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FLOOD FORECAST SKILL FOR EARLY ACTION: RESULTS AND LEARNINGS FROM THE DEVELOPMENT OF THE EARLY-ACTION PROTOCOL FOR FLOODS IN UGANDA

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CONTEXT AND OBJECTIVES

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- **Forecast-based Financing (FbF)**: using forecasts of natural hazards to initiate humanitarian preparedness actions → Anticipation is key (see https://www.forecast-based-financing.org/)

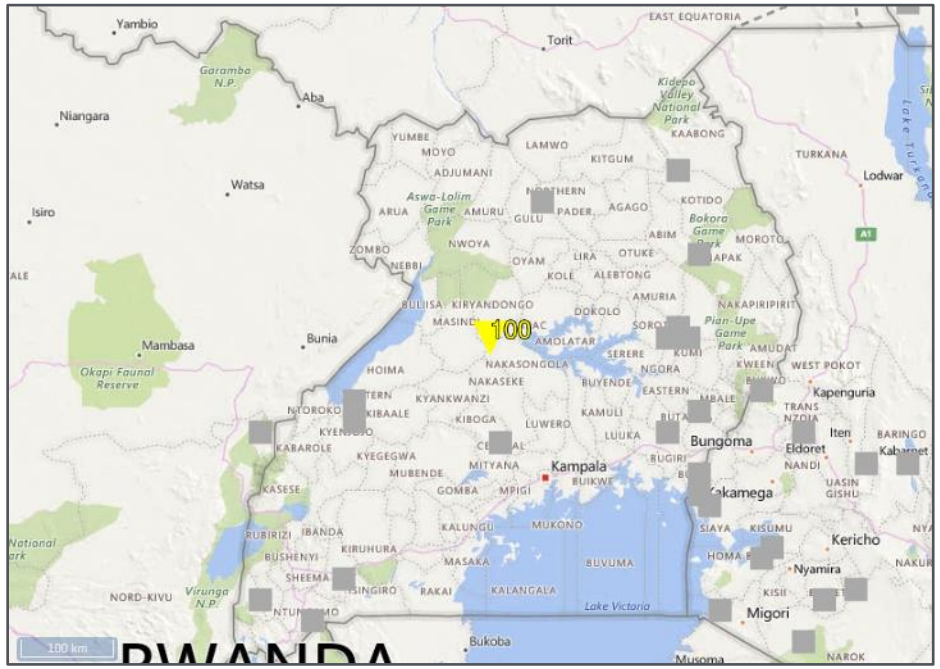
- An **Early Action Protocol (EAP)** describes the forecasts to be monitored, the risk analysis, the triggers and the related early actions as well as responsibilities of the different stakeholders
- The Uganda Red Cross Society (URCS) developed the **EAP for floods** (2020-ongoing), with support from the Uganda Ministry of Water and Environment - National Water Authority (DWRM), Uganda National Meteorological Authority (UNMA), 510Global, the Red Cross Climate Centre (RCCC) and the FATHUM's team at the University of Reading

- **Objective of the EAP**: plan cost-effective, targeted and timely flood-preparedness actions to help the most vulnerable communities in Uganda, based on risk analysis and forecast skill information
- **Objective of the forecast skill analysis**: support the development of the '*trigger statement*' of the EAP, providing information on skilful locations, and skilful lead times

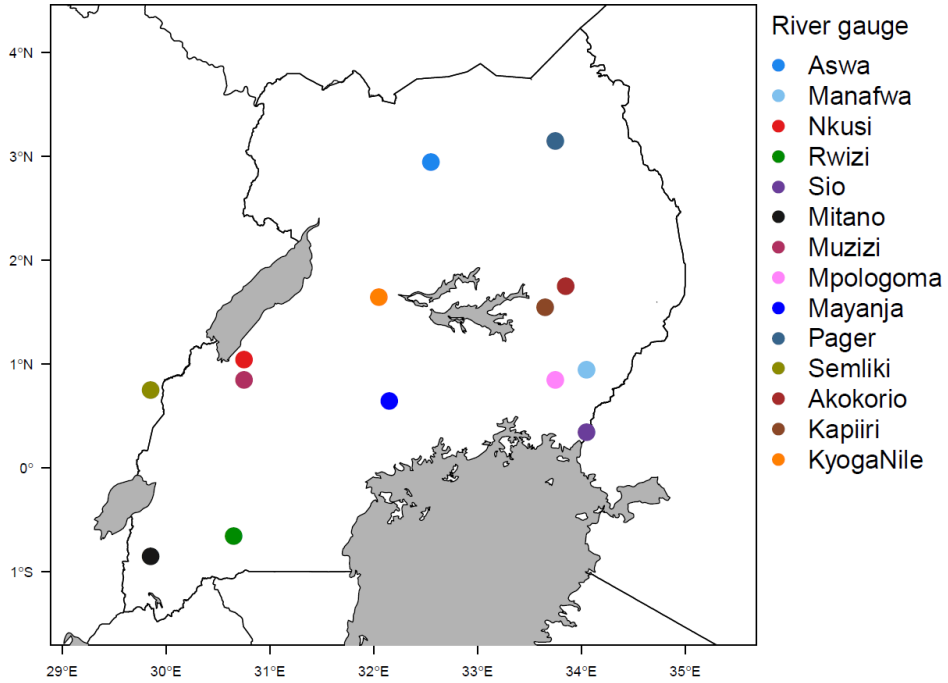
- Two main research questions from the forecast perspective:
  - **How far in advance floods can be forecast** with acceptable skill for FbF?
  - **How can we define triggers** (operational thresholds) for early action?

CASE STUDY: UGANDA

- **Current gap**: limited existing capacity for flood forecasting in Uganda
- Global forecasting models can support national agencies in filling this gap, while developing local models
- Flood forecasts from the **Global Flood Awareness System** (**GloFAS**, a Copernicus EMS service) are being used by URCS, alongside in-country knowledge to develop appropriate triggers
- GloFAS was used for an initial FbF pilot in Kapelebyong sub-county in 2015; now FbF is being scaled up
- Hydrological modelling challenges: small catchments, wetlands and lakes (natural and regulated)



www.globalfloods.eu

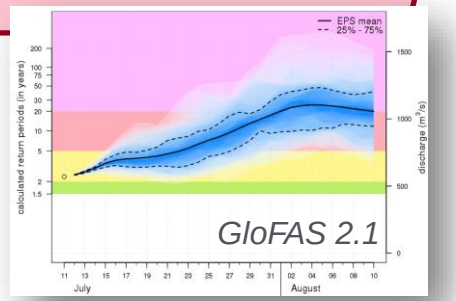


Sample of operational river gauges with available data (DWRM)

Methods: Flood Forecast Skill and Trigger Analysis

GloFAS Reforecast

- **Ensemble members**
- Once an **event** is defined → **probability**



Trigger Probability & Flood Threshold

- Probability of exceeding a threshold → **Trigger level**, e.g. 60% ==> 6 of 10 members above threshold

Yes/No Forecast Flood

If yes, trigger early action

River flow / water level observations

- **River gauge data**
- Data quantity & quality checks

Obs. flood threshold

- **Impacts** (high threshold, e.g. 5-yr RP)
- **Statistical analysis** (lower threshold for sample size, e.g. 90th percentile)

Yes/No Observed Flood

Exceedance of observed flood threshold

Action lifetime (AL): time period over which an action has benefits (*Coughlan de Perez et al. 2016*)
→ For URCS, AL=30 days
→ Hit / False Alarm definition

Skill Scores of interest
False Alarm Ratio (FAR)
Probability of Detection (POD)

Analysis of skill sensitivity to lead time & trigger probability

Trigger frequency analysis for selected trigger (flood threshold, forecast probability & lead time)

FORECAST SKILL & TRIGGER ANALYSIS RESULTS

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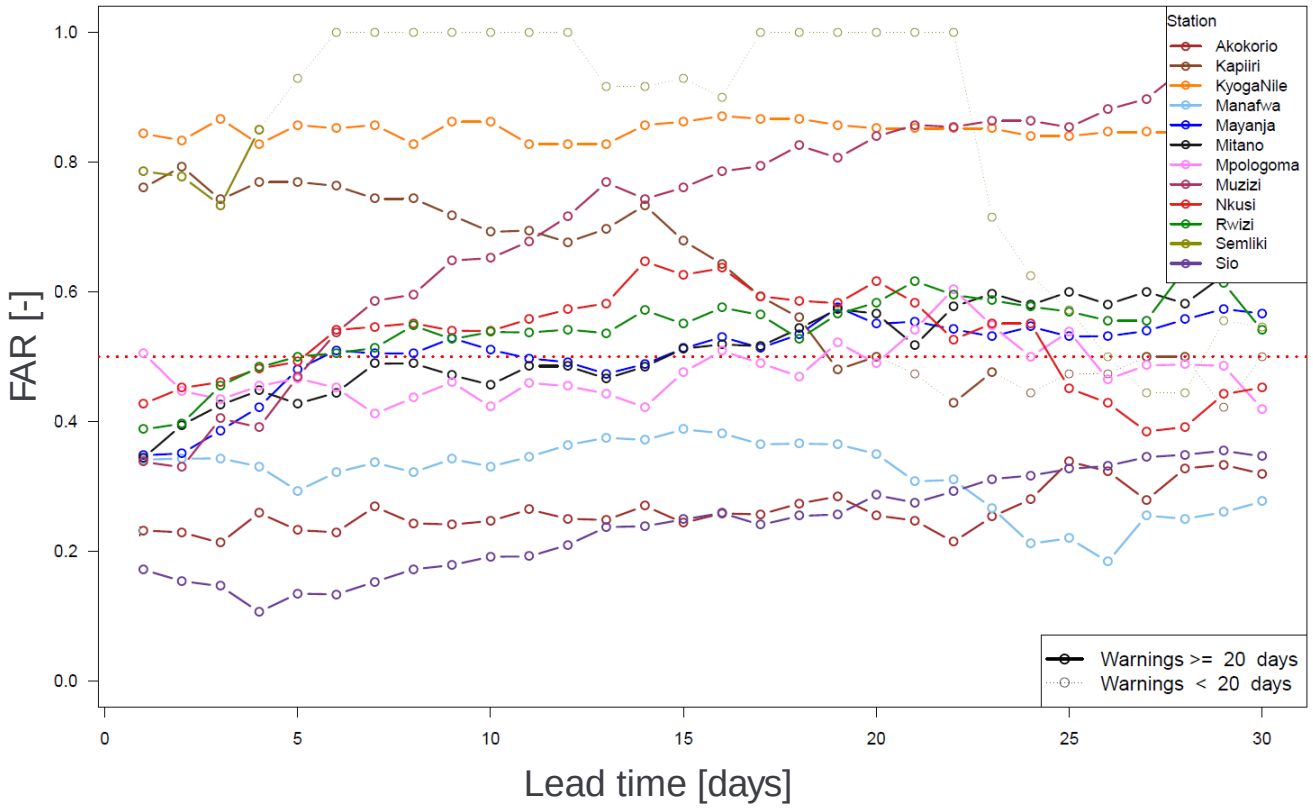
- **GloFAS v.2.1 reforecast data** (30-d lead-time; 1999-2019) for verification against river flow observations
- 5-day lead time or longer identified as needed for anticipatory action in Uganda
- Use of **lead-time dependent thresholds** calculated from the GloFAS reforecast climatology (*Zsoter et al. 2020*), which lead to higher forecast skill

False Alarm Ratio with lead-time for GloFAS v.2.1 vs. observations

Trigger probability: 60%; Lead-time dependent thresholds: 90th percentile *



- Maximum skillful lead time depends on the location
- Only a part of the rivers show ‘acceptable’ skill (FAR<0.5) at the lead times required for action
- 8 skillful stations at 5-d lead time, less at longer
- Low sensitivity of results to trigger probability (due to low ensemble spread)
- Trigger probability of 60% and 5-day lead time chosen by URCS, based on the skill analysis and early action needs

** all threshold exceedance events were kept in this analysis (no filter on dependent events) and a 90th percentile threshold was used to have a sufficient sample size*

TRIGGER FREQUENCY RESULTS & FURTHER WORK

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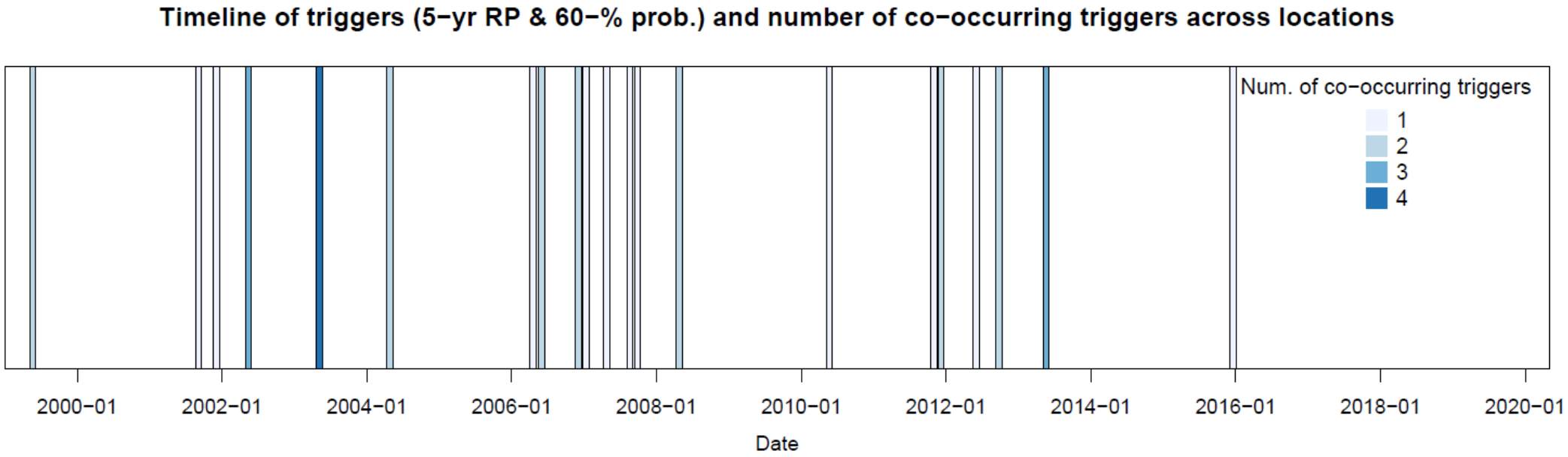
- Based on the GloFAS reforecast data (1999-2019) and the trigger selected (60% probability, 5-day lead time, 5-yr Return Period Flood), we can estimate the trigger frequency across the skilful locations
- The trigger frequency of the EAP cannot be too high at national level (e.g. < 1 in 3 years, limited resources)



- Adjustments of the triggers selected so far are needed to keep the trigger frequency lower (ongoing work)
- The trigger levels can be location-dependent and based on the risk profile at each location
- Further work needs to evaluate any possible change in forecast skill and trigger frequency with the updated GloFAS version (3.1) that will be released as operational soon

KEY MESSAGES AND LEARNINGS

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Methodology and tools

- The **forecast verification workflow** for trigger development can be applied to other Countries using either global or local hydrological forecasts, based on forecast availability and context
- A **team discussion** on the identification of appropriate triggers and on the action parameters is needed
- The **design of the analysis** must involve humanitarians and relevant local actors, from the very start
- Flood forecast analysis for EAPs and FbF development can be supported by **open-source informatic packages**, as our R package in preparation (available soon on GitHub, please contact us for more info), with ready-to-use and customisable functions

General learning

- Global flood forecasts can provide an **interim solution** for countries with limited local forecasting capabilities
- **Partnerships** can **benefit local agencies** by developing skills in forecasting, **& global forecasting centres** by providing local data and knowledge to conduct well informed, locally relevant forecast skill analysis
- Any analysis with global models needs to be **co-produced** with local partners and mandated agencies to be usable and **useful at the local level**, considering all constraints and the relevant context

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- Coughlan de Perez et al. (2016). “Action-based flood forecasting for triggering humanitarian action”, HESS, 20, 3549–3560. doi:10.5194/hess-20-3549-2016
- Zsoter et al. (2016). “Using ensemble reforecasts to generate flood thresholds for improved global flood forecasting”, Journal of Flood Risk Management, https://doi.org/10.1111/jfr3.12658

Flood Forecast Skill for Early Action: Results and Learnings from the Development of the Early-Action Protocol for Floods in Uganda

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Motivation and Objectives

- An **Early Action Protocol (EAP)** describes the forecasts to be monitored, the risk analysis, the triggers, early actions and responsibilities, under the **Forecast-based Financing (FbF) initiative**
- The **Uganda Red Cross Society (URCS)** developed the EAP for Floods with support from several partners, including the Uganda Ministry of Water and Environment (DWRM), 510Global, the Red Cross Climate Centre, and the University of Reading
- **Objective of the EAP**: plan cost-effective, targeted and timely flood-preparedness actions to help the most vulnerable communities in Uganda, based on risk analysis and forecast skill
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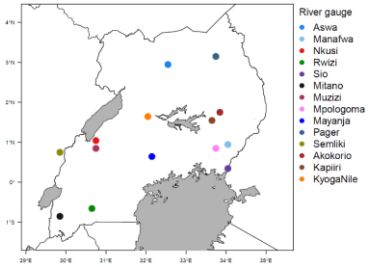
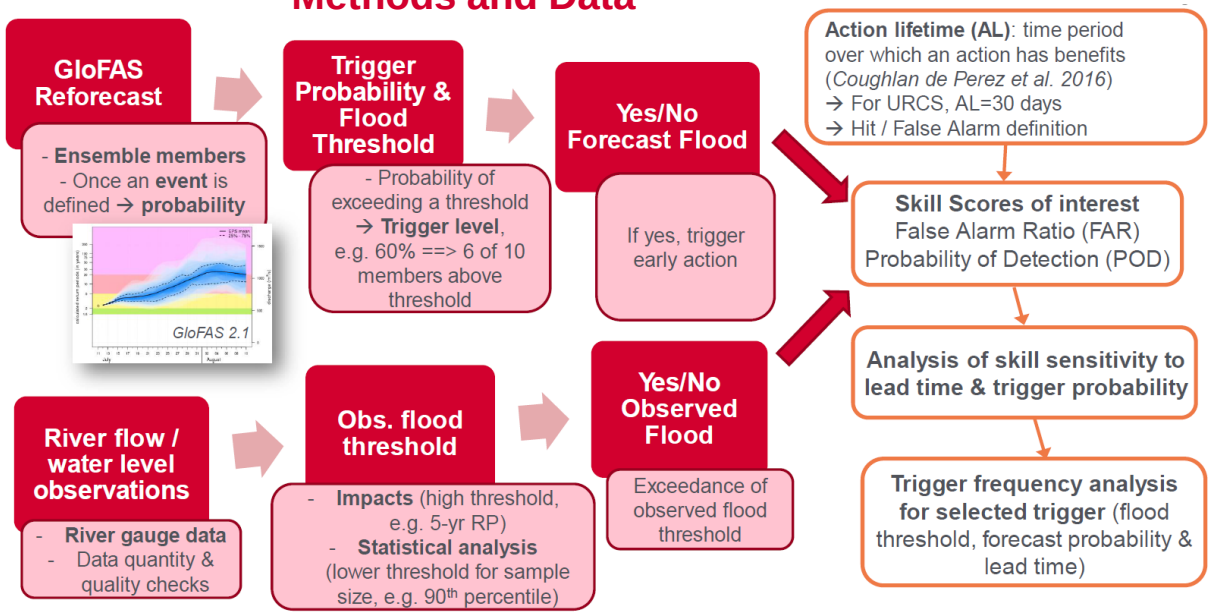


Set of 14 operational river gauges, Uganda (DWRM)

GLOFAS Global Flood Awareness System

www.globalfloods.eu

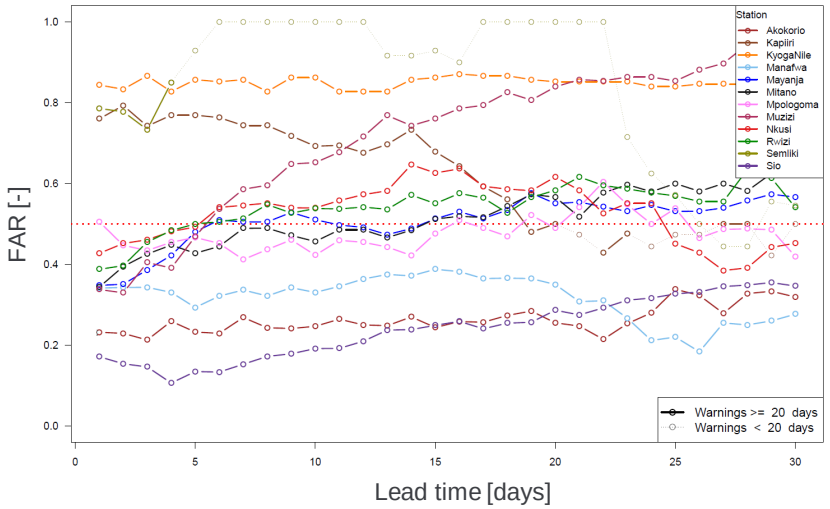
Methods and Data



Results

False Alarm Ratio (FAR) with lead-time for GloFAS v.2.1 vs. observations

Trigger probability: 60%; Lead-time dependent thresholds: 90th perc.



- 'Acceptable' skill: FAR<0.5
- 8 skilful stations at 5-d lead time
- Low sensitivity to trigger probability
- Trigger probability of 60% and 5-day lead time chosen by URCS

Key learnings

- **Global forecasts** can provide an **interim solution** for Countries with gaps in local forecasts
- The **design of the analysis** must involve humanitarians and all relevant local actors
- **Forecast skill and trigger analysis for EAPs** and FbF should be supported by **open-source informatic packages**, such as our R package in preparation

Further Work

- Local adjustments of the triggers are needed to **keep the trigger frequency acceptable**
- Changes in forecast skill are possible with the updated GloFAS version (3.1) released soon
- The verification **workflow for trigger development** is being **applied to other Countries**, e.g. in Bangladesh with FFWC (see Abstract *EGU21-13746 by Hossain et al.*)

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