NASA ADVISORY COUNCIL

EARTH SCIENCES SUBCOMMITTEE

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MEETING REPORT

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Byron Tapley, Chair

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Lucia Tsaoussi, Executive Secretary

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Introduction and Announcements

Dr. Byron Tapley, Chair of the Earth Sciences Subcommittee (ESS), opened the meeting, citing the Earth Sciences Division (ESD) program status and plans in view of the FY11 budget submission, and concern with NPOESS status, as two major foci of the meeting.

Requirements levied on ESD in light of the FY10 budget had previously been of great concern to ESS; however in light of improved FY11 budget, the subcommittee must re-evaluate concerns centered around plans in the context of the Decadal Survey. However, there are continuing concerns about aging orbital assets, international collaboration/planning for complete measurement coverage, inhomogeneity in data availability between NASA and international partners, the status of the National Polar-orbiting Operational Environmental Satellite System (NPOESS), and the transition of recent missions into monitoring mode to ensure continuity of measurement. Overall, it has been estimated that a total of $15B would be required to accomplish Decadal Survey and foundational missions, measured against a $1.27B annual ESD total budget.

ESD Overview, FY11 Budget and Plans

Dr. Michael Freilich, Director of the ESD, presented a status of the division. He began with an overview of current assets, addressing the aging condition of the orbital fleet, noting that QuickSCAT and ICESat have reached the end of their lifetimes. Missions with major international hardware or programmatic collaborations are Jason, OSTM/Jason, TRMM, CALIPSO, CloudSat, GRACE, Aqua, Terra and Aura. To this end, ESD has undertaken major discussions with the European Space Agency (ESA) to establish a framework for continuing to collaborate on Earth observations. Progress has been greatly aided by recent ESA policy decisions to embrace a free and open data exchange policy, without caveat, which Dr. Freilich emphasized as very good news. This policy will also be made retroactive to embrace particular missions, thus past mission data will be released in due time. Dr. Freilich urged ESS members to openly laud this development and publicly support the new ESA data policy. A draft document on this new data policy for missions, ground systems, research and campaigns will be available by the next ESS meeting. Dr. Steve Running asked if there had been a sense that ESA will augment data centers to serve a wider community, to which Dr. Freilich replied that ESA recognizes the need to build further capability and intends to do so.

As of the end of calendar year (CY) 2010, the International A-Train continues to work well. The PARASOL satellite has dropped in its orbit somewhat, thus is not always entrained with A-Train, but the system has made allowances for when the satellite drifts out of alignment. The A-Train is a highly unbureaucratic system that has worked well over many years. Glory will join the A-Train in 2010, followed by a Japanese Space Agency (JAXA) satellite in 2012 years, and the launch of the second Orbiting Carbon Observatory (OCO-2) in February 2013.

In anticipation of ICESat ending its mission lifetime, ESD selected an airborne DC-8 experiment called ICEBRIDGE to extend ICESat measurements to record ice topographies and properties. ICEBRIDGE will carry out both Arctic and Antarctic campaigns until ICESat 2 is launched in 2015. In recent events, other orbiting assets such as ASTER and EO/ALI have demonstrated their value and utility by identifying Haitian areas impacted by the recent earthquake; ASTER, e.g., imaged landslides and landslide hazards in mountainous terrain, but had insufficient resolution to see damaged buildings. SERVIR, an applied sciences portal, took a leading role in rapidly getting information out to responders, and also received a fair amount of press at the CNN level. UAVSAR, an unmanned airborne interferometric synthetic aperture radar, while carrying out a pre-planned program to image archeological features, forest structure, and vegetation, was able to obtain clearance to fly over Haiti to study ruptured and potential faults.

NASA's unmanned Global Hawk vehicle will make its first flight at the end of March 2010, from Dryden Research Center to Hawaii to the North Pole and back, for purposes of satellite validation and detection of fragments of the polar gyre. To date, ESD has integrated the instruments, performed a 9.5-hour test flight, and will undertake its first science test flight by the beginning of April. Obtaining permissions from the Federal Aviation Agency (FAA) for flyovers in commercial airspace remains an ongoing process. Within states of emergency such as during wildfire seasons in California, permissions had been easier to obtain. NASA now has direct access to fire control centers, as these centers are now counting on NASA data for deployment. There is also a NASA detailee at FAA who has been facilitating the process. NASA cannot fly at will but the FAA has been considering NASA's capabilities. In the meantime, NASA is developing a Global Hawk ground system at Wallops Island to support loiter time for real science.

The ESD Applied Sciences (AS) program is instituting a much more rigorous program, and is establishing metrics to improve efficacy. New solicitations are forthcoming, and a major effort has been made to place AS researchers on mission flight teams so that the applications community can understand how to propose to programs. A closer set of collaborations is expected as a result. SERVIR, for instance, has been the poster child for success in this program. While initiated by NASA, it is now funded largely by the United States Agency for International Development (USAID), and receives excellent support from the Department of State and the NASA Administrator. Dr. Raymond Hoff applauded these efforts.

ESD is also supporting a multiagency solicitation through ROSES that has both an Applied Sciences and Research and Analysis (R&A) component to study land and ecosystem management in a changing climate. Participating agencies include the US Geological Survey (USGS), the Forest and Wildlife Service, the National Park Service, and the Smithsonian Institution. The total pot is $5M, with $3.5M in support from ESD, and varying amounts from other agencies and institutions. NASA scientists and representatives have also formed a Climate Change Adaptation Science Team to study the range of climate change hazards that are posed to the various NASA Centers. The team will undertake an 18-month study that aims to facilitate efforts to use data products, simulations and projections to inform strategies for adapting to these climate change impacts. The team represents a joint effort of the ESD Applied Sciences and R&A programs.

Missions in Formulation and Implementation

OCO-2 is scheduled to fly in 2013, Glory in November 2010, Aquarius in December 2010, the NPOESS Preparatory Project (NPP) no earlier than September 2011, ICESat 2 in October 2015, Soil Moisture Active and Passive (SMAP) in November 2014, Global Precipitation Measurement (GPM) in November 2014, and the LandSat Data Continuity Mission (LDCM) nominally for December 2012. NPP, the NPOESS Preparatory Project, is serving as a risk reduction exercise for NPOESS. The Visible Infrared Scanner (VIIRS) instrument has been delivered and integrated. The NASA/National Oceanic and Atmospheric Administration (NOAA) portion of this project now has the acronym JPSS, for Joint Polar Satellite System.

The LDCM joint effort with USGS is moving along well; the actual commitment to Congress is a June 2013 launch.

Implications and planning in response to budget augmentation

A $1.3-1.6B cumulative augmentation has been received by ESD in the FY11 budget submission. The augmentation has been used to shore up the program of record and to start SMAP, ICESat II and Venture-

class missions. The new funds are also targeted to bolster missions in formulation, in order to budget them realistically. However, ESD has also received an additional $2.4B between FY11 and FY15; thus ESD has made the decision that the newest augmentation would *not* be used to shore up the previous program. NASA is continuing to press international partners, however, for GPM contributions. Dr. Daniel Jacob questioned whether the budget augmentation would actually come to pass. Dr. Freilich felt confident that the augmentation was authentic, considering open Congressional support for OCO-2. In addition, Dr. Freilich reported having briefed Congress several times on the matter, and having spoken to the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) in order to obtain clearance on what NASA is permitted to announce. Asked how the current budget compares with ESD's FY2000 budget, Dr. Freilich replied that the division has returned to the buying power it possessed in 2000. He noted that the upward trend of the curve, for ESD science specifically, the outyears is also significant.

The ESD augmentation came with few specific guidances; the language was general. This is considered a testament to the good relationship ESD has built with OMB over time. Notably, OMB understands the importance of the Decadal Survey. While assuring that OCO-2 will fly, ESD has not increased capability but has determined that it will be robustly instrumented. OCO-2 might be ready as early as 2013 to fly as a mission of opportunity, thus ESD is working on an accelerated effort on OCO-2 ($330M). |The remainder of the augmentation came in under a Climate Initiative line. Some internal guidance is included within this line. By March 17, ESD must submit a plan on what it will do with this Climate Initiative line. The division has since allocated monies to two general categories- about 1 one-third of the amount will go to Climate/Non-flight areas in the first year, and two-thirds to Climate/Flight for the first year. The overall strategy is to expand some existing programs, and to spend some funds in new and different areas.

Earth Science Plan/President's FY11 NASA Budget Request

All foundational missions are on schedule to be launched by 2013; these are OCO-2, Glory, Aquarius, NPP, LDCM, and GPM. Selected Decadal Survey missions are also being accelerated: i.e., all four Tier 1 missions are now funded at full capability, so that they can all launch between 2014 and 2017. The Tier 1 missions are SMAP, ICESat-II, Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) in 2017, and Climate Absolute Radiance and Refractivity Observatory (CLARREO-1) in 2017. Selected Tier 2 missions will also be brought into the decade, but cannot be identified at present. The Tier 2 mission working groups and science teams are aware of the ongoing planning efforts. Dr. Jacob expressed concern with the ballooning cost of CLARREO and asked about the anticipated budget. Dr. Freilich maintained that CLARREO is planned as a Decadal Survey-scale mission, and continues to satisfy both of its purposes. The budget, however, is nowhere near $950M.

The augmentation will also expand and accelerate the competitive, Venture-class, Principal Investigator (PI)-led program. Proposals are currently being evaluated for an April selection announcement. Dr. Freilich was prevented from commenting on specifics due to conflicts. Annual solicitations for major flight instruments will be held, in addition to biannual, alternating airborne and small-mission solicitations. First small satellite selections will be announced in 2012. The program will help to develop common instrument interfaces, and will encourage flights on the International Space Station (ISS), and with international and commercial partners. A major, competitive, instrument solicitation will be held every year ($90M), to help keep the research community tightly coupled to the flight program, and to ensure that instruments will be available when opportunities arise. In response to a question on funds spent on climate specificity, Dr. Freilich argued that ESD could be considered as climate-oriented all around, scientifically but noted that the Administration may ask ESD to focus on a specific area (e.g., ocean). However, he allayed fears that the Venture-class program would morph into a directed program; it will remain a true competition, with community involvement. Dr. Jacobs expressed concerns with

developing instruments that may simply sit on a shelf, and asked if it would not be tempting to fly these instruments on small satellites, to bring down the costs of small satellites in generally. Dr. Freilich answered that much more funding would be required to fly a full-up mission. Dr. Jacobs felt that PIs who do not have an instrument on the shelf would be disadvantaged in such proposal, and suggested putting more money into small satellite missions instead? Dr. Freilich averred that the $150M figure was a Decadal Survey figure cited for small satellites, and that it is quite likely that a $90M instrument would be a bit oversized for a small satellite mission. However, he conceded that he would love to have the conundrum to work through. Asked if ESS could provide some specific advice in this area, Dr. Freilich agreed to listen to how the discussion evolved. He noted however that he would not abide a discussion of gaming the system or of PIs getting toeholds in the solicitations.

Dr. Hoff suggested that the $180M sum over two years (that had been targeted for instruments) could be invested instead in a Venture-class mission. Dr. Jacobs suggested that $150M be set aside for small satellite missions, thereby addressing the underestimates of the Decadal Survey with the budget augmentation. Dr. Freilich felt that $150M would be a stretch, but that there were many in the community who were vocal and enthusiastic about the possibility of embracing real science goals within that cost cap. A meeting participant commented that the NuStar mission has a $160M cap, including a launch vehicle, thus the concept has been demonstrated in the Astrophysics Division via competitively selected science.

Dr. Tapley noted some inconsistency on demanding lower caps on some missions and expanding others. Asked if the instrument development program would be receiving augmented funding, Dr. Freilich noted that it would be being funded at about $250M per year through the outyears.

Dr. Freilich reviewed the language that had come from the budget, which had given NASA considerable latitude to address climate issues and to develop selected climate continuity missions. The budget language did call for Stratospheric and Aerosol Gas Experiment (SAGE-III) refurbishment/hexapod development for a flight to ISS in late CY 2013, however the budget had not been provided for this. The guidance to continue with the Gravity Recovery and Climate Experiment (GRACE) (GRACE-C following on jointly with Germany in late CY2015) was described as “deafening”. GRACE-C is definitively not GRACE-2, however. The budget also enables key non-flight activities such as a multi-year carbon-monitoring pilot program; SERVIR expansion, expansion of modeling, synthesis, computing capability; and geodetic ground expansion, among others.

Dr. Christy asked if JEWELs could be viewed as a NASA operational mission. Dr. Freilich felt that while JEWELS could not be posed as Earth Systems science writ large, ESD must take realistic steps that would ensure the necessary measurements could be developed. In areas like nadir altimetry, ESD has transitioned successfully to non-NASA sources (NOAA, Navy, Europe). Dr. Jacob noted that this still leaves open issues in stratospheric measurements, as to what JPSS is going to do for solar irradiance, microwave, sea surface temperatures, and other measurements. Dr. Freilich acknowledged that there is some political sensitivity, looking at what partners had already had in planning, while acknowledging that no partner will be able to exceed what NASA does- if NASA can get 80% of what it needs for zero dollars, it must leverage this opportunity. Dr. Jacob asked if CLARREO-2 would be part of the climate continuity missions. Dr. Freilich regretted that he could not discuss the subject in specific terms at present, under embargo conditions.

Dr. Hoff noted that with source and solar irradiation, the current system seems to have operated well, but asked: if NOAA is claiming ownership of climate data, will SAGE-III NASA data disappear when the mission ends? Dr. Freilich replied that he was open to ESS ideas on the matter. He added however that ESS was not giving NASA investigators their proper due, and that in fact, part of what NASA does in the

R&A program is to produce consistent, multi-year, synthesized validated data sets. The issue is between breadth and depth- better and more measurements will advance climate science. NASA has the demonstrated expertise in providing these, and in demonstrating their scientific utility. While NASA also wants to do Earth systems science, the agency clearly cannot do it all. By necessity, portions of the required science will not get done. The question to ask is, according to Dr. Freilich: are we pushing forward science and investing current funds well?

Dr. Tapley noted that the Decadal Survey posits an essential climate variable set of 28 measurements, and asked whether this was being addressed within ESD. Dr. Freilich cited ESA's parallel set of 24-26 measurements, and commented that a synthesizing discussion would have to take place over a long period of time to reconcile the two sets of measurements. Dr. Jacob suggested that the National Research Council (NRC) address the issue. Dr. Freilich suggested that Decadal Survey tackle these measurements as a future issue, and also address the depth of measurement that NASA can achieve now. Dr. Tapley agreed that the NRC would be a suitable source for analysis, and also for identifying a common set of parameters with ESA. Dr. Konrad Steffen, referring to the GRACE follow-on mission, suggested pitching the idea to minimize gaps so as not to constrain technology development- in this way one might be able to fly a laser-ranging package that would not be mission-critical, which would be key to having the DLR (German agency) strongly involved. Asked if there were an R&A component to GRACE, Dr. Freilich responded that an expansion of Venture-class and suborbital lines will provide some of this funding, but that a specific fund wedge has not yet been identified. Dr. Large asked if ESD were nimble enough to respond to the "too good to pass up" opportunities. Dr. Freilich noted that ESD is still exceedingly thin in staff, but also noted that the Agency has invited ESD to put in an augmentation request. In addition, Venture-class plans are a way to become more nimble. In hardware development, however, it takes 10-12 years to develop a space mission from conception to implementation.

Asked if Decadal Survey results were enough for making decisions, Dr. Freilich felt that current augmentation plans should not be a model for ESD planning; research and applied sciences are tightly wired, and are getting plenty of input. Production and plans are carried along through formal guidance, and the science moves faster than the space endeavor, which is tied to money and risk. ESD is trying to avoid constantly re-vectoring from one priority to another with the net outcome that nothing gets finished. Asked how the research operations hand-off has changed, Dr. Freilich commented that the future outlook has changed dramatically; however a substantial change will take more than a few years, adding that NASA didn't walk away from climate continuity but did not embrace it completely. For now, ESD is essentially going along with Decadal Survey recommendations in this area, dabbling in the possibilities and hedging bets. Other assessment activities are in progress; with the US Global Change Research Program, ESD is identifying additional Tier-2 missions to be developed for the 2019-20 timeframe.

Dr. Siegel asked about the existence of a carbon monitoring pilot. Dr. Jack Kaye responded to this question, explaining that ESD plans to connect its observational capabilities with short-term interest in atmospheric carbon as sources and sinks, and terrestrial or oceanic biomass. The goal for ESD is to figure out how to combine observations and models to form rigorously measured, useful data sets. A significant fraction of this program will be competed work. The program will work with existing data as well as consider what might be done with increased data sets in the future, as new missions fly and as capability grows. Global emphasis, and integration of oceanic and terrestrial aspects will appear as strong elements in the NASA purview. Dr. Freilich added that the SMD Science Plan will be used to guide these plans, including carbon monitoring, climate time series measurements in later Tiers, and cross-fertilization between science, flight, and applied sciences. Seed money has also been directed to some Tier-3 mission, and Dr. Freilich welcomed more ESS guidance on how these funds should be directed. Dr. Hoff asked if there were enough efforts under way for better definition of Tier-3 missions, noting that

CLARREO should not move into the next decade without having the appropriate science definitions. Dr. Freilich commented that there has been a strong community interest in growing the requirements for this mission. Dr. Hoff noted that in applications in flight, there would be a challenge in maintaining the timeline of 2020, and noted that one can get more involvement by applications scientists by getting more specific requirements and definitions, and pulling back dates to 2017 or so. Dr. Freilich commented that these missions would be Tier-2, adding that ESD had run a study called LiveX, which considered DESDynI as a radar and lidar mission. The study considered orbits and sampling characteristics; techniques were studied and trade-offs considered. Essentially the study looked at cost savings of a single mission which must launch at a given time, versus two separate, optimized missions. There is a question as to whether the vegetation community can use the new ICESat lidar. There are also commonalities of spacecraft, which could easily develop a second mission with the same team. To carry out the full DESDynI mission would require $2B in the 2018 timeframe. Dr. Steffen asked if the DESDynI orbit could be changed to observe sea ice. Dr. Freilich agreed to find out whether this was possible.

NPOESS Restructuring

Dr. Peg Luce gave a briefing on the status of NPOESS, which is now termed the Joint Polar Satellite System (JPSS). Briefly, the White House initiated a task force led by OSTP, which determined that the NPOESS mission could not have succeeded in its previous incarnation, hindered by a three-agency structure, management issues, and insufficient budget. On February 1, 2010, the Administration decided to break up responsibilities amongst agencies. As it now stands, NOAA and NASA are responsible for the afternoon orbit, and the Department of Defense (DOD) for early morning. Agencies will continue to share data and anticipate a successful future collaboration. The mid-morning orbit will be covered by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT); DOD will use the Defense Meteorological Satellite Program (DMSP) platforms longer than had been originally planned. Two lower-risk JPSS satellites will be acquired to replace the Charlie satellites. Observations are being maintained for the afternoon orbit. MIS measurements will be replaced by sensors on the Japanese Global Change Observation Mission (GCOM) satellite. Solar irradiance instruments (Clouds and the Earth's Radiant Energy System, CERES; and Total Solar Irradiance Sensor, TSIS) will be procured through a separate line, to be determined at a later time. Nodal time will not change over the lifetime of JPSS. Asked about the NPOESS terminator orbit, Dr. Luce explained that this is also to be determined. DOD may use DMSP 20, but it is DOD's decision entirely. DOD data will be made publicly available.

A transition team is in place to support JPSS. An IPO will be maintained for about a year, and work has been continuing so as to avoid delays in instrument development and other mission necessities. Instruments and the ground segment are currently subcontracted to Northrop Grumman, and will be eventually transitioned to Goddard Space Flight Center (GSFC). NOAA's JPSS budget will support JPSS through FY2026. The climate instruments are being developed under the existing NOAA Climate Program. Acquisition responsibilities will be shared. The same concerns exist for the Visible/Infrared Imager Radiometer Suite (VIIRS) that have been previously noted, but that ocean color may possibly be observable. In summary, NOAA and NASA are committed to working with DOD to ensure a successful transition, and can proceed independently of DOD if necessary. Currently, the NASA is looking at procurement and legal issues, and preparing to carry out contract transitions.

Dr. Luce detailed the proposed JPSS organizational structure, noting that funding was provided through NOAA. A NOAA/NASA agency level Program Management Council (PMC) will be maintained at NASA, and the effort will be leveraged off the NPOESS Preparatory Project (NPP). The baseline plan for the spacecraft is to procure a copy of the NPP bus under a sole-source contract. The new money begins in FY11, thus NASA must find a way to work within the FY10 budget, which may be complicated and may necessitate a slowing of work at Northrop Grumman. The contract transition will be managed such that work will not stop, however. If standards at Northrop Grumman are not up to par, they will be brought up to par at NASA. For the purposes of data processing, the goal is to leverage both NOAA and NASA data products; however it can't be guaranteed that the program will do everything that EOSDIS might have done. Dr. Andy Carson addressed the question of previously published NPOESS Climate Requirements. Dr. Luce noted that NASA does possess the program of record, and could possibly can add back some items. Dr. Marcus Watkins interjected to say that the actual starting point is in the IORD; if the requirements are outside the IORD, they will not be used.

Dr. Jean-Bernard Minster asked if ESD desired specific advice on JPSS. Dr. Freilich replied that an interesting situation has arisen for climate science: once there was a clear focus on weather. Now, JPSS has a simpler and realistic management system, but no normal money flow. NASA will be implementing for NOAA, thus Dr. Freilich requested that ESS think about how to manage requirements in that perspective; i.e., how to influence decisions that NOAA makes. Some ESS members likened the entire concept of NPOESS to a black box, and requested a briefing from either Jim Gleason or scientists at NOAA to figure out how NASA and NOAA would deal with instruments. Dr. Luce noted that the current understanding is that NASA will have access to previously established algorithms, but that Northrop Grumman information was not yet available. Dr. Tapley felt that the real question centered around what subset of requirements NASA would be able to address through JPSS. Dr. Luce commented that a baseline assumption held that NASA and NOAA should meet the needs of the nation with the program, and should thus consider stakeholder requirements. Concern abounded for the availability of information from NPOESS in the past. Dr. Freilich noted that while these problems are being solved, the ownership of requirements supported by insufficient resources remains. Dr. Large expressed concern with NOAA's launch-on-need policy, and the lack of a precise definition of that policy.

Dr. Jacob asked how NASA would ensure that requirements be adequately maintained for the climate instruments. Dr. Luce reiterated that instruments would be managed according to NASA standards and systems engineering requirements at GSFC. Several members of ESS requested further clarification on what the JPSS instruments could actually deliver. Dr. Watkins noted that NASA has just started this process, and ultimately could use guidance on what resources can cover what requirements.

Q & A with SMD Associate Administrator

The subcommittee engaged in a discussion with SMD Associate Administrator, Dr. Edward Weiler. Dr. Weiler opened the discussion by pointing out that the Earth Sciences community owed Dr. Freilich a considerable debt of gratitude for accomplishing "the impossible" and architecting a robust ESD plan. He cautioned, however, that the augmentation for ESD has yet to be supported by appropriations proceedings in Congress. The current election year may signify another Continuing Resolution, which would impinge on new starts. He did note that ESS could help with the following dilemma: that while the latest augmentation is great news for ESD, it is only good news for other divisions in SMD, and that other communities look at this budget hungrily. Dr. Weiler did feel however that the community does seem to understand the fairness of distribution over time. In response to a question on ESD flexibility, Dr. Weiler commented that if this was a reference to reserve, those reserve funds are long since gone. In the new ESD budget there are 70% confidence levels for programs, thus the division can't touch those funds because it is an agency requirement to maintain that reserve. Dr. Jacob, noting the skeleton staff for ESD,

asked if there were plans to hire more employees. Dr. Weiler replied that this was not likely, while noting that a long-term solution lay in hiring more civil servants to serve science.

The subcommittee discussed the importance of education in the STEM area. Dr. Weiler ensured ESS that Administrator Bolden recognizes that NASA has inspirational material for education, and has already met with the Department of Education in this regard. NASA is also pulling in outside, independent talent on education, but also needs to show that its efforts are leading to more graduates in math, science, etc. Some progress has been made in developing relevant metrics. For instance, Dr. Weiler noted that 10% of an entering MIT class had participated in a NASA robot program called FIRST. Dr. Gregory Jenkins suggested some human infrastructure to accompany the augmentation, such as a post-doc program, or having graduate or undergraduates work with NASA investigators. Dr. Weiler noted that SMD maintains fellowships in other divisions, and in addition puts aside 1% of funding for education. Dr. Freilich suggested that the Venture-class missions be used to involve students. Dr. Jenkins felt that issue must be raised to a higher level in underserved communities, which might be accomplished through instrument development programs, or by funding a summer program with a PI. Responding to an ESS assessment that 1% funding levels were too low, Dr. Kaye reported that NASA would be conducting a Senior Review- type assessment of how education funds can be used to integrate the data from multiple missions to tell a more complete story. He also recommended field campaigns as capacity-building activities that have been effective in training the next generation of students. Dr. Tapley also took note of NASA's graduate student support in the R&A program.

Dr. Jacob asked if any pushback on the ESD augmentation was expected. Dr. Weiler felt that the new budget was clearly defensible, and that Congress supported Earth Sciences in a bipartisan manner. Questioned about the visibility of Earth Science at NASA, Dr. Weiler noted that he routinely sends science highlights to the Administrator, some of which end up before the President. In this respect, Earth Science has more visibility than ever. Asked about the effects of a Continuing Resolution (CR), Dr. Weiler felt it would not affect outyear plans; OCO-2 would still fly, but at an expense to the pacing of other programs. Overall, a modest CR should have little impact. There is also the issue of uncosted reserve; the R&A program in ESD is still running about 15 months worth of uncosted grants. Obligated funds have improved dramatically, however. In a CR, Dr. Weiler cautioned that these uncosted funds could be diverted to carry forward other programs. He added that he recognized this as a cultural problem, and that NASA must work with the community to change it gradually.

Discussion

Dr. Tapley returned to subjects discussed earlier in the day and opened the table to discussion. Dr. Schutz felt encouraged by data availability from Europeans, and pondered whether this could open the door for improved collaborations with ESA missions, noting that it seemed a good idea to leverage the increase in the ESD budget with more collaborations with international missions. Dr. Freilich observed that this has been a point of discussion in bilateral meetings; NASA maintains many relationships with other countries, including Argentina. A fundamental challenge to the NASA/ESA partnership, however, is that ESA is driven by a process that involves competition followed by a reformulation by ESA. NASA, by contrast, adheres to a vision, and the approach is different enough from ESA's process to present issues. ESD is looking at several ways of collaborating with ESA, from small contributions to mission, 50-50 partnerships, sharing queues, alternating fields of interest, or identifying missions that are possible only when done together. It is an evolving framework. There are also modalities of cooperation in ground systems that require interoperability in telemetry. It is not as easy with ESA as it sounds. NASA must also be sensitive to other bilateral interactions- nadir altimetry and gravity are two of ESA's first ideas. Dr. Large commented that once data issues are overcome, bilateral missions would improve. Asked if NASA was always the biggest player in this arena, Dr. Freilich pointed out that NASA's research constellation is

larger than that of all of Europe, but ESA feels that NASA has nonetheless been rejuvenated. In order to participate in ESA opportunities, Dr. Freilich posed a scenario: if there is an instrument sitting around, and ESA has some additional money to spend to launch it, each side wins, and each side saves a bit of money. The time scale also must be taken into account; if NASA and ESA start talking early through a communications plan with regular talks, each agency can factor in possibilities sooner rather than later. Collaboration can also make missions more robust. Dr. Jacob noted that NASA also needed to have room with partners with strategic thinking, and asked if ESA was interested in the NASA vision. Dr. Freilich noted that the ESA ministers have a different vision, which he termed as "geo-reward." In collaborating, Dr. Freilich thought it would be helpful to concentrate on smaller tasks, or simply put people on the other's teams, and to apply confidence-building techniques over time.

Dr. Tapley highlighted areas of the NASA/ESA relationship that could be considered by ESS: philosophy of collaboration, the issue of follow-up, and addressing important measurements that need to be made, filling in gaps and "me-too" issues. Dr. Running suggested consulting Global Earth Observation System (GEOS) documents and the history of Earth-observing systems, noting that NASA is the only agency that has put real money up front on algorithms and advanced data systems. Dr. Freilich agreed that this scenario would not be likely to change, while also noting that it is a unique and strong position for NASA. NASA defines climate writ large (climate, water cycle, cryosphere, atmospheric composition, etc.). The program will be vetted against a whole range of the Administration's desires.

Dr. Jacob noted pressures within the United States Global Change Research Program (USGCRP) to shift away from physical to social sciences. Dr. Kaye commented that the Administration supports research, with a particular interest in climate adaptation, vulnerability and mitigation. He added that USGCRP is also doing a national assessment of needs, therefore NASA should pay attention to what is going on at an interagency level- NASA can be part of the dialogue and can explore how to contribute in the context of a growing budget. Dr. Hoff asked if there were an articulated vision at NASA as to how it will play in adaptation to climate. Dr. Kaye replied that this was not yet the case, but that the Applied Sciences program is relevant to this issue. Asked whether SAGE-III had hopes of being launched, Dr. Freilich explained that alternative ways of bringing cargo to the International Space Station (ISS), possibly through the Space Operations Mission Directorate (SOMD). Dr. Kaye interjected that NASA has retained the core intellectual assets for SAGE III, largely at Langley Research Center; the Center for Advanced Space Studies (CASS) is also still in operation.

Dr. Christy questioned the lack of funding supporting studies on natural variability, versus the notion that greenhouse gases cause everything. Dr. Judith Curry commented that NASA's satellites have the potential for sorting out measurements by providing global satellite data sets. The challenge of interpretation lies in the climate field, however, which is missing a key application of global integrated data sets. Dr. Freilich noted that some of ESD's augmentation would be spent on synthesis. Dr. Kaye suggested the Terra and Aqua satellite calls as a good area to look at natural variability, as well as Modern Era Retrospective. Dr. Lucia Tsaoussi cautioned that the discussion must not devolve to the personal level.
Dr. Tapley asked if there were a NASA subject area in which one can do fundamental modeling, using data not strongly influenced by anthropogenic variables. Dr. Kaye replied that if one wants to look at multi-decadal data, one can also consult with other agencies that are not constrained by NASA parameters, such as those that provide operational or *in situ* data. Dr. Large noted that ESD's program is climate research and monitoring, which is broad enough to include natural variability, and would be a likely program to propose to that purpose. Dr. Siegel asked how climate data from JPSS would meet global climate objectives. Dr. Freilich responded that JPSS must use a variety of measurements from sources over the long-term. While research and operations are difficult to harmonize, he added that he personally thought the opportunities for success are much greater than ever before thanks to NASA

participation. He suggested therefore that ESS also look at how ESD makes use of other sources and other agencies; it would not be inappropriate to consider the output of other programs and agencies. The question to ponder for ESS is how ESD should go about working with JPSS within NASA and within the government in order to best achieve ESD's Earth System science goals. Dr. Large suggested considering how the climate services already provided by NOAA might serve the program, as opposed to weather forecasting. Dr. Minster pointed out that one *de facto* responsibility for NASA is the organization of data generated by JPSS, as it is the only agency that can maintain data at that level and volume. Dr. Curry felt that an important NASA responsibility would be converting the data into information. Dr. Freilich cautioned that such data conversion would require resources, potentially at the expense of other programs.

Dr. Tapley delineated some potential findings: re-evaluation of a long-term 28 term climate parameter set; concerns about the Venture class program; the initial limited funding for Tier 3 missions; and a desired clarification about NPOESS from NOAA representatives to parse out responsibilities and science requirements. Dr. Running recommended a joint meeting between ESS and an equivalent NOAA committee. Dr. Hoff suggested agenda time for a briefing from the Applied Sciences committee. Dr. Steffen asked how NASA was positioning itself to play a part in federal climate services. Dr. Kaye responded that a national climate service will be more than NOAA and that it seemed clear that there must be a research component to climate services. ESS was instructed to read SMD's draft Science Plan to prepare for the next day's discussion.

March 17, 2010
Dr. Tapley opened the morning session.

Crafting the 2010 SMD Science Plan
Mr. Greg Williams presented aspects of the SMD Science Plan that bore relevance to the Earth Sciences, explaining that NASA publishes a Strategic Plan every three years, followed by an SMD Science Plan which defines science objectives articulated through the Research Opportunities in Space and Earth Science (ROSES) announcements of opportunity (AOs), and other mission activities. The timing is not always fortuitous, as it the plan is essentially misaligned with the ten-year Decadal Survey schedule and four-year election schedule. This year, the Science Plan has been influenced by NRC reports, a new FY11 budget, and a set of Decadal Surveys that will be published over the next few years, and SMD recognizes that the priorities of the science community across disciplines will be changing. This year, SMD has decided to simply update the 2010 Science Plan on a higher level, expecting more substantial changes by the next publication of the 2013 Science Plan. In addition, all four science divisions will undergo a performance assessment of all 4 divisions, tasked to the NRC, at the midpoint of the Decadal Survey for each division- there will be a mid-term assessment for ESD in roughly 2011. Decadal Survey details will remain a driver for any major changes in the Science Plan for Earth Sciences. Mr. Williams cited as an example of change of having Mars brought back into the solar system for the Planetary Science Division, a move that had been suggested by the Decadal Survey. Any grade of incomplete within the performance assessment can be dealt with in the next Science Plan, and through a required NASA response within 3 months of the assessment. It is generally thought that within such performance assessments that the NRC does not usually take into account the amount of resources available to carry out Decadal Survey missions. Dr. Marcus Allen commented that the NRC would require more specific guidance on how to fairly assess NASA progress against the Decadal Survey and the Science Plan. It was noted also that OMB and OSTP evaluate the NASA Science Plan several times per year, and once per year through the President's budget request, which contains specific guidance down to the project level.

Mr. Williams reviewed the schedule and welcomed comments from ESS for assimilation into the document. The Science Plan is scheduled for publication in May 2010. Mr. Williams stressed that NASA

was also working in the context of embargoed information, and Dr. Freilich added that he had been having discussions with OMB to address this scheduling problem. Proposed contents of the Science Plan will include national policy direction and agency-level goals, principal strategies and challenges, followed by a detailed implementation plan in each of the four science areas, in addition to how these science subjects support Exploration science and E/PO activities.

The Science Plan contains guidance on how SMD helps carry out the national agenda for science through leadership in fundamental research, environmental stewardship, educating the next generation and workforce, driving technological innovation, and extending partnerships internationally and domestically. The subcommittee briefly debated the parameters surrounding climate change issues and their appropriate place within NASA policy. Mr. Williams and Dr. Tsaoussi welcomed comments for modifications to the Science Plan that would address the controversial nature of NASA's role in environmental stewardship.

SMD principles, strategies and challenges are also communicated in this document. Principles remain essentially unchanged over time, but strategies do change. Dr. Jacob suggested expanding a statement about strategy in education, placing STEM education at a higher and more introductory level. Dr. Siegel recommended expanding a statement about partnership strategy statement to include domestic partners. Other editorial comments were collected and passed on to Mr. Williams.

Mr. Williams reviewed SMD challenges, which include access to space, the restoration of U.S. production capabilities for Pu-238, unrealized expectations, mission cost estimation and management, the development of a national strategy for Earth observation, and impediments to international collaboration on space missions. ESS commented variously on this section, suggesting some clarifications to the text that were noted by Mr. Williams, including a more forceful statement on challenges facing the planet as a whole. Science theme chapters were also reviewed, including key science questions, linkage to Agency-level goals and program structure, current missions, missions in development, and future missions. Mr. Williams asked for feedback on readability, usefulness, and applicability of science themes. Suggestions were the addition of an executive summary, and a salutary statement about the excellence of historical missions. Dr. Tsaoussi requested specific comments on accomplishments, etc.

Comments on Appendix 1 included a call for more statements about mitigation and response to environmental phenomena, adoption of a consistent style, and more specificity in research objectives. Dr. Hoff suggested strengthening statements on how NASA fundamentally recognizes the education pipeline from K-12 to post-docs to workforce development. Dr. Freilich asked ESS to comment on whether ESD should take the lead and develop the infrastructure to succeed in this latter subject, or to augment what is present in other programs. He cautioned that if ESD were to take the lead, the division must sacrifice other things. Dr. Steffen recommended simply highlighting the excellent NASA graduate fellowship programs. Others felt that the problem was more of a widespread nature and required a large effort than NASA could reasonably expect to put forth. Dr. Hoff suggested that ESS state in a finding that there is a critical educational need that needs to be addressed, especially in the earlier years, but he did not see this as a task of NASA- such impetus needs to come from the Department of Education and the National Science Foundation. Other suggestions were inclusion of commercial private sector employment context, addition of milestones and achievable objectives are lacking, strategic updates for research areas, and a clear statement of what NASA can provide in the provision of data, models and measurements that build on predictive capabilities for climate sciences. Mr. Williams noted that the Science Plan attempts to describe and promote Earth system science and NASA's particular part in it, and also recognizes that there is a larger idea of which NASA is a part. Dr. Michalak observed that other divisions seemed to offer a message of understanding, versus ESD's association with fear, and suggested a rewording of ESD's

capabilities in a more strategic light. Dr. Vorosmarty suggested that biodiversity loss and nitrogen pollution could be a topic for planetary sustainability.

Mr. Williams enumerated next steps, relating that Draft 2.0 would be provided to the NAC Science Committee for review before its April meeting. Dr. Tsaoussi requested that ESS come to a consensus as to how to change the Science Plan before that time.

Discussion of Science Plan

ESS worked to come to consensus on edits to the Science Plan, concentrating on mitigating omissions. Dr. Vorosmarty commented that more societal relevance would make it more competitive. Dr. Hoff suggested capturing the importance of global monitoring; seeing the planet as a whole, and casting NASA as an environmental, intelligence-gathering agency, calling out the uniqueness of the Agency. Dr. Tapley noted that NASA is the only agency that has the ability to do global, near-synoptic observations from space. Dr. Siegel suggested including discoveries yet to be made. Dr. Running recommended wording on sustainability and the finite nature of landmass. Dr. Large felt that adaptation and mitigation activity is appropriately originating from a national plan, across agencies; NASA could provide the climate monitoring aspect. Dr. Curry suggested highlighting extreme events and natural hazards. Dr. Freilich contemplated adding a fifth question about how to deal with global change, and how science might best inform approaches to mitigation and adaptation. Dr. Curry noted in this respect that NASA is not actually covering the "end-to-end" problems, and is not in the business of generating policy decisions, but NASA data can be used to guide policy decisions. Other edits were noted and passed on to Dr. Tsaoussi for further transmittal.

Discussion of Findings and Recommendations

The subcommittee turned to potential findings, including concerns about the Decadal Survey and the implementation of foundational missions that have since substantially improved with the augmentation. ESS also reported continuing concern about ESD's orbiting assets; international planning/data availability, but was pleased at having received assurances on ESA adopting an open skies policy. ESS expressed its misgivings about interagency collaboration regarding the new structure of NPOESS/JPSS and had ongoing questions on transitioning from measurement to monitoring mode. There were also questions on how NOAA and NASA will interact on climate measurements and in apportioning dedicated versus distributed facilities. ESS requested an in-depth briefing on NPP to be timed for its next meeting, regarding the issue of NASA/NASA and NOAA/NASA interfaces. Dr. Tsaoussi confirmed that ESS was within its purview to advise ESD to take actions based on the output of JPSS. Dr. Tapley also felt that ESS should assess how Earth Sciences is represented at the NAC Science Committee level, and pondered whether a NASA/NOAA joint advisory body/working group might be necessary to help funnel advice to JPSS. For the next meeting, Dr. Jacob requested a better description of instrument specifications and of who in NASA is minding the store.

Dr. Tapley asked what the protocol was for staying informed on JPSS. Dr. Freilich replied that ESS could propose a solution up the chain, and that ESS could comment on all Earth Science matters, beyond the sphere of ESD. He added that JPSS was still a work in progress on every level, and that it would be best to hope for the best outcome, and to get the right advice out as rapidly as possible; he believed that this would require more muscle than standing up another subcommittee. Dr. Tsaoussi commented that NOAA has been able in the past to obtain a climate sensor appropriations line, and has also made some progress in imagery.

ESS contemplated as a possible action a review of climate measurement requirements for NASA and ESA for long-term activities, and to request that the NRC examine the two sets of parameters and how they measure up against the 28 essential climate variables.

Dr. Jacob expressed concern about the way the Venture-class program was being restructured to include flight instrument development, and felt instead that ESD should integrate instrument development within the small satellite program, to help increase the budget in satellites, and because it is unclear what a separate instrument development program would lead to (i.e. conferring unfair advantage upon proposers if they have an instrument). Dr. Large thought that instrument development and small satellite should be separate, but entertained the notion that one might propose to fly an instrument on a satellite. Dr. Freilich noted in this context that multiple proposers can also compete to fly any instrument that gets developed and that the instrument development program could function as a feeder program for new satellites.

Dr. Jacob suggested raising the question of seed support for Tier 3 missions ($2-3M per year) to the level of a recommendation.

The next ESS meeting was tentatively for the first week in November 2010. Dr. Tapley adjourned the meeting.

Appendix A
Attendees

Committee members
Byron Tapley, ESS Chair, University of Texas
John Christy, University of Alabama, Huntsville
Judith Curry, Georgia Institute of Technology
Raymond Hoff, University of Maryland, Baltimore County
Daniel Jacob, Harvard University
Gregory Jenkins, Howard University
William Large, National Center for Atmospheric Research
Anna Michalak, University of Michigan
Jean-Bernard Minster, University of California, San Diego
Steve Running, University of Montana
Robert Schutz, University of Texas
Hank Shugart, University of Virginia
David Siegel, University of California, Santa Barbara
Mark Simons, California Institute of Technology
Konrad Steffen, University of Colorado, Boulder
Charles Vorosmarty, University of New Hampshire
Lucia Tsaoussi, Executive Secretary, NASA Headquarters

NASA Attendees
David Adavnec, NASA
Jay Al Saadi, NASA
Marcus Allen, NASA Headquarters
Stephen Ballard, NASA OER
Scott Barber, NASA Headquarters
Robert Bauer, NASA ESTO
Ellen Cohen, NASA Headquarters
David Considine, NASA Headquarters
Lucien Cox, NASA Headquarters
Mary DiJoseph, NASA GSFC
Richard Eckman, NASA Headquarters
Diane Evans, NASA JPL
T. Jens Feeley, NASA Headquarters
Robert Ferraro, NASA JPL
Lawrence Friedl, NASA Headquarters
Randall Friedl, NASA JPL
Michael Goodman, NASA Headquarters
Peter Hacker, NASA Headquarters
Peter Hildebrand, NASA GSFC
Jack Kaye, NASA Headquarters

William Lau, NASA GSFC
Tsengdar Lee, NASA Headquarters
Peg Luce, NASA ESD
Marian Norris, NASA Headquarters
Woody Turner, NASA Headquarters
Marcus Watkins, NASA Headquarters
Greg Williams, NASA Headquarters
Duane Waliser, NASA JPL
Azita Valinia, NASA GSFC
Lelia Vann, NASA
Stephen Volz, NASA Headquarters

Non-NASA Attendees
Terry Blankenship, Booz Allen
Dom Conte, General Dynamics
Corinne Cerovski-Darrain, AGI
Frank Eden, Eden Consulting
Ernest Hilsenrath, University of Maryland, Baltimore County
John McCarthy, Orbital Sciences
Maureen Moses, AGI
Linda Rowan, AGI
Mike Smith, Booz Allen
Cory Springer, Ball Aerospace
Joan Zimmermann, Harris Corporation

Appendix B
ESS Membership

Byron Tapley, ESS Chair
Director, Center for Space Research
University of Texas

John Christy
Earth System Science Center
University of Alabama, Huntsville

Judith Curry
School of Earth and Atmospheric Sciences
Georgia Institute of Technology

(GOV) James Hansen
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NASA

Raymond Hoff
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Daniel Jacob, ESS Vice Chair
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Harvard University

Gregory Jenkins
Department of Physics and Astronomy
Howard University

William Large
Oceanography Section
National Center for Atmospheric Research

Patrick McCormick
Co-Director, Center for Atmospheric Sciences
Hampton University

Anna Michalak
Department of Atmospheric, Oceanic and Space Sciences
University of Michigan

Jean-Bernard Minster
Institute of Geophysics and Planetary Physics
University of California, San Diego

Steve Running
Department of Ecosystem and Conservation Science
University of Montana

Robert Schutz
Center for Space Research
University of Texas

Hank Shugart
Department of Environmental Sciences
University of Virginia

David Siegel
Department of Geography/Institute for Computational Earth System Science
University of California, Santa Barbara

Mark Simons
Division of Geological and Planetary Sciences
California Institute of Technology

Konrad Steffen
Cooperative Institute for Research in Environmental Science
University of Colorado, Boulder

Charles Vorosmarty
Director, Water Systems Analysis Group
Director, Complex Systems Research Center
University of New Hampshire

Appendix C
Presentations

1. *Earth Science Division Update,* Michael Freilich
2. *NPOESS Restructuring Update/JPSS*, Peg Luce
3. *Crafting the 2010 SMD Science Plan*, Greg Williams

Distributed:
U.S. Interagency Call for Proposals: Climate and Biological Response/Research and Applications (brochure)

Appendix D

NAC Earth Science Subcommittee

NASA Headquarters

300 E Street SW, Washington, DC.

Agenda

16-March-10

8:30	8:45	Introductory Remarks Review & meeting charge	B. Tapley
8:45	9:45	Earth Science Division Update	M. Freilich
9:45	10:30	Climate Initiative	M. Freilich/ S. Volz/ J. Kaye
10:30	10:45	Coffee Break	
10:45	12:00	Discussion	All
12:00	1:00	Lunch	
1:00	2:00	NPOESS Restructuring (JPSS)	P. Luce
2:00	3:00	Q&A with SMD AA	E. Weiler
3:00	3:15	Coffee Break	
3:15	4:30	Discussion	All
4:30	Adjourn		

17-March-10

8:30	8:45	Session Overview	B. Tapley
8:45	9:45	NASA Strategic Plan & SMD Science Plan Update	G. Williams
9:45	10:30	Science Plan Discussion	All
10:30	10:45	Coffee Break	
10:45	12:00	Science Plan Recommendations	All
12:00	1:00	Lunch	
1:00	2:00	Letter writing/next meeting	All
2:15		Closing remarks / Adjourn	