The Sensitivity of Severe Convective Storm Mode to Updraft Initiation Morphology Across Large-scale Environments

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RESEARCH QUESTIONS

1) Is severe convective storm mode (SCSM) sensitive to the initial morphology of updrafts?

2) To what extent is SCSM jointly dependent on its large-scale environment (LSE) and initial updraft morphology?

MOTIVATION

- Severe hazard types (i.e. hail, tornadoes, straight-line winds) are dependent on SCSM
- Bulk environmental parameters are not always distinguishable between SCSM making hazard prediction more difficult

SCSMs

sRM – right-moving supercell

QLCS – quasi-linear convective system

Mixed – simultaneous sRM and QLCS

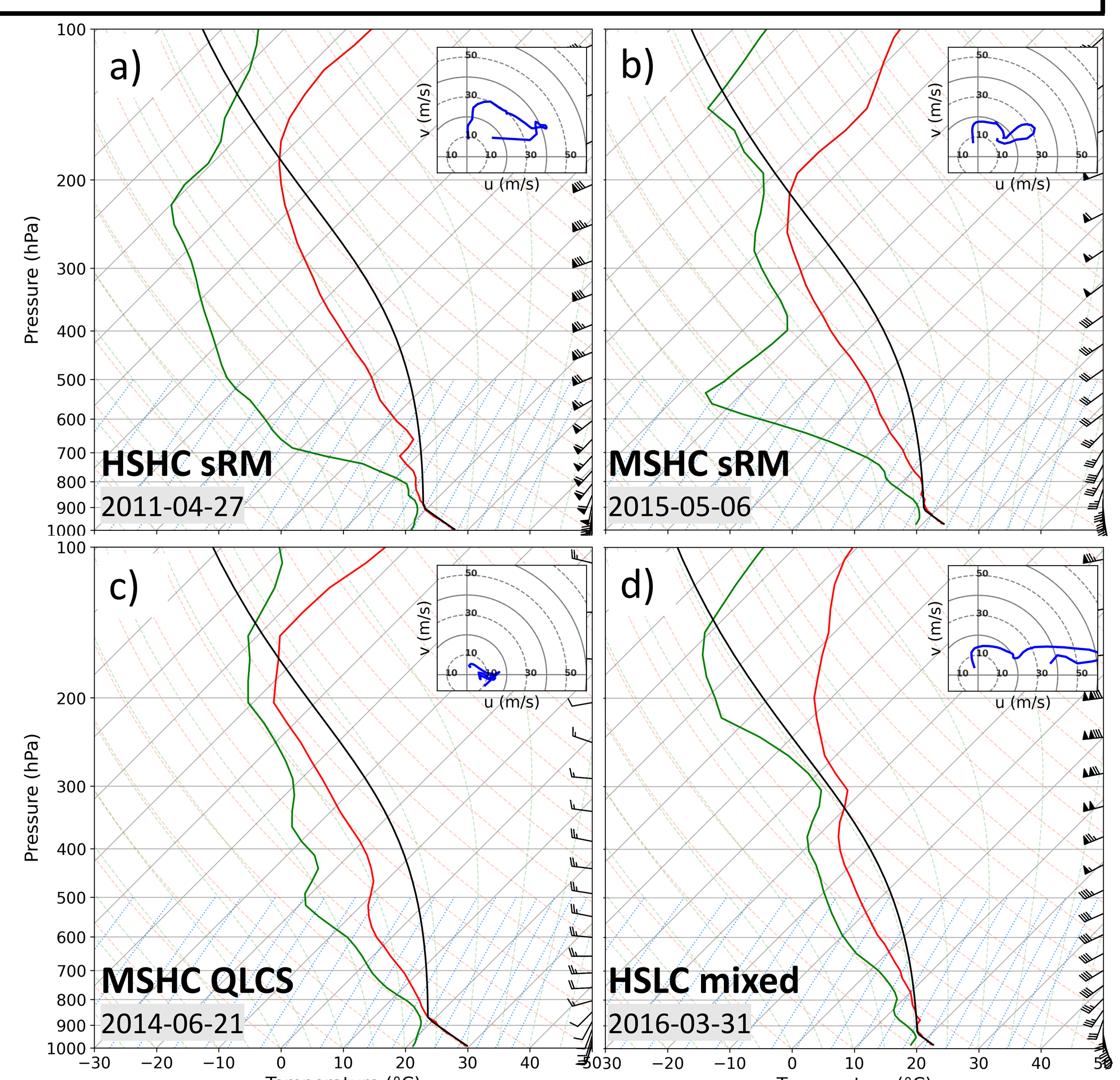


Figure 2. Vertical profiles of temperature (red), dewpoint (green), parcel profile (black), and wind profile (black barbs; kts) along with hodographs in the top right for the experiments associated with different SCSMs. a) High shear high CAPE (HSHC) discrete sRM. b) Moderate shear high CAPE (MSHC) discrete sRM. c) MSHC QLCS. d) High shear low CAPE (HSLC) mixed mode.

METHODS

18 updraft configurations are designed to represent various patterns that initiating updrafts may form in the real world (Fig. 1). Cloud Model 1 (CM1; Bryan and Fritsch 2002) is used to simulate storms using these configurations to determine if SCSM varies across them. Currently, these configurations are tested in 4 cases from the Smith et al. (2012) SCSM database that exhibit a range of LSEs and observed SCSMs (Fig. 2). Tobac (Sokolowsky et al. 2024) is used to objectively identify dominant storm modes throughout each simulation.

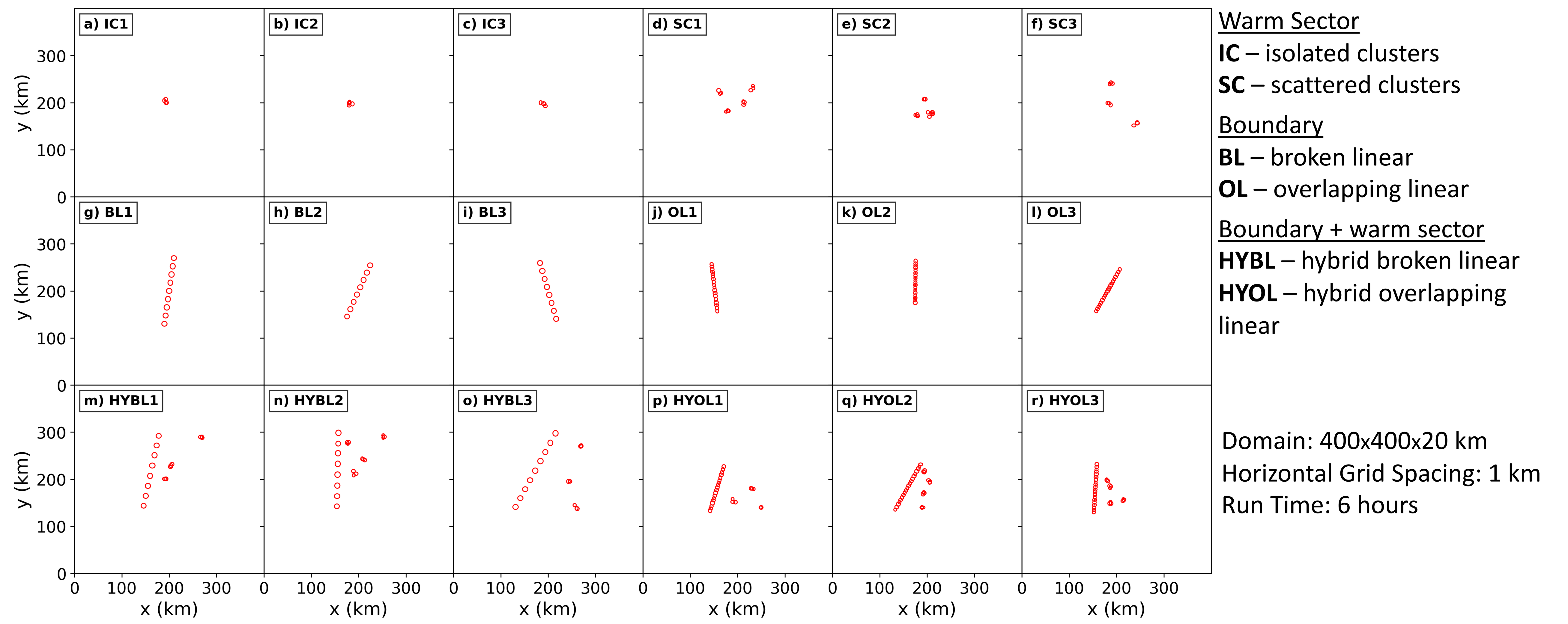
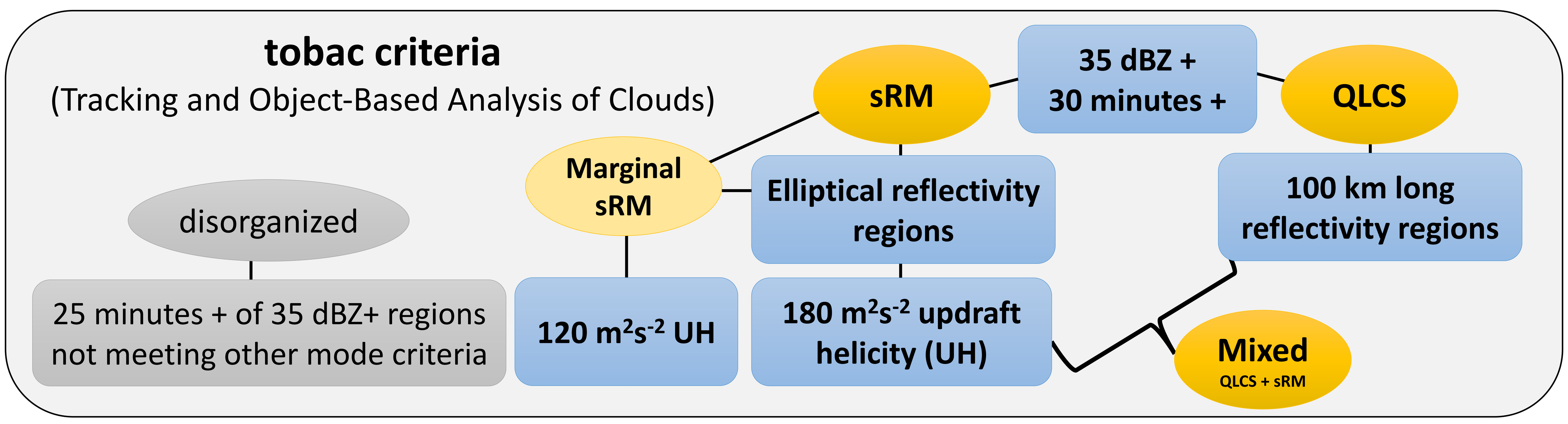


Figure 1. Initial updraft morphologies for experiments within the CM1 domain. Red contours indicate the forcing regions where upward-directed acceleration is applied over short periods with the maximum acceleration in the ellipsoid center, dropping off to zero at the edges (Mansell et al. 2010).



PRELIMINARY RESULTS

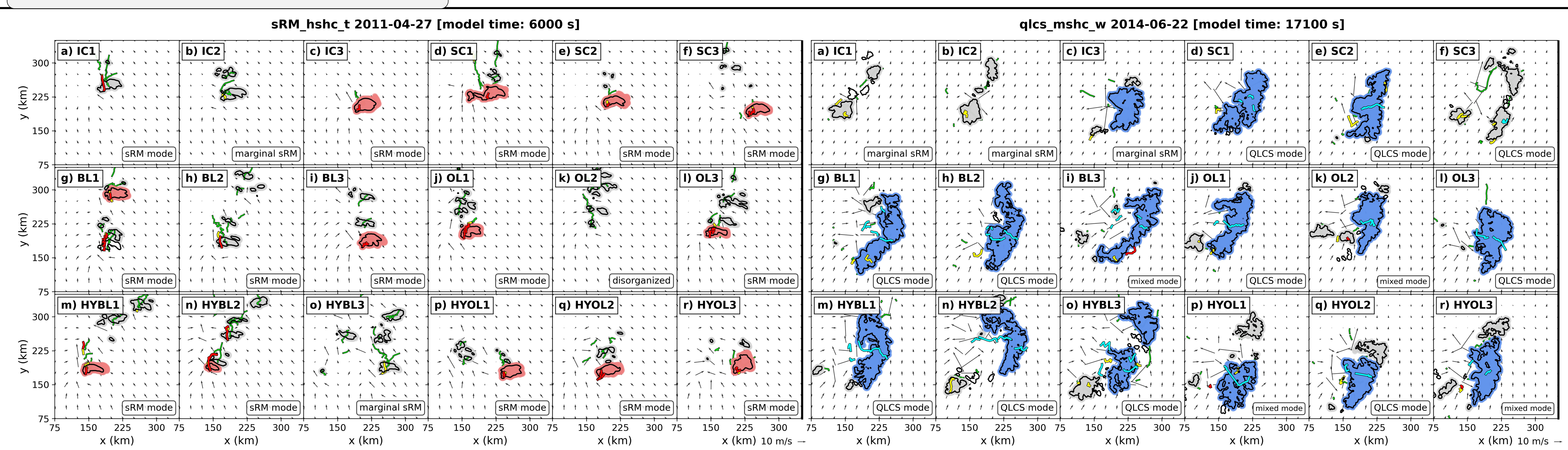


Figure 3. Showcase of tobac output at one timestep for each updraft configuration for the HSHC sRM (left panel) and MSHC QLCS (right panel) environments. Black contours are 35 dBZ simulated reflectivity at the lowest model level, red contours are full sRM tracks, yellow contours are full marginal sRM tracks, light blue contours are full QLCS tracks, and lime green contours are full disorganized tracks. Red (blue) shading highlights sRM (QLCS) convective-like regions at the simulation time while gray shading emphasizes potential disorganized regions. Wind vectors (ms^{-1}) are ground-relative at the lowest model level with magnitude in the bottom right. The entire model domain is not shown.

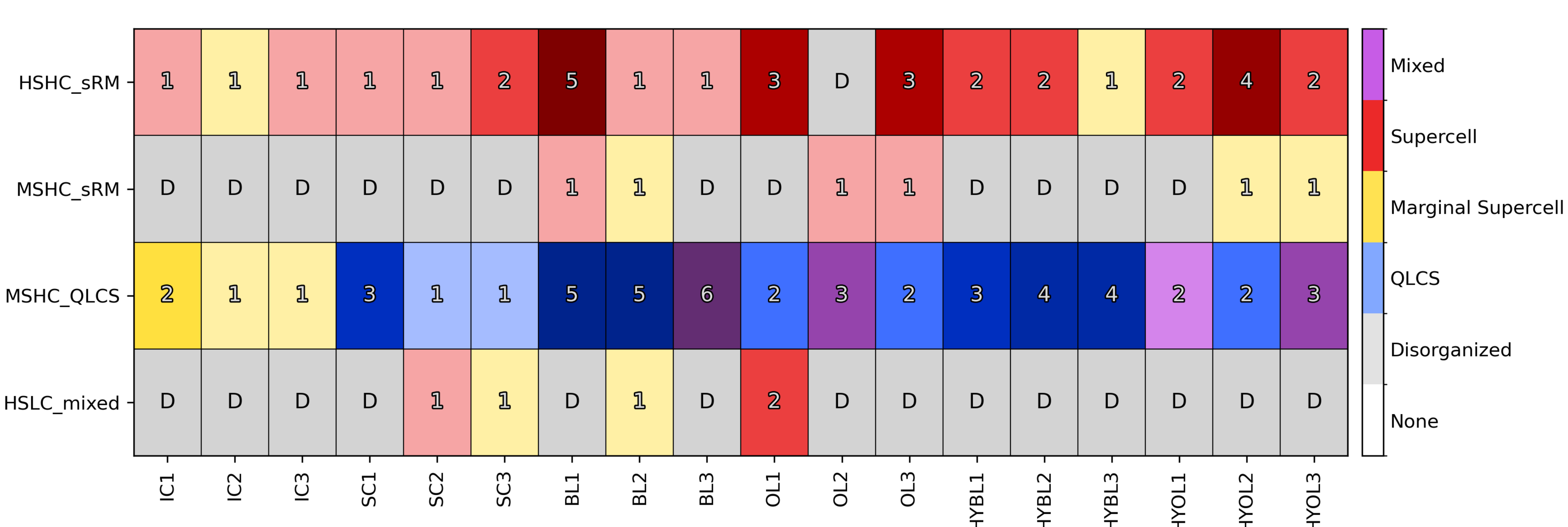


Figure 4. Chiclet diagram summarizing the number of tracks of the dominant/most intense SCSM from tobac for the 4 environments and 18 updraft configurations. Shading intensity reflects number of tracks labeled in each rectangle and color corresponds to mode. Note: in some cases, tobac generates multiple tracks for the same storm; efforts to improve temporal continuity in object ID are ongoing.

Preliminary Conclusions and Future Work

1) SCSM appears to have low (moderate) sensitivity to initial updraft morphology for high (moderate) shear environments
2) SCSM appears to be more sensitive to environment than to initial updraft morphology

Ongoing and next steps: systematically alter the deep-layer shear for each LSE to investigate its specific impact on SCSM, test more cases, and investigate severe hazard production.

References

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