NASA ADVISORY COUNCIL

EARTH SCIENCES ADVISORY COMMITTEE

NASA Headquarters
Washington, D.C.
November 4, 2021

TELECONFERENCE
MEETING REPORT

_____
Sara Tucker, Chair

_____
Lucia Tsaoussi, Executive Secretary

Prepared by Joan M. Zimmermann
Tom and Jerry, Inc.

November 4, 2021

Introduction

Dr. Lucia Tsaoussi, Executive Secretary of the Earth Science Advisory Committee (ESAC), opened the teleconference, which was devoted to the annual Government Performance Reporting Act Modernization Act (GPRAMA) exercise. Each committee member had reviewed reports on the science focus areas that serve as indicators for GPRAMA progress, in preparation for discussion and voting on GPRAMA. The committee assessed two metrics: Goals 1.1.8 and 1.1.9.

Dr. Sara Tucker, incoming ESAC Chair, initiated the proceedings, and welcomed new members to the committee. She commended NASA program managers for having produced a thorough report on the Earth Science Division's (ESD's) performance summarized through many publications. Dr. Tucker reminded ESAC that the report contained just highlights of the Research and Analysis (R&A) program, while covering a lot of ground and representing a lot of great work.

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.

1.1.8.1

Atmospheric Composition (1.1.8.1)

Dr. Daven Henze provided his summary, regarding reports that were largely related to emissions, and ground-based monitoring. In addition to addressing questions, Dr. Henze noted that the report clearly demonstrated that despite restrictions and delays due to COVID, NASA was able to carry out three successful airborne campaigns, including the TRacking Aerosol Convection interactions ExpeRiment (TRACER) project; in addition NASA was able to provide needed focus on wildfires. He provided feedback on the organization of the reported accomplishments, specifically the bridging between areas of research, as well as with a title in one of the sections regarding wildfires. Dr. Henze said he was a little surprised that the impacts of COVID were not consistently highlighted throughout the report, but greatly appreciated the inclusion of hyperlinks to publications. Overall, he felt the individual summaries were well written, and they did address the questions well. Dr. Tucker agreed with Dr. Henze's assessment, and added that she appreciated the report's attention to all the layers of the atmosphere.

Carbon Cycle and Ecosystems (1.1.8.2)

Dr. Colleen Mouw commented on this section, which addressed ocean biology, chemistry and biogeochemistry. The discipline has benefited from increased spatial and spectral resolution measurements; for PACE and GLIMR, this will be a matter of two- to three-fold improvement, in some cases, leading to improvements in detection of organic matter, and new possibilities in water quality management. She noted instances of improvement in monitoring ocean color, and also advances in understanding stemming from the use of polarimetry. Successes of the EXport Processes in the Ocean from Remote Sensing (EXPORTS) program were also highlighted in the report; the program has enhanced the understanding of transfer efficiencies, provided novel data on phytoplankton, demonstrated new approaches with the use of floats and gliders, and has captured different aspects of the North Atlantic blooms, all of which has led to improved decision-making abilities.

Dr. Lucy Hutyra felt that the report was particularly well-done in its treatment of the Arctic-Boreal Vulnerability Experiment (AboVE) campaign. She felt that some of the report, however, was disjointed regarding human impacts on the terrestrial ecosystem. Dr. Hutyra said she could have used more

hyperlinks to papers, and thought that some of the Airborne Campaign was unbalanced in representation; while she understood there had been some unavoidable cancellations, it would have been good to know the ultimate status. On the whole, she felt the report was comprehensive.

Dr. Nancy Glenn commented on aspects of terrestrial ecology, agreeing the report had done a nice job of covering ABoVE, particularly in the carbon budget section, supported by ICESat-2 data, which had made a considerable contribution. The report also addressed fire and monitoring GPP. There is data indicating that smoldering and overwintering of fires tends to generate larger fire years and deeper burning. Regarding land cover and land use change, the report did a nice job on studies in Southeast Asia. Dr. Glenn also commended the use of NASA data for supporting national REDD+ (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) policy and the monitoring of movement of populations in Mongolia. New GEDI (lidar) data on canopy and biodiversity, as well as data on wildlife movement, have also been valuable outcomes of NASA Earth Science research.

Climate Variability and Change (1.1.8.3)

Dr. Anastasia Romanou addressed this section, dealing with land, ice and oceans, and modeling, highlighting NASA's recent work in the understanding of several aspects of the climate system. Missions such as ICESat2, Sentinel, etc., have contributed greatly, and Dr. Romanou noted that the NASA website is now becoming a standardized tool for sea ice researchers. NASA data is also the basis for NOAA's daily reports on sea ice distribution. There is a new understanding of sea ice thickness and how it affects trends in sea ice distribution. In the area of land ice, there are new measurements for Greenland and Antarctica for parameters such as glacier velocity and composition, providing more insight into some glacier processes. In the area of ocean and climate, new studies from more detailed ocean measurements are indicating an uptick in the energy balance of the planet; in addition, two types of energy analysis in this area are maturing and agreeing with each other, leading to new understanding of how ocean affects climate. Hazards of climate extremes are also being assessed, with a greater understanding of phenomena that lead to coral bleaching and drought. Improvements in Earth system modeling, in part due to new coupling of variables, have been demonstrated at the Goddard Institute for Space Studies (GISS), and have contributed to the Intergovernmental Panel on Climate Change (IPCC) assessment effort. There have also been improvements in modeling at NASA's Greenbelt Center. Ocean assimilation data are also becoming more versatile with the advent of more high-resolution data, which are now being coupled with sea ice, ice sheets and ocean biogeochemistry. The report is well done.

Dr. Lisan Yu noted that the report provided a thorough look in ocean dynamics, components of systems, how ocean redistributes atmospheric heating. She felt that an especially nice point was the discovery of links between coastal sea level rise and ocean currents. Dr. Yu also liked the report on fresh water, ocean salinity and the water cycle, and particularly appreciated the section on water cycle amplification. The report also demonstrates the importance of long-term observations from space.

Dr. Indrani Das felt that the ICESat mission was the highlight for both land and sea ice; satellite data from 2003-2019 have shown how ice sheets are changing in both hemispheres including snowfall amounts on the ice. The combination of ICESat and CryoSat data has also been responsible for discovering new drivers of ice sheet change.

Earth Surface and Interior (1.1.8.4)

Dr. Rowena Lohman commented that the report demonstrated how hydrogeodesy is growing in importance, which in turn allows us to understand other signals once the water signal is eliminated. She noted the report reflected continued research on the effects of anthropogenic influence, and a better understanding of earthquakes and subduction zones, the decadal timescale of earthquake activity, new models on how ridges propagate and evolve, and new understanding of afterslip and aftershock (looking at how stress states evolve). More data on landslides have also proven valuable. Quantifying the effects of loading (removing the effect of tidal loading) allows a look at other signals in aquifers and land ice changes. Dr. Lohman noted improvements in understanding the vertical components of deformation. Preparations for the NASA-ISRO Synthetic Aperture Radar (NISAR) mission, in particular, presage further improvements in monitoring hazards, and also have provided a good opportunity for NASA to work closely with the Indian Space Research Organization (ISRO). The report also showed the results of NASA's impressive effort in geodetic imaging, including a lot of work done with UAVSAR in the rocky mountains and space-based geodesy which takes a lot of international collaboration, instrument calibration and validation, and reprocessing campaigns to help standardize data.

Dr. Robert Wright commented briefly, emphasizing the benefits of having long time-series data from multiple sensors that detect crustal movement. The volcano paper in particular highlighted that we now have a rich archive of data, enabling a real change in the amount of information that can be extracted. The NISAR effort has been very well staged. Spectroscopy has taken a back seat in previous GPRAMA reports, so it was nice to see this arise again. Dr. Wright had a minor issue with a paragraph on geodetic imaging, requesting that it be moved to a different section (hardware).

Water and Energy Cycle (1.1.8.5)

Dr. Venkataraman Lakshmi commented that the section reflected the importance of new observations, that will provide new data on the connection between Earth and the near-Earth atmosphere. New data are coming for the Surface Water and Ocean Topography (SWOT) and NISAR missions. Missions such as Global Precipitation Measurement (GPM), Moderate Resolution Imaging Spectroradiometer (MODIS), etc., will connect very nicely with SWOT and NISAR to help understand High Mountain Asia (including the Himalayas), often considered the "third pole." High Mountain Asia is the main source of water for a very large population, thus trying to do an accurate estimation of snowfall, and hence expected water supply, will be valuable. There is a big program coming up that will be able to (remotely) measure the elevation of water, which will help to supplement the lack of local stream and river gauges. This also connects nicely to the energy and water cycle. The well-written section on soil moisture emphasized the making of connections between ground water measurements and measurements of confined aquifers. New water color data has been helpful in improving evaluation of water quality.

Dr. Tucker added that the results on wildlife migration and snow patterns were also interesting.

Dr. Jasmeet Judge commented that it would be nice to tie soil moisture with the Cyclone Global Navigation Satellite System (CYGNSS) in this section; it is mentioned on p. 64, and maybe should be linked. Dr. Das agreed.

Dr. Yu asked if there were any discussion of activities related to the energy cycle. Dr. Tsaoussi noted that the format of the report is more tied to program funding lines, and thus the energy cycle is reported in other focus areas. Dr. Judge said she saw energy cycle data reflected in areas that deal with albedo, snow melt, etc.

Weather and Atmospheric Dynamics (1.1.8.6)
Dr. Belay Demoz discussed this section, noting that the report covered subjects very well, was very comprehensive, and addressed the importance of long-term data collection for data products. There was good reporting on the importance of the Global Ecosystem Dynamics Investigation (GEDI) and GPM. He felt the section was a little thin on the convective side, but that there was good work on clear sky radiance.

Dr. Tucker added that it was nice to see the culmination of gathering long-term data series (e.g., infrared and sounding data), as the community is gaining a better understanding of the observations. There is now an 18-year record of radiances, and also a lot of work on precipitation (TRMM, GPM and GPM constellation), that is helping to characterize how precipitation ties into how tropical cyclones develop or fail to develop. She also cited the inclusion of GMI (GPM Microwave Imager) for retrieving rainfall rates and observing surface emissivity. She thought this report was well done and thorough.

An ESAC member noted that there was a story on climate in the New York Times of 4 November, regarding CO2 monitoring by NASA during COVID. Dr. Plale asked for more information on NASA's Open Source Science Initiative (OSSI), and asked where in the report it might be appropriate to call such examples. Dr. Tucker said she would like to get feedback on this subject in future meetings.

Dr. Tucker reviewed the meaning of the GPRAMA grades (Green, Yellow, and Red), which are to reflect ESAC's evaluation of the year's science outcomes, measured against goals.

***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.

Dr. Tucker encouraged a briefer discussion of the next goal's subsections, citing much overlapping content with the previous goal that had been addressed in comprehensive detail.

Atmospheric Composition (1.1.9.1)
Dr. Henze briefly commented on the great work on aerosols, etc., adding that remote sensing has been detecting behavior that has been seen in models for some time. He also commended NASA's efforts in LIDAR, wildfires in Australia, transient air quality (AQ) changes and their health impacts, carbon cycle data, and stratospheric composition data. Overall, a well-done subsection.

Carbon Cycle and Ecosystems (1.1.9.2)
Dr. Glenn offered similar comments as in Goal 1.1.8, adding that there are now deeper observations with respect to methane emissions, as well as previously mentioned GPP.
Dr. Mouw cited better understanding of key biological processing in improving models. Dr. Hutyra felt that contributions from the Orbiting Carbon Observatory (OCO) and OCO-2 were missing in this section, but presented in section 1.1.9.1.

Climate Variability and Change (1.1.9.3)
Dr. Romanou felt this section was well laid out, covering better understanding of sea ice balance, and also of the timing of melt onset as a predictor of sea ice throughout year. There was also good research on land ice, the retreat of Greenland glaciers, and observations and interpretations of increased snowfall in the West Antarctic region, as well as some seminal work in ocean modeling; there is some work in connecting predictions of sea level rise with tides. In the modeling section, there was good work on the atmospheric river, tropical cyclones, and droughts. There have also been advances in cryospheric understanding. Missing, however, is information on carbon cycle modeling at NASA GISS; Dr. Romanou said she would send relevant papers to ESAC.

Dr. Das commented on highlights in land ice studies, illustrating how high-resolution bathymetry sensors for glaciers are proving to be important. There were also interesting observations about the effects of snowfall accumulation in a warming climate.

Dr. Yu added some comments on ocean components and societal benefits; it appears that more people are using NASA products, and it is good to see movement of more NASA data to the Cloud. She also commended efforts in predictions for tides, storms, and sea level rise.

Dr. Plale amplified on Dr. Yu's comments, noting that a valuable tool, developed by the sea level change team, has been made publicly accessible.

Earth Surface and Interior (1.1.9.4)
Dr. Wright noted that the historic NASA archive, now going back 20 years, will help prediction science; while the likelihood of an event in a given year, the measurements and modeling are helping us understanding which changes are significant drivers for events. Change in earthquake potentials can be measured by data on crustal thicknesses, as well as understanding of magma chambers.

Dr. Lohman appreciated the interconnection of the research areas, including how soil moisture state is tied to likelihood of landside onset, and commented that system-level studies, and more engagement with legal and technological issues, such as the use of UAVs, will be able to help users in the future.

Water Cycle (1.1.9.5)
Dr. Lakshmi offered some comments on the improved understanding of extreme weather derived from hydrological models; also better understanding of water availability, water quality and salinity, with ties to MODIS sensors.

Weather and Atmospheric Dynamics (1.1.9.6)
Dr. Demoz highlighted the importance of JEDI (Joint Effort for Data assimilation Integration) data assimilation efforts, and prediction improvements tied to CYGNSS, microwave and active sensor data, including GPM, in applications to urban hydrology, malaria outbreaks, monitoring of storm intensification, and lightning related to volcanic eruptions.

Dr. Tucker also noted the importance of the Joint Center for Satellite Data Assimilation (JCSDA), and that JEDI will be an important tool for data assimilation for a number of satellite systems into forecast models. She also cited the research in observations of lightning and its ties to other weather phenomena including mesoscale convective systems, and snowfall.

Dr. Jennifer Logan alluded to an omission on a previous section (1.1.8), in the carbon cycle area, a comment noted by Dr. Tsaoussi.

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

Dr. Tsaoussi noted 100% attendance of the committee, and that it was a good first meeting of the newly reconstituted committee. She said she would be working with ESD to put together a full meeting. Dr. Jack Kaye thanked everyone for participating. Dr. Tsaoussi adjourned the meeting at 2:50 p.m.

APPENDIX A
ATTENDEES

Earth Science Advisory Committee Members
Sara Tucker, ESAC Chair, Ball Aerospace
Indrani Das, Lamont-Doherty Earth Observatory (LDEO)
Belay Demoz, JCET, University of Maryland, Baltimore Campus
Nancy Glenn, Boise State University
Daven Henze, University of Colorado
Lucy Hutyra, Boston University
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, Columbia University
Robert Wright, University of Hawaii
Lisan Yu, Woods Hole Oceanographic Institution
Lucia Tsaoussi, Executive Secretary, NASA Headquarters

NASA Attendees
Eboni Whitfield-Miles
Bryan Johnson
Henry Selkirk
Jared Entin
Benjamin Phillips
Laura Lorenzoni
David Considine
Jack Kaye
Gerald Bawden
Jennifer Kearns

Non-NASA Attendees
Joan Zimmermann, Tom and Jerry, Inc.
Karmann Riter, RTI International
Jan Joris Brügmann, ESA
Brittany Webster, AGU
Richard Rogers, Stellar Solutions
John Kerekes, IEEE
Christine Joseph
John Bergstresser

APPENDIX B
ESAC MEMBERSHIP

Sara Tucker, ESAC Chair
Ball Aerospace

Indrani Das
Lamont-Doherty Earth Observatory (LDEO)

Belay Demoz
JCET, UMBC

Nancy Glenn
Boise State University

Daven Henze
University of Colorado

Lucy Hutyra
Boston University

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
Columbia University

Robert Wright
University of Hawaii

Lisan Yu
Woods Hole Oceanographic Institution