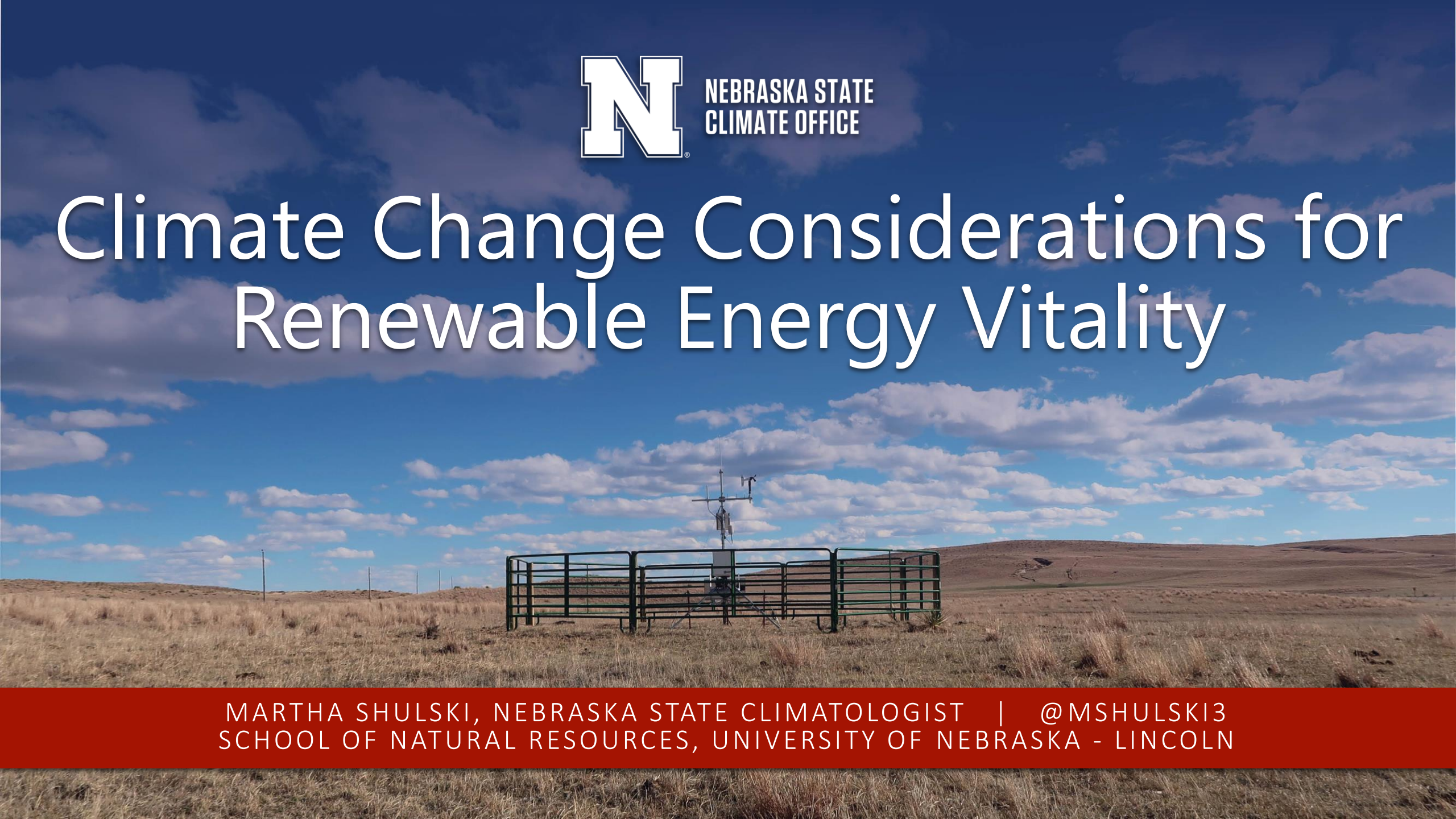
NEBRASKA STATE CLIMATE OFFICE

Climate Change Considerations for Renewable Energy Vitality



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Nebraska State Climate Office

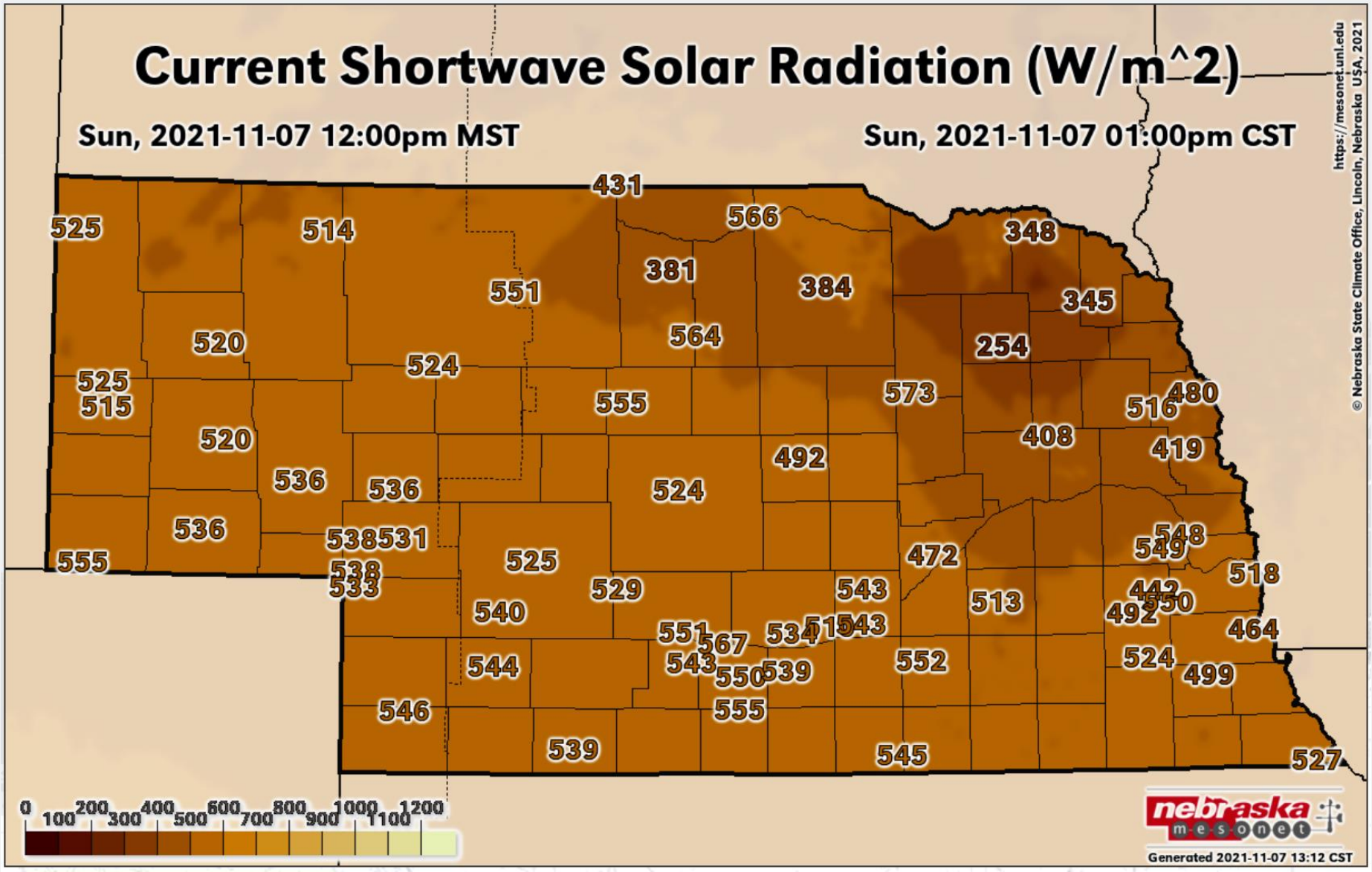
nsco.unl.edu

- Observe our environment.
- Engage stakeholders.
- Inform decisions.

Nebraska Mesonet weather station at Bushnell (Kimball Co.)

Observing Nebraska's Weather

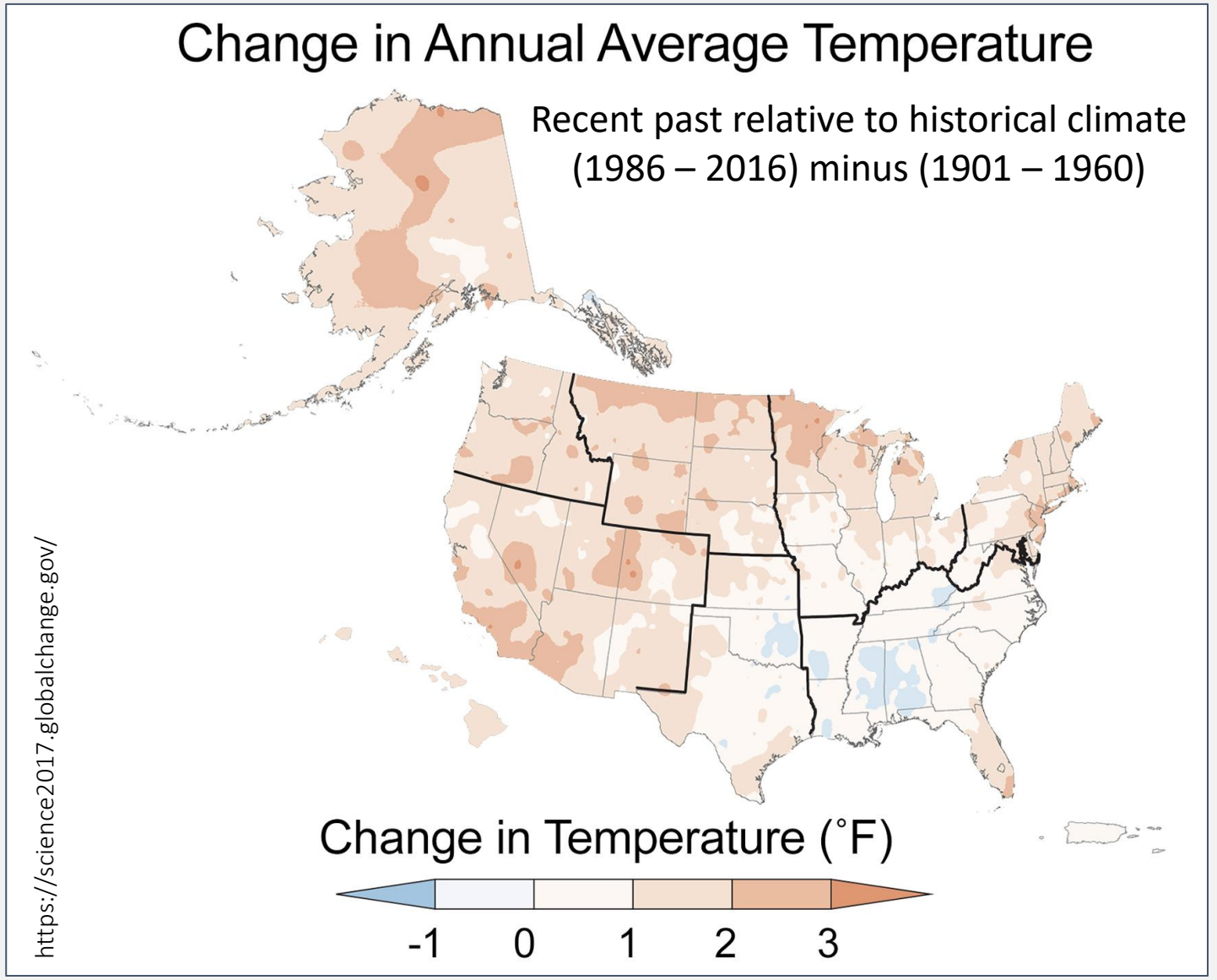
mesonet.unl.edu



Indicators of change

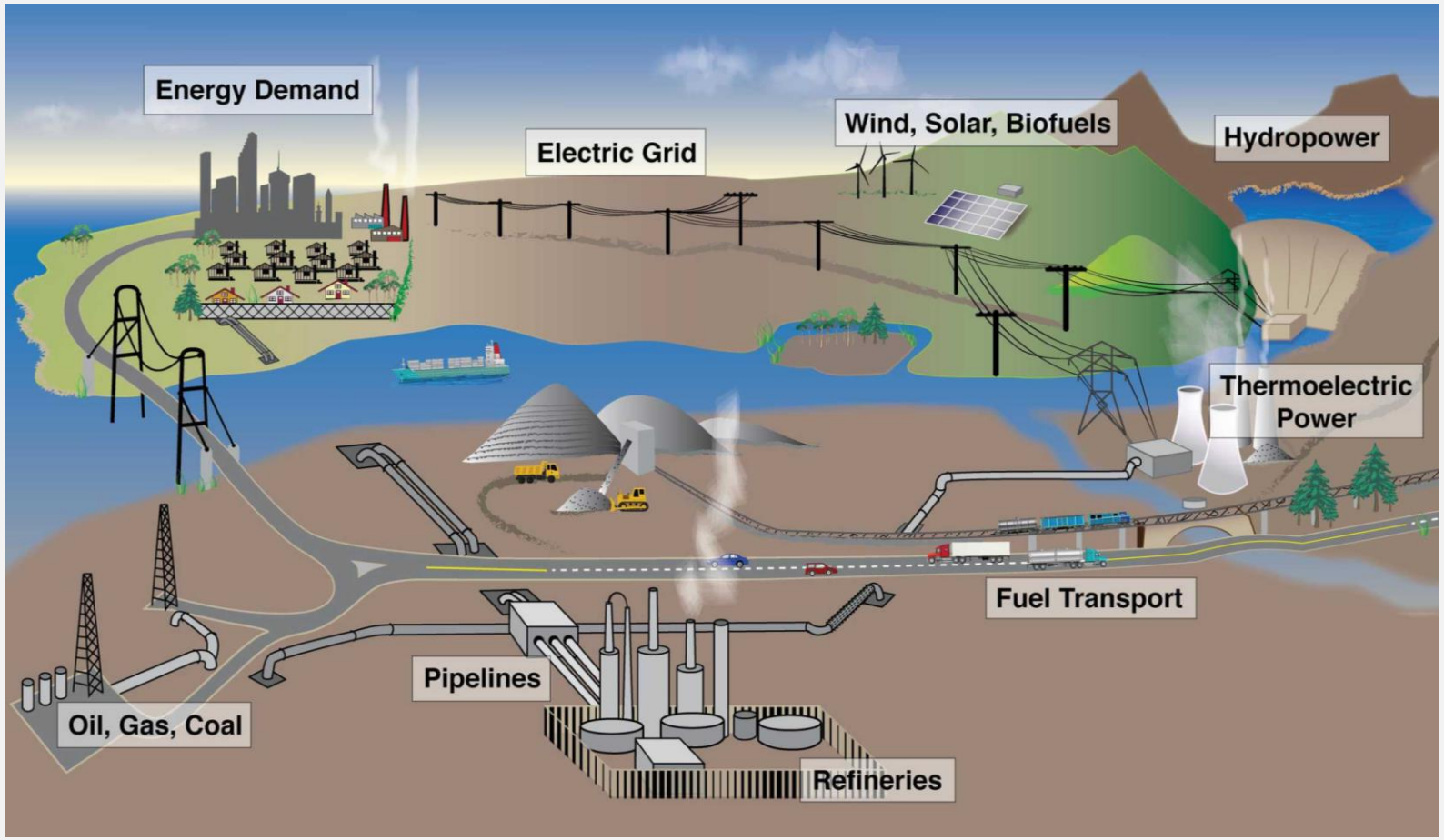
- Large scale warming, especially the Arctic.
- More heatwaves, heavier precipitation.
- Snowpack decline across western U.S.
- Increasing wildfire activity.
- Longer growing season.

“All regions and ecosystems of the United States are experiencing the impacts of climate change.” [U.S. National Climate Assessment, 2018]



Energy supply, delivery and demand

- The Nation's energy system *is already affected* by extreme weather events.
- ***Risks will increase*** due to more frequent and longer-lasting power outages affecting infrastructure and creating availability and demand imbalances.
- The energy system reliability, security, and resilience ***underpin virtually every sector of the economy***.



https://nca2018.globalchange.gov/chapter/4/

Nebraska's climate past

- Overall warming with nights warming twice as fast as days.
- Rate of warming accelerating in recent decades (except February).
- Trend toward wetter and more extreme rainfall.

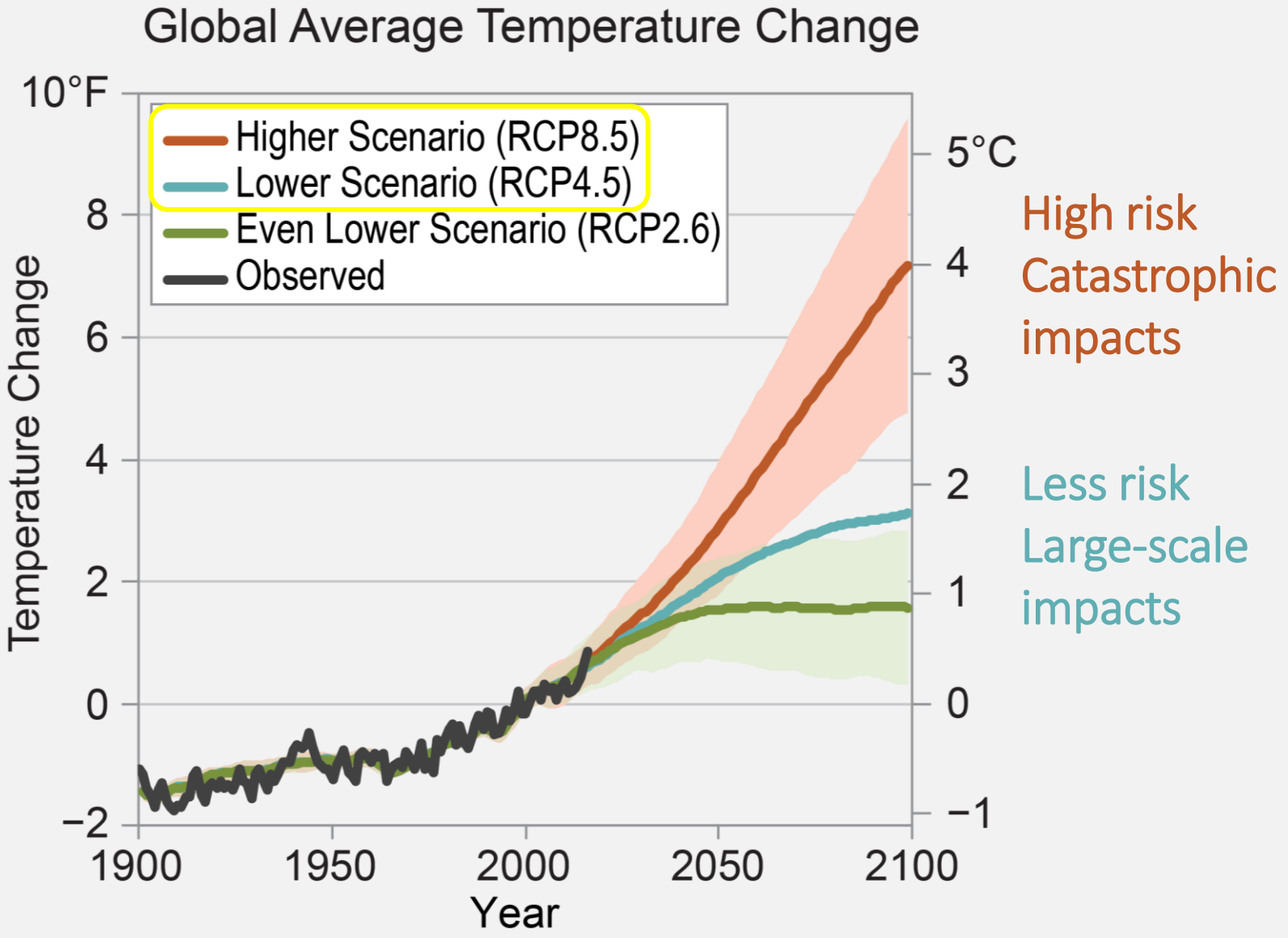
February's temper tantrum: Bitter end to winter part of worrisome trend in Nebraska

Nancy Gaarder Mar 3, 2021 Updated Aug 7, 2021 10

Our climate future is up to us

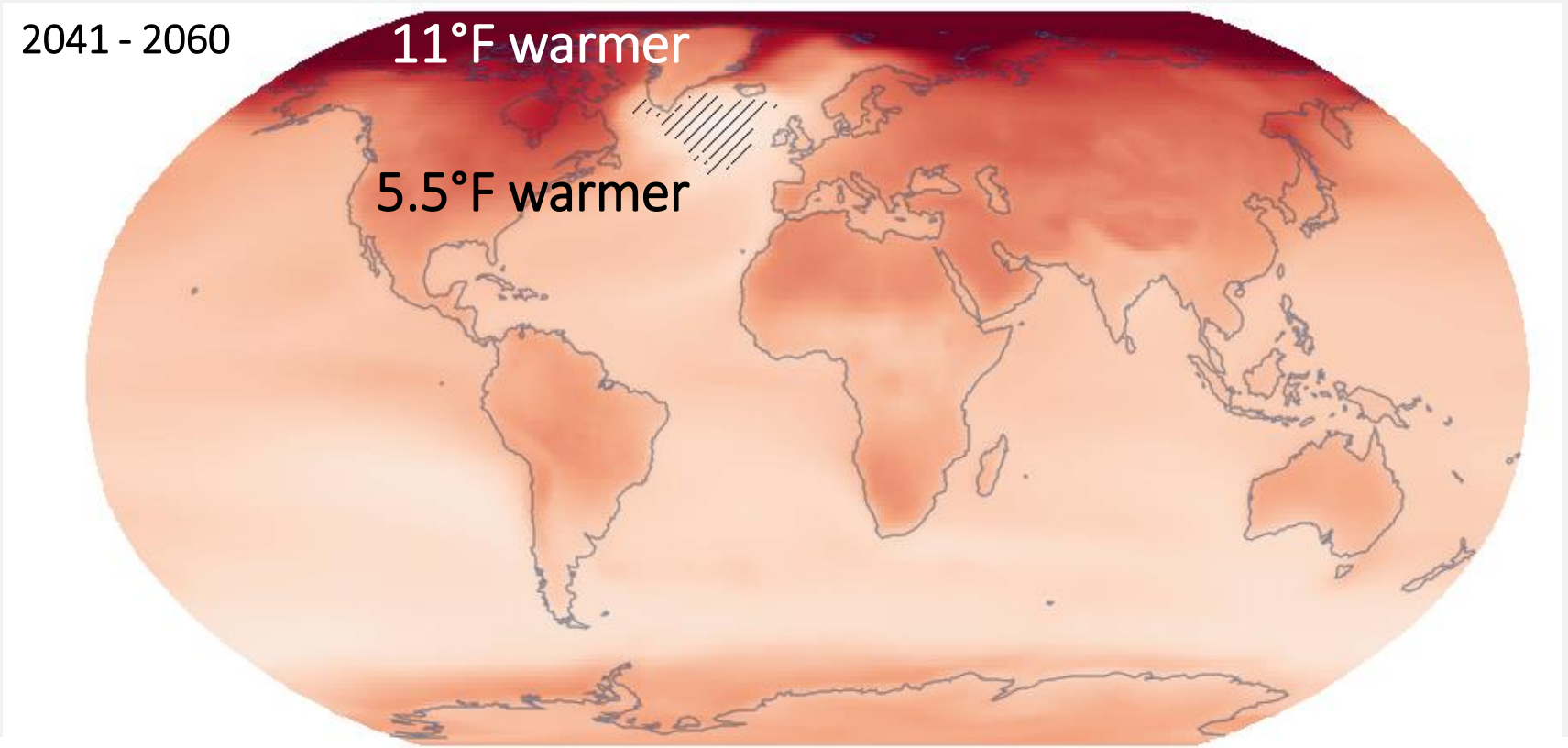
RCP Representative Concentration Pathway

Global wind and solar technologies do not measurably contribute to climate change mitigation *at current installation levels*.



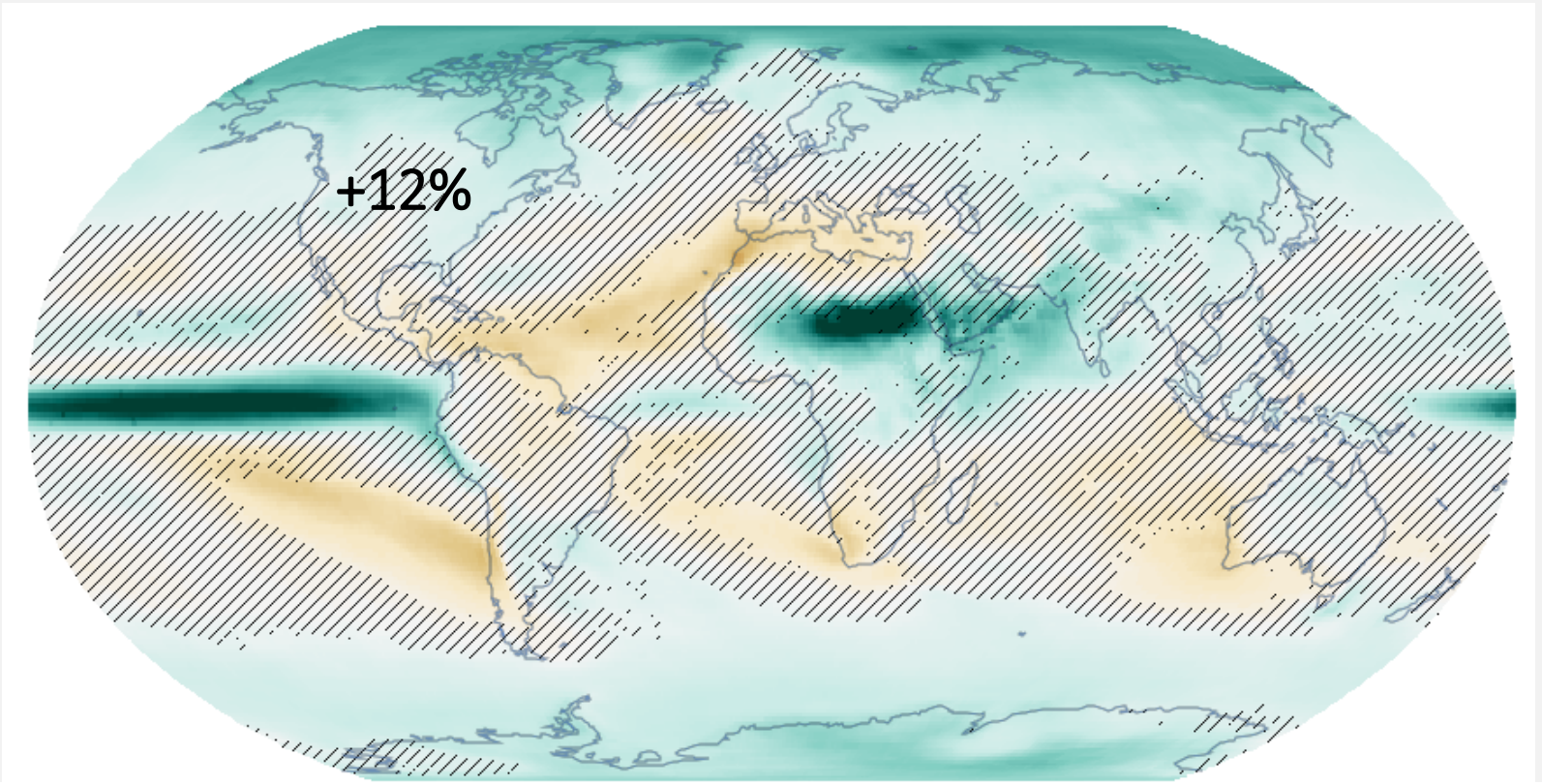
Our climate future

- Rate of warming will increase at an *unprecedented rate*.



Our climate future

- Generally, wet climates get wetter, dry climates get drier.



Our climate future

- *When and how* we get our precipitation will change.

Wetter during cold time of year.
Drier during summer.
Heavy rain events will increase.
Drought events will increase.

Spring snowmelt flood (Niobrara, 2019)

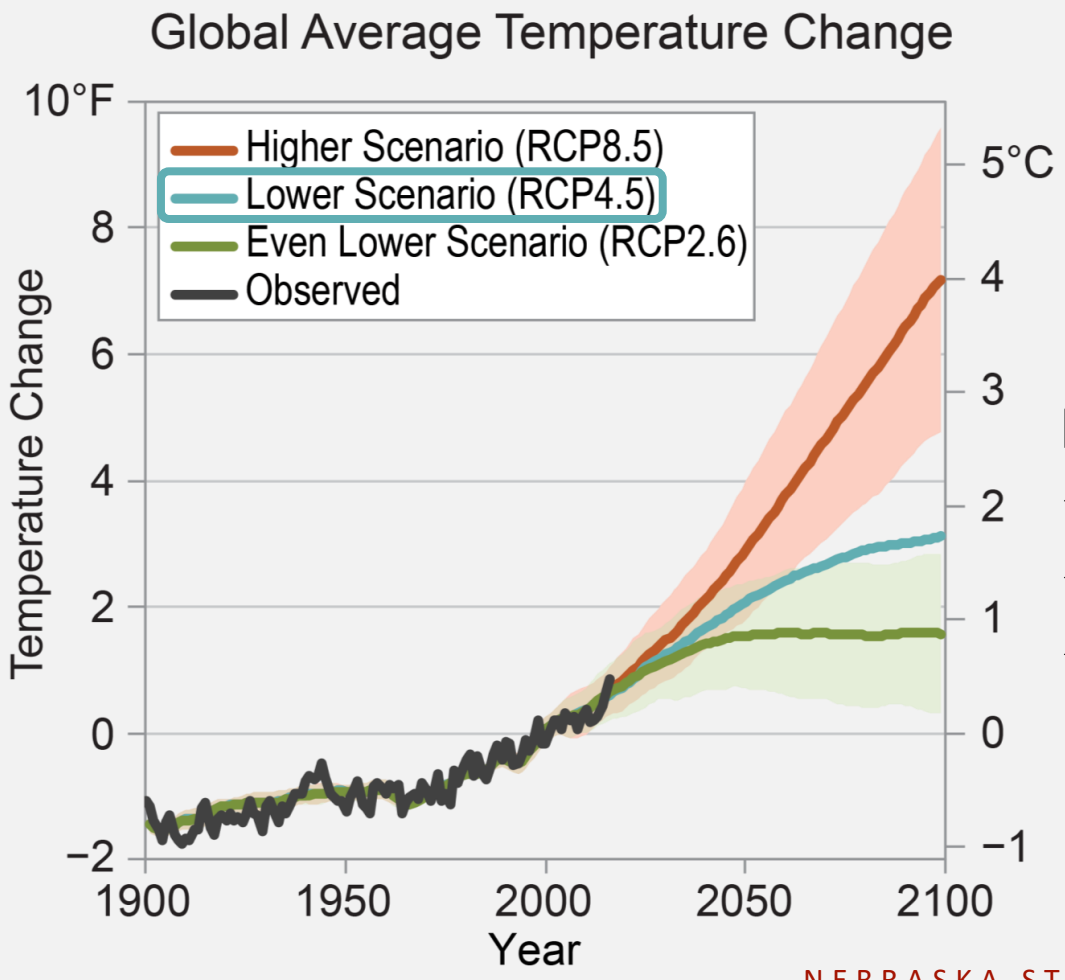
Our climate future

- Climate will be *more variable* with an *increase in extreme events*.

August 2021 flash flood event
Image: Jacob Buckingham
Courtesy KETV Omaha

Our climate future

- There is *no analog* for our future climate and *it will not stabilize* if we ignore solutions.



RCP4.5

✓ Stay within CO_2 concentration of ~450ppm.

✓ Decarbonization of the power sector by 2050.

✓ Renewables currently meet 14% of global demand.

Achieving a livable future

SOLAR

- Models have consistently underestimated PV deployment (annual growth ~38%).
- Technical potential exceeds projected energy demand, and is greater than wind potential.
- Could supply 30-50% of electricity in competitive markets.

LES solar field established in 2016.

Cruetzig et al. 2017. Nature Energy

Achieving a livable future

WIND

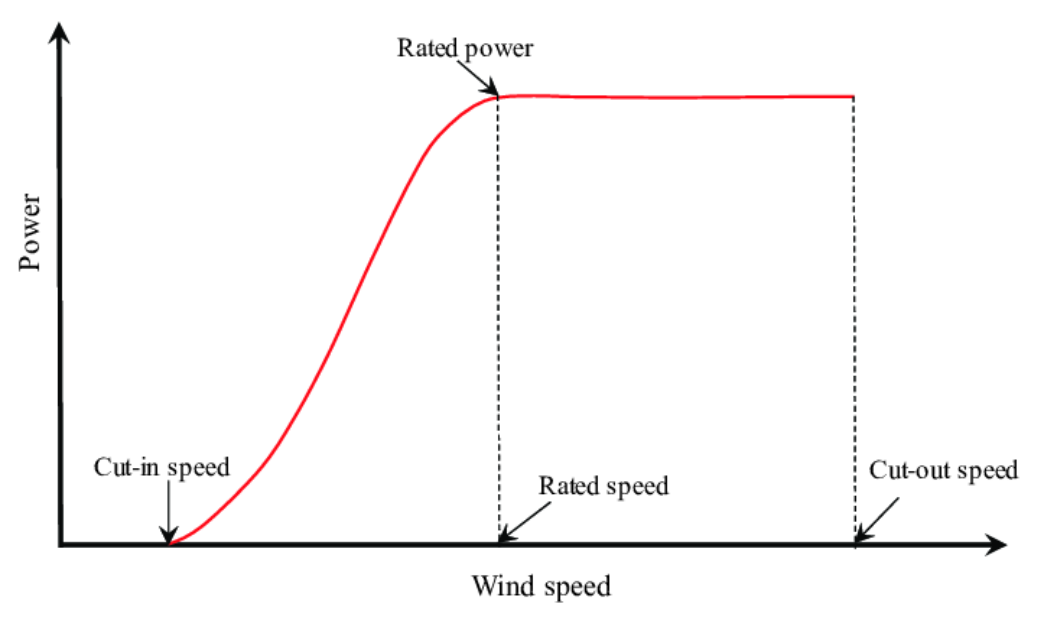
- Global extractable resource greatly exceeds present total primary energy supply.
- Wind could supply 10-31% of electricity worldwide by 2050.
- Growth of installed capacity is ~24% annually.

Barthelmie and Pryor, 2014. Nature Climate Change

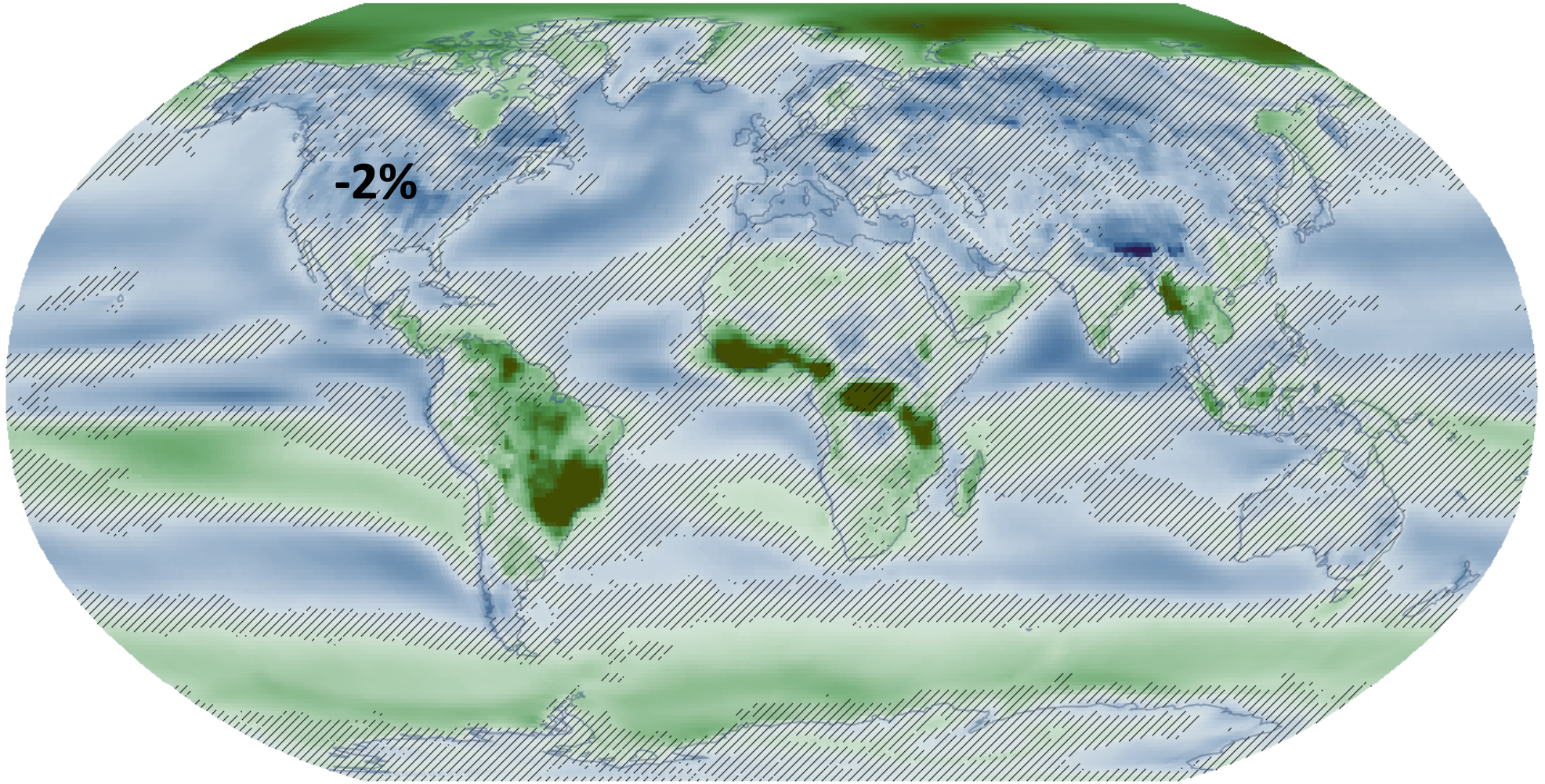
Implications for renewables - wind

- Global and regional models do not fully reproduce wind climates.
- There is large model-to-model variability in the climate change signal.

- Models suggest modest declines in mean wind speed over next 50 years (3%) and is within interannual variability.



Surface wind percentage change at mid-century (relative to present)



Surface wind - Change (%)
Medium Term (2041-2060) (SSP5-8.5) (rel. to 1981-2010)
CMIP6 - Annual (31 models)

High agreement
Low agreement

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

Implications for renewables - wind

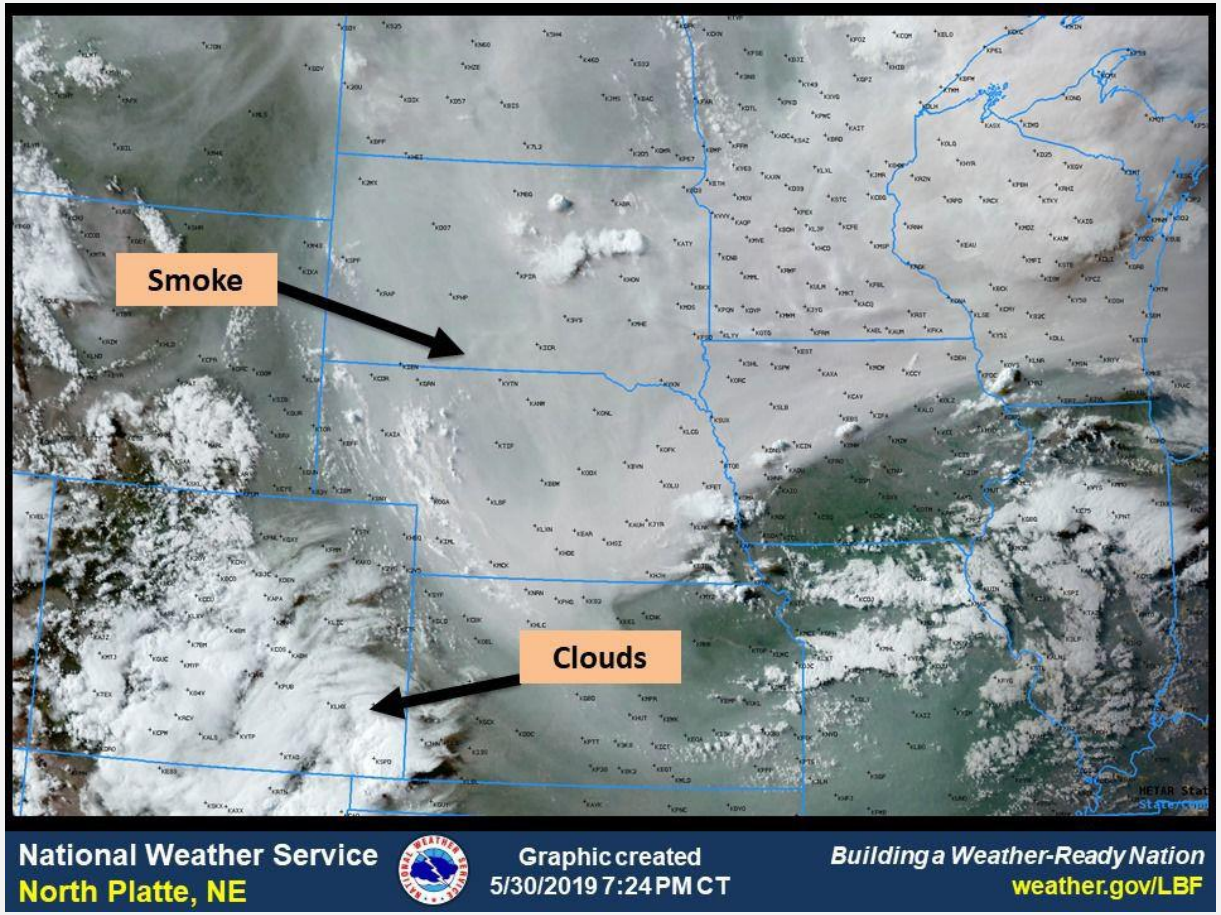
Climate change may also alter not only the wind resource, but the environmental context, operation, maintenance, design.

- Extreme speeds and gusts
- Icing events
- Operating temperature and decreasing air density

Implications for renewables - solar

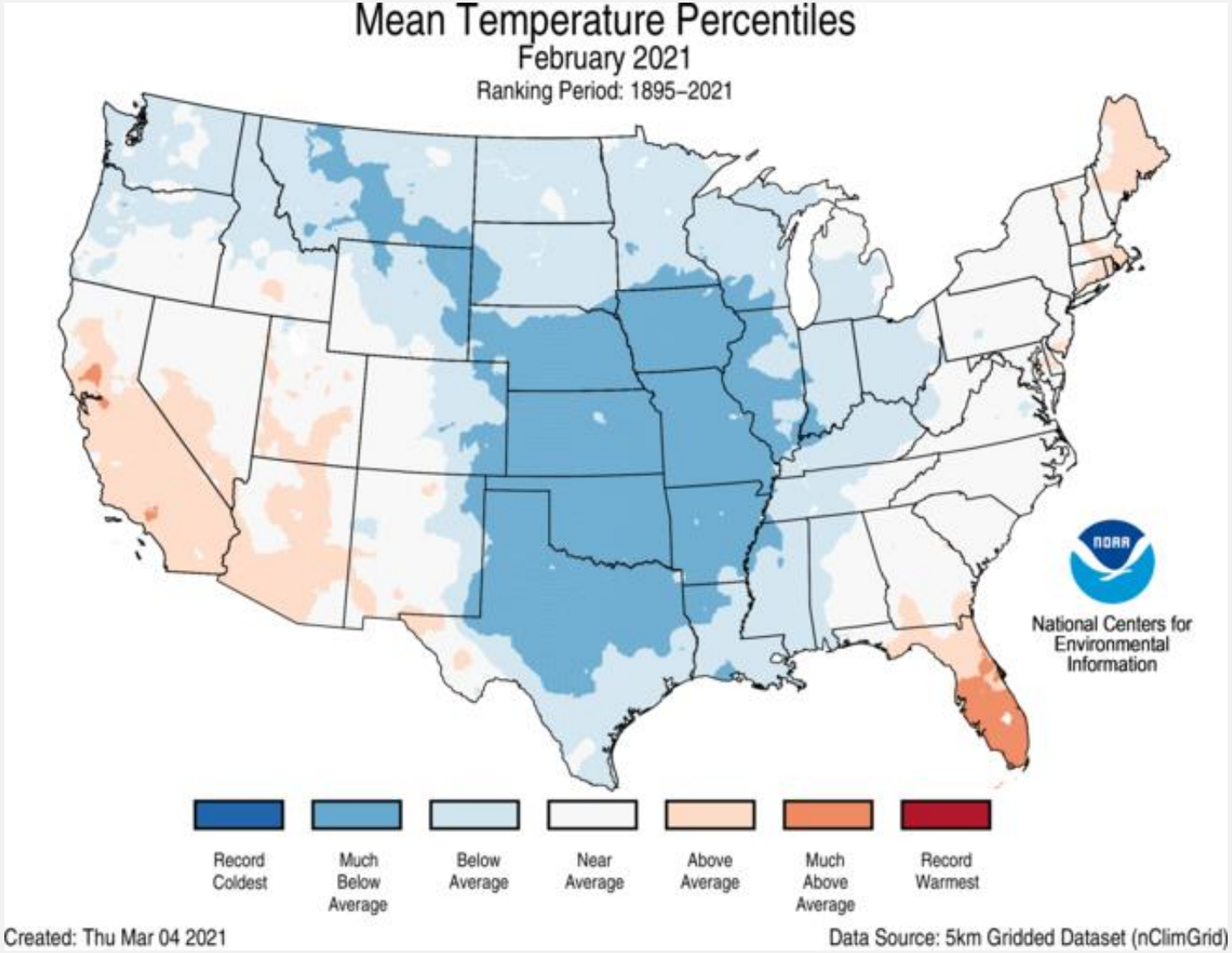
Climate change will result in an overall decrease of solar radiation.

- Variability associated with global ‘dimming’ and ’brightening’.
- Models predict a general decrease ~10% due to increased cloud cover.



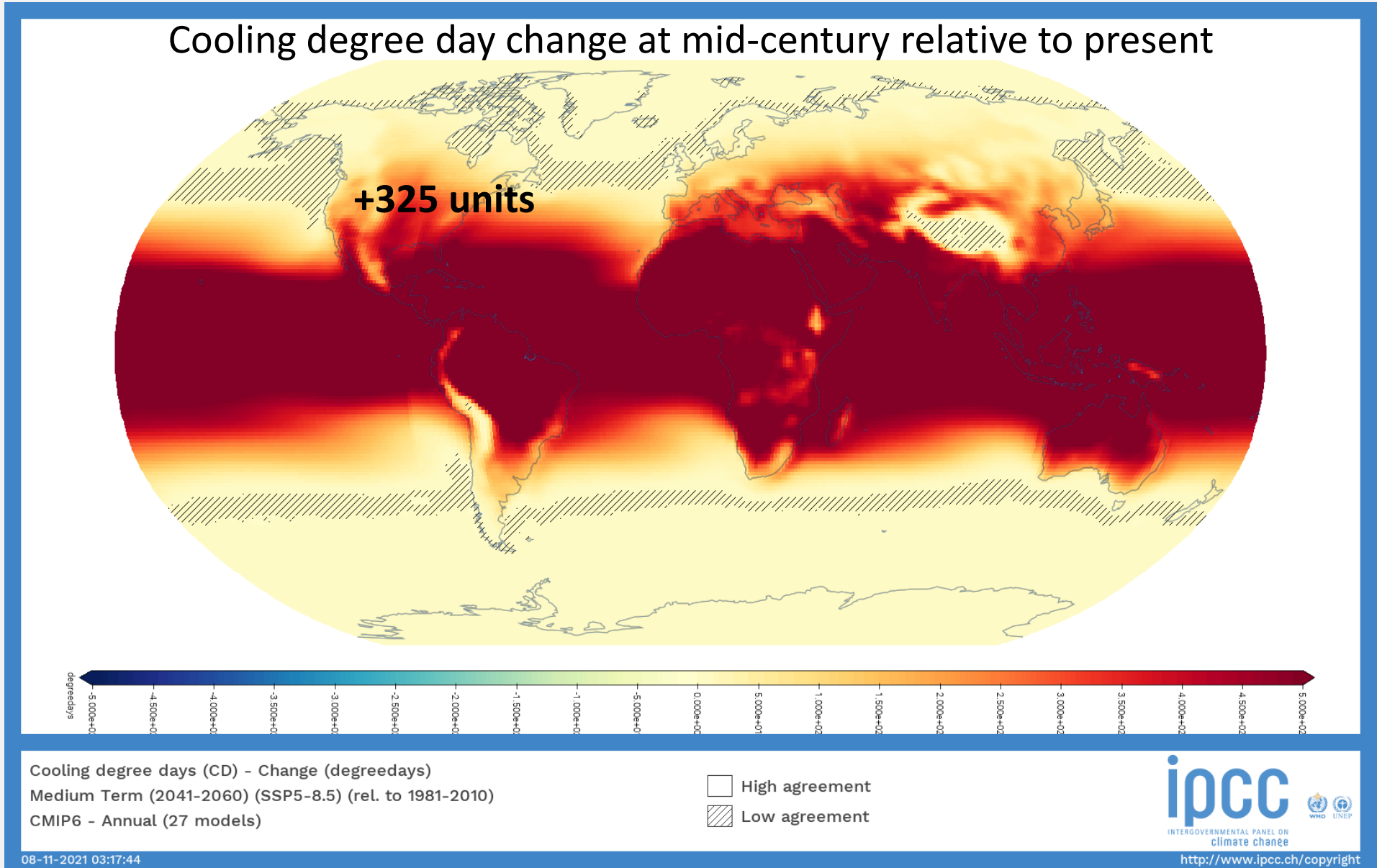
Considerations

- Nebraska and Northern Plains have cooled 5°F in February over past 30 years.
- Large-scale Arctic air outbreaks will be commonplace in the *near term*.



Considerations

- Summers will be warmer
  longer
  drier.

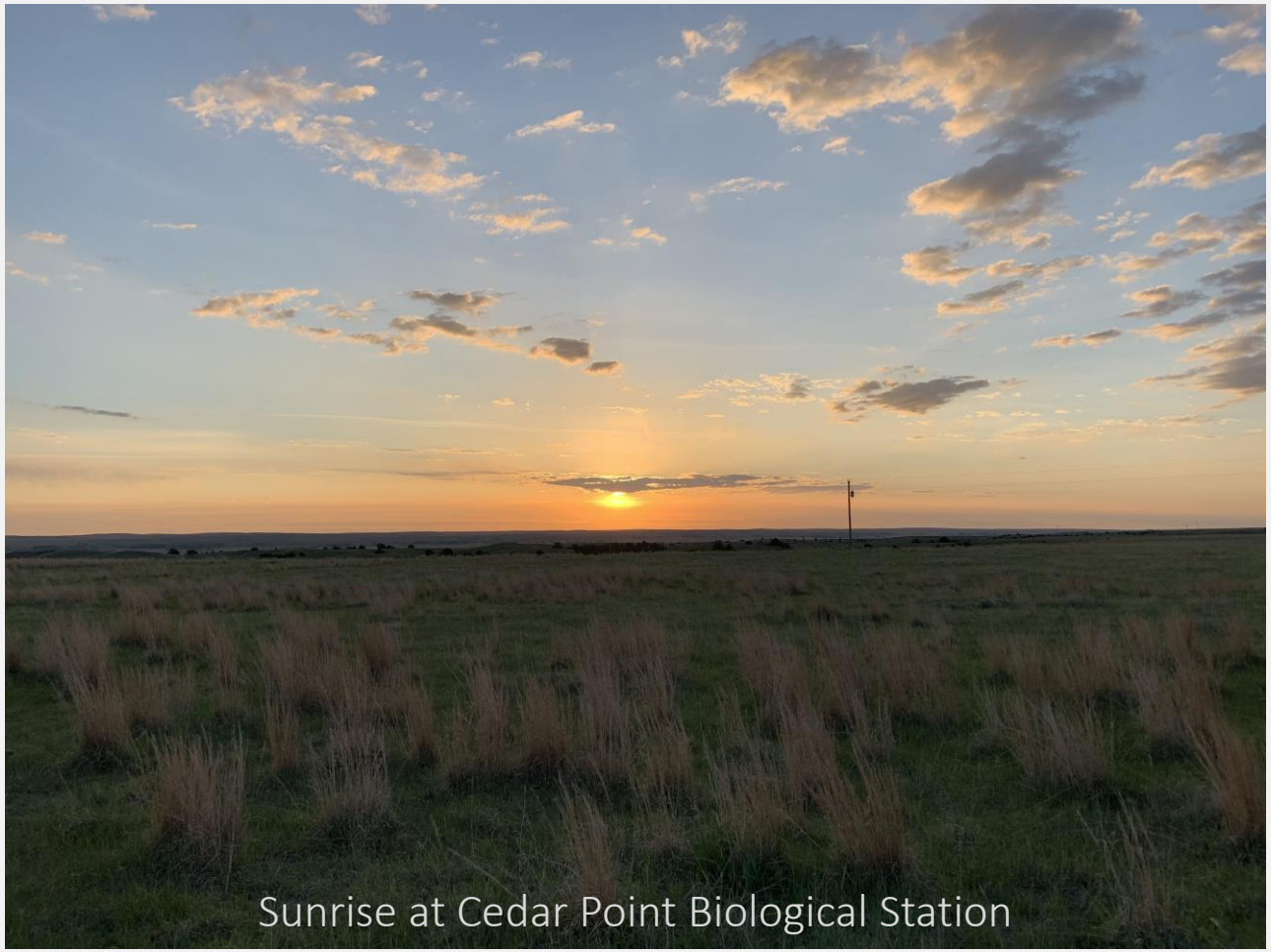


Considerations

- Large-scale strategy for end of life.

Considerations

- Global scale deployment of non-fossil sources must occur soon.
- Micro-hydro viability should be determined.
- Low-cost storage could play a pivotal role.
- To maximize renewable energy benefits, must occur with reduced energy use.



Sunrise at Cedar Point Biological Station

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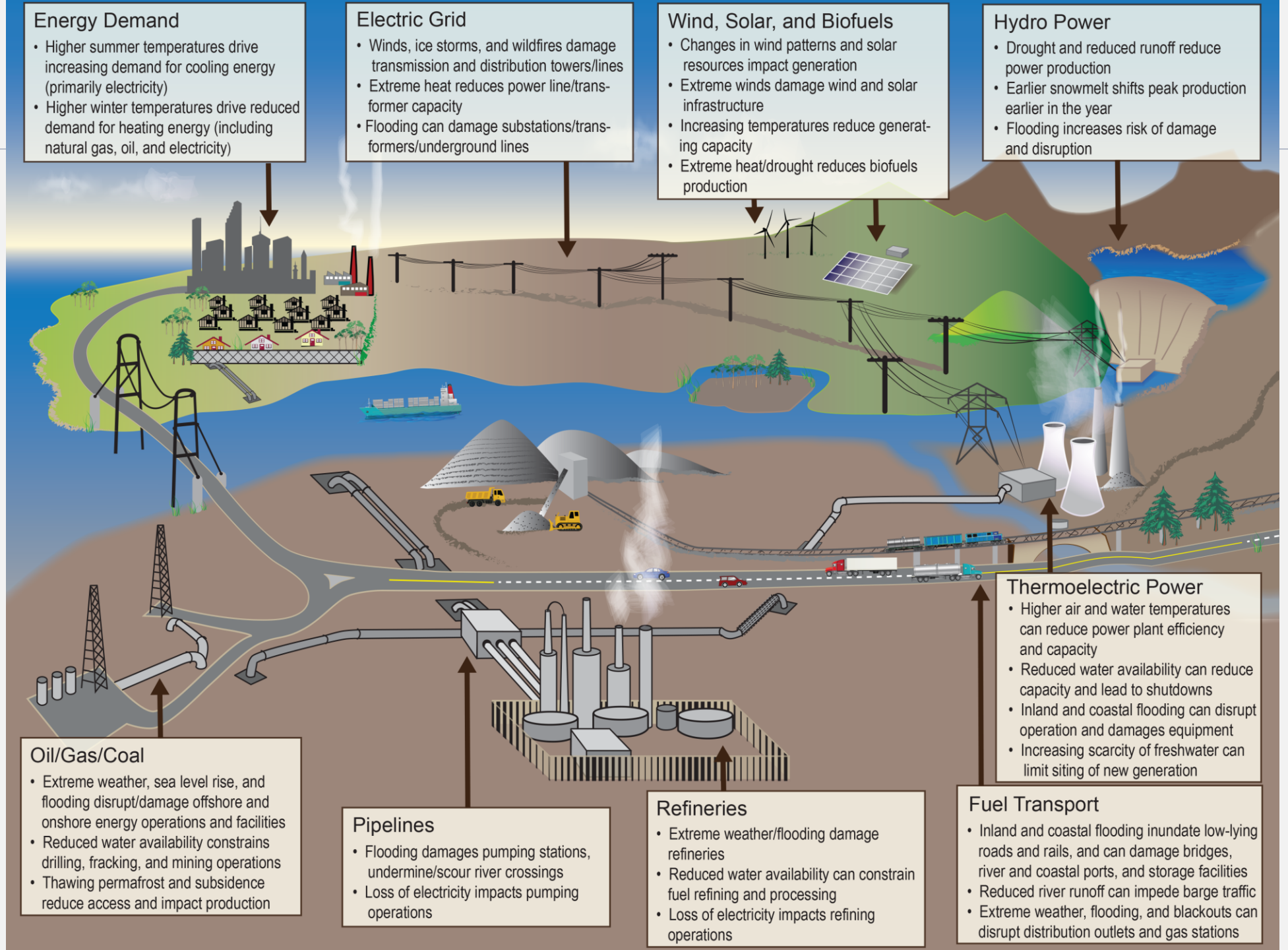
Energy Demand
• Higher summer temperatures drive increasing demand for cooling energy (primarily electricity)
• Higher winter temperatures drive reduced demand for heating energy (including natural gas, oil, and electricity)
Electric Grid
• Winds, ice storms, and wildfires damage transmission and distribution towers/lines
• Extreme heat reduces power line/transformer capacity
• Flooding can damage substations/transformers/underground lines
Wind, Solar, and Biofuels
• Changes in wind patterns and solar resources impact generation
• Extreme winds damage wind and solar infrastructure
• Increasing temperatures reduce generating capacity
• Extreme heat/drought reduces biofuels production
Hydro Power
• Drought and reduced runoff reduce power production
• Earlier snowmelt shifts peak production earlier in the year
• Flooding increases risk of damage and disruption
Thermoelectric Power
• Higher air and water temperatures can reduce power plant efficiency and capacity
• Reduced water availability can reduce capacity and lead to shutdowns
• Inland and coastal flooding can disrupt operation and damages equipment
• Increasing scarcity of freshwater can limit siting of new generation
Oil/Gas/Coal
• Extreme weather, sea level rise, and flooding disrupt/damage offshore and onshore energy operations and facilities
• Reduced water availability constrains drilling, fracking, and mining operations
• Thawing permafrost and subsidence reduce access and impact production
Pipelines
• Flooding damages pumping stations, undermine/scour river crossings
• Loss of electricity impacts pumping operations
Refineries
• Extreme weather/flooding damage refineries
• Reduced water availability can constrain fuel refining and processing
• Loss of electricity impacts refining operations
Fuel Transport
• Inland and coastal flooding inundate low-lying roads and rails, and can damage bridges, river and coastal ports, and storage facilities
• Reduced river runoff can impede barge traffic
• Extreme weather, flooding, and blackouts can disrupt distribution outlets and gas stations