NASA ADVISORY COUNCIL

EARTH SCIENCES ADVISORY COMMITTEE

NASA Headquarters
Washington, D.C.
October 19, 2023

TELECONFERENCE
MEETING REPORT

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Sara Tucker, Chair

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Lucia Tsaoussi, Executive Secretary/Designated Federal Officer

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T&J Inc.

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Introduction

Dr. Lucia Tsaoussi, Executive Secretary/Designated Federal Officer (DFO) of the Earth Science Advisory Committee (ESAC), opened the teleconference, which was to be devoted to the annual Government Performance Reporting Act Modernization Act (GPRAMA) annual review, as well as a subcommittee report on Unidentified Aerial Phenomena (UAP). ESAC members introduced themselves. Dr. Tsaoussi noted that the committee had a quorum present, and briefly described NASA's GPRAMA research rating process, and then turned the meeting over to Dr. Sara Tucker, Chair of the ESAC. Dr. Tucker described the annual performance goals and focus areas under discussion, as well as definitions for the grades associated with GPRAMA outcomes (Green, Yellow, and Red), which are associated with reporting requirements.

Annual Performance Goal 1.1.8: NASA shall demonstrate progress in characterizing the behavior of the Earth system, including its various components and the naturally-occurring and human-induced forcings that act upon it.

Atmospheric Composition (1.1.8.1)

Dr. Tucker reviewed the reporting in this section, which encompassed aerosols, clouds, radiative forcing, tropospheric conditions, health effects of pollution, biomass burning, and greenhouse gases (impact on carbon cycle and climate change), as well as ozone depletion in the stratosphere. She referenced data that has been collected from NASA's aircraft campaigns, ground-based systems, and satellite instruments. NASA observations have shown changes in smoke composition with respect to aerosol size, which has implications for radiative forcing. Lidar sensing has contributed to expanding measurements for modeling purposes. NASA assets are also starting to look at dust from high-latitude regions as they dry out. Other results include better understanding of how NO2 is distributed across urban areas, including the demonstration of heat inequalities in low-income areas. Higher-resolution data is now being obtained from low-Earth Orbit (LEO). Data from the COVID-19 lockdown, particularly from Suomi NPP, has shown, counter to expectations, that NOx species were not in fact reduced in urban areas. Dr. Tucker noted that Orbiting Carbon Observatory-2 (OCO-2) data has shown they can support nations that are developing their own emissions estimates, and also provide a check for nations that refuse to report. OCO-2 has also revealed the presence of methane superemitters in some drilling regions. Other data have shown that particles from volcanic eruptions are being ejected high into the atmosphere, and eventually reach the Earth's poles. Lastly, the Synergistic TEMPO Air Quality Science (STAQS) mission which was conducted this past summer, working with Tropospheric Emissions: Monitoring of POllution (TEMPO) data, is expected to produce some interesting results over the next few years.

Carbon Cycle and Ecosystems (1.1.8.2)

Dr. Colleen Mouw assessed the ocean and biodiversity aspects of this section, specifically ocean biology and biogeochemistry, which concerned novel approaches in the coastal ocean. The Geostationary Littoral Imaging and Monitoring Radiometer (GLIMR) mission reported some advances in measuring blue carbon (carbon captured and stored by oceans and coastal ecosystems), as well as in marine debris monitoring (e.g., hurricane debris plumes). There is now a twenty-year record of Earth observations which show that low-latitude oceans are becoming greener; in addition, heat waves have been associated with reductions in diatom populations. Changes in the timing of sea ice (freezing and thawing cycles) are affecting the incidence of algal blooms and giant kelp populations. NASA assets have been innovative in measuring volcanic ash, and have supported some review papers on the subject of extreme events, particulate matter, and estimations of water quality in the Arctic, as well as the impact of humans on biodiversity on fisheries, and the distribution of squid species. These represent the wide variety of ways in which NASA sensing is being used for both global and coastal ocean monitoring.

Dr. Natassa Romanou addressed report highlights in the wildfires section, a highly important emerging area with deep societal impacts. FireSense, a new, innovative NASA Earth system observation project, has the potential to improve capabilities in remote sensing, in-time/real-time information, and conditions before, during, and after fire events. NASA assets are also continuing to support extensive reporting on land cover use and change.

Climate Variability and Change (1.1.8.3)

Dr. Romanou discussed advances NASA's measurement of global climate change on decadal scales, particularly with regard to sea ice, land ice, oceans, and their interactions, and Earth system modeling aspects. In the area of land ice/cryosphere observations, there have been significant NASA efforts over the past few years, reflected in the variety of important publications on sea ice temperatures and flows, the susceptibility of the Antarctic ice sheet to global temperature increases, estimations of the heat imbalance of the climate system, and the sensitivity of ocean mixing below the surface. This section also introduces important information from the Surface Water and Ocean Topography (SWOT) mission, which will help assess open ocean and sea ice, as well as salinity and its effects on ocean heat uptake, and how quickly the ocean heat sink is changing. Ongoing studies are showing new connections between wildfires and Earth system's intrinsic variability, including a new type of study that will show how anthropogenic change affect the Earth system. Major advances have been made in the Goddard Institute for Space Studies (GISS) Model E effort, including a coupled Earth system model (geared toward centennial variability), and improvements in the GEOS model. GISS is putting together a new model with improved model biases and new variables. GISS recently developed BiomeE, a new vegetation model focused on vegetation dynamics and ecosystem biogeochemical cycles, which will work with the existing vegetation model. Chemistry modeling advances, based on many studies conducted after the pandemic, have shown changes in emissions (NO2, etc.). Other modeling studies undertaken with the Estimating the Circulation and Climate of the Ocean (ECCO) reanalysis system have resulted in better mapping of the ocean carbon sink and how it is changing.

Dr. Indrani Das added that some results in this section represented several years' worth of data, and found it interesting that the 1985-2020 data interval on ice shelf thickness revealed that some observed reductions in thinning may have been dependent on decadal time scales. Much has been done in the last year to understand the processes that influence the calving patterns of ice shelves.

Dr. Lisan Yu commented on work concerning the ocean's role in the climate system— ocean dynamics and Earth heat—and how the ocean stores and releases heat. There is a new NASA working group on ocean heat and quantification of heat storage. Salinity and water cycles affect ocean heat uptake and the regulation of Earth's freshwater stores. It has been shown, for example, that ocean salinity is a good predictor for heavy rainfall in the US Midwest region, which provides import data to farmers for use in crop planning. In the area of ocean extremes and coastal hazards, NASA data indicate that the widespread occurrence of ocean heatwaves has an impact on sea level on low-lying coastal regions.

Earth Surface and Interior (1.1.8.4)

Dr. Rowena Lohman described a number of publications on lithospheric processes, using GPS and Global Navigation Satellite Systems (GNSS), that connected snow load with surface deformation. NASA is growing tools to allow the community to further explore these phenomena. There are newly observed uplift and subsidence events associated with urban development, as well as increases in low-level seismicity that might be related to fracking and wastewater, all of which may point to aseismic effects. Better understanding of the full seismic cycle, based on advances in high-rate GNSS, could be an addition to the tool box. Researchers are still studying the 2019 Ridgecrest earthquake, analyzing displacement fields with in-situ observations. There are also continuing advances in predicting volcanic activity and submarine eruptions. Work is continuing on the 2022 Hunga Tonga eruption through geostationary satellite observations. Interferometric synthetic aperture radar (InSAR) data have revealed new features of

landslide/tsunami cascading hazards, improving tsunami predictions and enabling better detection of gravity waves. NASA is also looking at glacial outburst floods with an eye to improving disaster monitoring/preparedness. InSAR use in Samoa has shown that some regions are subsiding more than others. There have been improvements in geodetic imaging with regard to characterizing the stability of pixels. NASA is also holding workshops to prepare for the NASA ISRO SAR (NISAR) mission. The use of unmanned aerial vehicle (UAV) SAR helped provide a big response to the Mauna Loa eruption, and there has been much work on operational products from space geodesy. The NASA Space Geodesy Network is still working well, and efforts are underway at JPL to update the terrestrial reference frame more frequently.
Dr. Robert Wright commented that ancillary information is now being used to enhance data, and not just to check it, which he regarded as a good trend.

Water and Energy Cycle (1.1.8.5)
Dr. Venkat Lakshmi addressed the global dynamics of water storage and movement/water quality. NASA is already transitioning data from new missions; many discoveries in hydrology came from the Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow-on (GRACE-FO), demonstrating how satellites can capture drought, flood, and ice melt. One notable result is the observation of how Lake Victoria levels were greatly changed by flooding. Earth observations are shedding light on how the water cycle is connected to food security. NASA has a diverse sensor portfolio [e.g. Moderate Resolution Imaging Spectroradiometer (MODIS) and ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)], that is showing the importance of snow in the water cycle, including increasingly detailed and precise airborne snow observations on how communities rely on snow melt for their Spring water supplies. Data on surface water are now being harmonized over numerous sensors and satellites. SWOT, in particular, represents the latest and best data from NASA. The Soil Moisture Active Passive (SMAP) mission has also enabled big improvements in assimilation and model prediction. Combining SMAP and radar data is helping to attain significantly better resolution. InSAR, GNSS, and lidar instruments proving useful for monitoring ground water storage. NASA satellites are also providing data that will help to better detect and predict landslides. NASA's water and energy cycle portfolio is wide, and its impacts are even wider.

Dr. Jasmeet Judge added that results from NISAR and SWOT promise to be exciting next year, as soil moisture has become a key element of NISAR, as noted in a recent review of soil moisture algorithms. In addition, a Cyclone Global Navigation Satellite System (CYGNSS) paper showed how NISAR can be used for assessing soil moisture, in conjunction with SMAP.
Dr. Mouw added that advances in water quality assessment, based on coastal and inland optical data sets, represent an important achievement that will enable much future work.

Weather and Atmospheric Dynamics (1.1.8.6)
Dr. Belay Demoz commented on how NASA is integrating data from multiple platforms to generate long term data sets; the X-band in particular has allowed greater focus on winter cyclones and snow bands, a much-needed advancement. CYGNSS experiments included a study of ocean wind over large ocean surface areas; other studies are looking at radiance and flood systems. Open Science has been an excellent addition to this work. There has been much work on addressing Decadal Survey Designated Observables as well. Dr. Tucker added a comment on Artificial Intelligence (AI)/Machine Learning (ML) and how it can take advantage of hyperspectral data and Planetary Boundary Layer (PBL) technology efforts. There will be a lot of sensors and data coming online in the future, and AI/ML will be important to managing this data. And as NASA and NOAA continue to work together, there will be benefits to both. There are always new algorithms; NASA is looking at spatial and temporal scales in the Integrated Multi-satellitE Retrievals for GPM (IMERG) project. A field campaign conducted this year has yielded interesting new information on such phenomena as gamma ray glows and flashes in tropical thunderstorms.

***ESAC concluded the discussion of Goal 1.1.8. Dr. Tucker proposed a Green grade for this section. There was unanimous agreement.*

<u>Annual Performance Goal 1.1.9:</u> NASA shall demonstrate progress in enhancing understanding of the interacting processes that control the behavior of the Earth system, and in utilizing the enhanced knowledge to improve predictive capability.

Atmospheric Composition (1.1.9.1)
Dr. Tucker noted that this area has always provided excellent science in the areas of radiative forcing, smoke plume composition, ozone hole recovery, and the impact of aerosols and smoke in the upper atmosphere. Secondary organic compounds are being found in the atmosphere. Data indicate that we are likely to see an increase of surface warming as sea ice continues to diminish. There have been observations of cirrus cloud contamination affecting infrared radiance and biasing forecasts. Studies are looking at a parameterization of brown carbon in climate models, connected with biomass burning and wildfires. There have also been advances in understanding smoke chemistry, such as how fuel types and freshness of smoke can impact air quality and global health, and how PM2.5-attributable mortality is increasing, largely due to desert dust. NASA's Advanced Global Atmospheric Gases Experiment (AGAGE) is monitoring compliance with the Montreal Protocol, and observed a big jump in chlorinated fluorocarbons (CFCs) in China. In studies of pyrocumulonimbus clouds, it has been found that smoke is getting lofted high into the atmosphere, where it will contribute to long-term effects on future climate as the frequency of fires increases. Increased presence of chlorine in the atmosphere is creating the potential for future ozone loss, as well.

Carbon Cycle and Ecosystems (1.1.9.2)
Dr. Mouw commented on the development of a roadmap for emerging sensors to monitor carbon in ocean, which will help with fisheries management in the Pacific Ocean, as some species shift poleward. Dr. Romanou cited studies on terrestrial ecology, effects associated with vegetation fires (Suomi NPP), and COVID-19 era measurements as well as new tools for measuring biodiversity (mostly on land, hopefully extended to the ocean in the future).

Climate Variability and Change (1.1.9.3)
Dr. Das addressed land ice and the Earth's ice sheet mass balance, citing important studies that combined data from 15 different satellites during the period of 1992-2020. In the present decade, Greenland and Antarctica are accounting for 25% of all sea level rise. Dr. Lisan Yu noted data on the large-scale ocean energy heat budget, and mentioned ECCO as one important effort (MIT-JPL) that can combine almost all satellite and in-situ data sets to measure such things as river runoff; this is very important for community studies. The NASA sea level change team has dedicated an online portal to enable local decision makers to prepare for coastal sea level rise. NASA is also collaborating with a UN initiative to help international efforts to prepare low-lying islands for potential impacts to their coastlines.
Dr. Romanou commented on regional modeling techniques that have helped to illustrate how cyclones affect sea ice distribution, and an integrated Earth System modeling that is investigating drivers of atmospheric dynamics. Other major efforts were the simulation of the Hunga Tonga eruption, to study how emissions affected the stratosphere, atmospheric simulation for Future Climate Scenarios, and meltwater studies.

Earth Surface and Interior (1.1.9.4)
Dr. Lohman addressed efforts in understanding volcanic and landslide hazards, which have improved the ability to detect thermal anomalies, and enhanced forecasts for volcanic activity. Other significant work

was accomplished in analyzing effects of urbanization re: landslide mitigation planning, as well as hydrologic conditions (drought, heavy rain) and how they affect landslide forecasting.

Water Cycle (1.1.9.5)
Dr. Lakshmi detailed how NASA missions have been integrating Earth observations, leading to better predictive capabilities in the area of cascading hazards after wildfires. He noted that 70% of water is used for irrigation, and the criticality of long-term management of water resources. Many NASA missions contribute to this area and continue to do so.

Weather and Atmospheric Dynamics (1.1.9.6)
Dr. Demoz discussed the improved predictive capabilities made possible through continued satellite launches and the tools provided by NASA's Global Ecosystem Dynamics Investigation (GEDI), as well as by NOAA and DOD. GNSS and data buys from commercial satellites also play a role in the huge movement and streamlining of data. These advances can also help to test improvements in models. The predictive capability that came from the IMERG data set is quite notable. Radiative transfer data and AI/ML are also being incorporated into models. Dr. Tucker said that the Global Modeling and Assimilation Office (GMAO) extended their framework to use a 4D ?? scheme to include timing of radiative transfer and its effects on forecasting. Other notable work included the detection of upper tropospheric gravity waves from the Hunga Tonga eruption.

***ESAC concluded the discussion of Goal 1.1.9. Dr. Tucker proposed a Green grade for this section. There was unanimous agreement.*

Dr. Colleen Mouw stepped out of the meeting at the end of the GPRAMA review.

<u>Unidentified Aerial Phenomena Report</u>
Dr. Dan Evans, DFO for the Unidentified Aerial Phenomena (UAP) Independent Study Team, introduced a report on UAPs. The UAP Study Team was formed upon request by former Science Mission Director Associate Administrator Thomas Zurbuchen and NASA Administrator Bill Nelson. The Study Team was convened as a subcommittee of ESAC, such that the findings could be transmitted up the chain per FACA rules. UAPs are a key unsolved area of science. The UAPIST was convened to answer 8 key questions that should be answered, based on NASA's stated intent to turn a data-poor field into a data-rich field:

What types of scientific data?
What types of scientific data?
What other types of scientific data?
What analysis techniques?
What basic physical constraints?
What civilian airspace data?
What current reporting protocols?
What potential enhancements to ATM?.

UAPIST found that ASRS is a tool worth investigating, and that NASA should provide technical advice in this area. The last 3 questions were determined to be beyond the scope of NASA science and have more to do with civilian and airspace safety. Dr. Evans said that the purpose of the briefing was to ask ESAC to bring the findings upward.

Dr. David Spergel, Chair of the UAPIST, presented a brief summary of the effort, noting that NASA's assets typically cover large areas of the planet, and are not suited to the small scale imagery needed to better visualize and understand UAPs. NASA would be better suited to study the environment in which

UAPs occur. One of NASA's roles here is to raise the level of the data being collected, emphasizing standards of calibration and acquiring baseline data. The Team studied the role of AI/ML and determined that NASA could provide critical assistance here, as well as to lead efforts in public engagement.

The UAPIST report can be found at https://science.nasa.gov/uap/

Discussion

Dr. Tsaoussi reiterated that while the study was beyond the scope of ESAC expertise, it was suitable for the ESAC to provide some commentary. Dr. Tucker proposed that the ESAC find that the subcommittee addressed its TOR (all 8 questions), and the ESAC unanimously agreed to that the report be passed up to leadership. Dr. Lohman aired a concern that the findings might impact science through potential redirection of NASA assets. Dr. Tsaoussi said that only the utility of ESD assets are considered in the report, and that no change in observation strategy was recommended and made clear that the ESAC is not endorsing the report's recommendations, per se; the report itself is directed to the Agency.

Dr. Evans thanked the ESAC for considering the report.

Dr. Tucker recognized the hard work that all the Program Managers put in to support the GPRAMA review. Dr. Tsaoussi gave the floor to Dr. Jack Kaye, ESD Director of Research, who thanked the ESAC for their assessments and constructive feedback. He said it was a great privilege to be part of the program, with a wonderful investigative community that is passionate about the subject and is capable of much. He said he looked forward to reaping investments in the ESD flight program, field work, and modeling.

Dr. Tsaoussi mentioned that the ESAC would be onboarding 6 new members, and that she hoped to have an in-person meeting early in 2024, as well as a joint session with the Applied Sciences Advisory Committee (ASAC).

Dr. Tucker adjourned the meeting at 3:40pm.

APPENDIX A
ATTENDEES

Earth Science Advisory Committee Members
Sara Tucker, Chair, Ball Aerospace & Technologies Corp.
Indrani Das, Lamont-Doherty Earth Observatory (LDEO)
Belay Demoz, JCET, UMBC
Jasmeet Judge, University of Florida
Venkataraman Lakshmi, University of Virginia
Jennifer Logan, Northrop Grumman Aerospace Systems
Rowena Lohman, Cornell University
Colleen Mouw, University of Rhode Island
Beth Plale, Indiana University
Anastasia Romanou, NASA Goddard Institute for Space Studies
Robert Wright, University of Hawaii
Lisan Yu, Woods Hole Oceanographic Institution
Lucia Tsaoussi, Executive Secretary – NASA Headquarters

Non-NASA Attendees
Joan Zimmermann, T&J, Inc.

APPENDIX B
ESAC MEMBERSHIP

Sara Tucker, ESAC Chair
Ball Aerospace & Technologies Corp.

Indrani Das
Lamont-Doherty Earth Observatory (LDEO)

Belay Demoz
JCET, UMBC

Jasmeet Judge
University of Florida

Venkataraman Lakshmi
University of Virginia

Jennifer Logan
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Rowena Lohman
Cornell University

Colleen Mouw
University of Rhode Island

Beth Plale
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