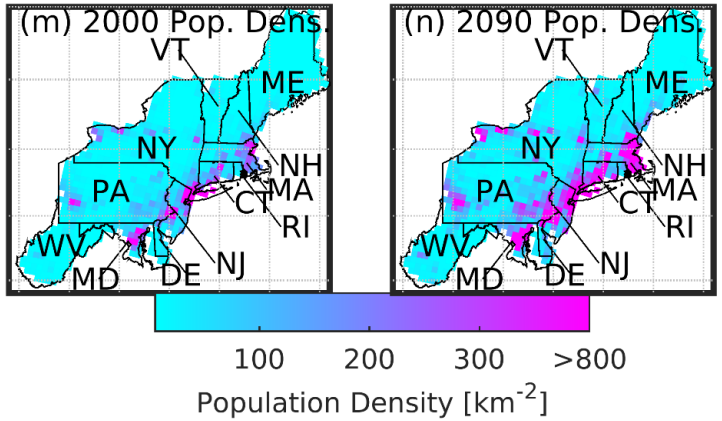
5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

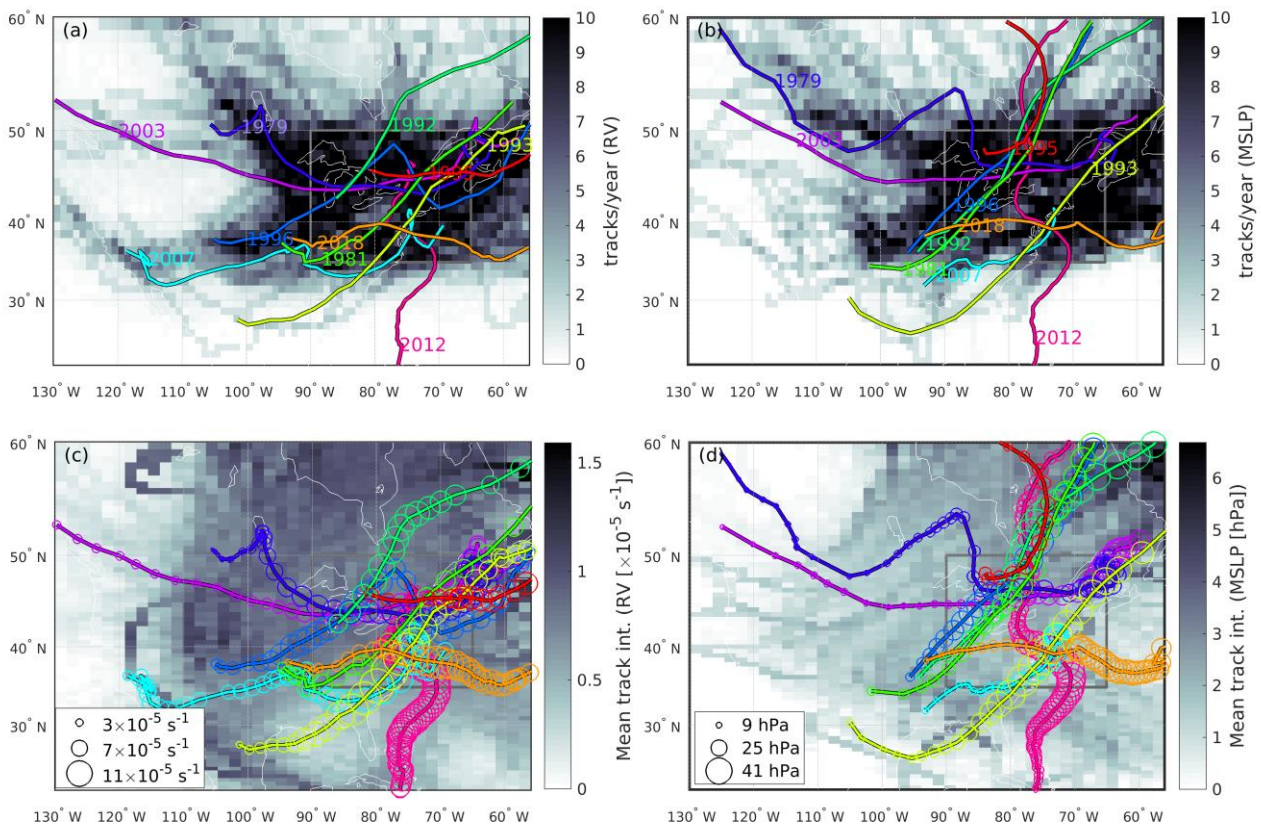
Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

- **Windstorms (extended duration of spatially expansive damaging wind speeds) associated with intense synoptic-scale cyclones & important natural hazard in northeastern US (+beyond).**
  13 NE states: 6% of CONUS land area. 20% of population & high-value assets.



- **Events identified using wide-spread U > U_{999} (99.9th percentile)**
  Top-10 (79-18): > 34 billion US$2020 damage.
  Top-10: Alberta Clippers and Colorado Lows =
  8. 2 = transitioning Tropical Cyclones.
  Low serial correlation in current climate.

Historical Storms tracked the ERA5 reanalysis



5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

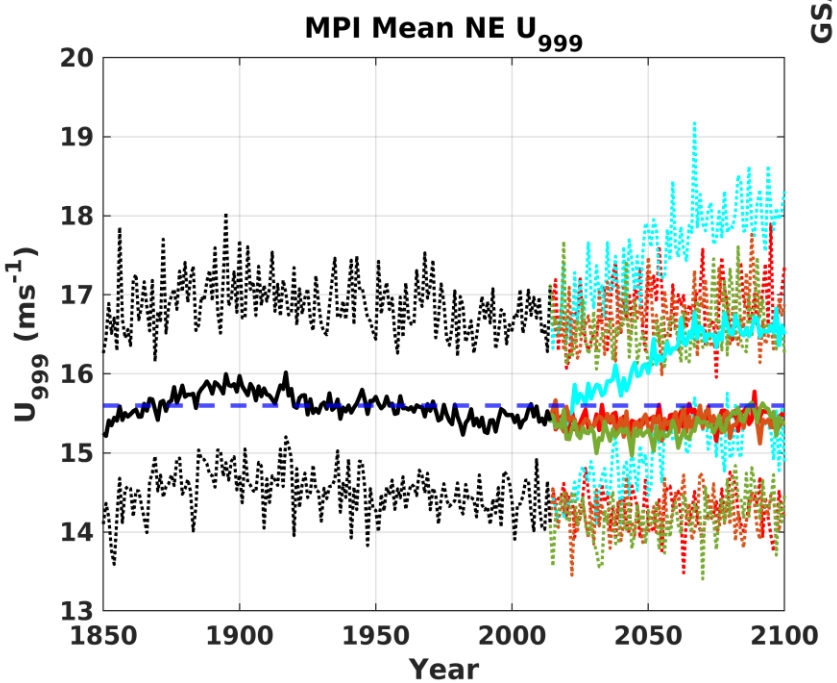
Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

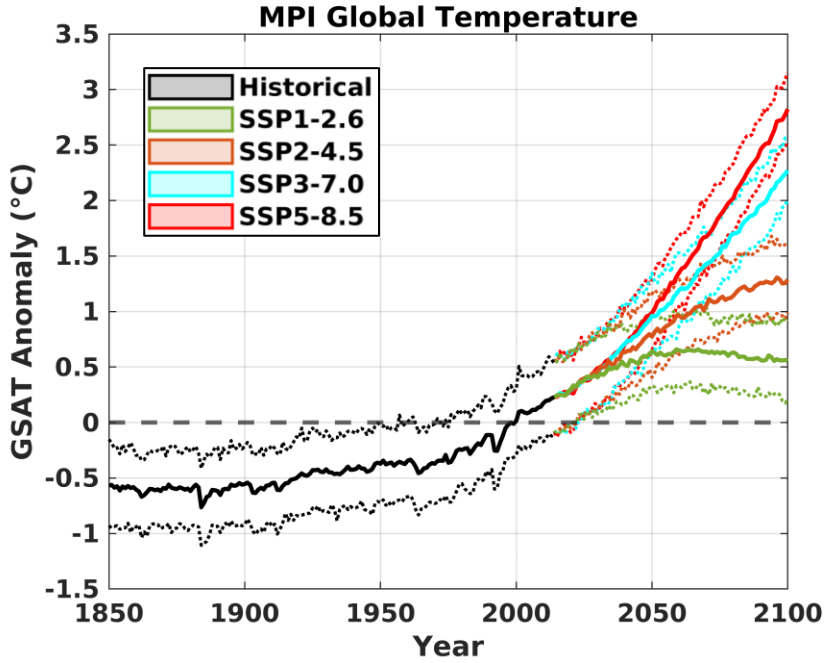
Why use Large Ensembles like the MPI?

- Historical variability may not capture the full range of variability in the system
  - *Unprecedented changes are difficult to assess a priori and add to vulnerability*
- Running the same Earth System model (i.e., same physics, parameterizations, boundary conditions) with slightly different initial conditions allows the model to generate N independent runs (ensemble members) of the same scenarios
- The range produced by such ensembles allows us to constrain estimates of externally forced signals, internal variability and extremes

Max Planck Institute (MPI) model

- MPI-ESM2-LR (CMIP6)
- 30 Ensemble Members
- Previously shown to capture internal modes relatively well





Variables Used

- **Sea level pressure**
- **Surface wind speed**
- Surface Air Temperatures
- Geopotential Height
- SSTs
- Landcover Fractions

5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

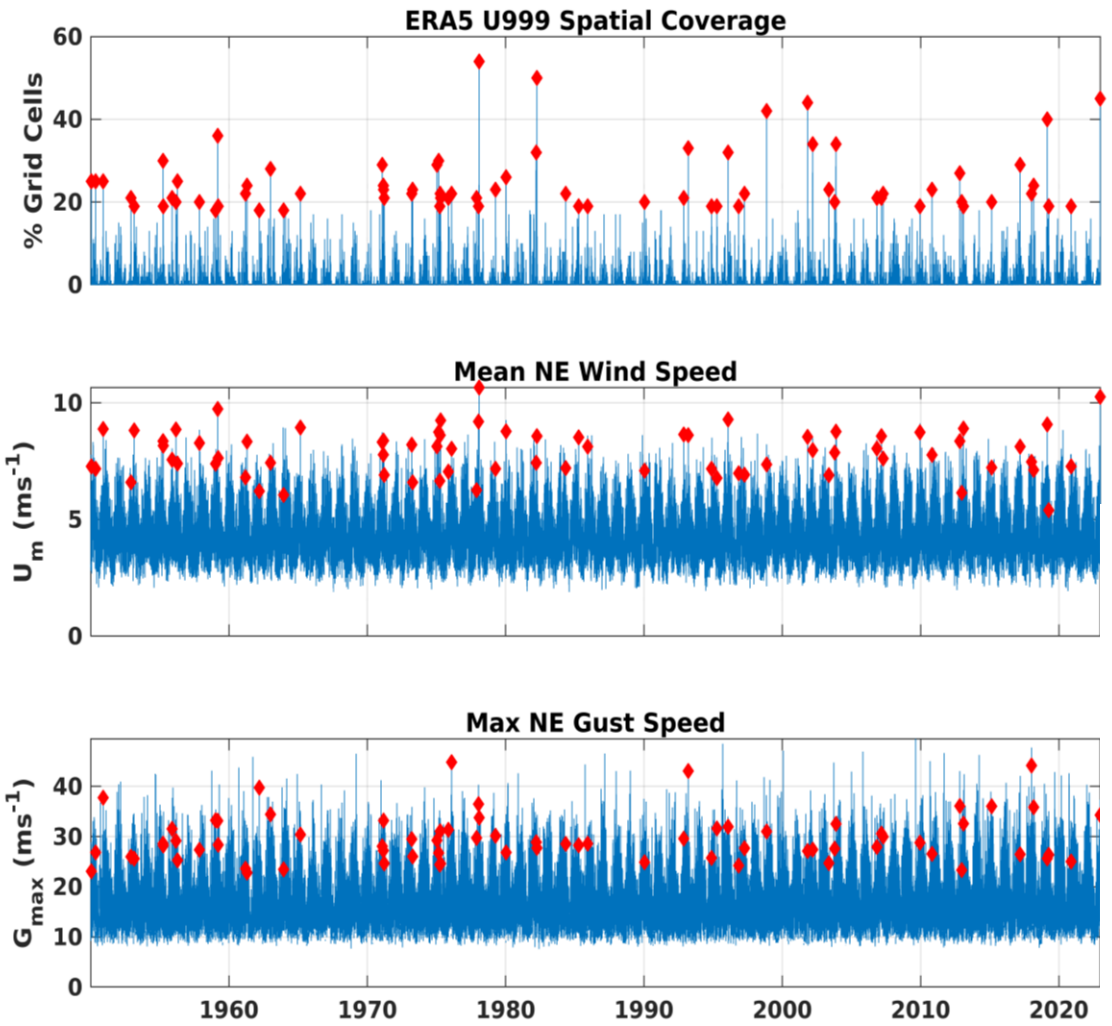
Windstorm Indicator

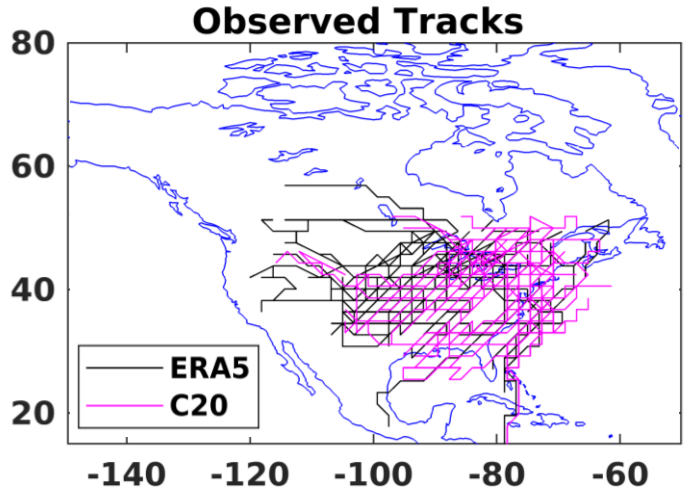
of grid cells within NE which exceed local U_{999} (99.9th percentile wind speed)

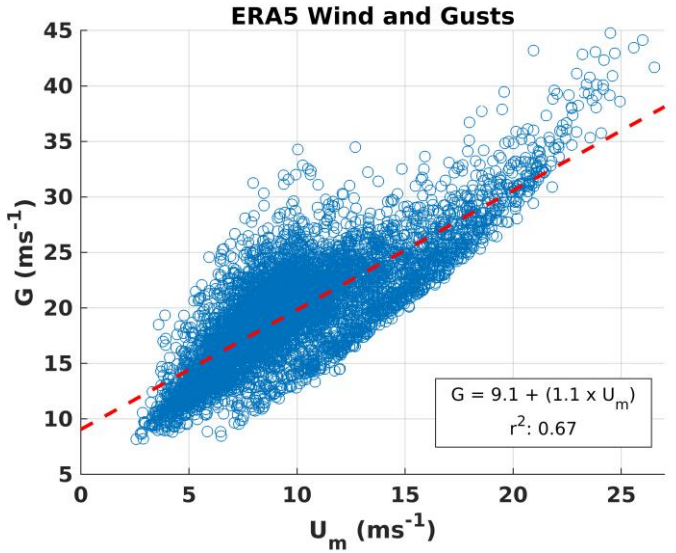
Find times of greatest coverage, equal to the number of years in the record (73 for ERA5, 66 for C20, 251 for MPI [1850-2100])

Track low pressure centers associated with U_{999}
- Low center ≤ 375 km from previous center

High winds & damaging gusts (> 24.5 ms^{-1}) are common within the ERA5 record







37th Conference on Climate Variability and Change
104th AMS Meeting - 2024

U.S. DEPARTMENT OF ENERGY | Office of Science
HYPERFACETS
A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

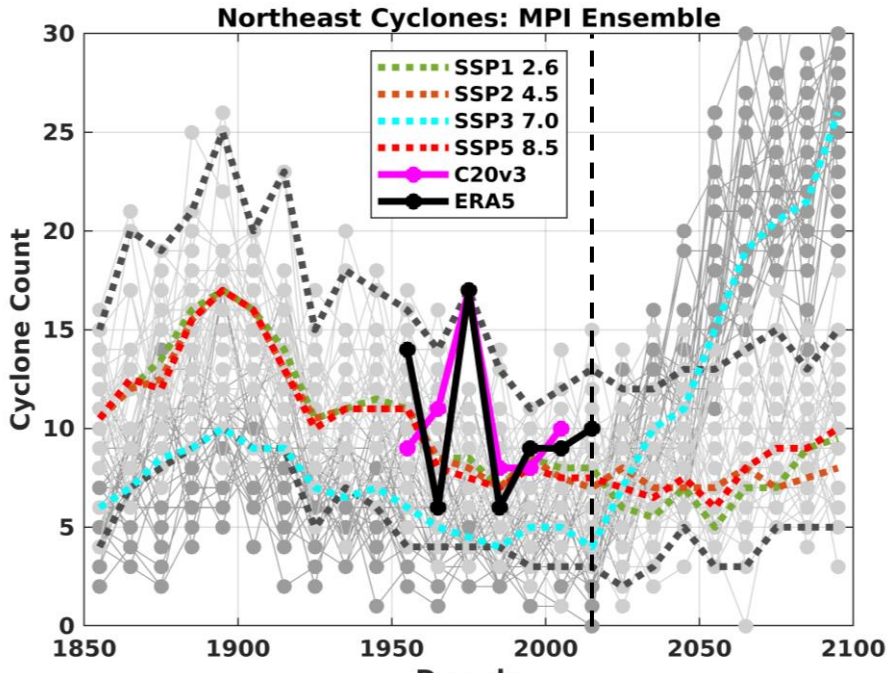
5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

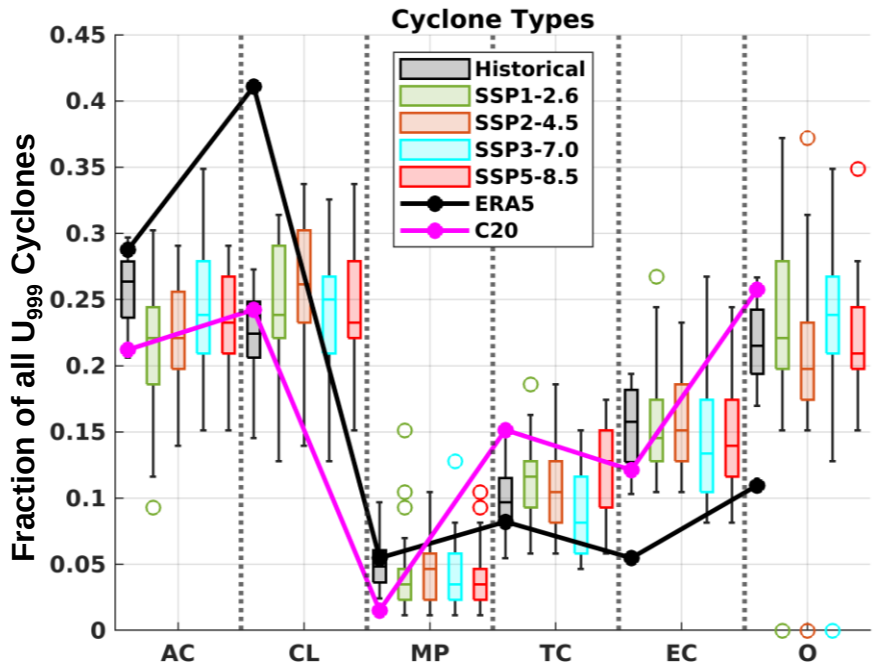
Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

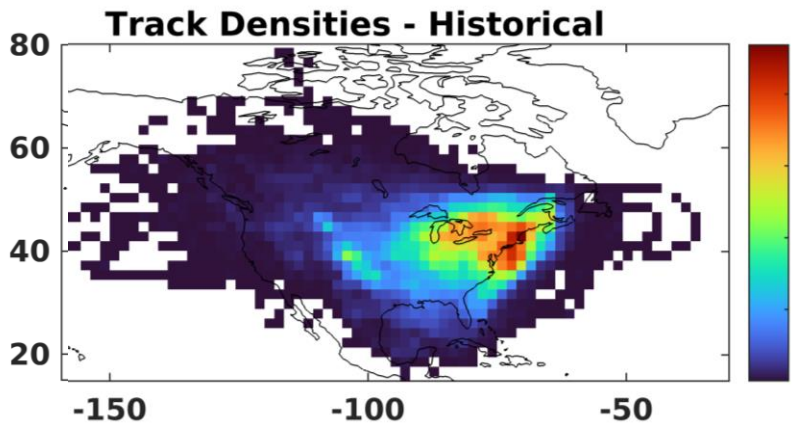
Range of Variability

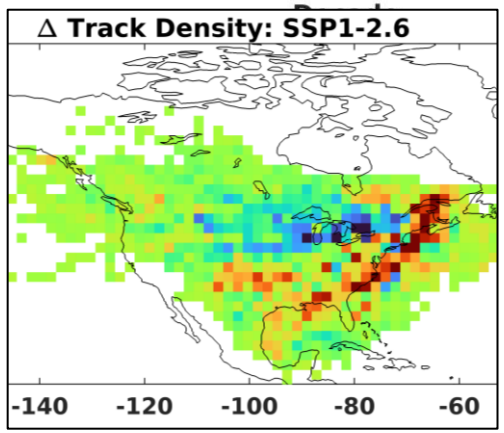
Numbers of cyclones, types (i.e., source regions) and tracks are broadly consistent with ERA5/C20

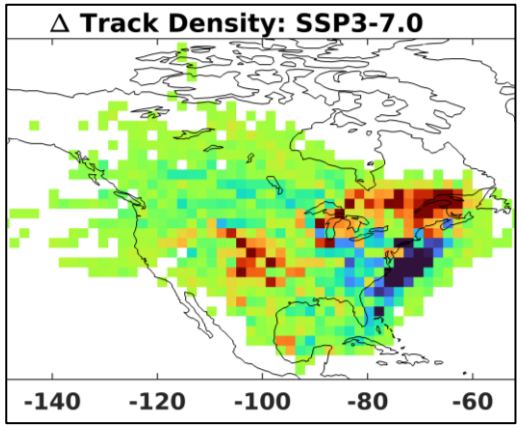
Cyclone characteristics (tracks, central low pressures, etc.) only exhibit minor differences between scenarios, though the number detected is highly SSP dependent (3-7.0 especially)

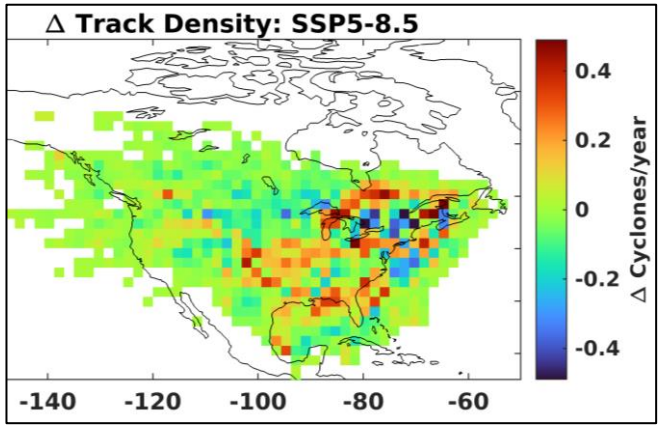












5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

Central Pressure

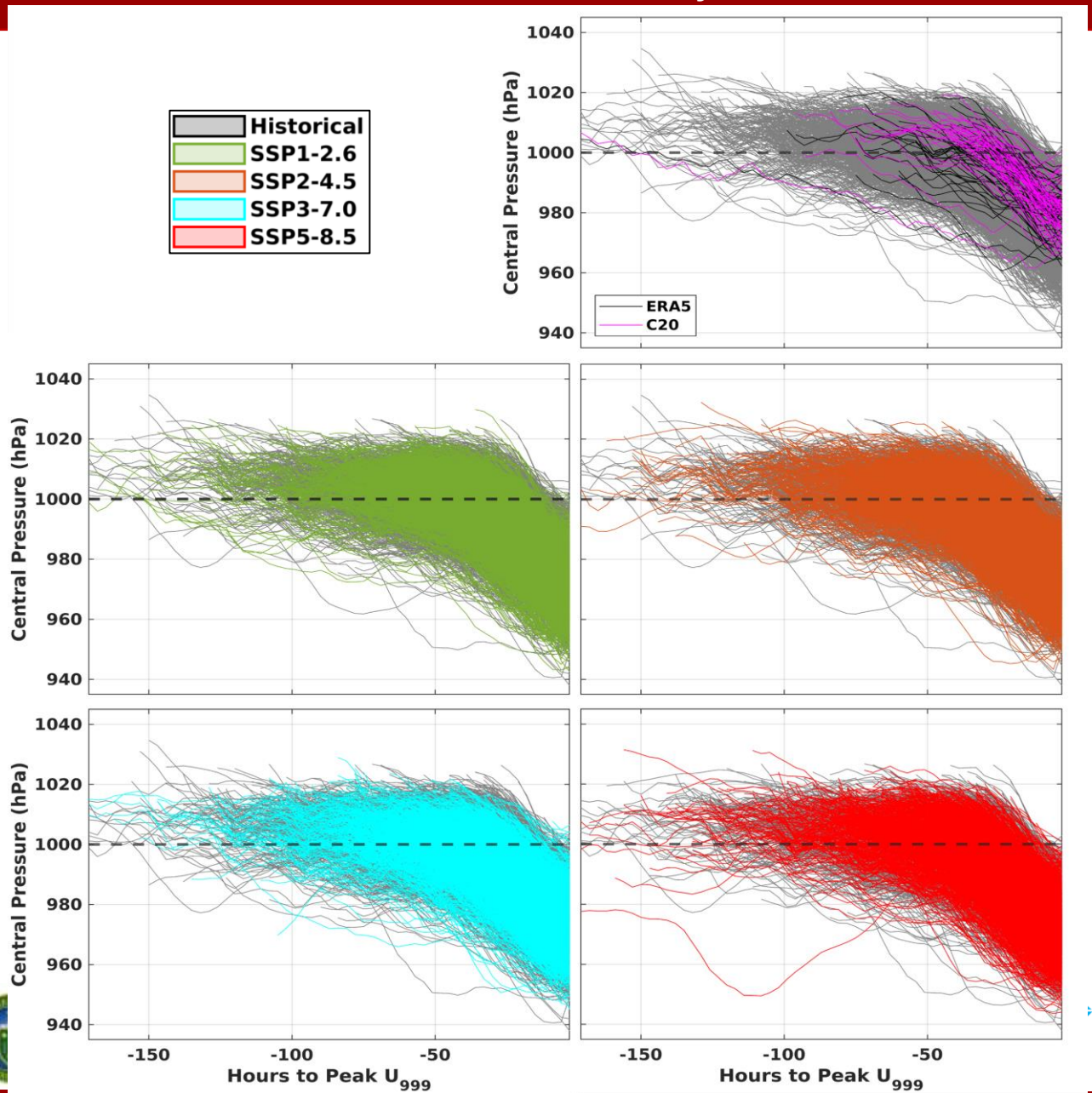
- Central pressure at $U_{999,\ peak}$ averages to ≈ 980 hPa
- Central pressure drops (lows deepen) under SSPs by ≈ 3 hPa
- Pressure drops are not proportional to the SSP

Cyclone Translational Speed

- Historical cyclone speeds vary in MPI from 0 – 125 km/hr (0-33 ms^{-1}) with a mean of ≈ 54 km/hr (15 ms^{-1})
- Changes in translational speed are insignificant across all SSPs

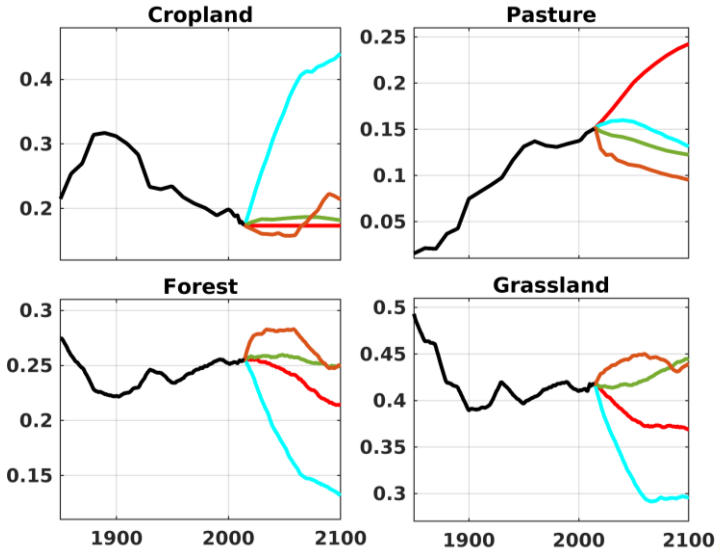
Cyclone Duration

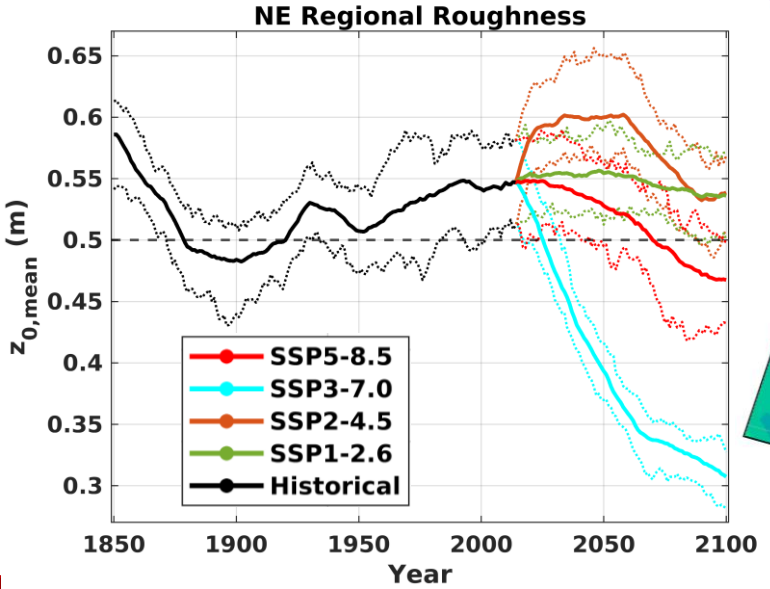
- Historical cyclone durations (i.e., num. hours a central low is detectable within 375 km) range from 6-168 hours
- Mean changes across SSPs are small and not significant, typically < 6 hours



5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

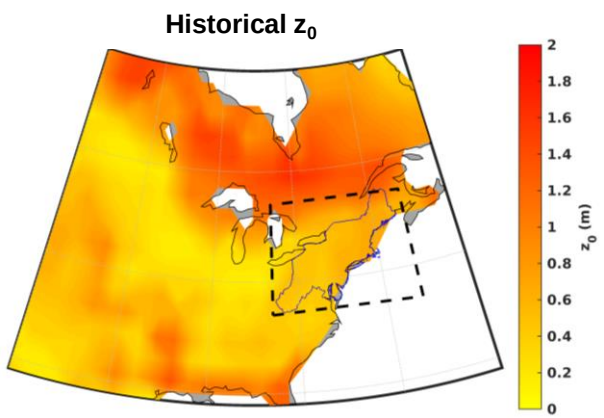
Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

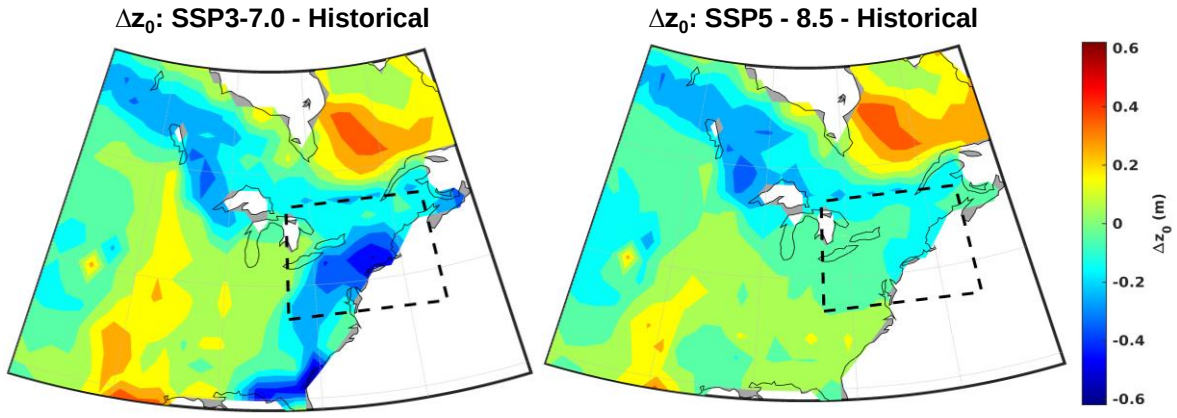


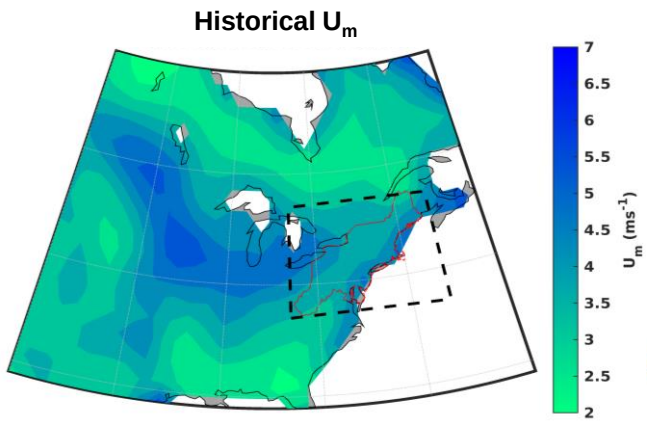


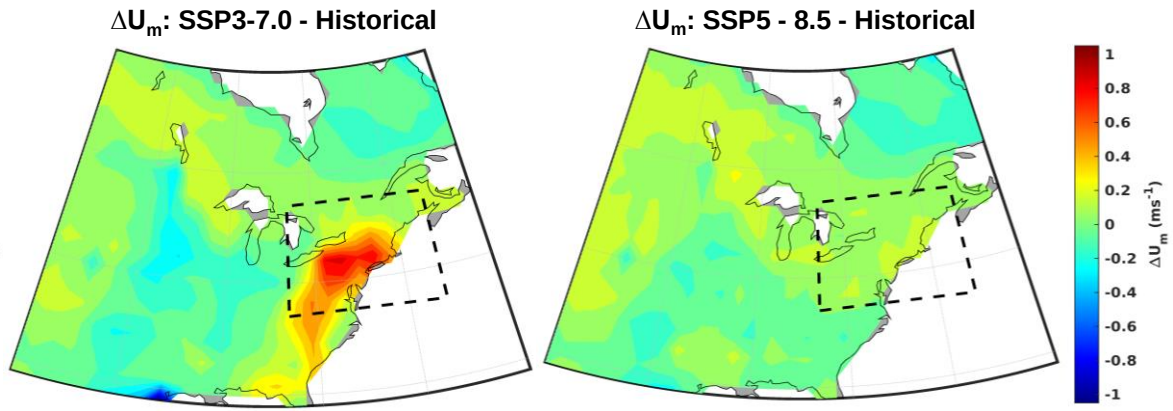
Causes of broadscale changes/differences between SSPs

The effects of landcover change









Cornell University

37th Conference on Climate Variability and Change
104th AMS Meeting - 2024

U.S. DEPARTMENT OF ENERGY | Office of Science

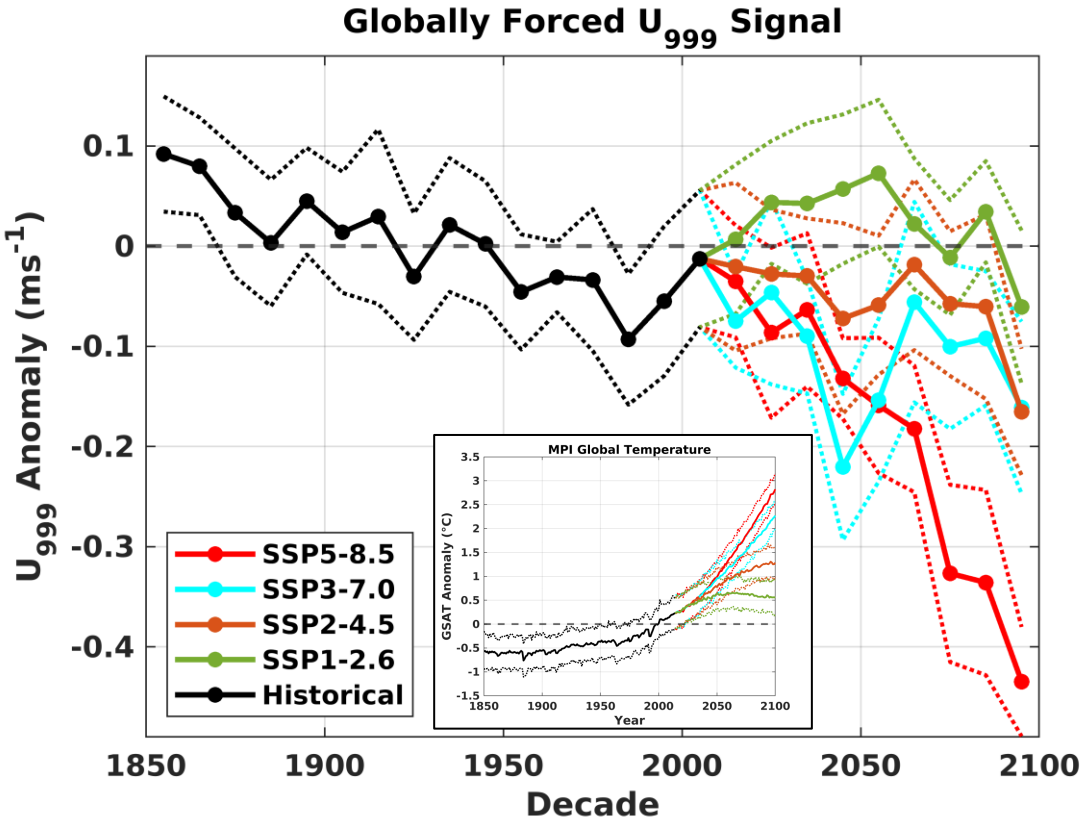
U.S. Department of Energy | Office of Science
HYPERFACETS
A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

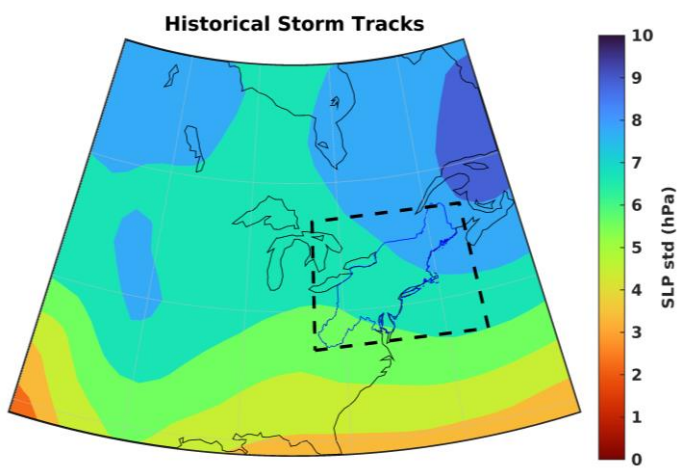
5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

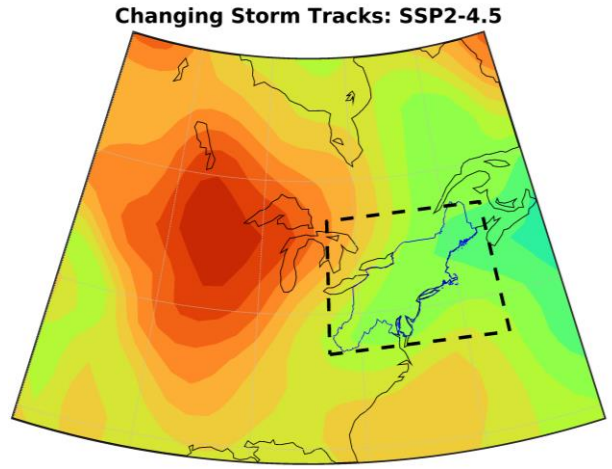
Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

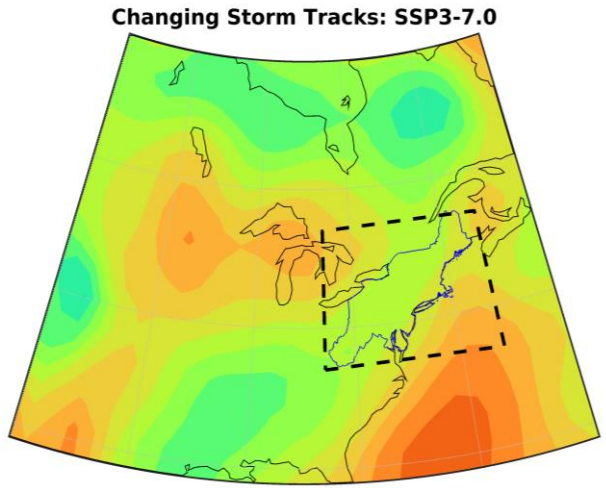
A role for global warming?

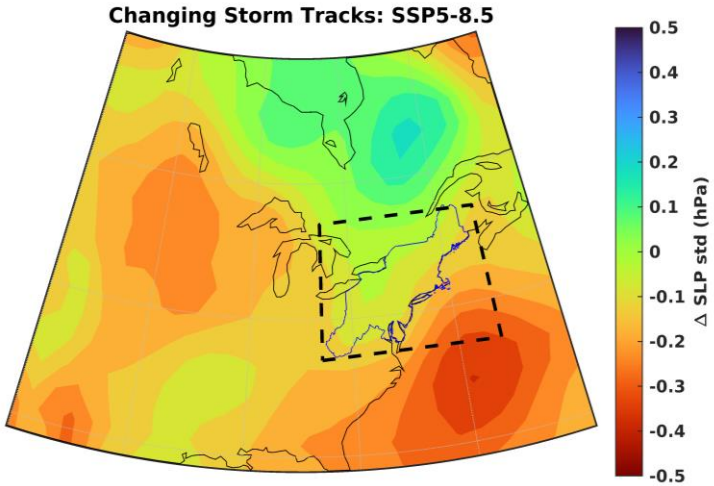
Use regression to remove the landcover signal from U999
U999 (no landcover) exhibits changes consistent with the SSPs – SAT↑ ≈ U999↓
Broadly consistent with changes in storm tracks (changes in standard deviations of daily SLPs)











37th Conference on Climate Variability and Change
104th AMS Meeting - 2024

U.S. Department of Energy | Office of Science
HYPERFACETS
A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

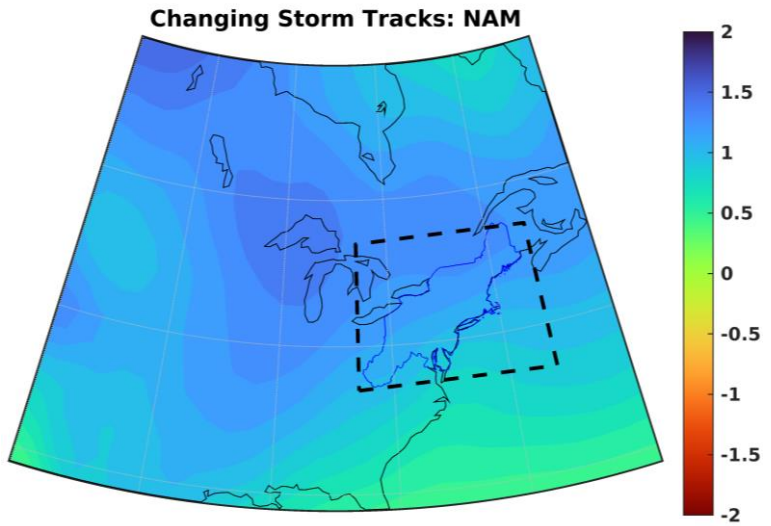
Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

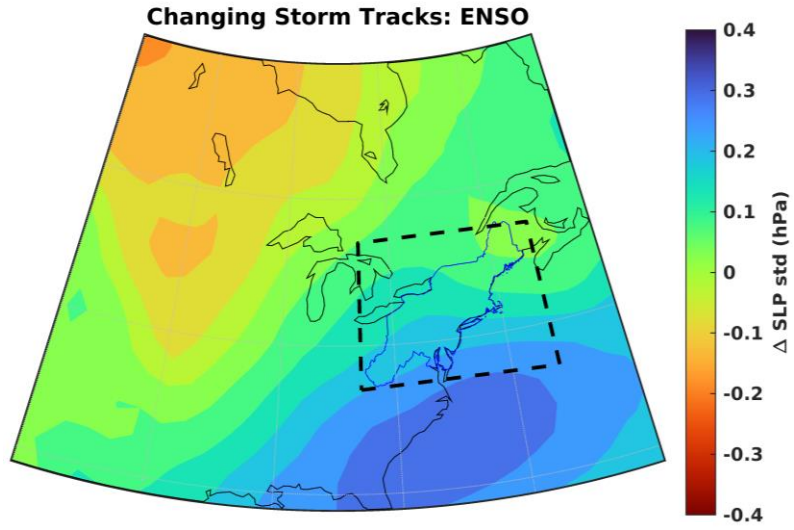
Internal Variability

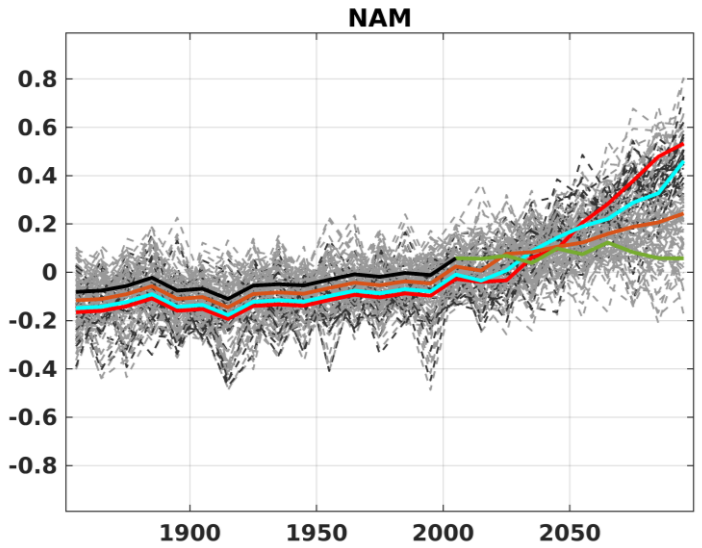
Modes of variability influence cyclone activity/tracks over the NE by changing the locations/intensities of storm tracks

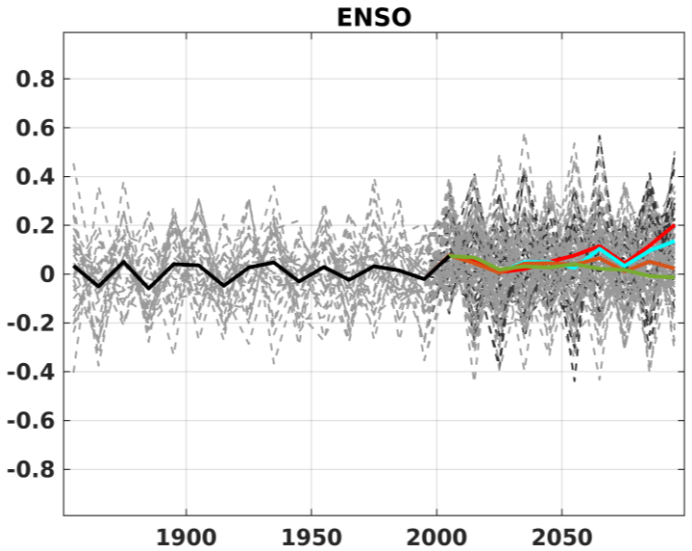
Modes are also changing under a changing climate, potentially altering the risks of extreme windstorms

Signals are highly uncertain, as most of the variability in U999 and the driving cyclones are due to landcover changes (historical and projected) and global scale changes (warming)









Cornell University

37th Conference on Climate Variability and Change
104th AMS Meeting - 2024

U.S. DEPARTMENT OF ENERGY | Office of Science

U.S. Department of Energy | Office of Science
HYPERFACETS
A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

5B.6 Northeastern Windstorms and Midlatitude Cyclones in the MPI Large Ensemble

Jacob Coburn (jjc457@cornell.edu), Fred Letson, Xin Zhou, Rebecca J. Barthelmie, Sara C. Pryor

Conclusions

- Windstorms ARE a major source of economic losses & energy disruptions in NE (and beyond)
- Triad of approaches to projections to leverage relative strengths.
- *Storylines-TGW imply little change in hazard intensity. e.g. no storm sharpening*
- *Transient WRF simulations imply strong dependence on nesting ESM. WRF-MPI has highest credibility & implies 3.5x increase in LI due to population increase (x2) PLUS higher wind speeds & more frequent passage over highest population density*
- **The MPI large ensemble (30 members) exhibits significant differences in cyclone counts between SSPs**
- **Cyclone characteristics exhibit minor variations between ensemble members/SSPs**
- **Historical variability in cyclone characteristics are captured by MPI, but the worst cases are still 'out there'**
- **The largest driver of changes in U999 are the historical and projected changes in landcover**
- **Global changes in climate/storm tracks act as a secondary driver of changes**

What next/now?

- 15ENERGY Extreme Wind Speeds at US Offshore Windfarms in the Future Climate [Monday, 1/29/2024]
- 37CVC Future Extreme Winter Windstorms in the Northeastern US: A Storyline-Based Pseudo-Global Warming Approach &
- 37CVC Historical and Future Windstorms Affecting the Northeast US: Their Impacts and Origins &
- 15ENERGY Hurricane Impacts on US East Coast Offshore Wind Energy Lease Areas [Wednesday, 1/30/2024]
- Storylines with dynamical forcing (PGW)
- Transient: New high resolution (dx = 4 & 12 km) decadal (2050's & 2000's) simulations