When Normal Weather Is Not Normal

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How many times have you had to analyze energy or demands across time? At Southern Company, we use similar analyses to do load forecasting, demand and energy analyses, and even flat rate pricing. These studies require putting each time period on an equal weather basis to exclude weather effects. This is called weather normalization. The most commonly used weather basis is normal weather.

What is normal weather? How do you define and select a normal weather profile? The most commonly used "normal" weather data within the utility industry are National Oceanic and Atmospheric Administration (NOAA) 30-year average, self-defined historical period average, or TMY (actual monthly data selected as "typical").

The NOAA 30-year average is a smooth profile that is adequate for use in developing energy forecasts. This is also true of the self-defined historical average. Because of the averaging, these profiles lack occurrences of extreme temperatures necessary to accurately forecast peak demand. Although TMY contains actual data, it is designed to represent typical rather than extreme conditions.

At Southern, we have studied alternate weather normals and have adopted the rank and average method many years ago. Dave Hanna of Itron, Inc. presented the rank and average method at the AEIC Load Research Workshop in April 2005. The following shows how this method is applied.

	Actual Temp.			Rank Hi - Low			Average
Day	Year1	Year2		Year1	Year2		
1	80	94		93	95		94
2	88	93		92	94		93
3	90	85		91	93		92
4	89	93		91	93		92
5	81	95		91	93		92
6	89	91		90	92		91
7	91	93	→	90	92	→	91
8	90	92		90	92		91
9	82	84		89	91		90
10	90	92		89	91		90
11	92	82		88	90		89
12	91	90		83	85		84
13	83	92		82	84		83
14	91	91		81	83		82
15	93	83		80	82		81

This approach can be developed by using any quantity of historical data. Dave pointed out the advantages of rank and average approach include it can be used with numerous meteorological variables, it can capture average extremes and it can be applied to adjacent weather stations and it can be assigned to any calendar year. This paper will explore the rank and average method even further. It will cover various options for ranking and selecting a reference year. A composite of Mobile, AL and Meridian, MS daily average temperatures for the historical period (1990-2002) formed the bases of the analysis for this paper.

Analysis of Ranking Methods

We have reviewed three methods for ranking the historical weather data: monthly, seasonally and annually. As we will see later, the choice of methods affects the results. In monthly ranking, the days in each month are treated separately and ranked resulting in twelve separate rankings. In seasonally, the days in each season are treated separately and ranked resulting in four separate rankings. In our example, the seasons are defined as Winter (Dec, Jan and Feb), Spring (Mar, Apr and May), Summer (Jun, Jul and Aug) and Fall (Sep, Oct and Nov.) In annually, the days in each year are simply ranked from hottest to coldest. The next step is to average these rankings over the 13 year period. The following table shows the highest average daily temperature based on the three ranking methods. The 13-year average is shown as a reference.

Max Temperatures Based on Ranking Method

	13-Year Average	Ranked Monthly
Jan	53.69	64.97
Feb	58.19	66.94
Mar	63.76	70.68
Apr	69.92	75.27
May	77.72	80.27
Jun	80.91	83.90
Jul	82.44	**85.74**
Aug	**82.95**	84.95
Sep	79.77	82.56
Oct	73.88	77.21
Nov	63.11	71.60
Dec	56.78	66.59

	Ranked Seasonally
Winter	68.96
Spring	80.27
Summer	**86.35**
Fall	82.56

	Ranked Annually
	86.35

The hottest monthly ranked temperature is 85.74 and occurred in July. The hottest annually ranked temperature is 86.35. The choice of calendar for the annual ranked method will impact which month is considered the "normal" peak month, yet the average of the hottest temperature for the annual method is higher than the monthly method. This is because some of the max temperatures occurred outside of July. A forecast based on the lower number (85.74) will produce lower peak demand than the 86.35 from annual

ranking. Since the hottest temperature can occur in any summer month, the "normal" peak temperature should ignore month and be based on either the seasonal or annual approach.

The hottest average daily temperature for the 13-year average is 82.95 and occurred on August 18. This day had more consistently hot temperatures across the 13 years. The monthly ranking showed the hottest temperatures in July, meaning historically the hottest temperatures occurred more often in the month of July. It's this discrepancy that leads us to question the selection of the appropriate reference year.

Analysis of Reference Year

During the 13 year historical period, there were only 4 years in which the peak occurred in August, 8 years in July and 1 year in June.

1990	86.71	28-Aug
1991	85.13	14-Jul
1992	84.88	12-Jul
1993	86.07	27-Jul
1994	84.82	27-Jun
1995	87.21	17-Aug
1996	85.59	22-Jul
1997	85.44	4-Jul
1998	87.54	8-Jul
1999	89.00	1-Aug
2000	90.42	29-Aug
2001	84.90	9-Jul
2002	84.86	18-Jul
Daily Average	**82.95**	**18-Aug**

The selected reference year will control what month the peak occurs for the annual and seasonal method. Which one should you select? Should you select a year with the peak in July or August? Maybe there is some other method that can help to select the "correct" reference year. We considered two methods. One compared each year to the 13-year average and selected the year with the lowest variance. Variance was calculated both before and after the annual ranking method was applied. The variance for the before, was calculated as the square of the difference between the period average and the actual temperature for each year. The variance for the after, was calculated as the square of the difference between the annual ranked temperature average and the ranked individual years. The following shows an example of the variance calculation.

Calculation of Variance Before Ranking Applied

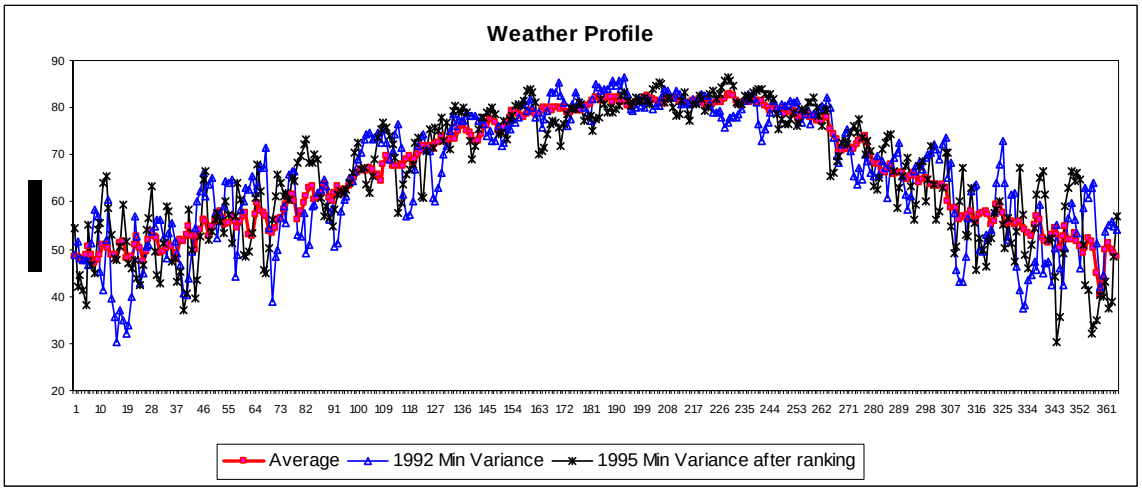
Day	Year 1	Year 2	Year 3	Average	Var Year 1	Var Year 2	Var Year 3
1	80.00	94.00	88.00	87.33	53.78	44.44	0.44
2	88.00	93.00	93.00	91.33	11.11	2.78	2.78
3	90.00	85.00	85.00	86.67	11.11	2.78	2.78
4	89.00	93.00	95.00	92.33	11.11	0.44	7.11
5	81.00	95.00	95.00	90.33	87.11	21.78	21.78
6	89.00	91.00	91.00	90.33	1.78	0.44	0.44
7	91.00	93.00	91.00	91.67	0.44	1.78	0.44
8	90.00	92.00	92.00	91.33	1.78	0.44	0.44
9	82.00	84.00	84.00	83.33	1.78	0.44	0.44
10	90.00	92.00	92.00	91.33	1.78	0.44	0.44
11	92.00	82.00	82.00	85.33	44.44	11.11	11.11
12	91.00	90.00	88.00	89.67	1.78	0.11	2.78
13	83.00	92.00	92.00	89.00	36.00	9.00	9.00
14	91.00	91.00	91.00	91.00	0.00	0.00	0.00
15	93.00	83.00	88.00	88.00	25.00	25.00	0.00
				Sum	289.00	121.00	**60.00**

Calculation of Variance After Ranking Applied

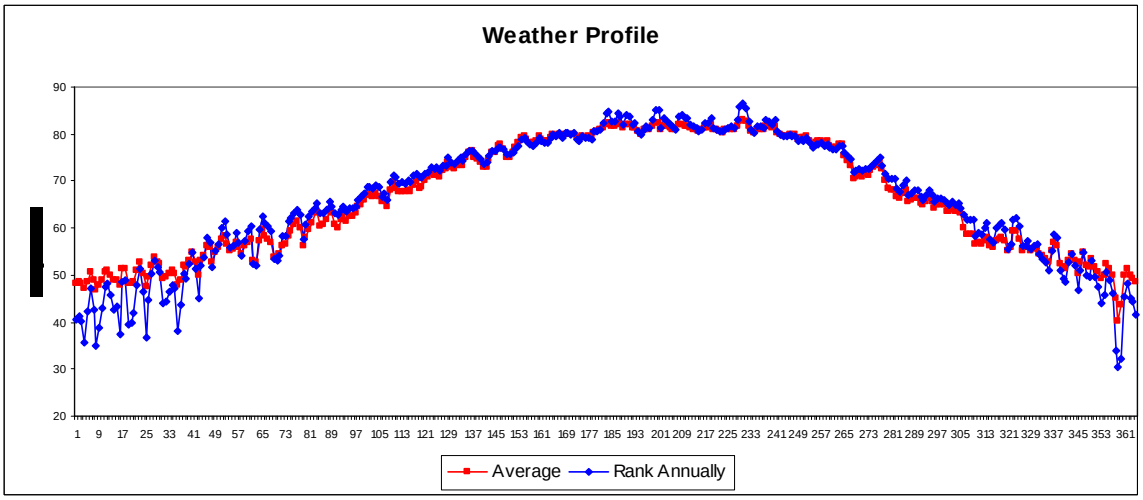
Rank	Year 1	Year 2	Year 3	Average	Var Year 1	Var Year 2	Var Year 3
1	93.00	95.00	95.00	94.33	1.78	0.44	0.44
2	92.00	94.00	95.00	93.67	2.78	0.11	1.78
3	91.00	93.00	93.00	92.33	1.78	0.44	0.44
4	91.00	93.00	92.00	92.00	1.00	1.00	0.00
5	91.00	93.00	92.00	92.00	1.00	1.00	0.00
6	90.00	92.00	92.00	91.33	1.78	0.44	0.44
7	90.00	92.00	91.00	91.00	1.00	1.00	0.00
8	90.00	92.00	91.00	91.00	1.00	1.00	0.00
9	89.00	91.00	91.00	90.33	1.78	0.44	0.44
10	89.00	91.00	88.00	89.33	0.11	2.78	1.78
11	88.00	90.00	88.00	88.67	0.44	1.78	0.44
12	83.00	85.00	88.00	85.33	5.44	0.11	7.11
13	82.00	84.00	85.00	83.67	2.78	0.11	1.78
14	81.00	83.00	84.00	82.67	2.78	0.11	1.78
15	80.00	82.00	82.00	81.33	1.78	0.44	0.44
				Sum	27.22	**11.22**	16.89

The second method used the 13-year average as the reference year. The following graphs show the normal weather profile using the annual ranking method and different reference years. Graph1 shows the reference year based on min variance which turned out to be 1992 for the pre-ranked and 1995 for the post-ranked data. Graph2 shows the results of the annual ranking using the period average as the reference year. In comparing Graph1 and Graph2, we can see that there is more day to day volatility in Graph1. We also show

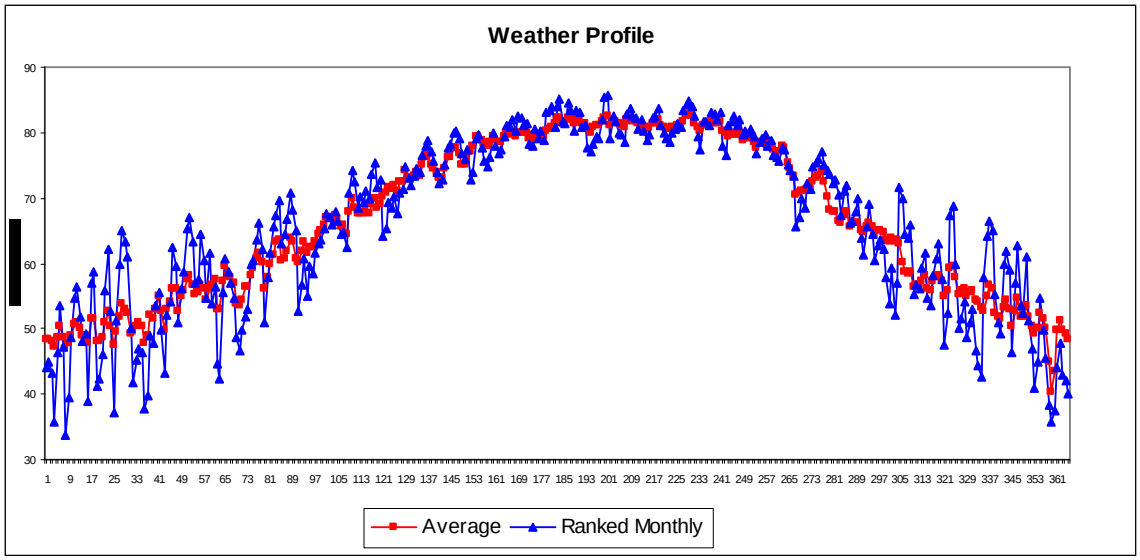
the results of the monthly ranking method using the average as the reference year in Graph3. In comparing Graph2 and Graph3, we also see more day to day volatility, especially in the winter season in Graph3.



(Graph1)



(Graph2)



(Graph3)

Conclusion

The annual ranked approach with the 13-year average reference year generates a "normal" profile with expected extreme hot temperature and yet provides a smooth shape that follows the period average.

- Rank and average method produces a normal profile appropriate for capturing extreme weather conditions.
- Seasonal or Annual ranking is preferable than monthly ranking to determine typical extreme temperatures.
- Using the period average as reference year is preferable over other selection methods.
    - It captures the peak temperature on the same day as period average.
    - It reduces the volatility from day to day across the year.