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 (Multi-angle 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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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

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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-flod 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

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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

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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

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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 fiellds 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

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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