AI-based rainfall forecasts for Early Warnings over the Greater Horn of Africa

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Resilience to Natural Hazards through AI solutions,
Session 2: AI models, methods and added value for tracking and forecasting | 08.05.2025

Objectives

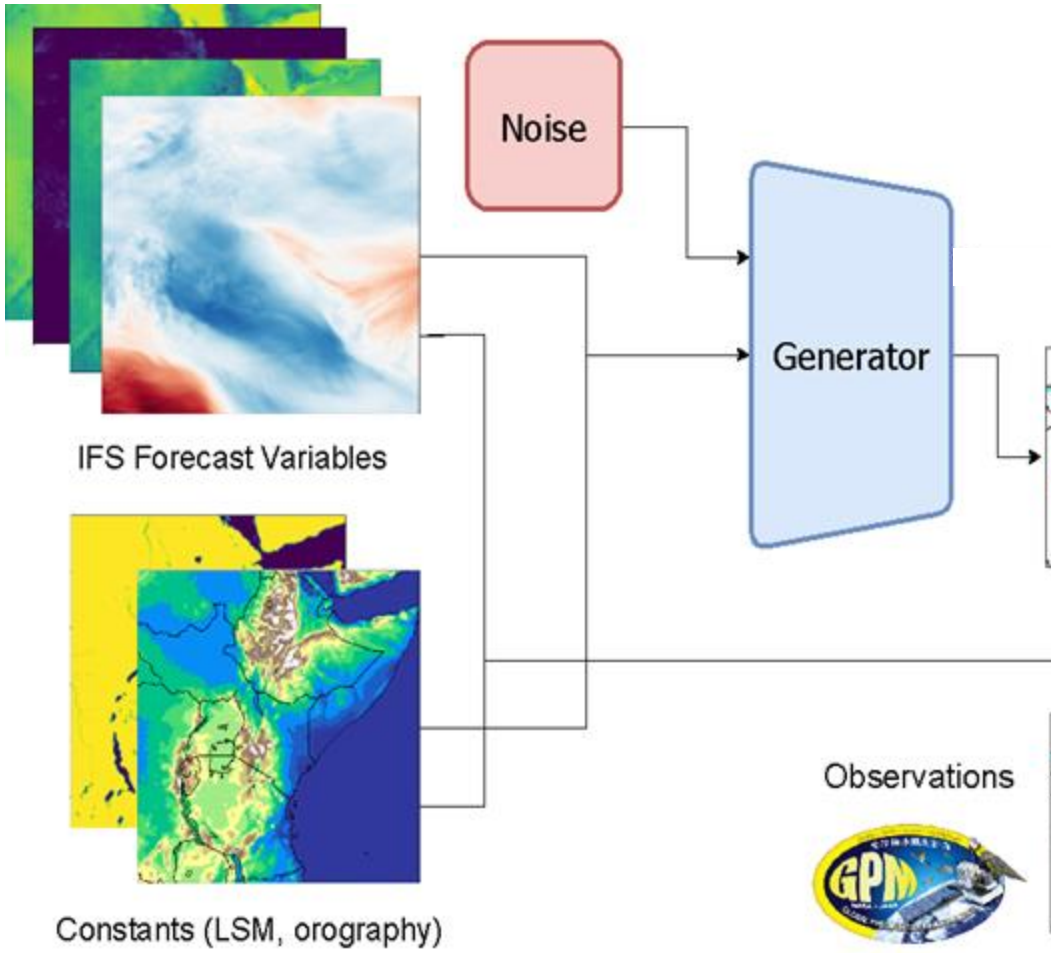
Exploring the **potential of cloud-optimized AI** based approaches to improve accuracy of **operational rainfall forecasts** and provide better **early warnings** over the **Greater Horn of Africa**

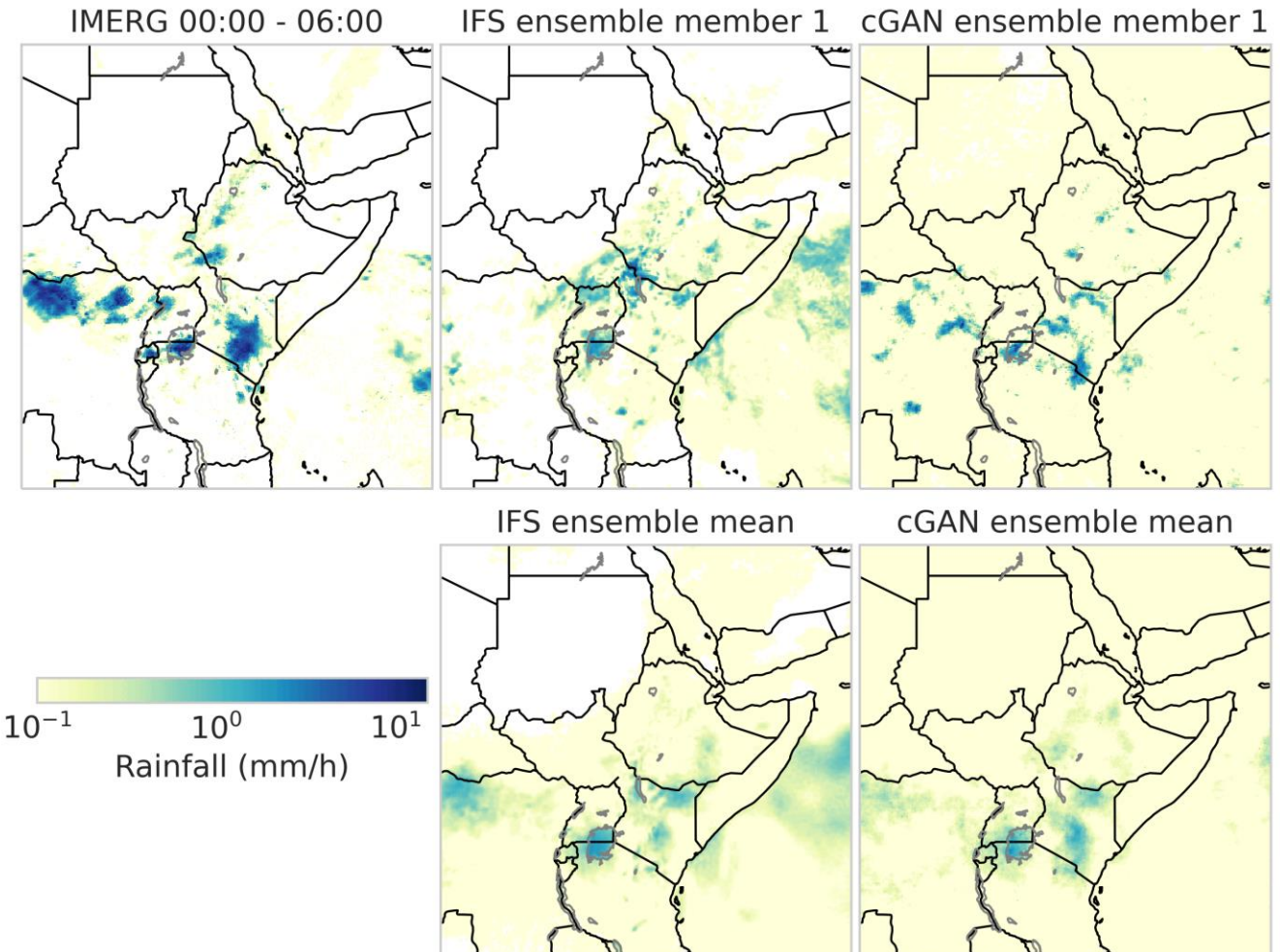
Low-cost forecast generation

Minimal infrastructure and data download

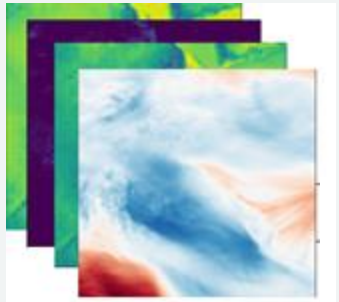
Mainly talk about journey towards evaluating **value added**

Current model set-up

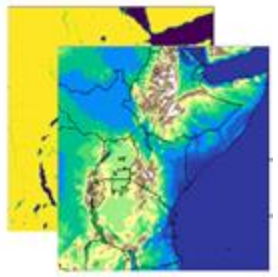




End-to-end early warning generation



IFS Forecast Variables



Constants (LSM, orography)

AI-model

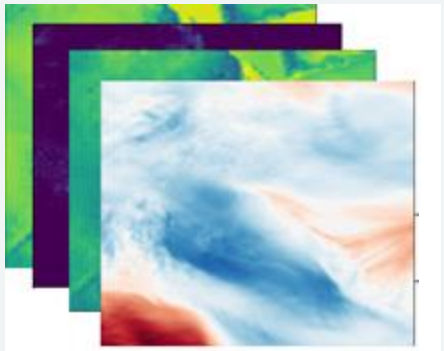
Warning Production

We still need to communicate probability as a **yes/no** for user-defined **rainfall levels**

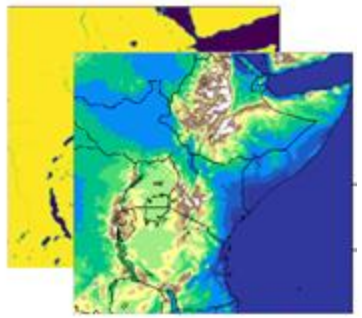
Triggering

Weigh **cost of action vs inaction,** for no-regret AA

Taking a step back



IFS Forecast Variables



Constants (LSM, orography)

cGAN

Criteria for method:

- Retains **latent representation of underlying distribution**
- Calibrated on scores **that cannot be hedged** (proper scores)
- Allows easy scanning of the economic value added under **different cost-loss ratios**

Additional task-specific **distillation step** for user-defined thresholds

Jack of all thresholds: Brier score optimized over **continuum of thresholds**

Master of a few

Cost-loss ratios?

	Event doesn't happen	Event happens
No preparation made	0	L
Preparation made	C	C

Economic value of:

- Our forecast:

$$E = (TP + FP) \cdot C + FN \cdot \mathrm{L}$$

- The default i.e. best out of always or never acting

$$\mathrm{E}_{clim} = \min\{(TP + FN) \cdot L, C\}$$

- A perfect forecast:

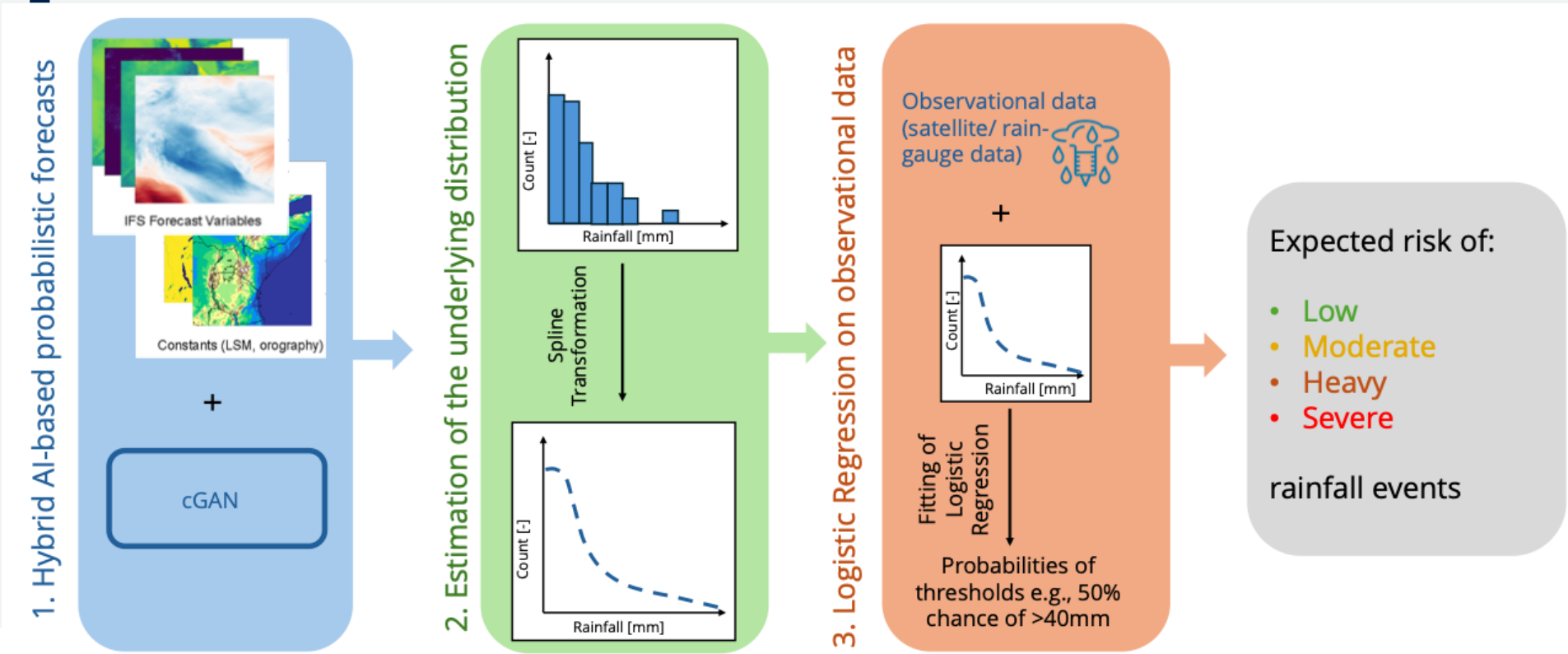
$$E_{perfect} = (TP + FN) \cdot C$$

At each C/L ratio, the relative economic value can be quantified:

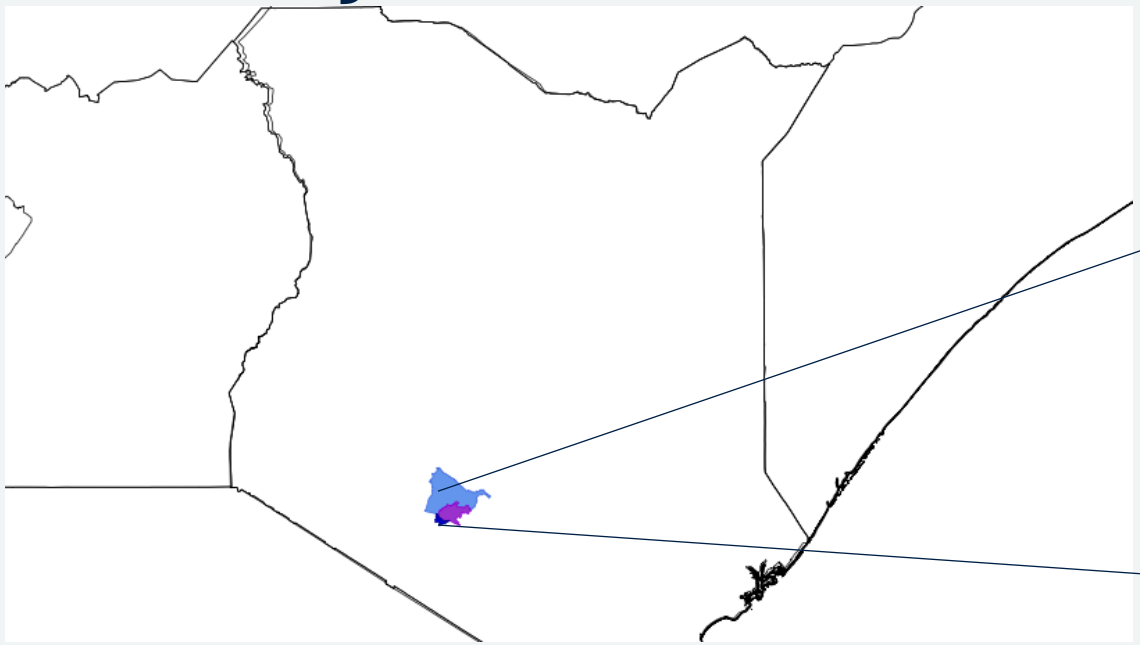
$$REV\left(\frac{C}{L}\right) = \frac{E_{clim} - E}{E_{clim} - E_{perfect}}$$

→ Well-calibrated p means we can set p=c/L!

Proposed framework



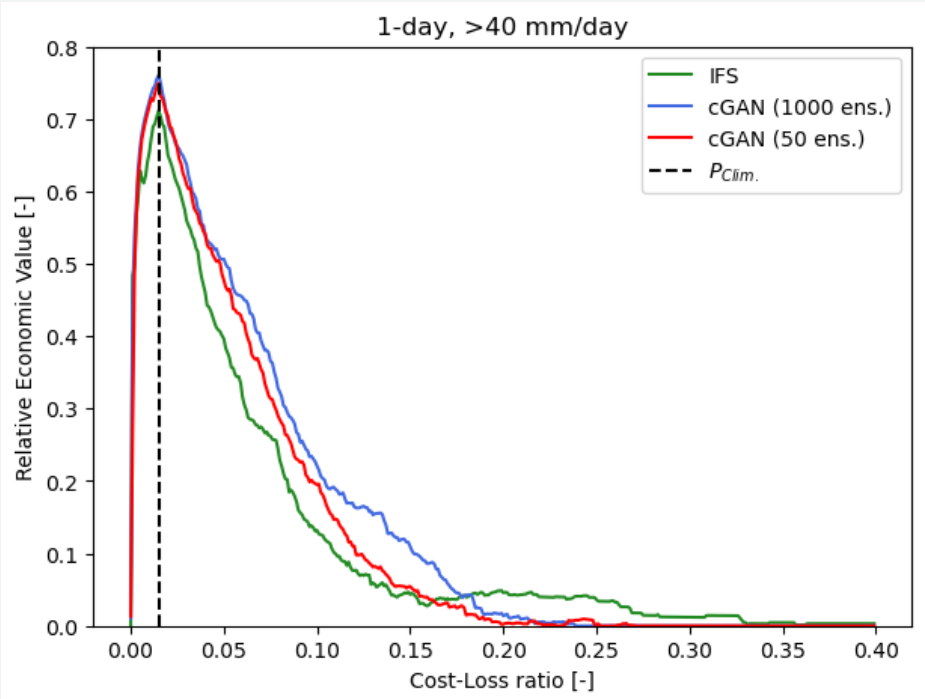
Case study

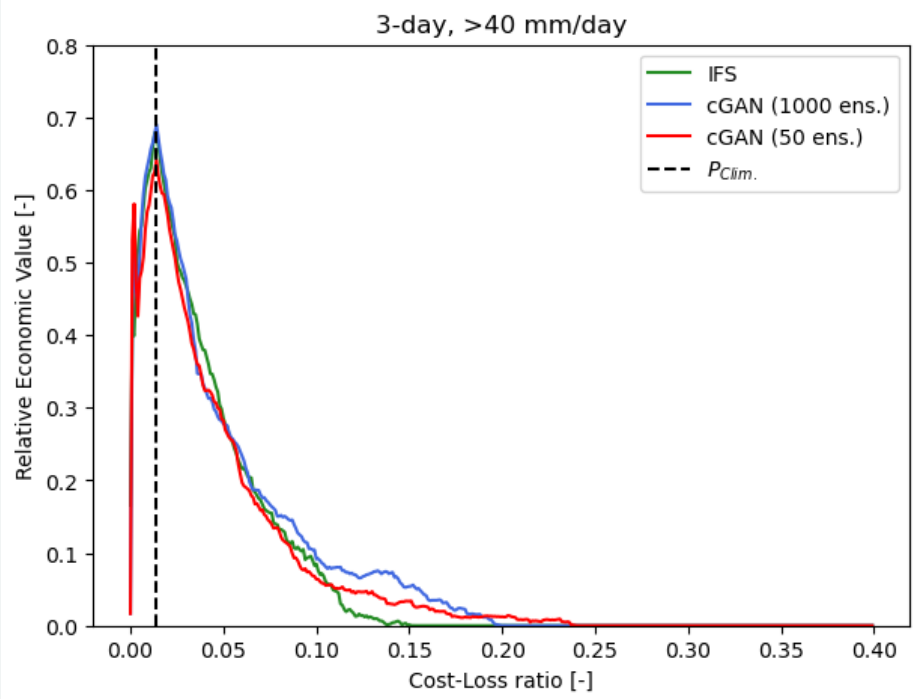


- Event: >40 mm/day
- Test period of focus: 2021,2023,2024

Urban flooding, personal camera, 22.04.2024

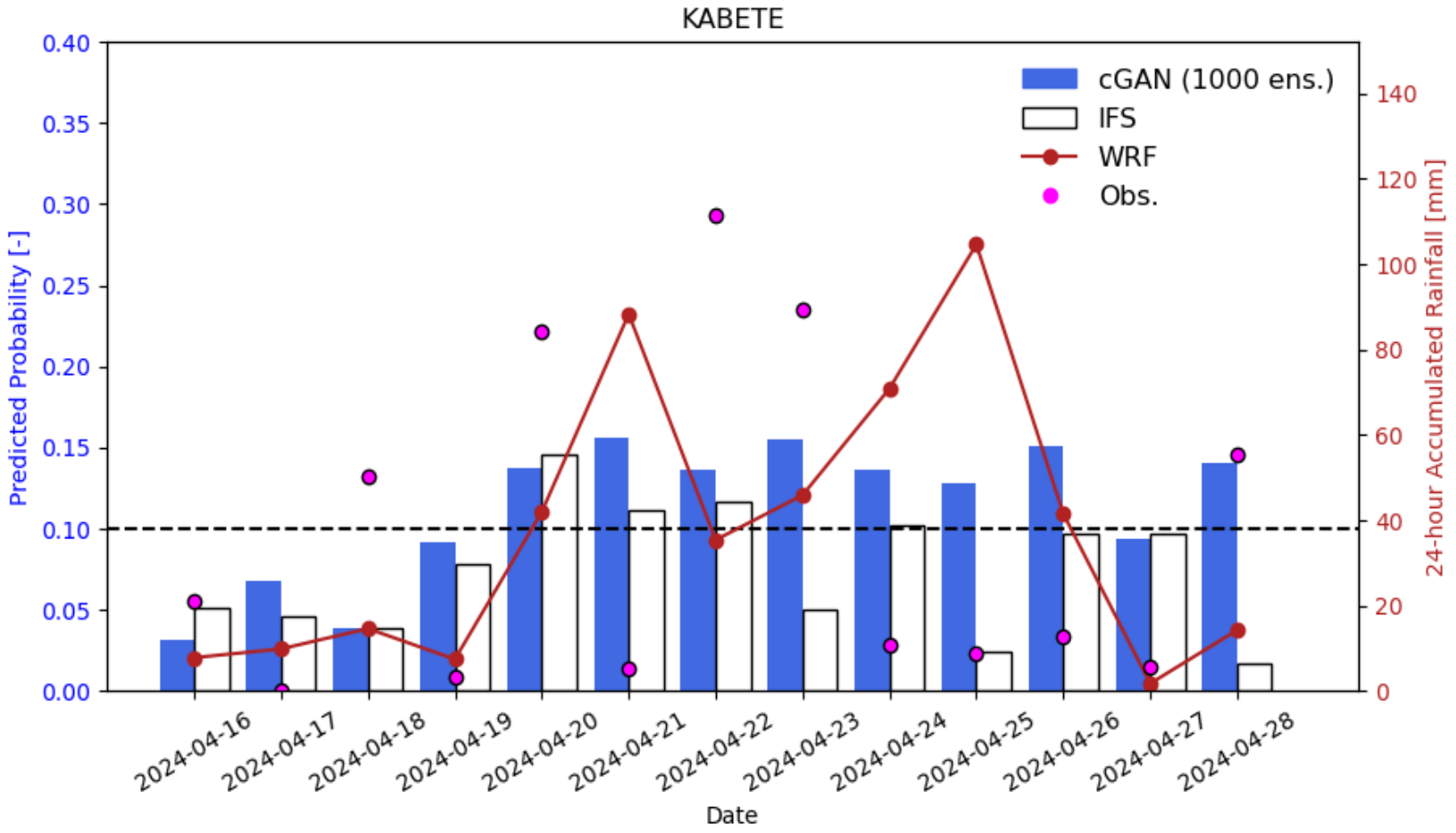
Economic value of forecast probabilities obtained





Calibration on individual rain gauge data

- cGAN is **betting on wetter periods**
- IFS tries to give more **precise probabilities**
- WRF also shows **elevated rainfall** over period
- Precisely pinpointing exact time of heavy rain may be tricky for convective active periods → **probabilities are important**!



Summary

- Operational value of probabilistic (AI) forecasts demonstrated by translation to “yes/no triggers” based on **event-specific probability thresholds** chosen via **cost-loss frameworks**

- Going from probabilistic forecasts to triggers requires **mapping** from the **true underlying distribution** to **well-calibrated probabilities** of threshold exceedance

- AI-generated, low-cost large ensembles can provide **better calibrated probabilities**

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