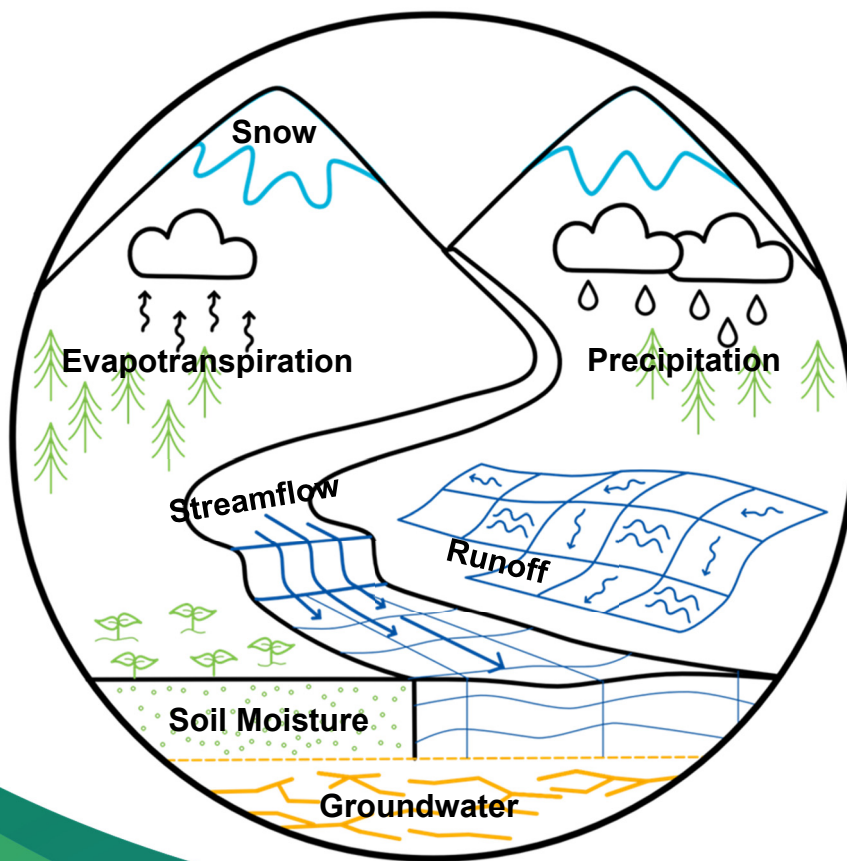




Online Workshop on Hydrological Forecasting: Training Needs and Opportunities

Organised by UK Centre for Ecology & Hydrology and West African Science Service Centre on Climate Change and Adapted Land Use

Adelaide Asante, Elsie Baeta, Lucy Barker, Amulya Chevuturi, Nathan Rickards, Martha Schlegel (UKCEH)

Benjamin Lamptey, Daouda Kone, Julien Adoukpe (WASCAL)

Arsène Kiema (AGHYMET)

2 September 2025



UK Centre for
Ecology & Hydrology

**NATIONAL CAPABILITY
FOR GLOBAL CHALLENGES**



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1. Workshop Aims

As the frequency and severity of hydrological hazards continue to increase under a changing climate, hydrological forecasting is becoming increasingly important for risk mitigation and resilience building. It has consequently emerged as a global priority for both scientific advancement and operational development. Against this backdrop, the online workshop on *“Hydrological Forecasting: Training Needs and Opportunities”*, held on 2 September 2025, focused on assessing the current landscape of hydrological forecasting in the West Africa region.

This workshop was jointly organised by the UK Centre for Ecology & Hydrology (UKCEH) and the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), with support from the UK Natural Environment Research Council’s National Capability for Global Challenges Programme.

The workshop brought together scientists and practitioners from across West Africa to discuss training needs, share experiences, and explore opportunities in the field of hydrological forecasting. Expert presentations from regional institutions, WASCAL and AGHRYMET, provided valuable context on ongoing activities and challenges across the region.

The workshop aimed to assess current capacity and identify priority areas for training in hydrological forecasting, with a focus on three key themes: forecast applications, hydrological datasets and hydrological modelling and tools. Through interactive discussions, participants were invited to share their perspectives on data requirements, modelling approaches, and the operational use of forecasts, as well as to highlight challenges such as infrastructure constraints and access to resources. During the sessions, particular attention was given to understanding the diversity of stakeholders engaged in hydrological forecasting, their levels of experience, and the specific topics or tools they considered most relevant to their work.

A key objective of the workshop was to inform the design of a hands-on, in-person training workshop to be held in Accra, Ghana, in early 2026. By capturing the perspectives of diverse stakeholders, the workshop aimed to ensure that upcoming and future training opportunities are aligned with the practical needs of hydrological forecasting in West Africa, thereby contributing to sustained capacity building and stronger regional collaboration in this field.



1.1 Agenda

Time (GMT)	Topic
09:00 – 09:15 (Talk)	Adelaide Asante (UKCEH) Presentation: Welcome and introduction to the aims of the workshop
09:15 – 09:30 (Talk)	Julien Adoukpe (WASCAL) Presentation: WASCAL's contribution to the advancement of Hydrological Science in West Africa
09:30 – 10:20 (Talk + Discussion)	Theme 1: Hydrological Forecast Applications, Lucy Barker (UKCEH) Presentation: Overview of projects and activities using seasonal forecasts at the global scale, and services providing regional to local operational forecasts (e.g., C3S Water Service, HydroSOS). Breakout discussion aims: To explore participants' 1) needs and requirements for seasonal forecasts (e.g., variables, lead times, spatial scales, data access and user guidance); and 2) the decisions users need to make using hydrological seasonal forecast information.
10:20 – 11:10 (Talk + Discussion)	Theme 2: Hydrological Datasets, Amulya Chevuturi (UKCEH) Presentation: Overview of hydrological data access, generation and analysis. Breakout discussion aims: To explore participants': 1) experience in data access (e.g., portals, peer-to-peer transfer, or APIs), and types of data they are interested in (e.g., observations, forecasts, climate projections and common formats of data used); and 2) preferred programming languages, platforms and data analysis approaches (e.g., forecast verification, visualisation, statistical analysis, parallel computing).
11:10 - 11:25	Break
11:25 – 11:40 (Talk)	Arsène Kiema (AGRHYMET) Presentation: Objective Seasonal Hydrological forecasting in West Africa and Sahel
11:40 – 12:30 (Talk + Discussion)	Theme 3: Hydrological Modelling & Tools, Nathan Rickards (UKCEH) Presentation: Overview of selected water resources modelling approaches and their applications. Breakout discussion aims: To 1) explore participants' experience with modelling tools, methods and coding languages; and 2) identify current needs, challenges, and areas of interest for further learning and application of water resources modelling and tools.
12:30 – 13:00 (Discussion)	Martha Schlegel (UKCEH) Group discussion: Next steps for hands-on training in 2026 and final Q/A.
Workshop close	

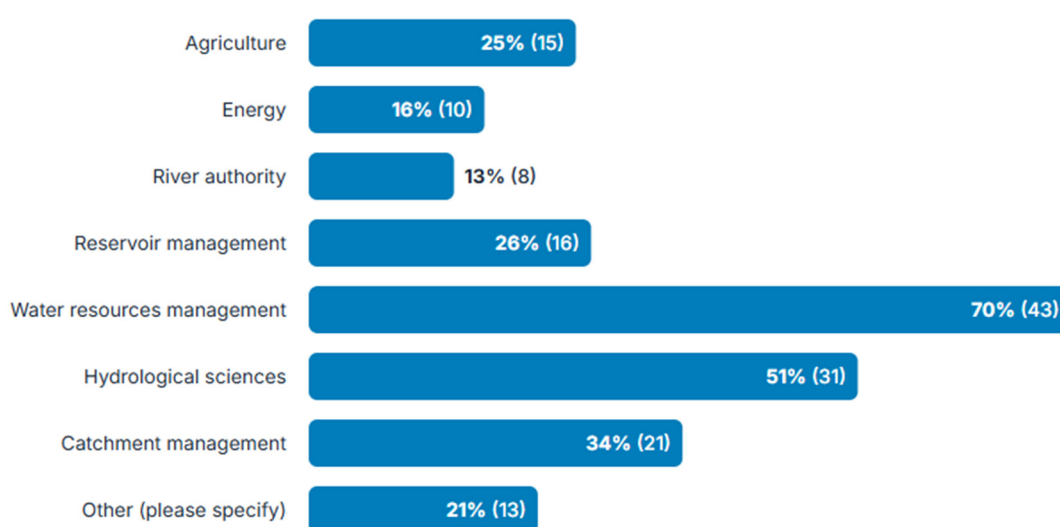


1.2 Registered participants survey

Participants registered for the online workshop. A total of 61 people registered, and of those 50 (82%) attended the workshop.

Most of those registering were from Ghana, but with participants also registering from Niger, Tunisia. 78% of those registering worked at Government Agencies, 16% in academia/research, 3% for NGO/non-profits and 3% 'other' (international/regional agencies).

The distribution of sectors represented are shown below (61 responses, multiple answers allowed).



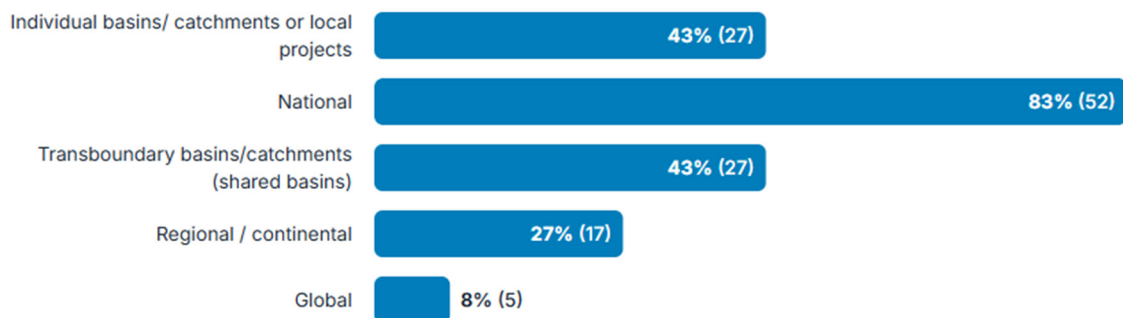
The 'other' sectors represented span technical, environmental, social, and disaster-related domains. There was a strong emphasis on water-related services, climate forecasting, and public health infrastructure.

Those registered were also asked about the spatial scale at which they work, the variables they use/are most relevant to their work, their use of global gridded data, in-situ observations, global/regional forecast products and hydrological models, and finally the topics of interest for the in-person training. These results are summarised below.



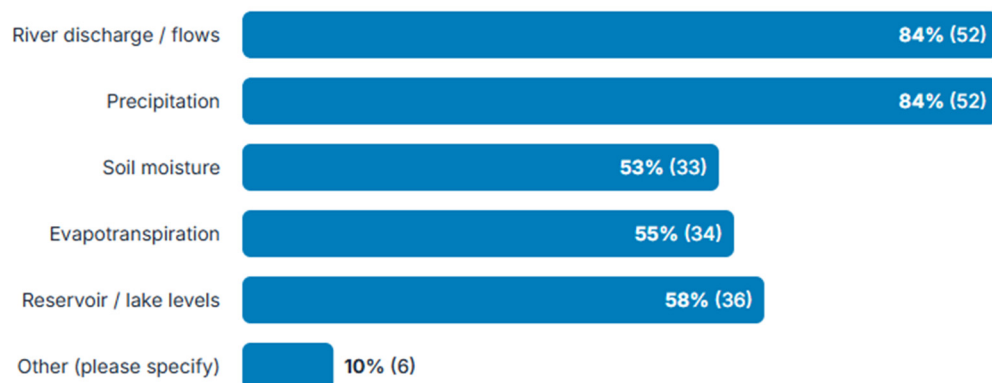
9. At what spatial scale do you work on? (multiple answers allowed)

Responses: 63



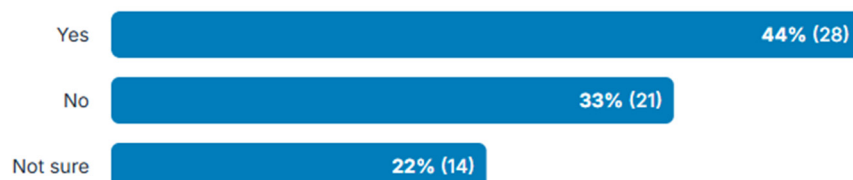
10. Which hydrological variables are most relevant to your work? (multiple answers allowed)

Responses: 62



11. Do you currently use any global gridded observations/reanalysis datasets (e.g., CHIRPS, TAMSAT, ERA5-Land) in your work?

Responses: 63

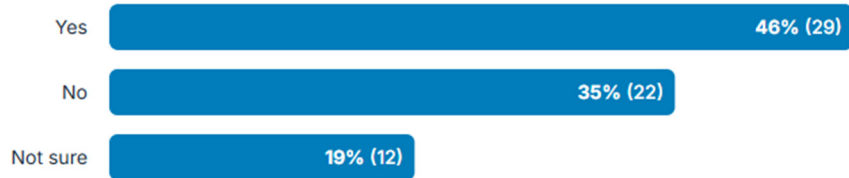


- CHIRPS was the most widely used dataset
- TAMSAT and ERA5/ERA5-Land were also frequently used, often in combination with CHIRPS
- There was a mix of satellite-based, station-based, and reanalysis datasets.
- The presence of Copernicus and JRA-3Q suggests interest in broader climate and marine variables beyond precipitation



13. Do you currently use any in-situ hydrological data (e.g., observations or model data) in your work?

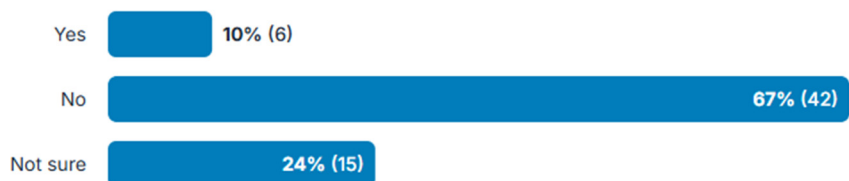
Responses: 63



- The data sources span global (GRDC, ROBIN), national (NRFA, GMet), and local (Black Volta gauges) sources
- There was a strong emphasis on observational hydrology, with some use of modelled and derived data (e.g., rating curves, hydrodynamic models)
- The variables cover both surface water (discharge, water level) and climate drivers (rainfall, temperature)

15. Do you currently use any global forecast products (e.g., GloFAS) for hydrological applications?

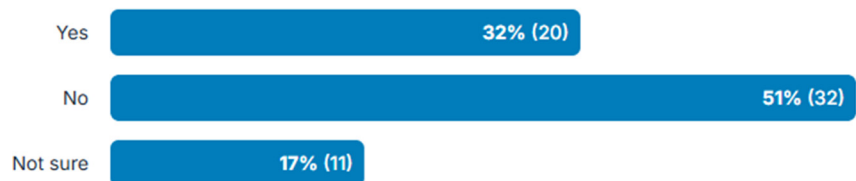
Responses: 63



- The systems listed include global-scale seasonal and hydrological forecasting systems, with a mix of multi-model ensembles, climate services, and operational models
- GloFAS was commonly noted, and SEAS5, WMO ensemble, WW-HYPE were also mentioned

17. Do you currently use hydrological models in your role?

Responses: 63



- SWAT, HEC-HMS, and HEC-RAS were the most frequently mentioned, often used together for comprehensive hydrological and flood studies
- WEAP was highlighted for catchment-scale planning and water allocation.
- GIS tools were used for spatial data handling and model integration
- Advanced models like ParFlow and WRF-Hydro suggest interest in high-resolution, process-based hydrological simulations



19. Do you currently provide/use any hydrological forecasts for West Africa in your role?

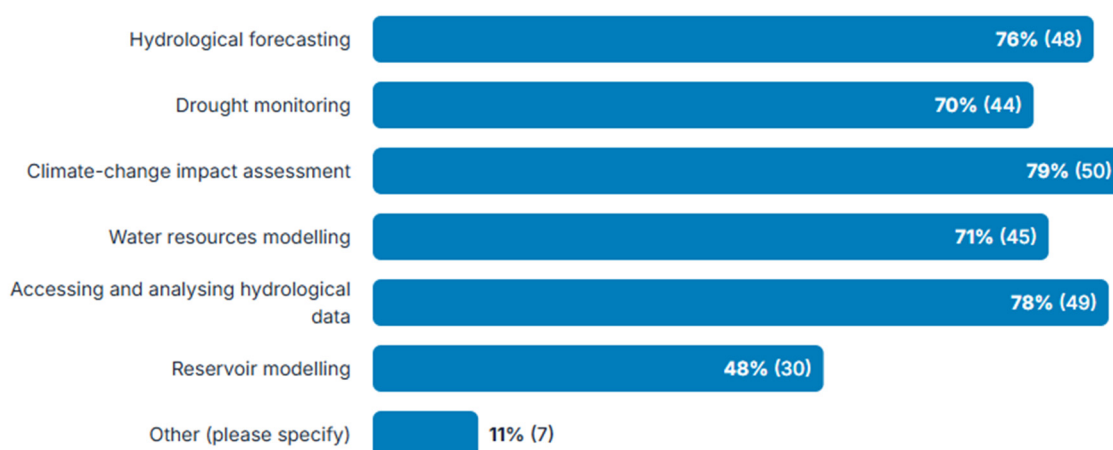
Responses: 62



- The focus was on seasonal climate forecasting, hydrological early warning, and impact bulletins for West Africa, especially the Volta Basin
- Tools like SPI, soil moisture, and regional forums (PRESASS, PRESAGG) are central to drought and flood preparedness
- National agencies (e.g. GMet) and platforms (e.g. MyDEWETRA, Volta-Alarm) support localized forecasting and decision-making

21. We are planning to run an in-person training workshop on hydrological forecasting in 2026 in Accra. Which of the following topics would you be MOST interested in attending? (multiple answers allowed)

Responses: 63



The other results could be split into two groups:

(1) Technologies & Platforms

- Cloud computing – for scalable data storage and processing
- GIS and Remote Sensing – for spatial analysis and environmental monitoring
- R programming – used for statistical analysis and modelling

(2) Environmental & Hydrological Modelling

- Soil moisture modelling
- Water quality modelling
- Flood risk maps
- Marine coastal modelling and analysis



2. Keynote Talks

2.1 Welcome address

Adelaide Asante, Head of West Africa Office for the UK Centre for Ecology & Hydrology, opened the workshop by welcoming participants and expressing gratitude to the co-organisers, WASCAL. She highlighted the UKCEH West Africa Office's aim of driving diverse capacity-building initiatives across the region, noting that this workshop exemplifies such efforts. She emphasised that these activities form part of UKCEH's broader commitment to fostering partnerships and collaborations throughout West Africa. She also outlined the workshop's objective of identifying training needs in hydrological forecasting, with the aim of tailoring the in-person training planned for early 2026 and informing the development of further programmes to strengthen long-term capacity in this field.

2.2 WASCAL presentation

Julien Adoukpe, Director of WASCAL Climate Change and Water Resource Doctoral Programme UAC/Benin, presented on "*WASCAL's contribution to the advancement of Hydrological Science in West Africa*".

The presentation highlighted the disproportionate impacts of climate change on Africa, which contributes only 4% of global greenhouse gas emissions yet faces severe vulnerabilities, compounded by limited resources to respond effectively. Established in 2012 as a consortium of ten West African countries, WASCAL's mission is to build regional capacity, enhance the density of observational networks, and deliver climate services. Capacity building has been achieved through PhD and MSc fellowships, as well as scientific research undertaken at the competence centres. Recognising gaps in hydrological data collection, WASCAL has prioritised expanding observational networks by commissioning multiple automatic weather stations and improving climate services. These efforts are supported through partnerships with universities, meteorological agencies and hydrological agencies worldwide.

A copy of the slides from the presentation can be found below.



**WASCAL CONTRIBUTION TO THE
ADVANCEMENT OF HYDROLOGICAL SCIENCE
IN WEST AFRICA**
Prof Julien Adoukpe
Director DRP on CC@WR
University of Abomey Calavi
Benin Republic
????????
02 September 2022

OUTLINE

WASCAL

- Creation
- Mission
- Vision
- Achievements
- Perspectives

BACKGROUND

- AFRICA IS PAYING HIGH PRICE FOR CLIMATE CHANGE IMPACTS EVEN THOUGH ITS CONTRIBUTION TO GHG EMISSION IS LESS THAN 4%
- IMPACTS ARE SEVERE DROUGHT, FLOODING, SEA LEVEL RISE WITH THEIR CONSEQUENCES
- LACK OR LITTLE HUMAN RESOURCE AND EQUIPMENTS TO DEAL WITH THE CLIMATE CHANGE ISSUES
- WASCAL created in February 2012, 10 WA Countries with the former BMBF (BMFTR =Federal Ministry of Research, Technology and Space)

MISSION

Filling up the gap by:

- Empowering (Capaciting) young scientists for research
- Densifying the observatory network for data collection
- Providing Climatic Services

**1- CAPACITY
DEVELOPMENT/BUILDING
DEPARTMENT**

2- COMPETENCE CENTER

WASCAL GRADUATE SCHOOLS IN WEST AFRICA

2012: 6 Masters, 6 PhDs

2019: 11 PhD Programmes, 6 Master Programmes, 4 up-graded to PhD, 4 Masters in Green Hydrogen

Legend: H2O, H2O + H2O, H2O + H2O + H2O

Climate change & Education, Climate change & Economics, Climate change & Agriculture, Climate change & Energy, Climate change & Human Habitat, Climate change & Disaster Risk Management, Climate change & Biodiversity, Climate change & Forestry, Climate change & Land Use, Climate change & Disaster Risk Management, Climate change & Water resources

ACHIEVEMENTS

700 enrolled, 100% scholarship, 17 PARTNERSHIPS FOR THE GOALS

13 GRADUATE SCHOOLS	Graduates
Climate change and Water Resources -UAC- Benin	40
Climate change and Land Use -Kumasi Ghana	49
West African Climate Systems FUTA Nigeria	50
Climate change Economics -UCAD Senegal	51
Climate change and Disaster Risk Management Togo	22
Climate change and Human Habitat -Mina Nigeria	20
Climate change and Biodiversity UPHB Cote d'Ivoire	38
Climate change and Agriculture (PR) Mali	36
Climate change and Education The Gambia	20
Climate change and Energy UAM Niger	20
Informatics for Climate Change UKI Burkina Faso	52
Climate Change and Marine Science Capa Verde	34
224 MSc. + 380 PhD	604

RESEARCH

PhD students
Masters students
Over 1,000 papers published in
Highly ranked Journals

**INTERNATIONAL MASTER
PROGRAMMES in
ENERGY & GREEN HYDROGEN**

Energy sector, mitigating GHG emission, CO2, basically

Cote d'Ivoire: Green Hydrogen Production & Technology/Geo Resources (Water, Wind)

Niger: Photovoltaic and System Analysis for Green Hydrogen Technologies

Senegal: Economics/Policies/Infrastructures and Green Hydrogen Technology

Togo: BioEnergy/Biofuel&Green Hydrogen Technology

WHERE WASCAL ALUMNI ARE OPERATING

University 29%, Self-employment, PhD 18%, Post Doctor fellow 6%, Private sector/NGO 18%, Ministries 8%, Research center/Service Provider 17%

ICRISAT, CCAAF, Institute of Rural Economy, Principal Environmental Scientist with the National Oil Spill Detection and Response Agency, NOSDRA (climate Change and Land Use), National Institute for Legislative and Democratic Studies (NILDS) Abuja (climate Change Economics), Center for Development Research, Team Leader, Islamic Development Bank, Jeddah, UAE, Post Doc, ClimAfrica Post-doctoral Researcher,

COMPETENCE CENTER

❑ **RESEARCH ON CC, IMPACTS AND ADAPTIVE SOLUTIONS**
WRAP 1 & WRAP 2

❑ **variables Measurement in ECOWAS**
(SOCLIME) 2,896,438 EUROS,

❑ **GERMAN COLLABORATION**

❑ **METEOROLOGICAL AGENCIES ACROSS WEST AFRICA**

❑ **HYDROLOGIC AGENCIES**

In a concerted effort with the German Government (BMBF) and its member countries, WASCAL has successfully completed the overall evaluation of the existing hydro-climate observation networks of West Africa. Then, it has deployed and equipped the national observation networks with fifty (50) automatic weather stations (AWS) and 60 Hydrological sensor (AHS)

www.wascal.org

CLIMATIC SERVICES

- Between 2017-2018 50 AWS were commissioned and installed by WASCAL
- An increase 40% of the previous synoptic network
- WASCAL has further commissioned sixty (60) cutting-edge water level and quality which are being deployed across major river basins for the benefit of flood disaster early warning and forecasting (Figure 2).
- This effort has greatly improved the densification of the measurement network, thus the availability of climatic data in the region,
- However, there are still gaps to be filled.

www.wascal.org

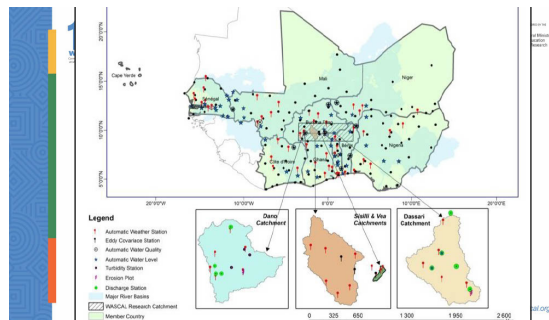


Table 1 : Number of WMO synoptic stations^a and acquired BMBF funded AWS per country

Name of countries	Number of synoptic stations on WMO platform	Number of AWS acquired in 1 st phase
Benin	3	4
Burkina Faso	9	6
Cape Verde	3	
Cote d'Ivoire	11	6
The Gambia	1	3
Ghana	25	6
Mali	9	5
Niger	16	5
Nigeria	9	6
Senegal	14	5
Togo	10	4
Total	110	50

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PARTNERSHIPS

❑ **GERMAN COLLABORATION**

❑ **METEOROLOGICAL AGENCIES ACROSS WEST AFRICA**

❑ **HYDROLOGIC AGENCIES**

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Strong collaboration with German Institutions for training and research

Some areas of Collaboration

- Sustainable collaboration
- Fund raising
- Research finding dissemination
- Publications
- Teaching and Research in the graduates schools
- Webinar
- Supervision
- Proposal writing and implementation
- Co-organizing events

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PERSPECTIVES

❑ **MAKE WASCAL A HUB OF CLIMATIC SERVICES FOR AFRICA**

❑ **DEVELOP CLIMATIC SERVICES TO END USERS**

❑ **WORKING WITHIN THE REGION & ACROSS AFRICA (SASSCAL)**

❑ **MUCH MORE LOOKING FORWARDS TO COLLABORATING WITH INSTITUTIONS ACROSS THE GLOBE in term of research and capacity building**

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CONCLUSION

Within 10 years period, major WASCAL objectives attained

- Human resources capacity development, over 700 PhDs and Masters graduated, contributing to combating CC through adaptive and innovative solutions,
- Densification of measurement networks, over 50 AWS deployed, along with 60 water level and quality automatic sensors

MUCH MORE LOOKING FORWARDS TO COLLABORATING WITH OTHER INSTITUTIONS ACROSS THE GLOBE in term research and capacity building

www.wascal.org

THANK YOU

WASCAL

Thank you

www.wascal.org

2.3 AGRHYMET presentation

Arsène KIEMA, expert in Hydrological Modelling at AGRHYMET, presented on “*Objective Seasonal Hydrological forecasting in West Africa and Sahel*”.

The presentation highlighted Africa’s high vulnerability to hydrological extremes, particularly floods and droughts, and the critical role of seasonal hydrological forecasts in water resource planning, disaster risk reduction, and infrastructure planning. AGRHYMET, as a Climate Regional Center for West Africa and the Sahel, currently produces consensual seasonal hydrological forecasts by combining climate model outputs, statistical techniques, and expert judgment in collaboration with national services from 17 West-Africa and Sahel countries. To improve transparency and reproducibility, AGRHYMET is developing a new generation of forecasts that integrate statistical methods, physically based hydrological models, and machine learning methods, with plans for operationalisations in the coming season. To enable adoption of the new system, AGRHYMET is launching a one-month capacity-building programme to strengthen national hydrological services across West Africa and the Sahel.

A copy of the slides from the presentation can be found below.

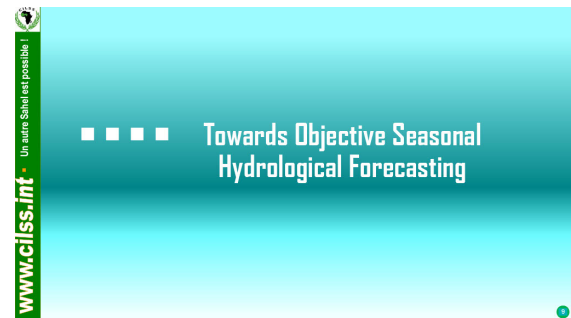
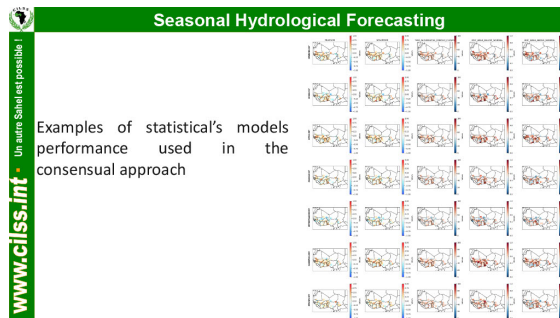
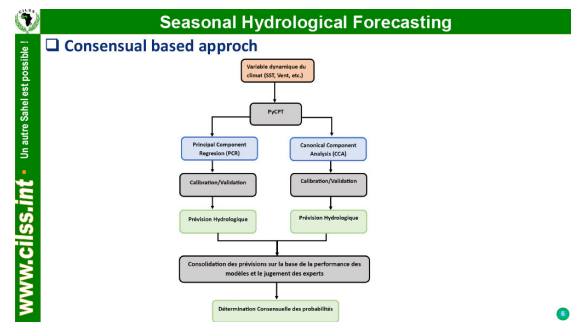
The image displays four slides from a presentation. The top-left slide is the title slide, featuring the CILSS logo and the text 'Seasonal Hydrological Forecasts in West Africa and the Sahel', 'September 2025', and 'AGRHYMET – Regional Climate Centre for West Africa and the Sahel'. The top-right slide is a blue gradient slide with the title 'Seasonal Hydrological Forecasting'. The bottom-left slide is titled 'Seasonal Hydrological Forecasting' and contains a section 'Motivation for hydrological forecasts' with three bullet points: 'West Africa is highly vulnerable to hydrological extremes (floods and droughts) due to climate variability and change.', 'Communities downstream of dams and rivers are particularly exposed to recurrent floods with severe socio-economic impacts.', and 'Seasonal hydrological forecasts are strategic services for:' followed by sub-bullets: 'Water resources planning', 'Drought and flood risk prevention', and 'Hydraulic infrastructure management'. The bottom-right slide is also titled 'Seasonal Hydrological Forecasting' and contains a section 'Motivation for hydrological forecasts' with three bullet points: 'AGRHYMET, as a Regional Climate Centre, plays a leading role in producing such forecasts to serve CILSS and ECOWAS member states.', 'In line with WMO Decision 9 (EC-72), AGRHYMET has developed the WAS-NexGen tool for operational, objective, and scientifically rigorous forecasts.', and 'WAS-NexGen tool for operational, objective, and scientifically rigorous forecasts.'



Seasonal Hydrological Forecasting

Current Approach : Overview of the consensual based hydrological forecasts

- Currently, AGRHYMET and its partenaires provide consensual seasonal hydrological forecasts. These forecasts combine:
 - Climate model outputs
 - Statistical techniques (e.g., Principal Component Regression, Canonical Correlation Analysis, etc.)
 - Expert judgement for estimating the probabilities associated with hydrological categories (deficit, normal, excess).
- At the beginning of each season, AGRHYMET organizes a **regional workshop** with national hydrology and meteorology services from 17 countries to coproduce and disseminate seasonal hydrological forecasts.



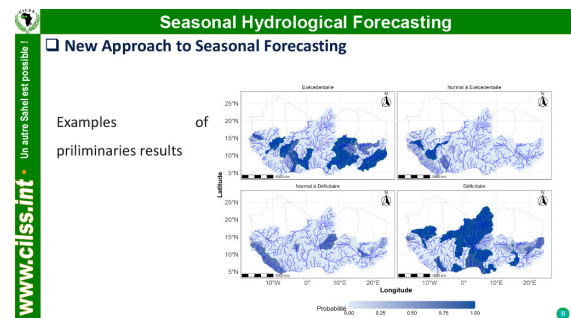
Seasonal Hydrological Forecasting

New Approach is under development to advance Seasonal hydrological Forecasting

To respond to the call for **objective seasonal forecasts**, AGRHYMET has initiated the development of a **new generation of seasonal hydrological forecasting** based on:

- Statistical methods
- Physically-based hydrological models
- Artificial intelligence algorithms

This new approach, currently under testing, could be operationalized in the upcoming season.



Seasonal Hydrological Forecasting

Key Messages

- Seasonal hydrological forecasts are critical inputs for water resources management, flood and drought risk reduction, and dam operation in West Africa.
- Current approaches rely on climate models, statistics, and expert judgment, with limited transability and reproducibility in the process.
- AGRHYMET is finalizing the developement of new generation of forecasts, combining statistical methods, physically-based hydrological models, and artificial intelligence.
- Capacity building and training are crucial to ensure that national services and stakeholders can adopt and operationalize these new forecasting tools.

Seasonal Hydrological Forecasting

Training and Capacity Building

- AGRHYMET has planned an **intensive capacity-building for NHSs in the upcoming months**.
- This training will target the **17 countries of West Africa and the Sahel national hydrological services** under the mission of AGRHYMET.
- The training will **highly be gender sensitive**
- The participants will be **appointed officially by the NHSs**;
- Private participation is also allowed

Seasonal Hydrological Forecasting

Thank you for your kind attention!

2.4 Wrap-up session

The closing session featured an open Q&A, giving participants the opportunity to revisit and clarify key points raised throughout the workshop. This was followed by a forward-looking discussion on next steps, including how the insights from the online sessions could be taken forward into future activities. The participants were informed of how the outcomes of the workshop will feed into future capacity-building activities. The session concluded with discussion about the in-person training planned for early 2026, and the ways in which it will build on the outcomes of the current workshop.



3. Theme 1: Hydrological Forecast Applications

This session described the need for global scale forecast initiatives and projects like the [WMO Hydrological Status and Outlook System \(HydroSOS\)](#) and the [Copernicus Climate Change \(C3S\) Water Service](#), and what these two systems are – or will – provide. A copy of the slides can be found below in Section 3.1. The interactive session for this Theme focussed on participants use of forecast systems, and their needs in terms of data, visualisation and support.

When asked if existing global/regional hydrological forecasting systems met their needs, 78% of respondents said ‘no’, citing access and the resolution being major reasons why not. The timescale and variables were also noted as issues/gaps in existing systems – in particular, the availability of soil moisture, river level and evapotranspiration data.

Participants were using these systems to support a range of decisions with water resources planning/allocation (including for energy and agriculture) and managing extremes (floods/droughts) common themes.

When asked about how they would prefer to visualise hydrological seasonal forecasts, most wanted to be able to see a combination of high-level information with more detailed information which included the full range of uncertainty and climatology, as well as forecast skill information. Most participants wanted to be able to see forecasts for gauged catchments (39%) and continuous basins (like HydroSheds, 25%). Detailed technical descriptions of the modelling framework and data was found to be the most useful form of user guidance (when ranked), followed by video explanations of forecast data, video tutorials on how to use applications and example scripts/notebooks demonstrating the use of the data.

The full results from the interactive session can be found below in Section 3.2.



3.1 Theme 1 slides

Hydrological Forecast Applications

Lucy Barker

Online Workshop on Hydrological Forecasting – Training Needs and Opportunities

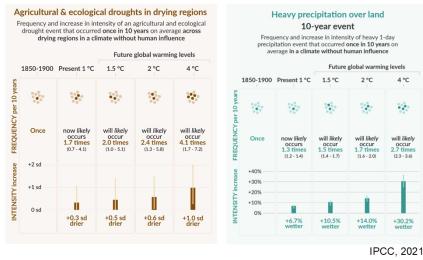
2nd September 2025

UK Centre for Ecology & Hydrology

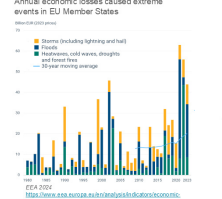
NATIONAL CAPABILITY FOR GLOBAL CHALLENGES
International science for net zero plus

ceh.ac.uk

...and in the future



The water challenge we face now



The Joint Research Centre EU Science Hub

Severe drought in Africa persists and is expected to worsen

Germany's deadly floods spread along Danube

Four dead, several missing in record Australia flooding

EU scientists sound alarm over escalating spring drought

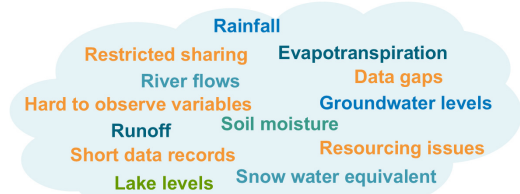
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We need information about water to better adapt

Enhanced resilience and sustainable management of water requires reliable hydrological information services



What data do we need?



What is HydroSOS?

HydroSOS is the link between monitoring and decision making

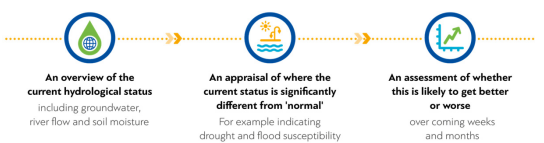


Supporting water management across sectors

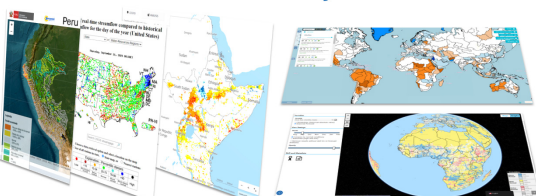
HydroSOS will help National Meteorological and Hydrological Services contribute more effectively to climate adaptation and support improved water management.



What will HydroSOS provide?

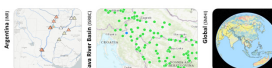


Doesn't that already exist?

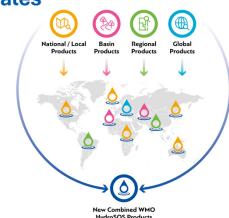


Connecting products across scales

The disconnect between top-down and bottom-up approaches is an impediment to action



HydroSOS will help enhance services at national, basin, regional and global scales and unite them in a coherent framework

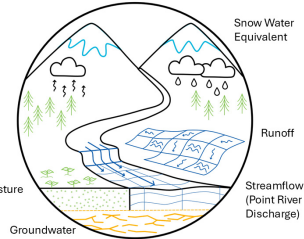




HydroSOS Products

5 Key starting variables:

HydroSOS Product Guidelines		
Multi-USE variable: Streamflow (Blue discharge)		
Product Name: Streamflow Parameters		
Version: February 2003		
Specification	Requirements	Notes
Character	- Streamflow (Blue discharge) - Point source observational or periodic prediction - Global modeled prediction	Other related related methods also acceptable
Value / Units / Interval / Method	Product should be derived using procedures estimated using a technical planning position (sheet) Minimum: Category e.g., defined using methods in the discharge Optional: Absolute value of streamflow in discharge Optional: Percentage of average and percentile	Not a number of categories should be utilized to allow for normal normal categories Documentation required



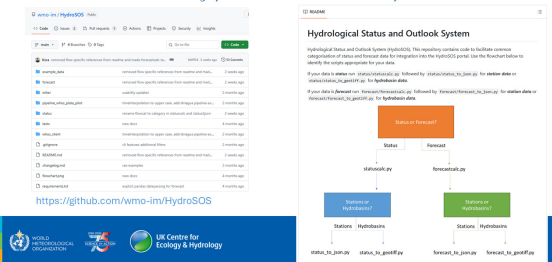
Methods Guidance

Calculating HydroSOS Products

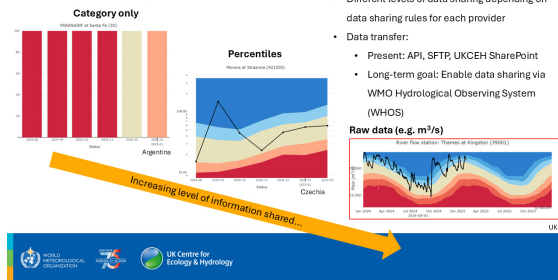


Methods Guidance

Calculating HydroSOS Products – GitHub code library



Data sharing options



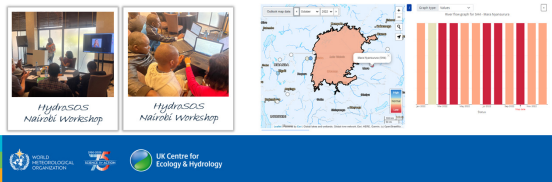
- Different levels of data sharing depending on data sharing rules for each provider
- Data transfer:
 - Present: API, SFTP, UKCEH SharePoint
 - Long-term goal: Enable data sharing via WMO Hydrological Observing System (WHOS)

Lake Victoria Basin Workshop

<https://wmo-hydroscs.ceh.ac.uk/casestudies/lvb>

Nairobi - August 2023

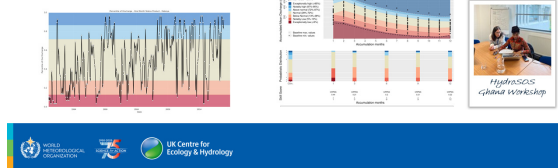
Participants used code developed by the Technical Team to calculate hydrological status



Ghana Workshop

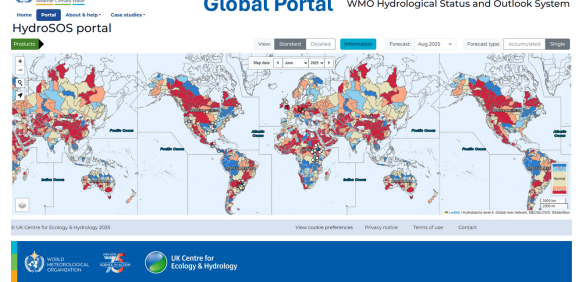
Wallingford - March 2023

Participants co-developed code to quantify hydrological status, and to run ESP for stations in Ghana, and produce visualisations



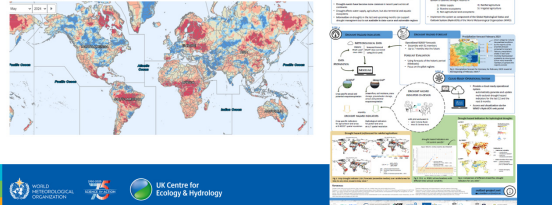
Global Portal

HydroSOS Portal WMO Hydrological Status and Outlook System

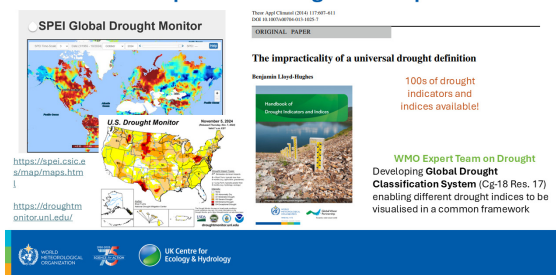


OUTLAST – Forecasting for drought hazards

Standardised Precipitation Index
Streamflow percentiles
Crop drought indicator



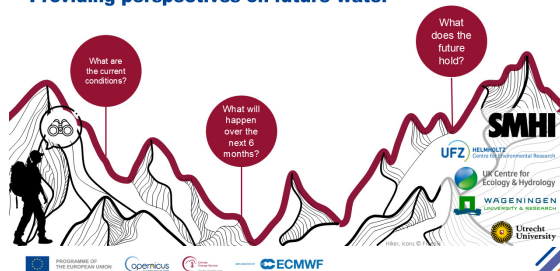
Additional potential drought status products



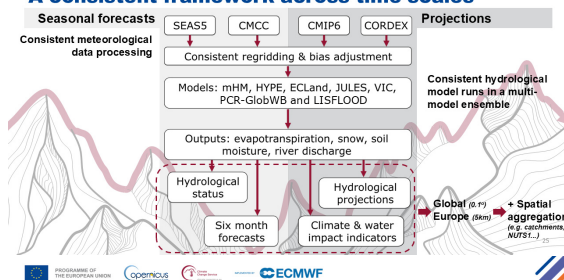
HydroSOS technical development and support

Methods	Tools and Guidance	Data transfer	Operationalisation
- Quality control - Data infilling - Forecasting methods and skill assessment - Blending global/local and status/outlook	- Status assessment - In-country forecasts (in development) - Quality control and infilling - Skill assessment	- Data storage and processing - Updating data in the Global and regional portals - Links to WMO WHOS	- Training for National Met and Hydro Services - Technical support - Implementing feedback

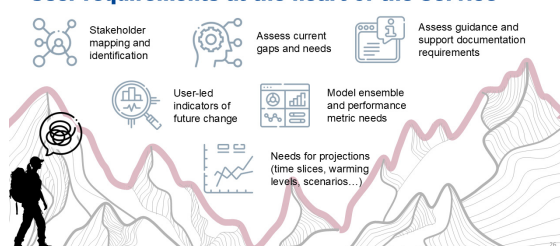
The Copernicus Climate Change Water Service: Providing perspectives on future water



A consistent framework across time scales



User requirements at the heart of the Service



Key questions

- Can we validate against observations?
- How do these forecasts compare to other (global or regional) forecast systems?
- How can they be used to support decision making at the global, regional and national scale?

Summary – and some questions for you!

There is lots of work at the global scale to develop systems to support adaptation

- Do they meet user needs? What are the gaps?
- Can they support decision makers and improve our resilience?
- What spatial scales and locations are relevant to decision makers?
- How do they need to display and show information to be effective?
- What support and guidance and support do users need to make the most of these systems?

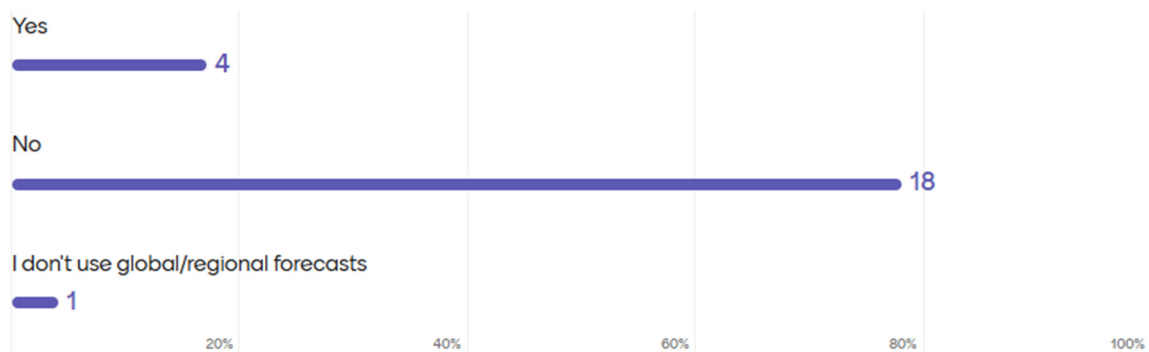


3.2 Results of the interactive session

The interactive session was run in [Menti](#), which allowed participants to respond to a range of questions on their mobile or in the web browser and for us to view and discuss the results in real time as they were submitted. The questions and the responses are given below. Overall, 29 people joined the survey. The number and percentage of people participating in each question is given in brackets after the question.

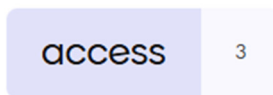
3.2.1 Do existing global or regional hydrological forecasting systems meeting your needs? (23/79% participation)



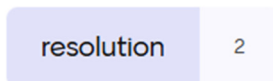


3.2.2 If not, why not? (15/52% participation)

Most popular



Also prominent



Other responses



3.2.3 If they don't meet your needs, what information do you need instead? (16/55% participation)

Most popular

access

3

Also prominent

better resolution

2

Other responses

access and restriction better access better spatial resolution community needs

confidence evapotranspiration finest spatial resolution high accuracy level

high resolution data high spatial resolution improved access local basin parameters

local data local scale local water basin specifi open data access real time data

real-time data river level data soil moisture temporal and spatial rlut

variables esp soil moistu

3.2.4 What decisions do you need to make using seasonal hydrological forecasts? (14/48% participation)

Catchment management and risk assessments	to help my local communities
Prep against extremes	To analyze hydrological impact on disease transmission
Water resources planning	decision making on flood impacts on irrigation scheme drought management reservoir operation
1. update input data 2. data processing	Policy direction
Help provide tailored solutions for local needs and users	Water allocation
Operational analysis Researching into future Extremes Precipitation Impact from Climate	Better resolution, real time data
water availability for water management, flood impact, drought impact	Drought management
Risk management in terms of high or low inflows	Reservoir management and energy generations
3. Water balance analysis to ensure sustainability	Spatial plan preparation and stakeholder engagement
Irrigation allocation	



3.2.5 How would you like to visualise forecasts for a given location? (15, 52% participation)
Participants were asked to rank the different options presented

> 1 A combination of these options

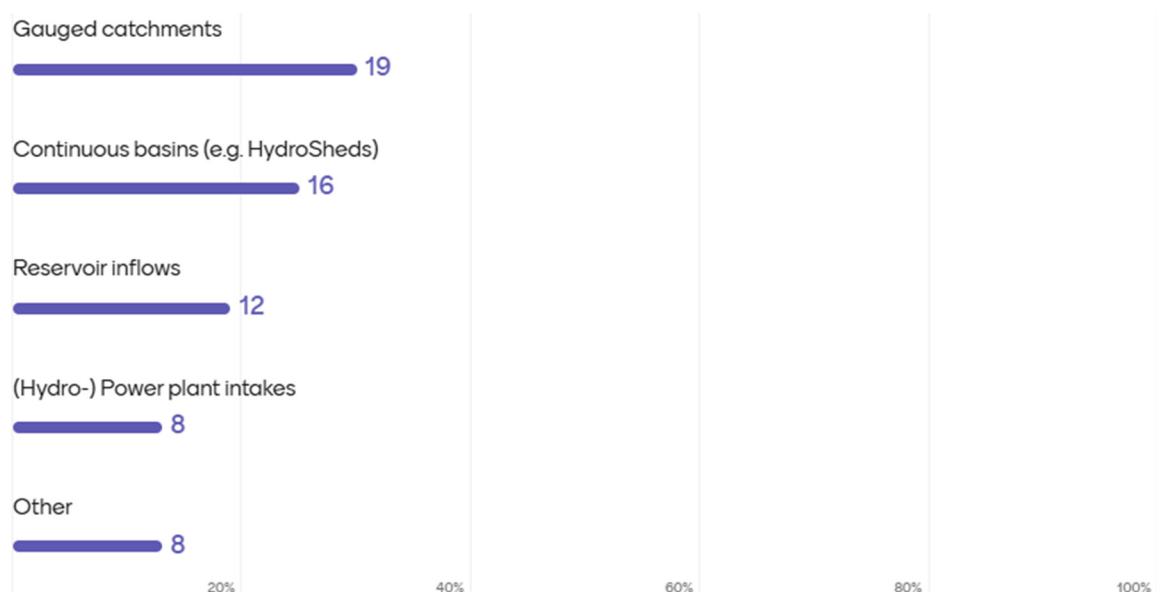
> 2 More detailed plots showing the spread of ensemble against climatology

> 3 Categories (showing ensemble spread)

> 4 Something else!

> 5 Single category (no uncertainty info)

3.2.6 What spatial scale would you like to be able to visualise forecasts at? (20/69% participation)



3.2.7 If you selected 'other', what spatial scale would you need to be able to see forecasts at? (1/3% participation)

Most popular

community scale 1

3.2.8 What user guidance and support would you find most helpful when using a global/regional hydrological forecasting system? (17/59% participation) *Participants were asked to rank the different options presented*

> 1 Detailed technical descriptions on the modelling framework and model set up

> 2 Video(s) explaining the forecast data

> 3 Video tutorials of how to use web applications

> 4 Example scripts or notebooks demonstrating how to work with the raw forecast data

> 5 Use cases demonstrating how others have used forecast systems

> 6 Fact sheets about modelled variables and outputs

> 7 Diagrams explaining the modelling framework



4. Theme 2: Hydrological Datasets

Hydrological datasets are the cornerstone of robust scientific research, providing the foundation for forecasting and projections, and supporting decision-making for hazard mitigation and water resource management. This session described the importance for easy-to-access, freely available, accurate and well described hydrological datasets. The presentation also highlighted the different hydrological datasets used by UKCEH in research and operational applications, the common issues (e.g., gaps in data and technical constraints) and the strategies employed to address them. A copy of the slides can be found below in Section 4.1.

The interactive session for this theme focused on exploring participants' experiences with hydrological datasets, including the types of data they use and how they use them, the challenges they face in accessing and analysing them, and the specific training needs that could help strengthen their capacity in this area.

Stakeholders highlighted both the importance and challenges of working with hydrological datasets (variables like rainfall, temperature, evapotranspiration, soil moisture, vegetation indices, streamflow, and land cover), especially over Ghana. These datasets were accessed through national institutions, global portals such as Copernicus and Google Earth Engine, in-house monitoring networks, automated downloads, and APIs.

Although a wide range of data sources and analysis platforms are being used, they are often constrained by limited coverage, outdated records, software and data licensing restrictions, data formatting, and irregular updates, among other issues. Technical barriers such as slow internet connectivity, difficulties using scripts, and limited metadata also cause issues.

Capacity building is the key priority to strengthen regional forecasting and operational applications. Training needs identified included programming and automation skills, hydrological data analysis and visualisation, handling large datasets, forecast verification, and applying machine learning to address data gaps and improve predictions. Stakeholders emphasised that building these skills, alongside better data management, open access sharing of data and centralised repositories, would strengthen regional capacity in hydrology.

The full results from the interactive session can be found below in Section 4.2.



4.1 Theme 2 slides

Hydrological Datasets

Amulya Chevuturi

Online Workshop on Hydrological Forecasting – Training Needs and Opportunities

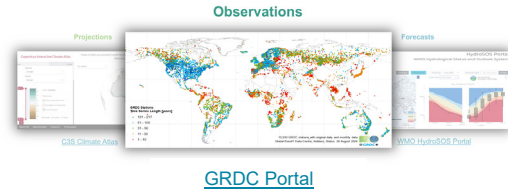
2nd September 2025

UK Centre for Ecology & Hydrology

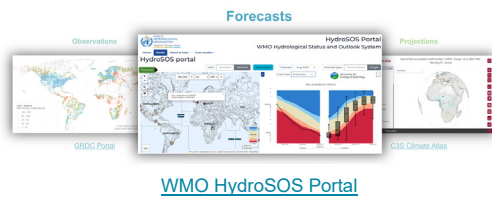
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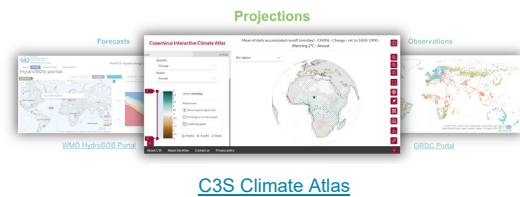
Hydrological Datasets



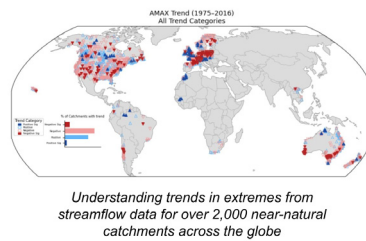
Hydrological Datasets



Hydrological Datasets

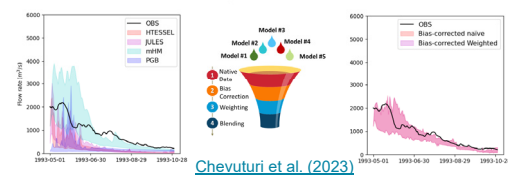


Observations



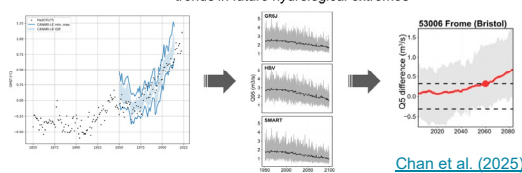
Forecasts

Blending multi-model forecasts to provide easy-to-interpret predictions

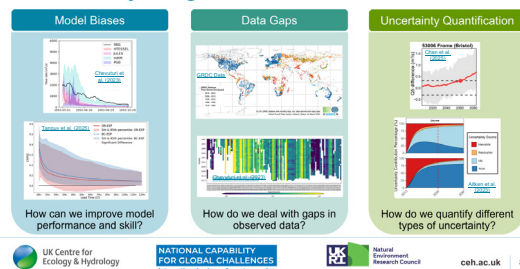


Projections

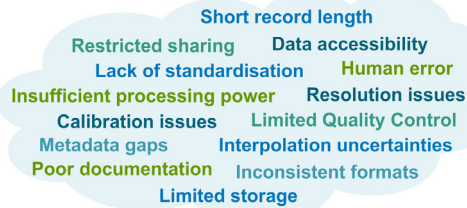
From large ensembles of future projections to evaluating trends in future hydrological extremes



Issues with hydrological datasets



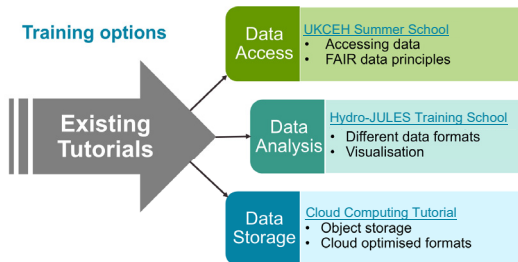
More issues with hydrological datasets



Engagements and training



Training options



Hydrological Datasets: Breakout Discussions

Part 1 Accessing data (~15 minutes)

Participant's experience in data access (e.g., portals, peer-to-peer transfer, or APIs), types of data they are interested in (e.g., observations, forecasts, and common formats of data used)

Part 2 Analysing data (~15 minutes)

Preferred programming languages, platforms and data analysis approaches (e.g., forecast verification, visualisation, statistical analysis, parallel computing)

Hydrological Datasets: Breakout Discussions

Part 1 Accessing data (15 minutes)

- What types of hydrological data do you use and what is the preferred way to access hydrological datasets? (e.g., portals, APIs, cloud services)
- What issues do you face when accessing these datasets? (technical, licensing, discoverability, speed)
- What training or support would help you most in improving your data access skills?

Hydrological Datasets: Breakout Discussions

Part 2 Analysing data (15 minutes)

- What types of platforms do you use for hydrological data analysis?
- Are there specific challenges you encounter during analysis?
- What topics or skills would you like training on? (e.g., forecast verification, visualisation, handling large datasets, object store, parallel computing).

4.2 Results of the interactive session

The interactive session was conducted as a breakout exercise, where participants were divided into three groups to discuss two key aspects of hydrological datasets (access and analysis), using an online [Microsoft Whiteboard](#) guided by a set of prompt questions. In the first part we explored participant's experience in data access (e.g., portals, peer-to-peer transfer, or APIs), and types of data they are interested in (e.g., observations, forecasts, climate projections and common formats of data used). In the second part we discussed

participant's preferred programming languages, platforms and data analysis approaches (e.g., forecast verification, visualisation, statistical analysis, parallel computing). Each of the three breakout rooms included around 15 participants, allowing for more in-depth discussion and active engagement from all. The key findings from all groups are summarised below for each aspect's prompt questions.

4.2.1 Accessing data

(1) What types of hydrological data do you use and what is the preferred way to access hydrological datasets (e.g., portals, APIs, cloud services)?

Rainfall, temperature, and evapotranspiration	Soil moisture, NDVI, and Vegetation Health Index (VHI)	Streamflow observed (from hydrological authorities or own monitoring equipment, for calibration)	Streamflow modelled (for long-term analysis, and filling data gaps)
River discharge and drainage basin characteristics, flood hotspots	Land cover and water bodies (for spatial planning)	Surface Water and Ocean Topography (SWOT)	Gridded meteorological datasets and model outputs
National institutional sources (e.g., Ghana Meteorological Services, Hydrological Authority)	Online portals (e.g., Copernicus, Google Earth Engine, OpenStreetMap, QGIS)	Own monitoring networks and in-house models	Downloaded datasets from websites, sometimes automated with scripts (e.g., bash scripts)
APIs and cloud services (with interest in development of repositories for regional offices)	Add text	Add text	Add text



(2) What issues do you face when accessing these datasets (technical, licensing, discoverability, speed)?

Limited real-time data availability due to few stations with telemetry (often with ~3-month delays)	Inadequate spatial coverage, with some basins and regions lacking monitoring stations.	Outdated datasets and large gaps in records. Limited data constrains modelling of climate change impacts & extremes.	Global datasets with fewer stations than national sources, reducing local relevance.
Restricted access (institutions unwilling to share data without formal agreements); Licensing barriers and paid datasets	Desire for free open-source datasets to encourage wider use.	Lack of a central repository for collating and archiving datasets, including historical records.	Need for better information sharing within the community about available and improved datasets.
Resolution and frequency of rainfall and streamflow data often too low for effective flood early warning.	Inadequate groundwater and soil moisture data for drought monitoring.	Vulnerable communities lack accessible & usable hydrological information for planning and preparedness.	Slow download speeds and unreliable internet connectivity.
Challenges in using scripts or technical tools for automated data access.	Dependence on international portals (e.g., CORDEX, US-based free datasets).	Technical documentation and metadata often insufficient, making it difficult to assess fitness for purpose.	Add text



(3) What training or support would help you most in improving your data access skills?

Development of national-scale streamflow forecasts (combine existing observations to improve resolution on global datasets)	Building good baseline datasets through collaboration with hydrological authorities (e.g., GMET).	Use of machine learning techniques to address data gaps and support predictions in data-poor areas.	Training in calibration of river gauge rating curves.
Guidance on establishing and using central data repositories, as data are often stored on individual computers.	Training on accessing, managing and harmonisation datasets and handling data gaps.	Support for automation of data downloads and workflows	Training in coding for data access; writing and understanding scripts (Python, R, Java).
Application of programming for hydrological modelling (e.g., SWAT) and data processing.	Add text	Add text	Add text

4.2.2 Analysing data

(1) What types of platforms do you use for hydrological data analysis?

Programming and Statistical Tools: Python, R, MATLAB (less common), NCL (common in the meteorological community)	Specific Spatial and GIS Tools: QGIS, ArcGIS	Cloud Platforms: Google Earth Engine, AWS	Other Tools: Microsoft Excel
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(2) Are there specific challenges you encounter during analysis?

Licensing and access restrictions on software use (e.g., ArcGIS)	Difficulty interpreting parameters from some platforms (e.g., Google Earth Engine)	Infrequent or irregular data collection; continuous data updates often lacking	Limited availability of key datasets, (e.g., soil moisture data for Ghana)
Issues with data formatting, conversions, and coordinate reference system (CRS) reprojection.	Add text	Add text	Add text

(3) What topics or skills would you like training on (e.g., forecast verification, visualisation, handling large datasets, object store, parallel computing)?

Programming: R, Python	Computing: Cloud computing (e.g., AWS), high-performance computing (HPC)	Hydrological modelling: SWAT, HEC-HMS, MIKE-SHE, LSTM,	Forecasting Skills: Inflow forecasting for reservoirs, forecast verification
Data Visualization: Various visualization tools beyond Excel	Data Analysis: Addressing data gaps, handling large datasets, statistical analysis	Machine Learning Applications: Applying ML techniques in hydrological modelling and data analysis	Add text



5. Theme 3: Hydrological Modelling & Tools

Hydrological modelling is a key element of water resources assessment and management strategy, and can be used to inform water practitioners of the potential impact of any changes in water availability for both present and future periods. This session highlighted some fundamental approaches and tools when quantifying changes in water resources, and the impact this may have on sectoral water use and demand. The presentation also demonstrated two applications of water resources modelling tools developed at UKCEH. The first being a GWAVA model application in the Upper Narmada basin, India, and the second of a data-driven approach to seasonal forecasting of reservoir storage in the UK. A copy of the slides can be found below in Section 5.1.

The interactive plenary session firstly focused on how the workshop participants currently use water resources tools, and their current knowledge of software and coding languages, along with the datasets they're using to drive and configure their models. Discussion then moved on to where there were current gaps in modelling knowledge, along with the training required to help address these gaps and the data needed to meet the requirements of water resource researchers and practitioners.

Participants highlighted a number of different modelling software packages currently in use in West Africa, many of which were seen as being fit for purpose at the basin scale, although lacking capacity to model at the national scale. Challenges were also highlighted around the acquisition of data for model validation at the relevant spatial and temporal scales, with finer resolution data currently lacking. For larger scale data, satellite observations are being blended to help meet local requirements.

During discussions, participants felt that training in machine learning and data-driven approaches would be beneficial in the assessment of water resources for a variety of applications, including streamflow and reservoir forecasting and data infilling and reconstruction. It was also highlighted that models and tools needed to better capture weekly to sub-seasonal change, along with requests for a water quality model, a groundwater model, and a finer resolution drought forecasting model to supplement the current modelling suite. A general need for training in statistical techniques was also highlighted, which in turn would facilitate the development and use of indicators for flood and drought forecasting.

The full results from the interactive plenary session can be found below in Section 5.2.



5.1 Theme 3 slides

Overview of selected water resources modelling approaches and their applications

Nathan Rickards & Helen Baron

2nd September 2025

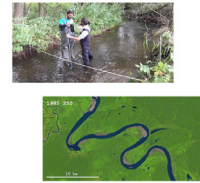
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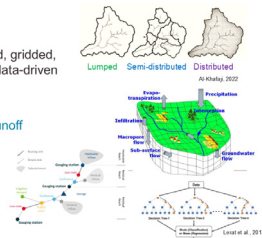
Modelling hydrology

- Useful to know **how much water there is**; where, when and how much of it is actually obtainable!
- Ground observations can tell us how much water **is/was available at specific locations**
- Cannot tell us directly what is available at **other locations**, nor what is likely to be **available in the future**



Water resource models

- Many common structures/types—lumped, gridded, systems models, conceptual, physical, data-driven etc.
- Water resources includes elements of **runoff generation with anthropogenic factors**
- Sectoral water use and water abstractions/allocations



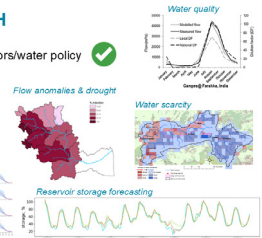
Why we use water resources models

- Assess **availability of water resources** and estimate how this will impact sectors
- Mediate between competing demands to **achieve equitable and sustainable water use** – for people and for environment
- Highlight future change** and reduce vulnerability



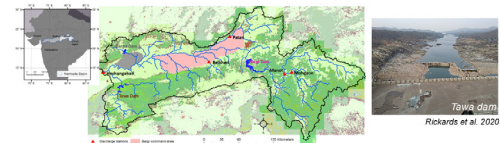
Model applications @ UKCEH

- Water Resource management across sectors/water policy
- Climate change impact assessment
- Reservoir storage status & forecast
- Floods
- Droughts
- Water quality modelling



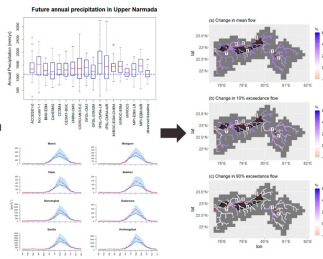
Water resources - gridded modelling approach

- replicate the hydrology of the heavily impacted **Upper Narmada, India**
- to assess the impacts of **future climate change** on the hydrological regime and future water resources of the basin.



Overview of work

- Future climate (CMIP5) used to drive hydrological model to assess future state of water resources
- Increased flows during monsoon season
- Increased high flows, little change in low flows during mid 21st century



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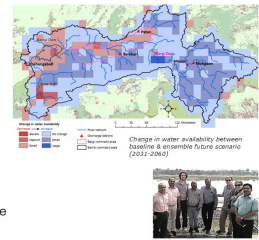
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Key messages

- Increased risk of flooding during monsoon.
- Increased intensity monsoon leading to more water in a shorter timeframe – lack of storage capacity in reservoirs.
- Timing means limited recharge, hence little change in low flows during dry season.
- Potential for greater water stress during the dry season due to timing of water availability outside of command areas and reservoir-fed regions.



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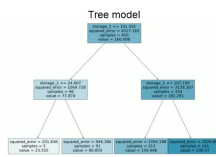
Machine learning – reservoir status & forecasting

What: Seasonal forecasts for reservoir storage at monthly timestep

Why: To give an indication of future water stocks

How: Ensemble tree model with multiple reservoirs

(relatively) simple
(partially) interpretable
fast



UK Centre for Ecology & Hydrology

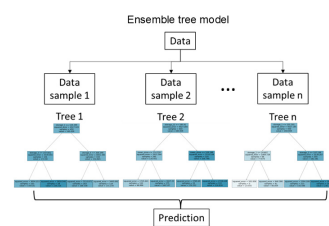
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Machine learning – reservoir status & forecasting



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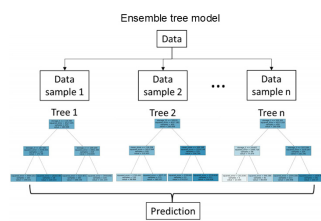
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Machine learning – reservoir status & forecasting



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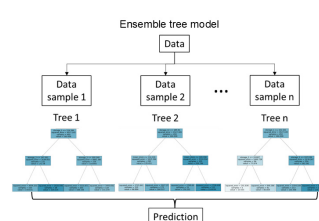
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Machine learning – reservoir status & forecasting



Data needs

- Monthly time-series reservoir storage, rainfall, temperature
- Reservoir characteristics GRanD, local data
- Basin characteristics CARAVAN, Hydro-Atlas, ERAS

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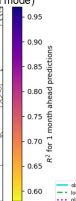
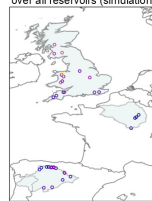
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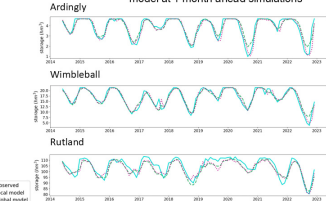
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Machine learning – reservoir status & forecasting

Model performance 1 month ahead over all reservoirs (simulation mode)



Comparing the local models to the global model at 1 month ahead simulations



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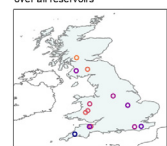
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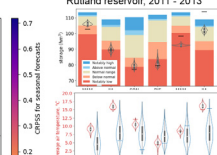
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Machine learning – reservoir status & forecasting

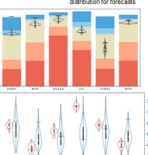
Seasonal forecast performance over all reservoirs



Example of seasonal forecast for Rutland reservoir, 2011 - 2013



Graph for observed values, distribution for forecasts



Model input: Historical weather analogues data produced by the Met Office, as described [here](#).

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Thank you

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Art by Kate Randall

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Breakout session



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Sessions aims

Gather information on where models and tools could address current needs in the assessment of water resources in the region

- An open, interactive discussion.
 - Discuss experiences and add your knowledge to the conversation
 - Add thoughts and comments to the whiteboard
 - Post comments in chat if can't access whiteboard



Water resource modelling & tools

 What is currently used? - experience with modelling tools and approaches, data handling and coding languages (15 mins)

 Needs, challenges, and areas of interest for further learning or application of water resources modelling and tools (15 mins)

Part 1 (~15 mins)

1. Which models and tools are you currently using to assess different aspects of water resources, and why?
2. Do you feel these tools are fit for purpose? What challenges do they pose, if any?
3. What datasets do you currently use? Are there any you feel are needed but aren't available?
4. Which coding languages are you familiar with?

Part 2 (~15 mins)

1. Where do you feel the current gaps are in the water resources tools available to you? What are the key areas that need addressing?
2. What are the main challenges in addressing the gaps in modelling tools?
3. What training do you feel is needed to help address some/all of the above challenges?
4. Would you be interested in WR model training and/or ML reservoir forecasting? What other types of modelling tools would you be interested in?

5.2 Results of the interactive session

A 50-minute interactive session was conducted via a plenary discussion, with all participants encouraged to engage on the two proposed themes around water resources modelling and tools. Verbal responses and input via the meeting chat were again captured using an online [Microsoft Whiteboard](#), with the discussion being guided by a set of eight prompt questions. The initial theme focussed on the current use of modelling tools for water resources assessment, along with data and associated challenges. The second theme then moved onto how these challenges could be met, and where the participants felt that training could help fill some of the skill and knowledge gaps that currently exist. This session included ~30 participants from a range of backgrounds and modelling experience around water resources. The key findings from the session are summarised below.

5.2.1 Current use of water resources modelling tools

(1) Which models and tools are you currently using to assess different aspects of water resources?

HEC-HMS: Freeware and robust	WEAP, MIKE-SHE, HEC-RAS	LSTM	SWAT model	WRF-Hydro	Hype
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(2) Do you feel they're fit for purpose. What challenges do they pose, if any?

Yes, the models are fit for the purpose. Challenge: Availability of observed data as required resolutions to validate models	They fit the purpose but mostly limited to river basin extent. We need tools that allows us to easily model water at national level at a go
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(3) Which datasets do you currently use? Are there any you need which aren't available/accessible?

The file format for dataset input is limited in HECHMS. For example the file format for gridded data set is mostly DSS - would be better if we could have geotiff, and others.	streamflow, climate, land use/cover, soil Access: MSWEP or CHIRPS for large scale data or local observations. Currently blending 12 satellite observations to get more coverage.	NOAA's datasets for climatic data
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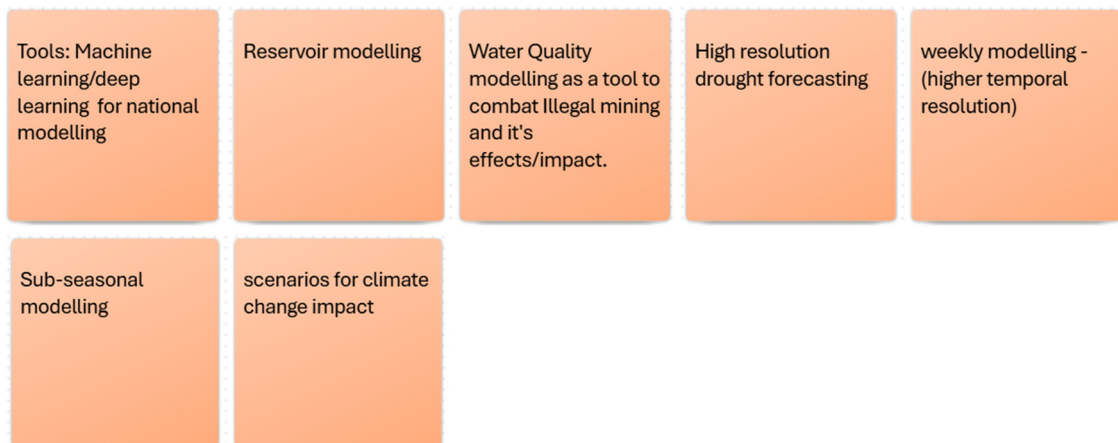


(4) Which coding languages are you familiar with?

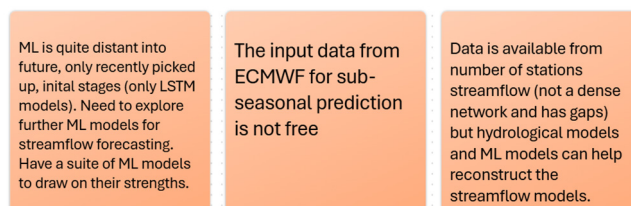


5.2.2 Needs, challenges and areas of interest for further learning or application of water resources modelling tools

(1) Where do you feel the current gaps are in the water resources tools available to you?
What are the key areas that need addressing?



(2) What are the main challenges in addressing the gaps in modelling tools?



(3) What training do you feel is needed to help address some/all the above challenges?

ML training for streamflow forecasting/reservoir

more training is coding (python,etc) advanced applications in water resources. i mean more applications in waters i know there are more being developed

statistical indicators for flood and drought forecasting, interpretation/visualization

Statistical techniques

(4) What types of modelling tools would you be interested in receiving training for?

GR6J

Training in the various models will be good and help improve our skills

Ground water modelling

Flood modelling

(5) Any other comments/thoughts?

Water resources models that consider both quality as well as quantity

Heavy metals immediately help to combat a pressing national issue



Acknowledgements

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