M.S. Defense Announcement
Christine Neumaier
September 8, 2023, at 10:00 a.m.

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Friday, September 8, 2023
10:00 a.m.

Defense
ATS Large Classroom (101 ATS) or Teams

Post Defense Meeting
Riehl Room (211 ACRC)

Committee:
Susan van den Heever (Advisor)
Leah Grant (Co-advisor)
Sonia Kreidenweis
Karan Venayagamoorthy (Civil and Environmental Engineering)

Cold Pool Train Dynamics and Transport

Convectively generated cold air outflows, referred to as cold pools, can initiate new convection and loft aerosols, such as dust or pollen. In the BioAerosols and Convective Storms Phase I (BACS-I) field campaign, we observed multiple cold pools passing over the same location on the same day, without colliding, which we refer to as a “cold pool train”. The goals of this study are to examine how the dynamics of cold pools in a cold pool train differ, how cold pools in a cold pool train affect the vertical distribution of aerosols, and how the results may change if the properties of the second cold pool change. We utilize idealized simulations of a cold pool train composed of two cold pools to investigate the dynamics of the cold pools in the train and how cold pool trains loft and transport aerosols. We test the sensitivity of the second cold pool’s evolution and aerosol lofting to its initial temperature deficit and timing relative to the first cold pool, based on the cold pool trains observed during BACS-I. Passive tracers are initialized at different times to represent the background aerosols present before cold pools, aerosols newly emitted after the passage of the first cold pool in the train, and aerosols within and ahead of each cold pool, to distinguish between how cold pools loft their own air compared to distinct environmental air.

We find that the first cold pool (CP1) in the cold pool train stably stratifies the environment ahead of the downshear side of the second cold pool (CP2) in the train. All else equal, this stabilization acts to decrease the height of CP2’s head and increase its propagation speed. However, the stratification also increases the horizontal wind shear ahead of CP2 by decreasing the lower level wind speeds, which opposes the stability effects and acts to deepen the head of CP2. In the CONTROL case, where CP2 is initialized two hours after CP1 and with the same temperature deficit as CP1, we find that the wind profile plays a more dominant role for the dynamics of CP2 because overall, CP2’s head is deeper and propagates slower compared to CP1. In the temperature deficit sensitivity experiments, we find that CP2’s head depth and propagation speed decreases with decreasing temperature deficit. Finally, in the timing sensitivity tests of CP2, we find CP2 initiated 90 minutes after CP1 had the deepest head, while CP2 in the CONTROL (120 minutes) experiment propagated the slowest.

Our analysis of the tracer lofting mechanisms in the simulations shows that the downshear leading edge of CP1 lofts the highest concentration of background aerosol, while the downshear leading edge of the CONTROL CP2 lofts less than half of the amount of background aerosol as CP1. However, the downshear leading edge of CP2 lofts more than double the concentration of newly emitted aerosol compared to the background aerosol lofted by CP1. The atmospheric stratification left behind by CP1 acts to trap the newly emitted aerosol near the surface, leading to greater concentrations lofted compared to the background aerosol which is well mixed in the boundary layer. Analysis of the tracers initialized within and ahead of the cold pools demonstrates that the lofted aerosol primarily originates from the air ahead of the cold pools, while the aerosol originating in the cold pools remains trapped within the cold pools. The CONTROL CP2 lofts the most aerosol of the temperature deficit sensitivity tests, and the CONTROL CP2, released the farthest apart temporally from CP1, lofts the most aerosol out of the timing sensitivity tests. Therefore, while the wind profile change ahead of CP2 plays a dominant role in its dynamics, atmospheric static stabilization plays a dominant role for the aerosol concentration lofted by CP2.