Climate challenges facing northern grasslands and ranches

Paul C. Stoy[1], Tobias Gerken[1], Gabriel Bromley[1], Ben Poulter[2]

Paul.stoy@montana.edu
[1] Montana State University
[2] NASA Goddard

waferx.montana.edu
bit.ly/StoyGScholar

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IPCC
U.S. Drought Monitor

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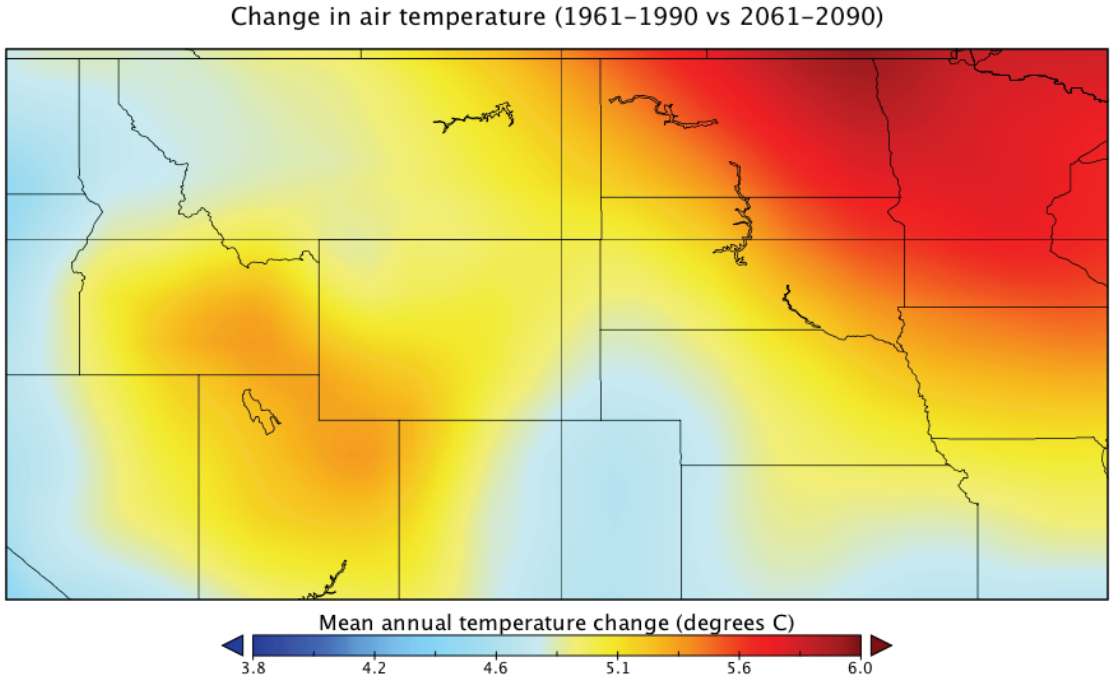
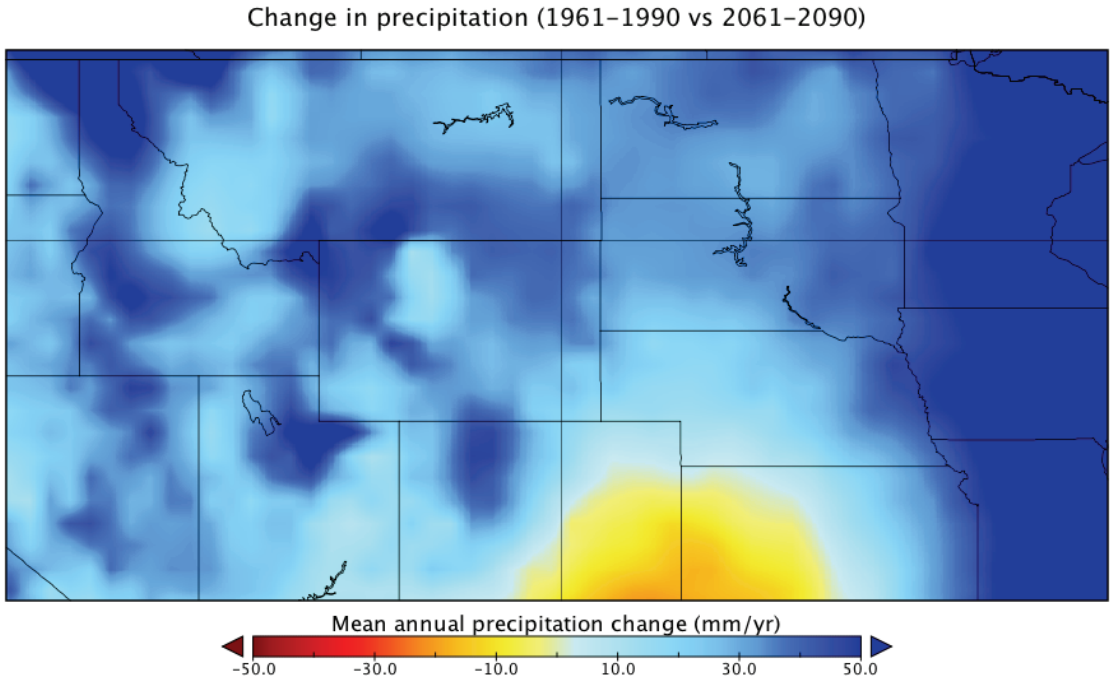
Outline

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



Will the Northern Plains get warmer?

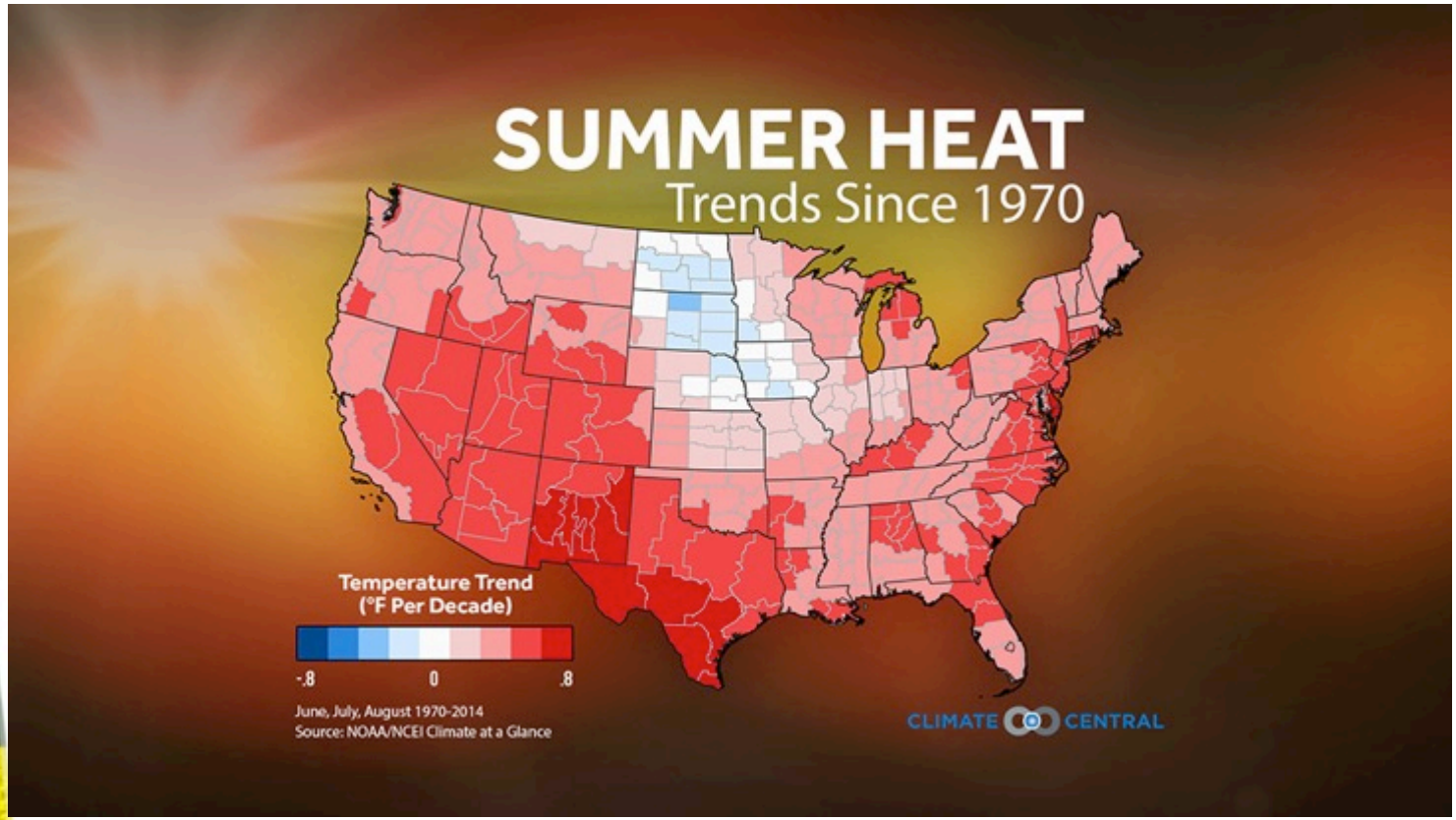
Yes, and perhaps wetter, too



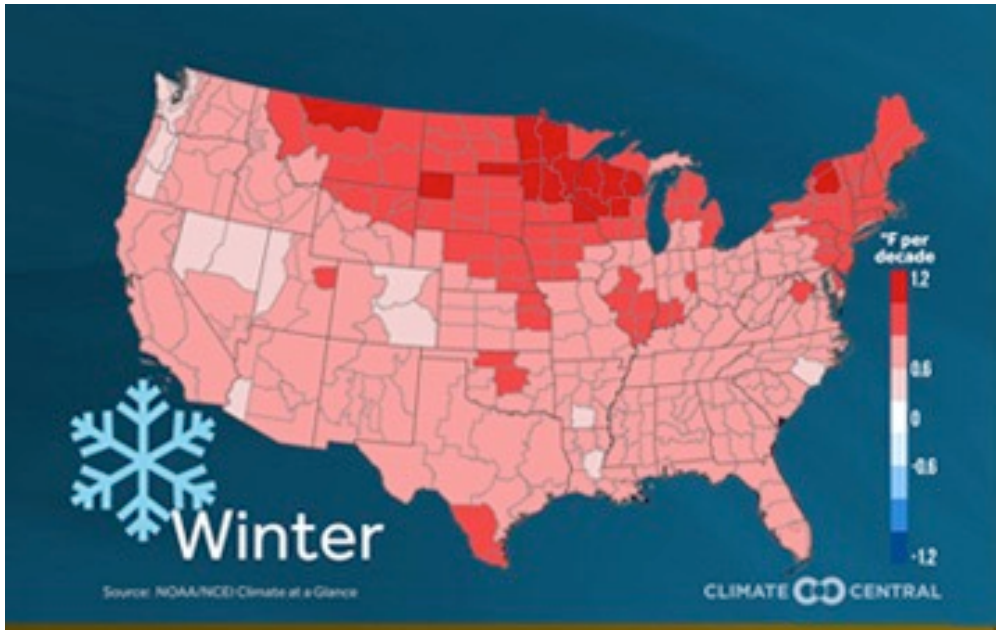
Stoy et al. (2018) *Bioscience*
Figure credit: Ben Poulter

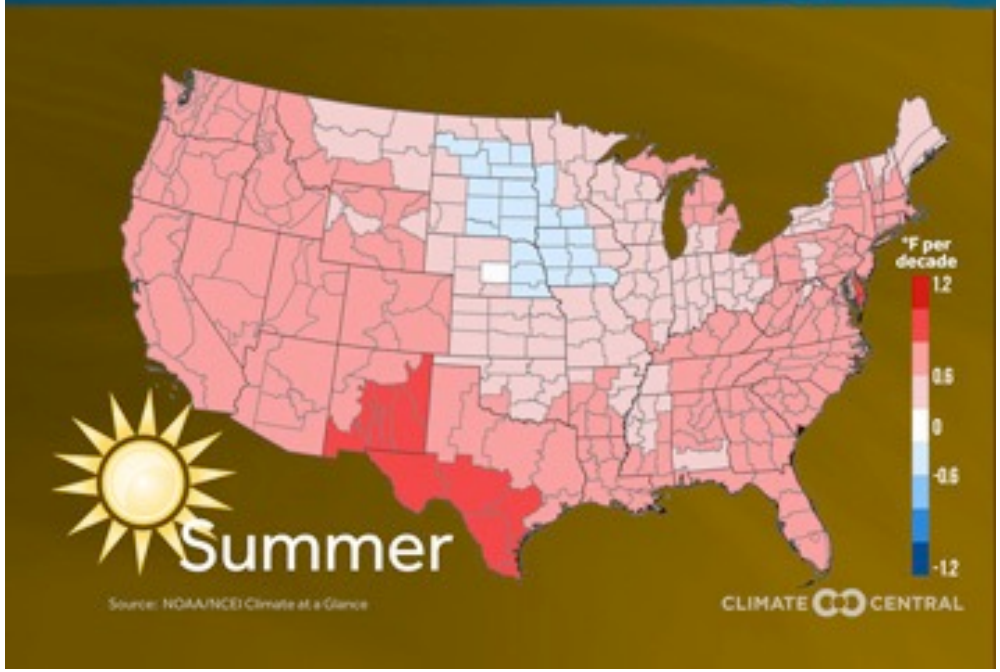
1) **Have the Northern Plains warmed in recent decades?**

Yes and no.

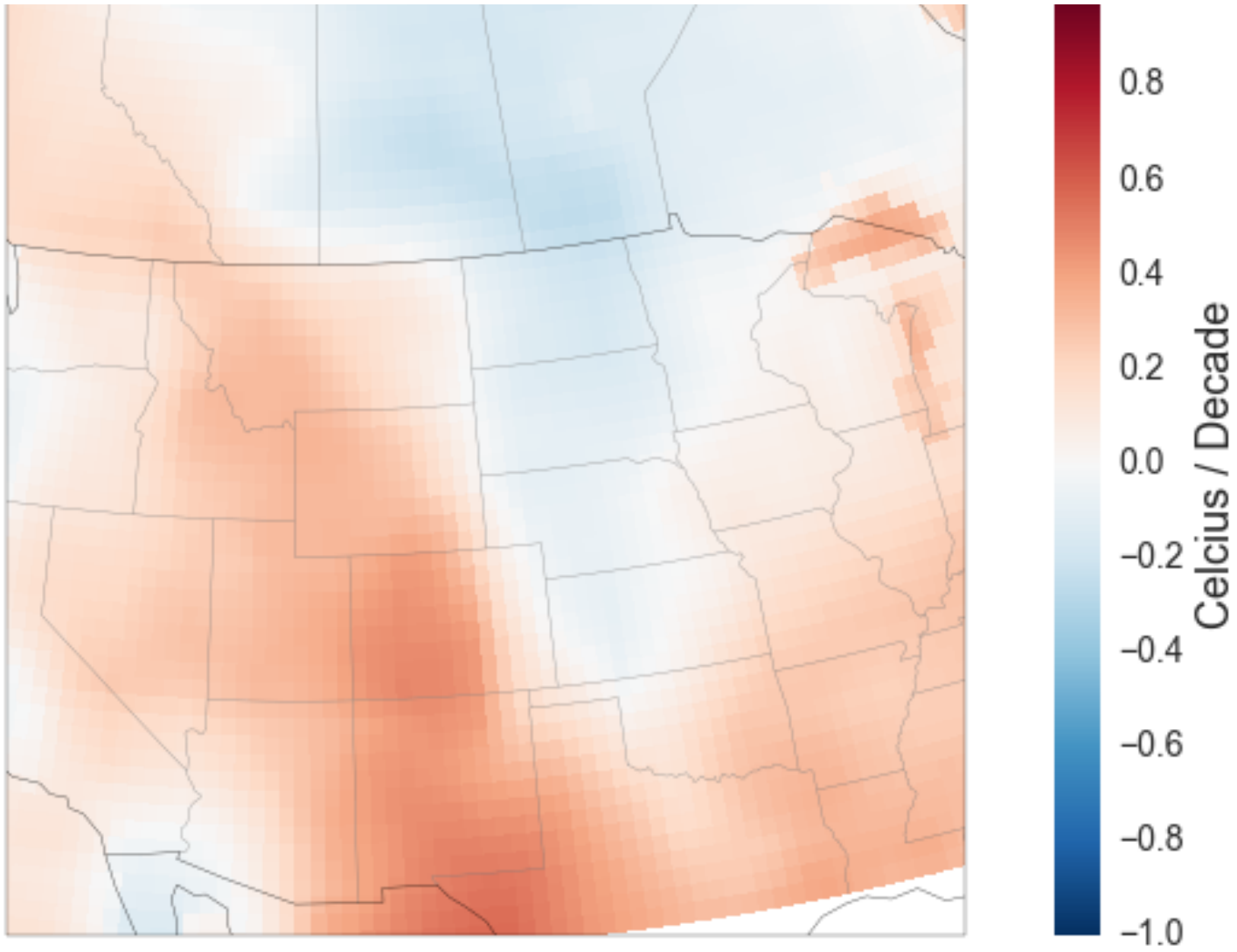


2) Why is there a cooling trend during summer?





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

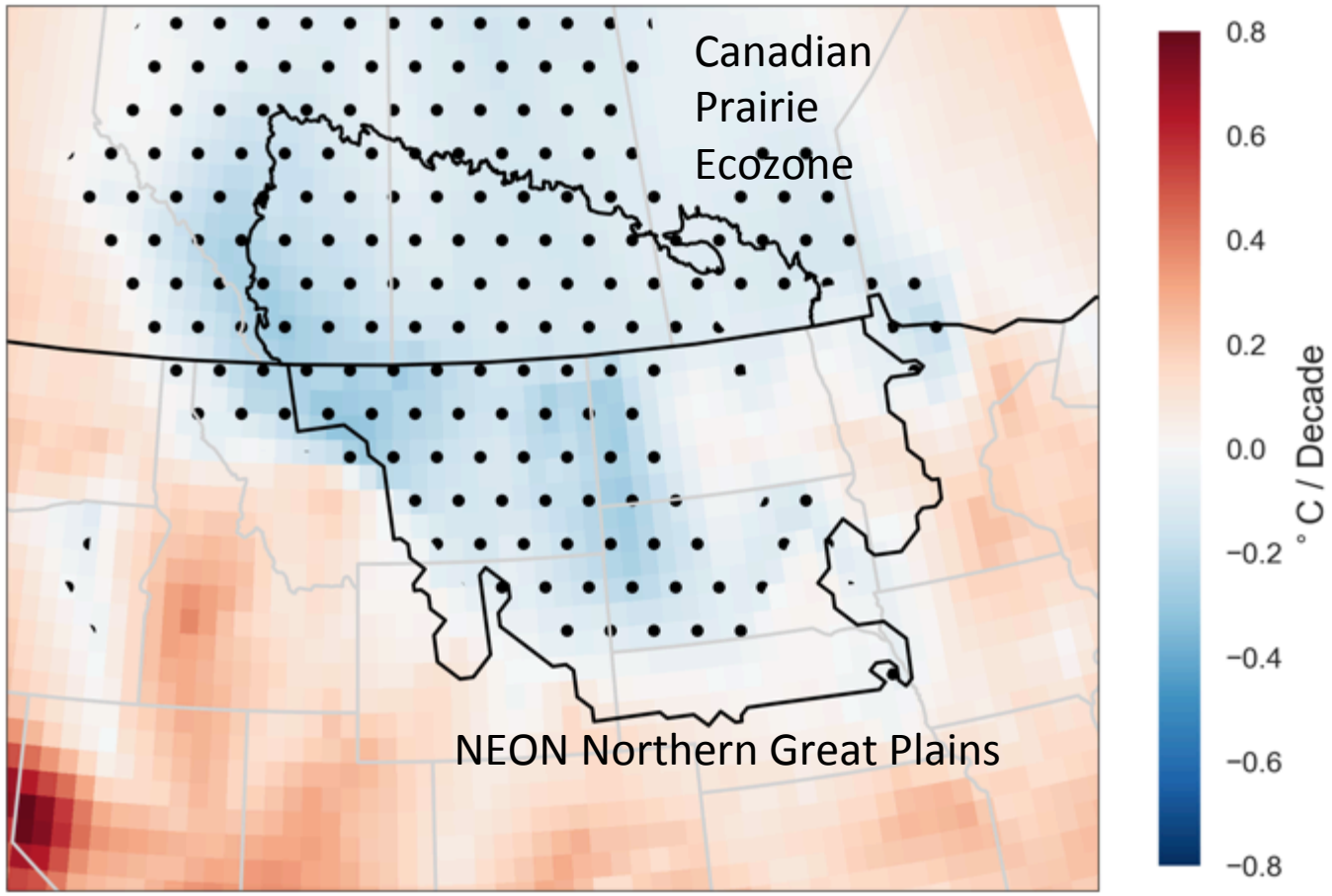


Figure credit: Gabriel Bromley

It is somewhat unique globally

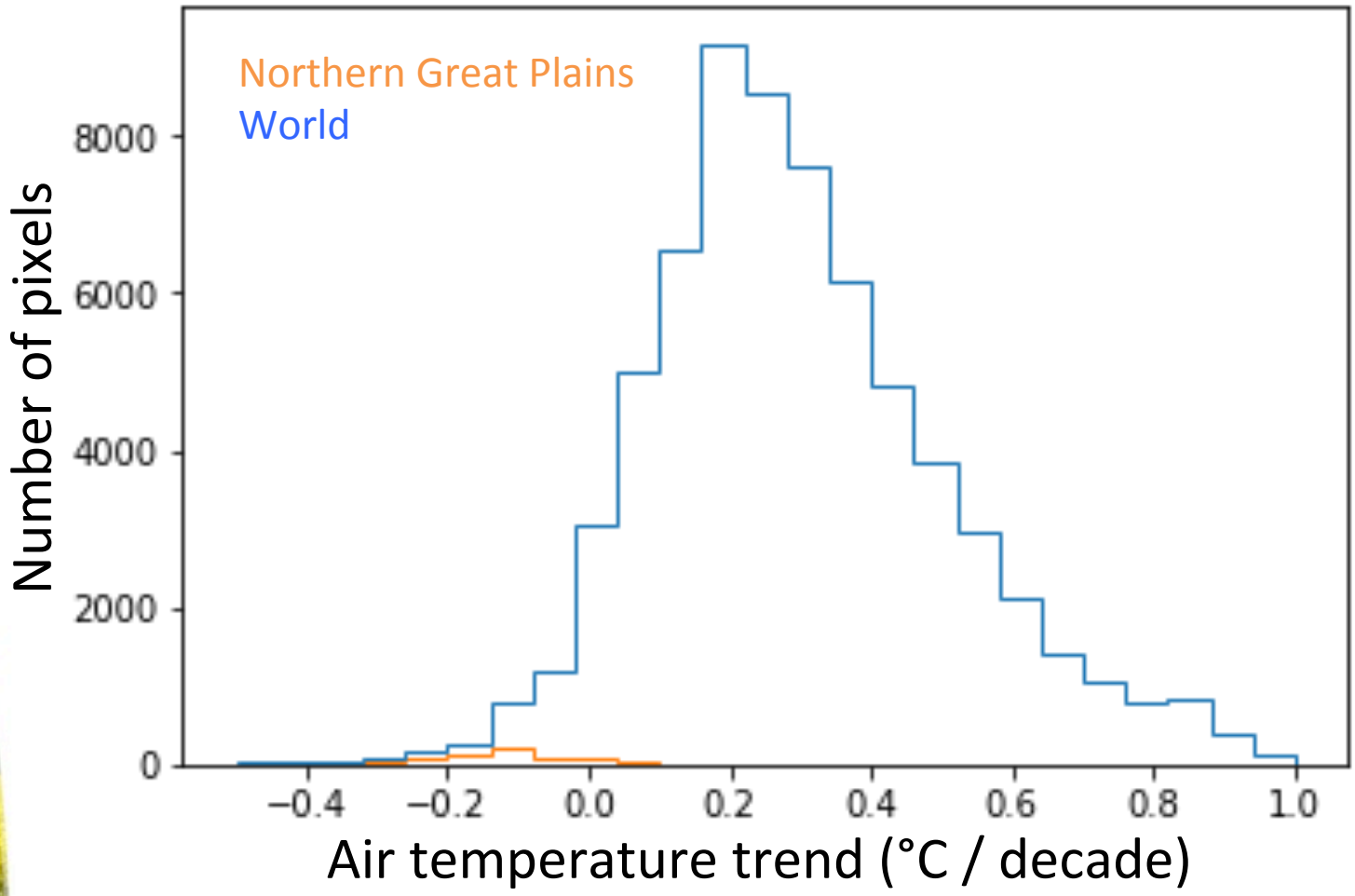
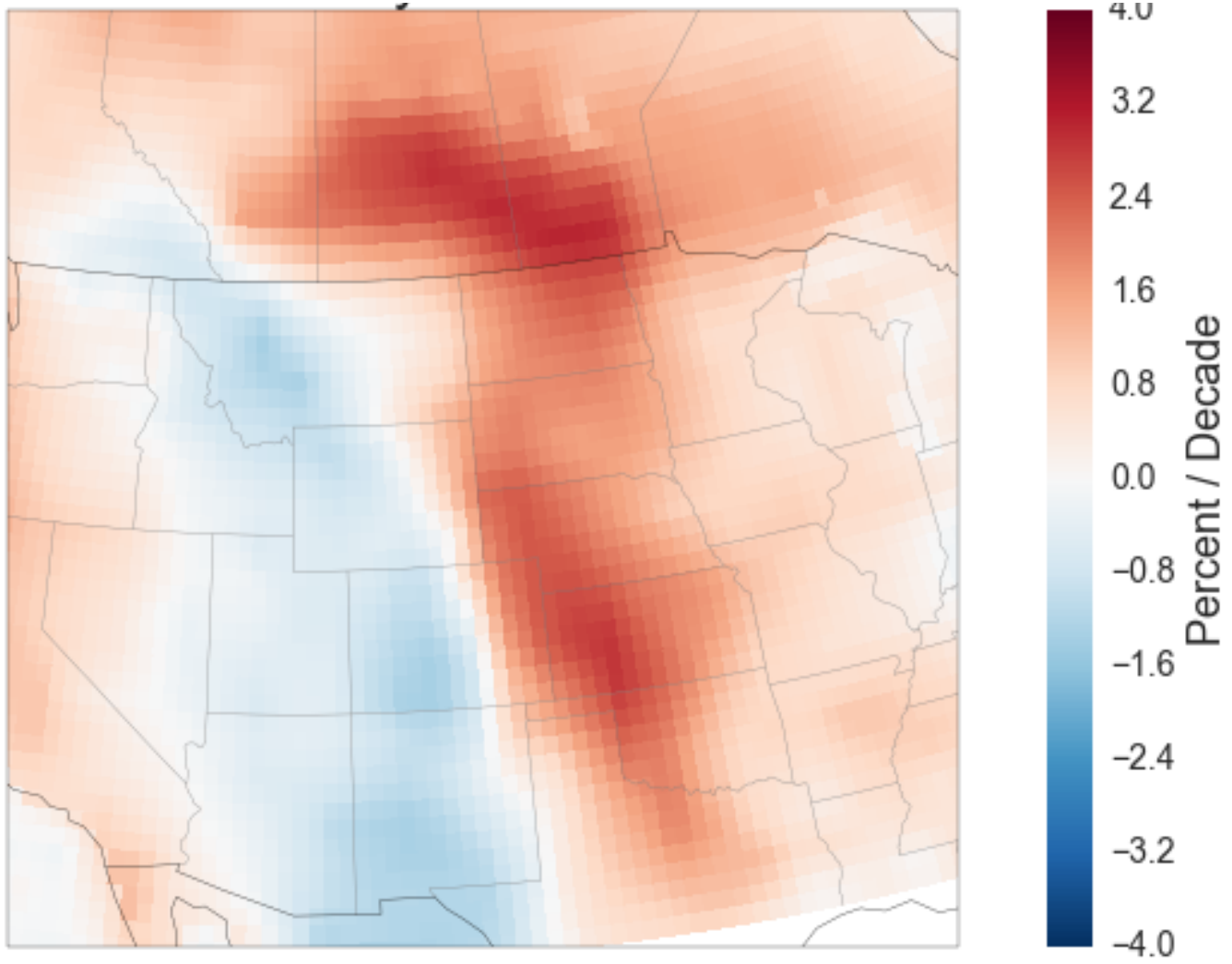


Figure credit: Gabriel Bromley

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

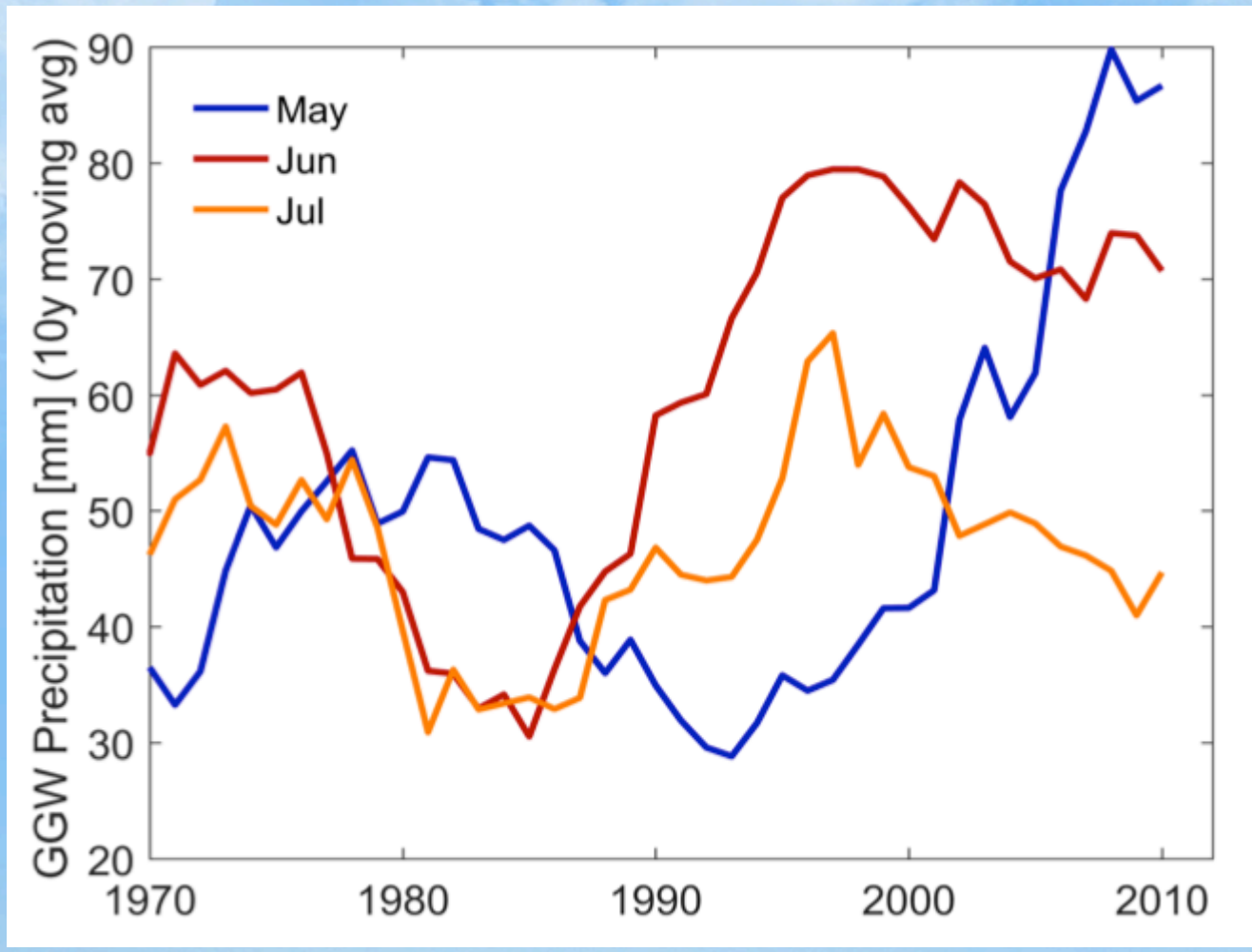


Figure credit: Tobias Gerken

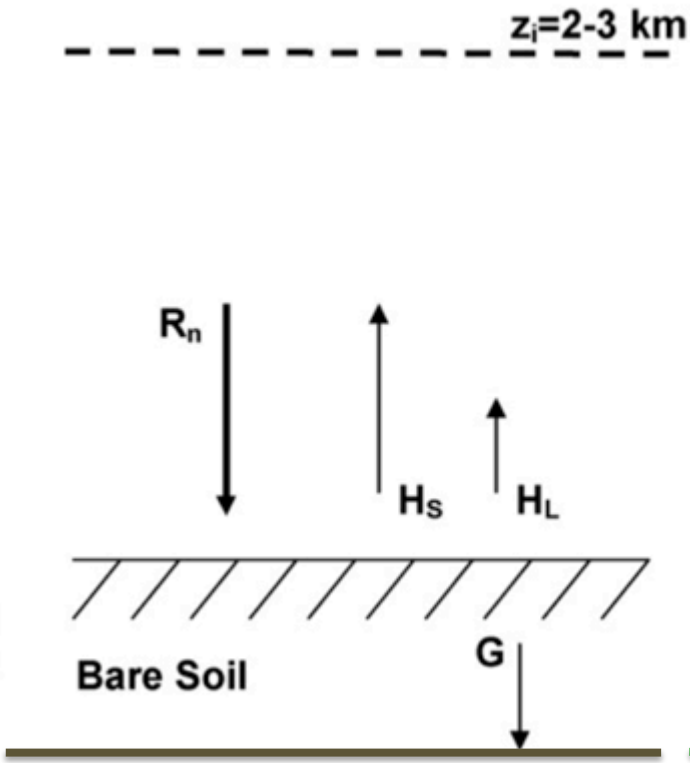
Why? Probably land use changes

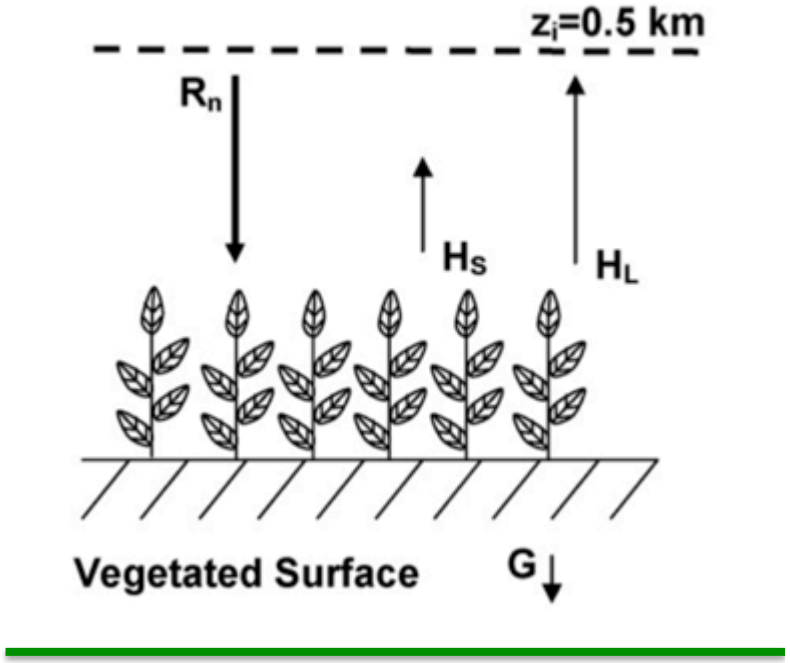
In the Canadian Prairies over the past 4 decades:
Summer maximum temperature: - 1 °C trend
Precip: + 10 mm/decade trend

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

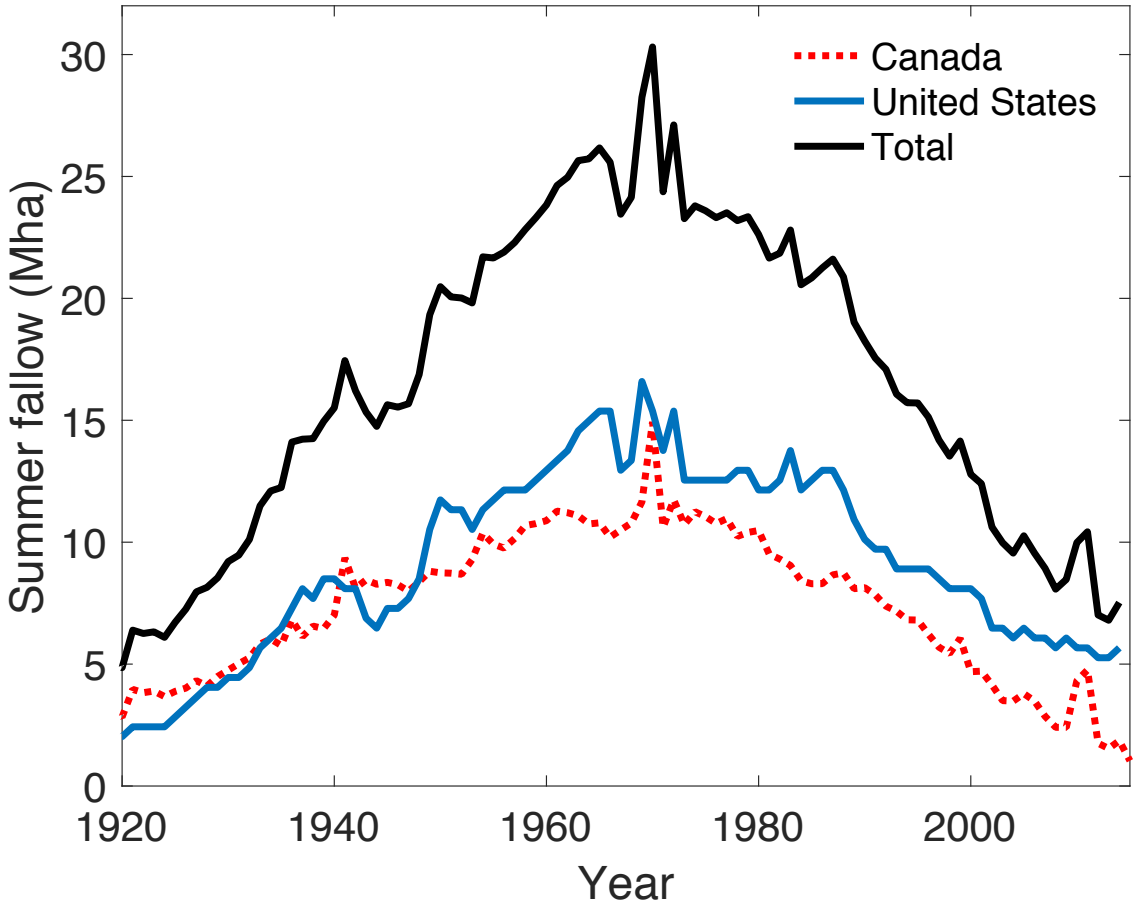
Anthropogenic warming +2.5 W m^{-2}

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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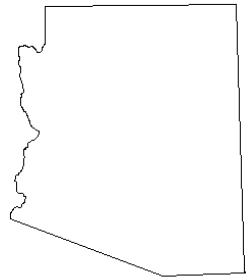
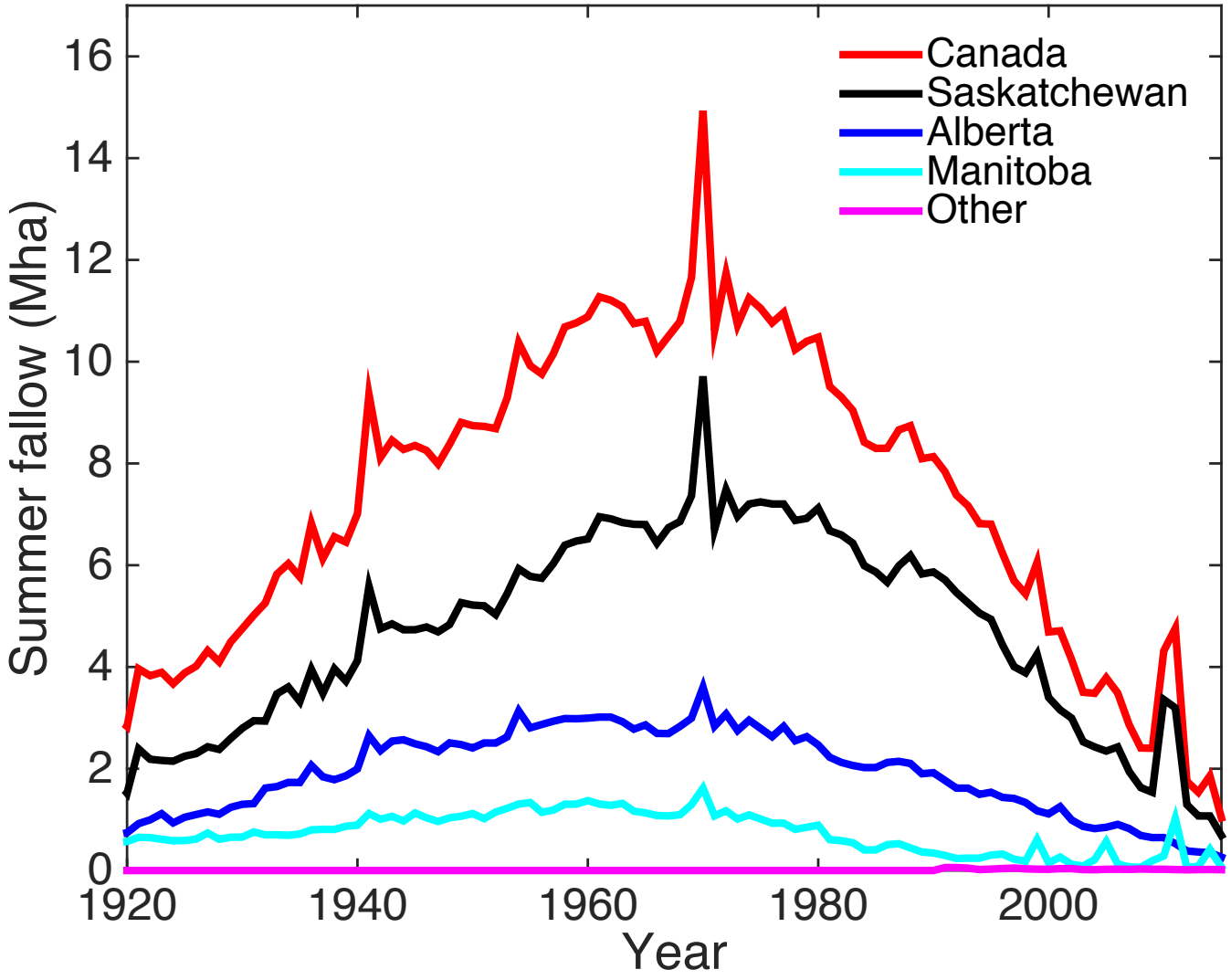
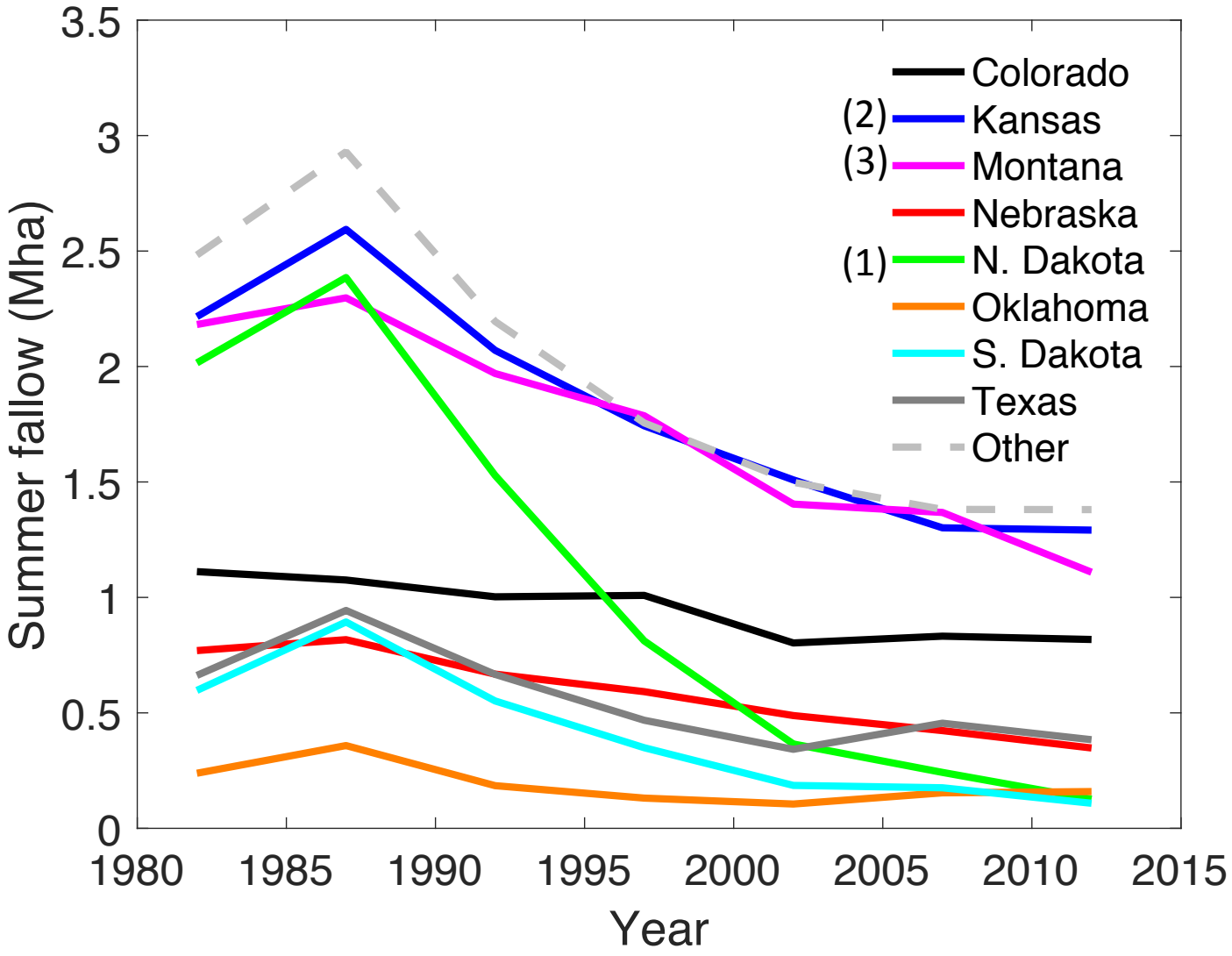


The largest fallow changes are in Saskatchewan…



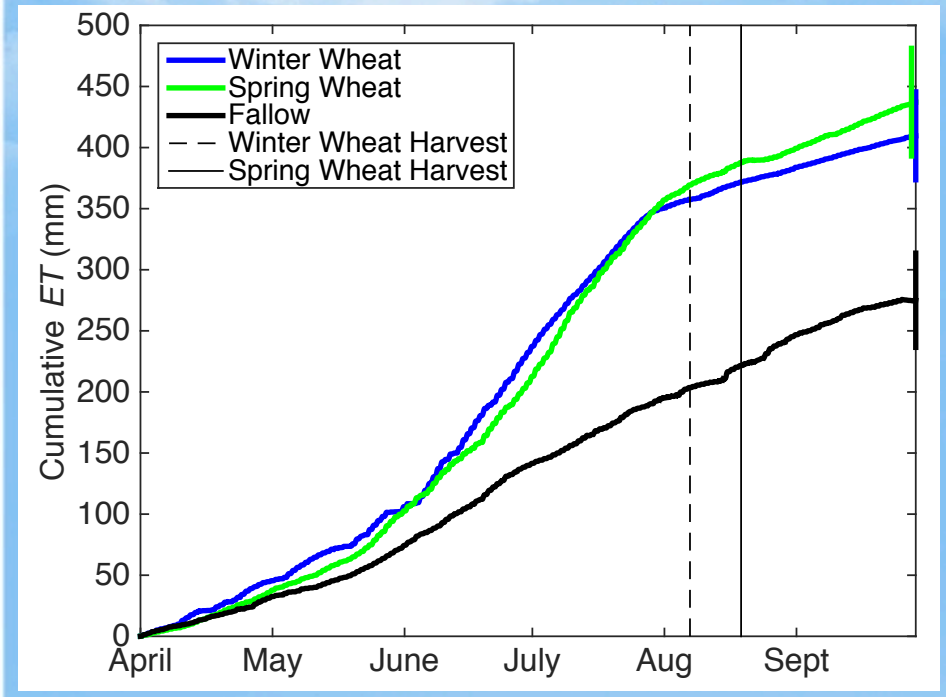
…and North Dakota.



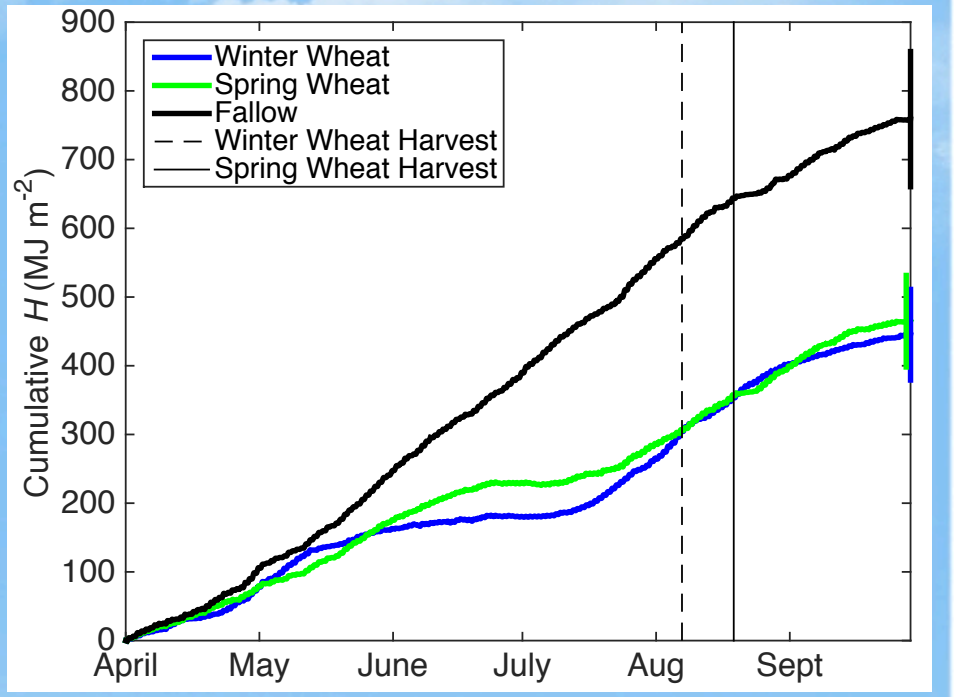
Is this a win-win-win scenario for regional climate, soil conservation, and income?

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

Evapotranspiration

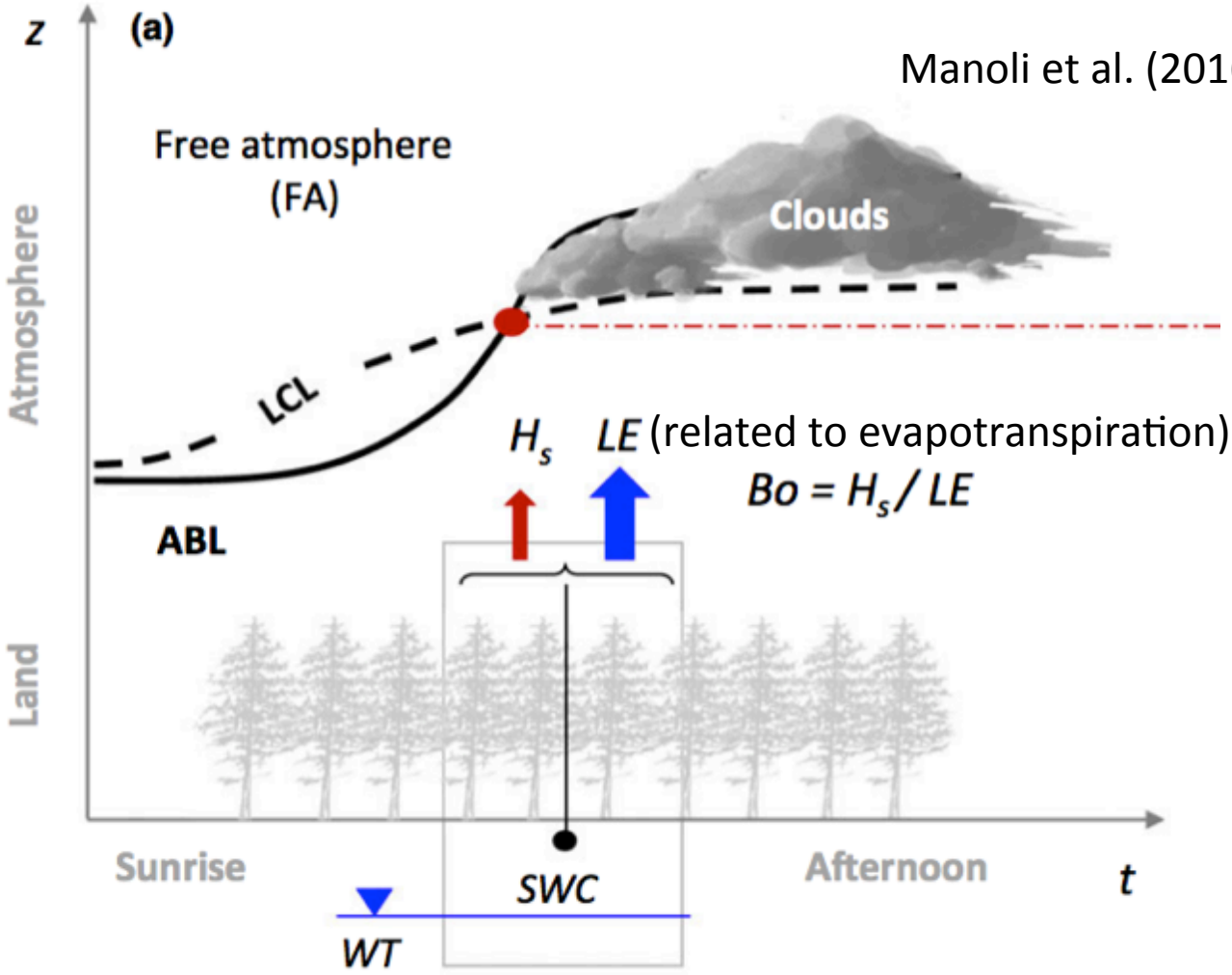


Sensible Heat



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

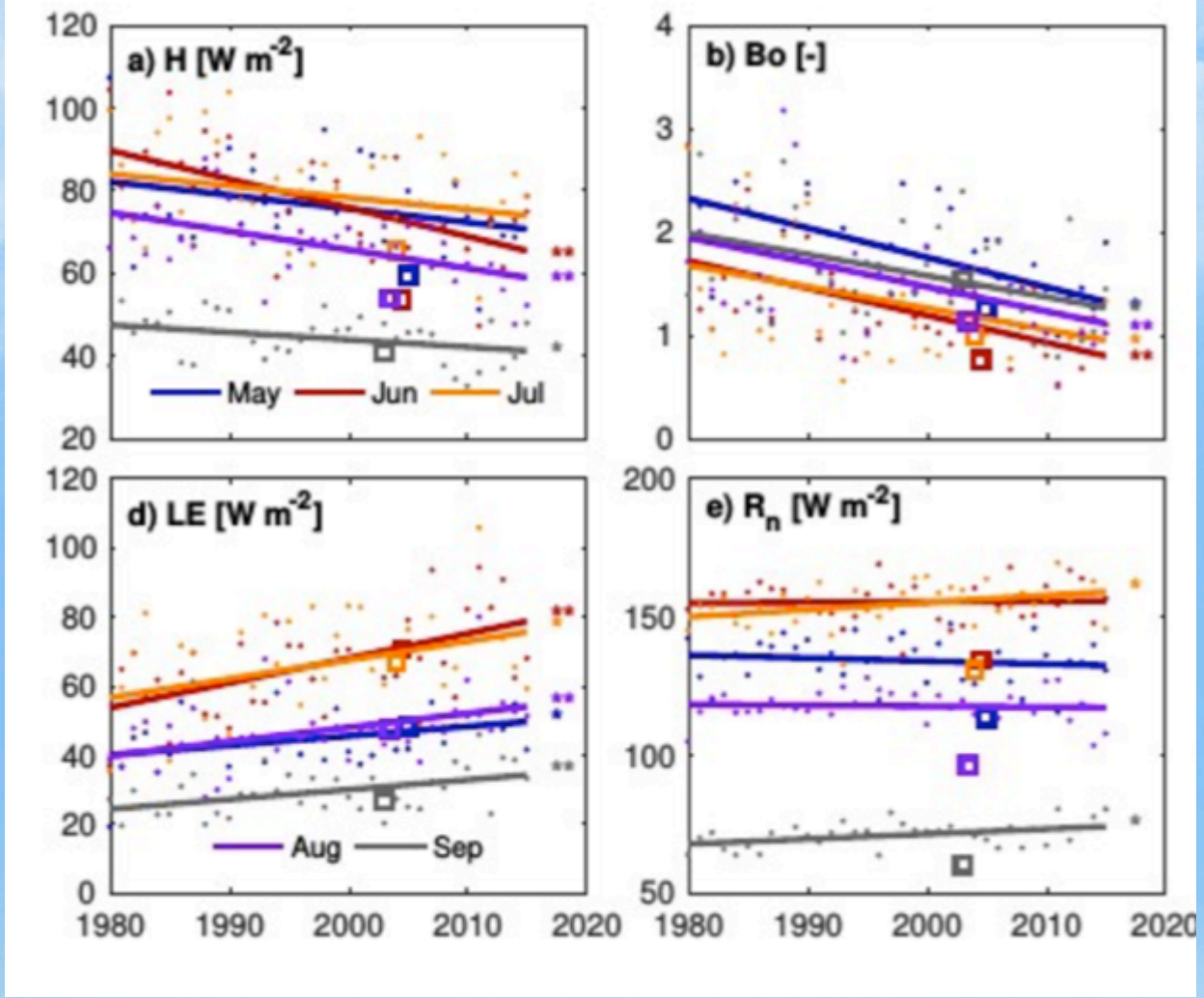
Atmospheric boundary layer (ABL) – lifted condensation level (LCL) crossing is a 'necessary but not sufficient' condition for convective precipitation



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

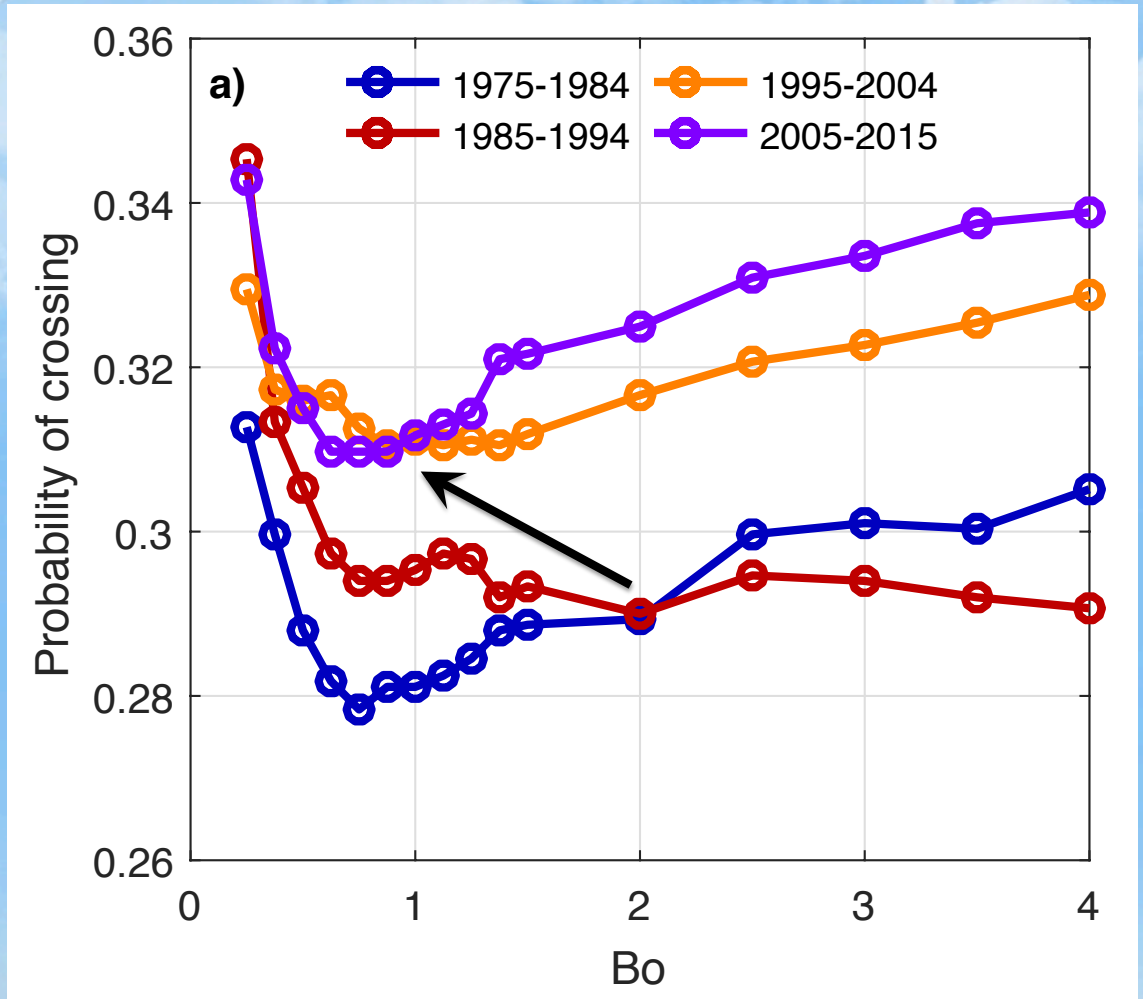


Figure credit: T. Gerken

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

Alternate hypotheses

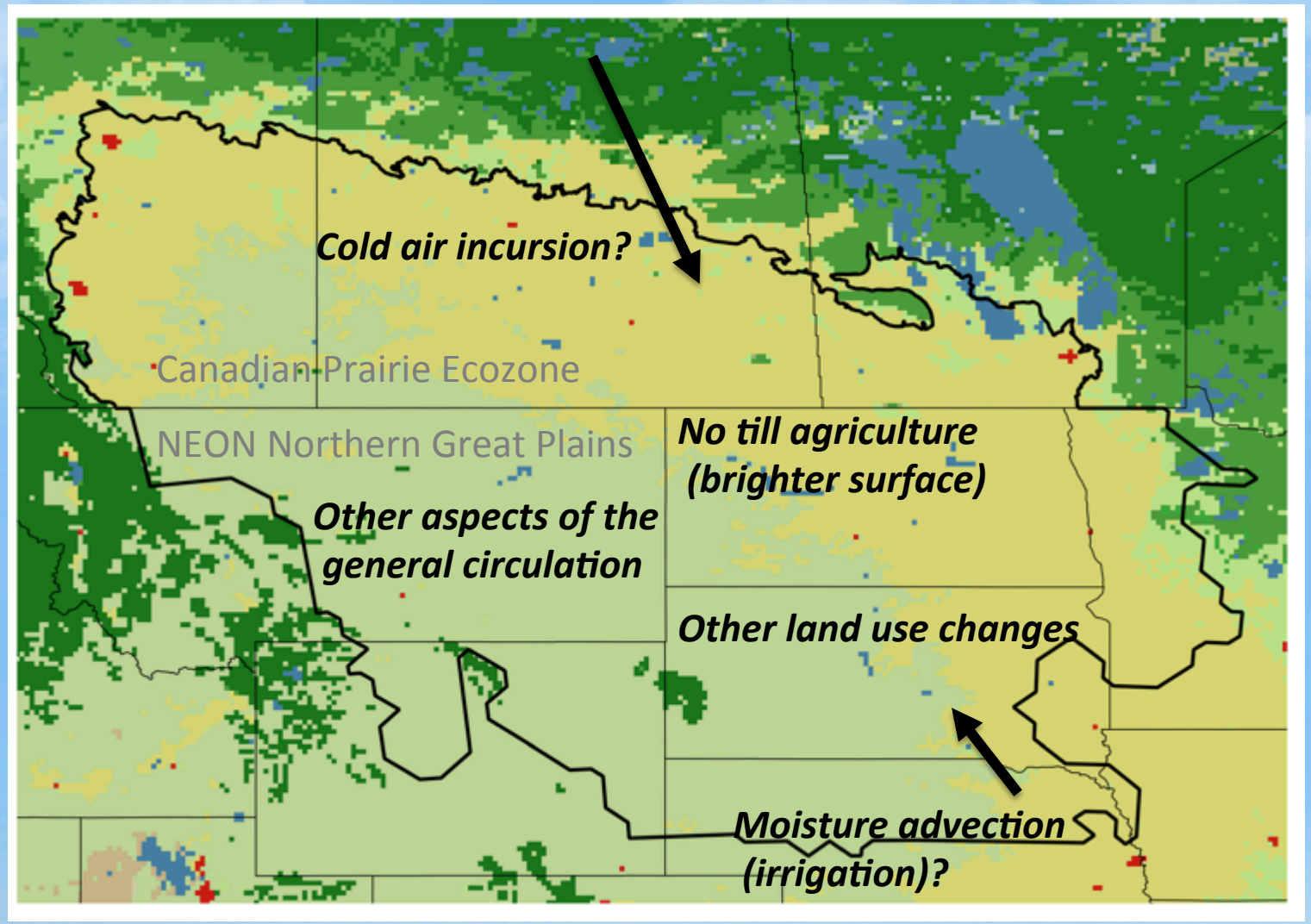
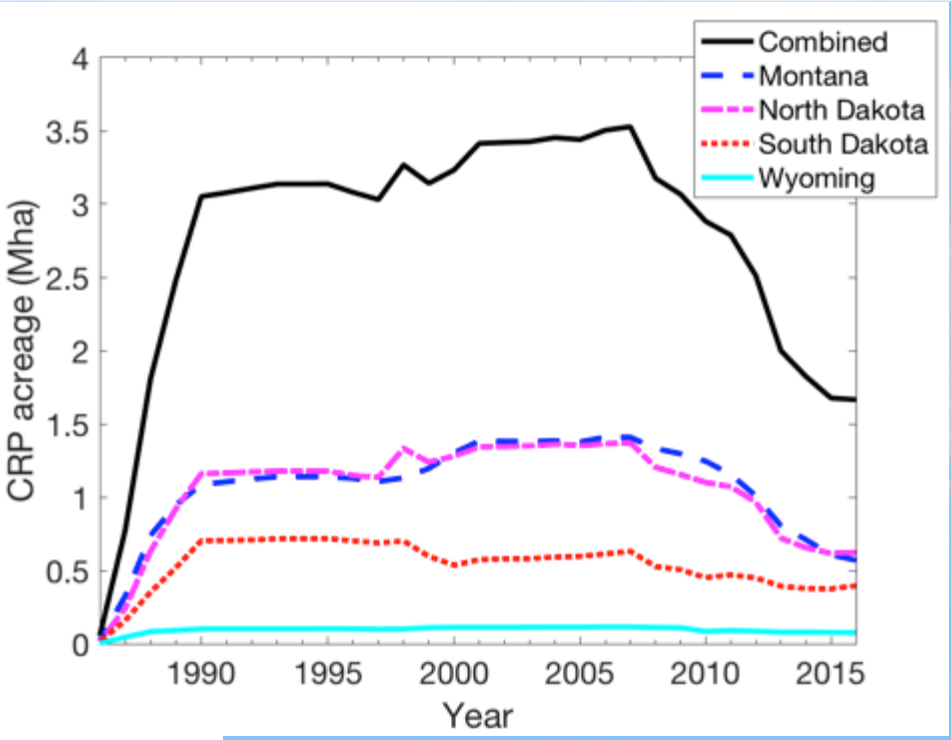
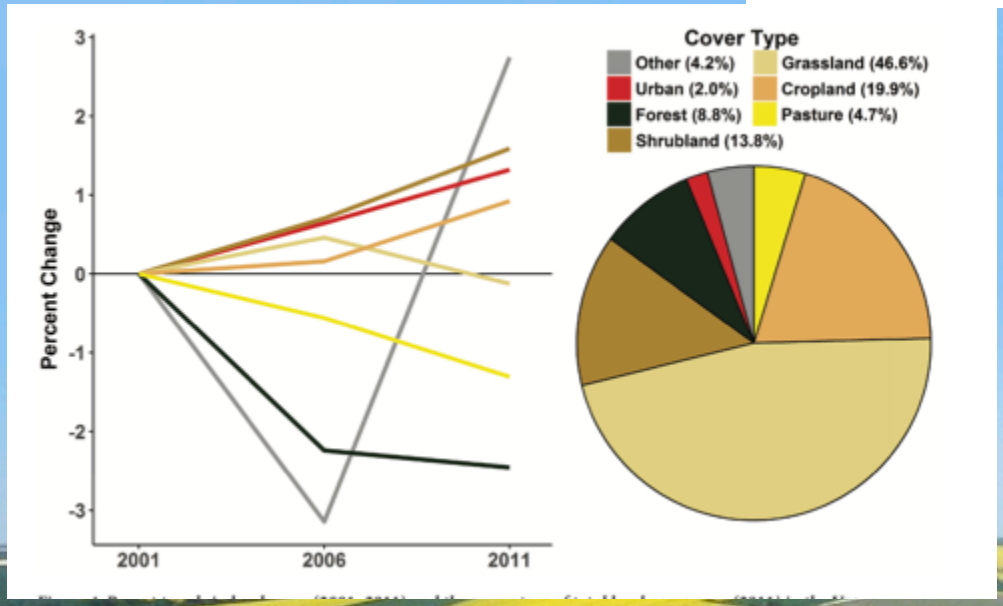


Figure credit: Gabriel Bromley

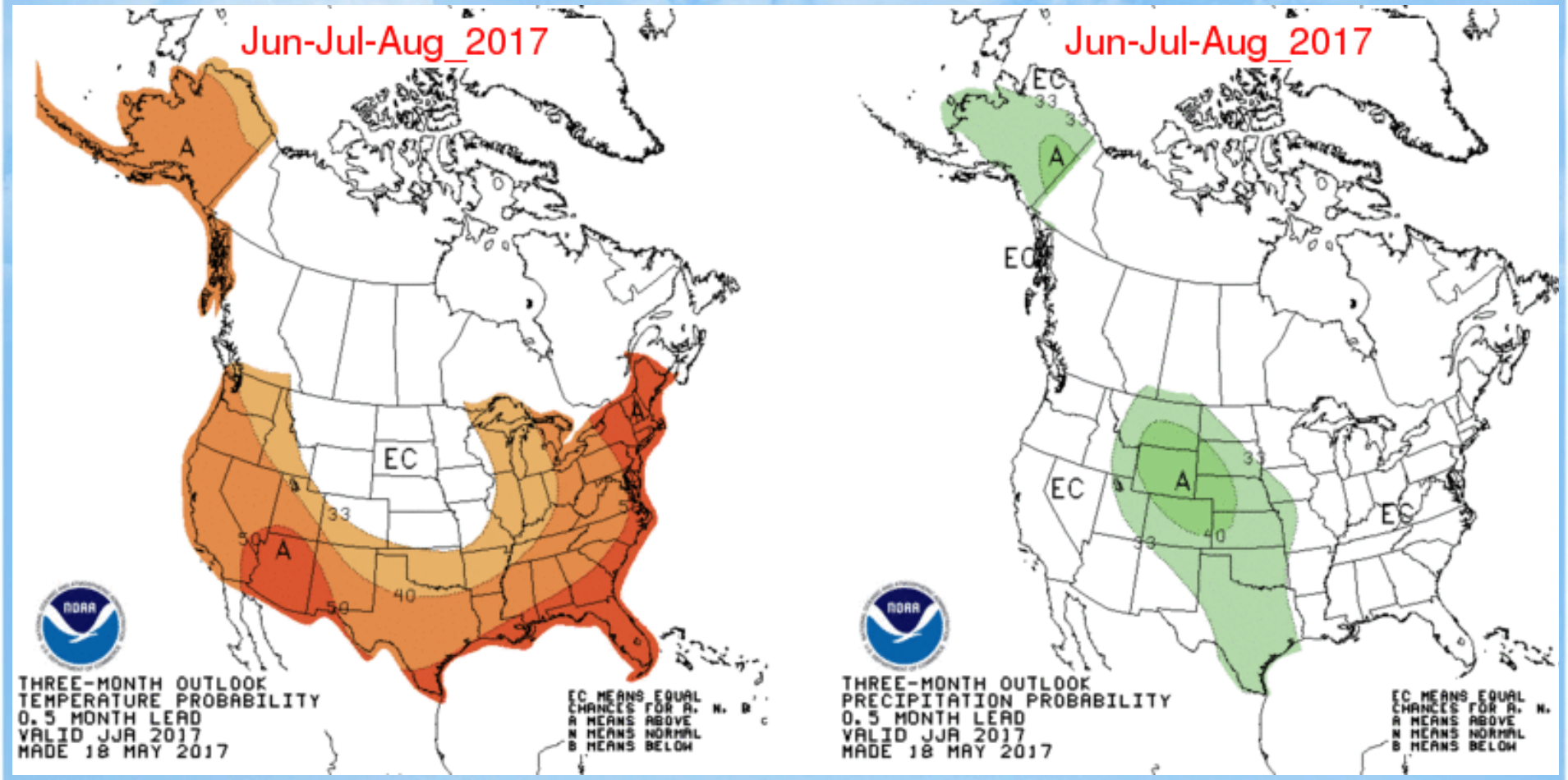
Example: CRP rise and fall





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)

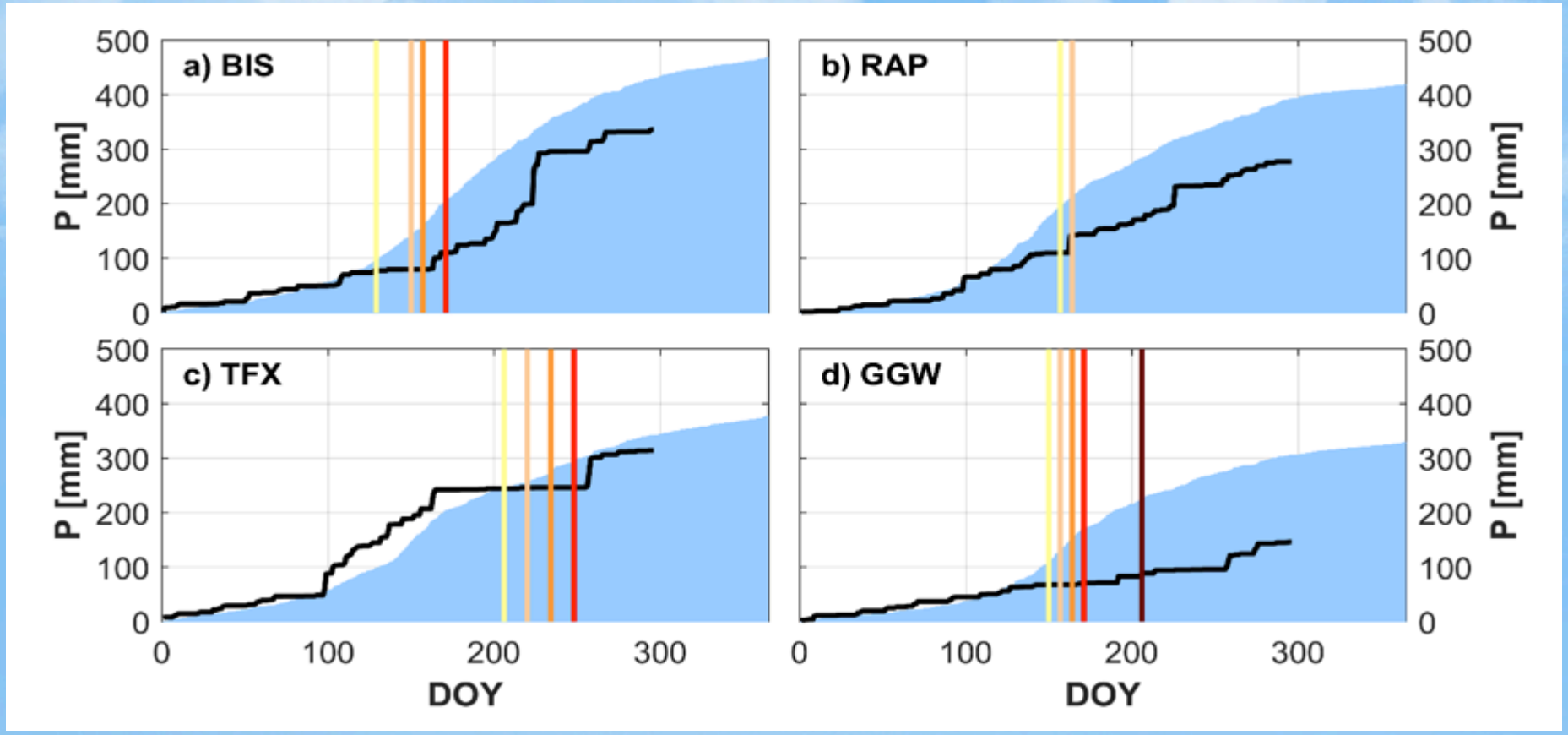
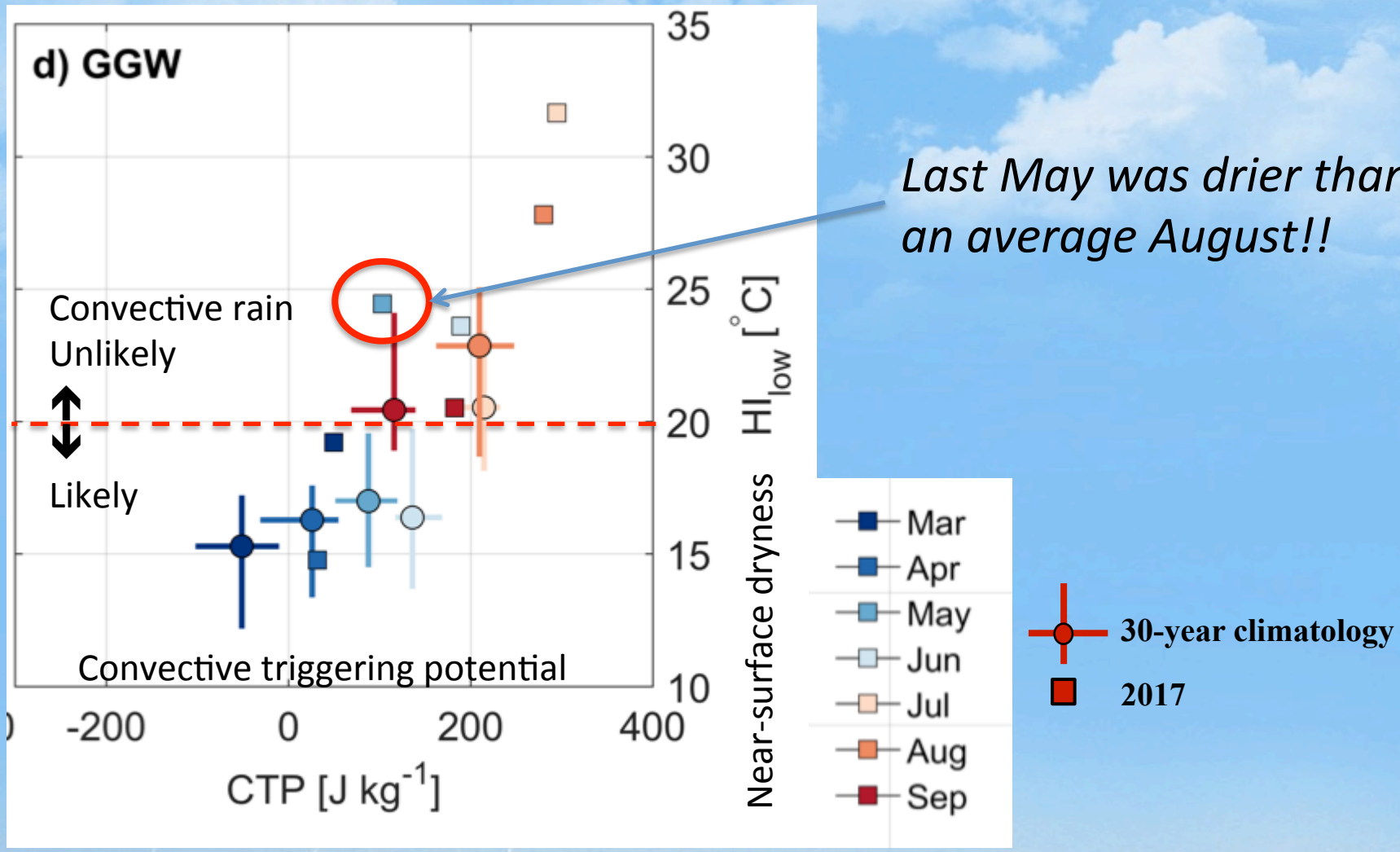


Figure credit: Tobias Gerken

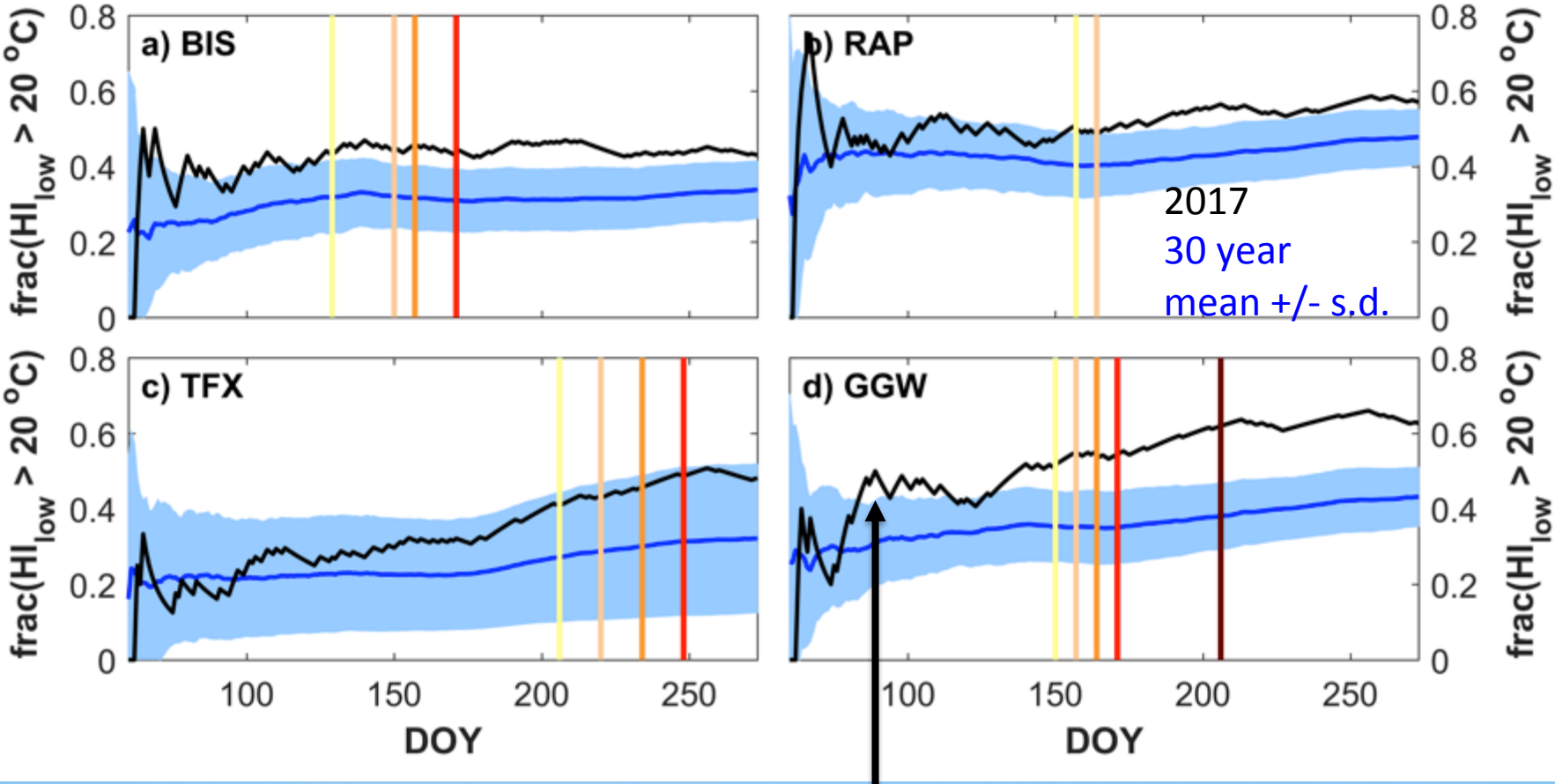
Was the atmosphere giving us clues that drought was imminent?



Last May was drier than an average August!!

Figure credit: Tobias Gerken

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

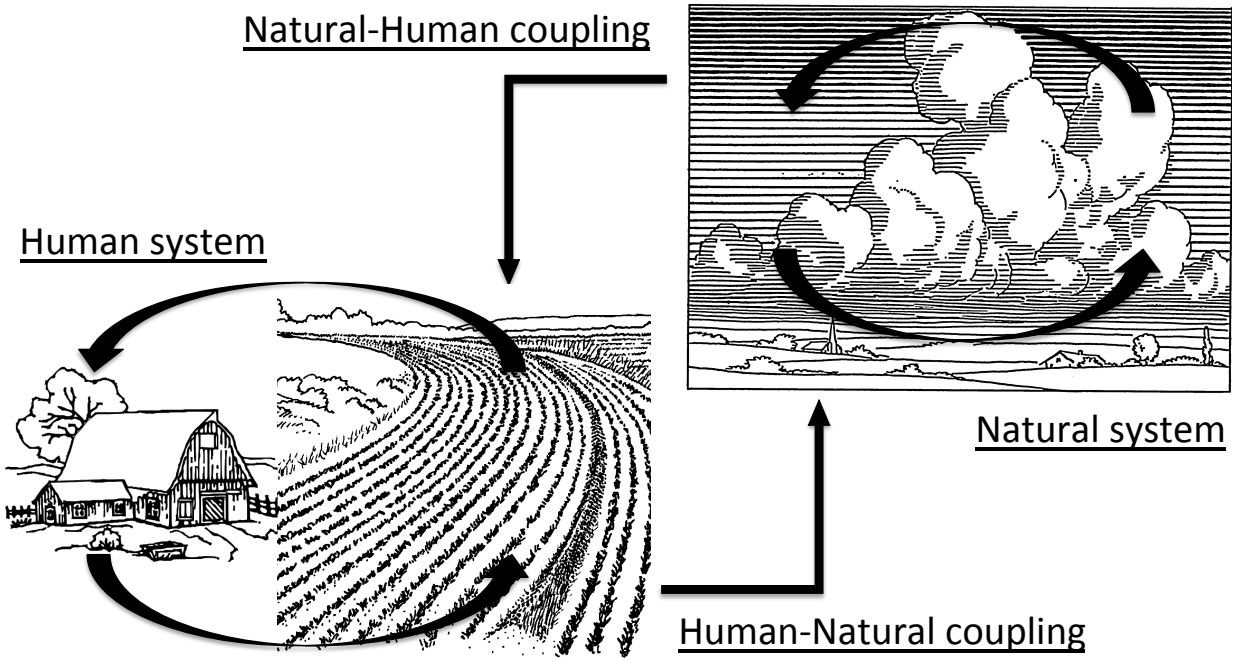


Early March was already anomalously dry in Glasgow

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.