NOAA TECHNICAL MEMORANDUM NWS AR-22

MONTHLY TEMPERATURE AND PRECIPITATION OUTLOOKS FOR ANCHORAGE, ALASKA USING DATA FROM PAST MONTHS AND SUNSPOT NUMBERS

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ABSTRACT. A forecast procedure was established for predicting the mean temperature and total precipitation departure from normal for the coming month. A statistically significant relationship was found between mean monthly temperatures and total precipitation values of the preceding three months, and sunspot numbers of the current year, and the following month's temperature and precipitation. Regression equations were derived; forecasts made from the equations were better than those prepared by the Extended Forecast Division of NMC.

BASIC TECHNIQUE

A review of monthly temperature and precipitation departures from normal for Anchorage, Alaska indicated that persistence could be an important factor in making monthly outlooks. A statistical forecast scheme was developed using combinations of past monthly temperatures and past monthly precipitation as predictors.

The data base consisted of the average monthly temperatures and the total monthly precipitation for the period 1916 through 1977. From these data an average temperature was computed for each month. These values were defined as "monthly temperature normals". Also for this period an average precipitation was computed for each month. These values were defined as "monthly precipitation normals".

Sunspot numbers were also used as a predictor. Many studies have shown various degrees of correlation between sunspot numbers and weather events. A good synopsis of previous studies with sunspot numbers can be found in an article by Mass and Schneider (1977). The degree of correlation and the applicability have varied widely, and an exact physical relationship between weather events and sunspot numbers has remained unknown. Nevertheless, sunspot numbers did offer some hope for being a useful statistical predictor.

The total yearly sunspot count for 1916 through 1976 was available. The yearly sunspot count for 1977 was estimated.

The predictors which could be used were restricted to those which are readily available to the Anchorage Forecast Office of the National Weather Service. Other predictors such as upper air anomolies or sea surface temperatures could not be used since they were not available. Thus the resulting statistical procedure offers limited, if any, room for further improvement by the Anchorage WSFO.

The predictands were temperature departure from normal and precipitation departure from normal. "Normal" was used as defined above.

A step-wise regression analysis was used to develop monthly prediction equations for temperature and precipitation departures from normal. Predictors were eliminated from the regression analysis when their 't' test value was less than 1.0. This analysis resulted in monthly equations for both the temperature outlook and the precipitation outlook using only the 1916 through 1969 data as the development sample and "normal" as defined above.

PREDICTOR SIGNIFICANCE

The temperature, precipitation, and sunspot data were compiled into the predictors listed in table 1. The order of listing in table 1 is from the highest to the lowest correlation of the predictor with the predictand as determined from the step-wise regression analysis used to develop the prediction equations. These correlations were computed by the month for 1916 through 1969. The monthly correlations were averaged to obtain a yearly value which was then averaged for the 55-year record. This final yearly average determined the ranking or order of the listing in table 1.

For the monthly temperature outlook equations, temperature persistence from the preceding month is, in general, the most significant predictor. Temperature departure from normal of the first prior month, temperature departure from normal of the second prior month, and precipitation departure from normal of the first prior month were the first three predictors selected. Sunspot numbers for the past 5 years was selected fourth.

Table 1.--Average rank of predictors selected in the step-wise regression analysis. DN= departure from normal, B= binary, C= continuous.

a. Temperature Predictors

Rank	Type	Form	Limit
1	Temperature DN 1 month prior	C	
2	Temperature DN 2 months prior	C	
3	Precipitation DN 1 month prior	B	> "normal"
4	Sunspot numbers, total past 5 years	C	
5	Precipitation DN 1 month prior	C	
6	Temperature DN 1 month prior	B	> "normal"
7	Sunspot number, current year	B	> 90
8	Temperature DN 3 months prior	C	
9	Sunspot number for current year	C	
10	Precipitation DN 3 months prior	B	> "normal"
11	Precipitation DN 3 months prior	C	
12	Temperature DN 2 months prior	B	> "normal"
13	Precipitation DN 2 months prior	B	> "normal"
14	Precipitation DN 3 months prior	B	> "normal"
15	Sunspot number current year (binary form) X temperature DN 1 month prior	B/C	< 50
16	Precipitation DN 2 months prior	C	
17	Sunspot number, current year, X temperature DN 1 month prior	C	

b. Precipitation Predictors

Rank	Type	Form	Limit
1	Sunspot number, total past 5 years	C	
2	Precipitation DN 3 months prior	C	
3	Sunspot number, current year	B	> 90
4	Temperature DN 3 months prior	C	
5	Temperature DN 2 months prior	C	
6	Precipitation DN 2 months prior	C	
7	Temperature DN 1 month prior	B	> "normal"
8	Temperature DN 3 months prior	B	> "normal"
9	Sunspot number for current year	C	
10	Precipitation DN 2 months prior	B	> "normal"
11	Temperature DN 2 months prior	B	> "normal"
12	Precipitation DN 1 month prior	C	
13	Temperature DN 1 month prior	C	
14	Precipitation DN 3 months prior	B	> "normal"
15	Sunspot number current year, X temperature DN 1 month prior	C	
16	Precipitation DN 1 month prior	B	> "normal"
17	Sunspot number, current year (binary form) X temperature DN 1 month prior	B/C	< 50

For the precipitation outlook equations, sunspot numbers ranked first and third, precipitation second and sixth, and temperature fourth and fifth, in the selection order.

FORECAST CATEGORIES

From the regression equations, temperature departures from normal and precipitation departures from normal are computed. In order to compare the regression outlooks, called the Anchorage (ANC) outlook, with the National Meteorological Center (NMC) 30-day outlook, called the NMC outlook, the ANC outlook was converted to the NMC categories. The NMC categories are defined as follows: For temperature, the highest three-tenths of observed values is above normal, the lowest three-tenths of observed values is below normal, the remaining four-tenths is normal. For precipitation, values above the median are "above" and those below are "below".

ANC outlooks were made from independent data for the period 1970 through 1977 and converted to the NMC categories. When the ANC outlooks were converted to NMC categories they were referred to the standard 30-year climatological normals which are used to define the NMC categories.

NMC outlooks were taken from the official monthly issuances. Since these depict geographic areas, the monthly outlook for Anchorage was taken to be the category which covered Anchorage on the chart. Thus, our verification results do not apply to the entire geographic areas on the NMC outlooks. Considering the large variations in climatology within only 100 kilometers of Anchorage and the much larger area depicted on the NMC outlooks, it is unlikely that Anchorage would be a representative site. On the other hand, for practical purposes, the category which applies to Anchorage on the NMC outlook must be used if the NMC outlook is to be issued to the public. What happens elsewhere, or how the larger area depicted on the NMC outlook verifies, is of little consequence.

VERIFICATION OF OUTLOOKS

To compare the ANC outlook and the NMC outlook, the categories were assigned numbers. Below normal was assigned 1, normal 2, above normal 3. Errors in outlooks were calculated by adding the absolute value of the difference of the forecast and observed category numbers and dividing by the total cases.

Since errors for precipitation are either 0 or 2, the average error will be somewhat higher than that for temperature.

Two other outlook methods were used for comparison. The first was to use persistence as the outlook for the following month. The second was to use the normal category as a temperature outlook for each month and the median as a precipitation outlook. Since the median precipitation is a single value, it is assumed that it never occurs and thus this outlook has a constant error of 1. For practical purposes this is the same as using the average monthly precipitation as a precipitation outlook.

The average errors for these four outlook procedures, applied to the 1970-1977 years, are listed in table 2. The average errors are summarized for the winter (October-March), for the summer (April-September), and for the year. The best outlook using this verification comparison is the one with the lowest error.

The best outlook and the best prediction scheme also depend upon the definition of the outlook categories. An experimental temperature outlook was made with the normal category eliminated. Using only above normal and below normal for a temperature outlook, the scores improve but of course the resolution of the outlook decreases.

Table 2.--Errors of the 4 outlook procedures.

	Temperatures				Precipitation			
	ANC Otlk	NMC Otlk	Nrml	Persist.	ANC Otlk	NMC Otlk	Medn	Persist.
Jan	1.1	1.0	.8	1.0	1.0	1.0	1.0	1.0
Feb	.8	.6	.9	.6	.8	1.6	1.0	1.5
Mar	.6	.9	.4	.8	.5	1.1	1.0	1.0
Apr	.8	.9	.5	.4	1.3	1.1	1.0	.3
May	.5	1.0	.8	.5	.8	1.4	1.0	.8
Jun	.4	.8	.6	.6	1.3	1.5	1.0	1.5
Jul	.4	1.1	.8	.9	.8	1.3	1.0	.8
Aug	.3	.6	.5	.6	1.3	.8	1.0	.3
Sep	.6	.9	.9	.3	1.0	1.4	1.0	1.8
Oct	.6	.9	.6	.3	.5	.9	1.0	1.5
Nov	.5	.6	.4	.8	.8	.6	1.0	1.3
Dec	.8	.6	.4	.8	1.0	.9	1.0	.0
Oct-Mar	.73	.77	.56	.69	.75	1.02	1.00	1.04
Apr-Sep	.48	.88	.67	.54	1.04	1.23	1.00	.88
Year	.60	.82	.61	.61	.89	1.12	1.00	.96

For winter temperature outlooks, the best results were obtained by forecasting the normal category all the time. For summer temperature outlooks, the best results were obtained by the Anchorage outlook from the regression equations.

For the winter precipitation outlooks, the best results were obtained by the Anchorage outlook. For the summer precipitation outlook, the best results were obtained by persistence.

SUMMARY

Using the procedures described in this paper, the Anchorage WSFO can prepare a monthly 30-day outlook for Anchorage in a few minutes which verifies better than the NMC outlook for Anchorage.

For practical application, it is necessary to make a short-range prediction of sunspot numbers. Our experience indicates that this can be done subjectively with sufficient accuracy. Also, the U. S. Army Communications-Electronics, Installation Agency, Fort Huachuca, Arizona makes predictions of sunspot numbers for each month of the year. These can be used in the regression equations. For 1978 their prediction was the same as ours.

It is very likely that the regression equation results would improve if additional related predictors were screened. However, the Anchorage WSFO does not have ready access to other potential predictors.

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REFERENCES

Mass, C. and S. H. Schneider, 1977: Statistical Evidence on the Influence of Sunspots and Volcanic Dust on Long-Term Temperature Records. Journal of the Atmospheric Sciences, 34, 1955-2004.

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