




## Module 2: Climate Modelling and Extreme Events Prediction

- Using AI/ML for climate simulations, trend detection
- Predicting floods, wildfires, heatwaves
- Datasets and challenges (e.g., low resolution, uncertainty)
- Use of deep learning models (CNNs, RNNs) in time-series forecasting
-  Mini-case study: AI predicting cyclone intensity or droughts

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Mission 4 "Education and Research" - Component 2: "From research to business" - Investment  
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



## Introduction & Importance

- 🌐 Climate change: urgency of better forecasting
- 🌐 Traditional climate models: strengths and gaps
- 🌐 Where AI/ML fits in

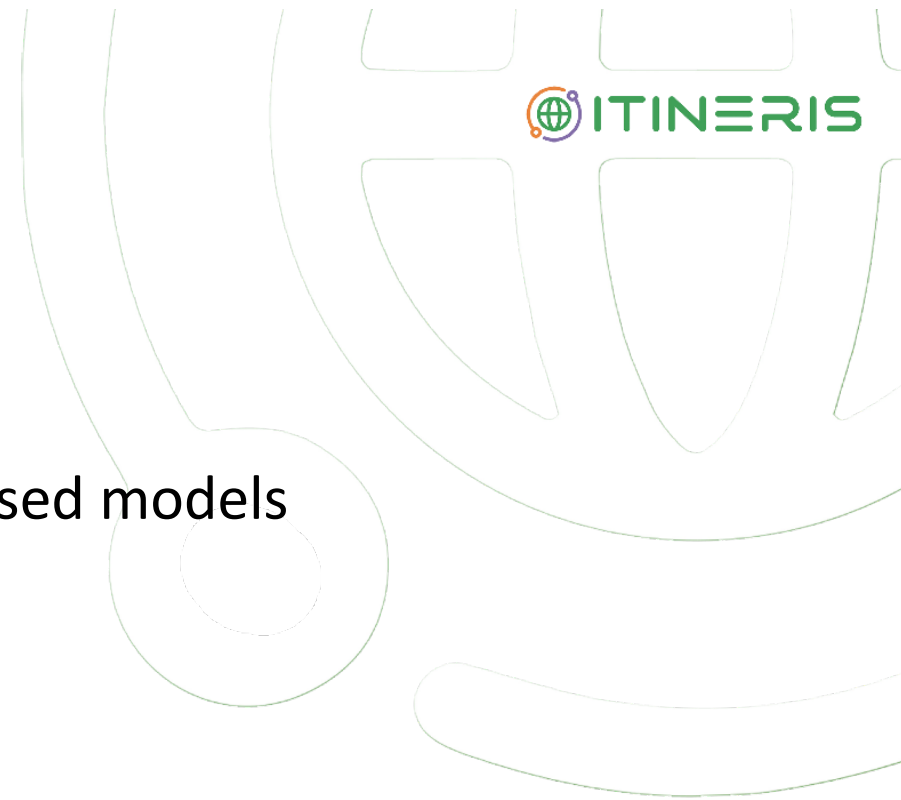


# From Simulations to Predictions

## Definitions:

- Climate simulation (long-term)
- Weather prediction (short-term)

## AI/ML as complementary tools to physics-based models



## Detecting Trends & Anomalies




- 🌐 Long-term climate trend detection using ML
- 🌐 AI in analyzing temperature, sea level, CO<sub>2</sub> data
- 🌐 Time-series insights beyond human capability



## Predicting Extreme Events

- 🌐 AI for early warning: floods, wildfires, heatwaves
- 🌐 Need for high spatial/temporal precision
- 🌐 Role of supervised learning, ensemble methods

## Mini-Case Study – Cyclone Intensity & Drought Prediction

-  Use of deep learning (e.g., RNNs, LSTMs) to model cyclone paths & intensities
-  Satellite data + historical events
-  Drought classification using CNNs with soil moisture and precipitation maps

# Climate Datasets & Their Challenges

🌐 Common datasets: ERA5, MODIS, CMIP6, NASA POWER

🌐 Issues:

- Low spatial resolution
- Incomplete records
- Noise & uncertainty

🌐 Need for data harmonization

# Climate Datasets

## CHELSA (Climatologies at High Resolution for the Earth's Land Surface Areas)

- What it is: High-resolution (30 arc-seconds) climate data based on statistical downscaling of reanalysis data.
- Includes: Historical and future climate scenarios (CMIP5/CMIP6).
- Great for: Mountainous regions and biodiversity applications.

## NASA POWER

- What it is: Daily weather and solar data from satellite and modeled sources.
- Tools: Download via API or web GUI.
- Variables: Temperature, humidity, wind speed, solar radiation

## Copernicus Climate Data Store (CDS)

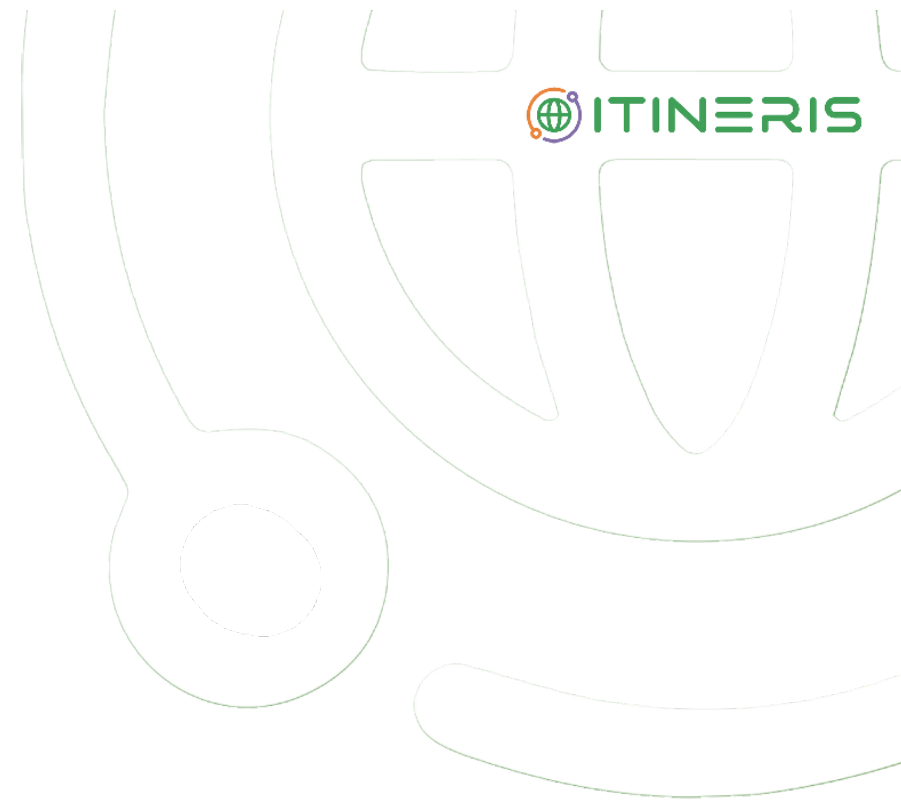
- What it is: Comprehensive data from ECMWF (European Centre for Medium-Range Weather Forecasts).
- Includes: ERA5 reanalysis, seasonal forecasts, and more.
- ERA5: Global climate reanalysis at ~30 km resolution, hourly data available.

## Deep Learning for Time-Series Forecasting

- 🌐 Recurrent Neural Networks (RNNs), LSTMs for sequential climate signals
- 🌐 CNNs for gridded atmospheric/satellite imagery
- 🌐 Example: Rainfall prediction using ConvLSTM

## AI + Physics = Hybrid Climate Models

- 🌐 Physics-informed neural networks (PINNs)
- 🌐 Learning residuals of physics-based models
- 🌐 Better generalization & interpretability



## Tools & Platforms

- 🌐 Tools: TensorFlow, PyTorch, xarray, ClimateLearn
- 🌐 Google Earth Engine, Copernicus Climate Data Store
- 🌐 Access to HPC + cloud resources for training models

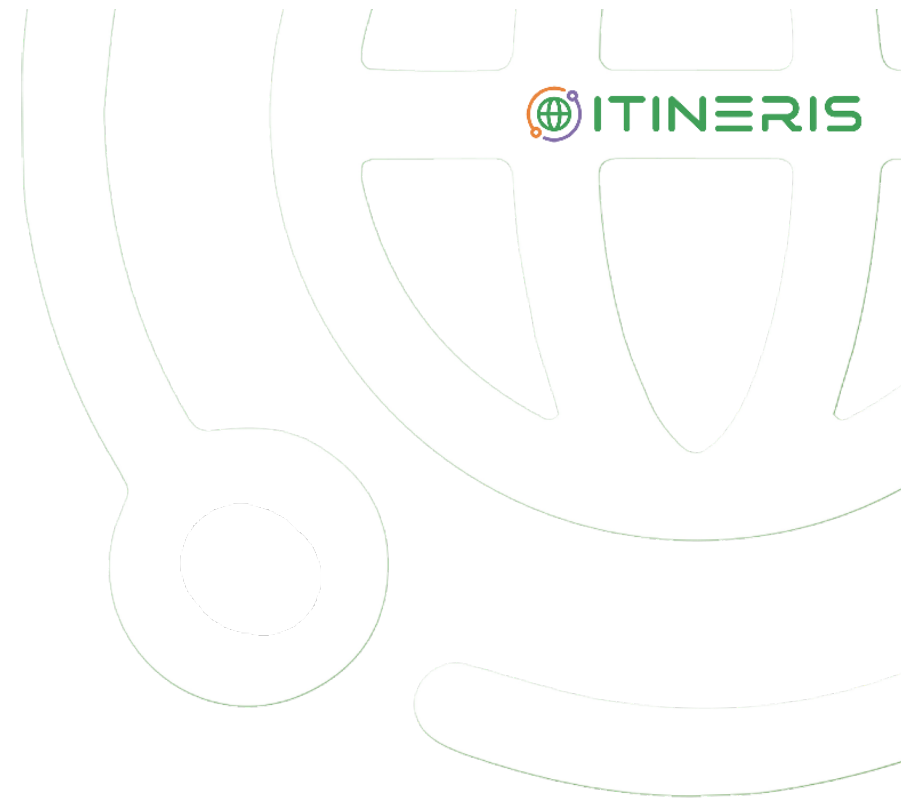
## Open Projects & Benchmarks

- 🌐 ClimateBench: ML benchmark dataset for climate variables
- 🌐 AI for Earth, DeepMind's GraphCast
- 🌐 ECMWF + NVIDIA AI models



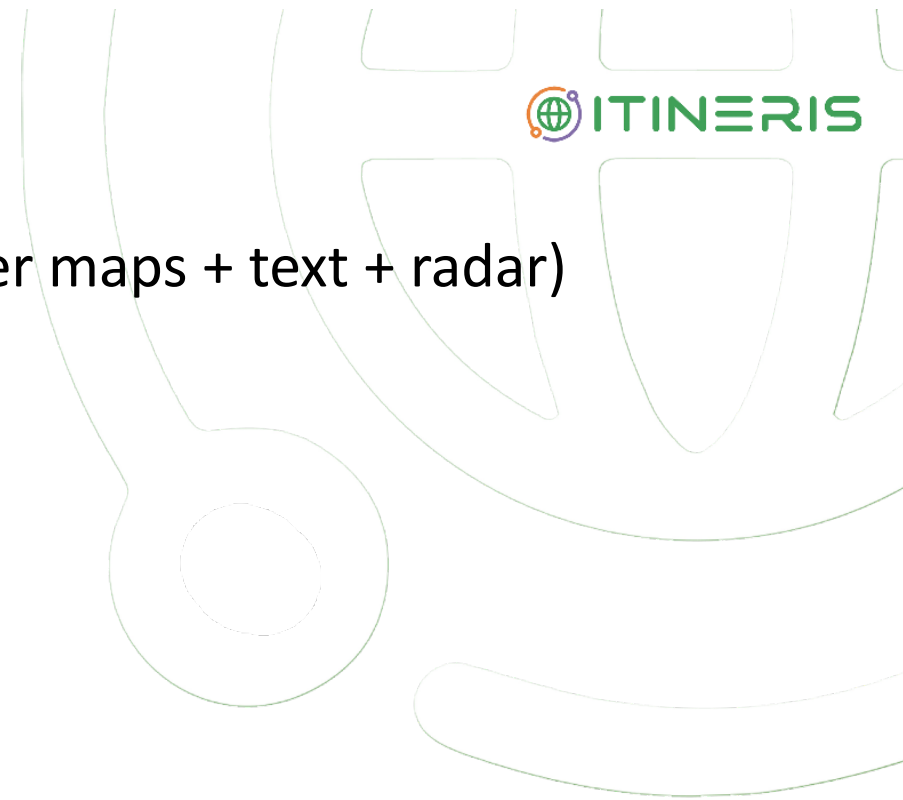
## Challenges & Ethical Considerations

- 🌐 Data bias, overfitting in ML models
- 🌐 Black-box risks in high-stakes decisions
- 🌐 Fair access to AI tools for global south



## Future Directions

- 🌐 Multimodal learning (e.g., combining weather maps + text + radar)
- 🌐 Transfer learning across regions
- 🌐 Citizen AI for community-based forecasting



## Key Takeaways

- 🌐 AI accelerates insights from complex climate data
- 🌐 Not a replacement, but a powerful ally to traditional models
- 🌐 Open collaboration is key to progress



## Q&A / Discussion

### Invite questions

- Prompt: “What’s a climate application in your region that could benefit from AI?”

