A downturn of the strong winter-warming trend in Europe?

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Surface-air temperatures measured in winter at 3 meteorological stations in central Europe rise substantially for most of the second-half of the 20th century. This means shorter winter, and longer growing season, which has positive implications for regional agriculture. However, these positive trends stopped in winter of 1996, and for the recent 7 years no further climatic amelioration is reported.
Surface-air temperatures in winter and early-spring in central Europe rose over the second half of the 20th century, as reported for somewhat different data-spans, and by different approaches \(^1,2,3\). Comparison of the different studies is difficult, inasmuch as there are disparities in trends evaluated for different spans of years and different locations. Observations at meteorological stations in central Europe are analyzed here for the years 1951–2002. For three groups of pentads (5-day periods) during January, February and March in Berlin and Poznań', the monthly average of the daily minimum surface-air temperature, \(T_{\text{min}}\), rose more steeply in the years 1951–1995 than that of the daily maximum temperature, \(T_{\text{max}}\). In Munich, the winter surface-air temperature rose in the period 1981-1995 at the rate of 2.77°C/decade, and the tropospheric temperature at 1.52°C/decade. We attribute the bulk of this sharp winter warming to stronger southwesterlies over the North Atlantic, with which the temperatures in Europe are strongly correlated\(^4,5\). However, for the most recent period, after 1995, a downturn of the warming is observed which we attribute to the concurrent 1996-2001 downturn of the ocean-surface southwesterlies over the North Atlantic\(^6\), which is associated with a change in the North Atlantic Oscillation, NAO. The warming and the downturn suggest an unfolding oscillation, which can have important implications for the climate of central Europe.

For three groups of pentads (5-day periods), 1 to 6 (January), 7 to 12 (February), and 13 to 18 (March), we analyze data from meteorological stations in Berlin (eastern Germany) and in Poznań (western Poland) for 1951-2002. Both the average daily maximum temperature, \(T_{\text{max}}\), and the average daily minimum temperature, \(T_{\text{min}}\), are examined. The 1951-1995 trends (slope of the best-fit line) in \(T_{\text{max}}\) and \(T_{\text{min}}\) are presented in Table 1, and the March temperatures for the entire 1951-2002 period are presented in Fig. 1 for Berlin (top panel), and for Poznań (bottom panel). The strong trend in \(T_{\text{min}}\) for March, 0.58°C/decade in Berlin and 0.76°C/decade in Poznań, is especially significant in agriculture, since the beginning of the planting and end of the growing season are very much constricted by the danger of frost. The March \(T_{\text{min}}\) in Poznań' was above the 0°C line in the early 1990s, whereas it was below −2°C in the early 1950s. We note, however, strong interannual variability: the standard deviation ranges from above
2°C to almost 4°C. This variability obviously negatively affects the growing season. In March, snow-melting occurs (the timing depends on region; there is little snow in March in west-central Europe), and the absorption of insolation by the much lower-albedo surface marks the arrival of spring.

From the study of the surface-air and tropospheric temperatures in winter (December-February) for Munich, Germany, we selected for analysis the years 1981-2002 (see Fig. 3). In this period the global annual mean temperatures, which fluctuated in a narrow range from 1940 to 1980, rise steeply starting in 1981, at the rate of ~0.2°/decade (data by Hadley Center, UKMO and Climate unit, Univ. East Anglia, see Trenberth). In this 1981-1995 span, the winter (January, February, and December of the preceding year) surface-air temperature in Munich trends positively at 2.77°/decade, and the tropospheric (850-300 mb layer) temperature at 1.52°/decade. This surface-air trend is much larger than the 1948-1999 trends of about 0.4°C/decade derived for central Europe (the center of the NCEP Reanalysis cell at 50.5°N; 11.2°E, some 250 km north of Munich) for the second half of February and first half of March, and are presented to hint at the magnitude of the trend, even though their statistical basis is not robust. The steeper increase at the surface compared with the tropospheric temperature is consistent with low-level warm (maritime-air) advection as the direct forcing, which produces a steeper lapse rate, strong vertical motions and increased cloudiness (since moisture is advected). The enhanced greenhouse effects can be regarded as a substantial positive feedback to the direct effect of the incursion of warmer airmasses. In contrast to this scenario of low-level advection, modeling the greenhouse-gas increases indicate just the opposite, a stronger warming in the troposphere than at the surface.

The strong trend for Berlin and Poznań appears to be broken starting in 1996. In 1996-2002 both T_min and T_max are essentially below their 1951-1995 trend lines in each of these three months, as illustrated for March in Fig. 1. The difference between the temperatures in 1996-2002 as "expected" from extrapolation, by continuations of the 1991-1995 trend-lines, and the actual observations (the seven-year average) amount to 0.86 and 1.12°C for T_max, and 0.98 and 1.68°C for T_min, for Berlin and Poznań respectively. Likewise, the 1996-2002 Munich temperatures are below the 1981-1995
trend-lines, by 2.38°C in the case of the surface-air, and by 1.47°C in the case of the 
troposphere.

We attribute the strong warming trend and the subsequent downturn to the parallel 
changes in the southwesterlies over the North Atlantic\textsuperscript{6}, analyzed from the National 
Centers for Environmental Prediction Reanalysis. The strength of the southwesterlies is 
computed as a specific index, by averaging the speed of the ocean-surface winds when 
from the quadrant 180°-70° (when the wind is from another direction, its contribution to 
the index is counted as zero). In 1981-1995, when the surface-air temperatures in Munich 
were rising at the rate 2.77°C/decade, the southwesterlies at 20°W; 55°N, at the gateway 
to Europe, were increasing at a rate of 1.11 ms\textsuperscript{-1}/decade, and at 20°W; 35°N (where the 
winds are negatively correlated\textsuperscript{11} with those at 55°N) were decreasing at the rate of 
1.76°C/decade. These strong trends in the surface winds are related to the trend in NAO 
index, which was increasing in March at the rate of 1.74 mb/decade (see Fig. 3). However, the trend to stronger southwesterlies was broken in the winter of 1996\textsuperscript{6}, which 
is related to the downturn that year in the NAO index shown in Fig. 3.

Stronger southwesterlies, to which we attribute the bulk of the 1951-1995 
temperature rise in Europe, could possibly be a consequence of circulation changes in the 
global warming due to the increasing levels of greenhouse gases. However, the 1996-on 
downturn in the Munich, Berlin and Pozna\'n indicates the oscillatory nature of the climatic 
change that we analyze, confirmed by parallel patterns in the North-Atlantic 
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 warming, which should have produced a more steady trend, is unlikely.

It appears doubtful that the pronounced increases in the plant growing season in 
central Europe that we observe till 1995 (see Table 1 and Figs. 1 and 2) will continue, 
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Acknowledgements: Temperature data for Fig. 2 were provided by Jim Angell, NOAA 
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Table 1. 1951-1995 trends in the surface-air temperature, for $T_{\text{max}}$ and for $T_{\text{min}}$ at two meteorological stations in central Europe, °C/decade.

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Figure Captions

Fig. 1  Maximum daily temperature $T_{\text{max}}$ and the minimum daily temperature $T_{\text{min}}$ 1950-2002, for pentad-group 13-18 (effectively March), for Berlin in the top panel, and for Poznan' in bottom panel.

Fig. 2  Winter (December-February) surface-air temperatures $T_s$ and the tropospheric temperature $T_l$ in Munich Germany, for the years 1981-2002.

Fig. 3  March NAO index for the years 1875-2000, with trends computed for 1950-1995 and 1981-1995.
Berlin 1951–2002 March (Pentads 13–18) Average

Fig. 1 top panel (Otterman, et al.)

Temperature (deg Celsius)
Poznan 1951–2000 March (Pentads 13–18) Average

![Graph showing temperature trends from 1950 to 2000 for Poznan, with lines indicating Tmax, Tmin, and trend lines for 1951–1995 with specified slopes and standard deviations.]

Fig. 1 bottom panel (Otterman, et al.)
Munich Surface Air/Troposphere Temperature – Winter

Fig. 2 (Otterman, et al.)
NAO Index Based on Normalized Anomalies

March

- NAO Index
- Trend from 1981–1995 (Slope=1.74 mb/decade)

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