EESI
Environmental and Energy Study Institute

Materials will be available at:
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Innovations in Weather Forecasting for a Changing Climate

Thursday, February 15, 2024

About EESI

Non-partisan Educational Resources for Policymakers

A bipartisan Congressional caucus founded EESI in 1984 to provide non-partisan information on environmental, energy, and climate policies

Direct Assistance for Equitable and Inclusive Financing Program

In addition to a full portfolio of federal policy work, EESI provides direct assistance to utilities to develop “on-bill financing” programs

Commitment to Diversity, Equity, Inclusion, and Justice

We recognize that systemic barriers impede fair environmental, energy, and climate policies and limit the full participation of Black, Indigenous, people of color, and legacy and frontline communities in decision-making

Sustainable Solutions

Our mission is to advance science-based solutions for climate change, energy, and environmental challenges in order to achieve *our vision of a sustainable, resilient, and equitable world*.

Policymaker Education

Briefings and Webcasts

Live, in-person and online public briefings, archived webcasts, and written summaries

Climate Change Solutions

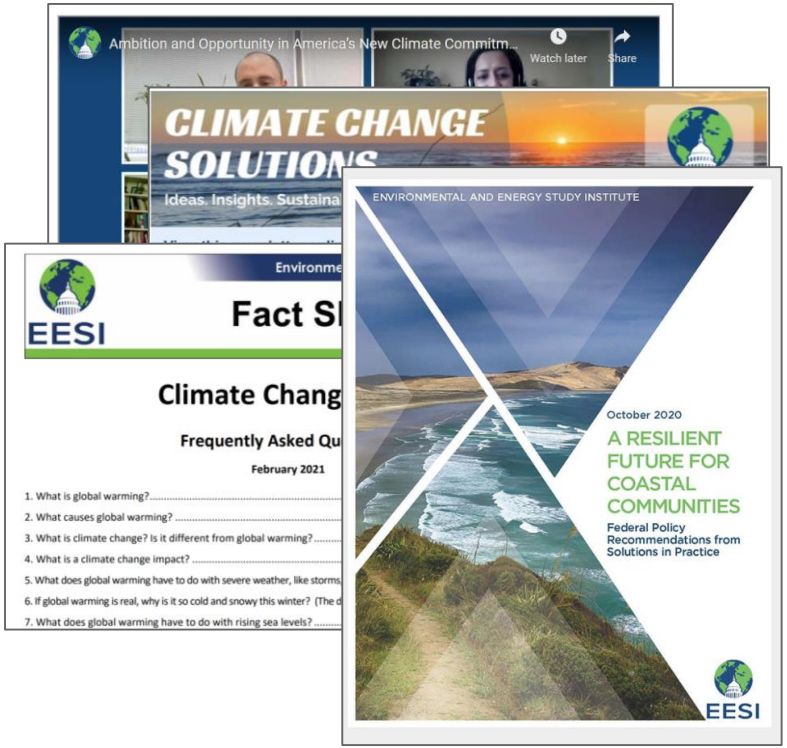
Bi-weekly newsletter with everything policymakers and concerned citizens need to know, including a legislation and hearings tracker

Fact Sheets and Issue Briefs

Timely, objective coverage of environmental, clean energy, and climate change topics

Social Media (@EESIOnline)

Active engagement on Twitter, Facebook, LinkedIn, and YouTube



EESI
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What did you think of the briefing?

Please take 2 minutes to let us know at:
www.eesi.org/survey

***Materials will be available at*:**
www.eesi.org/021524weather

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#eesitalk @eesionline

Thursday, February 15, 2024

Innovations in Weather Forecasting for a Changing Climate

Environmental and Energy Study Institute
February 15, 2024

Michelle Mainelli, Deputy Director, National Weather Service

NWS: 154 Years Young

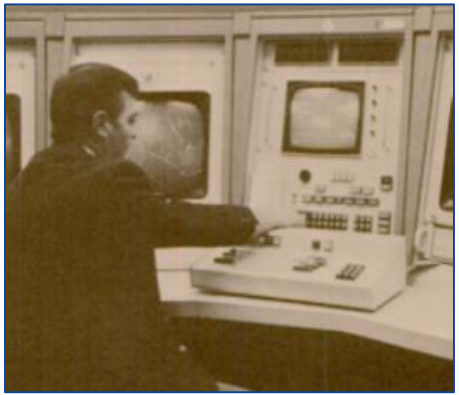
NWS runs **168** operational units, most of them **24/7**

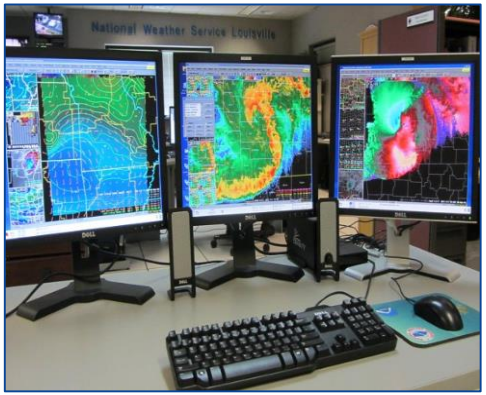
NWS has **~4450** employees, of whom **86%** are in the field

NWS issues ~**1.5 million** forecasts and ~**50,**000 warnings each year

NWS costs each person in the US about **$4.00**/year*

Supporting national security and public safety in every community, every day.



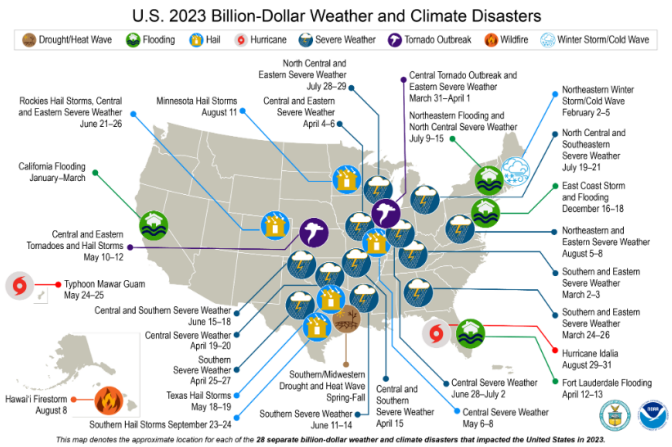


Why the National Weather Service Matters

2023
28 Billion Dollar Weather/Climate Disasters

Annual Average for weather/climate disaster events increasing

2000-2009	6.7 / year
2010-2019	12.8 / year
2020-2023	22 / year



Eye to Eye with Emergency Managers

Impact-Based Decision Support Services

Our forecasts & warnings: confidence, context, social science

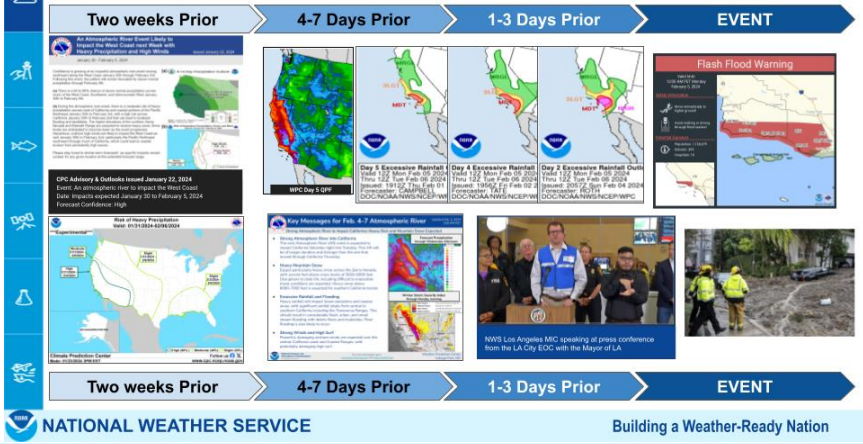
+

Tabletops, feedback, engagement: Trusted connections with decision-making partners

=

Impact-based Decision Support Services
Actionable Environmental Intelligence

February 4-7, 2024 Historic Southern California Rains



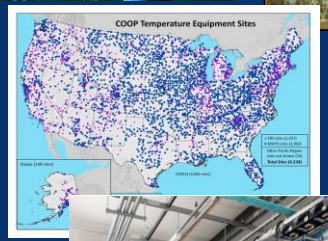
NATIONAL WEATHER SERVICE

Building a Weather-Ready Nation

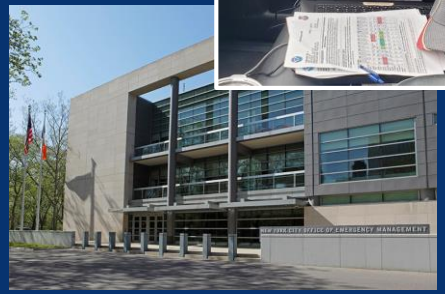
NWS Transformation Commitment

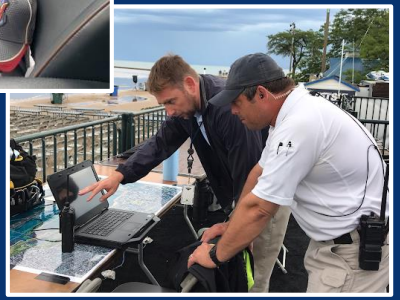
Becoming a more nimble, flexible, & mobile agency providing indispensable mission services eye to eye with decision makers





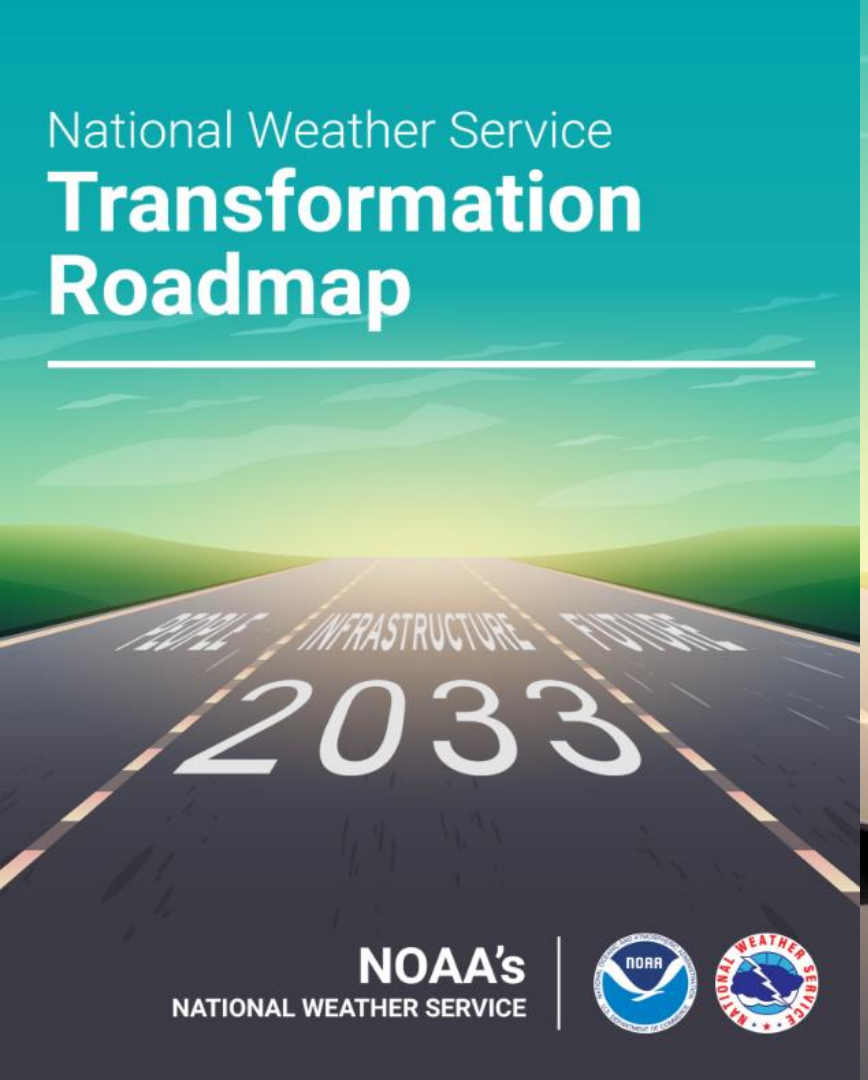



Observations/Data => Models/Guidance => Forecasts / Services => IDSS

Enable Prepared, Weather Ready, and Responsive Communities

National Weather Service

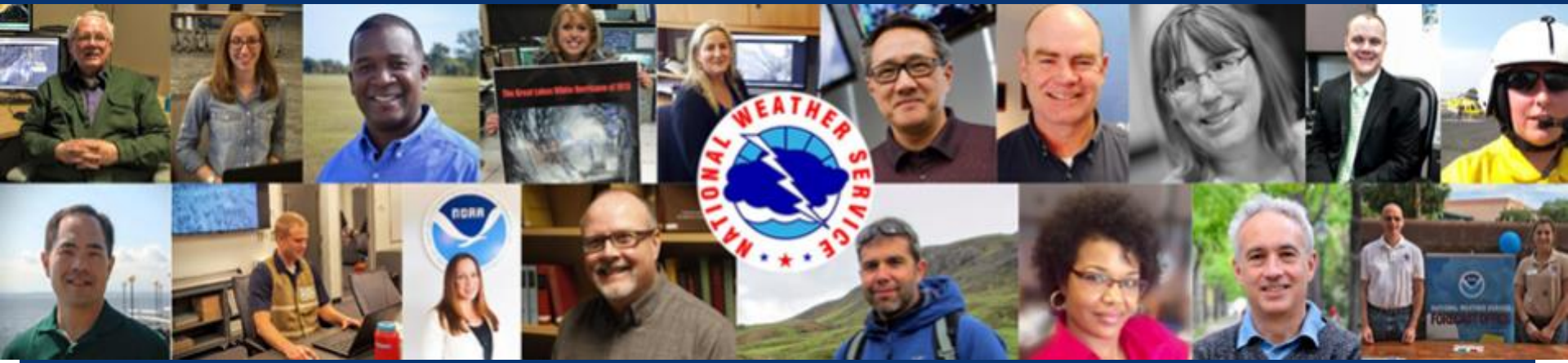
Transformation Roadmap



NOAA's
NATIONAL WEATHER SERVICE

Thank you!

michelle.m.mainelli@noaa.gov



tomorrow.io

Overview

Tomorrow.io

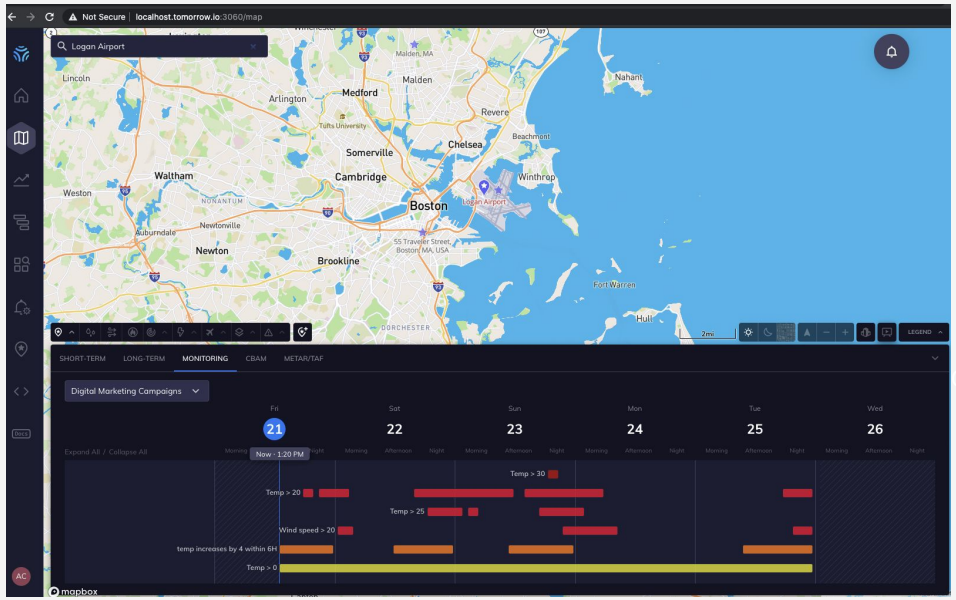
Climate Adaptation Platform, powered by Weather Intelligence.

tomorrow.io

Tomorrow.io at a glance

- Started in **2016** in Boston; over **$300M** in capital raised to-date
- Locations in U.S., Israel, and India
- Deploying groundbreaking LEO **smallsat** constellation of **weather radars** and **sounders**
- Partnering with the U.S. Air Force, NASA, JetBlue, Uber, Ford, and more
- Approximately **240** employees (~**50%** in R&D)

Scaling SaaS Weather Intelligence Globally



Weather Intelligence Alert

De-ice planes between 10 AM - 11 AM

Weather Intelligence Alert

Hail will start in 60 minutes. Move car to covered area and check road conditions

AEROMEXICO · Azul · DELTA · DRIZLY · evergy · facebook · Ford · FOX SPORTS · nationalgrid · IndiGrid · INMOBI · intact · ITS ConGlobal · jetBlue · KAJIMA · PATRIOTS · PORSCHE · Rappi · SB Energy · Denny's · Shipt · SWIGGY · Uber · UNITED · U.S. AIR FORCE · USTA - US OPEN · VIA · NASA · zomato

tomorrownow.org

BILL & MELINDA GATES foundation

NCAR UCAR

THE WORLD BANK IBRD • IDA

6M Farmers Reached (and growing!)

SMS agri-advisory program with KALRO, powered by high-resolution weather intelligence:

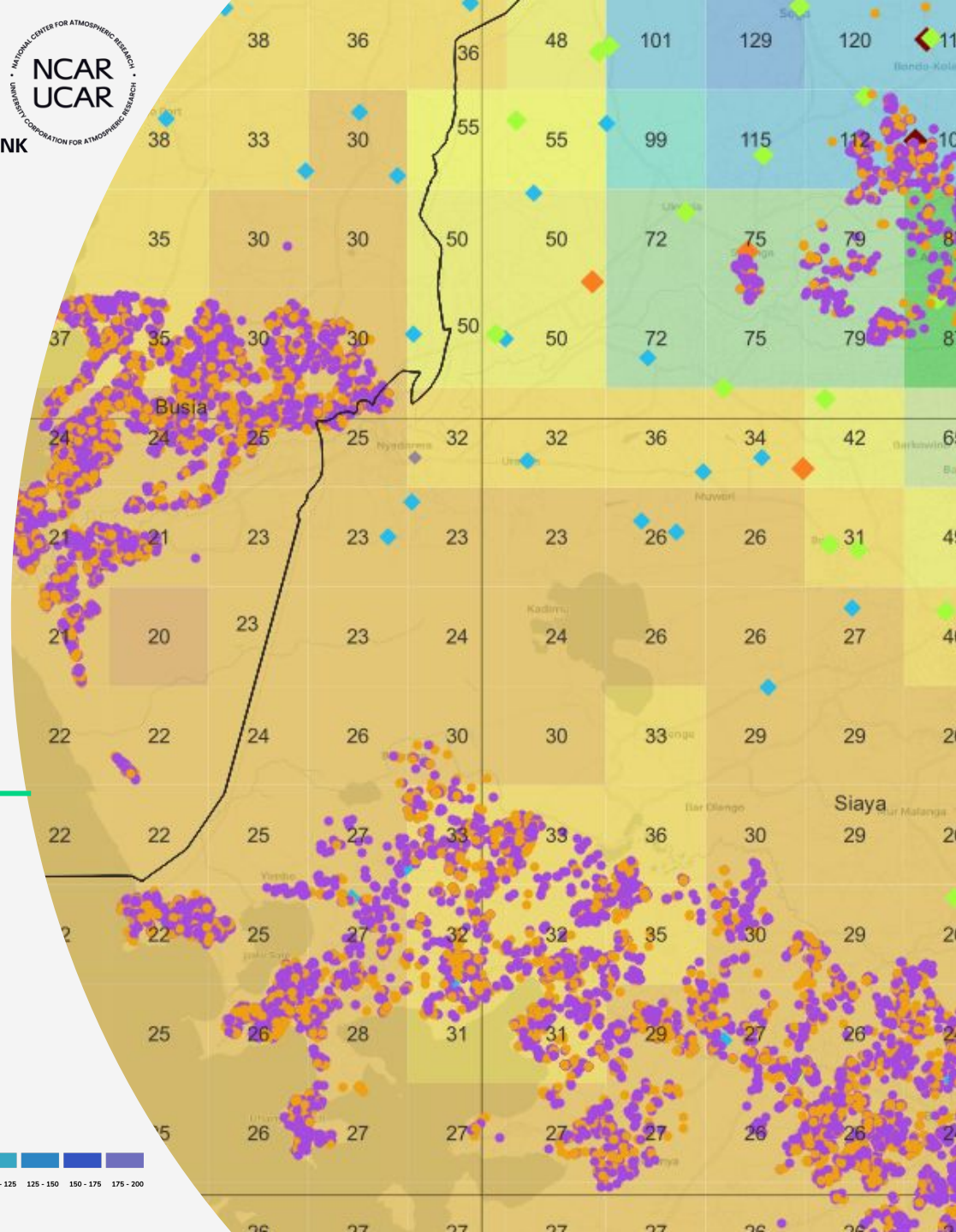
- Rapid scale - up to 6M farmers reached in 1 year
- High impact - Farmers more likely to report successful germination and less likely to report pests or damage to maize

KALRO tomorrow.io

tomorrownow.org

West & Central Kenya

Rainfall next 7 days from
17 October (October 17-24) at **3.5 km resolution**



Small Scale Producers (SSP)

- Female
- Male

Rainfall

0 - 1mm | 1 - 10 | 10 - 20 | 20 - 30 | 30 - 40 | 40 - 50 | 50 - 60 | 60 - 70 | 70 - 80 | 80 - 90 | 90 - 100 | 100 - 125 | 125 - 150 | 150 - 175 | 175 - 200

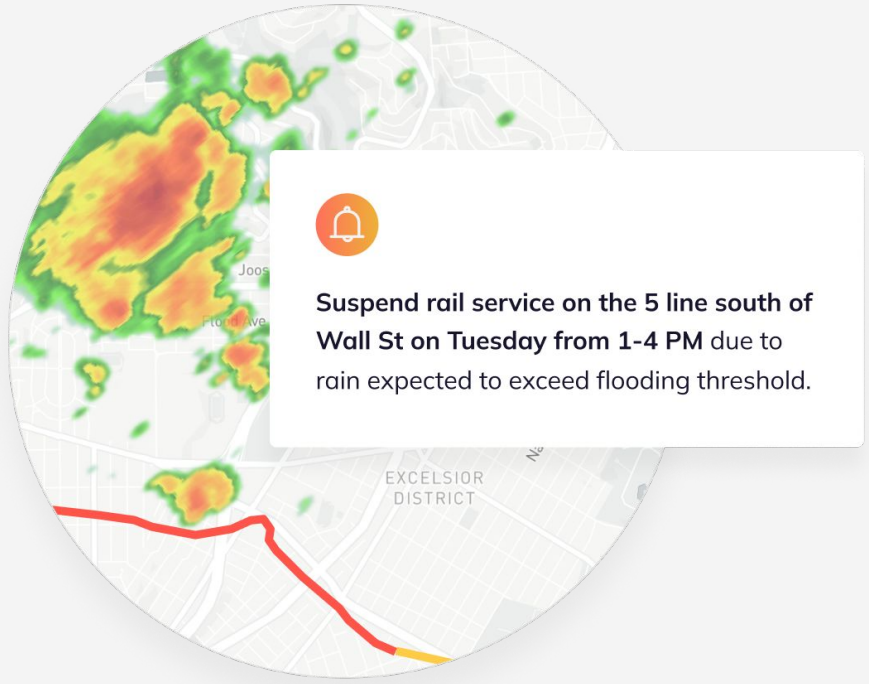
Tomorrow.io Created Weather Intelligence™

Weather Intelligence isn't focused on the weather, it's focused on the predictive impact of the weather, automated decisioning, and operational optimization.

12°

Mostly cloudy with a 40% chance of rain on Tuesday for New York City.

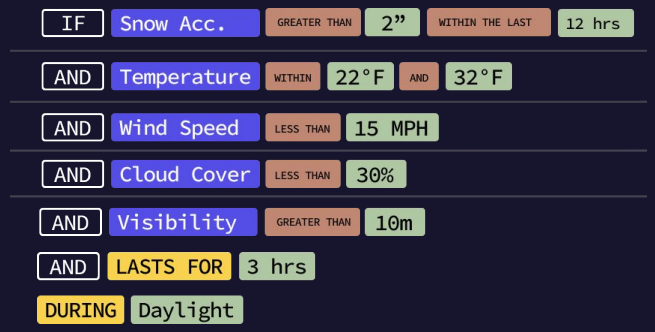
VS



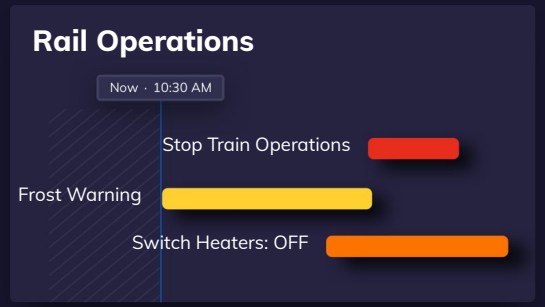
Suspend rail service on the 5 line south of Wall St on Tuesday from 1-4 PM due to rain expected to exceed flooding threshold.

Operationalizing the Forecast

Empowering organizations to standardize and automate operating protocols



Build **protocols** that **monitor** for **impact**

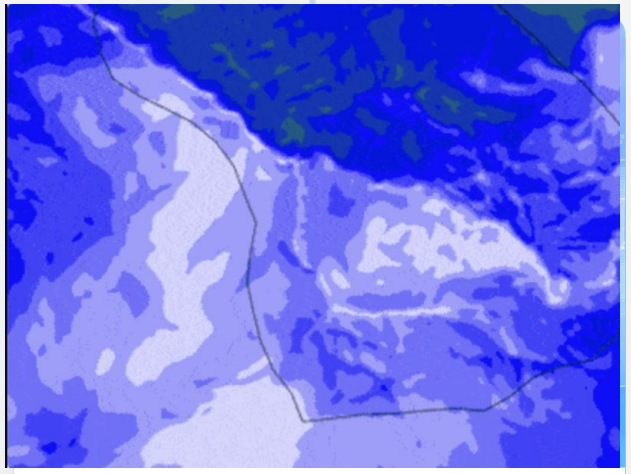


Get **signaled** when impact will occur

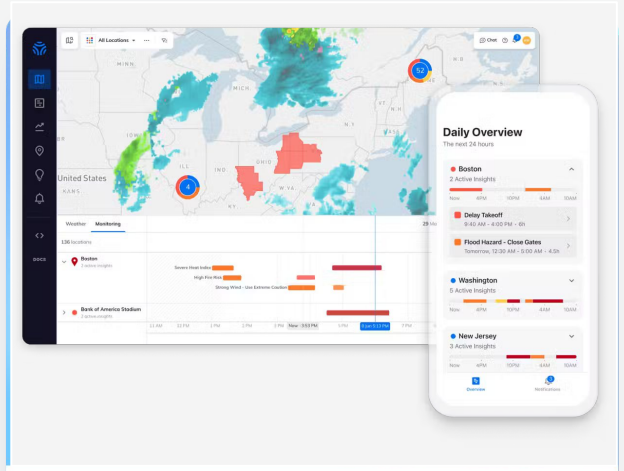
Drive **business outcomes**

Tomorrow.io Differentiated on 3 Fronts

Comprehensive Global Weather Observations & Measurements



Proprietary Weather Modeling. Powered by Physics, Supercharged with AI/ML.



Weather Intelligence SaaS/API

Quality Weather Information is Not Universal

Decades after the first weather radar was installed, **5 billion people still live outside of reliable radar coverage**

No radar coverage over oceans, where most high-impact weather originates

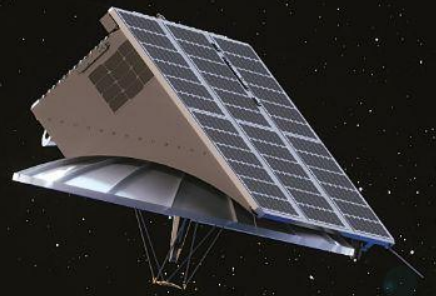
Existing satellites do not offer a solution for global high-revisit precipitation monitoring

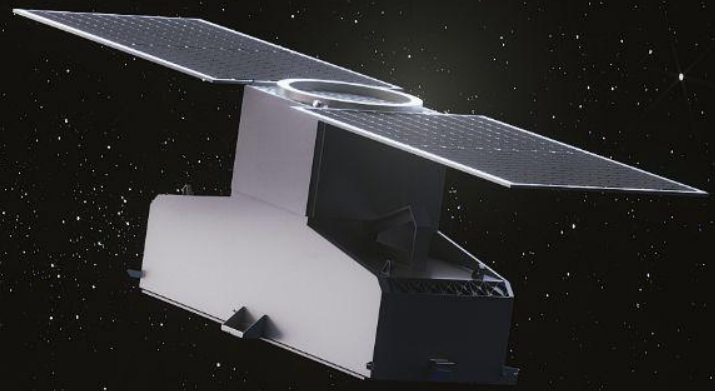
The Global Radar Gap

More than 70 years after radar was invented, more than 5 billion people still live outside of radar coverage making even the most basic forecasts a dream for the vast majority of humanity.

Limited
Global Coverage

Meet the Tomorrow.io Constellation





Tomorrow.io's constellation of 20 small satellites will provide:

- Full Global Coverage
- <1 hour average revisit rate
- World's first near real-time precipitation measurements and 3D atmospheric profiles
- Dramatic improvement in real-time weather forecasts, tropical cyclone warnings and flood alerts

Hybrid constellation of 30 small satellites in Low Earth Orbit

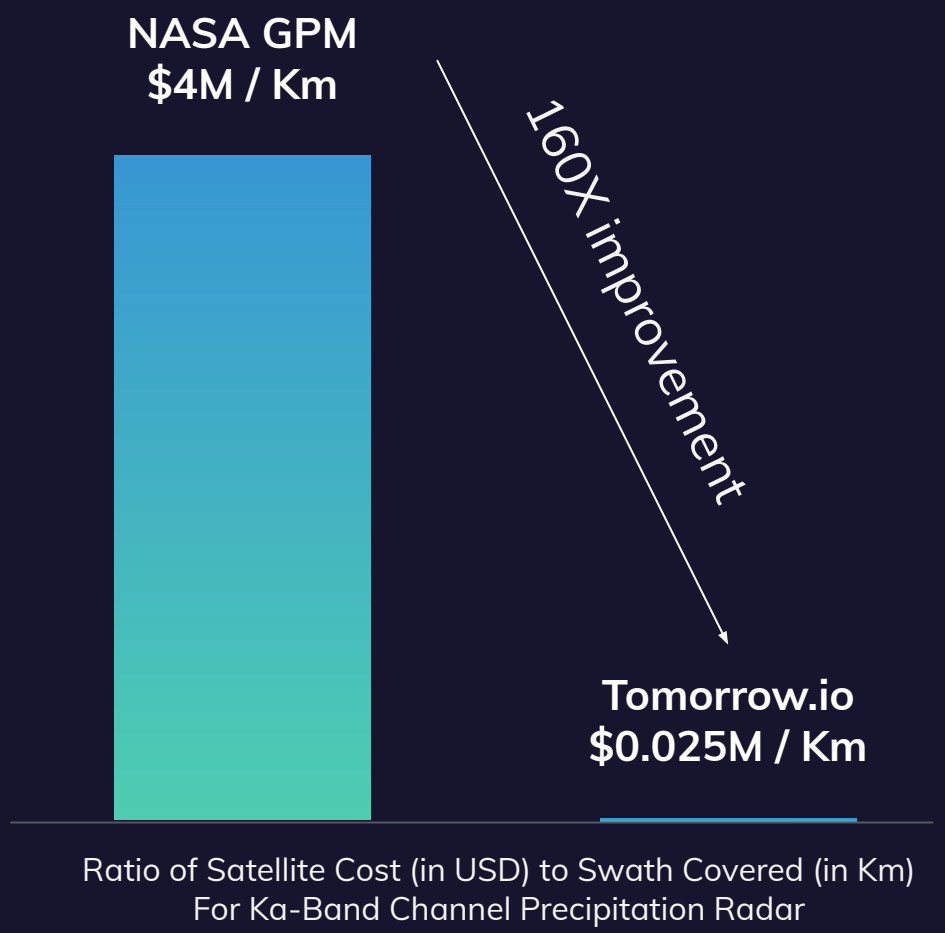
- 12 Ka-band radars
- 18 MW radiometers

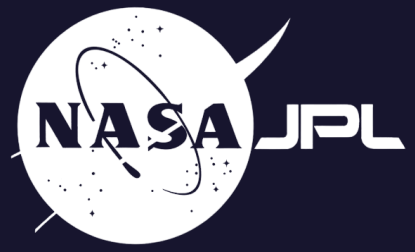
Timeline:

- Launched in Q2/23
- Constellation fully operational by EOY 2025

Radical Cost Reduction for Spaceborn Weather Radar

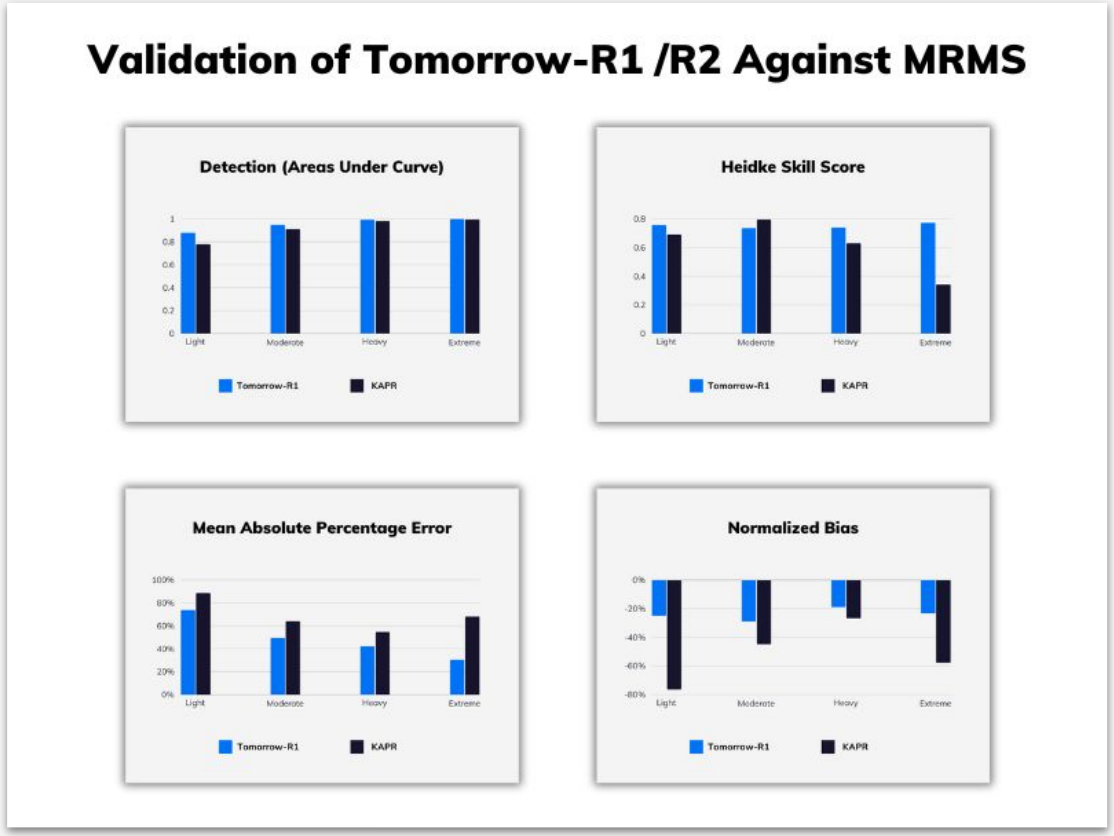
- Leveraging NASA/JAXA proven science and investing in massive cost reduction to enable operational utility and cost-effective science continuation
- 160X improvement in cost per scan from existing state-of-the-art

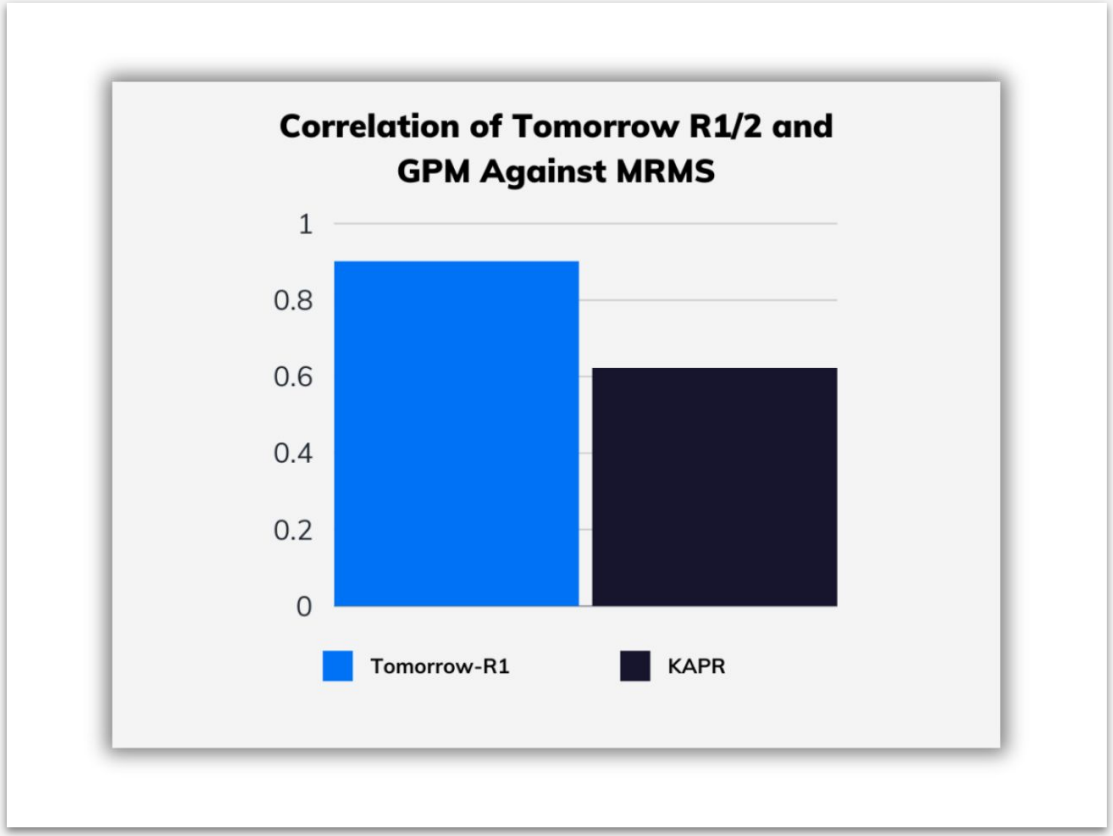




"A new [active radar] instrument architecture that is compatible with low-cost satellite platforms...will enable constellation missions and revolutionize climate science and weather forecasting."

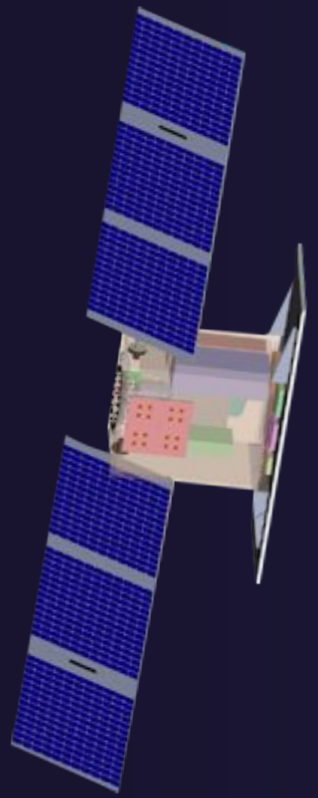
Pathfinder Results: Higher correlation to US NEXRAD precipitation product (MRMS) than NASA's current state-of-the-art GPM satellite





Full Atmospheric and Oceanic Observation System

Radar



3D Clouds & Precipitation

Tides and sea level rise

Coastal erosion

Sea heights

Marine wind/Wave warnings

Storm structure and intensity

Real-time Disaster warnings

Tropical cyclone forecasts

Real-time global precip

Flood alert

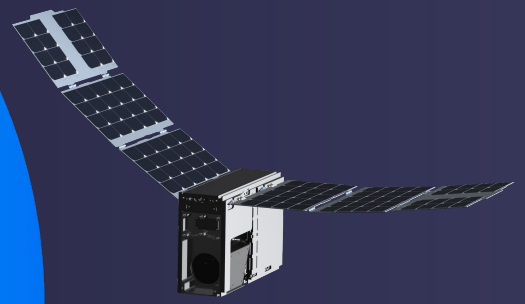
Drought monitoring

3D Temperature Profiles

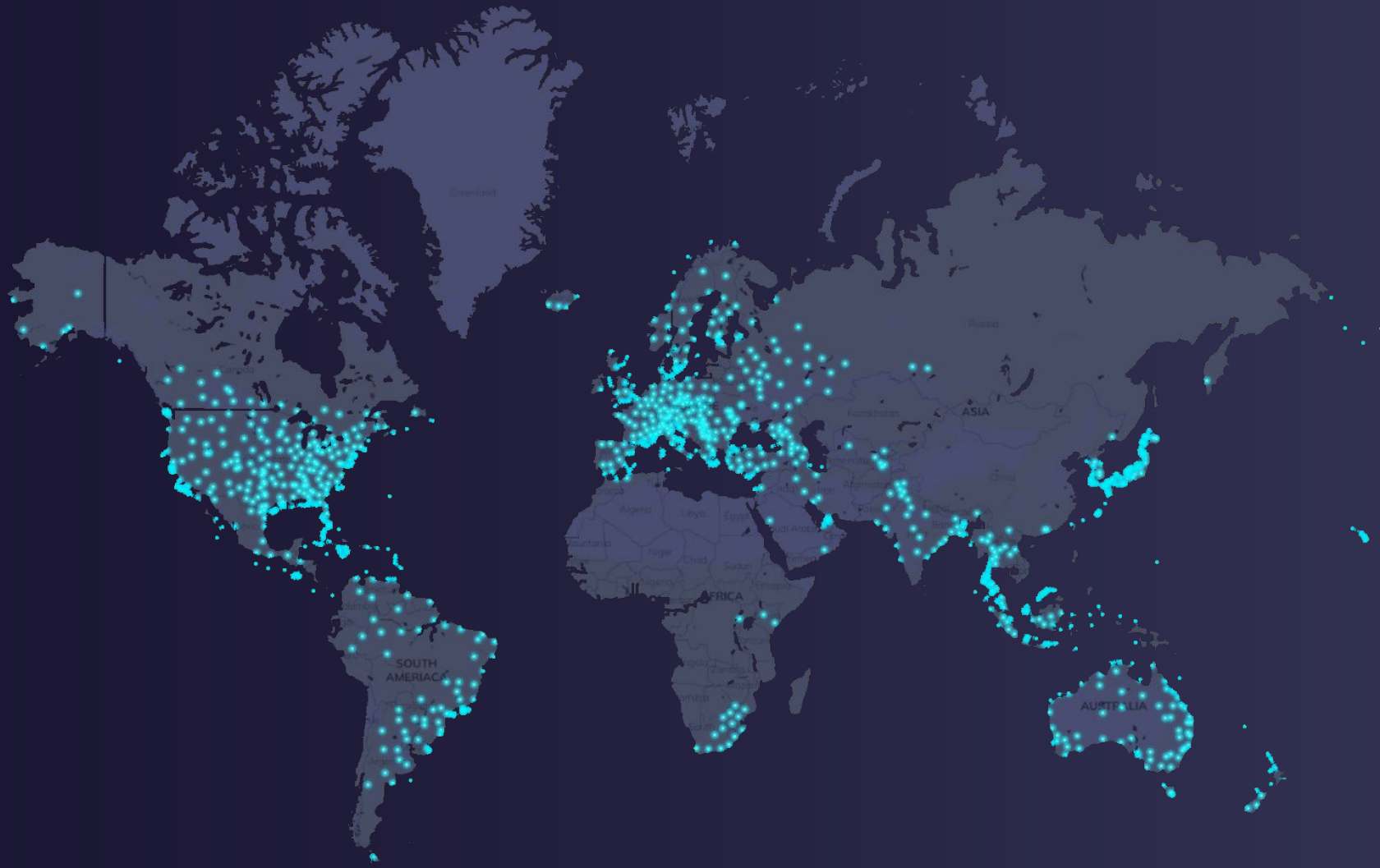
3D Humidity Profiles

Storm moisture structure

Microwave Sounders



Global Wx radar gap | Data required where DoD operates

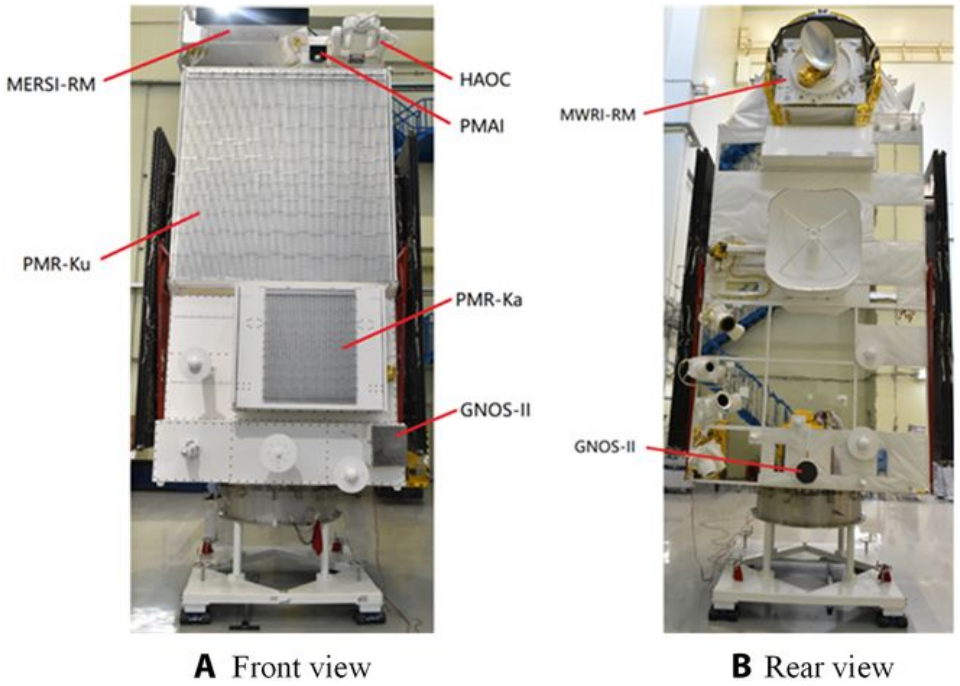


PRC launching advanced weather satellites

Journal of Remote Sensing
A SCIENCE PARTNER JOURNAL

REVIEW ARTICLE

FY-3G Satellite Instruments and Precipitation Products: First Report of China's Fengyun Rainfall Mission In-Orbit



A Front view **B** Rear view

In April '23, China launched FY-3G which is a derivative of the NASA/JAXA GPM architecture. FY-3G features the following payloads:

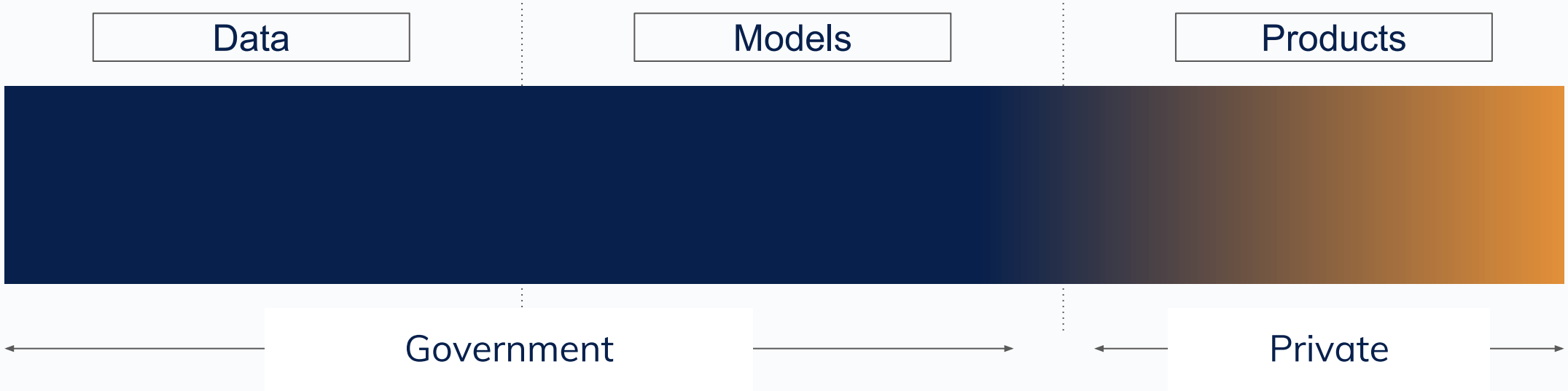
- Dual-frequency (Ku+Ka) band radar w/ 300 km swath
- Microwave imager (conical scan) w/ 26 channels (~900 km swath)
- Vis/IR imager with 8 channels and 500m resolution
- GNSS-R/RO receiver
- SWIR polarimeter

The article states that an identical satellite will be launched in 2028, followed by an FY-5 "constellation" consisting of 2 additional precipitation measurement satellites and an atmospheric dynamics satellite to measure wind (possibly wind lidar).

MWRI-RM channels (GHz)	MERSI-RM channels (μm)
V/H: 10.65, 18.7, 23.8, 36.5, 50.3, 52.61, 53.24, 53.75, 89.0 **V only:** 118.75±3.2, 118.75±2.1, 118.75±1.4, 118.75±1.2, 165.5 ±0.75,183.31±2.0, 183.31±3.4, 183.31±7	0.65, 0.865, 0.940, 1.38, 1.64, 3.8, 10.8, 12.0

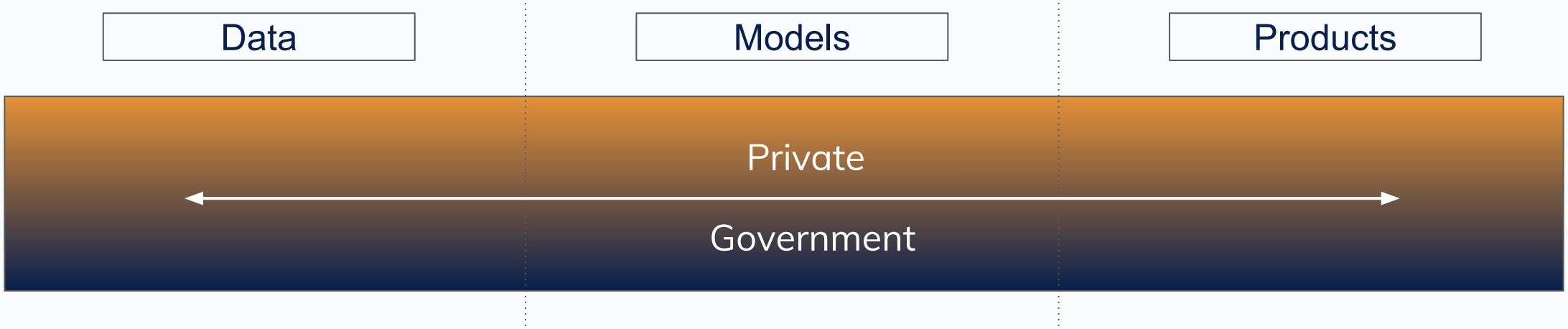
tomorrow.io

The Traditional Weather Enterprise



- Most of the work done by government agencies
- Private market focused on repackaging data, few contributions to underlying technology
- Access to reliable and useful weather/climate information - still a dream for most of world

Weather Enterprise 2.0



- Urgent need for improvement requires “whole-of-nation” approach
- Private market can and should take a much more significant role to augment and support government mission
- Industry is innovating across the value chain

Key structural changes

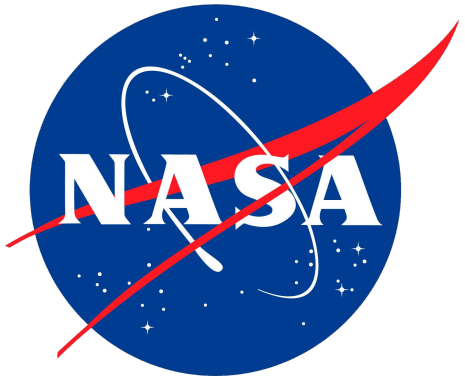
- Industry is not reliant on government as a customer (dual use technologies benefit industry and gov agencies)
- Leveraging private capital to develop and deploy new technologies
- Taking on risk of deployment (launch), replenishment, and will continue to innovate on new payloads, sensing modalities, modeling systems, and more

The result is that **industry will likely surpass government** in observations and modeling in the next few years. Industry and government must **develop better mechanisms for public-private partnership** in the weather enterprise

USG has limited mechanisms for purchasing commercial weather data

CWDP

So far limited to limited scope of technologies and data types



CSDA

Limited to scientific applications not operational meteorology

CWDP

Zeroed out in FY24 NDAA and Appropriations bill

Other agencies like USDA, DOE, DOI, etc. have unique needs which may not fit within the purview of these entities and yet have limited purchasing power for commercial weather solutions

COMMERCIAL WEATHER ALLIANCE

SAILDRONE

ORBITAL MICRO SYSTEMS

FROSTYFLAKE

tomorrow.io

SOFAR

BRANDYWINE PHOTONICS

WindBorne Systems

GS GREENSIGHT

BOULDER ENVIRONMENTAL SCIENCES & TECHNOLOGY

STRATODYNAMICS INC.

NEXTGEN FEDERAL SYSTEMS

A coalition of 11 commercial weather companies ***dedicated to promoting public-private partnership*** *and industry collaboration to* ***innovate across the entire U.S. weather and climate enterprise*** *value chain*

Legislative Opportunities

- Weather Act 3.0
- NASA Reauthorization
- Farm Bill
- NDAA

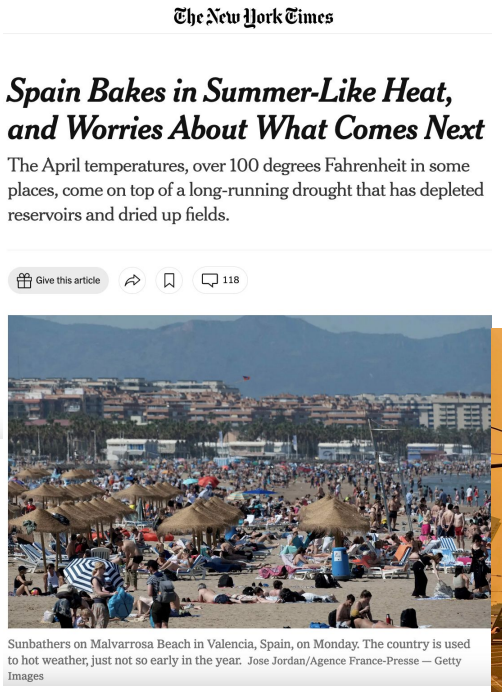
AI for weather and climate forecasting

Pierre Gentine
Columbia University
Director, LEAP center
CTO, Tellus AI

LEAP

tellus AI

Current gap: Climate Adaptation is Needed



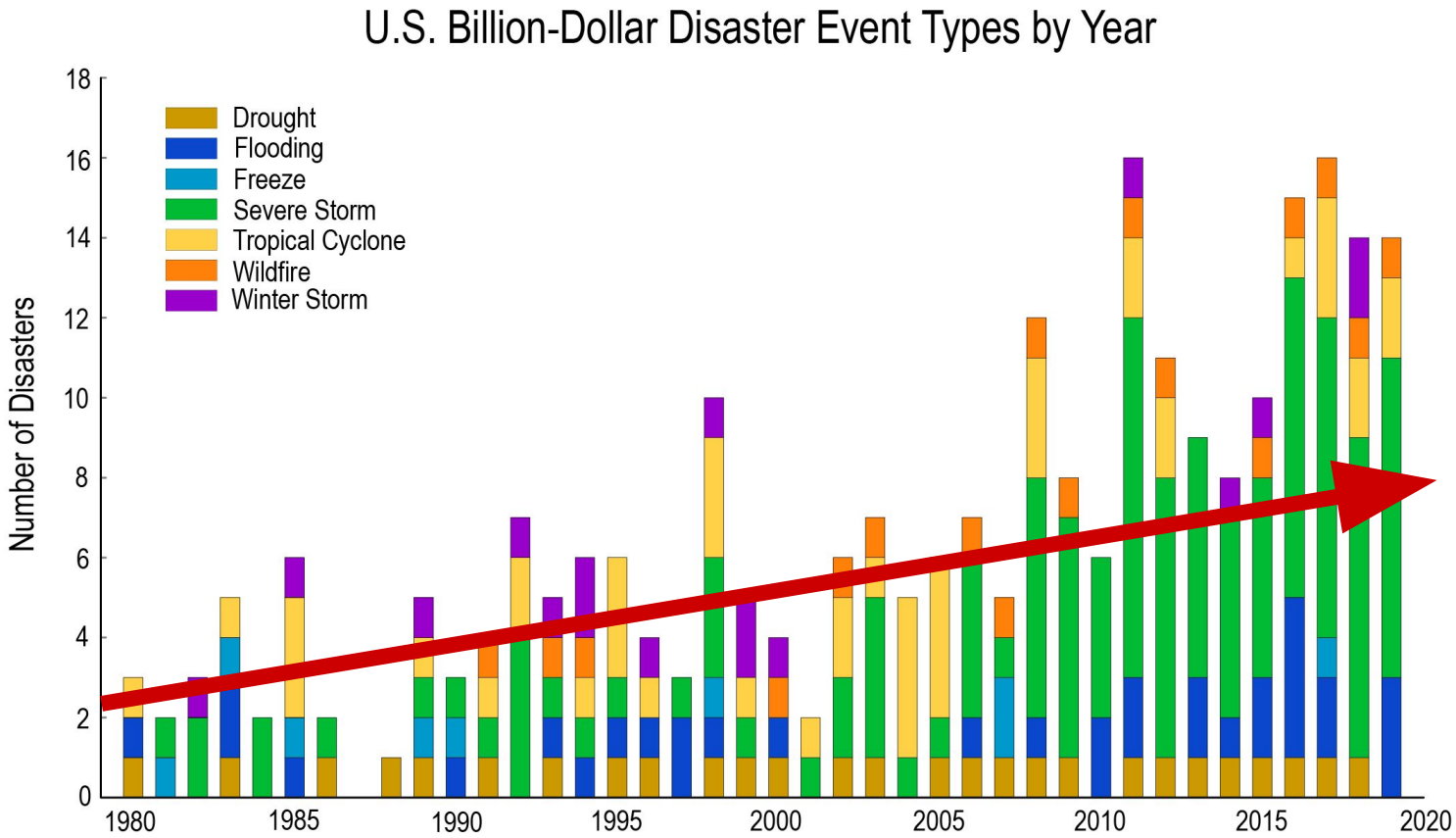
Climate change is happening *now* …
but we are *too* unprepared

LEAP

Flood Fort Lauderdale 2023, Extreme heatwave in India and Spain (April 2023)
Quebec wildfires - NYC

Current gap: Climate Adaptation is Needed

... and their associated cost.



NOAA 2020

How can AI help? 1. Resilience

Flood forecasting with machine learning models in an operational framework

Sella Nevo, Efrat Morin ✉, Adi Gerzi Rosenthal, Asher Metzger, Chen Barshai, Dana Weitzner, Dafi Voloshin, Frederik Kratzert, Gal Elidan, Gideon Dror, Gregory Begelman, Grey Nearing, Guy Shalev, Hila Noga, Ira Shavitt, Liora Yuklea, Moriah Royz, Niv Giladi, Nofar Peled Levi, Ofir Reich, Oren Gilon, Ronnie Maor, Shahar Timnat, Tal Shechter, Vladimir Anisimov, Yotam Gigi, Yuval Levin, Zach Moshe, Zvika Ben-Haim, Avinatan Hassidim, and Yossi Matias

Short-term, fast, flood prediction

Example Google flood forecasting

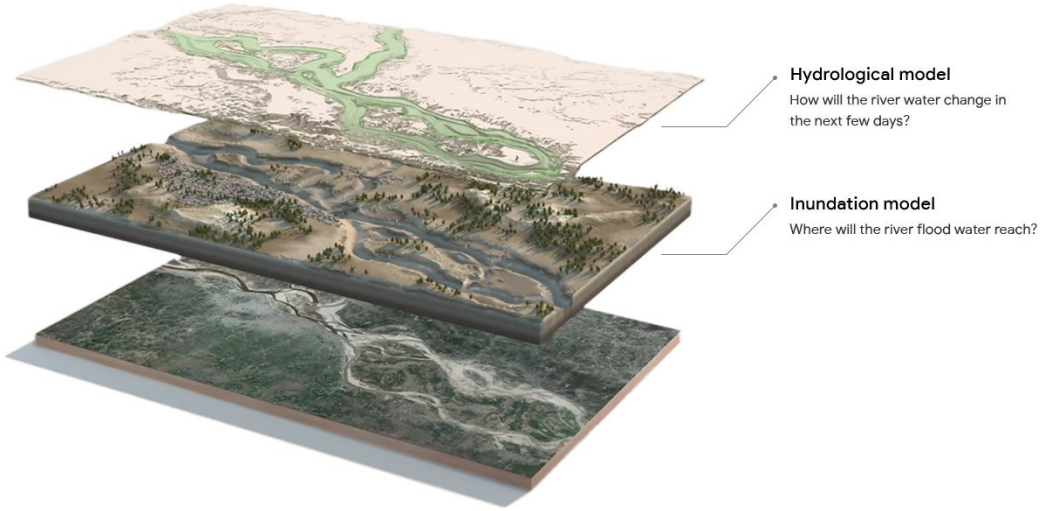
SUSTAINABILITY

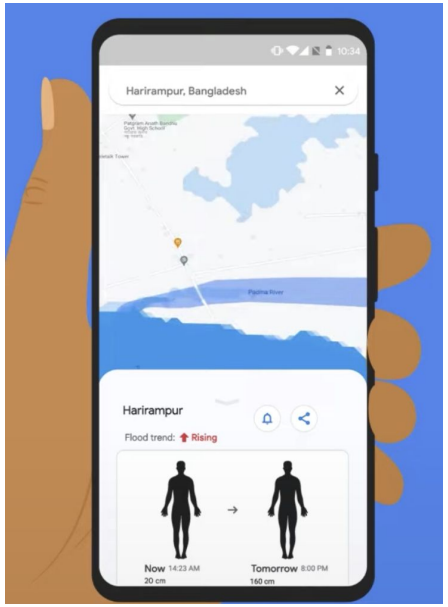
How we're using AI to help address the climate crisis

Nov 02, 2022 · 5 min read

Yossi Matias
VP Engineering & Research and Crisis Response Lead

Share

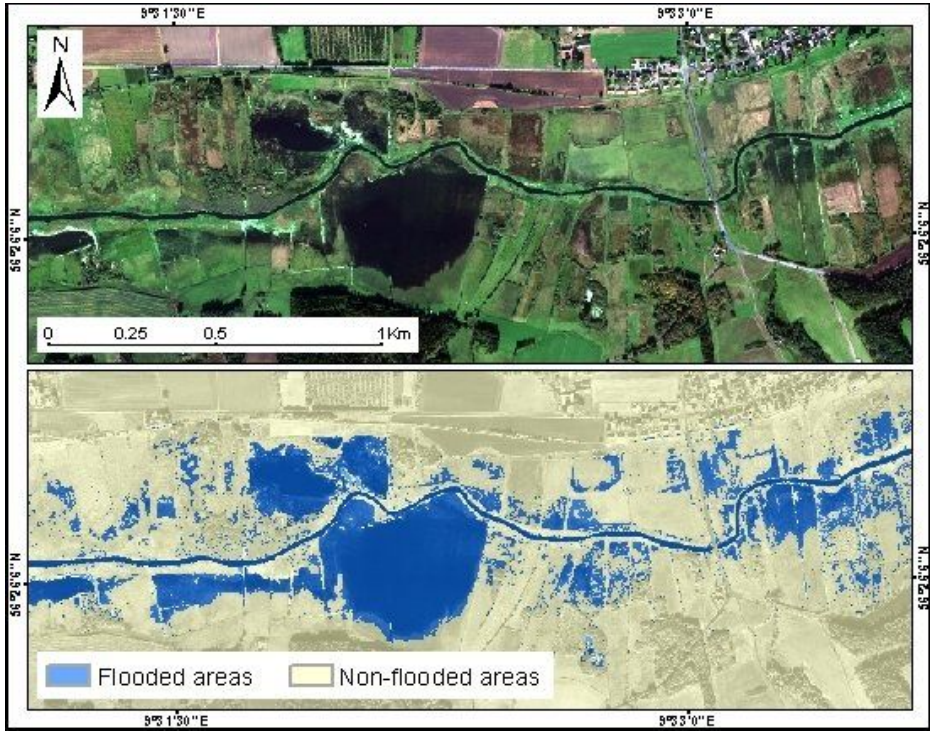




How can AI help? 1. Resilience

Monitoring: flood mapping
Using deep learning to map inundation, using meter-scale resolution satellite

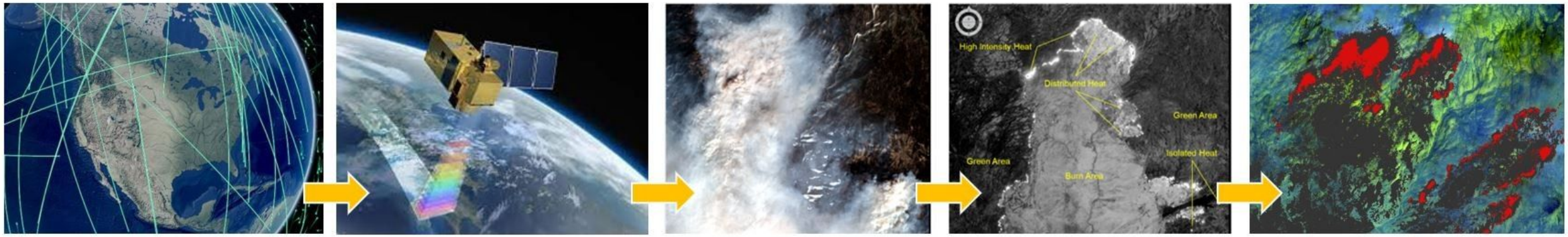
FLOODBASE



LEAP

How can AI help? 1. Resilience

Monitoring: wildfire progression
Using deep learning to track wildfire progression:
RADR - FIRE/ DOE PNNL
Rapid Analytics for Disaster Response



How can AI help? 2. Improved prediction

Weather: **up to 2 weeks**

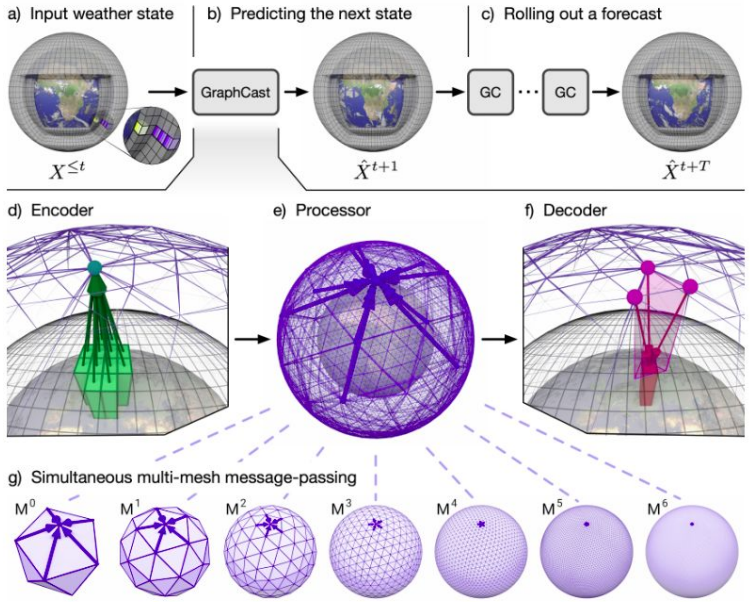
AI can have similar or *better* skill than weather centers prediction.
Europe is leading the way (integrating AI in weather forecasting)

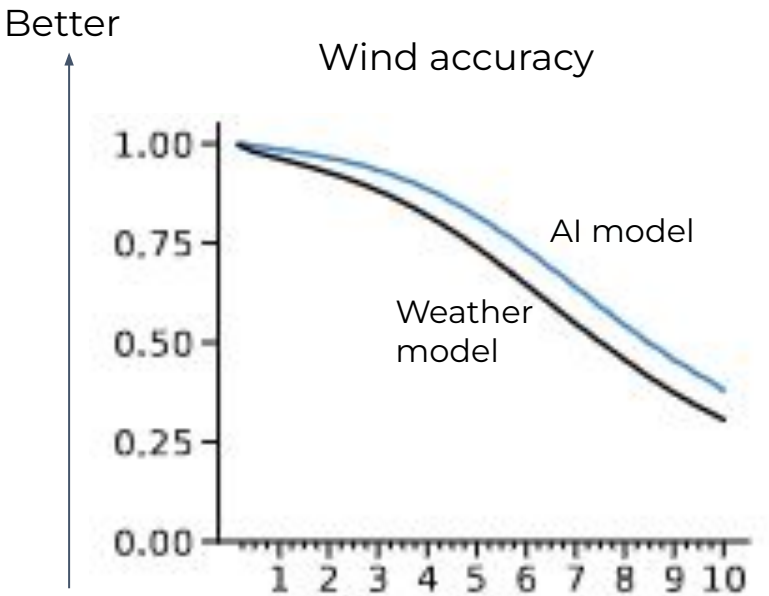
GraphCast: Learning skillful medium-range global weather forecasting

Remi Lam[*,1], Alvaro Sanchez-Gonzalez[*,1], Matthew Willson[*,1], Peter Wirnsberger[*,1], Meire Fortunato[*,1], Alexander Pritzel[*,1], Suman Ravuri[1], Timo Ewalds[1], Ferran Alet[1], Zach Eaton-Rosen[1], Weihua Hu[1], Alexander Merose[2], Stephan Hoyer[2], George Holland[1], Jacklynn Stott[1], Oriol Vinyals[1], Shakir Mohamed[1] and Peter Battaglia[1]
[*]equal contribution, [1]DeepMind, [2]Google

Google DeepMind

and Nvidia, Huawei, ECMWF etc

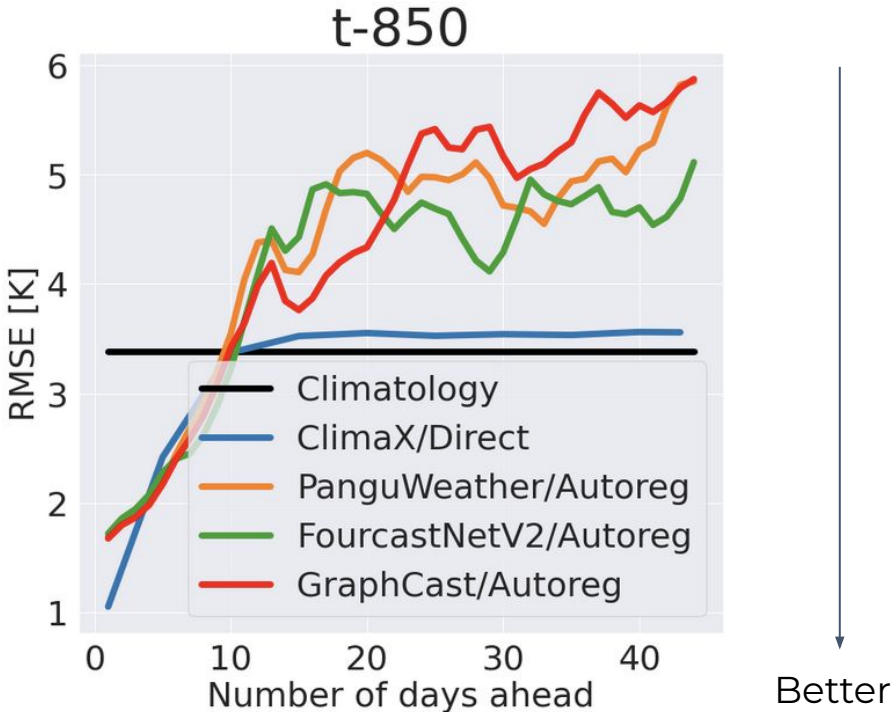




LEAP

How can AI help? 2. Improved prediction

After two weeks no accuracy from AI models (nor from physical models)



Subseasonal to seasonal prediction is a major challenge

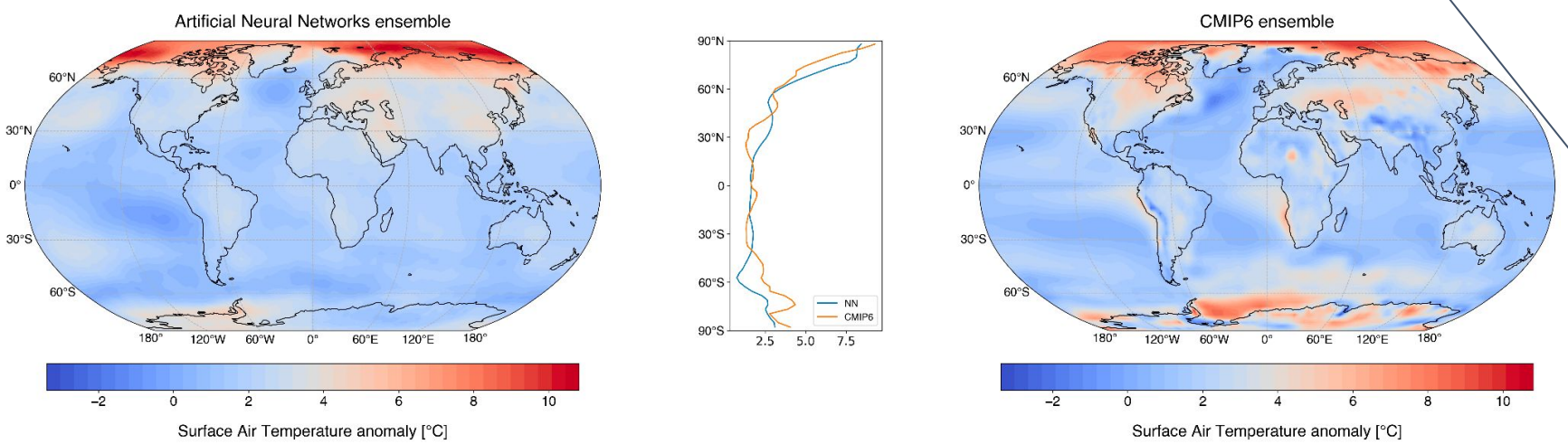
Critical for agriculture, insurance etc

Limited data: How many droughts or El Niño have we seen?

LEAP

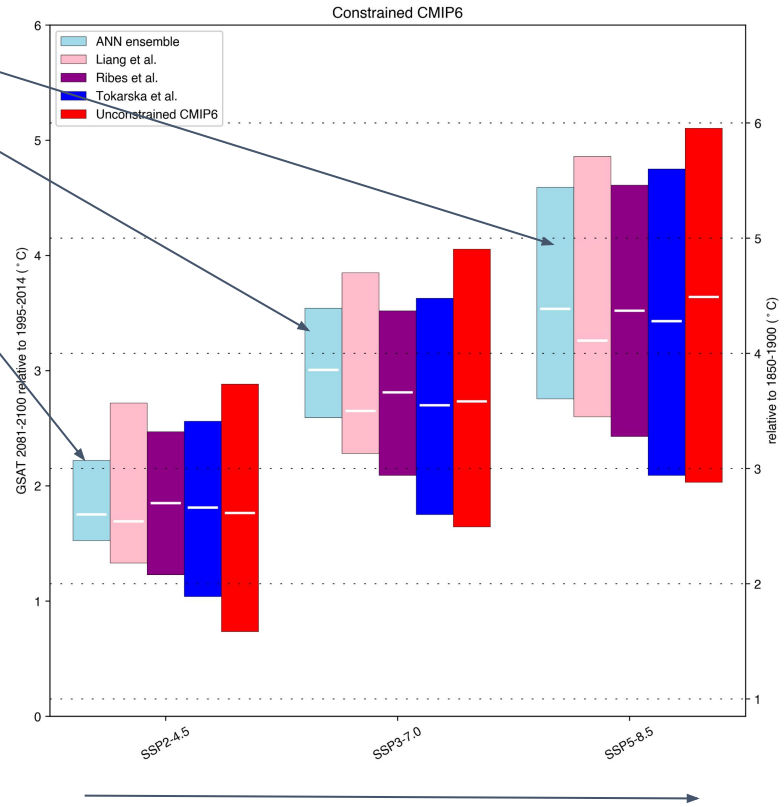
How can AI help? 3. Improved projections

AI can post-process climate models to correct them
and provide better estimate of climate change (here, temperature)



Machine learning projections

Physical model projections



More pessimistic greenhouse gas scenario

Immorlano, Gentine, Eyring, Aloiso, submitted

Summary

AI can help climate change adaptation & resilience in many ways

- Real-time Monitoring
- Prediction
  - Short-term weather forecasting
  - Short-term climate predictions (a few weeks to year)
  - Climate projections (>10 years)

Still some gaps:

- Seasonal to multi-year predictions, empirical indices for risks...
- Training data!

But we are in a *much better place to face risks* than a few years ago.

Not just academic work, tremendous private interest, boundaries are porous.

Feel free to reach out: pg2328@columbia.edu

How can AI help? 2. Improved prediction

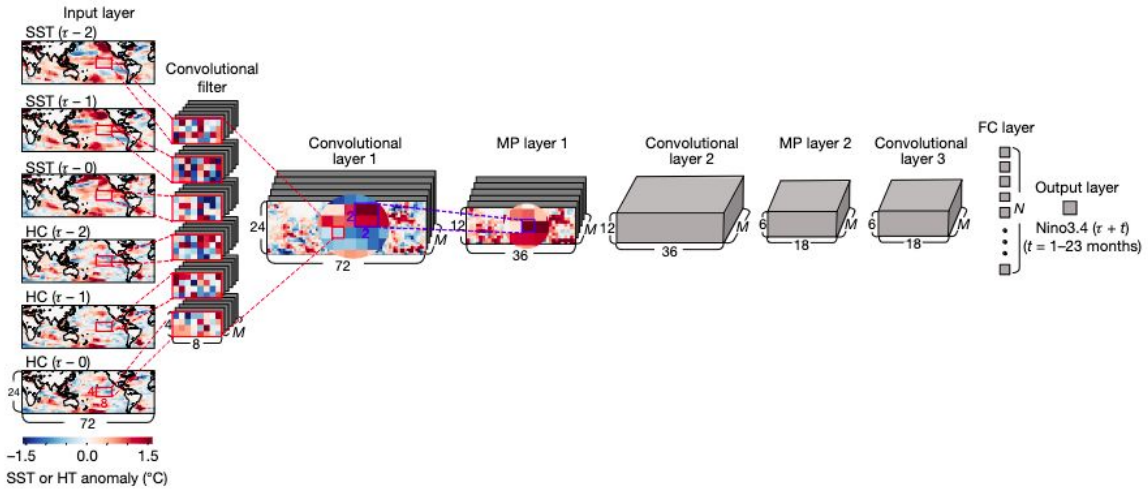
Seasonal to yearly **climate** prediction:
El Niño

LETTER

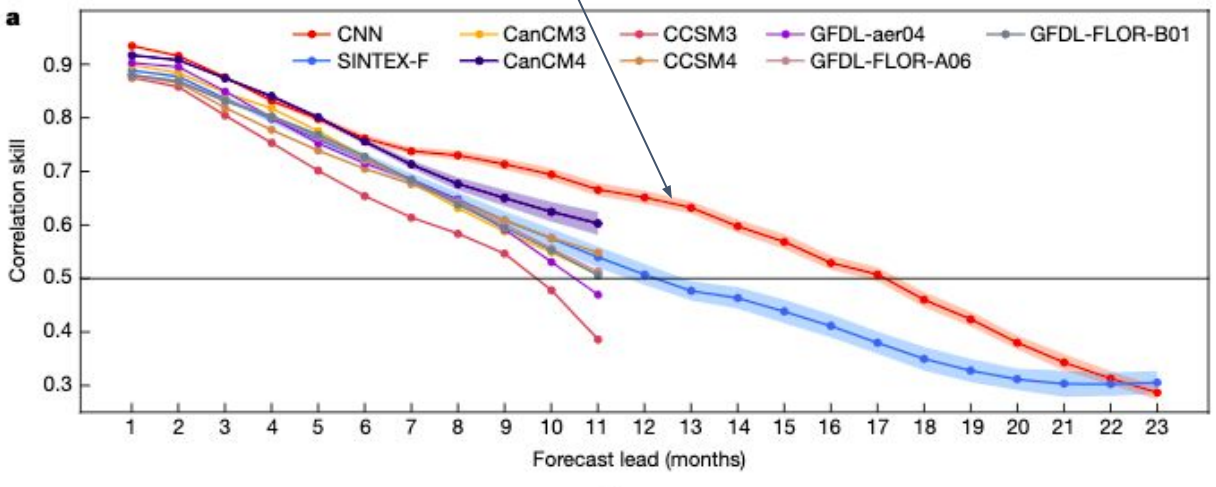
https://doi.org/10.1038/s41586-019-1559-7

Deep learning for multi-year ENSO forecasts

Yoo-Geun Ham[1]*, Jeong-Hwan Kim[1] & Jing-Jia Luo[2,3]

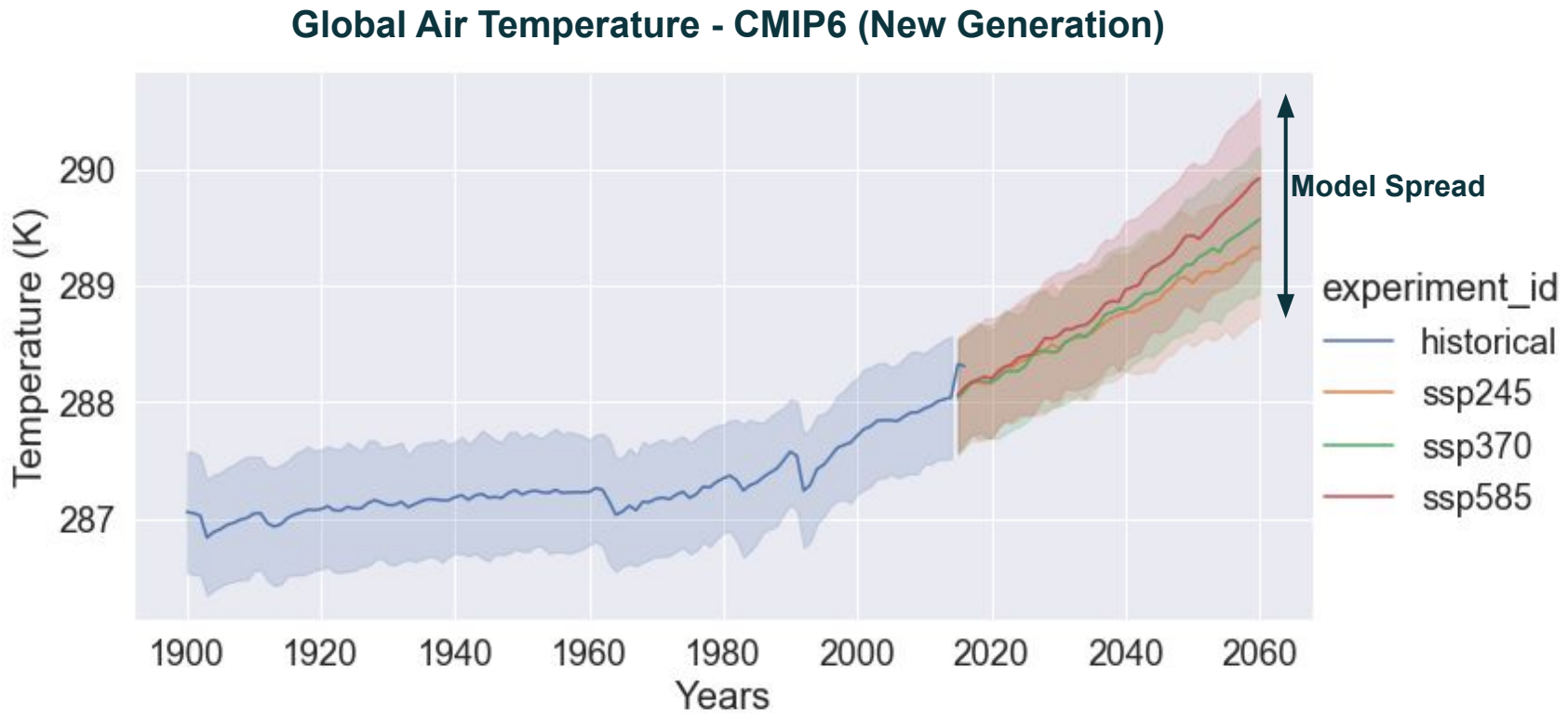


Better



Current gap: Climate Adaptation is Needed
but Requires Reliable Predictions and Projections

Current climate models are too uncertain



Climate models' forecasts do not translate into actionable adaptation

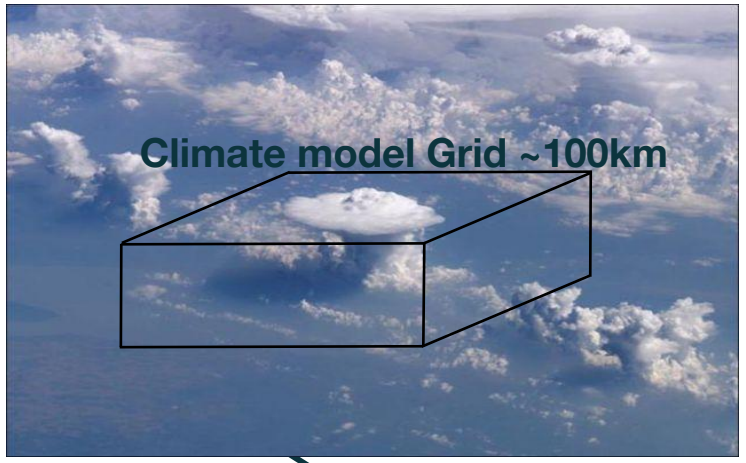
LEAP

How can AI help? 3. Improved projections

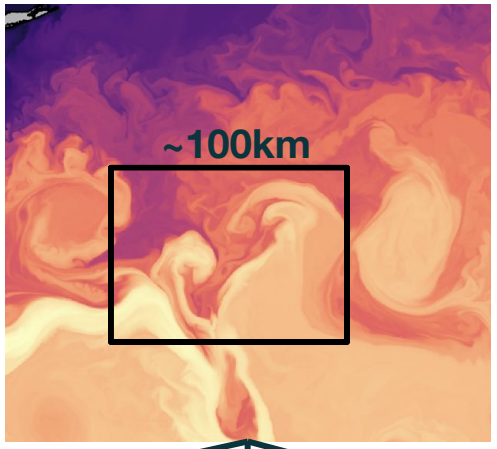
AI can help improve climate models:
unresolved physical processes cause model errors

Physical
+
Biological
Processes

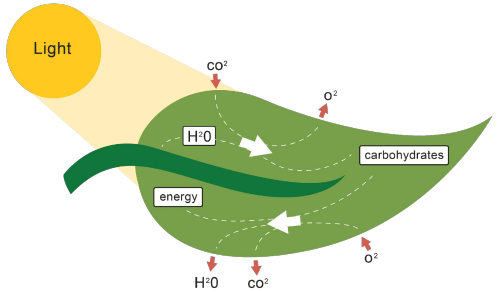
Clouds

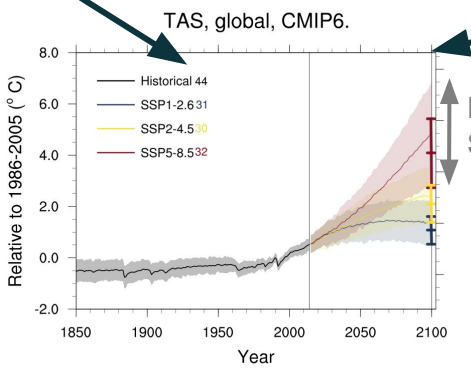


Ocean Eddies

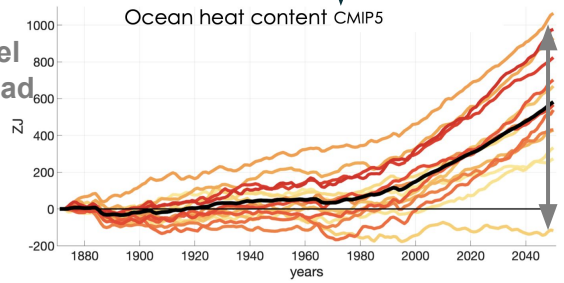


Photosynthesis

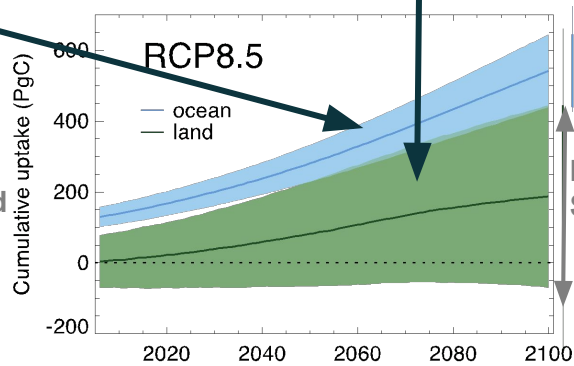




Model Spread



Model Spread

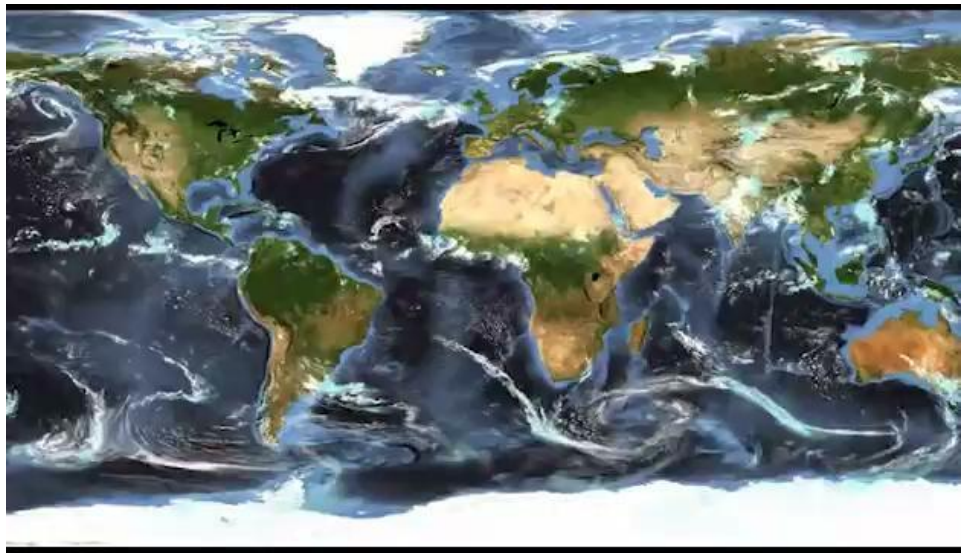


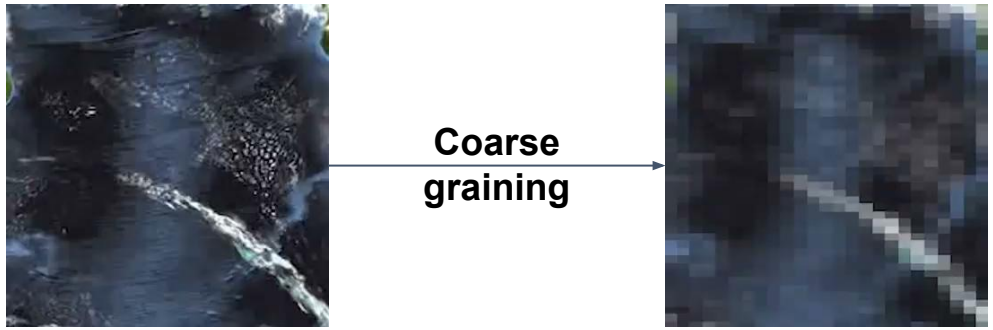
Model Spread

How can AI help? 3. Improved projections

Example of deep clouds (convection)

Deep learning to emulate physical processes at coarse resolution

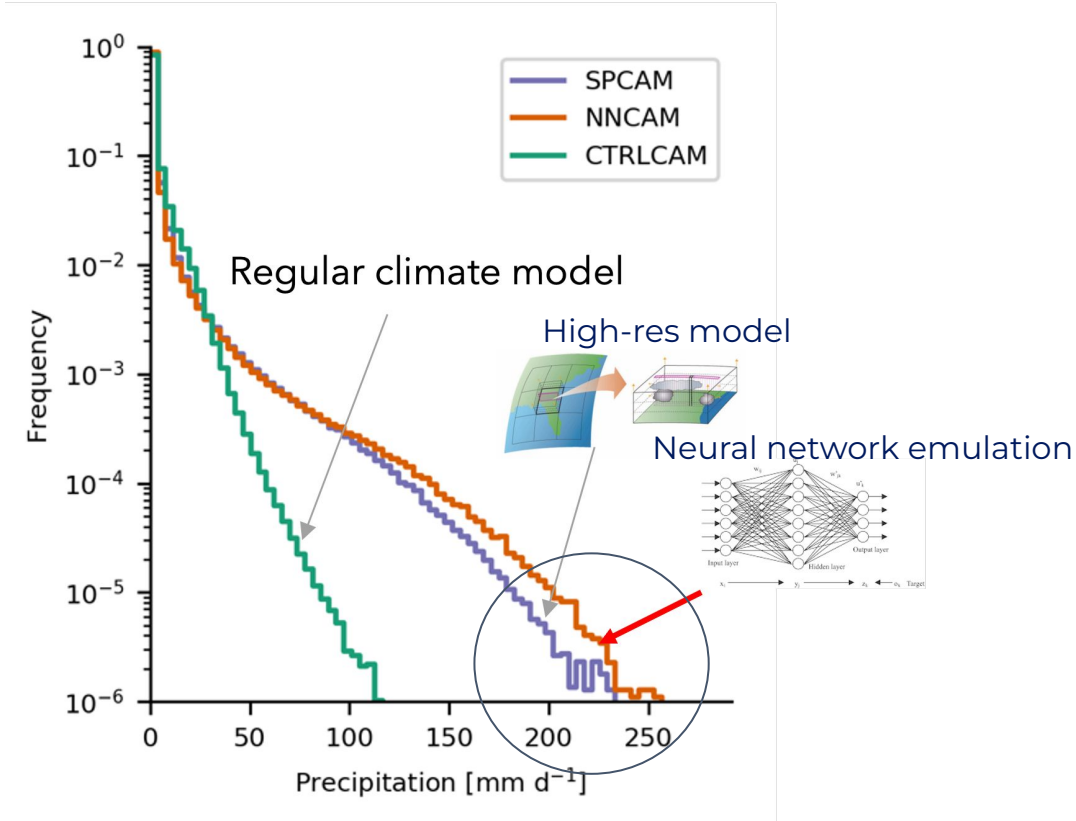




Gentine et al., 2018 *GRL*; Rasp et al., 2018 *PNAS*, Shamekh et al 2023, *PNAS*

How can AI help? 3. Improved projections

Step-change improvements in extremes
→ critical for inundation and flood projections



Rasp et al., 2018 PNAS; Shamekh et al .PNAS 2023

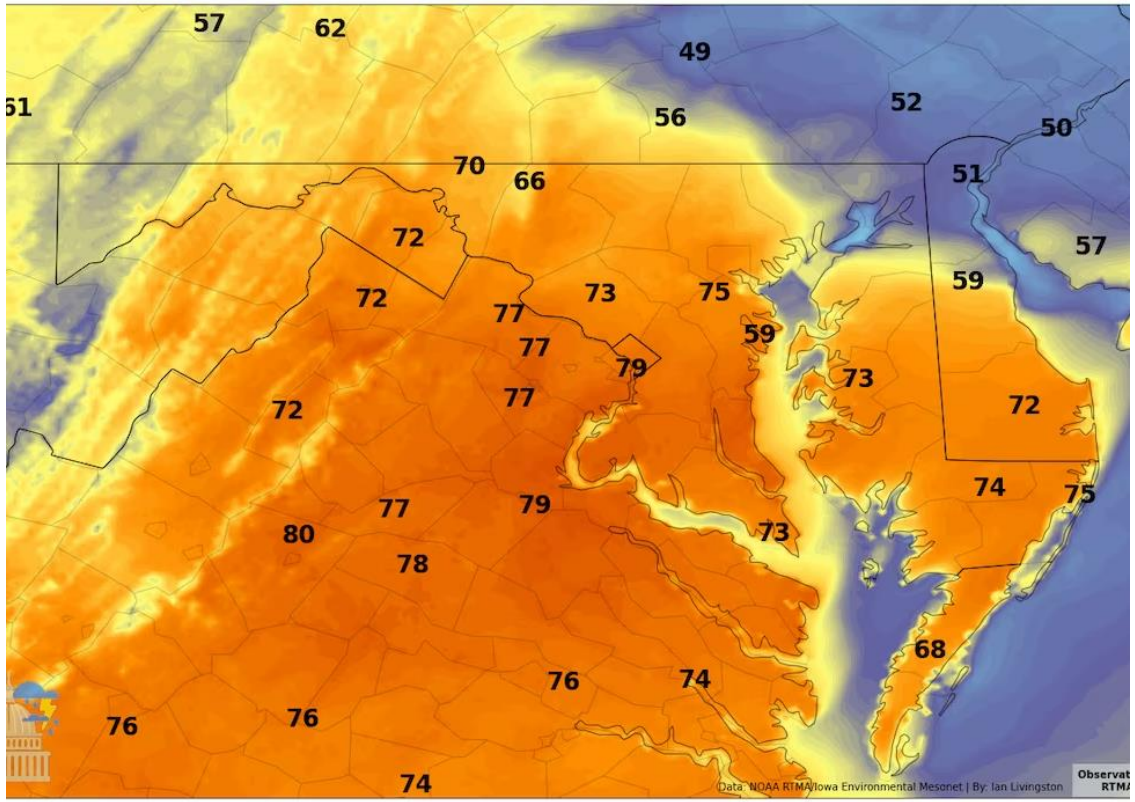
Weather Forecasting Challenges, and Efforts to Address Them

Dan Stillman,
Co-Founder and Meteorologist
The Washington Post's Capital Weather Gang

EESI Congressional Briefing
February 15, 2024

The Washington Post
Democracy Dies in Darkness

Washington soars to 80 degrees, its highest January temperature on record



1. https://www.washingtonpost.com/weather/2024/01/26/dc-record-january-temperature-climate/
2. https://www.washingtonpost.com/weather/2024/01/25/record-warmth-earth-climate-europe/
3. https://www.washingtonpost.com/weather/2024/01/17/climate-change-cold-extremes-arctic/

- Jan. 26: Highest January temperature in D.C. since record keeping began in 1872[1]
- Earliest 80-degree day by several weeks; previous earliest was Feb. 21 in 2018[1]
- Occurred during worldwide warm spell with record warmth on nearly every continent[2]
- Just a week after snow and arctic cold blast
- Intense cold snaps still happen in a warming world, but they are becoming less extreme
- Warm spells becoming more extreme
- Warm records outpacing cold records; 31,611 warm records in 2023 compared to 10,493 cold-weather records[3]

Model forecasts for Jan. 26

5-day forecast

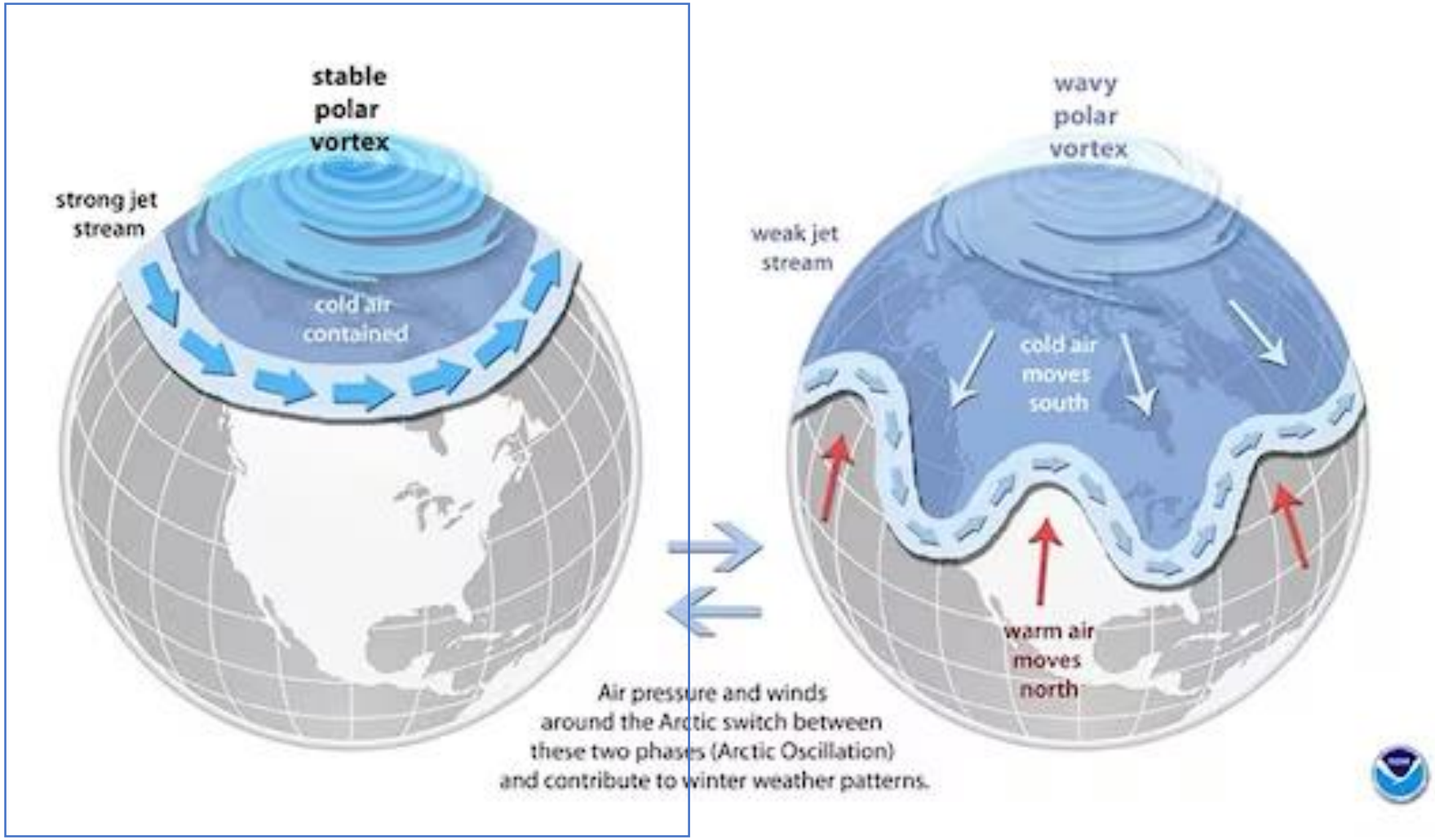
Model	Metric	Day 1 Sun 2024-01-21		Day 2 Mon 2024-01-22		Day 3 Tue 2024-01-23		Day 4 Wed 2024-01-24		Day 5 Thu 2024-01-25		Day 6 Fri 2024-01-26		Day 7 Sat 2024-01-27		Day 8 Sun 2024-01-28	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
ECMWF-EPS	Value	20	32	14	41	25	47	37	49	48	64	53	67	46	54	42	47
GFS-ENS	Value	16	31	18	37	28	41	37	51	50	63	55	65	50	59	41	51
GFS-ENS-BC	Value	17	32	16	37	28	39	35	46	44	60	54	65	50	61	41	53
GFS	Value	18	32	14	40	26	44	37	43	41	52	49	55	42	54	37	47
ECMWF	Value	21	32	12	40	25	48	38	50	51	65	53	71	45	57	42	46
ICON-GLOBAL	Value	17	34	18	41	32	43	38	45	42	47	44	64	39	50		
Ensemble Mean	**Value**	**19**	**32**	**15**	**38**	**26**	**43**	**39**	**50**	**50**	**62**	**54**	**65**	**48**	**55**	**43**	**48**
Operational Mean	Value	19	33	15	40	27	45	38	46	45	54	49	63	42	54	40	46
Climo		30	45	30	45	30	45	30	45	30	45	30	45	30	45	30	45
Prior Year		34	44	33	43	39	47	33	52	36	48	40	50	32	47	34	58
Records		-4 1985	70 1959	1 1893	76 1927	0 1936	72 1974	3 1963	73 1950	3 1935	75 1950	5 1948	80 2024	6 1935	75 1974	-2 1935	73 1949

1-day forecast

Model	Metric	Day 1 Fri 2024-01-26		Day 2 Sat 2024-01-27		Day 3 Sun 2024-01-28	
		Min	Max	Min	Max	Min	Max
ECMWF-EPS	Value	54	74	49	56	43	46
GFS-ENS	Value	55	73	49	57	43	51
GFS-ENS-BC	Value	53	72	48	57	42	52
GFS	Value	56	74	48	57	41	48
ECMWF	Value	52	74	48	58	40	48
ICON-GLOBAL	Value	53	70	45	56	42	46
Ensemble Mean	**Value**	**56**	**73**	**50**	**57**	**45**	**50**
Operational Mean	Value	54	73	47	57	41	47
Climo		30	45	30	45	30	45
Prior Year		40	50	32	47	34	58
Records		5 1948	80 2024	6 1935	75 1974	-2 1935	73 1949

Forecasts were as much as 10 to 15 degrees too low

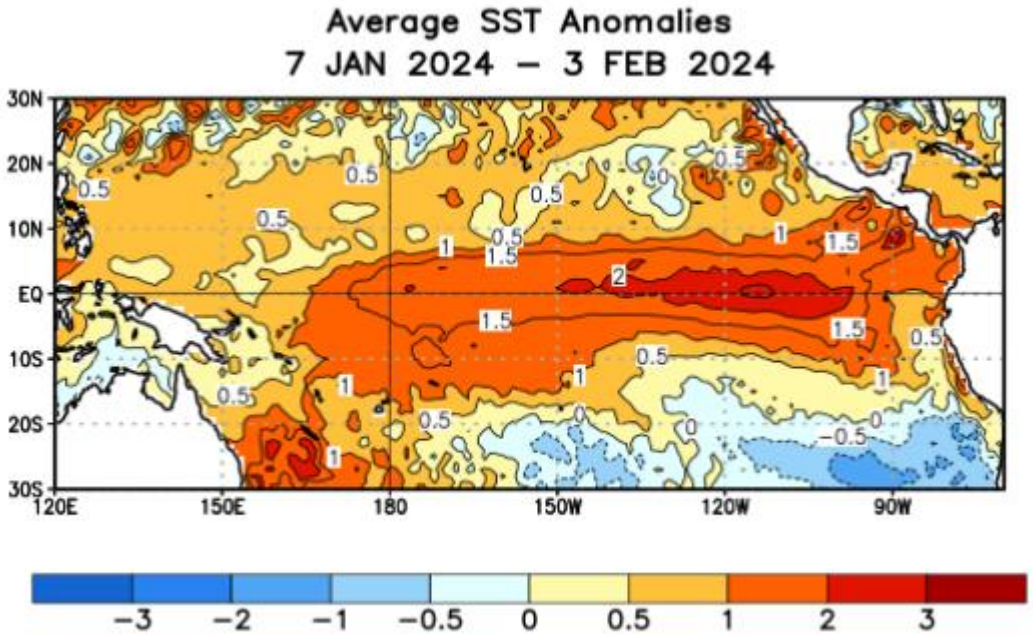
Contributing Factor: Strong, Stable Polar Vortex



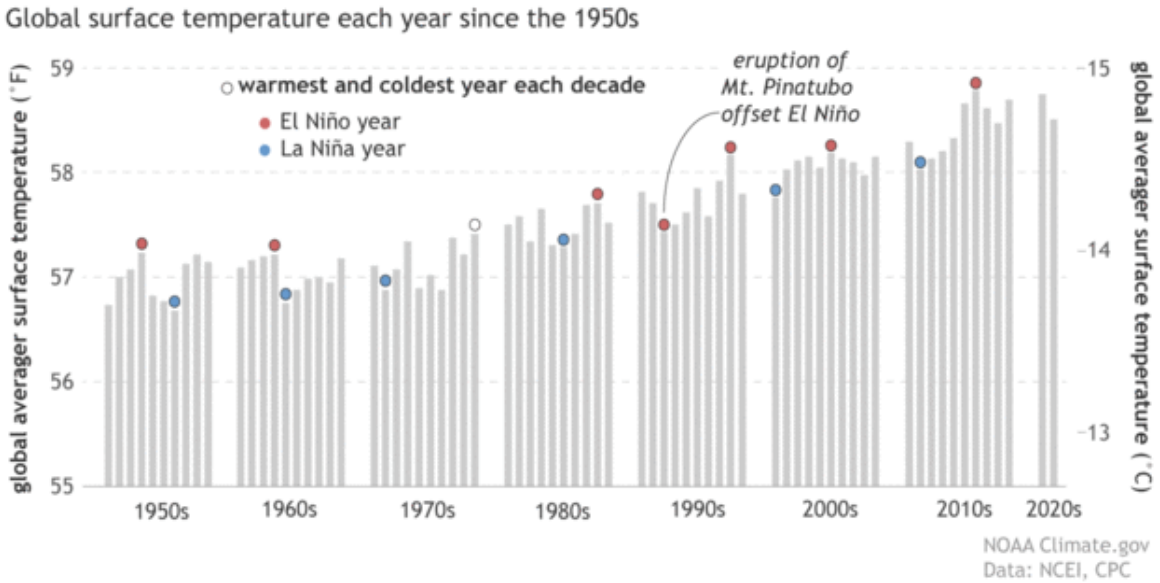
When polar vortex is strong and stable, cold air is locked up near Arctic

Contributing Factor: El Niño

Ongoing Strong El Niño

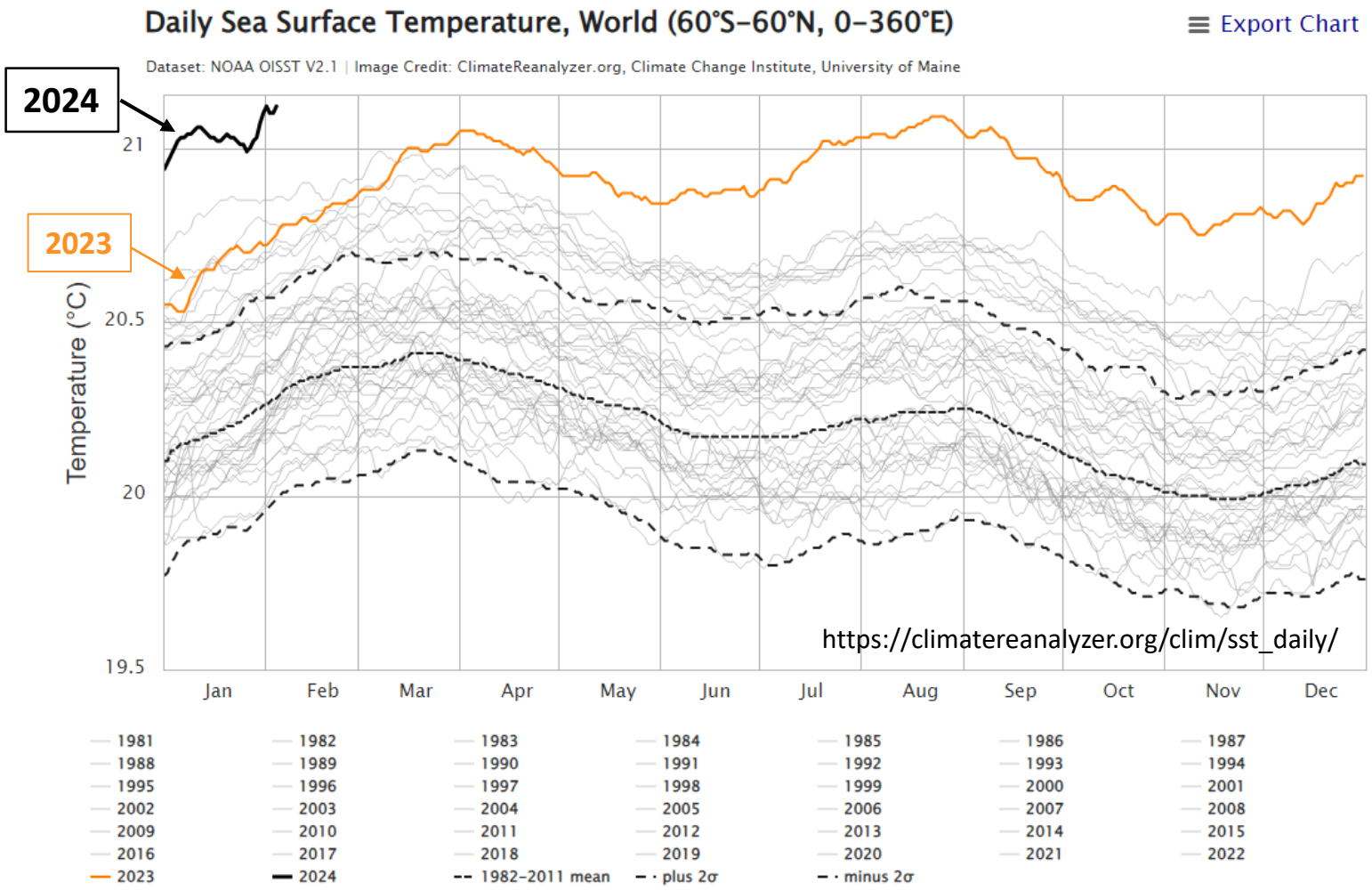


Warmest Years Are El Niño Years



El Niño increases the chance of breaking warm temperature records

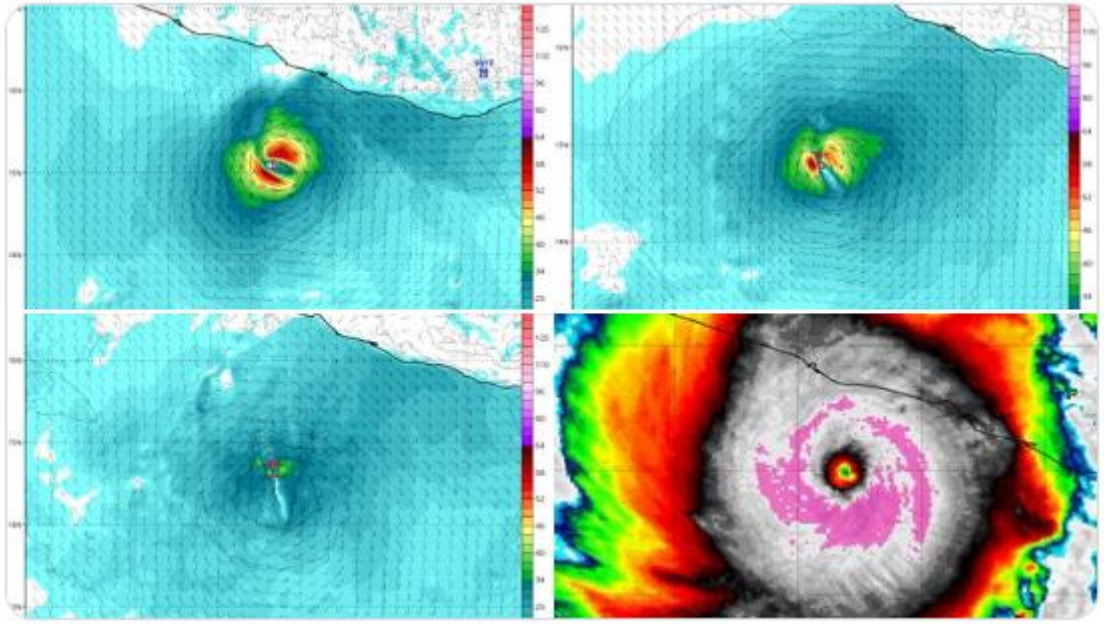
Contributing Factor: Record-Warm Oceans



Last year was warmest on record, even warmer to start 2024

Hurricane Otis forecast an ‘epic fail’

24-hour HWRF forecast **24-hour HMON forecast**

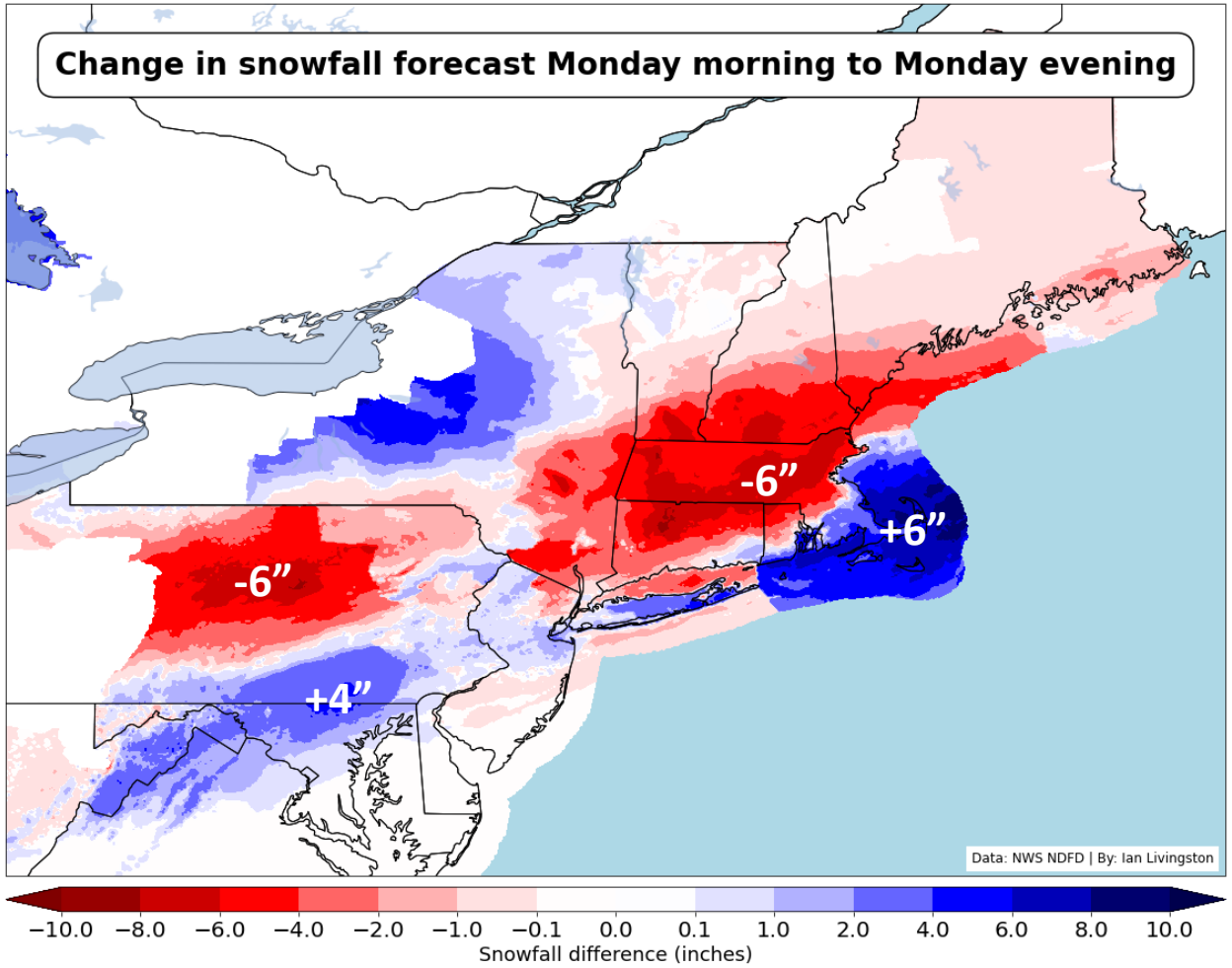


24-hour HAFS-A forecast **Actual**

Most models kept Otis below hurricane strength.
A day later it catapulted to a Category 5.

- Hurricane Otis made landfall on Acapulco Oct. 25, 2023
- First Pacific hurricane to make landfall at Category 5 intensity
- Winds increased by 90 mph, from a tropical storm to Category 5 hurricane, in 12 hours
- More hurricanes are rapidly intensifying due in part to warmer ocean waters and slower-moving storms
- Harder to predict, harder to prepare for

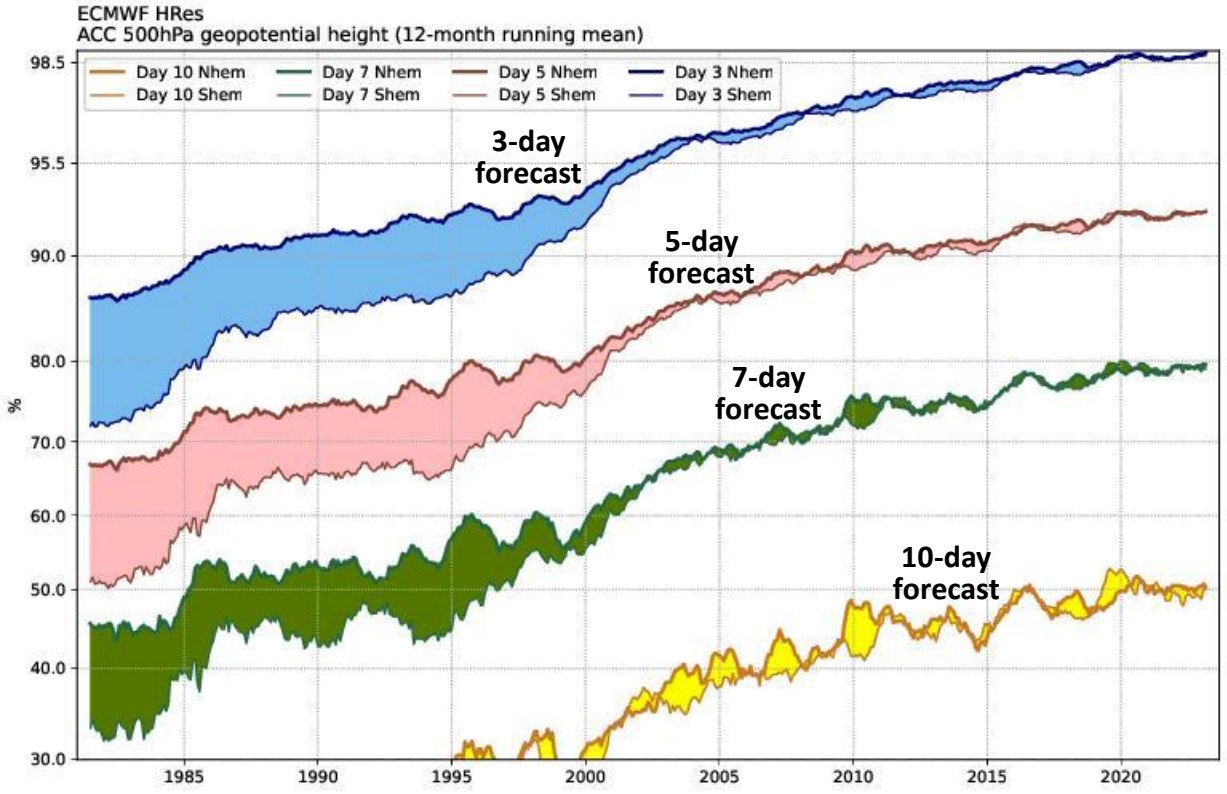
Feb. 13, 2024, Nor'easter confounds meteorologists



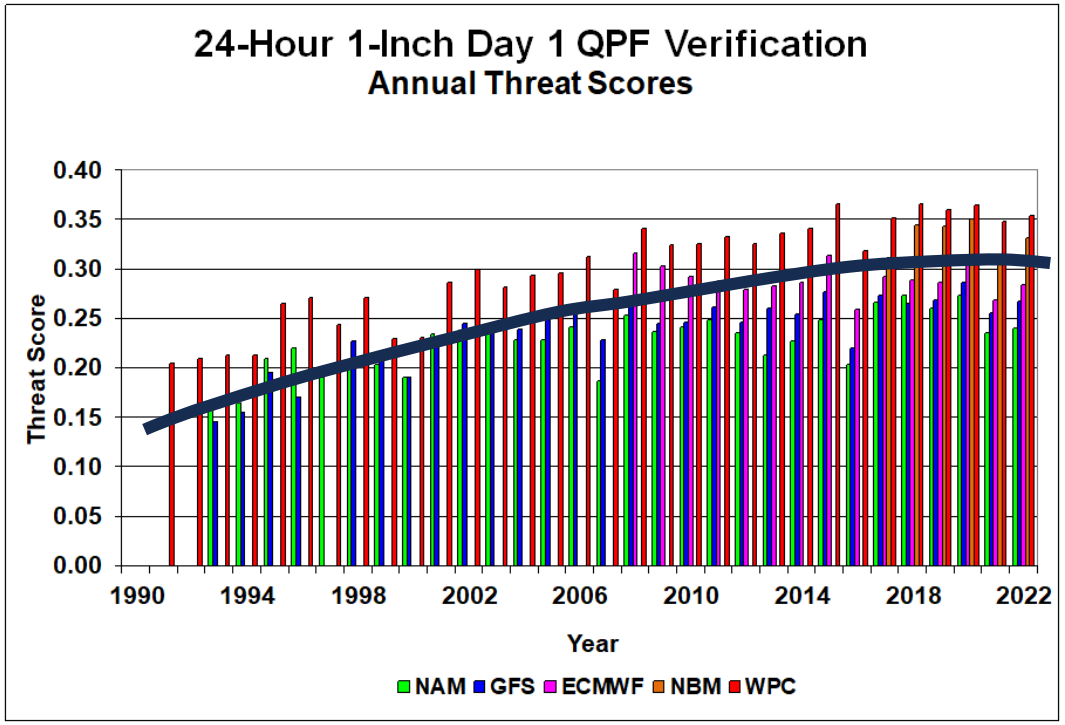
- Huge shift in snowfall forecasts the day before storm as models abruptly shifted storm significantly southward
- Boston forecast dropped from 7-13” to 4-8”; final total at Logan Airport was 0.1”
- Albany forecast dropped from 8-12” to 1-2”; final total: no accumulation
- Hartford forecast dropped from 8-12” to 4-8”; final total was 15”
- Forecast for portions of SE Mass jumped from 1-3” to 6-8”; final total was 4-6”

Flattening Rate of Forecast Improvement

Large-scale weather pattern accuracy

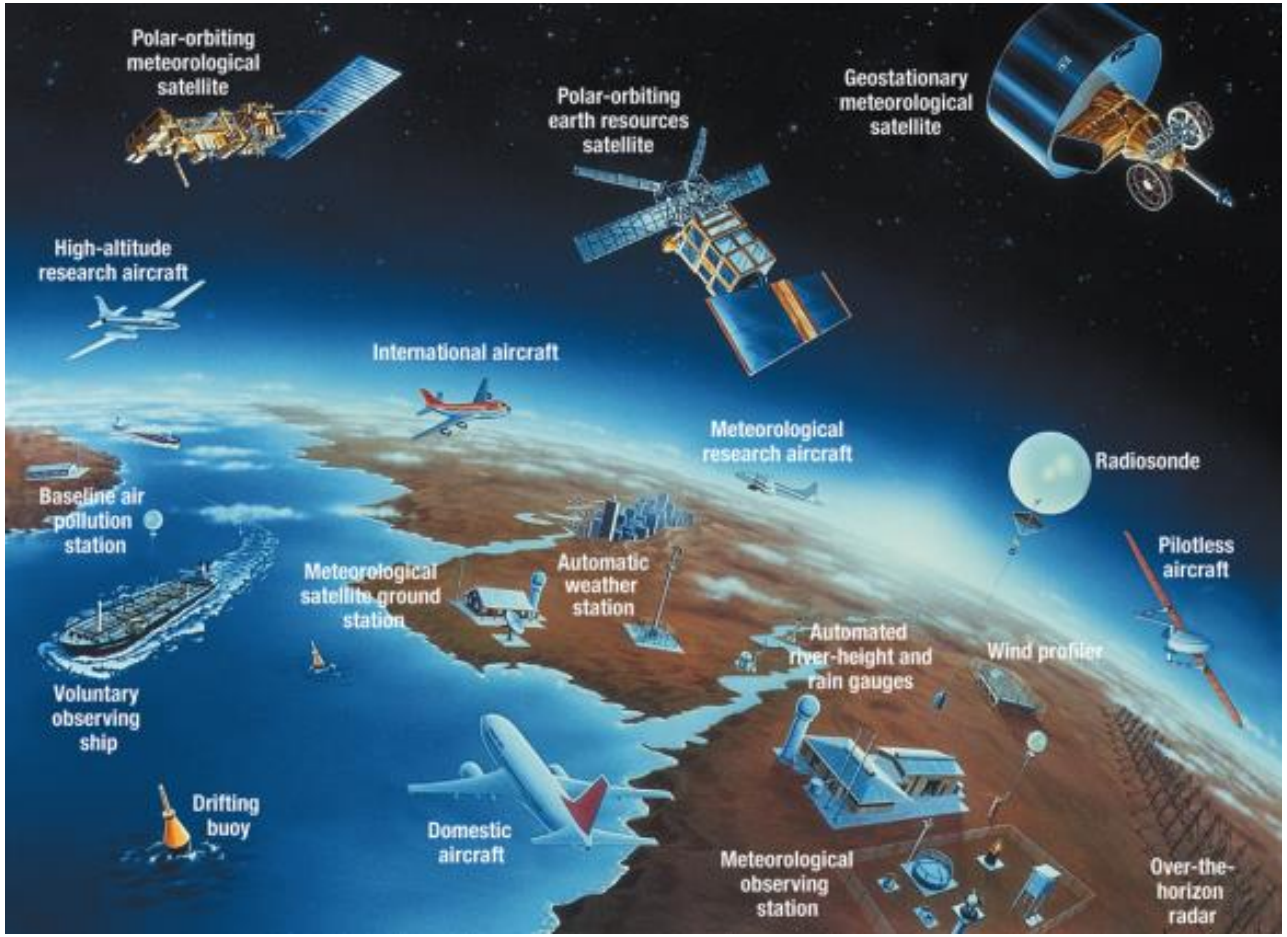


Precipitation forecast accuracy



Rate of forecast improvement has slowed, especially for precipitation,
but efforts to improve models continue

Backbone of Weather Forecasts: Observations



- NOAA and other government satellites, radars, weather balloons, aircraft, ground sensors, buoys, serve as backbone of global observation network
- International collaboration because local forecasts depend on global data
- Forecast models limited by incomplete, relatively scarce observations of surface and lower atmosphere
- NOAA continuing to explore and/or operationalize use of private-sector satellite, radar, buoy, and other data

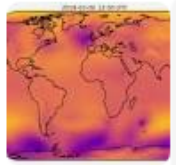
The Washington Post
Democracy Dies in Darkness

How Big Tech AI models nailed forecast for Hurricane Lee a week in advance

U.S. and European weather agencies are escalating their engagement with artificial intelligence as the technology rapidly advances

Washington Post

Google's AI weather forecast model is surprisingly accurate, study finds



Google has produced a weather forecasting model using artificial intelligence with better accuracy, faster speed and lower costs,...

Nov 14, 2023

Washington Post

Should we trust artificial intelligence to predict natural disasters?

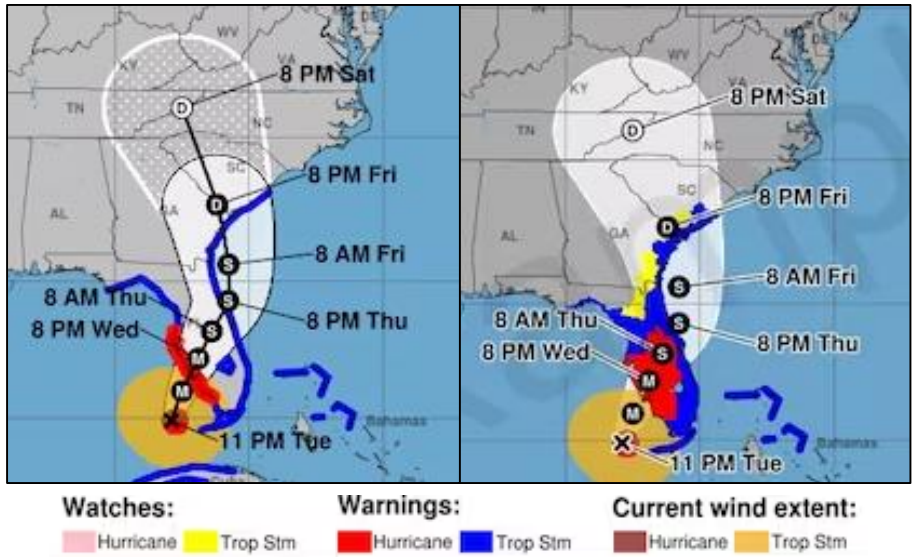
Count weather forecasting among the numerous industries AI has the potential to transform. Artificial intelligence is already helping...

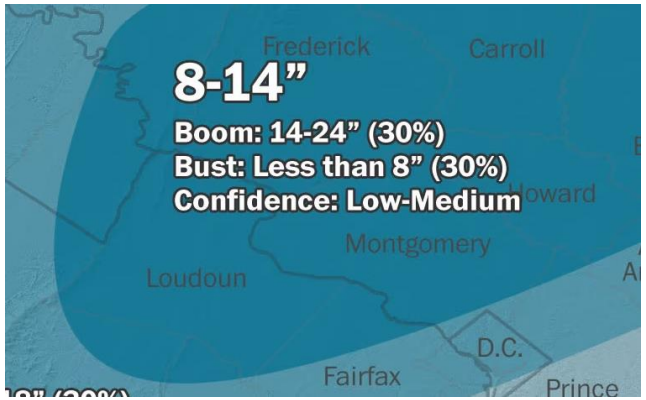
Jul 4, 2023

- Big Tech, including Google, Microsoft and Nvidia, have made rapid advances in AI weather modeling in the last 2 years
- AI models now as accurate, in some cases even more accurate, than traditional models
- AI models are less expensive and much faster to run than traditional models; could enable more confident forecasts and better capture extreme conditions
- But it's a symbiotic relationship. AI models are trained on traditional models and use their data as starting point to make forecasts
- Government weather agencies, including NOAA, accelerating AI modeling activities and collaborating with private sector

To Be Effective, Accurate Forecasts Must Be Effectively Communicated

Existing NHC Cone **Experimental NHC Cone**





Capital Weather Gang’s ‘Boom-Bust’ Snow Map

- Social science is key to turning forecasts into well informed decisions
- Forecasts for low-probability, high-impact events especially challenging
- Experimental National Hurricane Center forecast cone this coming season; will highlight inland threats, not just on the coast
- NWS emphasis on better communication with, and embedding forecasters with, emergency managers
- NOAA Weather Program Office projects looking at how people understand probabilities, interpret weather risk graphics, and respond to severe weather

Messages to Congress

- More accurate forecasts, earlier warnings, better characterization of extreme scenarios, and more effective communication will save thousands more lives and provide millions to billions of dollars in economic benefit

- When you properly fund weather and climate agencies, you are investing in the entire U.S. weather and climate enterprise—the public, private, and academic sectors

- When you underfund any one component of forecasting, you undercut the end-user forecast and potential for personal, organizational, and economic benefit


The Frontline of Climate Communication
How to effectively communicate the impacts of climate change on extreme weather events & global disasters
WUSA9
TEGNA MARKETING SOLUTIONS

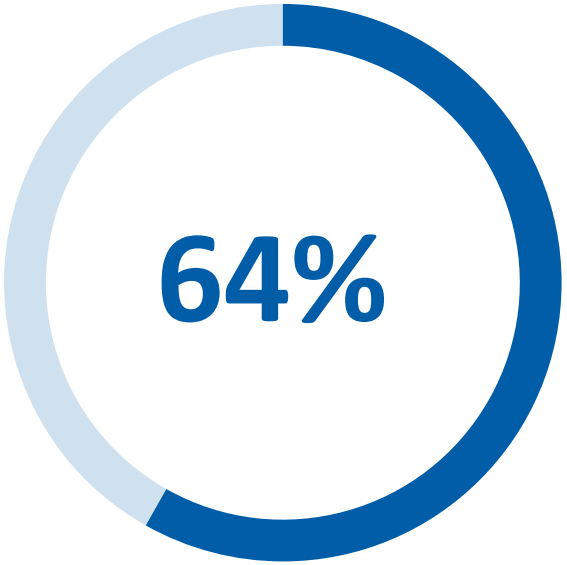
People Trust Meteorologists

Research shows that Broadcast Meteorologists are highly trusted sources of information about climate change.

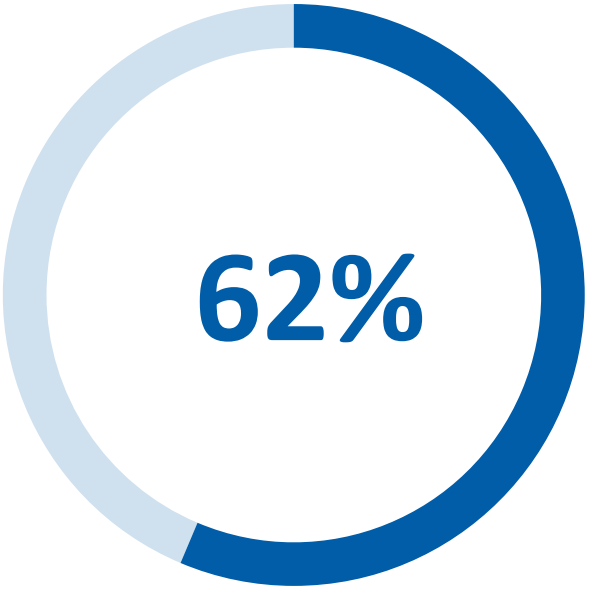
Source: Climate Matters

WUSA9 | TEGNA MARKETING SOLUTIONS

The Frontline of Climate Communication



Coverage of climate's impact on **local weather** is a strong reason to watch T.V.



Coverage of the climate's impact on **major weather events and disasters** is a strong reason to watch T.V.

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What Can We Do?

1 USE OUR PLATFORM

Access to the public through broadcast, digital and social media

2 EXPAND OUR ROLE

Cover stories about how climate change is impacting our community

3 CLOSE THE GAP

Helping the public understand climate science will lead to greater understanding, acceptance and action

How We Present Information

Meet our audience where they are

- Television
- WUSA9 app/website
- YouTube
- Instagram
- X
- Facebook

Make the big picture smaller

- Wildfire impacts on air quality
- Rising sea levels inundating the tidal basin
- Warming global temperatures & cherry blossoms
- Excessive rainfall and algae blooms
- Health impacts of extreme heat

Organizations We Partner With

- The National Weather Service
- NASA
- The National Oceanic and Atmospheric Administration
- Local Universities
- Covering Climate Now
- Yale Program on Climate Change Communications
- Climate Central

Solutions Journalism

Fruit Trees Need Winter

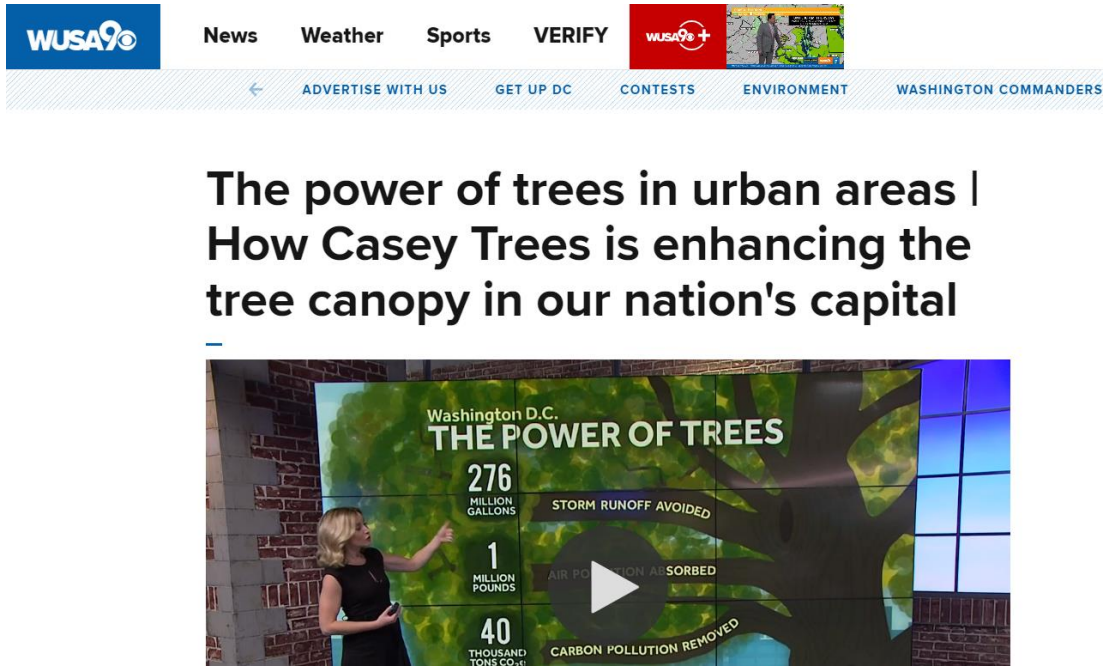
CLIMATE CENTRAL DATA

WUSA9 | TEGNA MARKETING SOLUTIONS

Solutions Journalism

The Power of Trees

CLIMATE CENTRAL DATA



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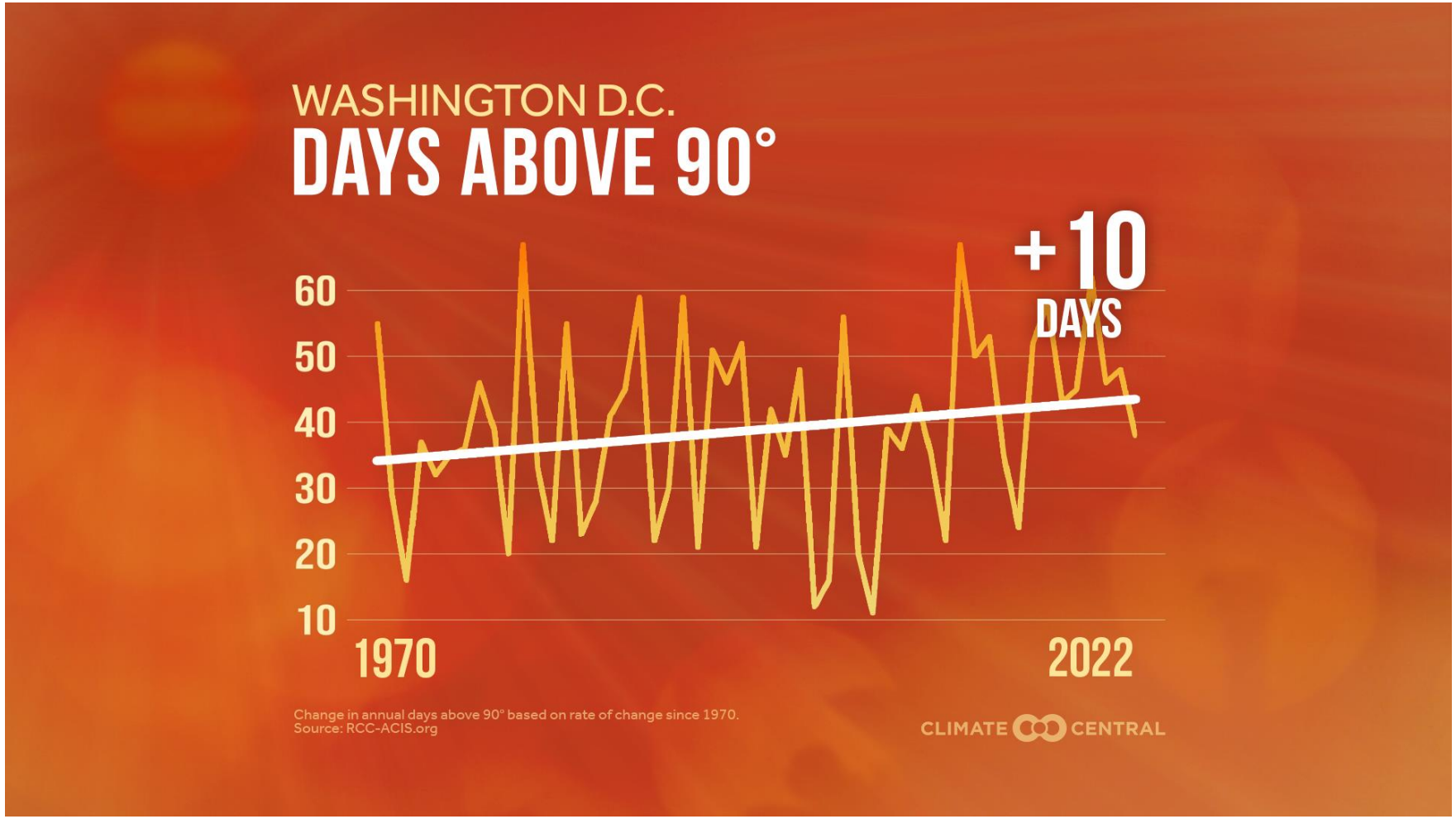
Using Climate Data in Weather Forecasts

A Climate Central Product



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Climate Shift Index

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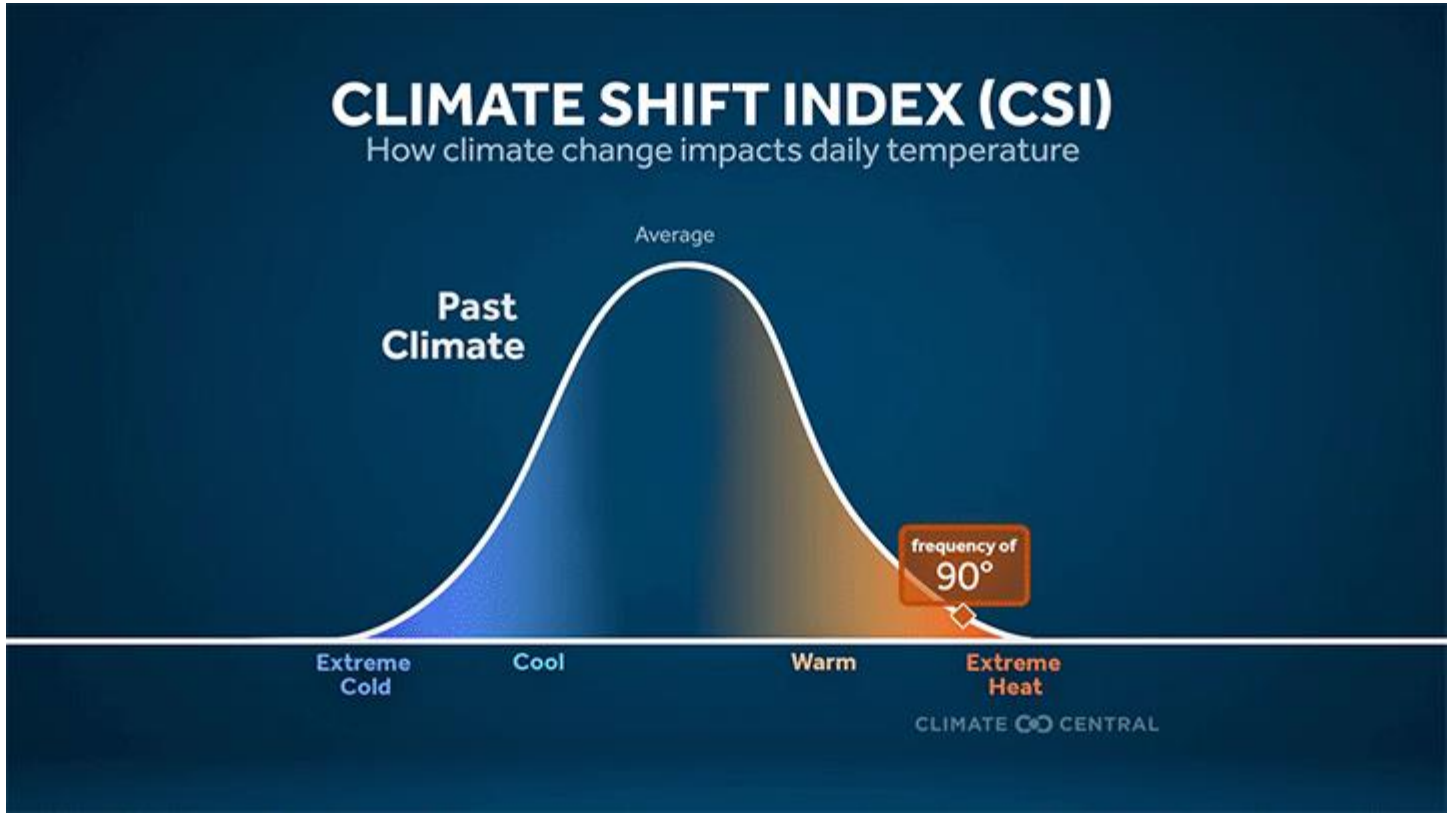

- CSI compares how often a given temperature will occur in our current climate, with the frequency of that temperature in a climate without global warming
- The scale used details how likely a temperature is in today's altered climate

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Temperatures that are more likely get a positive value, negative values indicate conditions that are less likely

Descriptor	CSI level	Interpretation	CSI level	Interpretation
No effect	**0**	The influence of climate change on the conditions (i.e. the daily high or low temperature) is not detectable. These conditions could occur about as often with or without climate change.	**0**	The influence of climate change on the conditions (i.e. the daily high or low temperature) is not detectable. These conditions could occur about as often with or without climate change.
Moderate	**1**	Climate change made the conditions at least 1.5 times more likely. A CSI level of 1 indicates a detectable climate influence.	**-1**	Climate change made the conditions at least 1.5 times less likely.
Strong	**2**	Climate change made the conditions at least twice as common. CSI levels of 2 and higher indicate a dominant climate influence.	**-2**	Climate change made the conditions at least 2x less common.
Very strong	**3**	Climate change made the conditions at least 3x more likely	**-3**	Climate change made the conditions at least 3x less likely
Extreme	**4**	Climate change made the conditions at least 4x more common. These conditions would be extremely rare without climate change.	**-4**	Climate change made the conditions at least 4x less common. These conditions are becoming extremely rare with climate change.
Exceptional	**5**	Climate change made the conditions at least 5x more likely, potentially far more. This is an exceptional event driven by climate change.	**-5**	Climate change made the conditions more than 5x less likely. These conditions are becoming exceptionally rare with climate change.

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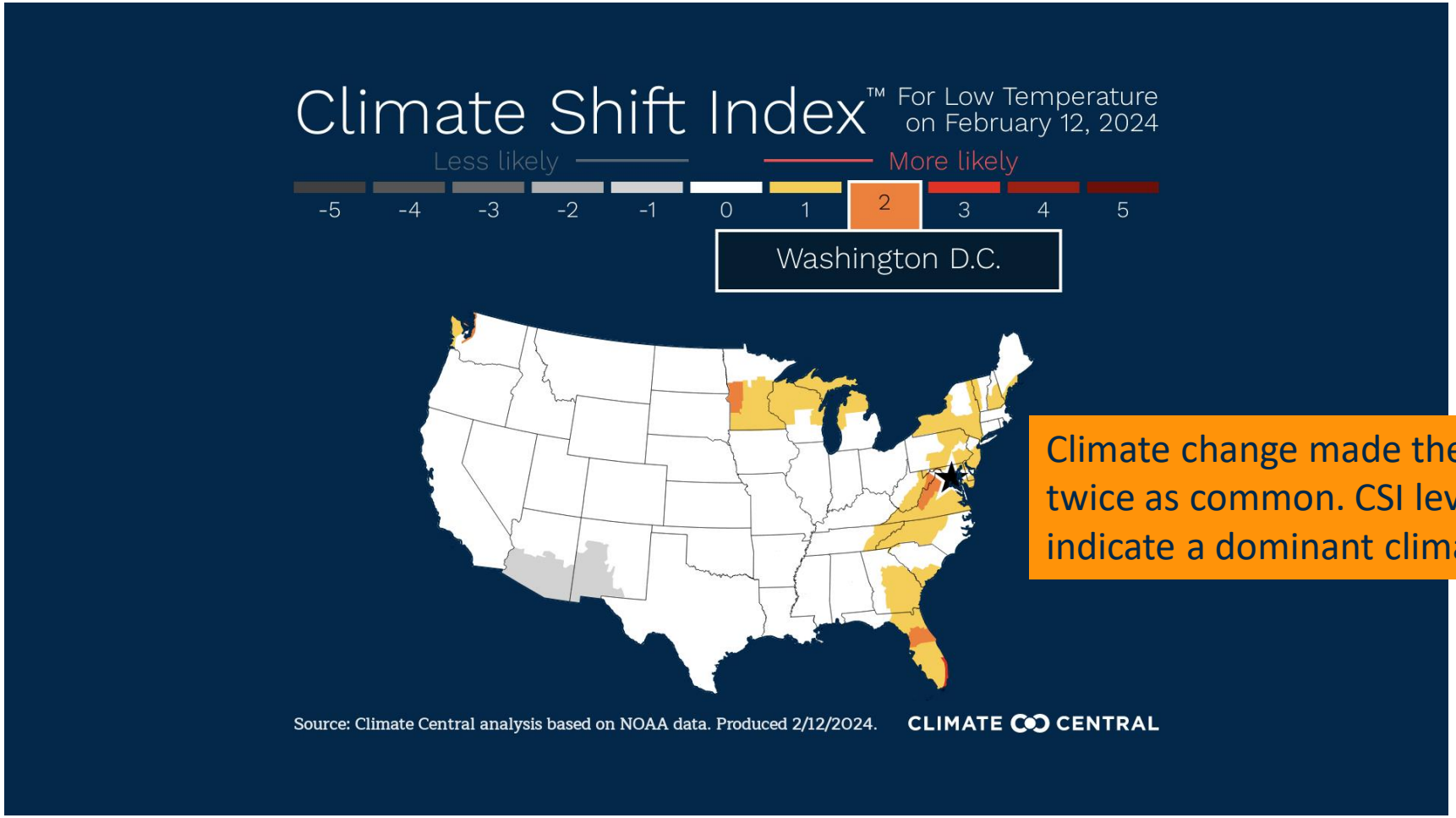

Climate change made the conditions at least twice as common. CSI levels of 2 and higher indicate a dominant climate influence.

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Thank you
Questions?
Let's connect!
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Resources

- Climate Central
- Covering Climate Now
- The National Weather Service
  - National Website
  - Local Office
- NASA
- The National Oceanic and Atmospheric Administration
- George Mason Center for Climate Change Communications
- Yale Program on Climate Change Communications