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A Comparison of Forecasting Skill Between Weather Trends International (WTI) YEAR-AHEAD and The Climate Prediction Center (CPC) at The National Oceanic and Atmospheric Administration (NOAA)

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INTRODUCTION

The purpose of this analysis is to compare the accuracy of three-month temperature and precipitation forecasts that are issued by the Climate Prediction Center (CPC) against the YEAR-AHEAD accuracy of similar forecasts issued by Weather Trends International (WTI). The comparison extends for 225 three-month forecast periods, from November/December/January, 2006-07 through July/August/September, 2025.

These forecasts were developed for many cities around the country and are issued by WTI at the end of the calendar month for the time period that is valid 11 months into the future. For example, the May 2010 forecast was issued by WTI in late June 2009. They are issued one month at a time, and three months are combined for the purposes of this analysis and to match up to CPC's forecast period. Once the forecasts are issued, they are not updated by WTI.

The CPC's forecasts are constructed differently; they are developed for three combined month intervals, but in this analysis, the CPC forecast developed one month prior to the three-month period was used in the comparison. Thus, for example, the May 2010 CPC forecast was utilized in this comparison to evaluate their June, July, and August 2010 forecast. Unlike the WTI forecasts, this permits the CPC to alter their forecasts through the time period, right up to the month before. All things being equal, this would offer an advantage to the accuracy of the CPC forecast as compared to WTI's.

During this evaluation period, 30-year normals were changed by NOAA every 10 years, and this is reflected in the data with normal changes occurring at the beginning of 2011 and 2021.

"Skill scores" were calculated by WTI for both sets of forecasts for each three-month period. The CPC has historically utilized the Heidke Skill Score (http://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Outlook/cas_score.shtml), which is defined as follows:

HSS (%) = 100 * (H - E) / (T - E)

where H = number of correct forecasts, E = expected number of correct forecasts (1/3 of total), and T = total number of valid forecast-observation pairs. An HSS above 0 translates to more "hits" than "misses" among all the forecasts for each three-month period; conversely, an HSS below 0 indicates more misses than hits. An HSS of 0 would be, in the long term, the random result if there were no forecasting skill.

There are three categories utilized by CPC in forecasting: above average, below average, and average (the CPC defines these as "above normal", "normal", and "below normal" (CPC, 2016; http://www.cpc.ncep.noaa.gov/products/predictions/long_range/tools.html). We have utilized a 2-class system of above and below average, thus eliminating the EC, which is basically no forecast at all, since

CPC almost never issues a "normal" forecast. Therefore, the area in white within Figure 1 is not included in the comparison, since there is a 33%-33%-33% chance of each of the three categories in that area. Thus, both the WTI and CPC forecast evaluation are based on a two-category system, above and below average, to keep the forecasts parallel.

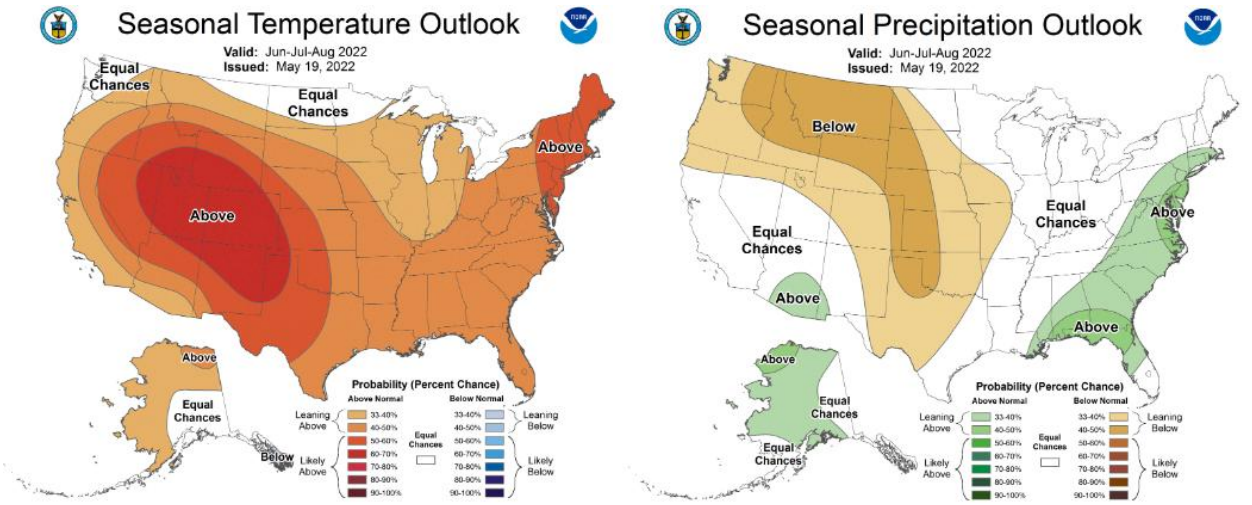

Figure 1. CPC seasonal forecast for Jun-Aug 2022, constructed 19 May 2022. Note the EC area, where there is an equal chance for above normal, normal, or below normal temperature conditions (white area between the 33 percent isolines).

Table 1 shows the comparison of skill scores for part of the temperature and precipitation data extending from the beginning of 2007 into 2008 (the full 225-month forecast comparison for the temperature and precipitation dataset is found in **Appendix 1**). The better skill score between WTI and CPC is color-coded for each forecast period. For the total period, WTI skill scores exceed the CPC scores for temperature in 185 of the 225 months, or 82.2 percent of the total forecasts issued during this time period. Thus, on average during this period, WTI bested the CPC on almost 5 out of every 6 temperature forecasts, a highly statistically significant difference in forecast accuracy.

For precipitation, WTI skill scores exceeded those for CPC in 190 of 225 months, or 84.4 percent of the total forecasts issued during the time period. These results were slightly better than those for temperature.

Year Start	Months	WTI Skill Score (Temp)	CPC Skill Score (Temp)	WTI Skill Score (Precip)	CPC Skill Score (Precip)
	NDJ	**0.6019**	0.2845	**0.1923**	0.0108
	DJF	**0.6077**	0.1444	**0.1693**	-0.0970
2007	JFM	**0.4750**	0.2112	**0.1808**	-0.0280
	FMA	**0.1404**	0.0690	**0.2558**	-0.0496
	MAM	**0.4346**	0.3233	**0.1693**	0.1034
	AMJ	**0.2962**	0.0000	**0.1577**	0.0129
	MJJ	**0.2327**	0.0043	**0.0654**	0.0108
	JJA	0.2097	**0.2543**	**0.0943**	0.0065
	JAS	0.2673	**0.4547**	**0.0654**	-0.0711
	ASO	**0.4520**	0.3599	**0.1866**	-0.0970
	SON	0.4866	**0.5927**	-0.0038	**0.0388**
	OND	**0.7346**	0.4030	**0.1981**	0.1293
	NDJ	**0.5673**	0.1509	0.0077	**0.2004**
	DJF	**0.4289**	0.1013	**0.2847**	0.1444
2008	JFM	**0.3423**	-0.0474	0.1347	**0.2026**
	FMA	**0.3770**	-0.0668	**0.1750**	0.1228
	MAM	**0.4981**	-0.0603	0.0770	**0.1466**

Table 1. Temperature and precipitation skill scores for a portion at the beginning of the evaluation period. Skill scores are based upon the Heidke algorithm found above. For the skill score columns, light green colored skill scores designate the winning score for either WTI or CPC.

Temperature Evaluation

In a vast majority of the three-month forecast periods, WTI scored positive Heidke skill scores, indicating many more forecast "hits" than "misses". During the 225-month forecast period, WTI registered only 4 missed forecasts as defined by Heidke skill scores (Figure 2; bottom two quadrats), which represents a 98.2% percent accuracy rate based upon skill scores, rather impressive considering that these forecasts were developed 11 months prior to the actual forecast date. CPC posted 41 missed forecasts (two quadrats to the left), which is an approximately 81.8 percent accuracy rate. It also represents approximately 10 times more missed forecasts than WTI, a significantly higher rate. The diagonal line in Figure 2 represents equal forecast accuracy by the two groups; dots to the left of that line represent a better skill score (forecast accuracy) by WTI; dots to the right represent a better accuracy by CPC. It is clear that the dots are strongly skewed to the left, indicating the superior skill scores by WTI. In fact, CPC had a superior skill score compared to WTI in just 40 of 225 forecast periods, a 17.8 percent rate

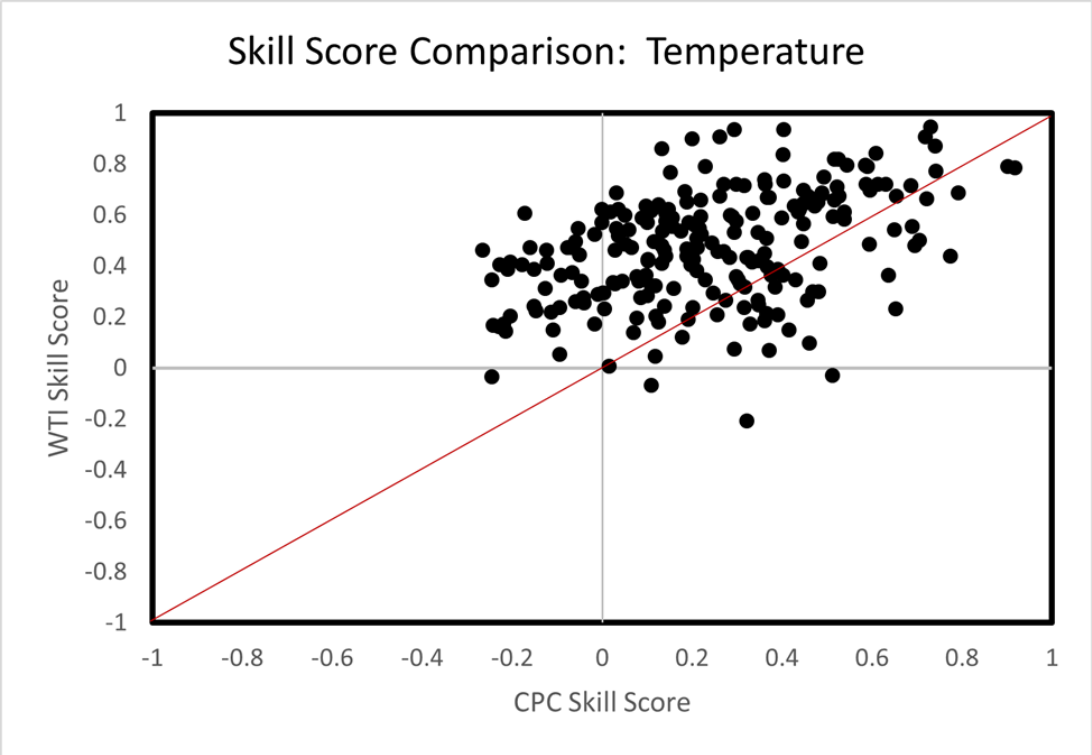

Figure 2. A comparison of temperature forecast "hits" vs. "misses" based upon Heidke skill scores for the 225-month evaluation period. The upper right quadrat includes forecast hits by both WTI and CPC. The upper left quadrat represents hits by WTI and misses by CPC. The lower right quadrat represents hits by CPC and misses by WTI. The lower left quadrat represents misses by both groups. Any points above the diagonal line indicate that WTI scores exceeded CPC's.

(this can also be seen in the full dataset, Appendix 1). Thus, WTI's temperature forecasts were more accurate than CPC's in approximately 5 out of every 6 forecasts during the evaluation period.

A temporal analysis of the temperature skill scores is instructive to see when forecast differentials were greatest (Figure 3). It is clear that WTI had greater forecast accuracy during a large majority of the time span, with the exception of some short periods scattered throughout the forecast period. At no point did CPC exceed WTI's skill score for more than four consecutive months, yet WTI's skill scores were higher for a 21 consecutive month period in 2008 and 2009, a 28 consecutive month time span during 2012 to 2014, and a 32 month period from 2018 to 2020.

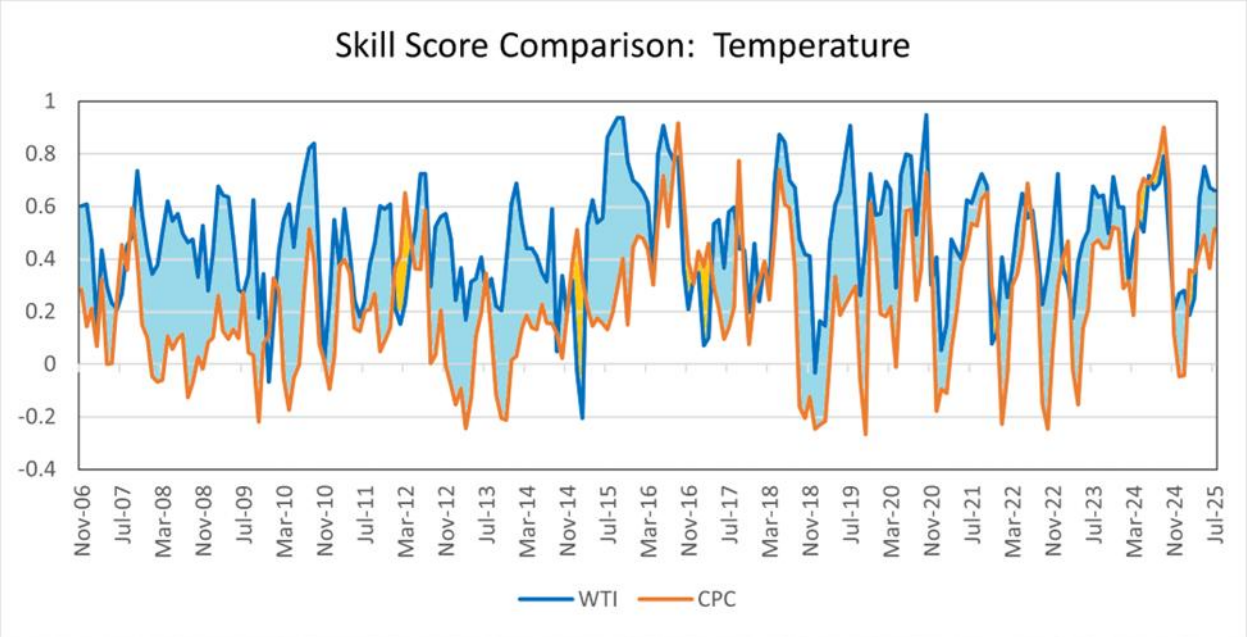

Figure 3. Skill score temperature comparison through the evaluation period. Blue areas represent periods when WTI's accuracy exceeded CPC's; orange areas show periods when CPC's skill scores were superior.

We also evaluated the magnitude of the skill scores using a series of intervals (Figure 4). Once again, WTI shows a clearly superior set of scores, translating into more accurate forecasts. CPC's more negative scores, and slightly positive scores, stand in contrast to the larger number of highly positive scores that are indicative of the WTI forecasts. The switch occurs at the 30% Heidke skill score; all intervals higher than that show WTI forecasts as more dominant; lower intervals are more populated by CPC forecasts, and by a sizable margin. The mode for WTI scores is between 40-50%, considerably higher than CPC's mode.

The analysis strongly suggests that WTI has offered much more accurate forecasts than CPC over the period of evaluation. This is in spite of the fact that the WTI forecasts are issued 11 months prior to the actual forecast period, while CPC's forecasts are issued a month before. In summary, the data indicate that WTI issues a more accurate temperature forecast over 82 percent of the time, CPC's forecasts are associated with negative skill score values at a rate much higher than WTI's, and WTI forecasts are associated with higher skill scores than CPC's in approximately 5 of every 6 months, on average, during the evaluation period.

Both CPC and WTI have improved temperature skill scores through the period of record (Figure 5). Through the 225-month evaluation period, the CPC skill scores have increased at a rate of 0.0144/year, and WTI's have increased by 0.0054/year; both are statistically significant at $p<.05$ level. Although the rate of improvement for CPC is higher, the skill scores still remain well below those for the WTI scores.

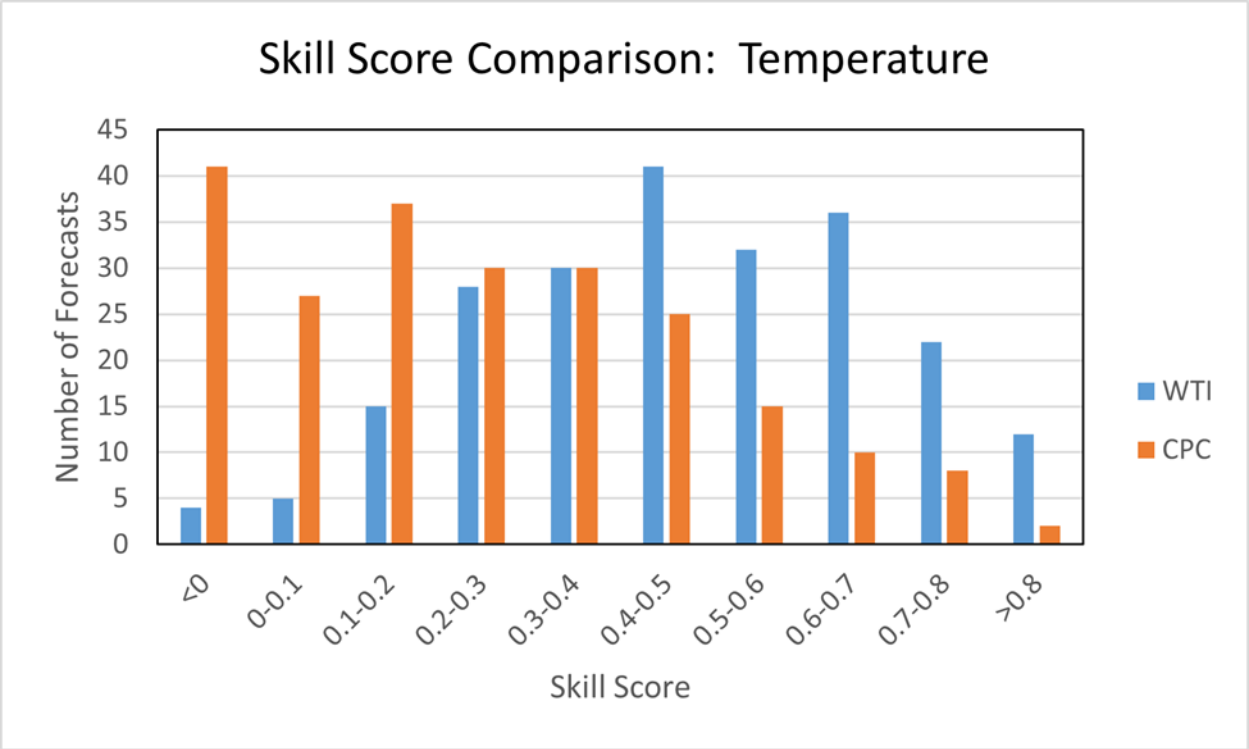

Figure 4. A comparison of temperature skill score intervals, shown in tenths. Negative skill scores are to the far left; the most accurate skill scores are to the right.

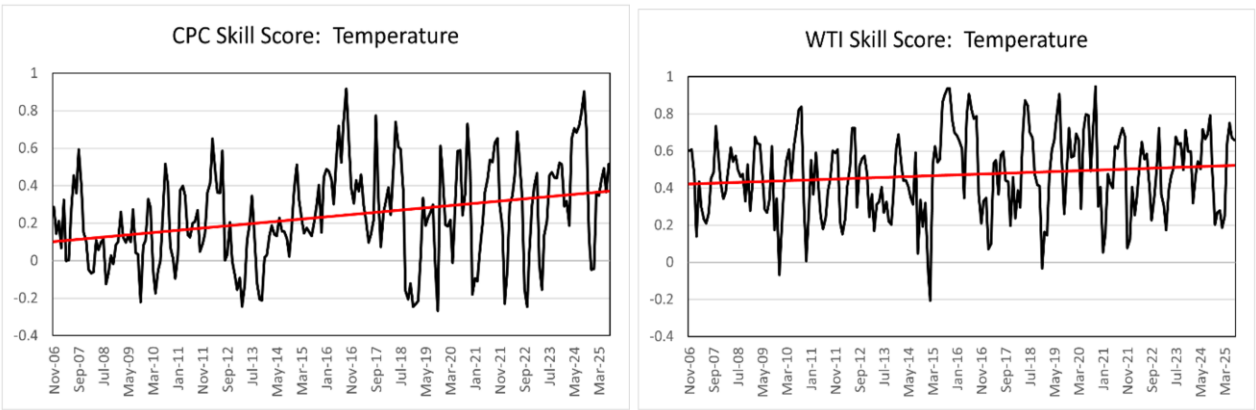

Figure 5. CPC temporal evaluation of temperature skill scores (left) and WTI temporal evaluation (right). Y-axis represents Heidke skill score value, x-axis represents month. Red line represents trend.

Precipitation Evaluation

There are many similarities between the temperature evaluation and the precipitation evaluation; in both, WTI skill scores exceed CPC skill scores by a significant amount (Figure 6).

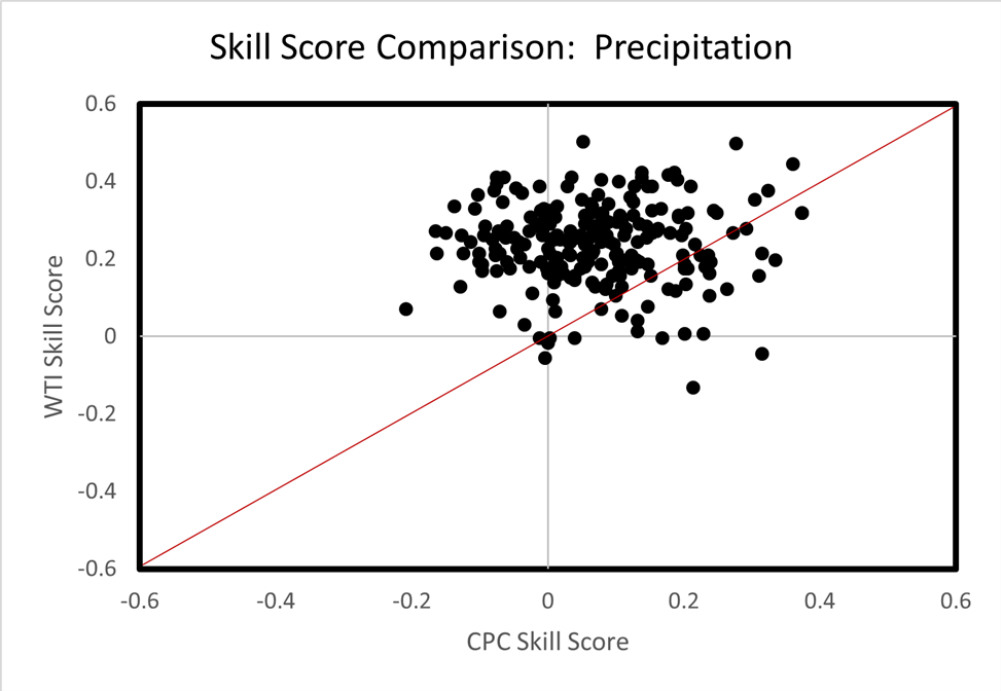

Figure 6. A comparison of precipitation forecast "hits" vs. "misses" based upon Heidke skill scores for the 225-month evaluation period. The upper right quadrat includes forecast hits by both WTI and CPC. The upper left quadrat represents hits by WTI and misses by CPC. The lower right quadrat represents hits by CPC and misses by WTI. The lower left quadrat represents misses by both groups. Any points above the diagonal line indicate that WTI scores exceeded CPC's.

Both CPC and WTI register "hits" for the majority of the time (upper right quadrat), but CPC shows considerably more "misses", as indicated by dots in the upper left quadrat. During the 225-month period, WTI shows only 8 misses (dots in two lower quadrats), representing an accuracy rate of 96.4%. CPC miss rates are considerably higher; there were 58 misses during the period, representing an accuracy rate of 74.2%.

Much like the temperature evaluation, the points are heavily skewed to the left of the diagonal line, indicating WTI's superior skill scores. WTI skill scores exceeded CPC's on 190 of the 225 three-month

periods, which is 84.4% of the time. This result for WTI/CPC precipitation comparison is slightly better than the temperature results discussed earlier in the evaluation.

The temporal analysis of the precipitation skill scores shows when the forecast differentials are greatest (Figure 7). Clearly, the WTI skill scores are superior throughout the evaluation period, and this often occurs for long consecutive monthly periods; the most notable occur during much of 2011 through 2014, 2016 through 2017, and 2018 through 2019. The temporal variation in CPC skill scores is clearly higher than for WTI, as apparent by the large swings from period to period in the CPC scores.

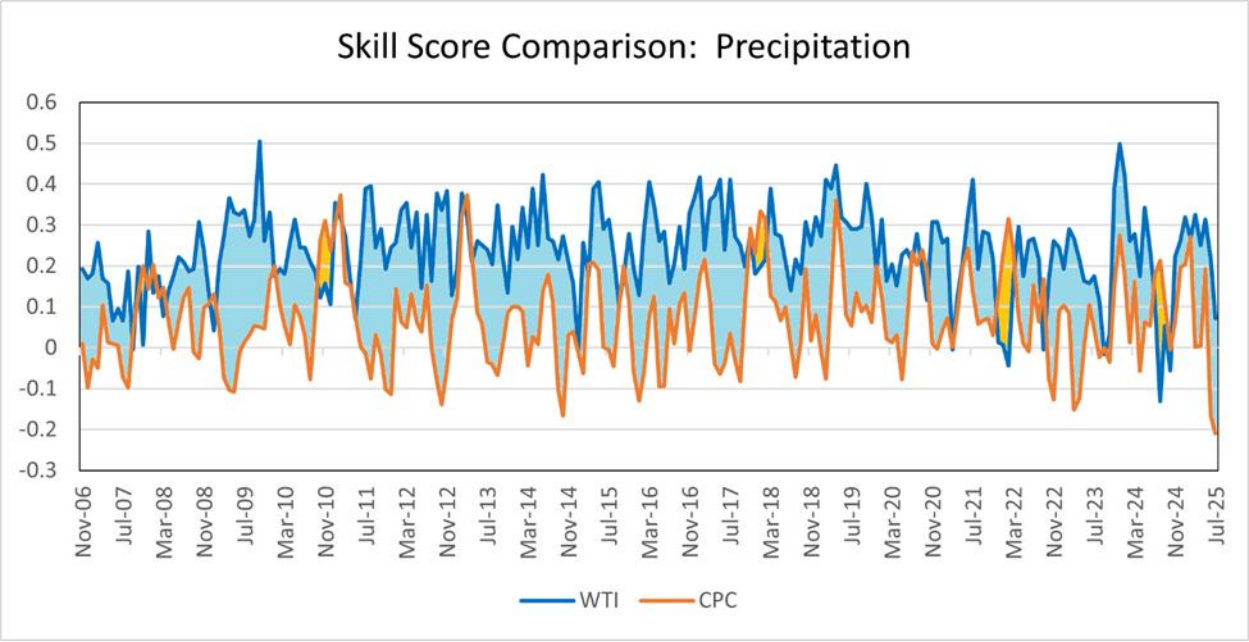

Figure 7. Skill score precipitation comparison through the evaluation period. Blue areas represent periods when WTI's accuracy exceeded CPC's; orange areas show periods when CPC's skill scores were superior.

We evaluated the magnitude of the precipitation skill scores using a series of intervals (Figure 8). Once again, WTI shows a clearly superior set of scores, translating into more accurate forecasts. CPC's more frequent negative scores, and frequent slightly positive scores, stand in contrast to the larger number of more highly positive scores that are indicative of the WTI forecasts. In general, skill scores for precipitation are lower for both CPC and WTI than those for temperature when comparing Figures 4 and 8. Many skill scores exceed 50% for temperature, while almost none reach that level for precipitation. As with the temperature histogram, the skill score mode is considerably higher for WTI when compared to CPC.

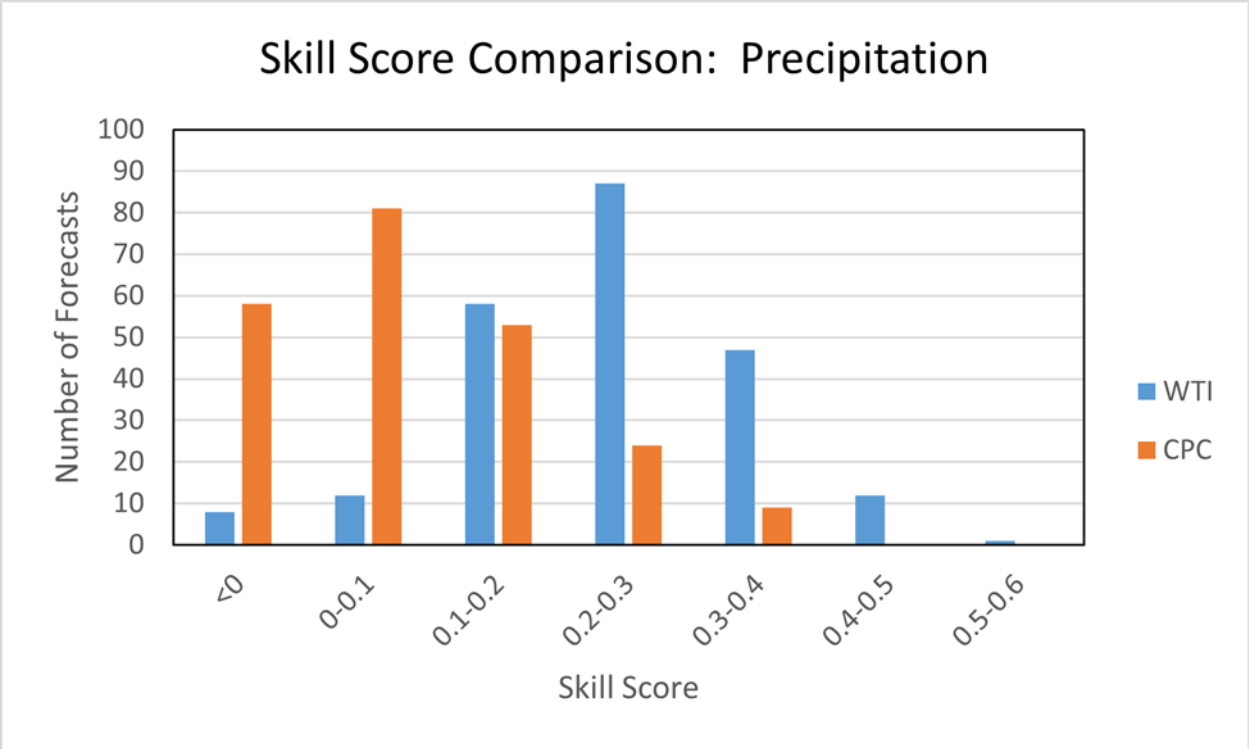

Figure 8. A comparison of precipitation skill score intervals, shown in tenths. Negative skill scores are to the far left; the most accurate skill scores are to the right.

During the evaluated time period, CPC and WTI skill scores have not changed much (Figure 9), unlike temperature, which has improved in statistically significant fashion for both skill score sets. However, clearly WTI is more accurate when forecasting precipitation, and the higher CPC temporal variability in forecasting also stands in contrast with WTI's much more consistent positive skill scores.

The evaluation strongly suggests that WTI has produced consistently better temperature and precipitation forecasting than CPC during the evaluation period. By every metric used here, there is a much higher probability that WTI will continue to produce a more accurate forecast than will CPC into the future. This parallels an earlier report developed by the authors, which showed similar findings up through 2021.

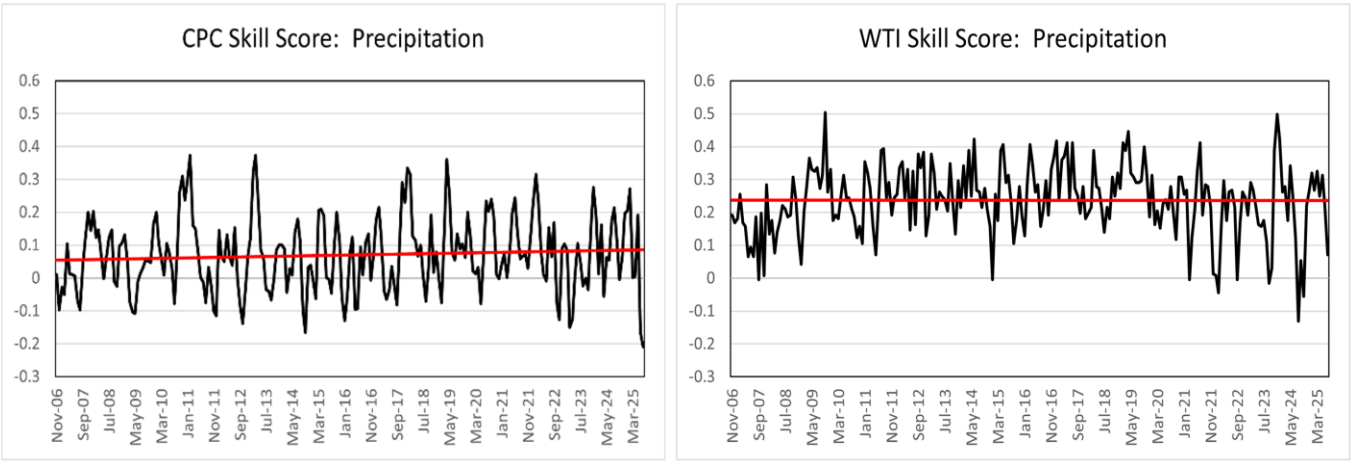

Figure 9. CPC temporal evaluation of precipitation skill scores. Y-axis represents Heidke skill score value, x-axis represents month. Red line represents trend.

CONCLUSION

Weather Trends International's **YEAR-AHEAD Temperature** forecasts outperformed NOAA's month ahead forecast **82.2%** of the time over the 225 forecast periods (nearly 19-year evaluation period 2006-2025).

Weather Trends International's **YEAR-AHEAD Precipitation** forecasts outperformed NOAA's month ahead forecasts **84.4%** of the time over the 225 forecast periods (nearly 19-year evaluation period from 2006 to 2025).

The analysis strongly suggests that WTI has offered much more accurate forecasts than CPC over the period of evaluation. This is in spite of the fact that the WTI forecasts are issued 11 months prior to the actual forecast period, while CPC's forecasts are issued a month before.

By every metric used here, there is a much higher probability that WTI will continue to produce a more accurate forecast than will CPC into the future. This parallels an earlier report developed by the authors, which showed similar findings up through 2021.

APPENDIX

SKILL SCORE VALUES FOR THE ENTIRE EVALUATION PERIOD

This is the total dataset for the entire evaluation period constructed by WTI. Skill scores for temperature are in the left colored columns; those for precipitation are on the right. Colored scores represent the higher skill score for either WTI or CPC.

Year Start	Months	WTI Skill Score (Temp)	CPC Skill Score (Temp)	WTI Skill Score (Precip)	CPC Skill Score (Precip)
	NDJ	**0.6019**	0.2845	**0.1923**	0.0108
	DJF	**0.6077**	0.1444	**0.1693**	-0.0970
2007	JFM	**0.4750**	0.2112	**0.1808**	-0.0280
	FMA	**0.1404**	0.0690	**0.2558**	-0.0496
	MAM	**0.4346**	0.3233	**0.1693**	0.1034
	AMJ	**0.2962**	0.0000	**0.1577**	0.0129
	MJJ	**0.2327**	0.0043	**0.0654**	0.0108
	JJA	0.2097	**0.2543**	**0.0943**	0.0065
	JAS	0.2673	**0.4547**	**0.0654**	-0.0711
	ASO	**0.4520**	0.3599	**0.1866**	-0.0970
	SON	0.4866	**0.5927**	-0.0038	**0.0388**
	OND	**0.7346**	0.4030	**0.1981**	0.1293
	NDJ	**0.5673**	0.1509	0.0077	**0.2004**
	DJF	**0.4289**	0.1013	**0.2847**	0.1444
2008	JFM	**0.3423**	-0.0474	0.1347	**0.2026**
	FMA	**0.3770**	-0.0668	**0.1750**	0.1228
	MAM	**0.4981**	-0.0603	0.0770	**0.1466**
	AMJ	**0.6192**	0.1078	**0.1404**	0.0647
	MJJ	**0.5443**	0.0582	**0.1750**	-0.0022
	JJA	**0.5731**	0.0991	**0.2212**	0.0668
	JAS	**0.4981**	0.1142	**0.2097**	0.1228
	ASO	**0.4635**	-0.1250	**0.1866**	0.1466
	SON	**0.4750**	-0.0690	**0.1923**	-0.0108
	OND	**0.3308**	0.0280	**0.3077**	-0.0259
	NDJ	**0.5269**	-0.0172	**0.2385**	0.0970
	DJF	**0.2789**	0.0841	**0.1289**	0.1078

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Year Start	Months	WTI Skill Score (Temp)	CPC Skill Score (Temp)	WTI Skill Score (Precip)	CPC Skill Score (Precip)
2009	JFM	**0.4231**	0.1013	0.0424	**0.1315**
	FMA	**0.6769**	0.2608	**0.2039**	0.0517
	MAM	**0.6423**	0.1250	**0.2731**	-0.0733
	AMJ	**0.6366**	0.0970	**0.3654**	-0.1034
	MJJ	**0.4808**	0.1315	**0.3308**	-0.1078
	JJA	**0.2847**	0.0991	**0.3250**	-0.0108
	JAS	0.2673	**0.2737**	**0.3366**	0.0129
	ASO	**0.3423**	0.0431	**0.2731**	0.0323
	SON	**0.6250**	0.0345	**0.3135**	0.0539
	OND	**0.1750**	-0.2198	**0.5039**	0.0517
	NDJ	**0.3423**	0.0797	**0.2616**	0.0474
	DJF	-0.0673	**0.1078**	**0.3308**	0.1659
2010	JFM	0.1750	**0.3276**	0.1750	**0.2004**
	FMA	**0.4346**	0.2823	**0.1923**	0.1056
	MAM	**0.5500**	-0.0539	**0.1808**	0.0539
	AMJ	**0.6077**	-0.1724	**0.2558**	0.0086
	MJJ	**0.4462**	-0.0517	**0.3135**	0.1056
	JJA	**0.6250**	-0.0022	**0.2443**	0.0776
	JAS	**0.7231**	0.2694	**0.2443**	0.0302
	ASO	**0.8212**	0.5151	**0.2097**	-0.0776
	SON	**0.8385**	0.4009	**0.1866**	0.0776
	OND	**0.3596**	0.0754	0.1231	**0.2629**
	NDJ	0.0077	**0.0151**	0.1577	**0.3103**
	DJF	**0.2385**	-0.0948	0.1058	**0.2371**
2011	JFM	**0.5500**	0.0302	**0.3539**	0.3039
	FMA	0.3654	**0.3750**	0.3193	0.3728
	MAM	**0.5904**	0.3987	**0.2731**	0.1595
	AMJ	**0.4231**	0.3470	**0.1577**	0.1509
	MJJ	**0.2443**	0.1379	0.0712	**0.0776**
	JJA	**0.1808**	0.1250	**0.2154**	0.0022
	JAS	**0.2385**	0.2004	**0.3885**	-0.0129
	ASO	**0.3827**	0.2091	**0.3943**	-0.0754
	SON	**0.4577**	0.2694	**0.2443**	0.0323
	OND	**0.6019**	0.0496	**0.2904**	-0.0172
	NDJ	**0.5904**	0.0884	**0.1923**	-0.1013
	DJF	**0.6077**	0.1401	**0.2443**	-0.1142

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Year Start	Months	WTI Skill Score (Temp)	CPC Skill Score (Temp)	WTI Skill Score (Precip)	CPC Skill Score (Precip)
2012	JFM	0.2154	**0.3642**	**0.2558**	0.1444
	FMA	0.1520	**0.4138**	**0.3366**	0.0647
	MAM	0.2327	**0.6509**	**0.3539**	0.0496
	AMJ	0.4116	**0.4828**	**0.2443**	0.1315
	MJJ	**0.5096**	0.3642	**0.3308**	0.0647
	JJA	**0.7231**	0.3621	**0.1462**	0.0388
	JAS	**0.7231**	0.5862	**0.3250**	0.1530
	ASO	**0.2962**	0.0022	**0.1635**	0.0000
	SON	**0.5212**	0.0345	**0.3770**	-0.0797
	OND	**0.5616**	0.2047	**0.3366**	-0.1379
	NDJ	**0.5731**	-0.0022	**0.3827**	-0.0474
	DJF	**0.4750**	-0.0776	**0.1289**	0.0690
2013	JFM	**0.2443**	-0.1530	**0.1923**	0.1207
	FMA	**0.3654**	-0.0927	**0.3770**	0.3233
	MAM	**0.1693**	-0.2435	0.3193	**0.3728**
	AMJ	**0.3135**	-0.1272	0.2097	**0.2241**
	MJJ	**0.3250**	0.1078	**0.2616**	0.0862
	JJA	**0.4058**	0.1961	**0.2500**	0.0582
	JAS	**0.2673**	0.3448	**0.2385**	-0.0345
	ASO	**0.3250**	0.1164	**0.2039**	-0.0409
	SON	**0.2212**	-0.1142	**0.3481**	-0.0668
	OND	**0.2039**	-0.2047	**0.2270**	0.0000
	NDJ	**0.3885**	-0.2112	**0.1347**	0.0862
	DJF	**0.6135**	0.0172	**0.2962**	0.1013
2014	JFM	**0.6885**	0.0302	**0.2154**	0.1013
	FMA	**0.5385**	0.1336	**0.3423**	0.0884
	MAM	**0.4404**	0.1875	**0.2443**	-0.0431
	AMJ	**0.4404**	0.1401	**0.3885**	0.0280
	MJJ	**0.4116**	0.1315	**0.2500**	0.0086
	JJA	**0.3481**	0.2284	**0.4231**	0.1379
	JAS	**0.3135**	0.1573	**0.2673**	0.1789
	ASO	**0.5904**	0.1552	**0.2616**	0.1121
	SON	0.0481	**0.1164**	**0.2154**	-0.1013
	OND	**0.3366**	0.0237	**0.2731**	-0.1659
	NDJ	**0.1923**	0.1897	**0.2097**	0.0323
	DJF	0.3193	**0.3836**	**0.1577**	0.0388

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Year Start	Months	WTI Skill Score (Temp)	CPC Skill Score (Temp)	WTI Skill Score (Precip)	CPC Skill Score (Precip)
2015	JFM	-0.0269	**0.5108**	**-0.0038**	-0.0129
	FMA	-0.2058	**0.3211**	**0.2558**	-0.0625
	MAM	**0.5269**	0.2198	0.1750	**0.2047**
	AMJ	**0.6250**	0.1466	**0.3885**	0.2091
	MJJ	**0.5385**	0.1746	**0.4058**	0.1897
	JJA	**0.5558**	0.1552	**0.2904**	0.0022
	JAS	**0.8615**	0.1315	**0.3135**	-0.0043
	ASO	**0.9019**	0.1983	**0.2270**	-0.0453
	SON	**0.9365**	0.2931	**0.1058**	0.0991
	OND	**0.9365**	0.4030	0.1750	**0.2004**
	NDJ	**0.7692**	0.1509	**0.2789**	0.1142
	DJF	**0.7000**	0.4461	**0.1923**	-0.0603
2016	JFM	**0.6827**	0.4871	**0.1289**	-0.1293
	FMA	**0.6539**	0.4784	**0.2847**	-0.0603
	MAM	**0.6135**	0.4353	**0.4058**	0.0776
	AMJ	**0.3481**	0.3017	**0.3481**	0.1250
	MJJ	**0.7981**	0.5431	**0.2616**	-0.0948
	JJA	**0.9077**	0.7177	**0.2847**	-0.0927
	JAS	**0.8212**	0.5237	**0.1577**	0.0948
	ASO	**0.7750**	0.7414	**0.2039**	0.0108
	SON	0.7865	**0.9159**	**0.2962**	0.1078
	OND	0.3654	**0.6358**	**0.1923**	0.1336
	NDJ	0.2097	**0.3901**	**0.3308**	-0.0065
	DJF	**0.3308**	0.3060	**0.3654**	0.0733
2017	JFM	0.3481	**0.4289**	**0.4173**	0.1767
	FMA	0.0712	**0.3707**	**0.2385**	0.2155
	MAM	0.1000	**0.4591**	**0.3596**	0.1207
	AMJ	**0.5327**	0.2931	**0.3712**	-0.0388
	MJJ	**0.5500**	0.2155	**0.4116**	-0.0647
	JJA	**0.3654**	0.0970	**0.2385**	-0.0366
	JAS	**0.5789**	0.1401	**0.4116**	0.0345
	ASO	**0.5962**	0.2177	**0.2731**	-0.0280
	SON	0.4404	**0.7737**	**0.2500**	-0.0819
	OND	**0.4346**	0.3211	**0.1981**	0.1142
	NDJ	**0.1981**	0.0754	0.2789	**0.2909**
	DJF	**0.4577**	0.2565	0.1808	**0.2306**

APPENDIX

Year Start	Months	WTI Skill Score (Temp)	CPC Skill Score (Temp)	WTI Skill Score (Precip)	CPC Skill Score (Precip)
2018	JFM	0.2385	**0.3147**	0.1981	**0.3341**
	FMA	0.3885	**0.3901**	0.2154	**0.3147**
	MAM	**0.2962**	0.2457	**0.3885**	0.1272
	AMJ	**0.6885**	0.4871	**0.2789**	0.1142
	MJJ	**0.8731**	0.7392	**0.2731**	0.0668
	JJA	**0.8442**	0.6078	**0.2097**	0.0991
	JAS	**0.7000**	0.5948	**0.1404**	0.0086
	ASO	**0.6712**	0.3707	**0.2154**	-0.0711
	SON	**0.4750**	-0.1616	**0.1808**	0.0194
	OND	**0.4173**	-0.2047	**0.3077**	0.1918
	NDJ	**0.4116**	-0.1228	**0.2500**	0.0172
	DJF	**-0.0326**	-0.2457	**0.3193**	0.0797
2019	JFM	**0.1635**	-0.2306	**0.2731**	-0.0086
	FMA	**0.1462**	-0.2155	**0.4116**	-0.0754
	MAM	**0.4635**	0.0280	**0.3885**	0.1466
	AMJ	**0.6077**	0.3341	**0.4462**	0.3599
	MJJ	**0.6539**	0.1875	**0.3193**	0.2478
	JJA	**0.7923**	0.2284	**0.3077**	0.0797
	JAS	**0.9077**	0.2608	**0.2904**	0.0539
	ASO	**0.5789**	0.2974	**0.2904**	0.1336
	SON	**0.2616**	-0.0603	**0.2962**	0.0884
	OND	**0.4635**	-0.2672	**0.4000**	0.1034
	NDJ	**0.7231**	0.6121	**0.3193**	0.0625
	DJF	**0.5673**	0.4461	0.1866	**0.2004**
2020	JFM	**0.5731**	0.1918	**0.3135**	0.1250
	FMA	**0.6942**	0.1832	**0.1635**	0.0216
	MAM	**0.6596**	0.2177	**0.2039**	0.0129
	AMJ	**0.2904**	-0.0108	**0.1520**	0.0323
	MJJ	**0.7173**	0.3147	**0.2270**	-0.0776
	JJA	**0.7981**	0.5841	**0.2385**	0.0539
	JAS	**0.7923**	0.5884	0.2097	**0.2349**
	ASO	**0.4923**	0.2435	**0.2789**	0.2026
	SON	**0.7404**	0.3599	0.1923	**0.2392**
	OND	**0.9481**	0.7284	0.1174	**0.1875**
	NDJ	0.3020	**0.4806**	**0.3077**	0.0108
	DJF	**0.4058**	-0.1789	**0.3077**	-0.0022

APPENDIX

Year Start	Months	WTI Skill Score (Temp)	CPC Skill Score (Temp)	WTI Skill Score (Precip)	CPC Skill Score (Precip)
2021	JFM	**0.0539**	-0.0948	**0.2558**	0.0431
	FMA	**0.1520**	-0.1099	**0.2673**	0.0733
	MAM	**0.4750**	0.0647	-0.0038	**0.0022**
	AMJ	**0.4289**	0.2026	**0.1231**	0.0841
	MJJ	**0.4000**	0.3664	**0.2097**	0.1983
	JJA	**0.6250**	0.4375	**0.3250**	0.2435
	JAS	**0.6135**	0.5366	**0.4116**	0.1379
	ASO	**0.6769**	0.5259	**0.1923**	0.0582
	SON	**0.7231**	0.6293	**0.2847**	0.0668
	OND	**0.6769**	0.6530	**0.2789**	0.0711
	NDJ	0.0770	**0.2931**	**0.2154**	0.0302
	DJF	0.1231	**0.1767**	0.0135	**0.1315**
2022	JFM	**0.4058**	-0.2284	0.0077	**0.2284**
	FMA	**0.2558**	-0.0409	-0.0442	**0.3147**
	MAM	**0.3596**	0.2974	0.1635	**0.2371**
	AMJ	**0.5327**	0.3448	**0.2962**	0.0776
	MJJ	**0.6481**	0.4461	**0.1750**	0.0108
	JJA	0.5558	**0.6875**	**0.2616**	-0.0086
	JAS	**0.5846**	0.5366	**0.2673**	0.1530
	ASO	**0.4173**	0.3319	**0.2154**	0.0647
	SON	**0.2270**	-0.1487	-0.0038	**0.1681**
	OND	**0.3481**	-0.2457	**0.1693**	-0.0754
	NDJ	**0.4866**	0.0517	**0.2616**	-0.1272
	DJF	**0.7231**	0.2974	**0.2443**	0.0905
2023	JFM	0.3654	**0.4009**	**0.1923**	0.1034
	FMA	0.3020	**0.4677**	**0.2904**	0.0841
	MAM	**0.1750**	-0.0172	**0.2673**	-0.1509
	AMJ	**0.3885**	-0.1530	**0.2154**	-0.1250
	MJJ	**0.4635**	0.1379	**0.1635**	0.0043
	JJA	**0.5096**	0.2091	**0.1577**	0.1056
	JAS	**0.6769**	0.4569	**0.1750**	0.0474
	ASO	**0.6366**	0.4720	**0.1116**	-0.0237
	SON	**0.6423**	0.4440	-0.0153	**0.0000**
	OND	**0.4981**	0.4418	**0.0308**	-0.0345
	NDJ	**0.7116**	0.5216	**0.3885**	0.1530
	DJF	**0.5962**	0.5129	**0.4981**	0.2759

APPENDIX

Year Start	Months	WTI Skill Score (Temp)	CPC Skill Score (Temp)	WTI Skill Score (Precip)	CPC Skill Score (Precip)
2024	JFM	**0.5962**	0.2888	**0.4231**	0.1853
	FMA	**0.3193**	0.3168	**0.2616**	0.0129
	MAM	**0.4693**	0.1875	**0.2789**	0.1616
	AMJ	0.5443	**0.6487**	**0.1750**	-0.0560
	MJJ	0.5039	**0.7047**	**0.3423**	0.0625
	JJA	**0.7173**	0.6853	**0.2385**	0.0539
	JAS	0.6654	**0.7198**	0.1231	**0.1767**
	ASO	0.6885	**0.7909**	-0.1307	**0.2134**
	SON	0.7923	**0.9009**	0.0539	**0.1078**
	OND	0.4808	**0.6940**	-0.0557	**-0.0043**
	NDJ	**0.2039**	**0.1185**	**0.2212**	0.0647
	DJF	**0.2673**	-0.0474	**0.2616**	0.1961
2025	JFM	**0.2789**	-0.0431	**0.3193**	0.2047
	FMA	0.1866	**0.3599**	0.2673	**0.2716**
	MAM	0.2500	**0.3470**	**0.3250**	0.0022
	AMJ	**0.6366**	0.4267	**0.2500**	0.0043
	MJJ	**0.7519**	0.4914	**0.3135**	0.1918
	JJA	**0.6712**	0.3664	**0.2154**	-0.1638
	JAS	**0.6596**	0.5151	**0.0712**	-0.2091

END