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Toward low-level turbulence forecasting at eddy-resolving scales in support of UAS operations

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Microscale turbulence in the atmospheric boundary layer (ABL) is characterized by significant spatiotemporal variability. Current turbulence prediction at regional scales is based on operationally produced numerical weather prediction model information, typically run at horizontal grid spacings of $\Delta \approx 10$ km. At these spatial resolutions, microscale turbulence and its effects on the resolved scales are fully parameterized. The recent emergence and rapid development of the unmanned aerial system (UAS) sector is revealing the need for a specific air traffic management system for UASs targeting low-altitude operations ($\sim 60 - 150$ m above ground level). Consequently, a change in the turbulence forecasting paradigm needs to occur, moving beyond average turbulence estimates at mesoscale grid resolutions (several kilometers) to eddy-resolving forecasts, in order to accommodate specific needs of UASs. To that end, the viability of dynamic downscaling to large-eddy simulation scales is evaluated. We present for the first time, multiday dynamic downscaling from currently available numerical weather prediction forecasts to a high-resolution grid spacing of 25 m. It is found that these eddy-resolving forecasts can realistically reproduce turbulence levels and peak events in the bulk of the daytime ABL (both vertical velocity and eddy dissipation rate, EDR), adequately capturing turbulence variability at sub-minute intervals. Moreover, probability distributions of turbulence quantities and their temporal rate of change are in very good agreement when compared to in situ sonic-anemometer observations. These results demonstrate the feasibility of eddy-resolving forecasts to derive accurate probabilistic estimates of turbulence in the ABL and provide a path toward real-time large-eddy simulation scale prediction.