Climate challenges facing northern grasslands and ranches

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Acknowledgements

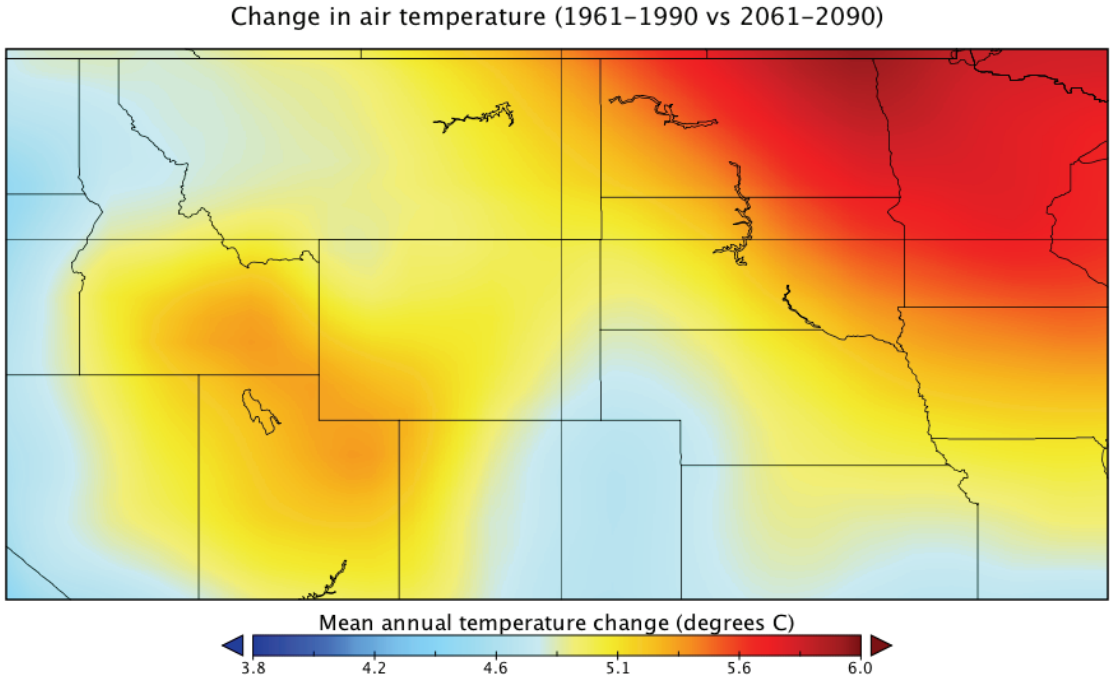
Funding
NSF (DEB 1552976, OIA 1632810)
Montana Wheat and Barley Committee
The Graduate School at Montana State University
USDA NIFA Hatch 228396

Data
National Weather Service/NOAA
CRU
ECMWF
IPCC
U.S. Drought Monitor

Kelsey Molloy & Tanja Franssen for the invitation

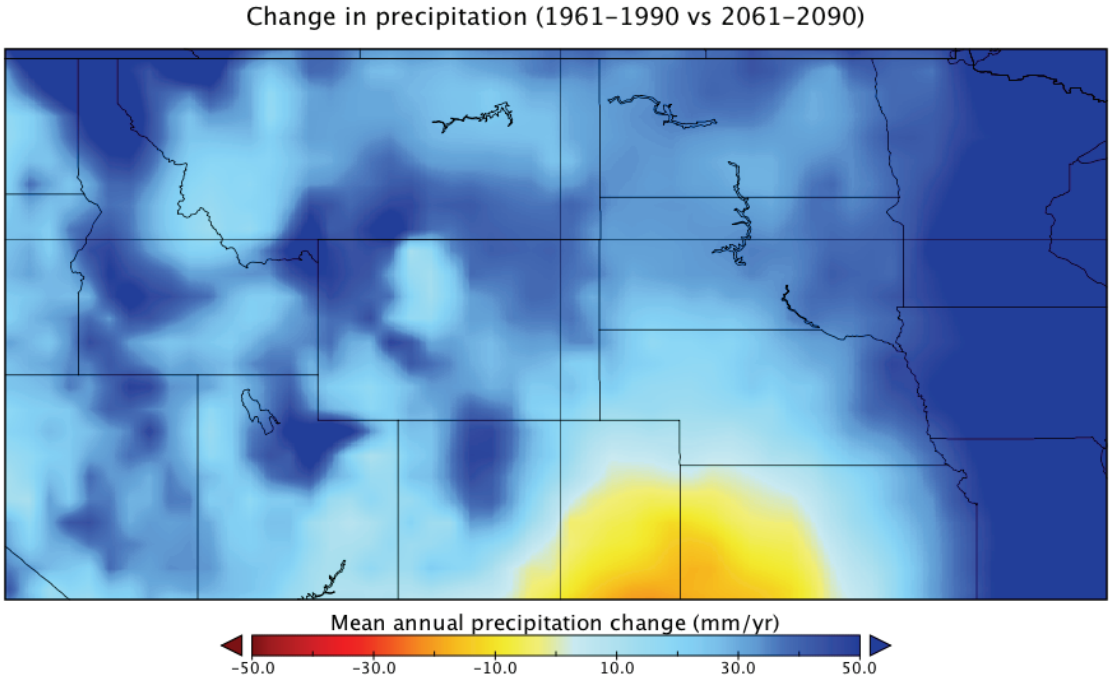
Outline

1. Future climate trends
2. Recent (decadal) climate changes
3. The 2017 Flash Drought



Will the Northern Plains get warmer?

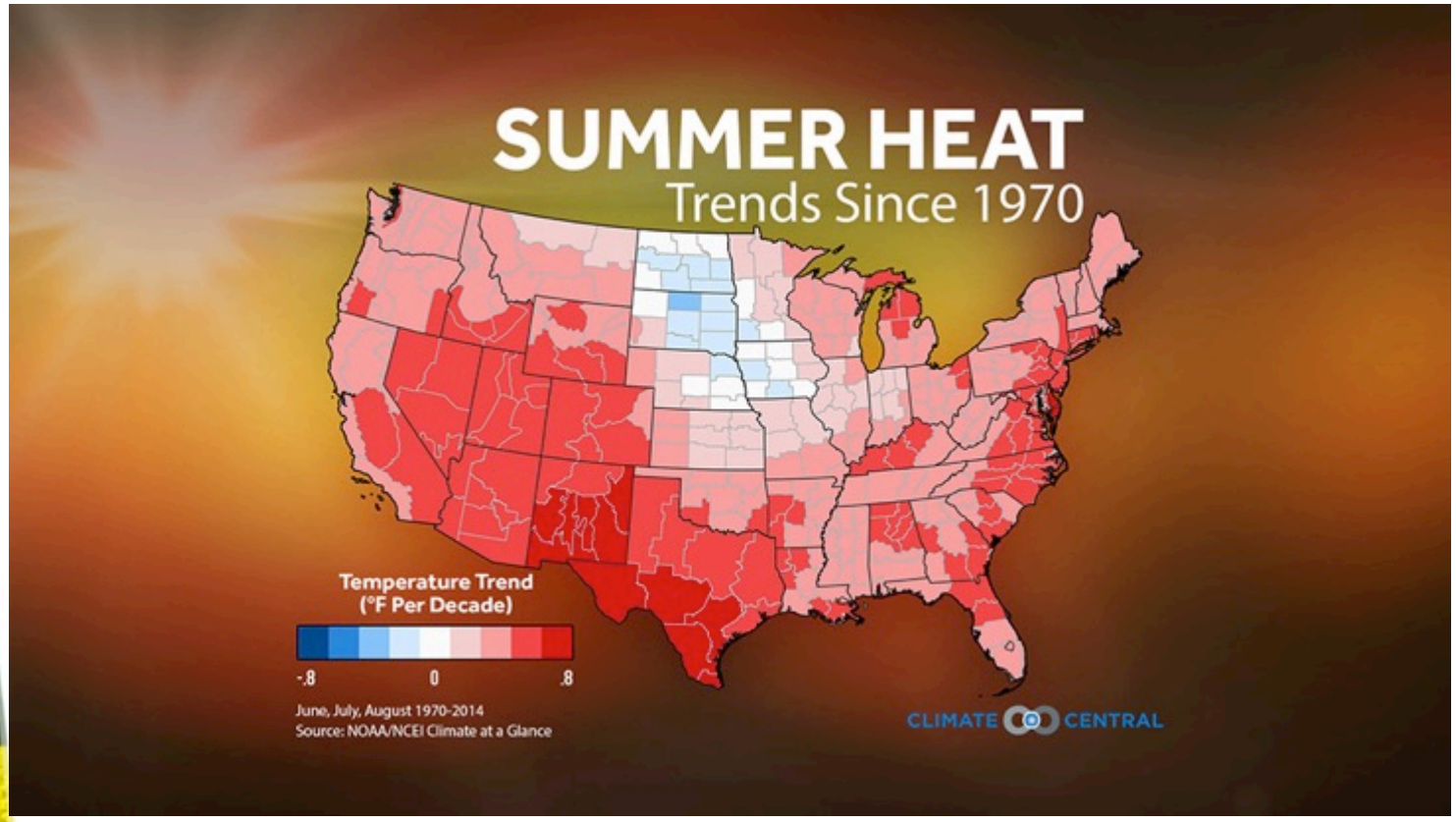
Yes, and perhaps wetter, too



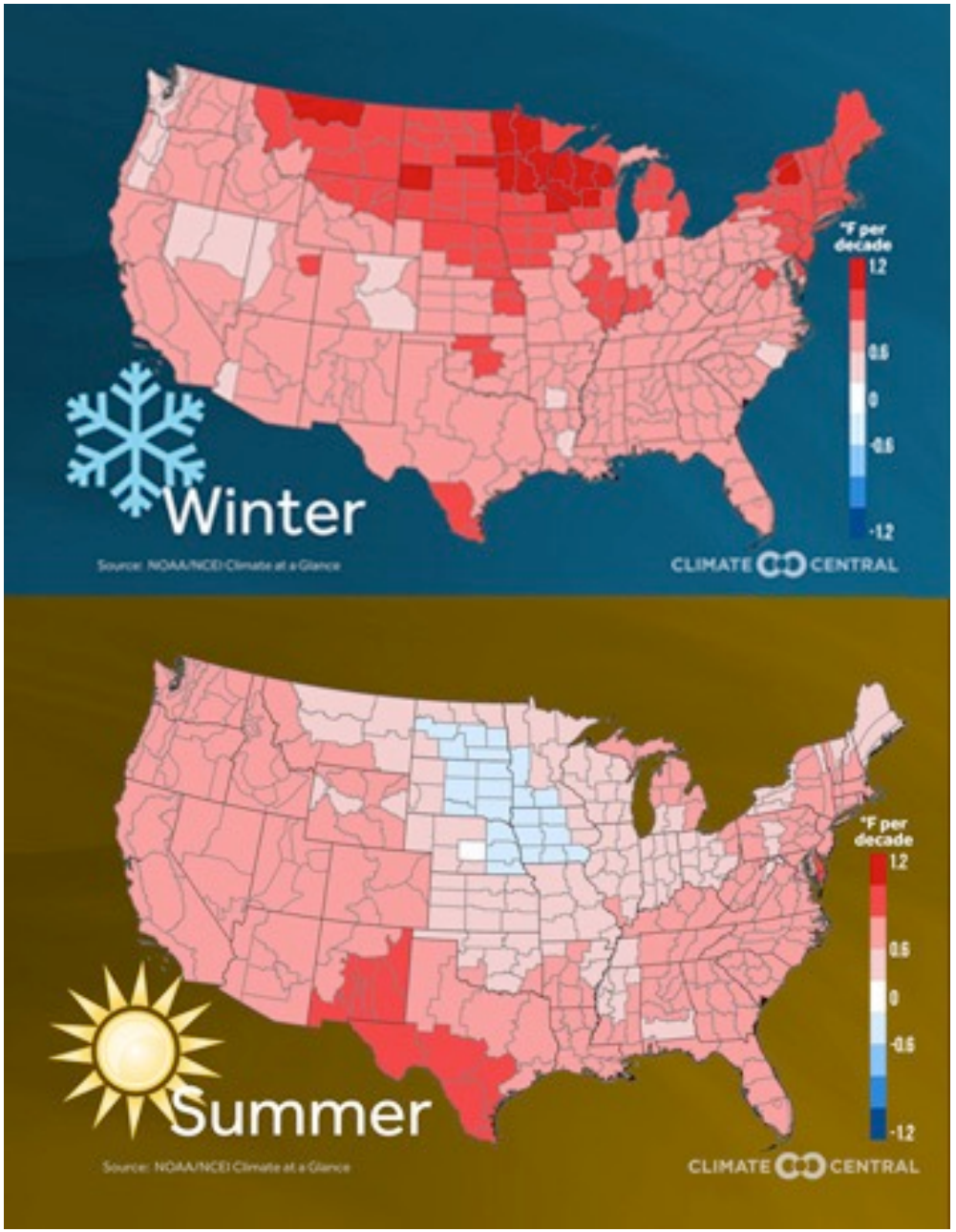
Stoy et al. (2018) *Bioscience*
Figure credit: Ben Poulter

1) **Have the Northern Plains warmed in recent decades?**

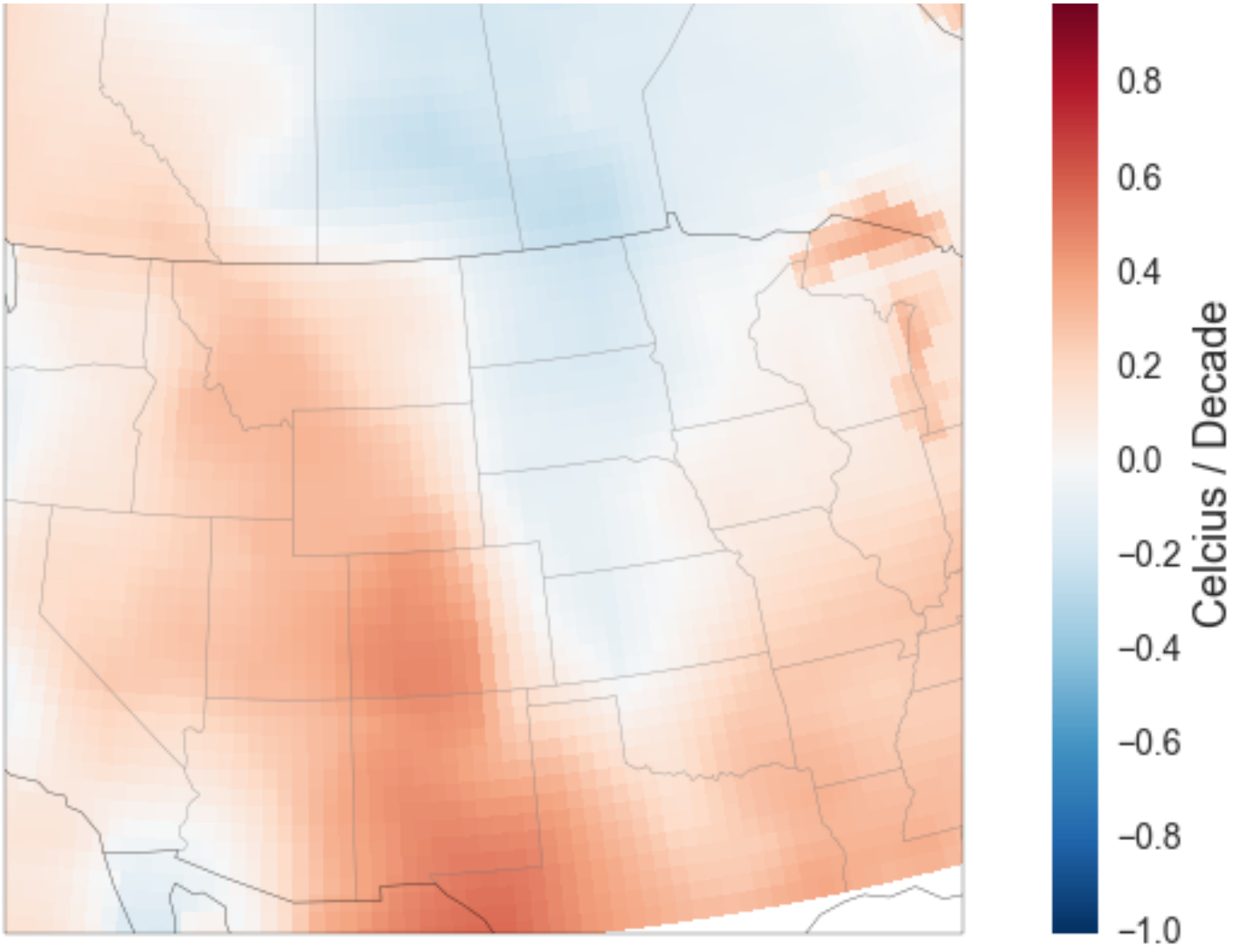
Yes and no.



2) Why is there a cooling trend during summer?



3) Is there a large country to our north?



MJJ mean temperature trend, 1970s-2016*, ECMWF-ERA-20 reanalysis.
Figure credit: Gabriel Bromley

The cooling trend is most pronounced in *Spring / early summer:* April-May-June

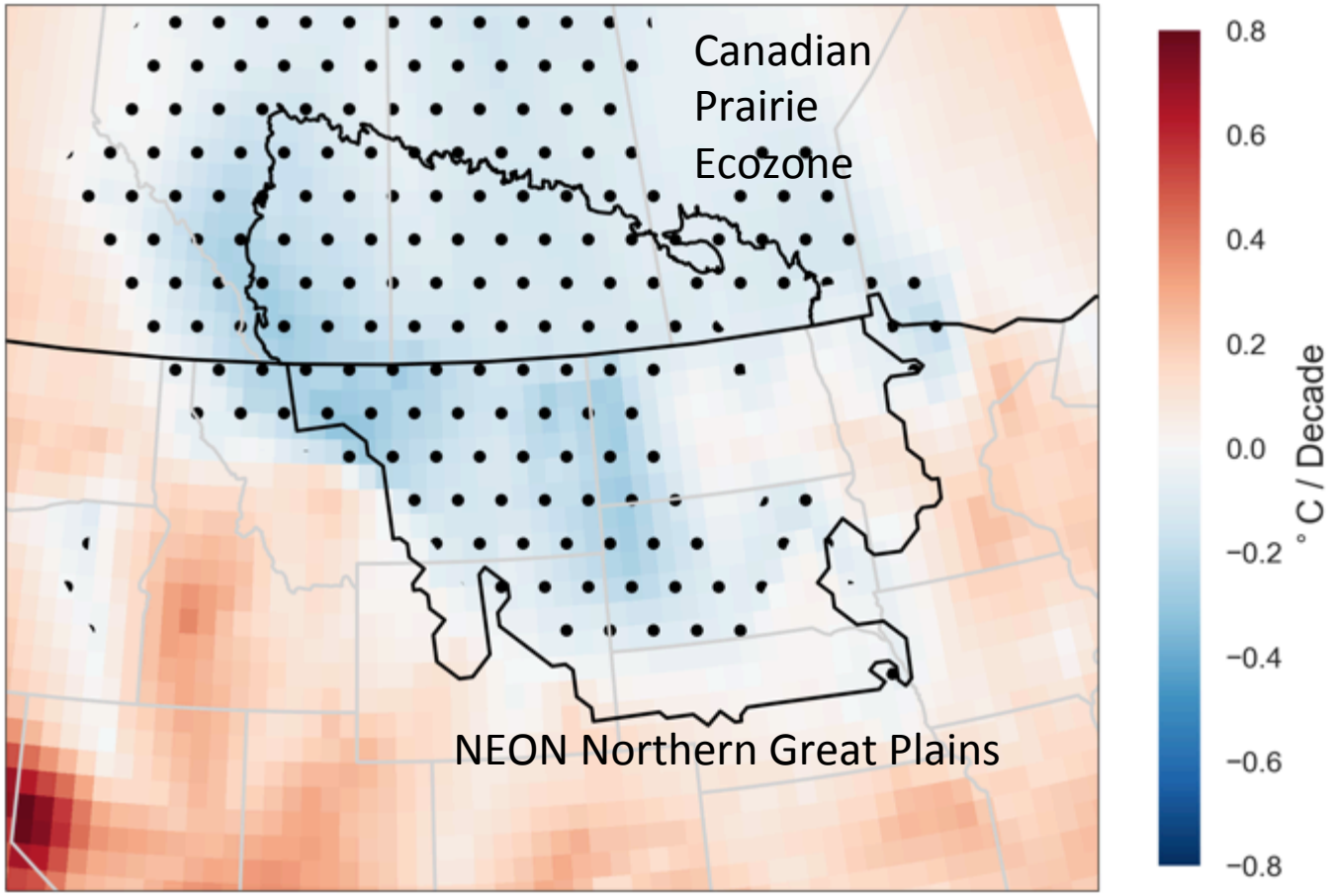


Figure credit: Gabriel Bromley

It is somewhat unique globally

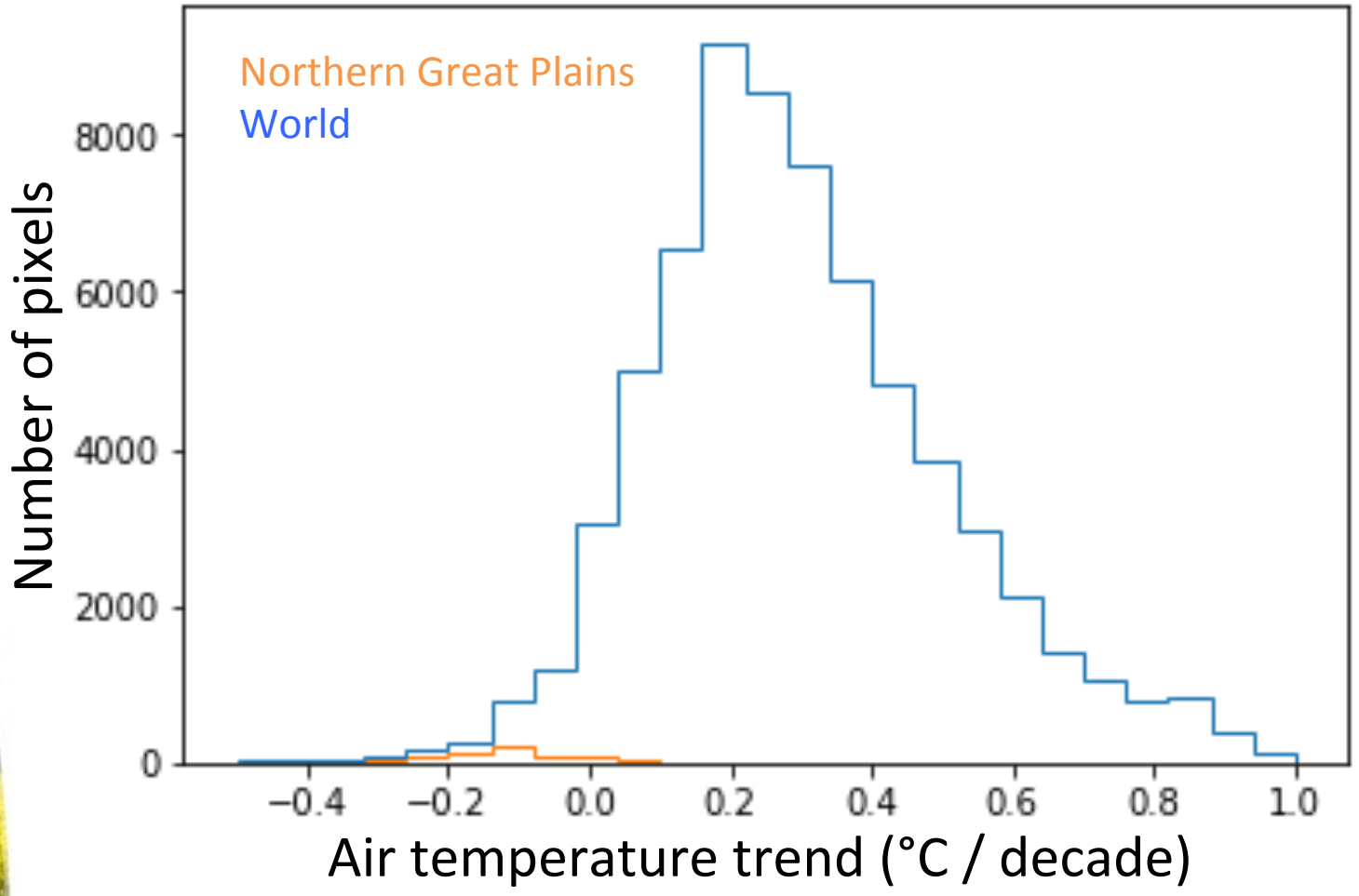
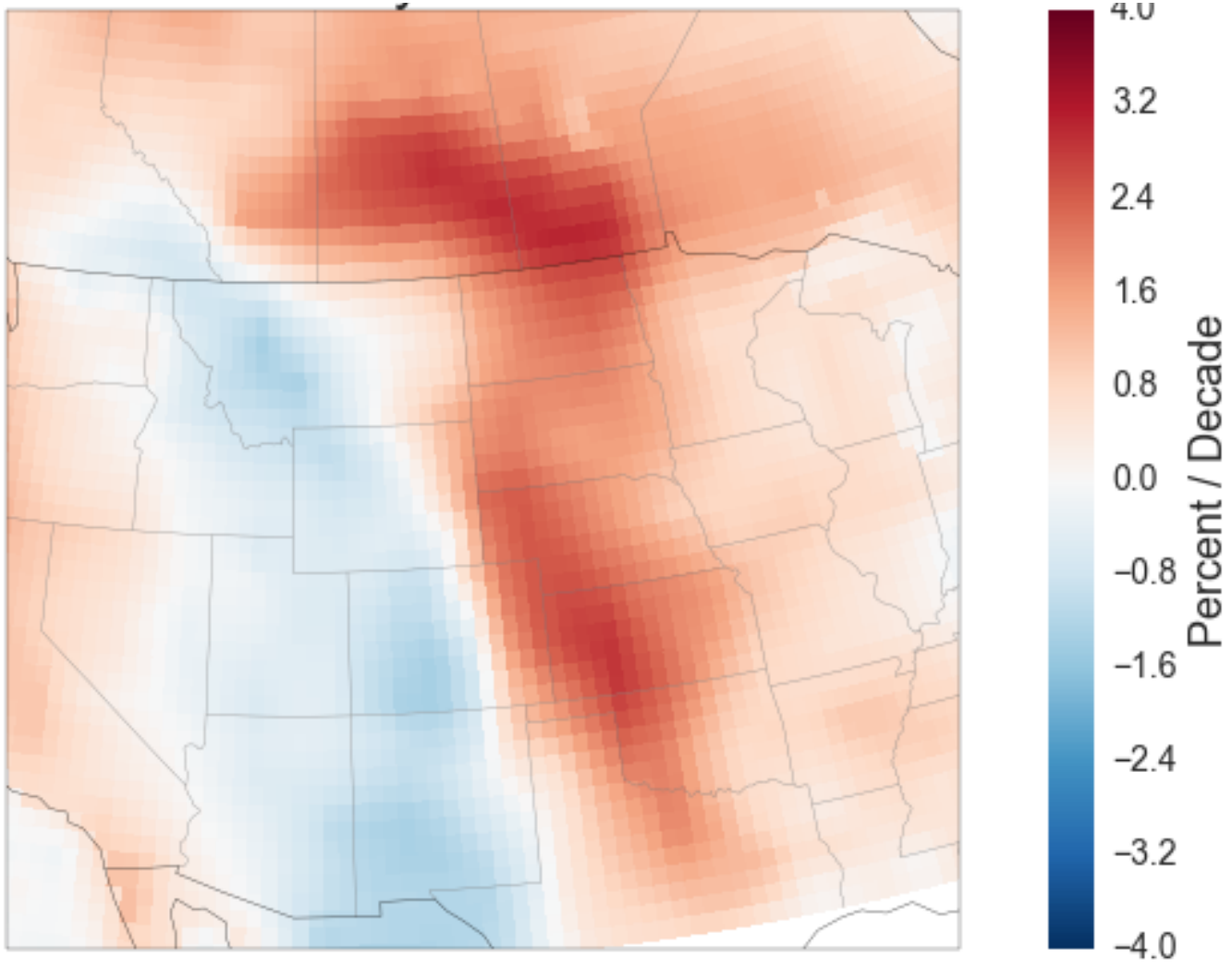


Figure credit: Gabriel Bromley

The North American Great Plains are also now more humid



MJJ mean RH trend, 1970s-present, ECMWF-ERA-20 reanalysis.
Figure credit: Gabriel Bromley

Glasgow receives 3x more rain in May now than it did in the 1990s

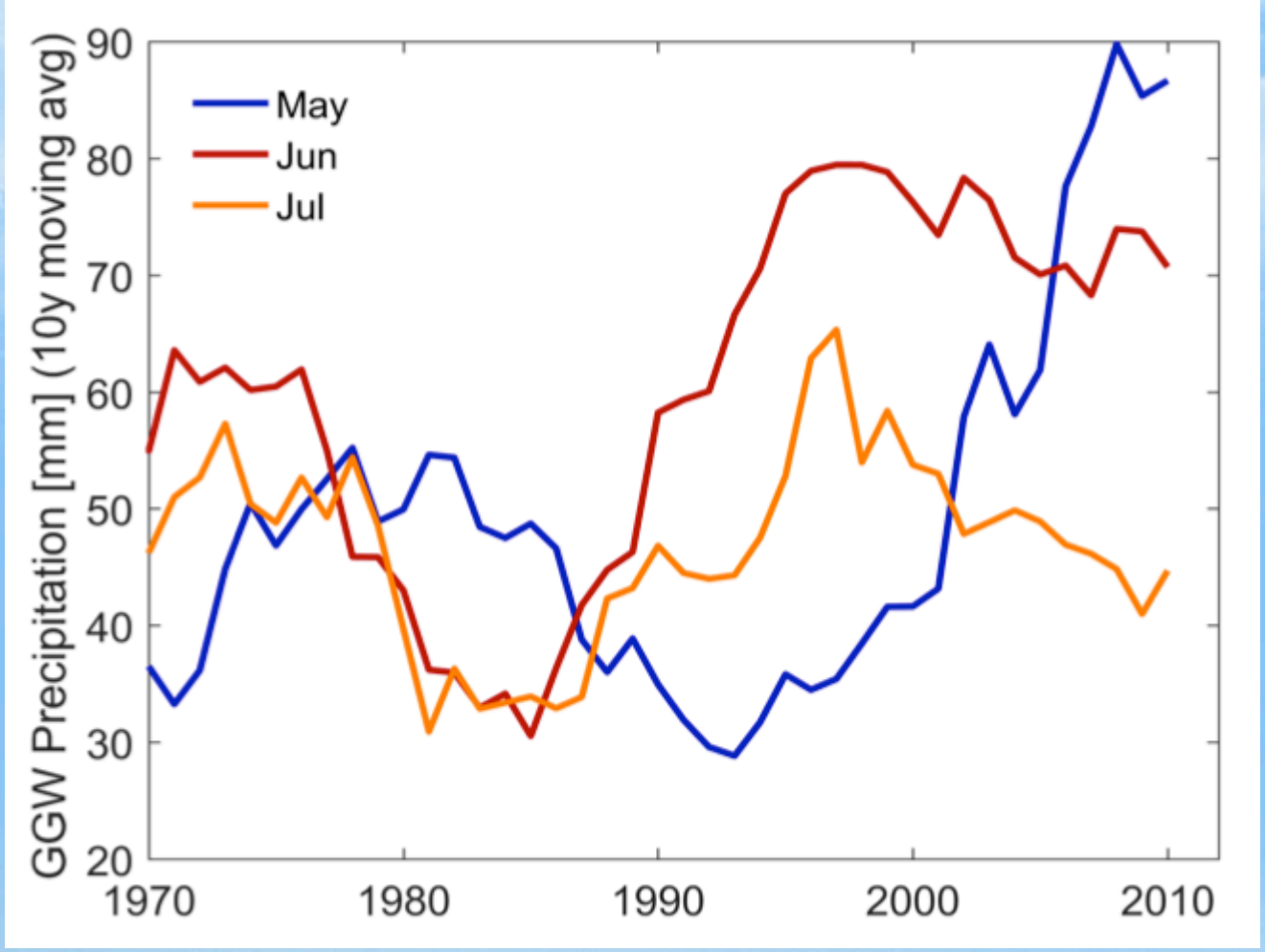


Figure credit: Tobias Gerken

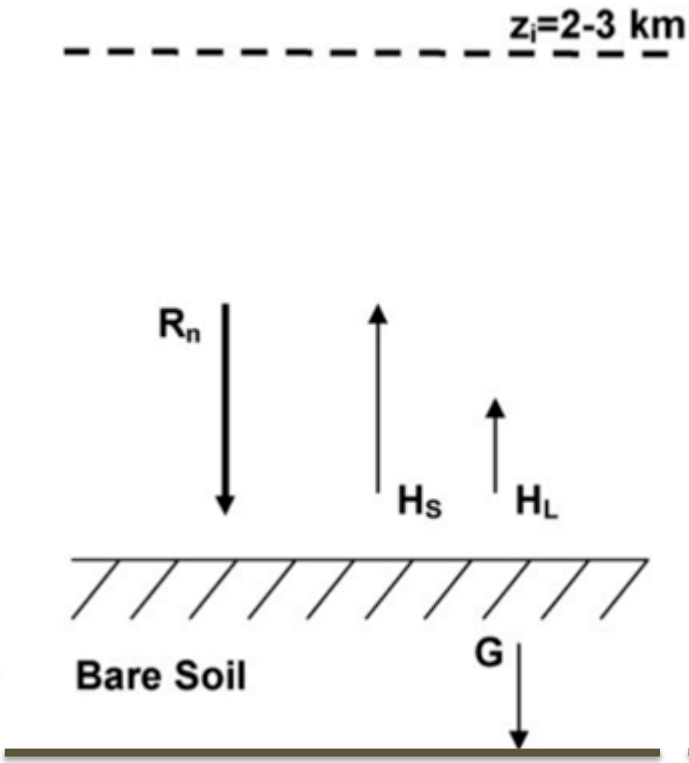
Why? Probably land use changes

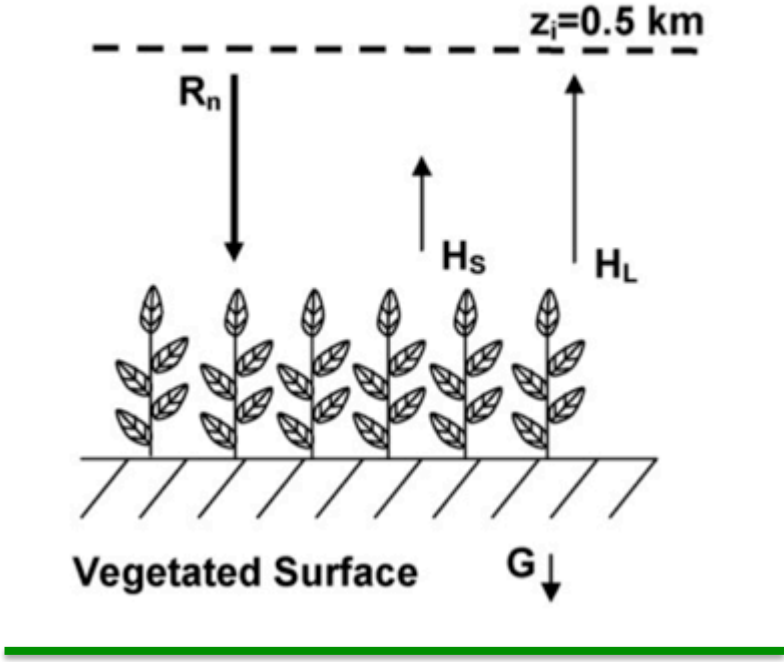
In the Canadian Prairies over the past 4 decades:
Summer maximum temperature: - 1 °C trend
Precip: + 10 mm/decade trend

-6 W m^{-2} summer forcing!

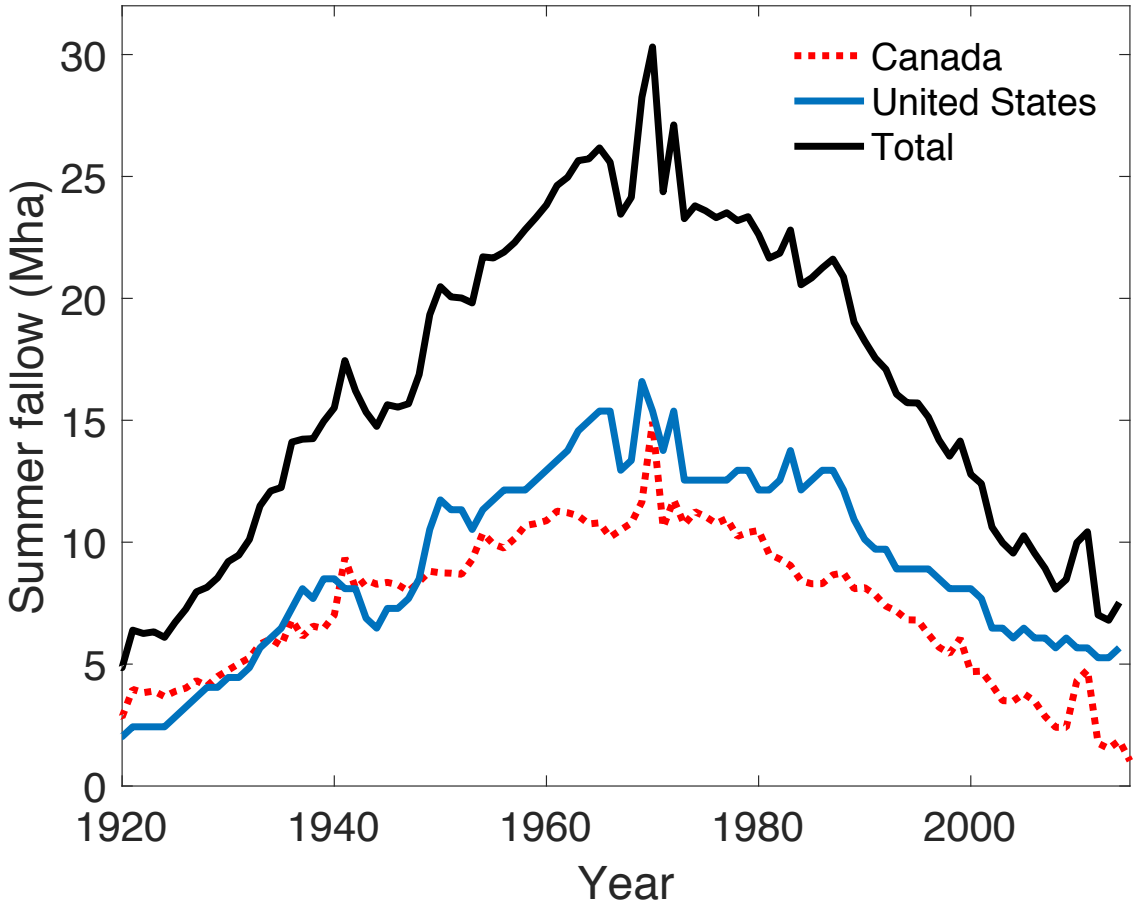
Anthropogenic warming +2.5 W m^{-2}

Gameda et al., (2007)
Betts et al. (2013 a,b)
Raddatz (2007)





There is now *ca*. 23 Mha less summer fallow than before



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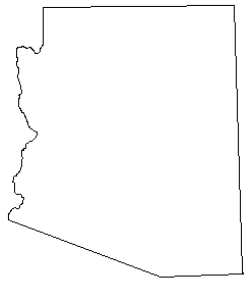
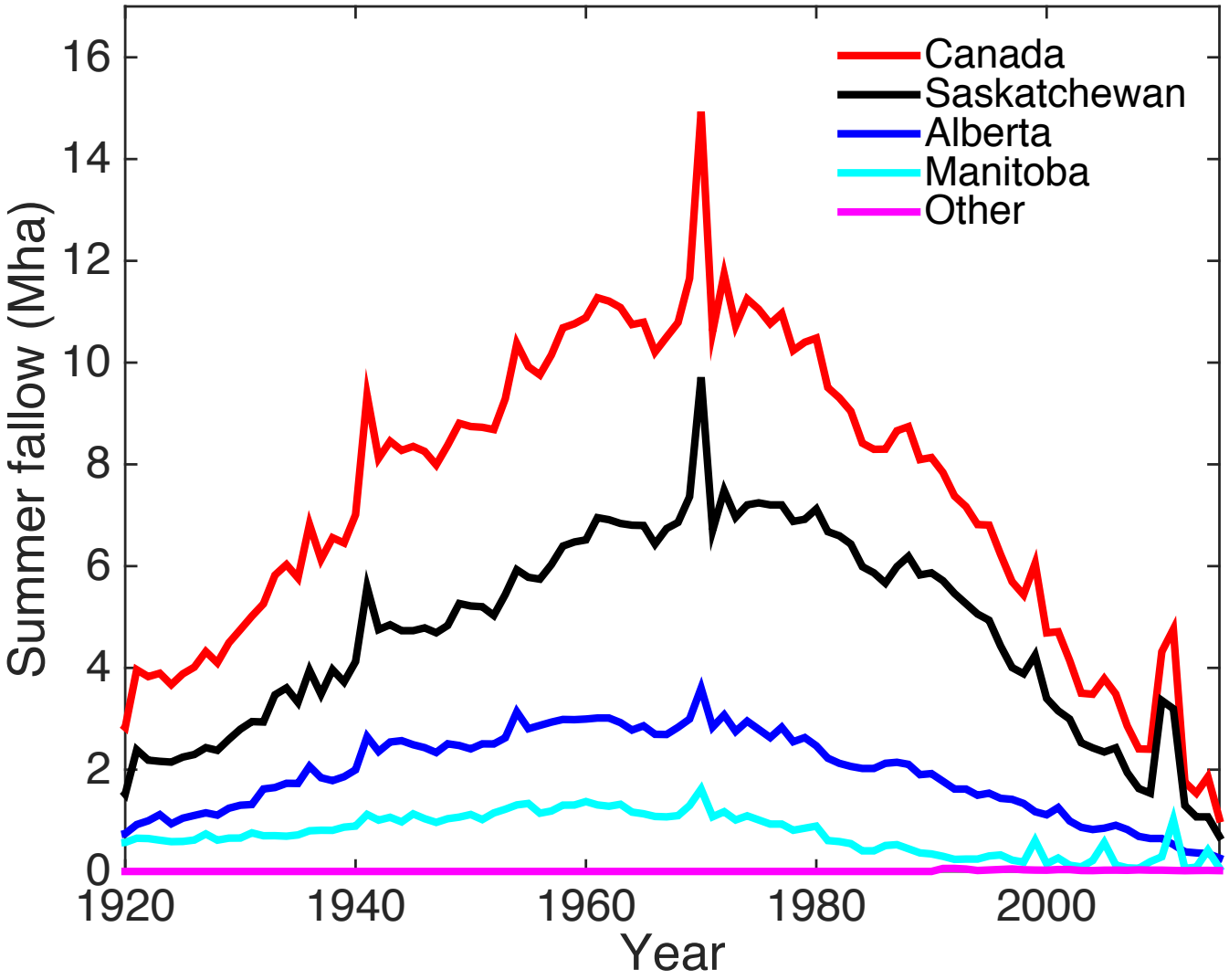
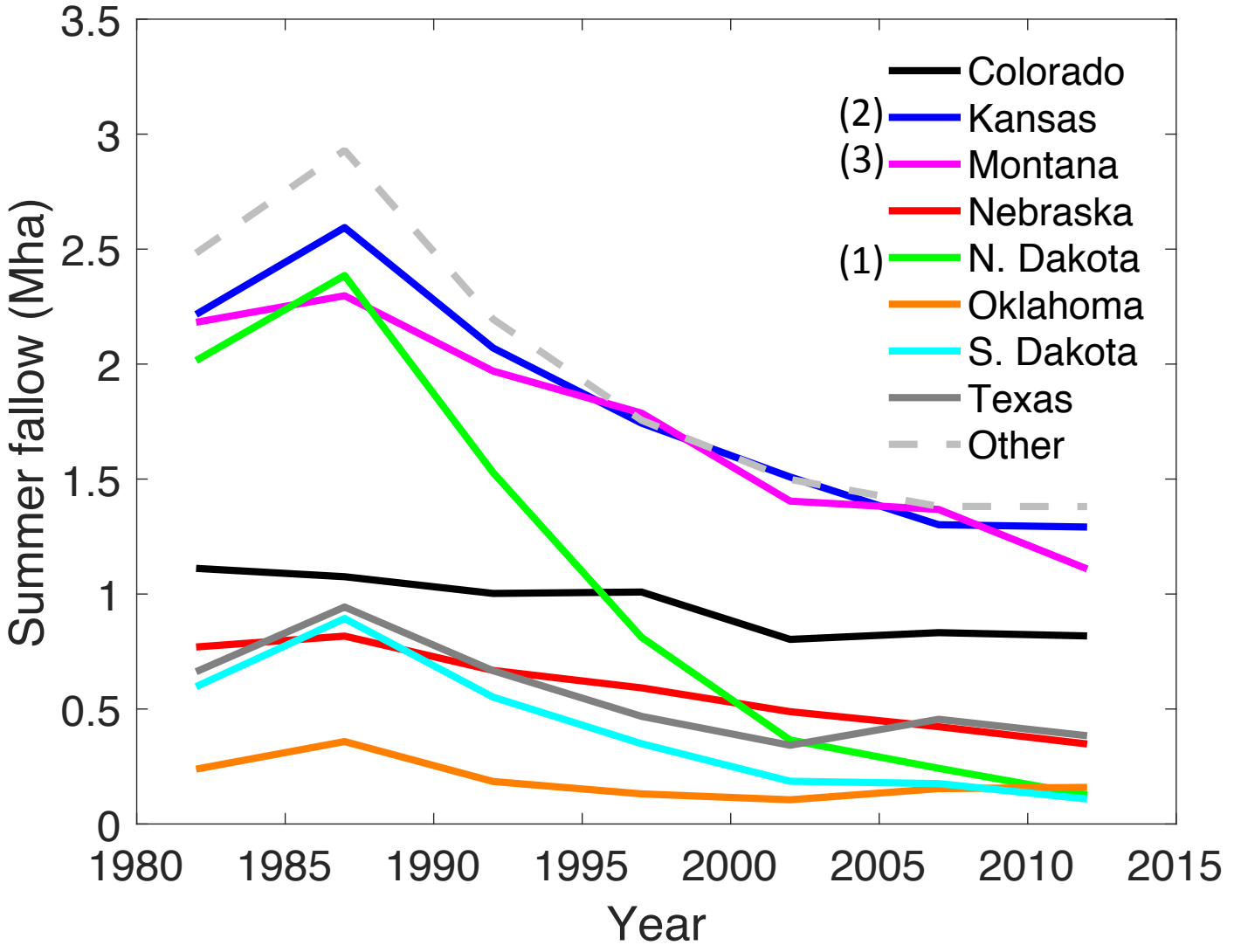


The largest fallow changes are in Saskatchewan…



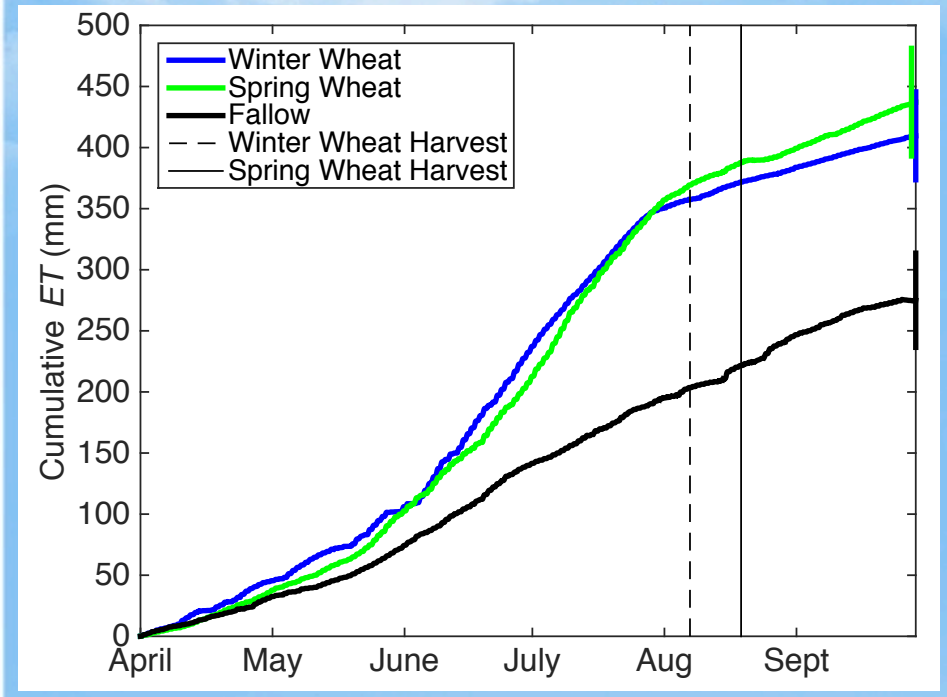
…and North Dakota.



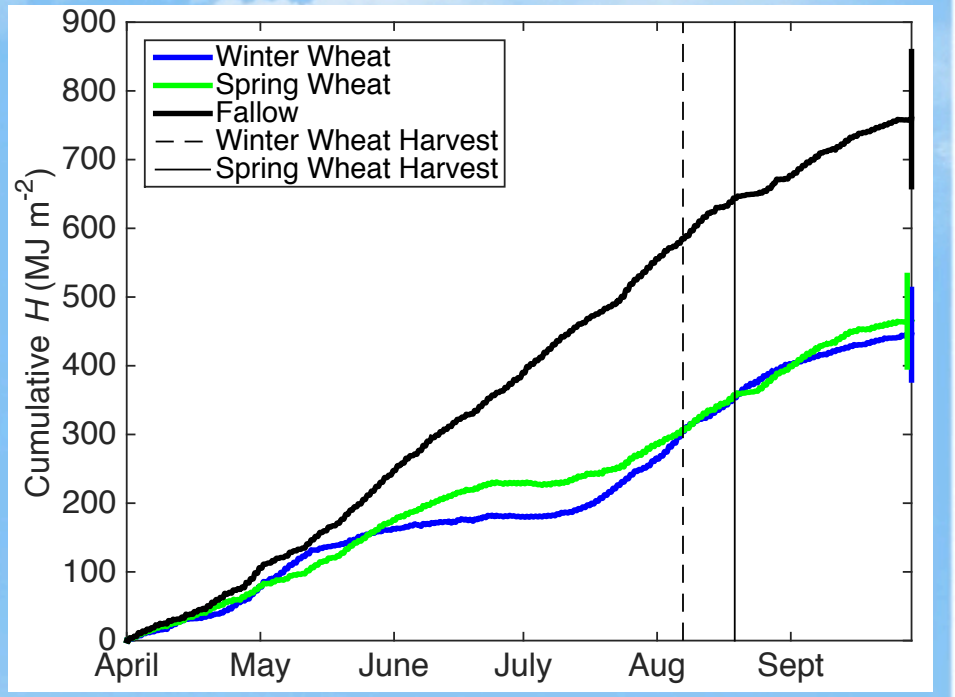
Is this a win-win-win scenario for regional climate, soil conservation, and income?

Cropping systems impact the water and energy fluxes that impact regional climate

Evapotranspiration

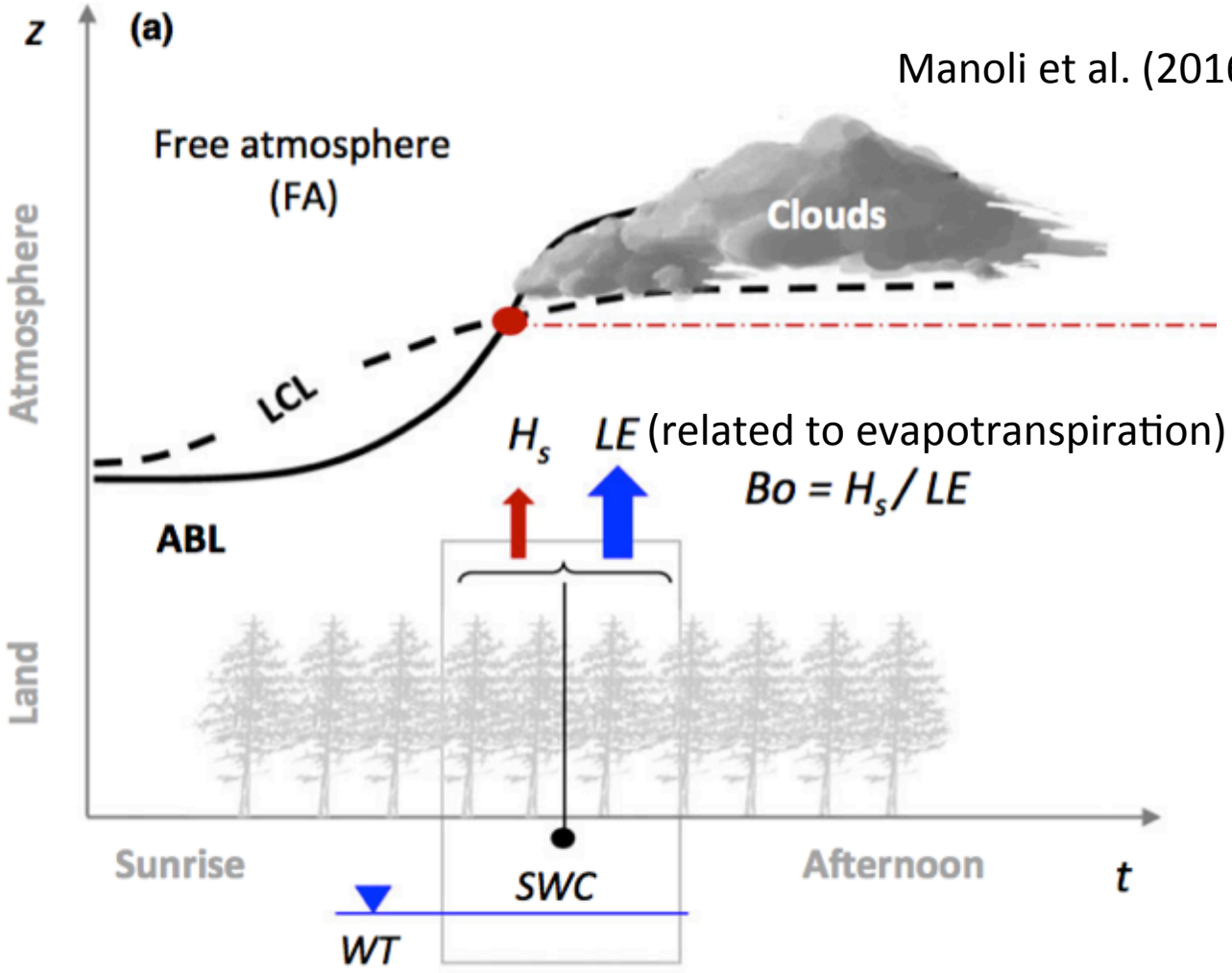


Sensible Heat



Vick, Stoy, Tang & Gerken (2016): Measurements from the Judith Basin, MT

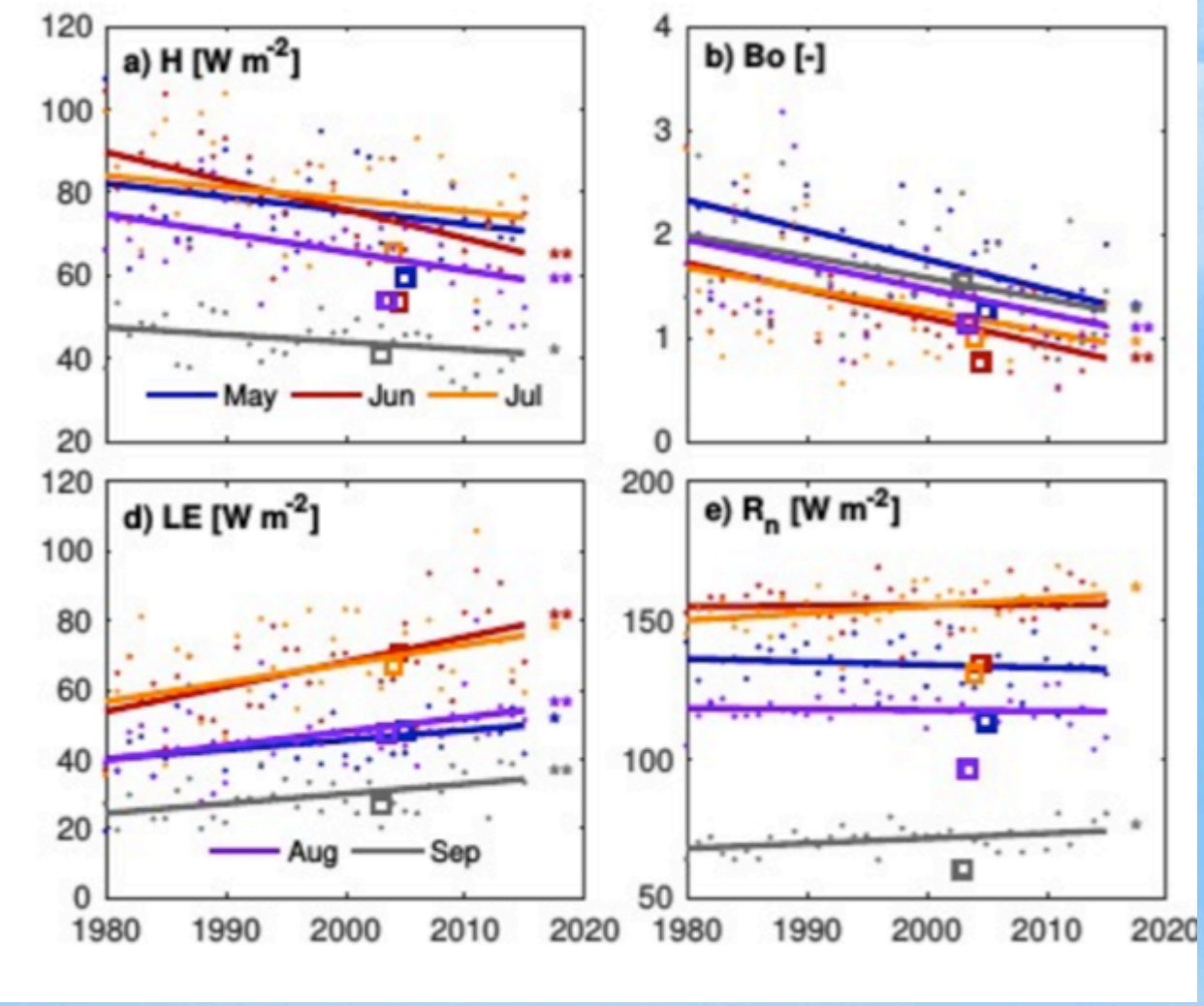
Atmospheric boundary layer (ABL) – lifted condensation level (LCL) crossing is a 'necessary but not sufficient' condition for convective precipitation



Manoli et al. (2016)

See also:
Findell and Eltahir (2003a,b), Juang et al. (2007a,b), Koenings et al. (2010), Porporato (2009) and many more

Decadal changes in surface and atmospheric conditions at Glasgow (GGW)



Gerken, Bromley & Stoy (2018) *Journal of Hydrometeorology*
Figure credit: Tobias Gerken

Convective likelihood is now 10% greater in NE Montana

Convection is sensitive to the land surface in the early season

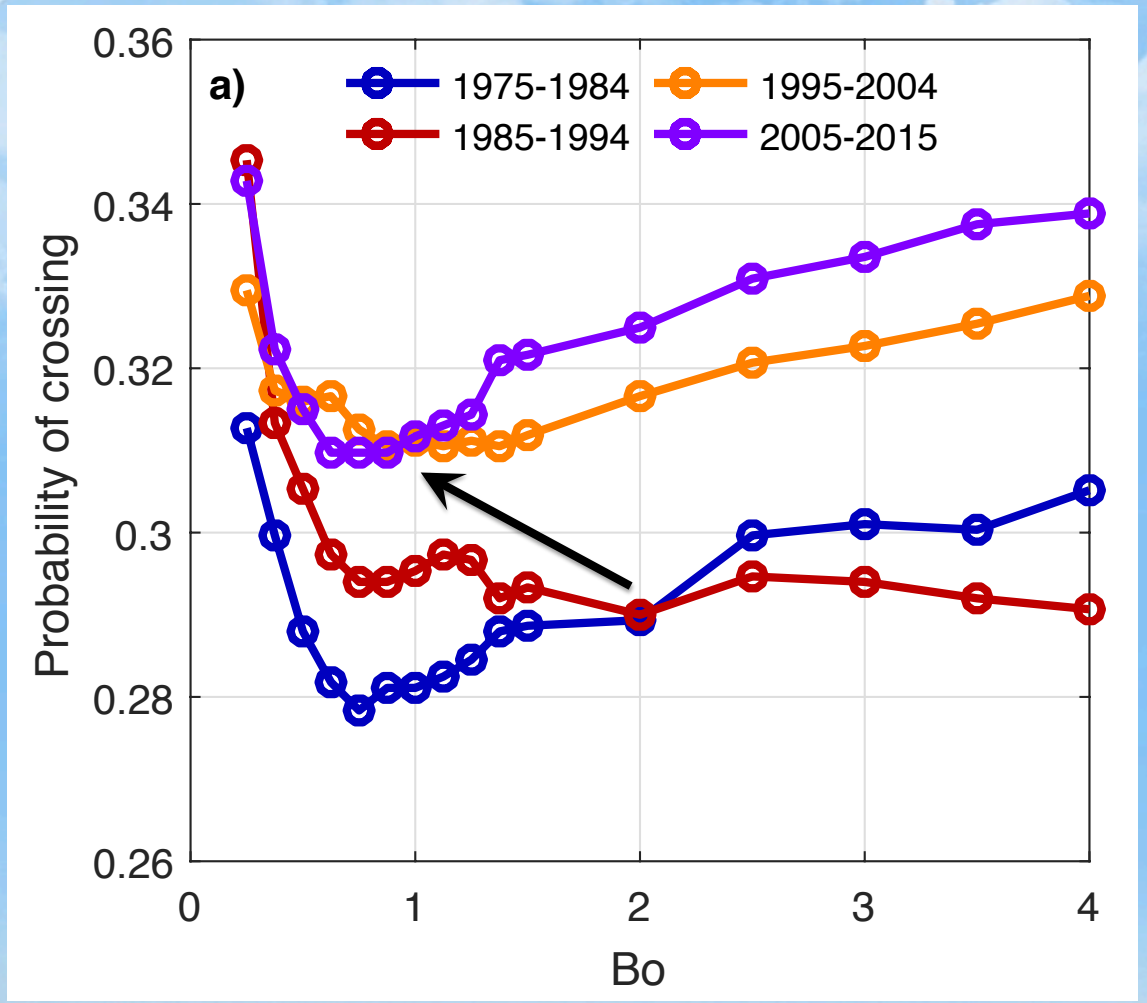


Figure credit: T. Gerken

Gerken, Bromley & Stoy (2018) *Journal of Hydrometeorology*

Alternate hypotheses

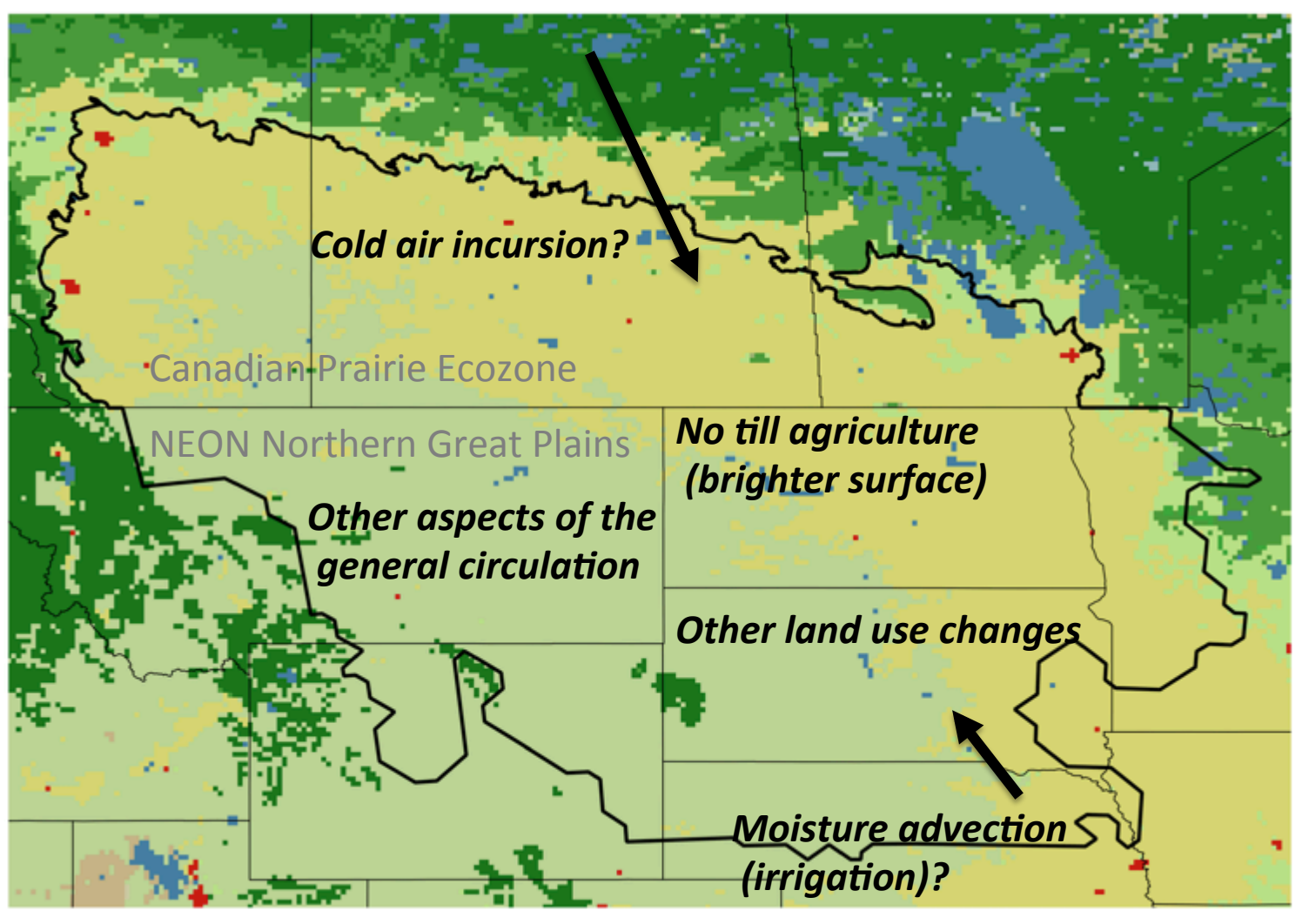
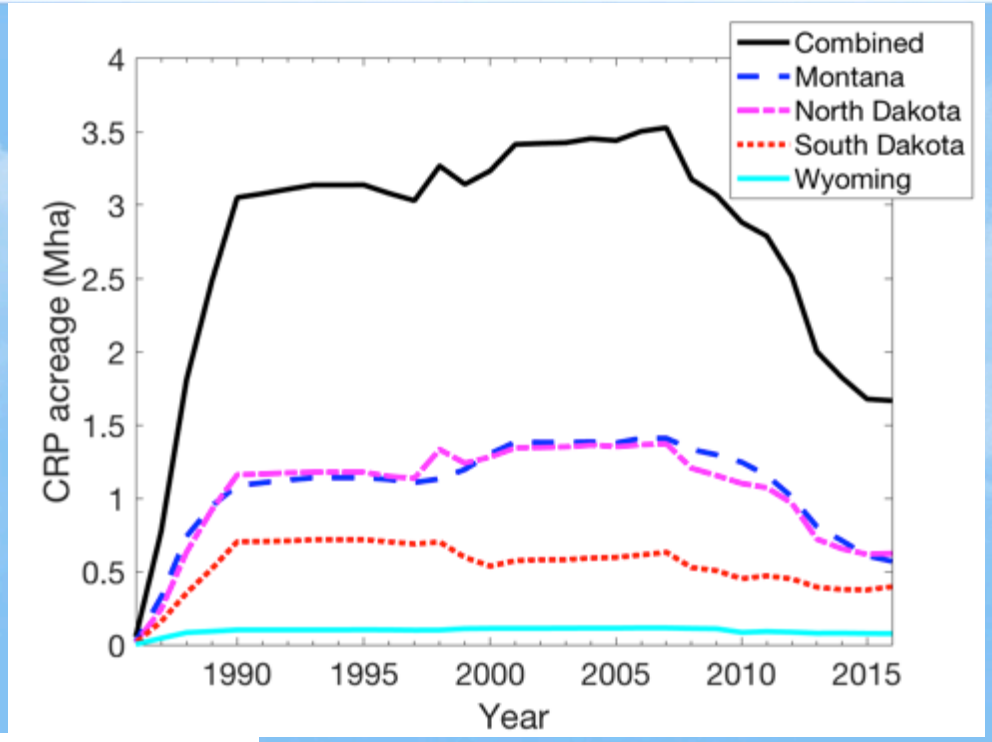
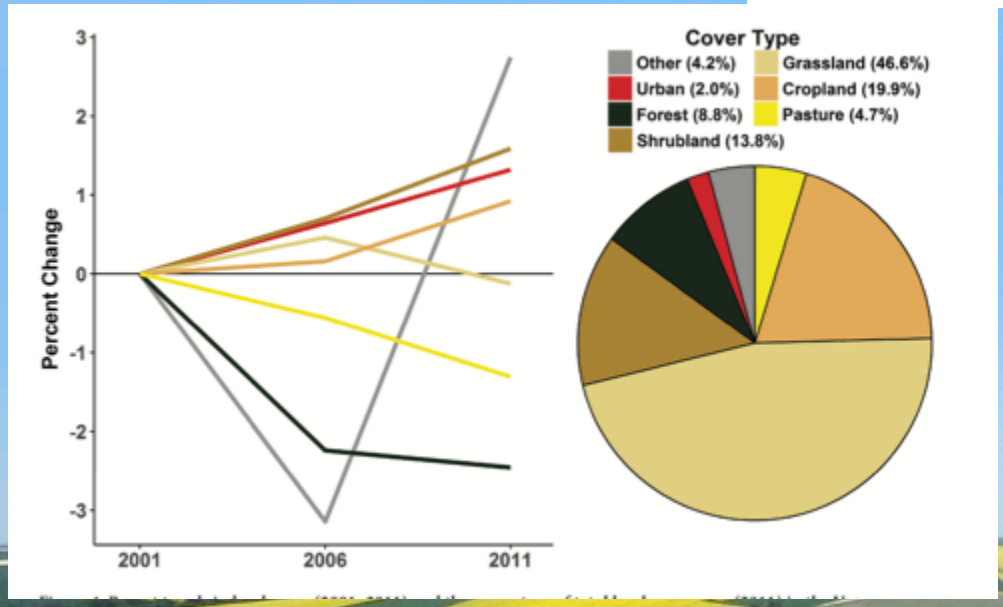


Figure credit: Gabriel Bromley

Example: CRP rise and fall

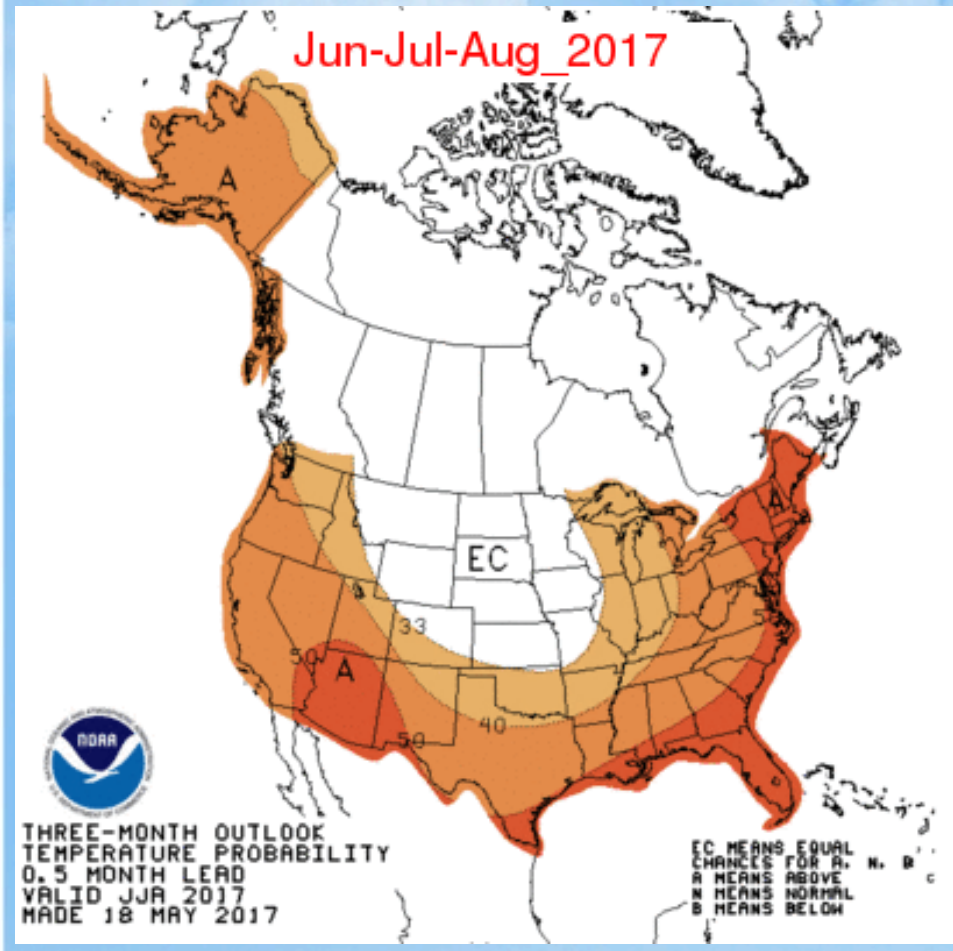


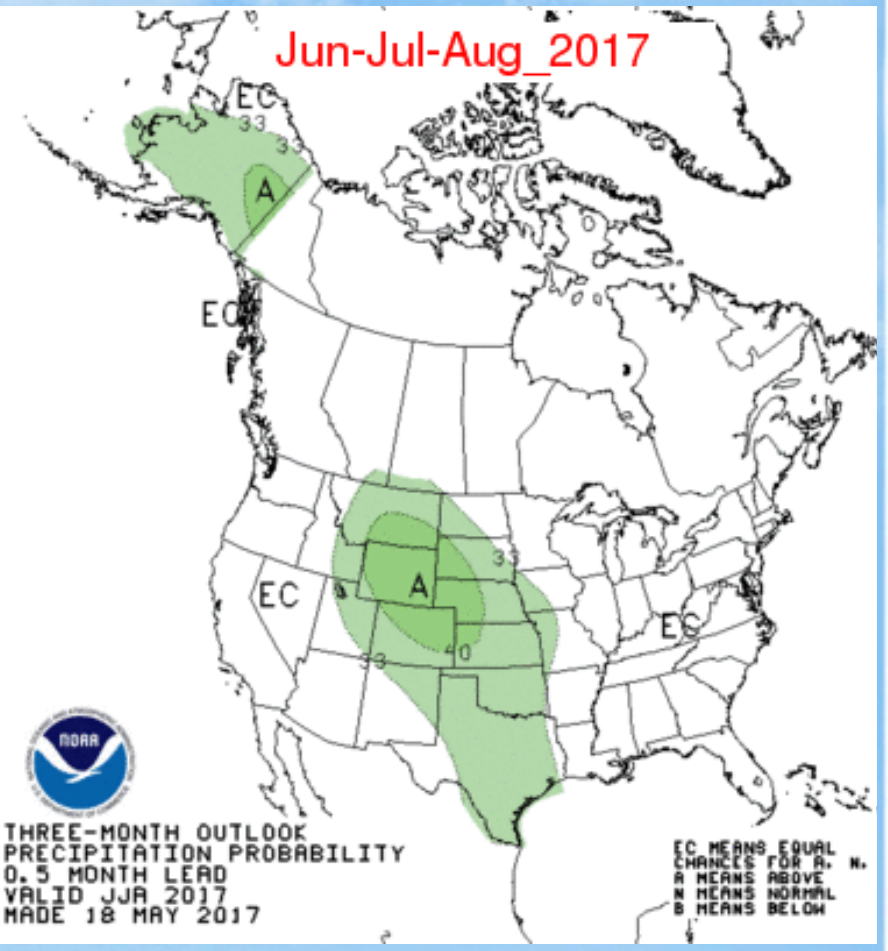


Grassland management

(data for the Upper Missouri)

A problem: This was the summer outlook issued last May 18





Precipitation during the last 30 years (blue) *versus* last year (black)

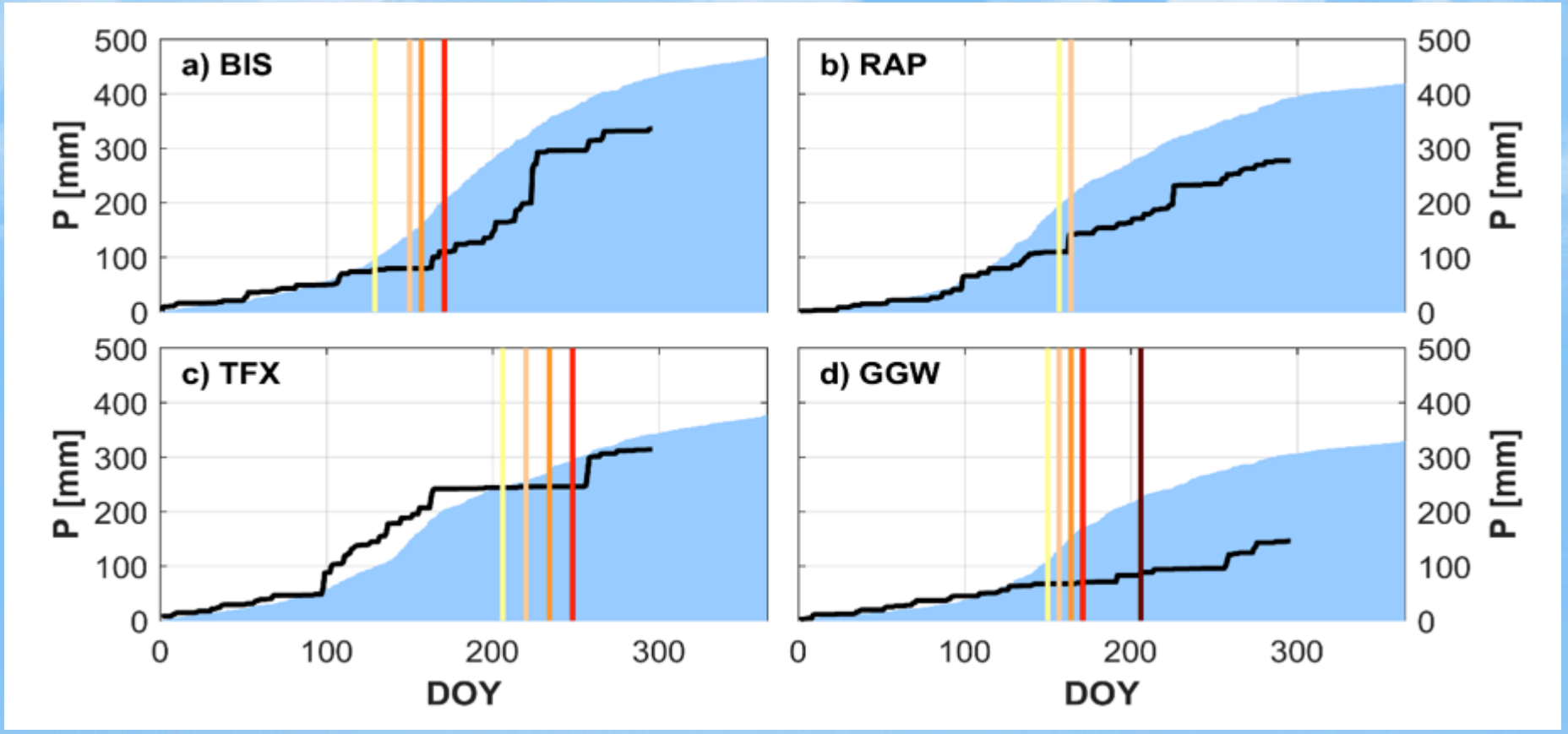
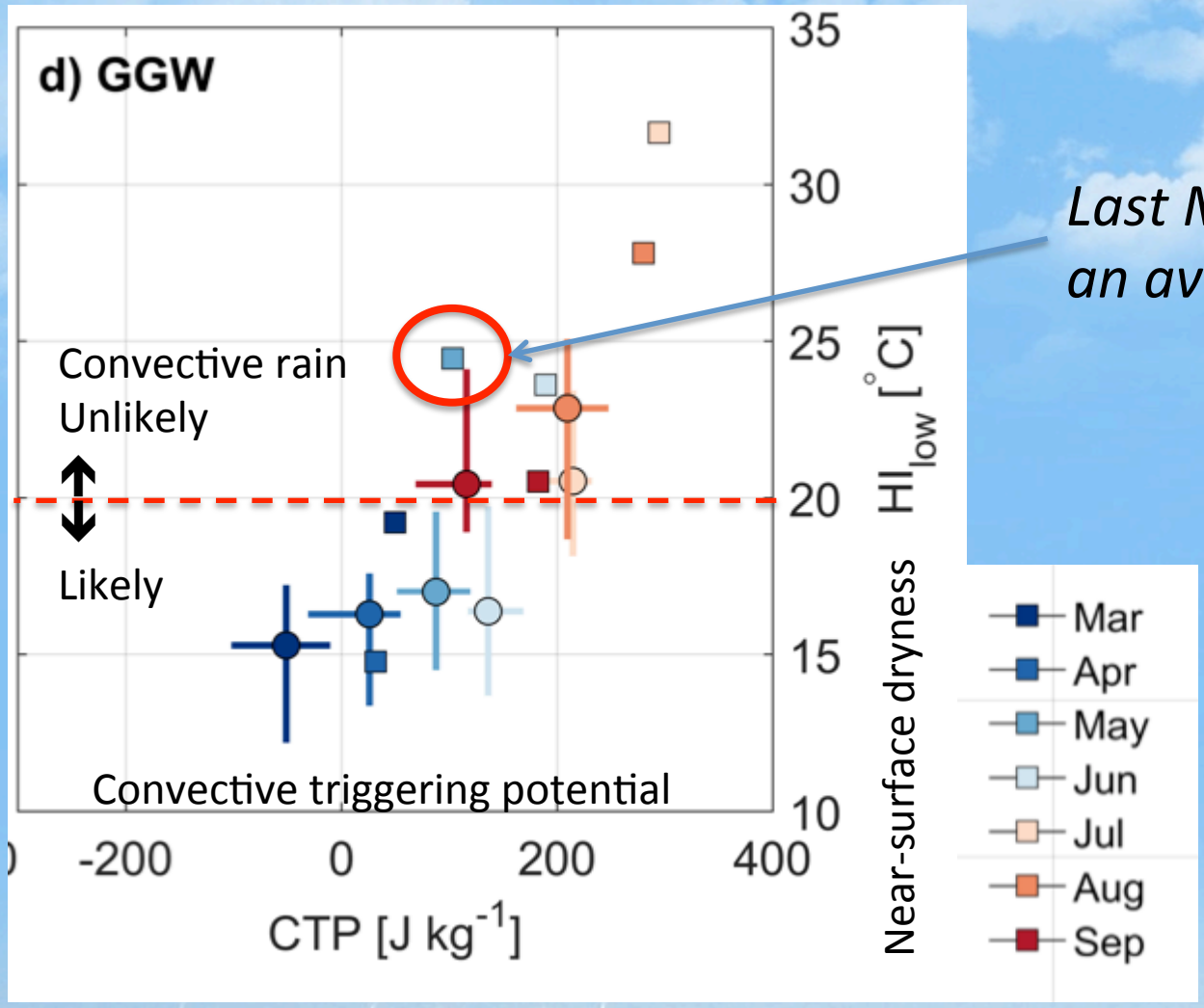


Figure credit: Tobias Gerken

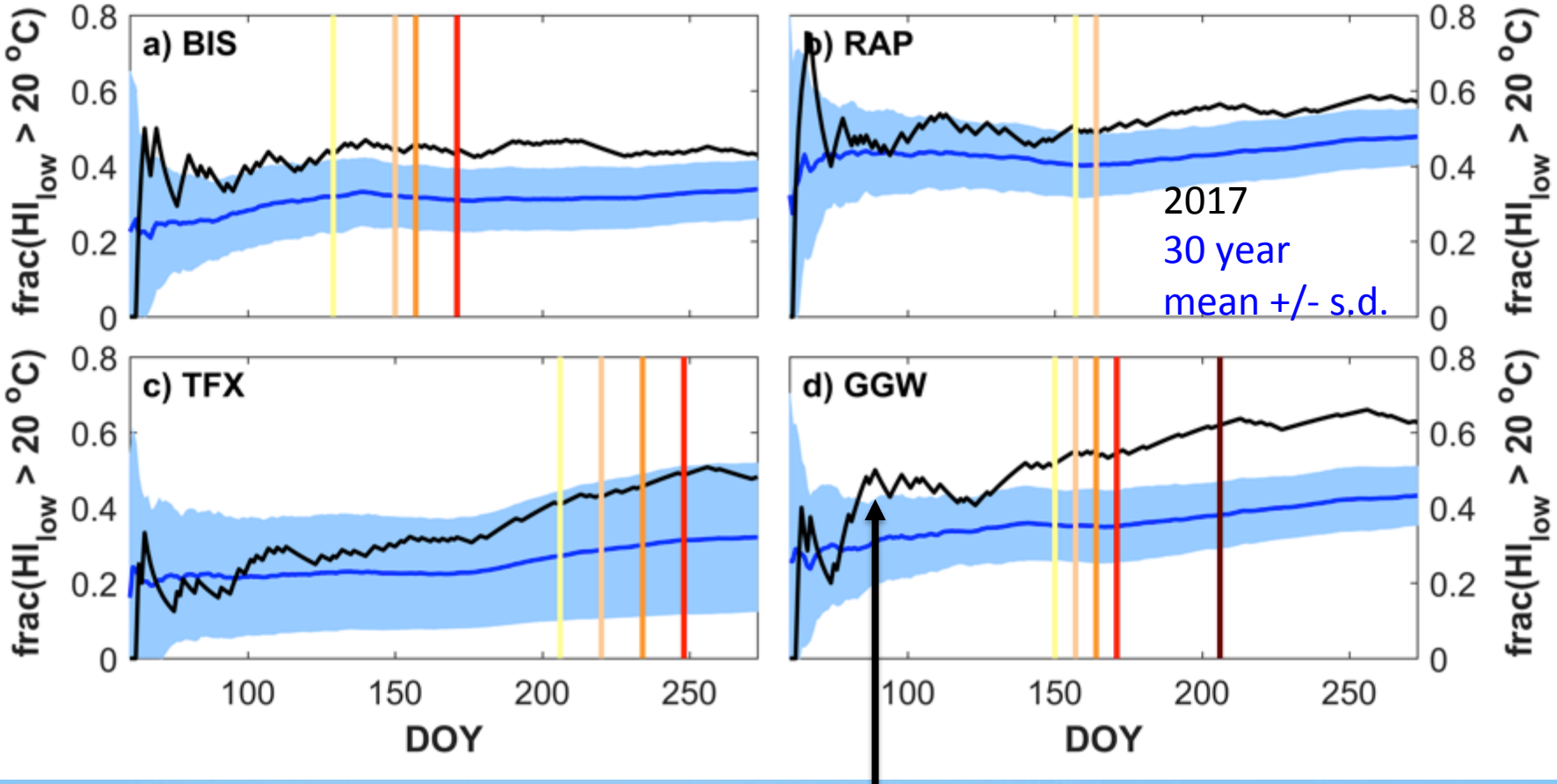
Was the atmosphere giving us clues that drought was imminent?



Last May was drier than an average August!!

Figure credit: Tobias Gerken

The running mean of days for which convective precip. was unlikely

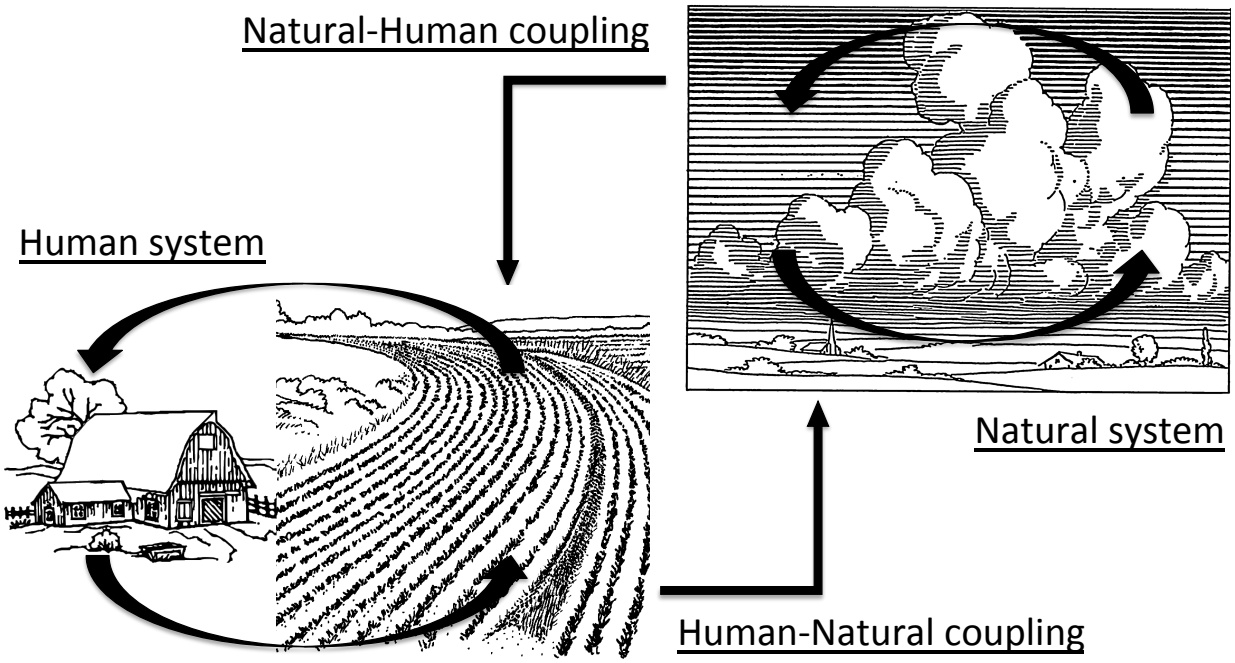


Early March was already anomalously dry in Glasgow

Summary. In the Northern *North American* Great Plains:

1) Warming except during spring / early summer;

2) Convective precipitation is coupled to land surface function early in the growing season (and land management trends make precipitation more likely);

3) The 2017 Flash drought was preceded by a breakdown of land-atmosphere feedbacks;

4) The response of land management to climate and *vice versa* should be further explored.