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The Southern Africa Regional Science Initiative dry season campaign was carried out during August and September 2000 at the peak of biomass burning. The intensive measurements in this campaign provided the opportunity to validate the surface products of the Multi-angle Imaging SpectroRadiometer (MISR), onboard NASA's EOS Terra platform. MISR validation team participated with a suite of ground-based instruments, including the PARABOLA and sun radiometers, to measure the surface bidirectional reflectance and atmospheric aerosol. A participating airborne sensor was the Cloud Absorption Radiometer (CAR) flown onboard the convair-580 research aircraft. The CAR observations provide measurements of the surface bidirectional reflectance (BRF). This paper presents a validation study of MISR surface products by comparing MISR retrieval of the surface BRF, at Sua Pan, Botswana, with those evaluated on the ground and from the air, using the PARABOLA and CAR observations, respectively.

GC51A-16 0830h POSTER

Performance of the MISR LAI and FPAR algorithm: A Case Study in Africa

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The Multi-angle Imaging SpectroRadiometer (MISR) instrument is designed to provide global imagery at nine discrete viewing angles and four visible/near-infrared spectral bands. The MISR standard products include green leaf area index (LAI) of vegetation and fraction of photosynthetically active radiation absorbed by vegetation (FPAR). These parameters are being routinely processed from MISR data at the Langley Atmospheric Sciences Data Center since October 2002. A principal objective of the MISR approach is to retrieve LAI and FPAR without requiring a static, pre-specified global biome map. Single angle retrievals require this information to constrain the results, and incorrect information on biome type in such algorithms can fatally impact the retrievals. The typical overall accuracy in most biome maps is about 70%. Thus, about 30% of LAI retrievals should be treated as unreliable in the case of single-angle data. Performance of the MISR LAI/FPAR algorithm for a limited set of data from Africa suggests that concurrently valid LAI retrievals and correct biome identification occurs, on average, in about 20% of the pixels, given the current level of uncertainties in the MISR surface reflectance data. The other 80% of the LAI values are retrieved using incorrect information about the biome type; however, the use of multiangle data minimizes the impact of biome misidentification on the LAI retrievals. In about 70% of the cases examined, uncertainties in the observations were the limiting factor in controlling the LAI uncertainty, not the ability to classify the biome type. Thus, the joint use of angular and spectral information without a prescribed biome map or training data results in comparable accuracy to LAI values obtained from single-angle retrievals that require a pre-defined biome map. The multiangle algorithm can therefore adapt to changing or unknown land cover.

GC51A-17 0830h POSTER

Combined Multiangular and Hyperspectral Observations for Improved Modeling of Forest Productivity

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There is a strong parallel between ecosystem productivity and land surface reflectance, in the sense that structural and foliar-chemical variables exert first order control over both processes. However, bidirectional reflectance and productivity are rarely linked explicitly in model analyses. Though some significant challenges exist, progress can be made by understanding the complementary information contained in the angular and spectral signatures of vegetation at the landscape scale, in the context of reflectance and productivity models. We present results from a combined multiangular (AirMISR) and hyperspectral (AVIRIS) remote sensing airborne campaign which was conducted over three northeastern U.S. forest research sites in 2003. Target sites included the Bartlett Experimental Forest, New Hampshire, USA; Howland Experimental Forest, Maine, USA; and Harvard Forest, Massachusetts, USA. Complementary, near-simultaneous field observations were obtained primarily in the Bartlett site, which has been extremely well-characterized spatially by previous field and modeling studies. Field observations include canopy hemispherical photography, from which several structural metrics have been obtained, and foliar nitrogen content.

GC51A-18 0830h POSTER

Forest Cover Indicator Based on Spectral and Directional Remote Sensing Data.

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The exact extend and change of Canada forests are of great importance in climate change and sustainable development as forests provide wildlife habitat and ecosystem mechanisms to clean air and water, and sequester carbon. Measuring the area of forested land in Canada on a regular basis provides an indicator of the availability of these important ecosystem services. A methodology was developed to quantify forest cover based on crown closure estimates. Field data, spectral and directional remote sensing imageries, and a canopy radiative transfer model (Five-Scale) are used for mapping crown closure at 1-km resolution. The main challenge of the research is in the transition zone between boreal forest and the tundra, where few inventory data are available and the trees are found in clusters. The results will be used in a Canada-wide forest indicator that aimed at monitoring yearly changes in the forest extend due in part to forest fires, insect defoliation, regrowth and changes due to climate change. Initial results using SPOT-VGT data and foliage clumping information from ADEOS-POLDER are presented.

GC51A-19 0830h POSTER

Multi-angle Imaging SpectroRadiometer Data Products and Tools

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The Multi-angle Imaging SpectroRadiometer (MISR) data are processed, archived and distributed by the Atmospheric Sciences Data Center (ASDC) at NASA's Langley Research Center. Available MISR data products include Level 1 calibrated instrument data, Level 2 aerosol, cloud, and land surface products and Level 3 globally gridded statistical summaries of selected Level 1 and Level 2 parameters aggregated over various time scales (daily, monthly, seasonal and annual). The ASDC also provides access to tools that aid in the visualization and analysis of the MISR data products. Web interface tools such as the MISR Browse Tool and the MISR Level 3 Imagery allow quick access to imagery. Software tools such as hdfscan and misr-view can aid in analysis of the data products. Detailed information about the MISR data products, tools and documentation are available from the ASDC web site, http://eosweb.larc.nasa.gov.

URL: http://eosweb.larc.nasa.gov

GC52A CC: 524 C Friday 1030h

Multiangle Remote Sensing of the Terrestrial Environment–I

Presiding: **D J Diner,** Jet Propulsion Laboratory, California Institute of Technology**; B Cairns,** Lamont-Doherty Earth Observatory

GC52A-01 1035h

Retrieval of Aerosol Optical Depth Over Europe Derived From ATSR-2 Data for the Year 2000

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At TNO Physics and Electronics Laboratory the retrieval of aerosol properties from ATSR-2 data (ERS-2 satellite) is performed by means of several scientific algorithms. The dual view algorithm for application over land and the single view algorithm for application over ocean have been merged into a fast and efficient algorithm that allows for near real-time processing and which is suitable for operational use. It includes all necessary corrections for surface and atmospheric effects including fully automated cloud screening procedures. The algorithm can be applied to retrieve the aerosol optical depth (AOD), Ångström parameter and the aerosol types. A preliminary analysis will be presented here from newly obtained data for the year 2000 over Europe. The retrieved AOD compares favorably with collocated sun-photometer data from the Aerosol Robotic Network (AERONET).

GC52A-02 1050h INVITED

Aerosol Properties from Multi-angle Satellite Imaging

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The MISR instrument, flying aboard the NASA Earth Observing System's Terra satellite, is pioneering the use of multi-angle imaging to monitor aerosols globally, from space. MISR obtains nine along-track images at view angles ranging from +70° through nadir to -70°, in each of four wavelengths, near-simultaneously. The instrument systematically covers air-mass-factors between one and three, and in mid-latitudes, samples scattering angles extending from about 60° to 160°. These data contain information about particle size distribution, shape, composition, and amount. Large air-mass-factors provide sensitivity to optical depth even for very thin hazes. Provided the aerosol optical depth is of order 0.15 or larger, size- and shape-discrimination makes it possible to distinguish non-spherical mineral dust and thin cirrus from spherical pollution particles over dark water, and to obtain information about the single scattering albedo as well as the size distribution of pollution components. If discrete features are visible in aerosol plumes, the height of the aerosol itself is obtained via stereo-matching. Such information is of value for identifying aerosol sources and sinks, for assessing the direct radiative impact of aerosols on global climate, and for aerosol transport model validation. Having constraints on aerosol micro-physical properties also improves the accuracy of optical depth retrievals. This work is performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

URL: http://www-misr.jpl.nasa.gov

GC52A-03 1110h

A Regional Analysis of Wintertime Aerosols Over the Greater Indian Region From MISR

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Aerosol microphysical properties from satellite meteorological instruments have traditionally been confined to oceanic regions due to the limited accuracy of single or dual spectral channel retrieval techniques over land. With the launch of the EOS-Terra satellite, MISR and MODIS are delivering global, high spatial resolution aerosol products over ocean and land. MODIS accomplishes this by extending the number of spectral channels used in the aerosol retrieval algorithm, while MISR uses a unique multi-angle, multi-spectral aerosol retrieval algorithm. These algorithms are currently undergoing strict validation activities over both land and water through comparison with ground-based and in situ measurements of aerosol properties. In this presentation, we will extend the validation of the MISR aerosol properties through comparison with ground-based estimates over Kathmandu, and through a climatological analysis of the product over the greater Indian region for the past four winters. We will show the strengths and current limitations of the MISR aerosol product, as well as demonstrate its overall scientific utility. Of particular interest is MISR's ability to extract aerosol optical depths at four shortwave spectral channels as well as information on the aerosol type, shape, and size distribution. We will show that the greater Indian region during winter has very little mineral dust, as one would expect during the winter monsoon, but a large amount of aerosols that are anthropogenic in origin. These anthropogenic aerosols are wide spread over land and ocean and persistent over the winter seasons. The highest concentrations of these aerosols occur in the Ganges Valley in Northern India, where about 25% of the population of India resides. Winter climatological aerosol optical depth values (blue channel) in this region can be as high as 1, with typical values of 0.6 - 0.7.

GC52A-04 1125h

Use of Multiangle Satellite Measurements for Evaluating Shortwave and Longwave Top-of-Atmosphere Radiative Flux Estimates from the Clouds and the Earth's Radiant Energy System (CERES) Instrument

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The Clouds and the Earth's Radiant Energy System (CERES) provides top-of-atmosphere (TOA) shortwave (SW), longwave (LW) and window (WN) radiance measurements and radiative flux estimates together with coincident cloud and aerosol properties inferred from the Moderate Resolution Imaging Spectrometer (MODIS). These data are needed to investigate the critical role that clouds and aerosols play in modulating the radiative energy flow within the Earth-atmosphere system. TOA fluxes are estimated from each CERES field-of-view (FOV) by applying scene-dependent empirical Angular Distribution Models (ADMs) that describe the angular dependence or anisotropy of the radiation field. ADMs are developed empirically from approximately two years of CERES measurements. One of the unique features of the CERES instrument is its ability to acquire measurements in several scan modes: crosstrack, alongtrack and rotating azimuth plane (where CERES rotates in azimuth as it scans in elevation). In this study, CERES alongtrack data are combined with coincident MODIS nadir radiances to provide near-simultaneous multi-angle measurements over the same scene for testing the self-consistency of ADM-derived TOA fluxes with viewing geometry. MODIS pixel-level radiances located within CERES FOVs are weighted by the CERES point-spread-function (PSF) to optimize the spatial matching between CERES and MODIS. MODIS visible radiances are converted to broadband radiances by performing narrow-to-broadband regressions from coincident nadir CERES and MODIS radiances over 1-deg latitude-longitude regions. For the same regions, oblique-view CERES and "broadband" MODIS nadir radiances are converted to SW and LW TOA fluxes using the CERES ADMs. Since TOA flux is independent of viewing geometry, TOA flux estimates at the oblique and nadir angles should be identical. If the fluxes differ, this means the ADMs fail to represent the anisotropy of the scene. 40 days of global alongtrack CERES and nadir MODIS measurements are considered. SW and LW TOA flux consistency test results are presented for cloud-free conditions over ocean, land, desert and snow, and for cloudy conditions as a function of cloud type (e.g., low, middle high, thin, thick, overcast, broken etc.).

GC52A-05 1140h INVITED

An Evaluation of the Polarized Phase Functions of Cirrus Clouds During CRYSTAL-FACE

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Recent in situ observations made during the CRYSTAL-FACE field experiment have indicated that ice crystals have smaller sizes and are more reflective than is commonly assumed in most current climate models. The size of the particles appears to be principally determined by temperature with the smallest particles being found at the coldest temperatures. Unfortunately, the in situ measurements did not include measurements of the asymmetry parameter for the coldest temperatures, less than 220 K, and for the smallest particle sizes, less than 10 micron effective radius. It also appears that at the coldest temperatures, less than 202 K, surface nitric acid molecules affect the cirrus crystal habit which may modify the scattering behavior as compared to that observed for warmer clouds. In this paper we use multi-angle measurements made by the Research Scanning Polarimeter (RSP) together with water vapor and temperature profiles derived from NAST-I measurements to examine the polarized phase functions and sizes of ice crystals in cold thin cirrus clouds. The RSP makes measurements in nine spectral channels including one at 1880 nm where a strong water vapor absorption band is located. This channel is of particular use for retrieving the properties of thin cirrus clouds because it is insensitive to the surface, or aerosols in the lower troposphere. This behavior also provides a straightforward operational definition of "thin" wherein a cirrus cloud is defined to be "thin" if it is detected in the 1880 nm channel, but not by other "visible" channel cloud masking tests. The RSP scan was biased so that the view angle range was from 0 to 75 degrees to the rear of the Proteus aircraft and from 0 to 45 degrees to the front and was oriented to scan along the groundtrack of the aircraft. This allowed observations of a single target over a maximum scattering angle range of 120 degrees. The RSP measurements can be used to estimate cloud height in a manner analogous to the hyper stereo method used by MISR. This information together with the temperature and water vapor profiles from NAST-I allows us to determine the temperature of the cloud and to correct the 1880 nm measurements for the effects of water vapor. Here we present the results of our analysis of thin cirrus clouds including estimates of particle effective radius and an evaluation of whether current models of ice crystals provide an adequate description of the observed polarized scattering behavior of these clouds.

URL: http://www.giss.nasa.gov/data/rsp_air/data_analysis.html

GC53A CC: 524 C Friday 1330h

Multiangle Remote Sensing of the Terrestrial Environment–II

Presiding: **M M Verstraete,** Joint Research Centre, Institute for Environment and Sustainability**; W Abdou,** Jet Propulsion Laboratory, California Institute of Technology

GC53A-01 1335h

Potential of Airborne Measurements of Bidirectional Reflectance Distribution Function

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Airborne measurements of angular distribution of reflected radiation by various types of surfaces, for example, vegetated surfaces (forests, grasslands, etc.), cloud, ocean, and snow/ice can enable validation of surface parametric models that are used to interpret satellite data. The scattering and absorption by the atmosphere, however, need to be taken into account. In this study we use a new algorithm that allow the use of airborne radiation measurements with Cloud Absorption Radiometer (CAR) and ground-based measurements with AERONET sun/sky radiometer to retrieve simultaneously aerosol optical characteristics and surface optical properties. From the derived surface bidirectional reflectance distribution functions from CAR data taken over southern Africa during SAFARI 2000, we attempt to validate some of the surface parametric models used in radiation schemes of MODIS (Moderate Resolution Imaging Spectroradiometer) and MISR (Multiangle Imaging SpectroRadiometer) BRDF/albedo products.

URL: http://car.gsfc.nasa.gov

GC53A-02 1350h INVITED

Assessing Information on Vegetation Structure from Near-simultaneous Optical Multiangle Remote Sensing

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Recent studies have highlighted the importance of vegetation structure, both in the context of carbon fixation and with regard to ecosystem productivity. The foliage distribution patterns, and the density of these phytoelements in determining the pattern of light attenuation within a canopy directly influence the photosynthesis, respiration, transpiration, nutrient cycling, and thus all basic processes controlling the carbon fluxes between the vegetation, the soil and the atmosphere. Near-simultaneous multispectral and multiangle remote sensing measurements from space, as

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