Autumn warming and the bulb-planting window in the Netherlands

A three-generation analysis of the five principal KNMI stations (1901-2022)

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Abstract

We analyse the homogenised daily temperature series (version 2.0, 2026) of the five principal stations of the Royal Netherlands Meteorological Institute (KNMI) to quantify how the autumn climate, and with it the window for planting spring-flowering bulbs, has shifted over the last century. Comparing three standard 30-year climate normals (1931-1960, 1961-1990 and 1991-2020), the national mean autumn (September-November) temperature stayed almost flat between the first two generations (+0.10 C) and then rose +0.76 C in the most recent generation, +0.86 C in total (station range 0.70 to 0.95 C). The trend over the full series is 0.18 C per decade and is significant at all five stations (Mann-Kendall p < 1e-9). The date of the first autumn frost has moved later at every station and is everywhere significant, by about 8 days nationally over two generations, but the per-station and per-generation picture is uneven, so we treat frost as supporting rather than headline evidence. The warming lengthens the mild, workable tail of the autumn planting window; the horticultural rule that bulbs can be planted until the ground freezes is unchanged. All data and methods are open and reproducible.

Keywords: phenology, climate normals, autumn temperature, first frost, Mann-Kendall, Netherlands, flower bulbs, planting window

1. Introduction

For the Netherlands, autumn is the season in which spring-flowering bulbs (tulip, daffodil, crocus, hyacinth) are planted: they go into the ground before the first frost so they can root before winter. The timing of that window is therefore governed by two autumn quantities, how mild the season stays and when the first frost arrives. This paper measures how both have shifted over roughly a century, using the longest homogenised station records available for the country. We keep the meteorological finding strictly separate from the horticultural rule it informs.

2. Data

We use the KNMI homogenised daily temperature series, version 2.0 (2026), for the five principal stations: De Bilt (260), Vlissingen (310), Eelde (280), De Kooy (235) and Beek (380). For each station we use the daily mean (TG) for the autumn average and the daily minimum (TN) for frost. The homogenisation method is peer-reviewed and openly documented (de Valk and Brandsma, 2026; KNMI report WR-26-01). De Bilt runs from 1901 to early 2026; the other four run from 1907 to 2022. All five cover the three normal periods 1931-1960, 1961-1990 and 1991-2020, with one gap: Vlissingen and De Kooy have no observations for the war winter 1944-45 (Vlissingen from 1 October 1944, De Kooy from 1 September 1944, both until mid-1945). Version 2.0 is the basis for all headline figures; the previous homogenisation (2016) is used as a robustness check and gives near-identical results.

3. Methods

We follow two independent lines of evidence and require both to agree before making a claim. First, a normals comparison over three generations: we compare the three standard WMO climate periods (midpoints around 1945, 1975 and 2005) for both the autumn mean (mean of the daily-mean temperature over September, October and November) and the first-autumn-frost date. A frost day is a day with a minimum below 0.0 C; a frost year runs from 1 July to 30 June so a winter is not split by the calendar-year boundary. A frost year with any missing value from September on, or an autumn with a missing day, is excluded rather than read as frost-free or averaged over the days that remain; frost years without any frost are counted separately. Second, a trend over the full

series using the Mann-Kendall test (direction and significance) and the Sen slope estimator, the standard non-parametric approach that is robust to outliers. The national figure is the mean of the five stations, with the spread reported as the band between the lowest and highest station.

4. Results

Table 1 gives the autumn mean per generation, the total warming over two generations, the Sen slope, and the shift in the first-frost date, per station and for the national mean. The warming is concentrated in the most recent generation: nationally the autumn mean rose from 10.33 C (1931-1960) to 10.43 C (1961-1990), a step of only +0.10 C, and then to 11.19 C (1991-2020), a step of +0.76 C. All five stations share this shape, and the full-series trend of 0.18 C per decade is significant at each of them with very small Mann-Kendall p-values (from about 7e-10 to 2e-13).

Station	1931-60	1961-90	1991-20	Warming	Trend	Frost
	C	*C*	*C*	*2 gen, C*	*C/decade*	*shift, d*
De Bilt	9.97	10.16	10.89	+0.92	0.18	+4.5
Vlissingen	11.47	11.53	12.32	+0.85	0.17	+12.1
Eelde	9.53	9.54	10.23	+0.70	0.18	+3.4
De Kooy	10.65	10.77	11.60	+0.95	0.19	+14.4
Beek	10.05	10.16	10.93	+0.88	0.18	+5.8
Netherlands	**10.33**	**10.43**	**11.19**	**+0.86**	**0.18**	**+8.0**

Table 1. Autumn (SON) mean temperature per climate generation, total warming over two generations, Sen slope, and the shift of the first-autumn-frost date (positive = later). Frost-free winters occur only at Vlissingen: three, all since 2013; De Kooy and the inland stations have none.

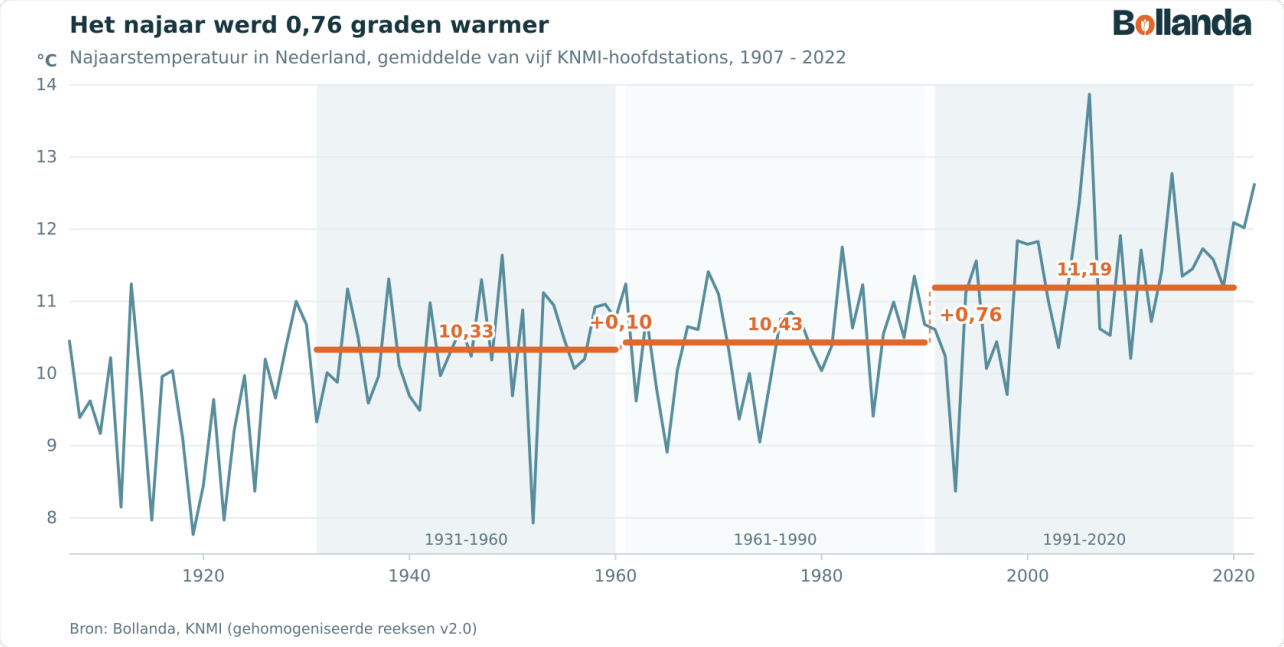

Figure 1. National annual autumn temperature (thin line), averaged over the five principal stations, with the mean per climate generation (thick bars). The level was almost flat for half a century and then stepped up.

4.1 First autumn frost

The first autumn frost falls later over the full century at all five stations, everywhere significant, by about 8 days nationally over two generations. The shift is largest at the coast (De Kooy +14.4 days, Vlissingen +12.1 days) and smaller inland (Eelde +3.4, De Bilt +4.5, Beek +5.8 days). Between the two most recent generations the change at De Bilt is close to zero, so the century trend and the generational step do not point equally consistently in the same direction for frost. Early radiative frost also depends on clear, calm nights, not only on the mean climate. We therefore report frost as supporting and honestly framed, and claim no sharp generational frost jump. Crucially, the story is not one of disappearing frost: apart from three recent winters at Vlissingen (2013-14,

2019-20 and 2021-22), every observed winter at every station had frost.

5. Interpretation: the planting window

The data establish that autumn has warmed. The step to 'you can plant later' is horticultural knowledge, not a weather statistic, and we keep the two separate. The established rule is that spring bulbs are planted in autumn, before the first frost, and can go in as long as the soil is not frozen (Royal Anthos, via FlowerBulbs.com). A longer mild autumn lengthens the late edge of that window. A supporting measure from our own data points the same way: the date on which the seven-day mean air temperature first drops below 10 C moves about three days later per generation. This is an air temperature, not a soil temperature, so we use it as a trend indicator only.

6. Data and code availability

The per-station comparison table is available as an open CSV at https://bollanda.nl/onderzoek/plantvenster-klimaat/stations-vergelijking.csv, and the full study, with interactive figures, at https://bollanda.nl/onderzoek/plantvenster-klimaat. The analysis script and method are reproducible; the underlying KNMI series and the homogenisation source code are public. This paper and its figures are released under CC BY 4.0: reuse is free with attribution to Bollanda and a link to the study.

Revision note (version 1.1, 25 September 2026). Version 1.0 counted the war winter 1944-45 at Vlissingen and De Kooy as frost-free and based Vlissingen's autumn 1944 on September alone, because missing observations were not excluded. Correcting this changes Vlissingen's 1931-1960 autumn mean from 11.56 to 11.47 C (so its 1945-1975 step becomes +0.06 C instead of -0.03 C) and its number of frost-free winters from four to three, De Kooy's from one to none, and the national 1945-1975 step from +0.08 to +0.10 C (total +0.86 instead of +0.84 C). The 0.76 C step in the most recent generation, the trends and all first-frost dates are unchanged.

7. References

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