



# Trustworthy Artificial Intelligence for Weather



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# NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography (AI2ES)



AI2ES is developing *novel, physically based* AI techniques that are demonstrated to be *trustworthy*, and will directly improve *prediction, understanding, and communication* of high-impact weather and climate hazards, improving climate resiliency.



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# Brightband Mission

Make AI weather forecasting tools available to all, to help humanity adapt to increasingly extreme weather



Building an end-to-end probabilistic forecasting system

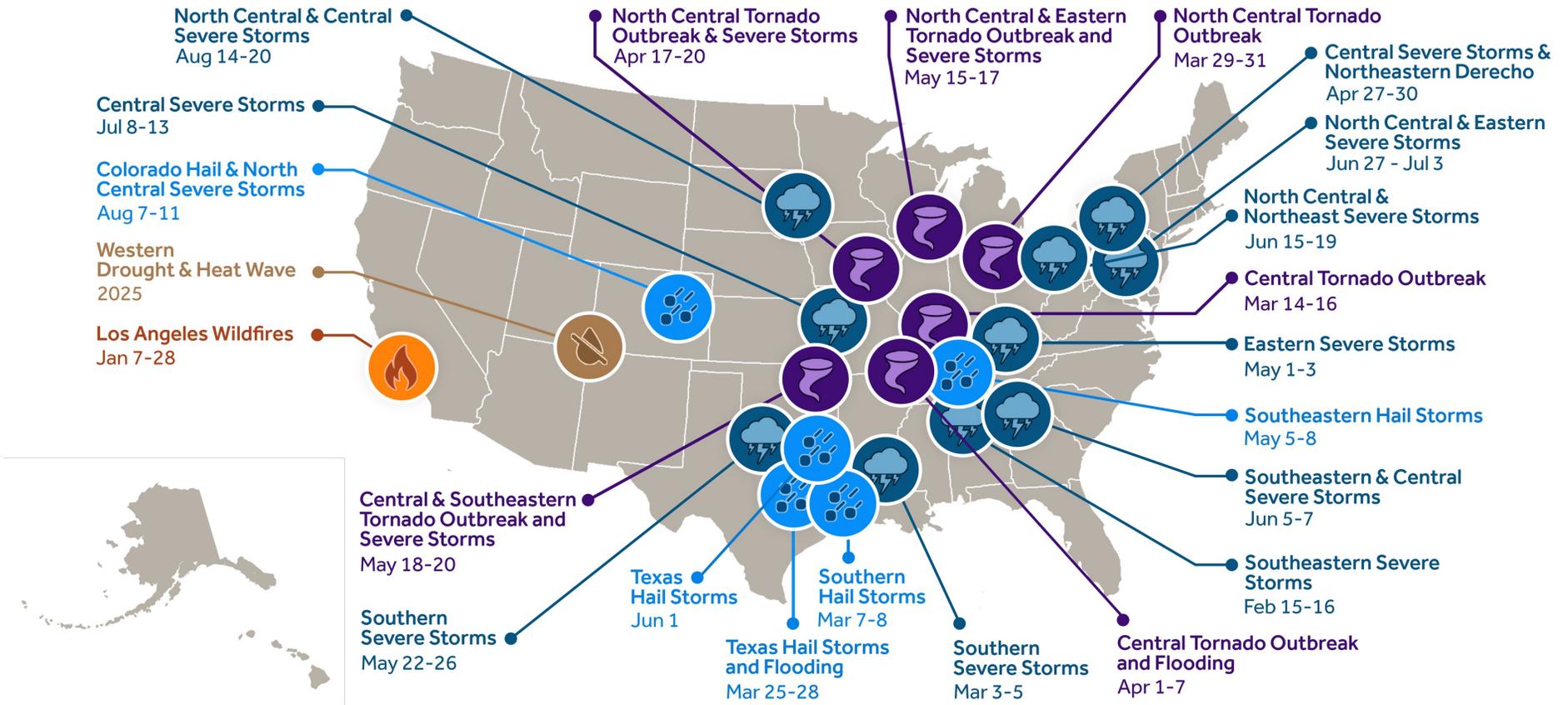


Open-sourcing benchmark datasets, models and metrics to spur innovation in AI weather forecasting



Providing AI weather forecasting tools to all

# U.S. 2025 Billion-Dollar Weather & Climate Disasters



This map shows the approximate location for each of the 23 separate billion-dollar weather and climate disasters that impacted the United States from January-December of 2025.



# Trustworthy Artificial Intelligence

- Artificial Intelligence (AI) encompasses automated methods to synthesize large amounts of data to improve decision making
- Trustworthy AI provides timely, reliable, and actionable information to decision makers

**Example:** AI can provide advance warning on droughts to enable farmers to prepare and save crops and livestock

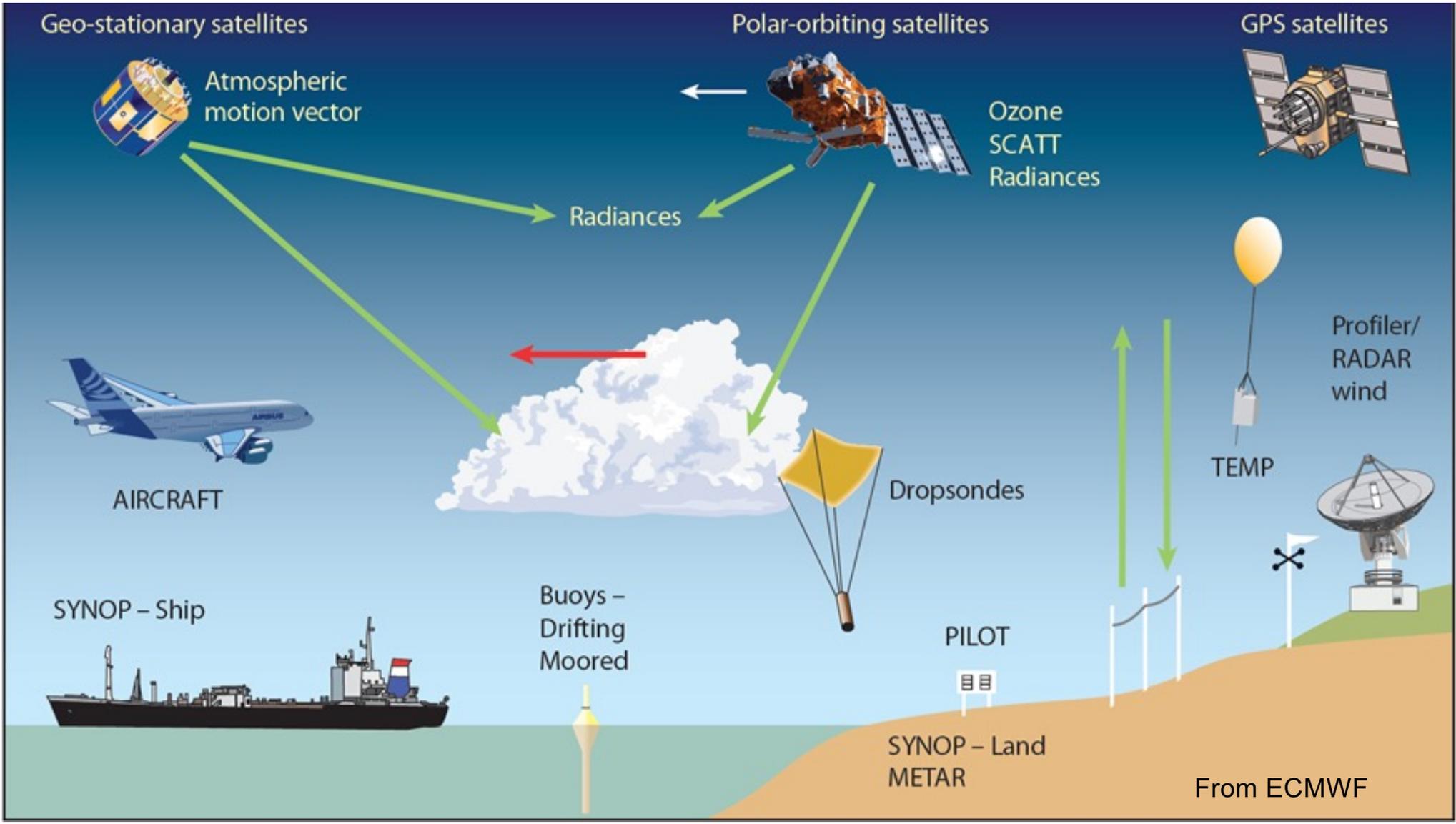


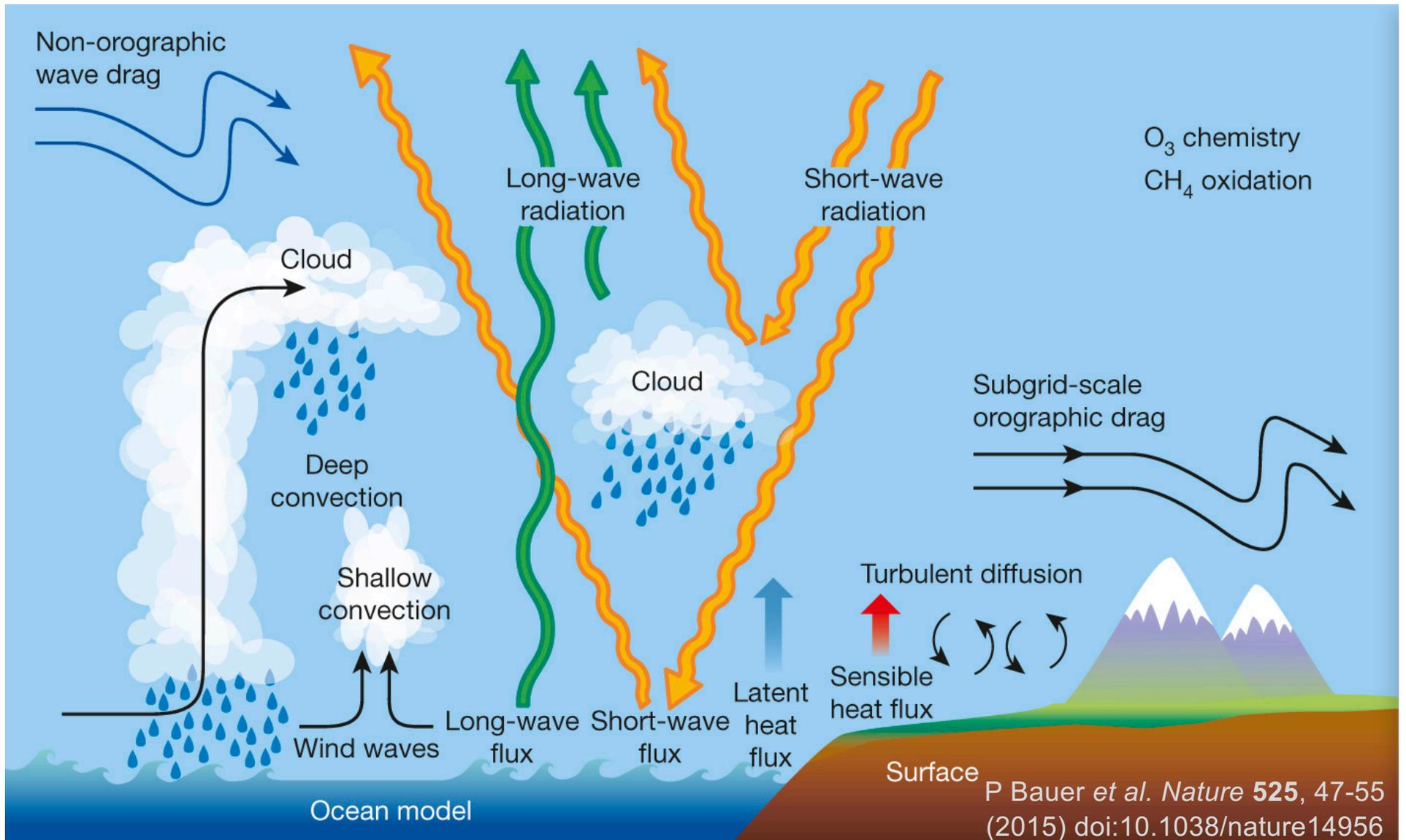
## Potential Impacts of Trustworthy AI for Agriculture

Improved weather prediction can:

- Saves lives
- Protect property and crops
- Guide planting and watering



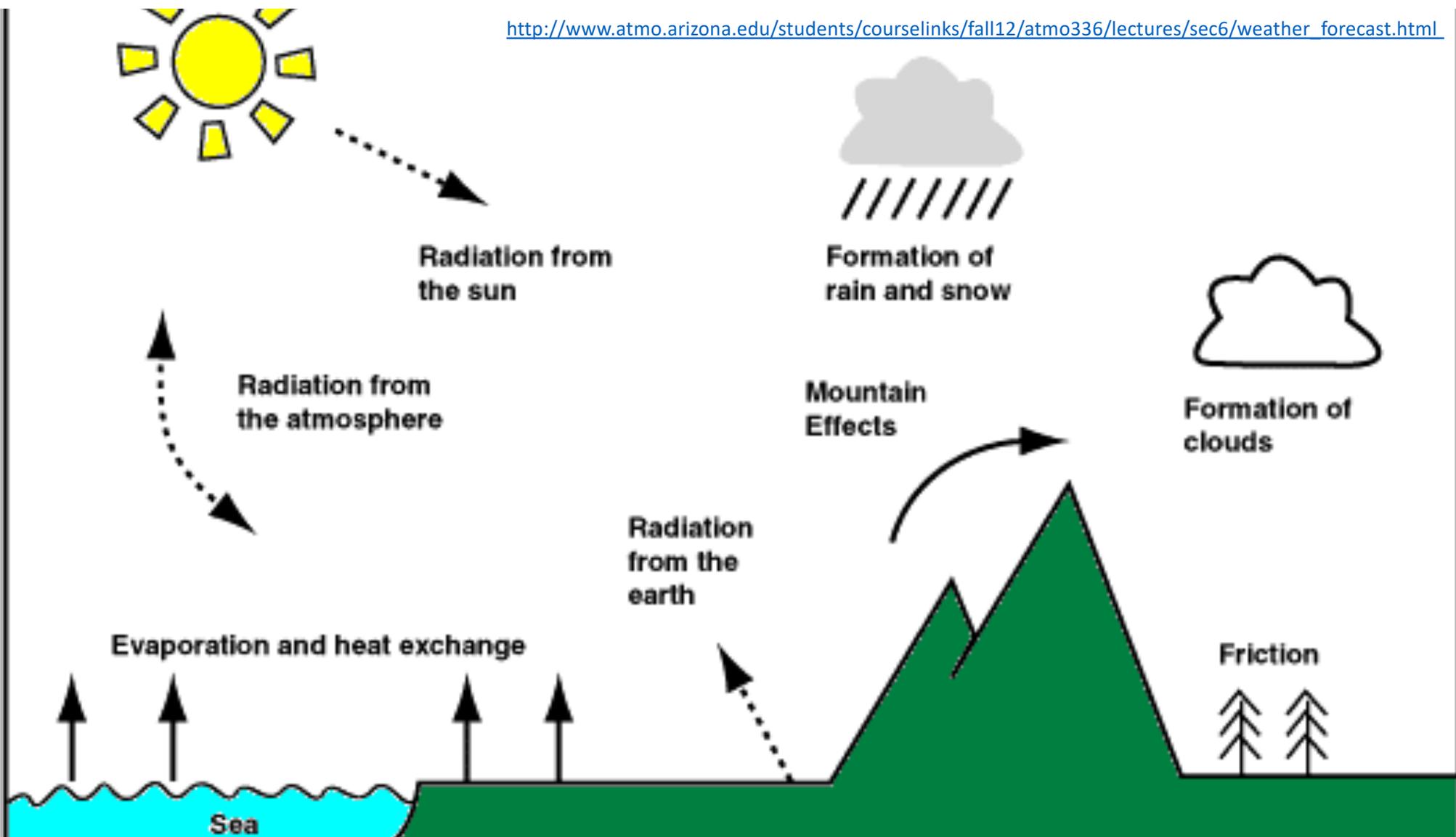




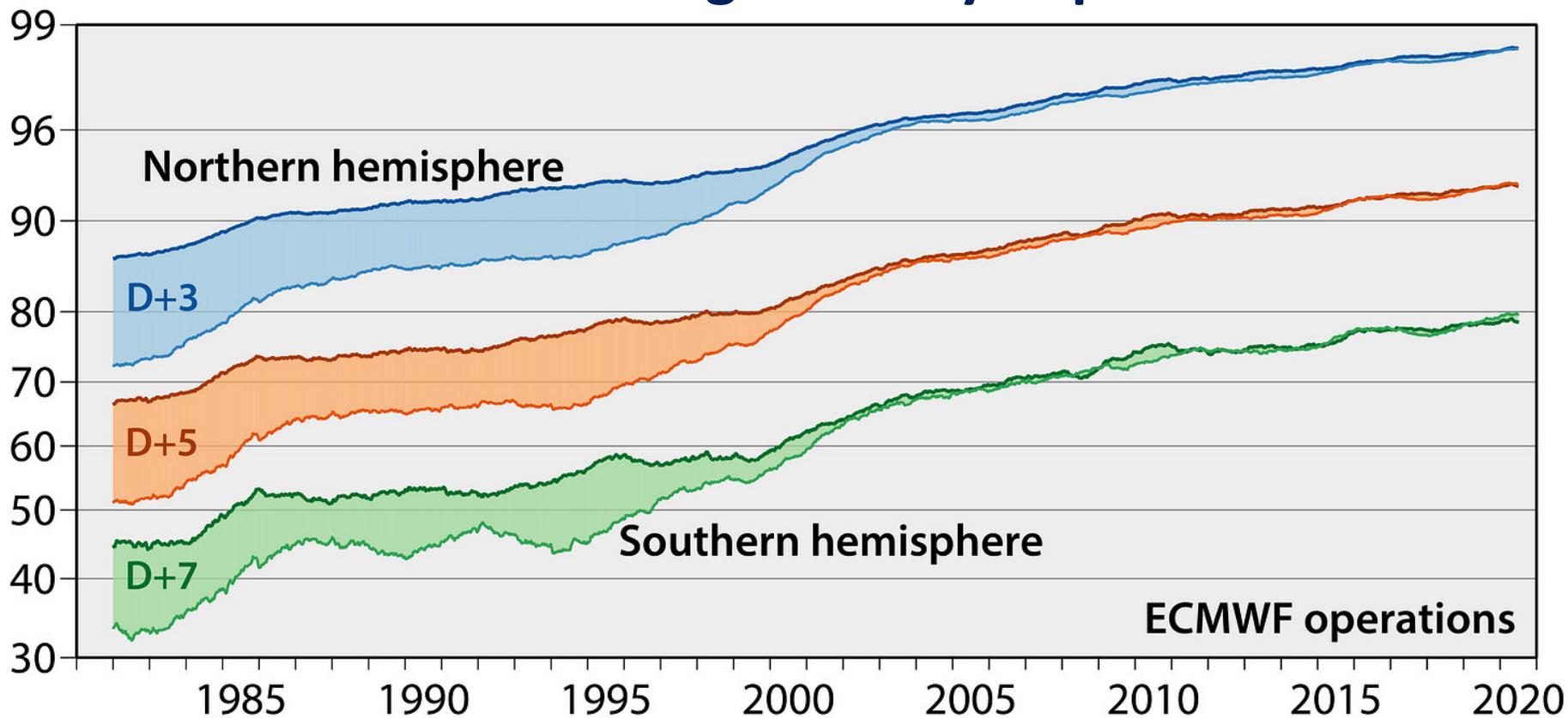
# Numerical Weather Prediction

- World is broken into cubes
- Weather and physics simulated in each cube
- Cubes talk to neighbors





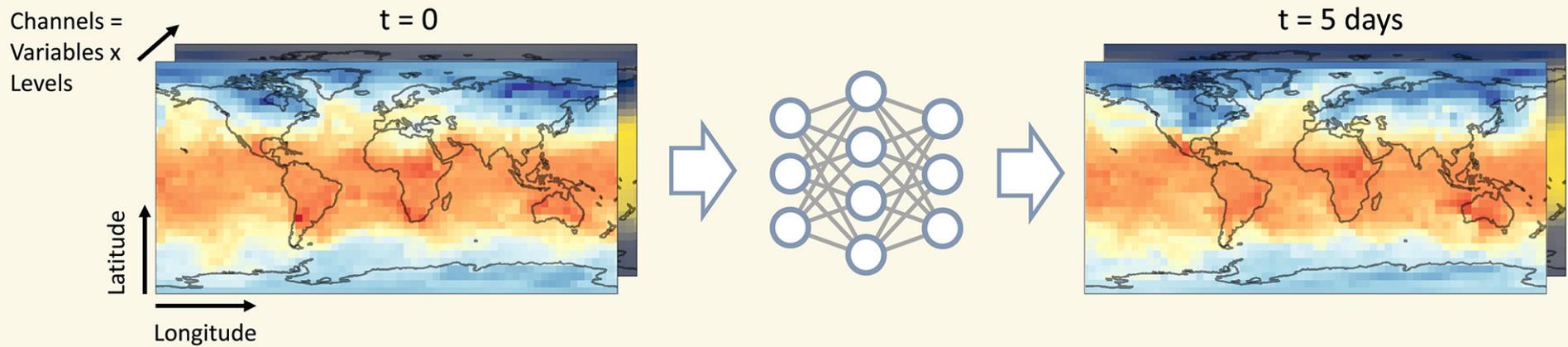
# Weather forecasting accuracy improvements



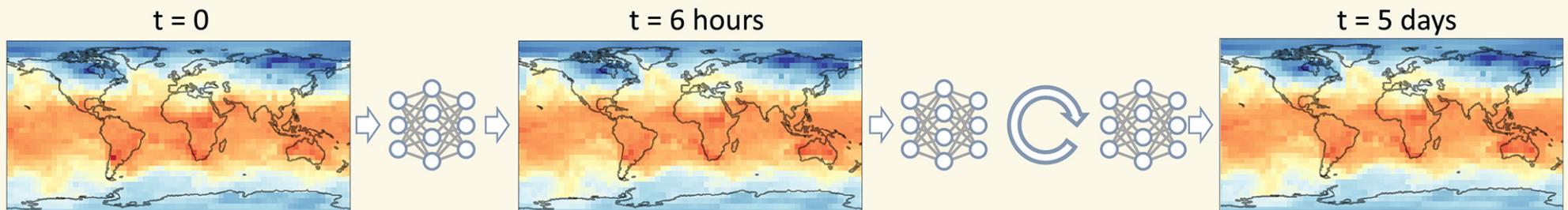
<https://chartingprogress.substack.com/p/weather-forecasting>

# AI/Data Driving Weather Forecasting

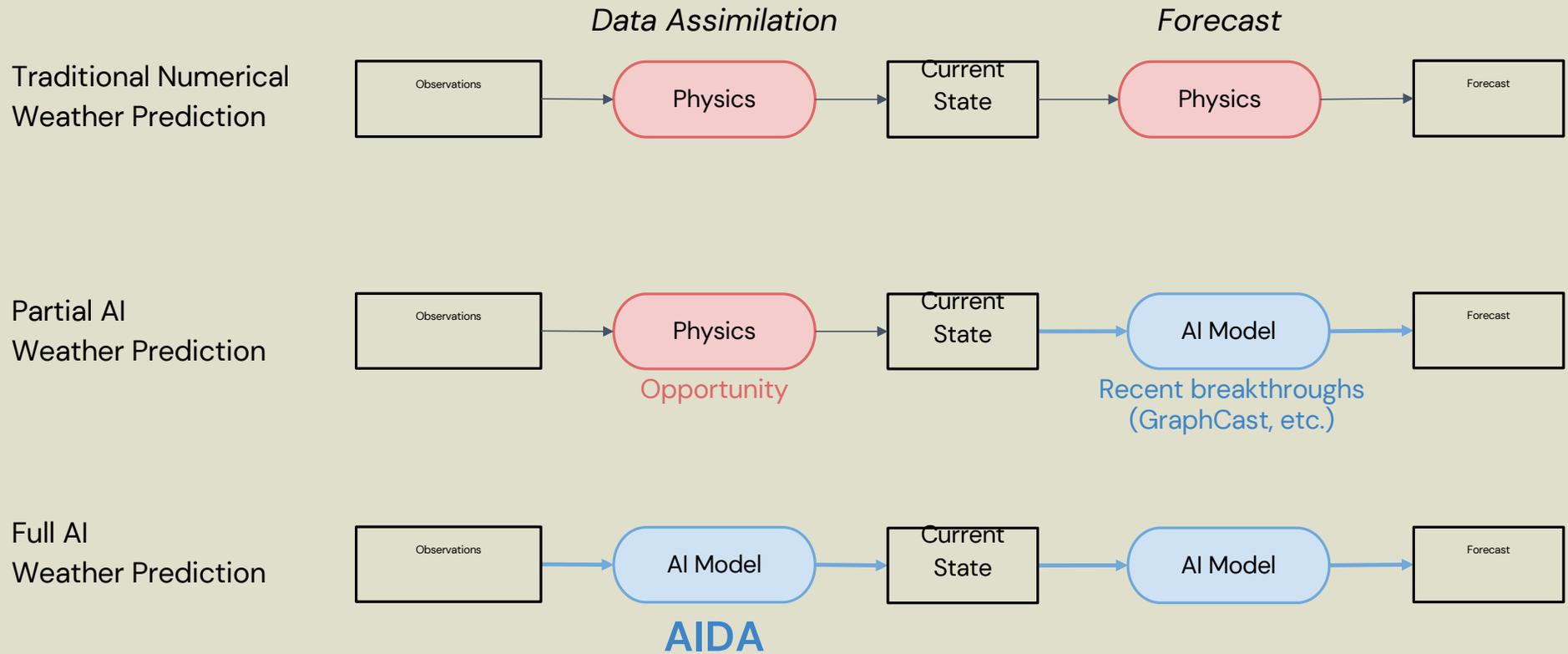
## (a) Direct prediction



## (b) Iterative prediction



# The Future of AI Weather is Observations

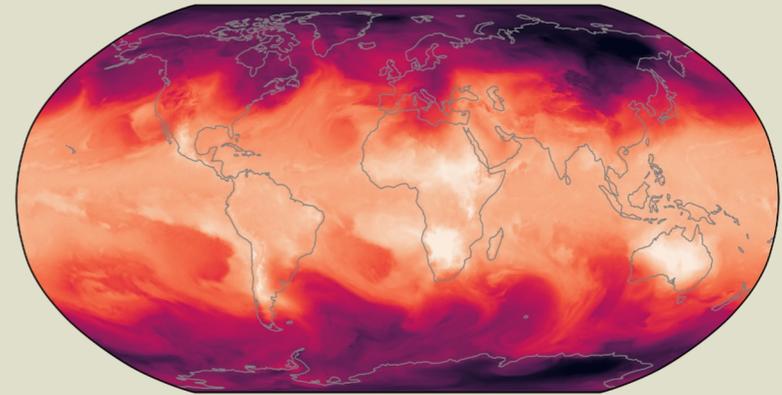
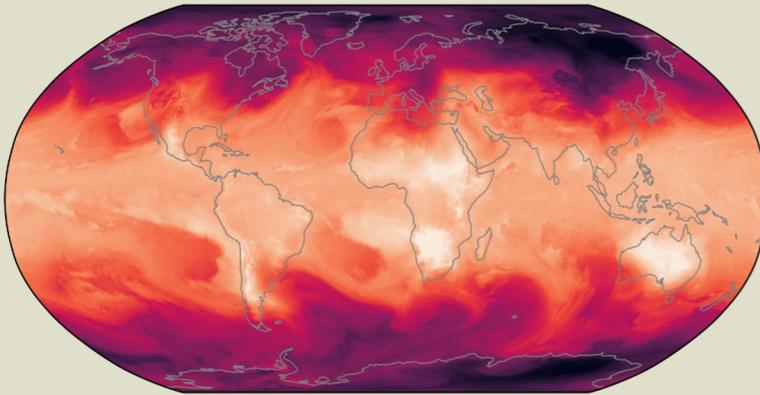


# IFS vs AIDA: Analysis

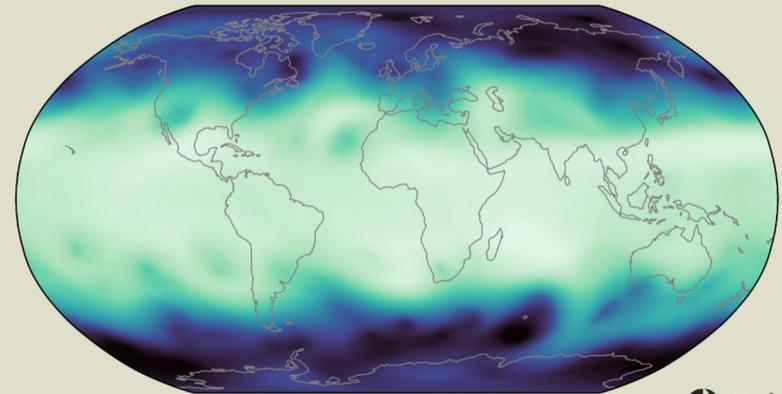
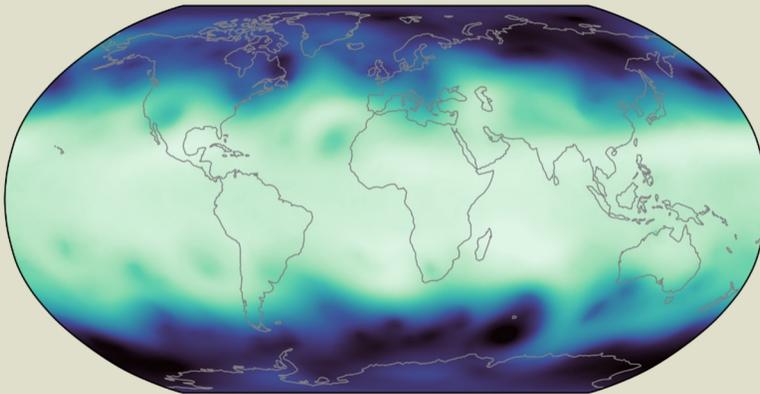
IFS

AIDA

T850



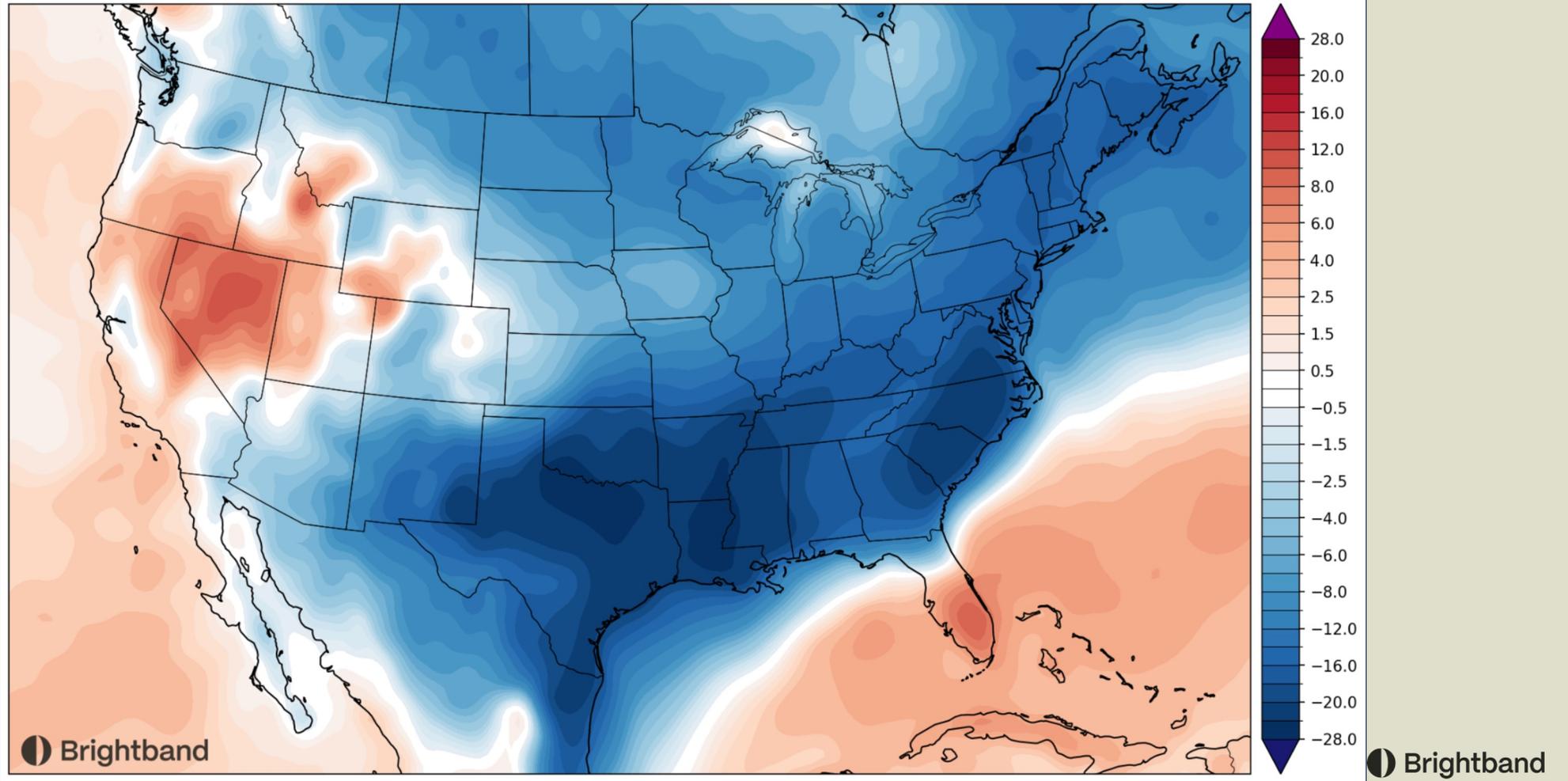
Z500



Valid time: 2025-11-23T18

**AIFS Ensemble | AIDA | 2m Temp Anomaly (°F)**

Init: 18Z Jan 20 2026 → Valid: 18Z Jan 26 2026 (144 hr)

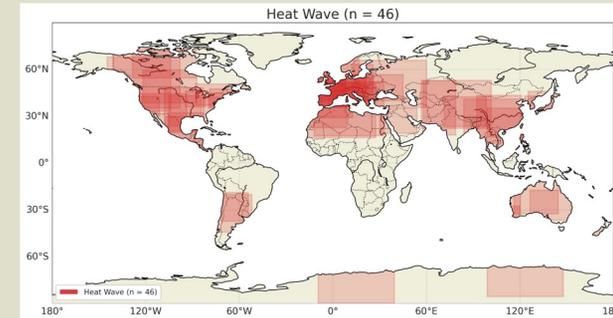




How do  
you know  
what  
model to  
trust?

- Experience with the model over time
  - See how well it works on YOUR tasks
  - Look at scorecards
    - Extreme Weather Bench
- 

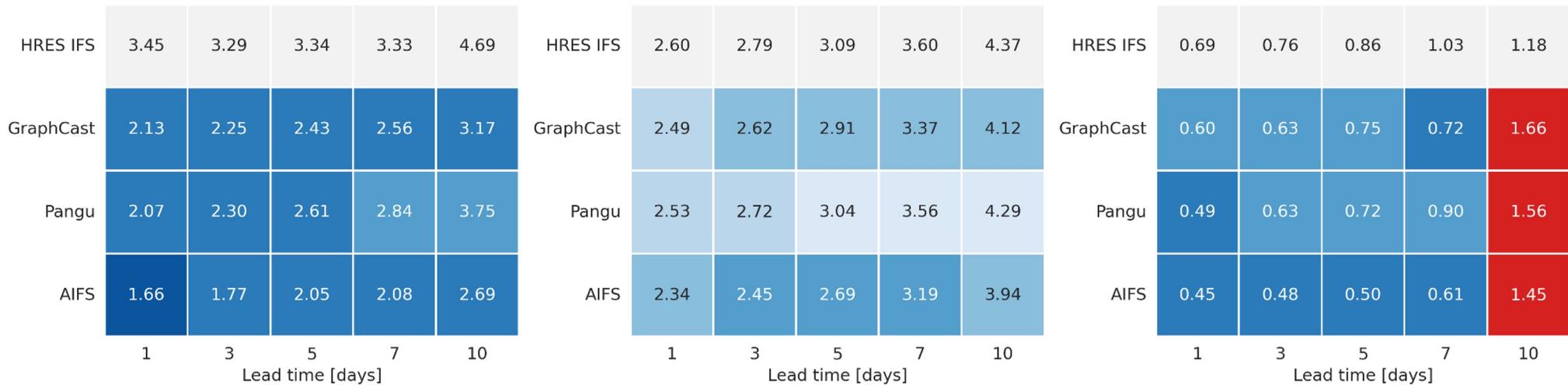
# Extreme Weather Bench: Global Heat Waves



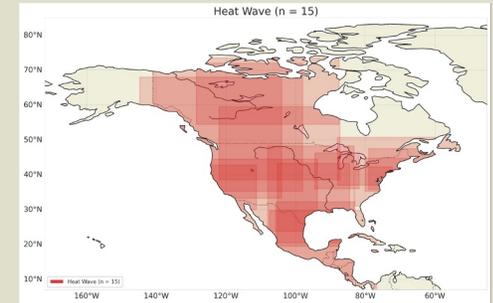
MAE of Event High

RMSE

MAE of Event Low



# North American Heat Waves



MAE of Event High

	1	3	5	7	10
HRES IFS	3.07	2.82	2.84	2.95	4.44
GraphCast	1.99	2.23	2.60	2.87	3.14
Pangu	1.93	2.26	2.80	2.98	4.48
AIFS	1.49	1.63	1.98	2.28	2.58

RMSE

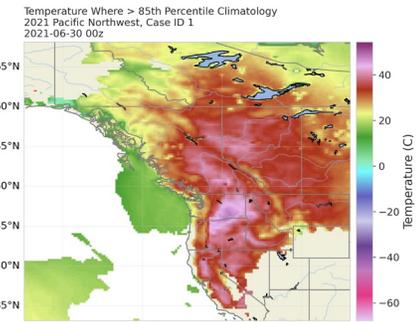
	1	3	5	7	10
HRES IFS	2.43	2.66	2.92	3.40	4.13
GraphCast	2.26	2.44	2.72	3.17	4.01
Pangu	2.25	2.51	2.86	3.43	4.28
AIFS	2.14	2.25	2.46	2.89	3.81

MAE of Event Low

	1	3	5	7	10
HRES IFS	0.37	0.47	0.63	0.87	1.25
GraphCast	0.49	0.47	0.57	0.64	1.86
Pangu	0.34	0.40	0.53	0.69	1.75
AIFS	0.32	0.34	0.42	0.46	1.75



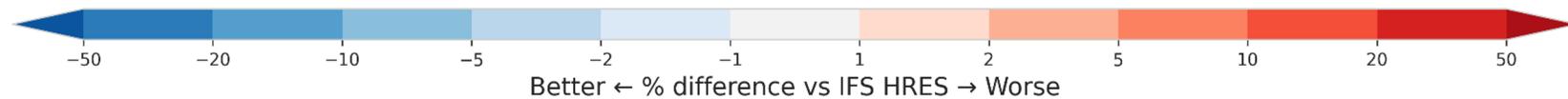
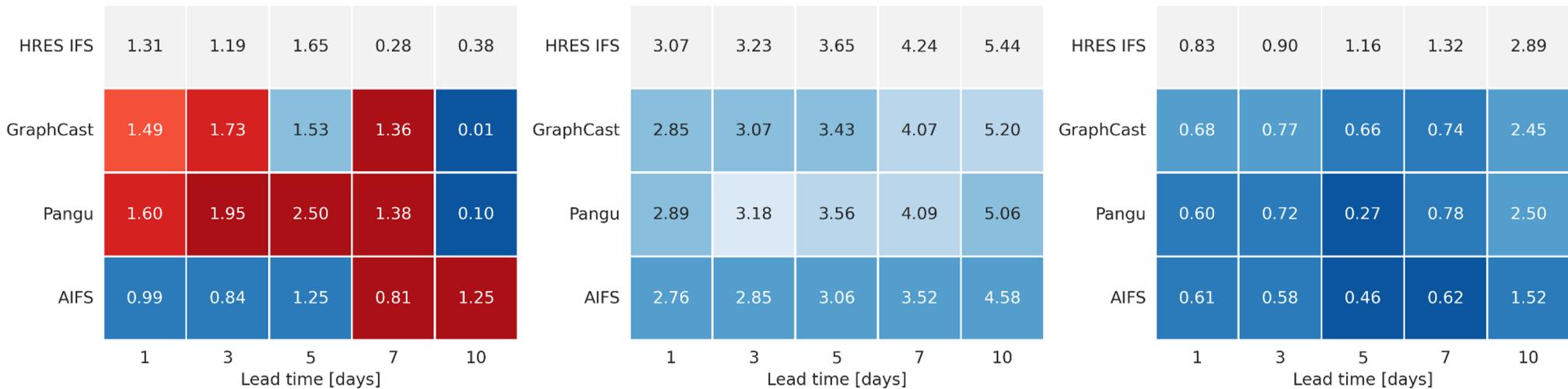
# Pacific Northwest 2021



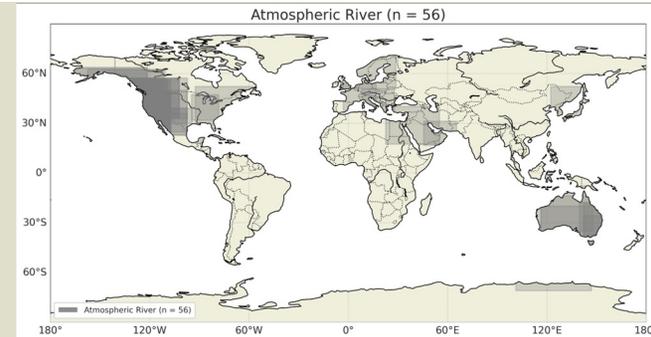
MAE of Event High

RMSE

MAE of Event Low



# Worldwide Atmospheric Rivers



Critical Success Index

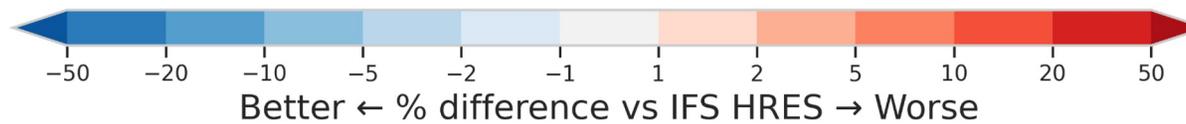
	1	3	5	7	10
HRES IFS	0.28	0.21	0.13	0.08	0.04
GraphCast	0.69	0.51	0.38	0.21	0.10
Pangu	0.68	0.49	0.33	0.17	0.07
AIFS	0.67	0.51	0.38	0.22	0.11

Lead time [days]

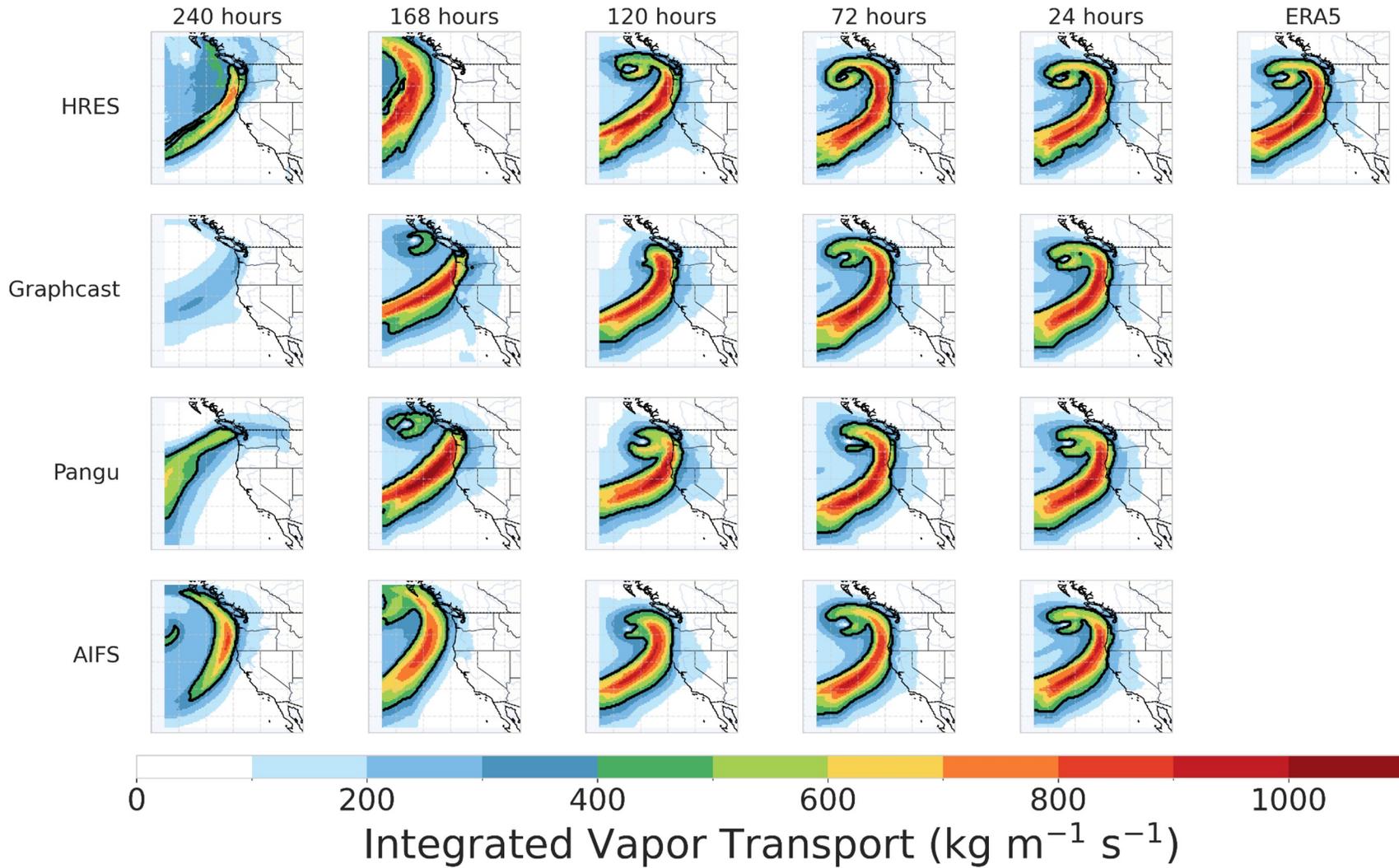
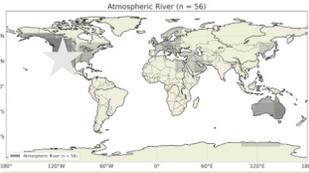
Spatial Displacement

	1	3	5	7	10
HRES IFS	106	166	303	430	571
GraphCast	80	136	234	363	574
Pangu	88	151	229	387	598
AIFS	81	128	209	362	543

Lead time [days]



# Case 95: November 2024 West Coast US on 2024-11-20 00:00:00

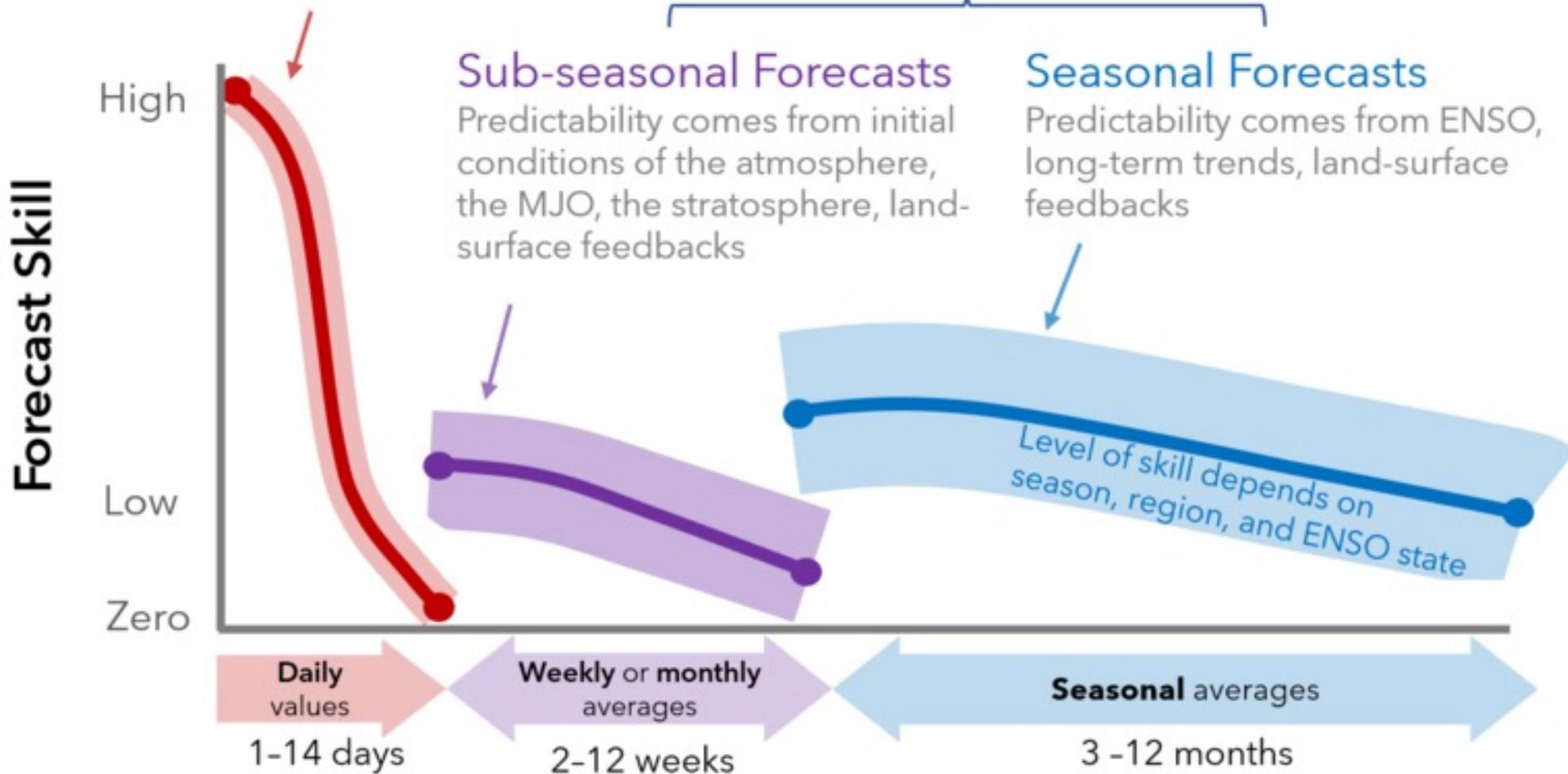


## Weather Forecasts

Predictability comes from initial conditions of the atmosphere

[https://coloradoriverscience.org/Weather\\_and\\_climate\\_forecasts](https://coloradoriverscience.org/Weather_and_climate_forecasts)

## Climate Forecasts



# AI for Weather is Transformational

- AI is making transformational improvements in the prediction of weather and climate with impacts on agriculture
- My vision: Multi-agency, multi-sector, transdisciplinary center
- **The novel work in trustworthy AI for weather will continue in many ways**
  - **We need to continue to fund large-scale grants to facilitate convergence research!**
- This material is based upon work supported by the National Science Foundation under Grant No. RISE-2019758.



ai2es.org

