Ph.D. Defense Announcement
Minnie Park
August 28, 2020 at 9:00 a.m.

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Ph.D. Defense

Friday, August 28, 2020
9:00 a.m.

Defense
Virtually (details to come)

Post Defense Meeting
Virtually

Committee:
Susan van den Heever (Adviser)
Sonia Kreidenweis
Kristen Rasmussen
Steven Miller (CIRA)
Daniel Cooley (Statistics)

ENVIRONMENTAL CONTROLS AND AEROSOL IMPACTS ON TROPICAL SEA BREEZE CONVECTION

Nearly half of the world's human population resides within 150 km of the ocean, and this coastal population is expected to continue increasing over the next several decades. The accurate prediction of convection and its impacts on precipitation and air quality in coastal zones, both of which impact the health and safety of all life in coastal regions, is therefore becoming increasingly critical. Thermally driven sea breeze circulations are ubiquitous and serve to initiate and support the development of convection. In spite of their importance, forecasting sea breeze convection remains very challenging due to the coexistence, covariance, and interactions of the thermodynamic, microphysical, aerosol and surface properties of littoral zone. The overarching goal of this dissertation research is therefore to enhance our understanding of the sensitivity of sea breeze circulation and associated convection to various environmental parameters and aerosol loading. More specifically, the objectives are the following: (1) to assesses the relative importance of ten different environmental parameters previously identified as playing critical roles in tropical sea breeze convection; and (2) to examine how enhanced aerosol loading affects sea breeze convection through both microphysical and aerosol-radiation interactions, and how these effects are modulated by the environment.

In the first study, the relative roles of five thermodynamic, one wind, and four land/ocean-surface properties in determining the structure and intensity of sea breeze convection are evaluated using ensemble cloud-resolving simulations combined with statistical emulation. The results demonstrate that the initial zonal wind speed and soil saturation fraction are the primary controls on the inland sea breeze propagation. Two distinct regimes of sea breeze-initiated convection, a shallow and a deep convective mode, are also identified. The convective intensity of the shallow mode is dominated by the inversion strength, whereas the boundary layer potential temperature is the dominant control of the deep mode. The processes associated with these predominant controls are analyzed, and the results of this study underscore possible avenues for future improvements in numerical weather prediction of sea breeze convection.

The sea breeze circulation and associated convection play an important role in the transport and processing of aerosol particles. However, the extent and magnitude of both direct and indirect aerosol effects on the sea breeze convection are not well known. In the second part of this dissertation, the impacts of enhanced aerosol concentrations on sea breeze convection are examined. The results demonstrate that aerosol-radiation-land surface interactions produce environments that are less favorable for sea breeze convection through direct aerosol forcing. When aerosol-radiation interactions are eliminated, enhanced aerosol loading leads to stronger continental updrafts in the warm-phase region of the clouds through increased condensational growth and latent heating. This occurs irrespective of the sea breeze environment. While condensational invigoration is therefore robust in the absence of aerosol direct effects, the cold-phase convective responses are found to be environmentally modulated, and updrafts may be stronger, weaker, or unchanged in the presence of enhanced aerosol loading. Surface precipitation responses to aerosol loading also

appear to be modulated by aerosol-radiation interactions and the environment. In the absence of the aerosol direct effect, the impacts of enhanced aerosol loading may produce increased, decreased, or unchanged accumulated surface precipitation, depending on the environment in which the convection develops. However, when aerosols are allowed to interact with the radiation, a consistent reduction in surface precipitation with increasing aerosol loading is observed, although the environment once again modulated the magnitude of this aerosol-induced reduction.