AUGUST 2003 HEAT WAVE IN WESTERN EUROPE: AN ANALYSIS AND PERSPECTIVE

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West Mediterranean Region SST

Seasonal mean SST time series in the Western Mediterranean shows the historic maximum of June-August 2003. In the whole Mediterranean basin, the anomalies were about 5°C above the climatological mean, with the monthly mean exceeding 25°C in July and August. These SST anomalies directly mirror the air temperatures registered at the surface and aloft.

Global anomalies

To investigate the rareness of the warm anomaly over western Europe, the standard deviations of the 1000-500 mb thicknesses were computed with respect to the period of record of the NCEP-NCAR Reanalysis. Thick contours show regions where the temperature anomaly or height anomaly exceeds 2 standard deviations above or below the mean.

In June, the center of the positive 200 mb height anomaly was centered over Switzerland. In July, the center of the warm 200 mb height anomaly moved to Finland, while it weakened in August and had moved southwestward to Great Britain. The 1000-500 mb thickness temperature departures for the same months are characterized by +3°C anomalies centered over Switzerland, Finland, and northern France, respectively.

For each individual month, the heat wave as seen in both the 200 mb height and thickness temperature anomalies is unusual in that it exceeds 2 standard deviations from average. For the summer as a whole, the European heat wave is centered over France and appears quite unusual in that it exceed 3 standard deviations and is the largest anomaly worldwide.

Gulf of Guinea SST and West Mediterranean

An interannual climate analysis shows that the mean and anomalous SST in the Gulf of Guinea, through their effect on the West African monsoon, influence the central-western Mediterranean summer climate. A southward shift of the monsoonal activity is related to cooler and wetter conditions over the central and western Mediterranean Sea in mid-late summer.

Conversely, when the West African monsoon reaches further north and is more intense than average, the summer tends to be hotter and drier than average in the western portion of the Mediterranean region. This is evident in the composite differences of geopotential at 500 mb, calculated for June through August, over the period 1979-2003.

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Observations

Record-breaking temperatures were recorded in Europe in the summer of 2003. Among the many examples of local records, in Paris a maximum temperature of 40°C was observed. In Rome the temperature maxima exceeded 35°C for 42 days during June through August 2003. Nighttime minima were also much above average: a minimum of 25.5°C in Paris was the highest minimum temperature ever recorded in the city.
During the hot months of 2003 in Europe, high pressure at all levels over the Atlantic and the Iberian peninsula was particularly strong, and covered the Provence, the Cote d’Azur, and as far as east the Italian peninsula. In conjunction there was an anomalous low over Iceland. This pressure configuration shifted the Atlantic storms very far north, towards the Scandinavian peninsula and the Barents Sea.

The Atlantic storms resumed their track towards Europe and the Mediterranean only in September, but even then their number was below the decadal climate average.

The meridional circulation is studied using the mass streamfunction computed from the monthly-averaged meridional momentum component of the NCEP-NCAR Reanalysis dataset. We examined the Hadley cell zonally averaged along a latitudinal circle, and averaged over two adjacent regions: the Atlantic (40°W-10°W), and Africa (10°E-40°E, including the Mediterranean). In July 2003, the ITCZ over Africa was located at higher latitudes with respect to its average position, shifting the boreal meridional circulation northward. In August the ITCZ continued to lie just north of its climatological position. A northward shift of the ICTZ would tend to shift the descending portion of the Hadley circulation towards western Europe.

This study demonstrates that the summer 2003 heat wave in Europe was not a direct result of a globally averaged warmer lower troposphere, but was primarily associated with large scale circulation changes. Due to lack of data, this analysis could not assess the extent that land-surface feedback processes were responsible for the severity and duration of this heat wave, but it may have been a contributing factor. Other heat waves in Europe need to be investigated in the same manner as applied in this study.

Dry soils stemming from an anomalously warm and dry spring 2003 in Europe may have exacerbated the surface temperature anomalies, as less of the solar heating is transferred by evaporation from soils and transpiration from plants, and more by sensible turbulent heating. Such soil moisture feedback has been found to be a key factor in explaining the 1930s ‘Dust Bowl’ years in the U.S. Currently is under evaluation the role played by soil dryness on this event.