The Climate of Belgium and Luxembourg

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Abstract

The present climate of Belgium and Luxembourg is shown to be oceanic warm-temperate, benefitting from the warming effect of the North Atlantic Drift. Mean annual air temperatures are around 10 °C and vary spatially mainly as a function of elevation. Annual temperature amplitudes are in the 13–17 °C range. Annual rainfall depths vary from ~700 mm in western Belgium to 1300–1400 mm in the wettest areas of NE and SW Ardenne. Belgium and Luxembourg are located in the zone of seasonal shift of the north polar front and the associated mid-latitude, or polar front jet stream.

Keywords

Climate • Temperature • Precipitation • Atmospheric circulation

3.1 Introduction

Located between 49° 30′ and 51° 30′ N, and 2° 30′ and 6° 30′ E, Belgium and the Grand-Duchy of Luxembourg (GDL) are entirely situated in the 0–700 m elevation range, with a 66-km-long coast where Western Belgium meets the southern North Sea and maximum elevations in eastern Belgium (694 m asl) and northern Luxembourg (560 m asl). They are dominantly crossed by SW moist air masses (Fig. 3.1) coming from the Atlantic Ocean and having first passed across NW France or the British Isles. Such dominant winds in this mid-latitude region determine a *Cfb* climate according to the updated Köppen-Geiger classification (Peel et al. 2007), i.e., a warm-temperate climate without dry season (oceanic type), with warmest month's mean temperature <22 °C and mean temperature of the four warmest months >10 °C. Except in easternmost Belgium and parts of GDL, where January's mean temperature is between 0 and −0.5 °C, the coldest month's mean temperature is >0 °C in the two countries. Owing to the presence of the North Atlantic Drift, which continues the Gulf Stream along the coasts of Western Europe and, especially during winter, warms the air masses coming from the west, the mean annual temperature of 9.7 °C recorded at Brussels over the period 1833–2015 (Statbel 2016) is fairly high for latitudes around 50° (Alexandre et al. 1992). Nevertheless, the dominant westerlies occasionally give way to advection of continental air masses coming from the east. Originating in high pressures centered in Scandinavia or Eastern Europe, these masses may cause prolonged episodes, sometimes several weeks long, of very dry and hot (during summer) or very cold (during winter) conditions over Belgium and GDL. These recurrent westward general circulations explain why only 700–800 mm annual rainfall is observed in most of Low and Central Belgium, which is rather unimpressive with regard to the oceanic character of the climate.

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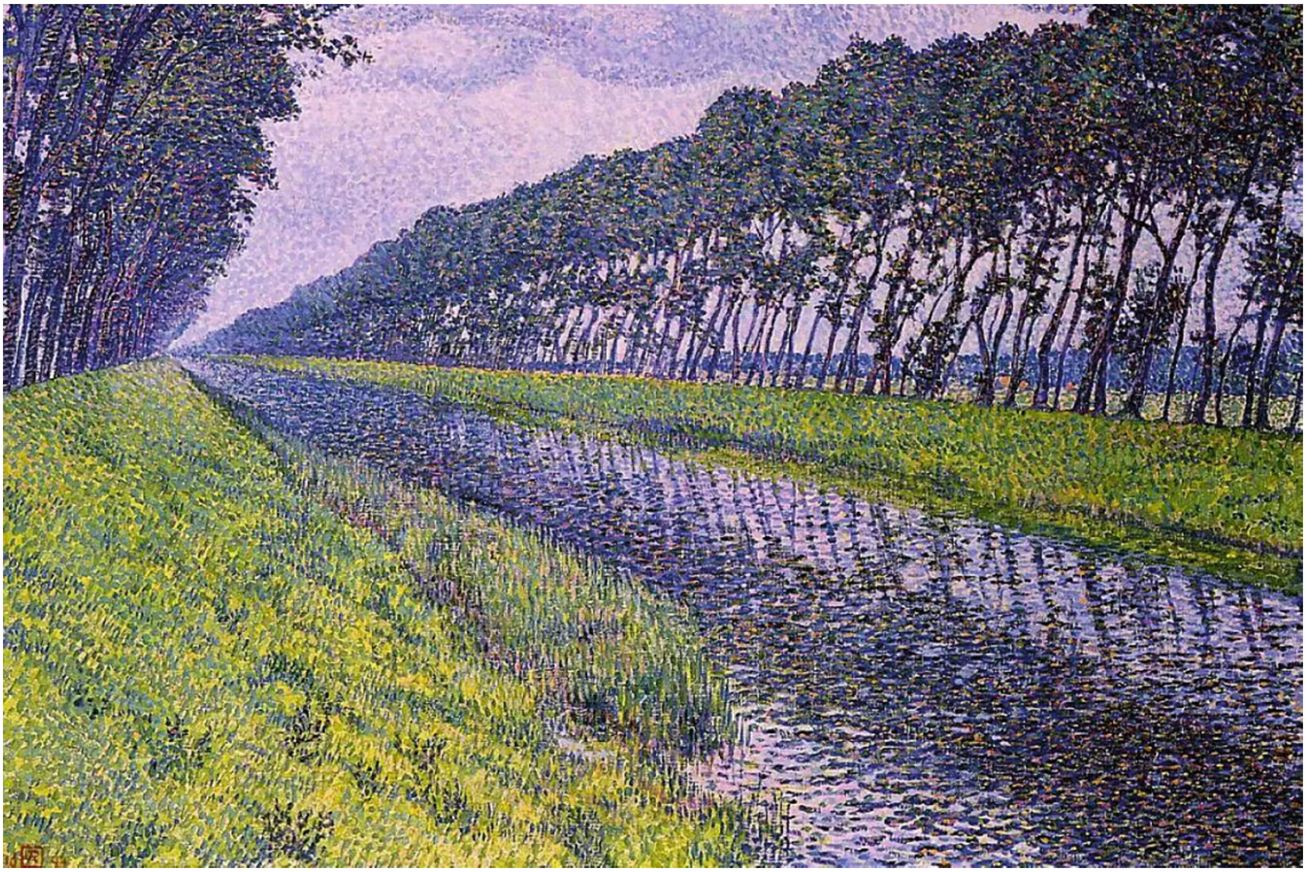

Fig. 3.1 *Rows* of inclined poplars along a canal in Flanders as seen by the Flemish painter Théo van Rysselberghe (oil on canvas, 1894), showing the effect of the dominant westerlies

3.2 Main Climatic Features

3.2.1 Temperature

The −0.6 °C/100 m vertical gradient in air temperature is the main factor responsible for altitude-dependent spatial variations of temperature across Belgium and GDL. However, throughout the year, the proximity of the sea also contributes to milder temperatures in NW Belgium in the case of air advection from the west. Overall, the isotherms are markedly parallel to the contour lines, with mean annual air temperatures between 10.5 and 11 °C in the lowlands of NW Belgium, around 10 °C in the low-elevated plateaus (100–200 m asl) of Central Belgium, and below 9 °C in the core of the Ardenne-Oesling (or Eislek, in Luxembourgian dialect) uplifted area (>450 m asl). However, this pattern of elevation-dependent temperatures is locally altered by

- the nature of the ground and its cover, such as the predominance of sandy soils producing, for example, above-average daily and annual temperature amplitudes in Campine
- the foehn effect, which warms the rain shadow side of Ardennian summit ridges whose windward flank has intercepted heavy rainfall and dried the downward winds
- site effects related to the topography, which induce for instance lower minimum temperatures in the Ardennian valley bottoms than on the plateau under clear sky, justifying the plateau setting of most Ardennian villages (Fig. 3.2)
- site effects related to densely urbanized areas.

The amplitude of mean monthly temperature variations over the year is fairly uniform throughout Belgium and GDL, from ~13 °C at Oostende, North Sea coast, through ~15 °C at Bastogne, central Ardenne, and Leopoldsburg, Campine, to ~17 °C in the slightly more continental setting of Luxembourg City. As for annual mean temperatures, they display a 0.8 °C interannual variability (1σ) overprinting a long-term trend since 1833 that fairly replicates the global warming over the same period. Going farther back in time, historical archives attest that the twelfth century (i.e., the end of the medieval climatic optimum, when vineyards were common in Belgium) was marked by warm springs and dry

Fig. 3.2 Thick frost in the Amblève valley *bottom* near Aywaille on December 3, 1989 (see location on Fig. 3.4). The temperature inversion is marked by the *horizontal upper* limit of the frost

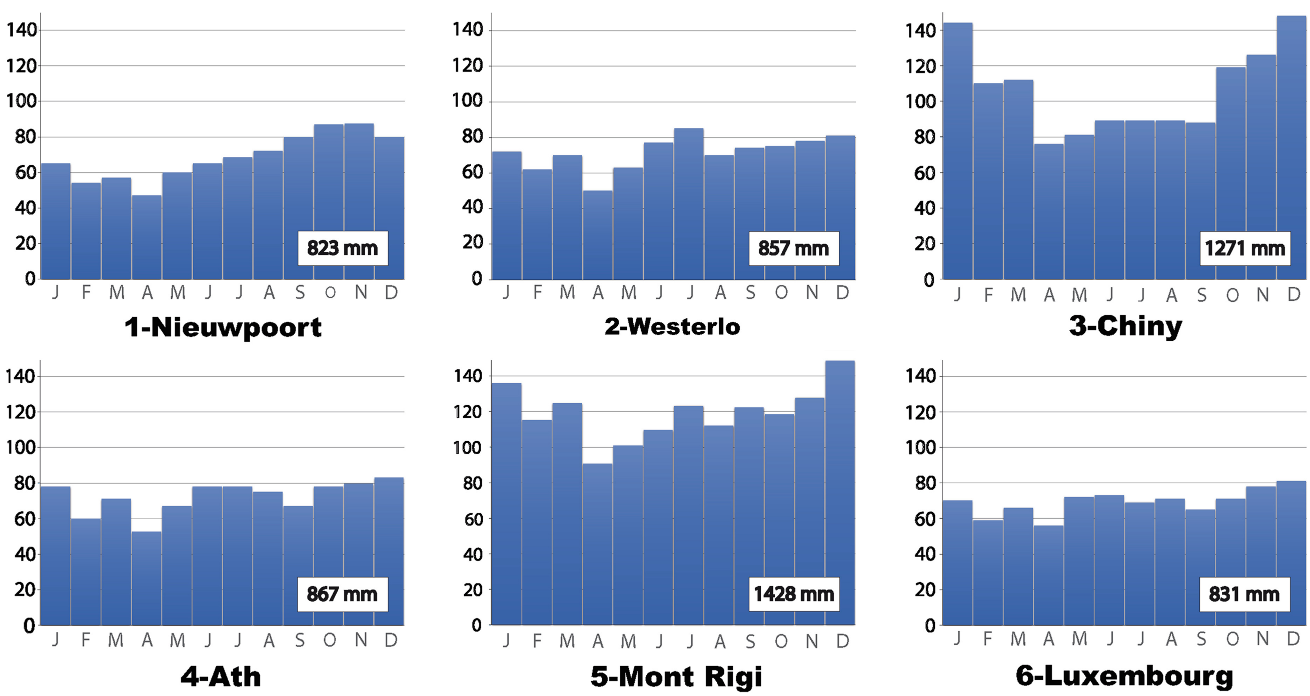

Fig. 3.3 Monthly precipitation histograms for six selected stations (see location on Fig. 3.4), averaged over the 1981–2010 period (modified after IRM 2016b)

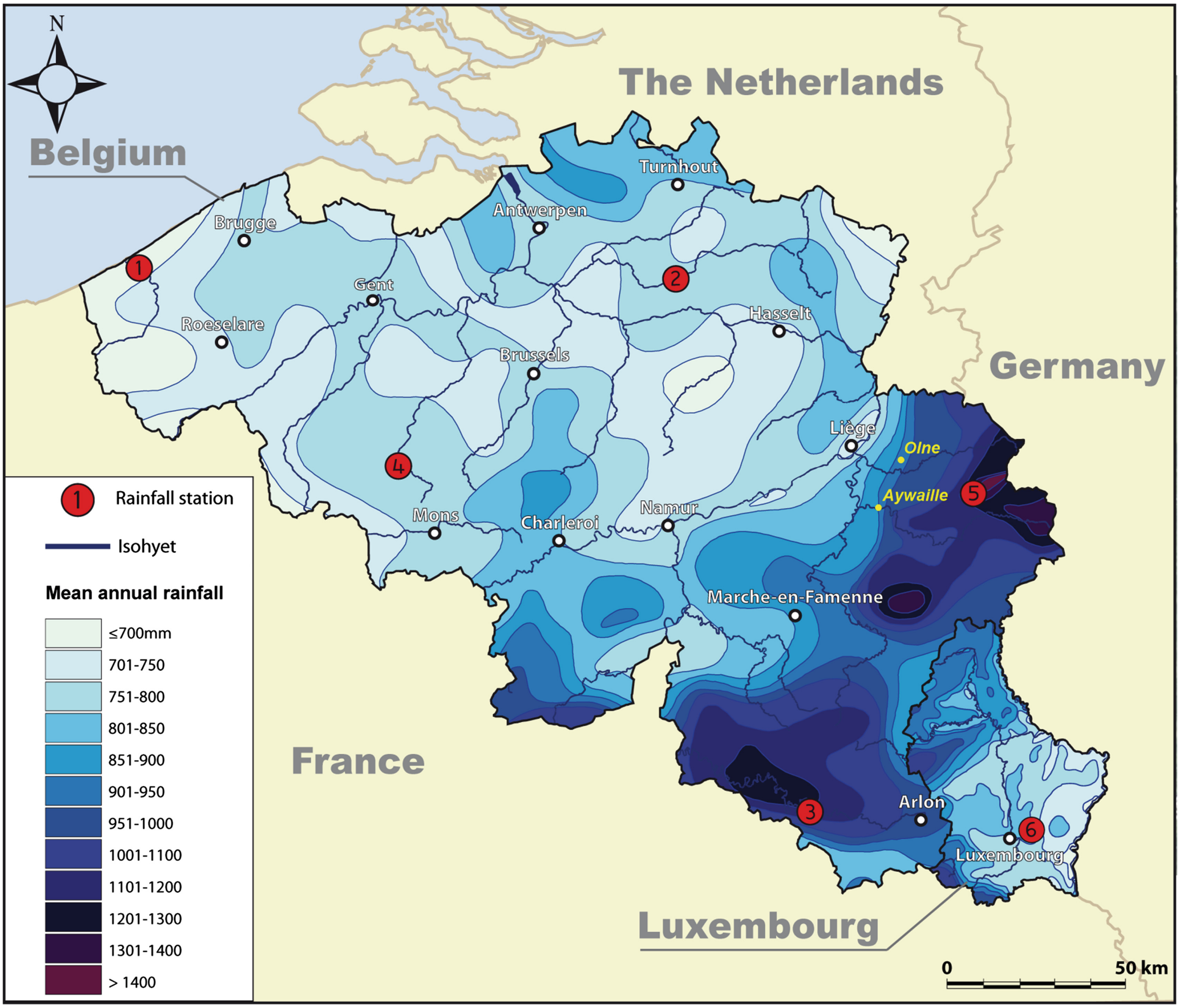

Fig. 3.4 Mean annual precipitations, averaged over the 1961–1990 and 1981–2010 periods for Belgium and Luxembourg, respectively

summers, in sharp contrast with the highly humid springs and summers and cold winters that caused the great famines of the fourteenth century (Alexandre 1987) and possible landsliding (see Chap. 20). After temporary warming during the fifth century, the Little Ice Age was marked in Belgium and GDL by very cold winters and wet, cold springs from 1550 to 1850.

3.2.2 Precipitation

Annual rainfall depths are fairly equally distributed over the year, with a poorly marked seasonal minimum in early spring (April) (Fig. 3.3). Annual rainfall range from ~700 mm in westernmost Belgium, in downwind areas of east-central Belgium, and in SE GDL (Moselle valley) to 1300–1400 mm in the Hautes Fagnes plateau of NE Ardenne and in the lower Semois area of SW Ardenne (Pfister et al. 2005; IRM 2016a) (Fig. 3.4). At Brussels, mean annual precipitations amount to 805 ± 119 mm, indicating non-negligible interannual variability and showing a minimum of 406 mm in 1921 (Statbel 2016). The oceanic character of the Belgian and GDL climate is underlined by the high percentages of rainy days, with daily precipitation exceeding 1 mm for more than 33% of the days in any season. The residual analysis of the linear regression between yearly precipitation amount and altitude (Alexandre et al. 1992) supports the correlation but displays residual patterns that suggest either its nonlinear character and/or an orographic effect (Alexandre et al. 1998). Although precipitation regimes may significantly vary across Belgium and GDL (Fig. 3.3), a weak monthly rainfall minimum is observed

Fig. 3.5 0.35-m-thick snow cover at Olne, 220 m asl, southern Herve Plateau, on December 26, 2010 (see location on Fig. 3.4)

during the winter–spring transition (February–April) in most weather stations (Alexandre et al. 1992). Geomorphologically effective precipitations take the form of either periods of prolonged rainfall causing widespread flooding (e.g., summer 1980: 243 mm in Uccle from June 21 to July 20; winters 1993–94 and 1994–95) or storms and intense convective rainfall events liable to provoke flash floods in small catchments (e.g., 168 mm/24 h at Brasschaat, Campine, September 15, 1998).

Although snow is here a minor climatic component that shows high interannual variability, a continuous snow cover may occasionally persist for more than one month over the High Ardenne plateau above 500 m. Snowfalls are more frequent in January–February, generally accumulating less than 0.3 m of snow (Fig. 3.5). Since 1950, a >1-m-thick snow cover was observed only three times in the Hautes Fagnes plateau, namely in February 1952 and 1953 and in the beginning of March 1988. Between 1983 and 2014, the average yearly number of days with a snow cover varied from 12 to 16 at 100 m asl (Brussels area, where snow hardly reaches the ground during the mildest winters) to 22 at 300 m asl. On the Ardennian summits, this number significantly increases from west to east (40 days in Saint-Hubert at 550 m asl, 60 days at the top of the Baraque de Fraiture at 650 m asl, 75 days in the Hautes Fagnes area between 650 and 700 m asl). Noteworthily, rapid melting of the snow cover combined with a heavy rainfall event during a sudden return to milder conditions is responsible for ~50% of the floods recorded in the Ardenne valleys.

3.2.3 Other Climatic Features

A main characteristic of Belgian and GDL climates is the high numbers of overcast days (60–75% from November to March) and days with cumuliform clouds (80% on average from April to October). December mean sunshine durations are consequently as low as 45, 35, and 45 h at Oostende (Belgian coast), Botrange (NE Ardenne) and Luxembourg airport, respectively. These same locations record July

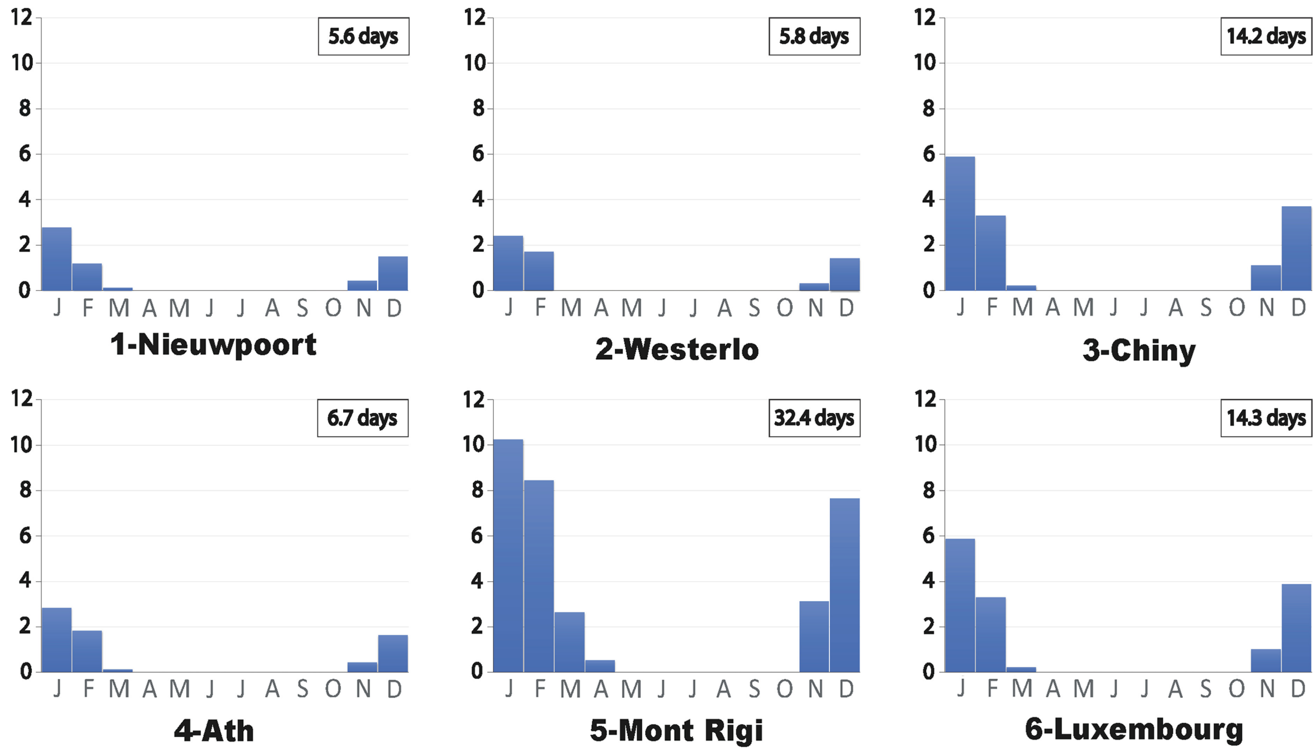

Fig. 3.6 Monthly numbers of days of continuous frost (maximum temperature <0 °C) for six selected stations (see location on Fig. 3.4), averaged over the 1981–2010 period (modified after IRM 2016b)

means of 225, 190, and 250 h and annual means of 1730, 1400, and 1730 h over the period 1981–2010, i.e., about 20–25% of the potential sunshine duration in winter and 40–50% in summer.

Whereas snow is not so frequent in Belgium and GDL, days with night frost are much more common, from ~50 per year near the coast to >120 in the areas of the Ardennian plateau above ~580 m asl. Likewise, yearly numbers of days with continuous frost (maximum temperature <0 °C) increase from 6 in the coastal area to >30 in High Ardenne above 580 m (Fig. 3.6). Severe cold conditions occasionally cause temperatures to drop between −20 and −30 °C, especially in the incised Ardennian valleys prone to high daily amplitudes of temperature.

3.3 Atmospheric Circulation

The latitudinal position of Belgium and GDL locates them in the zone of seasonal shift of the polar front and the associated mid-latitude, or polar front jet stream. The polar front is characterized by the convergence of cold polar and warm subtropical air masses, inducing a strong temperature gradient that generates the barotropic eddy-driven jet streams and embedded storm tracks, bringing moist air from the ocean over Europe. While a stronger Azores High pushes the polar front northward in summertime, allowing warm subtropical air to invade Belgium and GDL and moving storm tracks further north, its winter weakening combined with a deepening of the Icelandic Low has the opposite effect, bringing the polar front and its attendant low pressures, cold air and rainfall-laden westerlies over our region. In addition to this seasonal shift of the polar front, weather interannual variability in Belgium and GDL is controlled by the varying strength of the Azores High and Icelandic Low, imposing varying pressure gradients over the North Atlantic that are known as the North Atlantic Oscillation (NAO). A large pressure gradient between strong high and low centers (positive NAO index) reduces the polar front jet undulations and strengthens it in a more northern position, notably causing mild and wet winters in Belgium and GDL such as that of 2006–07, but also storms. Conversely, weakened Icelandic Low and Azores High determine a negative NAO. Westerlies are displaced southward; they slow and start to undulate, allowing frequent southward intrusions of polar air. Belgian winters tend then to be colder and drier and summers are cool and humid, such as in 1980.

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