

provided by the Multi-angle Imaging SpectroRadiometer (MISR), offer new and unique opportunities to document the angular variations of land surface reflectances. The geophysical interpretation of such reflectance anisotropy patterns over terrestrial surfaces has only recently permitted to relate these signatures in a quantified manner to the structure and intra-pixel three-dimensional organization of the vegetated surface. This contribution outlines simple physical principles supporting the interpretation of the anisotropy of spectral radiances exiting terrestrial surfaces in terms of a signature of vegetation structure. The shape of the anisotropy function is represented with two model parameter values which may be mapped and interpreted in their own right. The value of one of these parameters permits us identifying geophysical conditions where the three-dimensional vegetation structure becomes significant. The joint analysis, based on computer simulations, of the shape of the anisotropy function together with combinations of vegetation structure variables, that are readily measurable in the field, reveals remarkable patterns of organization. It thus seems possible for multiangular instruments, like MISR, to deliver a pixel-based information about the structure of vegetation that is in agreement with canopy structure characterizations obtainable by other means.

GC53A-03 1410h

### Improving Vegetation Classification using EOS MISR and MODIS Data

Limin Yang<sup>1</sup> (6055946039; lyang@usgs.gov)

Wenhan Qin (3018672129; wenhan\_qin@ssaihq.com)

Jinxun Liu (6055942806; jxliu@usgs.gov)

<sup>1</sup>SAIC/USGS EROS Data Center, SAIC/USGS EROS Data Center, Sioux Falls, SD 57198, United States

The relationship between surface Bidirectional Reflectance Factor (BRF) and vegetation properties is complex and varies with the degree of heterogeneity and architecture of a vegetation canopy. Research has demonstrated that surface BRF pattern is detectable from airborne or spaceborne multi-angle and multi-spectral observations. However, application in large-area vegetation characterization using spaceborne multi-angle remote sensing data is still in its infancy. The primary motivation of this study was to test if and to what extent vegetation classification can be improved through a data mining technique using multi-spectral, multi-temporal and multi-angle data (MISR and MODIS) in a semi-arid environment in the United States. The study area is around the Jornada Rangeland in New Mexico, USA with grassland, shrubland, woodland and some desert barren land. Satellite data used for this study include MISR surface BRF and the MODIS 16-day composite NDVI data from year 2002 (all resampled to 1 km resolution). Training data of eight vegetation/land cover types were selected from a digital vegetation map with 30-meter spatial resolution. Total of 669 samples were randomly selected for evaluating algorithm performance. Several vegetation classifications were made by use of a Decision Tree (DT) algorithm and an Artificial Neural Network (ANN) classifier. The DT implements a gain ratio criterion in rule development and pruning and includes boosting and cross-validation features. Preliminary results show that overall accuracy from a 5-fold cross-validation using MODIS NDVI data is 45% (with standard error of 2.6) as compared to 51% (standard error of 2.3) using MISR data. For individual classes, the accuracy obtained from using MISR data is equal or higher than those using MODIS data (0-28

GC53A-04 1425h

### Biophysical Land Surface Products From ADEOS-2/POLDER-2

Roselyne Lacaze<sup>1</sup> (33561273221; lacaze@medias.cnes.fr)Fabienne Maignan<sup>2</sup> (33169086218; maignan@lscs.saclay cea.fr)Francois-Marie Breon<sup>2</sup> (33169089455; fmbreon@cea.fr)Marie Weiss-Cohen<sup>3</sup> (33432722423; weiss@avignon.inra.fr)Frederic Baret<sup>4</sup> (33432722363; baret@avignon.inra.fr)<sup>1</sup>Medias-France, CNES bpi 2102 18 avenue Edouard Belin, Toulouse Cedex 9 31401, France<sup>2</sup>Laboratoire des Sciences du Climat et de l'Environnement, CEA Saclay Orme des merisiers batiment 709, Gif sur Yvette 91191, France<sup>3</sup>Noveltis, Parc Technologique du Canal 2 avenue de l'Europe, Ramonville 31520, France<sup>4</sup>INRA/CSE, Agroparc, Avignon 84014, France

Monitoring of terrestrial vegetation from satellites at global and regional scales requires accurate and frequent measurements of surface reflectance. In this context, the POLDER instrument leads a key improvement providing, at high temporal resolution, measurements of the Bi-directional Reflectance Distribution Function corrected for atmospheric effects. In the frame of the ADEOS-2/POLDER-2 project, advanced Land Surface Level 3 algorithms have been developed to retrieve the spectral Directional-Hemispherical Reflectances (DHR), the Normalized Difference Vegetation Index (NDVI) corrected for directional effects, the Leaf Area Index (LAI) and the Fraction of Vegetation Cover (FVC). A multi-temporal filtering module removes the observations contaminated by residual clouds and/or aerosols, the inversion of a semi-empirical kernel model fitting the hot spot gives the BRDF coefficients which lead to the DHR and NDVI, a neural network inverting a radiative transfer model in the vegetation retrieves the LAI and the FVC. Furthermore, an error depending on the noise on the input data (i.e. the measured bi-directional spectral reflectances) and on the retrieval algorithm, is assessed for each parameter. We present the Land Surface Level 3 products generated from ADEOS-2/POLDER-2 bi-directional reflectances acquired from April to October, 2003. The retrieved parameters are validated, first to estimate their accuracy for the user community, and also to provide feedback so that retrieval algorithm can be improved. The validation procedure relies on the following steps: 1) Analyze of the spatial and temporal variability; 2) Comparison with previous ADEOS-1/POLDER-1 products; 3) Comparison with available equivalent products derived from other sensors by similar or different approaches; 4) Comparison with in-situ measurements: data collected during international campaigns or regional studies, and spatially-distributed reference data sets like those produced in the frame of the VALERI (Validation of Land European Remote sensing instrument) project.

URL: <http://medias.obs-mip.fr/postel/>

GC53A-05 1440h

### Understanding Vegetation Response to Climate Variability From Space: Recent Advances Towards the SPECTRA Mission

Massimo Menenti<sup>1</sup> (menenti@sepia.u-strasbg.fr);Michael Rast<sup>2</sup> (Michael.Rast@esa.int); FredericBaret<sup>3</sup> (baret@avignon.inra.fr); Bart van denHurk<sup>4</sup> (hurk@knmi.nl); Wolfgang Knorr<sup>5</sup>(wknorr@bgc-jena.mpg.de); Wolfram Mauser<sup>6</sup>

(w.mauser@iggf.geo.uni-muenchen.de); John

Miller<sup>7</sup> (jrmiller@yorku.ca); Jose Moreno<sup>8</sup>(jose.moreno@uv.es); Michael Schaepman<sup>9</sup>

(Michael.Schaepman@wur.nl); Michel

Verstraete<sup>10</sup> (michel.verstraete@jrc.it)<sup>1</sup>LSIT, Université Louis Pasteur, 5 Blvd. S. Brant, Illkirch 67400, France<sup>2</sup>ESA-ESTEC, P.O. Box 299, Noordwijk 2200 AG, Netherlands<sup>3</sup>INRA-CSE, Agroparc, Avignon 84 014, France<sup>4</sup>KNMI, P.O. Box 201, De Bilt 3730 AE, Netherlands<sup>5</sup>Max Planck Inst. Meteorology, Bundesstr. 55, Hamburg 20146, Germany<sup>6</sup>Ludwig-Maximilians University, Luisenstrasse 37, Munich 80333, Germany<sup>7</sup>Department of Physics and Astronomy, York University, 4700 Keele Street, Toronto, ON M3J 1P3, Canada<sup>8</sup>Universitat de Valencia D. to de Termodinamica, Av. Moliner, Burjassot 46100, Spain<sup>9</sup>Dept. of Geography, University of Zurich, Winterthurerstrasse 190, Zurich 8057, Switzerland<sup>10</sup>JRC - IES, TP 440, Via E. Fermi 1, Ispra, VA 21020, Italy

Many vegetation properties are related to features of reflectance spectra in the region 400 nm - 2500 nm. and to emittance in region 8 mm - 14 mm Detailed observations of spectral reflectance reveal subtle features related to biochemical components of leaves such as chlorophyll and water. Exchange of energy between the biosphere and the atmosphere is an important mechanism determining the response of vegetation to climate variability. This requires measurements of the component temperature of foliage and soil. The latter are closely related to the angular variation in thermal infrared emittance. The architecture of vegetation canopies determines complex changes of observed reflectance and emittance spectra with view and illumination angle. Quantitative analysis of reflectance and emittance spectra requires, therefore, an accurate characterization of the anisotropy of radiance. This can be achieved with nearly - simultaneous observations at different view angles. The Surface Processes and Ecosystem Changes Through Response Analysis (SPECTRA) Mission has been conceived to perform these observations at high spatial resolution by taking advantage of

the spacecraft agility. Scientific preparations are pursued along two avenues: a) the nature of the expected data and candidate algorithms are evaluated by generating and using synthetic hyper - spectral multi - angular/radiometric data; b) algorithms are evaluated with actual hyper - spectral data collected with a variety of airborne systems and concurrent ground measurements; Campaigns have been performed using radiometric observations provided by ATSR, AATSR, Air-MISR, CHRIS - PROBA and a variety of airborne hyperspectral systems. The paper will cover highlights of these studies.

GC54A CC: 524 C Friday 1530h

### Multiangle Remote Sensing of the Terrestrial Environment-III

**Presiding:** L Di Girolamo, University of Illinois at Urbana-Champaign; G de Leeuw, TNO Physics and Electronics Laboratory

GC54A-01 1535h INVITED

### The Advanced Along-Track Scanning Radiometer (AATSR) on the ENVISAT Satellite - Precise SST From a Dual-Angle View

David T Llewellyn-Jones<sup>1</sup> (44-116-252-5238; dlj1@le.ac.uk)Gary K Corlett<sup>1</sup> (44-116-252-5240; gkc1@le.ac.uk)Sean P Lawrence<sup>1</sup> (44-116-252-5239; spl5@le.ac.uk)John J Remedios<sup>1</sup> (44-116-223-1319)<sup>1</sup>Space Research Centre, Department of Physics and Astronomy University of Leicester University Road, LEICESTER, Le1 1ER, United Kingdom

The dual-angle viewing geometry of the AATSR sensor, like that of its two predecessors, provides special advantages over single-angle viewing sensors, especially in the presence of excessive atmospheric aerosol. This enables the ATSR series of instrument to provide an exceptionally accurate and stable time-series of Global sea0-surface temperature, in order to meet the needs of modern climate research activities. The AATSR instrument will be briefly described and some early validation results will be presented. Some inter-comparisons of AATSR global SST fields with similar fields from other sensors such as MODIS and AVHRR will also be shown. These inter-comparisons illustrate very graphically the significant advantages offered by the dual-angle view in the presence of atmospheric aerosol. Examples of data-products and of applications of AATSR data will also be given. Some preliminary results from an on-going study of climate change observations from the ATSR instruments will also be discussed.

GC54A-02 1555h

### Sideways Looks at Broken Clouds: From Geometry to Optics with Three-Dimensional Radiative Transfer

Anthony B Davis<sup>1</sup> (+1-505-665-6577; adavis@lanl.gov)Igor N Polonsky<sup>1</sup> (+1-505-665-9482; polonsky@lanl.gov)<sup>1</sup>Los Alamos National Laboratory, Space & Remote Sensing Sciences Group, P.O. Box 1663 (Mail Stop B-244), Los Alamos, NM 87545, United States

Conspicuously broken clouds are possibly the easiest to identify in multi-angle remote sensing. This makes their geometry (height, size) and kinematics (advective tendency) amenable to straightforward geometric methods. What is missing is an estimation of the isolated cloud's optical properties, particularly its optical thickness. To this end, we address theoretically the problem of radiative transfer through dense clouds that are homogeneous but not plane-parallel. The diffusion approximation we use for idealized spherical and cylindrical cloud geometries is validated with a Monte Carlo solution of the full 3D radiative transfer equation. Based on these analytical solutions, we propose a simple method for inferring the optical depth of broken or isolated cumulus clouds that is not expected to be sensitive to the cloud's aspect ratios. We exploit the fact that compact cloud shapes enable simultaneous views of reflected and transmitted light, which is a topological impossibility for the standard plane-parallel cloud model used in operational remote sensing irrespective of cloud geometry. This observation is further facilitated by oblique viewing angles. The new algorithm is validated using detailed 3D radiative

transfer simulations for known cloud models with synthetic but realistic fractal structure, and then applied to Multispectral Thermal Imager (MTI) data with very encouraging results. Finally, we list potential applications that will benefit remote sensing of surface and clear-sky properties.

URL: <http://nis-www.lanl.gov/~adavis>

#### GC54A-03 1610h

##### Multi-angle Measures of Cloud Tracked Winds

Roger Davies<sup>1</sup> ((818) 393-7236;  
[roger.davies@jpl.nasa.gov](mailto:roger.davies@jpl.nasa.gov))

Catherine Moroney<sup>1</sup>  
([catherine.moroney@jpl.nasa.gov](mailto:catherine.moroney@jpl.nasa.gov))

David Nelson<sup>1,2</sup> ([dlnelson@jpl.nasa.gov](mailto:dlnelson@jpl.nasa.gov))

<sup>1</sup>Jet Propulsion Laboratory California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, United States

<sup>2</sup>User Technology Associates, Inc, 283 S. Lake Ave, Pasadena, CA 91109, United States

Stereo matching of cloud reflectivity patterns using two or more pairs of viewing directions can be used to obtain instantaneous cloud tracked winds and cloud heights from a polar orbiter. Under ideal conditions and using MISR measurements at a resolution of 275 m, the accuracy of cloud tracked winds for a 70 km domain is nominally 4 m/s rms, with a height resolution of 400 m. Comparisons by the NASA Goddard's Global Modeling and Assimilation Office of model analyzed wind fields with the MISR operational products based on only two camera pairs yielded normalized uncertainties (i.e. rms/mean) of about 0.7, or 6.2 m/s for lower tropospheric winds. Here we examine the lessons learned regarding the need for accurate co-registration, quality control of stereo matching (especially the treatment of multilevel clouds), and the merits of adding a third camera pair. Provided co-registration can be

guaranteed, addition of a third camera pair appears to improve the wind product by about 2 m/s rms.

#### GC54A-04 1625h

##### Stereoscopic, thermal, and true deep cumulus cloud top heights

Steve C Sherwood<sup>1</sup> (203 432-3167;  
[Steven.Sherwood@yale.edu](mailto:Steven.Sherwood@yale.edu))

Jung-Hyo Chae<sup>1</sup> ([Junghyo.chae@yale.edu](mailto:Junghyo.chae@yale.edu))

Pat Minnis<sup>2</sup> ([p.minnis@nasa.gov](mailto:p.minnis@nasa.gov))

Matt McGill<sup>3</sup> ([Matthew.J.McGill@nasa.gov](mailto:Matthew.J.McGill@nasa.gov))

<sup>1</sup>Yale University, PO Box 208109, New Haven, CT 06520, United States

<sup>2</sup>NASA, Langley Research Center, Hampton, VA, United States

<sup>3</sup>NASA, Goddard Space Flight Center, Greenbelt, MD, United States

We compare cloud-top height estimates from several sensors: thermal tops from GOES-8 and MODIS, stereoscopic tops from MISR, and directly measured heights from the Goddard Cloud Physics Lidar on board the ER-2, all collected during the CRYSTAL-FACE field campaign. Comparisons reveal a persistent 1-2 km underestimation of cloud-top heights by thermal imagery, even when the finite optical extinctions near cloud top and in thin overlying cirrus are taken into account. The most severe underestimates occur for the tallest clouds. The MISR "best-sinds" and lidar estimates disagree in very similar ways with thermally estimated tops, which we take as evidence of excellent performance by MISR. Encouraged by this, we use MISR to examine variations in cloud penetration and thermal top height errors in several locations of tropical deep convection over multiple seasons. The goals of this are, first, to learn how cloud penetration depends on the near-tropopause environment; and second, to gain further insight into the mysterious underestimation of tops by thermal imagery.

#### GC54A-05 1640h

##### Combined Infrared Stereo and Laser Ranging Cloud Measurements from Shuttle Mission STS-85

Redgie S Lancaster<sup>1</sup> ((301) 614-6284;  
[lancaster@viril.gsfc.nasa.gov](mailto:lancaster@viril.gsfc.nasa.gov))

James D Spinhirne<sup>2</sup>

Kathrine F Manizade<sup>3</sup>

<sup>1</sup>Goddard Earth Science and Technology Center, University of Maryland Baltimore County, Baltimore, MD 51047, United States

<sup>2</sup>NASA Goddard Space Flight Center, Code 912, Greenbelt, MD 20771, United States

<sup>3</sup>Science Systems and Applications, Inc., Greenbelt Pkwy, Lanham, MD, United States

Multiangle remote sensing provides a wealth of information for earth and climate monitoring, such as the ability to measure the height of cloud tops through stereoscopic imaging. As technology advances so do the options for developing spacecraft instrumentation versatile enough to meet the demands associated with multiangle measurements. One such instrument is the infrared spectral imaging radiometer, which flew as part of mission STS-85 and was the first earth-observing radiometer to incorporate an uncooled microbolometer array detector as its image sensor. Specifically, a method for computing cloud-top height with a precision of 620 m from the multispectral stereo measurements acquired during this flight has been developed, and the results are compared with coincident direct laser ranging measurements from the shuttle laser altimeter. Mission STS-85 was the first space flight to combine laser ranging and thermal IR camera systems for cloud remote sensing.

## Reference Style for Abstracts

When referencing a meeting abstract, please use the following format, which indicates that this abstract volume is a supplement to the regular *Eos* issue. This format meets all AGU requirements for a complete reference.

Pfister, R. G., and M. S. Nestler (2004), Sharing community data, services and tools using the EOS clearinghouse (ECHO), *Eos Trans. AGU*, 85(17), Joint Assembly Suppl., Abstract OS41B-06.

Cite abstracts as: Authors (2004), Title, *Eos. Trans. AGU*, 85(17), Joint Assembly Suppl., Abstract #####-##.