The future of weather models

AI, physics and the road ahead

February 2025

Karolina Stanisławska

BELGINGUR

aiweatherhub.substack.com

AI-based

ML-based

data-driven

MLWP

NWP	AI
✅ *physics-based* ✅ *interpretable* ✅ *trusted* 📉 *expensive* 📉 *imperfect approximations*	✅ *automatically learns patterns* ✅ *faster inference* ✅ *cost-efficient* 📉 *black-box models* 📉 *lacks physical constraints*

HOW AI AND NWP CAN WORK TOGETHER

Improved training data

High-resolution reanalyses to train models

Physics-informed AI

ML models trained with physical constraints

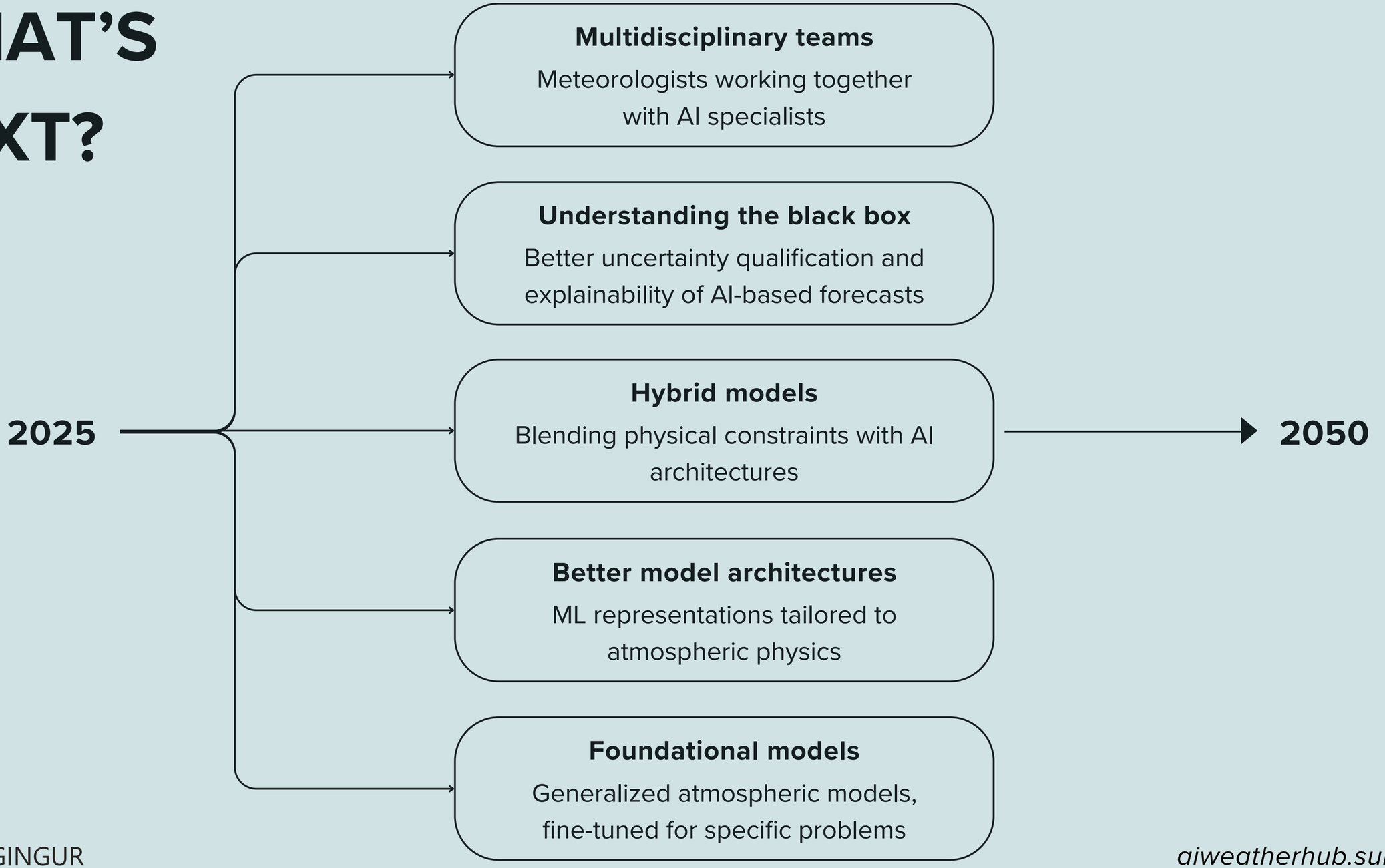
Downscaling

AI models to downscale “first guess” from low resolution NWP

AI-based parametrizations

Mix the NWP model with AI-models for processes difficult to capture

WHAT'S NEXT?


2025
Multidisciplinary teams
Meteorologists working together with AI specialists
Understanding the black box
Better uncertainty qualification and explainability of AI-based forecasts
Hybrid models
Blending physical constraints with AI architectures
Better model architectures
ML representations tailored to atmospheric physics
Foundational models
Generalized atmospheric models, fine-tuned for specific problems
2050

AI MODELS WILL CONTINUE TO IMPROVE

ATMOSPHERIC MODELLING WILL REQUIRE ML SKILLS

WE WILL GET BETTER FORECASTS