Ph.D. Defense Announcement
Jennie Bukowski
January 29, 2021 at 10:00 a.m.

Jennie Bukowski
Ph.D. Defense

Friday, January 29, 2021
10:00 a.m.

Defense
Virtually in Zoom

Post Defense Meeting
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Committee:
Sue van den Heever (Adviser)
Christine Chiu
Kristen Rasmussen
Shantanu Jathar (Mechanical Engineering)
Mary Barth (NCAR)
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MINERAL DUST LOFTING AND INTERACTIONS WITH COLD POOLS

Convective dust storms, or haboobs, form when strong surface winds loft loose soils in convective storm outflow boundaries. Haboobs are a public safety hazard and can cause a near instantaneous loss of visibility, inimical air quality, and contribute significantly to regional dust and radiation budgets. Nevertheless, reliable predictions of convective dust events are inhibited by a lack of understanding regarding the complex and non-linear interactions between cold pools, dust radiative effects, and land surface processes, and their associated uncertainties in numerical models. In this dissertation, model simulations of real and idealized haboobs are used to address limitations in regional dust modeling, the direct radiative effect of mineral dust on cold pool properties and dynamics, and feedbacks between haboobs and the land surface.

In the first study, we assess the influence of horizontal resolution, specifically parameterized versus convection-allowing resolution, on dust lofting, vertical transport, and aerosol heating rates in the WRF-Chem regional model. On average, convection-permitting simulations exhibit higher surface wind speeds, enhanced convective activity, and drier soil, which leads to more dust emissions to the atmosphere. More frequent and stronger vertical velocities also transport dust further aloft and increase the atmospheric lifetime of these particles. We conclude that tuning dust emissions in coarse-resolution regional simulations can only improve the results to first-order and cannot fully rectify discrepancies in the representation of convective dust transport in terms of aerosol distributions or the net aerosol radiative effect.

The second study, WRF-Chem is utilized to simulate the effect dust radiation interactions have on a long-lived haboob case study that spans three distinct radiative regimes: day (high shortwave), evening (low shortwave), and night (longwave only). A sophisticated algorithm, known as TOBAC, is used to track and identify the numerous cold pool boundaries and assemble statistics that represent the impact of including dust radiative effects. To first order, dust scattering in the day leads to a colder, dustier, and faster moving cold pool. In the transition period of early evening, the shortwave effects diminish while longwave absorption leads to warmer and slower cold pools that loft less dust as they propagate. At night, the haboob is again warmer due to dust absorption, but gustier in the more stable nocturnal surface layer.

Lastly, the third study focuses on feedbacks between parameters that affect both dust mobilization and cold pool dynamics. The Elementary Effects statistical method is applied to an ensemble of 120 idealized RAMS simulations of daytime and nighttime haboobs. This sensitivity analysis identifies and ranks the importance of different input factors in predicting haboob properties as: initial cold pool temperature, surface type, soil type, and finally soil moisture. Most of these parameters modify the cold pool via their impacts on surface fluxes, although the effect of surface type is dominated by the change in roughness length. A semi-linear

connection between haboob dust and cold pool temperature is detected in the statistics, and a relationship between dust flux and cold pool temperature is proposed which relates haboob strength to the thermodynamic environment.

Topic: Ph.D. Defense: Jennie Bukowski
Time: Jan 29, 2021 10:00 AM Mountain Time (US and Canada)

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