MEETINGS

Science in NASA's Exploration Strategy

Workshop on Science Associated With the Lunar Exploration Architecture, Tempe, Arizona, 27 February to 2 March 2007

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The NASA Advisory Council held a workshop on science associated with lunar exploration planned for the Vision for Space Exploration. The workshop focused on science objectives in astrophysics, Earth science, heliophysics, planetary science, and planetary protection. The goal of the workshop was to assess and prioritize science objectives within the context of the developing exploration architecture. Science is one of six themes of the exploration strategy, and NASA wants to ensure that activities of highest priority to the science community are not precluded by the architecture to the extent that is feasible and affordable.

Key objectives from a planetary science perspective fall within four main themes. First is the Moon as a recorder of the impact history of the inner solar system and of events that might have occurred to perturb various impactor populations elsewhere. Second is the Moon as a recorder of early planetary differentiation processes through studies of its crust and interior. Key to understanding the Moon's interior is a geophysical network, especially to better determine global seismic structure. Third is the potential record of volatile deposition processes, especially near the poles, and the possibility of concentrated volatile-element deposits in permanently shaded craters. Fourth is to better delineate the character and distribution of potential resources and to better understand potential hazards to sustained human presence. Some of these objectives can be accomplished at a polar outpost site whereas others require access to multiple locations and sample collection.

For astrophysics, high priorities for lunar surface deployment include meter-wavelength radio observations from the radio-quiet lunar farside to seek evidence of the strongly redshifted 21-centimeter H line from the early universe and laser-ranging retroreflectors or transponders to probe gravitational theory. Observations from free space (especially Lagrange points) enabled by the lunar architecture offer the most promise for high-sensitivity observations including gamma rays, single-aperture far-infrared observations, exoplanet detection, and other potential "Great Observatory" class missions.

For Earth science, the Moon would provide a unique, stable, and serviceable platform for global, long-term, full-spectrum views of Earth to address climate variability, pollution sources and transport, natural hazards such as extreme weather and volcanic plumes, and changes in the terrestrial cryosphere. Such observations would complement and provide synergetic context for current orbital assets (LEO, GEO, GPS).

For heliophysics, the Moon is a unique vantage point from which to better understand the Sun-Earth space environment. The analysis of lunar regolith will provide a history of the Sun. Work is needed to develop predictive capabilities for solar radiation events to safeguard human exploration activities and to better understand the dust-plasma environment at the lunar surface.

Lunar exploration will not require special planetary protection controls; however, it will provide the opportunity for an integrated test bed of technologies and methods needed to protect samples and to understand and control mission-associated contamination on long-duration expeditions such as to Mars.

The members of the workshop synthesis committee were Bradley Jolliff (Washington University), Clive Neal (Notre Dame University), Heidi Hammell (Space Science Institute), John Mather (NASA Goddard Space Flight Center), Michael Ramsey (University of Pittsburgh), Kamal Sarabandi (University of Michigan), Jean-Bernard Minster (University of California, San Diego), James Spann (NASA Marshall Space Flight Center), Barbara Giles (NASA Science Mission Directorate), Nancy Ann Budden (Office of the Secretary of Defense), Catherine Conley (NASA Science Mission Directorate), Andrew Steele (Carnegie Institution of Washington), Charles Shearer (University of New Mexico), Lars Borg (Lawrence Livermore National Laboratory), Lawrence Taylor (University of Tennessee), Ariel Anbar (Arizona State University), Gerald Kulcinski (University of Wisconsin), Michael Wargo (NASA Exploration Systems Mission Directorate), Paul Hertz (NASA Science Mission Directorate), and Harrison Schmitt (NASA Advisory Council Chair).

The full text of this meeting report can be found in the electronic supplement to this *Eos* edition (http://www.agu.org/eos_elec/) and in a separate NASA report. The workshop program, presentations, and white papers are available at http://www.lpi.usra.edu/meetings/LEA/.

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Peatlands and the Carbon Cycle: From Local Processes to Global Implications

First International Symposium on Carbon in Peatlands, Wageningen, Netherlands, 15–18 April 2007

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Boreal and subarctic peatlands cover about 3% of the Earth's land surface and store 15–30% of the world's soil carbon (200–400 petagrams) as peat. This large C pool, in addition to C in Arctic soils, lies at higher latitudes that are experiencing ongoing climate change. Tropical peatlands also contain large C reservoirs, the stability of which is threatened by ongoing land use change. In response to a call from PeatNet (a National Science Foundation–supported research coordination network), Juul Limpens and Gabriela Schaepman-Strub proposed a small workshop on peatland C cycling, an idea that morphed into a meeting with 180 participants from 18 countries.

The meeting goals were to (1) advance our understanding of peatland C cycling through integration across disciplines and research approaches and (2) move toward a synthetic picture of the past, present, and future role of peatlands in the global C cycle and climate system, recognizing the potential for feedbacks related to changes in climate, management, and land use patterns. Plenary presentations introduced poster sessions on thematic areas including biogeochemistry; microbial, plant, and landscape ecology; ecohydrology; paleoecology; and climate modeling and spatial upscaling. Most of the contributions focused on boreal, subarctic, and cool temperate peatlands.

Common themes ran through the meeting. The presence of massive peat deposits is a testament to the historical function of peatlands as sinks for atmospheric C, contributing to global cooling on millennial scales. While the net C sink in individual peatlands displays a large interannual variability, peatlands unaffected by human activities most likely function as a global contemporary net C sink. Nonetheless, accumulating evidence indicates that peatland C balances are influenced by drought, water table drawdown, enhanced atmospheric N deposition, and fire, often diminishing the net C sink or converting a peatland to a net C source.

Two challenges emerged from the meeting: (1) effective upscaling of CO_2 and CH_4 emissions from plots and sites to regional and global scales, and (2) integrating peatlands into coupled carbon-climate modeling efforts. Most of the land surface schemes of global climate models that include a formal representation of the C cycle do not include a realistic representation of organic peatland soils. A few groups are working on this integration, but closer collaborations are needed between peatland researchers and the carbon-climate community. This integration needs to link peatland CO_2 and CH_4 cycling with ecohydrology, changing temperature regimes, changing atmospheric N deposition, ongoing permafrost melt, and fire impacts, the effects of which may differ among peatland types. Future workshops will help achieve such integration. The organizers envision a Second International Symposium on Carbon in Peatlands, in 2009 or 2010.

For more information, see the symposium Web site at http://www.peatnet.siu.edu/CC07MainPage.html.

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Sahel Climate Change

Workshop on Sahel Climate Change, Columbia University, New York, 19–21 March 2007

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The Sahel transition to persistent drought in the early 1970s is an archetypal example of recent abrupt climate change. This workshop assessed the mechanisms for variability at interannual and interdecadal timescales, and discussed mechanisms of future climate change and sources of model disagreement. Participating scientists brought a diverse range of expertise: mesoscale and paleo observationalists; atmospheric dynamicists; dust and vegetation modelers.

There was strong agreement that the main driver of the Sahel drought was sea surface temperature (SST) variations and not land use or cover changes associated with human activity. This conclusion stems from general circulation model studies reporting successful simulations of multidecadal Sahel rainfall variations given the long-term history of observed SST. Attribution is uncertain, as possible ultimate causes of SST and rainfall variability include anthropogenic forcing by greenhouse gases and aerosols, variations to the Atlantic meridional overturning circulation, and dust forcing from the Sahara. Specific atmospheric mechanisms connecting SST anomalies to the Sahel region remain uncertain, as do the relative roles of the Indo-Pacific warming and North Atlantic SST anomalies. Atmospheric changes from aerosols may directly influence Sahel rainfall without mediation from SST.

Simple extrapolation of twentieth-century SST-Sahel rainfall relationships to 21st-century Sahel rainfall changes is unlikely to work, because of nonlinear interactions with the basic state. Other remote influences might become more relevant, in particular, those resulting from convection changes in neighboring South America and equatorial Africa. Different model sensitivities to the direct radiative effect of carbon dioxide and to land/atmosphere and cloud/radiative feedbacks can amplify or reduce ocean-forced precipitation changes. If these feedbacks are crucial, a correct representation of mesoscale convective systems and African easterly waves and the diurnal cycle may be essential.

There is urgent need for a more authoritative attribution of twentieth-century Sahel drought. Attribution studies with standard methodologies are readily performed using the latest Coupled Model Intercomparison Project (CMIP) archive and uncoupled atmospheric simulations of the Climate of the 20th Century International Project (C20C) and the Global Land-Atmosphere Coupling Experiment (GLACE), if these can be supplemented with complementary coupled simulations from some major modeling groups with individual forcing agents. These attribution studies face difficulty since estimates of natural variability in these models are suspect, given the difficulty of simulating droughts of the Sahel's magnitude.

To address variability among different models, a suite of idealized atmospheric general circulation model experiments exploring regional SST, aerosol, or tropospheric warming influences with multiple models as well as multiple configurations (fixed SST or slab ocean; interactive or fixed vegetation) are recommended.

New dynamical insights arising from the African Monsoon Multidisciplinary Analyses (AMMA) effort could shed light. Finally, more paleoclimate information is needed to determine whether the Sahel is sensitive to abrupt climate changes in the North Atlantic, as suggested by model studies, and also by the Indian monsoon analog.

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