Creation of RFC- and Season-Specific Weights For Estimation of 6-Hour Average Temperatures from Daily Maximum and Minimum Values

Shucai Guan, Shaorong Wu, David Kitzmiller
Office of Hydrologic Development

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Abstract

New statistically-based weighting coefficients for estimating mean temperatures for fixed 6-hour periods from daily maximum and minimum values have been derived for the areas covered by the Colorado Basin, California-Nevada, and Alaska River Forecast Centers. The method used is similar to that applied to the Northwest River Forecast Center to provide new weights in 2005. The new weights and the resulting biases and RMS errors within the development datatset are documented.

Needs

The current logic of the temperature forecast preprocessor in the Operational Forecast System (OFS) relies on ingest of point values of daytime maximum and nighttime minimum temperature. The river forecast system itself requires average temperatures in the fixed six-hour period 0000-0600, 0600-1200, 1200-1800, and 1800-0000 UTC. For example, the mean temperature for the 1800-0000 UTC period is estimated from a weighted average of the daytime maximum and the minimum on the following night.

Originally, only one set of weights were specified for use in all locations. Though precise documentation is lacking, the weights were based on observed temperature data from the eastern U.S.. Because the diurnal temperature cycle on the West Coast and in Alaska lags that of the eastern U.S. by several hours, biases were noted in the estimates. For the evening period 0000-0600 UTC, the default estimation method yielded results biased low, because too much weight was placed on the overnight minimum. For the early morning period 1200-1800 UTC, the default estimate was biased high, since too much weight was placed on the next-day maximum. The default weights gave estimates with relatively small biases for the 0600-0000 and 1800-0000 UTC periods, since over North America longitude has a relatively small effect on these overnight and afternoon periods.

Method

To provide new weights yielding unbiased results, we re-evaluated the relationships between max/min and 6-h average temperatures within a large sample of observed hourly and max/min data within each of the River Forecast Center (RFC) regions for the Colorado Basin, California-Nevada, and Alaska RFC’s (CBRFC, CNRFC, and AKRFC respectively). New coefficients specific to the Northwest RFC were previously derived from an 8-year sample spanning 1996-2004.

Data were collected from National Climatic Data Center (NCDC) archives. For each RFC, we selected 30 stations with a roughly uniform distribution across the covered area. The primary criteria for this selection were completeness of record (generally starting in the 1970's) and coverage of the area of interest. Note that our aim is capturing a representative diurnal temperature cycle, not creating a detailed spatial climatology. The collection process yielded a large number of case-days for each RFC, as shown in Table 1.

New weights were derived by determining the combination of values that minimizes the root-mean squared (RMS) error within the sample. This was done by iteration, with test weights being incremented by intervals of 0.01. This method is not guaranteed to minimize bias, since the temperature distribution may be such that either large positive or negative errors might dominate the sample. However, it assures the most robust result in terms of minimizing large errors in general. The final results are nearly identical to those yielded by more screening regression algorithm applied such that a zero constant value is assumed.

We excluded cases in which the indicated maxima and minima were inconsistent with the calculated 6-h averages, as can occur when the diurnal temperature range is very restricted or air mass changes caused the maximum and minimum to be nearly identical. This eliminated up to 25% of the autumn and winter events in Alaska, and 20% of the events elsewhere. As noted below, situations where the common diurnal temperature cycle is disrupted simply can't be handled consistently by this approach.

Results

Results were consistent with those obtained in the earlier project for NWRFC, and by Eric Anderson for Fairbanks, AK. Thus for the 0000-0600 period, higher weight was given to the afternoon maximum than was given by the default relationship. For the 1200-1800 period, higher more weight was given to the previous night's minimum (see Tables 2-5). We also noted that for the AKRFC area (Table 5), the changes were more pronounced than for the RFCs within the CONUS, a logical result considering that this area lies still farther west.

We believe that our approach is sound based on the finding that there was little change in the weights, relative to the default values, for the CONUS RFC's for the 0600-1200 and 1800-0000 periods; also that there was a physically logical change in the weights relative to the mean longitude of the RFC areas. For the springtime weights, 0000-0600 period, the maximum temperature was weighted progressively higher as west longitude increased and the UTC time of the diurnal maximum changed to later times. Thus the weight for maximum temperature is given as 0.45 for the default set (eastern U.S.), 0.61 for CBRFC farther west, 0.63 and 0.65 for NWRFC and CNRFC respectively, and as 0.79 for

AKRFC. Likewise, for spring and summer, the weight given the minimum temperature in the 1200-1800 estimate increased with longitude.

It must be remembered that particularly for the cool season, the basic assumptions about the diurnal temperature cycle relative to 6-h averages don't hold. The magnitude of the maximum-minimum difference is relatively small in the autumn and winter, and conditions with near-constant temperature for long periods become common. In such cases this approximation method merely insures that the 6-h average temperature falls within the given forecast range.

Biases and RMS errors within the development samples for CBRFC, CNRFC, and AKRFC areas, by season and time of day, are shown in Tables 6-8. For comparison, we also show the statistics that would be realized if the default or NWRFC weights were applied. In general, improvement in terms of smaller biases and RMS errors is quite evident, when the new coefficients are considered relative to the defaults. As might be expected, the statistics for CNRFC show only small improvements between the newest region-specific approximation and the NWRFC weights, since these regions lie in nearly the same longitude region. However even for this set of cases the introduction of region-specific weights lead to reduction in the RMS error by a few tenths of a degree.

Finally, it must also be noted that though these results lead to very small biases when data are aggregated over all sites within the regions, they cannot guarantee unbiased results at all points considered individually. An analysis of data within the CBRFC area showed that there is some spatial dependence on the biases that result from using a single set of weights. For instance, these diurnal-cycle estimates were biased slightly high in some areas of the region's cooler areas, and slightly low in areas with relatively warmer mean temperatures. At most points the magnitude of this local bias was < 1 °C, considerably smaller than the overall bias of -2.4 °C that occurs with the default weights. Nevertheless this condition clearly indicates the need to apply physically based forecasts for specific times of day, rather than only maximum and minimum values.

Summary

The approach of applying region-specific max/min to 6-h temperature estimation weights will decrease biases and RMS errors in the estimates, particularly for the spring and summer seasons and the periods 0000-0600 and 1200-1800 UTC. However, our analysis indicated that it would be far more preferable to use actual gridded forecasts, which will have the added benefit of directly accounting for synoptic-scale and local conditions. There is an ongoing project to determine the best of several methods for spatially interpolating Model Output Statistics forecasts of point temperatures, or NWP-model generated grids, to grids in operational use.

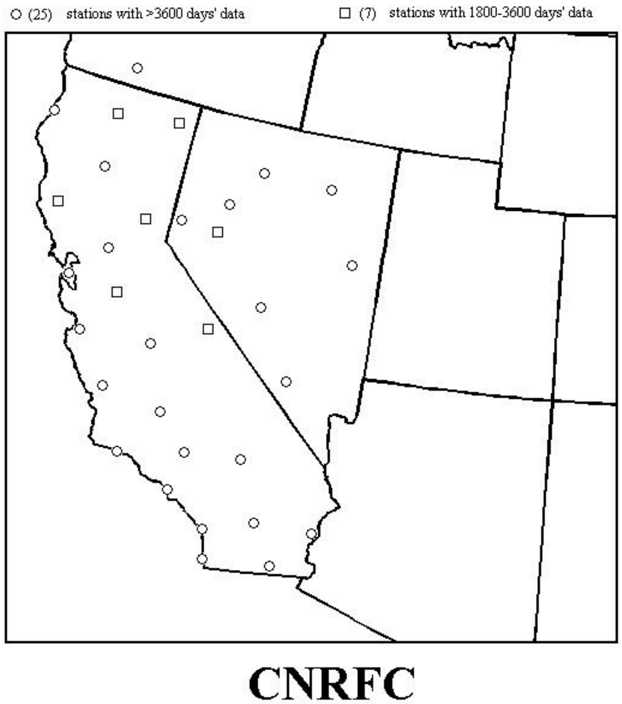

Figure 1. Distribution of climatic observing sites used to derive temperature estimation weights, CNRFC forecast area.

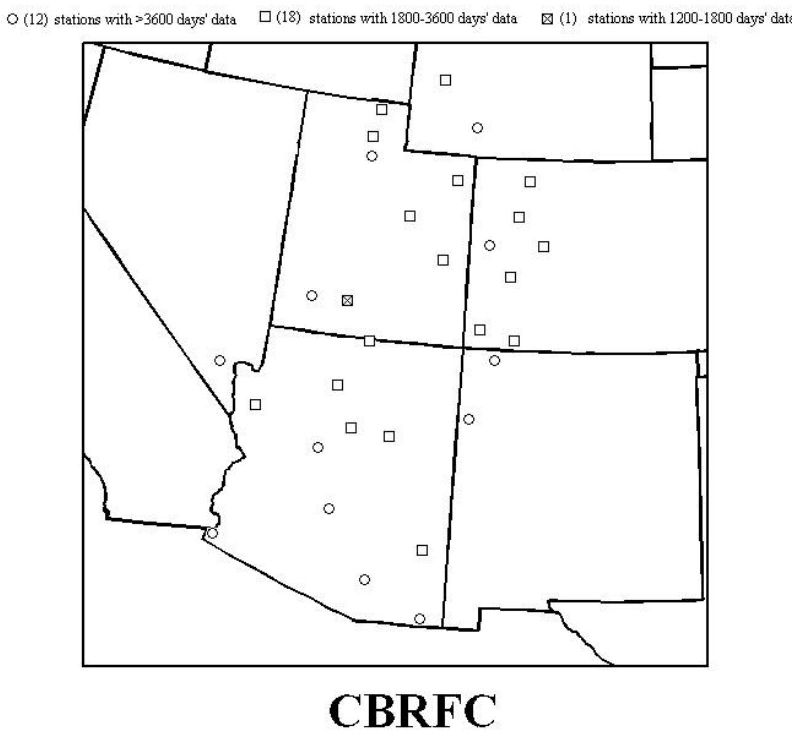

Figure 2. As in Fig. 1, except for the CBRFC forecast area.

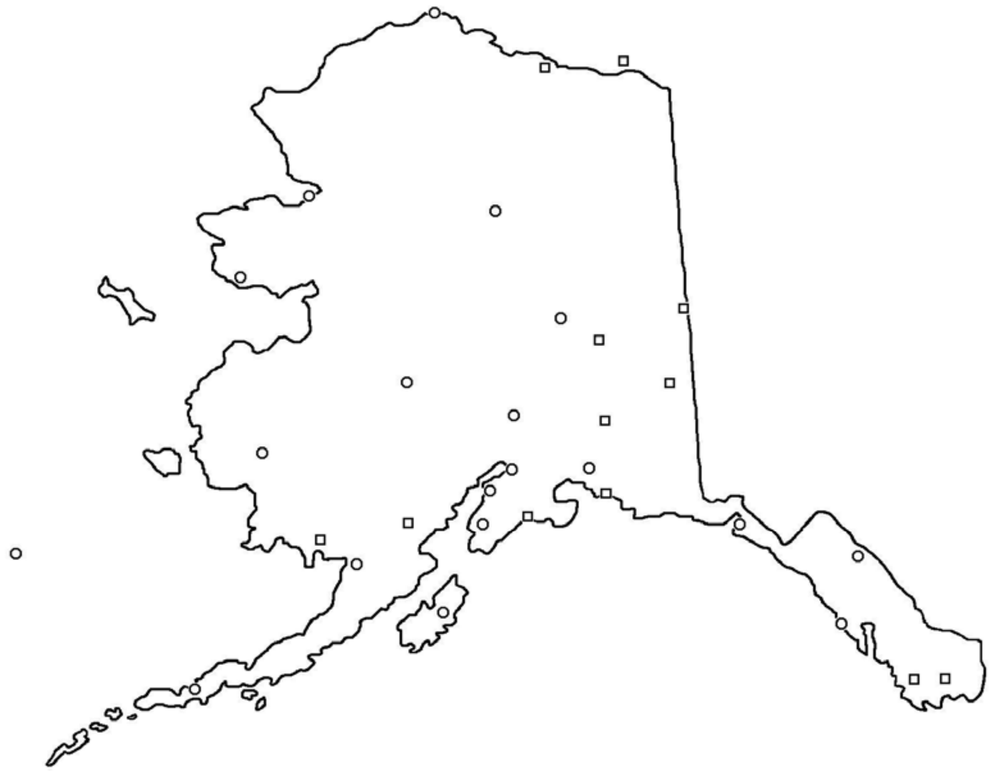

Figure 3. As in Fig. 1, except for the AKRFC forecast area.

Table 1. Data sample sizes and number of observing stations used in deriving temperature conversion weights for western RFC regions.

RFC	Number of stations	Number of total case days	Length of data record (years)
CBRFC	31	128094	30
CNRFC	32	164371	30
AKRFC	31	155873	30

Table 2. Default conversion weights, and new conversion weights for the NWRFC area (new weights derived in 2005).

	1200-1800		1800-0000			0000-0600		0600-1200	
	Tmin	Tmax	Tmin	Tmax	Tmin2	Tmax	Tmin	Tmax	Tmin
Default	**0.55**	**0.45**	**0.10**	**0.80**	**0.10**	**0.45**	**0.55**	**0.25**	**0.75**
Spring	0.70	0.30	0.10	0.83	0.07	0.63	0.37	0.21	0.79
Summer	0.68	0.32	0.09	0.84	0.07	0.67	0.33	0.20	0.80
Autumn	0.73	0.27	0.11	0.85	0.04	0.59	0.41	0.22	0.78
Winter	0.77	0.23	0.19	0.78	0.03	0.57	0.43	0.27	0.73

Table 3. New conversion weights for CBRFC area.

	1200-1800		1800-0000			0000-0600		0600-1200	
	Tmin	Tmax	Tmin	Tmax	Tmin2	Tmax	Tmin	Tmax	Tmin
Spring	0.64	0.36	0.02	0.87	0.11	0.61	0.39	0.2	0.8
Summer	0.61	0.39	0.02	0.87	0.11	0.61	0.39	0.19	0.81
Autumn	0.69	0.31	0.02	0.88	0.1	0.53	0.47	0.19	0.81
Winter	0.76	0.24	0.07	0.85	0.08	0.52	0.48	0.22	0.78

Table 4. New conversion weights for CNRFC area.

	1200-1800		1800-0000			0000-0600		0600-1200	
	Tmin	Tmax	Tmin	Tmax	Tmin2	Tmax	Tmin	Tmax	Tmin
Spring	0.73	0.27	0.07	0.84	0.09	0.65	0.35	0.23	0.77
Summer	0.71	0.29	0.08	0.85	0.07	0.69	0.31	0.23	0.77
Autumn	0.77	0.23	0.08	0.86	0.06	0.6	0.4	0.22	0.78
Winter	0.81	0.19	0.14	0.82	0.04	0.57	0.43	0.23	0.77

Table 5. New conversion weights for AKRFC area.

	1200-1800		1800-0000			0000-0600		0600-1200	
	Tmin	Tmax	Tmin	Tmax	Tmin2	Tmax	Tmin	Tmax	Tmin
Spring	0.78	0.22	0.20	0.69	0.11	0.79	0.21	0.35	0.65
Summer	0.79	0.21	0.15	0.69	0.16	0.77	0.23	0.32	0.68
Autumn	0.73	0.27	0.23	0.64	0.13	0.69	0.31	0.36	0.64
Winter	0.61	0.39	0.28	0.53	0.19	0.61	0.39	0.42	0.58

Table 6 Mean temperature bias and RMS error for CBRFC area.

		Bias (^oC)				RMSE (^oC)			
		1200-1800	1800-0000	0000-0006	0006-1200	1200-1800	1800-0000	0000-0006	0006-1200
Spring	New Coeff	0.23	0.08	0.06	-0.09	1.92	1.24	1.92	1.45
	Def Coeff	1.63	-1.02	-2.4	0.68	2.45	1.75	3.21	1.62
	NW Coeff	-0.71	-0.56	0.37	0.07	2.14	1.46	1.95	1.45
Summer	New Coeff	0.3	0.1	0.09	0.04	1.98	1.32	2.23	1.4
	Def Coeff	1.3	-1.07	-2.57	1.04	2.27	1.82	3.49	1.77
	NW Coeff	-0.87	-0.41	1.09	0.2	2.3	1.45	2.49	1.42
Autumn	New Coeff	0.12	0.1	-0.04	-0.09	1.6	1.19	1.99	1.38
	Def Coeff	2.24	-1.12	-1.27	0.83	2.77	1.77	2.4	1.66
	NW Coeff	-0.49	-0.36	0.89	0.37	1.72	1.32	2.19	1.45
Winter	New Coeff	-0.05	0.08	-0.03	-0.04	1.33	1.16	1.86	1.49
	Def Coeff	2.63	-0.56	-0.92	0.34	3.17	1.35	2.11	1.56
	NW Coeff	-0.18	-0.82	0.61	0.6	1.34	1.55	1.96	1.66

Table 7 Mean temperature bias and RMS error for CNRFC area.

		Bias (^oC)				RMSE (^oC)			
		1200-1800	1800-0000	0000-0006	0006-1200	1200-1800	1800-0000	0000-0006	0006-1200
Spring	New Coeff	0.09	0.07	0.22	0	1.43	1.12	1.79	1.39
	Def Coeff	2.54	-0.48	-2.48	0.27	3.05	1.29	3.44	1.41
	NW Coeff	0.5	-0.07	-0.05	-0.27	1.5	1.14	1.82	1.43
Summer	New Coeff	0.17	0.03	0.38	0.09	1.63	1.14	2.06	1.53
	Def Coeff	2.71	-0.76	-3.42	0.4	3.25	1.47	4.55	1.55
	NW Coeff	0.65	-0.12	0.07	-0.39	1.72	1.16	2.08	1.64
Autumn	New Coeff	-0.02	0.16	0.19	-0.01	1.49	1.23	1.93	1.49
	Def Coeff	3.27	-0.74	-2.08	0.44	3.86	1.53	3.15	1.56
	NW Coeff	0.58	0.02	0.04	-0.01	1.61	1.24	1.94	1.49
Winter	New Coeff	-0.06	0.14	0	-0.17	1.35	1.29	1.62	1.5
	Def Coeff	3.03	-0.09	-1.42	0.07	3.69	1.31	2.27	1.51
	NW Coeff	0.42	-0.34	0	0.31	1.46	1.37	1.62	1.57

Table 8 Mean temperature bias and RMS error for AKRFC area.

		Bias (°C)				RMSE (°C)			
		1200-1800	1800-0000	0000-0006	0006-1200	1200-1800	1800-0000	0000-0006	0006-1200
Spring	New Coeff	0	0.1	0.14	0	1.53	1.52	1.44	1.66
	Def Coeff	2.04	1.07	-2.82	-0.88	2.83	1.9	3.67	1.94
	NW Coeff	0.71	1.33	-1.25	-1.22	1.75	2.08	2.15	2.17
Summer	New Coeff	0.07	0.19	0.16	0.07	1.29	1.41	1.49	1.4
	Def Coeff	2	1.07	-2.39	-0.49	2.55	1.75	3.3	1.55
	NW Coeff	0.95	1.39	-0.64	-0.89	1.63	1.98	1.77	1.79
Autumn	New Coeff	-0.09	0.07	0.07	-0.11	1.71	1.44	1.46	1.74
	Def Coeff	1.09	1.12	-1.59	-0.87	2.18	1.89	2.43	1.94
	NW Coeff	-0.09	1.46	-0.62	-1.07	1.71	2.14	1.68	2.06
Winter	New Coeff	-0.03	-0.02	-0.06	-0.24	2.23	2.08	1.95	2.34
	Def Coeff	0.38	1.84	-1.22	-1.47	2.29	3.01	2.41	2.76
	NW Coeff	-1.13	1.7	-0.35	-1.33	2.6	2.9	1.99	2.67