Convective instability indices as thunderstorm predictors for Catalonia

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MOTIVATION

Flash-floods have a strong social impact in Catalonia (NE Iberian Peninsula)

GOAL

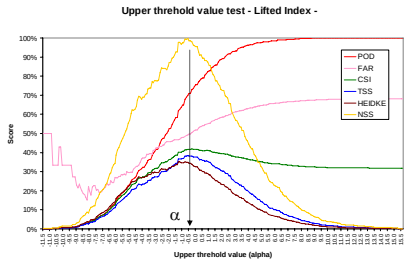
To improve the usefulness of Convective Instability Indices (CII) as thunderstorm predictors, by means of:

- Find the most useful CIIs for the region
- Establish local CII thresholds to use them as dichotomous predictors

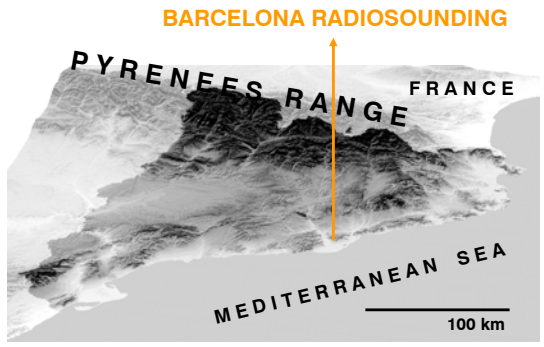
METHOD

To assess the CII usefulness and to find the best dichotomous threshold, contingency tables and derived skill scores were used:

- Probability of Detection, False Alarm Ratio, Critical Success Index
- True Skill Statistic, Heidke Skill Score & Normalized Skill Scores



AREA OF STUDY

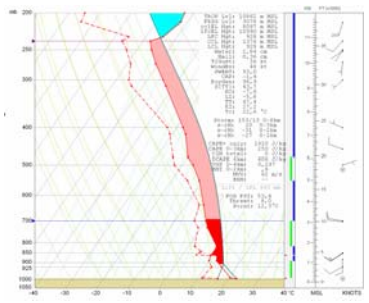


CATALONIA (32,000 km²)

DATASET

PREDICTOR

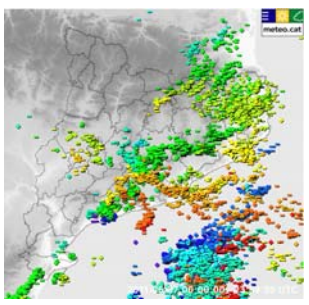
Almost 70 CII analyzed, derived from the Barcelona Radiosounding database (years 2004 to 2010, soundings twice a day, 00 and 12 UTC). The DB underwent a complex quality control (see Abellan et al., poster in session 7, nº 256)



7th June 2011 12:00 UTC

PREDICTAND

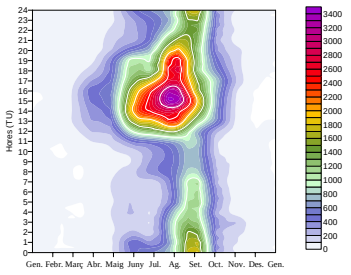
Lightning Location System covering the region since 2003. The LSS is composed of four VAISALA's LS8000 Total Lightning Sensors.



Lightning Climatology (2004-2010)

95% of activity from April to October

70% of activity after 12 UTC and 40% of activity between 12 and 18 UTC



DIFFERENT SCENARIO TESTING

S #1 THUNDERY IF ≥1 CG ≥ 10 CG ≥ 100 CG

How to define a "thundery" case? Only one CG lightning is enough?

Lifted Index	Thundery	Non-Th.	α	Heidke	POD	FAR	CSI
Th. ≥ 1 CG	1174	1755	-0.8	0.35	0.63	0.39	0.45
Th. ≥ 10 CG	932	1997	-1.3	0.35	0.62	0.47	0.40
Th. ≥ 100 CG	558	2371	-3.3	0.34	0.49	0.54	0.31
Thompson	**Thundery**	**Non-Th**	**α**	**Heidke**	**POD**	**FAR**	**CSI**
Th. ≥ 1 CG	1174	1755	21.4	0.34	0.70	0.42	0.47
Th. ≥ 10 CG	932	1997	27.3	0.34	0.51	0.42	0.37
Th. ≥ 100 CG	558	2371	28.3	0.33	0.55	0.57	0.32
CAPE	**Thundery**	**Non-Th**	**α**	**Heidke**	**POD**	**FAR**	**CSI**
Th. ≥ 1 CG	1174	1755	140	0.36	0.73	0.41	0.49
Th. ≥ 10 CG	932	1997	220	0.35	0.72	0.48	0.43
Th. ≥ 100 CG	558	2371	1098	0.32	0.46	0.54	0.30

Best results correspond to Th≥1. However, defining 'thundery' cases with only one or more lightning includes too many 'thudnery' cases, resulting in low thresholds. Th.≥10 is a better compromise for our aim of study.

S #2 FORECAST LEAD TIME + 3H + 6 H + 12 H

How representative is a sounding after 3/6/12 hours? Different lead times has been tested

Lifted Index	Thundery	Non-Th.	α	Heidke	POD	FAR	CSI
H+12	932	1997	-1.3	0.35	0.62	0.47	0.40
H+6	748	2181	-3.3	0.34	0.44	0.44	0.32
H+3	545	2384	-3.3	0.35	0.49	0.55	0.31
Thompson	**Thundery**	**Non-Th.**	**α**	**Heidke**	**POD**	**FAR**	**CSI**
H+12	931	1897	27.3	0.34	0.51	0.42	0.37
H+6	747	2081	27.3	0.33	0.53	0.51	0.35
H+3	545	2283	28.3	0.34	0.55	0.57	0.32
CAPE	**Thundery**	**Non-Th.**	**α**	**Heidke**	**POD**	**FAR**	**CSI**
H+12	815	1620	220	0.35	0.72	0.48	0.43
H+6	667	1768	739	0.33	0.53	0.49	0.35
H+3	491	1944	1038	0.32	0.48	0.56	0.30

Forecast CIIs skills seems to be more or less similar for the different lead times analyzed, according to the Heidke Skill Score.

S #3 ONLY 12 UTC SOUNDING + 6 H

Thunderstorm activity concentrates between 12 and 18 UTC. Which CII perform better for a lead time of 6 hours after 12 UTC?

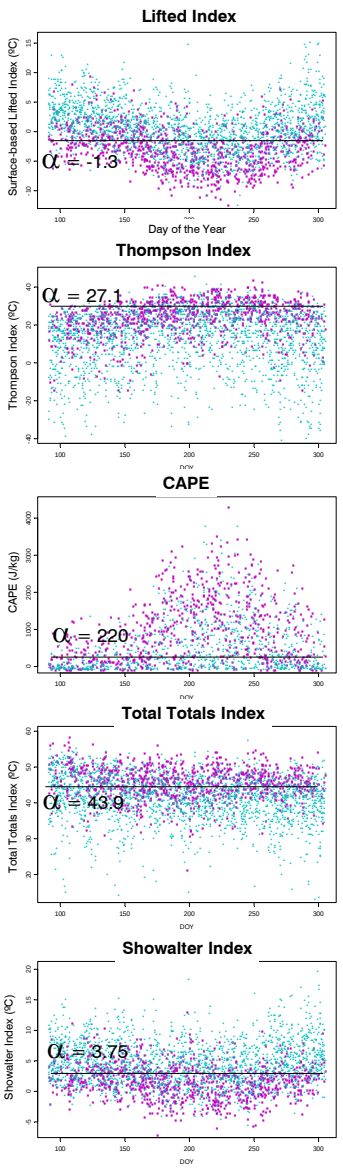
CII	Heidke	α	POD	FAR	CSI
Total Totals	0.434	45.5	0.637	0.357	0.470
Thompson	0.429	23.7	0.668	0.363	0.484
S{TT}	0.427	30.8	0.824	0.425	0.512
Jefferson	0.416	24.2	0.709	0.401	0.481
Showalter	0.415	3.6	0.659	0.386	0.466
K Index	0.385	20.9	0.689	0.411	0.465
Boyden	0.372	96.1	0.680	0.428	0.450
CAPE	0.360	249.6	0.769	0.450	0.472
Lifted Ind.	0.359	-1.3	0.680	0.438	0.444
Vertical Totals	0.350	26.6	0.654	0.437	0.434
CAPE Hail	0.349	94.6	0.730	0.458	0.451
CAPE+	0.341	309.5	0.697	0.455	0.440
TQ Index	0.334	12.1	0.650	0.447	0.426
NCAPE	0.329	0.1	0.504	0.391	0.380
Deep Conv. Ind.	0.298	24.1	0.444	0.388	0.346

When considering only the 12UTC dataset, the best results were obtained for a 6 hour lead time. The table presents the 15 CIIs with a best score according to Heidke.

BEST LOCAL INDICES

Table. Convective Indices sorted by best Heidke Skill Score, Optimal threshold (α), POD, FAR, CSI

CII	Heidke	α	POD	FAR	CSI
Lifted Index	35.1	-1.3	61.9	46.7	40.1
Thompson	34.8	27.1	50.7	41.6	37.3
CAPE	34.6	220	71.7	48.4	37.9
CAPE+	32.2	220	67.3	50.4	39.9
CAPE Hail	32.1	49	70.6	51.3	40.5
Total Totals	31.8	43.9	77.8	52.7	41.7
Showalter	30.6	3.75	70.8	52.3	39.8
NCAPE	30.6	0.03	69.3	52.3	39.4
Jefferson	28.8	24	73.3	53.6	39.7
S{TT}	28.3	35.8	65.9	51.4	38.8
K Index	27.4	20.9	71.9	54.2	38.8
Boyden	26	96.2	64.3	54.2	36.5
Vertical Totals	23.4	26.4	67.6	56.4	36.1
Deep Conv. Ind.	22.9	24	40.7	49.7	21.7
TQ Index	22.5	12.8	60.7	55.9	34.3
Cross Totals	21.9	20.4	43.8	52.3	29.6
WBZ	17.8	3392	35.8	53.2	16.7
KO	17.8	-1.9	70.1	59.7	21.3
GOES HMI	14.5	2.4	71.8	59.6	34.8
SWEAT	14.3	149	39.3	57.9	25.5

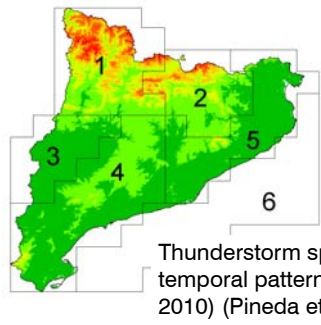


DISCUSSION & FUTURE WORK

In general, skill scores obtained in this study were lower than the ones presented in similar studies (i.e. Haklander & van Delden; 2003; Kunz, 2007). The reason is that the Barcelona radiosounding-derived CII were used to predict thunderstorms in a larger area, with a complex orography. Besides, the best CIIs in H&vD (LI_{100}, LI_{50}, $SWISS_{12}$) were not tested in the present study.

An interesting result is that when forecasting only 6 hours after 12 UTC, CIIs with better scores are different from the best ones for the full dataset. CIIs using the parcel evolution from surface are worse predictors for 12 UTC+6H than the ones that use only variables obtained from the atmospheric conditions at that moment.

Future work will deal with the regional representativeness of the sounding. For this purpose, we will use the regions arising from the thunderstorm spatial and temporal classification (Pineda et al., 2011), see figure. Another point that should be analyzed in detail is the "thundery" day definition. Days of sparse showers with little lightning occur under different conditions compared to an outbreak of severe thunderstorms in summer. A threshold on the number of lightning seems a too simple criterion. Other factors like radar reflectivity, thunderstorm extension and persistence, and severe weather reports should be considered.



Thunderstorm spatial and temporal patterns (2004-2010) (Pineda et al., 2011)