Surface Water Ocean Topography (SWOT) Mission - Applications 2021 Early Adopter Hackathon - Workshop Report

8-11 March 2021
Location: Virtual (broadcast via Zoom from The University of Washington, USA)

Prepared by

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EXECUTIVE SUMMARY

The Surface Water and Ocean Topography (SWOT) mission is a research satellite planned for launch in late 2022, and is being jointly developed by NASA and Centre National D'Etudes Spatiales (CNES), with participation from the Canadian and United Kingdom space agencies. SWOT will provide the first global survey of Earth's surface waters including rivers, reservoirs, lakes, and wetlands, as well as unprecedented detail in the topography of the ocean surface—serving both the hydrology and oceanography research and applied science communities.

Following a successful virtual SWOT Applications Early Adopters (EA) Hackathon event in May 2020, the second virtual SWOT Early Adopters Hackathon workshop was organized for 8-11 March 2021 and was conducted from the University of Washington (UW). This workshop was organized primarily by Dr. Faisal Hossain from UW, a Co-Lead on the SWOT Application Working Group (SAWG), with support from the other Co-Leads, Alice Andral (CNES), and Margaret Srinivasan (NASA JPL). The work of the SAWG is supported by the NASA Applied Sciences Program, The SWOT Project and Science Team, and by CNES.

The overarching objective of the SWOT Applications effort is to maximize readiness of SWOT data by a broad range of user communities after launch. To accomplish this, the SAWG engages with representative individual and organizations from user communities who may benefit from the incorporation of SWOT data into their operational systems. The Hackathon is a mechanism to introduce these groups to the anticipated capabilities of SWOT, and to its eventual data and information products. Through close coordination and training in the use of proxy data and data simulators, SWOT data can be more readily incorporated into the decision-making or application process of users when it becomes available.

Information about and summaries from all previous SWOT EA and Applications workshops is available online (https://swot.jpl.nasa.gov/applications.htm). All hackathon materials, videos and tutorials are available online (http://depts.washington.edu/saswe/swot).

INTRODUCTION

BACKGROUND

The Surface Water and Ocean Topography (SWOT) mission, developed jointly by NASA and CNES, and with contributions from the Canadian and UK space agencies, will provide high spatial and temporal frequency measurements of global surface water extent and elevation, and other key derived parameters. Scheduled to launch in late 2022, the SWOT satellite includes cutting edge interferometric radar technology, along with traditional nadir altimeter and positioning instruments, to continue and expand on the nearly 30-year time series of ocean and large water body surface height measurements.

The NASA Applied Sciences Program, the SWOT Project, the CNES SWOT Downstream Program, the SWOT Applications Working Group (SAWG), and members of the SWOT Science Team (ST) are coordinating efforts in support of the SWOT Early Adopter (EA) Program. SWOT EAs are a growing community working to incorporate future SWOT data into the operational and applied science activities of their organizations.

The SWOT Applications and EA programs support recommendations of the National Research Council's 2017 report "Thriving on Our Changing Planet; A Decadal Strategy for Earth Observation from Space", (the Decadal Survey, NASEM, 2018), in objectives related to hydrologic cycles and water resources. Specifically, the SWOT Applications objectives can be captured under Objective H-3b from the *Science and Applications Priorities Table* (Table 3.3 in the 2017 Decadal Survey), *"Monitor and understand the coupled natural and anthropogenic processes that change water quality, fluxes, and storages in and between all reservoirs (atmosphere, rivers, lakes, groundwater, and glaciers), and response to extreme events."*

The general goals of the NASA ASP are to discover and demonstrate innovative uses and practical benefits of NASA Earth science data, scientific knowledge, and technology. The SWOT EA effort aligns directly with these goals, as they, specifically:

- Promote applications research,
- Facilitate development of accessible data products for non-science users,
- Identify and engage a broad community of users to maximize societal benefit of
- NASA Earth science data, and
- Encourage and enable the applications community to contribute to Earth-observing satellite design and mission planning in the long term.

At the time of the 2nd SWOT Applications Early Adopter Hackathon, the SWOT EA cohort was represented by 20 individuals and organizations. Since that time, a new EA has joined, making the total 21 organizations (see Table 1). These EAs represent various hydrology and oceanography domains, and organizations including both domestic U.S. and international private sector companies, academia,

nonprofit, operational agencies, State and national-level government organizations, and research communities.

Figure 1. SWOT Applications, Project and Institutional leadership.

The efforts of the SAWG to build strong engagement with the applications community began in 2014. This workshop was intended to support the SWOT EA community in developing and advancing their proposed activities, and to demonstrate potential real-world benefits of the use of SWOT data products when they become available. Cooperation between SWOT Applications, and Program and Project leadership (Figure 1), and the support of NASA, CNES, JPL and members of the SWOT Science Team, are key components contributing to the success of the SWOT Applications efforts.

SWOT EARLY ADOPTERS

NASA and CNES began a focused program to actively recruit and engage individuals and organizations into the SWOT Early Adopters program in 2018. Since that time, SWOT EAs have joined from seven different countries across Asia, Europe and North America (Figure 2), with a total of 21 Early Adopters (EAs) joining the program to date (see Table 1).

The primary goals of the SWOT Early Adopter program are;

1) To expand the user communities with tangible and potential applications that would benefit from the use of SWOT data sets,
2) To facilitate feedback on SWOT data products *pre-launch*, and

3) To accelerate the use and integration of SWOT products into applications *post-launch* by providing specific support to Early Adopters who commit to engage in pre-launch applied research.

The EA program is a non-funded activity (for NASA and CNES) for projects to be completed with quantitative metrics prior to launch.

Where are SWOT Early Adopters?

Figure 2. *SWOT Early Adopters span the globe with a wide range of operational and applied project topics. Visit swot.jpl.nasa.gov/applications/early-adopters/ for information about EA projects.*

Each of the EA project leads have identified a region within their working programs where SWOT data has the potential to provide measurable to substantial improvements in their knowledge base for operations. Information about the SWOT EA program, as well as project summaries for the EA organizations can be accessed at https://swot.jpl.nasa.gov/applications/early-adopters/. As EA projects progress, updates are posted in the section of each EA summary titled, 'Current Progress and Future Steps'. For updated information, we suggest that you check the web site periodically.

SWOT Early Adopters

1	Asian Disaster Preparedness Center (ADPC)/SERVIR-Mekong
2	BRL Ingénierie (BRLi), Nimes, France
3	Centre for Water Resources Development and Management (CWRDM), Kerala, India
4	Collecte Localization Satellite (CLS), Tolouse, France
5	Companie Nationale du Rhône (CNR), Lyon, France
6	Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI), Cambridge, MA
7	Environment and Climate Change Canada (ECCC), Gatineau QC Canada
8	FM Global, Boston, MA
9	Indian Institute of Technology Bombay
10	Indian Institute of Technology Delhi
11	Mercator Ocean, Ramonville Saint-Agne, France
12	NASA Short-term Prediction Research and Transition (SPoRT) Center, Univ. Alabama
13	NOAA/CIRES University of Colorado Boulder
14	Ohio State University, Columbus, OH
15	Pakistan Council of Research in Water Resources (PCRWR), Lahore, Pakistan
16	Stantec Consulting Services Inc. (Stantec)
17	Texas Water Development Board (TWDB), Austin, TX
18	U.S. Air Force Weather's Land Information System (LIS), Offutt AFB, NE
19	U.S. Geological Survey, Northborough, MA
20	University of Bonn and Helmholz-Zentrum Geesthacht
21	VORTEX.IO, Toulouse, France

Table 2. SWOT Early Adopters span seven countries and represent 21 organizations.

SAMPLE DATA PRODUCTS

In the early days of the SWOT EA program, project teams were limited to using similar or proxy datasets (for example, Jason 2 and Jason 3 satellite data and in situ data) which were missing important structural components of actual future SWOT data products. Within the past few months, the SWOT Project and Science Team have made sample data sets available for selected hydrologic and oceanographic regions. These data sets share many characteristics (with respect to format, content, volume, etc.) with eventual future SWOT data products. These data sets are openly available on the NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC) web site for use by SWOT EAs and others. The data products, accompanying Release Notes, as well as links to the Product Description

Documents can be accessed from: https://podaac.jpl.nasa.gov/swot?tab=datasets&sections=about%2Bdata. These sample data products are intended to enable users to become familiar with the format and content of the expected science data products from the SWOT mission. This can allow users to prepare their operational systems for routine ingestion of SWOT mission data soon after launch in late 2022. The SWOT Project team has been very clear that these products "should not be used in any way to interpret performance of the inflight data or to perform scientific analyses". Figure 3 illustrates sample data in oceanic and hydrologic locations.

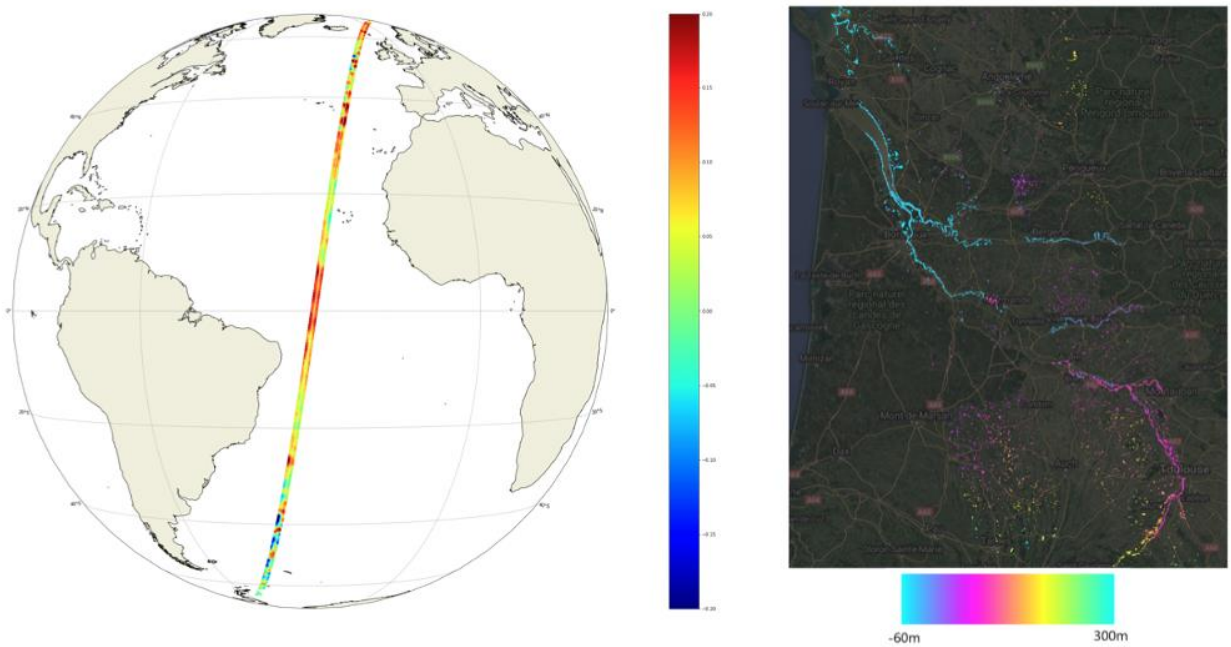

Figure 3. *Illustration of sea surface height anomaly from one pass (Pass 7) of the L2_LR_SSH product (left), and water surface elevation in 100-meter resolution L2_HR_Raster sample products (right). Source: Release Notes for Sample Data Products (tinyurl.com/SWOTSampleNotes).*

WORKSHOP GOALS AND OBJECTIVES

Following the successes of the 2020 Virtual 1st SWOT Early Adopter Hackathon (Hossain, et al 2020), the SAWG Leads elected to hold a second virtual SWOT EA Hackathon to support veteran and new EAs in their project development in March 2021.

The general goals for this and all SWOT EA workshops are to:

- Provide Early Adopters with an opportunity to share their SWOT-related application projects and progress,
- Facilitate peer-to-peer collaborative learning,

- Provide hands-on training on a cloud computing platform to process, analyze, and make decisions using large amounts of satellite data in the cloud,
- Familiarize EAs with SWOT-like data on water elevations,
- Identify concerns and needs of EAs and to promote successful completion of their projects,
- Document activities and outcomes of the workshop for the broader Earth applied science community and to maximize societal relevance of the SWOT mission and its future data products.

A pre-workshop survey was provided to participants in order to identify issues, hurdles and needs of EAs on their projects in advance of the workshop in order to facilitate higher level of engagement and utility during the event.

The agenda (Table 2) was designed to provide substantive, but limited SWOT and topical overview. The first day opened to a broader audience including SWOT EAs, potential EAs, Project team members, and other interested persons. The Hackathon began with welcome messages from Programmatic leads from NASA and CNES, reflecting recognition of the importance of the SWOT Applications program and engagement activities at the organizational level. Welcome messages were followed by articulation of the workshop objectives and a demonstration of the CNES HYDROWEB-NG multi-sensor hydrology data portal which will incorporate SWOT data in a user-friendly web interface. A series of overview talks covered topics such as reservoir monitoring techniques using satellites, and introductions to the CNES ocean data simulator and the NASA Earthdata Cloud, and a PO.DAAC demonstration of a user case story. Update talks on SWOT hydrology data products were followed by an overview talk of services and programs of the Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI), a SWOT EA organization.

AGENDA

SESSION 1 (March 8 Monday) – *OPEN TO ALL*
Welcome & Introduction to SWOT Application Working Group-SAWG (**Faisal Hossain** and **SAWG Leads**)
Welcome note by SWOT Program leads *Nadya Vinogradova-Shiffer, NASA HQ Physical Oceanography (SWOT)* *Annick Sylvestre-Baron, CNES SWOT Program Lead* *Bradley Doorn, NASA HQ Applied Sciences Program (Water)*
Overview of Hackathon objectives: Why are we doing this? (**Faisal Hossain**)
Demonstration of HYDROWEB-NG (**Lionel Zawadzki, CNES**)
Reservoir Volume Monitoring in France using Sentinel satellites (**Santiago Pena-Luque, CNES**)
Introduction to CNES SWOT Ocean Simulator (**Lucile Gaultier, OceanDataLab**)
Introduction to Earth Data Cloud (**Catalina Oaida, JPL**)
Demonstration of PO.DAAC User Case Story for an Early Adopter project -1 (**Jack McNelis**, **Catalina Oaida, JPL**)
Overview of SWOT Hydrology Data Products (**Tamlin Pavelsky, UNC**)
Overview of SWOT Discharge Algorithm and Products (**Mike Durand, The Ohio State University**)

Overview of Education and Outreach Services of CUAHSI (Consortium of Universities for the Advancement of Hydrologic Science) (**Jerad Bales, CUAHSI**)
Q&A for Early Adopters about Earth Data Cloud, Ocean Simulator, SWOT Data products, SWOT Discharge Algorithms
SESSION 2 (March 9 Tuesday) *FOR EARLY ADOPTERS ONLY*
Showcasing how Early Adopters have used SWOT Simulator and ancillary data for applications
1. *Demonstration & lessons learned on how IIT Bombay applied SWOT Simulator and data to explore the value of SWOT for hydrology applications in India* (**Indu Jayaluxmi, IIT Bombay**)
2. *Demonstration & lessons learned on how NASA SPoRT applied SWOT Simulator and data to explore the value of SWOT in data assimilation for river forecasting* (**Nicholas Elmer, NASA SPoRT**)
3. *Demonstration & lessons learned on how Univ. of Bonn applied SWOT Simulator and data to explore the value of SWOT in data for river and estuarine applications* (**Luciana Fenoglio-Marc, Univ. of Bonn**)
4. Q&A from Early Adopters for IIT Bombay, Univ. of Bonn or NASA SPoRT (**30 mins**)
Introduction of Newest Early Adopters and their plans to assess the SWOT mission data
Texas Water Development Board (TWDB)
Central Water Resources Development and Management (CWRDM)- Kerala and IIT Bombay
Hacking EA projects **(2 hours)**
Parallel Zoom breakout session for **IIT-Delhi** (Helper: Akhilesh Nair, IITB)
Parallel Zoom breakout session for **ADPC** (Helper: Nishan K. Biswas, UW)
Parallel Zoom breakout session for **PCRWR** (Helper: Shahryar K. Ahmad, UW)
Parallel Zoom breakout session for **FMGlobal** (Helper: Nicholas Elmer, NASA SPoRT)
Parallel Zoom breakout session for **CWRDM** (Helper: Vinayak Huggannavar , IITB)
SESSION 3 (March 10, Wednesday) *FOR EARLY ADOPTERS ONLY*
Hacking EA projects **(2 hours)**
Parallel Zoom breakout session for **UniBonn, Stantec and Mercator, IGE** (Group discussion with Lucile Gaultier, Ocean Data Lab; Luciana Fenoglio-Marc of UniBonn, Mounir Ben-Kiran of Mercator, Sammy Metref of IGE, Stantec EA rep)
Parallel Zoom breakout session for **Texas Water Development Board** (Helper: Hisham Eldardiry, UW)
Parallel Zoom breakout session for **IIT-Delhi** (Helper: Akhilesh Nair, IITB)
Parallel Zoom breakout session for **ADPC** (Helper: Nishan K. Biswas, UW)
Parallel Zoom breakout session for **PCRWR** (Helper: Shahryar K. Ahmad, UW)
Parallel Zoom breakout session for **CWRDM** (Helper: Vinayak Hugganvar, IITB)
SESSION 4 (March 11 Wednesday) *FOR EARLY ADOPTERS ONLY*
Hacking EA projects **(2 hours)**
Parallel Zoom breakout session for **Texas Water Development Board** (Helper: Hisham Eldardiry, UW)
Parallel Zoom breakout session for **FMGlobal** (Helper: Nicholas Elmer, NASA SPoRT)
Parallel Zoom breakout session for **Univ. of Bonn, Stantec, Mercator IGE** ((Group discussion with Lucile Gaultier, Ocean Data Lab; Luciana Fenoglio-Marc of UniBonn, Mounir Ben-Kiran of Mercator, Sammy Metref of IGE, Stantec EA rep)
CLOSING SESSION
Hearing from EAs on needs and 'what else?' for future planning
Discussions, Q&A

Table 2. Agenda for the 2nd SWOT Early Adopter Hackathon—a virtual workshop, 8 - 11 March 2021.

Attendance on day two was limited to SWOT EAs and other SWOT Applications persons, as well as the Hackathon Helpers who worked directly with EAs on their projects. This second day began with three “demonstration” and lessons learned reports by EAs who have advanced experience in the program and were willing and able to share their work and experiences for broader EA community benefit; The Indian Institute of Technology (IIT) Bombay, NASA Short-term Prediction Research and Transition (SPoRT), and the University of Bonn.

The two newest EAs to the program at the time of the Hackathon were introduced and gave brief overviews of their project plans and work; the Texas Water Development Board (TWDB), and the Central Water Resources Development and Management (CWRDM) from Kerala, India.

The remainder of the workshop included two parallel sessions, each being two hours long, over the span of two days for each of the participating EA groups. During such sessions, called ‘hack’ or ‘help’ session, helpers hackathon with advanced training on IT and specialized expertise on the SWOT mission, its data, simulator engaged 1-1 with the Early Adopter to troubleshoot technical issues for the project proposed by the EA. The entire help session was facilitated online via distance learning and gaining access to the EA’s operational environment using a training protocol developed during the first Hackathon called MEDSCARF (see Hossain, Elmer, Srinivasan and Andral, 2020).

OUTCOMES

Close to 60 participants registered for the workshop. Representatives from over 32 organizations and agencies hailing from eight countries participated, and represented both the hydrology and oceanography user communities of SWOT.

The stakeholder agencies represented public and private sector, academia, and government agencies at regional and national levels. The full list of SWOT Early Adopters can be found in Table 1. SWOT EAs represented during the workshop included; Asian Disaster Preparedness Center (ADPC), Indian Institute of Technology Bombay (IITB), Indian Institute of Technology Delhi (IITD), Pakistan Council for Research in Water Resources (PCRWR), Consortium of Universities to Advance Hydrologic Science Institute (CUAHSI), Center for Water Resources Development and Management (CWRDM), NASA Short-term Prediction Research and Transition (SPoRT) Center, The Ohio State University, Mercator Ocean, University of Bonn, Stantec, Texas Water Development Board (TWDB), Compagnie Nationale du Rhône (CNR), Collecte Localisation Satellites (CLS), and FM Global. Several participants from the NASA and CNES SWOT Mission HQ and SWOT Science Team (ST) were also present in order to support the workshop and to better understand the needs of future SWOT user communities.

FUTURE PLANS

THE 2021 SWOT Early Adopter Hackathon was another successful engagement of our EA community, SWOT Project personnel, the SWOT science community, and the SAWG. Hands-on work between the U. Washington and SWOT EA helpers and mentors, and the new and seasoned SWOT EAs provided important

support for active and new EA projects. This work to introduce and familiarize the community with mission data simulators, proxy datasets, methodologies, as well as the wide variety of EA projects, is designed to advance the project objectives of individual EA organizations and the future operational systems that will incorporate SWOT data.

We recognize a continued need to improve training with SWOT simulated data and the SWOT hydrology and ocean data simulators. Advanced training on accessing and manipulating data from and within the cloud will also provide high value to current and future EAs. Continued guidance and engagement from the SAWG, the SWOT Project, and from SWOT Science Team members for troubleshooting problems will remain a valuable benefit.

The following are foci for future SWOT Applications activities that were identified based on feedback from EAs in the closing session of the workshop:

ACTION ITEMS FOR FUTURE SWOT APPLICATION ACTIVITIES (2021-2022)

1. Provide expert presentations on SWOT for rivers, estuaries and coastal topics,
2. Provide expert presentation on SWOT for water inundation modeling and detection ,
3. Provide expert presentation on expected SWOT uncertainty (from post-Hackathon survey),
4. Address challenges with narrow rivers in hack session or in a presentation,
5. Consider more hydrology simulator training session,
6. Consider more Ocean simulator training session,
7. Provide more presentations on application scenarios/examples from Early Adopters or Science Team; consider a session just on application examples,
8. Get experts who developed RiverObs and CNES Simulator more involved; have them talk and be present during training session,
9. Provide speakers who can explain how SWOT's various instruments and techniques (KaRIN) are expected to work, and
10. Provide hands-on session on ways to recreate SWOT discharge products from example pixel cloud/raster data over a river.

POST-HACKATHON UPDATES

An offline Hydrology Help Session was held on 29 March 2021 to support the following EAs who identified additional needs after the main Hackathon Sessions. These EAs included the University of Bonn and Stantec.
Recommendations and follow on to the EAs after this session included requesting sample input and output data files from the EA team at IITB; further exploration of the Google Earth Engine toolbox developed by JPL's Matthew Bonnema for generating lake shapefiles for us in the simulator; and reaching out to SWORD

database team to streamline shapefiles for the Rhine River in order to conserve processing time.

Requests can be made to the SAWG Leads by new Early Adopter teams for an offline one-on-one session to “hack” outstanding issues with their project. Please contact any SAWG Lead to inquire.

PO.DAAC

Tutorials; Catalina Oaida of JPL’s PO.DAAC reported that the PO.DAAC GitHub repository now contains the Jupyter notebooks demonstrated by the PO.DAAC team on the first day of the event. They are available at: https://github.com/podaac/tutorials/tree/master/notebooks/SWOT-EA-2021. Questions by SWOT EAs on any PO.DAAC SWOT assets, future SWOT data access, Earthdata data in the cloud, or the data recipes can be directed to Catalina Oaida (catalina.oaida@jpl.nasa.gov) or Jack McNelis (jack.mcnelis@jpl.nasa.gov). SWOT EAs, please copy one of the SAWG leads (Faisal Hossain, Margaret Srinivasan, Alice Andral) on inquiries.

Sample Data

SWOT Project-approved SWOT sample files are now available through the PO.DAAC SWOT mission page, for most expected data products at https://podaac.jpl.nasa.gov/SWOT?tab=datasets&sections=about%2Bdata

A Release Note is included with the sample files and is also available at the link above. We encourage the Early Adopters to review the document for information and guidance from the Project on the intent of these sample files. We recommend starting with lake products, as they are easier to understand, and then advance to river products later.

Peer-Reviewed Publications

Please share with the SAWG Leads details of any peer-reviewed publications that involve your SWOT EA project so that we may include them in the Publications page of the SWOT web site.

SWOT EA Continuing Communications

Quarterly telecons for the SWOT EA program are opportunities to share progress, ask questions, get help, express interest or concerns, and interact with other SWOT EAs. Please plan to participate in these if you are able. We are open to alternate timing of the telecons, or alternate communication formats. If you have suggestions, please share them.

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