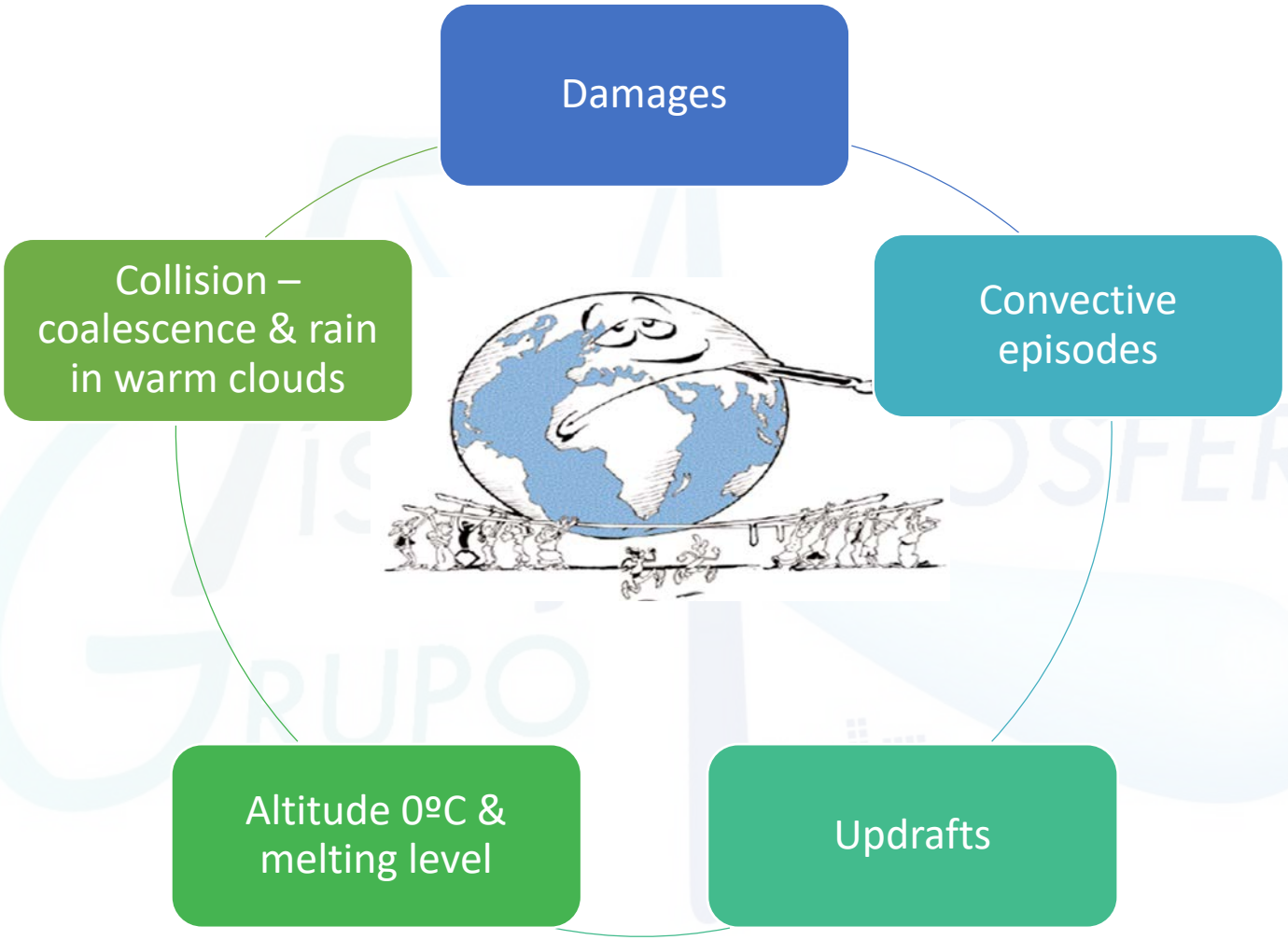
Are meteorological conditions that favor hail precipitation changing in Southern Europe? Analysis of the period 1948–2015

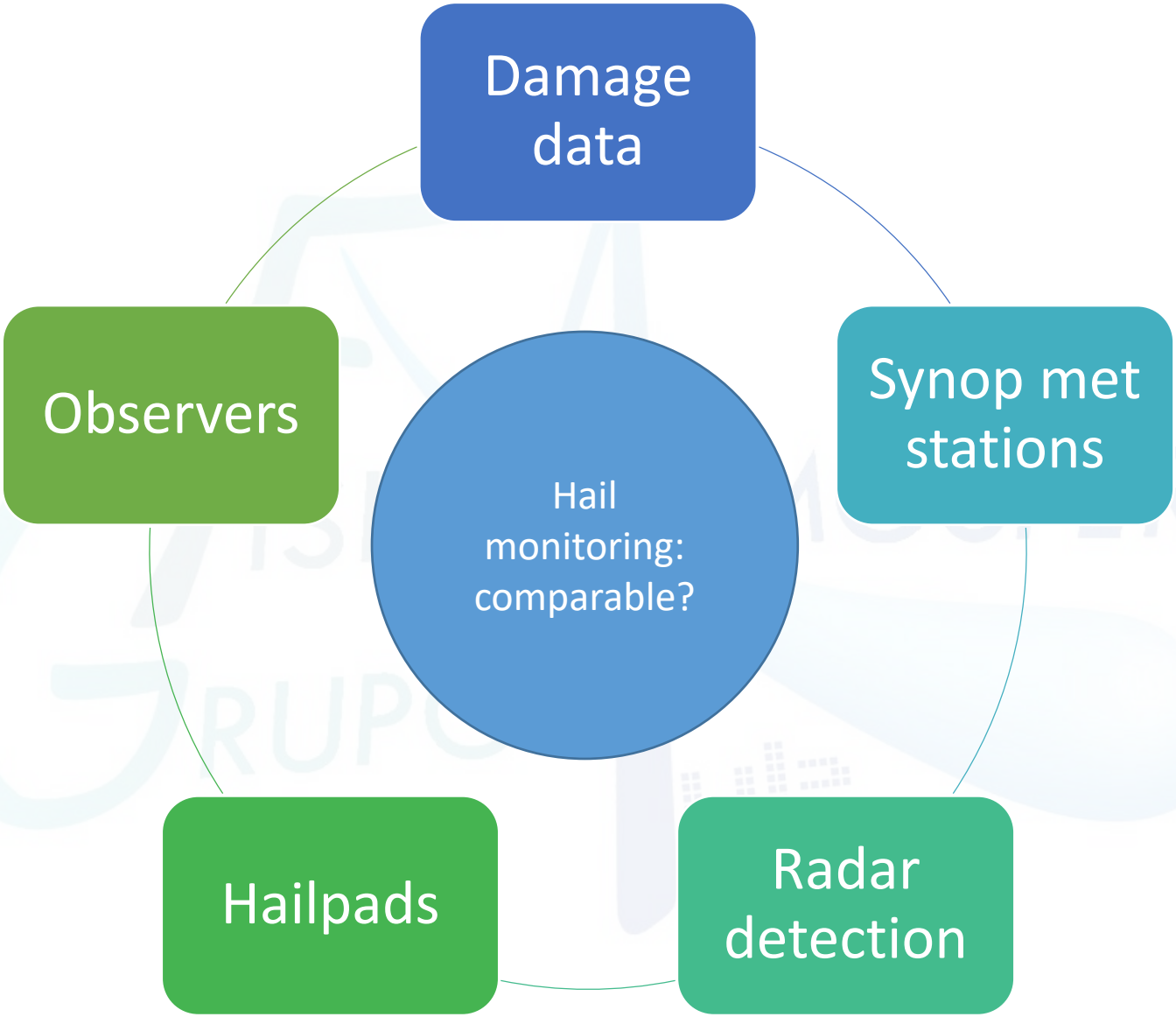
J. L. Sanchez [1] P. Melcon [1] A. Merino [1] J. L. Marcos [1] J. Dessens [2] C. Berthet [2]

1. University of Leon, Spain
2. ANELFA, France

2nd European Hail Workshop

- **IPCC: global temperatures may increase as much as 2 °C by 2050**




Damage data
Synop met stations
Radar detection
Hailpads
Observers
Hail monitoring: comparable?

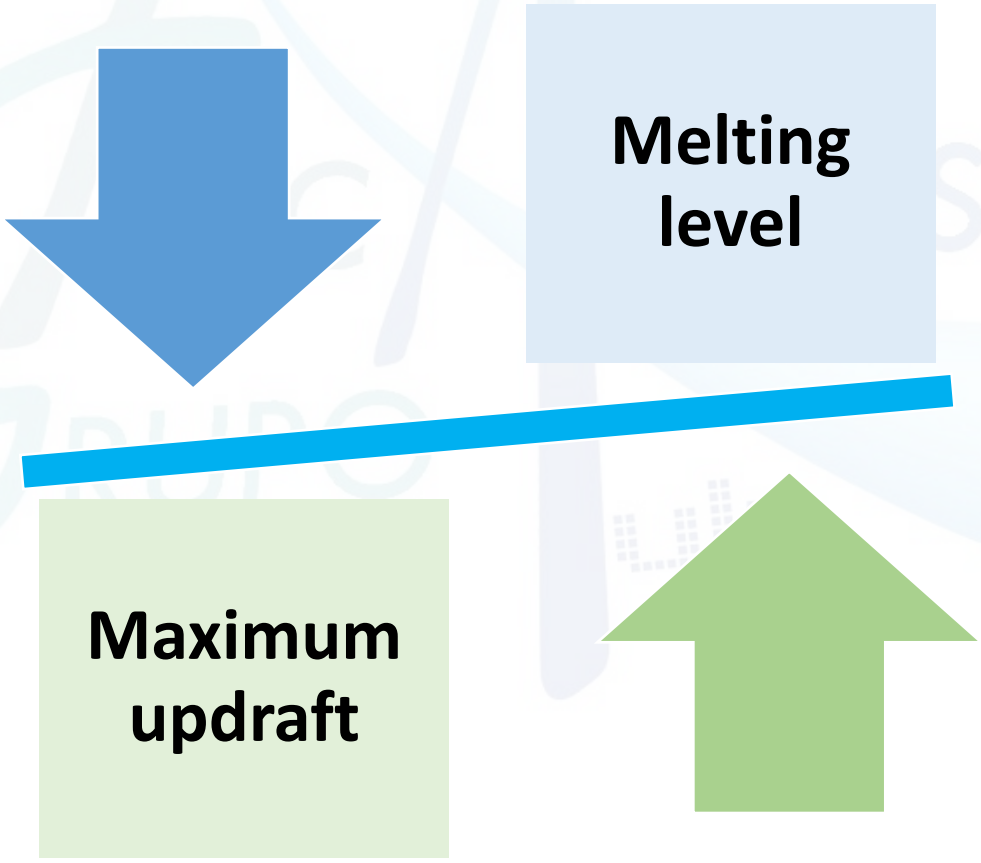
Positive trend:
Atmospheric stability: over **Central Europe**
An increase in the number of hail observed in **Germany**
Losses in crops in **Italy**
Increase in intensity **Croatia**
More extreme events in **Italy** (hailpads)
Hail records in **Romania**

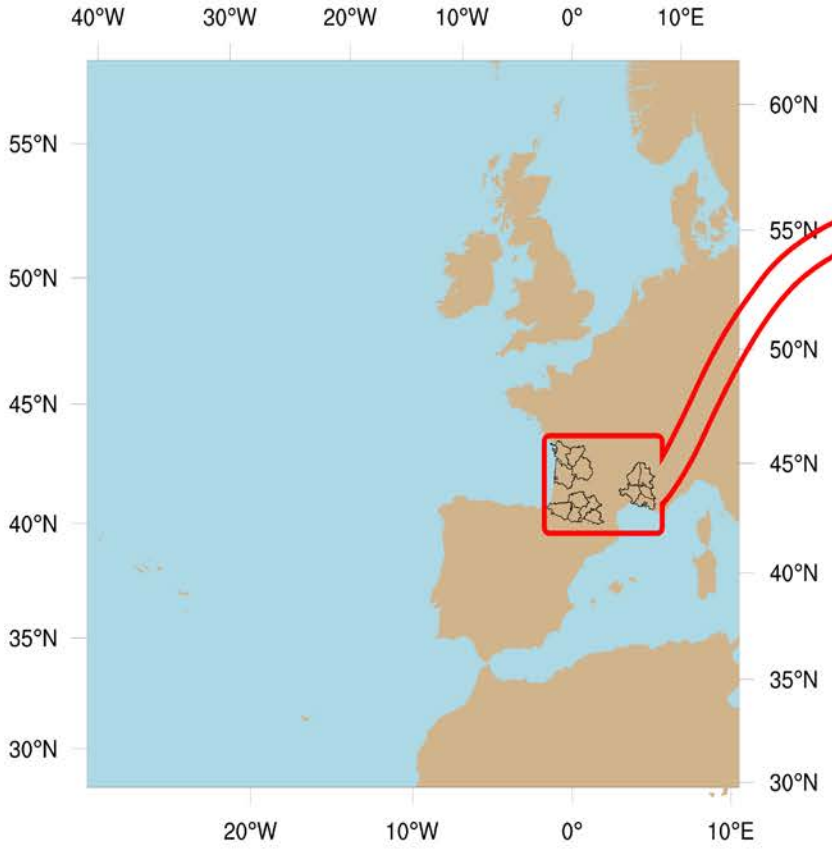
Negative trend:
Hail frequency in Serbia

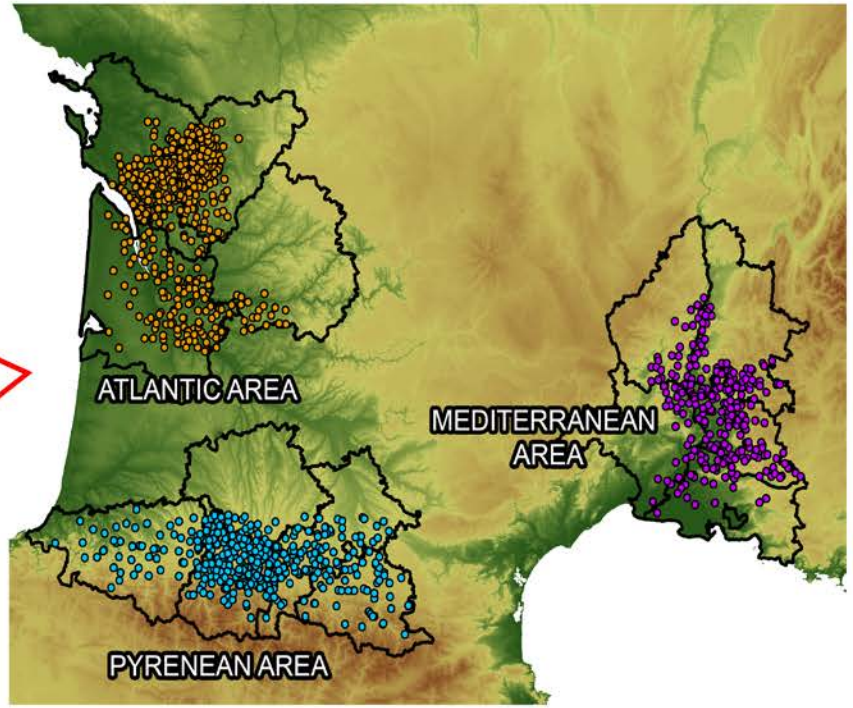
France: (hailpads)
Hail frequency: some areas positive trends
Melting level: increasing
Changes in hailstone size distribution with an increase in the melting level height

Spain: **(hailpads)**
Hail frequency has increased dramatically

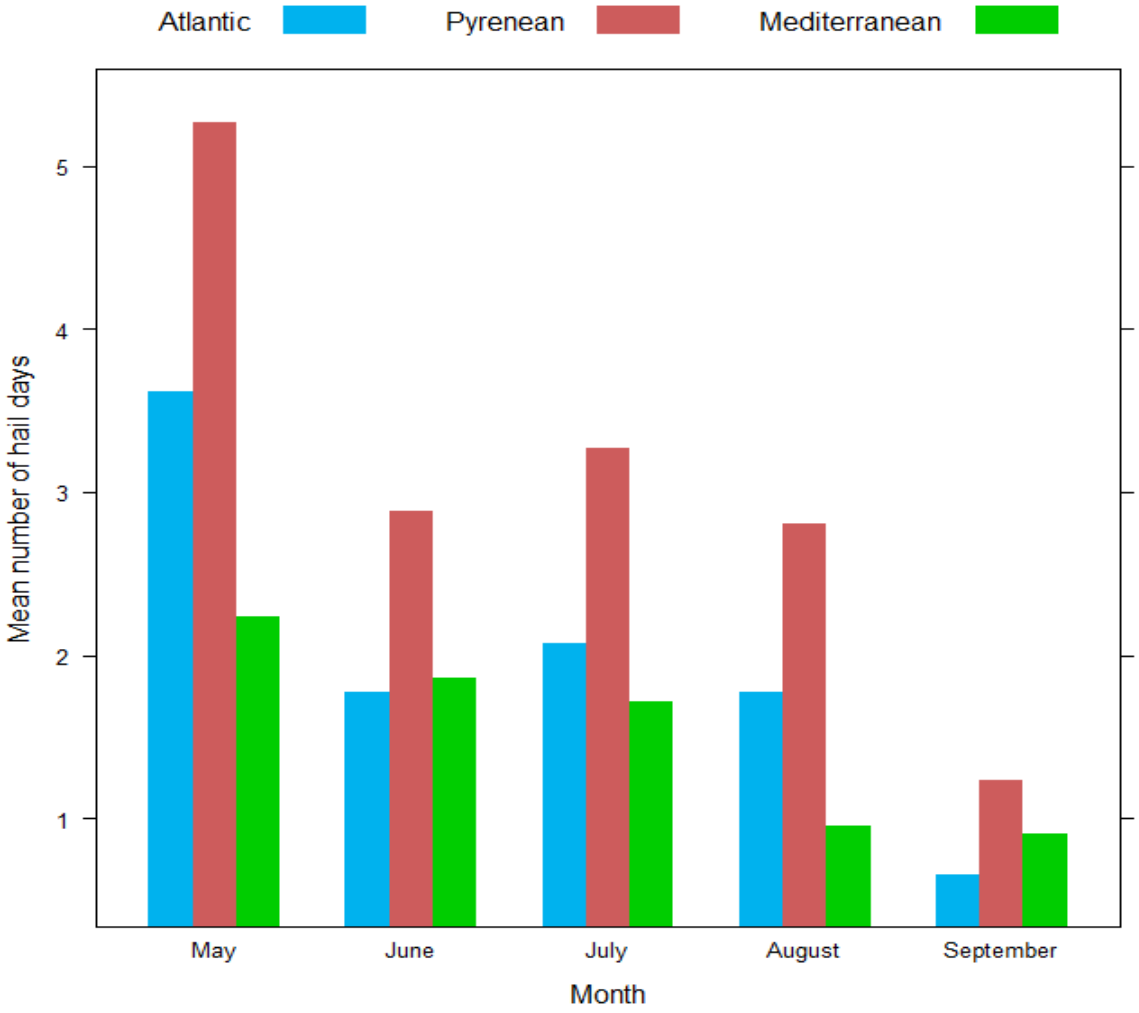
PROJECTIONS to 2040
Increase of 500 m
Significant increase of kinetic energy (40%),
No significant change in hail frequency




40°W
30°W
20°W
10°W
0°
10°E
60°N
55°N
50°N
45°N
40°N
35°N
30°N


ATLANTIC AREA
MEDITERRANEAN AREA
PYRENEAN AREA

	Atlantic area		Pyrenees area		Mediterranean area*	
	Z	p-value	Z	p-value	Z	p-value
Hail days (1989-2014)	-0.11	0.91	**2.08**	**0.04**	-0.18	0.86
Hail days (1989-2010)*	-0.66	0.51	1.93	0.05	–	–



*1994 - 2014

SYNOPTIC PATTERNS

HAILSTORM OCURRENCE: previous works

CONVECTIVE DEVELOPMENT

Synoptic/mesoscale

Patterns/factors

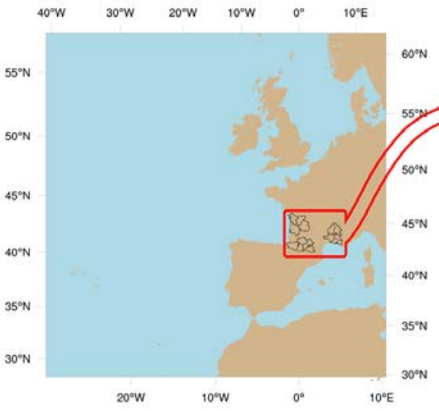
Clusters

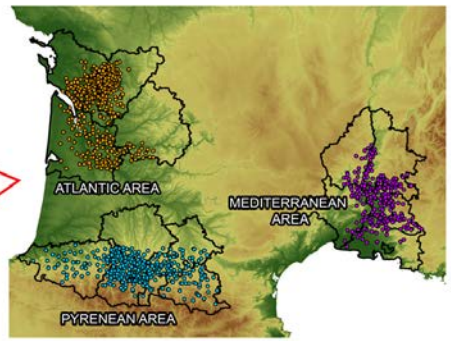
Stability indexes:

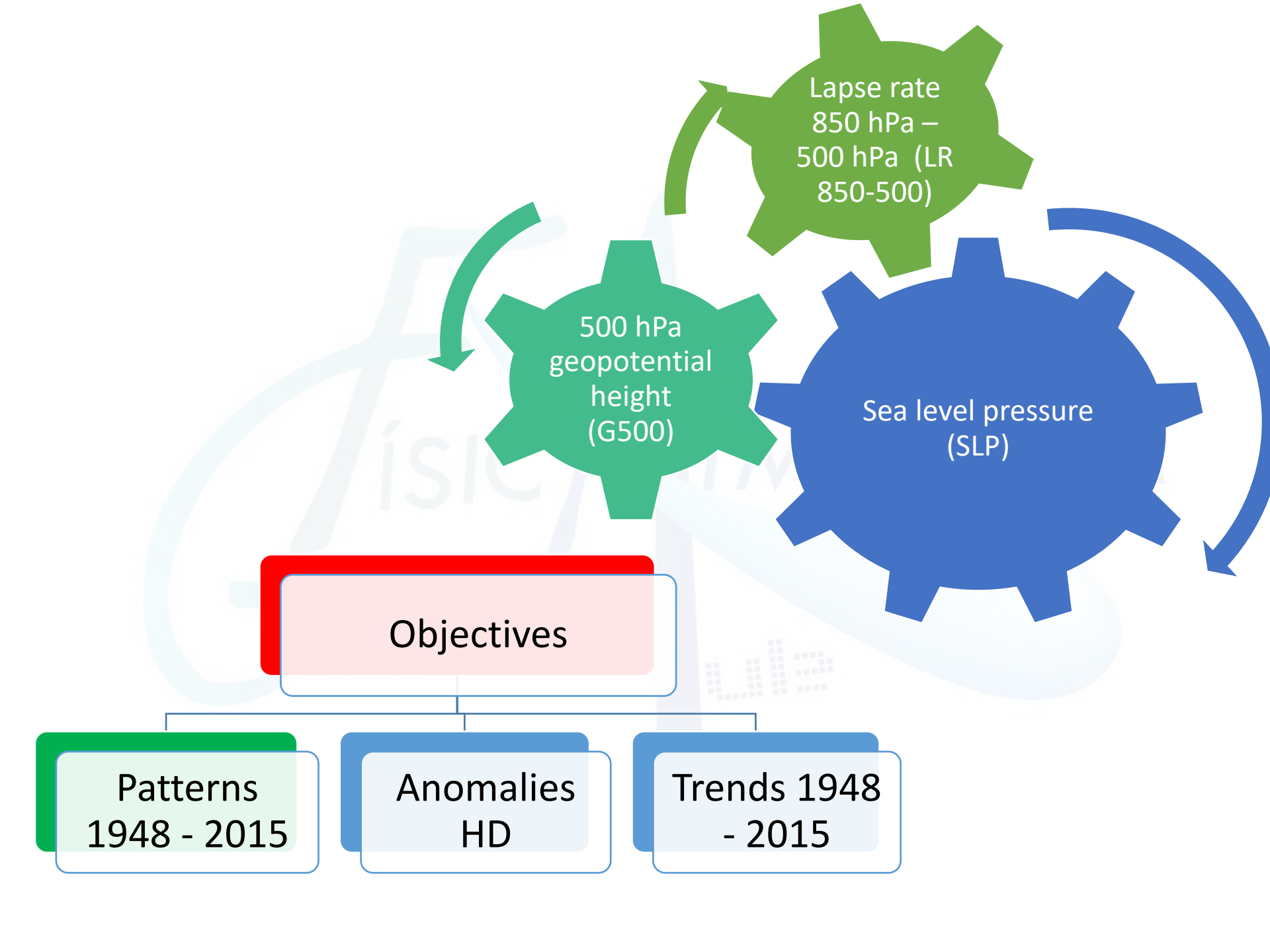
Numerical Simulations

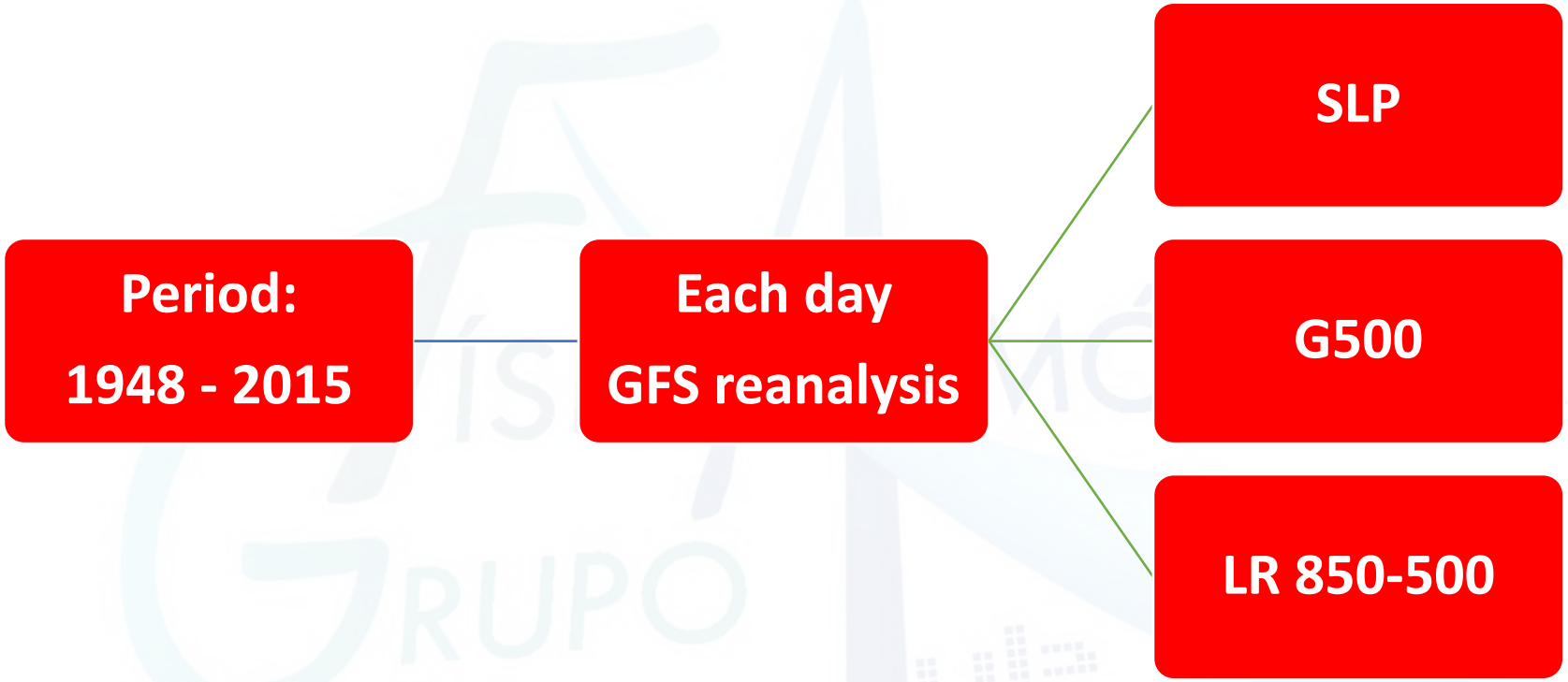
Spatial distribution

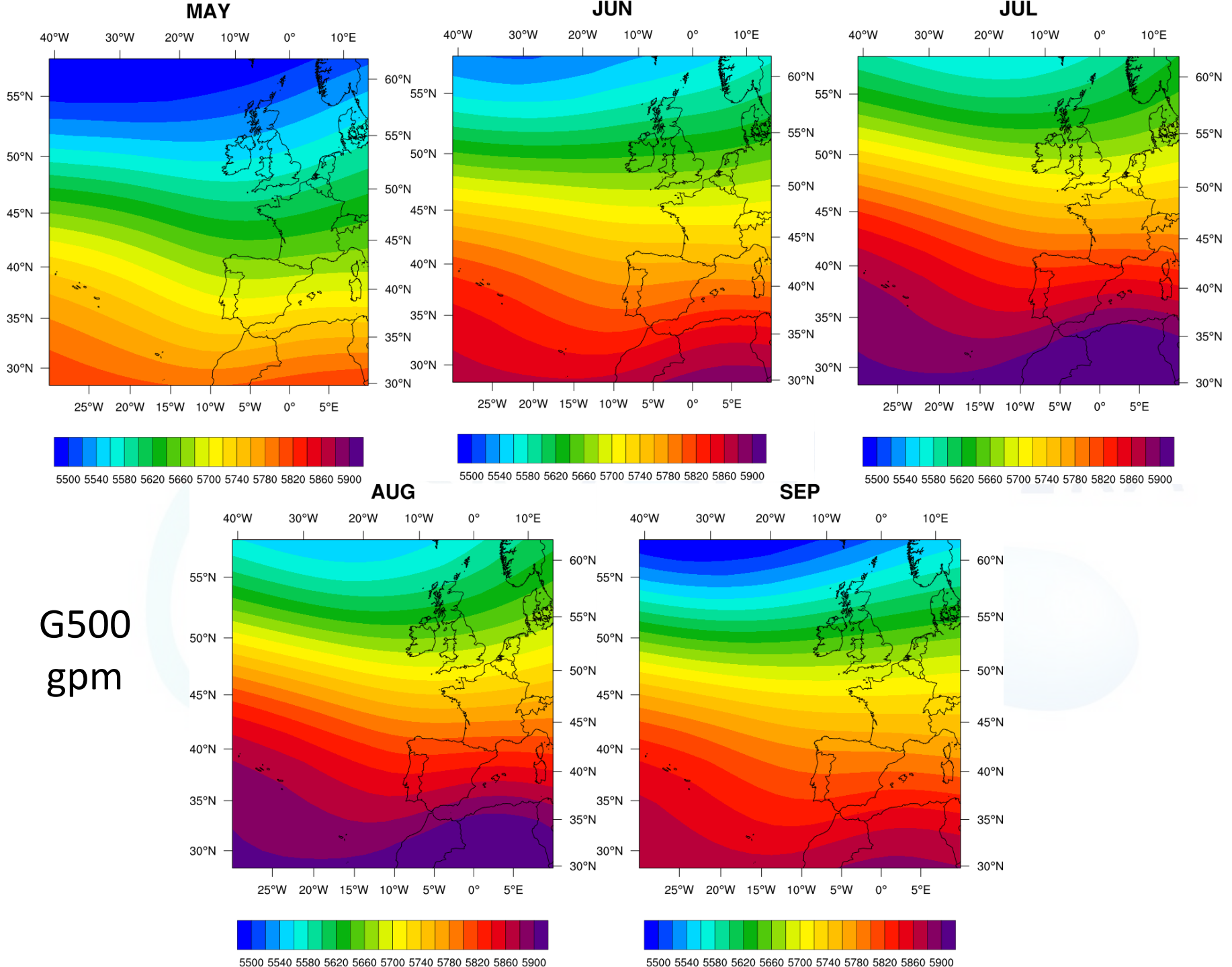
Clusters



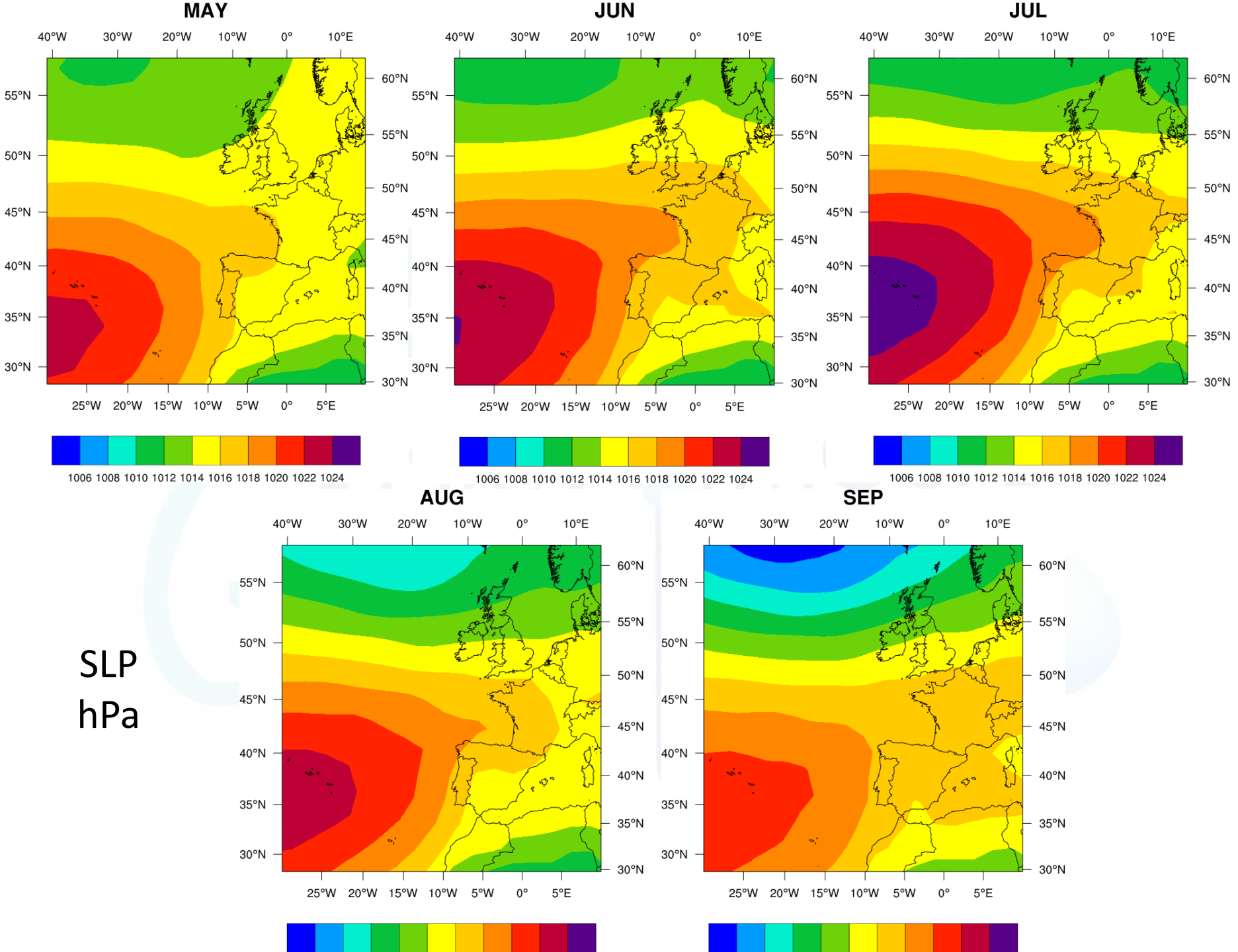



Lapse rate 850 hPa – 500 hPa (LR 850-500)
500 hPa geopotential height (G500)
Sea level pressure (SLP)
Objectives
Patterns 1948 - 2015
Anomalies HD
Trends 1948 - 2015

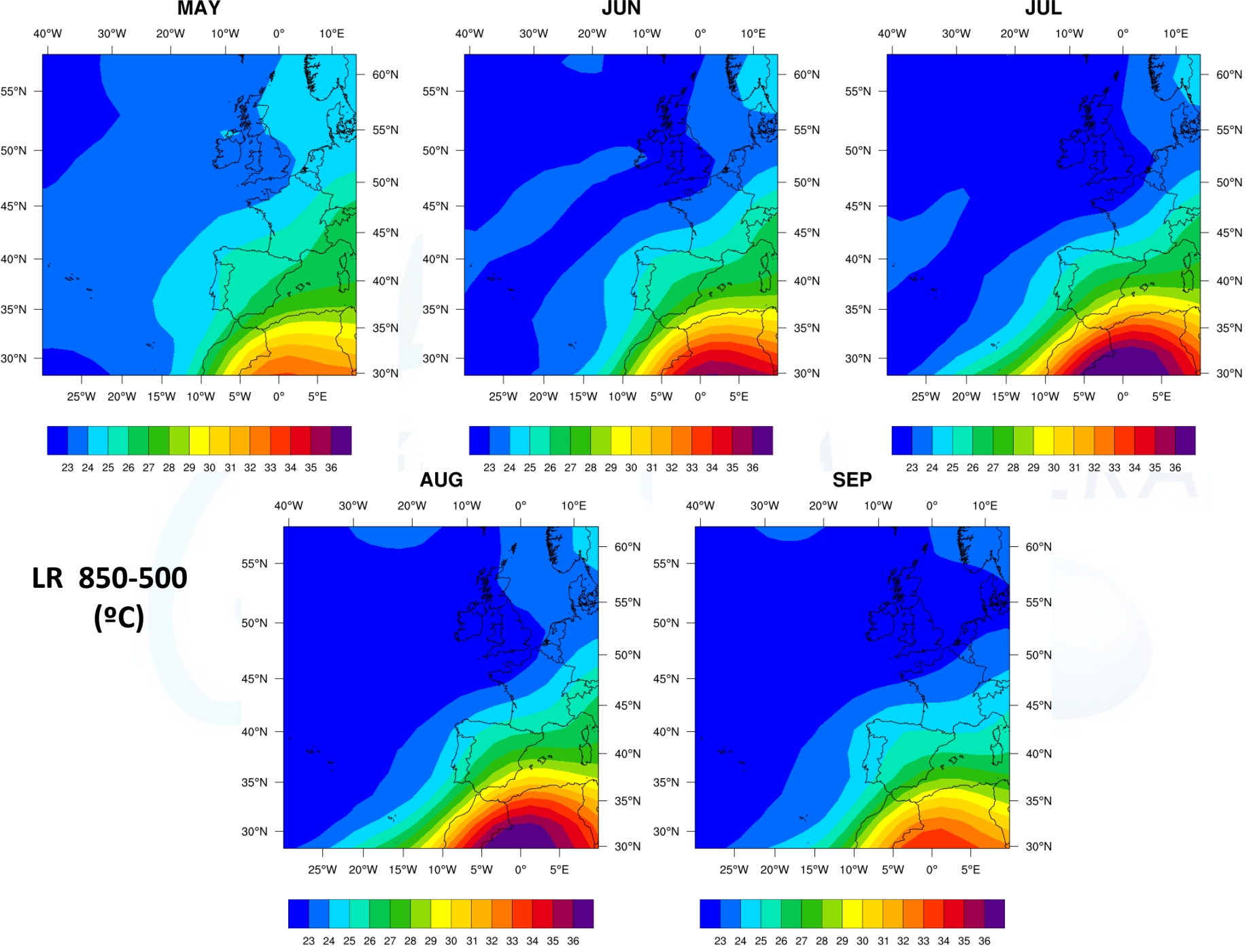

Period:
1948 - 2015
Each day
GFS reanalysis
SLP
G500
LR 850-500

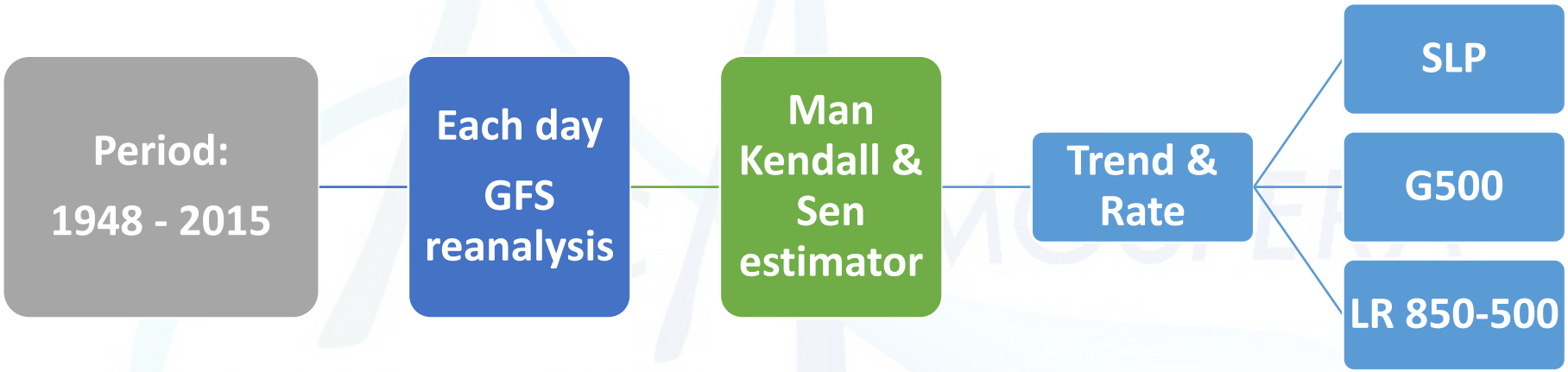

MAY
JUN
JUL
AUG
SEP
40°W 30°W 20°W 10°W 0° 10°E
60°N 55°N 50°N 45°N 40°N 35°N 30°N
25°W 20°W 15°W 10°W 5°W 0° 5°E
5500 5540 5580 5620 5660 5700 5740 5780 5820 5860 5900

G500
gpm


MAY
JUN
JUL
AUG
SEP
40°W 30°W 20°W 10°W 0° 10°E
60°N 55°N 50°N 45°N 40°N 35°N 30°N
25°W 20°W 15°W 10°W 5°W 0° 5°E
1006 1008 1010 1012 1014 1016 1018 1020 1022 1024
SLP
hPa

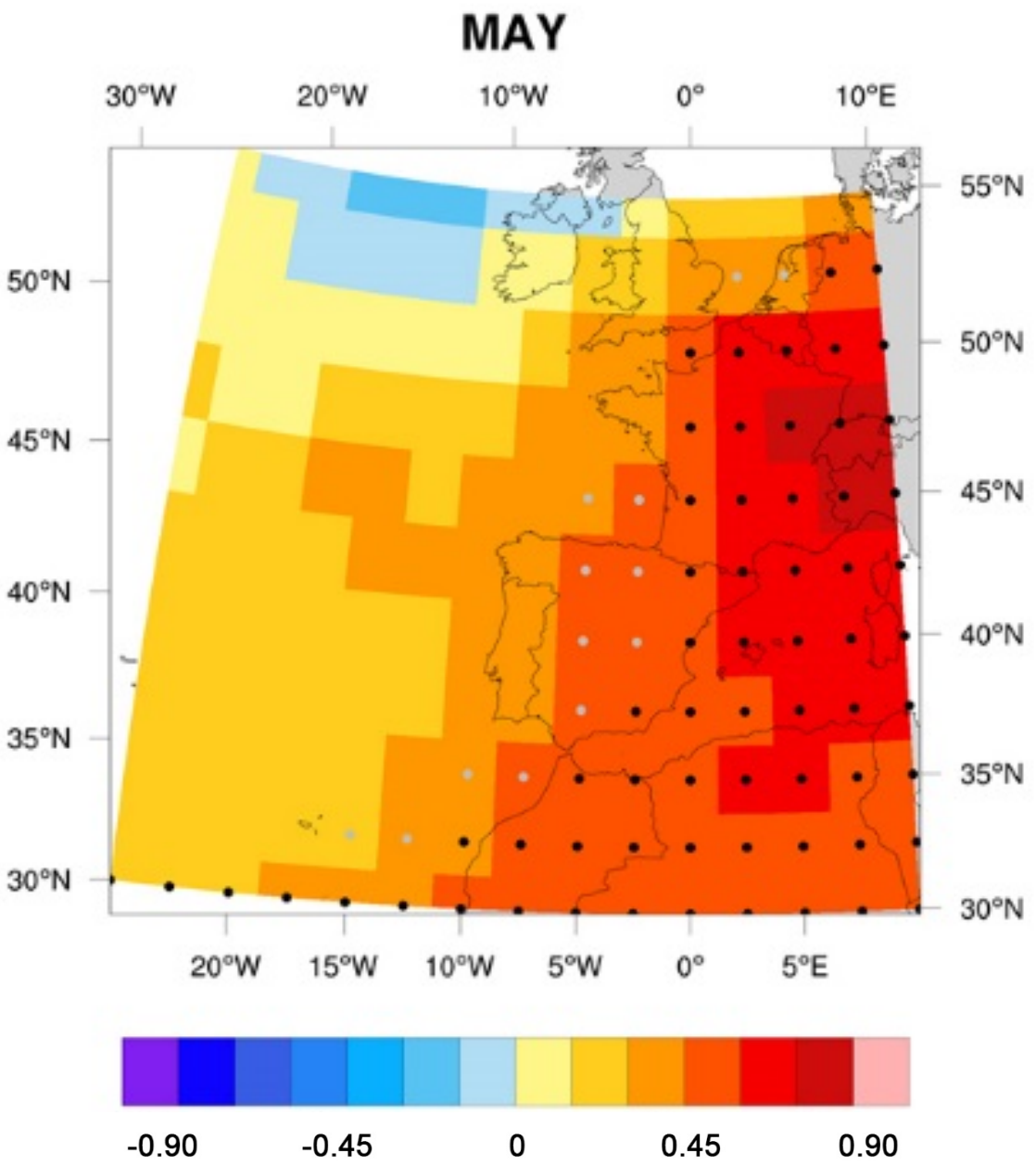
LR 850-500 (ºC)


MAY
JUN
JUL
AUG
SEP
40°W 30°W 20°W 10°W 0° 10°E
60°N 55°N 50°N 45°N 40°N 35°N 30°N
25°W 20°W 15°W 10°W 5°W 0° 5°E
23 24 25 26 27 28 29 30 31 32 33 34 35 36


Period:
1948 - 2015
Each day
GFS
reanalysis
Man
Kendall &
Sen
estimator
Trend &
Rate
SLP
G500
LR 850-500

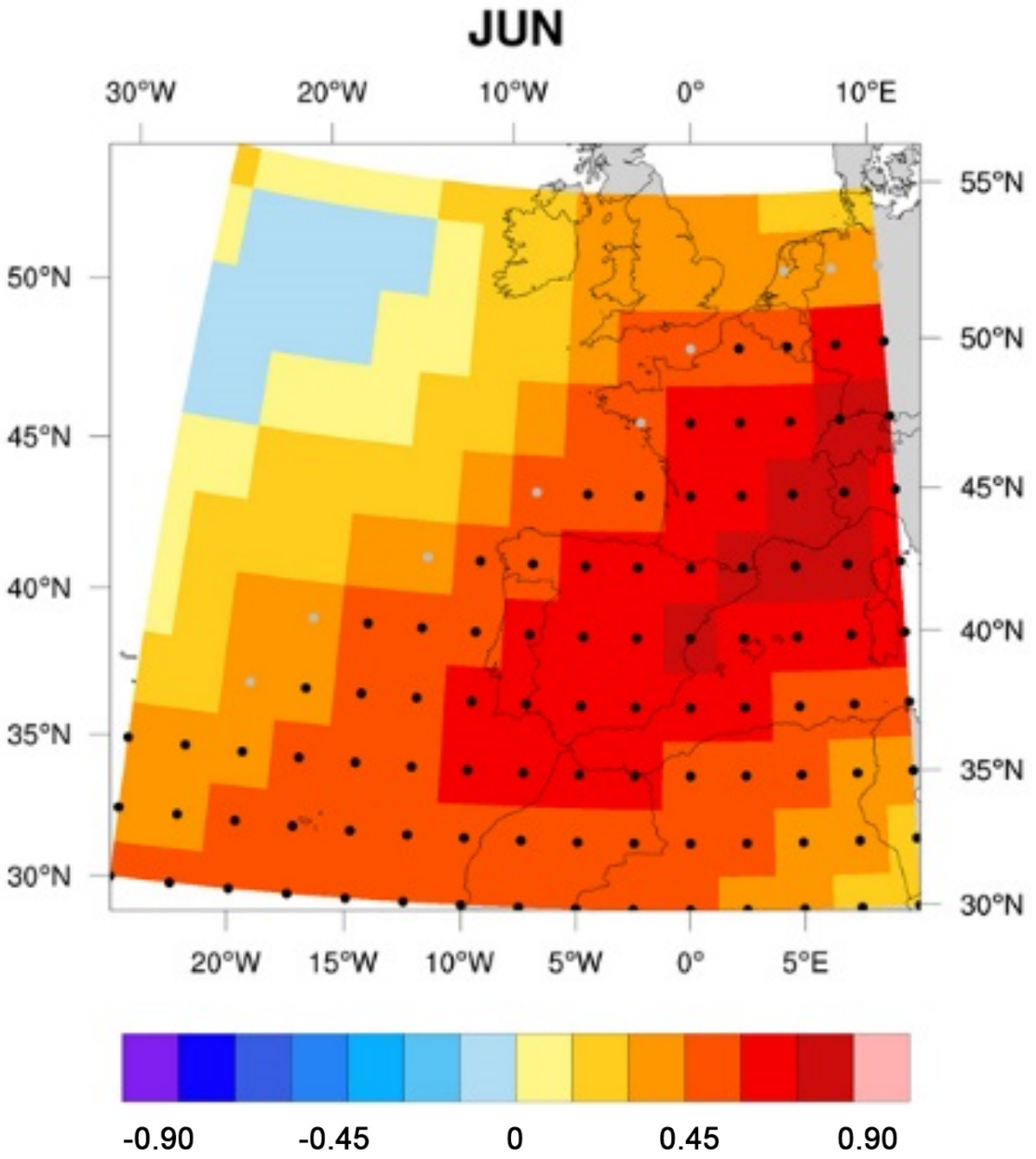
annual rate of G500 (gpdm) black dots 0.05 level grey dots 0.1 level

Trends
G500



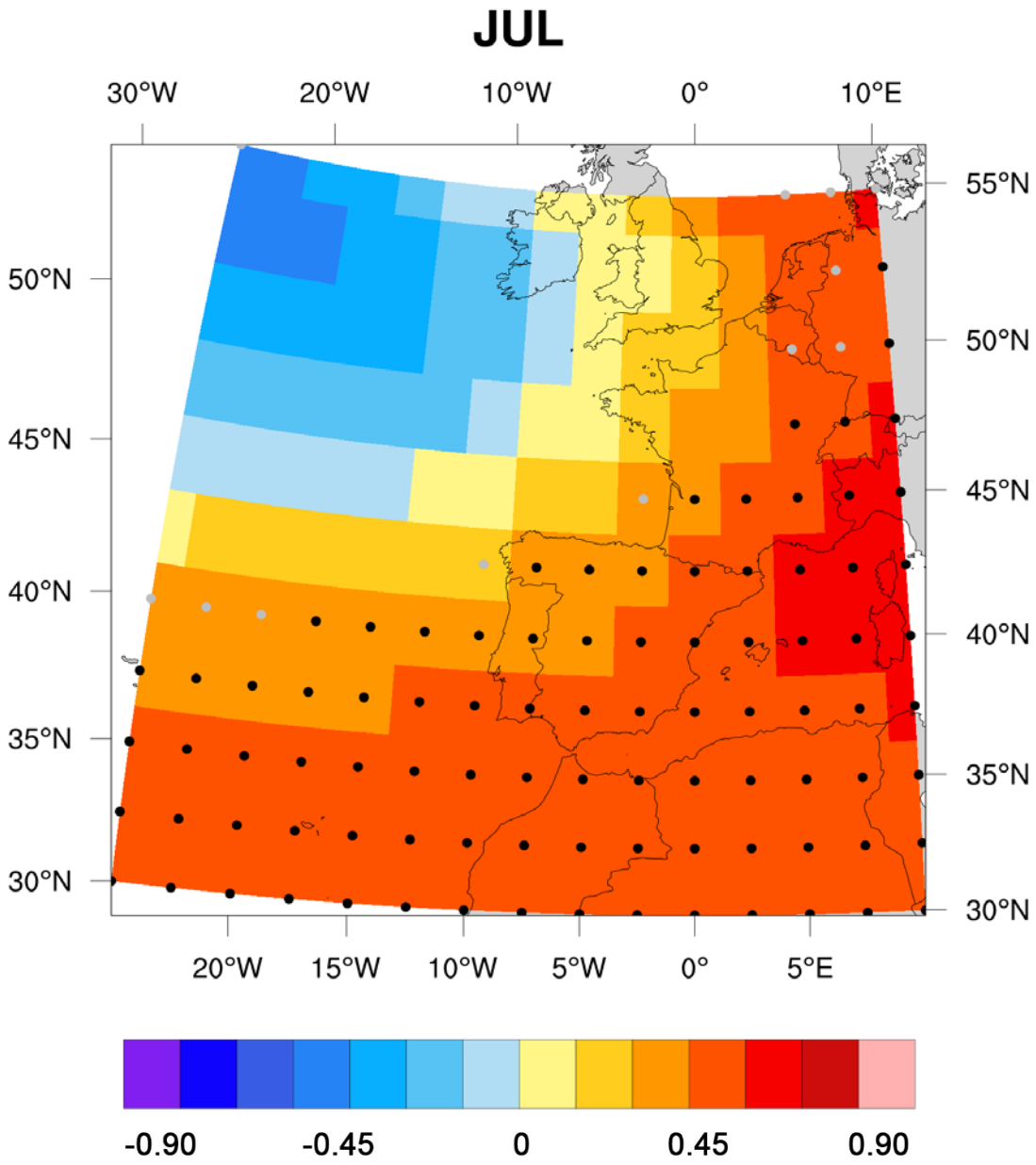
annual rate of G500 (gpdm) black dots 0.05 level grey dots 0.1 level

Trends G500



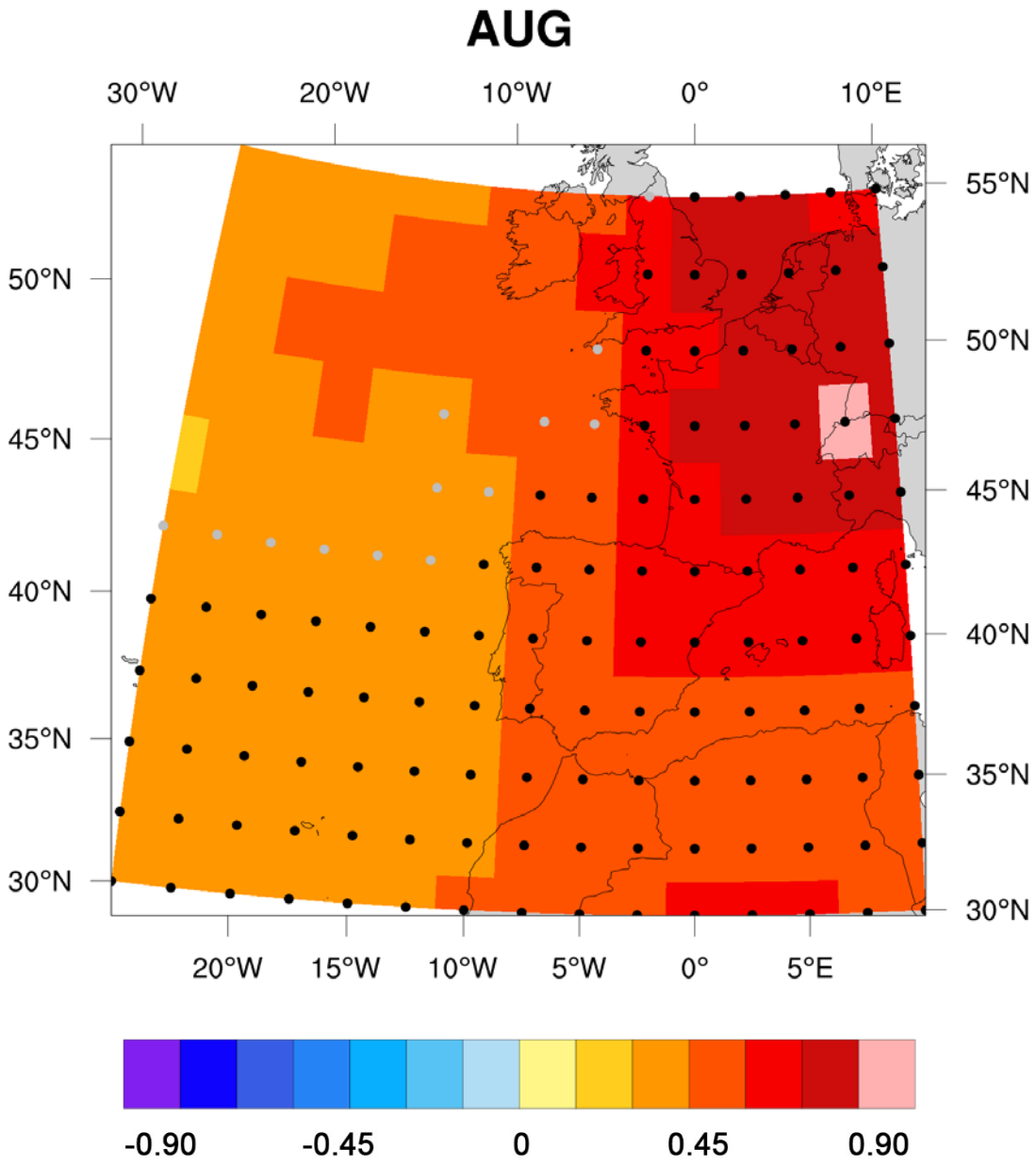
annual rate of G500 (gpdm) black dots 0.05 level grey dots 0.1 level

Trends G500

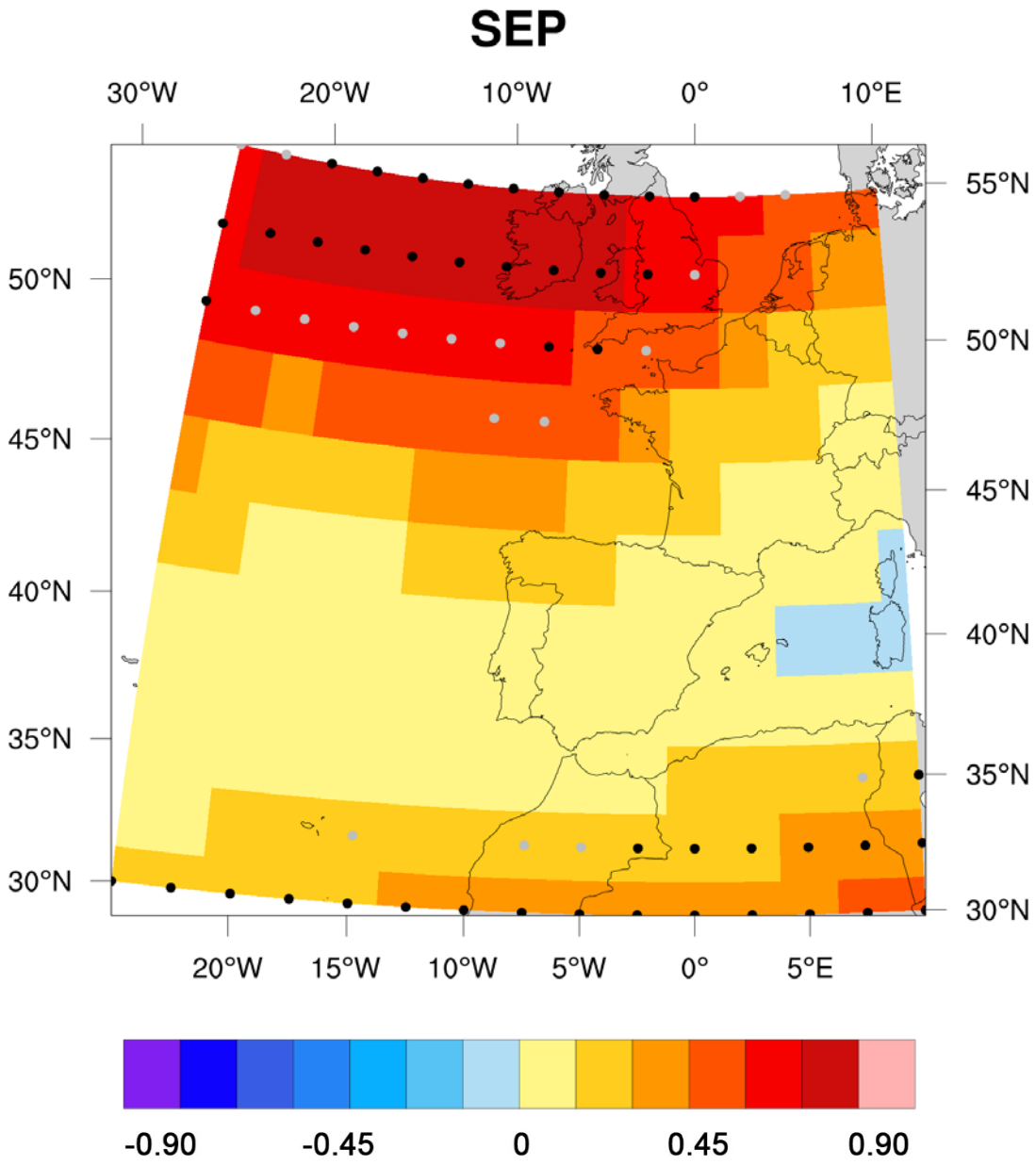


annual rate of G500 (gpdm) black dots 0.05 level grey dots 0.1 level

Trends G500

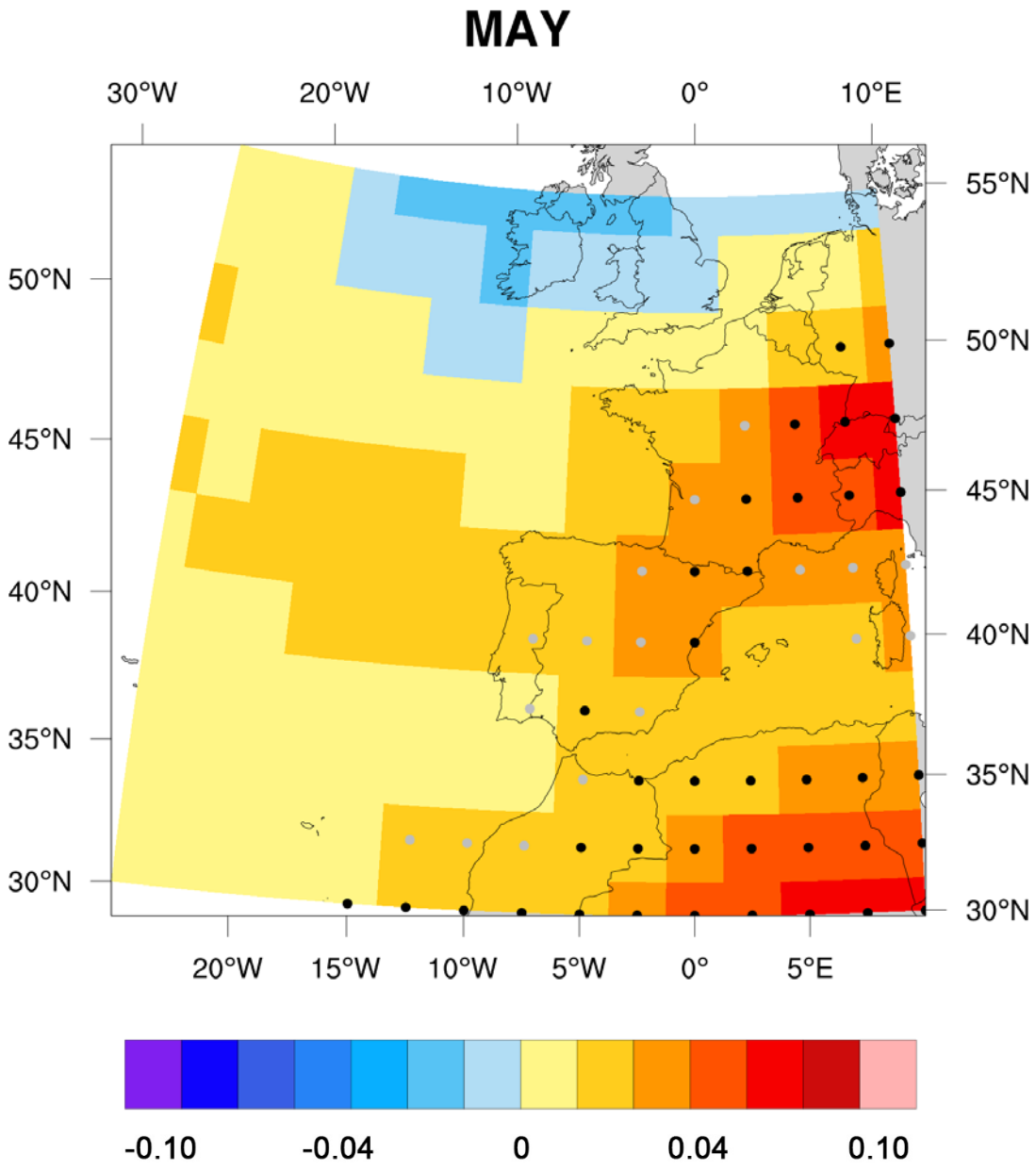


Trends
G500


SEP
30°W
20°W
10°W
0°
10°E
55°N
50°N
45°N
40°N
35°N
30°N
20°W
15°W
10°W
5°W
0°
5°E
-0.90
-0.45
0
0.45
0.90

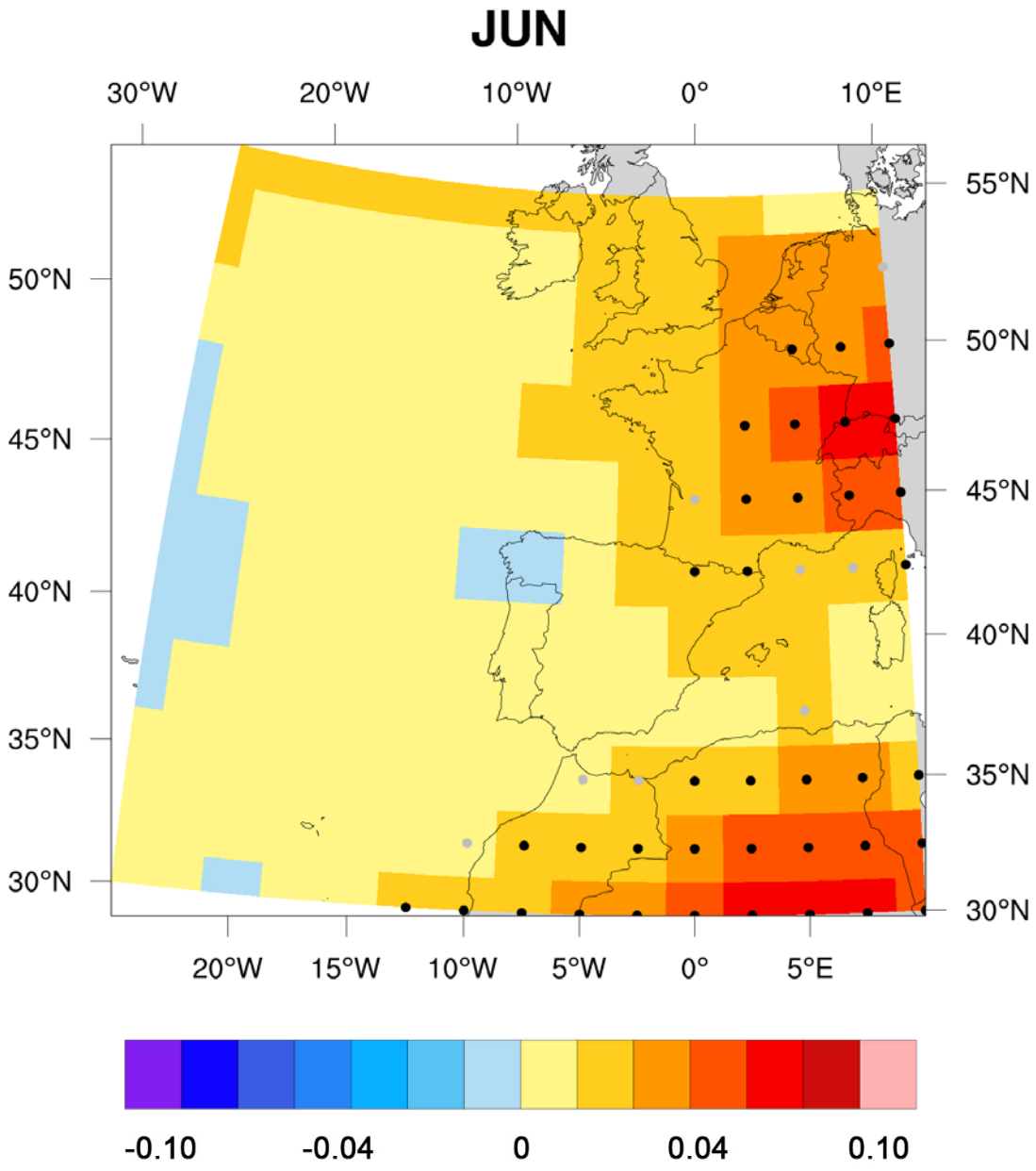
annual rate of SLP (hPa) black dots 0.05 level grey dots 0.1 level

Trends SLP



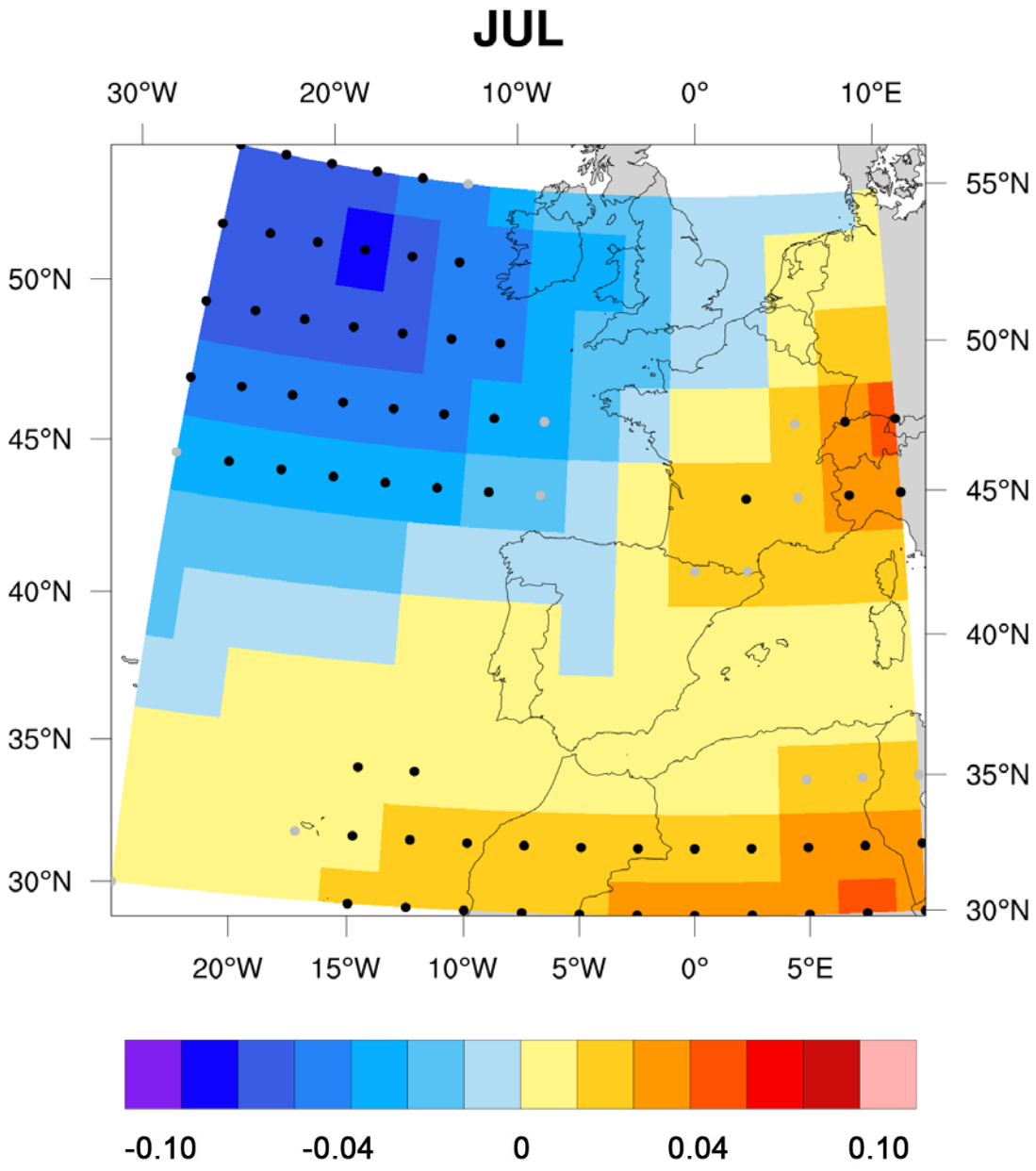
annual rate of SLP (hPa) black dots 0.05 level grey dots 0.1 level

Trends SLP



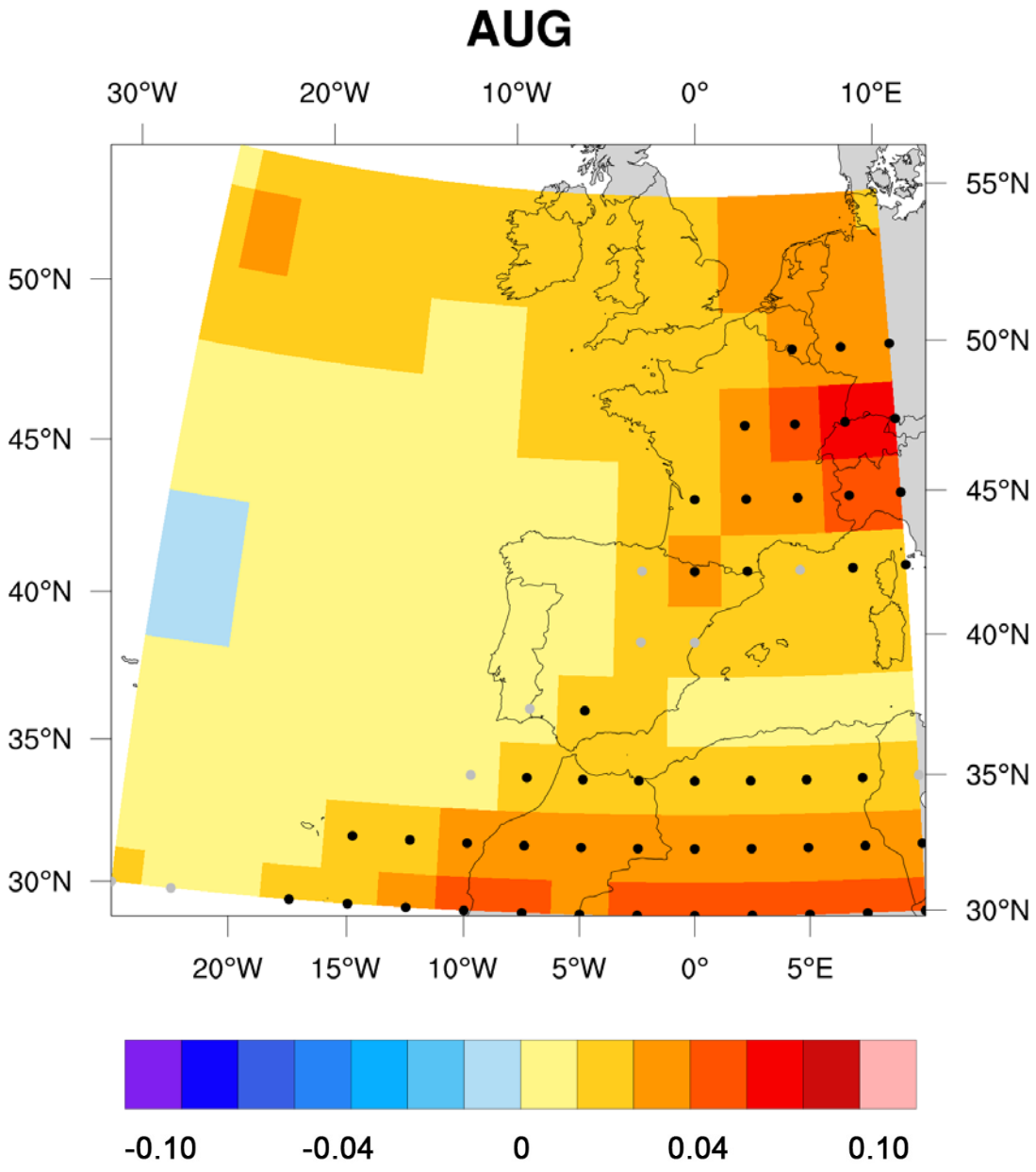
annual rate of SLP (hPa) black dots 0.05 level grey dots 0.1 level

Trends SLP



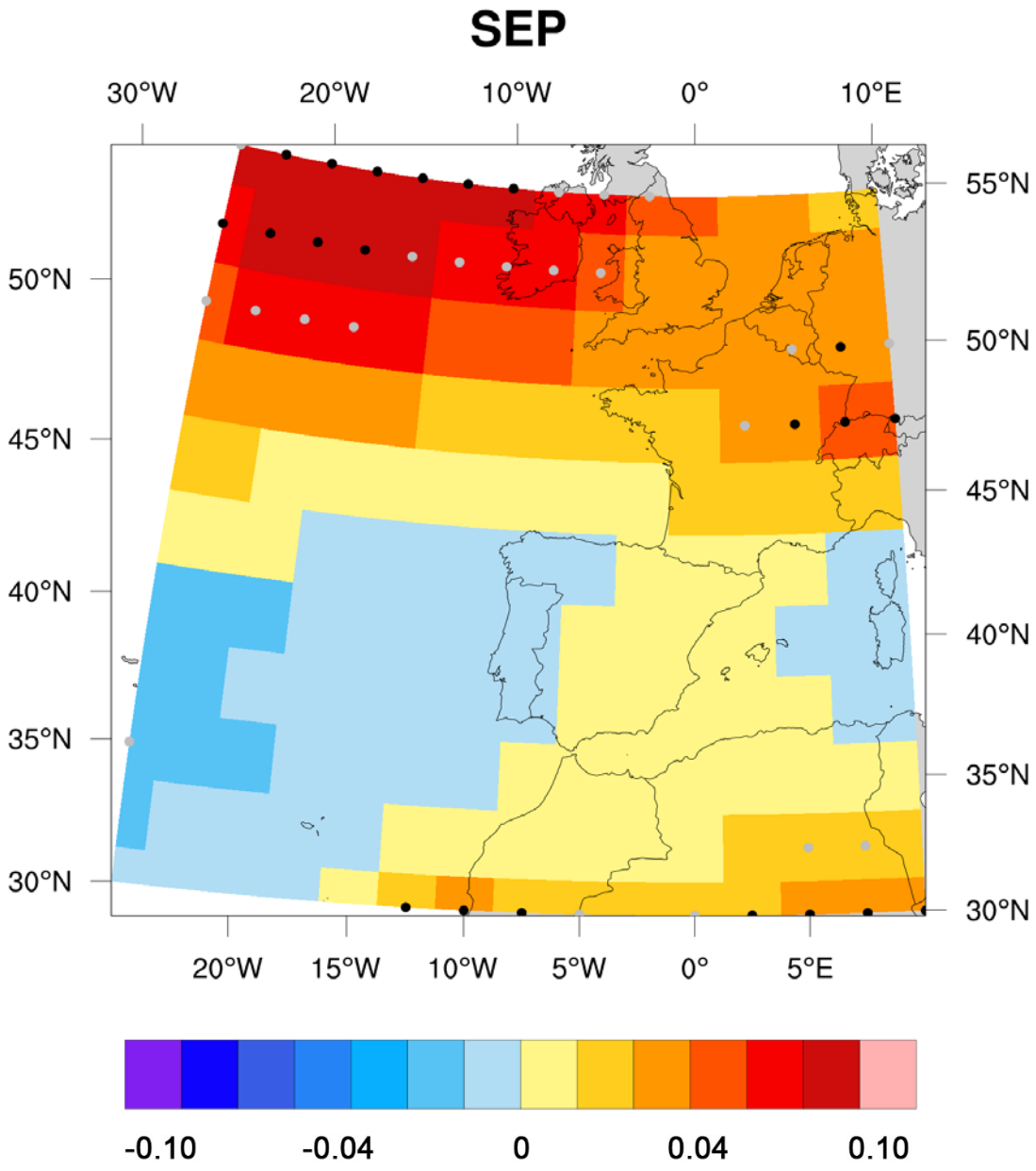
annual rate of SLP (hPa) black dots 0.05 level grey dots 0.1 level

Trends SLP



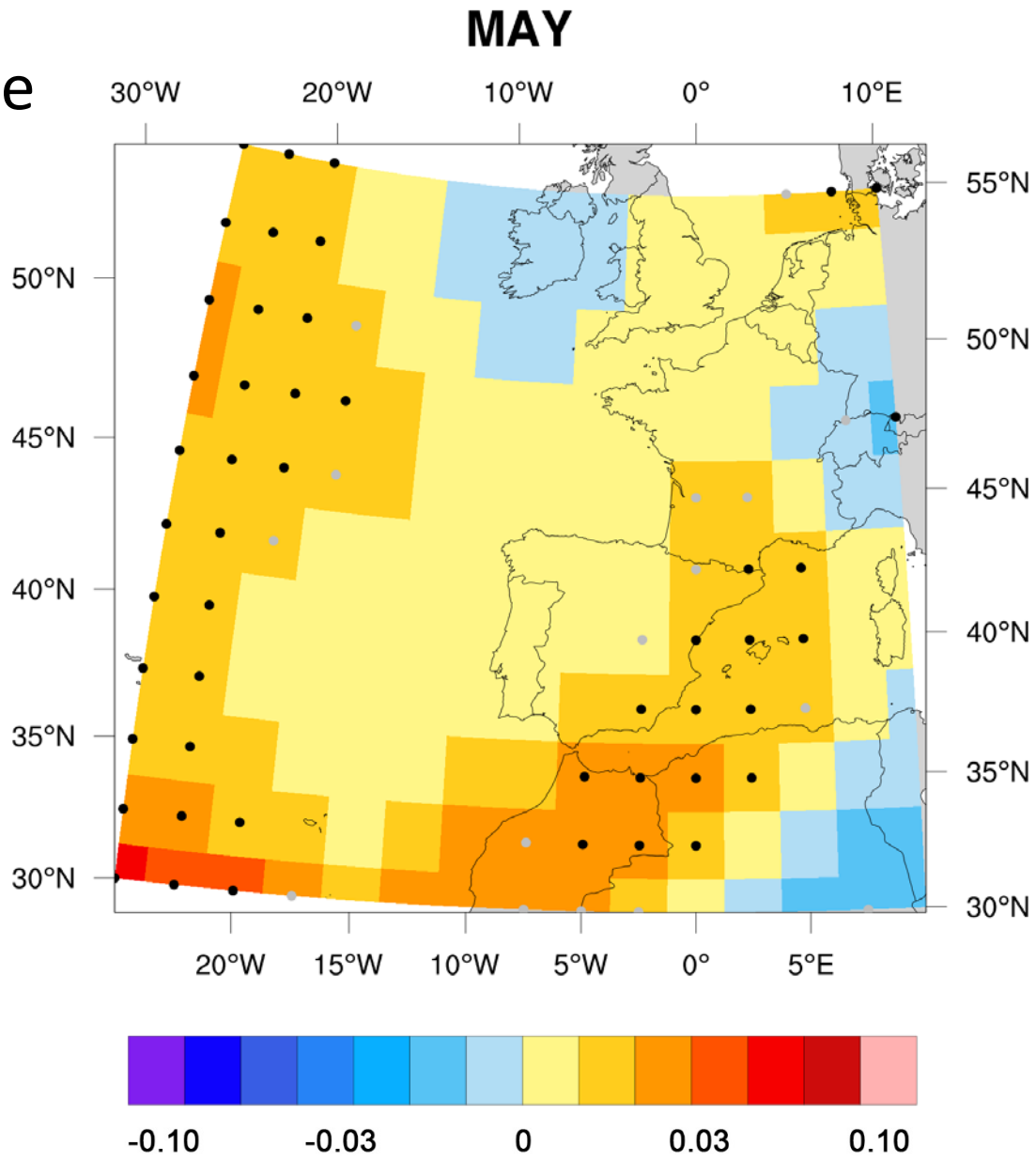
annual rate of SLP (hPa) black dots 0.05 level grey dots 0.1 level

Trends SLP



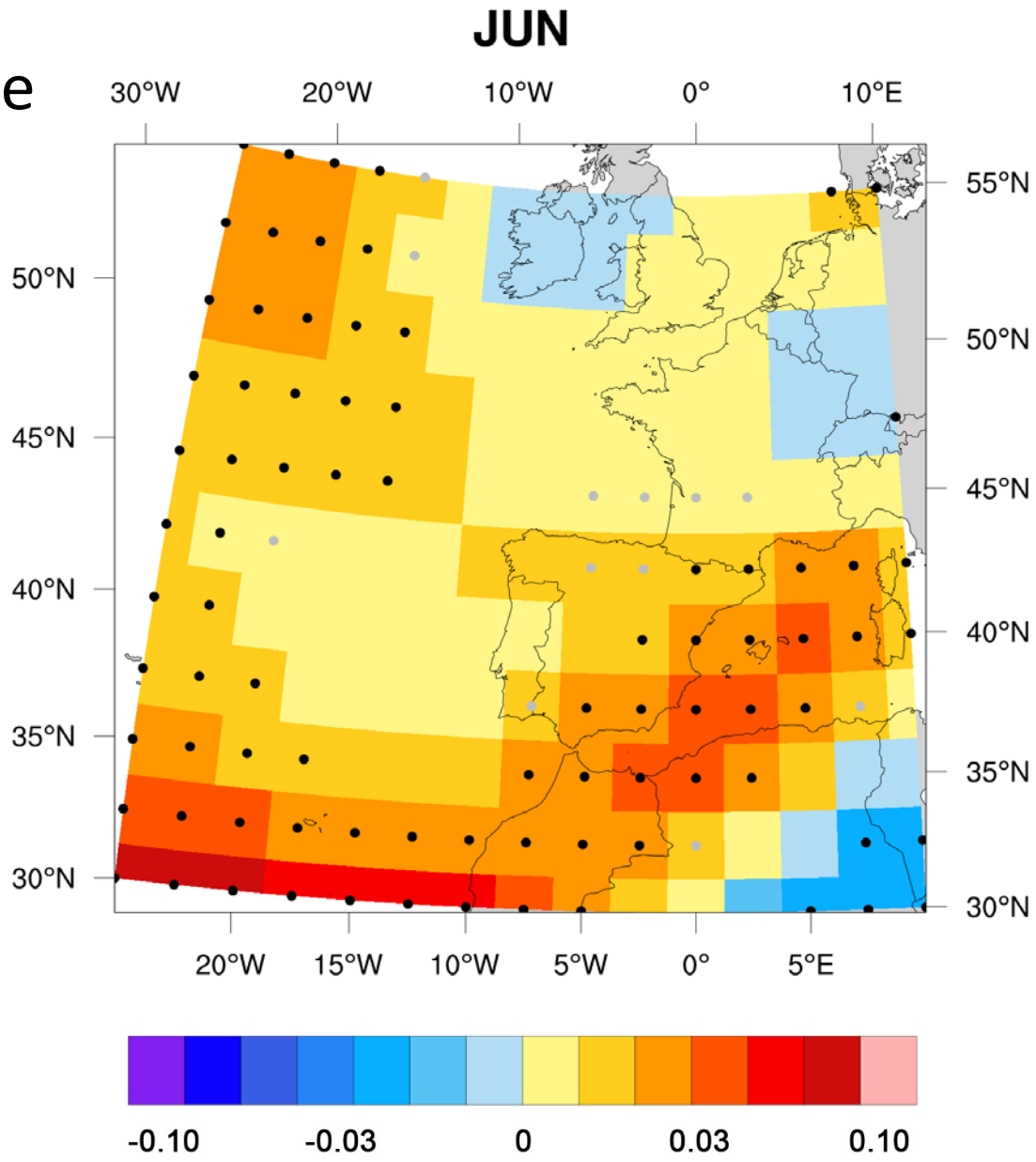
annual rate of LR 850-500 (ºC) black dots 0.05 level grey dots 0.1 level

Trends Lapse-rate

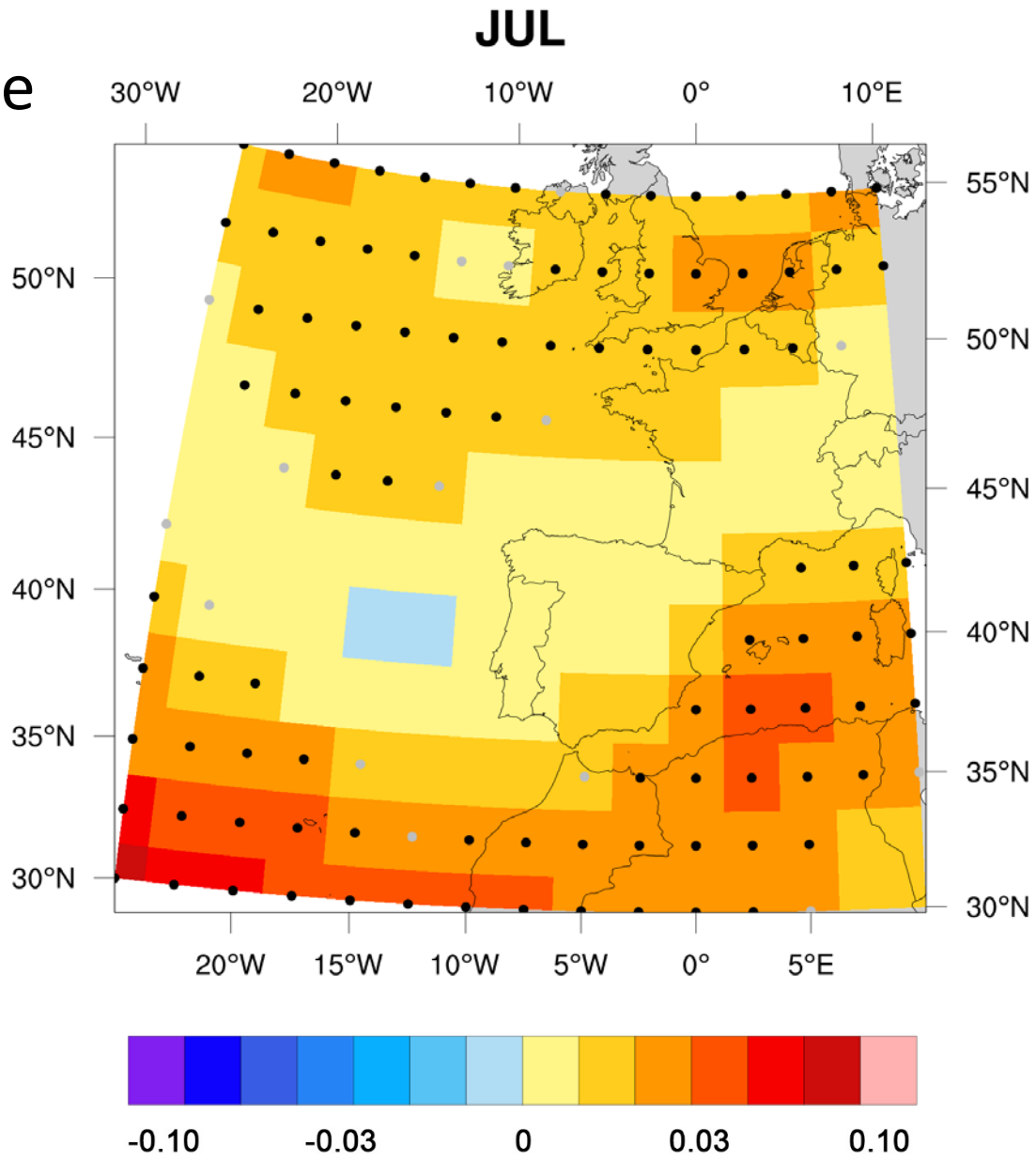


annual rate of LR 850-500 (ºC) black dots 0.05 level grey dots 0.1 level

Trends Lapse-rate

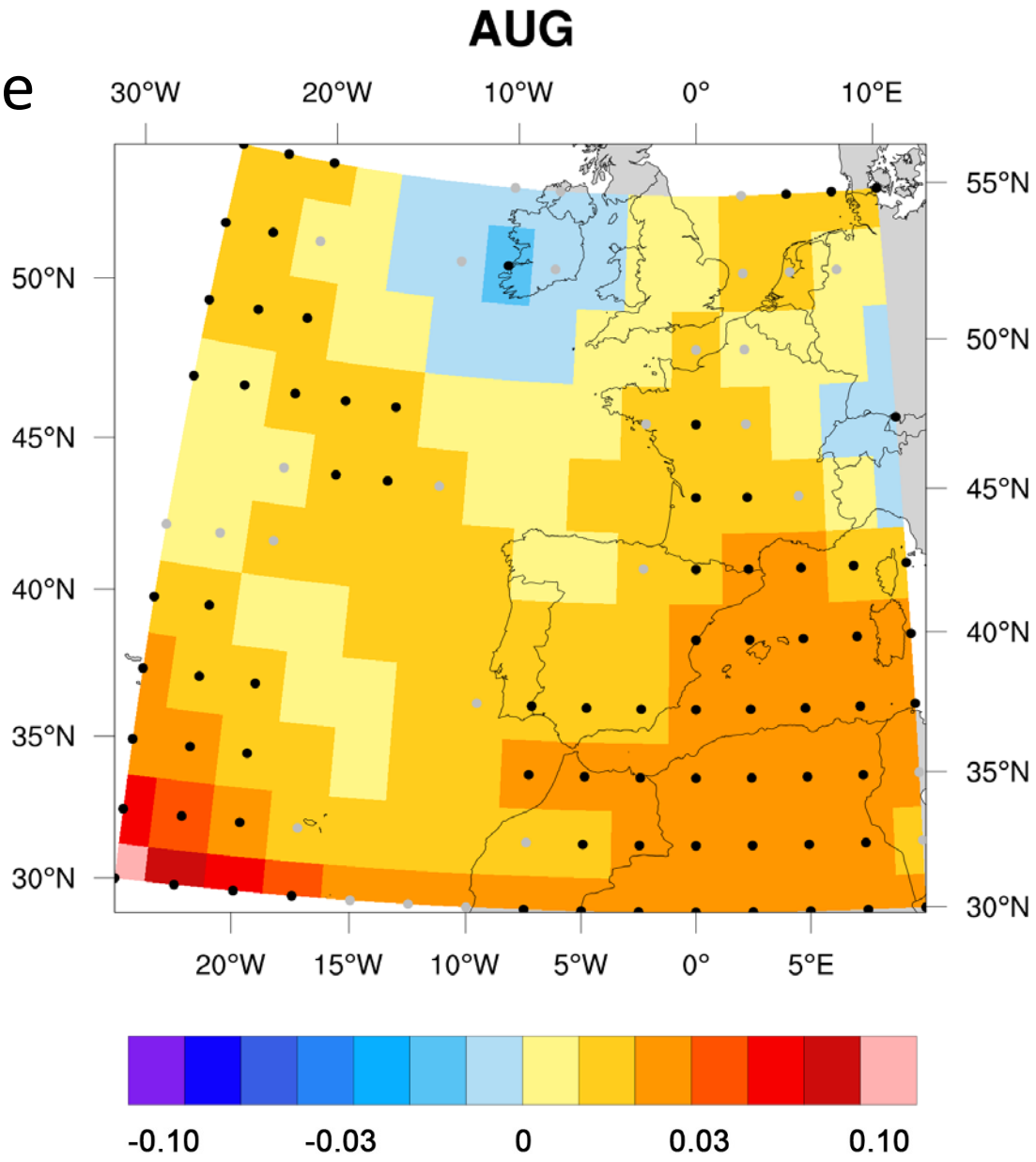


Trends Lapse-rate



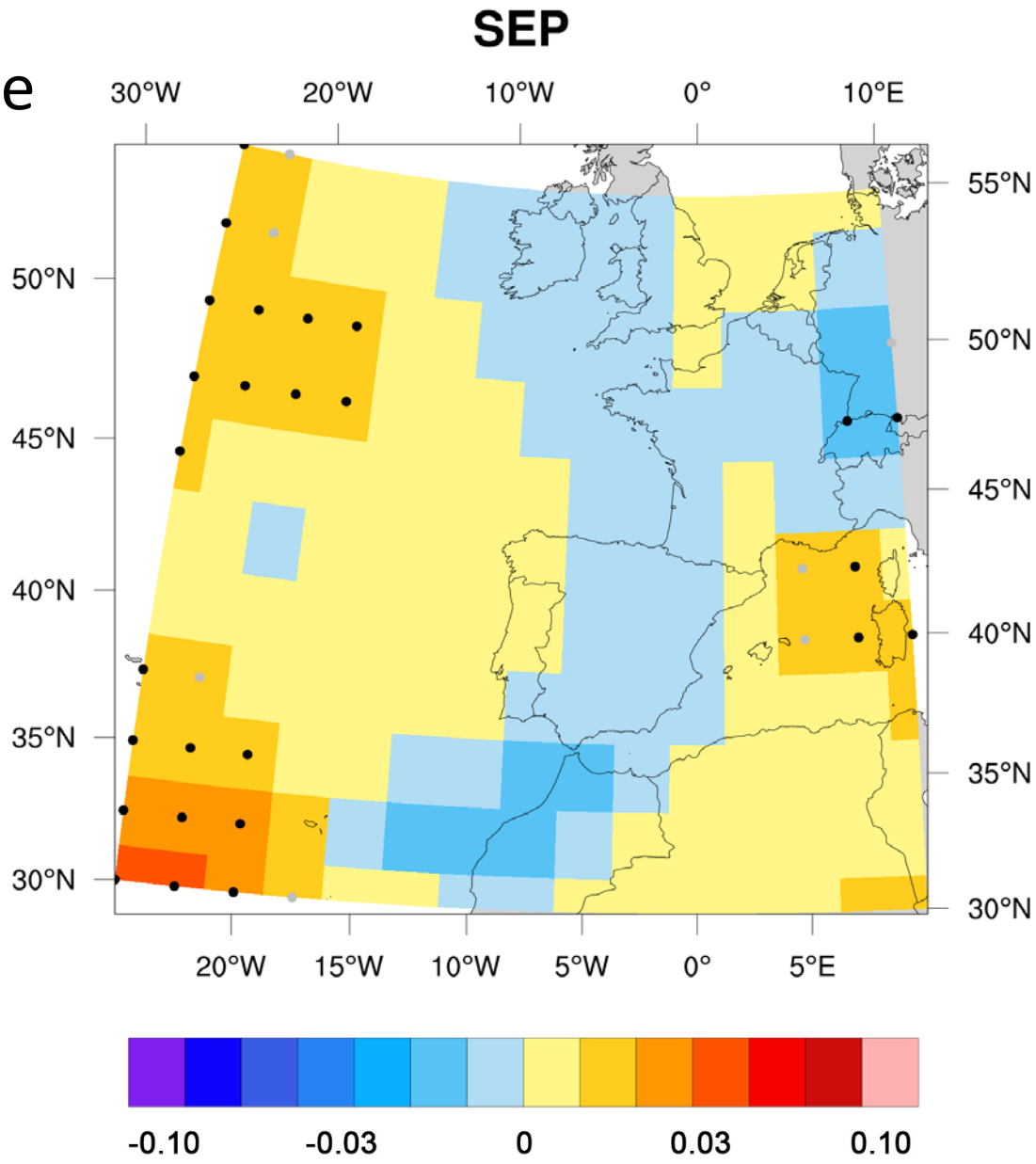
annual rate of LR 850-500 (ºC) black dots 0.05 level grey dots 0.1 level

Trends Lapse-rate



annual rate of LR 850-500 (ºC) black dots 0.05 level grey dots 0.1 level

Trends Lapse-rate



Analysis between 1948 and 2015

1. **The synoptic meteorological fields analyzed showed a trend to be more favorable environments for the development of convection**
2. **However, this does not necessarily causes an increase in the frequency of hail precipitation. Other factors involve in the occurrence of hail precipitation may have an opposite effect (i.e. melting level)**
3. **In the Pyrenees area, the hail frequency is increasing significantly (at 0.05 level) positive trends are being detected in the number of HD. (low effect of melting level)**
4. **The influence of African air masses causes that the thermal instability has a positive trend in the Mediterranean area**
5. **From dynamic point of view, the trends suggest a strengthening of western Mediterranean ridge and North Atlantic trough, being the synoptic environments more favorable for severe convection**