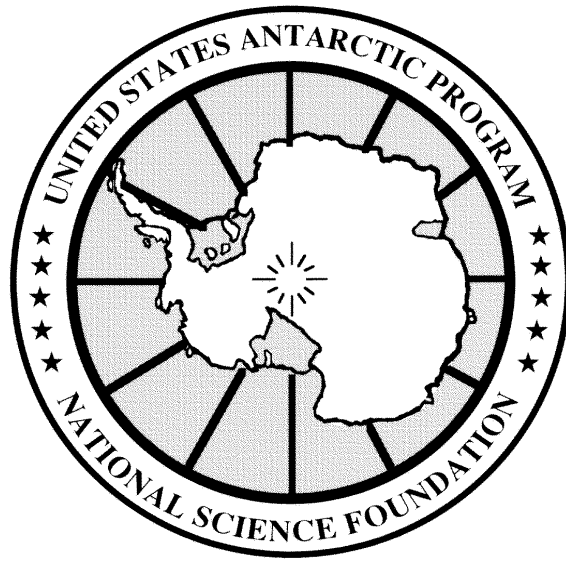


# Appendices





## A1. Errata

Over the past few years we have enhanced our data processing techniques and quality assurance measures. In doing so, we have discovered errors and inconsistencies in earlier volumes of the NSF UV Network CD-ROMs. This section describes all known flaws in previously published data and documentation.

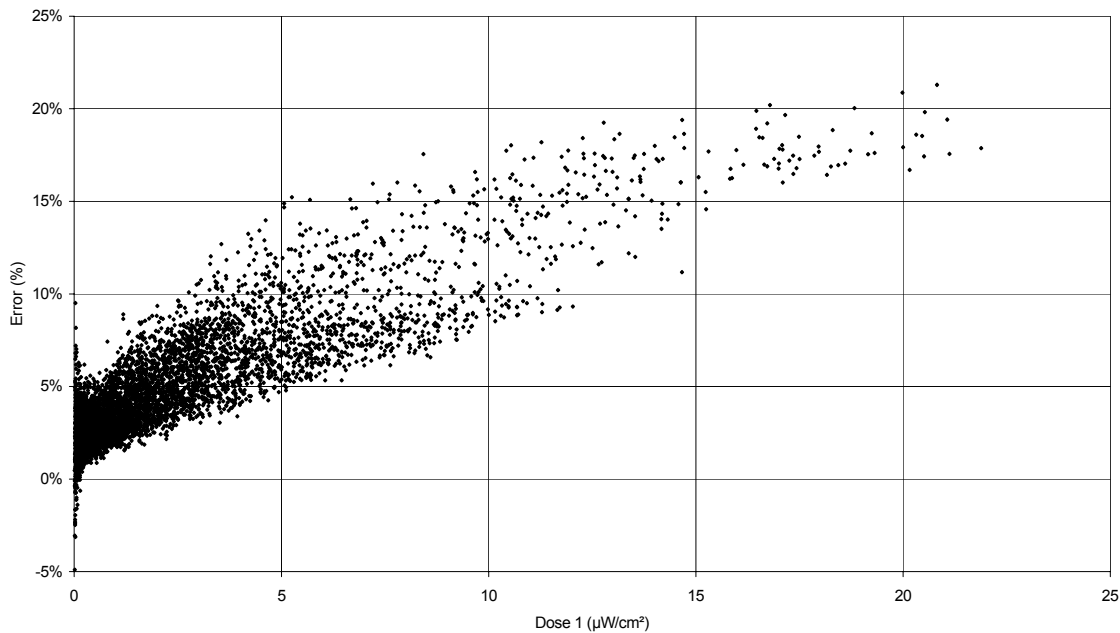
On the CD-ROM Volumes 1-5 erythema dose 1 was calculated incorrectly. Weighted function

$$W(\lambda) = \frac{0.04485}{1 + \frac{\exp\{\lambda - 311.4\}}{3.13}} + \frac{4 \cdot 0.9949 \cdot \exp\left\{\frac{\lambda - 296.5}{2.692}\right\}}{1 + \exp\left\{\frac{\lambda - 296.5}{2.692}\right\}^2}$$

was coded instead of

$$W(\lambda) = \frac{0.04485}{1 + \exp\left\{\frac{\lambda - 311.4}{3.13}\right\}} + \frac{4 \cdot 0.9949 \cdot \exp\left\{\frac{\lambda - 296.5}{2.692}\right\}}{\left\{1 + \exp\left\{\frac{\lambda - 296.5}{2.692}\right\}\right\}^2}$$

As a result, the dose was overestimated by approximately 5%-10%. Figure A.1.1 illustrates the effect of this error on Palmer dataset April 1995 - April 1997 (11,000 observations). This error does not appear in the other more popular erythemal doses.



**Figure A.1.1** Inaccuracy in Palmer 1995 – 1997 data caused by error in dose 1 calculation.

Due to an error in the early versions of the decoding software, the spectral integral 303.507-307.693 nm was calculated instead of the integral 303.03-307.692 nm. This error affected Column 14 of Database Three on the first three volumes of the CD-ROM. Also, on the same CD-ROMs, Column 21 of Database Two was incorrectly reported as being calculated from Item 2. In actuality, 313.5 nm irradiance is obtained from Item 1.

On CD-ROM Volumes 2 and 3 the time/date stamps in the databases (in both \*.csv and \*.xls files), are truncated after the hundredths value of the Microsoft Excel time/date format. This means that only the date

and hour of the data record are accurate. In order to obtain the correct time, users are encouraged to add four minutes to the beginning of the data scan as identified by the scan name. This error did not affect the recorded solar angles since they were calculated using the correct time.

Starting with CD-ROM Volume 4, there were several improvements in the data processing that resulted in minor inconsistencies with the earlier volumes. These changes are listed in Table A.1.1.

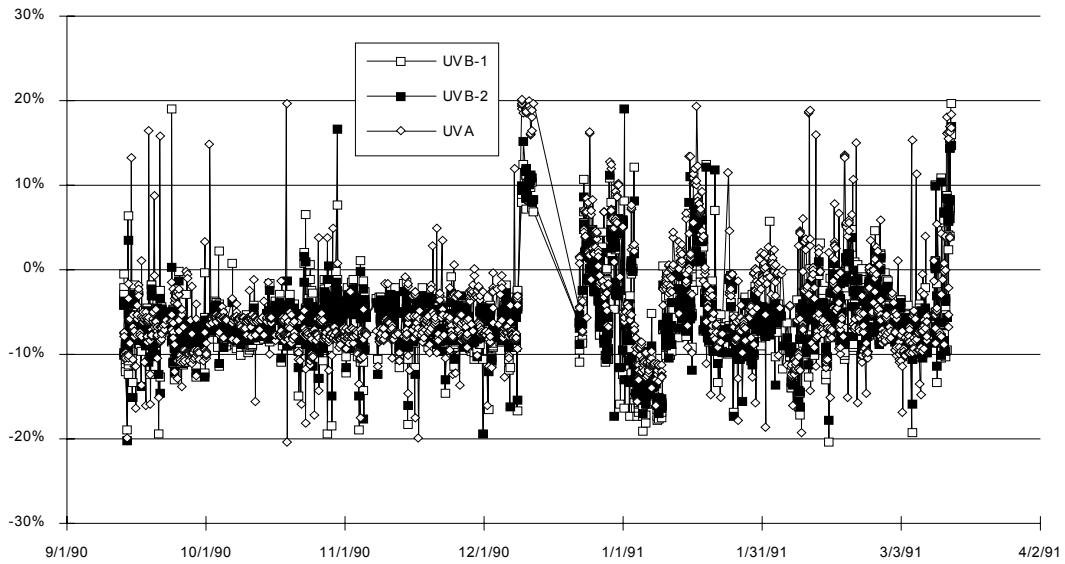
**Table A.1.1. Changes in data processing.**

Parameter	Location		Change
	Database	Col.	
Error Code	1	2	Reports errors encountered by each item of the data scan and corresponding response and wavelength scans, e.g. "0 0 0(R: 0 0 0 0 0 W: 0 0 0 0 0 0 0)" means no error condition.
	5	2	Reports errors encountered by each item of the response and corresponding wavelength scans, e.g. "0 0 0 0 0(W: 0 0 0 0 0 0 0)" means no error condition.
Time / Date	1	8	Extracted from Item 1 and not from Item 3, as before.
	2,3, and 4	2	Identifies the beginning of the second item of the data scan in order to be consistent with calculations of the solar angles and major integrals (previously extracted from Item 3).
TSI coefficient of variation	1	37	Measured as $StDev /  Mean $ based on data from all items. Formerly was obtained from the first item as $StDev / (n Mean)$ , where $n$ was the number of AXSS readings in Item 1.
	4	16	
Dark current standard deviation	1	38-40	Calculated as variance and used instead of the parameter reported earlier as "Dark current coefficient of variation."
TSI	4	13	An average of all readings taken during data scan, while before it was defined as $(Mean_1 + Mean_2 + Mean_3) / 3$ , where $Mean$ was an averaged value from the corresponding item.
Eppley PSP		14	
Eppley TUVR		15	
	1	41-49	These columns were sacrificed to reduce the database size.

Barrow and Ushuaia data presented on CD-ROM Volume 1 were inaccurate. Barrow data were revised and published on the next CD-ROM. As shown in Figure A.1.2, data from Ushuaia were underestimated by up to 8%. The corrected data are now available upon request from Biospherical Instruments Inc. Also, minor gaps in the data reported on Volume 1 have been restored and are available.

In Volume 6 data on CD-ROM, several scans were published, when the instrument was saturated. Primarily data from Ushuaia and San Diego were affected. These scans should not be used. Scan names are compiled in Table A.1.2.

There has also been a revision of the documentation. In the *Weather* section of the Appendix of Operations Reports 1991-1993 and 1993-1994, the precipitation amounts (in mm) for codes 991-998 in Table 3590 (the last table in the report) were inadvertently omitted.



**Figure A.1.2.** Inaccuracy in Ushuaia 1990 data measured as  $\frac{\text{CDROMvalue} - \text{RevisedValue}}{\text{RevisedValue}}$  for three major variables.

**Table A.1.2 Saturated scans of Volume 6**

McMurdo	DD971200.063	DD972100.078	ED971615.016	ED972030.025
AD960700.039	DD972000.063	DD971200.079	ED971600.017	ED972045.025
AD961000.356	DD972100.063	DD971200.079	ED971615.017	ED972100.025
Palmer	DD972100.063	DD971200.079	ED972345.017	ED972115.025
BD971000.024	DD972100.063	DD971300.079	ED971600.018	ED972130.025
BD971000.030	DD972200.063	DD971300.079	ED971615.018	ED972145.025
BD971100.030	DD972200.063	DD971300.079	ED972345.018	ED972200.025
BD972300.034	DD971300.064	DD971400.079	ED971600.019	ED972215.025
Ushuaia	DD971100.065	DD971300.082	ED971615.019	ED972230.025
DD971100.036	DD971200.065	DD971300.082	ED971545.020	ED972245.025
DD972100.037	DD972100.065	DD971300.082	ED972345.021	ED972300.025
DD972300.037	DD971100.066	DD971300.089	ED971600.022	ED972315.025
DD972200.038	DD971300.066	DD971200.090	ED972000.024	ED972330.025
DD971100.039	DD972000.068	DD971300.090	ED972015.024	ED972345.025
DD971200.039	DD972100.069	DD971500.090	ED972030.024	ED970000.026
DD971100.041	DD971200.070	DD971800.090	ED972045.024	ED970015.026
DD971200.041	DD971200.070	DD972000.090	ED972100.024	ED970030.026
DD971000.042	DD971200.070	DD972030.090	ED972115.024	ED970045.026
DD971100.043	DD971400.070	San Diego	ED972130.024	ED970100.026
DD971100.045	DD971400.070	ED961430.238	ED972145.024	ED971500.026
DD971100.046	DD971400.070	ED961530.315	ED972200.024	ED971515.026
DD972200.046	DD972000.070	ED961545.333	ED972215.024	ED971530.026
DD971100.047	DD972100.070	ED961600.334	ED972230.024	ED971545.026
DD971300.047	DD971100.071	ED962315.334	ED972245.024	ED971600.026
DD971200.049	DD971200.071	ED961545.335	ED972300.024	ED971615.026
DD971300.049	DD971200.071	ED961600.335	ED972315.024	ED971630.026
DD971100.050	DD971200.071	ED962315.335	ED972330.024	ED971645.026
DD971200.050	DD971400.071	ED961545.336	ED972345.024	ED971700.026
DD971100.051	DD971400.071	ED961600.336	ED970000.025	ED971715.026
DD971100.052	DD971400.071	ED962315.336	ED970015.025	ED971730.026
DD972100.052	DD971200.072	ED961545.337	ED970030.025	ED971745.026
DD971100.053	DD971200.072	ED961600.337	ED970045.025	ED971800.026
DD971200.053	DD971200.072	ED962315.337	ED970100.025	ED971815.026
DD972200.054	DD971400.072	ED961600.338	ED970115.025	ED971830.026
DD971100.055	DD972100.072	ED961600.339	ED971445.025	ED971845.026
DD971200.055	DD971100.073	ED961600.340	ED971500.025	ED971900.026
DD971300.055	DD971100.073	ED961600.342	ED971515.025	ED971915.026
DD971200.056	DD971200.073	ED961600.343	ED971530.025	ED971930.026
DD972200.056	DD971200.073	ED961600.350	ED971545.025	ED971945.026
DD971200.057	DD971200.073	ED961600.351	ED971600.025	ED972000.026
DD972200.057	DD971400.073	ED961600.354	ED971615.025	ED972015.026
DD972000.058	DD971400.073	ED961600.357	ED971630.025	ED972030.026
DD972000.059	DD971400.073	ED961600.358	ED971645.025	ED972045.026
DD972000.059	DD972000.073	ED961615.359	ED971700.025	ED972100.026
DD971100.060	DD972100.073	ED961600.360	ED971715.025	ED972115.026
DD971200.060	DD972100.074	ED961615.360	ED971730.025	ED972130.026
DD971300.060	DD971200.076	ED961545.364	ED971745.025	ED972145.026
DD972000.060	DD971200.077	ED961600.364	ED971800.025	ED972200.026
DD972200.060	DD971400.077	ED971600.004	ED971815.025	ED972215.026
DD972000.061	DD971400.077	ED971615.004	ED971830.025	ED972230.026
DD972200.061	DD971200.078	ED971615.006	ED971845.025	ED972245.026
DD971100.062	DD971200.078	ED972330.006	ED971900.025	ED972300.026
DD971200.062	DD971200.078	ED971615.007	ED971915.025	ED972315.026
DD971300.062	DD971300.078	ED971615.008	ED971930.025	ED972330.026
DD972200.062	DD971900.078	ED971615.009	ED971945.025	ED972345.026
DD972200.062	DD972100.078	ED971615.010	ED972000.025	ED971330.148
DD971100.063	DD972100.078	ED971600.015	ED972015.025	

## A2. References

*Note:* \* References that utilize NSF UV Spectroradiometer Network data

- Anderson, S., J. Hoffman, G. Wild, I. Bosch, and D. Karentz. (1993). Cytogenetic, cellular, and developmental responses in Antarctic sea urchins (*Sterechinus neumayeri*) following laboratory ultraviolet-B and ambient solar radiation exposures. *Antarctic Journal of the United States, 1993 Review*, 28(5), 115-116.\*
- Bais, A.F., C.S. Zerefos, C. Meleti, I.C. Ziomas, and K. Tourpali. (1993). Spectral measurements of solar UV-B radiation and its relations to total ozone, SO<sub>2</sub>, and clouds, *J. Geophys. Res.*, 98, 5199-5204.
- Bais, A. F., B.G. Gardiner, H. Slaper, M. Blumthaler, G. Bernhard, R. McKenzie, A.R. Webb, G. Seckmeyer, B. Kjeldstad, T. Koskela, P. Kirsch, J. Gröbner, J.B. Kerr, S. Kazadzis, K. Leszczynski, D. Wardle, C. Brogniez, W. Josefsson, D. Gillotay, H. Reinen, P. Weihs, T. Svenoe, P. Eriksen, F. Kuik, A. Redondas, (2001). The SUSPEN intercomparison of ultraviolet spectroradiometers, *Journal of Geophysical Research*, 106(D12), 12,509-12,526.\*
- Benavides, H., L. Prado, S. Díaz, and J.I. Carreto. (1994). An exceptional bloom of *Alexandrium catenella* in the Beagle Channel, Argentina. Proceedings of the 6th International Conference on Toxic Marine Phytoplankton; Nantes; October 18-22, 1993.\*
- Bernhard, G. and G. Seckmeyer, Uncertainty of measurements of spectral solar UV irradiance, *J. Geophys. Res.*, 104(D12), 14,321-14,345, 1999.
- Bernhard, G., C.R. Booth, J.C. Ebrahimian, S.A. Lynch, and V.V. Quang. (2001). UV Spectroradiometer Monitoring Program: Influence of Total Ozone, Cloud Cover, and Surface Albedo on UV doses in Barrow, Alaska, Climate Monitoring and Diagnostics Laboratory No. 25. Summary Report 1998-1999.\*
- Bernhard G., C.R. Booth, and J.C. Ebrahimian. (2002). Comparison of measured and modeled spectral ultraviolet irradiance at Antarctic stations used to determine biases in total ozone data from various sources. in: *Ultraviolet Ground- and Space-based Measurements, Models, and Effects*, edited by J.R. Slusser, J.R. Herman, and W. Gao, Proceedings of SPIE, Vol. 4482, 115-126. Also available at [www.biospherical.com/nsf/presentations.asp](http://www.biospherical.com/nsf/presentations.asp).\*
- Bernhard G., C. R. Booth, J.C. Ebrahimian. (2003). The quality of data from the National Science Foundation's UV Monitoring Network for Polar Regions", in: *Ultraviolet Ground- and Space-based Measurements, Models, and Effects II*, edited by J.R. Slusser, J.R. Herman, and W. Gao, Proceedings of SPIE, Vol. 4896, in press. Also available at [www.biospherical.com/nsf/presentations.asp](http://www.biospherical.com/nsf/presentations.asp).\*
- Blumthaler, M. and W. Ambach. (1988). Solar UVB-albedo of various surface, *Photochem. Photobiol.*, 48(1), 85-88.
- Blumthaler M., W. Ambach, and M. Salzgeber. (1994a). Effects of cloudiness on global and diffuse UV irradiance in a high-mountain area, *Theoretical and Applied Climatology*, 50, 23-30.
- Blumthaler M., A.R. Webb, G. Seckmeyer, A.F. Bais, M. Huber, and B. Mayer. (1994b). Simultaneous spectroradiometry: a study of solar UV irradiance at two altitudes, *Geophys. Res. Lett.*, 21(25), 2805-2808.
- Blumthaler, M., W. Ambach, and R. Ellinger. (1997). Increase in solar UV radiation with altitude, *J. Photochem. Photobiol. B: Biology*, 39, 130-134.

- Bodeker, G.E., and R.L. McKenzie. (1996). An algorithm for inferring surface UV irradiance including cloud effects, *J. Appl. Meteorol.*, 35, 1860-1877.
- Bojkov, R.D., V.E. Fioletov, and S.B. Díaz. (1995). The relationship between solar UV irradiance and total ozone from observations over southern Argentina. *Geophysical Research Letters*, 22(10), 1249-1252.\*
- Booth, C.R., C.S. Weiler, and P.A. Penhale. (1988). Collection and distribution of data from the United States Antarctic Program's UV Monitoring Network. *Workshop on Ultraviolet Radiation and Biological Research in Antarctica*, edited by C.S. Weiler. 23-24. NSF publication 88-108.\*
- Booth, C.R., T.B. Lucas, J. Yeh, and D.A. Neuschuler. (1990). Antarctic Ultraviolet Spectroradiometer Monitoring Program. *Climate Monitoring and Diagnostics Laboratory, Summary Report 1989*, edited by W.D. Komhyr, U.S. Dept. of Commerce, Boulder, Colorado, 18, 85-87.\*
- Booth, C.R., T.B. Lucas, J.H. Morrow, D. Neuschuler, J. Tusson, and J. Yeh. (1991). Antarctic Ultraviolet Spectroradiometer Monitoring Program: South Pole and Barrow contrasts in UV Irradiance. *Climate Monitoring and Diagnostics Laboratory, Summary Report 1990*, U.S. Dept. of Commerce, Boulder, 19, 83-84.\*
- Booth, C. R., T. B. Lucas, T. Mestechkina, J. Tusson, D. Neuschuler, and J. Morrow. (1992). *NSF Polar Programs UV Spectroradiometer Network 1991-1992 Operations Report*. National Science Foundation/Biospherical Instruments, Biospherical Instruments Inc., San Diego, CA.\*
- Booth, C.R., T.B. Lucas, J.H. Morrow, and T. Mestechkina. (1992). Antarctic Ultraviolet Spectroradiometer Monitoring Program: South Pole and Barrow Contrasts in UV Irradiance. *Climate Monitoring and Diagnostics Laboratory, Summary Report 1991*, U.S. Dept. of Commerce, Boulder, 20, 87-88.\*
- Booth, C.R., T.B. Lucas, and J.H. Morrow. (1992). High resolution UV spectral irradiance monitoring program in polar regions: Five years (and growing) of data available to polar researches in ozone- and ultraviolet-related studies. *Antarctic Journal of the United States, 1992 Review*, 27, 338-341.\*
- Booth, C.R., T.B. Lucas, J.R. Tusson IV, J.H. Morrow, and T. Mestechkina. (1993). Antarctic Ultraviolet Spectroradiometer Monitoring Program: South Pole and Barrow Contrasts in UV Irradiance. *Climate Monitoring and Diagnostics Laboratory, Summary Report 1992*, U.S. Dept. of Commerce, Boulder, Colorado, 21, 81-83.\*
- Booth, C.R., T.B. Lucas, and J.H. Morrow. (1993). High resolution UV spectral irradiance monitoring program in polar regions - Six years (and growing) of data available to polar researches in ozone- and ultraviolet-related studies. *Antarctic Journal of the United States, 1993 Review*, 28(5), 338-341.\*
- Booth, C.R., and S. Madronich. (1994). Radiation amplification factors: improved formulation accounts for large increases in ultraviolet radiation associated with Antarctic ozone depletion. *Antarctic Research Series*, edited by C.S. Weiler and P.A. Penhale, 62, 39-42.\*
- Booth, C. R., T. B. Lucas, T. Mestechkina, J.R. Tusson VI, D.A. Neuschuler, and J.H. Morrow. (1993). *NSF Polar Programs UV Spectroradiometer Network 1991-1993 Operations Report*. National Science Foundation/Biospherical Instruments Inc., San Diego, CA.\*
- Booth, C.R., T.B. Lucas, J.H. Morrow, C.S. Weiler, and P.A. Penhale. (1994). The United States National Science Foundation's polar network for Monitoring Ultraviolet Radiation. *Antarctic Research Series*, edited by C.S. Weiler and P.A. Penhale, 62, 17-37.\*
- Booth, C.R., T.B. Lucas, J.R. Tusson IV, J.H. Morrow, and T. Mestechkina. (1994). Antarctic Ultraviolet Spectroradiometer Monitoring Program: Contrasts in UV Irradiance at the South Pole and Barrow, Alaska. *Climate Monitoring and Diagnostics Laboratory, Summary Report 1993*, U.S. Dept. of Commerce, Boulder, Colorado, 22, 98-100.\*



- Booth, C.R., T.B. Lucas, T. Mestechkina, and J. Tusson. (1994). High resolution UV spectral irradiance monitoring program in polar regions: nearly a decade of data available to polar researchers in ozone and UV-related studies. *Antarctic Journal of the United States*, 1994 , 29(5), 256-259.\*
- Booth, C. R., T. B. Lucas, T. Mestechkina, and J. Tusson IV. (1995). High-resolution ultraviolet spectral irradiance monitoring program in polar regions-Nearly a decade of data available to polar researchers in ozone and ultraviolet-related studies. *U. S. Antarctic Journal. Review 1994*. NSF.\*
- Booth, C.R., T.B. Lucas, T. Mestechkina, J.R. Tusson IV, J.P. Schmidt, D.A. Neuschuler, and J.H. Morrow (1996). NSF Polar Programs UV Spectroradiometer Network 1994-1995 Operations Report, 182 pp., Biospherical Instruments Inc., San Diego, CA.\*
- Booth, C. R., T. B. Lucas, T. Mestechkina, J. Schmidt, and J. Tusson IV. (1996). High Resolution UV Spectral Irradiance Monitoring Program - Contrasts in UV Exposure in Antarctica and the Americas. *U. S. Antarctic Journal. Review 1995*. \*
- Booth, C.R. (1997). "Synthetic Spectroradiometry", IRS '96: Current Problems in Atmospheric Radiation, ed. W.L. Smith and K. Stamnes, Deepak, Hampton, VA, 849-852.\*
- Booth, C.R., et al. (1997). Invited Review: Impacts of solar UVR on aquatic microorganisms. *Photochemistry and Photobiology*, 65(2), 252-269.\*
- Booth, C. R., J.H. Morrow, T.P. Coohill, J.J. Cullen, J.E. Frederick, D.P. Hader, O. Holm-Hansen, W.H. Jeffrey, D.L. Mitchell, P.J. Neale, I. Sobolev, J. van der Leun, R.C. Worrest. (1997). Impacts of solar UVR on aquatic microorganisms. *Photochemistry and Photobiology*, 65(2), 252-253.
- Booth, C. R., J. Ebrahimian, T. Mestechkina, L. Cabasug, J. Robertson, Tusson, J., IV. (1998). *NSF Polar Programs UV Spectroradiometer Network 1995-97 Operations Report*. National Science Foundation/Biospherical Instruments Inc., San Diego, CA. \*
- Booth, C. R. and J. R. Tusson. (1998). Proceedings of the International Symposium on Environmental Research in the Antarctic. *Mem. Natl. Inst. Polar Res. (Japan)*, Spec. Issue, 52, 111-121.\*
- Booth, C.R., G. Bernhard, J.C. Ebrahimian, L.W. Cabasug, V.V. Quang, and S.A. Lynch. (2000). NSF Polar Programs UV Spectroradiometer Network 1997-1998 Operations Report, 231 pp., United States National Science Foundation/Biospherical Instruments Inc., San Diego, CA.\*
- Booth, C.R., G. Bernhard, J.C. Ebrahimian, L.W. Cabasug, V.V. Quang, and S.A. Lynch. (2000). NSF Polar Programs UV Spectroradiometer Network 1998-1999 Operations Report, 218 pp., United States National Science Foundation/Biospherical Instruments Inc., San Diego, CA.\*
- Bordewijk, J.A., H. Slaper, H., H.A.J.M. Reinen, and E. Schlamann. (1995). Total solar radiation and the influence of clouds and aerosols on the biologically effective UV, *Geophys. Res. Lett.*, 22, 2151-2154.
- Boucher, N.P., and B.B. Prézelin. (1996). Spectral modeling of UV inhibition of *in situ* Antarctic primary production using a field-derived biological weighting function. *Photochemistry and Photobiology*, 64(3), 407-418.\*
- Brühl C., and P. Crutzen. (1989). On the disproportionate role of tropospheric ozone as a filter against solar UV-B radiation, *Geophys. Res. Lett.*, 16(7), 703-706.
- Caldwell, M.M. (1971). Solar UV irradiation and the growth and development of higher plants. *Photophysiology*, edited by A.C. Giese, 6, 131-177.

- Chubarova, N. Y., N. A. Krotkov, I. V. Geogdzhazev, T. V. Kondranin, and V. U. Khattatov. (1997). Spectral irradiance: the effects of ozone, cloudiness and surface albedo. *Proceedings of the International Radiation Symposium, Fairbanks, AL\**
- Climate Monitoring and Diagnostics Laboratory (CMDL). (2002). Summary Report No. 26: 2000-2001, U.S. Dept. of Commerce, Boulder.
- Corell, R. W., The U.S. Interagency UV-Monitoring Network Plan, U.S. Global Change Research Program, USGCRP-95-01, National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230.
- Cullen, J.C., P.J. Neale, and M.P. Lesser. (1992). Biological Weighting Function for the Inhibition of Phytoplankton Photosynthesis by Ultraviolet Radiation. *Science*, 258, 646-650.\*
- Day, T. A., C. W. Grobe, and C. T. Ruhland. (1998). Impacts of climate change on Antarctic vascular plants: Warming and ultraviolet-B radiation. *Antarctic Journal Review 1996*. NSF98-28, 226-227.
- Day, T.A., Ruhland, C.T., Grobe, C.W., and Xiong, F. (in press). Growth and reproduction of Antarctic vascular plants in response to warming and UV-radiation reductions in the field. *Oecologia*.
- Dahlback, A. (1996). Measurements of biologically effective UV doses, total ozone abundances, and cloud effects with multichannel, moderate bandwidth filter instruments. *Applied Optics*, 35(33), 6514-6521.\*
- d'Almeida, G.A., P. Koepke, and E.P. Shettle., (1991). Atmospheric aerosols: their global climatology and radiative characteristics, 561 pp., A. Deepak, Hampton, Va.
- Degünther M., R. Meerkoetter, A. Albold, and G. Seckmeyer. (1998). Case study on the influence of inhomogeneous surface albedo on UV irradiance, *Geophys. Res. Lett.*, 25, 3587-3590.
- Díaz, S.B., J.L. Verdile, C.R. Booth, and T. Lucas. (1990). Medición de la radiación ultravioleta solar sobre. *Proceedings of the Simposio Latinoamericano Sobre Medio Ambiente y Ecología*.\*
- Díaz, S.B., C.R. Booth, T.B. Lucas, and I. Smolskaia. (1991). Evolución de la radiación ultravioleta sobre Ushuaia desde Noviembre de 1988. *Proceedings of Congremet VI. Meteorological Centre in Argentina*.\*
- Díaz, S.B., C.R. Booth, T.B. Lucas, and I. Smolskaia. (1994). Effects of ozone depletion on irradiances and biological doses over Ushuaia. *Arch. Hydrobiol. Beih: Ergebn. Limnol.*, 43, 115-122.\*
- Díaz, S.B., J.E. Frederick, I. Smolskaia, W. Esposito, T.B. Lucas, and C.R. Booth. (1994). Ultraviolet solar radiation in the high latitudes of South America. *Photochemistry and Photobiology*, 60(4), 356-362.\*
- Díaz, S. B., J. E. Frederick, T. Lucas, C. R. Booth, and I. Smolskaia. (1996). Solar ultraviolet irradiance at Tierra del Fuego: Comparison of measurements and calculations over a full annual cycle. *Geophysical Res. Let.* 23(4), 355-358.\*
- Díaz, H. G., Avaria, S., V. E. Villafane, E. W. Helbling. (1997). Acclimation and sensitivity of Antarctic phytoplankton species to solar ultraviolet radiation. *Revista de Biología Marina y Oceanografía*, 32(2), 157-175.
- Díaz, S. B., J. H. Morrow, and C. R. Booth. (2000). UV Physics and Optics; in: *The effects of UV radiation in the marine environment*, edited by , S. de Mora, S. Demers, and M. Vernet. Cambridge environmental chemistry series 10, Cambridge University Press.\*
- Díaz, S.B, G. Deferrari, C.R. Booth, D. Martinioni, and A. Oberto. (2001). Solar irradiances over Ushuaia (54.49° S, 68.19° W) and San Diego (32.45° N, 117.11° W) geographical and seasonal variation. *Journal of Atmospheric and Solar-Terrestrial Physics*, 63, 309-320.\*

- Diffey, B.L. (1987). A comparison of dosimeters used for solar ultraviolet radiometry. *Photochemistry and Photobiology*, 46, 55-60.
- Dutton, E.G., and D.J. Endres. (1991). Date of snowmelt at Barrow, Alaska, U.S.A., *Arctic Alpine Res.*, 23(1), 115-119.
- Early, A., Thompson, A., Johnson, C., DeLuisi, J., Disterhoft, P., Wardle, D., Wu, E., Mou, W., Sun, Y., Lucas, T., Mestechkina, T., Harrison, L., Berndt, J., and Hayes, D. (1998). The 1995 North American Interagency Intercomparison of Ultraviolet Monitoring Spectroradiometers. *J. Res. Natl. Inst. Stand. Technol.* 103(1), 15.\*
- Early, E. A., Thompson, E. A., and P. Disterhoft. (1998). Field calibration unit for ultraviolet spectroradiometers. *Applied Optics*, 37(28), 6664-6670.
- Ehramjian, J.C., C.R. Booth, L.W. Cabasug, J.S. Robertson, and T. Mestechkina. (1998). Antarctic UV Spectroradiometer Monitoring Program: Contrasts in UV Irradiance at the South Pole and Barrow, Alaska, *Climate Monitoring and Diagnostics Laboratory, Summary Report 1996-1997*, U.S. Dept. of Commerce, Boulder, Colorado, 24, 126 - 128.\*
- Farman, J.C., B.G. Gardiner and J.D. Shanklin, (1985). Large losses of total ozone in Antarctica reveal seasonal ClO<sub>x</sub>/NO<sub>x</sub> interaction. *Nature*, 315, 207-210.
- Fioletov, V.E., L.J.B. McArthur, J.B. Kerr, D.I. Wardle, Long-term variations of UV-B irradiance over Canada estimated from Brewer observations and derived from ozone and pyranometer measurements *J. Geophys. Res.*, 106(D19) 23009-23027, 2001.
- Frederick, J.E., and H.E. Snell. (1988). Ultraviolet radiation levels during the Antarctic spring. *Science*, 241, 438-440.
- Frederick, J.E., A.D. Alberts. (1991). Prolonged enhancement in surface ultraviolet radiation during the Antarctic spring of 1990. *Geophysical Research Letters*, 18(10), 1869-1871.\*
- Frederick, J.E., P.F. Soulen, S.B. Diaz, I. Smolskaia, C.R. Booth, T.B. Lucas and D.A. Neuschuler (1993): Solar ultraviolet irradiance observed from southern Argentina: September 1990 to March 1991. *Journal of Geophysical Research*, 98(D5), 8891-8897.\*
- Frederick, J. E., D. Lubin. (1994). Solar Ultraviolet Irradiance at Palmer Station, Antarctica. *Antarctic Research Series*, 62, 43-52. Eds. C.S. Weiler and P.A. Penhale, AGU, Washington, D.C.\*
- Frederick, J. E., S.B. Diaz, I. Smolskaia, W. Esposito, T. Lucas, and C.R. Booth. (1994). Ultraviolet solar radiation in the high latitudes of South America. *Photochemistry and Photobiology*, 60(4), 356-362.\*
- Frederick, J.E., C. Erlick. (1995). Trends and interannual variation in erythemal sunlight, 1987-1993. *Photochemistry and Photobiology*, 62(3), 476-484.\*
- Frederick, J. E. and C. Erlick. (1997). The attenuation of sunlight by high latitude clouds: spectral dependence and its physical mechanisms. *J. Atmos. Sci.*, 54, 2813-2819.\*
- Frederick, J. E., Z. Qu, and C. R. Booth. (1998). Ultraviolet Radiation at Sites on the Antarctic Coast. *Photochemistry & Photobiology*, 68(2), 183-190.\*
- Frederick, J. E., V.W. Manner, and C. R. Booth. (2001). Interannual variability in solar ultraviolet irradiance over decadal time scales at latitude 55° South. *Photochemistry and Photobiology*, 74(6), 771-779.\*

- Fuenzalida, H. (1998). Global ultraviolet spectra derived directly from observations of multichannel radiometers. *Applied Optics* 37(33), 7912-7919.
- Gardiner, B. G. and T. J. Martin. (1997). On measuring and modeling ultraviolet radiation. *IRS96*, 917-920.
- Gautier, C., G. He, S. Yang. (1994). Role of clouds and ozone on spectral ultraviolet-B radiation and biologically active UV dose over Antarctica. *Antarctic Research Series*, 62, 83-91, Eds. C.S. Weiler and P.A. Penhale, AGU, Washington, D.C.
- Gautier, C., P. Ricchiazzi and S. Yang. (1998). Surface UV radiation environment over the Antarctic: Role of surface and cloud processes. *Mem. Natl. Inst. Polar Res. (Japan), Spec. Issue*, 52, 122-134.
- Gautier, C., P. Ricchiazzi, and S. Yang. (1997). Could clouds partly mitigate the biological effects of ozone depletion in the Antarctica. *IRS96*, 974-979.
- Green, A.E.S., T. Sawada, and E.P. Shettle. (1974). The middle ultraviolet reaching the ground. *Photochemistry and Photobiology*, 19, 251-259.
- Grenfell, T.C., S.G. Warren, and P.C. Mullen. (1994). Reflection of solar radiation by the Antarctic snow surface at ultraviolet, visible, and near-infrared wavelengths. *J. Geophys. Res.*, 99(D9), 18,669-18,684.
- Gröbner J., A. Albold M. Blumthaler, T. Cabot. A. De la Casiniere, J. Lenoble, T. Martin, D. Masserot, M. Müller, R. Philipona, T. Pichler, E. Pougatch, G. Rengarajan, D. Schmucki, G. Seckmeyer, C. Sergent, M.L. Toure, and P. Weihs. (2000). Variability of spectral solar ultraviolet irradiance in an Alpine environment, *J. Geophys. Res.*, 105(D22), 26,991-27,003.
- Gurney, K. R. (1998). Evidence for increasing ultraviolet irradiance at Point Barrow, Alaska. *Geophysical Res. Lett.*, 25(6), 903-906.
- Harris, G.W. (1988). Specifications of the United States Antarctic Program's equipment system for monitoring UV radiation; 21-22 in, Weiler, C.S., *Workshop On Ultraviolet Radiation and Biological Research in Antarctica*, National Science Foundation, 88-108, 28 pp.
- Helbling, E. W., B. E. Chalker, W. C. Dunlap, O. Holm-Hansen, and W. E. Villefane. (1996). Photoacclimation of Antarctic marine diatoms to solar ultraviolet radiation. *J. Of Experimental Marine Biology and Ecology*, 204, 85-101.
- Herman, J.R. , R.L. McKenzie, S. Diaz, J. Kerr, S. Madronich, and G. Seckmeyer. (1999). UV Radiation at the Earth's Surface, in: UNEP/WMO Scientific Assessment of Ozone Depletion: 1998, edited by D.L. Albritton, R.T. Watson, and P.J. Aucamp, World Meteorological Organisation, Geneva
- Holm-Hansen, O. (1997). The Ecological Significance of Solar UVR in the Polar Regions. *Korean Journal of Polar Research*, 8 (1,2): 1-8.
- Holm-Hansen, O., E.W. Helbling, and D. Lubin. (1993). Ultraviolet Radiation in Antarctica: Inhibition of Primary Production. *Photochemistry and Photobiology*, 58(4), 567-570.\*
- Holm-Hansen, O. and D. Lubin. (1994). Solar Ultraviolet Radiation: Effect on Rates of CO<sub>2</sub> Fixation in Marine Phytoplankton. In: *Photosynthetic Carbon Metabolism and Regulation of Atmospheric CO<sub>2</sub> and O<sub>2</sub>*, N. E. Tolbert and J. Preiss (eds.), 55-74. Oxford Press, N.Y.
- Holm-Hansen, O., D. Lubin, and E.W. Helbling. (1993). Ultraviolet Radiation and Its Effects on Organisms in Aquatic Environments. "Environmental UR Photobiology", edited by A.R. Young et al. Plenum Press, New York. 379-425.\*

- Holm-Hansen, O., V. E. Villafane, and E. W. Helbling. (1998). Photoinhibition in Antarctic phytoplankton by ultraviolet-B radiation in relation to column ozone values. *Antarctic Journal Review* 1996; NSF98-28.
- Holm-Hansen, O., V. E. Villafañe, and E. W. Helbling. (1997). Effects of Solar Ultraviolet Radiation on Primary Production in Antarctic Waters. In: *Antarctic Communities: Species, Structure, and Survival* (B. Battaglia, J. Valencia, and D.W.H. Walton, eds.), 375-380; Cambridge University Press, Cambridge, UK.
- Hunter, J.H., J.H. Taylor, and H.G. Moser. (1979). The effect of ultraviolet irradiation on eggs and larvae of the northern anchovy, *Engraulis mordax*, and the pacific mackerel, *Scomber japonicus*, during the embryonic stage. *Photochemistry and Photobiology*, 29, 325-338.
- Johnsen, B., and M. Hannevik. (1997). "The 1995 intercomparison of UV and PAR instruments at the University of Oslo". *StralevernRapport* 1997, 7.
- Josefsson W. and T. Landelius. (2000). Effect of clouds on UV irradiance: as estimated from cloud amount, cloud type, precipitation, global radiation and sunshine duration, *J. Geophys. Res.*, 105, 4926-4935.
- Kalliskota, S., J. Kaurola, P. Taalas, J. Herman, E. Celarier and N. Krotkov. (2000). Comparison of daily UV doses estimated from Nimbus 7/TOMS measurements and ground-based spectroradiometric data, *J. Geophys. Res.*, 105(D4), 5059-5067.\*
- Karentz, D. (1994). Ultraviolet tolerance mechanisms in Antarctic marine organisms. *Antarctic Research Series*, 62, 93-110, Eds. C.S. Weiler and P.A. Penhale, AGU, Washington, D.C.
- Karentz, D. (1991). Ecological considerations of Antarctic ozone depletion. *Antarctic Science* 3, 3-11.
- Karentz, D. and L. H. Lutze. (1990). Evaluation of biologically harmful ultraviolet radiation in Antarctica with a biological dosimeter designed for aquatic environments. *Limnol. Oceanogr.*; 35(3), 549-561.
- Karentz, D., and H.J. Spero. (1995) Response of a natural Phaeocystis population to ambient fluctuations of UVB radiation caused by Antarctic ozone depletion, *J. Plankton Res.*, 17, 1771-1789.
- Karentz, D., W. C. Dunlap and I. Bosch. (1997). Temporal and spatial occurrence of UV-absorbing mycosporine-like amino acids in tissues of Antarctic Sea urchin *Sterechinus neumayeri* during springtime ozone depletion. *Marine Biology*, 129(2), 343-353.
- Karentz, D., W.C. Dunlap and I. Bosch. (1992). Distribution of UV-absorbing compounds in the Antarctic limpet, *Nacella concinna*. *Antarctic Journal of the United States* 27, 121-122.
- Koskela, T., A. Heikkila, J. Damski, P. Taalas, and A. Kylling. (1997). UV-B Radiation at common optical air masses: geographical comparison and model performance tests. *Proceedings of the International Radiation Symposium*, Fairbanks, AL.
- Komhyr, W.D., and L. Machta. (1973). *The Perturbed Troposphere of 1990 and 2020*, 28 Feb - 3March 1973. Vol. IV. CIAP, Dept. of Transportation, Washington, DC.
- Kostkowski, H.J. (1979). The relative spectral responsivity and slit-scattering function of a spectroradiometer, Chapter 7 in *NBS Technical Note 910-4*, U.S. Government Printing office, Washington.
- Krotkov, N. A., P. K. Bhartia, J. Herman, E. Celarier, and T. Eck. (1997). Estimates of spectral UVB irradiance from the TOMS instrument: effects of clouds and aerosols. *IRS '96*, 873-876.

- Krueger, A.J. Editor. (1987). Scientific and Operational Requirements for TOMS Data. *NASA Conference Publication 2497*.
- Krueger, A.J., P.E. Ardanuy, F.S. Sechrist, L.M. Penn, D.E. Larko, S.D. Doiron, and R.N. Galimore. (1988). The 1987 Airborne Antarctic Ozone Experiment - The Nimbus-7 TOMS Data Atlas. *NASA Reference Publication 1201*, March 1988.
- Krzyscin, J. W. (2000). Impact of the ozone profile on the surface UV radiation: Analyses of the Umkehr and UV measurements at Belsk (52°N, 21°E), Poland, *J. Geophys. Res.* 105(D4), 5009-5016.
- Kurucz, L., I. Furenlid, J. Brault, and L. Testerman. (1984). Solar Flux Atlas from 296 to 1300 nm, National Solar Observatory Atlas No. 1., National Solar Observatory, Kitt Peak, Arizona.
- Kylling A., Albold A., and Seckmeyer G. (1997). Transmittance of a cloud is wavelength-dependent in the UV-range: physical Interpretation, *Geophys. Res. Lett.*, 24(4), 397-400.
- Kylling, A., A Dahlback, and B. Mayer. (2000a). The effect of clouds and surface albedo on UV irradiances at a high latitude site, *Geophys. Res. Lett.*, 27,(9), 1411-1414.
- Kylling, A., T. Persen, B. Mayer, T. and Svenøe. (2000b). Determination of an effective spectral surface albedo from ground based global and direct UV irradiance measurements, *J. Geophys. Res.*, 105, 4949-4959.
- Ladizesky, M., Z. Lu, B. Oliveri, N. San Roman, S. Díaz, M.E. Holick and C. Mautalen., (1995) Solar ultraviolet B radiation and photoproduction of vitamin D<sub>3</sub> in central and southern areas of Argentina., *Journal of Bone and Mineral Research*, 10(4), 545-549.\*
- Lantz K., P.Disterhoft, E.A.Early, J.DeLuisi, A.Thompson, J.Berndt, L.Harrison, P.Kiedron, J.Ehramjian, G.Bernhard, L.Cabasug, J.Robertson, W.Mou, T.Taylor, J.Slusser, D.Bigelow, B.Durham, G.Janson, D.Hayes, M.Beaubien, and A.Beaubien. (2002). The 1997 North American interagency intercomparison of ultraviolet spectroradiometers including narrowband filter radiometers. *J.Res.Natl.Inst.Stand.Technol.*, 107, 19-62.\*
- Lapeta, B., O. Engelsen, Z. Litynska, B. Kois, A. Kylling. (2000). Sensitivity of surface UV radiation and ozone column retrieval to ozone and temperature profiles *J. Geophys. Res.* 105(D4), 5001-5008.
- Lenoble J. (2000). Influence of the environment reflectance on the ultraviolet zenith radiance for cloudless sky, *Appl. Opt.*, 39, 4247-4254.
- Lesser, M. P., P. J. Neale, and J. J. Cullen. (1996). Acclimation of Antarctic phytoplankton to ultraviolet radiation: Ultraviolet-absorbing compounds and carbon fixation. *Molecular Marine Bio. and Biotech.* 5(4), 314-325.
- Lewis, R. (1997) Antarctic fish eggs indicate UV damage. *Biophotonics International*, May/June 1997, 30-31.\*
- Lubin. D. (1989).The ultraviolet radiation environment of the Antarctic Peninsula. Ph.D. dissertation University of Chicago, Chicago, IL.\*
- Lubin, D., and J.E. Frederick. (1989). Ultraviolet monitoring program at Palmer Station, Spring, 1988. *Antarctic Journal of the United States, 1989 Review*, 24(5), 172-174.\*
- Lubin, D., J.E. Frederick, C.R. Booth, T.B. Lucas, and D.A. Neuschuler. (1989). Measurements of enhanced springtime ultraviolet radiation at Palmer Station, Antarctica, *Geophysical Research Letters*, 16, 783-785.\*

- Lubin, D., and J.E. Frederick (1990). Column ozone measurements at Palmer Station, Antarctica: variations during the austral springs of 1988 and 1989. *Journal of Geophysical Research*, 95, 13883-13889.\*
- Lubin, D., and J.E. Frederick. (1991). Ultraviolet radiation environment of the Antarctic Peninsula: The roles of ozone and cloud cover. *Journal of Applied Meteorology*, 30(4), 478-493.\*
- Lubin, D., and J.E. Frederick (1992). Observations of ozone and cloud properties from NSF Ultraviolet - monitor measurements at Palmer Station, Antarctica. *The Antarctic Journal of the United States, 1990 Review*, 25(5), 241-242.\*
- Lubin, D., B.G. Mitchell, J.E. Frederick, A.D. Alberts, C.R. Booth, T.B. Lucas, and D.A. Neuschuler. (1992). A contribution toward understanding the biospherical significance of Antarctic ozone depletion. *Journal of Geophysical Research*, 97(D8) 7817-7828.\*
- Lubin, D., P. Ricchiazzi, C. Gautier, and R. H. Whritner. (1994). A method for mapping Antarctic surface ultraviolet radiation using multispectral satellite imagery. *Antarctic Research Series*, Vol. 62, 53-81, Eds. C.S. Weiler and P.A. Penhale, AGU, Washington, D.C.
- Lubin, D. and O. Holm-Hansen. (1995). Atmospheric Ozone and the Biological Impact of Solar Ultraviolet Radiation. In: *Encyclopedia of Environmental Biology* (W. A. Nierenberg, ed.), Vol. 1, Academic Press, Inc., New York, 147-168.\*
- Madronich, S. (1994). Increases in biologically damaging UV-B radiation due to stratospheric ozone reductions: A brief review. *Arch. Hydrobiol. Beih: Ergebn. Limnol.*, 43, 17-30.\*
- Madronich, S. (1993). UV radiation in the natural and perturbed atmosphere, in *UV-B Radiation and Ozone Depletion: Effects on Humans, Animals, Plants, Macroorganisms, and Materials*, edited by Manfred Tevini, pp. 28-29, Lewis Publishers, Boca Raton.\*
- Madronich, S., L.O. Bjorn, M. Ilyas, and M.M. Caldwell. (1991). Changes in biologically active ultraviolet radiation reaching the earth's surface. *Environmental effects of ozone depletion: 1991 Update. Panel report pursuant to Article 6 of the Montreal Protocol on Substances that Deplete the Ozone Layer Under the Auspices of the United Nations Environment Programme (UNEP)*, Nairobi, Kenya, pp. 1-13.\*
- Malloy, K.D., M.A. Holman, D. Mitchell, and H.W. Detrich III. (1997). Solar UVB-induced DNA damage and photoenzymatic DNA repair in Antarctic zooplankton. *Proceedings of the National Academy of Science, USA*, 94, 1258-1263.\*
- Martin, T.J., B.G. Gardiner, and G. Seckmeyer. (2000). Uncertainties in satellite-derived estimates of surface UV doses, *J. Geophys. Res.*, 106(D22), 27005-27011.
- Mayer, B. (1997). Messung und Modellierung der spektralen UV-Bestrahlungsstärke in Garmisch-Partenkirchen (Measurement and modeling of spectral UV irradiance in Garmisch-Partenkirchen), Ph.D.-thesis, pp.135, Fakultät für Mathematik und Naturwissenschaften der Technischen Universität Ilmenau, 1996, published in IFU-Schriftenreihe, Vol 45, Wissenschafts-Verlag Dr. W. Maraun, ISBN 3-927548-94-4.
- Mayer B., A. Kylling, S. Madronich, and G. Seckmeyer. (1998). Enhanced absorption of UV irradiance due to multiple scattering in clouds: experimental evidence and theoretical explanation, *J. Geophys. Res.*, 103(D23), 31,241-31,254.
- McKenzie, R.L., M. Blumthaler, C.R. Booth, S.B. Diaz, J.E. Frederick, T. Ito, S. Madronich, and G. Seckmeyer. (1994). Surface Ultraviolet Radiation. *Scientific Assessment of Ozone Depletion: 1994. World Meteorological Organization Global Ozone Research Monitoring Project*, 37, 9.1-9.22.\*

- McKenzie, R.L., P.V. Johnston, D. Smale, B.A. Bodhaine, and S. Madronich. (2001). Altitude effects on UV spectral irradiance deduced from measurements at Lauder, New Zealand, and at Mauna Loa Observatory, Hawaii, *J. Geophys. Res.*, 106(D19), 22,845-22,860.
- McKinlay, A.F., and B.L. Diffey. (1987). A reference action spectrum for ultra-violet induced erythema in human skin, in *Human Exposure to Ultraviolet Radiation: Risks and Regulations* (Eds. W.R. Passchler and B.F.M. Bosnjakovic), pp. 83-87, Elsevier, Amsterdam.
- Mestechkina, T., C. R. Booth, J. R. Tusson IV, and J. C. Ebrahimian. (1996). Antarctic UV Spectroradiometer Monitoring Program: Contrasts in UV Irradiance at the South Pole and Barrow, Alaska. *Climate Monitoring and Diagnostics Laboratory No. 23. Summary Report 1994-1995*, U.S. Dept. of Commerce, Boulder, Colorado, 23, 135-137.\*
- Mims(III), F.M. and Frederick. (1994). J.E, Cumulus clouds and UV-B, *Nature*, 371, p. 291.
- NASA. (1988). Present state of knowledge of the upper Atmosphere 1988: An Assessment Report. R.T. Watson and Ozone Trends Panel, J.J. Prather and Ad Hoc Theory Panel, and M.M. Kurylo and NASA Panel for Data Evaluation. NASA publ. 1208.
- Orce, V.L., and E.W. Helbling. (1997). Latitudinal UVR-PAR measurements in Argentina: extent of the 'ozone hole'. *Global and Planetary Change*, 15, 113-121.
- Prézelin, B. B., M. A. Moline, and H. A. Matlick. (1998). Icecolors '93: Spectral UV Radiation Effects on Antarctic Frazil Ice Algae. Antarctic Sea Ice: Biological Processes, Interactions and Variability; M. Lizotte, K. Arrigo, Editors. *Antarctic Research Series*, Volume 73, 1998.
- Qu, J., F. Smith, A. Riebau, M. Sestak, L. Smith, and S. G. Coloff. (1997). Global solar ultraviolet-B radiation measurements and simulation in remote areas. *IRS '96*, 942-945.
- Quesada, A., L. Goff and D. Karentz. (1998). Effects of natural UV radiation on Antarctic cyanobacterial mats. *Proceedings of the National Institute of Polar Research Symposium on Polar Biology*, 11:98-111.
- Reinen, H., H. Slaper, and R. Tax. (1998). SUSPEN intercomparison campaign in: *Standardization of ultraviolet spectroradiometry in preparation of a European network (SUSPEN)* edited by A.F. Bais, Final report to the European Commission, Directorate Generale XII, 1998.
- Ricchiazzi, P., C. Gautier and S. Yang. (1996). Do clouds mitigate the biological effects of ozone depletion in the Antarctic?. *Proceedings of the Sixth Atmospheric Radiation Measurement (ARM) Science Team Meeting*. March 1996, San Antonio, Texas.
- Ricchiazzi, P., C. Gautier, and D. Lubin. (1995). Cloud scattering optical depth and local surface albedo in the Antarctic: Simultaneous retrieval using ground-based radiometry. *Journal of Geophysical Research*, 100, 21091-21104.
- Ricchiazzi, P.J. and C. Gautier. (1998). Investigation of the effect of surface heterogeneity and topography on the radiation environment of Palmer Station, Antarctica, with a hybrid 3-D radiative transfer model. *J. Geophys. Res.*, 103(D), 6161-6176.
- Rousseaux, M.C., C.L. Ballaré, A.L. Scopel, P.S. Searles, and M.M. Caldwell. (1998). Solar ultraviolet-B radiation affects plant-insect interactions in a natural ecosystem of Tierra del Fuego (southern Argentina). *Oecologia*, October 1998, 116(4), 528-535.
- Rowland, F.S. (1996) Stratospheric ozone depletion by chlorofluorocarbons. *Angew. Chem. Int. Ed. Engl.*, 35, 1786-1798.\*



- Rowland, F.S. (1989) Chlorofluorocarbons and the depletion of stratospheric ozone. *American Scientist*, 77, 36-45.
- Schofield, O., B. M. A. Kroon, and B. B. Prezelin. (1995). Impact of ultraviolet-B radiation on photosystem II activity and its relationship to the inhibition of carbon fixation rates for antarctic ice algae communities. *J. Phycol.* 31, 703-715.
- Searles, P. S., S. D. Flint, S. B. Diaz, M. C. Rousseaux, C. L. Ballare and M. M. Caldwell. Solar. (In press). Ultraviolet-B influence on Sphagnum bog and corex fen ecosystems: firstfield season findings in Tierra del Fuego, Argentina. *Global Change Biology*.
- Seckmeyer, G., B. Mayer, G. Bernhard, R.L. McKenzie, P.V. Johnston, M. Kotkamp, C.R. Booth, T.B. Lucas, T. Mestechkina, C.R. Roy, H.P. Gies, and D. Tomlinson. (1995). Geographical differences in the UV measured by intercompared spectroradiometers. *Geophysical Research Letters*, 22(14), 1889-1892.\*
- Seckmeyer G., B. Mayer, and G. Bernhard. (1998). The 1997 Status of Solar UV Spectroradiometry in Germany: Results from the National Intercomparison of UV Spectroradiometers, Garmisch-Partenkirchen, Germany, Schriftenreihe of the Fraunhofer-Institute for Atmospheric Environmental Research, 55, 166 pp., Shaker Verlag, Frankfurt am Main, Germany.
- Seckmeyer G., Albold A., and Erb R.. (1996). Transmittance of a cloud is wavelength-dependent in the UV-range, *Geophys. Res. Lett.*, 23(20), 2753-2755.
- Setlow, R.B. (1974). The wavelength in sunlight effective in producing skin cancer: a theoretical analysis. *Proceedings of the National Academy of Science, USA*, 71(9), 3363-3366.
- Slaper, H. (1997). Methods for intercomparing instruments, Section 2B, in: *Advances in solar ultraviolet spectroradiometry* edited by A.R. Webb, pp. 153-164, Air pollution research report 63, Office of the official publications for the European communities, Luxembourg.
- Slaper, H. and T. Koskela. (1997). Methodology of intercomparing spectral sky measurements, correcting for wavelength shifts, slit function differences and defining a spectral reference, in: The Nordic intercomparison of ultraviolet and total ozone instruments at Izana, October 1996, Final report edited by B. Kjeldstad, B. Johnsen, and T. Koskela, pp. 89-108, Meteorological Publication No. 36, Finnish Meteorological Institute, Helsinki.
- Slaper, H, H.A.J.M. Reinen, M. Blumthaler, M. Huber, and F. Kuik. (1995). Comparing ground-level spectrally resolved solar UV measurements using various instruments: A technique resolving effects of wavelength shift and slit width, *Geophysical Research Letters*, 22, 2721-2724.
- Smith, R.C. and K.S. Baker. (1982). Assessment of the influence of enhanced UV-B on marine primary productivity, in *The Role of Solar Ultraviolet Radiation in marine Ecosystems*, edited by J. Calkins, pp. 509-537, Plenum.
- Smith, R.C. and K.S. Baker. (1989). Stratospheric ozone, middle ultraviolet radiation and phytoplankton productivity. *Oceanography*, November 1989, 4-10.\*
- Smith, R.C., K.S. Baker, D. Menzies, K. Waters. (1991). Biooptical measurements from the IceColors 90 cruise 5 Oct -21 Nov 1990. *SIO*, Ref 91-13, 121.\*
- Smith, R.C., B.B. Prezelin, K.S. Baker, R.R. Bidigare, N.P. Boucher, T. Coley, D. Karentz, S. MacIntyre, H.A. Matlick, D. Menzies, M. Ondrusek, Z. Wan, K.J. Waters. (1992). Ozone Depletion: Ultraviolet Radiation and Phytoplankton Biology in Antarctic Waters. *Science*, 256, 952-959.\*
- Smith, R., B. Prezelin R. Bidigare, D. Karentz, S. MacIntyre. (1991). IceColors'90: Ultraviolet Radiation and phytoplankton biology in Antarctic Waters. *The Antarctic Journal of the United States*, 1991.

- Smith, R.C., Z. Wan, and K.S. Baker. (1992). Ozone depletion in Antarctica: Modeling its effect under clear-sky conditions. *Journal of Geophysical Research*, 97(C5), 7383-7397.\*
- Sobolev I. (2000). Effect of column ozone on the variability of Biologically effective UV radiation at high southern latitudes, *Photochem. Photobiol.*, 72(6), 753-765.
- Solomon, S. (1990). Progress towards a quantitative understanding of Antarctic ozone depletion. *Nature*, 347, 347-354.
- Stamnes, K. (1993). The stratosphere as a modulator of ultraviolet radiation into the biosphere, *Surveys in Geophysics*, 14, 167-186.\*
- Stamnes, K., Z. Jin, J. Slusser, C.R. Booth and T.B. Lucas. (1992). Several-fold enhancement of biologically effective ultraviolet radiation levels at McMurdo Station Antarctica during the 1990 Ozone "Hole", *Geophysical Research Letters*, 19(10), 1013-1016.\*
- Stamnes, K., J. Slusser, and M. Bowen. (1991). Derivation of total ozone abundance and cloud effects from spectral irradiance measurements. *Applied Optics*, 30, 4418-4426.\*
- Stamnes, K., J. Slusser, M. Bowen, C.R. Booth, and T.B. Lucas. (1990). Biologically effective ultraviolet radiation, total ozone abundance, and cloud optical depth at McMurdo Station, Antarctica, September 15, 1988 through April 15, 1989. 1990. *Geophysical Research Letters*, 17, 2181-184.\*
- Thiel, S., K. Steiner, and H.K. Seidlitz. (1997). Modification of Global Erythemal Effective Irradiance by Clouds, *Photochem. Photobiol.*, 65(6), 969-973.
- Thompson, A., E.A. Early, J. Deluisi, P. Disterhoft, D. Wardle, J. Kerr, J. Rives, Y. Sun, T.B. Lucas, T. Mestechkina, and P. Neale. (1997). The 1994 North American interagency intercomparison of ultraviolet monitoring spectroradiometers. *Journal of Research of the National Institute of Standards and Technology*, 102(3), 279-322.\*
- UNEP. (1998). *Environmental Effects of Ozone Depletion: 1998 Assessment*. Panel report pursuant to Article 6 of the Montreal Protocol on Substances that Deplete the Ozone Layer Under the Auspices of the United Nations Environment Programme (UNEP). Nairobi, Kenya, *Journal of Photochemistry and Photobiology B: Biology*, Volume 46.
- UNEP: Madronich, S., R. L. McKenzie, M. M. Caldwell, and L. O. Bjorn. (1994). Changes in ultraviolet radiation reaching the earth's surface (Chapter 1). *Environmental Effects of Ozone Depletion: 1994 Assessment*, 1-22; UNEP (ISBN 92 807 1457 0).
- UNEP. (1991). Environmental effects of ozone depletion: 1991 Update. Panel report pursuant to Article 6 of the Montreal Protocol on Substances that Deplete the Ozone Layer Under the Auspices of the United Nations Environment Programme (UNEP). Nairobi, Kenya.\*
- Urbach, F. (editor), (1989). The Biological Effects of Increased Ultraviolet Radiation: An Update. *Photochem. Photobiol.* 50 (4), 439-580.
- Vernet, M., E. A. Brody, O. Holm-Hansen, and B. G. Mitchell. (1994). The response of antarctic phytoplankton to ultraviolet radiation: absorption, photosynthesis, and taxonomic composition. *Antarctic Research Series*. 62, 143-158, Eds. C.S. Weiler and P.A. Penhale, AGU, Washington, D.C.
- Wardle, D. I., J. B. Kerr, and D. R. Francis. (1997). Ozone Science: A Canadian Perspective on the Changing Ozone Layer. Environment Canada CARD, 97-3.
- Weatherhead, E.C., et. al. (1997). Factors affecting the detection of trends: statistical considerations and applications to environmental data, *J. Geophys. Res.*, 103(D14), 17149-17161.

- Weiler, C.S. (editor)(1988). Workshop on Ultraviolet Radiation and Biological Research in Antarctica. National Science Foundation, NSF 88-108. 28 pp.
- Wilson, W.H. (1980). Solar Ephemeris Algorithm, *Scripps Institution of Oceanography Reference SIO Ref.80-13*, July, 1980.
- World Meteorological Organization (WMO). (1994). Report of the WMO Meeting of Experts on UV-B measurements, data quality and standardization of UV indices, *WMO GAW report No. 95*.
- World Meteorology Organisation (WMO). (1999). *Scientific assessment of ozone depletion:1998, Global ozone research and monitoring project, Report No. 44*, Geneva, Switzerland.
- Yoon, H.W., C.E. Gibson, and P.Y. Barnes. (2002). Realization of the National Institute of Standards and Technology detector-based spectra irradiance scale. *Applied Optics 41(28)*, 5879-5890.
- Zerefos C., D. Balis, M. Tzortziou, A. Bais, K. Tourpali, C. Meleti, G. Bernhard, and J. Herman. (2001). A note on the interannual variations of UV-B erythemal doses and solar irradiance from ground-based and satellite observations. *Annales Geophysicae*, 19, 115-120.\*

### A3. Code Fragments for Dose Weightings and Integrations

To show how the dose weighting and spectral integrals were calculated, the following code fragments were reproduced. The new software was written in Visual Basic 5.0 for 32-bit Windows development.

All functions designed to calculate different spectral integrals use three major arrays: *Irradiance()*, calculated irradiances (or weighted irradiances) at certain wavelengths; *Wavelength()*, where corrected wavelengths from all items are stored; and *Points()*, which references the location of the data from a particular item. To be more specific, *Points()* is a two-dimensional array, where the first index is 1 for item start or 2 for item stop, and the second index is item. For example,

```

Points(1,1) - beginning of Item 1 (= 1),
Points(2,1) - end of Item 1,
...
Points(1,item) - beginning of item item (= Points(2,item-1) + 1),
Points(2,item) - end of item item,
...
Points(1,last_item) - beginning of item last_item (= Points(2,last_item-1) + 1),
Points(2,last_item) - end of item last_item (and total number of points in the scan).

```

Also  $(Points(2,item) - Points(1,item) + 1)$  is the number of points in a particular item. Generally speaking, *CalculateIntegral* is the main function, while other functions derive weighted irradiance from *Irradiance()* and the given weight function, and reference to *CalculateIntegral*.

#### A3.1. Spectral (Non-weighted) Integrals

The function *CalculateIntegral* uses the three arrays mentioned above as well as three other input parameters - *wStart*, *wStop* and *Item* - as a definition of integration limits and source of data (Item 1, 2 or 3). If, for some reason, data from a requested item are not available, this function returns -999 (indicating missing data).

Function *CalculateIntegral* (wStart, wStop, Item, Points() As Integer, Wavelength() As Single, Irradiance() As Single) As Single

```

Dim i As Integer, iStart As Integer, iStop As Integer
Dim Wav As Single, Irr As Single, Integr As Single

If UBound(Points, 2) < Item Then CalculateIntegral = -999: Exit Function
iStart = Points(1, Item): iStop = Points(2, Item)

While (Wavelength(iStart) <= wStart) And (iStart < iStop): iStart = iStart + 1 : Wend
If (iStart = Points(1, Item)) Or (iStart = Points(2, Item)) Then CalculateIntegral = -999: Exit Function

While (Wavelength(iStop) >= wStop) And (iStop > iStart): iStop = iStop - 1: Wend
If (iStop = Points(2, Item)) Or (iStart = iStop) Then CalculateIntegral = -999: Exit Function

i = iStop
Irr = InterpolateIrradiance(i, wStop, Item, Points(), Wavelength(), Irradiance())
If Irr < -998 Then CalculateIntegral = -999: Exit Function
Integr = (Irradiance(iStop) + Irr) / 2 * (wStop - Wavelength(iStop))

i = iStart
Irr = InterpolateIrradiance(i, wStart, Item, Points(), Wavelength(), Irradiance())
If Irr < -998 Then CalculateIntegral = -999: Exit Function

Wav = wStart
For i = iStart To iStop
    If Irradiance(i) < -998 Then CalculateIntegral = -999: Exit Function
    Integr = Integr + (Irradiance(i) + Irr) / 2 * (Wavelength(i) - Wav)
    Wav = Wavelength(i): Irr = Irradiance(i)
Next i
CalculateIntegral = Integr
End Function

```

## A3.2. Dose Weightings

Several alterations to the code were performed to accommodate changes in the data and response scans. In previous software releases, the highest resolution scan (Item 1) was used for calculations below 310 nm, the medium resolution scan (Item 2) – between 310 and 340 nm, and the lowest resolution scan (Item 3) – above 340 nm. No data beyond 400 nm was utilized. With the new version, these limits have changed: interval (285, 340) nm is covered by Item 1 and interval (340, 400) nm is covered by Item 2. If data are not available (or only partially available), doses are not determined and the corresponding functions return “-999.” Keeping in mind that there are 1-minute pauses between the items and that items with smaller subsequent numbers are performed at higher resolution, the new calculation appears to be more precise.

In order to generalize the determination of wavelength segments and simplify accommodation of any future changes, two new functions were added to the code. One of them – **DoseItem** – defines what scan item can be used for dose calculation and the other one – **DoseBreak** – determines what wavelength segment might be utilized from this particular item. If a certain wavelength segment is available from various items, higher resolution data are preferred. Assuming that a few beginning points of each item might be compromised by monochromator backlash, and because items overlap by at least 10 nm, it is possible to improve data quality by engaging only “middle” points. Variable *OverlapWavelength* determines the size of the segment that will be sacrificed.

The two-dimensional structure *Header(item, scan)* contains information about scan parameters, such as start wavelength, stop wavelength, etc., and variable *scan = 3* for data scan. Array *Items(scan)* defines the numbers of items in the scan, e.g., *Items(3)* is the number of items in a particular data scan.

Function **DoseItem** (Wav As Single, Points() As Integer, Wavelength() As Single) As Integer

```

Dim i As Integer, item As Integer

item = 0
For i = 1 To UBound(Points, 2)
    If (Wavelength(Points(1, i)) <= Wav) And (Wav < Wavelength(Points(2, i)) - OverlapWavelength) Then
        If item = 0 Then
            item = i
        ElseIf Header(i, 3).Conditions.StepW1 < Header(item, 3).Conditions.StepW1 Then
            item = i
        End If
    End If
Next i
DoseItem = item
End Function

```

Function **DoseBreak** (Wav As Single, item As Integer, Points() As Integer, Wavelength() As Single) As Single

```

Dim i As Integer

If Wav < Wavelength(Points(2, item)) Then
    DoseBreak = Wav
Else
    i = Points(2, item) - Int(OverlapWavelength / Header(item, 3).Conditions.StepW1)
    While (Wavelength(i) < Wavelength(Points(2, item)) - OverlapWavelength)
        i = i + 1
    If i = Points(2, item) Then
        DoseBreak = Wavelength(Points(2, item)) - OverlapWavelength: Exit Function
    End If
    Wend
    DoseBreak = Wavelength(i)
End If
End Function

```

## Erythema Dose1

Unfortunately, in previous software versions *Dose1* was calculated incorrectly. Thanks to Sari Kalliskota, this problem was noticed and fixed in the latest software revision. Precisely, weighted function

$$W(\lambda) = \frac{0.04485}{1 + \frac{\exp\{\lambda - 311.4\}}{3.13}} + \frac{4 \cdot 0.9949 \cdot \exp\left\{\frac{\lambda - 296.5}{2.692}\right\}}{1 + \exp\left\{\frac{\lambda - 296.5}{2.692}\right\}^2}$$

was coded instead of  $W(\lambda) = \frac{0.04485}{1 + \frac{\exp\{\lambda - 311.4\}}{3.13}} + \frac{4 \cdot 0.9949 \cdot \exp\left\{\frac{\lambda - 296.5}{2.692}\right\}}{\left\{1 + \exp\left\{\frac{\lambda - 296.5}{2.692}\right\}\right\}^2}$ .

Function Dose1 (Points() As Integer, Wavelength() As Single, Irradiance() As Single) As Single

```

Dim i As Integer, item As Integer
Dim Wav As Single, Wav1 As Single, Wav2 As Single
Dim integrI As Single, integr As Single
Dim WeightedIrrr() As Single: ReDim WeightedIrrr(Points(2), Items(3)))

Wav2 = 286: integr = 0
While Wav2 < 400
    Wav1 = Wav2: item = DoseItem(Wav1, Points(), Wavelength()): If item = 0 Then Dose1 = -999: Exit Function
    Wav2 = DoseBreak(400, item, Points(), Wavelength())
    For i = Points(1, item) To Points(2, item)
        Wav = Wavelength(i)
        If (Wav1 - 1 <= Wav) And (Wav <= Wav2 + 1) Then
            WeightedIrrr(i) = Irradiance(i) * (0.04485 / (1 + Exp((Wav - 311.4) / 3.13)) + 4 * 0.9949
                * Exp((Wav - 296.5) / 2.692) / (1 + Exp((Wav - 296.5) / 2.692) ^ 2))
        End If
    Next i
    integrI = CalculateIntegral(Wav1, Wav2, item, Points(), Wavelength(), WeightedIrrr())
    If integrI < -998 Then Dose1 = -999: Exit Function
    integr = integr + integrI
Wend
Erase WeightedIrrr
Dose1 = integr
End Function

```

## Erythema Dose2

Function Dose2 (Points() As Integer, Wavelength() As Single, Irradiance() As Single) As Single

```

Dim i As Integer, item As Integer
Dim Wav As Single, Wav1 As Single, Wav2 As Single
Dim integrI As Single, integr As Single, Weight As Single
Dim WeightedIrrr() As Single: ReDim WeightedIrrr(Points(2), Items(3)))

Wav2 = 286: integr = 0
While Wav2 < 400
    Wav1 = Wav2: item = DoseItem(Wav1, Points(), Wavelength()): If item = 0 Then Dose2 = -999: Exit Function
    Wav2 = DoseBreak(400, item, Points(), Wavelength())
    For i = Points(1, item) To Points(2, item)
        Wav = Wavelength(i)
        If (Wav1 - 1 <= Wav) And (Wav <= Wav2 + 1) Then
            Select Case Wav
                Case Is < 295: Weight = 10 ^ (-1.215837 + (Wav * 0.004728))
                Case 295 To 300: Weight = 10 ^ (10.73862 + (Wav * -0.035795))
                Case 300 To 305: Weight = 10 ^ (17.54579 + (Wav * -0.058486))
                Case 305 To 310: Weight = 10 ^ (50.49061 + (Wav * -0.166502))
                Case 310 To 320: Weight = 10 ^ (27.87686 + (Wav * -0.093554))
                Case 320 To 335: Weight = 10 ^ (15.3893 + (Wav * -0.054531))
                Case 335 To 365: Weight = 10 ^ (1.703584 + (Wav * -0.013555))
                Case 365 To 380: Weight = 10 ^ (8.365825 + (Wav * -0.031808))
                Case Is > 380: Weight = 10 ^ (-1.705338 + (Wav * -0.005305))
            End Select
            WeightedIrrr(i) = Irradiance(i) * Weight
        End If
    Next i
    integrI = CalculateIntegral(Wav1, Wav2, item, Points(), Wavelength(), WeightedIrrr())
    If integrI < -998 Then Dose2 = -999: Exit Function

```

```

        integr = integr + integrI
    Wend
    Erase WeightedIrr
    Dose2 = integr
End Function

```

### Erythema Dose3

Function **Dose3** (Points() As Integer, Wavelength() As Single, Irradiance() As Single) As Single

```

    Dim i As Integer, item As Integer
    Dim Wav As Single, Wav1 As Single, Wav2 As Single
    Dim integrI As Single, integr As Single, Weight As Single
    Dim WeightedIrr() As Single: ReDim WeightedIrr(Points(2), Items(3)))

    Wav2 = 286: integr = 0
    While Wav2 < 400
        Wav1 = Wav2: item = DoseItem(Wav1, Points(), Wavelength()): If item = 0 Then Dose3 = -999: Exit Function
        Wav2 = DoseBreak(400, item, Points(), Wavelength())
        For i = Points(1, item) To Points(2, item)
            Wav = Wavelength(i)
            If (Wav1 - 1 <= Wav) And (Wav <= Wav2 + 1) Then
                Select Case Wav
                    Case Is < 298: Weight = 1
                    Case 298 To 328: Weight = 10 ^ (0.094 * (298 - Wav))
                    Case Is > 328: Weight = 10 ^ (0.015 * (139 - Wav))
                End Select
                WeightedIrr(i) = Irradiance(i) * Weight
            End If
        Next i
        integrI = CalculateIntegral(Wav1, Wav2, item, Points(), Wavelength(), WeightedIrr())
        If integrI < -998 Then Dose3 = -999: Exit Function
        integr = integr + integrI
    Wend
    Erase WeightedIrr
    Dose3 = integr
End Function

```

### Setlow Dose

Function **Setlow** (Points() As Integer, Wavelength() As Single, Irradiance() As Single) As Single

```

    Dim i As Integer, item As Integer
    Dim Wav As Single, Wav1 As Single, Wav2 As Single
    Dim integrI As Single, integr As Single, Weight as Single
    Dim WeightedIrr() As Single: ReDim WeightedIrr(Points(2), Items(3)))

    Wav2 = 286: integr = 0
    While Wav2 < 340
        Wav1 = Wav2: item = DoseItem(Wav1, Points(), Wavelength()): If item = 0 Then Setlow = -999: Exit
Function
        Wav2 = DoseBreak(340, item, Points(), Wavelength())
        For i = Points(1, item) To Points(2, item)
            Wav = Wavelength(i)
            If (Wav1 - 1 <= Wav) And (Wav <= Wav2 + 1) Then
                Select Case Wav
                    Case Is < 290: Weight = 10 ^ (13.04679 + (Wav * -0.047012))
                    Case 290 To 295: Weight = 10 ^ (20.75595 + (Wav * -0.073595))
                    Case 295 To 300: Weight = 10 ^ (30.12706 + (Wav * -0.105362))
                    Case 300 To 305: Weight = 10 ^ (42.94028 + (Wav * -0.148073))
                    Case Is > 305: Weight = 10 ^ (45.24538 + (Wav * -0.15563))
                End Select
                WeightedIrr(i) = Irradiance(i) * Weight
            End If
        Next i
        integrI = CalculateIntegral(Wav1, Wav2, item, Points(), Wavelength(), WeightedIrr())
        If integrI < -998 Then Setlow = -999: Exit Function
    Wend

```

```
        integr = integr + integrI
    Wend
    Erase WeightedIrr
    Setlow = integr
End Function
```

## Hunter Dose

Function **Hunter** (Points() As Integer, Wavelength() As Single, Irradiance() As Single) As Single

```
    Dim i As Integer, item As Integer
    Dim Wav As Single, Wav1 As Single, Wav2 As Single
    Dim integrI As Single, integr As Single
    Dim WeightedIrr() As Single: ReDim WeightedIrr(Points(2), Items(3)))

    Wav2 = 290: integr = 0
    While Wav2 < 340
        Wav1 = Wav2: item = DoseItem(Wav1, Points(), Wavelength()): If item = 0 Then Hunter = -999: Exit
    Function
        Wav2 = DoseBreak(340, item, Points(), Wavelength())
        For i = Points(1, item) To Points(2, item)
            Wav = Wavelength(i)
            If (Wav1 - 1 <= Wav) And (Wav <= Wav2 + 1) Then
                WeightedIrr(i) = Irradiance(i) * Exp(61.1381 - 0.21551 * Wav)
            End If
        Next i
        integrI = CalculateIntegral(Wav1, Wav2, item, Points(), Wavelength(), WeightedIrr())
        If integrI < -998 Then Hunter = -999: Exit Function
        integr = integr + integrI
    Wend
    Erase WeightedIrr
    Hunter = integr
End Function
```

## Caldwell Dose

Function **Caldwell** (Points() As Integer, Wavelength() As Single, Irradiance() As Single) As Single

```
    Dim i As Integer, item As Integer
    Dim Wav As Single, Wav1 As Single, Wav2 As Single
    Dim integrI As Single, integr As Single
    Dim WeightedIrr() As Single: ReDim WeightedIrr(Points(2), Items(3)))

    Wav2 = 286: integr = 0
    While Wav2 < 313
        Wav1 = Wav2: item = DoseItem(Wav1, Points(), Wavelength()): If item = 0 Then Caldwell = -999: Exit Function
        Wav2 = DoseBreak(313, item, Points(), Wavelength())
        For i = Points(1, item) To Points(2, item)
            Wav = Wavelength(i)
            If (Wav1 - 1 <= Wav) And (Wav <= Wav2 + 1) Then
                WeightedIrr(i) = Irradiance(i) * 2.618 * (1 - (Wav / 313.3) ^ 2) * Exp((300 - Wav) / 31.08)
            End If
        Next i
        integrI = CalculateIntegral(Wav1, Wav2, item, Points(), Wavelength(), WeightedIrr())
        If integrI < -998 Then Caldwell = -999: Exit Function
        integr = integr + integrI
    Wend
    Erase WeightedIrr
    Caldwell = integr
End Function
```



**Weighted TSI (Dose4)**

Function **WeightedTSI** (Points() As Integer, Wavelength() As Single, Irradiance() As Single) As Single

```

Dim i As Integer, item As Integer
Dim Wav As Single, Wav1 As Single, Wav2 As Single
Dim integr1 As Single, integr As Single
Dim WeightedIrr() As Single: ReDim WeightedIrr(Points(2), Items(3)))

Wav2 = 320: integr = 0
While Wav2 < 392
    Wav1 = Wav2: item = DoseItem(Wav1, Points(), Wavelength()): If item = 0 Then WeightedTSI = -999: Exit Function
    Wav2 = DoseBreak(392, item, Points(), Wavelength())
    For i = Points(1, item) To Points(2, item)
        Wav = Wavelength(i)
        If (Wav1 - 1 <= Wav) And (Wav <= Wav2 + 1) Then
            If Wav < 367 Then
                WeightedIrr(i) = Irradiance(i) * (0.005598382 + Wav * -0.00004901834
                    + Wav * Wav * 0.0000001420638 + Wav * Wav * Wav * -1.361036E-10)
            Else
                WeightedIrr(i) = Irradiance(i) * (-0.08228739 + Wav * 0.0006492523 + Wav
                    * Wav * -0.00000170513 + Wav * Wav * Wav * 0.000000001490757)
            End If
        End If
    Next i
    integr1 = CalculateIntegral(Wav1, Wav2, item, Points(), Wavelength(), WeightedIrr())
    If integr1 < -998 Then WeightedTSI = -999: Exit Function
    integr = integr + integr1
Wend
Erase WeightedIrr
WeightedTSI = integr
End Function

```

