Odele Coddington (nee Hofmann)

Laboratory for Atmospheric and Space Physics, University of Colorado, 3665 Discovery Drive, Boulder, CO 80303-7819
Phone: (303) 492-9318
email: Odele.Coddington@lasp.colorado.edu

Home Page: http://lasp.colorado.edu/home/personnel/odele.coddington/
ResearcherID: http://www.researcherid.com/rid/F-6342-2012

Education

2009   **Doctorate of Philosophy, Atmospheric and Oceanic Science**, May 2009,
              University of Colorado, Boulder, CO
              Dissertation: The application of airborne shortwave spectral irradiance
              measurements to atmosphere and surface remote sensing.
              Advisor: Peter Pilewskie

2002   **Bachelor of Arts, Physics**, University of Colorado, Boulder, CO

Appointments

2013-   **Research Associate II,** Laboratory for Atmospheric and Space Physics,
                University of Colorado Boulder

2009-2013   **Research Associate I,** Laboratory for Atmospheric and Space Physics, University
                of Colorado Boulder

2005-2009   **Graduate Research Assistant**, LASP/ATOC University of Colorado Boulder

2003-2005   **Graduate Research Assistant**, Center for Limb Atmospheric Sounding, Boulder,
                Colorado

2001-2003   **Student Command Controller,** Laboratory for Atmospheric and Space Physics,
                University of Colorado Boulder

Research Activities

Radiative Transfer Modeling

> Developed improvements to an existing spectral radiative transfer (RT) model used to simulate irradiance as measured by the Solar Spectral Flux Radiometer (SSFR). Improvements include: better sampling resolution, extended spectral range, improved accuracy, updated gas absorption coefficients and additional species. Enhanced current radiance modeling capabilities to allow for modeling zenith and nadir radiances, modeling cloud and aerosol in a single scene, and implemented an improved numerical approximation for calculation of Rayleigh optical depth. Responsible for maintaining RT code and instructing junior scientists and graduate students in its use.

Applications to surface, aircraft and satellite remote sensing

> Demonstrated an iterative technique to retrieve surface albedo from airborne measurements of spectral irradiance by correcting for atmospheric contributions in an aerosol-laden scene. Compared SSFR surface albedo area-averaged and along-track retrievals to Moderate Resolution Imaging Spectroradiometer (MODIS) satellite retrievals in a polluted environment. Retrieved cloud optical properties (cloud optical thickness and effective radii) from airborne SSFR

measurements of albedo and surface SSFR measurements of transmitted radiance. Demonstrated the potential for a low bias in retrieved optical thickness and effective radius when an overlying absorbing aerosol layer is present above the cloud. Compared SSFR cloud retrievals to MODIS satellite retrievals in the presence of overlying aerosol layers.

Field campaign experiments

Assisted in the calibration and operation of the SSFR on the Sky Research Jetstream-31 and the CIRPAS Twin Otter aircrafts during two measurement field campaigns: the Megacity Initiative: Local and Global Research Observations (MILAGRO) and the Gulf of Mexico Atmospheric Composition and Climate Study (GoMACCS). Remotely supported the download and analysis of SSFR data and infrared pyrgeometer from the NOAA WP-3D and the NOAA Ship Ron Brown during Aerosol Radiation and Cloud Processes affecting Arctic Climate (ARCPAC) and SSFR data from the NASA P-3 Orion during Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS). Provided surface albedo and cloud reflectance and transmittance look up tables for the Deep Convective Clouds & Chemistry Experiment (DC3) campaign.

Information Theory, General Inverse Problems, Bayesian Frameworks

Applied the Generalized Nonlinear Retrieval Analysis (GENRA) methodology for general inverse problems to compute the Shannon information content of hyperspectral cloud albedo data. This research has implications for the effective and efficient use of hyperspectral data, retrieval characterization, and to guide wavelength channel choices in retrieval methods and during mission development. Expanded the GENRA technique to analyze the probability of retrieving cloud thermodynamic phase from reflected and transmitted shortwave radiation and to the characterization of new cloud spectral transmittance retrieval methods. Investigating new information-theoretic approaches for objective model selection (of different degradation models) using An Information Criterion (AIC) as applied to the time series of SORCE SIM spectral irradiance data.

Total Solar Irradiance Sensor (TSIS) satellite mission

The Total Solar Irradiance Sensor (TSIS) will make future measurements of total (W m-2) and spectral (W m-2 nm-1 between 200 nm - 2400 nm) solar irradiance and is the follow on to the LASP-built instruments of the Solar Radiation and Climate Experiment (SORCE) and the TSI Calibration Transfer Experiment (TCTE). The TSIS measurements are designed to continue the observations of total and spectral irradiance, albeit with higher accuracy, increased precision, and improved stability. Expected launch date is 2017. My contributions to the TSIS project include a) Lead author of the TSIS Algorithm Theoretical Basis Document (ATBD), and b) Contributed to the calibration, characterization, and daily operation plan of the TSIS Spectral Irradiance Monitor (SIM) instrument, and c) Contributed to the Calibration and Validation plan (technical document).

Exposure-Related degradation of space instrument optics

Contributed to an independent evaluation of the long-term relative degradation of the SORCE SIM instrument. Efforts have focused on refining the uncertainties in the SORCE SIM solar exposure time, and in investigating impact on instrument degradation from solar exposure time compared to that based on the photon flux (i.e. the photon flux striking the prism is not constant with time and will be dependent upon solar variability and the distance between the spacecraft and the Sun). Investigated new approaches for the selection of SORCE SIM degradation model using Information Theory, specifically An Information Criterion (AIC), by defining an objective evaluation of different candidate degradation models.

Climate Data Records of Total Solar Irradiance and Spectral Solar Irradiance

a) Provide daily and monthly TSI and SSI from 1882 to the present, and annual TSI and SSI since 1615. Primary responsibility for translating extant, research–grade source codes of the Naval Research Laboratory Total Solar Irradiance Model (NRLTSI-2) and the Naval Research Laboratory Spectral Solar Irradiance Model (NRLSSI-2) to functional, robust programs for use operationally. Aid in code development for calculating the sunspot and facular solar proxy inputs needed for the models. Responsible, as part of team effort, for validating the climate data record, numerical testing, assessing internal consistency, and comparing model output to observations.

b) Investigate the application of Bayesian Framework methodologies for aiding the development of a composite long-term record of Mg-II (solar index of chromospheric variability) measured by multiple instruments at the same, or different, times. Primary satellite data sets are the Solar Radiation and Climate Experiment (SORCE), Solar Backscatter Ultraviolet (SBUV/2), Global Ozone Monitoring Experiment (GOME), and Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY).

Publications

In preparation -

LeBlanc, S. E., P. Pilewski, K. S. Schmidt, and **O. Coddington**, A generalized method for discriminating thermodynamic phase and retrieving cloud optical thickness and effective radius using transmitted shortwave radiance spectra, *submitted to Atmos. Meas. Tech*.

LeBlanc, S., E., P. Pilewskie, **O. Coddington**, and K. S. Schmidt, Statistical evaluation of parameters used to discriminate cloud thermodynamic phase and retrieve optical thickness and effective radius from transmitted shortwave radiance spectra

Schmidt, K. S., **O. Coddington**, and P. Pilewskie, Quantifying the probability of retrieving cloud thermodynamic phase of clouds over bright surfaces from passive remote sensing

Coddington, O., P. Pilewskie, K. S. Schmidt, and T. Vukicevic, Characterizing the retrieval of Arctic cloud properties from optical remote sensing

Kren, A., P. Pilewskie, and **O. Coddington**, Where does the atmosphere get its energy?

Coddington, O. P. Pilewskie, and E. Richard, Investigating the impacts of degradation model selection and a model selection uncertainty on the long-term record of solar spectral irradiance as measured by SORCE SIM.

Published -

Coddington, **O**., P. Pilewskie, K. S. Schmidt, P. J. McBride and T. Vukicevic (2013), Characterizing a new surface-based shortwave cloud retrieval based on transmitted radiance for soil and vegetated surface types, special topic issue "Advances in Studies of Atmospheric Aerosol and clouds Using Remote Sensing Techniques", *Atmosphere*, 4(1):48-71.

Coddington, **O**., P. Pilewskie, and T. Vukicevic (2012), The Shannon information content of hyperspectral shortwave cloud albedo measurements: Quantification and practical applications, *J. Geophys. Res.*, 117, D04205, doi:10.1029/2011JD16771.

Kindel, B. C., P. Pilewskie, K. S. Schmidt, **O. Coddington**, and M. D. King (2011), Solar spectral absorption by marine stratus clouds: Measurements and modeling, *J. Geophys. Res.*, doi: 10.1029/2010JD015071.

R. W. Bergstrom, K. S. Schmidt, **O. Coddington**, P. Pilewskie, H. Guan, J. M. Livingston, J. Redemann, and P. B. Russell (2010), Aerosol spectral absorption in the Mexico City area: results from airborne measurements during MILAGRO/INTEX B, *Atmos. Chem. Phys.*, 10, 6333-6343.

Vukicevic, T., **O. Coddington**, and P. Pilewskie (2010), Characterizing the retrieval of cloud properties from optical remote sensing, *J. Geophys. Res.*, 115, D20211, doi:10.1029/2009JD012830.

Schmidt, K.S., P. Pilewskie, R. Bergstrom, **O. Coddington**, J. Redemann, J. Livingston, P. Russell, E. Bierwirth, M. Wendisch, W. Gore, M. K. Dubey, and C., Mazzoleni (2010), A new method for deriving aerosol solar radiative forcing and its first application within MILAGRO/INTEX-B, *Atmos. Chem. Phys*, 10, 7829-7843.

Coddington, **O**., P. Pilewskie, J. Redemann, S. Platnick, P. B. Russell, K. S. Schmidt, W. Gore, J. Livingston, G. Wind, and T., Vukicevic (2010), Examining the impact of overlying aerosols on the retrieval of cloud optical properties from passive remote sensing, *J. Geophys. Res.,* doi:10.1029/2009JD012829.

Coddington, **O**., The application of airborne shortwave spectral irradiance measurements to atmosphere and surface remote sensing, PhD Thesis, University of Colorado, 2009.

Schmidt, K. S., G. Feingold, P. Pilewskie, H. Jiang, **O. Coddington**, and M. Wendisch (2009), Irradiance in polluted cumulus fields: Measured and modeled cloud–aerosol effects, *Geophys. Res. Lett.*, *36*, L07804, doi:10.1029/2008GL036848.

Livingston, J. M., J. Redemann, P. B. Russell, O. Torres, B. Veihelmann, P. Veefkind, P., R. Braak, A. Smirnov, L. Remer, R. W. Bergstrom, **O. Coddington**, O., K. S. Schmidt, P. Pilewskie, R. Johnson, and Q. Zhang (2009), Comparison of aerosol optical depths from the Ozone Monitoring Instrument (OMI) on Aura with results from airborne sunphotometry, other space and ground measurements during MILAGRO/INTEX-B, *Atmos. Chem. Phys.,* 9, 6743-6765.

Coddington, **O**., K. S. Schmidt, P. Pilewskie, W. J. Gore, R. W. Bergstrom, M. Román, J. Redemann, P. B. Russell, J. Liu, and C. C. Schaaf (2008), Aircraft measurements of spectral surface albedo and its consistency with ground-based and space-borne observations, *J. Geophys. Res.*, *113*, D17209, doi:10.1029/2008JD010089.

Technical Documents

Richard, E., **O. Coddington**, D. Harber, M. Triplett, et al., (2013) TSIS Calibration and Validation Plan, LASP Technical Document

Coddington, O., P. Pilewskie, E. Richard, G. Kopp, J. Lean et al., Total Solar Irradiance Sensor (TSIS): Algorithm Theoretical Basis Documents (ATBD) (*draft submitted 10/29/2013*).

Invited Conference Presentations

Coddington, O., P. Pilewskie, and T. Vukicevic, Quantifying the Information Content of Hyperspectral Cloud Data, Hyperspectral Imaging and Sensing of the Environment (HISensE): Toronto, Canada, July 10-14, 2011.

Conference Papers

Coddington, O., P. Pilewskie, and T. Vukicevic (2011), Quantifying the Information Content of Hyperspectral Cloud Data, in *Hyperspectral Imaging and Sounding of the Environment*, OSA Technical Digest (CD) (Optical Society of America, 2011), paper HWB3.

Contributed Conference Presentations

Future -

Coddington, O., P. Pilewskie, and K. S. Schmidt, Quantitative evaluation of retrievals of cloud properties from spectral transmittance and reflectance, 14th Conference on Atmospheric Radiation, Boston, MA, 7-11 July, 2014.

LeBlanc, S., P. Pilewskie, K. S. Schmidt, O. Coddington, J. Redemann, P. Russell, and C. Flynn, Cloud remote sensing using spectral features in transmitted shortwave radiation, 14th Conference on Atmospheric Radiation, Boston, MA, 7-11 July, 2014.

Pilewskie, P., K. S. Schmidt, and O. Coddington, Information Content in Remote Sensing: A perspective on Twomey's influence on present and future observations, 14th Conference on Atmospheric Radiation, Boston, MA, 7-11 July, 2014.

Schmidt, K. S., P. Pilewskie, G. Feingold, O. Coddington, and S. Song, Relating shortwave passive remote sensing and radiative effects of aerosol-immersed broken cloud fields, 14th Conference on Atmospheric Radiation, Boston, MA, 7-11 July, 2014.

Schmidt, K. S., S. Song, P. Pilewskie, and O. Coddington, New Observational and Modeling Approaches for Understanding Radiative Effects in Polluted Boundary Layer Clouds, EGU General Assembly, Vienna, Austria, 2 May, 2014.

Song, S., K. S. Schmidt, P. Pilewskie, and O. Coddington, Exploring new methods to exploit the relationship between cloud spatial structure and their spectral radiative signature in remote sensing and energy budget applications, EGU General Assembly, Vienna, Austria, 2 May, 2014.

Past –

Coddington, O., P. Pilewskie, E. Richard, and A. Kren, Applying Information-Theoretic Approaches for Objective Model Selection and Quantification of a Model Selection Uncertainty, Boulder Solar Day, Boulder, CO., March 18, 2014.

Coddington, O., P. Pilewskie, E. Richard, and A. Kren, Applying Information-Theoretic Approaches for Objective Model Selection and Quantification of a Model Selection Uncertainty, 2014 SORCE Science Team Meeting, Cocoa Beach, FL., Feb. 28-31, 2014.

Coddington, O., P. Pilewskie, J. Lean, and A. Kren, Total and Spectral Solar Irradiance, Climate Data Record Development Project, Asheville, NC, July 29-Aug 1, 2013.

Schmidt, S., **O. Coddington**, and P. Pilewskie, Retrieving cloud properties over bright surfaces from shortwave spectral observations, Davos Atmosphere and Cryosphere Assembly 2013, Davos, Switzerland, July 8-12, 2013.

LeBlanc, S., S. Song, **O. Coddington**, P. McBride, C. Flynn, K. S. Schmidt, and P. Pilewksie, Ground based spectral radiance and irradiance measurements of aerosols and clouds during the DC3 field campaign, AGU, 2012.

Coddington, O., E. Richard, S. Beland, and P. Pilewskie, A new look at solar exposure and SORCE degradation, presented at SSI Trends Workshop, Annapolis, MD, Sept.17, 2012.

Bearden, L., **O. Coddington**, M. Snow, and E. Richard. Trends in the Short-Term SSI Variability during the Declining Phase of SC23: Spectral Decomposition over 100 Carrington rotations from the UV through the near IR, presented at 2012 SORCE Science Team Meeting, Annapolis, MD, Sept. 18-19, 2012.

Schmidt, K. S., P. Pilewskie, **O. Coddington** and B. Kindel, Aircraft and ground-based measurements of spectral solar radiation, presented at 2012 SORCE Science Team Meeting, Annapolis, MD, Sept. 18-19, 2012.

Pilewskie, P., S. Schmidt, **O. Coddington**, Y. Roberts, and B. Kindel, Monitoring Earth's Climate with Shortwave Hyperspectral Reflectance, International Radiation Symposium, Berlin, Germany, August 6-10, 2012.

Schmidt, K. S., P. Pilewskie, G. Feingold (*presenter*), **O. Coddington**, S. Song, and A. McComiskey, Spectral radiative effects and remote sensing of aerosol-immersed cumulus cloud fields, 16th International Conference on Clouds and Precipitation, Leipzig, Germany, July 30-August 3, 2012.

Schmidt, K. S., **O. Coddington**, P. Pilewskie (*presenter*), and S. Song, Cloud inhomogeneities, aerosol particles, thermodynamic phase, and crystal shape in hyperspectral shortwave measurements and model calculations, International Radiation Symposium, Berlin, Germany, August 6-10, 2012.

Coddington, O., TSIS Algorithm Theoretical Basis Document, TSIS Quarterly Science Team Meeting, Greenbelt, Maryland, Feb. 1, 2012.

Pilewskie, P., and **O. Coddington**, TSIS Update, NOAA Climate Data Record Annual Meeting, Asheville, NC., Aug 1-3, 2012.

Coddington, O., Pilewskie, P., Vukicevic, T., Livingston, J., Platnick, S., Wind. G., Redemann, J., and Russell, P. B., Airborne radiometer measurements of above cloud reflectance in the presence and absence of aerosols, Hyperspectral Imaging and Sensing of the Environment (HISensE): PHTuC6, Vancouver, Canada, April 27-29, 2009.

Coddington, O., P. Pilewskie, S. Platnick, G. Wind, J. M. Livingston, J. Redemann, and P. B. Russell, Retrieval of cloud optical depth and effective radius from SSFR irradiance measurements made in the presence of overlying aerosol layers during NEAQS-ITCT and comparison to MODIS cloud product, in Eos Trans., no. A41E-0163 in Fall Meet. Suppl. 89(53), AGU, 2008.

McBride, P., P. Pilewskie, K. S. Schmidt, **O. Coddington**, and S. Kittelman, Cloud and aerosol retrieval methods with scattered surface-based radiance measurements, in Eos Trans., no. A11E-0194 in Fall Meet. Suppl. 89(53), AGU, 2008.

Livingston, J. M., O. Torres, P. B. Russell, J. Redemann, R. R. Johnson, R. W. Bergstrom, B. Veheilmann, A. Smirnov, B. N. Holben, L. Remer, K. S. Schmidt, **O. Coddington**, and P. Pilewskie, Comparison of airborne sunphotometer and satellite retrievals of aerosol optical depth during MILAGRO/INTEX-B, in Eos Trans., no. A12A-01 in Fall Meet. Suppl. 88(52),

AGU, 2007b.

McBride, P., P. Pilewskie, K. S. Schmidt, and **O. Coddington**, New insights into the column radiative budget using ground based hyperspectral zenith radiance measurements, in Eos Trans., no. A41A-0021 in Fall Meet. Suppl. 88(52), AGU, 2007.

Pilewskie, P., K. S. Schmidt, **O. Coddington**, R. Bergstrom, and J. Redemann, Advances in quantifying the radiative effects of aerosol particles on climate from airborne field studies, in Eos Trans., no. A34A-01 in Fall Meet. Suppl. 88(52), AGU, 2007.

Coddington, O., K. S. Schmidt, P. Pilewskie, W. J. Gore, R. W. Bergstrom, M. Roman, J. Redemann, P. B. Russell, J. Liu and C. Schaff, Measurements of area resolved surface spectral albedo and validation of MODIS land albedo product during MILAGRO, GoMACCS, and TC4, in Eos Trans., no. A43C-1415 in Fall Meet. Suppl. 88(52), AGU, 2007.

Livingston, J. M., O. Torres, P. B. Russell, J. Redemann, R. R. Johnson, R. W. Bergstrom, B. Veheilmann, A. Smirnov, B. N. Holben, L. Remer, K. S. Schmidt, **O. Coddington**, and P. Pilewskie, Comparison of airborne sunphotometer and satellite retrievals of aerosol optical depth during MILAGRO/INTEX-B, in Eos Trans., no. A12A-01 in Fall Meet. Suppl. 88(52), AGU, 2007.

Coddington, O., K. S. Schmidt, and P. Pilewskie, Measurement and error analysis of spectral surface albedo during MILAGRO, ARM Science Team Meeting, Monterey, CA, 2007.

Pilewskie, P., P. McBride, W. Gore, J. Pommier, and **O. Coddington**, The SWS at SGP, ARM Science Team Meeting, Monterey, CA, 2007.

Hofmann, O., P. Pilewskie, B. Kindel, W. Gore, P. Russell, J. Livingston, J. Redemann, R. Bergstrom, S. Platnick, J. Daniel, and T. Garrett, Cloud properties derived from visible and near-infrared reflectance in the presence of aerosols, ARM Science Team Meeting, Albuquerque, New Mexico, 2006.

Pilewskie, P., **O. Hofmann**, B. Kindel, W. Gore, P. Russell, J. Livingston, J. Redemann, R. Bergstrom, S. Platnick, J. Daniel, and T. Garrett, Cloud properties derived from visible and near-infrared reflectance in the presence of aerosols, in Eos Trans., no. A14B-07 in Fall Meet. Suppl. 86(52), AGU, 2005.

Proposals

2014	**Principal Investigator**: Retrieval Studies in Support of Cloud Property Products from the PACE Ocean Color Imager *to be submitted March, 2014.*
2014	**Co-Investigator:** Total Solar Irradiance (TSI) and Spectral Solar Irradiance (SSI) FCDR (NOAA) *funded*
2013	**Co-Investigator:** Earth Climate Hyperspectral Observatory (ECHO) for Earth Venture Instrument -2 (NASA) *pending*
2013	**Principal Investigator:** Characterizing the retrieval of Arctic cloud properties from optical remote sensing: Quantifying current capabilities and determining future expectations (NASA New (early career) Investigator Program in Earth Science) *pending*
2013	**Co-Investigator:** Retrieving multi-pixel multi-spectral aerosol and cloud parameters in broken cloud fields (NASA) *pending*
2010	**Co-Investigator**: Development and Validation of New Spectral Cloud and Aerosol Retrievals (09-RST09-101) *funded*

2009   **Co-Investigator**: Developing a Climate Data Record for Total and Spectral Solar Irradiance (NOAA Award number N109NES4400016) *funded*

Planned –
  2014   Atmospheric Composition Spectral Climate Signal (NASA)

Ph.D. Committees
  2012-   Ph.D Candidate Andrew Kren

Graduate Students
  2009-   Mentoring students of Professor Peter Pilewskie (Department of Atmospheric and Oceanic Studies at CU-Boulder and LASP) Atmospheric Radiation Group: Shi Song, Samuel LeBlanc, Patrick McBride. Provide coding assistance, assistance with paper editing, writing fellowship proposals, and research guidance.

Seminars and Public Lectures
  2012   **ATOC Seminar** *Shannon Information Content: A diagnostic to effectively analyze remotely sensed data and retrieval techniques*
  2011   **LASP Public Lecture** *Clouds in the Earth's Lower Atmosphere; Views from Near and Far give Insight into their Regulation of Climate*

Education and Outreach
  2014   **LASP REU Mentor** *Bayesian approaches to developing long-term data records: A composite Mg-II record - with student Sarah Swenson.*
  2014   **Science at 100,000 feet Mentor** a program designed to guide middle school students in defining a science question and experiment to be researched at 100,000 feet through launching high-altitude weather balloons.
  2013-   **LASP Office of Communications and Outreach (OCO) Committee Member** a working-group chartered to reevaluate the breadth and scope of programs in Education and Public Outreach and communications at LASP
  2012   **LASP REU Co-Mentor** *As the sun turns: Changes in spectral irradiance   at ultraviolet, visible, and infrared wavelengths due to solar rotation - with student Lauren Bearden.*
  2012   **Earth Explorers Mentor** a middle school videography program designed to drive interest in STEM disciplines, 2012.
  2011   **LASP REU Co-Mentor** *Climate change during the recent solar cycle minimum - with student Christopher Maloney.*
  2010   **LASP REU Co-Mentor** *Using a generalized nonlinear method to characterize the retrievals of cloud optical thickness and effective radius from passive remote sensing - with student Leandra Merola.*

Synergistic Activities
  2012   **Poster Judge** *Annual ATOC poster conference, Nov 26. 2012.*
  2012   Lead content developer for the joint LASP-NASA Goddard Sun-Climate Research Center webpage: *http://lasp.colorado.edu/home/scrc/*

Awards

2006   **Award-Winning Poster** *Cloud properties derived from visible and near-infrared reflectance in the presence of aerosols, 2006 ARM Science Team Meeting, Albuquerque, NM.*

2005   **NASA Group Achievement Award** *AURA Team*

Professional Memberships

American Geophysical Union (AGU)

American Meteorological Society (AMS)

American Association for the Advancement of Science (AAAS)