UN-SPIDER/DLR/GLOFAS/ZFL International Training Workshop On Space Technologies for Flood Management

Report

UN Campus
Bonn, Germany
20 to 22 February 2023

The UN-SPIDER/DLR/GLOFAS/ZFL international training workshop included nearly 30 participants from national disaster management agencies, space agencies, other government agencies and university students. Participants came from Algeria, Barbados, Germany, Ghana, Italy, Kenya, Mexico, Mozambique, Nigeria, Pakistan, South Africa, Spain, Sri Lanka, Türkiye, Uganda, and the United Kingdom. The workshop was inaugurated with opening remarks by representatives from UN-SPIDER, ZFL, GLOFAS, and DLR.

Session 1: Global Flood Awareness System (GLOFAS)

During this session, the expert from GLOFAS gave participants an overview of GLOFAS, including how it operates internally using meteorological forecasts from ECMWF, geospatial information on the morphology of rivers, land cover and land use; and the LISFLOOD hydrological software to carry out the rainfall-runoff and routing computations to forecast discharges in all segments of rivers. The expert also explained the updates and upgrades of GLOFAS in 2023, such as the improvement of spatial resolution from 10km to 5km, and the addition of 700 stations across the world for calibration purposes. The expert from GLOFAS explained the Map Viewer including its various layers available through several tabs located in the viewer's upper part. These layers include:

- **Initial conditions**
- **Meteorological**
- **Hydrological**
- **Flood Risk**
- **Evaluation**
- **Static**
- **Monitoring,**

Precipitation and climate data are available in the **Initial Conditions** tab and the **Meteorological** tab. Additionally, information on potential floods can be viewed using the **Hydrological** tab. Such information is presented in four temporal periods:

- **1 to 3 days**
- **4 to 10 days**
- **11 to 30 days**
- **1 to 30 days (since December 2022)**

The expert commented that GLOFAS displays the potential level of floods in different segments of channels of rivers in three categories:

- Floods exceeding those which have a period of return of 2 years (yellow color pixels).
- Floods exceeding those which have a period of return of 5 years (red color pixels).
- Floods exceeding those which have a period of return of 20 years (purple color pixels).

The speaker also commented that the classification is done based on historic climatic data, as specific discharge data is not available for all segments of rivers of the world. Participants took note that the forecast related to the **1-to-3-day** period is more reliable, while the forecast for the **11-to-30-day** period is normally affected by higher uncertainty but it provides information about what can be expected in the coming weeks throughout the basin.

The expert explained that GLOFAS calibrates its outputs using in-situ discharge data provided by institutions worldwide and is continually seeking to expand that database of discharge data to improve the accuracy of the forecasts. However, as of today, the GloFAS database still misses in-situ discharge data for some regions of the world.

During the discussion session, some participants commented on the use of GLOFAS in their countries in combination with information provided by their national meteorological offices.

The GLOFAS staff member noted that information related to the model's performance could be found in the **Evaluation** tab and highlighted that it is important to view this information to comprehend the reliability of the estimation of potential floods. In addition, the speaker commented that GLOFAS provides a risk assessment of a country's provinces based on complementary information on elements that may be exposed and vulnerable, including communities, roads, critical infrastructure including schools and hospitals, and agricultural areas. This information can be viewed in the **Flood Risk** tab.

The expert also informed participants of how GLOFAS generates reporting points that can give additional information on the potential floods and hydrograph charts spanning a 30-day period presenting information on the trends of potential floods linked to the thresholds used by GLOFAS.

The experts gave the participants tasks to improve their independent use of GLOFAS and concluded her remarks by providing information regarding the GLOFAS Wiki and the user guide, developed for users to find additional technical details on GLOFAS.

Session 2: rapid flood mapping

This session presented three procedures that can be used for rapid mapping of floods using Sentinel-1 radar imagery and cloud-based processing tools.

An expert from UN-SPIDER introduced participants to the use of radar imagery to map floods, describing the characteristics of this type of satellite imagery and commenting on the advantages and disadvantages of using such imagery to map floods. The expert remarked that one of the key advantages is the capacity to map flooded areas even under cloudy conditions or at night. However, the constraints include the incapacity to use radar imagery to map floods in urban areas and dense forests or vegetation.

The expert indicated that satellites with the capacity to acquire radar imagery are active, meaning that such satellites send a signal in the microwave region of the electromagnetic spectrum to the planet's surface. Radar systems are usually side-looking systems, meaning that the signals are sent to one side at a certain angle. For standing water surfaces, this leads to specular reflection away from the sensor and, therefore, to the reception of a low signal. In contrast, the built environment, bare soil, and vegetation have rough, coarse surfaces and will reflect the signal or parts of it to the satellite and cause further backscattering.

The procedure then links a lack of reflection with the presence of water. In the final image, it is possible to identify water surfaces as dark or black pixels (low signal measurements), whereas other surfaces would appear bright in the image (high signal measurements).

Participants took note of the fact that when using this type of imagery, the issue of polarization of the signal is a crucial factor and suggested the use of specific types of polarizations to extract the extent of floods.

Subsequently, the expert presented the UN-SPIDER Recommended Practice that uses Sentinel 1 radar imagery and Google Earth Engine to map the extent of floods. He commented that the procedure compares radar imagery before and after the floods to extract the polygon of the flood extent. The required inputs to use this UN-SPIDER Recommended Practice are:

- An Area of Interest (AOI) that can be prepared using a drawing tool within the procedure or by using prepared geodata.
- Specification of a temporal period when there are no floods (before).
- Specification of a temporal period when floods are present.
- Parameters for filtering the Sentinel 1 imagery database: polarization and pass direction.
- Difference threshold for the decision if a pixel is marked as flooded or not.

The expert commented that the procedure will automatically compare the satellite imagery before and during floods and extract the location of floods in the Area of Interest.

The experts used as an example the floods that occurred in March 2019 in Mozambique to present this step-by-step procedure. Participants were asked to follow the procedure using their own laptops and took note of the need to change the polarization and pass direction to acquire the respective satellite imagery depending on the case study

Subsequently, an expert from DLR presented another UN-SPIDER Recommended Practice which can be used to map the extent of floods using a Jupyter Notebook hosted on a cloud environment called Google Colab. The code was provided through the UN-SPIDER GitHub repository. The expert explained to the participants the preliminary steps that are required to prepare and set up the Python/Jupyter working environment.

The expert explained to participants that this Recommended Practice extracts flooded areas from one single Sentinel-1 image by distinguishing flooded and non-flooded pixels through an automatically determined separation threshold in the image’s histogram. The inputs required to run this Recommended Practice are:

- Selection of Area of Interest.
- Selection of the temporal period to find available Sentinel-1 satellite imagery.

The Recommended Practice can handle the manual input of an Area of Interest drawn by the user in the map or load a file for the Area of Interest. The expert recommended that when Areas of Interest are loaded as files, such areas of interest should best be in SHP, KMZ, KML or GeoJSON format.

The expert commented that this procedure should be used for rapid mapping of ongoing floods, as it uses the most recent satellite imagery available in the Copernicus Open Access Hub. Mapping floods for periods older than six months is not recommended, as the Copernicus Open Access Hub archives imagery older than six months. If archive data is provided, the tool can still be used by deselecting the section dedicated to data download.

As in the previous cases, participants were asked to carry out the process on their laptops. For this case, recent floods that happened at the end of January 2023 in the Ambatoboeny area in Madagascar were used as a case study.

The expert mentioned that it is necessary to use the correct geographical region and time period so that the procedure can differentiate between flooded and non-flooded areas. He noted that selecting an area of interest that is too large will require a considerable amount of time and might cause the memory (RAM) to exceed.

Another expert from DLR made a presentation on flood detection using artificial intelligence procedures in the Google Earth Engine platform powered by the Google Cloud Infrastructure. The expert made participants aware of the disaster mapping efforts made by DLR's Earth Observation Center (Charter Space and Major Disasters and ZKI) in case of various events such as tsunamis and floods. The speaker then introduced participants to the procedure in Google Earth Engine, indicating that it is necessary to introduce:

- The Area of Interest
- The interval of time for the analysis

The expert then guided participants on various steps like postprocessing the floods mask layer and adding Copernicus Global Landcover data into the map to visualize the affected settlements and roads in the area of interest. In the last step, participants created a flood damage assessment map based on the flooded mask layer and the urban area.

Subsequently, the expert from GLOFAS made a presentation on the Global Flood Monitoring tool (GFM), which presents information on the flood extent based on Sentinel-1 satellite imagery. It is available around eight hours after the acquisition of the Sentinel-1 satellite imagery and is available under the Monitoring tab of the Map Viewer of GLOFAS. There are three layers available:

- Observed flood extent
- Observed water extent that includes water, lakes and rivers
- Reference water mask

The expert referred to the GFM wiki for technical information and the Quick Start Guide. The speaker commented that data is currently available as of 2020.

Session 3: Simulation

In this session, participants were divided into five groups and were asked to generate information on potential floods using GLOFAS and to elaborate maps of flooded areas using the procedures presented in session 2. Four geographical areas were selected. These areas experienced severe floods in recent years:

- Mexico floods, November 2020
- Mozambique floods, March 2022
- Nigeria floods, September 2022
- Pakistan floods, September 2022

Participants were asked to analyze the information presented in GLOFAS for the initial days related to these events, specifically to identify trends for the next 30 days, areas that could be flooded, and relevant information on the forecasted discharges. Participants were also asked to comment on layers that should be revised daily and layers that need to be revised only once or twice during large floods.

Subsequently, participants were asked to use the procedures to map the extent of floods related to those events in specific areas of interest that were provided by the Organizing Team and to create a final presentation of their results, including screenshots of their use of GLOFAS and a map product showing the flood extends. In the last part of this session, each group presented its results to the audience.

Discussion

At the end of the third session, there was a discussion segment where participants commented on their views about the potential use of GLOFAS, the procedure presented by DLR, and the UN-SPIDER Recommended Practices.

Participants noted the usefulness of GLOFAS to monitor potential floods and the usefulness of the procedures developed to map floods rapidly using cloud-based platforms such as Google Earth Engine and Google Colab. Furthermore, participants emphasized the urgency to strengthen the partnership between international space agencies and policymaking to develop effective space technologies research, improve institutional capacity, and enhance coordination mechanisms activities for disaster mitigation efforts.

UN-SPIDER commented that together with ZFL and other partners, UN-SPIDER is implementing the Flood GUIDE project that aims to enhance the use of GLOFAS and historical information on the impacts of floods to improve flood early warning systems incorporating impact-based forecasts.

UN-SPIDER also noted that disaster management agencies could use these tools in case of floods and remarked that academic research is needed to develop and improve such platforms and tools. Finally, the benefits of cloud-based solutions were highlighted, comparing what it took to process satellite imagery decades ago and what it takes to process satellite imagery now using such platforms as Google Earth Engine.