B51E-1016 0830h POSTER

Remote Quantification of Vegetation Biophysical Characteristics: Algorithms, Calibration and Validation

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There is considerable interest in assessing biophysical characteristics of vegetation, such as vegetation fraction (VF), leaf area index (LAI), and the magnitude of carbon sources and sinks for agricultural lands, grasslands, and forests. In this paper, we discuss novel techniques to assess remotely VF, LAI and CO2 fluxes in crops. We suggest Visible Atmospherically Resistant Index (VARI) for estimating VF; VARI uses only visible (either green or red edge, blue, and red) spectral channels. The index showed linear relationship with VF in wheat, maize and soybean. To estimate LAI and green leaf biomass we used reflectances in two spectral channels either in the green around 550 nm, or in the red edge near 700 nm, and in the near infra-red (NIR) beyond 750 nm. The technique was tested in agricultural fields under maize and soybean canopies, and proved suitable for accurate estimation of LAI ranging from 0 to more than 6. To estimate CO2 fluxes we used a model developed for assessing leaf chlorophyll content. At canopy level the model relates total chlorophyll concentration in the canopy (per volume) with CO2 fluxes. Differences of reciprocal reflectances [(rGreen)-1-(rNIR)-1] and [(rRedEdge)-1-(rNIR)-1] accounted for more than 80 percent of the variability in mid-day canopy photosynthesis of maize and soybean. The technique was validated by an independent data set; root mean square error in predicting mid-day canopy photosynthesis was 0.17 mg/m2/s by [(rRedEdge)-1-(rNIR)-1] and 0.2 mg/m2/s by [(rGreen)-1-(rNIR)-1].

B51E-1017 0830h POSTER

Modeling seasonal vegetation variation and its validation against satellite-based observations

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Seasonal variation of vegetation, determined by plant phenology, impacts the seasonality of surface and atmospheric water cycles by controlling the leaf area available for transpiration. It also impacts the seasonality of land surface energy balance by controlling the intra-annual surface albedo changes. At the same time, leaf seasonal variations respond to both cumulative and concurrent hydro-meteorological conditions. In order to account for this vegetation feedback at the seasonal time scale, we incorporate a predictive plant phenology scheme into the land surface model CLM and evaluate its performance against satellite-based observations. The atmospheric forcing data from the NCEP/NCAR reanalysis is used to drive the land surface model, and the AVHRR Normalized Difference Vegetation Index (NDVI) is used for model validation. Existing problems and the need for further model development will be identified based on this work.

B51E-1018 0830h POSTER

Changes in Mongolia Vegetation Productivity (1982-1998) Derived From Satellite Observations

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Mongolia is dominated by rangelands that are utilized by humans for livestock grazing. Pastoral systems apply pressure to vegetation productivity that already may be stressed by water limitation. Northern Eurasia appears to be undergoing dramatic climate warming during the past several decades that also impacts the ecosystem dynamics in the region. Ninety percent of Mongolia is vulnerable to desertification, and recent overgrazing in recent decades is thought to be responsible for land degradation. A shift around 1990 in the sociopolitical system from collectivization to privatization has likely impacted Mongolian rangelands. In this study, we used a two-decade-long time series of the normalized difference vegetation index together with a carbon cycle model to assess recent changes in net primary production (NPP). Over the entire country, NPP has increased slightly during the 1982-1998 period. Comparisons with a map of soil degradation reveals both increases and decreases in areas with severe degradation, and areas not identified by the map exhibit decreases. We compared NPP from the first half of the record (1982-1990) with that of the second half (1991-1998). NPP generally decreased more in the 1990s and was substantially more variable than in the 1980s. Changes in precipitation and possibly climate warming coupled with land-use change likely drive much of this behavior.

B51E-1019 0830h POSTER

Recent geographic variations in terrestrial carbon cycle based on new production efficiency model

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The terrestrial carbon budget must be understood more accurately for the prediction of future changes in climate and carbon cycle. The goal of this study is to estimate spatial and temporal patterns of the carbon fluxes more accurately using the newly developed terrestrial biosphere model and satellite data. Our model consists of terrestrial carbon cycle and hydrology submodels. An advantage is a new approach in the LUE (Light Use Efficiency) concept, which calculates temperature and water stress factor in LUE model from a photosynthetic model and stomatal conductance formulation. In carbon cycle model, GPP is calculated from the LUE concept and satellite-based fPAR dataset. The soil carbon cycle model is based on CENTURY model with optimized water and temperature factor. Hydrological submodel is based on BIOME3, calculating ET is used by Penman-Monteith method. The model was run for 18 years (1982-1999) on a global scale, and we simulated the geographic distributions of the terrestrial carbon fluxes. We have checked simulated vegetation growth limiting factor with stress factor of MODIS NPP algorithm. Large differences were found in the northern mid and high latitude forests because soil moisture stress is not incorporated into MODIS NPP algorithm. Although responses of stress factors in MODIS NPP algorithm are mostly similar to our theoretically based one, our model works well in the soil moisture limited regions. Global total NPP was estimated at 61.7GtC/yr, and total NEP variations are strongly related with ENSO. Validation using measured values from the GPPDI database showed that our NPP estimation was within a reasonable range. The temporal patterns of the terrestrial carbon flux showed that NPP increased in the northern middle/high latitudes, central Africa, and India. In contrast, NPP decreased in the south Amazon region, the middle latitudes of the southern hemisphere, a part of North America, and Southeast Asia. Sensitivity analysis indicated that NPP variations were largely affected by fAPAR, solar radiation, temperature, and precipitation variations. Our new model was shown to be an appropriate tool to estimate the spatial and temporal patterns of the terrestrial carbon fluxes.

B51E-1020 0830h POSTER

Role of global oceanic forcing and local vegetation feedback in the 20th century Sahel drought: results from the coupled GENESIS-IBIS model

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Previous studies have indicated that both large-scale forcing from the ocean and land surface feedback may have contributed to the severe drought in the 20th century over the Sahel region. In this study we investigate the role of these two factors in the variability of the Sahel rainfall using a sophisticated global biosphere-atmosphere model GENESIS-IBIS. The observed global sea surface temperature in the 20th century are used as as the model driving forcing. Using this coupled global model, we experiment on treating vegetation as a static boundary condition and as a dynamic component of the earth climate system. Our results indicate that the global oceanic forcing can cause a severe drought in the simulated climate system with vegetation being a dynamic component. However, the 20th century Sahel drought may not have occurred if the vegetation were kept as static. Our study emphasizes the important role of dynamic vegetation in regulating the rainfall variability over the Sahel region, and confirms some previous findings from less sophisticated models.

B51F MCC: 3002 Friday 1020h

Human Interactions and the Carbon Cycle in North America *(joint with A, H, OS, GC, PA)*

Presiding: **L Dilling,** National Center for Atmospheric Research**; G Marland,** Oak Ridge National Laboratory

B51F-01 1020h

A review of the role of carbon cycle science in supporting carbon management policy

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Over the past few centuries, concentrations of carbon dioxide and other greenhouse gases have increased in the atmosphere, leading to potential changes in climate. Concern has risen such that societies are now contemplating actions designed to mitigate or prevent further increases. A variety of approaches has been suggested: direct reduction of emissions, deliberate manipulation of the natural carbon cycle to enhance sequestration, and capture and isolation of carbon from fossil fuel use. Policy development to date has laid out some of the principles to which carbon management should adhere, including quantification and verification, additionality and separation, permanence, and environmental acceptability. Much of this policy is still being debated, however, and many of the issues involve significant scientific and technological challenges. This presentation will summarize these carbon management principles, and briefly review examples of the scientific knowledge base available to support specific application of policy options. The issues of scaling of observations and mechanistic understanding of the carbon cycle in North America will be emphasized.

B51F-02 1035h INVITED

Carbon fluxes in urban areas

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Although urban areas are widely recognized as important sources of atmospheric carbon dioxide (CO2) little attention has, as yet, been directed to measuring the magnitude of the releases of CO2 nor to quantifying rates of uptake by urban vegetation. Attempts to quantify the role of urban areas on the global carbon budget have focused largely on inventories of emissions (from estimates of fossil fuel consumption, cement production, etc) and sinks (the amount of carbon sequestered in urban vegetation based on biomass estimates). Surface-atmosphere exchanges of carbon dioxide can be measured directly using micrometeorological techniques (eddy covariance equipment mounted on tall towers). This approach has been employed for other ecosystems (notably grasslands, forests and wetlands) as part of the global FLUXNET program and important data is emerging on the role of different ecosystems, their variability, and controls. This paper will present an overview of this approach and discuss some of the inherent problems in urban settings, and then present results of a series of short and long-term measurements conducted in contrasting urban environments: vegetated suburbs of Baltimore, MD (part of the NSF ULTER Baltimore ecosystem study); residential neighborhoods in Chicago, IL; and the densely urbanized core of Marseille, France. Particular attention will be directed to spatial and temporal variability in carbon releases and uptake within and between cities, and the effects of human activities and urban vegetation as controls on release and uptake, respectively.

B51F-03 1050h INVITED

Material Flows and Carbon Cycles

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The industrial sector emits almost 43 percent of the global anthropogenic carbon dioxide emissions to produce materials and products. Furthermore, energy is used to move materials and products and process the waste. Hence, a large amount of energy is consumed and CO2 is emitted to sustain our materials system. Until recently, studies investigating mitigation options focused on changes in the energy system. For industrial processes most studies evaluate how the current materials system can be maintained producing fewer greenhouse gas emissions. Three elements of a strategy to improve the long-term materials productivity are the reduction of dissipative uses of non-biodegradable materials, secondly, the re-design of products to use less material or design for re-use or recycling, and thirdly, develop more efficient technologies for material conversion and recycling. This will reduce or eliminate the need to extract virgin materials from the environment, and reduce CO2 emissions from the energy-intensive production processes. To assess measures to reduce materials consumption, fossil fuels consumption and CO2 emissions, detailed understanding of the material system is needed. The lifecycle of materials has to be investigated including all branches of industry with all the inputs and outputs. We start with a discussion of materials and the carbon cycle focusing on the contribution of materials to anthropogenic carbon flows. We discuss CO2 emissions from energy use in materials extraction and production, fossil (e.g. plastics) and biomass carbon (e.g. lumber, paper) used as feedstock of materials, and mineral sources (e.g. cement). We discuss opportunities to reduce CO2 emissions by improving the efficiency with which society uses materials through product design, material substitution, product reuse and material recycling.

B51F-04 1105h INVITED

BIOENERGY, THE CARBON CYCLE, AND CARBON POLICY

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The evolving energy and land-use policies across North America and Africa provide critical case studies in the relationship between regional development, the management of natural resources, and the carbon cycle. Over 50 EJ of the roughly 430 EJ total global anthropogenic energy budget is currently utilized in the form of direct biomass combustion. In North America 3 - 4 percent of total energy is derived from biomass, largely in combined heat and power (CHP) combustion applications. By contrast Africa, which is a major consumer of 'traditional' forms of biomass, uses far more total bioenergy products, but largely in smaller batches, with quantities of 0.5 - 2 tons/capita at the household level. Several African nations rely on biomass for well over 90 percent of household energy, and in some nations major portions of the industrial energy supply is also derived from biomass. In much of sub-Saharan Africa the direct combustion of biomass in rural areas is exceeded by the conversion of wood to charcoal for transport to the cities for household use there. There are major health, and environmental repercussions of these energy flows. The African, as well as Latin American and Asian charcoal trade has a noticeable signature on the global greenhouse gas cycles. In North America, and notably Scandinavia and India as well, biomass energy and emerging conversion technologies are being actively researched, and provide tremendous opportunities for the evolution of a sustainable, locally based, energy economy for many nations. This talk will examine aspects of these current energy and carbon flows, and the potential that gassification and new silvicultural practices hold for clean energy systems in the 21st century. North America and Africa will be examined in particular as both sources of innovation in this field, and areas with specific promise for application of these energy technologies and biomass/land use practices to further energy and global climate management.

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B51F-05 1120h

Cropland and Population Changes Through 208 Years in the Conterminous United States

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Broad patterns of human influence on the landscape can be seen in our data set of population size and area of cropland within each county. Our purpose was to provide data on the timing of land conversion as an input to dynamic models of the carbon cycle, although a wide variety of applications exist in the physical, biological, and social sciences. We used U.S. Census data to reconstruct a history of land disturbance for the conterminous United States. The population time series begins with the first census in 1790, and continues at 10 year intervals through the 1990 census. The cropland time series begins in 1850, with data added at 10 and 5 year intervals through 1997. We have used the population data to extrapolate the cropland time series back to 1790. Spatial data sets of the historical county boundaries were used for linking to the census tables, and modern county boundaries were used for visualizing and analyzing the time series and for data distribution. The data set has more spatial detail than previously available compilations. The patterns of agricultural development reflect the influences of climate, soil productivity, increases in population size, variations in the general economy, governmental policies, and technological changes in the energy, transportation, and agricultural sectors. There was a peak in the area of cropland in 1940, with distinct regional trends and patterns.

B51F-06 1135h

Spatial and Temporal Patterns in Carbon Emissions to the Atmosphere

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Data on global fossil-fuel emissions of CO2 to the atmosphere for year 2000 show that the range of national average per capita emissions, in metric tons of carbon per person, includes values of 5.40 for the United States, 2.61 for Germany, 0.29 for India and 0.04 for Liberia. This range is more than two orders of magnitude. Similar data on national fossil-fuel emissions for the United States vary by more than an order of magnitude, from 34.18 metric tons of carbon per person for Wyoming to 2.70 for California. The state data also show differing patterns of change over time. The Kyoto Protocol would require ratifying developed countries to reduce greenhouse gas emissions to quantified negotiated targets. The concept of contraction and convergence (C&C) has been widely touted as a possible basis for ultimate, more strict limits on greenhouse gas emissions. The idea of C&C is that per-capita emissions of CO2 for all countries would converge toward some common value that is consistent with stabilization of global climate. The U.S., on the other hand, has proposed intensity-based emissions targets whereby goals would be defined in terms of emissions per unit of gross domestic product, or perhaps emissions per unit of output for specific activities. This paper describes the data set on U.S. CO2 emissions by state, and begins to explore the patterns between states and over time.

B51F-07 1150h

Implications of Ozone on Carbon Sequestration and Climate Policy in the U.S. Using the MIT Integrated Global Systems Model

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Exposure of plants to ozone inhibits photosynthesis and therefore reduces vegetation production and carbon sequestration. The damaging effects of tropospheric ozone vary spatially because human activities responsible for the emissions of ozone precursors are highly concentrated in urban and industrial centers. We developed scenarios of ozone-precursor emissions and the resultant ozone concentrations using the MIT Integrated Global Systems Model (IGSM) through the year 2100 and explored the consequent effects on terrestrial ecosystems using the Terrestrial Ecosystem Model (TEM). We then used the Emissions Prediction and Policy Analysis (EPPA) model, a component of the IGSM, to evaluate the cost of increased mitigation efforts required to offset lost carbon sequestration. We considered both a global climate policy that limits future greenhouse gas (GHG) emissions and an air quality policy that limits pollutant emissions to their 1995 levels in the developed countries. We also considered agricultural management that includes optimal irrigation and fertilization and no irrigation and fertilization for croplands. We found that the loss of carbon sequestration in the U.S. at the end of the 21st century due to ozone pollution ranged from negligible to as much as 0.3 PgC yr^{-1} depending upon the policy options pursued. We valued these reductions in terms of the change in the net present value of the cost to the U.S. through 2100 of a global carbon policy designed to approximately stabilize atmospheric CO_2 levels at 550 ppm. For the U.S., failure to consider ozone damages to vegetation would by itself raise the costs over the next century of stabilizing atmospheric concentrations of CO_2 by 11 to 19% ($0.3 to $0.6 trillion) because emissions from fossil fuels will need to be reduced more to compensate for the reduced carbon sequestration by terrestrial ecosystems. With a pollution cap, damages are reduced to 6 to 12% ($0.2 to $0.3 trillion) of the total cost. However, climate policy that reduces fossil fuel use and methane emissions would also reduce the emissions of the ozone precursors and therefore, ozone concentrations and ozone damages. The savings in reduced carbon emissions reductions costs are estimated to be between 1 and 17% ($0.09 to $0.3 trillion) of the cost of the climate policy. The cost estimates are sensitive to the assumed 5% discount rate and the details of the climate policy and how the burden is allocated among countries. Tropospheric ozone effects on terrestrial ecosystems produce a surprisingly large feedback in estimating climate policy costs that, heretofore, has not been included in cost estimates.

B51F-08 1205h

Carbon Cycling in Long Island Sound Over the Last 1000 Years

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Long Island Sound is a eutrophied urban estuary that suffers from anoxia during the late summer months. Is the narrow western part of the estuary prone to anoxia as a result of poor circulation during warm periods or is the anthropogenic eutrophication the main driver for the seasonal anoxia? We have reconstructed the history of bottom water oxygenation through the use of stable isotope studies of foraminifera in sediment core samples. The paleo water temperature was approximated from Mg/Ca measurements in shells of the foraminifer Elphidium excavatum and the paleo salinity was calculated from the foram shell's delta 18O values and the temperature estimates. The measured delta 13C values of the shells were corrected for salinity, using our river-seawater mixing model, and the excess delta 13C values were recast into additions of milligrams of algal carbon per liter of water through an isotopic mass balance statement. The equivalent oxygen consumption was then used to calculate the water oxygen contents, which was divided by the saturated oxygen contents of the waters at the calculated temperature and salinity. The resulting percent oxygen saturation values for 5-10 year average values (time in a sediment slice) were plotted as a function of time (cores were dated with a variety of isotopic and pollen techniques). The results show that from 1000 AD to about 1850 AD, mean levels of oxygen saturation were about 70-80 percent; these values started dropping in the mid 19 and 20 century, reaching 30-40 percent saturation values over the last 50 years. The temperature record shows evidence for the warm Mediaeval period, but there is no evidence that the Sound suffered from anoxia at that time. Organic carbon contents of the sediment increased over the last 250 years and organic carbon accumulation rates increased almost 5 fold. Both the amount of sediment-stored organic carbon and the oxidized organic carbon fraction of the total primary productivity increased during the gradual eutrophication of the Sound. We conclude that the main driver of the seasonal anoxia in western Long Island Sound is the release of nutrients (mainly nitrogen compounds) from sewage and run-off, which leads to eutrophication and excess algal carbon production. Modern global warming may provide an additional effect by enhancing water column stratification.

B51G MCC: 2002-2004 Friday 1020h

Astrobiology as a Unifying Theme for Solar System Exploration I *(joint with P)*

Presiding: **D Morrison,** NASA Astrobiology Institute**; B Runnegar,** University of California, Los Angeles

B51G-01 1020h INVITED

Astrobiology as an Integrating Theme in Solar System Exploration

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The discipline of astrobiology examines (i) the origin and evolution of life on Earth and the detailed interplay between biological and planetary evolution, (ii) the evolution of our solar system and the potential and actual distribution of life within it, (iii) the occurrence of planets around other stars and their potential for life, and (iv) the interplay between each of these areas. In our own solar system, astrobiology encompasses much more than just the search for life on Mars or Europa. Our goal is to understand the nature of planetary habitability–which planets have evolved to have environments that are habitable by microorganisms, and which have not. By understanding the processes that control the architecture of our solar system, we can extrapolate how these same processes might have played out in other planetary systems and what the distribution of habitability might be beyond our own system. In this context, Mars and Europa appear as potentially habitable worlds either today or in the past, Ganymede and Callisto might have deep subsurface oceans and be habitable, Venus might have been habitable early on but does not appear to be today, and Titan probably has had intermittent liquid water as well as ongoing chemical evolution involving organic molecules. Looking more broadly, the origin and the evolution of the gas-giant planets and their dynamical effects have had a major influence on the terrestrial planets; the characteristics of the Kuiper belt and Oort cloud influence our understanding of early chemical and volatile processes that affect habitability; and asteroids have had a tremendous impact on the terrestrial planets throughout their history. In order to understand planetary habitability in general, and the implications of a discovery of the presence or absence of life on any given object, we need to understand the detailed origin and evolution of our solar system as a whole and of the individual bodies within it. A broad program of planetary exploration is the best way to investigate the astrobiology of our solar system.

B51G-02 1040h

Planetary Protection: A Major Challenge in the Exploration of Life in the Solar System

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The picture of Mars that is now emerging from the Mars Global Surveyor and Odyssey results stands in marked contrast from that portrayed shortly after the Viking missions of the mid-1970s. The abundance of water ice seen both in the polar caps themselves, and in lower latitudes outside of the polar regions is particularly intriguing, and adds to the heightened consideration Mars as a planet that might support life–either Mars life or life brought from Earth. Elsewhere in the Solar System the situation also intrigues those looking for habitable niches. The tides of Europa are thought to keep its icy shell melted, thus providing ample liquid water in an ocean that may be on the order of 100 km deep. Other icy bodies may also be as interesting, whether they orbit Jupiter or are found around Saturn or the other outer planets. The intriguing nature of these bodies, and their potential niches for life, highlight the problems involved with possible biological contamination that may be carried by future missions, and its possible effects. A particular challenge are missions carrying perennial heat sources of high capacity and longevity (e.g., Radioisotope Thermoelectric Generators) which could, by non-nominal landings or other mission operations, be introduced to close contact with water ice–potentially forming Earthlike environments that could accommodate the growth of contaminant organisms. Maintaining the cleanliness of solar system bodies from biological growth is of critical importance to the future success of NASA's science and exploration missions, as is protecting the Earth from the importation of life from elsewhere, if it exists. Recently, the ICSU Committee on Space Research (COSPAR) has published an international consensus planetary protection policy that provides a standard to address the prevention of biological contamination in sensitive areas on Mars, and in the Jovian moons.. Furthermore, as our array of missions grow, new data will drive future planetary protection concerns. A framework for assessing required contamination control measures must be developed.

B51G-03 1055h INVITED

Exploring for Biosignatures of Extant Life in Martian Ground Ice

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The strategy for the next decade of Mars exploration emphasizes the discovery of favorable sites for sampling ancient, aqueously-formed sedimentary rocks, especially those capable of capturing and preserving fossil biosignatures. Nevertheless, it is widely accepted that habitable zones of deep groundwater, able to support extant Martian life, could also be present in the subsurface today. Generally speaking, access to subsurface groundwater habitats could require drilling to depths of several km, far deeper than could be accomplished with the current generation of robotic landers and rovers. But, in the absence of advanced drilling technologies and perhaps human explorers needed to operate them, is it still possible, with present capabilities, to gain access to a deep subsurface hydrosphere on Mars during the robotic phase of exploration? Subsurface cryosphere-magma interactions appear to have been active throughout Martian history. Magma bodies emplaced into the shallow cryosphere would set up deeply convecting hydrothermal systems that would, in turn, carry subsurface organic chemistry and any organisms present in subsurface groundwater, upward into the shallow crust. Upon cooling, these materials could be incorporated into shallow ground ice. Such ice deposits may be accessible to future surface robotic missions via shallow drilling (tens to hundreds of meters depth) of recently active igneous/volcanic areas. Discoveries from the Mars Global Surveyor and Odyssey missions have already discovered several geological environments on Mars favorable for such magma-cryosphere processes. These include numerous small gully systems ("seeps"), mostly found on steep, poleward-facing slopes at high latitudes (Malin and Edgett 2000; Christensen 2003), sites marginal to the Martian polar caps where periodic outflooding events appear to have occurred (Clifford 1987) and recent volcanic constructs situated in ground ice-rich regions at high latitudes. While the strategy for exploring for cryopreserved biosignatures of extant life in near surface ice deposits needs additional study, it appears that the shallow cryosphere of Mars offers many tantalizing opportunities for future astrobiological exploration.

B51G-04 1110h

Past Habitability of Mars: Interpretations of Mars Global Surveyor TES

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A primary question in habitability studies of Mars is whether significant surface water was present in the past. If large water deposits were present, then carbonate deposits likely would have formed. Thus, much debate about the past climate and habitability centers on whether carbonate deposits have been detected. Here we discuss relevant infrared spectral evidence; implications for astrobiology; and the unifying research needed to address astrobiology concerns. Under specific conditions, carbonates exhibit spectral features near 6.5, 11, and 33 microns. Several past studies proposed detection of carbonates on Mars (reviewed Roush et al. [1993]). The detections have not widely been perceived as conclusive. Two recent orbited instruments (1996 Global Surveyor TES; 2001 Odyssey THEMIS) were intended to resolve the question. However, no 11 or 33 micron band detections have been reported. Complexities in atmospheric unmixing significantly delayed and complicated analysis of the 6.5 micron region. Bandfield et al. [2003] recently proposed detection of a 6.5 micron carbonate feature in the surface dust. However, TES did not detect the 11 and 33 micron bands, placing the interpretation again in the debated category. Christensen et al. [2001] concluded that TES detected no carbonate to the 10 percent per pixel level, and Bandfield et al. [2003] in selected dark regions to 5 percent. The 2003 rover Mini-TES is comparable to TES, and is similarly intended to resolve the minerals present. One interpretation of those results is that the types of carbonate deposits expected from large bodies of water are not present. One inference is that no large, standing bodies of water on Mars existed. However, discussion of a key issue to the debate has been missing: What impacts whether a mineral deposit is detectable by these instruments? We will demonstrate that rough surface texture can cause large mineral deposits, including rocks, to have subdued spectral signatures [Kirkland et al. 2001, 2002, 2003]. Subdued signatures can make a mineral undetectable ("infrared stealthy"). For example, the Mars "White Rock" deposit exhibits no detectable TES bands [Ruff et al. 2001]. Yet White Rock certainly is made of something. Grain scale roughness can be a primary cause of infrared stealthy behavior. The astrobiology community should be alerted to the following: 1. Accurate interpretations of these data sets require knowledge of the expected target texture. The textures are poorly known for the formation and weathering conditions on Mars. 2. An assessment of texture and dectectability will require collaboration between scientists who research astrobiology, geology of Mars, and the physics of spectral behavior. The unifying theme is identification of materials of interest to the astrobiology community on Mars by an infrared spectrometer, and conversely, defining when such materials will remain undetected. 3. Interpretations based on non-detection need to be revisited based on improved understanding of the true detection capabilities. 4. Interpretations founded on detection of a single spectral feature when more than one feature is expected should be viewed cautiously. References. Bandfield et al. Science 301, 1084 (2003); Christensen et al. JGR 106, 23823 (2001); Kirkland et al. Appl. Opt., 40, 4852 (2001); Kirkland et al. Remote Sens. Env., 80, 447 (2002); Kirkland et al., JGR in press, preprint www.lpi.usra.edu/science/kirkland (2003); Roush et al. Ch. 16 Remote Geochem. Analysis (1993); Ruff et al. JGR 106, 23921 (2001).

URL: http://www.lpi.usra.edu/science/kirkland

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A Search for Life in the Subsurface At Rio Tinto Spain, An Analog To Searching For Life On Mars.

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