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 \textit{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

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

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
Alternate hypotheses

Canadian Prairie Ecozone

NEON Northern Great Plains

Cold air incursion?

No till agriculture (brighter surface)

Other land use changes

Other aspects of the general circulation

Moisture advection (irrigation)?
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.