EESI
Environmental and Energy Study Institute

Materials will be available at:
www.eesi.org/041322climatechange
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CONGRESSIONAL BRIEFING

Living with Climate Change: The Polar Vortex Anticipating Threats and Building Preparedness

Wednesday, April 13, 2022

About EESI...

EESI
Environmental and Energy Study Institute

NON-PROFIT

Founded in 1984 by a bipartisan Congressional caucus as an independent (i.e., not federally-funded) non-profit organization

NON-PARTISAN

Source of non-partisan information on environmental, energy, and climate policies

DIRECT ASSISTANCE

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

SUSTAINABLE SOCIETIES

Focused on win-win solutions to make our energy, buildings, and transportation sectors sustainable, resilient, and more equitable

Policymaker Education

Briefings and Webcasts

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

Climate Change Solutions

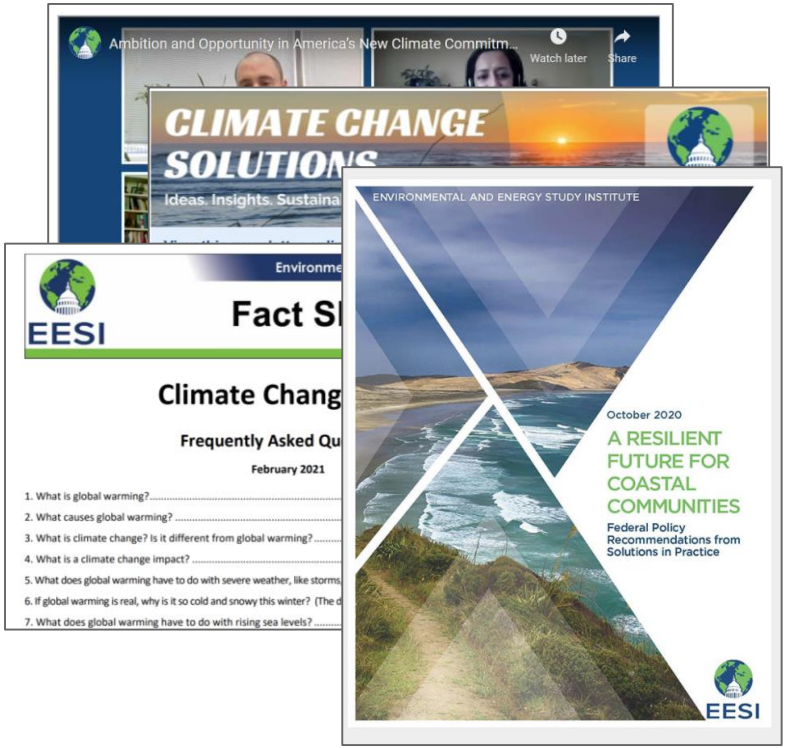
Bi-weekly newsletter with everything policymakers and concerned citizens need to know, including a legislation and hearings tracker

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



Upcoming Briefings & Series

Living with Climate Change

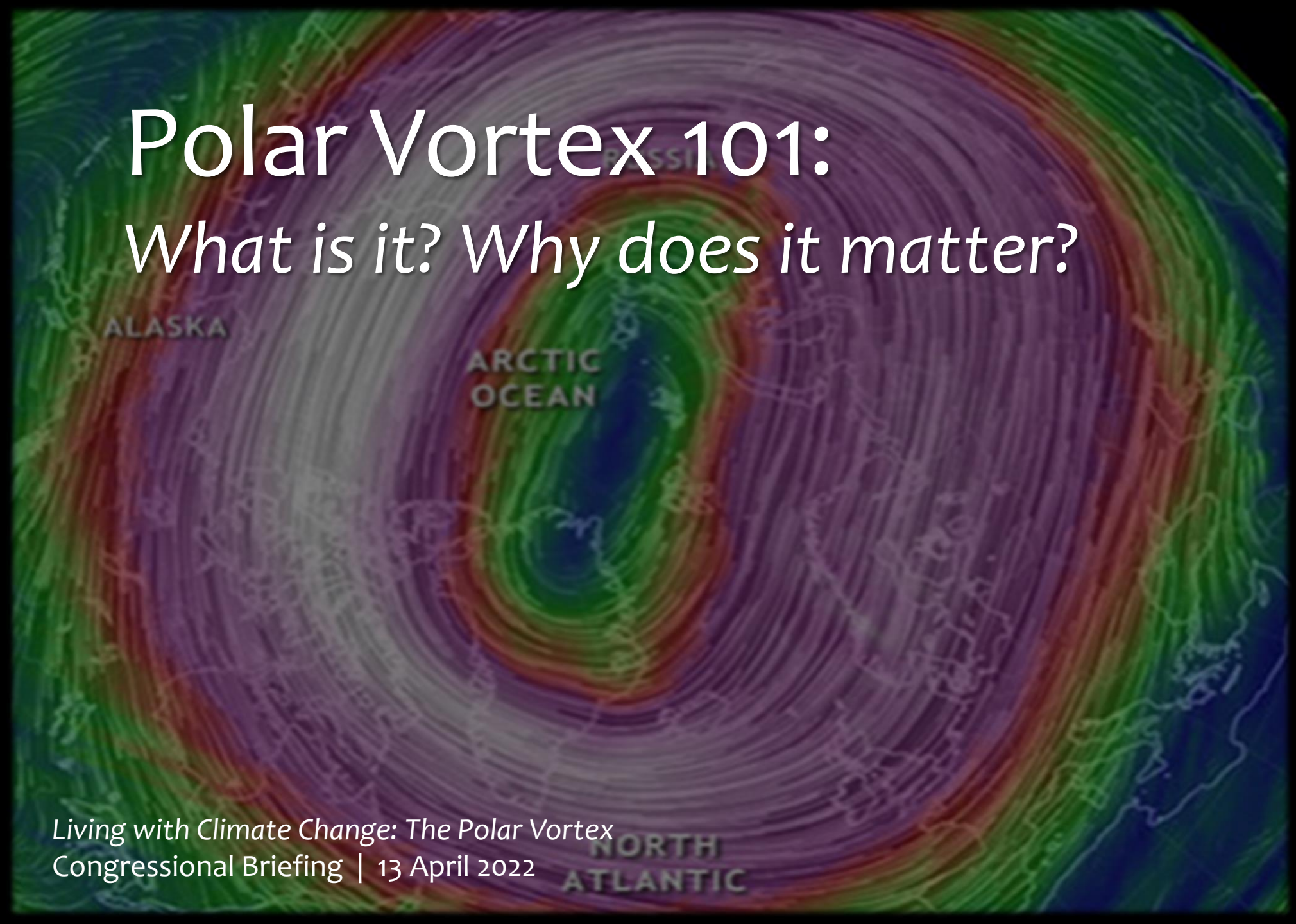
- **Polar Vortex**
- **Sea Level Rise**
- **Wildfires**
- **Extreme Heat**

Scaling Up Innovation to Drive Down Emissions

- **Green Hydrogen**
- **Direct Air Capture**
- **Offshore Wind Energy**
- **Electric Vehicle Charging**

Polar Vortex 101:

What is it? Why does it matter?



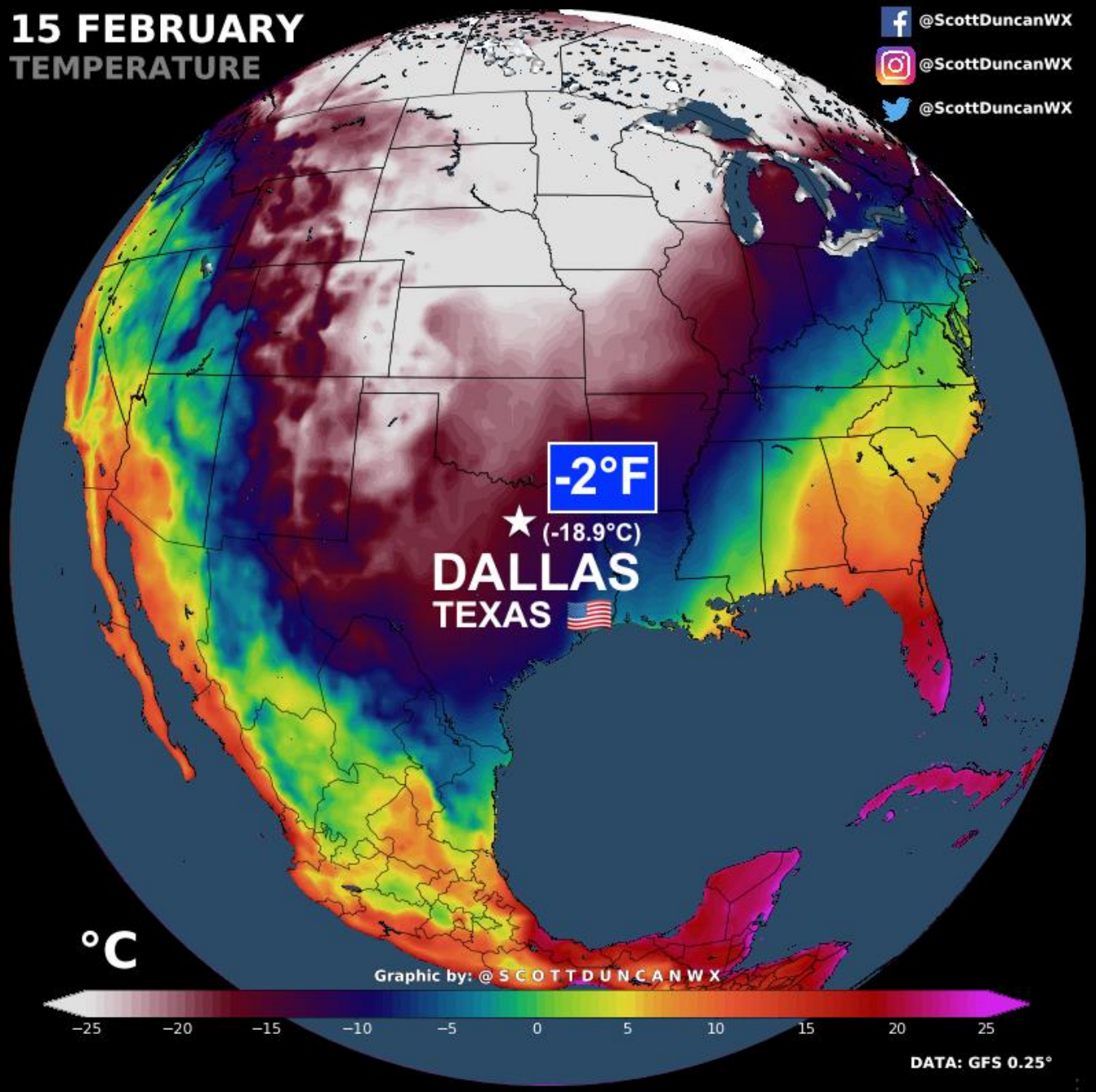
Living with Climate Change: The Polar Vortex
Congressional Briefing | 13 April 2022

Jennifer Francis PhD
Senior Scientist

Woodwell Climate Research Center

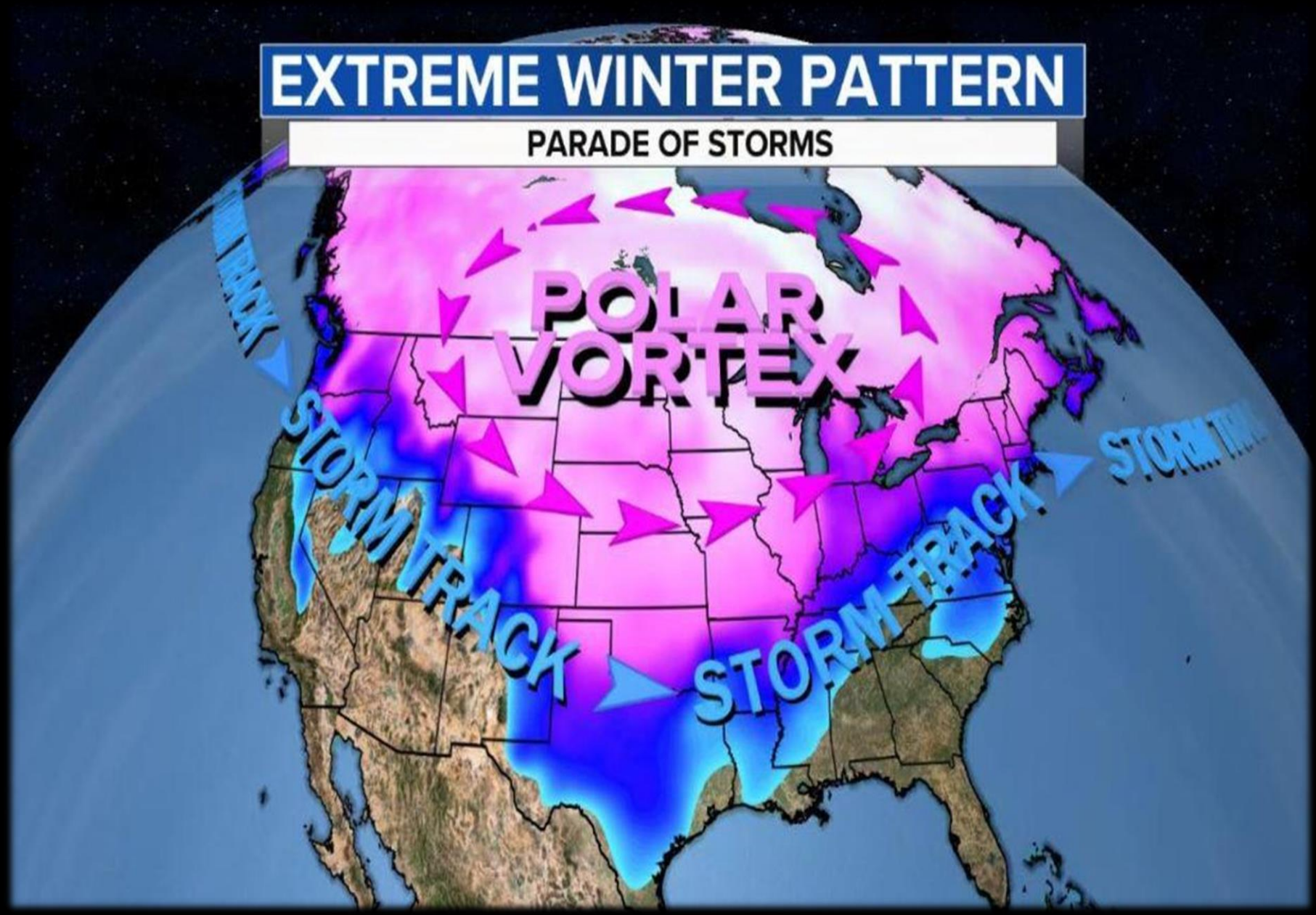
jfrancis@WoodwellClimate.org

Temperatures on 15 February 2021

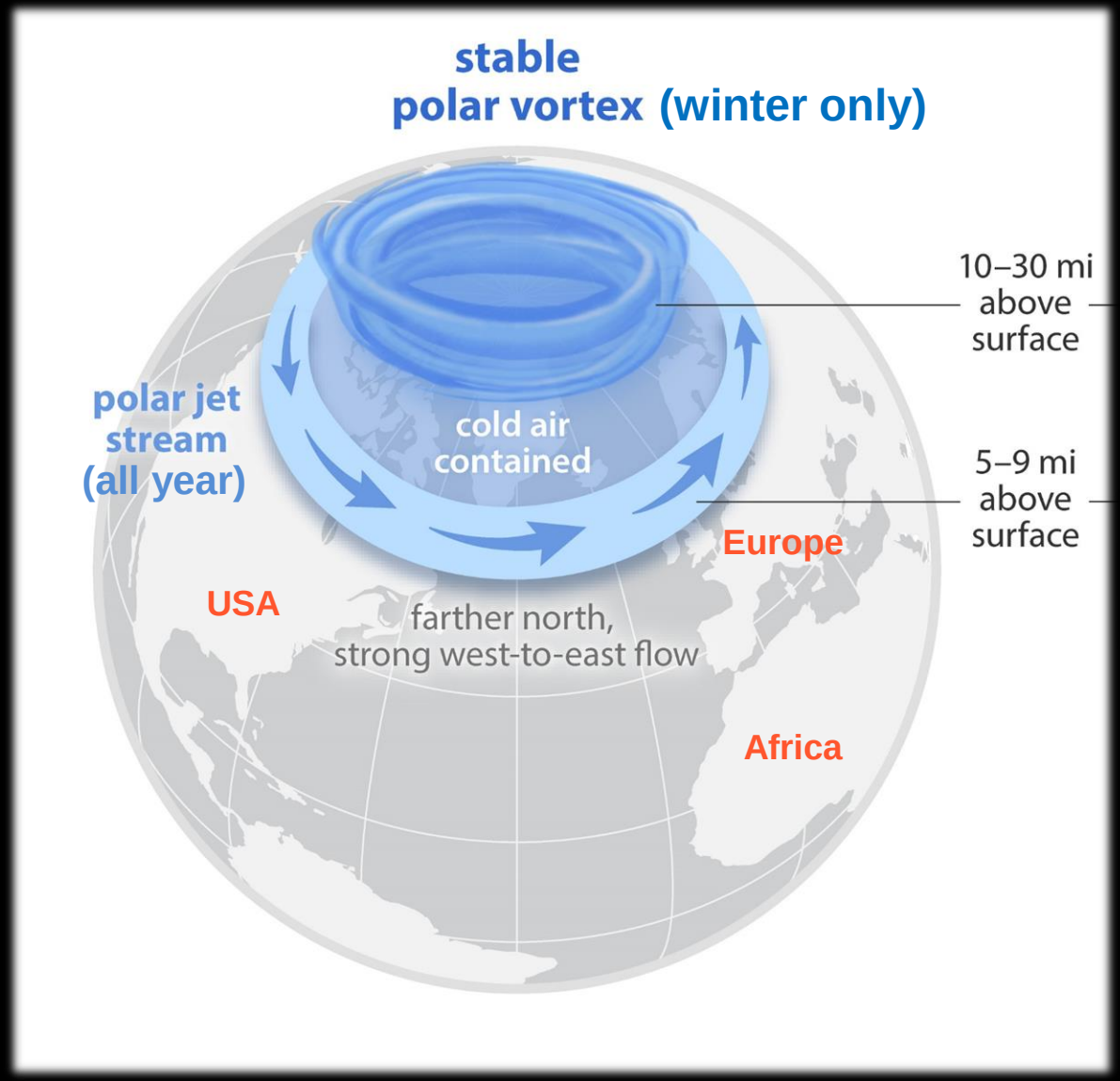


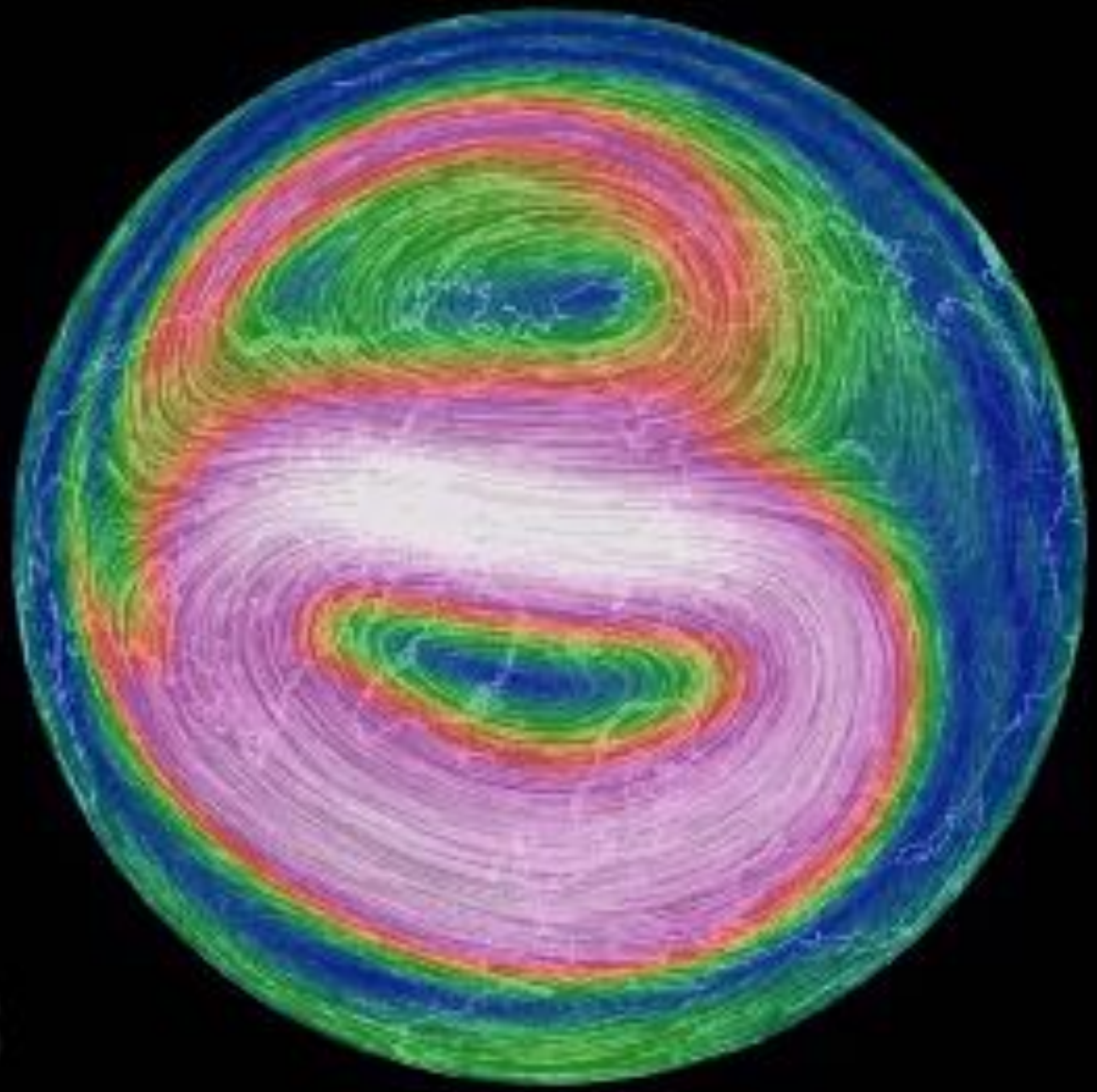
Why was this cold spell so severe?

Extreme jet stream + disrupted polar vortex



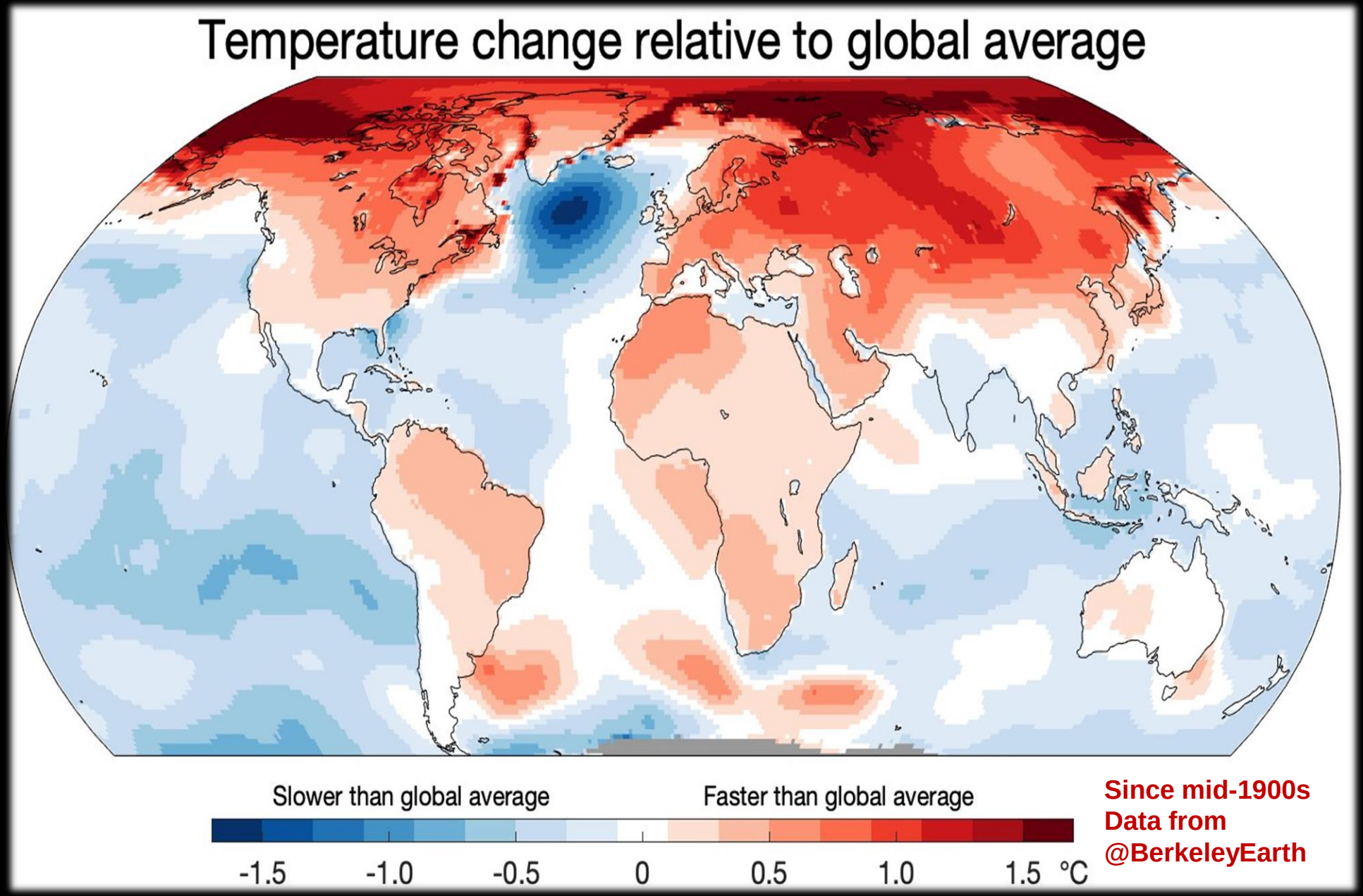
What is the polar vortex?





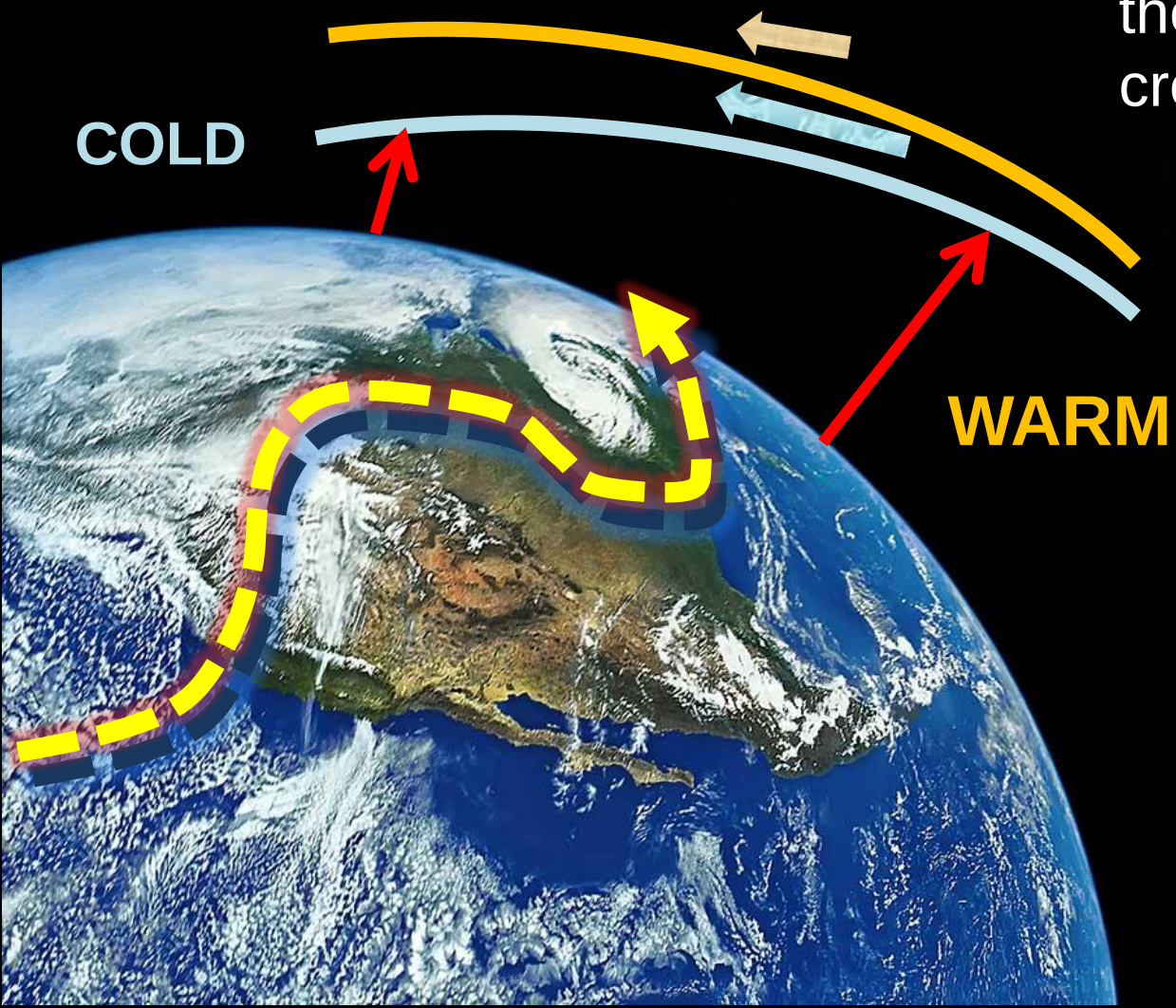
by S. Clark @simonoxfphys

Arctic warming greatly exceeds global-average warming



Plot by Ed Hawkins

Because warm air expands, the layer is thicker here (warm) than the Arctic.(cold)



Air flows down this “hill”, turns to the right as the Earth spins, and creates the *Jet Stream*

As the Arctic warms faster, the hill flattens…

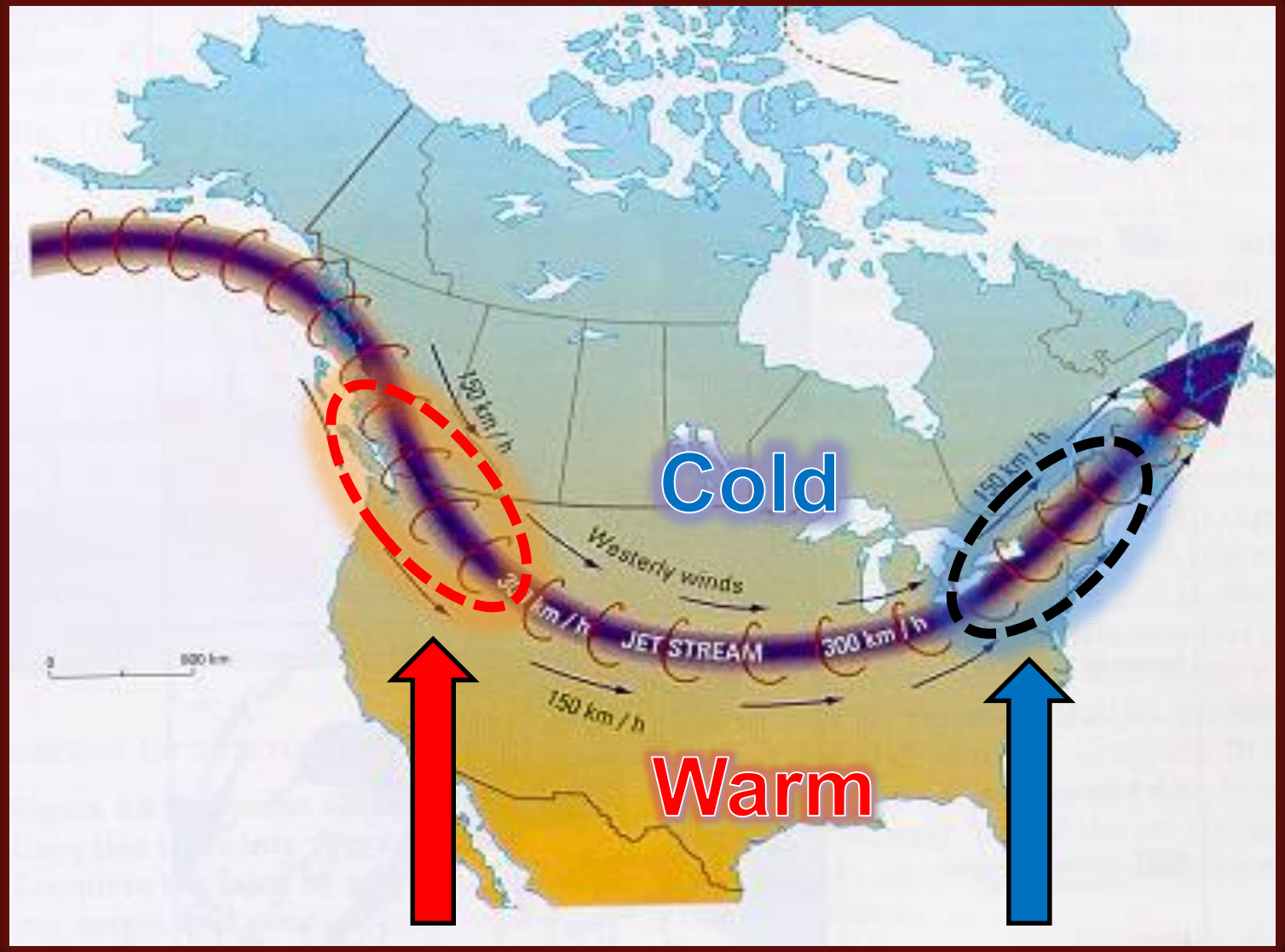
the west winds of the jet stream weaken,

And a weak jet meanders more.

Why do we care about these waves?

They make our weather…

and bigger meanders shift eastward more slowly, causing persistent weather conditions.

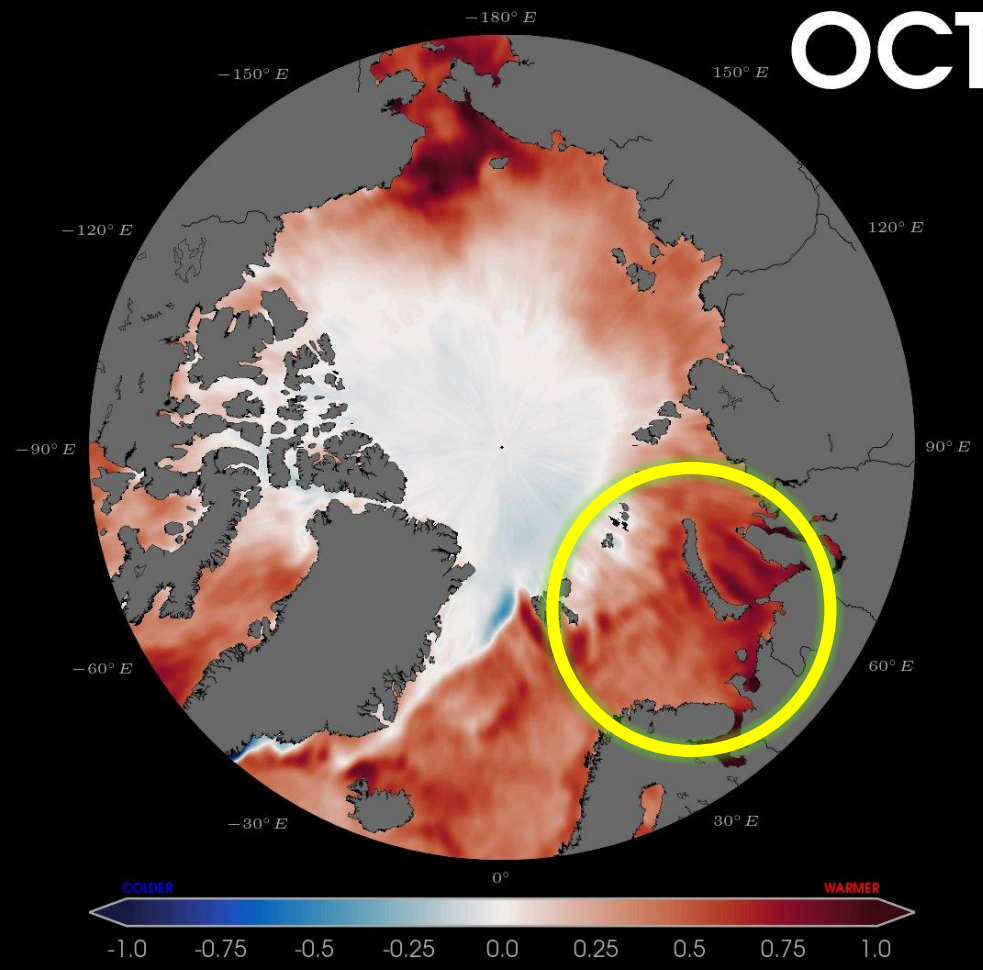


Surface temperature trends

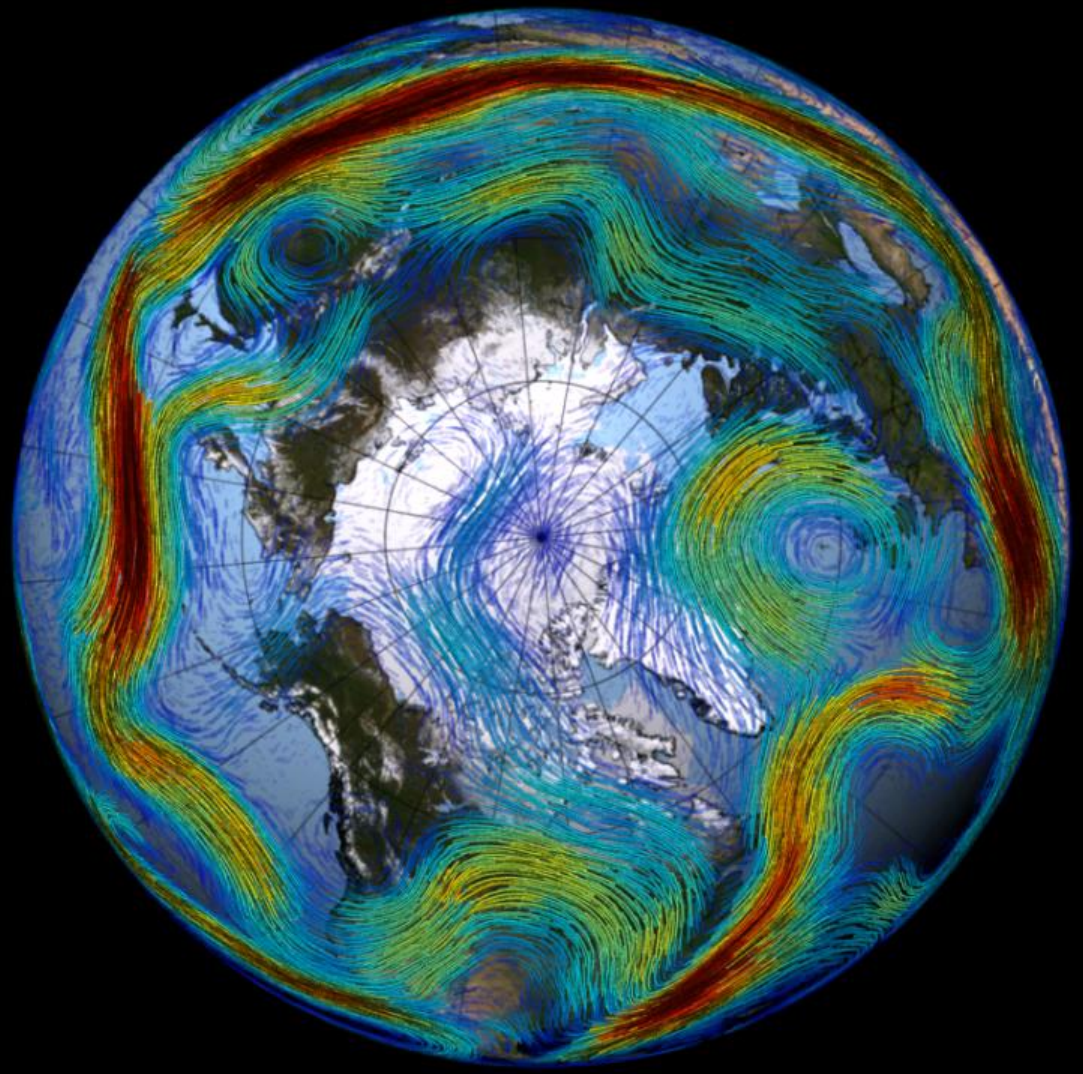
October 1982-2020

Strong, prolonged warmth here can disrupt the polar vortex

GRAPHIC: Zachary Labe (@ZLabe)
SOURCE: https://www.ncdc.noaa.gov/oisst/optimum-interpolation-sea-surface-temperature-oisst-v21
DATA: NOAA Optimum Interpolation (OI) Sea Surface Temperature (SST) V2.1



by Zack Labe @ZLabe



by NASA's Science Visualization Studio

Thank-you!

Jennifer Francis, PhD

Senior Scientist

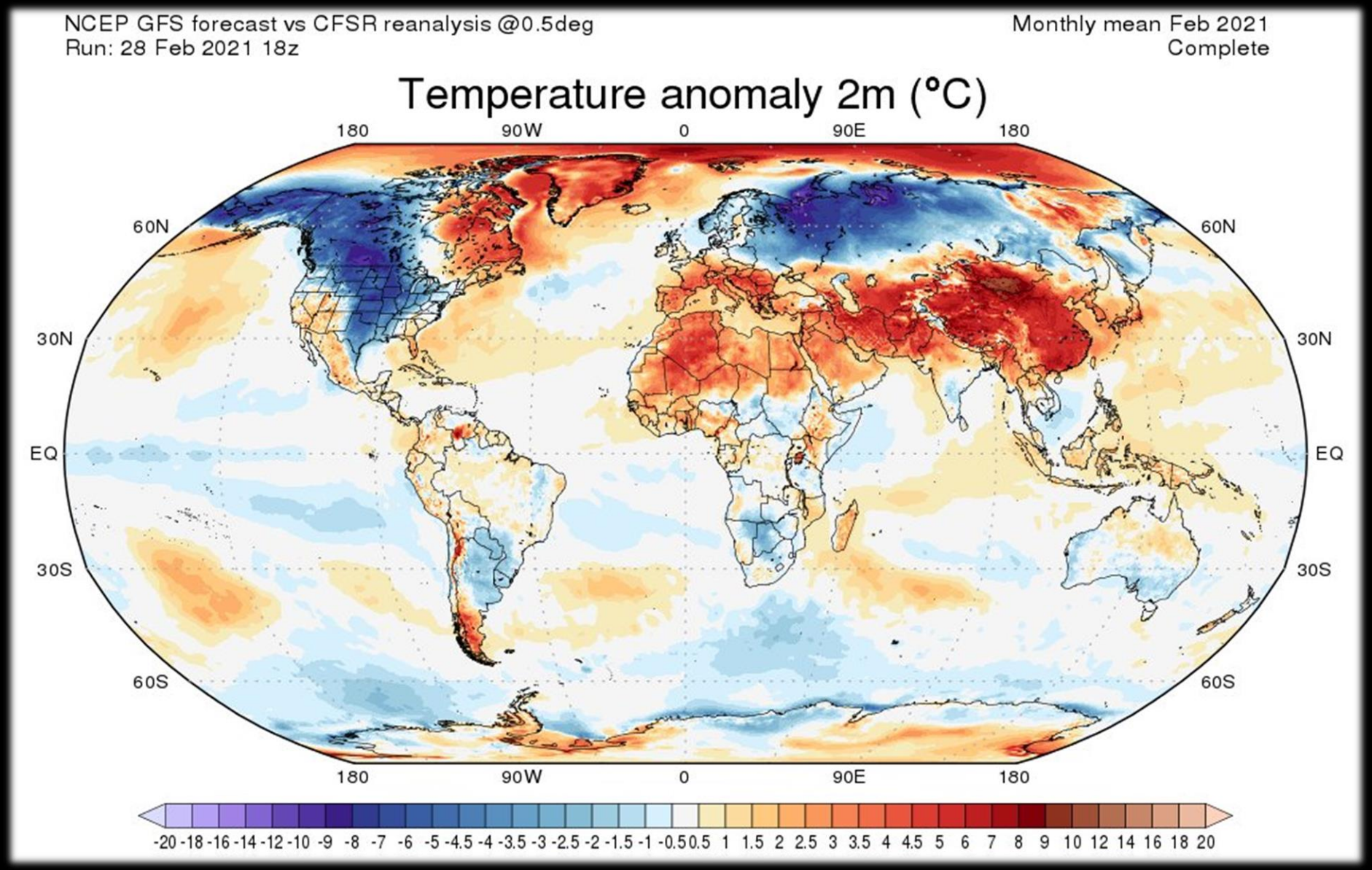
jfrancis@WoodwellClimate.org

Woodwell Climate Research Center

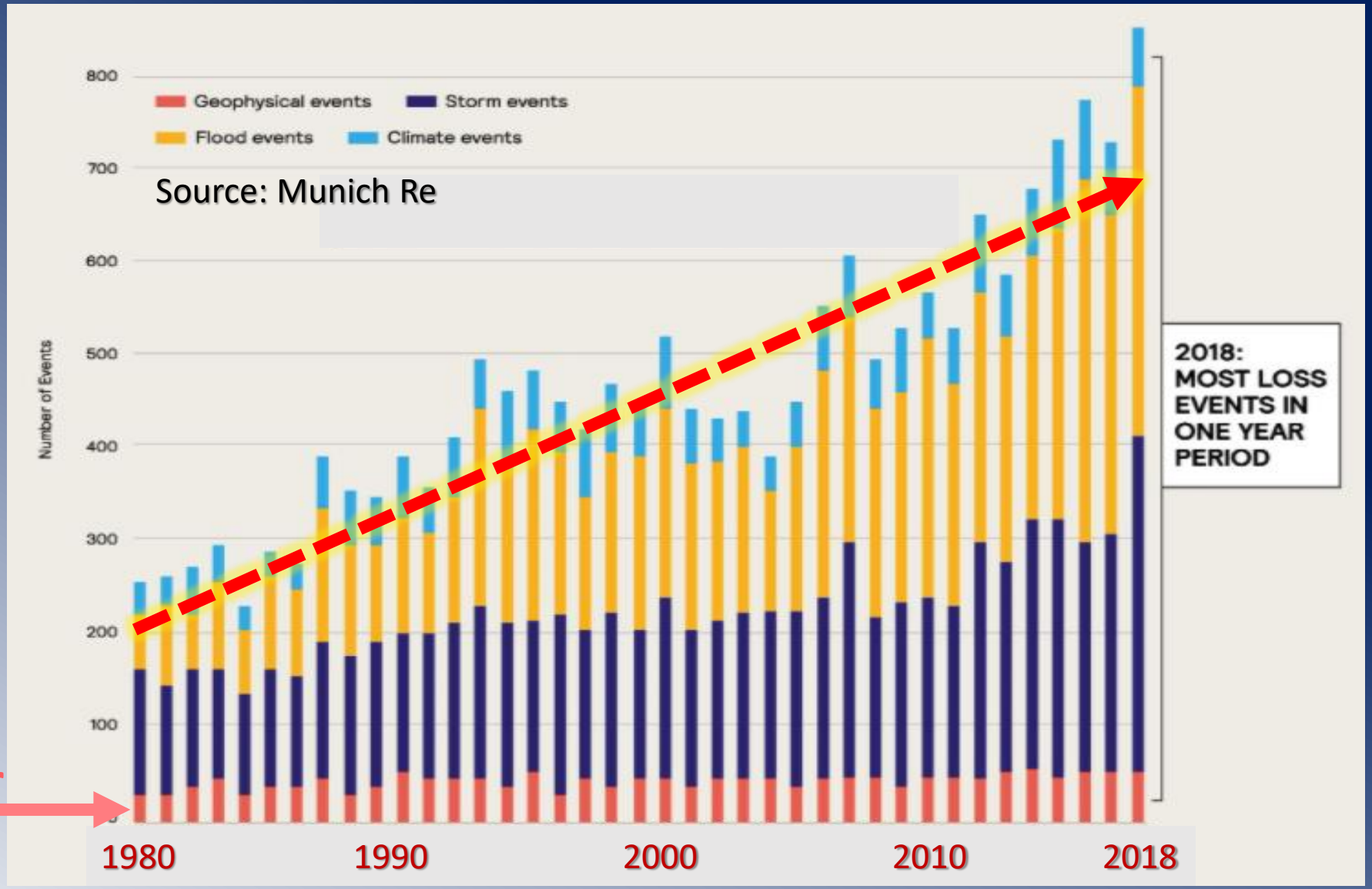
Extras

The Bigger Picture

Temperature differences from average



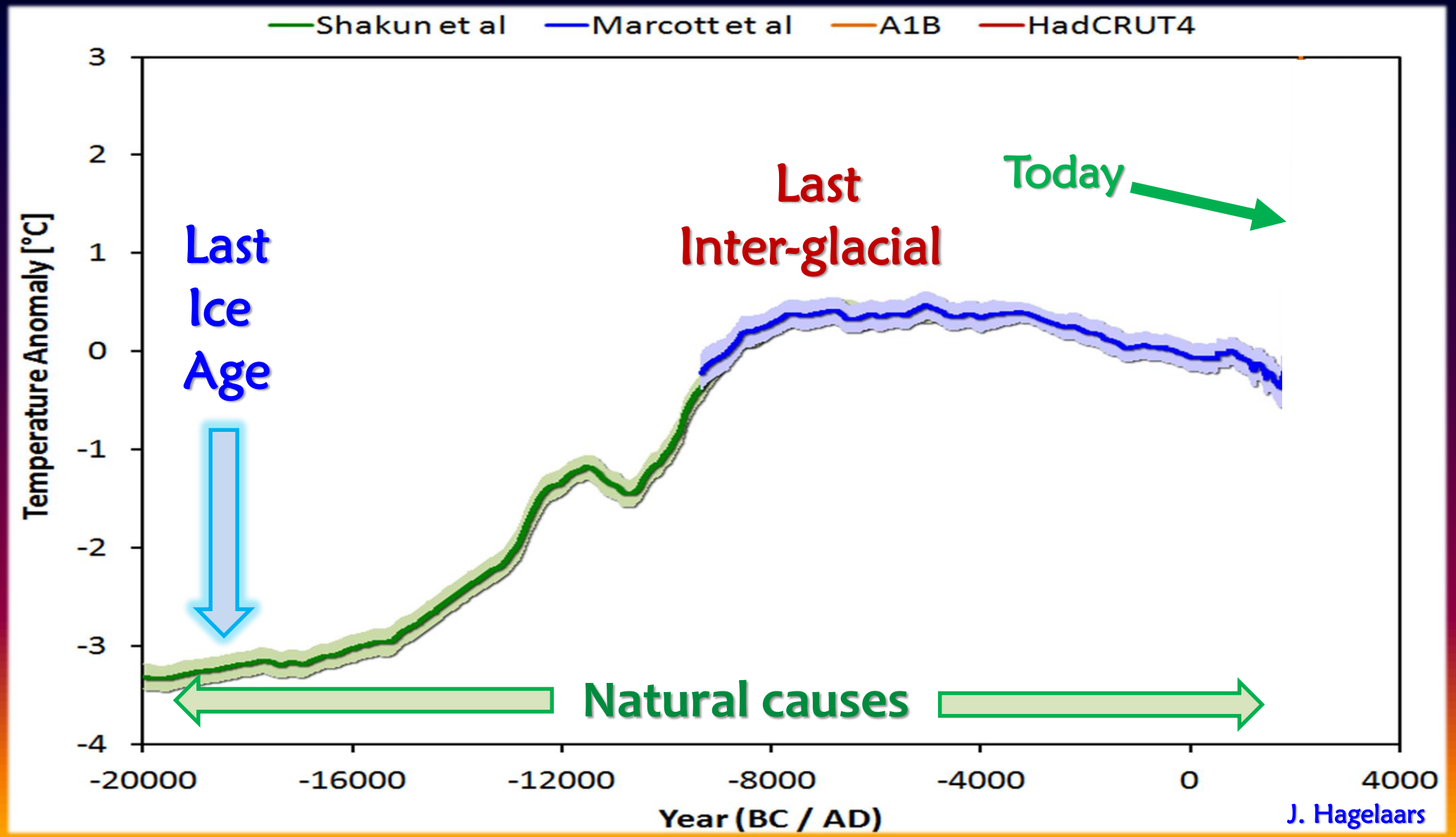
Weather-related extreme events have TRIPLED since 1980



Non-weather related

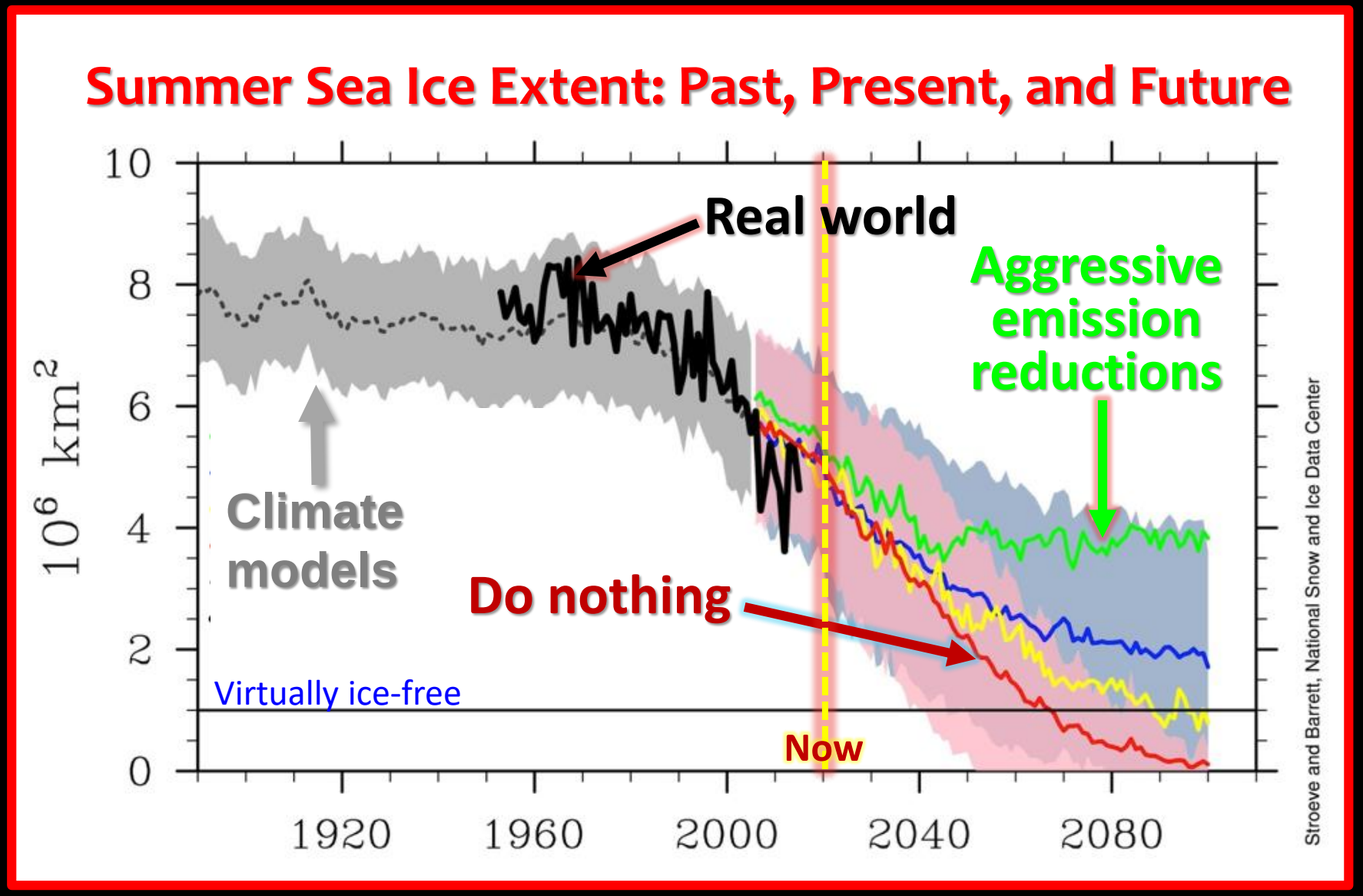
Woodwell Climate Research Center

20,000 Years of Global Temperatures



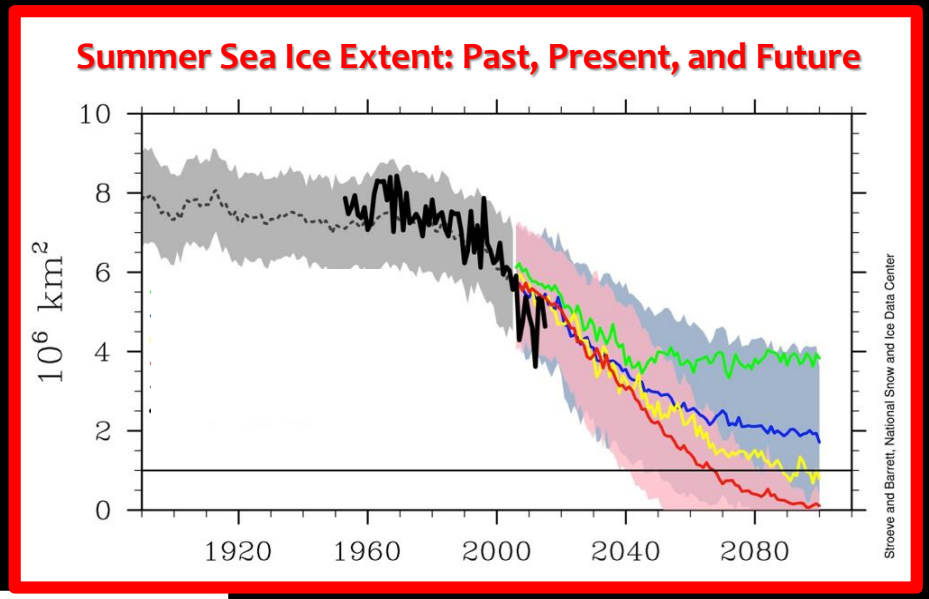
What does our future hold?

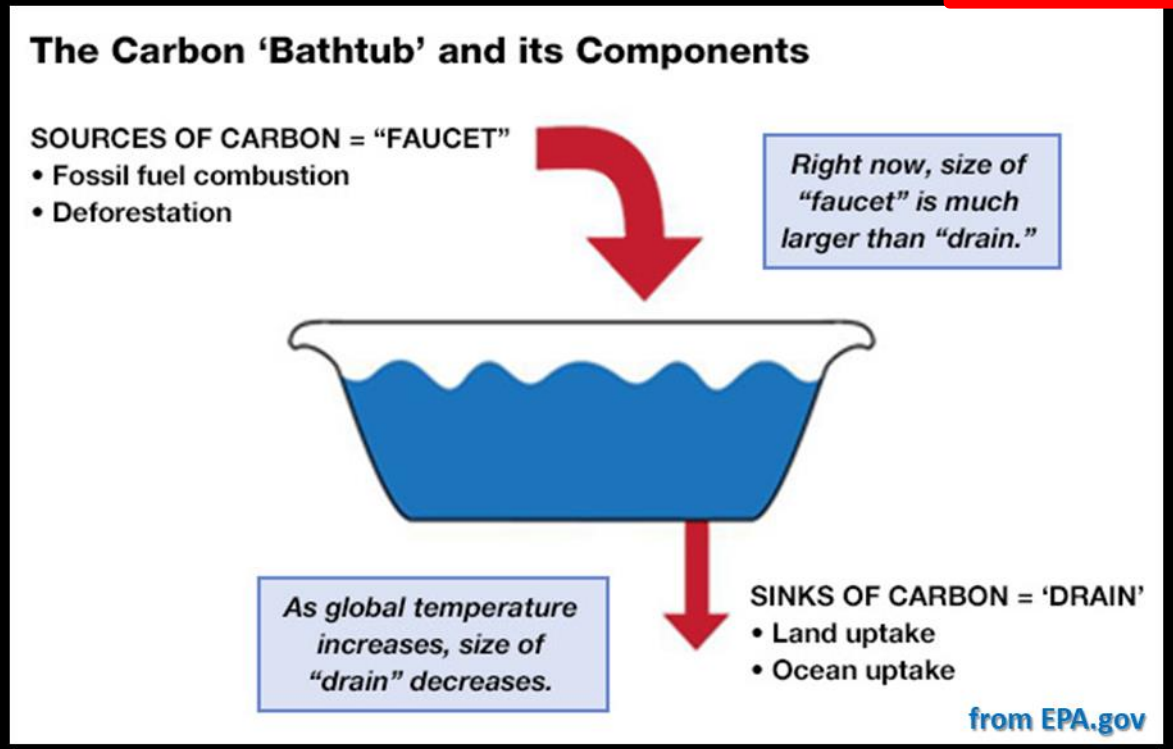
The sea ice story…



How can we stay on the green line?

- Emit less heat-trapping gases
- Create more gas absorbers



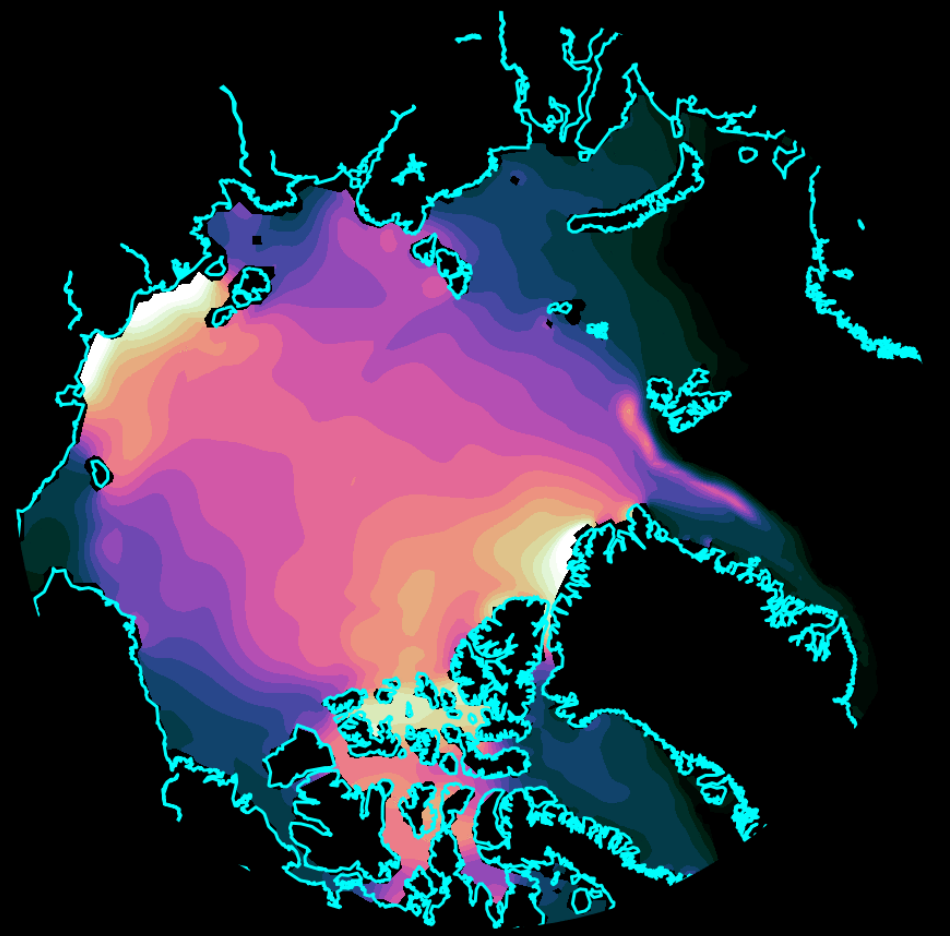


Arctic sea ice thickness and volume 1979-2021

1979

23,201

SEA ICE VOLUME (km^3)



GRAPHIC: Zachary Labe (@ZLabe)
SOURCE: http://psc.apl.uw.edu/research/projects/arctic-sea-ice-volume-anomaly/
DATA: PIOMAS V2.1 (Zhang and Rothrock, 2003) (DECEMBER)

Zack Labe @Zlabe

What happens in the Arctic doesn't stay in the Arctic

Half of the sea ice cover has disappeared,

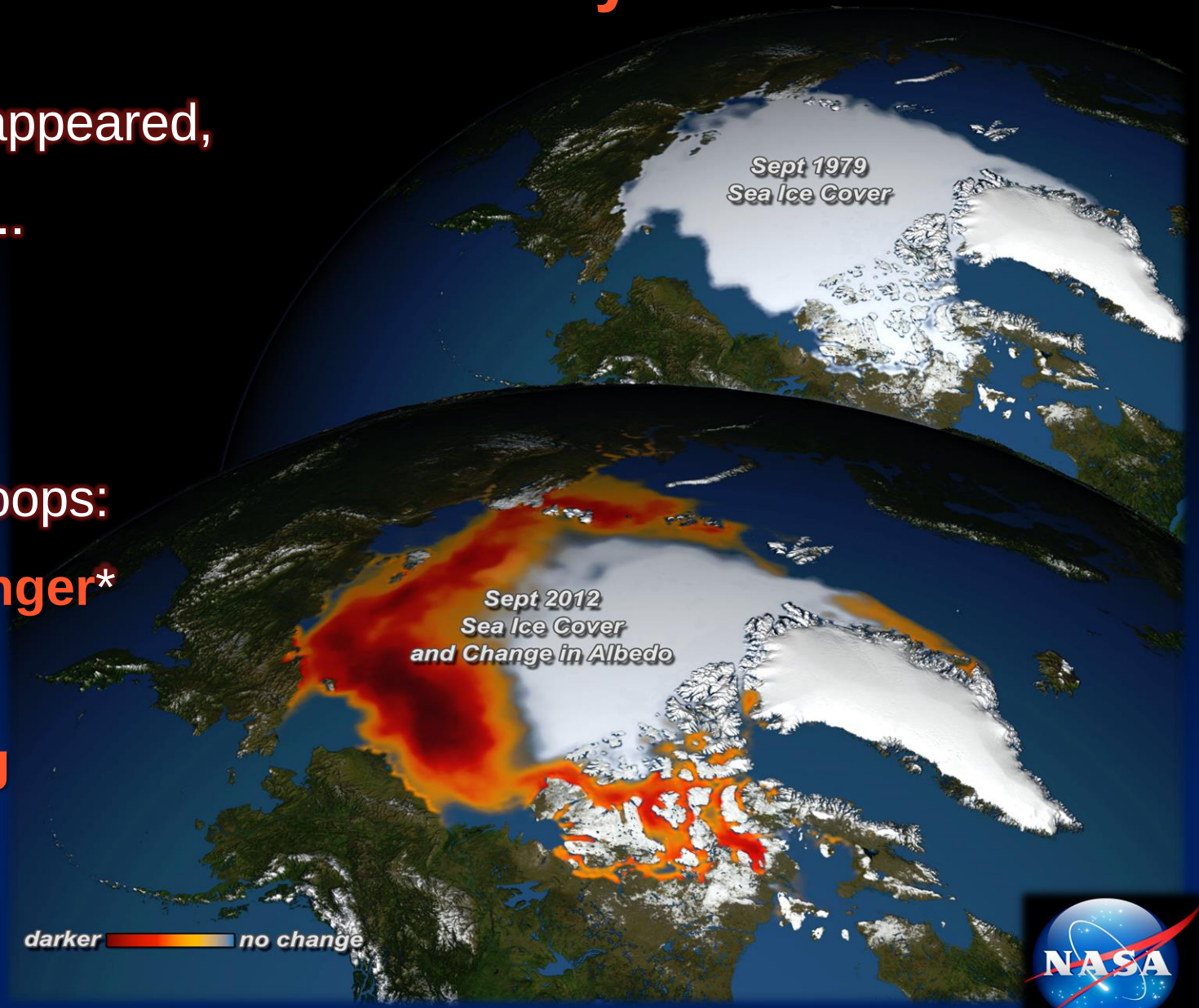
Ice volume has declined by **75%**...

In less than a generation.

The Arctic surface is **darker** now.

Sea-ice loss is **key** to feedback loops:

- Global warming 25-40% **stronger***
- Greenland melt **accelerating**
- Permafrost thaw **accelerating**
- Jet-stream winds **disrupted**



*Pistone et al (2014), Duan et al (2019)

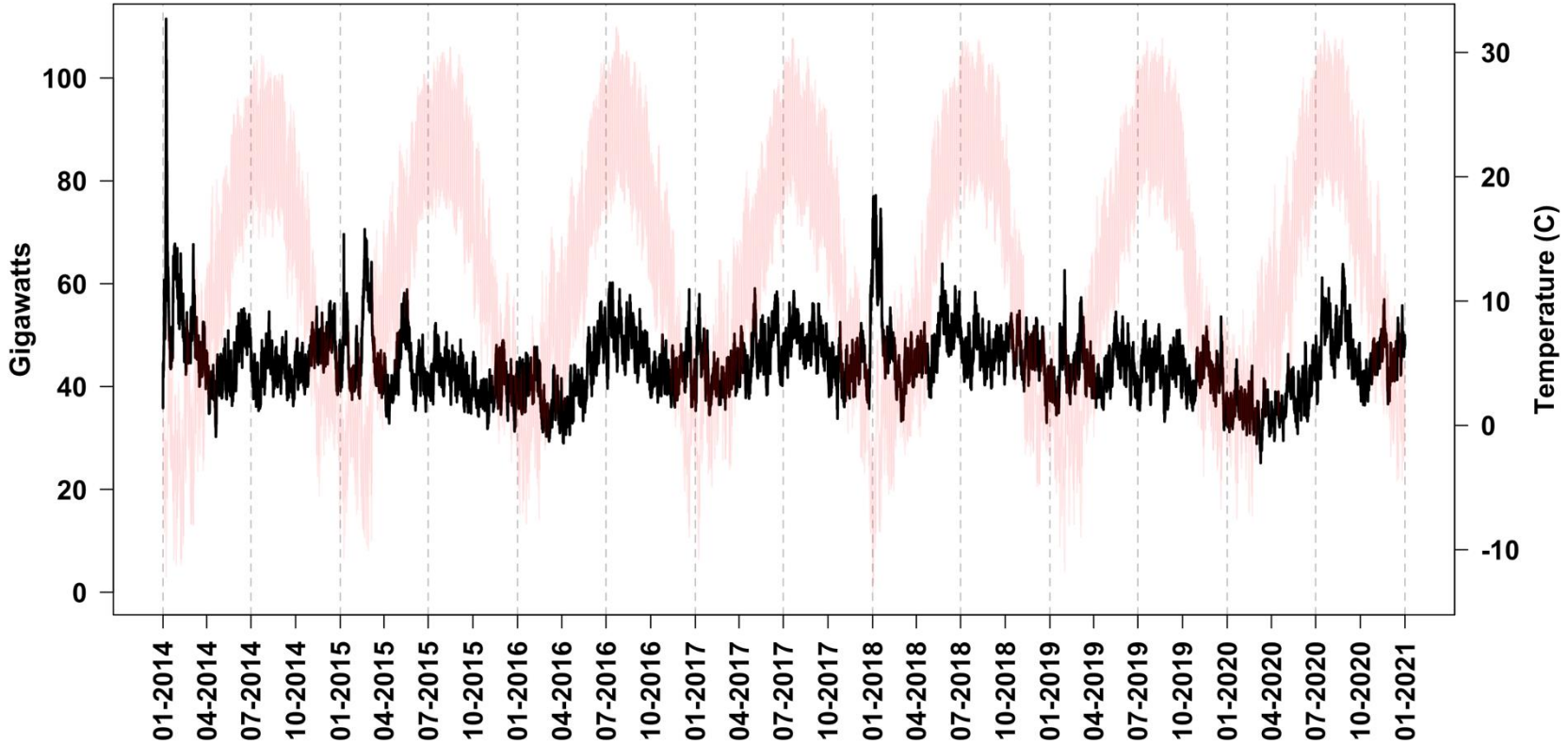
The Evolving Role of Extreme Weather Events in the U.S. Power System with High Variable Generation

Murali Baggu Ph.D.
Laboratory Program Manager - Grid Integration

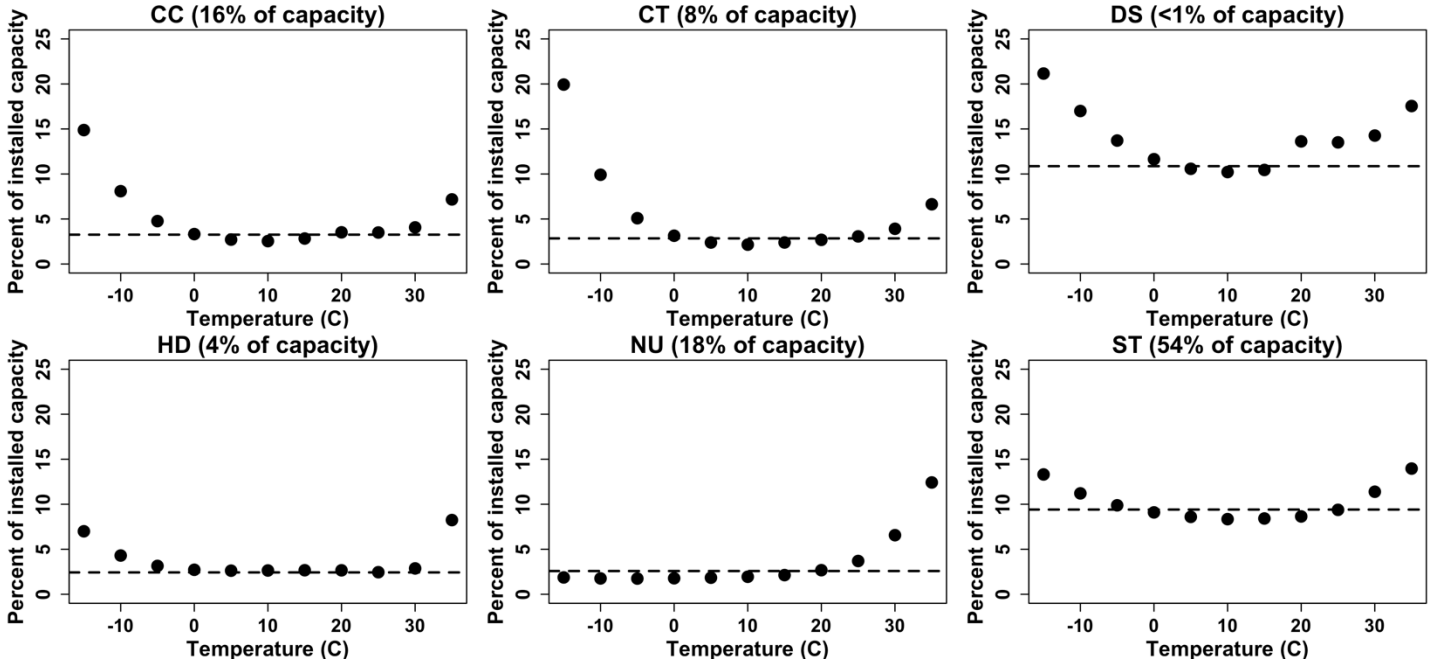
Living with Climate Change: The Polar Vortex
Anticipating Threats and Building Preparedness
Wednesday, April 13, 2022 12:00pm - 1:30pm EDT

Aggregate unavailable generation capacity with temperature overlay

All plots are:
- Hourly time series
- Unscheduled events only
- CONUS generators only



Temperature dependence in PJM thermal/hydro generators

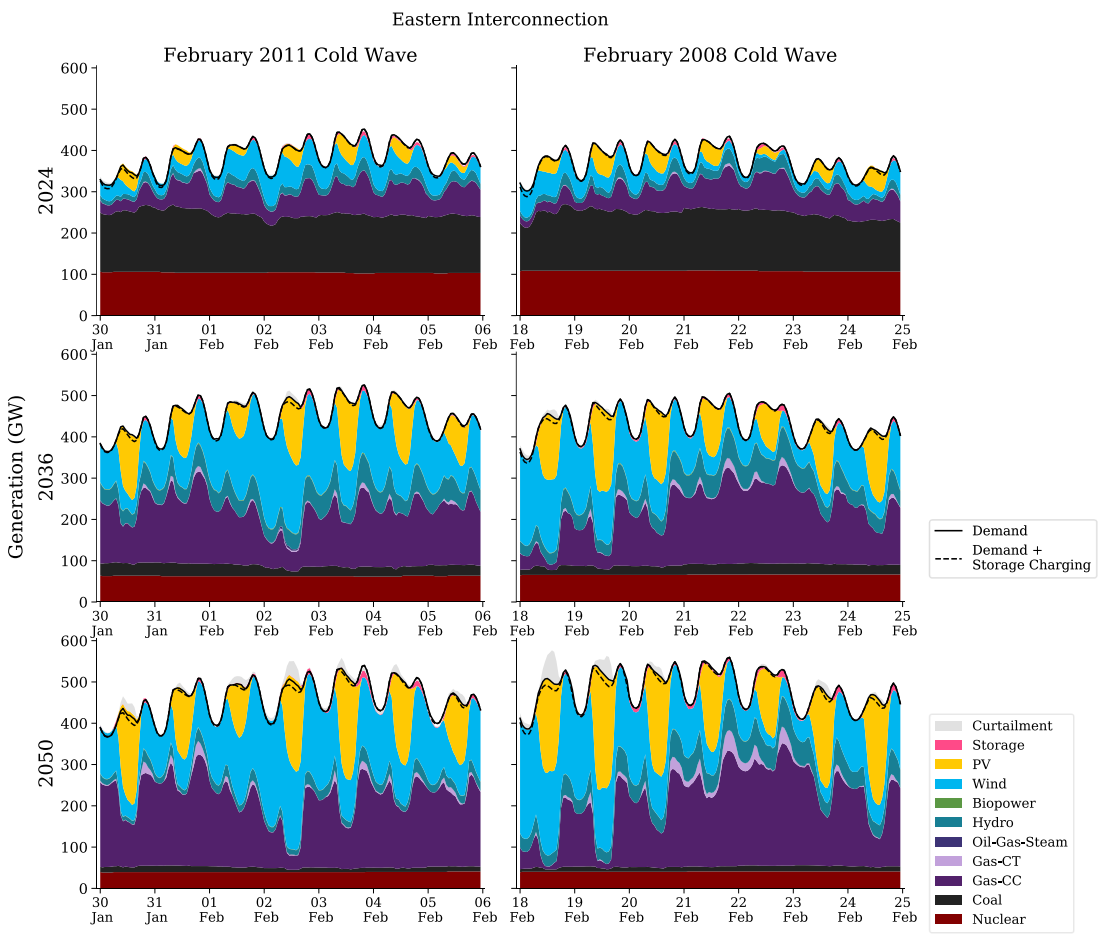


Murphy, S., Sowell, F., Apt J. "A time-dependent model of generator failures and recoveries captures correlated events and quantifies temperature dependence." Applied Energy. November 2019. https://doi.org/10.1016/j.apenergy.2019.113513

Unit type key:

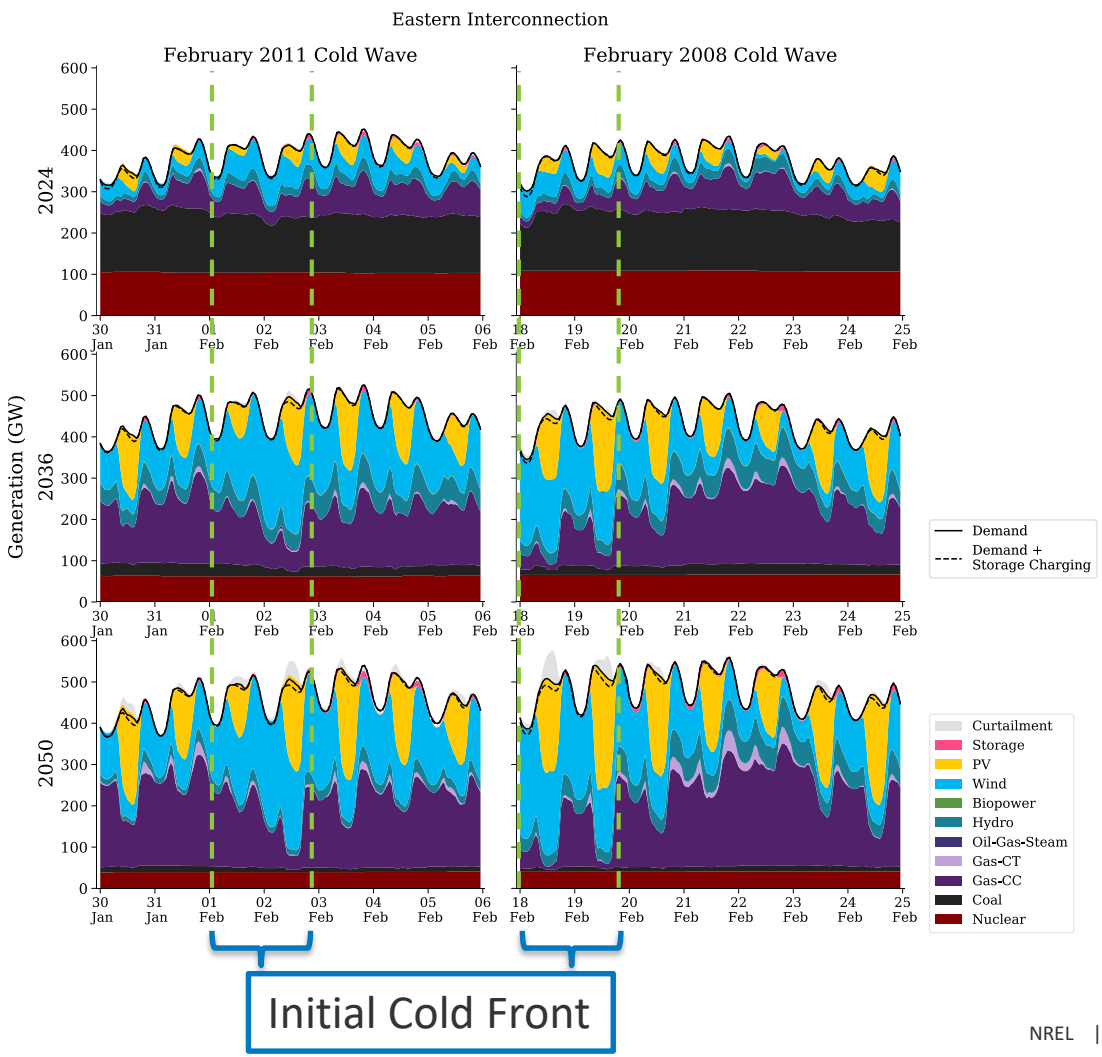
CC: combined cycle gas	HD: hydroelectric
CT: simple cycle gas	NU: nuclear
DS: diesel	ST: steam turbine (coal)

Evolution of operations during cold waves driven by wind dynamics



Evolution of operations during cold waves driven by wind dynamics

In both cold waves, wind and solar generation provide >80% of generation in the EI even as load increases as the cold front moves across the continent.



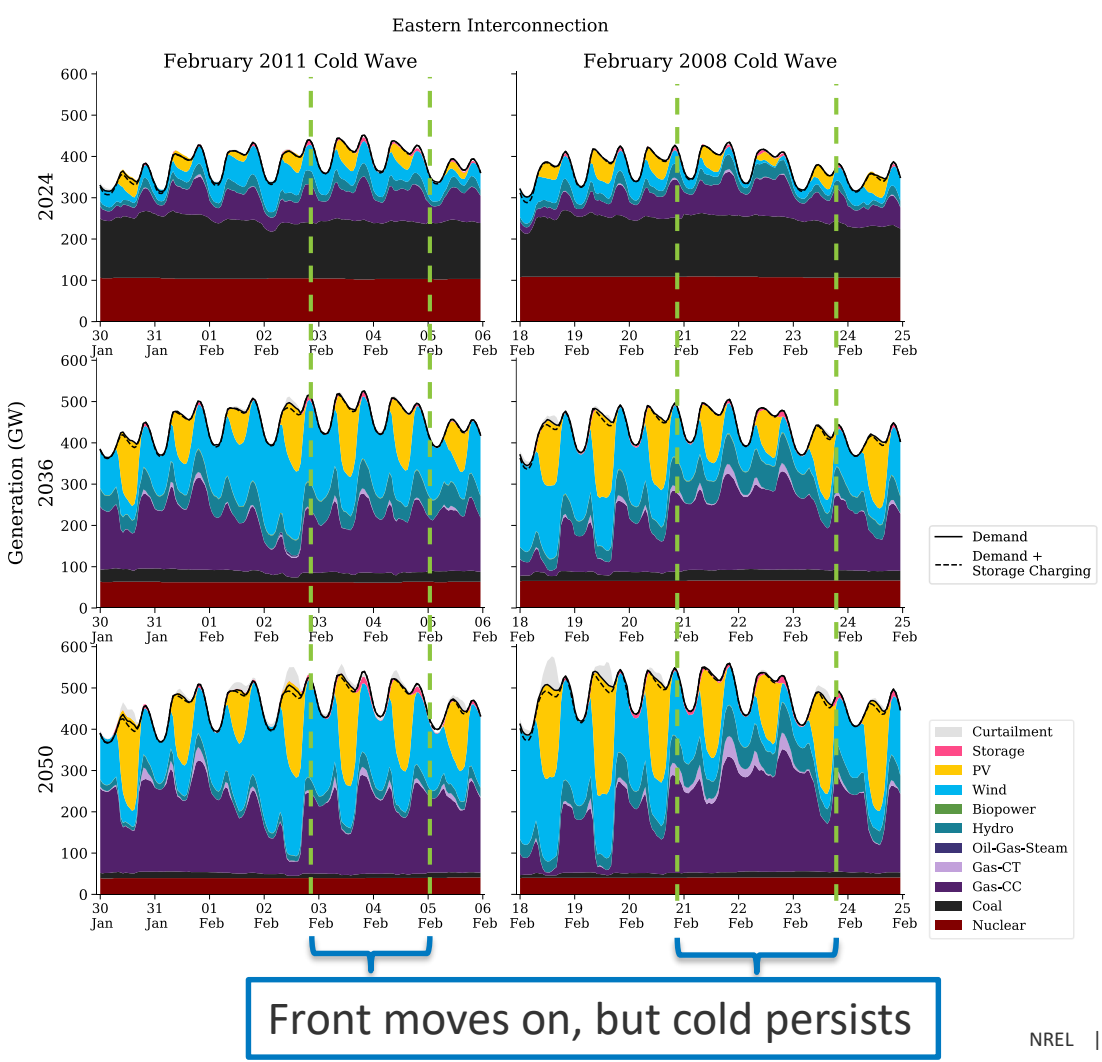
Evolution of operations during cold waves driven by wind dynamics

2011 Extreme Cold Wave

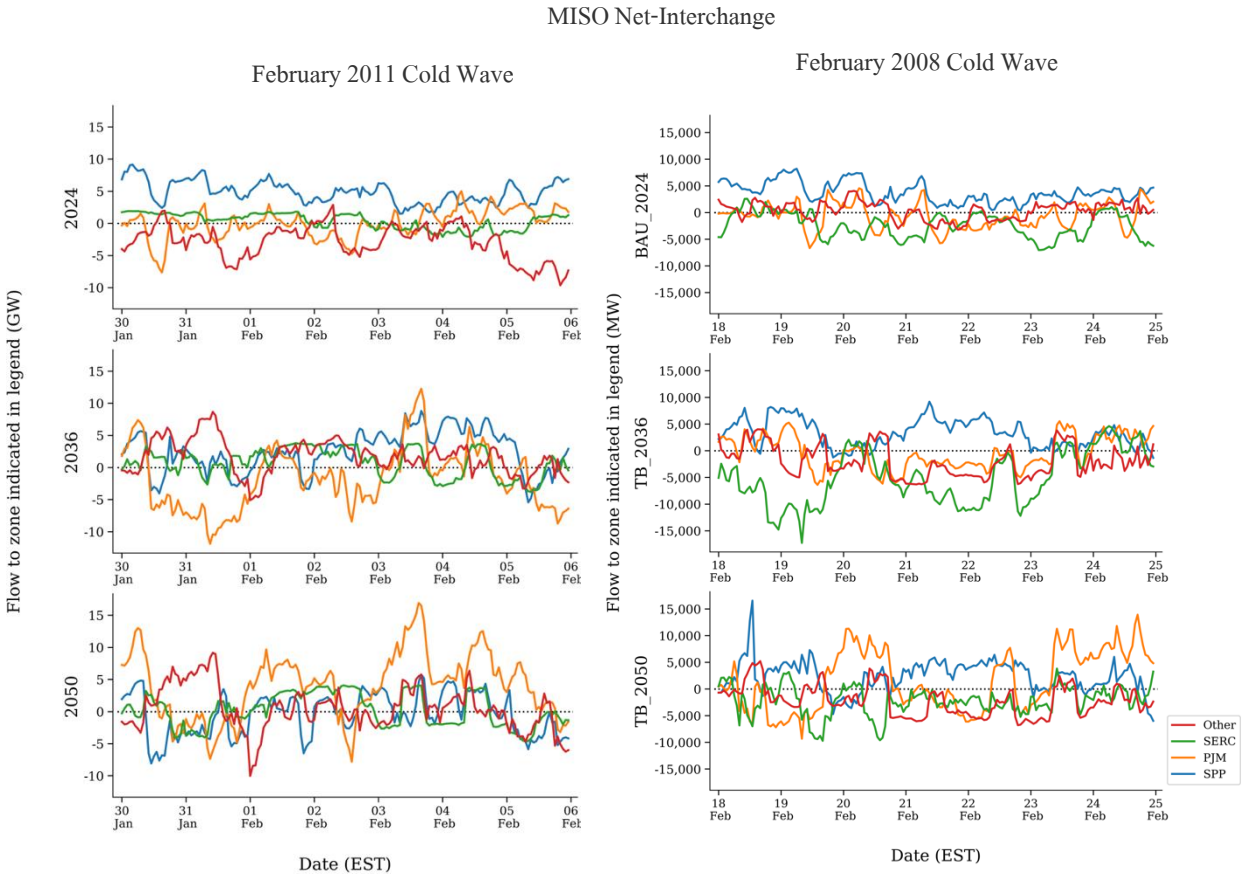
Wind and solar continues to serve ~50% of load after front moves through and load is elevated.

2008 Milder Cold Wave

Overnight wind penetrations drops below 10% of all generation. Offline thermal reserves drop in MISO and SPP.



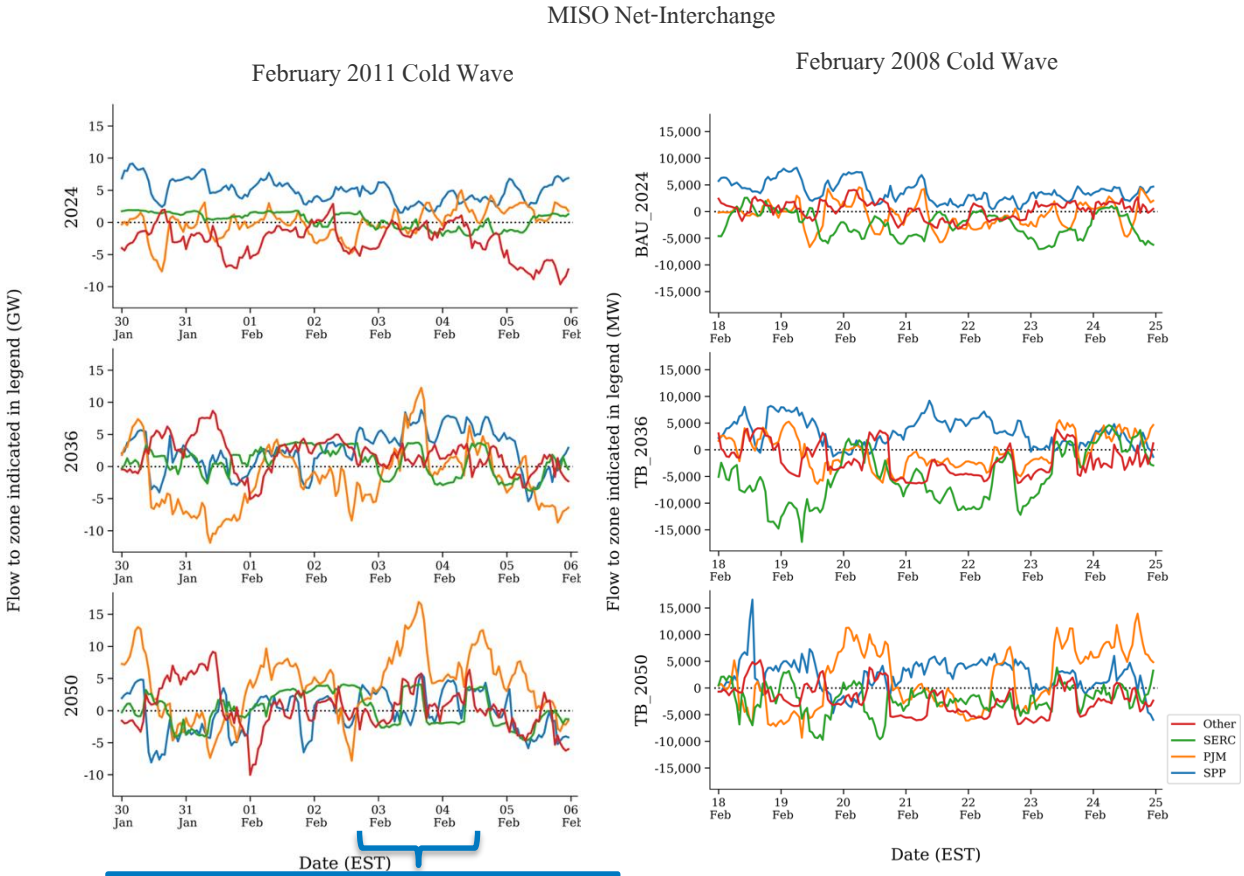
Evolution of operations during cold waves driven by wind dynamics



Evolution of operations during cold waves driven by wind dynamics

2011 Extreme Cold Wave

Transmission enables usage of geographic diverse wind and solar resources.

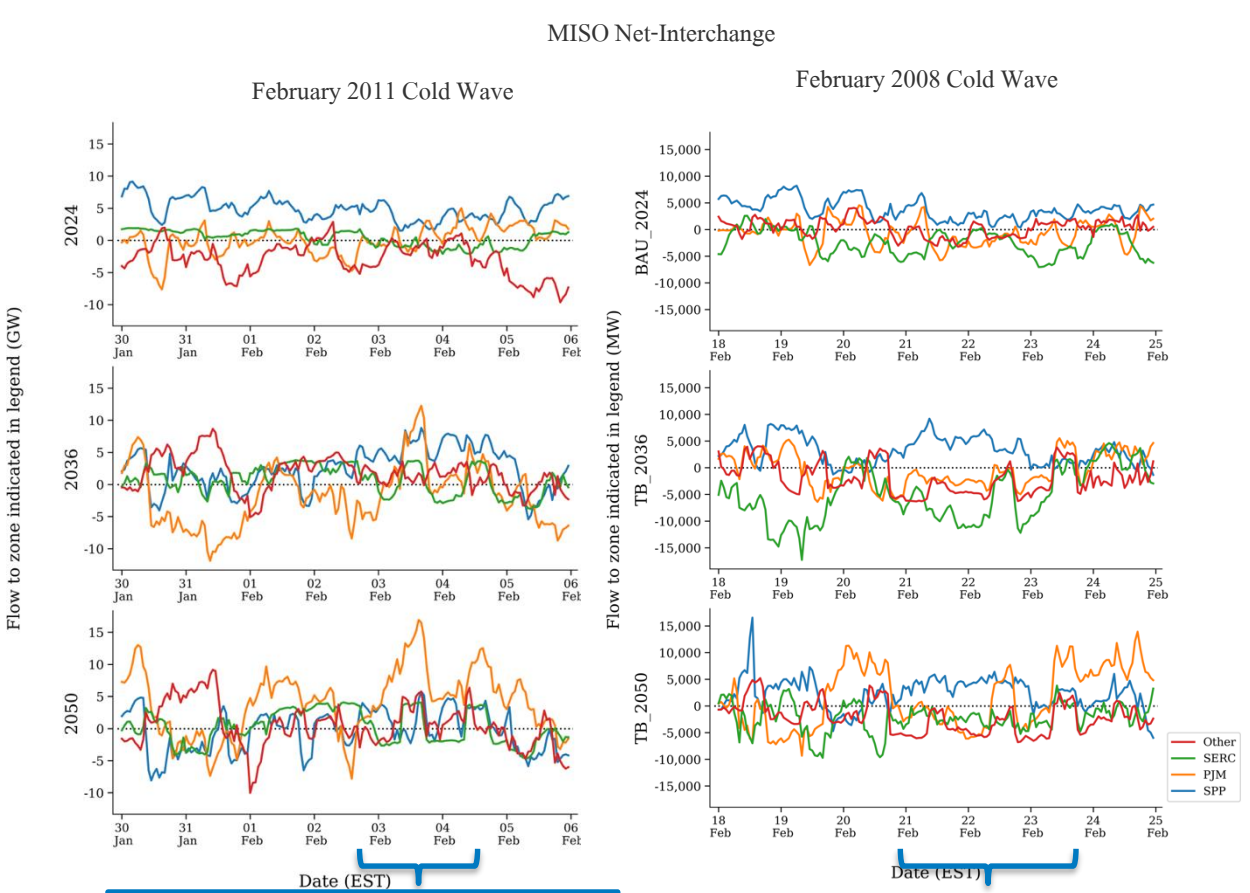


Swing in MISO exports to PJM used to serve SERC and NYISO

Evolution of operations during cold waves driven by wind dynamics

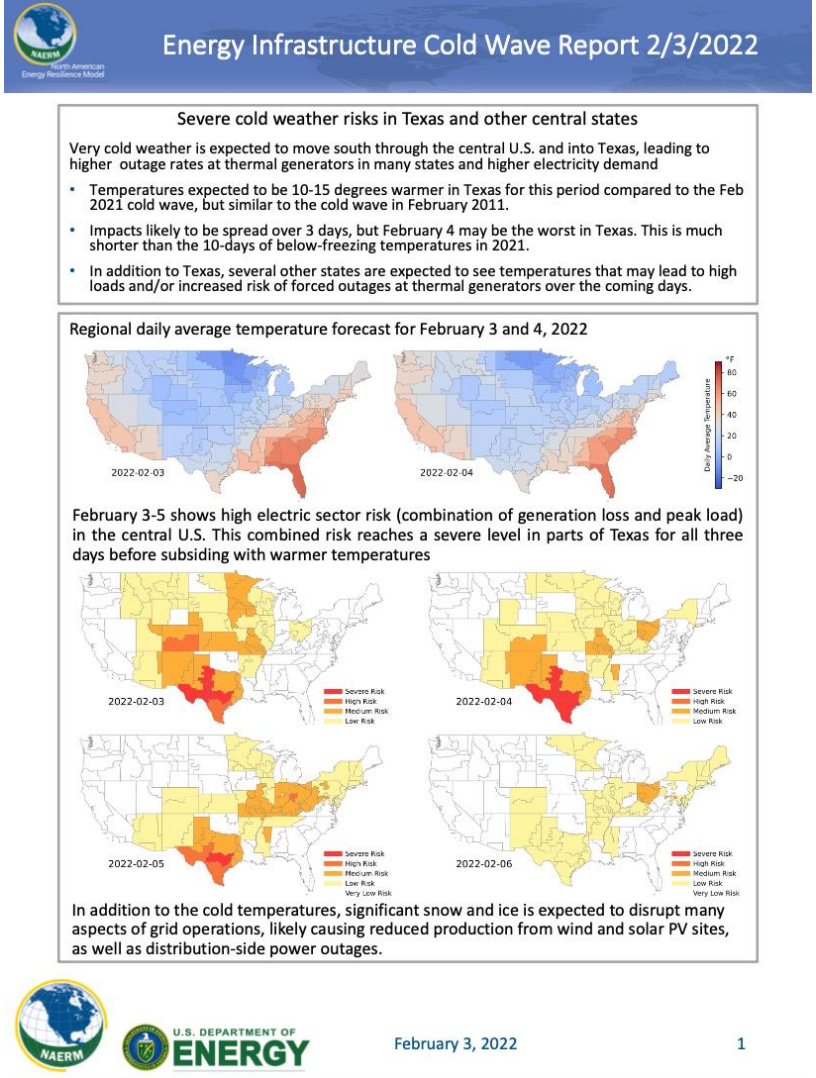
2011 Extreme Cold Wave
Transmission enables usage of geographic diverse wind and solar resources.

2008 Milder Cold Wave
Transmission **also** enables geographic diverse thermal fleet.



Swing in MISO exports to PJM used to serve SERC and NYISO

Thermal, wind, and PV less impacted in Atlantic states

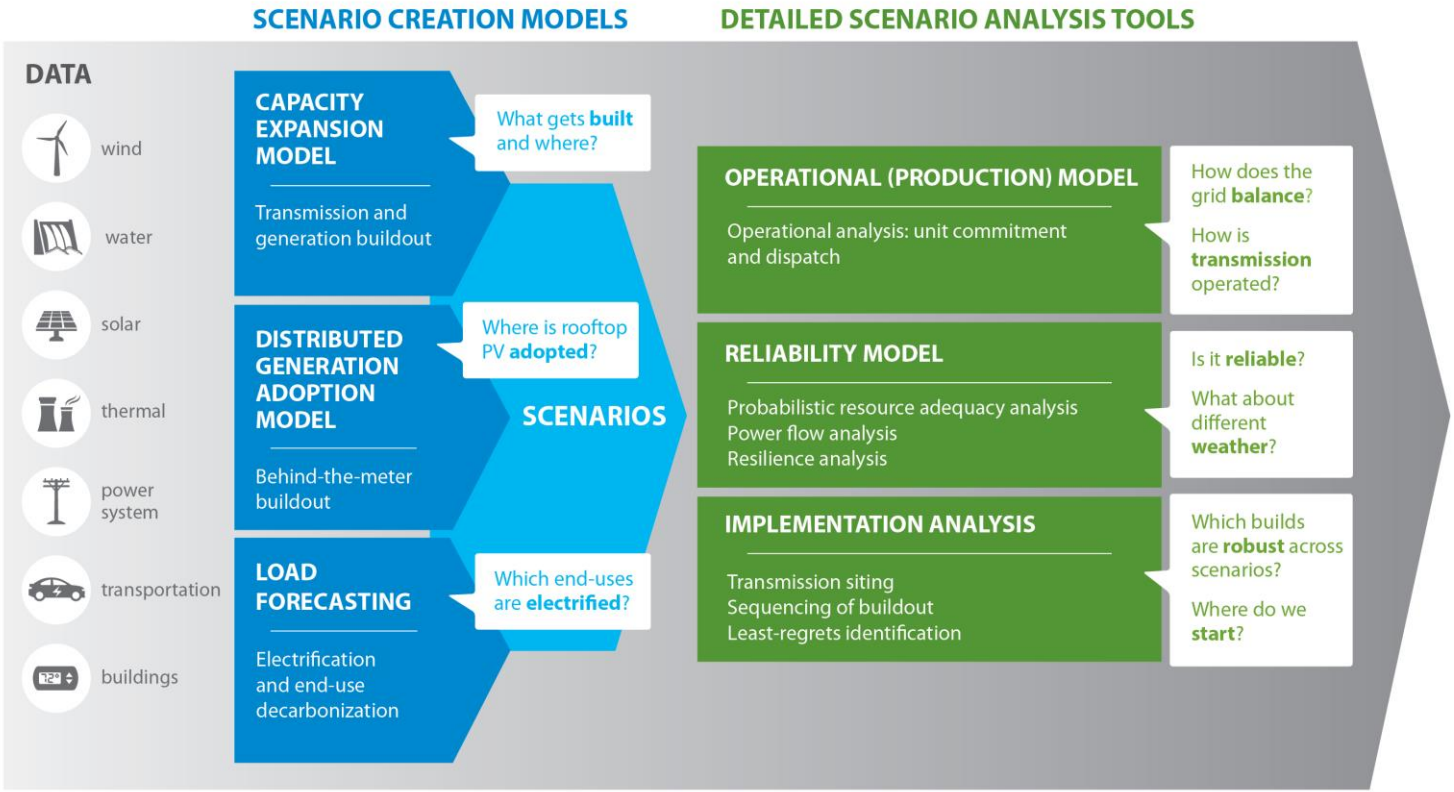


NAERM Cold Wave Report

The North American Energy Resilience Model (NAERM) is a multi-lab effort to identify resilience risks across the energy sector. NAERM is developing a beta version of a **cold wave report** to provide system operators awareness of forecasted cold weather and winter storms and the associated power system risks.

- Increased generator outage
- Regions with above normal forecasted load
- Snow and ice impacts on T&D infrastructure, wind power, and solar power

National Transmission Plan and NAERM



Key Takeaways

- Corelated Modeling
- Planning
- Operational Forecasts vs. Resource Adequacy
- Transmission Flexibility
- Longer Duration Storage (day long or multi-day storage)

Thank you

NREL
Transforming ENERGY

The Road to Resilience

Living with Climate Change: Surviving the Polar Vortex In a Warming World

Megan Levy

Resilience Strategist & Energy Assurance Coordinator

Wisconsin Office of Energy Innovation

2018 Flooding HWY 2 WI

Wisconsin State Journal

Friday

March 5 1976

Madison, Wisconsin

46 pages ★★★ 15 cents

Storm ties up city

Mayor decrees an emergency

More on storm: Section 4, Page 1

It's bad all over Midwest

OEI

Wisconsin Office of Energy Innovation

A Brief History of the Office of Energy Innovation: Home of Wisconsin's State Energy Office

- 56 Energy Office (50 states 6 territories)
- Energy Policy & Conservation Act of 1975
- Each state is required, under 42 U.S.C. § 6323(e)(1), to submit an energy emergency plan that it will utilize in the case of an energy supply disruption.
- Moved in 2015 to PSCW, (ch. 16.955 Department of Administration, State Planning and Energy has been updated to Ch. 196.025(7) as of January 2018.

Chapter 196.025(7) Information.

"**(7)** State energy office.

(a) The commission shall do all of the following:

1. In cooperation with the other state agencies, collect, analyze, interpret, and maintain the comprehensive data needed for effective state agency energy planning and effective review of those plans by the governor and the legislature.

2. Administer federal energy grants, when so designated by the governor pursuant to s. 16.54.

3. Prepare and maintain contingency plans for responding to critical energy shortages so that when the shortages occur they can be dealt with quickly and effectively.

(b) The commission may provide technical assistance to units of government other than the state to assist in the planning and implementation of energy efficiency and renewable resources and may charge for those services. The commission may request technical and staff assistance from other state agencies in providing technical assistance to those units of government.

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Wisconsin's Efforts to Build Resilience

Threats we face- from methane emissions to flooding to derechos, tornadoes, ice storms, and the polar vortex.

The last two decades have been the warmest on record in Wisconsin and the past decade has been the wettest. **Extreme events** are already causing immense disruptions across the state and impacting health, economy, and natural resources.

Effective collaboration is the only way to facilitate the change that we need to foster – sooner than later!

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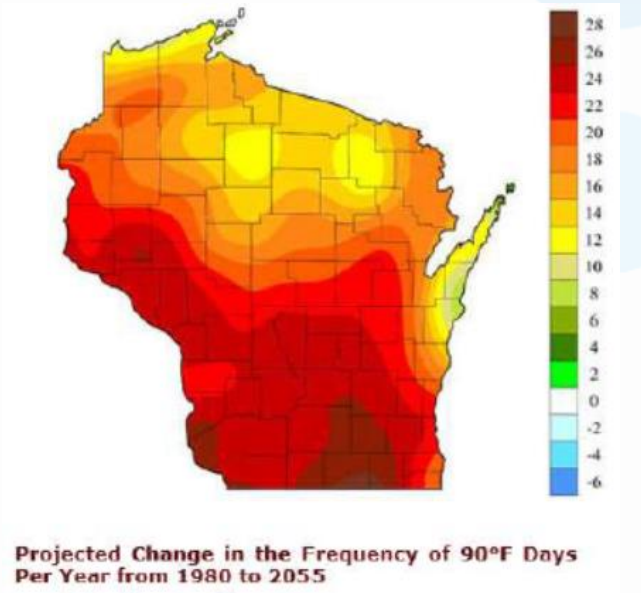
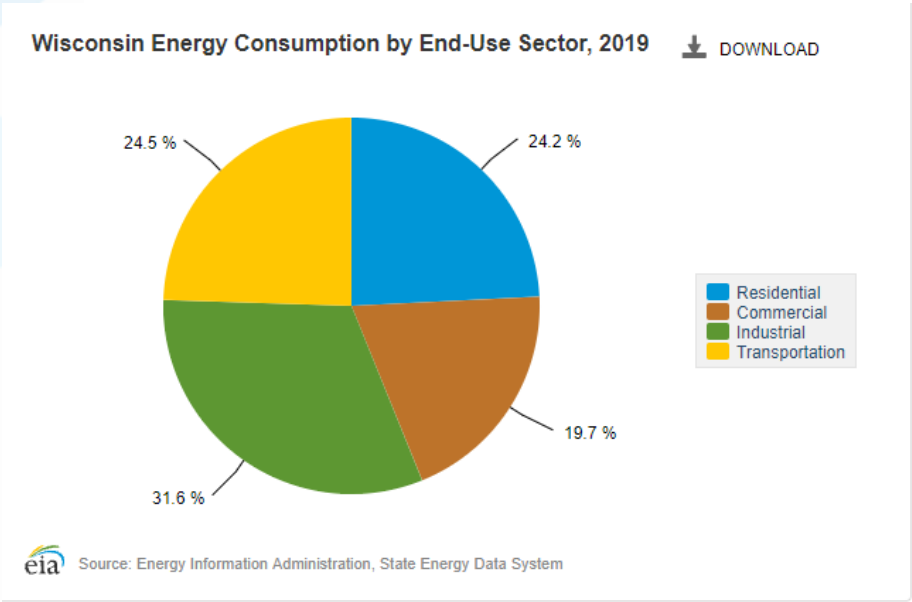
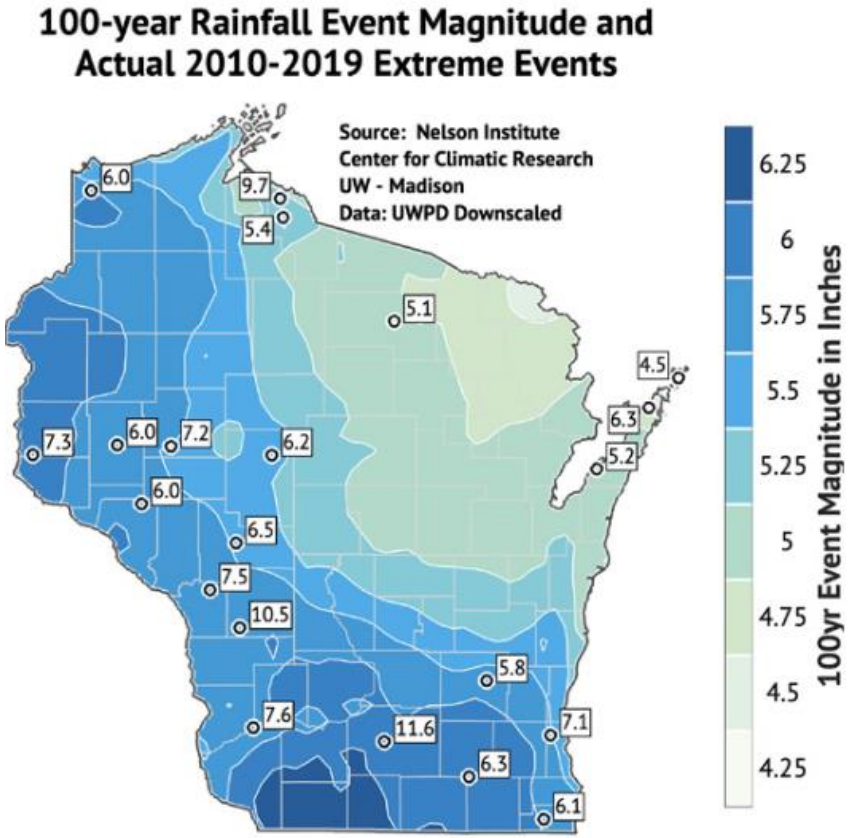
The $14 Billion Problem

- *Wisconsin consumes 6 times more energy than it produces.*
- *Despite a warming climate on the whole, Wisconsin will have thermal needs that are difficult to satisfy as well as more cooling load in the summer.*







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A Brief History of OEI Programs Promoting Resilient Communities

ENERGY INDEPENDENT COMMUNITIES PROGRAM

"Generate 25% of Wisconsin power and transportation fuels from renewable resources locally by 2025"

- **150 Energy Independent Communities**
- **50 Communities received grant funding for creating sustainable energy plans for government operations in 2009 and 2010. More communities have written plans in the ensuing years. Updated goals- 100% carbon free**
- **Encompasses 3.41 million people**
- **58.7% of Wisconsin's population**

Municipal Energy Efficiency Technical Assistance Program- MEETAP

Petroleum Shortage Contingency Planning

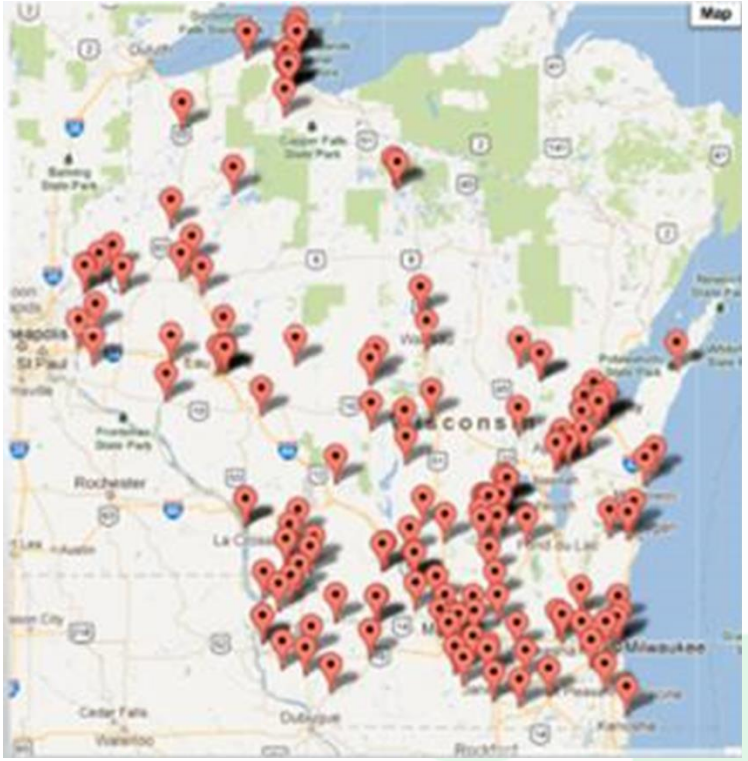
Energy Security Planning and Response

Focus on Energy Ag/Propane Incentive Program

Statewide Assistance For Energy Resilience and Reliability

SAFER2

- **Recruit Tribes and Communities to update emergency plans and participate in "deep-dive analysis"**
- **Deep-dive components (customized to participants' needs and goals):**
- **Wisconsin Clean Cities Alternative Fuel fleet assessment**
- ***Micro-grid feasibility study of critical infrastructure***



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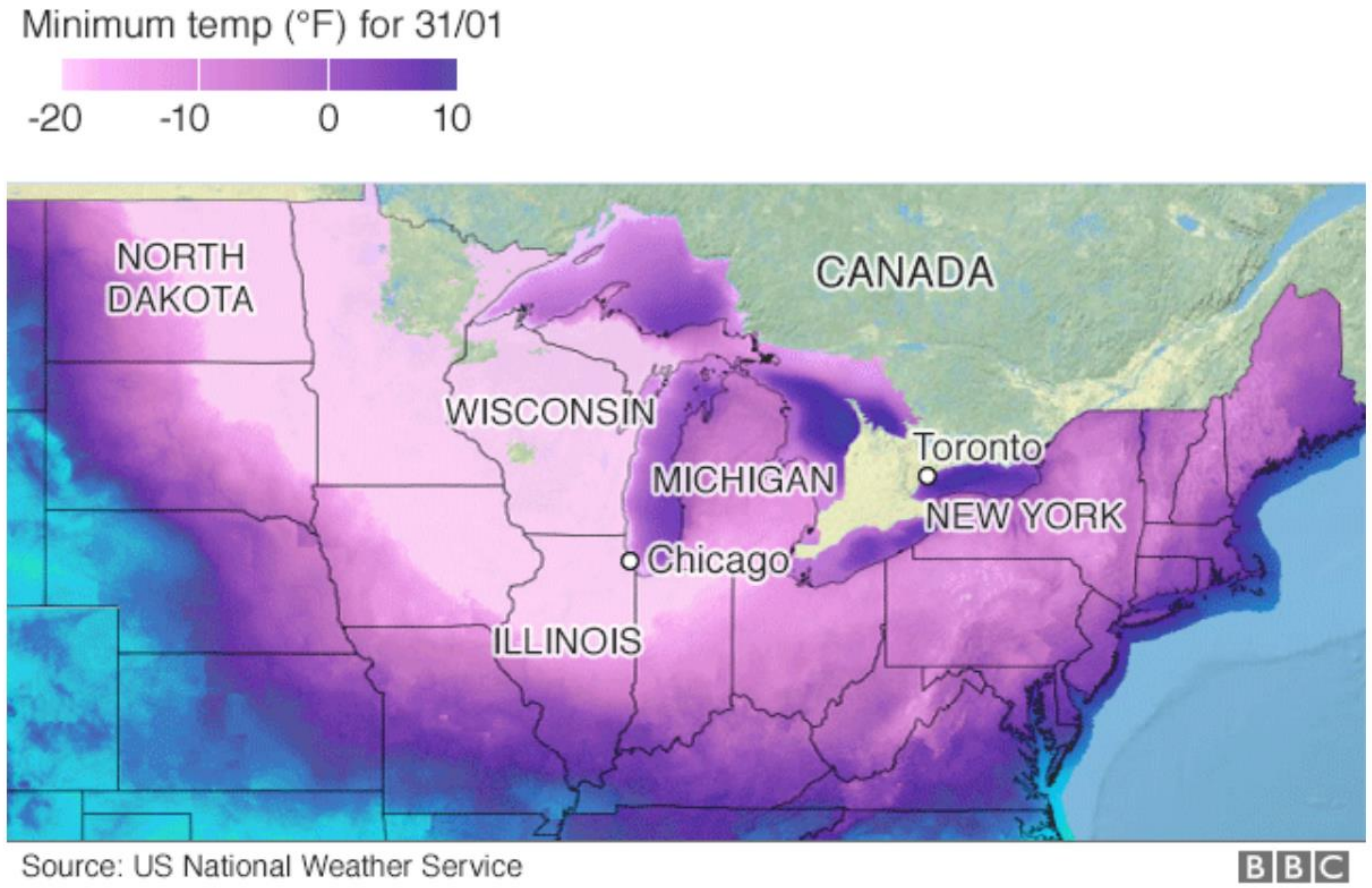
2014 Polar Vortex and Associated Energy Emergency



- ❑Bumper Corn Crop
- ❑Late harvest (lots of rain)
- ❑Low propane inventories due to increased exports
- ❑Reversal of key pipeline that brought LP to MN
- ❑POLAR VORTEX

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2014 Polar Vortex – Deepest Cold Temperatures

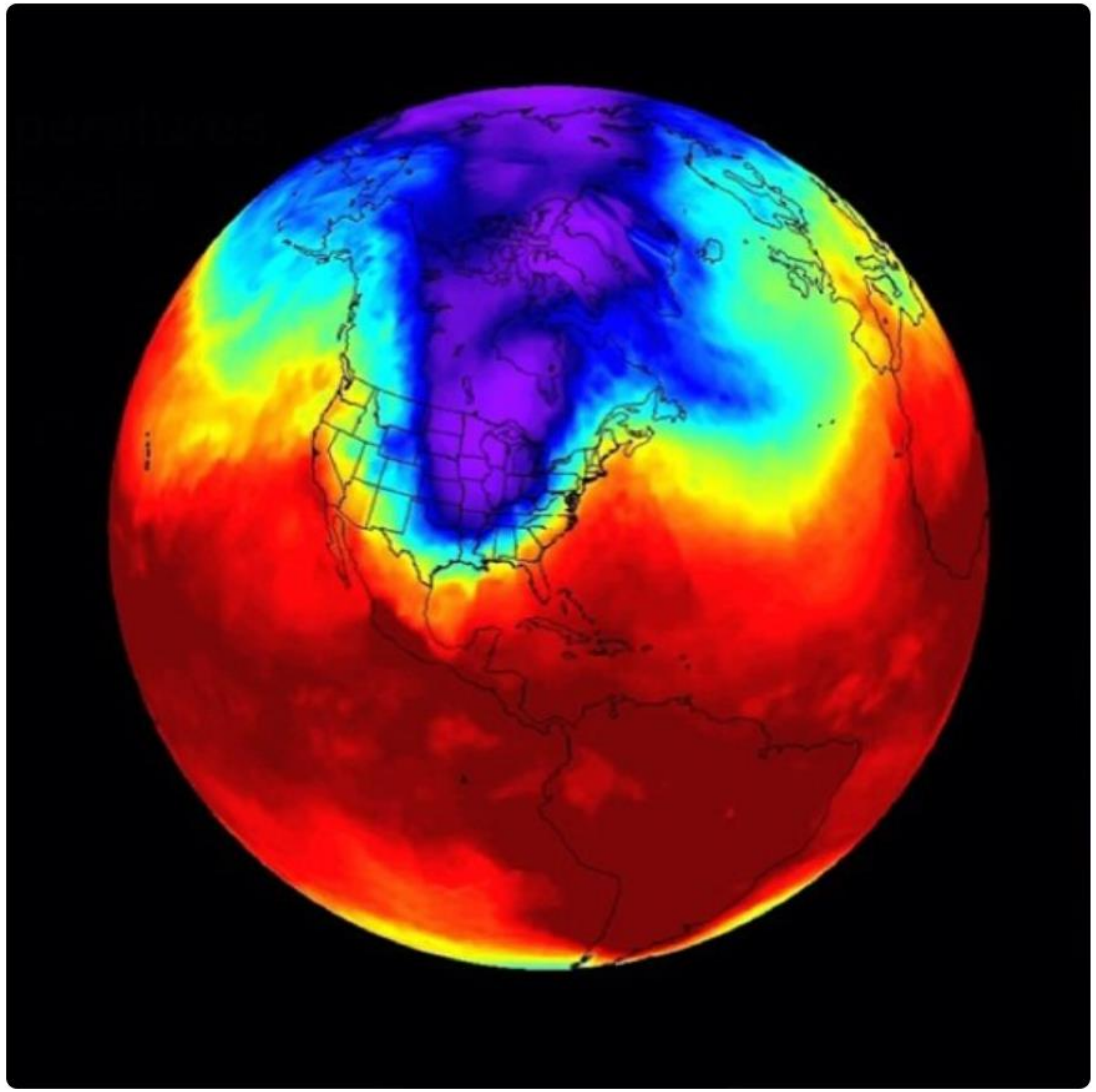

Image credit: NASA

- **Price for LP hit $5/gallon (record high) wholesale at Conway, Kansas hub.**
- Trains can't use brakes in extreme cold weather (40% or more LP in Wisconsin delivered via rail)
- 260,000+ residents use LP for home heating, 26,000 low-income/vulnerable

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2019 Polar Vortex – MISO Emergency- NG curtailment

- Infrastructure designed for bitter cold temperatures.
- Insulated wind turbines, heat traced pipes
- Crushers to break up piles of coal
- 11 deaths directly related to temperatures, record lows including -55 F wind chill

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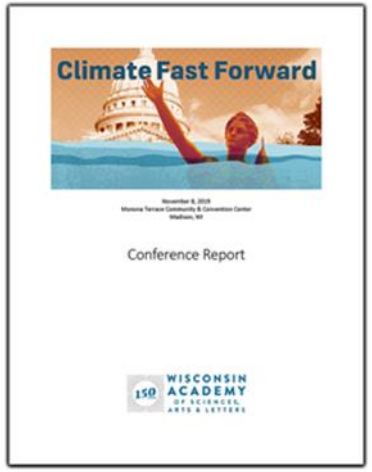
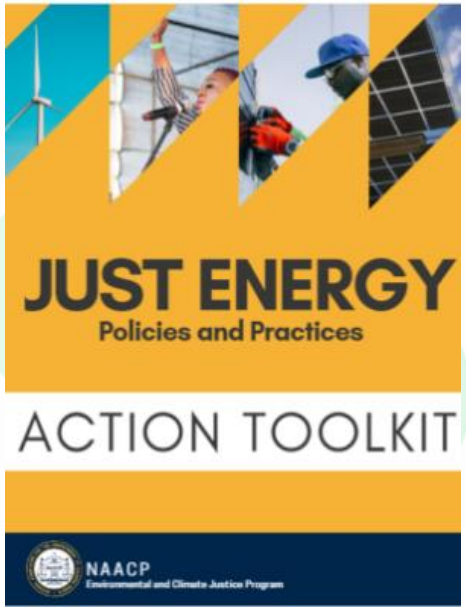
Energy Justice is a Critical Component of Energy Security

Figure 1 Wind events July 2019 https://www.weather.gov/grb/071919_severe_event



Energy Storage for Social Equity Initiative -- https://www.pnnl.gov/projects/energy-storage-social-equity-initiative



https://www.naacp.org/climate-justice-resources/just-energy/

2010 San Bruno Pipeline Explosion

OEI Wisconsin Office of Energy Innovation

Energy On Wisconsin

OEI Extension UNIVERSITY OF WISCONSIN-MADISON Wisconsin Office of Energy Innovation

Critical Infrastructure Microgrid & Community Resilience Center Pilot Grant Program

- **The Pilot Grant Program (CIMCRC)** design details were established by the Public Service Commission in an open meeting on April 15, 2021

- **Federally Funded** through U.S. Department of Energy by the State Energy Program

- Program Design Memorandum staff researched programs in:
  - New York (NY Prize)
  - Connecticut
  - New Jersey
  - Rhode Island
  - Maryland
  - Massachusetts

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Strategic Objectives

- **Energy Security:** Foster critical infrastructure security and resilience, improving the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.
- Prioritize reliability and resilience benefits (during outages not caused by events beyond a utility's control) and benefits of avoiding major power outages (i.e. outages caused by major storms or other events beyond a utility's control).
- **Clean Energy Equity:** Help provide equitable access to the benefits of clean energy, efficiency, and preparedness by reaching broad applicant types. This includes applicants who may traditionally face barriers to adopting clean energy solutions and the benefits they provide, or whose communities may be disproportionately impacted by the negative effects of traditional fossil fuel and inefficient energy systems.

Critical Infrastructure Microgrid & Community Resilience Center Grant Program

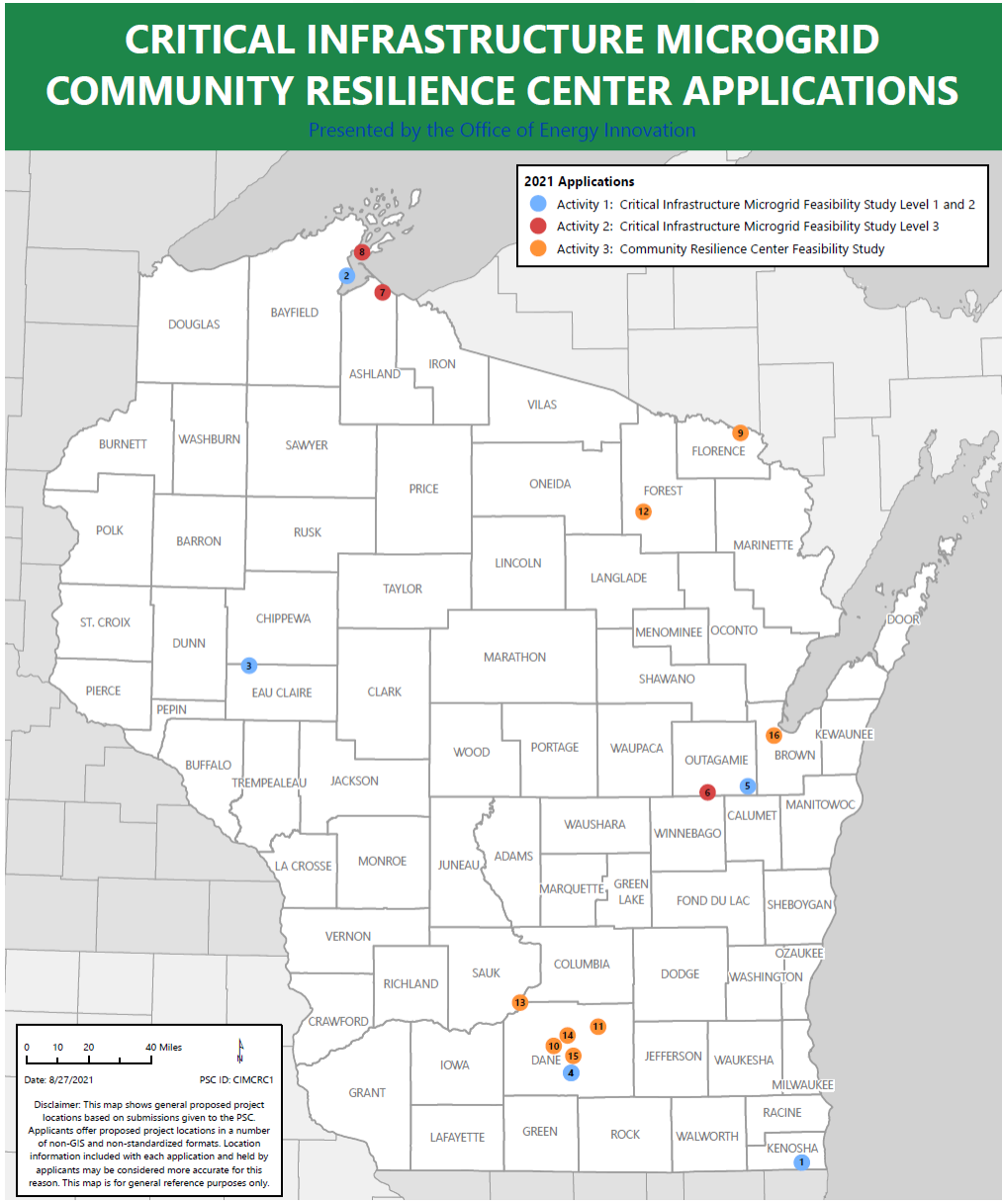
15 projects funded to study the feasibility of Microgrids for resilience across Wisconsin:

Projects include:

Hospital, Airport, Police Operations Center, Business Park, Mobile Microgrid, Mini-grid (combination of 3 microgrids), Water Treatment Facility, Wastewater Treatment Facility, and more!

$915,000 awarded

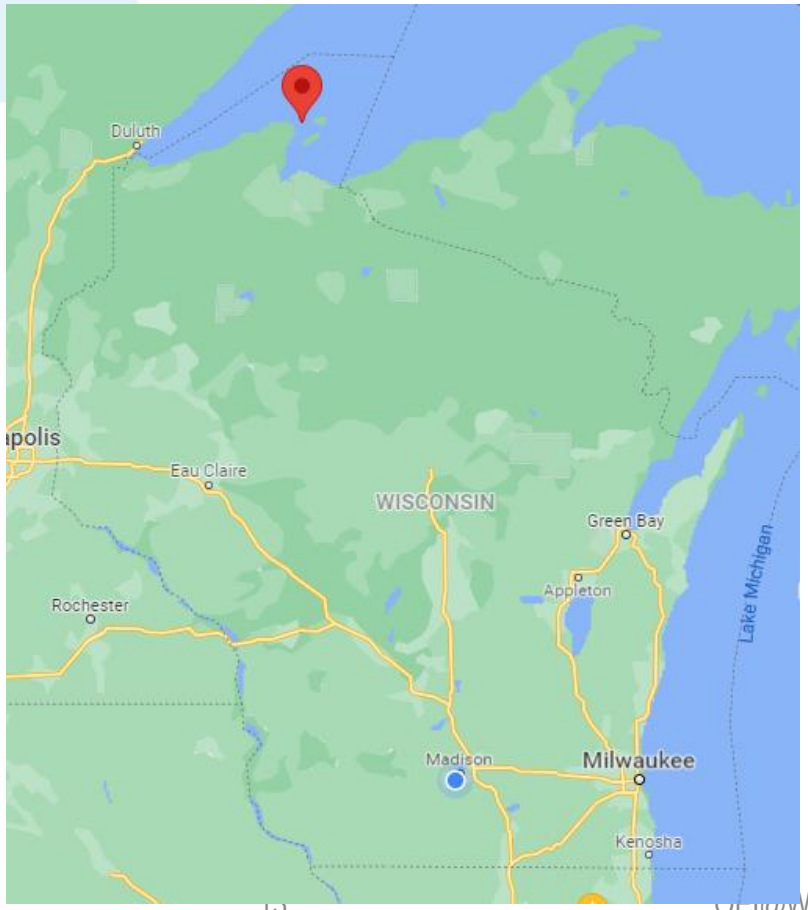
Docket# [9705-FG-2020]

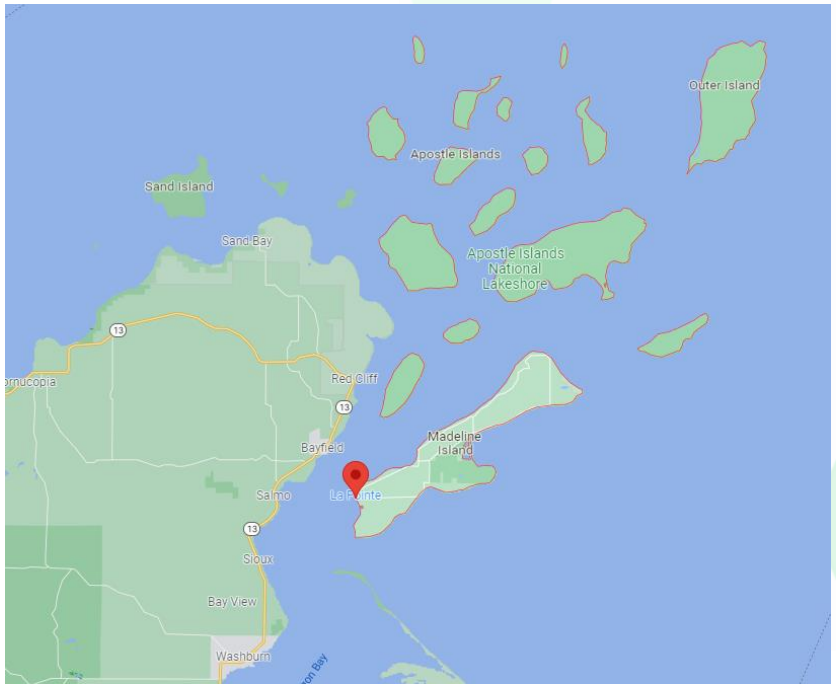


Town of La Pointe Microgrid Feasibility Study

Level 3 Critical Infrastructure Study:

Remote community located on Madeline Island, part of Apostle Islands National Lakeshore





Wisconsin Office of Energy Innovation

Town of La Pointe Microgrid Feasibility Study

Level 3 Critical Infrastructure Study:

Key to the project- existing DERs and propane generators- considering lithium-ion battery storage, controls, solar.

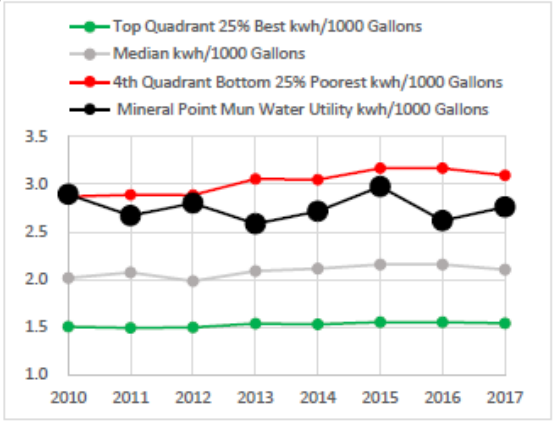
Technical Assistance Programs: MEETAP- Water Utility Analysis

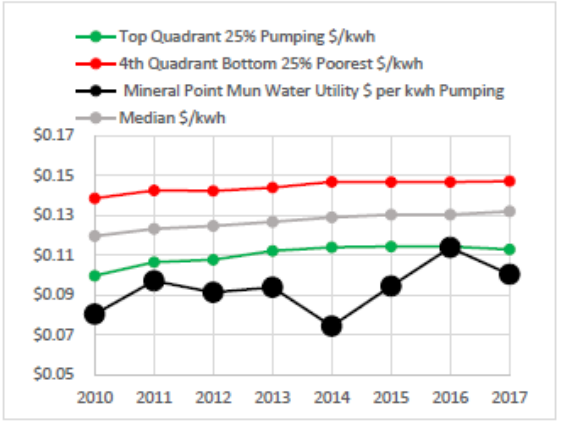
Quartile Statistical Benchmarks where 1 = Top Quadrant 25% Best, 2 = 2nd Quadrant Good, 3 = 3rd Quartile below Median & 4 = 4th Quadrant Bottom 25% Poorest

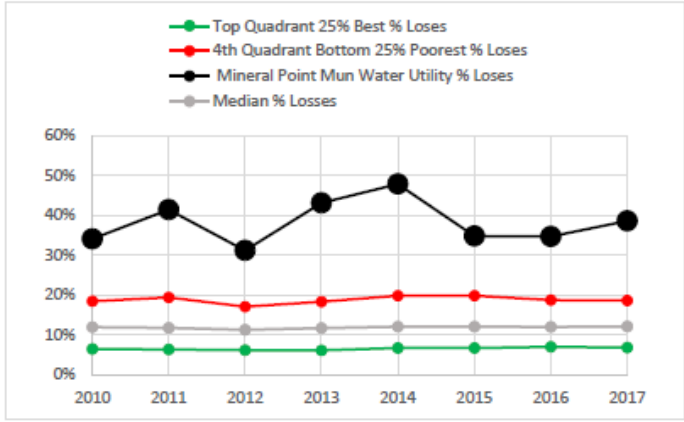
Utility ID	Utility	Performance Benchmark	2010	2011	2012	2013	2014	2015	2016	2017	2010-2017 Average
3740	Mineral Point Mun Water Utility	kwh/1000 Gal Quad	4	3	3	3	3	3	3	3	3
3740	Mineral Point Mun Water Utility	% Water Losses Quad	4	4	4	4	4	4	4	4	4
3740	Mineral Point Mun Water Utility	$ per kwh Pumping Quad	1	1	1	1	1	1	1	1	1
3740	Mineral Point Mun Water Utility	$ per 1000 Gallons Quad	2	3	3	2	2	2	3	2	2

Water utilities with benchmarks of 3 (Yellow) and 4 (Red) can request that MEETAP prepare a system analysis of wells, towers and pumps to estimate demand, energy and cost savings (capacity and average operating characteristics – on-peak, capacity factor, constant flow high pressure control vs variable flow constant pressure, etc.).

Utility ID	Utility	Performance Benchmark	2010	2011	2012	2013	2014	2015	2016	2017	2010-2017 Average
3740	Mineral Point Mun Water Utility	kwh/1000 Gallons	2.89	2.67	2.80	2.58	2.72	2.97	2.62	2.76	2.75
3740	Mineral Point Mun Water Utility	% Water Losses	34.07%	41.39%	31.15%	43.07%	47.78%	34.77%	34.66%	38.55%	38.18%
3740	Mineral Point Mun Water Utility	$ per kwh Pumping	$ 0.08	$ 0.10	$ 0.09	$ 0.09	$ 0.07	$ 0.09	$ 0.11	$ 0.10	$ 0.09
3740	Mineral Point Mun Water Utility	$ per 1000 Gallons	$ 0.23	$ 0.26	$ 0.26	$ 0.24	$ 0.20	$ 0.28	$ 0.30	$ 0.28	$ 0.26







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The Renewable Natural Gas Opportunity

Photo 5: Pipeline injection of biogas from a Dane County Landfill, Dane County Public Works, Madison, WI

WI Biogas Survey 2015:
WisconsinBiogasSurveyReport.pd

WI Biogas Survey 2020:

WI Biogas_Feedstock Survey Report Final (05_18_21).pdf

Photo 3: High strength equalization tank with truck, Waste Water Treatment Facility, Stevens Point, WI

Photo 2: Manure Anaerobic Digester Facility, EnTech Solutions in partnership with Northern Biogas, Middleton, WI

Photo 4: Food waste-to-energy biodigester facility, Forest County Potawatomi Community Renewable Generation, LLC,

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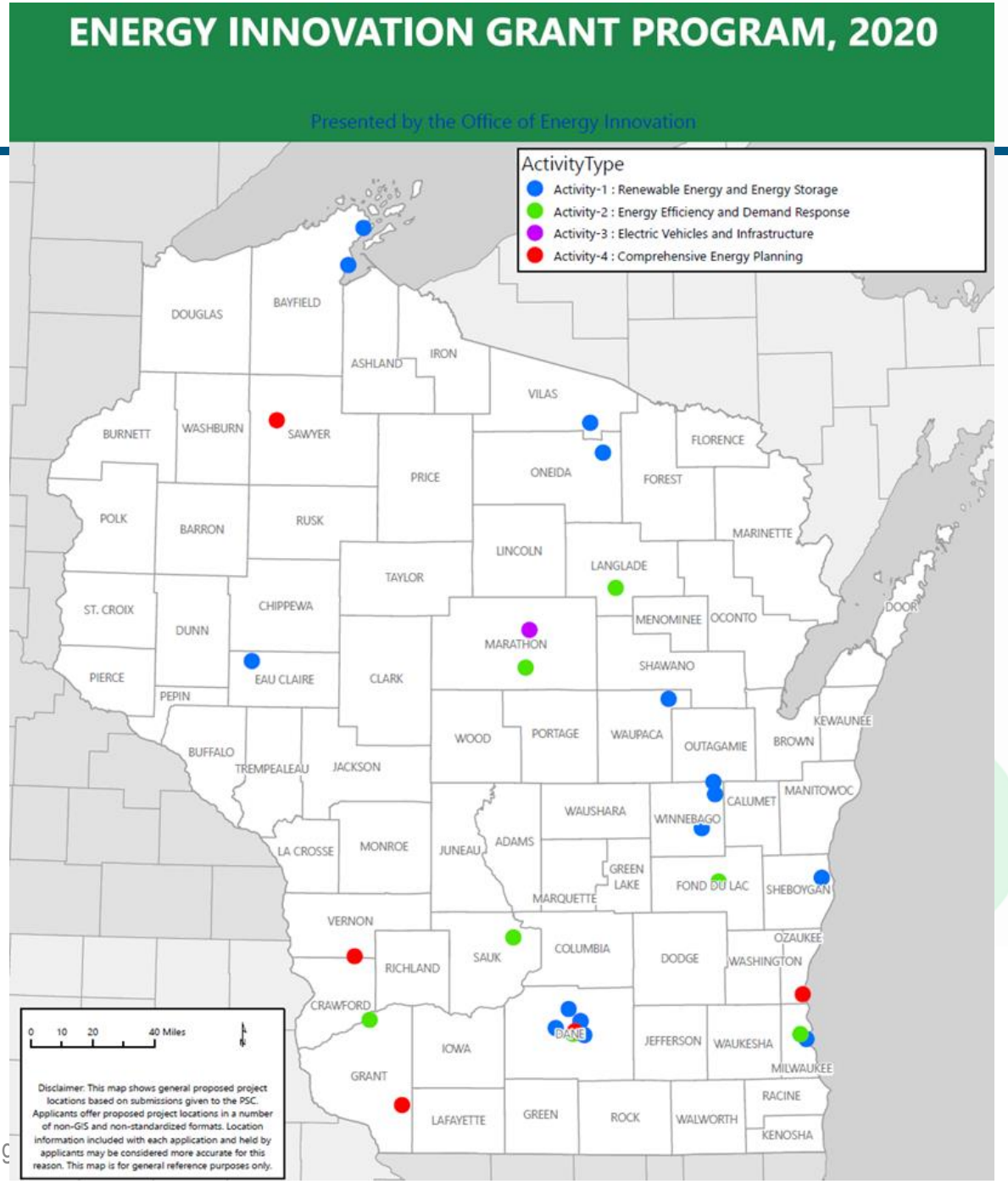
2020 EIGP

$7M Grant Round

32 Projects Funded

- 15 Renewable Energy
  (12 included battery storage)
- 9 Efficiency
- 2 Clean Transportation
- 6 Comprehensive Planning

Docket 9709-FG-2020



Questions?

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RMI
ENERGY. TRANSFORMED.

Hours of Safety

How Better Buildings Help Us Shelter In Place in Extreme Cold Events

April 13, 2022

What happens when extreme cold brings down the grid?

- Most appliances stop working
- Roads may become inaccessible
- Indoor temperatures begin to drop

Prolonged cold exposure can be deadly

Death toll from Texas cold snap in February rises to 210

21 People Died in Weather-Related Incidents During the Polar Vortex

Hundreds of Deaths as Europe Struggles With Snow Amid an Intense Cold Snap

Cold weather-related deaths reach 17 in Iowa during winter season

More than 2 dozen deaths blamed on record-setting cold blast

Most Vulnerable Populations:

- Low income residents
- Renters
- Elderly residents
- Children
- Those with prior medical conditions
- Rural/isolated areas

Temp Range	Stress Scale
64 °F	Min safe temp for vulnerable populations
60-64 °F	Safe temp for healthy populations
50-60 °F	Mild cold stress
40-50 °F	Moderate cold stress
Below 40 °F	Severe cold stress

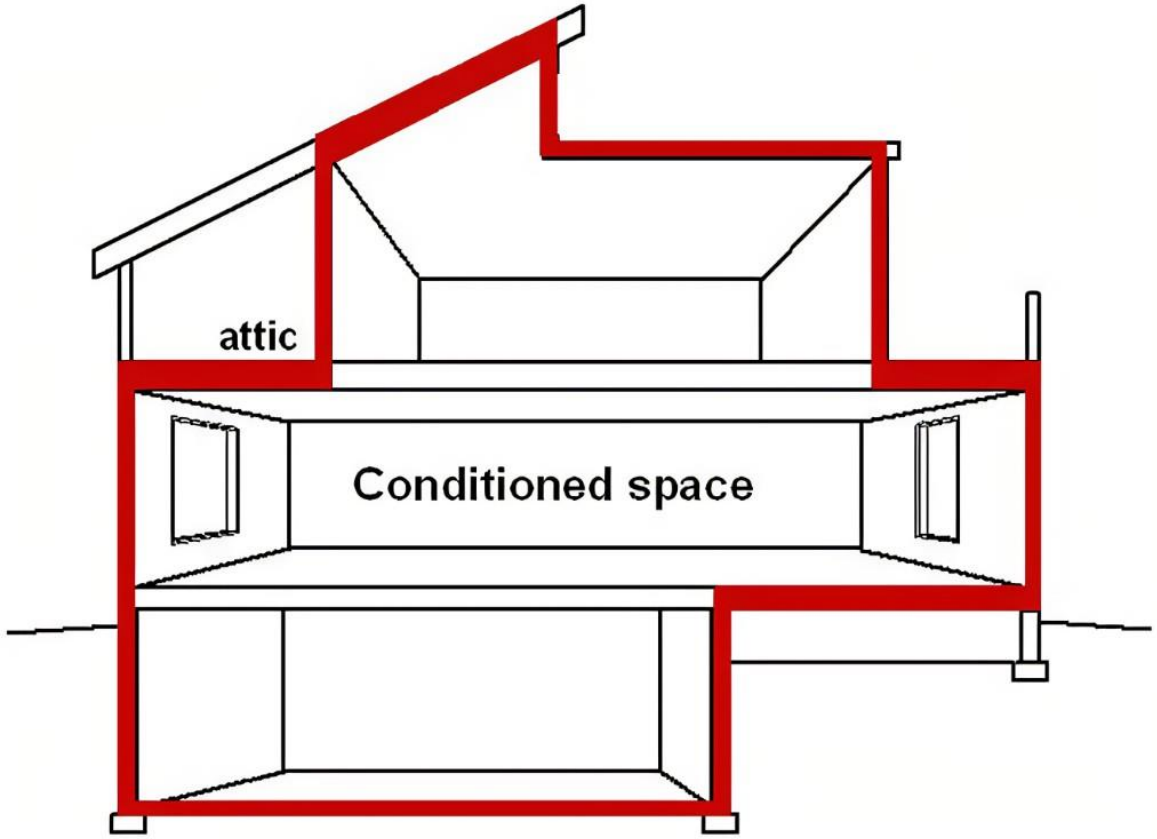
Proposed Cold Stress Thresholds

Building envelopes and passive resilience

A building envelope is the outer shell that separates indoor from outdoors:

- Walls
- Roofs
- Foundations, slabs, and basements
- Windows and doors

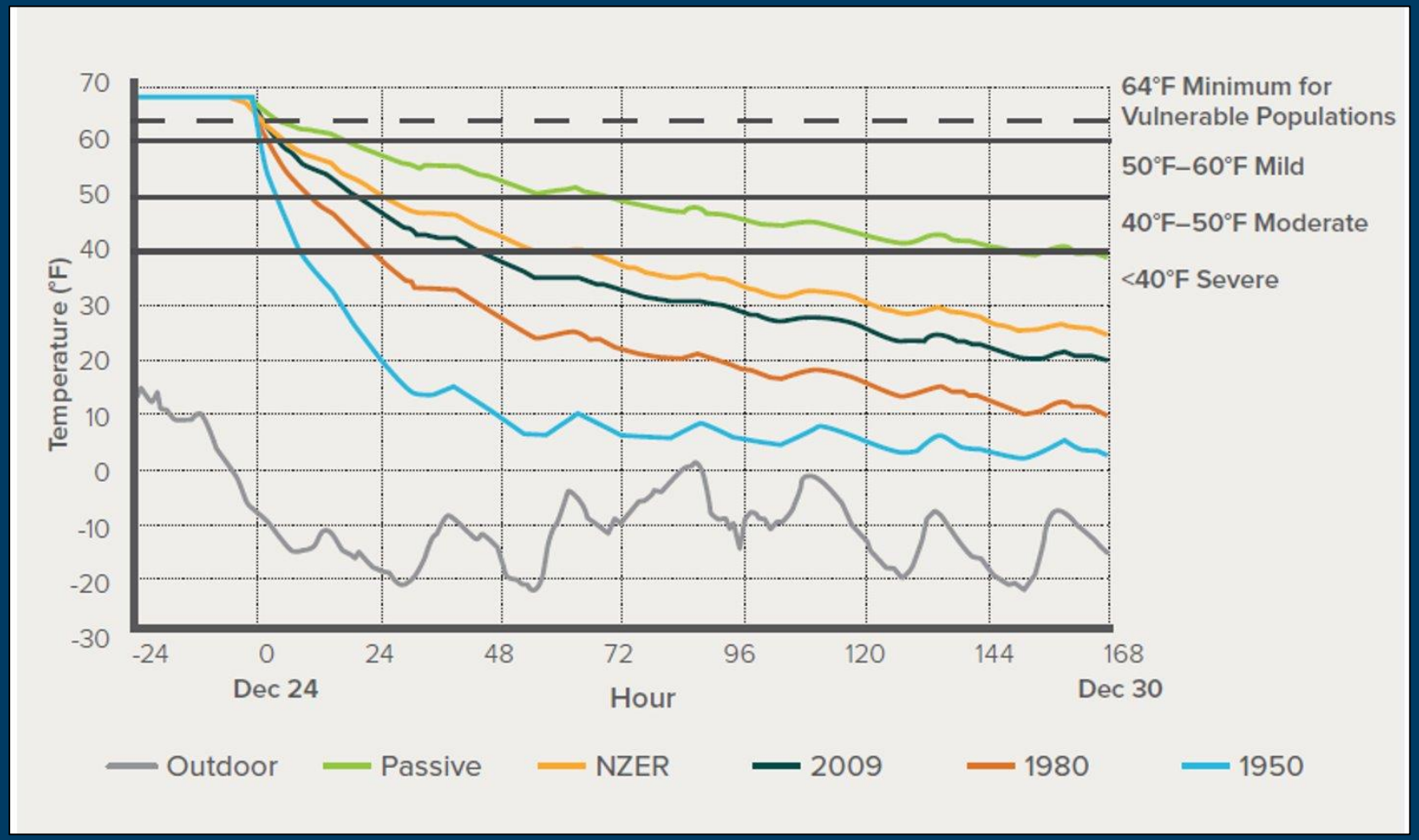
For most buildings, the envelope is your **only protection from extreme weather** once the grid goes down.



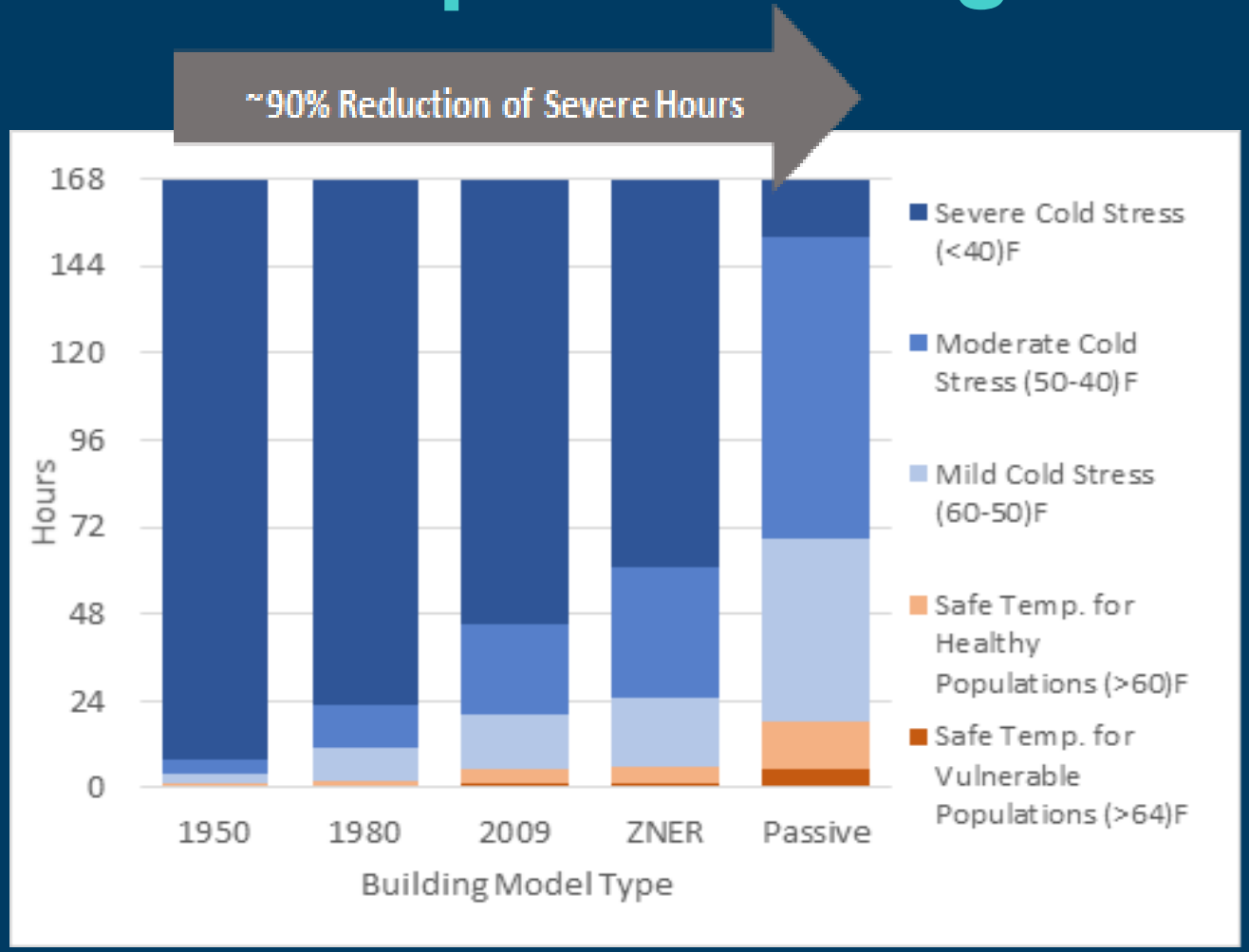
Better building envelopes allow residents to shelter in place through outages

RMI Modeling:

- Real weather event from Duluth, MN in 2017
- Temperature ranged between 5 to -25 °F over seven days
- Modeled a typical single family home with different levels of envelope performance:
  - 1950s era home
  - 1980s era home
  - 2009 IECC code
  - DOE Zero Energy Ready Home
  - Passive House

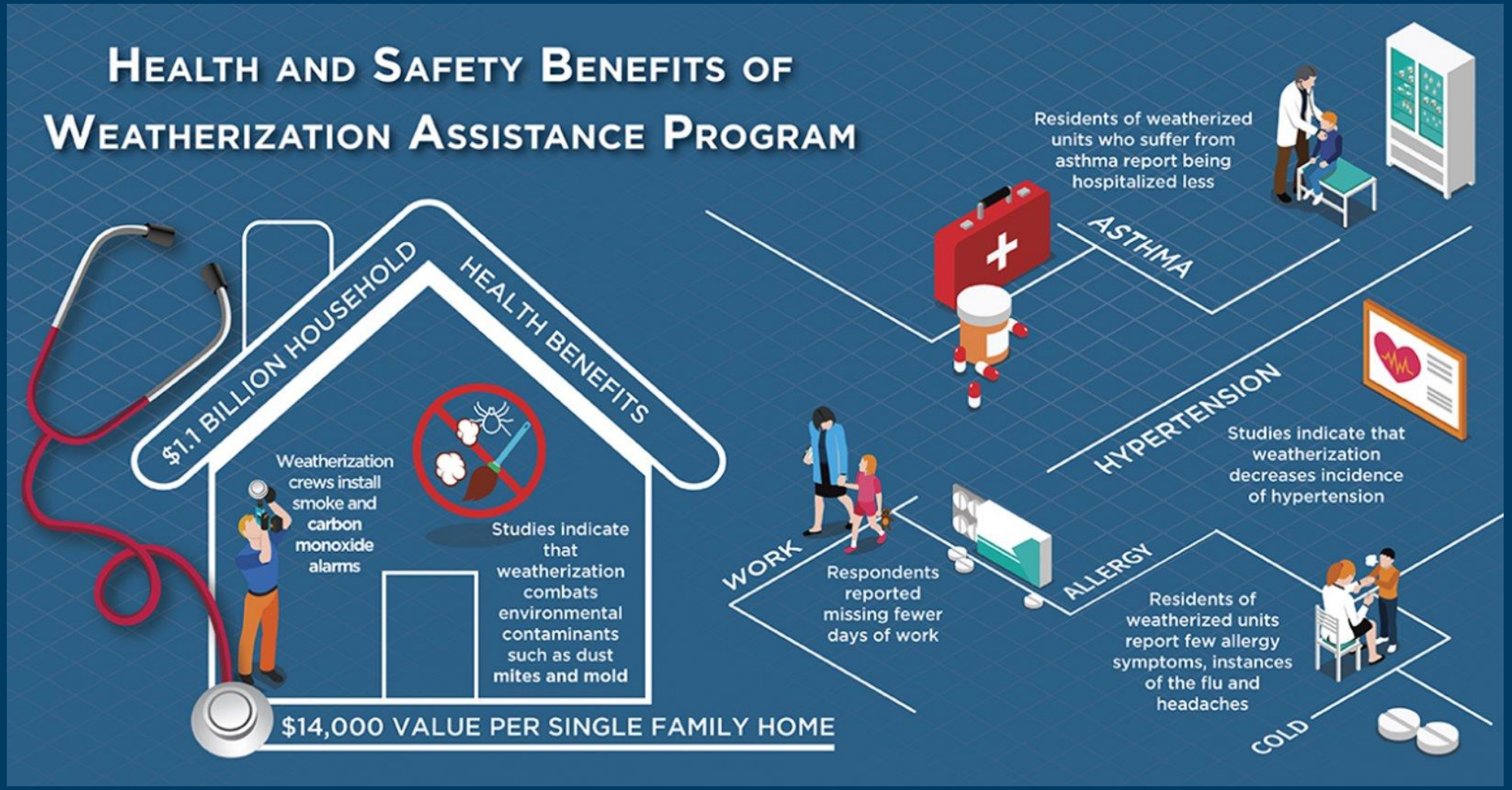


Better building envelopes allow residents to shelter in place through outages



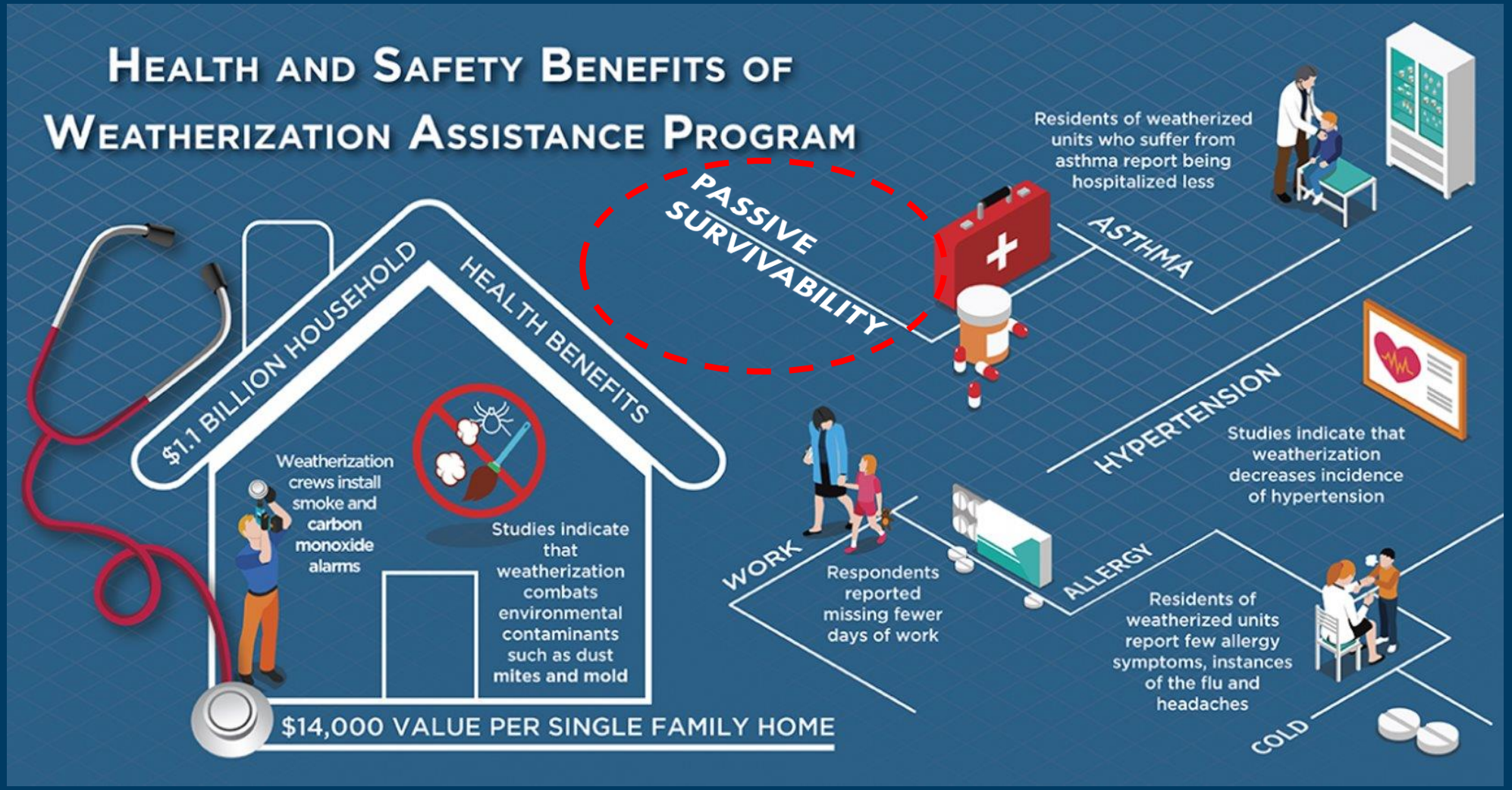
Modeled Home	Hours of Safety (40 °F threshold)
1950s era home	8
1980s era home	23
2009 IECC Code	45
DOE Zero Energy Ready Home (ZERH)	61
Passive House	152

This benefit isn't quantified– and it should be!



Source: National Association for State Community Services Programs

This benefit isn't quantified– and it should be!



Source: National Association for State Community Services Programs

It'll take time to deploy the Hours of Safety concept

- ❑ Better understand the health impacts/risks of sustained cold exposure
- ❑ Define correlation between various building characteristics and hours of safety for…
  - Different weather events (hot vs cold, short vs sustained duration)
  - Different building types
  - Different at-risk populations
- ❑ Create a standard Hours of Safety metric calculated using existing data streams
- ❑ Crafting guidelines for city/state adoption and utilization

Congress can support home resilience now

1. **Continue to scale-up funding for home retrofits** and ensure programs and incentives for weatherization, health and safety, clean energy, and affordability can be easily stacked together to create holistic, one-stop-shop retrofit programs.

2. **Support High Efficiency Home Rebate Program in reconciliation:** As envelopes tighten, IAQ becomes more of a concern, so it will be important to also support electrification. This program also provides funding for insulation and air sealing.

For more information…

https://rmi.org/insight/hours-of-safety-in-cold-weather/

Contact: mgartman@rmi.org

EESI
Environmental and Energy Study Institute

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www.eesi.org/041322climatechange

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Wednesday, April 13, 2022