Using Large-Scale Patterns to Predict Extreme Precipitation over the Mediterranean in Medium/Extended-Range Forecasts

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MOTIVATION

Previous work[i] has demonstrated strong connections between Extreme Precipitation Events (EPEs) in the Mediterranean (Med.) and large-scale atmospheric flow patterns over the domain. Here, we assess the skill of the ECMWF extended-range forecasts in predicting these patterns, and their usefulness for indirectly predicting EPEs.

DATA

ERA5[ii]: 1979–2020; ECMWF reforecasts: 1–45 lead days, 11 ensemble members, cycle 46r1, (2200 dates/lead day)

Selected Variables (at daily temporal scale)	Spatial Resolution
Total Precipitation (TPr)	0.25° x 0.25°
Mean Sea Level Pressure (SLP)	1.00° x 1.00°
Mean Geopotential Height at 500 hPa ($Z500$)	1.00° x 1.00°

METHODOLOGY

1. ERA5: generate the 9 Mediterranean patterns (**Fig. 2**).
How? EOF analysis & K-means clustering on SLP & Z500 anomalies.

2. ERA5: connect Med. patterns to P95 EPEs (**Fig. 3**).
How? Derive Conditional Probabilities (CP) of EPEs for each pattern.

3. Forecasts: Assess skill in predicting the patterns (**Fig. 4**).
*How? a) Allocate forecast members to pattern of min Euclidean dist.
b) Use Brier Score (BS) & Brier Skill Score (BSS) for assessing the skill.
Ref. score for BSS: min. of: i) persistence, ii) 91-day mov. wind. freq.*

4. Forecasts: Assess indirect skill in predicting EPEs (**Fig. 1**).
*How? a) Replace each member with its CP of EPEs based on the forecasted pattern. & get ens. mean b) Use BSS for EPEs prediction.
Ref. score: min of: i) 31-day mov. wind.-, ii) seasonal- freq. of EPEs.*

5. Forecasts: Compare the forecasting horizon of the indirect & the direct (using forecasted precipitation) methods (**Fig. 5**).

REFERENCES

[i]Mastrantonas N, Herrera-Lormendez P, Magnusson L, Pappenberger F, Matschullat J. Extreme precipitation events in the Mediterranean: Spatiotemporal characteristics and connection to large-scale atmospheric flow patterns. Int J Climatol. 2021; https://doi.org/10.1002/joc.6985 [ii]Copernicus Climate Change Service (C3S) (2017): ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate. Copernicus Climate Change Service Climate Data Store (CDS). https://cds.climate.copernicus.eu/cdsapp#!/home

Want to know more about the general PhD project? Check the short video

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We can use large-scale patterns to better predict extreme precipitation in the Mediterranean at medium & extended range forecasts.

0~2	3~4	5~6	7~8	9~10	11~12	13~14	15~19
0.1	0.92	5.02	14.47	26.74	15.04	3.32	1.18

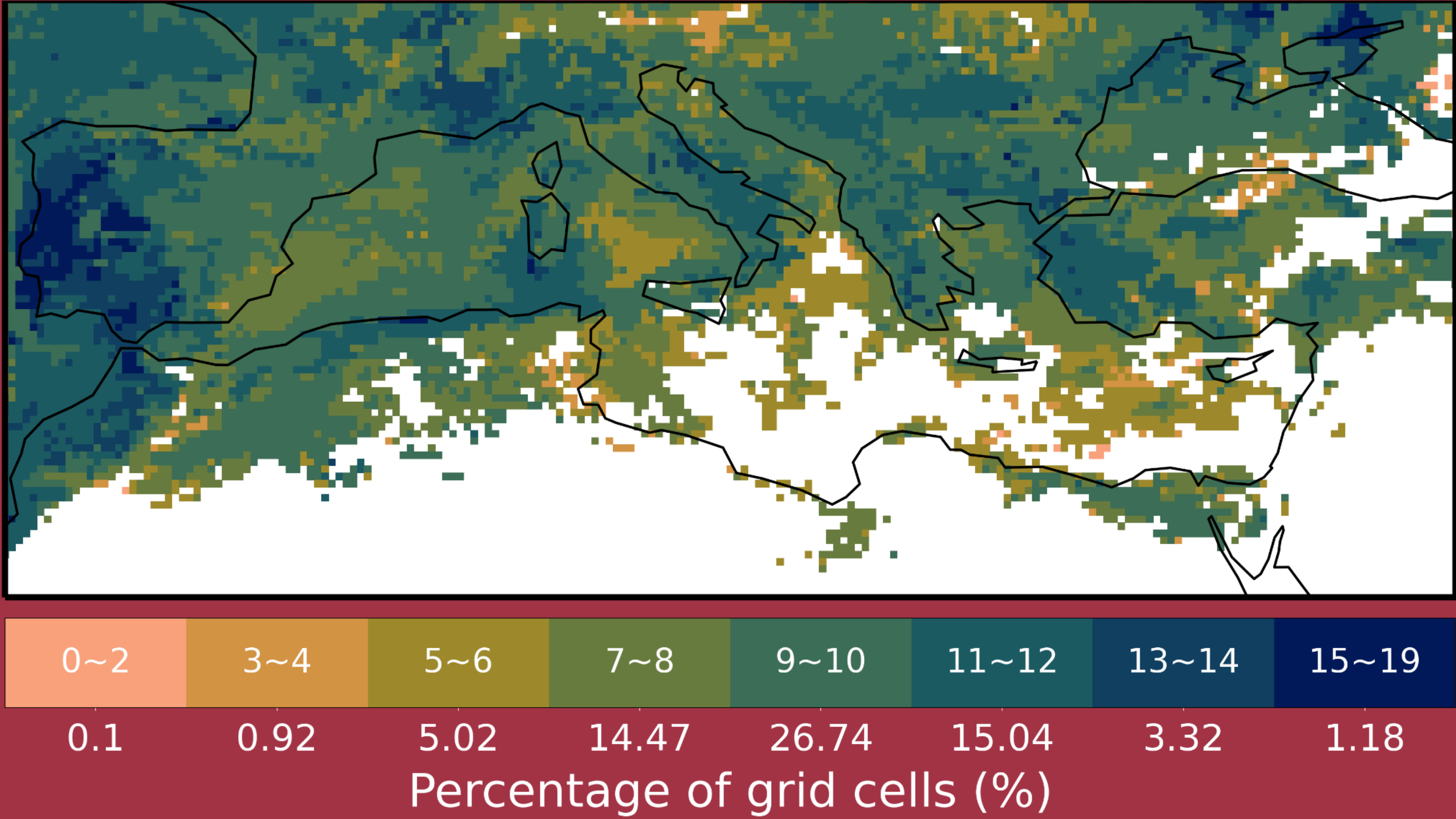**Percentage of grid cells (%)**

Fig. 1: Forecasting horizon (lead-days) up to when ECMWF model outperforms reference scores in predicting extreme precipitation, when indirectly predicting extremes with the use of the 9 Mediterranean patterns.

Attending the main AMS conf.?
Talk on 27th Jan. 11:30 AM CST
Session 14.B4 – online (more info)

Paper

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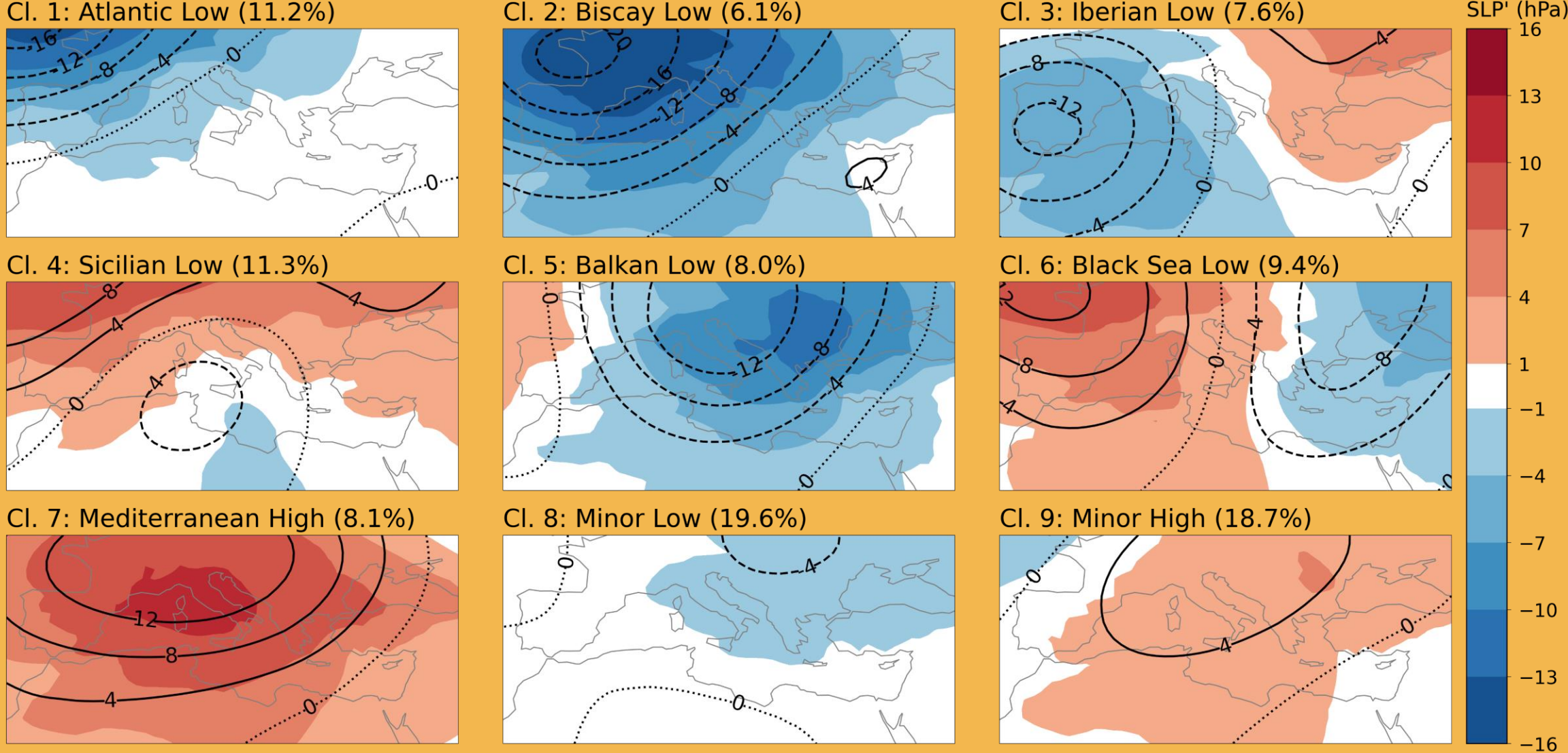nikolaos.mastrantonas@ecmwf.int

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Supportive Information

Fig. 2: Composites of weather regimes, derived with K-means clustering on the principal components' projections of SLP and Z500 anomalies. Colour shading refers to SLP anomalies (hPa), and contours to Z500 anomalies (dm). Percentages indicate the occurrence of each cluster to the total days of the analysis (Mastrantonas et al. 2021).
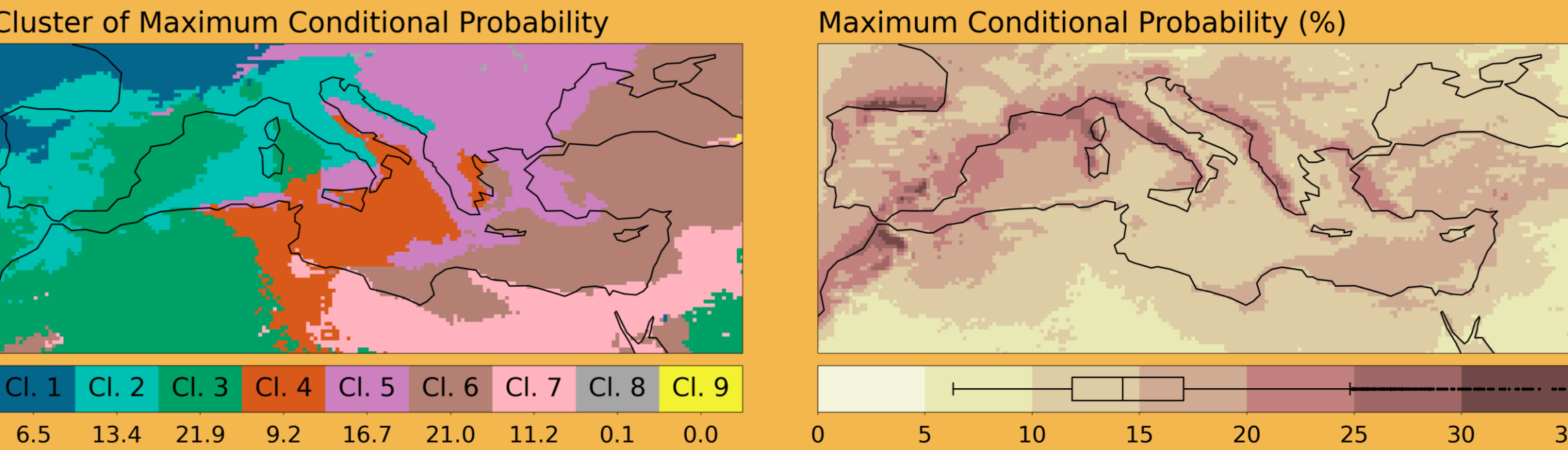

Fig. 3: P95 EPEs: Pattern of Maximum Conditional Probability (MCP) for each grid cell and associated MCP considering the annual statistics.

$$BS = \frac{1}{N}\sum_{t=1}^{N}(f_t - o_t)^2$$
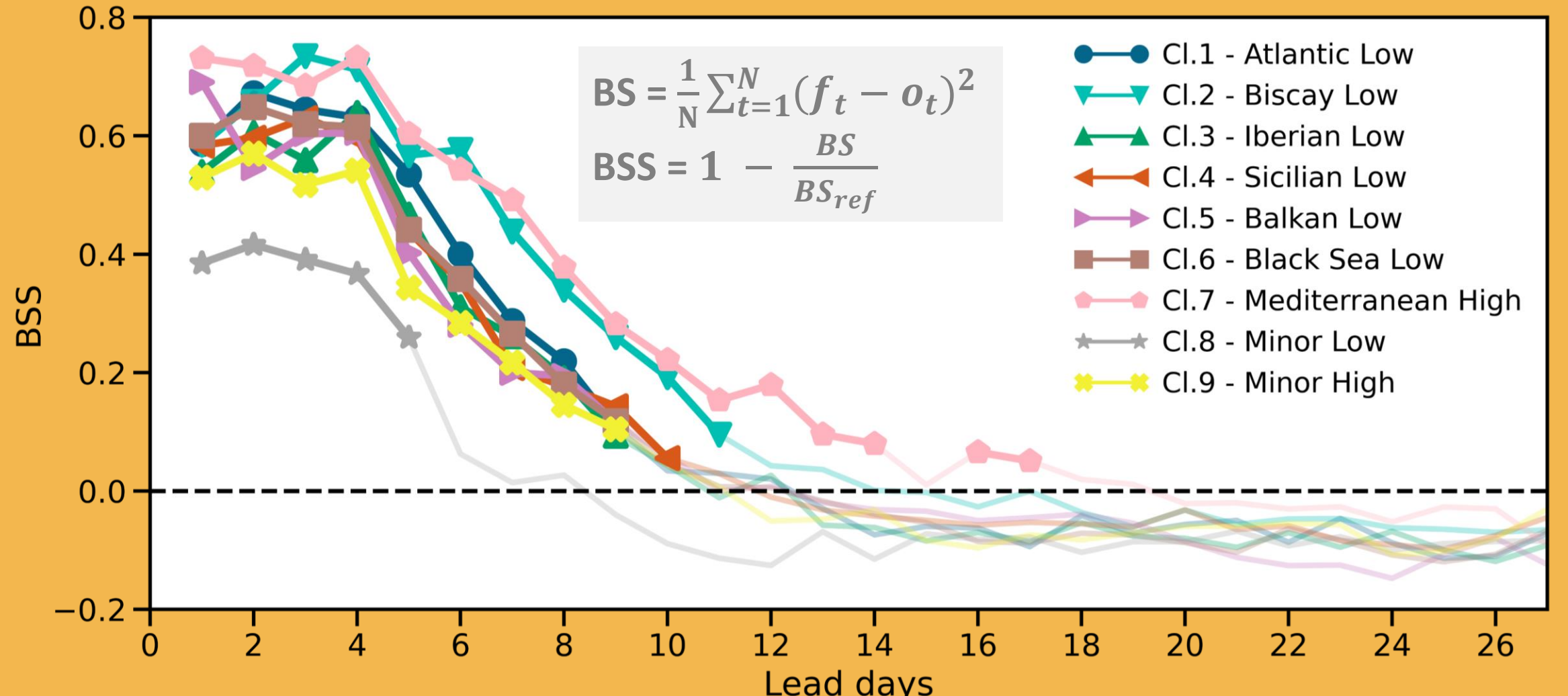$$BSS = 1 - \frac{BS}{BS_{ref}}$$

Fig. 4: Brier Skill Score of the Mediterranean patterns. Results refer to winter-half, points and thick lines show statistically significant outperformance of reference score (90% one-tailed confidence interval of 1,000 bootstraps).
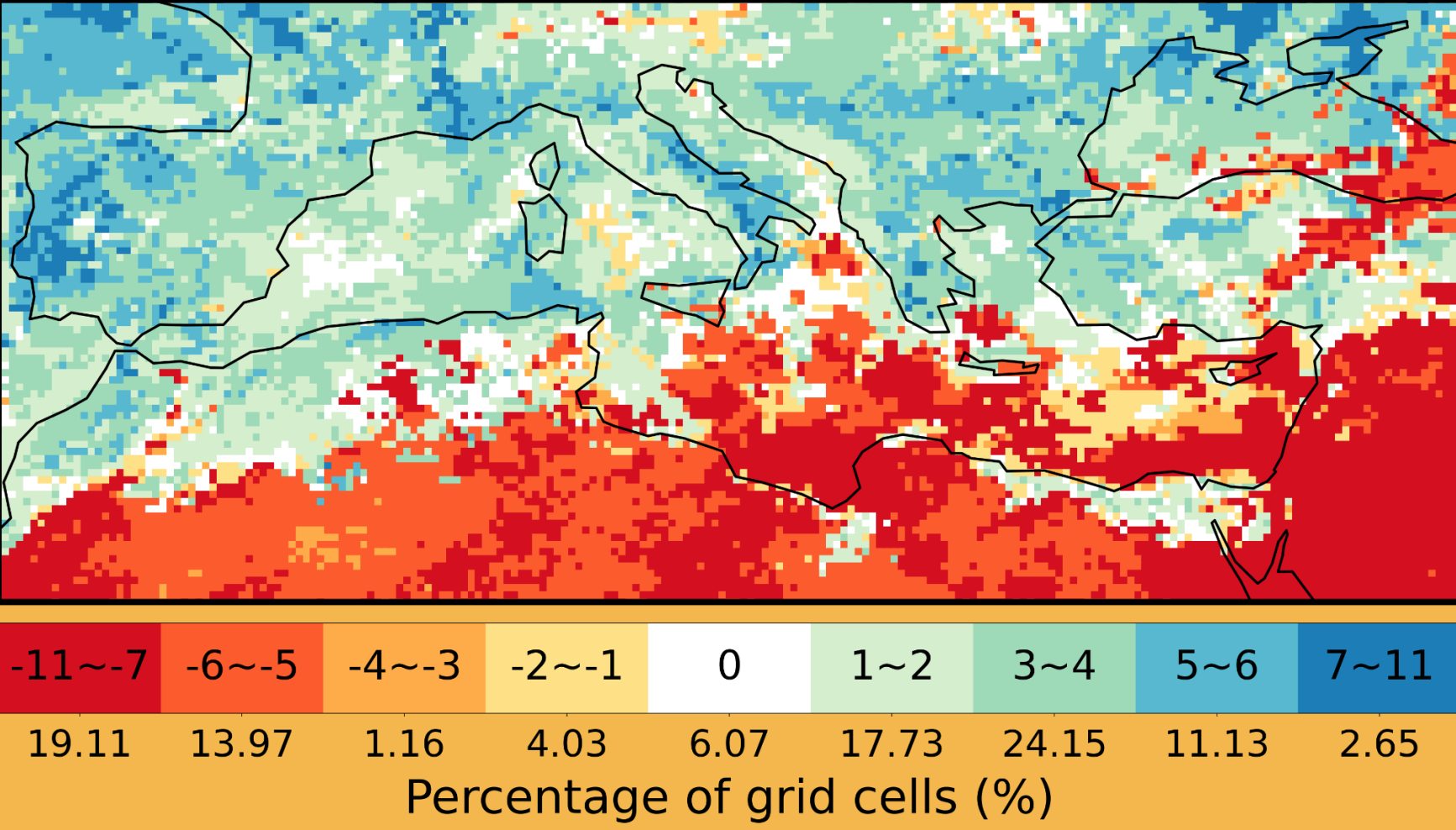

Fig. 5: Difference of the forecasting horizon (in lead days) for EPEs prediction from the two analysed methods (indirect – direct method).

-11~-7	-6~-5	-4~-3	-2~-1	0	1~2	3~4	5~6	7~11
19.11	13.97	1.16	4.03	6.07	17.73	24.15	11.13	2.65

Percentage of grid cells (%)