Trends in the annual temperature of de Bilt: warmer atmosphere or changed advection?

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Extended abstract

The annual temperature at De Bilt is 9.3°C and the year-to-year standard deviation is 0.6°C. The 1881-1993 series show a weak positive trend of 0.7°/century. Particularly the last decade of the series is responsible for the significance of the trend. There are two possible explanations: the air has become systematically hotter or there was more advection from warmer regions.

We tried to separate the advection-effect from the large-scale warming. This was primary done by using the Grosswetterlage (GWL) climatology. The procedure was as follows (See also BÁRDOSSY and CASPARY, 1990). First, for all 30 GWLs separately we determined in all months (of the period 1961-1985) their mean temperatures T_{GWL}. We call T_{GWL} the advection-temperature. The deviations in T_{GWL} from the monthly normals provide a first guess of the contribution of advection to the daily temperature. Then, we calculated from the series of daily GWL- classification (GERSTENGARBE and WERNER, 1993) the annual mean T_{GWL} for each year. The series of T_{GWL} provides (in first approximation) the advection-generated temperature; the difference of T_{GWL} with the observed temperature T represents the advection-corrected temperature minus the long-term mean. A signal in $T-\overline{T}_{GWL}$ may indicate an intrinsic atmospheric warming on a large scale around the Netherlands.

Fig. 1 shows the observed temperature T, advection-generated temperature $\overline{T}_{GWL}$ and $T-\overline{T}_{GWL}$, which is the deviance of the advection-corrected temperature from the long-term mean. The following can be seen:

(1) The trend is only apparent in $\overline{T}_{GWL}$, not in $T-\overline{T}_{GWL}$.

(2) The variance in $T-\overline{T}_{GWL}$ is reduced by a factor of two, with respect to that of $\overline{T}_{GWL}$.

(3) There is still a high correlation in the fluctuations of $\overline{T}_{GWL}$ and $T-\overline{T}_{GWL}$.
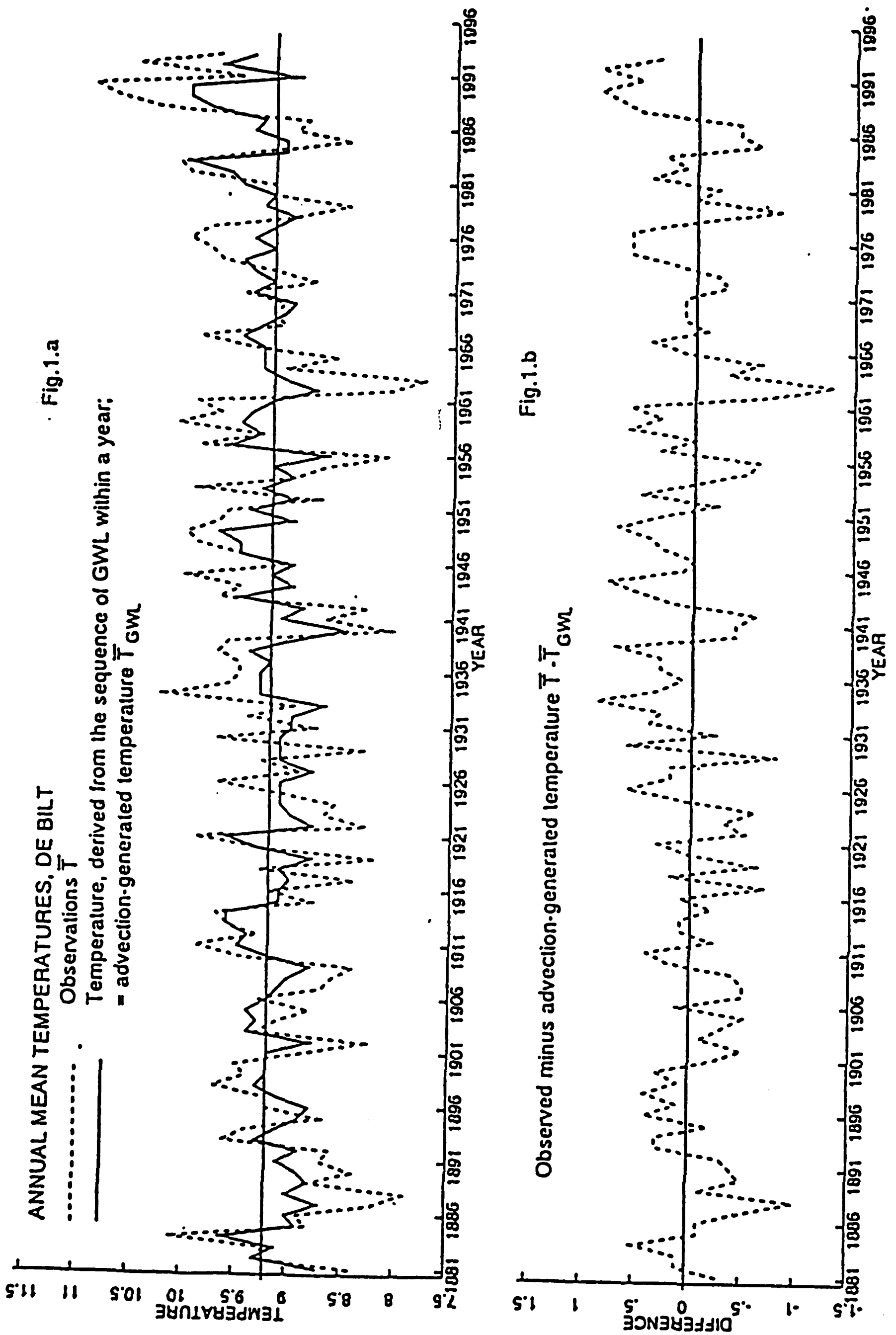
Fig. 1. (a) Observed annual temperatures $\overline{T}$ at de Bilt (dashed line) and advection temperature $\overline{T}_{GWL}$ calculated from the Grosswetterlage climatology (solid line). (b) The deviance of the advection-corrected temperature from the long-term mean (9.3°C).

Fig. 2 shows the correlation between $\overline{T}$ and $\overline{T}_{GWL}$ for all individual years. The stars represent the points of the last (warm) 13 years. Although 4 of them represent the warmest years in the 1881-1993 series, the positions of these points does not disagree with the remaining of the plot.

It should be noted that the slope of the regression line in Fig. 2 is not unity, but about 1.6. This means that even if there were no scatter in the plot, the magnitude of the year-to-year fluctuations in $\overline{T}_{GWL}$ would be only 60% of that of the actual fluctuations.

The following conclusions can be drawn:

- The trends in the De Bilt $\overline{T}$-series should be explained by a (temporary) change in circulation (hence in advection) rather than by an intrinsic atmospheric warming.
- The GWL-description of the temperature explains only part of the advection-induced year-to-year fluctuations.
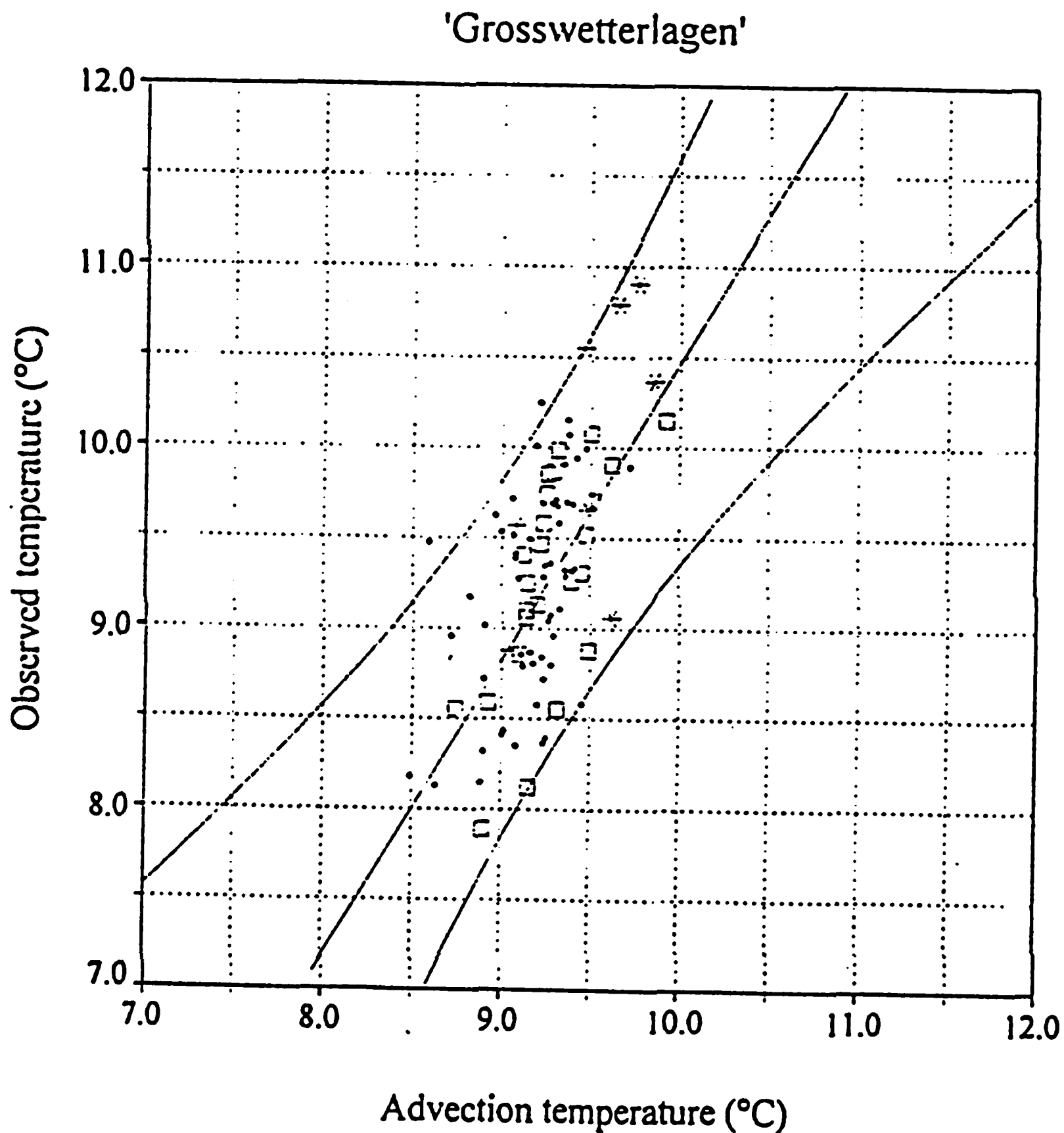

'Grosswetterlagen'

Advection temperature (°C)

Fig. 2. Relation between observed annual temperature $\overline{T}$ and the advection temperature $\overline{T}_{GWL}$. The regression line and the climatology of the Grosswetterlagen are calculated from the 1961-1985 data (squares). The stars are the years 1986-1993; the dots refer to 1881-1960. The 95% confidence intervals of the regression line are also given.

Fig. 3 shows the relation between the observed temperature and the advection temperature, calculated now using the objective P27 circulation classification of

KRUIZINGA (1979). The figure shows that objectivation of the circulation classification reduces the scatter of the points, but does not affect the slope of the regression line. Improvement is to be expected when the effect of persistence in the climatology of circulations is also taken into account.
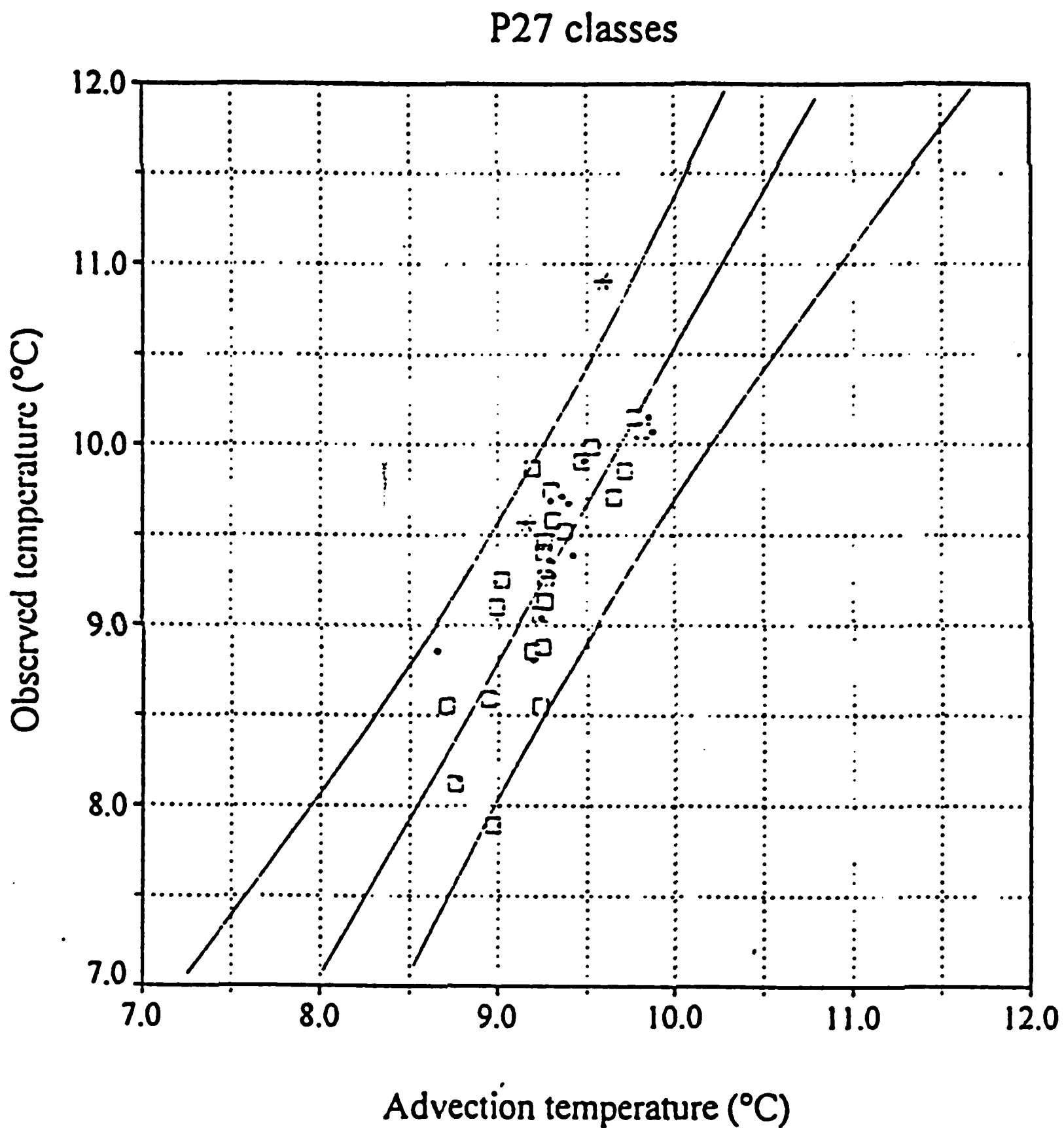
P27 classes

Fig. 3. As figure 2, but now the climatology of the objective P27 circulation classification is used for the calculation of the advection temperature. Squares refer to 1961-1985; dots 1949-1960; stars 1989 and 1990. Regression line and climatology are based on 1961-1985 (squares).

References

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