

# A 500 year pheno-climatological view on the 2003 heatwave in Europe assessed by grape harvest dates

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## Abstract

In 2003, Europe was affected by a record-breaking heatwave in summer, which is statistically extremely unlikely. However, there are indications that comparably anomalous warm summers might have occurred in the more distant historical past, for instance in 1540. Dates of grape harvesting in Western Europe, starting in 1484, allow a concise assessment of growing season temperatures. The maturity of grapes strongly depends on growing season temperatures, and 84 % of the year-to-year variability is explained by April to August temperature. When reconstructing the growing season temperatures by these historical grape harvest dates, the heatwave of 2003 stands out as an extreme, not only for the instrumental period, but also during the preceding 500 years.

## Zusammenfassung

Im Jahr 2003 ist Europa von einem Rekordsommer getroffen worden, der statistisch als extrem unwahrscheinlich einzustufen ist. Es gibt aber auch Hinweise, dass vergleichbare, außergewöhnlich warme Sommer in der entfernteren Vergangenheit aufgetreten sein könnten, z.B. im Jahr 1540. Daten zur Weinlese in Westeuropa seit 1484 erlauben eine genaue Abschätzung der Temperaturen während der Wachstumsperiode, denn die Reife der Weintrauben hängt stark von den Temperaturen während der Vegetationsperiode ab. 84 % der inter-annuellen Variabilität wird von der Temperatur der Monate April bis August erklärt. Bei einer Rekonstruktion der Sommertemperaturen anhand dieser historischen Weinlesedaten zeigt sich, dass die Hitzewelle 2003 nicht nur in der instrumentellen Periode, sondern auch in den letzten 500 Jahren als ein Extrem hervorsteht.

## 1 Introduction

In 2003 Europe was affected by a record-breaking heatwave from June to September. The mean summer (June to August) temperatures exceeded the 1961–90 mean by  $\sim 3^\circ\text{C}$ , this summer temperature anomaly being statistically extremely unlikely, even when the observed warming trend is taken into account (SCHÄR et al., 2004). Similar results are reported by SCHÖNWIESE et al. (2004) for Germany: summer temperature 2003 exceeded the 1961–1990 climatological mean by  $+3.4^\circ\text{C}$  followed by the second warmest summer of the instrumental period 1947 ( $+2.2^\circ\text{C}$ ). This record heatwave has been seen as a “shape of things to come”, reflecting the extremes of temperatures that summers are projected to occur under enhanced atmospheric greenhouse gas concentrations at the end of the 21st century (BENISTON, 2004). Looking into the past, SCHÄR et al. (2004) supposed that, despite a large return period of those extreme events, comparably anomalous warm summers may have occurred in the more distant historical past. However, based on the historical analyses of PFISTER et al. (1999), BENISTON (2004) suggested that 2003 is likely to have been the warmest summer since 1540.

Thus, the question is whether such extreme summers in the past are similar to the 2003 heatwave. In this short communication a quantitative assessment of central European summer temperatures and their extremes during the last 500 years by phenological proxy data is presented.

## 2 Material and methods

The timing of agricultural works, such as grape harvest, is found to be directly related to temperature patterns over the preceding months (PFISTER et al. 1999, BRADLEY 1991), thus they can be used as a climate indicator for growing season or summer temperatures. At the northern limit of commercial viticulture, grape maturity is highly sensitive to the temperature of the entire growing season, particularly midsummer temperatures (LANDSTEINER, 1999). We used the well known area-averaged series of grape harvest dates (1484–1879) for local series from western and central Europe (northern and central France, Switzerland, Alsace, Rhineland) (Le Roy LADURIE and BAULANT, 1980). The dates were transformed in DOY (days of the year) units. Monthly temperature anomalies for the period 1851–2003 were obtained from JONES et al. ([www.cru.uea.ac.uk/cru/data/temperature/](http://www.cru.uea.ac.uk/cru/data/temperature/)) and were

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