The Abdus Salam
International Centre for Theoretical Physics

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International Atomic Energy Agency

1968-5

Conference on Teleconnections in the Atmosphere and Oceans

17 - 20 November 2008

Was the 2003 summer heat-wave teleconnected to anything?

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Conference on Teleconnections in the Atmosphere and Oceans
ICTP, Italy, 17 - 20 November 2008

Was the 2003 summer heat-wave teleconnected to anything?

Jagadish Shukla

George Mason University (GMU), USA

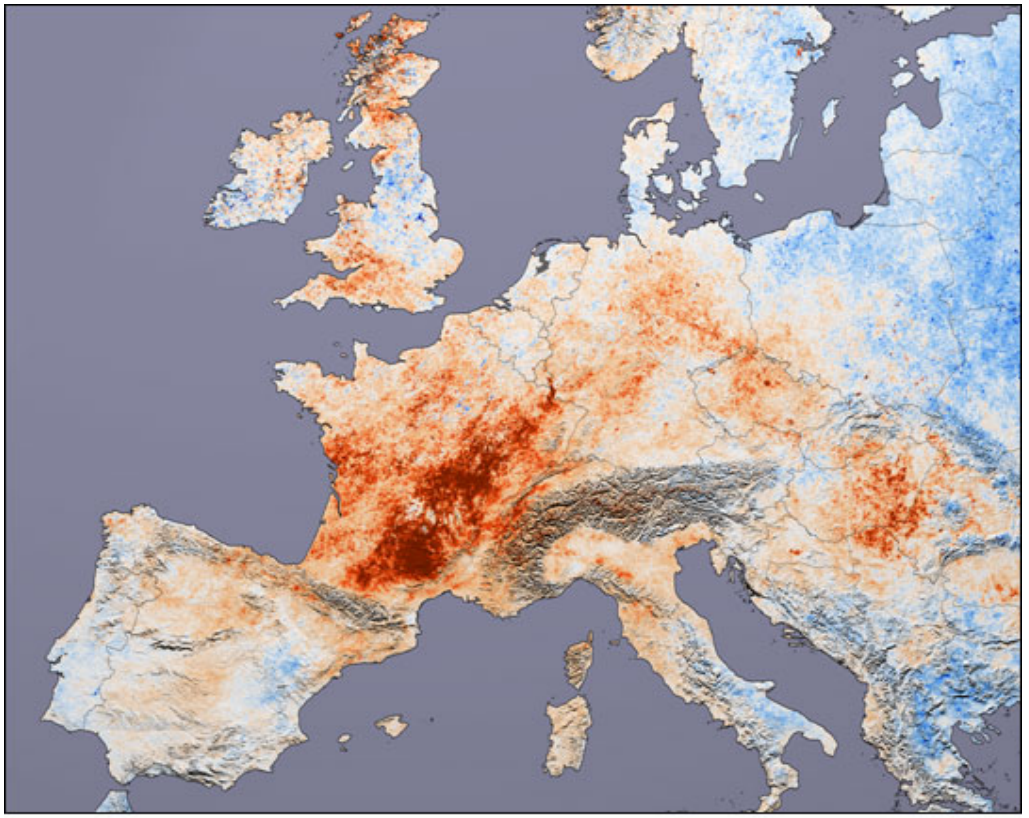
Institute of Global Environment and Society (IGES)

Feudale, L. and J. Shukla, 2007: Role of Mediterranean SST in enhancing the European heat wave of summer 2003. *Geophys. Res. Lett.*
Feudale, L. and J. Shukla, 2008: Influence of Sea Surface Temperature on the European HeatWave of Summer 2003: An Observational and Modeling Study. Under preparation.

JJA 2003 Summer European Heatwave

By NASA/GSFC ORBIMAGE

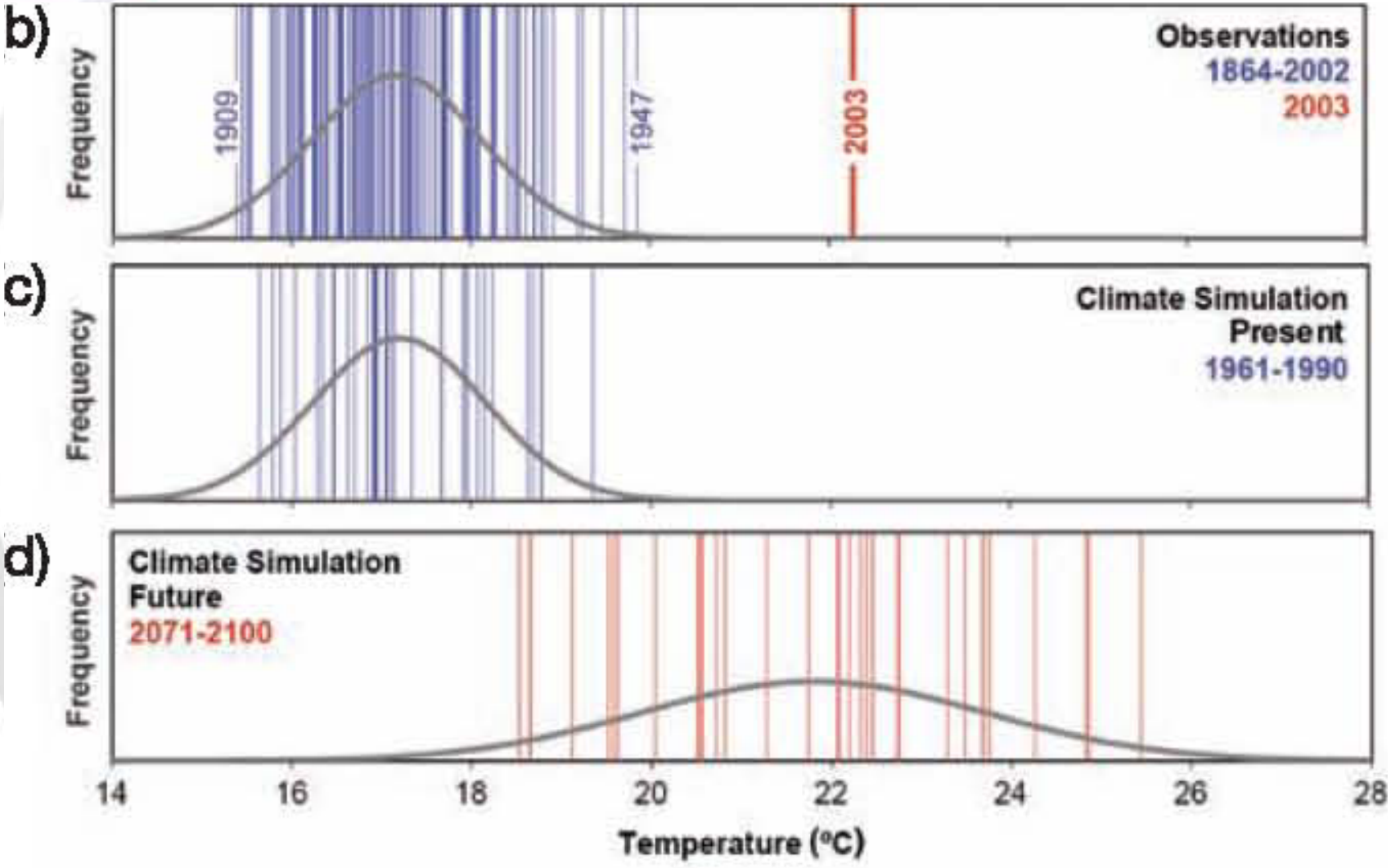
- Images from satellite show that Europe during August 2003 was cloud free
- The haze over the western part is likely combinations of dust, air pollution and smoke from wild fires, resulting from heat and lack of rain



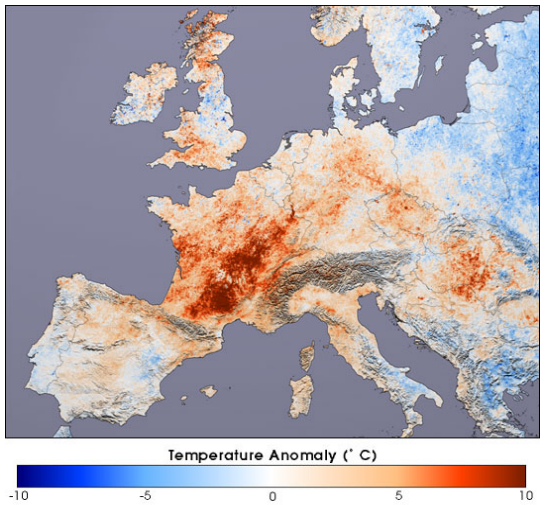
By R. Stockli and R.Simmons, NASA

- Differences in daily time ts collected in JJA 2001 and JJA 2003 by MODIS on NASA's Terra satellite.

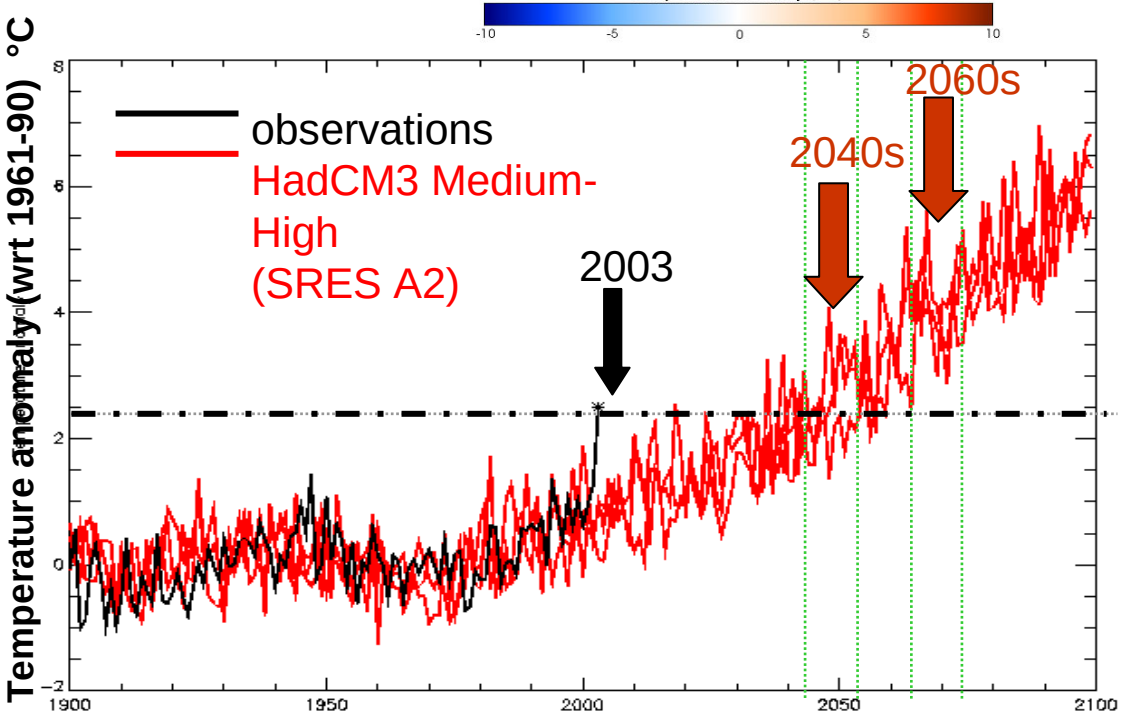
Characteristics of the summer 2003 heatwave



GEC is more acute than ever



- 2003
- Heat wave hits Europe
- 40,000 people die in Europe



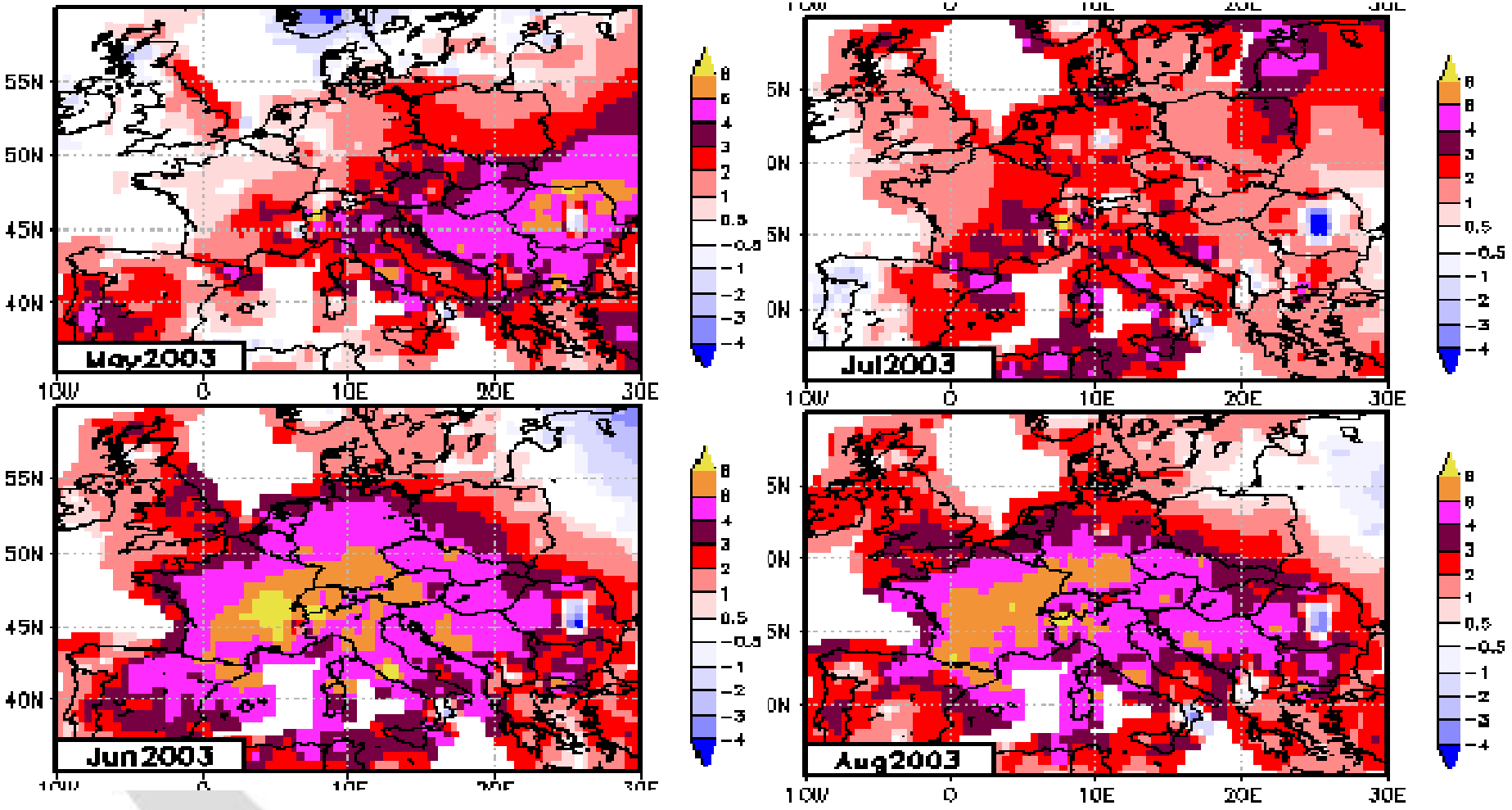
IGBP CHANGE

2003 Summer: Exceptionally Warm in Europe

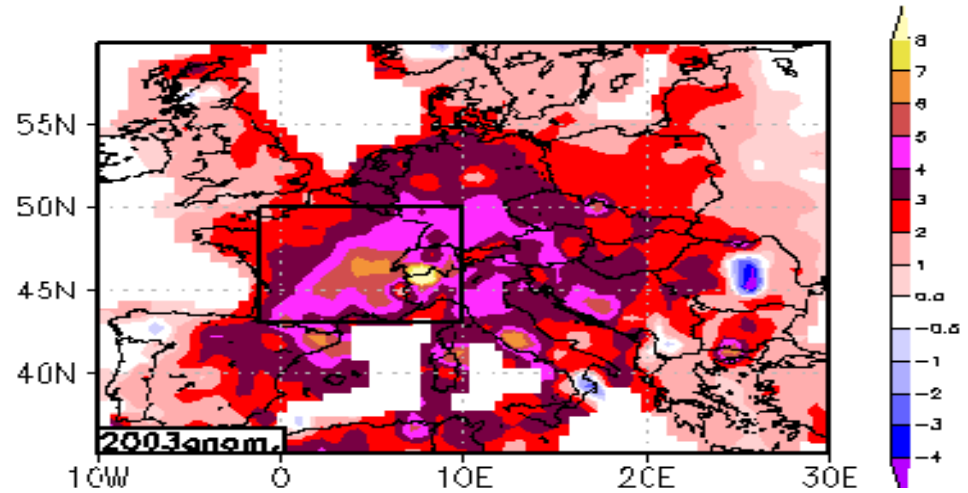
- Schar et al. (2004): using a long terms temperature series from Switzerland showed that summer 2003 was the warmest since 1894;

- Lutherbacher et al. (2004): using multiproxy data showed that summer 2003 was warmer than any other summer since 1500.

2003 Observed T_{max} Anomaly

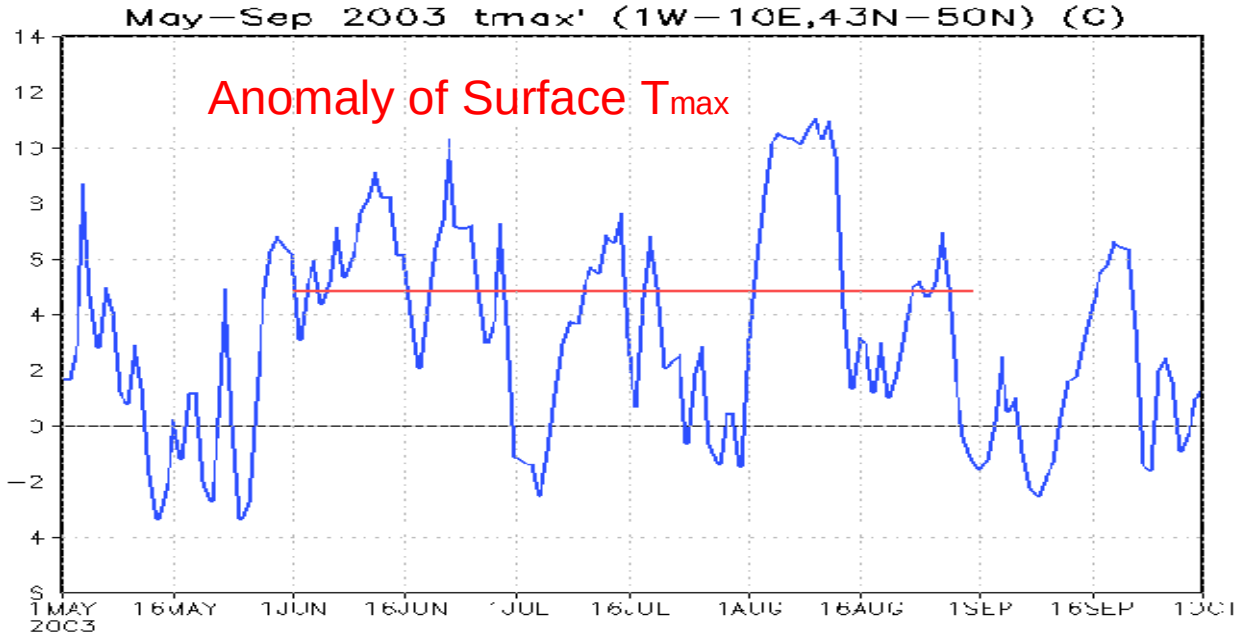


JJA 2003 Summer European Heatwave



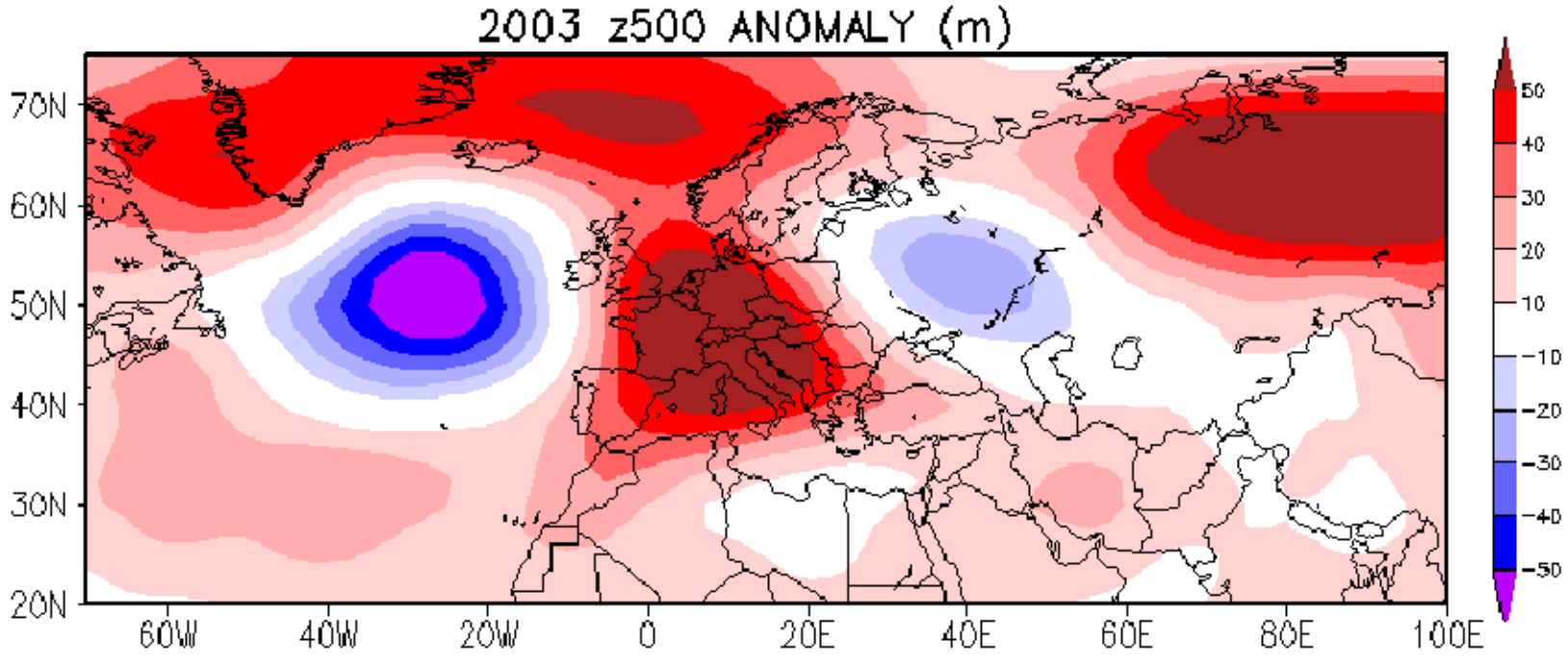
Tcmx JJA 2003

(Pingping Xie data)



JJA 2003 Summer European Heatwave

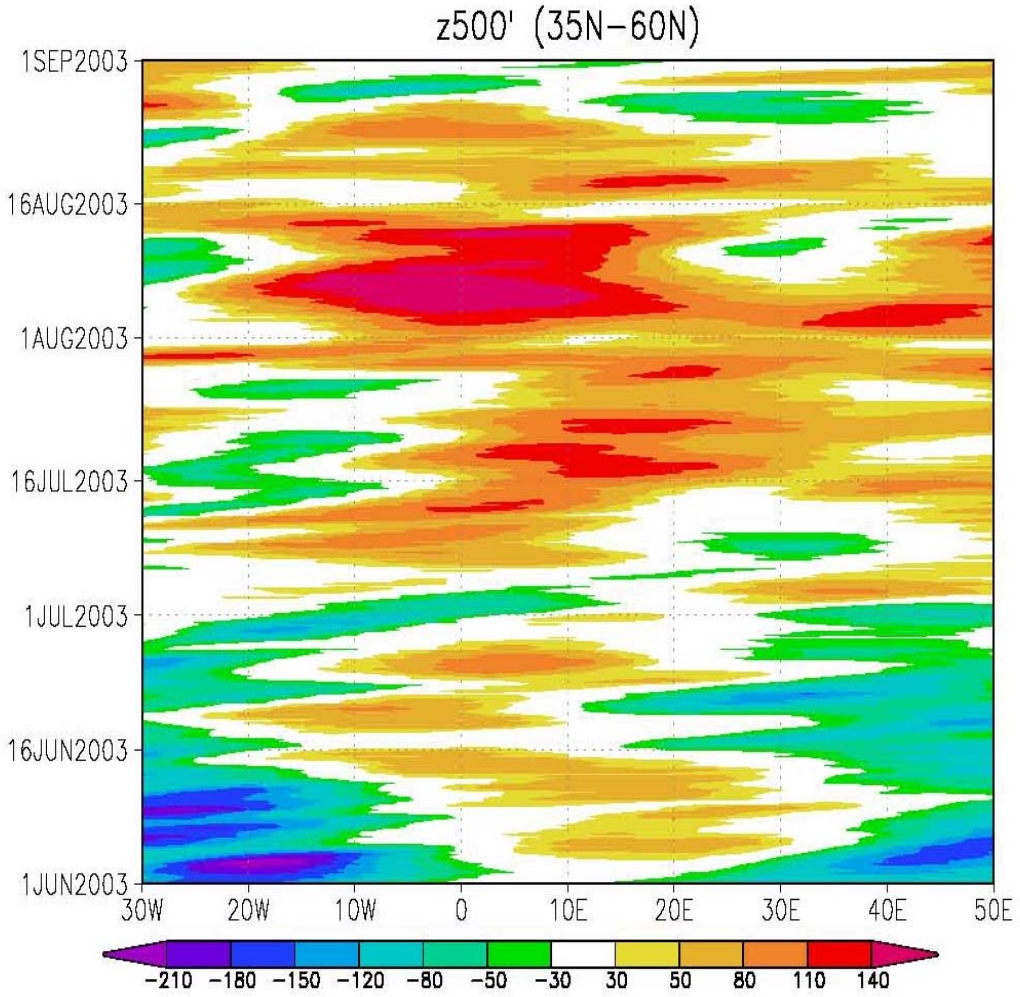
Geopotential Height Anomaly at 500 hPa



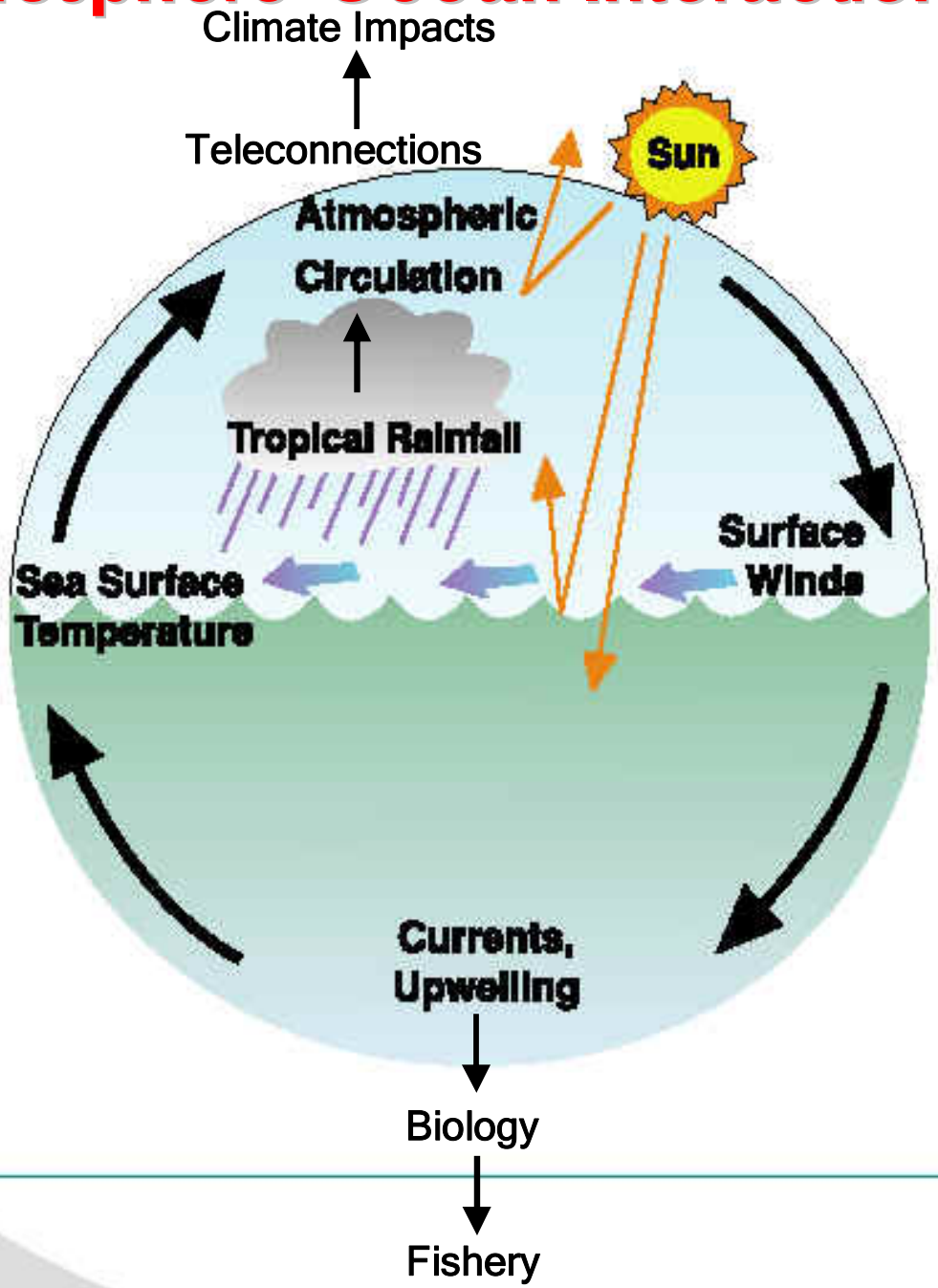
- Strong anticyclonic circulation over Europe: “blocking Ω pattern”

Time-Longitude Diagram of 35N-60N Averaged GPH 500

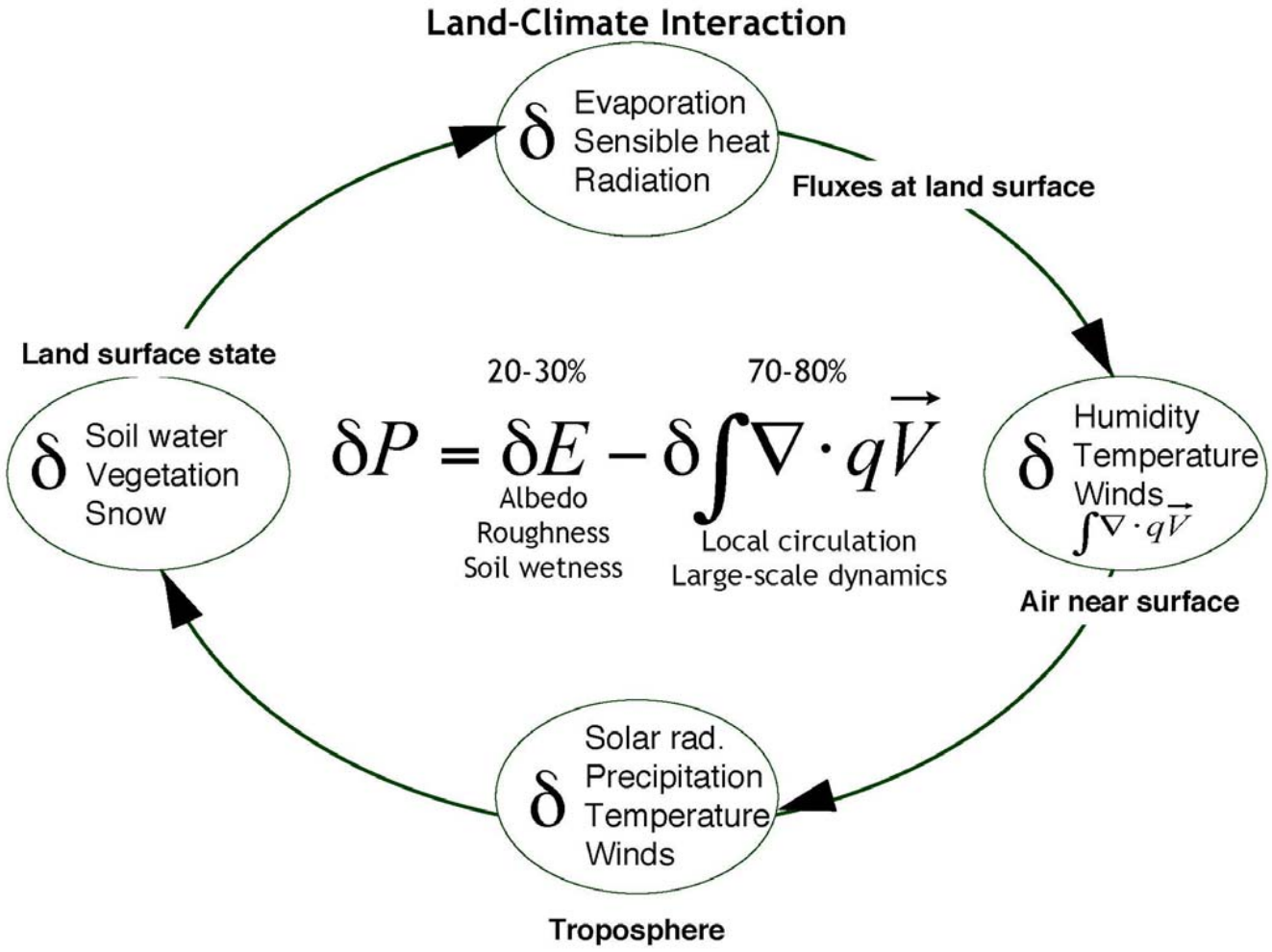
(from May 1 to Sep 1 2003)



Atmosphere-Ocean Interaction



Atmosphere-Land Interaction



Global SST influence in creating and maintaining the 2003 European HW

Experiments:

COLA AGCM v2.2.7 integrations from Jan 1st-Sep 30th 2003 (IC:clim SW)

- ***10 ensemble members*** -

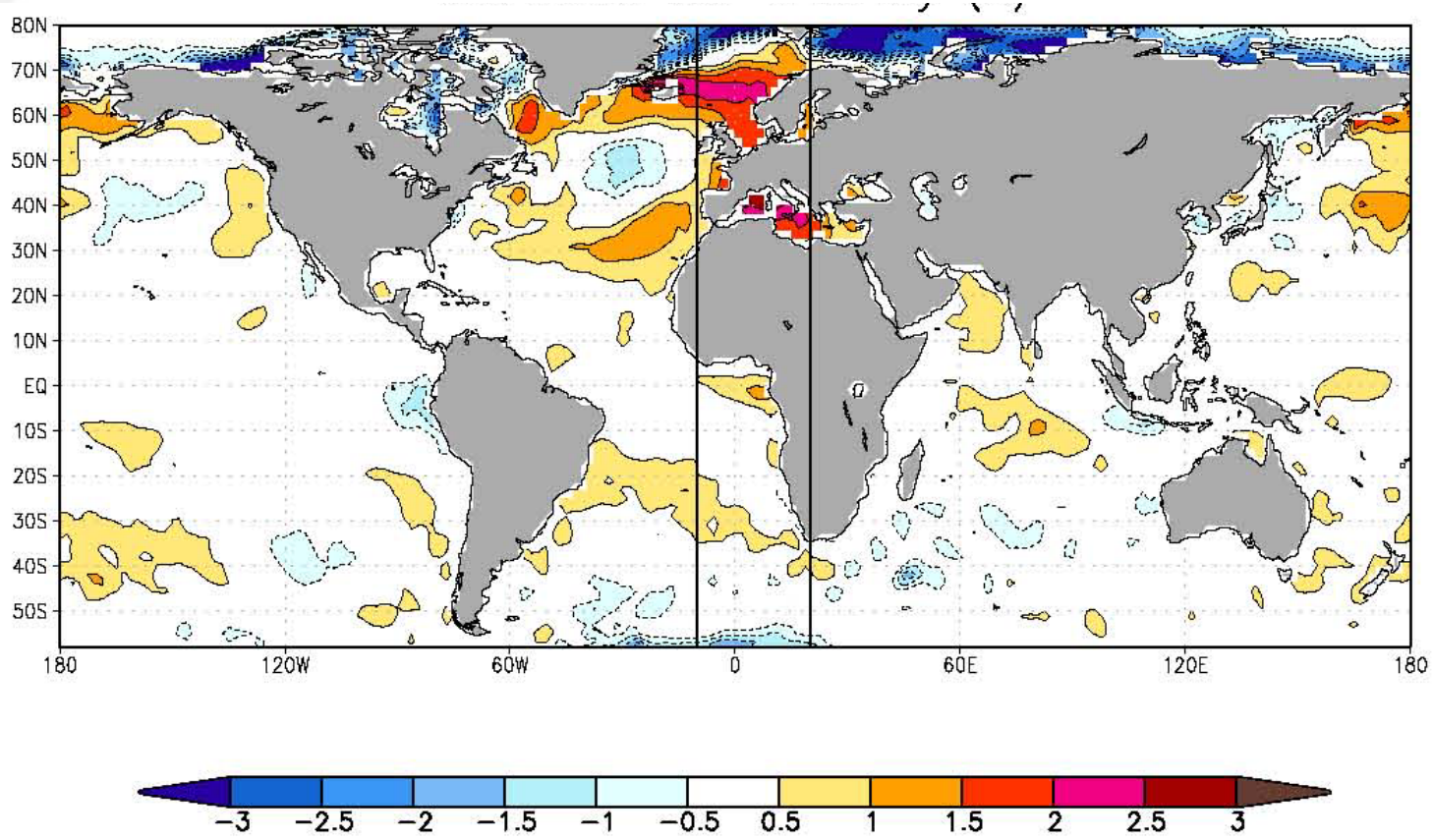
1. **run CLIM-SST → BC:** *global daily climatological OISST-V2 (1982-2003)*

2. **run OBS-SST → BC:** *obs 2003 global, daily SST*

⇓

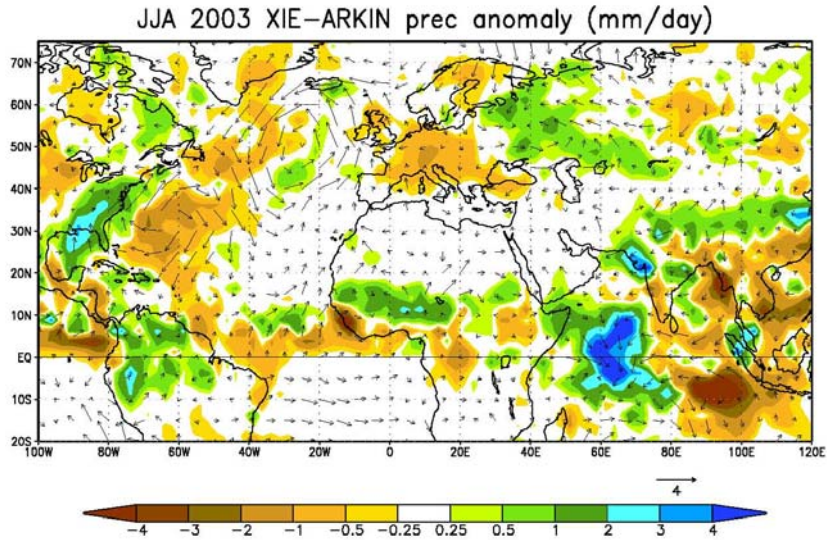
EXP	IC	LEN	BC (SST)	# ENS.
CLIM.SST	00Z01Jan03	9 mo	daily climatological OISST-V2	10
OBS.SST	00Z01Jan03	9 mo	daily 2003 OISST-V2	10

JJA 2003 SST Anomaly



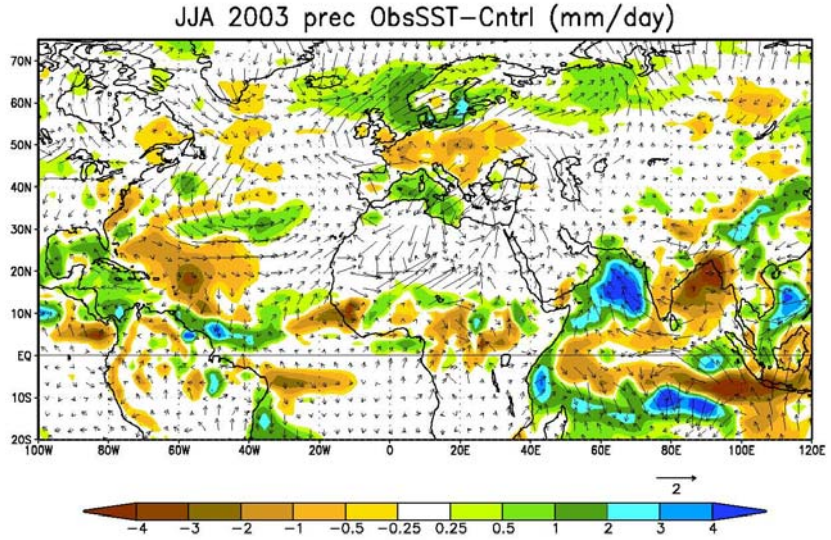
JJA 2003 Precipitation Anomaly

CMAP



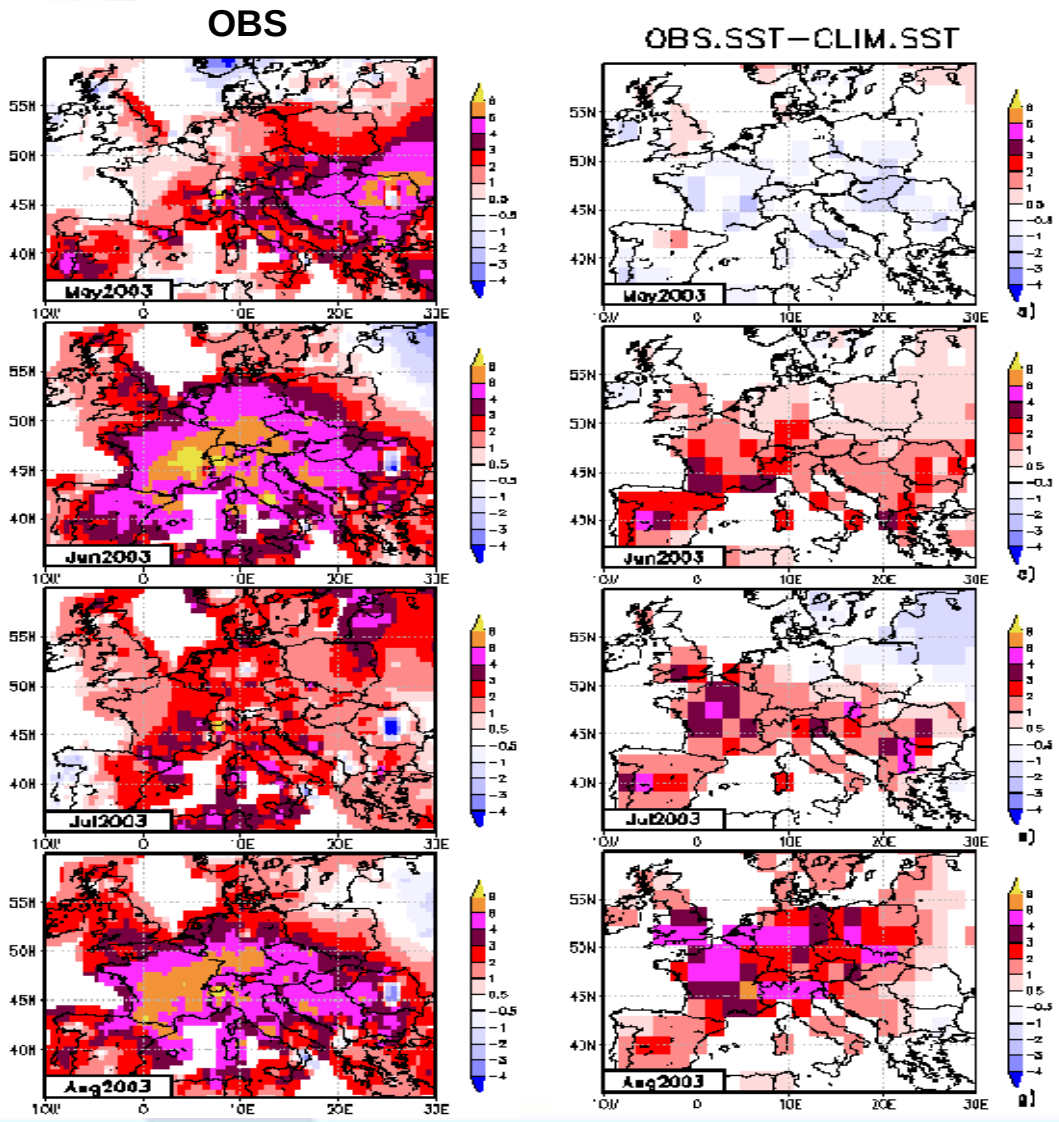
AGCM

OBS.SST-CLIM.SST
Global SST effect



COLA

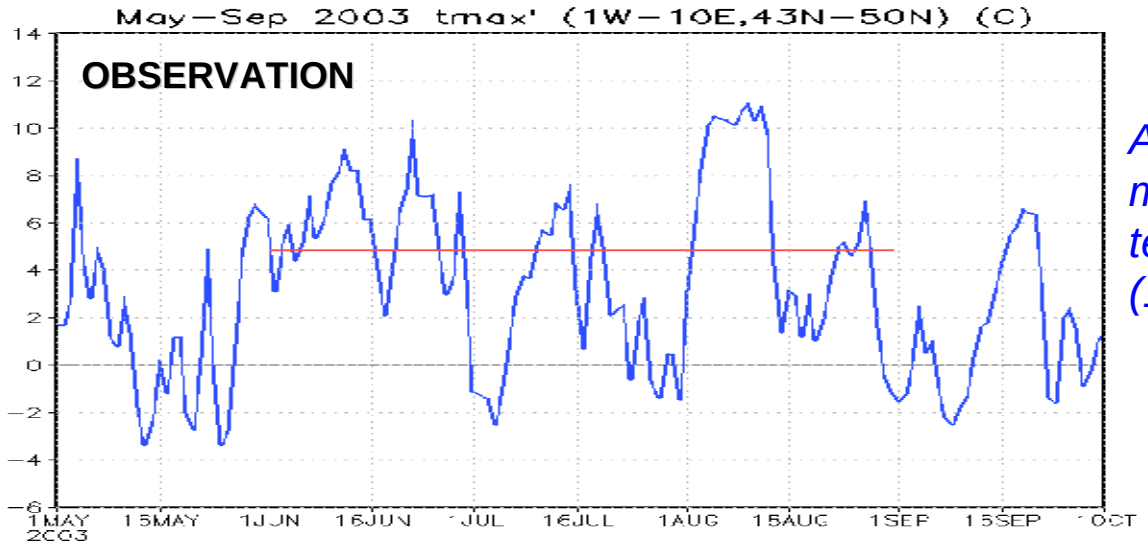
GEORGE MASON UNIVERSITY

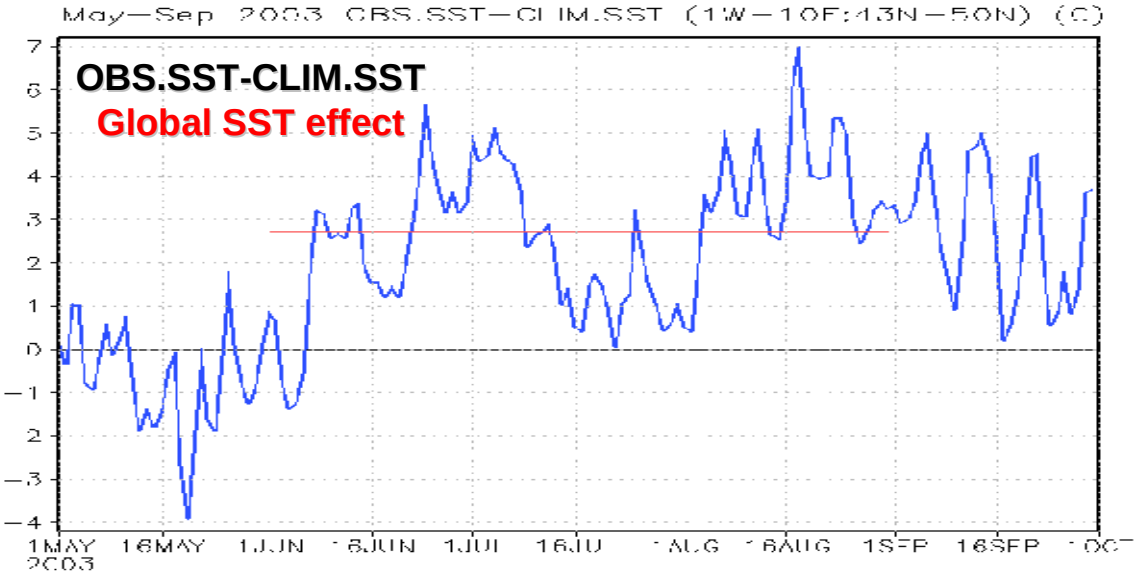


T_{MAX} anomaly:

Comparison between observations and global SST run

MJJAS 2003 Tmax Anomaly



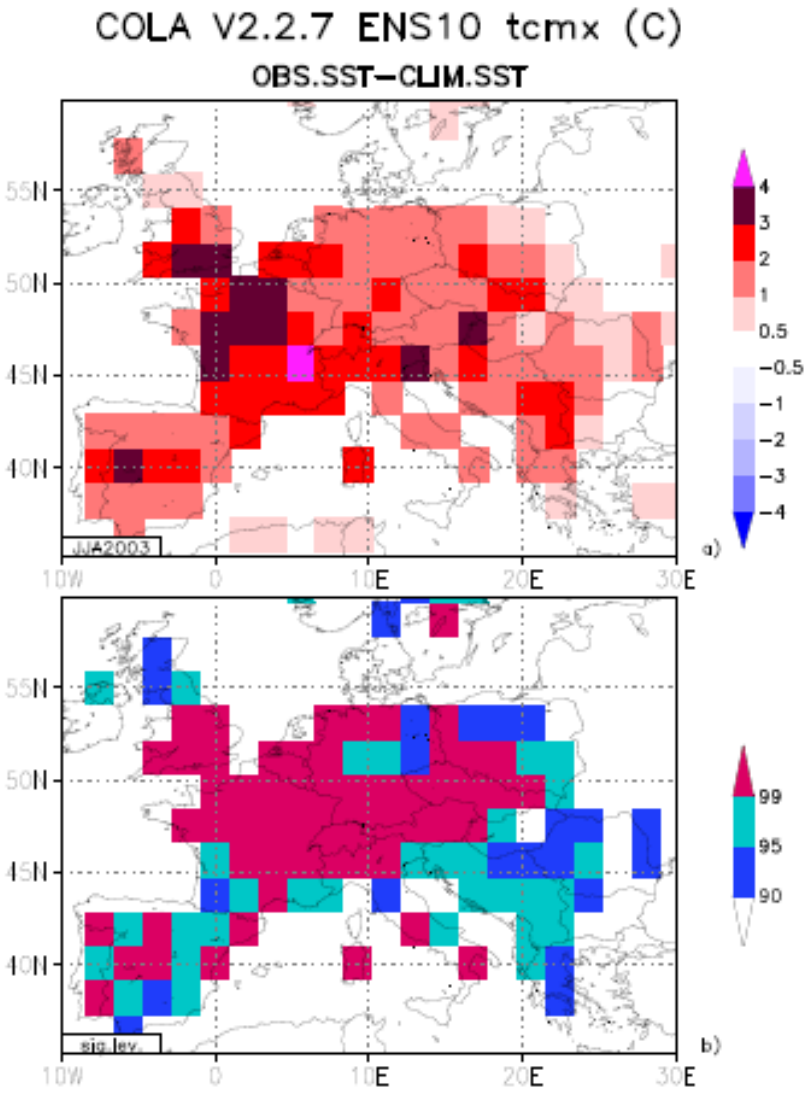


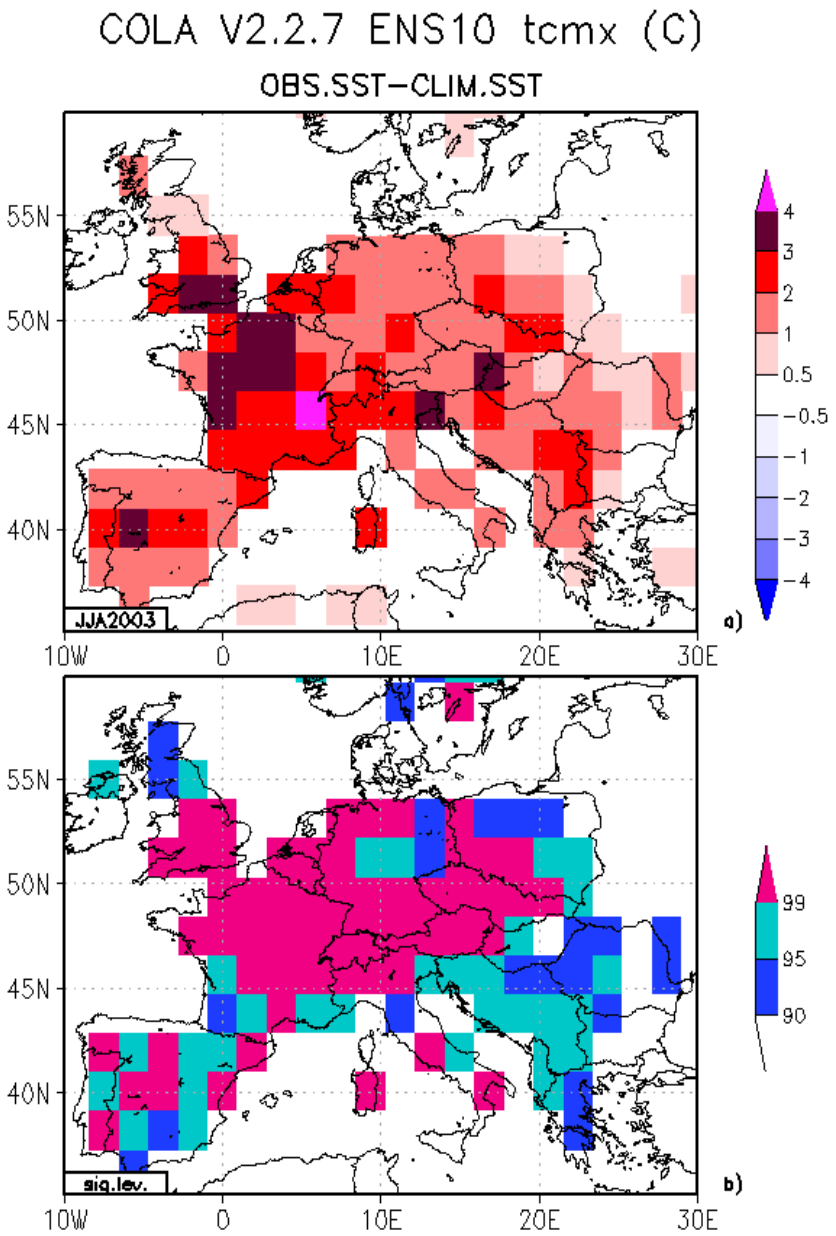
Anomaly of maximum surface temperature on (1W-10E;43N-50N)

Simulated JJA 2003 Tmax Anomaly

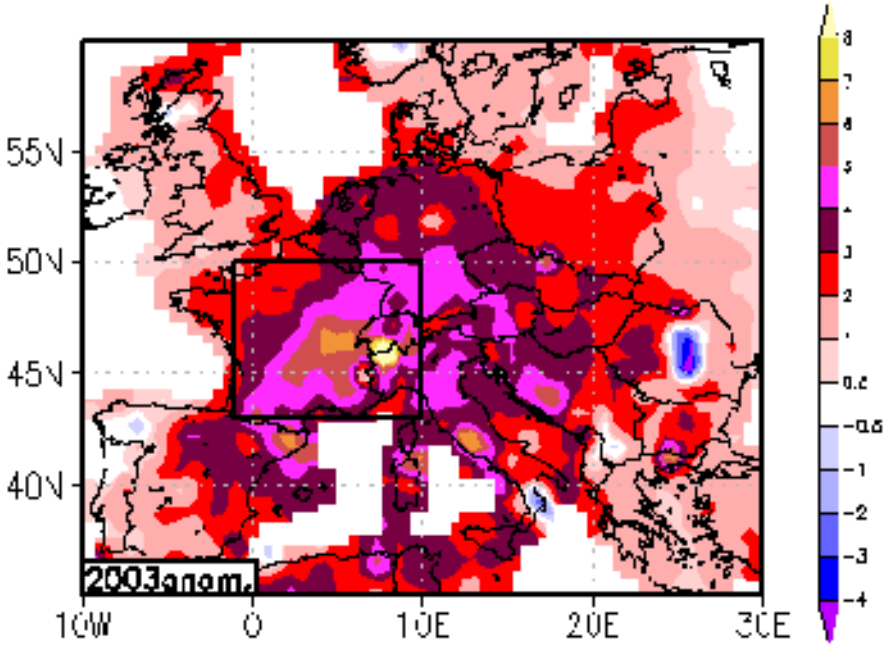
(a) 2003 JJA Tmax Anomaly from the COLA AGCM

(b) The areas where it is significant at more than 90% significance level.





JJA obs



OBS.SST-CLIM.SST exp. result significant at more than 90% sig.lev.

Interim conclusions

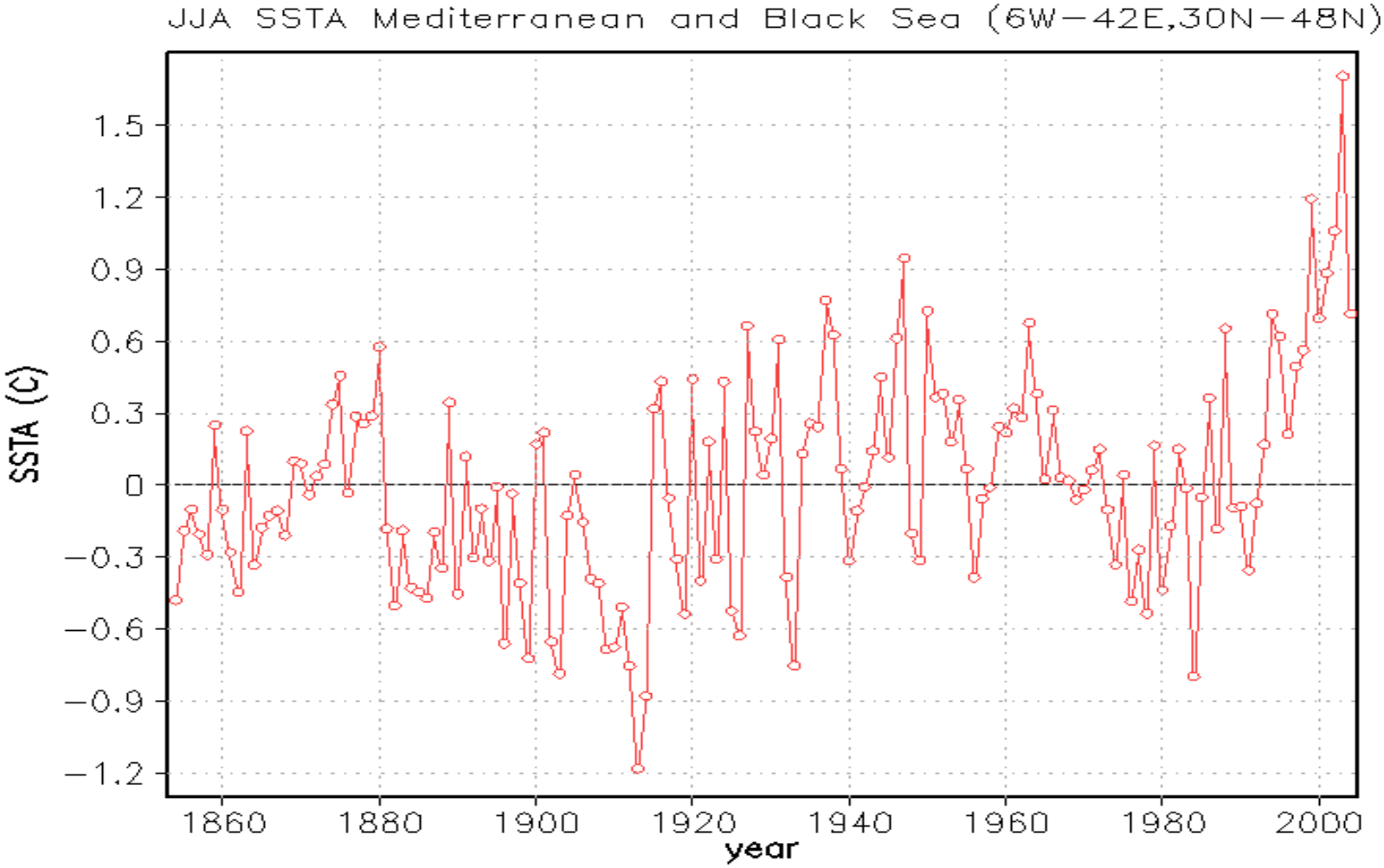
- Global SST is able to capture major features of the 2003 European heat wave.

Next major question:

What was the role of the Mediterranean SST in enhancing the heat wave?

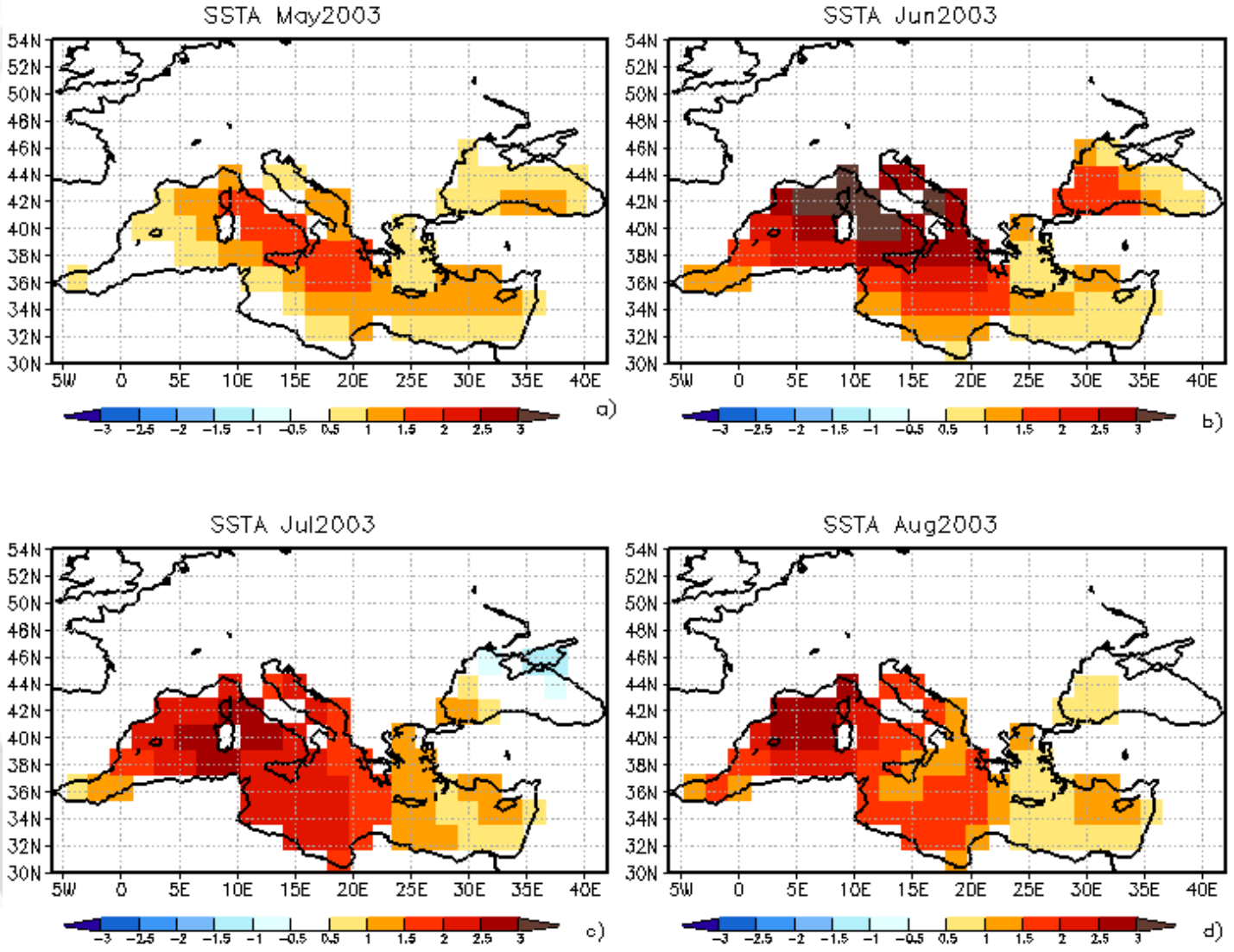
Observed SST

Smith and Reynolds historical reconstructed SST

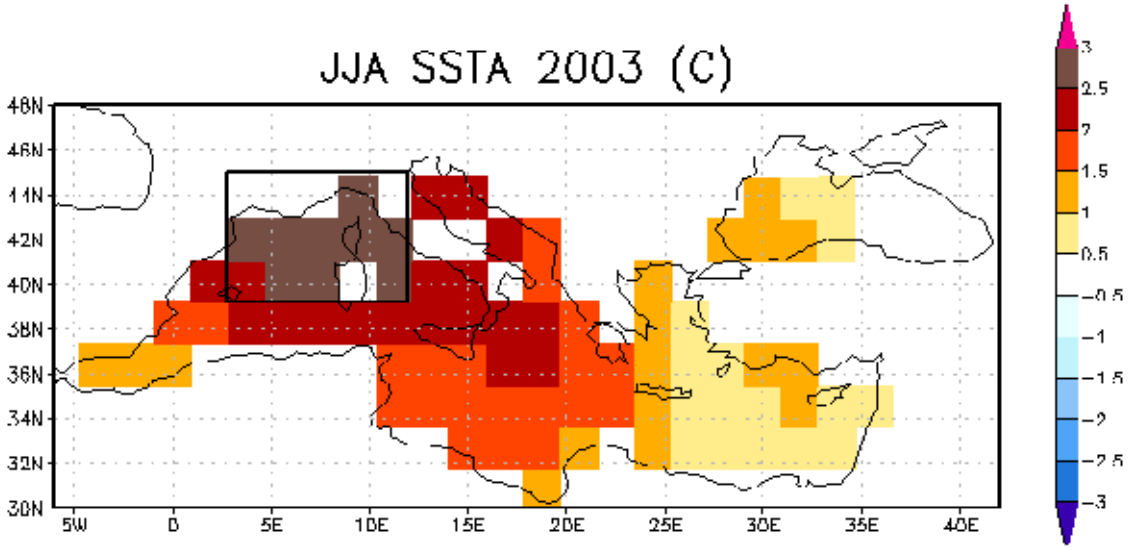


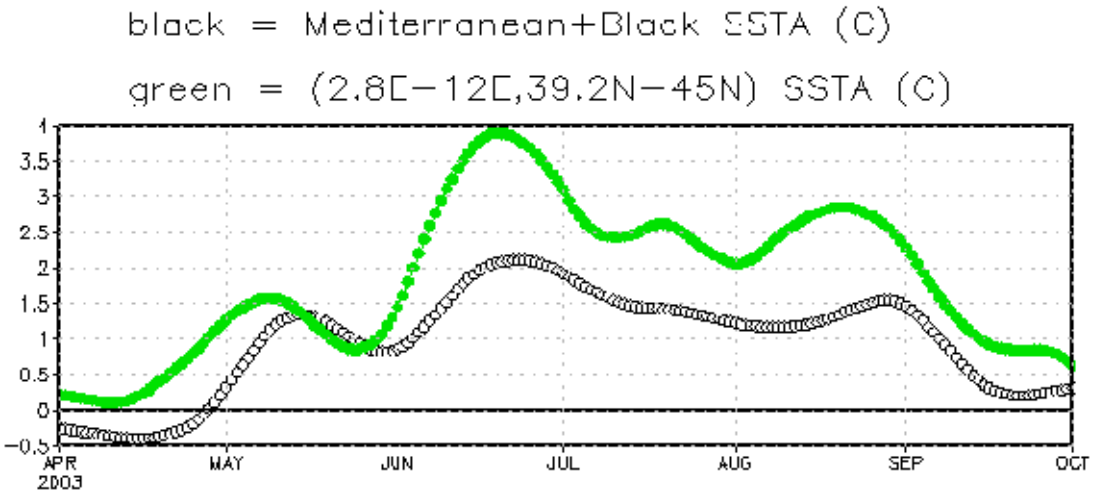
MJJA 2003 SST Anomaly

Mediterranean and Black Sea)



JJA 2003 SST Anomaly



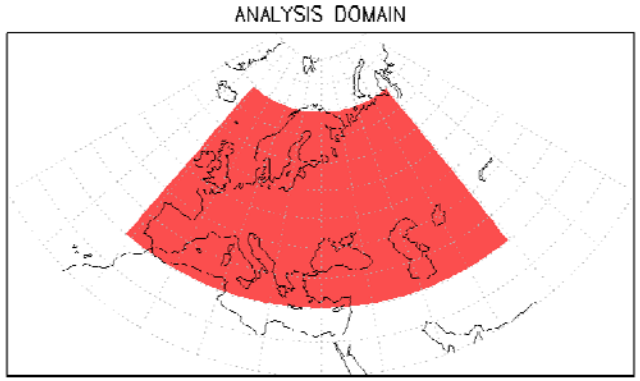


Composites of Warm Events

- We identified the following major summer warm events occurred in Europe between 1950-2003 using a method we devised:

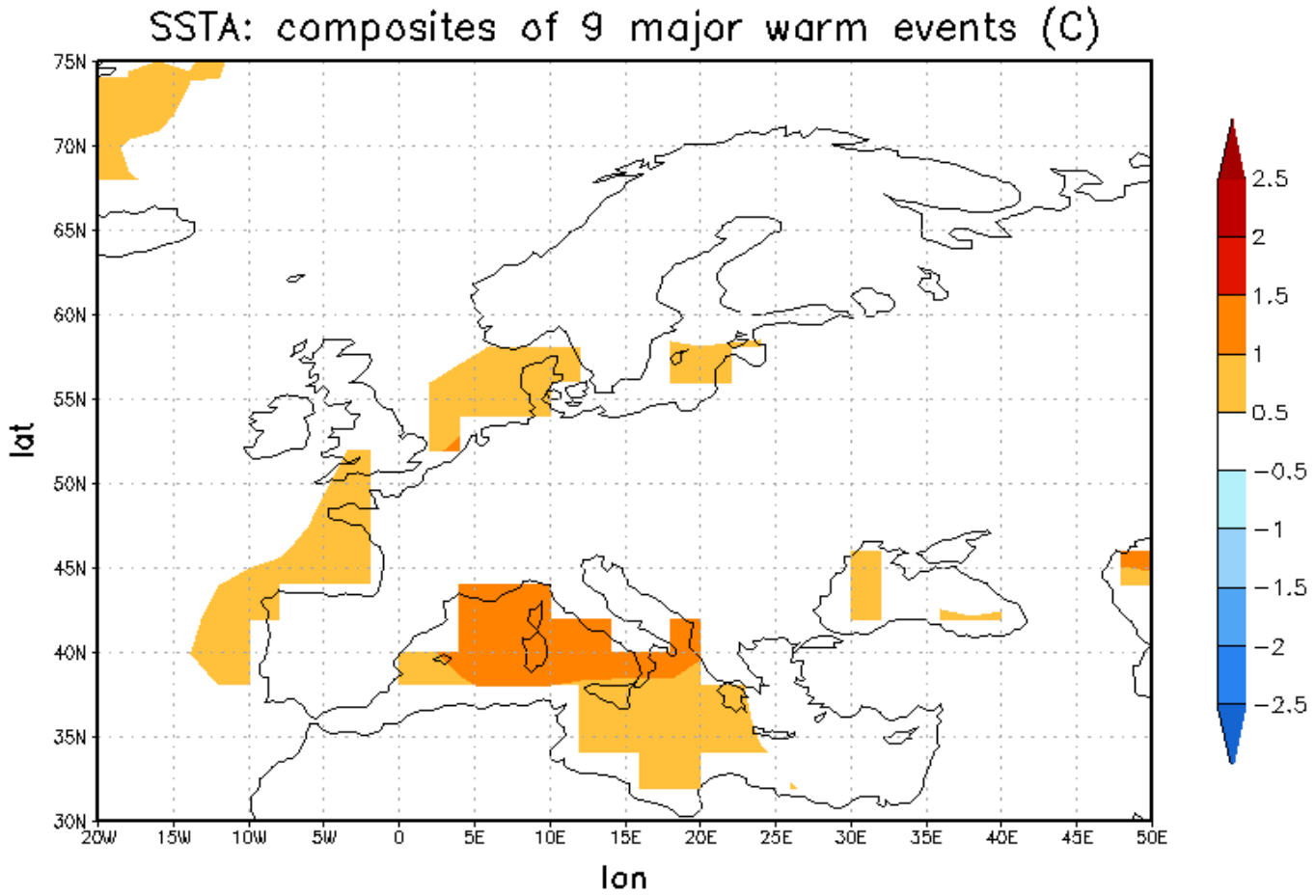
duration (days)	start.time	end.time
17	24 jun 1952	10 jul 1952
15	23 jun 1976	7 jul 1976
16	7 jul 1983	1 aug 1983
16	16 aug 1992	31 aug 1992
31	18 jul 1994	17 aug 1994
15	30 jul 1998	13 aug 1998
23	9 aug 2000	23 aug 2000
31	13 jun 2002	2 jul 2002
33	6 jun 2003	8 jul 2003

(9 grid points above 95 percentile for more than 15 days)



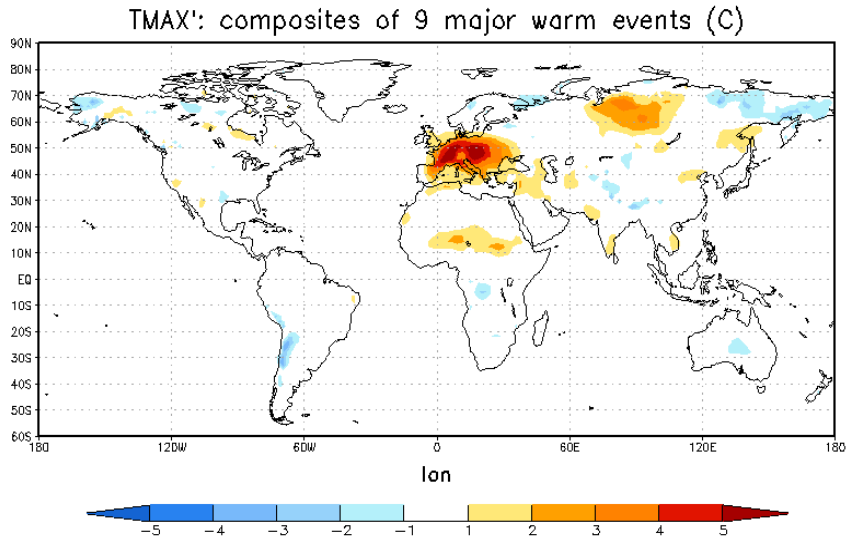
• Of these 9 events we constructed composites of the anomalies of different meteorological fields (eg. Z_{500}, t_{air}, ….) and SST.

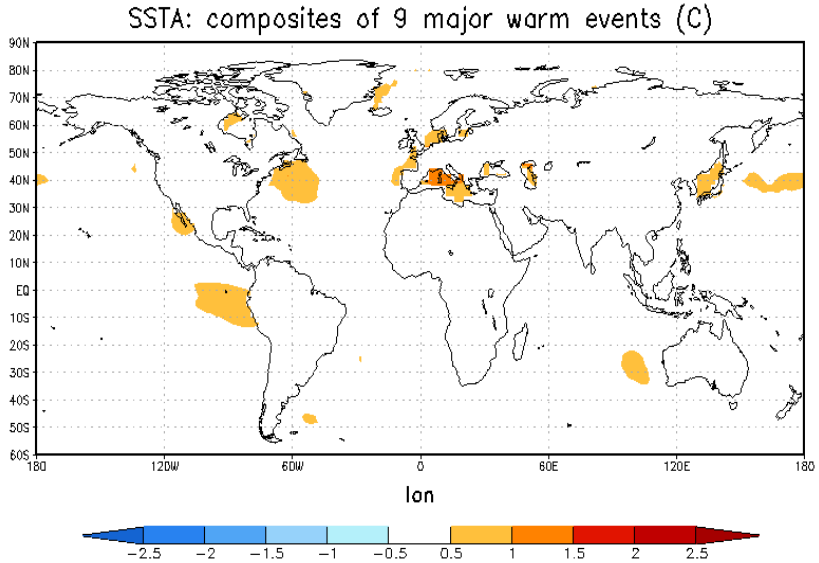
SSTA influence?

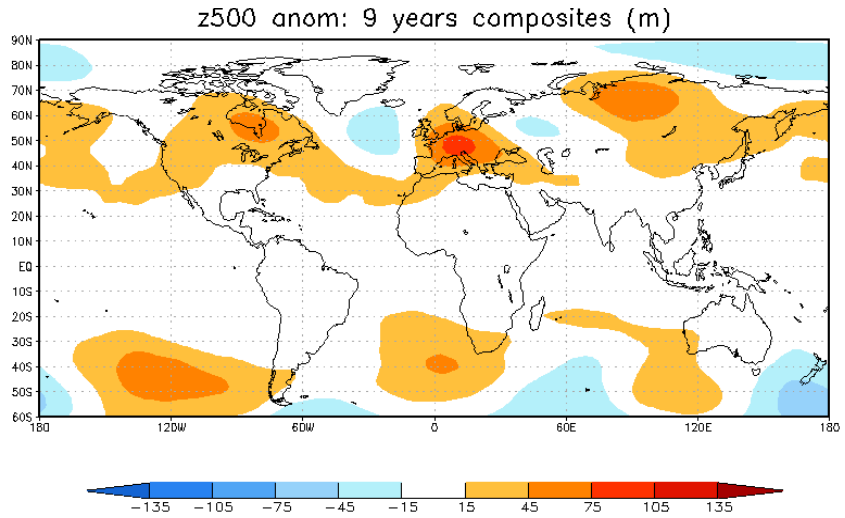


- Is this Mediterranean SST anomaly playing a role in **creating** and/or **maintaining** the heat waves occurring in the European region?

Composites of 9 Major Warm Events during JJA 1950-2003







Mediterranean SST influence in creating and maintaining the 2003 European Heatwave

Experiments:

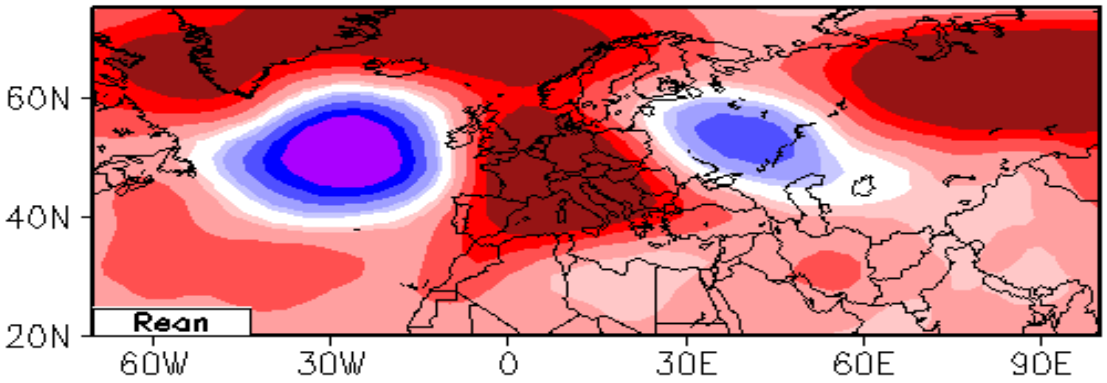
COLA AGCM v2.2.7 integrations from Jan 1st-Sep 30th 2003 (IC:clim SW)

- ***10 ensemble members*** -

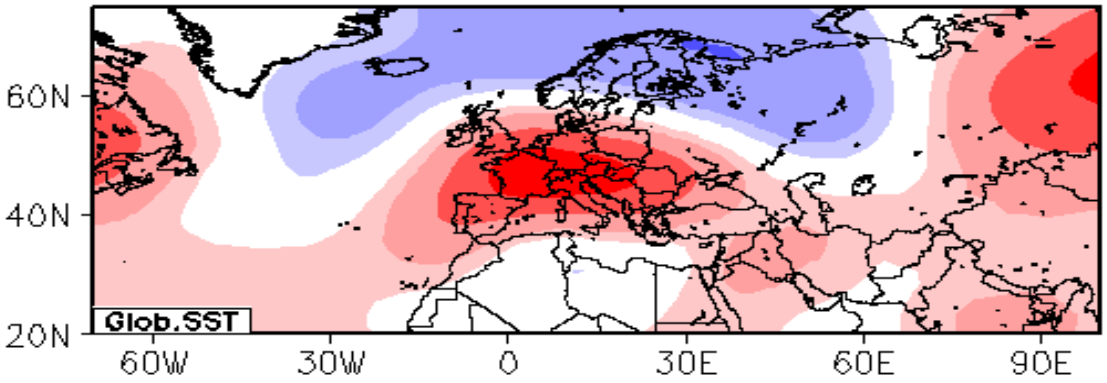
1. **run CLIM-SST → BC***: global daily climatological OISST-V2*
2. **run OBS-SST → BC:** *obs 2003 global, daily SST*
3. **run OBS-MED → BC:** *obs 2003 (Med.Sea+Bl.Sea) SST; the rest clim. OISST-V2*
4. **run CLIM-MED: → BC:** *daily climatological OISST-V2 in the Med.Sea+Bl.Sea; the rest obs 2003*

EXP	IC	LEN	BC (SST)	# ENS.
CLIM.SST	00Z01Jan03	9 mo	daily climatological OISST-V2	10
OBS.SST	00Z01Jan03	9 mo	daily 2003 OISST-V2	10
OBS.MED	00Z01Jan03	9 mo	daily (MedBl 2003+rest clim) OISST-V2	10
CLIM.MED	00Z01Jan03	9 mo	daily (MedBl clim+rest 2003) OISST-V2	10

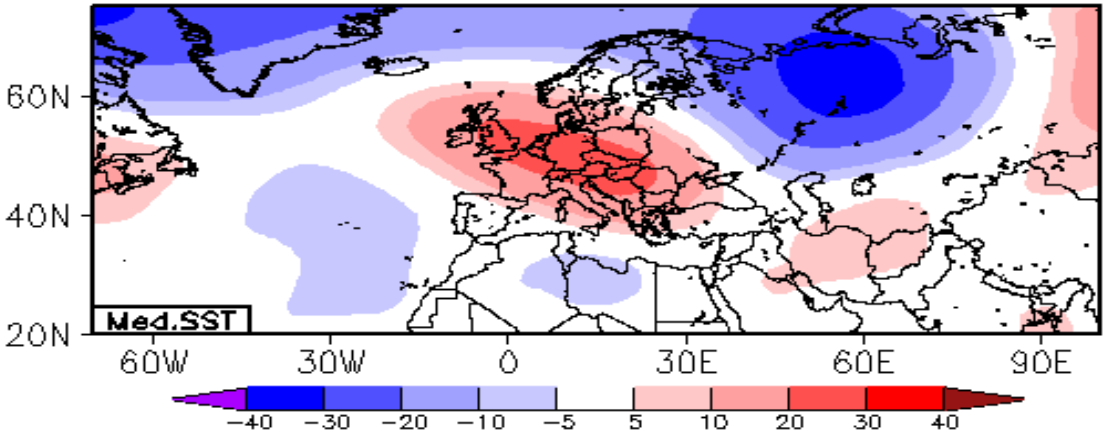
a) NCEP Reanalysis



b) Global SST effect



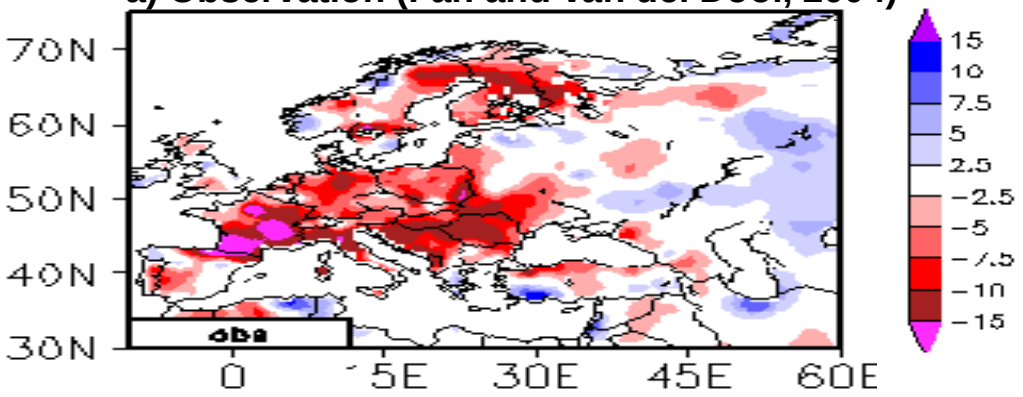
c) Mediterranean SST effect



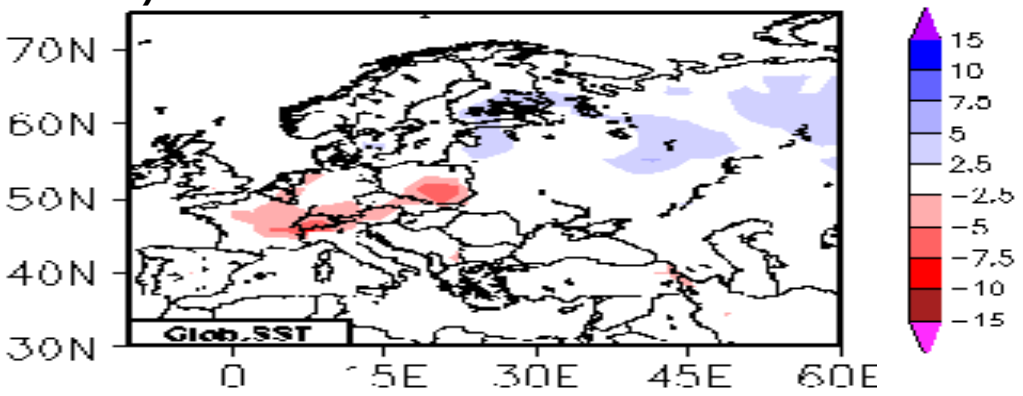
JJA 2003: Exp results

500 hPa Geopotential Height Anomaly (m)

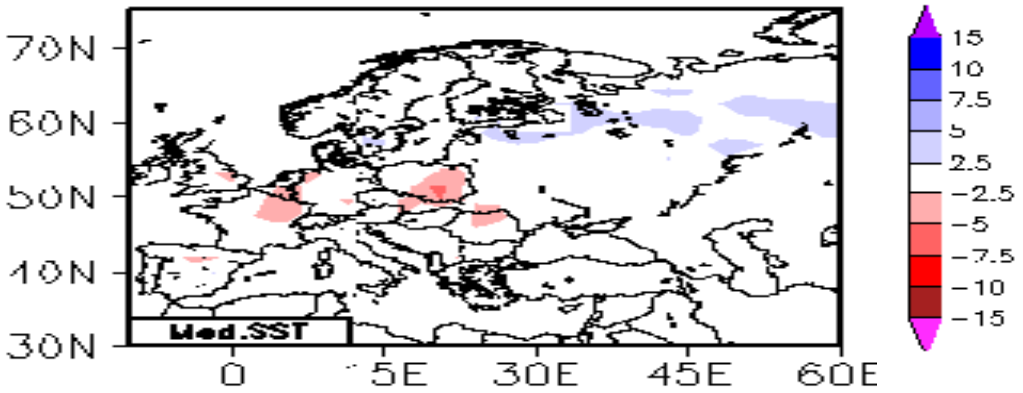
a) Observation (Fan and van del Dool, 2004)



b) Global SST effect



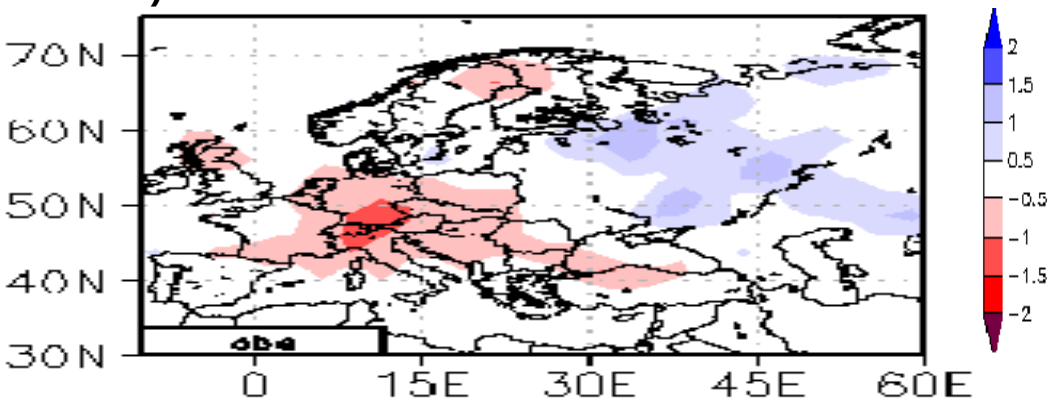
c) Mediterranean SST effect



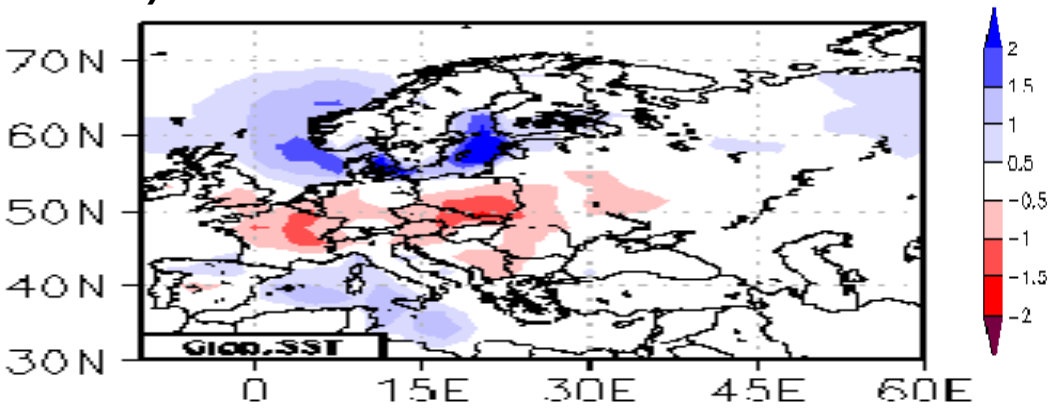
JJA 2003: Exp results

Soil Moisture Anomaly (%)

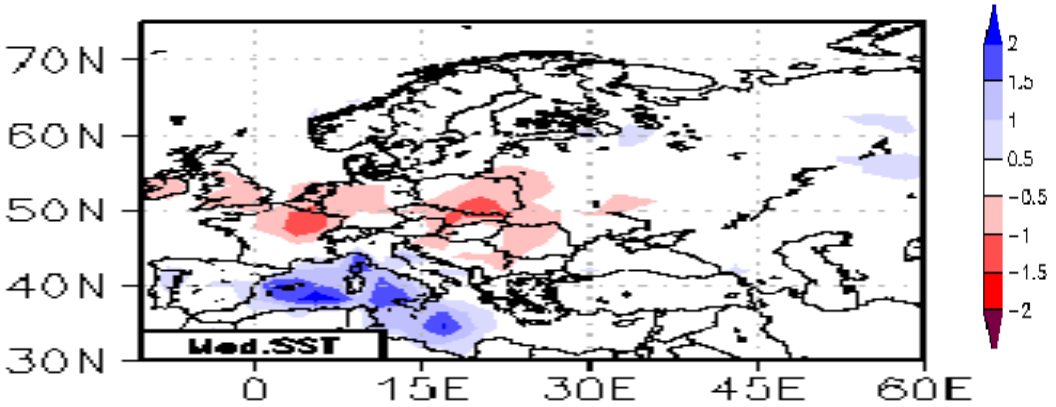
a) CMAP



b) Global SST effect



c) Mediterranean SST effect

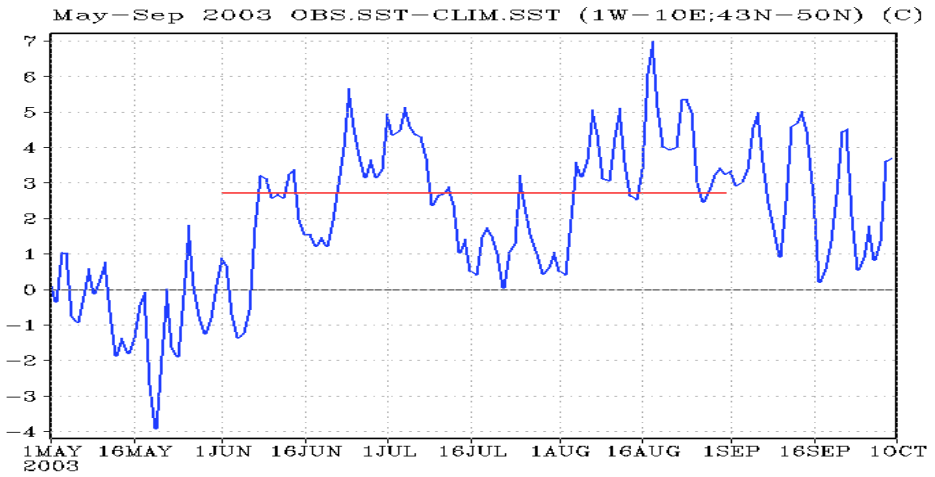


JJA 2003: Exp results

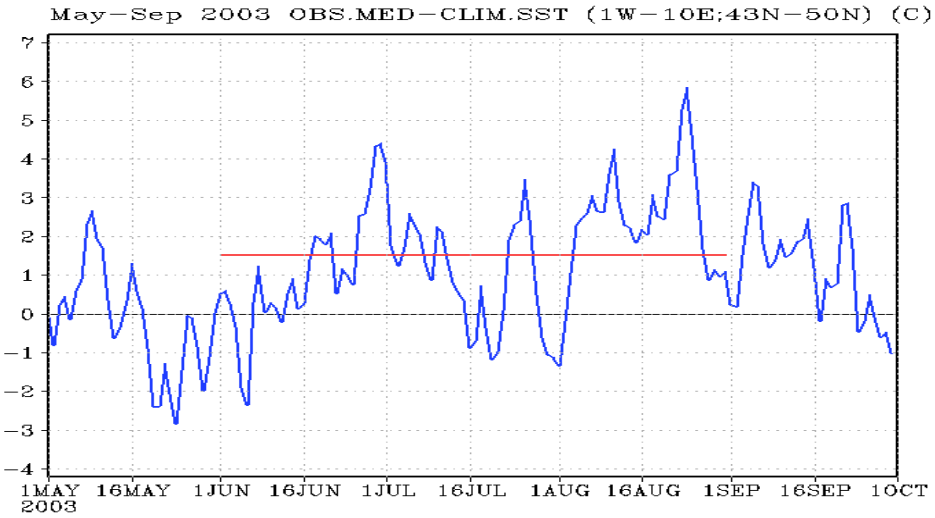
Precipitation Anomaly (mm/day)

Surface T_{max} Anomaly

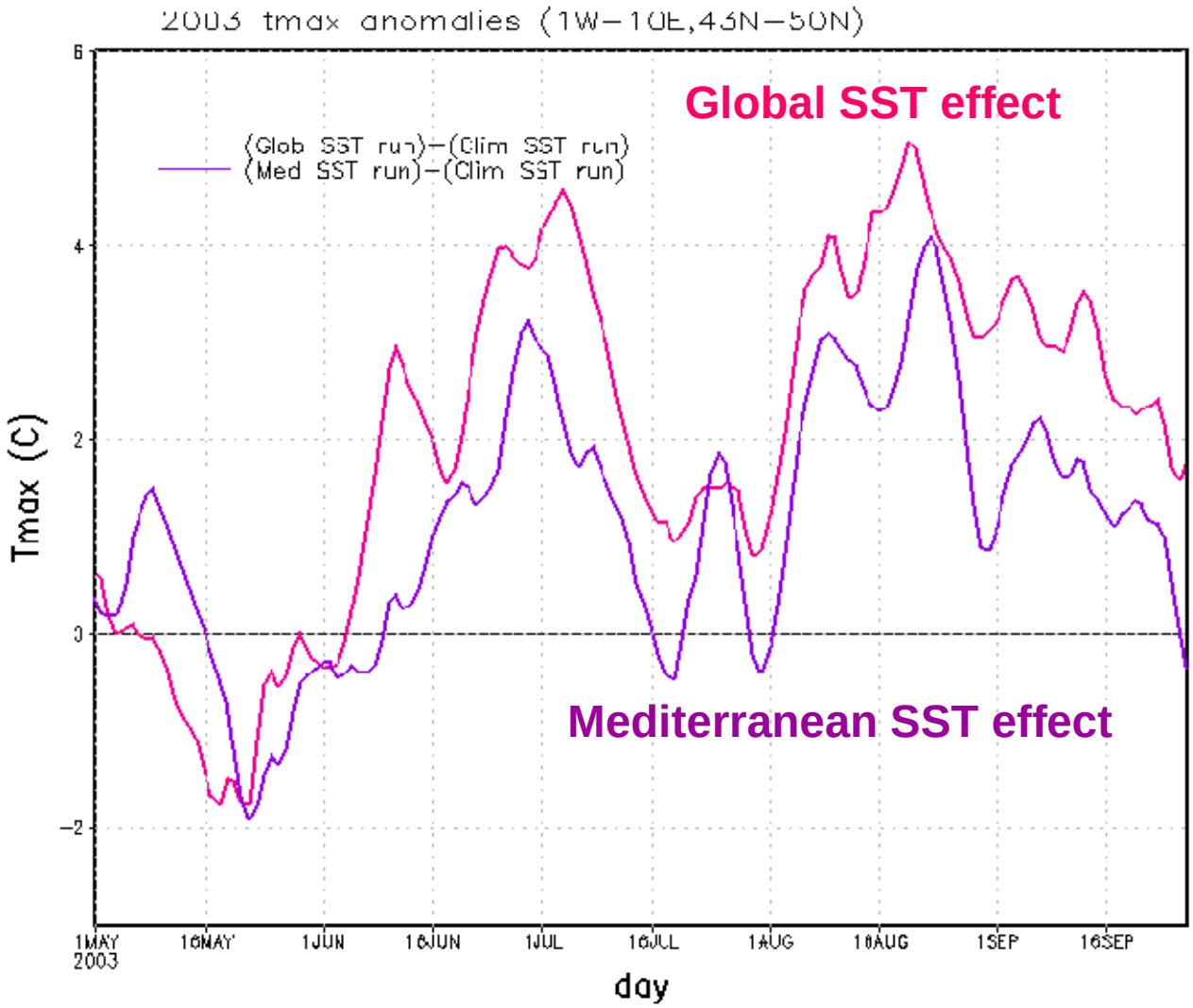
OBS.SST-CLIM.SST
Global SST effect



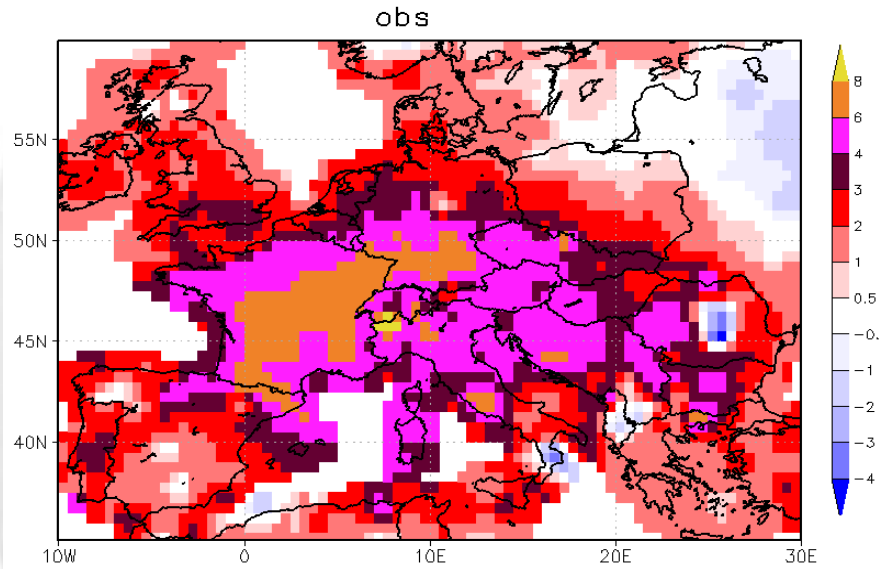
OBS.MED-CLIM.SST
Mediterranean SST effect

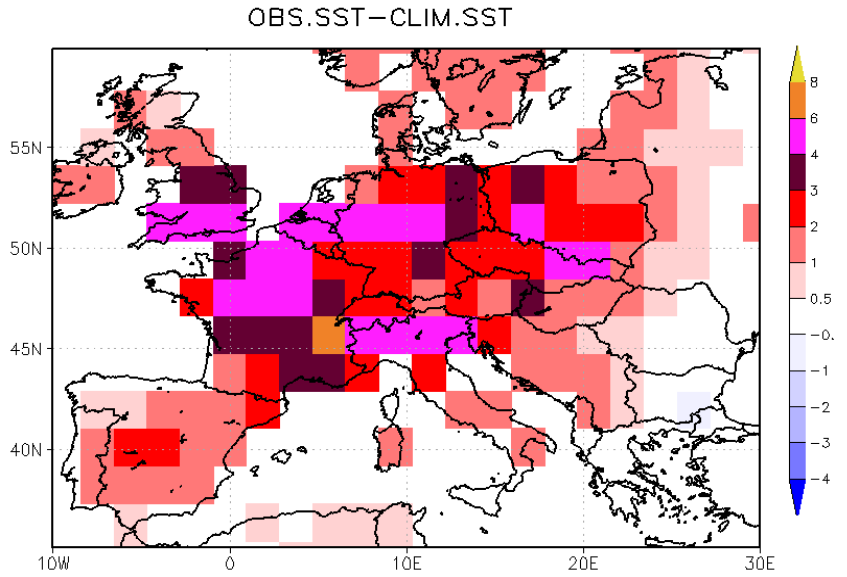


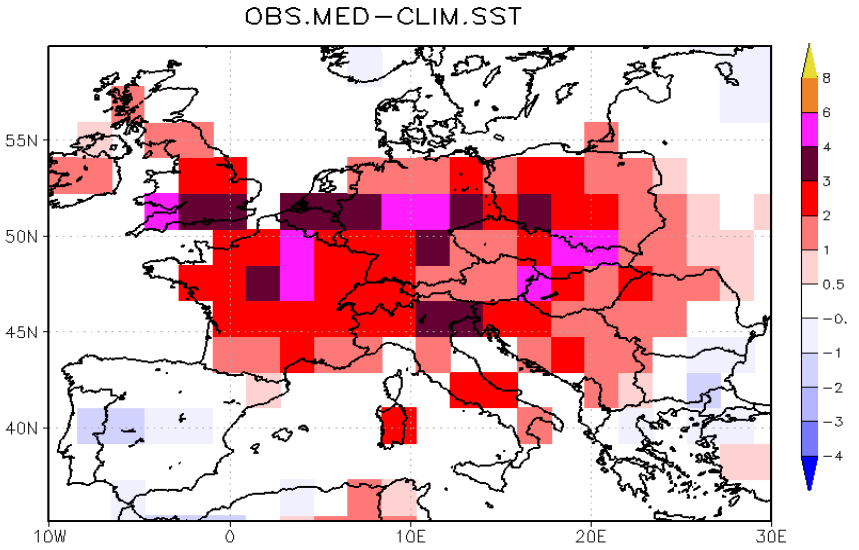
2003 T_{max} Anomaly



August 2003 T_{max} Anomaly

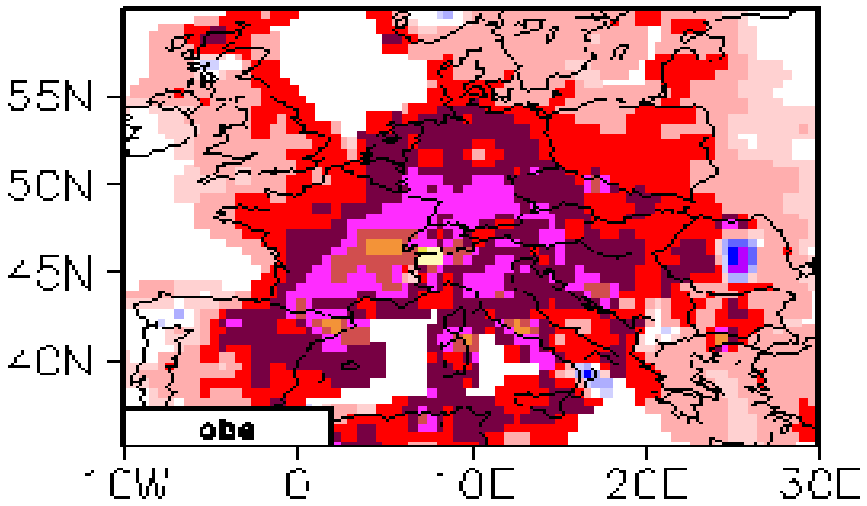




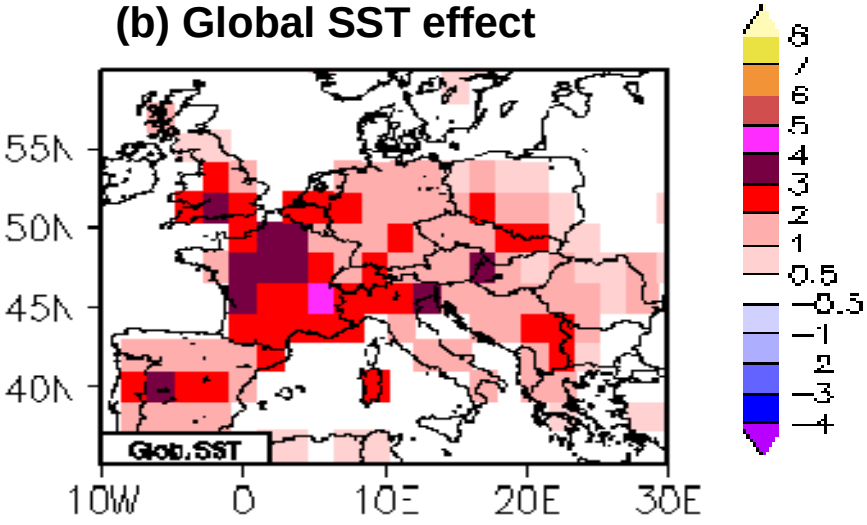


JJA 2003 T_{max} Anomaly

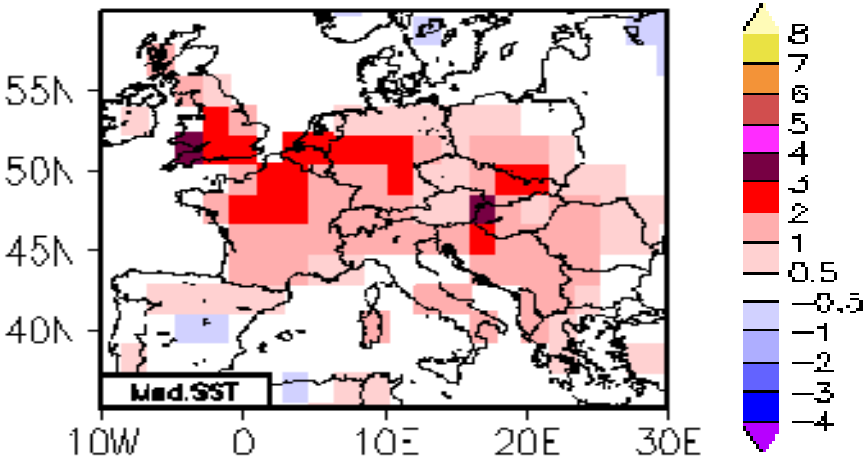
(a) Observations



(b) Global SST effect



(c) Mediterranean SST effect



Conclusions

1. If observed SST were used to force the AGCM starting from Jan 2003 to Sep 2003, the model captured all the major features, except magnitude (~half of observations).

2. It was remarkable that the Mediterranean and Black Sea SSTA could explain more than half of the global SST effect, especially in August: the Mediterranean Sea+Black Sea played an important role in enhancing the European heat wave.

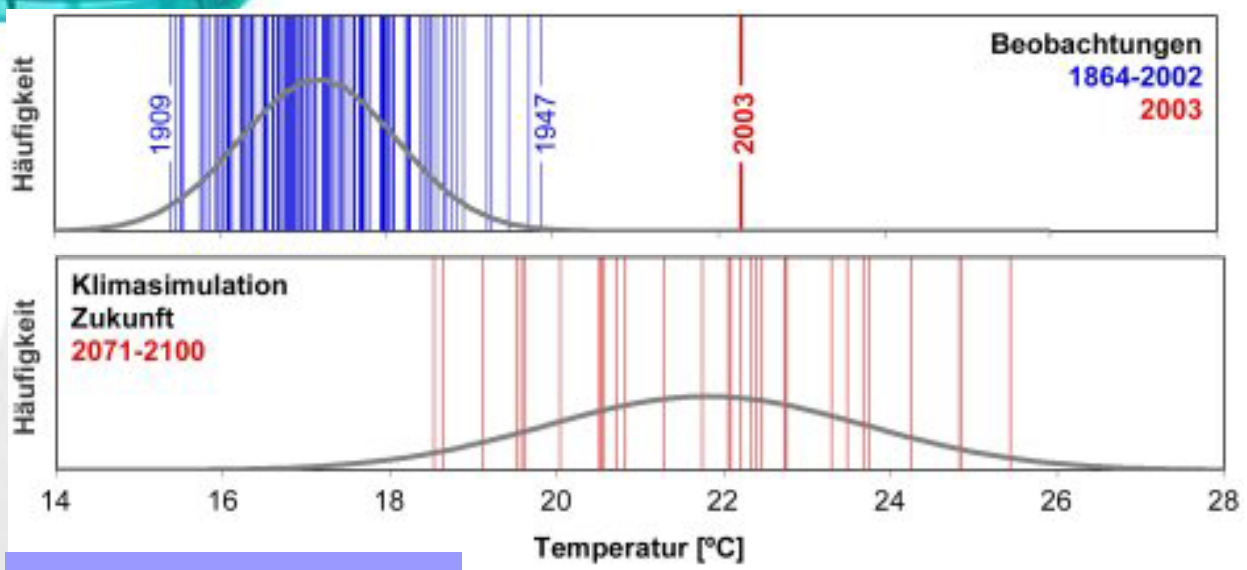
3. The lower magnitude of the simulated heat wave was partly because of warm model climatology.

4. Atmosphere-land interaction was not correctly simulated. That could further enhance the simulated heatwave.

5. Precipitation has the opposite sign (--> high convection over Med.Sea due to the high positive SSTA) --> the soil was not as dry as obs: soil wetness forcing would enhance the result

THANK YOU!

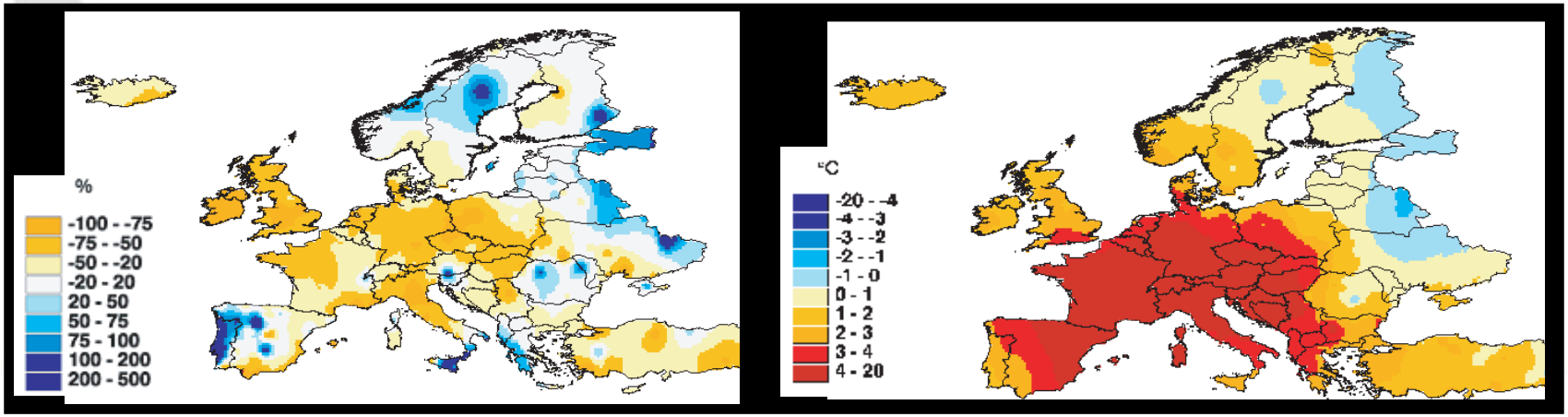
Case study: Summer heat wave 2003



- ***Heat stress***
- ***Drought stress***
- ***Wildfires***

Schär et al. 2004

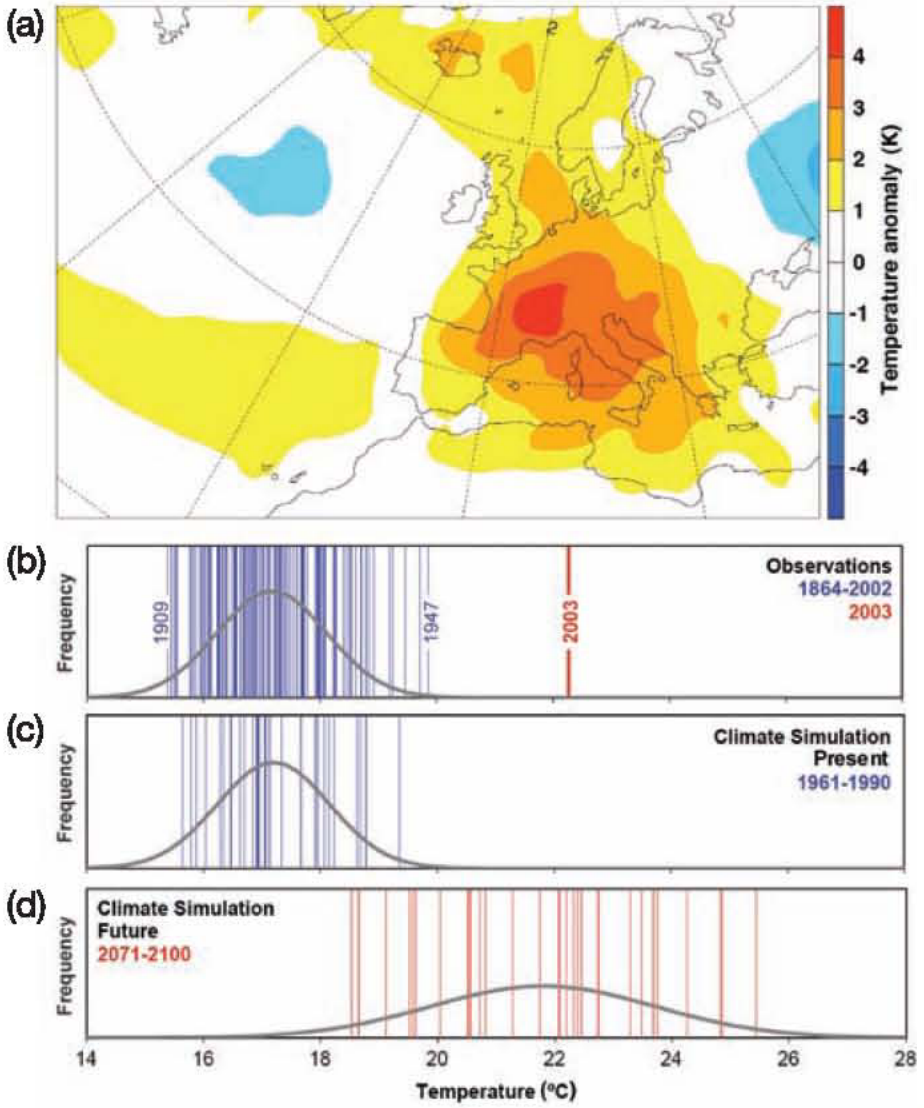
Precipitation ***Max. temperature***



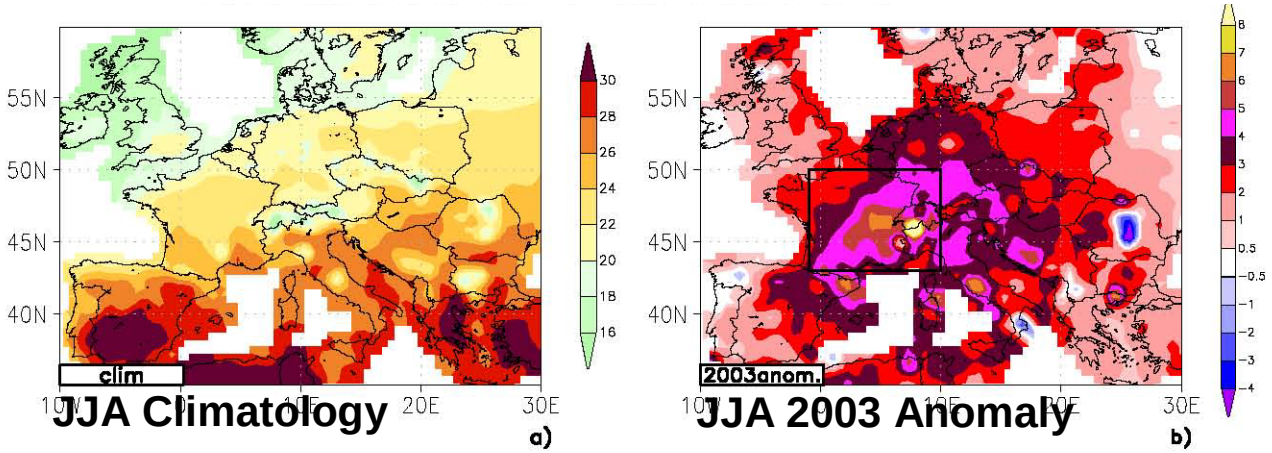
Rebetez et al. 2006

August 2003

Characteristics of the summer 2003 heatwave

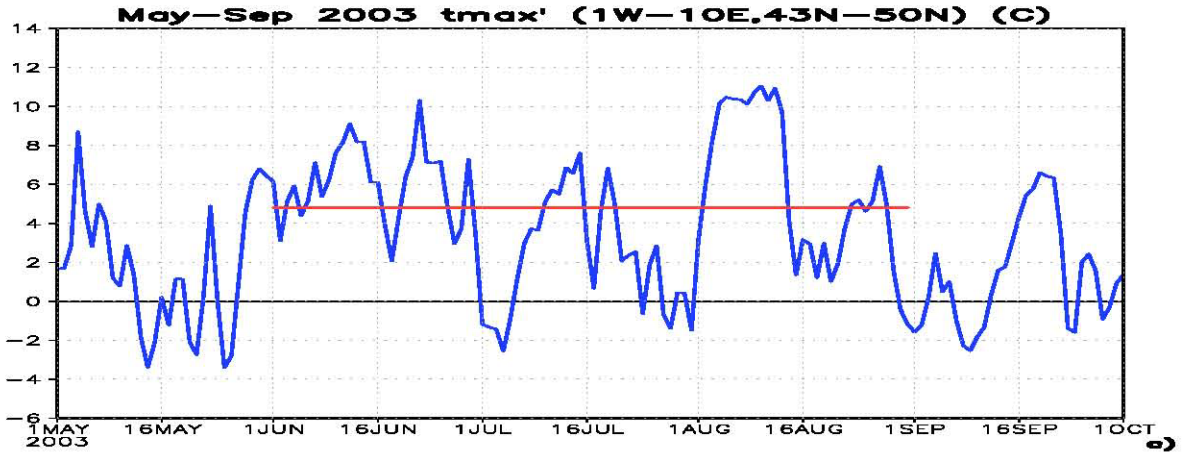


JJA Maximum Temperature

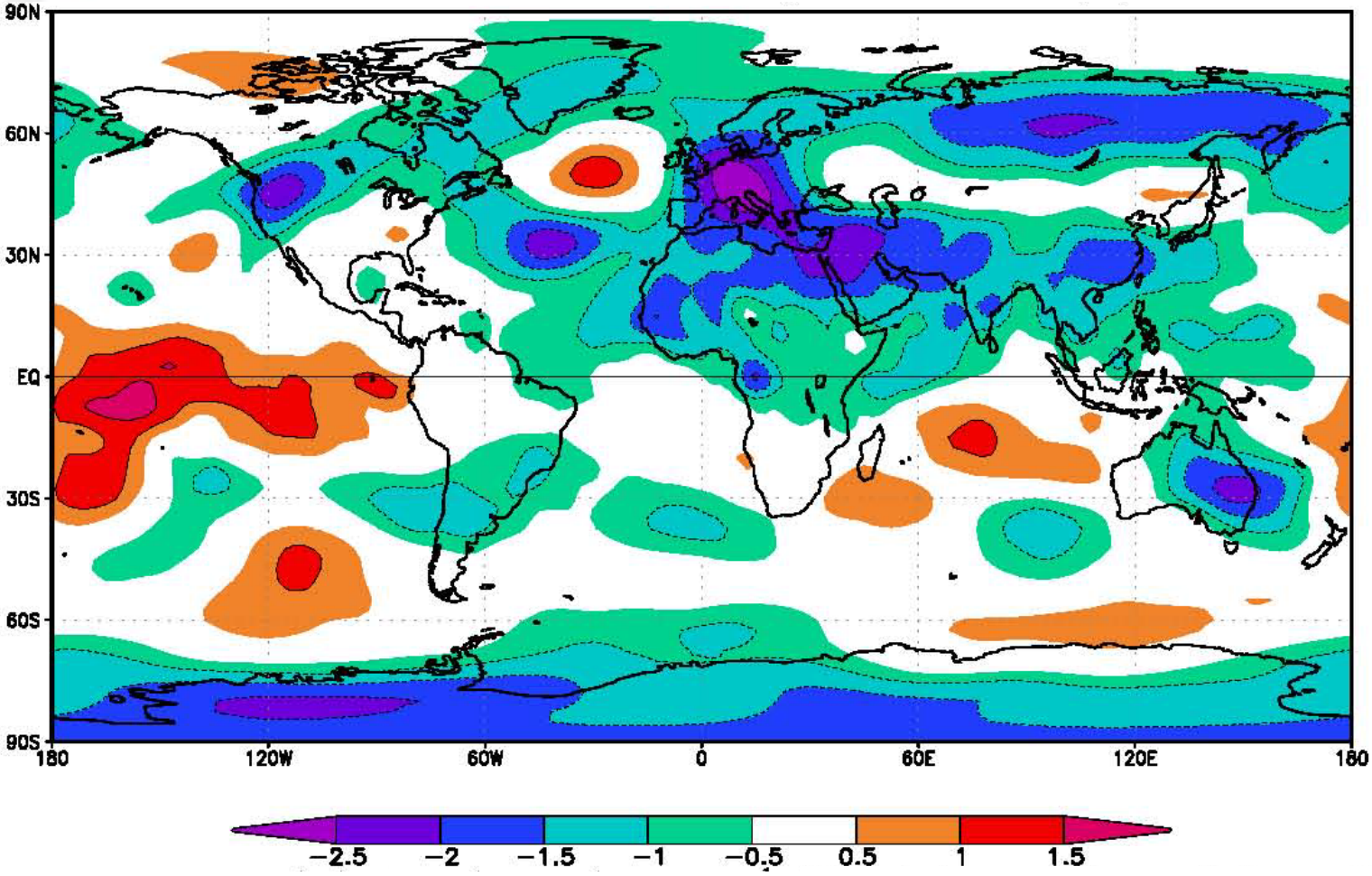


JJA Climatology

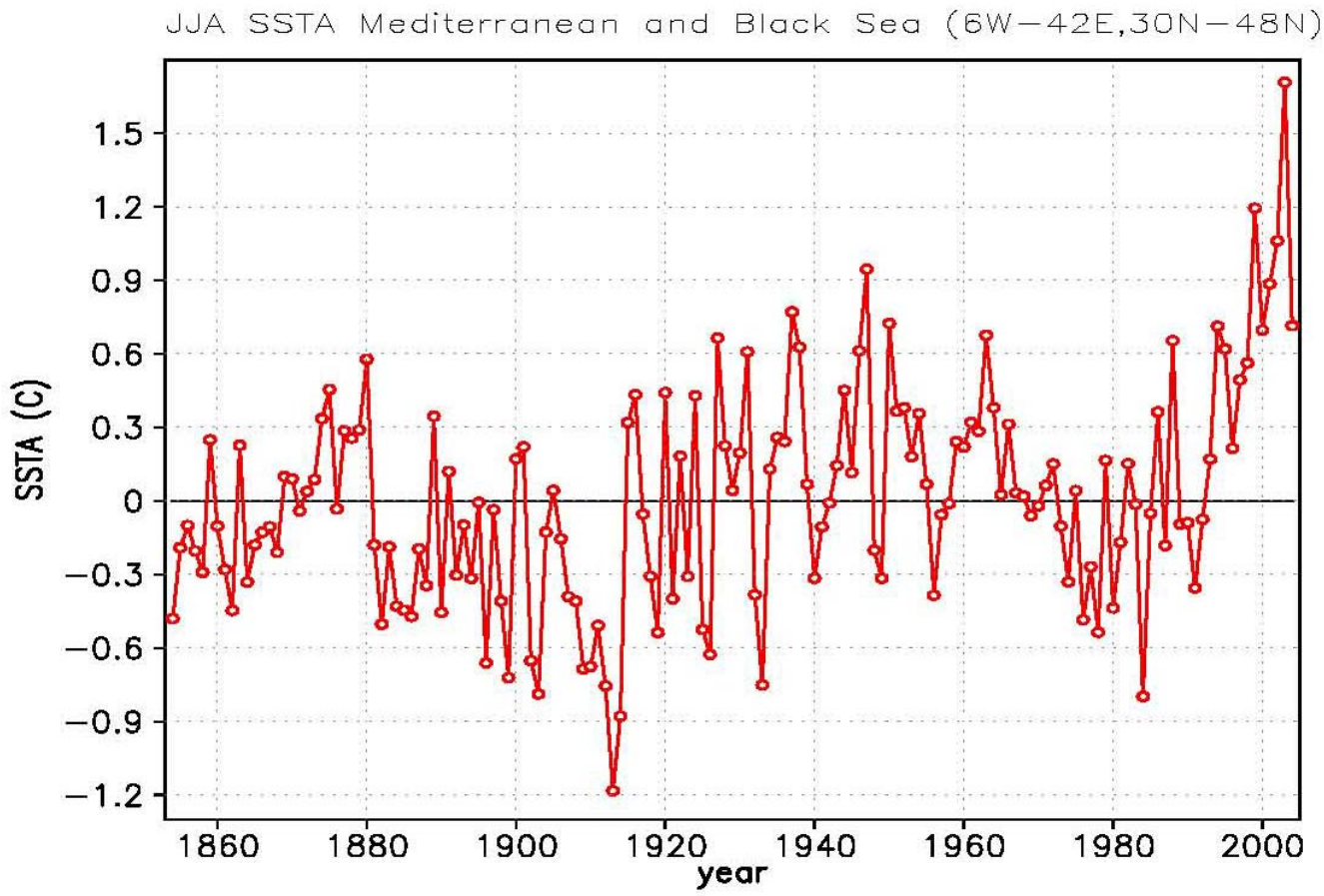
JJA 2003 Anomaly



JJA 2003 Lower Stratosphere Temp. Anomaly



JJA SSTA in the Mediterranean and Black Sea

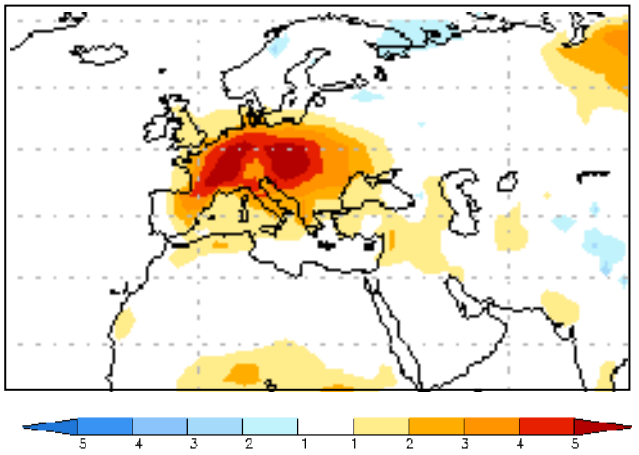


Composites of Major Summer Warm Events in Europe: SSTA influence?

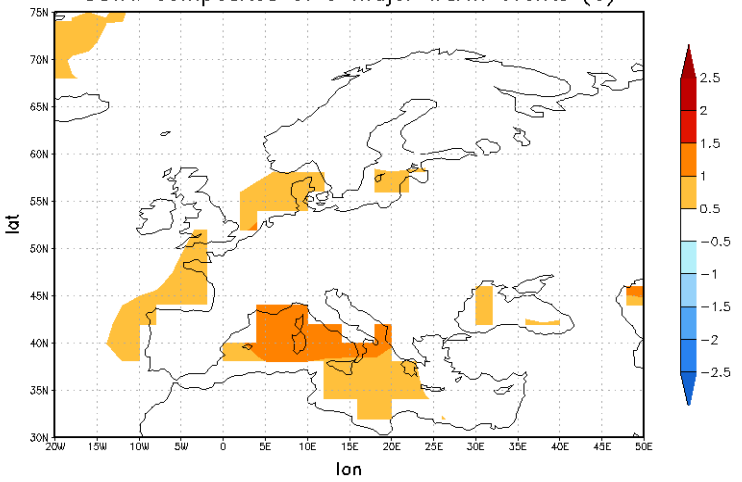
- Is this Mediterranean SST anomaly playing a role in **enhancing** and/or **maintaining** the heat waves occurring in the European region?

We tested this “thesis” in a particular case study: **the European heat wave of summer 2003**

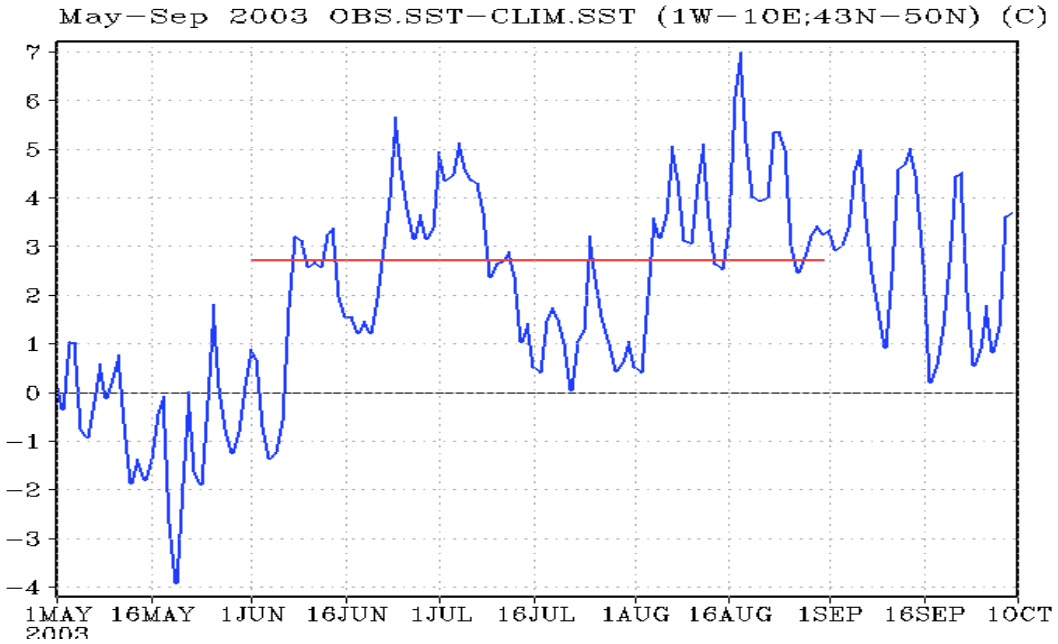
TMAX’: composites of 9 major events (C)



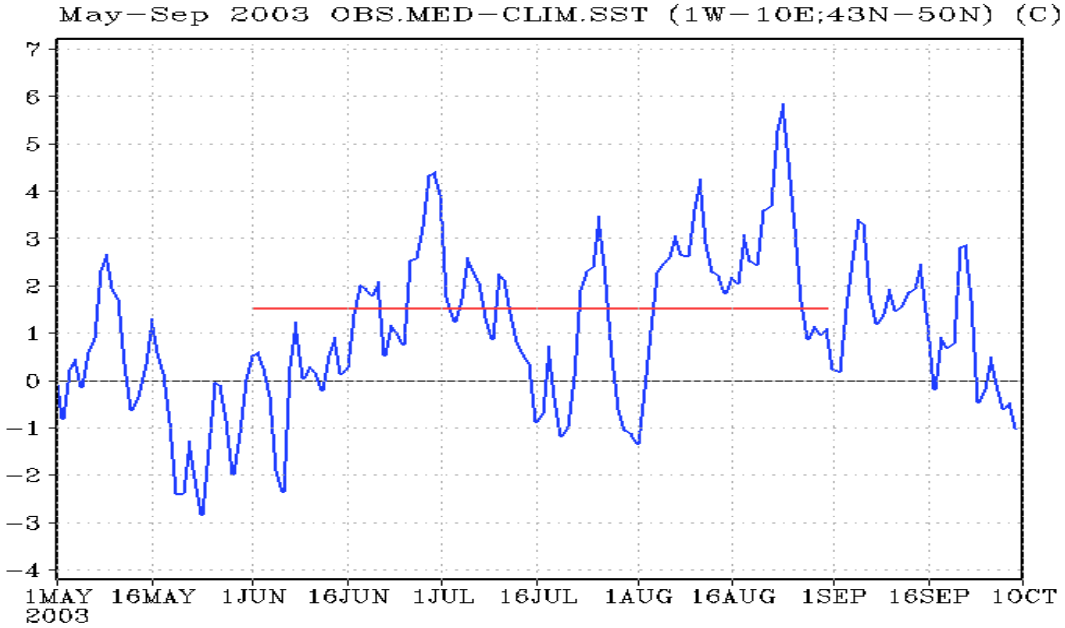
SSTA: composites of 9 major warm events (C)



OBS.SST-CLIM.SST
- Global SST effect-



OBS.MED-CLIM.SST
- Mediterranean SST effect -



Max surface temperature anomaly

Conclusions

1. When **obs.SST** were used to force the AGCM starting from Jan 2003 to Sep 2003, the model captured all the major features of the 2003 heat wave, except its magnitude (~half of observations).
2. It was remarkable that the **Mediterranean & Black Sea SSTA** could explain more than **half of the global SST effect**, especially in August: the Mediterranean Sea+Black Sea played an important role in enhancing the European heat wave.
3. The lower magnitude of the simulated heat wave was partly because of warm model climatology.
4. The soil was not as dry as obs: soil wetness forcing would enhance the result

Ref.: **Feudale, L., and J. Shukla (2007),** Role of Mediterranean SST in enhancing the European heat wave of summer 2003, *Geophys. Res. Lett*., 34, L03811,doi:10.1029/2006GL027991.

Feudale, L. (2006), Large scale extreme events in surface temperature during 1950-2003: An observational and modeling study, Ph.D. thesis, 218 pp., George Mason University, Fairfax, Va, USA

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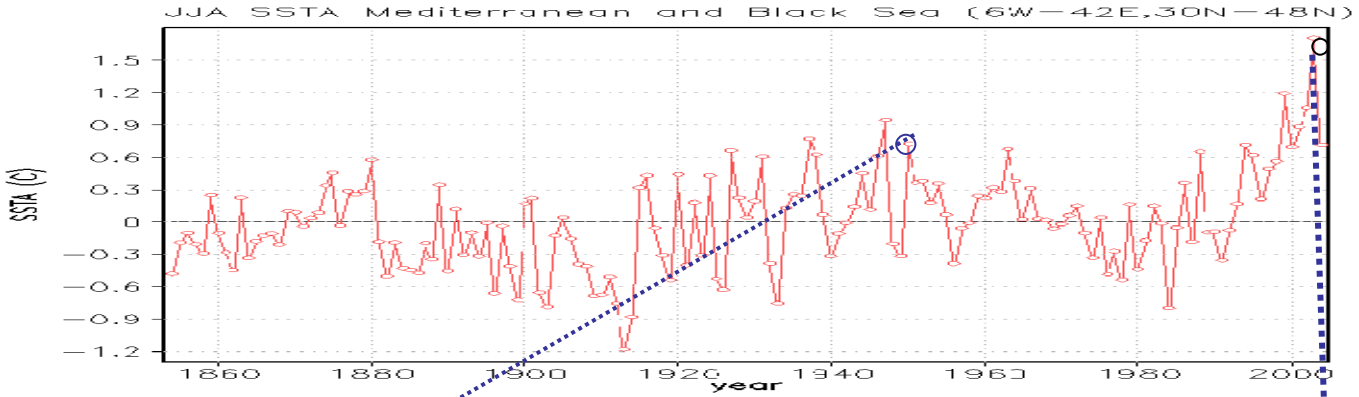
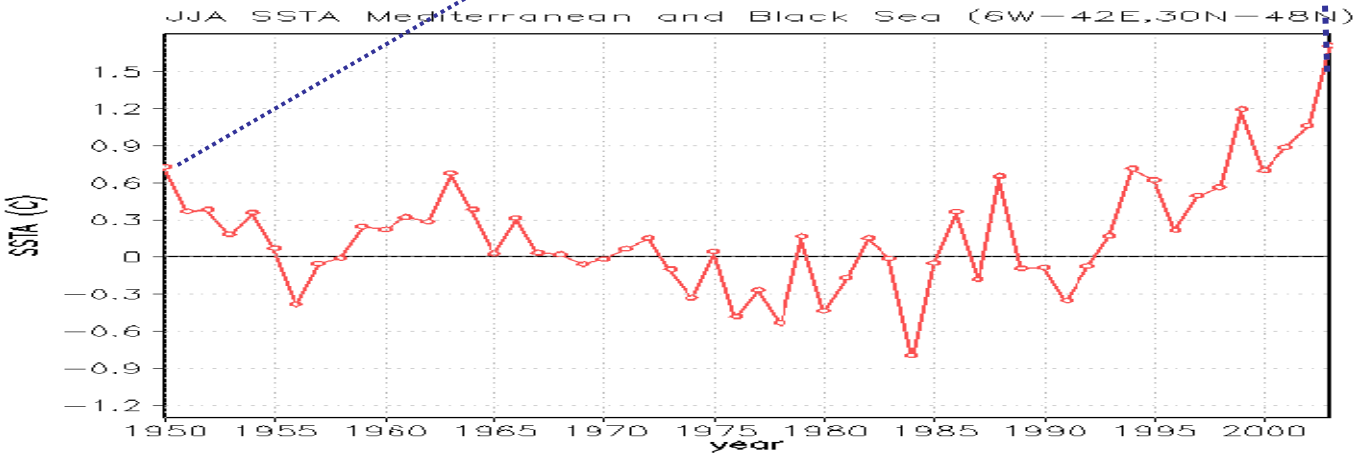
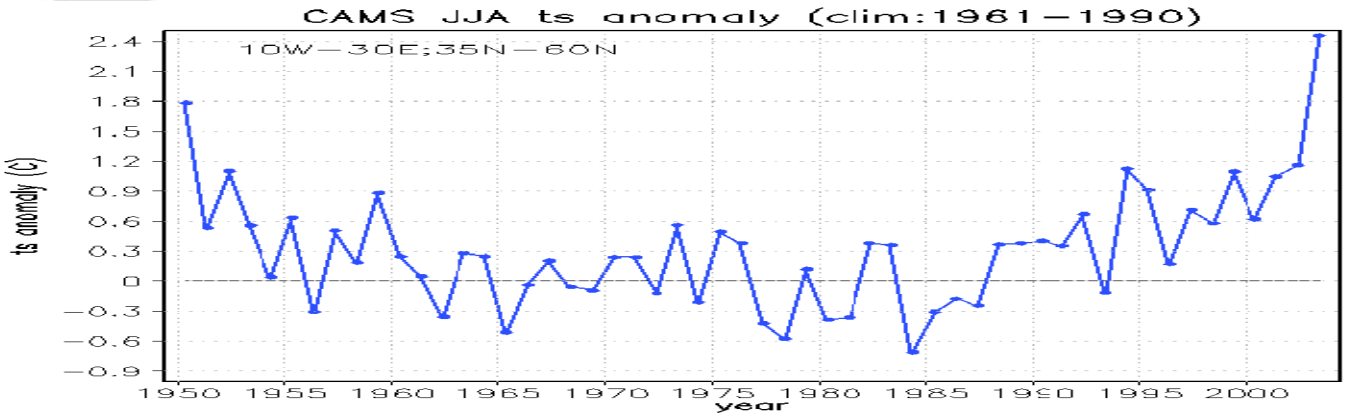
Observed SST



MEDITERRANEAN SSTA: 1854-2004

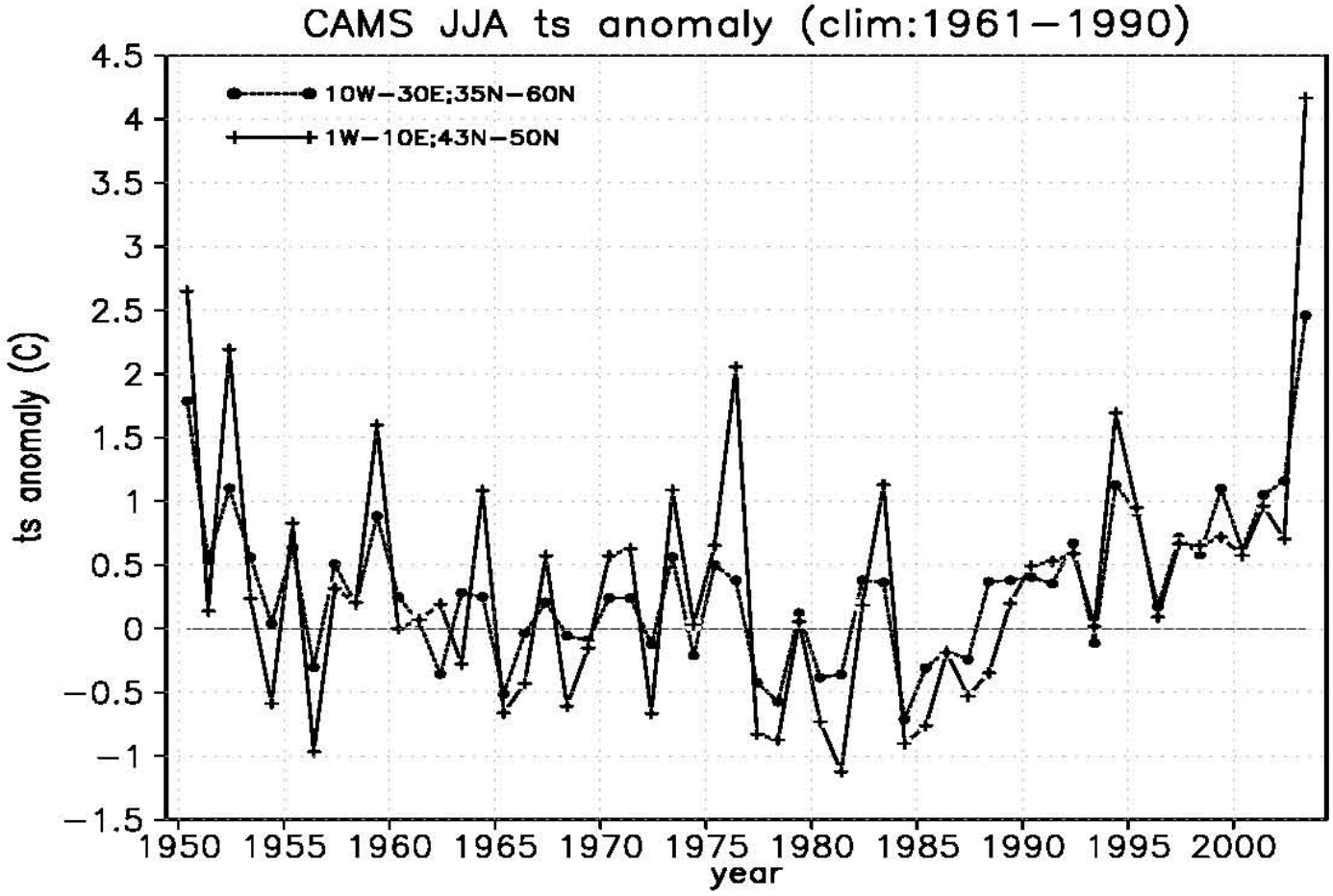


MEDITERRANEAN SSTA: 1950-2003



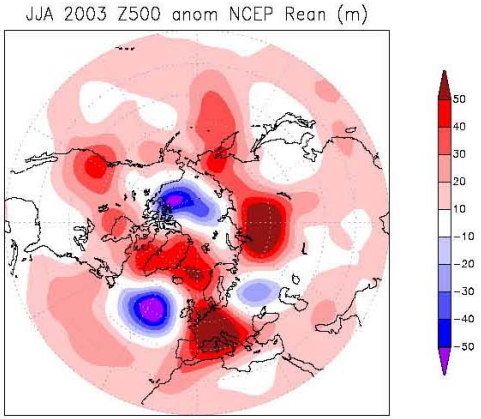
EUROPE LAND TS: 1950-2003 (CAMS)

JJA Surface Temperature Anomaly (1950-2003)

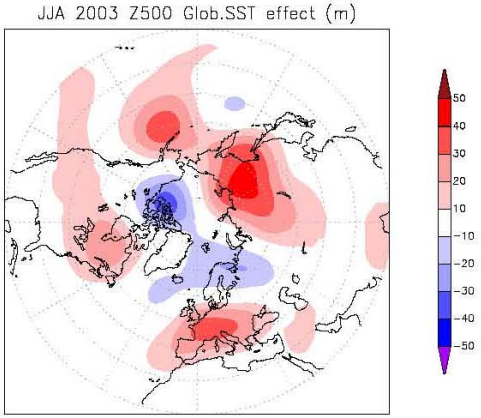


JJA 2003 Z500 Anomaly

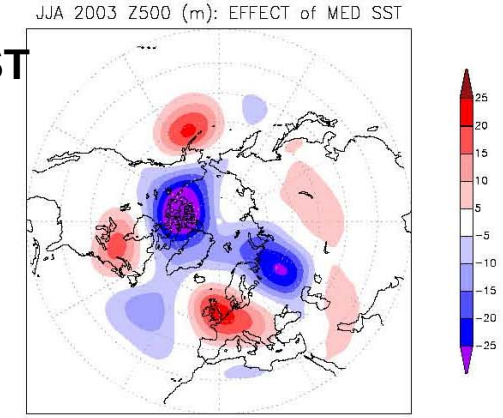
NCEP reanalysis



Global SST

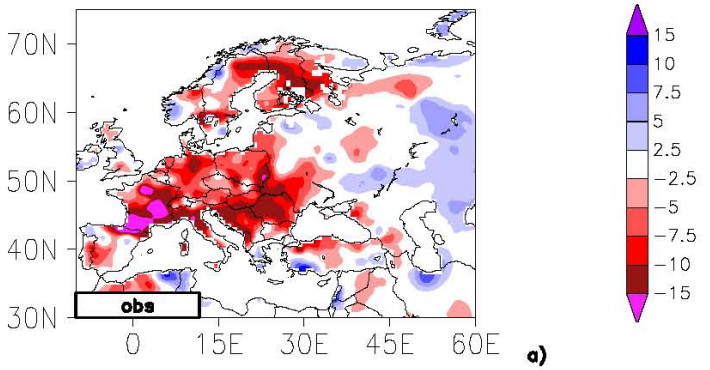


Mediterranean SST

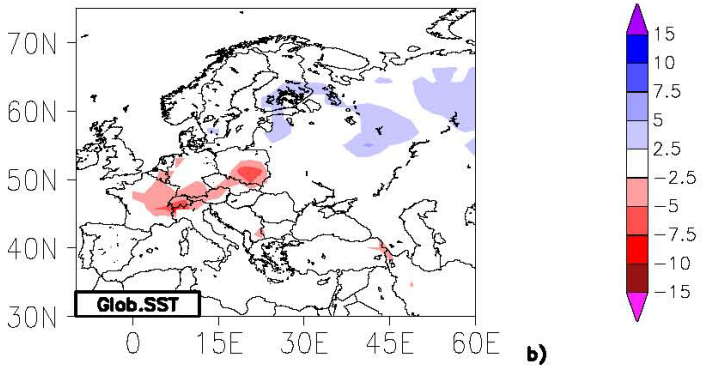


JJA 2003 Soil Moisture Anomaly (%)

Fan and van den Dool (2004) dataset



Global SST



Mediterranean Sea SST