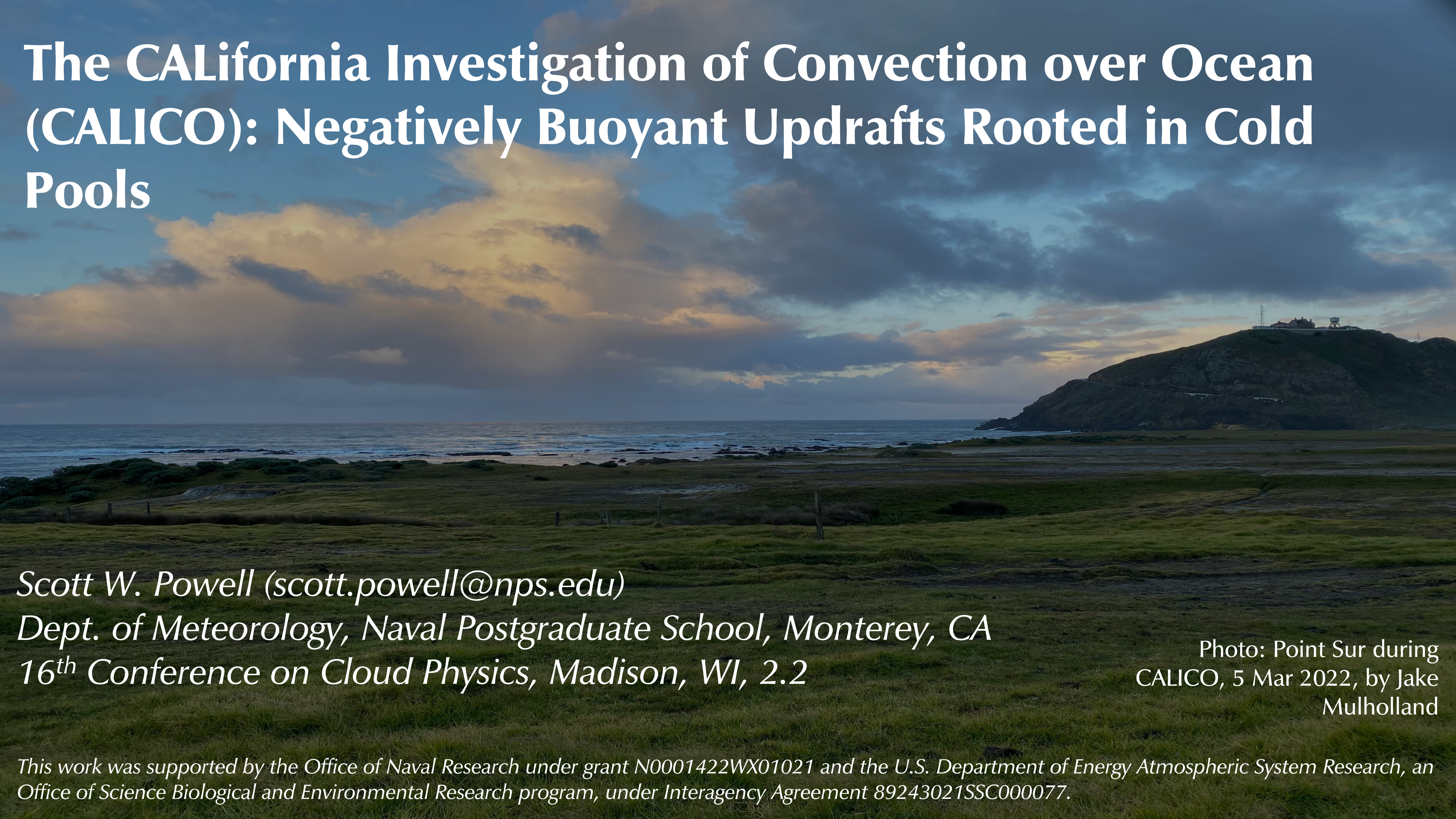

The CALifornia Investigation of Convection over Ocean (CALICO): Negatively Buoyant Updrafts Rooted in Cold Pools

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16th Conference on Cloud Physics, Madison, WI, 2.2

Photo: Point Sur during CALICO, 5 Mar 2022, by Jake Mulholland

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All CALICO participants:

Sponsored by Office of Naval Research Code 322

NPS: Scott Powell (Lead PI), Daniel Bazemore, Jessica Wasserman, Mark Boothe, Anthony Bucholtz, Roy Woods
- *+ numerous students for launching weather balloons*
- *+ thanks to Ryan Yamaguchi and Jesus Ruiz-Plancarte for helping with setup*
- *+ Zivko Aeronautics for flying the plane*

PSU: John Peters (Co-PI)

UND: Jake Mulholland

CSU: Bowen Pan

SJSU: Craig Clements, Kate Forrest

Stanford: Ipshita Dey, Laurel Regibeau-Rockett

NRL: Coastal remote sensing observations

Overview of CALICO Observations

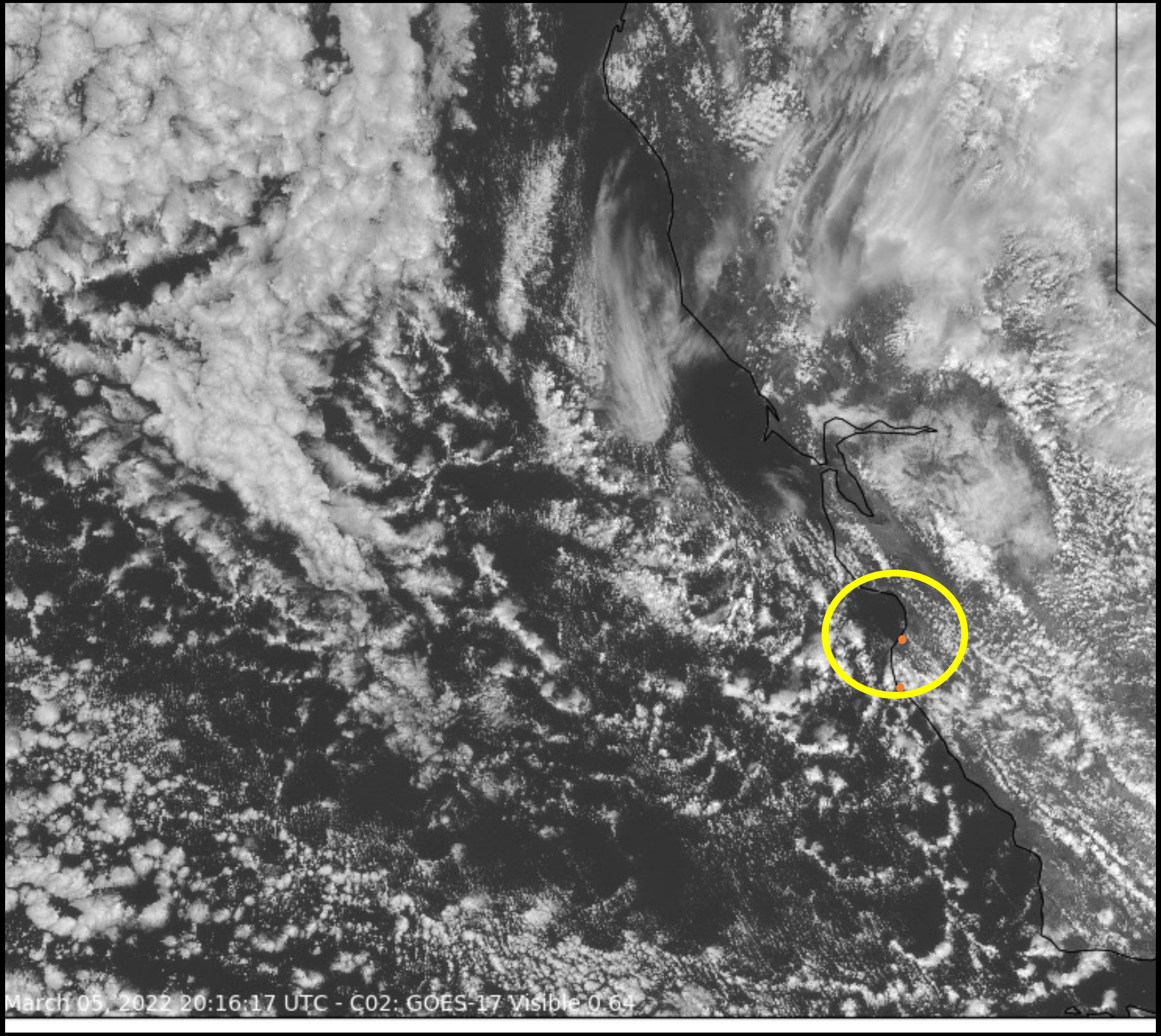
NPS Twin Otter

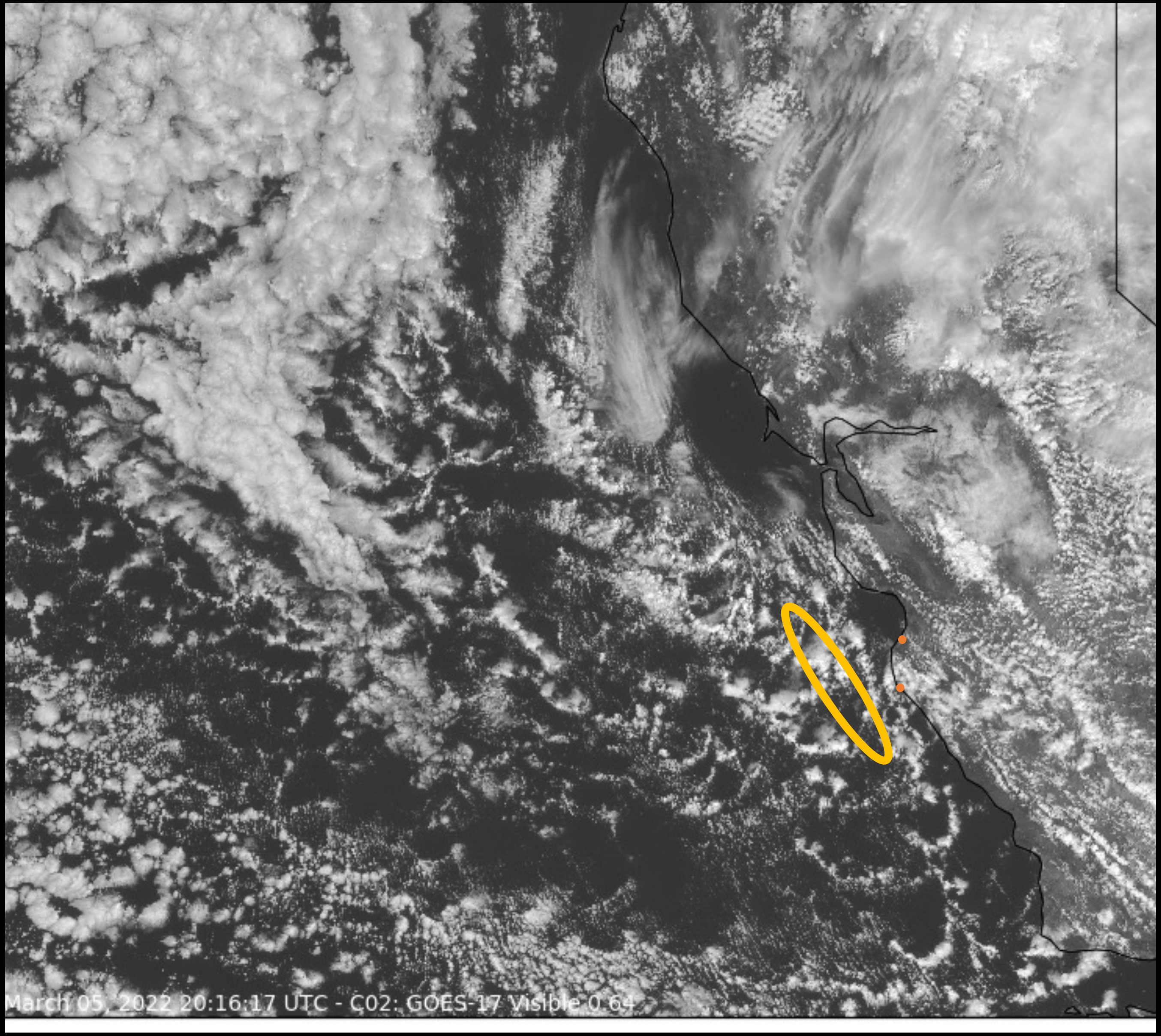
NRL-CEOBS

Rawinsondes

Three convective events:
22 February
5 March
19 March (weak shallow cumuli)

GOES-17 640 nm
2016 UTC
5 March 2022
Credit: SJSU





GOES-17 640 nm
2016 UTC
5 March 2022
Credit: SJSU

Flight pattern parallel to cloud motion vector

Flew mostly near cloud base

Some sub-cloud layer legs on 22 Feb

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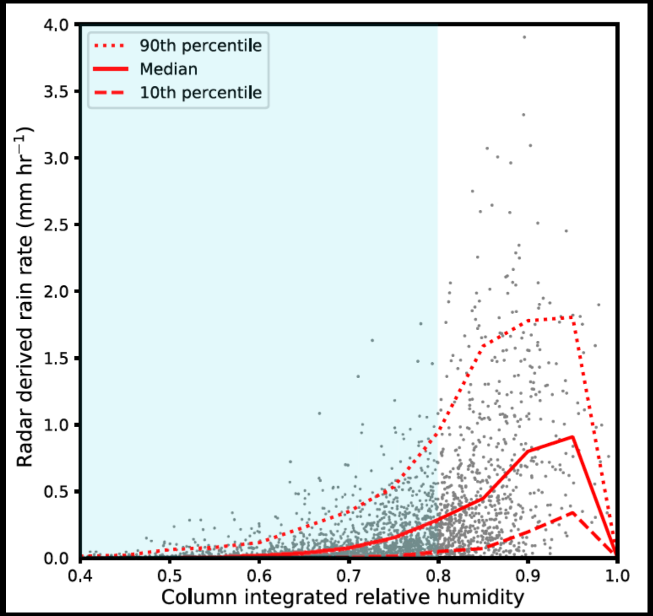
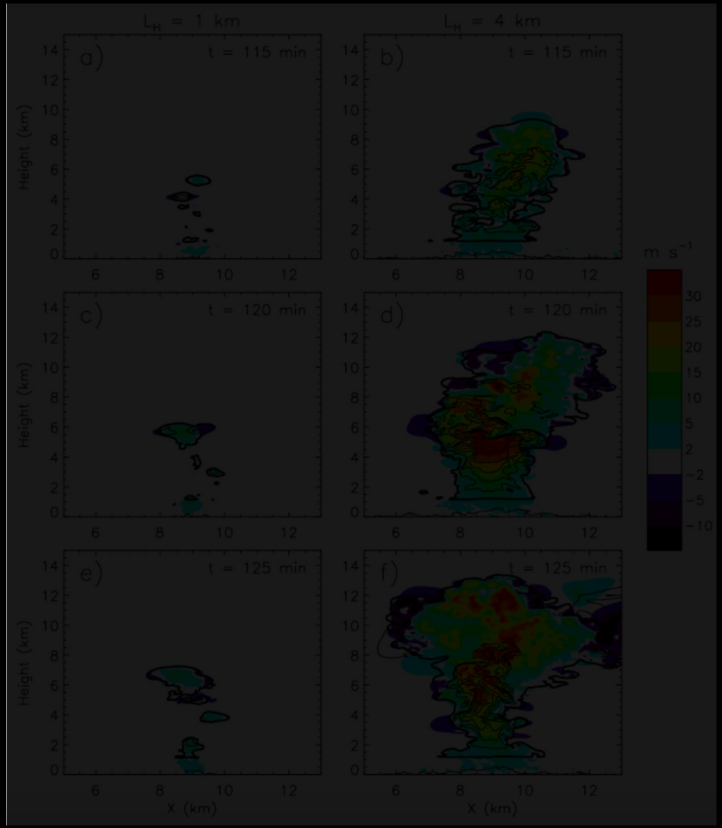
But this isn't the full story for why deep convection forms and is sustained.



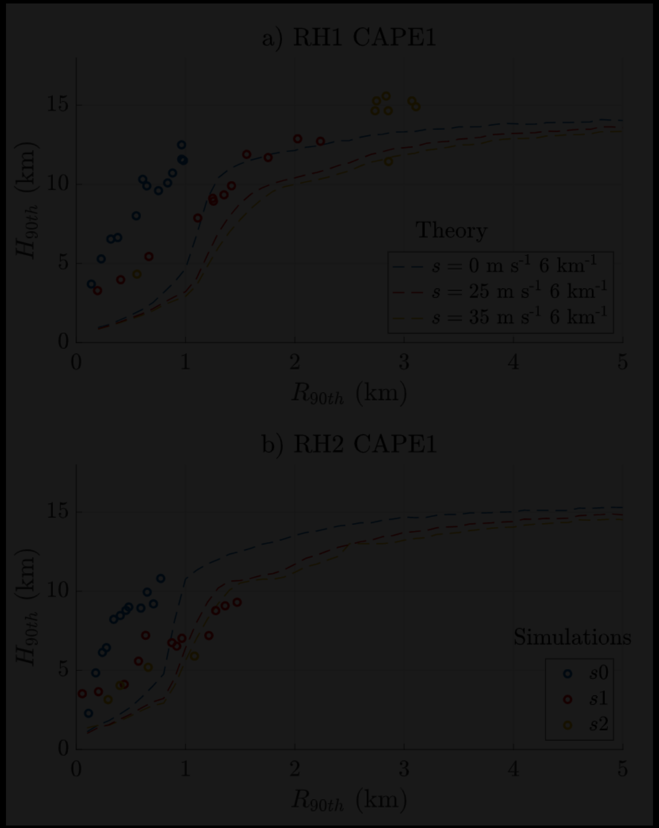
Powell (2019)

Updraft radius and RH



Morrison et al. (2021)

R, RH, and Vertical Shear



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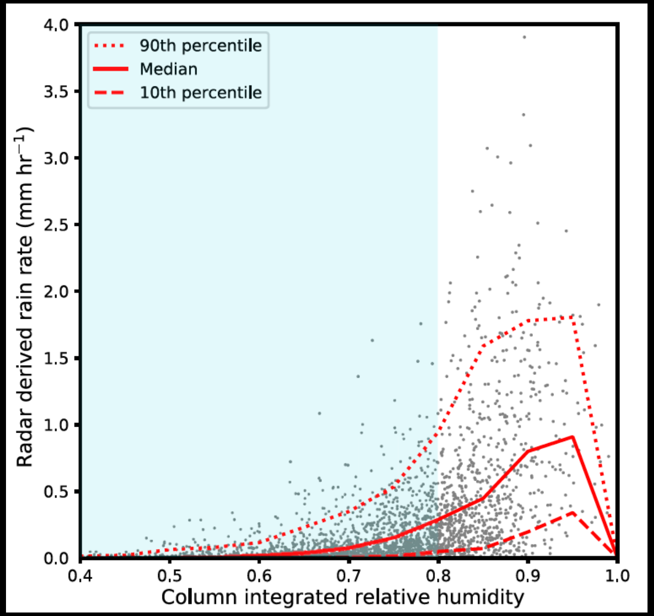

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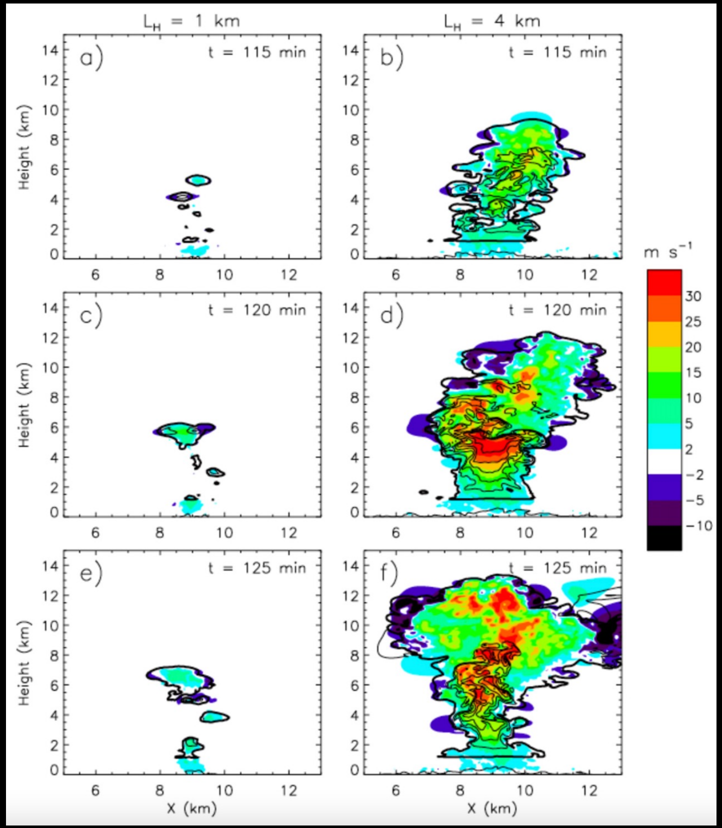

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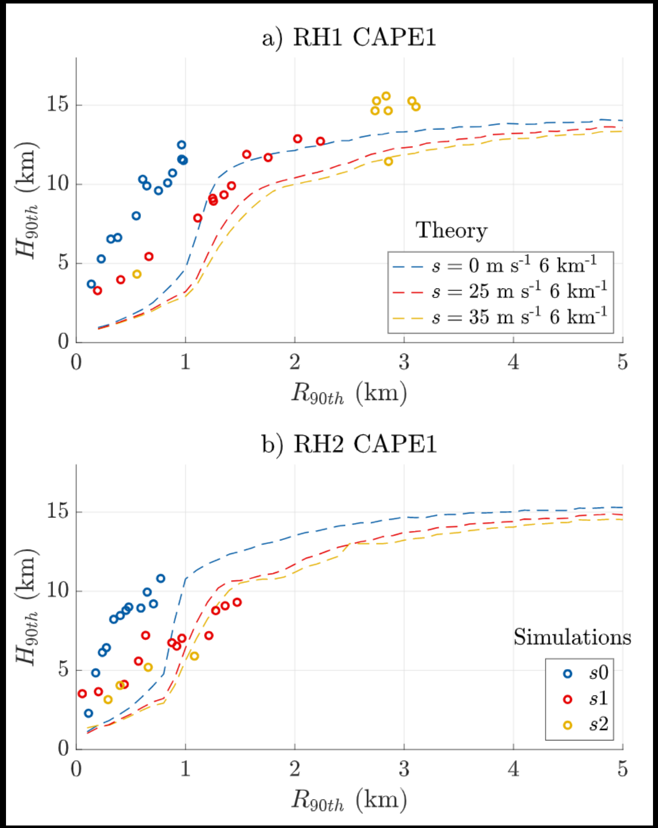


Peters et al. (2022)

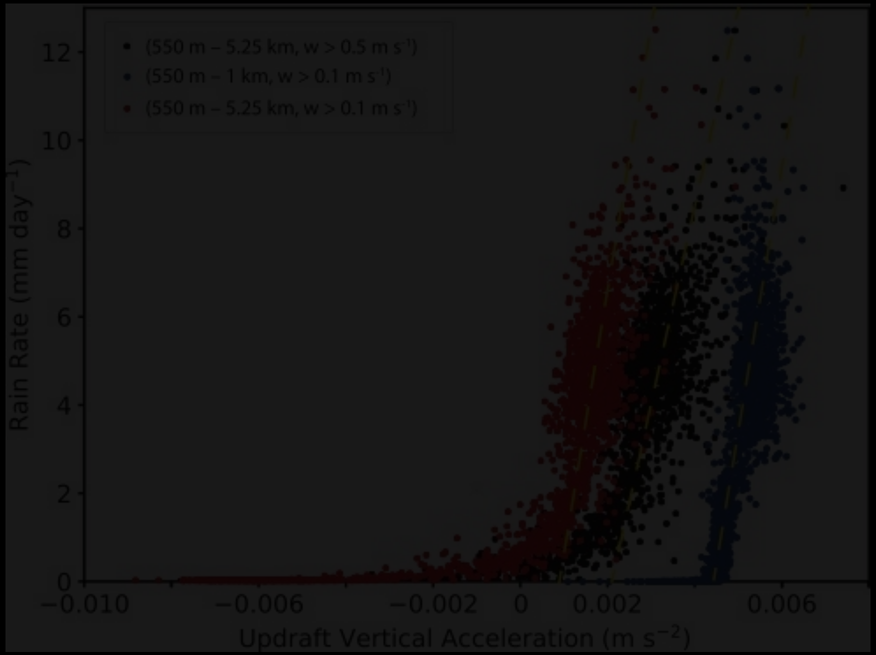
“Archimedean buoyancy”

$$\frac{Dw}{Dt} = -\frac{1}{\rho}\frac{\partial p'}{\partial z} + B$$

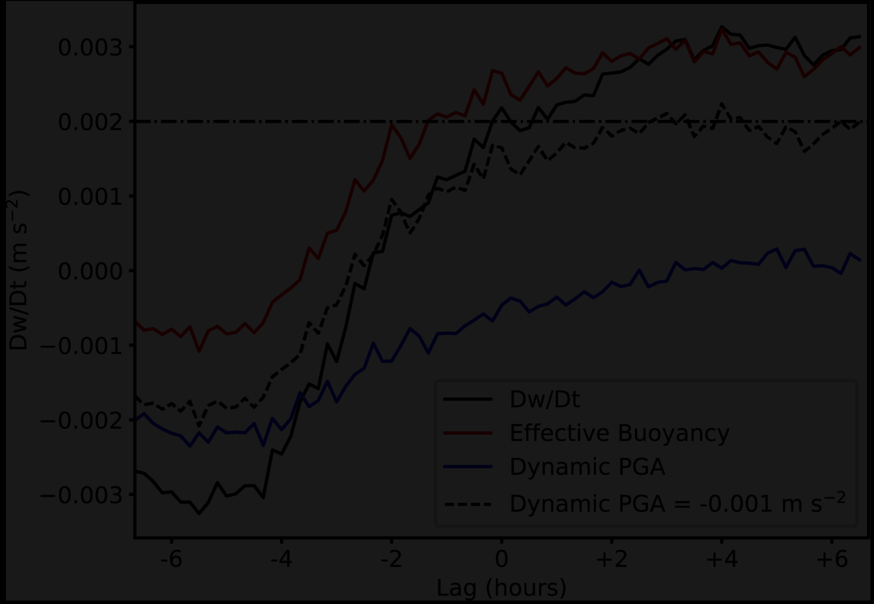
$$\frac{Dw}{Dt} = -\frac{1}{\rho}\left(\frac{\partial p_D}{\partial z} + \frac{\partial p_B}{\partial z}\right) + B$$

“Effective buoyancy”

Domain-mean updraft Dw/Dt vs domain-mean rain rate



Domain-mean updraft Dw/Dt decomposed into components



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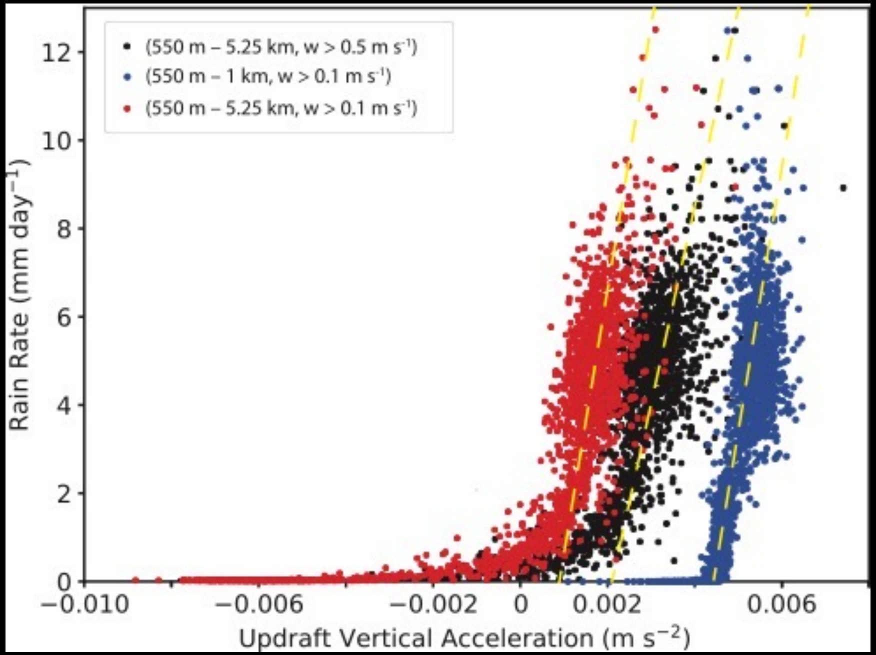
CM1 Domain-mean updraft Dw/Dt vs domain-mean rain rate



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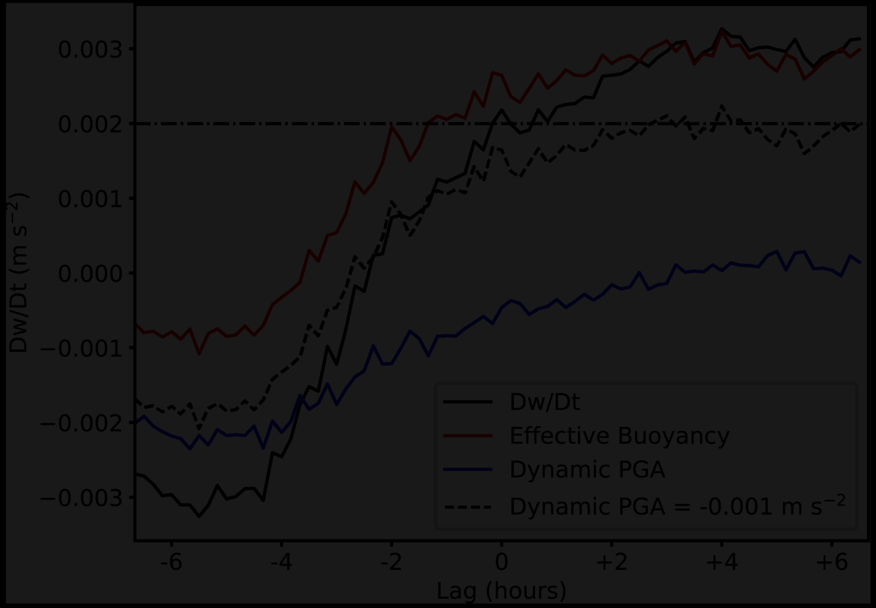

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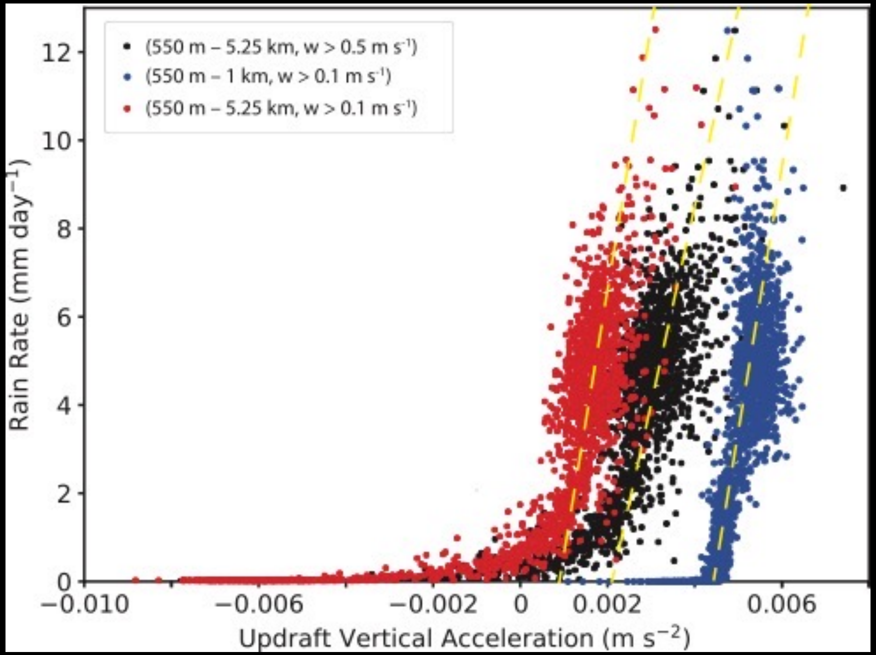

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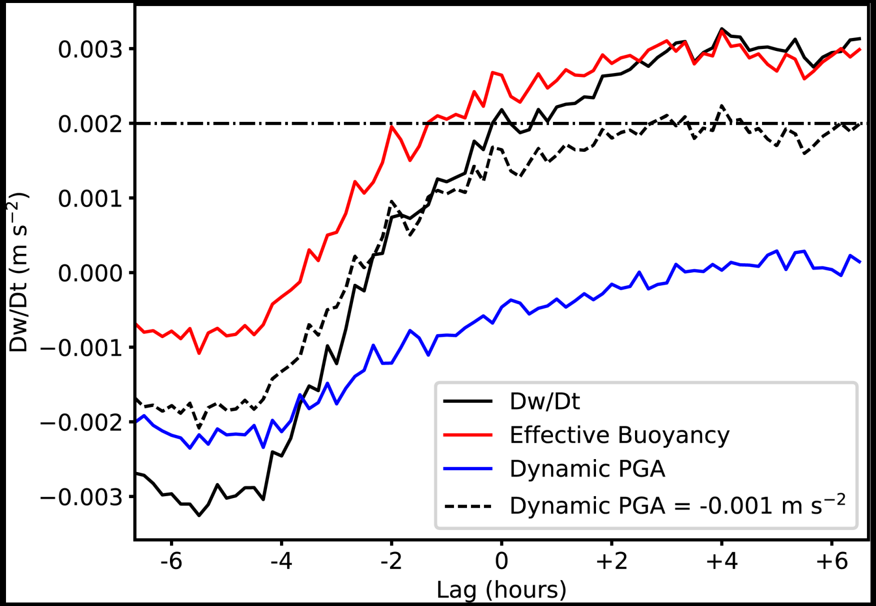

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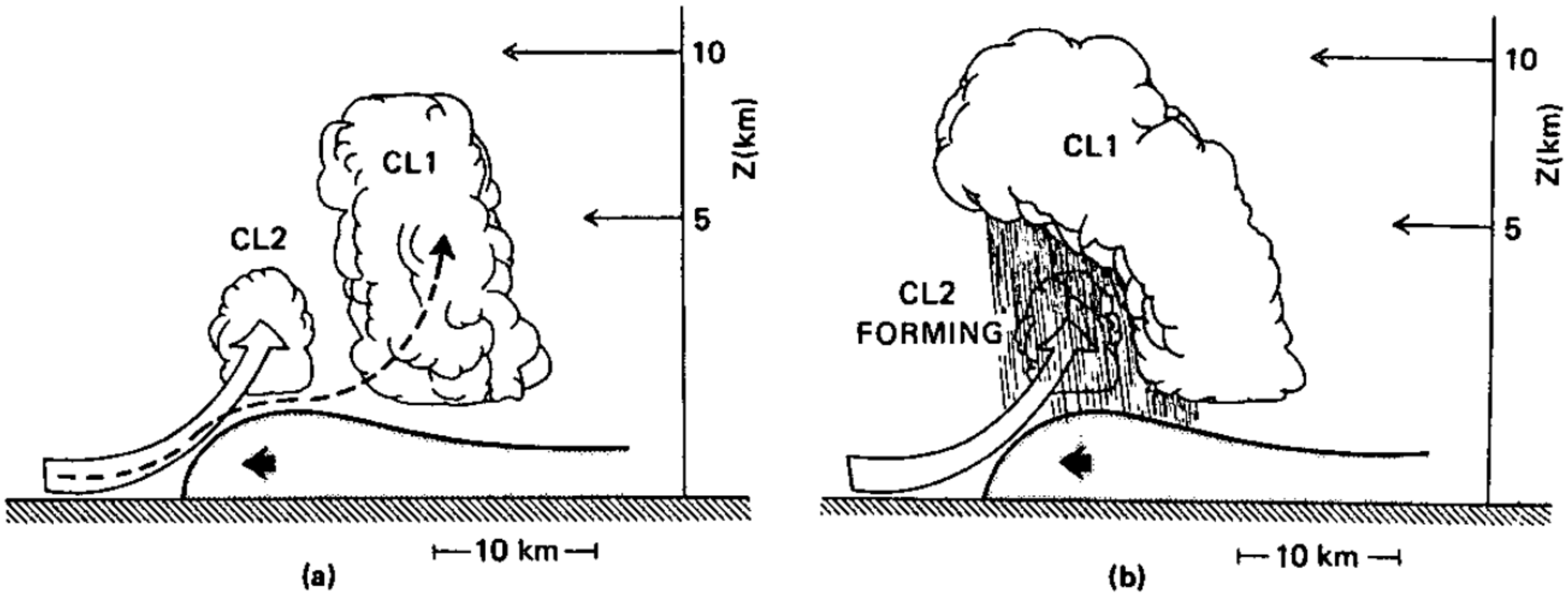
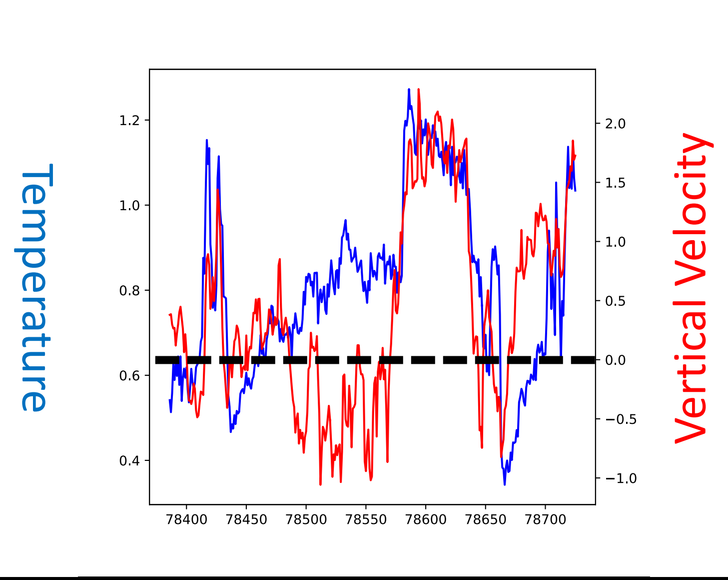
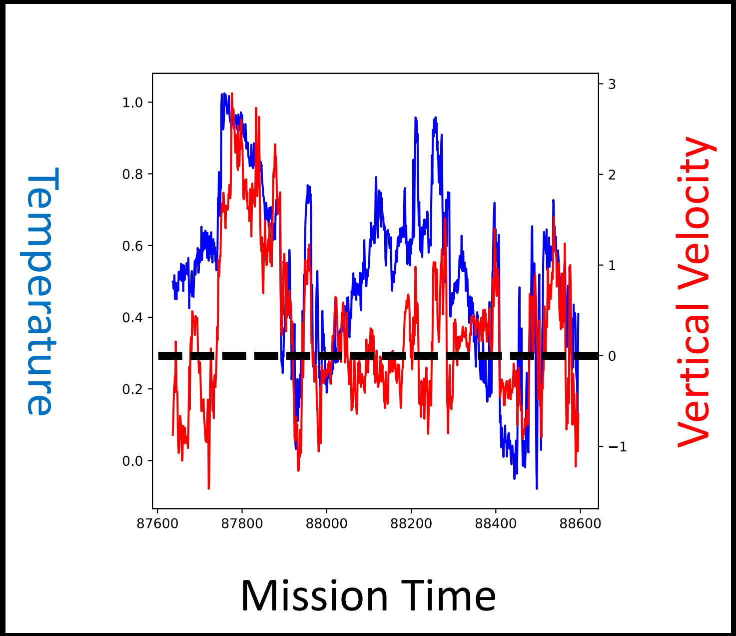


FIG. 20. Vertical cross-section schematic diagrams along the outflow collision line illustrating (a) the way in which cell CL2 captures air and blocks it from reaching CL1 and (b) the suppression of CL2s growth by rain falling from the tilted downdraft of CL1.

Droegemeier and Wilhelmson (1985)

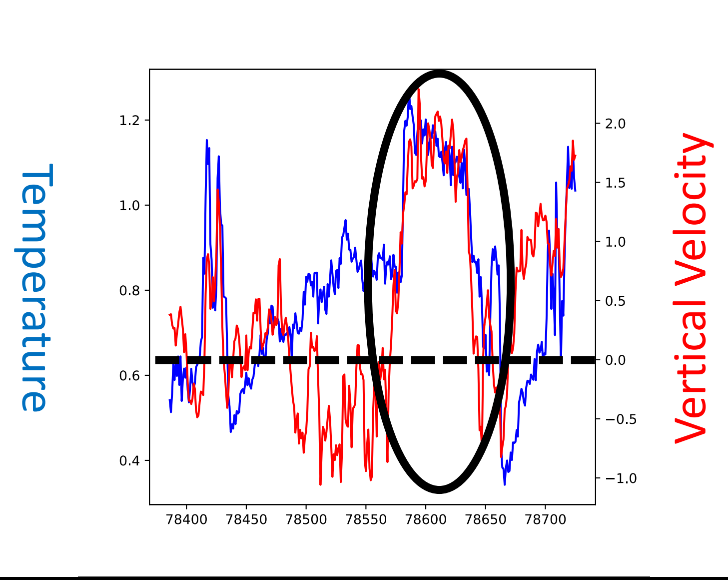
Warm Updrafts

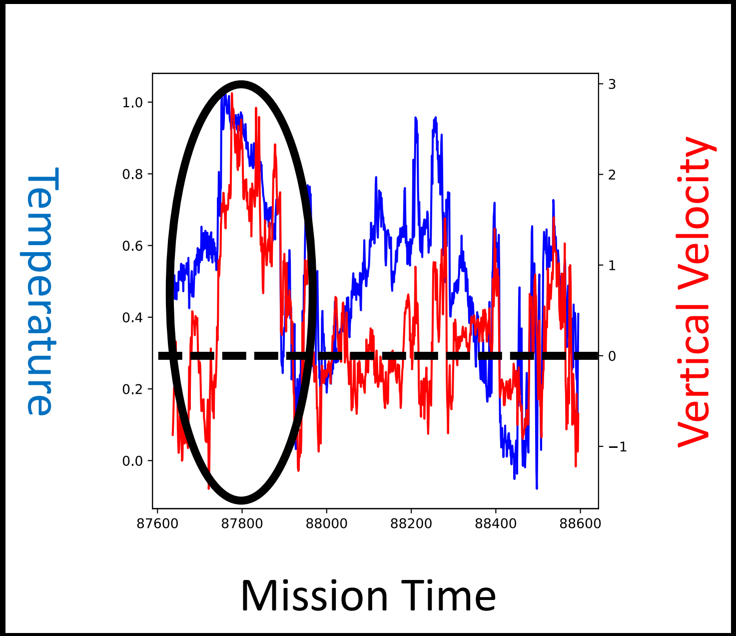




Flight level: 800–900 m
(near cloud base)

Warm Updrafts



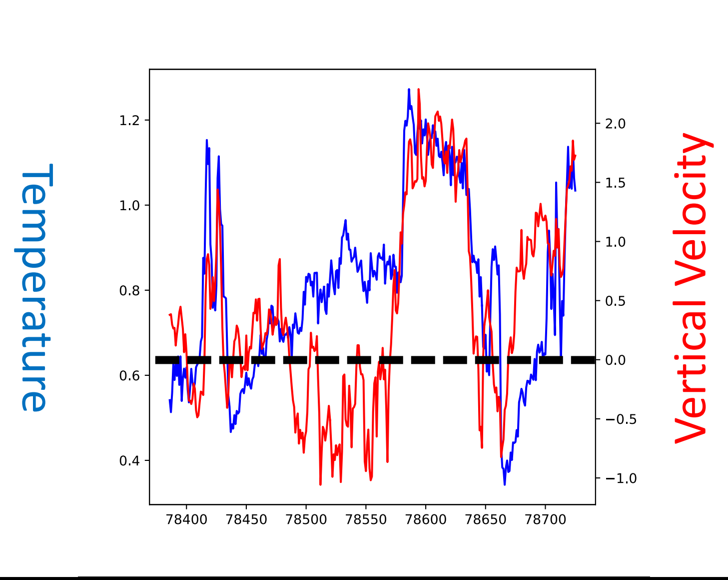


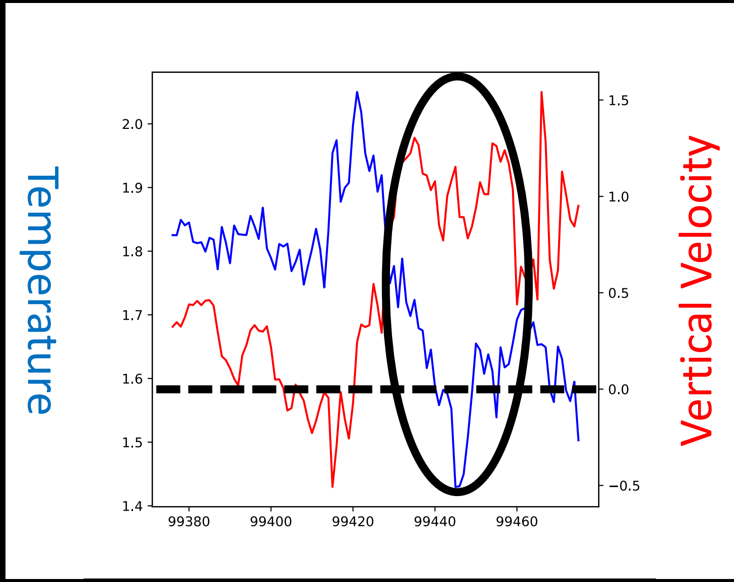
Flight level: 800–900 m
(near cloud base)

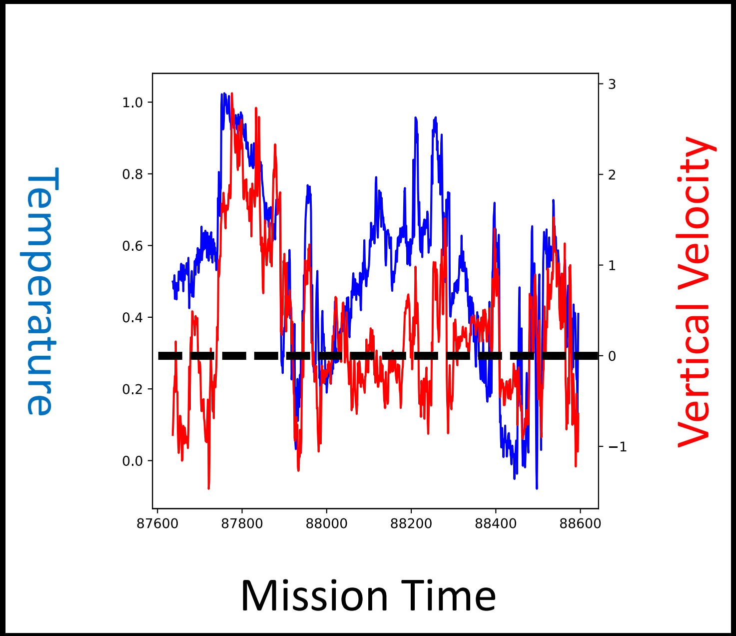
Warm Updrafts

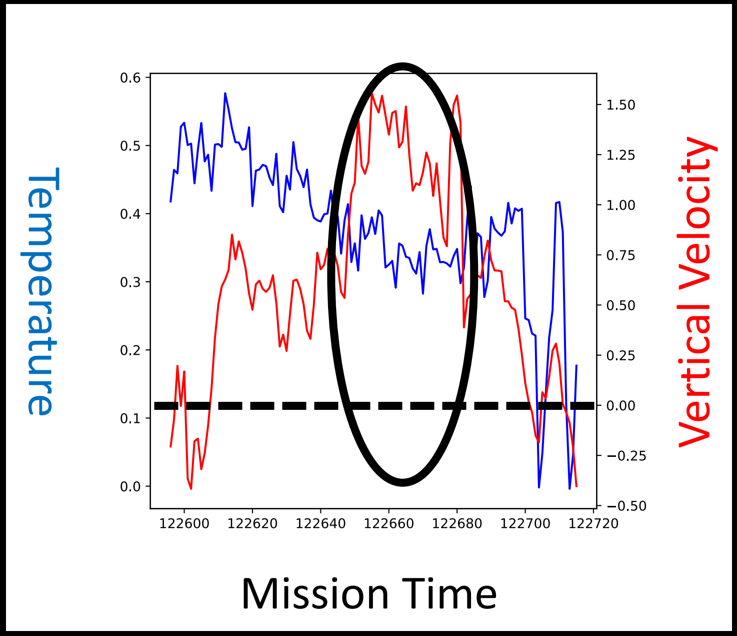
Cold Updrafts

Flight level: 800–900 m
(near cloud base)



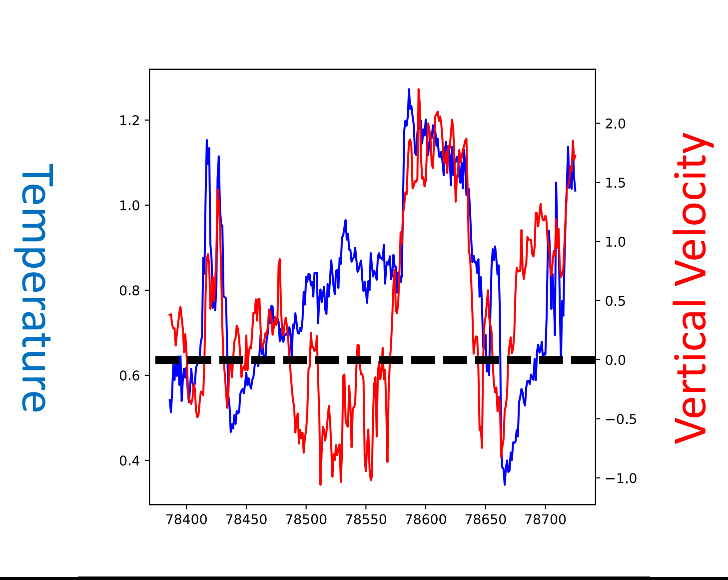


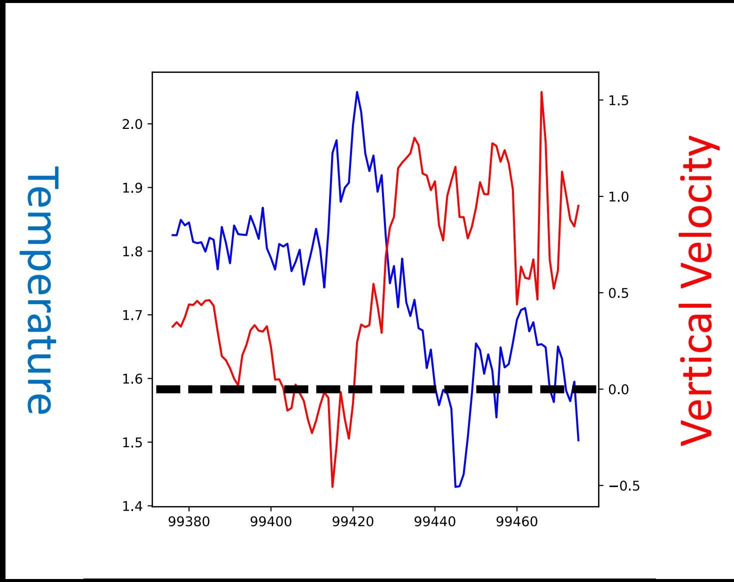




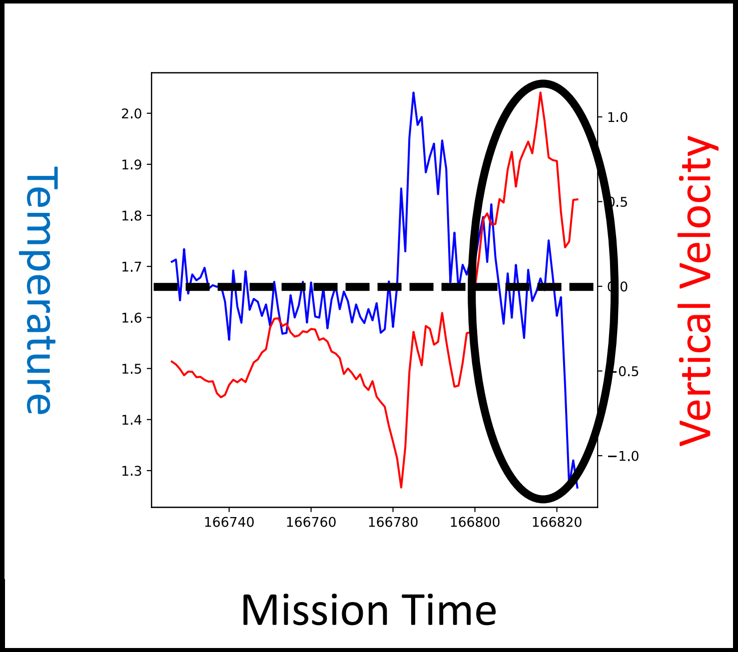
Warm Updrafts

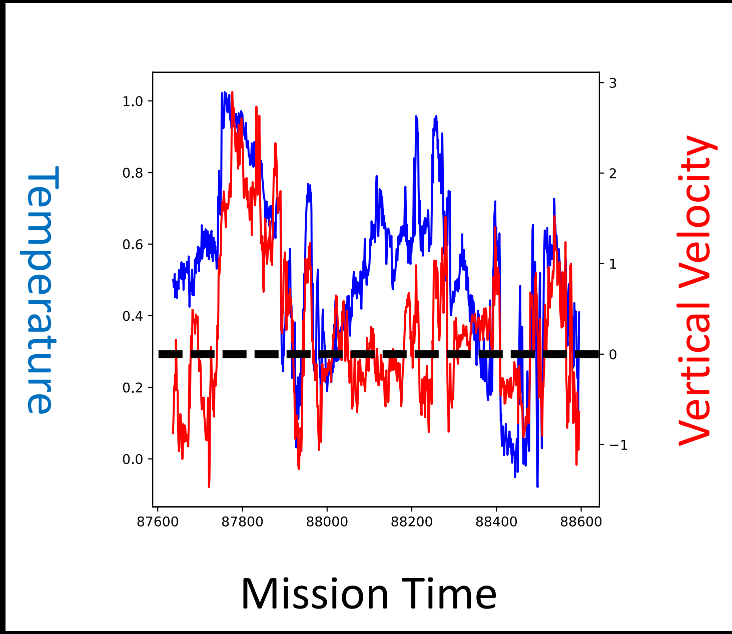
Cold Updrafts

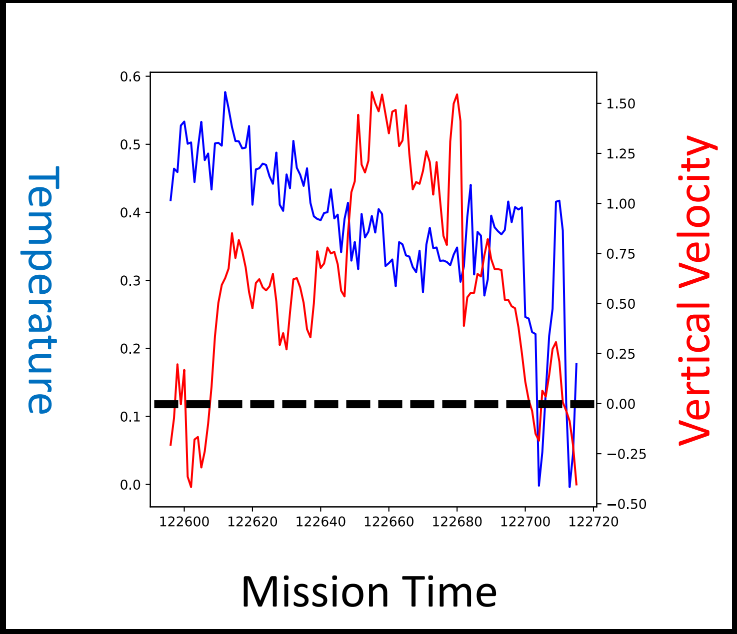




Flight level: 800–900 m
(near cloud base)







15–25% of observed updrafts were cold regardless of the length of the cross-section sampled.

Are there cold updrafts in LES of CALICO convection?

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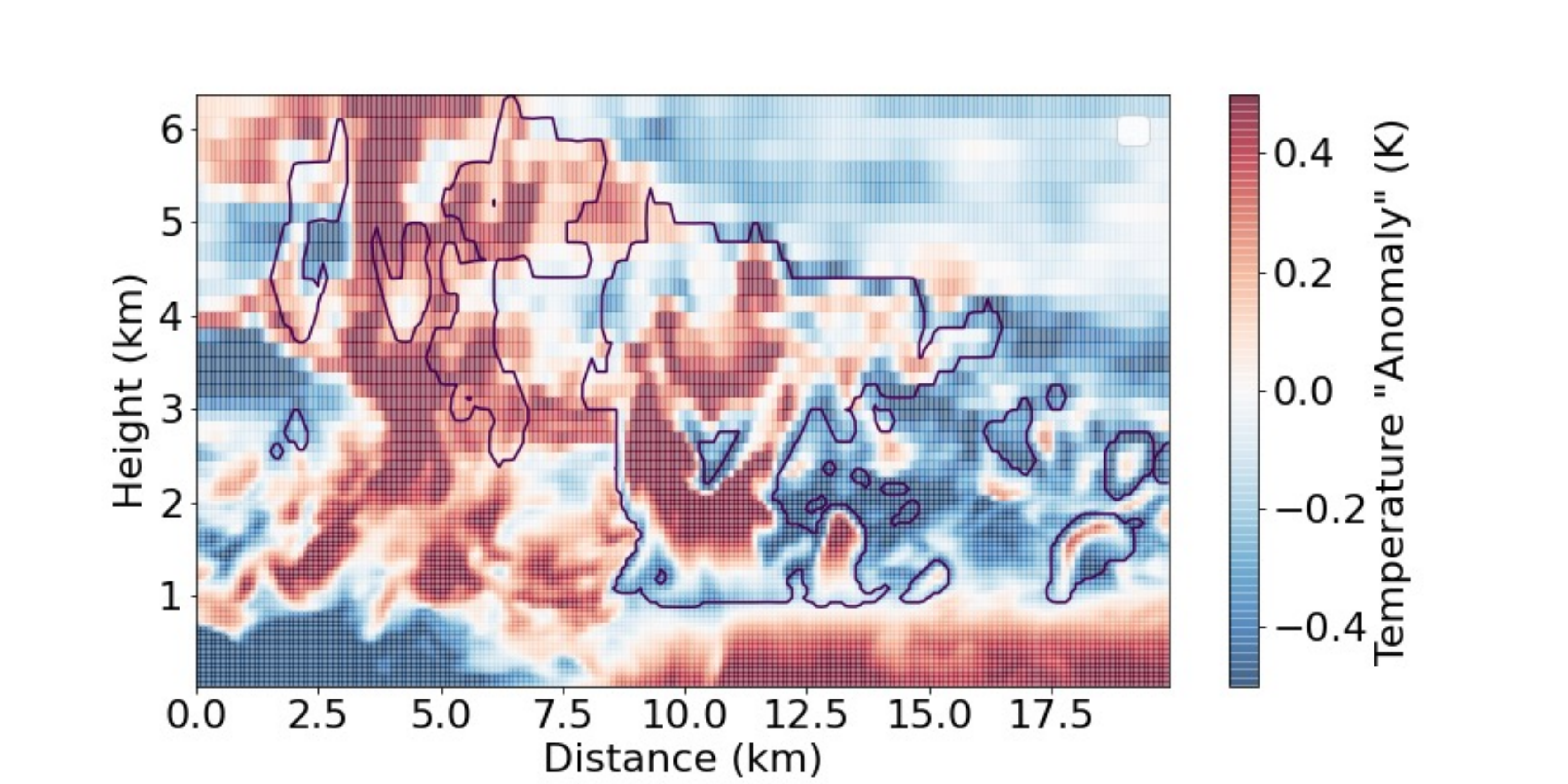
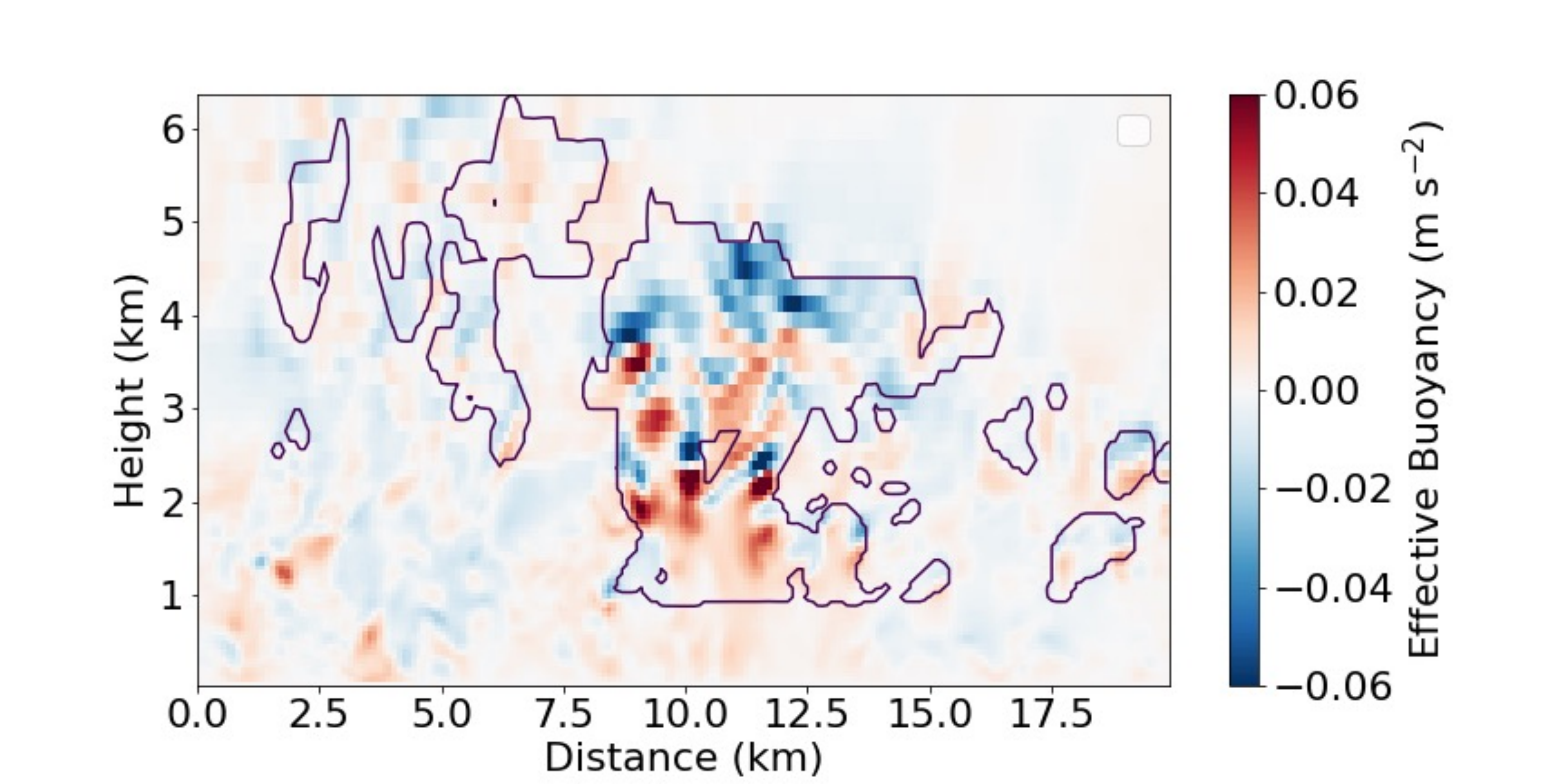
Potential Temperature "Anomaly"



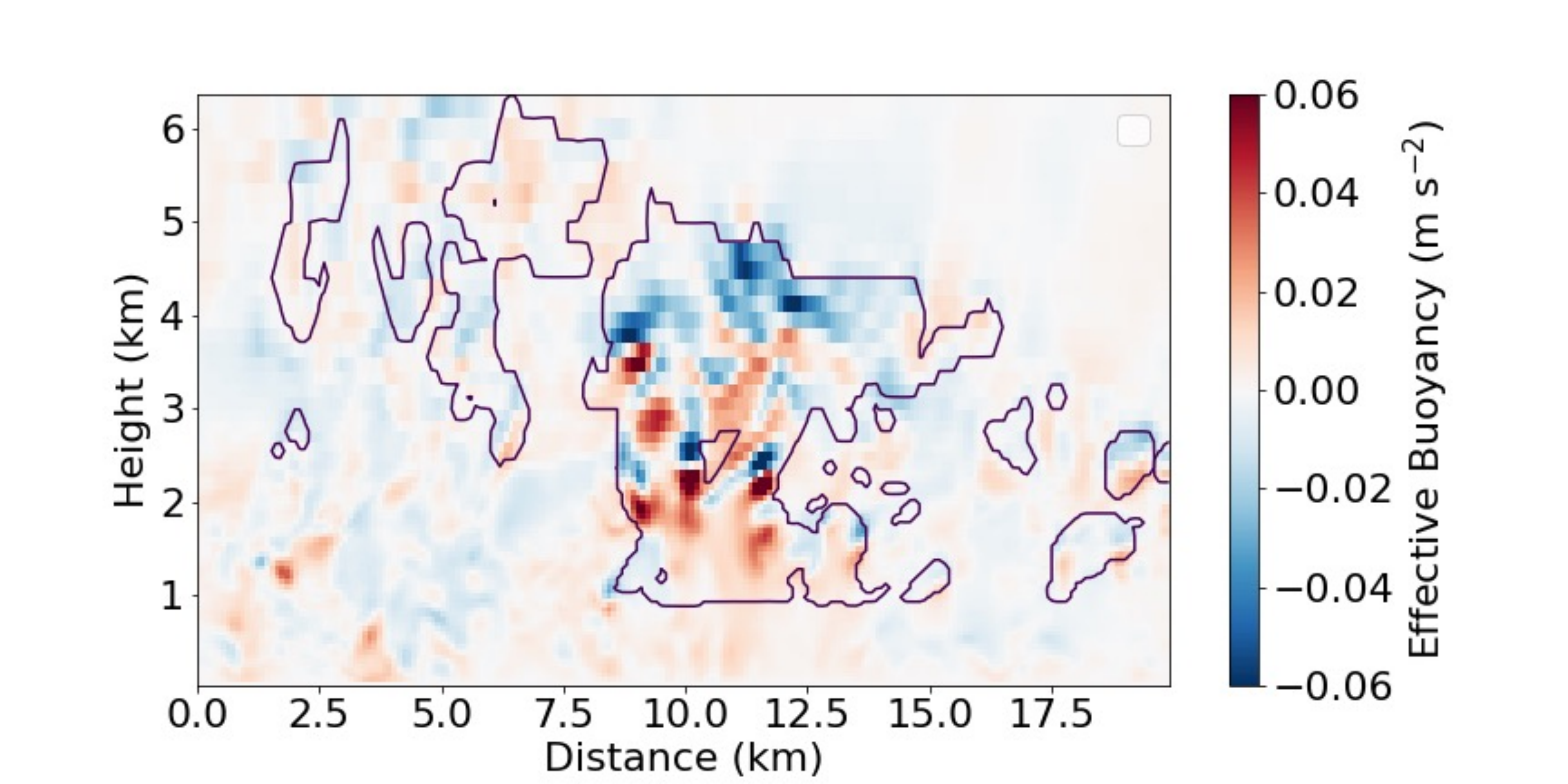
Are there cold updrafts in LES of CALICO convection?

Dw/Dt



Are there cold updrafts in LES of CALICO convection?

D*w*/D*t*



Depending on updraft size, 15–25% of updrafts in CM1 were cold.

Conclusions

- Most convection observed during postfrontal Pacific convective events was cold pool driven.

- Roughly 15–25% of observed and simulated convective elements in postfrontal convection were cooler than immediately environment. These updrafts were negatively buoyant even containing the virtual correction for moisture.

- In cold updrafts, the pressure gradient acceleration was directed upward to make total Dw/Dt positive.

- How much of the total vertical mass flux in cold pools is driven by updrafts that are negatively buoyant at cloud base?