

# NASA Space Weather Council

August 8-9, 2024

NASA Headquarters and Teleconference

## MEETING MINUTES

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Nicole Duncan, Chair

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Kelly Korreck, Designated Federal Officer

# NASA Space Weather Council Meeting Minutes, August 8-9, 2024

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*Prepared by Jeanette Edelstein  
Tom & Jerry, Inc.*

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## Thursday, August 8, 2024

### Welcome from the Heliophysics Director

Dr. Joe Westlake, Heliophysics Division (HPD) Director at NASA, thanked everyone for joining the meeting and noted that the in-person meetings are very productive and that the Space Weather Council (SWC) provides a great service to the community.

### Welcome from NASA Space Weather Program Director

Mr. Jamie Favors, Director of the NASA Space Weather Program (SWP), remembered the energy of the meeting at the beginning of 2024 and said he looked forward to continuing those conversations and hearing new ideas.

### Welcome from Nicole Duncan

Dr. Nicole Duncan, Chair of the SWC, thanked everyone for taking time to attend the meeting and said she looked forward to the discussions.

### Adoption of the Minutes of the Last Meeting

Dr. Nicole Duncan skipped the adoption of minutes from the last meeting for time considerations and initiated a roll call of the members of the SWC.

#### *SWC Members in Attendance*

Nicole Duncan, Ball Aerospace  
Alexa Halford, NASA Goddard Space Flight Center  
Janet Green, Space Hazards Applications  
Paul O'Brien, Aerospace Corporation  
Ron Turner, ANSER  
Dan Baker, University of Colorado  
Dan Welling, University of Michigan  
Harlan Spence, University of New Hampshire

Dr. Duncan introduced Dr. Matina Gkioulidou, Senior Staff Scientist from the Johns Hopkins Applied Physics Laboratory and Heliophysics Advisory Committee (HPAC) member, to talk about the HPAC assignments for the meeting and review the presentation from the previous HPAC meeting. [The meeting was interrupted by technical issues at this point and the session was closed.]

Upon resetting the meeting and adjusting the agenda, Dr. Duncan welcomed everyone back, thanked the team who reset the technology, and introduced the first session.

### Coordination with Other Space Weather Groups

Dr. Ron Turner introduced Task 1, which ensures coordination between the various Space Weather (SW) entities, such as SWC and the Space Weather Advisory Group (SWAG). He spoke about the communications of meetings and between meetings of the various groups. There was an action from the last SWC meeting to put together a coherent description of how the different organizations work, what their lanes are, and how they intersect. He noted that there is cross membership between, for example, SWAG, SWC, and the Roundtable, and said that is critical to coordination and presents no conflict of interest.

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Dr. Duncan said there is a lot of coordination already happening; in particular, NASA HPD is present in many other meetings and has a lot of awareness. She added that SWC does not have to report back on activities, but other findings around coordination are welcome.

Dr. Harlan Spence added that there is some confusion in the community regarding roles, responsibilities, and interactions between the advisory groups, and suggested that would be another undercurrent to the discussion.

### Updates from SWAG

Dr. Tamara Dickinson, the chair of SWAG, began her update by speaking about the loss of colleague and friend Jennifer Gannon in May 2024, which has taken a toll on the committee; community; and Dr. Dickinson, personally.

Dr. Dickinson then reviewed the committee's charge. She listed the requirements for the group's user needs survey, which were laid out in the PROSWIFT Act. The SWAG divided the user needs survey into sectors which were organized into two rounds. She mentioned that the global navigation satellite system (GNSS) portion is a very broad sector that has not been surveyed in the past and will take two years.

Regarding the user survey process, Dr. Dickinson acknowledged the help of Science and Technology Policy Institute (STPI). The survey included focus groups for each sector and the report will be delivered to the Space Weather Operations, Research, and Mitigation (SWORM), Congress, and made public on September 26, 2024. Although the report does not include participant information, anonymized quotes and high level summaries from STPI will be included. Because the GNSS survey will take two years, there will be no findings or recommendations in the report this year. To date, there has been a town hall, a session at AMS for first impressions of input, and a public meeting.

Dr. Dickinson next reviewed the planned roll out for the user needs survey report (to be posted on the SWAG website upon release), which will occur at the next SWAG meeting on September 25-26, 2024. The meeting will convene former and future members of SWAG and will be a handoff. The first day will include updates from various groups and, potentially, a briefing on the Decadal; the second day will be a White House Space Weather Summit to include...

- Tribute to Jenn Gannon and official naming of the space weather storm of May 2024 as the Gannon Storm
- Discussion of that May 2024 storm and its impact on aviation and power grid sectors
- Brief overview of findings and recommendations
- Two moderated roundtable discussions on 1) various sectors and 2) the Research and Education sector, with senior leaders in the research field from academic, federally funded research academic centers [FFRDCs], and labs
- Discussion with the SWORM regarding future tasks for the SWAG

Dr. Dickinson said that the new SWAG will continue the user needs survey and likely take up integrated strategies for coordinated observations, which is part of its charter.

She reviewed the PROSWIFT Act guidance on membership and noted that, although the SWAG reports to the SWORM under OSTP, it is administered by National Oceanic and Atmospheric Administration (NOAA). The SWORM is conducting the process to select new members, from which a chair will be selected. The new terms are expected to start on October 1, 2024.

Regarding coordination and collaboration, Dr. Dickinson noted that there has been overlapping membership although it's unknown whether that will continue. She cautioned that official updates and information is best done via the chairs, the designated federal officers, or the delegate: joint committee

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members may not be fully aware of all activities and that has caused some issues. Dr. Dickinson has been seeing less confusion about the roles of the groups, although she thinks there is still confusion over the roles of the federal agencies.

Dr. Dan Baker asked who the most prominent and engaged champions are for SWC in the House and Senate. Although she thought she may not be the best person to answer, Dr. Dickinson said she communicates a lot with congressional staffer Brent Blevins, but there are others. Dr. Baker expressed his appreciation of former U.S. Representative Ed Perlmutter work across the aisle and activity promoting Space Weather. He said he hasn't seen another leader emerge in the House.

Dr. Spence asked about the assessment that the community is less confused: is it people who should have known better and now do or people who are not very active in space weather but are part of a broader space physics community who are better informed now. Dr. Dickinson said it is some of both. Her gut impression is that, although people were confused by the launch of three new entities (SWAG, Roundtable, and SWC) at roughly the same time, the amount of communication about roles and coordination has been helpful.

Dr. Spence asked whether the uncertainty of the roles and responsibilities of federal agencies seems to be the community's perception or the agencies' own confusion about their roles. Dr. Dickinson said the agencies seem pretty clear; she was referring to people on the various advisory groups (e.g., discussions about what NOAA should be doing when an issue is not really part of NOAA's charge). She said people in the community might not understand boundaries between tasks, but that it is easy to fix and not surprising.

### Updates from SWR

Dr. Geoff Crowley, co-chair of the National Academies Space Weather Roundtable (SWR) with Sarah Gibson, shared the membership organizational chart and the SWR's charge. He spoke about the loss of Jenn Gannon. He noted ex-officio members from NSF, NASA, and NOAA and that the Roundtable is drawn from different communities: commercial, academic, and government.

Dr. Crowley agreed that there is less confusion about the various groups but added that there is a plan, led by Jesse Woodruff, to publish a paper for release in late summer 2024 that will explain the committees, the coordination, and the differences.

Dr. Crowley then reviewed the SWR's ongoing activities and mentioned that the SWR is not a FACA and, therefore, has fewer restrictions on what they can discuss. They work from the perspective of improving on the standard ("business as usual is not in the national interest") and consider themselves a brainstorming group.

Next, Dr. Crowley reviewed the SW Table Top Exercise (TTX) meeting that occurred in May 2024. The Roundtable has been asked to review the report before it goes public. The TTX was government-only, except that it was organized by APL, and had two components: one at APL and one in Colorado, which included the Denver Region 8 Federal Emergency Management Agency (FEMA) group, invited by the Space Weather Prediction Center (SWPC). Attendees represented NOAA, National Science Foundation (NSF), NASA, FEMA, Office of Science Technology and Policy (OSTP), U.S. Air Force, federal and state and local government, and travel government. The TTX described an evolving situation near Solar Max and explored various and potential group responses, hour-by-hour and day-by-day. Conceptually for the TTX, NOAA began tracking and SWPC issued notifications. Dr. Crowley mentioned that the "Gannon Storm" was occurring at the same time, which introduced an air of reality. One discovery was the need for better communication, education, and awareness, both with the public and throughout the government; it would have been useful to have the power grid community and the communications system community in the exercise. In fact, FEMA was putting out alerts during the Gannon Storm and, as a result of the TTX, they were changing alerts in real time. Dr. Crowley pointed out that FEMA has very

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little in terms of space weather in their communications, which is needed to understand impacts on critical infrastructure. Overall, the TTX was a great success. Another TTX in the near future will parallel this one but will be classified and include national security groups.

Dr. Crowley gave an overview of the Gannon Storm impacts next. He talked about impacts to the grid, GNSS-related systems, aviation, and space traffic management; he also talked about space weather predictions. He said that the mitigation efforts of the past 10 years have been successful in lessening the impacts of this first major storm in 20 years. Overall, the impacts were not the major impacts that did occur were not those of a superstorm. In fact, SWPC is downplaying the size and has asked that it not be called a superstorm.

Dr. Crowley briefly discussed the proposal, made in Europe, to name the storm the Gannon Storm. Relatedly, he mentioned a proposal for naming large storms after scientists but said the international standards body did not accept it. So, the May 2024 storm is being called the Mother's Day storm in Europe and the Gannon storm in the United States; more generally, this means storms have different names in various places.

Next, Dr. Crowley gave an update on activities at the most recent in-person meeting of the SWR in July 2024. There was discussion about the Geospace Dynamics Constellation (GDC), including impacts for the operational space weather community, and a Department of Defense (DoD) civil space weather collaboration and cooperation discussion, specifically about eliminating duplicate efforts, leveraging work that's been done by other agencies, and working together to get funding.

Dr. Crowley talked about the funding issue at DoD, which impacts instrument and data availability and, potentially, national security. The DoD would like an open forum regarding coordination and collaboration with civil agencies. There was a consensus that this discussion needs to be taken up at the federal agency management level.

Another discussion involved space weather issues in long-term data continuity and archiving, sparked by the knowledge that the NOAA National Centers for Environmental Information (NCEI) group responsible for archiving space weather data will no longer be archiving ionosonde data. Implications for research and data archiving benchmarking, and the development of large language models for exploring databases with artificial intelligence (AI) were also discussed. Dr. Crowley said that it will no longer be the scientists' or investigators' responsibility to find the data owing to the arrival of AI models.

Dr. Crowley skipped a review of successes in R2O and O2R, in the interest of time. The Roundtable marked for future discussion the potential of commercial provider contributions.

According to Dr. Crowley, it was clear from the TTX that more exquisite reports and warnings would be useful to have, but NOAA and SWPC are not in a position to tailor reports and warnings for specific users. So, this may be a function of the commercial sector. There was discussion about the potential for weather systems to be a model for SW.

Dr. Baker expressed concern that the messaging about the Gannon Storm is that society is ready to deal with what the sun throws at us. He referenced a July 2, 2024 article in the New York Times with an interview with a SWPC space weather forecaster who said the effects of a major storm would be fairly minimal owing to the preparatory work done by the agencies. Dr. Baker thought it unwise for NOAA or SWPC to be making such statements and it is up to panels like SWR to set the record straight. Dr. Crowley agreed with the concern. SWPC was asking that it not be labeled a super storm and, while improvements in the power grid are great, there were plenty of outages and communications impacts. He said people in the room were hesitant to talk about impacts and there is a long way to go. Dr. Baker said it seemed that the SWC, or some agency with imprimatur, should make comments to put the storm into context and, whereas credit is due for preparation, a false sense of security will be damaging in the long

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run. Dr. Green said there was SWR agreement to come back to it. Dr. Turner noted that there is a community workshop on this storm pending, which may provide input to the next Roundtable meeting. Dr. Dickinson noted that the upcoming American Meteorological Society (AMS) meeting has sessions on the Gannon Storm, one on forecasting and one on impacts, which will have Q&A and discussion with the audience.

Dr. Crowley mentioned satellite operators' concerns over impacts and collisions. Although there didn't seem to be any collisions, orbits dropped significantly, managing them took more time, and the Kessler Syndrome could create a catastrophic impact. Dr. Duncan asked whether there is a responsibility for a certain agency to coordinate discussion around impacts and Mr. Favors said he didn't think so, that it's typically a NOAA thing in Terrestrial Weather and it seems to be the way it's happening in SW. Dr. Green said the power grids have regulations that tell them they have to measure impacts and they showed the best response during this storm, they seemed very coordinated regarding impacts, alerts, and post-storm assessment. She suggested that the next Roundtable could discuss whether there is a gap in coordination that could be addressed.

### Updates from SWORM \*

*Owing to schedule changes, Topic 1, Discussion of ESA Space Weather Service Network occurred directly after the Updates from SWR, and the Updates from SWORM was provided via slide presentation, only.*

### SWC Discussion of Coordination \*

*Owing to schedule changes, SWC Discussion of Coordination was moved within the agenda.*

### Discussion of ESA Space Weather Service Network

Jussi Luntama, from the Space Weather Office of the European Space Agency (ESA) Space Safety Program Office, began by reviewing the space weather objectives in the ESA Space Safety Programme. He said the funding schemes and mandate in ESA are straightforward: funding is coordinated by member states and everything ESA does is based on the funding and mandate from the member states. The funding is provided by the Ministerial Council and the next meeting of that council is at the end of 2025. Dr. Luntama also discussed the customer requirements document and how it is used to capture the needs of the European end users of space weather services and data.

The main message is that ESA is a development agency; an agency yet to be named will take responsibility of operational space weather services. The Space Safety Programme does the R2O and O2R work and is building a framework for that.

Dr. Luntama reviewed how development happens, including collaboration with the network of expert groups: industry, space weather, prototypes, software, and ground-based observation systems. The network allows for testing, verifications, and validation of capabilities; ESA's role is to facilitate; manage; and guide the development, testing, and verification; and build the space-based observations that facilitate these services. The network is a major international collaboration, covering 21 of the 22 ESA member states; hopefully Ireland will join the network by the end of 2025. They also collaborate with international partners (e.g., NOAA, NASA, Korean Meteorological Administration [KMA]) and ground-based observation and sensor systems.

Dr. Luntama said that the ESA Space Weather Service Network is designed to be an R2O tool, but is already providing near-24/7 pre-operational space weather services. Availability of the system is ~96% - 98%. He said most of the basic information is openly available and with registration there is further access; it's not restricted, registration is mostly for understanding of usage and ability to update users. There are more than 50 industry, institute, and academic groups participating in this network. He provided the link to the system: <https://swe.ssa.esa.int>.

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Dr. Luntama then reviewed the development of space weather capabilities in Europe. With R2O it's a complex system, with many capabilities and a lot of prototypes and models that need testing and validation. He reviewed the development cycle and mentioned that ESA places customer requirements before feasibility to allow for customer requirements to be defined without limitations; also, users are in the loop for the pre-operational provision step. When ESA gets a proposal for capability development, it is expected that the developing team has engaged with the end users who will stay involved throughout the development and at the time of testing and validation; resolution of issues takes needs of real users into account.

Dr. Luntama reviewed the validation, verification, and performance assessment processes at ESA. He mentioned that they have already defined methods and metrics for product validation, there are guidelines for the validation campaigns, and validation is continued after development is complete. The network provides both an opportunity and a commitment that the new capabilities are developed utilizing the existing assets in the network.

Implementing a standardized R2O(2R) process requires user engagement from the beginning, consistent validation and verification, and recognition that not all users have the same needs. The levels of user expertise varies, so there are trainings and webinars, tailored campaigns, meetings, and questionnaires regarding all of the above.

Dr. Luntama reviewed a few examples of space weather monitoring missions with international collaboration and then described collaboration with international partners and industry. First, the tech maps that monitor the atmospheric electron content would not be possible without global observation systems. When ESA's ground-based observations identified a gap in the European ground-based network it had a project to complement the existing systems with additional magnetometers, in addition to ensuring existing data is available in near-real time. Dr. Luntama expressed concern about the availability of data from existing global ground-based networks in the future, owing to uncertainty about funding and planning for the networks and upgrades.

Dr. O'Brien asked whether the expectation is that ESA funds these services long-term, periodically makes decisions about sunsetting, and also helps manage nodes in the network. Dr. Luntama said that ESA plans to start the first initial operational European Space Weather service in 2025. It will be small and limited initially, with room for growth. The idea is that tested and validated prototypes will be transitioned into this operational framework, ESA's responsibility will end, and the governing body for the operational service will take over. Dr. O'Brien asked about the longest lived service operating on the pre-operational network. Dr. Luntama thought it was the Total Electron Content (TEC), which has been there for 10 years. Once the operational framework is in Europe, the transitions will start.

Dr. Crowley asked about ESA's role in funding and development and the reliance on universities or the commercial sector. Dr. Luntama responded that ESA contracts out the development, after specifying requirements and writing a statement of work for competition. ESA does little work in-house, except for verification and validation. Shadow engineering and in-house experts provide validation and trust. He said about 80% of the development work is done by academia, but industrial developments and space start-up companies – especially those looking at machine learning and AI – are increasingly interested in space weather activities will probably get involved within the next year.

Dr. O'Brien asked for clarification about the people developing the tools and their responsibility for doing the validation and verification and whether ESA then does the oversight rather than the validation and verification themselves. Dr. Luntama confirmed that verification and validation is part of the statement of work and the expectations for the group, in addition to ESA doing their own checks and balances.

Dr. Turner thanked Dr. Luntama for his presentation and there was brief discussion about adjustments to the agenda.



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### Discussion of Coordination with Other Space Weather Groups

Dr. Turner invited members to begin the discussion by presenting actions or follow-ons to pursue in this area. Dr. Baker wanted to discuss how effectively forecasting is being done for satellite operations. He said NASA has the greatest need for forecasting at Mars and elsewhere in the solar system and it ought to be within NASA's purview and responsibility to take on the forecasting. He said the council should consider it and weigh in. Mr. Favors acknowledged that it would be controversial and potentially beyond the bounds of the council. Dr. Duncan reiterated that SWC is set up as a FACA committee and sub-committee to HPAC, so there are rules about discussion topics, but SWC can request that HPD consider a particular topic for an upcoming meeting. Dr. Turner added that space-based support to the human missions is included in the charter.

Dr. Duncan said that SWC provided those human exploration findings and recommendations over the last two meetings. Mr. Favors said there was not a task on human exploration for the current meeting; it doesn't mean there won't be one in the future. Mr. Favors confirmed that Sabrina Savage from Marshall Space Flight Center will be starting in the SWP at HQ in August 2024. Her title is Lead for Exploration – meant to be broad, human and robotic exploration. Dr. Korreck noted that there is a desire to have Dr. Savage establish her focus first but a valid suggestion to send to HPAC is that SWC is interested in a deep dive into human robotics exploration.

Dr. Duncan brought up the gap SWC perceived regarding human exploration activities that fell outside of HPD. Dr. Turner said that HPD funds the Moon to Mars (M2M) Office which provides input to the SRAG and others and the robotics community. The lack of clarity about who has responsibility is uncomfortable. Dr. Green mentioned that the suggestion might fall under the task on agency coordination.

Mr. Favors reminded the council that a Decadal is coming up and they were given materials on human exploration and M2M. Also, NOAA SWPC has an agreement with NASA to provide forecasting for human exploration missions. Dr. Korreck added that this is not an oversight committee meeting but, rather, an advisory council. Dr. Baker reiterated that the SWC should provide advice on this.

Dr. Duncan said that she wanted to focus on models of how the agency could partner with other agencies. Dr. Turner said Dr. Savage should be a speaker at the next SWC. Dr. Duncan asked for a finding and a recommendation around that for consideration at SWC's next meeting. She noted that the SWAG is tasked with advising on interagency responsibilities and gaps, and SWC can provide their feedback to the SWAG.

Dr. Crowley would like to see the SWC discussing the differences between ESA and NASA/U.S. processes, because they may be small but results may be significant. For example, ESA is not taking full responsibility for validation and verification for all the tools that are being developed; is there a bottleneck on making tools and products available to the broader community in the United States based on validation and verification at NASA or NOAA? The European approach seems to be more community-driven, one in which NOAA and NASA would take over more of an oversight role in the European model, which could accelerate the R2O process and make models and tools more available than they currently are. What improvements could be made to the U.S. process? Dr. O'Brien said the SWC would return to the discussion of the ESA model in the afternoon.

Regarding coordination with other groups, Dr. O'Brien said members may be missing information because there is no system to flag and send communications to membership. He requested that SWORM, SWAG, and Roundtable documents and reports be forwarded to the team. Dr. Duncan asked Dr. O'Brien to write up a recommendation on the suggestion. Dr. Dickinson commented that the SWAG has been doing two things: 1) maintaining a list from which to invite members to SWAG meetings and to use for announcements about reports and other items, and 2) sending information for distribution through the chairs to their committees.

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Dr. Green said the Roundtable talked about the importance of space weather to the DoD, who will rely on civil space weather data models and applications, and how they prioritize it. They are willing to promote different research tools and applications. She said NASA has to talk to the right people at DoD to foster better coordination. They said it has to happen at lower levels than the SWORM. Mr. Favours said that there was just an MOU signed codifying Department of Air Force involvement in these conversations.

Mr. Favours said the European model differs from NASA in the identification of the user, definition of requirements, and the solicitation based on those needs, which isn't how NASA approaches it right now, outside of a paragraph on use cases which is broad and general. Dr. Turner brought up the Earth Science approach and wondered whether it was more similar than the European approach.

Mr. Favours wondered about ownership of the partnerships – is it owned at HQ or by the researchers? ESA owns the partnerships and then identifies needs and solicits it out. In the Earth Science approach, the researchers build the relationships. Dr. Turner suggested that it's a third model (Earth Science). Mr. Favours noted that ESA will own partnerships and define requirements, whereas the NASA Earth Science approach was to give money to the researchers via a proposal that shows you've talked to the end user and figured it out. Dr. Halford said the commonality was identifying the industry partners and requirements at the very beginning, whether it's owned by ESA or NASA or the researcher and the PI. Mr. Favours agreed and wants to see the user involved from, not just day zero, but day -100.

### Comments from the Heliophysics Advisory Committee (HPAC)

A recap of the HPAC response to the previous findings of the SWC and the charges for this meeting was given by Dr. Korreck on behalf of Dr. Gkioulidou, owing to the change in the agenda.

- *Task 1: Advisory Group Coordination.* A white paper is being coordinated for Fall 2024. HQ is not requesting additional HPAC or SWC action.
- *Task 2: Gap Analysis.* There is no specific response or follow up at this time; HPD will re-examine the need for more information or advice in the fall.
- *Task 3: Moon to Mars.* Onboarding of Dr. Sabrina Savage in Fall 2024; no specific requests before that. Confirmation that recommendations from SWC will be made available to Dr. Savage.
- *Task 4: Agency Coordination.* Continue to report on domestic and international partnerships and opportunities to expand coordination. HPD requests that HPAC and SWC examine the characteristics of effective models of international or domestic collaboration for large scientific intragovernmental projects that may include commercial, e.g., science, particle physics, or earthquakes. What are the characteristics that make them successful?
- *Requested Task 5: R2O2R, Charge from February:* Report on ways HPD can make the R2O2R program more accessible to proposers by gathering feedback from principal investigators (PIs). Entire program undergoing a revamp; when ready it will come back to community for feedback.
- *HPD Requested Task 6: Revision of SW Scales:* In general, “refine space weather benchmarks that provide qualitative baseline analysis to assess the intensity of space weather events.” This includes study to see whether space weather scales should be revised. NASA seeks to understand what areas of space weather scientific research and modeling and observations would be affected by this change. Request for the SWC to investigate where and how space weather scales are used and what impact they could have.

Dr. Halford asked about how will decisions be made on what is timely – especially in regards to M2M slipping and the effects of that on HPD in terms of investment and funding. Even if the schedule is 3 to 5 years out, preparatory work is needed now to ensure the infrastructure needed at Mars is there, even 15 to 20 years in advance. Dr. Korreck said the timeline refers to the immediacy (couple of months) of focused staff (Dr. Savage) coming on board. Dr. Halford wondered, in general and considering timelines of other agencies, how will those timeliness decisions be made? Dr. Korreck said there are two considerations about timing. First, what does the SWC advise on and in what timeline; and, second, what can HPD and

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the SWP implement on certain timelines. Dr. Halford said it would be useful to know when the limitation is resources.

### Topic 1: Models for Domestic and International Collaboration in Space Weather

#### NASA Introduction to Topic

Dr. Korreck said NASA values domestic and international partnerships for SWP and would like to consider what can be learned from effective models for collaboration for large scientific intra-governmental plus commercial projects. HPD requests that the HPAC and the SWC look at characteristics of an effective model of international collaboration for large scientific intra-governmental projects. Dr. Korreck presented the five questions for review: are there specific examples in the science of effective collaboration, what characteristics lead to success, how were they formed, what is their funding structure, what type of non-governmental partnerships have been successful?

Mr. Favors reminded everyone that coordination and collaboration is part of the strategic plan. The strategic plan from 4 years ago is being revisited in preparation for the Decadal release, including the addition of two new liaison positions: one focused on commercial and one a DoD liaison. Mr. Favors acknowledged possible gaps, mainly about users missing from conversations and not knowing what the actual gaps are. He also said the UK was one of the main groups SWP has talked to and pulled successes from over the last year.

Dr. O'Brien spoke about the International Cooperative Research and Development program (ICR&D) and the Coalition Warfare Program (CWP) facilitation of collaboration with international partners. A U.S. government agency identifies a foreign partner on a project and provides half the U.S. funding, DoD provides the other half, and the foreign agency has to match that amount. This has been used for the Short-term Prediction Research and Transition (SPoRT) CubeSat. Mr. Favors noted that there seem to be multiple funding mechanisms for international partnership across the government.

#### Global Seismic Network (GSN)

Dr. Green introduced Dave Wilson, Laboratory Director of the Albuquerque Seismic Lab, part of the United States Geological Survey (USGS) and the Geologic Hazard Science Center, to speak about their approach to international and agency coordination dealing with earthquakes.

Dr. Wilson said the National Earthquake Information Center (NEIC), within the Department of the Interior, is tasked with monitoring and reporting on geologic hazards, including earthquakes – domestic and global. He said their goal is to reduce risk to life and loss of property. He shared the mapping of the seismic stations around the world and magnitude 6+ and 7+ earthquakes over the last 10 years.

Dr. Wilson reviewed some origins of the GSN. He said the Incorporated Research Institutions in Seismology (IRIS), made up mostly of universities, was a pool that could buy instruments so that individual researchers could borrow from a network rather than buying all their own equipment. Built on a footprint of previous networks and as a collaboration between IRIS (now called EarthScope) and the USGS, it operated the worldwide seismographic network from the 1960s into the 1980s.

The origin of the GSN in the 1980s was based on new technology and a desire to pull the networks together and standardize equipment. Supplemental funding allowed an upgrade to the network for compliance with the International Monitoring System (IMS) and the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) monitoring observations; this allowed for adding other types of sensors and the first non-seismic sensors. After the 2004 tsunami, there was a push to ensure a fully telemetered, real-time network and a move for USGS NEIC to 24/7 operations.

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Dr. Wilson said IRIS has merged into EarthScope for Earth science support. Funded through NSF, it provides instrumentation to researchers and operates 40 stations. There is a USGS GSN advisory committee, typically Earth science researchers, that gives advice and direction to both station operators. The relationship has worked well; around the world, some groups would prefer not to work with a government agency, whereas some would. Also, as a private entity, EarthScope can lobby for funding. All data is freely available through a consortium-hosted data center – getting data from a private web service is easier for researchers than getting data from a government agency.

Dr. Wilson reviewed a map of the GSN today which showed global diversification and overlap between the two agencies. The goal for the network is 2000 km station spacing; but, there are spaces that can't be covered, e.g., in the ocean.

For the USGS, one of the primary goals is earthquake monitoring for hazard reduction. The NEIC is constantly monitoring the data for distribution to emergency managers and other agencies, such as FEMA. There is a real-time display of large/global as well as smaller/domestic earthquakes and partnerships with regional networks in the United States, typically run by universities. Dr. Wilson described the NEIC ShakeMap, which shows intensity of shaking and provides the sort of information that emergency managers can use, and the ground shaking map derived from public input. All this data is put together in the Prompt Assessment of Global Earthquakes for Response (PAGER). Population density shows how many people were affected, including estimates for fatalities and property loss, which helps agencies such as the United States Agency for International Development (USAID) determine exactly how much damage there may be.

Dr. Wilson spoke about GSN applications. GSNs have been operating for over 50 years and most of what we know about the interior structure of the Earth is from seismic data. GSN upgrades have improved resolution and enabled new observations.

Next, Dr. Wilson spoke about some of GSN's partnerships, including a strong partnership with NOAA and the tsunami warning centers. GSN tsunami warnings are based on data regarding seismic waves. With early detection and characterization, there is quite a bit of prediction time for a possible tsunami. GSN picks up other signals on their instruments, including geomagnetic storms. They've recently partnered with the USGS Geomag group, and USGS has installed magnetometers and is starting a network to look at variations across the United States. There is also a close partnership with the CTBTO. Each country has a bit of ownership for the station. Data is typically used for explosion detection and discrimination.

Dr. Wilson talked about the observations GSN has provided, including information about the 2022 Hunga Tonga eruption, where barometers picked up an oscillation at a specific frequency in the atmosphere in the days after the explosion. Some observations show peaks in seismic data and barometers and others show the ground pressure as related to seismic waves.

The GSN has been a huge research success. Shipments of data are in high demand and are turned over more than other agencies.

The GSN has limitations. Dr. Wilson said there are large areas without sensors because there is no land to put them on. And, there is interest in setting stations on the ocean floor, but it is a challenge in relation to station lifetime possibilities.

Future challenges for the GSN include budget, which has been relatively flat for a while. In the past, upgrades have been enabled by one-time injection of funds from DoD or DOE; sometimes the CTBTO is supported by the Department of State. Funding has not been stable enough for planning and the EarthScope portion is NSF-funded, which comes with proposal cycles and the need for justifications of spending. There is only one new station planned. In the last few years, due to budget, there is an effort to rely on local station operators for small/simple equipment changes.

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Dr. Halford asked how USGS/GSN has been able to maintain data consistently, i.e., demonstrating value or treaty monitoring. Dr. Wilson said the treaty monitoring is a relatively small part. The biggest push has been the research success. In meetings with the funders they highlight the papers – especially discoveries – that have come out using GSN data. EarthScope is researcher-driven. When researchers are putting in their own NSF proposals, they're encouraged to include how they're using the GSN data.

Dr. Halford noted that GSN has long-term, longitudinal studies to show funders this is worthwhile to maintain going forward. Dr. Wilson said several research discoveries have only been possible with a decades-long records (e.g., climate change and oceanic storms), which used GSN science data, or the study of the rotation of the inner core, based on earthquakes occurring in the same location over decades.

Dr. Baker was concerned about partnerships, and specifically leaders, and wondered how important the academic involvement has been to making this a successful international effort. Dr. Wilson said it was very important. For example, in Russia the university is still allowed to work on this. The researcher-to-researcher relationship makes this work: the people on the ground will do anything they can to keep the site running and have some local ownership of it.

Dr. O'Brien had several questions about the allocation of responsibility and standardization, the production of finished projects versus those that are being shipped. He asked, in terms of local maintenance, whether that is funded or how centralized versus local maintenance is handled. Dr. Wilson said the recorded data does not take a lot of post-processing. Researchers can use the raw data and meta data. As far as local support, there's a wide range; there are agreements with some sites to pay a yearly stipend for electricity or station visits, for example.

Dr. Spence asked about substantial challenges in terms of policy and approaches and things that should be avoided. Dr. Wilson responded that, from the USGS side, the Congressional mandate for monitoring has really helped. The challenge mostly comes from the research side, but the research success through the years has kept it going. Early success leads to later success, including for funding justifications.

Mr. Favors asked about non-research work, with emergency managers and DoD, and whether that kind of work helps sustain data collection or funding, i.e., whether the use case is anything more than a helpful bonus. Dr. Wilson replied that he hadn't seen that type of work result in long-term research success. Once the data is produced, you never know where the research might lead.

Dr. Halford asked how the group handles getting the data to the research community quickly and whether the data are accessible to the public. Dr. Wilson said it's all public. There haven't been hurdles releasing data. Occasionally a partner does not want their data released, but all of the data from the sites operated by NEIC are freely available.

Dr. Duncan asked whether there were more projects, and what kind of engagement there is with the user community. Dr. Wilson said it is basically two different communities for research versus monitoring. On the research side, the EarthScope consortium accesses data from hundreds of small universities around the world. From the monitoring side, it is part of the Congressionally mandated National Earthquake Hazard Reduction Program. He then spoke to the user communities. There are federal agencies, like FEMA, but there are also local agencies, like the City of Los Angeles and San Francisco. From the research side, since the data is open access, it's graduate students and anyone who wants to pull the data.

Dr. Baker asked about the relationship with earthquake signals and underground nuclear tests. Dr. Wilson said the data are shared with the national data center run by the Air Force at the Air Force Technical Application Center and, if an earthquake is detected, they would put out any announcements. GSN helps work with them for verification. Dr. Wilson said dual use is a benefit, as they're not just monitoring large earthquakes, but other events – including magnetic storms.

Dr. Green asked whether there is really a separation between research data and operational monitoring data. Dr. Wilson said it helps to have that committee, but it's really about the malleability and filterability of the data.

Dr. Duncan asked about IRIS (EarthScope) and whether it is more of a consortium for research or for operating and maintaining the hardware and the network of sensors, or a mix. Dr. Wilson said it's more for research. The idea was to fund the buildout of the GSN but also to purchase a large pool of instruments that people from any of the network universities could use. They've funded almost a third of the GSN operations through that mechanism.

Dr. Duncan noted that SW centers may be analogous as they are formed around research questions and topics. She asked whether, initially, there was competition among other centers or it was meant to be a general observatory network for an entire community. Dr. Wilson replied that it was meant more to be for the entire community. For NSF proposals, people can build in the ability to borrow instruments from IRIS, then NSF builds that into their funding structure.

#### SWC Discussion of Models for Collaboration in Space Weather

Dr. O'Brien made suggestions about organizing the findings and recommendations, specifically calling out examples from the presentations – such as USGS's funding structures with NSF – in the SWC's findings. Dr. Korreck encouraged the members to raise their own examples in the discussion. Dr. Halford talked about using better examples, such as what is being done by the seismographic group and also polar programs run out of NSF, which does a good job of having observatories and instruments going over long periods. And space weather changes on decades or longer time scales, so science that needs longer-term scales would be great to be able to do.

There was a discussion about a central document for all data sets and acknowledgment that NASA's open data policy is revolutionary and it works towards getting maximum value out of the data. Mr. Favors asked whether there are ways the community can help NASA be focused on what the right data sets are. Dr. O'Brien said agency-level engagement provides justification and goes further than having an identified user. He wondered whether the list would come from SWC, the Roundtable, or SWAG. Dr. Spence mentioned the issue of access to international data, particularly from the Chinese.

Dr. Duncan, using the example of the Office of Polar Programs and their dissemination of data to the polar community, said a one-stop shop of advocates and data stewards works well. She said there needs to be an owner and it would be great if NASA took it up. Dr. O'Brien talked about the nuance to releasing data after the fact for research. With an ESA-like system with space weather services, there would be a bigger need for real-time data release and that could be an issue; USGS can release data in real time based on applicability to civilians. He gave the radiation test facilities for quarks and solar cells as another model of domestic collaboration that is coordinated but not centrally funded. He suggested that NASA and DoD could buy up free time to keep the facilities going, as the radiation group does at NASA Goddard Space Flight Center (GSFC) and Marshall. Dr. Green added that EarthScope does that, too. There was discussion about ESA's paradigm doing both models and ground-based data, as making the most sense for essential observations. For example, NASA's CubeSat capability could be used by SW for observations that are like the USGS paradigm. Dr. Duncan offered that there is a third option: a separate entity charged with data curation, data management, and user services as primary goal, with data products developed to help users, dissemination, and advocacy for the release of the data which would be adjacent to the central mission of providing data. Dr. O'Brien said there is overlap with NCEI efforts for non-real-time data and SPDF efforts, but not how it's being described and not for real time. NOAA has some involvement in real time space data, but they are not big or dynamic enough to support this type of research.

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Dr. Duncan suggested that centralizing the efforts to make data accessible to a group that has data centers and users at their core function would save time and energy and be a real user service. Dr. O'Brien said centralizing efforts is a great idea but is challenging with different schemas and different kinds of data. Mr. Favors spoke about commercial providers' ability to monetize – to do the work of data processing and then set up applications (e.g., Microsoft's AI for Earth and Google Earth Engine) that can be hosted in interesting ways. The agencies just need to make sure their data archives are available for software engineers. Dr. Duncan cautioned that, for that much data, someone needs to figure out who is storing it and how to access it, and that cloud storage is very expensive. Dr. O'Brien agreed and said the NOAA split between SWPC for real-time data and NCEI for archived data is a hurdle; the cost issue is not trivial, but you don't want the data to be in a different organization. Dr. Duncan said a general observatory would be simpler to do than a space-based or magnetometer network.

Dr. O'Brien asked Mr. Favors for guidance on how the fiscal situation might affect things and how big of a role should cost effectiveness play in SWC's recommendations? Mr. Favors responded that any of the recommendations are scalable and SW has been fortunate to see \$20M to \$25M in the last few years. Considerations should include the size of the community being supported and how well the stories highlight the societal benefits of using the data and justify the costs. Mr. Favors suggested that there are ways to lean into storytelling that would give the application/societal benefit picture as well as the science story. Dr. Korreck said SWC is being asked to talk about the idea, coherence, or program that will get the scientific results that will help the operators and feed into the applications. SWC should be thinking about what consortiums, what partnerships with universities, other international partners are needed, and how to scale what may need to start as very small.

Dr. O'Brien referenced Dr. Luntama's charts, which included information about the use of services and number of hits and allows for knowledge of what external consumers are doing. It's difficult with the NASA paradigm, where projects are run, papers are written, there are capabilities, but there isn't anywhere to put it because it's not part of an official network and there is a reluctance to engage with it. The ESA paradigm has the ability to bring wins owing to aggregate user statistics. Dr. Green added that the research consortium of EarthScope is also part of that institution that does seismology as part of IRIS, so the research is also coordinated.

Dr. Duncan said it goes back to the general observatory model in space: because it is so focused on individual science questions, it is difficult to answer questions across missions. With a majority of PI-led missions, it's hard to assemble intentionality between missions in that paradigm.

Dr. O'Brien suggested a multi-layered system with true operational systems for NOAA, the proto-operational systems for NASA, and the experiments. The GSN is a model that assumes the collection of general data will support a variety of new discoveries. NASA should still have missions with hypotheses to test, but SW is more opportunistic and has less time; it is particularly sensitive to this problem with general observatories.

Dr. Baker said NASA should be the agency to step up to lead. Although it is a mission agency, it should embrace the idea of taking a longer view and more integrative role. Dr. Duncan agreed with the concept of the importance of long-term modeling and NASA's potential role, which falls within the letter of the law of PROSWIFT. She said there are a lot of arguments for what long-term monitoring can do for science discovery. She noted the parallel to SW that NSF, a science agency not an operational "agency," is sponsoring IRIS and Unavco. It was noted that these collaborations can be made possible simply by mutual agreement to do it.

Dr. Korreck asked about the mechanisms to connect NASA and NSF, and the mechanism of collaboration for GSN. Dr. Green said there is a consortium of universities to define the research side and an advisory committee to connect that to the agencies.

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Dr. Spence noted that China and Europe are asserting leadership in the space weather domain and NASA needs to step up to assert leadership, as well.

Dr. Korreck asked, with universities and federal agencies playing an important role, how NASA could become a player in the research network. She noted that it doesn't seem that USGS (i.e., the federal agency) is not the head of the research network, and the advisory committee is not a FACA committee. It would not be the equivalent to a SWC. Dr. Duncan thought the analogous role is the fact that NSF funds IRIS and now EarthScope, so they dictated the scope of the consortium and drives that, and the USGS came in to partner. So the agency still directs how their ground network is being utilized and deployed. She added, for space-based sensors, NASA would have a consortium to run and organize tasked with establishing the initial sensor network capabilities. Dr. Wilson said research scientists would include the capabilities in proposals, which could expand the network.

Dr. O'Brien said it seemed USGS was able to set some priorities and the organizations understood the mutual benefit. Dr. Green suggested that, since NASA has PI-led missions, maybe a research consortium could be created by the PIs., although it was noted that in the existing paradigm joint research can't be prioritized over what you are contracted for as a PI. Dr. Green thought it could be part of the proposal to have to participate in the consortium. Dr. O'Brien said it's a place for the infrastructure missions to plug in, a good place for SW to stay in senior review, you can set aside your PI-mode and go into space weather-mode.

Mr. Favours mentioned early adopters and how to talk about the users from day one of the mission. There could be a binding part of what goes on across the portfolio of missions, as well. Members added that the consortium also provides a single point of contact for PIs and that it could help with the stove piping that happens across communities. NASA would probably need to make it a narrow area: GSN is only focused on seismometers, not atmospheric pressure systems or anything else. NASA would need to pick a good small test case, such as drag, to start. Dr. Duncan said it could be CubeSat-size from a cost perspective but also from an accessibility standpoint. CubeSat has more entrance points, opportunities to train students, and can foster international collaboration. It would be good to enable more organizations to have heritage in space-based systems.

Dr. Turner brought up the AI community as one that will be a major driver in establishing these databases and access to them in realistic and usable form. It is making major strides in pulling disparate data sets together to be machine-readable and usable. Dr. O'Brien said that NASA HP paid people to make an AI-ready solar imagery data set, which is something SW should latch onto. Various data set collectors use different products. Dr. Turner mentioned the AI HP SW program at AMES: four different groups trying to play with data sets for various extractions.

Dr. Korreck asked whether there are places of coordination or collaboration – other than data – such as educating people on how to use their network, instrumentation or hardware, or other pieces that should be considered in a collaboration model. Are there other things SWC would consider in a domestic/international/commercial collaboration model?

Dr. O'Brien noted that ESA, and seemingly everyone else, had an education piece. There was a discussion about implementing an education program, like an education and public outreach (EPO) program for professionals, for users on the SWC and SWP, potentially with guidance from standing groups with users. Dr. Duncan said SW users of data are usually super users and a good technical understanding of the scales is necessary to be able to use them. Without enough applications being created, there are pockets of specialty that occur within industry and a lot of companies are building in-house capabilities. On the other end of the spectrum, agriculture was one of the most impacted communities during the Gannon Storm and the materials generated were too general. Dr. O'Brien gave an example about farmers' questions based on misunderstanding, e.g., asking about flares instead of Defense Navigation Satellite System (DNSS) impacts. He said the updaters of the scales should go back and look



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at storms and think of who was not well served by the labels or information given. The better and more granular the alerts and warnings are, the fewer people have to become experts. There was a discussion about how many people would be helped by a little bit of information versus a lot of depth, i.e., the many farmers versus the dozen satellite manufacturers. It was noted that international communities may value space weather work the most.

### Working Session on Topic 1 for SWC

[No notes were requested for the working session.]

### Adjourn

The meeting adjourned at 5:00 p.m.

**Friday, August 9, 2024**

Overview of Agenda

Dr. Duncan welcomed everyone and thanked the group for their work the previous day before reviewing the agenda for the day.

Public Comment Period

The public comment period began at 9:05 a.m. There were no public comments.

Topic 2: Impact of Revisions of Space Weather Scales on NASA Science and Missions

Intro to Topic

Dr. Korreck, in defining the topic, said there's a study underway to refine space weather benchmarks. She asked the council to consider what supplementation might be necessary in regards to data archives and scales. She noted that, in longitudinal research, a scale change is important to note retroactively for consideration about, for example, whether modeling is affected by scale, cross calibration of instruments, and new articles. Mr. Favors reiterated that the conversation in this group is not about the scales revision but about the implications of those revisions for NASA once they're changed.

Revision of Space Weather Scales

Dr. Dan Welling introduced Asha Balakrishnan of STPI to talk about revision of space weather scales. Dr. Balakrishnan noted that Bill Murtagh from SWPC was unavailable for this meeting. For background, she noted that STPI is an FFRDC created to support OSTP and that NOAA has asked STPI to do a study on the revision of the scales.

Dr. Balakrishnan clarified that the STPI study on revising NOAA space weather scales is about the scales, not the benchmarks. STPI is seeking input from users of NOAA's three scales, G, S, and R: Space Radiation Analysis Group (SRAG), M2M, Human Space Flight at NASA, and Rail. There are two other audiences for the scales: government leadership (e.g., for the recent TTX) for making high level decisions, for which OSTP will have a fast track action committee for input; and the public (e.g., broadcast meteorologists).

The study is about broad reach, including to the international community (e.g., World Meteorological Organization [WMO], Committee on Space Research [COSPAR], International Space Environment Service [ISES], ESA), NOAA, OSTP, SWORM, and additional government experts). They are nearing the end of data collection, having had about 70 engagements, including interviews and roundtables, and a request for information (RFI) with 80 responses – in total, about 250 people.

They asked six fundamental questions for this basic, qualitative work: What do people use? How do they use it? What do they like and what don't they like? If the scales went away, what would the impact to operations missions be? Do they think the scales should change? If there were a new scale, what would they want to see? Note: There is no implication that NOAA will be issuing a new scale.

Dr. Balakrishnan reviewed some common responses: by and large, the scales are used as a situational awareness trigger; the communications are outdated with no discussion of uncertainty; and users want to understand the magnitude of the impact on their systems. Common responses about all SW services included that, even though Level 1 is a baseline and people start to pay attention at Levels 2 and 3, people want an all-clear. Most end-users take action at G/S/R Levels 4 and 5. There is disagreement about granularity – some want more, some want less, others would be satisfied with a binary.

*G-Scale Preliminary Responses.* After the May 2024 storm at a G4 and G5, there are people calling for recalibration; others would prefer expansion at the higher level. Some would prefer more granularity and use of the Kp-index rather than the G-scale. The Space Domain Awareness (SDA) group is worried about

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atmospheric drag, which can cause large errors to orbital predictions, and is using Kp-index as a proxy and not really using the scales. G-scale is more effective for local emergency managers and they would like it to align with FEMA recommendations.

*S-scale Preliminary Responses.* Responses indicate that the 10-MeV level is too low and, although it works for certain communities, like SRAG, the aviation communities and others are looking for higher thresholds. They're interested in the 50-MeV or 100-MeV, but they don't see a scale-based outcome.

*R-scale Preliminary Responses.* Responses indicate that this scale is generally misleading because of its name because it only covers the high frequency radio band. Emergency managers would like to see the scale band expanded to include a broader swath of the radio frequency spectrum.

Dr. Balakrishnan discussed potential new scales next. There was a discussion of a T-scale and metrics and underlying phenomenon measurement. Interviewees suggested a need for scales that cover ionospheric scintillation, changes in neutral density, radio burst across all communication frequencies, dosimetry, geoelectric field, and spacecraft charging. Other input included that STPI is only looking at the scales, which is hard to do in isolation, and SWAG is looking across the board at all the different products and information. STPI is awaiting the SWAG report on scales. NOAA/SWPC is interested in both the scales piece and the broader services piece.

Dr. Halford asked how the 10 industries included in the study were chosen and what future activities might reach out to more. Dr. Balakrishnan clarified that those listed are sectors, as directed by NOAA, owing to subscriber privacy; they shared the sectors they get called about or have developed relationships with. Their focus was understanding the user community and stakeholder engagement.

Dr. Spence noted the potential for confusion with different scales in different countries for the same phenomenon (e.g., the Torino scale for near-Earth asteroids). Dr. Balakrishnan said there is a desire to learn about international scales. NOAA has been in close contact with international communities for a long time. A lot of scales are based on a NOAA scale, and in some countries they are watching what NOAA is doing or, in Japan for example, they both use the NOAA scales and have their own and a lot of the sectors use the NOAA scales.

Dr. Welling asked whether STPI talked to the researcher sector and Dr. Balakrishnan said they were really interested in the end user, but people who work on the scales are also doing research, perhaps through joint appointments. There was input from people at COSPAR, but it wasn't a focus.

Dr. O'Brien asked about localization. He said you can talk about the general state of space weather but you may need to specify how it affects people locally (e.g., farmers in one part of the country versus another.) Dr. Halford said more local applications of space weather should be part of the SWC discussion. Dr. Balakrishnan has heard a lot that the scales are based on phenomenology, they're not impact-based. Users don't care about phenomena as much as impact, and everybody has a different level of protection on their system, so there is difficulty in predicting impact. Dr. Halford noted that weather alerts are still phenomenology (e.g., flood warning, tornado warning) and wondered whether SW user communities are less aware of how the phenomena will affect their systems. Should SW mimic Terrestrial Weather and have scales that are directly related to impact? Mr. Favors said that the other NOAA scales have changed with engineering impacts in mind. Dr. Balakrishnan said that when parallels happen between the SW community and tornados or flood warnings, there is a need to recognize that it's a fairly nascent field in terms of what we can understand. But hopefully SW will be able to get a little closer to the impacts in a particular place, and/or get a little bit more certainty and regional information.

Dr. O'Brien talked about the difference between a warning that indicates the cross over a percentage threshold and generic, high-level language (e.g., "once a year," "once a decade"). He thinks the current scales have the impacts you should expect, at this scale, and the things to be warned about. Getting more

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granular, is probably getting into products. If someone says the scale is not good and they need a Kp, they're looking for a product; there is no need to overburden the scales. Dr. Green said that the problem is the phenomenology the scales are based on don't tie directly to the impacts, e.g., the G-scale doesn't tell you what neutral density is doing.

Mr. Favors appreciated the granularity of user feedback and asked how it will be included in the final report. Dr. Balakrishnan said that a lot of that information can be captured in raw form. The RFIs are public and available at Regulations.gov. The STPI agreement with SWPC calls for provision of options SWPC should consider going forward and the impact of those changes. There might be a public version and a government-only version.

Dr. O'Brien asked, if NASA is going to make a new scale, where does the responsibility exist for those long-term reference data sets for determination of recalibration? Is that something NOAA will do, should NASA be prepared to do that? How should the quantitative part of this work be done? Dr. Balakrishnan noted that the scales were started before the benchmarks. Benchmark work is getting started, and STPI will not necessarily be leading that but will be coordinating.

There was discussion about whether scales updates will all be forward looking and that was the general assumption. It was noted that it would make historical comparison of storms difficult if they were only forward looking. Mr. Favors said there have been discussions about inviting speakers from other fields to study how this has been handled.

Dr. Duncan and Dr. Balakrishnan discussed the research sector's input on impacts. Out of 60 interviews, three or four were with researchers. The sectors for the SWPC and the SWAG report are very similar. Mr. Favors said the SWAG user survey does include researchers, but they are supporting SWORM and scales are specific to NOAA. He doesn't think they see the research community as users of the products. Dr. Duncan suggested that not including the researchers could be an oversight that would make it harder to bring researchers and end users together. Dr. Halford agreed and talked about the launch decisions, data collection, the predictions and forecasting those scales contextualize. She said the researchers are also user communities for the scales, although they're different than other user groups and potentially smaller.

Dr. Balakrishnan and Dr. Halford discussed methods to reach the research community, specifically PI forums and workshops and agreed to follow up offline. Dr. Balakrishnan said they could potentially use a simple survey to reach out to those communities. Mr. Favors cautioned that it is a bit outside the task and talked about scale changes based on user needs versus fidelity.

Dr. Duncan asked how the outputs of this exercise influence not just the scales but what the research objectives need to be. She also wondered whether there will be enough information in the results for NASA to use the input to see if there needs to be more research conducted to help guide the decisions. The study considered what decisions are made on an operational basis when you're using the scales. A lot of people surveyed do not understand the phenomenon or the research. Dr. Duncan said they don't need to: the experts come in and adjust things in the research or applications community to meet user needs. She thought it could be a recommendation for NASA to connect with NOAA to make sure there's the data necessary for this information.

Dr. O'Brien said that, if NOAA is going to change or develop new scales, it makes sense for NASA to look into what the decision aids would look like. He said usually government provides the forecast and some commercial entity provides the tool for decision making. These scales fit into decision aids. He gave an example of a power company improving operations around space weather. The scientists had to help the commercial providers develop their own tools. In the United States that role initially sits with NASA, so there needs to be a reaction to improvement of the scales in regards to decision aids. Dr. Welling noted that in the example given, they have moved completely away from that model and now work closely with

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scientists and engineers to use case studies to build emergency responses – more of a benchmark reaction than a scale-based reaction. The power grid managers were in fairly constant contact with the scientists and engineers who helped build and deploy the benchmark responses during the May event. Scales fell by the wayside a bit.

### CCMC and Space Weather Scales

Yihua Zheng, with the Community Coordinated Modeling Center (CCMS) at GSFC spoke about the International Forum for Space Weather Capability Assessment, COSPAR/ISWAT (International Space Weather Action Team) Initiative. Dr. Zheng reviewed the chart that described the initiative, which is a global hub for collaborations addressing challenges across the field of space weather.

Next, Dr. Zheng discussed the Essential Space Environment Quantities (ESEQs) as the bridge that connects space environment to impacts. The ESEQs units are measurable and can be translated to impact. The power grid is very complex and, from a space environment and scientist point-of-view, the focus is on the geomagnetic field variations, rather than the impacts. ESEQ can be predicted by modeling and validation. NOAA adopts a space weather modeling framework by moving proven models to a NOAA hub.

Dr. Zheng reviewed the impact of satellite drag, for which there are drivers from both solar and geomagnetic activity. To determine the drag effect, a satellite model and orbit propagation are necessary. For an HP space scientist, the thermospheric density model – a dominant source for uncertainty – is the most important factor for assessing impact and is used for model validation.

Next, Dr. Zheng reviewed the amplitude index and phase scintillation that describes the signal strength over time for navigation and communication. It's a direct measurement of impact, but depends on the receiver technology and is not an objective measure of atmospheric state. Dr. Zheng discussed the rate of total electron content [TEC] index (ROTI). Due to the complexity of the quantities, a scale for the users cannot be defined. Dr. Zheng said a researcher at the National Institute of Information and Communications Technology (NICT) Japan proposed a unifying ionospheric storm scale which is a 0 to 3 scale of storm strength (0=quite, 1=moderate, 2=strong, 3=severe) and can be used as a positive or negative scale.

Dr. Zheng discussed impacts on space assets and aviation. The measurements for internal charging versus surface charging are different, as is the time scale of these impacts. She reviewed quantities for surface charging, internal charging, single event effects, total dose in orbit and in the atmosphere, and aviation. She said that for space environment a Spectro parameter would be needed. From the impact user perspective for aircraft, a D-index has been proposed instead of the I-scale. Dr. Zheng next discussed impacts on human exploration of radiation storms due to solar energetic particles (SEPs) and the Johnson Space Center/SRAG measurements versus those for NOAA's S-scale.

Ultimately, Dr. Zheng's presentation was less about scale and more about the user perspective of how research can be transitioned into operations. The transition needs to be user-specific and tailored to where you are, where your assets are, where your concerns are, and what your needs and susceptibilities are. She said for scales, multiple phenomena increase complexity and magnitude (e.g., there is a difference between flares vs. SEPs at high-latitude, but both cause irregularities), all of which needs to be kept in mind.

Dr. Halford noted the distinctions between scales or products and decision aids. Dr. O'Brien said things are location dependent: the earthquake scale is not a global state of earthquakes, it's a measure of the intensity of a local event. Has anybody started talking about scales as descriptors of specific local things rather than scales that are global, or are we just talking about "products will be localized and all of space weather is one place"? Dr. Zheng said a lot of the phenomena can be localized; although sometimes a region is deemed safe, even when extreme events can expose a satellite. For ground support equipment,

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the peaks can be very localized. In some countries/regions they already have a local product (e.g., Japan/NICT has their own TEC product to aid communication and navigation).

Dr. Halford asked whether there is a need for reference orbits or other references when talking about scales and benchmarks; for example, would something in between a global scale and a product be needed? Dr. Green noted that there is one earthquake scale but you can sign up for different alerts, so emergency managers can define the regions that they want alerts from. There could be a similar thing for space weather: one scale for the environment but you can define low altitude, low Earth orbit (LEO), or geosynchronous orbit (GEO). Dr. Halford said NASA would be able to help identify the reference orbits that are the most useful or help with validation in certain cases. NASA could help determine which models are better to transition over to NOAA and knowing what those are would help the research community communicate more effectively with end users.

Dr. Zheng said that, when the Community Coordinated Modeling Center (CCMC) does the validation for reference orbits, they benchmark by choosing a reference model, then deriving the satellite quantity over the model domain, but that reference orbits may not be necessary because there are assets all over and plenty of data. Dr. O'Brien said, using the earthquake analogy, the scale would be the same regardless of the orbit you're looking at as a satellite operator, but it would be localized. That's different than the current paradigm. NASA needs to make sure that NOAA can exploit the wealth of data.

Dr. Turner, circling back to the bigger picture, used the tornado alert anecdote to illustrate that there is a difference between global warnings and specific warnings. How does the National Weather Service use the research community to improve localized tornado warnings and how did they handle the need to have both broad and specialized warnings? Dr. Halford wondered whether Earth Science could help SW navigate their role in that transition. Mr. Favors asked to identify as a goal studying the data sets and models that help them do that using R2O. There was a discussion about the specificity of the goal, but Dr. Korreck said evaluating whether the necessary temporal and spatial scales are available is a good recommendation.

Dr. Welling noted that, regarding impacts versus phenomena, there's a point where information about the end users' situation or equipment is required to determine whether to talk about impact generally or granularly. Depending on the nature of the updated scales, NASA might want to evaluate to what degree to get into trying to translate phenomena into impacts. Does NASA want to support that through funding opportunities or dedicated studies? Mr. Favors mentioned the shift in Earth Science to pull more social scientists into their research projects, which hasn't been done much in SW. Dr. Halford said it sounds like SW's end users aren't as familiar with how the environments will impact their area; communicating that with one scale is a great place to learn from social scientists. Drs. Green and Halford proposed making a recommendation to revisit this issue after the report comes out. At this point, Dr. Halford reviewed some recommendations on the table: the temporal versus spatial scales; the need for better distinction between scales, products, and decision aids; better outreach between the research and user community, including common language about needs and the environment's effect on the user community; more communications and commonality with language and terms.

Dr. Halford thanked Dr. Zheng for her presentation.

### SWC Discussion

Drs. Halford and Welling posed a series of questions in service to the preliminary work on findings and recommendations for Task 6. It was suggested that scales are only used in paper introductions and discussions, occasionally when making launch calls, and infrequently to compare magnitudes of historical events; all of this demonstrates their value, but they are not sufficient to provide the granularity necessary for base research. In fact, in general, scales are not used as they do not provide sufficient granularity for strength, locale, or slide.

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Dr. Turner said it's important to note that scales appear to be almost irrelevant in the research community's estimation. It was thought to be infrequent that the scales are used in the research community as a communication tool in a comparative way. Dr. Halford said the indices are used more frequently than the scales. Dr. Duncan sought to confirm that the current effort only focuses on scales, with no impact to the indices and Dr. Green commented that Kp exists whether there are scales or not. Dr. Welling said there is some crossover between the indices and scales and there is some dependency where the scales find use from deriving information from the geomagnetic indexes. It could be that the updated scales call for creation of a new geomagnetic index. Dr. Halford thought the new scales might pull more from the indices. Mr. Favours said the scales can't be updated based on user needs because there are not the data to support that.

*Are the scales used in the research community?* Data and indices are used for statistical analysis across solar cycles and clear inter-storm or inter-impact comparisons. The research community does treat the indices like scales.

*Why change?* Common use and understanding of the new scales would enable better communication across communities. More granularity, especially with the G-scale, might help communicate environments and impacts; there is need for precise communication of likelihood of impacts.

*Why not change?* Communication may be sufficient already, maybe users don't need the granularity that scientists do, changing might make communication more confusing especially in time of transition (not understanding the changes of scale and the implications for levels of concern for particular levels – could lead to a loss of trust between communities).

Dr. Duncan did not agree that users don't need the granularity that scientists do and there is a wider range of users than some appreciate at times. Dr. Halford agreed and said these questions are about why scientists at NASA should care and how they might need to respond.

*Is there long term support for generating observations that drive new scales?* The majority of observations would probably still probably be used in the research community, especially the long longitudinal studies. Are missions or ground campaigns needed to support long-term scales being developed, what is the overlap of needs of scales and the research community that may drive NASA priorities, are NASA data archival services able to support scale generation long term (if the operational communities are not going back to adjust the previous scales, maybe NASA could help), is there a role for NASA to help translate phenomena to impacts?

Dr. O'Brien said that NASA SW has a unique role and is in a better position than NOAA to handle the impacts to satellites because NASA flies its own satellites. NASA is in a good position to use historical data to formulate and quantify how new scales relate to user impacts, particularly NASA's own fleet of satellites. Dr. Duncan wanted to expand that to human impacts, as well. Dr. Turner said it's a major impact to the science community – to help characterize the scale of the impacts and be able to identify what's needed at the research level to be able to identify the scale.

Dr. Halford said, as a scientist she would want more data and more missions; more granularity, temporal resolution, spatial resolution...more than what is needed by the user community. In the USGS example, the research community was able to provide the plus up.

Dr. Korreck wanted to note as a point to consider the difference between a pure research satellite and a SW investigation. A SW investigation should be a marriage between the end user and the science; whereas just for science there may be a need for more data. There is room for compromise but it needs to be taken into consideration now.

Dr. Halford said speculating about how the scales may change is not the SWC's role, but maybe with localization there is a role for NASA's to add data observatories to localization that NOAA decided was good. Dr. Turner reiterated the requirement on the research community to help inform the user

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community regarding granularity of events and observations and modeling impacts as it moves to a very specialized forecast. Dr. Halford said it should be a discussion between the researchers and the end users, as they often have different needs. There was discussion about what the researchers can convey to the users about the scales and what the effects will likely be based on those scales, but users also need to give input as to what they need and care about.

Dr. Turner asked about expansion on the research and observation capability in order to improve understanding of the granularity of these events and the implications of that granularity to the research community. What is needed in order to get the granularity to improve (more observations, new class of models, AI), regardless of the impact on the user community? Dr. Welling added that NASA should continue to pursue this, e.g., get physical granularity to inform impact granularity. Dr. Turner offered that the proposals that get funding define something specific like an architecture that will increase the granularity of the observations by an order of magnitude, rather than a new sensor with increased capabilities.

Dr. Halford noted that standardization and meta-data and interoperable data sets are needed for inter-calibration between instruments and between scales. She then suggested a move into recommendations and noted that there is one about temporal and spatial scales for current data and what the density of that is.

Dr. Duncan spoke about the importance of making sure that the data is available so the agency and the researchers can draw inferences about what is needed, instead of it just being a report solely for the scales; that the data has a dual use and, when released, should be brought back as a topic for the SWC to analyze potential gaps to consider.

Dr. O'Brien went through a draft of a finding/recommendation that it might be appropriate for the SWP to issue a small announcement of opportunity (AO) for a decision aid development and update simultaneously with the release of the new scales. He asked Mr. Favors where NASA draws the line for decision aids, in relation to potentially encroaching on what the commercial sector might provide. He said Aerospace stops at the prototyping, can demonstrate it and provide it in real time or keep it at generic level. He expressed caution about giving NASA advice to do things that would normally be left to the private sector. Mr. Favors responded that NASA won't get into the operational stand up of a tool, but will take it all the way to transition. He offered for discussion how can this work in SW without oversteps? How does SW take the feasibility model that could be a transition to SWPC? How does SW engage with the commercial sector to open up what we've done for someone else to pick up and run with?

Dr. Green said NASA also supports SBIR which develop these kinds of decision aids. Dr. Turner asked how far to go with NASA developing specialized models for products that are appropriate for specialized users when SRAG is developing specialized models to warn the NASA astronauts on the risk of a solar particle event, and M2M, funded by HP, is developing models to try to inform solar system assets on when they're at risk. Where is the line? Dr. Halford argued that NASA needs to be able to protect NASA assets. Dr. Turner asked whether that is where the line is defined and talked about the notion of building the model up through the prototype level that demonstrates feasibility and applying it until someone comes and tries to take it over.

Dr. Korreck said there should be collaboration when there can be open and free competition. Maybe part of the exploration here in SW is figuring out how to partner well. Maybe things we get to feasibility that are useful are not only SWPC products but also other commercial lines.

Dr. Turner said there is a risk to protecting NASA assets and keeping hands on: it becomes very insular so the research community doesn't understand the kinds of models SRAG is developing, so they don't have the insight to contribute. Mr. Favors said some of the special topics in R2O2R solicitations have been driven by SRAG needs.



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Dr. O'Brien said it is appropriate for NASA to provide frameworks even where there aren't NASA assets at risk. Even if the private sector makes another version, NASA may be the only group that can build the bridge. He doubts there is a lot of venture capital funding to develop at risk activities in the SW services sector and the government has to prime the pump. Nurturing is appropriate, but NASA has to watch the line and be ready to step back when the commercial sector is ready to take the reins.

Dr. Halford introduced the topic of regional and more localized impacts and how researchers can gain more value with the initial infrastructure, whereas adding more data points allows for leveraging science and helping future scale development. Dr. Turner said if they don't go in that direction, then it's incumbent on the research community to inform the user community of the limitations of the less granular forecasts. It's the research community's role to inform the users about the relative impact of the phenomena's granularity versus the granularity of the scale. Mr. Favours agreed and said one recommendation could be for NASA to ensure that things learned in the process of analyzing the scales could inform the research NASA does, whether or not it is used in the scales update.

Dr. Duncan noted that how much the users understand the possibilities dictates what they can even ask for. It could be useful to consider how SW reaches out to users so they know what to ask for, and that it needs to remain reciprocal to maintain trust. Research needs to define what the phenomenological scale is in order to inform users about what they need to/can worry about.

Dr. Halford proposed a topic for the next meeting: NASA can help facilitate communications of how the scales or the physics ultimately impact various user communities. There was clarification that you have to do the science to know what the scales are followed by a suggestion to plan to start the communication about how the science impacts different communities and then improve that when the new scales are available. There was discussion about scale articulation and the need for SWC to revisit this issue once the scales are released. Dr. Halford reminded the group of the potential benefit of an AO coming out quickly after the scales are made available so people can work on prototyping for the decision aids.

Dr. Welling said there will be a need once the scales are released to educate and communicate to the research community what those scales mean, how they work, what they're based on. The following recommendation was proposed: NASA should take a leadership role in encouraging the research community to incorporate space weather scales into their work and the way they communicate, both with each other and across sectors. It was agreed that it was premature before we know how the scales have changed. There was discussion about putting work into the context of scales (i.e., using the levels) and language of users.

Dr. Duncan suggested an addition to the agenda to discuss requests for HPAC to consider topics for the next SWC meeting.

### Topics for Consideration: HPAC

The SWC held a discussion about the addition of a staff member, Dr. Sabrina Savage focusing on human exploration. They noted that the next meeting of the SWC would be a few months after the release of the decadal and Dr. Savage would likely be in a good position to give a presentation to the group about the decadal and human exploration. Dr. Duncan suggested that SWC narrow down the request to HPAC for specific topics they need some guidance to navigate. Suggested topics included M2M, priorities for the budget cycle from the agency to Congress, relevance of SW in relation to the decadal, how NASA 2040 vision is being implemented within the Science Mission Directorate (SMD) and how it might impact HPD, a more general request to HPAC to be aware of anything rolling out that might impact HP.

Dr. Spence mentioned the need to amplify the group's voice and Dr. Korreck talked about a communications strategy. There was discussion about leading all communications with the strong science

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results, communicating up the chains and to SMD and at the HPD meeting. Dr. Korreck also mentioned other pieces of innovation – applications, hardware, data sides – that could also be a focus.

Dr. Spence added that corporate engagement can suffer because SW doesn't communicate well across these sectors and that it may be helpful to have the communications team coach or translate.

Dr. Korreck suggested that, with roles for commercial and DoD liaisons, there might be advice about how to interface best with the community. Is there a way to have more meaningful open forums or roundtables, like the Idea Labs at NSF, as concentrated focused time together to work on a specific topic? There was discussion about the differences between Living With a Star (LSW) Teams, Idea Labs, and International Space Science Institute (ISSI) workshops. Dr. Korreck said SWC could point out the models they like and ask for ways to support the request. Dr. Spence said he would favor having a separate conversation about this topic and having an informed recommendation based on first-hand testimony. Dr. Korreck clarified that it would be helpful to know what SWC is recommending: media training, workshops for connections, funding models, bringing in a social science or communications expert or psychologist, maybe the visual arts – what will be the most helpful?

Dr. Turner mentioned that the Space Technology Mission Directorate (STMD) just completed a gaps analysis which included a handful of technologies that were HP-related. He wondered if the HP community was aware of and in communication with STMD to make sure their needs are accurately represented, and what could be done to ensure that happens, and that HP needs for technology and instrumentation is appreciated by STMD. There was a robust discussion about the potential for a briefing and formulation of advice and it was suggested that this may not be as pressing as other items at this time. Dr. Duncan suggested that the SWC could ask HP if they would like the council to pursue this topic. Dr. Turner suggested asking, "Does HPD believe their technology gaps were adequately represented and considered in the STMD gap analysis," and letting the answer guide the SWC. Dr. Korreck said that the possibility of a gap may be more appropriate as a finding for HP. Dr. Duncan noted that STMD has asked for responses to the list; there was an RFI type process open to the community.

### SWC Work Session for Writing Preparatory Material on Topics 1 & 2

[No notes were requested for the working sessions.]

### SWC Summary and Closing Remarks

The findings and recommendations by task were posted and presented. There were clarifying discussions about some findings and recommendations and edits were made to the document, as warranted.

Dr. Duncan reviewed suggested topics for the next meeting. A brief discussion led to the addition of a new task regarding the HP Decadal – when NASA determines its response to HP Decadal, the SWC would welcome a conversation about the agency's response and rollout-plans for SW.

Dr. Korreck thanked everyone for their work over two days. She said these are great recommendations to be taken back to the HPAC to look at to send up to HPD. Mr. Favors reiterated the thank you and appreciation. Dr. Duncan also thanked everyone and noted that these meetings are always deeply satisfying and that the nature and openness of the conversations are very valuable.

### Adjourn

The meeting was adjourned at 5:08 p.m.

## Appendix A Participants

### *Space Weather Council Members*

Nicole Duncan, BAE Systems, Inc., *Chair*  
Kelly Korreck, NASA Headquarters, *Executive Secretary*  
Daniel Baker, University of Colorado  
Janet Green, Space Hazards Applications  
Alexa Halford, Goddard Space Flight Center  
Paul O'Brien, The Aerospace Corporation  
Harlan Spence, University of New Hampshire  
Ronald Turner, Analytic Services Inc.  
Daniel Welling, University of Michigan

### *Other*

Asha Balakrishnan  
Geoff Crowley  
Tamara Dickinson  
Jeanette Edelstein  
Jamie Favors  
Matina Gkioulidou  
Therese Jorgensen  
Jared Leisner  
Jussi Luntama  
Asal Naseri  
Arik Posner  
Esayas Shume  
Joe Westlake  
Dave Wilson  
Yihua Zheng

## Appendix B Council Membership

**Nicole Duncan, Chair**

Ball Aerospace

**Kelly Korreck, Executive Secretary**

NASA Headquarters

Sage Andorka  
United States Space Force

Daniel Baker  
University of Colorado

Michele Cash  
NOAA Space Weather Prediction Center

Janet Green  
Space Hazards Applications

Alexa Halford  
NASA Goddard Space Flight Center

Piyush Mehta  
West Virginia University

Paul O'Brien  
The Aerospace Corporation

Harlan Spence  
University of New Hampshire

Ronald Turner  
Analytic Services Inc.

Angelos Vourlidas  
Johns Hopkins University  
Applied Physics Lab

Daniel Welling  
University of Michigan

Appendix C  
Agenda

Thursday, August 8, 2024		
9:00	Welcome from Heliophysics Director	Joe Westlake, NASA HQ
9:05	Welcome from NASA Space Weather Program Director	Jamie Favors, NASA HQ
9:10	Welcome	Nicole Duncan, BAE Systems, SWC Chair
9:15	Adoption of the Minutes of Last Meeting	SWC Members
9:25	Comments from the Heliophysics Advisory Committee (HPAC)	Matina Gkioulidou, HPAC Member
<i>Coordination with Other Space Weather Groups</i>		
9:45	Updates from SWAG	Tammy Dickinson SWAG Chair
10:05	Updates from SWR	Geoff Crowley & Sarah Gibson SWR Co-Chairs
10:05	Updates from SWORM	Ursula Rick SWORM
10:35	SWC Discussion of Coordination	
11:05	Topic 1: Discussion of ESA Space Weather Service Network	Jussi Luntama ESA
11:20	Discussion of Coordination with Other Space Weather Groups	
12:00	Lunch Break	
<i>Topic 1: Models for Domestic and International Collaboration in Space Weather</i>		
13:00	NASA Intro to Topic	Kelly Korreck
	Global Seismic Network	Dave Wilson
14:40	SWC Discussion of Models for Collaboration in Space Weather (Potential issues for findings or recommendations)	
15:30	Break	
15:45	SWC Work Session for Writing Preparatory Material on Topic 1	Closed Session
17:00	Adjourn	

Friday, August 9, 2024		
9:00	Overview of Agenda	Nicole Duncan

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		BAE Systems, SWC Chair
9:05	Public Comment Period	Virtual Only
<i>Topic 2: Impact of revisions of space weather scales on NASA science and missions</i>		
09:10	Intro to Topic	Kelly Korreck
	Revision of Space Weather Scales	Asha Balakrishnan, STPI
	CCMC and Space Weather Scales	Yihua Zheng, GSFC/CCMC
10:40	SWC Discussion (Potential issues for findings or recommendations)	
12:00	Lunch Break	
13:30	SWC Work Session for Writing Preparatory Material on Topic 2	Closed Session
14:45	Break	
15:00	SWC Work Session for Writing Preparatory Material on Topic 1 & 2	Closed Session
16:00	SWC Summary and Closing Remarks	SWC to HPAC representative
17:00	Adjourn	