ENVIRONMENTAL CONSERVATION BRANCH

SCIENCE DIVISION

REPORT

UV FORECAST VERIFICATION

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INTRODUCTION

This paper compares Ultraviolet (UV) radiation forecasts for Penticton, B.C. issued by the Canadian Meteorological Centre (CMC) to observed UV Index values at nearby Summerland. The study then compares the accuracy of CMC UV forecasts with that of persistence and UV climatology. The results of this study show that the accuracy of CMC UV forecasts is comparable to that of UV forecasts based on 1978-91 climatology adjusted for current year conditions. The accuracy of the CMC UV forecasts was also found to be comparable to that of UV forecasts based upon persistence.

OBJECTIVES

Two objectives were established for the study as follows:

1. Determine the accuracy of CMC UV Index forecasts using UV climatology (1978-91) and UV persistence as standards for comparison.

2. Compare the accuracies of the 12Z and the 00Z CMC forecasts.

DATA

The study spans the period of July 15 to September 30, 1993. Observed UV Index values were compared to the CMC UV forecasts, UV climatology, and persistence of daily UV.

UV forecasts are issued twice daily by CMC (Canadian Meteorological Centre), based on observations at 12Z and at 00Z for a number of Canadian sites. Forecast clear sky values of UVB (i.e. unattenuated by cloud) are contained in the bulletin FXCN21 for several weather stations. In British Columbia, the FXCN21 bulletin carries a UV forecast for Penticton (YYF, 49° 28′ N, 119°36′ W, 344m). Although UV is not being measured at Penticton, it is being monitored by a Vital Technologies BW100 sensor at the Summerland autostation (WUS, 49°28′ N, 119°39′ W, 454m), located some 20 kilometres northwest of Penticton. Differences in UV between these two sites due to latitudinal effects would be negligible (0.02 to 0.05 UV index points). Assumptions made and techniques used to gather and analyze the data are outlined below.

1. CMC UV forecast values assume that maximum UV flux occurs at solar noon under clear sky conditions.

2. The peak daily value of UV has been defined as the maximum 5-minute average in the hour during which solar noon occurs. Because of their geographic location, Penticton and Summerland experience solar noon at approximately 12 noon Pacific Standard Time. Observed UV maxima occurring at other times of the day due to cloudiness at solar noon are ignored in this study. Sky conditions are determined by means of an electronic sunshine sensor with a sampling frequency of 1000 per hour.

3. Climatological clear sky UV index values have been used in this study. These values were extrapolated from "Climatology of Daily Total Ozone and Ultraviolet-B Radiation Levels" (Burrows et al, 1992) and represent the average UV flux based on Total Ozone Mapping Spectrophotometer (TOMS) data between 1978 and 1991. Since ozone thicknesses have been shrinking over the last 15 years, it would be expected that climatological UV values would be lower than the current mean UV.

4. Persistence forecasts are predictions based solely on the maximum UV radiation observed on the previous day, when the clear sky UV Index was available for that day.

The final data set consisted of 42 records which met the following conditions:

- data exists for observed UV, forecast UV (12Z and 00Z) and climatology for a particular day.
- observed 5-minute UV maxima occurred between 11 am and 1 pm Pacific Standard Time (around solar noon).
- observed 5-minute maxima occurred during clear sky conditions, defined as sunshine values in excess of 800 (of a possible 1000) during the previous hour.

To compute statistics for persistence, only successive days with sunshine were considered. Twenty-seven such cases exist for the period.

RESULTS AND DISCUSSION

Scatter plots of the data for four comparisons are shown below.

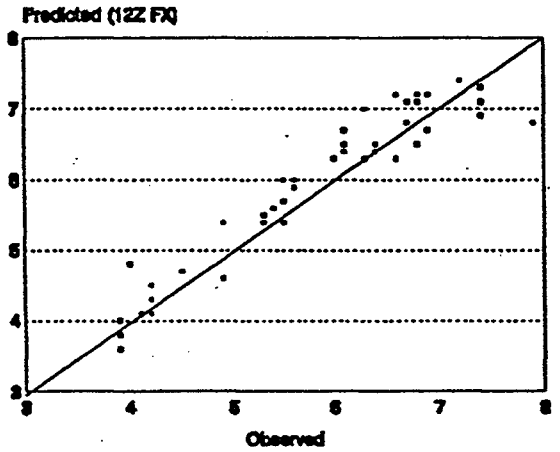

Figure 1: Observed UV vs 12Z Forecast n=42

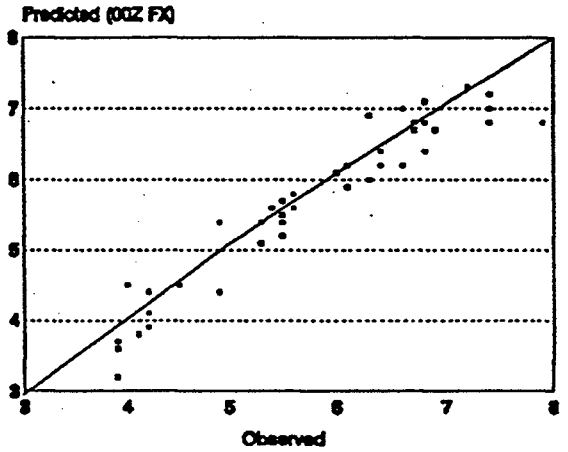

Figure 2: Observed UV vs 00Z Forecast (n=42)

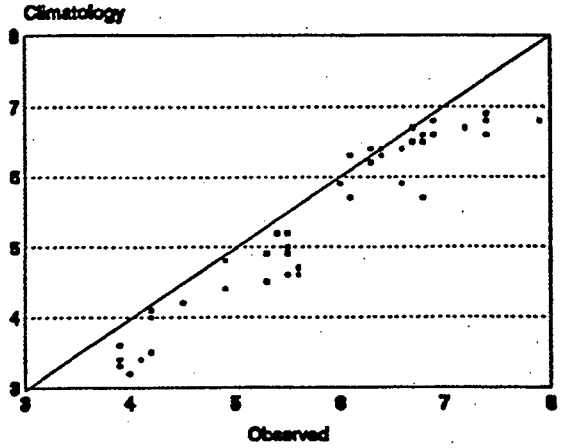

Figure 3: Observed UV vs Climatology (n=42)

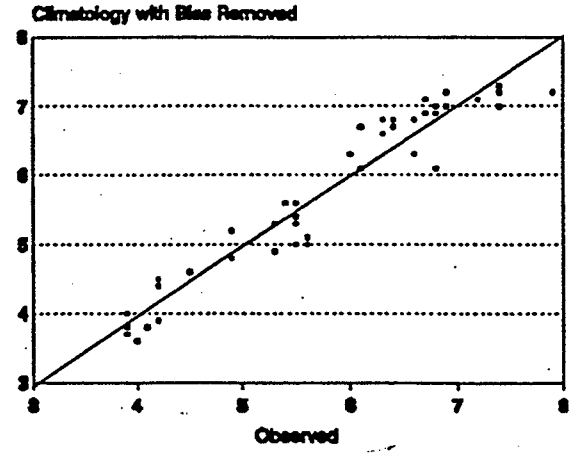

Figure 4: Observed vs Climatology-Bias (n=42)

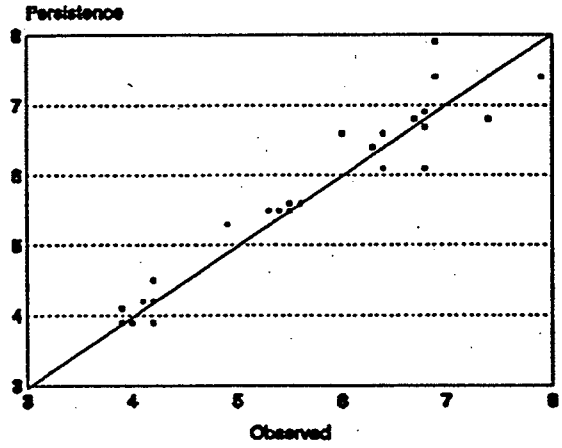

Figure 5: Observed UV vs Persistence (n=27)

Figures 1 and 2 both indicate close agreement (r=0.95 and r=0.96 respectively) between observed and predicted UV Index values for 42 pairs of CMC forecasts (12Z and 00Z). Points are well distributed on both sides of the diagonal line indicating little if any tendency to under- or over- forecast the UV Index.

Figure 3 shows that observed values of UV are underestimated by 1978-91 climatology with most points lying below the diagonal line. This negative bias may be explained by the generally higher UV irradiance in 1993 relative to the 1978-91 climatology, possibly because ozone thicknesses over British Columbia were much lower than normal during that period. A strong correlation (r=0.96) between predicted and observed values exists. Figure 4 compares the observed UV with the 1978-91 climatology which has the negative bias removed. Once the bias is removed from the climatology to reflect 1993 conditions, the data is much more evenly distributed about the diagonal line.

The relationship between observed UV and persistence is shown in Figure 5. Again, the clustering of points about the diagonal line indicates good agreement between these two parameters (r=0.95).

An error table showing the results of statistical tests run on the data are provided in Table 1.

STATISTIC	OBS vs 12Z Forecast	OBS vs 00Z Forecast	OBS vs Climatology	OBS vs Climatology - bias	OBS vs Persistence
BIAS	0.12	-0.09	-0.42	--	-0.10
RMSE	0.37	0.34	0.52	0.32	0.35

Table 1. Statistical tests performed on UV Index verification data.

The Bias and RMSE statistics are now discussed:

1. BIAS - (indicates average direction of deviation of errors) - A very slight negative bias in the CMC 00Z forecast and an almost equally small positive bias for CMC 12Z were noted. This would indicate a slight tendency to over-forecast the UV index based on 00Z data and a slight tendency to under-forecast based on 12Z data. The more significant bias of -0.42 related to climatology is in agreement with peak UV values exceeding the mean by about 10% in the summer of 1993. A bias in the persistence forecast is of roughly the same magnitude as that for the CMC forecasts. (Note that a bias of 0.02 points would normally be expected due to a difference in latitude of 6 minutes between the observing site (Summerland) and the forecast site (Penticton).

2. Root Mean Square Error (RMSE) - (indicates average magnitude of errors) - RMSE values of 0.37 and 0.34 indicate little difference in accuracy between the 00Z and 12Z CMC forecasts. The fact that both scores are lower than that obtained for climatology (RMSE=0.52) implies that the UV forecast is more accurate than climatology. However when the bias is removed from climatology (clim+0.42-obs) the accuracy improves to that of the CMC forecasts (RMSE=0.32). Likewise, persistence forecasts appear to be just as accurate as the CMC forecasts (RMSE=0.35).

CONCLUSION

A comparison between CMC UV Index forecasts for Penticton and actual UV observations at nearby Summerland formed the basis for a UV forecast verification. The following conclusions were reached as a result of the study:

1. A comparison based on root mean square error (RMSE) showed that the accuracy of UV persistence forecasts, or forecasts based upon UV climatology with the bias removed, were comparable to CMC UV forecasts.

2. There was no difference in accuracy between the 12Z and the 00Z UV Index forecast by CMC. Neither was there any significant bias in either forecast.

Our assessment, therefore, is that current CMC UV forecasts offer little improvement over forecasts based on either persistence or UV climatology when RMSE and Bias statistics are used as tools to determine accuracy. It may therefore be productive to explore the development of a statistical UV Index forecast based upon persistence and climatology. The desired accuracy of this product should be based upon the needs of the client, which in general is the public.

REFERENCES

Burrows S.R., Vallee M., Wilson L.J., "Climatology of Daily Total Ozone and Ultraviolet-B Radiation Levels", Atmospheric Research Directorate (Research Report MSRB 92-005), October, 1992.