

NASA ADVISORY COUNCIL

EARTH SCIENCES ADVISORY COMMITTEE

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MEETING REPORT

Sara Tucker, Chair

Lucia Tsaoussi, Executive Secretary

***Prepared by Kerry Pettit
Tom and Jerry, Inc.***

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Introduction

Dr. Lucia Tsaoussi, Executive Secretary of the Earth Science Advisory Committee (ESAC), opened the meeting by introducing herself and invited the committee members to introduce themselves. She then reminded everyone that all findings and recommendations would need to be discussed in the room because it is an open meeting. It was also noted that Dr. David Saah would be in attendance, as chair of Applied Sciences Advisory Committee.

Dr. Sara Tucker, ESAC Chair, welcomed everyone and stated that ESAC exists to support the Earth Science Division (ESD) and provide advisory information in the form of findings and recommendations. She emphasized that as the committee members listen to the presentations, they consider what should be recommended to the Division. She then indicated that the meeting would start with the topic of ethics training.

Special Government Employees Ethics Training

Ms. Clevette Lee, NASA General Counsel” provided the standard Ethics Training course for the ESAC members as they are categorized as Special Government Employees.

Earth Science Division Update (and ESO Strategy)

Dr. Karen St. Germain, NASA ESD Director, stated that the ESD greatly values the insights the ESAC brings to how the ESD approaches their jobs. She hopes to have a very fruitful session. In addition, ESD has two advisory committees: the ESAC and the Applied Science Advisory Committee. The ESAC has a broader scope, but it is very much related to, and it encompasses in many ways, the Applied Science group. The Applied Science Advisory Committee is chaired by Dr. David Saah. In the last couple of years, Dr. St. Germain stated, there has been an increased recognition that the Earth’s system is changing.

Dr. St. Germain stated that she will talk about the “why” and the “what.” You will hear more about “how” from our ESD team. I’ll include some of the challenges we are facing. You may have advice on how to navigate those challenges. Every year since 2013, I look at the World Economic Forum Global Risk Report. It highlights what people around the world—not just scientists—see as risks to global well-being. That is, what the public sees as the top risks to Earth systems are denoted in that risk report, from weapons of mass destruction to climate change. And for the last several years, Dr. St. Germain said, environmental risks have dominated that risk report in terms of both likelihood and impact. Couple that with the fact that over the course of a decade, maybe 12 years, we will have another few million people on the planet who will need food, shelter, and water. The demands on the resources of the planet will increase as the global distributed impacts of climate change increase. So, Dr. St. Germain explained, our space-based assets may provide some real benefit in mitigating these challenges, but only if we can get actionable information about Earth science. What is the NASA Earth science piece of that broader challenge, Dr. St. Germain posited? As we look forward, we are seeing not just that the climate is changing, but we are seeing distributed impacts around the world of that change. Climate change is experienced through wildfires, more intense draught, or flooding. That drives us to think about how to carry out our work. In the next few years, we will be looking at distributed effects. In response to the anticipated effects, Dr. St. Germain, stated that NASA’s Applied Sciences Advisory Committee is looking for actionable plans. Accelerating the pace of discovery, accelerating our understanding, and also the pace we get that information out to inform decisions. Development of actionable information. She acknowledged that this isn’t the job of NASA Earth Science alone, which is why she is so concerned about improving our data

capturing mechanisms and observing systems.

Dr. St. Germain then moved on to explaining the “what.” Three categories were developed as a result: “Deliver on our commitments. Aspire for the future we want to see. Inspire others.”

In the “Deliver” category, Dr. St. Germain noted that the ESD is working on delivering on their portfolio, which is no small thing given what has happened during the pandemic over the last couple years. They recently got first light from EMIT on ISS, demonstrating a successful EVI. She stated that she was at NASA’s Jet Propulsion Laboratory on launch day, in June, when two of the Division’s six TROPICS satellites were lost. NASA took a risk on a new launch company, and added that they are working with Launch Services to figure out the path forward.

This fall ESD is launching Surface Water and Ocean Topography (SWOT), which Dr. St. Germain stated will revolutionize oceanography, enabling scientists to see features they think are important in the roles oceans play in Earth systems and the change in climate. But there is more, she informed. Inland freshwater views will be seen at an amazing resolution. In the United States, we have a good inventory but SWOT will provide the first global inventory of inland fresh water.

ESD’s data systems do an amazing job (65 petabytes) of capturing and processing Earth Science data, she noted and SWOT/NISAR will double the data needs. The data team has a massive influx of new data to manage, and innovative ways to manage data are being created. Dr. St. Germain emphasized that this mind-boggling amount of data is delivered day in and day out. Currently NASA is serving out 250 TB/day, to 1 million registered users. She mentioned trying to deliver this level of service in the face of uncertainty and given the hiccups in workforce and supply chain. Changes in the way people work bring challenges and opportunities, she surmised.

She moved on to discuss the “aspire” aspect. ESD’s open-source science initiative represents technical and cultural changes. It can accelerate scientific discovery and the pace ESD can move from discovery to applications and actionable information. Dr. Julie Robinson, the new Deputy Director of ESD has been beneficial to Dr. St. Germain in moving the enterprise forward. At the same time, using the open-source science has a potential flip side, which is increasing the burden for the community to adhere to principles. Dr. St. Germain noted that this needs to be done smoothly. The Division must be very thoughtful, and it must initiate intelligent conversations. Last year, the Division announced the Earth System Observatory. The core missions of the observatory are the observables the Academy identified as important.

In Applied Sciences, the ESD has expanded applications to new areas of environmental justice, qualifiers in climate resilience, which are forming up applications now. The Division is also working on plans for an Earth Information Center. The idea is to make data and tools more relevant to more audiences. Dr. St. Germain stated that her team is optimizing the work being conducted within the Division and taking advantage of opportunities through philanthropies and non-profits. When the Earth System Observatory is launched, ESD wants to do it using open-source science principles and do it in such a way that those missions are on-orbit at the same time. The question for the Division is how to maximize not just the science for individual missions and support but also the cross-cutting science teams? The open-source science initiative will change the culture of science and the reward system, Dr. St. Germain stated. She added that she thinks NASA can enable more vibrancy in the community.

Dr. St. Germain then spoke to the notion of “inspire.” The ESD is ramping up its communications capabilities with those outside the scientific boundaries. She described an example in which she was attending a commodity consortium in March of 2022 where a number of people told her they had no idea that NASA had anything to do with agriculture. She stated that she thinks we learn by asking questions. Would farmers share data with us? Last month, she added, she went to a California-based agriculture

meeting. Water issues are different there. She's embarking on an agriculture road show in Kansas and Nebraska, stating that inspiration is a big focus, and she's reaching out to make connections.

In summary, Dr. St. Germain informed that the ESD is bringing new people into the workforce/enterprise. The demands for what the Division does are ever-increasing, all in an effort to collectively do better every day. She ended her presentation by noting that NASA is better-known for the aspirational, exploratory work in the universe, but Earth holds everyone we know and everyone we love. Dr. Tsaoussi then asked for questions from the committee.

Dr. Jasmeet Judge stated that SWOT could miss some quick floods, given that it can make one to two observations every 20 minutes. What are your thoughts of the future (10 years) to start making these radar missions quicker? How do we hasten the temporal revisit times? Dr. St. Germain offered a couple answers, which rely on a portfolio of tools. NASA has to have a mix of missions that make observations with higher fidelity so new discoveries can be made about processes and so NASA can learn from those that improve performance. However, she added, NASA cannot field everything at the highest trend of performance and refresh. That's one part of the answer. It's a mix of capabilities. The other piece of this answer, she indicated is partnerships. Partnerships are important. NASA just signed a partnership with the European Space Agency to coordinate planning. This will give scientists the potential to enable the broader Earth science community. Also, domestic partnerships are very important, as with NASA and the National Oceanic and Atmospheric Administration. Dr. Judge thanked Dr. St. Germain for her thoughts on the topic.

Dr. David Saah asked Dr. St. Germain what she believes to be her biggest challenge. Dr. St. Germain replied that she thinks it is a combination of trying to deliver on what is an aspirational set of commitments and, at the same time, make the adjustments NASA is trying to make to increase the pace of the future. The biggest challenge she feels is meeting the demands of the future. She added that simultaneously delivering on commitments and trying to scale. She mentioned in passing the partnerships with philanthropies and non-profits. To really leverage and take advantage of the interest and resources requires an investment of time to build relationships. She added that this scaling problem puts a real strain on her team at times; trying to scale what the team does to have the desired impact is a big challenge. Dr. St. Germain indicated that Dr. Saah posed a good question that she hopes to come back to later.

Dr. Belay Demoz asked if open science would be a one-time thing. Dr. St. Germain stated that "open science" is thought of as the general principles talked about broadly. "Open-source science" is the NASA response, the policies, the initiatives, etc. In the case of open-source science and what it enables, like artificial intelligence, which is a Science Mission Directorate (SMD)-wide initiative. Earth Science has been asked to lead. In FY 2023, NASA is bringing in partners, like the American Geophysical Union (AGU), to lead initiatives to train the community. Once it is cracked open, it will stay open. With regard to the initiative to engage with new communities, Dr. St. Germain thinks NASA is committed to those activities, and also realizes there are things to learn (framed as pilot activities). It's a "learn-as-we-go" model, she added.

Dr. Lucy Hutyra posed a question concerning the Oak Ridge National Laboratory (ORNL Distributed Active Archive Center), and how the organization has been overwhelmed with requests for data. The speaker noted that they would like to hear an update on where the DAACs fit in. Dr. St. Germain stated that instead of doing a deep dive, she would say that the ESAC will hear more about that later. All of the DAACs are responding to increasing requests in data to serve users across the domains. We can't meet every user's demands. We're working on scaling what we do, taking advantage of cloud technologies.

So how will the gap be bridged? What about capabilities in communications? Dr. St. Germain noted that the data still adds value even if people don't know where it comes from. She doesn't want to overly emphasize the credit in all of this. Feedback is essential. It all starts with communicating. She stated that we should have communicators help communicate—the program is hiring people write the higher-impact stories to communities, and not just send messages on NASA websites, for example. Communications support is being put in place to communicate what we do and what we're planning to do. The Applied Sciences group is focusing domestically. They have something similar to a Help Desk. Dr. Saah said that on Applied Sciences side, SERVIR works globally to conduct assessments to help farmers. This ties into the open science component. Dr. St. Germain indicated that they've had partnerships but they're focusing on new types—who are the trusted organizations in place?

A final thought was expressed about gaining an understanding of what falls into the Deliver, Aspire and Inspire approach. Dr. St. Germain noted that it is a multi-year effort. She added that ESD is discussing bringing more people into the enterprise and talking about commercial data buy, which is a rapidly changing landscape.

Earth Systematic Missions & Explorers Update

Dr. Katie Boggs indicated that she would focus her presentation on Earth Systematic Missions (ESM) Program and Mr. Greg Stover would discuss the Earth System Science Pathfinders (ESSP) Program, including some of the challenges faced to date. She provided a quick overview of the entire portfolio. Four missions are in pre-formulation; two in formulation; 13 in development; and roughly two dozen missions on orbit. She indicated that the ESM and ESSP make up about half of the Earth Science budget. ESD program executives have to be flexible, and are given multiple missions in different phases of formulation and development, and of different sizes to give them a broad range of experience.

Regarding the various missions – The Atmospheric Observing System (AOS), in pre-formulation, is undergoing an independent review. There was an anomaly on Suomi-NPP, but everything is back and operating now. The JPSS-2 OMPS limb instrument has been integrated, the JPSS-3 OMPS Limb in storage, and JPSS-4 will be delivered for integration and test on 9/22. There was an issue with the SWOT transport – it was supposed to be on a Ukrainian aircraft, but now they are looking into US Air Force transport. They also discovered some interference between the SIT-2, L-SAR, & S-SAR payloads in testing. They are re-evaluating cost and schedule and will meet with ISRO and the joint steering group in August 2022.

NISAR & PACE were in a critical build phase when COVID hit. Covid impacts in 2020 & 2021 range ~\$100M/year – largely in the NISAR & PACE programs.

On PACE, CDR was held Feb 2020, and it is an in-house GSFC build. The Ocean Color Instrument (OCI) is fully integrated, ready for system level I&T. PACE KDP-D in November is likely to slip a little. The Launch Readiness Date (LRD) is currently – May 2024. On PACE – we will get the performance we build, vs. what was planned. The design to cost approach has been influenced by the government shutdown and COVID. For TSIS-2 – It is supposed to launch on a General Atomics spacecraft, which is new to space industry. The launch is under VADR – a new launch contract task order – which means the program gets the launch vehicle before the mission PDR.

Sentinel 6B is in a holding pattern until launch in 2026. Landsat Next is on the cusp of going to KDPA. After discussing the current operating Earth systematic missions, Dr. Boggs welcomed any questions. A question was posed pertaining to potential supply problems with the launch vehicles. Dr. Boggs stated that across the program, the long-lead parts have been challenging to secure. We're seeing long leads as much as two years on things. Also, inflation is another issue. NASA's inflation index is a concern.

Dr. Lucy Hutyra asked about the impact of the Russians pulling out of the International Space Station (ISS). Dr. Boggs indicated that they don't have any official communications being pulled by the Russians on the ISS. No official impact on right now on us. For most missions under Greg's management, we're looking for extensions on those dealing with ISS. That may certainly be a challenge. There's the Commercial Low-Earth Orbit Destination activity, which will help support missions.

Dr. Henze indicated that K. St. Germain mentioned greenhouse gases earlier. He asked Dr. Boggs if the committee would hear more about the carbon monitoring with the Environmental Protection Agency. Dr. Boggs stated that she did not plan on talking to that. She added that the Earth Science Flight Missions will provide carbon observation data.

A final question was directed about how Dr. Boggs is working to flow the diversity down (the designated deliverables) in her teams. Is there something we as a committee can do to help? Dr. Boggs mentioned that one of the teams is currently all male, but she is working with the project managers and partners at Goddard and the Jet Propulsion Laboratory to include women. She added that diversity is not something she can direct, but she noted the importance of bringing more women and minorities into the program. She thinks endorsement for that continued focus would help. Dr. Tsaoussi indicated that diversity initiatives within the SMD and the ESD actively support greater inclusion actions.

Earth System Explorers Program Office

Dr. Boggs then provided insight on the Earth System Explorers (ESE) Program. The program's establishment and tailoring approach was approved by the SMD Associate Administrator and endorsed by the Program Project Management Board in July 2022. System Requirements Review and System Definition Review will be combined. KDPI will be held by end of 2022. ESE will be a 2 Step AO – 1st with the first step later this fiscal year and a 9-month phase A. Working to stagger the missions with other divisions. Budget will be \$310M, FY24, with NASA to provide launch services. The team is working to identify potential members to establish the Standing Review Board for ESE.

The Earth System Observatory, within the Earth System Explorers Mission, will focus on the following targeted observables: greenhouse gases, ozone and trace gases, atmospheric winds, ice elevation, snow depth and water content, 3D ecosystem structure, and ocean surface winds and currents.

A question was posed concerning when the actual mission will fly. Dr. Boggs stated that the mission flight will occur later this decade (2028-2029). It'll be before the next decadal survey; all missions are experiencing timeline challenges right now.

ESAC Discussion:

The group then discussed ways to increase diversity and bring in students, mentioning areas of success such as field work in SBG, where scientists work aggressively to bring in students.

Lucy Hutyra commented that supporting MSIs, and diversity, is important. There are large requirements for (up to 1/3) grant budgets to go to MSIs, but the support is not there - they don't have the implementation and institutional capacity. Need to help build capacity.

Jack Kay then discussed how R&A is engaging MSI's using a tactical vs. strategic approach. They are working with and tightening the relationship with the Office of STEM engagement, EPSCOR, SPaceGrant, and other groups making targeted efforts. Cost collaboration efforts going on in the ocean biology area. R&A has also directed funding specifically to MSIs to increase participation in surface-based measurement networks. They asked the question of what would be most helpful and then did a ROSES

element to provide funding for Aeronet and Pandora networks. They received 22 proposals and will probably fund 15 of them. They will separately provide funds to buy the instruments thus helping to build institutional capacity. These efforts will give students experience with the data and instrument support, satellite validation, atmospheric physics and chemistry.

Open-Source Science

Ms. Katie Baynes, NASA Deputy Chief Science Data Officer, discussed the relevant topics in open-source science. She began by defining what the term, “open-source science” means to NASA: it is the agency’s method for putting open science into practice. She explained that the practice aims to:

- Open the entirety of the scientific process from start to finish.
- Engage the community in the scientific process and development of best practices.
- Create openness and accessibility of data, software, and publications to facilitate inclusion, transparency, and reproducibility.

An SMD-approved strategy has been established for transformational open science through continuous evolution of the division’s science data and computing systems. The three goals of this strategy are to:

1. Develop and implement capabilities to enable open science.
2. Enable continuous evolution of data and computing systems.
3. Harness the community and strategic partnerships for innovation.

Ms. Baynes then explained why open science is so important. For example, the scientific community at large needs more people—more hands, more eyes, more brains—with diverse experiences to participate so that the best questions can be asked, and the best solutions can be found. Open science accelerates the pace of science, increases the impact of science, expands applications of data and science, and shares hidden knowledge and expands participation in science.

The four open-source science principles (i.e., transparency, inclusiveness, accessibility, and reproducibility) embrace the values of “FAIR” (Findable, Accessible, Inclusive, and Reusable). Open **transparent** science requires scientific processes and results to be visible, accessible, and understandable. Open **accessible** science necessitates that data, tools, software, documentation, and publications be accessible to all. Open **inclusive** science means that processes and participants should welcome participation and collaboration with diverse people and organizations. Finally, open **reproducible** science refers to scientific processes and results that are open such that they are reproducible by members of the community.

Ms. Baynes added that advancing science requires the sharing of information. How information is shared matters—it affects the impact, the transparency, the reproducibility, and the accessibility of research. She noted that it is important to be as open as possible, and as closed as necessary. The current Scientific Information Policy (SPD-41) in effect pertaining to data, software, and publications at NASA is as follows:

- **Data:** Scientific data shall be made publicly available with a clear, open, and accessible data license no later than the publication of the research. Mission data shall be openly available with no period of exclusive access.
- **Software:** Research software should be publicly available no later than the publication of the research and assigned a permissive software license.

- **Publications:** Versions of accepted manuscripts shall be deposited in a NASA repository and made publicly available within 12 months. Mission publications shall additionally be made publicly available at the time of their publication.

Proposed updates to SPD-41* (SPD-41a) include the following (in blue text):

- **Data:** Scientific data **should be FAIR** and shall be made publicly available with a clear, open, and accessible data license no later than the publication of the research **and be citable**. Mission data shall be openly available with no period of exclusive access.
- **Software:** Research software **shall** be publicly available no later than the publication of the research and assigned a permissive software license **and be citable**. **Mission software shall additionally be developed openly in a publicly accessible, version-controlled platform that allows for contributions and engagement from the community.**
- **Publications:** Versions of accepted manuscripts shall be deposited in a NASA repository and made publicly available within 12 months. **Publishing as open access is supported and posting preprints is encouraged.** Mission publications shall additionally be made publicly available at the time of their publication. Science workshops and meetings shall be open to broad participation and documented in public repositories.

***Note:** Open science activities will be considered in reviews of proposals.

Ms. Baynes then spoke about a proposal for SMD (slated to be complete in three years) to provide common capabilities useable by all divisions. The directorate will develop core data and computing services to be used as building blocks by divisions and the open science community. The four objectives of this proposal include:

- Divisions will develop and operate division-specific requirements (missions and science capabilities) within SMD core systems.
- Meet open-source science goals in the data and computing strategy for SMD and requirements in SPD-41.
- Reduce cloud environment development duplication and barriers to speed of adoption.
- Improve computing infrastructure to seamlessly provide access to high-performance computing and cloud resources while reducing cybersecurity risk.

Ms. Baynes explained that SMD's core data and computing services will expand to include infrastructure to support open science. Scientific data and computing capabilities will be reusable by all divisions. These core services will include research data and software archives; hybrid/cloud scientific computing environments; publicly available collaboration tools (e.g., GitHub and Jira); scientific information and knowledge management; and open-source science training.

Dr. Tucker asked if costs of infrastructure and archiving would this be covered in a PIs proposal and budget. Ms. Baynes explained that her team has asked for cost models, as an example. Longer term, they will take a more intentional approach. They've been looking at what the National Science Foundation has been doing. What they call the hybrid/cloud scientific computing environments refers to internal NASA missions.

Ms. Baynes described how her team is reflecting on ways they can adapt existing infrastructure to better serve users while evolving Earth science data systems to support open science. Migrating data to the

cloud environment, preparing for the Earth System Observatory era, and community engagement are focal areas. Ms. Baynes indicated that the top 75 data products will be migrated (and supported) to the Amazon cloud by the end of 2022. The general public is the intended user base. They plan to support the same model they have always supported—download and process. How does her team size right-size it? They are looking at creating a NASA OpenSpace.

After the open-source science summary, Dr. Judge asked about how Ms. Baynes plans to confirm data quality. Dr. Robert Wright added that he doesn't want NASA to propagating rubbish. Ms. Baynes explained that the Data Quality Act applies to government data, not research data. She believed two separate things are being conflated, noting that they don't want to put individual researcher data into the data archive. There's a DAC selection process; tracing of data origins, she added. Dr. Indrani Das asked if there was a way to avoid publishing data without data assessing process? Ms. Baynes replied that there absolutely is a way, and it is a very official, intentional process.

ESAC Committee discussion focused on providing clarity behind the requirements. NASA needs to provide clear instructions to PI's on what to do to make data open, and clear definitions of terms such as "available" and what constitutes "software" that must be provided, and where data must be stored and for how long. And how these terms may vary for each level of funding (grant, mission, etc.). The overall concern was about burden of the OSS requirements on PI's.

Dr. Robert Wright also mentioned that data should come with description of what it can do and with uncertainty values.

There was a discussion about the need to change incentivization from H# (H-index – publications) to teaching, but that cultural barriers, especially in academia, may be difficult to overcome. Katie Baynes indicated that NASA is putting **\$40 M toward encouraging cultural adoption, including the** core open science curriculum funding to AGU to develop material/courses on how to share data, archive etc. Folks can get a TOPS badge. AGU is also designating 2023 the year of open science.

Earth Venture Update - G. Stover

Greg Stover reviewed Earth Venture (EV) missions, characterizing them as 1-2 year observation missions for quick understanding of something. He claims they have an "immutable cost cap" and that they can be Class D, meaning they tolerate more risk, hopefully getting greater science for the cost.

Regarding TROPICS – the satellites don't have good cross section (meaning they will suffer more drag) and they have no propulsion, so NASA will launch 1 pair next, then figure out an optimal node for the last launch (2nd pair). TROPICS SV-1 will go to a polar orbit.

GLIMR to launch ~2025 to GEO (340-1040 nm spectral range), and the INCUS EV-M launch will be NET 2027. On MAIA – David Diner collaborated with health organizations to look at impact of air quality on health. Instrument development for MAIA will finish September this year, and they will get a ride from Italian Space agency to get access to space. GEOCarb still has a solicitation out for spacecraft. The TEMPO air quality instrument is being integrated on a Maxar IntelSat commercial Comm. ECOSTRESS & CYGNSS – and moving into extended operations. ECOSTRESS - Showing plant health and impacts of heat.

Modeling Strategy Development D. Considine

The group is looking to have fully comprehensive models that can assimilate aircraft, ground, space data. They will provide a draft of the strategy to ESAC. Modeling tools include coupled data assimilation (DA) with NOAA/NASA (GEOS-DAS), NASA GEOS, and Unified WRF (regional).

The efforts leverage external components and processes (modeling code – e.g. NOAA sea-land surface model).

NASA feels they can't rely on competition, but rather need to act as the hub of a wheel – covering the large scale programmatically important & directed work, with competed efforts as the spokes. They will use peer review on the core work.

Regarding computational resources – they need to move toward exascale and expand & improve internal model resources. They are developing internal science cloud computing (ADAPT).

When asked about computing resources vs. cloud - Tsengdar Lee referred to the HEC. They rely on computing strategy, accelerated GPUs, and higher resolution with faster processes. When asked about JCSDA he mentioned NASA is involved and part of the solution for JEDI DA system and coupled earth system model. JCSDA is a very important partner. Coupled earth system models, coupled E.S. assimilation, initial conditions. JC is moving toward coupled data analysis. Also working w/ ECMWF/ESA project.

Decadal Survey Incubation Studies R. Bauer

Robert Bauer reviewed the Decadal Survey Incubation objectives and the work done so far in this area, and reviewed the projects that were funded under the recent ROSES call. They have funded \$29M in total so far. Some of it was DIRECTED work (augmentations) for the DSI program to leverage other efforts. The CPEX-CV field campaign was directed. When asked how many people on the study team were selected for incubation studies, Robert was unsure. NASA will also issue an RFI for other community involvement.

ESAC Discussion

Dr. Daven Henze asked if anything is being done with machine learning and artificial intelligence (ML/AI) capabilities within OSS? The answer was “not yet”.

Dr. Lucy Hutyra asked if Greg could talk more about GeoCarb. Greg said that Lockheed Martin is working on the spectrometer and they are finding the optical alignment to be very challenging. In addition, there are not a lot of GEO spacecraft due to issues with SEC clearing C-band, pushing GEO missions to accelerate their timeline.

Indrani asked about Ice Sheet models? In the bigger ice-sheet system models. Tsengdar replied that, like cloud resolving models, it's hard to plug them in with sufficient details.

Someone mentioned developing an emulator of the model and using a copy of the model to optimize - using AI/ML and observations to focus on developing a better modeling system. JPL (Echo System) has some GEOS-5 AI/ML.

Dr. Beth Plale made a few comments – first she emphasized the need to elevate the OSS initiative, “it's good and forward looking.” Katie Boggs led off talking about gender gap, which is good. “Women are the face of flight” however NASA needs to bring in allies in so women aren't responsible for doing it alone. Dr. Plale is also concerned about public assets initiative NPD2200.1 out of the office of chief scientist and feels ESD will need to harmonize OSS with that. She also mentioned that underserved institutions are short on supporting staff and cyber-infrastructure – so NASA needs to work to get them help. Perhaps help connect Amazon Web Services to underserved institutions.

Robert Wright mentioned the 2008, JPL PI-Launchpad workshop and suggested that SMD hold more of these and advertise more.

Dr. Lucy Hutyra posed a question about diversifying the PI pool. Dr. Colleen Mouw mentioned a science team she's familiar with that has only one female on it. Dr. St. Germain responded that “there is a lot of memory in the system” and that these are fair criticisms, but they are taking steps.

Dr. Mouw also brought up the need to deal with Institutional Offenders as often this information is not fed

forward. Offenders continue to be superstars @ institutions because they get funding.

NASA response was that they have gotten reports from Institutions and now they have rules about selection that can go higher than what the panel selection may have chosen.

Dr. Lucy Hutyra suggested a Recommendation to include FINESST awardees in more investigations, and suggested providing more FINESST awards.

Jasmeet Judge suggested inviting students from MSI's to be on review panels to introduce them to the reviewer part of it all. She suggested having 2-3 guests to observe the process (e.g., in person or remotely) vs. participate. NASA response was that it is not possible to just observe.

Dr. Belay Demoz encouraged earlier evaluation of pilot experiments and emphasized that a long and intentional focus was needed to maintain trust.

Jack Kay mentioned that they are looking more closely at composition of panels. Lack of MSI's may have biased results in the past. Now they often do virtual panels which increases participation. Virtual panels open up opportunities, but the downside is you lose the benefit of interacting w/ peers. Now 75% of panels are virtual, some are hybrid. They are giving exception – like building new community. Dr. Kay also mentioned the MSI surface-based measurements effort to include people from MSIs, but emphasized that it's good to get their input/feedback to build a real community of investigators and reviewers. He also thought folks could use more reminders to self nominate – and suggest alternates from peers to improve panel diversity. He also mentioned that first time panel reviewers take the process really seriously and are very thorough.

Dr. Julie Robinson mentioned that Ben Philipps presenting on IDEA tomorrow – and that this topic is very cross disciplinary. She asked the committee to think about what's good for ESD what's good for SMD. This is a cross-cutting issue. She wondered if perhaps they should invite all committees to sit in on a FACA meeting on this topic, and suggested looking at at SERVIR for (ideas).

Dr. Tucker adjourned at 5:03 p.m. EDT.

Day 2 – 3 August 2022

Justice, Equity, Diversity, and Inclusion

Dr. Tucker introduced Dr. Ben Phillips, NASA's Earth Surface and Interior Focus Area Lead, to discuss current Justice, Equity, Diversity, and Inclusion (JEDI) efforts within NASA. Dr. Phillips began by presenting background information on NASA's SMD and ESD activities. At NASA, he explained, inclusion is a core value. NASA is committed to a culture of diversity, inclusion, and equity, where all employees feel welcome, respected, and engaged. For example, SMD Science Strategy 4.1 seeks to increase the diversity of thought and backgrounds represented across the entire SMD portfolio through a more inclusive and accessible environment. This cultural perspective at NASA aligns with President Biden's 12 Executive Orders/Memos, which promote the advancement of racial equity and support underserved communities through the Federal agencies, policies, and programs.

The NASA Equity Action Plan of 2022 includes four foundation focus areas: 1) Equity in Climate Data Accessibility and Environmental Justice (ESD's alignment area); 2) Equity in Procurements and Contracts; 3) Equity in Grants and Cooperative Agreements; and 4) Equity in Civil Rights Compliance and Accessibility to Limited-English Populations. Dr. Phillips indicated that the ESD JEDI Working Group falls within the first foundational focus area with a mission to create and promote a just, equitable, diverse, inclusive, and an

accessible environment for underrepresented groups within ESD and the communities it serves by identifying, proposing, and implementing achievable actions. Dr. Tucker emphasized the importance of implementing achievable and *measurable* actions.

Dr. Phillips stated that alongside the JEDI efforts, the ESD Equity and Environmental Justice (EEJ) function has established the following five distinct goals, rooted in the present with the intention of growing into the future:

- Goal 1: Assess ongoing environmental justice engagements, barriers, gaps, and opportunities.
- Goal 2: Engage with organizations involved with environmental justice and harvest lessons and potential partnerships for the strategy.
- Goal 3: Host data accessibility and utility sessions.
- Goal 4: Enable transdisciplinary science and applications that integrate physical and social science using NASA datasets.
- Goal 5: Incorporate Equity and Environmental/Climate Justice themes across ESD programs.

One approach instituted within ESD is the “Speak Up (Did You Know) Series.” Dr. Phillips stated these series have been produced and curated by JEDI and championed by ESD leadership. The goal of this series is to promote the use of inclusive language that demonstrates commitment to making everyone feel like they belong at NASA and beyond.

Dr. Phillips then presented the ESD EEJ programmatic initiatives. Of particular interest is the Research Opportunities in Space and Earth Sciences (ROSES)-2021, A.49 initiative. This ESD program element solicited proposals to advance progress on EEJ domestically through the application of Earth science, geospatial, and socioeconomic information. ESD is especially interested in proposals from or partnered with non-Federal domestic organizations, community-based non-profit institutions, tribal governments, local governments, and academic institutions active in addressing EEJ issues that would benefit from the insights offered by NASA Earth science information.

Dr. Phillips stated that selection for ROSES-2021, A.49 is complete. The initiative will focus on three areas of interest: landscape analyses, feasibility studies, and data integration projects. First, landscape analyses, which will use participatory data collection and assessment processes to increase NASA’s understanding of the EEJ “landscape” through short-term efforts focused on specific communities. The duration of the analyses will be between 6-9 months and less than \$100K per award. Dr. Phillips added that feasibility studies will explore and test ways to address environmental issues facing environmental justice and underserved communities with the help of Earth science and geospatial information. Near-term studies will determine feasibility of use for further pursuit. These studies will have a duration period of 12-18 months. Each award will be less than \$150K. Finally, Dr. Phillips spoke to the data integration component of the ROSES-2021, A.49 initiative. The goal is to develop, test, and demonstrate sustained use of integrated Earth science, geospatial, and socioeconomic data, tools, and/or applications to support environmental justice communities with novel insights into community-level management. This component of the initiative will be 12-24 months in duration and less than \$250K per award.

Dr. Phillips then explained geographic reach of the 39 proposals accepted. Specific thematic areas will address direct and indirect community impact throughout the United States. The breakdown follows:

- Landscape Analyses: agriculture and agricultural burning; air quality; climate hazards; extreme heat and urban heat islands; flooding; greenspace/tree equity; transit stops/prisons; water resources; wildfires; and cross-cutting.
- Feasibility Studies: air quality; coastal resilience; energy; extreme heat and urban heat islands; greenspace/tree equity; transit stops/prisons; wildfires; and cross-cutting.
- Data Integration Projects: agriculture and agricultural burning; air quality; climate hazards;

extreme heat and urban heat islands; greenspace/tree equity; transit stops/prisons; water resources; and wildfires.

Dr. Phillips indicated that diversity is key in selecting the ROSES Review Panel. Guidelines for selection of panelists were codified in the SMD Science Policy Document (SPD). SPD-08: Requirements for Selection Documentation for NASA Research Announcements, including ROSES, includes the following requirement:

“An outlined of how Program Officers addressed diversity (including, but not limited to gender, race, career stage, and institution type) during panelist recruitment and promoted inclusive panel conduct. Where possible, Program Officers should report on panel diversity in an aggregated and anonymized form.”

Dr. Lohman stated that the ROSES Review Panel approach reminds her of faculty searches that include a diversity statement in some applications. She asked Dr. Phillips if there was a plan to give potential Principal Investigators (PIs) training for what should be included in the efforts. Dr. Phillips responded affirmatively, adding that they have also pulled language in to articulate what is expected. Dr. Hutyra stated that it may be a good idea to create a template to standardize the diversity and inclusion plans for panelists too. Dr. Plale asked about how NASA is learning from this pilot effort and Dr. St. Germain responded that each division has something like this effort and the division directors will get together a year from now and pull evaluations together for the second phase.

Dr. Phillips segued into an overview of the new mission PI resources, which include a webpage to capture resources supporting proposal writing, mission resource planning and management, and references to NASA’s policies on harassment and non-discrimination. Launchpad Workshops are another tool for new mission PIs. These three-day training seminars help make developing flight mission proposals more transparent and accessible. They also include discussions on forging scientific, technical, and management partnerships to support development of an Earth Venture proposal.

Dr. Phillips also presented concepts from the partnership between NASA and the Indian Space Research Organization Satellite Aperture Radar (NISAR) collaboration. The NISAR IDEA Working Group has been stood up to unlearn racism in geoscience. The number one goal of this group is to ensure that members can model behaviors reflective of diversity and inclusion principles. The second goal is to establish and nurture partnerships and mechanisms that foster inclusion of diverse communities in NISAR science. The third goal is to develop science and applications projects and engagement centered on environmental and social justice. To date, several universities are actively engaged. Hampton University has established satellite data analysis involving minority students in environmental science. Prairie View A&M University is studying global climate change and ecological changes over time. Howard University is evaluating wildfires and biomass burning and the impact on climate change soil interactions.

Dr. Phillips concluded the presentation on NASA JEDI by emphasizing that actions are most effective when developed cooperatively with the ESD community. He left the ESAC members with a few questions for consideration:

- What are the primary challenges you and your institutions are facing?
- What kinds of solutions are your institutions bringing forward?
- How might these apply to NASA ESD JEDI efforts?

Dr. Lohman mentioned that the Inclusion Plan is a fantastic idea, especially for established researchers and noted that new faculty or PI’s may need help on how to create it, and wondered how this requirement

might impact young/diverse research faculty. Dr. Mouw suggested having a DEI expert present on all panels. This effort needs to go beyond the ESD program – all ROSES programs need to require DEI if NASA is really serious about this. Dr. Hutyra mentioned that NASA could learn from NSF. NSF is looking at the broader impacts of these requirements. Dr. Das stated that in order to really do things right, perhaps PIs could have a secondary PI who is a social scientist? Dr. Henze applauded the effort and mentioned that the community needs clarity on what D&I means. If it's only a "special matter" then panelists are not sure what to do with the information. Dr. Lohman acknowledged that these changes take time to filter through the system, and Dr. Demoz thanked Dr. Phillips and appealed to other program officers to take a similar approach to including D&I in proposals.

NASA mentioned that D&I is being required in the EVI-6 AO, and that PI launchpads are being held every other year to help address questions.

Research & Applications Coordination

Dr. Jack Kaye, Associate Director for Research of ESD of NASA's SMD, presented highlights from the 2017 decadal survey—developed by the National Academies of Sciences, Engineering, and Medicine—which identifies scientific priorities and opportunities and makes funding recommendations to maximize the advancement of planetary science, astrobiology, and planetary defense in the next 10 years. Dr. Kaye focused on an element of the decadal strategy: amplifying the cross-benefit of research and applications.

He indicated that curiosity-inspired science will always be central to Earth observation and analysis. But a growing portion of our science is use-inspired or closely related to the applications it enables. Inspiration goes both ways, he noted. Science inspires applications scientists and engineers, and end-use needs can inspire research scientists and engineers. Embedding science in the applications process often reveals new and inspirational scientific questions driven by those end-uses not well-recognized by research scientists.

Dr. Kaye mentioned the concept of Tiger Teams (TT) to co-develop proposals with local communities. Such proposals go through a mini review process to see if they can get funding for a special project to get application into use. There have been 4-5 TT projects per year. In the AS area, the Health & Air Quality Science Team (HAQAST) is on 3rd iteration of teams with 12-13 researchers funded per team. Team members have two roles (1) do research (2) act as tiger team (TT) members.

Dr. Kaye also mentioned several other activities taking place in the R&A area, and talked about R&A funding augmentation to extend work into applications and promote end-user engagement. Many of these opportunities have an open due date, but they have found that they end up seeing few responses. Someone on the committee asked, what are the requirements for getting the "applications" funding and suggested a guide book for people who may wish to join the A.S. Teams.

Dr. Friedl mentioned the Future of Earth Science Division (ESD) Teams (FEST-ive) – Strategic working group, designed to explore new model of science teams (STs). The group is studying success criteria, government structures, financing models, OSS, IDEA composition, purpose/process, & change management. They plan to have a final report by end of CY2022

Dr. Lohman mentioned that students have an increasing desire to get into applications and asked if there could be a FINESST call with an applications focus?

Others expressed concern that FINESST acceptance rates are low and asked if students have what they need to join applications teams.

Venkat also suggested that anything that comes out of the Applied Science efforts that could go into publications will help students because "output" is really important for students.

Dr. Kaye then presented a recap of an ESAC meeting held March 10-11, 2020. ESAC was expected to review ESD's approach and its current activities to amplify the cross-benefit, providing advice about strengths, missions, and commissions. ESAC is expected to identify any findings and recommendations on the topic as well as identify any issues to address at future meetings. The result of that session was a summary of where ESD might have strategic opportunities to amplify cross-benefit. To ensure consistency in usage during the current discussion among ESAC members, Dr. Kaye defined baseline terms applied during the March 10-11, 2020, ESAC meeting. NASA Earth Science has defined *science* to include research, applied research, and applications.

- **Research:** A fundamental learning to explain phenomena and understand processes in the natural world.
- **Applied Research:** Development of scientific knowledge directed to particular results and codification of knowledge in models and tools for predictive capabilities.
- **Applications:** Uses of data, information products, and model outputs to inform decisions and actions of organizations for non-research purposes, such as policy, business, and management activities.

ASAC Report

Dr. David Saah gave an update on the Applied Sciences Advisory Committee (APAC). He mentioned that membership is very diverse in APAC and includes people from conservation organizations, industry, USAID, and others. The committee meets once per year and the last meeting was December 2021. During the meeting the group spent a lot of time talking about diversity. He mentioned that there are a lot of varying ideas on the committee so finding consensus for recommendations has taken some time. During the APAC meeting they received a Detailed overview on ESD changes, flight program, and discussion about how to get applications into the flight program early on. The group had a long conversation about how to get private sector engagement and infrastructure in place. They also had a conversation about academic reward structure and the need to shift from H-index. They noted that if one wants the diversity to be real, a diverse funding capability is needed. The group discussed several questions such as, "how to build a cross-disciplinary team? How to build careers with different incentives. How to build consortium ." Dr. Saah discussed the idea of coordinating future ASAC and ESAC meetings so that they would overlap for a joint committee meeting one afternoon?

ESAC Discussion

Dr. Hutyra mentioned that many students are now wanting to come to university to do something more than pure science, however under the core/basic sciences it's hard to find funding for students to do applications work. Still, the desire is stronger now in students to do applications, so NASA could help with funding them.

Jack mentioned the augmentation program that requires 5 pages in a professor's proposal to add augmentation to the award for doing applications. Dr. Hutyra mentioned that she hadn't heard about the new augmentation effort and suggested that the barrier to get such funding should be low and should not rely on the target (professor's work). Likewise Dr. Mouw was concerned that 1 year of funding is not enough to get applications work done and felt that NASA shouldn't make it a requirement for the Science PI to apply for the Applications funding. All agreed that NASA will need to teach faculty that there are incentives to do Applications. Dr. Lakshmi mentioned that there are also congressional fellowships in policy. Dr. Hutyra mentioned that students are often coming to university for experiential development, and to learn new ways of doing things. She also commented that regarding Policy vs. Applications – perhaps policy briefings could be considered as publications. Dr. Lohman wanted to emphasize the flexibility element of funding for students. She mentioned an example of a JPL internship experience

where the person is still working w/ JPL after graduation.

Dr. Demoz described a student program at NOAA funded centers – NOAA Experiential Research Program (NERP). Last round there were 12 students in the program and only 3 eventually went to work at NOAA – largely because they had good relationships with mentors @ NOAA. He expressed concern about some professors being able to properly advise students in Applications, even if they get funding.

Dr. Plale revisited the topic of university tenure being based on fundamental research vs. teaching and applications. She agreed that it will require changing academic culture and that we may need to add other metrics for tenure - in addition to academics, value could be placed on programmatic and having supported application breakthroughs @ an agency level.

Dr. Saah felt that incentive structures will eventually broaden, so faculty can meet tenure objectives while better serving students interested in applications and society.

Dr. Hutyra referred to the open data science model, mentioning that we now have DOIs on data sets → and thus impact factors on data sets (recognition of contributions). She also asked if there were plans to expand the Tiger Teams model. Dr. Friedl answered that different program managers choose to do it more and if TT's are something to consider more of, to let him know.

Dr. Judge that there were multiple DEIA initiatives that were getting funding and suggested that SMD add incentivizing applications work and adding social scientists to research teams/proposals. If additional funding were available from NASA it would accommodate adding more of these skills.

Dr. Hutyra suggested that applications be “baked in” versus adding it afterward as an augmentation- perhaps by offering fewer awards to accommodate the expanded efforts?

Regarding Environmental Justice (E.J.), Dr. Plale asked if NASA was moving to the cloud the 50 most requested data sets vs. those that most contribute to E.J. Dr. Baynes said that the choice of which data sets to move to the cloud is driven by many factors: use, ease of use, migration challenges, etc. But E.J. was not part of the decision. Dr. Plale suggested that a recommendation might be that NASA consider Environmental Justice in deciding which sets are migrated.

Regarding data archives and software Dr. Yu mentioned that better guidelines are needed for how to manage software archive. Do instrument development algorithms need to be made public? Does NASA need source code which has years of development? Are rights protected? How will organizations follow instructions for SPD-41A but still protect intellectual property?

Dr. Baynes responded that they will provide guidance and that they are working w/ ESA partners and Github, documenting efforts in that area. They also want to be sensitive to issues of Intellectual property vs. copyright. They are developing open source science training with AGU to be available within the next 6 months.

Dr. Das inquired about how to handle misunderstandings of the way data can be used and how to protect IP and encourage collaboration? Dr. Baynes said that working with experienced archive centers (such as NSIDC) they are learning tools to avoid misinterpretation and create more trust.

Dr. Wright emphasized the importance of training grad students in many different areas and referred to an NSF requirement to help students work on workforce development plans. 10% (1/2 day week) students are supposed to think about what they want to do in the area of career development and their advisor/mentor has to help in this area.

Dr. Tsaoussi reminded the committee that they can't add or remove recommendations after the meeting. She reminded that NASA is looking to the decadal survey and the National Academy of Science for recommendations on Science, while this committee is to provide guidance and recommendations on how to implement the DS goals.

Commercial Data Buy - Alfreda Hall, K. Baynes, W. McCarty

The Commercial Smallsat Data Acquisition (CSDA) program Pilot began in 2017. Blanket purchase agreements (BPA) were established in September 2018 with Maxar, DigitalGlobe, Planet, Spire Global. The

pilot program ended early 2020. The restricted nature of the EULA's has presented a challenge. Currently the program is in its third onramp phase. The group is also looking at long term data preservation and coordination with other agencies.

One approach to commercial data is to have different prices for different tiers of data, with higher priced or older data tiers allowing for greater distribution of the data. The concept of "uplifts" (bringing data to a higher tier to make it more widely available) was presented, using Spire as an example, where CSDA users have full access to Spire's GNSS Science data catalog. There are close to 2000 approved users now. Many users joined in July 2021 when some of the data sets were uplifted.

The 2nd CSDA onramp is with a few companies (1) Airbus DS GEO – SAR data products. Final report from the scientists looking at this data are due December 2022 (2) Blacksky BPA joined in September '21, with the final report from scientists due June 2023. The third OnRamp will have 4 new vendors: Capella space, IcEye US Inc, GeoOptics, and GHGSat. In addition, a ROSES 2022 call named A.44 – Scientific Use of purchased data will be released soon. NASA will also change the contract vehicle, moving from BPA to multiple award, indefinite delivery-indefinite quantity (IDIQ) with firm fixed price (FFP) orders on data, to be out in FY2023.

When asked about calibration of these data, Dr. McCarty stated that they don't have full calibration on each sensor and while stability of the sensor is important, the lifespan of each sensor is short so it can be challenging to calibrate. In an agile development world, calibration is not as good, plus often there are issues with proprietary data and information about the sensors themselves.

When asked about how to reconcile this with Open Source Science, Dr. McCarty replied that the vendors are open and eager to helping get science publications out. Each vendor works with the publisher on making the data available with the publication. Such availability of data allow scientists to go after new science questions.

Dr. Saah commented that this effort provides an opportunity for NASA to scale its assets. He commented that machine learning and AI work can help improve the results.

Dr. Plale commented that the commitment to preservation of data is important and asked about the strategy for continuity of measurements (e.g. 100 years down the road). NASA said the program is growing at a steady rate (e.g. up to 45k occultations/day from Spire).

Dr. Wright asked if Space Grant Fellows are eligible to access data? Dr. Hall said they will check.

Discussion

The committee had some discussion about metrics and efforts to collect voluntary DEIA data on PI's that comes through NSPIRES. Is NASA baselining, reporting, and tracking such metrics? Such information is important for assessing programs and setting metrics for success. Dr. St. Germain said that DEI is part of everyone's performance review/evaluation in ESD.

Dr. Lohman had a question about how to improve access to cloud resources through training, funding, etc.

Dr. Tucker adjourned the meeting a 3:04 p.m. EDT

APPENDIX A
ESAC MEMBERSHIP

Dr. Sara Tucker, ESAC Chair, Ball Aerospace.

Dr. Lucia S. Tsaoussi, ESAC Executive Secretary, Earth Science Division, NASA Headquarters

Dr. Indrani Das, Lamont-Doherty Earth Observatory, Columbia University

Dr. Belay Demoz, University of Maryland Baltimore County

Dr. Nancy Glenn, Boise State University

Dr. Daven Henze, University of Colorado

Dr. Lucy Hutyra, Boston University

Dr. Jasmeet Judge, University of Florida

Dr. Venkat Lakshmi, University of Virginia

Dr. Jennifer Logan, Northrup Grumman Aerospace Systems

Dr. Rowena Lohman, Cornell University

Dr. Colleen Mouw, University of Rhode Island

Dr. Beth Plale, Indiana University

Dr. Anastasia Romanou, Columbia University

Dr. David Saah, PhD, Harney Science Center

Dr. Robert Wright, University of Hawaii

Dr. Lisan Yu, Woods Hole Oceanographic Institution

Non-NASA Attendees

Kerry Pettit, Tom & Jerry Inc.