Meteorological Forum of 2025 World Artificial Intelligence Conference:
AI powered Meteorology for Early Warnings for All

Planning for the Use of AI in Enhancing Meteorological Warnings in Brazil
Agency: National Institute of Meteorology
Brazil/Brasil-巴西 (Bāxī)

Hello! I'm Tatyane Paz Dominguez
I'm a Meteorologist, and:

- Technologist of Science and Technology at **INMET**
- MSc in Meteorology (**University of São Paulo**)
- Currently Phd candidate at Meteorology program of the **University of São Paulo**
- Research in nonlinear analysis of Madden-Julian Oscillation (**MJO**).

你好！我是塔蒂雅妮·帕兹·多明格斯。
我是气象学家:

- **巴西国家气象研究所的科技技**术员
- **圣保**罗大学气象学硕士
- 现为气象学博士候选人。
- **我的研究方向是**马登-**朱利安振**荡**的非**线性分析。

Planning for the Use of AI in Enhancing Meteorological Warnings in Brazil

WAIC 2025

Shanghai – China – july 2025

Motivation

Why Consider AI in Meteorological Warnings?

- Growing demand for more accurate and localized warnings
- Massive volume of data generated by meteorological models
  - These outputs carry unpredictability and errors, especially as the forecast horizon increases
- Need for faster responses in risk areas and for vulnerable populations
- **AI** has potential to assist in targeted corrections

🎯 Objectives

Present the planning and potential of using AI to improve and increase the efficiency of warning mechanisms in Brazil, highlighting:

- Operational tools currently used by INMET
- Integration with CENAD (National Center for Risk and Disaster Management) and Civil Defense agencies
- Possible applications of **AI** in the **warning systems**

What's INMET?

National Institute of Meteorology:

Founded in Brazil in 1909, it is an agency under the Ministry of Agriculture and Livestock.

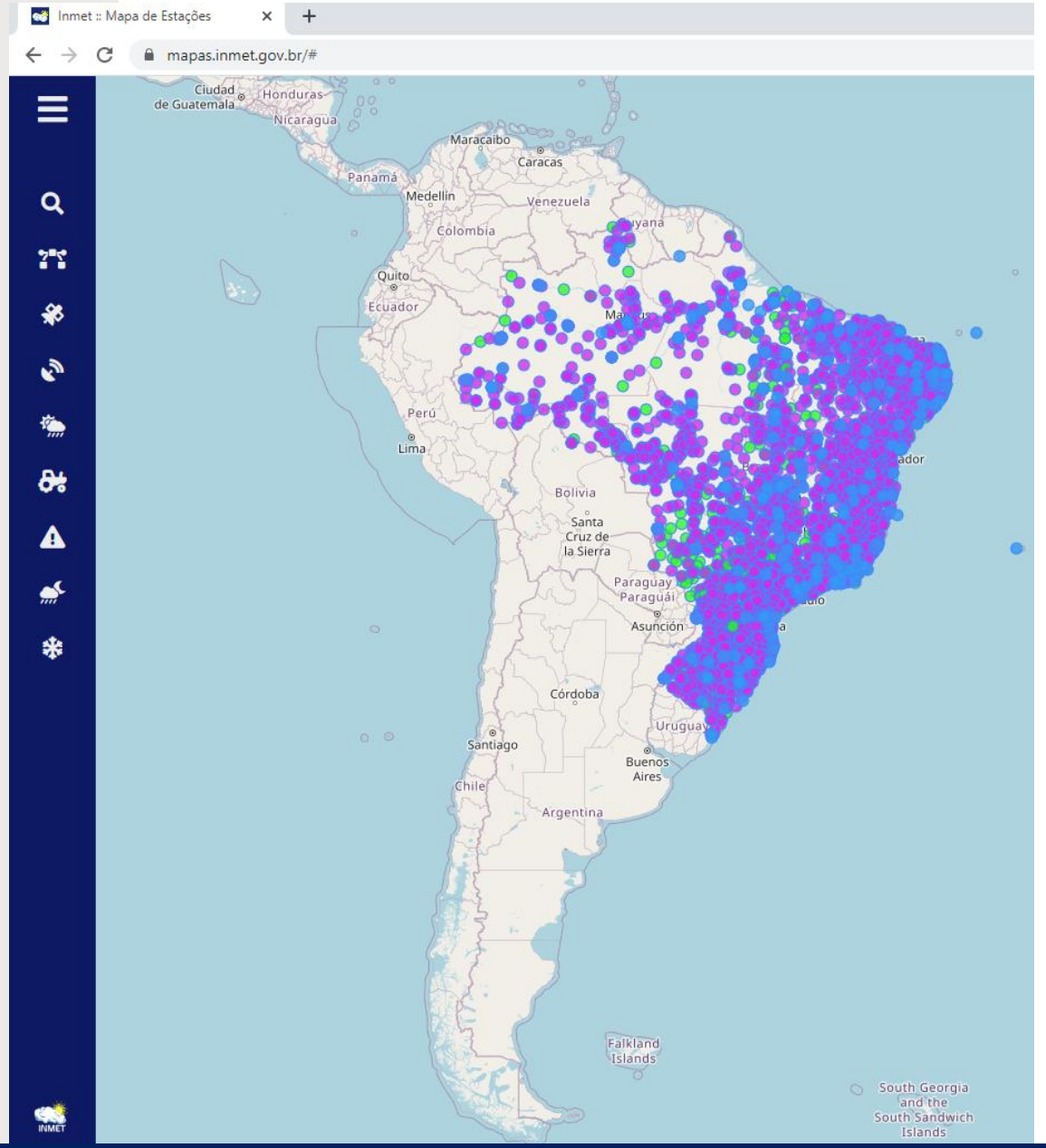
It is the official representative of Brazil at the World Meteorological Organization (WMO).

Responsible for weather monitoring, forecasting, climate prediction, and the issuance of meteorological warnings.

• Works in partnership with CENAD/Civil Defense for meteorological warnings.

Overview of the Observation Network

- 212.6 million
- Country area 8.516.00 Km²
  - W-E: ~ 4.300 km
  - N-S: ~ 4.400 km
- 27 states, 5.570 municipalities
- 560 automatic weather stations
  - In operation since 2001
- 127 conventional stations
  - In operation since 1909



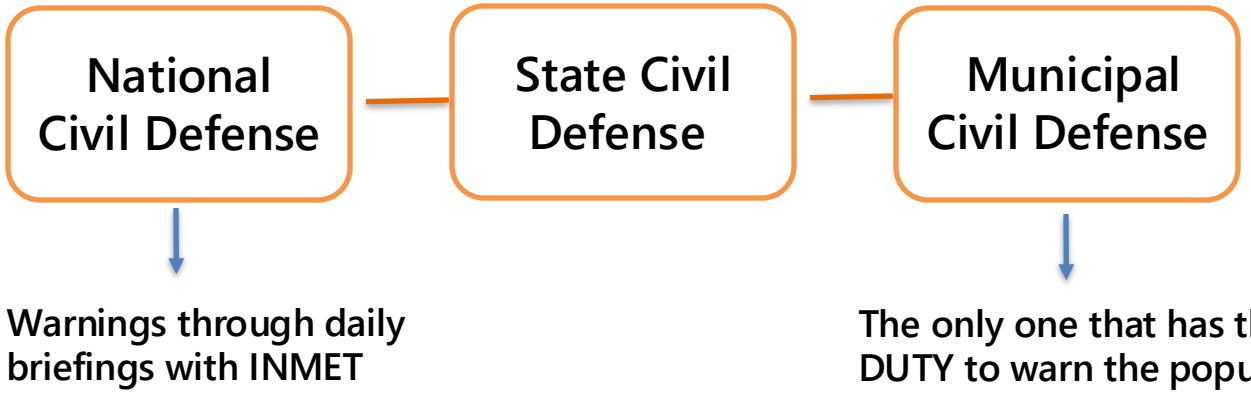
Issuance of Warnings – Procedures

Support for decision-making by emergency, health, and safety agencies

- **Daily synoptic analysis** by INMET meteorologists
  - Integration with numerical weather prediction models

- Warning coverage area defined via PREVMET (an internal system that operationalizes multiple tools)
- Daily briefing meetings with CENAD
- Civil Defense: alerts issued using the **CAP** format (Common Alerting Protocol), with support from CENAD
  - International protocol that encapsulates all types of alerts (including disaster-related messages)

INMET's Role in the Warning System



- Separate warnings for each day
  (with publication date and the end date – validity)
- Warning types translated into colors by degree or severity
- Visual spacial translation

Warning Classification System: Severity Levels

Based on the intensity and the temporal persistence of each event.

POTENTIAL DANGER

DANGER

GREAT DANGER

Where Does AI Fit into the Process?

AI as a Post-Processing Correction Tool

Given that warnings are a product derived from the analysis of model outputs:

- Correction of ICON model outputs
- Use of machine learning techniques to adjust raw forecasts
- Supervised learning based on observational data from INMET's weather station network.

ICON model

Non-hydrostatic model with **icosahedral** grid

- ICON (ICOsahedral Nonhydrostatic) gets its name from its icosahedron-based grid structure and its non-hidrostatic formulation.

Developed by DWD (Germany) and MPI-M, with partners such as DKRZ, KIT and C2SM.

- **(DWD) Deutscher Wetterdienst**
- **(MPI-M) The Max Planck Institute for Meteorology;**
- **(DKRZ) Deutsches Klimarechenzentrum;**
- **(KIT) Karlsruhe Institute of Technology;**
- **(C2SM) The Center for Climate systems Modeling.**

- It is applicable to weather, climate, and environmental forecasting.
- Internationally recognized, with both operational and scientific use
- Designed for **high performance**, **scalability**, and **refined mesh** capabilities.

ICON model

Why is ICON Strategic for INMET?

- **Scalable down to 1 km** or finer — ideal for high-risk areas and nowcasting
- Allows static grid refinement up to the mesosphere
- Better conservation of physical properties compared to previous global models
- **High parallelization potential**, compatible with modern architectures (GPU/CPU)
- Supports innovation in national climate and weather services
- Enables integration with a wide range of **external libraries**, including GRIB, NetCDF, CDI, and ECMWF's ecCodes

Planned Implementation

- 7 km resolution over South America
- Nested grid with 2.8 km resolution over Brazil
- 1 km resolution in areas selected for nowcasting

Priority Areas of BR for AI Application (in enhancing nowcasting)

Where to start: Regions of interest for Nowcasting

- 1 km resolution is planned for:
  - Areas with potential **loss of life**
  - Regions with **vulnerable populations,** more **susceptible to disasters**
  - Significant economic damage zones
  - Precision agriculture regions
  - **Densely populated** urban areas
- Preliminary tests are planned for agricultural regions

Technical and Operational Challenges

Obstacles to Implementation

- Lack of **GPUs** to run the model with the desired performance
- Limited computational resources for data storage
- Dependence on CPUs, which restricts processing volume and speed

Experience with Preliminary Tests

Initial processing tests with international support

- In 2023, ICON test run using 16 Grace Hopper GPUs (NVIDIA)
  - Tests conducted by MeteoSwiss (Federal Office of Meteorology of Switzerland)

- We provided boundary conditions, nested areas, and forecast timeframes for each resolution (7 km, 2.8 km, and 1 km)
- Runtime: **1h40** for a **7-day forecast**
- New test runs are being planned with loaned hardware
- Objective: certify performance, although we still lack our own infrastructure

Next Steps
(and expected learnings)

Future Work and opportunities for advancement:

- Gather insights from this event (WAIC 2025) and establish collaborations
- Seek funding and GPU infrastructure
- Define predictor variables using robust methods, such as:
  - Principal Component Analysis (PCA)
  - Automatic selection via regularized regression (LASSO, Ridge)
  - Random Forests for variable importance analysis
- Develop greater autonomy in pre-processing and data analysis

Final considerations

INMET reaffirms its commitment to Science and to society.

We remain available for any questions or collaborations.
Special thanks to **CMA**, **SMS**, and the **WMO**.

Obrigada a todos!

感谢大家! Gǎnxiè dàjiā!

Thank you!

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