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Representation of the Saharan atmospheric boundary layer in the Weather and Research Forecast (WRF) model: A sensitivity analysis.

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The Saharan atmospheric boundary layer (SABL) during summer is one of the deepest on Earth, and is crucial in controlling the vertical redistribution and long-range transport of dust in the Sahara. The SABL is typically made up of an actively growing convective layer driven by high sensible heating at the surface, with a deep, near-neutrally stratified Saharan residual layer (SRL) above it, which is mostly well mixed in humidity and temperature and reaches a height of ∼5-6km. These two layers are usually separated by a weak (≤1K) temperature inversion. Model representation of the SPBL structure and evolution is important for accurate weather/climate and aerosol prediction. In this work, we evaluate model performance of the Weather Research and Forecasting (WRF) to represent key multi-scale processes in the SABL during summer 2011, including depiction of the diurnal cycle. For this purpose, a sensitivity analysis is performed to examine the performance of seven PBL schemes (YSU, MYJ, QNSE, MYNN, ACM, Boulac and MRF) and two land-surface model (Noah and RUC) schemes. In addition, the sensitivity to the choice of lateral boundary conditions (ERA-Interim and NCEP) and land use classification maps (USGS and MODIS-based) is tested. Model outputs were confronted upper-air and surface observations from the Fennec super-site at Bordj Moktar and automatic weather station (AWS) in Southern Algeria Vertical profiles of wind speed, potential temperature and water vapour mixing ratio were examined to diagnose differences in PBL heights and model efficacy to reproduce the diurnal cycle of the SABL. We find that the structure of the model SABL is most sensitive the choice of land surface model and lateral boundary conditions and relatively insensitive to the PBL scheme. Overall the model represents well the diurnal cycle in the structure of the SABL. Consistent model biases include (i) a moist (1-2 gkg-1) and slightly cool (∼1K) bias in the daytime convective boundary layer (ii) underestimation of the near surface nocturnal inversion (iii) overestimation of LLJ wind speeds and underestimation of the magnitude of the surface diurnal cycle ion wind speed (iv) a mid-level (∼7km height) warm bias (∼1-3K)