Letter to: Nature

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

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Popular Summary

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 Poznan', the monthly average of the daily minimum surface-air temperature, T_{min}, rose more steeply in the years 1951–1995 than that of the daily maximum temperature, T_{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 Poznan' (western Poland) for 1951-2002. Both the average daily maximum temperature, T_{max}, and the average daily minimum temperature, T_{min}, are examined. The 1951-1995 trends (slope of the best-fit line) in T_{max} and T_{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_{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_{min} in Poznan' 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[7].

From the study of the surface-air and tropospheric temperatures in winter (December-February) for Munich[2], 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[8]). 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[5], 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[9]. 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[8].

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[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°-270° (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^{-1}/decade, and at 20°W; 35°N (where the winds are negatively correlated[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[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 Poznań indicates the oscillatory nature of the climatic change that we analyze, confirmed by parallel patterns in the North-Atlantic southwesterlies, and in their control[10], the NAO index. Thus a linkage to the global 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, which has implications for agriculture in Europe.

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Table 1. 1951-1995 trends in the surface-air temperature, for T_{max} and for T_{min} at two meteorological stations in central Europe, °C/decade.

For:	January		February		March	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{max}	T_{min}
Berlin	0.51	0.44	0.47	0.49	0.44	0.58
Poznan'	0.55	0.67	0.60	0.77	0.63	0.76

References

1. Ross, R.J., Otterman, J., Starr, D.O., Elliott, W.P., Angell, J.K., Susskind, J.: Regional trends of surface and tropospheric temperature and evening-morning temperature difference in Northern latitudes, *Geophysical Research Letters,* **23**, 31729-?, 1996.

2. Angell, J.K: Comparison of surface and tropospheric temperature trends estimated from a 63-station radiosonde network, 1958-1998, *Geophys. Res. Lett.,* **26**, 2761-2764, 1999.

3. Hansen, J.E., Ruedy, R., Gascoe, J., and Stato,M.: GISS analysis of surface temperature change, *J. Geophys, Res.,* **104**, 30997-31022, 1999.

4. Otterman, J., Atlas, R., Ardizzone, J., Starr, D., Jusem, J.C., and Terry, J.: Relationship of late-winter temperatures in Europe to North Atlantic surface winds: A correlation analysis, *Theor. Appl. Climatol.,* **64**, 201-211, 1999.

5. Otterman, J., Atlas, R., Chou, S.-H., Jusem, J.C., Pielke Sr., R.A., Chase, T.N., Rogers, J., Russell, G. L., Schubert, S.D., Sud, Y.C., Terry, J.: Are stronger North-Atlantic southwesterlies the forcing to the late-winter warming in Europe?, *Int. J. Climatol.,* **22**, 743-758, 2002.

6. Otterman, J., Angell, J.K., Ardizzone, J., Atlas, R., Schubert, S., Starr, D., Wu, M.-L.: North –Atlantic surface winds examined as the source of winter warming in Europe, *Geophys. Res. Lett.,* (submitted), 2002

7. Otterman, J., Ardizzone, J., Atlas, R., Hu, H., Jusem, C., and Terry, J.: Winter-to-spring transition in Europe 48-54°N: from temperature control by advection to control by insolation, *Geophys. Res. Lett.,***27**, 561-564, 2000.

8. Trenberth, K.E.: The IPCC assessment of global warming, FAILSAFE® The electronic journal of the forum for environmental law, science, engineering, and finance™ (F.E.L S.E.F.®)http://www.felsef.org/spring01.htm., 2001.

9. Otterman, J., Angell, J., Atlas, R., Bungato, D., Schubert, S.D., Starr D., Susskind, J., Wu, M.-L.C.: Advection from the North Atlantic as the forcing of winter greenhouse effect over Europe, *Geophys. Res. Letters,* April 15, 2002.

10. Rogers, J.: North Atlantic storm track variablity and its association to the North Atlantic oscillation and climate variablity of Northern Europe, *J. Clim.,* **10**, 1635-1647, 1997.

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Figure Captions

Fig. 1 Maximum daily temperature T_{max} and the minimum daily temperature T_{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_t 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.

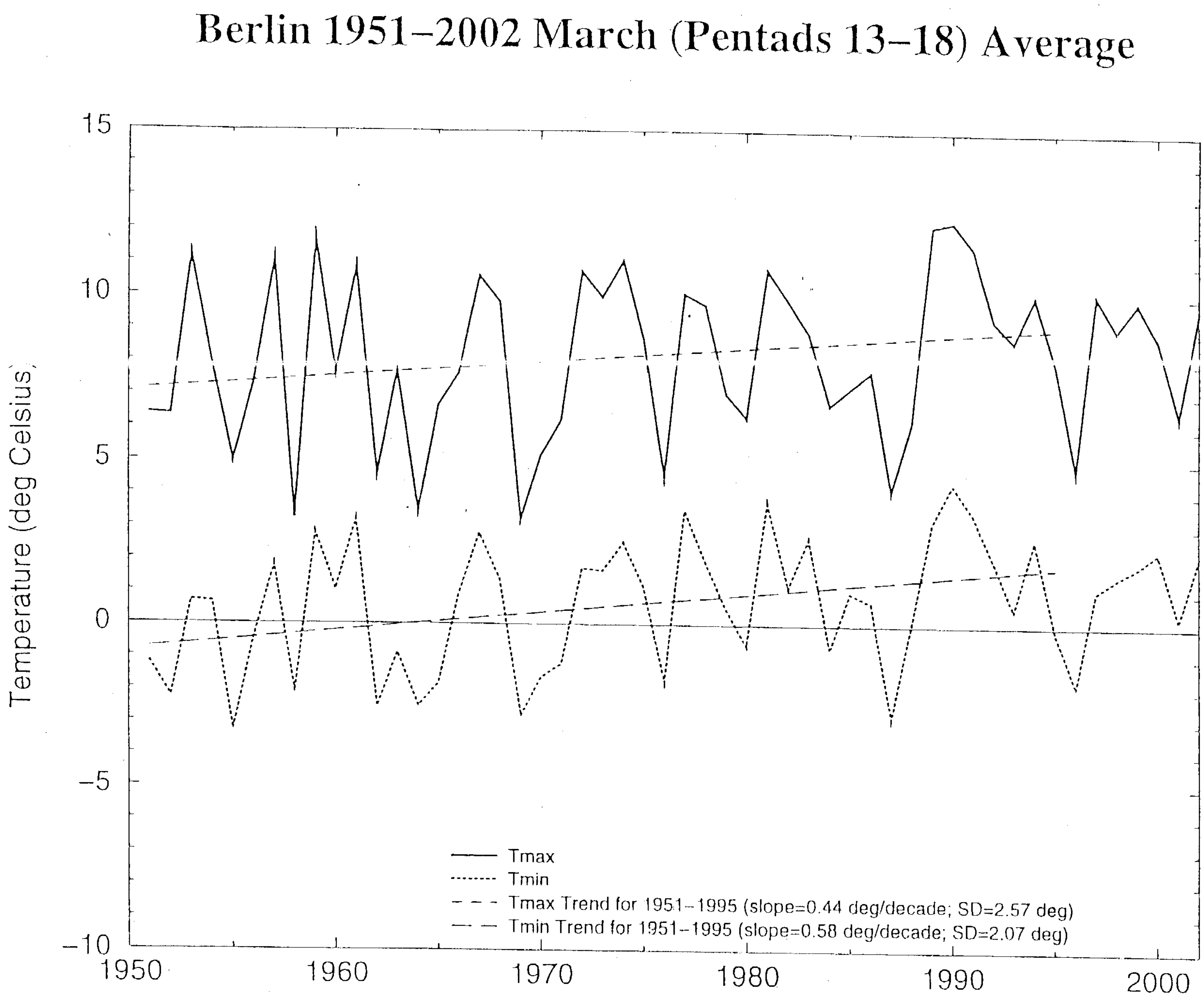

Fig. 1 top panel (Otterman, et al.)

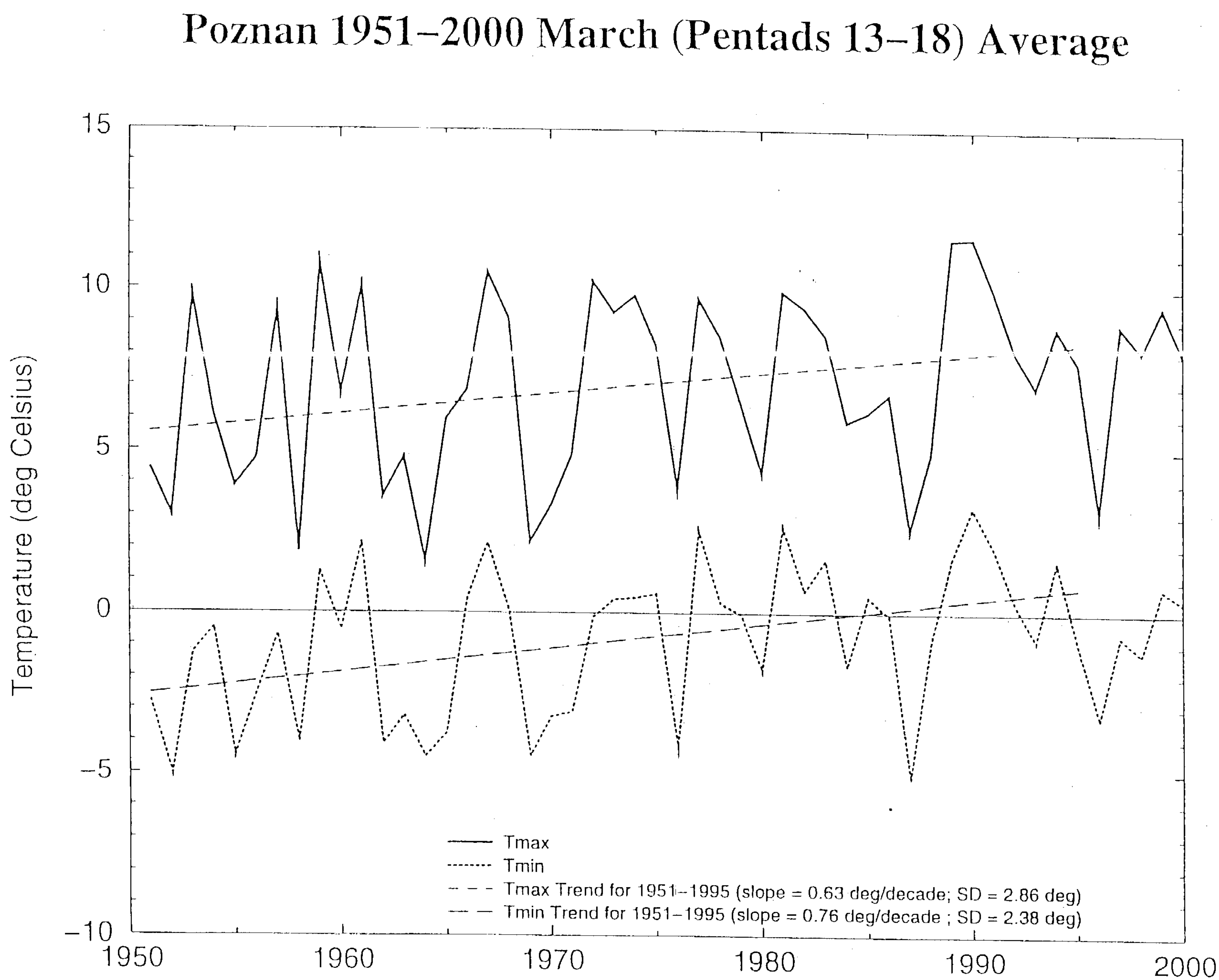

Fig. 1 bottom panel (Otterman, et al.)

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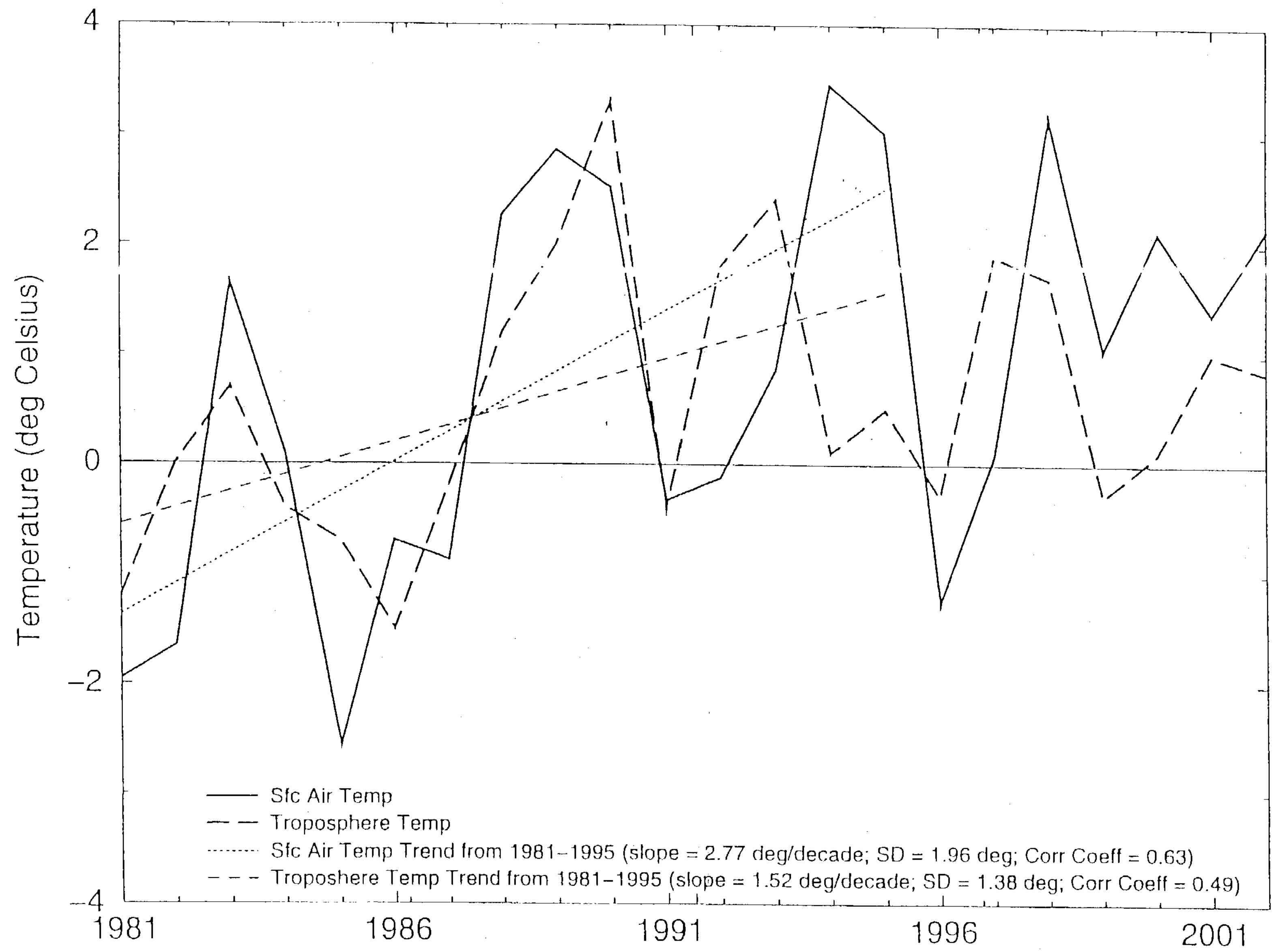

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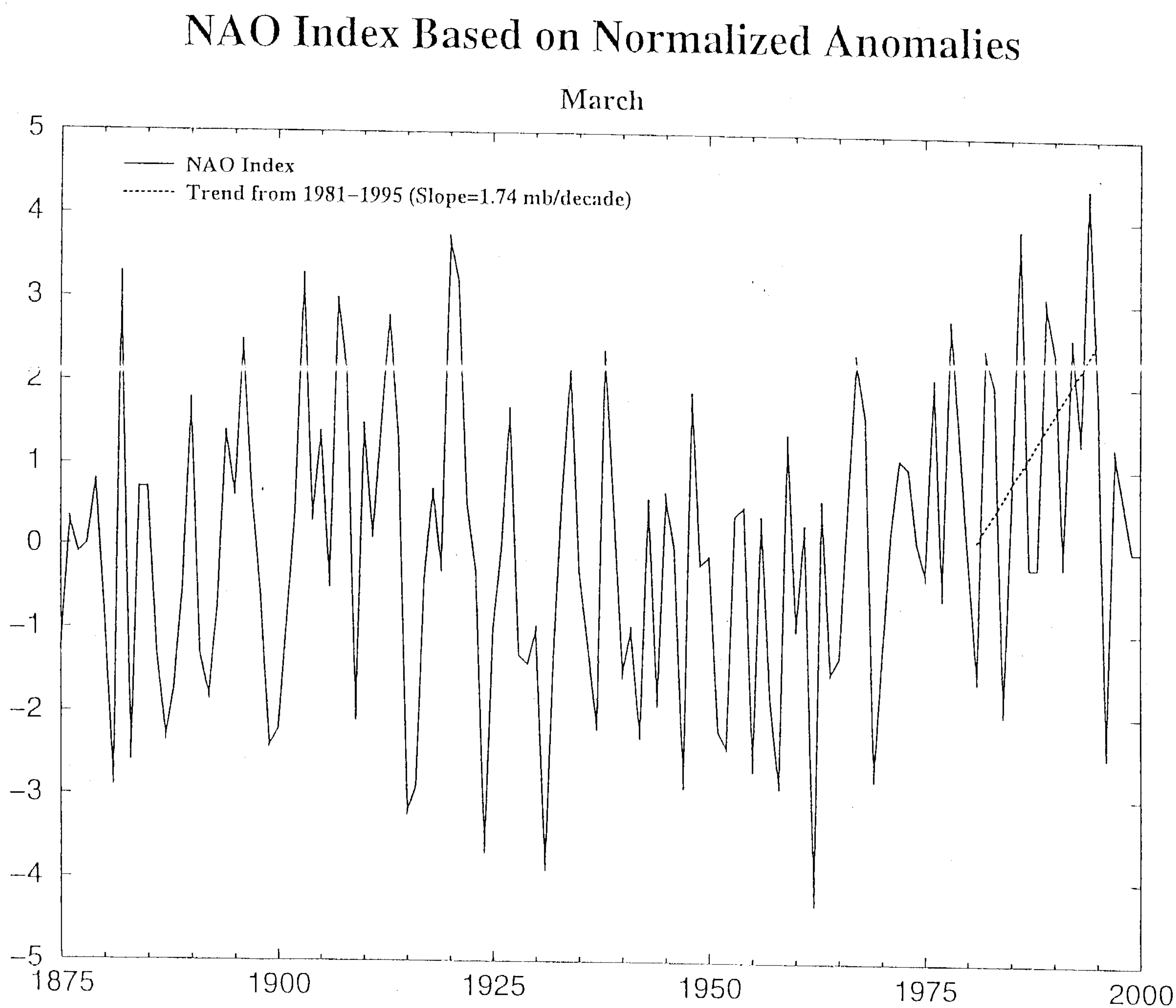

Fig. 3 (otterman, et al.)

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9. Otterman, J., Angell, J., Atlas, R., Bungato, D., Schubert, S.D., Starr D., Susskind, J., Wu, M.-L.C.: Advection from the North Atlantic as the forcing of winter greenhouse effect over Europe, *Geophys. Res. Letters,* April 15, 2002.

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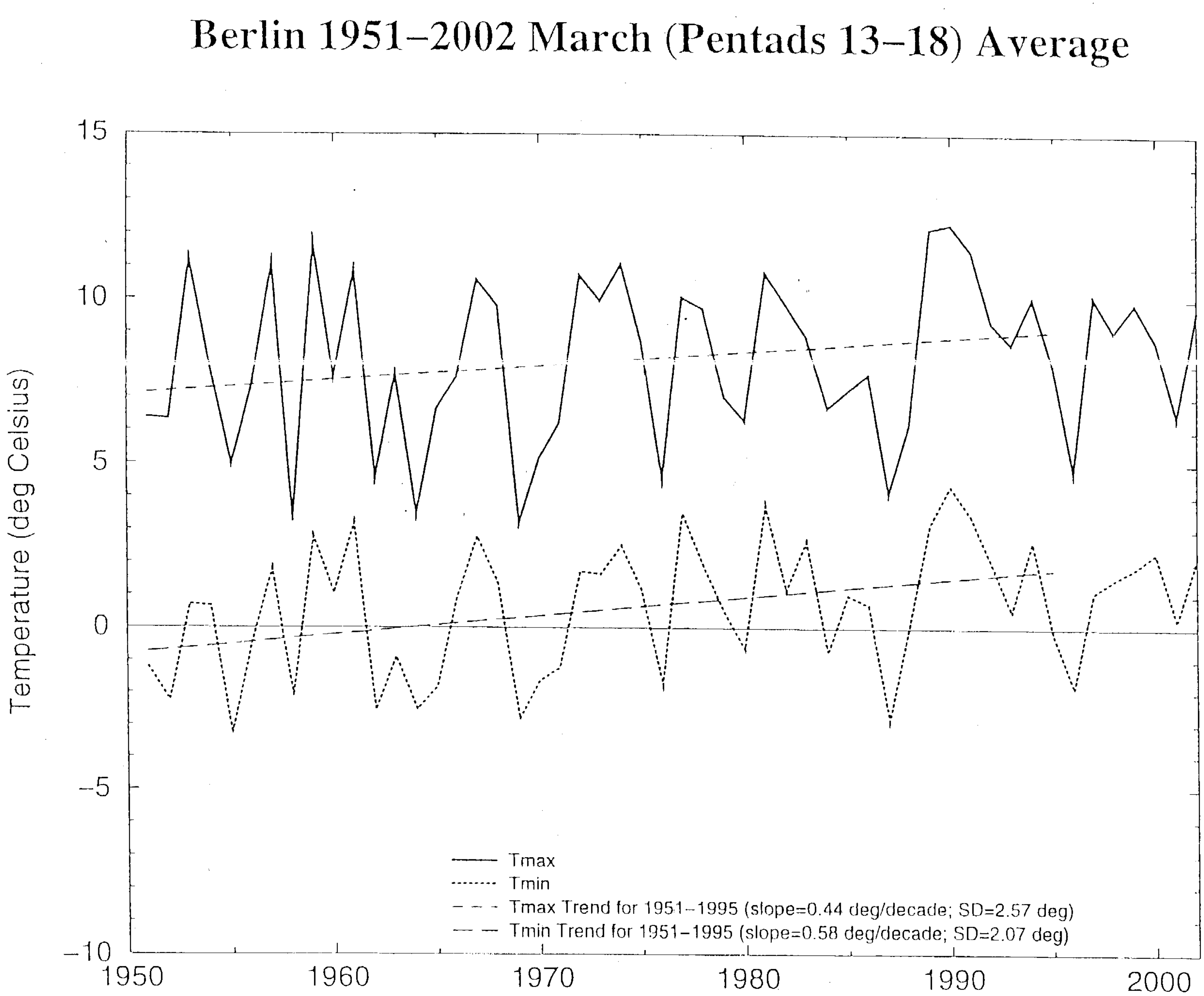
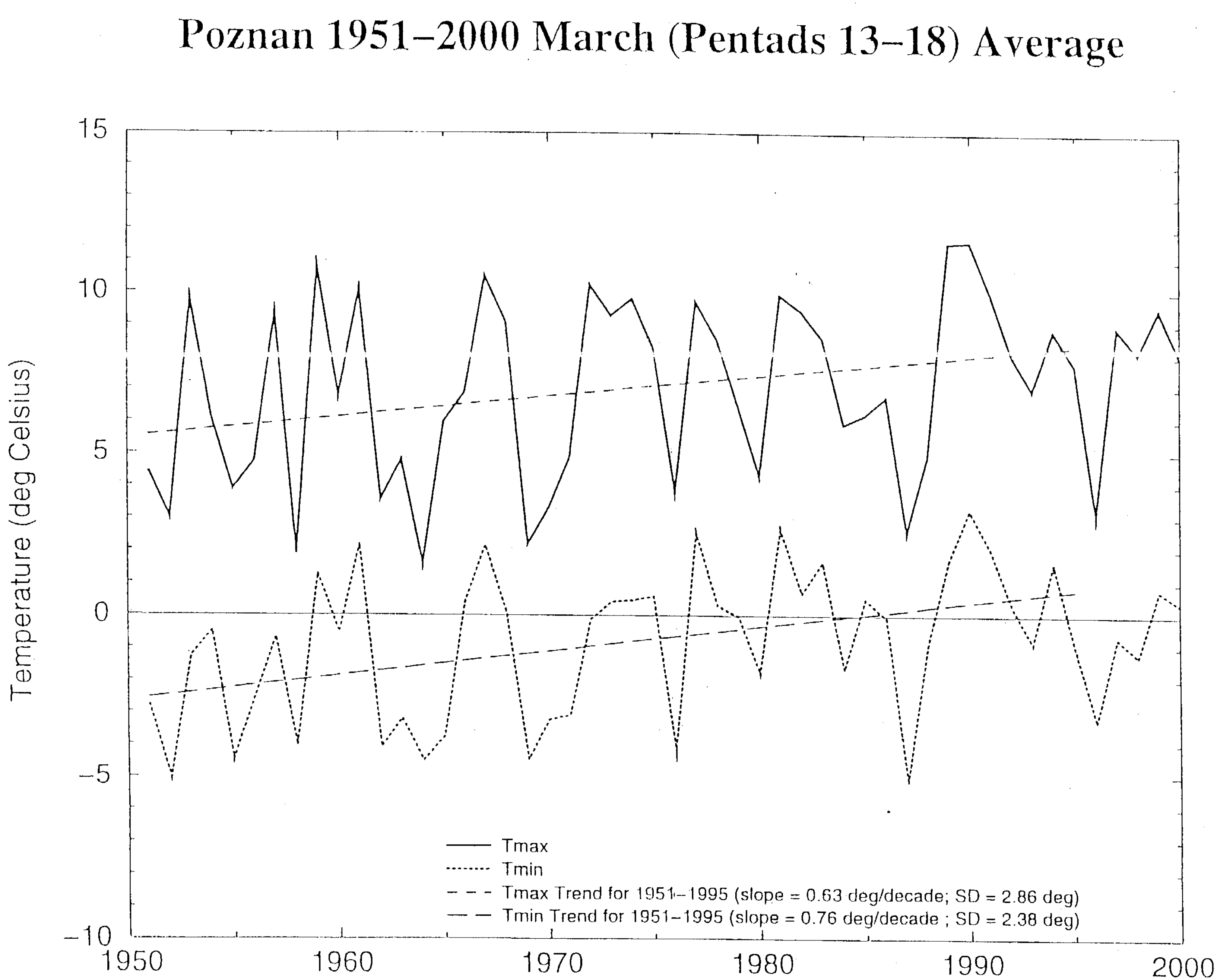


Fig. 1 top panel (Otterman, et al.)



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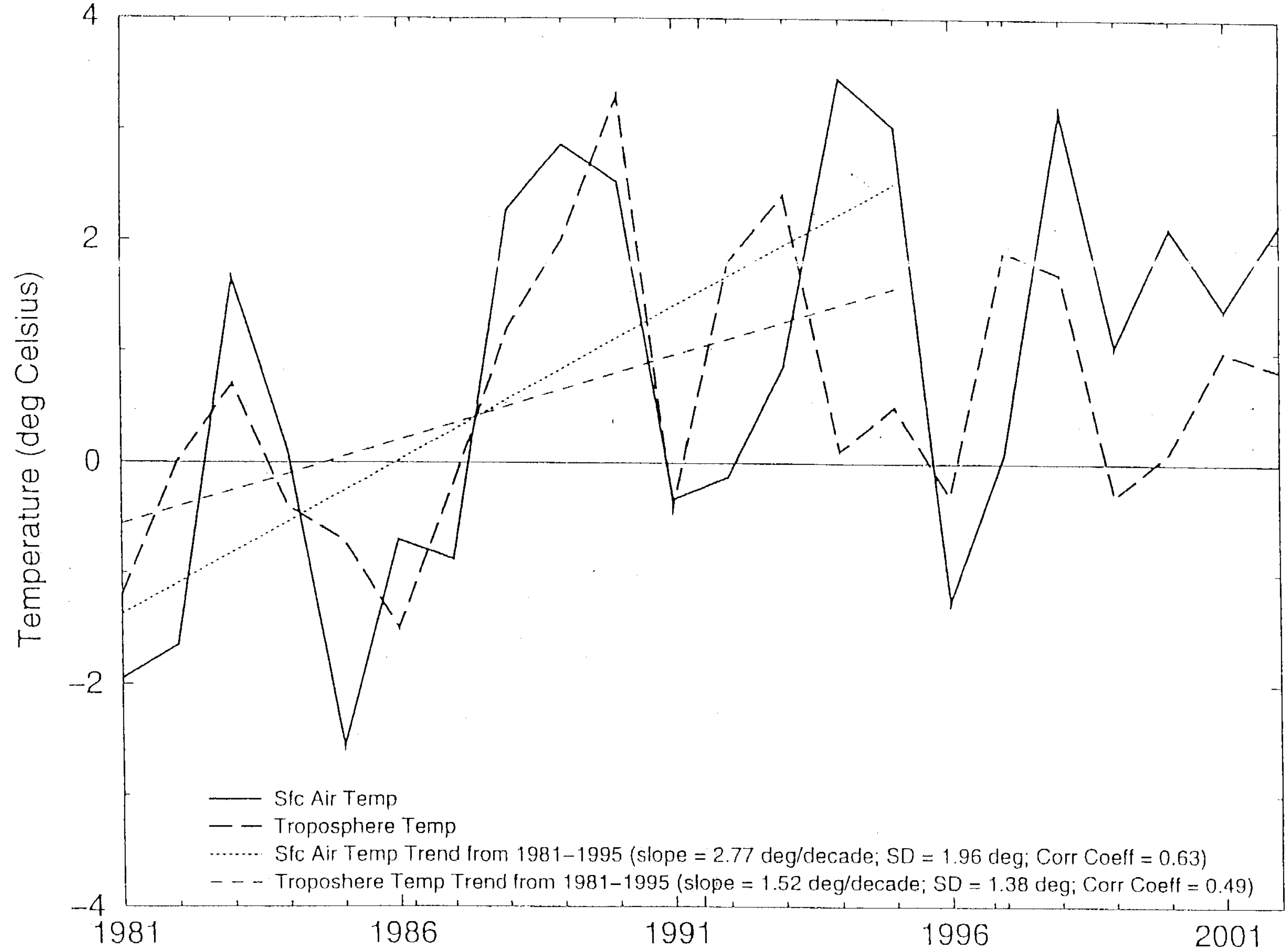
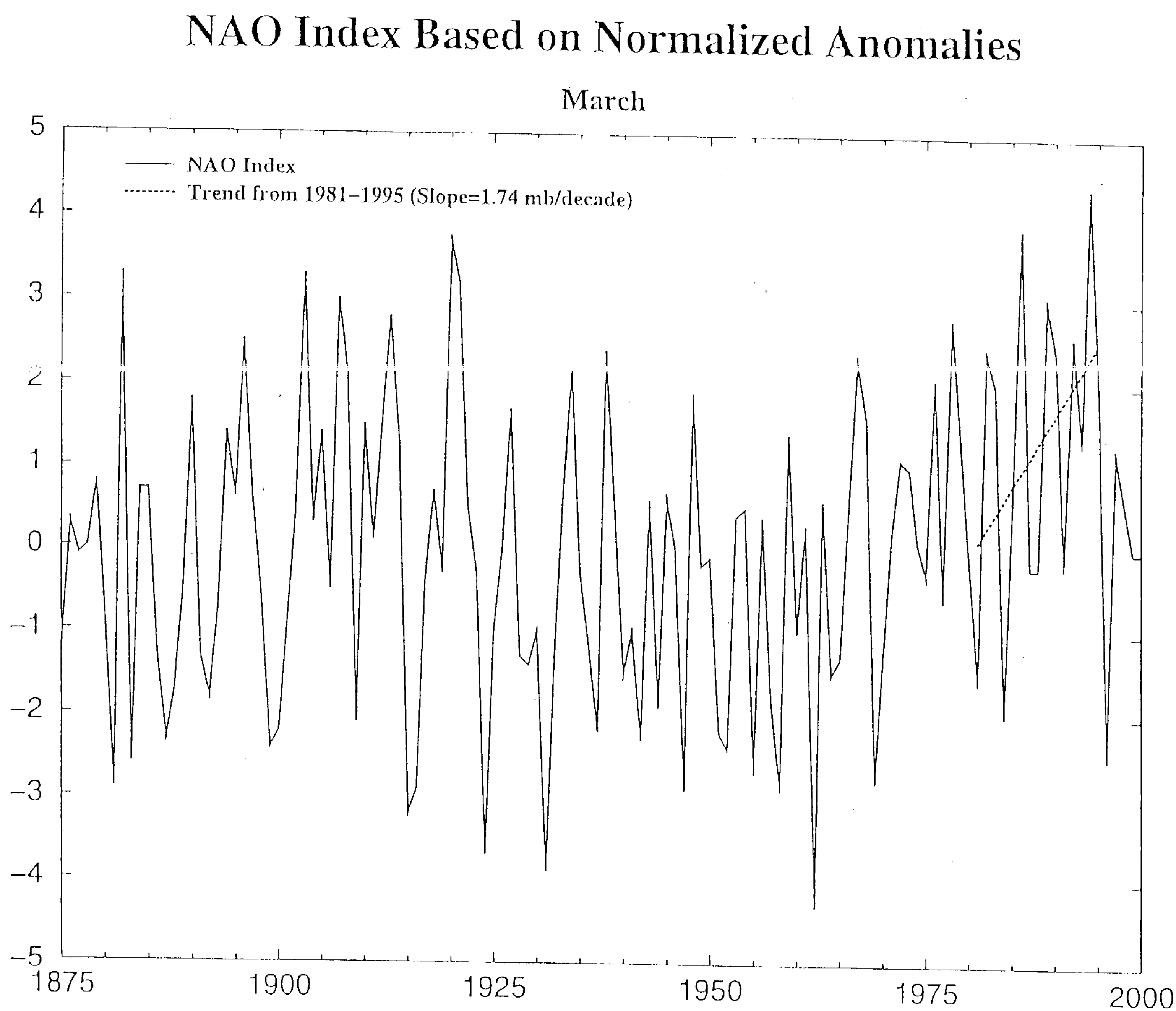


Fig. 2 (Otterman, et al.)



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