GenAI for Weather Prediction

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You Should Care!

The implications extend beyond improving predictions of New Haven snowfall.

Weather disasters: 10,000 people die each year from hurricanes and tropical storms

Farming = weather prediction: 10% of global population is food-insecure

Power grids require forecasting: Weather alters both demand and supply

Evolution of Weather Models

Numerical physics models

Computers solve systems of scientific equations

Derivative form of simplified moisture equation

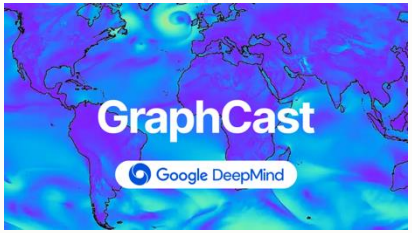
$$\frac{\partial q}{\partial t} = -\bar{U}\,\frac{\partial q}{\partial x}$$

Finite difference form of simplified moisture equation

$$\frac{\left(q^{t+1} - q^{t}\right)_{x,y}}{\Delta t} = -\bar{U}\,\frac{q^{t}_{x+1,y} - q^{t}_{x-1,y}}{2\Delta x}$$

End-to-end GenAI models

Graph neural networks (GNNs) applied iteratively



GraphCast (Google Deepmind)

Graph Neural Network (GNN): input is spatially-tagged snapshot of global atmosphere (temperature, wind, pressure, humidity, etc), **output** is prediction of atmospheric snapshot one period (e.g. 6 hours) later

Autoregressive: To predict 6 periods from now, start with next period and **extrapolate out** (*surprising finding: errors do not explode*)

Training data: Decades of weather patterns, for learning to **predict next period**

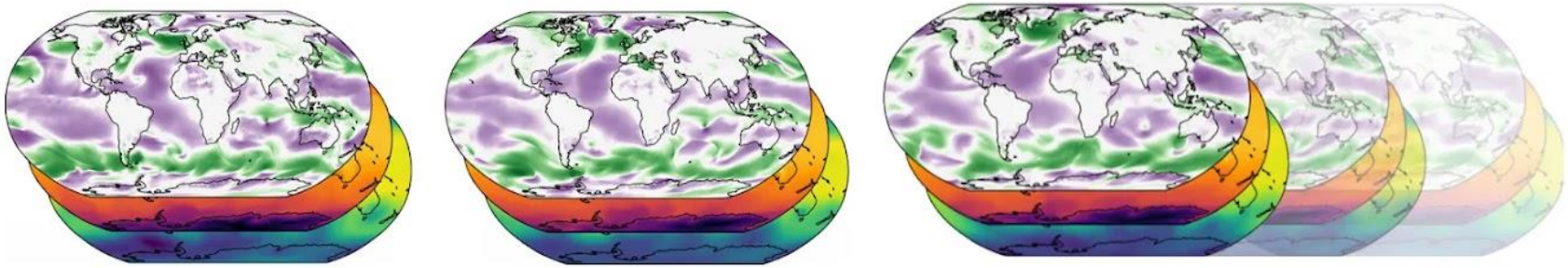
Key advantages: Cheaper + faster to compute than solving huge equation systems so can **update** more frequently; **very accurate** especially in 3-10 day range

Cons: Climate changing; not guaranteed to match laws of physics, lose interpretability

a) Input weather state

b) Predict the next state

c) Roll out a forecast



"Making 10-day forecasts with GraphCast takes **less than a minute** on a **single Google TPU v4 machine**. For comparison, a 10-day forecast using a conventional approach…can take **hours** of computation in a **supercomputer** with hundreds of machines."

"When we limited the evaluation to the … region of the atmosphere **nearest to Earth's surface** where accurate forecasting is most important, our model outperformed HRES on **99.7%** of the test variables."

Open Questions

1. What happens as **climate change worsens**?
2. Is the optimal approach actually an AI + physics model mixture via a **hybrid model**?
3. What **metric** matters? Raw accuracy? Ability to detect crisis events? Avoiding false alarms?
4. Should this technology be **open-source** or **proprietary?**