Abstracts for the 2004 Joint Assembly 17–21 May 2004

Union

U11A CC: 517 A Monday 0830h

Remote Observation of Earth and Planetary Environments: The Challenge of Spatial Complexity

Presiding: **M M Verstraete,** Joint Research Centre, Institute for Environment and Sustainability**; A B Davis,** Los Alamos National Laboratory

U11A-01 0830h INVITED

Radiative Transfer of Solar Light in Dense Complex Media : Theoretical and Experimental Achievements by the Planetary Community

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Visible and near infrared imaging spectroscopy is one of the key techniques to detect, map and characterize mineral and volatile species existing at the surface of the planets. Indeed the chemical composition, granularity, texture, physical state, etc, of the materials determine the existence and morphology of the absorption bands. However the development of quantitative methods to analyze reflectance spectra requires mastering of a very challenging physics: the reflection of solar light by densely packed, absorbent and highly scattering materials that usually present a fantastic structural complexity at different spatial scales. Volume scattering of photons depends on many parameters like the intrinsic optical properties, the shapes, sizes and the packing density of the mineral or icy grains forming the natural media. Their discontinuous and stochastic nature plays a great role especially for reflection and shading by the top few grains of the surface. Over several decades, the planetary community has developed increasingly sophisticated tools to handle this problem of radiative transfer in dense complex media in order to fulfill its needs. Analytical functions with a small number of non physical adjusting parameters were first proposed to reproduce the photometry of the planets and satellites. Then reflectance models were built by implementing methods of radiative transfer in continuously absorbent and scattering medium. A number of very restricting hypothesis forms the basis of these methods, e.g. low particles density, scattering treated in the far field approximation. A majority of these assumptions does not stand when treating planetary regoliths or volatile deposits. In addition, the classical methods completely bypass effects due to the constructive interference of scattered waves for backscattering or specular geometries (e.g. the opposition effect). Different, sometimes competing, approaches have been proposed to overcome some of these limitations. In particular Monte Carlo ray tracing simulations have been recently carried out to investigate properties of particulate media that are traditionally ignored or crudely treated: packing density, micro-roughness, etc. The efforts of the community to address the later problems are not only theoretical but also experimental with the development of several dedicated goniometers.

U11A-02 0850h INVITED

Sunglint Research in the Lab, and Spatial Micro-Complexity

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We are beginning a new investigation into polarized sunglint in a laboratory setting, using a wave tank. The wave tank has the capability of generating almost any combination of gravity and capillary waves under computer control, from simple sine waves to essentially random seas. Our aim is to perfect sunglint models, which have advanced little since the work of Cox and Munk in the 1950s using digitized photographs taken from an airplane. Sunglint patterns, even when viewed from elevated platforms, but more and more so when viewed from low Earth orbit and beyond, have a kind of coherence and stability which transcends a pixel-by-pixel interpretation. The light forming the pattern is a sum of contributions from several or even many waves which are far from adjacent. Thus glint is a phenomenon that can only be understood in the large and never on a pixel-by-pixel basis. Applications of sunglint to problems of ocean biology, aerosol, and CO2 retrieval will be noted.

U11A-03 0910h INVITED

Origin and Impact of 3-D Structural Effects in the Radiative Signature of Vegetation

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Vegetation canopies are inherently 3-D, with various levels of clumping occuring at different scales: the within-crown, the tree, and the canopy level. As such their reflectance anisotropy in the optical domain is not accurately simulated by adopting a purely turbid medium representation. For example, the local reflection maximum in the retro-reflection direction - known as the 'hot spot' - is precisely due to the finite size of the scatterers in the canopy layer, as well as the spectral contrast with the underlying background. Structurally homogeneous canopy representations (i.e., plane-parallel vegetation layers containing uniformly distributed finite-sized scatterers with specified distributions of their orientation: 1-D') thus constitute the simplest canopy representation capable of matching multi-spectral space borne reflectance measurements under almost any view and illumination geometry. In actual situations where a hierarchy of scales related to vegetation clumpiness exists the structural information of a given surface target is exposed through multi-directional reflectance measurements. This presentation will address the aptitude of 1-D' canopy repesentations to match multi-angular and multi-spectral reflectance observations over 3-D target surfaces, for a variety of spatial resolutions and structural target characteristics. A variety of arguments will be presented as to the causes of the spatial resolution dependent divergences between the radiation fields of 1-D' and 3-D canopy representations, including: sensor footprint location, structural target characteristics, and horizontal photon migration.

U11A-04 0930h

Comparing Synthetic Imagery using a 3-D Monte-Carlo Model & An Analytical Model For Shallow Water Hyperspectral Remote Sensing Applications.

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Monte Carlo and analytical models are used to derive shallow water synthetic images under the conditions of 1) shallow water surface waves, 2) various bottom types, 3) water depths and 4) water constituents. We demonstrate the use of these models and the role of the above variables on the influence of the spatial variability to be expected in airborne hyperspectral imagery. The modeled geographical area is the Sebastian Inlet, in Central Florida, which connects to the Atlantic Ocean and the Indian River Lagoon. We demonstrate the important role of depth, wind speed, direction and fetch along with the 3-D transport volume size as the characteristics dominating in the spatial scale of change in the synthetic imagery.

U11A-05 0945h

Applying 3D radiative transfer and electromagnetic scattering techniques for new laser scanner and multiangular remote sensing techniques and on ground measurements

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Recent trends in terrestrial and planetary remote sensing include multiangular and laser scanning techniques. Both of them are capable to reveal new complex spatial information from the target. The interpretation of the multiangular signals has already gained much attention, but the backscattered laser intensity signal is mostly unexploited. Modelling schemes for both multiangular and backscattered signals are similar, but backscattering requires significantly greater accuracy. Many geometric and electromagnetic phenomena, such as shadow hiding, corner reflections, coherent backscattering etc. are at extremum in the backscattering direction. The modelling issue is approached here from three perspectives: 1. Monte Carlo ray–tracing provides the only solution technique for really complex 3D radiative transfer problems. This has been applied to snow, soil and vegetation. Some results and algorithm properties will be discussed 2. Adding is a versatile 1D radiative transfer technique, that is extended to minor 3D variations and dense packing effects. Using Monte Carlo initialisation, it applies well to snow, soil and other dark or bright isotropic media (or to mid and low layers of that) where pure Monte Carlo is too slow. 3. cyclic electromagnetic wave coherence is said to play a major role in backscattering. The models are reviewed and applications to natural targets are discussed. The models are compared to measured data, in the few cases where models and targets overlap, and the applicabilities to other targets are discussed.

U12A CC: 517 A Monday 1030h

Remote Observation of the Cloudy Atmosphere: The Challenge of Spatial Complexity

Presiding: **D J Diner,** Jet Propulsion Laboratory, California Institute of Technology**; B Pinty,** European Commission Joint Research Center, Italy

U12A-01 1030h INVITED

Optical Depth of Heterogeneous Cloud Using a Multiangle Remote Sensing Technique

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At least two effects act to make the retrieval of cloud optical depth a major challenge for passive remote sensing techniques. One is the significant departure of most real world clouds from the plane parallel ideal so readily assumed by one-dimensional inversion techniques. The other is the rapid loss of information about depth due to saturation effects at bright cloud top reflectivity. Analysis of multi-angle measurements by MISR indicates the heterogeneity effect typically influences the optical depth retrieval of over 70% of all clouds. Over 15% of all clouds are also strongly affected by the saturation effect. Deep convective clouds, of noteworthy relevance to the climate system because of their radiative and hydrological importance, frequently exhibit both saturation effects and heterogeneity effects. In order to estimate their optical depths from space using passive remote sensing, it is necessary to adopt a three-dimensional radiative transfer approach.