Earth Science Subcommittee Report
May 28-29, 2014 Meeting
NASA Headquarters

From: The NASA Earth Science Subcommittee – Steven W. Running (Chair, swr@ntsg.umt.edu), Roland Burgmann, Greg Carmichael, Andrew Dressler, Efi Foufoula-Georgiou, S. Prasad Gogineni, Kathleen Green, Thomas Herring, Ian Joughin, Chris Kummerow, William Large, Patrick McCormick, Anna Michalak, Mahta Moghaddam, Anne Nolin, Richard B. Rood, Raymond W. Schmitt, J. Marshall Shephard, Herman H. (Hank) Shugart, Jr. and David A. Siegel

To: David McComas (Chair, NAC Science Committee)

Cc: Jens Feeley (NAC Science Committee Executive Secretary), Lucia Tsaoussi (Earth Science Subcommittee Executive Secretary), Michael Freilich (ESD Director), Peg Luce (ESD Deputy Director), Jack Kaye (ESD Associate Director for Research), Stephen Volz (ESD Associate Director for Flight Program), Lawrence Friedl (Associate Director for Applied Sciences).

Date: August 4, 2014

Dear Dr. McComas:

The Earth Science Subcommittee (ESS) met on May 28-29, 2014 at NASA Headquarters. Dr. Lucia Tsaoussi, Executive Secretary of the Earth Science Subcommittee (ESS) of the NASA Advisory Committee (NAC) began the meeting by noting the presence of several new members. This was also Dr. Steve Running's first meeting as ESS chair. The meeting was open to the public, with a public comment period scheduled for the end of the first day. The Subcommittee members were to receive Ethics Training in a closed session on the second day of the meeting.

Dr. Michael Freilich, Director of NASA's Earth Science Division (ESD), provided an update on Division activities, starting with an overview and leading into more detailed discussions of three areas: sustained land imaging, ongoing measurements that have shifted to ESD, and education/public outreach (EPO).

The Division has a good number of missions under development, including an unprecedented five that will launch this year. The Global Precipitation Measurement (GPM) satellite was launched successfully in February, 2014. The first Orbiting Carbon Observatory (OCO)-1 had a launch vehicle failure in 2009, but OCO-2 launched successfully on July 1st from a Delta II. The Soil Moisture Active Passive (SMAP) mission will launch in November (now January 2015) on a Delta II. There will be nine more ESD EO launches before 2022.

FINDING: *ESD is to be complimented for bringing to launch 5 satellite missions for 2014, their reinvigorated and enhanced airborne program, now being used to capacity, and their implementation (and early success) of the Venture class programs*.

Two current missions are instruments developed for and in conjunction with the International Space Station (ISS). In summer and fall of 2014, two instruments for ISS will launch; they are RapidSCAT and the Cloud-Aerosol Transport System (CATS). Both were funded by the ISS program. ESD will take on data analysis once they are in orbit.

FINDING: *We find that the International Space Station (ISS) provides a good platform for sensor development, in addition to providing a good platform for deploying some fully developed high TRL instruments. Because of cost sharing with the ISS office, ESD also has the opportunity to test instruments at earlier stages of development, before a stand-alone mission can be justified. The ES investigators can gain experience with a space deployment of their sensor, and collect large quantities of data with control over the payload, and the ability to build test algorithms for processing.*

The Venture Class missions are science-driven, led by Principal Investigators (PIs), competitively selected, cost- and schedule-constrained, and regularly solicited, reflecting a high priority of the ESD Decadal Survey (DS). Venture Class has three strands: suborbital; small-sat/missions; and instruments. Venture Class accounts for 12 percent of the ESD budget. Dr. Frelich provided more detail about the three strands:

- EV-suborbital (EV-1) is solicited every 4 years. All five investigations selected in the first round are well into sustained field campaigns.
- EV-M (EV-2) is also solicited every 4 years, off-set from EV-1 by 2 years. These are small satellites. The Cyclone Global Navigation Satellite System (CYGNSS) had a successful Key Decision Point-C (KDP-C) in February 2014 and is going extremely well. It involves eight small satellites that fly in formation to measure extreme weather events. The FY15 budget includes funds for the next EV-2 solicitation.
- EV-I (Instrument) is solicited every 18 months. The Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument had a successful KDP-B in April. EV-I is well along in the selection process for the submissions from the second solicitation.

FINDING: *Science-driven, PI-led, regularly solicited Venture-Class missions and instruments (suborbital and orbital) are a very positive addition to the Earth Science Program and should be a continuing part of the ESD program plan. This program allows for the development of new scientific advances, and measurement approaches as technology matures, and generally expands and stabilizes the opportunities for science leadership, institutional involvement and student development.*

An Applied Sciences Program Early Adopters program brings in potential end users early in the mission design cycle to help familiarize them with the planned data sets and help the mission understand their needs. SMAP was the key initial mission to try this concept, with about 35 early adopters. The intent is that after SMAP launch, the Early Adopters will kickstart much more rapid incorporation of the data products into both science and land management application than has occurred in previous land imaging missions.

FINDING: *ESS recognizes the success of the SMAP "Early Adopters" program and suggests that ESD consider similar early adopter program, particularly for future missions with immediate application potential. Early Adopters both gives valuable early feedback to the*

mission scientists that can better fit mission datasets to the user community needs, and also engages the user community more quickly to begin using the data.

ESTO is a targeted, science-driven, competed, and actively managed technology program. It has four strands: Instrument Incubator Program (IIP); Advanced Component Technologies (ACT); Advanced Information Systems Technology (AIST); and, In-Space Validation of Earth Science Technologies (InVEST). ESD is the first division in NASA's Science Mission Directorate (SMD) to explore the use of Cubesats for validation.

FINDING: *We request a report from the technology program at our next meeting, highlighting ESTO innovations and accomplishments, success in future mission fusion, and explaining the potential consequence of funding shortfalls/gaps that they perceive. This information will help the committee understand if a small increase in the technology program investment could result in large savings in the flight programs*.

In the next Decadal Survey, it is important that the NRC focus on a comprehensive and executable Earth science program. NRC must consider that the Administration and Congress have input, and ESD will need to implement sustained measurements to support the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS). The ESD budget will not increase substantially and may even decrease. Mission costs, schedules, and so on can only be pre-defined or controlled in competitively selected and constrained programs like Venture Class. Directed missions to NASA centers are essential to the Agency in certain situations. However costs and schedules have been much less controlled in those missions. The named-mission backlog from the first ESD DS is substantial. The next DS needs to reflect budgetary realities, however, or it will not be as useful.

Useful inputs from the DS include the recommended target budgetary balance between flight and non-flight programs. In the non-flight portion of the program, the DS can recommend the substance, not the percentage, of what should be done. In the flight portion of the program, the balance between competed and directed missions should be addressed. The following questions need to be addressed:

- Are there missions ESD should not try?
- What is the maximum acceptable cost?
- Should there be other Venture Class-like programs with different caps?
- What about flight mission architecture and approach?
- Where should the engineering investments originate?

RECOMMENDATION: *ESS looks forward to the next Decadal Survey study. For this new Decadal Survey, we recommend that the mission priorities and budgetary limitations be linked more directly to lead Earth science questions, and that the missions are considered in the larger context of integrated Earth system science activities, including data systems and modeling. The missions named in the first Decadal Survey that have not begun development should be re-evaluated and reprioritized, not simply passed forward.*

Dr. Freilich discussed ESD's Sustained Land Imaging program. Landsat 8 launched in late winter of 2013 and is exceeding specifications. The Obama Administration values sustained

land imaging, and the President's budget for FY14 featured a new activity to design such a system, with three basic attributes:

- Sustainable – realistic budgets over the long haul;
- Continuity – continue the long-term Landsat data record with usable products that define the utility of the data record; and,
- Reliability – functional redundancy, so there is no overreliance on a particular instrument, though not everything has to come from the U.S. government.

NASA's role is to lead the system architecture, and to design, implement, launch, and commission on-orbit the USGS spaceborne segment. The USGS role is representing the user communities, while also engaging in operations and data activities. Dr. Freilich zeroed in on the mission's requirement to image each point on the globe every 16 days, preferably every 8 days. A NASA and USGS architecture study team has defined a huge range of architectures encompassing instruments, spacecraft platforms, risk, launch vehicles, potential technology infusion, partnership, and business models Cost is a constraint, at an average of $120 million per year for NASA over the system lifetime. NASA is to examine international and private sector partnerships, with the results due in August, 2014. The FY14 and FY15 budget requests included consideration of standalone new instruments and satellites. Congress is concerned about Landsat 9, however, and the international partnerships. Congress therefore asked for a plan with a $650 million total mission cost, substantially below what the Administration requested.

FINDING: *We request that the Sustained Land Imaging scoping document be distributed to the ESS as soon as released, so our subcommittee can schedule a detailed presentation, and make comments at our next meeting. We find it particularly appropriate for the committee to consider the ramifications of the 20yr strategic planning horizon for the sequence of satellites being requested.*

The Climate Action Plan (CAP) and Climate Data Initiative (CDI) are an Administration priority; the CDI is a data-intense effort that will leverage Federal climate-relevant data beyond the government. NASA was asked to lead CDI, which involves populating an online catalogue of climate data, creating innovation challenges and incentives, engaging stakeholders, and developing commitments from non-government players. Many of these activities overlap and intersect. CDI has seven societal benefit themes, each with a lead agency. The meta-data are delivered in well-defined form to a climate data website. NASA received $6 million in FY14 to support CDI and the Big Earth Data Initiative (BEDI). CDI and BEDI are related, with the former having a near-term focus and BEDI looking more long-term. CDI includes a targeted effort related to climate resilience. BEDI standardizes and optimizes the management and delivery of Federal Earth observation data.

Dr. Steve Volz of ESD spoke about Radiation, Ozone, Atmospheric Measurements (ROAM). He began by showing the President's FY15 budget justification, in which responsibility for the following three measurements was transferred to ESD from NOAA:

- Radiation Budget Instrument (RBI) on Joint Polar Satellite System 2 (JPSS-2);
- Ozone Mapper and Profiler Suite (OMPS) Limb on JPSS-2; and
- Total and Spectral Solar Irradiance Sensor 2 (TSIS-2) on a platform yet to be determined.

The budget is available to secure a single extension of each of these for one generation, into the early 2020s. Some funding was sent to ESD for ROAM, but the rest came from reallocation. NASA has supported and will continue data integration, analysis, processing, algorithms, and maintenance for these over the long term.

FINDING: *The ESD is recognized for their capability to deliver nationally valuable and policy relevant data, and as a result is being asked to do more. ESD scope is expanding as illustrated by the activities associated with longer term observations, and the new ROAM activity related to climate parameters and Landsat activities. While these represent great opportunities, continued efforts are needed to ensure that these activities are optimally integrated into the program, and with appropriate funding that does not compromise ESD priorities.*

The final decisions on how to manage EPO have yet to be made at the higher levels, including SMD and Congress. NASA policy directives 1380.1 and 1388.1 define education and communications. "Education" covers activities designed to enhance the science, technology, engineering, and mathematics (STEM) content area learning using NASA's unique capabilities. "Communications" involves conveying to the public and other stakeholders what NASA has done and the impact of its activities on their lives. This is broad, and covers media and public engagement.

The Global Learning and Observations to Benefit the Environment (GLOBE) is possibly the longest operating STEM program in ESD. GLOBE operates at both national and international scales, provides students with hands-on activities, and is essential to building on the NASA "brand". In 20 years of GLOBE, about 66,000 teachers have been active for at least a year, in turn affecting their students. The program has taken more than 90 million Earth system measurements, and has done science validation. GLOBE supports U.S. diplomatic efforts through an office at the State Department. There are 109 international country partners.

RECOMMENDATION: *ESS is concerned about how Earth science can be better presented for K-12 science students, and with appropriate educational success metrics. While PIs know the science best, they are not all well trained in how to translate their science to grade-appropriate material, or how to engage young students. For example, we find the value and success of GLOBE is directly related to the intimate connection between PI scientists, the GLOBE data-system and the teachers. We think NASA and ESD public outreach may be the best of all the science agencies, and recommend it stay close to the science, rather than be centralized. We recommend the NAC Science Committee discuss the effective roles scientists, education professionals and communication experts in EPO can play across all the science subcommittees.*

Dr. Jack Kaye introduced the topic of NASA's Arctic science coordination by discussing the polar portfolio. Satellite observations for polar and Earth system science address a broad range of science questions using a variety of satellites and sensors. There are many airborne and field campaigns. Topics include ice sheets, sea ice, snow melt, atmosphere, clouds, tides, and ocean biology. Operation Ice Bridge (OIB) is bridging the gap in data collection between ICESat-1 and ICESat-2, linking to CryoSat-2, and making key measurements for predictive models. Dr. Diane Wickland discussed the ABoVE program, which studies environmental

change in the Arctic and boreal regions of western North America, as well as the implications for ecological systems and society.

FINDING: *The ESS found the Arctic science project presented to be a great example of integrated multi-scale science. The coordinated deployment of satellite data, aircraft flights, ground measurements and modeling synthesis is an example to be emulated by other projects. We encourage continuing international collaboration on similar projects*.

Dr. Kaye explained that ESD is involved in the National Climate Assessment (NCA) through its interagency coordination efforts and participation in the various groups involved, particularly the U.S. Global Change Research Program (USGCRP). The Global Change Research Act of 1990 requires a quadrennial report under USGCRP, though this report has not always been issued; there have only been three. The third NCA:

- Assesses the science of climate changes, analyzes current trends and impacts, and projects major trends for the next 25-100 years;
- Documents impacts and responses for various sectors and regions; and
- Aims to inform public and private decision-making at all levels.

NASA was the first agency to issue a research call to support sustained, assessment-relevant science. The Center Call addressed three areas: enabling tools; assessment products and capabilities; and 2013 NCA sections. The initial project duration was set for 27 months, and selection was for 14 projects with a total budget of $7.5 million, though the budget became $8.9 million.

FINDING: *NASA ESE has done a good job of supporting the National Climate Assessment, including the recent national rollout on May 6. We find the Global Change Information System will be a particularly valuable link between climate impact observations and the supporting datasets. We also find the cross agency coordination was admirable, and integration of physical, biological and social sciences to be a critical step towards integrated global change analysis at the national level.*

The next committee meeting is planned for Fall 2014.

Sincerely,

The Earth Science Subcommittee
Steven W. Running, Chair