

# Health and Environmental Impacts of the oustanding 2003 heatwave in Europe

**Ricardo Machado Trigo**



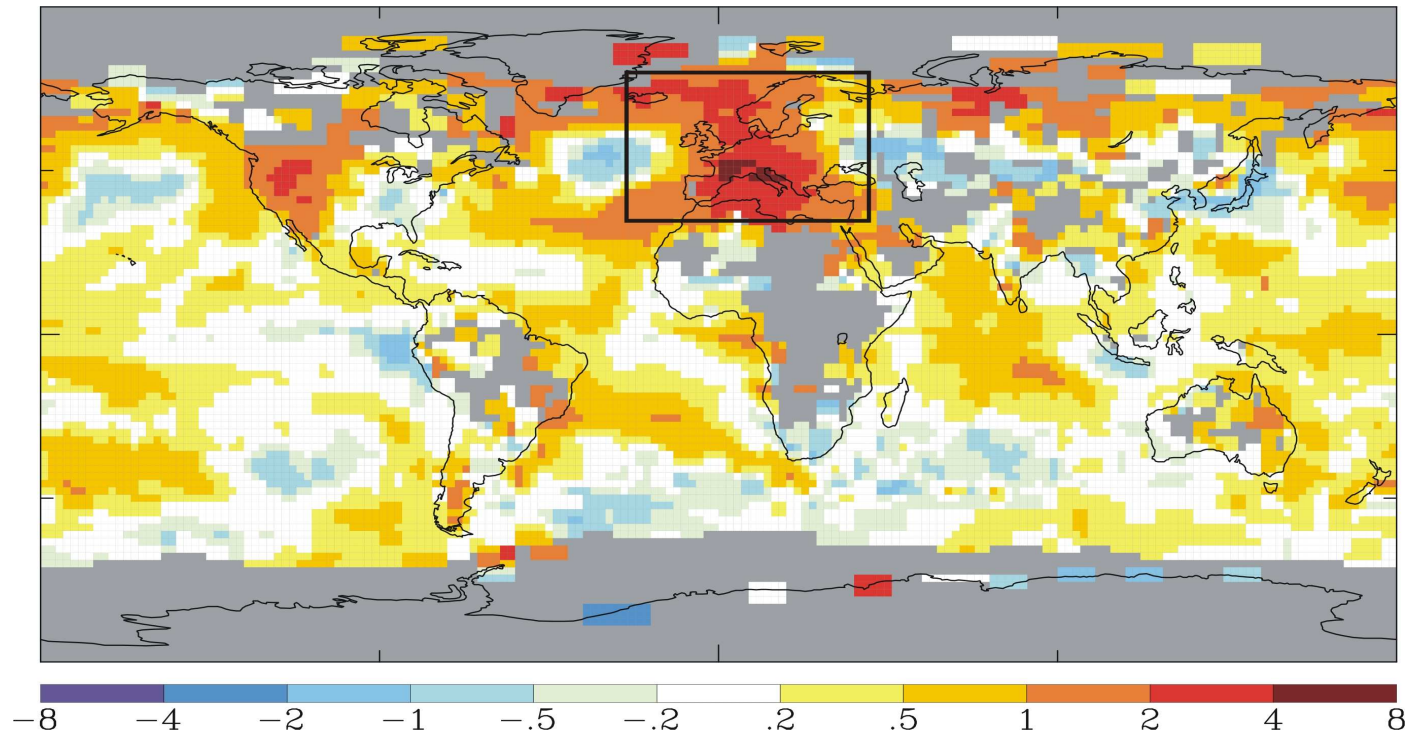
**CGUL, IDL, Faculdade de Ciências da  
Universidade de Lisboa, Portugal**

Colaborations:

Alexandre Ramos, Ricardo Garcia Herrera, Paulo Nogueira, Celia Gouveia, Maria Antonia Valente, Isabel Trigo, Julio Diaz, F.D.Santos

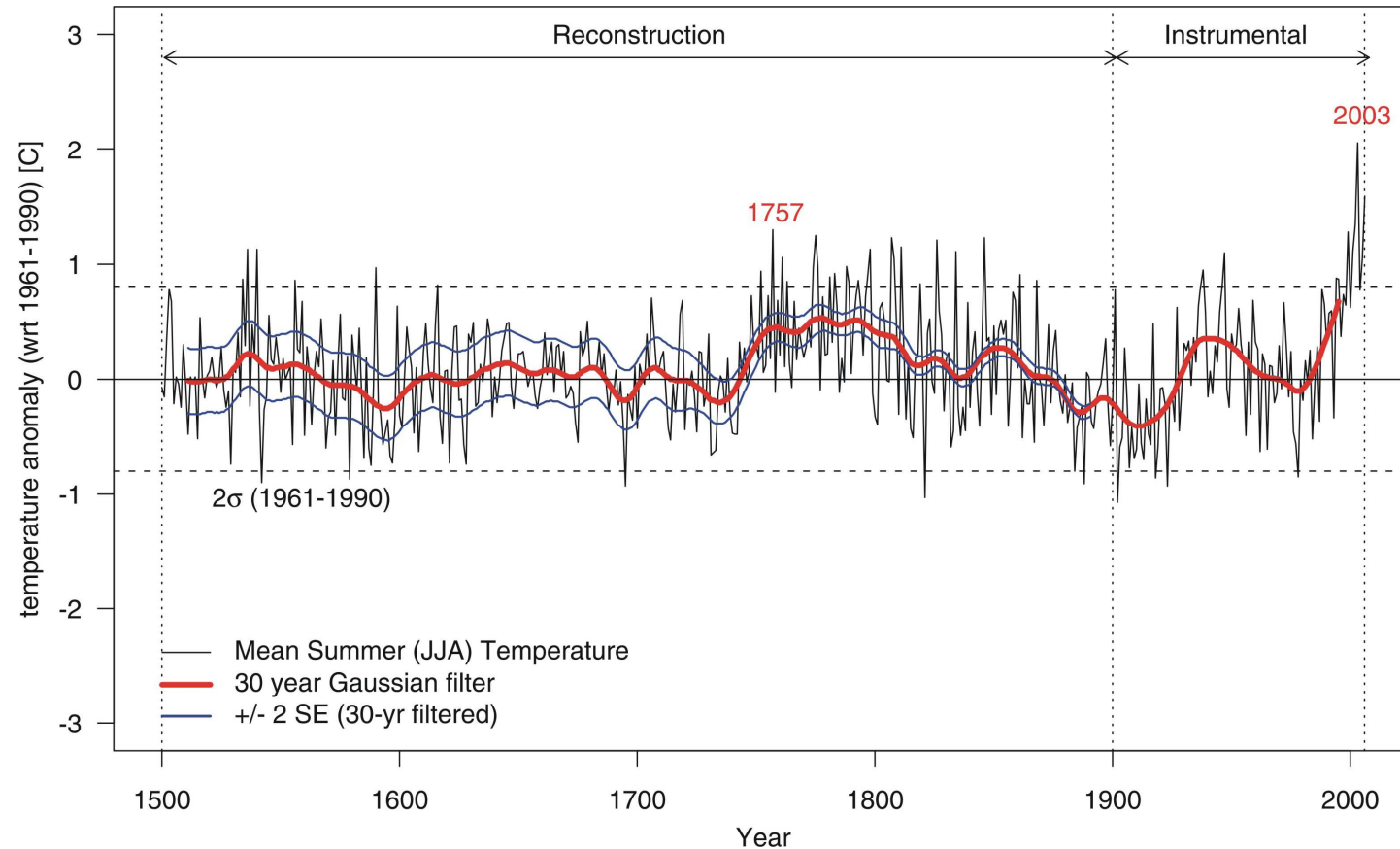


# The spatial extent

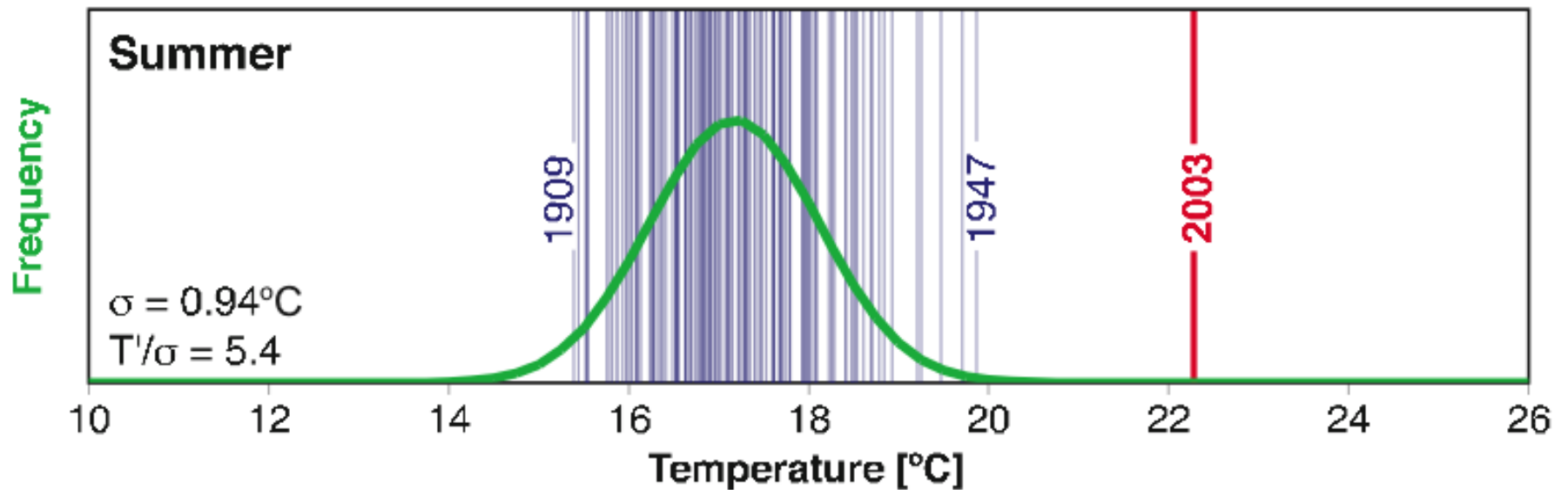


*Surface air temperature anomalies of summer (June-August) 2003.  
Data source: Hansen et al. 2001; NASA/GISS*

# The warmest summer in 500 years...



*Summer (JJA) averaged-mean European temperature Anomaly time series from 1500 to 2006 (Luterbacher et al. 2004). Dashed horizontal lines: 2SD of 1961–1990 period.*



Summer temperatures in Switzerland from 1864 to 2003 are, on average, about  $17^{\circ}\text{C}$  (green). During the extremely hot summer of 2003, average temperatures exceeded  $22^{\circ}\text{C}$  (red). The fitted Gaussian distribution is indicated in green.



# National excessive mortality

Country	Deaths	Period analysed	Source
France	14802	4-13 August	Valleron and Boumendil, 2004; Poumadere et al. 2005
Spain	6500	June-August	Martínez et al. 2004
Portugal	2099	30 July-15 August	Botelho et al. 2004, Nogueira and Paixão (2007)
Italy	3134	1 July-15 August	Kovats et al. 2004a, Michelozzi et al. 2005
England and Wales	2139	4-13 August	Johnson et al. 2004
Switzerland	975	June-August	Grize et al. 2005; Thommen Dombois and Braun-Fahrländer 2004
The Netherlands	1400-2200	June-August	Garssen et al. 2005; Fischer et al. 2005
Germany	7000	June-September	Schär and Jendritzky 2004 .
Belgium	1250	July-September	Sartor 2004

# The summer 2003 heatwave in Europe

Luterbacher et al. (2004, **Science**)

Beniston (2004)

Schär et al. (2004, **Nature**)

Beniston and Diaz (2004)

Ogi et al. (2005)

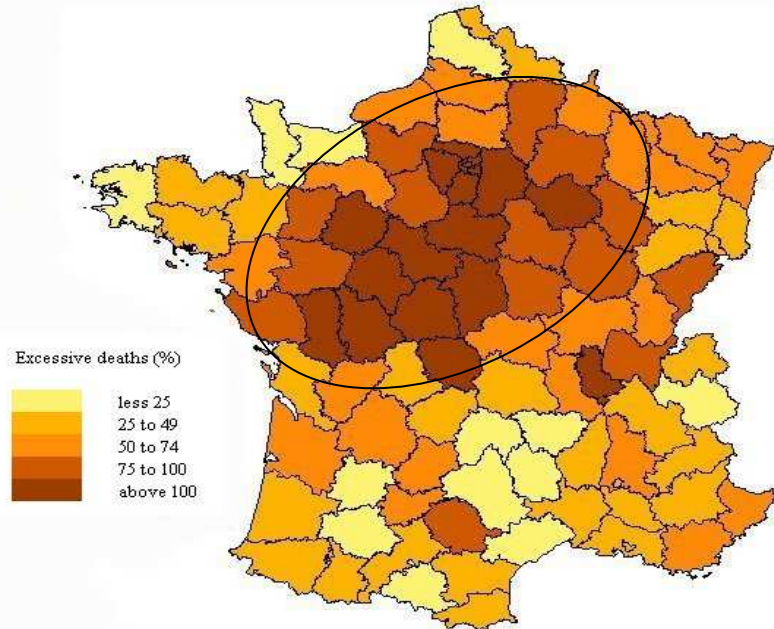
Analysis at the **monthly**  
and **seasonal** scales

- **40.000** excessive deaths in **Europe**
- Worst **fire** season in Portugal “ever”  
(450.000 ha of total burnt area +21 direct deaths)

## **Sub-monthly analysis**

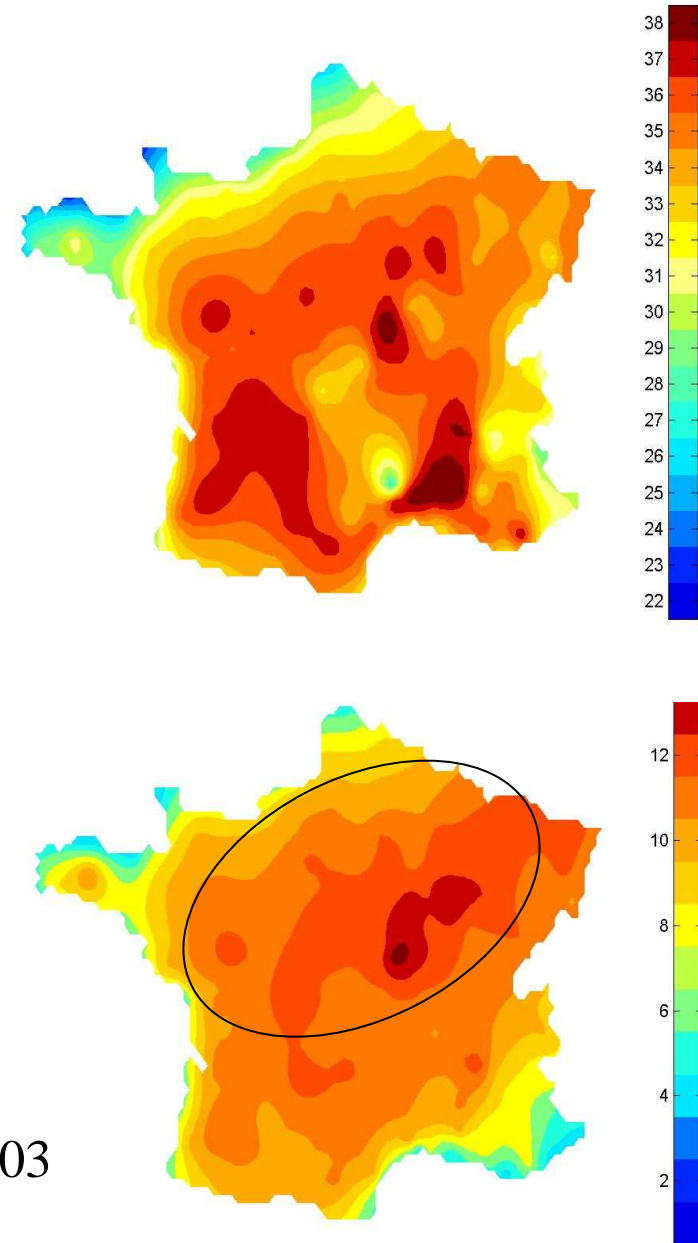
## Tmax 1-15 August 2003

## Excessive mortality 1-15 August (vs 2000-2002 average)



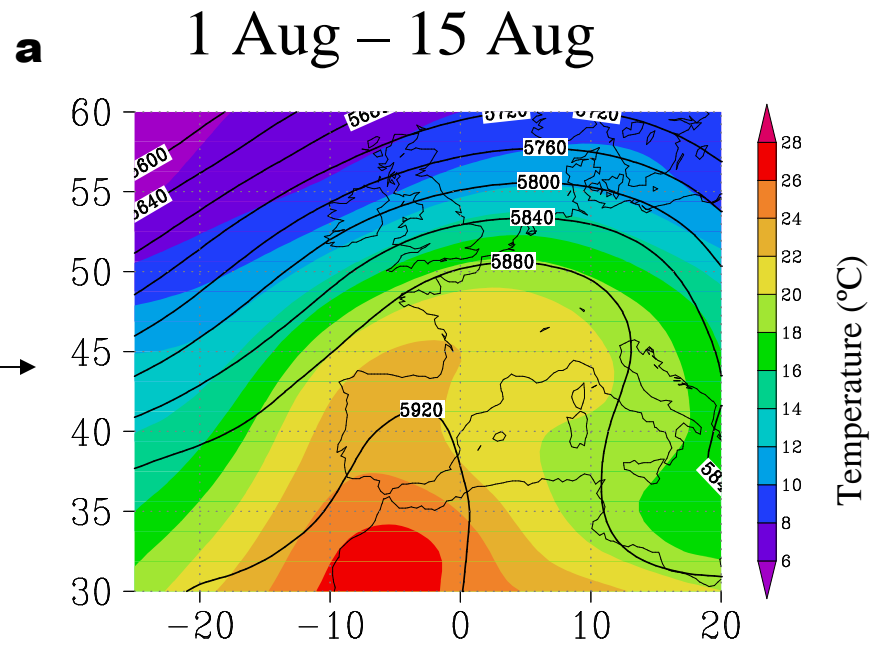
(Trigo et al., 2005, GRL)

## Tmax anomaly 1-15 August 2003

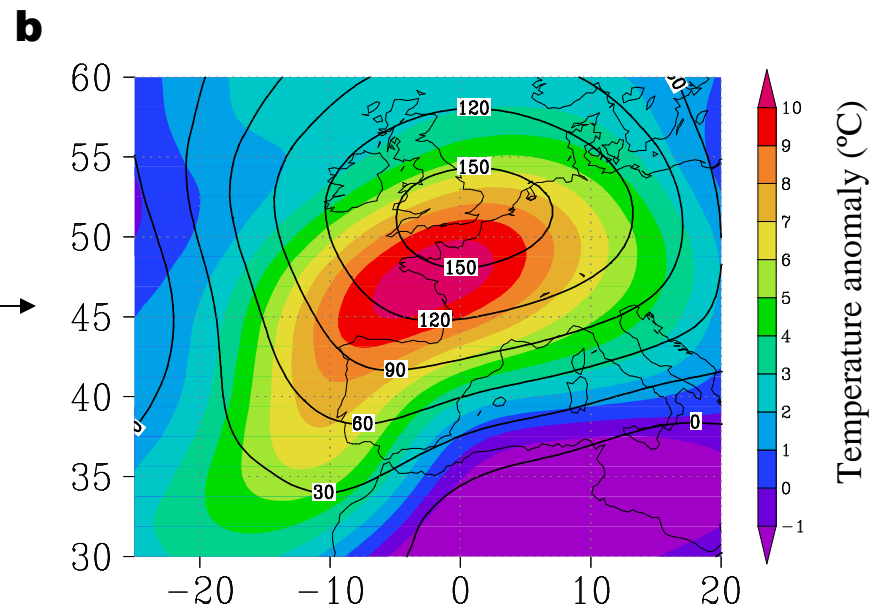


500 hPa geopotential height and  
850 hPa Temperature

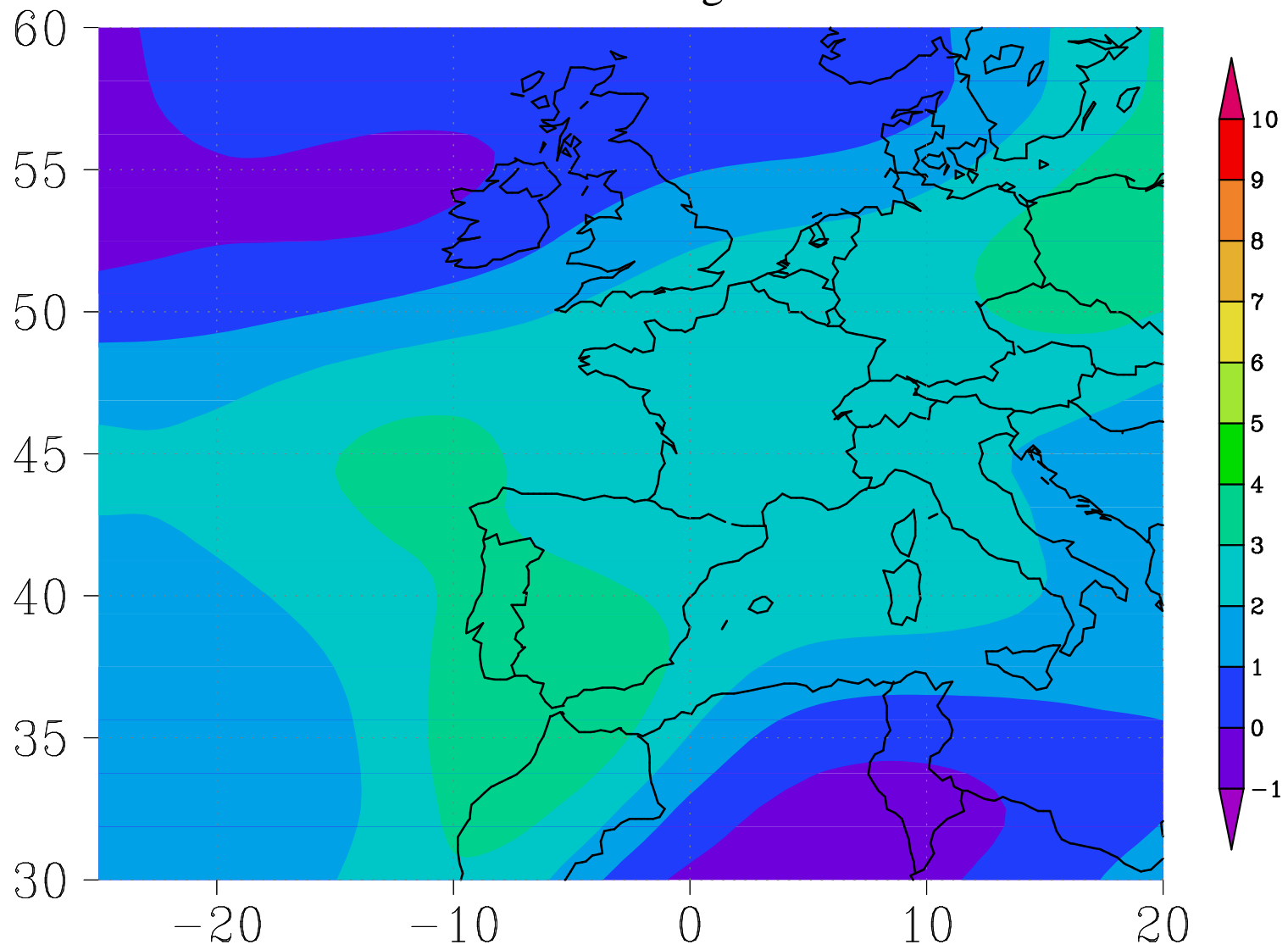
Average



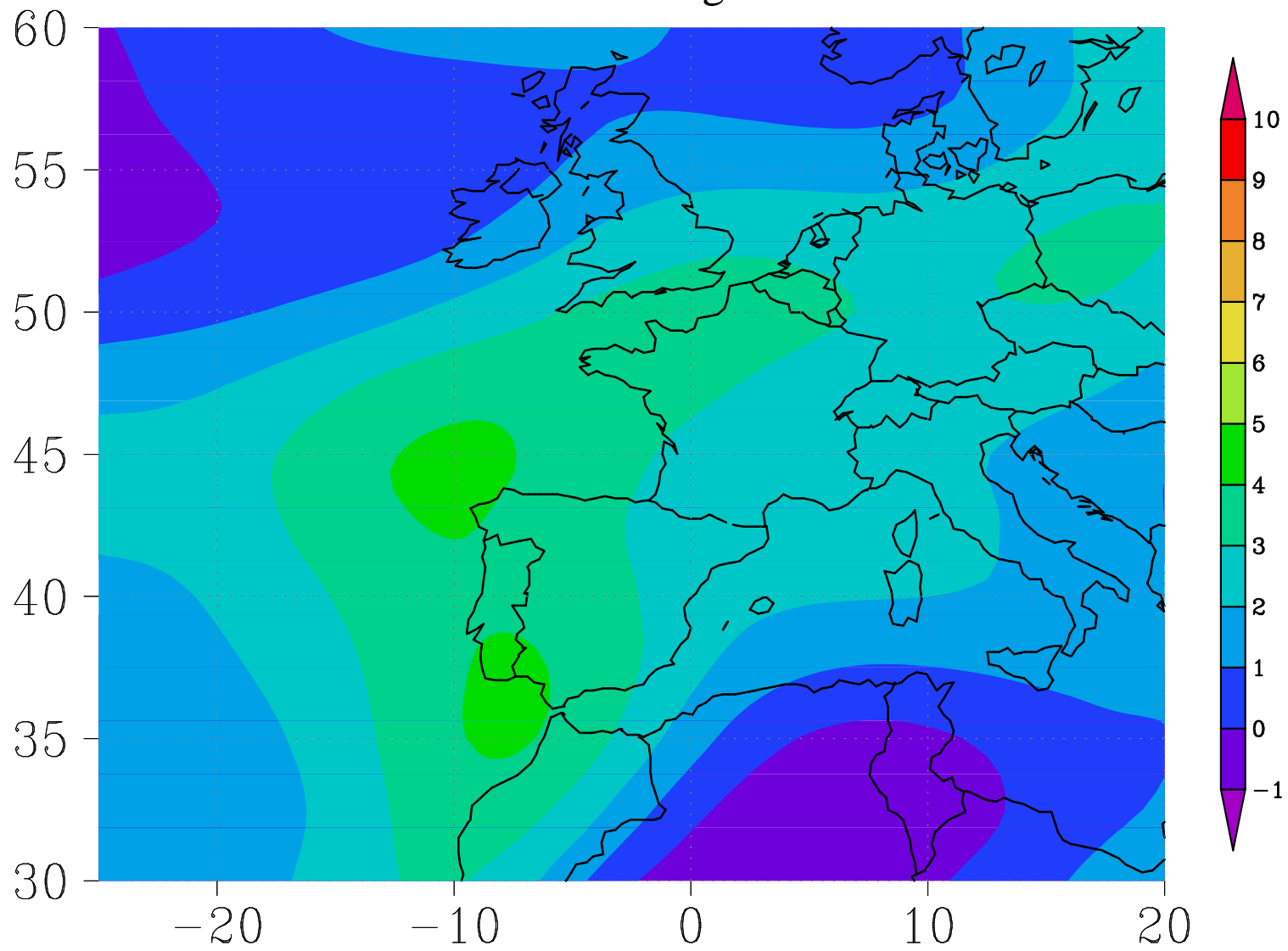
Anomaly



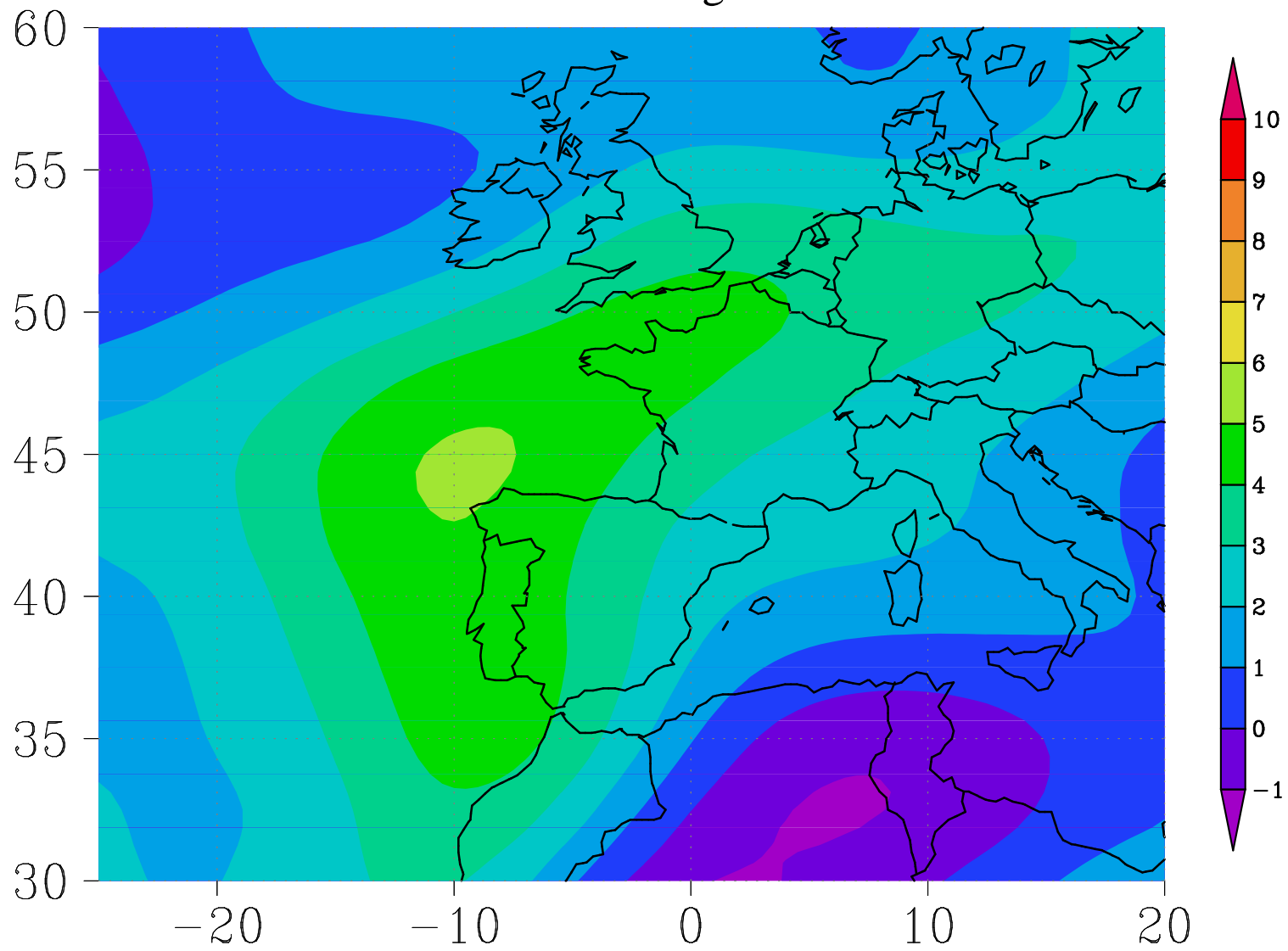
22 Jul - 5 Aug 2003



23 Jul - 6 Aug 2003

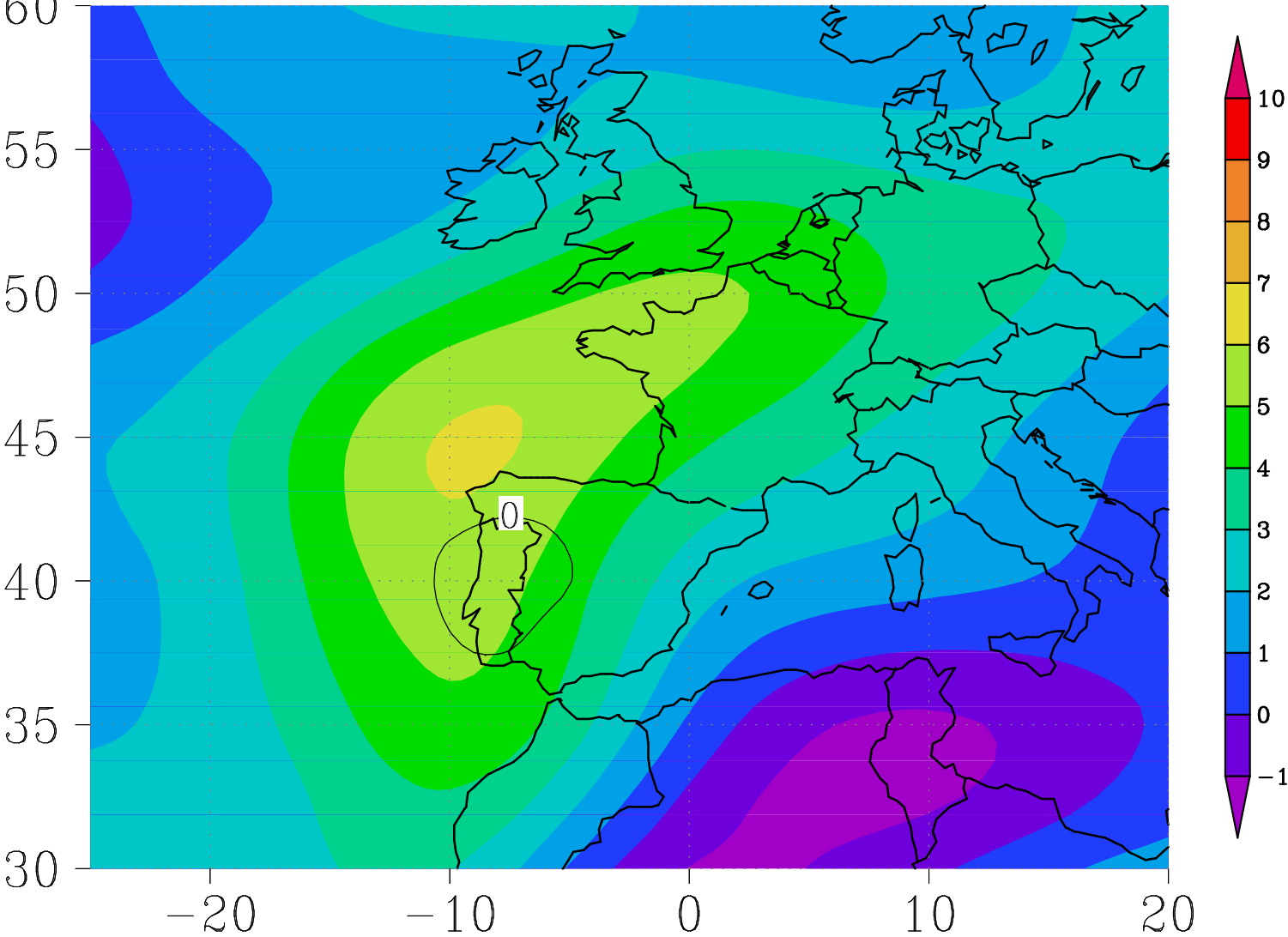


24 Jul - 7 Aug 2003

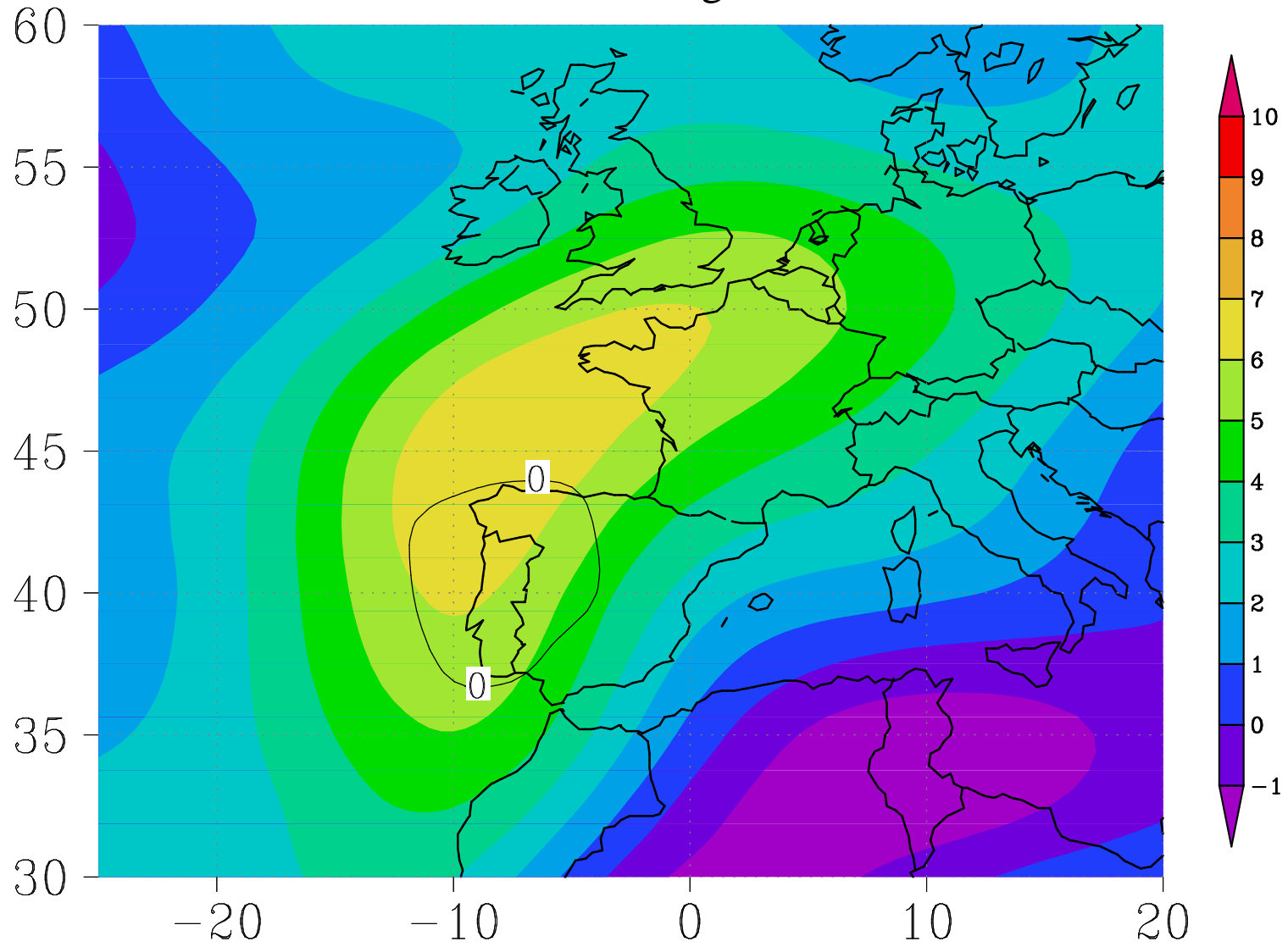




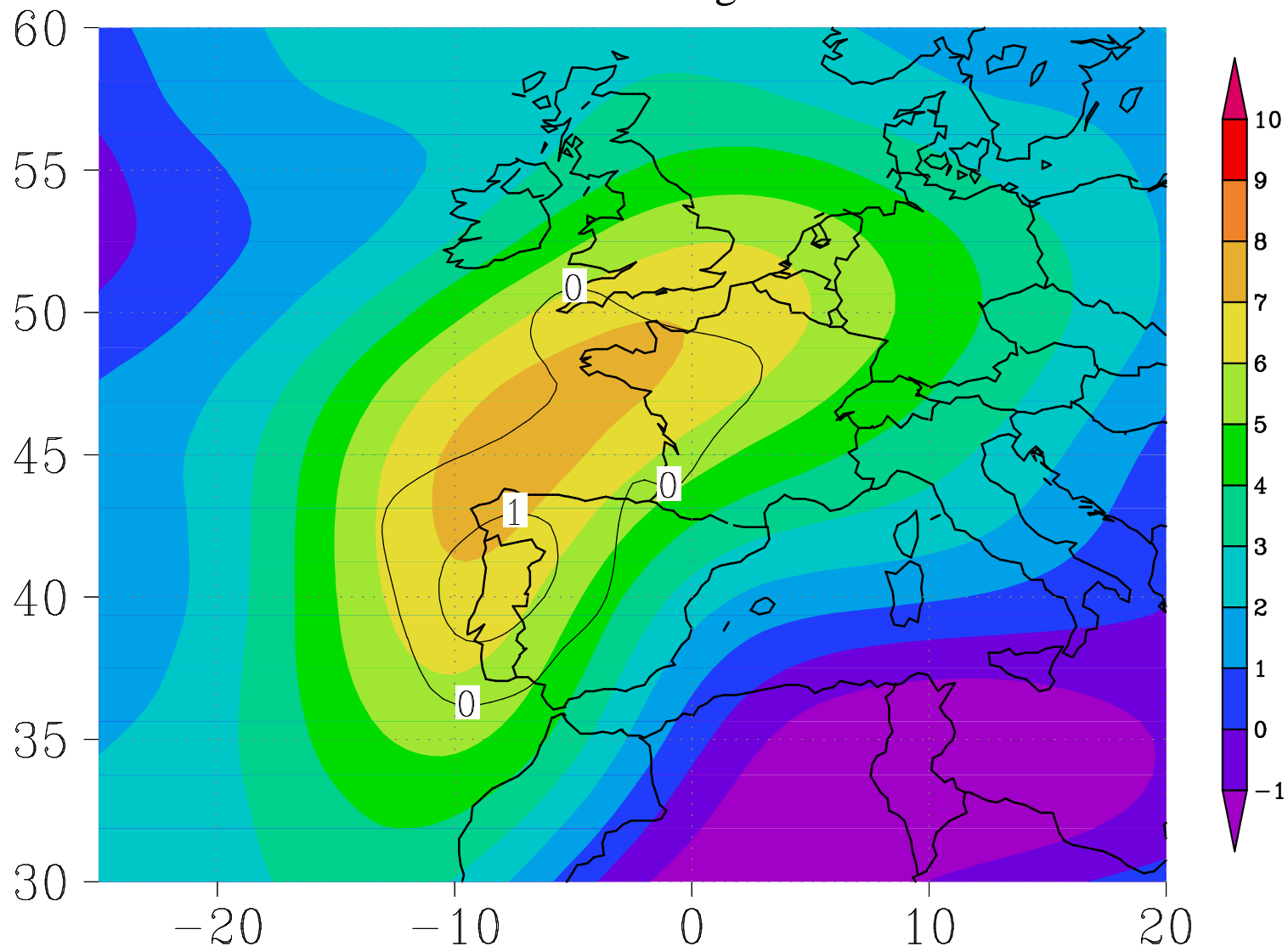
25 Jul - 8 Aug 2003



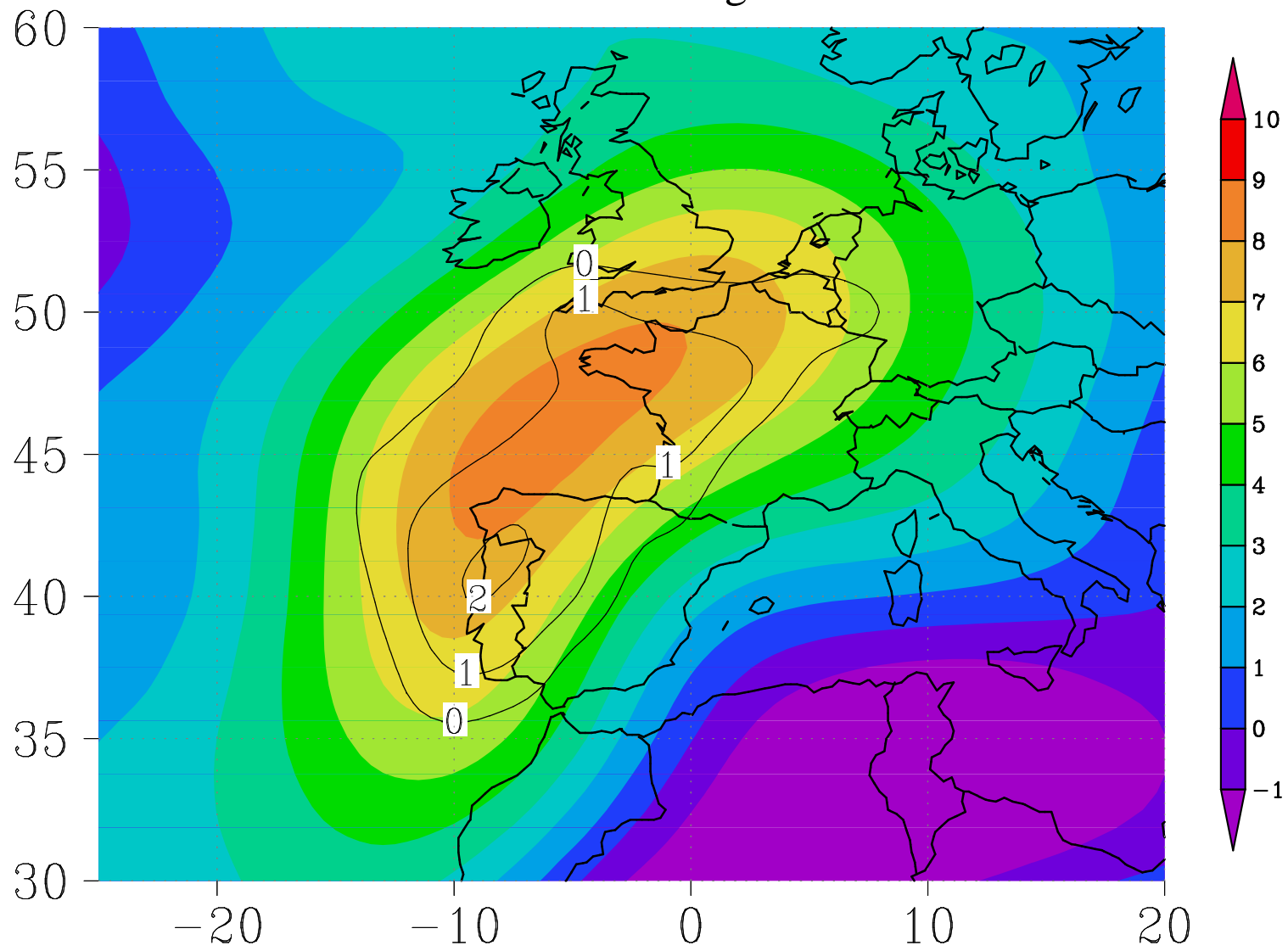
26 Jul - 9 Aug 2003



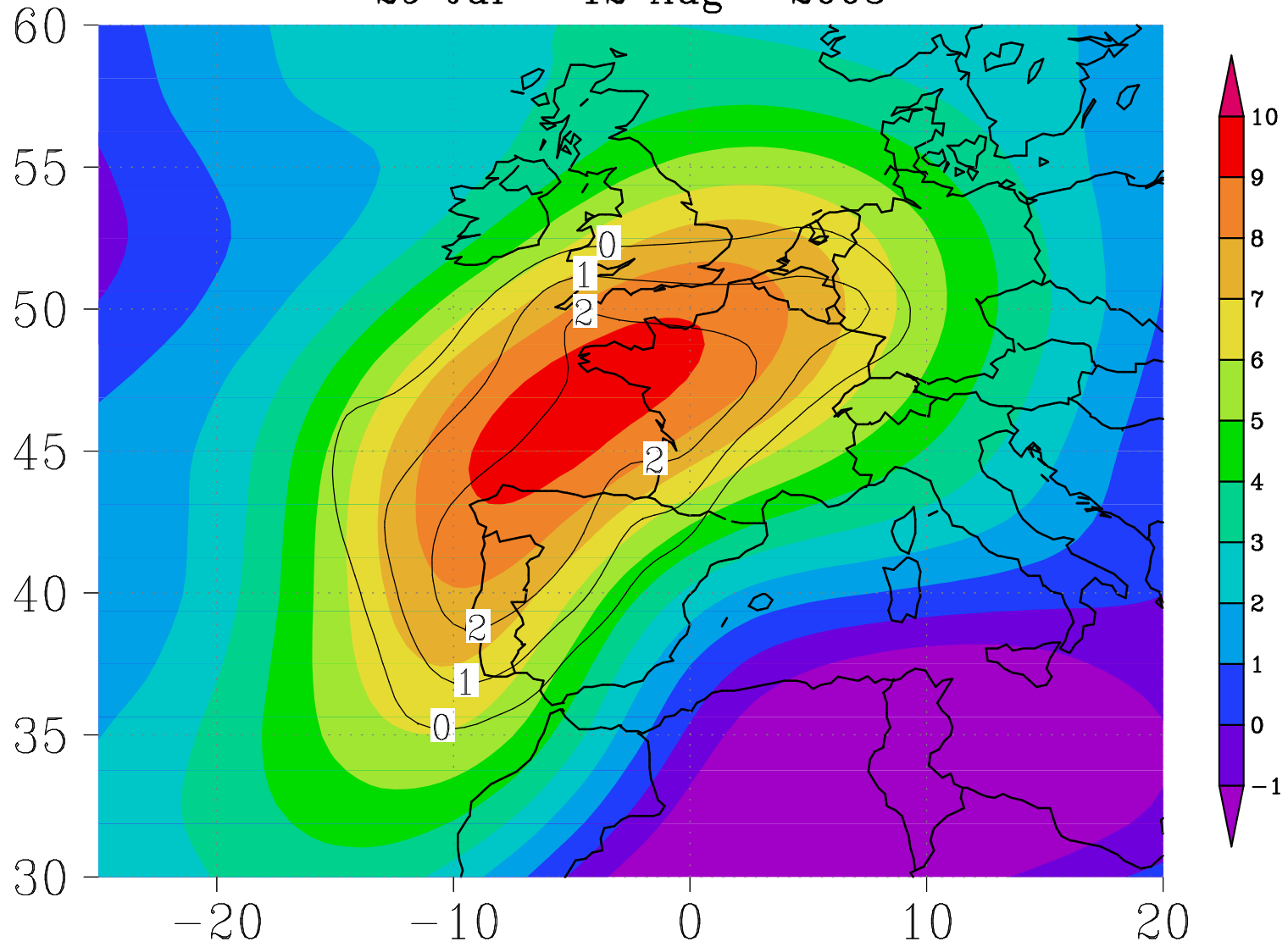
27 Jul - 10 Aug 2003



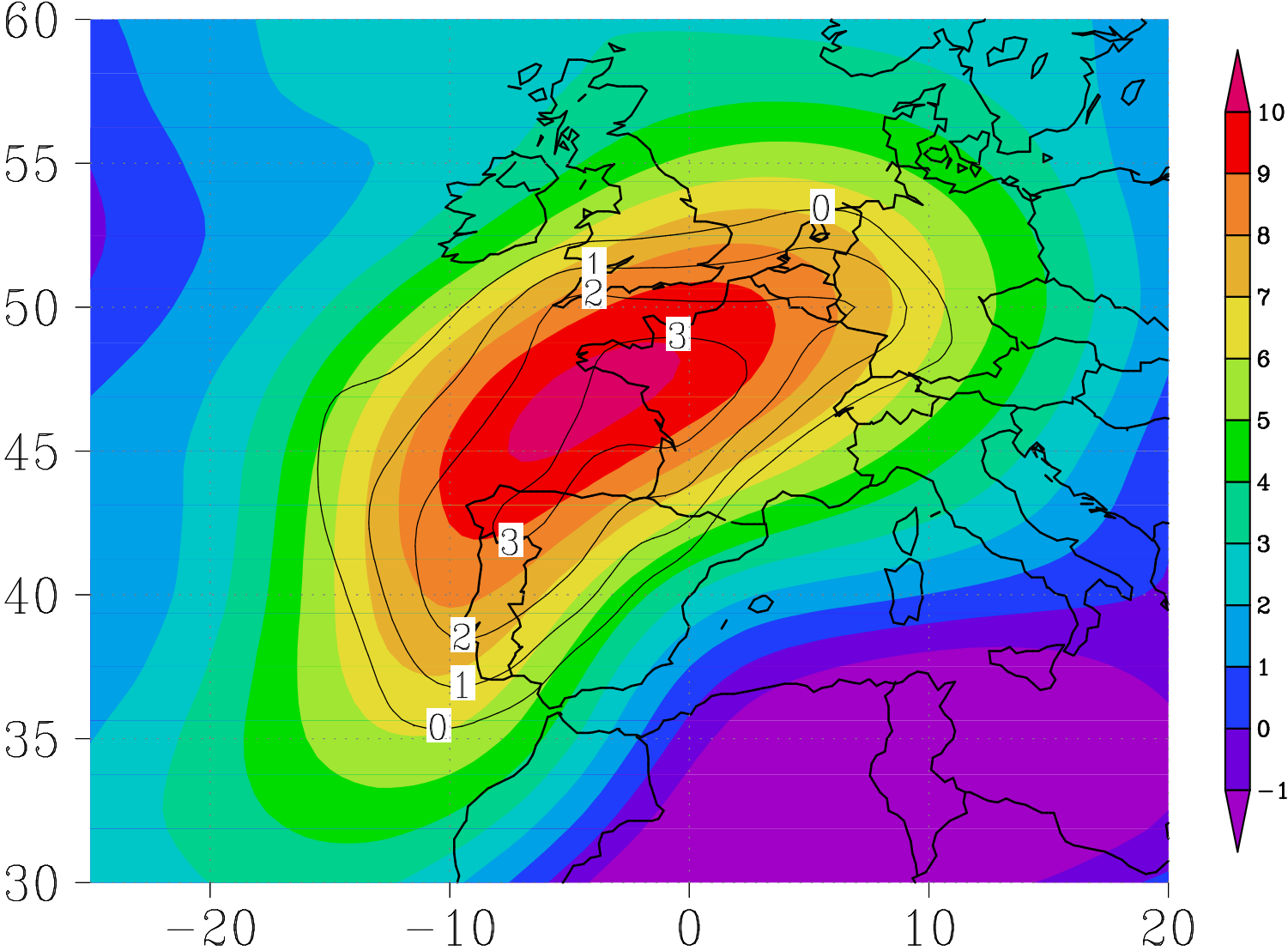
28 Jul - 11 Aug 2003



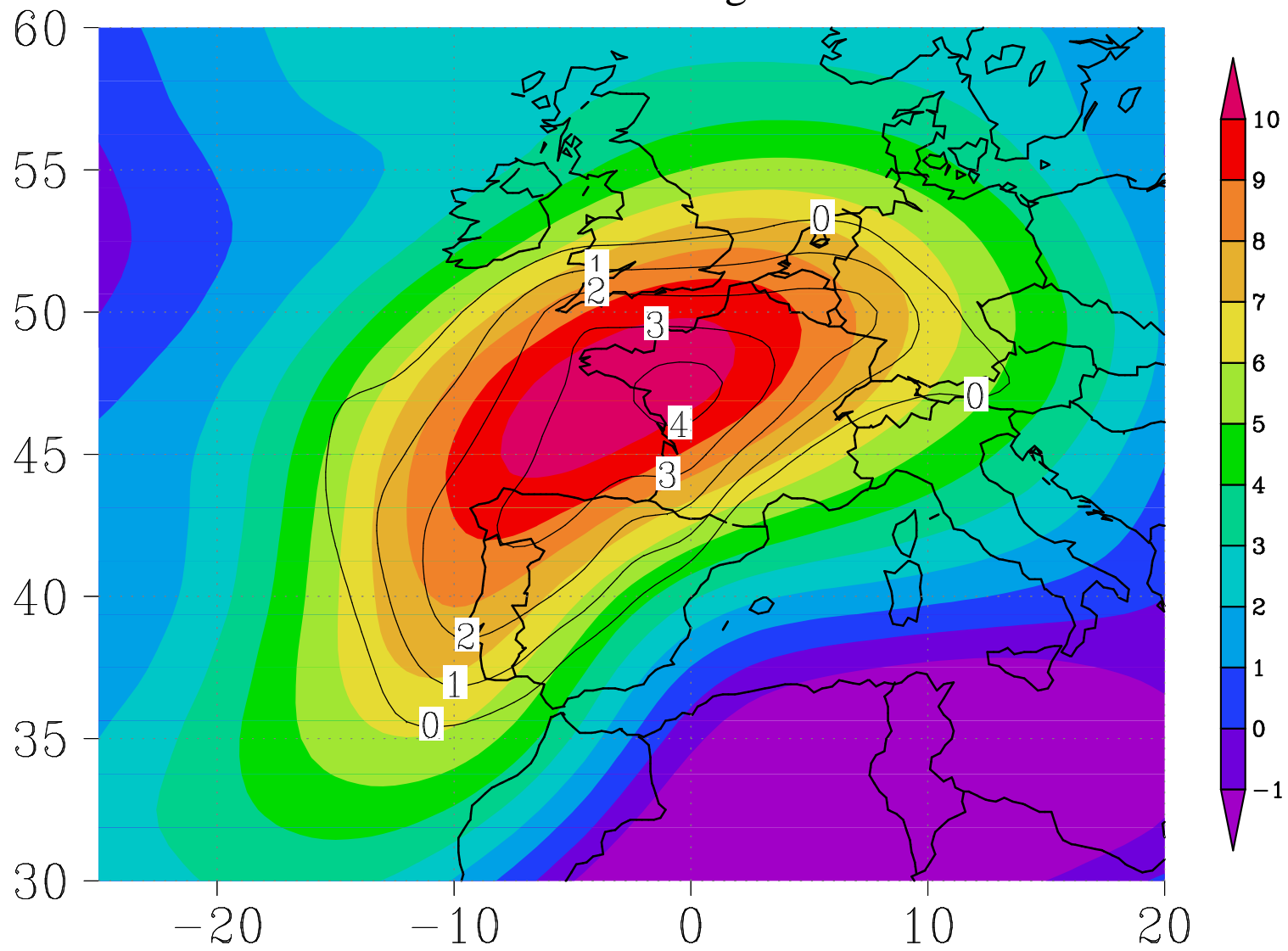
29 Jul - 12 Aug 2003



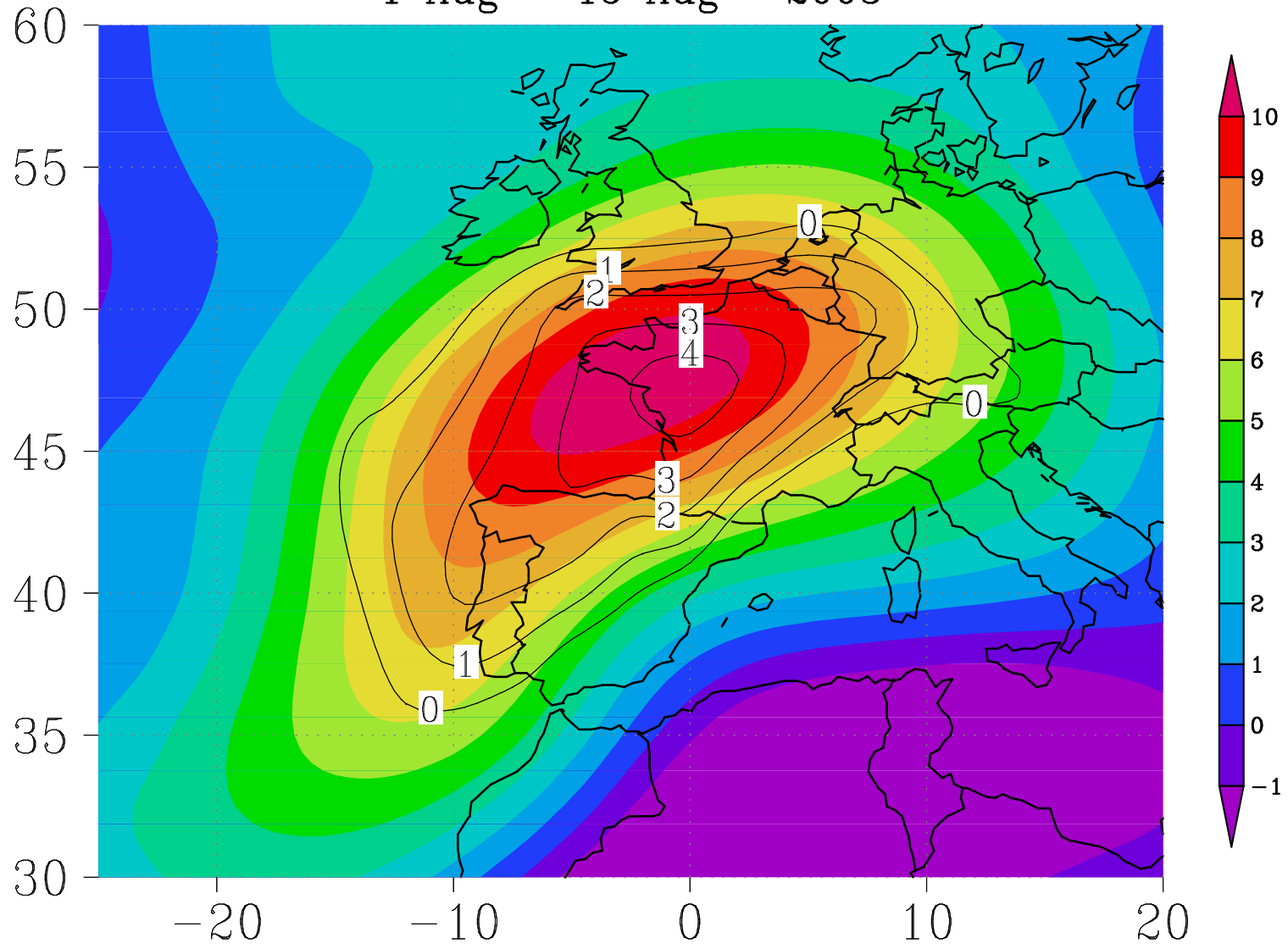
30 Jul - 13 Aug 2003



31 Jul - 14 Aug 2003

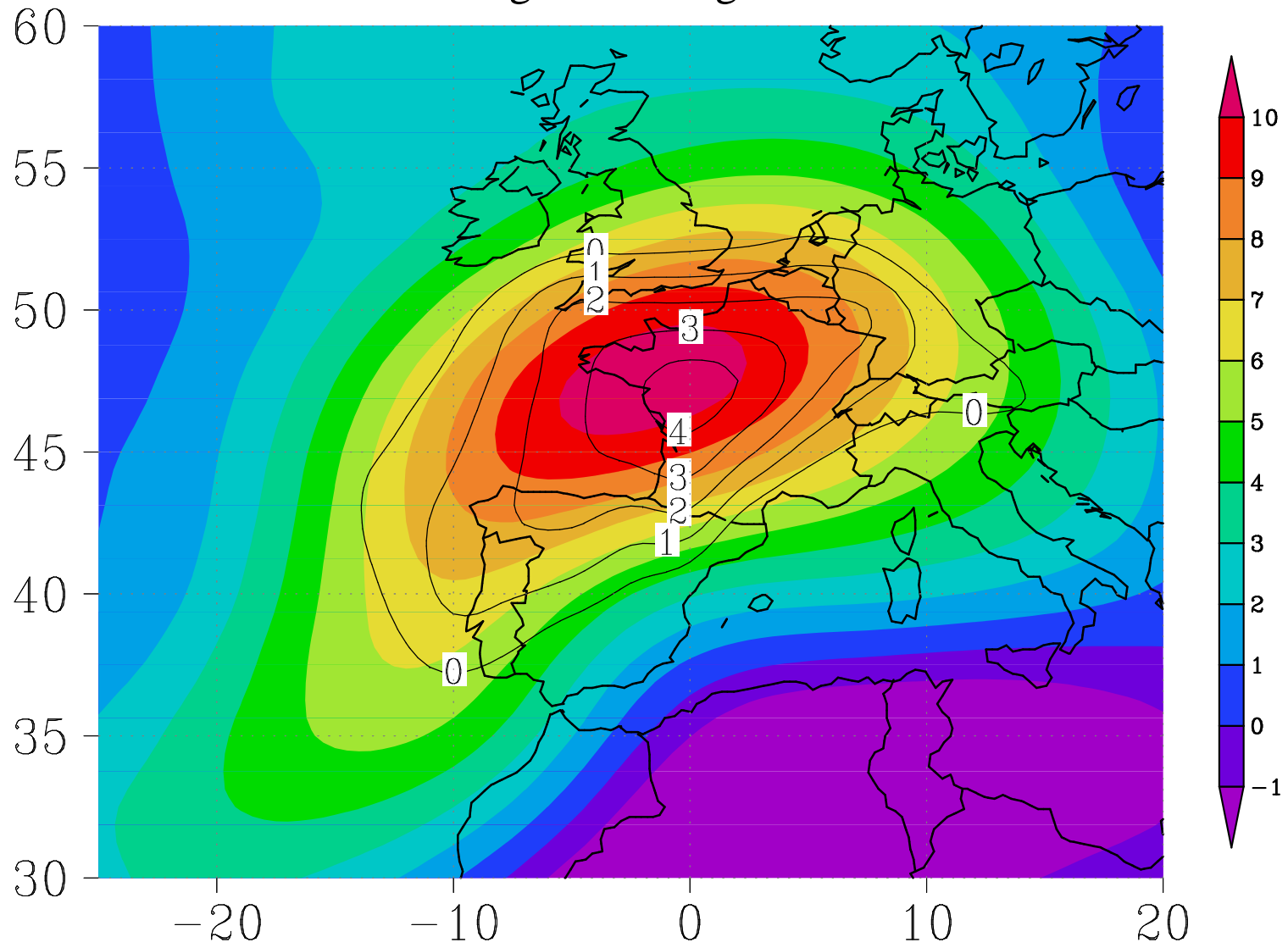


1 Aug - 15 Aug 2003

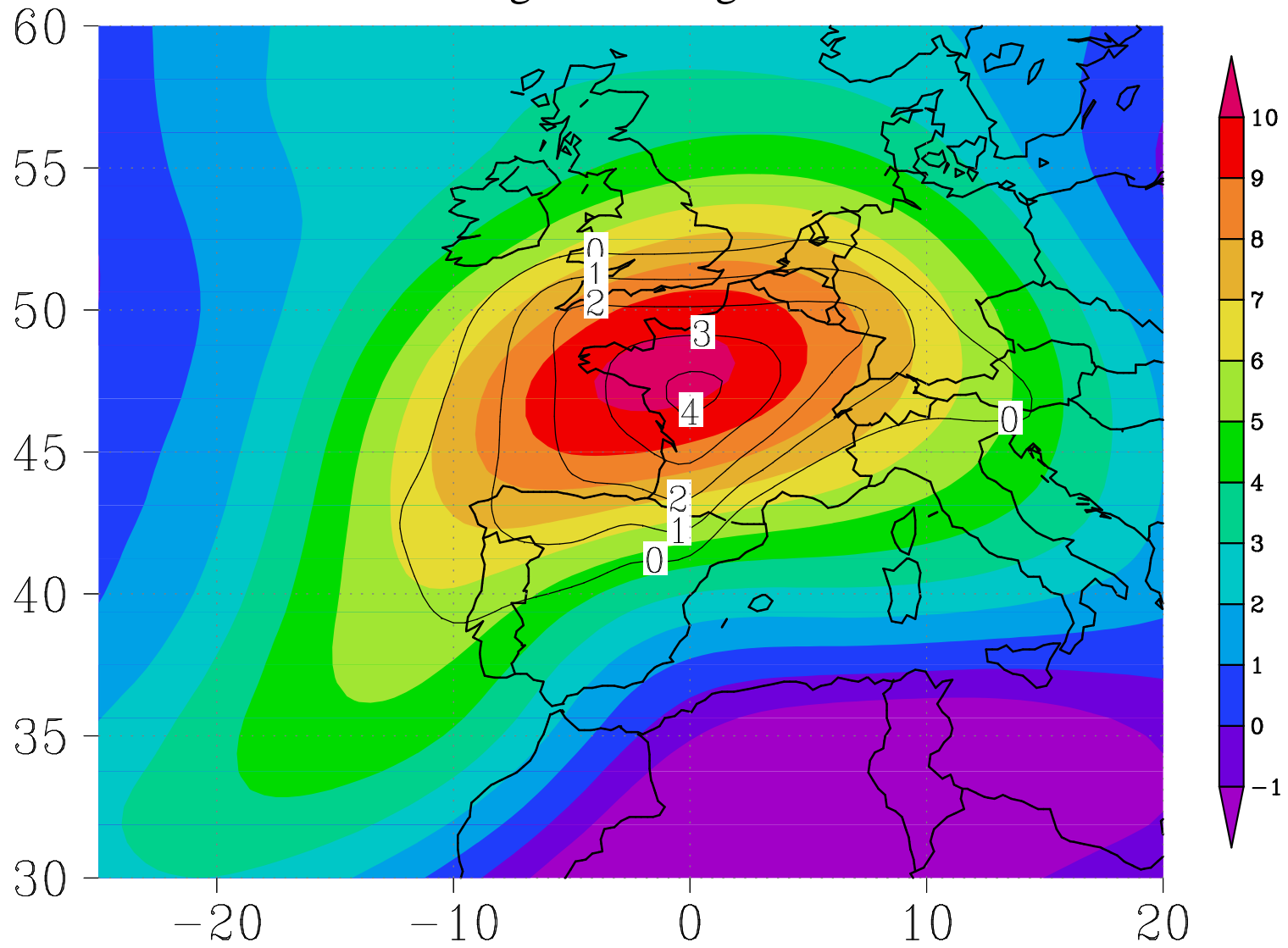




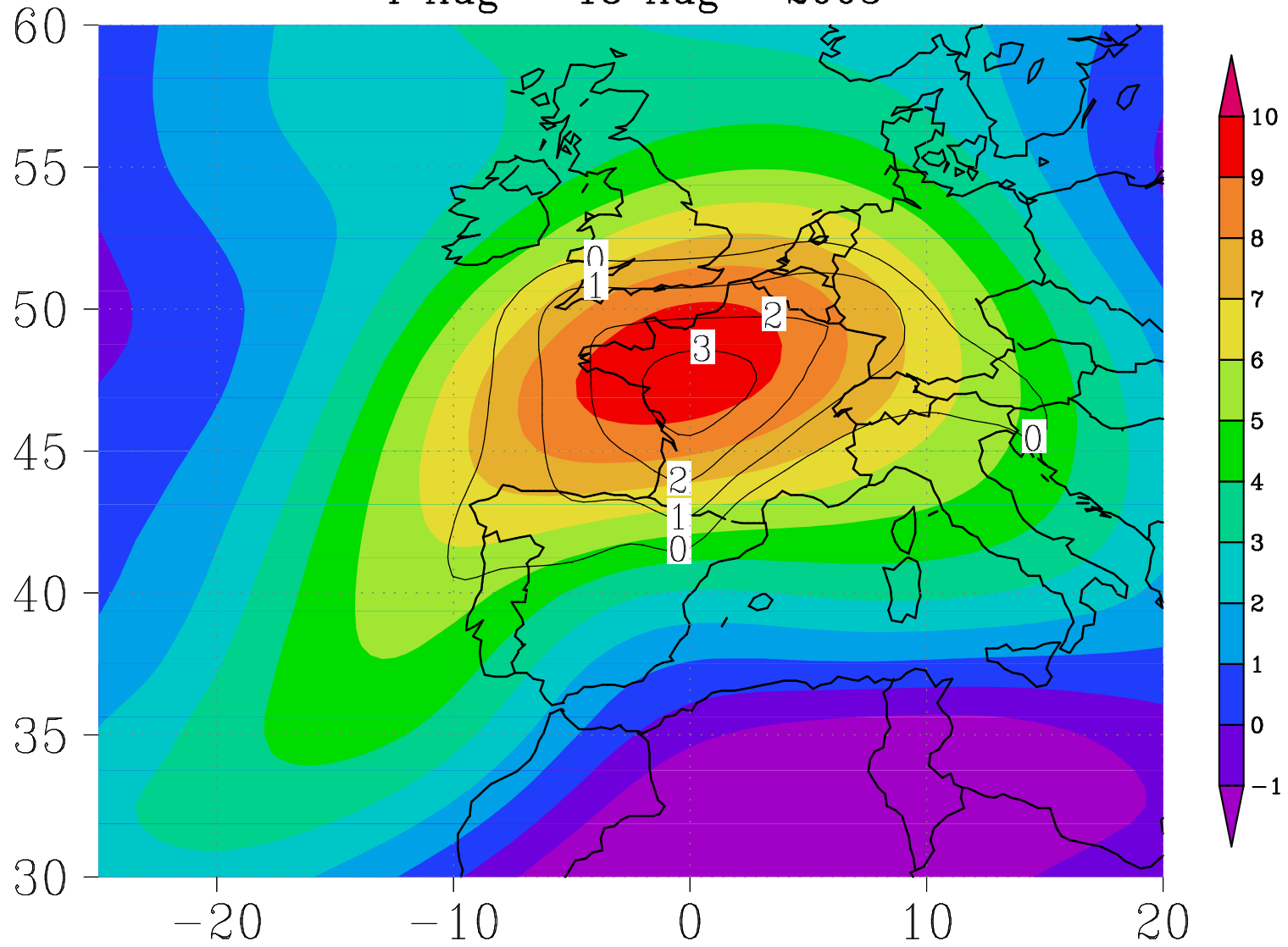
2 Aug - 16 Aug 2003



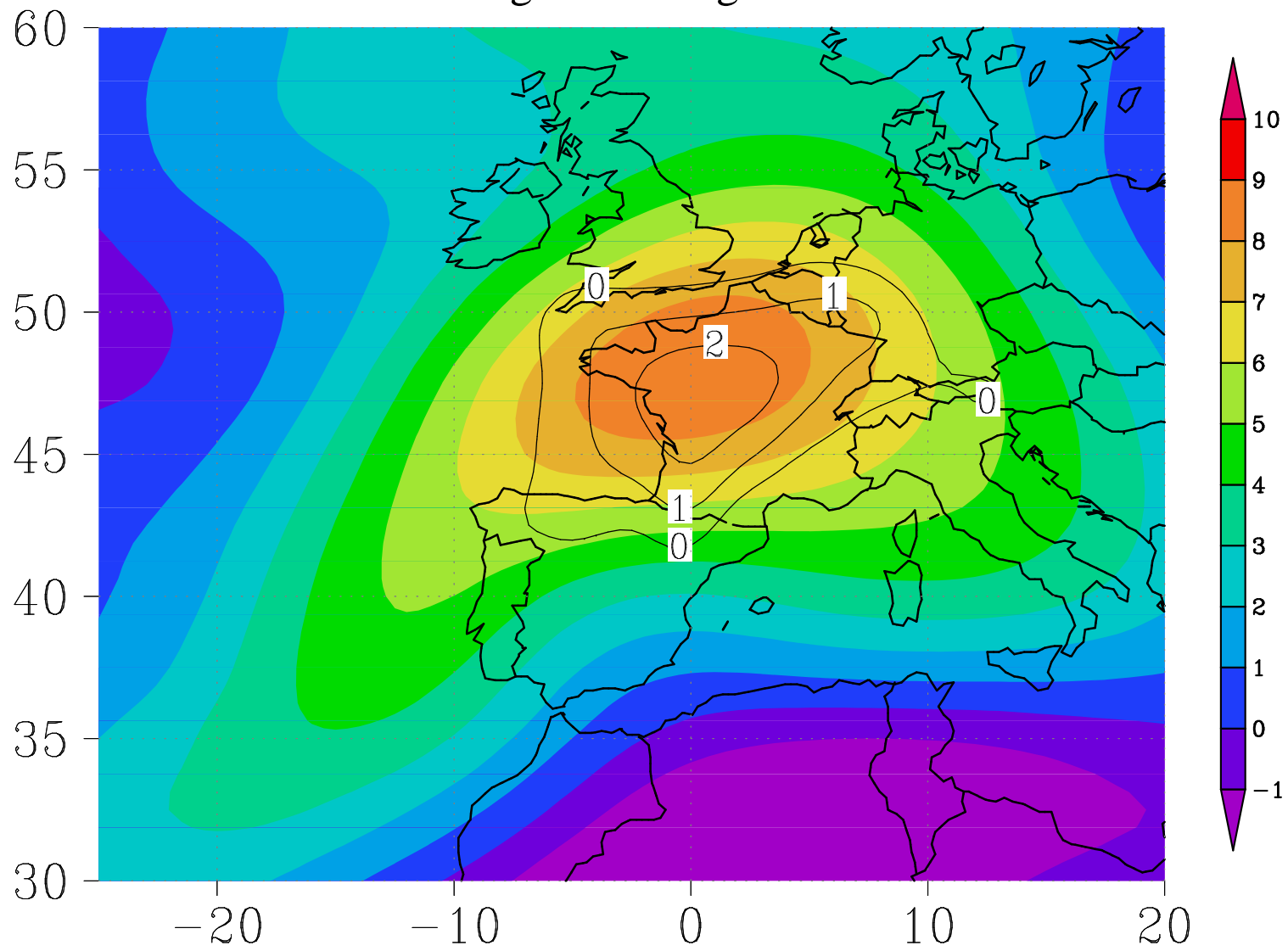
3 Aug - 17 Aug 2003



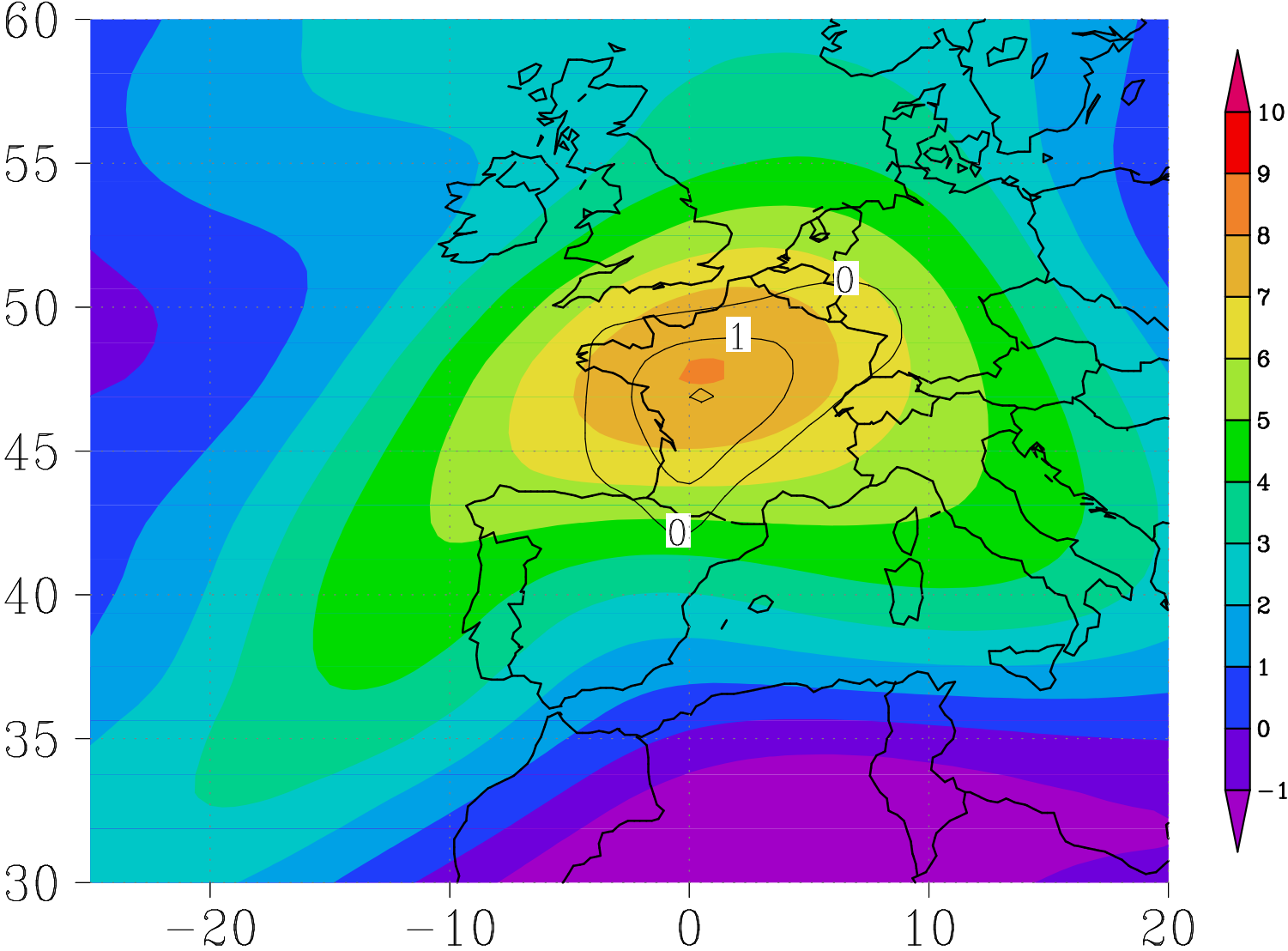
4 Aug - 18 Aug 2003



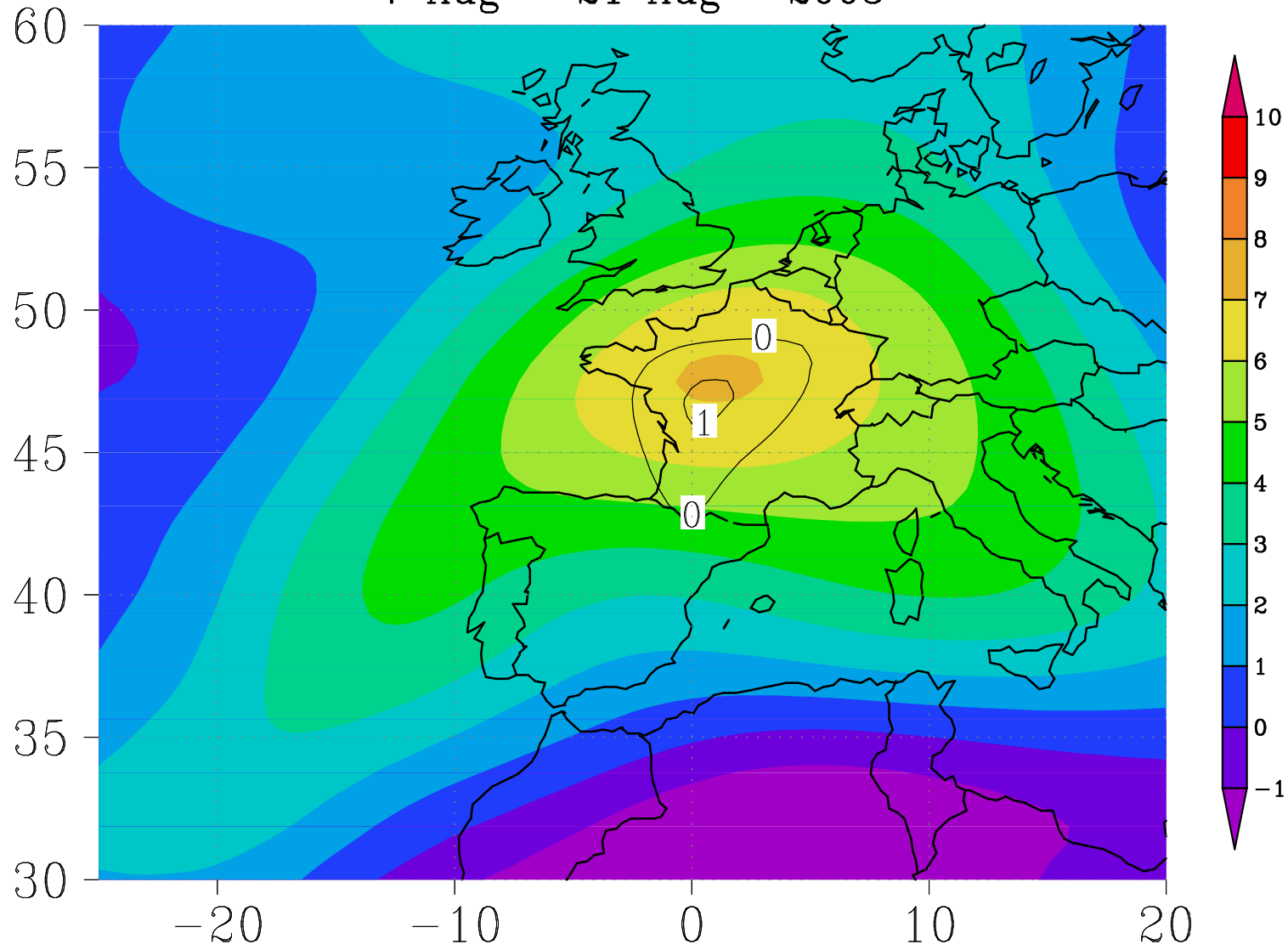
5 Aug - 19 Aug 2003



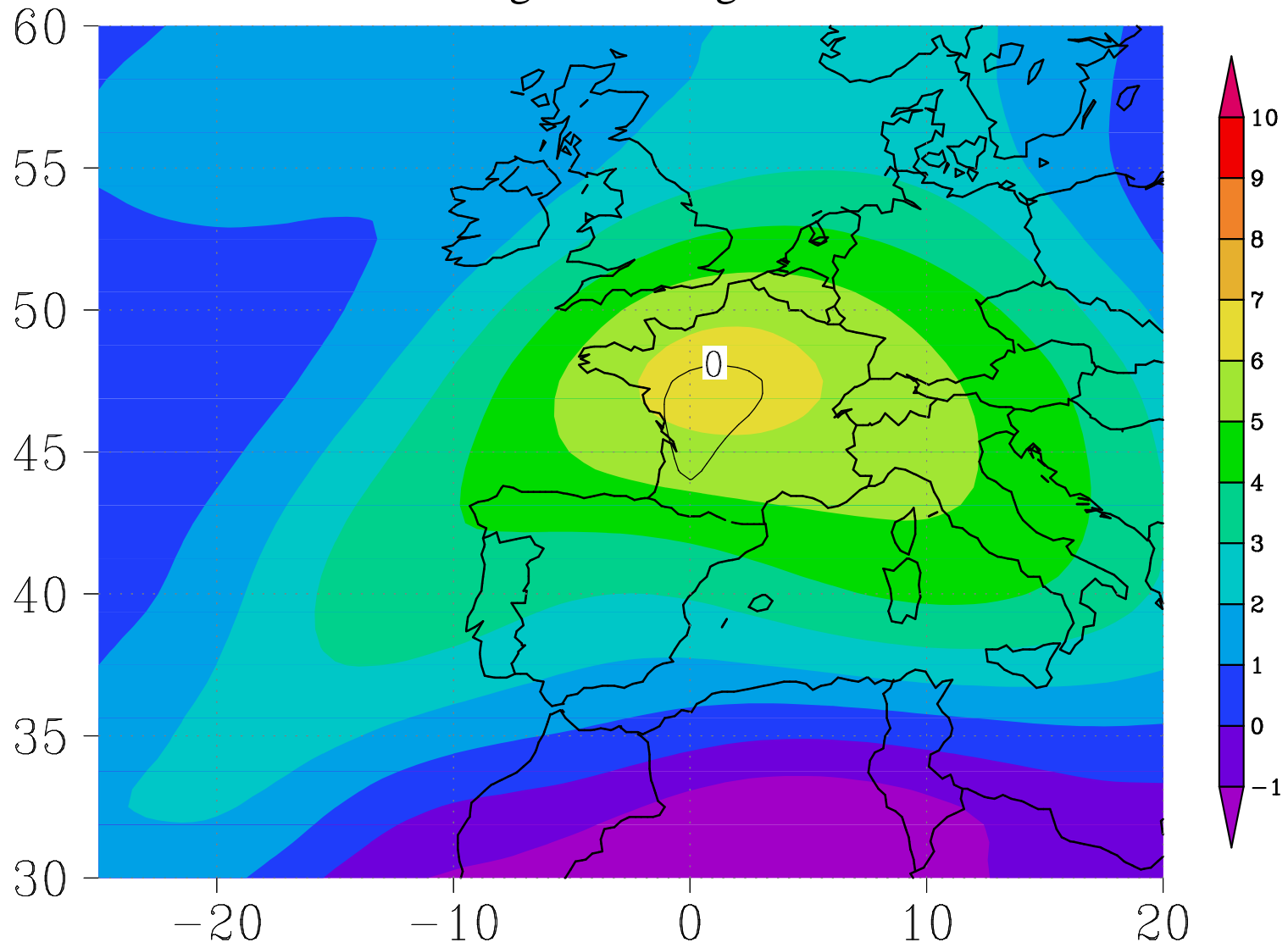
6 Aug - 20 Aug 2003



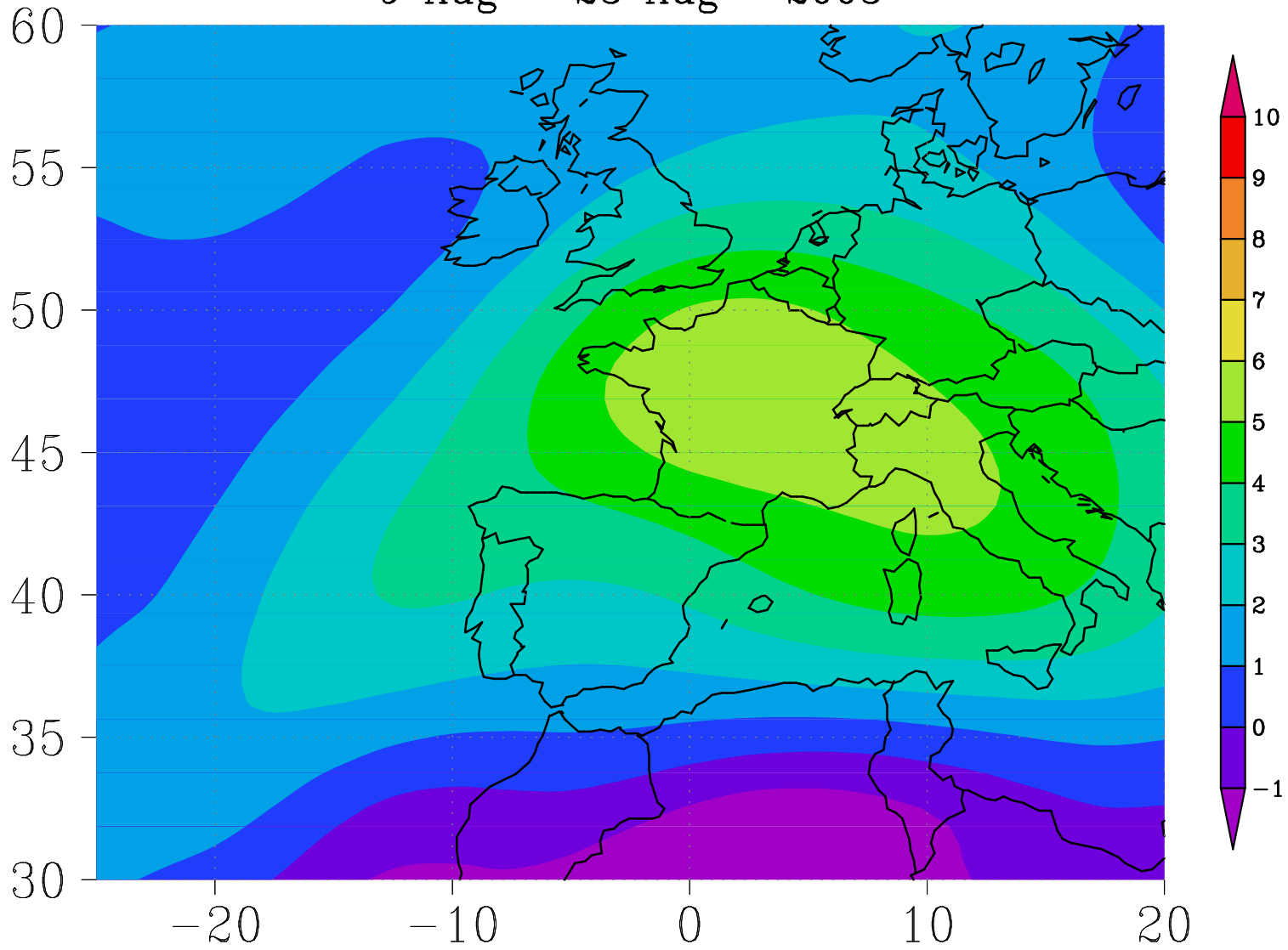
7 Aug - 21 Aug 2003



8 Aug - 22 Aug 2003



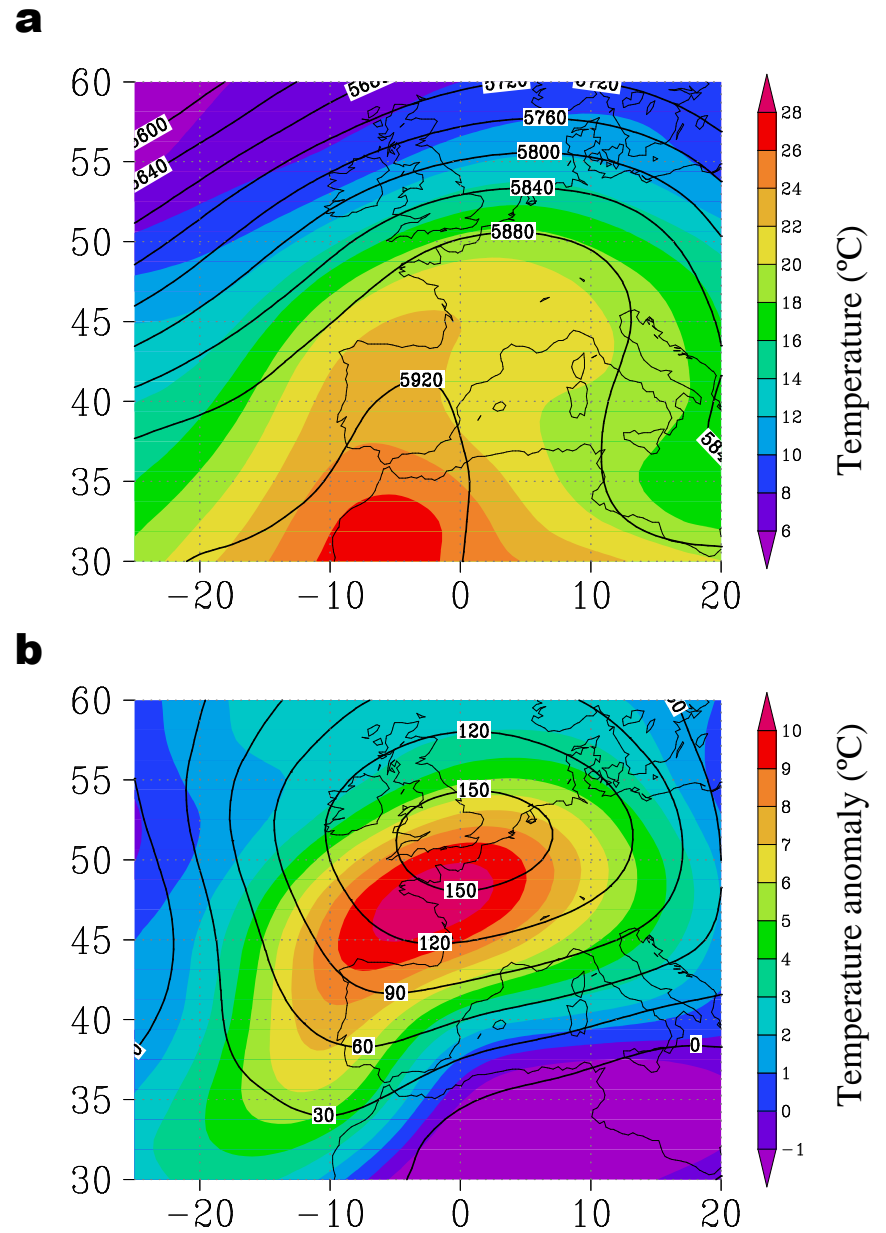
9 Aug - 23 Aug 2003





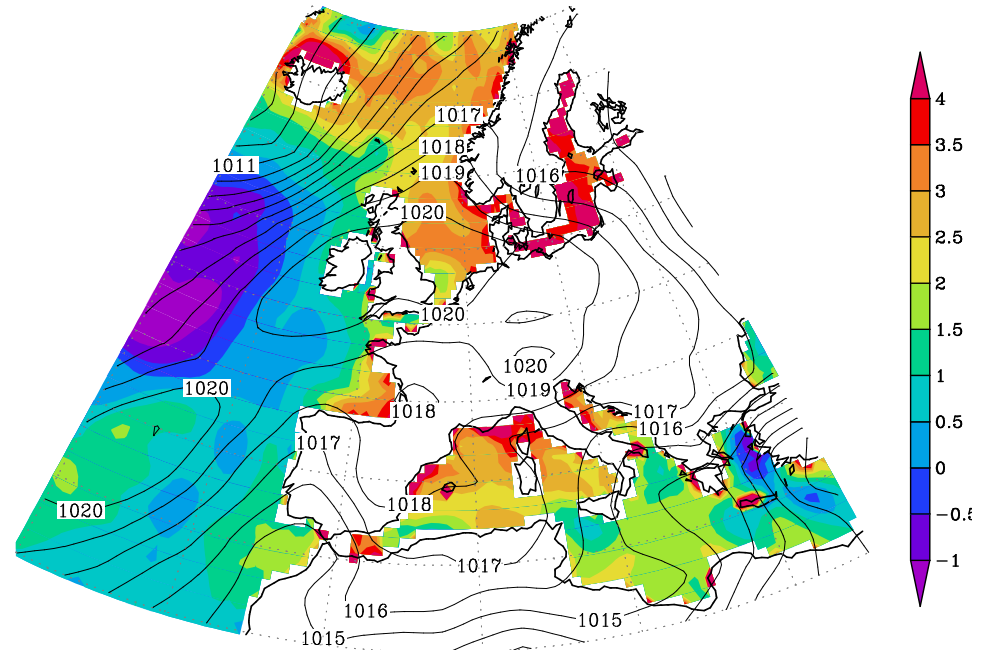
# Short-term mechanism: Record **blocking** episode

(Trigo et al., 2005, GRL)



## Long-term mechanism 1

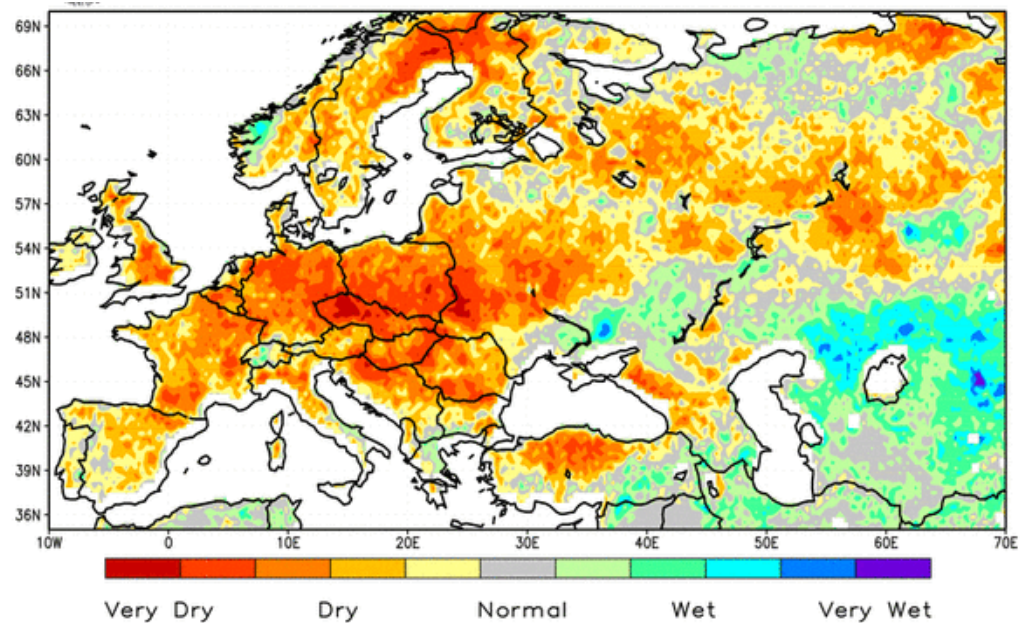
Record high SST between  
May and August

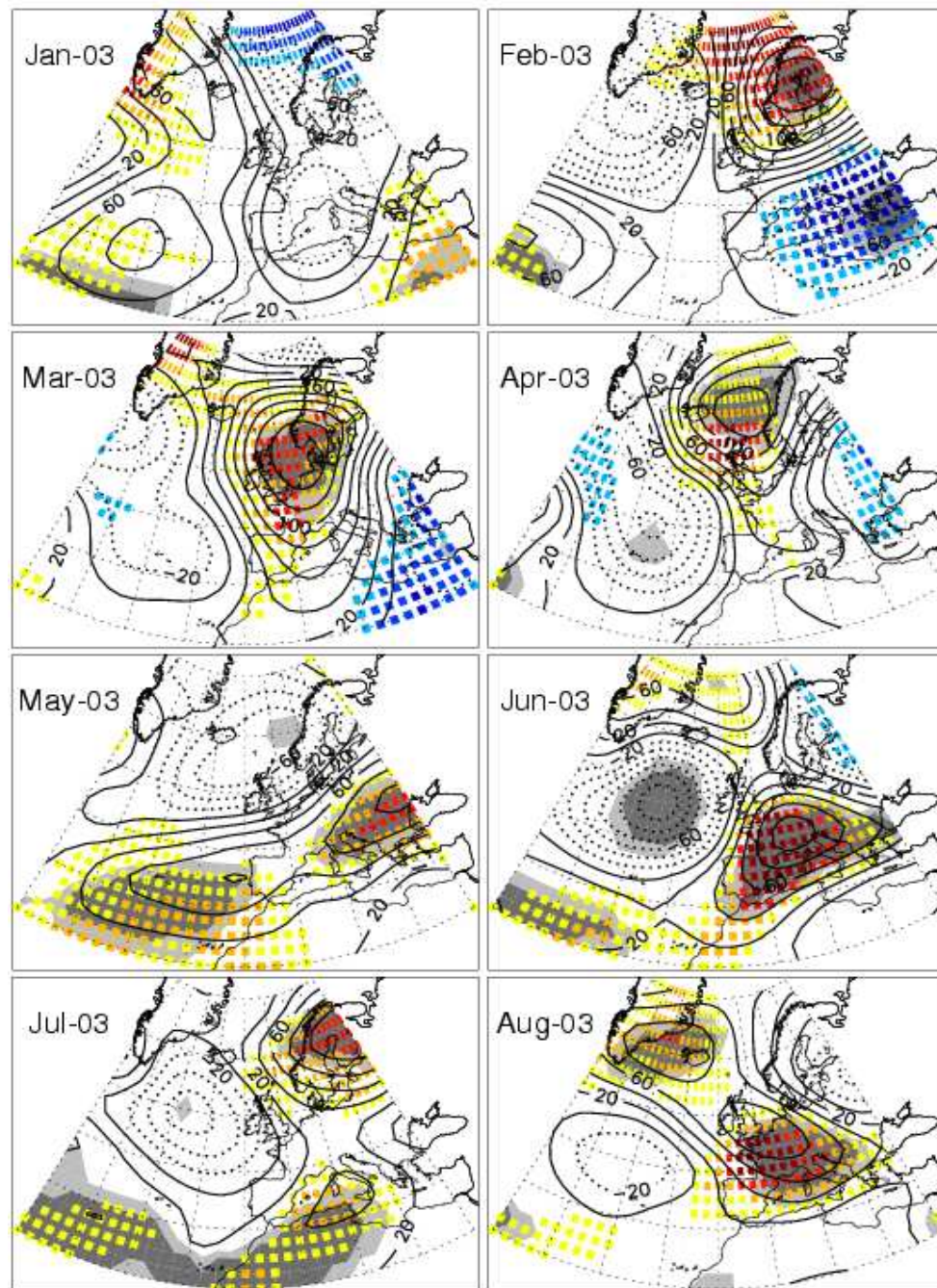


## Long-term mechanism 2

Anomaly field of surface liquid water  
derived from satellite measurements  
for summer (JJA) 2003.

Climatology for the 1988-2003 period

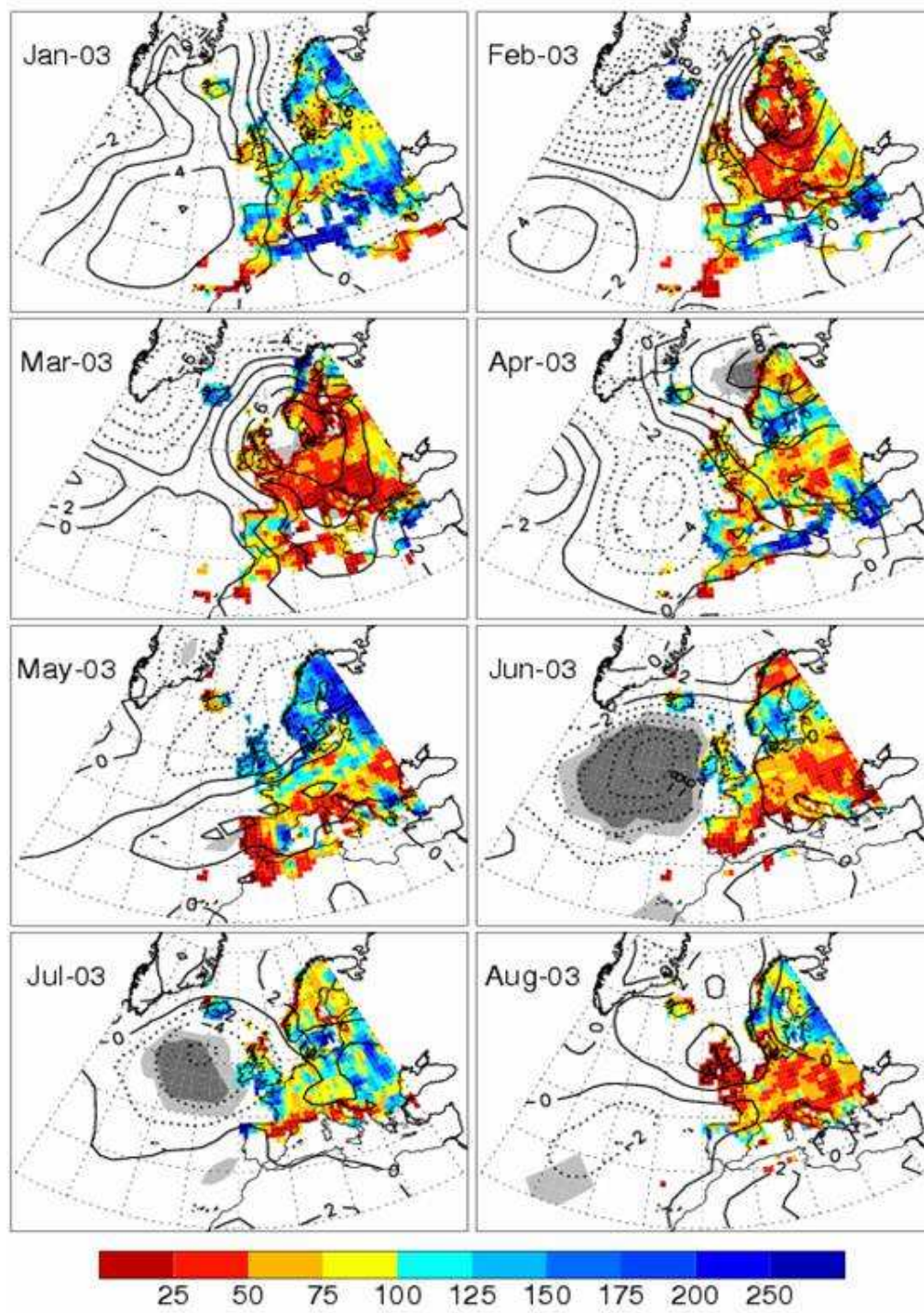


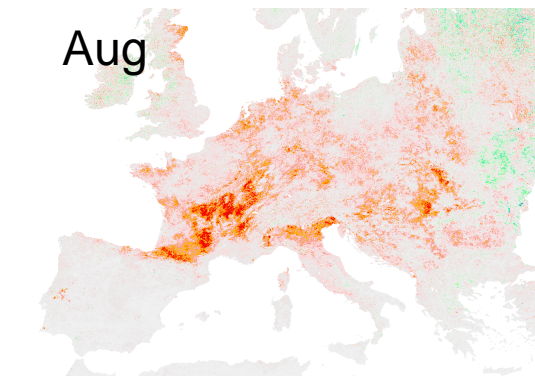
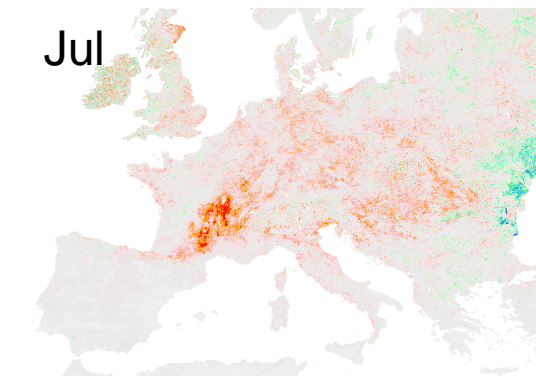
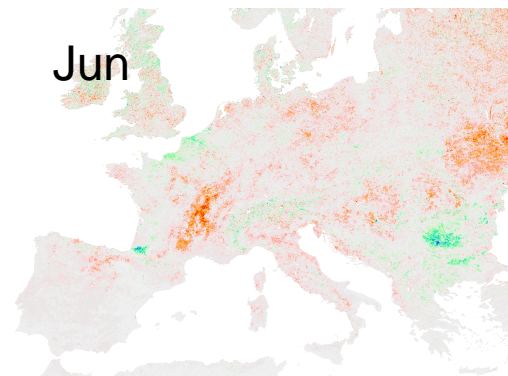
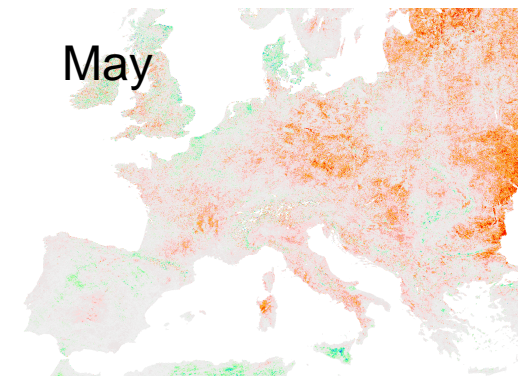
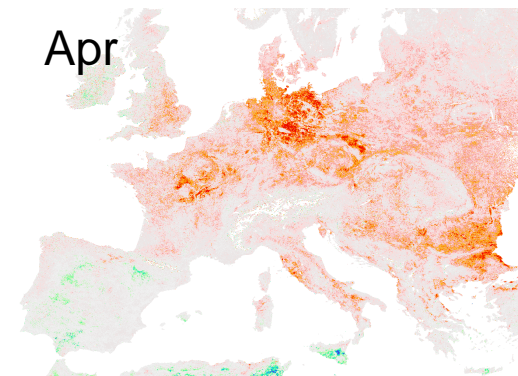
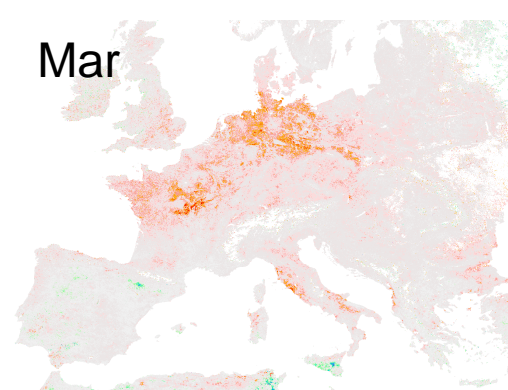
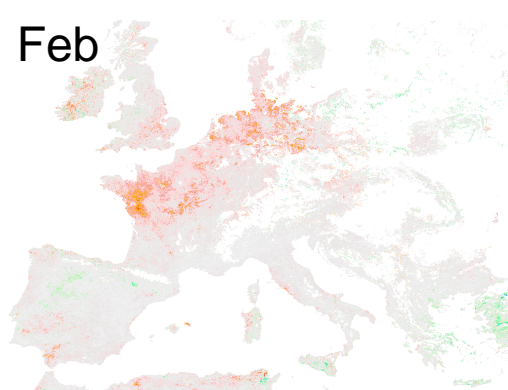
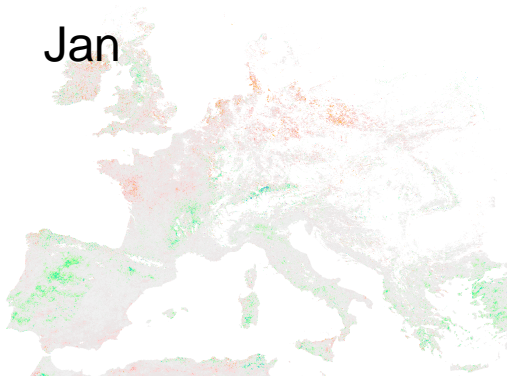


Garcia-Herrera et al. (2009)



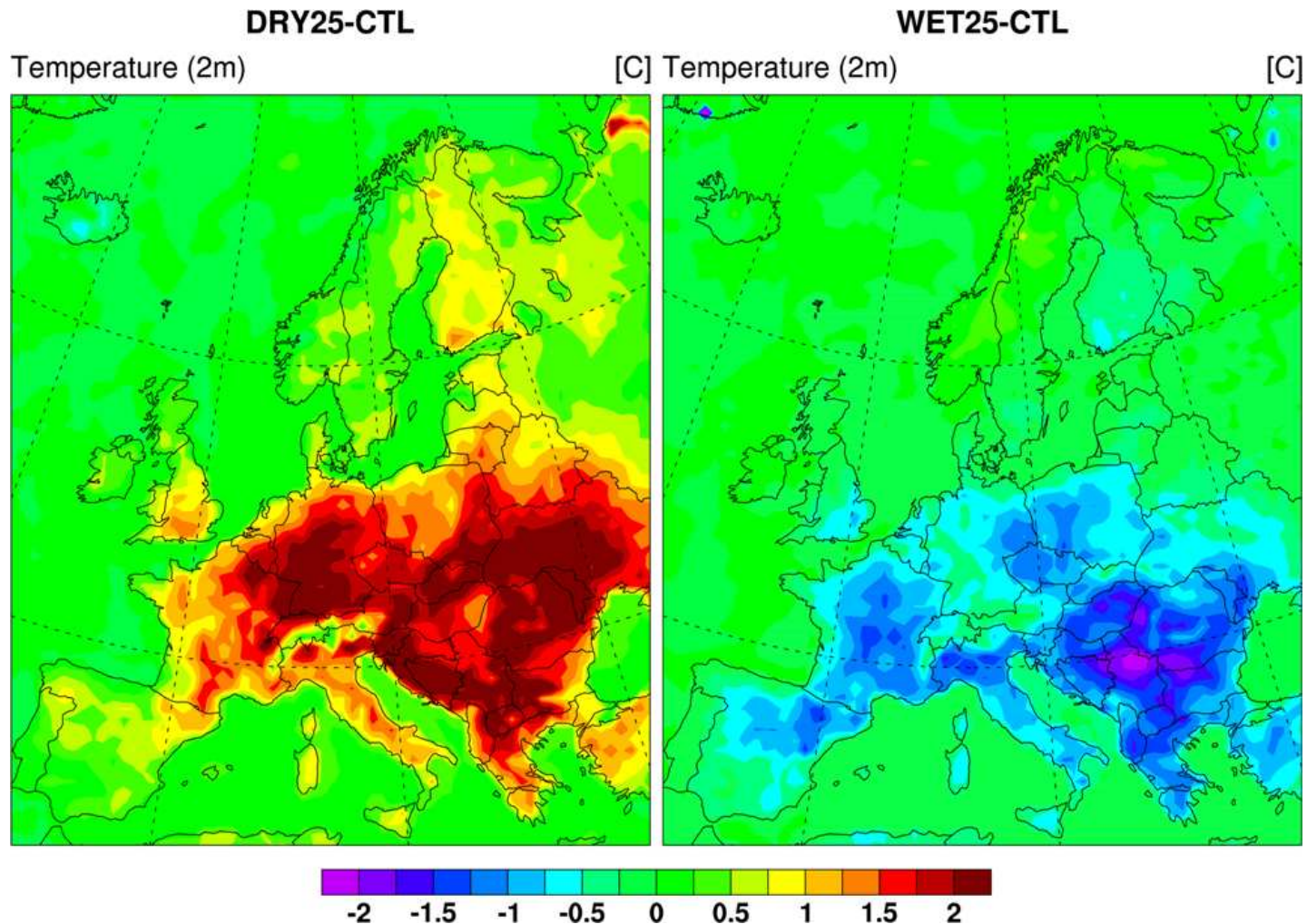
Garcia-Herrera et al. (2009)





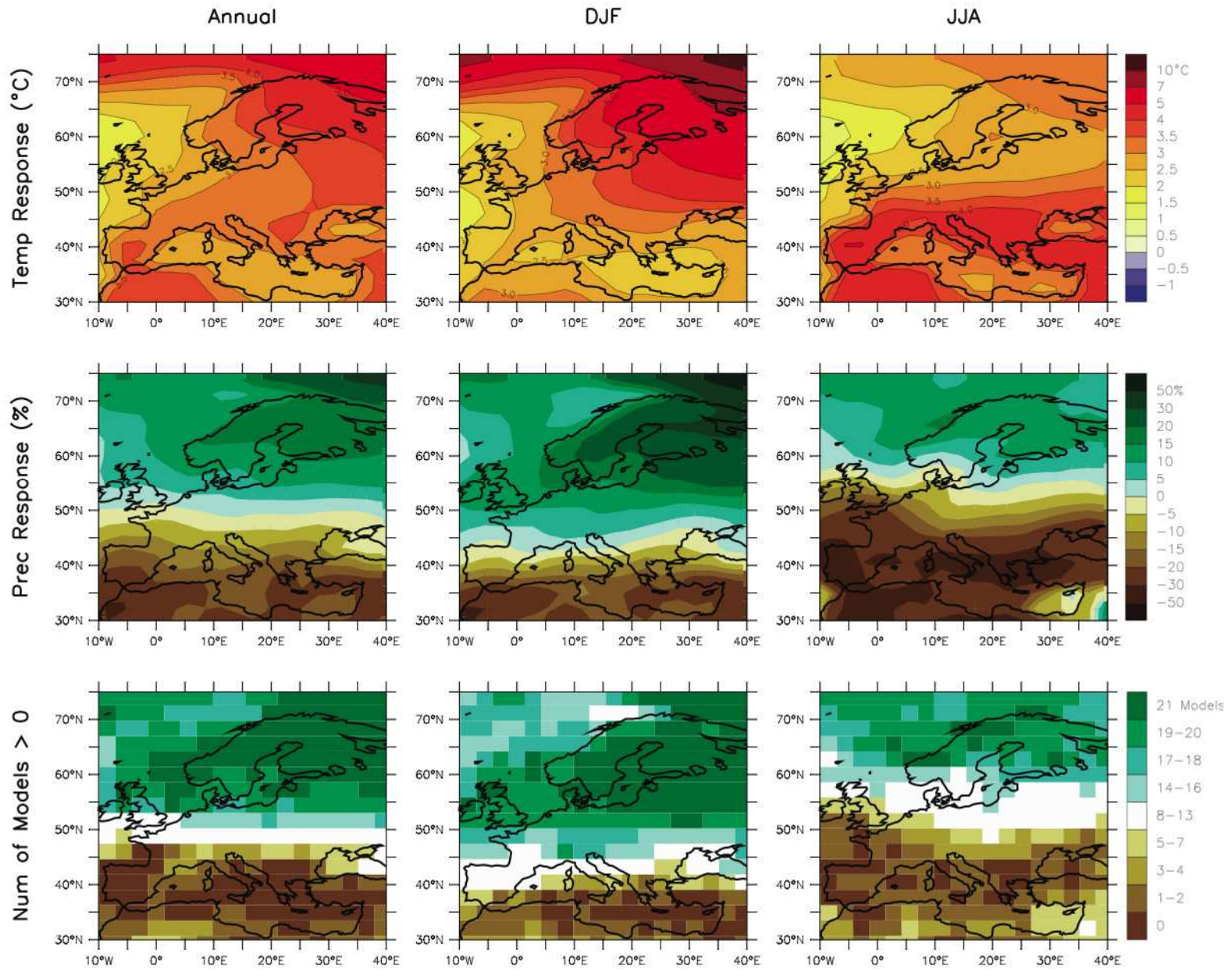
NDVI





**Figure** Simulated summer temperature (at 2m) anomalies due to spring soil moisture perturbation in (a) DRY25-CTL and (b) WET25-CTL experiments (CHRM regional climate model). The anomalies were averaged for summer (JJA) 2003 wrt to a model climatology 1970-2000 (Fischer et al. 2007)

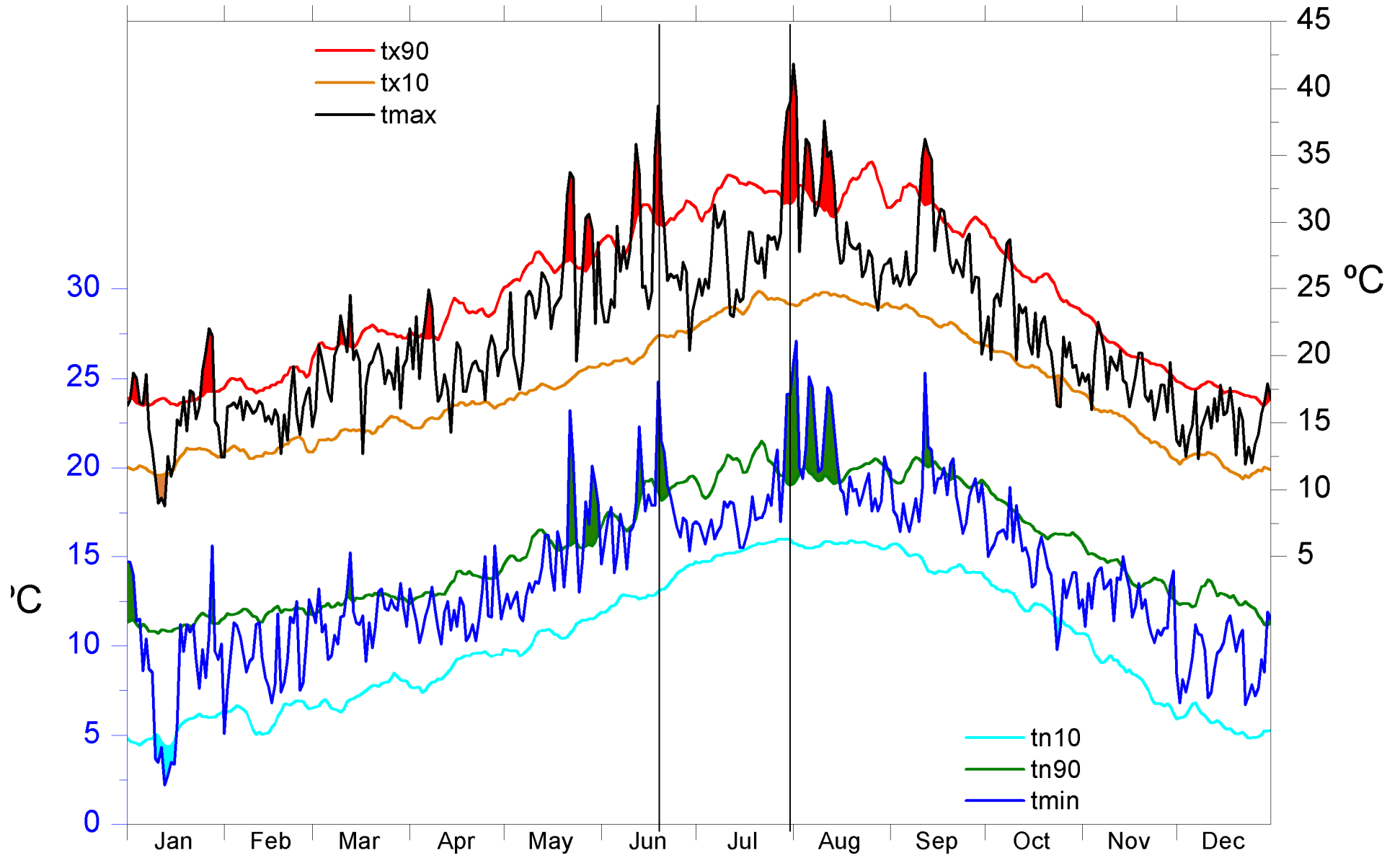
# Temperature and precipitation changes over Europe (A1)



## **Sub-weekly analysis**



# Lisbon 2003



# Wildfires in Portugal

The outstanding summer 2003  
fire season

(Total burnt area: **450.000 ha**)

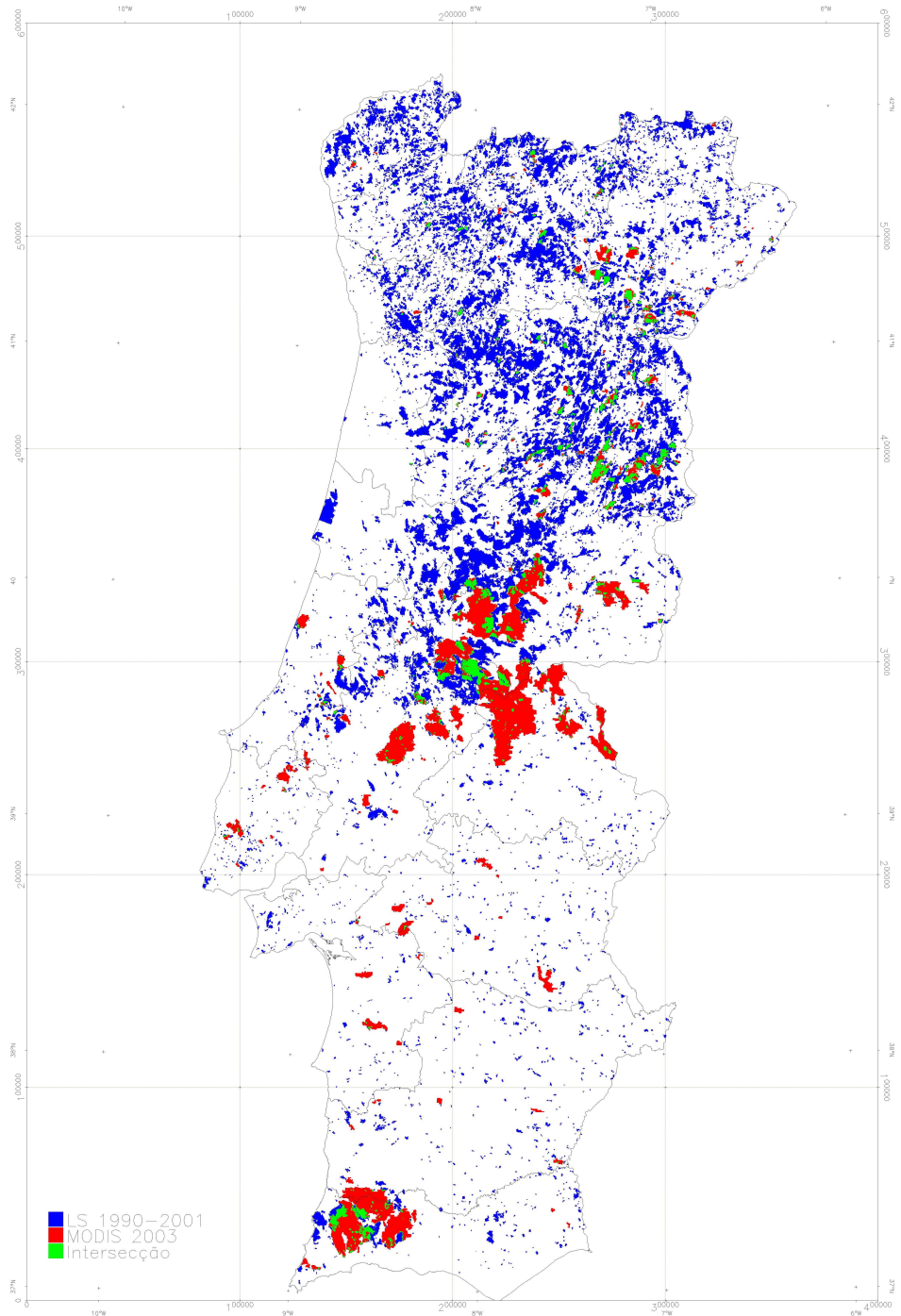
(Equivalent to the rest of Europe)

**Blue:** burned between 1990-2001

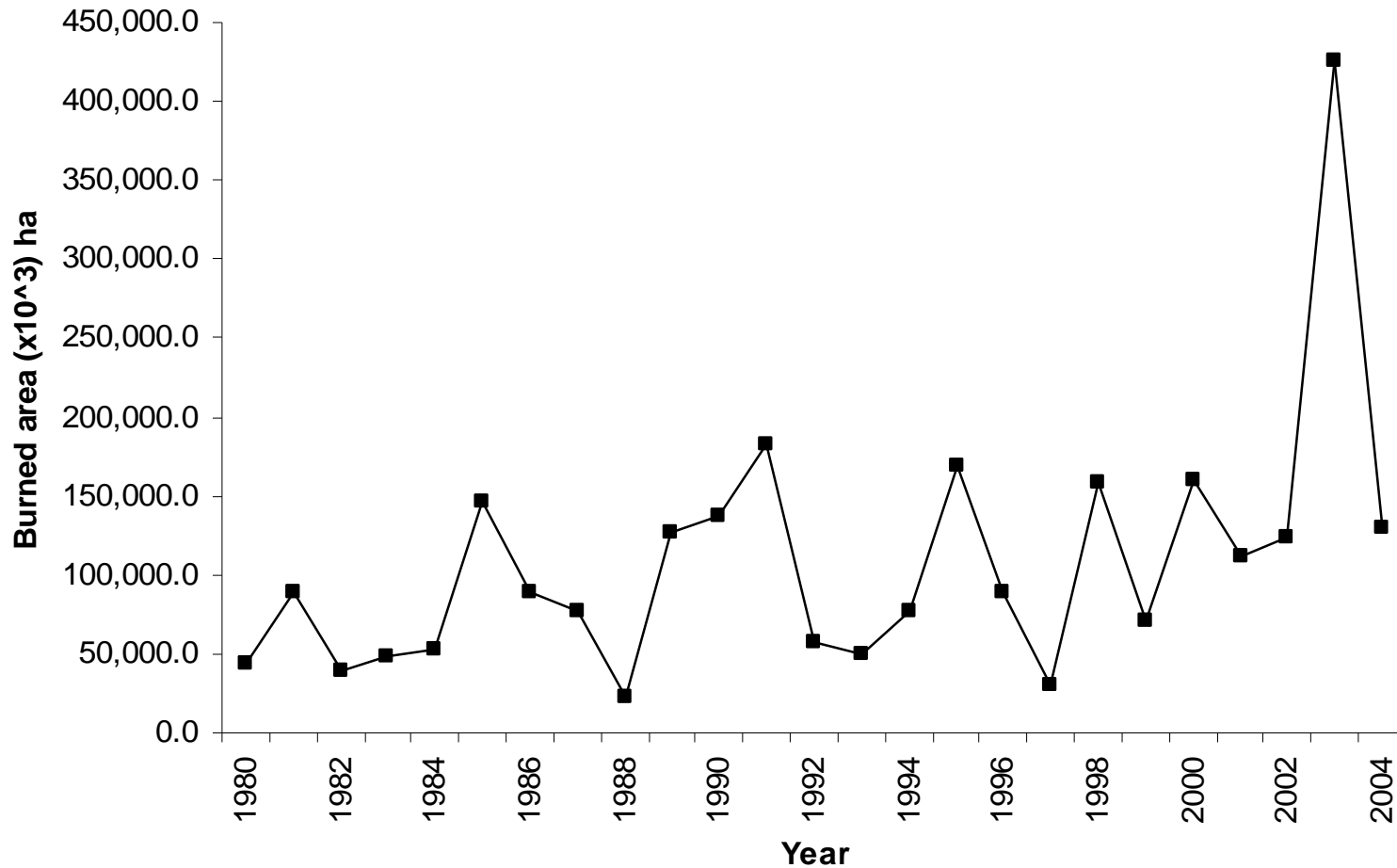
**Red:** burned only 2003

**Green:** burned in 2003 and before

(Trigo et al., 2006)



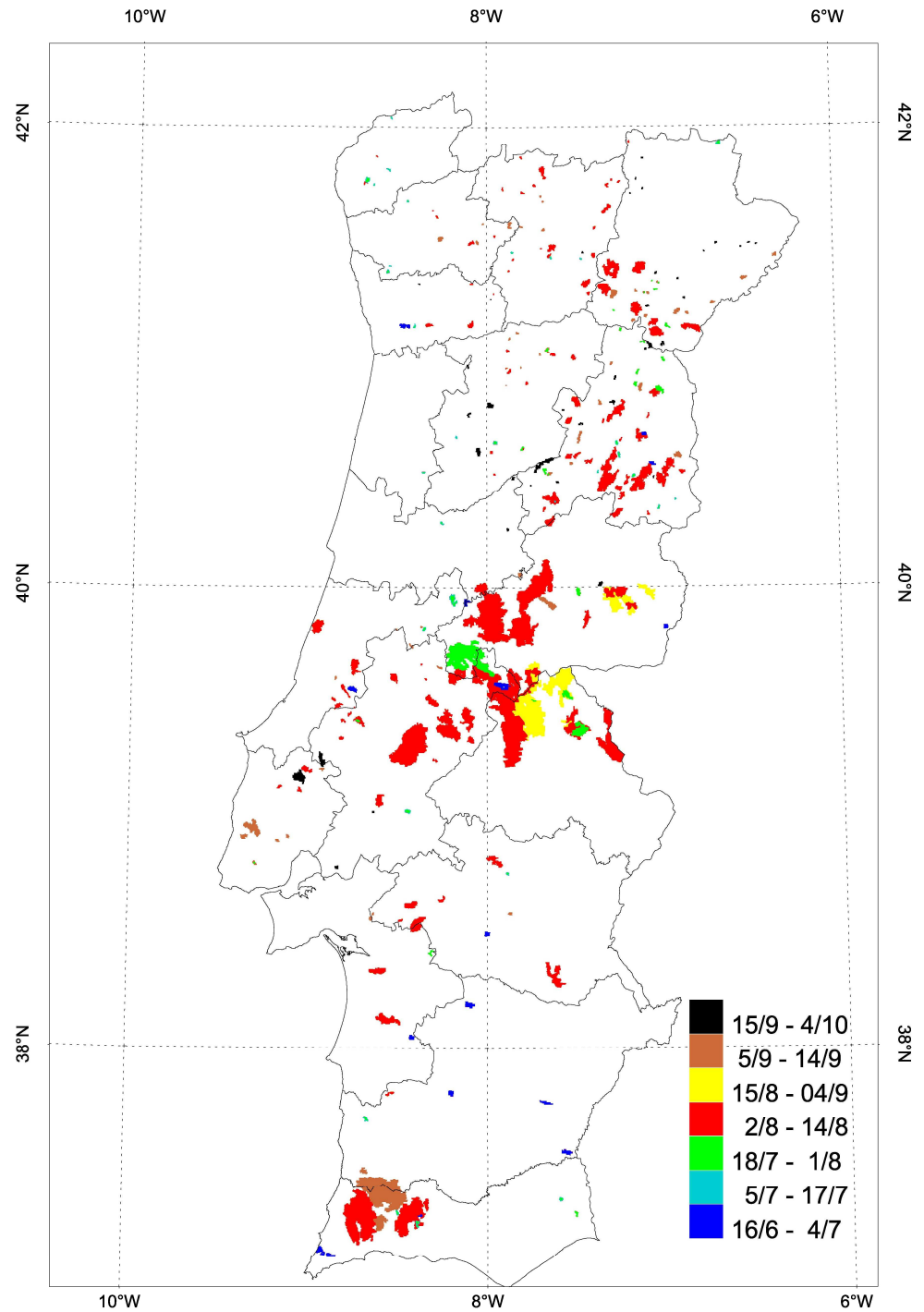
Annual values of total burnt area between 1980 and 2004 compiled by the Portuguese Forest Institute (DGRF).



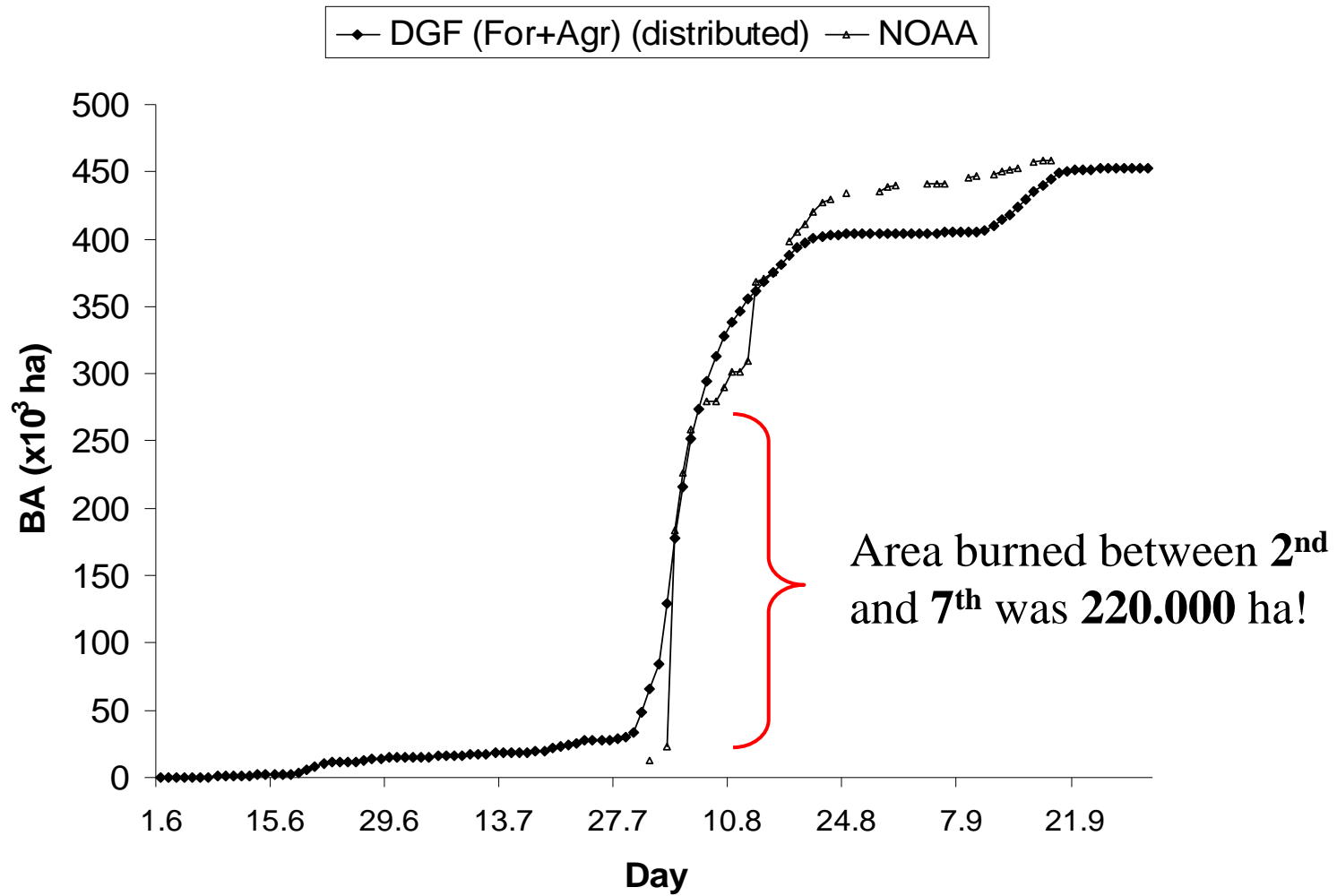
Garcia-Herrera et al. (2009)

Total burnt area: **450.000 ha**  
Mostly during the first 2 weeks  
of August (red colour)

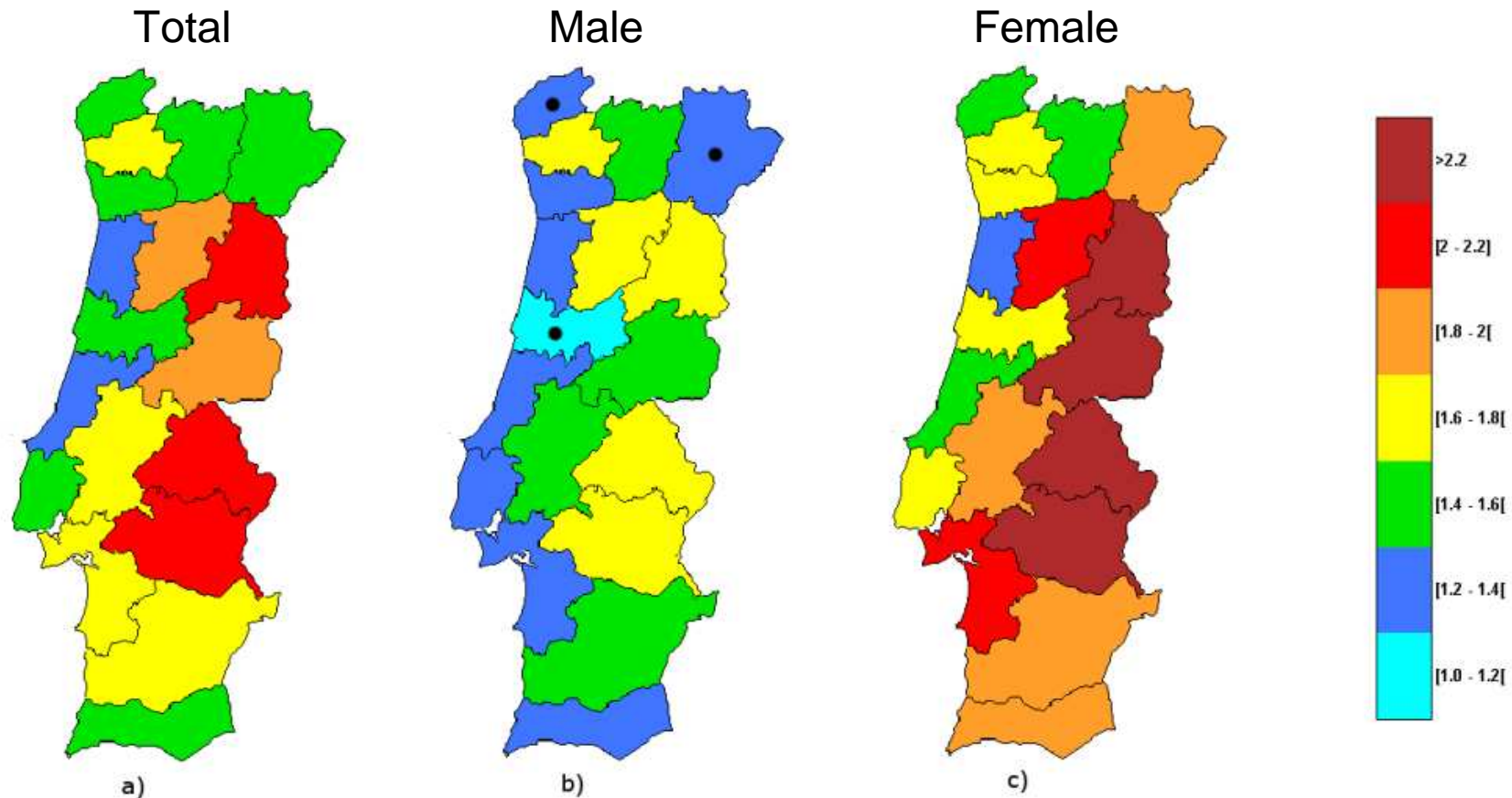
**Garcia-Herrera et al. (2009)**



## Acumulated BA (2003)



# Mortality per District and Gender



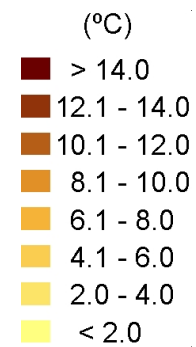
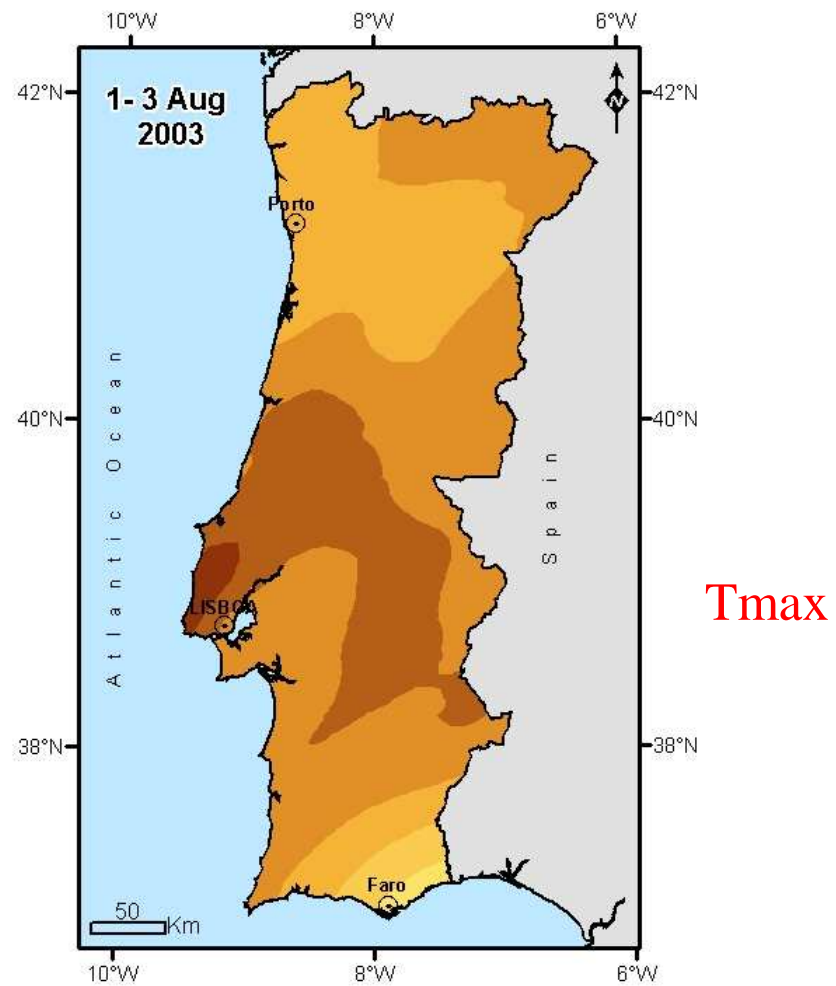
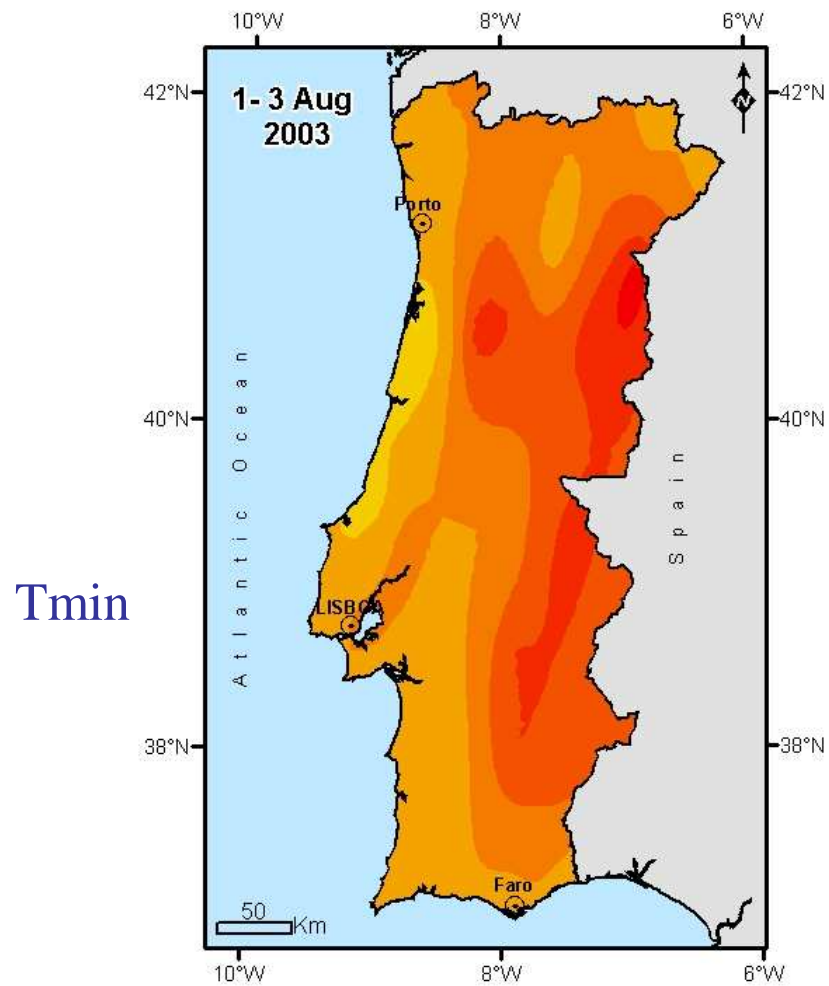
Spatial variability of the Observed/Expected (O/E) ratio per district, considering (a) the total population (b) male and (c) female population. All the increments are statistically significant (5% significance level) except those identified with the black dots.

**Trigo et al. (2009, in revision)**

Table 1 – Observed (O) and expected (E) deaths for the period 30 July - 15 August of 2003. Also shown are estimates of excess deaths (O-E) and O/E ratio. Expected mortality computed using the 2000-2004 period.

	Observed Deaths (O)		Expected Deaths (E)		Excess of Deaths (O-E)		O/E		p	
	M	W	M	W	M	W	M	W	M	W
<b>Men</b>	2974		2110.5		863.5		1.41		p < 0.001	
<b>Women</b>	3495		1960.3		1534.8		1.79		p < 0.001	
<b>Total</b>	6469		4070.8		2398.25		1.58		p < 0.001	
<b>Age Groups</b>										
<b>0-14</b>	21	26	21	18.3	0	7.8	1.00	1.42	1.000	0.102
<b>15-24</b>	38	16	37	9.5	1	6.5	1.03	1.68	0.913	0.067
<b>25-44</b>	191	64	164.5	54.8	26.5	9.3	1.16	1.17	0.039	0.240
<b>45-64</b>	476	229	395.25	197.3	80.8	31.8	1.20	1.16	0.000	0.024
<b>65-74</b>	675	469	496.00	328.0	179	141.0	1.36	1.43	0.000	0.000
<b>≥ 75</b>	1573	2691	996.75	1352.5	576.3	1338.5	1.58	1.99	0.000	0.000

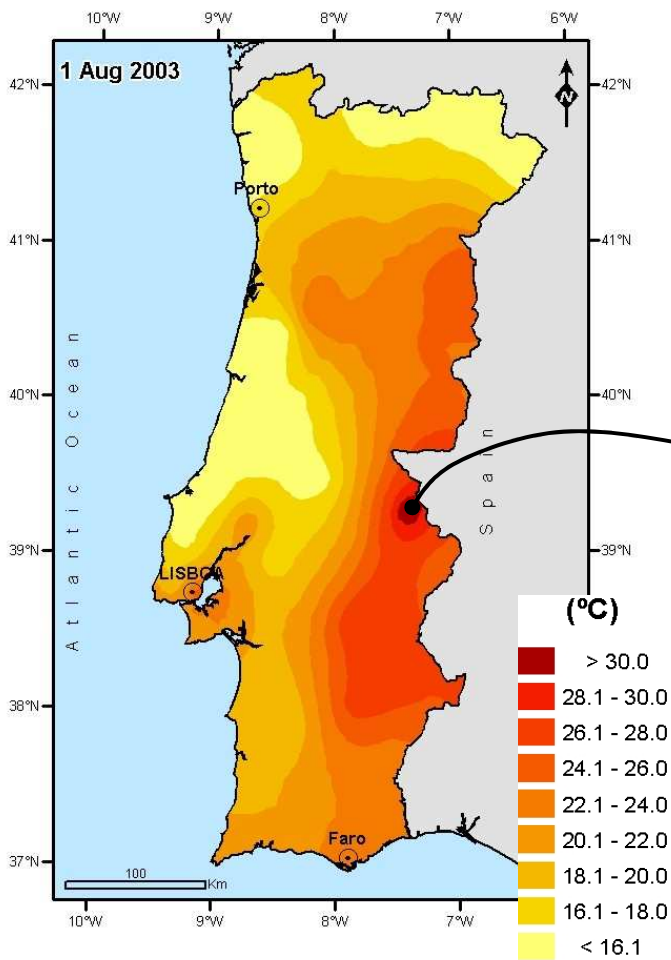
Trigo et al. (2009, in revision)





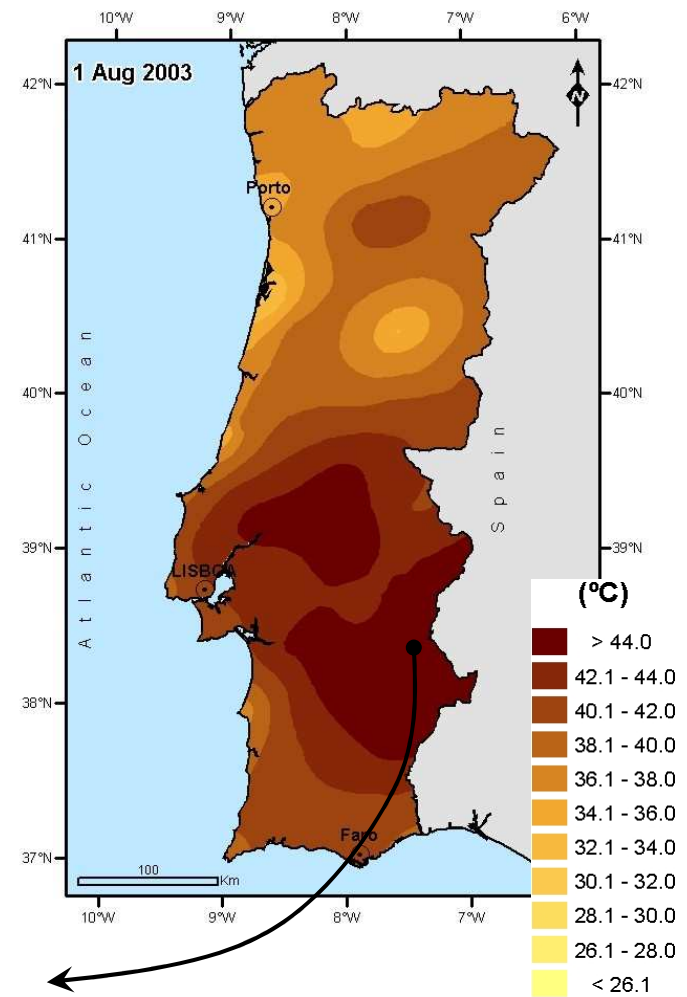
# New absolute daily records for **Tmin** and **Tmax** (1<sup>st</sup> August)

**Tmin**



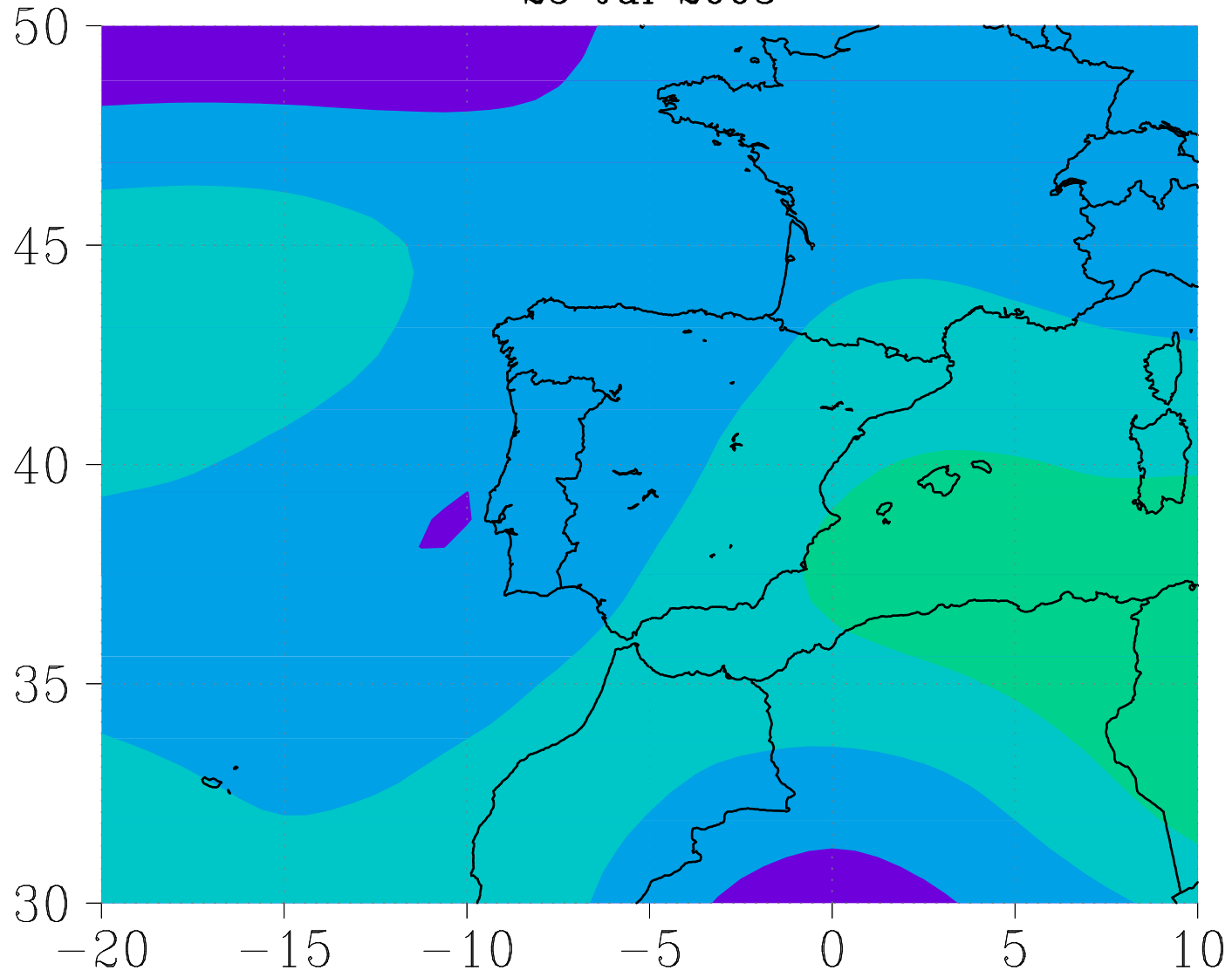
**30.6°C**

**Tmax**

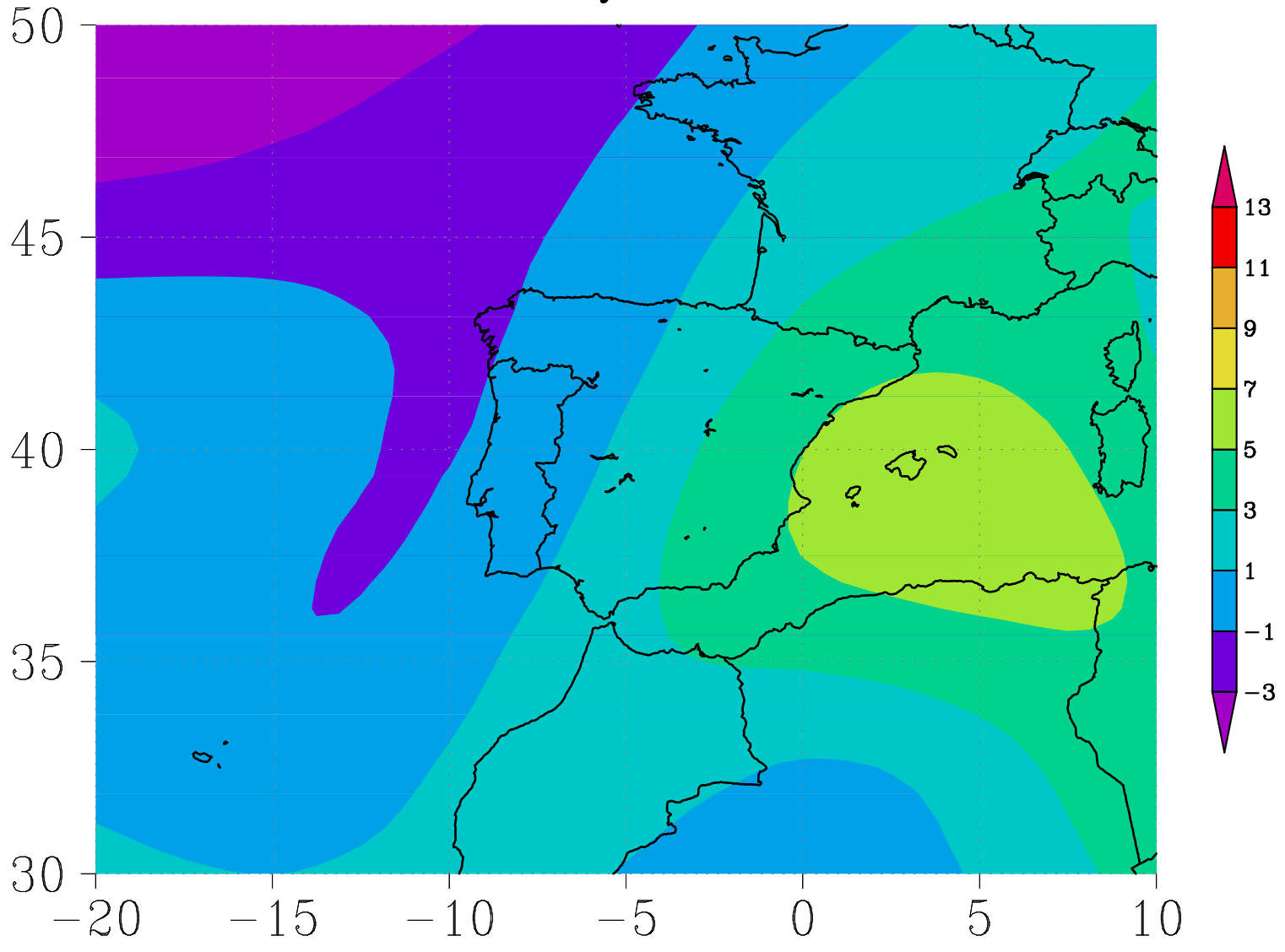


**47.3°C**

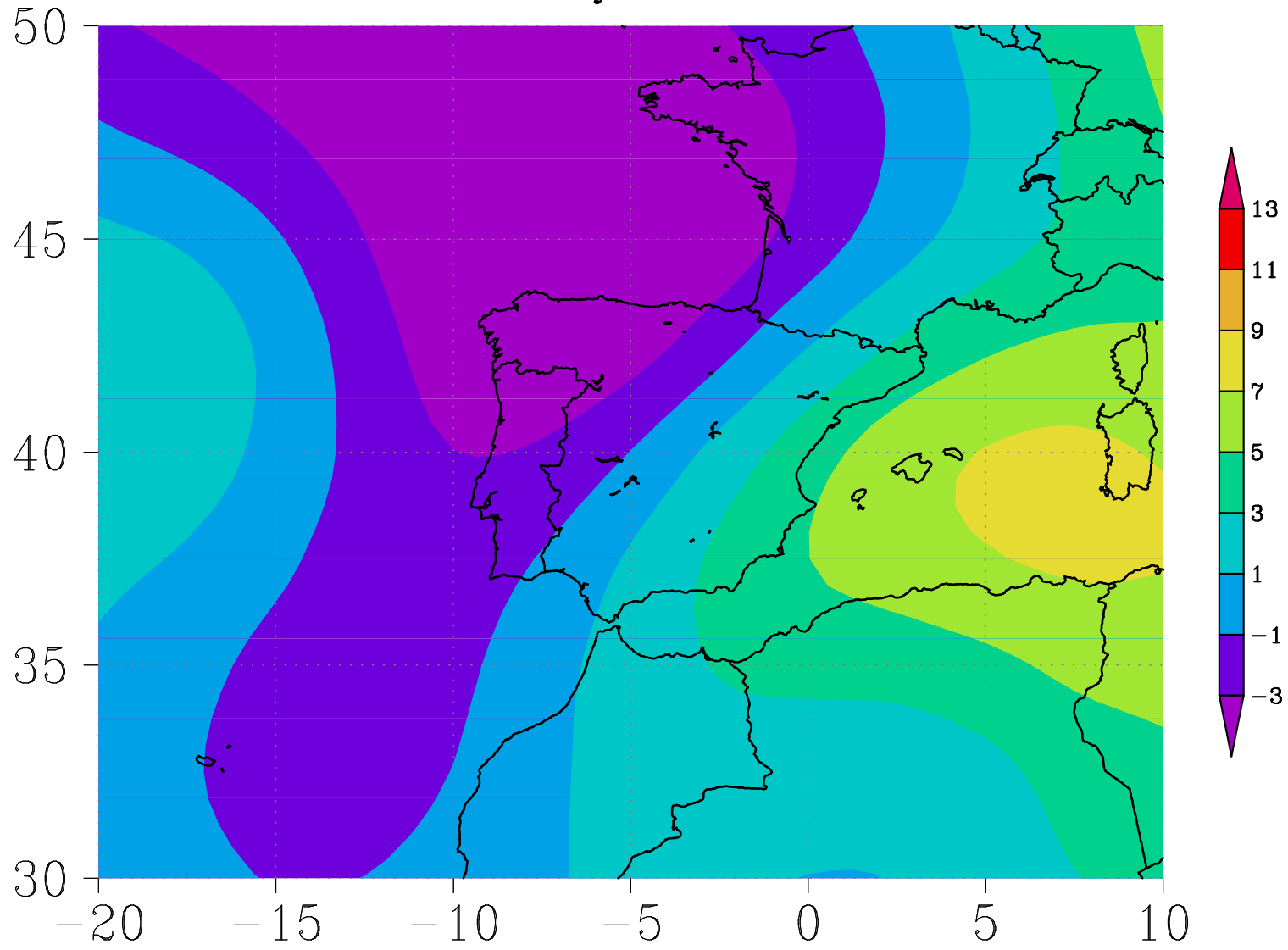
25 Jul 2003



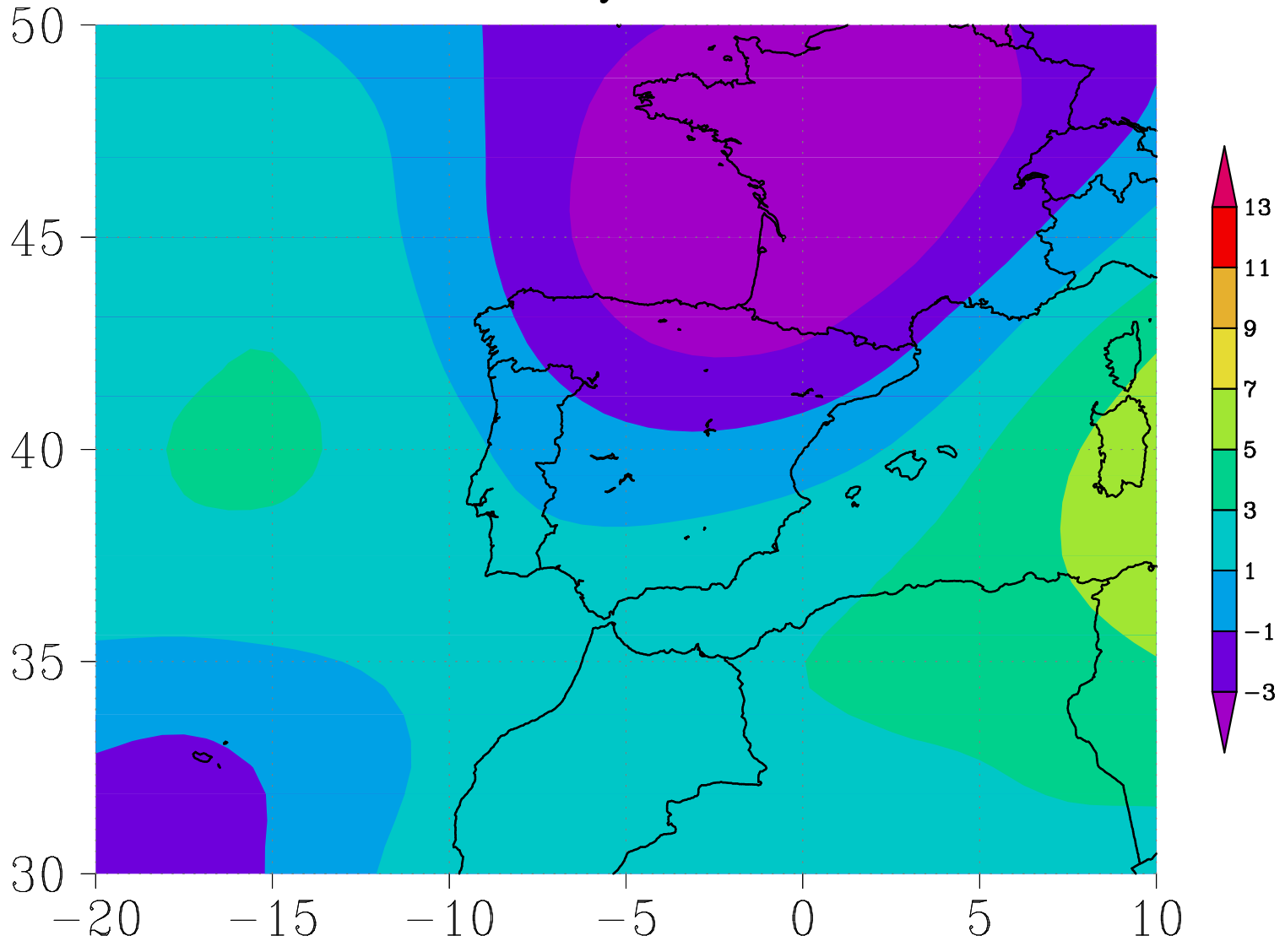
26 July 2003



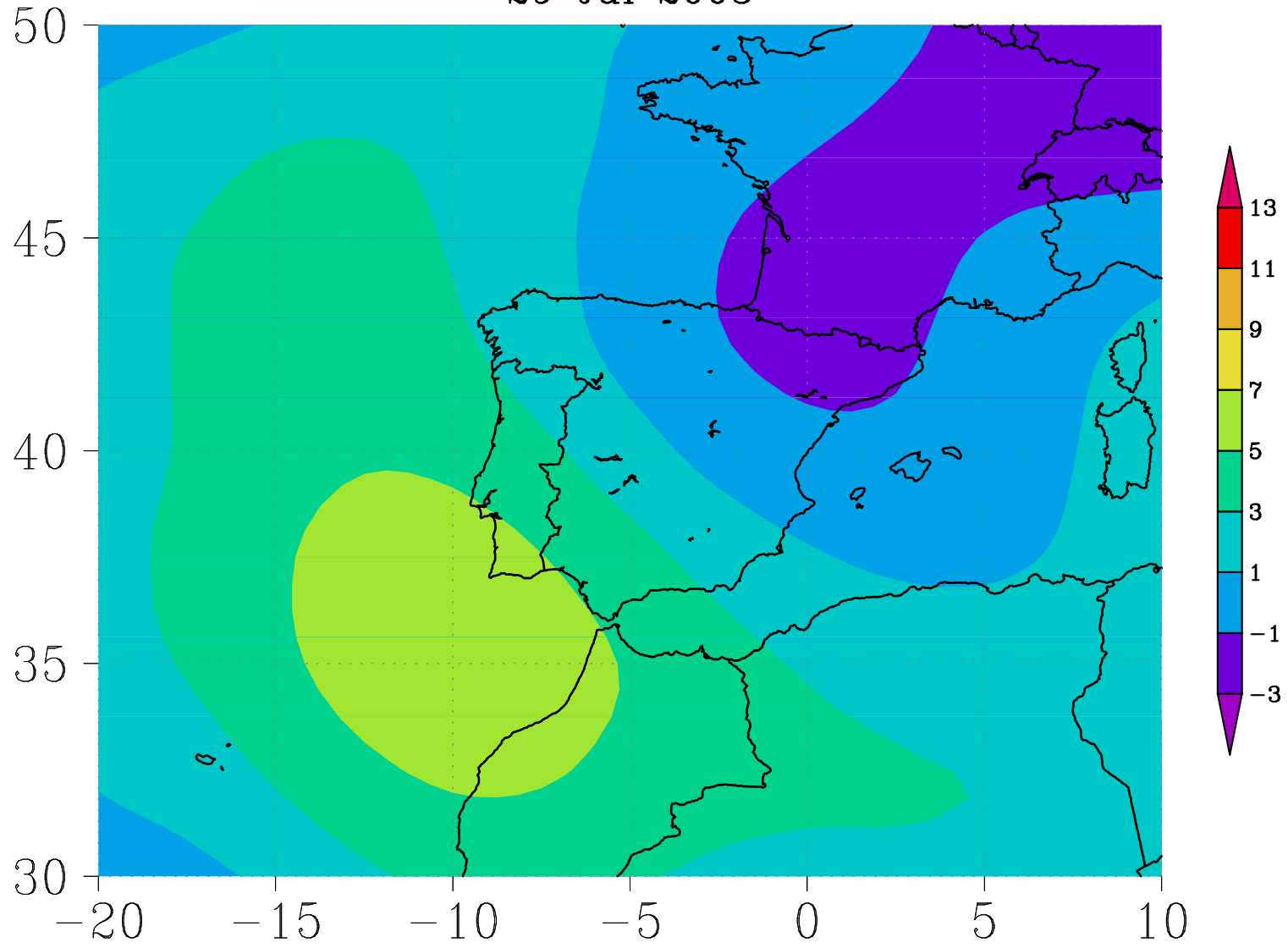
27 July 2003



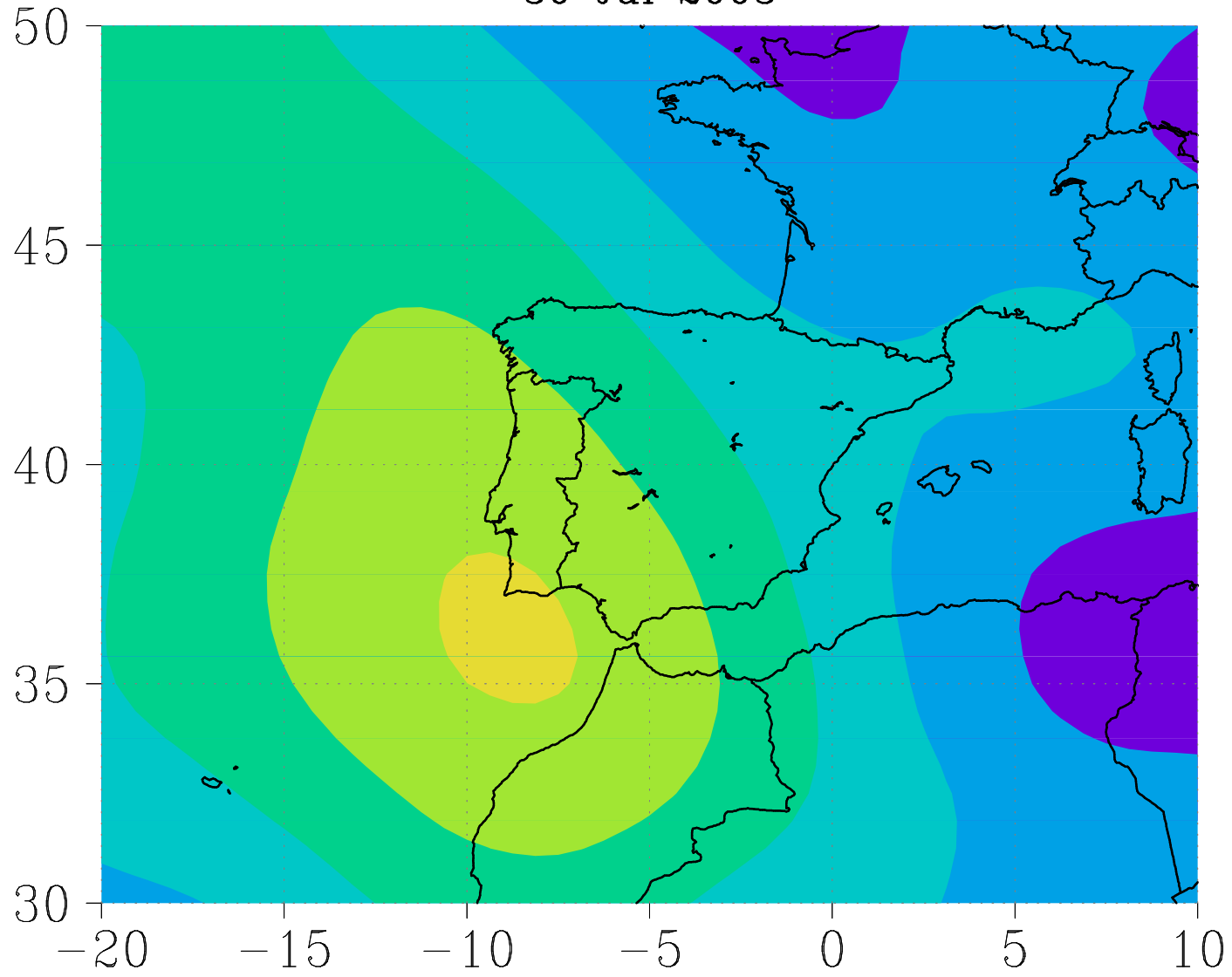
28 July 2003



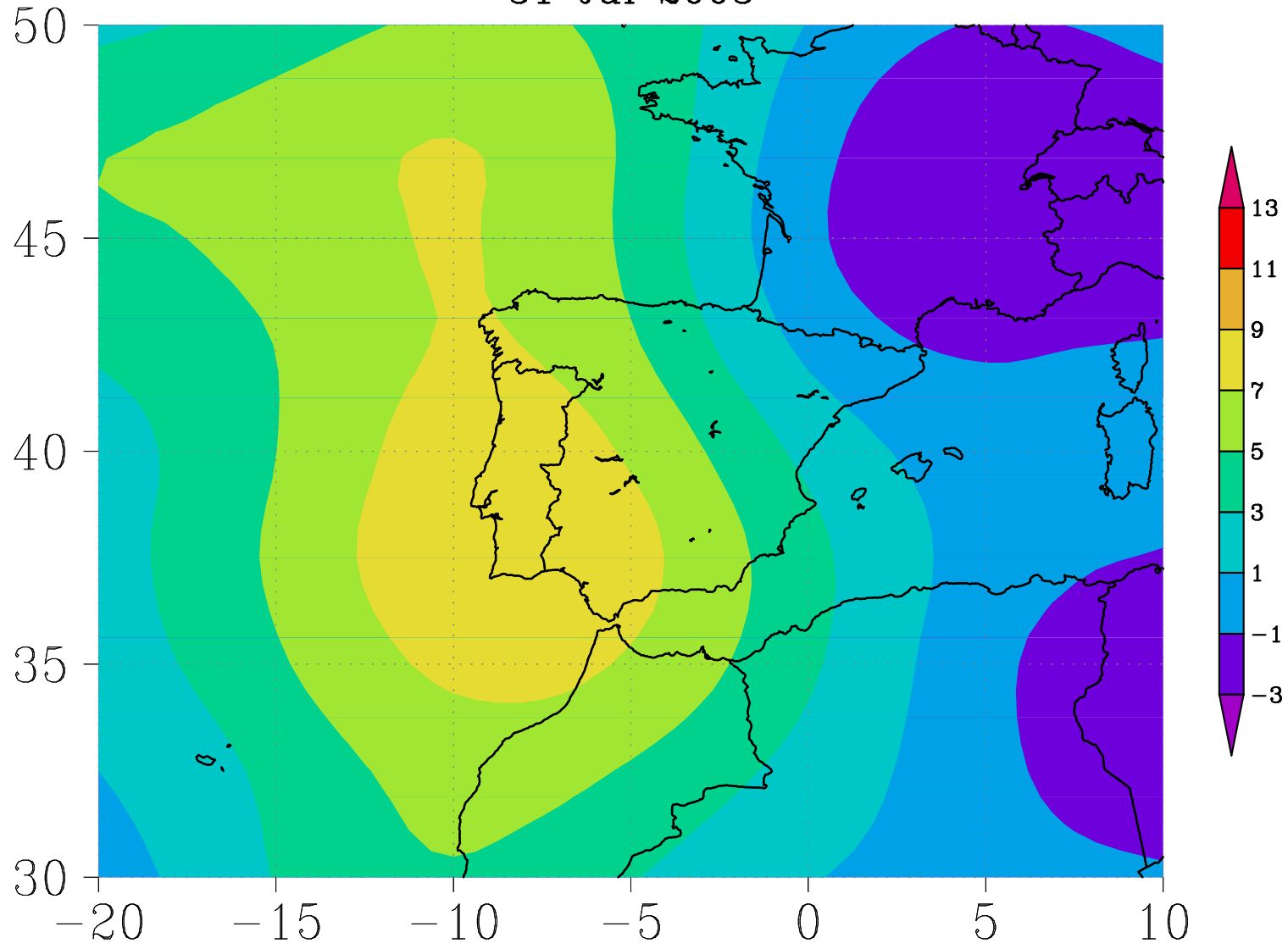
29 Jul 2003



30 Jul 2003

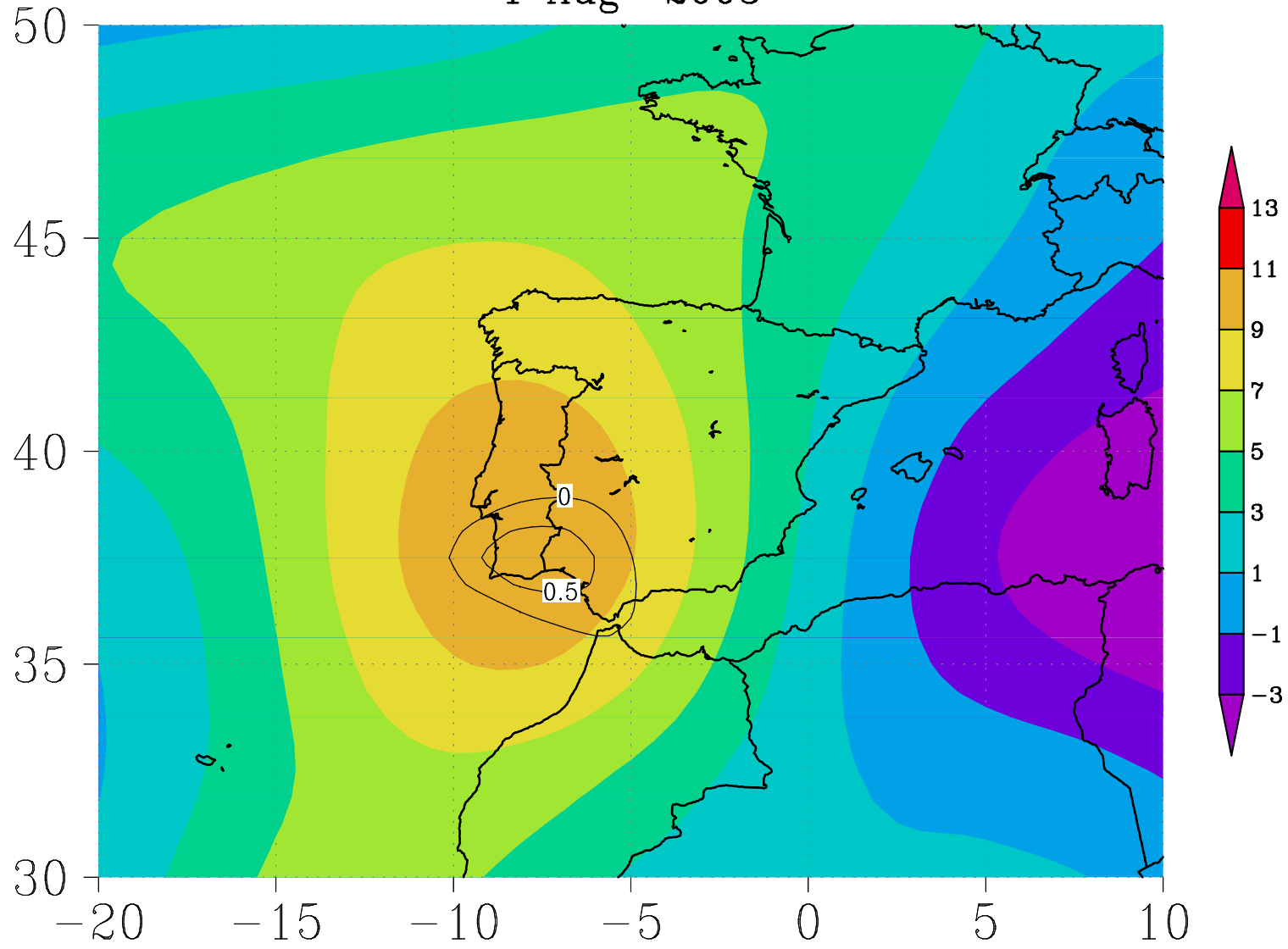


31 Jul 2003

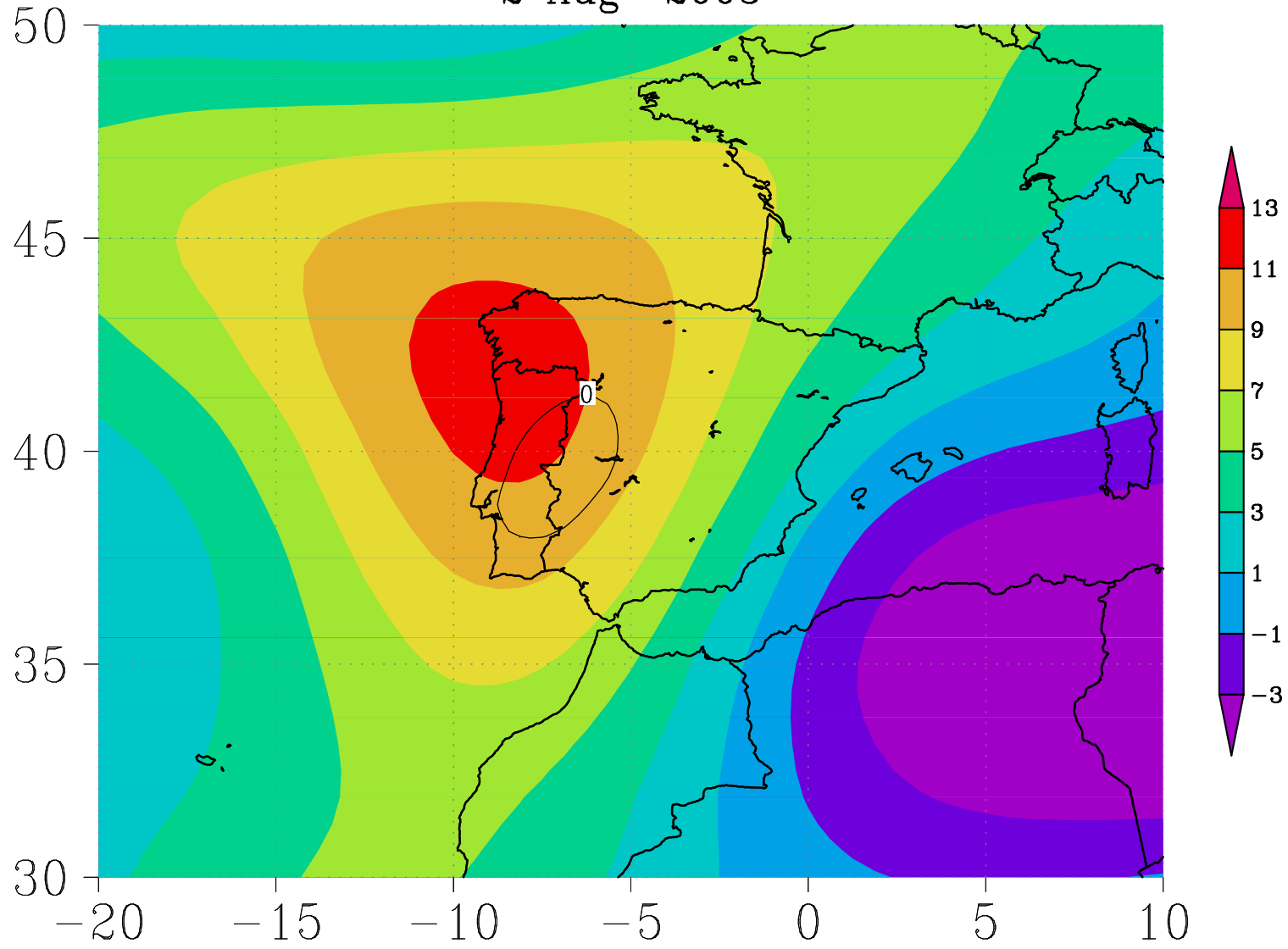




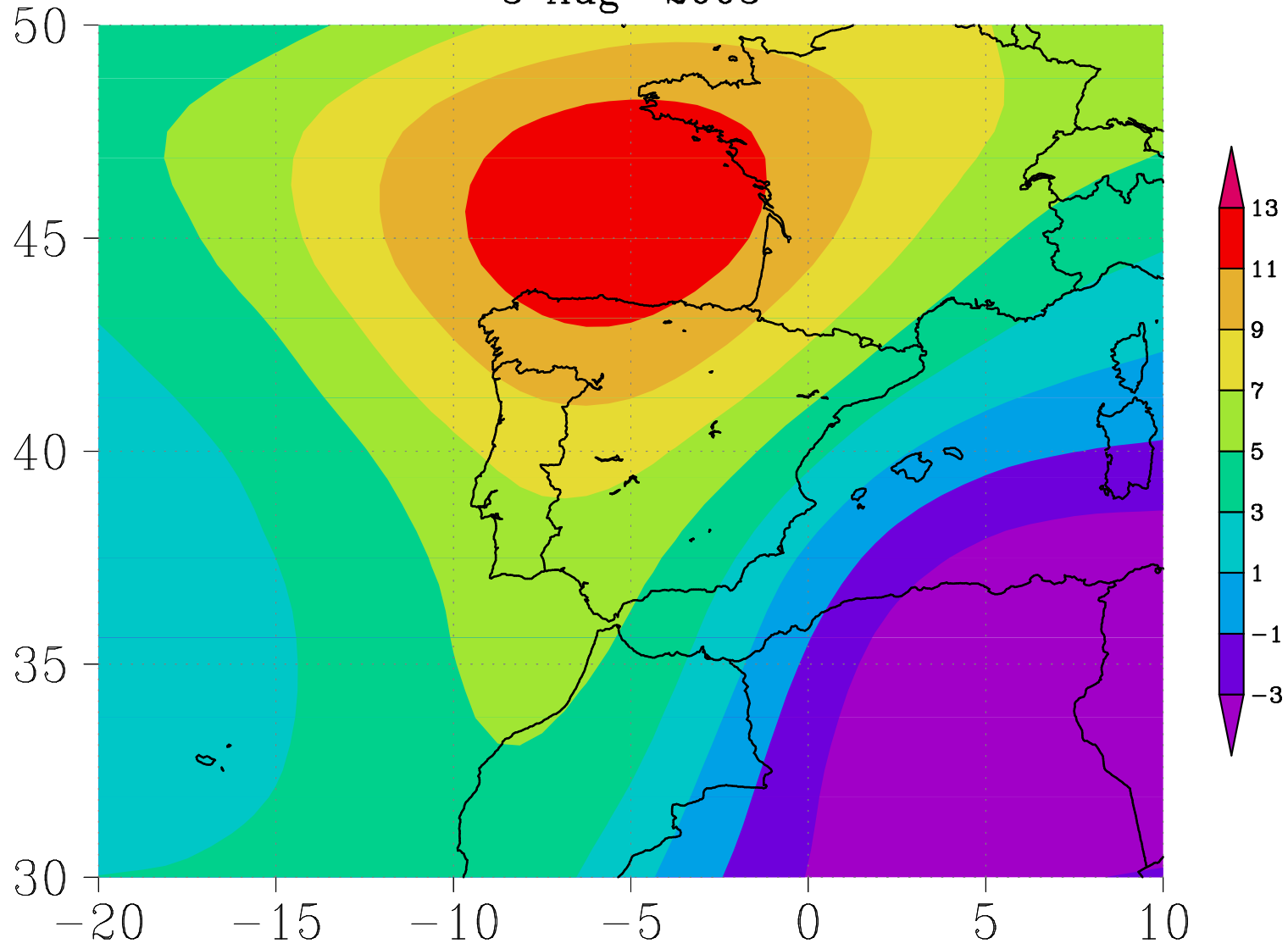
1 Aug 2003



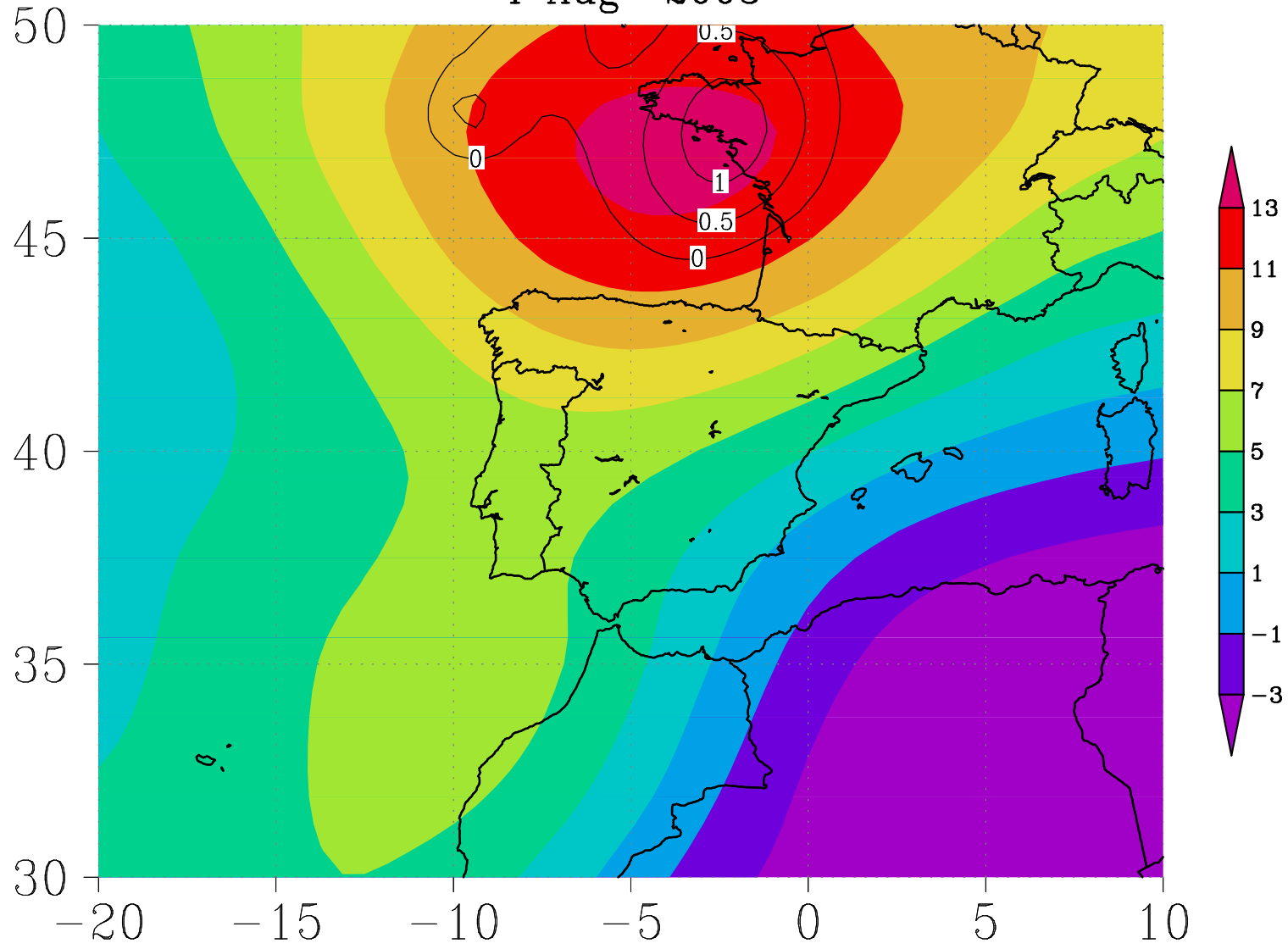
2 Aug 2003



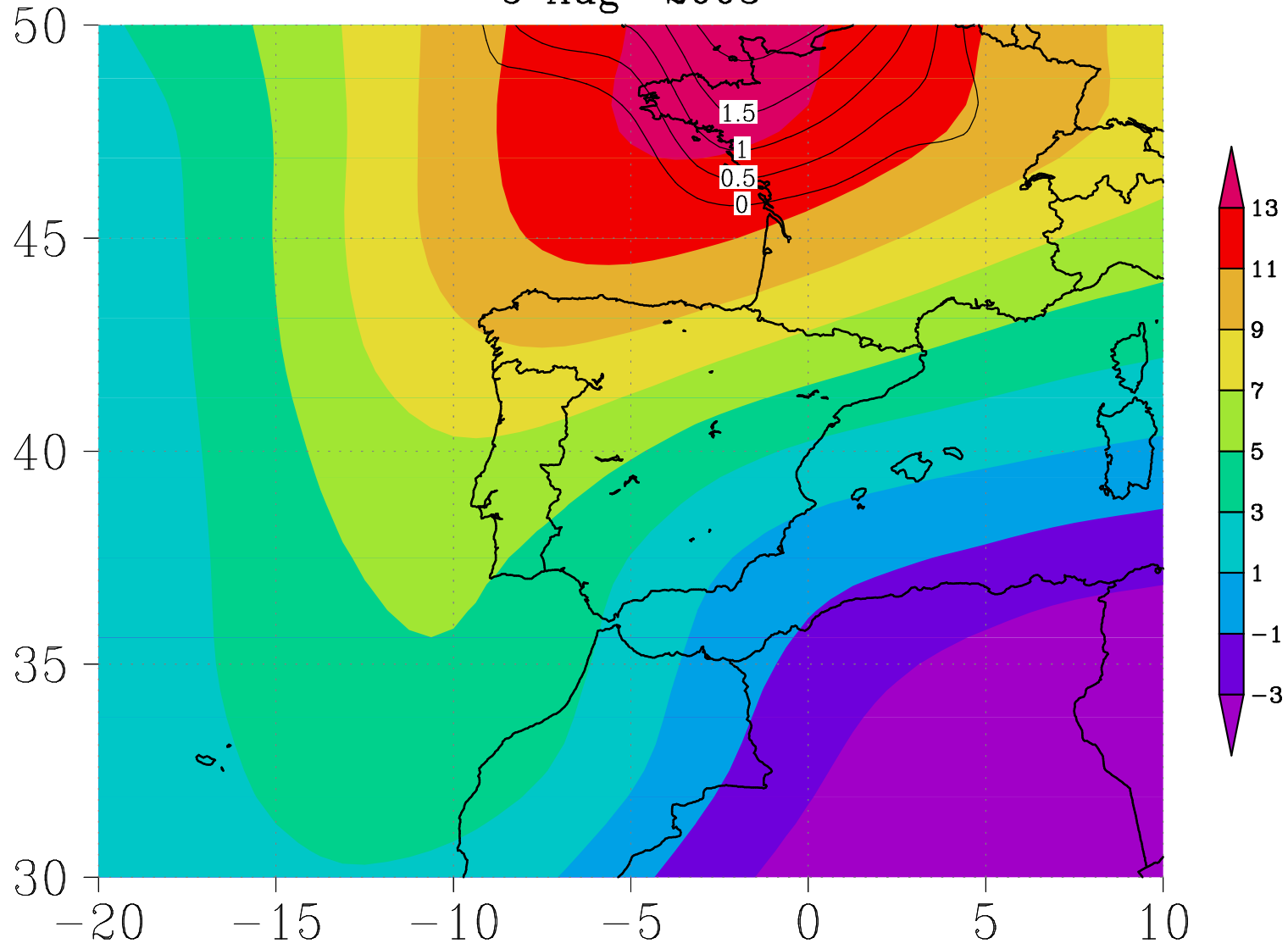
3 Aug 2003



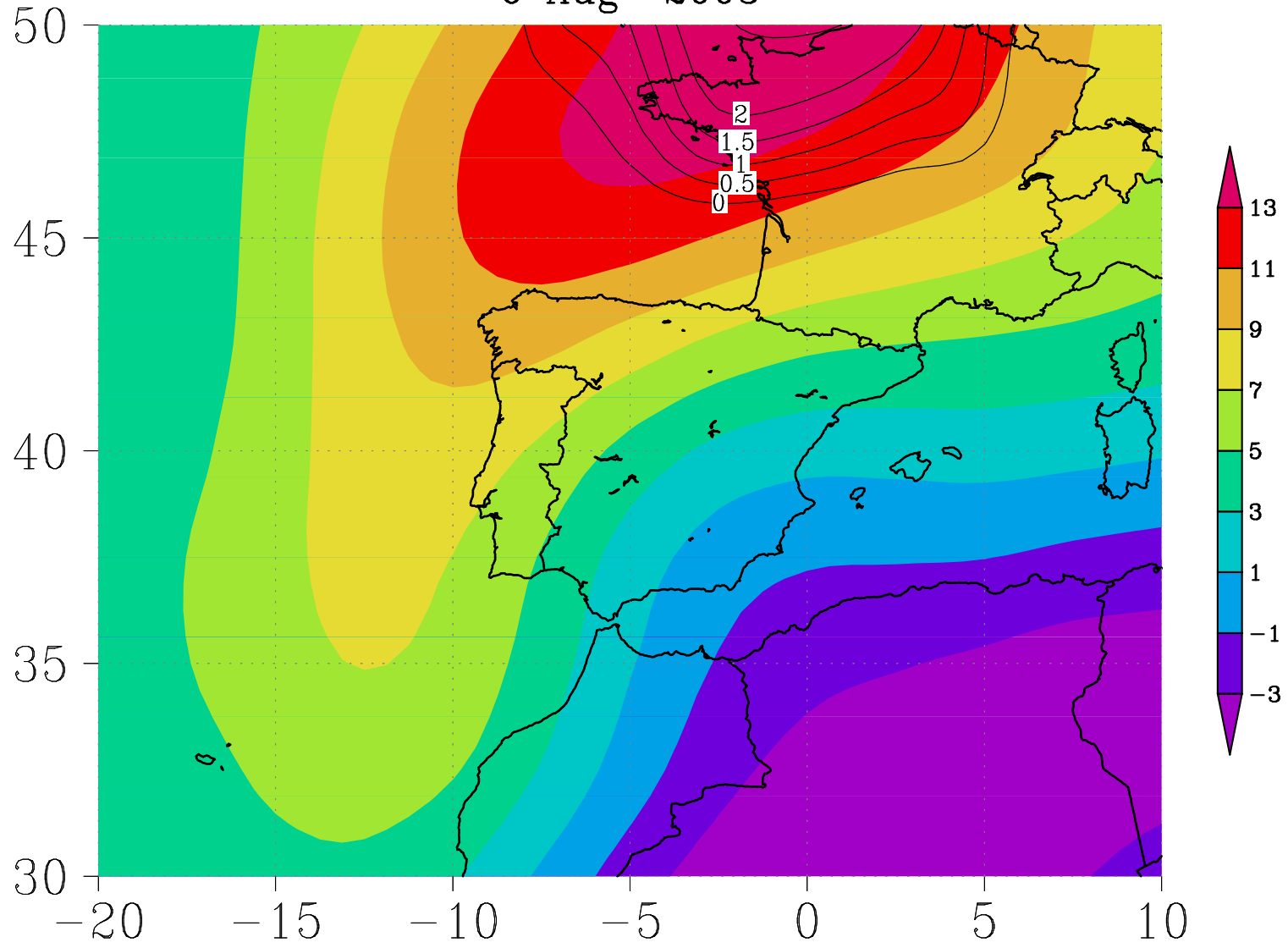
4 Aug 2003



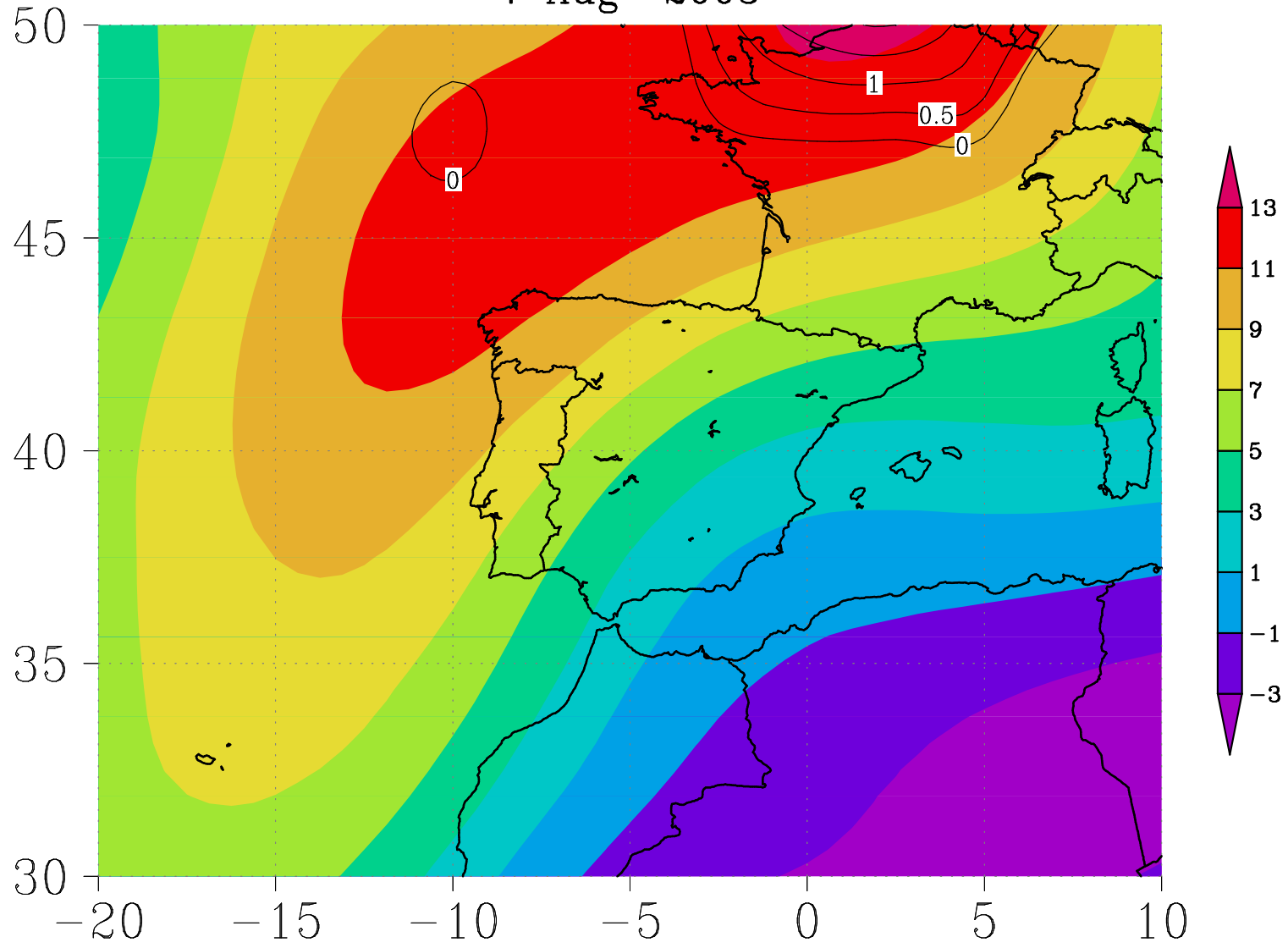
5 Aug 2003



6 Aug 2003

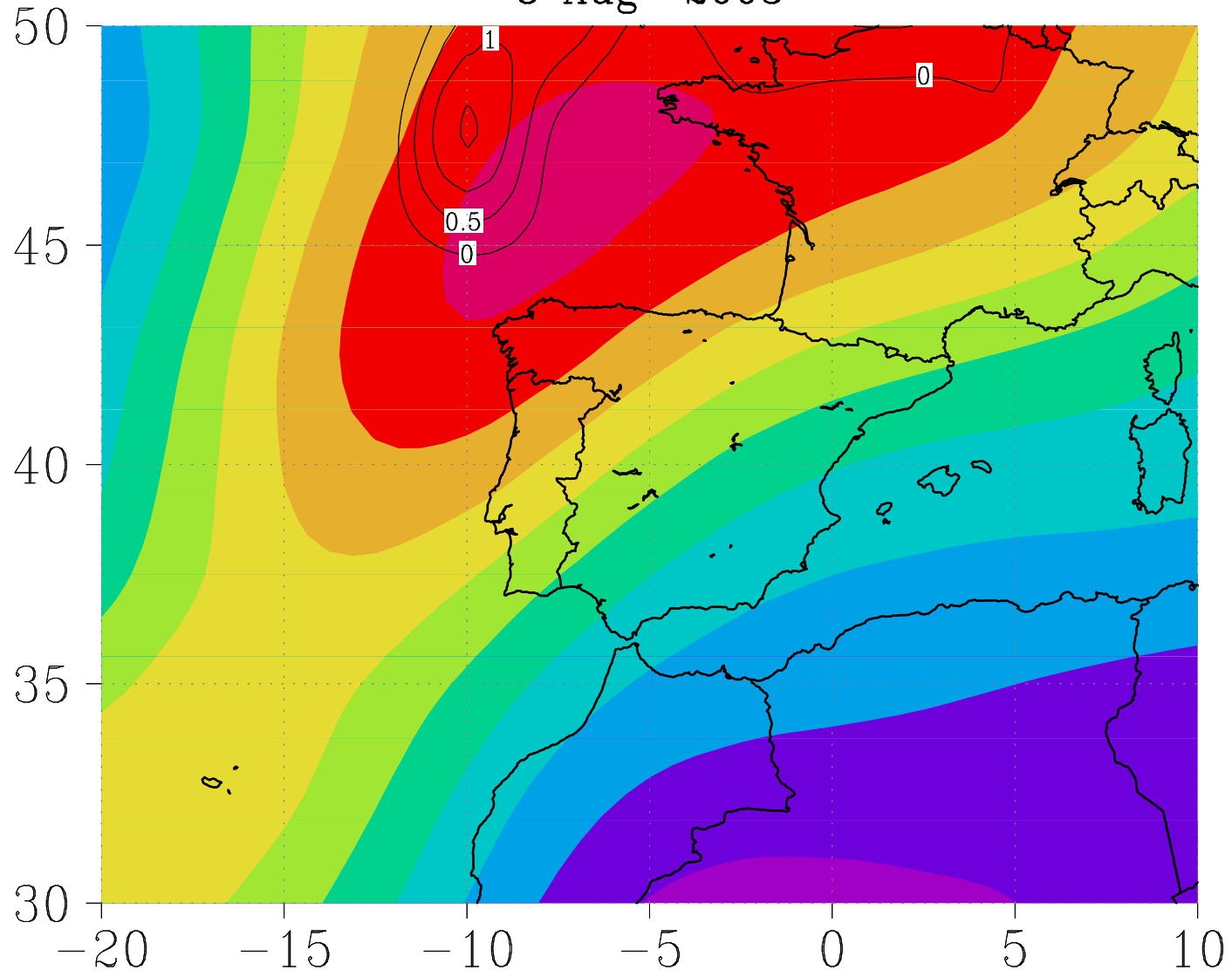


7 Aug 2003

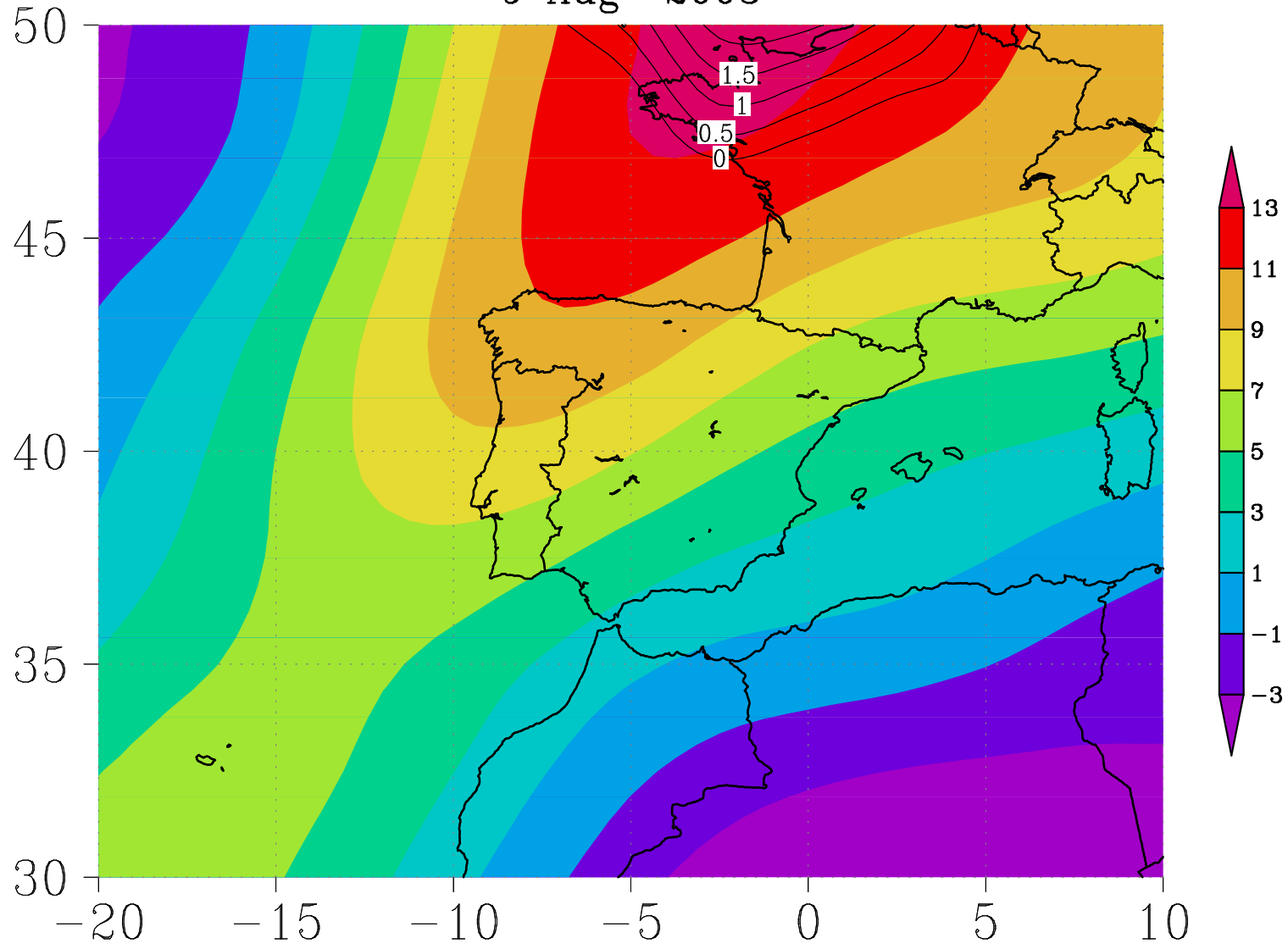




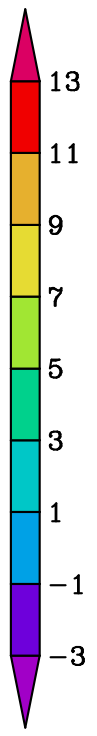
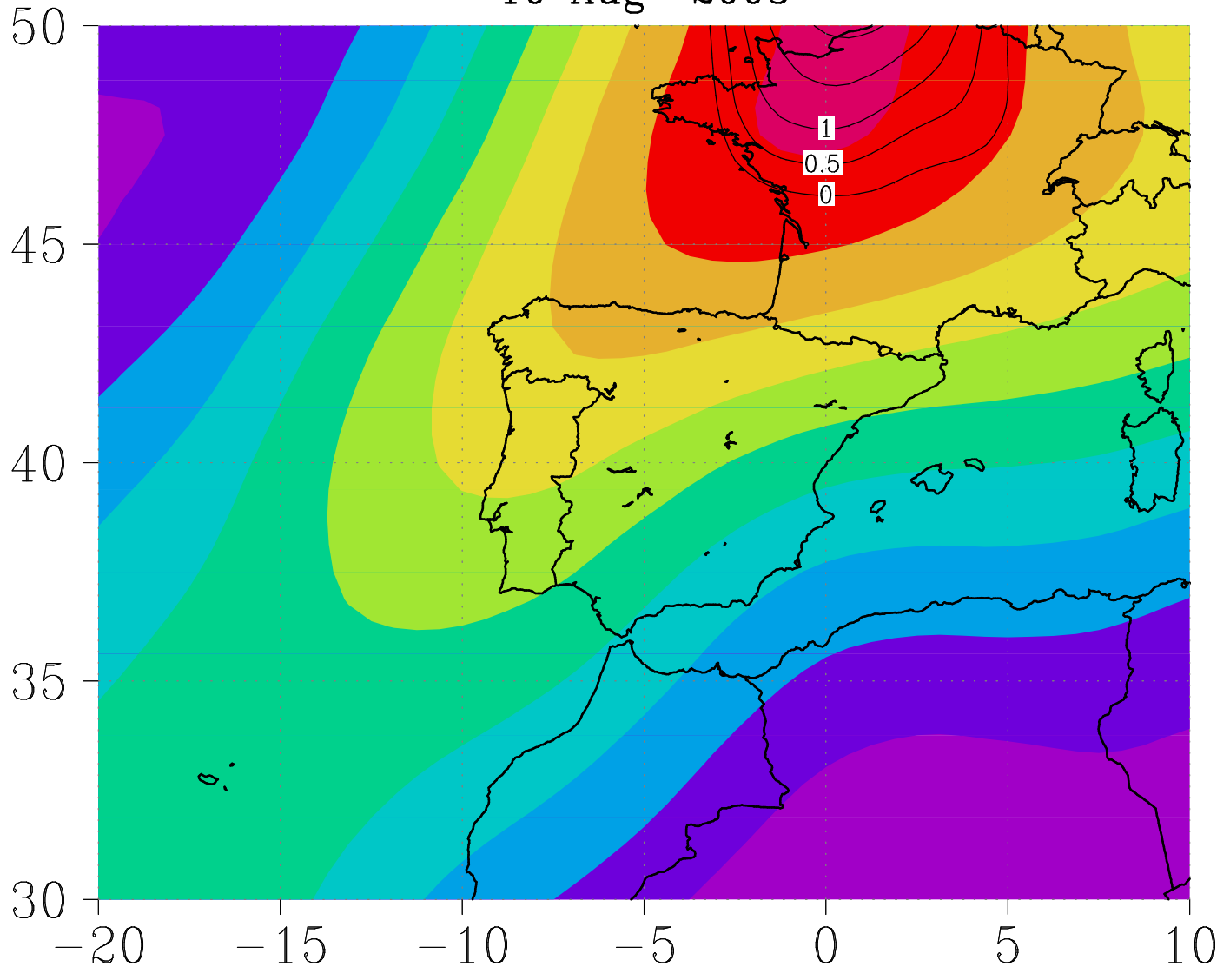
8 Aug 2003



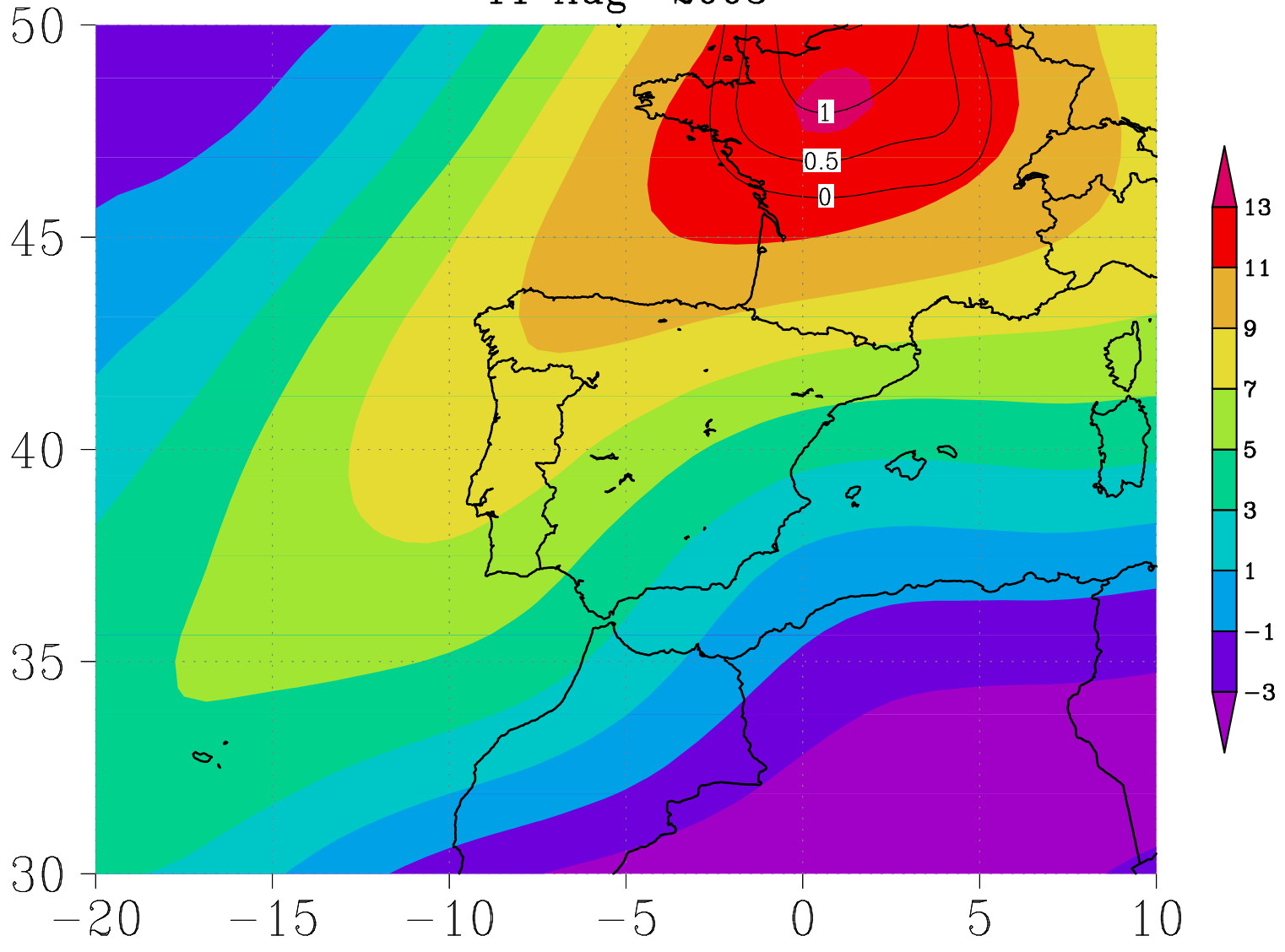
9 Aug 2003



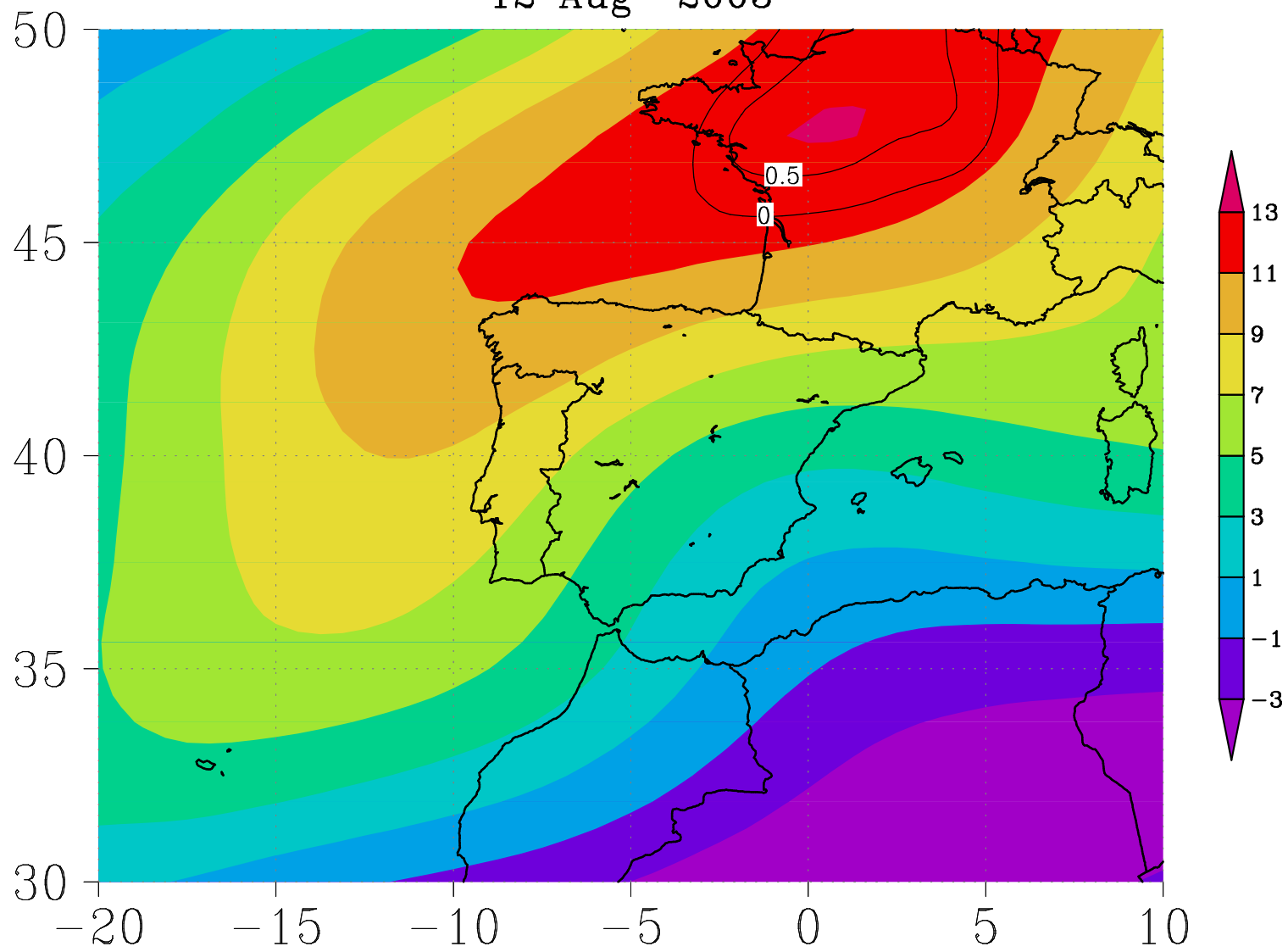
10 Aug 2003



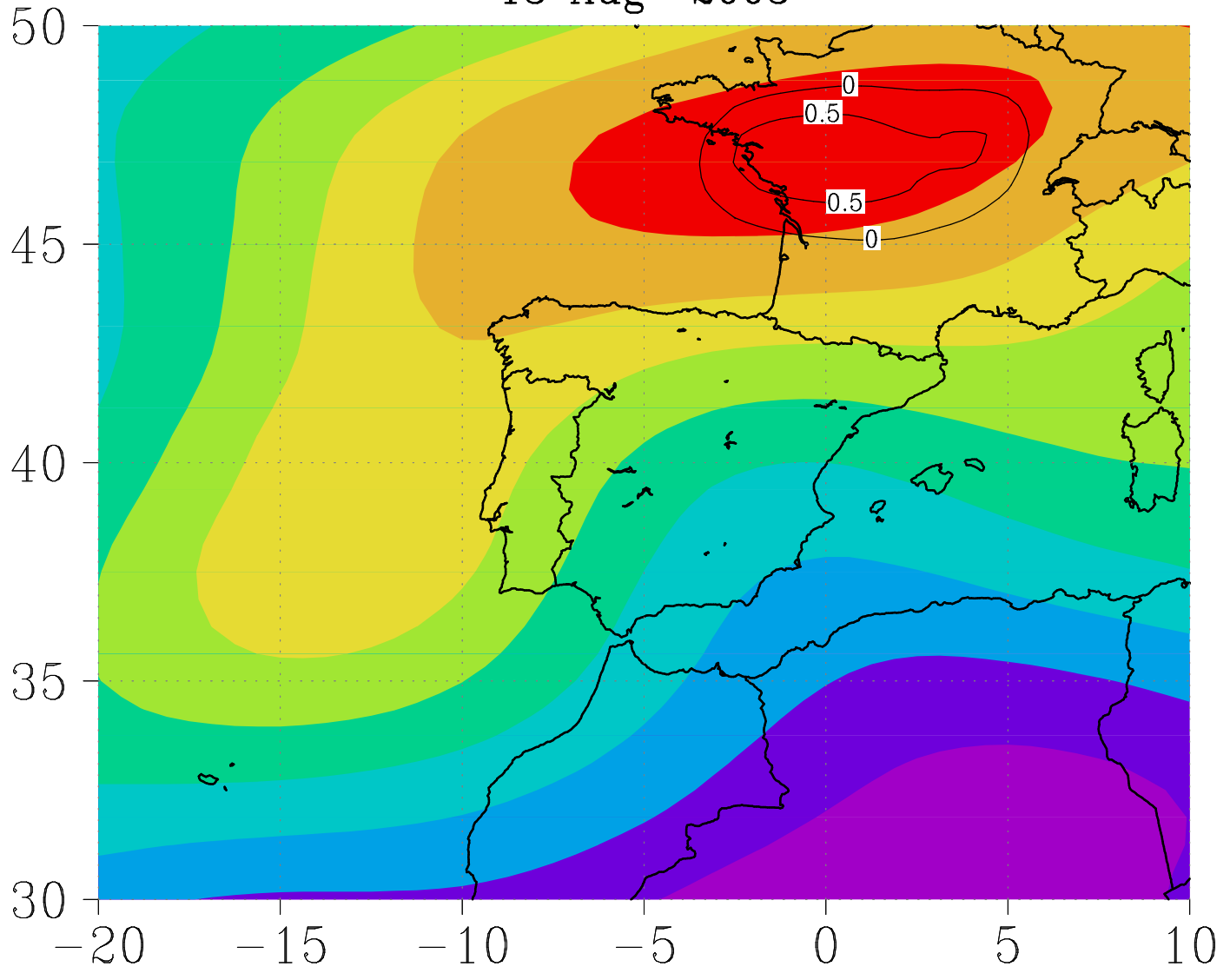
11 Aug 2003



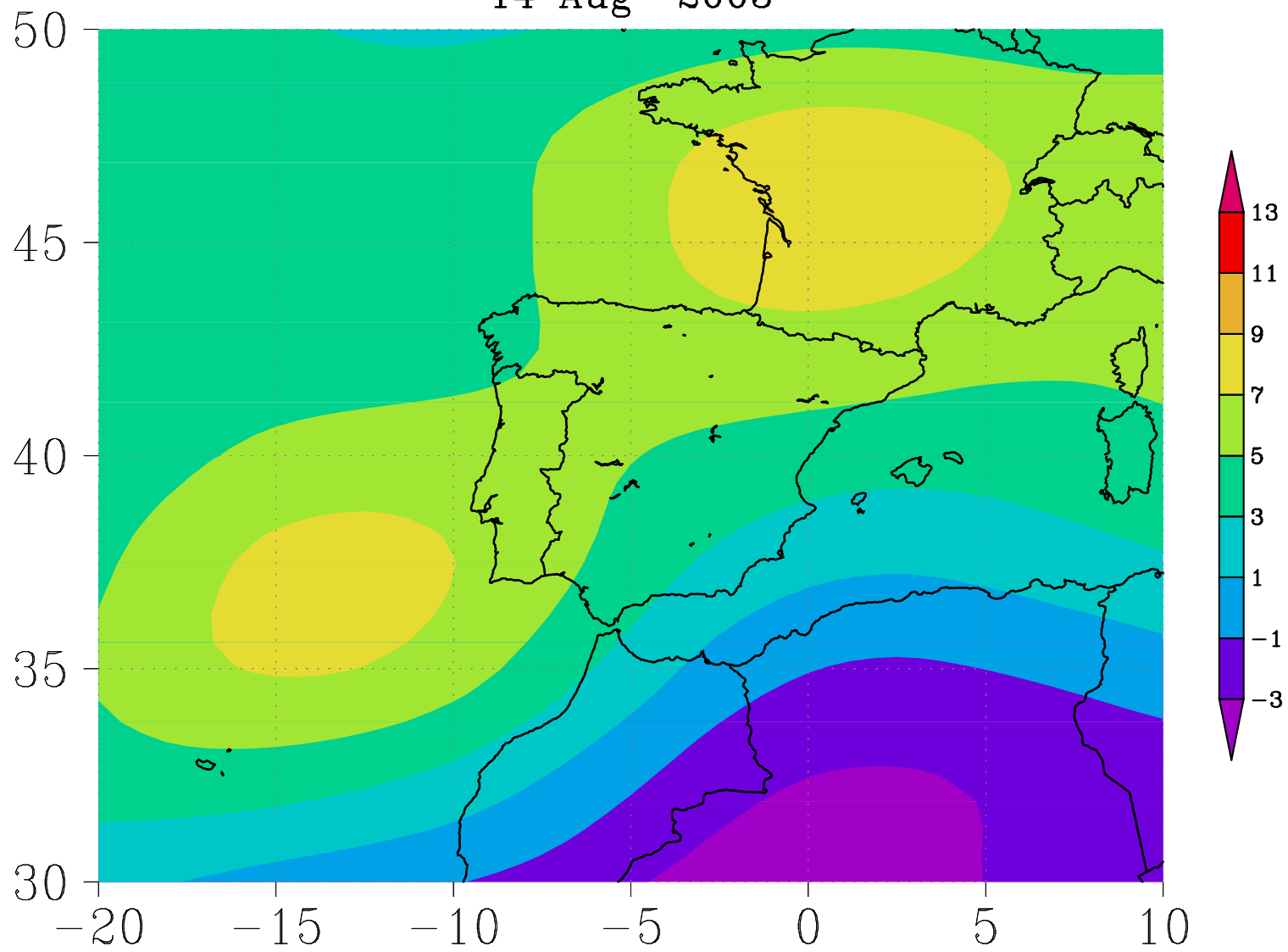
12 Aug 2003



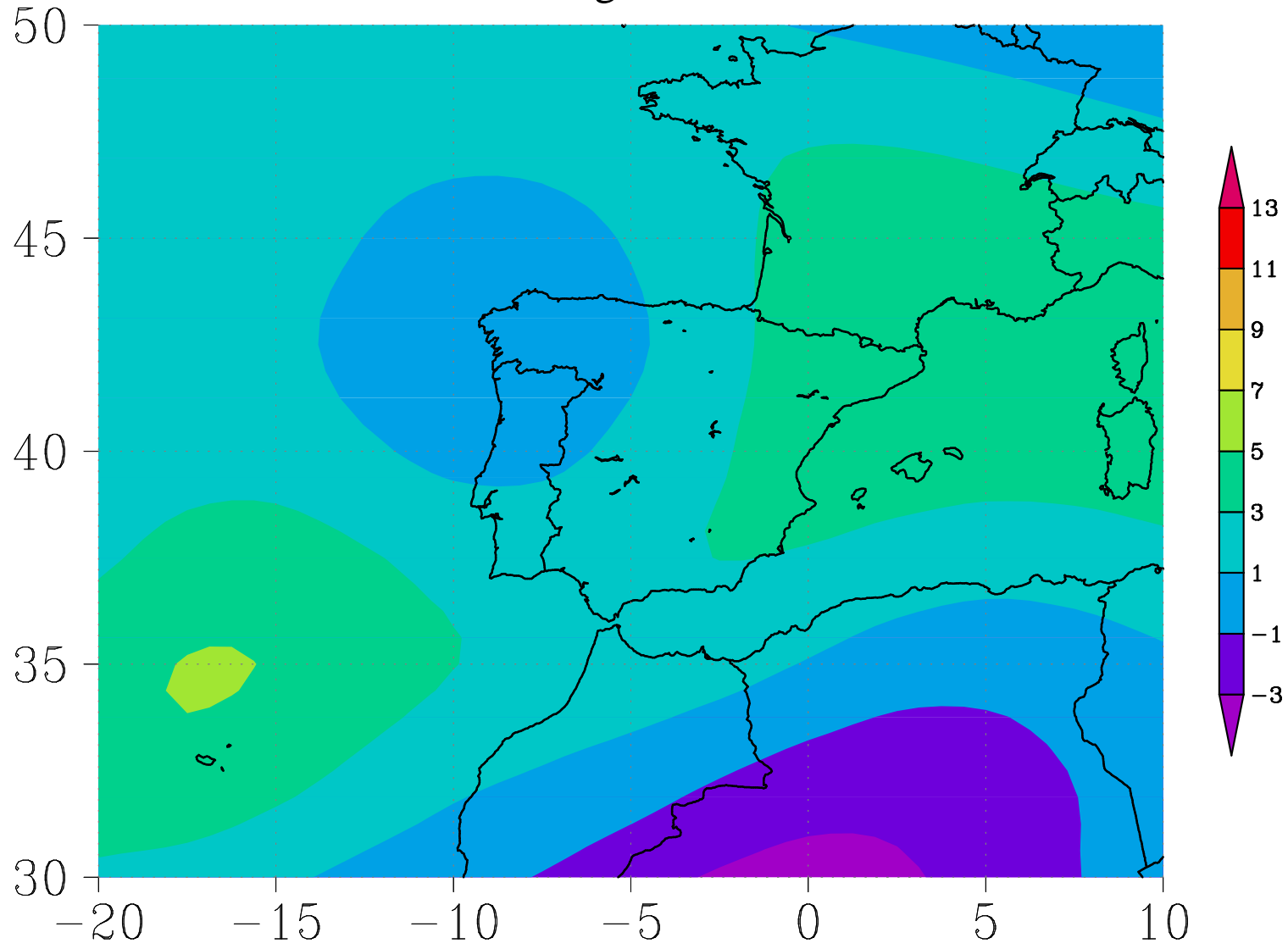
13 Aug 2003



14 Aug 2003



15 Aug 2003





## Summary

1. The **heatwave** of summer of 2003 was exceptional at the **monthly/seasonal**, but also at the **weekly** and **daily** time scales.
2. Climatologies should be smoothed at the daily scale and sub-monthly analysis dealt accordingly.
3. Excessive **mortality rates in France/Portugal** are linked to record breaking daily/weekly temperatures and associated to an intense **blocking** atmospheric circulation pattern.
4. **Fires in Portugal** were triggered at the daily scale (1<sup>st</sup> and 2<sup>nd</sup> of August, with new absolute record for **Tmin** and **Tmax**).
5. Winter/spring **drought conditions** have exacerbated the strength of the summer heatwave.

# Publications

Trigo et al., 2005 (Geophysical Research Letters)

Garcia-Herrera et al., 2005 (Annales Geophysics)

Trigo et al., 2006 (Int. Journal of Climatology)

Gouveia et al., 2008 (Nat. Hazards and Earth Sys. Sci.)

Garcia-Herrera et al., 2009 (Crit. Rev. Env. Sci. & Tec)

Trigo et al., 2009 (Env. Science & Policy) (in revision)



Thanks!



Obrigado!