IS THE JANUARY THAW A STATISTICAL PHANTOM?

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Similar patterns occur often enough in random series resembling real data that this famous bit of folklore is unlikely to be a genuine climatic phenomenon.

Meteorological conditions that tend to occur on or near a specific calendar date more frequently than chance might suggest have been termed singularities (e.g., Huschke 1959) or calendaricities, a term introduced by Brier et al. (1963) to avoid confusion with the mathematical usage of "singularities." These features are commonly identified as consistently observed warm or cold departures from the annual march of temperature, or as wet or dry departures from some background annual precipitation trend.

Historically, the most studied singularity in European weather lore is an alleged cold period during 11–14 May, popularly known as the Ice Saints, named after the last killing frosts that seemingly tend to occur on days dedicated to Saints Mamertus, Pancras, Servatius, and Boniface on the ecclesiastical calendar (e.g., Buchan 1869; Talman 1919; Huschke 1959). Other hypothesized singularities have been discussed by Talman (1919) in a detailed bibliography of 144 worldwide publications from 1820 to 1917.

In the United States, a well-known example of a precipitation singularity is the onset of the monsoon in the Southwest in early July (e.g., Bryson and Lowry 1955). The most widely recognized temperature singularity is the January thaw, a purported anomalous warming in the northeastern United States around 20–24 January. The January thaw may be particularly notable in weather folklore and the public imagination because it occurs around the time of expected minimum annual temperature and brings relief from below-freezing temperatures. It has been hypothesized to be associated with anomalies in other parameters such as sea level pressure (e.g., Wahl 1952; Brier 1954; Lanzante and Harnack 1982; Kalnicky 1987), zonal and meridional indices (e.g., Brier 1954; Duquet 1963), upper-level geopotential height (e.g., Dickson 1959; Duquet 1963; Lanzante 1983), tornadoes (Dickson 1959), and ocean-wave directions on the east coast of the United States (Hayden 1976). Table 1 summarizes previous studies of the January thaw, including the geographical coverage, the period of climatological record, meteorological variables used in the analyses, and the authors' conclusions.

Whether particular singularities such as the January thaw are dynamically important, statistically significant features of the atmosphere, or mere weather

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Table 1. Brief summary of studies of the January thaw.

Study	Geographical coverage	Period of record	Analyzed variables	Conclusions
Esten and Mason (1910)	Storrs, CT	1888–1909	Record max and min; max, min, and avg temperature	Singularity
Marvin (1919)	Continental United States	1778–1865	Avg weekly temperature	No strong singularity
Nunn (1927)	Northeast United States	1873–1925	Avg temperature	Singularity
Slocum (1941)	Northeast United States	1871–1939	Avg temperature	No conclusion
Wahl (1952)	Northeast United States	1873–1952	Avg temperature, sea level pressure	Singularity
Wahl (1953)	Boston, MA	1873–1952	Avg temperature	Singularity
Brier (1954)	Northern Hemisphere	1899–1939	Sea level pressure	No conclusion
Lautzenheiser (1957)	Boston, MA	1911–1950	Avg temperature	No strong singularity
Dickson (1959)	Nashville, TN	1871–1950	Avg temperature, tornados	Singularity
Bingham (1961)	Northeast United States	1896–1956	Avg weekly temperature	No strong singularity
Duquet (1963)	Northeast United States	1872–1961	Avg weekly temperature	Singularity
Newman (1965)	Boston, MA	1872–1964	Max and min temperature	No strong singularity
Frederick (1966)	United States and SW Canada	1897–1956	Avg, max, and min temperature	Singularity
Hayden (1976)	East Coast United States	1954–1970	Mean of surf heights	Singularity
Logan (1982)	Portland, ME	1965–1979	Avg temperature	No conclusion
Lanzante and Harnack (1982)	New Brunswick, NJ	1858–1981	Max temperature	Singularity
Lanzante (1983)	North America, Atlantic, and Pacific Oceans	1947–1976	700-mb heights	Singularity
Kalnicky (1987)	Northern Hemisphere	1899–1969	Sea level pressure	No conclusion
Guttman and Plantico (1987, 1989)	Eastern United States	1951–1980	Max and min temperature	Singularity
Guttman (1991)	Central Park, NY	1876–1987	Max and min temperature	No strong singularity

folklore, seems to excite perpetual controversy among forecasters and researchers. One argument against the existence of singularities is the absence of a viable physical mechanism for these phenomena. Indeed, singularities in general, and the January thaw in particular, could be given much more credence if a physical mechanism were determined. Explanations that have been offered for why departures of temperature or precipitation from a smooth annual cycle might occur include the following: meteor showers (e.g., Bowen 1956), sunspots (Newman 1965), melting snow and ice cover (e.g., Talman 1919, p. 556; Ruschy et al. 1991), atmospheric coupling to sea surface temperatures in the Pacific Ocean (e.g., Lanzante 1983), and a relationship to the planetary-scale flow patterns such as the semipermanent centers of action (e.g., Talman 1919, p. 556). Unfortunately, few of these papers can confidently demonstrate the physical connection to the purported singularities.

Greely (1888, 117–119), Nunn (1927), Wahl (1952), and Lanzante and Harnack (1982) found that the warmth of the January thaw in the northeast United States was associated with southerly flow from a midlatitude cyclone tracking over the northern states. The January thaw was terminated by a shift to colder, northwesterly flow over New England associated with a continental anticyclone and an offshore trough (Wahl 1952). Aloft, Dickson's (1959) composite 500-hPa maps and Lanzante's (1983) composite 700-hPa maps are consistent with the results for the surface. Dickson's (1959) 500-hPa maps showed southwesterly flow over the eastern United States during the January thaw becoming more zonal after the January thaw, associated with rising heights centered over Louisiana and falling heights centered over Maine. Lanzante's (1983) 700-hPa maps showed the passage of a trough over the midwest United States (associated with the surface pressure trough) during the time of the January thaw and the arrival of a ridge from over Alaska into the western and central United States (associated with the surface anticyclone) that terminated the January thaw. Frederick (1966) provided further support for this evolution by showing the eastward progression of the warm spell across the United States (from 7–10 January in the Pacific Northwest to 19 January in Florida), suggesting that it may be related to eastward-moving offshoots of the Aleutian low, consistent with Duquet's (1963) analysis.

A second argument against singularities was raised by Marvin (1919) who claimed that since the annual march of surface temperature should be dominated primarily by incoming solar radiation, which is a smooth annual curve, the annual march of surface temperature should also be a smooth annual curve (i.e., harmonics beyond second order, annual and semiannual, should be small). If higher-order harmonics were large, a preferred periodicity to singularities within the year may be indicated. At 24 stations across the United States, Marvin found that the first two harmonics of the weekly mean temperature were generally adequate to represent the total time series. Oftentimes, the residual temperature trace indicated 13–14 features that Marvin claimed may have been singularities, but these residual anomalies were not explained easily by higher-order harmonics. Guttman and Plantico (1989) also tested this hypothesis with 16 eastern U.S. stations and found similar results. Therefore, singularities, if they exist, are not likely to be explained by a particular harmonic of the annual cycle; instead, they are likely to be isolated anomalies apart from the annual cycle.

A third argument is that the apparent temperature anomalies are a result of too short a data record (i.e., given enough data, these anomalies would be smoothed out). Using tests on the daily temperatures at Boston, Wahl (1952) and Newman (1965) were able to show at the 93% and 99% confidence levels, respectively, the existence of above-normal temperatures around the time of the January thaw, although Newman (1965) dismissed the likelihood of a singularity because the probability of obtaining this result by chance was high. Guttman (1991) found a significant warming trend on 25 January (and a significant cooling trend on 8 January) at Central Park, New York, at the 95% level. Finally, Guttman and Plantico (1987) examined 74 stations across the eastern United States and found, at the 95% confidence level, a significant warm period in New England during 22–27 January and in a band from Michigan to Virginia during 20–26 January, and a significant cold period in New England during 30 January–2 February, results consistent with earlier studies that failed to perform tests of statistical significance.

Without any identifiable physical basis for presumed climatic singularities such as the January thaw, a competing hypothesis must be that they have arisen simply by chance in the averaging of finite climate records. In this paper, we investigate this possibility for the January thaw in the northeastern United States.

DEFINITION OF THE JANUARY THAW.

This investigation will focus on five northeastern cities where the January thaw has been studied most frequently or where other authors have concluded in previous research that there is evidence for the phenomenon. Temperature data for Portland, Maine (1920–August 1999), Central Park, New York (1876–August 1999), Washington, D.C. (1948–August 1999), New Brunswick, New Jersey (1893–1993), and two periods of weather records for Boston, Massachusetts were used in this analysis. One of the Boston records is the same (1873–1952) as that used by Wahl (1952). The second period for Boston extends from 1920–August 1999. In separate analyses, day-by-day means of both average daily temperatures [(max+min)/2] and maximum daily temperatures were calculated over the period of record, excluding leap days. Annual cycles were then defined by smoothing these 365 daily means with six Fourier harmonics, which capture the modest but obvious deviations of the annual cycle from a single sine wave but are smooth enough to allow high-frequency features such as the January thaw to appear clearly as anomalies.

Denote by $\bar{x}_t$ ($t = 1, \ldots, 365$) the raw daily means, and let μ_t be the climatological mean for each day defined by the smooth Fourier function. The standard deviation of $\bar{x}_t$ for each day of the year s_t is given by

$$s_t = \sqrt{\frac{1}{n^2}\sum_{i=1}^{n}(x_{i,t} - \mu_t)^2}, \tag{1}$$

where n is the number of years in the period of record with a valid temperature observation $x_{i,t}$ on day t in year i. Note that since Eq. (1) pertains to the standard deviation of the daily sample means $\bar{x}_t$, it is smaller by a factor of $\sqrt{n}$ than the standard deviation of the daily observations $x_{i,t}$ (e.g., Wilks 1995). These standard deviations are larger in winter and smaller in summer, reflecting the fact that the underlying daily temperatures $x_{i,t}$ composing the means are also more variable in winter (e.g., Fig. 1). Accordingly it is not surprising that deviations from the smooth annual cycle of daily mean temperature, such as the January thaw, stand out most strongly in winter (a point also made by Bingham 1961), and this effect has probably contributed to the popularity of the January thaw as an object of speculation and study. However, a fair analysis of the unusualness of excursions from the annual cycle must not be confounded by differences in the intrinsic variability of the atmosphere in different seasons. Thus, in the following we analyze nondimensional mean temperature data.

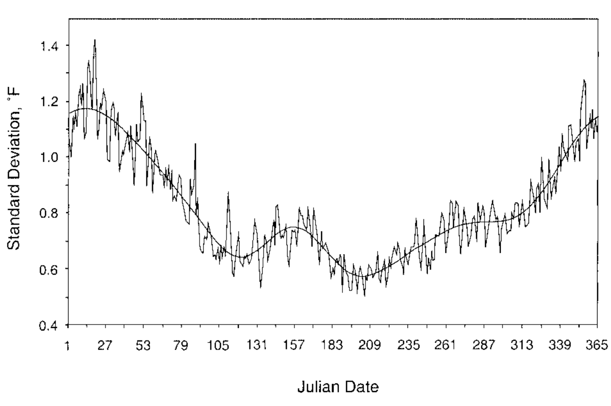

Fig. 1. Portland, ME (1920–99) average daily temperature std dev s_t, and std dev smoothed with six-wave harmonic function (smooth curve) σ_t. These std dev are larger in winter and smaller in summer, reflecting the fact that the underlying daily temperatures are intrinsically more variable in winter.

Define a dimensionless standardization z_t for each day of the year t by

$$z_t = \frac{\bar{x}_t - \mu_t}{\sigma_t}. \tag{2}$$

Here σ_t are the standard deviations s_t [Eq. (1)] smoothed with a six-wave Fourier function (e.g., the smooth curve in Fig. 1). Time series of the standardized values z_t exhibit excursions around the mean ($\bar{z} = 0$), at least some of which derive from sampling variations within the finite climate record. That is, suppose the true annual cycle of the daily temperature means is smooth, in a manner that is well approximated by a six-wave Fourier function, and contains no high-frequency (periods shorter than a week or so) components such as a January thaw. Any finite (e.g., 80-yr) series of observations from such a climate will exhibit variations of the raw daily means or their standardized counterparts [Eq. (2)] around the smoothly varying climatological march of the seasons. How large are the reported instances of the January thaw in relation to these sampling variations?

In order to investigate this question quantitatively, an event definition is necessary. Define the index

$$\psi = \begin{cases} \sum_{t=d}^{d'} \left| z_t - \frac{|z_t|}{z_t}\zeta \right| & \text{if } d' - d \geq \tau \\ 0 & \text{if } d' - d < \tau \end{cases}, \tag{3}$$

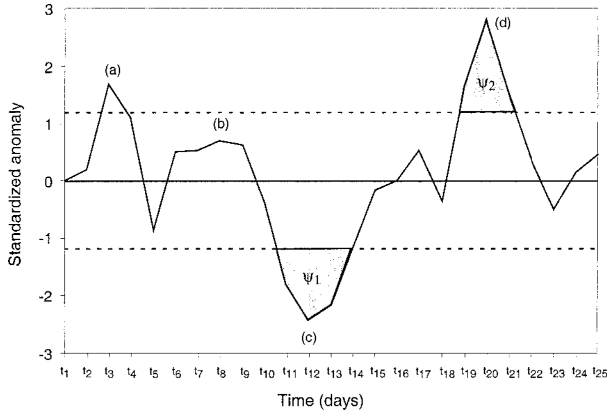

Fig. 2. Hypothetical standardized anomalies z_t [Eq. (2)], and their transformation to ψ values according to Eq. (3), using ζ = 1.2 and τ = 3 days. Excursions (a) and (b) do not meet the duration or magnitude requirements, respectively, and are assigned zero ψ values. Excursions (c) and (d) meet the requirements to be classified as putative singularities, and are assigned ψ values approximately equal to the shaded areas.

where ζ is a threshold anomaly (i.e., cutoff parameter) defining extreme values of z_t, and the summation is taken over any sequence of consecutive days with z_t more extreme than ζ, provided that there are at least τ such consecutive days in the particular run. The first date of an excursion that exceeds ζ in absolute value is denoted by *d*, and the last such consecutive date is denoted by *d′*. If the difference between *d′* and *d* is at least τ, the excursion is assigned a nonzero singularity index value ψ.

Figure 2 illustrates the application of Eq. (3), assuming ζ = 1.2 and τ = 3 days. The singularity index for excursion (a) in Fig. 2 is zero, because this excursion does not persist for at least τ = 3 consecutive days. Similarly, ψ = 0 for excursion (b) because it does not exceed the threshold anomaly, ζ. Excursions (c) and (d) each exceed the threshold anomaly in absolute value for at least three days and thus are each assigned nonzero ψ values. Geometrically, Eq. (3) approximates the area enclosed by the excursion between z_t and $\pm\zeta$ over a period of at least τ consecutive days (shaded). Equation (3) differs from the thaw index defined by Lanzante and Harnack (1982), which considers exactly two days in late January and is quantified by dimensional residuals.

Note that Eq. (3) contains two adjustable parameters, ζ and τ. Different values for these parameters will produce different ψ values for a given sequence of consecutive mean temperature anomalies. For each of the observed time series, the values for these parameters were found which resulted in the ψ value for the late January warm anomaly being ranked as highly as possible among all such excursions from the annual cycle. For the 1920–1999 Boston average daily temperature data, letting ζ = 0.6 and τ = 5 days leads to a ψ index of 3.01 and a rank of 8 for the purported January thaw centered on 24 January (Fig. 3): the departure from the smooth climatic mean (equivalent to z_t = 0) centered on this date is the eighth largest such excursion in therms of ψ, and no other choices for ζ and τ result in a better-ranked January thaw for this series. Similarly, optimized assignments for the ζ and τ parameters were made for the other temperature series considered here, as shown in Table 2. Also shown in Table 2 is the *P* value that is defined in section 3a below. The dates of the observed thaw at these locations range from 22 to 25 January, a result consistent with results from previous papers that the thaw falls on or around these dates (e.g., Nunn 1927; Wahl 1952; Lautzenheiser 1957; Lanzante and Harnack 1982).

STATISTICAL SIGNIFICANCE.

Hypothesis tests. To test the significance of the anomalous warming in average daily temperatures at the end of January, a time series model was constructed to statistically simulate periods of record similar to the real data. Each *n*-yr time series of daily temperatures x_t was simulated using the cyclostationary (e.g., von Storch and Zwiers 1999) first-order autoregressive model

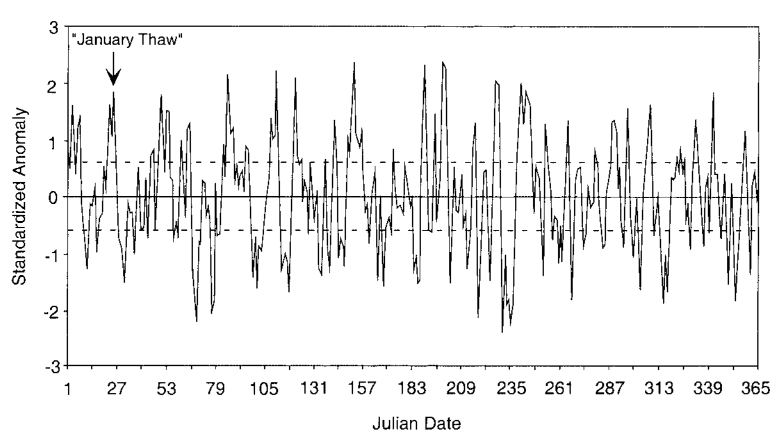

Fig. 3. Standardized anomalies z_t [Eq. (2)] for the annual cycle of average daily temperatures at Boston, 1920–99. Dashed lines show $\pm\zeta$ = ±0.6. The Jan thaw is the eighth largest singularity according to Eq. (3), with ζ = 0.6 and τ = 5 days.

Table 2. Observed January thaw statistics for each of the five northeastern cities; parameters ζ, τ, and ψ from Eq. (3); and p values pertaining to the null hypothesis that each has arisen through chance sampling variations as evaluated through 10 000 realizations of n-yr synthetic temperature series.

Dataset	Variable	Rank	"Thaw" date	ζ	τ (days)	ψ index	p value
Boston, MA (1920–99)	Avg temperature	8	24 Jan	0.6	5	3.01	0.34
	Max temperature	7	24 Jan	1.1	3	1.63	0.22
Boston, MA (1873–1952)	Avg temperature	1	22 Jan	1.2	3	2.35	0.84
	Max temperature	1	22 Jan	1.4	3	1.62	0.79
Central Park, NY	Avg temperature	1	23 Jan	1.3	5	2.46	0.40
	Max temperature	2	22 Jan	1.1	3	3.42	0.33
New Brunswick, NJ	Avg temperature	1	23 Jan	1.4	4	2.21	0.47
	Max temperature	1	24 Jan	1.1	7	4.53	0.15
Portland, ME	Avg temperature	2	24 Jan	1.0	5	2.12	0.56
	Max temperature	1	24 Jan	0.8	6	3.22	0.87
Washington, D.C.	Avg temperature	4	25 Jan	0.6	6	4.88	0.23
	Max temperature	4	25 Jan	1.2	5	2.23	0.02

$$x_t = \mu_t + \phi_k (x_{t-1} - \mu_{t-1}) + \varepsilon_t. \quad (4)$$

Here μ_t is the mean temperature on day t, ϕ_k is the autoregressive parameter (lag-1 autocorrelation coefficient) for month k, and the ε_t are independent Gaussian random numbers. While the autoregressive parameters ϕ were allowed to vary by month and location, they are generally close to 0.6 as is typical for daily temperature data (e.g., Richardson 1981, 1982). The random numbers are produced by a Gaussian random number generator using the Box–Muller method (Bratley et al. 1983), and have mean zero and standard deviation

$$\sigma_{\varepsilon,t} = \sqrt{(1-\phi_k)^2 \sigma^2_{x,t}} \;, \quad (5)$$

where $\sigma^2_{x,t}$ is the temperature variance on day t. Both μ_t and $\sigma^2_{x,t}$ are specified by smooth, six-wave Fourier functions. This is a conventional and reasonable model for daily temperature variations (Wilks 1995; Wilks and Wilby 1999), and it produces synthetic series with statistical characteristics similar to those of the real data. Each n-yr realization of daily temperatures from this model was averaged for each of the 365 days in the year, and six Fourier harmonics were fit to each synthetic annual cycle of mean temperature and its standard deviation; exactly as for the real temperature data, as described previously. The synthetic mean series show excursions from their climatological mean that are similar in both character and magnitude to excursions in the observed mean series (Fig. 4).

Realizations of synthetic daily average and maximum temperature series were analyzed in the same manner as were the real data, except that apparent climate singularities were defined using Eq. (3) and the ζ and τ parameters optimized for the *observed* data. Frequency distributions of ψ indices having the same rank as the January thaw in the observations were then tabulated in each case. This procedure was repeated 10 000 times for each city and data type, producing, for example, 10 000 second-ranked ψ indices for Portland daily average temperature, 10 000 first-ranked ψ indices for Central Park daily average temperature, 10 000 eighth-ranked ψ indices for 1920–99 Boston daily average temperature, and so on (Table 2). In comparison to the observed anomalies, the synthetic series produce many apparent events of similar and larger magnitudes, and these occur randomly throughout the year and are equally divided between warm and cool deviations.

The observed January thaw ψ indices were compared to the distributions of synthetic ψ indices (e.g., Fig. 5), and p values (see below) pertaining to the null hypothesis that the January thaw occurs by chance were evaluated according to the magnitudes of the observed ψ indices in relation to these synthetic distributions. The large frequency of zero in Fig. 5 for Boston, 1920–99, results from the numerous (3012) synthetic series in which the standardized z_t did not exceed $\zeta = 0.6$ in absolute value for at least $\tau = 5$ consecutive days, at least 8 times in the annual cycle, so that the eighth-ranked ψ value had magnitude zero. Note that, for cases where Table 2 indicates that the observed January warm period could not be made into the largest singularity in the annual cycle, comparison to distributions of synthetic ψ indices of the same rank essentially allows for the possibility of other, more prominent, singularities elsewhere in the year. Since these ψ indices are necessarily no larger than the first-ranked ψ indices in each n-yr realization, the procedure used here is as favorable as possible to detection of a January thaw.

The results of these analyses are summarized in Table 2 for all cities and temperature variables considered. Of the locations in this study, only the results for the Washington, D.C., maximum temperatures show nominal statistical significance, with a computed p value of 0.02 (i.e., the observed ψ value in this case was larger than 98% of those generated randomly). However, when evaluating the results of multiple hypothesis tests, it is likely that a small fraction of the results will appear to be statistically significant, even if all null hypotheses are true. If each test result is independent, the probability that at least $r = 1$ result of $N = 12$ tests would have a p value of $p = 0.02$ or smaller can be evaluated quantitatively using the binomial distribution,

$$\Pr\{R = r\} = \binom{N}{r} p^r (1-p)^{N-r}, \qquad (6)$$

where the R indicates the random variable (in this case, the number of nominally significant hypothesis tests) whose precise value is unknown, and r denotes a specific particular value that the random variable can take on (e.g., Livezey and Chen 1983; Wilks 1995). The result in this case is that $\Pr\{R \geq 1\} = 1 - \Pr\{R = 0\} = 0.215$. While it seems superficially plausible that a p value of 0.02 provides evidence for the January thaw, the binomial distribution indicates that this result could have occurred by chance with a sufficiently high probability (0.215) that the test results in aggre-

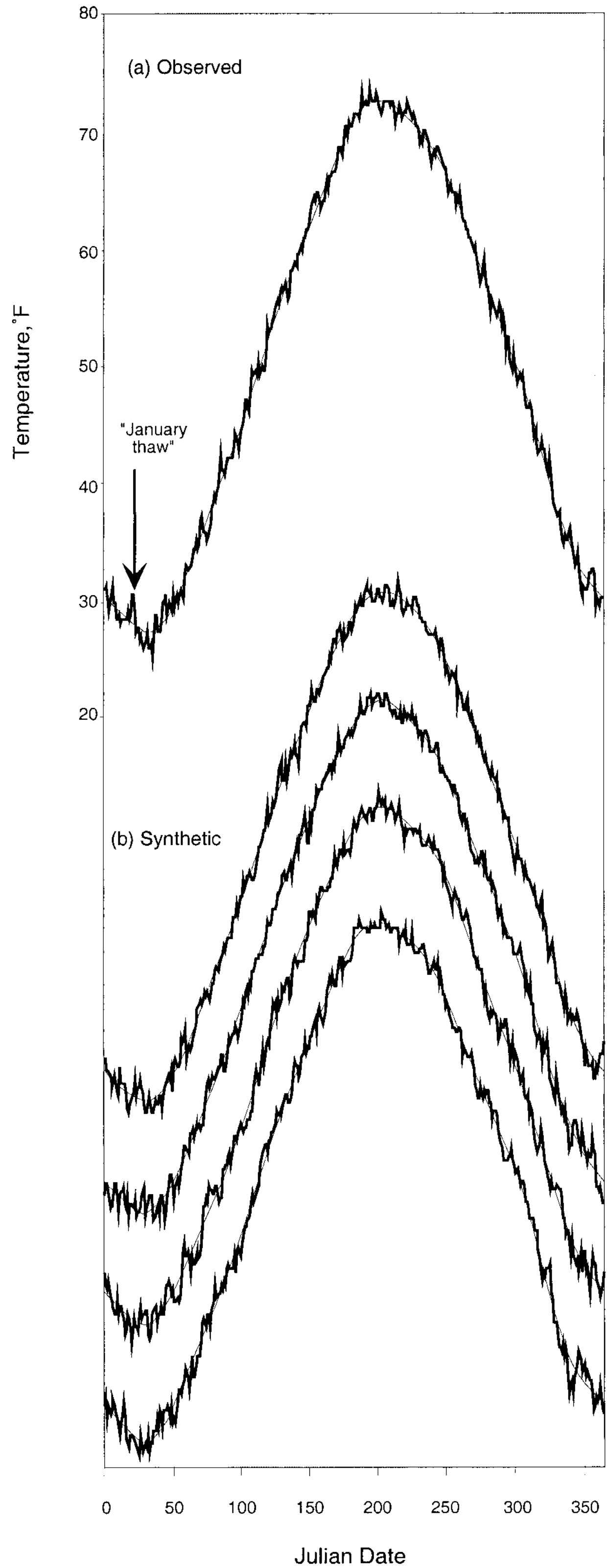

Fig. 4. (a) Observed annual cycle of mean (n = 80 yr of record) average daily temperatures $\bar{x}_t$ (heavy line) and corresponding smooth mean series μ_t (light line) for Boston, 1873–1952. (b) Corresponding results for four example 80-yr synthetic series (temperature scales suppressed) with statistical properties derived from the 1873–1952 Boston record.

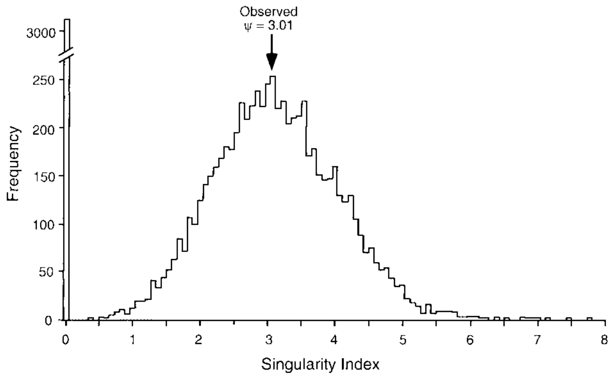

Fig. 5. Histogram of ψ indices produced 10 000 80-yr series generated using daily average temperature statistics for Boston, 1920–99. Arrow indicates the actual ψ index for the observed series.

gate cannot be considered to have achieved statistical significance. To the extent that these 12 cases have been chosen on the basis of the same data that are analyzed in the tests, and that the results of the 12 tests may be correlated, the evidence for the January thaw is even weaker. It is also important here to note that, since in each case the definition of the ψ index has been tuned to emphasize the January warm excursions in the observed data, the p values reported in Table 2 are smaller than the true probabilities for the individual tests, which further weakens any case for the January thaw.

How big would a January thaw need to be? The results in the previous section indicate that the observed late January warm period, as defined according to Eq. (3), is not unusually large relative to the sampling variations occurring inevitably in random processes of the same length, even when the parameters of Eq. (3) have been tuned to maximally emphasize this feature in the observed records. The observed data in Figs. 3 and 4 also suggest that excursions of this magnitude are typical elsewhere in the observed annual cycle, especially (e.g., Fig. 4, upper) in the cold part of the year when temperatures are intrinsically more variable.

It is interesting to consider how extreme a departure from the smooth annual cycle would be necessary in order to reject the null hypothesis in the tests presented above. Addressing this question is complicated by the fact that, assuming the January thaw exists as a physically real phenomenon, we do not know its true structure (e.g., its threshold magnitude ζ, duration τ, or overall amplitude ψ). However, assuming the reasonableness of Eq. (3) as an index for the January thaw and the optimized ζ and τ values in Table 2, one can calculate how much the observed January warm excursions would need to be inflated in order to reject the null hypothesis (and thus "detect" the January thaw) at specified test levels. For example, in order to reject the null hypothesis of a purely sampling source for average temperature excursions at the 5% level, the observed ψ index would need to be larger than all but 500 of the 10 000 maximum synthetic ψ indices. If ζ and τ are fixed, the ψ index is increased by magnifying the excursions of the observed temperature means from their smooth annual cycle.

Figure 6 shows the resulting hypothetical excursions corresponding to the 5% and 1% test levels (gray curves), relative to the observed temperature means (dark thin curve) and smooth annual cycle (heavy smooth curve) for the first 60 days of the annual cycle of average daily temperature at Boston, 1873–1952. That is, the dark thin curve is reproduced from the first 60 days of Fig. 4 (upper curves), and the gray excursions indicate magnitudes of January thaws inflated sufficiently to reject the null hypothesis of a random source for them, at the indicated test levels. This figure is typical of the other 11 cases listed in Table 2 (not shown). The observed excursion is roughly half the magnitude that would be necessary to provide convincing evidence. Note that, when plotted on this expanded scale, it can be seen that the late January warm excursion is only slightly larger than another apparent warm excursion in mid-February.

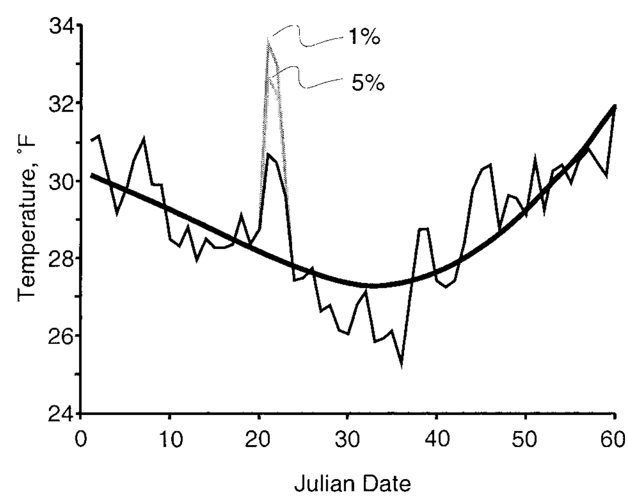

Fig. 6. First 60 days of the raw (dark thin curve) and smoothed (dark heavy smooth curve) annual cycles of the mean of average daily temperatures at Boston, 1873–1952 (as in Fig. 4), with hypothetical Jan thaws (gray curves) large enough to allow rejection of the null hypothesis of a purely sampling source for this excursion, at the indicated test levels.

CONCLUSIONS. The hypothesis tests in section 3 show clearly that mere sampling effects are wholly adequate to account for the observed warm deviations from the annual cycle of temperature during late January in the northeastern United States: the observed warm spells are well within the limits of what might be expected to occur by chance alone in a stationary climate during any random period of n yr. These negative results were obtained despite the fact that the testing procedure employed here is biased to favor the January thaw; both because the parameters ζ and τ in Eq. (3) were tuned in each case to maximally accommodate the observed late January warm excursions in mean temperature; and because the tests have involved the same (nondependent, or in-sample) data in which the putative features were first tentatively identified.

It is a recognized characteristic of human psychology that people will find patterns in the world around them, whether or not those patterns result from coherent underlying causes. "The tendency to impute order to ambiguous stimuli is simply built into the cognitive machinery we use to apprehend the world. It may have been bred into us through evolution because of its general adaptiveness. . ." (Gilovich 1993, chapter 2). While this powerful human capacity to find order in nature has served and continues to serve us extremely well, it also sometimes leads us to falsely impute meaning to chance events. Gilovich nicely illustrates this problem using the statistics of consecutive hit or missed shots in basketball (the "hot hand"), where statistical independence can reasonably be assumed. When dealing with the nonindependent statistics of the atmosphere, the problem of "detecting" spurious patterns is amplified by the statistical relatedness of data that are nearby in time or space or both (see Livezey and Chen 1983, for a good example), and here the instinctive tendency to read too much into apparent patterns must be guarded against especially strongly. In the case of the January thaw, what superficially appear to be coherent singularities in the observed data can be adequately explained as products of time dependence, spatial dependence, and chance weather occurrences.

It is important to recognize that we have not proved, and cannot prove, that the January thaw does not exist. We have failed to reject the null hypothesis that mere sampling variations have produced the warm excursion in northeastern U.S. temperature records during late January, despite having biased the test toward rejecting a random source for this feature of mean temperature records in this region. Note, however, that no dynamical basis, or even a plausible physical mechanism, has been advanced in the literature to explain why a warming in northeast U.S. temperatures should occur during this particular narrow time window. To date, studies noting relationships between the January thaw and atmospheric circulation features have been wholly empirical; and the coincidence of warm surface temperatures, with, for example, southerly flow, ridging, or poleward movement of the jet (at any time of year) are hardly surprising. Indeed, the warm surface temperatures are mainly consequences of such flow features, which are themselves subject to chaotic variations. If a dynamical basis for their phase-locking to late January were to be found, then the statistical analysis presented here would be of no interest. However, in the absence of such a physical rationale, our results leave one with little reason to look beyond simple statistical sampling variations as the cause of the January thaw. This is the same conclusion reached long ago by Marvin (1919), who wrote that "each striking feature on a long record is, therefore, no evidence of the persistent recurrence of peculiar irregularities, but is simply the residual scar or imprint of some unusual event, or a few which have been fortuitously combined at about the time in question."

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