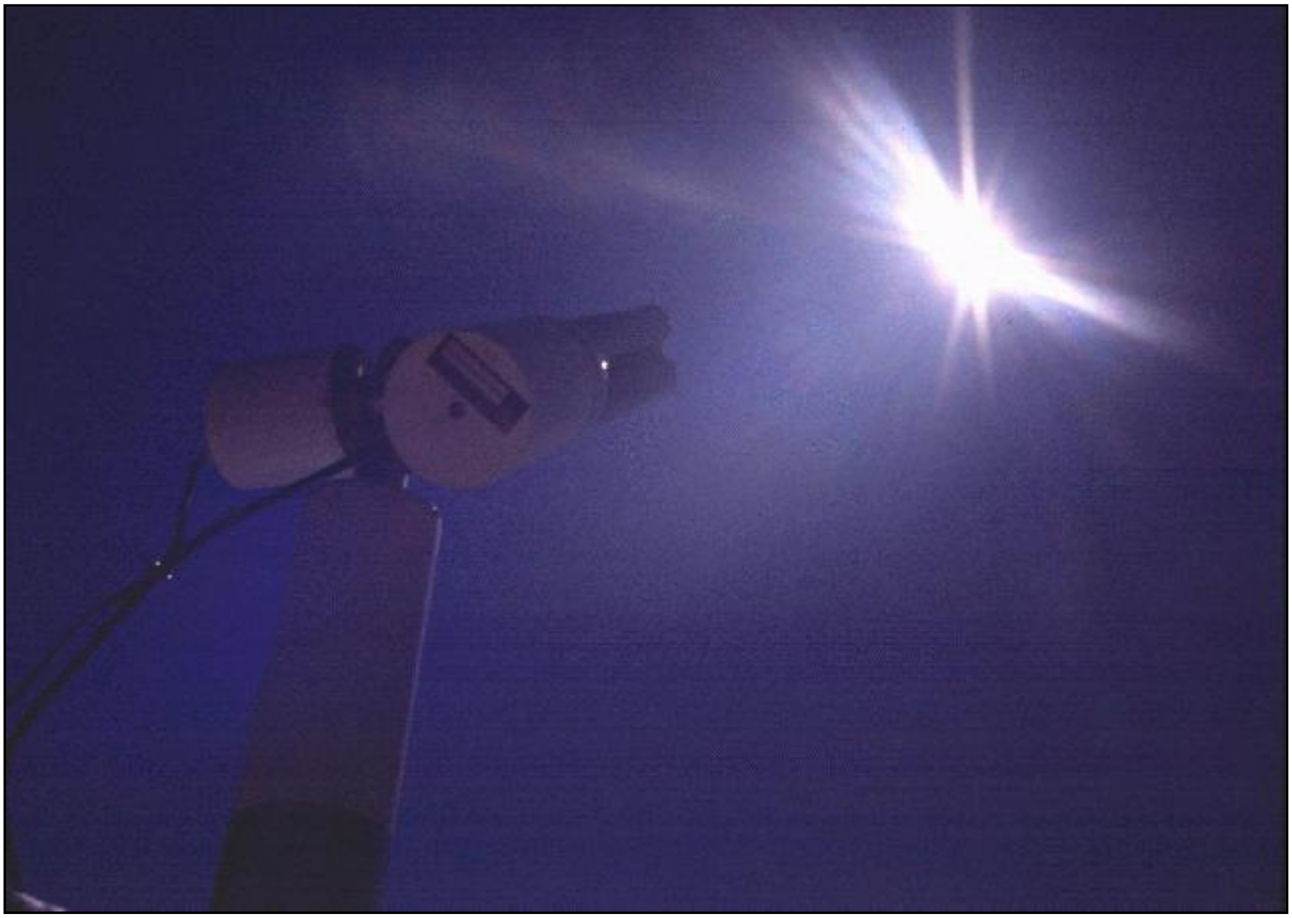
THE FIRST NASA/LTER WORKSHOP ON SUNPHOTOMETRY/ATMOSPHERIC CORRECTION OF REMOTELY SENSED DATA



Report of a workshop on operational atmospheric correction of satellite remote sensing data June 25 - June 27, 1995

John R. Vande Castle - University of Washington

Eric F. Vermote - University of Maryland

This workshop was funded in part by NASA grant#NAGW-4565 and held at facilities of the Long-Term Ecological Research Network Office in the College of Forest Resources, University of Washington

Table of Contents

---

1. Atmospheric effects and remote sensing data: effects, theory and applications

1.1 Logistics, Introduction, Objectives, Background

- *John Vande Castle*

Operational aspects were covered for this workshop at facilities of the Long-Term Ecological Research Network Office in the College of Forest Resources at the

University of Washington. The primary objective of this workshop was to involve LTER scientists with use of sun photometer data for operational atmospheric correction of satellite remote sensing data. The main objective is to use automated sun photometer data to generate atmospheric corrections for satellite data, in particular for Landsat-Thematic Mapper (TM) data. As a secondary objective, operational approaches involving NOAA-Advance Very High Resolution Radiometer (AVHRR) satellite data, hand-held sun photometer data, and airborne datasets such as AVIRIS were also included. There was a focus on operational aspects of atmospheric data corrections. More specific research applications were not ignored for their importance of more general applications of the sun photometer data.

1.2 Atmospheric effect on remote sensing data: theory

- *prepared by E. F. Vermote and J.C. Roger, presented by E. F. Vermote*

A background presentation was given for a description of how the atmosphere influences the earth signal measured from space in the 0.4-2.4mic region of the solar spectrum. The focus was to present the formulation of the atmospheric effect as well as to describe the atmospheric parameters one needs to properly simulate the signal (pressure, aerosol concentration and type, water vapor, ozone). The general equation of the signal in the case of a lambertian, uniform target was presented and each of the terms in the equation analyzed in detail. The order of magnitude of the effect of the atmospheric effects on the signal was discussed in the case of Landsat-Thematic Mapper data.

Some more advanced modeling efforts like the influence of the BRDF of the surface and the heterogeneity of the target background were also discussed but in less detail. This presentation was an introduction to the 6S radiative transfer code (Second Simulation of the Satellite Signal in the Solar Spectrum, Vermote et al, 1995). This code is recommended for use by the LTER investigators in the framework of this project. The last version of this code has been successfully implemented at the LTERnet computing facility (see section 2.4)

1.3 What are the Sun Photometer Data ?

- *Brent Holben*

Data obtained by a network of automated sun photometer instruments was established in 1994 for some LTER sites after experimental acquisitions at Harvard Forest and Virginia Coast Reserve LTER sites in 1993. The LTER instruments are part of a larger effort to provide sun photometer information on a global scale. Background information leading to this work can be found in previous workshop reports on-line on the LTERnet.edu computer. Background information on the sunphotometer work can be found in the bibliography. These instruments provide data on atmospheric aerosol and water information that are needed for precise atmospheric correction of satellite data. The raw sun photometer data are transmitted via GOES satellite and processed at NASA/Goddard. The data are maintained on-line which is also mirrored on the LTER computer servers (LTERnet.edu, time.lternet.washington.edu). The raw data are processed by a specialized program written at NASA/Goddard called "demonstrat". This program is a key component of the sun photometer data since it organizes the data, and process them with accepted algorithms to provide a wide variety of information needed for various aspects of atmospheric correction of satellite data. As an example, the program provides a view of the time and location for all sun photometer data collected within the network. (figure 1). These data are critical for the atmospheric correction work in this effort since they provide the information on atmospheric aerosols needed for atmospheric correction of satellite data. Further information regarding this is given in section 2.3

1.4 Atmospheric effects on remote sensing data: applications

- prepared by E. F. Vermote and J.C. Roger, presented by E. F. Vermote

Eric Vermote covered operational implementation aspects of the atmospheric correction problem. For both TM and AVHRR sensors a description of the processing steps needed to get from raw data to useful physical quantities (i.e. the surface reflectance) was given. The different stages of processing were described, including navigation/geometric correction, cloud screening, absolute calibration, ozone correction using TOMS data, Rayleigh correction using Digital Elevation Models, stratospheric aerosol correction, water vapor database inversion and correction, and aerosol inversion and correction. The limitations of the atmospheric corrections in general, were also discussed.

During the presentation, the version 0 of the atmospheric correction software that processes TM (fast format) data was run remotely at GSFC on two TM full scenes. The corrected images were transferred to the LTER computers for evaluation on day 3.

1.5 Overview of the atmospheric processing software for TM

- Eric Vermote

Version 0 of the atmospheric correction software for TM data was described in more detail. The effects of other atmospheric constituents and their relation to atmospheric corrections was also presented. The changes envisioned for version 1 were discussed. These involve the inclusion of size distribution input, aerosol optical thickness (AOT) at 550nm, input and adjacency effect correction, and correction for elevation at 50km by 50km resolution.

2. Data access and correction software: Interface to photometer data

2.1 Introduction to LTER satellite and sun photometer data archive.

- John Vande Castle

The sun photometer data for LTER work are transferred to the LTER computer servers automatically each day. The LTER Network Office also routinely archives these data for long-term storage. The sun photometer processing software has been ported to the LTER computer systems. The sun photometer data stored on the LTER computer systems is limited to data important to the LTER research. This reduces confusion with other datasets and permits the processing software to run much more quickly. LTER researchers have the advantage in working with the data from their personal LTER computer accounts, as well as access to other software maintained at the Network Office. Accessing the data and software are similar to access on the computer at NASA/Goddard as describe in the next section.

2.2 How to access the sun photometer data -

-Brent Holben

The sun photometer data are accessed though a specialize program named "demonstrat". This program was written specifically for processing the automated sun photometer, or similar photometer/radiometer data. A general user account for LTER investigators is available on a machine at NASA/Goddard, currently called "spamer.gsfc.nasa.gov". The demonstrat program can be accessed on the Internet and uses "X11" display capabilities for the graphical interface of the program. The "X11" access from local personal computers will vary with the local configuration, but the machine "spamer.gsfc.nasa.gov" is able to display to most remote "X11" displays. This whole process can be easily automated. An example of how to access the program in a non-automated procedure is as follows:

- Enable "X11" displays to your local computer

This is normally done with the command "xhost spamer.gsfc.nasa.gov", or by entering this machine name in the local xhost table.

- Run a "Telnet" session.

This is normally done with the command "telnet spamer.gsfc.nasa.gov". A login prompt will be given, at which the general user account and password are entered.

- Redirect the "X11" display

This is normally done with the command (on spamer.gsfc.nasa.gov) "setenv DISPLAY computer:0.0", where "computer" is the name or Internet IP number of the local machine.

- Run the "demonstrat" program.

This is done with the command "demonstrat". When the command is entered, the opening display will start on the local machine. This initial display can take a while to start since all the data in the archive is scanned by default. There are other options which can be used, including entering the instrument number in the "demonstrat" command to access data for only one machine.

2.3 How to evaluate the quality of sun photometer data

-Brent Holben

The raw sun photometer data are processed and evaluated using the "demonstrat" software. The initial display (figure1) allows the user to select a given dataset for evaluation. A dataset is selected by scrolling through a "timeline" or by drawing a box around a selected region of the earth. Once a dataset is selected, it is processed by selecting the dataset name. A specific portion of the timeline can also be selected. The dataset selected will, by default, be displayed in a graphical window showing a plot of optical aerosol thickness vs. time for each channel of the instrument (figure2). Options in this window allow the user to filter the raw data, and remove data the user does not need. Individual segments of the data can be selected, as shown in an example of data from the Sevilleta LTER site (figure3). A single day can be selected (figure4) as well as other parameters including atmospheric water vapor (figure5). Information derived by processing the data through known algorithms, for instance estimated particle size distribution (figure6), can be selected as well. The data can be estimated through a "Bird model" (figure7) for any time of day, and these data can be fitted to estimates of Aerosol Optical Thickness (AOT) for sensors of the Cimel instrument as well as satellite sensor systems such as Landsat-TM (figure8).

2.4 Presentation and Use of the 6S code

- Eric Vermote

A working session was conducted on the use of the 6S for satellite signal simulation. The latest version of the code (3.2 alpha) has been successfully installed at the LTERnet computing facility. An example of a data file was distributed the working group. The code was run by the group and both data and results were extensively commented on by Eric Vermote. Finally, the working group was asked to modify the example data file and run the code again for TM band 2. The Graphical Interface (GUI) to the 6S program was run remotely at GSFC and presented to the working group. This GUI interface will be implemented later at LTERnet computing facility.

2.5 First TM test dataset proposal

-John Vande Castle

John Vande Castle presented the first TM dataset selected for the project. This dataset contains scenes already acquired by NASA as part of the Global Change data acquisition. Initial data for the project included those in conjunction with sun photometer measurements. For more data in 1994 and 1995, additional scenes in the archive as well as to be acquired will be added for the BNZ, SEV, AND, and NTL sites. AVHRR test datasets were also discussed for the MCM, NTL, BNZ sites.

2.6 Site presentation by participants:

2.6.1 **MCM**: McMurdo - Taylor Polar Dry Valley

Biome: Polar desert oases

Hydrologist, Gayle Dana studies glaciers at the MCM site, and conducts research in the evolution of the inter-annual variation in the melting process for global warming/cooling related study. She has used measurements of the amount of melting by various processes including the monitoring of the thickness of the ice sheet using poles. The site of interest is about 400km2 Remote sensing interest is in the visible and the thermal data, to assess the energy exchange at this LTER site. Gayle underlined the difficulty of getting remote sensing because of a lack of TM coverage (no receiving station right now), the cost of SPOT-HRV data, and the difficulty of getting AVHRR 1km data.

Automatic sun photometer measurements were acquired from January 10, 1995 to January 24, 1995 at the MCM site (-77°37';162°52') along with BRDF (4° azimuth, 7° view angle, several solar angles) and nadir measurement of different surface type spectra (Goetz instrument, 18° FOV, 0.4-2.5mic spectrum). Data collection will continue again in December of 1995. AVHRR data may be available from the McMurdo HRPT receiving station.

2.6.2 **AND**: H.J. Andrews Experimental Forest

Biome: Temperate coniferous forest.

Warren Cohen presented remote sensing research related to establish land cover mapping of the biome and change detection using high spatial resolution data, primarily Landsat-TM. In the broader perspective, this site is closely associated with the EOS Global Land Cover test site validation concept. In terms of remote sensing, this site is problematic because of the large topographic effects it exhibits.

2.6.3 **SEV**: Sevilleta National Wildlife Refuge

Biome: -semi-desert site

Greg Shore presented the research conducted on the Sevilleta site, where the study of hydrology and vegetation response to available precipitation is crucial for this arid region. The most important factor in this almost undisturbed site seems to be the ENSO phenomenon. Precipitation is actually monitoring by two indirect methods: (1) monitoring through analysis of lightning strike data, and correlation with response of vegetation through NDVI after precipitation. Some additional water availability measurements collected by Barbara Nolen are also used in the study. The studies uses primarily Landsat-TM data for calculation of NDVI. SEV needs images every month for efficient monitoring of the vegetation. An other important subject of research may be the study of natural fire in the area and the associated response of the ecosystem in terms of change in land-cover. A sun photometer has been permanently installed at the Sevilleta site since June, 1994.

2.6.4 **NTL**: North Temperate Lakes

Biome: North Temperate Forest/Lake/Agricultural/Urban

David W. Bolgrien and Randolph H. Wynne presented the activity at NTL/MADISON LTER sites. The two research areas there cover a wide range of studies related to atmosphere, fresh water pigment detection, remote sensing, atmospheric correction, and cloud screening analysis. A variety of airborne and satellite based sensor systems are used in this work, from high to low spatial and spectral resolution. The team appears to be a potentially strong support element to this program through its expertise in the research proposed. A sun photometer was installed at the northern lake site in 1994, but was moved to the roof of the Space Science and Engineering (SSEC) building at the University of Wisconsin campus where it can be maintained on a continuos basis.

2.6.5 **BNZ**: Bonanza Creek site

-Biome: Alaska / Polar Evergreen forest site

Phyllis Adams and Dave Verbyla presented their remote sensing work which includes classification of land cover at the BNZ LTER site of an area roughly 300km x 300km. Other research at the BNZ site includes work with the Fairbanks SAR facility at the University.

2.6.6 **KNZ**: Konza Prairie:

-Biome: Prairie

Doug Goodin presented research efforts which include the continuation of the FIFE program at the Konza prairie site. There was extensive sun photometer work done at KNZ within the FIFE program, but calibration of the data was problematic.

2.6.7 **HFR**: Harvard Forest

- *Biome Deciduous Forest*

Mary Martin presented the remote sensing studies at HFR concerning estimation of chemical content of the vegetation using remote sensing data. Much of this work has been done using data from AVIRIS. Although some sun photometer data was collected at the site in 1993, suitable remote sensing data concurrent with these data were not acquired.

3. Operational aspects

3.1 Technical, logistical issues and work plan

- *John Vande Castle*

A couple of issues were brought up by John Vande Castle concerning the mechanism to evaluate the atmospheric correction effect on satellite data.

- Evaluation should be made for algorithm results by using atmospheric correction reflectances or top of the atmosphere calibrated reflectances ("exo-atmospheric") and not raw data.
- The "deliverables" used for this work will always be both atmospheric correction reflectances and top of the atmosphere calibrated reflectances with a cloud mask. For Landsat-TM, the processing software is also provided (ingest and output fast format). For AVHRR only the data sets are provided since this is not an operational product. Processing software for TM is provided with explicit

documentation. AVHRR data sets are provided with minimal documentation. Top of the atmosphere temperature is also provided.
- The impact of using the cloud mask available with the data should be assessed both for atmospheric correction reflectances or top of the atmosphere calibrated reflectances (expertise discussed during the workshop at the NTL site is requested on that particular topic).
- Some LTER sites active in the remote sensing arena are missing automatic sun photometer. We need to explore ways the way to get additional instruments for those site ASAP. This will require both a procedure to acquire instruments, and the ability for sites to commit to the maintenance of the instruments. Just as an example, Harvard Forest (HFR) has an active remote sensing research program including a number of other NASA projects in progress. The sites is also a good reference biome for the "dark target approach" and has very dynamic aerosol characteristics too. The Konza Prairie (KNZ) is also a well documented and sampled site (past NASA "FIFE" site) with a very active remote sensing research program.
- Input dataset quality: The Landsat 5-TM instrument is already operating beyond expected duty cycle. Several datasets acquired for LTER research have had some problems with noise. Even physical problems are developing, for instance the sweeping mechanism is showing weaknesses (the mirror bumper is getting old). The final results of this work will provide knowledge and information on how to transfer operational aspects developed here to sensors which replace this instrument.
- AVHRR NOAA-14 needs to be calibrated absolutely before use in this work. Pre-flight calibration coefficients, including those of other AVHRR instruments are not accurate enough.

3.2 Present and futures datasets

-John Vande Castle

John Vande Castle summarized the datasets presently available for the project, both Landsat-TM data in the LTER archive (with no sun photometer data), those data already acquired with sun photometer data, and plans for future datasets. Future dataset descriptions have been identified and will be discussed further through the "spam@lternet.edu" email group. This acquisition effort will need to be coordinated with NASA Headquarters. The requested TM Path/Row for the different sites were discussed and include the following:

Site Path/Row

- AND 46/29
- BNZ 69/15 or 70/15 or 69/14 or 70/14 (sun photometer location)
- HFR/HBR- 13/30 or 13/29
- KNZ- 28/33
- JRN- 33/37
- MCM 55/115
- NTL 24/30 (sun photometer location), 25/28 (site), 24/28 (secondary)
- SEV 33/36

3.3 Sun photometer network status and plan

-John Vande Castle

The sun photometer network for LTER research has been running well. All sites currently participating are interested in continued acquisition of data. This situates sun photometer installation on a continuous basis for SEV and NTL sites. A sun photometer is installed from April through September at BNZ, and moved to MCM for use from December through February. An instrument is installed at the H.J. Andrews experimental Forest LTER (AND)from April through October and has been used in the polar summer for SeaWifs work at the PAL LTER site. Future plans call for polling interest by LTER sites for additional instrument installations. A "spare" sun photometer could also be maintained at the LTER Network Office to cover specific over-flights at LTER sites. Future work with EOS validation work is planned to include extensive use of the sun photometer data at LTER sites as well as expansion of work in this workshop to other sensor platforms.

3.4 LTER discussion for dataset evaluation plan

- all

The workshop participants discussed procedures on evaluation of the corrected data sets. John Vande Castle suggested that LTER investigator apply any currently used remote sensing algorithms to both corrected and uncorrected data. This could be in the form of image classification or even NDVI analysis. Some of the data sets (e.g. AVHRR) are relatively new for some of the LTER investigators, and may not yet be applicable to operational corrections. It was decided to give some more thought in the next few months to the evaluation process (see schedule). An Email group was created for use by sun photometer/atmospheric correction work called "spam@lternet.edu", and this will be used in the future by those associated with LTER sun photometer/atmospheric correction work.

3.5 Action items and schedule

-John Vande Castle

- Articles and background materials on the atmospheric correction +6S delivery to LTERnet
- Distribute documentation for Landsat-TM atmospheric correction processing software
- Compile pertinent papers from NASA/GODDARD and distribute to LTER researchers
- Send "6S" manual to John Vande Castle for distribution via LTER computer systems (on-line)
- Get sun photometer download cable and PC downloading software to each site for manual data acquisition
- Get GUI interface for 6S running on LTER computer systems
- Get TM processing software running on LTER SPAM/GIS research machine (time.lternet.washington.edu)

- Upgrade CPU and add disk space on "time" for use by LTER investigators
- Work on acquiring additional sun photometers and consider having an LTER "floating" instrument
- TM first test dataset processed and quality controlled, and delivered to LTER computer
- Version 1 of TM atmospheric correction processing software running on LTERnet
- AVHRR test dataset processed and delivered
- Interaction with LTER Investigators on FTDA (first test dataset analysis)
- Plan Workshop Meeting in Maryland on FTDA
- Distribute demonstrat documentation to LTER- Investigators (or on-line)
- Dataset distribution to LTER Investigators for analysis
- Form an LTER/NASA atmospheric correction/SPAM Email group alias
- Analysis of first test dataset by LTER investigators
- Have this group send comment/ideas/suggestions for future work
- Investigate dataset acquisition and programming- Eric Vermote with C. Justice for MCM (TM, SPOT-HRV, and AVHRR) and BNZ (TM data)
- Hold workshop meeting in Maryland on FTDA

---

1. **4. BIBLIOGRAPHY**

Remer, L.A., Y.L. Kaufman and B.N. Holben. 1995. The size distribution of ambient aerosol particles: smoke vs. urban/industrial aerosol. Proceedings, Chapman Conference on Biomass Burning.

Holben, B.N., T.F. Eck, I Slutsker, D. Tanr, J.P. Buis, A. Setzer, E. Vermote, J.A. Reagan and Y.K. Kaufman. 1994. Multi-band automatic sun and sky scanning radiometer system for measurement of aerosols. Proceedings: Sixth International Symposium Physical Measurements and Signatures in Remote Sensing.

Hall, F.G., D.E. Stebel, J.E. Nickeson and S.J. Goetz. 1991. Radiometric rectification: toward a common radiometric response among multidate, multisensor images. Remote Sens. Environ: 35:11-27

Vande Castle, J. R. 1991. Remote sensing and modeling activities for long-term ecological research. Proceedings: GIS/LIS'91, Atlanta ACSM/ASPRS pp. 544-550

5. WORKSHOP FINAL AGENDA

Day 1. - Sunday, June 25,1995

Atmospheric effects and remote sensing data: effects, theory and applications

8:15 Van departs Hotel

8:30 Room 261 Bloedel, Logistics, Introduction, Objectives - John Vande Castle

9:00: Atmospheric effect on remote sensing data: theory - Eric Vermote

10:30: Break

11:00: What are the Sun Photometer Data -Brent Holben

12:30: Lunch

1:30: Atmospheric effects on remote sensing data: applications - Eric Vermote

3:00: Break

3:30: Overview of the atmospheric processing software for TM

5:00- Adjourn - Salmon BBQ at John Vande Castle's / sunset discussion at Carkeek Park

Day 2. - Monday, June 26,1995

Hands-on use of data access and correction software

8:30am: Introduction to LTER"NET" satellite and sun photometer data archive, and interface with data correction software - John Vande Castle

9:00am: How to access the sun photometer data - Brent Holben

10:00am: Break

10:30am: How to evaluate the quality of sun photometer data - Brent Holben

12:30am: Lunch

1:30pm: Presentation and Use of the 6S code - Eric Vermote

2:15pm: first TM test dataset proposal -Eric Vermote

2:30pm: Site presentation by participants: 5:30pm: Adjourn

Day 3. - Tuesday, June 27,1995

Operational aspects

9:00am: Technical, logistical issues and work plan - Eric Vermote

9:30am: Present and futures datasets -Eric Vermote

10:00am: Sun photometer network status and plan - John Vande Castle

10:30am: LTER discussion for dataset evaluation plan - all

11:00am: Schedule -Eric Vermote

11:30am: adjourn

---

6. LTER/NASA Workshop Participants:

Phyllis Adams Site: BNZ

Institute of Northern Forestry

308 Tanana Drive

Fairbanks, AK 99775-5500

LTERnet address: PAdams@LTERnet.edu

E-Mail: pAdams@spruce.lter.alaska.edu

Phone: (907) 474-3310

FAX: (907) 474-3350

David W. Bolgrien Site: NTL

University of Wisconsin - Madison

1225 W. Dayton St. Rm. 1201

Madison, WI 53706-1695

LTERnet address: DBolgrien@LTERnet.edu

E-Mail: bolgrien@facstaff.wisc.edu

Phone: (608) 263-3266

FAX: (608) 262-5964

Organization(s): LTER

Warren B. Cohen Site: AND

USDA Forest Service

Forestry Sciences Lab

3200 SW Jefferson Way

Corvallis, OR 97331

LTERnet address: WCohen@LTERnet.edu

E-Mail: cohen@fsl.orst.edu

Phone: (503) 750-7322

FAX: (503) 750-7329

Gayle Dana Site: MCM

Desert Research Institute

University and Community College System of Nevada

7010 Dandini Boulevard (89512), PO Box 60220

Reno, NV 89506-0220

LTERnet address: GDana@LTERnet.edu

E-Mail: gdana@maxey.unr.edu

Phone: (702) 674-7538

: (702) 674-7539

FAX: (702) 673-7397

Organization(s): LTER

Doug Goodin Site: KNZ

Kansas State University

Department of Geography

Manhattan, KS 66506

LTERnet address: DGoodin@LTERnet.edu

E-Mail: dgoodin@ksu.ksu.edu

Phone: (913) 532-6727

Organization(s): LTER

Joshua Greenberg Site: NET

College of Forest Resources, AR-10

University of Washington

Seattle, WA 98195

LTERnet address: JGreenberg@LTERnet.edu

E-Mail: josh@debris.lternet.washington.edu

Phone: (206) 543-4512

Organization(s): LTER

Brent N. Holben

NASA

Goddard Space Flight Center

Mailstop 923.0

Greenbelt, MD 20771

LTERnet address: BHolben@LTERnet.edu

E-Mail: brent@kratmos.gsfc.nasa.gov

Phone: (301) 286-2975

FAX: (301) 286-1757

Organization(s): NASA

Mary Martin Site: HFR

University of New Hampshire

Complex Systems Research Center

Morse Hall

Durham, NH 03824

LTERnet address: MMartin@LTERnet.edu

E-Mail: mem@woody.unh.edu

Phone: (603) 862-4098

: (603) 862-3033

FAX: (603) 862-0188

Barbara Nolen Site: JRN

New Mexico State University

Department of Biology

Box 30001, Dept. 3AF

Las Cruces, NM 88003

LTERnet address: BNolen@LTERnet.edu

E-Mail: bNolen@nmsu.edu

Phone: (505) 646-4465

FAX: (505) 646-5665

Gregory A. Shore Site: SEV

University of New Mexico

Department of Biology

Biology Annex

Albuquerque, NM 87131

LTERnet address: GShore@LTERnet.edu

E-Mail: gShore@sevilleta.unm.edu

Phone: (505) 277-2109

FAX: (505) 277-0304

John R. Vande Castle Site: NET

LTER Network Manager

University of Washington

LTER Network Office

College of Forest Resources, Box 352100

Seattle, WA 98195-2100

LTERnet address: JVandeCastle@LTERnet.edu

E-Mail: jvc@LTERnet.edu

Phone: (206) 543-6249

FAX: (206) 543-7295

Dave Verbyla Site: BNZ

University of Alaska, Fairbanks

Department of Forest Sciences

Fairbanks, AK 99775

LTERnet address: DVerbyla@LTERnet.edu

E-Mail: dVerbyla@merlin.salrm.alaska.edu

Phone: (907) 474-6927

Organization(s): LTER

Eric Vermote

NASA Goddard Space Flight Center

Code 923

Room N8, Building 16W

Greenbelt, MD 20771

LTERnet address: EVermote@LTERnet.edu

E-Mail: eric@kratmos.gsfc.nasa.gov

Phone: (301) 286-6232

FAX: (301) 286-3221

Organization(s): NASA

Sally Westmoreland

Department of Geography

San Diego State University

San Diego, CA 92182-4493

LTERnet address: SWestmoreland@LTERnet.edu

E-Mail: sjw@photon.com

Phone:

FAX:

Randolph H. Wynne Site: NTL

UW-Madison Environmental Remote Sensing Center

Atmospheric, Oceanic, and Space Sciences, Rm 1249

1225 West Dayton Street

Madison, WI 53706-1695

LTERnet address: RWynne@LTERnet.edu

E-Mail: rhw@albert.ersc.wisc.edu

Phone: (608) 263-6584

FAX: (608) 262-5964