Adding value and user context: Local knowledge, perception, policy, and contemporary forecast information

Micha Werner

IHE Delft Institute for Water Education, Delft, Netherlands

Deltares, Delft, the Netherlands

public.wmo.int/en/events/workshops/flash-flood-guidance-system-ffgs-global-workshop

WORLD METEOROLOGICAL ORGANIZATION

Weather · Climate · Water

English

Flash Flood Guidance System (FFGS) Global Workshop

Contact:

Add to calendar

4 Start date **4 November 2019**

8 End date **8 November 2019**

Co-Sponsors:

U.S. Agency for International Development/Office of the U.S. Foreign Disaster Assistance (USAID/OFDA)

Location: **Antalya, Turkey**

While there are several types of floods, a **flash flood is the most dangerous.** They have enough power to change the course of rivers, bury houses in mud, and sweep away or destroy whatever is on their path. They are among the **world's deadliest disasters with more than 5,000 lives lost annually** and result in significant social, economic

Linking Local Knowledge to Larger Scale Meteorological Datasets to Support Flash Flood Warning in Northern Malawi

Agathe Bucherie
IHE Delft
(now at 510 - The Netherlands Red Cross)

Micha Werner	IHE-Delft
Marc Van Den Homberg	510 Red Cross
Aklilu Teklesadik	510 Red Cross

BACKGROUND

Weather related hazards: Flash floods are the most deadly

Climate intensification leading to more frequent flash flood events & inequality in impacts

Multiple root causes, Small temporal and spatial scale

Flash Flood Forecasting systems exist, but often based on sophisticated data & models.

Developing countries : lack of monitoring, data, and resources.

Malawi- AFP

Lamalou-les-bains- France 3

HUMANITARIAN VISION

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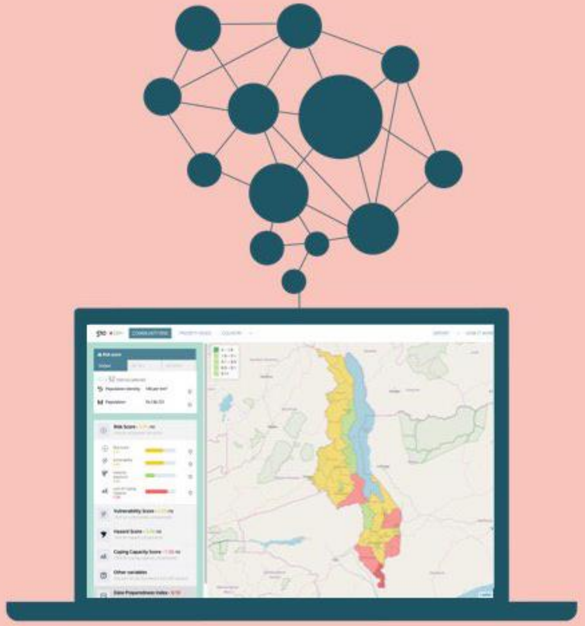
Climate Centre

DATA PREPAREDNESS & FORECAST-BASED FINANCING

UNDERSTANDING RISK

- DATA COLLECTION
- DEVELOP RISK MODELS
- PREDICT VULNERABLE AREAS
- COMMUNITY RISK ASSESSMENT



IDENTIFY DANGER

- HISTORICAL EVENTS DATA
- ANALYSIS & INSIGHTS
- IMPACT ON POPULATION
- IDENTIFY TRIGGER LEVELS

IMPACT FORECAST

- IDENTIFY VULNERABLE PEOPLE
- TRIGGER EARLY ACTION
- RELEASE FUNDS
- EXPEDITE FUNDS

OBJECTIVE

Bridging the gap between scientific and local knowledge

?

Use **local knowledge,**
together with **catchment characteristics,**
and **large scale hydro-meteorological conditions**,
to understand <u>spatio-temporal distribution</u> of flash flood
and help to <u>predict</u> their occurrence and impacts

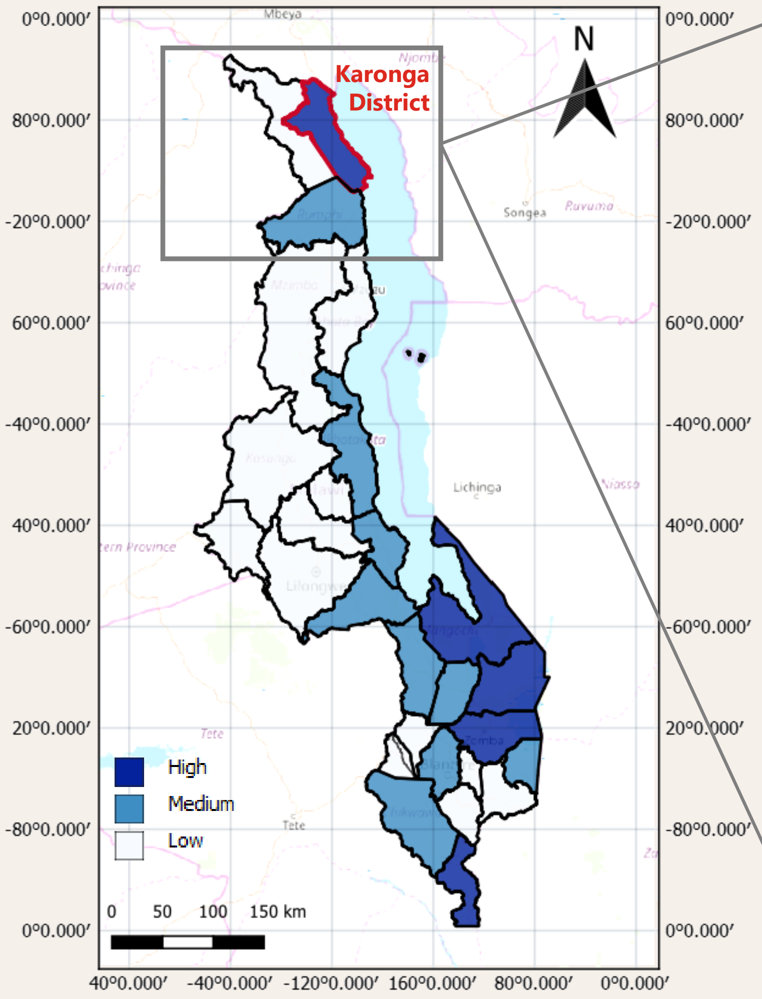
Understanding flash flood risk

Identify factors leading to flash flood

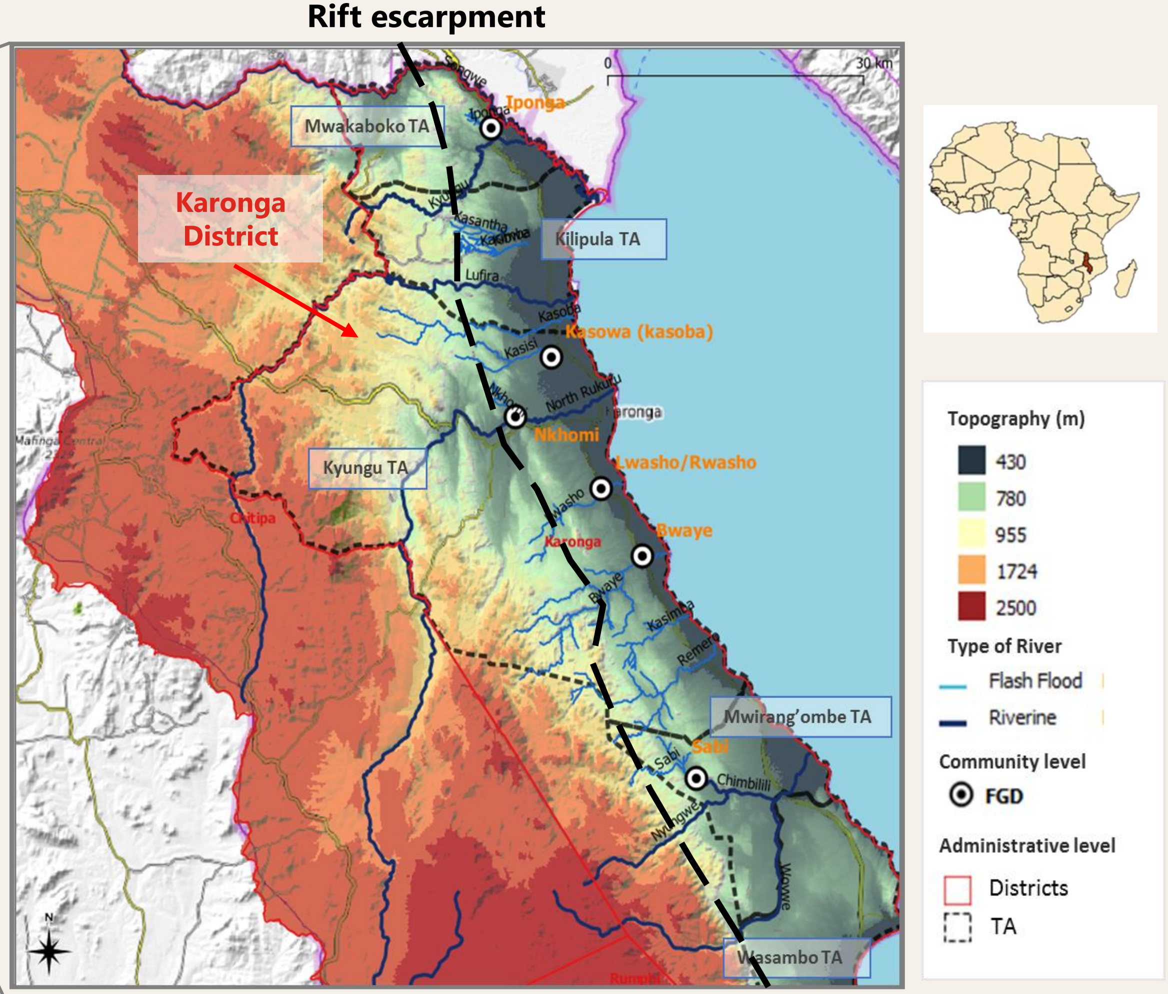
Predicting flash flood

Northern Malawi Case Study

NORTHERN MALAWI



Frequency of occurrence of floods
DoDMA (ICA 2015)



North Malawi Topography and Districts

UNDERSTANDING RISK : DATA COLLECTION

Objective

Understand the spatial and temporal occurrence of flash floods and their impacts, and how are flash floods experienced by local communities

Methods

Secondary data collection
Online databases (EMDAT…) , humanitarian reports, online media..

When
Where
Impacts

3 filters

District | TA | GVH

Flash flood occurrence and impacts

Primary data collection
Semi-structured interviews

GVH | District and National

6 FGD

4 KII

Local knowledge

Outputs

Database of flash flood occurrence and impacts

Thematic analysis
- Flash flood definition
- Root causes
- Signs prior to FF

Outcomes

Spatial and temporal analysis

Impact severity classes

FF list at GVH level

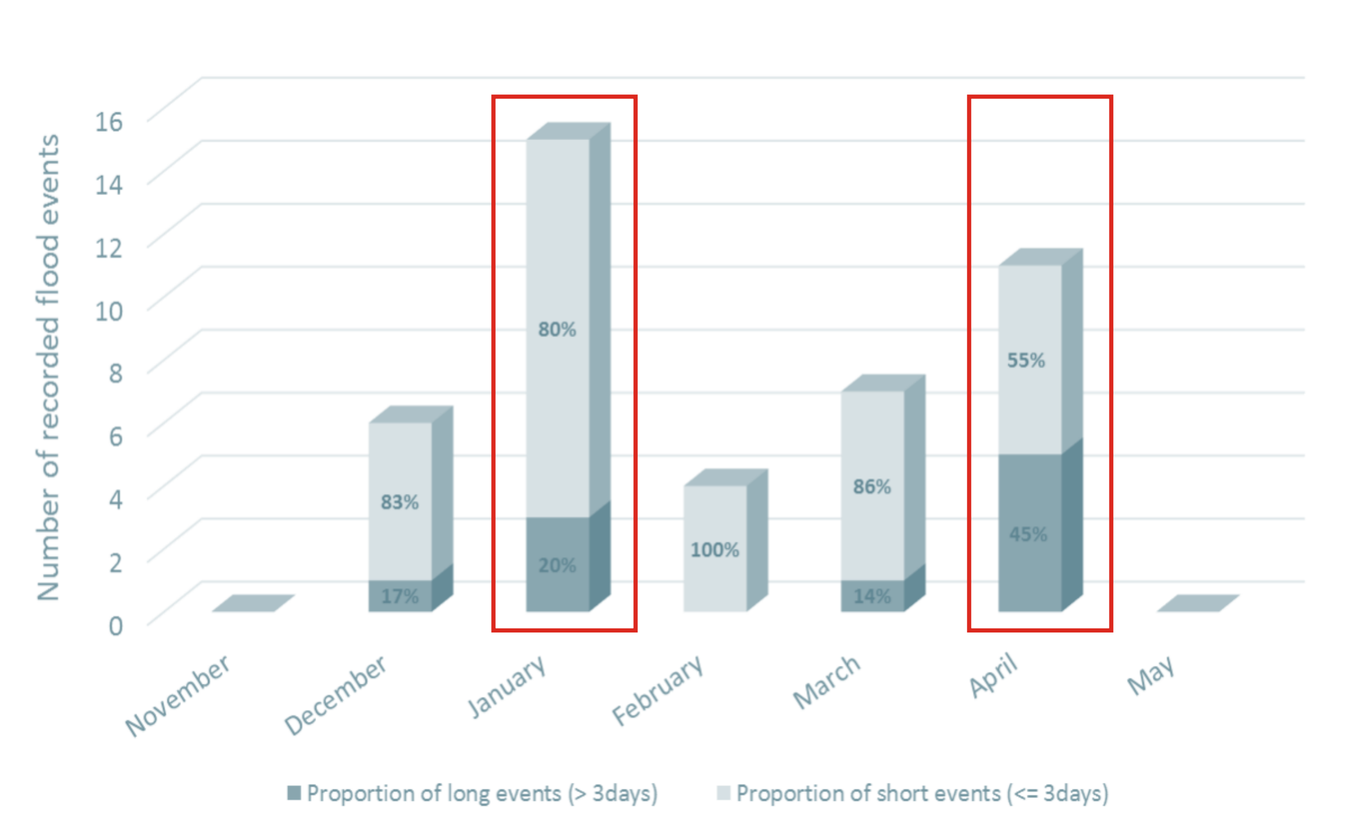
Community drawing

Transect walks

Focus Group Discussions

SPATIO-TEMPORAL FLOOD DISTRIBUTION

Flood occurrence and duration per month



Monthly flood events frequency based on 2000-2018 secondary data collection (43 recorded events), and associated proportion of short duration (<=3days) and long duration (>3days) recorded flood events.

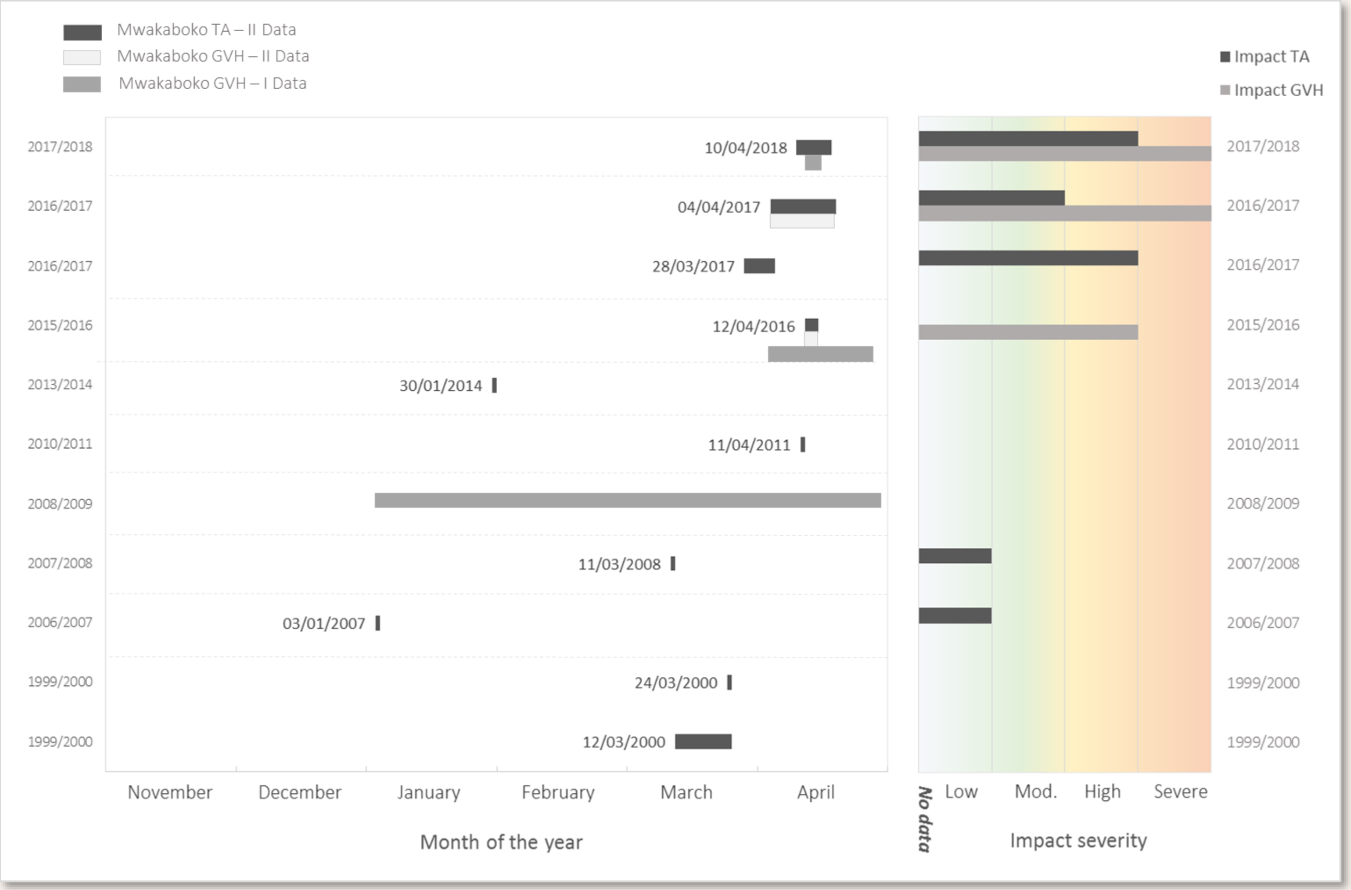
January
Smaller scale events in January.

Occurrence
Several times a year January/April

April
More events in the North than in the South

IMPACT OF FLOODS IN KARONGA

Timeline of flood occurrence and impacts



For each community

People: Number of fatalities, people injured, affected or displaced
Structural: Damaged Houses, collapsed houses, damaged toilets
Livelihood: Ha of crop damage & Livestock killed

→

Impact severity classes

Low	Green
Moderate	Orange
High	Yellow
Severe	Red

Community

1 event can affect up to 400 ha and damage 200 households

North-South

Higher damage in the North (higher population)

IDENTIFY FACTORS : DATA EXTRACTION

From local to scientific knowledge

Identify factors that lead to an increased flash flood hazard.

Local Knowledge

Root causes, aggravating factors

Meteorological signs prior to flash flood

Data extraction

DEM → Catchment delineation

STATIC
1. Geomorphology:
Surface and morphometric characteristics

DYNAMIC
2. Precipitation
3. Large scale Hydro-Meteorological data

Root causes :
River sedimentation and deforestation
Proximity to escarpment
Soil type

Meteorological signs :
Wind, cloud direction from South
Localized cloud buildup & thunder/lightning
Intense rainfall
Rise in temperature

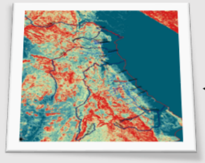
RELATIVE CATCHMENT SUSCEPTIBILITY TO FLASH FLOODS

PCA for each catchment characteristic category

DEM - 90m SRTM

Catchment selection and delineation

Gridded Level



Slope

MASDAP (Malawi government data) → Soil type, Land use

COPERNICUS Global Land Service → NDVI

Catchment Level

Catchment shapefile

Catchment geometry
- ✓ Contributing area
- ✓ Length to Width
- ✓ Elongation ratio
- ✓ Basin circularity

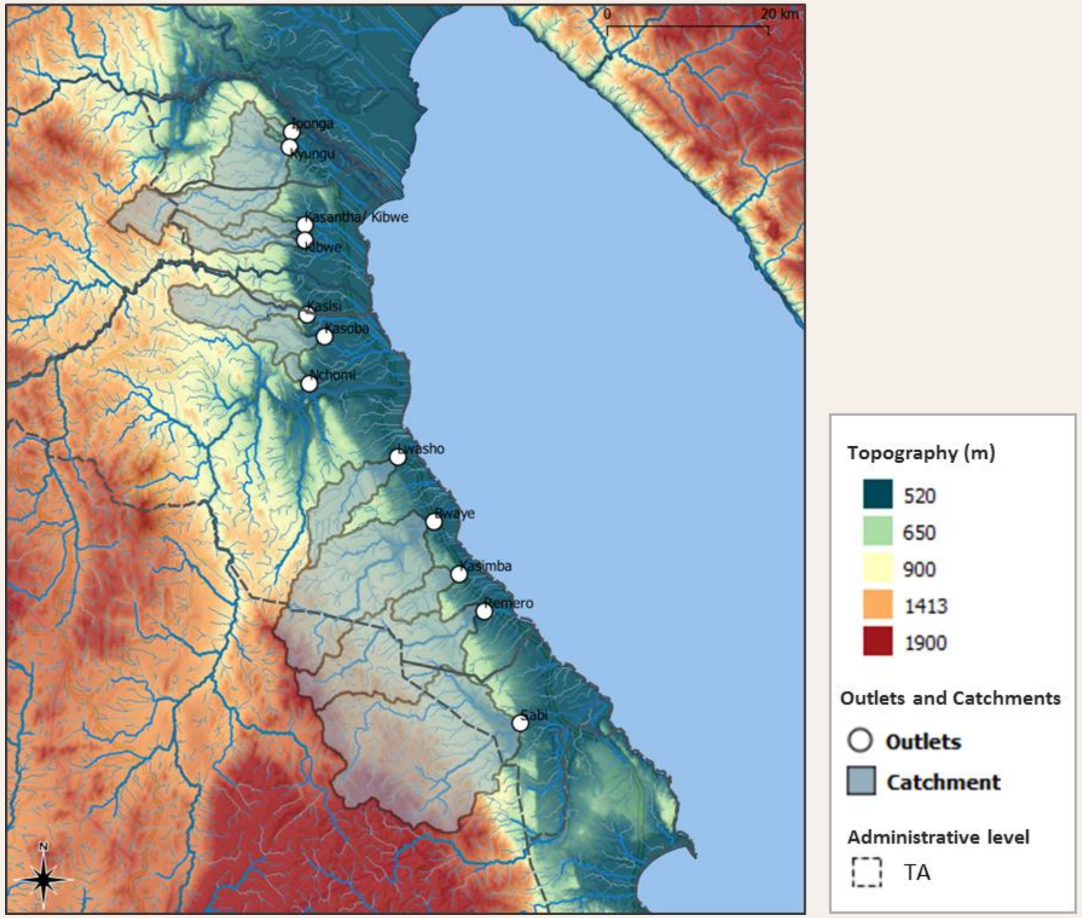
Catchment hypsometry
- ✓ Average slope
- ✓ Relative Relief
- ✓ Elevation Relief Ratio

Channel shapefile

Catchment drainage system
- ✓ Cum stream Length
- ✓ Drainage density and relief ratio
- ✓ Bifurcation ratio
- ✓ Basin Stream order

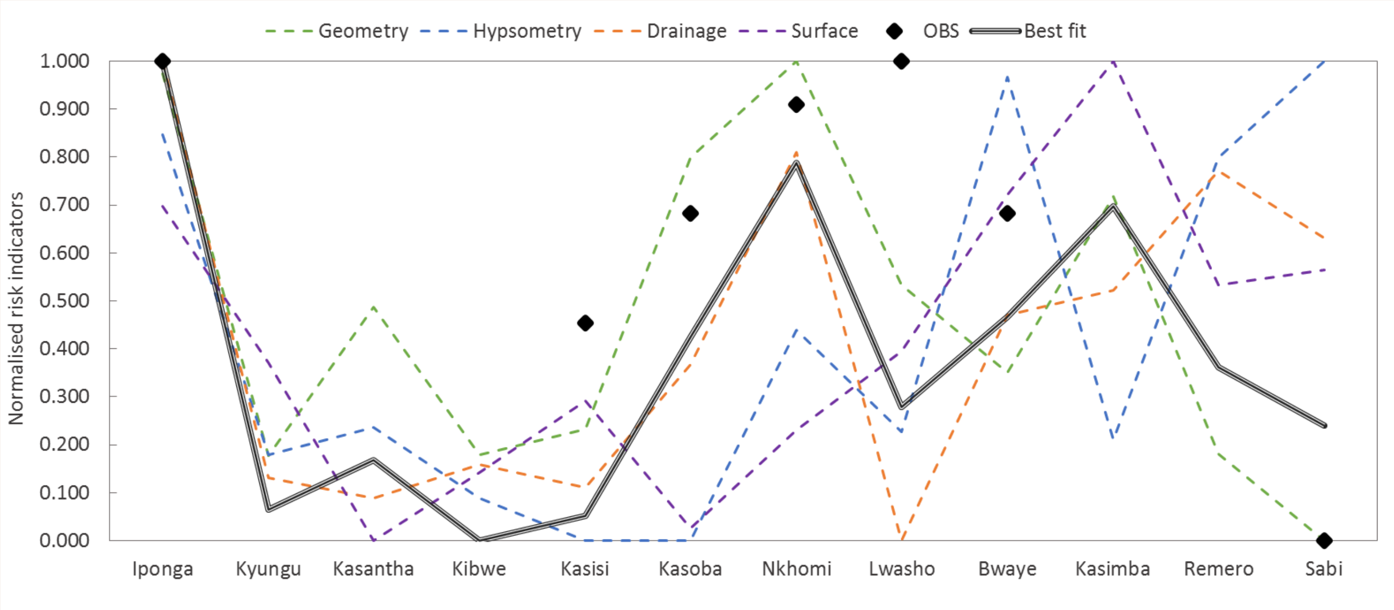
Catchment surface characteristics
- ✓ Average Soil type index
- ✓ Average Landuse-Landcover Index
- ✓ Average Greeness Index

Delineation of 12 catchments in Karonga District



RELATIVE CATCHMENT SUSCEPTIBILITY TO FLASH FLOODS

Comparison with local knowledge using flash flood frequency



Catchment surface characteristics

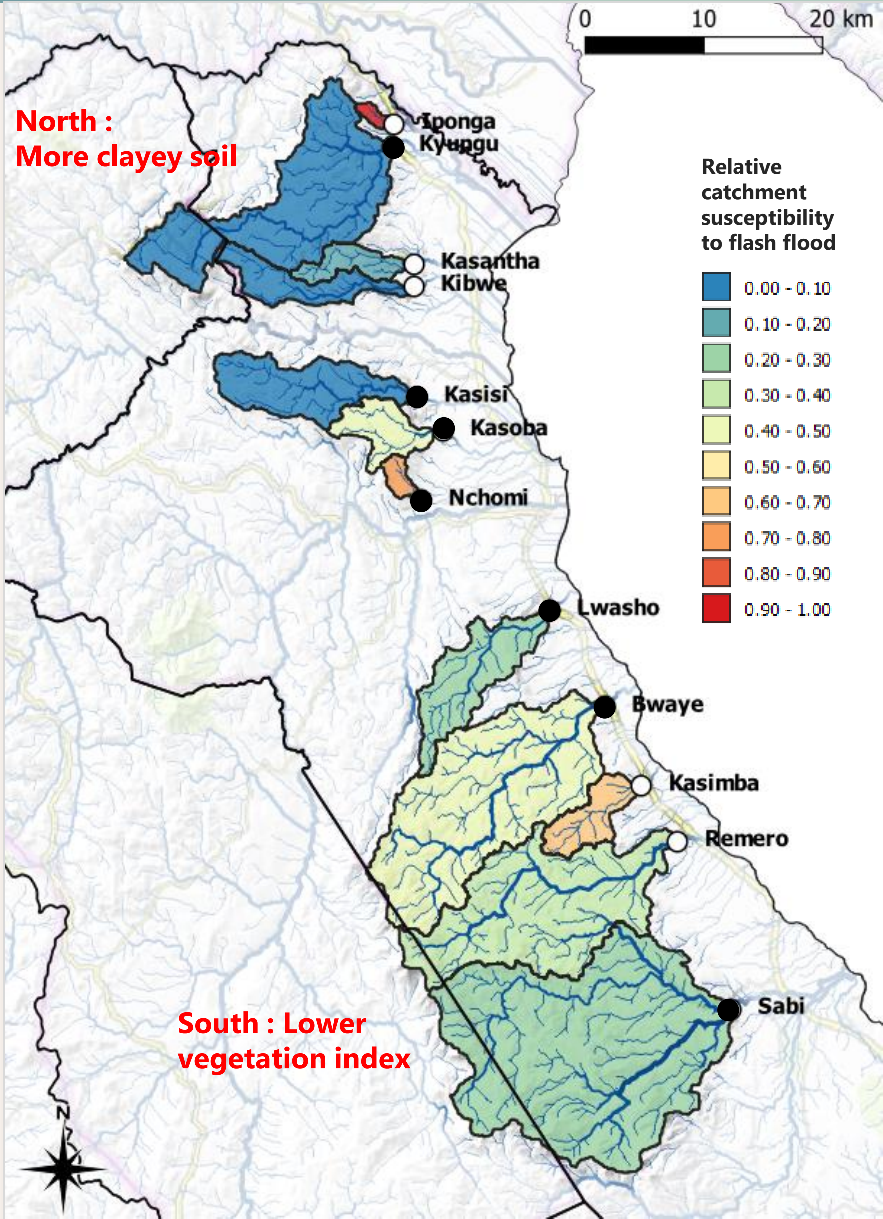
More clayey soil type in the North.

Bare vegetation in the South at the beginning of the wet season

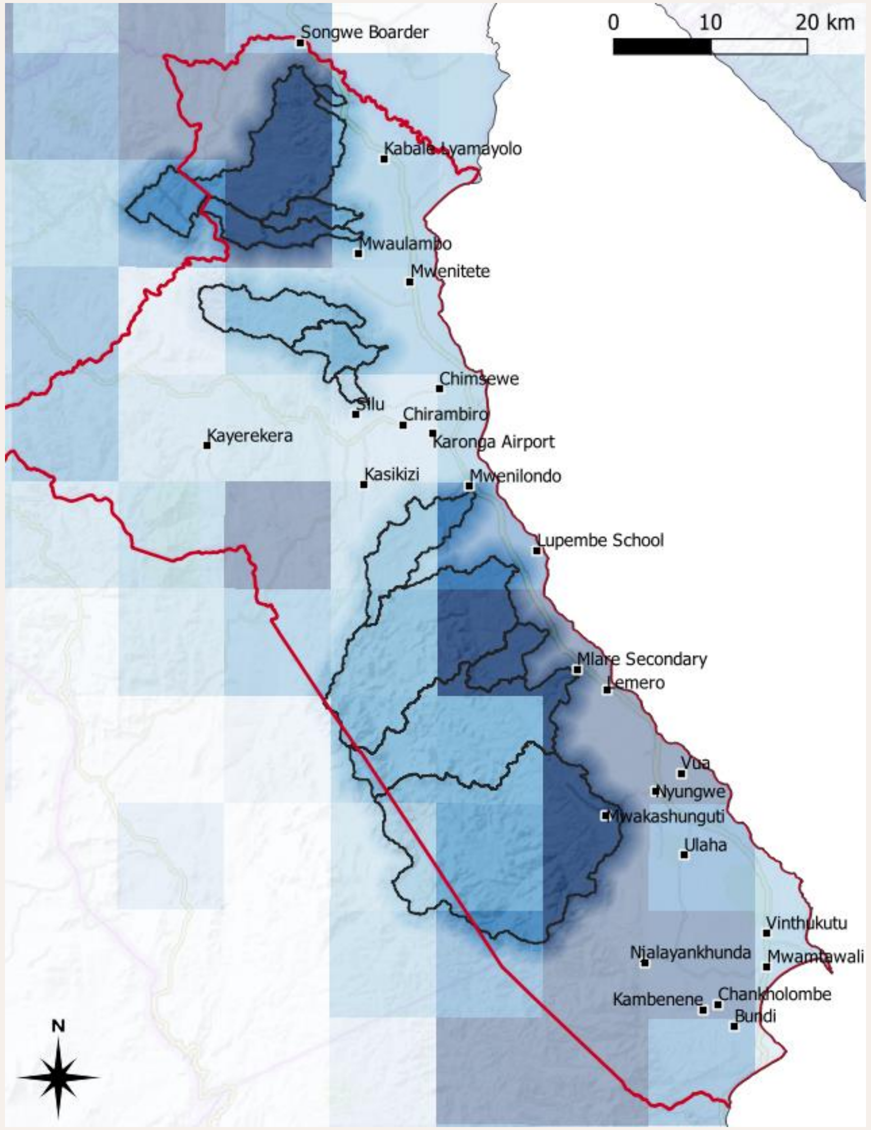
Catchment geometry

Smaller and more circular catchments have higher FF susceptibility.

Time of concentration: 40 minutes to 4 hours



HISTORICAL EXTREME RAINFALL ANALYSIS



Precipitation Dataset

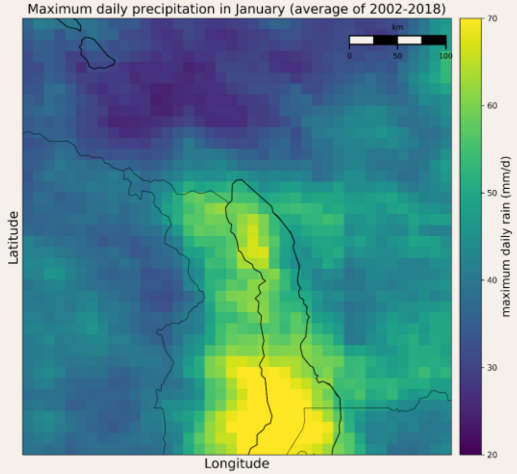
- raingauges
- GSMaP dataset
- Catchments
- Karonga District

GSMaP dataset (Global Satellite Mapping of Precipitation) : JST-CREST and the JAXA Precipitation Measuring Mission (PMM).

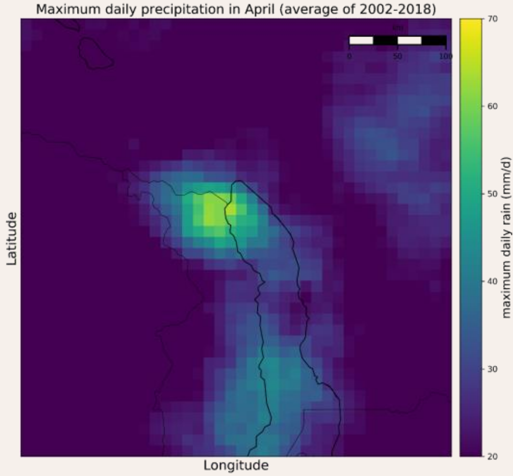
Hourly data

0.1º

January
Max daily rainfall



April
Max daily rainfall



January

More intense, frequent events in January

Smaller scale events

April

Mainly in the North

Larger scale longer duration

LARGE SCALE HYDRO-METEOROLOGICAL ANALYSIS

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ECMWF ERA5

Climate Reanalysis model : 2000-2018

Resolution : 0.25º, hourly

Local Knowledge

Different Hydro-meteorological conditions beginning/end of the wet season

JANUARY :
Maximum atmospheric instability, high RH, weaker and variable winds
= risk for convective localized storm

APRIL :
Strong and constant wind pattern from the South
= Orographic rainfall in the North.

ERA5 standard daily average (2000-2018)

2m Air Temperature

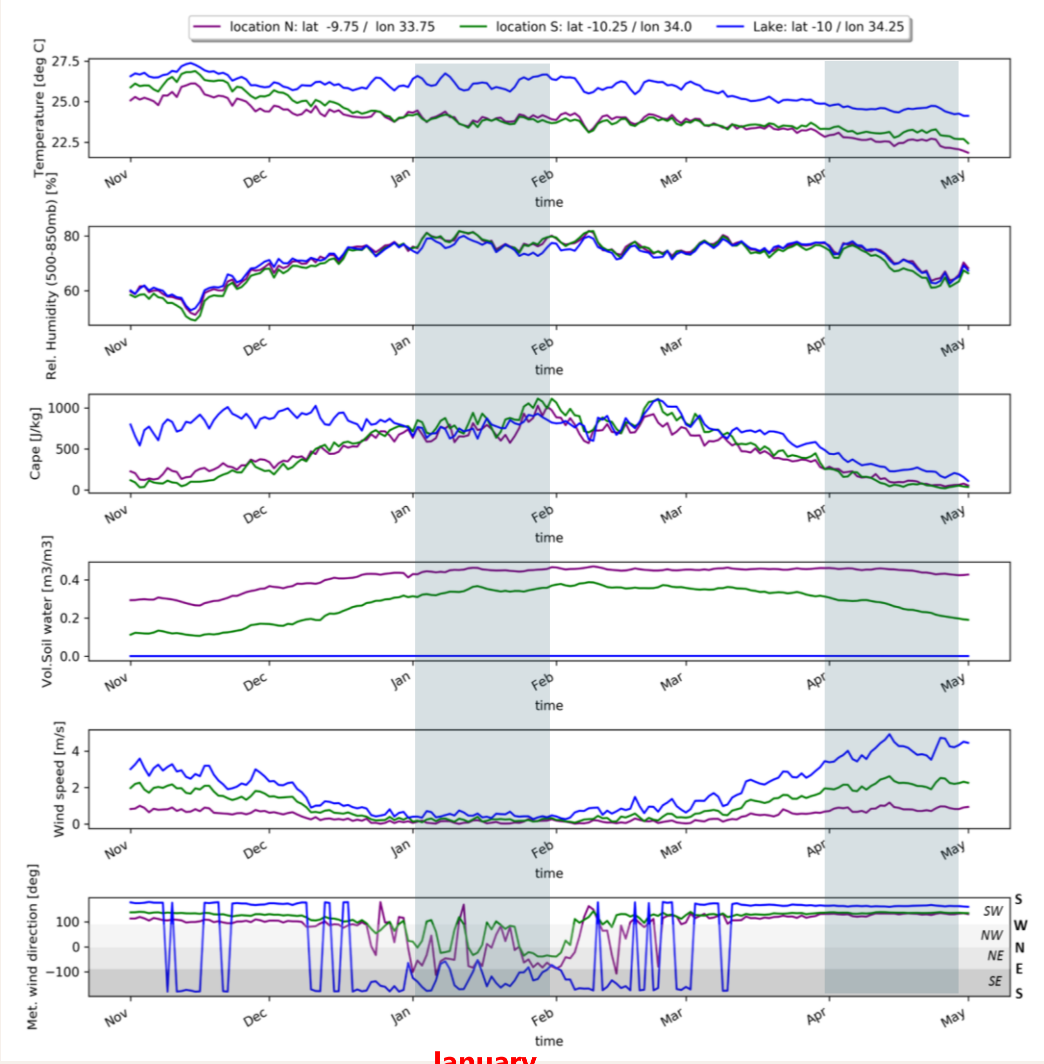
Relative humidity

CAPE

Volumetric Soil Water (top 7cm)

Wind speed

Wind direction



January
ITCZ above Malawi

HYDRO-METEOROLOGICAL PREDICTIVE INDICATORS

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List of historical flash flood events

Most predictive Hydro-meteorological indicators

Time-series

Statistical extreme statistics

Rainfall indicators

- The maximum hourly rainfall during event
- Antecedent rainfall at the end of the wet season

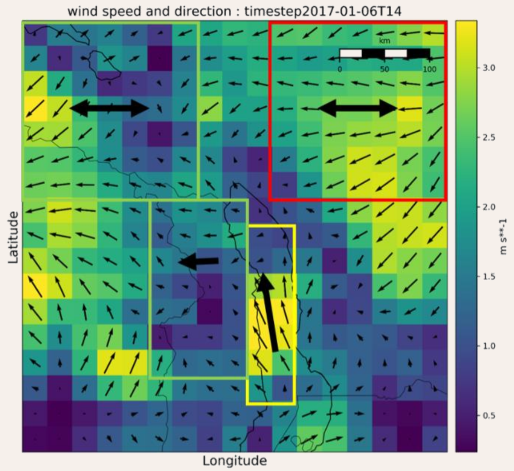
Large scale antecedent meteorological indicators

RH, CAPE and Wind for the early wet season.

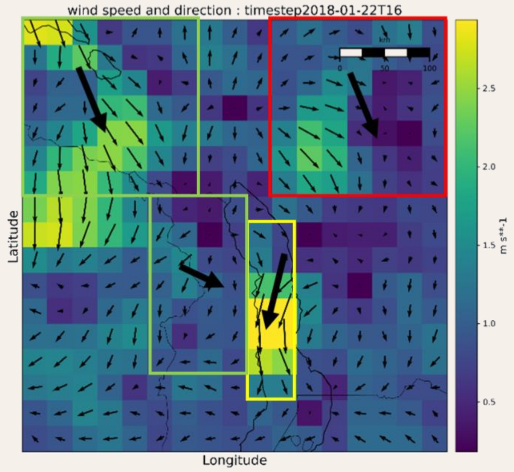
- 1 day RH
- 3 days CAPE
- Wind as a condition for spatial distribution

January FF events

Pattern for FF affecting the North

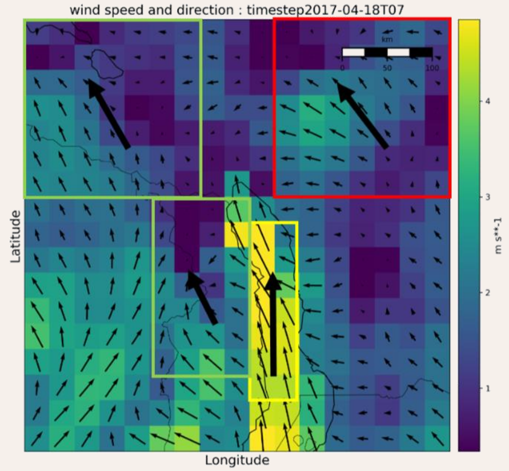


Pattern for FF affecting the South

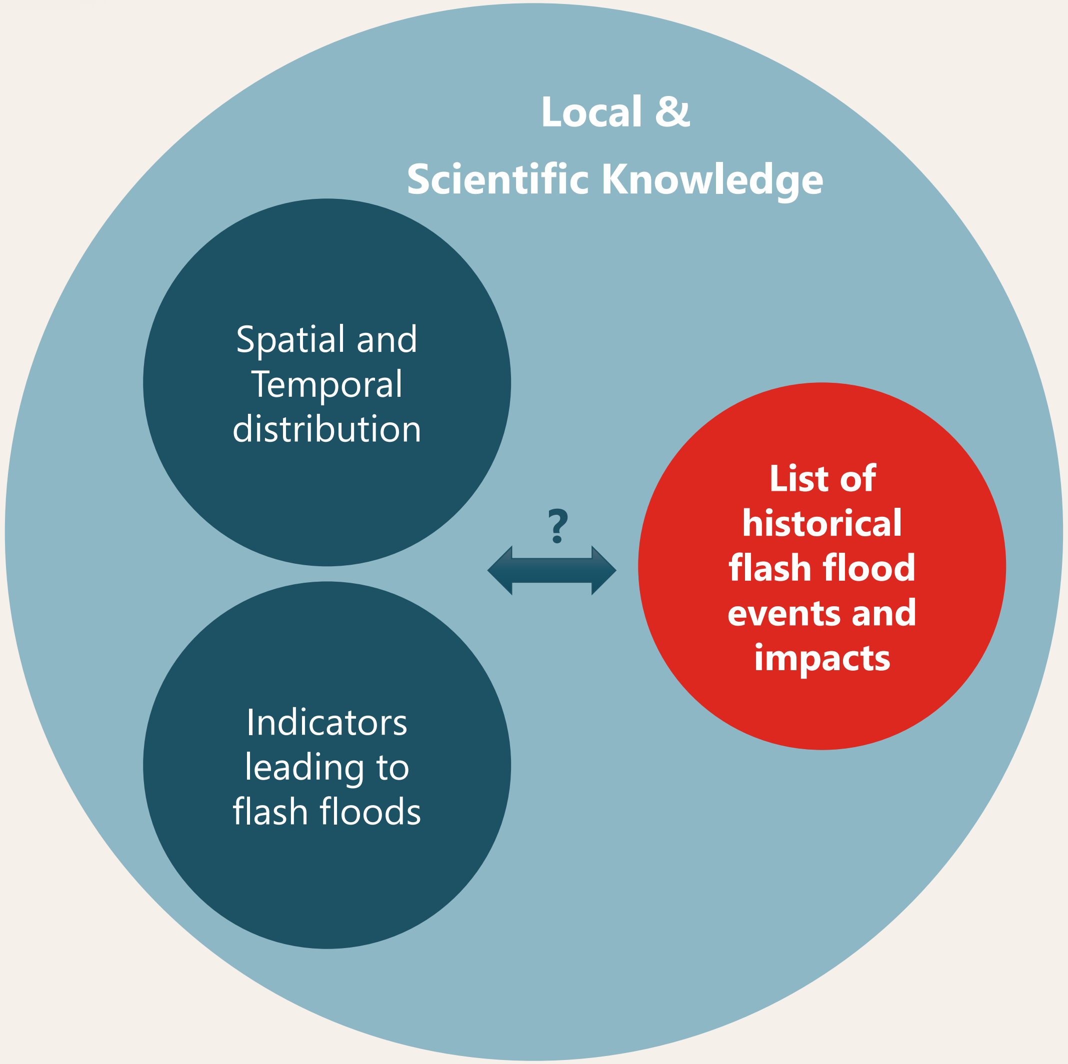


April FF events

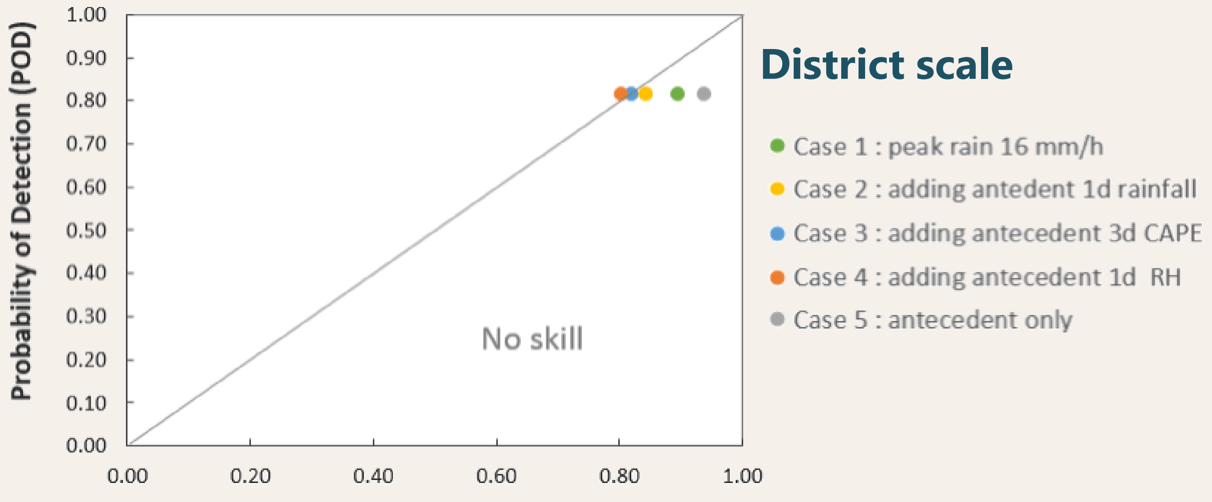
FF affecting the North only

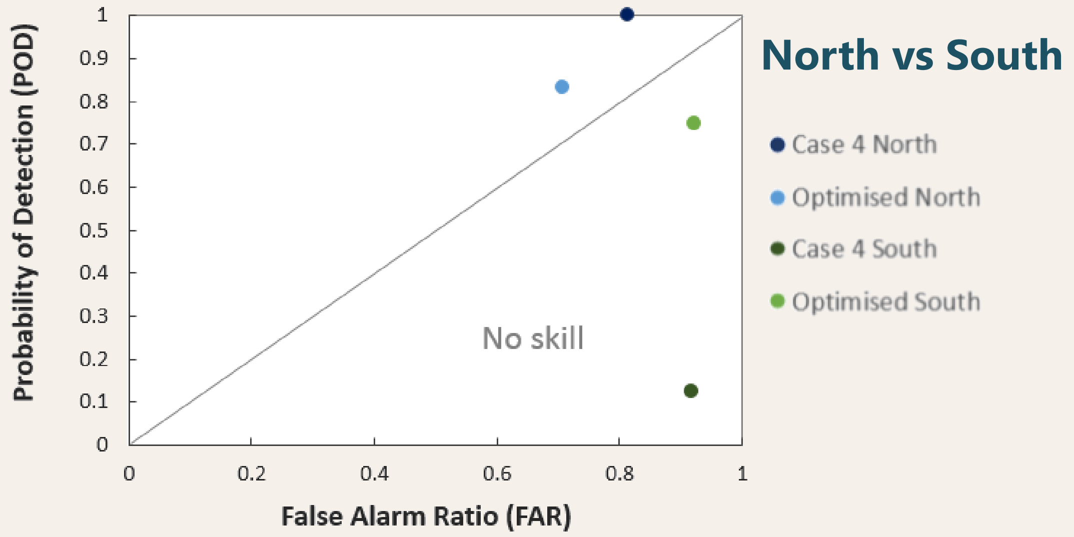


PREDICTING FLASH FLOODS



Simple skill score method
FAR, POD, POFD computed at different scales





FROM UNDERSTANDING RISK TO WARNING

Local knowledge confirmed by geomorphological and hydro-meteorological diagnosis → valuable information for early warning

Characterization of flash flood risk:
Disaster data gap
Documenting local knowledge

Factors Increasing flash flood risk:
Spatial and temporal diagnosis using local & Scientific knowledge

Predictability of flash floods :
Spatial and temporal scale to consider for early warning

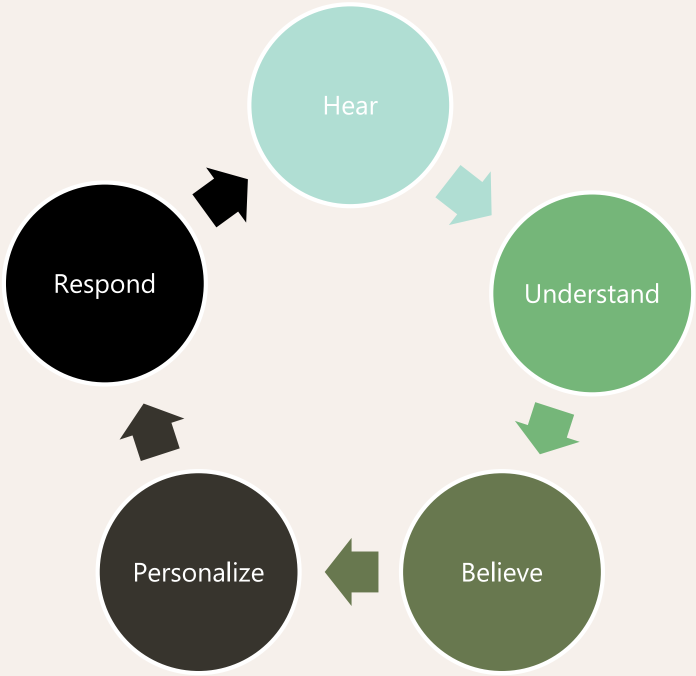
Further work :

Disaster data management

Work closely with meteorologists

- Extreme rainfall forecast
- Toward impact prediction
- How to apply this to FbF

Towards actionable warnings



Amount of information

Type of information

Warning clarity

Linking local knowledge and scientific forecast

Warning information that reflects local knowledge of the signs that lead to flash floods in the area

Informing water allocation polices and decision process in 3 irrigated areas using seasonal forecasts

Ebro Basin, Spain

Murrumbidgee Basin, Australia

Sitka District, West Rapti, Nepal

Ebro Basin Stakeholders: concerns and information needs

Preliminary conclusions of workshop with stakeholders

Concerns

- Water scarcity in the medium and long term due to climate change and expansion of irrigated area
- Drought a concern, primarily due to issues with drinking water and impacts to ecosystems, particularly to forests in the basin

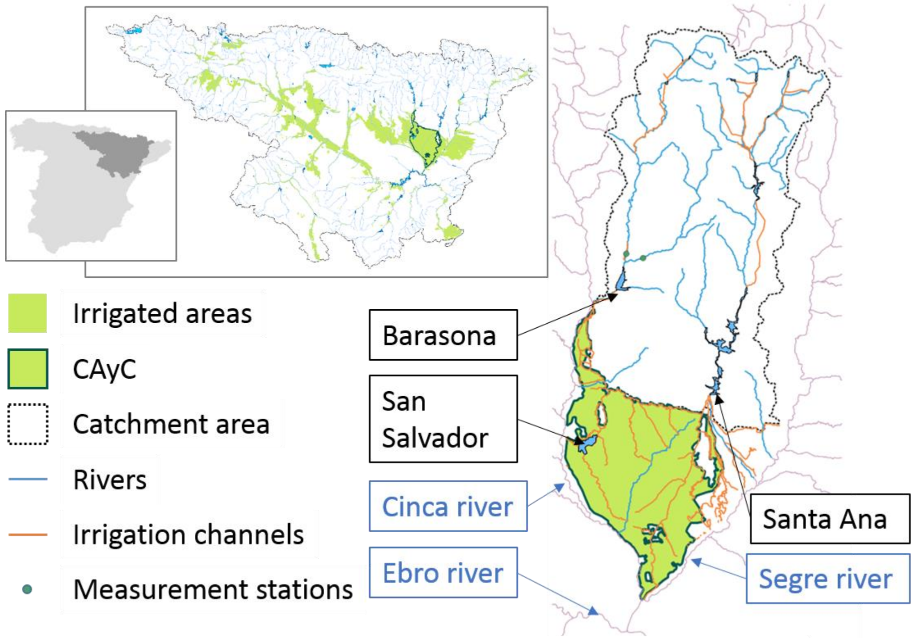
Interests

- Interested in tools that provide better and more detailed information for monitoring drought; drought prediction/forecasting
- Research in links between droughts and forest fire

HUMID

Quintana-Seguí et al. 2018, Informe sobre las necesidades de las partes interesadas, HUMID Project, deliverable 2a

Decision making & allocation of water resources. How useful are additional datasets of hydrological variables and/or seasonal forecasts?



Decision making based on available water resources for irrigation season
Reservoir operators look at expected resource and demand --> curtailments
Farmers respond by taking decision on what to plant → influence demand

eartH2Observe

Linés, C., Iglesias, A., Garrote, L., Sotés, V., and Werner, M.: Do users benefit from additional information in support of operational drought management decisions in the Ebro basin?, Hydrol. Earth Syst. Sci., 22, 5901-5917, https://doi.org/10.5194/hess-22-5901-2018, 2018

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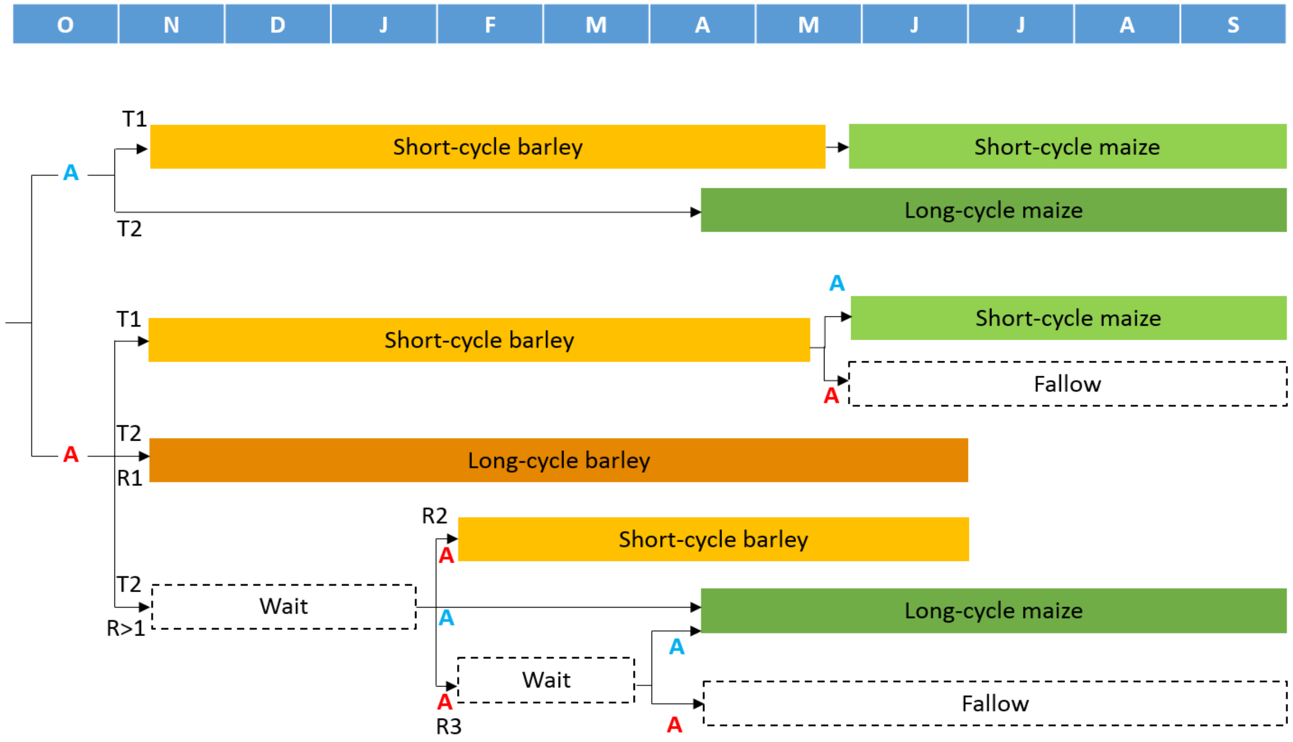
“Farmer – Reservoir Operator” decision model

A : Good water availability
A: Poor Water availability

T1: Technified farmers
T2: Non-technified farmers

R# : Level of risk taking

R1: Risk Averse
R2-3: Risk Seeking



Available Water Resource Estimation
(expected **supply** and **demand**)

Decision on planting (influencing **demand**)

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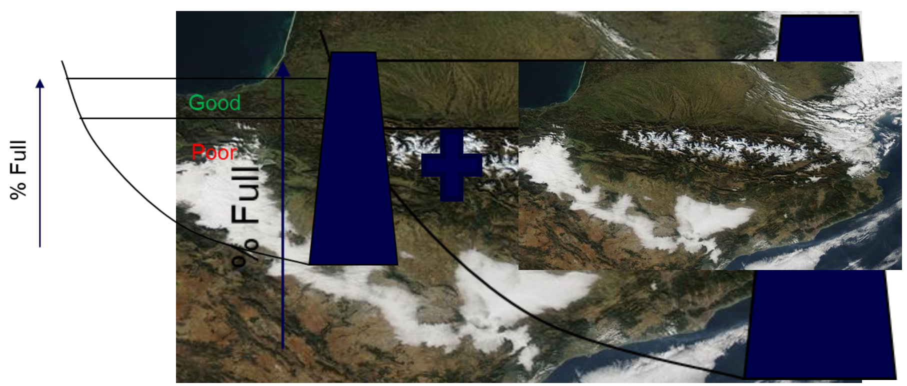
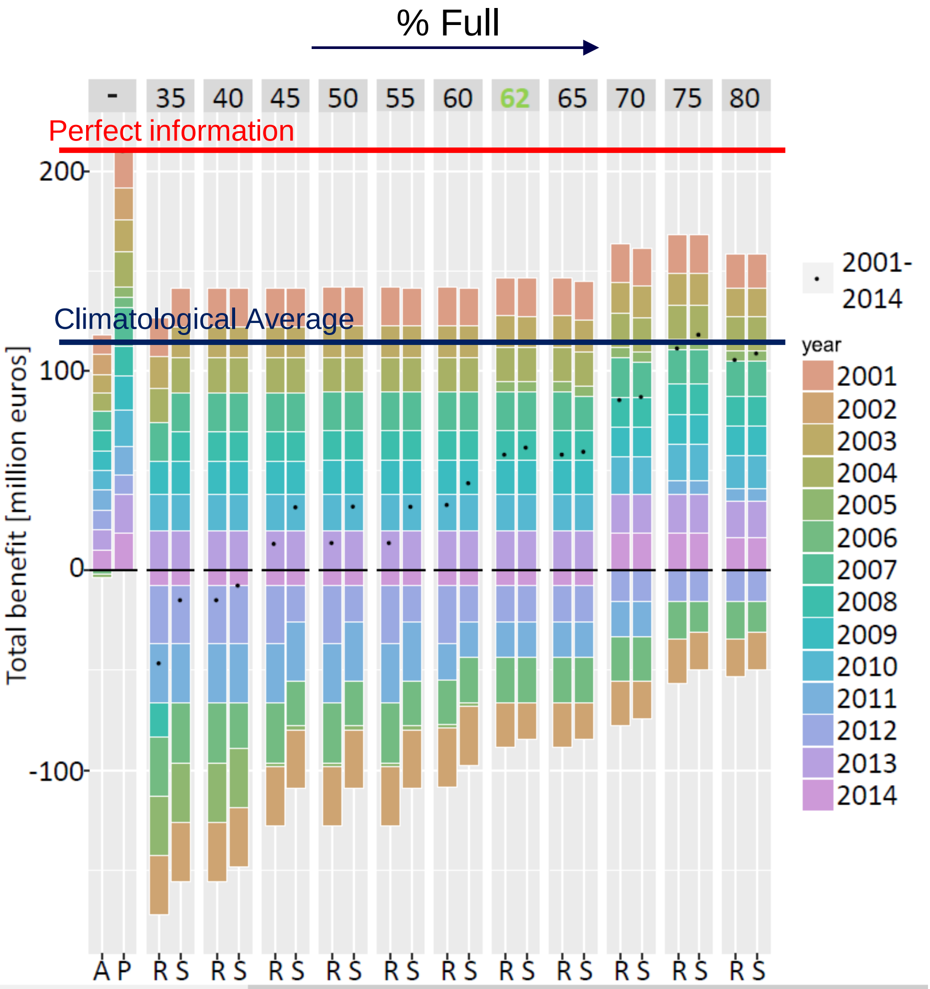
Linés, C., Iglesias, A., Garrote, L., Sotés, V., and Werner, M.: Do users benefit from additional information in support of operational drought management decisions in the Ebro basin?, Hydrol. Earth Syst. Sci., 22, 5901-5917, https://doi.org/10.5194/hess-22-5901-2018, 2018

Costs and Benefits of using additional information

Utility of information on estimate of water resource

- Reservoir levels only (left column)
- Reservoir levels + remote sensing of snow (right column)





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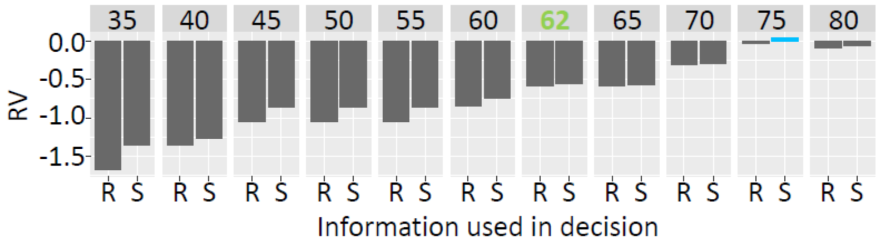
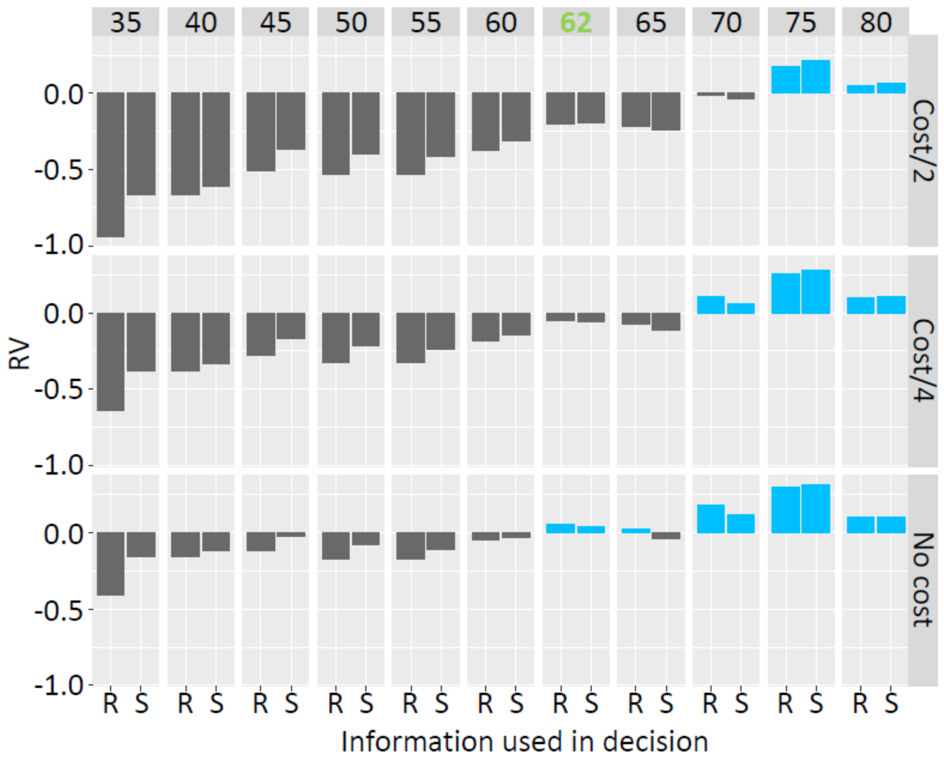
Trade-off in using additional information

BUT:
depends on ratio of planting costs to return on yield!



Actual Costs

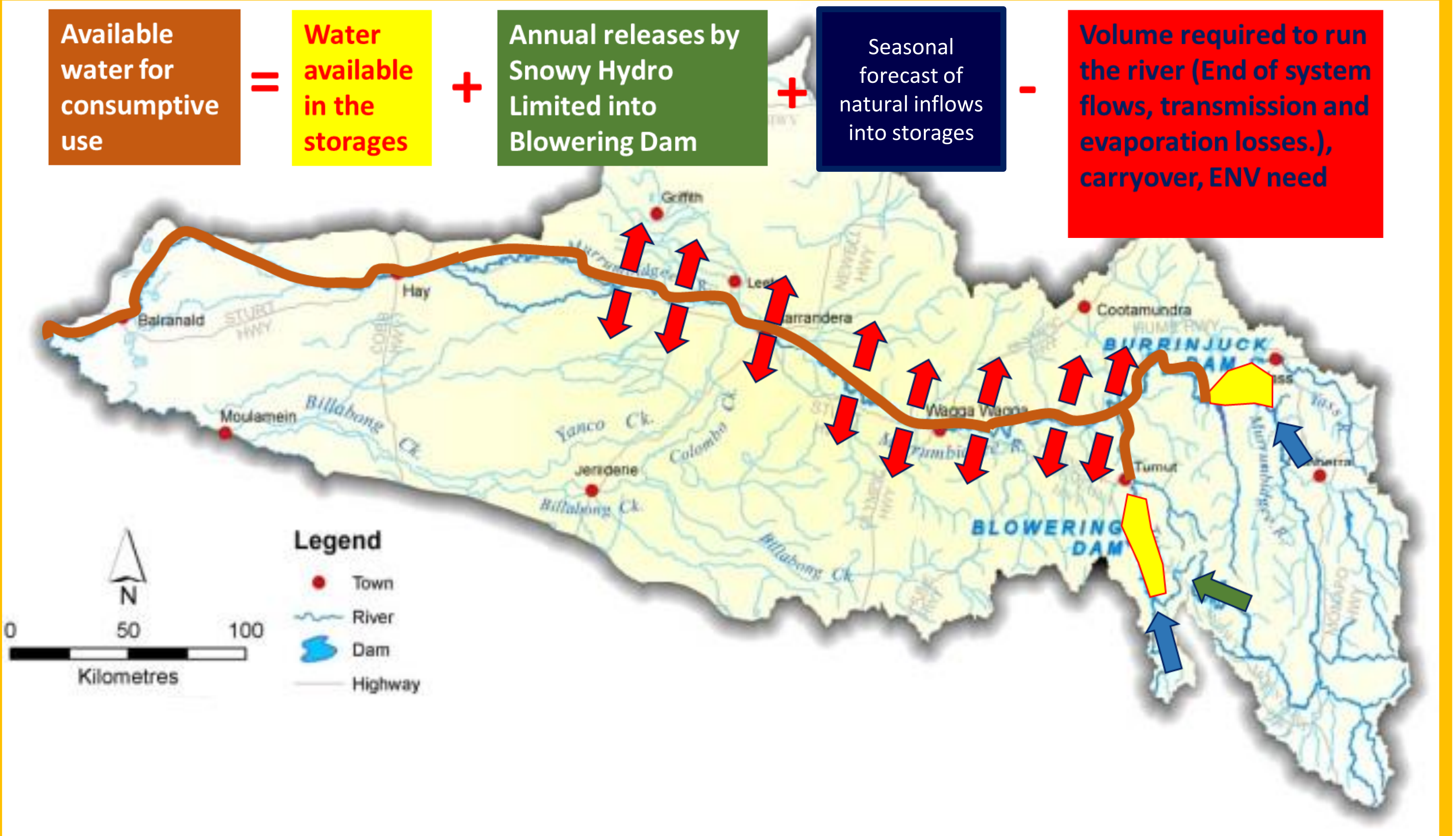


What did we learn?

- Marginal benefit to using snow info as a forecast of available water
- Uncertainties due to product informing on snow cover and not on snow water equivalent
- Risk averseness influences value of additional data – little value to risk averse farmers
- Utility of information dominated in this case by the ratio of cost of planting to profit of harvest

Linés, C., Iglesias, A., Garrote, L., Sotés, V., and Werner, M.: Do users benefit from additional information in support of operational drought management decisions in the Ebro basin?, Hydrol. Earth Syst. Sci., 22, 5901-5917, https://doi.org/10.5194/hess-22-5901-2018, 2018

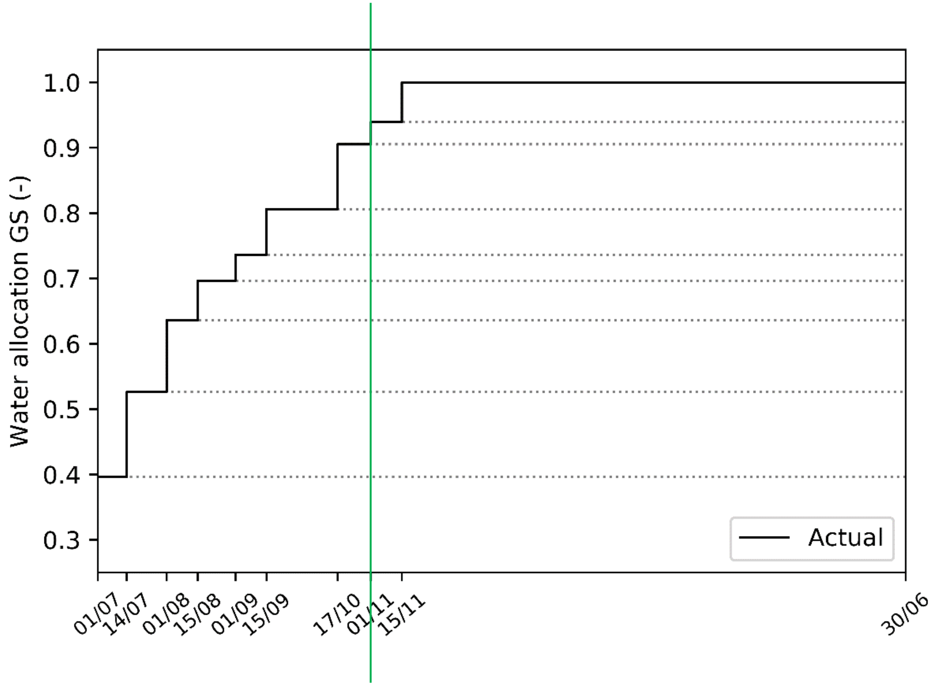
Water Allocation Policy in the Murrumbidgee Basin, Australia



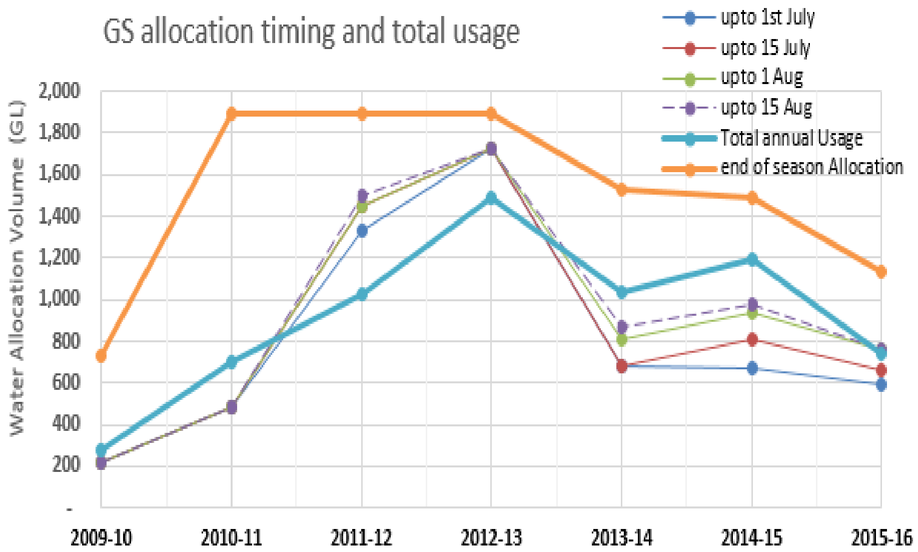
Kaune A, Choudhury F, Werner, M, Bennett J. 2019. The benefit of using an ensemble of seasonal streamflow forecasts in water allocation decisions, *in preparation*

Water Allocation in a typical season

Ratio of allocation of concession (example for 2016)



Water allocation utilised



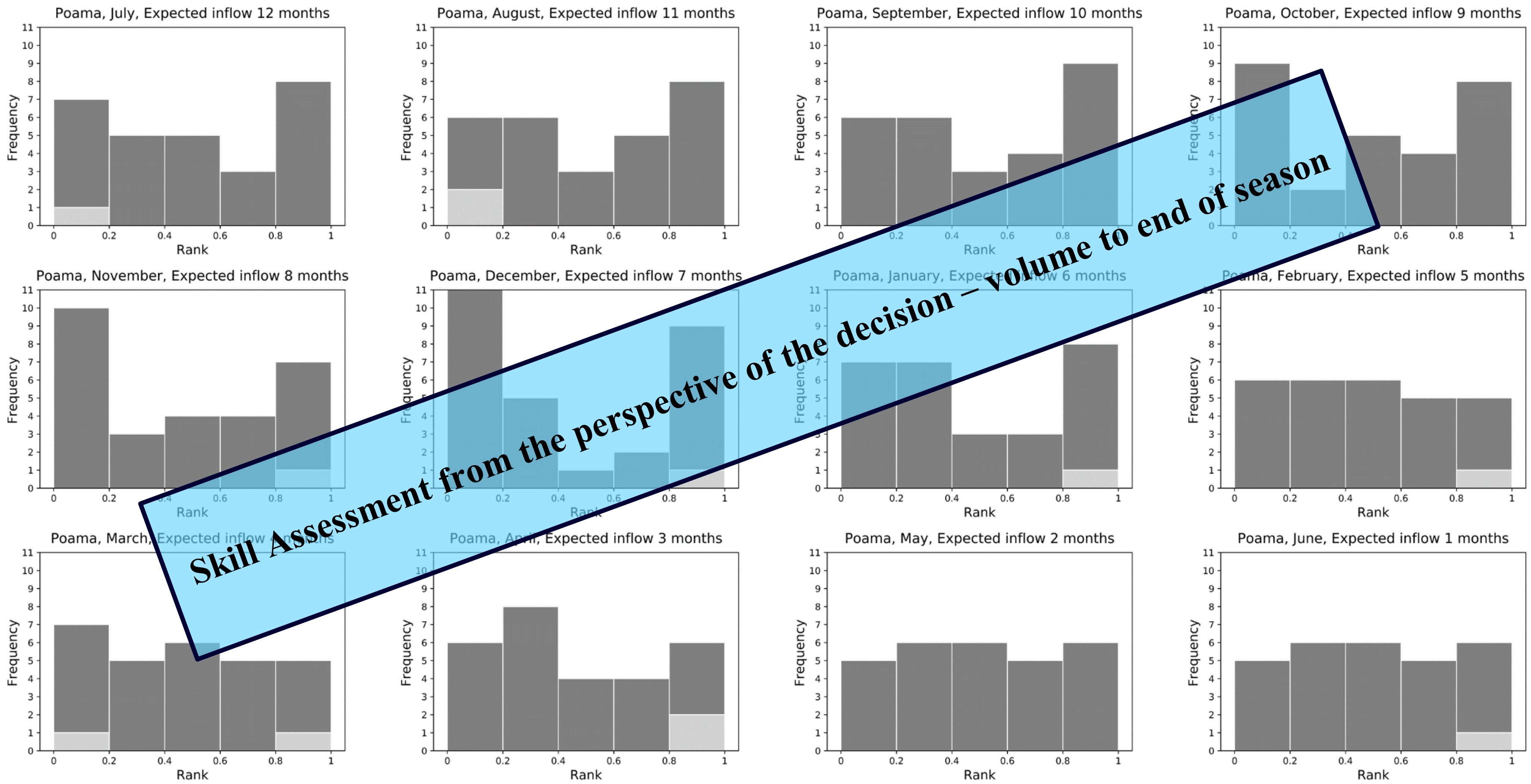
Start of cropping season for annual crops

Decision on full allocation of concession too late to be useful to farmers

Kaune A, Choudhury F, Werner, M, Bennett J. 2019. The benefit of using an ensemble of seasonal streamflow forecasts in water allocation decisions, *in preparation*

Seasonal Forecasts - FoGSS

12 month lead time hydrological forecast
Forecast Guided Stochastic Scenarios (FoGSS)
POAMA M2.4 seasonal climate forecasting system



Rank histogram using POAMA datasets from FoGSS (Bennett et al., 2016, 2017; Turner et al., 2017) for expected inflow in the next n months (Starting July) in the Burrinjuck reservoir

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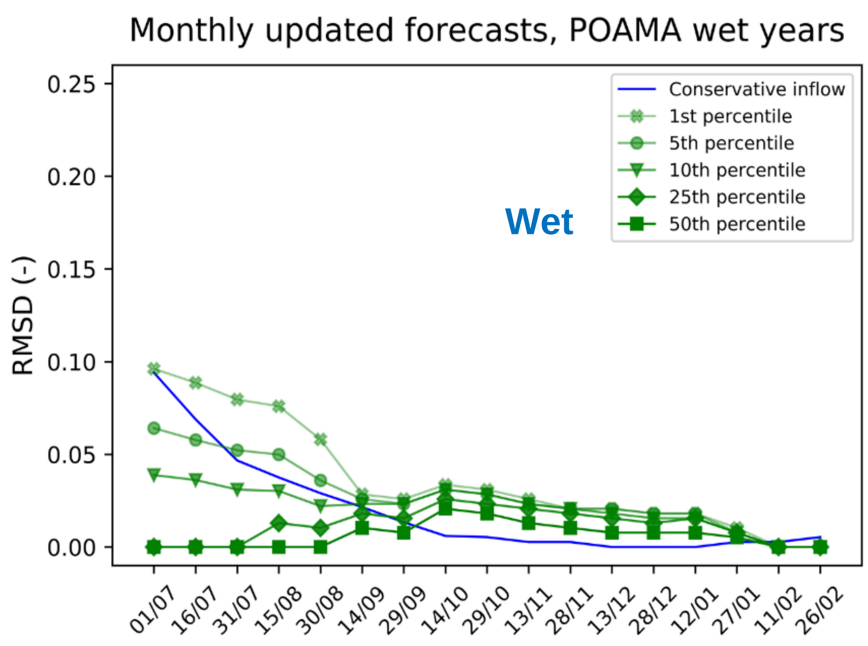
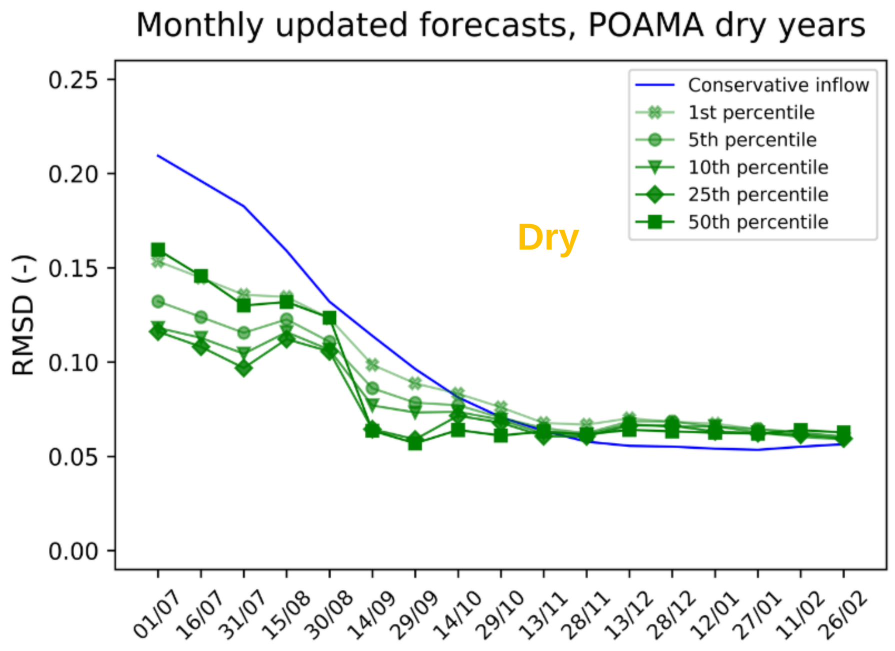
Kaune A, Choudhury F, Werner, M, Bennett J. 2019. The benefit of using an ensemble of seasonal streamflow forecasts in water allocation decisions, *in preparation*

Does the ensemble forecast improve the decision?

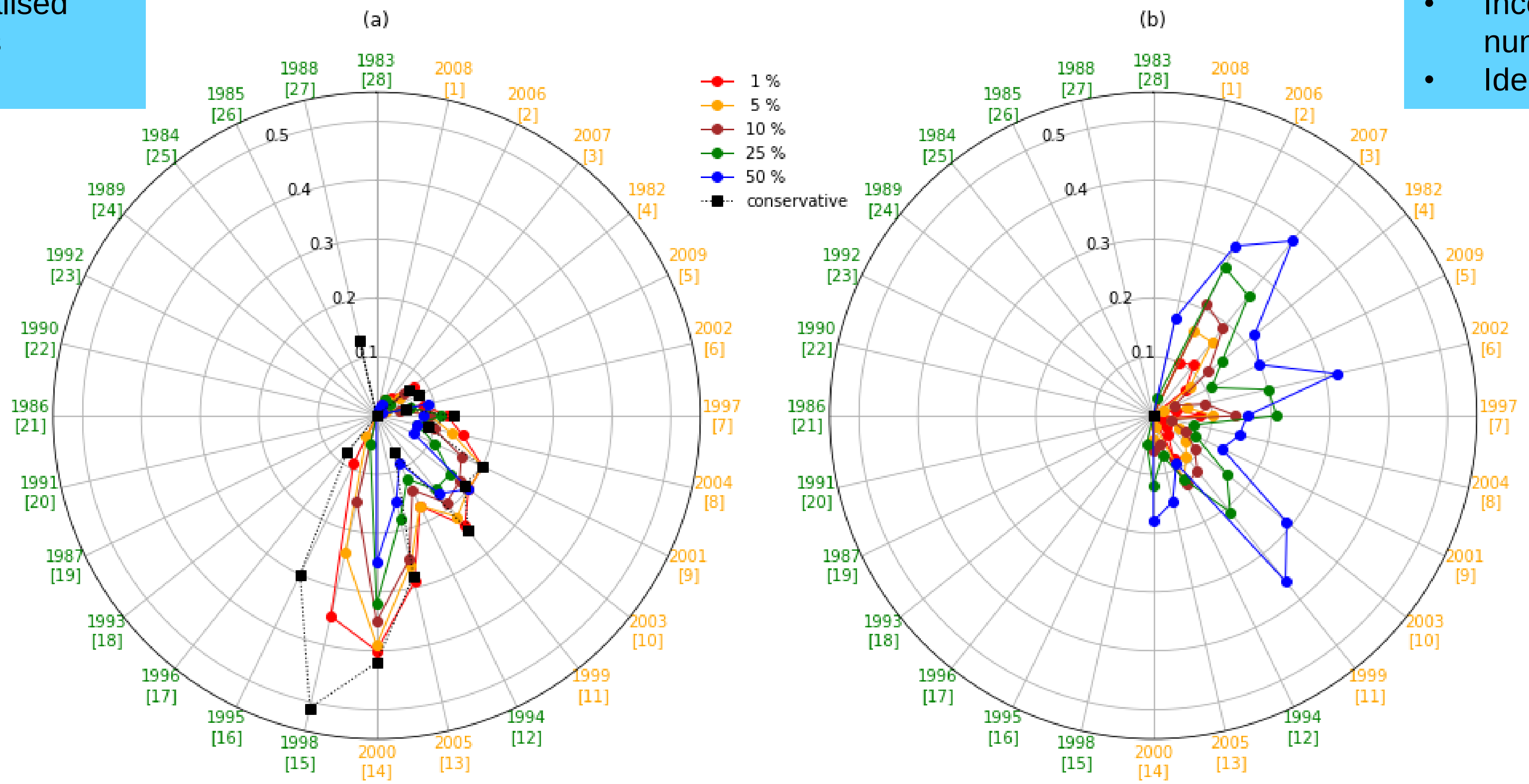




RMSD shows deviation of decision from perfect decision across all 28 years

Kaune A, Choudhury F, Werner, M, Bennett J. 2019. The benefit of using an ensemble of seasonal streamflow forecasts in water allocation decisions, *in preparation*

Left circle
- Inconsistency index: Normalised number of upward revisions
- Ideally as few as possible



Right circle
- Inconsistency index: Normalised number of downward revisions
- Ideally as few as possible

What did we learn?
- Informing water availability with seasonal forecasts does lead to better (earlier) decision on allocation
- But… in dry years there may be downward revisions of allocation – is this politically acceptable?
- Trade-off of risk between water allocator and water user (farmer). Who carries what risk?

Kaune A, Choudhury F, Werner, M, Bennett J. 2019. The benefit of using an ensemble of seasonal streamflow forecasts in water allocation decisions, *in preparation*

Assertion

New, rich datasets are of utility in supporting water allocation decisions

True, but only

when considered within the full context of the decision processes and policies; and the social, economic, behavioural and political realities within which those decisions are taken

www.hepex.org

Prof Hannah Cloke
Reading University, UK

Keynote lecture: Fly me to the moon

10 Years ago: Challenges in Ensemble Forecasting

- Improving numerical weather prediction
- Understanding the total uncertainty in the system
- Data Assimilation
- Having enough case studies (which report quantitative results)
- Having enough computer power
- How to use Ensemble Prediction Systems in an operational setting
- Communicating uncertainty and probabilistic forecasts

Visiti www.hepex.org for references, blogs, views, (serious) games; next workshop in 2020, likely in Paris, France

We have made it to the moon and perhaps beyond -
– now it is time to come back down to earth

Still plenty work to do…

…. but (probabilistic) forecasts, remote sensing datasets have reached an unprecedented level of technological readiness and availability

… let us now put them to good use

But to do so we ourselves may need to change

- Increasing need to focus research on how these can data can have real utility in supporting decisions and practical application to realise utility
- Interdisciplinary is key: Social Sciences; Economics; Behavioural Sciences; Communication Sciences: and more….
- Bottom-up & user oriented. Ultimately this will innovate the science of data provision in the climate services value chain.

We stand to learn a lot from users

Acknowledgements: Agathe Bucherie, Clara Linés, Alex Kaune, Mohammad Faysal & Alka Subedi