An observational evaluation of RKW theory in the southern Great Plains

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Rotunno, Klemp, and Wilhelmson (1988) proposed a novel theory (henceforth termed “RKW” theory) for squall-line maintenance that remains relevant to this day. This theory may be distilled into two components: (i) that a vorticity balance between cold-pool baroclinicity and environmental vertical shear along the leading edge of the cold pool gives rise to a locally upright updraft, and (ii) an upright leading updraft enhances the strength and longevity of the convective system. Due to its general simplicity and inherent relevance to observed and numerically simulated deep convection, RKW theory has been incorporated into the fabric of mesoscale meteorology. It is included in modern meteorology textbooks and commonly cited in any study of squall lines or mesoscale convective systems. Nevertheless, careful observational evaluation of this theory has been limited by the inability to observe the key quantities contained in it, including the cold-pool buoyancy profile and the tilt of the leading updraft. This study exploits observations from the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) observatory in Lamont, OK to critically evaluate the predictions of RKW theory. To this end, we analyze data from multiple continuous observational facilities include surface meteorology stations, surveillance S-band weather radar, a vertically staring Doppler wind Lidar, and a recently developed retrieval of thermodynamic profiles from an Atmospheric Emitted Radiance Interferometer (AERI). Cold-pool intensity, vertical wind shear, subcloud updraft tilt, and multiple metrics of system intensity are estimated for 11 squall lines that impinged upon the SGP observatory over 2013-2023. This talk describes and justifies the methods used to estimate these quantities and their errors. It also directly evaluates RKW theory by investigating the sensitivity of subcloud updraft tilt, system intensity, and system evolution to the leading-edge vorticity balance. Preliminary results suggest that the theory can reasonably explain the observed trends in system tilt, strength, and duration, but the trends are uncertain (due to the limited sampling) and extremely sensitive to the evaluation of environmental vertical wind shear. Co-authored: Kapil Dev Sindu and Dave D Turner

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Refreshments 1:45PM

Please also join colleagues for refreshments and informal discussion after the seminar until 3:30pm

NCAR-Foothills Laboratory, 3450 Mitchell Lane

FL2-1022, Large Auditorium

Seminar will also be live webcast

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Participants may ask questions during the seminar via Slido.