Ocean Optics Protocols for Satellite Ocean Color Sensor Validation: Revisions 3 & 4 Working Group 5 and 8 Recommendations

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SIMBIOS Science Team

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Ocean Optics Protocols for Satellite Oceanography, Revision3

- **CHAPTER 1: OCEAN COLOR RADIOMETRY AND BIO-OPTICS (almost unchanged)**
- ***Mueller, J.L., R. W. Austin , G. S. Fargion and C. R. McClain***
- **CHAPTER 2: FUNDAMENTAL DEFINITIONS, RELATIONSHIPS AND CONVENTIONS (new)**
- ***Mueller, J.L and A. Morel***
- **CHAPTER 3: DATA REQUIREMENTS FOR OCEAN COLOR ALGORITHMS AND VALIDATION (Almost Unchanged)**
- ***Mueller, J.L., G. S. Fargion and C. R. McClain***
- **CHAPTER 4 INSTRUMENT SPECIFICATIONS, CHARACTERIZATION AND CALIBRATION OVERVIEW**
- *Mueller, J.L.*
- **CHAPTER 5: INSTRUMENT PERFORMANCE SPECIFICATIONS (Almost Unchanged)**
- ***Mueller, J.L. and R. W. Austin***
- **CHAPTER 6: CHARACTERIZATION OF OCEANOGRAPHIC AND ATMOSPHERIC RADIOMETERS (Modest Revisions)**
- ***Mueller, J.L. and R. W. Austin → (C. Johnson, J. Mueller, et al. TBD in Rev. 4)***

- **CHAPTER 7: CALIBRATION OF SUN PHOTOMETERS AND SKY RADIANCE SENSORS (modest revisions)**
- *Pietras, C., M. Miller, E. Ainsworh, R. Frouin, B. Holben, K. Knoblespeiss and K. Voss*
- **CHAPTER 8: STABILITY MONITORING OF FIELD RADIOMETERS USING PORTABLE SOURCES (unchanged)**
- *Hooker, S. B.*
- **CHAPTER 9: OVERVIEW OF MEASUREMENT AND DATA ANALYSIS PROTOCOLS**
- *Mueller, J.L.*
- **CHAPTER 10: IN-WATER RADIOMETRIC PROFILE MEASUREMENTS AND DATA ANALYSIS PROTOCOLS. (almost unchanged)**
- *Mueller, J.L.→(+ TBD???)*
- **CHAPTER 11: MOBY, A RADIOMETRIC BOUY FOR PERFORMANCE MONITORING AND VICARIOUS CALIBRATION OF SATELLITE OCEAN COLOR SENSORS: MEASUREMENT AND DATA ANALYSIS PROTOCOLS (New)**
- *Clark, D.K., M.A. Yarbrough, M. Feinholt, S. Flora C. Johnson,S. Brown, W. Broenkow, Y.S. Kim and J.L. Mueller*
- **CHAPTER 12: ABOVE-WATER RADIANCE AND REMOTE SENSING REFLECTANCE MEASUREMENTS AND DATA ANALYSIS PROTOCOLS (almost unchanged)**
- *Mueller, J.L., C. Davis, R. Arnone, R. Frouin, K. Carder, Z.P. Lee, R.G. Steward,S. Hooker, C.D.Mobley, and S. McLean →(+TBD??)*
- **CHAPTER 13: NORMALIZED WATER-LEAVING RADIANCE AND REMOTE SENSING REFLECTANCE: BIDIRECTIONAL REFLECTANCE AND OTHER FACTORS (New)**
- ***Morel, A. and J. L. Mueller***
- **CHAPTER 14: SUN PHOTOMETER AND SKY RADIANCE MEASUREMENTS AND DATA ANALYSIS PROTOCOLS (moderate revisions)**
- *Frouin, R., B. Holben, M. Miller, C. Pietras , E. Ainsworth, J. Porter, K. Knoblespeiss and K. Voss*
- **CHAPTER 15: DETERMINATION OF SPECTRAL ABSORPTION COEFFICIENTS OF PARTICLES,DISSOLVED MATERIAL AND PHYTOPLANKTON FOR DISCRETE WATER SAMPLES (Significant Revision)**

Ocean Optics Protocols: New Chapters in Rev 3

- **CHAPTER 2: FUNDAMENTAL DEFINITIONS, RELATIONSHIPS AND CONVENTIONS**
  - *Mueller, J.L and A. Morel*
- **CHAPTER 11: MOBY, A RADIOMETRIC BOUY FOR PERFORMANCE MONITORING AND VICARIOUS CALIBRATION OF SATELLITE OCEAN COLOR SENSORS: MEASUREMENT AND DATA ANALYSIS PROTOCOLS**
  - *Clark, D.K., M.A. Yarbrough, M. Feinholt, S. Flora C. Johnson,S. Brown, W. Broenkow, Y.S. Kim and J.L. Mueller*

- **CHAPTER 13: NORMALIZED WATER-LEAVING RADIANCE AND REMOTE SENSING REFLECTANCE: BIDIRECTIONAL REFLECTANCE AND OTHER FACTORS**
  - ***Morel, A. and J. L. Mueller***

Ocean Optics Protocols..Rev 4
Working Groups 5+8 Recommendations

- SCHEDULE: "Final" drafts of all new and revised chapters to SIMBIOS Project Office by *ca.* 15 July 2002 (minor revisions will be accepted after this, but no major ones
- Recommendations of Working Groups 5 and 8 presented below by Protocol Chapter.
- Rev 4:
  - 3 NEW Chapters (N1, N2, N3)
  - 4 Planned Significant Revised Chapters (2, 6, 10 and 12)
  - "Maintenance" Revisions, as appropriate, to balance of chapters by Lead Authors and Co-authors. Expected revisions to AOT and Sky Radiance Chapters 7 (Pietras et al) and 14 (Frouin et al)

Ocean Optics Protocols for Satellite Ocean Color Sensor Validation (Rev. 4) – NEW CHAPTERS

- **CHAPTER N1: RADIOMETRIC AND BIO-OPTICAL MEASUREMENTS FROM MOORED AND DRIFTING BUOYS: MEASUREMENT AND DATA ANALYSIS PROTOCOLS**
  - *Chavez, F, P. Strutton, V. Kuwahara, S. Mclean, T. Dickey, M. Abbott, M. Lewis. and others TBD*
  - In Feb 02, Chavez and Mueller will schedule ~2 day meeting in MBARI to assemble a strawman first draft, based on existing outline by Chavez et al. T. Dickey and other co-authors will be invited to attend, and those who cannot will have the opportunity to contribute via E-Mail iteration of the chapter draft.
- **CHAPTER N2: RADIOMETRIC OCEAN COLOR MEASUREMENTS FROM AIRCRAFT: MEASUREMENT AND DATA ANALYSIS PROTOCOLS**
  - *Davis, C., L. Harding, F. Hogue, S. McLean, E. Zelewski, P. Bissett, and TBD*
  - By 15 March, co-authors to send “off the shelf” notes, reprints, TM’s and reference citations to Mueller. Mueller will E-mail strawman draft to co-authors and hopefully a first author will emerge and lead the way to 15 July delivery

Rev. 4 New Chapters contd.

- **CHAPTER N3: INHERENT OPTICAL PROPERTIES: CALIBRATION, MEASUREMENT AND DATA ANALYSIS PROTOCOLS**
  - (more than 1 chapter, perhaps?? TBD)
  - *Pegau, S., R. Zaneveld, R. Maffione, R. Morrisson, and others TBD.*
  - *Late Apr/early May: Mueller to visit Corvallis for ~10 days to work with Pegau and Zaneveld to produce a first draft chapter. Other potential co-authors will be invited, or will have the opportunity to contribute via E-mail.*

Ocean Optics Protocols for Satellite Ocean Color Sensor Validation (Rev. 4) –CHAPTER REVISIONS

- **CHAPTER 2: FUNDAMENTAL DEFINITIONS….** Mueller and Morel
  - Mueller and Morel will evolve and expand the chapter to address
    - Atmospheric Optical Properties and Radiometric Relationships
    - Uncertainty Budgets: Definitions, Conventions and Statistical Methods
- **CHAPTER 6: CHARACTERIZATION OF … RADIOMETERS …** Johnson, Mueller, Hooker, Zibordi, Meister, McLean, Menzies and others TBD
  - Schedule and detailed approach TBD pending discussions with C. Johnson.
  - Initial revision inputs will be solicited by E-mail from interested co-authors
    - NIST 2000 scale – strategy to adopt it
    - SIRCUS (C. Johnson and NIST colleagues – not part of E-mail thing)
    - Irradiance immersion factor characterization, strengthen protocols regarding methods for assuring optical clean water and clean water surface, and other specific aspects of procedure.
    - Plaques: BRDF adjustments or characterization, illumination/reflectance variations across plaque & sensor alignment protocols.
    - Distance offset in r^{-2} scaling of FEL spectral irradiance scales

Ocean Optics Protocols (Rev. 4) –CHAPTER REVISIONS Cont'd

- **CHAPTER 10: IN-WATER RADIOMETRIC PROFILE…..** Mueller, Hooker, Zibordi, McLean and others TBD??
  - Initiate revisions by E-mail exchanges
    - Methods for extrapolating $L_u(z)$ to $L_u(0^-)$. Approach development of protocols by initiating a new DARR series over the Intenet. Mueller will provide strawman draft of protocols specifying criteria for DARR-data example profile content and formats, criteria for comparing results between alternate profile analysis and extrapolation methods, and protocols for reporting results, method descriptions and uncertainties of results.
- **CHAPTER 12: ABOVE WATER RADIOMETRY…** Mueller et al (as now + others TBD)
  - Uncertainties to date to large to support radiometric validation
  - Emphasize potential applications and uncertainty budgets associated with ratios of reflectances at different wavelengths, vice absolute values
  - Add protocols for reporting uncertainties on future experiments comparing above- water and in-water exact normalized water-leaving radiances or ratios.
  - Suggest a path for eventual convergence on the status and utility of specific proposed protocols.

Normalized Water-Leaving Radiance (Gordon and Clark (1981)

$$L_{\mathrm{WN}}(\lambda,\theta,\phi)=\frac{L_{\mathrm{W}}(\lambda,\theta,\phi)}{E_{\mathrm{d}}(0^{+},\lambda)}\bar{F}_{\mathrm{o}}(\lambda)=R_{RS}(\lambda,\theta,\phi)\bar{F}_{\mathrm{o}}(\lambda),\ \mu\mathrm{W\ cm^{-2}nm^{-1}sr^{-1}}, \tag{13.8}$$

or

$$L^{\mathrm{S}}_{\mathrm{WN}}(\lambda,\theta,\phi)=\frac{L^{\mathrm{S}}_{\mathrm{W}}[\lambda,\theta,\phi,\theta_{\mathrm{o}},\tau_{\mathrm{a}},W,Chl]}{t(\lambda,\theta_{\mathrm{o}})\cos\theta_{\mathrm{o}}\left(\frac{d_{\mathrm{o}}}{d}\right)^{2}}, \tag{13.18}$$

Exact Normalized Water-Leaving Radiance (Morel and Gentili 1996; also see Chapter 13)

$$L^{\mathrm{ex}}_{\mathrm{WN}}(\lambda)=L^{\mathrm{S}}_{\mathrm{WN}}(\lambda,\theta,\phi)\frac{\Re_{\mathrm{o}}}{\Re(\theta',W)}\frac{f_{\mathrm{o}}(\lambda,\tau_{\mathrm{a}},Chl)}{Q_{\mathrm{o}}(\lambda,\tau_{\mathrm{a}},Chl)}\left(\frac{f(\lambda,\theta_{\mathrm{o}},\tau_{\mathrm{a}},Chl)}{Q(\lambda,\theta',\phi,\theta_{\mathrm{o}},\tau_{\mathrm{a}},Chl)}\right)^{-1}, \tag{13.20}$$

$$L^{\mathrm{ex}}_{\mathrm{WN}}(\lambda)=L^{\mathrm{inw}}_{\mathrm{WN}}(\lambda)\frac{f_{\mathrm{o}}(\lambda,\tau_{\mathrm{a}},Chl)}{Q_{\mathrm{o}}(\lambda,\tau_{\mathrm{a}},Chl)}\left(\frac{f(\lambda,\theta_{\mathrm{o}},\tau_{\mathrm{a}},Chl)}{Q_{\mathrm{n}}(\lambda,\theta_{\mathrm{o}},\tau_{\mathrm{a}},Chl)}\right)^{-1}. \tag{13.21}$$