NASA Earth Science Advisory Committee

October 28, 2024

NASA HQ and Teleconference

MEETING MINUTES

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Sara Tucker, Chair

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Lucia Tsaoussi, Executive Secretary

Prepared by Jeanette Edelstein
Tom & Jerry, Inc.

October 28, 2024

Opening Remarks

Dr. Lucia Tsaoussi, Executive Secretary/Designated Federal Officer (DFO) of the Earth Science Advisory Committee (ESAC), opened the annual Government Performance Reporting Act Modernization Act (GPRAMA) meeting and reviewed Federal Advisory Committee Act (FACA) rules. ESAC members introduced themselves. Dr. Tsaoussi reviewed the purpose and process of the meeting, including the performance goals, focus areas, and ratings levels (Green, Yellow, and Red) for GPRAMA. Dr. Sara Tucker, Chair of ESAC, said there were two performance goals to be discussed and reiterated that the committee would be offering and discussing highlights of work that addressed those goals.

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.

Climate Variability & Exchange

Dr. Lisan Yu gave an overview of some of the most significant achievements in the 2023-2024 period, including cryospheric sciences; ocean physics; and modeling, analysis, and prediction. She highlighted reports in the areas of ice dynamics and their effects on the global climate, oceans, and integrated Earth system modeling. On the land ice front, studies have focused on the regular retreat and thinning of glaciers, particularly in Greenland, which contributes to global sea level rise. Dr. Yu said NASA's Physical Oceanography (PO) Program has significantly advanced understanding of how ocean dynamics regulate Earth's heat and the influence on the system. Dr. Yu gave suggestions for studies to demonstrate the significant progress in advancing our understanding and ability to predict our changing planet using integrated Earth system modeling and NASA satellites, such as ICESat-2. These advancements in climate predictions benefit forecasting, disaster preparations, and public health. Dr. Indrani Das added that ICESat-2 was used in many innovative ways and highlighted several reports, including a paper that demonstrated how the ocean can intrude underneath the grounding zone, in this case up to 14 to 15 km.

Dr. Helen Pillar focused on the ocean sections and noted that NASA continues to play an integral role in constraining the atmospheric partitioning of heat, the redistribution of heat, and other climatically important properties. She added that investigations into mechanisms in changes to the Atlantic Meridional Overturning Circulation (AMOC) and its constituent parts are important and noted that studies suggest an apparent contradiction in the Florida Straights and AMOC trends, which would be good to reconcile in future studies. Surface Water and Ocean Topography (SWOT) is providing truly transformative information for studying small scale and rapidly changing ocean features. In the future, she said, it will be important to leverage this data fully through data assimilation and make the most of these unprecedented spatial scales, even in the absence of high temporal resolution.

Earth's Surface & Interior

Dr. Rowena Lohman reviewed the domain of this science focus area and began with lithospheric processes and properties, beginning with hydrogeophysics and subsurface fluids. She said this is

a rapidly evolving field, being advanced by space-based observations; Gravity Recovery and Climate Experiment (GRACE); Global Navigation Satellite System (GNSS); NASA-Indian Space Research Organization (ISRO) Synthetic Aperture Radar (SAR) (NISAR); and in-situ observations. Notable studies this year included observations of spatiotemporal variations in subsidence related to groundwater depletion, which could provide insight into aquifer resilience; demonstration that predictions of subsidence in the future depend on the subsurface properties used in modeling; the use of NISAR to examine the effects of ground water-related subsidence in Mexico City and the effects on infrastructure. Dr. Lohman added highlights from reports on research in the areas of soil moisture; fault dynamics; minerology; natural hazards; and vulcanology – including the application of machine learning, the use of NISAR and digital elevation models; submarine eruptions, as related to the Hunga Tonga eruption; and cascade-inherent hazards. For Deep Earth Processes, she mentioned the studies on processes that can be linked between the deep Earth and surface changes, including the impact of melting ice sheets, glaciers, and other global water storage variations on the rotation of the Earth. She highlighted work on the magnetic field and geodetic imaging. Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) has been very active in a range of collaborative, international studies, and the NASA Space Geodesy Project provides foundational geodetic data that enables most activities in this report.

Dr. Rob Wright mentioned how the research was impacting societal impact or human causality, e.g., the impact of infrastructure in Mexico city, groundwater depletion, seismic imaging related to oil production, water storage, and coastal subsidence. He noted that NASA's Earth Surface and Interior's (ESI's) funded research was increasingly impacting people. Dr. Tucker connected that to the theme of the Earth Science Division's (ESD's) Earth Science to Action (ES2A).

Water & Energy Cycle

Dr. Venkataraman Lakshmi said the water and energy cycle area has been very active in modeling and observations for distribution, transport, and movement of water and also supports the World Climate Research Program (WCRP) and the Global Energy and Water Exchanges (GEWEX). He said most of the results in this report are the results of satellite sensors, specifically the Soil Moisture Active Passive (SMAP), the Global Participation Measurement Mission (GPM), SWOT, and GRACE, and modeling. This focus area also supported the snow experiments, which used all types of sensors, including lidar. There have been many studies for estimating ground water and the loss of ice and glaciers, important for understanding the loss of terrestrial water storage. GRACE is also used to study how earlier snow melt due to increased temperature changes permafrost, which has a big impact on societal habitation. He spoke of the loss of ground water and the new law, the Sustainable Ground Water Act (SIGMA), in California that mandates the sustainable use of water. Dr. Lakshmi said one of NASA's biggest assets is SWOT, which can be used along with hydraulic models to figure out the discharges in river basins. He also mentioned the uses of NASA's Global Ecosystem Dynamics Investigation (GEDI) to compute the roughness coefficient to figure out the flow of water, SMAP for stream flow observations, and Landsat to determine connectivity between lakes and channels. Soil moisture studies are going on with SMAP, including analyzing how downscale values correlate with the vegetation index. Snow is an important part of the hydrological cycle and many investigations have studied the Snow Water Equivalent (SWE). Other studies have used Interferometric Synthetic Aperture Radar (InSAR) to see shadow snow packs and the SnowSAR

experiment to validate models. The High Mountain Asia Program released a paper that used NASA MODIS surface temperature to map the permafrost zonation index. Dr. Lakshmi said studies about the connections between plant responses and rainfall are ongoing, as are studies about the freeze/thaw transition. Finally, he noted that the Global Energy and Water Exchanges (GEWEX) science meeting was well attended and a big success.

Weather

Dr. Belay Demoz noted 76 weather papers published over broad subject areas, including AI/ML, new satellites, and new algorithms for categorizing the behavior of the Earth system. Rising to the top was the area of fire monitoring-related atmospheric conditions characterizations, which discussed methods for imaging and sounding from infrared (IR) data. Artificial intelligence (AI) for Planetary Boundary Layer (PBL) monitoring shows maturation and should be ready for the next crop of satellites. Dr. Demoz noted the ability of the Cyclone Global Navigation Satellite System (CYGNSS) to distinguish inland water bodies. There was work that characterized tropical cyclones and established the utility of small to medium satellites, such as the NASA Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellations of Smallsats (TROPICS), Temporal Experiment for Storms and Tropical Systems (TEMPEST), and others. There has been 3D lightning mapping work with CubeSpark, specifically the modeling aspect in collaboration with Los Alamos for low intensity lightning flashes. Legacy data sets continue to improve. Field campaign papers mentioned by Dr. Demoz included those about IMPACTS campaign and those about winter storms in microphysics that will set the pace for the Earth Venture Mission-3 (EVM-3) program.

Dr. Tucker underscored the productivity of the IMPACTS campaign; it wrapped in 2023 and there have been 30 published articles already, and not just about the data from the campaign but looking at new algorithm developments that can be applied to space-based observations. The Atmospheric Infrared Sounder (AIRS) continues interesting work about ways to improve convection using air parcels measured with AIRS. Supporting that helps develop algorithms that can be used with data from future operational sounders. Dr. Tucker noted that the lightning monitoring is interesting because gamma-ray flashes and flickering gamma-ray glows show activity scientists are not typically aware of.

Atmospheric Composition

Dr. Dylan Millet gave an overview; Dr. Christine Chiu was unable to attend but provided written feedback. Dr. Millet said the focus area highlights included accomplishments across a wide range of areas, which speaks to ESD's strength in this area. Many of the studies were timely and focused on topics such as fuel changes, wildfire smoke, and volcanic eruption and provided valuable insights for society. There is a substantial body of work analyzing the impacts of Hunga Tonga that clarified the power of the Microwave Limb Sounder (MLS) for tracking and quantifying these types of events. Dr. Millet noted that MLS is going away and the report speaks to the importance of continuing that work in some way. Dr. Chiu's comments noted that the studies highlighted were somewhat conflicting about the impact inferred about stratospheric ozone and, so, follow-up efforts to address that would be good. Dr. Millet said ESD supported retrieval development, validation, and science analysis activities with non-NASA instruments, such as GOES satellite instruments, Gravity and Extreme Magnetism Small Explorer (GEMS), and Comet Nucleus TOUR (CONTOUR) Remote Imager/Spectrograph (CRISP), which is

important to the continuation of the international and interagency nature of the observing system. There were several high impact studies using Earth Venture Suborbital (EVS) and other NASA aircraft campaign data, for instance work that showed how stratospheric intrusions can drive new particle formation in the upper troposphere. There was extensive use of Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) and Clouds and The Earth's Radiant Energy System (CERES) data to better understand aerosol, clouds, and Earth's radiation balance. Emerging CO2 data, with other spaceborne measurements, was used to explore carbon cycle responses to climate variability, including flash flooding and La Niña, to look at emergent questions about how the carbon cycle is changing. Finally, NASA-supported ground-based and airborne observations are playing an important role to enable science and validate spaceborne observations. Dr. Tucker added that there is an increase in use of international data and international organizations using NASA data – a more global approach to Earth system science.

Carbon Cycle & Ecosystems

Dr. Jennifer Watts provided written comments, which Dr. Tucker read into the record. Notable activities included actively providing the White House Office of Science and Technology Policy (OSTP) with information to support key reports on blue carbon ecosystems that include mangroves, marshes, and sea grasses and examining their potential as nature-based climate systems. Improving the ability to identify and quantify changing wetlands versus open water conditions and to delineate the wetland type and condition is a high priority need within the science community. There was NASA-enabled research on aquatic biogeochemistry contributing to regional carbon cycle assessment and Phase 2 synthesis activities. One notable finding was that the loss of sea ice cover has enhanced the ocean's CO2 uptake almost as much as the atmospheric CO2 increase over the last 34 years; however, the increased ocean uptake of CO2 in Arctic zones is also driving ocean acidification and will likely lead to changes in primary productivity. Dr. Watts appreciated the inclusion of indigenous traditional knowledge and study of coastal zone management examining the potential impacts of sea rise. Especially commendable is NASA's launch of Plankton, Aerosol, Cloud, ocean Ecosystem (PACE), in February 2024, which offers many opportunities for novel research, including detecting and tracking locations for marine plastic litter. PACE is the first of exciting planned aquatic focus missions within this decade, including the Geostationary Littoral Imaging and Monitoring Radiometer (GLIMR); Surface Biology and Geology (SBG) missions; and the Cloud and Aerosol Lidar for Global Scale observations of the Ocean-Land-Atmosphere (CALIGOLA), a potential partnership with the Italian Space Agency (ASI) – all of which will allow NASA to study and monitor the health of global aquatic marine and inland systems in new ways. In the Terrestrial Ecology Program, NASA's ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) Mission has been instrumental in providing high resolution and evapotranspiration data used to identify water availability and plant water use; ECOSTRESS is a good complement to SMAP and the European Space Agency's (ESA's) Soil Moisture and Ocean Salinity (SMOS) missions. Improving the ability to quantify and track the status of water in terrestrial systems should remain a high research priority for NASA. NASA's investment in spaceborne lidar systems, including GEDI, continues to support fundamental research in forest structure and dynamics, forest biodiversity, and ecosystem vulnerability. The resulting science informs global carbon mitigation and land management policies. Dr. Watts noted the three airborne field campaigns that NASA has supported: FireSense, the Arctic-Boreal Vulnerability Experiment (ABoVE), and the Biodiversity Survey of the Cape (BioSCape).

Dr. Sara Rivero-Calle highlighted that the airborne and fieldwork campaigns are critical, particularly in the Arctic. The amount of work in terrestrial ecosystems, fires, and forest disturbance and degradation was impressive. The launch of PACE is critical for her community, and, despite its recent launch, there are promising results from simulations and interest in what might be provided in terms of habitat for fish migrating. She noted the interest in lidar, the large number of researchers who are combining information from different sensors, and the interest in high-spatial resolution data from Landsat and also from new technologies for inland and coastal ecosystems. She echoed the positive sentiments for and importance of working with indigenous, traditional knowledge in local communities within the projects. Ms. Melanie Preisser added that, in the various focus areas, it was mentioned that commercial data was used to augment some observations and collection methodologies to support the research. She wondered whether other commercial solutions can help with the focus areas in the future.

Dr. Tucker proposed a rating of Green for Section 1.1.8. Dr. Demoz seconded the rating. No one opposed. Dr. Tucker finalized the rating.

Annual Performance Goal 1.1.9: 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.

Climate Variability & Change

Dr. Das gave an overview of work done in the land ice section, mainly targeted to improve projections of sea level rise, including reports that showed the importance of using transient grounding zones, discoveries about sensitivities of ice mass loss, and also the wide variability of ice mass change depending on the type of model used. More studies like these are needed to determine the best ways to use observations and what models are best used for various climate scenarios and improved projections.

Dr. Pillar noted that NASA is making major contributions around the improved predictions of natural hazards with significant socioeconomic impacts. She said the NASA-funded Estimating the Circulation and Climate of the Ocean (ECCO) is supporting rigorous investigation of ongoing trends of ocean warming and sea level rise. NASA did critical work in wildfire monitoring and prediction, the accuracy of which is essential for informed responses to protect communities from direct and environmental effects. She mentioned the importance of the new ensemble forecast, the Hazardous Air Quality Ensemble System (HAQES), a multi-agency synthesis that predicts poor air quality to support decision making. Finally, GOES data was used to investigate remote cause of forcings and mechanisms of extreme rainfall events on the West Coast associated with atmospheric rivers, which is important despite the relative lack of predictability on seasonal timescales. Dr. Yu added that NASA's Physical Oceanography Program modeling activities around ECCO has done so much for ocean heat estimates, sea level rise, and coastal flooding, for example, in addition to improving modeling.

Earth Surface & Interior

Dr. Wright mentioned the use of thermal data to predict volcanic activity. He said the papers about the impact of ground water pumping and the model produced of thin air magnetic fields

both demonstrate predictive capability. Dr. Lohman added that she liked that this report noted a continued increase in studies that use more than one observable. It highlights the effort the ESI community has put into improving the accessibility of data and algorithms, which allows people to do interdisciplinary work and have more insight into forecasting. The space geodesy component touches on many things one would want to do in forecasting, for example GNSS and its use in earthquake early warning.

Water & Energy Cycle

Dr. Lakshmi talked about NASA's large systems: the Global Land Data Assimilation System (GLDAS); and the Land Information System (LIS), which is at a higher spatial resolution; and NASA's global atmospheric reanalysis Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2) – all of which are used in understanding the connections between land and atmosphere. He noted papers about ML/AI that tried to link the top surface soil moisture to stream flow in mid-scale river basins, as well as using GRACE anomalies to see the onset of floods caused by persistent rainfall and monsoons. Moderate Resolution Imaging Spectroradiometer (MODIS) was used to look at snow systems and to figure out seasonal scale forecasts of soil moisture. He noted most of these use publicly available data sets.

Weather & Atmospheric Dynamics

Dr. Tucker said a key highlight in this area was the continued investment in the Joint Center for Satellite Data Assimilation (JCSDA) Joint Effort for Data assimilation Integration (JEDI). This investment focuses on NASA's internal global Earth observing system modeling efforts at Goddard, specifically for coupled Earth systems data. Tools like this are being made available for Principle Investigator (PI)-level development. The new JEDI Skylab 8.0 includes new data inputs such as radar, visible reflectance, and soil moisture and they are starting to improve compatibility among high-performing systems. The assimilation of aerosol data with the Community Radiative Transfer Model (CRTM) is good to see. The Ocean/Marine Data Assimilation will be integrated into NASA/NOAA next generation systems, such as the GEOS upgrade. Papers are starting to come out from the 2022 Convective Processes Experiment (CPEX) campaign. Dr. Demoz added that everyone seems to be moving into JEDI from other assimilation systems. He also mentioned the demonstration that non-rimed crystals colliding with each other have the strongest electromagnetic fields, which is new in microphysics. He also noted the CPEX data specific to 3D winds, predictions and forecasting, and the ongoing Observing System Simulation Experiment (OSSE) activity. Dr. Plale underlined JEDI as the data assimilation integration framework for NASA/NOAA/DOD and said that is a good use of cross-agency investment for frameworks that tend to have large uptakes and large impacts.

Atmospheric Composition

Dr. Millet highlighted studies that focused on new model developments that improve the ability to predict atmospheric composition and quantify fluxes, including the exploration of the utility of CO2 data for quantifying regional CO2 fluxes which called out the need for more temporally resolved observations to quantify regional emissions. He noted a paper that uses synthetic data to inform the use of Tropospheric Emissions Monitoring of Pollution (TEMPO) observations for resolving emissions. Finally, he mentioned the use of model observation synthesis to look at atmospheric processes, including how lightning affects ground level ozone concentration, the use of formaldehyde data to quantify VOC emissions from oil and gas, and the impacts of Australian

mega fires on stratospheric ozone. Dr. Tucker mentioned a study that looked at micro-pulse lidar data along with Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) data to retrieve cloud properties without any a priory assumptions, a study that underscores the value of ground- and spaceborne assets in passive and active remote sensing.

Carbon Cycle & Ecosystems

Dr. Rivero-Calle mentioned, in biodiversity and ecological conservation, the work done in South Africa in the BioSCape campaign, combining in situ work with airborne data. It was comprehensive, with integration with local stakeholders to help in decision making. She noted an interesting new concept called the Internet of Animals (IOA), a unique way to understand global biodiversity and behavior. There was work on land cover and land use change, using deep learning with the random forest machine learning algorithm applied to measure the expansion of the Hindu Kush Himalaya. There was a study that underscored the vital role that satellites play in understanding the ocean and its role in the carbon cycle but also found that it remains largely unexplored and more work should be done using satellites. In terrestrial ecology, Dr. Rivero-Calle noted the emphasis on the 10-year field and modeling effort in the Arctic ecosystems through the ABoVE project.

Dr. Tucker proposed a rating of Green for Section 1.1.9. Dr. Lakshmi seconded the rating. No one opposed. Dr. Tucker finalized the rating.

Closing Remarks

Dr. Tucker thanked the members of the committee for their time reading the report and the members of the NASA ESD who have put time and effort into funding this research and ensuring it resulted in valuable science.

Dr. Tsaoussi thanked everyone for their time and input. She said the report is used for a number of reporting agency activities and the committee's feedback is always appreciated. She reminded the committee that some members have an appointment end date of November 3, 2024, thanked exiting members for their service, and spoke about the committee transition. She encouraged everyone to continue to communicate through the community forums.

Adjourn

The meeting adjourned at 1:48 p.m.

APPENDIX A
Participants

Earth Sciences Advisory Committee Members
Sara Tucker, Chair, BAE
Lucia Tsaoussi, Executive Secretary, NASA Headquarters
Indrani Das, Lamont-Doherty Earth Observatory (LDEO)
Belay Demoz, JCET, UMBC
Venkataraman Lakshmi, University of Virginia
Jennifer Logan, Northrop Grumman Aerospace Systems
Rowena Lohman, Cornell University
Beth Plale, Indiana University
Robert Wright, University of Hawaii
Lisan Yu, Woods Hole Oceanographic Institution
Dylan Millet, University of Minnesota
Melanie Preisser, York Space Systems
Helen Pillar, University of Texas
Christine Chiu, Colorado State University
Jennifer Watts, Woodwell Climate Research Center
Sara Rivero-Calle, University of Georgia

Attendees
Jeanette Edelstein
Craig Ferguson
Bryan Johnson
Jennifer Kearns
Tsengdar Lee
Barry Lefer
Hal Maring
Justin Stachnik

APPENDIX B
Earth Sciences Advisory Committee Membership

Sara Tucker, Chair, BAE

Lucia Tsaoussi, Executive Secretary, NASA Headquarters

Christine Chiu, Colorado State University

Indrani Das, Lamont-Doherty Earth Observatory (LDEO)

Belay Demoz, JCET, UMBC

Venkataraman Lakshmi, University of Virginia

Jennifer Logan, Northrop Grumman Aerospace Systems

Rowena Lohman, Cornell University

Dylan Millet, University of Minnesota

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