A Detailed Examination of a High Shear, Low CAPE Mesovortex

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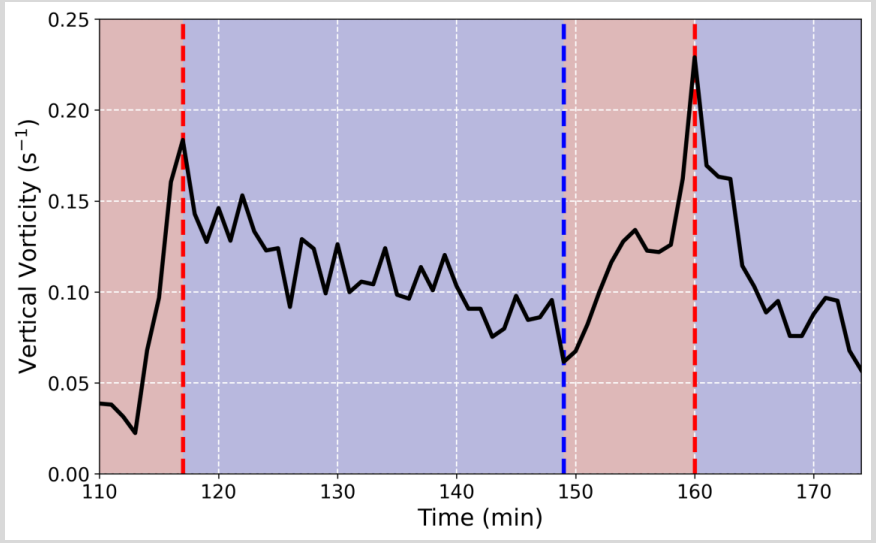
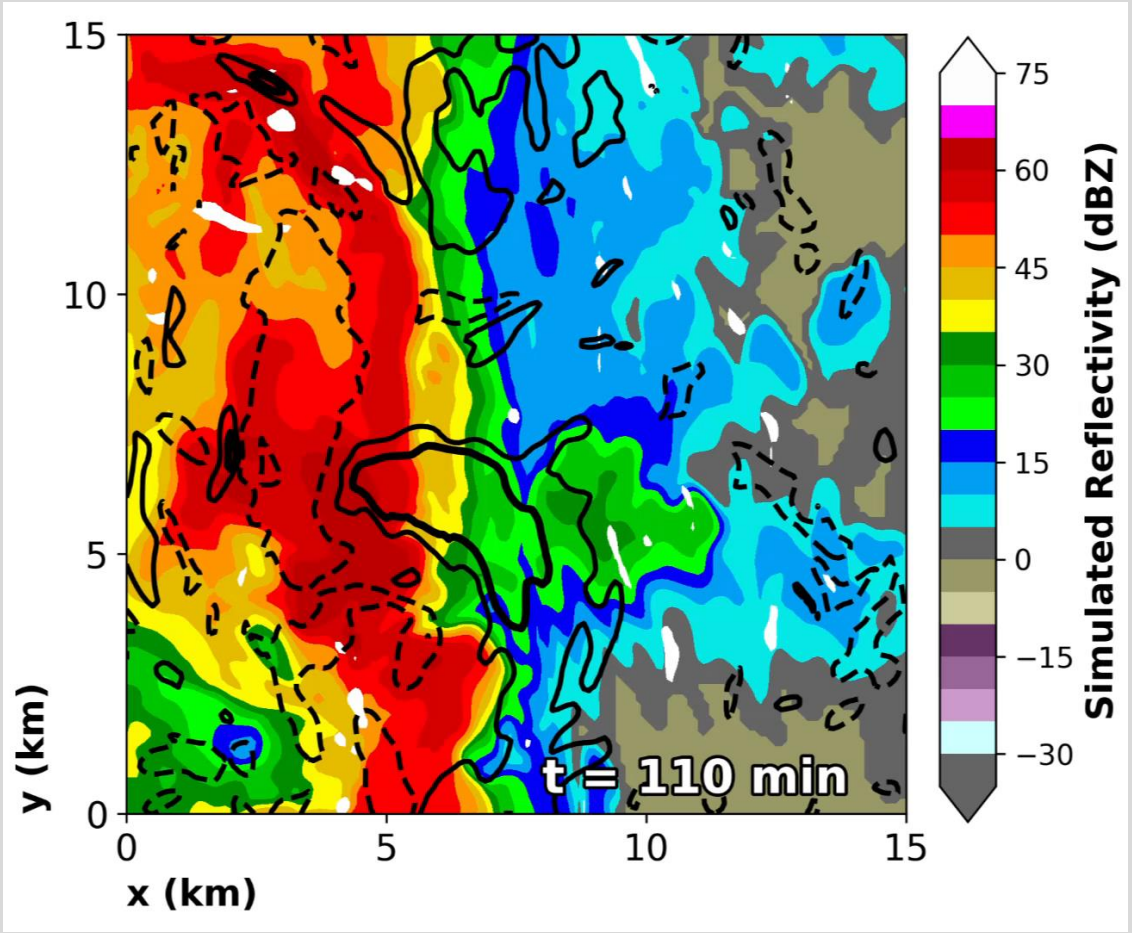
Methodology

- CM1 simulation using PERiLS HSLC environment (30 March 2022)
- Simulation details:
  - 201x201x16 km domain
  - 100 m horizontal grid spacing
  - 30 m grid spacing in lowest 3 km





(Some) Key Findings

1. Updraft cores key to intensifying vortices
2. Shear effects/convergence along cold pool important for sustaining small, shallow vortices over long periods
3. Vortex feedbacks on system promote vortex-updraft alignment
4. Evidence points to variety of mechanisms responsible for vortex formation, maintenance, and intensification
   - HSI
   - Baroclinity (streamwise and crosswise)
   - Friction
   - Environment

Vertical Accelerations

Buoyancy Pressure

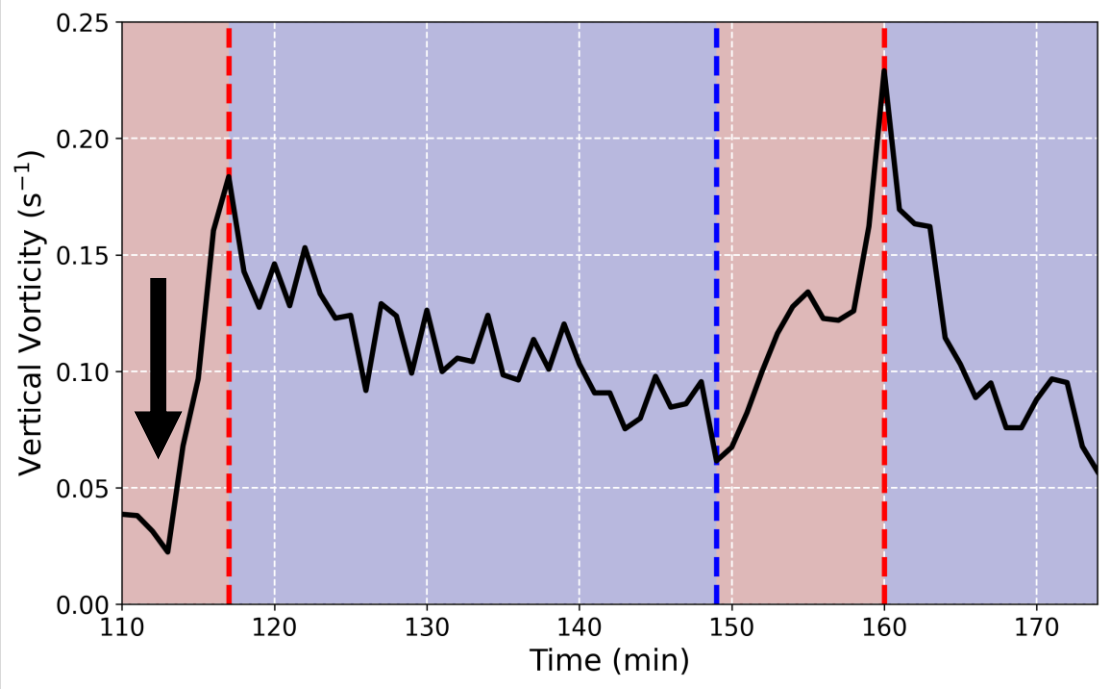
$$p'_B \propto -\frac{\partial(\bar{\rho}B)}{\partial z}$$

Dynamics Pressure

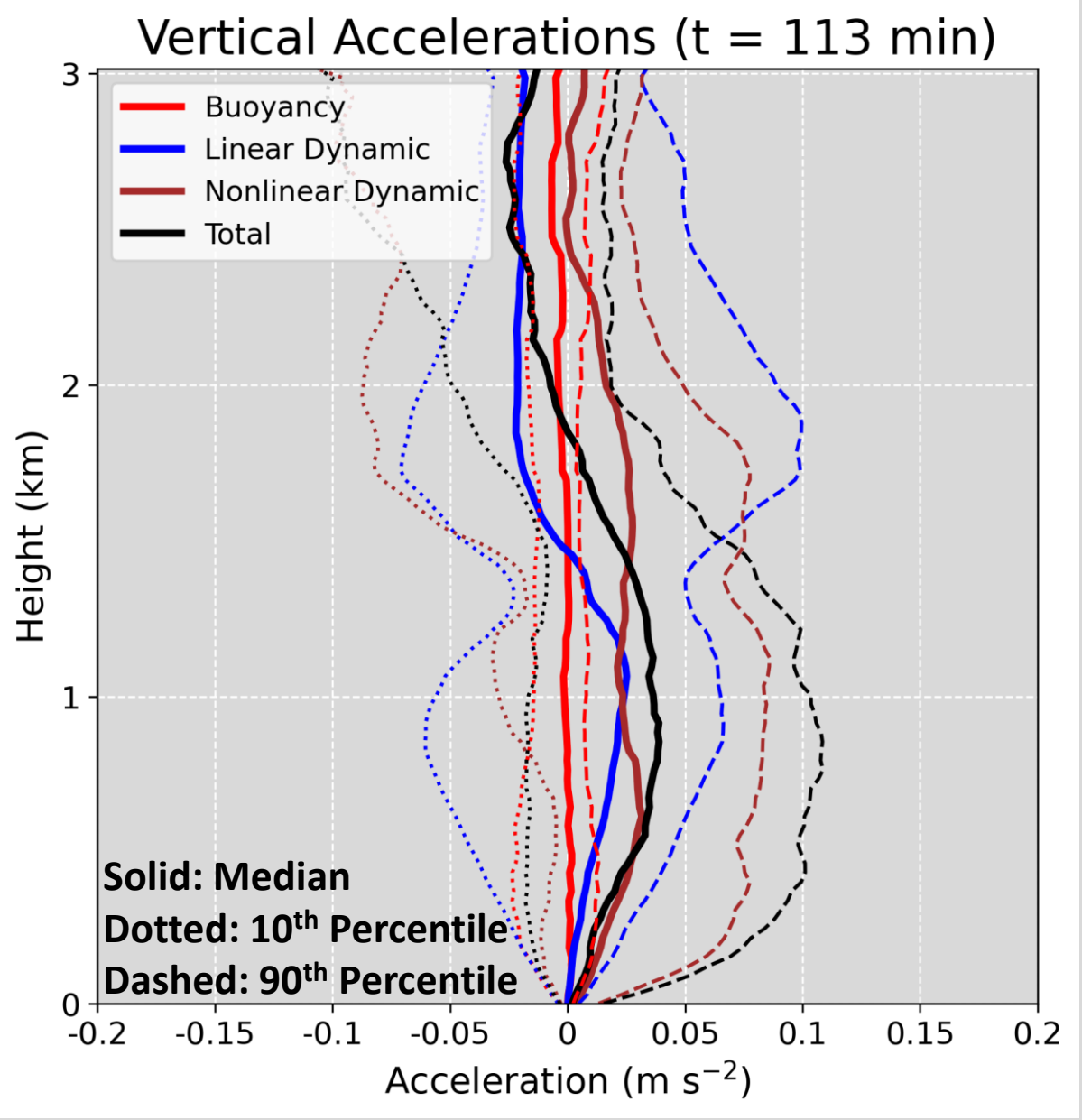
$$p'_D \propto e_{ij}^2 - \frac{1}{2}|\vec{\boldsymbol{\omega}}|^2$$

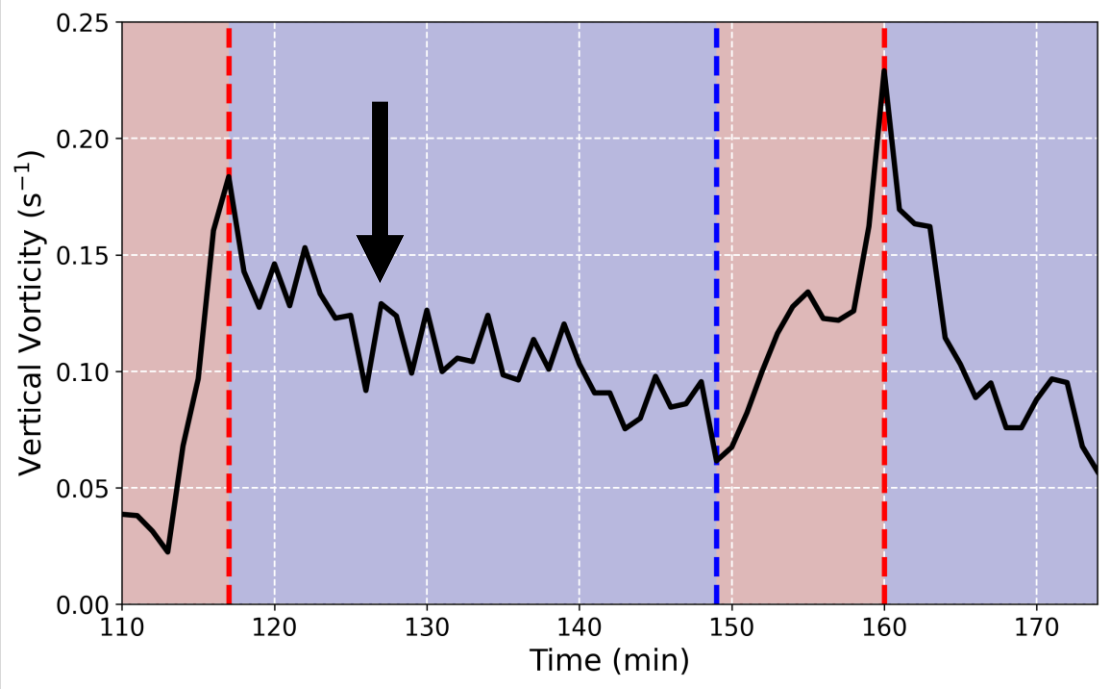
Deformation tensor

$$e_{ij}^2 = \frac{1}{4}\sum_{i=1}^{3}\sum_{j=1}^{3}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)^2$$

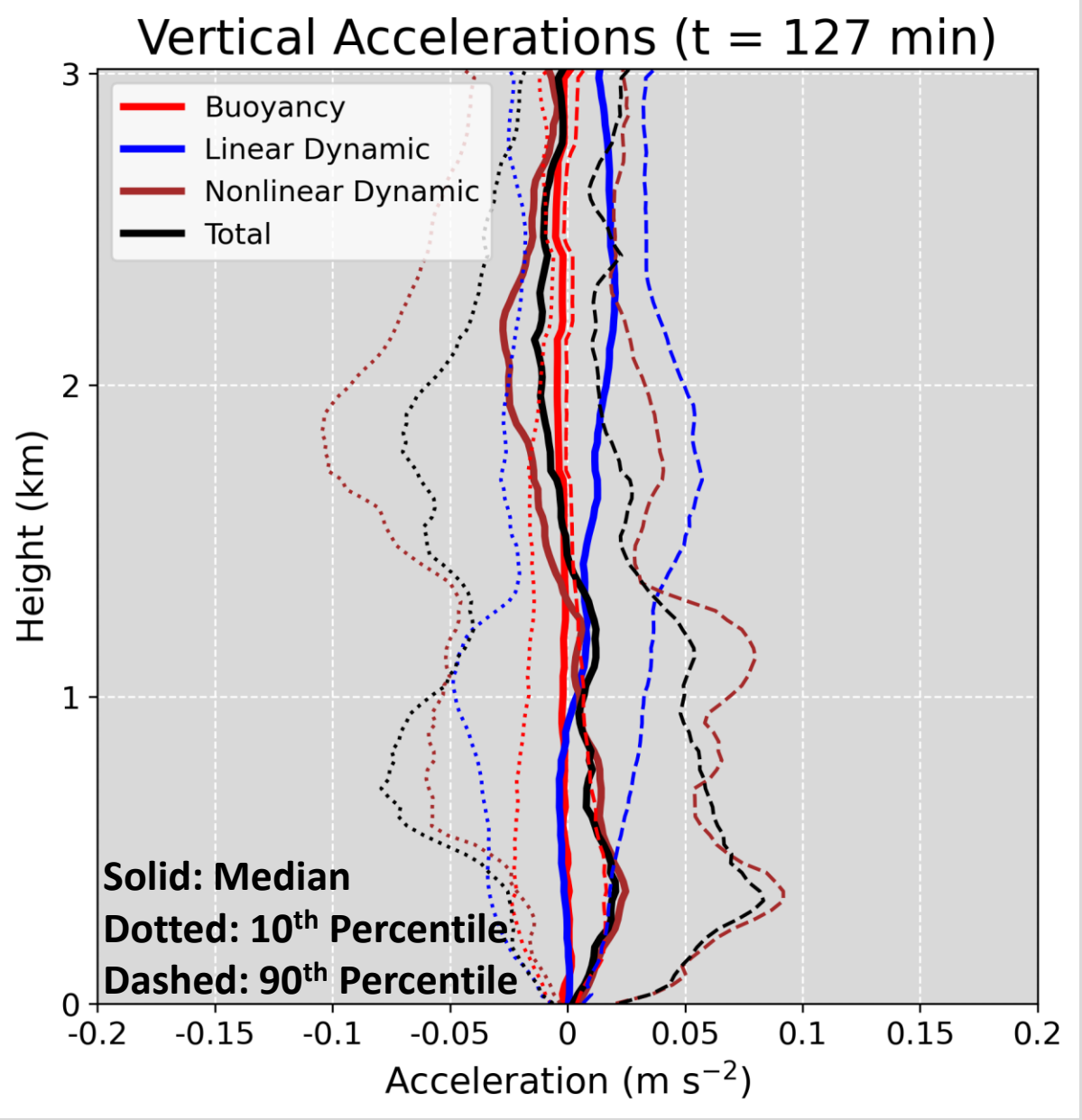


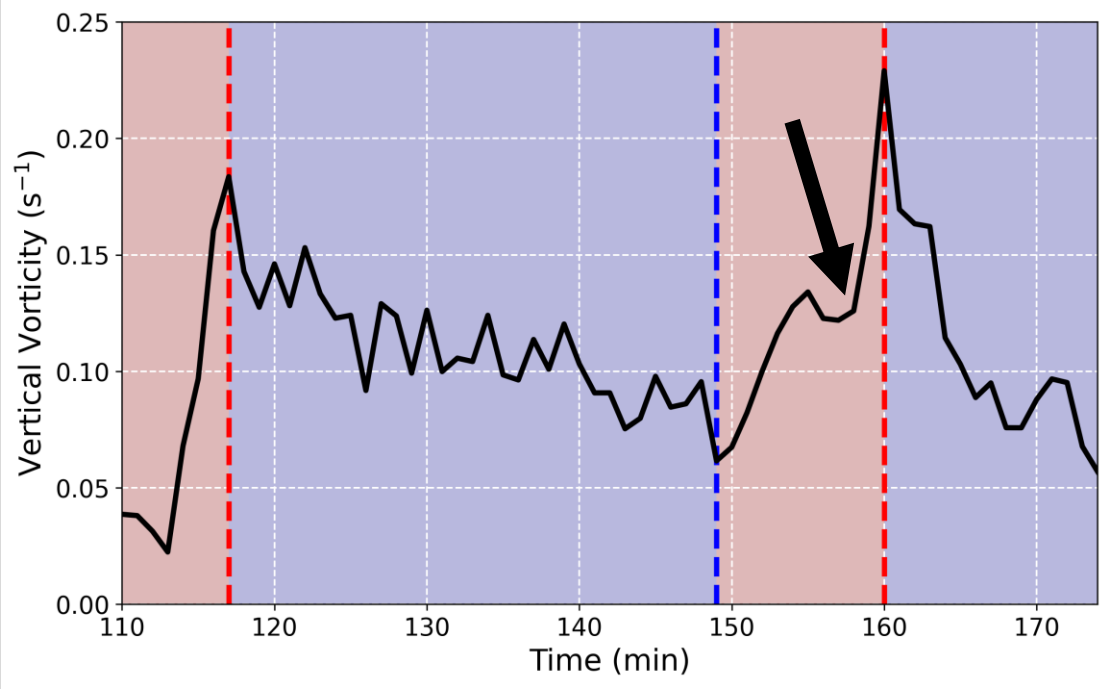
- Rotating updraft - dynamic contributions to updraft dominant
  - Persistent updraft rotation aloft and cold pool near ground
- Relatively deep net upward acceleration



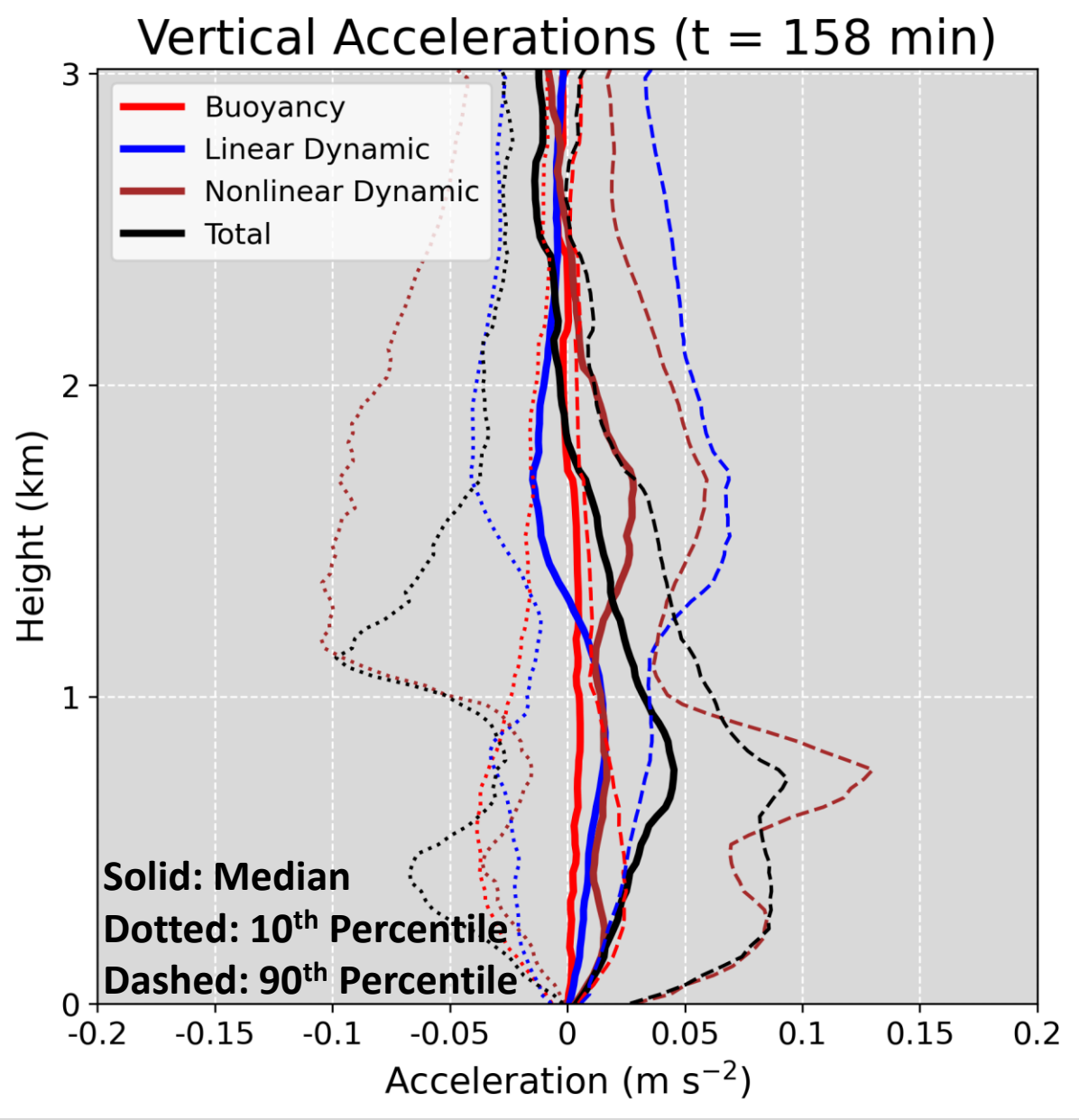


- Disorganized updraft
  - Shallower, weaker layer of net positive accelerations
  - Near-ground convergence along cold pool primarily drives upward motion

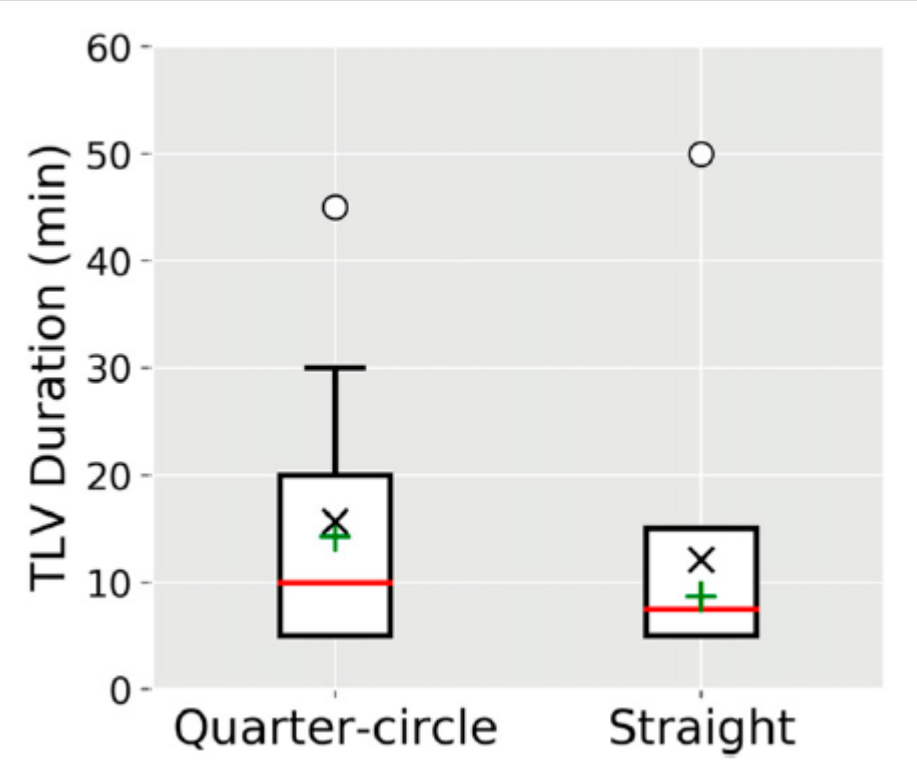




- Dynamic contributions to updraft dominant
  - Cold pool near ground and intermittent rotation aloft
- Strong downward acceleration above ~1 km due to lack of updraft rotation

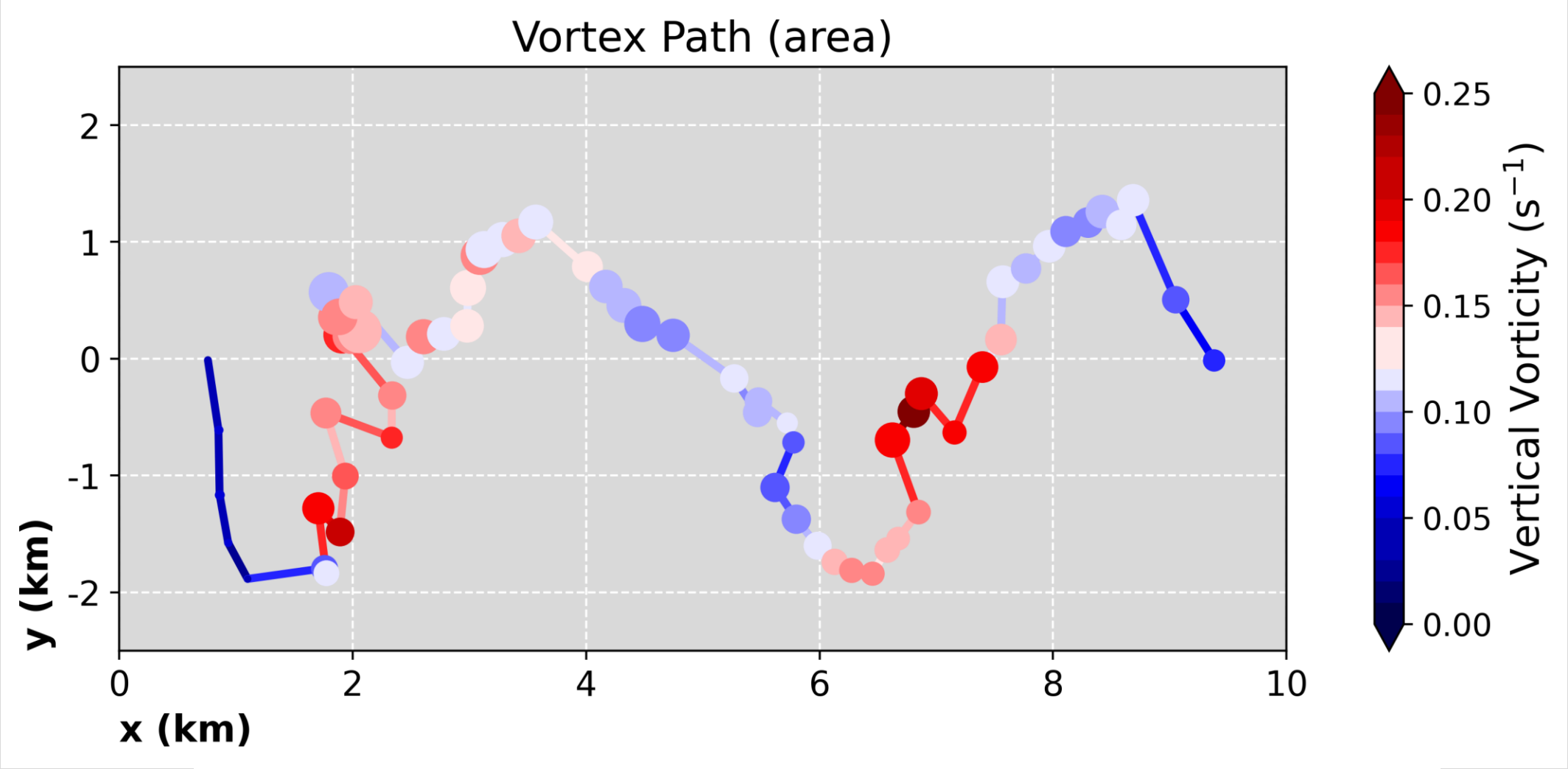


Vortex-updraft alignment

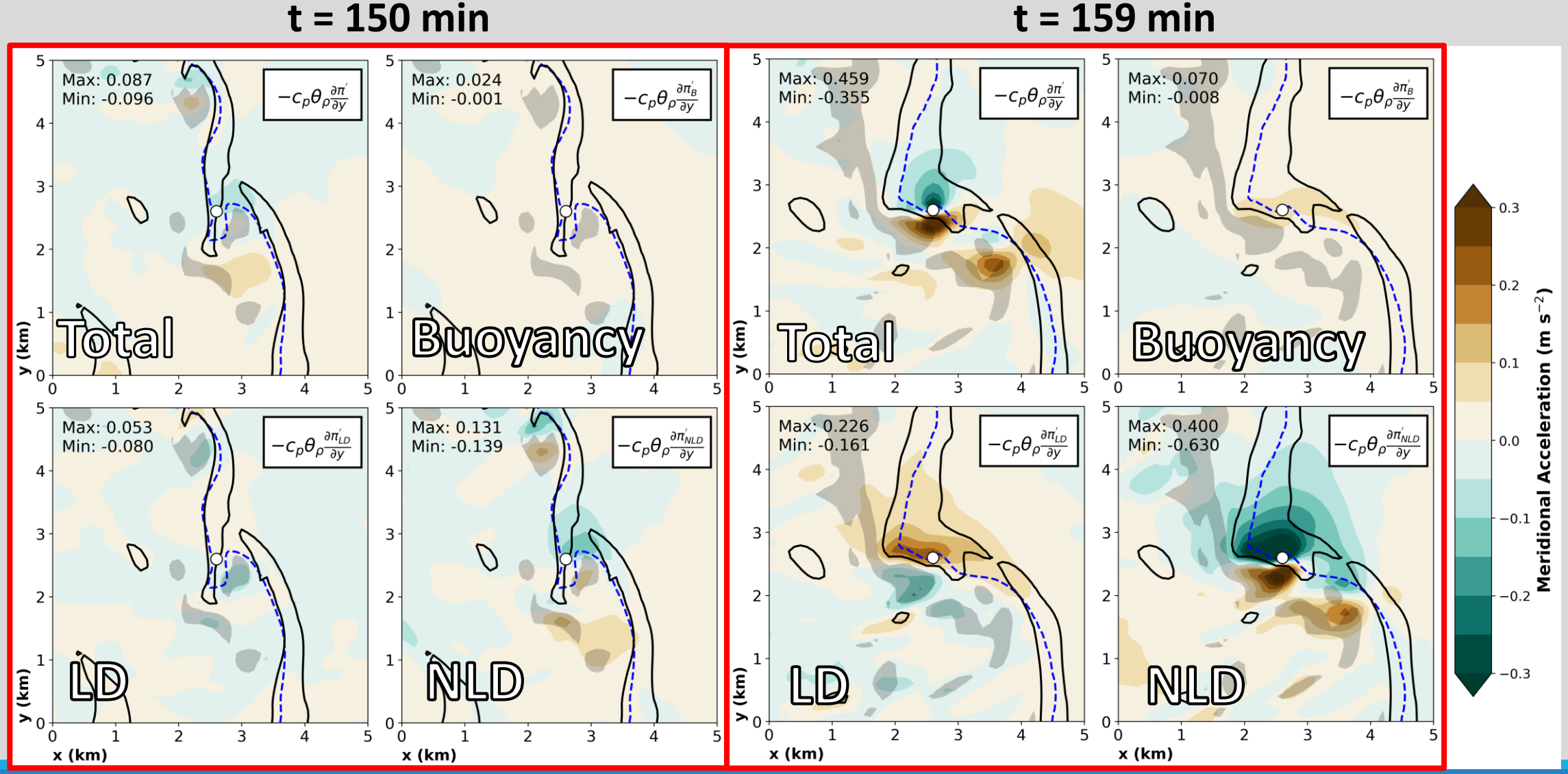


Marion and Trapp 2020, Fig. 9

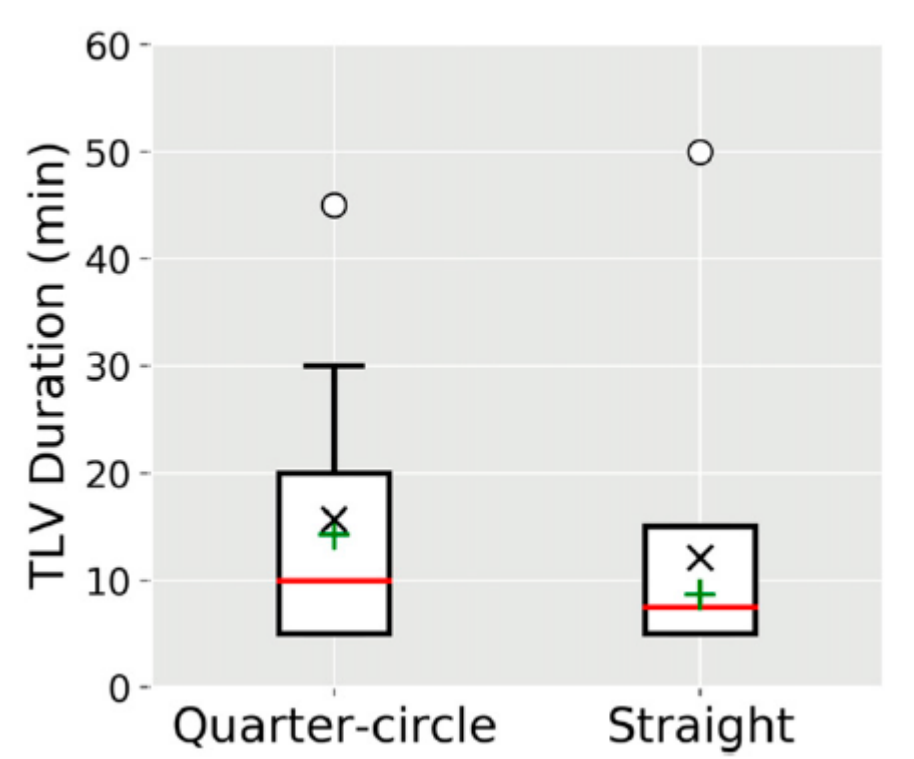
Vortex Motion



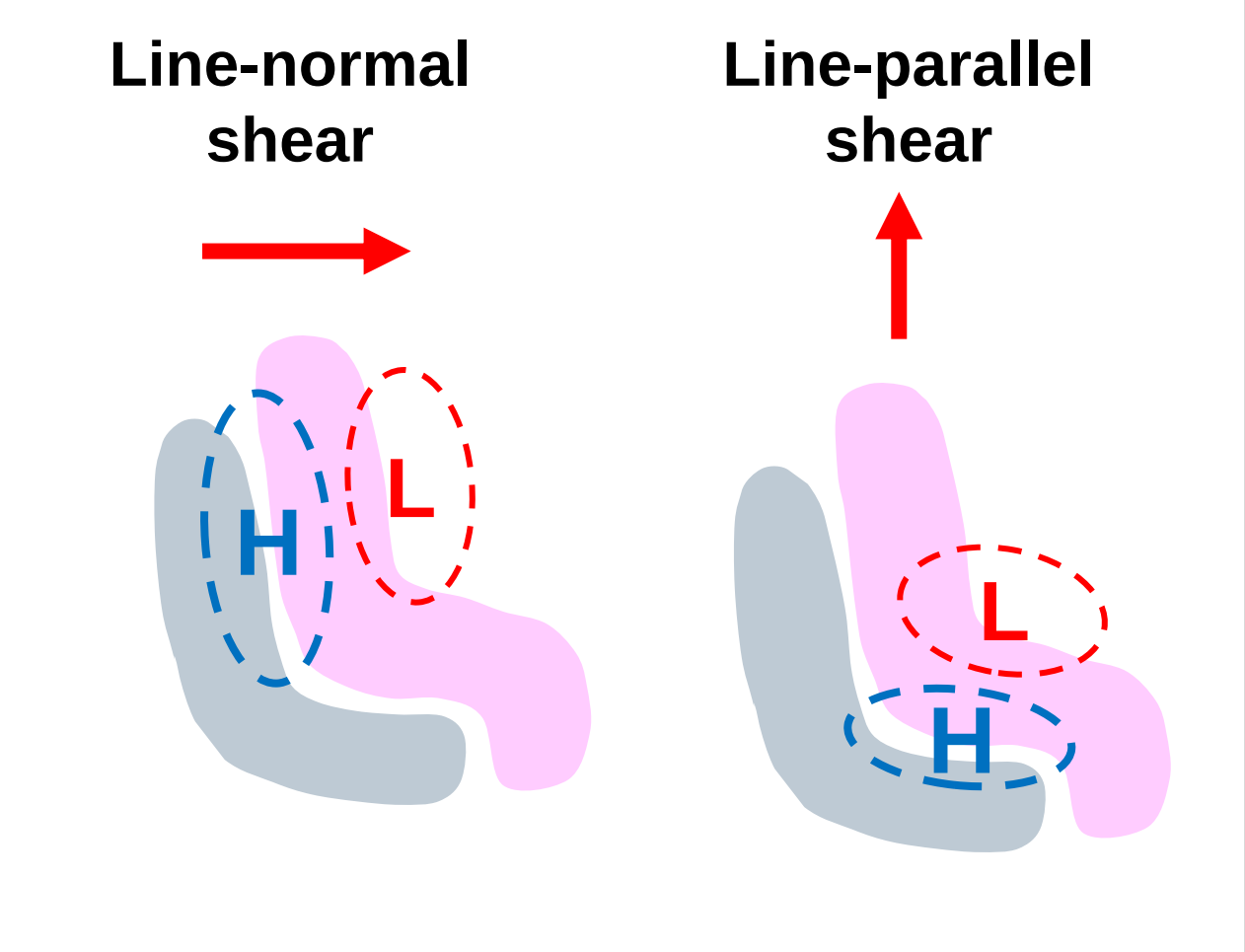
Meridional Accelerations



Vortex-updraft alignment

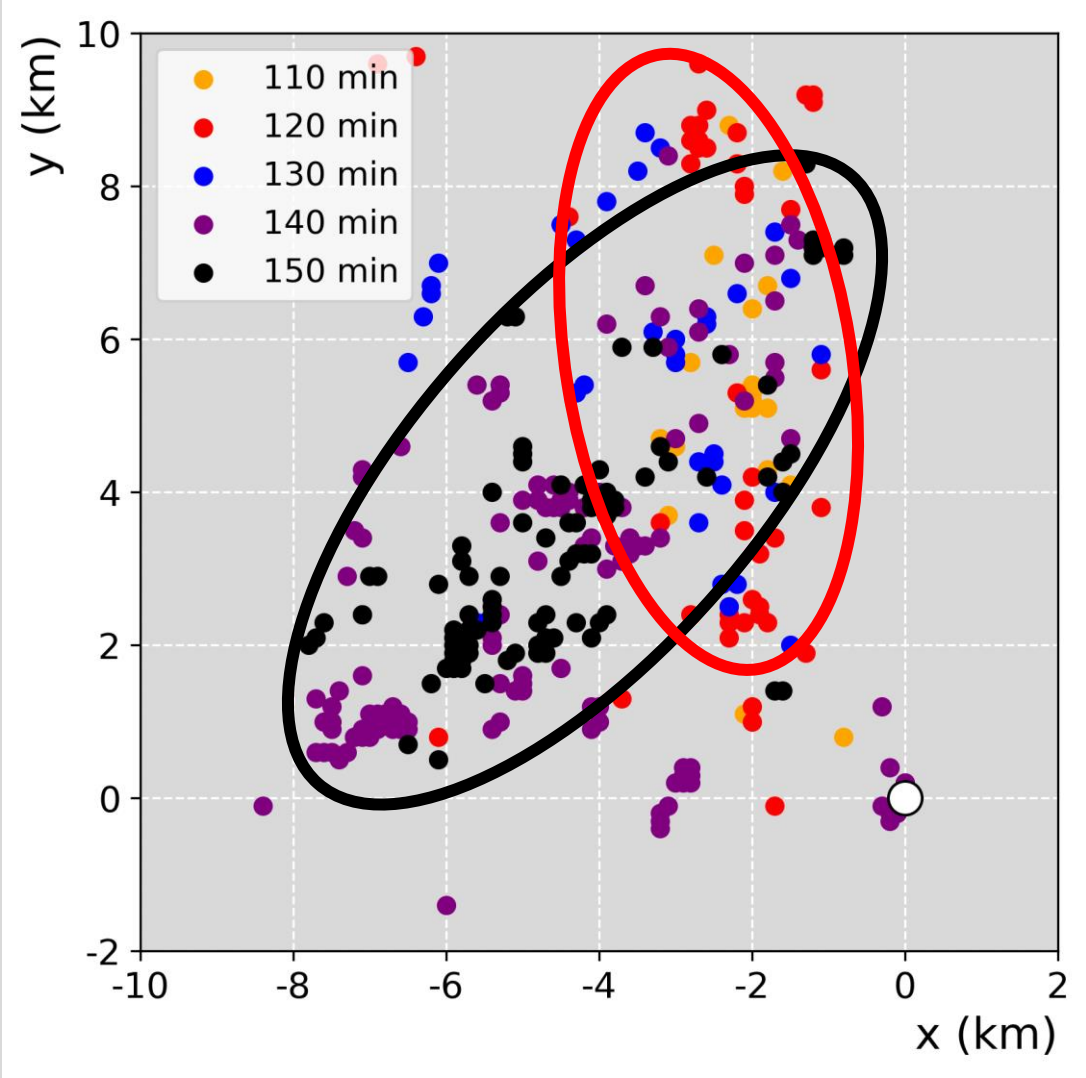


Marion and Trapp 2020, Fig. 9



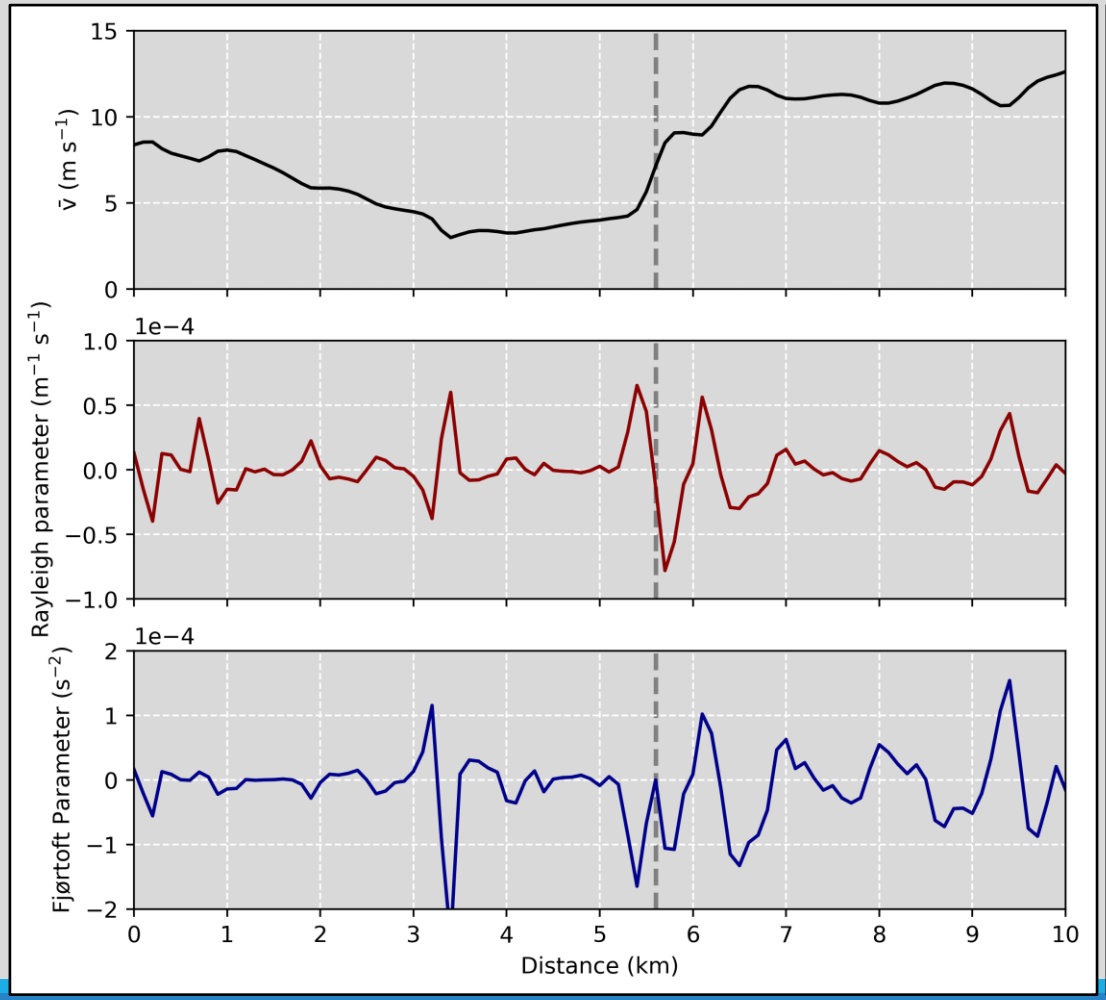
Parcel trajectories

- Initialized every 10 min
- Parcels that enter the lowest 100 m of vortex
- Differences in sources/source regions throughout lifetime

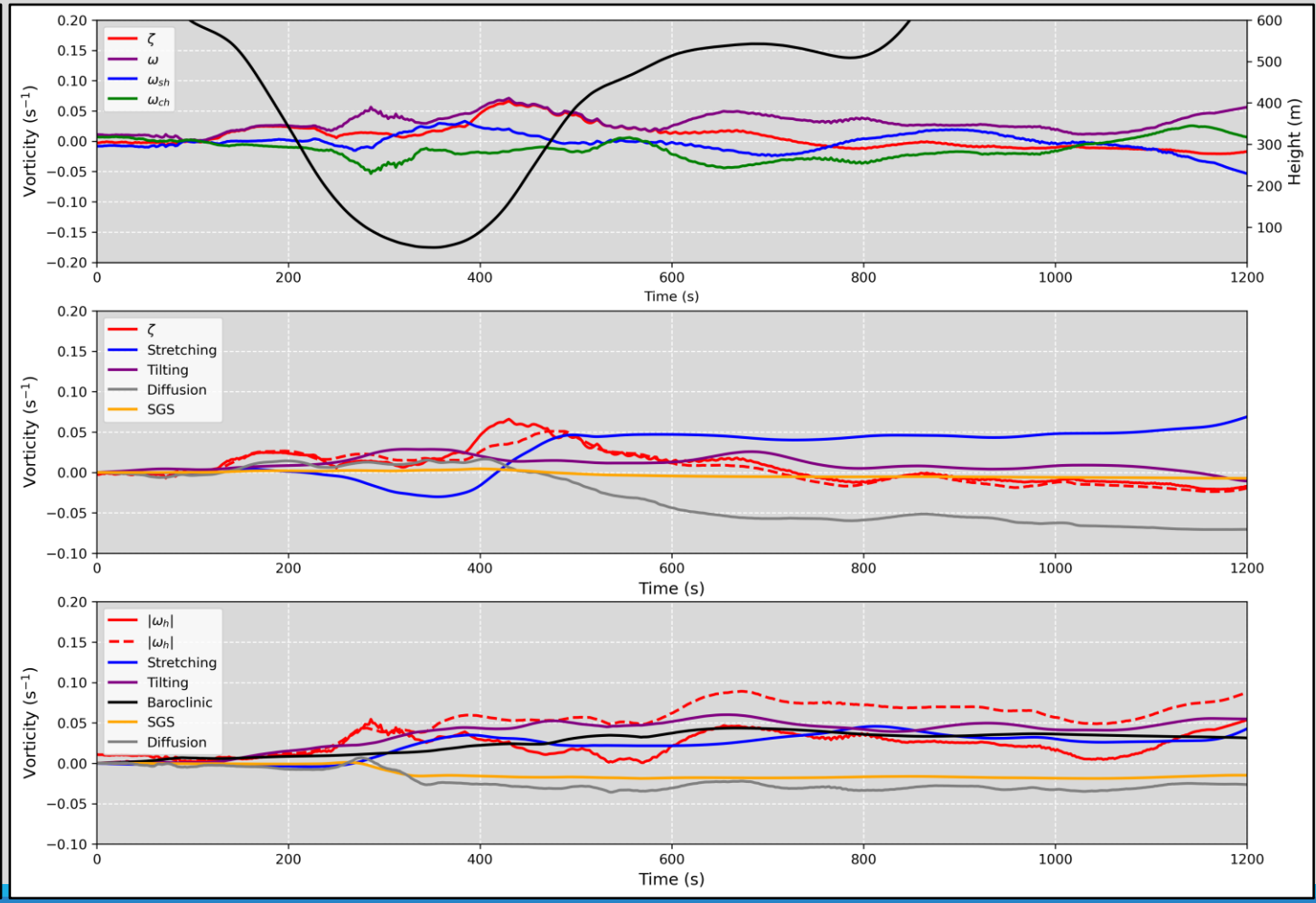


Vorticity Sources - Examples

Formation - HSI

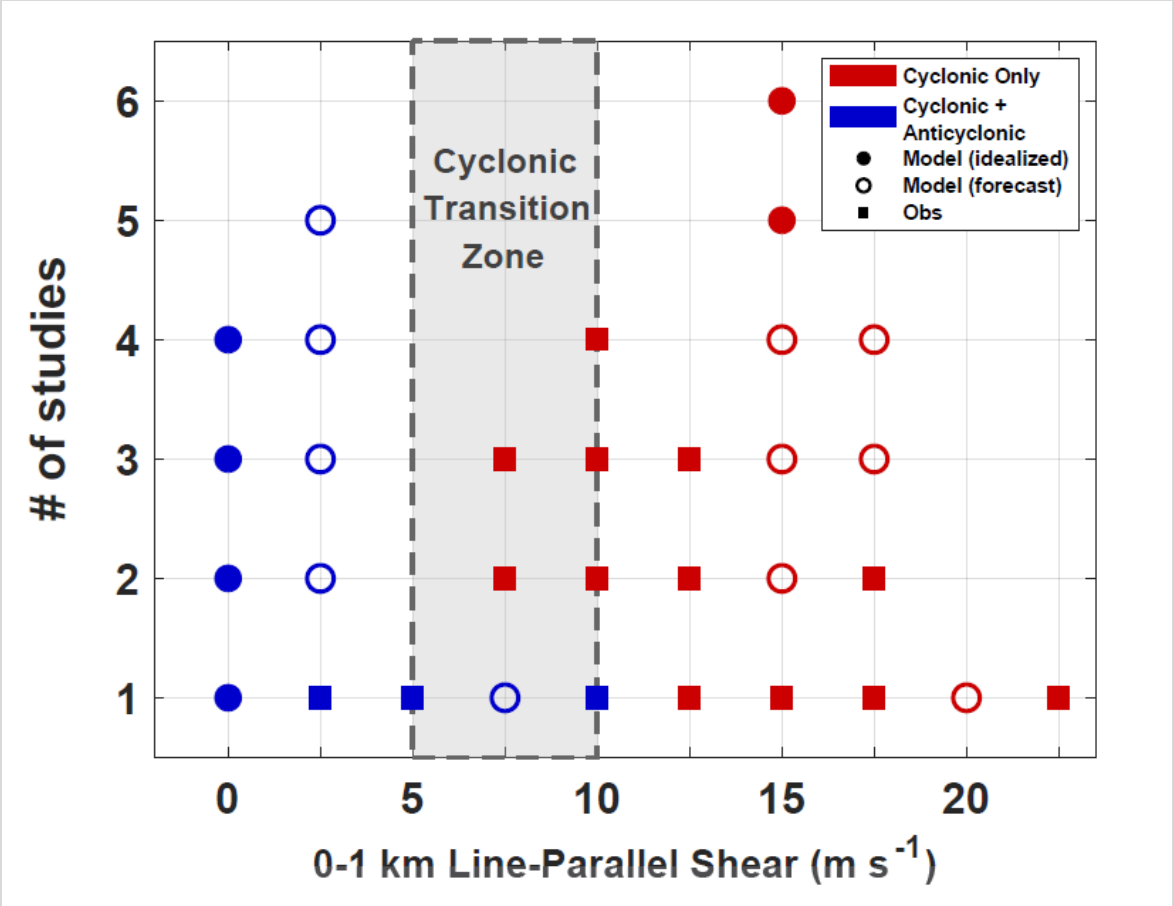


Maintenance – TW03



Ongoing and Future Work

- Matthew Brown (NSSL): impact of low-level hodograph curvature on draft, mesovortex production
- Revisiting the Trapp and Weisman (2003) mechanism
  - The role of planetary vorticity and hodograph curvature on cyclonic/anticyclonic vortex production
- Understanding dynamical differences between high-to-moderate and low-CAPE QLCSs



Brown et al., submitted to MWR