An Interesting Wintertime Temperature Phenomenon

Laurent Hodges
Iowa State University

AN INTERESTING WINTERTIME TEMPERATURE PHENOMENON

Laurent Hodges
Physics Department
Iowa State University
Ames, Iowa 50011

In the course of studying residential energy use in central Iowa, I kept track of the hourly temperatures recorded in Des Moines. The temperatures were simply those published daily in the *Des Moines Register* (with occasional obvious corrections). I noticed that during the winter months in Iowa there are occasionally long periods (up to a few days) when there is remarkably little change in outdoor air temperature, and these always occur near the freezing point of water.

For example, between Nov. 1, 1982 and Mar. 31, 1983, the five longest periods of absolutely steady temperatures (to the nearest degree Fahrenheit) were:

> 18 hours at 35° F on Mar. 26-27
> 17 hours at 33° F on Nov. 27-28
> 15 hours at 35° F on Nov. 28-29
> 14 hours at 28° F on Dec. 15-16
> 13 hours at 34° F on Feb. 15-16

The most interesting way to show the data is to plot the daily temperature range (the difference between the high and low temperatures) against the daily mid-range temperature (the average of the high and low temperatures).

Figure 1 is a plot of the data I collected. The points are seemingly scattered all over the diagram, except at low values of the range, where the plot "funnels" down to the freezing point of water. For example, ranges of 2 degrees (Fahrenheit) occurred twice for mid-range temperatures of 32° and 34°, ranges of 3 degrees occurred for mid-range temperatures of 31.5°, 33.5°, and 34.5°, and ranges of 4 degrees occurred for mid-range temperatures of 34° and 36°. By contrast, a 10-degree range occurred for mid-range temperatures as low as 24° and as high as 40°, while 19-21 degree ranges occurred for mid-range temperatures from 10° to 52.5°.

This phenomenon is clearly due to the presence of large amounts of moisture (snow, ice, water) at or near the phase change temperature. Any warming trend is counteracted by the absorption of heat by melting snow or ice, while any cooling trend is counteracted by the release of latent heat of water in the process of freezing. The effect can, of course, be destroyed by weather fronts bringing in significant amounts of cold or warm air, but it is surprising how long a time the air temperature may remain near the freezing point of water.

To have a narrow temperature range far from freezing is not impossible, but it is rare. It can occur on rainy days when the large heat capacity of the rainwater counteracts any warming or cooling trend. No latent heat effect is involved in this case.

This phenomenon provides an opportunity for an interesting inquiry-based activity. Students can gather data using an inexpensive minimum-maximum thermometer (available at many hardware stores), which marks the lowest and highest temperatures attained since the last resetting. Reset the minimum-maximum thermometer each day at the same time, after recording the minimum and maximum temperatures for the previous 24 hours. Compute the temperature range and the mid-range temperature, and plot these daily during the cold months. As the weeks pass by, the diagram will begin to take shape, and students will have the opportunity to make the same discovery which I experienced in the winter of 1982-83.

It is also possible to use any daily newspaper which prints hourly temperature data, such as the *Des Moines Register,* or to use the records of any weather station with a recording thermometer.
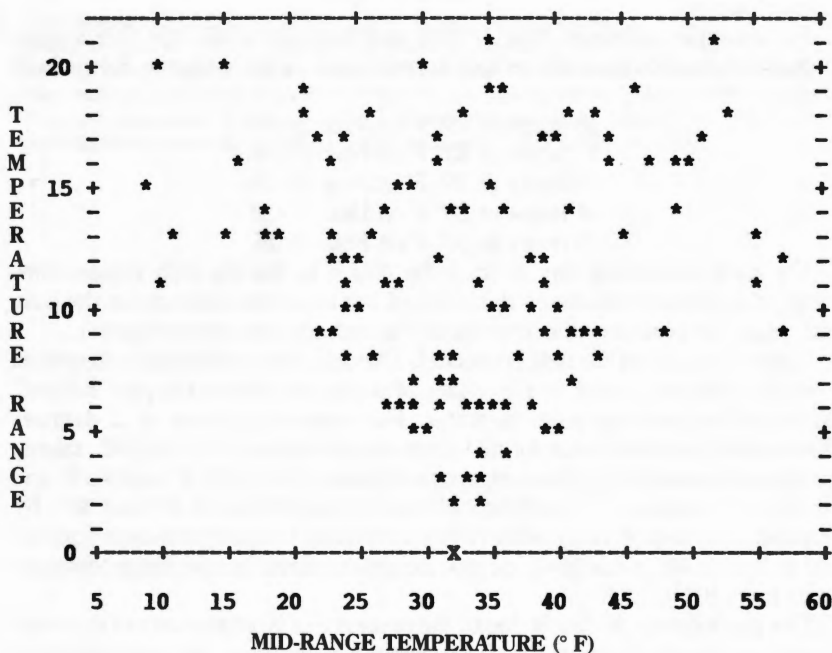
```
          -----+----+----+----+----+----+----+----+----+----+----+----+
          -                           *              *            -
     20 + *      *          *                 *                   +
          -                 *            **            *          -
  T       -           *    *      *      * *              *       -
  E       -             * *       *      **    *      *           -
  M       -       *      *        *            * * **             -
  P    15 + *                **     *                             +
  E       -           *      *     ** *     *                     -
  R       -     *   * **   * *            *        *    *         -
  A       -           ***     *      **                       *  -
  T       -   *         * **     *      *              *          -
  U    10 +           **        ** * *                        +
  R       -           **          * ***       *          *    -
  E       -        * *     **      *  *  *                    -
          -             * **       *                          -
  R       -          *** * ****  *                            -
  A     5 +           **         **                           +
  N       -                    * *                            -
  G       -                  * **                             -
  E       -                  * *                              -
          -                                                   -
      0 +----+----+----+----+----+----X----+----+----+----+----+----+
          5    10   15   20   25   30   35   40   45   50   55   60
                        MID-RANGE TEMPERATURE (° F)
```

Figure 1

Plot of daily temperature range (Fahrenheit degrees) versus mid-range temperature (degrees Fahrenheit) for Des Moines, Iowa, Nov. 1, 1982 through Mar. 31, 1983. All points for temperature ranges up to 21 degrees and mid-range temperatures up to 60° F are shown.