### 3.2.8. ARCTIC UV MONITORING

***Introduction***

In June 1998, with continued support from the NOAA Arctic Research Initiative (ARI), CMDL deployed two additional Biospherical Instruments, Inc. (BSI), five-channel UV filter-based radiometers at the NWS facilities at Nome (64°N, 165°W) and St. Paul Island (57°N, 170°W). The three Alaska UV monitoring sites are identified in Figure 3.23. The instruments at Nome and St. Paul are identical to the one deployed at BRW in September 1997 except that the 340-nm channel was replaced by a wide-band channel that measures across the 400-700 nm part of the spectrum (known as photosynthetically active radiation or PAR). Thus these instruments have three channels in the UV-B region (305 nm, 313 nm, and 320 nm) and one channel in the UV-A region (380 nm). All three UV instruments produced excellent data in 1998 and 1999, other than a temporary malfunction in the 380-nm channel at St. Paul in 1999. All three instruments continue to operate within normal parameters with the exception of 1 week of downtime at Nome in July 2000 because of a brownout requiring the return of the data acquisition computer for repair.

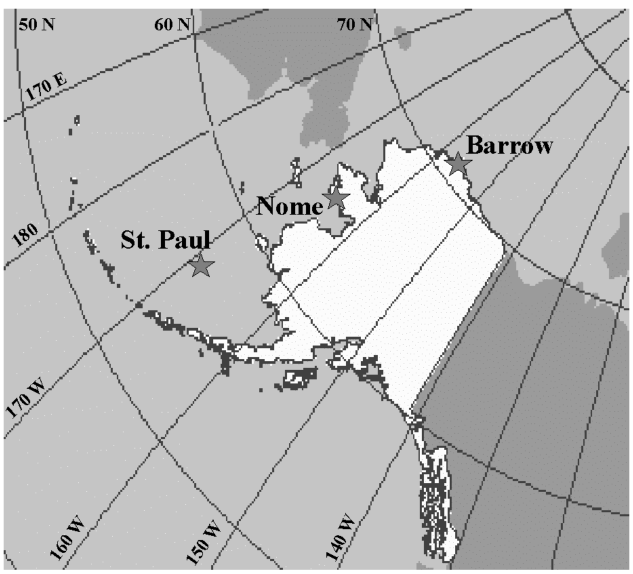


Fig. 3.23. CMDL arctic UV Network.

The three instruments continue to undergo regular annual calibration by the manufacturer during the winter period (November–January). The calibration of the BSI instrument is tied to a spectroradiometer used in the National Science Foundation's Polar UV Monitoring Network. This high resolution scanning spectroradiometer (the BSI model SUV-100) has a well-documented calibration history. In addition to the SUV-100, BSI has a series of multi-channel reference instruments (RGUVs) installed at their San Diego facility, similar to those installed at the three CMDL sites. These RGUVs have been operated next to the spectroradiometer since 1995, allowing for intercomparison on a continuous basis. Thus far solar calibrations of the RGUVs relative to the SUV have indicated the stability of the RGUVs to be about ±3% across all channels. These RGUV instruments are then used as the basis for calibration of other BSI multi-channel UV instruments. The process generates a calibration scale factor for each optical channel that is used to determine any changes in instrument sensitivity. Analysis of the calibrations for all three instruments has shown changes in sensitivity of 2-11%.

***Data Analysis***

One year of data (1998) was analyzed for all three sites. For Barrow, the observation period was May 18-October 26; for Nome, June 12-October 22; and for St. Paul, June 8-October 23. Figure 3.24 shows the daily total energy for each site at the individual UV wavelengths for the period during which the instruments were taking observations in 1998. The 400-700 nm measurements from the Nome and St. Paul instruments are not presented here, although they show the same variability as the other four channels. The 305-nm channel is multiplied by ten so that it can be more easily seen on the charts. Because of missing data during the integration process (integrated for the entire 24-hr day), Barrow is missing 2 days; Nome is missing 7 days; and St. Paul is missing 4 days. Nonetheless, the figure shows large day-to-day variations for all three sites and a decrease in UV at all wavelengths over the observation periods.

A regression analysis was conducted to investigate the correlation of ozone with each of the UV wavelengths at the three sites. This was done by first removing the variability in UV because of SZA by filtering the daily 1-min values between 69.5° and 70.5°. This yielded two reduced sets of data for each day (AM and PM values), which were then combined into one dataset, effectively yielding two data points for each day. Unfortunately this also resulted in a loss of about 1 month's data for Barrow (because of a rapidly setting sun) but captured nearly all of the observational period at Nome and St. Paul. In addition, because of limited clear-sky data at all three sites, ratios were taken to reduce the effects of clouds at the shorter wavelengths of 305 nm, 313 nm, and 320 nm. At Nome and St. Paul there are no 340-nm channels, so the ratios used the 380-nm wavelengths. Total column ozone values were obtained from the Dobson spectrophotometer at the Barrow Observatory and from the NASA Total Ozone Mapping Spectrometer (TOMS) at all three sites for the same periods as the UV observations. During the observation period in Barrow there were 62 days without Dobson observations. Only 5 days of TOMS ozone data were missing for Barrow. Therefore, a combined Dobson/TOMS ozone dataset was used for the regression. Three Dobson observation sets are usually obtained for each day: in the morning, near local noon, and in the afternoon. Where available, the Dobson value most closely matching the UV measurement time was used. When this was not possible, the single daily representative value from TOMS was used. At the other two sites, only the TOMS ozone data are available, and there were 26 days missing for

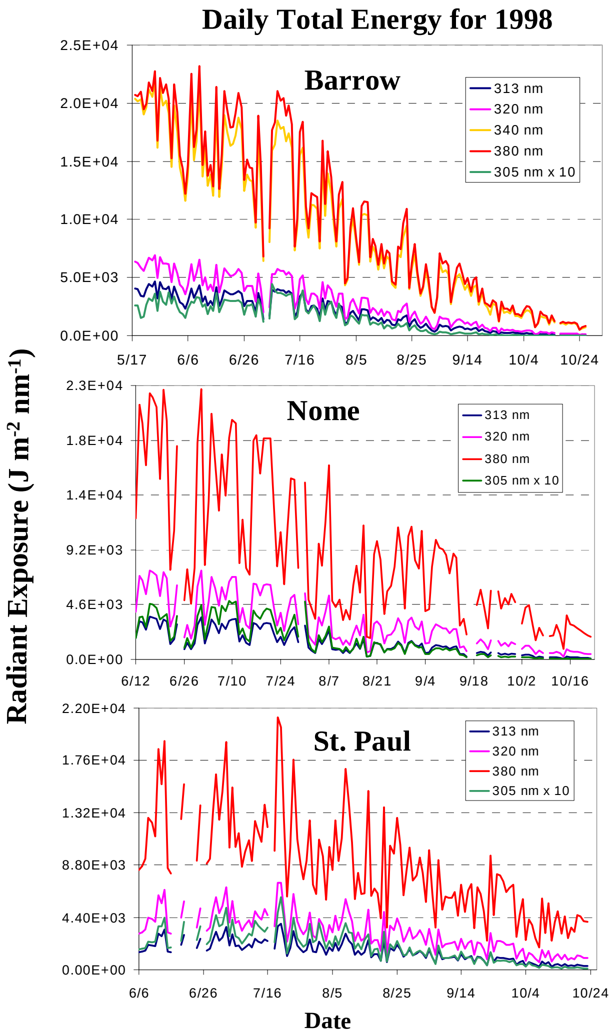


Fig. 3.24. The 1998 daily total energy for Barrow, Nome, and St. Paul, Alaska.

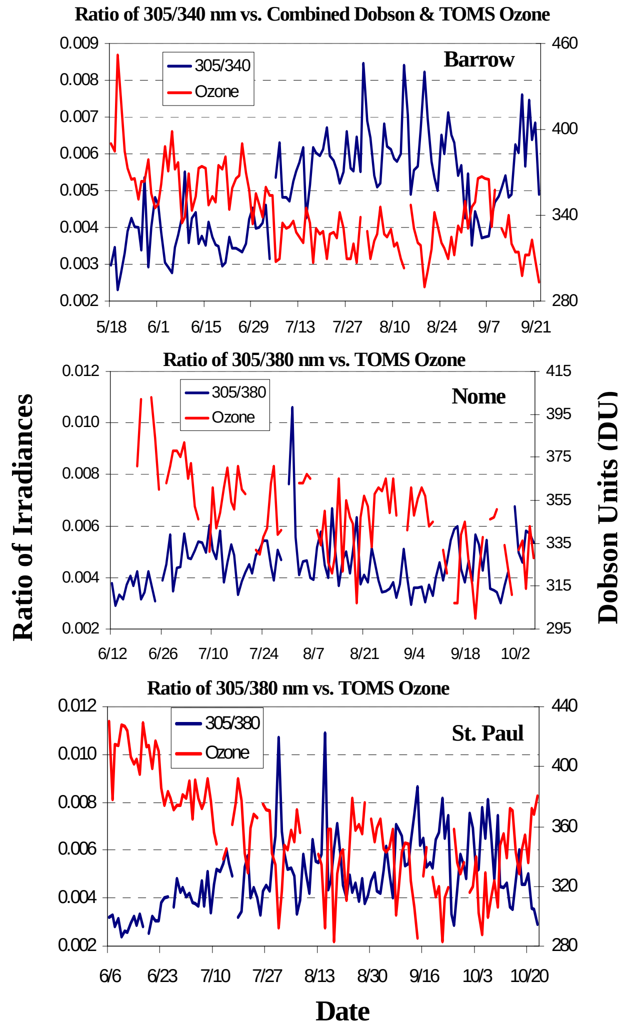


Fig. 3.25. The 1998 time series of ozone and UV for Barrow, Nome, and St. Paul, Alaska.

Nome and 11 days missing for St. Paul. However, this allowed a sufficient sample size to obtain significant correlations. Figure 3.25 shows the time series of the ratio of irradiances and ozone at the three sites using the shortest wavelength of 305 nm, to illustrate the direct correspondence between these two variables. Figure 3.26 shows three regressions demonstrating the correlation between ozone and the 305-nm/380-nm wavelengths (305-nm/340-nm for BRW). As expected there is a strong negative correlation between ozone and UV at the 305 nm wavelength at both Barrow and St. Paul. However, there is only a weak negative correlation at Nome. It is not clear why Nome would have such a significant difference from the other two sites. It is possible that the Nome UV instrument is being affected by pollutants emitted from aircraft, since the installation is on the roof of the NWS office right next to the airport. This will necessitate further investigation.

A multiple linear regression analysis was conducted using UV (the ratio of the irradiances for the 305-, 313-, and 320-nm wavelengths, but individually for 340 and 380 nm, and PAR), ozone, and cloud cover. Cloud cover data were obtained from the NOAA National Climatic Data Center. The cloud cover is a fraction of the total celestial dome in tenths. In order to ensure equality across all three variables, the cloud cover value most closely matching the period of time for the AM and PM values of UV observations was used. The relative strengths of the individual predictors (ozone and clouds) with the five wavelengths are shown in Table 3.10 for Nome and St. Paul and in Table 3.11 for Barrow. As expected the bivariate correlations between ozone and the shorter wavelengths (305, 313, and 320 nm) are negative at all three sites with the strongest relationship seen for Barrow and St. Paul. There is no relationship between ozone and UV at the 380-nm and PAR (400-700 nm) wavelengths, as expected. On the basis of the correlation analyses with ozone and clouds, ozone alone contributed most of the variance in UV at 305, 313, and 320 nm. The cloud cover fraction offers little additional predictive power in the regression model summary, although the correlations (Tables 3.10 and 3.11) at the longer wavelengths at St. Paul and Barrow (380 nm) and at all five wavelengths at Nome are significant. For St. Paul and Barrow this would be expected, given that the 380-nm

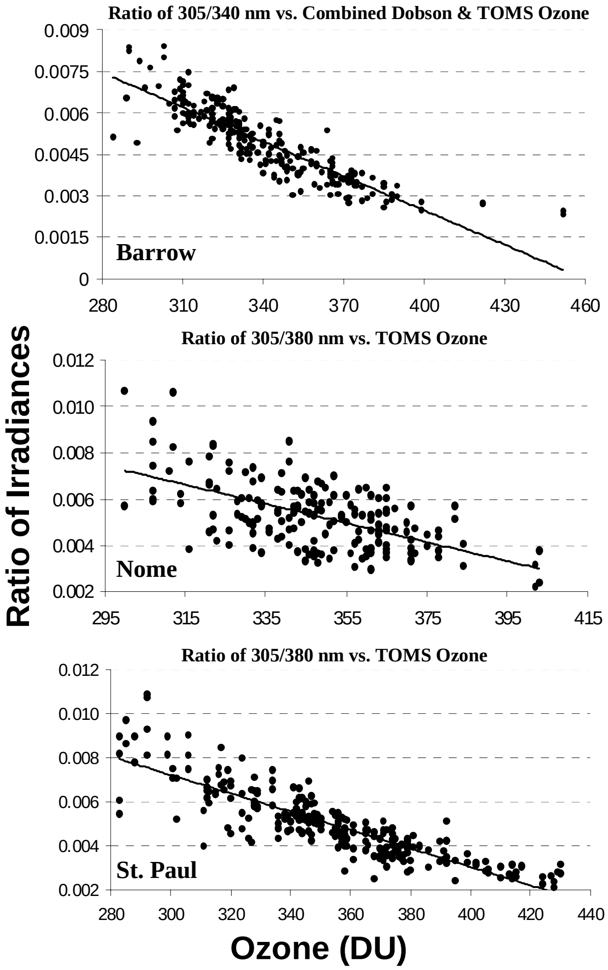


Fig. 3.26. The 1998 linear regressions of UV and ozone at Barrow, Nome, and St. Paul, Alaska. For all three sites, the regression equation is $y = (-4 \times 10^{-5}) \times +0.02$. The Pearson product-moment correlation coefficient (r) for Barrow, Nome, and St. Paul was 0.88 (n = 248), 0.58 (n = 178), and 0.87 (n = 254), respectively.

wavelength and PAR are more influenced by clouds instead of ozone. It is not entirely clear why there are significant correlations between clouds and all five wavelengths at Nome.

TABLE 3.10. The 1998 Nome and St. Paul Pearson Correlations (r) Between Each Predictor (Ozone and Clouds) and UV

| | Nome (64ºN, 165ºW) | | St Paul (57ºN, 170ºW) | |
|---|---|---|---|---|
| Wavelength | TOMS (n = 178) | Clouds (n = 225) | TOMS (n = 254) | Clouds (n = 261) |
| 305 nm/380 nm | -0.58* | 0.26* | -0.87* | -0.01 |
| 313 nm/380 nm | -0.43* | -0.26* | -0.79* | 0.03 |
| 320 nm/380 nm | -0.27* | 0.27* | -0.59* | 0.09 |
| 380 nm | 0.10 | -0.28* | 0.01 | -0.29* |
| 400-700 nm (PAR) | 0.06 | -0.27* | -0.01 | -0.30* |

*Correlation is significant at the 0.01 level (2 tailed).

TABLE 3.11. The 1998 Barrow Pearson Correlations (r) Between Each Predictor (Ozone and Clouds) and UV

| Wavelength | Dobson (n = 115) | TOMS (n = 246) | Combined (n = 248) | Clouds |
|---|---|---|---|---|
| 305 nm/340 nm | -0.90* | -0.91* | -0.88* | -0.06 |
| 313 nm/340 nm | -0.83* | -0.87* | -0.83* | -0.03 |
| 320 nm/340 nm | -0.62* | -0.70* | -0.65* | 0.01 |
| 340 nm | 0.39* | 0.41* | 0.49* | -0.12 |
| 380 nm | 0.34* | 0.36* | 0.34* | -0.15† |

*Correlation is significant at the 0.01 level.
†Correlation is significant at the 0.05 level.

***Conclusions***

The existence of these three new sites in Alaska greatly enhances the capability of monitoring UV in the arctic. The data are currently being archived at CMDL and are available to any user upon request. As shown in this preliminary analysis, the data can be used to investigate the relationship between changes in ozone and changes in UV. With a continued decrease in ozone in the arctic (as demonstrated by the SAGE III Ozone Loss and Validation Experiment), these three sites provide an excellent opportunity to establish baseline values of UV in the Alaskan arctic. The data can be used to determine column ozone amounts (for comparison with the Dobson spectrophotometer at Barrow), UV doses, and cloud effects. The data can be used to test and validate algorithms aimed at determining surface UV exposure in the arctic from satellite data. Finally, the data can be used by ecologists who are interested in studying the potential effects of increasing UV on arctic marine and terrestrial ecosystems, as well as on human health.