BAMS
Meeting Summary

Accelerating Applications for Planned NASA Satellite Missions

A New Paradigm of Virtual Hackathons during a Pandemic and in the Post-Pandemic Era

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2020 SWOT Virtual Early Adopter Hackathon

What: A virtual hackathon was organized using Zoom web conferencing for early adopters of the Surface Water and Ocean Topography (SWOT) mission that is planned for launch in 2022. Thirty-eight participants representing early adopters and support staff collaborated intensively to resolve bottlenecks and software hurdles associated with the generation and use of simulated SWOT data over 4 days.

When: 26 May–1 June 2020

Where: Virtual (organized by the University of Washington)

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While the primary mission of NASA's Earth Science Division (ESD) is to develop a scientific understanding of the Earth system and how it is responding to human and natural drivers of change, an implicit need is also to understand how best to promote the use of NASA satellite mission products and information for application activities that directly benefit society and our environment. In fact, the 2018 National Academies on Science, Engineering, and Medicine Decadal Survey for NASA, "*Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space*," clearly underscores the tremendous value of satellite mission data, which "enabled societal applications that provide tremendous value to individuals, businesses, the nation, and the world. Such applications are growing in breadth and depth, becoming an essential information infrastructure element for society as they are integrated into people's daily lives" (National Academies of Sciences, Engineering, and Medicine 2018).

The NASA Applied Sciences Program (ASP) was set up to empower people around the world to use NASA satellite data to solve relevant problems by providing support and funding to institutions and individuals to make better decisions. To maximize the value of satellite data for planned missions, NASA ASP has developed a prelaunch protocol called the Early Adopter Program (EAP) for engaging with the broader user community (Brown and Escobar 2019). In the vision of the EAP, each selected Early Adopter (EA) proposes an activity for the use of planned satellite data using either proxy datasets or simulated data that mimic the anticipated mission during the post-launch era. EAs are defined as those groups and individuals who will have a potential or clearly defined need for data from the planned mission, and who are planning to apply their own resources to demonstrate the utility of planned satellite mission data for their application, system, or model. Experience from recently-launched satellite missions such as Soil Moisture Active Passive (SMAP) has shown that the sooner this prelaunch engagement begins and is sustained, the better are the outcomes on the use of mission data beyond the declared goals of scientific query and data generation (Escobar et al. 2016).

The Early Adopter Program for the SWOT satellite mission

The planned Surface Water and Ocean Topography (SWOT) mission, scheduled for launch in 2022, is one such planned satellite mission that has had an Early Adopter Program since 2018 (Hossain et al. 2017, 2020). The SWOT mission (Alsdorf et al. 2007; Biancamaria et al. 2016), jointly developed by NASA and the French national space agency (CNES) with contributions from the Canadian and UK space agencies, is designed to provide a spatially distributed and high-frequency measurement of water elevation data for the hydrology and oceanography communities for the first time (Morrow et al. 2019). By virtue of its stated scientific goals, SWOT satellite data are expected to have tremendous societal impact in various sectors that involve water, such as disaster management, reservoir operations, water management, ecosystem services planning, hydropower and navigation, fisheries (freshwater and marine), and marine shipping. Readers interested in knowing more about the application potential of the SWOT mission are referred to its websites at http://swot.jpl.nasa.gov and at http://www.aviso.altimetry.fr/swot.

In the initial cohort of the SWOT EAP, 11 EAs were selected from various hydrology and oceanography domains. These were the Asian Disaster Preparedness Center (ADPC)/SERVIR-Mekong; NASA Short-Term Prediction Research and Transition (SPoRT) Center; Pakistan

Council of Research in Water Resources (PCRWR); Indian Institute of Technology (IIT Bombay); University of Bonn (UBonn); Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI); FM Global; Collecte Localisation Satellites (CLS); Compagnie Nationale du Rhône (CNR); BRL Ingénierie (BRLi); and Mercator Ocean. In preparation for the first EAP engagement activity that was organized in the form of a workshop (20–21 May 2019), organizers from SWOT Application Working Group (SAWG) worked proactively with many EAs to explain the purpose of the program and specific expectations. EAs were mentored individually since 2018 by SAWG leadership and were encouraged to think carefully about the core issues in advance of the 2019 EAP workshop. Each EA was requested to imagine desired future press releases or newspaper headlines that their EA project might enable. These press release titles were aspirational. Their realization is dependent on numerous conditions beyond the control of the EA or the SWOT mission. Nevertheless, the articulation of an eventual title summarizing the success of each EA project was deemed a useful exercise to define the ultimate destination of the SWOT EAP (Hossain et al. 2020).

Of the many recommendations that emerged from the first EAP workshop in 2019, one was as follows: "Close and more frequent mentoring support for EAs is needed as EA projects mature and EAs begin facing new challenges with data structure and processing. EAs will continue to require guidance and pointers on data access and with queries on data structure/handling. Effective support of EAs will set a good precedent to maximize the user readiness of SWOT data after launch."

However, the current pandemic due to COVID-19 has posed significant challenges to the SWOT EAP and presumably for other planned satellite missions, as in-person interaction are now difficult to implement. Furthermore, the post-COVID-19 era is likely to result in a world where participants are more globally connected and literate with widely-used information technology tools (such as Zoom, Cisco Webex, Microsoft Teams, or Skype). Such a likely scenario presents us with an opportunity to innovate to a newer normal for the SWOT EAP in the post-COVID-19 era. In particular, information technology tools now allow us to innovate our EA engagement protocols to scale up and engage more efficiently to a broader community that is now more connected than before. In this paper, we present a new paradigm for the SWOT EAP in the form of a virtual hackathon in response to challenges posed by the pandemic. We believe that this novel approach has merit for consideration across all the EAP activities of the NASA Applied Sciences Program.

The proposed virtual paradigm: Virtual hackathon based on MEDSCARF principle

Our proposed virtual paradigm for SWOT EAP is in the form of a hackathon based on four essential features: medically safe (contactless), scalable (cost-effective), rapidly deployable, and focused on learning outcomes (MEDSCARF).

The hackathon architecture. While a standard definition is lacking, a hackathon for the SWOT EAP typically signifies a sprint-like event with computer programmers and domain experts to collaborate intensively on EA projects. Etymologically, the word hackathon is a marriage of two words, "hack" and "marathon," where "hack" here refers to exploratory computer programming and not computer security breach (Trainer et al. 2016). The core architecture is outlined in Fig. 1. It is designed as a 4-day, completely virtual hackathon with one session per day lasting up to 4 h. The limit on each day is to minimize fatigue from online connectivity and to accommodate diverse time zones for a more global audience. We propose the first 2 days for building SWOT data literacy and awareness of tools and to "prepare" the EAs to dive into the intense one-on-one hack sessions during the last 2 days. Our virtual hackathon is also premised on the availability of pre-recorded audio-visual content, which is basically an repository of videos on tutorials and hands-on activities by domain experts and the SWOT

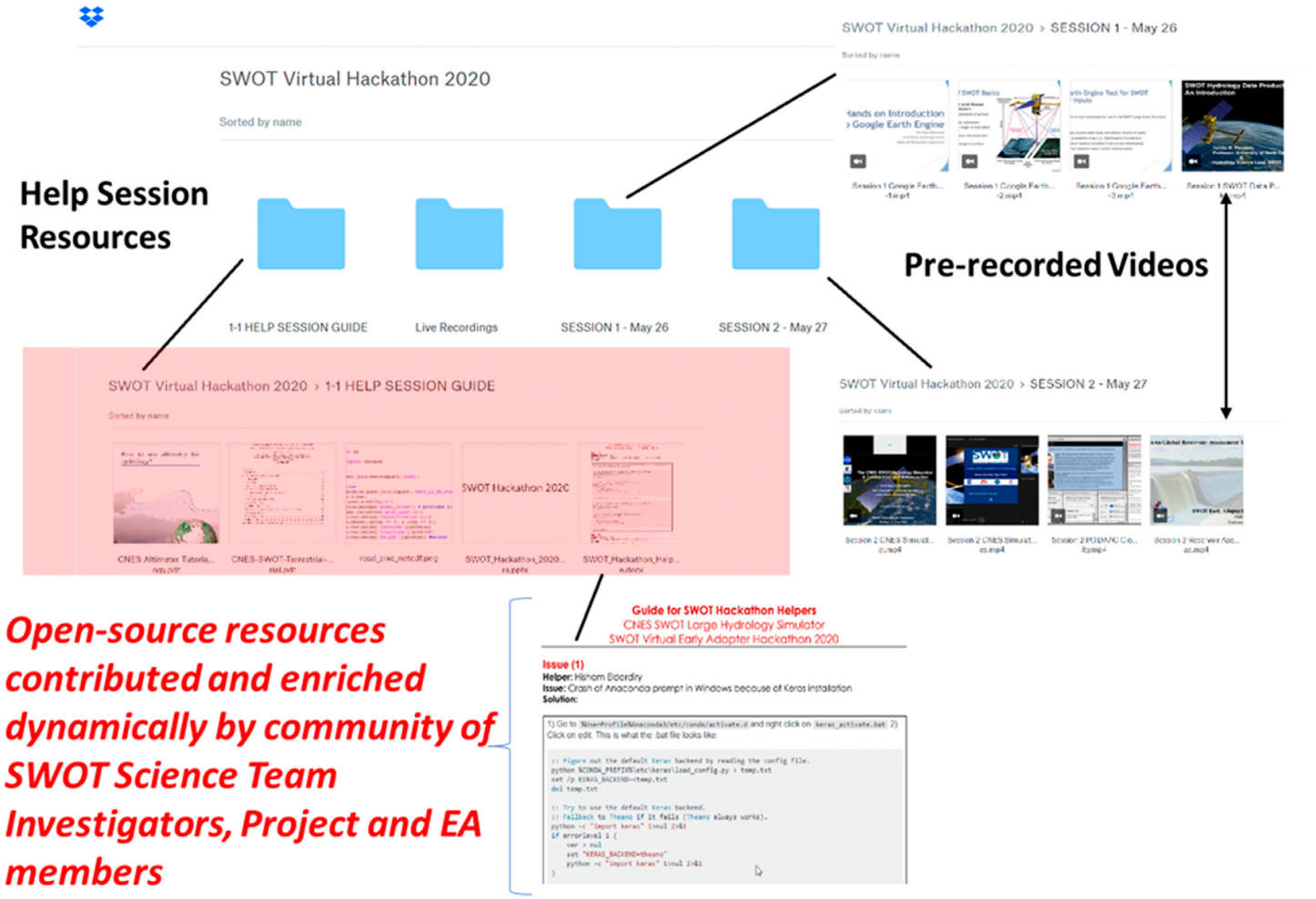

Fig. 1. The overall virtual hackathon architecture for SWOT EAP based on a 4-day event. The first 2 days (sessions 1 and 2) are tutorials and talks by subject matter experts on SWOT data. The one-on-one help session guide is an open-source community contributed by EAs and helper hackers. These materials can be accessed from the SWOT Virtual Hackathon 2020 website at https://swothackathon.github.io/.

support team. We believe that making the contents available for EAs to peruse beforehand will make interactions during the live sessions over the 4 days much more interactive, and EAs will know what specifically to ask on their EA projects. Finally, in this proposed virtual hackathon architecture, the last 2 days involve intense one-on-one help sessions via a web-conferencing tool such as Zoom to "look under the hood" by highly qualified trainers (known hereafter as "helper hackers") into the EA's local device to examine tools/data/models used for the SWOT EA project.

Our proposed virtual paradigm based on the MEDSCARF principle is based on the fundamental availability of three key resources:

1) pre-recorded hackathon education materials for EAs to prepare well in advance for the live hackathon session;
2) pre-hackathon orientation of each EA to hackathon objectives and logistics;
3) volunteer helpers who serve as hackers to help hack the coding/data or model hurdles faced by EA on their EA projects. A mature EA who has developed mastery with SWOT data structure and its application may serve as a volunteer helper hacker.

Implementing the virtual hackathon for SWOT mission based on MEDSCARF principle

We organized the first SWOT Virtual Hackathon for our EAs during 26 May–1 June 2020 based

on the four essential features of MEDSCARF using the Zoom web-conferencing utility. We prepared all necessary audio-visual content for the live sessions during the hackathon dates two weeks in advance to allow our EAs to be more proactive in their learning and preparations. We also recruited a team of volunteer helper hackers comprising University of Washington graduate students and mature EAs who had already developed significant SWOT data literacy. For example, one EA from NASA SPoRT (co-author Nicholas Elmer) was at an advanced stage of the EA project. He was already contributing to the EAP by developing tutorials and training sessions for fellow EAs in preparation of the virtual hackathon. Our experience with the pre-recorded audio-visual educational content yielded the following findings:

- EA interaction in the form of making inquiries and learning outcomes were maximized during the live hackathon.
- EA teams demonstrated better coordination and preparation for the hackathon one-on-one live session.
- Comparing data on a number of queries and actions taken between the 2019 in-person workshop and 2020 virtual hackathon, a 200% increase in EA interaction and resolution of project issues were observed in the virtual paradigm.

Figure 2 demonstrates the inauguration of the hackathon over Zoom.

Fig. 2. First day of the SWOT Virtual Hackathon for Early Adopters, 26 May 2020.

The one-on-one hack sessions of "looking under the hood" of EA projects. During the intense one-on-one hack sessions on days 3 and 4, we utilized the full functionalities of Zoom web conferencing on "looking under the hood" of each EAP model/data/tool. Each EA first had to pre-schedule an appointment in advance of the hackathon to be guaranteed a helper hacker for troubleshooting of his/her EAP during their one-on-one session. This was needed as there was a limited number of volunteer helper hackers available to fully dedicate to individual EA teams. Once an EA team had scheduled a one-on-one intense collaboration time slot, a designated helper hacker was then assigned to the EA and made familiar with the issues and data pertaining to the EA project. This was done a week before the live

hackathon. The volunteer helper hacker was also trained in the use of the SWOT simulator and the full functionalities of Zoom and carried out mock runs with simulated EAs on "looking under the hood" of tools, data, and models. Here "looking under the hood" refers to having remote access to the local device of the EA; sharing codes/scripts, files, and sample data live over standard file transfer protocols of Zoom; sharing screens; and using breakout rooms. Breakout rooms in Zoom provided privacy for the designated helper hacker and the EA team and is considered an essential feature of our proposed virtual hackathon (Fig. 3). The helper

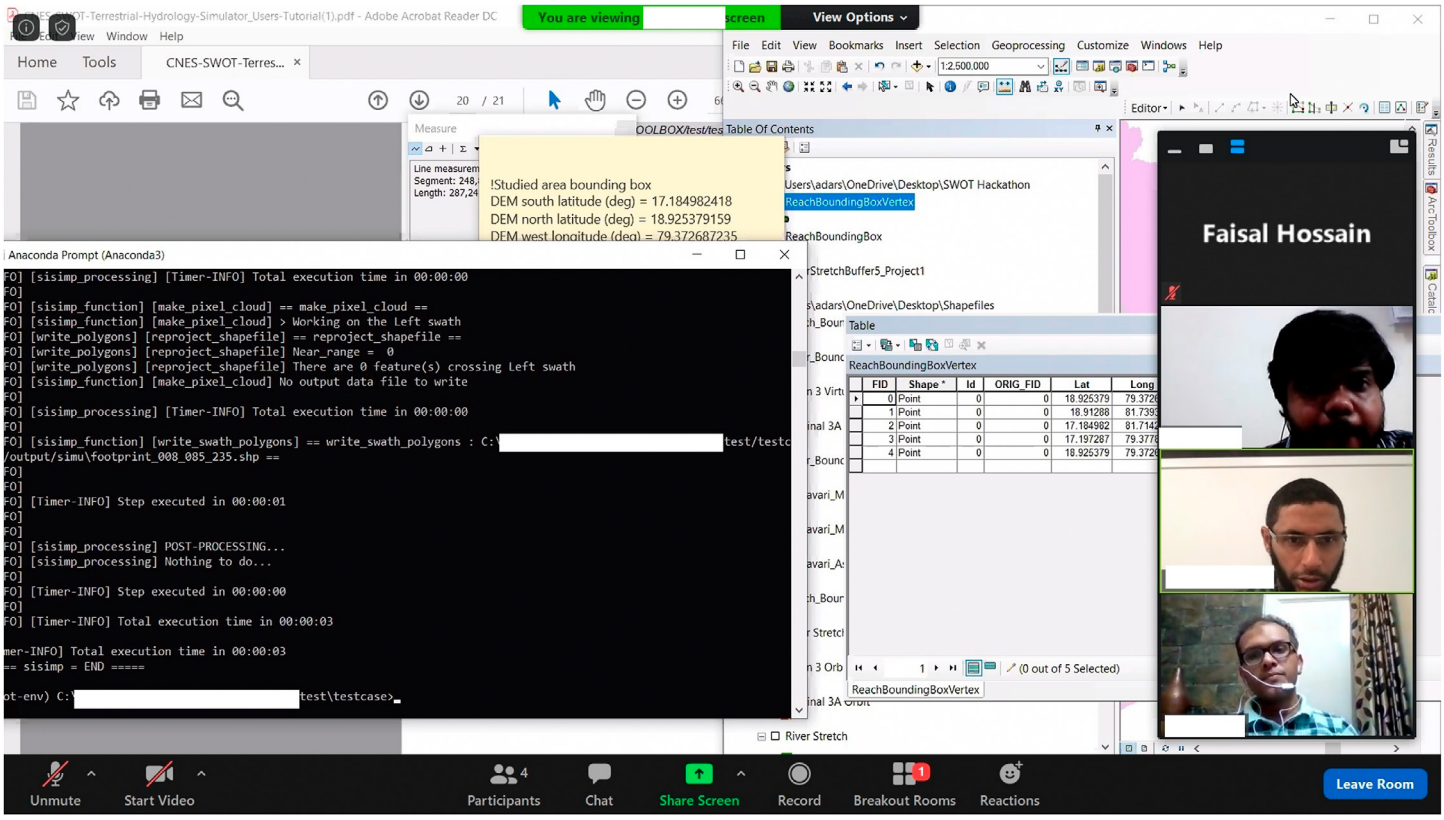

Fig. 3. EA-3 and a helper hacker working intensely via Zoom breakout room. Here, the helper (second person from bottom) is "looking under the hood" of EA code and data remotely and making changes as needed.

was then formally briefed before the hackathon with specific details on how to interact and avail the hacker's hack skills during the one-on-one session. A help tutorial was created for executing the hack session over Zoom.

For each EA, as the hack session progressed, the helper summarized the diagnosis of the issues on the first day of the hack session (Fig. 4; see also "Videos and Help Guides" on the SWOT Hackathon website). This allowed the helper hacker to spend time later that day offline on identifying possible solutions beforehand for the more intense and longer hack session the next day (the second one-on-one hack session). Each diagnosis and resolution of issues (with a summary of unresolved issues) were summarized for all EAs, with EA teams assigned privileges to edit, contribute to content, and share tools in video recordings in the online open-source repository at "Videos and Help Guides" (see also Fig. 1). The entire spirit of this virtual hackathon was guided by the principle of unselfish cooperation by helper hackers and EAs to share their lessons learned, tools, and data for fellow EAs who may be facing similar hurdles.

An example of the one-on-one hack session for an EA. As an example, we present below the sequence of actions for a typical 2-day hack session involving diagnosis (first day) and resolution (second day) that progressed for an EA (EA-3, the Indian Institute of Technology Delhi).

DIAGNOSIS for EA-3 after first 1-1 Help Session on ZOOM

Goal: Examining the applicability of SWOT in improving flood forecasting, inundation mapping and mitigation over the Godavari basin.
Sample Technical Questions/Issues raised by EA-3:
Is the width equal to river width only or also in case of monsoon season it will include the inundation extent?
How is the slope calculated in the SWOT simulator?
There is an area in Southwestern India (Cochin city/Kerala region) that is not included in High Resolution (HR) SWOT coverage.
SWOT Simulator Issues:
Issue: The SWOT simulator is running over Godavari basin but not producing any results (pixel cloud shapefile not found in the output folder).
Suggested Solution: The issue was solved after revising the "parameter_sisimp.rdf" file and defining the correct directory for orbits.

Plan for Next 1-1 Help session to Fix Issues:
Run the SWOT simulator after fixing the orbit directory issue and explore the output (water surface elevation).

Fig. 4. Summary of diagnosis of project hurdles for EA-3 based on the first one-on-one hack session lasting 2 h on 27 May 2020 in Zoom using breakout session functionalities.

- EA-3 joined SWOT EAP in late 2019 and is considered to be at the beginner level for SWOT data literacy.
- Helper hacker assigned to EA-3 was a University of Washington doctoral student and a volunteer working on a project similar to the EA team's proposed project on SWOT.
- Helper hacker was trained beforehand on SWOT simulator, acclimatized with pre-recorded videos and with EA-3 project objectives.
- First one-on-one help session lasted 2 h on 27 May 2020, where diagnosis of key hurdles/issues after "looking under the hood" was completed (Fig. 4).
- Second one-on-one help session lasted 4 h, where resolution of key hurdles by working under the hood was completed (Fig. 5).

RESOLUTION for EA-3 after first 1-1 Help Session on ZOOM

Issues addressed
- If the RiverObs calculates the average of river variables, can we have a utility to provide both "average products" and "pixel-specific products"?
- Is the error introduced to the SWOT simulator the same as expected from the actual SWOT mission? In that case, this can help in deciding locations of taking in-situ measurements.
- It is not clear what information is provided by the Vector file vs Pixel Cloud (PIXC) file?
- The vector file when uploaded to GIS was geo-located in a different location from the PIXC file.

RiverObs Issues:
- **Issue:** "estimate_swot_river.py" doesn't exist.

Solution: The file doesn't exist in the "src/bin" folder but there is another script with a similar name "EstimateSWOTRiver.py" in the "src/SWOTRiver" folder. The issue is resolved after copying this file to "src/bin".

Issue: "SWOTWater Module" doesn't exist.
Solution: The "__init__.py" file is missing from the "SWOTWater" library. We had to copy "__init__.py" from another folder (e.g., from SWOTRiver).

Fig. 5. Summary of resolution of project hurdles for EA-3 based on the second one-on-one hack session lasting 4 h on 28 May 2020 in Zoom using breakout session functionalities. More than 50% of trivial issues were resolved on the fly within the first 2 h and are therefore not summarized here.

The one-on-one help session interaction in Zoom's breakout room was recorded by some EAs for future reference. We found that these recordings of a live EA break session were useful immediately after the session ended for other EAs facing similar issues. A good example is the demonstration by a helper hacker on how to process a time series of multiple shapefiles

for time-varying water surface elevations in the SWOT simulator, an issue that multiple EA teams needed help addressing. All the hackathon's materials (videos, presentations, tutorials, etc.) are available for all on the SWOT hackathon website (https://swothackathon.github.io/).

Post-hackathon survey

Immediately after our virtual hackathon ended with the completion of the one-on-one hack sessions, we carried out a survey of EAs who participated in the 4-day event based on our proposed virtual paradigm premised on the MEDSCARF principle. We also documented the unresolved issues for each EA project that were relayed to relevant subject matter experts for quick closure. All such post-hackathon interaction continued to be made available in the open-source online repository under "Videos and Help Guides," where EAs continued to share their lessons learned, scripts, and fixes to tools/codes for fellow EAs. We present below a graphical summary of the survey results for some of the key questions asked (Figs. 6–12).

The following picture emerges from the survey summarized in Figs. 6–12. More than 70% of EAs found all or some of the virtual hackathon content useful, with 85% finding the one-on-one online hack session able to resolve issues with their EA project (Figs. 6 and 7). All

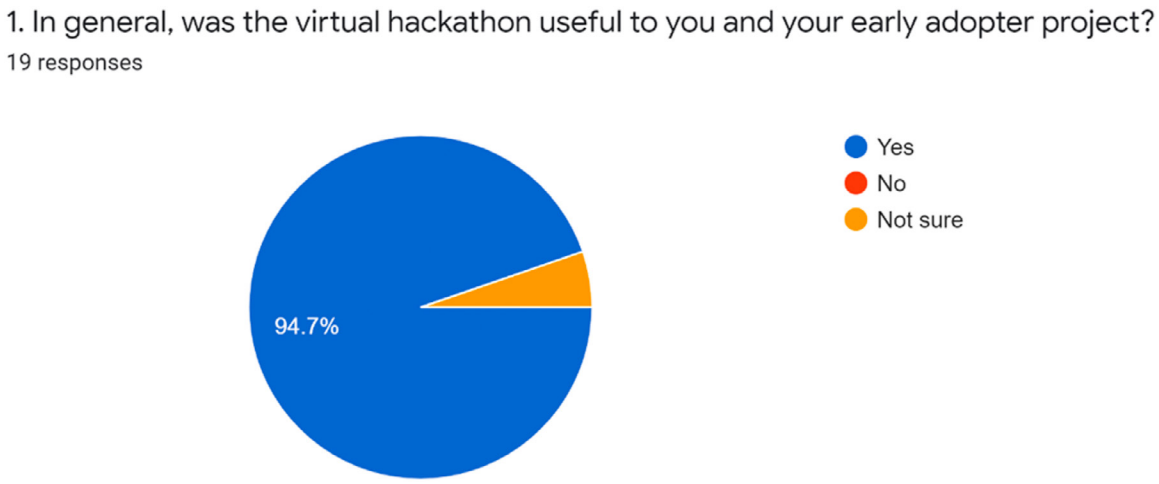

Fig. 6. General perception by EAs on how useful the virtual hackathon was based on MEDSCARF principle.

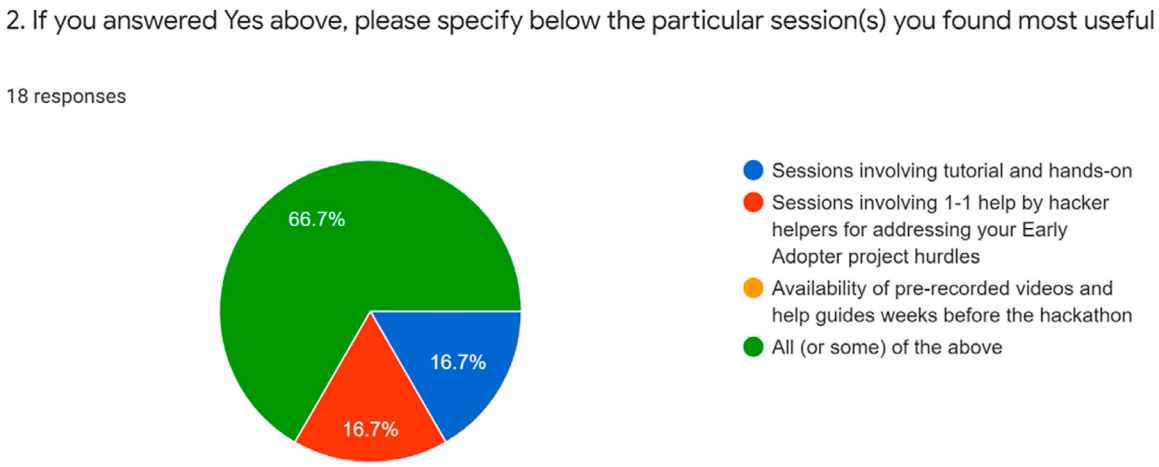

Fig. 7. Breakdown of general perception in Fig. 6 into components EAs liked most for the virtual hackathon.

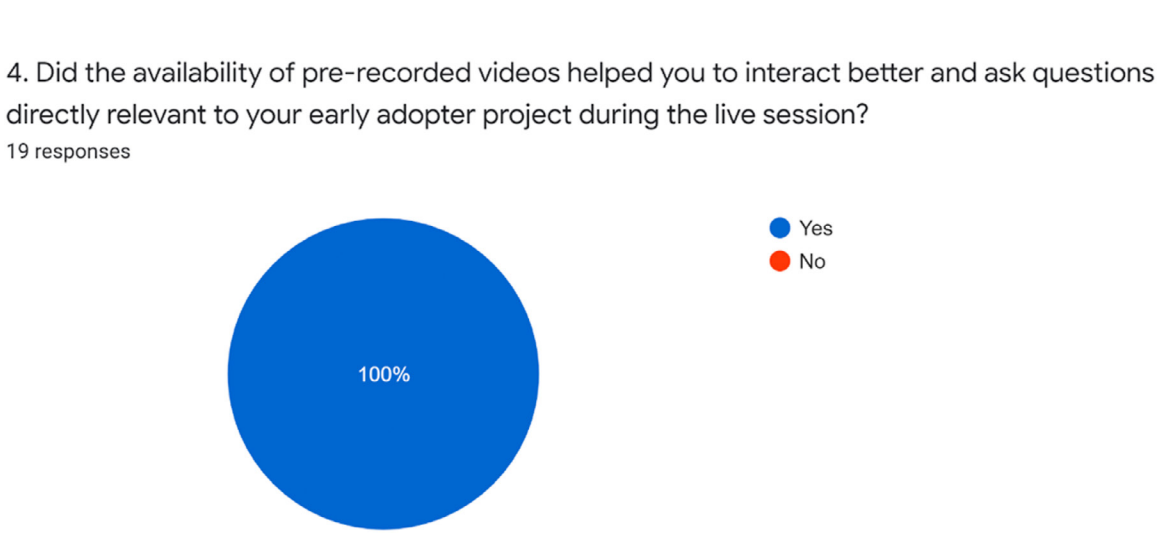

Fig. 8. Survey showing the impact of pre-recorded audio-visual content on preparing and interacting during the live hackathon sessions.

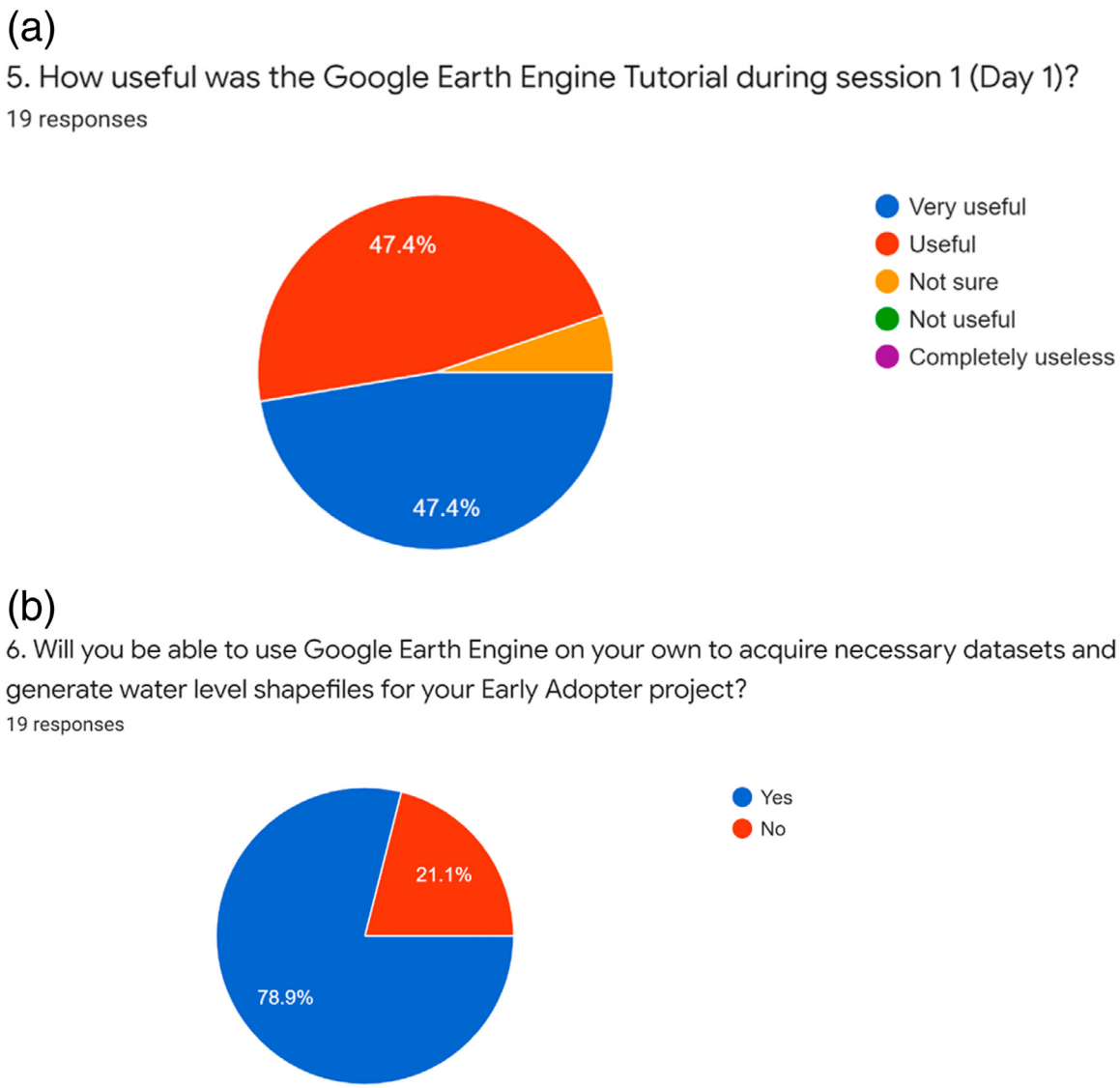

Fig. 9. (a) Survey of EAs on usefulness of the tutorial on cloud computing using Google Earth Engine the first day. (b) Survey of EAs on the literacy gained on cloud computing using Google Earth Engine during the first day.

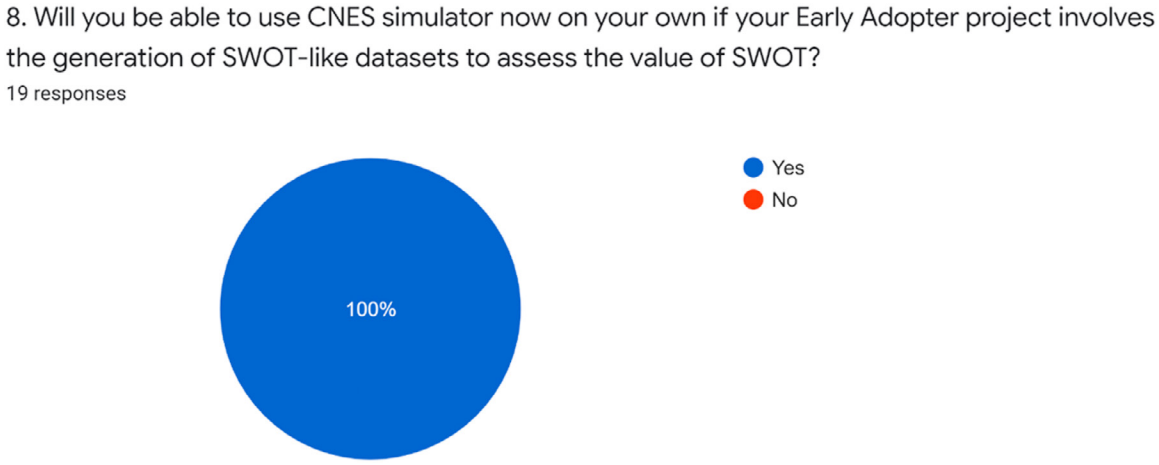

Fig. 10. Survey of EAs on the literacy gained on the use of the SWOT simulator (which simulates SWOT-like data) built by CNES.

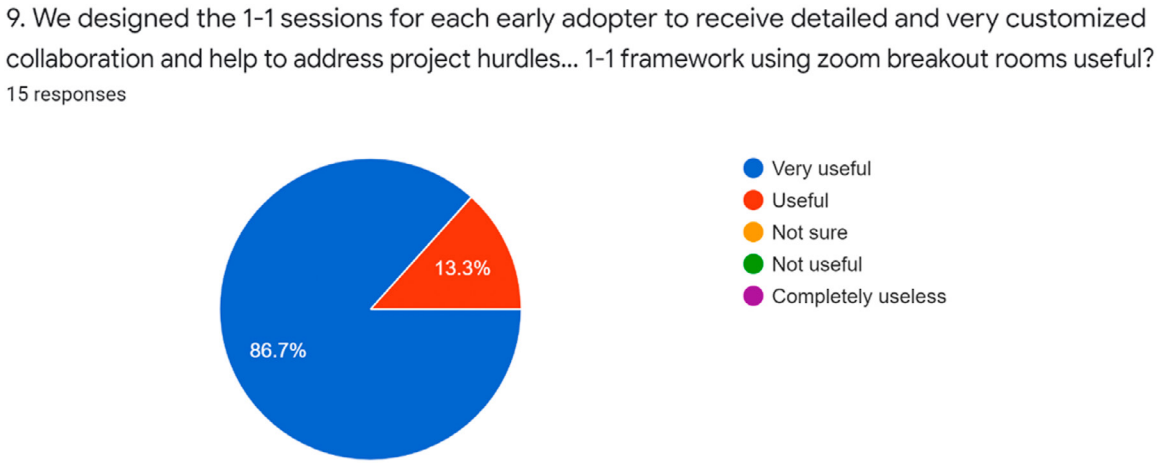

Fig. 11. Survey on the usefulness of the one-on-one hack sessions of "looking under the hood" conducted in breakout sessions in Zoom.

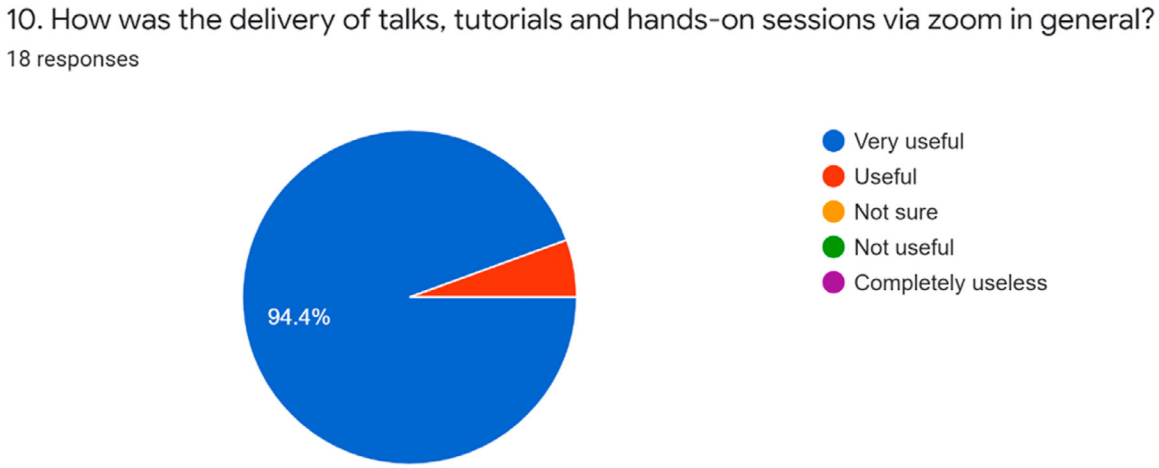

Fig. 12. Survey of EA perception on the use of Zoom for the virtual hackathon in general. Note that EAs spanning three continents with varying Internet bandwidth and time zones attended the SWOT virtual hackathon.

(100%) EAs found that the availability of pre-recoded audio-visual content on tutorials and talks by subject matter experts helped them engage better during the live sessions, ask more specific questions in the "flipped" style of instruction (Fig. 8). Here "flipped" refers to providing lecture materials and study aids in advance of the live session for the lecture so that participants have more time to ask questions. All (100%) EAs indicated that they now have acquired significant SWOT mission data literacy and feel confident in cloud computing and using the SWOT simulator to assess SWOT-like data in the pre-launch period (Figs. 9 and 10).

Conclusions

In this paper, we proposed a new engagement paradigm for the Early Adopter Program based on four essential features: medically safe (contactless), scalable (cost-effective), rapidly deployable, and focused on learning outcomes (MEDSCARF). In late spring 2020, we implemented our proposed virtual hackathon based on MEDSCARF principles for the planned Surface Water and Ocean Topography (SWOT) mission, whose EAP was launched in 2018. Thirty-eight participants representing 13 Early Adopter agencies took part in the virtual hackathon that involved intense one-on-one online hack sessions, an online repository of pre-recorded audio-visual education content, and live tutorials and talks by subject matter experts. A post-hackathon survey indicates that our proposed virtual paradigm based on MEDSCARF was successful in achieving learning outcomes for 100% of all EAs.

Our proposed virtual paradigm relies on the availability of the following essential components: 1) volunteer helper hackers with SWOT data literacy and advanced understanding of the satellite mission; 2) pre-recorded audio-visual educational content; and 3) breakout session capability that provides privacy for the EA team and helper hacker with full functionalities to remotely "look under the hood" for the EA project tools, data, and models. Our proposed virtual paradigm (MEDSCARF-based virtual hackathon) was successful for the SWOT mission, and we recommend that the concept and lessons learned be adopted across all planned NASA and CNES satellite missions in anticipation of the post-COVID-19 era of a more globally connected community.

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