Special Climate Summary
Exceptional Heat and Dryness in Europe
During April-August 2003

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1. Overview

Most of Europe was struck by an extreme heat wave during June-August (JJA) 2003. In France 11000 heat-related deaths were reported between late July and mid-August (Reuters/Associated Press). These deaths resulted not only from the extreme daily heat, but also from the frequency of extremely hot and dry days in areas not accustomed to such conditions. These conditions were part of a prolonged warm and dry spell that began in April in response to a persistent upper-level ridge centered over the continent. The extreme persistence of this ridge is partly related to a prolonged positive phase of the East Atlantic teleconnection pattern.

2. Extreme temperatures in Europe during June-August

Most of the region from southern Spain to central France experienced daily maximum temperatures exceeding 34°C (90°F) on 30-50 days during June-August, which is 20 days more than the climatological mean (Fig. 1). Central and northern France experienced 10-30 days with maximum temperatures above 34°C, well above the climatological mean of five days or less.

Two distinct periods of exceptional heat occurred during the season, the first in June and the second during the first half of August. The August heat wave was the more serious of the two, since it coincided with the climatological peak in summer temperatures (Fig. 2a) and was accompanied by almost no rainfall (Fig. 2b). Daily maximum temperatures during this period averaged more than 40°C across most of interior Spain, 36°-38°C across

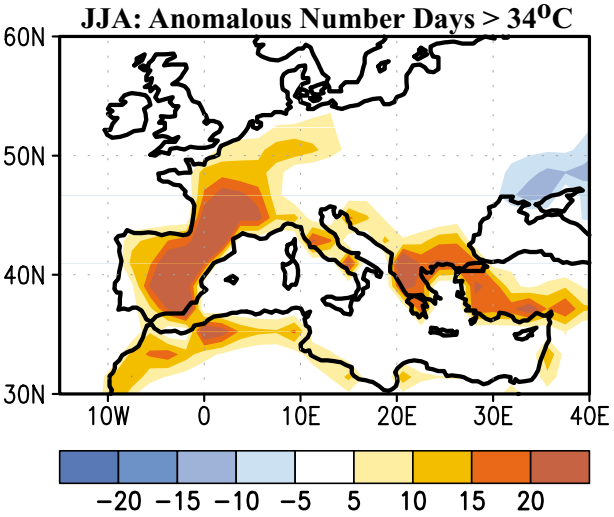

Fig. 1. June-August 2003: Anomalous number of days with maximum surface temperatures reaching 34°C. Anomalies are departures from the 1971-2000 base period daily means.

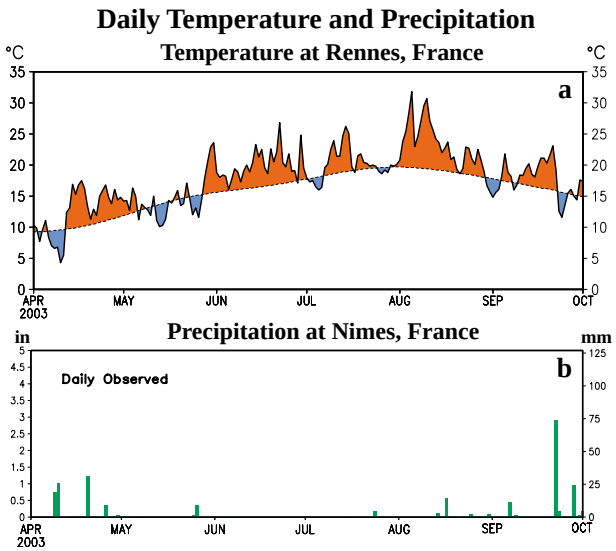

Fig. 2. Daily mean (a) surface temperatures (°C) at Rennes, France and (b) precipitation at Nimes, France. Temperature anomalies in (a) are shaded, with red indicating above-average temperatures. Scale for precipitation is inches (on the left) and mm (on the right).

southern and central France and 32°-36°C across northern France (contours, Fig. 3). These temperatures are generally 7.5°-12.5°C above average (shading). In France, a region accustomed to much cooler conditions, this extreme heat was associated with an estimated 11,000 deaths.

3. Large-scale Conditions

Surface temperatures were actually well above average across Europe throughout April-August, with the largest mean departures exceeding +2.5°C across central Europe and +1.5°C across northern (shading, Fig. 4a). Precipitation totals were also well below average during this period, with deficits of 75-100+ mm observed throughout central Europe (shading, Fig. 4b).

The largest temperature and precipitation anomalies coincided with the mean position of a very persistent upper-level ridge (Figs. 4a, 5a). These regions were also situated south of the axis of an enhanced North Atlantic jet stream (Fig. 5b), resulting in large-scale sinking motion and a reduction in the number and intensity of storms, precipitation events, and cold frontal passages.

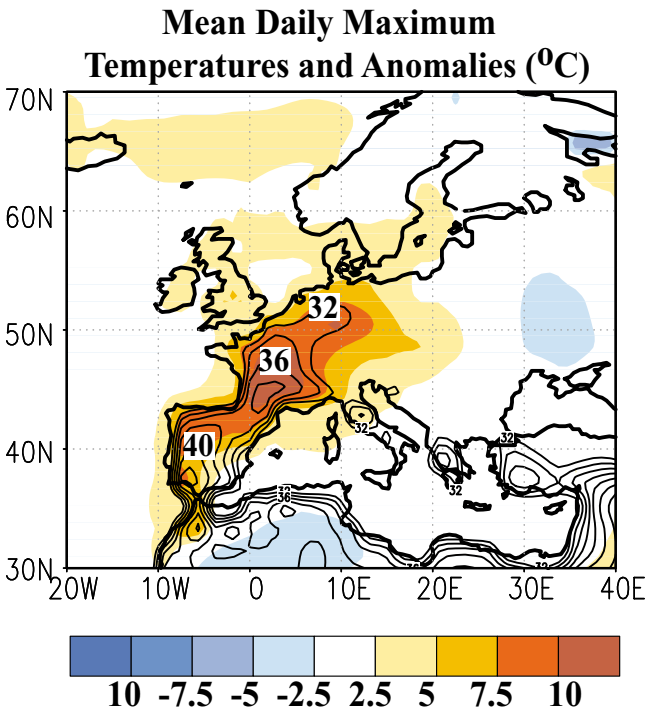

Fig. 3. August 1-15, 2003 mean daily maximum surface temperature (contours, interval is 2 °C) and anomalies. Anomalies are departures from the 1971-2000 base period daily means.

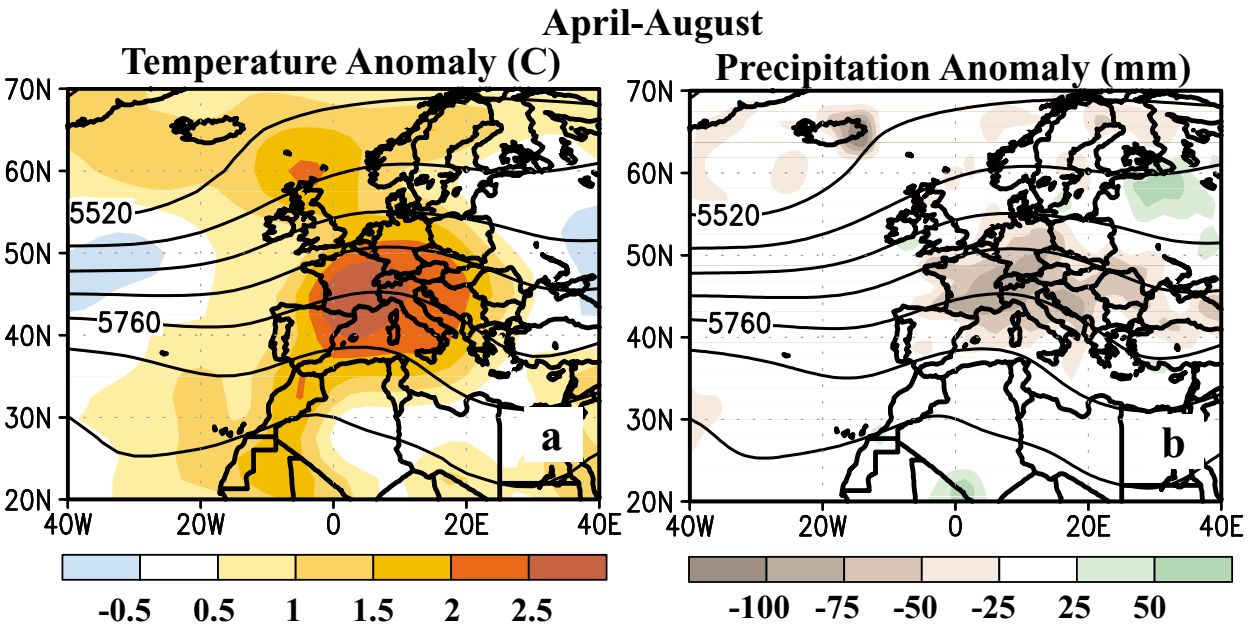

Fig. 4. April-August 2003 mean 500-hPa heights (contours, interval is 60 m) overlaid with (a) surface temperatures anomalies (°C) and (b) precipitation anomalies (mm). Anomalies are departures from the 1971-2000 base period monthly means.

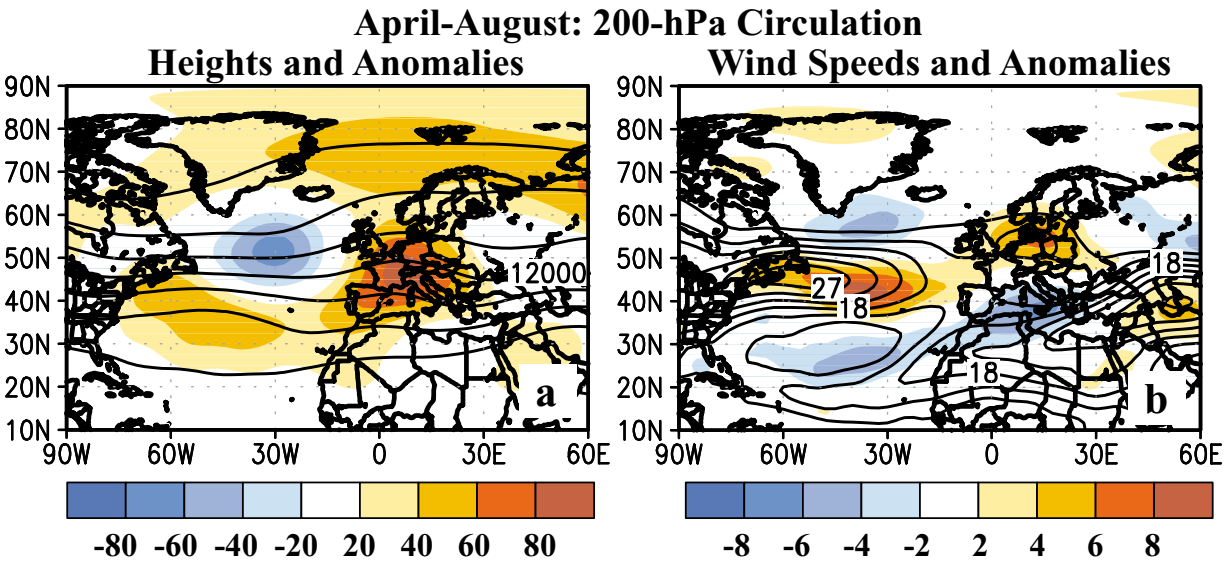

Fig. 5. April-August 2003: 200-hPa (a) heights and anomalies (m) and (b) wind speeds and anomalies (m s^{-1}). Anomalies (shading) are departures from the 1971-2000 base period monthly means.

For example, daily temperatures at Rennes, a representative station in northwestern France (Fig. 2a), indicate a near-absence of cold frontal passages during the 5-month period, with daily mean temperatures often reaching 5°-7°C above normal. At Nimes in southeastern France, notable rainfall occurred on only seven days between April and late September, and on only 2 days during June-August (Fig. 2b).

These conditions were associated with a larger-scale anomalous circulation characterized by below-average heights at high latitudes from Canada to Great Britain, and above-average heights in the middle latitudes from the northeastern U.S. to eastern Europe and in the subtropics (Fig. 5a). This anomaly pattern reflects a strong positive phase of the East Atlantic (EA) teleconnection pattern (Fig. 6a). The standardized EA index values for June-August were 2.1, 0.9, and 1.3, respectively. The EA pattern is qualitatively similar to the positive phase of the North Atlantic Oscillation (NAO) (Fig. 6b), but with its anomaly centers shifted south from those associated with the NAO.

The southern center of anomalies associated with the NAO also tends to be confined to the anticyclonic flank of the North Atlantic jet stream, whereas the EA pattern exhibits a strong link to the subtropical North Atlantic. During April-August the

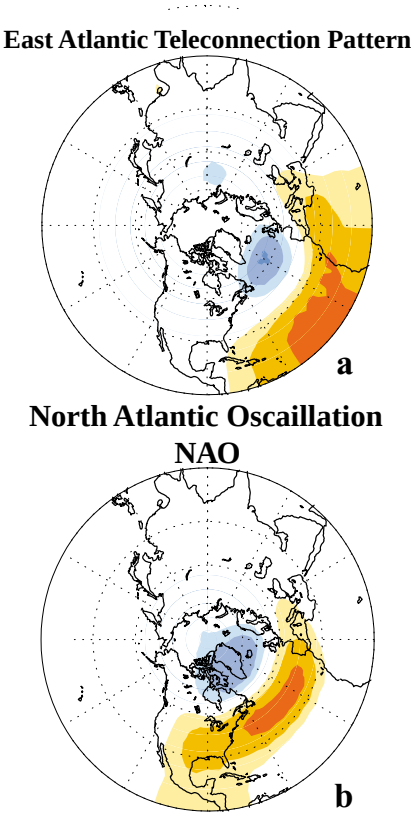

Fig. 6. The positive phases of (a) the East Atlantic teleconnection pattern and (b) the North Atlantic Oscillation (NAO) as indicated by 500-hPa height anomalies. Positive anomalies are shaded orange, negative anomalies are shaded blue.

positive height anomalies in this region were associated with an amplified subtropical ridge from the eastern U.S. to northern Africa. This enhanced subtropical ridge was a contributing factor to the above normal 2003 Atlantic hurricane season.

A pronounced change in the circulation then occurred during September-October across the North Atlantic and Europe, resulting in markedly cooler conditions across central Europe (Fig. 7a), above-average precipitation across southern Europe, and a northward shift in the area of below-average precipitation to Great Britain and southern Scandinavia (Fig. 7b). This circulation featured a blocking ridge over the high latitudes of the North Atlantic and a broad upper-level trough over central Europe (Fig. 8a). It also featured enhanced jet stream winds across southern Europe and northern Africa (Fig. 8b). The cooler conditions across central Europe were associated with anomalous northerly flow downstream of the ridge axis. The above-average precipitation across southern Europe and northern Africa is related to their proximity to both the large-scale trough axis and to the cyclonic shear side of the enhanced North African jet stream.

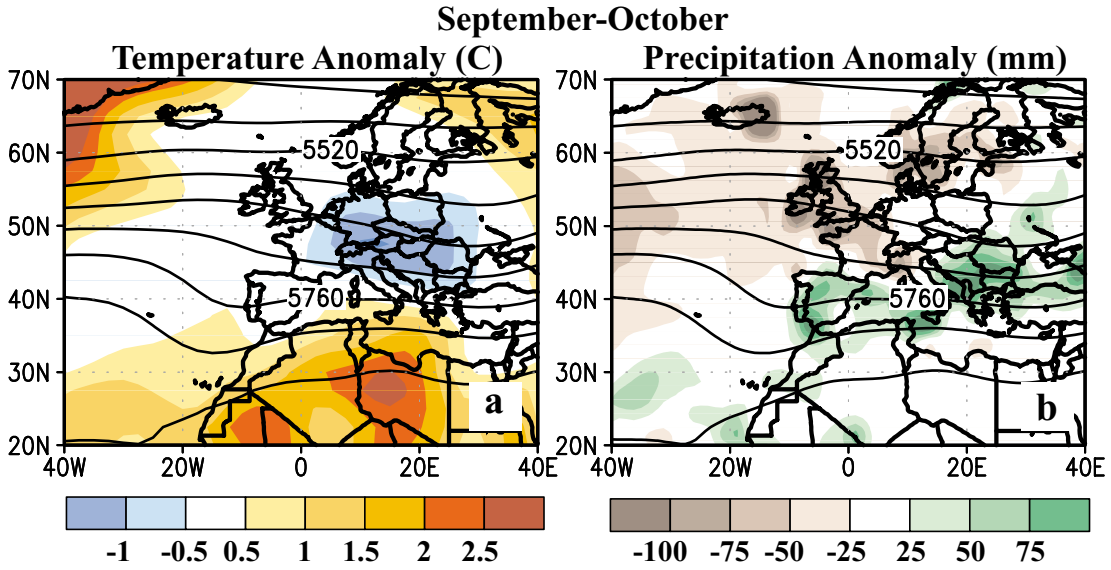

Fig. 7. September-October 2003 mean 500-hPa heights (contours, interval is 60 m) overlaid with (a) surface temperatures anomalies (°C) and (b) precipitation anomalies (mm). Anomalies are departures from the 1971-2000 base period monthly means.

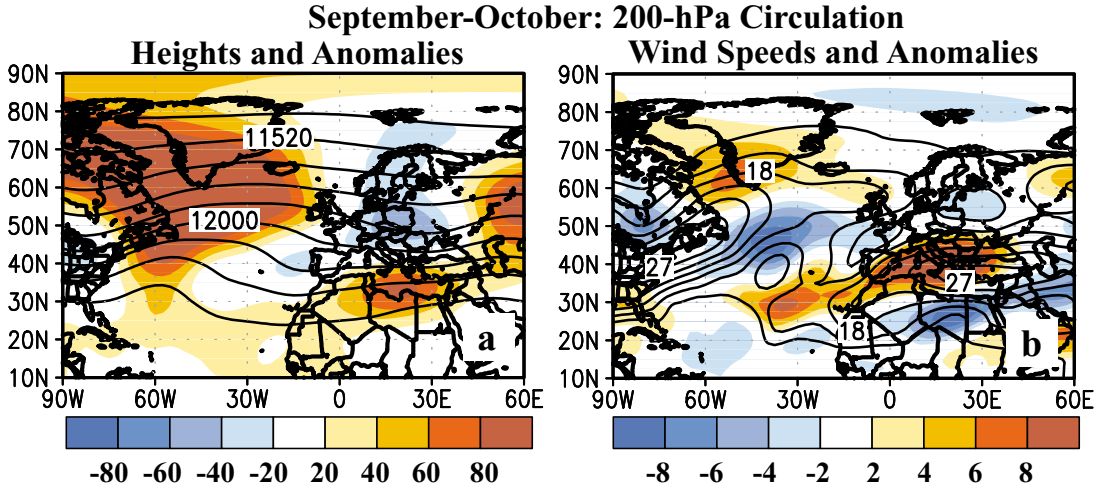

Fig. 8. September-October 2003: 200-hPa (a) heights and anomalies (m) and (b) wind speeds and anomalies (m s^{-1}). Anomalies (shading) are departures from the 1971-2000 base period monthly means.