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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Was the 2003 summer heat-wave teleconnected to anything?

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Institute of Global Environment and Society (IGES)

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

b) Observations 1864-2002

1909 1947 2003

1947 2003

Climate Simulation Present
1961-1990

Climate Simulation Future
2071-2100

Temperature (°C)
• 2003
• Heat wave hits Europe
• 40,000 people die in Europe

GEC is more acute than ever

Temperature anomaly (wrt 1961-90) °C

-2 -1 0 1 2 3 4 5 6 7 8

observations

HadCM3 Medium-High (SRES A2)

2003

2040s

2060s
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 $T_{\text{max}}$ Anomaly

Center of Ocean-Land-Atmosphere studies
JJA 2003 Summer European Heatwave

Anomaly of Surface $T_{max}$

$T_{cmx}$ JJA 2003

(Pingping Xie data)
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-Land Interaction

Land-Climate Interaction

- Evaporation
- Sensible heat
- Radiation

Fluxes at land surface

Land surface state
- Soil water
- Vegetation
- Snow

Land surface state
- 20-30%
- Albedo
- Roughness
- Soil wetness

δP = δE - δ∫∇ · qV

70-80%
- Local circulation
- Large-scale dynamics

Air near surface

Humidity
Temperatures
Winds

Troposphere

δ

Solar rad.
Precipitation
Temperature
Winds
Experiments:
COLA AGCM v2.2.7 integrations from Jan 1st-Sep 30th 2003 (IC: clim SW)
- 10 ensemble members -
2. run OBS-SST → BC: obs 2003 global, daily SST

<table>
<thead>
<tr>
<th>EXP</th>
<th>IC</th>
<th>LEN</th>
<th>BC (SST)</th>
<th># ENS.</th>
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<tbody>
<tr>
<td>CLIM.SST</td>
<td>00Z01Jan03</td>
<td>9 mo</td>
<td>daily climatological OISST-V2</td>
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JJA 2003 SST Anomaly
JJA 2003 Precipitation Anomaly

CMAP

JJA 2003 XIE-ARKIN prec anomaly (mm/day)

AGCM

OBS.SST-CLIM.SST
Global SST effect

JJA 2003 prec ObsSST–Cntrl (mm/day)
T_{MAX} anomaly:

Comparison between observations and global SST run
Anomaly of maximum surface temperature on (1W-10E;43N-50N)
(a) 2003 JJA $T_{\text{max}}$ Anomaly from the COLA AGCM

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

JJA SSTA Mediterranean and Black Sea (6W–42E, 30N–48N)
MJJA 2003 SST Anomaly
Mediterranean and Black Sea

SSTA May 2003

SSTA Jun 2003

SSTA Jul 2003

SSTA Aug 2003
Composites of Warm Events

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

<table>
<thead>
<tr>
<th>duration (days)</th>
<th>start.time</th>
<th>end.time</th>
</tr>
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<tbody>
<tr>
<td>17</td>
<td>24 jun 1952</td>
<td>10 jul 1952</td>
</tr>
<tr>
<td>15</td>
<td>23 jun 1976</td>
<td>7 jul 1976</td>
</tr>
<tr>
<td>16</td>
<td>7 jul 1983</td>
<td>1 aug 1983</td>
</tr>
<tr>
<td>16</td>
<td>16 aug 1992</td>
<td>31 aug 1992</td>
</tr>
<tr>
<td>31</td>
<td>18 jul 1994</td>
<td>17 aug 1994</td>
</tr>
<tr>
<td>15</td>
<td>30 jul 1998</td>
<td>13 aug 1998</td>
</tr>
<tr>
<td>23</td>
<td>9 aug 2000</td>
<td>23 aug 2000</td>
</tr>
<tr>
<td>31</td>
<td>13 jun 2002</td>
<td>2 jul 2002</td>
</tr>
<tr>
<td>33</td>
<td>6 jun 2003</td>
<td>8 jul 2003</td>
</tr>
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(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.
• 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

TMAX*: composites of 9 major warm events (°C)

SSTA: composites of 9 major warm events (°C)

z500 anom: 9 years composites (m)
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

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<td>9 mo</td>
<td>daily (MedBl 2003+rest clim) OISST-V2</td>
<td>10</td>
</tr>
<tr>
<td>CLIM.MED</td>
<td>00Z01Jan03</td>
<td>9 mo</td>
<td>daily (MedBl clim+rest 2003) OISST-V2</td>
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a) NCEP Reanalysis

b) Global SST effect

c) Mediterranean SST effect

JJA 2003: Exp results

500 hPa Geopotential Height Anomaly (m)
JJA 2003: Exp results

Soil Moisture Anomaly
(%)
Precipitation Anomaly (mm/day)

JJA 2003: Exp results

a) CMAP

b) Global SST effect

c) Mediterranean SST effect
Surface $T_{\text{max}}$ Anomaly

OBS.SST-CLIM.SST
Global SST effect

OBS.MED-CLIM.SST
Mediterranean SST effect
2003 $T_{\text{max}}$ Anomaly

Global SST effect

Mediterranean SST effect
August 2003 $T_{\text{max}}$ Anomaly
Center of Ocean-Land-Atmosphere studies

JJA 2003 $T_{\text{max}}$ 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 2003 Lower Stratosphere Temp. Anomaly
JJA SSTA in the Mediterranean and Black Sea

![Graph showing JJA SSTA Mediterranean and Black Sea (6W-42E, 30N-48N)]
• 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.
Max surface temperature anomaly
Conclusions

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- 10W–30E;35N–60N
- 1W–10E;43N–50N

Year

Temperature anomaly (°C)
JJ A 2003 Z500 Anomalty

NCEP reanalysis

Global SST

Mediterranean SST
JJA 2003 Soil Moisture Anomaly (%)

Fan and van den Dool (2004) dataset

Global SST

Mediterranean Sea SST