Revisiting Environmental Wind and Moisture Calculations in the Context of Tropical Cyclone Intensification

Samantha Nebylitsa, Sharanya J. Majumdar and David S. Nolan

Weather and Forecasting (2023)

Speaker：Mao-Cheng Li

Apr. 23 2024

Outline

- Introduction
- Data and methods
- Probability density functions
- Time series
- Shear-relative quadrants
- Shear direction
- New levels for shear and RH computations
- Conclusions

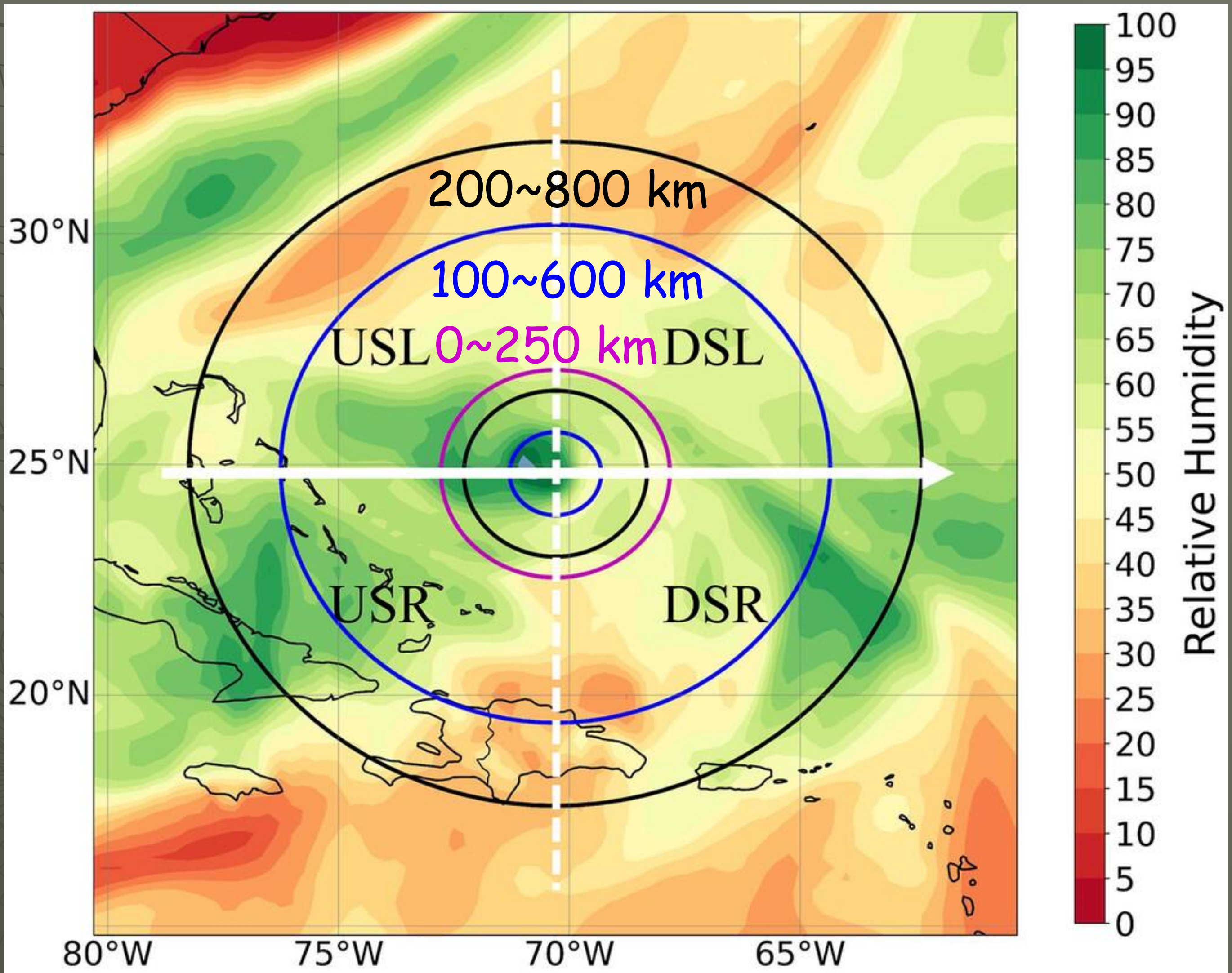
1. Introduction

- This study is to differentiate how shear and RH progress during the onset of different intensification rates, within three defined annuli near and around TCs.
- This study encompasses all intensifying TCs in the North Atlantic from 1980 to 2021, and we will present the distribution of shear and moisture and their respective evolutions, for three different intensification brackets.

2. Data and methods

- Six-hourly TC times are chosen based on the National Hurricane Center best track database (HURDAT2).
- The previous 24-h intensification from HURDAT2 is used to classify storm times into slightly intensifying [SI, 5–10 kt (24 h)^−1], moderately intensifying [MI, 15–25 kt (24 h)^−1] ,and rapidly intensifying [RI, ≥30 kt (24 h)^−1].
- Each consecutive 6-h period is the beginning of a new event, and therefore a singular TC may undergo multiple SI, MI, and RI events across its lifetime.

2. Data and methods cont.

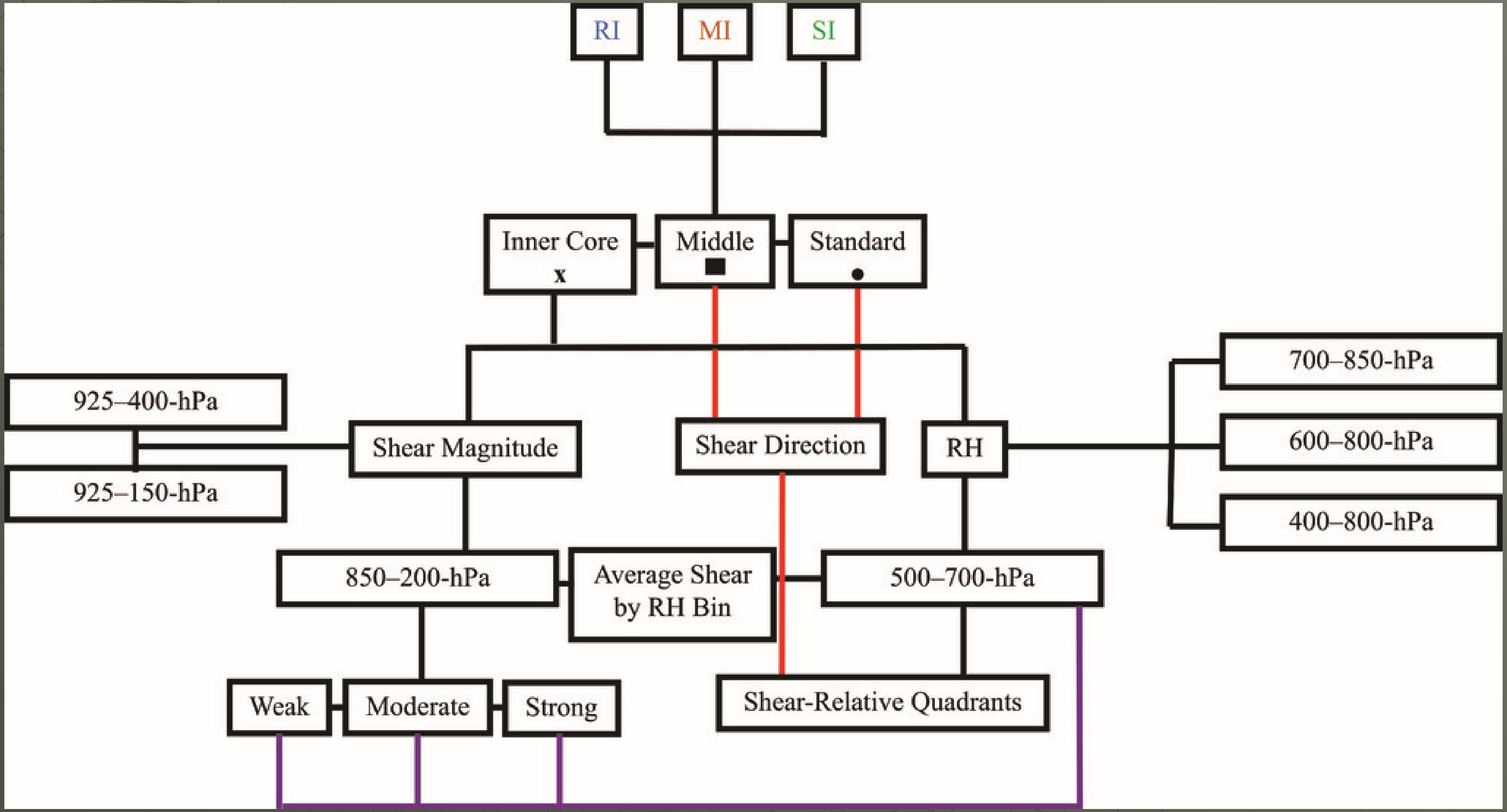


- Gridded 0.25° × 0.25° European Centre for Medium-Range Weather Forecast version 5 (ERA5) data are used throughout this study.

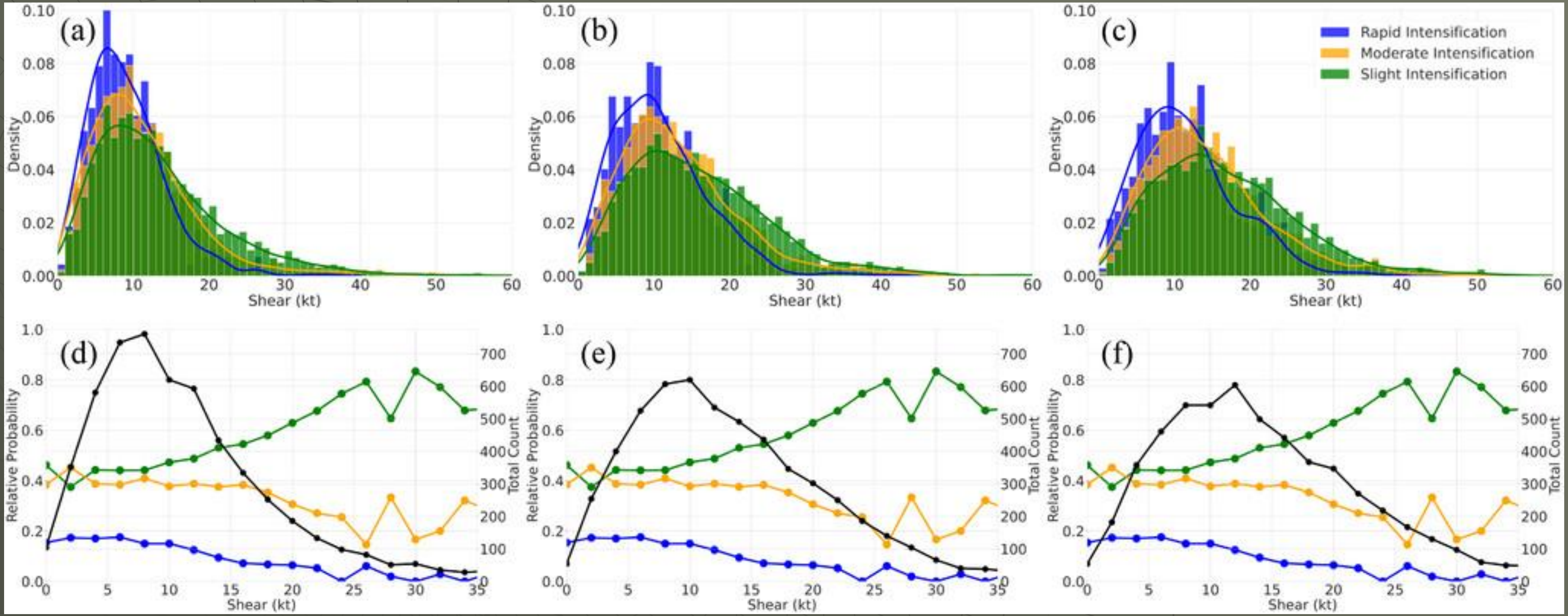
2. Data and methods cont.

Shear	RI	MI	SI
All	695 (190 first event)	2069	2777
Homogeneous set	376 (121 first event)	982	1365
Weak shear (<9 kt)	125	226	224
Moderate shear (9–20 kt)	213	567	678
Strong shear (>20 kt)	38	189	463

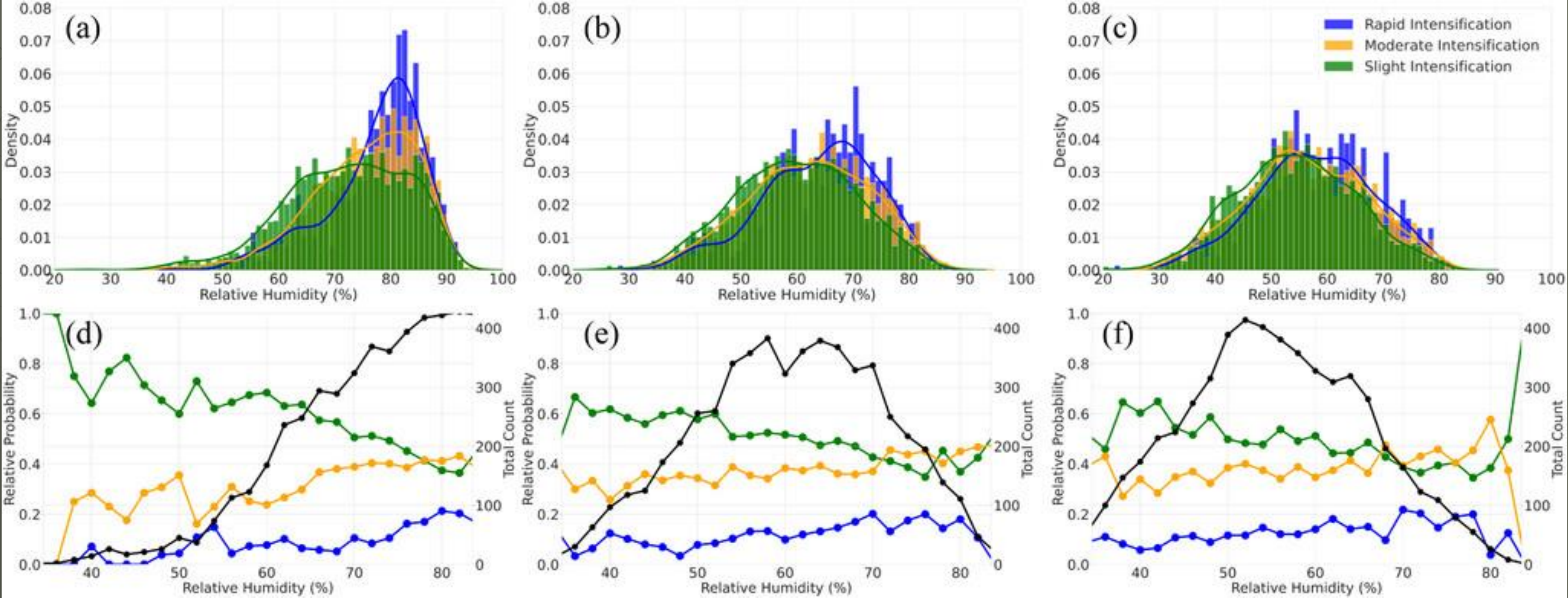
2. Data and methods cont.



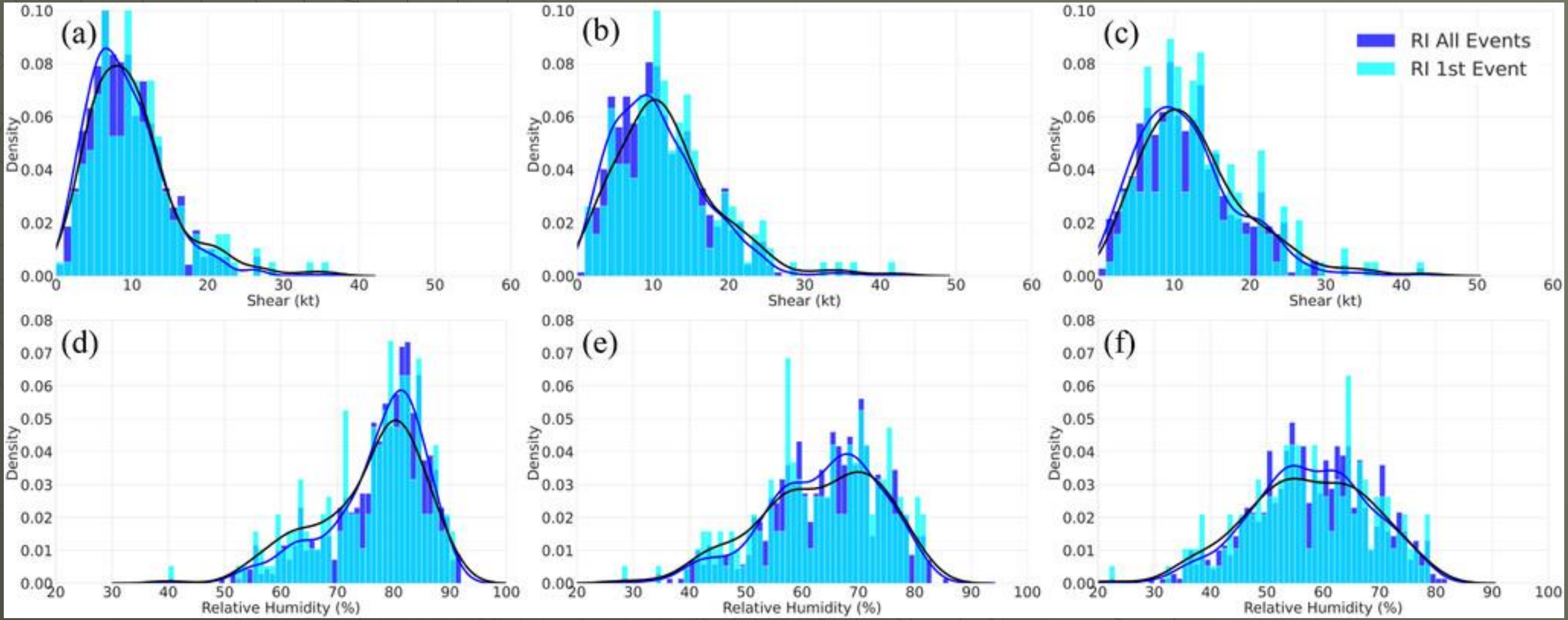
3. Probability density functions



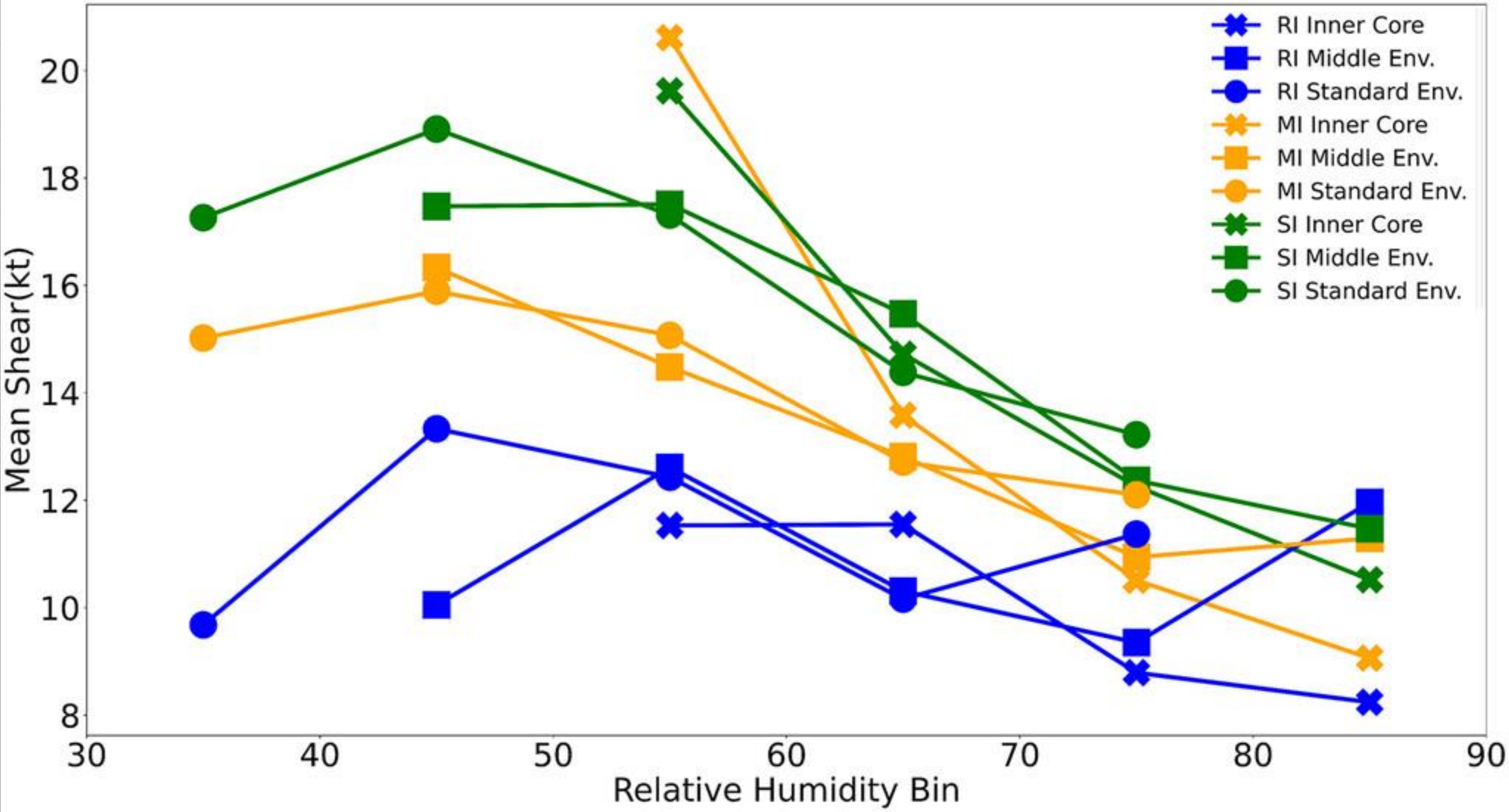
3. Probability density functions cont.



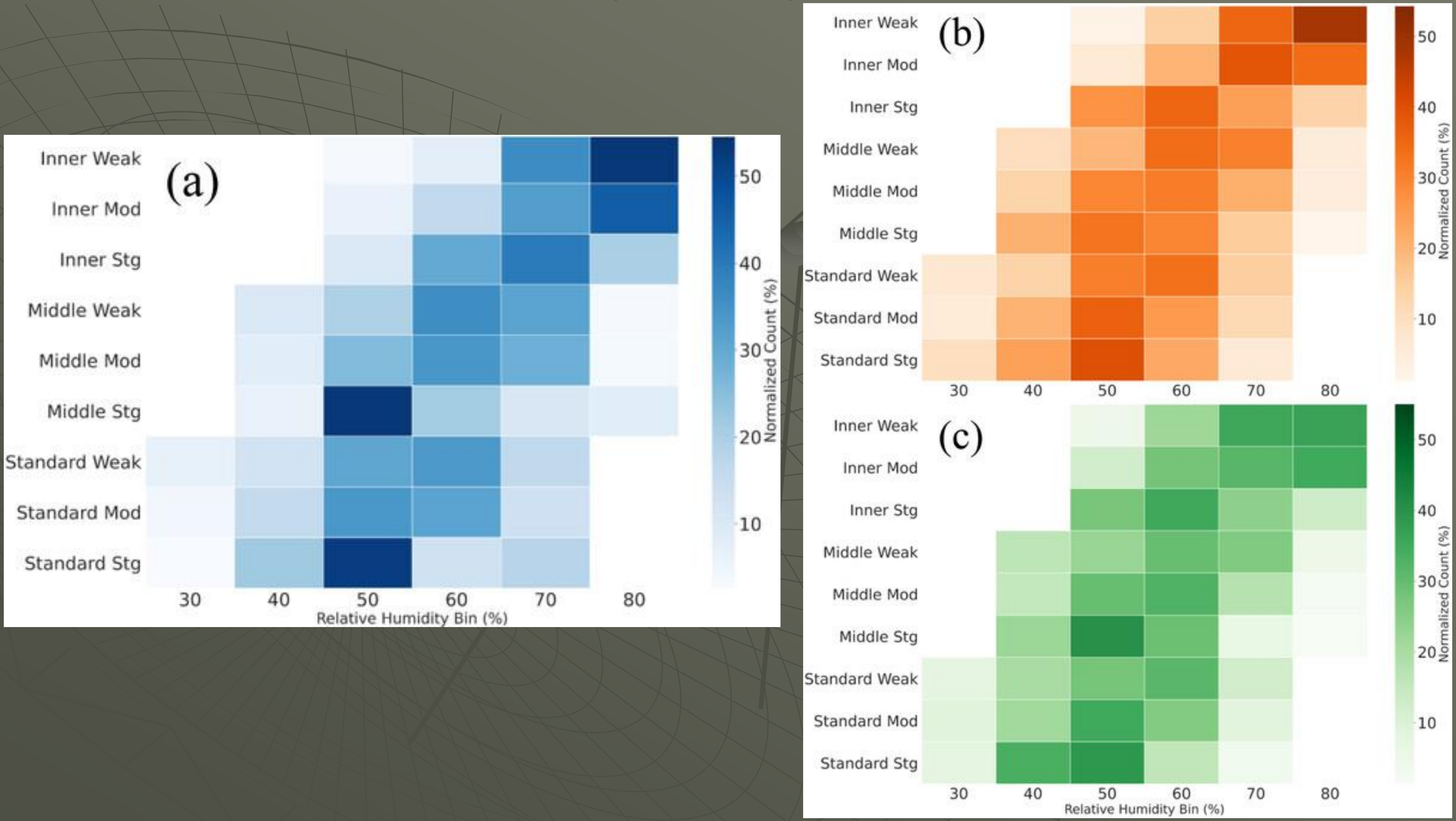
3. Probability density functions cont.



3. Probability density functions cont.

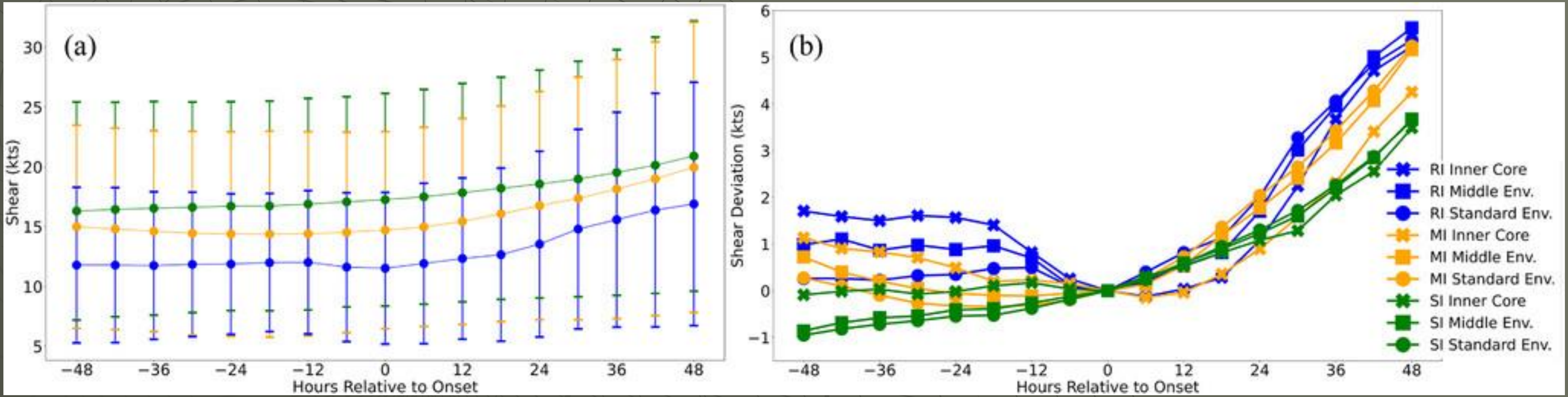


3. Probability density functions cont.



4. Time series

850–200 hPa



4. Time series cont.

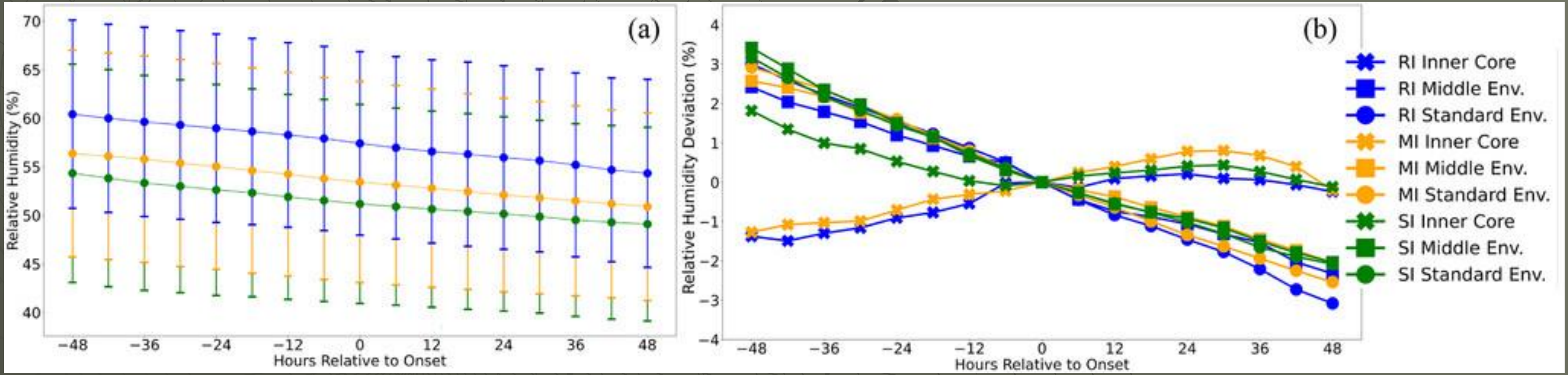
Radius	Intensification	Onset value (kt)	−48 to 0 (%)	−24 to 0 (%)	−12 to 0 (%)	0 to 12 (%)	0 to 24 (%)
Inner	RI	8.6	−16.5	−15.4	−8.7	0.4	12.5
	RI (first event)	9.1	−19.7	−14.5	−7.8	0.2	17.8
	MI	11.9	−8.9	−4.1	−1.9	−0.3	7.7
	SI	13.4	0.7	0.1	−1.3	3.9	8.1
Middle	RI	10.4	−8.6	−7.8	−6.3	5.1	16.3
	RI (first event)	10.9	−11.2	−8.7	−8.4	9.3	18.9
	MI	13.8	−5.0	0.4	0.8	3.9	12.8
	SI	16.4	5.5	2.6	1.6	3.6	7.5
Standard	RI	11.5	−2.2	−3.0	−4.1	7.1	17.5
	RI (first event)	11.7	−7.2	−5.6	−6.4	10.7	20.7
	MI	14.7	−1.8	2.7	2.2	4.9	13.7
	SI	17.3	5.8	3.2	2.2	3.4	7.5

4. Time series cont.

Variable	Comparison	−48	−42	−36	−30	−24	−18	−12	−6	0
RH	MI/SI inner	X	X							
Shear	MI/SI inner	X	X	X	X	X	X			
	RI middle/standard	X	X	X	X	X	X			
	MI middle/standard	X	X	X	X	X	X	X		
RH in weak shear	MI/SI inner	X	X	X	X	X	X			
	MI/SI middle	X	X	X	X	X	X	X	X	X
	MI/SI standard	X	X	X	X	X	X	X	X	X
	RI/MI inner							X		
RH in moderate shear	RI/SI inner	X	X							
	MI/SI inner	X	X	X		X				
RH in strong shear	MI/SI inner	X	X	X	X	X	X	X	X	X
	MI/SI middle	X	X	X	X	X	X	X	X	X
	MI/SI standard	X	X	X	X	X	X	X	X	X
	RI/MI inner		X	X	X	X				
DSR RH	MI/SI inner	X	X	X						
	MI/SI middle	X								
USR RH	MI/SI inner	X	X							
USL RH	MI/SI inner	X								
DSL RH	MI/SI inner	X	X	X	X	X				
	MI/SI middle	X					X	X	X	X
	MI/SI standard						X	X	X	X
925–400-hPa shear	RI/MI inner	X	X							
700–850-hPa RH	RI/SI inner	X	X	X						
	MI/SI inner	X	X	X	X	X	X	X	X	
	RI/MI inner						X		X	
600–800-hPa RH	MI/SI inner	X	X	X	X					
400–800-hPa RH	MI/SI inner	X	X							
	MI/SI middle	X	X							
	MI/SI standard	X	X	X	X		X			

4. Time series cont.

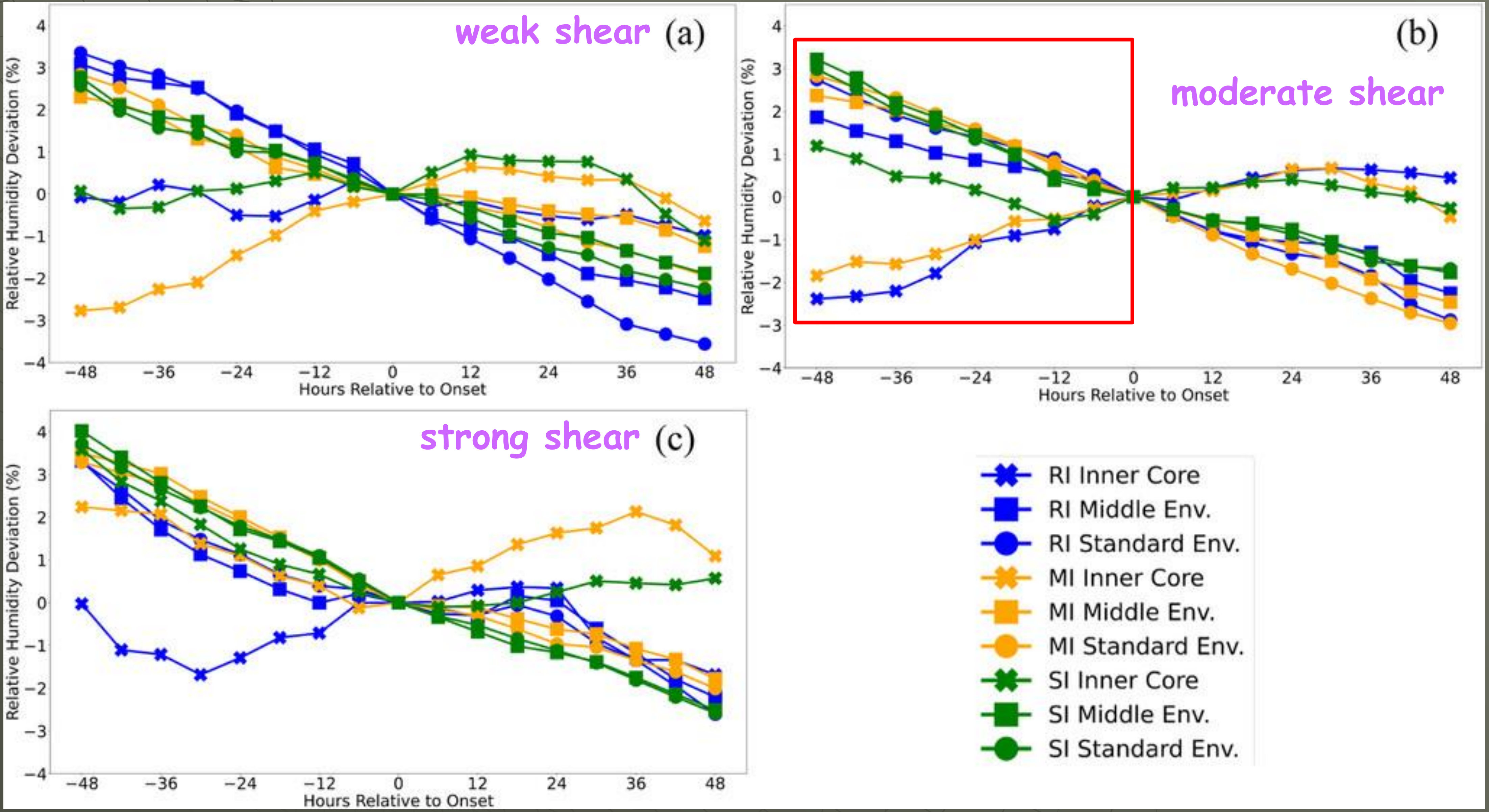
500-700 hPa



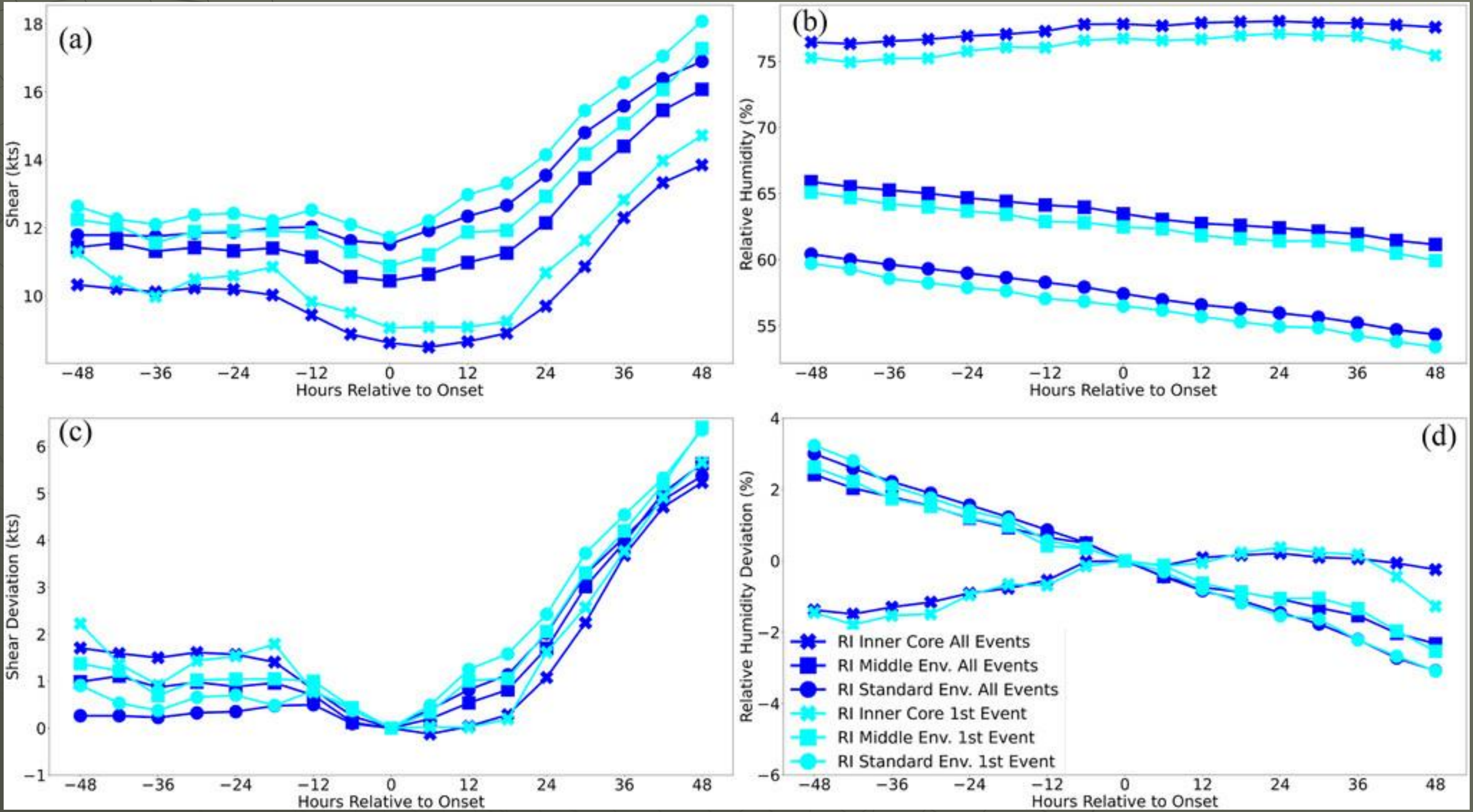
4. Time series cont.

Radius	Intensification	Onset value (%)	−48 to 0 (%)	−24 to 0 (%)	−12 to 0 (%)	0 to 12 (%)	0 to 24 (%)
Inner	RI	77.8	1.8	1.2	0.7	0.1	0.3
	RI (first event)	76.7	1.9	1.3	0.9	−0.1	0.5
	MI	74.5	1.7	1.0	0.4	0.5	1.1
	SI	71.2	−2.5	−0.7	0	0.3	0.6
Middle	RI	63.5	−3.7	−1.9	−1	−1.2	−1.7
	RI (first event)	62.5	−4.0	−1.9	−0.7	−1.0	−1.7
	MI	59.2	−4.2	−2.5	−1.2	−0.6	−1.5
	SI	56.8	−5.7	−2.6	−1.2	−1.0	−1.6
Standard	RI	57.4	−5.0	−2.6	−1.5	−1.5	−2.5
	RI (first event)	56.5	−5.4	−2.4	−1.0	−1.4	−2.7
	MI	53.4	−5.2	−2.9	−1.5	−1.2	−2.5
	SI	51.2	−5.8	−2.7	−1.4	−1.1	−2.0

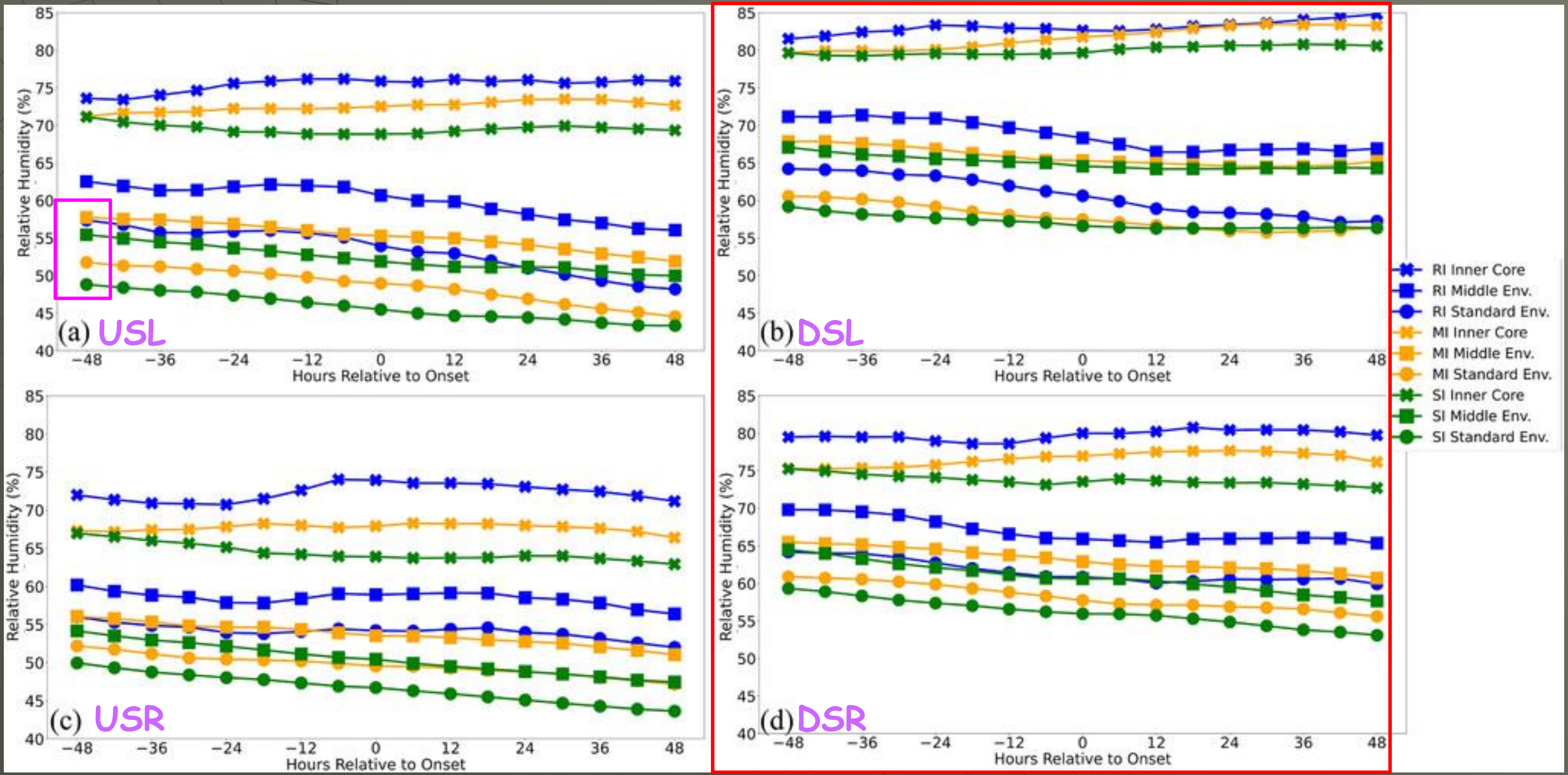
4. Time series cont.



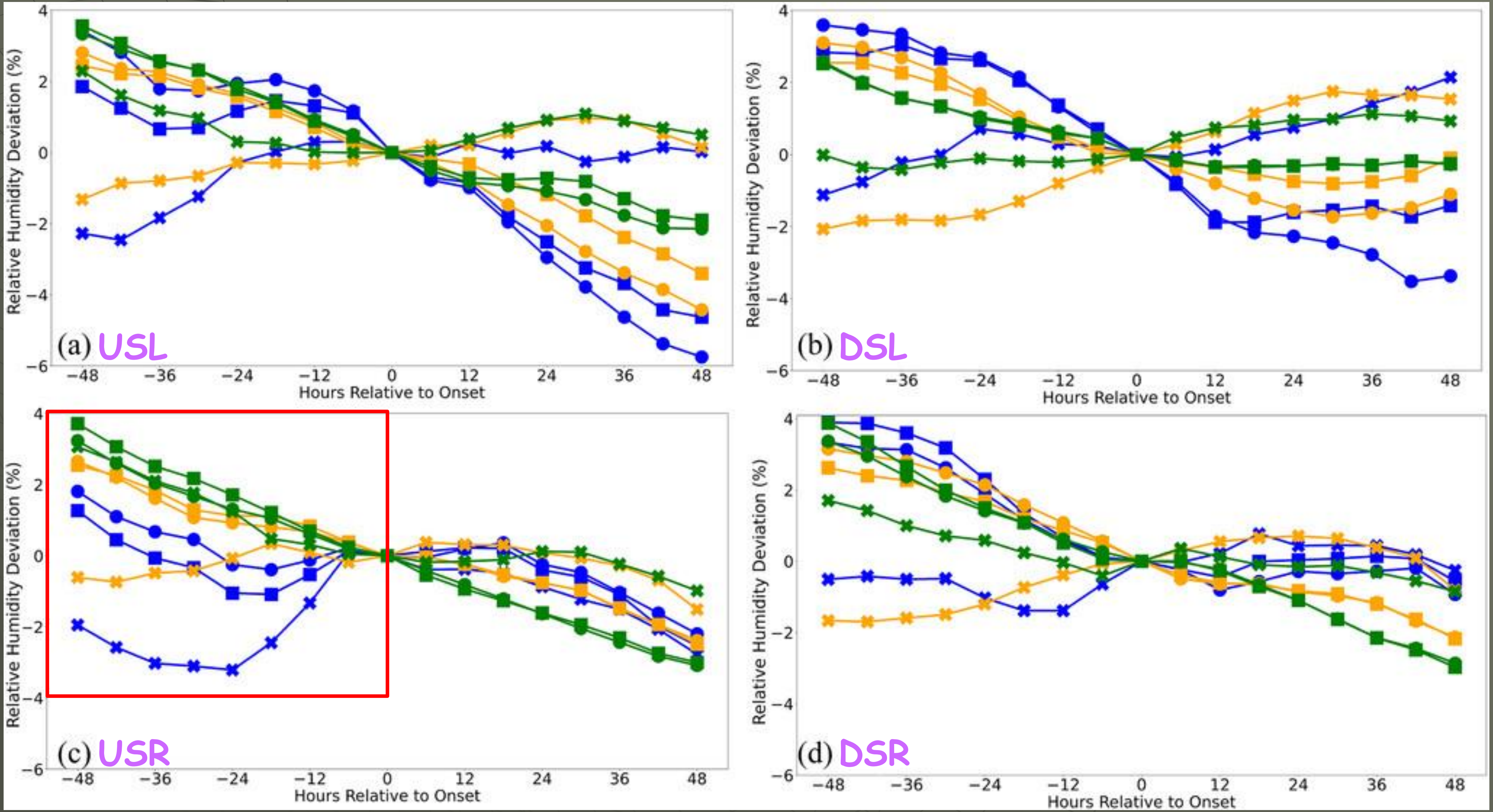
4. Time series cont.



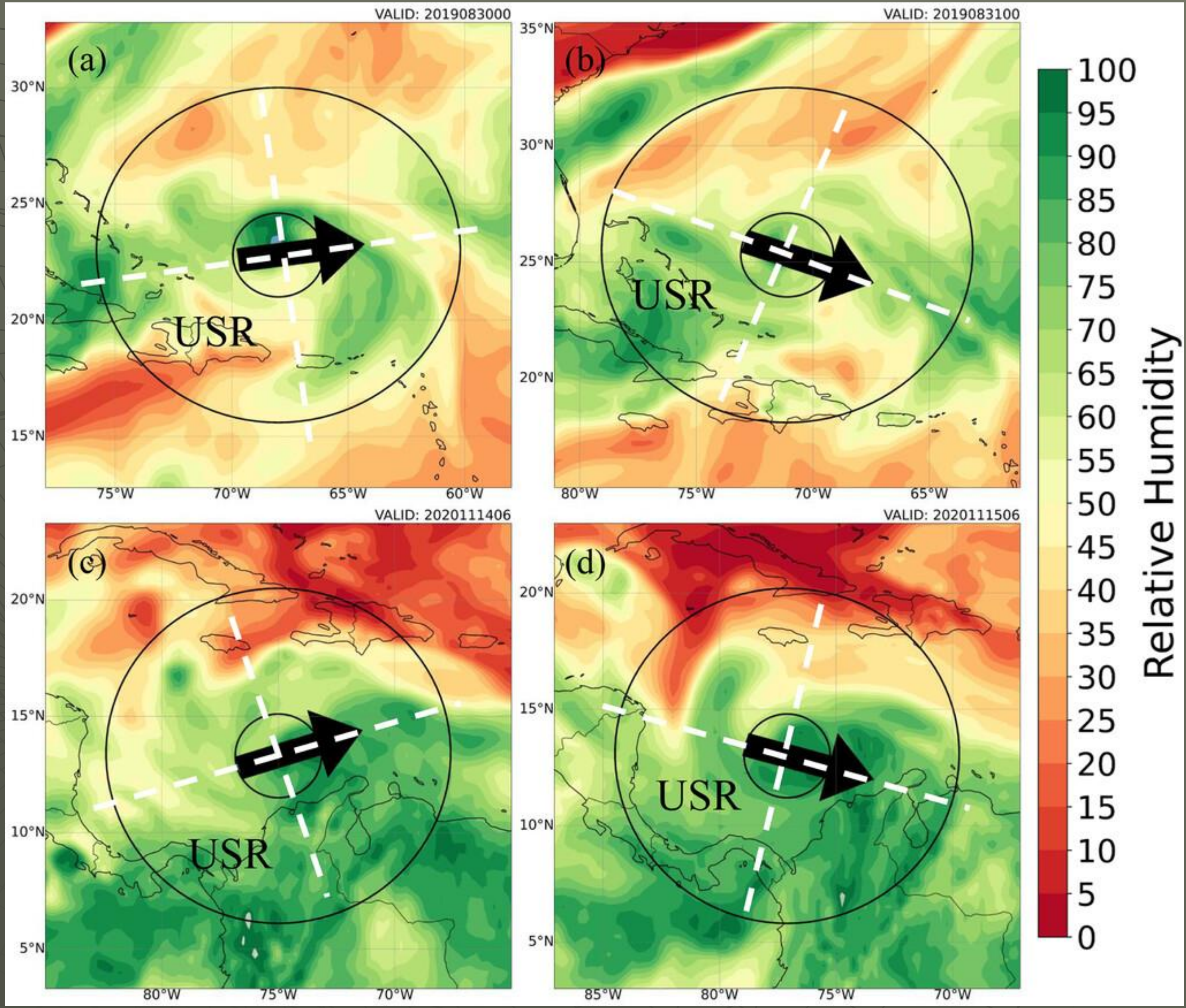
5. Shear-relative quadrants



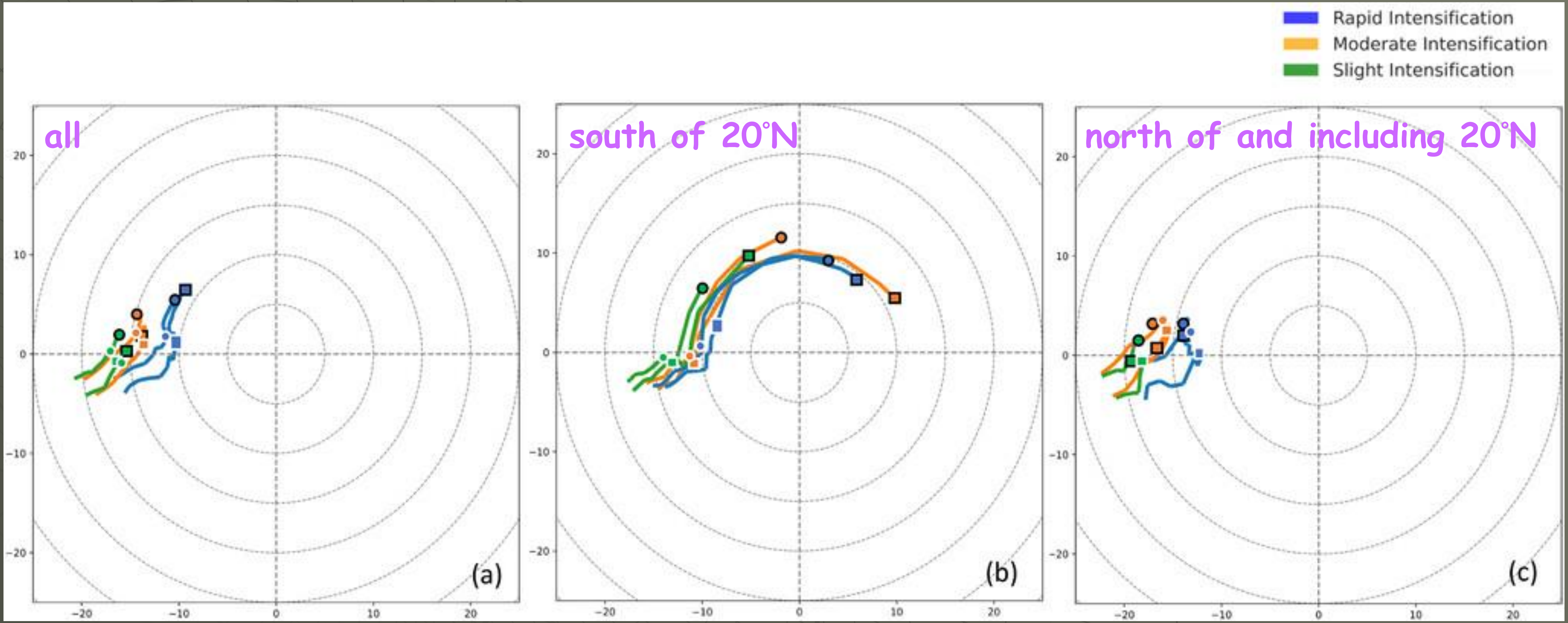
5. Shear-relative quadrants cont.



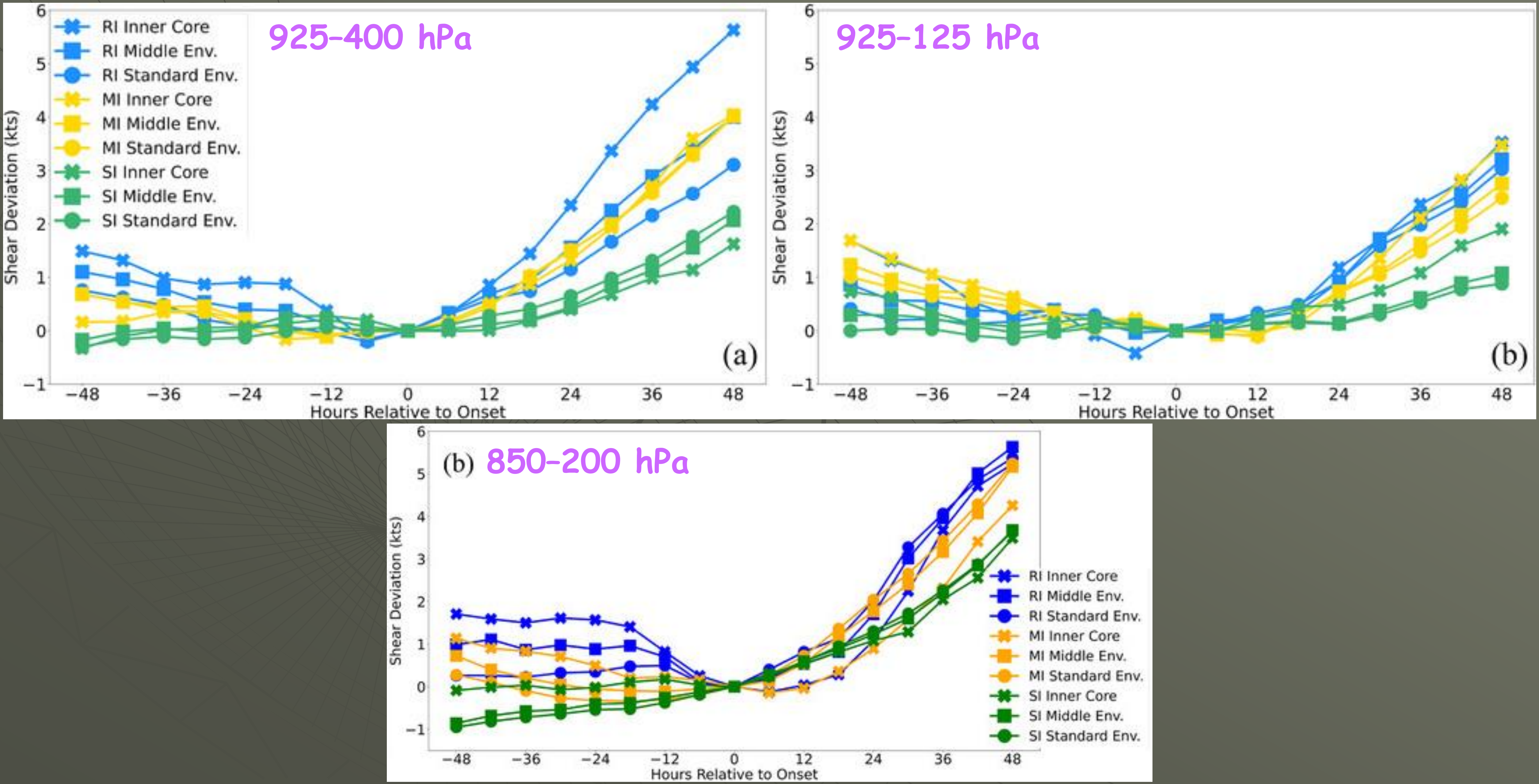
5. Shear-relative quadrants cont.



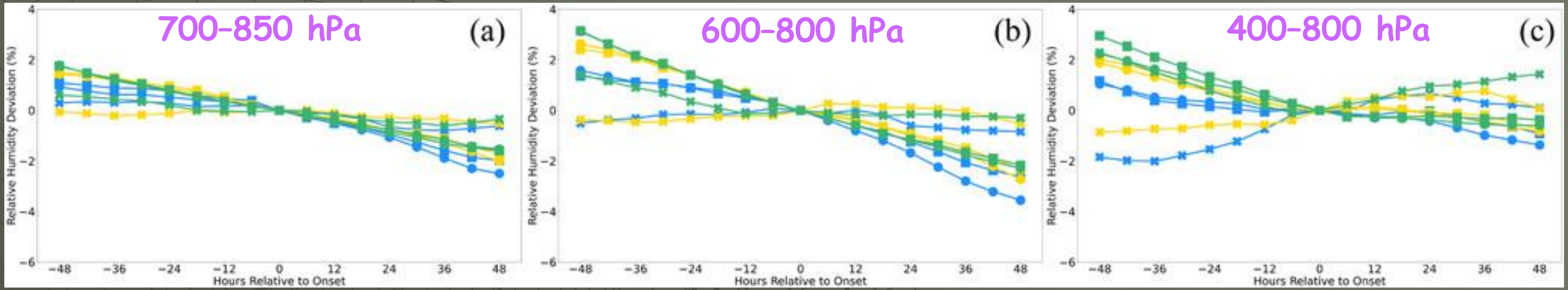
6. Shear direction

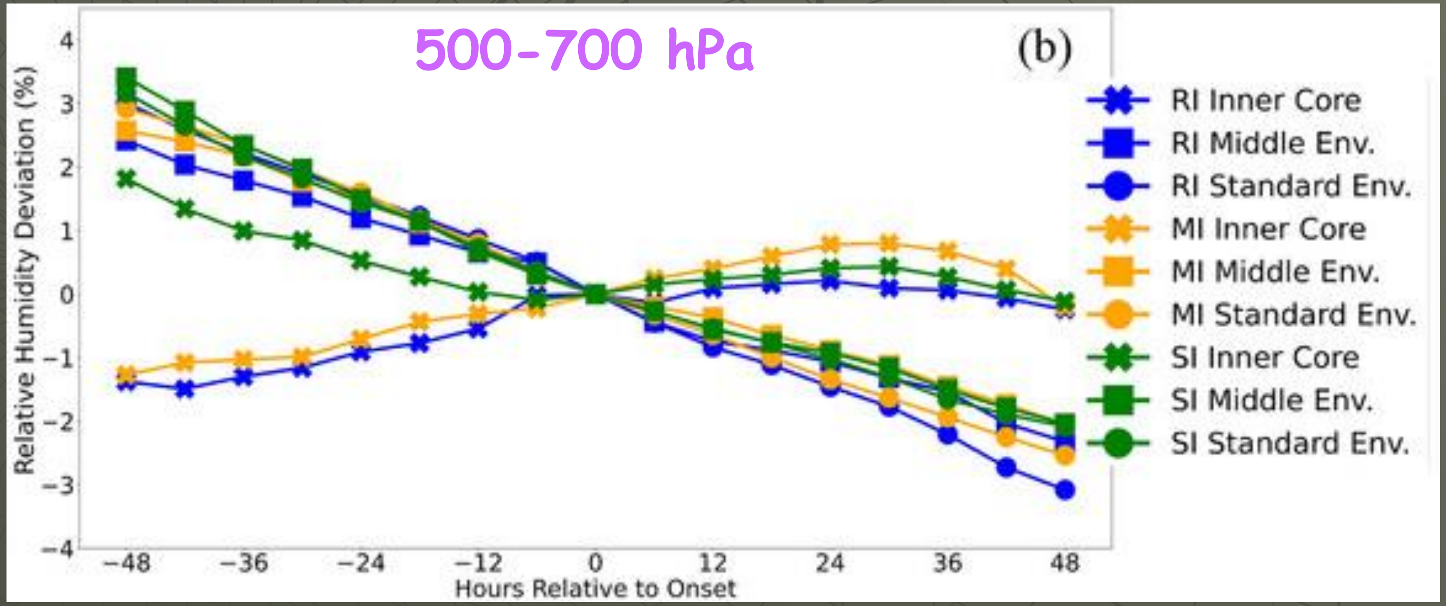


7. New levels for shear and RH computations



7. New levels for shear and RH computations cont.





8. Conclusions

- Combining changes over time and significance, we make the following recommendations, in order of importance, for forecasters and intensification models to further assess the adaptability of our results into TC RI forecasting.

- The significance is focused on the differences between annuli and intensification rate as opposed to individual changes over time.

- The first is a focus on the increase in USR RH, in contrast to an environmental decrease in the other quadrants, as this occurred for 90% of our homogeneous sample of cases.

- The last suggestion would be to look at the shear within the 925-400 hPa layer, a shallower, lower layer than the current 850-200 hPa layer in SHIPS-RII, as all annuli for RI had a significant change between 48 h pre-onset and onset.

The End…

Thanks !

Questions??