Microsoft

AI for Earth Grantee Profile

Michael Souffront

Global streamflow prediction

Summary

Michael Souffront, a software engineer at Aquaveo, developed a high-density hydrologic model and visualization tool for forecasting global floods. The GloFAS-RAPID model produces streamflow forecasts not just from major rivers, but also medium-sized and smaller streams—helping advance flood preparedness, especially in developing countries.

Solving the challenge of increasing flood frequency and severity in developing countries

Although floods are a natural phenomenon that humans have dealt with since our first settlements, they are becoming an increasingly acute problem as weather-related disasters increase and become more severe. According to an article on Floodlist, a recent United Nations study reveals that weather-related disasters increased 14 percent from 1995 to 2004, with floods representing a significant portion of those disasters. Between 1995 and 2015, floods accounted for 47 percent of all weather-related disasters and 43 percent of all natural disasters combined.

> By 2030, river floods could affect 2 million more people, with climate change driving 70 percent of that increase.

Climate change projections suggest that the frequency and severity of floods will increase in years to come as temperatures rise. Warm air holds more moisture and increases precipitation, leading to more floods. According to the Potsdam Institute for Climate Impact Research (PIK), the US, parts of India and Africa, Indonesia, and Central Europe are at the greatest risk of severe floods over the next two to three decades.

Although a worldwide issue, according to World Resources Institute, nearly 80 percent of the total population affected by floods each year live in just 15 countries—all considered least developed or developing. In Pakistan alone, 715,000 people are at risk today. By 2030, river floods could affect 2 million more people, with climate

change driving 70 percent of that increase. As flooding increases, forecasting precipitation and rainfall run-off will be critical. However, developing countries often lack the data, tools, and experience to implement flood prediction systems.

Improving methods for flood prediction

Launched in 2011, the Global Flood Awareness System (GloFAS) helps developing countries predict floods up to two weeks in advance. Jointly developed by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF), GloFAS couples state-of-the-art weather forecasts with a hydrological model. With its continental-scale setup, the system provides downstream countries with information on upstream river conditions as well as continental and global overviews.

However, the GloFAS analysis is run on areas greater than 10,000 square kilometers, which limits forecasting to only major rivers—excluding medium-sized and smaller streams. These streams are of great importance for flood preparedness and other localized water needs, such as early warning systems, land-use planning, and agriculture. This is particularly true in developing parts of the world where little, if any, observational or modeled data exists.

High-resolution flood forecasting in the cloud

Michael Souffront, a software engineer at Aquaveo, developed a methodology to produce a higher-density version of the GloFAS model. The model, GloFAS-RAPID, can produce streamflow forecasts from watersheds at a scale as small as a few kilometers. This downscaling process enables forecast prediction for not just major rivers, but also critical medium-sized and smaller streams—helping advance flood preparedness, especially in developing countries.

> Processing data for one region of the world was reduced from 4 hours to just 20 minutes, enabling a truly global streamflow prediction.

However, the GloFAS-RAPID computation is an arduous and time-consuming process that needs to be run daily and can take hours to complete. Additionally, hosting the web portal to communicate results requires a costly server to be always running. On-premises compute resources are another challenge. They are prone to downtime, forcing Souffront to spend valuable time resetting the machine and hunting configuration bugs.

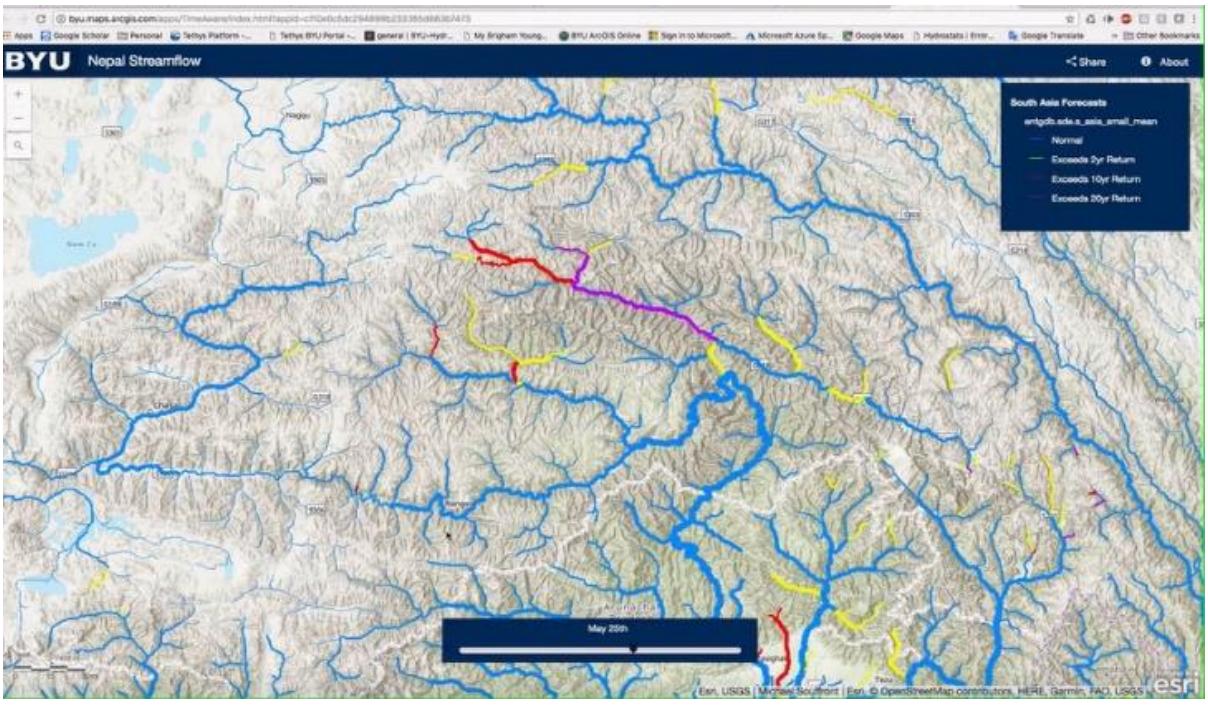
In 2017, while still a PhD candidate and research assistant at Brigham Young University (BYU), Souffront was awarded an AI for Earth grant to help advance the GloFAS-RAPID project with Microsoft cloud computing

resources and Esri ArcGIS, a geospatial mapping and analytics platform. Souffront moved the streamflow prediction workflow to Microsoft Azure, dramatically reducing the GloFAS-RAPID compute time. Before moving to Azure, it took four hours to process data for one region of the world. Now it takes just 20 minutes, allowing Souffront to add more regions—enabling a truly global streamflow prediction.

The flexibility of Azure allows Souffront to spin up the forecast generation server only when needed—just once a day—dramatically reducing costs. Additionally, Azure provides increased reliability and easier systems management, freeing up Souffront to focus on science instead of administration.

Communicating flood risk with cutting-edge visualizations

Improving how GloFAS-RAPID forecasts are shared with governments, agencies, and other researchers was a major part of Souffront's work. Using ArcGIS Enterprise on Azure, Souffront developed the Streamflow Prediction Tool—a web-based application for visualizing the GloFAS-RAPID forecasts. Originally developed by Esri for the US national water model, visualizations show animated flood warnings on individual streams over time—providing a level of detail not previously available. These state-of-the-art visualizations will help forecasters more easily monitor flood conditions in thousands of headwater streams, such as shown in the following picture of South Asia.



An animated food warning visualization of Nepal from the Streamflow Prediction Tool.

Souffront is also planning a corresponding API service to help other scientists, developers, and research teams develop derivative products such as flood mapping, impact assessments, and flood/drought early warning systems. The tool will allow forecasts to be downloaded for use in existing systems and models—such as climate resilience plans and food security models.

About Michael Souffront

Michael Souffront is a software engineer at Aquaveo, a pioneer of GIS-based software solutions for hydraulic, hydrologic, and groundwater modeling. Formerly a graduate research assistant at Brigham Young University (BYU) specializing in large-scale hydrologic modeling, hydro-informatics, and water data management and visualization, Souffront earned his doctorate in Civil Engineering at BYU in December 2018. Souffront's work at Aquaveo includes maintaining the more efficient and granular global streamflow forecasting service he developed for his dissertation at BYU.

Resources

Websites

GloFAS home site
AI for Earth

Documentation

Richard Davies. "UN – 1995 to 2015, Flood Disasters Affected 2.3 Billion and Killed 157,000". FloodList. January 11, 2016.

Potsdam Institute for Climate Impact Research (PIK). "Adaptation now: River flood risks increase around the globe under future warming." ScienceDaily. 10 January 2018.

Tianyi Luo, Andrew Maddocks, Charles Iceland, Philip Ward, Hessel Winsemius. "World's 15 Countries with the Most People Exposed to River Floods". *Insights*. World Resources Institute. March 5, 2015.