Leaf Reflectances: Perkin-Elmer (OTTER)

Summary:

Absolute (diffuse & specular) reflectance of leaves measured in the lab by Perkin-Elmer spectrophotometer to aid in understanding remotely sensed spectral data.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Leaf Reflectances: Perkin-Elmer (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 which 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 to verify the predictions through direct measurements of process rates or controls on processes.

Objective/Purpose:

To measure the hemispherical reflectance of leaves as an aid to understanding remotely sensed spectral data obtained at the same point in the growing season.

Summary of Parameters:

Two parameters were investigated in this study: The emitted radiation and the reflected radiation.

Discussion:

Hemispherical reflectance of leaves throughout the 400-2400 nm region has been measured as an aid to understanding remotely sensed spectral data collected at approximately the same point in the growing season. Of particular interest is the spectral influence of biochemical absorption by nitrogen, lignin, chlorophyll, starch and cellulose. Also of interest is examination of gross spectral properties such as the near-IR/red ratio and chlorophyll red-edge characteristics. These data may identify spectral regions upon which to concentrate aircraft data analysis, provide an input to leaf-level radiative transfer models, or provide a check for aircraft data which have been processed into reflectance.

Related DataSets:

Canopy Chemistry Forest-BGC Model Leaf Area Index Data Leaf Reflectances: LICOR 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 SE-590 Low Altitude Reflectances Timber Measurements

2. Investigator(s):

Investigator(s) Name and Title:

Name: Lee F. Johnson, Research Scientist

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Electronic Mail Address: lfjohnson@ames.arc.nasa.gov

Title of Investigation:

OTTER Perkin-Elmer Spectrophotometer Data

Contact (for Data Production Information):

Name: ORNL DAAC User Services Office

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

Telephone Number: (865)-241-3952

Electronic Mail Address: ornldaac@ornl.gov

3. Theory of Measurements:

Obtaining leaf spectra in the laboratory reduces or eliminates the confounding effects of atmosphere, platform instability, understory, exposed soils, mixed species, and canopy architecture which influence aircraft data.

4. Equipment:

Sensor/Instrument Description:

Spectrophotometer: A photometer for measuring the relative intensities of light in different parts of the spectrum.

Collection Environment:

Open-air forest

Source/Platform:

Laboratory

Source/Platform Mission Objectives:

To measure absolute reflectance of foliage samples from the OTTER transect with a Perkin-Elmer spectrophotometer.

Key Variables:

Hemispherical Reflectance

Principles of Operation:

The sprectrophotometer operates with: Spectral Range: 400-2400 nm Bandwidth: 6 nm Sampling Interval: 2 nm

Sensor/Instrument Measurement Geometry:

Information not available.

Manufacturer of Sensor/Instrument:

Perkin-Elmer Corp., Analytical Instruments Main Avenue (MS-12) Norwalk CT 06856

Calibration:

Specifications:

One reflectance standard, three wavelength standards, dark current, and background were measured and calibrated.

Tolerance:

Information not available.

Frequency of Calibration:

Information not available.

Other Calibration Information:

Standards manufactured by: Labsphere, Inc. Box 70 Shaker Street North Sutton, NH 03260

5. Data Acquisition Methods:

Five foliage samples were collected by shotgun or pruning pole from mid-upper canopy at each of the following OTTER sites: Scio (control/fertilized Western hemlock), Warings Woods (Douglas fir), Cascade Head (Western hemlock/red alder). Collection date was 3-4 June 1991. Each sample was separated into two portions, one for the spectral analysis reported here and another for chemical assay as part of the official Overflight data set. Each spectral analysis sample was immediately inserted along with a wadded-up wet paper towel into a transparent plastic bag and sealed airtight. These were in turn inserted into black plastic bags to shield from light exposure, and stored either in ice chest or refrigerator until removed for spectral measurement. The spectral measurements were made during the period 14-18 June 1991. The nearest Multisensor Aircraft Campaign to this time period occurred 15-22 May 1991.

6. Observations:

Data Notes:

The chemistry data (Total Nitrogen, Total Phosphorus, amino acids, sugar, starch, chlorophyll-A, chlorophyll-B) and description are available through the Forest Science Data Bank at Oregon State University.

Field Notes:

Information not available.

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

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

Spatial Coverage Map:

Not applicable.

Spatial Resolution:

Not applicable.

Projection:

Not applicable.

Grid Description:

Not applicable.

Temporal Characteristics:

Temporal Coverage:

Field Collection: 3 June 1991 through 4 June 1991 Laboratory Analysis: 14 June 1991 through 18 June 1991

Temporal Coverage Map:

Not applicable.

Temporal Resolution:

Not applicable.

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:

Laboratory

Data Range:

Approximately 2 <--> 85

Sample Data Record:

Wavelength: 400.0 402.0 404.0 406.0 408.0 410.0 412.0 414.0 416.0 418.0 420.0 422.0 424.0 426.0 428.0 430.0 432.0 434.0 Reflected Radiation: 2.849 2.887 2.935 3.030 3.078 3.135 3.184 3.241 3.270 3.327 3.365 3.403 3.441 3.470 3.500 3.539 3.568 3.598

8. Data Organization:

Data Granularity:

The data are organized into two columns. The first column is the wavelength (nm) region in which the data have been measured. The second column is the measured hemispherial reflectance.

Data Format:

There are 25 ASCII data sets available. In addition, there is an ASCII dataset companion file: perkin.doc, included with the complete data set.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

p(abs) = p(std) * [(x - xo) / (r - xo)]

Data Processing Sequence:

Processing Steps:

For each sample, several needles including the twig (or in the case of the alder, one entire leaf) were placed in the instrument sample holder and scanned. The instrument produced raw reflectance for each scan by comparing target response with that of an aluminum-oxide standard of unknown (to the investigators) characteristics. Absolute reflectances reported to PLDS were developed by adjusting raw reflectance per channel by use of a spectralon reflectance standard (Labsphere SRS-75-020-4582-E) of known reflectance factor by using the above formula.

Processing Changes:

Not applicable.

Calculations:

Special Corrections/Adjustments:

A localized smoothing operation was performed on each spectrum at about 875 nm, to remove a spike which occurred due to detector change.

Calculated Variables:

p(abs) = absolute reflectance of sample p(std) = reflectance factor of standard x = raw reflectance of foliage r = raw reflectance of standard xo = raw reflectance of dark current

Graphs and Plots:

Not applicable.

10. Errors:

Sources of Error:

No objective effort was made to control for either biomass or architecture presented to the instrument. This could account in part for variations in reflectance magnitude observed among scans. Particularly high variation is evident in the scans from the Warings Woods site.

The elapsed time between harvest and scan may have caused some biochemical differences to arise between the spectral samples and the corresponding assay samples.

Quality Assessment:

Data Validation by Source:

Information not available.

Confidence Level/Accuracy Judgment:

Information not available.

Measurement Error for Parameters:

Because of the slow scan time (~20 minutes per scan), only one scan was taken of each sample. Therefore the standard deviation at each channel is unknown.

Wavelength accuracy was shown by the spectral calibration to be plus or minus 2 nm throughout the spectral range, and no adjustment was made to the measured spectra.

Additional Quality Assessments:

Information not available.

Data Verification by Data Center:

Information not available.

11. Notes:

Limitations of the Data:

Information not available.

Known Problems with the Data:

A residual effect of the spike described above may remain at about 875nm.

These data are very noisy at wavelengths greater than 1900nm.

Usage Guidance:

Information not available.

Any Other Relevant Information about the Study:

The absolute reflectance reported to the PLDS includes both diffuse and specular reflectance from the leaf. The conifer samples typically covered 90-95% of the sample port; thus these measurements will include a component of direct reflectance from the background (which is on the order of 4% throughout the spectral range). No background was exposed to the detector during the alder scans.

12. Application of the Data Set:

The emitted and reflected radiation 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 laboratory study with field work and remote sensing techniques will help to simulate and predict ecosystem processes.

13. Future Modifications and Plans:

None, 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: (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: (865)-241-3952 FAX: (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 on-line via the World Wide Web at http://daac.ornl.gov.

17. References:

Information not available.

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 Science Division (Oak Ridge National Laboratory) FTP File Transfer Protocol NASA National Aeronautics and Space Administration nm nanometers ORNL Oak Ridge National Laboratories Oak Ridge, Tennessee, U.S.A. OTTER Oregon Transect Ecosystem Research

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