Investigation of the January Thaw in the Blue Hill Temperature Record

Michael J. Iacono
Blue Hill Meteorological Observatory
January 2010

One of the most familiar and widely studied features of winter temperature is the perceived, occasional warming in mid-winter known as the January thaw. This is defined as a multi-day period of much above average temperature (generally above freezing) in middle to late January. This period has the greatest temperature variability, despite being the coldest time of the year in the Northeast. Certainly the highly variable nature of winter weather in New England ensures that warm days will occur in January on occasion. The question is whether a period of warming occurs with persistence during the same time of the month from year to year, or whether an apparent increase in mean temperature is due to a few extreme readings that skew the average or to occasional moderately warm temperatures.

Many studies have examined the statistical validity of the January thaw in the northeastern United States as summarized by *Godfrey et al.* (2002). Some of these studies concluded that there is a signal, or singularity, that represents this feature in average temperatures (*Wahl*, 1953; *Duquet*, 1963), while others have shown that there is no strong singularity (*Lautzenheizer*, 1957; *Newman*, 1965; *Guttman*, 1991). Although looking at averages over time is an essential step in analyzing the January thaw, averages do not necessarily address how the thaw is perceived, which is likely dominated by the instances of notable warming even if they do not recur annually. Therefore, examining the distributions of January daily temperature may also be insightful.

Since the 125-year temperature record at the Blue Hill Observatory (BHO) is among the longest and most consistent in North America, this provides an excellent context to investigate the existence of the January thaw in southeastern New England. At Blue Hill, maximum and minimum temperatures continue to be recorded with mercury-in-glass and alcohol-in-glass thermometers, respectively, within a Hazen shelter that has been on the same location for over a century. For the purposes of this study, daily mean temperature is defined as the average of the daily maximum and minimum. However, since this method introduces a small positive bias, the long-term temperature record of the Observatory is derived from a separate, more accurate, and essentially unbiased averaging method that corrects the mean to the average of 24 hourly values.

To place the variations in January daily temperatures in a larger context, Figure 1 shows the BHO daily mean temperatures for the entire winter season (December-February) averaged over the full period of record (starting with 1886 for January and 1885 for February and December). At first glance, it is apparent that even a record as long as 125 years is insufficient to provide a smoothly varying mean of daily temperatures. The warmest period occurs in the first week of December, while the coldest period of the year (based on these daily means) occurs from later January to early February. Variations from day to day of roughly 1 deg C (1.8 deg F) are fairly common during the winter. The two largest variations occur from 23-25 December and from 21-26 January. The latter interval, which deviates by about 1.4 deg C (2.5 deg C) from the days that precede and follow it, is the period typically referred to as the January thaw.

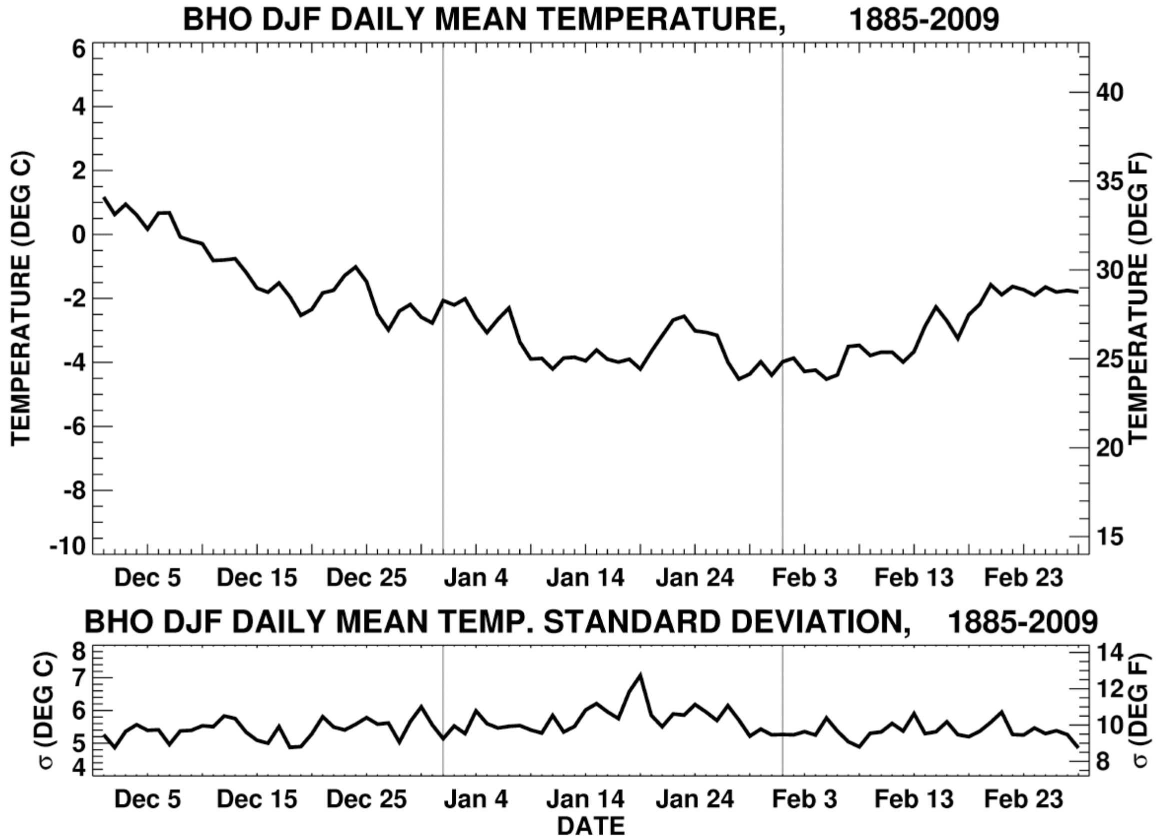

Figure 1. Daily mean temperature (top panel) and standard deviation (bottom panel) for winter (December-February) at the Blue Hill Observatory over the full period of record.

Winter temperatures generally have the highest variability, and other studies have shown that the January thaw is not a statistically significant feature relative to the high variability of temperature at this time of year (*Godfrey et al.*, 2002). The lower panel in Figure 1 shows the standard deviation of BHO daily winter temperatures, and the highest values just above 5.5 deg C (10 deg F) occur in mid-January with a small peak on 19 January. In mid-summer, daily temperature standard deviations are typically about 4 deg C (7.2 deg F), and variations from day to day of about 0.6 deg C (1.0 deg F) or more in the daily mean temperatures occur during summer. In other words, normalized by the variance, the apparent signal of the January thaw in daily mean temperatures is not substantially larger than similar features that appear in the temperature record throughout the year.

While average temperatures tell part of the story of the January thaw, these small variations of a few degrees are not generally perceptible. A noticeable perception of warming in mid-January generally requires departures well above the average, whether they occur frequently or infrequently. This raises the question of whether the distribution of mean temperatures is substantially different (shifted or skewed) on the dates in January associated with the apparent mid-winter thaw. A simple way to illustrate this is to count the number of days on each date that exceed a particular threshold. Figure 2 shows the total number of days with mean temperature greater than 32 deg F (in blue) and greater than 36 deg F (in red) for each winter date over the full period of record (out of a maximum of 124 days for January and 125 days for February and

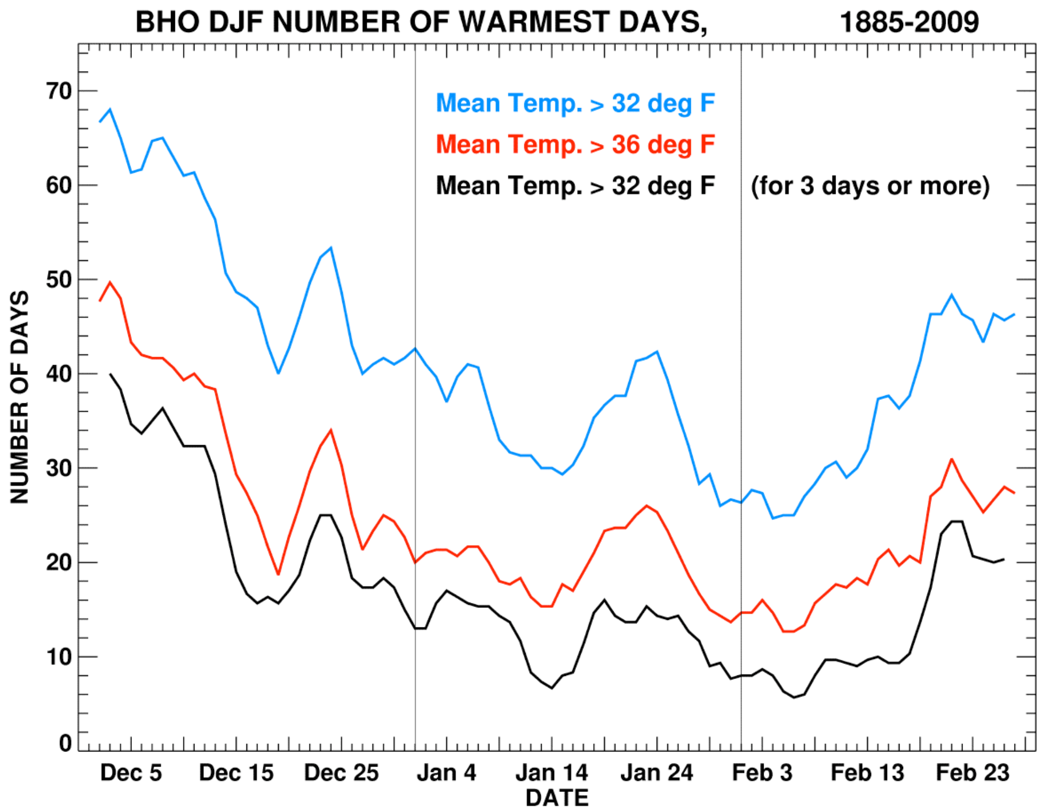

Figure 2. Total number of days for each winter date with a mean temperature at BHO above 32 deg F (blue), above 36 (red) and above 32 for three or more consecutive days around each date (black).

December). Also plotted is the total number of occurrences of a mean above 32 deg F for three consecutive days around each date (in black), which is more indicative of the duration of the anomalous warm periods. All curves in Figure 2 have been smoothed with a 3-day running mean. This shows that a mean temperature above freezing has occurred about one-third of the time (42 out of 124) on the dates near 24 January and less than one-fourth of the time in the days near 14 January and 1 February. Similarly, a mean temperature above 36 has occurred nearly twice as often in the 21-26 January period than in the 30 January – 9 February period. For instances of three days or more with a mean above 32, the thaw period is still apparent but less prominent relative to the dates one week before and after it. It must be pointed out that there are also short periods in December and February with elevated frequencies of warm temperatures, which reinforces the impression that the January interval is not especially unusual.

Do the periods of higher frequency of warm temperatures in January correspond to different distributions of daily mean temperature? This is illustrated in Figure 3, which shows the daily mean temperature distribution for 16 January (in blue), 23 January (in red) and 30 January (in green). The distributions are plotted as the total number of days (out of 124) in which the mean temperature falls within various three-degree temperature intervals. Clearly, the upper part of the distribution for 23 January is substantially skewed relative to the distributions for the other two dates, which are nearly identical. It is interesting to note that the frequency of the extremes (the tails of the distributions) is similar among all three dates, and that most of the difference in the distribution on 23 January occurs for daily means within ten degrees of the overall mean.

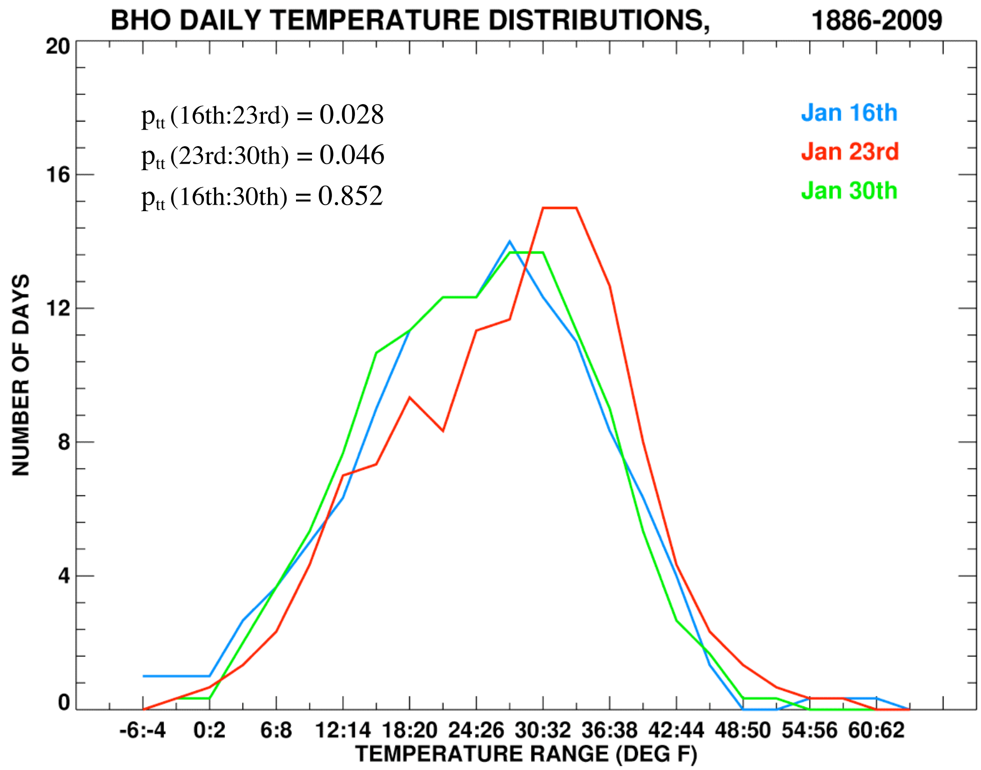

Figure 3. Distributions of BHO daily mean temperature for 16 January (blue), 23 January (red) and 30 January (green) showing the number of days (out of 124) in various three-degree temperature intervals. Student's T-test probability comparing the means for each pair of dates is also shown.

The significance of differences in means between samples of large numbers is most rigorously tested using statistical methods. One common method is Student's T-test, which is often used to test the hypothesis that two sets of numbers have the same mean, or equivalently that each set was randomly selected from a larger population of numbers with the same mean. Also listed at the upper left in Figure 3 is the T-test probability, p_{tt}, for mean temperatures between each pair of dates shown in the figure. The probabilities are 0.028 between the 16^{th} and 23^{rd}, 0.046 between the 23^{rd} and 30^{th}, and 0.852 between the 16^{th} and 30^{th}. These numbers indicate the probability that rejecting the hypothesis that the mean temperatures for each date are the same is wrong. In other words, for the 16^{th} and 23^{rd}, there is only a 2.8 percent probability that the means for these dates are the same, or alternately, it can be said that the means are significantly different at the 97% confidence level. Similarly, for the 23^{rd} and 30^{th}, the means are significantly different at the 95% level. Finally, comparing the 16^{th} and the 30^{th}, there is an 85 percent probability that it is incorrect to reject that these dates have the same mean. That is, their similarity is significant at the 85% level. While not a comprehensive analysis of significance, these numbers suggest that the January thaw feature seen in Figure 1 near 23 January is a significant signal relative to temperatures one week before and after this date.

Another characteristic of the temperature departures in January is the extent to which they persist throughout the period of record. Figure 4 shows the centered, three-day running average of January daily mean temperature (top panel) and standard deviation (bottom panel) at BHO for different multi-year periods. The 1886-2009 full period of record for January (in black) shows the slight rise in mean temperature from the 21st to the 26th that corresponds to the peak near those dates in Figure 1. It can be seen from Figure 4 that the 1886-1910 period (in red) contributes most significantly to this rise from the 21st to 23rd, and the 1971-2000 period (in orange) contributes to the higher mean from the 23rd to 26th. The 1941-1970 period (in blue) also contributes to the rise to a lesser degree, but over a broader range of dates from the 20th to 27th. The 1911-1940 period and the most recent years from 2001-2009 have contributed little to the higher mean around the 23rd. In fact, during much of the second half of January, the first decade of the 21st century is the coldest interval among the periods plotted. This has been compensated by higher temperatures in the first half of January relative to the earlier time periods.

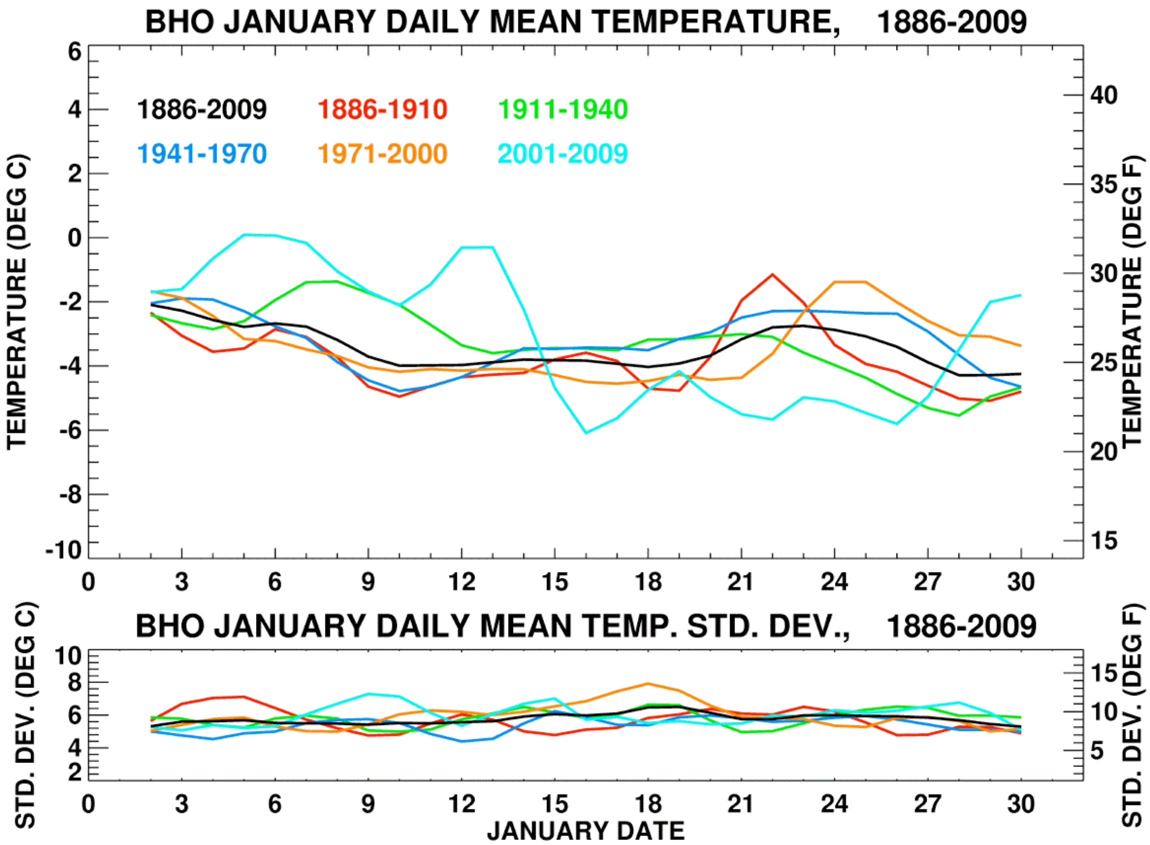

Figure 4. Centered three-day running average of BHO January daily mean temperature (top panel) and standard deviation (bottom panel) for several multi-year periods.

In summary, the extensive and highly consistent temperature record of the Blue Hill Observatory provides an excellent context in which to study the existence and significance of the January thaw in southeastern New England. Several pieces of evidence suggest that a period of warming from 21-26 January has some degree of statistical significance, though it does not recur every year and it may not appear for many consecutive years. Mean temperatures for one date during the thaw period are significantly different from means one week before and after that date. In addition, days with warmer temperatures are much more frequent during the thaw period. Finally, an increase in the mean on these dates is apparent in many periods through the 125-year record of the Observatory. The absence so far of a plausible physical mechanism to explain the January thaw is a considerable obstacle to its acceptance as a real feature, though this also ensures there will be further analysis of this intriguing characteristic of winter temperature.

References

Duquet, R. T., The January warm spell and associated large-scale circulation changes. *Mon. Wea. Rev.,* **91,** 47–60, 1963.

Godfrey, C. M., D. S. Wilks, and D. M. Schultz, Is the January thaw a statistical phantom?, *Bull. Amer. Meteor. Soc.,* **83**, 53-62, 2002.

Guttman, N. B., January singularities in the northeast from a statistical viewpoint. *J. Appl. Meteor.,* **30,** 358–367, 1991.

Lautzenheiser, R. E., The January thaw. *Weekly Wea. Crop. Bull.,* **44** (6), 7–8, 1957.

Newman, E., Statistical investigation of anomalies in the winter temperature record of Boston, Massachusetts. *J. Appl. Meteor.,* **4,** 706–713, 1965.

Wahl, E. W., Singularities and the general circulation. *J. Meteor.,* **10,** 42–45, 1953.