MAY 29-31
AIM for Scale Weather
Partnership Convening

AIM FOR SCALE

WEATHER PACKAGE

# LUNCH

# 12:00 - 1:00

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# Welcome and Overview of AIM for Scale

# AIM for Scale

The Agricultural Innovation Mechanism for Scale (AIM for Scale) introduces a new approach to help farmers in low- and middle-income countries (LMICs) by assembling the necessary financial, technical, and operational resources to scale-up innovations with rigorous evidence of impact and cost-effectiveness.

Evidence-based + convening power

# Our Approach

- AIM for Scale creates tailored innovation packages to scale-up solutions through partnerships with key players
- Designed to be small, nimble, and catalytic → leverage complementarities among existing stakeholders.
- Innovation packages combine funding, technical expertise, implementation capabilities
- Focuses on a limited set of focus areas for which it delivers comprehensive solutions

# Meet our Organizing Team

**ADRIENNE**

**IMARA**

**AMIR**

**TOBI**

**FARRAE**

AIM FOR SCALE

# Welcome to our Global Weather Partnership Convening!

## Creating a Productive Space

- We'll use a "parking lot of ideas" to capture valuable ideas that fall outside our scope
- Raise one finger to share a new point, and two fingers to build on or respond to someone else
- This is a working convening—please ask questions and flag anything that's missing
- Help us stay on track by keeping comments concise and respecting time limits
- Please explain acronyms!
- Focus on solutions and next steps, not just challenges

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# Roadmap for the Convening and Objectives

# Weather Package: Evidence & Recommendations

**$103 to $365**

annual benefits

to farmers

**100s of Millions**

of small holders

could benefit

**Observation Networks**

**Forecast Production**

**Benchmarking & Validation**

**Dissemination**

**Learning**

# Successful Launch at COP29

4/25, 6:45 PM $1B to strengthen weather forecasting for farmers announced at CC

devex
Do Good. Do It Well.™

Inside Development
COP29

$1B to strengthen weather forecasting for fa
announced at COP29

The package of new and existing investments come fro
of partners as part of AIM for Scale, an initiative launch
scale up innovations to help farmers on the frontlines o
change.

By Ayenat Mersie // 15 November 2024

Alamy

## Concrete Announcements

*“**ADB** will invest approximately **$300 million** in weather forecasts tailored for the needs of farmers in Asia and the Pacific as part of its portfolio during 2025-2027.”*

*“**IDB** expects to leverage weather forecasts in its portfolio of **$280 million** in loans in the coming three years.”*

*“The **Ministry of Agriculture of India** plans to digitally deliver weather forecasts to **tens of millions of farmers** in 2025, building on a successful initiative that reached 9.45 million in 2024.”*

*“The **Mohamed bin Zayed University of Artificial Intelligence** and the **University of Chicago**’s Human-Centered Weather Forecasts and AI for Climate (AICE) initiatives launched a research and training program to improve access to high-quality, farmer-centered AI-supported predictions in more than **30 LMICs**.”*

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# AIM for Scale Global Weather Partnership

**Purpose**

- Launch the AIM for Scale Weather Package implementation phase.
- Bring together NMHS, Ministries of Agriculture, MDBs, technical partners, and donors.
- Build consensus and momentum around operational plans for scaling weather services.

**Key Objectives**

- Co-design forecast dissemination strategies tailored to farmers.
- Define agricultural use cases to guide benchmarking and validation.
- Identify training needs for NMHS and design an AI forecasting curriculum.
- Outline country-specific roadmaps for 2025–2027 implementation.

# Convening Agenda Highlights

**Today - May 29**

- Overview of AIM for Scale efforts and country partners
- Sessions on AI forecasting training, benchmarking dissemination, and data observation
- Evening reception with Google at Mr. Pang’s at 7:30

**Tomorrow - May 30**

- Keynote by Professor Michael Kremer
- Interactive workshops on:
  - Agricultural use cases for forecast generation
  - Training curriculum design
  - Tools to optimize dissemination
  - Country-specific forecasting roadmaps
- Dinner at Beit e Selam. Meet at the Lobby at 6:30

**Saturday - May 21**

- Stocktaking and implementation planning sessions
- Final reflections and next steps
- Optional visit to Giraffe Center. Meet at the Lobby at 2:00

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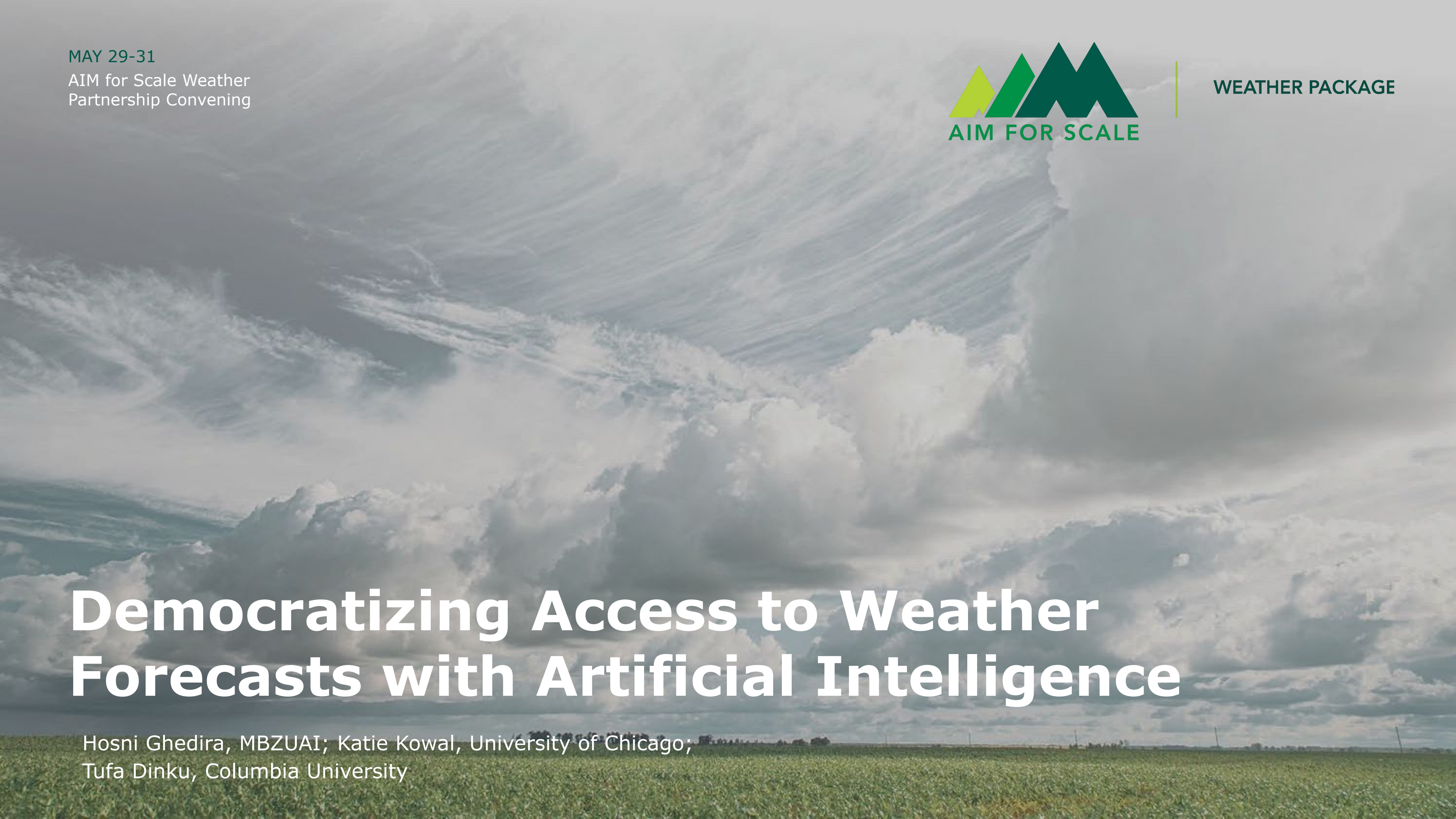

# Democratizing Access to Weather Forecasts with Artificial Intelligence

Hosni Ghedira, MBZUAI; Katie Kowal, University of Chicago;
Tufa Dinku, Columbia University

# Introduction

## Thank you for collaborating with us to support agriculture through forecasting innovations

We're thrilled to present how we plan to make a significant impact in agriculture for LMICs and collaborate with you to further democratize access to weather forecasting with the use of AI.

## With you, we aim to democratize access to weather forecasts using Artificial Intelligence (AI)

- ○ Today we will share our vision for making forecasts more accessible, accurate, and efficient for LMIC farming applications
- ○ We look forward to hearing your insights on how we make the training curriculum as impactful as possible in September.

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# Training Program Can Further Democratize Weather Forecasts Through Capacity Building in Key Areas

Throughout this presentation, we will cover some highlights from recent developments in the weather forecasting field, the kinds of forecasts we are aiming to improve, and some core goals of our training program. **We look forward to hearing your insights on how the curriculum could continue to take shape.**

01

### Types of Forecasts Targeted

Types of forecasts the training program is currently designed to support

02

### Opportunities from recent AI advancements

How recent AI developments are providing opportunities to advance the weather forecasting field

03

### Need for Training Programs

How training programs can support capacity building and showcase pros and cons of AI, pathways to integrate model breakthroughs into existing forecasting frameworks

04

### Goal 1: Accessibility

How training programs can improve accessibility to AI-based forecasts by showcasing different forecast models available and how to use them

05

### Goal 2: Accuracy

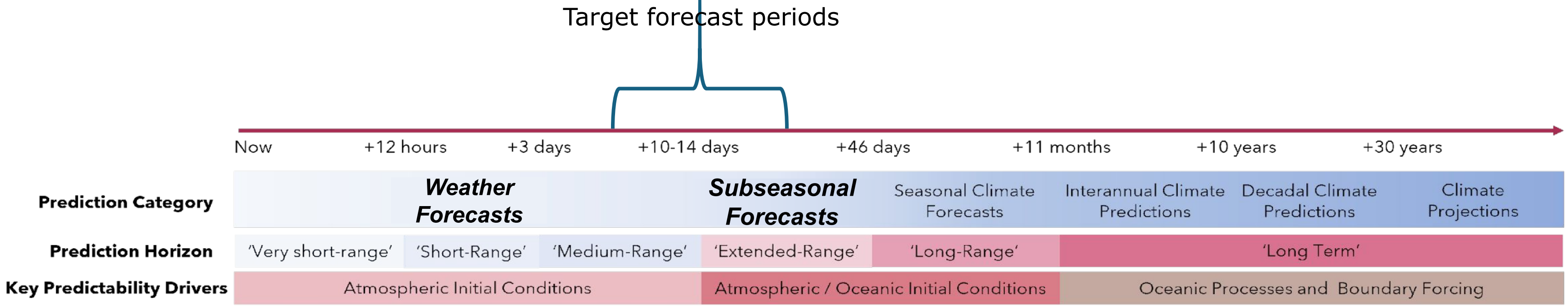
How training programs could position LMICs to further improve models by using their local observations to assimilate into models

06

### Goal 3: Autonomy

How training programs can build capacity to run and evaluate forecasts locally to further improve their usefulness

# Training Program Forecast Targets: 1-4 Weeks Ahead



Target forecast periods

Now | +12 hours | +3 days | +10-14 days | +46 days | +11 months | +10 years | +30 years

**Prediction Category**: ***Weather Forecasts*** | ***Subseasonal Forecasts*** | Seasonal Climate Forecasts | Interannual Climate Predictions | Decadal Climate Predictions | Climate Projections

**Prediction Horizon**: 'Very short-range' | 'Short-Range' | 'Medium-Range' | 'Extended-Range' | 'Long-Range' | 'Long Term'

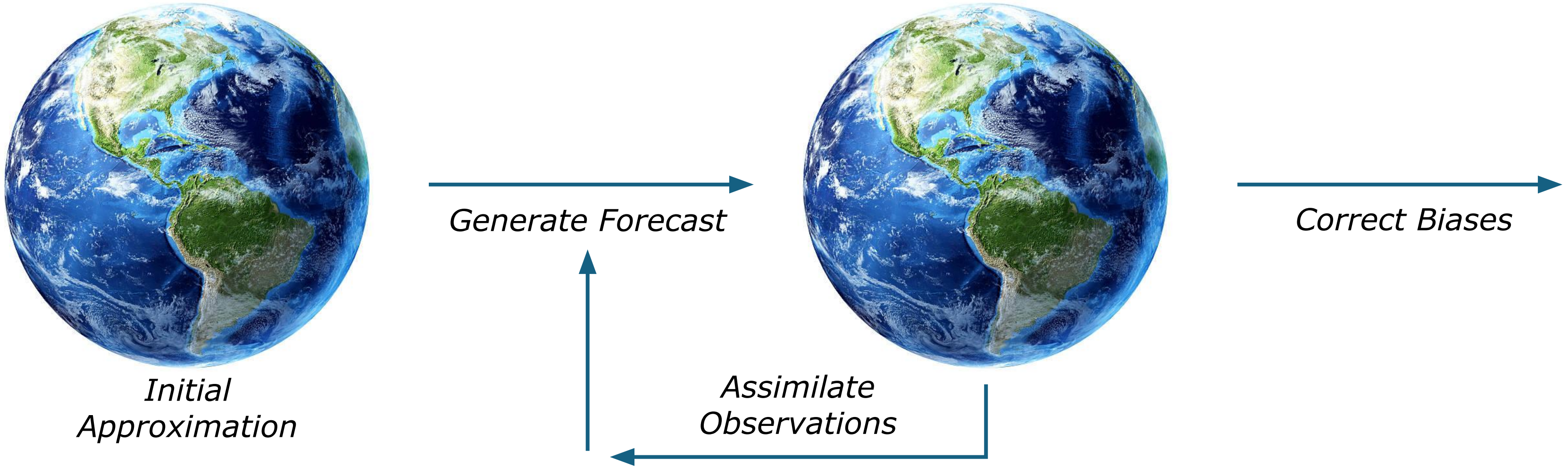
**Key Predictability Drivers**: Atmospheric Initial Conditions | Atmospheric / Oceanic Initial Conditions | Oceanic Processes and Boundary Forcing

**Planned Forecast Range for Training Program:**

- **'Medium-Range' forecasts** (e.g. 10 days ahead): timeframe where AI-based methods have performed well
- **'Subseasonal' forecasts** (14 to 40+ days ahead): key decision-making window for agriculture and a known predictability challenge for all models. AI-based methods are improving over this window

**Current model plan:** cover **global models** needed for forecasts at medium-range and subseasonal timescales, including **deterministic and probabilistic outputs** (deterministic less useful after 2 weeks ahead)

# Traditional Forecast Pipeline: Numerical Weather Prediction (NWP)



*Initial Approximation*

*Generate Forecast*

*Assimilate Observations*

*Correct Biases*

**Approximate Current State of Earth System**

Inputs vary, e.g. satellites, radar, ground sensors

**Use Physical Equations to Model How Earth System Will Evolve**

Standard governing equations to approximate motion and energy

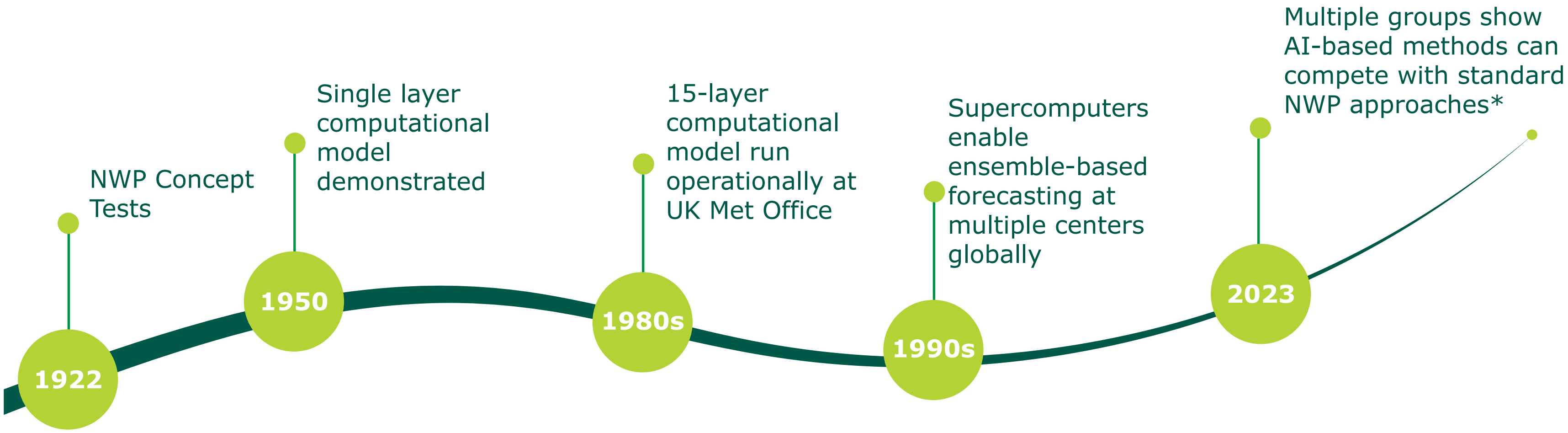
**Assimilate New Observations into Model**

Additional observations can keep model realistic once it has run for a period

**Post-process raw model outputs to correct biases**

Machine learning statistics often already used to correct raw outputs

# Recent AI Model Developments Are Changing the Weather Forecasting Field



**Lewis Richardson computes NWP forecast by hand**
(6 days to calculate)

**Single Variable Computational Forecast**
(Charnay, Fjortoft and Neumann)

**Improvements in Super Computers Advance NWP Forecast Pipeline**

**Recent AI Advances Are Changing Forecasting Paradigm**

*Benchmark models, metrics, and ground-truth are critical to evaluating success

# Recent AI Model Development Highlights

*2018*

### Scientific Tests of Modelling Possibilities

Dueben & Bauer (2018), Weyn et al. (2019, 2020, 2021)
Rasp & Theurey (2021), Clare et al. (2021)

*2022*

### First Competitive Medium-Range Forecasts

NVDIA FourCastNet efficiencies vs. ECMWF IFS (Jan 2022)

Keisler GraphNN comparable to NOAA GFS (Jan 2022)

Huawei Pangu-Weather shows more accurate Tropical Cyclone tracks vs. IFS (Nov 2022)

Google Deepmind introduces GraphCast, comparable to IFS (Dec 2022)

*2023*

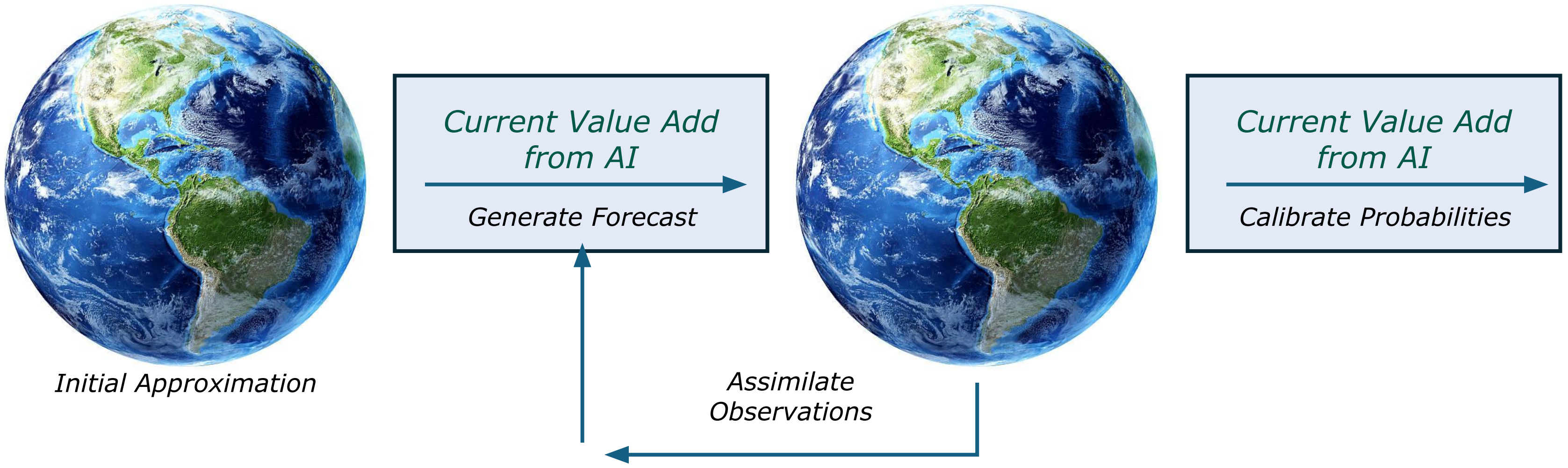
### Operational Implementation

ECMWF introduces AIFS (2023) and releases experimental ensemble version (2024), running operationally alongside IFS as of 25 February 2025

***Notes***

- Model developments are advancing rapidly
- AI-based modelling methods vary (e.g. NeuralGCM, AIFS, GenCast) and perform differently at different timescales
- Operational centers are especially keen for feedback on where their models are working or not

# Integration of AI into Forecast Pipeline Offers Several Opportunities, Including Efficiency, Accuracy, & Autonomy



*Current Value Add from AI*

*Generate Forecast*

*Current Value Add from AI*

*Calibrate Probabilities*

*Initial Approximation*

*Assimilate Observations*

***Opportunities include:***

- **Efficiency:** AI models can speed up the initial forecast runs significantly and prove more cost effective
- **Accuracy:** AI models can ingest multiple types of data and train on historical data to improve forecast accuracy
- **Autonomy:** Once an AI model is trained, it can be run locally on a desktop computer

# Key Need for Training Programs – Flexible Tool Agnostic Capacity

## Awareness of the Latest Models and Methods

- The weather forecasting field is changing rapidly and training can help keep up with latest advances

## Understand Limits of Conventional NWP and new AI Weather Forecasts

- AI-based models are data-driven – if there is limited data to train on, results will be impacted
- AI-based models do not currently provide a replacement for NWP models
- Extreme weather events need careful consideration for model applications

## Evaluation is Critical For Effective Use

- Comparisons will have different results depending on the models, metrics, and ground-truth data used
- Changing climate can affect predictability, making frequent model evaluation even more critical

## Integration of Weather Forecasts into Operational Decision-Making Remains a Significant Challenge

- Bringing people together across disciplines to further strategize how to operationalize weather information and make it effective for decision-making is a significant need

# Democratizing Forecasting in Africa: Opportunities

## Leapfrogging technology?

The mobile revolution

AI weather forecast represents a quantum leap in weather forecasting technology

# Democratizing Forecasting in Africa: Opportunities

- **Empowering Forecasting:** transforming weather forecasting , making it more accessible by enabling NMHS to produce their own custom forecasts without relying on expensive infrastructure;
- **Global Weather Equity:** Democratization ensures all regions, including resources limited and data-scarce areas, benefit from reliable forecasting tools;
- **Open-Source data and software:** Different initiatives provide free access to high-quality models and training datasets;
- **Edge Computing Integration:** AI models deployed locally reduce latency, improve security, and enhance resilience.

# Democratizing Forecasting in Africa: Opportunities

**Societal benefits of democratized weather forecasting:**

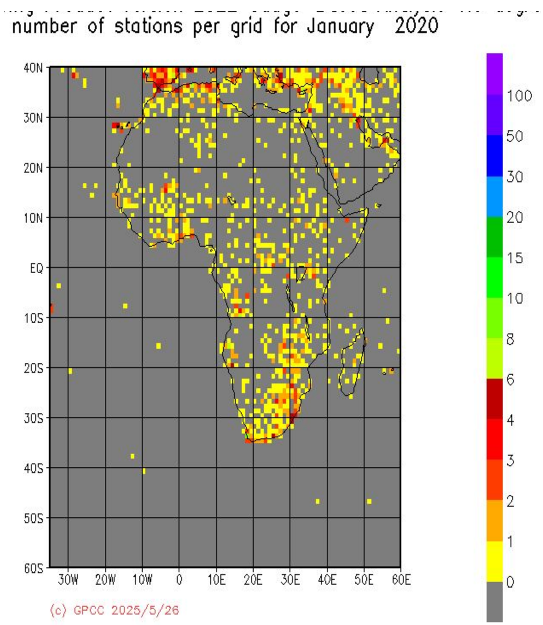
- Improved safety and preparedness for extreme weather events;
- Enhanced decision-making in agriculture, water, energy, and other sectors:
  - *Better resource management, such as optimizing water allocation and reducing energy consumption;*
- Reduced economic losses from weather-related disasters;
- Small-scale farmers who can better plan their planting and harvesting schedules.

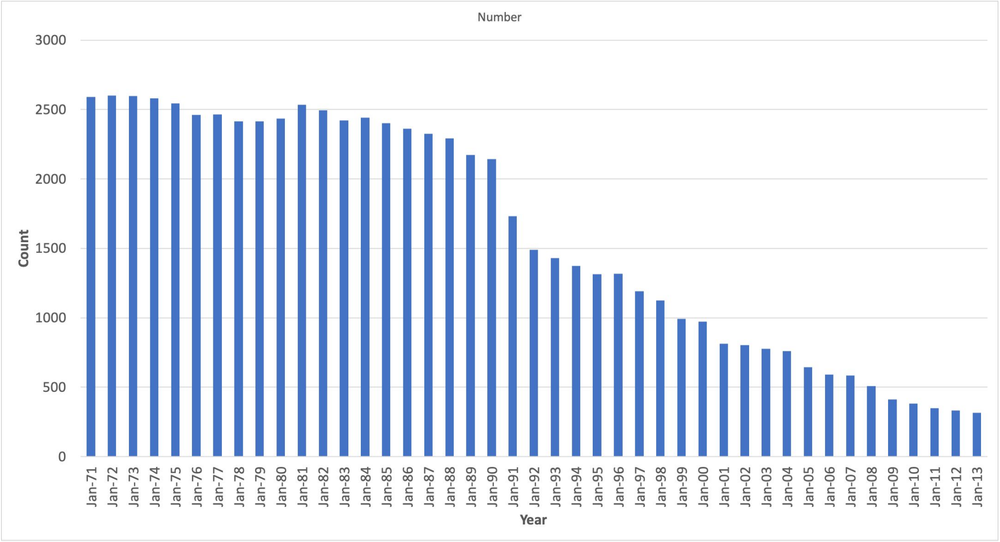
# Weather Forecasting in Africa: Challenges

- **Algorithmic Bias:** Training data imbalances can skew forecast against underserved regions;
- **Interpretability of AI models**: It can be difficult to understand why AI models make certain predictions, which can raise concerns about trustworthiness;
- **Computational requirements**: While AI models can be run on desktop computers, some models still require significant computational power;
- **Misinformation Risks**: Overconfidence in automated predictions can mislead the public and emergency response efforts;
- **Data availability and quality**: AI models require vast amounts of data for training, which can be challenging to obtain in some regions.

# Weather Forecasting in Africa: Challenges

## Data availability and quality: a serious challenge



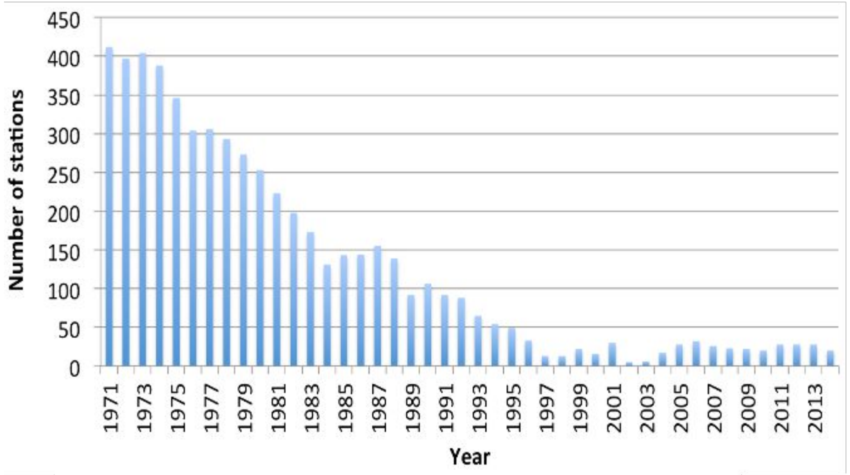


Data uses in the Global Precipitation Climatology Project (GPCC) gridded data sets from Africa

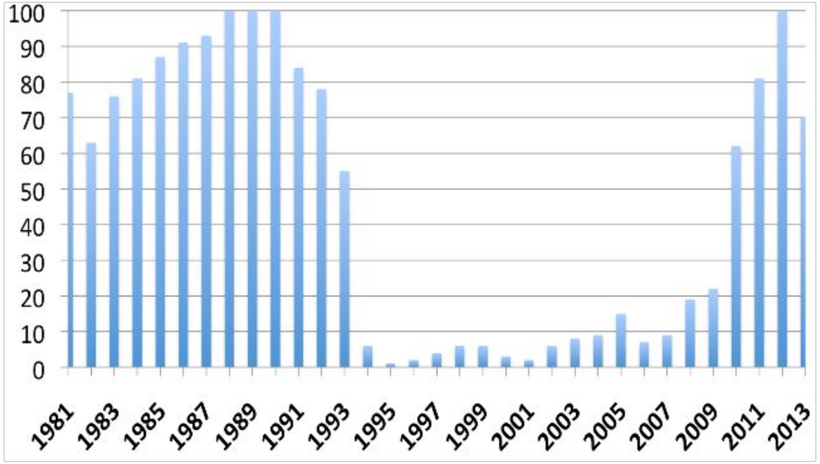
# Weather Forecasting in Africa: Challenges

## Data availability: Two main challenges

Number of stations that reported data for each year



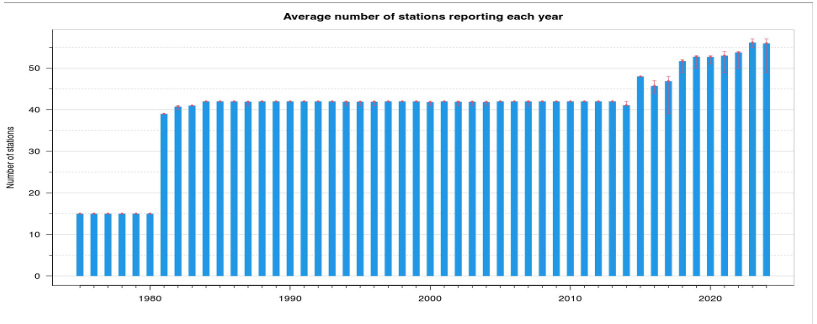
**Declining investment in observation infrastructure**

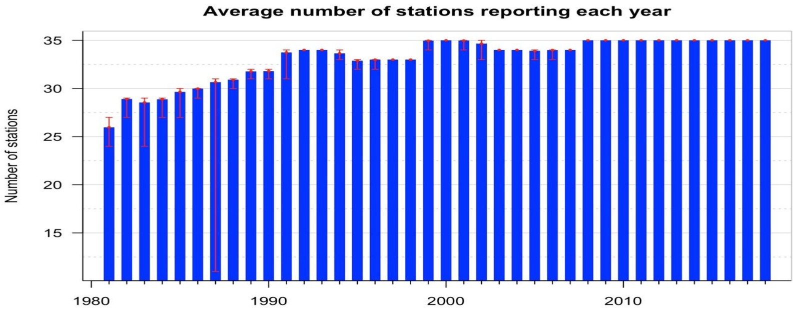


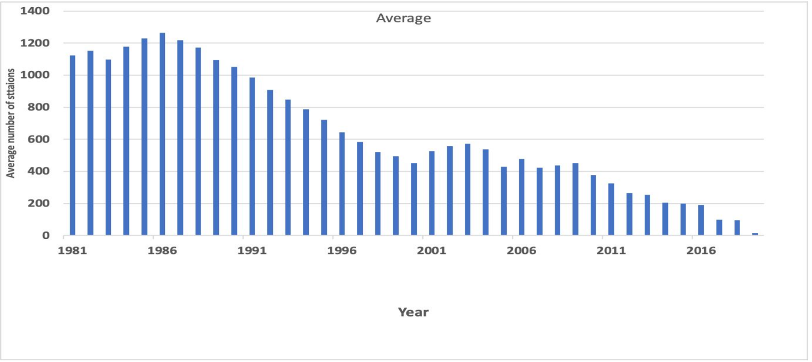
**Conflict/unrest: distraction and disruption**

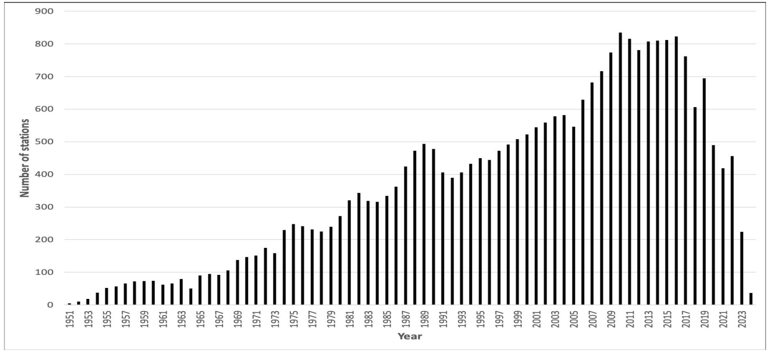
# Weather Forecasting in Africa: Challenges

## Data availability: NMHS in AIM for Scale









Number of stations reporting data for each year

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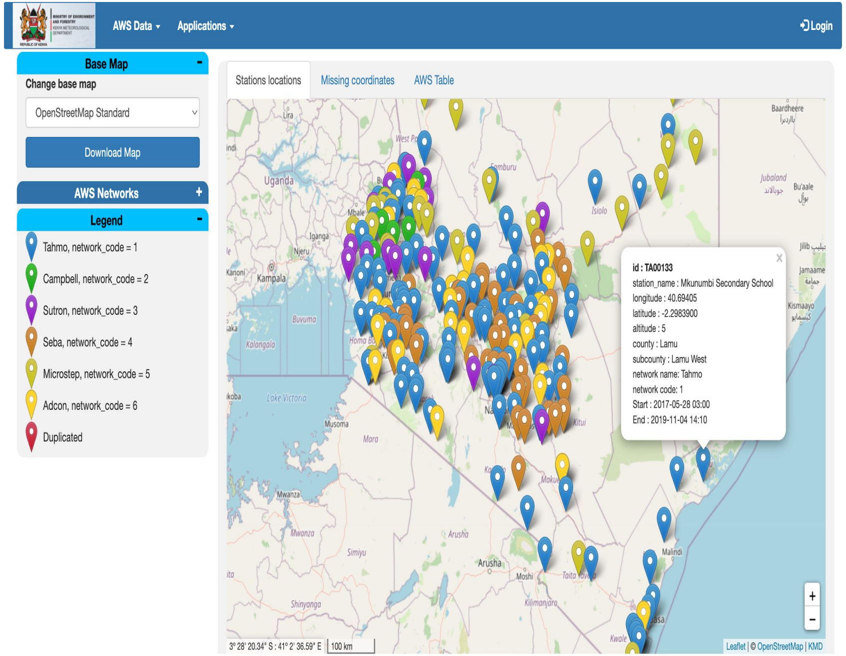
# Weather Forecasting in Africa: Challenges

## Data availability: Some challenges with AWS

- Different AWS systems provided by different donors
- Maintenance challenges (spare parts)
- Datasets in different formats, and may even be stored on different computers
- Challenge for NMS to organize and use the data from the different AWS systems
- Challenge for WIS2

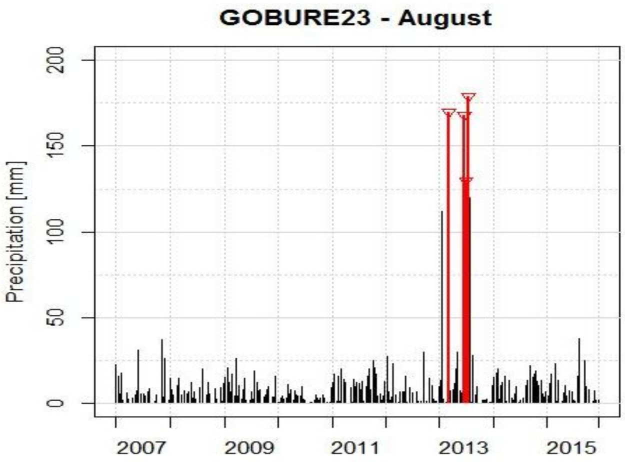


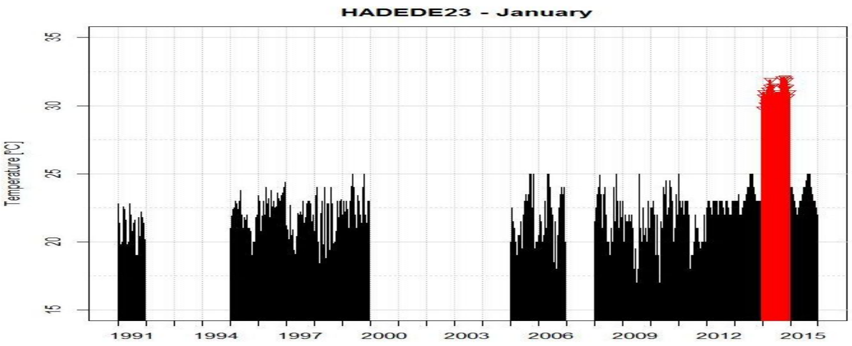
Tahmo, network_code = 1
Campbell, network_code = 2
Sutron, network_code = 3
Seba, network_code = 4
Microstep, network_code = 5
Adcon, network_code = 6
Duplicated

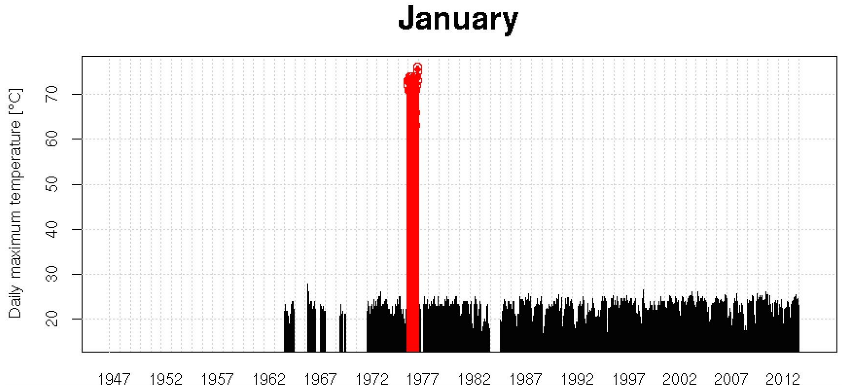
**id : TA00133**
station_name : Mkunumbi Secondary School
longitude : 40.69405
latitude : -2.2983900
altitude : 5
county : Lamu
subcounty : Lamu West
network name: Tahmo
network code: 1
Start : 2017-05-28 03:00
End : 2019-11-04 14:10

# Weather Forecasting in Africa: Challenges

## Data Quality







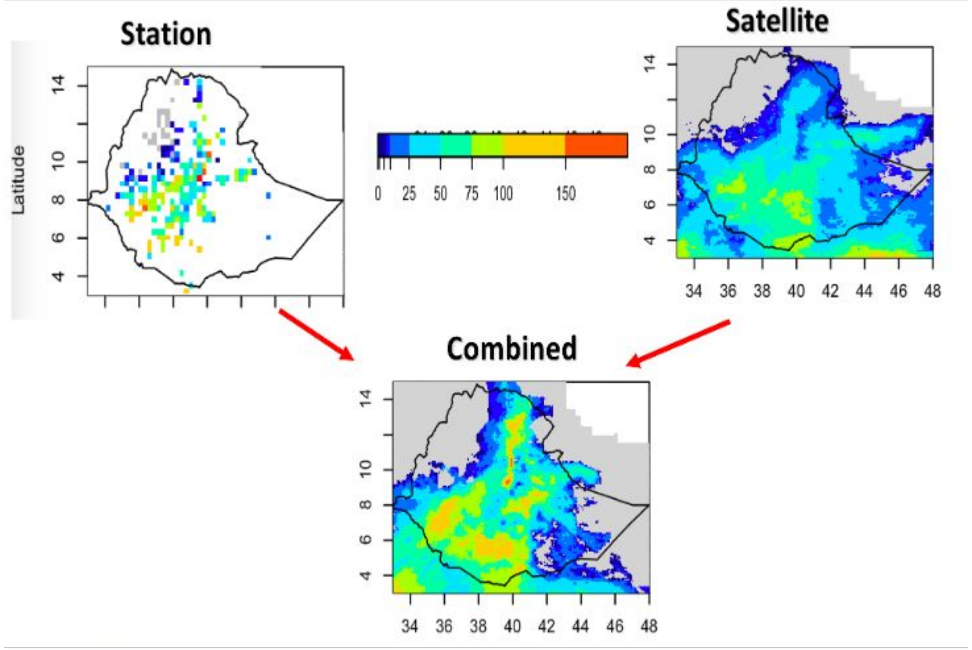
Data quality issues: some QC outputs for RR and TT

# Weather Forecasting in Africa: Challenges

## Data Issues: What can we do?

Blends quality-controlled station data with proxies(satellite rainfall estimates and reanalysis products)

Generates RR and TT data at 4km spatial resolution from 1981 until present

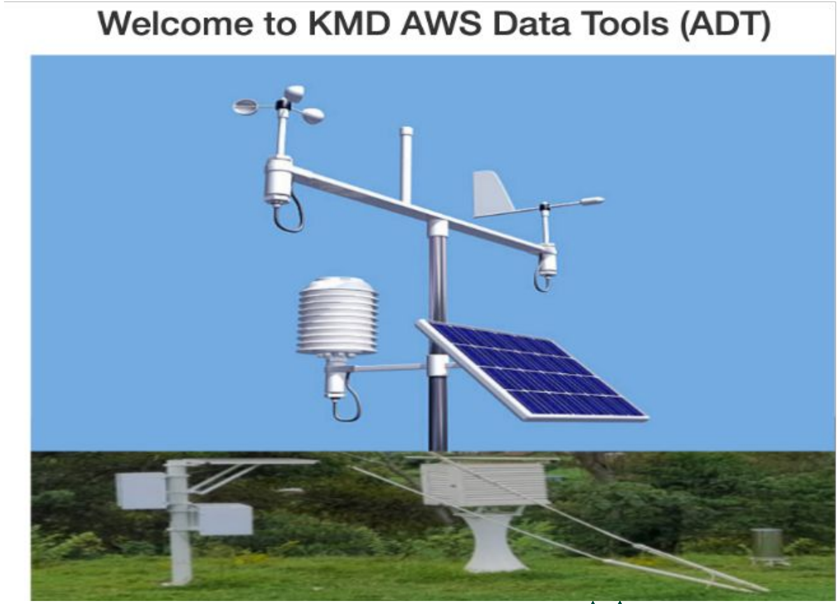


# Weather Forecasting in Africa: Challenges

## Data Issues: What can we do?

### The Automatic Weather Station Data Tool (ADT)

- Bring data from different AWS systems into one integrated database
- Data processing including QC
- Monitoring functionality of stations on real time
- Share current observations with users through an online portal



Welcome to KMD AWS Data Tools (ADT)

# Capacity Building Goals: Accessibility, Accuracy, Autonomy

---

## Accessibility

- **Showcase AI-based models that are publicly available (e.g. AIFS, NeuralGCM, GenCast)**
- **Cover foundations of how to create AI-based models, train them, and validate results**

## Accuracy

- **Highlight how assimilating local observations into model training can improve an AI-based model**
- **Share evaluation protocols that clarify how well different models perform for forecasts of interest**

## Autonomy

- **Hands-on tutorials on running a pre-trained AI-based model(s) on a local machine**
- **Hands-on tutorials on evaluating an AI-based model(s)**
- **Create a space for collaboration across forecasters and decision-makers to develop frameworks to integrate forecasts into strategic roadmaps and concept of operations plans**

# Scaling Weather Forecast Access through Training

Develop a training curriculum and program for **NMHS** & Ministry of Agriculture (**MoA**) staff from LMICs on state-of-the-art AI Weather forecasting methods.

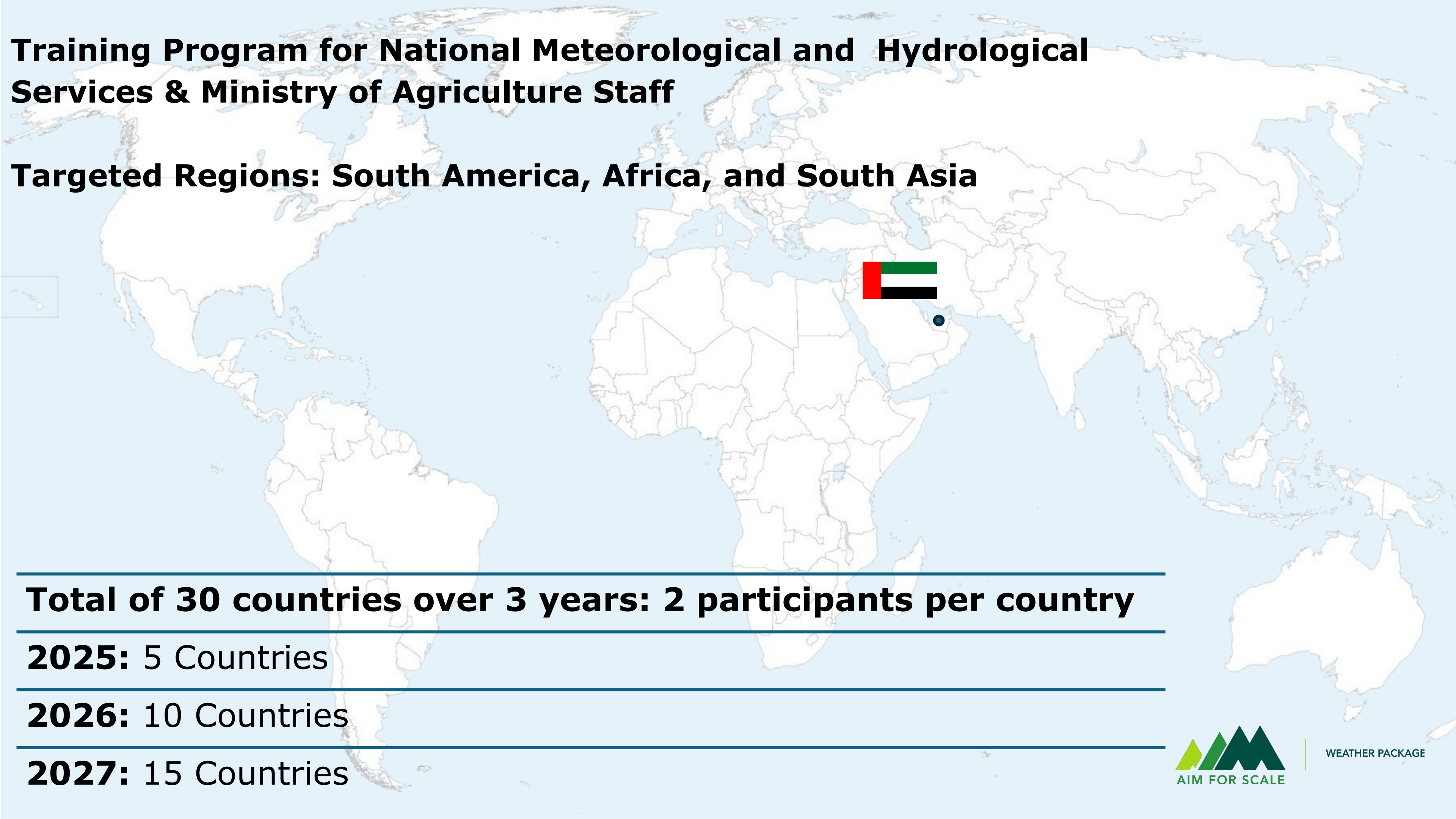
Leverage on existing training programs offered by partner institutions (WMO, ECMWF)

Training will be jointly hosted at Mohamed ben Zayed University of Artificial Intelligence (**MBZUAI**) and UAE National Center of Meteorology (**NCM**)

A total of 60 individuals from 30 **LMICs** will benefit from this training program.

# Training Program for National Meteorological and Hydrological Services & Ministry of Agriculture Staff

## Targeted Regions: South America, Africa, and South Asia

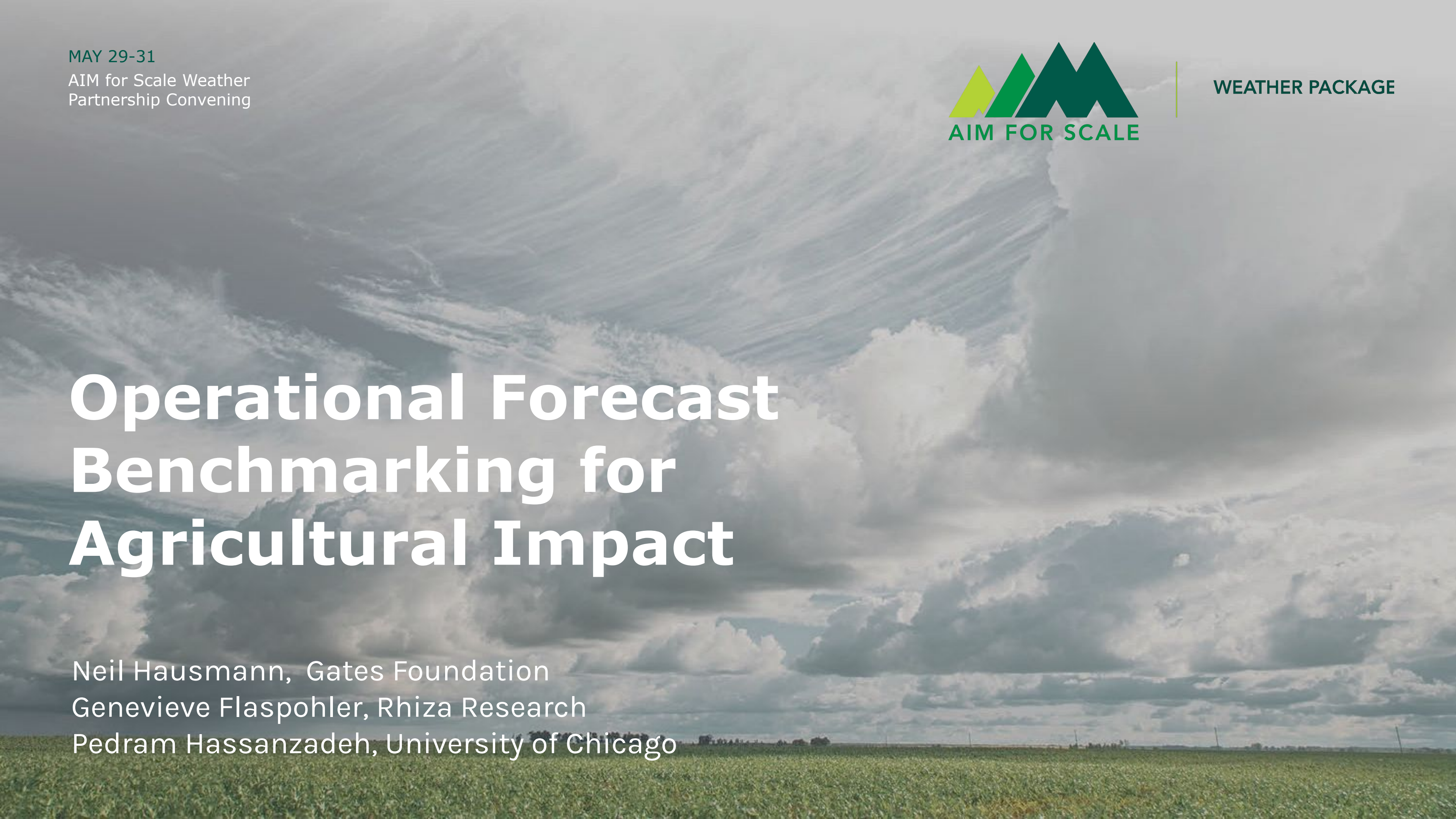


**Total of 30 countries over 3 years: 2 participants per country**

**2025:** 5 Countries

**2026:** 10 Countries

**2027:** 15 Countries



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# Operational Forecast Benchmarking for Agricultural Impact

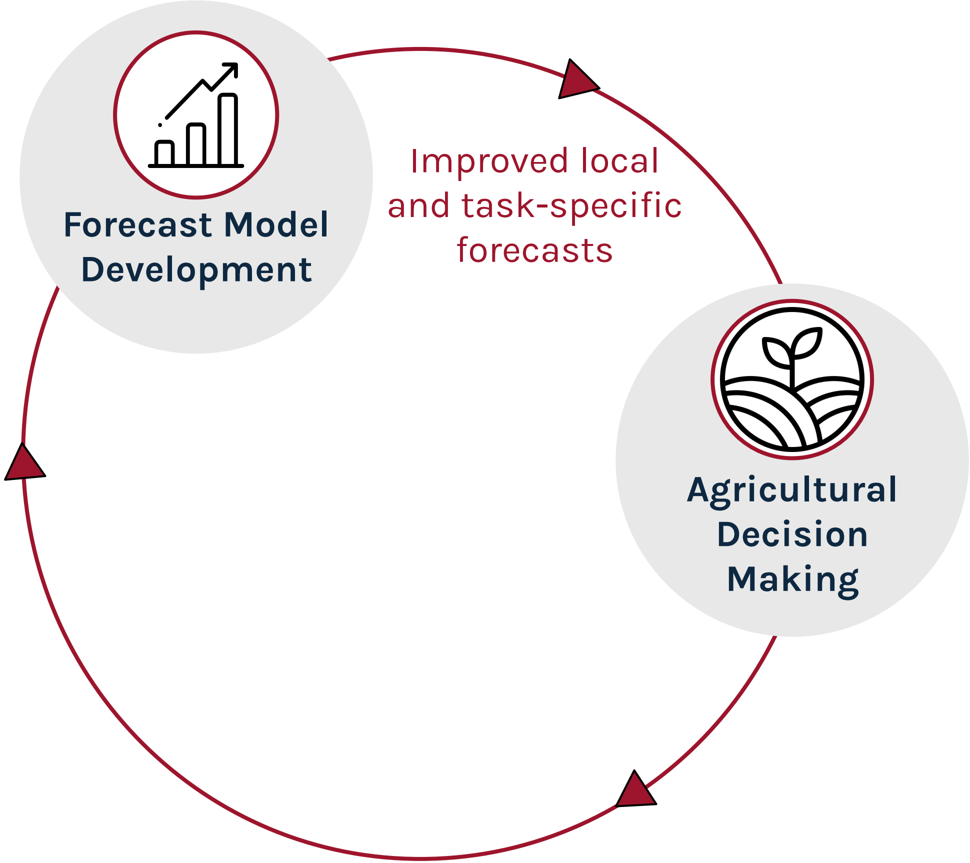
Neil Hausmann, Gates Foundation
Genevieve Flaspohler, Rhiza Research
Pedram Hassanzadeh, University of Chicago

# Weather intelligence for agriculture

**Agricultural Decision Making**

Gates Foundation

# Weather intelligence for agriculture



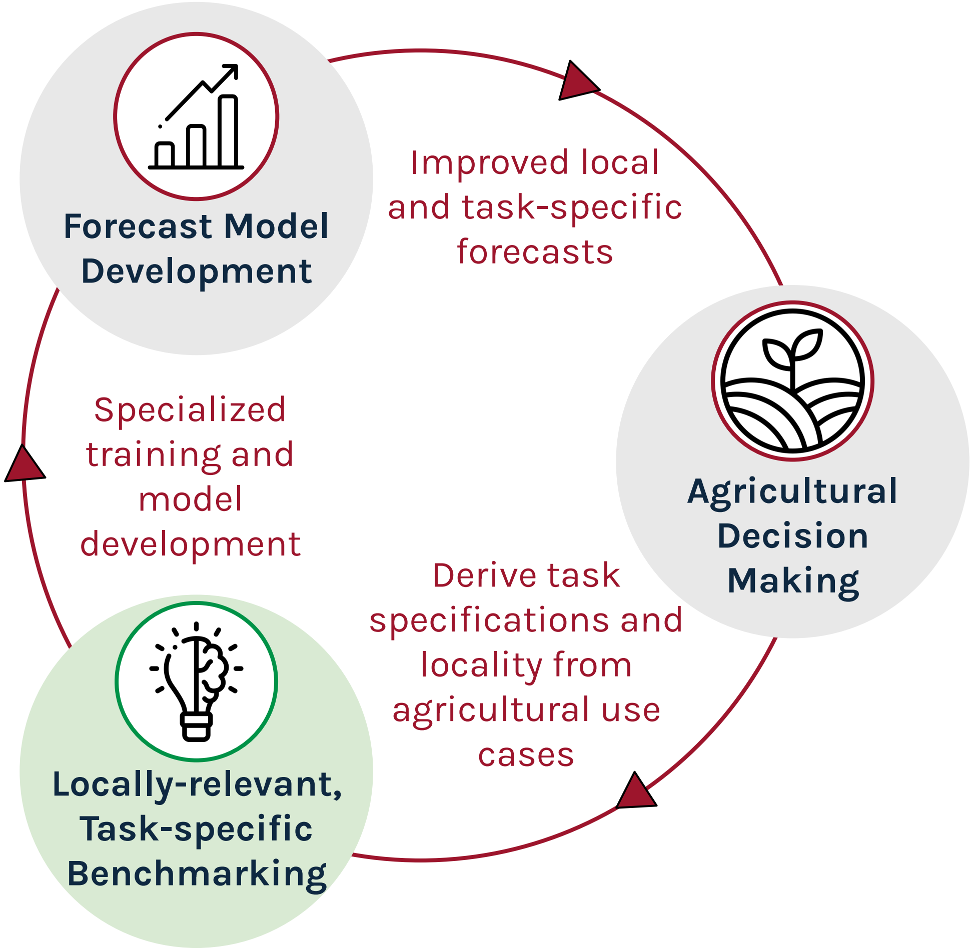
**Forecast Model Development**

Improved local and task-specific forecasts

**Agricultural Decision Making**

Gates Foundation

# Weather intelligence for agriculture



**Forecast Model Development**

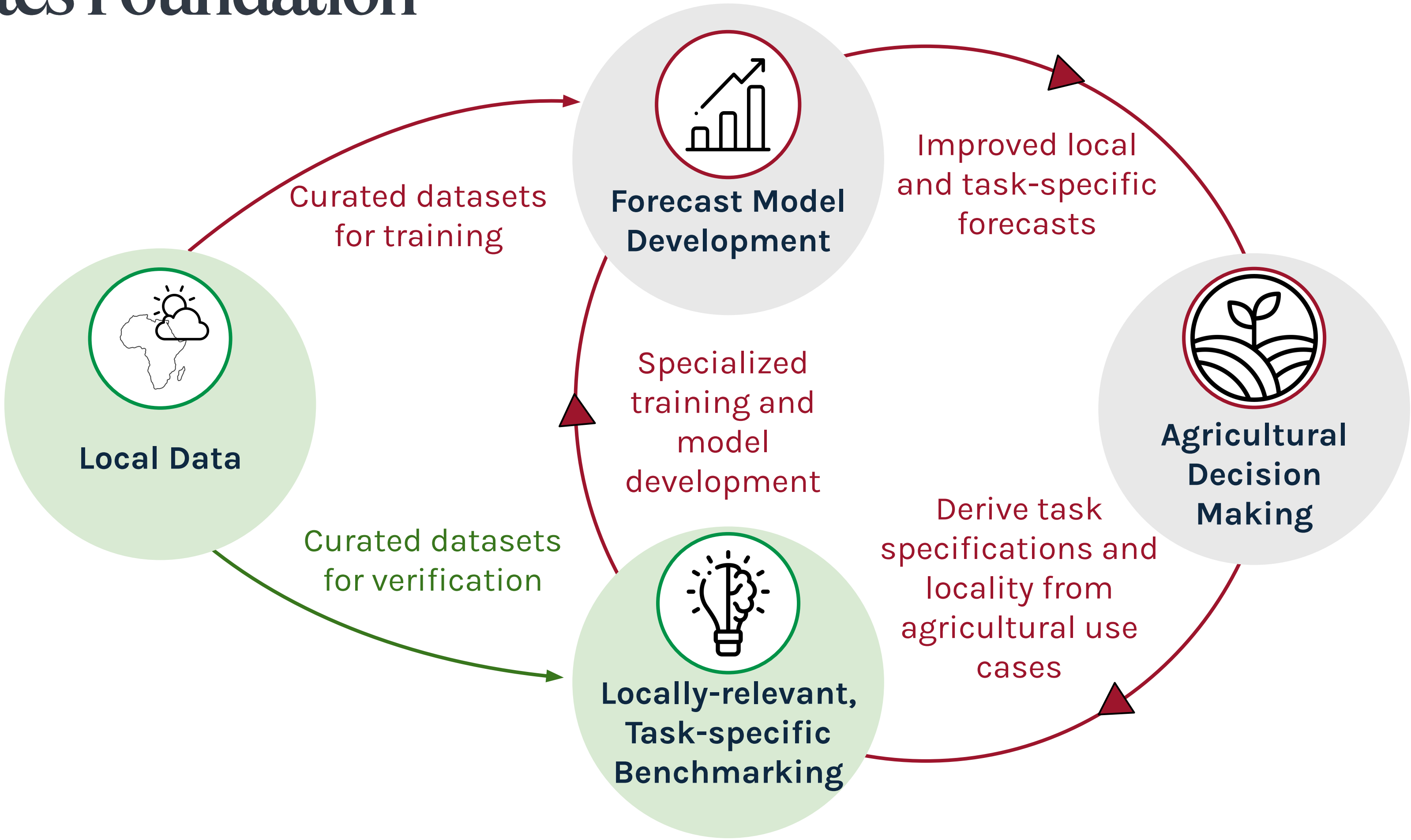
Improved local and task-specific forecasts

**Agricultural Decision Making**

Derive task specifications and locality from agricultural use cases

**Locally-relevant, Task-specific Benchmarking**

Specialized training and model development



**Forecast Model Development**

Improved local and task-specific forecasts

**Agricultural Decision Making**

Derive task specifications and locality from agricultural use cases

**Locally-relevant, Task-specific Benchmarking**

Specialized training and model development

**Local Data**

Curated datasets for training

Curated datasets for verification

# Why benchmarking?

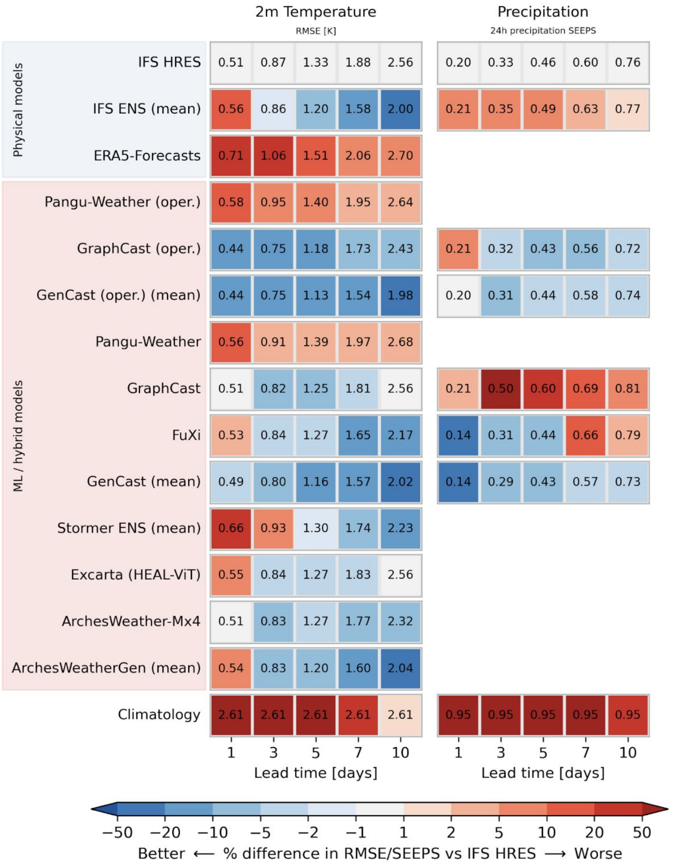
In the past 5 years, AI weather prediction (AIWP) models have **surpassed the skill** of leading numerical weather prediction (NWP) models.

These AIWP models are **wildly** cheaper than NWP models.

AI model: 3 min on 1 A40 GPU - **$3K USD**

IFS 9km: 1 hour on 12500 CPUs of Cray XC40 supercomputer - **$125M USD**

**WeatherBench 2**



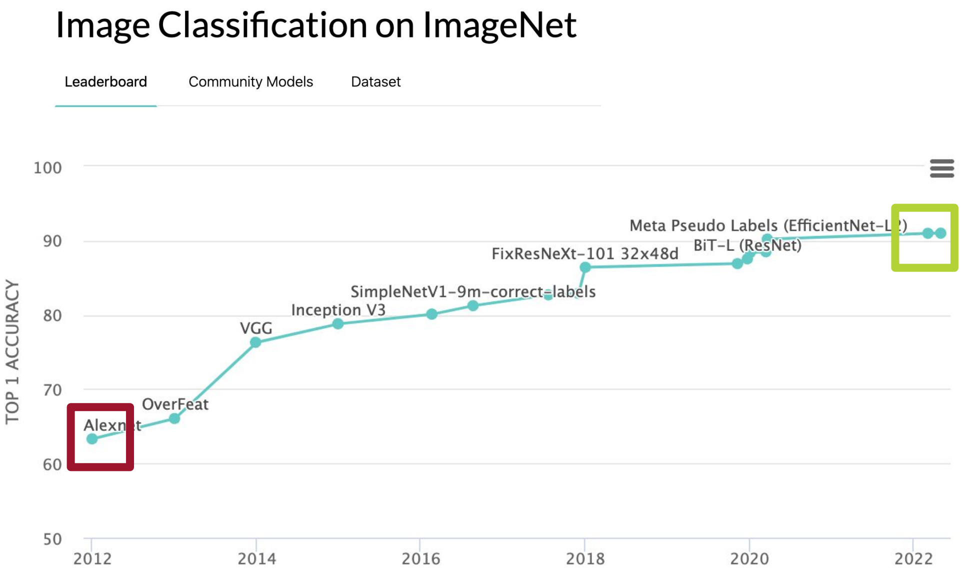
| | | 2m Temperature | | | | | Precipitation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 3 | 5 | 7 | 10 | 1 | 3 | 5 | 7 | 10 |
| Physical models | IFS HRES | 0.51 | 0.87 | 1.33 | 1.88 | 2.56 | 0.20 | 0.33 | 0.46 | 0.60 | 0.76 |
| | IFS ENS (mean) | 0.56 | 0.86 | 1.20 | 1.58 | 2.00 | 0.21 | 0.35 | 0.49 | 0.63 | 0.77 |
| | ERA5-Forecasts | 0.71 | 1.06 | 1.51 | 2.06 | 2.70 | | | | | |
| ML / hybrid models | Pangu-Weather (oper.) | 0.58 | 0.95 | 1.40 | 1.95 | 2.64 | | | | | |
| | GraphCast (oper.) | 0.44 | 0.75 | 1.18 | 1.73 | 2.43 | 0.21 | 0.32 | 0.43 | 0.56 | 0.72 |
| | GenCast (oper.) (mean) | 0.44 | 0.75 | 1.13 | 1.54 | 1.98 | 0.20 | 0.31 | 0.44 | 0.58 | 0.74 |
| | Pangu-Weather | 0.56 | 0.91 | 1.39 | 1.97 | 2.68 | | | | | |
| | GraphCast | 0.51 | 0.82 | 1.25 | 1.81 | 2.56 | 0.21 | 0.50 | 0.60 | 0.69 | 0.81 |
| | FuXi | 0.53 | 0.84 | 1.27 | 1.65 | 2.17 | 0.14 | 0.31 | 0.44 | 0.66 | 0.79 |
| | GenCast (mean) | 0.49 | 0.80 | 1.16 | 1.57 | 2.02 | 0.14 | 0.29 | 0.43 | 0.57 | 0.73 |
| | Stormer ENS (mean) | 0.66 | 0.93 | 1.30 | 1.74 | 2.23 | | | | | |
| | Excarta (HEAL-ViT) | 0.55 | 0.84 | 1.27 | 1.83 | 2.56 | | | | | |
| | ArchesWeather-Mx4 | 0.51 | 0.83 | 1.27 | 1.77 | 2.32 | | | | | |
| | ArchesWeatherGen (mean) | 0.54 | 0.83 | 1.20 | 1.60 | 2.04 | | | | | |
| | Climatology | 2.61 | 2.61 | 2.61 | 2.61 | 2.61 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |

# Benchmarking has two theories of change

1. **AI benchmarking:** Using benchmarks to drive breakthroughs in AI-based forecasting skill on high-impact prediction tasks.

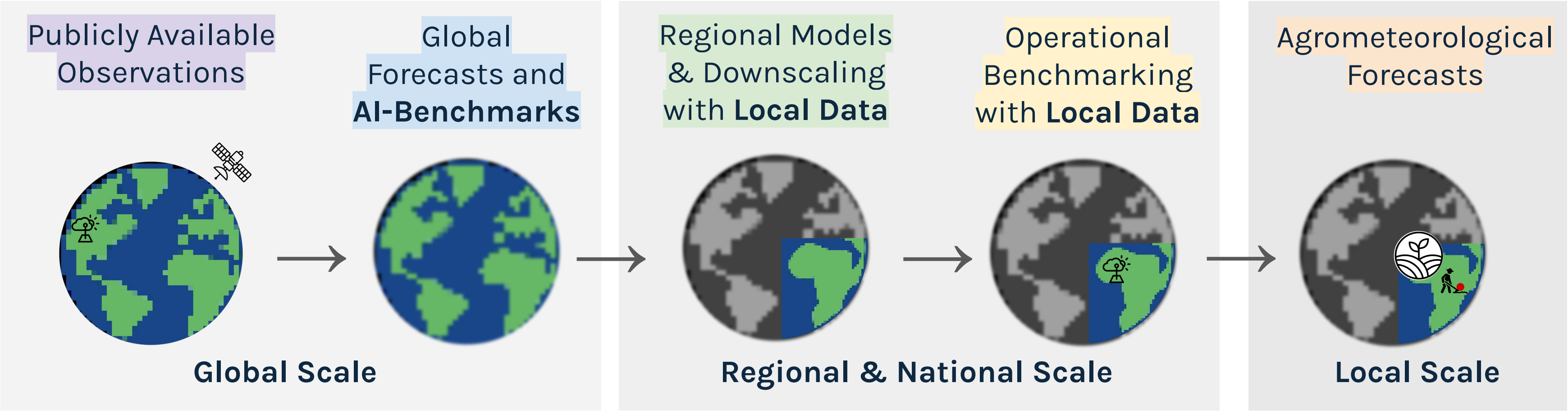
IMAGENET

ImageNet fundamentally transformed what automated systems are capable of.



# Benchmarking has two theories of change

1. **AI benchmarking:** Using benchmarks to drive breakthroughs in AI-based forecasting skill on high-impact prediction tasks.
2. **Operational benchmarking / verification (our focus today):** Helping NMHSs decide which novel forecasting models and outputs (if any) to operationalize.



Publicly Available Observations → Global Forecasts and **AI-Benchmarks** → Regional Models & Downscaling with **Local Data** → Operational Benchmarking with **Local Data** → Agrometeorological Forecasts

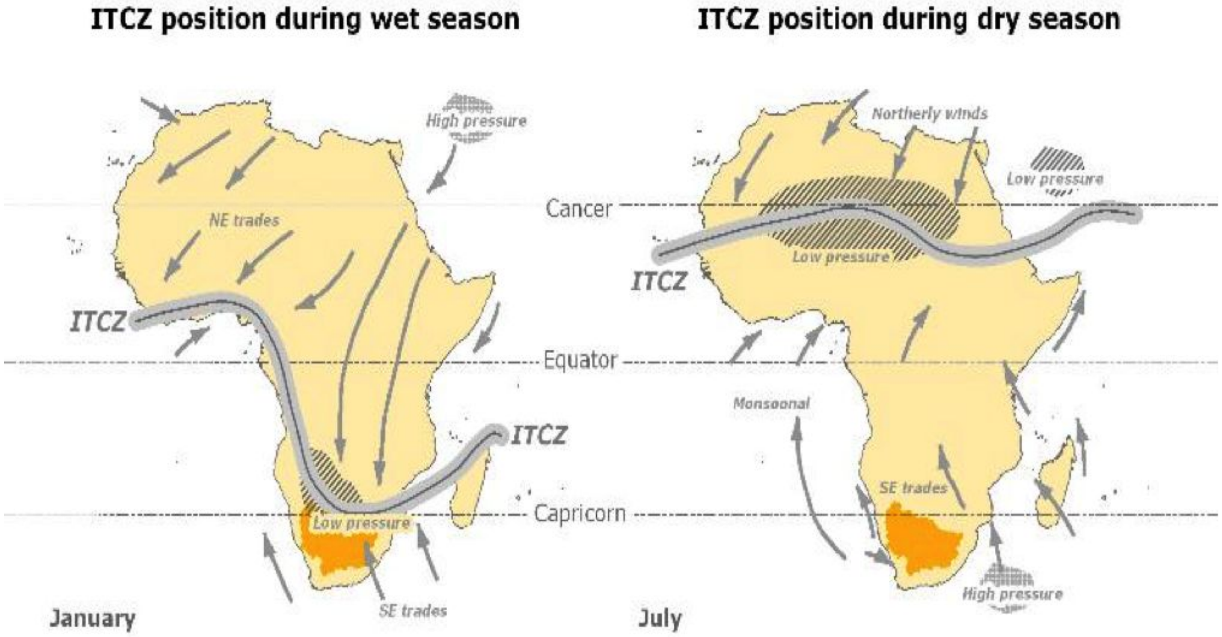
**Global Scale**

**Regional & National Scale**

**Local Scale**

If you are a smallholder farmer in Machakos county, Kenya, your farm is in a semi-arid environment, ~1200 meters above sea level.

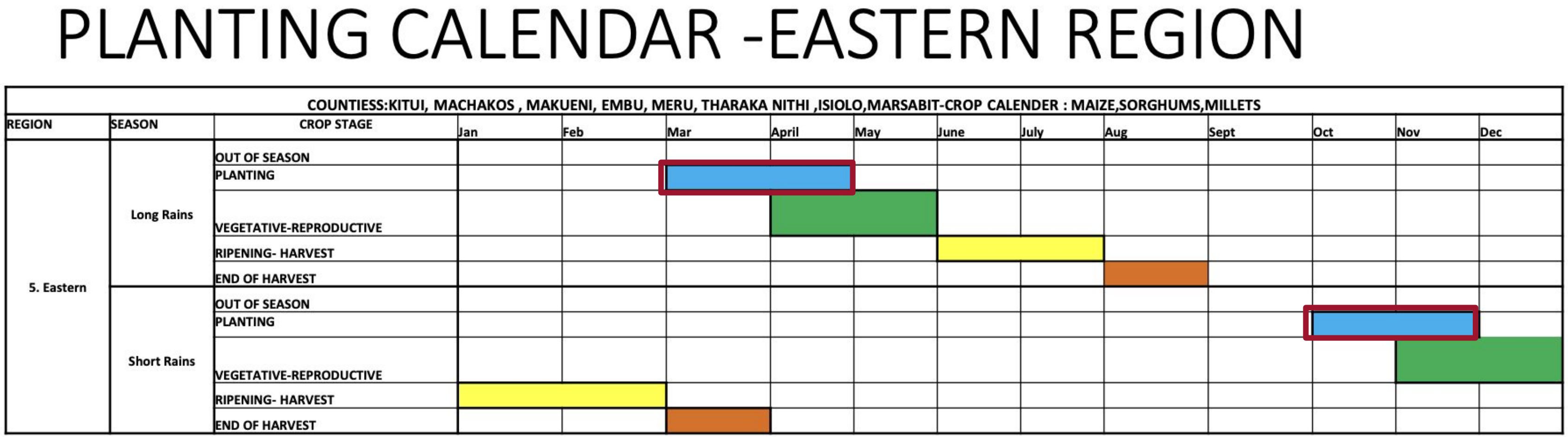
# In Machakos, there are two wet seasons each year driven by the ITCZ: *the March-April-May (MAM/“long”) rains and the October-November-December (OND/“short”) rains.*



Each season, to plant, you must decide:

What crop varietal seeds do you purchase? When do you plant? How densely do you space your crops? Do you have money for fertilizer and pesticides? If so, when do you apply them?

You likely grow maize, sorghum, and millet, and you have little or no access to irrigation. You need ~70 days for your crop to mature, and generally plant in October.



# PLANTING CALENDAR -EASTERN REGION

COUNTIESS:KITUI, MACHAKOS , MAKUENI, EMBU, MERU, THARAKA NITHI ,ISIOLO,MARSABIT-CROP CALENDER : MAIZE,SORGHUMS,MILLETS

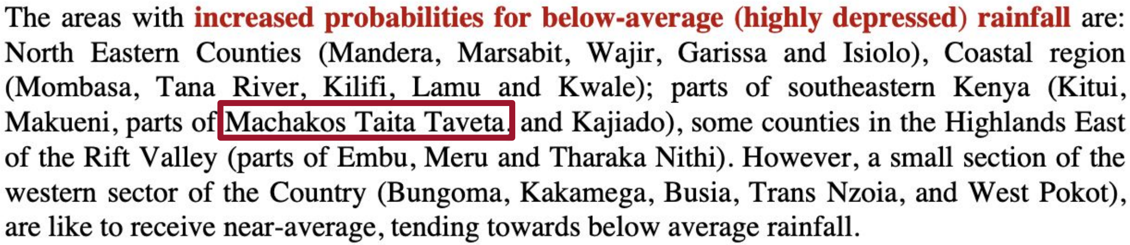
| REGION | SEASON | CROP STAGE | Jan | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5. Eastern | Long Rains | OUT OF SEASON | | | | | | | | | | | | |
| | | PLANTING | | | 🟦 | 🟦 | | | | | | | | |
| | | VEGETATIVE-REPRODUCTIVE | | | | 🟩 | 🟩 | | | | | | | |
| | | RIPENING- HARVEST | | | | | | 🟨 | 🟨 | | | | | |
| | | END OF HARVEST | | | | | | | | 🟧 | | | | |
| | Short Rains | OUT OF SEASON | | | | | | | | | | | | |
| | | PLANTING | | | | | | | | | | 🟦 | 🟦 | |
| | | VEGETATIVE-REPRODUCTIVE | | | | | | | | | | | 🟩 | 🟩 |
| | | RIPENING- HARVEST | 🟨 | 🟨 | | | | | | | | | | |
| | | END OF HARVEST | | | 🟧 | | | | | | | | | |

REPUBLIC OF KENYA

**Ministry of Agriculture & Livestock Development**

KALRO
Kenya Agricultural & Livestock Research Organization

# On September 2, 2022, KMD releases their seasonal outlook for the OND rainy season.



The areas with **increased probabilities for below-average (highly depressed) rainfall** are: North Eastern Counties (Mandera, Marsabit, Wajir, Garissa and Isiolo), Coastal region (Mombasa, Tana River, Kilifi, Lamu and Kwale); parts of southeastern Kenya (Kitui, Makueni, parts of Machakos Taita Taveta, and Kajiado), some counties in the Highlands East of the Rift Valley (parts of Embu, Meru and Tharaka Nithi). However, a small section of the western sector of the Country (Bungoma, Kakamega, Busia, Trans Nzoia, and West Pokot), are like to receive near-average, tending towards below average rainfall.

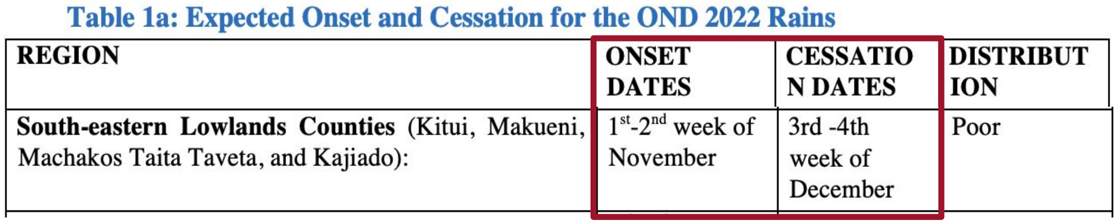
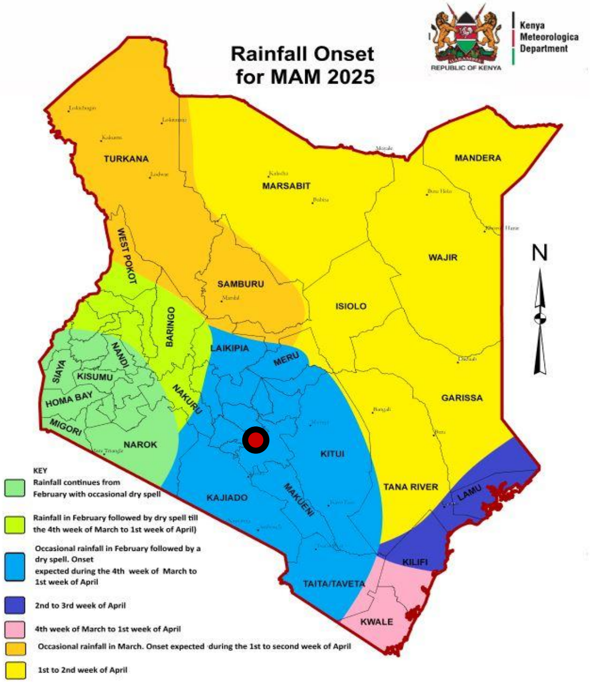


**Table 1a: Expected Onset and Cessation for the OND 2022 Rains**

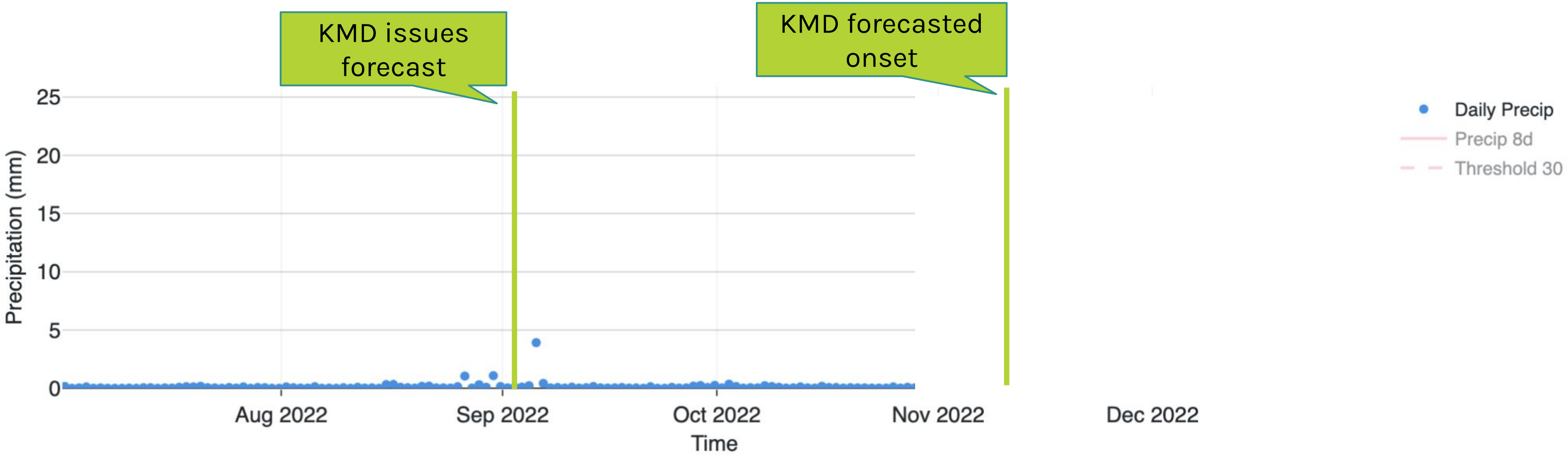
| REGION | ONSET DATES | CESSATION DATES | DISTRIBUTION |
|---|---|---|---|
| **South-eastern Lowlands Counties** (Kitui, Makueni, Machakos Taita Taveta, and Kajiado): | 1st-2nd week of November | 3rd -4th week of December | Poor |

**The forecast predicts an OND season that comes late and is short, between 46 and 60 days long.**

*Example of onset forecast maps (note from 2025)*

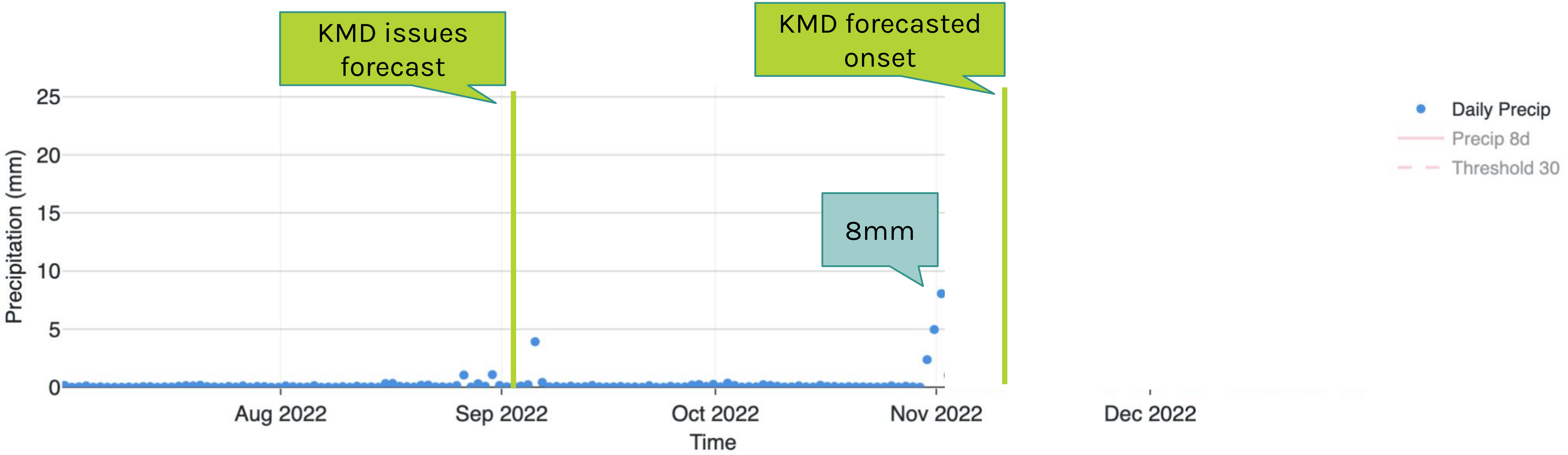


# At the end of October, the soil is parched,

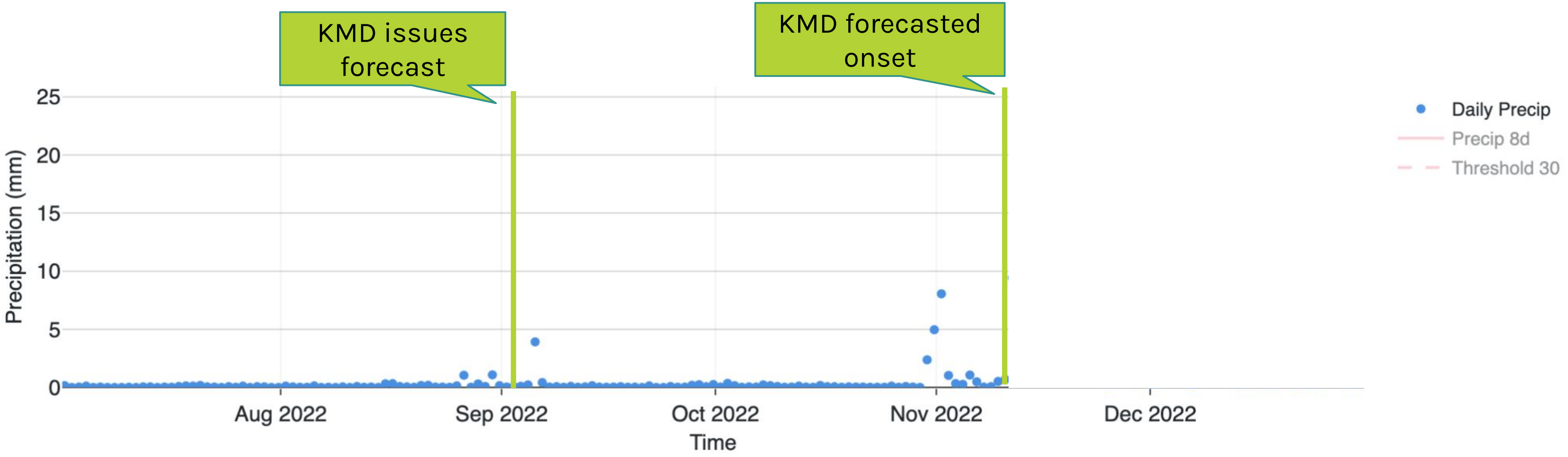

KMD issues forecast

KMD forecasted onset

# In the last week of October, the rain starts. Do you plant?



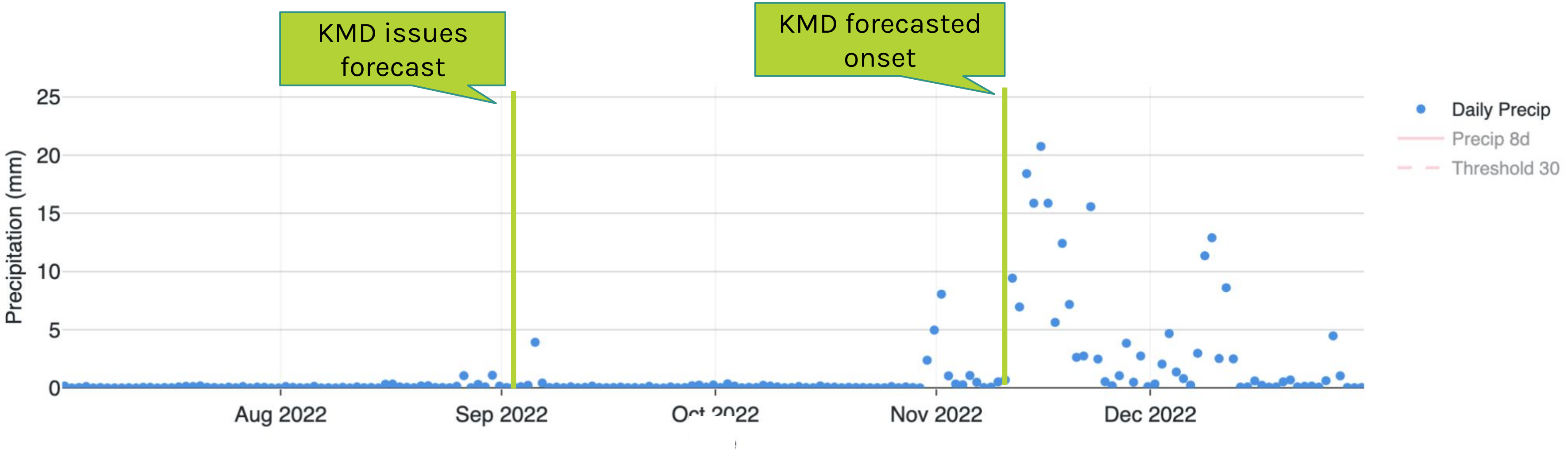
# 9 days pass, and no more substantial rain falls. If you planted, your seeds may not germinate.



KMD issues forecast

KMD forecasted onset

# On Nov 11, rains begin in earnest and sustain until Dec 13, with late season rain on Dec 26



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# When was the optimal time to plant, in retrospect?

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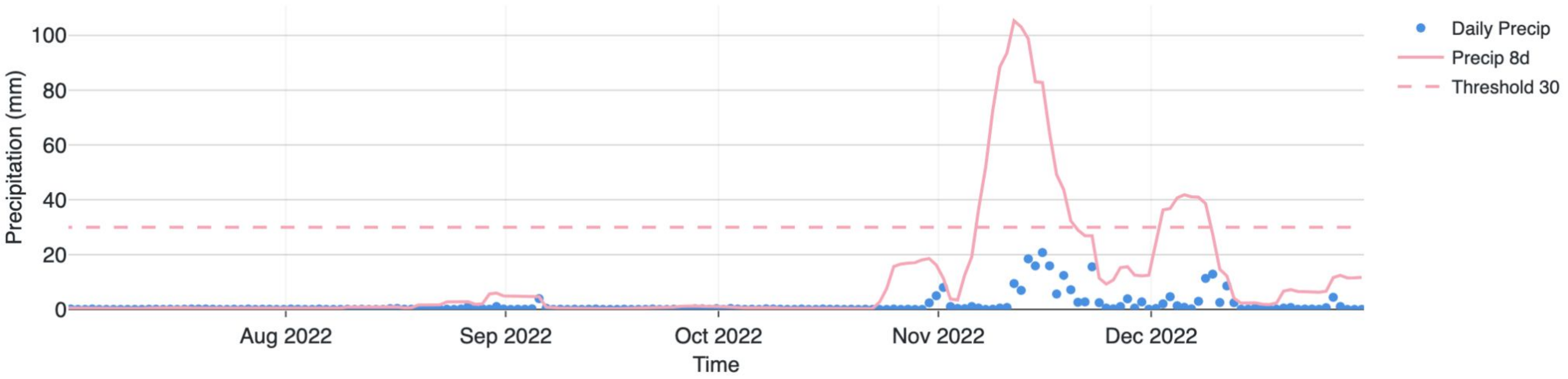

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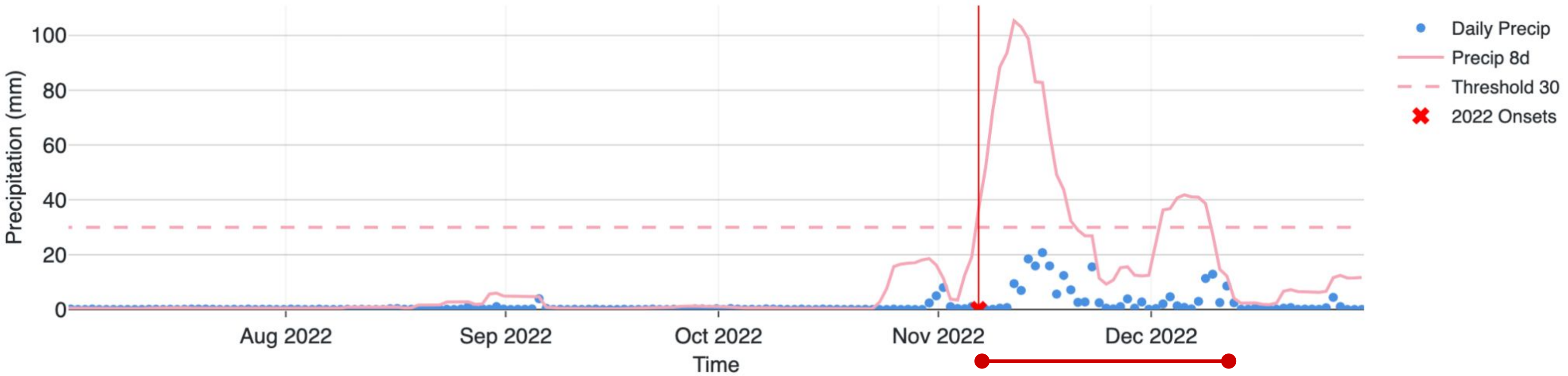
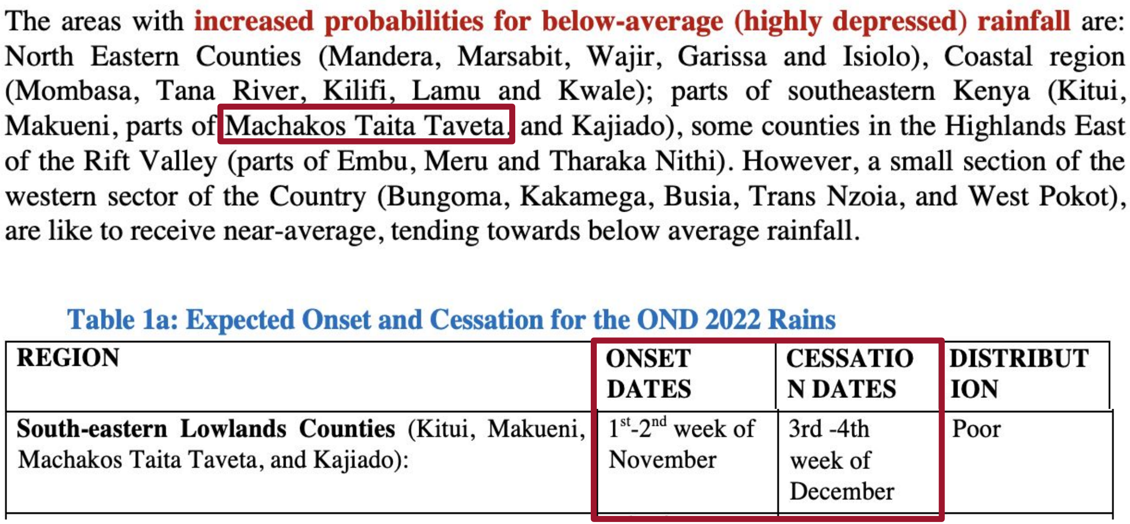


The OND rainy season in 2022 lasted for ~46 days, from Nov 6 - Dec 23

# On September 2, 2022, KMD releases their seasonal outlook for the OND rainy season.



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✓

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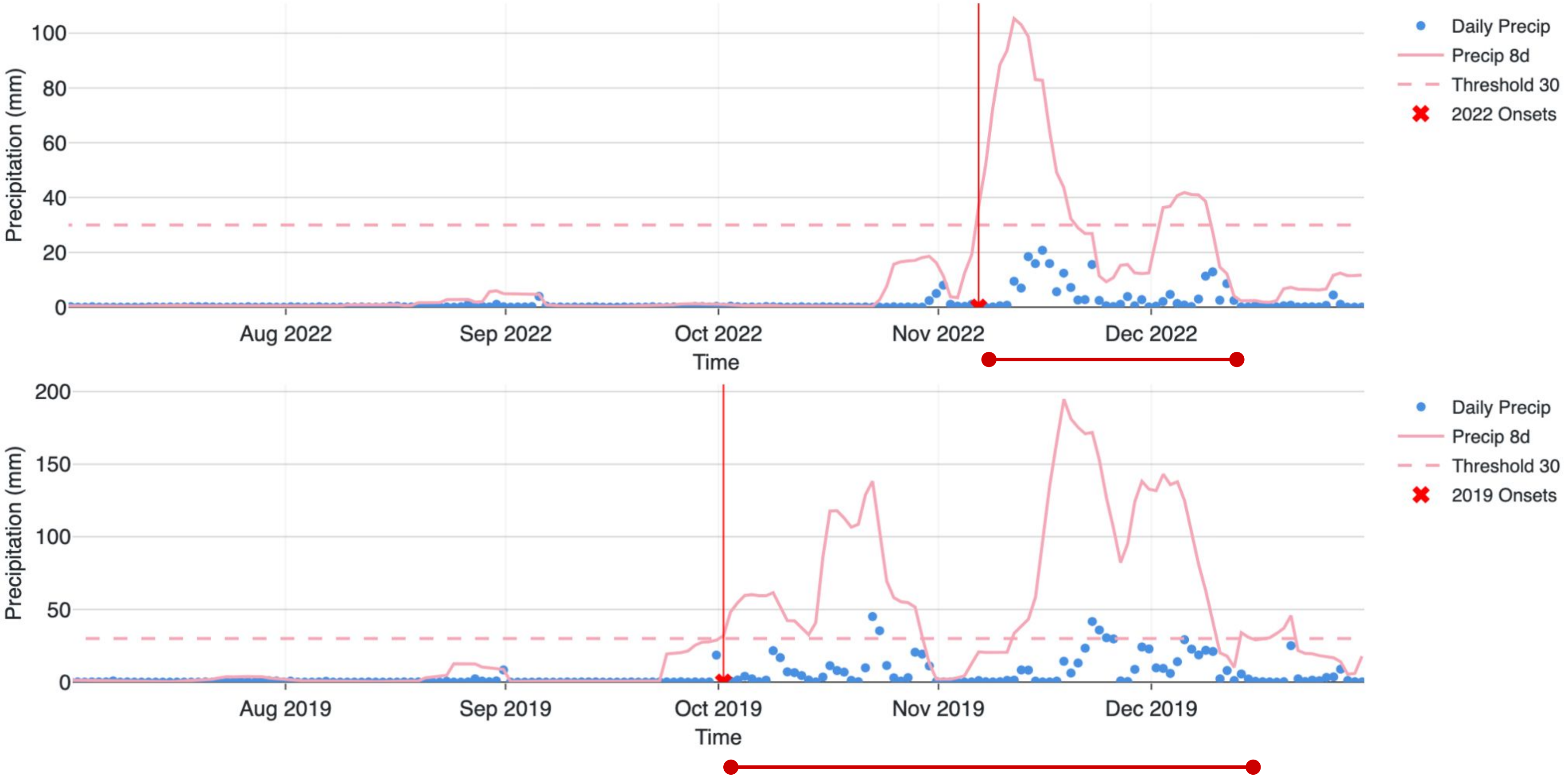
# Compare 2022 to 2019, which lasted 85 days.



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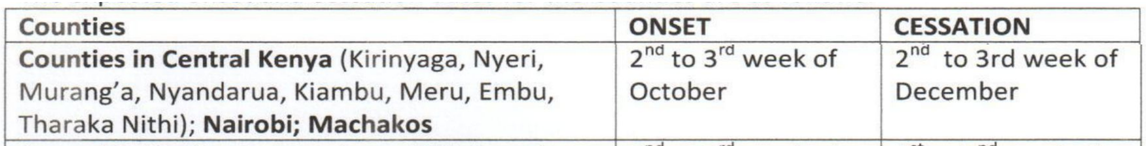
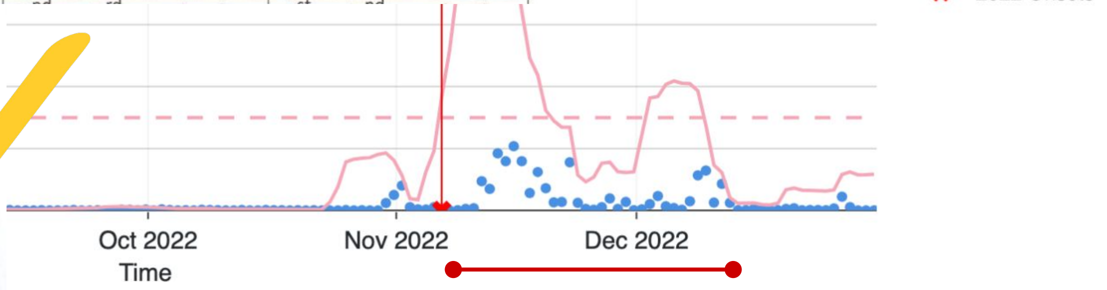
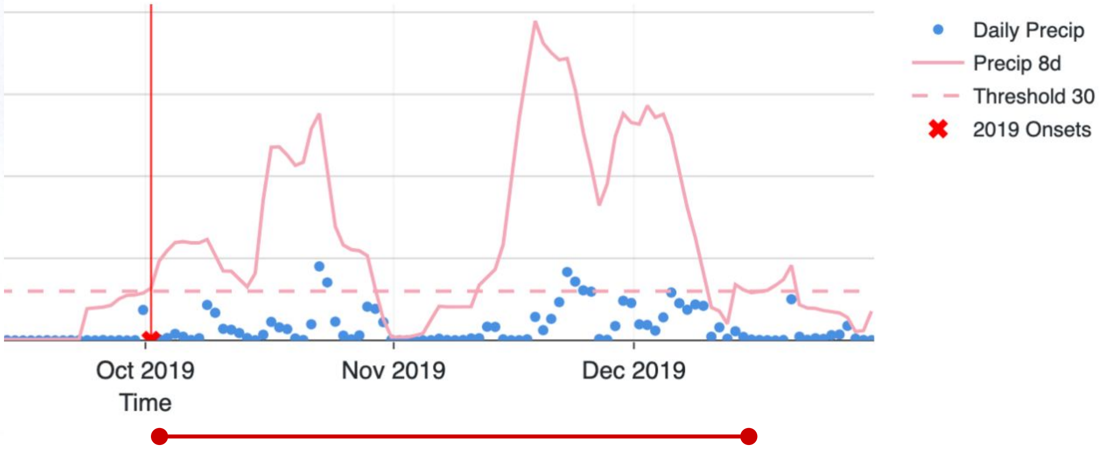


| Counties | ONSET | CESSATION |
|---|---|---|
| **Counties in Central Kenya** (Kirinyaga, Nyeri, Murang'a, Nyandarua, Kiambu, Meru, Embu, Tharaka Nithi); **Nairobi; Machakos** | 2nd to 3rd week of October | 2nd to 3rd week of December |

*Figure 2: Expected Onset for the OND 2019 Season*





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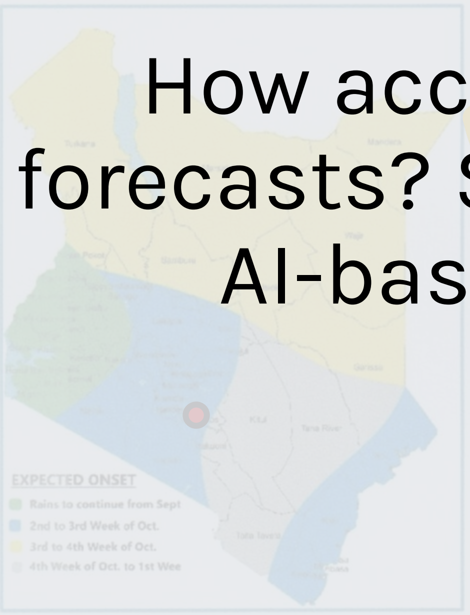

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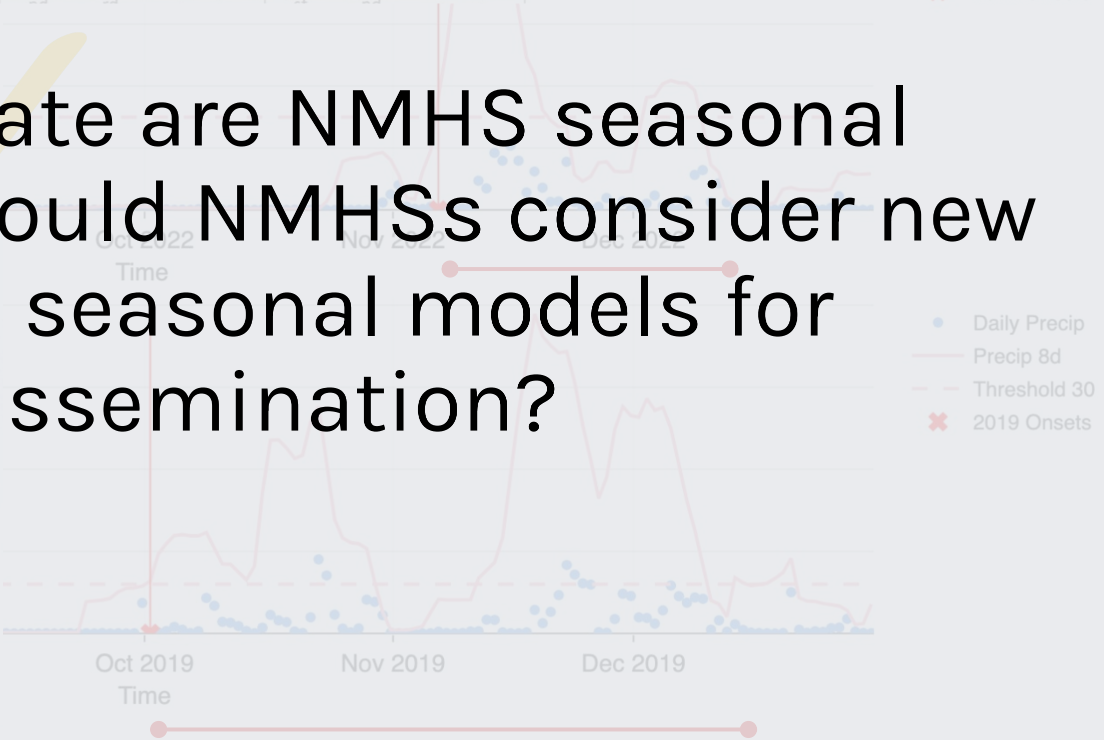
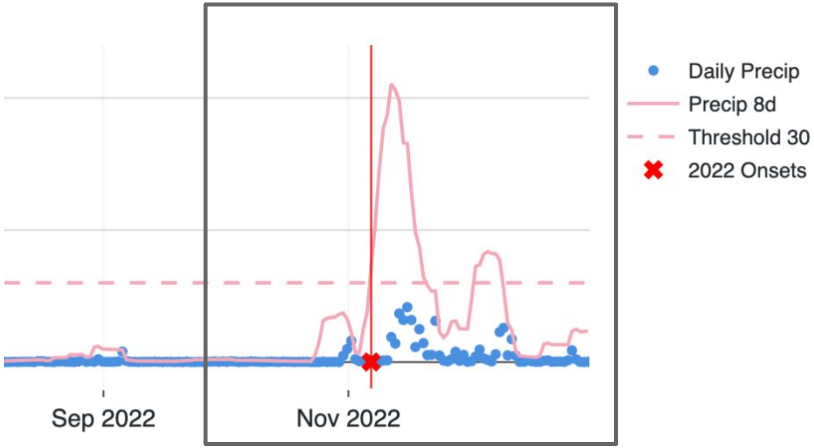


How accurate are NMHS seasonal forecasts? Should NMHSs consider new AI-based seasonal models for dissemination?

# Rainy seasons in East Africa are characterized by bursty, short rainfall events, leading up to true onset.



OND
season

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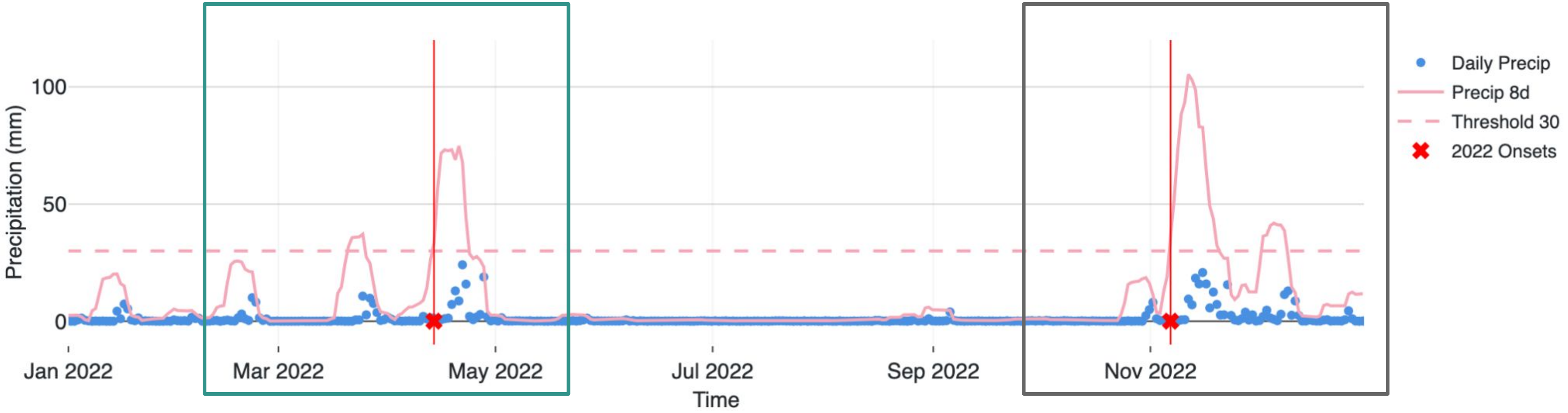
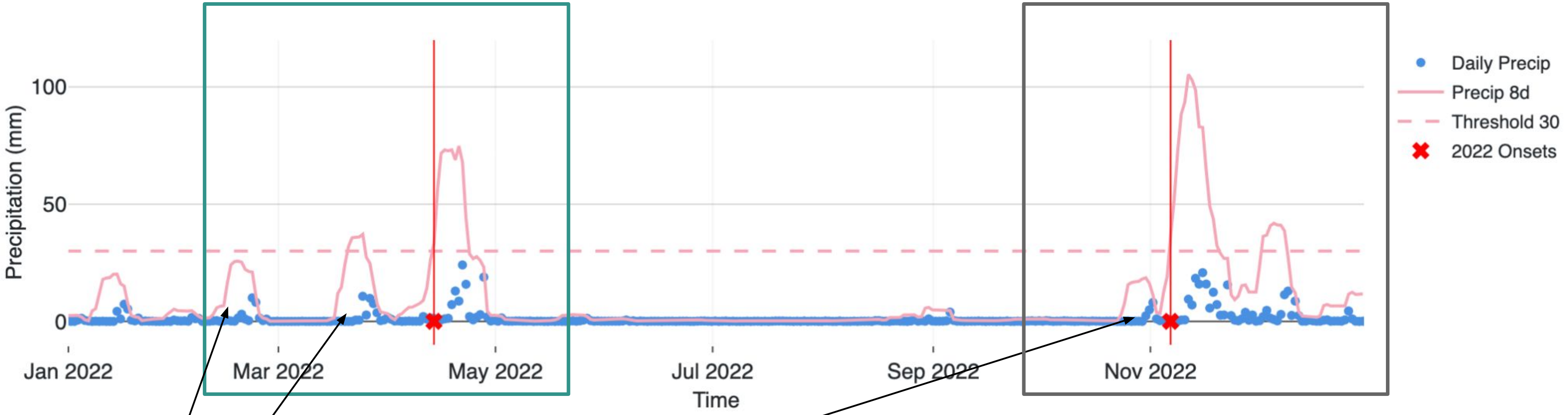


MAM
season

OND
season

# Dry spell forecasting during onset can provide farmers critical information on when to plant.



MAM
season

OND
season

False onsets followed by dry spells

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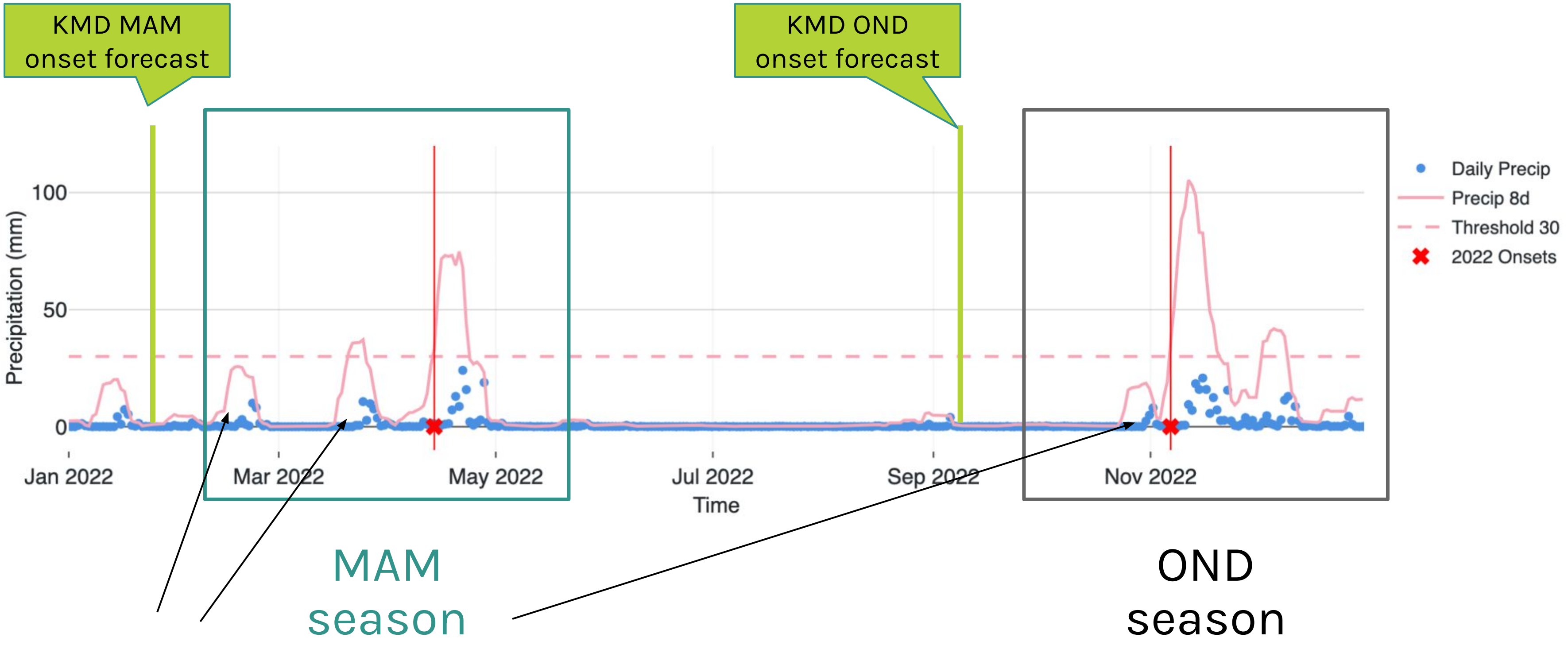

KMD MAM onset forecast

KMD OND onset forecast

MAM season

OND season

False onsets followed by dry spells

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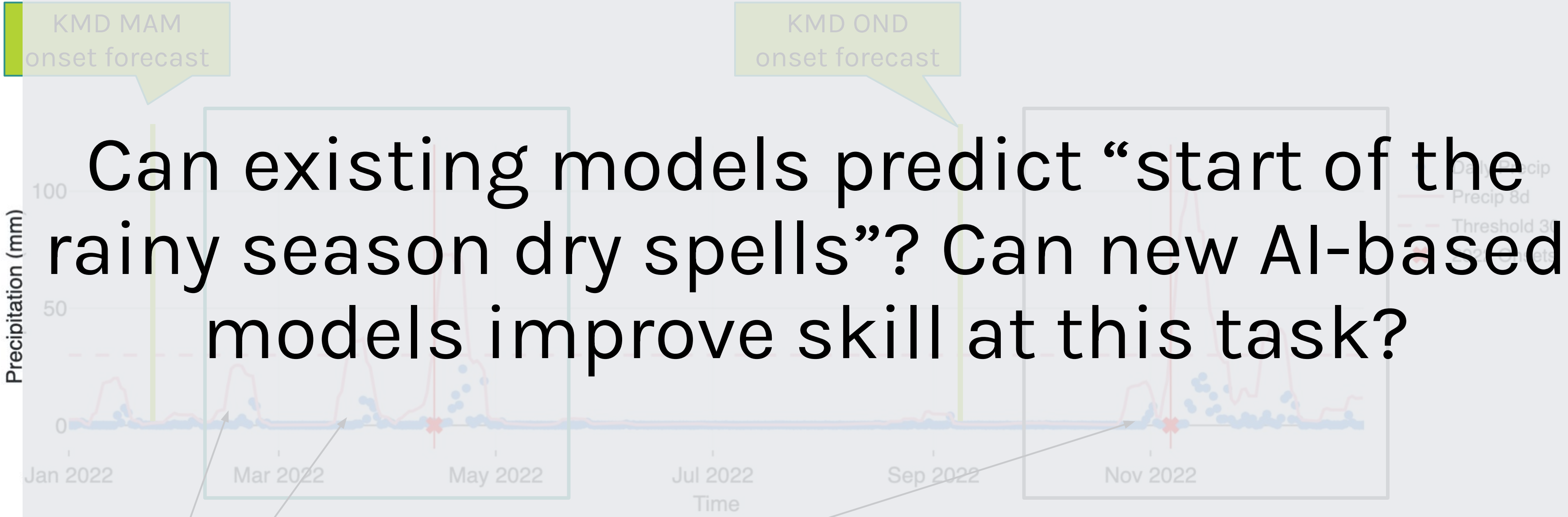


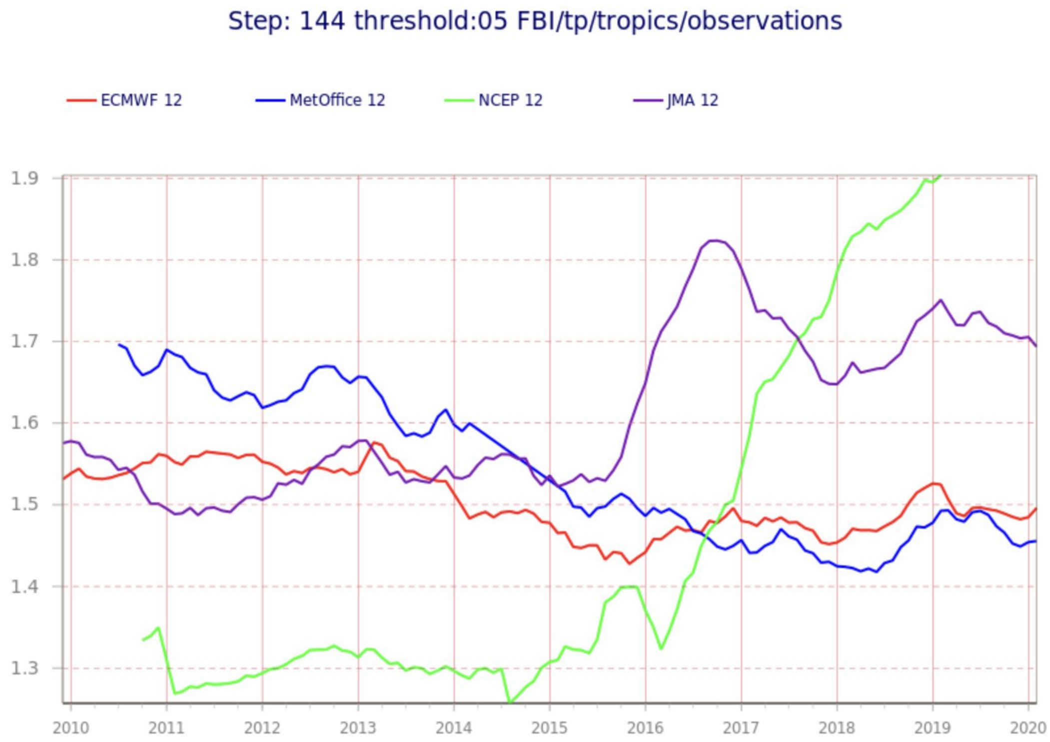
Can existing models predict “start of the rainy season dry spells”? Can new AI-based models improve skill at this task?

MAM season

OND season

False onsets followed by dry spells

# Today’s benchmarks / model verifications are not local or task specific, and cannot answer these questions.

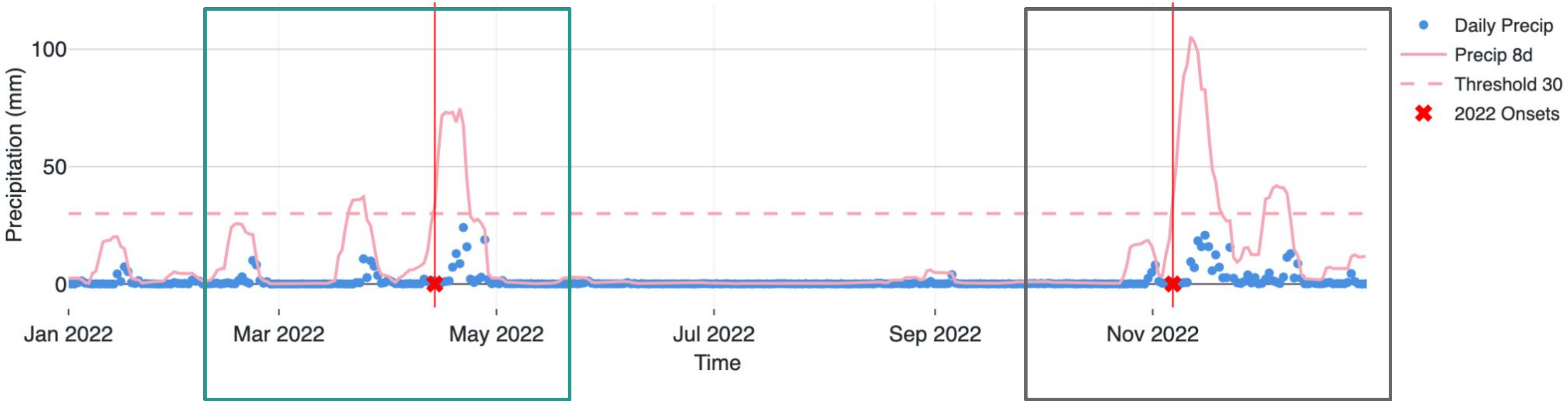


WMO’s Dynamical Model Verification

Global-scale verification based on few stations, generic metrics,

# Local data and expertise are critical for verification.

## IMERG satellite-based rainfall data

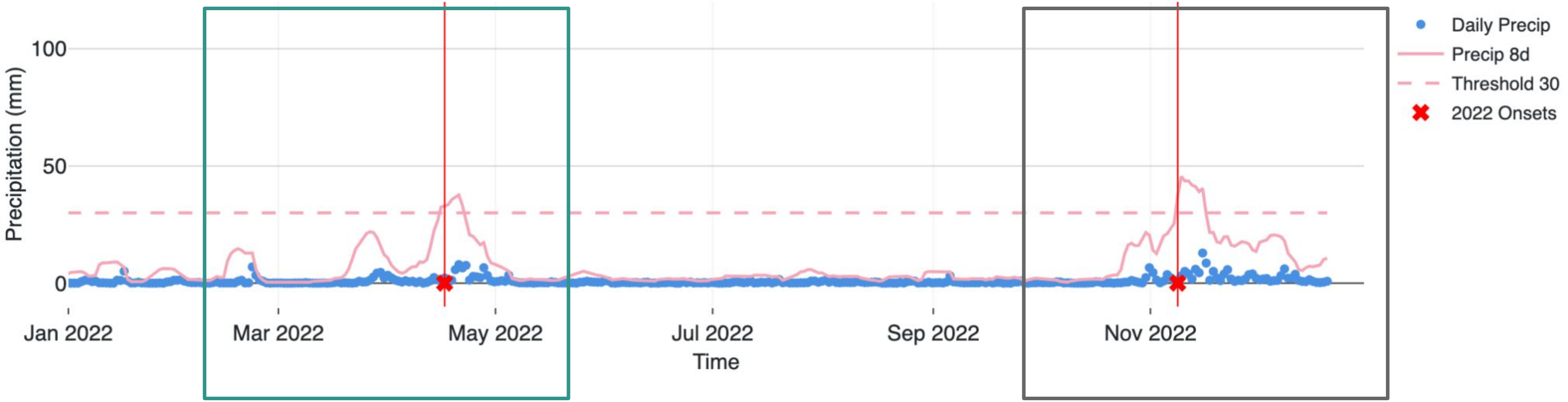


MAM
season

OND
season

# Local data and expertise are critical for verification.

## ERA5 reanalysis data

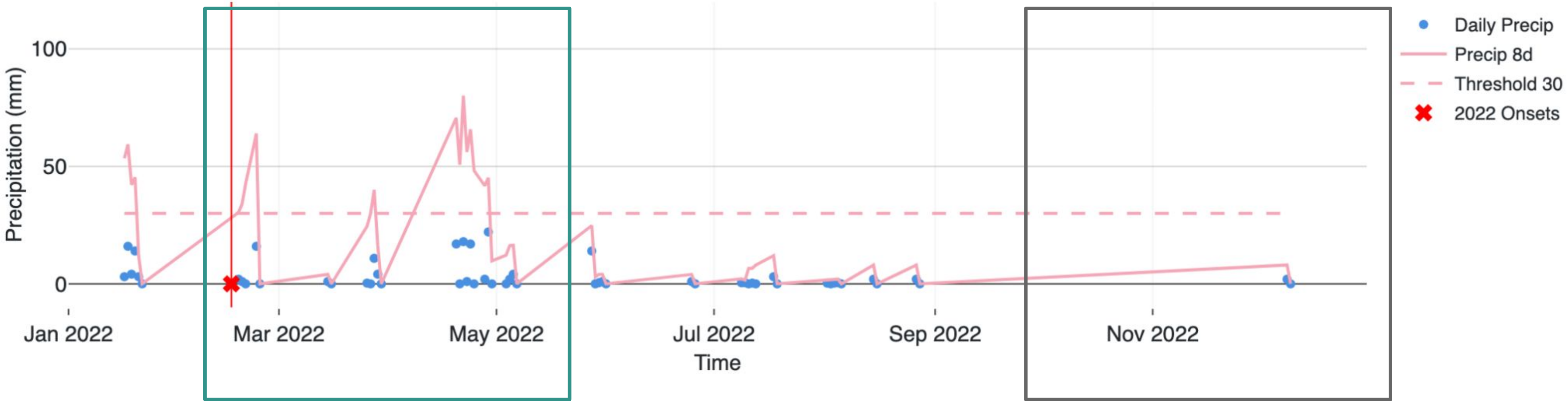


MAM
season

OND
season

# Local data and expertise are critical for verification.

**GHCN station data**



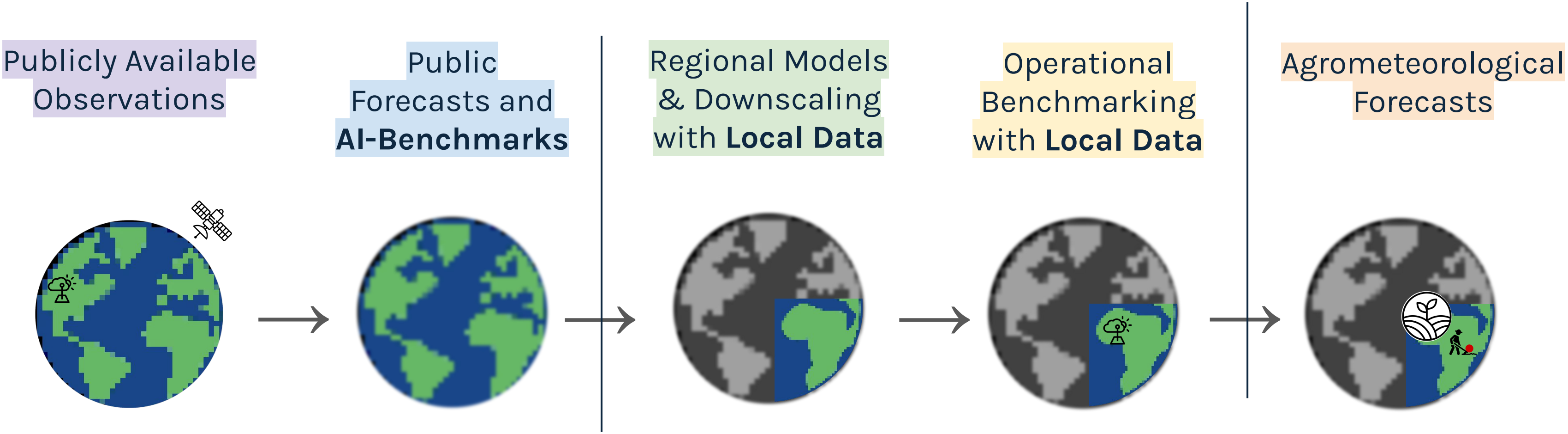
MAM
season

OND
season

A strong **operational benchmark** helps NMHSs decide which novel forecasting models and outputs (if any) to operationalize locally.

# Benchmarking 5- to 30-day Forecasts of Indian Monsoon Onset

To inform model selection for dissemination to millions of farmers



Publicly Available Observations

Public Forecasts and **AI-Benchmarks**

Regional Models & Downscaling with **Local Data**

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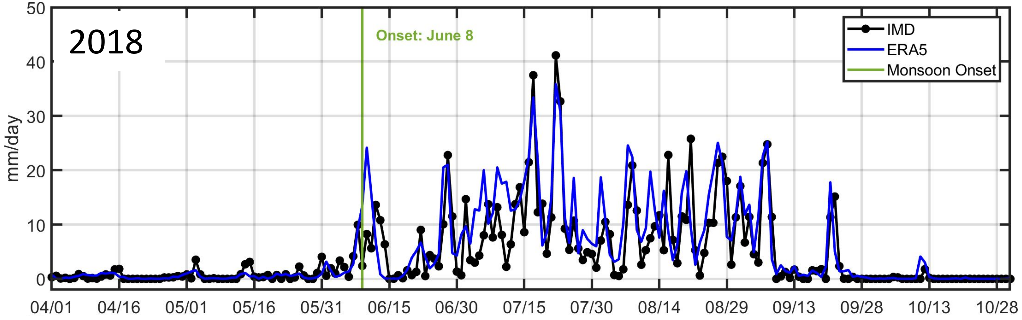
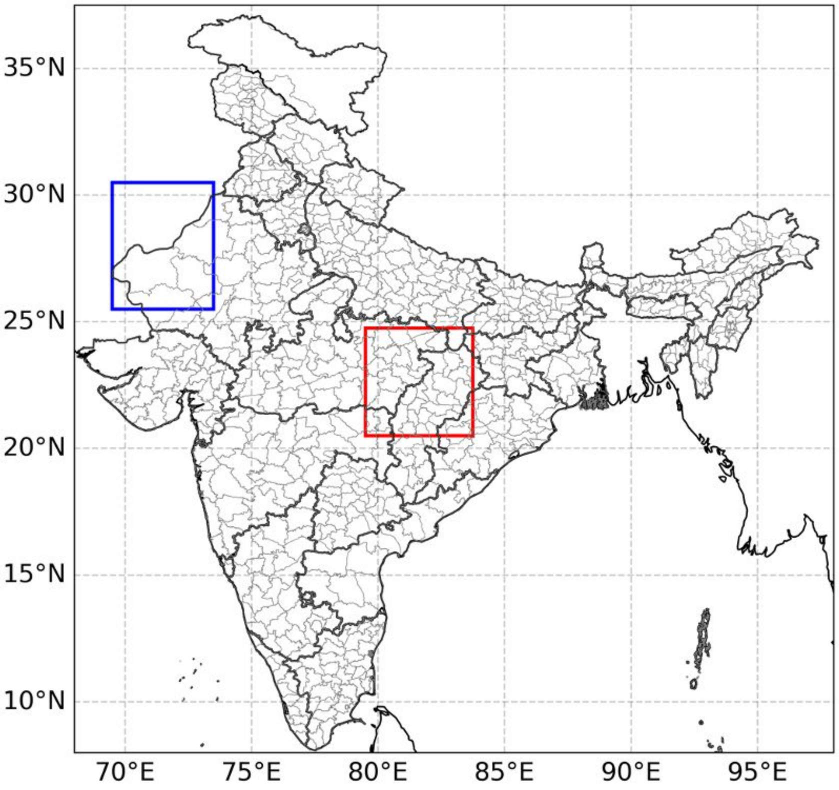




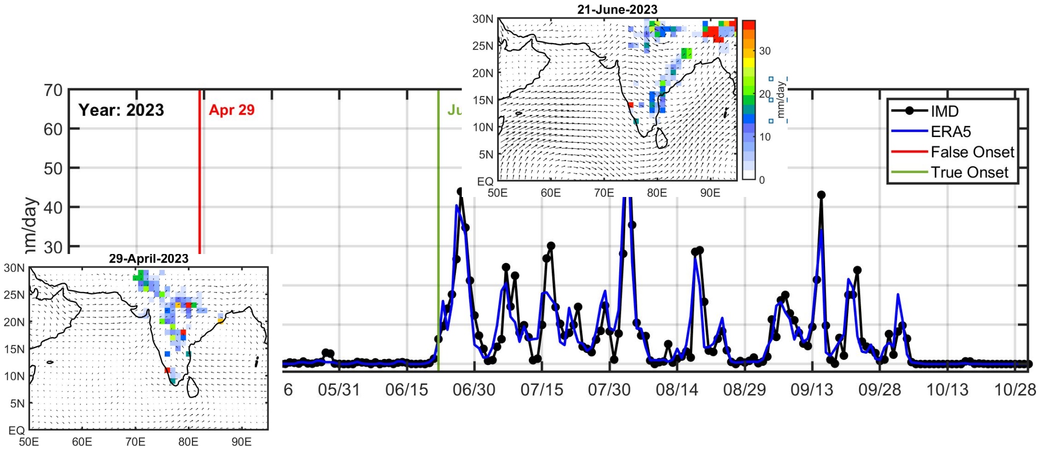
**Ground truth** (Pai et al. 2014):
High-quality IMD rain-gauge data, 1° gridded data from 1901-2024

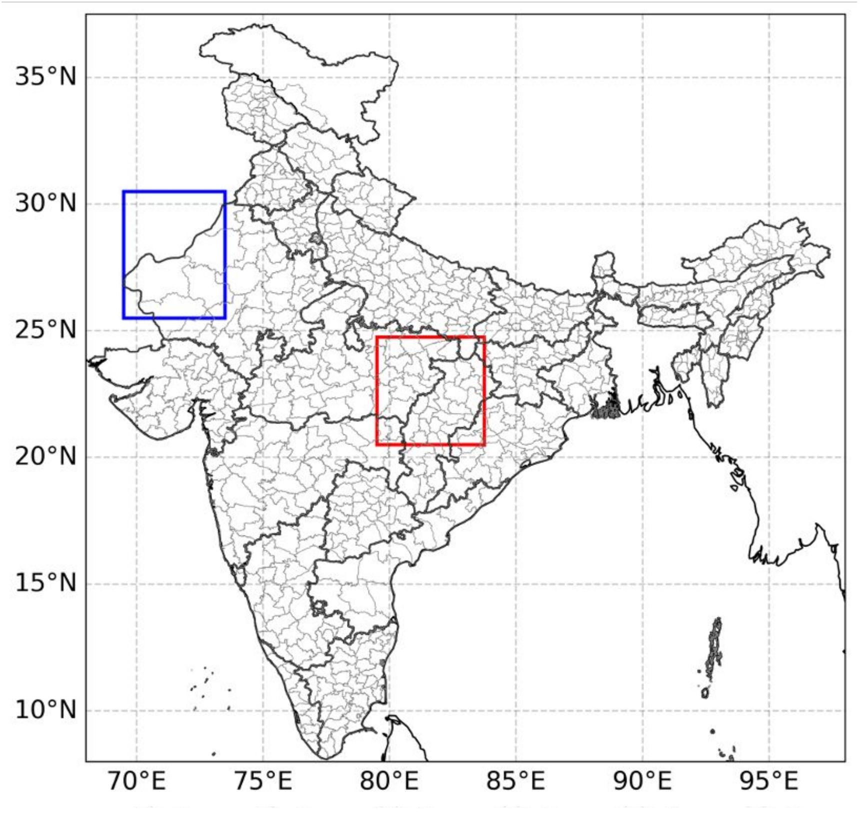
# Benchmarking 5- to 30-day Forecasts of Indian Monsoon Onset

To inform model selection for dissemination to millions of farmers

Moron & Robertson (2014) :
After April 1st, first day of 5-day accumulated rainfall above 38 mm, not followed by 10-day accumulated rainfall below 5 mm in the next 30 days

Provides actionable information to farmers (Burling, Jina et al, 2024)





# Benchmarking 5- to 30-day Forecasts of Indian Monsoon Onset

## Comparing AI, NWP, and Climatology

| Baseline & NWP | Years |
|---|---|
| Climatology (history) | 1901-2023 |
| IFS/IFS S2S (NWP) | 2004-2024 |

| AI models | Training | Fine-tuning |
|---|---|---|
| AIFS | 1979-2020 | 2019-2020<br>(IFS HRES) |
| GenCast* | 1979-2018 | None |
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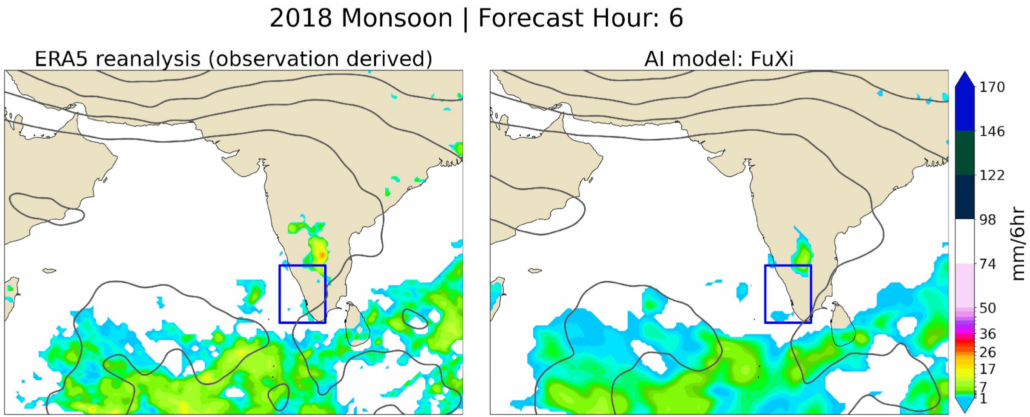
2018 Monsoon | Forecast Hour: 6

ERA5 reanalysis (observation derived)

AI model: FuXi


AI model: 3 min on 1 A40 GPU ($3K)


IFS 9km: 1 hour on 12500 CPUs of Cray XC40 supercomputer ($125M)

# Benchmarking 5- to 30-day Forecasts of Indian Monsoon Onset

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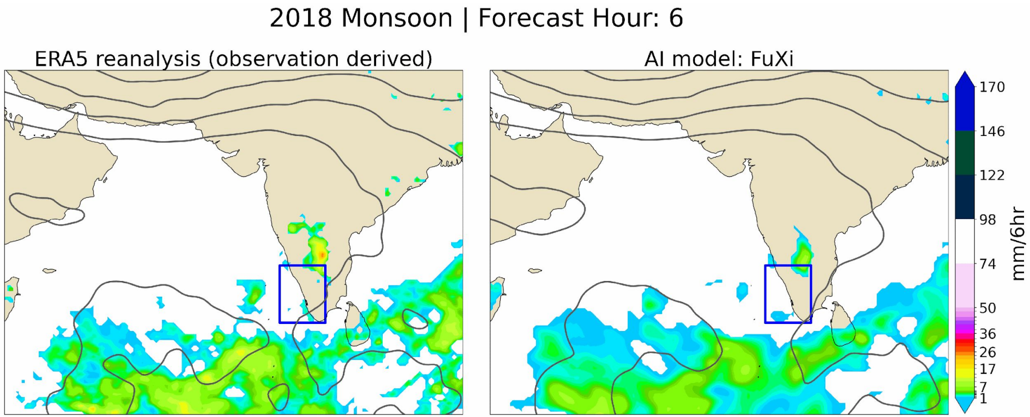
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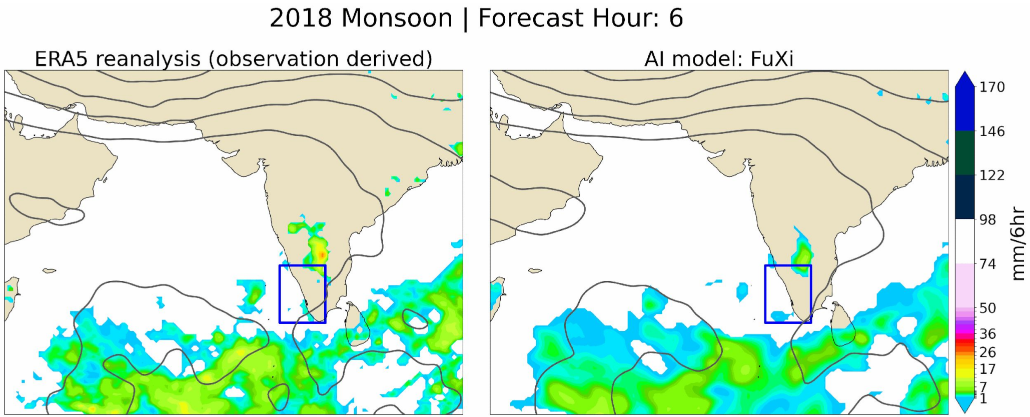

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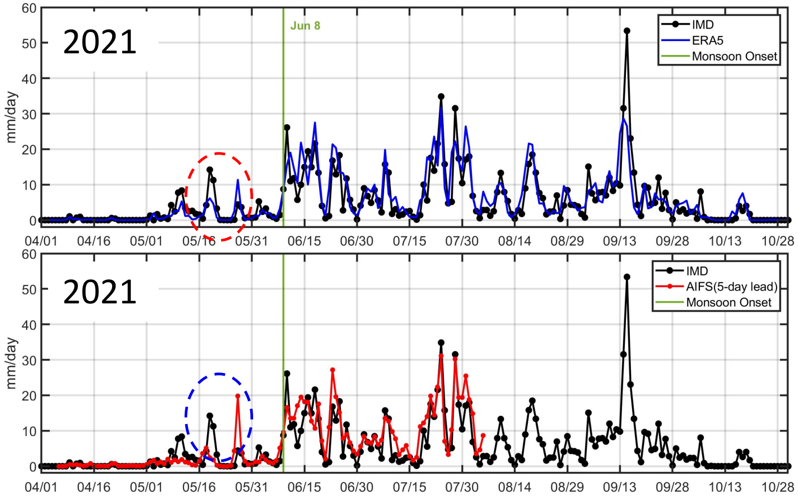
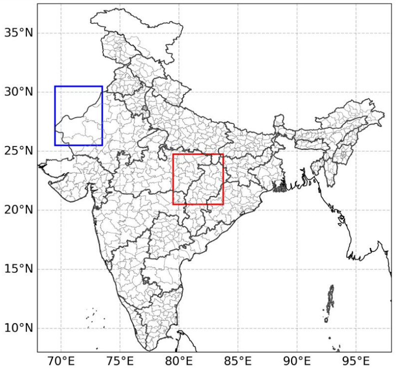
- Small test sample size is a major challenge for subseasonal-to-seasonal (S2S) benchmarking

- Models vary in data they need for operation, cost, forecasted variables, etc. (e.g., soil moisture in only one model)

# Indian Monsoon Onset Forecasts: 5- to 15-day lead times

## AI models can outperform NWP and climatology



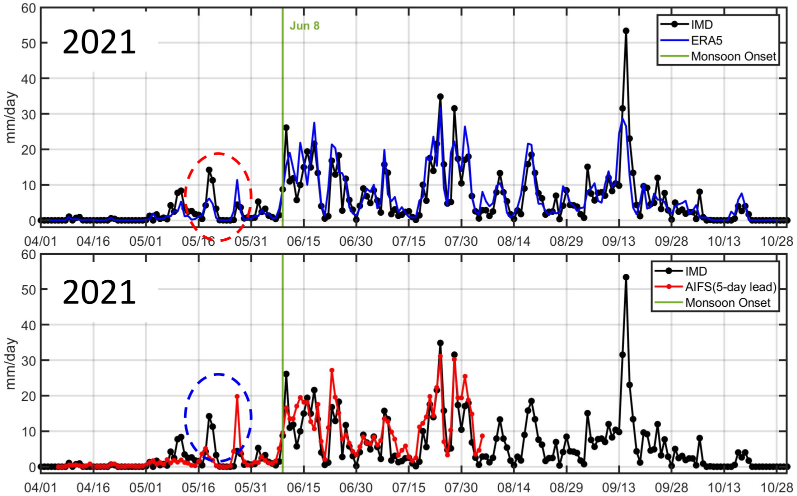


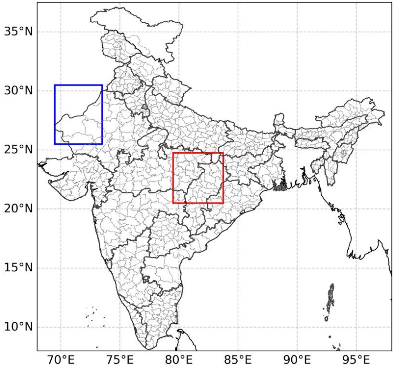
Mean-absolute-error (MAE) for 15-day forecasts (test years, 2018-2023):

| | Clim | IFS S2S | AIFS | GenCast | NGCM | Fuxi | GCast |
|---|---|---|---|---|---|---|---|
| MAE (days) | 7.0 | 3.3 | 0.56 | 2.5 | 2.0 | 1.33 | 2.5 |
| Miss rate | | 0% | 0% | 40% | 60% | 50% | 0% |

# Indian Monsoon Onset Forecasts: 5- to 15-day lead times

## AI models can outperform NWP and climatology





Mean-absolute-error (MAE) for 15-day forecasts (test years, 2018-2023):

| | Clim | IFS S2S | AIFS | GenCast | NGCM | Fuxi | GCast |
|---|---|---|---|---|---|---|---|
| MAE (days) | 7.0 | 3.3 | 0.56 | 2.5 | 2.0 | 1.33 | 2.5 |
| Miss rate | | 0% | 0% | 40% | 60% | 50% | 0% |

4.5 days and 0% for 2004-2023

2.7 days and 0% if we include 1965-1978 too

3.7 days and 0% if we use probabilistic 1965-1978 and 2018-2023 test years

Lowest global Z500 ACC

- There are various ways to measure the accuracy (metric, averaging area etc.)

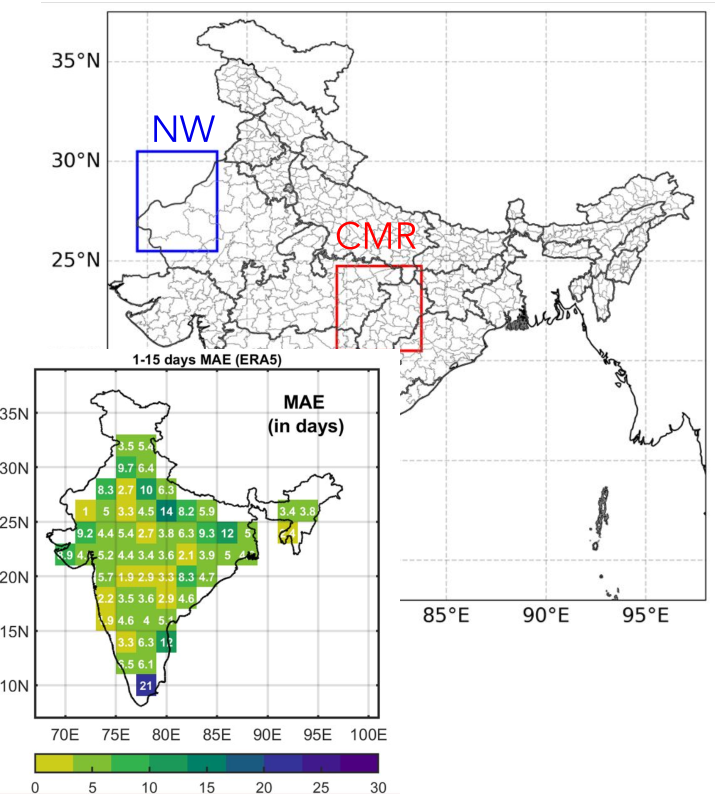
- Top-performing models remain the same

- Technical details (would love feedback!)

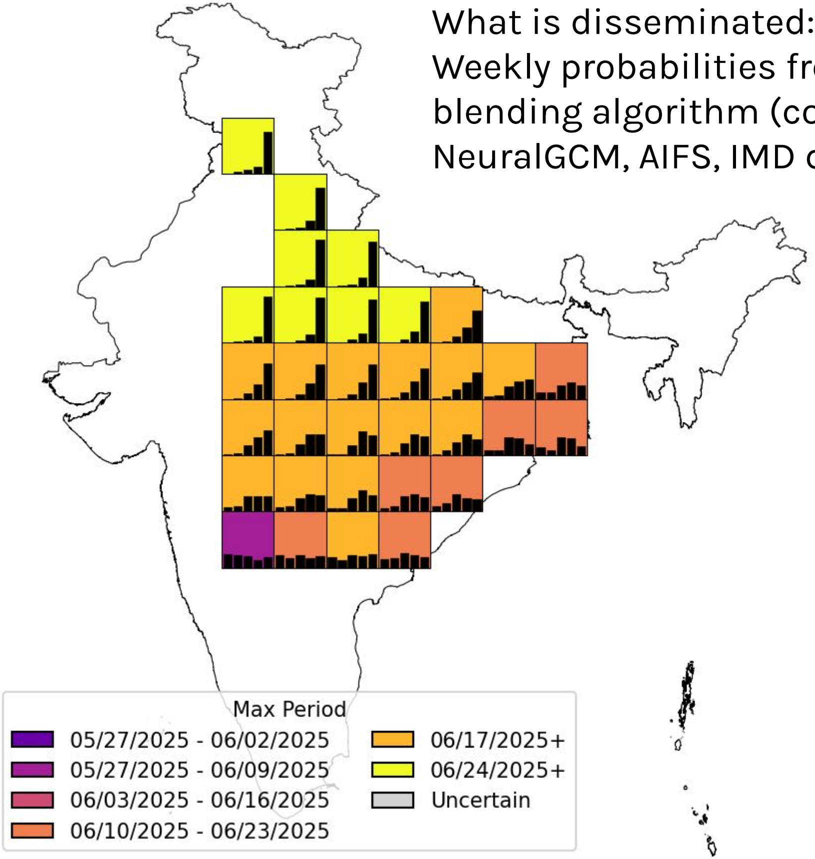
https://envfluids.github.io/monsoon-operational/index.html

# Indian Monsoon Onset Forecasts: 30-day lead times

## AI models can outperform climatology

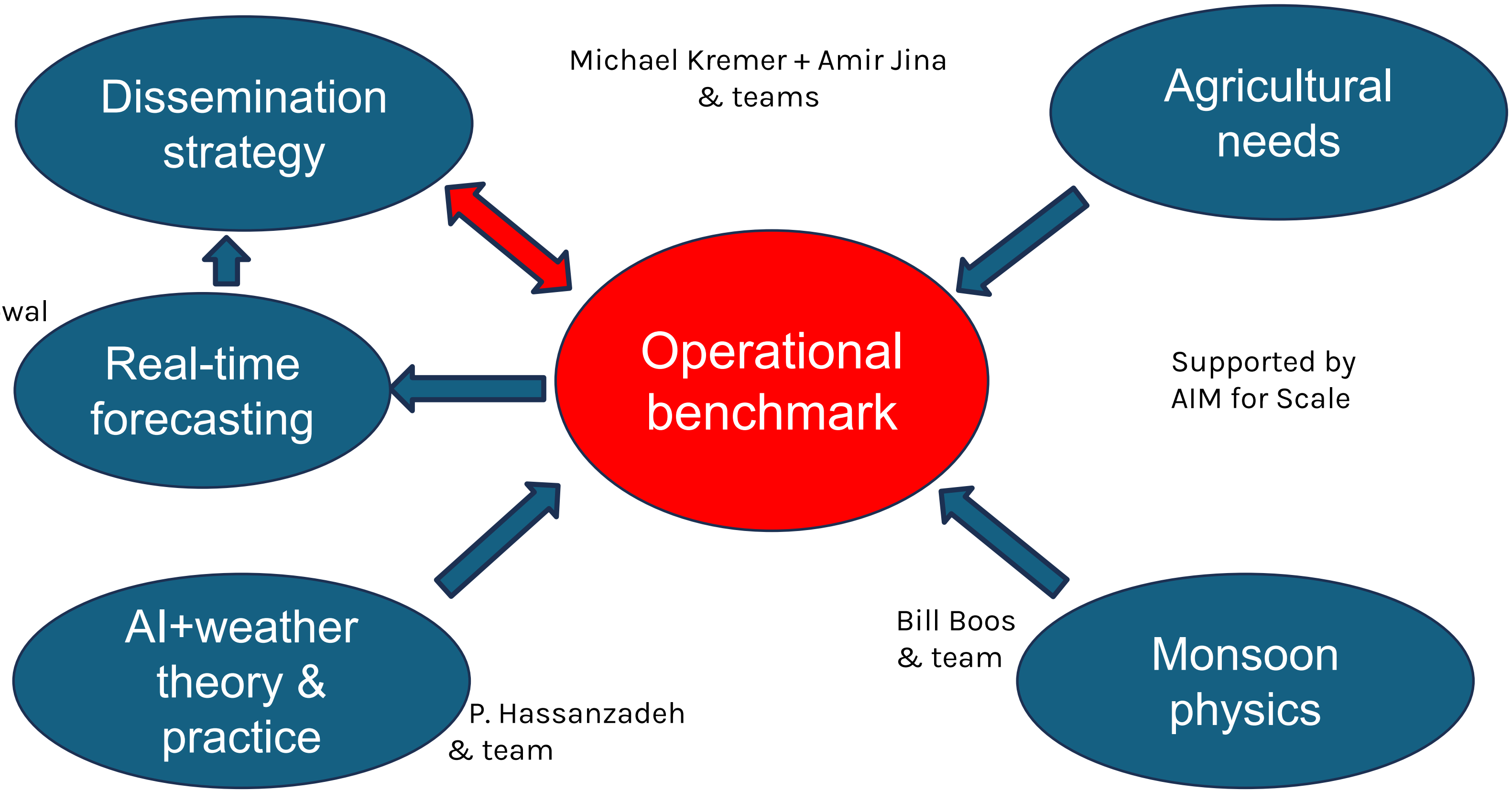


What is disseminated:
Weekly probabilities from a model blending algorithm (combining NeuralGCM, AIFS, IMD data)



# Benchmarking that Informs Decision-Making & Dissemination

Requires a multi-disciplinary team and a feedback loop



Dissemination strategy

Michael Kremer + Amir Jina
& teams

Agricultural needs

Katie Kowal
& team

Real-time forecasting

Operational benchmark

Supported by
AIM for Scale

AI+weather theory & practice

P. Hassanzadeh
& team

Bill Boos
& team

Monsoon physics

# Benchmarking Indian Monsoon Onset Forecasts

## Lessons learned (so far)

- Even existing AI models are promising, including for tropical rainfall!
    - A lot more potential with localication and debiasing etc.
    - A lot lot more potential with S2S models and tailoring for tropical dynamics
- Interdisciplinary teams and feedback loops are essential
- Need special care:
    - Validation data
    - Real-time operational use
    - Designing indices and metrics most informative to farmers
        - Correct physics + maximum usefulness for farmers
    - Small test sample size
        - Benchmarking on pre-1979 data
        - Mechanistic analysis to ensure that the "model is doing the thing for the right reason"

# Benchmarking Indian Monsoon Onset Forecasts

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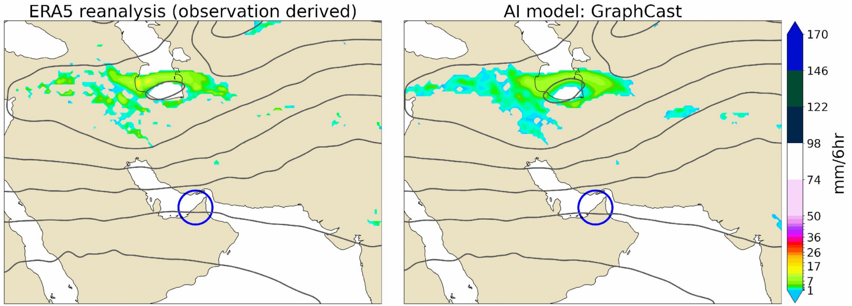
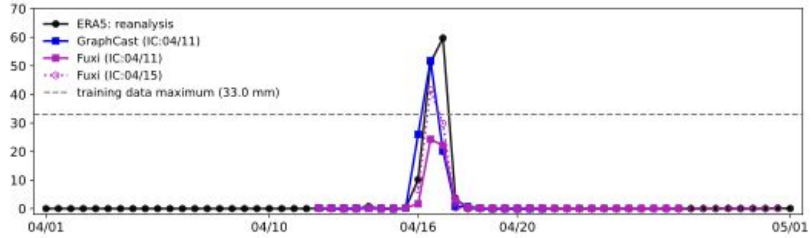
2024 Dubai Flood | Forecast Hour: 6

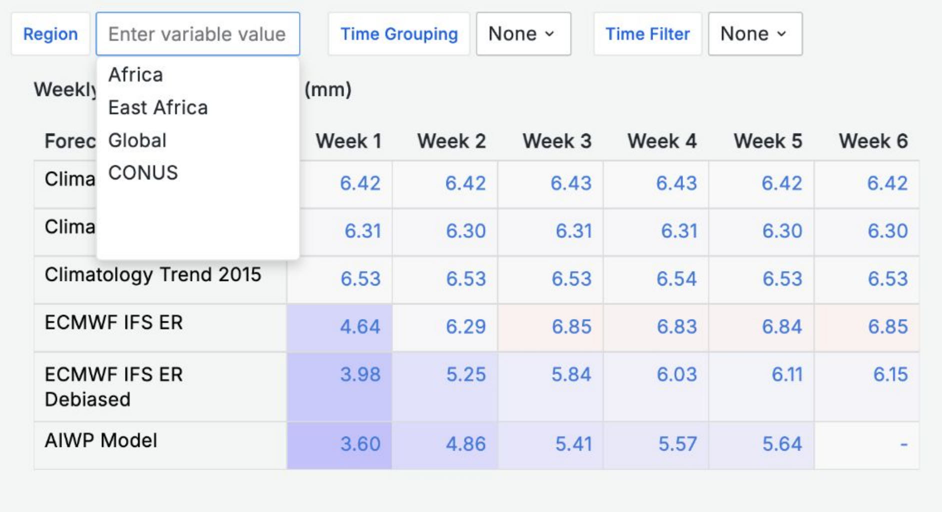


**e) Pred :** 12h accumulated precip in Dubai area (100km X 100km mean)



Sun et al. (2025a,b)

# First Convening: **AI Experts to Provide Input on AI Benchmarking**



Time Grouping: None

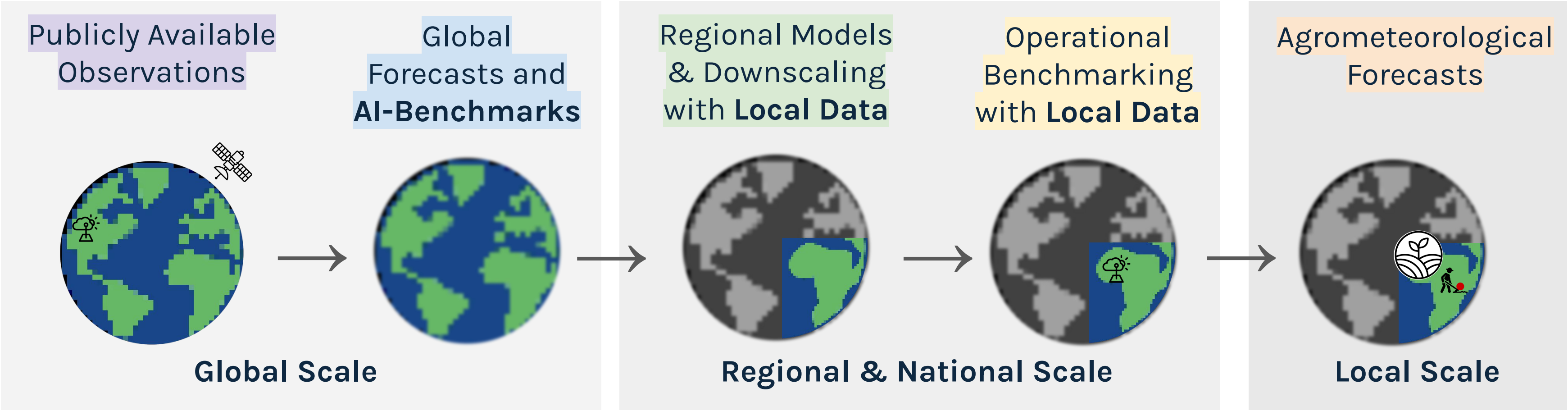
Time Filter: None

Weekly (mm)

| Forec | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 |
|---|---|---|---|---|---|---|
| Clima | 6.42 | 6.42 | 6.43 | 6.43 | 6.42 | 6.42 |
| Clima | 6.31 | 6.30 | 6.31 | 6.31 | 6.30 | 6.30 |
| Climatology Trend 2015 | 6.53 | 6.53 | 6.53 | 6.54 | 6.53 | 6.53 |
| ECMWF IFS ER | 4.64 | 6.29 | 6.85 | 6.83 | 6.84 | 6.85 |
| ECMWF IFS ER Debiased | 3.98 | 5.25 | 5.84 | 6.03 | 6.11 | 6.15 |
| AIWP Model | 3.60 | 4.86 | 5.41 | 5.57 | 5.64 | - |

# This Convening:
# Operational Experts to Provide Input on Operational Benchmarking / Verification

Our theory of operational benchmarking / verification



Publicly Available Observations

Global Forecasts and **AI-Benchmarks**

**Global Scale**

Regional Models & Downscaling with **Local Data**

Operational Benchmarking with **Local Data**

**Regional & National Scale**

Agrometeorological Forecasts

**Local Scale**

https://www.menti.com/aleht9dmxo51

# Instructions

Go to

**www.menti.com**

Enter the code

**5991 6339**

Or use QR code

**Questions**

Q: Are you interested in making use of AI weather forecasting at your institution?  Yes, No, I don’t know

Q: Do you believe that AI weather forecasting is more accurate today than existing models in your locality? Yes, No, I don’t know

Q: Who should be involved in benchmarking / verifying forecasting models locally? NMHSs; Regional Climate Centers; WMO; Other

Q: When you produce forecasts, which forecasting centers to you look at? ECWMF, NCEP, JMA, UKMET, Google, CMA, ICPAC, other.

Q: Do you find that some models perform better during the rainy season? If so, which forecasting centers to you look at? ECWMF, NCEP, JMA, UKMET, Google, CMA, ICPAC, other, all perform the same.

Q: Do you find it challenging to select which models to trust when making a forecast? Yes, No; I don’t produce forecasts.

Q: When producing forecasts from multiple models, do you produce a subjective combination or an objective combination? Subjective; Objective;  I don’t produce forecasts

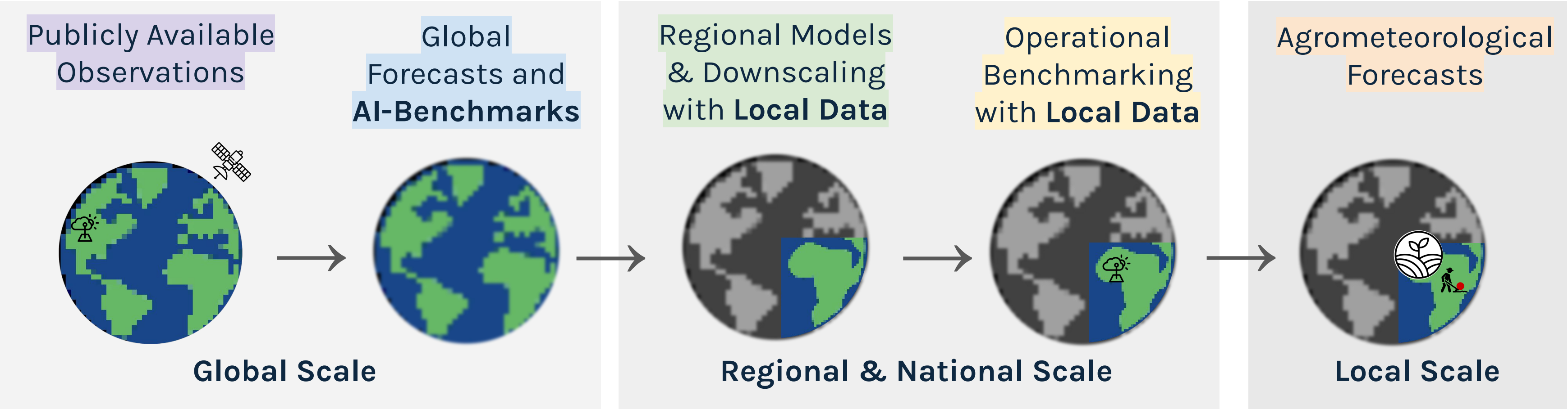
Q: How do you decide which models to trust for your forecasts? [Select multiple] I use guidance from WMO based on global verifications; I have preferred models that I always use; I verify models vs local data visually and choose the best performing; I verify models vs local data computationally and choose the best performing; Other; I don’t produce forecasts

Q: What data would you use as ground truth in model verification? Station data; radiosonde data; remote-sensing data; reanalysis data; other

Q: What conditions would use use to define rainy season onset? Accumulated rainfall; soil moisture; upper atmospheric winds; MJO state; ITCZ state; other

# Benchmarking has two theories of change

1. **AI benchmarking:** Using benchmarks to drive breakthroughs in AI-based forecasting skill on high-impact prediction tasks.
2. **Operational benchmarking / verification (our focus today):** Helping NMHSs decide which novel forecasting models and outputs (if any) to operationalize.



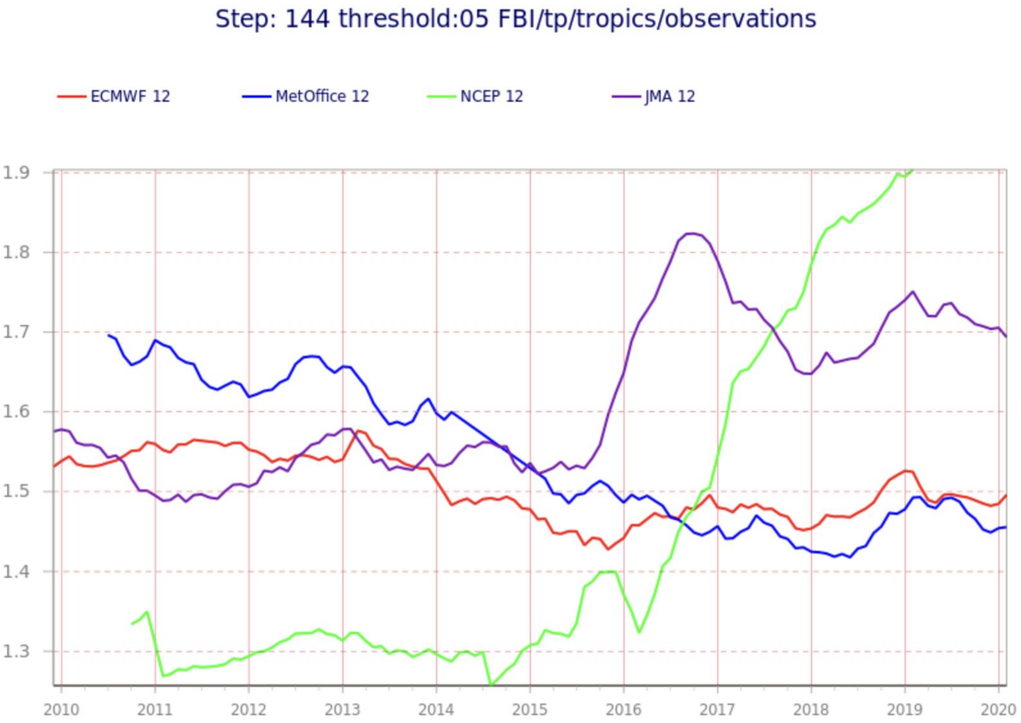
Publicly Available Observations → Global Forecasts and **AI-Benchmarks** → Regional Models & Downscaling with **Local Data** → Operational Benchmarking with **Local Data** → Agrometeorological Forecasts

**Global Scale**

**Regional & National Scale**

**Local Scale**

# Would a verification like this be useful for your forecasting?

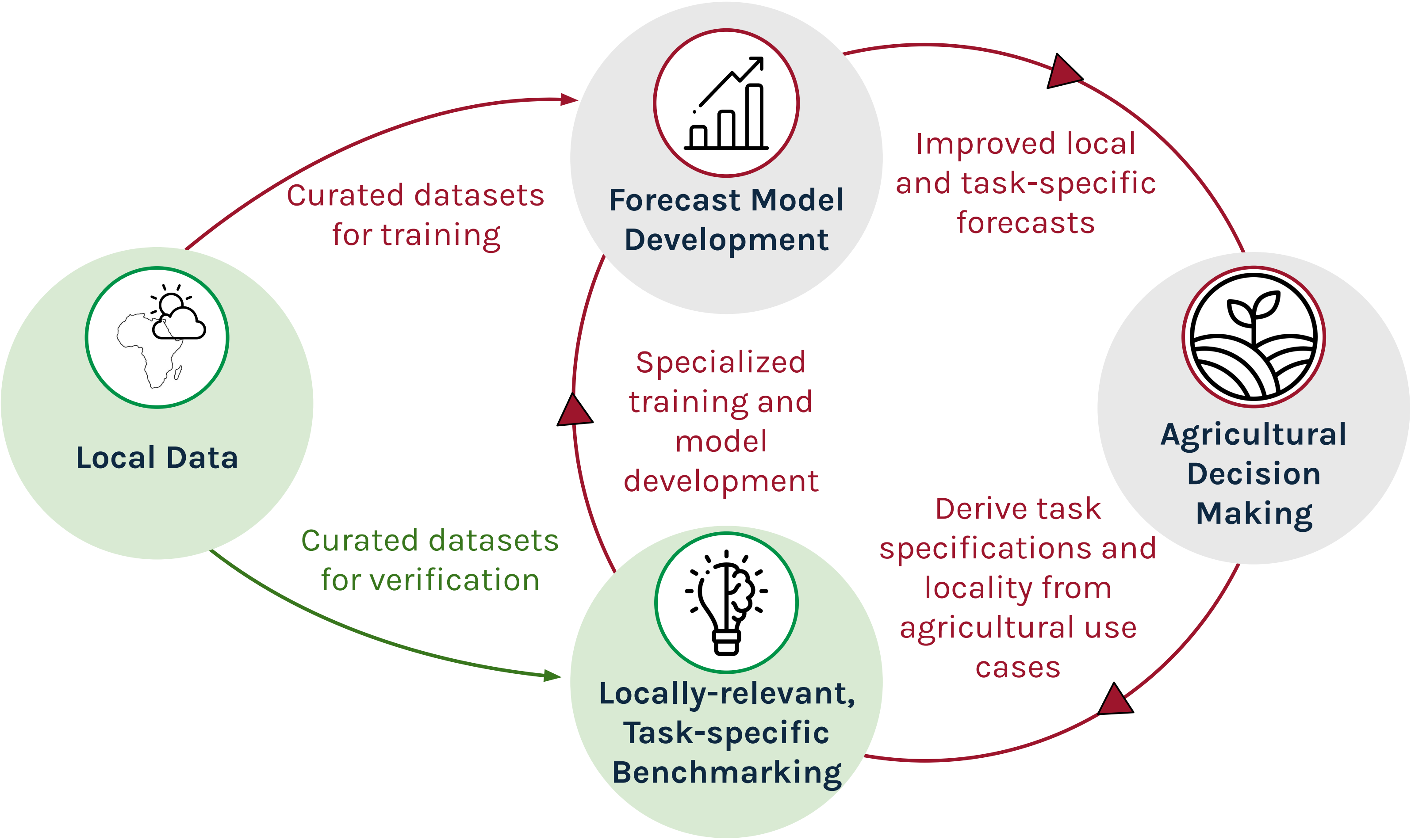


WMO's Dynamical Model Verification

# Objectives for this event

1. Documentation of existing verification and benchmarking practices within NHMS partners,
2. List of the gaps in verification processes at NMHS partners , e.g., timely and unified access to station data, availability of objective digital forecasts,
3. Definition of the “rainy season onset” and “dry spell” agrometeorological task across NMHS and MoA partners,
4. Identification of other high-impact agrometeorological forecasts (soil moisture, runoff-causing rainfall, etc.)

# The Nimbus Program: operational benchmarking for NMHSs



**Local Data**

Curated datasets for training

**Forecast Model Development**

Improved local and task-specific forecasts

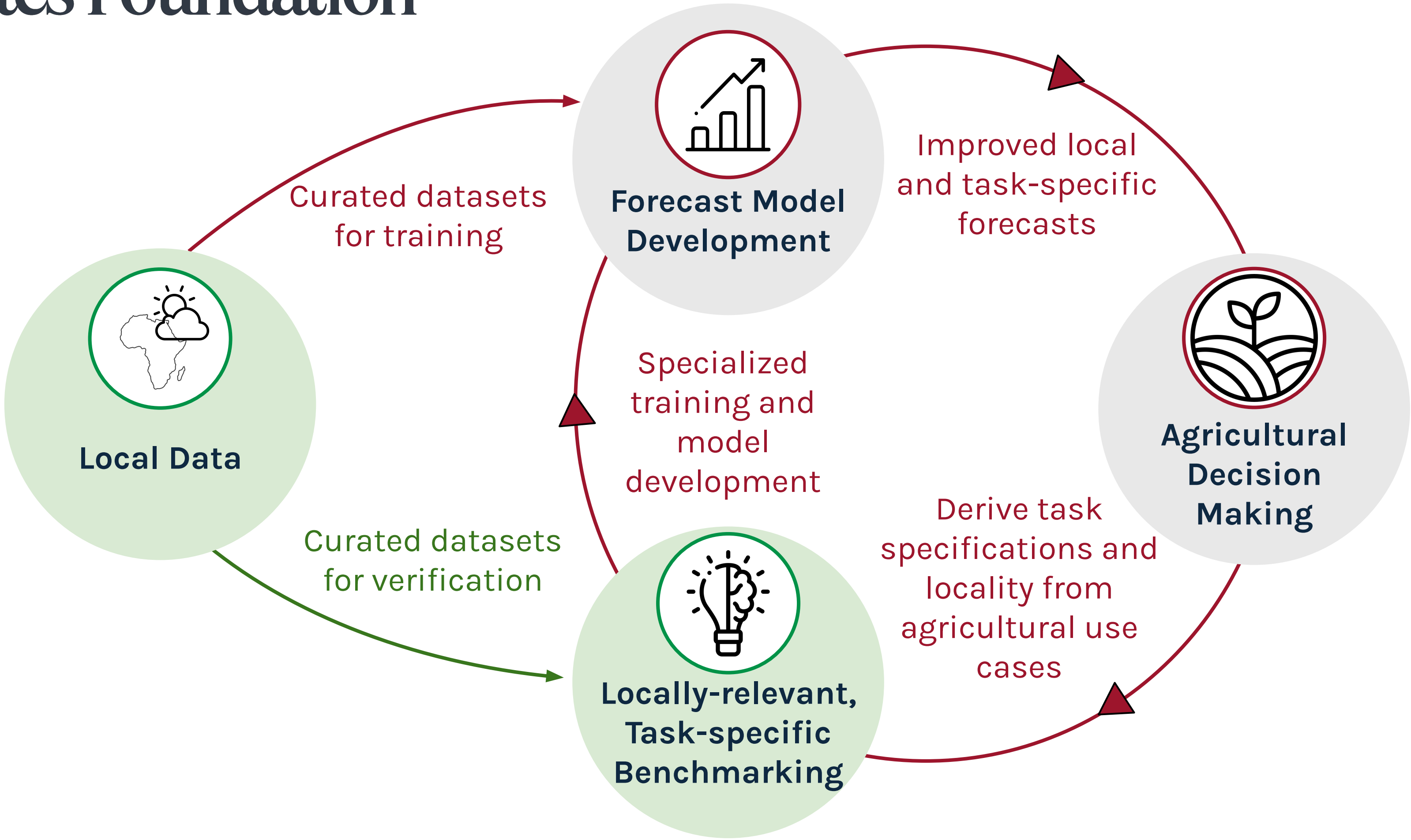
**Agricultural Decision Making**

Derive task specifications and locality from agricultural use cases

**Locally-relevant, Task-specific Benchmarking**

Specialized training and model development

Curated datasets for verification



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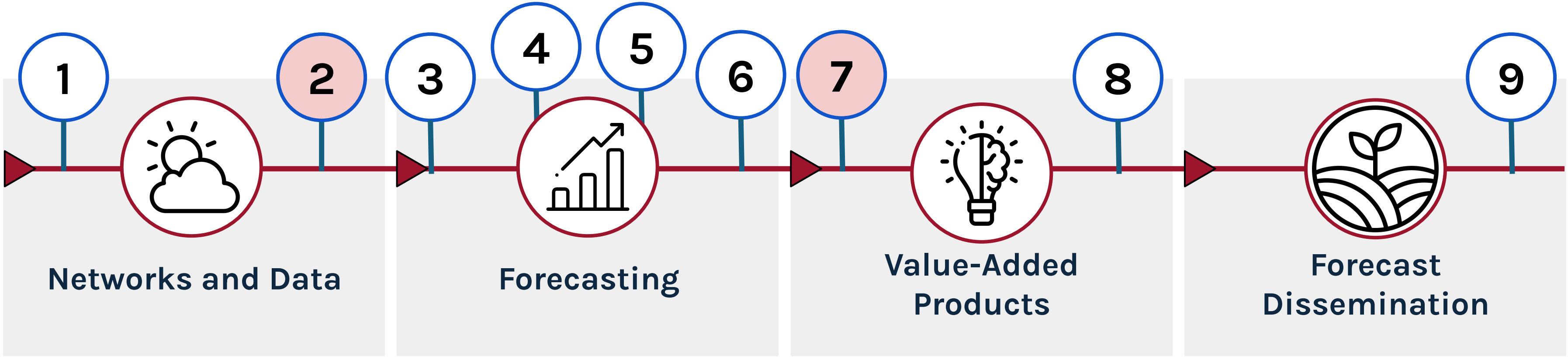


**Gap 1**: Automated management and quality control of manual and automated weather stations

🔴⚠️ **Gap 2**: Centralized access to data from meteorological sensors, in formats supporting downstream forecasting processes and products

**Gap 3**: Enhanced capacity to efficiently run and assimilate data within operational forecasting models

**Gap 4**: Processes for validating and improving existing operational forecasts using station data

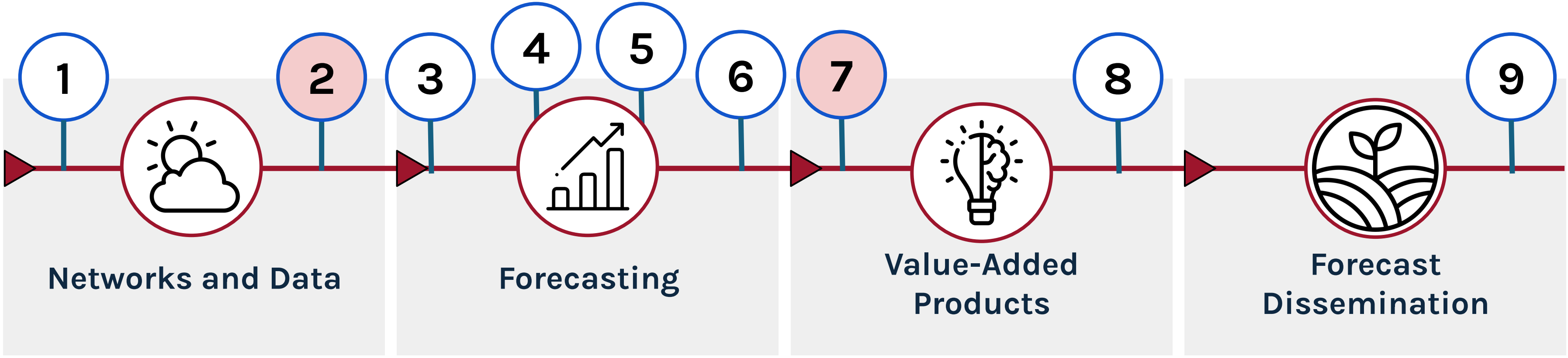
**Gap 5**: Capacity to run, debias, and downscale emerging ML & AI forecasts for operational use

**Gap 6**: Improve subseasonal forecasting skill using ML & AI, especially around rainy season parameters

🔴⚠️ **Gap 7**: Post-processing of forecast outputs to provide a machine-readable API for downstream products

**Gap 8**: Enhancement of value-added products for agricultural and other application-based customers

**Gap 9**: Digital user interface platforms and digital dissemination for external products



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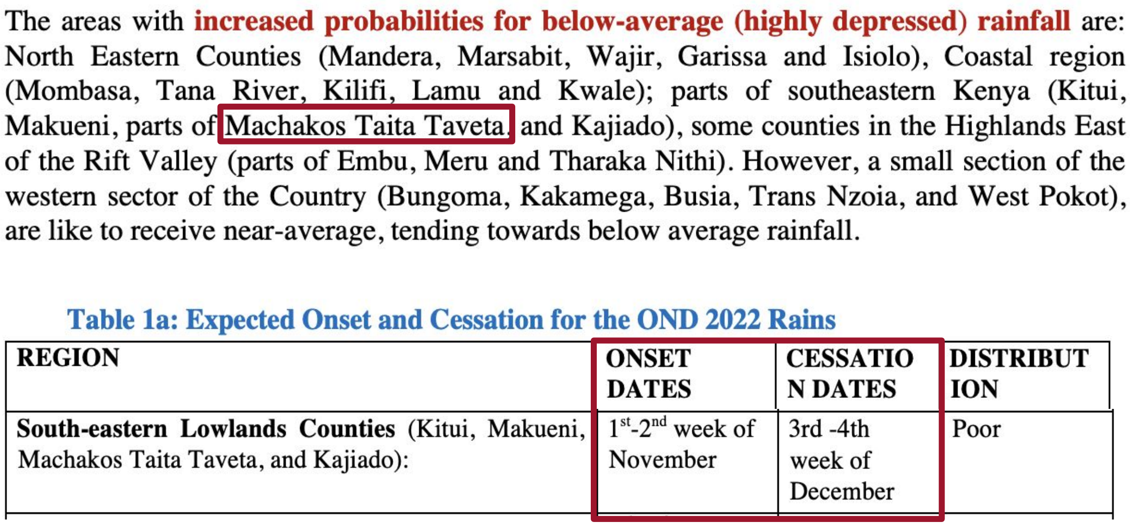
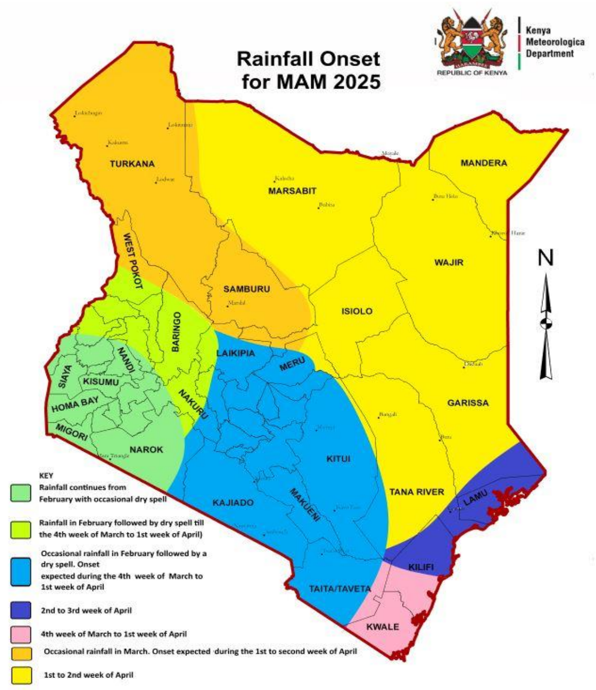
# Forecasts are subjective, and available in bulletin formats.



The areas with **increased probabilities for below-average (highly depressed) rainfall** are: North Eastern Counties (Mandera, Marsabit, Wajir, Garissa and Isiolo), Coastal region (Mombasa, Tana River, Kilifi, Lamu and Kwale); parts of southeastern Kenya (Kitui, Makueni, parts of Machakos Taita Taveta, and Kajiado), some counties in the Highlands East of the Rift Valley (parts of Embu, Meru and Tharaka Nithi). However, a small section of the western sector of the Country (Bungoma, Kakamega, Busia, Trans Nzoia, and West Pokot), are like to receive near-average, tending towards below average rainfall.

**Table 1a: Expected Onset and Cessation for the OND 2022 Rains**

| REGION | ONSET DATES | CESSATION DATES | DISTRIBUTION |
|---|---|---|---|
| **South-eastern Lowlands Counties** (Kitui, Makueni, Machakos Taita Taveta, and Kajiado): | 1st-2nd week of November | 3rd -4th week of December | Poor |



# Forecasts are subjective, and made available in bulletin formats.

## NMHS Capacity 3:

Provide verified forecasts in a machine readable format that’s compatible with downstream use.

The areas with **increased probabilities** [illegible] North Eastern Counties (Mandera, Marsabit, Wajir, Garissa and Isiolo), Coastal region (Mombasa, Tana River, Kilifi, Lamu and Kwale); parts of southeastern Kenya (Kitui, Makueni, parts of Machakos, Taita Taveta and Kajiado), some counties in the Highlands East of the Rift Valley (parts of Embu, Meru and Tharaka Nithi). However, a small section of the western sector of the Country (Bungoma, Kakamega, Busia, Trans Nzoia, and West Pokot), are likely to receive near average, tending towards below average rainfall.

**Table 1a: Expected Onset and Cessation** [illegible]

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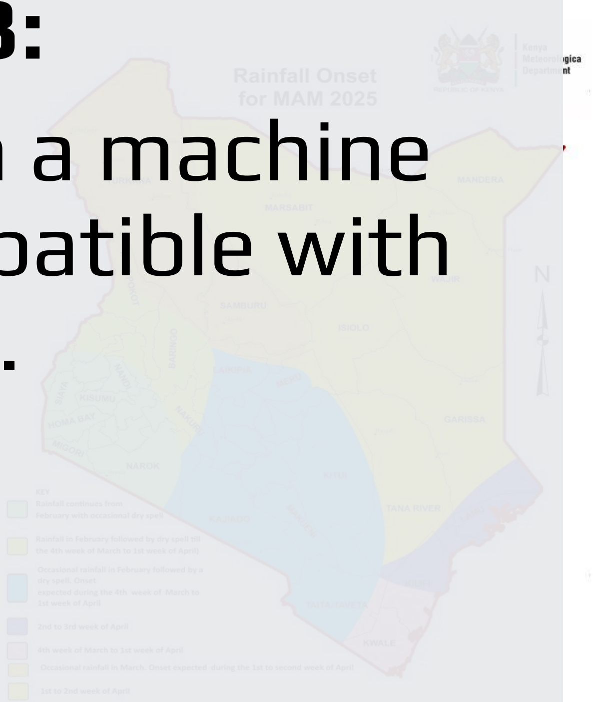
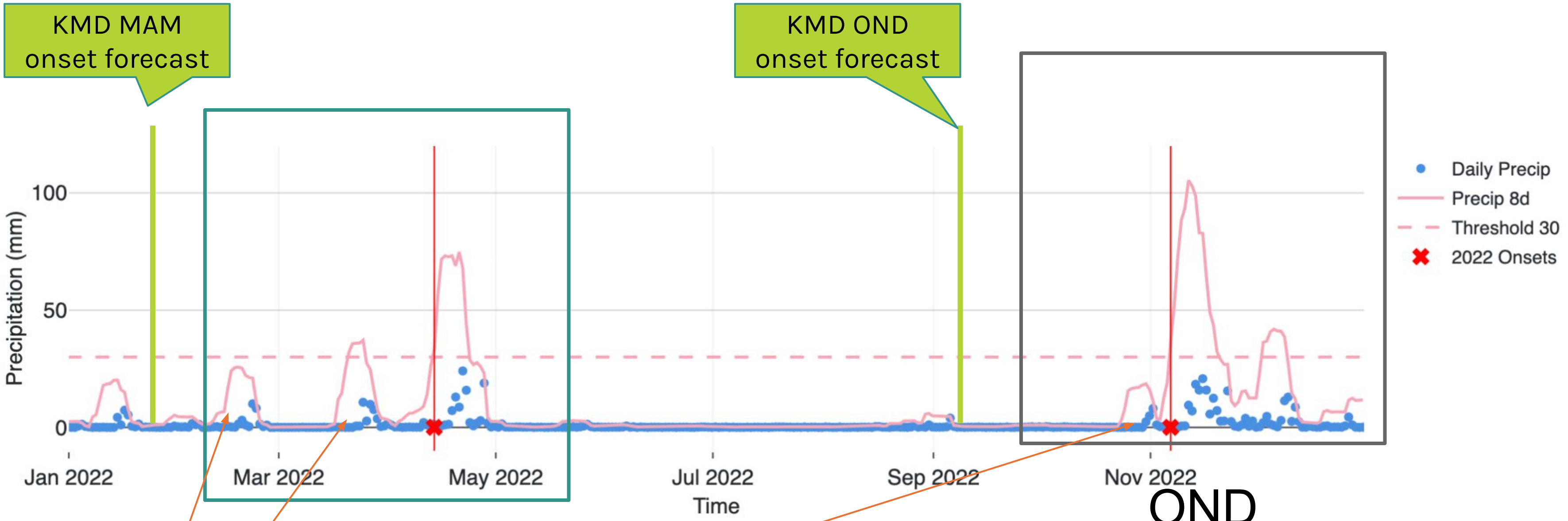


The rainy season drives livelihoods for millions farmers in sub-Saharan Africa, and yet **actionable onset advisories are not available to many farmers**.

# Onset forecasts are made at the start of the season.



KMD MAM onset forecast

KMD OND onset forecast

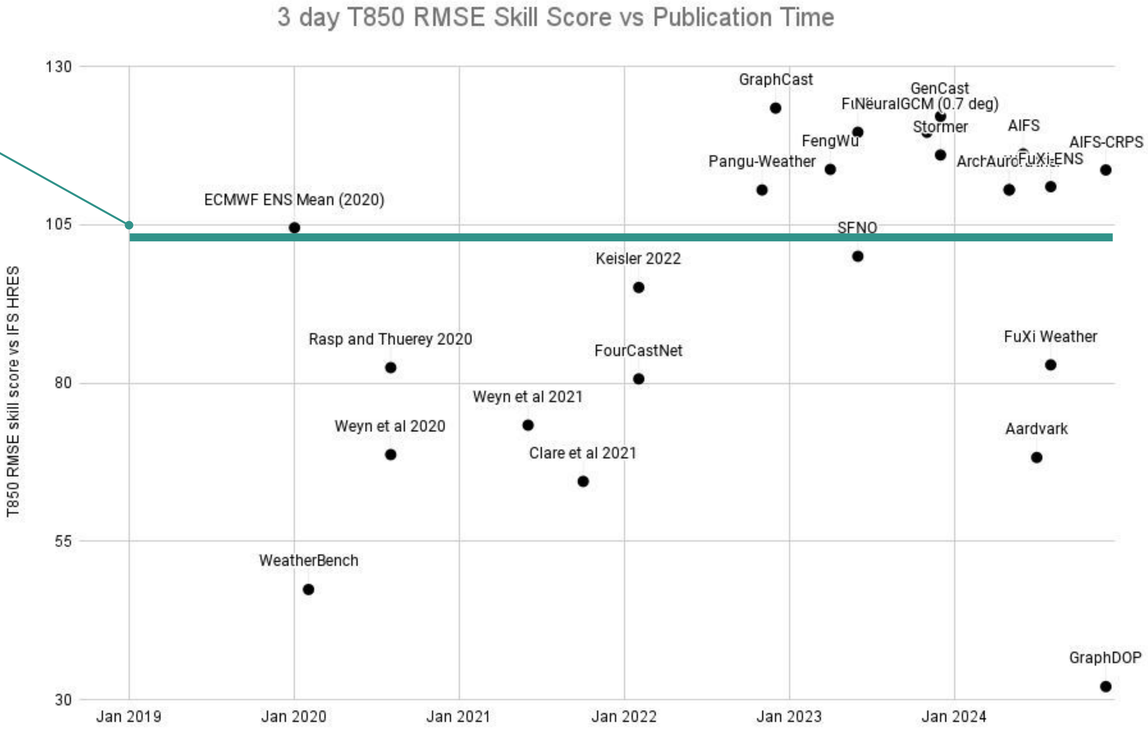
MAM season

OND season

False onsets followed by dry spells

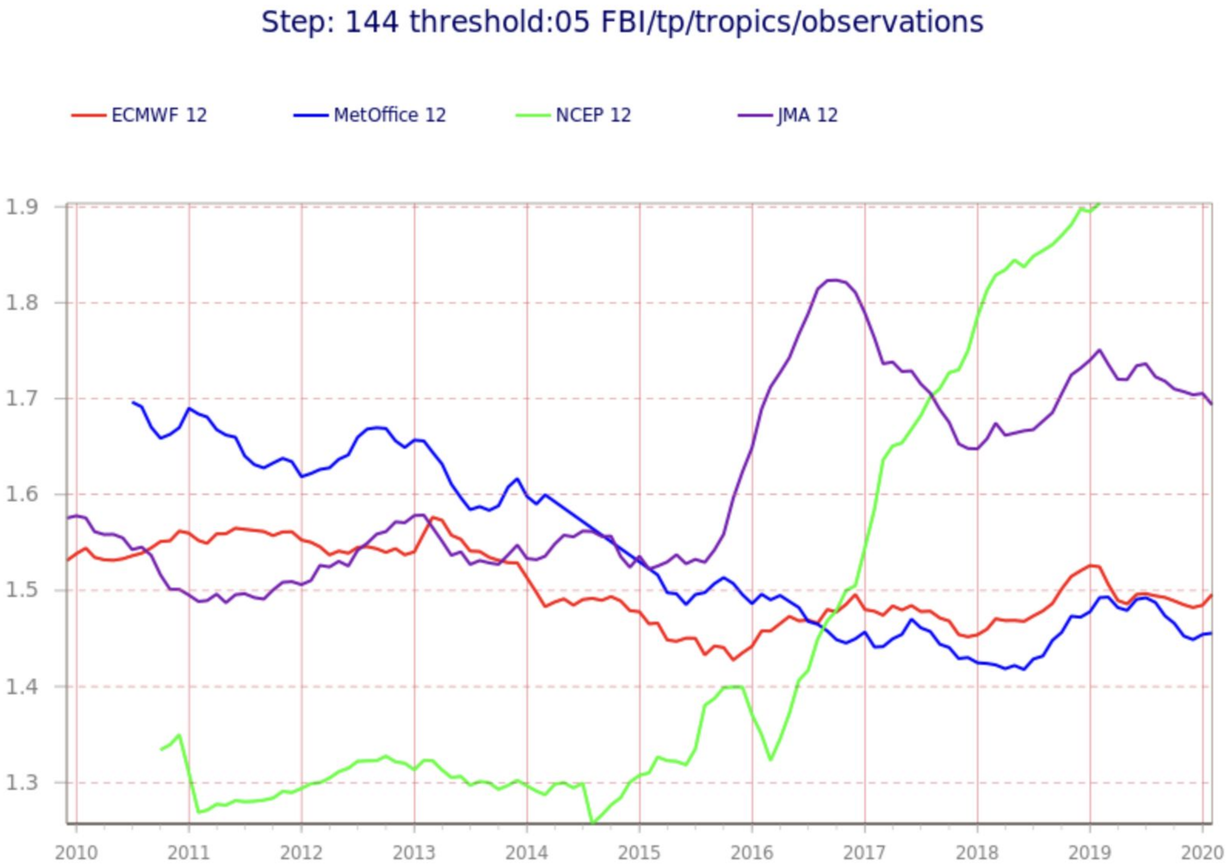
In the past 5 years, AI weather prediction (AIWP) models have **matched and then surpassed the skill** of leading numerical weather prediction (NWP) models.

Lots of important caveats here: coarse resolution, short time scales, focused on temperature evaluation, physics-based reanalysis as input ...

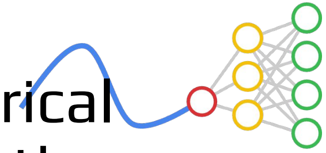


Graph from Stephan Rasp, Google Research

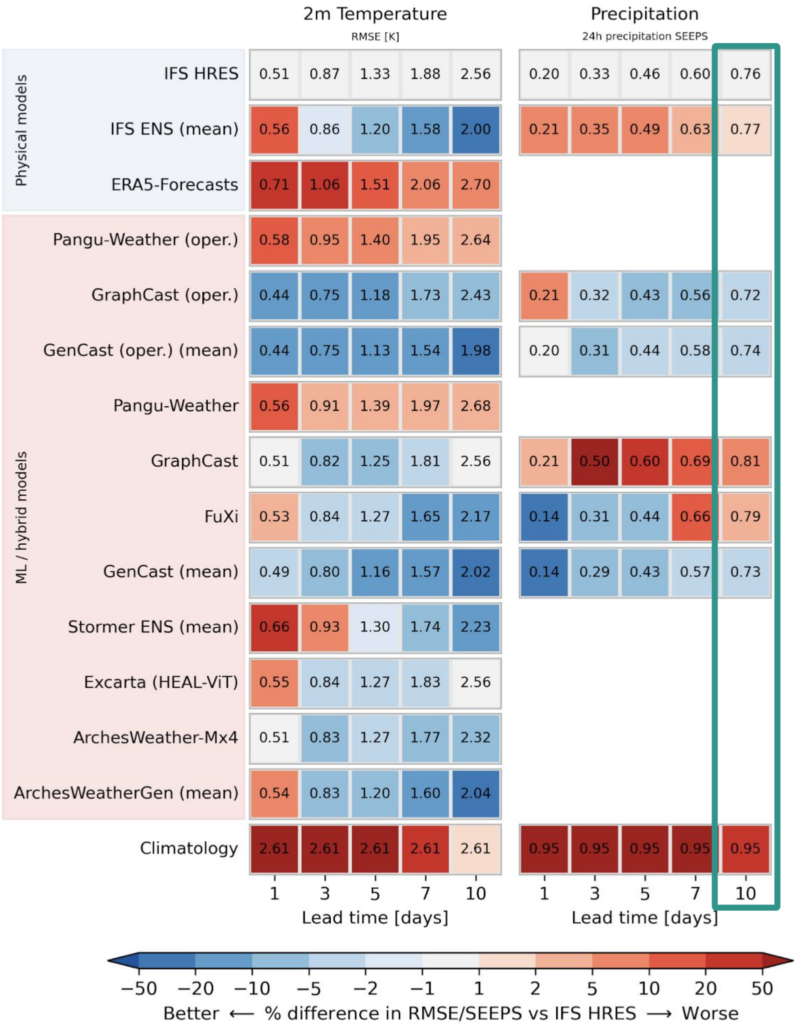
# WMO's Dynamical Model Verification



# WeatherBench 2



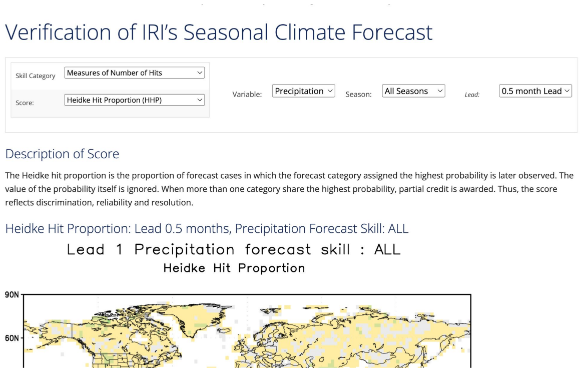
# Do existing numerical and AI-based weather prediction (NWP/AIWP) models produce **usable** EA rainy season forecasts?



| | | 2m Temperature | | | | | Precipitation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RMSE [K] | | | | | 24h precipitation SEEPS | | | | |
| | | Lead time [days] | | | | | Lead time [days] | | | | |
| | | 1 | 3 | 5 | 7 | 10 | 1 | 3 | 5 | 7 | 10 |
| Physical models | IFS HRES | 0.51 | 0.87 | 1.33 | 1.88 | 2.56 | 0.20 | 0.33 | 0.46 | 0.60 | 0.76 |
| | IFS ENS (mean) | 0.56 | 0.86 | 1.20 | 1.58 | 2.00 | 0.21 | 0.35 | 0.49 | 0.63 | 0.77 |
| | ERA5-Forecasts | 0.71 | 1.06 | 1.51 | 2.06 | 2.70 | | | | | |
| ML / hybrid models | Pangu-Weather (oper.) | 0.58 | 0.95 | 1.40 | 1.95 | 2.64 | | | | | |
| | GraphCast (oper.) | 0.44 | 0.75 | 1.18 | 1.73 | 2.43 | 0.21 | 0.32 | 0.43 | 0.56 | 0.72 |
| | GenCast (oper.) (mean) | 0.44 | 0.75 | 1.13 | 1.54 | 1.98 | 0.20 | 0.31 | 0.44 | 0.58 | 0.74 |
| | Pangu-Weather | 0.56 | 0.91 | 1.39 | 1.97 | 2.68 | | | | | |
| | GraphCast | 0.51 | 0.82 | 1.25 | 1.81 | 2.56 | 0.21 | 0.50 | 0.60 | 0.69 | 0.81 |
| | FuXi | 0.53 | 0.84 | 1.27 | 1.65 | 2.17 | 0.14 | 0.31 | 0.44 | 0.66 | 0.79 |
| | GenCast (mean) | 0.49 | 0.80 | 1.16 | 1.57 | 2.02 | 0.14 | 0.29 | 0.43 | 0.57 | 0.73 |
| | Stormer ENS (mean) | 0.66 | 0.93 | 1.30 | 1.74 | 2.23 | | | | | |
| | Excarta (HEAL-ViT) | 0.55 | 0.84 | 1.27 | 1.83 | 2.56 | | | | | |
| | ArchesWeather-Mx4 | 0.51 | 0.83 | 1.27 | 1.77 | 2.32 | | | | | |
| | ArchesWeatherGen (mean) | 0.54 | 0.83 | 1.20 | 1.60 | 2.04 | | | | | |
| | Climatology | 2.61 | 2.61 | 2.61 | 2.61 | 2.61 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |

## WMO's Dynamical Model Verification

## IRI's Seasonal Forecast Verification



Verification of IRI's Seasonal Climate Forecast

Skill Category: Measures of Number of Hits

Score: Heidke Hit Proportion (HHP)

Variable: Precipitation

Season: All Seasons

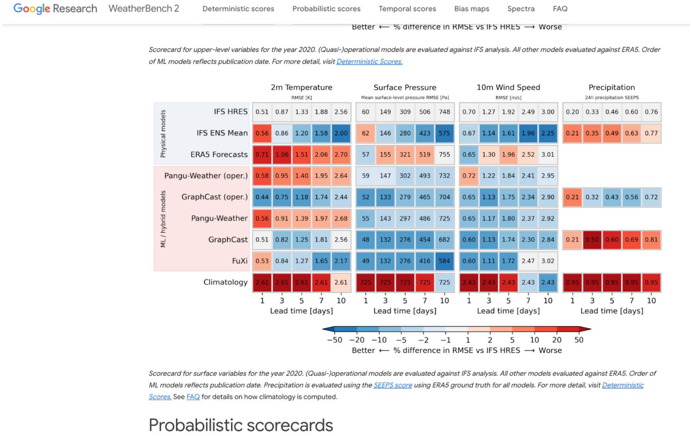
Lead: 0.5 month Lead

Description of Score

The Heidke hit proportion is the proportion of forecast cases in which the forecast category assigned the highest probability is later observed. The value of the probability itself is ignored. When more than one category share the highest probability, partial credit is awarded. Thus, the score reflects discrimination, reliability and resolution.

Heidke Hit Proportion: Lead 0.5 months, Precipitation Forecast Skill: ALL

## Google Research's WeatherBench 2 / X



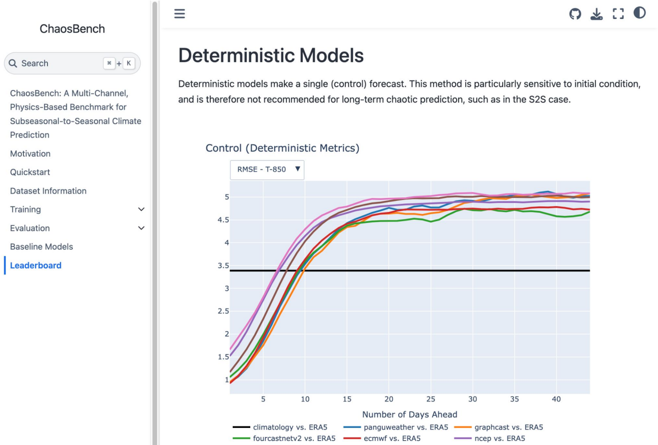
*Scorecard for upper-level variables for the year 2020. (Quasi-)operational models are evaluated against IFS analysis. All other models evaluated against ERA5. Order of ML models reflects publication date. For more detail, visit Deterministic Scores.*

| | | 2m Temperature<br>RMSE [K] | | | | | Surface Pressure<br>Mean surface-level pressure RMSE [Pa] | | | | | 10m Wind Speed<br>RMSE [m/s] | | | | | Precipitation<br>24h precipitation SEEPS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Physical models | IFS HRES | 0.51 | 0.87 | 1.33 | 1.88 | 2.56 | 60 | 149 | 309 | 506 | 748 | 0.70 | 1.27 | 1.92 | 2.49 | 3.00 | 0.20 | 0.33 | 0.46 | 0.60 | 0.76 |
| | IFS ENS Mean | 0.56 | 0.86 | 1.20 | 1.58 | 2.00 | 62 | 146 | 280 | 423 | 575 | 0.67 | 1.14 | 1.61 | 1.96 | 2.25 | 0.21 | 0.35 | 0.49 | 0.63 | 0.77 |
| | ERA5 Forecasts | 0.71 | 1.06 | 1.51 | 2.06 | 2.70 | 57 | 155 | 321 | 519 | 755 | 0.65 | 1.30 | 1.96 | 2.52 | 3.01 | | | | | |
| ML / hybrid models | Pangu-Weather (oper.) | 0.58 | 0.95 | 1.40 | 1.95 | 2.64 | 59 | 147 | 302 | 493 | 732 | 0.72 | 1.22 | 1.84 | 2.41 | 2.95 | | | | | |
| | GraphCast (oper.) | 0.44 | 0.75 | 1.18 | 1.74 | 2.44 | 52 | 133 | 279 | 465 | 704 | 0.65 | 1.13 | 1.75 | 2.34 | 2.90 | 0.21 | 0.32 | 0.43 | 0.56 | 0.72 |
| | Pangu-Weather | 0.56 | 0.91 | 1.39 | 1.97 | 2.68 | 55 | 143 | 297 | 486 | 725 | 0.65 | 1.17 | 1.80 | 2.37 | 2.92 | | | | | |
| | GraphCast | 0.51 | 0.82 | 1.25 | 1.81 | 2.56 | 48 | 132 | 276 | 454 | 682 | 0.60 | 1.13 | 1.74 | 2.30 | 2.84 | 0.21 | 0.50 | 0.60 | 0.69 | 0.81 |
| | FuXi | 0.53 | 0.84 | 1.27 | 1.65 | 2.17 | 49 | 132 | 276 | 416 | 584 | 0.60 | 1.11 | 1.72 | 2.47 | 3.02 | | | | | |
| | Climatology | 2.61 | 2.61 | 2.61 | 2.61 | 2.61 | 725 | 725 | 725 | 725 | 725 | 2.43 | 2.43 | 2.43 | 2.43 | 2.43 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| | Lead time [days] | 1 | 3 | 5 | 7 | 10 | 1 | 3 | 5 | 7 | 10 | 1 | 3 | 5 | 7 | 10 | 1 | 3 | 5 | 7 | 10 |

*Scorecard for surface variables for the year 2020. (Quasi-)operational models are evaluated against IFS analysis. All other models evaluated against ERA5. Order of ML models reflects publication date. Precipitation is evaluated using the SEEPS score using ERA5 ground truth for all models. For more detail, visit Deterministic Scores.* See FAQ for details on how climatology is computed.

Probabilistic scorecards

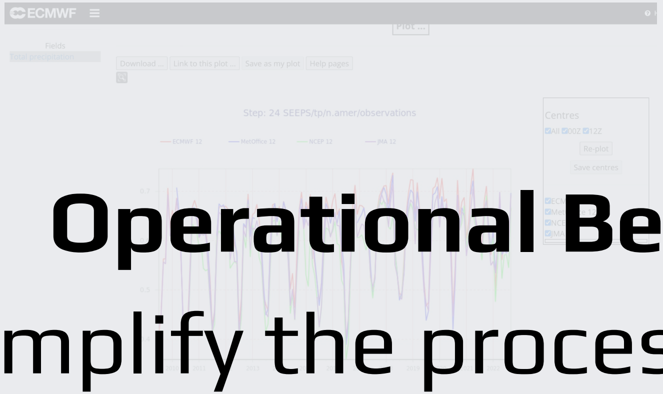
## Columbia and UCLA's ChaosBench



Deterministic Models

Deterministic models make a single (control) forecast. This method is particularly sensitive to initial condition, and is therefore not recommended for long-term chaotic prediction, such as in the S2S case.

WMO's Dynamical Model Verification

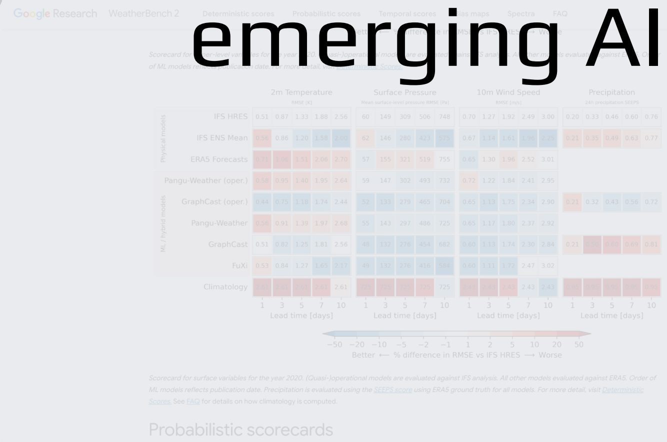


IRI's Seasonal Forecast Verification

# Operational Benchmarking Goal 1:

Simplify the process for NHMSs to desrisk new forecasting targets and emerging AI forecasting models.

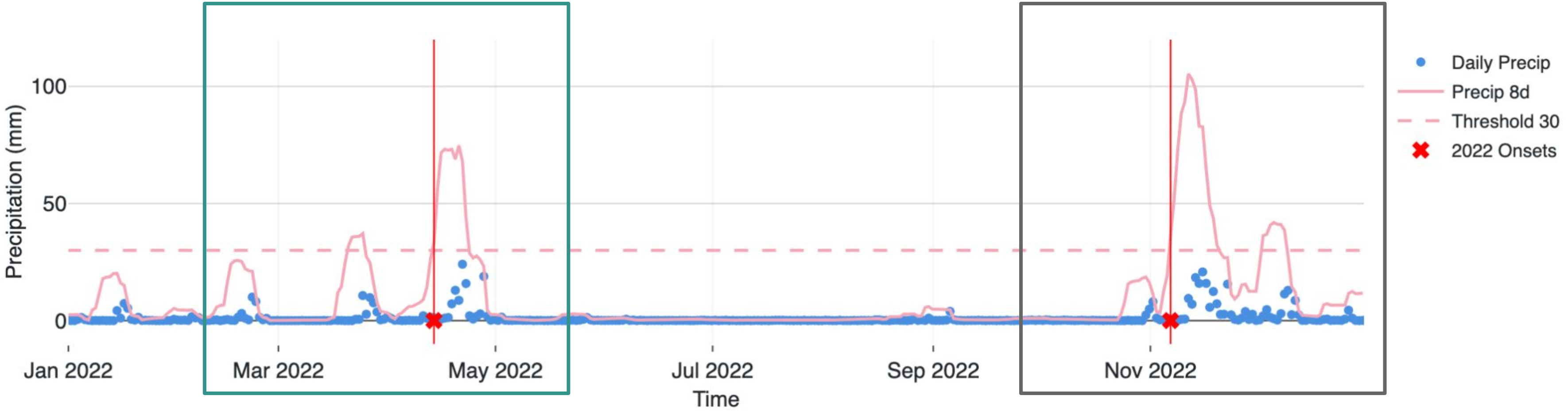
Google Research's WeatherBench / X



Columbia and UCLA's ChaosBench

# Local data and expertise are critical for verification and localization.

## IMERG satellite-based rainfall data

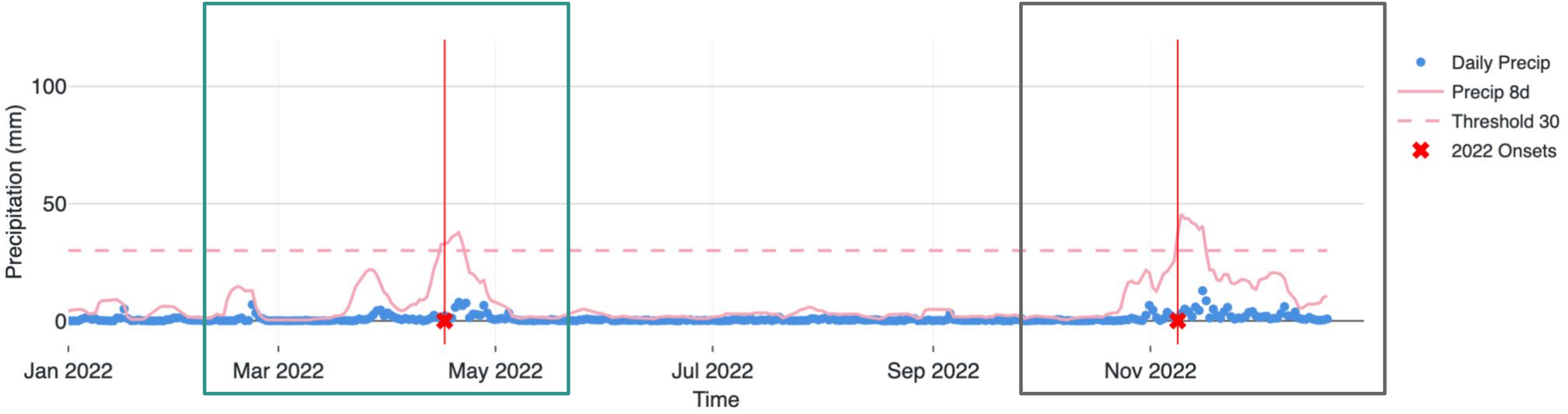


MAM
season

OND
season

# Local data and expertise are critical for verification and localization.

## ERA5 reanalysis data

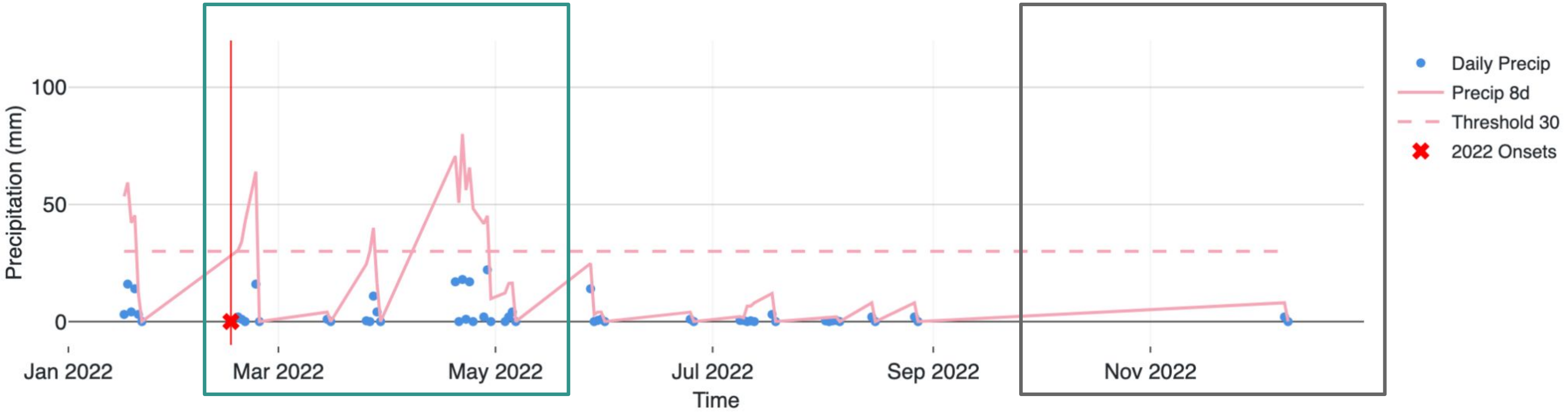


MAM
season

OND
season

# Local data and expertise are critical for verification and localization.

GHCN station data



MAM season

OND season

ADB

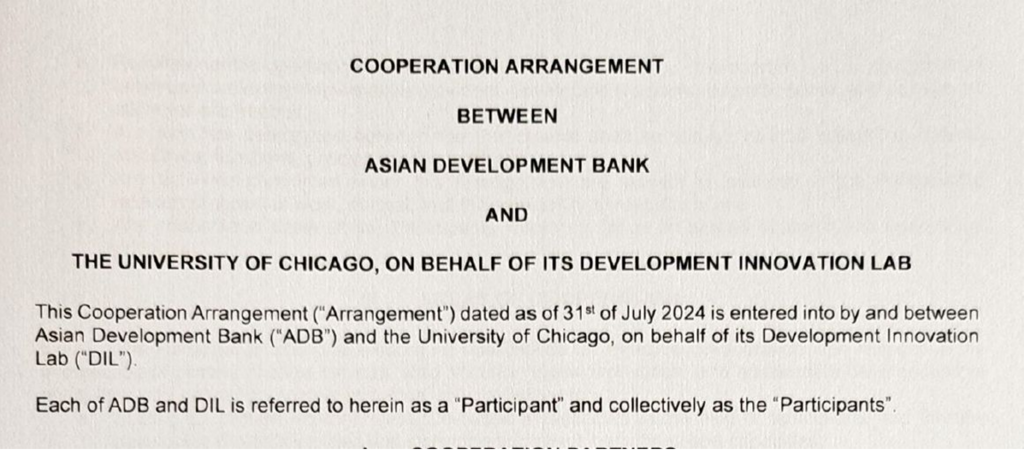
# Bridging the Last Mile: Forecast Dissemination at Scale

AIM FOR SCALE | WEATHER PACKAGE

May 29, 2025

Monica Petri
Senior Natural Resources and Agriculture Specialist,
Emerging Areas Team, SG-AFNR, ADB

# Introduction… from COP28



COOPERATION ARRANGEMENT

BETWEEN

ASIAN DEVELOPMENT BANK

AND

THE UNIVERSITY OF CHICAGO, ON BEHALF OF ITS DEVELOPMENT INNOVATION LAB

This Cooperation Arrangement ("Arrangement") dated as of 31st of July 2024 is entered into by and between Asian Development Bank ("ADB") and the University of Chicago, on behalf of its Development Innovation Lab ("DIL").

Each of ADB and DIL is referred to herein as a "Participant" and collectively as the "Participants".

Further to the impactful presentation of AIM for Scale at COP28, ADB started a collaboration with the DIL/UChicago

Cooperation agreement
Signature 31st of July 2024 in India

This established the basis for the ADB activities to scale up weather forecast, digital agriculture, and other innovations.

# Table of contents

# ADB approach to the AIM for Scale

- All innovations that could be sustained and scaled up through digitalization are presented to member countries as a single package to multiple ministries related to the agricultural sector.

- On a demand driven basis, countries are approached based on their interest for digitalization of the agricultural government sector or interest in supporting digital start-up environment.

01

**Strategic allocation**

Prepare interregional TA(s) to support countries with scaling up interest while also checking existing under preparation pipeline

02

**Breaking the silos**

Create ADB appetite, build on interdepartmental team(s) including staff on resident missions, inclusion, natural capital, gender, AI experts, etc.

03

**Join hands**

Establish national and international expert team to support assessment and concept development

04

**Assessment**

Weather and agrometeorological forecast status in countries

05

**Proposal**

investment conceptualization and submission to government or support to ongoing investments' preparation

06

**Repeat**

# Plan for operationalization

**2024**

Strategic allocation, breaking silos, join hands
Also, identify support to relevant ongoing pipeline

**2025**

Focus on weather

Assessment and conceptualization.
Support pipeline

**2026**

Focus on digital

Assessment and conceptualization.
Support pipeline

**2027**

Etc

# Meteo versus agrometeo

**Meteorological Information**

Includes: seasonal forecasts (e.g., onset of rains) extreme weather alerts, heat/cold wave forecasts

Key Features
Time-sensitive and safety-critical, location-specific and general (not agri-specific), short and simple

Strategies
-Analog Dissemination, SMS  Local radio & community loudspeakers, Television & social media + normal apps
-Agricultural extension workers, local leaders or community radio hosts
-Simplification, local languages, simple phrasing and icon, interoperable and bundled ( i.e. DPI)

**Agrometeorological (decision support)**

Includes: Actionable agro-advisories Integrated with weather forecasts

Key Features
Context-specific (requires knowing crop/livestock/fishery calendar, soil, variety, etc.), Behavior-changing (actions)

Strategies
- Include meteo and agrometeo together, make it time-standard, farmer expects it/search for it
-Mixed dissemination, local radio & community loudspeakers, social media, IT applications, geotags
-Agri-extension agents or cooperatives to deliver messages, messages delivered via trusted persons or platforms, farmer groups, tech comp, feedback loops
-Simplification, local languages, simple phrasing and icon, interoperable and bundled ( i.e. DPI)

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# By country description

1. Ongoing activities and plans

2. After there is a project or an investment in place, how to reach the last mile

- with weather information
- with agrometeorological recommendations

# India – weather, agrometeorology

01 **Signature of CA**

Join mission with Senior Director and Nobel Laureate Micheal Kremer to present activities and sigh CA

02 **TA start up mission**

Join mission with international consultant, proposing TA workplan, ask demand side requirements

03 **Assessment**

Study the present weather and agrometeorology situation, survey for farmer needs.
Collaborate with ongoing pipeline development

04 **Investment concept**

Deliver a clear, concise, usable concept for further approval

## National level

Study the present weather and agrometeorology situation available by UChicago
Deliver concept

## State level

Study the present weather and agrometeorology situation, survey for farmer needs.
Collaborate with ongoing pipeline development
Deliver concept 2 States

*Note:*
*SMS weather communication system and national agrometeorological system are in place*

# India – last mile

## National level

Existing SMS application for weather forecast and seasonal alert clarified

Quality improved and simplification of the message

## State level

Include States that does not have an agrometeo system

Tailor to production system (i.e. livestock)

Ensure extension services include agrometeo in their routing activities

Bundle with DPI such as Agri Stack farmer registry

# Bangladesh – Weather, DPIs, startups

01

### TA start up mission

Join mission with international consultant, proposing TA workplan, ask demand side requirements

02

### Assessment

Study the present weather and agrometeorology situation, survey for farmer needs. Collaborate with ongoing pipeline development

03

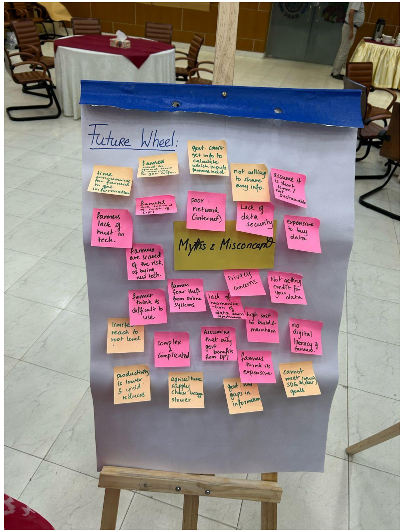
### Foresight workshop

Explore pathways to further develop the present agricultural intersectoral digital infrastructure

04

### Investment concept

Deliver a clear, concise, usable concept for further approval



Note: agrometeorological system is in place

# Bangladesh – last mile

## Future meteo

Note: existing reach (apps, radio, tv) is well advanced

Improved seasonal/long term forecast

Study: further inclusion to find ways for alerts to reach the last mile

## Future agrometeo

Note: existing reach use radio, tv, loudspeakers, and extension

Include improved flood forecast, improve quality to increase trust

More details by production system (i.e. livestock, aquaculture, irrigation)

Study: ensure extension services include agrometeo in their routine activities

Bundle within national apps such as Khamari and IT private sector

# Laos – weather, livestock value chain

01

### TA start up mission

Join mission with Uchicago and international consultant, proposing TA workplan, ask demand side requirements

02

### Assessment

Study the present weather and agrometeorology situation, survey for farmer needs. Collaborate with ongoing project implementation

03

### Investment concept

Explore pathways to further develop the present agricultural intersectoral digital infrastructure

Note: agrometeorological system is in place

# Laos – last mile

## Future meteo

Note: existing reach (apps, radio, tv) is well advanced

Improved time of delivery of forecast, improve seasonal/long term forecast

Study: further inclusion to find ways for alerts to reach the last mile

## Future agrometeo

Note: existing reach use radio, tv, loudspeakers, and extension

Include improved flood forecast, improve quality to increase trust

Link livestock traceability (ADB) with livestock zoonotic forecast and farm registry

Study: more work on extension services link with loudspeaker advisory

# Conclusion - Next phase

- In Asia, in most cases some form of government digital or at least automatized systems is in place, and there is an active digital startup environment
- The target remain to reach the plans announced at COP30 by ADB, to invest $300 million in weather forecasts for farmers in 2025-2027, either by contributing to the present under preparation projects targeted at 2025 approval, or by forming part of the teams preparing new projects since 2026
- Governments in Asia seems eager and have clear ideas about how to expand their present weather and agrometeorological forecast system to additional use cases
- At the moment, actively planning next round in a phased approach to include up to 8 more countries

# The end

mpetri@adb.org

WEATHER PACKAGE

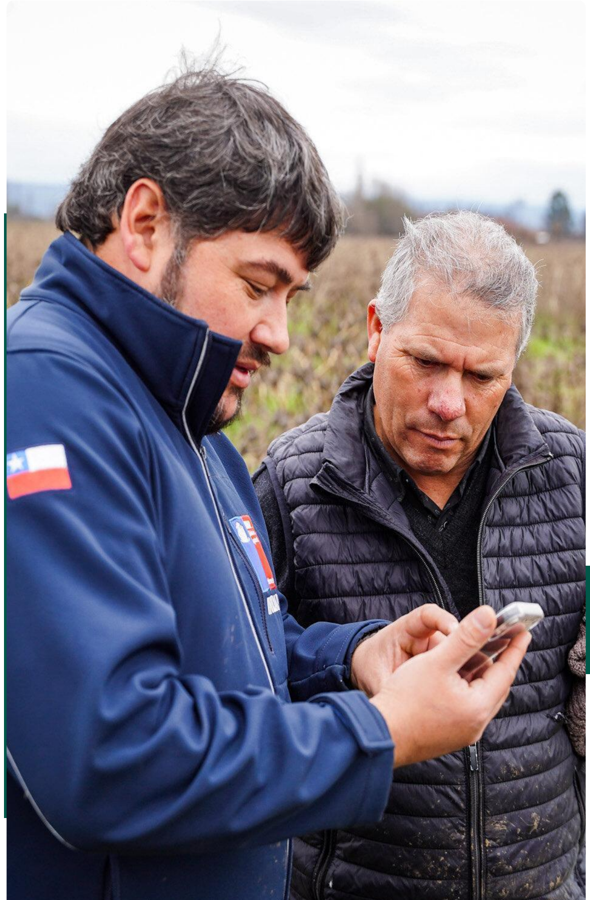
MAY 29-31
AIM for Scale Weather
Partnership Convening

# Inter-American Development Bank (IDB) – Improving agro-climatic recommendations in Latin America

**Romina Ordoñez**
**Inter-American Development Bank - IADB**
**Agriculture and Rural Development Division (PTI/ARD) – Senior Specialist**

# Table of Contents

# Our Goal at IDB



To influence an IDB loan portfolio of US$ 280 million in the coming 3 years through the execution of pilots to improve the digital dissemination of agro-climatic farmer-centered recommendations in LAC (US$ 900,000 of grant resources)

# Andean Countries Technical Cooperation

## Developing regional approaches to enhance the provision of weather forecasts and soil health data to farmers through digital services

RG - T4550

PTI/ARD – Agriculture and Rural Development Division

AIM FOR SCALE

WEATHER PACKAGE

# Andean Countries Technical Cooperation

## Objective

To enhance agricultural productivity and climate resilience for small and medium landholder farmers by encouraging climate-smart practices using digital technologies for weather and soil management, with a gender and diversity approach.

## Main Information

○ Bolivia, Peru and Colombia

○ US$ 700.000

○ Source of funds: Canadian Gov

○ Disbursement period: 36 months

○ Starting in July 2025

AIM FOR SCALE

# Components of the Technical Cooperation: piloting to scale

01 Country assessments of technical assistance needs with a farmer-centered approach.

02 Country assessment of weather forecasting and soil data management capacities and digital extension readiness.

03 Design of digital solutions and relevant information products around weather and soil.

04 Strengthen local capacities to produce improved weather and soil recommendations.

05 Piloting of digital provision of weather and soil-related recommendations
+ evaluations
+ policy guidelines
+ dissemination.

# Technical Cooperation in Chile

## Strengthening dissemination of farmer-relevant agro-climatic recommendations to farmers

CH-T1348
PTI/ARD – Agriculture and Rural Development Division
MINAGRI – Chilean Ministry of Agriculture
DMC – National Meteorological Service of Chile

AIM FOR SCALE | WEATHER PACKAGE

# Technical Cooperation in Chile

## Objective

This TC aims to strengthen agro-climatic advisory with digital tools to benefit smallholders across the country

## Main Information

- ○ Chile
- ○ US$ 200.000
- ○ Disbursement period: 36 months
- ○ Starting in September 2025

AIM FOR SCALE

# Some ongoing initiatives to build on

## Peru

- Farmer registry covering 2MM+ farmers. New app for farmers auto-georeferenciation
- Senamhi (NMHS) is very strong on agromet and has developed several models to predict pest and disease spread based on hydromet conditions (even daily forecasts)

## Chile

- IDB project approved in 2024 that aims to modernize the extension system using digital tools and to strengthen the agromet stations network.
- Mesas Agroclimaticas Participativas (MAPS).
- Agromet webpage recently added an alert system (SMS) for frosts and sunstrokes.
- INIA has developed several tools that use weather and soil data to improve recommendations

## Bolivia

- IDB project to be approved that will strengthen the national hydrometeorological network and produce improved climatic information services with focus on agriculture, disaster risk management and water resources.

## Regional

- ENANDES project (led by the WMO, implemented by NMHS in Colombia, Peru and Chile) focused on co-creation of agroclimatic services better adapted to users' needs, the design of local adaptation plans and coordination between relevant institutions

**… huge potential to work here, learn and scale!**

# Some issues we will have to consider

- Best way to assess farmers’ main information needs: develop a tool/methodology and use it across the region? MAPS? Surveys to farmers and experts?
- Importance of having tools to assess forecasting capabilities
- Prioritize some value chains for pilots: market-oriented or smallest farmers?
- Challenges:
    - ✔ Very weak and decentralized traditional extension services ☐ opportunity for digital support
    - ✔ Fragile coordination between public agencies (NMHS, extension, research, DRM, subnational) ☐ fragmented projects and tools that reach few
    - ✔ Weak digital literacy of old farmers (and extensionists) ☐ intrahousehold dynamics in use of cellphone
    - ✔ Lack of farmers registries ☐ best tools to generate them?
    - ✔ Lack of soil data ☐ potential of digital soil mapping?
- WhatsApp seems best alternative to reach farmers in LAC
- Importance of tracking and building on progress by relevant initiatives/ partners in the region
- What can we learn from progress in other regions (Asia)?
- Training: also focus on strengthening local capacities for setting up public digital advisory systems + production of relevant and adequately- framed content

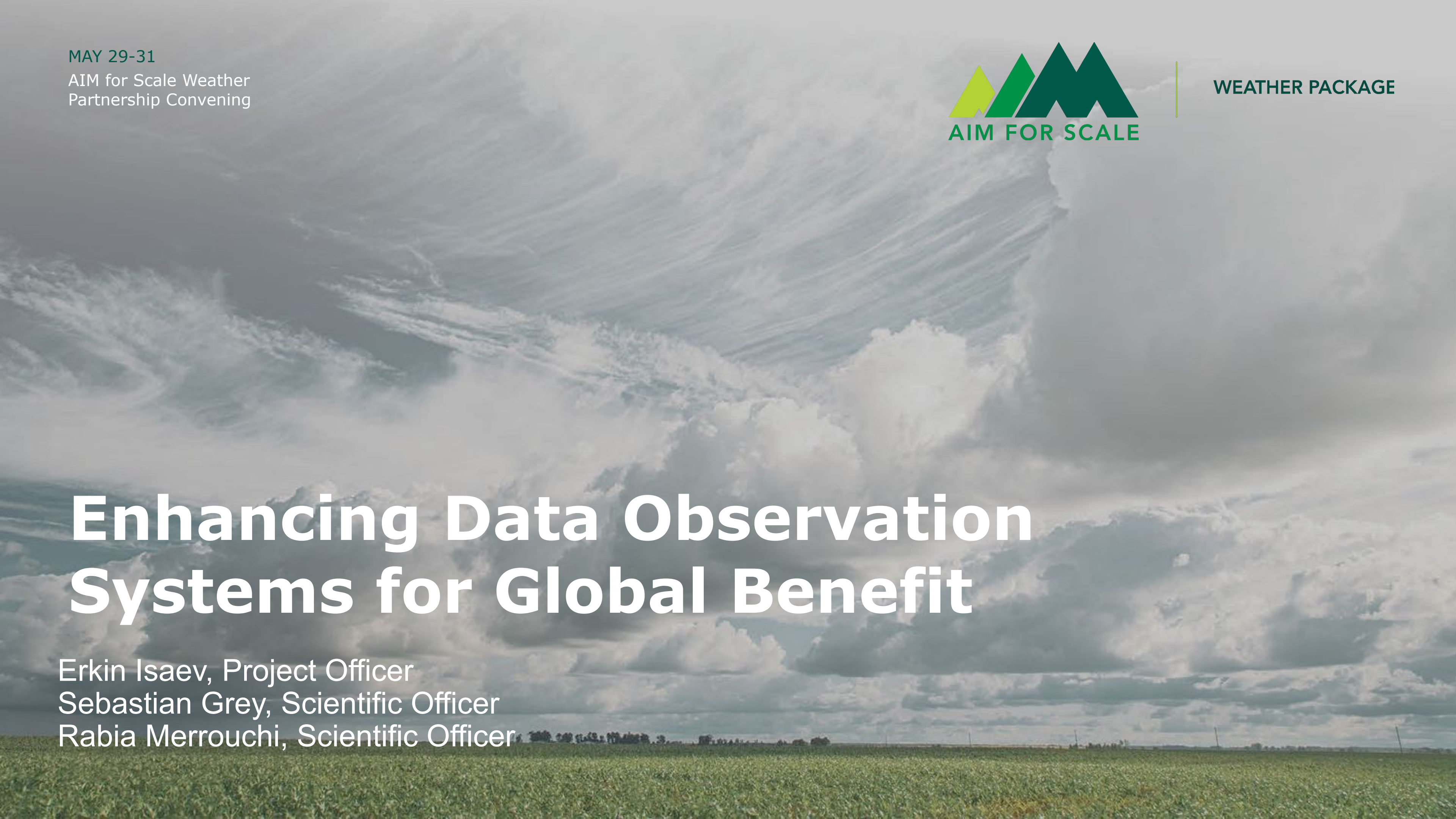
# Thanks!

**Romina Ordonez**

▶ **Email :** rominao@iadb.org

IDB
Inter-American
Development Bank

AIM FOR SCALE | WEATHER PACKAGE



MAY 29-31
AIM for Scale Weather
Partnership Convening

AIM FOR SCALE

WEATHER PACKAGE

# Enhancing Data Observation Systems for Global Benefit

Erkin Isaev, Project Officer
Sebastian Grey, Scientific Officer
Rabia Merrouchi, Scientific Officer

# World Meteorological Organization

## *WMO – A short introduction*

- Initiated on 23 March 1950
- Successor to International Meteorological Organization (IMO, created in 1873)
- **Specialized agency of the United Nations for meteorology (weather and climate), operational hydrology and related geophysical sciences.**
- **WMO provides its services to Members (193 countries and territories)**

- **Facilitate worldwide cooperation**;
- **Rapid exchange of data information**
- Promote **standardization**;
- Encourage **research and training**

Mandate

Weather

Climate

Water

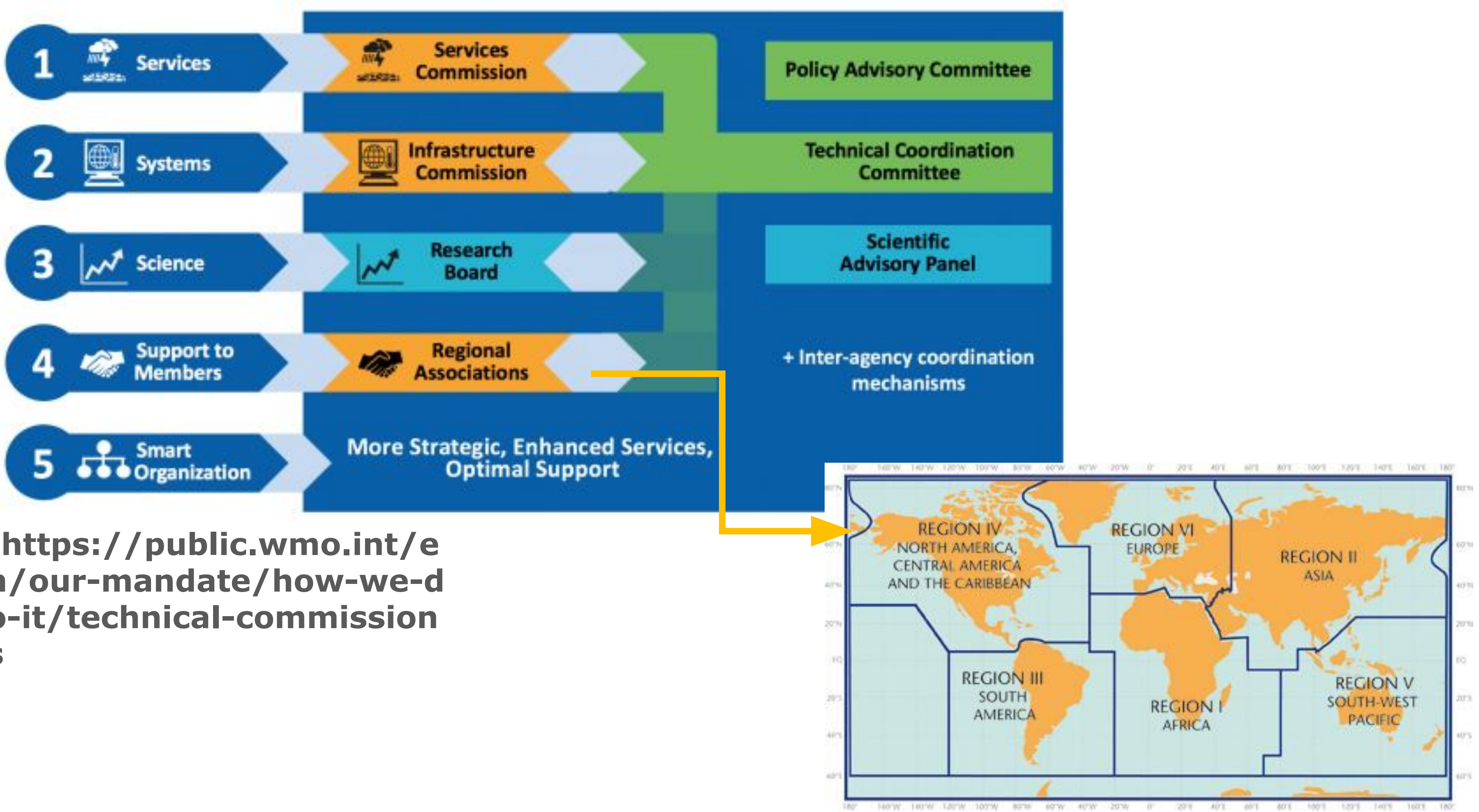
Environment

Research

Capacity development

World Meteorological Organization | (wmo.int)

# WMO Structure



1 Services

2 Systems

3 Science

4 Support to Members

5 Smart Organization

Services Commission

Infrastructure Commission

Research Board

Regional Associations

More Strategic, Enhanced Services, Optimal Support

Policy Advisory Committee

Technical Coordination Committee

Scientific Advisory Panel

+ Inter-agency coordination mechanisms

- ❑https://public.wmo.int/en/our-mandate/how-we-do-it/technical-commissions

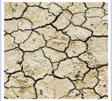
# WMO Priorities in Agricultural Meteorology 2024-27

Provide guidance to Members on weather and climate applications for agriculture and food security

Enhance integration of local and indigenous agroclimatic knowledge for countries

Provision of agrometeorological knowledge and guidance products, technical advice, and appropriate tools to stakeholders

Provide online, innovative capacity building on agrometeorology to WMO Members



Assistance to countries on drought monitoring and early warning systems; and development of national drought plans/policies

Early Warnings for All

Continued links with donor projects and programmes on weather and climate services for agriculture

# Early Warnings for All: Protecting everyone on earth with end-to-end early warning systems

## Disaster risk knowledge

Systematically collect data and undertake risk assessments

- Are the hazards and the vulnerabilities well known by the communities?
- What are the patterns and trends in these factors?
- Are risk maps and data widely available?

## Detection, observations, monitoring, analysis and forecasting of hazards

Develop hazard monitoring and early warning services

- Are the right parameters being monitored?
- Is there a sound scientific basis for making forecasts?
- Can accurate and timely warnings be generated?

## Preparedness and response capabilities

Build national and community response capabilities

- Are response plans up to date and tested?
- Are local capacities and knowledge made use of?
- Are people preapred and ready to react to warnings?

## Warning dissemination and communication

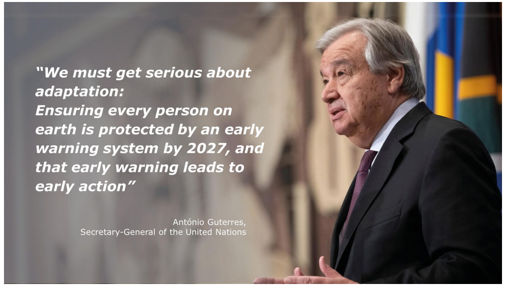
Communicate risk information and early warnings

- Do warnings reach all of those at risk?
- Are the risks and warnings understood?
- Is the warning information clear and usable?

# Rapid Assessment of Country Capacity (Pillar 2)

## Approach

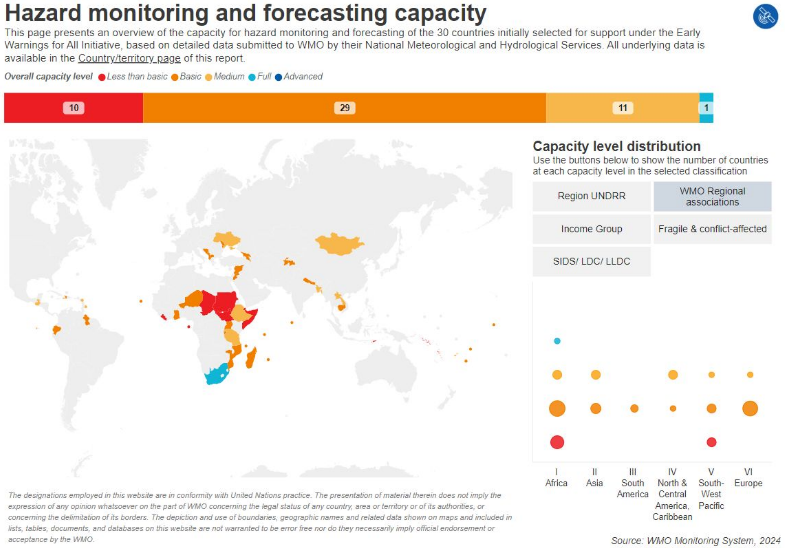
- **Conducted in 51 countries**, predominantly LDCs, LLDCs and SIDS
- A standardized methodology along the elements of the hydrometeorological value cycle
- A maturity score produced on a scale of 1-5, gaps identified
- **All results and data available** on Early Warnings for All Dashboard (see *MHEWS Capacity*)



***"We must get serious about adaptation: Ensuring every person on earth is protected by an early warning system by 2027, and that early warning leads to early action"***

António Guterres,
Secretary-General of the United Nations

## Access



### Hazard monitoring and forecasting capacity

This page presents an overview of the capacity for hazard monitoring and forecasting of the 30 countries initially selected for support under the Early Warnings for All Initiative, based on detailed data submitted to WMO by their National Meteorological and Hydrological Services. All underlying data is available in the Country/territory page of this report.

*Overall capacity level* ● *Less than basic* ● *Basic* ● *Medium* ● *Full* ● *Advanced*

| Less than basic | Basic | Medium | Full |
|---|---|---|---|
| 10 | 29 | 11 | 1 |

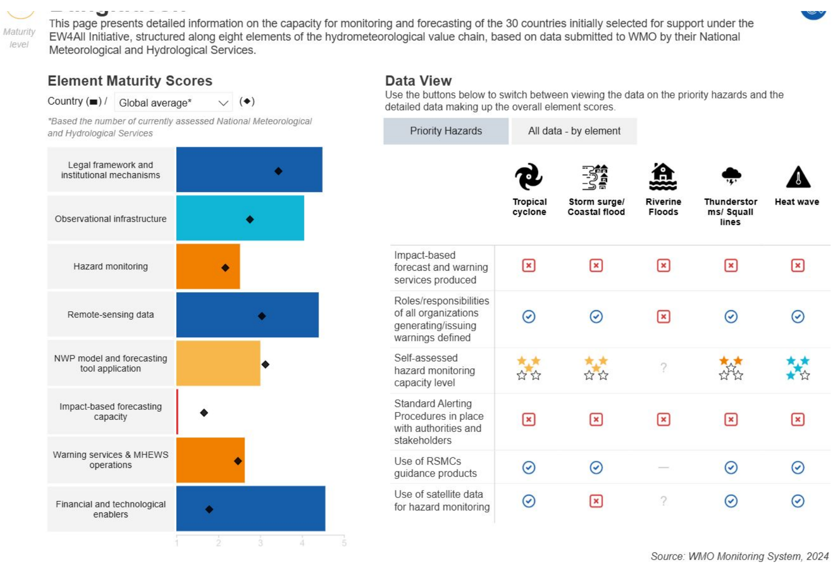
**Capacity level distribution**

Use the buttons below to show the number of countries at each capacity level in the selected classification

Region UNDRR | WMO Regional associations | Income Group | Fragile & conflict-affected | SIDS/ LDC/ LLDC

*The designations employed in this website are in conformity with United Nations practice. The presentation of material therein does not imply the expression of any opinion whatsoever on the part of WMO concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases on this website are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the WMO.*

*Source: WMO Monitoring System, 2024*



This page presents detailed information on the capacity for monitoring and forecasting of the 30 countries initially selected for support under the EW4All Initiative, structured along eight elements of the hydrometeorological value chain, based on data submitted to WMO by their National Meteorological and Hydrological Services.

**Element Maturity Scores**

Country (■) / Global average* (◆)

**Based the number of currently assessed National Meteorological and Hydrological Services*

**Data View**

Use the buttons below to switch between viewing the data on the priority hazards and the detailed data making up the overall element scores.

Priority Hazards | All data - by element

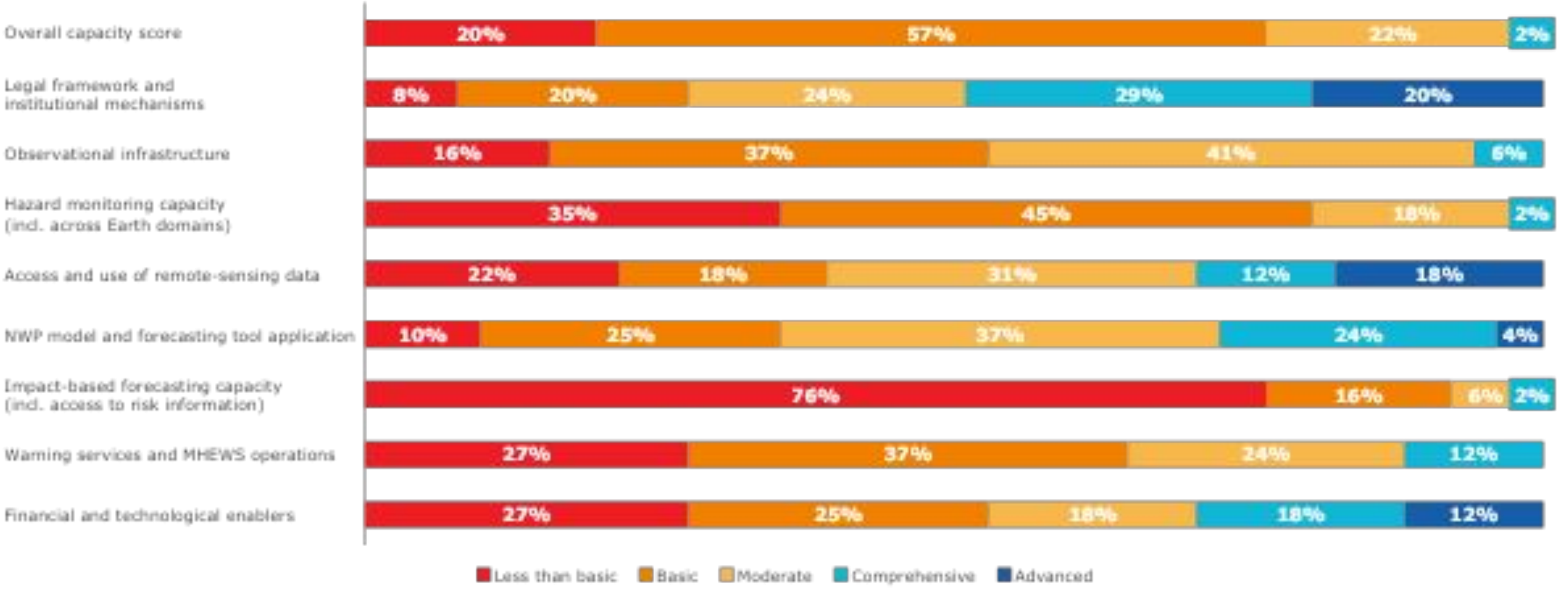
| | Tropical cyclone | Storm surge/ Coastal flood | Riverine Floods | Thunderstorms/ Squall lines | Heat wave |
|---|---|---|---|---|---|
| Impact-based forecast and warning services produced | ☒ | ☒ | ☒ | ☒ | ☒ |
| Roles/responsibilities of all organizations generating/issuing warnings defined | ✓ | ✓ | ☒ | ✓ | ✓ |
| Self-assessed hazard monitoring capacity level | ★★★☆☆ | ★★★☆☆ | ? | ★★☆☆☆ | ★★★★☆ |
| Standard Alerting Procedures in place with authorities and stakeholders | ☒ | ☒ | ☒ | ☒ | ☒ |
| Use of RSMCs guidance products | ✓ | ✓ | — | ✓ | ✓ |
| Use of satellite data for hazard monitoring | ✓ | ☒ | ? | ✓ | ✓ |

*Source: WMO Monitoring System, 2024*

**Results**

# Rapid Assessment of Country Capacity

Over half of the 51 NMHS operate with basic monitoring and forecasting capacity, and a fifth with less-than-basic capacity.



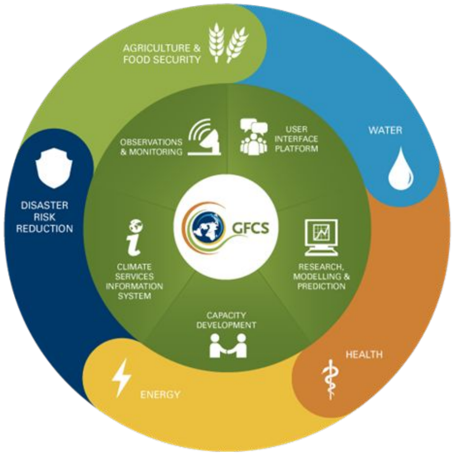
*EW4All Pillar 2 capacity levels of hydro-meteorological services in 51 developing countries, of which 40 are least-developed countries, small island developing states, or landlocked developing countries (data collected by WMO in 2023-2024).*

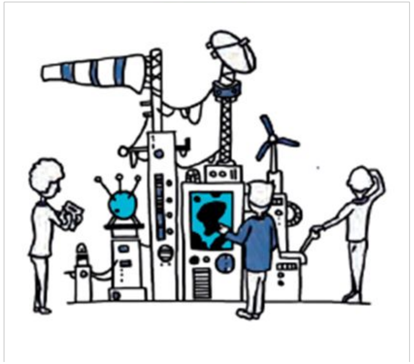
Biggest gaps: <u>impact-based forecasting capacity</u> (incl. skills, technical resources and risk data) and <u>insufficient observations </u>(incl. lack of network maintenance, data management and access to monitoring data across Earth domains).

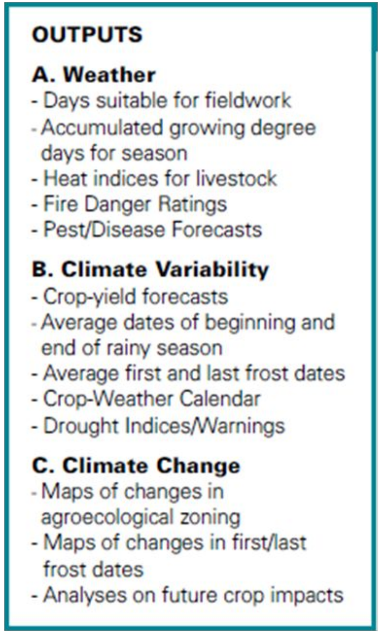
# Agromet services: User needs and engagement

WORLD
METEOROLOGICAL
ORGANIZATION

# Climate services and farmer needs







**OUTPUTS**

**A. Weather**

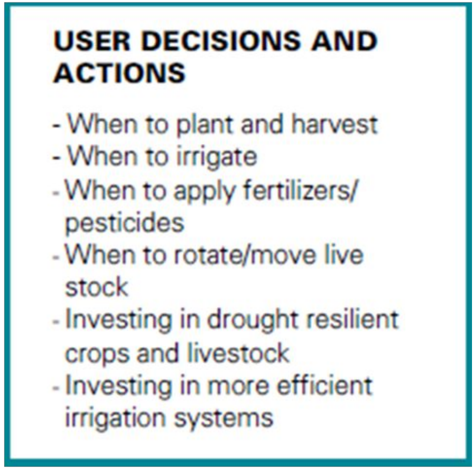
- Days suitable for fieldwork
- Accumulated growing degree days for season
- Heat indices for livestock
- Fire Danger Ratings
- Pest/Disease Forecasts

**B. Climate Variability**

- Crop-yield forecasts
- Average dates of beginning and end of rainy season
- Average first and last frost dates
- Crop-Weather Calendar
- Drought Indices/Warnings

**C. Climate Change**

- Maps of changes in agroecological zoning
- Maps of changes in first/last frost dates
- Analyses on future crop impacts



**USER DECISIONS AND ACTIONS**

- When to plant and harvest
- When to irrigate
- When to apply fertilizers/ pesticides
- When to rotate/move live stock
- Investing in drought resilient crops and livestock
- Investing in more efficient irrigation systems

- Users in agriculture could include farmers, agricultural policy makers, grain management authorities (public stockholders), agricultural planners, extension agents, agricultural research institutes, seed producers and more

Agricultural extension service

Other institutions

Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs)

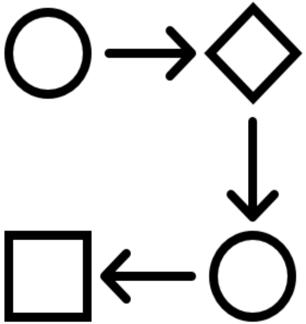
Knowledge brokers

Local social networks and leaders

Journalists

Private sector organizations

**The coproduction approach**: shift from being provider-driven services to more user-centric, inclusive and participatory services that bring users, intermediaries and climate service providers together

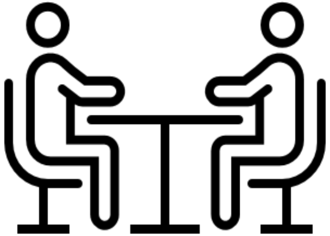


## Traditional model

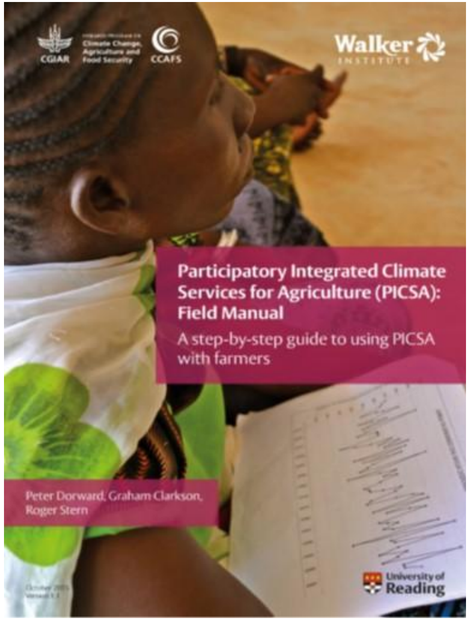
- Unidirectional: Information flows from providers to users.
- Does not consider the needs of users.
- Users may not fully trust or understand the information
- No feedback mechanism

## Co-production

- Bidirectional: Interaction between providers and users (and intermediaries/ knowledge brokers like extension).
- Users participate in the design and co-production of information.
- Greater user trust in information.
- Feedback is received to improve the service



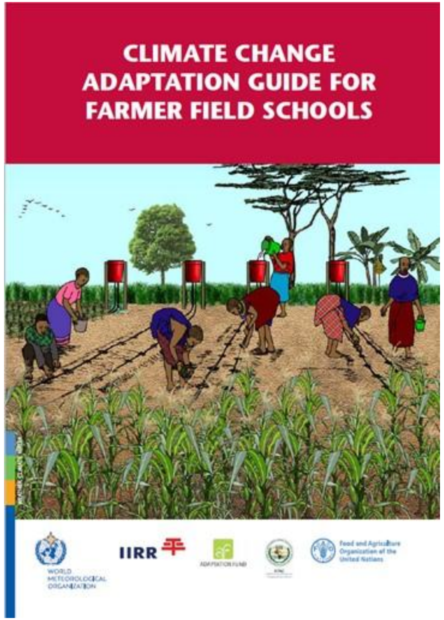
# Participatory process for climate services in agriculture



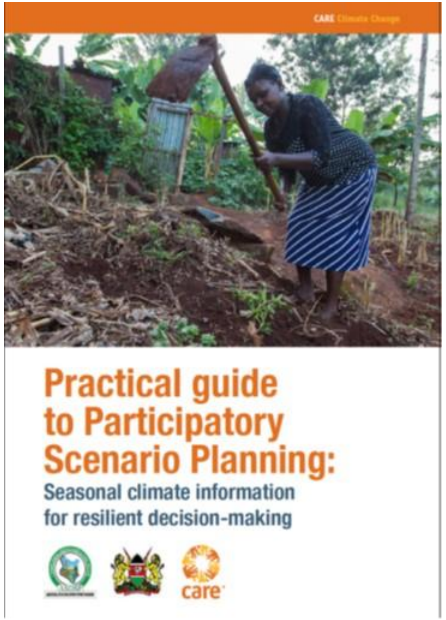
Participatory Integrated Climate Services for Agriculture (PICSA): Field Manual

A step-by-step guide to using PICSA with farmers

Peter Dorward, Graham Clarkson, Roger Stern



CLIMATE CHANGE ADAPTATION GUIDE FOR FARMER FIELD SCHOOLS



CARE Climate Change

Practical guide to Participatory Scenario Planning:

Seasonal climate information for resilient decision-making

Roving Seminars on Weather, Climate and Farmers
A Concept Note

World Meteorological Organization

1. Introduction

# Some key issues

**Multi-stakeholder partnerships** are necessary to improve climate services coordination and close the gap between users & service providers.

**Involvement and engagement** of farmers and other agriculture stakeholders is key

**Participatory approaches & coproduction** can be a key means of increasing trust in and ownership of climate services

Sustainability of **interactions with local communities** needs to be looked at closely during project design, implementation and closing

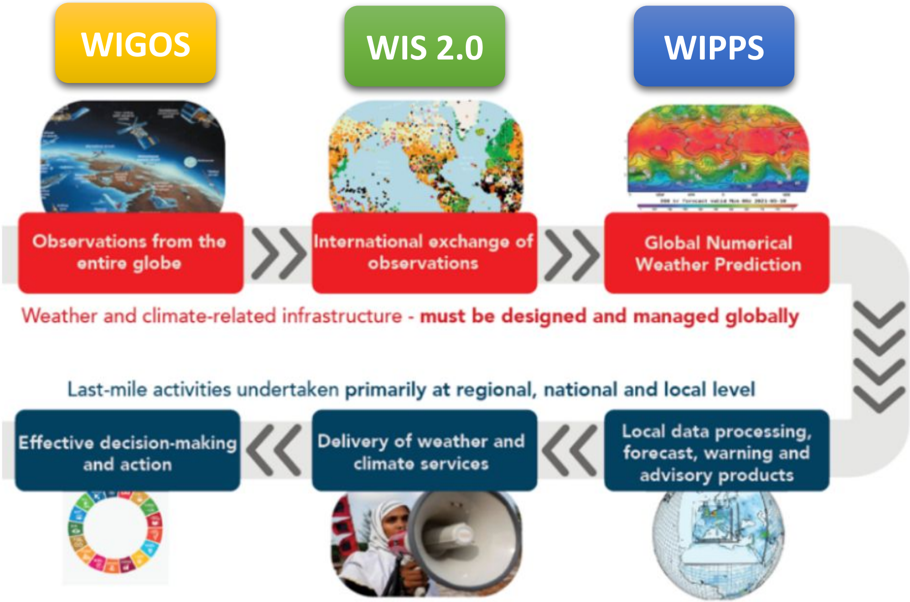
**Financial support** for NMHSs, especially for enabling them to interact with the farming communities is needed

Appropriate packaging and communication of climate information is crucial: **simple and locally appropriate technologies** are often needed

# Enhancing Data Observation Systems for Global Benefit

WORLD
METEOROLOGICAL
ORGANIZATION

# WMO Operational Infrastructure



**WIGOS**

**WIS 2.0**

**WIPPS**

Observations from the entire globe

International exchange of observations

Global Numerical Weather Prediction

Weather and climate-related infrastructure - **must be designed and managed globally**

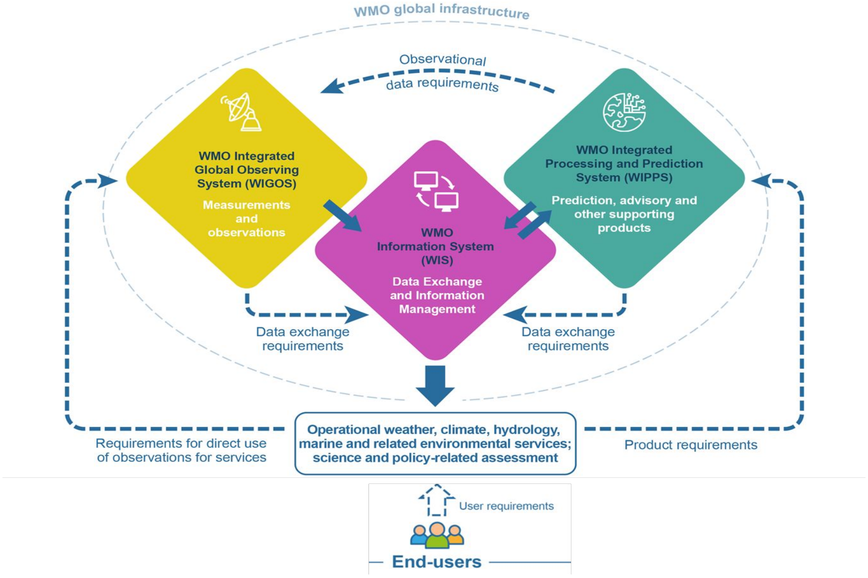
Last-mile activities undertaken **primarily at regional, national and local level**

Effective decision-making and action

Delivery of weather and climate services

Local data processing, forecast, warning and advisory products

The services value chain, from observations through to effective decision making and action



WMO global infrastructure

Observational data requirements

**WMO Integrated Global Observing System (WIGOS)**

Measurements and observations

**WMO Information System (WIS)**

Data Exchange and Information Management

**WMO Integrated Processing and Prediction System (WIPPS)**

Prediction, advisory and other supporting products

Data exchange requirements

Data exchange requirements

Requirements for direct use of observations for services

**Operational weather, climate, hydrology, marine and related environmental services; science and policy-related assessment**

Product requirements

User requirements

**End-users**

- **WIPPS**: WMO Integrated processing and Prediction System
- **WIGOS**: WMO Integrated Global Observing System
- **WIS**: WMO Information System (Data exchange)

# WMO Integrated Global Observing Systems

- A WMO foundational activity addressing the needs of Members services ***(weather, climate, water and environmental services)*** for observations
- An umbrella for all WMO and co-sponsored observing systems following common standards and procedures ***(WIGOS Regulatory & Guidance material)***.
- With an Earth system perspective, WIGOS is designed to manage observations **from a diversity of surface- and space-based** observing systems across physical domains.
- These observations are acquired by a variety of players with the aim of providing **an integrated**, composite set of observations that are **well-managed, reliable and accessible** to many users and are suitable for many service and science applications.

**Integration & increased interoperability of systems** – across disciplines/domains, organizational, technological and performance boundaries,

**Sharing internationally** (more) data and metadata

**Partnerships & cooperation** – at national and regional levels

**Leadership** – of NMHSs

**Planning** – National Observing Strategy – WIGOS Implementation Plans

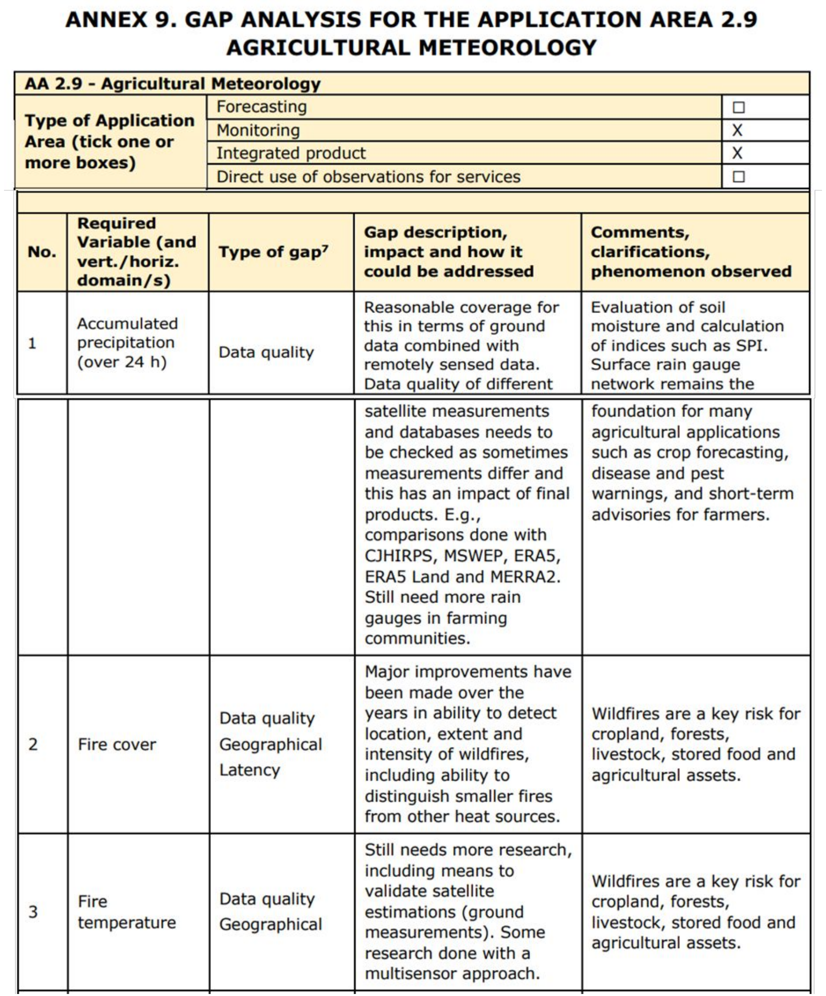
**Culture of compliance** (with regards to the WMO Technical Regulations)

**Following guidance** – Aware and use of guidance material for implementation of WIGOS

# WIGOS Vision 2050

## The Rolling Review of Requirement (RRR) process for the WIGOS Application Areas

- Global NWP
- High-resolution NWP
- Nowcasting and very short-range forecasting
- Sub-seasonal to longer predictions
- Aeronautical meteorology
- Forecasting atmospheric composition
- Monitoring atmospheric composition
- Atmospheric composition - Urban and populated areas
- Ocean applications
- Agricultural meteorology
- Hydrology
- Climate monitoring
- Space weather
- Climate science /Climate applications



### ANNEX 9. GAP ANALYSIS FOR THE APPLICATION AREA 2.9 AGRICULTURAL METEOROLOGY

| **AA 2.9 - Agricultural Meteorology** | | |
|---|---|---|
| **Type of Application Area (tick one or more boxes)** | Forecasting | ☐ |
| | Monitoring | X |
| | Integrated product | X |
| | Direct use of observations for services | ☐ |

| **No.** | **Required Variable (and vert./horiz. domain/s)** | **Type of gap[7]** | **Gap description, impact and how it could be addressed** | **Comments, clarifications, phenomenon observed** |
|---|---|---|---|---|
| 1 | Accumulated precipitation (over 24 h) | Data quality | Reasonable coverage for this in terms of ground data combined with remotely sensed data. Data quality of different satellite measurements and databases needs to be checked as sometimes measurements differ and this has an impact of final products. E.g., comparisons done with CJHIRPS, MSWEP, ERA5, ERA5 Land and MERRA2. Still need more rain gauges in farming communities. | Evaluation of soil moisture and calculation of indices such as SPI. Surface rain gauge network remains the foundation for many agricultural applications such as crop forecasting, disease and pest warnings, and short-term advisories for farmers. |
| 2 | Fire cover | Data quality<br>Geographical<br>Latency | Major improvements have been made over the years in ability to detect location, extent and intensity of wildfires, including ability to distinguish smaller fires from other heat sources. | Wildfires are a key risk for cropland, forests, livestock, stored food and agricultural assets. |
| 3 | Fire temperature | Data quality<br>Geographical | Still needs more research, including means to validate satellite estimations (ground measurements). Some research done with a multisensor approach. | Wildfires are a key risk for cropland, forests, livestock, stored food and agricultural assets. |

# Integrated Observing Systems

- All observations are documented publicly (metadata)
- Instruments are calibrated and mantained
- Observations are exchanged and compared
- Obsolete instrumentation may be de-commissioned
- User requirements can be met better at less cost

# Role of NMHSs in Enhancing National Observations under WIGOS

NMHSs have a national leadership role in the continued improvement of national observing capabilities that build on WIGOS principles, practices and procedures.

1

**Implement WIGOS Nationally**

- Develop National Observing Strategy & WIGOS Implementation Plan

2

**Manage Station Identifiers**

- Assign WIGOS Station Identifiers to national stations

3

**Engage Non-NMHS Operators**

- Promote data sharing for national, regional, and global benefit

4

**Communicate Benefits**

- Highlight advantages of data contributions to WMO and NMHSs

5

**Establish Agreements**

- Use MoUs or contracts to define roles and partnership benefits

6

**Promote Standards & Tools**

- Encourage adoption of WIGOS standards (e.g., WMO-No. 1192) and tools (e.g., OSCAR/Surface)

7

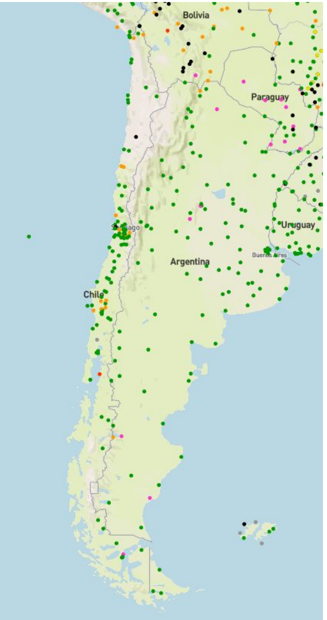
**Conduct CD activities**

- Supporting outreach and training related to WIGOS, and mechanisms for observational data exchange

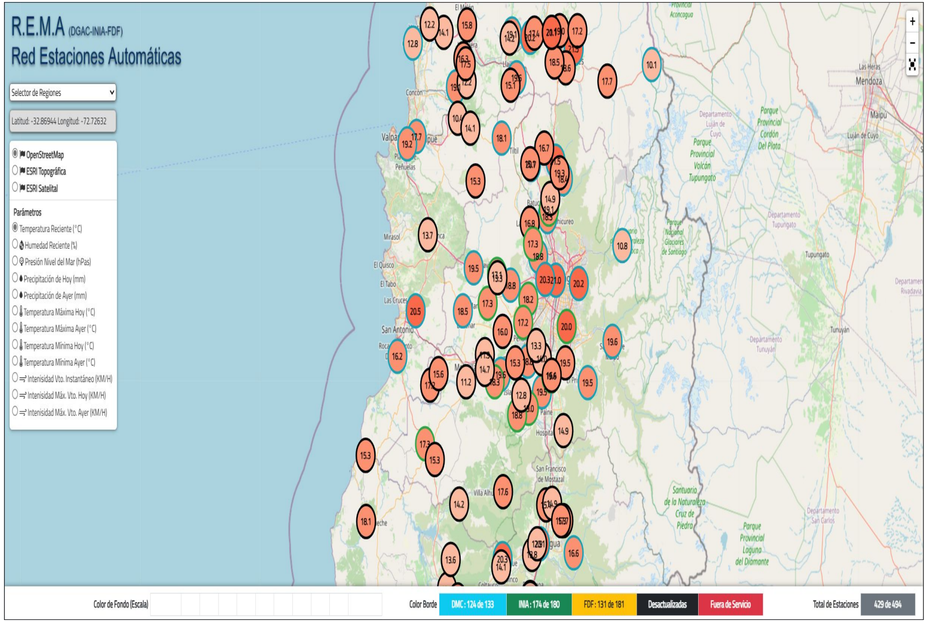
# National integrated and fit for purpose observing networks

197 stations registered in OSCAR/Surface, 179 over land

Hourly data shared internationally from more than 133 stations



Hourly data from nearly 500 stations, part of the NMHS and partner networks, is accessible through the Meteo Chile website.



R.E.M.A (DGAC-INIA-FDF)
Red Estaciones Automáticas

Selector de Regiones

Latitud: -32.86944 Longitud: -72.72632

- ● OpenStreetMap
- ○ ESRI Topográfica
- ○ ESRI Satelital

Parámetros

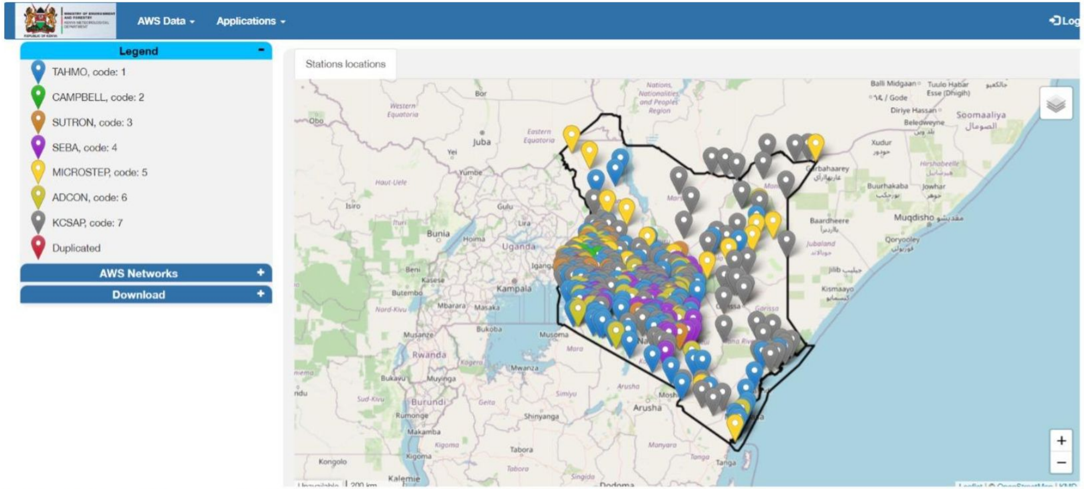
- ● Temperatura Reciente (°C)
- ○ Humedad Reciente (%)
- ○ Presión Nivel del Mar (hPas)
- ○ Precipitación de Hoy (mm)
- ○ Precipitación de Ayer (mm)
- ○ Temperatura Máxima Hoy (°C)
- ○ Temperatura Máxima Ayer (°C)
- ○ Temperatura Mínima Hoy (°C)
- ○ Temperatura Mínima Ayer (°C)
- ○ Intenisidad Vto. Instantáneo (KM/H)
- ○ Intenisidad Máx. Vto. Hoy (KM/H)
- ○ Intenisidad Máx. Vto. Ayer (KM/H)

Color de Fondo (Escala)

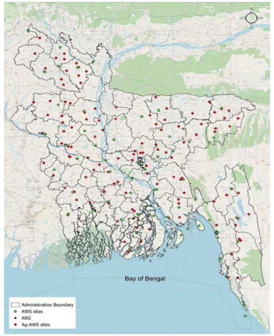
Color Borde: DMC : 124 de 133 | INIA : 174 de 180 | FDF : 131 de 181 | Desactualizadas | Fuera de Servicio

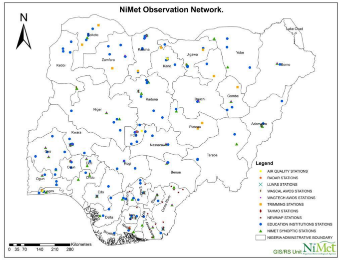
Total de Estaciones: 429 de 494

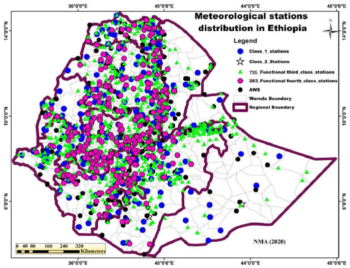
# National integrated and fit for purpose observing networks



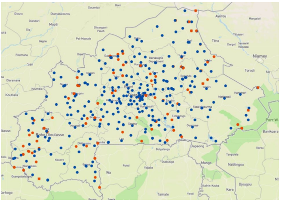
The ADT web interface for Kenya showing seven different types of AWS networks, as well as duplicate coordinates identified.

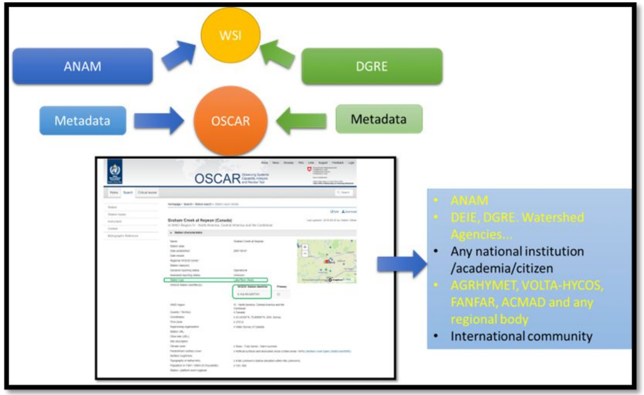






Hydromet metadata and data collection and exchange in Burkina Faso.





WSI

ANAM

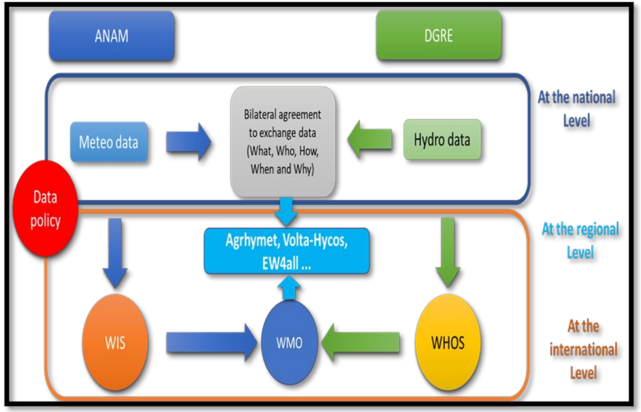
DGRE

Metadata

OSCAR

Metadata

- ANAM
- DEIE, DGRE. Watershed Agencies...
- Any national institution /academia/citizen
- AGRHYMET, VOLTA-HYCOS, FANFAR, ACMAD and any regional body
- International community



ANAM

DGRE

Meteo data

Bilateral agreement to exchange data (What, Who, How, When and Why)

Hydro data

At the national Level

Data policy

Agrhymet, Volta-Hycos, EW4all ...

At the regional Level

WIS

WMO

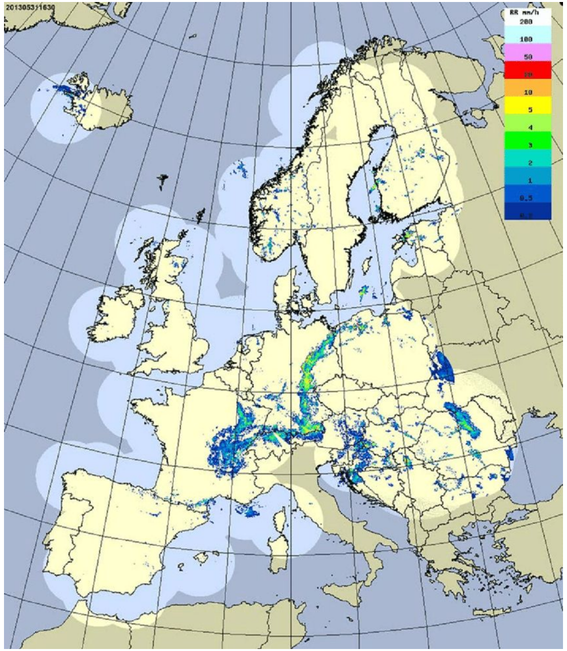
WHOS

At the international Level

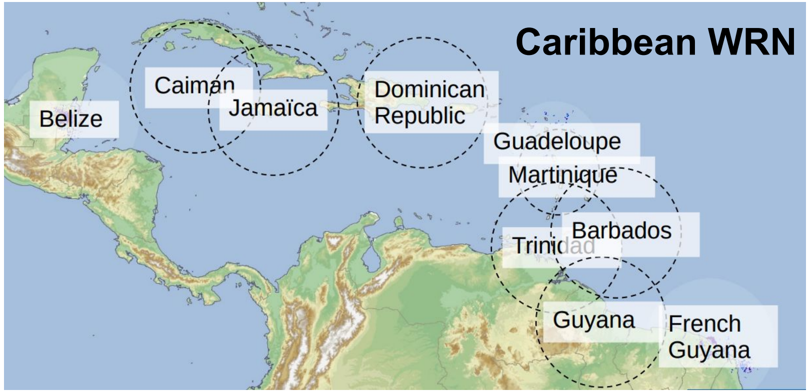
Mutual benefit of sharing data at national and/or regional levels

Standardized and interoperable data format

HL Guidance
Peer to peer
Pilot countries and projects



EWRN Opera Network



Caribbean WRN

# WMO support to Observation

**Network design**

user requirements, national needs, tiered networks, integration of partners networks, WIGOS implementation, SPO, M&O plans

**Instruments and Observing Systems**

Space programs, transition to MM, withdraw of mercury instruments, siting, classification, calibration and traceability, technical specifications, WMO N°8

**Network Monitoring**

Monitoring the performance of the observing networks in terms of data availability, quality and timeliness

**Data Management**

Metadata and Data collection, First Mile concept, data format, data interoperability, QC, data sharing. WIS 2.0

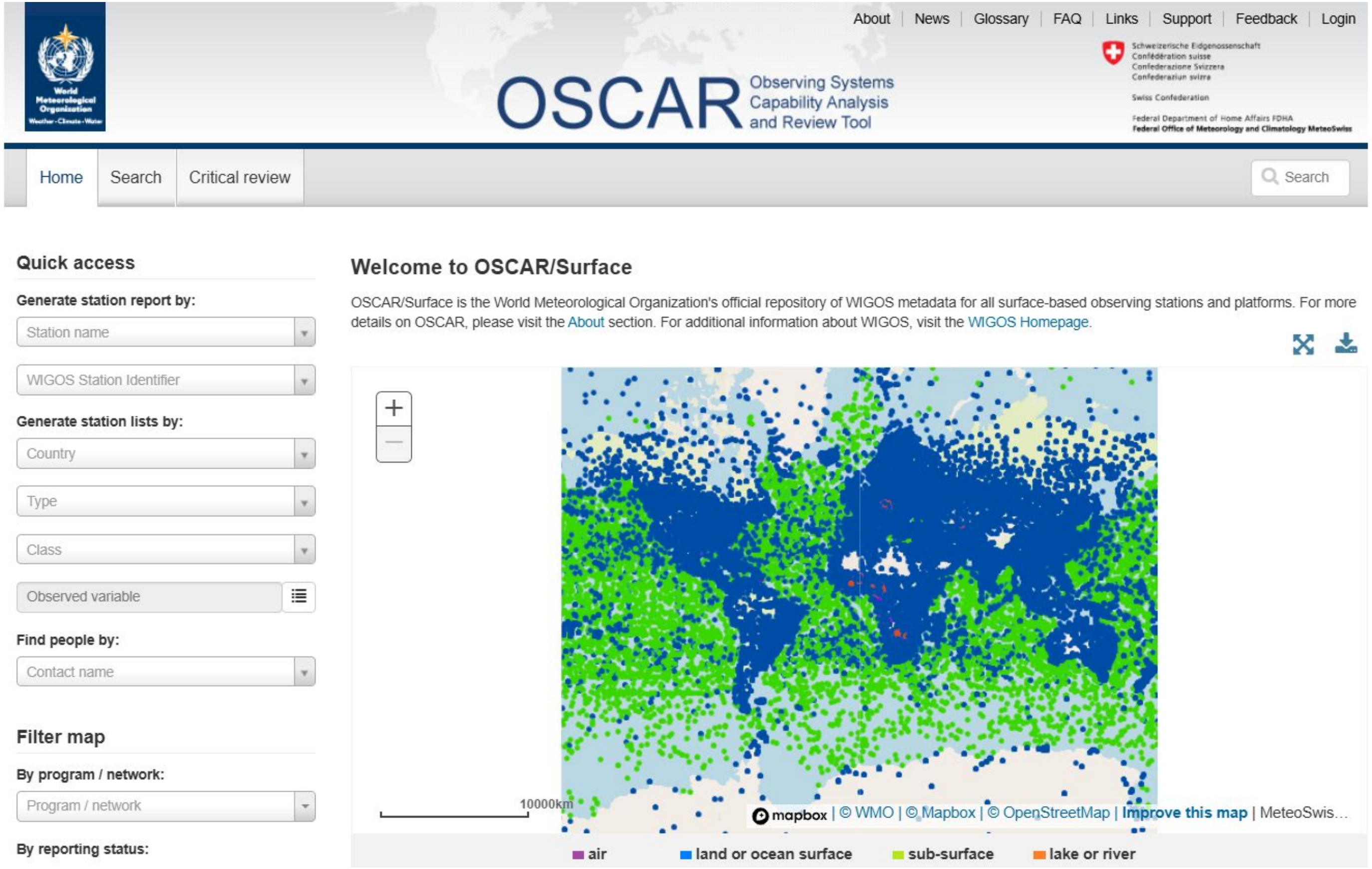
WMO Regional Instrument Centers

WMO Regional Training Centers

WMO Regional WIGOS Centers

WMO lead and Specialized Centers

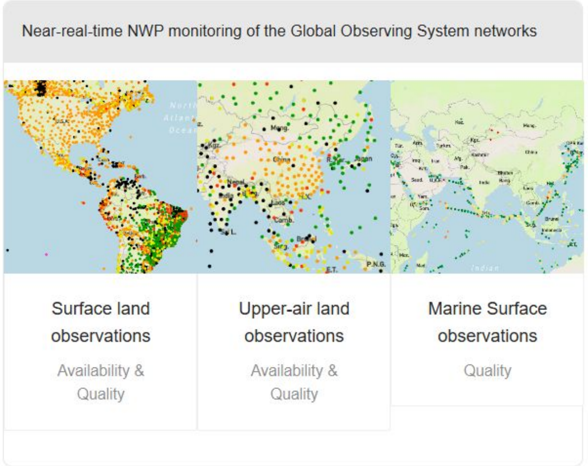
**OSCAR**
Observing Systems
Capability Analysis
and Review Tool



## Welcome to OSCAR/Surface

OSCAR/Surface is the World Meteorological Organization's official repository of WIGOS metadata for all surface-based observing stations and platforms. For more details on OSCAR, please visit the About section. For additional information about WIGOS, visit the WIGOS Homepage.

# WIGOS Data Quality Monitoring System

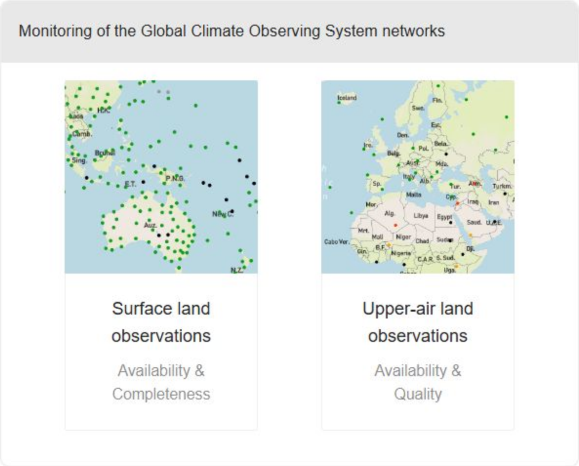


Near-real-time NWP monitoring of the Global Observing System networks

Surface land observations
Availability & Quality

Upper-air land observations
Availability & Quality

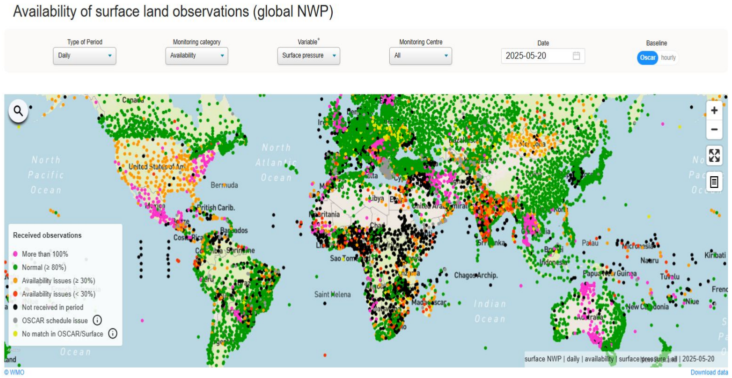
Marine Surface observations
Quality



Monitoring of the Global Climate Observing System networks

Surface land observations
Availability & Completeness

Upper-air land observations
Availability & Quality



Availability of surface land observations (global NWP)

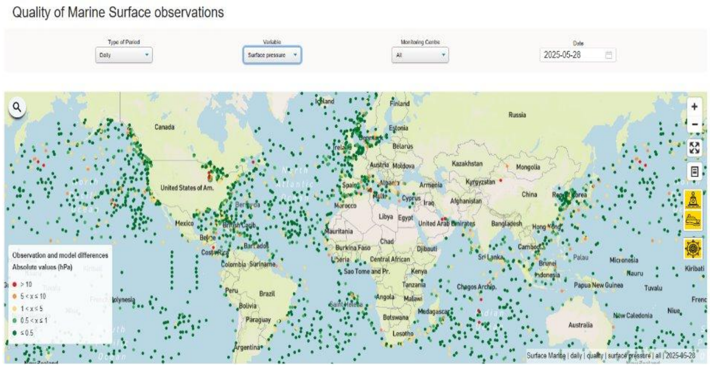
Type of Period: Daily
Monitoring category: Availability
Variable*: Surface pressure
Monitoring Centre: All
Date: 2025-05-20
Baseline: Oscar hourly

Received observations
- ● More than 100%
- ● Normal (≥ 80%)
- ● Availability issues (≥ 30%)
- ● Availability issues (< 30%)
- ● Not received in period
- ● OSCAR schedule issue ⓘ
- ● No match in OSCAR/Surface ⓘ

surface NWP | daily | availability | surface pressure | all | 2025-05-20

© WMO

Download data



Quality of Marine Surface observations

Type of Period: Daily
Variable: Surface pressure
Monitoring Centre: All
Date: 2025-05-28

Observation and model differences
Absolute values (hPa)
- ● > 10
- ● 5 < x ≤ 10
- ● 1 < x ≤ 5
- ● 0.5 < x ≤ 1
- ● ≤ 0.5

Surface Marine | daily | quality | surface pressure | all | 2025-05-28

**SOFF**
The Systematic Observations Financing Facility

•**SOFF is a partner to the Aim for Scale Weather Innovation Package** announced at COP29.

•**The Weather Innovation Package prominently positions GBON/SOFF**. It states as Activity 'Mobilize support for countries to generate and internationally exchange essential observation data according to the WMO Global Basic Observing Network (GBON) and to improve access to improved forecasts' and as corresponding outputs '10-15 additional countries sharing data publicly or through a federated system by 2027, USD 50 million in additional investments for data collection infrastructure by 2026.'. These USD 50 million were envisioned as contribution from UAE and Gates foundation to SOFF.

•**SOFF Impact Bond info package**: SOFF is confronted with huge country demand. Fully ready investment funding requests correspond to USD 70 million. In order to innovate fundraising, SOFF aims at announcing the creation of a SOFF Impact Bond at COP30. UAE and Gates are targeted as potential contributors.

•**ECMWF SOFF impact studies and experiments**: ECMWF Deputy DG Florian Pappenberger presented at last week's SOFF Steering Committee meeting the findings of the first-of-its-kind impact experiments for surface based observations. Conclusions are striking. For example, if Africa achieved compliance with GBON standard density (currently compliance rate below 10 percent, Germany has more reporting surface stations than whole Africa), **forecast error reduction by more than 30 percent**

# WMO Information System (WIS 2.0)

**1963** World Weather Watch

**1970s** Global Telecommunication System (GTS)

**2007** WMO Information System (WIS)

**2019** WMO Reform (Earth System Approach)

**2021** WMO Unified Data Policy (Core, Recommended)

**Resolution 34 (EC-76)**
Implementation plan update of the WMO Information System 2.0
[WMO-No. 1314, pg. 1147]

**Resolution 25 (Cg-19)**
Technical Regulations of the WMO Information System 2.0
[WMO-No. 1326, pg. 209] ✓

## WIS 2.0

*… collaborative system of systems using Web-architecture and open standards to provide simple, timely and seamless sharing of trusted data and information …*

- Open Standards (OGC, W3C, IETF, …)
- Free and Open Source tooling
- Data sharing through Web and real-time notifications with publication/subscription (pub/sub) protocols
- Cloud ready (turn-key solutions)
- Web services and APIs (Application Programming Interface)

# WIS2 Context

## WIS2.0 Technical Foundations

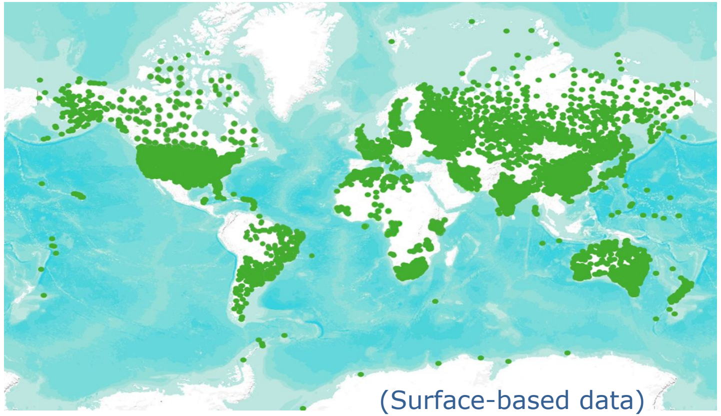
- Message Queuing Protocols
- OGC Metadata Standard
- Provide expandable services-architecture
- Unified monitoring approach

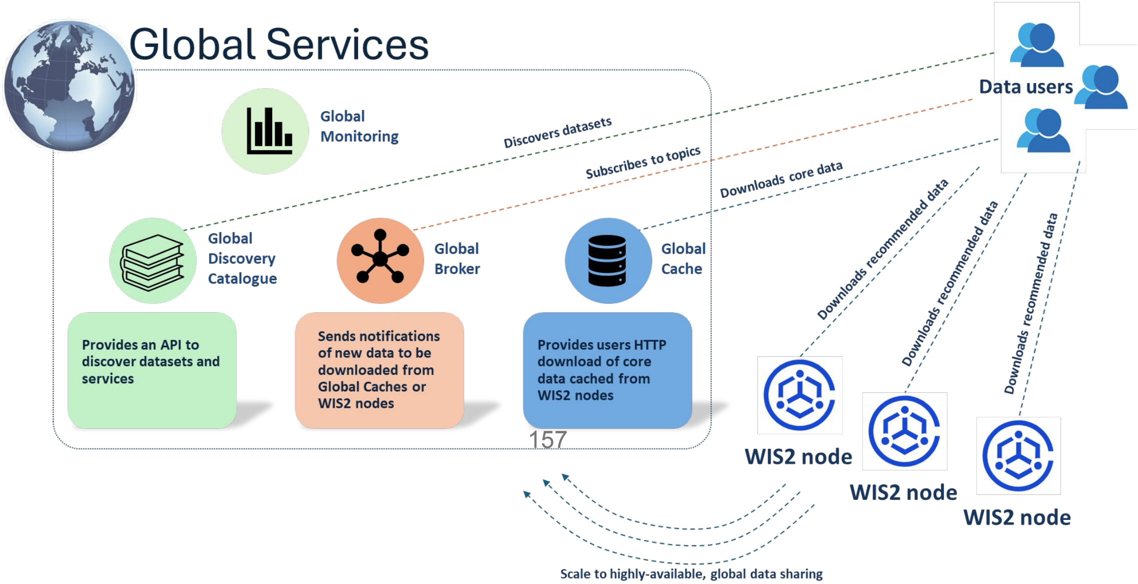
## Functional Requirements

- Using open standards
- Using Web solutions
- Cloud ready solutions
- Support Big Data

## Business Requirements

- Emerging Data Issues
- Support GBON
- Support Unified Data Policy
- Support All WMO Programmes
- Replace GTS


(Surface-based data)



## Global Services

**Global Monitoring**

**Global Discovery Catalogue**

Provides an API to discover datasets and services

**Global Broker**

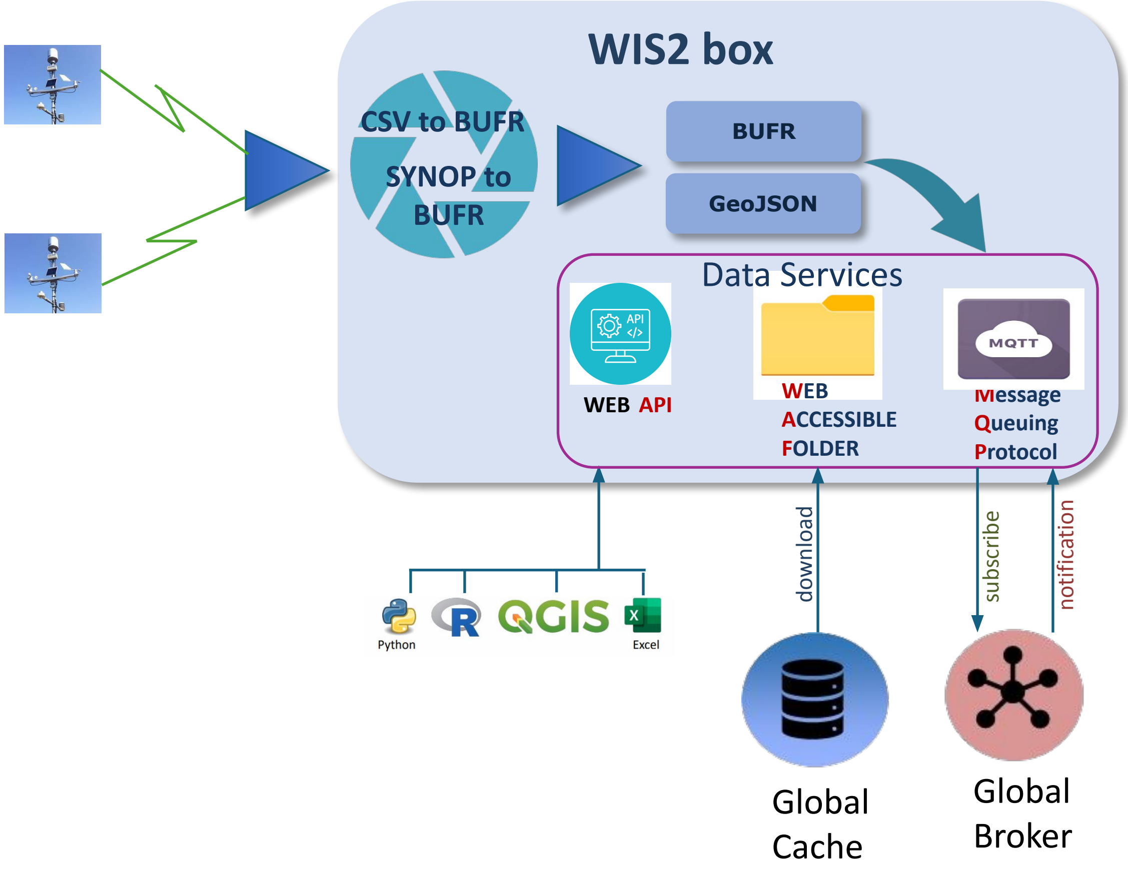
Sends notifications of new data to be downloaded from Global Caches or WIS2 nodes

**Global Cache**

Provides users HTTP download of core data cached from WIS2 nodes

# WIS2box: enabling broad participation in WIS2

- **"WIS2 in a box" is a reference implementation of a WIS2 Node**
  - **MQTT**
  - **HTTP**
- **Software** (not hardware)
- **Publishing facility/capability** compliant to WIS 2.0 Architecture
  - Provides basic data transformation
  - Can **integrate** with existing data management systems



WIS2 box

CSV to BUFR

SYNOP to BUFR

BUFR

GeoJSON

Data Services

WEB API

WEB ACCESSIBLE FOLDER

Message Queuing Protocol

download

subscribe

notification

Python

QGIS

Excel

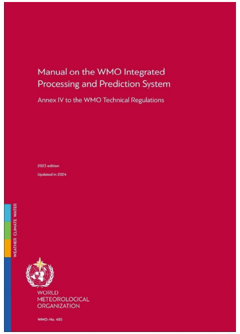
Global Cache

Global Broker

# WIPPS is …

- Definition: worldwide network of operational centres operated by WMO Members
- Aim: make defined products and services operationally available to WMO Members and relevant operational organizations
- Defined products
  - Analysis, forecast, including probabilistic information
  - Specialized products tailored for specific applications
- Entities responsible for producing the products
  - WIPPS Designated Centres (WIPPS DCs) and National Meteorological Centres (NMCs)
    - WIPPS Centres consist of WIPPS DCs and NMCs
    - WIPPS DCs encompass different names, such as World Meteorological Centre (WMC), Global Producing Centre (GPC), Regional Specialized Meteorological Centre (RSMC), Reginal Climate Centre (RCC) (RCC-Network), Regional Specialized Hydrological Centre (RSHC) and Lead Centre (LC)
- Modalities for delivering the products
  - WIS –*mandatory products defined in the Manual on the WIPPS (minimum set)*
  - Websites of WIPPS Centres
  - Direct download from the WIPPS Centres – ftp, API and …
  - Other platforms such as Copernicus

Manual on the WMO Integrated Processing and Prediction System (2024 update)



Manual on the WMO Integrated
Processing and Prediction System

Annex IV to the WMO Technical Regulations

2023 edition

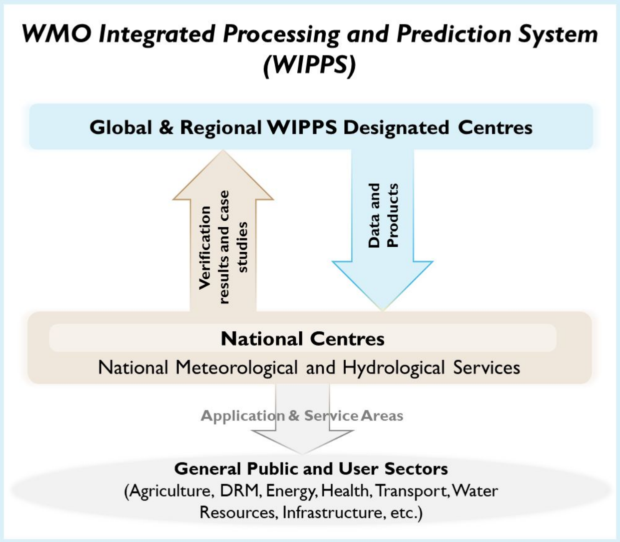
Updated in 2024

WEATHER CLIMATE WATER

WORLD
METEOROLOGICAL
ORGANIZATION

WMO-No. 485

# WIPPS Structure and Activities



*WMO Integrated Processing and Prediction System (WIPPS)*

**Global & Regional WIPPS Designated Centres**

**National Centres**
National Meteorological and Hydrological Services

**General Public and User Sectors**
(Agriculture, DRM, Energy, Health, Transport, Water Resources, Infrastructure, etc.)

Global producing centre for Sub-Seasonal Predictions (GPC-SSP)

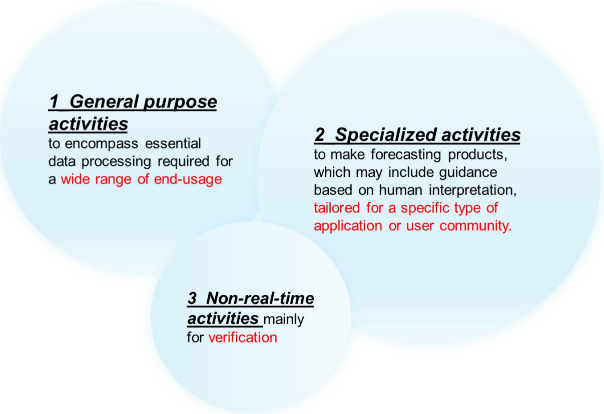
Beijing
CPTEC
ECMWF
Moscow
Tokyo

The GPC-SSP are committed to fulfilling a set of mandatory functions aiming to enhance consistency and usability of forecast information and to facilitate the exchange of data. The timely provision of forecast data to the LC-SSPMME is one of the mandatory functions (WIPPS).

Contributing centres

Centre for global climate reanalysis (GCR), ECMWF and NASA (USA)

Lead Centre for seasonal prediction multi-model ensemble (LC-SPMME), Seoul & Washington



***1 General purpose activities***
to encompass essential data processing required for a wide range of end-usage

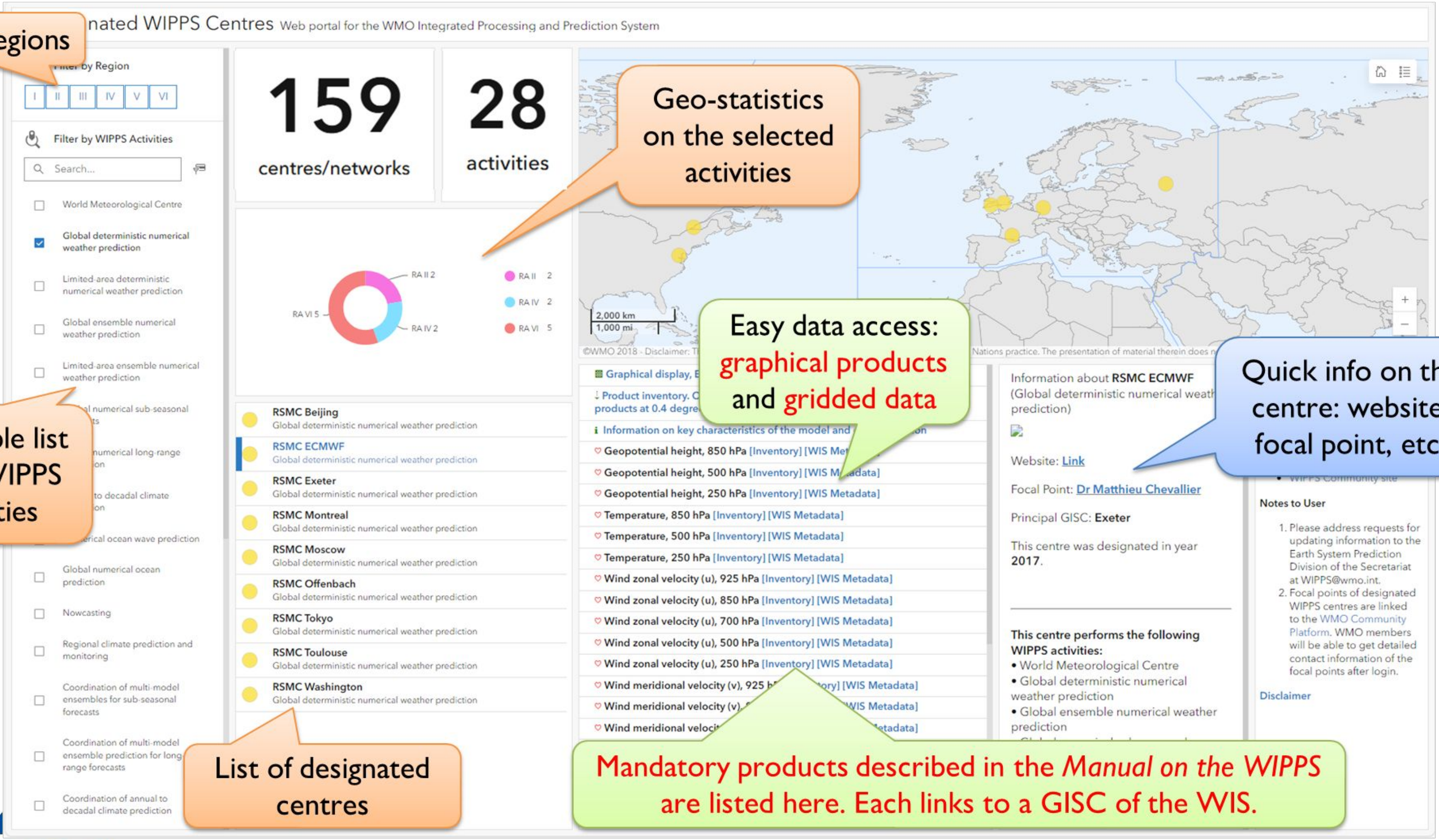
***2 Specialized activities***
to make forecasting products, which may include guidance based on human interpretation, tailored for a specific type of application or user community.

***3 Non-real-time activities*** mainly for verification

- WMO Secretary-General Professor Celeste Saulo has highlighted the urgent need to strengthen communication efforts and to ensure universal access to information for preparedness when facing extreme weather, climate and water events, especially for the most vulnerable.
- This will require making Earth system science user-friendly for experts and non-experts, a critical step towards effective climate action and ensuring that meteorological, climatological and hydrological services receive the political backing they deserve. **Artificial intelligence (AI) language models present a promising solution to these challenges.**
- Task Team on Artificial Intelligence for Weather (TT-AI4Wx)

# WIPPS Designated Centres (WIPPS DCs)

WIPPS Web Portal | World Meteorological Organization (wmo.int)



nated WIPPS Centres Web portal for the WMO Integrated Processing and Prediction System

Filter by Region

I II III IV V VI

Filter by WIPPS Activities

Search...

- ☐ World Meteorological Centre
- ☑ Global deterministic numerical weather prediction
- ☐ Limited-area deterministic numerical weather prediction
- ☐ Global ensemble numerical weather prediction
- ☐ Limited-area ensemble numerical weather prediction
- al numerical sub-seasonal ts
- numerical long-range on
- to decadal climate on
- rical ocean wave prediction
- ☐ Global numerical ocean prediction
- ☐ Nowcasting
- ☐ Regional climate prediction and monitoring
- ☐ Coordination of multi-model ensembles for sub-seasonal forecasts
- ☐ Coordination of multi-model ensemble prediction for long range forecasts
- ☐ Coordination of annual to decadal climate prediction

**159**

centres/networks

**28**

activities

**RSMC Beijing**
Global deterministic numerical weather prediction

**RSMC ECMWF**
Global deterministic numerical weather prediction

**RSMC Exeter**
Global deterministic numerical weather prediction

**RSMC Montreal**
Global deterministic numerical weather prediction

**RSMC Moscow**
Global deterministic numerical weather prediction

**RSMC Offenbach**
Global deterministic numerical weather prediction

**RSMC Tokyo**
Global deterministic numerical weather prediction

**RSMC Toulouse**
Global deterministic numerical weather prediction

**RSMC Washington**
Global deterministic numerical weather prediction

Graphical display, E

Product inventory. C products at 0.4 degre

Information on key characteristics of the model and on

- ♡ Geopotential height, 850 hPa [Inventory] [WIS Met
- ♡ Geopotential height, 500 hPa [Inventory] [WIS M adata]
- ♡ Geopotential height, 250 hPa [Inventory] [WIS Metadata]
- ♡ Temperature, 850 hPa [Inventory] [WIS Metadata]
- ♡ Temperature, 500 hPa [Inventory] [WIS Metadata]
- ♡ Temperature, 250 hPa [Inventory] [WIS Metadata]
- ♡ Wind zonal velocity (u), 925 hPa [Inventory] [WIS Metadata]
- ♡ Wind zonal velocity (u), 850 hPa [Inventory] [WIS Metadata]
- ♡ Wind zonal velocity (u), 700 hPa [Inventory] [WIS Metadata]
- ♡ Wind zonal velocity (u), 500 hPa [Inventory] [WIS Metadata]
- ♡ Wind zonal velocity (u), 250 hPa [Inventory] [WIS Metadata]
- ♡ Wind meridional velocity (v), 925 h ory] [WIS Metadata]
- ♡ Wind meridional velocity (v), WIS Metadata]
- ♡ Wind meridional veloci etadata]

Information about **RSMC ECMWF** (Global deterministic numerical weath prediction)

Website: Link

Focal Point: Dr Matthieu Chevallier

Principal GISC: **Exeter**

This centre was designated in year **2017**.

**This centre performs the following WIPPS activities:**

- World Meteorological Centre
- Global deterministic numerical weather prediction
- Global ensemble numerical weather prediction

Notes to User

1. Please address requests for updating information to the Earth System Prediction Division of the Secretariat at WIPPS@wmo.int.
2. Focal points of designated WIPPS centres are linked to the WMO Community Platform. WMO members will be able to get detailed contact information of the focal points after login.

Disclaimer

WMO Regions

Geo-statistics on the selected activities

Easy data access: graphical products and gridded data

Quick info on the centre: website, focal point, etc.

Selectable list of all WIPPS activities

List of designated centres

Mandatory products described in the *Manual on the WIPPS* are listed here. Each links to a GISC of the WIS.

WM

# Digital transformation of NMHSs

**Common Alert Protocol / Cap composer /**

**ClimWeb**

Built on top of Wagtail

User friendly website Content Management System

CAP Alerts Publishing

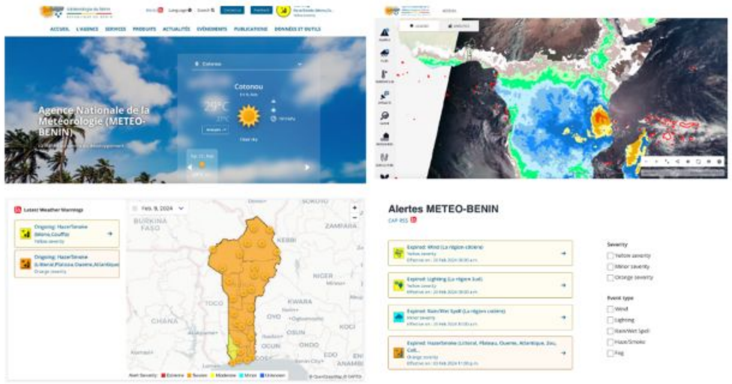
Interactive Georeferenced data visualisation

Events registrations and Integration with Online Meeting Platforms (Zoom)

Email Marketing integration

User Analytics

Survey creation and results analysis



Supporting seamless digital dissemination

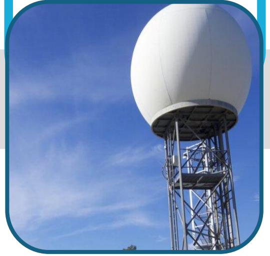
Increased products and warnings made available to the public and end users under various digital channels

WMO OMM

# What can WMO contribute to the AIM for Scale ?

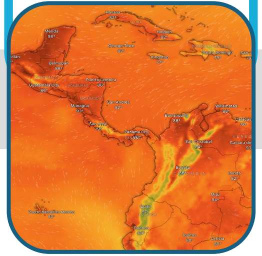
## Technical advisory and guidance

**Observations**



**Data exchange & modelling**

**Forecast products**



**Service provision**

**Decision support**

Research & Development, Standards, Capacity Dev, Education & Training, M&E

SUSTAINABLE DEVELOPMENT GOALS

UNITED NATIONS PARIS CLIMATE AGREEMENT SIGNING CEREMONY 22 APRIL 2016

SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030

> **More** and **better data**
> leads to **better weather forecasts**
> and **climate information**
> **services** for **agriculture**

Celeste Saulo
WMO Secretary-General

# Thank you.

MAY 29-31
AIM for Scale Weather
Partnership Convening

AIM FOR SCALE

WEATHER PACKAGE

# Key Takeaways and Next Steps