Climate challenges facing northern grasslands and ranches

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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.
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

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

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

2017
30 year
mean +/- s.d.
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.