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A clear-air turbulence episode related to convective activity: turbulence mechanisms, large-eddy simulations and operational predictability at 'grey-zone' grid spacings

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Strong midlatitude cyclones exiting the Rocky Mountain region in late winter and early spring are often responsible for disruptive weather across eastern continental United States. These synoptic disturbances can also provide environments that are conducive to turbulence at commercial aviation cruising altitudes in the upper-troposphere lower-stratosphere region (UTLS). Turbulence related to these complex weather scenarios is difficult to predict, due to the disparate-scale interactions between large-scale storm circulation patterns and small-scale turbulence instabilities. In this talk, we examine a specific clear-air turbulence (CAT) event that took place on 30 April 2017 in the northwestern portion of South Dakota, where many pilot reports and in-situ eddy dissipation rate measurements reported significant turbulence levels, and that developed in the clear air several hundred kilometers away from the most deep and intense convection. To gain insight into these intricate phenomena we perform simulations with the Weather Research and Forecasting model that span South Dakota and a portion of the surrounding states with large-eddy simulations (LESs) at an unprecedented fine grid spacing of Δx= 250 m, Δz= 100 m. The mechanisms responsible for this turbulence event are investigated using these turbulence-resolving simulations, also providing understanding of the contribution of moist effects in the resulting dynamics. Moreover, we show that mesoscale simulations at a 'grey-zone' grid spacing, Δx= 1 km, near the current operational resolutions, start to resolve these turbulence features, and we demonstrate that the choice of the planetary boundary layer (PBL) parameterization has a strong impact on the presence, structure and intensity of both the modeled gravity waves and turbulent features. The LES results are used as reference to systematically investigate the role of turbulent diffusion in the free troposphere arising from PBL parameterizations, and its impact on the predictability of this type of CAT.