The Early Adopter Program for the Surface Water Ocean Topography Satellite Mission: Lessons Learned in Building User Engagement during the Pre-launch Era

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38

What: A workshop was organized on the Surface Water and Ocean Topography (SWOT) mission that is planned for launch in 2021. Eleven early adopters representing a wide range of stakeholders of the SWOT mission presented projects for evaluation of SWOT's application potential and helped identify pathways to achieving successful application of data from the SWOT mission.

When: May 20-21, 2019

Where: Centre for National D'Etudes Spatiales (CNES), Paris, France

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Summary

SWOT is a research satellite mission, planned for launch in 2021, and is being jointly developed by the National Aeronautics and Space Administration (NASA) and Centre for National D'Etudes Spatiales (CNES), with participation from the Canadian and United Kingdom space agencies. The SWOT mission will serve both the hydrology and oceanography communities by providing the first global survey of Earth's surface water including rivers, reservoirs, lakes, and wetlands, as well as unprecedented detail in the topography of the ocean surface. During May 20-21, 2019, a workshop was organized at CNES headquarters (HQ) in Paris (France) to assess the status of the Early Adopter Program (EAP) that was launched for SWOT Early Adopters (EA) in 2018. Here, the key lessons learned from this Early Adopter program for SWOT mission are shared.

INTRODUCTION

The Surface Water and Ocean Topography (SWOT) mission (*Alsdorf et al., 2007; Biancamaria et al., 2016*), jointly developed by NASA and CNES, and with contributions from the Canadian and UK space agencies, is designed to provide for the first time spatially distributed and high frequency measurement of water elevation data for the hydrology and oceanography communities (Morrow et al., 2019). The NASA Applied Sciences Program, the SWOT Applications Working Group (SAWG), the CNES SWOT Applications Program, the SWOT Project, and members of the SWOT Science Team (ST) have been coordinating these efforts and recently launched the SWOT Early Adopter (EA) Program.

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The Early Adopter program (EAP) supports recommendations of the National Research Council's 2017 report "*Thriving on Our Changing Planet; A Decadal Strategy for Earth Observation from Space*" (NASEM, 2018). In the vision of the EAP, each selected EA proposed an activity for the use of SWOT data. EAs were defined as those groups and individuals who will have a potential or clearly defined need for SWOT surface water or ocean topography data or information, and who are planning to apply their own resources to demonstrate the utility of SWOT data for their use, system or model. The goal of this EAP is to accelerate the use of SWOT products after launch of the satellite by providing specific support to EAs who commit to engage in pre-launch research that would enable integration of SWOT data in their real-world applications. This research would provide a fundamental understanding of how SWOT data products may be scaled and integrated into their organizations' policy, business and management activities to improve decision-making efforts (*Hossain et al. 2017*).

In the initial cohort (beginning in 2018), eleven Early Adopters were selected from various hydrology and oceanography domains. These were: 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); Mercator Ocean.

WORKSHOP GOALS AND OBJECTIVES

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The key goal for the workshop was to provide a voice for selected EAs to share their application projects involving SWOT data, their decision-making activity, to share their progress, and to highlight their concerns and future needs. This workshop aimed to bring the EAs to a focal point for collaborative learning and sharing of lessons on what has worked for exploring the utility of SWOT data, and what more can be done in the years remaining before launch.

Over the span of two days, the workshop was designed to achieve the following objectives:

1) To provide selected EAs an opportunity to share their SWOT-related application projects and their progress with the SWOT Mission and Science Team.

2) To facilitate peer-to-peer collaborative learning for selected Early Adopters through lessons learned in other early adopter projects.

3) To provide hands-on training on cloud computing to train Early Adopters available cloud-computing platform to process, analyze and make decisions using massive amounts of satellite data in the cloud. [Note: *This objective is designed to acclimatize EAs to NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC), which will jointly host SWOT data products with the CNES data center, and their plans for hosting SWOT data on a cloud-computing platform*.]

4) To identify concerns, and needs of EAs for successful completion of their projects.

In order to maximize the effectiveness of the workshop and the chances of fulfilling the workshop objectives, organizers worked proactively with many EAs to explain the purpose and specific expectations. EAs were mentored individually by SAWG leads and were encouraged to think carefully about the core issues in advance of the workshop. Each EA was requested to

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imagine desired future press releases or newspaper headlines that their EA project might enable. This could be an outcome of their use of SWOT data that they would like to aspire to as a success story of their project. These press releases are hypothetical and their realization is dependent on numerous conditions beyond the control of the EA or the SWOT mission. However, the workshop organizers felt that this was a good way to design a project trajectory for each EA, delineate a tangible goal as a shared-vision and then work closely with EAs to realize that press release.

The supplementary file to this article provides a summary of the progress made by each EA, their needs, concerns, hurdles as well as their desired future press release. Based on feedback from EAs and discussions, we present here the key findings and lessons learned from the EAP for SWOT mission.

COMMON UNDERLYING NEEDS OF EARLY ADOPTERS

Based on feedback shared by EAs, the following key underlying needs emerged as common to all EAs:

1. EAs need simulated SWOT data for hydrology application that mimics the real-world geophysical constraints of SWOT observation due to topography, climate and vegetation.
2. EAs need clear and timely meta-data information on SWOT data products now to begin their project if they are to use SWOT simulated (or actual) data properly and be acclimatized to actual SWOT data after launch.

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3. Many EAs require engagement support to visit a research center/collaborator relevant to SWOT mission that can allow them to engage in weeklong immersive training to solve the specific application problems.
4. Many EAs require online training programs and tutorials/webinars on how to handle SWOT data.
5. EAs would benefit from SWOT-specific "hackathons for Early Adopters" to rapidly prototype solutions for their EA project, particularly for building components that require team-based thinking.

The key risks of the EAP can be summarized as follows:

1. Lack of access to simulator data for hydrologic application over river basins with steep topography, vegetation and humid climates,
2. Lack of training in managing large volume of data in cloud computing environment,
3. Lack of prompt guidance/engagement from SAWG and ST for troubleshooting problems with EA projects as they emerge.

FUTURE IMAGINED PRESS RELEASES BY EAs

The future imagined press releases suggested by EAs with fictitious newspaper/magazine titles and year were as follows:

- *SWOT helps supporting early flood preparedness in Myanmar (ADPC)*
- *SWOT data enables popular and blameless management of waterlogging in Sindh Province of Pakistan (PCRWR)*

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- *SWOT data helps in rationalizing irrigation supplies while preventing loss of land to waterlogging (PCRWR)*
- *SWOT data improves reservoir outflow forecasting to reduce downstream flood risk in Kerala (IIT-Bombay)*
- *The NOAA National Water Model forecast accuracy is improved*
- *Demand for CUAHSI workshops on use of SWOT streamflow products is high (CUAHSI)*
- *SWOT data improves navigability prediction and integrated resources water management on the Sangha River (CNR)*
- *SWOT mission improves mapping of potential sites for hydropower projects in the Congo basin (CNR)*
- *Assimilation of SWOT data improves forecasting skill of NOAA National Water Model (NASA-SPoRT)*
- *SWOT follow-on mission in development after successful use of SWOT data in operational forecasting (NASA-SPoRT)*
- *SWOT helps in predicting the 100-year event of Elbe water level extremes from Hamburg City to coast (UBonn)*
- *Small scales dynamics in ocean circulation in Danish Straits (UBonn)*

Assuming that all "press releases" were achievable through very close mentorship from the SAWG leads, the press releases were subjected to a vote by workshop participants for prioritization for future action by SAWG leads. Each workshop participant therefore chose their three favorite press release that they thought were most feasible and important to show the unique value of SWOT. The top three (with one tied) most popular future press releases were:

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1st place. *Assimilation of SWOT data improves forecasting skill of NOAA National Water Model (by NASA SPoRT)*

2nd place. *SWOT helps supporting early flood preparedness in Myanmar (by ADPC)*

3rd place (tie). *SWOT data enables populate and blameless management of waterlogging in Sindh province of Pakistan (by PCRWR)*

3rd place (tie). *SWOT follow-on mission in development after successful use of SWOT data in operational forecasting (by NASA SPoRT)*

CONCLUSIONS FROM THE WORKSHOP

The following conclusions emerged from the workshop for the SWOT Project and science community:

1. The SWOT Early Adopters have all made the demonstration of the usefulness of the future SWOT data in their tools and decision-making covering a wide range of applications from flood prediction, hydropower potential, water resources management to the operational oceanography.

2. SWOT hydrology simulated datasets that represent accurate performance characteristics due to geophysical constraints (lay-over, vegetation, dark water) and to spatio-temporal

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sampling and that follows the SWOT data product definition need to be made available to EA for their projects.

3. A faster SWOT simulator is an acceptable start and can help EAs acclimatize to SWOT data product structure. Such a simulator can be useful for large water bodies (lakes and reservoirs) in flat terrains.

4. The EA community would benefit from additional online resources for tutorials on a) cloud computing using platforms such as Google Earth Engine; b) explanation of SWOT mission, how it works and its data type; c) collection of existing tools and datasets that may be relevant to SWOT for the EA projects.

5. SAWG leads should consider organizing hackathons for SWOT EA projects to solve specific hurdles and build tangible solutions. The EA projects are now gradually maturing and will likely need to start using high resolution SWOT simulated data soon for complete the first run of proof of concepts for next year's reporting. This means that hackathons tailored to enable rapid prototyping of real-world solutions for EAs using SWOT data is now timely.

6. Programs that encourage deeper engagement for EAs at academic or research centers for immersive learning or training in USA/France are required for EA organizations and future SWOT user communities.

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7. Close and more frequent mentoring support for EAs is needed as projects mature and they begin facing new challenges with data structure and processing. EAs will continue to require guidance, 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.

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