Forecasting and Forecasting Systems

From eager grad student to seasoned professional: Is forecasting coming of age?

Micha Werner, IHE Delft

United Nations Educational, Scientific and Cultural Organization
IHE DELFT Institute for Water Education in partnership with UNESCO

From eager grad student to seasoned professional: Is forecasting coming of age?

Reflections from three intertwined stories

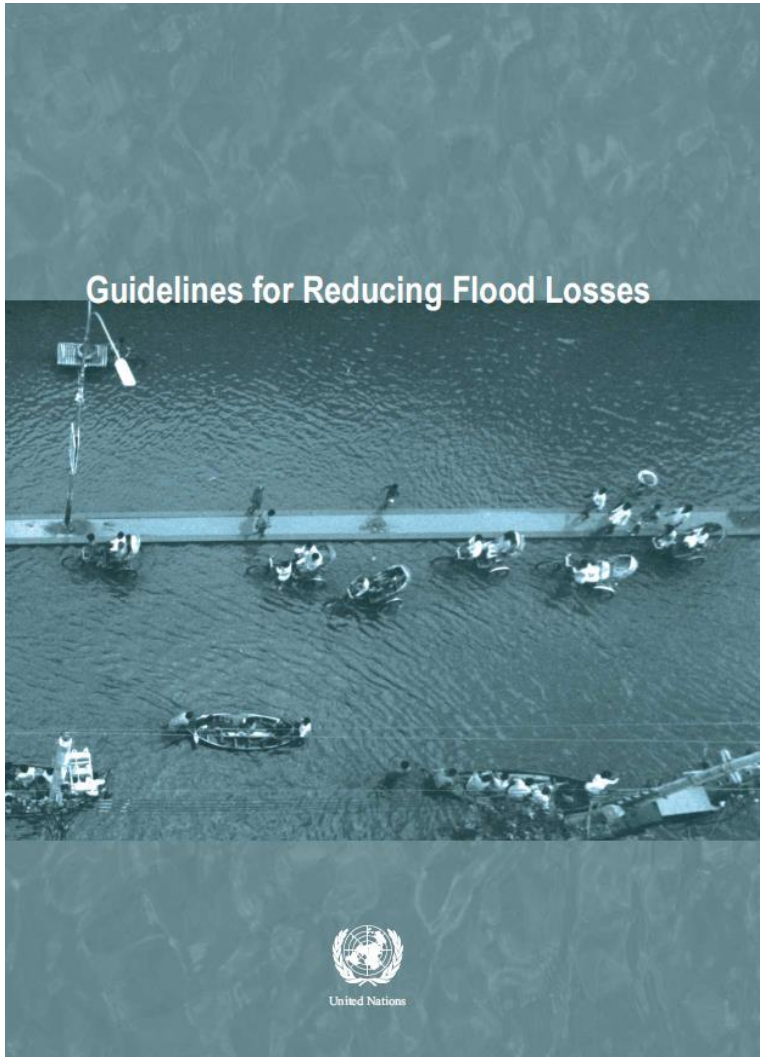
A coming of age of forecasting

A coming of age of Delft FEWS

Perspectives from a personal journey

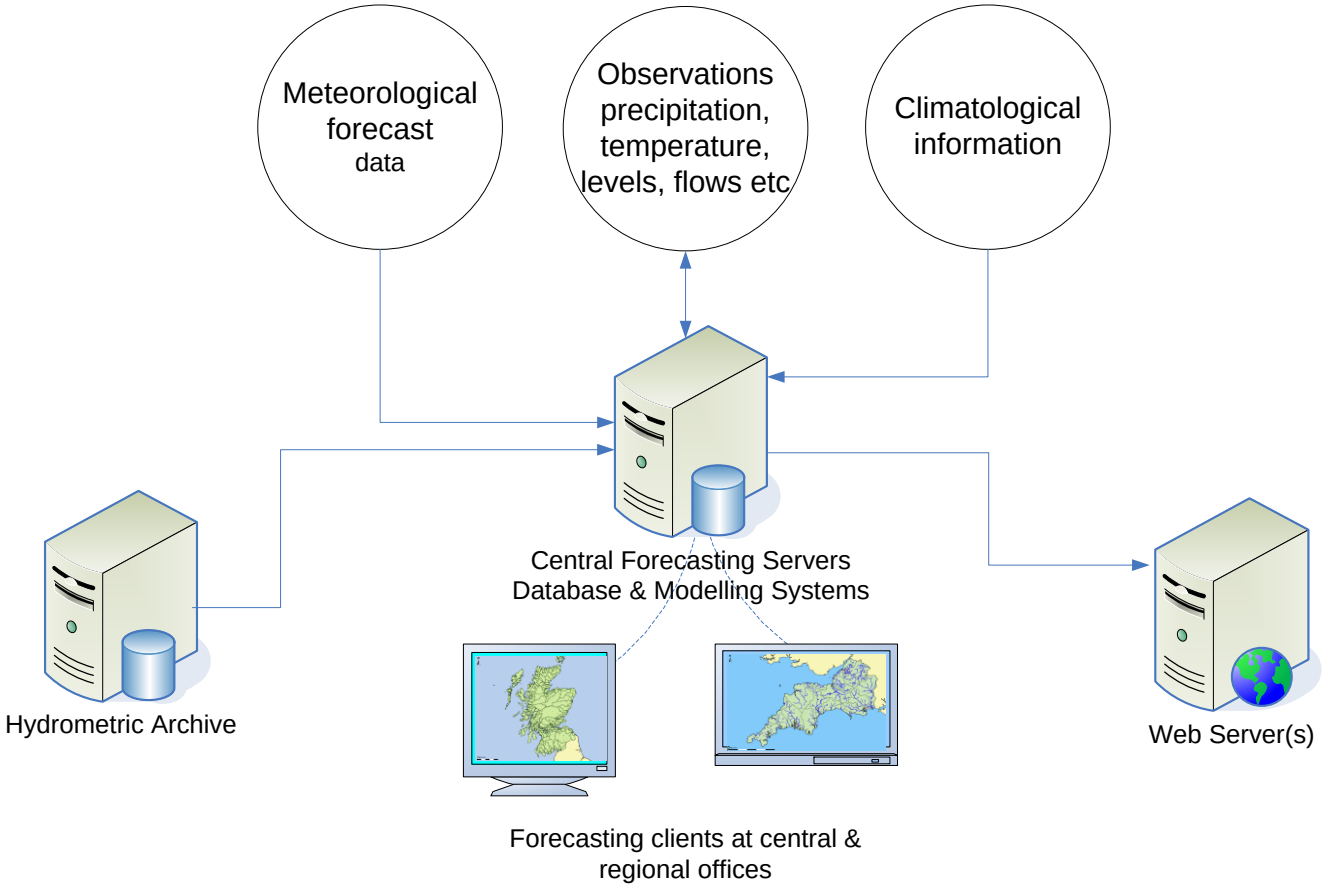
Flood warning systems and communication methods

"The operation of a flood warning and response system is the most effective method for reducing the risk of loss of life and economic losses"



United Nations Office for Disaster Risk Reduction (UNDRR, 2002)

Enter the eager grad student… (and the flood forecasting system)



Werner M. Schellekens J. Gijsbers P. van Dijk M. Heynert K. Akker O.. 2013. The Delft-FEWS flow forecasting system. *Environmental Modelling & Software* 40: 65-77.

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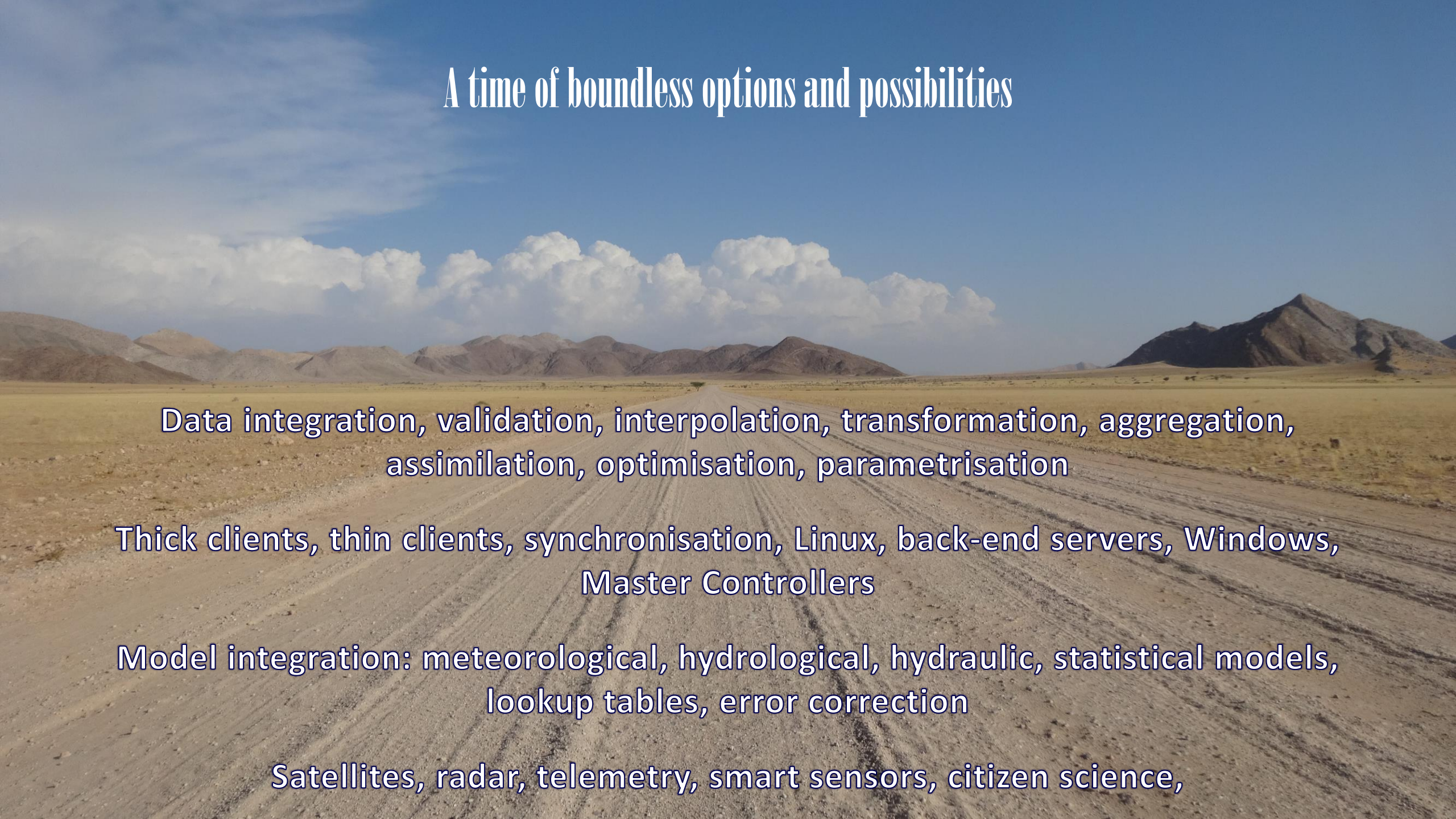
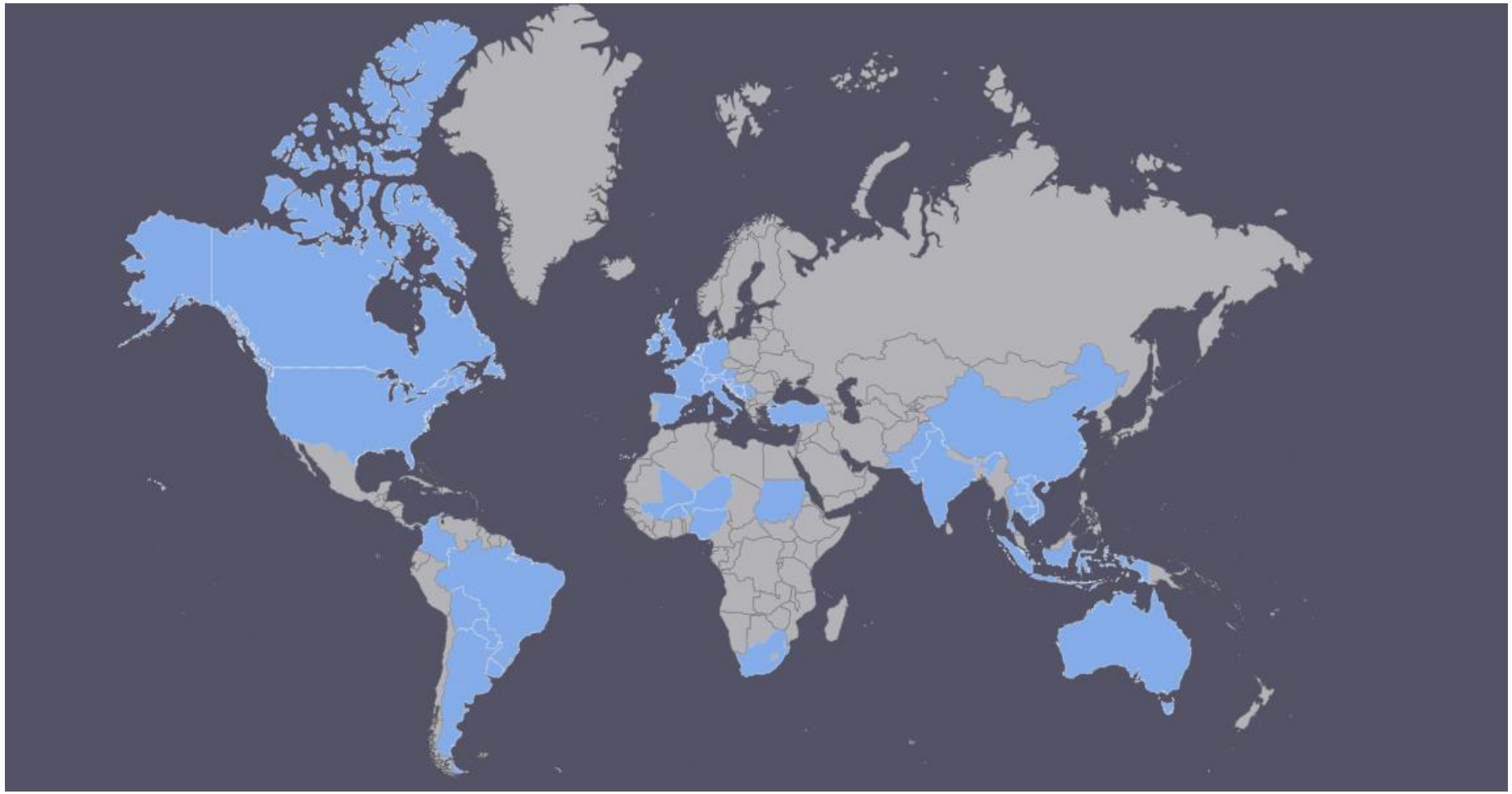

A time of boundless options and possibilities
Data integration, validation, interpolation, transformation, aggregation, assimilation, optimisation, parametrisation
Thick clients, thin clients, synchronisation, Linux, back-end servers, Windows, Master Controllers
Model integration: meteorological, hydrological, hydraulic, statistical models, lookup tables, error correction
Satellites, radar, telemetry, smart sensors, citizen science,

What is the ambition of the Delft FEWS group – where will we be in 10 years?



Marc's response: "Well, we do have ambition, Delft FEWS used in 50% of the world"

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What was the research community talking about at the time?

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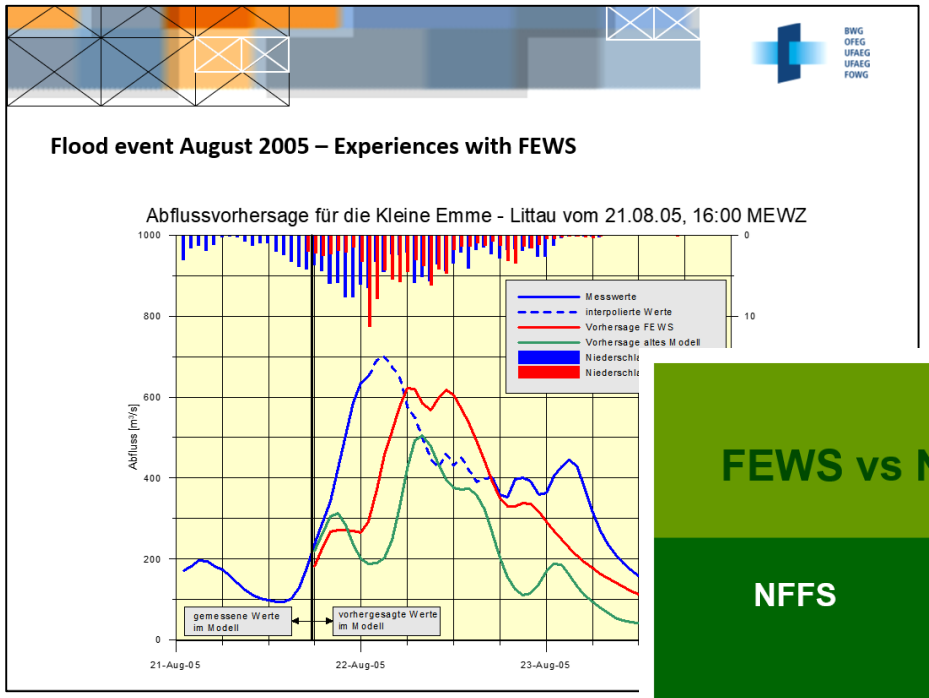
What was the Delft FEWS community talking about at the time?

FEWS User days 2005

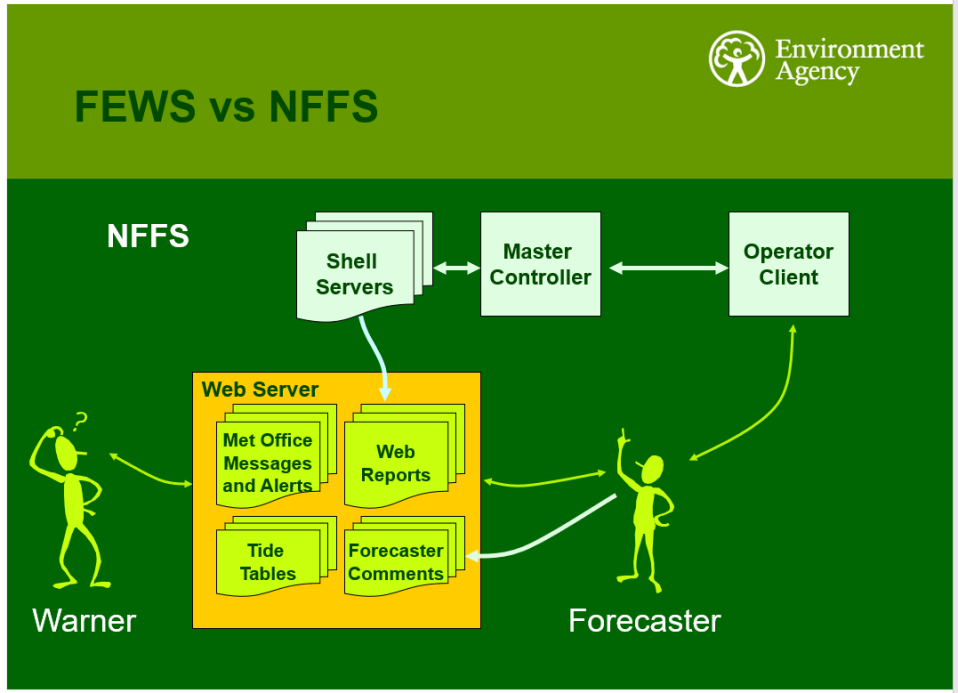
- Doug Whifiled: NFFS UK
- Stevan Vogt: FEWS Switzerland
- Ming Horng: FEWS Taiwan:
- Slivano Pecora: FEWS Po
- Günther Reichel: FEWS Austria
- Jutta Thielen: EFAS



Source: Vogt, 2005

Topics addressed & worries

- How to develop forecasting systems and forecast processes?
- How to integrated data and models?
- How well did the system do in forecasting floods events?



Source: Whitfield, 2005

Becoming more mature … recognising and addressing forecast uncertainty

Journal of Hydrology 375 (2009) 613–626

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Review

Ensemble flood forecasting: A review

H.L. Cloke [a,*], F. Pappenberger [b]

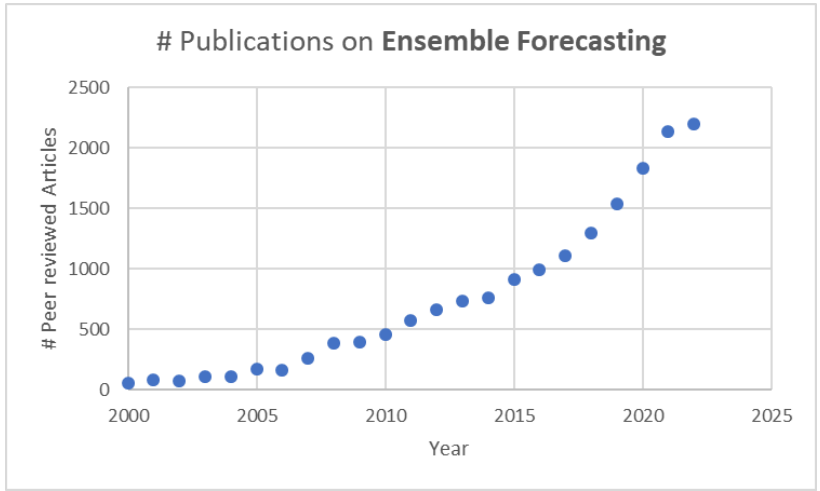
[a] Department of Geography, King's College London, Strand, London WC2R 2LS, UK
[b] European Centre for Medium Range Weather Forecasts, Shinfield Park, Reading RG2 9AX, UK

Computers & Geosciences

Volume 36, Issue 4, April 2010, Pages 453-463

Application of generic data assimilation tools (DATools) for flood forecasting purposes

Albrecht H. Weerts, Ghada Y. El Serafy, Stef Hummel, Juzer Dhondia, Herman Gerritsen



Source: scopus.com

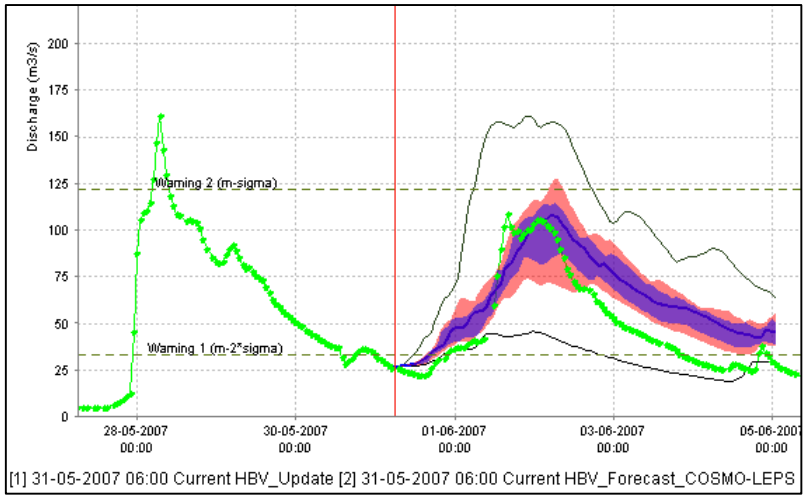
Journal of Hydrology

Volume 540, September 2016, Pages 712-726

Streamflow forecast uncertainty evolution and its effect on real-time reservoir operation

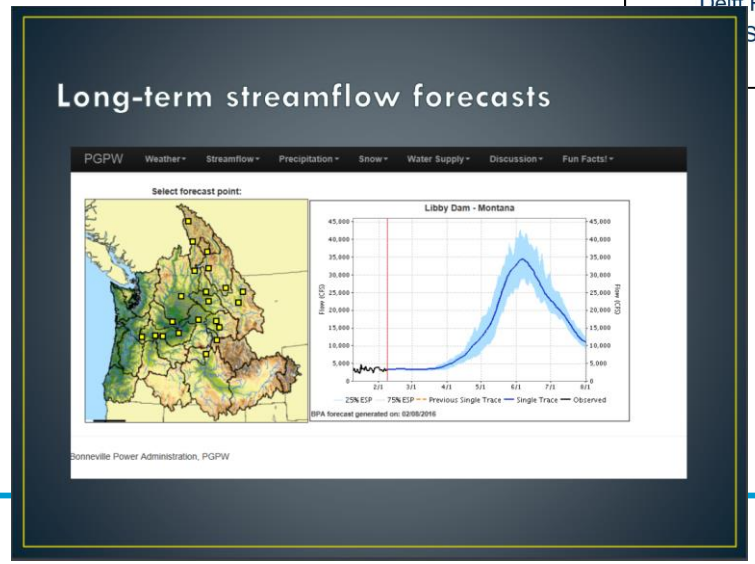
Lu Chen [a], Vijay P. Singh [b], Weiwei Lu [a], Junhong Zhang [c], Jianzhong Zhou [a], Shenglian Guo [d]

Delft FEWS community – embracing ensemble forecasting and beyond

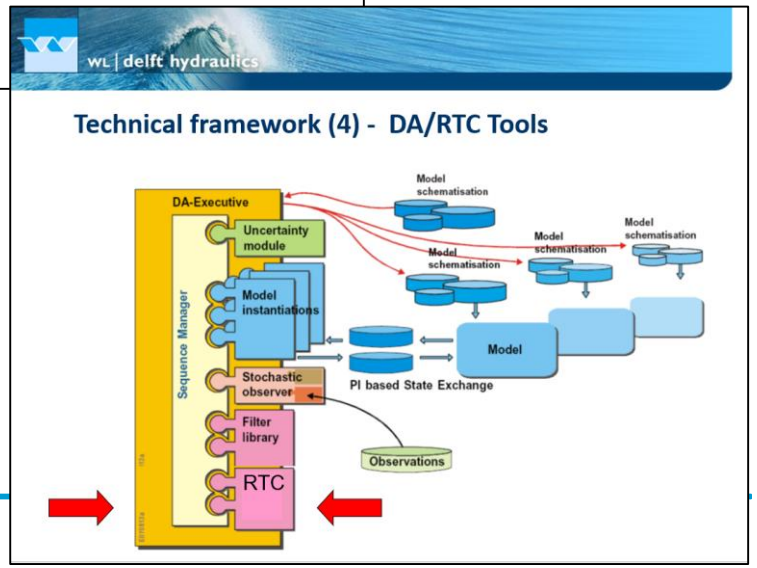


An “early” ensemble forecast – FEWS-CH

Schwanenberg, 2007



McManamon, 2016
(Bonneville Power Admin.)



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Oh please don’t let me be misunderstood…

Meteorological Applications
Science and Technology for Weather and Climate
Open Access
RMetS

Special Issue Article | Free Access

Challenges in communicating and using ensembles in operational flood forecasting

David Demeritt, Sébastien Nobert, Hannah Cloke, Florian Pappenberger

First published: 17 June 2010 | https://doi.org/10.1002/met.194 | Citations: 85

Demeritt, 2020
FEWS User Days

Meteorological Applications
Science and Technology for Weather and Climate
Open Access
RMetS

Special Issue Article | Free Access

Communicating uncertainty in hydro-meteorological forecasts: mission impossible?

Maria-Helena Ramos, Thibault Mathevet, Jutta Thielen, Florian Pappenberger

Rajabali, 2020
FEWS User Days

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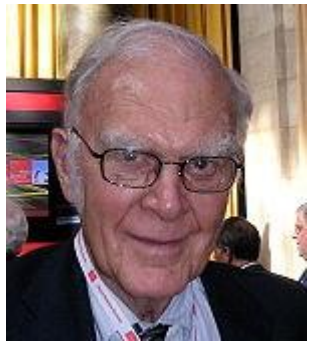
The midlife crisis…



Frank Sherwood Rowland (1927 – 2012)
Nobel Laureate, Chemistry 1995

"What's the use of having developed a science well enough to make predictions, if in the end, all we're willing to do is stand around and wait for them to come true?"

Hydrol. Earth Syst. Sci., 21, 4517–4524, 2017
https://doi.org/10.5194/hess-21-4517-2017

Hydrology and Earth System Sciences
Open Access
EGU

Should seasonal rainfall forecasts be used for flood preparedness?

Erin Coughlan de Perez[1,3,4], Elisabeth Stephens[2], Konstantinos Bischiniotis[3], Maarten van Aalst[1,4], Bart van den Hurk[5], Simon Mason[4], Hannah Nissan[4], and Florian Pappenberger[6]

[1]Red Cross Red Crescent Climate Centre, The Hague, 2521 CV, the Netherlands
[2]School of Archaeology, Geography and Environmental Science, University of Reading, Reading, RG6 6AH, UK
[3]Institute for Environmental Studies, VU University Amsterdam, 1081 HV, the Netherlands
[4]International Research Institute for Climate and Society, Columbia University, New York, 10964, USA
[5]Royal Netherlands Meteorological Institute (KNMI), De Bilt, 3731 GA, the Netherlands
[6]European Centre for Medium-Range Weather Forecasts, Reading, RG2 9AX, UK

**Are Flood Warnings Futile?
Risk communication in emergencies**

**The Australasian Journal of Disaster and Trauma Studies
ISSN: 1174-4707
Volume : 2000-2**

**Are Flood Warnings Futile?
Risk communication in emergencies**

Handmer, 2002

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Bigger, Better, Faster, More [Data & Models]

Does better data & forecasts, more ensembles, improved models and data assimilation lead to better decisions?

Challenges & Barriers

Translation of information provided in forecasts into information that is useful and usable

Incorporation of social and behavioural factors & local knowledge and customs of those who are expected to respond

Understanding of multi-temporal and multi-scalar dimensions of the impacts of extreme events and options to respnond to them

Lack of transdisciplinary approaches across the full forecast and climate services value chain

Re-assessing how we look at forecasting & warning – starting from the user perspective

Meteorological Applications
Science and Technology for Weather and Climate
Open Access
RMetS

Research Article | Free Access

Understanding and enhancing the public's behavioural response to flood warning information

D. J. Parker, S. J. Priest, S. M. Tapsell

Improving the social performance of flash flood early warnings using mobile services

Received 7 August 2014
Revised 5 December 2014
Accepted 7 December 2014

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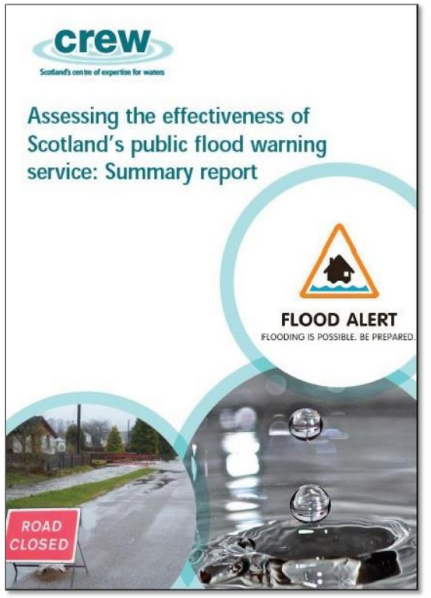
Deltares, Delft, The Netherlands
Micha Werner
Deltares, Delft, The Netherlands and UNESCO-IHE Institute for Water Education, Delft, The Netherlands
Karen Meijer
Deltares, Delft, The Netherlands and German Development Institute, Bonn, Germany
S.H.M. Fakhruddin
Politecnico di Milano, Milano, Italy and Regional Integrated Multi-Hazard Early Warning System (RIMES), Bangkok, Thailand, and
Ahmadul Hassan
Centre for Environmental and Geographical Information Services (CEGIS), Dhaka, Bangladesh

Research Questions

- Are customers happy with the flood alerts and warnings they receive?
- What information would customers like to receive in advance of/immediately prior to and during potential flooding?
- What action, if any, do customers take on receipt of flood messages to reduce the impact of flooding?



Journal of
Flood Risk Management
CIWEM

Flood warning responses of farmer households: a case study in Uria Union in the Brahmaputra flood plain, Bangladesh

M.A.R. Shah[1,2], W.J.A.M. Douven[1], M. Werner[1] and J. Leentvaar[1]

1 UNESCO-IHE Institute for Water Education, Delft, The Netherlands
2 R&D and Training Division, Center for Environmental and Geographic Information Services (CEGIS), Dhaka, Bangladesh

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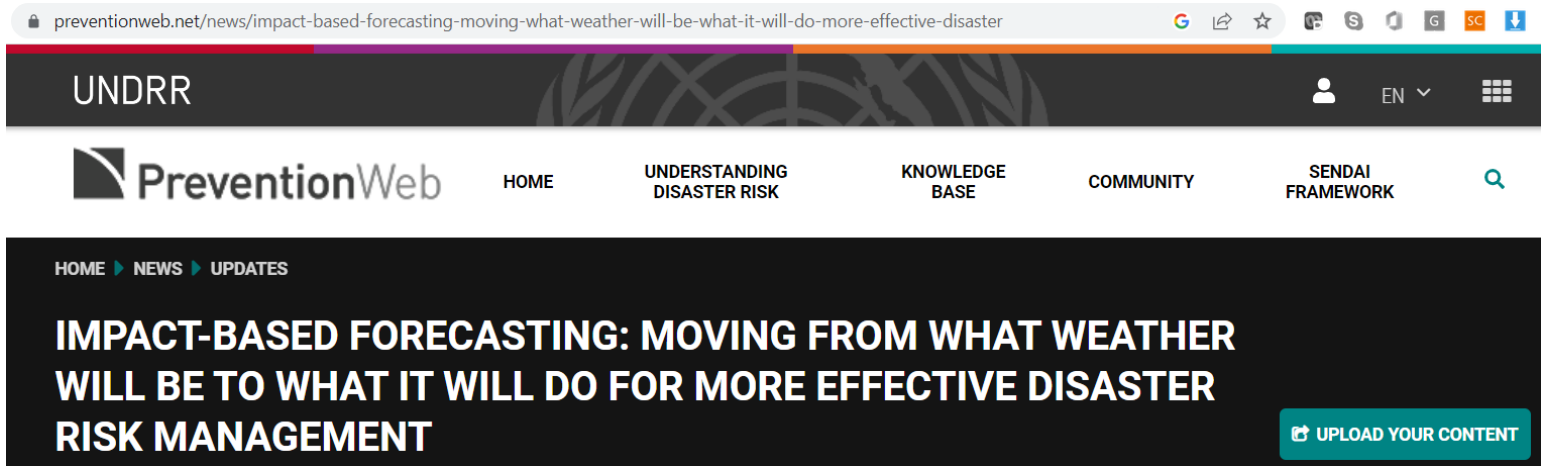
The advent of impact-based forecasting



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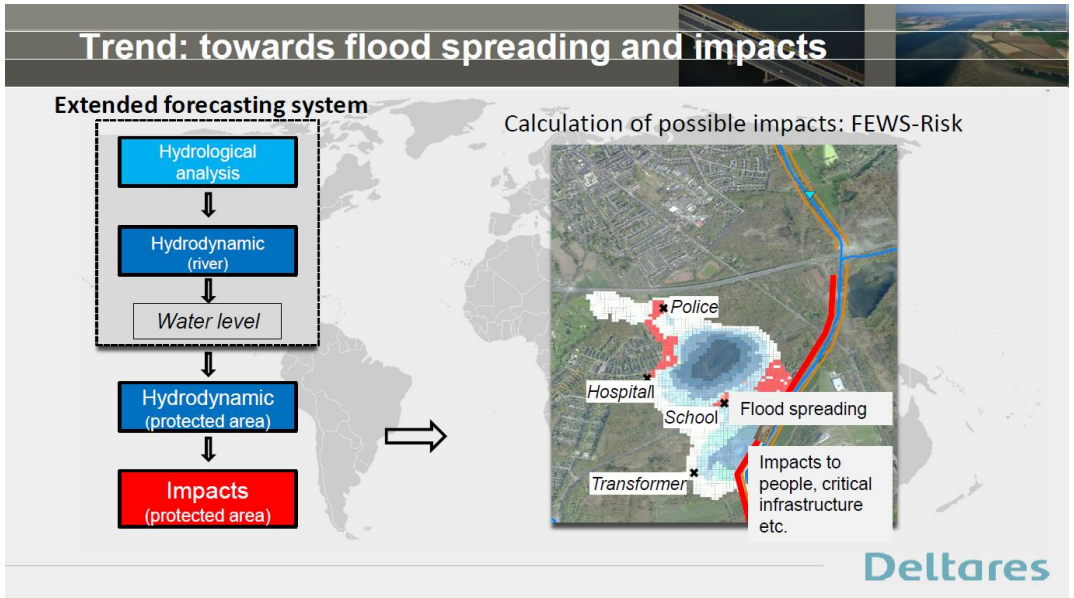
Impact based forecasting in the Delft FEWS community

Peerce & De Kleermaeker, 2019

"After a demo of the Mackay inundation forecasting (research) system we asked the district disaster and emergency coordinators…

1. What decisions do you make that are affected by weather?
2. Where do you get the information from currently?
3. How would you improve on it if you had a magic wand?

And they said…. "



Boot, 2018

DOI: 10.1111/jfr3.12587

ORIGINAL ARTICLE

CIWEM Chartered Institution of Water and Environmental Management | Journal of Flood Risk Management | WILEY

Exploring protective decision-making in the context of impact-based flood warnings

Erika R. Meléndez-Landaverde[1] | Micha Werner[1,2] | Jan Verkade[2]

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Recognising that multiple knowledges are used in taking a response decision

Journal of Applied Meteorology and Climatology

Volume 56: Issue 8

Sections

References

Editorial Type: Article

Article Type: Research Article

The Best of Both Worlds: A Decision-Making Framework for Combining Traditional and Contemporary Forecast Systems

Roan D. Plotz, Lynda E. Chambers, and Charlotte K. Finn

Print Publication: 01 Aug 2017

DOI: https://doi.org/10.1175/JAMC-D-17-0012.1

Page(s): 2377–2392

Natural Hazards
https://doi.org/10.1007/s11069-022-05468-8

REVIEW ARTICLE

Check for updates

Exploring the integration of local and scientific knowledge in early warning systems for disaster risk reduction: a review

Thirze D. G. Hermans[1] · Robert Šakić Trogrlić[2] · Marc J. C. van den Homberg[3] · Hannah Bailon[3] · Rebecca Sarku[1] · Anuszka Mosurska[1]

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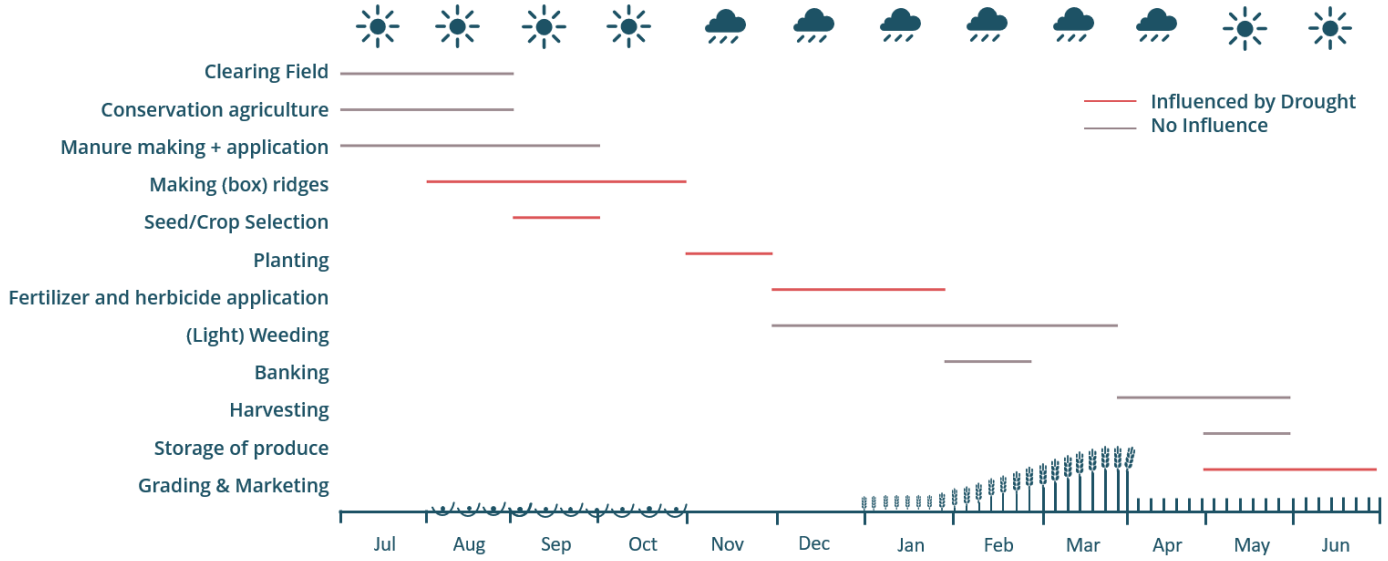
Example: Combining local knowledge and scientific data for drought early warning: Salima, Mangochi & Zomba Districts, Malawi



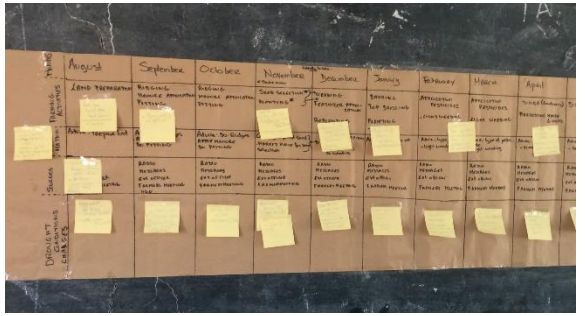
Agricultural Practices during the Season and the Influence of Drought (source: Streefkerk, 2021)

3 examples of many identified

Decision Type	Activity	Criteria	Cues	Month
When	Manure Making	Drought Conditions	Advice (Extension); from seas. forecast	October
What	Seed selection	Drought or Normal	Advice (Extension): from seas. forecast	Nov/December
What	Applying Pesticides	Type of pests	Advice (Extension)	Feb/March

Environmental cues and actions farmers take (after Calvel et al, 2020)

Exploring seasonal calendar in a Focus Group Discussion (Streefkerk et al, 2021)



Farming calendar built during focus group discussions with farmers (Calvel et al, 2020)

Calvel A, Werner M, van den Homberg M, Cabrera Flamini A, Streefkerk I, Mittal N. Whitfield S. Langton Vanya C. Boyce C. 2020. Communication Structures and Decision Making Cues and Criteria to Support Effective Drought Warning in Central Malawi. Front. Clim. 2:578327. doi: 10.3389/fclim.2020.578327

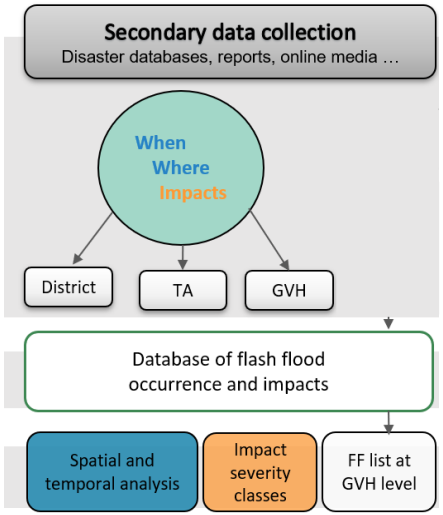
Example: Using local knowldge to identify hydro-meteorological conditions associated with flash flooding and catchments susceptible to flash flooding: Karonga, Malawi

Building common knowledge of flash flooding – where, when, why & signs

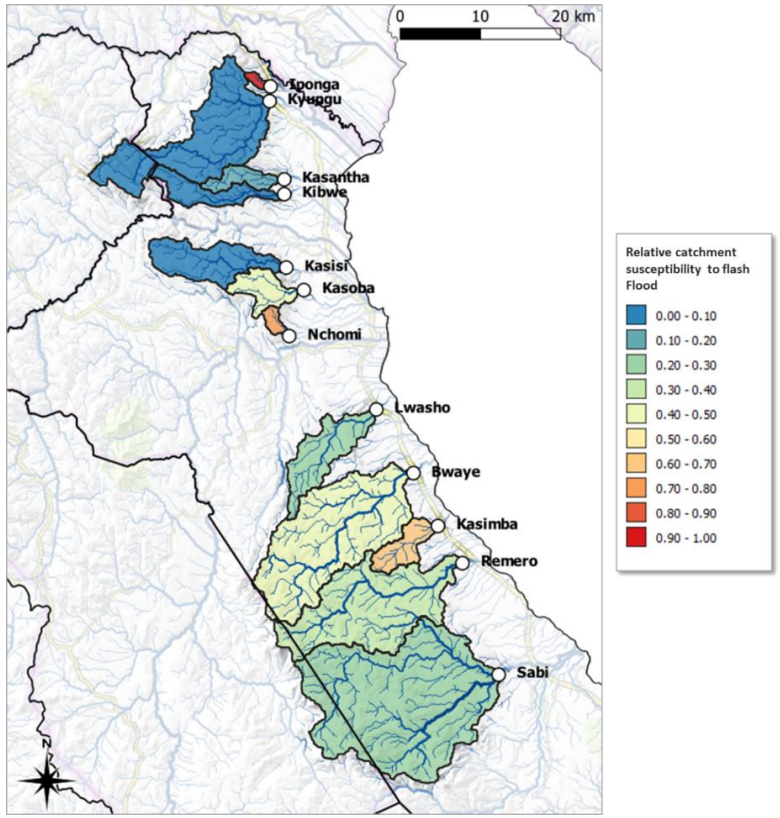
Transect walks

Focus Group Discussions

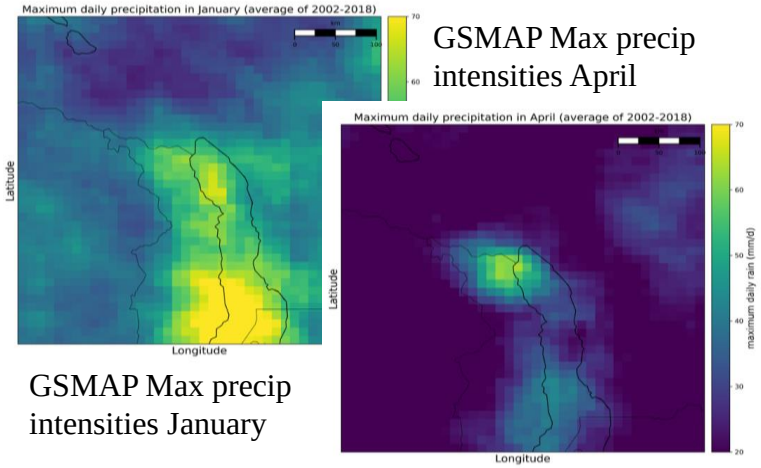
Community drawing



Mapping flash-flood susceptibility based on geomorphological data



Identifying hydro-meteorological conditions associated with flash flooding



GSMAP Max precip intensities April

GSMAP Max precip intensities January

ECMWF CDS

Wind Speed & Direction
Temperature & Humidity
Convective available potential energy
Soil Moisture

510 AN INITIATIVE OF THE NETHERLANDS RED CROSS

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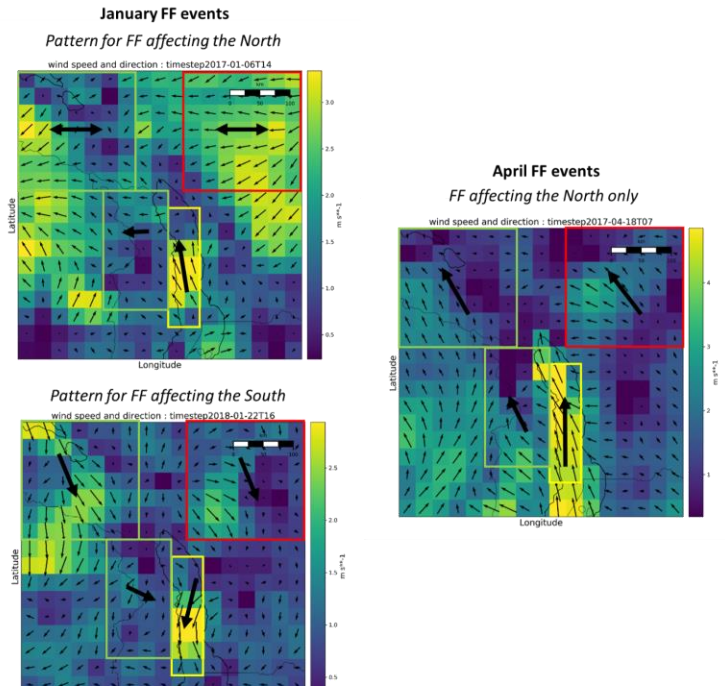
Bucherie A., Werner M., van den Homberg M., Tembo S., 2022, Flash Flood warning in context: combining local knowledge and large-scale hydro-meteorological patterns. Nat. Hazards Earth Syst. Sci., 22, 461–480, https://doi.org/10.5194/nhess-22-461-2022.

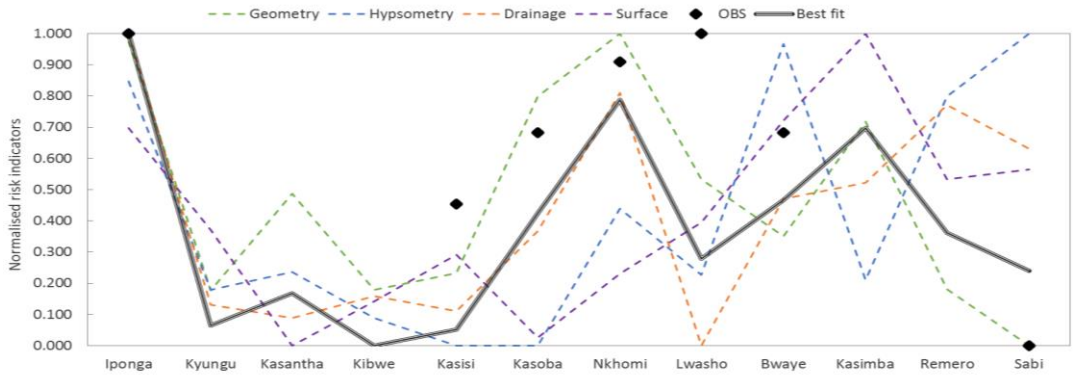
Example: Using local knowldge to identify hydro-meteorological conditions associated with flash flooding and catchments susceptible to flash flooding: Karonga, Malawi

What the people were saying ⟺ What the data were saying

Local & Scientific hydro-meteorological Knowledge

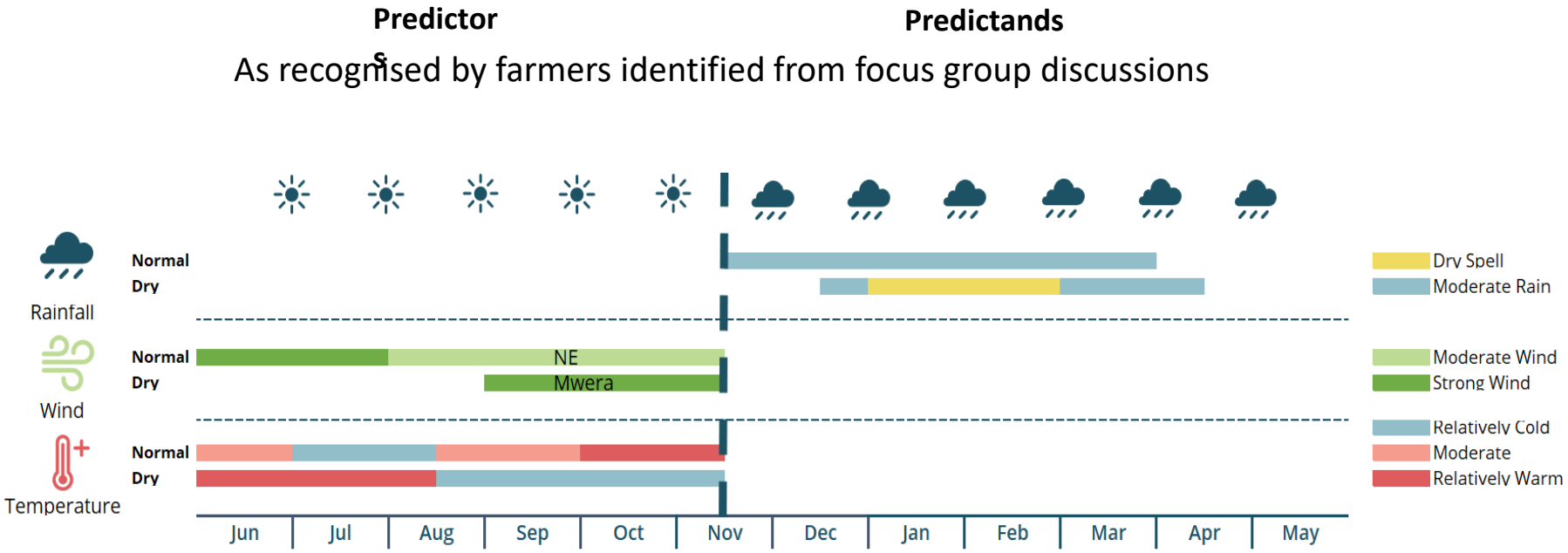
Precipitation	Short and intense precipitation events are indicated as the main trigger of flash floods for all communities.	The analysis of high resolution GSMaP precipitation during flash flood events confirms that daily maximum hourly rainfall rates are the most important indicator explaining historical flash flood events.
Temperature	An increase of temperature is experienced before flash flood events	Daily Temperatures from ERA5 do not reveal any specific increase before FF events. However, a rise in humidity is observed in ERA5 data before flash flood events, potentially linked to an increase in ambient temperature.
Soil Moisture	The higher soil water saturation in the flat plain along Lake Malawi in April is responsible for an increased flood duration.	ERA5 volumetric soil water data confirm higher values during the late wet season and in the North.
Wind	Change in wind direction and strength associated with flash flooding. Some communities reported strong winds from the lake as a precondition to flash floods.	ERA5 wind data reveals two different regimes at the beginning and at the end of the wet season, with higher instability during the early wet season potentially linked to LK observation.
Storms	Localised storms, with rotating black clouds and thunder are described as conditions associated with flash floods.	ERA5 CAPE and Relative Humidity are good indicators of the susceptibility of convective events developing. These show promising signals of FF potential during the early wet season.





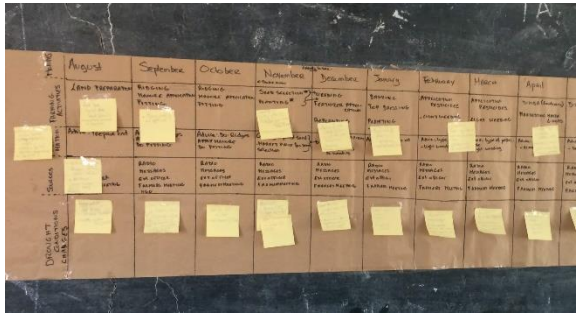
Bucherie A., Werner M., van den Homberg M., Tembo S., 2022, Flash Flood warning in context: combining local knowledge and large-scale hydro-meteorological patterns. Nat. Hazards Earth Syst. Sci., 22, 461–480, https://doi.org/10.5194/nhess-22-461-2022.

Example: Combining local knowledge and scientific data for drought early warning: Salima, Mangochi & Zomba Districts, Malawi



Conditions before and in the rainy season during normal and dry conditions, according to farmers. NE = North Easterly winds. Mwera = strong South Easterly winds (Source: Streefkerk et al, 2021)

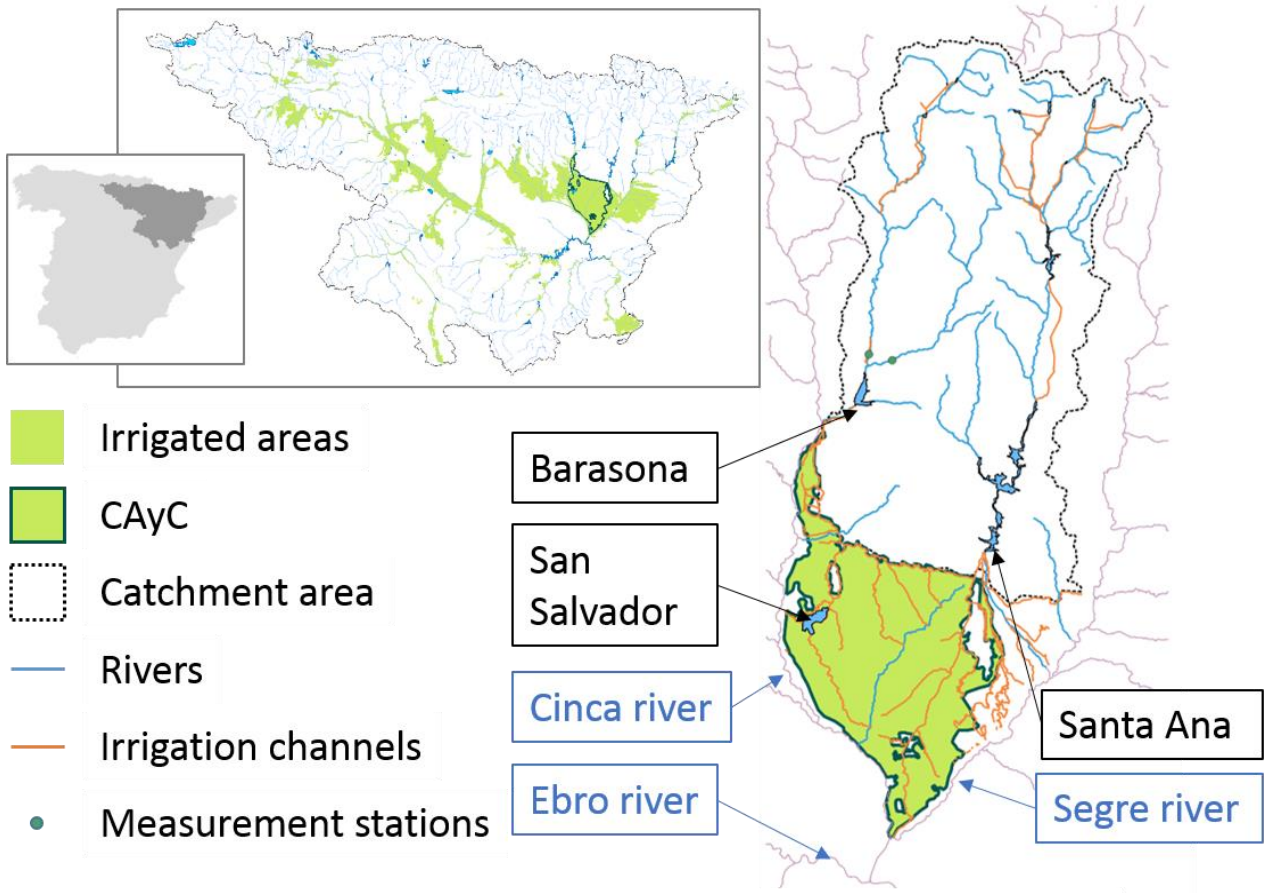
Exploring seasonal calendar in a Focus Group Discussion (Streefkerk et al, 2021)



Farming calendar built during focus group discussions with farmers (Calvel et al, 2020)

Streefkerk I, van den Homberg M, Whitfield S, Mittal N, Pope E, Werner M, Winsemius H, Comes T, Ertsen M. 2021. Contextualising seasonal climate forecasts by integrating local knowledge on drought in Malawi. Climate Services, 25, 100268, https://doi.org/10.1016/j.cliser.2021.100268

Example: Water Allocation in the Ebro Basin, Spain – Key questions in managing drought impacts



Irrigation Association

What do they want to know?
Availability & demand to end of Season

What are they worried about?
Not having enough to reach end of season

What influences those worries?
Uncertainty of inflow to reservoir
Uncertainty of demand – what will the farmers do?

Farmers

What do they want to know?
Water available to end of season

What are they worried about?
Not getting enough for planted crops

What influences those worries?
Formal information & perceptions of available water – What will the operator do? Apply curtailments that reduce yield & reduce return on investment?

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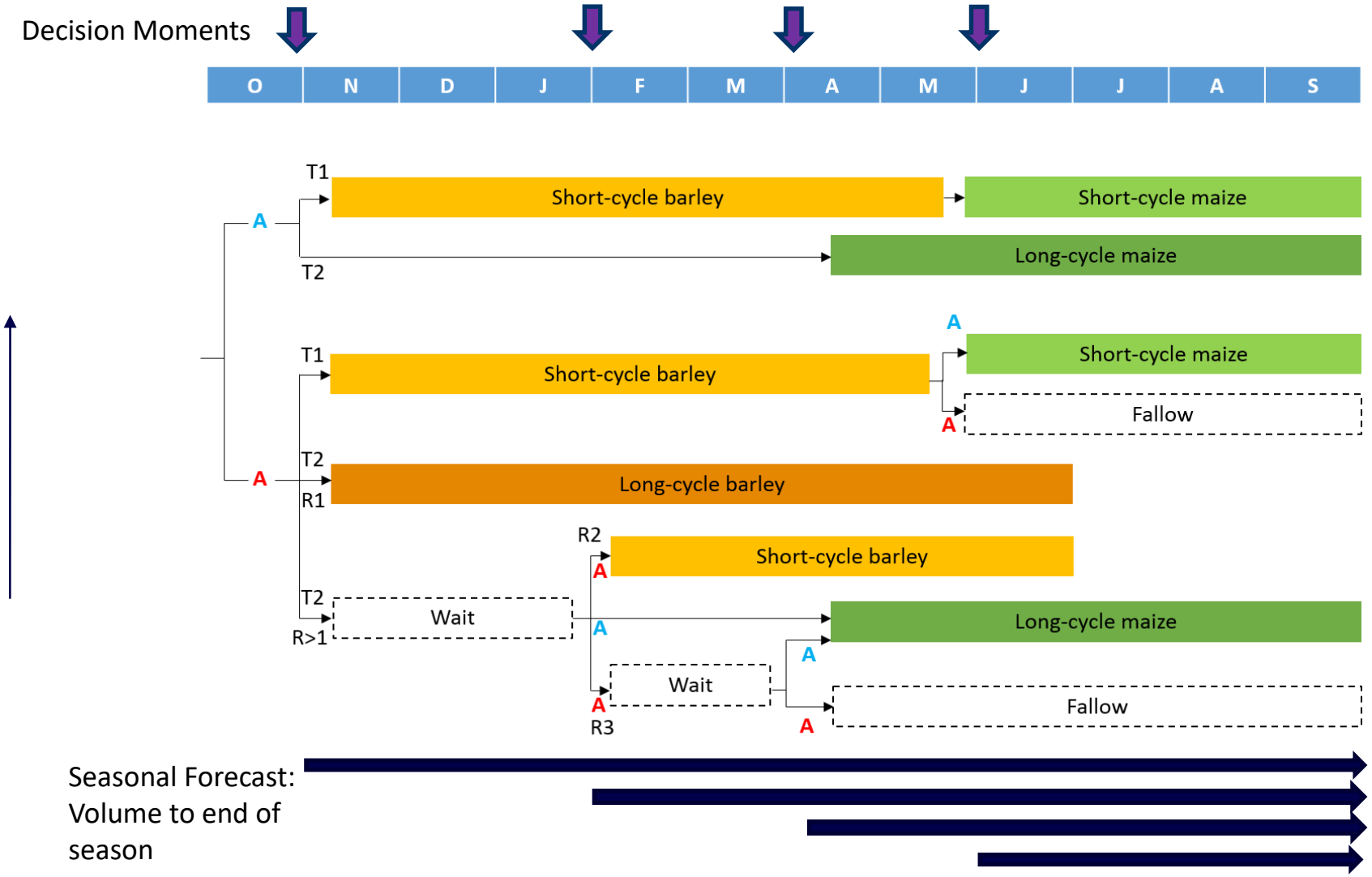
Linés, C., Iglesias, A., Garrote, L., Sotés, V., and Werner, M.: Do users benefit from additional information in support of operational drought management decisions in the Ebro basin?, Hydrol. Earth Syst. Sci., 22, 5901-5917, https://doi.org/10.5194/hess-22-5901-2018, 2018

Example: Water Allocation in the Ebro Basin, Spain – Key questions in managing drought impacts

Available Water Resource Estimation (expected supply and demand)

Decision on planting (influencing demand)



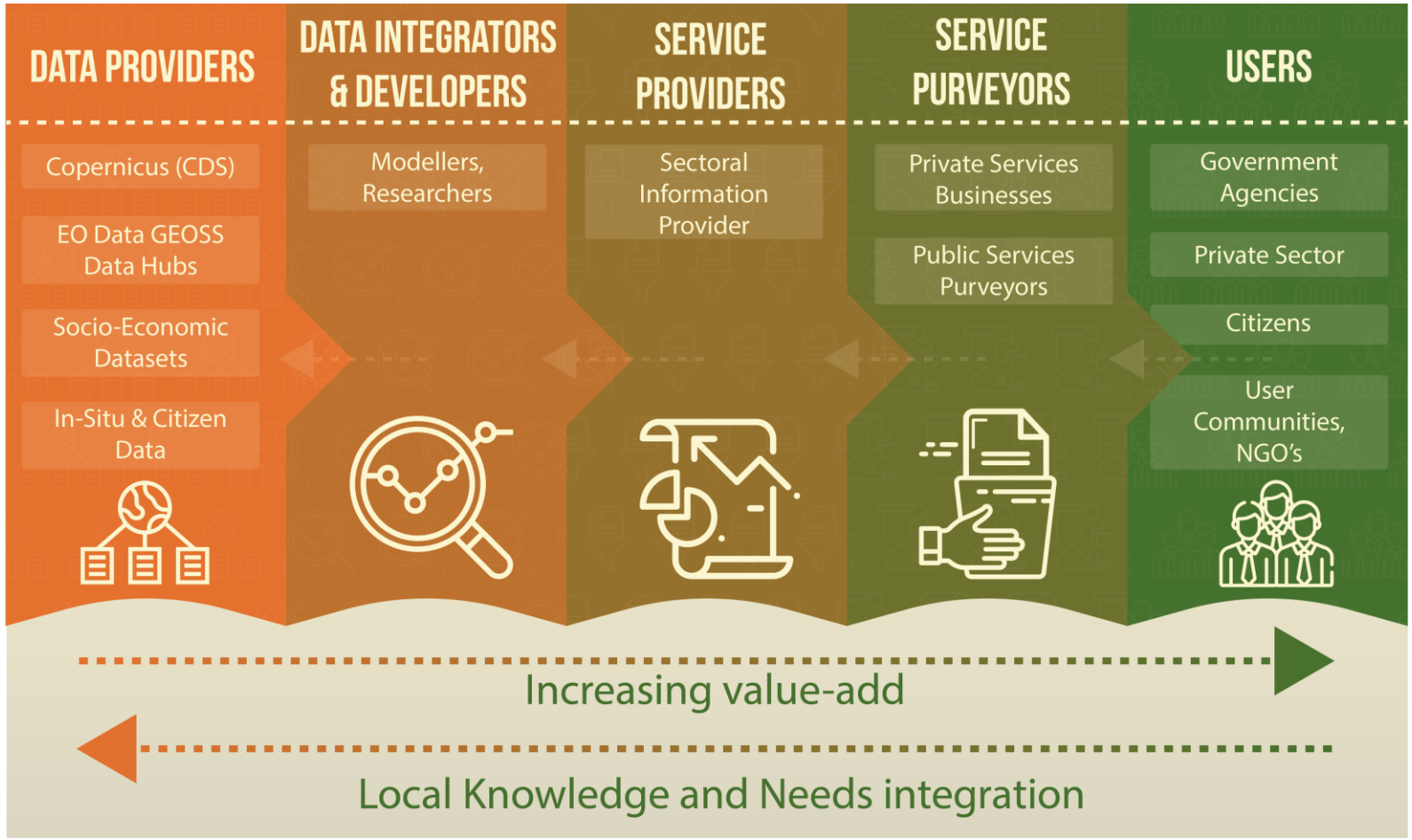
Linés, C., Iglesias, A., Garrote, L., Sotés, V., and Werner, M.: Do users benefit from additional information in support of operational drought management decisions in the Ebro basin?, Hydrol. Earth Syst. Sci., 22, 5901-5917, https://doi.org/10.5194/hess-22-5901-2018, 2018

A question of equity – who benefits and who does not?

Subsistence Maize Farming, Lesotho

Irrigated agriculture, Ebro Basin, Spain

H2020 EU-Project: Innovating Climate Services through Integration of local & Scientific Knowledge



Key objectives

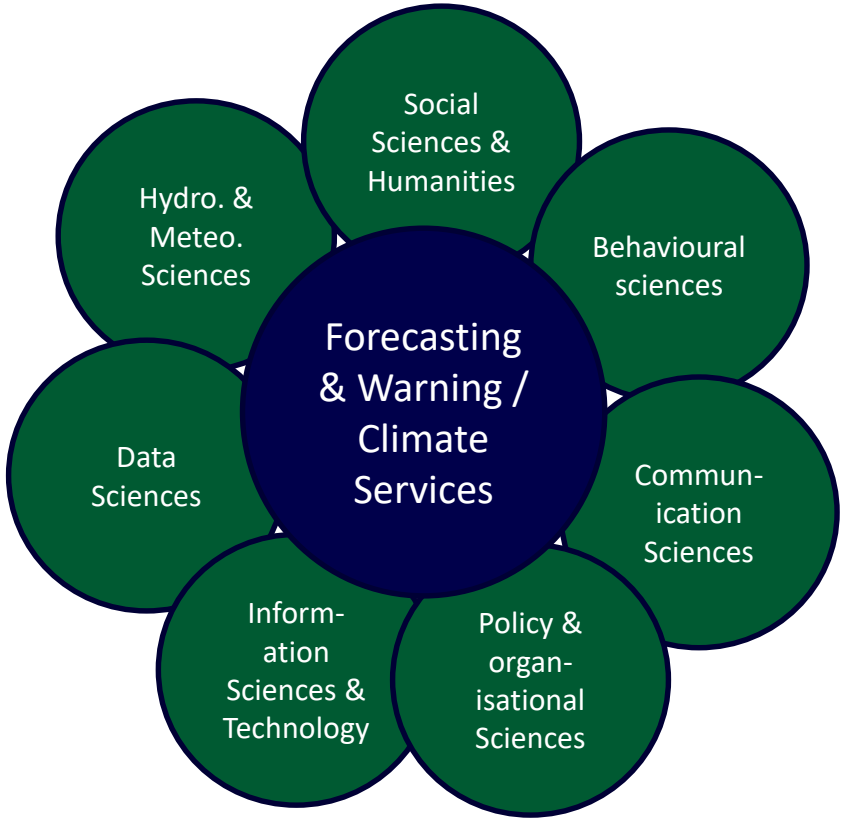
- Framework for co-creation of next-generation, human-centred climate services
- Advance integration of scientific [Copernicus, GEOSS, etc) & local data and knowledge
- Foster access to & use of climate information and insights into short and long term feedbacks to avoid maladaptation
- Demonstrate value-proposition through pre-operational CS co-created with actors in Seven Living Labs

I-CISK
HUMAN CENTRED CLIMATE SERVICES

https://icisk.eu

The science and practice of forecasting has come of age…

A seasoned professional!
Irrigation canal headworks operator for 42 years, Alazani Basin, Georgia



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..right on time to meet new global challenge

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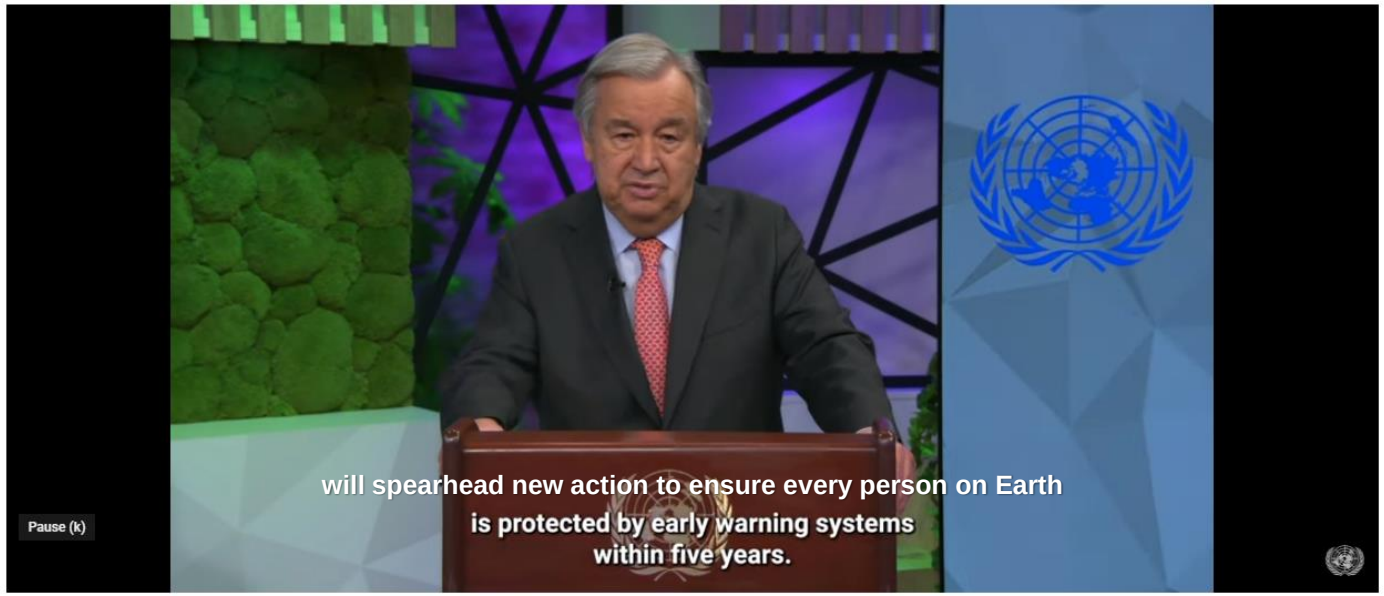
UN weather agency to spearhead 5 year early warning plan, boosting climate action

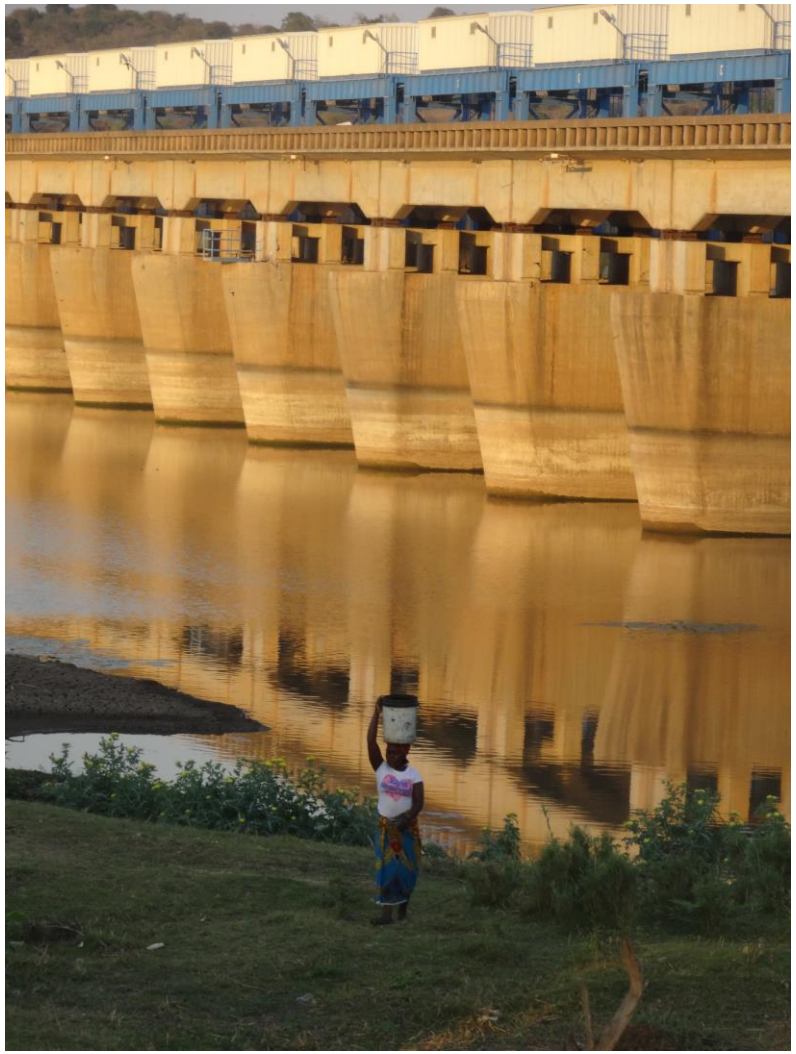


António Guterres (UN Secretary-General) on the International Meteorological Data (March 23rd).…….plan of action to be announced at COP27

…with many challenges ahead

- *A hydometeorological challenge*: developing skillful forecasts to support decision making at scales relevant to users
- *A data challenge*: availability and reliability of (in-situ) data at the global scale
- *A capacity and sustainability challenge*: establishing sufficient expertise at global scale and maintaining investment & commitment
- *A social challenge*: understanding how environment, people and livelihoods are impacted, the options available, and the social, economic, behavioural and political realities within which decisions are taken
- *An equity challenge*: ensuring all benefit, particularly those more vulnerable
- *A transdisciplinary challenge*: bringing together different scientific, local and indegenous knowledges to enhance trust and usage

We will no doubt discuss and contribute to addressing some of these challenges!!



Thanks

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