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Advancements in the understanding and prediction of high-shear, low-CAPE tornadoes

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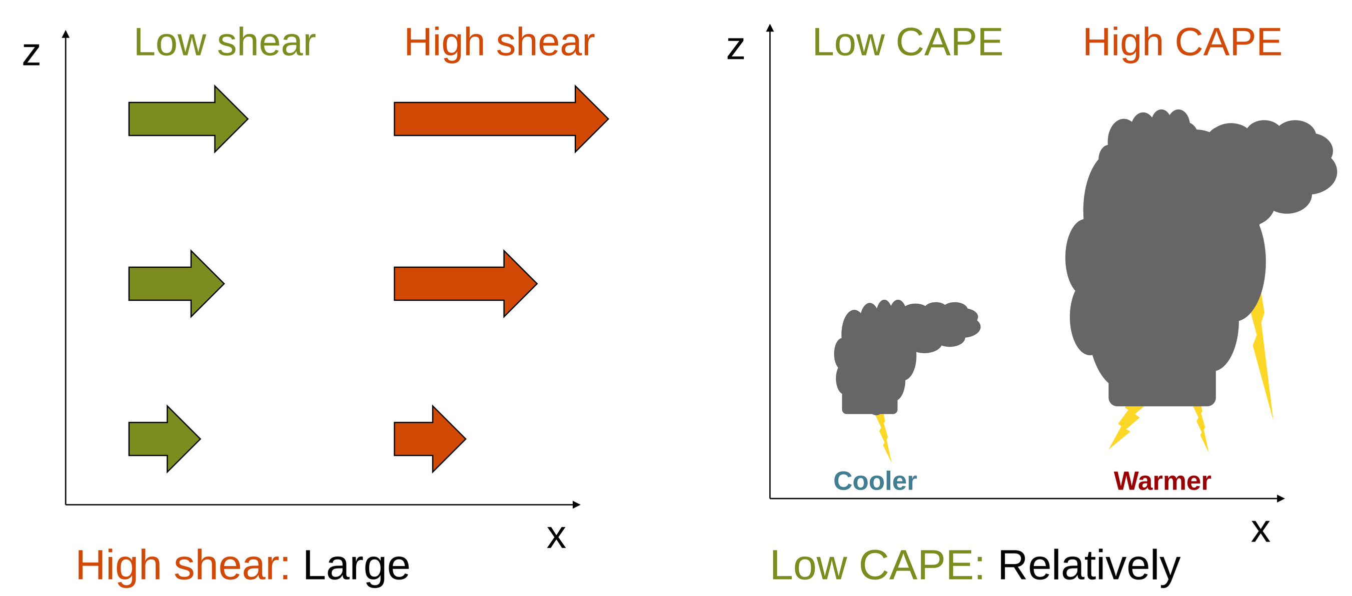
Introduction

➢ What are high-shear, low-CAPE environments?

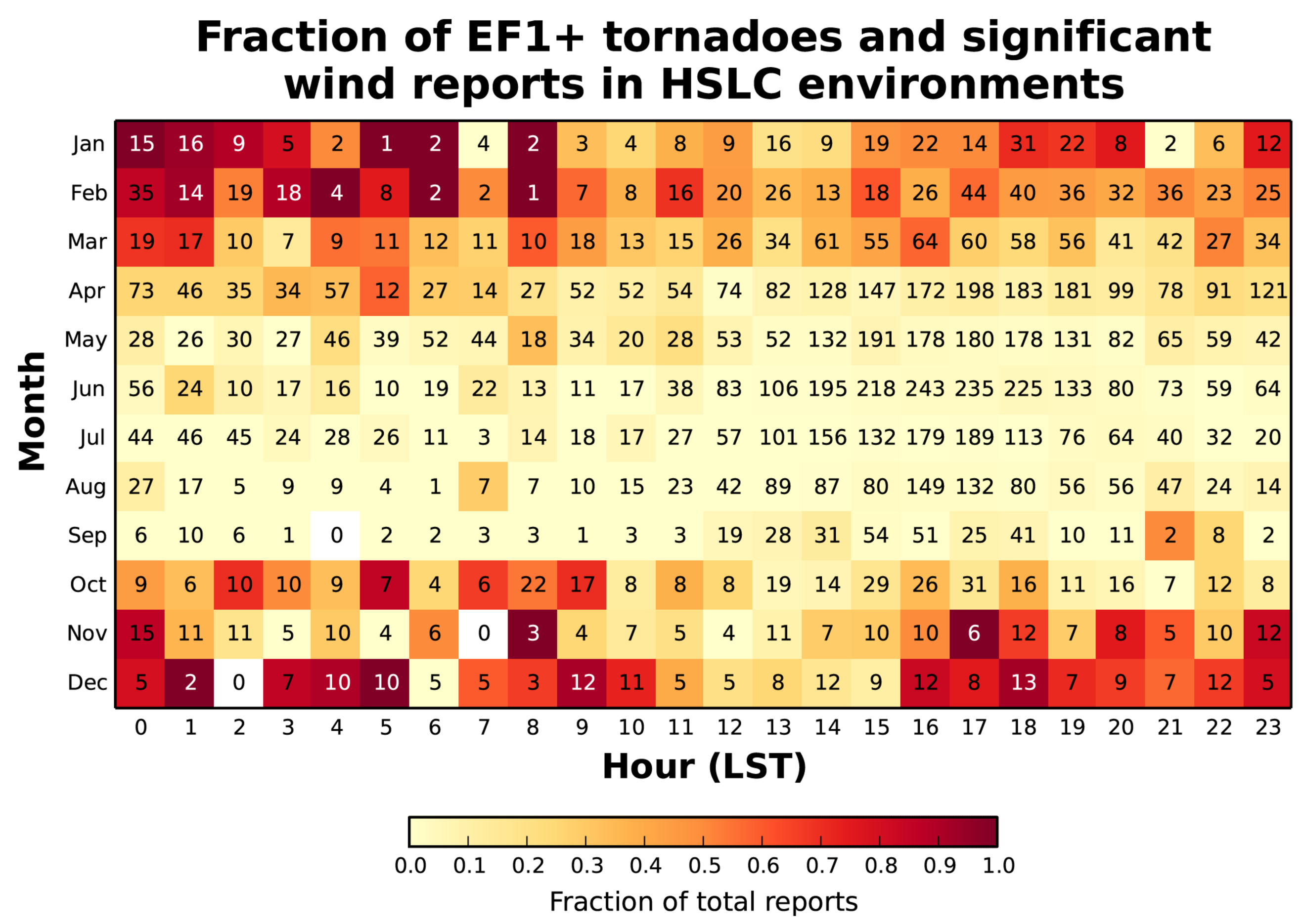
(Convective Available Potential Energy)



High shear: Large change in wind speed and/or direction with height

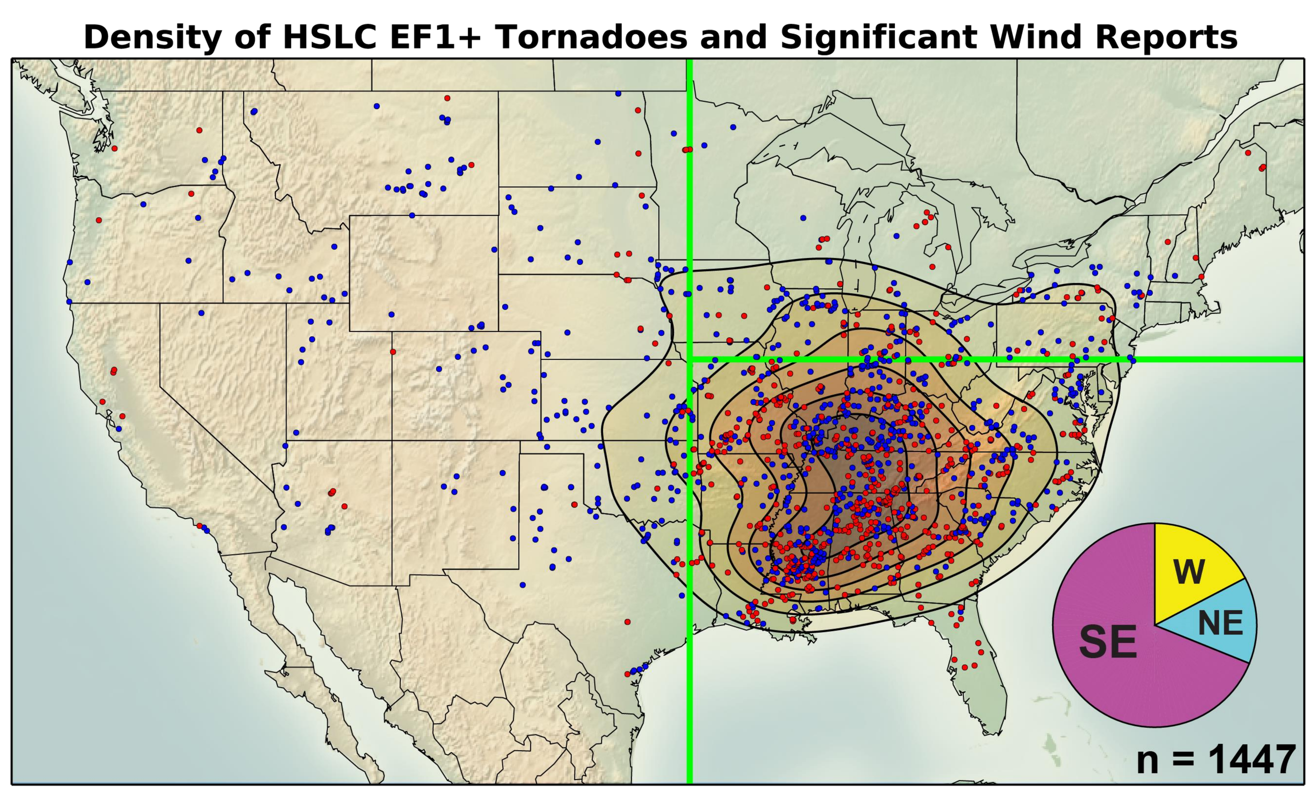
Low CAPE: Relatively weak environmental buoyancy for updrafts

➢ When and where do they produce severe weather?



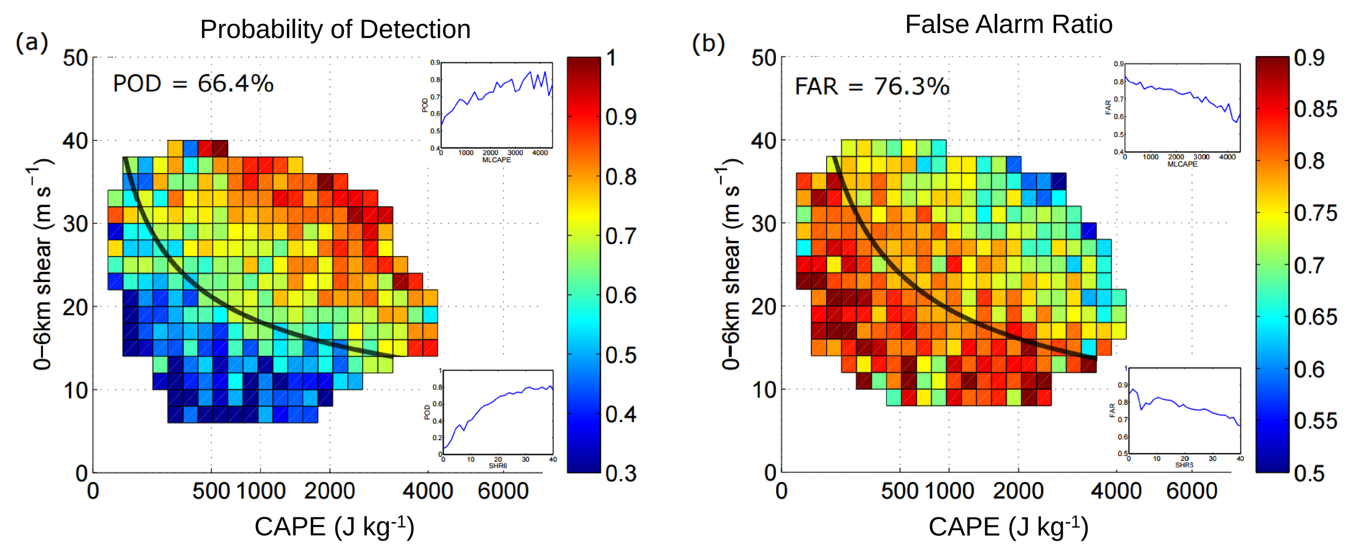
Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	15	16	9	5	2	1	2	4	2	3	4	8	9	16	9	19	22	14	31	22	8	2	6	12
Feb	35	14	19	18	4	8	2	2	1	7	8	16	20	26	13	18	26	44	40	36	32	36	23	25
Mar	19	17	10	7	9	11	12	11	10	18	13	15	26	34	61	55	64	60	58	56	41	42	27	34
Apr	73	46	35	34	57	12	27	14	27	52	52	54	74	82	128	147	172	198	183	181	99	78	91	121
May	28	26	30	27	46	39	52	44	18	34	20	28	53	52	132	191	178	180	178	131	82	65	59	42
Jun	56	24	10	17	16	10	19	22	13	11	17	38	83	106	195	218	243	235	225	133	80	73	59	64
Jul	44	46	45	24	28	26	11	3	14	18	17	27	57	101	156	132	179	189	113	76	64	40	32	20
Aug	27	17	5	9	9	4	1	7	7	10	15	23	42	89	87	80	149	132	80	56	56	47	24	14
Sep	6	10	6	1	0	2	2	3	3	1	3	3	19	28	31	54	51	25	41	10	11	2	8	2
Oct	9	6	10	10	9	7	4	6	22	17	8	8	8	19	14	29	26	31	16	11	16	7	12	8
Nov	15	11	11	5	10	4	6	0	3	4	7	5	4	11	7	10	10	6	12	7	8	5	10	12
Dec	5	2	0	7	10	10	5	5	3	12	11	5	5	8	12	9	12	8	13	7	9	7	12	5

High shear, low-CAPE (HSLC) environments produce the majority of tornadoes and damaging winds during the cool season, especially overnight

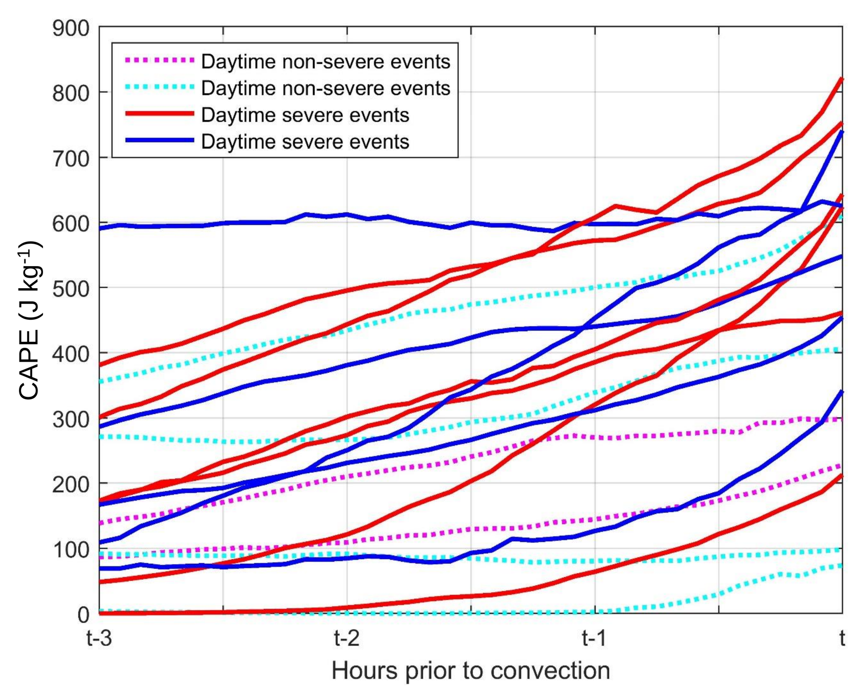


HSLC tornadoes (red) and damaging winds (blue) occur throughout the U.S. but are most common from Deep South through Ohio Valley, extending eastward into Mid-Atlantic

➢ Why are they a concern for forecasters and public?



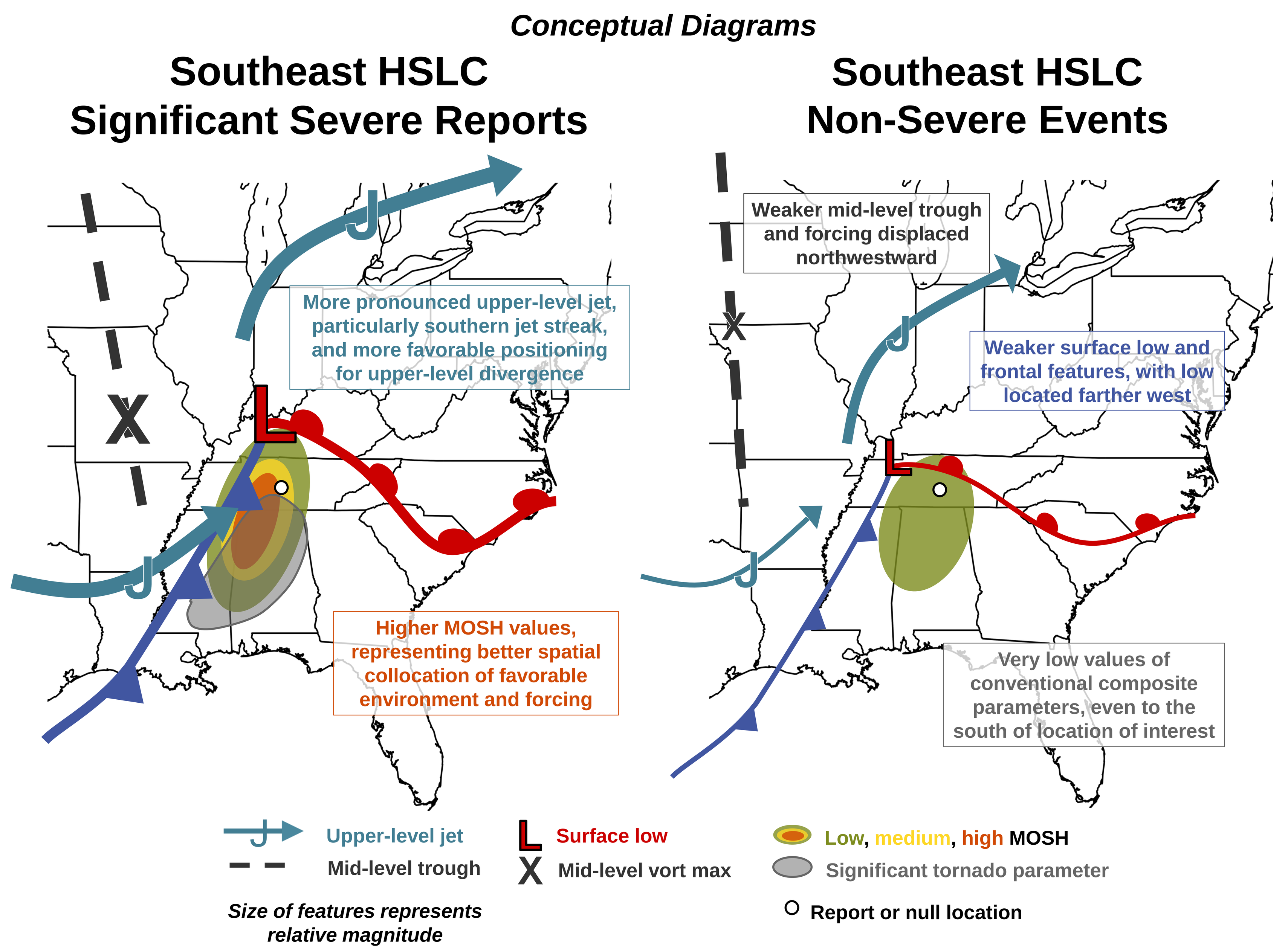
From Anderson-Frey et al. (2016): Probability of detection is low for HSLC tornadoes, while the false alarm rate of associated tornado warnings is high



Left, from King et al. (2017): Rapid environmental evolution ahead of convection may not be captured by conventional observation networks or numerical weather prediction

Not shown: Poor radar resolution leads to little discrimination between tornadic and nontornadic vortices (Davis and Parker 2014)

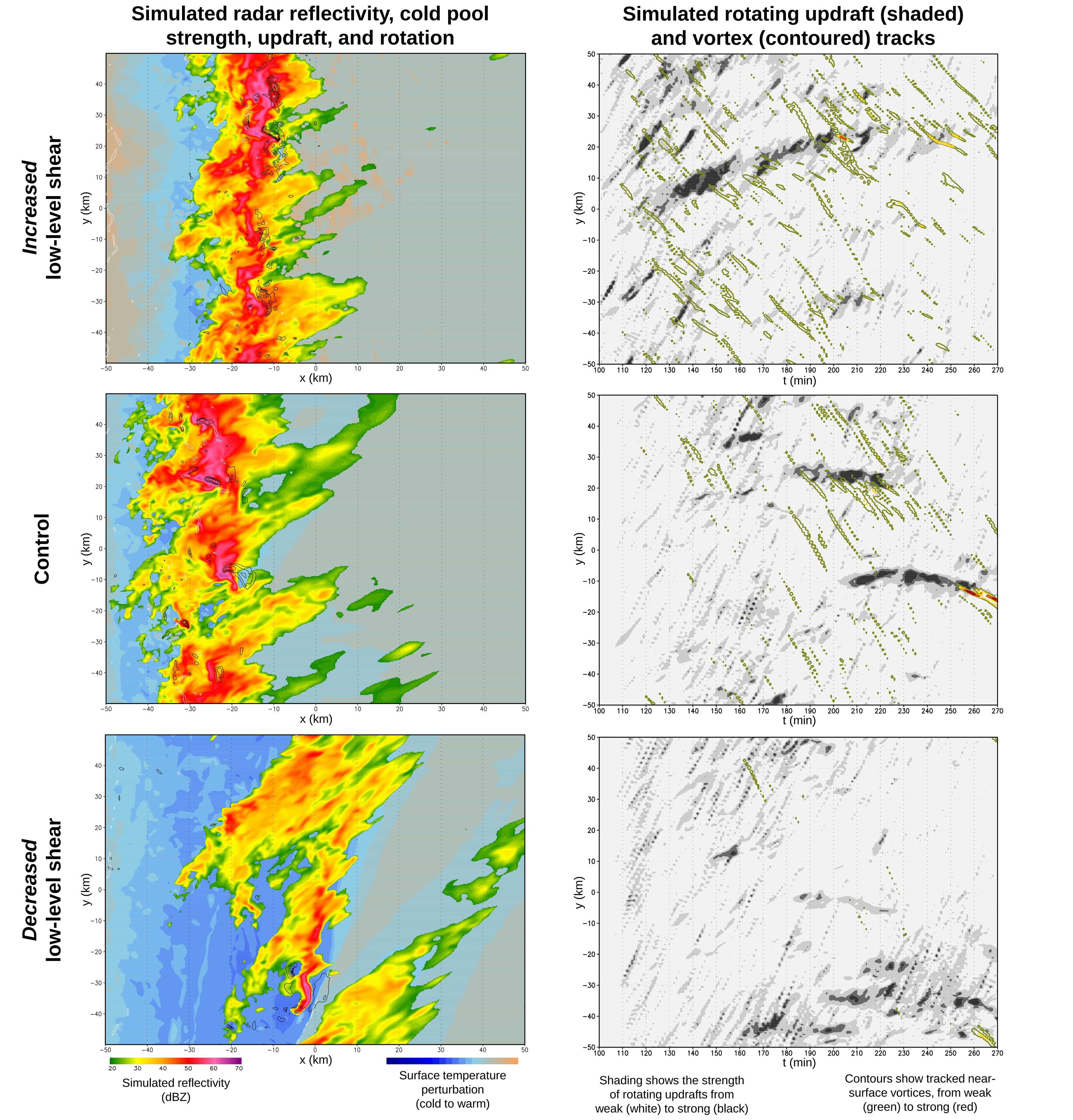
Forecasting Advancements



MOSH, or the Modified Severe Hazards in Environments with Reduced Buoyancy parameter, shows where forcing and a favorable environment are collocated

Ongoing Work

Methodology: Using an idealized numerical modeling framework, systematically alter the strength of lower tropospheric shear and CAPE to determine their effects on resulting development and evolution of simulated convection.



Objective: Determine the dynamic differences between environments supporting convection that produces strong, long-lived, near-surface vortices capable of tornadoes or damaging straight-line winds and those that do not.

Preliminary Findings and Future Work

- The importance of **low-level shear vector magnitude appears to be tied to** its role in the development of numerous strong **low-level updrafts**. These updrafts are necessary for the development of strong near-surface vortices.
- Increased low-level shear leads to **more strong low-level updrafts and near-surface vortices**. This, in turn, ***increases the probability of vortices strengthening and producing tornadoes or damaging winds***.
- Ongoing work seeks to elucidate the importance of low-level CAPE and mid-level shear vector magnitude.
- Decomposition of governing equations will allow us to determine dominant processes and how they are sensitive to changing environmental variables.
- Trajectory analysis will allow us to determine how strong near-surface vortices form and how they produce tornadoes or damaging winds.

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