Meeting 7 – *Space Weather, the Heliophysics Program, and NASA's Lunar Initiative*

June 14, 2006

Introduction

The New England Space Science Consortium (NESSC) creates a cross-disciplinary, multi-institutional forum to address cutting edge research topics with a broad view toward collaboration on major opportunities in solar and space science. The consortium brings together researchers and students at Boston University (BU), the Harvard-Smithsonian Center for Astrophysics (CfA), the MIT, the Air Force Research Laboratory (AFRL) at Hanscom AFB, the University of New Hampshire (UNH), Dartmouth College, the Haystack Observatory, and Tufts University.

The consortium is a grass roots organization founded by Nathan Schwadron and Nancy Crooker at Boston University, John Raymond at CfA, Justin Kasper at MIT, Chuck Smith and Eberhard Moebius at the UNH, and Mary Hudson at Dartmouth College. The group has begun a series of informal monthly meetings in which highly relevant, interdisciplinary research topics are presented and discussed. The consortium's broad scope has, thus far, engaged researchers from the solar, heliospheric, solar wind, magnetospheric and ionospheric communities. Continued growth in the consortium's scientific breadth and depth will be encouraged.

The format for discussion in the New England Space Science Meetings has evolved and will continue to do so. Recent meetings have taken place in the Boston area, and often involve one to two hour discussions and lunch. This format provides a friendly atmosphere where colleagues can become more familiar with one another, forge new collaborations, raise questions, and share information and insights. The forum also presents a unique opportunity to provide students with a broad view of the field of space science. One or more half-day or full-day workshops will be convened annually.

We have been convening meetings on the first Wednesday of each month. The meeting on June 14 was a week late but appeared at an opportune time. There were three topics (Space Weather, the Heliophysics Program, and the Lunar Initiative) that are summarized below. Much of the presented content from meetings is posted on our website (http://www.bu.edu/csp/NESSC/), which is maintained by David Bradford at BU.

Space Weather (Discussion lead by Justin Kasper)

Justin lead off the discussion by advancing two questions,

- What areas need to be developed?
- How can we advance the specification and prediction of the space environment?

Justin showed an interesting slide that summarizes the needs for space weather prediction (included on our website). On the x-axis is lead-time (hours to solar cycle), and on the y-axis is frequency. The assets we need to protect include power utilities, astronauts, and military assets (radar communications).

A number of other assets came up in discussion.

- Airlines increasingly rely on polar routes and cannot afford blackouts. In addition, radiation exposure at high altitudes can be a serious issue and crew members have been wearing dosimeters to monitor radiation exposure.
- Oil platforms rely on GPS, which is, in turn, susceptible to changes in the ionosphere caused by space weather.
- Power companies have begun to rely on large 500 kV transformers, which are produced at a very low rate. If 5-6 of these transformers are destroyed in a single event, we may have limited capacity to replace them. The transformers typically operate at 99.5% capacity. Small DC currents can cause big problems.
- The effect of drag on S/C is a continued concern to the Air Force.

This is only a handful of the topics raised in the discussion. The most recent Space Weather Week (http://www.sec.noaa.gov/sww/) demonstrated that the issue is becoming increasingly relevant to a broad range of industries and sectors of the government. The bottom-line is that space has become a commercial enterprise, and there is greater urgency than ever to advance space weather specification and prediction.

There are a number of references to the National Space Weather Strategic Plan, Implementation Strategy, and Architecture that may be valuable (http://www.ofcm.gov/nswp-sp/text/a-cover.htm, http://www.ofcm.gov/nswp-ip/tableofcontents.htm, http://www.ofcm.gov/Tplan/swatp.html)

The missions/measurements that address (or will address) space weather goals include ACE & Wind, STEREO, Sentinels, and ground based and remote sensing measurements. In addition, missions such as Solar Probe and Solar Orbiter will be extremely important for advancing our understanding of the physical mechanisms responsible for acceleration of solar wind, the formation of coronal mass ejections, and the acceleration of energetic particles. It is essential that our models that predict space weather become increasingly based on the physics behind the phenomena.

There was considerable discussion about how we advance space weather models. On one hand, we have significant holes in our knowledge of the physical phenomena that underlie space weather. This leads to models that often rely, at least in part, on empirical relations, as opposed to physical principles. On the other hand, we cannot afford to wait to transition research models into operational models. This leads to a tension of priorities between developing operational models versus developing missions, new experiments and theories to understand the sources of space weather. Both areas of development need to advance.

The Heliophysics Program (Discussion lead by Nathan Schwadron)

We began our discussion of the heliophysics program by going through the letter from the Heliophysics subcommittee to the NASA Advisory Council and discussing the agenda for the next NAC/Subcommittee meeting in July.

There were a variety of concerns raised about the subcommittee and about the Heliophysics Program as a whole. The simple fact that the last Explorer AO was in 2002 speaks to lack of balance in our program. Traditionally, heliophysics has made great strides through a broad range of small or medium-sized missions, strong support for R&A, and an appropriate mix of suborbital programs that have provided the training grounds for our workforce of experimentalists and observers. The current lack of opportunity in the Explorer Program and the sub-orbital Program is very troubling. It will weaken our future workforce, narrow the scope of our research, and hinder our ability to rapidly advance high priority and urgent new areas of heliophysics. The cuts to R&A are also a great concern to our community.

NASA's Lunar Initiative (Discussion lead by Harlan Spence)

Our community is being solicited for ideas concerning potential measurements, experiments, etc, that would be of scientific interest in future lunar exploration. There will likely be a meeting in the fall that focuses on the topic.

Although a number of interesting ideas surfaced, our community appears to be concerned that history will repeat itself. The similarities between the lunar initiative and the International Space Station are striking and disturbing. Fundamentally, the motivation to go to the moon is not scientific, and while there are some interesting studies to be made, lunar science is not a high scientific priority in Heliophysics.

Justin Kasper raised the issue of a lunar based radio array.

> The surface of the Moon offers the opportunity to conduct unique astronomical observations, not possible from the Earth. The Earth's ionosphere absorbs radiation at wavelengths longer than about 10 meters, precluding entirely observations at these wavelengths from the Earth's surface. Construction of a lunar radio astronomy observatory (LRAO) would open a nearly unexplored portion of the electromagnetic spectrum for astronomical observations.
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> Astronomical targets for the LRAO include the Sun; planets, both solar and extrasolar; radio galaxies and clusters of galaxies; and cosmological observations,

potentially including the epoch of reionization; in addition, because there have been only a few astronomical observations at these wavelengths, from small, relatively insensitive spacecraft, the LRAO offers a considerable potential for discovery.

This observatory would be developed in a phased manner. Initially a small test array operating over a limited wavelength range would be deployed on the near side. As experience and lunar deployment capabilities increase, a larger array could be deployed eventually on the far side; in addition to the absence of an ionosphere, the far side offers natural shielding from terrestrially-generated interference.

Bill Waller (Tufts) raised the following suggestion for a small lunar telescopic observatory

> During NASA Administrator Mike Griffin's talk to the AAS this past January, he suggested that the astronomical community re-visit the prospects for carrying out astronomical observations from the lunar surface. Meanwhile, some astronomers have spoken out about this being a poor choice compared to free-flying space observatories (e.g. Dan Lester in a recent Sky & Telescope editorial). Others, including an entire conference of Europeans, have gone on record in favor of a lunar astronomical observatory. Given the incremental long-term nature of lunar exploration building up to settlement, I would suggest that one could test the viability of Moon-based astronomy by first transporting and installing a small telescopic facility -- perhaps optimized for the UV or IR, where the Earth's atmosphere degrades most groundbased observations. This would obviously build on the precedent of the UV telescope that George Carruthers (NRL) built, and the Apollo astronauts deployed on the Moon. As a first step, I recommend that we propose a symposium (at BU?) or a full-day special session at some AAS meeting to flesh out the prospects for Moon-based astronomical research -- including the many pros and cons that people will have to offer.

While measurements of solar wind composition on the moon have already been made, it may be possibly to investigate the history of solar wind composition by taking core samples. The problem here is that the regolith is strongly mixed. The success of the concept would require that a geological region is found where the lunar surface is stratified. Given what we know now, this appears unlikely.