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Boundary Layer Parameterizations to Simulate Fog over Atlantic Canada Waters

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Dense fog occurs frequently and lasts for days over Northwest Atlantic Waters, which significantly affects marine transport, offshore oil and gas activates and other marine operations. However, accurate numeral simulations and forecasts of marine fog are a big challenge. We present numeral simulations and forecasts of a series of fog events that occurred near Halifax, Canada, during June 20 to July 31 2016. The Weather Research and Forecasting Model version 3.8.1 (WRF) is used to study the sensitivity to fog simulation with five local and nonlocal Planetary Boundary Layer (PBL) schemes. In situ and satellite remotely sensed observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) are used to validate fog simulation, and give a new exponent for the Kunkel visibility equation to predict visibility. Results show that these five PBL schemes in WRF lead to overestimates in liquid water content (LWC), especially the nonlocal schemes, and that they are biased earlier than observations, while local schemes are more consistent with observations. Results show that the local schemes work better than the nonlocal schemes, except for MYJ, which missed a fog event on July 5 2016. Thus, we recommend MYNN2.5 as providing the best PBL for fog simulation over the Northwest Atlantic as a result of this study, because it succeeds in capturing every fog event in this study, with high correlation coefficient and low RMSE. In this methodology, the Kunkel equation is used to calculate visibility based on WRF modelling of LWC. Comparisons with observed visibility show that the original Kunkel formulation sometimes fails to predict fog dissipation. Thus we present a modification of this formulation with the new exponent (1.271) for visibility that shows improved agreement with observations and more accurate fog dissipation.
In summary, in comparison with the other PBL formulations considered, our study provides a best PBL scheme (MYNN2.5) to simulate fog over Atlantic Canada Waters, and gives a new exponent (1.271) in the Kunkel formulation to predict visibility. Thus, our study helps to improve our ability to predict fog over Atlantic Canada Waters. However, fog prediction is still a big challenge, and continued improvements in the PBL scheme and visibility parameterization are needed for more accurate fog prediction.