Case Study – Vertical Structure of a Cold Pool

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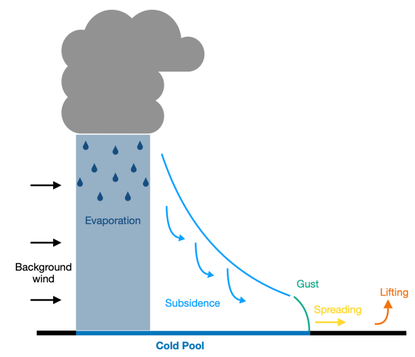
1 Introduction/Motivation

Cold pools are regions of cold, dense air formed by evaporative cooling during precipitation under convective storms. As rain evaporates, it lowers the surrounding temperature, creating a density current that radially propagates from the precipitation area.[1]

Cold pools are usually characterized by
- sudden temperature drop
- increase in pressure
- increase in wind speed & gusts
- change in wind direction
- increase in specific humidity



This study seeks to explore the vertical structures of cold pools, which have remained relatively understudied until now.

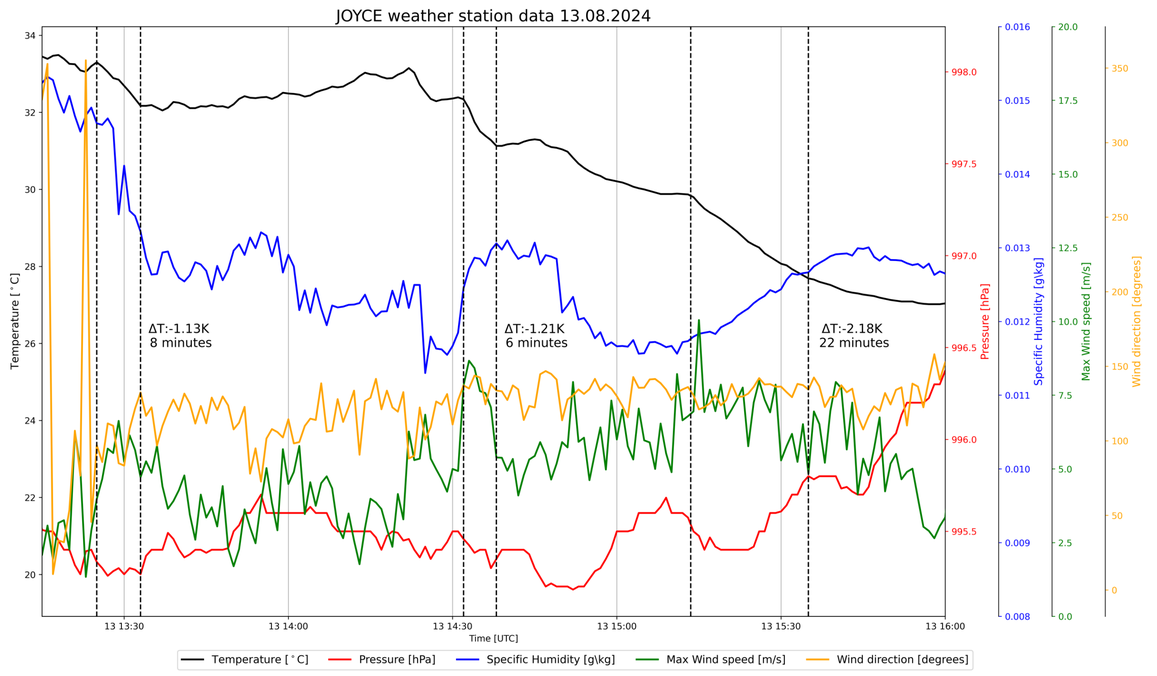
2 Method and Instrumentation

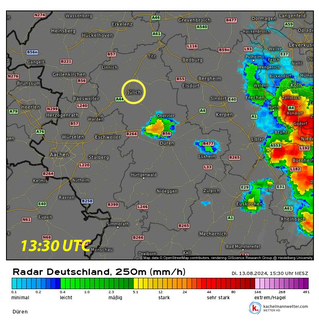
HATPRO Microwave Radiometer
- Vertical temperature profile

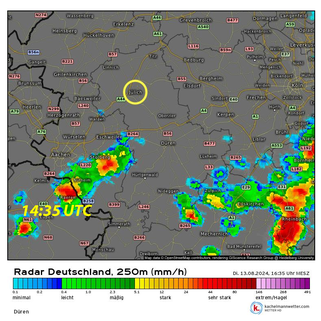
HALO Doppler Wind Lidar
- Profiles of vertical and horizontal wind
- Wind direction profile

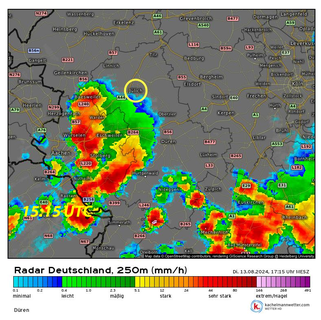
JOYCE weather station
- Temperature
- Pressure
- Specific humidity
- Wind

3 Cold Pool on 13 Aug 2024





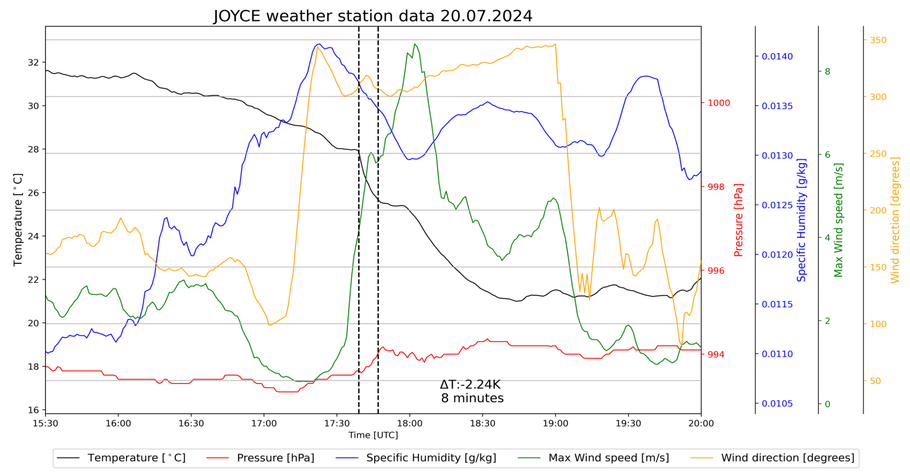


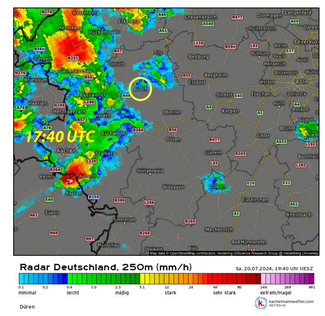


Advection of cold air from distant convective cells with relatively small temperature drops accompanied by increases in wind gusts but no significant pressure, humidity or wind direction variations. (13:30 UTC, 14:35 UTC)

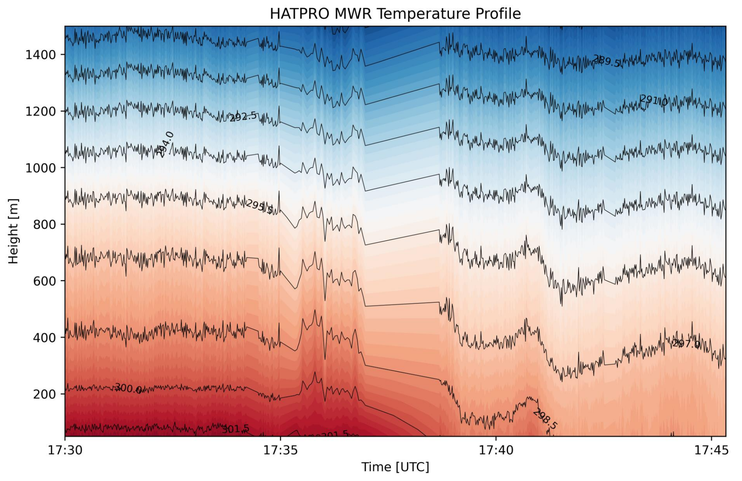
Advection of cold air from a convective storm approaching from the southwest causing a notable but slow drop in temperature but no significant changes in the other thermodynamic variables. (15:15 UTC)

4 Cold Pool on 20 July 2024



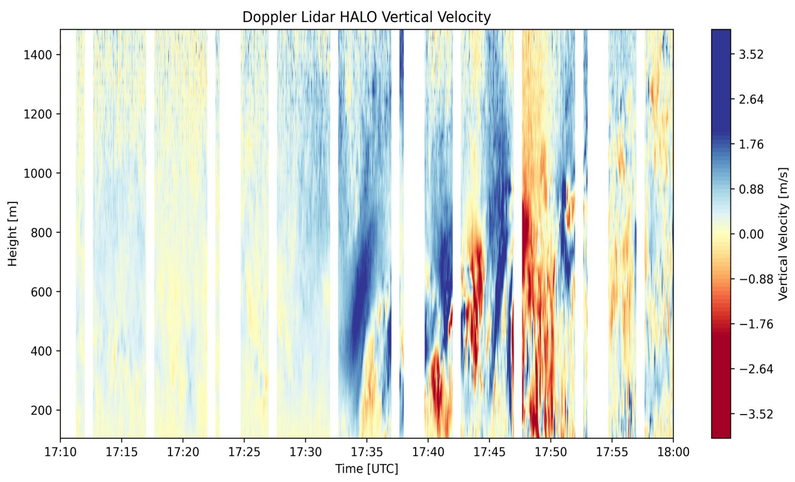


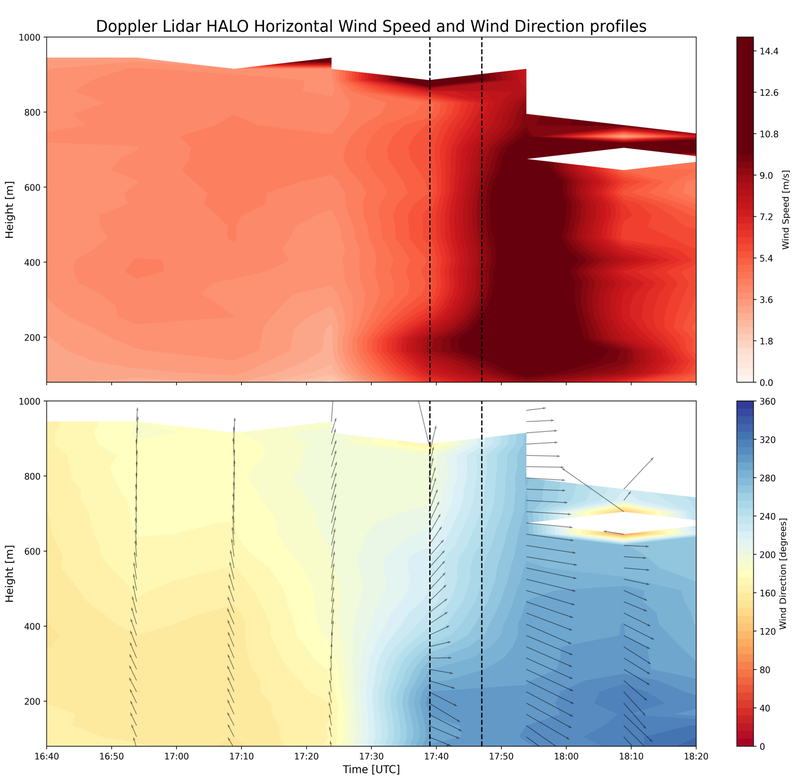
Advection of cold air from approaching convective cells associated with a notable temperature drop, a slight peak in pressure, an increase in wind gusts and a change in wind direction and specific humidity.



Vertical profile of temperature indicating temperature drops up to heights of 1000 m during cold pool event, corresponding to the **cold pool depth**.

Vertical velocity profile showing updrafts prior to the cold pool front, where convergence and eddies create lifting. Downdrafts are more prominent during the cold pool event, while the oscillating pattern suggests **eddies of varying sizes** at the cold pool edge.





The profiles of wind speed and wind direction indicate the expected increase of strength and change of direction associated with a cold pool event up to heights of over 800m. The cold pool front can be visualized by the wind shift from **weak southeasterlies to strong northwesterly winds.**

6 Summary/Outlook

Although no distinct cold pool event was observed during the HErZ period, data from July 20th was analyzed as a case study. Remote sensing instruments were used to examine the vertical structure of relevant thermodynamic variables. The temperature profile provided insights into the depth of the cold pool and indicated temperature drops at various heights, while the 3D wind profiles helped explore the mechanisms within the cold pool and those associated with its leading edge. All the vertical profiles suggest that the cold pool deepened after the front passed.

In future studies, it would be valuable to determine the initial heights at which the cold pool reaches to better estimate the vertical structure of its edge. For this, both high temporal and vertical data are essential.

References:
[1]Kirsch, B., F. Ament, and C. Hohenegger, 2021: Convective Cold Pools in Long-Term Boundary Layer Mast Observations. Mon. Wea. Rev., 149, 811–820
[2]Radar images: https://kachelmannwetter.com/de/regenradar/nordrhein-westfalen/20240720-1625z.html

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