

Snow Cover, Vernal Window, & Winter Whiplash

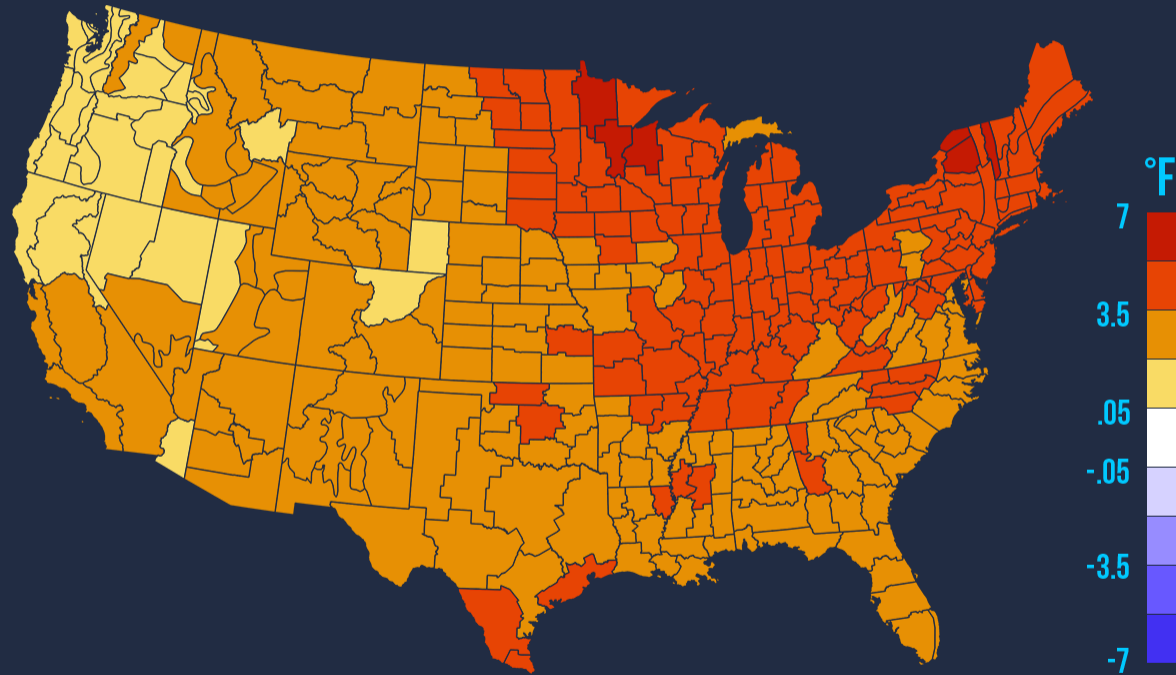
Dr. Liz Burakowski, Ph.D., University of New Hampshire

CAW Climate Summit 2021
May 27, 2021

How has *winter* climate changed in the past?


WINTER WARMING

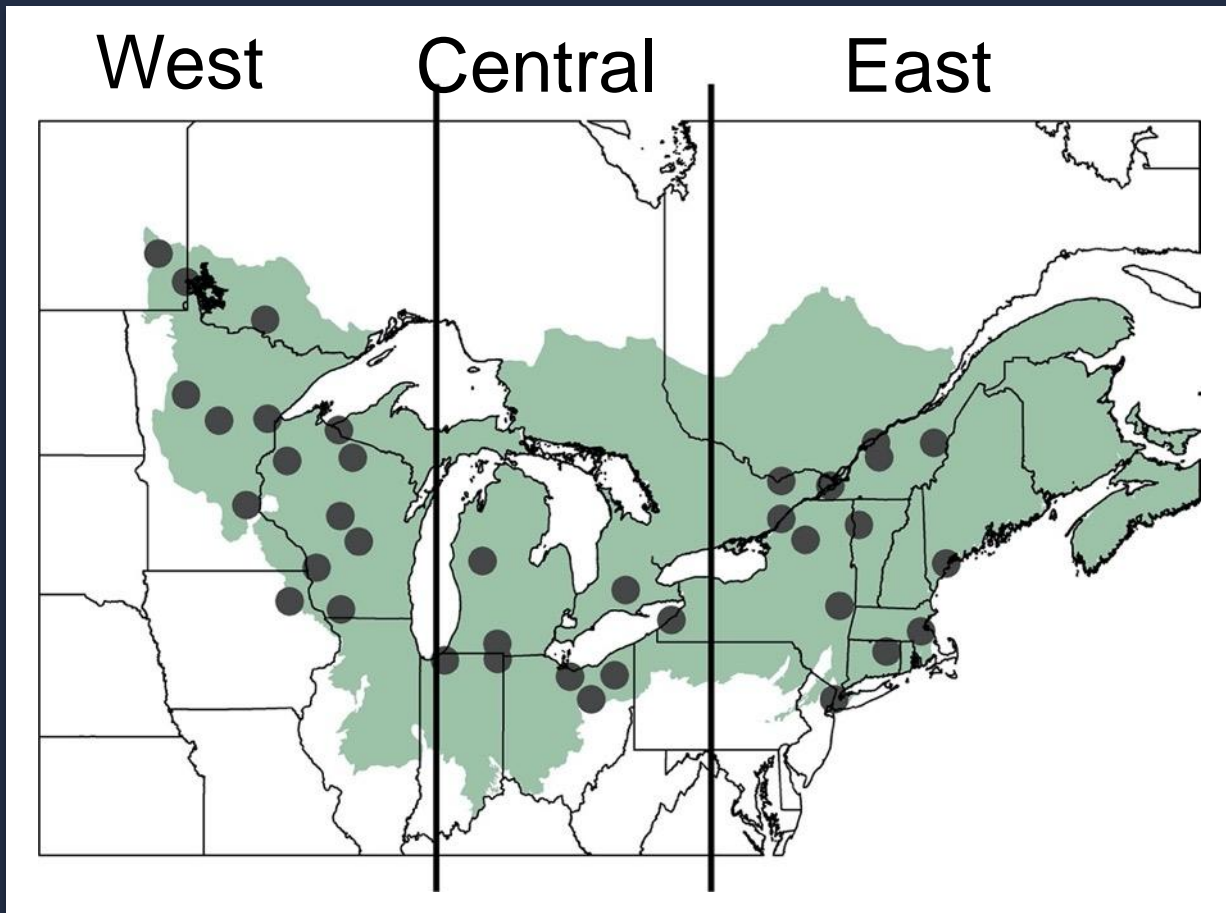
Since 1970



Source: NOAA/NCEI Climate at a Glance. Average winter temperature (Dec-Feb). Produced 11/26/2019

Northern forest winters have lost cold, snowy conditions that are important for ecosystems and human communities

ALEXANDRA R. CONTOSTA ^{1,18} NORA J. CASSON ² SARAH GARLICK,³ SARAH J. NELSON,⁴ MATTHEW P. AYRES ⁵
ELIZABETH A. BURAKOWSKI ¹ JOHN CAMPBELL,⁶ IRENA CREED ⁷ CATHERINE EIMERS,⁸ CELIA EVANS,⁹
IVAN FERNANDEZ,¹⁰ COLIN FUSS,¹¹ THOMAS HUNTINGTON ¹² KAIZAD PATEL,^{4,13} REBECCA SANDERS-DEMOTT ¹
KYONGHO SON ¹⁴ PAMELA TEMPLER,¹⁵ AND CASEY THORNBRUGH^{16,17}



Confronting Our Changing Winters

*Indicators of
Winter Climate
Change in the
Northern Forest*



Science Links
2019

Key Findings:

- 1. We are losing cold –**
fewer days below freezing,
less frequent extreme cold
days ($< 0^{\circ}\text{F}$)



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Garlick et al., 2019;
Available at: hubbardbrook.org

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- 2. We are losing snow** – fewer days with snow cover



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Key Findings:

- 1. We are losing cold** – fewer days below freezing, less frequent extreme cold days ($< 0^{\circ}\text{F}$)
- 2. We are losing snow** – fewer days with snow cover
- 3. Winters are shorter** – sustained cold period shortening, largely due to earlier spring



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Winter Weather Whiplash



Photo: Jessica Hill/AP

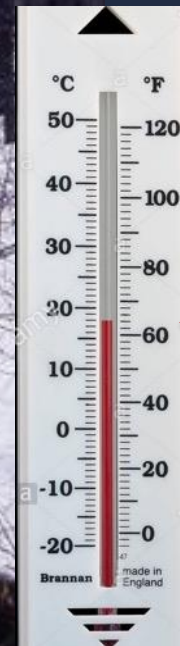


Photo: Alix Contosta

Winter Weather Whiplash at Hubbard Brook



Streamflow increased FIVE TIMES during “winter heat waves” compared to winter base flow.



64.4°F

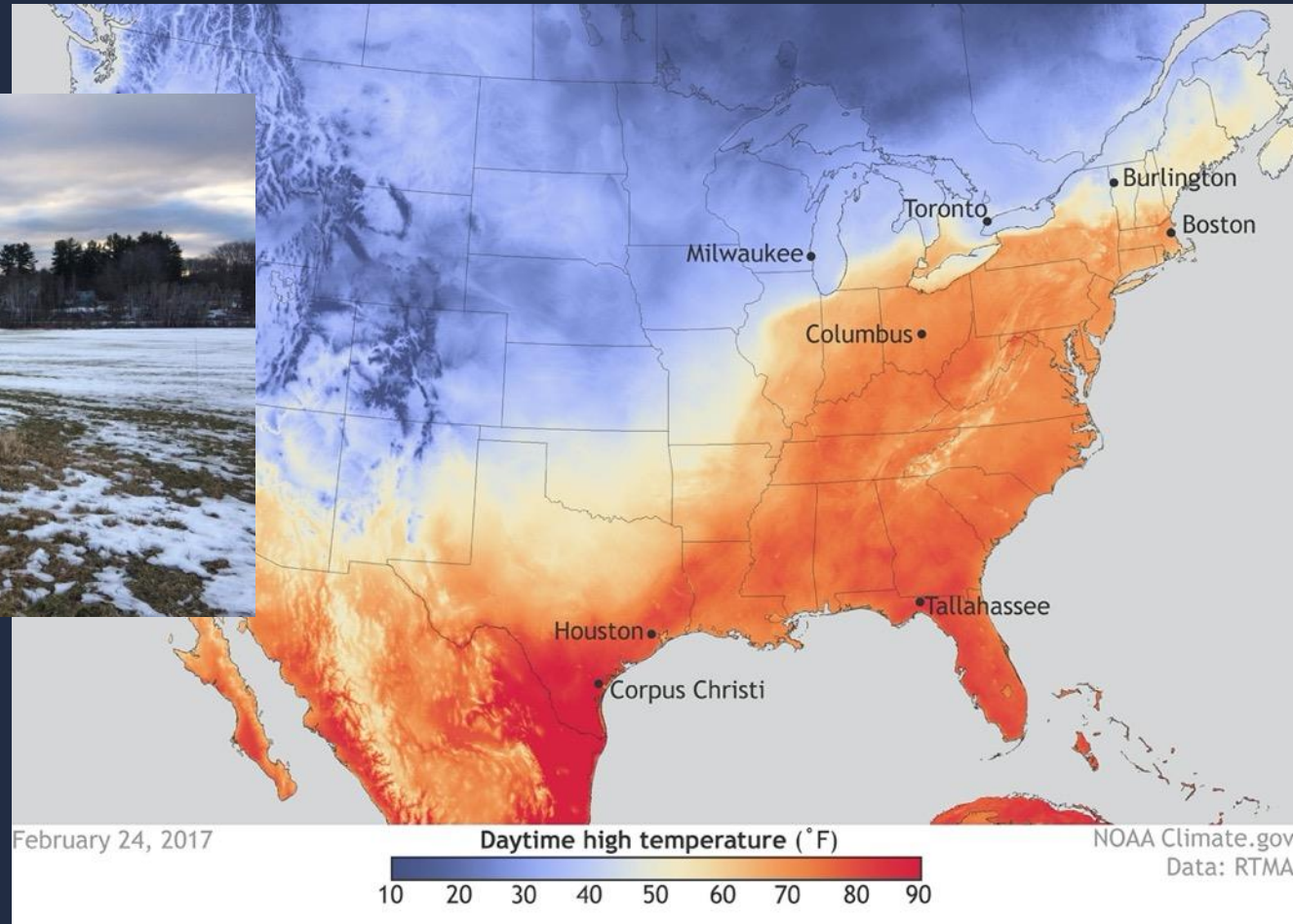
Streamflow increased an ORDER OF MAGNITUDE during “rain-on-snow” compared to winter base flow.



“Winter heat waves” increase in frequency in a warming climate. Less frequent rain-on-snow for all but highest elevations



UNH Kingman Farm
Feb 24, 2017



February 24, 2017

Daytime high temperature (°F)

NOAA Climate.gov

Data: RTMA

10 20 30 40 50 60 70 80 90

What about the future of snowmegeddons & snowpacolypses?



Zarzycki, 2018; O’Gorman, 2014;
Ning & Bradley, 2015

Photo: Lindsey Webb, 2014

What about the trends in snowmegeddons & snowpacolypses?

... it's complicated.



Photo: Lindsey Webb, 2014

The Future of Northeast Snowstorms? It's complicated.

- warmer atmosphere holds more moisture.
- overall increase in winter precipitation.
- however, precipitation more likely to fall as rain instead of snow
- decreases in both large and small snowstorms, but the decrease is larger for smaller storms

A longer mud season?

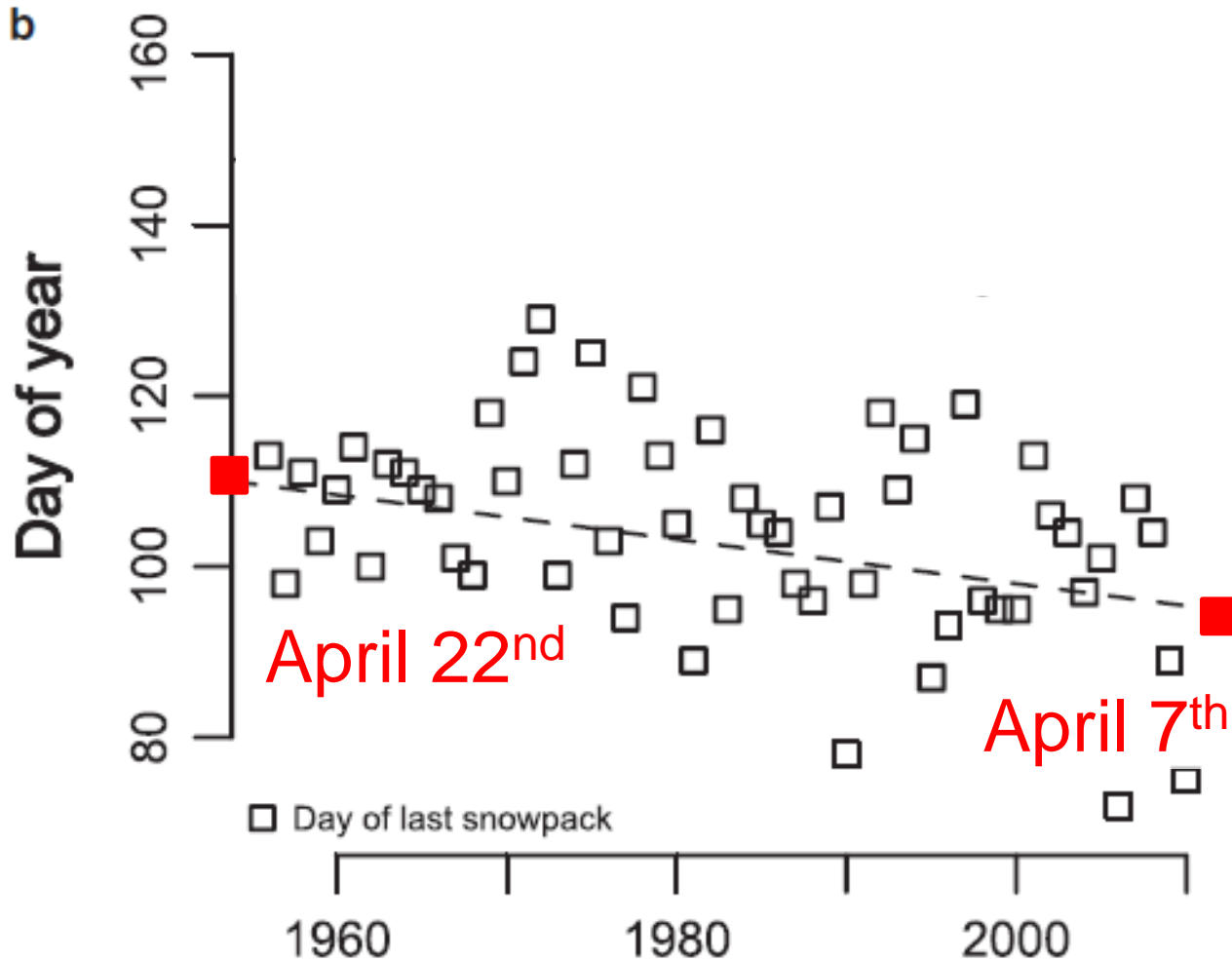


Snowmelt to Canopy Closure

Groffman et al. 2012
Creed et al. 2015
Contosta et al. 2017



Hubbard Brook snowpack disappears ~ 15 days earlier.

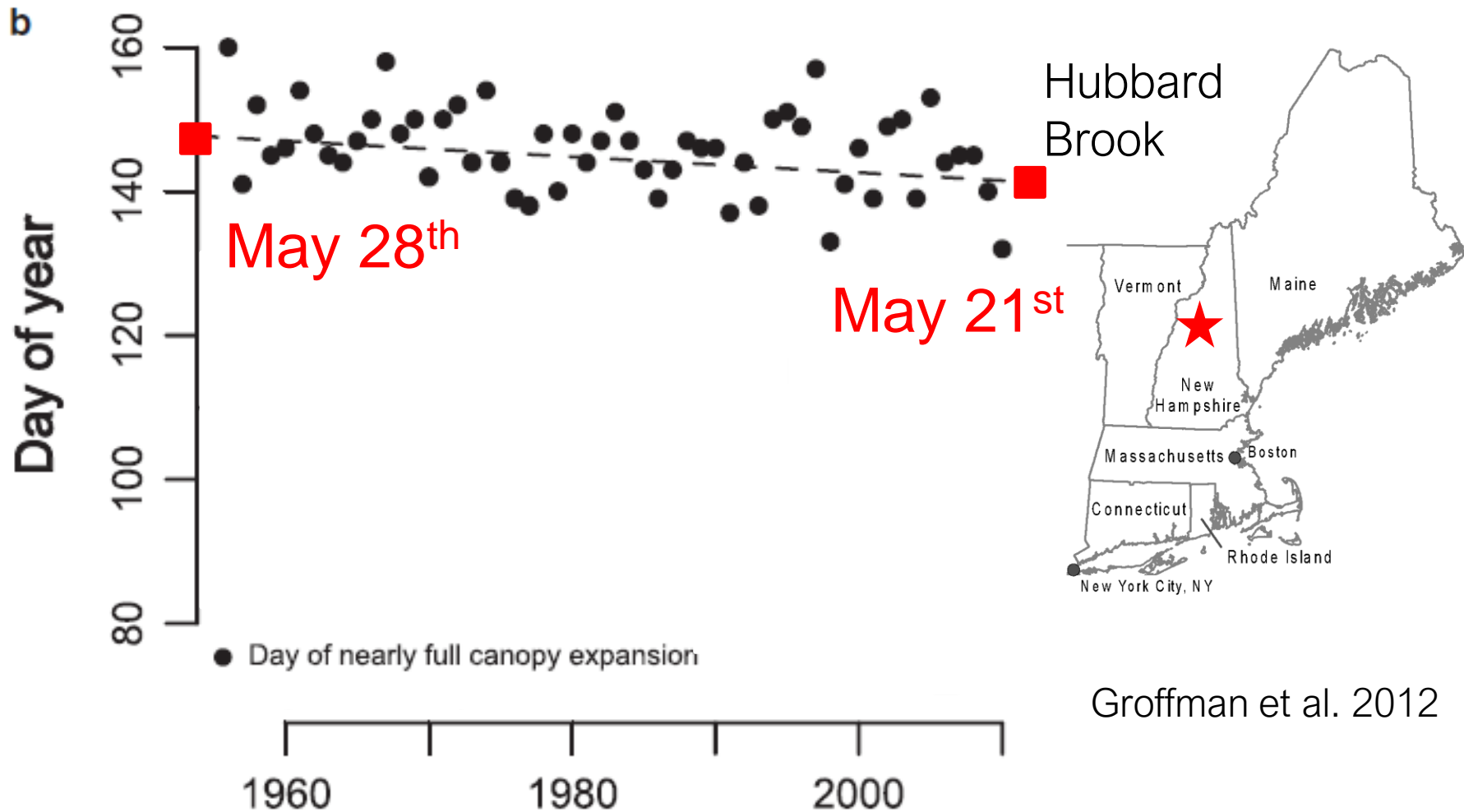


Groffman et al. 2012

Earlier snowmelt lengthens the vernal window.



Hubbard Brook canopy closes ~ 7 days earlier.

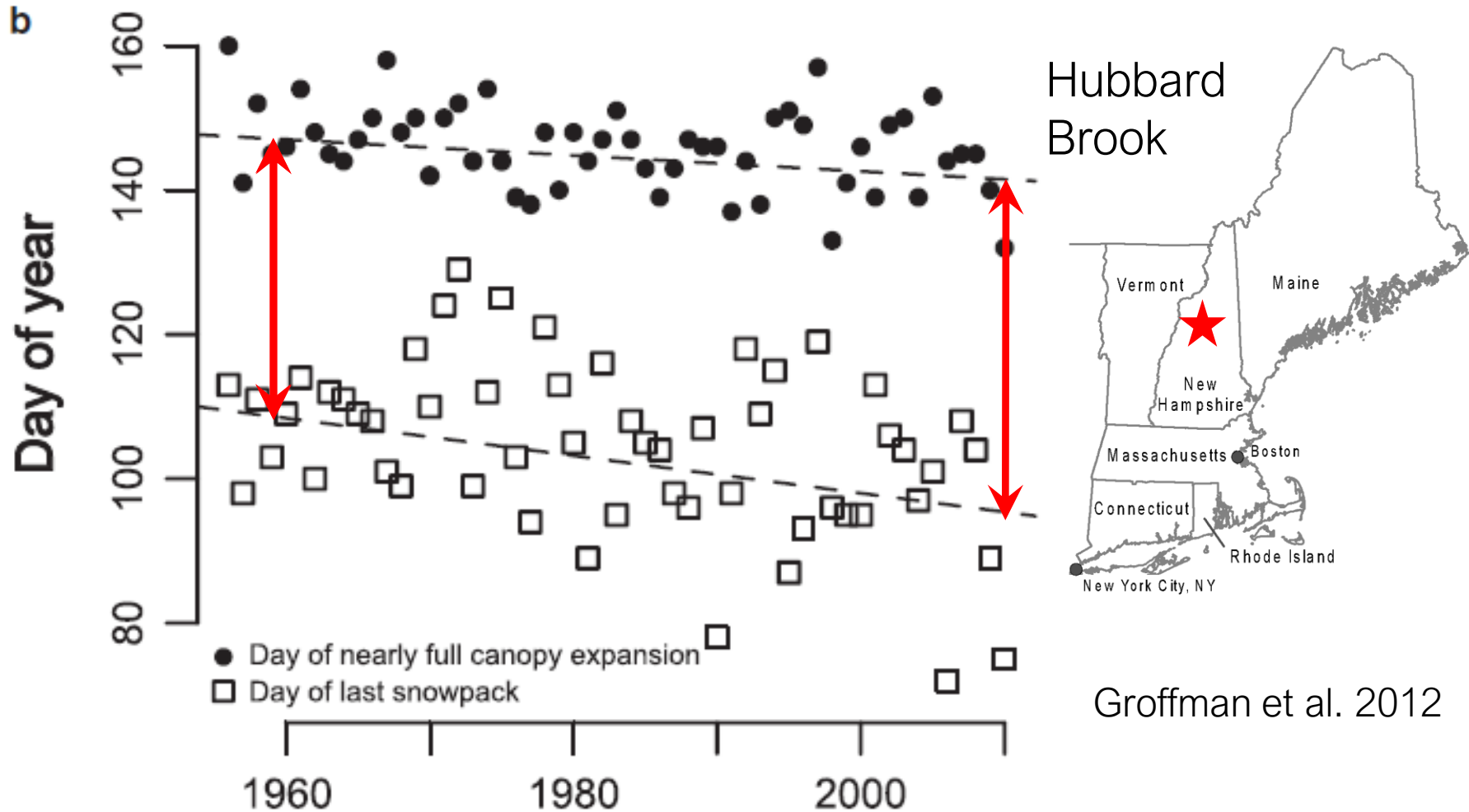


Groffman et al. 2012

Canopy closure also earlier, but at slower pace than snow disappearance.



An overall lengthening of the vernal window, by ~ 8 days.



What will the vernal window look like in the future?

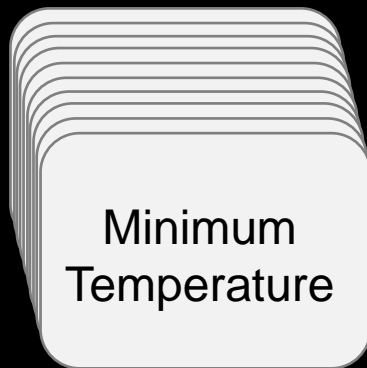
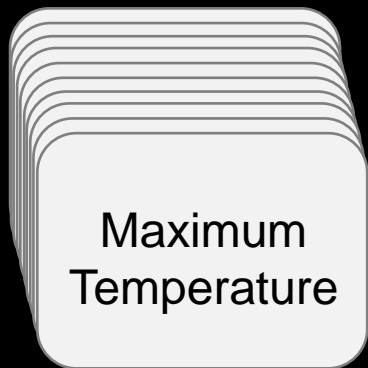


What will the vernal window look like in the future?

February 26, 2017
Kingman Farm, Durham, NH

This is the warmest February day ever recorded in Boston. *Boston Globe*

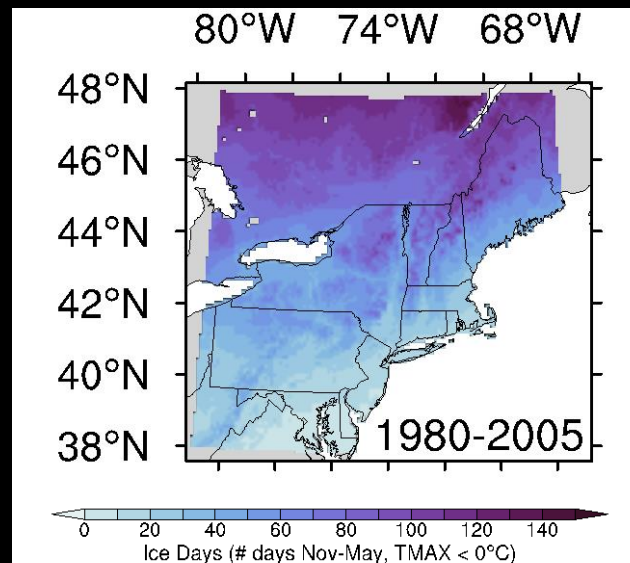


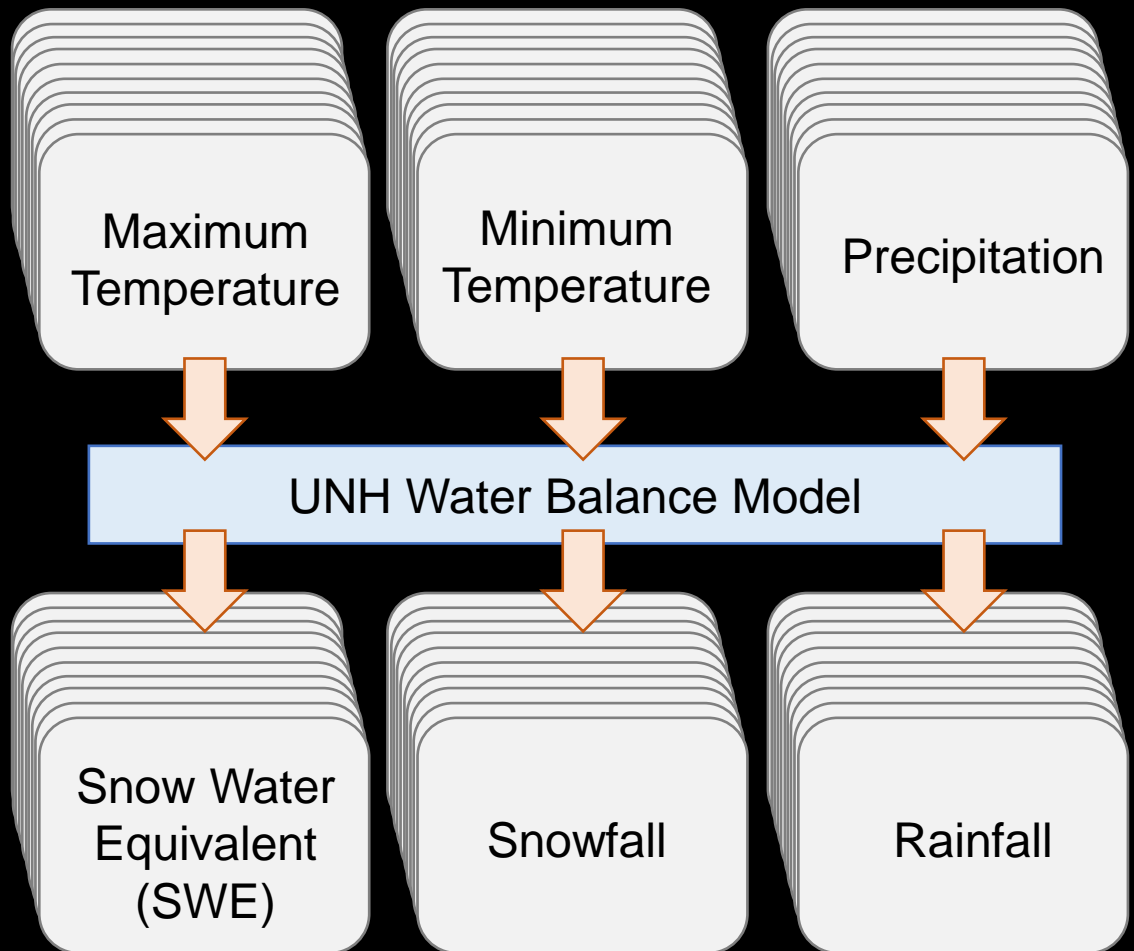


Localized Constructed Analog (LOCA)

Pierce et al.
2014

- 1/16 degree (~ 7 km)
- Daily data, 1980-2099
- Northeastern US domain
- 29 CMIP5 models
- lower (RCP4.5) and higher (RCP8.5) climate scenarios





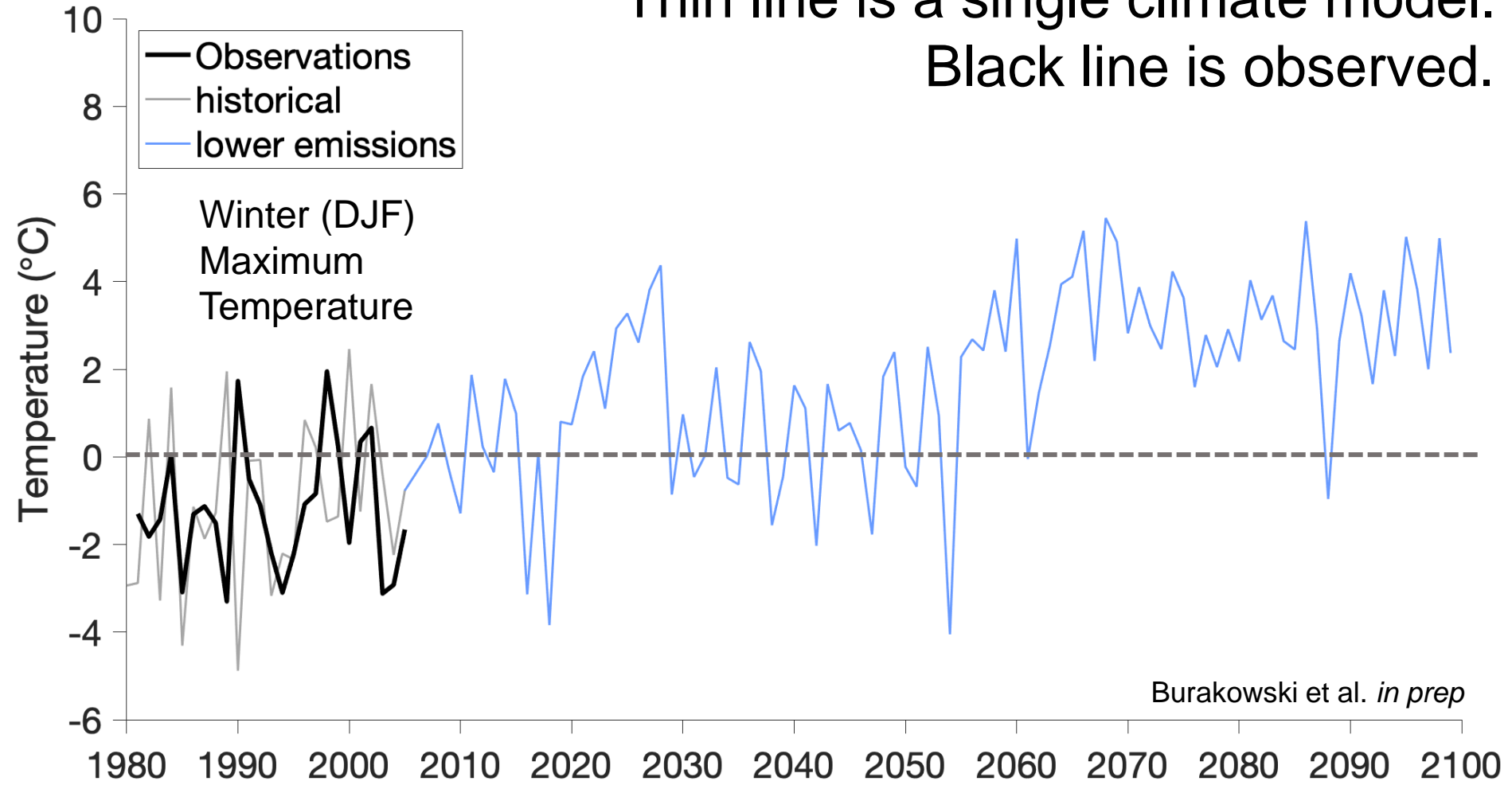
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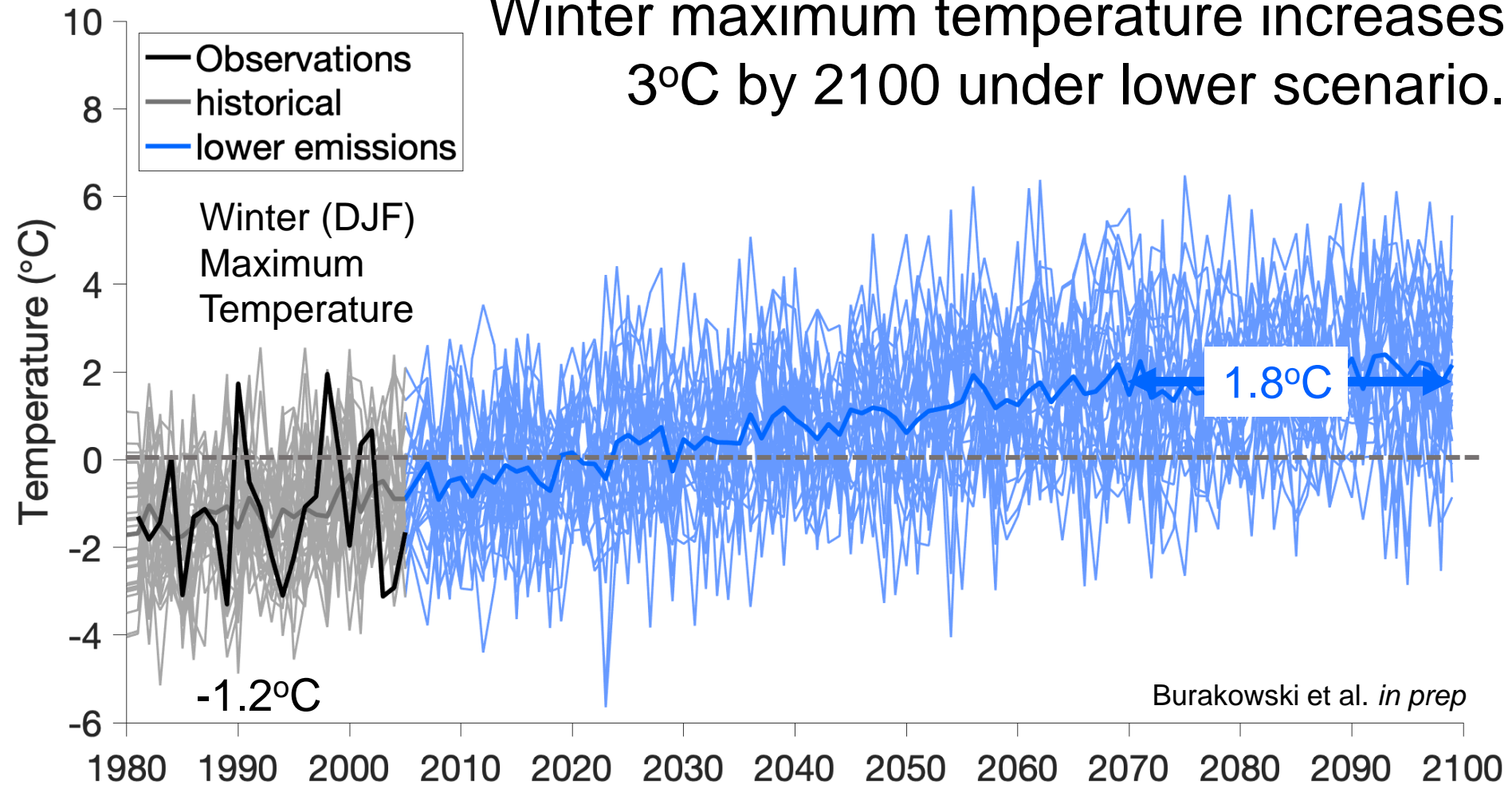
UNH Water Balance Model (WBM)

Grogan et al.
2016, 2020

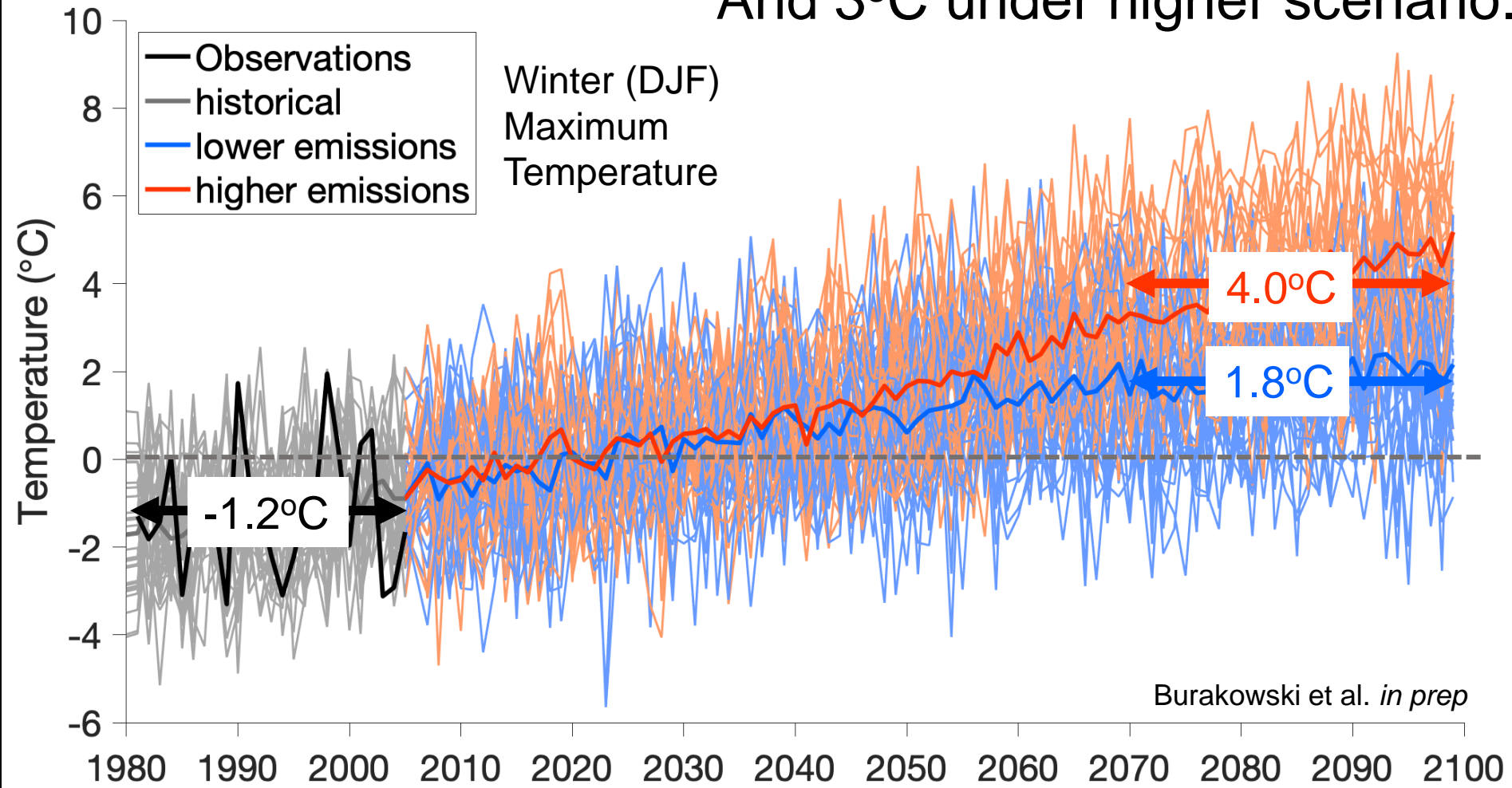
Thin line is a single climate model.
Black line is observed.



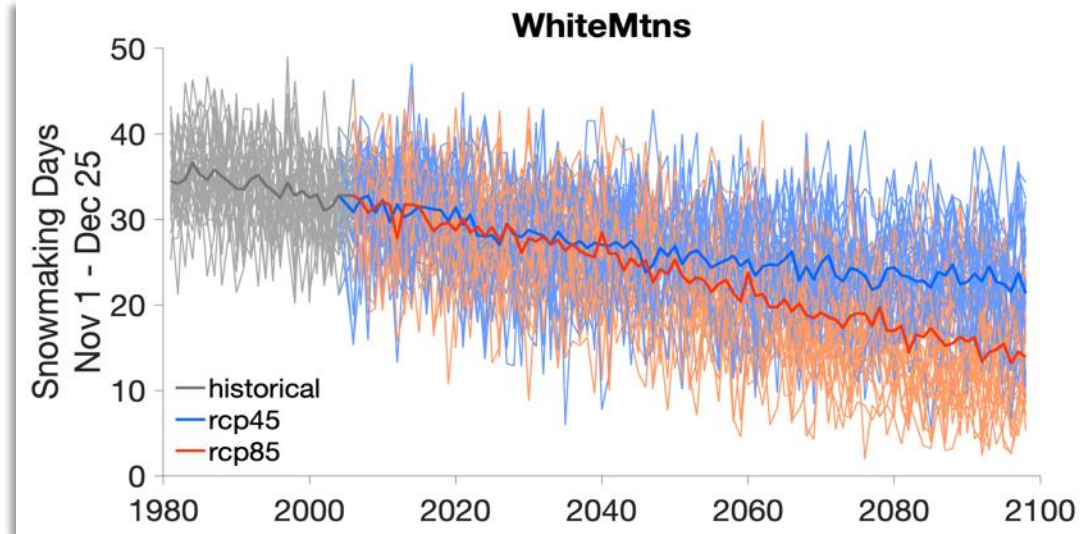
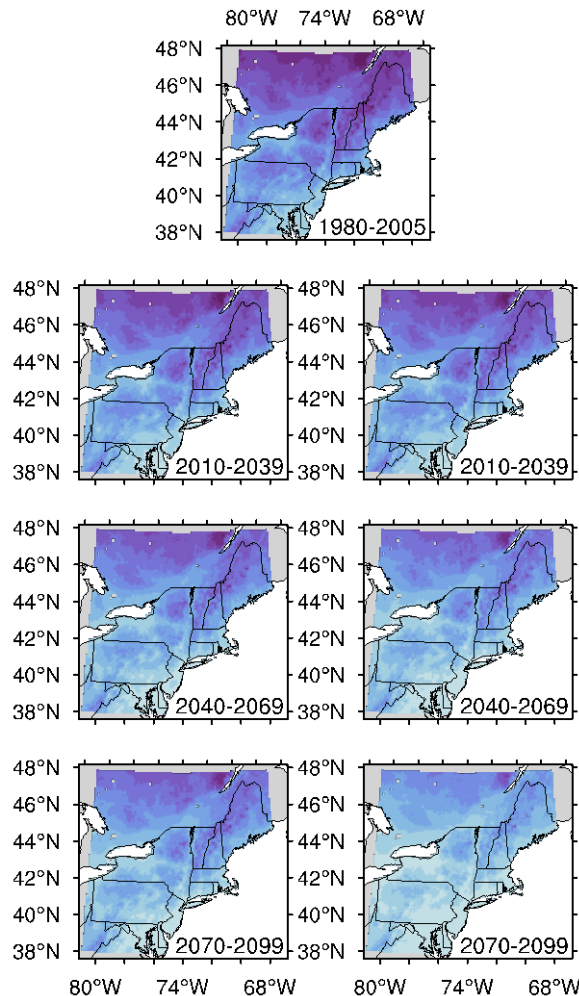
Winter maximum temperature increases
3°C by 2100 under lower scenario.



And 3°C under higher scenario.



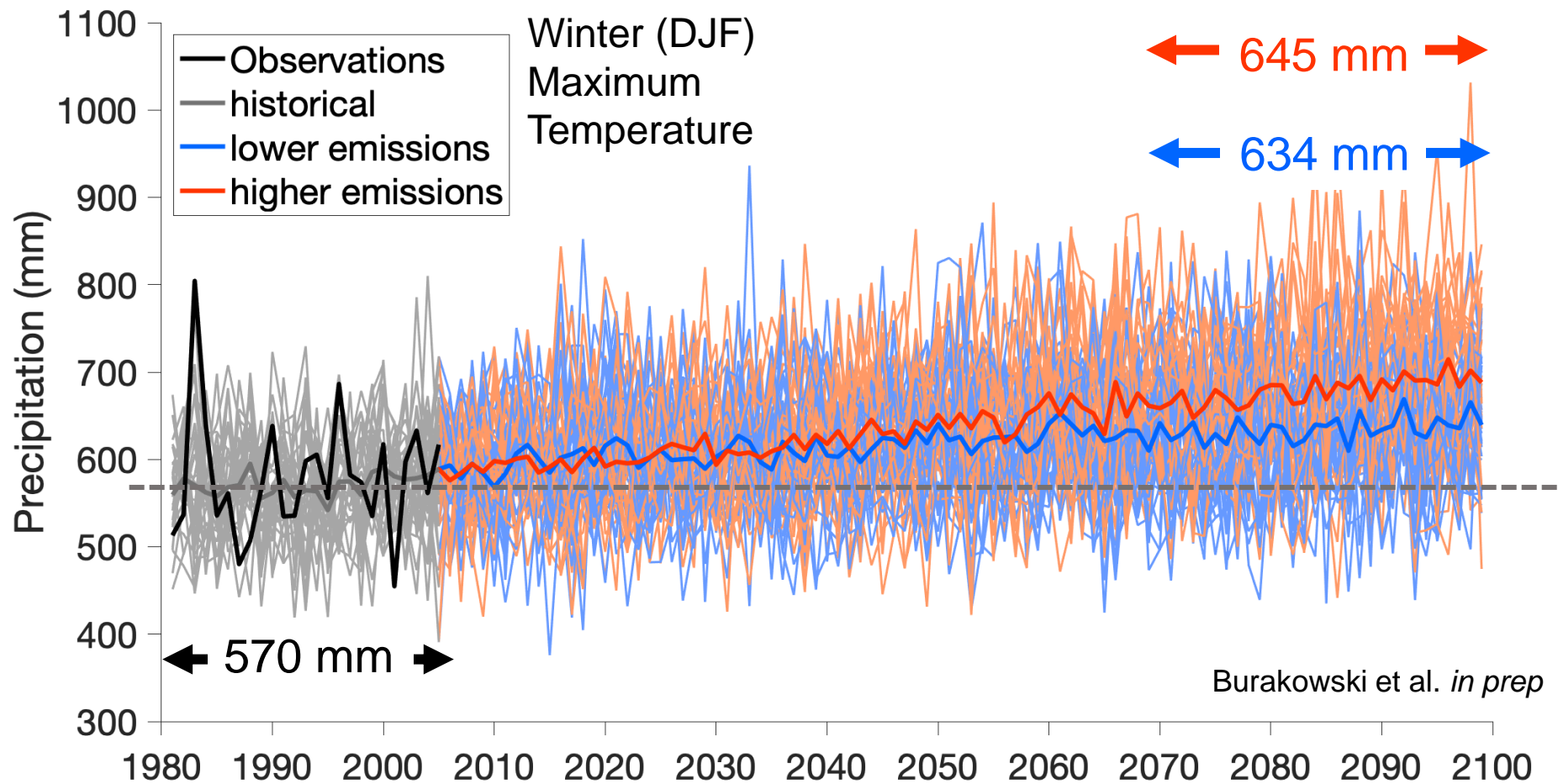
Snowmaking Days (daily minimum < -5°C)



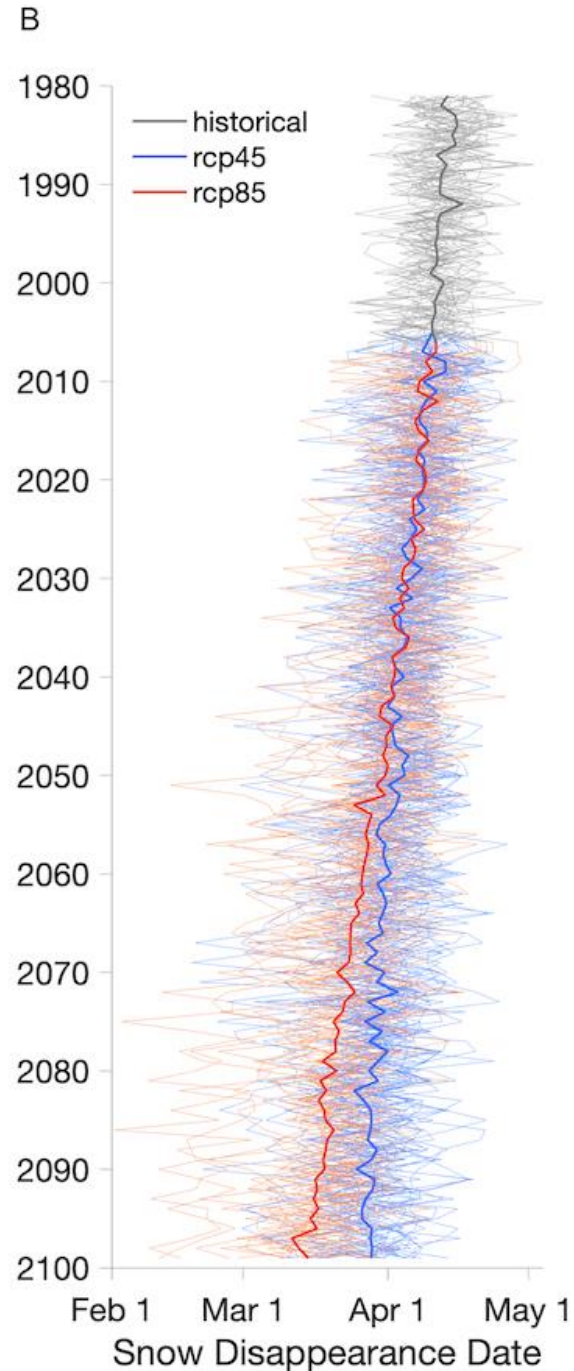
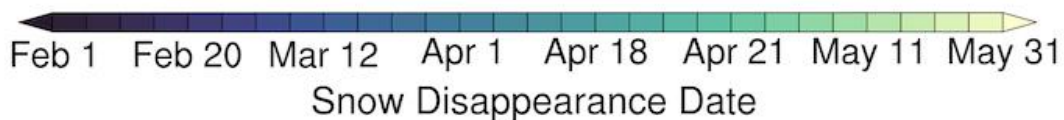
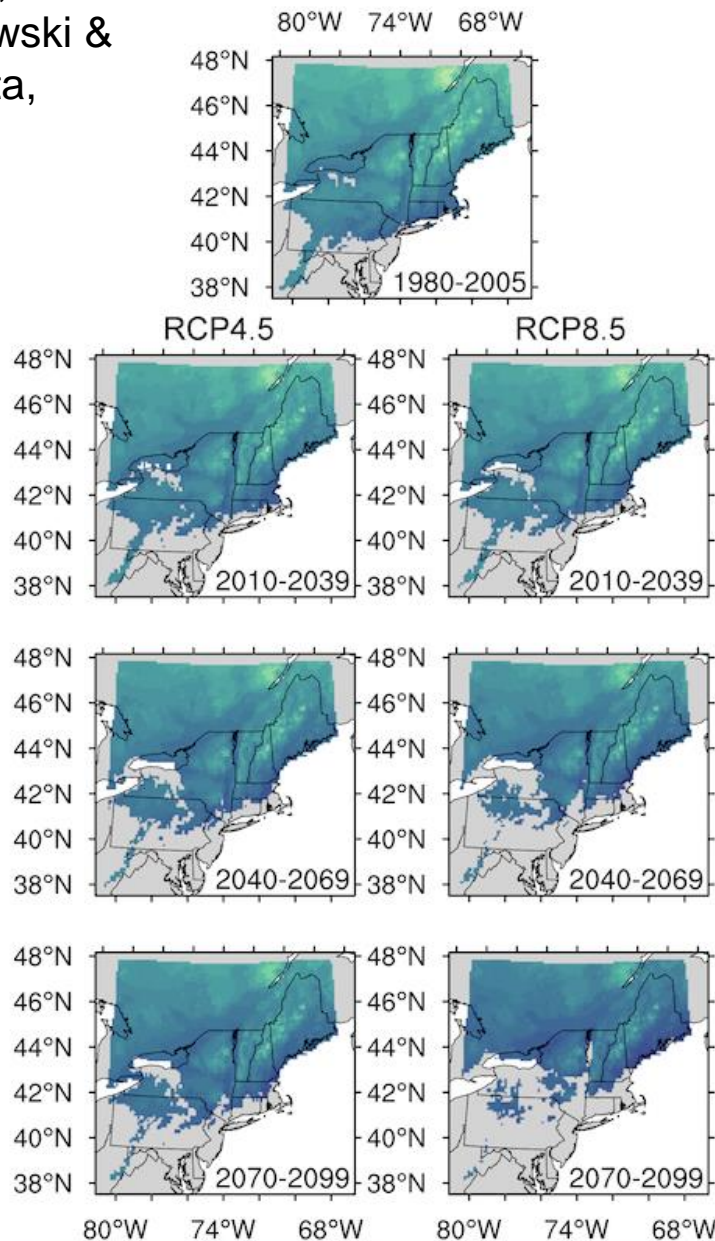
0 5 10 15 20 25 30 35 40 45 50 55
Snowmaking days (# days Nov-Dec 25, TMIN < -5°C)

- Historically, White Mountains average **one month** of snowmaking days, Nov 1 - Dec 25th.
- By 2100, reduced to **three weeks** under lower scenario and to **two weeks** under higher scenario.

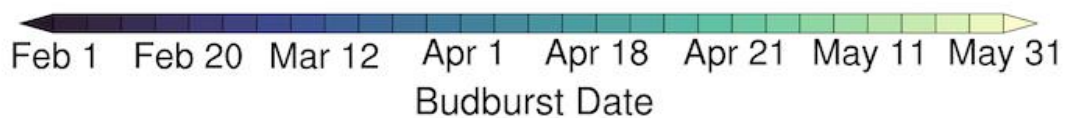
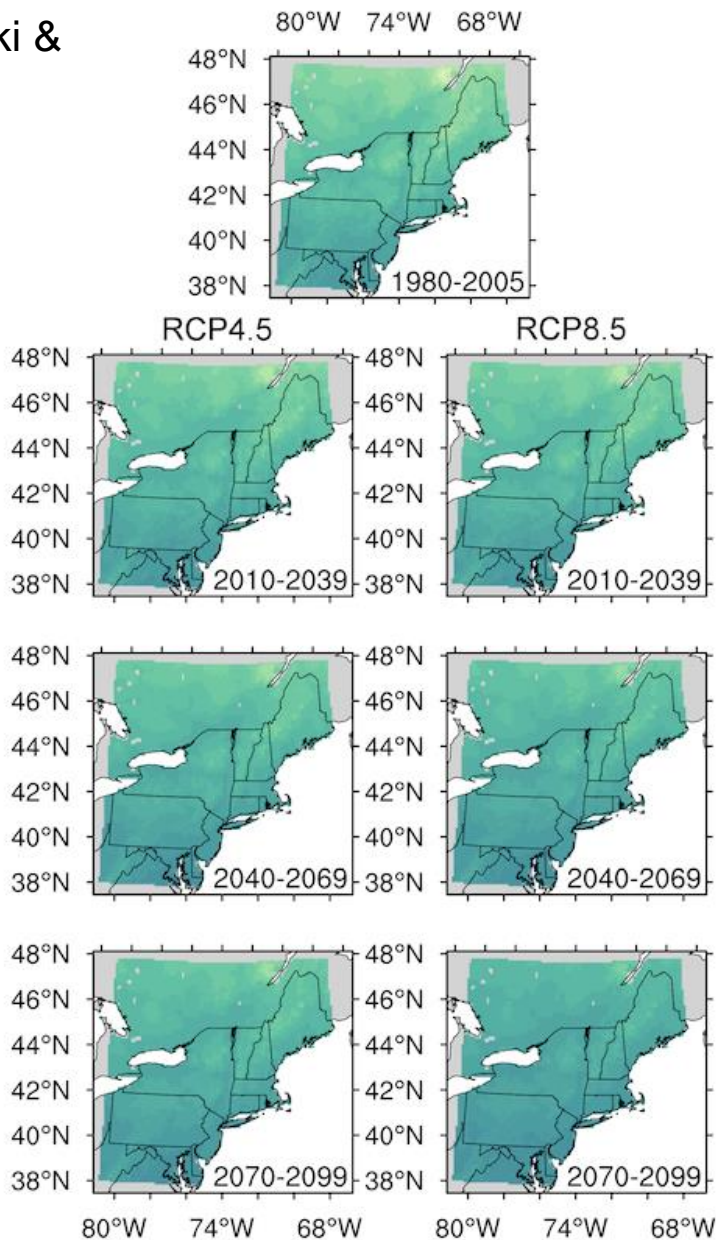
Increases in 'cold season' precipitation, though with larger uncertainty than temperature



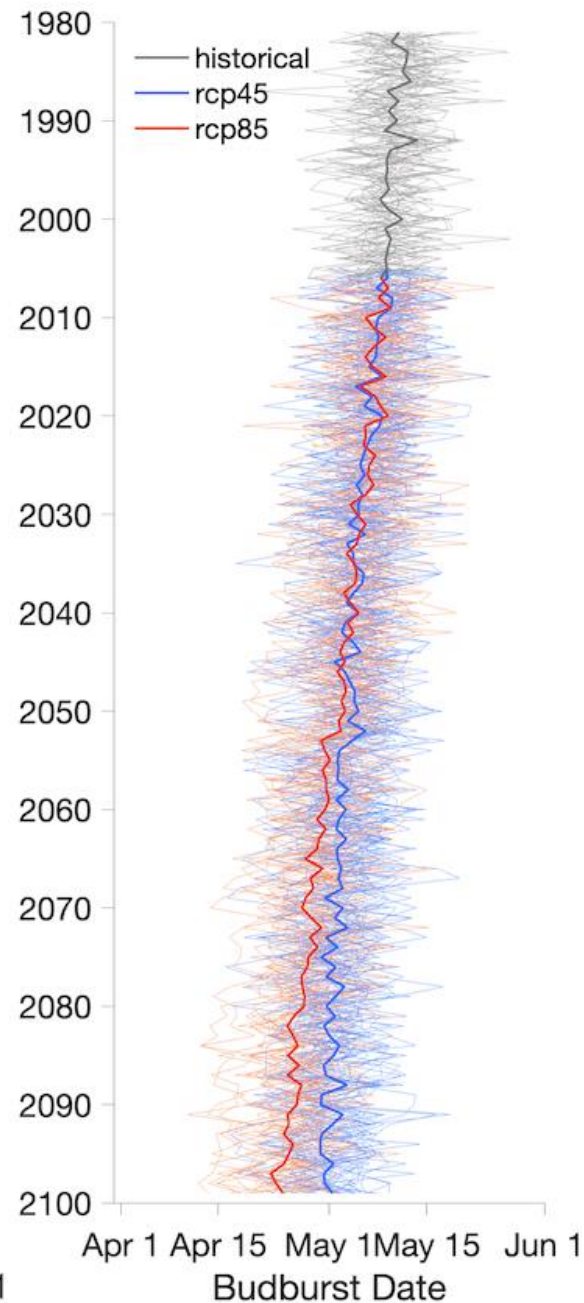
Grogan,
Burakowski &
Contosta,
2020
ERL



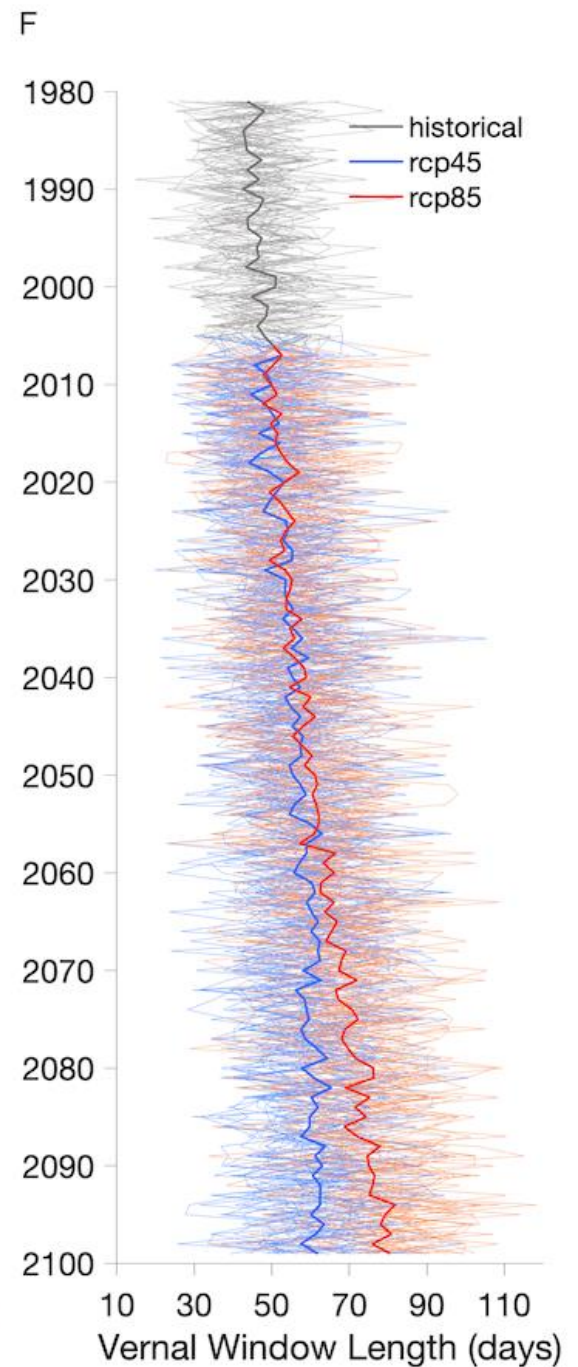
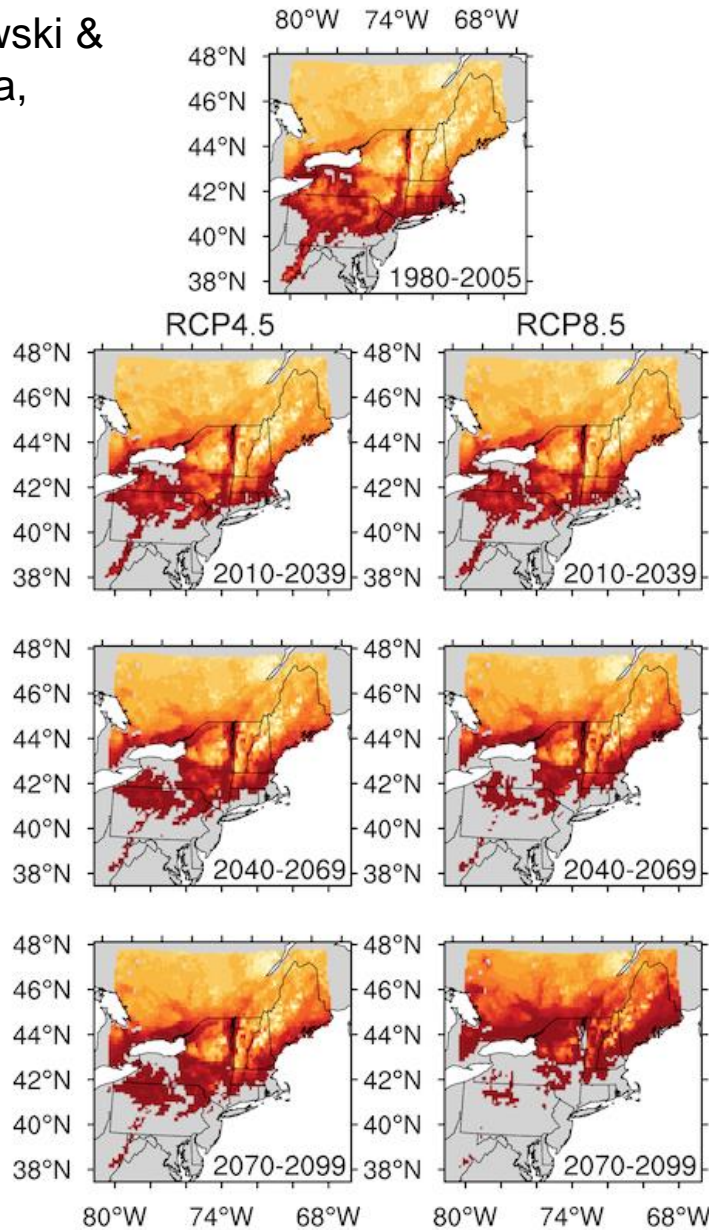
C



D



Grogan, E
Burakowski &
Contosta,
2020
ERL



elizabeth.burakowski@unh.edu



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