SE-590 Low Altitude Reflectances (OTTER)

Summary:

Low altitude (Ultralight) spectral reflectances of OTTER research sites measured by Spectron SE590 spectrophotometer.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

SE-590 Low Altitude Reflectances (OTTER)

Data Set Introduction:

The Oregon Transect Ecosystem Research (OTTER) Project was a cooperative effort between NASA and several universities to discern the ecology of western coniferous forests using remote sensing technology supported by ground observations. OTTER is an interdisciplinary project that tested a model that estimated the major fluxes of carbon, nitrogen, and water through a temperate coniferous forest ecosystem.

Six Oregon sites across an elevational and climatic gradient were intensively studied. The transect began at the Pacific coast at the site called Cascade Head, passed through the outskirts of Corvallis, through a dense Douglas fir forest at Scio, through a mountain hemlock/subalpine fir community at Santiam Pass, through a Ponderosa pine community near Metolius, and ended at a site east of Sisters called Juniper. In all, the transect stretched some 300 kilometers west to east.

Goals of the project were to simulate and predict ecosystem processes such as photosynthesis, transpiration, above-ground production, nitrogen transformation, respiration, decomposition, and hydrologic processes; combine field, lab, and remote sensing techniques to estimate key vegetation and environmental parameters; construct a "geo-referenced" database for extrapolation and testing of principles, techniques, and prediction; and verify the predictions through direct measurements of process rates or controls on processes.

Objective/Purpose:

OTTER was designed to study the ability of remote sensing to detect biophysical characteristics of plant canopies. The data sets correlating to this document contain data that has been remotely sensed by a spectroradiometer for the six different sites.

Summary of Parameters:

Two parameters were investigated: Emitted radiation and reflected radiation.

Discussion:

During the OTTER project, ultralight aircraft provided low-altitude reflectance and video records of the research sites. These data allowed ground measurements to be scaled to satellite observations.

Previous remote sensing studies have employed truck-mounted booms and helicopters to provide near-surface spectral measurements (Bauer et al.,1981, Williams et al., 1984; Ripple et al., 1987). Light aircraft have provided near-surface measurements in cases where boom operations were not feasible or helicopters proved too expensive (Foran and Pickup 1984; Howard and Barton 1973).

Ultralight aircraft were introduced as part of the OTTER project in 1989 (McCreight and Waring, 1990). They were operated in accordance with Federal Aviation Flight rules as public research aircraft. Research flights were performed by McCreight, a certified pilot with over 2400 flight hours experience. The addition of a ballistic parachute, designed to recover the aircraft and crew in the event of an emergency, provided an added margin of safety.

Related DataSets:

Canopy Chemistry Forest-BGC Model Leaf Area Index Data Leaf Reflectances: LICOR Leaf Reflectances: Perkin-Elmer Meteorology Optical Thickness Data: Aircraft Optical Thickness Data: Ground Reflectance Reference Targets SE-590 Field-Measured Reflectances SE-590 Lab-Measured Reflectances SE-590 Landscape Reflectances Timber Measurements

2. Investigator(s):

Investigator(s) Name and Title:

Name: Richard W. McCreight, Research Scientist, Co-director Contact: Richard H. Waring, Professor, Director

Addresses: Oregon State University U.S.A.

Telephone Numbers: 1-(541)-737-2668

Electronic Mail Address: waring@fsl.orst.edu

Title of Investigation:

OTTER Spectron Spectral Reflectance Measurements

Contact (for Data Production Information):

Name: ORNL DAAC User Services Office

Address: Oak Ridge National Laboratory U.S.A.

Telephone Number: 1-(865)-241-3952

Electronic Mail Address: ornldaac@ornl.gov

3. Theory of Measurements:

During the OTTER project, ultralight aircraft provided low-altitude reflectance and video records of the research sites. These data allowed ground measurements to be scaled to satellite observations.

4. Equipment:

Sensor/Instrument Description:

During 1989 and 1990, ultralight observations were made with a Quicksilver Model MXLI. This aircraft has a single seat with a 45 hp engine and a 125 kg load capacity. The aircraft is configured with 3-axis control surfaces to ensure adequate stability of the platform in turbulent weather. By 1990 increased remote sensing instrument loads were approaching the payload capacity of the aircraft. Therefore, during the winter of 1990-91 a "third-generation" ultralight, the Quicksilver Model GT500 was acquired. The increased wing size and 65 hp engine of the GT500 significantly improved platform performance, with a payload of 195 kg.

Remote sensing instruments were mounted to the airframe near the center of gravity of the aircraft, adjacent to the pilot's seat and with an unobstructed view of the ground below the aircraft. Upon this mount, three or four sensors were attached, depending on research objectives.

A Sony Model TR5 8mm video camera recorded the surface features measured by the SE590 spectroradiometer. The standard optics of the video camera provide an instantaneous field-of-view from 3 cm at 100 m altitude to 5 m at 1000 m altitude. The video camera documented SE590 spectroradiometer coverage along the flight-line with ancillary data such as altitude, air speed, direction, and weather observations recorded on the sound-track. Time, recorded on both the video and spectral output, served as a flight index that allowed precise cross-referencing between data sets.

A Matrox graphics board and the Resource Analysis Software were used for numerical analysis.

The Spectron Engineering SE590 visible and near-infrared spectroradiometer provided continuous reflectance spectra between 380 and 1100 nm at a nominal 10 nm spectral resolution. Outfitted with a one degree field-of-view lens, the ground resolution of this instrument was approximately 4.5 m at 300 m altitude. The instrument employs a linear array of detectors with a spectral dispersing grating in front of the array to provide rapid acquisition of the continuous spectra, a critical factor in flight operations. Considerable experience has been accumulated with the SE590 instrument (Williams et al. 1984; Petzold and Goward 1988) and its performance is relatively well understood.

The SE590 system was linked, through an RS-232 cable system to a Toshiba portable computer (model 1200 HD). This computer sits in the lap of the pilot/scientist and provides direct control of measurement acquisition and recording (on the hard disk). The software that accomplishes these operations was provided by D. Williams and M. Kim, NASA Goddard Space Flight Center and was tested extensively (Williams and Walthall 1990).

Collection Environment:

Low altitude atmosphere.

Source/Platform:

Field investigation Ultralight airplane

Source/Platform Mission Objectives:

To collect information in the field by remotely sensing data in an Ultralight, an extremely small, lightweight airplane flown at low altitudes.

Key Variables:

Not applicable.

Principles of Operation:

The Spectron instrument is a portable, battery-powered spectroradiometer, weighing about 1 kg, with interchangeable detector heads. The three measurement heads have the following spectral ranges: 350-1100 nm, 400-800 nm, and a shortwave infrared (SWIR) head with a 1100-2500 nm range.

Each of the detector heads uses a diffraction grating to disperse the incoming light onto a linear photodiode array. The signal is conducted to the controller electronics via a cable. The controller is microprocessor based and processes the signal from the detector head. Integration times are from 1/60 sec to 1.0 sec. The integration time can be automatically selected by the instrument or manually chosen by input from a key pad. The SWIR head always collects data with a 1.0 sec integration time.

Sensor/Instrument Measurement Geometry:

Information not available.

Manufacturer of Sensor/Instrument:

Video camera: Sony Resource Analysis Software: Decision Images, Inc. 1989 Reflectance spectroradiometer: Spectron Engineering

Calibration:

Specifications:

The SE590 spectroradiometer was shipped to the NASA Goddard Space Flight Center, where F. Wood and M. Kim, under support from D. Williams, carried out the required measurements on the GSFC integrating sphere and monocrometers. In addition, during 1990, J. Dungan, NASA Ames Research Center, carried out spectroradiometric assessments of the sensors at the field sites in Oregon. In general, the instruments performed nominally within specification.

Tolerance:

Information not available.

Frequency of Calibration:

The SE590 spectroradiometer was recalibrated annually for both spectral and radiometric sensitivity.

Other Calibration Information:

The OSU SE590 sufferred minor damage in August of 1990 and, as a result, shifted 10 nm from its calibration. The instrument was returned to the manufacturer for repair.

5. Data Acquisition Methods:

The ultralight flight schedule was coordinated with intensive ground measurements and flights of NASA aircraft. Ultralight flights were carried out in June, August, and October of 1990 and June through July, 1991. Flights were made when skies were clear at solar zenith angles above 50 degrees and winds were less than 50 km/hr. Flights were usually made between 0800 and 1600 hr (solar time). At nadir, video and spectroradiometer data were collected from an altitude of 300 m at a flight speed of approximately 55 km/hr. Spectral data were recorded along parallel flight lines oriented nearly perpendicular to the solar plane. Generally, 20 to 70 SE590 observations were acquired over each study site and replicated over time.

At all times, a Sony Model TR5 8mm video camera recorded the surface features measured by the SE590 spectroradiometer. The standard optics of the video camera provide an instantaneous field-of-view from 3 cm at 100 m altitude to 5 m at 1000 m altitude. In addition, the camera's color (red/green/blue) separation of the recorded signal gives an approximation of visible wavelength landscape spectral patterns at relatively high spatial resolution. Over 230,000 images were recorded by this system in a two-hour tape.

6. Observations:

Data Notes:

Spectral reflectance, the radiance reflected from the test surface ratioed against reflectance of incoming solar radiation off of a standard halon panel, served to characterize the general spectral properties of each scene. This measurement normalizes the observations for variations in incident radiation and atmospheric conditions. Such a reference is essential to compare measurements over time (Spanner 1989; Williams et al., 1990; Ripple et al., 1987).

Field Notes:

Information not available.

7. Data Description:

Spatial Characteristics:

Site 1: Cascade Head Latitude 44 03' N, Longitude 123 57' 30" W Site 1A: Cascade Head Alder Stand Latitude 44 03' N, Longitude 123 57' 30" W Site 2: Warings Woods Latitude 44 36' N, Longitude 123 16' W Site 3: Scio Control Latitude 44 40' 30" N, Longitude 123 36' 40" W Site 3F: Scio Fertilized Latitude 44 40' 30" N, Longitude 123 36' 40" W Site 4: Santiam Pass Latitude 44 025' 20" N, Longitude 121 50' 20" W Site 5: Metolius Control Latitude 44 25' N, Longitude 121 40' W Site 5: Metolius Fertilized Latitude 44 25' N, Longitude 123 40' W Site 6: Juniper Latitude 44 17' 30" N, Longitude 121 20' W

Spatial Coverage:

Information not available.

Spatial Coverage Map:

Information not available.

Spatial Resolution:

Information not available.

Projection:

Information not available.

Grid Description:

Information not available.

Temporal Characteristics:

Temporal Coverage:

13 August 1990 7 October 1990 8 October 1990 11 October 1990 20 October 1990 3 July 1991

Temporal Coverage Map:

Information not available.

Temporal Resolution:

Information not available.

Data Characteristics:

Parameter/Variable:

Emitted radiation Reflected radiation

Variable Description/Definition:

- Emitted radiation: Energy (propogated in the form of electromagnetic waves) that is released into the atmosphere from the surface of the earth and other substances on the earth's surface.
- Reflected radiation: A measure of the amount of radiation that is turned back from the surface upon which it strikes.

Unit of Measurement:

nm (nanometers)

Data Source:

Field investigation and an ultralight airplane.

Data Range:

Emitted radiation: Approximately 0.00000 <--> 10.00000 Reflected radiation: Approximately 0.00000 <--> 30.00000

Sample Data Record:

Emitted radiation: 0.214786 0.189959 0.199291 0.184114 0.195249 0.180612 0.196208 0.188734 0.199222 0.182595 0.192172 Reflected radiation: 2.486660 2.412042 2.370137 2.298254 2.275676 2.230471 2.212390 2.169934 2.155368 2.126143

8. Data Organization:

Data Granularity:

The data are organized into three fields of information within each file in the data set. The first field is the wavelength (nm) region in which the data have been measured. The second field is a measure of the reflected radiation, while the third field is a measure of the emitted radiation.

Data Format:

There are 10 ASCII data sets, each accompanied by an XY plot. In addition, there are two data set companion files included with the complete data set: mccreigh.doc and se590.doc.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

The incident solar radiation at the surface at the time of the over-flight was approximated by extrapolating in-flight calibration measurements as follows:

S = R1 - (R2 - R1)

where,

S = incident solar radiation estimated at the surface R1 = halon panel reference at 300 m altitude R2 = halon panel reference at 600 m altitude

Data Processing Sequence:

Processing Steps:

Numerical analyses of the images obtained by the Sony video camera were done by linking the video camera to a computer system via a Matrox graphics board and the Resource Analysis Software. Individual frames of the video imagery were selected visually and then electronically transferred to the computer system. The image processing system digitizes the red, green, and blue spectral components of the color video-image separately. This provides a three-component spectral data base which can then be subjected to spectral classification.

By making measurements of incident solar radiation with the SE590 at 300 m interval between 1200 m and 300 m, atmospheric effects were recorded and removed. The SE590 spectroradiometer recorded data while the aircraft was in level flight oriented at a 45 degree angle to the solar plane. These measurements provided an estimate of the most important atmospheric effects due to both small particle (aerosol) scattering and water vapor absorption.

Estimates of solar irradiance at the surface were ratioed to target radiance values to calculate reflectance factors.

Processing Changes:

Not applicable.

Calculations:

Special Corrections/Adjustments:

Remote sensing data were reviewed immediately upon landing to ensure adequate data quality and coverage. In the laboratory, spectral data were geo-referenced and indexed using the video flight record. Observations made over roads, clouds, or during aircraft maneuvers were removed before calculating site-averaged reflectance values.

Calculated Variables:

S = R1 - (R2 - R1)

where,

S = incident solar radiation estimated at the surface R1 = halon panel reference at 300 m altitude R2 = halon panel reference at 600 m altitude

Graphs and Plots:

There is an XY plot for each data set to show obvious discrepancies in the spectra.

10. Errors:

Sources of Error:

Surface reflectances: The relative importance of accounting for atmospheric attenuation of radiation can be observed by comparing the Cascade Head reflectance measurements (sites 1A and 1OG) to western sites. The large drop in recorded spectral reflectance centered at 950 nm, for the Cascade Head site, is the result of water vapor in the 300 m of atmosphere below the aircraft. Due to rapid changes in cloud cover over the sites, it was not possible to obtain complete altitude profile measurements needed to extrapolate the airborne spectral measurements to the ground.

Instrument performance: An inspection of the data signal to noise ratio of the SE590 spectroradiometer indicates a significant amount of noise in wavelengths below 400 nm and above 1000 nm. Nonlinear shifts in spectral sensitivity of 3 to 10 nm were also noted for the instrument over the period of the OTTER study. Annual calibrations were necessary to compensate for variations in the instrument spectral sensitivity.

Quality Assessment:

Quality assessment information is not available.

11. Notes:

Limitations of the Data:

Information not available.

Known Problems with the Data:

Information not available.

Usage Guidance:

Information not available.

Any Other Relevant Information about the Study:

Site-averaged reflectance spectra for sites 2 to 6 were calculated from October, 1990 coverage. The Cascade sites were measured in July, 1991. No attempt was made to normalize reflectance spectra for background illumination (i.e., sunlit vs shadow area). Video images representing the central third of each study site were acquired from 300 m above the ground in July, 1991. Video coverage from an altitude of 100 m and 1200 m is also represented for site 2.

12. Application of the Data Set:

The low altitude measurements are a key portion in the OTTER project goals. They give hard, physical data about the sites in the study. The combination of this remote sensing technique with field study with laboratory work will help to simulate and predict ecosystem processes.

13. Future Modifications and Plans:

No future plans, the OTTER campaign is complete.

14. Software:

Software Description:

The public domain software package, Imdisp, is provided for image display on IBM compatibles. The popular shareware program, Stuffit, is necessary to extract the execution file for the Macintosh image display program, Image4pds.

Software Access:

Software to display most of the OTTER image data (except Aviris and Asas data) on Macintosh and IBM personal computers (and compatibles) is provided on the CD-Rom disc containing the data sets.

15. Data Access:

Contacts for Archive/Data Access Information:

Name: ORNL DAAC User Services Office

Address: ORNL DAAC User Services Office Oak Ridge National Laboratory U.S.A.

Telephone Number: 1-(865)-241-3952

Electronic Mail Address: ornldaac@ornl.gov

Data Center Identification:

ORNL DAAC

Procedures for Obtaining Data:

Contact the ORNL DAAC User Services Office Oak Ridge National Laboratory U.S.A.

Telephone: 1-(865)-241-3952 FAX: 1-(865)-574-4665 Internet: ornldaac@ornl.gov

Data Center Status/Plans:

To be determined.

16. Output Products and Availability:

Available via FTP file or on CD-ROM.

Also available online via the World Wide Web at http://daac.ornl.gov.

17. References:

Bauer, M. E., C. S. T. Daughtry, and V. C. Vanderbilt. 1981. Spectral-agronomic relations of corn, soybeans and wheat canopies. LARS Purdue University, West Lafayette, Indiana, Tech. Report 091281.

Foran, B. D., and G. Pickup. 1984. Relationship of aircraft radiometric measurements to bare ground on semi-arid desert landscapes in central Australia. Australian Rangeland Journal 6 : 59-68.

Howard, J. A., and I. J. Barton. 1973. Instrumentation for remote sensing solar radiation from light aircraft. Applied Optics 12 : 2472-2476.

McCreight, R. W., and Waring, R. H. 1990. An ultralight system for environmental monitoring. Airborne Geoscience Newsletter, 90-3:9.

Ripple, B., R. W. McCreight, A. Long, and B. Barnet. 1987. Spectral reflectance patterns of some key Cascade west slope vegetation types, In: Proceedings of the National Remote Sensing and Photogrammetric Engineering Symposium, Anchorage, Alaska.

Williams, D. L., S. N. Goward, and C. L. Walthall. 1984. Collection of in situ forest canopy spectra using a helicopter: A discussion and preliminary results. In: 10th International Symposium on Machine Processing of Remotely Sensed Data. IEEE, pp. 94-106, Purdue University, West Lafayette, Indiana.

Williams, D. L. and C. L. Walthall. 1990. Helicopter-based multispectal data collection over the northern experimental forest: Preliminary results from the 1989 field season. In: 10th Annual International Geoscience and Remote Sensing Symposium, Institute for Electrical and Electronic Engineers, pp. 875-878, College Park, Maryland.

18. Glossary of Terms:

Glossary terms can be found in the Glossary list.

19. List of Acronyms:

Additional acronyms can be found in the Acronyms list. ESD Environmental Sciences Division (Oak Ridge National Laboratory) FTP File Transfer Protocol kg kilogram NASA National

Aeronautics and Space Administration nm Nanometer ORNL Oak Ridge National Laboratories Oak Ridge, Tennessee, U.S.A. OTTER Oregon Transect Ecosystem Research SWIR Shortwave Infrared

20. Document Information:

30 July 1996 (data set citation revised on 19 November 2002)

Document Review Date:

30 July

Document ID:

ORNL-OTTER-013

Citation:

Please cite this data set as follows (citation revised on 19 November 2002):

McCreight, R. W., and R. H. Waring. 1994. SE-590 Low Altitude Reflectances (OTTER). [SE-590 Low Altitude Reflectances (Oregon Transect Ecosystem Research)]. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/86.

Curator:

DAAC Staff

Document URL:

http://daac.ornl.gov