of thunderstorms is based on a novel machine learning method named Cb-TraML [1] (see Fig.1), which employs multiple input time steps of Meteosat Second Generation and lighting data. Cb-TraML delivers pixelwise thunderstorm probabilities based on a lightning data ground truth for a specific forecast

time. Validation of our method has shown that it outperforms alternative methods for nearly all relevant lead times and metrics [2]. Furthermore, alternatives are restricted to deterministic predictions, whereas Cb-TraML delivers a valuable probability score.

In order to establish the suitability of nowcasting for the IAM, we have built Cb-TraML into a drone flight planning form NOVA by Unisphere GmbH (see Fig.1). With relevant case studies, we demonstrate the operational advantage for the IAM in comparison to currently employed NWPs in NOVA; Fig.1 shows Cb-TraML predictions as a layer on the right map.

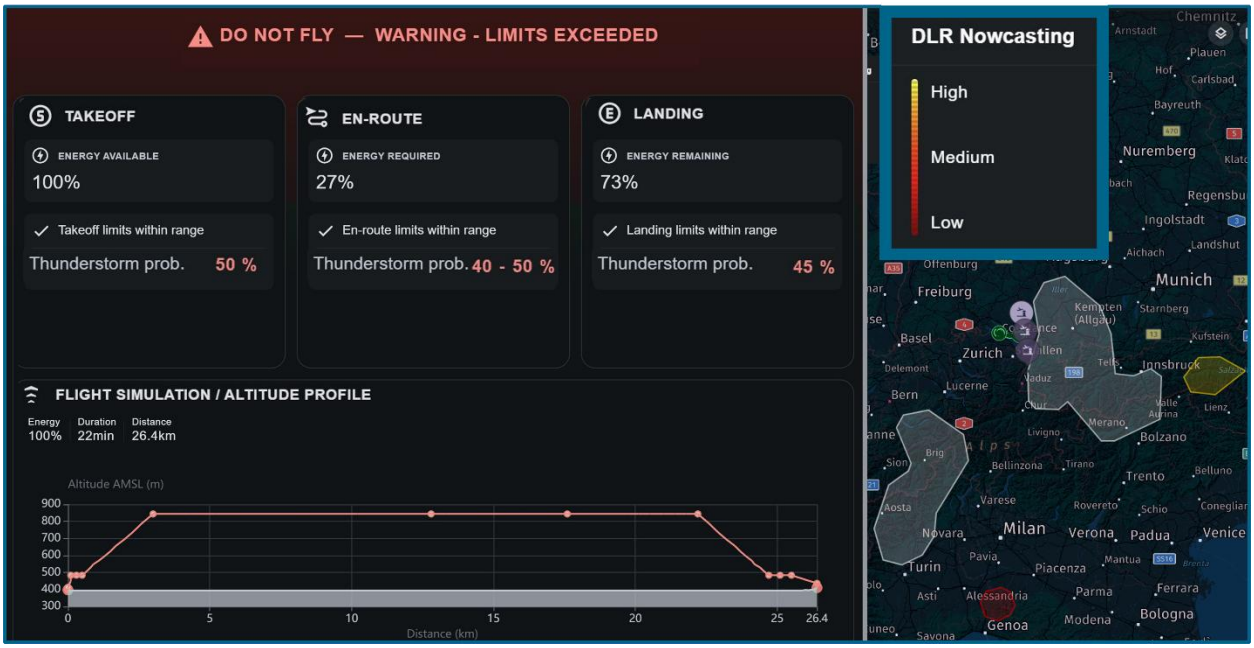

Figure 1 - Unisphere's NOVA platform (left: quantitative flight metrics, right: qualitative map).

This talk highlights the added benefit of thunderstorm nowcasting for automatic and optimized drone flight planning in uncertain weather situations. This tactical forecasting of thunderstorms has the ability to close the gap between reactionary and strategic weather forecasting tools (sensors and NWP, respectively). Less drone flights will undergo cancellations as well as flights, while also delivering increased safety, as thunderstorms are detected more reliably. It may also allow for feasible U-space regulations. Learnings from this study may be expanded to further weather phenomena.

[1] METZL, C., K. VAHID YOUSEFNIA, R. MÜLLER, V. POLI, M. CELANO, T. BÖLLE, 2025: Physical scales matter: The role of receptive fields and advection in satellite-based thunderstorm nowcasting with convolutional neural networks. – Artif. I. Earth Syst. (4), DOI: 10.1175/aies-d-25-0035.1.

[2] STRAUB, P., C. METZL, R. MÜLLER, V. POLI, M. CELANO, T. BÖLLE, 2025: Deep learning vs. traditional satellite-based thunderstorm nowcasting: Outline of a model benchmark study. – 12th European Conference on Severe Storms, DOI: 10.5194/ecss2025-124.

Biography

Niklas Wartha

Since 2020, Dr.-Ing. Niklas Wartha works for the German Aerospace Center's (DLR) Institute of Atmospheric Physics. In 2026 he completed his PhD at RWTH Aachen University, focusing on the topic of wake vortices. He received his M.Eng.from the University of Glasgow, with a year of study at TU Delft. His research focuses on the impact of adverse weather on the safety and efficiency of aviation.