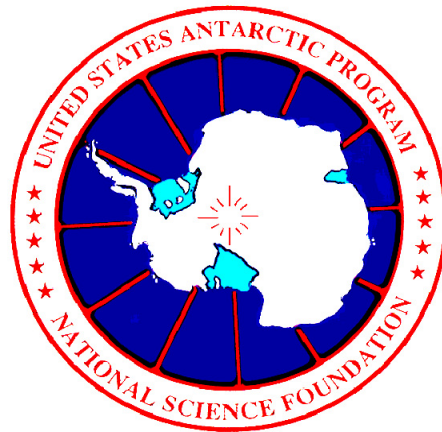


Appendices



A1. Errata

There are no known errors in data of Volumes 7-14, which have not been reported in the Operations Reports complementing these volumes. For known errors in data of Volumes 1-6, please refer to the Operations Reports of Volumes 7-12.

A2. References

Note: References marked with an asterisk (*) use NSF UV Spectroradiometer Network data.

- Anav, A., C. Rafanelli, I. Di Menno, and M. Di Menno. (2004). An algorithm to evaluate solar irradiance and effective dose rates using spectral UV irradiance at four selected wavelengths, *Radiat. Prot. Dosim.*, 111(3), 239-250.*
- Anders, A., H.-J. Altheide, M. Knaelmann, and H. Tronnier. (1995). Action spectrum for erythema in humans investigated with dye lasers, *Photochem. Photobiol.*, 61(2), 200-205.
- 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, SO₂, 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.*
- Ballaré C.L., M.C. Rousseaux, P.S. Searles, J.G. Zaller, C.V. Giardino, T.M. Robson, M.M. Caldwell, O.E. Sala, and A.L. Scopel. (2001). Impact of solar ultraviolet-B radiation on terrestrial ecosystems of Tierra del Fuego (southern Argentina). An overview of recent progress, *Journal of Photochemistry and Photobiology B: Biology*, 62, 67-77.*
- 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.*
- Bernhard, G. and G. Seckmeyer (1999). Uncertainty of measurements of spectral solar UV irradiance, *J. Geophys. Res.*, 104(D12), 14,321-14,345.
- 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*, pp. 113-115, U.S. Department of Commerce, Boulder, CO. *

- Bernhard G., C.R. Booth, and J.C. Ebrahimjian. (2002a). UV Spectroradiometer Monitoring Program: Calculation of Total Column Ozone from Spectra of Global Irradiance Measured at the South Pole and Barrow and Comparison with CMDL/Dobson and NASA/TOMS Ozone Data, in: *Climate Monitoring and Diagnostics Laboratory Summary Report 2000-2001, No 26*, edited by D.B. King, R.C. Schnell, R.M. Rosson, and C. Sweet, pp. 136-138, U.S. Department of Commerce, Boulder, CO.*
- Bernhard G., C.R. Booth, and J.C. Ebrahimjian. (2002b). 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.*
- Bernhard G., C. R. Booth, J.C. Ebrahimjian. (2003a). 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, 79-93. Also available at www.biospherical.com/nsf/presentations.asp.*
- Bernhard, G., C.R. Booth, and R.D. McPeters. (2003b). Calculation of total column ozone from global UV spectra at high latitudes. *J. Geophys Research*, 108(D17), 4532, doi:10.1029/2003JD003450.*
- Bernhard, G., C.R. Booth, and J.C. Ebrahimjian. (2003c). Real-time UV and column ozone from multi-channel UV radiometers deployed in the National Science Foundation's UV monitoring network. in: *Ultraviolet Ground- and Space-based Measurements, Models, and Effects III*, edited by J.R. Slusser, J.R. Herman, and W. Gao., *Proc. SPIE Int. Soc. Opt. Eng.*, Vol. 5156, 167-178.*
- Bernhard, G., C.R. Booth, J.C. Ebrahimjian. (2003d). 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 W. Gao, J.R. Herman, G. Shi, K. Shibasaki, and J.R. Slusser, *Proc. SPIE Int. Soc. Opt. Eng.*, Vol. 4896, 79-93.*
- Bernhard, G., C. R. Booth, J. C. Ebrahimjian, and V. V. Quang. (2003e). NSF Polar Programs UV Spectroradiometer Network 2000-2001 Operations Report Volume 10.0, 225 pp. Biospherical Instruments Inc., San Diego, CA.*
- Bernhard, G., C. R. Booth, and J. C. Ebrahimjian. (2004a). Version 2 data of the National Science Foundation's Ultraviolet Radiation Monitoring Network: South Pole, *J. Geophys. Res.*, 109, D21207, doi:10.1029/2004JD004937.*
- Bernhard, G., C.R. Booth, and J.C. Ebrahimjian. (2004b). UV and total ozone climatology at the South Pole based on Version 2 NSF network data. in: *Ultraviolet Ground- and Space-based Measurements, Models, and Effects IV*, edited by J.R. Slusser, J.R. Herman, W. Gao and G. Bernhard, *Proc. SPIE Int. Soc. Opt. Eng.*, Vol. 5545, 1-6.*
- Bernhard, G., C.R. Booth, and J.C. Ebrahimjian. (2004c). UV Spectroradiometer Monitoring Program: Spectral global irradiance and total column ozone measurements at South Pole and Barrow. in: *Climate Monitoring and Diagnostics Laboratory Summary Report 2002-2003, No 27*, edited by R.C. Schnell, A.-M. Buggle, and R.M. Rosson, pp. 139-141, U.S. Department of Commerce, Boulder, CO.*
- Bernhard, G., R.D. Evans, G.J. Labow, and S.J. Oltmans. (2005a). Bias in Dobson Total Ozone Measurements at High Latitudes due to Approximations in Calculations of Ozone Absorption Coefficients and Airmass. *J. Geophys. Res.*, 110, D10305, doi:10.1029/2004JD005559.*

- Bernhard, G., C. R. Booth, and J. C. Ebrahimian. (2005b). Real-time ultraviolet and column ozone from multichannel ultraviolet radiometers deployed in the National Science Foundation's ultraviolet monitoring network. *Optical Engineering*, 44(4), 041011-1 - 041011-12.*
- Bernhard, G., C. R. Booth, and J. C. Ebrahimian. (2005c). UV climatology at Palmer Station, Antarctica, in: *Ultraviolet Ground- and Space-based Measurements, Models, and Effects V*, edited by G. Bernhard, J. R. Slusser, J. R. Herman, W. Gao, Proc. SPIE Int. Soc. Opt. Eng., 588607-1 - 588607-12.*
- Bernhard, G., C. R. Booth, J. C. Ebrahimian, and V. V. Quang . (2005d). NSF Polar Programs UV Spectroradiometer Network 2001-2002 Operations Report Volume 11.0, 201 pp. Biospherical Instruments Inc., San Diego, CA.*
- Bernhard, G., C. R. Booth, J. C. Ebrahimian, and V. V. Quang . (2005e). NSF Polar Programs UV Spectroradiometer Network 2002-2003 Operations Report Volume 12.0, 213 pp. Biospherical Instruments Inc., San Diego, CA.*
- Bernhard, G., C. R. Booth, J. C. Ebrahimian, and V. V. Quang . (2005f). NSF Polar Programs UV Spectroradiometer Network 2003-2004 Operations Report Volume 13.0, 215 pp. Biospherical Instruments Inc., San Diego, CA.*
- Bernhard G., C.R. Booth, J.C. Ebrahimian, and S.E. Nichol. (2006) UV climatology at McMurdo Station, Antarctica, Based on Version 2 data of the National Science Foundation's Ultraviolet Radiation Monitoring Network, *J. Geophys. Res.*, 111, D11201, doi:10.1029/2005JD005857.*
- 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 researchers 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 researchers 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*.*
- 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 1995-1997 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.*
- Booth, C.R., G. Bernhard, J.C. Ebrahimian, V.V. Quang, and S.A. Lynch. (2001). *NSF Polar Programs UV Spectroradiometer Network 1999-2000 Operations Report*, 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.*
- Boucher, N., Prézelin, B.B., Evens, T., Jovine, R., Kroon, B., Moline, M.A., and Schofield, O. (1994). Icecolors '93: Biological weighting function for the ultraviolet inhibition of carbon fixation in a natural Antarctic phytoplankton community, *Antarctic Journal, Review 1994*, 272-275.
- 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.*

- Cullen, J. J. and P. J. Neale. (1997). Biological weighting functions for describing the effects of ultraviolet radiation on aquatic systems, pp. 97-118. *In* D.-P. Häder [ed.] Effects of ozone depletion on aquatic ecosystems. R. G. Landes.
- 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*.
- Day, T.A. C.T. Ruhland, F.S. Xiong, Influence of solar ultraviolet-B radiation on Antarctic terrestrial plants: results from a 4-year field study, *Journal of Photochemistry and Photobiology B: Biology*, 62, 78-87, 2001.*
- 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.
- De Fabo, E.C., F. P. Noonan, T. Fears, G. Merlino. (2004). Ultraviolet B but not ultraviolet A radiation initiates melanoma. *Cancer Research*, 64, 6372-6376.*
- 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.*

- Díaz, S.B., D.W. Nelson, G. Deferrari, and C. Camilion. (2002). Determination of spectral irradiances from broadband instrument measurements. in: *Ultraviolet Ground- and Space-based Measurements, Models, and Effects*, edited by J.R. Slusser, J.R. Herman, and W. Gao, *Proc. SPIE Int. Soc. Opt. Eng.*, Vol. 4482, 194-202.*
- Díaz, S.B., P. Vigliarolo, C. Vera, and G. Deferrari (2002). Cloud spectral transmittance in the UV and visible at Ushuaia (54°49'S, 68°19'W). in: *Ultraviolet Ground- and Space-based Measurements, Models, and Effects*, edited by J.R. Slusser, J.R. Herman, and W. Gao, *Proc. SPIE Int. Soc. Opt. Eng.*, Vol. 4482, 115-126.*
- Díaz, S., D. Nelson, Don, G. Deferrari, and C. Camilión. (2003). Estimated and measured DNA, plant-chromosome and erythral-weighted irradiance at Barrow and South Pole (1979-2000), *Agr. Forest. Meteorol.*, 120, 69-82.*
- Díaz, S., D. Nelson, Don, G. Deferrari, and C. Camilión. (2003). A model to extend spectral and multi-wavelength UV irradiances time series: model development and validation. *J. Geophys. Res.*, 108(D4), 10.1029/2002JD002134.*
- Díaz, S., C. R. Booth, R. Armstrong, C. Brunat, S. Cabrera, C. Camilion, C. Casiccia, G. Deferrari, H. Fuenzalida, C. Lovengreen, A. Paladini, J. Pedroni, A. Rosales, H. Zagarese, and M. Vernet (2005). Multichannel radiometer calibration: a new approach, *Appl. Opt.*, 44(26), 5374-5380.*
- 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_x/NO_x interaction. *Nature*, 315, 207-210.
- Fioletov, V.E., L.J.B. McArthur, J.B. Kerr, D.I. Wardle. (2001). 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.
- Flint, S. D. and M. M. Caldwell. (2003). A biological spectral weighting function for ozone depletion research with higher plants, *Physiologia Plantarum*, 117, 137-144.
- 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.*
- Frederick, J.E, and Y. Liao. (2003). Behavior of solar ultraviolet irradiance at high southern latitudes over decadal time scales. in: *Ultraviolet Ground- and Space-based Measurements, Models, and Effects III*, edited by J.R. Slusser, J.R. Herman, and W. Gao, *Proc. SPIE Int. Soc. Opt. Eng.*, Vol. 5156, 37-47.*
- Frederick, J.E. and Y. Liao. (2005). Photosynthetically active sunlight at high southern latitudes, *Photochem. Photobiol.*, 81, 603-608.*
- 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.
- Grujil, F.R., H.J.C.M. Sterenborg, P. D. Forbes, R.E. Davies, C. Cole, G. Kelfkens, H. van Weelden, H. Slaper, and J. C. van der Leun. (1993). Wavelength dependence of skin cancer induction by ultraviolet irradiation of albino hairless mice, *Cancer Res.*, 53, 53-60.
- 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 CO₂ Fixation in Marine Phytoplankton. In: *Photosynthetic Carbon Metabolism and Regulation of Atmospheric CO₂ and O₂*, 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.*
- Kancler, E., C. Gautier, P. Ricchiazzi, S. Yang, and P. Pilewskie. (2005). Spectral observations and modeling of the Arctic surface radiation environment, *J. Geophys. Res.*, 110, D23203, doi:10.1029/2005JD005813.*
- 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. (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., 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 *Stereochinus 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.
- Karentz, D., I. Bosch, and D.M. Mitchell. (2004). Limited effects of Antarctic ozone depletion on sea urchin development. *Marine Biology*, 145, 277-292, DOI 10.1007/s00227-004-1310-1.*
- Kaye, J.A., B.B. Hicks, E.C. Weatherhead, C.S. Long, J. Slusser. (1999). U.S. Interagency UV monitoring program established and operating, *EOS*, 80(10), 113-116.
- Kerr, J.B., and G. Seckmeyer. (2003). Surface Ultraviolet Radiation: Past and Future, in: *Scientific Assessment of Ozone Depletion: 2002*, pp. 5.1-5.46, Global Ozone Research and Monitoring Project Report No. 47, World Meteorology Organisation, Geneva, Switzerland.*
- 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.

- 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 D₃ in central and southern areas of Argentina., *Journal of Bone and Mineral Research*, 10(4), 545-549.*
- Lakkala, K., A. A. Redondas, O. Meinander, C. Torres, T. Koskela, E. Cuevas, P. Taalas, A. Dahlback, G. Deferrari, L. Edvardsen, and H. Ochoa (2005). Quality assurance of the solar UV network in the Antarctic, *J. Geophys. Res.*, 110, D15101, doi:10.1029/2005JD005584.*
- 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 cloud-less 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.*
- Liao, Y. and J.E. Frederick. (2005). The ultraviolet radiation environment of high southern latitudes: springtime behavior over a decadal timescale, *Photochem. Photobiol.*, 81, 320-324.*
- 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.*
- Lubin D., K.R. Arrigo, and G. L. van Dijken. (2004). Increased exposure of Southern Ocean phytoplankton to ultraviolet radiation. *Geophys. Res. Lett.*, 31, L09304, doi:10.1029/2004GL019633.*
- 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.

- Mayer, B. and A. Kylling. (2005). Technical note: The libRadtran software package for radiative transfer calculations - description and examples of use, *Atmos. Chem. Phys.*, 5, 1855-1877.
- 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. Ehranjian. (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.*
- Neale, P.J., and D.J. Kieber. (2000). Assessing biological and chemical effects of UV in the marine environment: spectral weighting functions, in: *Issues in Environmental Science and Technology No. 14*, edited by R.E. Hester and R.M. Harrison, Royal Society of Chemistry, Cambridge, UK.
- Nichol, S.E., G. Pfister, G.E. Bodeker, R.L. McKenzie, S.W. Wood, and G. Bernhard. (2003). Moderation of Cloud Reduction of UV in the Antarctic due to high surface albedo. *J. Appl. Meteorol.*, 42(8), 1174-1183.*
- 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.
- 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.
- Ricchiuzzi, 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.
- Ruhland, C.T., F.S. Xiong, W.D. Clark, and T.A. Day. (2005). The influence of ultraviolet-B radiation on growth, hydroxycinnamic acids, and flavenoids of *Deschampsia antarctica* during springtime ozone depletion in Antarctica, *Photochem. Photobiol.*, 81(5), 1086-1093.*
- 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., and G. Bernhard. (1993). Cosine error correction of spectral UV irradiances, in: *Atmospheric Radiation*, edited by Knut H. Stamnes, *Proc. SPIE Int. Soc. Opt. Eng.*, 2049, 140-151.
- 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*.
- 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. and 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*, Geneva, Switzerland.
- World Meteorology Organisation (WMO). (1998). *Report of the WMO-WHO meeting of experts on standardization of UV Indices and their dissemination to the public*, *WMO GAW Report No. 27*, WMO, Geneva, Switzerland.
- World Meteorology Organisation (WMO). (1999). *Scientific assessment of ozone depletion: 1998, Global ozone research and monitoring project, Report No. 44*, Geneva, Switzerland.*
- World Meteorology Organisation (WMO). (2003). *Scientific assessment of ozone depletion: 2002, Global ozone research and monitoring project, Report No. 47*, Geneva, Switzerland.*
- Wuttke S., G. Seckmeyer, G. Bernhard, J. Ehranjian, R. McKenzie, P. Johnston, and M. O'Neil. (2006). New spectroradiometers complying with the NDSC standards, *J. Atmos. Ocean. Tech.*, 23(2), pages 241–251.*
- 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 WeightedIrr(i) 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 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
            WeightedIrr(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(), WeightedIrr())
    If integrI < -998 Then Dose1 = -999: Exit Function
    integr = integr + integrI
Wend
Erase WeightedIrr
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 WeightedIrr(i) 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 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
            WeightedIrr(i) = Irradiance(i) * Weight
        End If
    Next i
    integrI = CalculateIntegral(Wav1, Wav2, item, Points(), Wavelength(), WeightedIrr()):
    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
```