Land-surface-snow-cloud climate coupling

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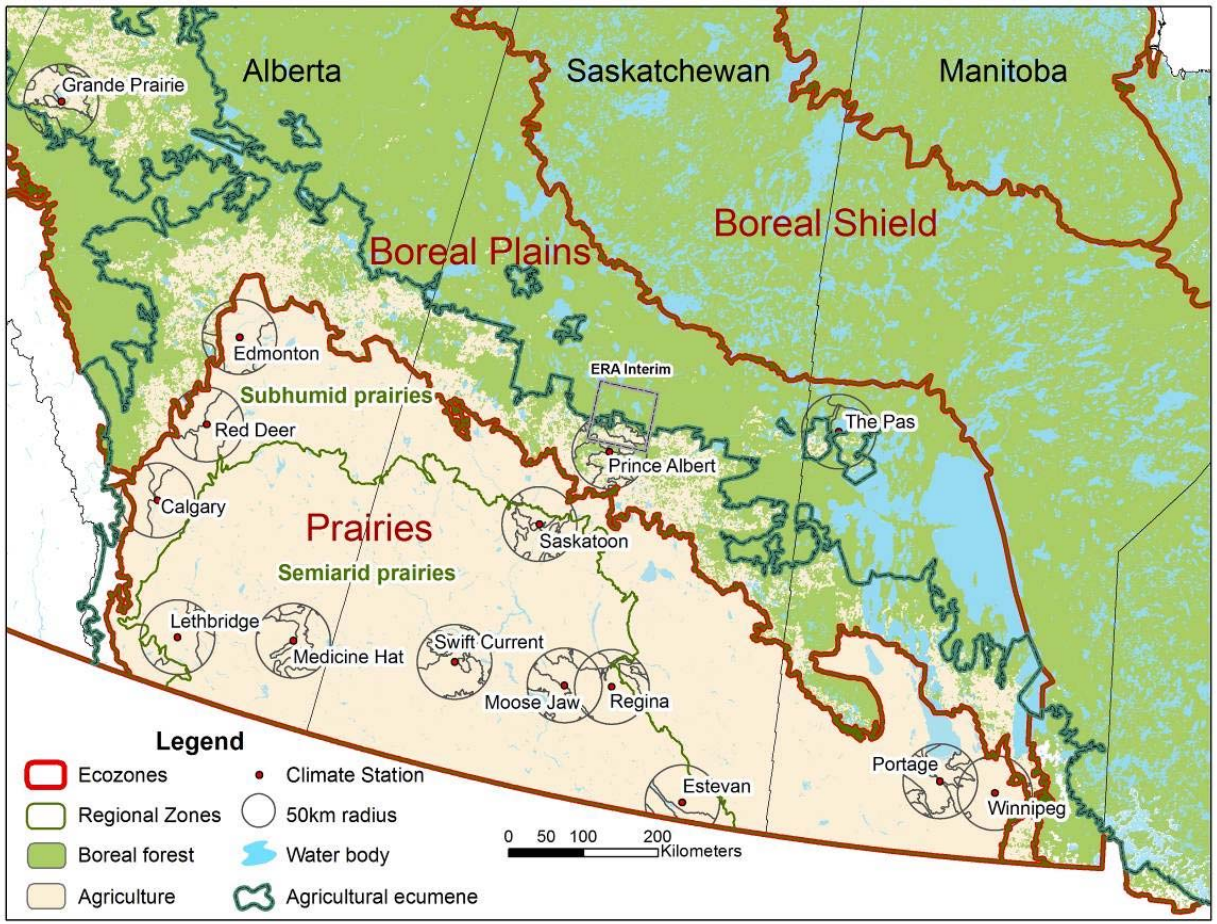
41th Northeastern Storm Conference

Saratoga, NY

March 6, 2016

14 Prairie stations: 1953-2011



- ***Hourly*** **p, T, RH, WS, WD, Opaque Cloud by level, (SW_{dn}, LW_{dn})**
- ***Daily*** **precipitation and snowdepth**
- **Ecodistrict crop data since 1955**
- **Albedo data (MODIS/CCRS: 250m, after 2000)**

Outline

- **Distinct warm and cold season states**
- **Snow cover is a "climate switch"**
- **Canadian Prairies: $\Delta T = -10^{o}C$**
- **Vermont: $\Delta T = -6^{o}C$**

- **Distinct cloud coupling to climate**
  - **No-snow 'Warm when clear' - convective BL**
  - **Snow 'Cold when clear' - stable BL**

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References

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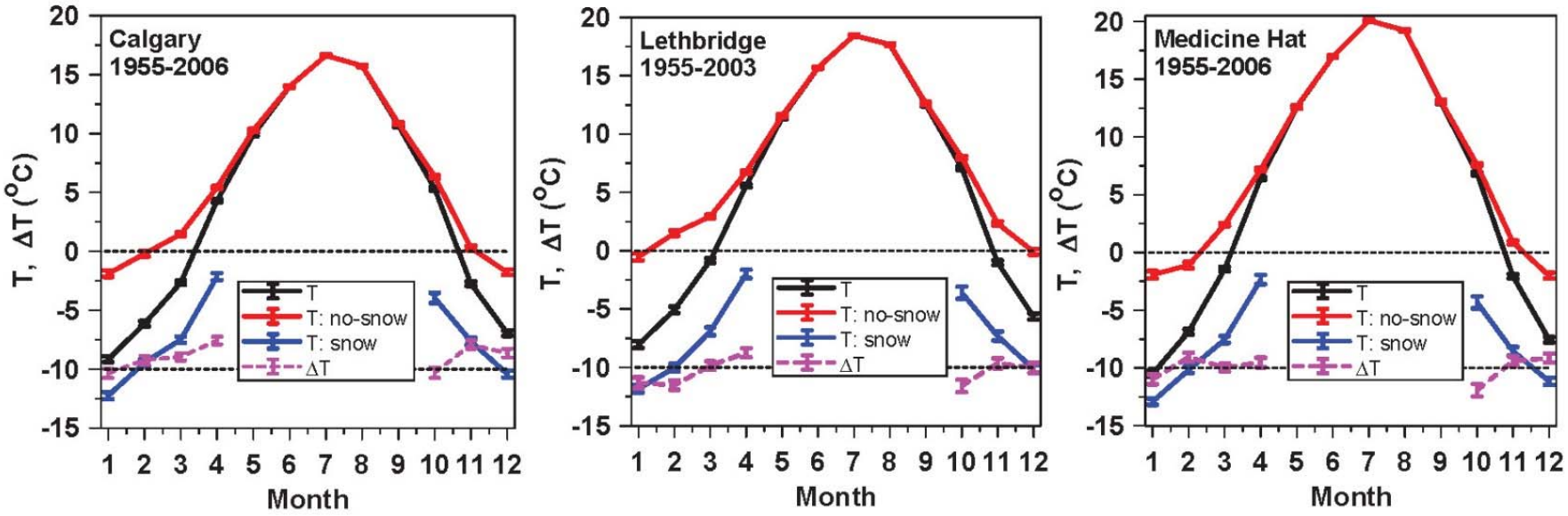
Climatological Impact of Snow

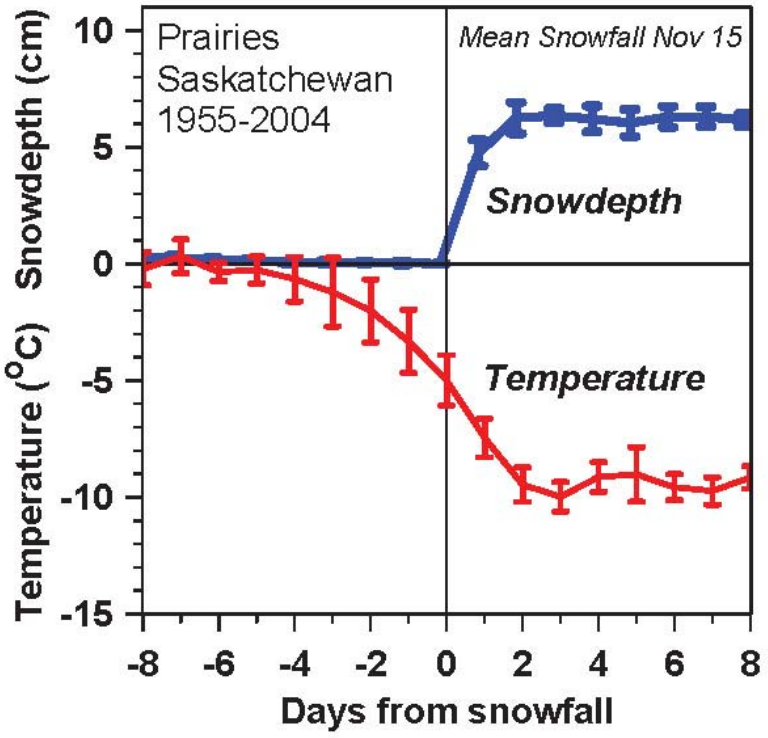


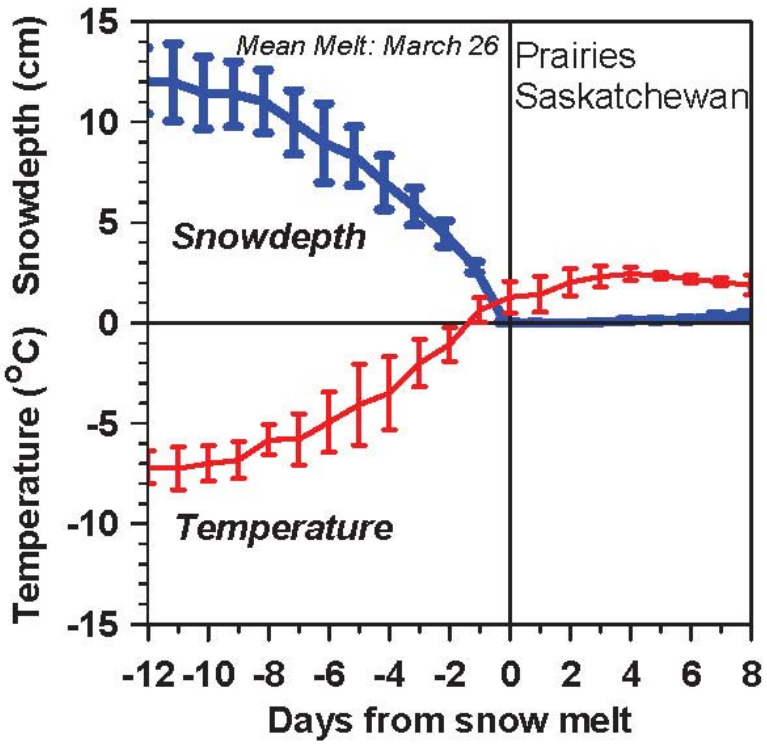
Separate mean climatology into days with no-snow and Snowdepth: SD>0

ΔT = T:no-snow –T:snow = -9.8(±0.8)°C

Snowfall and Snowmelt

Winter and Spring transitions





- **Temperature falls/rises about 10K with first snowfall/snowmelt**
- ***Snow reflects sunlight; shift to cold stable BL***
  - ***Local climate switch between warm and cold seasons***

Betts et al. 2014

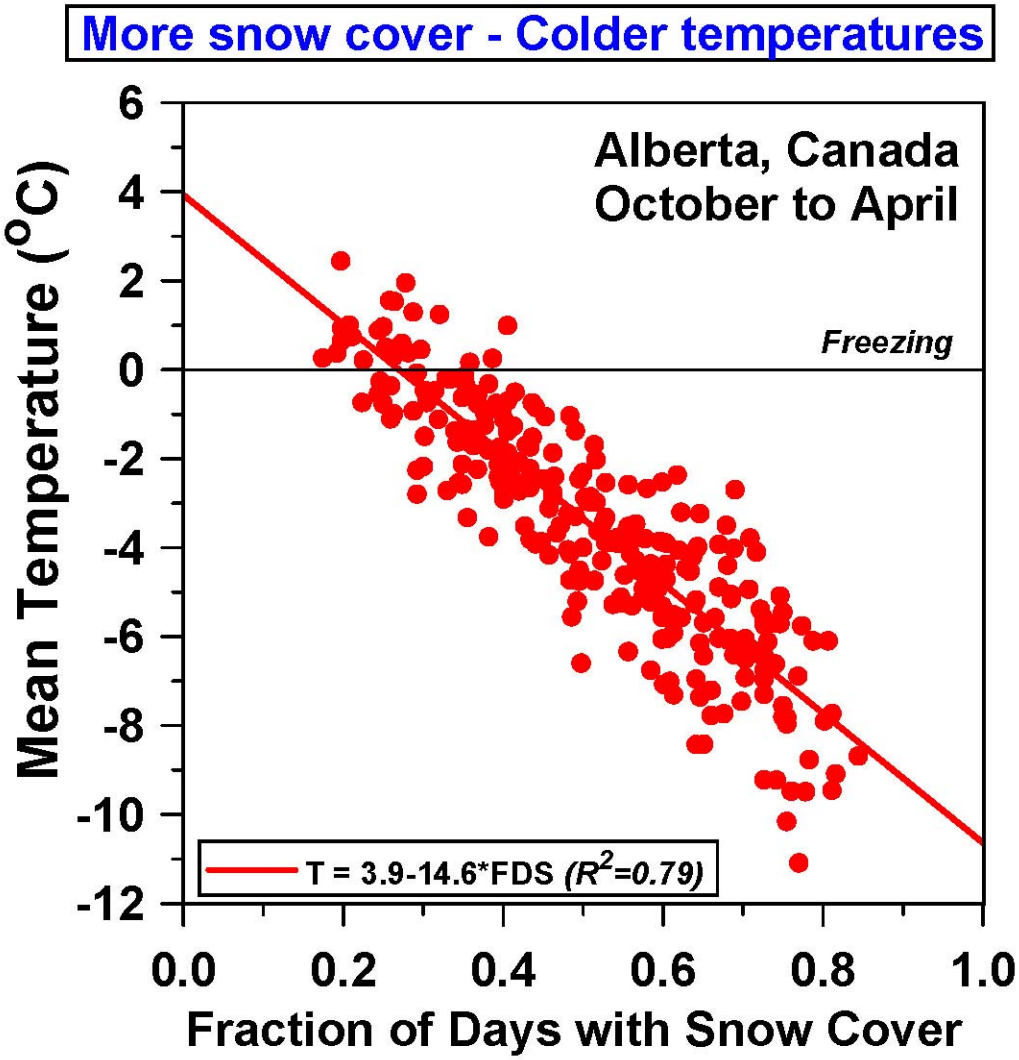
Interannual variability of T coupled to Snow Cover

- **Alberta: 79% of variance**
- **Slopes T_m -14.7 (± 0.6) K**

10% fewer snow days

= 1.5K warmer

on Prairies



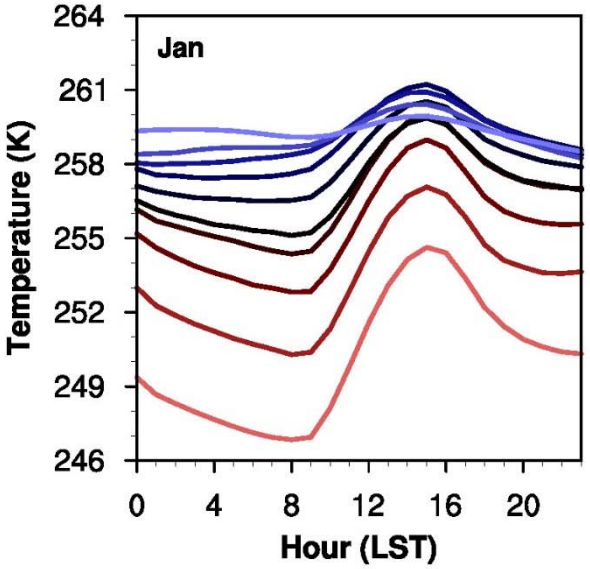
Diurnal cycle: Clouds & Snow

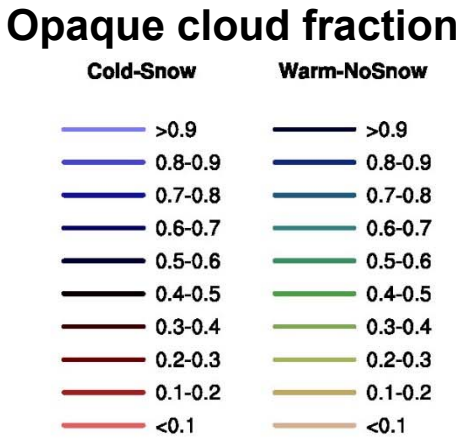
Canadian Prairies
660 station-years of data

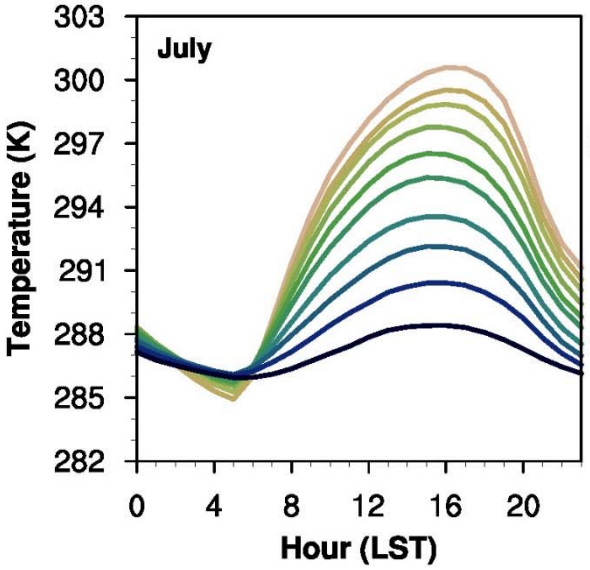
Winter climatology
- Colder when clear
- LWCF dominant with snow

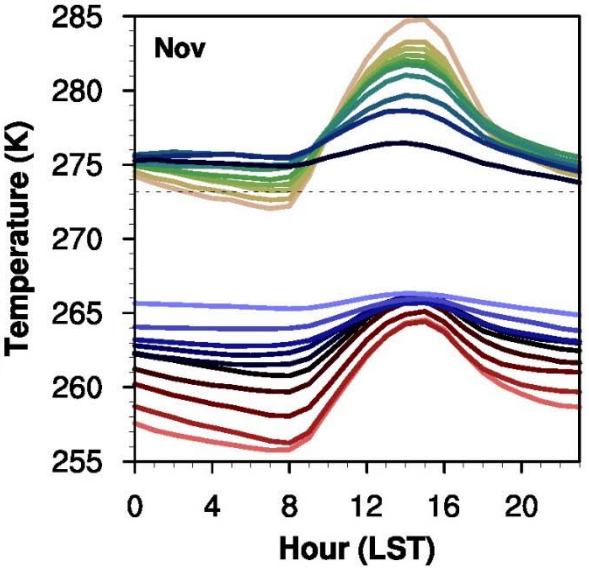
Summer climatology
- Warmer when clear
- SWCF dominant: no snow

Transition months:
- Show both climatologies
- With 11K separation
- Fast transitions with snow
- Snow is “Climate switch”

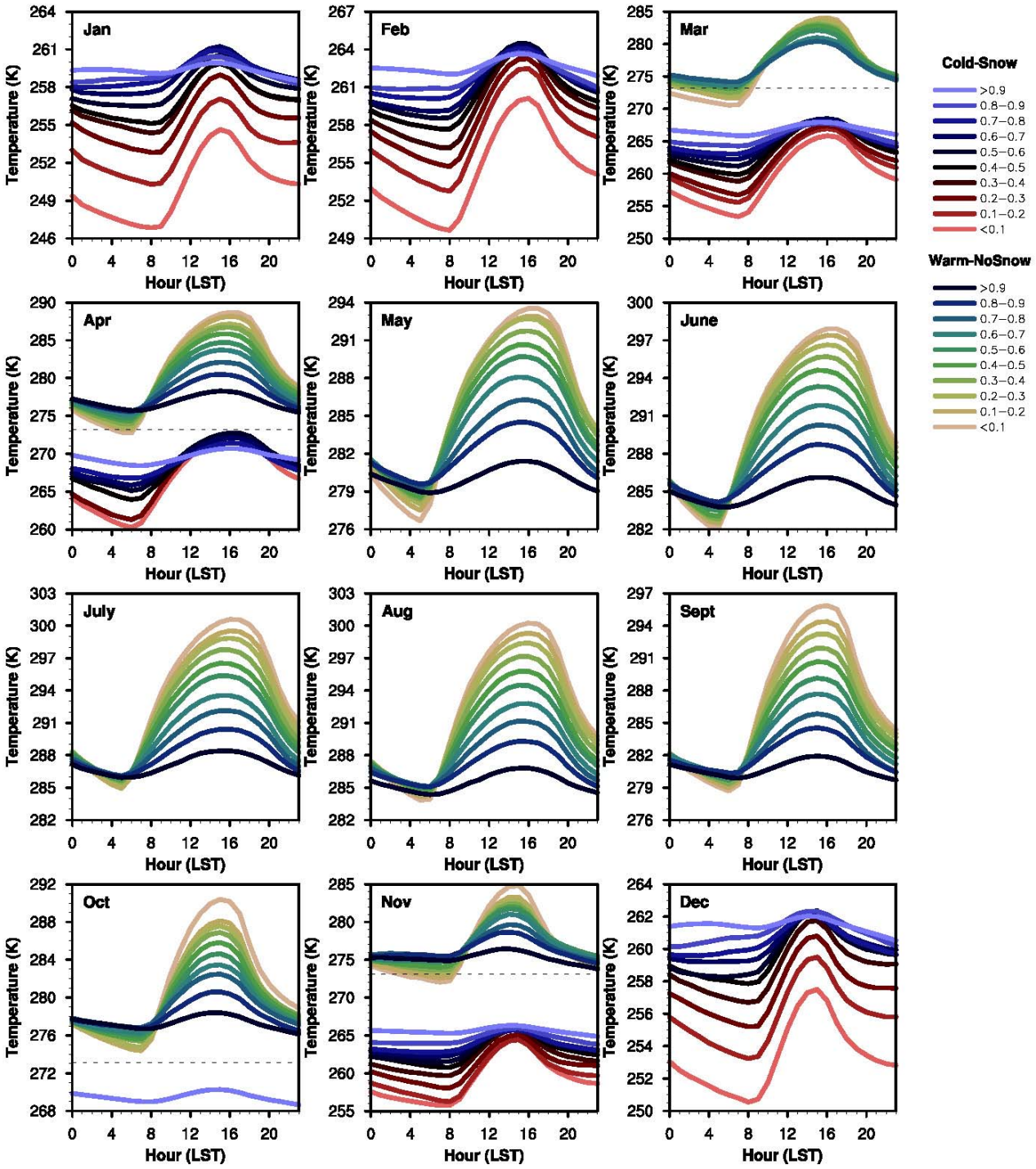




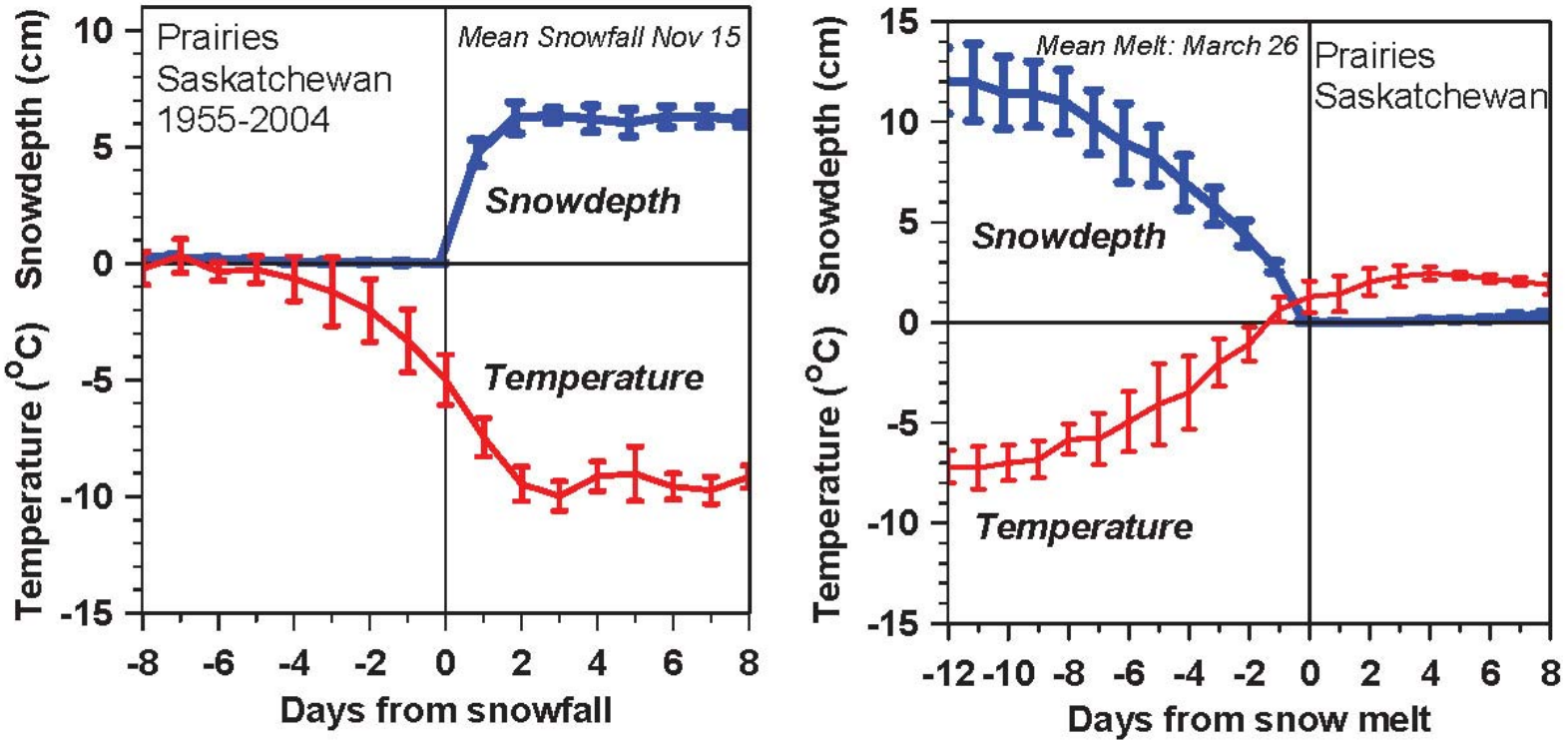




Monthly diurnal climatology (by snow and cloud)



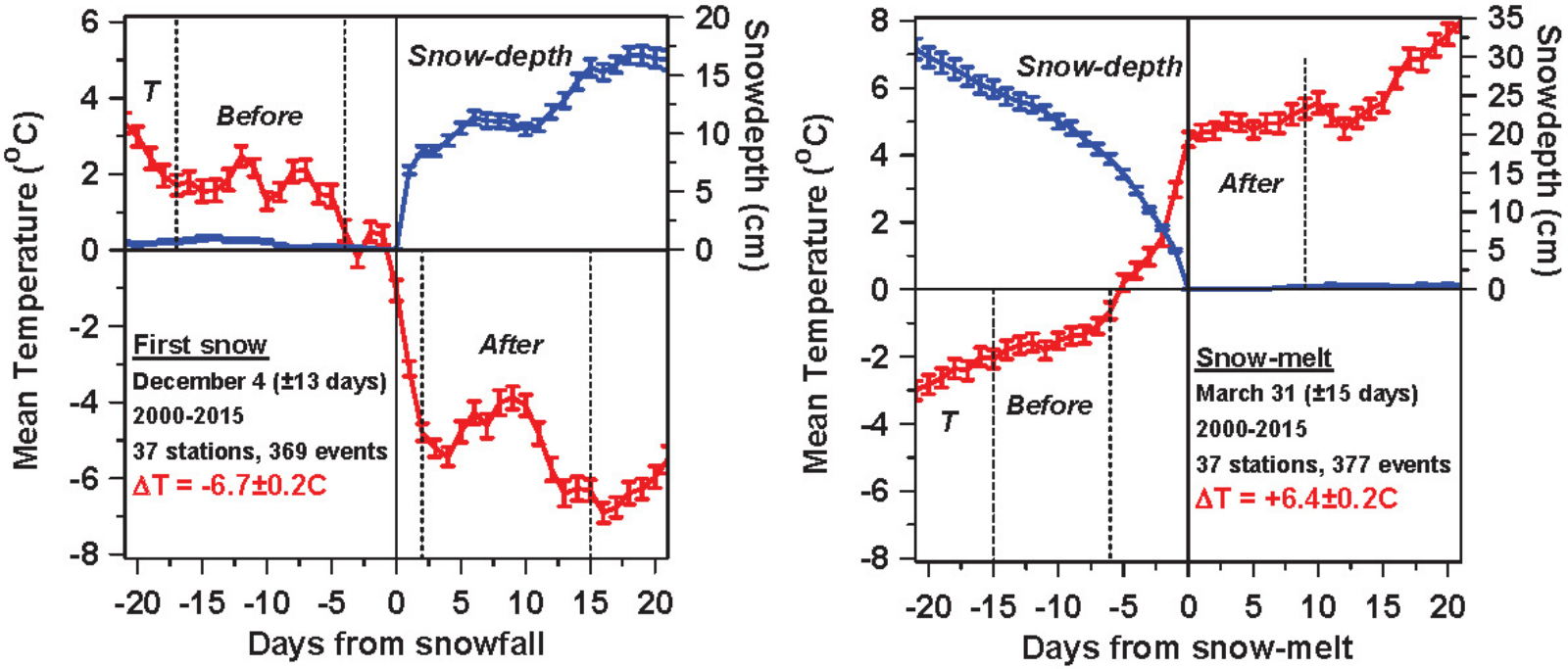
Snowfall and Snowmelt
ΔT Canadian Prairies



- **Temperature falls/rises 10K with first snowfall/snowmelt**
  - ***Local climate switch between warm and cold seasons***

Betts et al. 2014

Snowfall and Snowmelt
ΔT Vermont

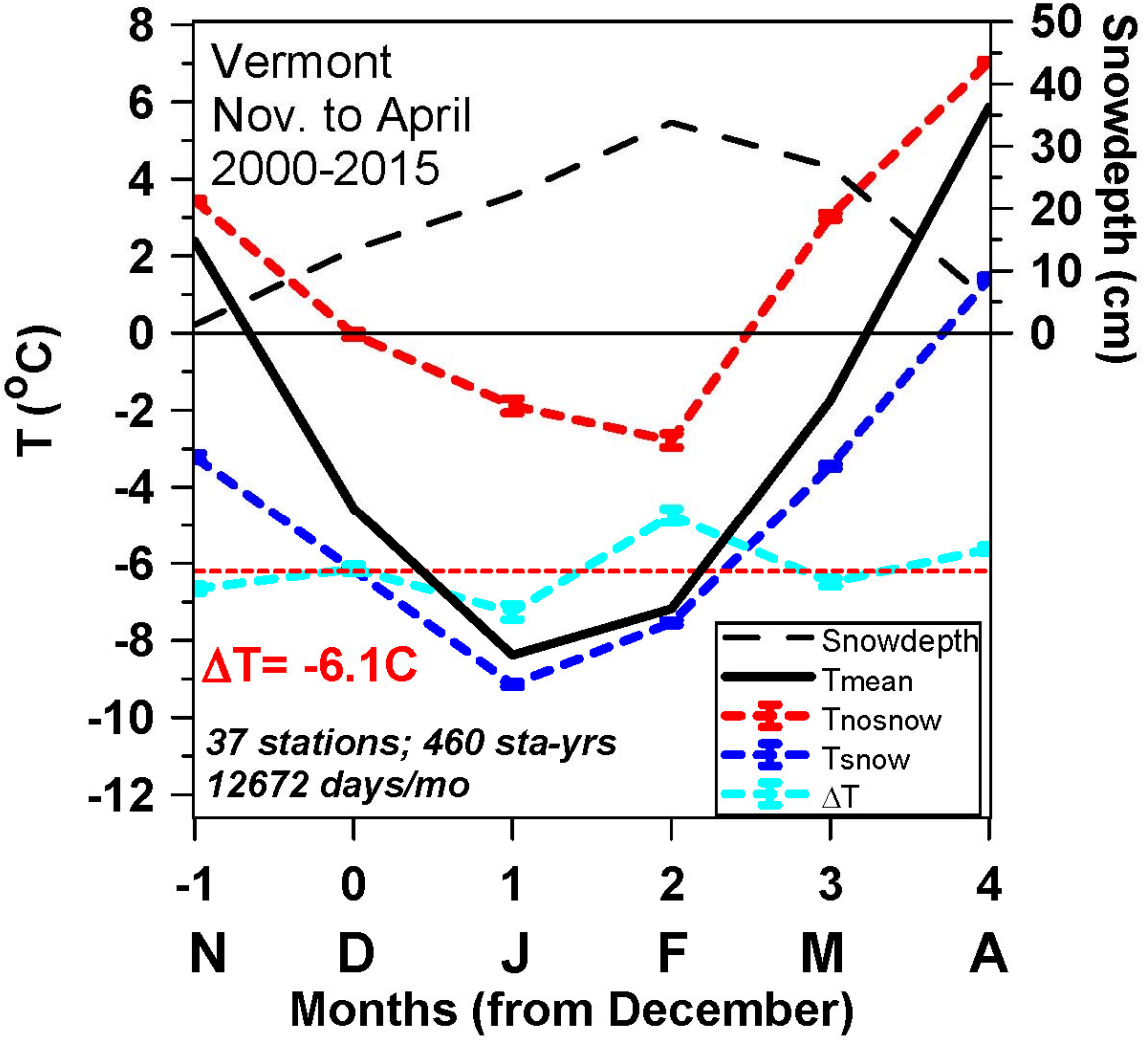


- **Temperature falls/rises 6.5 °C with first snowfall/snowmelt**
- **Albedo with snow less than Prairies**

Climatological Impact of Snow: Vermont

Separate mean climatology into days with no-snow and with snow

Difference ΔT= -6.1(±0.7)°C



Summary

- **Distinct warm and cold season states**
- **Snow cover is a "climate switch"**
- **Prairies: ΔT = -10°C (winter albedo = 0.7)**
- **Vermont: ΔT = -6°C (winter albedo 0.3 to 0.4)**

- **Snow transforms BL cloud coupling**
  - **No-snow 'Warm when clear' - convective BL**
  - **Snow 'Cold when clear' - stable BL**

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