

# Dynamic and Thermodynamic Drivers of Severe Sub-Hourly Precipitation Events in Mainland Portugal

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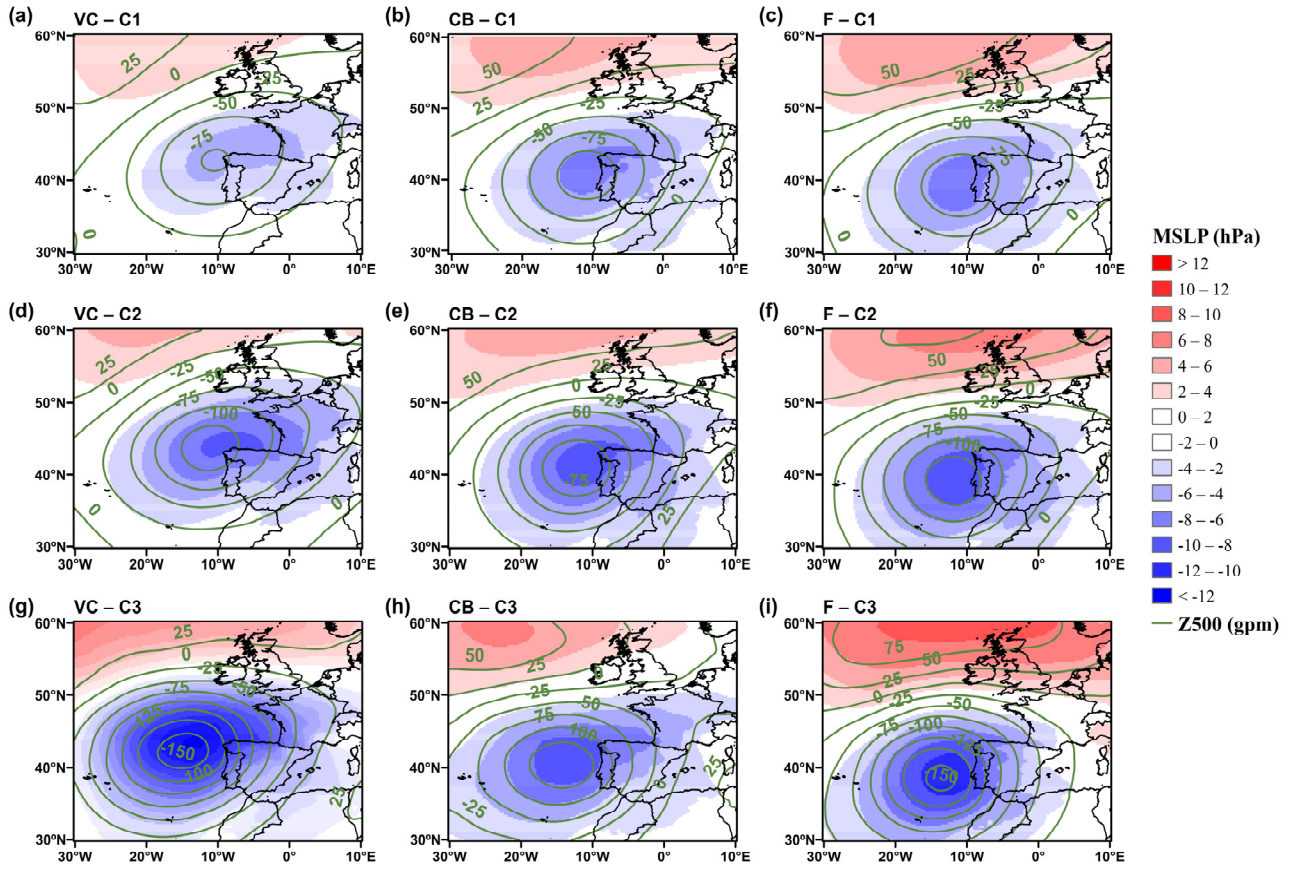
## Supplemental Material

**Tabela S1.** List of the selected 34 weather stations (WS) in mainland Portugal. Their codes and names are shown. The corresponding percentages of missing values on the daily timescale precipitation over the recording period are also provided.

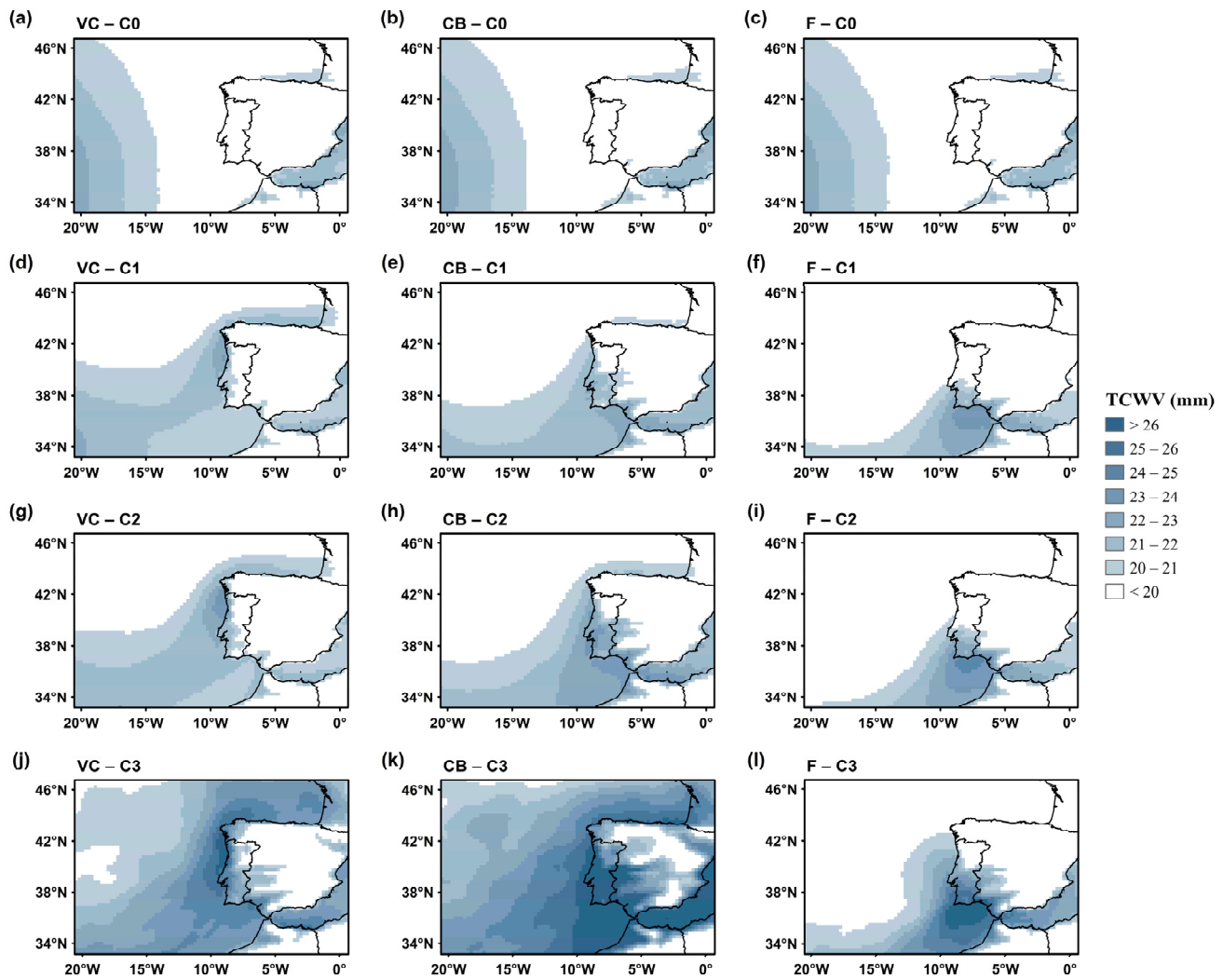
Code	Weather station name	Nb. of days with data	Missing data (%)
541	Sines Monte	8185	3
604	Geres Carris	7399	12
566	Vila Real	8388	0
545	Porto Pedras Rubras	7781	7
707	Coimbra	8363	0
568	Penhas Douradas	7979	5
557	Évora	8384	0
579	Lisboa Gago Coutinho	7971	5
535	Lisboa Geofísico	7810	7
<b>551</b>	<b>Viana do Castelo</b>	<b>8134</b>	<b>3</b>
<b>554</b>	<b>Faro Aeroporto</b>	<b>7488</b>	<b>11</b>
560	Viseu CC	8177	3
562	Beja	7805	7
<b>570</b>	<b>Castelo Branco</b>	<b>7840</b>	<b>7</b>
571	Portalegre	8007	5
575	Bragança	7632	9
577	Odemira S. Teotónio	6805	19
611	Montalegre	6921	18
616	Chaves Aeródromo	7472	11
619	Cabril	7180	15
632	Mirandela	6947	17
635	Miranda do Douro	6803	19
637	Mogadouro	7087	16
683	Guarda	7159	15
685	Nelas	7342	13
697	Lousã Aeródromo	7184	14
705	Anadia	7044	16
803	Zebreira	7072	16
812	Alvega	7213	14
824	Avis Benavila	7013	17
835	Elvas	7715	8
837	Estremoz	6775	19
867	Castro Marim	6785	19
878	Portimão Aeródromo	7294	13

**Tabela S2.** Number and percentage of events recorded in each station and by precipitation class.

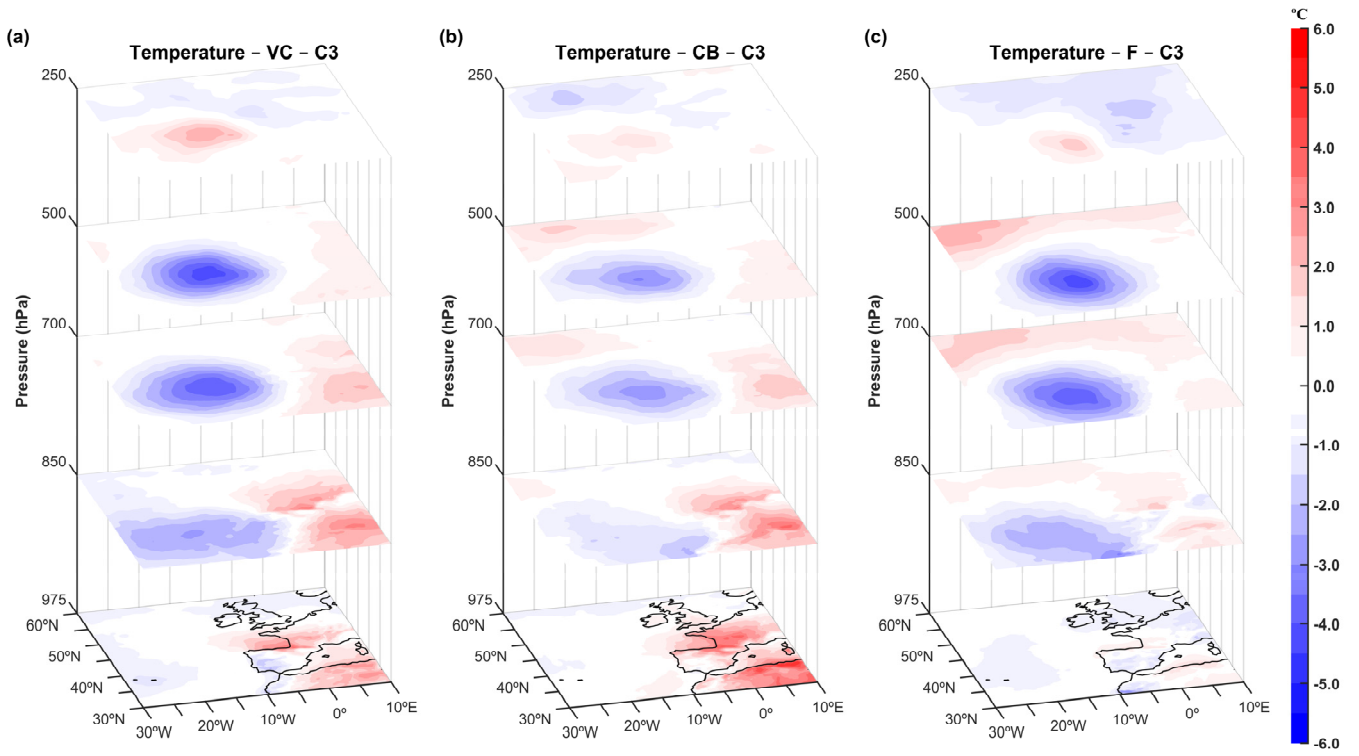
Weather Station	Composites	Nb. of Events	Pct. of Events
Viana do Castelo (VC)	C0	6248	65.4
	C1	2035	21.3
	C2	1215	12.7
	C3	60	0.6
Castelo Branco (CB)	C0	6153	72.8
	C1	1391	16.5
	C2	853	10.1
	C3	51	0.6
Faro (F)	C0	5747	76.2
	C1	1063	14.1
	C2	659	8.7
	C3	75	1.0



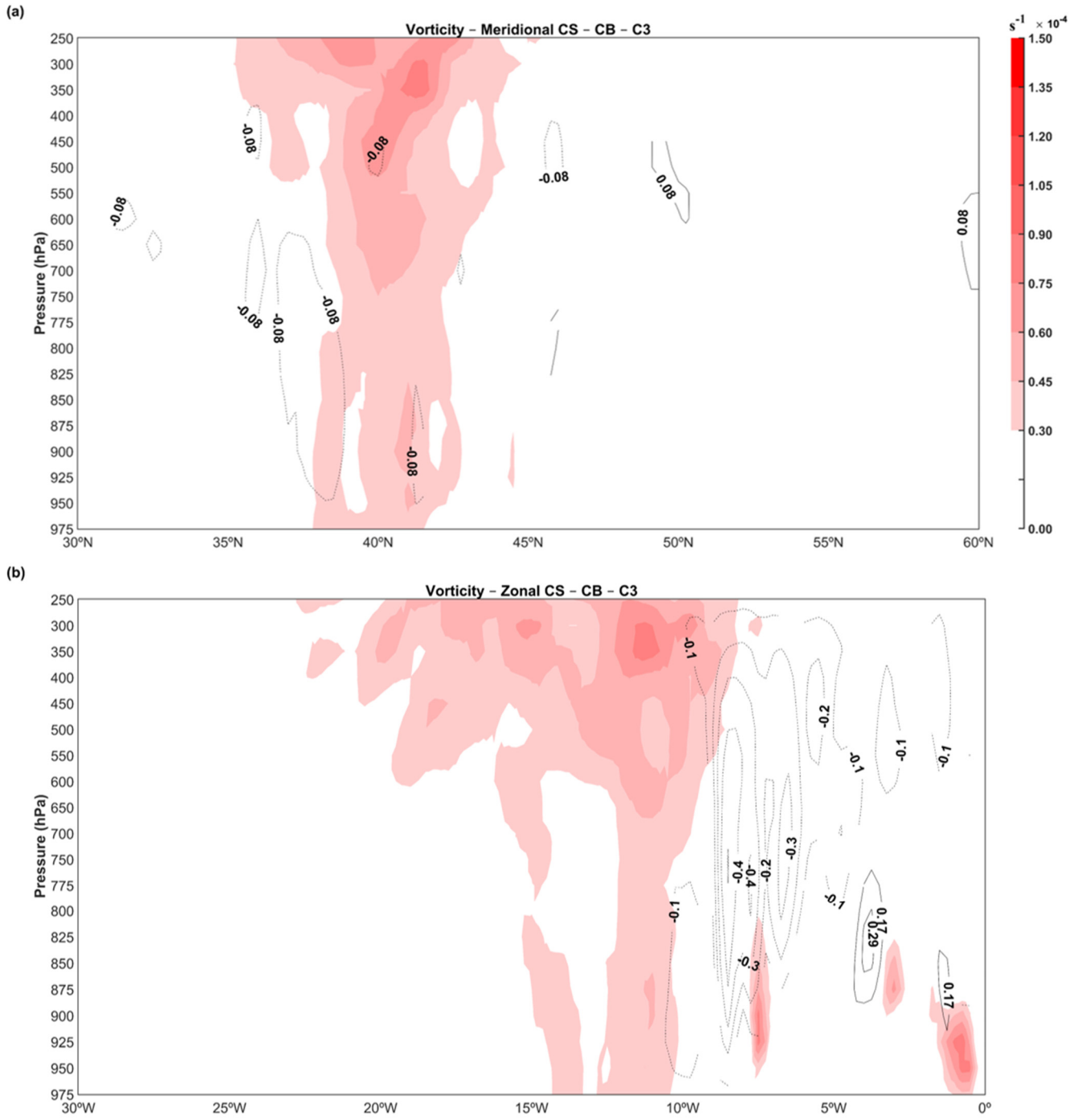
**Figure S1.** Composites of hourly anomalies of MSLP (in hPa) (shading) and Z500 (in gpm) (contours lines represented in green, with a spacing of 25 gpm) for (a,b,c) C1, (d,e,f) C2, and (g,h,i) C3.



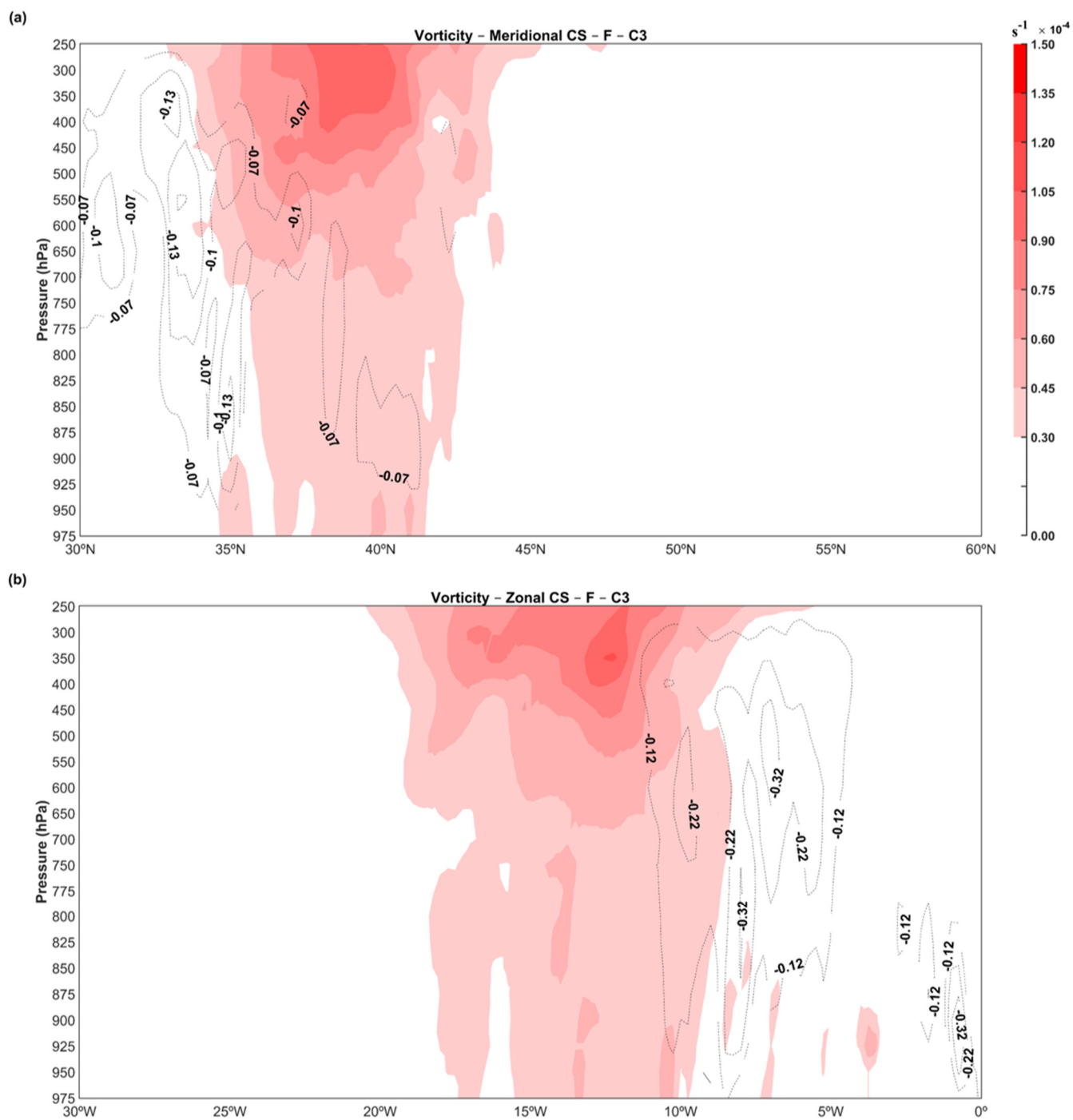
**Figure S2.** Hourly composites of total column water vapour (TCWV, shading in mm) for precipitation classes (a,b,c) C0, (d,e,f) C1, (g,h,i) C2, and (j,k,l) C3 in each WS (VC, CB, and F).



**Figure S3.** Composites of hourly anomalies of temperature anomaly (in °C) for precipitation class C3 (SHHP events), at different vertical levels, and for (a) VC, (b) CB, and (c) F.

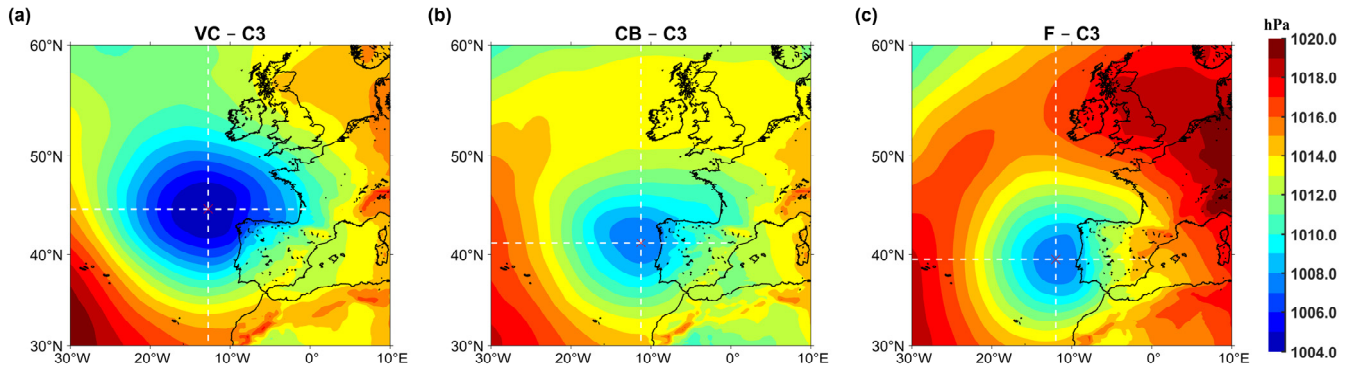


**Figure S4.** (a) Meridional and (b) zonal cross-sections of relative vorticity composites of hourly anomalies (shading in  $\text{s}^{-1}$ ) and omega-vertical velocity (contours in  $\text{Pa s}^{-1}$ , positive/negative values in solid/dashed lines) for class C3 and CB.

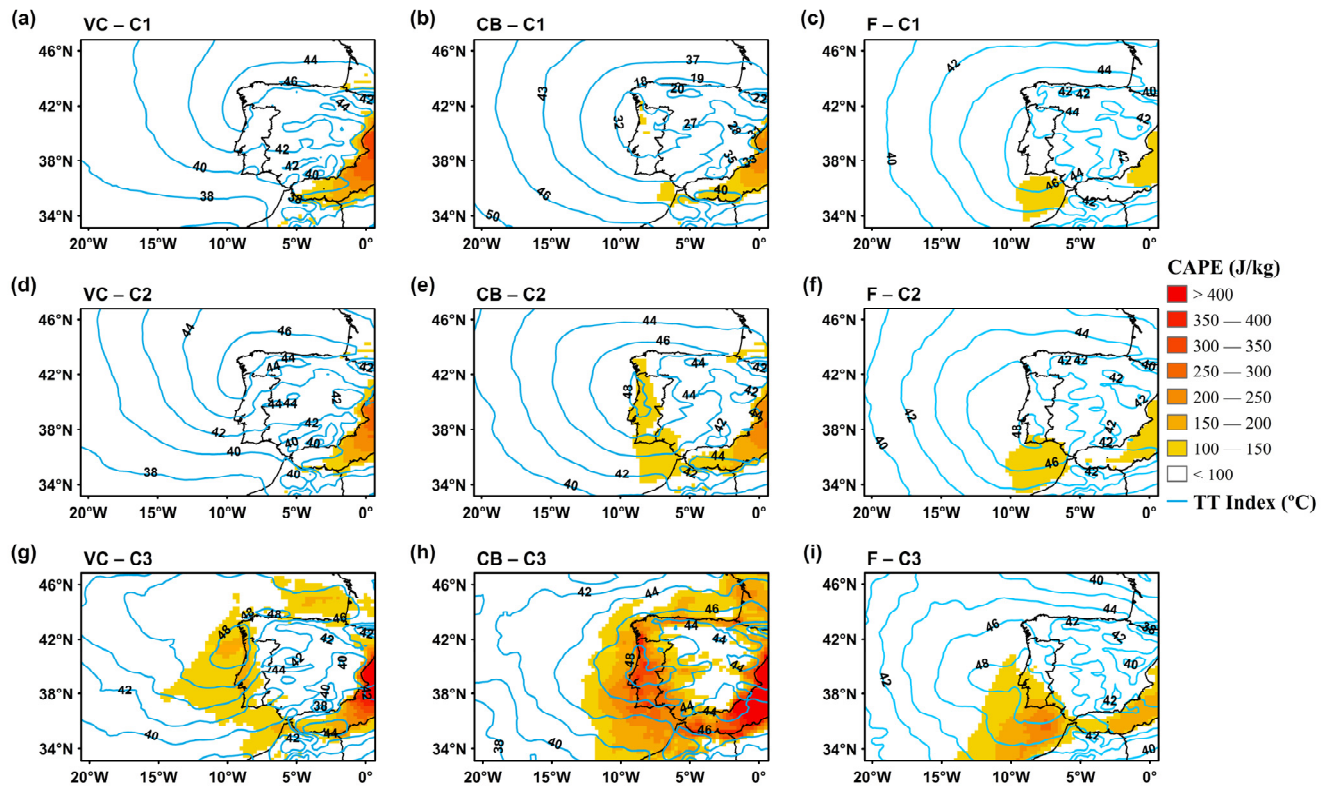


**Figure S5.** (a) Meridional and (b) zonal cross-sections of relative vorticity composites of hourly anomalies (shading in  $\text{s}^{-1}$ ) and omega-vertical velocity (contours in  $\text{Pa s}^{-1}$ , positive/negative values in solid/dashed lines) for class C3 and F.

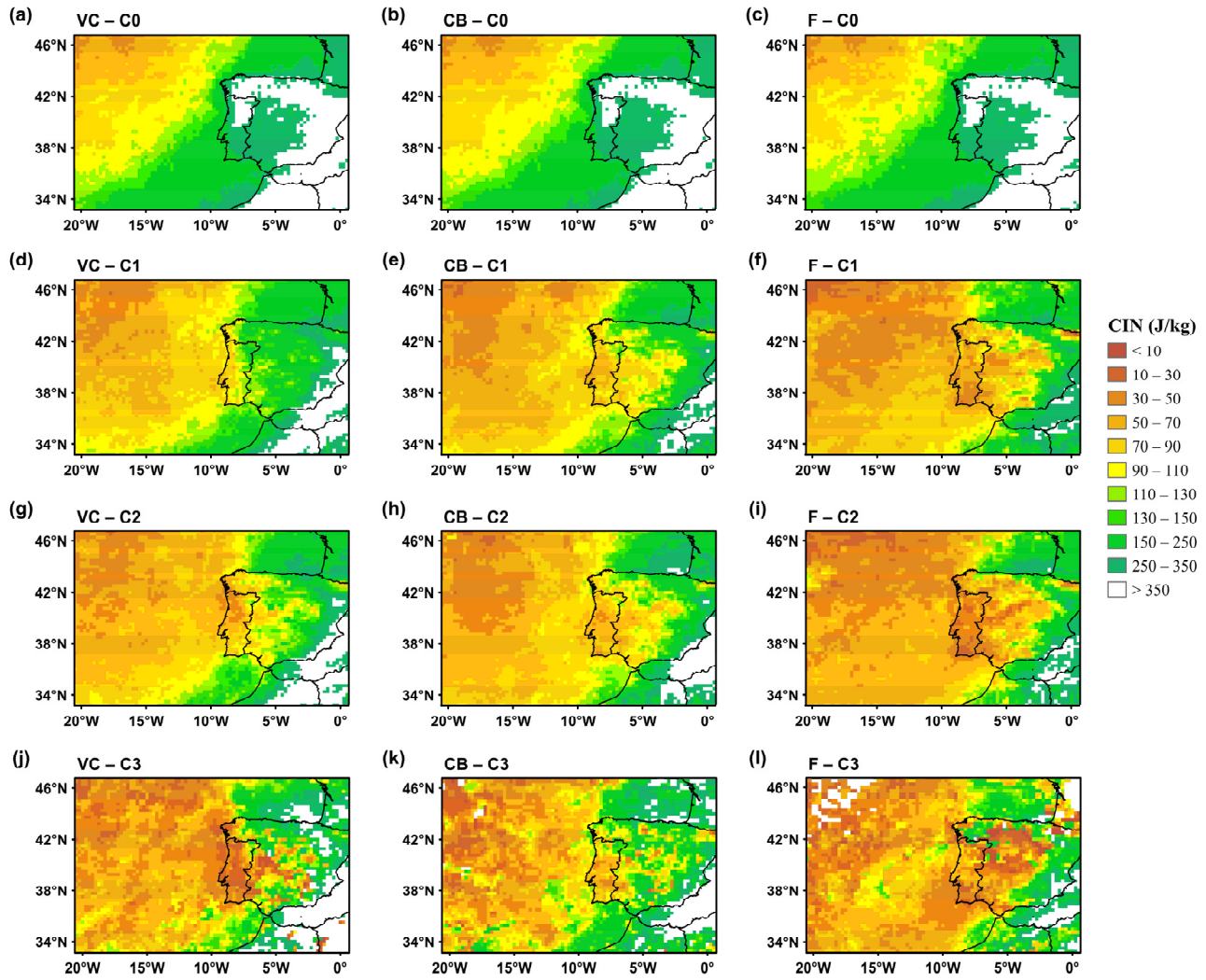




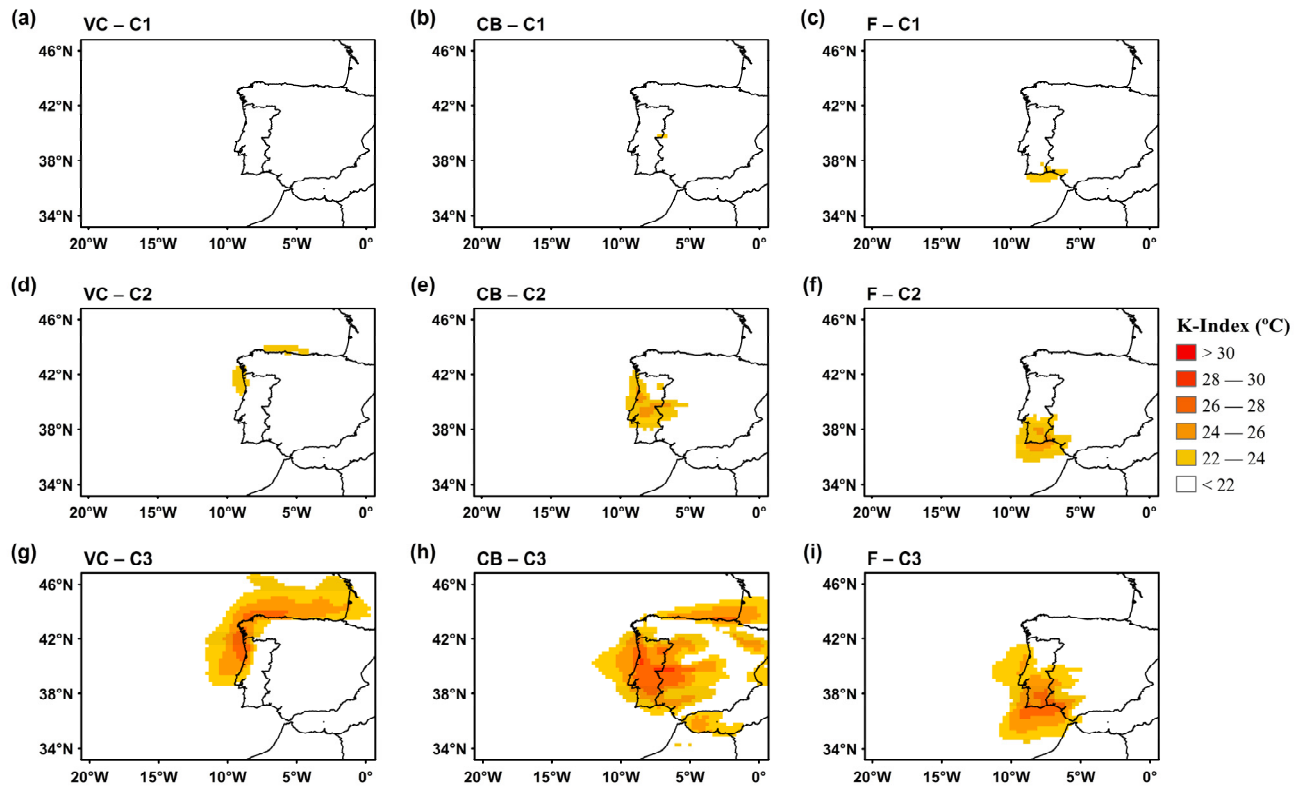
**Figure S6.** Hourly composites of MSLP (shading in hPa) and position of meridional and zonal cross-sections (white dashed lines) for precipitation class C3 (SHHP events), for (a) VC, (b) CB, and (c) F.



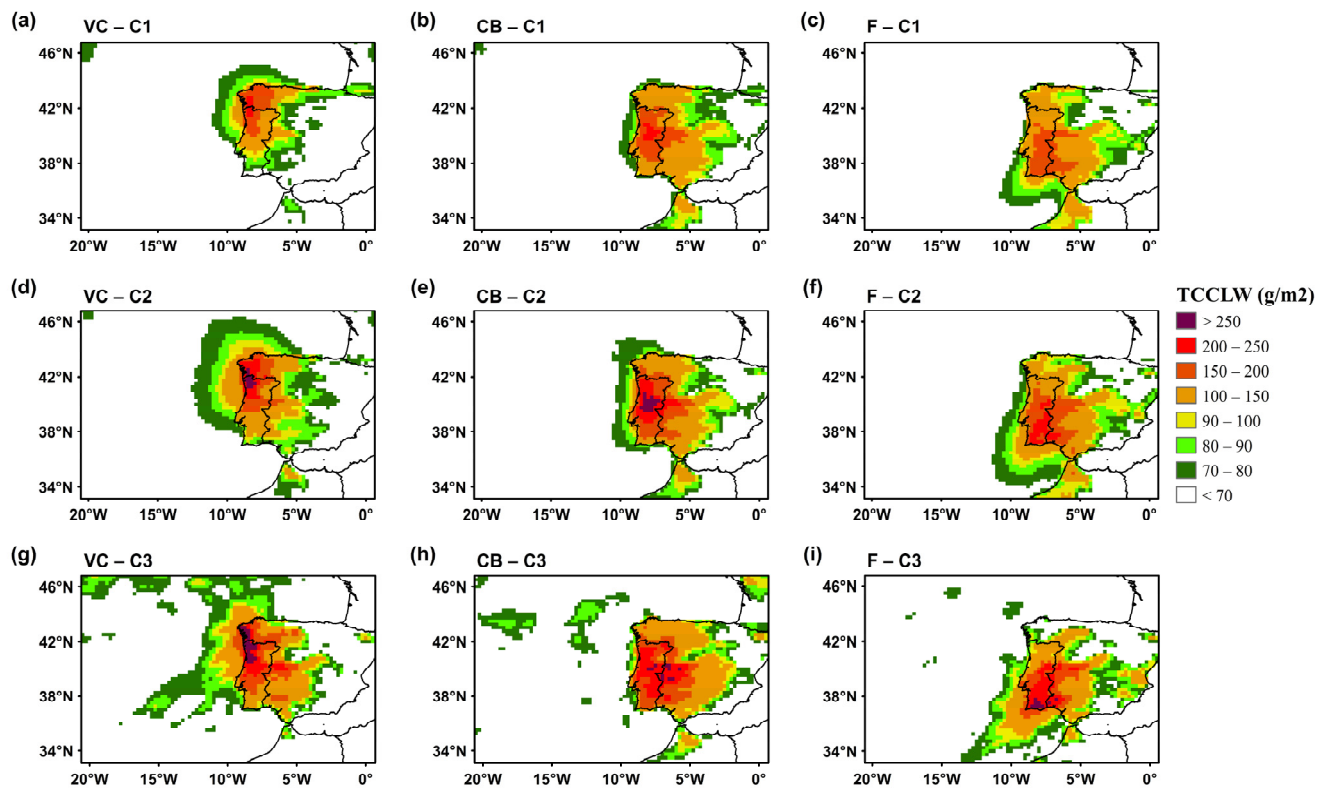
**Figure S7.** Hourly composites of CAPE (shading in J kg<sup>-1</sup>) and Total-Totals index (blue contours in °C, 2 °C spacing), for (a,b,c) C0, (d,e,f) C1, (g,h,i) C2 (j,k,l), and C3 in each WS (VC, CB, and F).



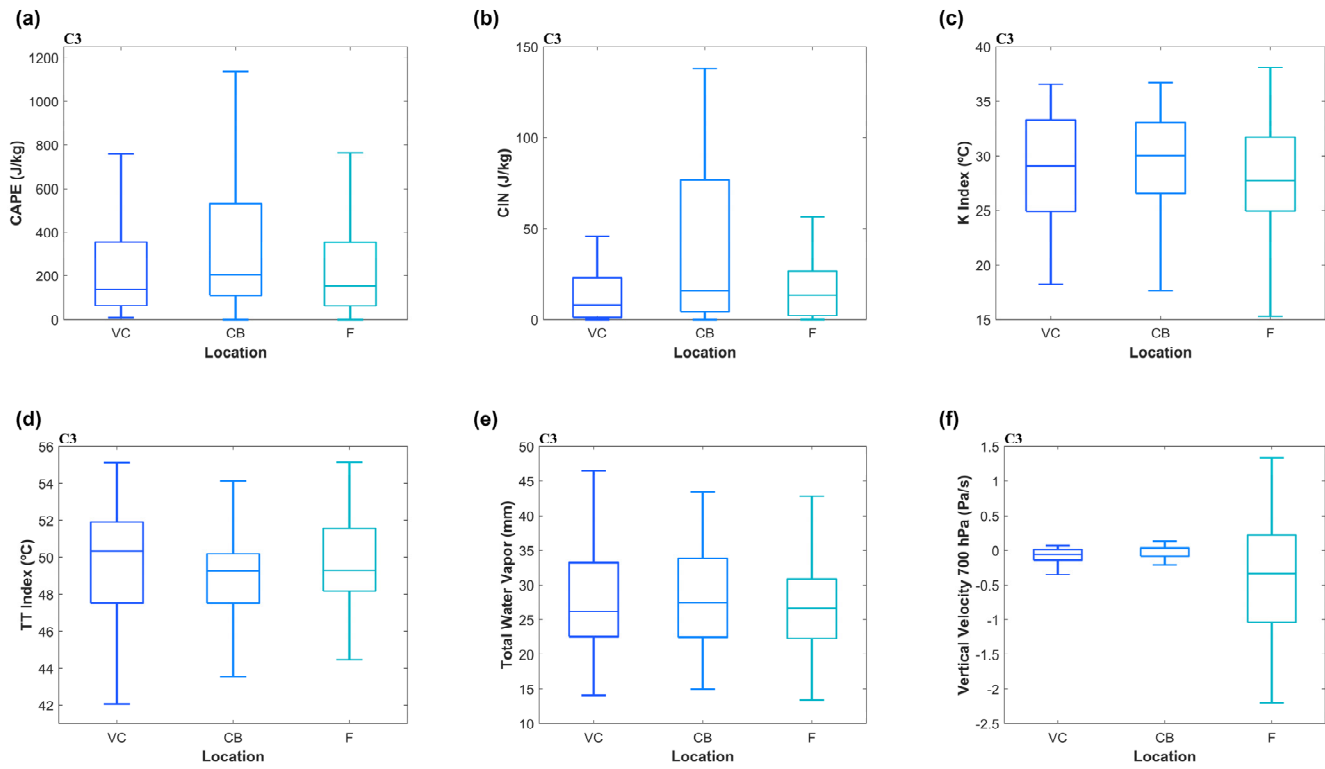
**Figure S8.** Hourly composites of convective inhibition (CIN, shading in  $\text{J kg}^{-1}$ ) for precipitation classes (a,b,c) C0, (d,e,f) C1, (g,h,i) C2, and (j,k,l) C3 in each WS (VC, CB, and F).



**Figure S9.** Hourly composites of K-index (shading in °C ) for (a,b,c) C0, (d,e,f) C1, (g,h,i) C2 (j,k,l), and C3 in each WS (VC, CB, and F).



**Figure S10.** Hourly composites of total column cloud liquid water, TCCLW (shading in  $\text{g m}^{-2}$ ) for precipitation classes (a,b,c) C1, (d,e,f) C2, and (g,h,i) C3 in each WS (VC, CB, and F).



**Figure S11.** Boxplots of (a) CAPE (in  $\text{J kg}^{-1}$ ), (b) CIN (in  $\text{J kg}^{-1}$ ), (c) K-index (in  $^{\circ}\text{C}$ ), (d) TT-index (in  $^{\circ}\text{C}$ ), (e) TCWV (in mm), and (f) vertical velocity 700 hPa (in  $\text{Pa s}^{-1}$ ) for precipitation events C3 in each WS (VC, CB, and F).