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EARTH SCIENCES ADVISORY COMMITTEE

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MEETING REPORT

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J. Marshall Shepherd, Chair

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Lucia Tsaoussi, Executive Secretary

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Prepared by Joan M. Zimmermann
Zantech IT, Inc.

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Introduction and Announcements

Dr. Lucia Tsaoussi, Executive Secretary of the Earth Science Advisory Committee (ESAC), opened the meeting and made administrative announcements. Dr. Tsaoussi introduced the ESAC Chair, Dr. J. Marshall Shepherd, and other members and attendees introduced themselves around the table. Dr. Shepherd noted that this was his first meeting as Chair and welcomed discussion on the key programmatic issues provided by the agenda.

Earth Science Division (ESD) Overview

Dr. Michael Freilich, Director of the Earth Science Division (ESD), presented an overview of division activities. First addressing the latest budget news, Dr. Freilich described elements of the Fiscal Year 2018 (FY18) and FY19 budget packages, noting that NASA is nearly halfway through FY18 and is operating under a Continuing Resolution (CR), which in turn is funded at both FY17 and FY16 levels. This funding level remains sufficient for executing the current program under ESD's program-defining plan. Under a CR, NASA must follow Congressional directives, but can also make changes that arise from program management, the latter of which are subject to Committee approval. The FY18-22 detailed budget request for FY18 proposes a drop from $1.95B to $1.75B, and the termination of five missions: the Deep Space Climate Observatory (DSCOVR) Earth-Observing instruments; Orbiting Carbon Observatory (OCO)-3; Climate Absolute Radiance and Refractivity Observatory (CLARREO); Pathfinder, Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE); and the Radiation Budget Instrument (RBI), as well as the termination of a $10M line for carbon monitoring in the Research and Analysis (R&A) program, and a modest reduction of other ESD research activities. The budget is currently being reviewed by Congress and will require an action by 23 March: this action can be another CR, an appropriation through the end of FY18, or a government shutdown. In the meantime, an actual budget bill was passed and signed by the President in February of this year, a key feature of which removed the sequester caps and allowed Congress to have more flexibility in allocating appropriations for FY18 and FY19. This move will give more flexibility for funding the Science Mission Directorate (SMD). The House version of the budget has the $1.7B markup, and the Senate has $1.95B along with the suggestion that the terminations not be incorporated (except for RBI). In each case, ESD will have executable budgets, pending suggested Congressional changes to the content of the program.

In the flight program of record for FY17, ESD has roughly 17 instruments or missions on orbit, and 20 missions or instruments in development between now and 2023. One mission in development, RBI, has been discontinued. The flight program covered by FY18 and FY19 funding includes the important missions that have been chosen for termination, but there is remaining program content that is common to both. For FY19, the bottom line is that Administration is calling for similar cuts as FY18. Congress has been focusing on FY18, so there has not been much feedback on FY19. FY19-23 does allow continuation of a balanced ESD portfolio. In this latter runout scenario, Landsat 9 remains on course, as do sustainable land imaging activities with the US Geological Survey (USGS), Venture-class missions, the Applied Sciences Program and the Earth Science Technology Office (ESTO), and a small satellite constellation

data buy pilot program. Dr. Christian Kummerow asked, in view of the flat funding scenario, if ESD had any plans to manage funds beyond cutting programs proportionally. Dr. Freilich said the plan was to avoid a "peanut butter spread" of funding reductions; ESD is now working with a $250M uncertainty over a five-year period and has adopted a strategy of balancing the available funds inside the program. Dr. Shepherd asked, given the losses in the budget, if there were any "winners" in the new budget. Dr. Freilich felt these matters were beyond the Committee's ability to discuss. Dr. Anastasia Romanou commented that it seems the requested budget is cut across the disciplines. Dr. Freilich said that the cuts would be tied to the phasing of missions over the next five years. The President's Budget Request (PBR) removes some significant monies, but ESD will retain its 60:40 flight to nonflight ratio, with an eventual goal of 50:50. Asked if the latest Decadal Survey had any influence yet on budget negotiations, Dr. Freilich said the that the Survey content would processed into the mix by September of this year.

Dr. Freilich addressed recent and upcoming notable events in the flight program, which remains vigorous. In 2017, ESD held a Senior Review that looked at all on-orbit missions and made the recommendation to continue every on-orbit mission, judging that they were efficient in terms of science per dollar. The Quick Scatterometer (QuikSCAT) mission will be terminated at the end of this fiscal year; while its antennae have malfunctioned for some time, QuikSCAT is still being used to cross-calibrate other satellites. The Gravity Recovery and Climate Experiment (GRACE) mission has ended, with the last of its two satellites re-entering the atmosphere 16 years after launch. The Cloud Aerosol Transport System (CATS) mission on the International Space Station (ISS) is also finished. The Jason-2 and CloudSat satellites have been moved to safer orbits, to get out of the way of the "A-Train" grouping of satellites. RBI has been discontinued, but ESD is continuing to work on Decadal Survey-recommended Venture-class instruments for making radiation budget measurements, for launch in 2026. For now, ESD is getting series measurements from Terra, Aqua, Suomi NPOESS Preparatory Project (NPP), and Joint Polar Satellite System (JPSS-1), which will provide continuity for some time. The Total and Spectral Solar Irradiance Sensor (TSIS-1) was launched to ISS, where all is going well. A number of cubesats have also been launched. The OCO-3 instrument is being pursued under the CR and will be completed and flight-ready by April/May; it is currently manifested for the end of the calendar year, and no later than February 2019. GRACE-FO is on track for a 29 April launch. IceSAT-2 is due to launch in September, and ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) and Global Ecosystem Dynamics Investigation (GEDI) are on track to launch by the end of 2018. Tropospheric emissions: Monitoring of pollution (TEMPO) will be delivered as soon as possible, likely by 2019, after which a commercial geostationary host will be sought for a 2020/21 launch date. A hyperspectral aerosol mineralogy/composition instrument has been selected from the fourth Venture-class instrument call.

The NASA Observing System Innovations program includes flying instruments in novel ways: heterogeneous constellations with open data exchange that provide the ability of a virtual observatory; semi-homogeneous constellations such as the Global Precipitation Measurement (GPM) constellation, anchored by the Japanese Space Agency (JAXA), with cross-calibrating measurements of precipitation; and homogeneous constellations such as Cyclone Global Navigation Satellite System (CYGNSS), that increase the frequency of sampling. Dr. Andrew Dessler asked what differentiates OCO-2 and OCO-3. Dr. Freilich noted that OCO-3 is made from flight spares from OCO-2. OCO-2 is flying in sun-

synchronous orbit, while OCO-3 will be on ISS (a non-sun-synchronous, lower orbit than that of OCO-2). The Venture class program, supported by the Decadal Survey, remains a science-driven, Principal-Investigator (PI)-led, cost- and schedule-constrained program: it comprises suborbital mission, small complete mission, and instrument "strands." Venture Class remains fully funded and is an important part of the ESD program. A Venture Class Continuity program is a new 2017 Decadal Survey recommendation and will be rolled into the next budget request.

In addition to Flight, the other major ESD elements are the R&A, Technology, and Applied Sciences Programs. R&A is the integrative element that advances knowledge of Earth as a system. The Applied Science Program (ASP) builds capacity on the part of the users, and addresses the needs of the broader user community. ESTO is developing technologies for future ES instruments. In terms of highlights of R&A, there are plans for a variety of major field programs in the competitive research calls, which will support communities in a sustained way and bring in multiple disciplines to focused research initiatives. For modeling data and simulation, ESD is investing in high-end computing on both coasts, and is working with the National Oceanic and Atmospheric Administration (NOAA) Geostationary Operational Environmental Satellite (GOES) satellites to develop user products. R&A also includes ground-based (GB) networks. ESTO manages the Advanced Technology Initiatives (ATI), which includes the Advanced Component Technology (ACT), InVEST (including the Instrument Incubator Program) and Advanced Information Systems Technology (AIST); the idea is to develop technologies for future missions, in concert with Decadal Survey recommendations. The ASP has a wide set of foci that range from capacity-building activities to disaster response/research water resources, food security, and wildfire monitoring. ASP rapidly coordinates with the federal agencies that have mandates to respond to hurricanes, earthquakes, and wildfires, and was proven as critical to the disaster response during September 2017's natural disasters.

GPM measurements enhanced hurricane forecasts during the most recent hurricane season, as with Hurricane Irma, where it imaged the eyewall replacement cycle at high resolution. ESD is pursuing partnerships with nonfederal organizations for mutual benefit, such as Conservation International, Google, MercyCorps, and Microsoft, where it is working to advance remote sensing and increase public access to Earth images. ESD recently had assets in Argentina when one of its submarines went missing in November 2018, and was able to help in search and rescue efforts.

The private-sector, small satellite constellation pilot includes the current CYGNSS mission and Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS; a recent selection). ESTO's in-space validation program, InVEST, is doing space-borne technology validation. Venture Class Launch Services, a joint activity with the NASA Launch Services Program (LSP), is developing small, low-cost launch vehicles capable of orbiting small payloads at low-Earth orbit (LEO). A small payload is defined as a 100-200 kg cubesat, at up to a 700-km orbit. ESD is providing many opportunities to propose small satellite solutions for answering science questions and is looking to the private sector to see if they can provide data valuable to NASA, from existing small satellite constellations. For the data buy pilot, Requests For Information (RFIs) were issued in 2016 and 2017; FY18 funding is available and Congress concurs with the approach. NASA intends to issue sole-

source contracts to all qualifying respondents. Examples of data under consideration include radio-occultation data and multispectral imagery. Funding will be $20 to $25M for the entire pilot, including existing data products, and distribution to the research community, who will evaluate the data. Participants will be chosen primarily from the ESD-funded community. NASA is not asking researchers to write papers in this exercise; the purpose is to discover whether or not the data is useful. Dr. Daven Henze asked if the data were to be publicly available. Dr. Freilich said the contracts would adhere to ESD's open-data policy, and that commercial cost sensitivities for each provider would be determined by discussion during the evaluation period. The pilot's objective is to engage substantively with both the private sector and the community. Dr. Lucy Hutyra asked what level of data product would be available. Dr. Freilich said the goal would be to obtain the raw data, subject to the cost sensitivities of the providers. Dr. Romanou noted that researchers would need to know how the data was produced, as well as the associated codes. Dr. Ian Joughin asked if investigators had any say in the tasking. Dr. Freilich said this was also under discussion, and that NASA would rather evaluate what the providers have, rather than make the pilot contingent on targeting. The hope is to get a year's worth of data that is globally extensive and to see how valuable it is. Dr. Freilich welcomed ESAC's feedback on this new way of doing business. Dr. Sara Hunter commented that NOAA has been doing this for a while, wherein companies can sell data for a certain price. Dr. Freilich said that ESD has held many conversations with NOAA and has aligned with their RFIs; NOAA has the near-real-time domain, and they have a large set of requirements that NASA can be a lot more flexible about. NASA is also talking with other agencies that hold blanket purchase agreements. Dr. Kummerow noted that NOAA starting to run into conflicts of interest with respect to evaluations. Dr. Freilich said he was aware of this, and hoped to have a broad range of researchers to evaluate the pilot data.

Dr. Freilich provided a snapshot of the 2017 Earth Science Decadal Survey, which was publicly released in January 2018. Importantly, the new Survey endorses and defines the ESD program of record. The new Survey has prioritized observations with an emphasis on competition (where it makes sense), and explicitly allows for implementation flexibility. The Survey explicitly notes the value of, but does not prescribe, the use of international partnerships. There is a strong emphasis on completion of the prior program as a cost-control method. The Survey also endorsed existing balances in the ESD flight/non-flight portfolio, and provides a series of graded recommendations for the second half of the decade in five categories of "observables": Aerosols; Clouds, Convection and Precipitation; Mass Change; Surface Biology and Geology; and Surface Deformation and Change. It calls for the cost-capping of all missions, as well as a new, competed "Explorer" flight line cost-capped at $350M (choosing from three science areas, from six science areas identified), and an "incubator program" to mature technologies for the next Decadal Survey; the latter is to be a collaboration between Flight and Technology. The Survey also calls for a fourth "strand" in the Venture class program. This is a "Continuity Measurement" for sustainable continuity of measurements over a long time horizon. Some of these measurements could include purchased data. ESD will focus on community forums over the next 12-18 months to translate the recommendations and develop a response to the Decadal Survey. ESD has put aside about $10-15M per year for new mission studies.

Decadal Survey Summary

Dr. Shepherd initiated a discussion on the newly released Decadal Survey and provided some leading questions for the Committee to consider, the first of which asked if there were any glaring omissions in various Earth Science mission priorities. Dr. Dessler was concerned about how the Survey recommendations were to be converted into missions, as Town Hall meetings don't seem to be effective. Dr. Freilich said the initial approach would be to use community forums. The intent is that each forum will have a specific limited set of objectives; and these could be strategic objectives, initially. He stressed that these forums will not be a bunch of campaign events to encourage the more vocal people to vote. ESD wants to generate a range of ideas. Dr. Kummerow felt that the focus of ESAC should be how to take designated missions from vague concept to reality, and how to best involve the community in the process. Dr. Shepherd asked, given the three- to four-year budget ramp-up, when the forums might begin. Dr. Freilich said that ESD has been meeting weekly in order to have a plan within the next couple of months to structure the forums; this will be followed by 12-18 months of discussion, during which time some strategic decisions will be made. There is no need to make decisions now.

Dr. Yin Fan Reinfelder noted that the Decadal Survey provides clear guidance on priorities, and that it was not clear what ESAC's actual charge is in this context. Dr. Shepherd felt ESAC should ideally look for information gaps and bring individual member expertise to bear on each issue. Dr. Romanou asked if the Survey were the most definitive document for determining future missions. Dr. Freilich noted that there are many different sources; science evolves over time, and there are many stakeholders (Administration, Congress). The Decadal Survey has the advantage of rigorous review, thus its recommendations are elevated in terms of impact. Dr. Romanou suggested that NASA have some sort of post-Decadal Survey RFI activity to give feedback on implementation, technology, and costs, especially since some Earth Science missions are targeted for termination. The results could be presented to the community. An RFI could engage many more people and give more substantive impact. Drs. Kummerow and Hunter concurred, Dr. Hunter citing experience with some forums attended by NASA's former Chief Scientist, Dr. Waleed Abdalati. Dr. Shepherd noted that one concern about a NASA-issued RFI was a fear that people would get up in arms about "pet projects." Dr. Hunter said that stratospheric chemistry in general seemed to be given short shrift in the Survey, which was acknowledged by Dr. Abdalati.

Dr. Shepherd asked if the ESAC was in a position to fix something: Did stratospheric chemistry experience a real omission? Is a community seriously underrepresented? Dr. Freilich noted that the ocean community felt under-represented in the 2007 Survey; a letter describing this under-representation was referenced in the new Decadal Survey. In the past, ESD put together a "Climate Architecture" that contained an executable plan for the Survey and then sent it through the US Global Change Research Program (GCRP). The Climate Architecture, however, is not a specific Survey item. In 2007, NASA was faced with unrealistic cost estimates from the Decadal Survey, as well as a diminishing budget. NASA took the initiative to create an executable plan, and created the architecture that was subsequently reviewed by Headquarters, and then infused into both managerial and science priorities. The Climate Architecture includes copious references to the Decadal Survey. Dr. Joughin felt that scientists would expand the Decadal Survey charter, rather than reign it in. He felt ESAC could suggest a way to give the

workshops a menu of choices. Dr. Freilich agreed, saying defining specific objectives would be important, and he invited ESAC to be aggressive with its advice. Dr. Joughin was pleased to see the Decadal Survey focus on competition and wished to reinforce this approach. Dr. Henze felt that the six targeted observables constituted an interesting approach, and wondered how the specific missions being cut might overlap with these areas; is it a priority for ESAC to pay more attention to these areas to backfill the missions being cut? Dr. Tucker noted one mission could cover three observables; she knew of many organizations that were thinking about squeezing more science into fewer missions. Dr. Kummerow suggested asking the community about expanding science by taking advantage of overlapping areas; that would be useful information for building missions. Dr. Tucker cited her experience, since moving to industry from NOAA, was that industry was more closed-door in nature, and felt it important to have industry allowed into those community forums to provide realism re: cost and technology. Dr. Freilich said that industry would be most welcome to these forums.

Dr. Shepherd asked if the two Decadal Surveys had been dealing with similar budget landscapes. Dr. Freilich said that the scenarios were vastly different: in 2007, in addition to ESD's having absorbed a 30% decrease in funding, the Survey of that time had been extraordinarily optimistic. The present outlook is quite different, and this Decadal Survey is much more conservative. However, there are too many objectives in every Decadal Survey, often at cross purposes. He added that ESD tries to use each Decadal Survey as a means of unifying the community.

Dr. Glenn suggested the ESAC try to outline the structure of a forum that could take the community from observables to missions. Dr. Colleen Mouw was concerned that aspirational thought would be quashed by the constrained budget; where will be in 10 years? There is a lot of ocean-related material in the Decadal Survey that does not seem to be supported budgetarily. Dr. Freilich noted that the ESD is in the midst of formally closing out pre-formulation studies, which will subsequently be re-vectored in order to accommodate the new Survey.

Dr. Ricky Rood commented by email that oceanography in the Decadal Survey does appear to be neglected, as does predictive climate modeling; they both appear to be backward-looking. Dr. Tucker agreed with Dr. Rood's statement and asked what NASA's mission was with respect to prediction vs. operations. She emphasized that there must be current investment to support better predictive capabilities, but asked what NASA's mission was in this situation. Dr. Shepherd noted that NASA's Dr. Tsengdar Lee, Program Manager for High-End Computing, also had similar questions about the new Decadal Survey re: high-performance computing, modeling, and prediction. Dr. Romanou was concerned more about gaps in observation and felt it wrong to frame the questions in terms of scale. The question of how seasonable variability changes with the decades is more a NASA question. She felt ESAC should not judge NASA and NOAA in terms of differing scales. Dr. Jack Kaye clarified that NOAA does operational forecasting, while NASA is in the position to make the connection between new observational capabilities and getting them into the operational system. This difference applies as well as to models. The Global Modeling and Assimilation Office (GMAO) at Goddard Space Flight Center (GSFC) is one pipeline. Dr. Kaye didn't see it as a scalar problem, as weather and climate are intimately intertwined. Dr. Rood commented that if you think about the predictive capabilities needed going forward, that rely on the

interactions between sea and land, the observations targeted by the new Survey don't seem well positioned to get the necessary data from the ocean. One of the issues is that NOAA modeling is not thinking about coupled-model paradigms; a lot of research that is essential for climate adaptation planning is missing from the 2017 Decadal Survey. Dr. Shepherd felt the issue might be worthy of a finding. Dr. Reinfelder asked for examples of missing critical measurements. Dr. Rood noted that dynamic sea level and salinity measurements that get to dynamics in a sustained way did not come out as a predictive priority. Dr. Rood said that, speaking as a generalist, these measurements seem to be essential on both the NASA and NOAA sides. Politically, the Survey looked like it was making an appeal to weather-scale and Earth monitoring observations. Predictive data seemed to fall into the political black hole, guided by what people are afraid to say. Dr. Reinfelder asked, in that regard: is the importance of understanding the mechanism missing, or do the recommended observables do not give us the means of understanding the mechanism? Dr. Rood thought the science of predictability on scales longer than weather-scales were neglected. The problems of predictability are true research problems; sea level rise is accelerating by every measure, thus we have to focus on how to predict that (for societal/safety reasons), as well as ask questions that focus on why the sea level is rising. These questions are underrepresented in the Decadal Survey. Dr. Dessler commented that he felt a 15-minute discussion should not precipitate a finding that oceanography is shortchanged by the Decadal Survey. Dr. Freilich commented that ESAC ideas will have the greatest impact if they are actionable: e.g., a specific recommendation on how NASA might deal with the absence of some observations that the community feels are missing.

Discussion

Dr. T. Jens Feeley sat in for Dr. Tsaoussi for part of the afternoon session. Dr. Shepherd continued the discussion on the Decadal Survey, with the aim of generating other specific findings and recommendations that would be useful to SMD. Dr. Kummerow said that community forums should not be focused on specific missions; one question they might deal with would be how to leverage more than one science question per mission. Forum questions should be styled to find synergies. Dr. Henze suggested that groups be invited to discuss and engage, rather than to pitch ideas. Dr. Shepherd felt a guiding structure would be necessary to prevent a free-for-all for those who are militating for their favorites. Dr. Tucker felt that one objective might be to have a presentation of possibilities, such as what industry should be investing in with its own money to help NASA. Dr. Freilich thought the key element should be within the objectives identified for each forum: How does the community view competed missions versus directed? What sort of cross-question evaluations could be answered in a proposal? Dr. Raymond Schmitt said a possible example could be to identify instruments with overlapping wavelengths, such as expanding lidar coverage to help include oceanographic measurements. Dr. Kummerow felt the idea of having cross-disciplinary questions to frame objectives seemed to rise to the top. Dr. Romanou asked if continuity might be the theme of one forum, to assess the importance of new types of measurements in this context. Dr. Glenn suggested having forums organized around a multi-function measurement, such as lidar or synthetic aperture radar (SAR), to avoid disciplinary siloes. Dr. Tucker noted that between Incubation and the Earth Venture programs, there are six types of program elements; is Incubation enough to overcome the Valley of Death to Earth Venture/Explorer missions? Does the Instrument Incubator Program (IIP) go far enough? What should be in it? Dr. Kummerow commented that there might be a different path to flying something in space at reduced cost. Dr. Tucker asked if an X-37

could be used in something between an IIP and an Earth Venture mission. Dr. Kummerow seconded Dr. Tucker's thought, and felt it was important to sustain technology development beyond the laboratory. Alternatively, ESAC could ask SMD to study the space between IIP and the Earth Venture-class program. Asked if ESD were still restricted to commercial launch, Dr. Freilich noted that NASA-supported launches must meet certain criteria. Further, the Incubator products should be focused on target areas; they don't have to be flown, but they should be at technology readiness level (TRL)-6. Importantly, Venture Class instruments are not restricted to one orbit or approach. NASA has to figure out the mechanism and can accept suggestions from the proposers. In addition, ESD will be doing a "road show" to broadcast NASA opportunities to the international community. The NASA centers are also exploring international partners for various aspects of missions. Internationals are always invited to community forums.

Dr. Henze suggested that NASA also present its "bounding box" at these forums. Asked about prior experience with forums, Dr. Freilich said NASA had held similar workshops in the late 1980s/90s with similar objectives. Dr. Kaye noted that ESD focus areas have also been the subject of workshops; e.g., Earth Surface and the Interior, and the Weather, and Carbon Cycle communities. Dr. Joughin noted that the NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) community did this successfully as well. Dr. Shepherd said he had been involved in the Weather community forums and did recall a well-done report on the subject of vectoring weather in ESD, and thought it was useful. He added that ESAC may want to consider a finding in support of community forums. He suggested ESD find other ways to join the discussion, as through webinars or other digital media. Dr. Romanou suggested that white papers emanating from the workshops be put out to the community for public comment. Dr. Kaye related that before the National Climate Assessment, NASA held many listening sessions via webinar and satellite hook-ups. He added that one thing that must be decided is what to do with the information that is obtained. Dr. Freilich felt the objectives should be two-fold: to get more and better input; and to seek greater engagement with as many people as possible on the subject of the Decadal Survey. Dr. Shepherd thought ESAC might formulate a finding on studying other ways to engage the community. Dr. Henze asked if there were a budget to support these forums. Dr. Freilich replied in the affirmative. Dr. Tucker suggested taking advantage of the American Geophysical Union (AGU) annual meeting.

Dr. Freilich noted that the ESAC could comment on the role of the Observing System Simulation Experiments (OSSEs) in setting up missions, or on how to structure solicitations and discussions to create a broad solution space. Dr. Joughin requested an ESD roadmap for translating the Survey into missions. Dr. Freilich agreed to distribute the roadmap. Dr. Kummerow suggested ESAC provide a list of useful workshop themes. Dr. Reinfelder recommended a vision statement as well as a top-down summary to react to. Dr. Shepherd said ESAC will eventually hear the top-down direction; for now, ESAC has the opportunity to mold the vision. Dr. Romanou observed that the Survey has provided observables but did not account for the constrained budget atmosphere. Dr. Shepherd noted that ESAC can propose and advise based on current information on strategies to get to missions. For now, ESAC should consider how to hold the forums, what the questions are, and what mechanisms can be used to get the information. Asked if the missions proposed for termination could be part of the discussion, Dr. Freilich thought that

forums which look at the second half of the next decade would be useful here, without debating the terminated missions. Dr. Tucker noted that these communities that are threatened by shrinking budgets and attacks on science, tend to get fractured. She suggested that these forums be assigned leadership that knows how to handle that situation (rapporteurs or facilitators). Dr. Shepherd concurred, adding that ESAC could specifically recommend this to the SMD.

ESD Airborne Science Evolution

Dr. Jack Kaye presented an overview of ESD's airborne research results. Airborne platforms provide a way to bridge the scales between the satellite's typically global perspective and local *in-situ* observations. The airborne program provides a way to do comprehensive studies on specific regions of interest; get an initial sense of Earth-system parameters before a satellite mission; test new instruments; do targeted observations; and provide training and educational opportunities through all phases of a project. Airborne science at NASA provides unique capabilities in platform, sensors, systems, people, and opportunities, all of which combine in efficient ways. The linkage among these five areas is critical in terms of synergy, as it integrates space-based and surface-based measurements. The platform includes a NASA-owned and operated fleet of aircraft, as well as subsidized vehicles, from S3-Bs to unmanned Global Hawks to manned DC-8s, that operate over a spectrum of range and altitude. Sensor types include facility and facility-like, and principal investigator-operated. Many instruments have a long history of use on NASA airborne platforms. Dr. Dessler asked how the Global Hawk was working out. Dr. Kaye said it is no longer a subsidized platform at NASA, as it has not played out as well as hoped.

Airborne instrument technology transition selections help to get instruments to the point where the R&A program can keep them going. ESD's Airborne Instrument Technology Transition (AITT) program's 2016 selection included a number of spectrometers, radiometers, and scatterometers. Major passive remote-sensing instruments include hyperspectral infrared (IR), broader IR, and ultraviolet (UV)/visible. ESD is also developing airborne lidar instruments oriented to molecules, vertical profiles of columns, and clouds. The communications-based satellite sensor network provides global sharing of instrument data; other advantages of the network are real-time payload communication and control systems for situational awareness, data for shared models, and standard hardware interfaces. The Airborne program also helps to maintain a stable and trained group of investigators who can define objectives and plan missions. The program offers numerous opportunities with a mix of ways to facilitate mission and instrument development: open/competitive; specific competitive, directed, and instrument selections. The Earth Venture Suborbital (EV-S) program includes investigations in root zone soil moisture, coral reefs, and ocean-ice interface data. EV-S's third call was released in November 2017, and incorporated some changes that resulted from community feedback. There are now two classes of campaigns, small and large, and an increased focus on results documentation, dissemination and community engagement during the course of the mission. Dr. Dessler asked how much money was spent on the actual mission versus post-mission data analysis. Dr. Kaye noted that while the program has made changes in ways of disseminating data, it's up to the R&A programs to support data analysis. The data analysis (DA) plan should be part of every proposal.

Dr. Kaye provided a history of the airborne program, which has encompassed stratospheric chemistry; hurricanes; clouds, radiation and aerosols; surface deformation; terrestrial ecosystems; and applications. Stratospheric chemistry goes back to 1984, a highlight of which was the discovery of ozone hole's relationship to fluorocarbons. Clouds, aerosols and radiation investigations go back to 1996. Numerous airborne hurricane campaigns and precipitation calibration/validation (Cal/Val) campaigns contributed to the GPM satellite mission. The Airborne program has often played key roles in supporting national needs, such as disaster response to oil spills, fires, earthquakes, etc.,

Recent, current and planned activities include ship campaigns, Operation Ice Bridge to connect the Ice, Clouds, and land Elevation Satellite (IceSAT) 1 and IceSAT 2 missions, SnowEx (2017), balloons that study volcanic aerosols, and air quality studies in wildfire areas (Fire Influence on Regional and Global Environments Experiment; FIREX-AQ 2019). Opportunities and issues that are looming include the need to consider large platform replacements, and the consideration of the proper use of unmanned aircraft systems (UASs) in the airborne science program.

The DC-8 aircraft is aging. ESD needs to think about replacements, with their associated requirements and costs. Another issue to be considered is that the community seems to be moving to smaller UASs, and Global Hawk is now an unsubsidized platform: what is NASA's role here? Improved descriptions of airborne mission results are also needed, specifically focusing on improved clarity. Dr. Kaye noted that while science may be getting more incremental, NASA still wants to publish the results. Some researchers may be putting too much focus on the new data acquisition process in favor of documenting the old data in a concise way for external communications. Specifically, investigators need to better answer the question: What did we learn and how did it make a difference?

As to the ability to implement missions internationally, lately more roadblocks have arisen to international work. NASA needs to have ways to respond to short-term opportunities. For long-term stability for and evolution of airborne instruments, NASA needs to have facility and facility-like instruments that can be counted on to be available when needed. Can NASA respond immediately in the event of a volcanic eruption, for example? Dr. Kaye noted that ESD recognizes that there's a problem, and a white paper is coming out on this issue. Dr. Freilich asked for ESAC's advice in order to clarify priorities.

Discussion on Airborne Program

Dr. Kummerow noted that in the last Decadal Survey, a question came up on process understanding, or the marriage between the satellite and airborne programs. The programs are not yet integrated: would NASA consider more integration between the two programs? Dr. Kaye felt the airborne program was not well configured to do this at present, but he welcomed ESAC feedback on whether it could be made to do so. Dr. Freilich thought the R&A program is more suited to dealing with integration; a lot of the power of the spaceborne measurements lies in the large area coverage. Dr. Kaye noted that airborne components could be greater than what the R&A program can handle. Dr. Tsaoussi said ESD has proposed studies that include both airborne and satellite data, and putting together existing data sets. One thing ESD tries to do

in airborne is to take advantage of satellite overpasses, which may address this desire to integrate the data sets. One example of this was a California flight that timed to pick up an overpass of the A-Train and Terra. Dr. Tucker noticed that AITT is heavily dominated by NASA centers, and asked what would enable non-NASA PIs to be a bigger part of the airborne program. Dr. Kaye noted that *in-situ* sensors have more community and other government agency participation; the NOAA Earth System program and and the National Center for Atmospheric Research (NCAR) have been large providers of these opportunities. There are also a lot of university-based people working on *in-situ* sensors. Dr. Tucker asked, in terms of the aircraft large platform replacement issue, how many aircraft have optical ports for lidar, as lidar is growing is a growing field. Dr. Kaye noted that some upcoming G-5 planes will have two optical ports apiece (17-inch holes).

R&A Charge to SMD Advisory Committees

Dr. Michael New presented a charge from the SMD Associate Administrator, specifically addressing whether the SMD R&A Program has effective processes in place to solicit, review and select high-risk/high-impact projects. It's always good practice to periodically step back and review processes, and this charge is an ideal task for the newly reconstituted advisory committees (ACs) and Science Committee. NASA is asking the ACs to work on the "how" and not the "why," and hopes to obtain tactical, novel use-focused advice in addressing a series of sub-questions. NASA will provide materials to the ACs, if needed.

High-impact, for the purpose of the charge, is defined as research outcome would have a substantial and measureable effect on current thinking methods or practice. High-risk is defined largely as intellectual risk. The research can be multidisciplinary, interdisciplinary, and interdivisional. The ACs will be asked to improve these definitions if they wish to do so. For reference, the working definitions have been set by the National Science Foundation (NSF) in other areas. The thought is to utilize up to two AC meetings to deliberate on the charge, with a response due in July 2018. The ACs are permitted to hold a Federal Advisory Committee Act (FACA)-governed teleconference to complete the task. The response should be in the form of a presentation to the AA, with the option of also providing a letter. One question to be considered is whether R&A set aside monies specifically for high-risk, high-impact research. Dr. Schmitt commented that review panels generally don't like high-risk concepts, but the problem is one doesn't know whether a proposal is high-impact until the risk is overcome. Dr. New agreed with this assessment, which has in fact led to the charge being levied.

Dr. Joughin said high-risk might be redefined as novel, significant and "credible" hypotheses. Dr. New countered that a more germane example of intellectual risk was the introduction of prion theory, a mechanism of protein-induced infection which had been long pooh-poohed as impossible and incredible. Dr. Shepherd worried that there is much non-credible theory out there. Dr. Dessler said funding many proposals was necessary in order to uncover and support high-risk concepts, adding that consensus "is almost always right." Dr. Reinfelder suggested retaining the term "high-impact," while acknowledging as a subtext the high-impact nature. Dr. Kummerow asked if R&A would institute a unified policy on the issue. Dr. New said that no preconceptions were implied. NASA may just have to acknowledge common features of the research and allow implementation to be variable. Dr. Henze noted that high-risk implies

lack of preliminary data; maybe it is best fund these ideas incrementally, as seed grant competitions. Dr. New said this mechanism was often used in the Exobiology program and was open to suggestions. Asked if anyone had looked at how interdisciplinary solicitations actually are, Dr. Kaye said it would be hard to answer this question; R&A is trying to allow for larger tasks in order to allow larger interdisciplinary teams, and has been relying on the review process to defend these proposals as interdisciplinary. There are former NSF staffers in SMD who bring some of their own experience to the process. NSF generally puts some money aside for high-risk ideas; there is a cultural difference between NSF and NASA program managers (PMs), however, in how they view innovative research. Dr. Glenn said the Department of Energy (DOE) has some Program Officers who deal with high-risk concepts.

The scale of the projects under discussion is confined primarily to ROSES-type proposals, but the project can be larger, if clearly stated. Dr. Kaye noted that panels for fellowship programs, for instance, are inherently interdisciplinary, and may be a good way to think about the process. In general, NASA PMs are empowered and encouraged to decide that if there is something that falls in the in-between range that is high-risk, high-yield, selectors should feel free to use that as criteria for selection. Dr. Tsaoussi confirmed Dr. Kaye's remarks in her experience. Dr. New said that for ROSES 2017, NASA has asked all the review panels to provide their assessments of the risk, impact, interdisciplinary nature of proposals.

Wrap-up Discussion

Dr. Kummerow said ESAC should address the fact that review panels don't look favorably on things they don't understand. Dr. Dessler added that reviewers are always looking for reasons to reject a proposal, and the culture will have to change to allow truly high-risk, high-impact proposals. A program manager can't save a proposal that is too far underwater; NASA must instruct the panels in a better way. Dr. Tsaoussi noted that NASA does collect statements, and considers panel comments, and reviewer comments to proposers. Dr. Dessler suggested it may be useful to have people self-identify speculative proposals, making it an explicit category. Dr. Glenn added that early career scientists also have a real reluctance to take risks. Dr. Tucker noted that the NASA Institute for Advanced Concepts (NIAC) and Earth Science Technology Office (ESTO) programs have some tolerance for risk, and asked if NASA wanted to separate technical proposals from R&A. Dr. Freilich said that from the standpoint of the SMD AA, each division has an R&A program; it's not a grading exercise. ESAC should stick to thinking about R&A, and perhaps iterate its conclusions in other areas across SMD. Dr. Romanou asked how many proposals are actually found to be high-risk, high-reward and in the middle grading range; the answer would influence ESAC's evaluation. Dr. Joughin noted that there's an art to writing a good proposal; sometimes people don't know how to express ideas. Should NASA have proposal writing workshops to help this along?

Dr. Shepherd took an action to synthesize three possible findings from the day's proceedings.

March 15, 2018

Special Government Employee Ethics Training
The Committee received its required annual ethics training.

Morning Discussion- Synthesis of Thoughts
Dr. Shepherd presented a number of issues for discussion and possible adoption, the first a proposed recommendation on NASA-issued RFIs for the purpose of developing concepts and missions deriving from the 2017 Decadal Survey. Dr. Romanou, citing her own experience on the Decadal Survey panels, described having asked the various communities to write up RFIs that had specific implementation strategies and instruments. NASA might combine this type of RFI to determine what the community workshops/forums should be, to answer key objectives, with end-products as white papers to NASA, in line with Decadal Survey findings. Dr. Shepherd was concerned that these forums avoid the stovepiping of communities, as the real need is to focus on continuity, cross-disciplinary concepts, multifunction measurables, and international perspectives to promote science and applications.
Two further potential recommendations were that ESD consider "out-of-the-box" facilitation strategies, and to hold webinars, and use other digital media platforms, to disseminate information to the community.

In addition, ESD is seeking guidance on how to structure selection criteria to understand what can be proposed based on Decadal Survey guidance. What are the roles of OSSEs in this area? How do we encourage a broad response? ESAC would like more insight into programmatic thinking, or to view an ESD roadmap to missions. Dr. Freilich felt the OSSEs provided opportunities to see unique contributions that are not specific to a particular mission; he felt that the primary question was how to encourage observing system engineers to continue to examine small satellite constellations and distributed systems, at the same time they are looking at a more conventional satellite mission, when there is a strong tendency to do things in a classical way.

Addressing airborne missions, Dr. Shepherd was not sure much was needed from ESAC in terms of advice. Questions to consider might be: What fraction of investments should be spent on current understanding? Is the rapid response capability of airborne assets adequate to respond to sudden events such as volcanic eruptions? Should the DC-8 be replaced? Dr. Romanou suggested thinking beyond the concept of airborne missions, to embrace anything suborbital, ships, submersibles, etc. to expand the science value of satellite missions. Dr. Freilich noted that ESD has core support for airborne, as well as the availability of other assets (reimbursable) for such craft as ships. Dr. Kaye added that it's not just the cost of the aircraft to consider, but also the cost of modifications (optical ports) and onboard data systems.

Public Comment
No public comments were noted.

ESD Approaches for International Mission Coordination

Dr. Freilich presented a talk on both international and interagency partnerships, primarily focused on flight missions. Many ESD missions have international involvement: Jason-2 (NOAA and the French space agency, CNES); SAGE-III carries a precision pointing platform from the European Space Agency (ESA); Terra has an instrument from JAXA; Landsat is coordinated with USGS; and Aura has various international instruments. DSCOVR is a partnership with the US Air Force and NOAA; Suomi (NOAA); and GPM (JAXA) are other partnerships. The entire GPM constellation involves other agencies as well, such as NOAA, the Department of Defense (DoD), JAXA, CNES, and ISRO. Missions in development include the GRACE-Follow-On (GRACE-FO, with the German Research Centre for Geosciences), Sentinel 6A/B (NOAA, ESA's EUMETSAT constellation), Landsat 9 (USGS); Surface Water and Ocean Topography (SWOT; with CNES) and NISAR (ISRO). Sentinel 6A/B is the start of a collaboration with ESA and the European Community, and is part of a hardware collaboration under Europe's Copernicus program. Sentinel has a tie-in to long-term continuity measurements that Europe is heavily investing in. ESD is still constrained by law from working with China. However, within the balance of the statute and Congress, NASA interacts with China, within legal limits, when it is of benefit to the US.

Interacting with the various space agencies takes a bit of cultural delicacy, and depends on the continuing efforts of the ESD and on NASA's support for international efforts (Office of International and Interagency Relations; OIIR). These efforts are helping to improve both the cultural and scientific aspects in both sides of the partnership. Dr. Glenn asked if NASA helps with international private entities. Dr. Freilich explained that NASA does not do so directly. However, NASA is a member of the Committee on Earth Observation Studies (CEOS), an influential body that helps to coordinate efforts and governs seven virtual constellations in areas such as land surface imaging and atmospheric composition, with working groups, and *ad hoc* bodies. NASA provides funds to systems engineering groups in CEOS. CEOS is also the satellite coordination arm of GEO. There is also close coordination between NASA and JAXA on carbon monitoring, with tight collaboration on calibration, algorithms, and measurements.

NASA engages in multi-mission international partnerships. ISS in particular has facilitated many international collaborations. GPM and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) are representative missions. The NASA-ESA Joint Program Planning Group, until recently, was hindered by Europe's closed data policy. In 2010, this policy changed, and NASA and ESA signed a formal Earth Science and Observation Framework for Cooperation, leading to the establishment of the Joint Program Planning Group (JPPG), which reports annually to ESA/NASA executive management. Three JPPG subgroups have been established in mission and technology, Cal/Val, and field campaigns, and ground segment and data. The JPPG enabled data acquisitions for soil moisture after a NASA instrument failure, and supports continued harmonization of Landsat and Sentinel-2 products. Answering a question about PACE, Dr. Freilich said the mission was slated for termination by PBR, but under the CR, NASA is continuing progress on the mission. In terms of international collaboration, there is an aerosol polarimeter available for PACE, and NASA is in a lengthy discussion about it. If NASA does fly a polarimeter, it will be from the Netherlands space agency. Asked if NASA had communications with ISSI, a Swiss think tank that sponsors meetings on sea level rise, Dr. Kaye said he was familiar with

them, but had never pursued a relationship. Dr. Kummerow asked, since the data policy was resolved, if were there any things that could be improved in the ESA/NASA collaboration. Dr. Freilich noted that the partnership is going very well, and while it does take time and energy, it is a beneficial relationship.

ESD International Non-Flight Engagement Forums

Dr. Jack Kaye presented the first part of a briefing on international collaborations in ESD's non-flight programs. Key types of engagement, in addition to CEOS, include NASA's ongoing relationship with Coordination Group on Meteorological Satellites (CGMS), Group on Earth Observations, and World Meteorological Organization. On the research side, there is the World Climate Research Program, which has four core projects, and which is evolving with the introduction of a new strategic plan. The program encompasses seven grand challenges including melting ice and global consequences, clouds, circulations and climate sensitivity. There is also Future Earth, which has subsumed previous programs, including the International Geosphere-Biosphere Program. Future Earth has 22 research projects; among those of interest to NASA are: Global Land Programme (GLP), Global Carbon Project (GCP), and Future Earth Coasts. Future Earth is also developing "knowledge-action networks" to help align social science components with Earth Science programs. The US Global Climate Research Group (USGCRP) and NSF provide funds to Future Earth.

CGMS is helping to inform Earth observations and has a number of international science working groups on areas such as clouds, winds, radio-occultation. Other related initiatives include the Global Space-Based Intercalibration System (GSICS).

Mr. Lawrence Friedl led a briefing on the international Group on Earth Observations (GEO), which provides Earth Science communities with a political arm, brings awareness of EO data to political ministers, and strives to improve the availability of EOs. GEO has 105 members countries and about 115 participating organizations (CEOS is one of them). GEO manages a three-year work plan to improve coordination across different countries. GEO is important also in that it offers a forum in which the US can push things such as an open-data policy. Last year, the Chinese used the forum to announce their open data policy on the TanSat carbon-monitoring mission. In the early days, it was a matter of GEO re-branding projects, but now there are original projects, such as GEOGLAM (global agricultural monitoring), which help to provide a neutral space to discuss issues like food security. GEOGLAM is providing more transparency about crop failures, which in turn can help reduce price volatility to improve food security. GEOGLAM also helped get a declaration into the G20 meeting of 2011 to call attention to food security. As a result, there is now a monthly newsletter on growing conditions. In the US, there is a US group on Earth observations (USGEO) that helps to coordinate US participation in global earth observation activities. Dr. Kaye added that the World Meteorological Organization (WMO) maintains a set of groups, such as the Expert Team on Satellite Utilization and Products. There is also much international engagement with ESD's airborne campaigns, particularly for overflight permissions. Dr. Shepherd asked if there were any guidance the ESAC could provide on fleet sustainability. Dr. Kaye welcomed the ESAC perspective, not just on the platform but on spare parts as well. Bruce Tagg noted that a platform study is ongoing in the Aeronautics Division, which should produce a report in about six months. Dr. Shepherd welcomed the report at the Fall meeting.

NASA-supported global ground networks include the Advanced Global Atmospheric Gases Experiment (AGAGE) for the monitoring of chlorofluorocarbons, NASA Space Geodetic Network (NSGN), Network for the Detection of Atmospheric Composition Change (NDACC), Southern Hemisphere ADditional OZonesondes (SHADOZ) (balloons for vertical profiling of ozone), and Pandora (ground-based trace gas measurements). The International GNSS Service (IGS) Central Bureau, hosted by the Jet Propulsion Laboratory (JPL) obtains the network data, then archives and distributes it, and also oversees day-to-day and long-term management of the data. A sample of one such mission was a 2017 balloon campaign to study the Asian tropopause aerosol layer (ATAL); BATAL launched small, low-altitude balloon flights over a month's time to study the optical, physical and chemical properties of the ATAL. Dr. Freilich mentioned that the Astrophysics Division (APD) has a vigorous balloon program that ESD regularly takes advantage of.

On the research side, there is the South/Southeast Asia Research Initiative (SARI), a regional research education and capacity building program, to advance land cover/land use change (LCLUC) science in the region. The Northern Eurasian Earth Science Partnership Initiative, having accomplished more than 12 years of research, is a predecessor program that inspired SARI.

Mr. Friedl related that in September 2015, the United Nations (UN) endorsed the "2030 Agenda for Sustainable Development," which put forth United Nations Sustainable Development Goals: these are 17 goals with different targets and reportable indicators. Overall, there are more than over 232 indicators that address social, economic and environmental aspects of sustainability. Countries report periodically on indicators such as forest cover. NASA has issued solicitations on Goals 14 and 15 (oceans and forests) to fund research and applications. In Colombia, total forest cover is an important UN indicator. Landsat scenes, with over 25 years of data, have proven useful for reporting these indicators to the UN. NASA is using Colombia as an example to scale up efforts to help other countries.

NASA's Earth Science Disasters Program uses a tiered system that helps determine when NASA gets involved in disaster response. Categories range from an initial assessment, to Tier 1 (short term and best effort response and recovery; e.g. Napa earthquake 2014) through Tier 3 (major importance, e.g. Hurricane Katrina, September 11).

Dr. Kaye described NASA participation in several periodic international assessments, as well as special assessments for the Intergovernmental Panel on Climate Change (IPCC): these are the World Meteorological Organization/United Nations Environment Programme (WMO/UNEP) Ozone Assessment, the World Ocean Assessment, and the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (which aspires to be the IPCC equivalent for biodiversity); and the Arctic Monitoring and Assessment Program (Snow, Water, Ice and Permafrost in the Arctic; SWIPA). NASA provides US Participating Investigator (USPI) funding as a means of letting researchers propose to non-US missions. Seven projects were selected in 2017 for European and Asian space missions, for a total of $5.1M over 5 years. USPI goes back to 2008, and has enabled participation in ESA's Sentinel program, among other international missions. NASA's High Mountain Asia Team functions as the

"glacial melt tool" for NASA. Glacial melt has great meteorological impact on large populations. Education and capacity building efforts include GLOBE and the Applied Sciences Program's SERVIR. GLOBE involves students in hands-on measurements, data collection, and following science protocols, and spans 117 countries, more than 30,000 schools and 28,000 teachers.

Mr. Friedl provided more details on SERVIR (from the Spanish: to serve), a cooperative effort between the US Agency for International Development (USAID) and NASA, that supports USAID efforts in international development with Earth observations, to benefit the community. SERVIR has hubs in East Africa, the Mekong Delta, and the Hindu Kush. Under SERVIR, there is an Applied Remote Sensing Training (ARSET), a program that "trains the trainers" with live and recorded courses and in-person computer lab training sessions, and which is reaching about 4000 people per year.

Dr. Kaye presented issues and opportunities; i.e. if NASA had the ability to act bilaterally with China, this could add value to both sides; the Decadal Survey has weighed in on the problem. A recent binding agreement with Russia, signed under the Arctic Council, may facilitate more cooperation with Russia in the future. It is important to address the rapid pace of change in the Arctic climatic system. Since the shift to Future Earth occurred, there have been changes that NASA must keep up with, and must continue to engage with the international community to do so.

Asked if anything in particular rose to the top in terms of importance, Dr. Kaye pointe to bilateral observational activities, which NASA engages in with many countries; and then the relationships with the research communities, and the melding of research and applications. Mr. Friedl said he saw lots of general support for internationals, particularly in language about technical innovation and agility in applications. NASA is currently working on the 2018 National Plan for Civil Earth Observations. In this context, what does the Decadal Survey language mean for the national plan going forward? Dr. Shepherd noted the importance of Arctic change, and Siberian snow cover's influence on seasonal weather. Dr. Kaye added the issues of environmental impacts on ice melt, sea ice distribution, and ocean-atmosphere interactions. Dr. Tucker asked how ESD prioritizes funding for each organization, and if it worked with the State Department in any depth. Dr. Kaye said there was not a large amount of funding in play. ESD funds investigators and not coordination mechanisms, *per se*. The State Department funds support for the IPCC Secretariat. NASA works with State through the OIIR. For ground-based networks, there is an agreement for every international network that is facilitated through OIIR. State also helps NASA to get into places like Namibia and the Arctic, and provides public diplomacy efforts at the international climate summits. Dr. Freilich noted that NASA has significant investments in capacity-building and SERVIR; these are line items in ESD. He pointed out that NASA is unique in that it has statutory authority to make international agreements without the intervention of State. He also noted that while NASA remains steadfast in supporting open data, not everyone does. ESD often plays a key role in negotiating for data products and making them available to NASA-funded investigators. Mr. Friedl added that ASP invests generally where it feels it can best have an influence.

Discussion/Findings and Recommendations

Dr. Shepherd returned to findings and recommendations, first requesting a briefing on the aircraft assessment report that Bruce Tagg is conducting, to be presented at the Fall meeting of ESAC.

Members discussed a finding on international efforts: ESAC finds that ESD international collaborations are working successfully and efficiently and will enable effective implementation of Decadal Survey recommendations. Dr. Reinfelder commented that NASA invests impressive manpower into collaborations and should be applauded for doing this. Dr. Henze suggested NASA might consider participating in the Belmont forum and Future Earth. Dr. Schmitt's impression of the Belmont forum was that it involved tremendous overhead, and it was challenging to put proposals together. The forum may not be worthwhile for a US investigator. Dr. Glenn noted that there had been a recent NSF Belmont call in an Earth observation component, and that there may be an opportunity to pair up with NSF on the call.

As to a finding on the high impact/high-risk R&A charge, ESAC generally concurred on Dr. Shepherd's thoughts on the definitions. Dr. Henze asked to see some review panel anecdotes on selecting high-risk high-impact proposals, and also outcomes of program reviews, in order to get a better sense of the landscape. Dr. Romanou asked for information on how many high-risk proposals were actually selected. Dr. Tsaoussi felt it would be almost impossible to answer the question but added that there is a 2017 review of the Research Opportunities in Earth and Space Science (ROSES) program that is attempting to get a snapshot of how high risk proposals are being viewed in the current process. ESD is still going through the data, but it is important to know that this is not a final analysis. Dr. Glenn felt that some of the uncertainty has come from a clash of different ideas with what has been continuously or consistently funded in one program. Several committee members agreed on this note. Dr. Reinfelder recommended that a testable hypothesis be associated with each high-risk proposal. Dr. Tucker felt it would be useful to know whether reviewers were assigning risk to the investigation and not to the investigator. Dr. Tsaoussi noted that an inexperienced investigator does indeed pose a risk, and panelists must consider this as well.

On the subject of airborne missions, Dr. Kaye raised the question of whether ESD should own versus buy. There is also the question of whether NASA should have more sensors on the plane or more humans. Dr. Shepherd asked that ESAC address the issue in more depth after the release of the white paper. Dr. Tucker cautioned that if NASA does put instruments on other aircraft, it should be careful about the rules imposed on aircraft (pilot ratings, etc.) that can cause unexpected cancellations.

Wrapping up the Decadal Survey discussion, Dr. Joughin commented that there's a lot of work in the forums just to develop the mission, in addition to the considerable effort to avoid stovepiping. Dr. Kummerow argued that the Decadal Survey does not name implementations, and that it's important to keep multiple avenues as long as possible. The community must keep options open to take advantage of different or novel synergies with other missions. Panels must also address continuity; what does it mean? Is someone else going to fly the mission in the future? Dr. Dessler thought that ESAC should ask for some clarification on what NASA means by continuity. Dr. Tsaoussi suggested emphasizing the term continuity measurement, and not a specific mission. She also asked that ESAC clarify whether NASA should issue the RFI, and also make recommendations on how to implement the community forums. Dr.

Henze suggested using multiple rounds, beginning with open forums in 6 to 8 locations, followed by a selection of people invited to a smaller number of forums, engaging the "thoughtful responders."
Dr. Tucker suggested soliciting white papers from the community on priorities and key objectives that can lead up to mission implementation plans for Decadal Survey concepts. There can be three rounds: white paper, phase 1 broad community capture, then a third down-selection. Dr. Glenn felt community forums should cast a wide net, after which ideas can be narrowed down to targeted outcomes.

Drs. Shepherd and Tsaoussi confirmed that findings and recommendations were in consensus. Dr. Shepherd expressed his gratitude to the committee and to the support staff for their efforts. He adjourned the meeting at approximately 3 p.m.

Appendix A
Attendees

Earth Science Subcommittee members

J. Marshall Shepherd, ESAC Chair, University of Georgia
Andrew Dessler, Texas A&M
Nancy Glenn, Boise State University
Daven Henze, Colorado University at Boulder
Thomas Herring, Massachusetts Institute of Technology
Lucy Hutyra, Boston University (telecom)
Ian Joughin, University of Washington
Christian Kummerow, Colorado State University
Colleen Mouw, Oregon State University (telecom)
Anne Nolin, Oregon State University
Ying Fan Reinfelder, Rutgers University
Anastasia Romanou, Columbia University
Richard Rood, University of Michigan (telecom)
Ray Schmitt, Woods Hole Oceanographic Institute
Sara Tucker, Ball Aerospace
Lucia Tsaoussi, Executive Secretary, NASA Headquarters

NASA Attendees

Steve Cole, NASA HQ
David Considine, NASA HQ
T. Jens Feeley, NASA HQ
Michael Freilich, NASA HQ
Lawrence Friedl, NASA HQ
Sandra Cauffman, NASA HQ
Jamie Favors, NASA HQ
Ken Jucks, NASA HQ
Jack Kaye, NASA HQ
Barry Lefer, NASA HQ
Hal Maring, NASA HQ
Michael New, NASA HQ
Bruce Tagg, NASA HQ
Woody Turner, NASA HQ

Non-NASA Attendees
Lamont DiBiasi, SWRI
Mary Floyd, Zantech IT
Grace Hu, OMB
Eliana Perlmutter, Lewis-Burke Associates
Joan Zimmermann, Zantech IT

Appendix B
ESAC Membership

J. Marshall Shepherd, ESAC Chair
University of Georgia

Roland Burgmann
University of California, Berkeley

Ginny Catania
University of Texas at Austin

Greg Carmichael
University of Iowa

Andrew Dessler
Texas A&M

Nancy Glenn
Boise State University

Kass Green
Kass Green and Associates

Daven Henze
University of Colorado

Thomas Herring
Massachusetts Institute of Technology

Lucy Hutyra
Boston University

Ian Joughin
University of Washington

Jasmeet Judge
University of Florida

Christian Kummerow
Colorado State University

Colleen Mouw
University of Rhode Island

Anne Nolin
Oregon State University

Anastasia Romanou
Columbia University

Richard Rood
University of Michigan

Raymond Schmitt
Woods Hole Oceanographic Institute

Sara Tucker
Ball Aerospace

Appendix C
Presentations

1. Earth Science Division Update; *Michael Freilich*
2. Decadal Survey Summary; *J. Marshall Shepherd*
3. ESD Airborne Science Evolution; *Jack Kaye*
4. R&A Charge to SMD Advisory Committees; *Michael New*
5. ESD Approaches for International Mission Coordination; *Michael Freilich*
6. ESD International Non-flight Engagement Forums; *Jack Kaye, Lawrence Friedl*

Appendix D

Agenda

NASA Earth Science Advisory Committee

NASA Headquarters

Conference Room 3H42

300 E Street SW

Washington, DC 20546

March 14-15, 2018

Agenda

Wednesday, 14-March-2018

8:30	Call to Order, Opening remarks	L. Tsaoussi
8:50	Introductions & Meeting charge	M. Shepherd
9:00	Earth Science Division Update	M. Freilich
10:15	Coffee Break	
10:30	Decadal Survey Summary	J. M. Shepherd
11:00	Discussion	ESAC Members

11:45 1:00 Lunch

1:00	Discussion	ESAC Members
2:00	ESD Airborne Science Evolution	J. Kaye

3:00	Coffee Break	
3:15	Discussion	ESAC Members
4:00	High Impact Research	M. New
4:15	Discussion	ESAC Members

5:00 Adjourn

Thursday, 15-March-2018

8:30	SGE Ethics Training	T. Hayes
9:30	Public Comment	
9:45	ESD Approaches for International Mission Coordination	M. Freilich / E. Ianson
10:15	Coffee Break	
10:30	ESD International Non-Flight Engagement Forums	J. Kaye / L. Friedl
11:30	Discussion	ESAC Members

12:00 1:30 Lunch

1:30	Findings & Recommendations	ESAC members
2:45	Closing Remarks	J. M. Shepherd / L. Tsaoussi

3:00 Adjourn

Dial-In and WebEx Information

For entire meeting March 14-15, 2018

Dial-In (audio): Dial the USA toll free number 1-800-369-2007 or toll number 1-415-228-4743 and then enter the numeric participant passcode: 6340871. You must use a touch-tone phone to participate in this meeting.