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Analysis of synoptic conditions leading to positive and negative sea level extremes along the coast of the Mediterranean Sea

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Negative storm surges in history ….

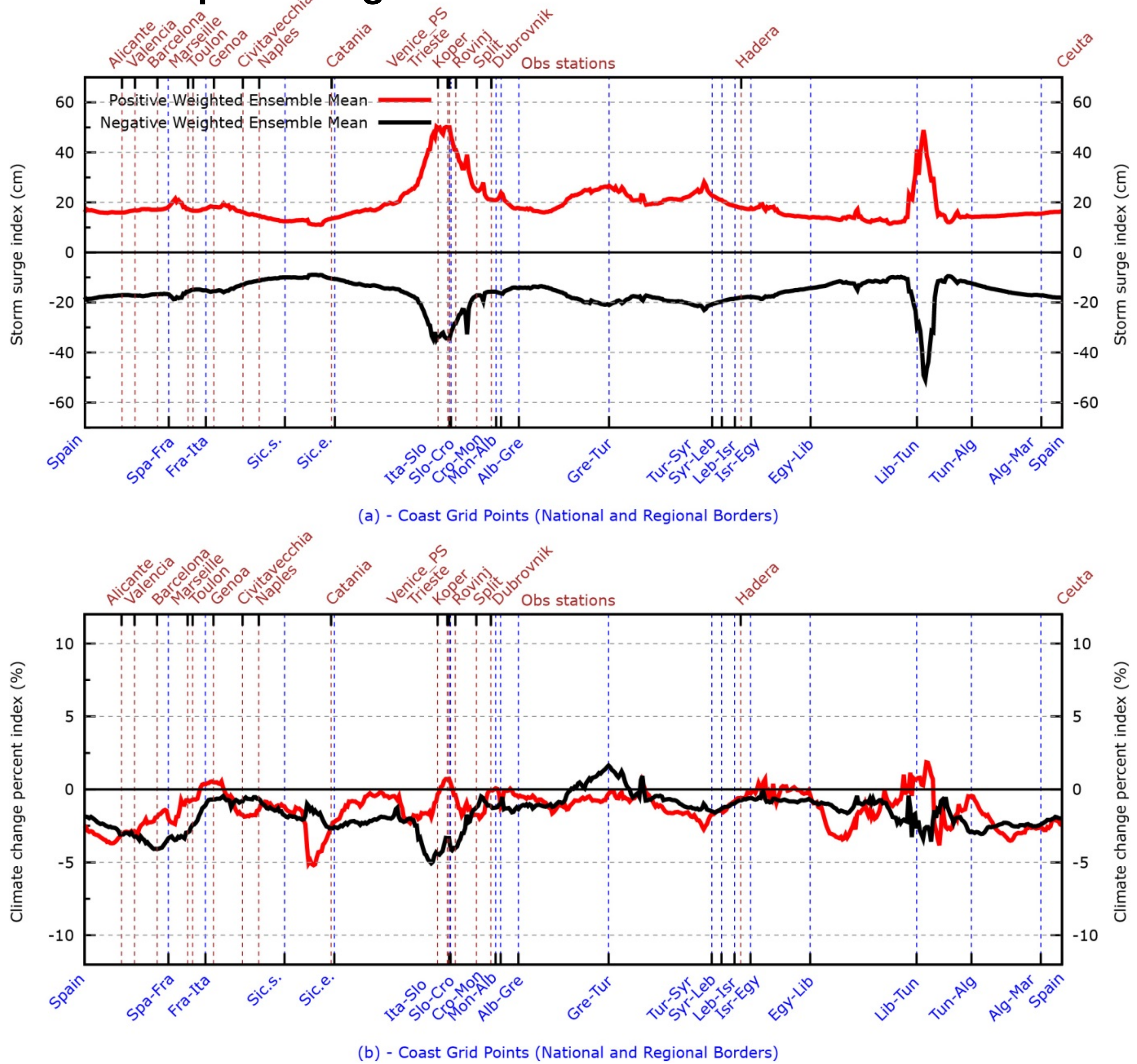
Then Moses stretched out his hand over the sea; and the Lord drove the sea back by a strong east wind all night, and made the sea dry land, and the waters were divided. And the people of Israel went into the midst of the sea on dry ground, the waters being a wall to them on their right hand and on their left. [.. .. ..] So Moses stretched forth his hand over the sea, and the sea returned to its wonted flow when the morning appeared.[.. .. ..] The waters returned and covered the chariots and the horsemen and all the host of Pharaoh that had followed them into the sea; not so much as one of them remained.

… Why authors got to look at this ….

Conte, D., and P. Lionello. "Characteristics of large positive and negative surges in the Mediterranean Sea and their attenuation in future climate scenarios." *Global and Planetary Change* 111 (2013): 159-173.

Authors analyzed large positive and negative storm surges along the Mediterranean coast in a 7-member climate model ensemble covering the period 1951–2050 under the A1B emission scenario. A hydro-dynamical shallow water model (HYPSE, Hydrostatic Padua Sea Elevation model) was driven by 6-hourly meteorological fields produced by the state-of-the-art global and regional climate models that have been used in the CIRCE fp6 project (Climate Change and Impact Research: the Mediterranean Environment). […] ***the model ensemble mean shows a modest (about -5%), but clear and widespread, decrease of the amplitude of both positive and negative large storm surges along the coast of the Mediterranean Sea.***

Ensemble mean storm surge index (cm) for positive (red line, cm) and negative (black line, cm) surges in the present climate in model simulations (top panel). Climate change percent index (%) for positive (red line) and negative (black line) surges. Coastal points are ordered clockwise starting from Gibraltar. Country national borders and some stations used are marked to help locating the different stretches of the Mediterranean coastline



The inverse barometer effect

negative surges

high pressure system, anti-cyclone

↓

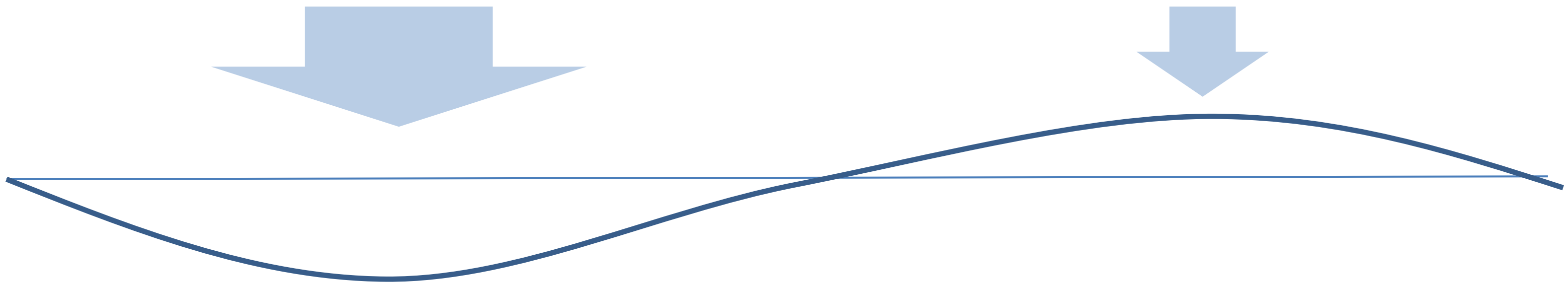
negative sea level anomaly

positive surges

low pressure system, cyclone

↓

positive sea level anomaly

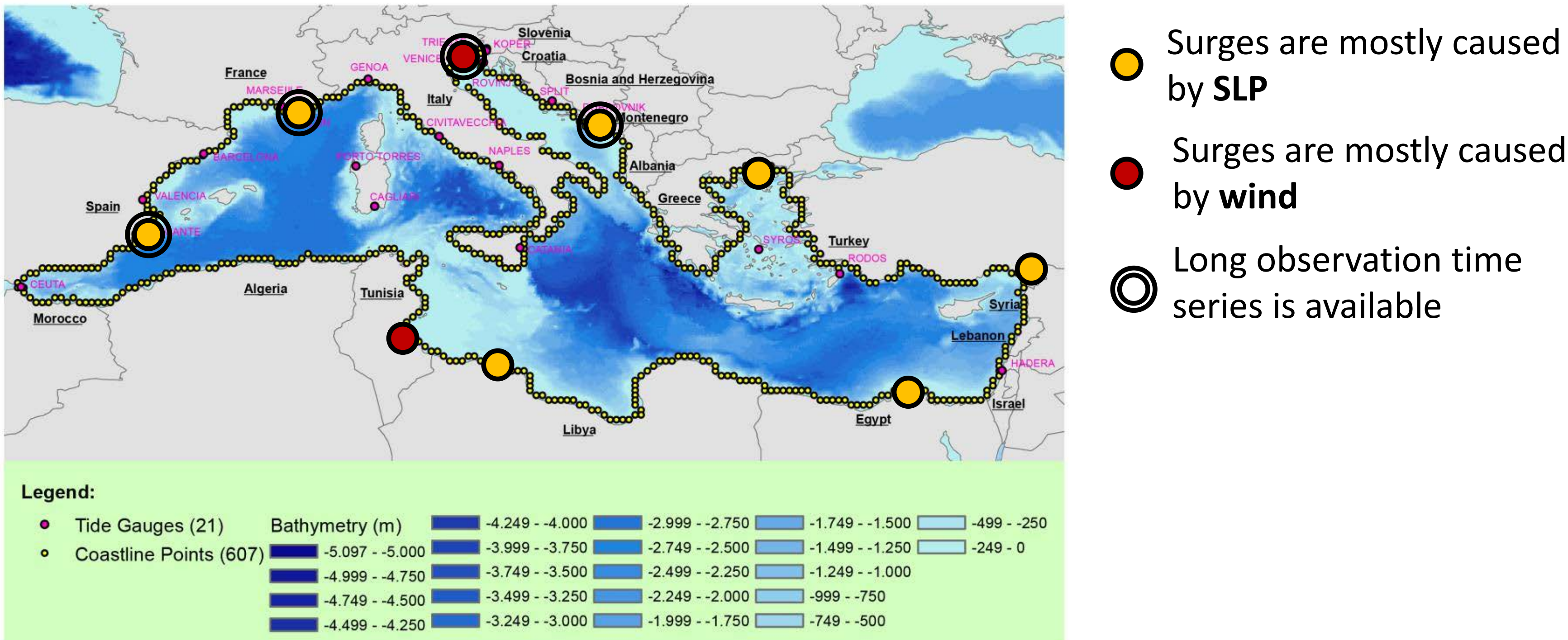


…. It is about 1cm per hPa

Questions:

As future projections show similar trends for both positive and negative surges, what have those two opposite phenomena in common?

Large positive surges are well known to be caused by intense cyclones. Are also negative surges caused by cyclones?

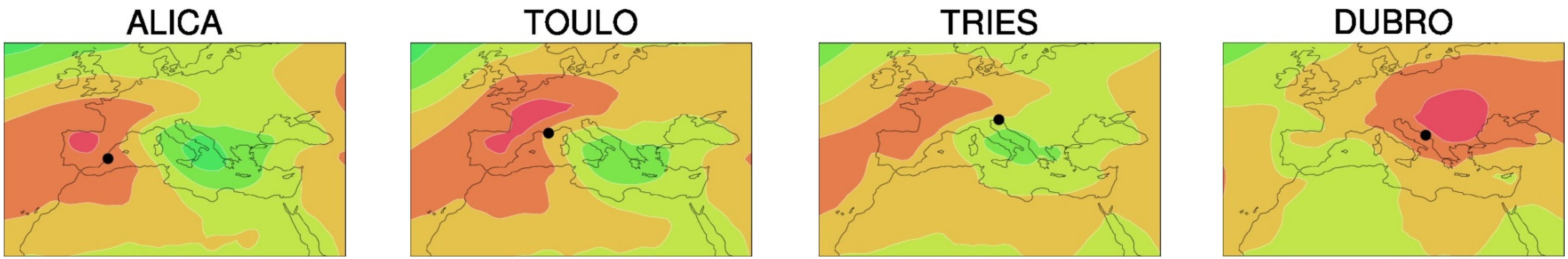


This analysis is based on SL simulations carried out with a two-dimensional model based on depth averaged currents (HYPSE), implemented on grid covering the whole Mediterranean sea with a 0.2 degs Lat-Lon regular mesh. HYPSE is forced by SLP and surface winds hourly fields, which are provided by the European project HIPOCAS (Sotillo et al., 2005, Ratsimandresy, 2008a et al, 2008), for the period 1958-2001 on a 0.5 x 0.5 degree grid. 9 stations have been selected and 88 events have been considered for each of them

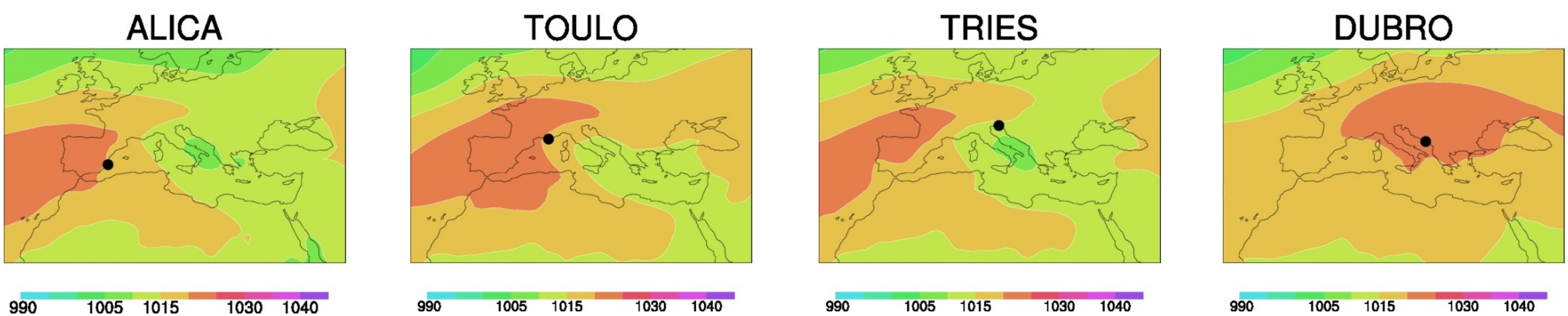
Is the analysis of the model simulations leading to the correct synoptic conditions?

NEGATIVE SURGES

Composites based on 88 largest **simulated** surges



Composites based on 88 largest **observed** surges



Synoptic conditions leading to positive and negative surges

POSITIVE SURGES

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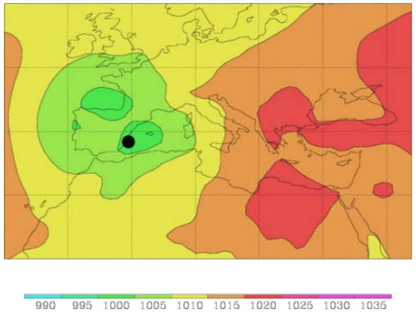
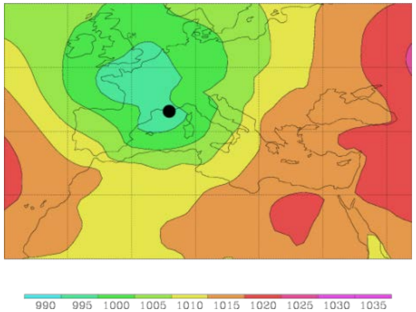


TOULON



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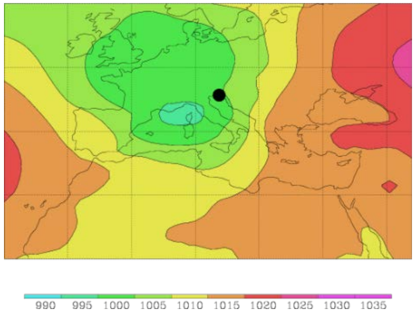

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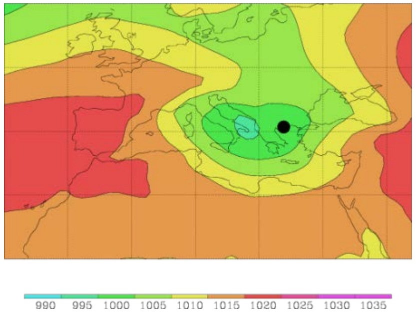
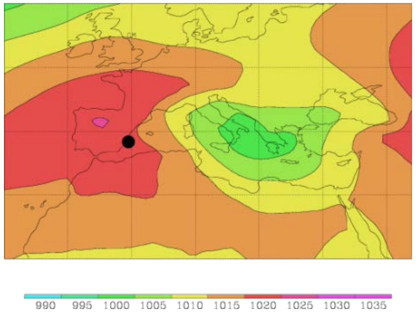


NEGATIVE SURGES

ALICANTE



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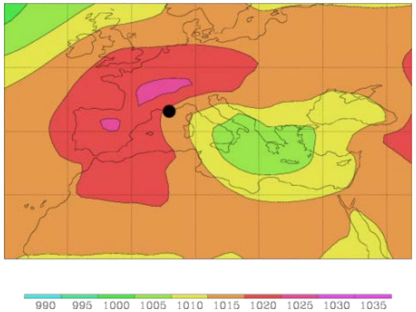

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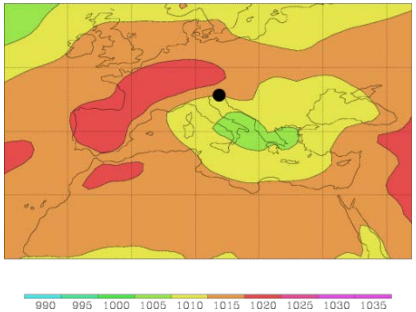

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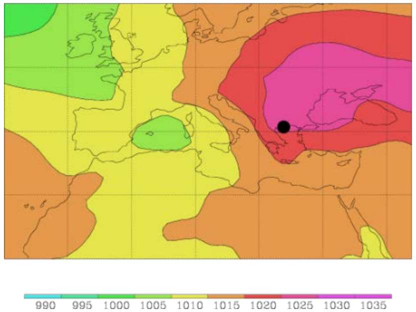
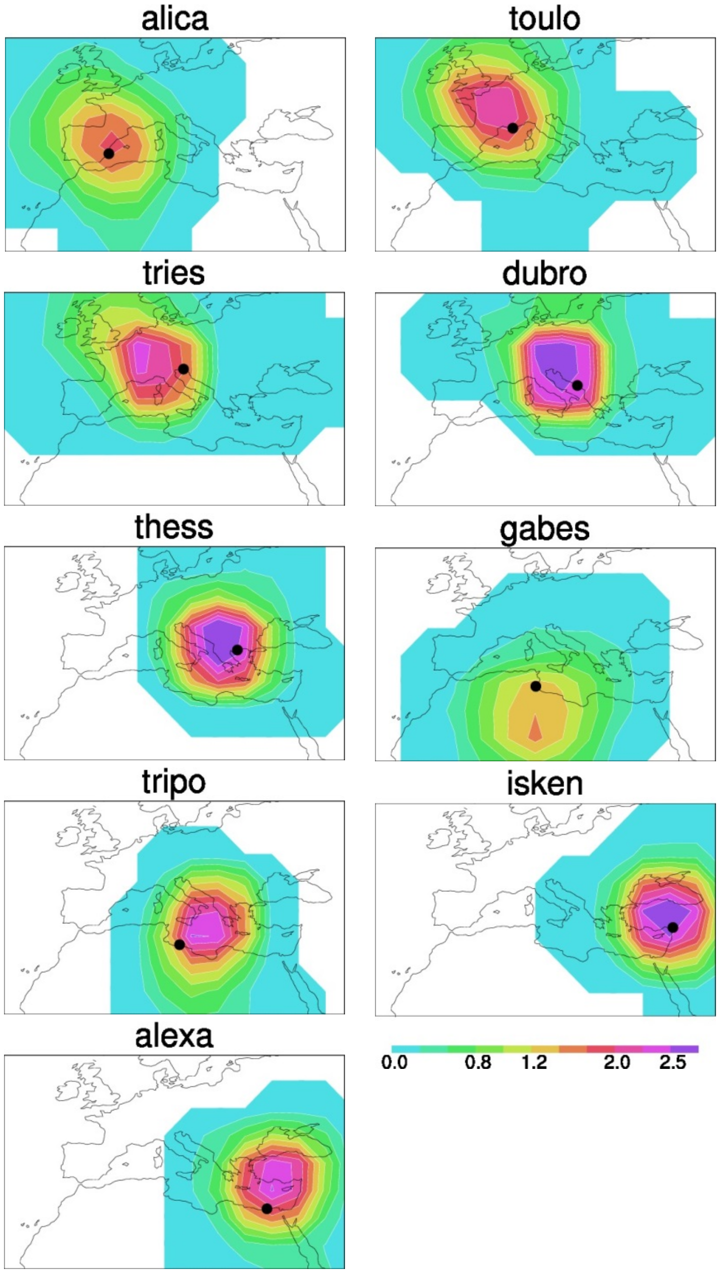
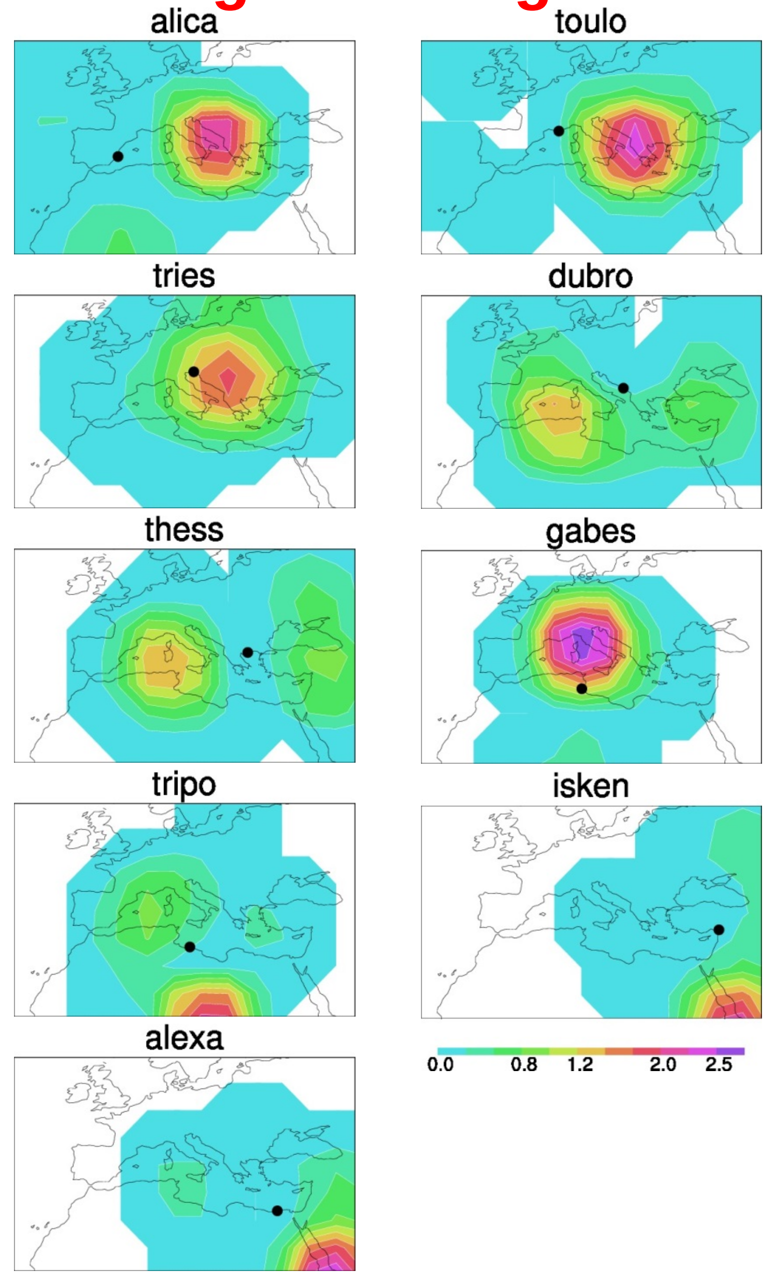


Density of cyclones producing

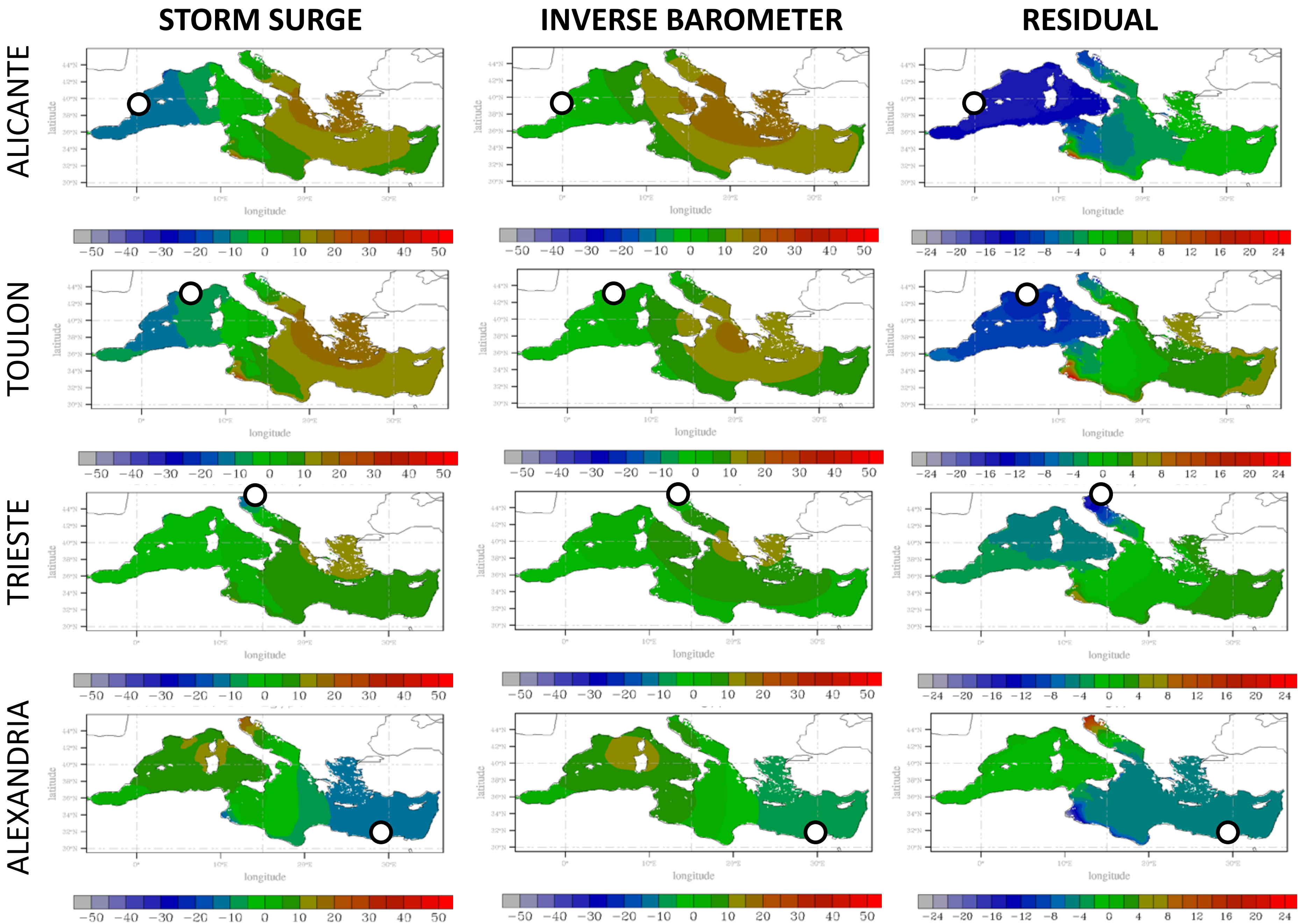
Positive surges



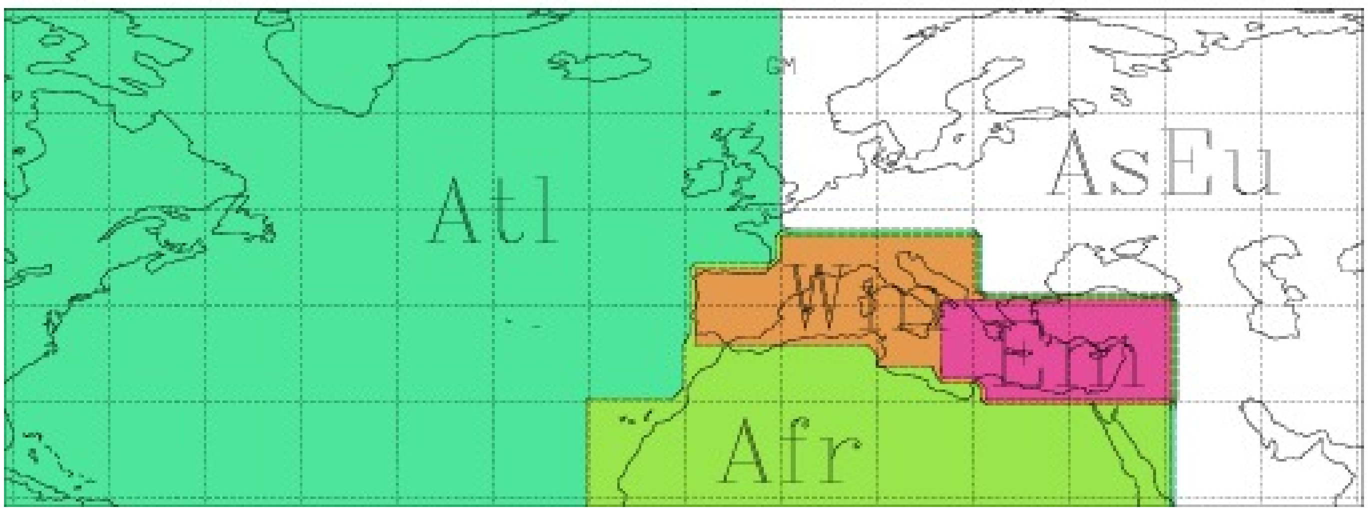
negative surges



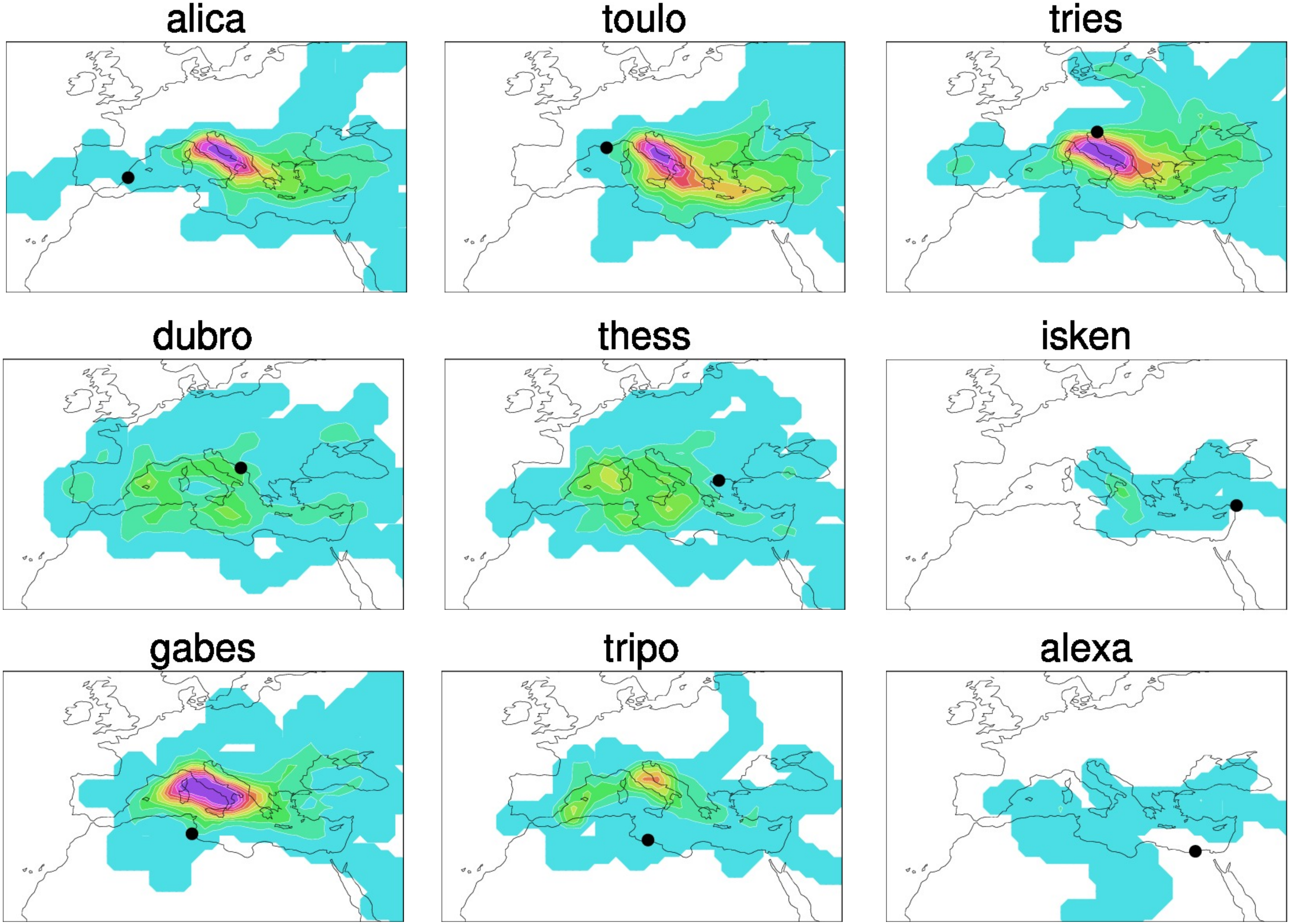
NEGATIVE STORM SURGES



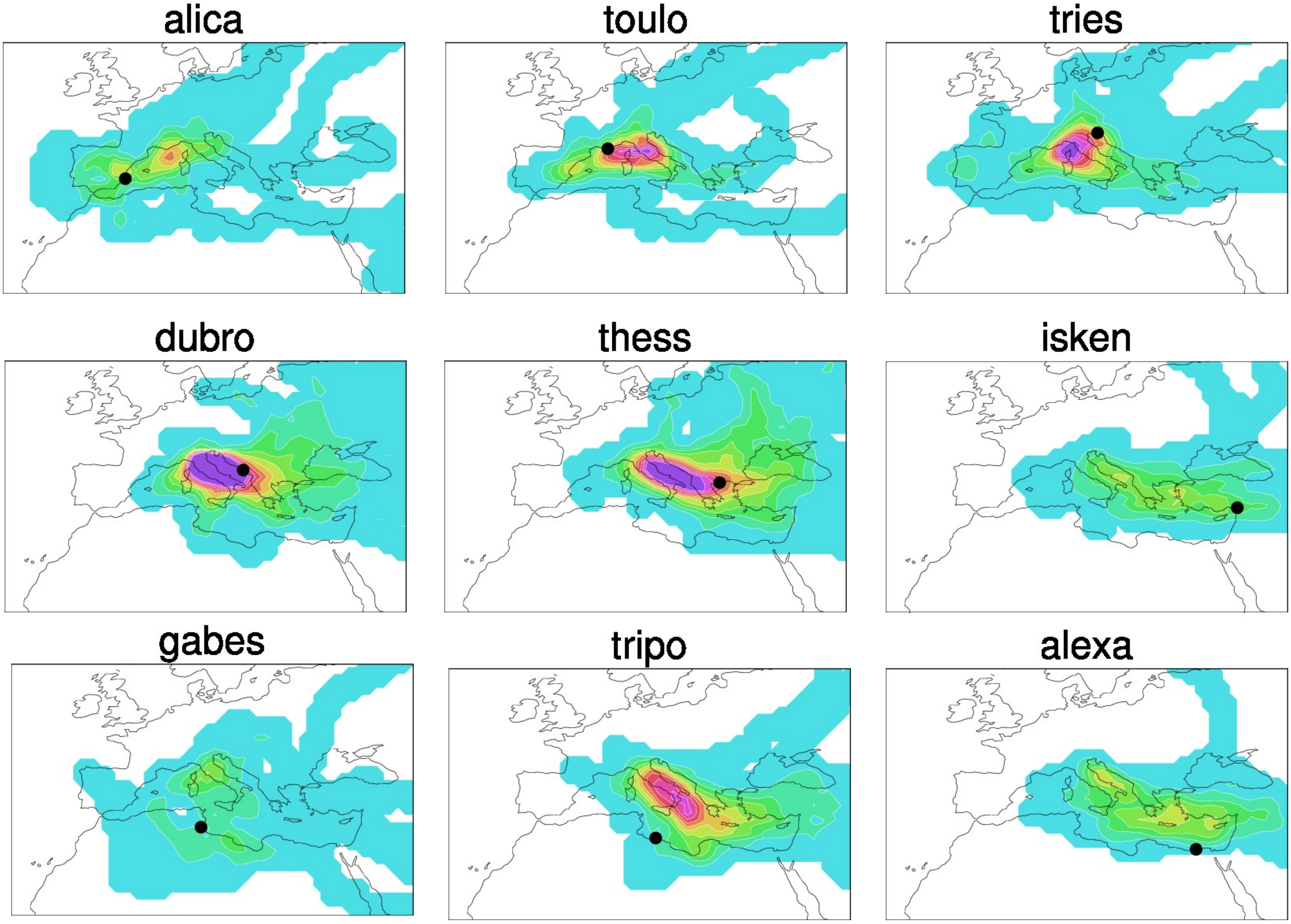
Classification of areas of cyclogenesis



negative surges: tracks for cyclogenesis inside the Western Mediterranean



positive surges: tracks for cyclogenesis inside the Western Mediterranean



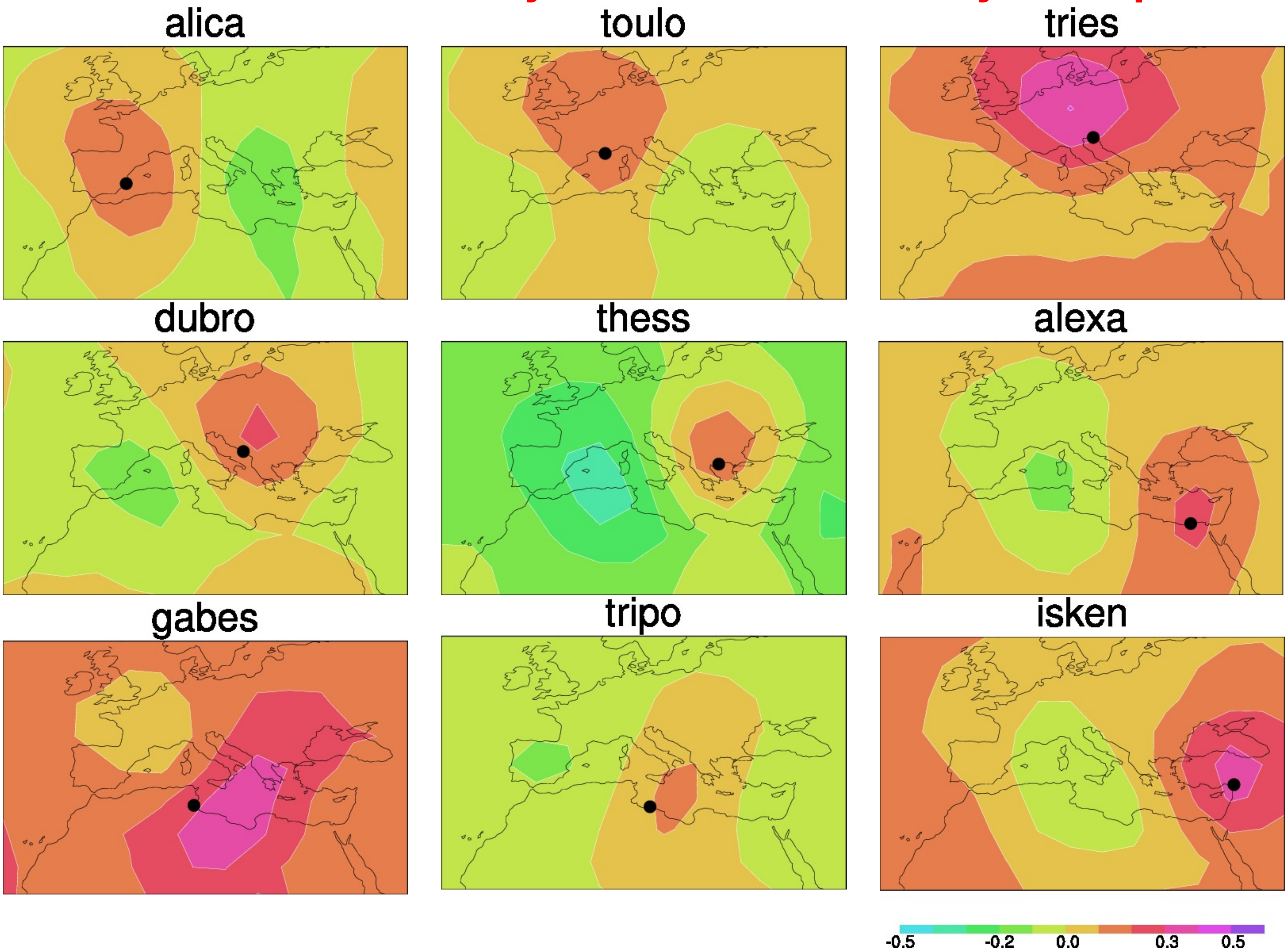
Location	Atl	Afr	WM	EM	Other
Alicante	47	22	18		
Toulon	66	6	18		2
Trieste	50	7	27	2	9
Dubrovnik	41	5	51	1	6
Thessaloniki	19	8	53	5	5
Iskenderun	8	13	25	40	10
Tripoli	14	28	38	6	
Gabes	8	47	15	3	1
Alexandria	15	23	28	25	5

Number of cyclogenesis causing positive surges

Number of cyclogenesis causing negative surges

Location	Atl	Afr	WM	EM	Other
Alicante	27	27	42	2	
Toulon	19	9	47	7	5
Trieste	22	3	39	4	11
Dubrovnik	13	26	20	10	5
Thessaloniki	6	51	25	15	8
Iskenderun		24	3	6	26
Tripoli	10	61	16	1	5
Gabes	17	24	48	2	2
Alexandria	2	52	6	6	13

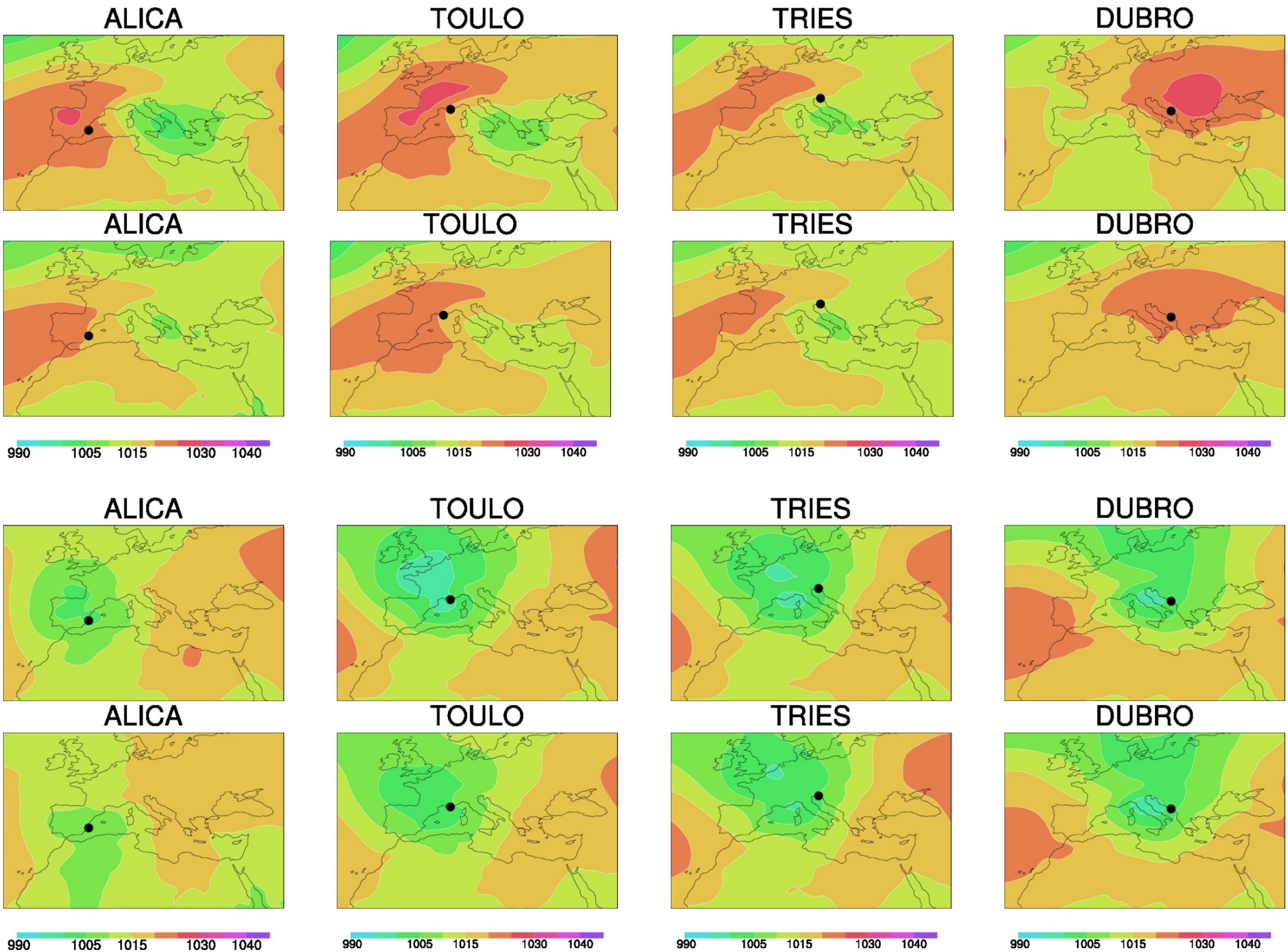
Mean sea level anomaly as function of the cyclone position



Conclusions

- When a cyclone crosses the Mediterranean, its impact on sea level consists of positive and negative anomalies in different part of the basin, depending on the position of the cyclone
- Western Mediterranean cyclogenesis causes positive surges in the south western Med and negative in the north western Med. Atlantic cyclones produce positive surges in the western Med
- To a substantial extend negative surges in the Mediterranean are caused by a redistribution of water within the basin.
- During negative surges the Mediterranean Sea behaves partially as a closed basin, as the water flow across Gibraltar is not sufficient to allow the sea level to adjust to the inverse barometer effect
- It is therefore plausible that in the Mediterranean Sea a future reduction of storminess will determine a reduction of both positive and negative large sea level anomalies

appendix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