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How much do we really know about river flooding?

Authors:
Mark Trigg, Cathryn Birch, Jeffrey Neal, Paul Bates, Andrew Smith, Chris Sampson, Dai Yamazaki, Yukiko Hirabayashi, Florian Pappenberger, Emanuel Dutra, Philip Ward, Hessel Winsemius, Peter Salamon, Francesco Dottori, Roberto Rudari, Melanie Kappes, Alanna Simpson, Giorgis Hadzilacos and Timothy Fewtrell
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Jenny Griffin

Abstract

Have you ever experienced rain where it rained so hard or for so long that you feared you may soon be up to your eyeballs in water? Sadly, many people in the world have witnessed this firsthand, and this is likely to increase due to climate change unless we do something to prepare for flooding disasters. Some areas are more prone to floods than others, and the people living there are more at risk.

Scientists have developed computer models in an effort to map flood prone areas. Decision makers use the results from those computer models to plan for future flooding events to limit destruction and save lives. But are they accurate enough considering human lives may depend on them? To answer this question we compared the results from six computer models which simulate flood risk in Africa. The models agreed in less than 40% of the cases about where exactly it would flood and how much damage there might be.

Introduction

Flooding is one of the most destructive natural disasters, responsible for huge economic losses and many deaths. (Fig. 1) The risk and impact of flooding is likely to increase due to climate change and a growing human population, putting more people at risk. We need to know what the flood hazard is for an area or region so that we can reduce this risk. Some ways we can do that are: avoiding building houses in flood areas, building protection around areas already at risk, and managing the rivers to minimize flooding.

Currently, river flood risk for many regions of the world has not yet been mapped. In some regions where it has, the information is inconsistent and unreliable. This makes planning for flooding and reducing the impact of floods difficult. Some countries have not collected any information about areas where floods are most likely and would be most damaging. In such cases, a flood model covering the entire continent may be useful in estimating the local risk.

Scientists use computer models to simulate which areas are most likely to flood. A river flood model can estimate the expected river flow. It can also simulate the flow of water in river channels and over floodplains. These models can now provide decision makers with critical information to assist them with planning. This will help them to prepare for flooding and to take action to reduce the impact of floods on an area and the people living there.

Few of these global models, however, have been properly tested to determine their accuracy. We decided to compare some of these models and find out their strengths and weaknesses.

Figure 1:
A truck washed away by flash floods in Morocco in 2014. (Photo: BBC/AFP)

Methods

We compared the results from six global scientific models for flood risk in Africa. It is one of the continents with the least amount of flood hazard information. Our results can help us understand how flooding could potentially impact the lives and livelihoods of people living on that continent.

There are two main types of global flood models: one based on climate model data, the other based on river gauge readings. We tested both types of models.

We compared flood maps across the entire African continent. We accounted for floods of varying rarity and intensity (less common events have a higher intensity). We estimated river flow for each of them and simulated the extent of flooding when a river overflows.

There are three types of flooding:

1. Fluvial - when a river overflows its banks. It happens when the river flow exceeds the amount of water the river channel can hold and the remainder goes onto the surrounding floodplain. (Fig. 1)

2. Pluvial - when water accumulates on a surface due to heavy rainfall and causes flooding that might have nothing to do with a river channel.

3. Coastal surge - flooding caused by seawater that is driven over the highwater mark as a result of storms. It is also known as a storm surge.

Our research focused on fluvial flooding. We studied what would happen when a river bursts its banks.

We mapped the information using computer mapping technology called GIS. We then overlapped the maps of flooded areas with maps of population distribution and economic data to determine the risk to human populations and loss of income. Then, using statistical analysis, we set about assessing how much the models agreed or disagreed with each other. In essence, for each model, we calculated how many other models agreed with the flooded areas simulated by it.

Results

The results show that there are many areas where the models agree. These tend to be mostly areas alongside large rivers that have distinct floodplain boundaries. That is, rivers that lie in a valley with high areas on either side.

We then compared the models on a continent-wide scale, instead of country-by-country. We found a lot of disagreement between the six models about which areas are most at risk of flooding. (Fig. 2) When we used them to map flooding across a whole continent, we observed less than 40% agreement between the models that we compared.

Please see page 3, Figure 2

Discussion

Even though the models agree in the extent of flood risk in some areas, in most areas they don't. They also produced different results about where the flooding is likely to occur. This prevents us from accurately determining which human populations will be most exposed to the risk. It also makes it difficult to figure out which economic sectors, that contribute to a country's economy, could be adversely affected. Therefore, decision-makers need to take this into account and use the models with caution.

Another key aim of our work was figuring out a way to improve the models. The first step is knowing where they disagree. This is not a sign of failure but a normal part of the scientific process, as it shows us where to focus our efforts to improve the models.

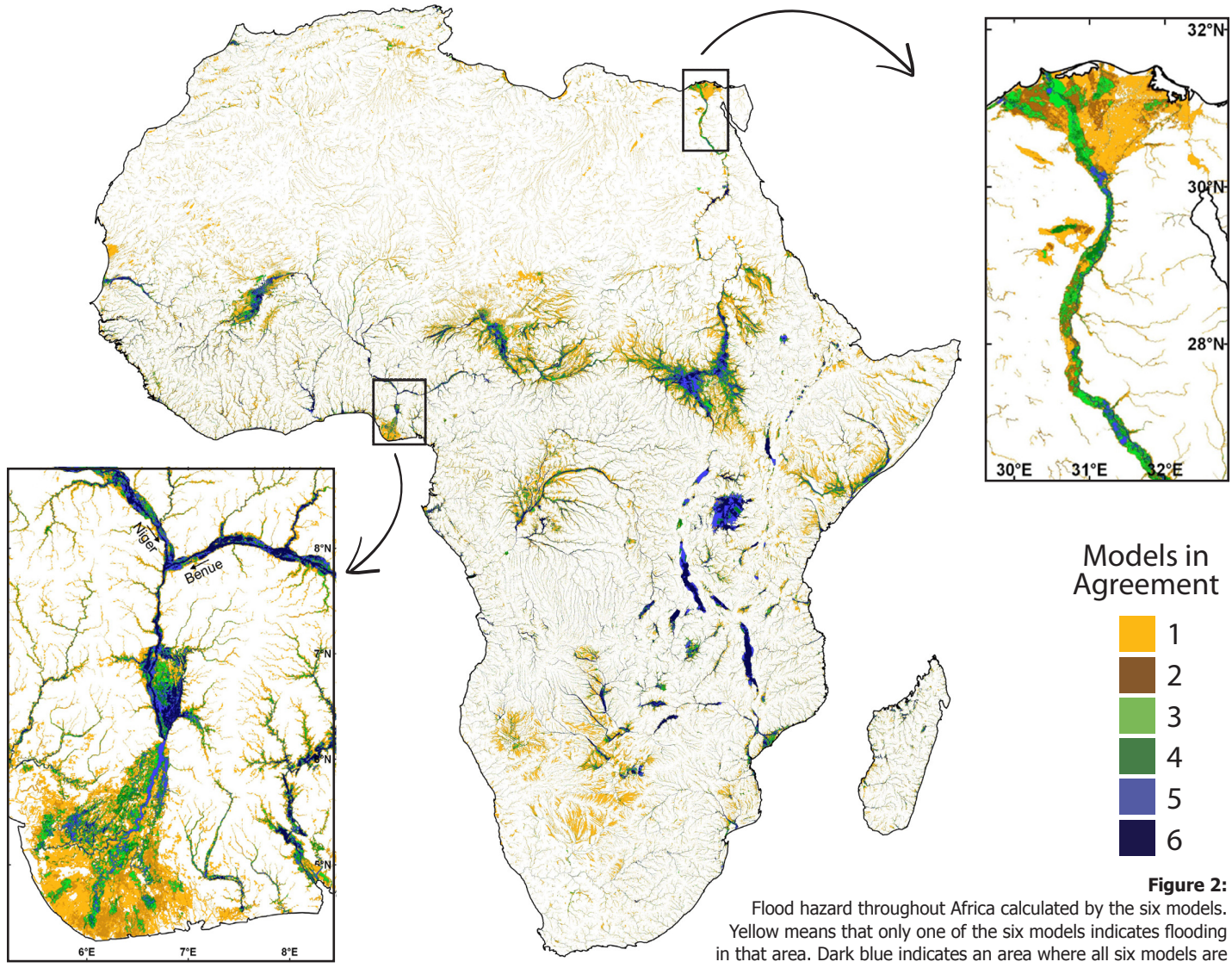

Figure 2:
Flood hazard throughout Africa calculated by the six models. Yellow means that only one of the six models indicates flooding in that area. Dark blue indicates an area where all six models are in agreement. What do you notice about Nile's delta?

Conclusion

Computer models are tools that can help us make important decisions. But, as we can see from this study, we must be careful when using them to choose the right tool for the job.

Being prepared for flooding can mean the difference between life and death. Simple things like having an emergency kit and emergency telephone numbers handy, knowing where to go in an emergency and what evacuation route to take, can save you in the event of flooding or any other natural disaster.

Glossary of Key Terms

Scientific Model (aka a computer simulation) – A computer program that attempts to simulate a particular system and to predict how the system would behave in the real world.

Floodplain – An area of land adjacent to a river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high flow discharge.

Coastal flooding (Surge Flood)– A coastal flood occurs in areas that lie on the coast of a sea, ocean, or other large body of open water. It is typically the result of extreme tidal conditions caused by severe weather. Storm surge — produced when high winds from hurricanes and other storms push water onshore — is the leading cause of coastal flooding and often the greatest threat associated with a tropical storm. In this type of flood, water overwhelms low-lying land and often causes devastating loss of life and property.

Decision maker – Typically (but not limited to) government or municipal officials that are tasked with making decisions in the best interest of the general population and the environment.

Fluvial flooding (River Flood) – Fluvial, or riverine flooding, occurs when excessive rainfall over an extended period of time causes a river to exceed its capacity. It can also be caused by heavy snow melt and ice jams. The damage from a river flood can be widespread, often causing dams and dikes to break and swamp nearby areas.

GIS mapping technology – GIS is short for geographic information system — a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographical data, typically as digitized overlay maps.

Gross Domestic Product (GDP) – is the monetary value of all the finished goods and services produced within a country's borders in a specific time period.

Pluvial flooding (Surface Flood) – A pluvial, or surface water flood, is caused when heavy rainfall creates a flood event independent of an overflowing water body. One of the most common misconceptions about flood risk is that one must be located near a body of water to be at risk. Pluvial flooding debunks that myth, as it can happen in any urban area — even higher elevation areas that lie above coastal and river floodplains.

Check your understanding

1. Why is it important to understand the flood risk of a given area?

2. How accurate are global river flood risk maps at the moment?

3. River floods are discussed in this paper. Can you think of any other types (causes) of floods?

4. What can you personally do to limit your flood risk?

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