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Image-based nowcasting of dust storms by predicting SEVIRI desert dust RGB composites

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Dust storms are frequent high-impact weather phenomena that directly impact human life, e.g., by disrupting land and air traffic, posing health threats, and affecting energy delivery from solar-energy systems. Timely and precise prediction of these phenomena is crucial to mitigate negative impacts.

Currently operational numerical weather prediction (NWP) models struggle to reliably reproduce or resolve dynamics which lead to the formation of convective dust storms, making short-term forecasts based on observations (“nowcasts”) particularly valuable. Nowcasting can provide greater skill than NWP on short time-scales, can be frequently updated, and has the potential to predict phenomena that currently operational NWP models do not reproduce. However, despite routine high frequency and high resolution observations from satellites, as of January 2024, no nowcast of dust storms is available.

In this study, we present an image-based nowcasting approach for dust storms using the SEVIRI desert dust RGB composite. We create nowcasts of this RGB composite for a large domain over North Africa by adapting established optical-flow-based methods as well as a machine learning approach based on a U-net. We show that our nowcasts can predict phenomena such as convectively generated dust storms (“haboobs”) which currently operational NWP may not reliably reproduce. Furthermore, we show that a machine learning model offers crucial advantages over optical-flow-based nowcasting tools for the application of predicting complete RGB images.

Our approach therefore provides a valuable tool that could be used in operational forecasting to improve the prediction of dust storms, and indeed other weather events. Due to the technical similarity of RGB composite imagery from geostationary satellites, this approach could also be adapted to nowcast other RGB composites, such as those for ash, or convective storms.