"Extreme" Responses in Global Warming Simulations

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Rich Gudgel and Tom Knutson, GFDL

Workshop on North American Weather and Climate Extremes
Aspen, CO
16 July 2005

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The effects of global warming on snowfall and heavy snow events over eastern North America

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Methodology

- Examine snowfall trends in IPCC simulations (A2 scenario) using GFDL R30 coupled model for the period 1965-2100.
- Focus on eastern North America.
- Look for relationships with large-scale changes in the hydrologic cycle.

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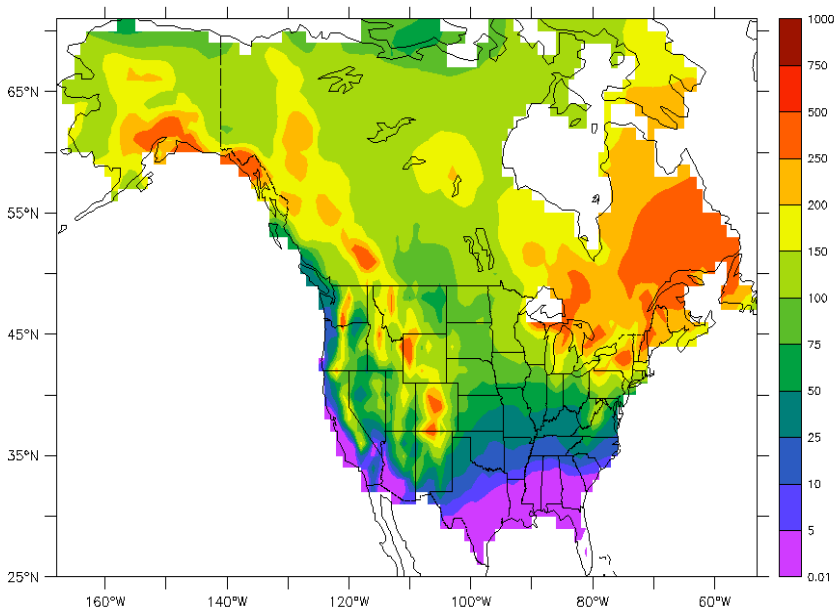
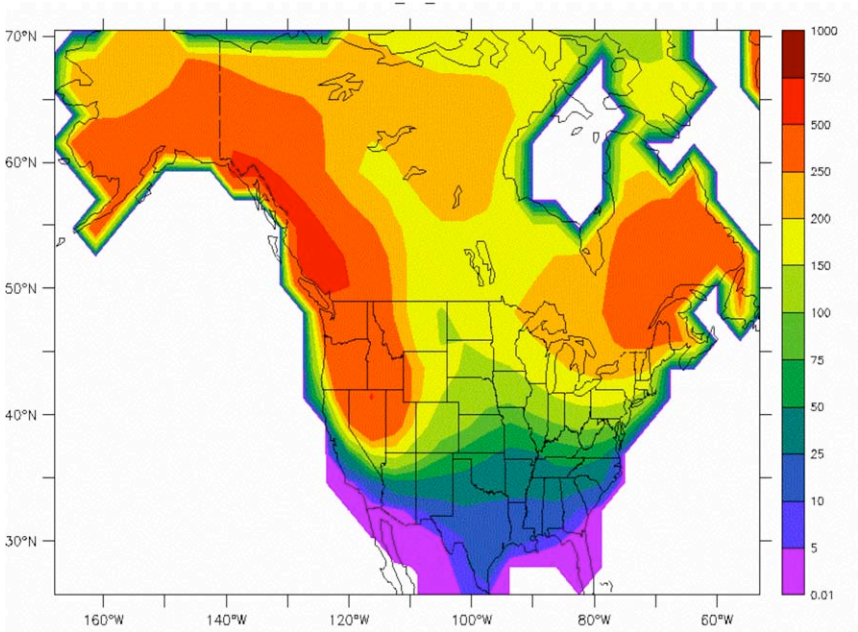
Annual Snowfall Climatology [cm]

Observed



Simulated



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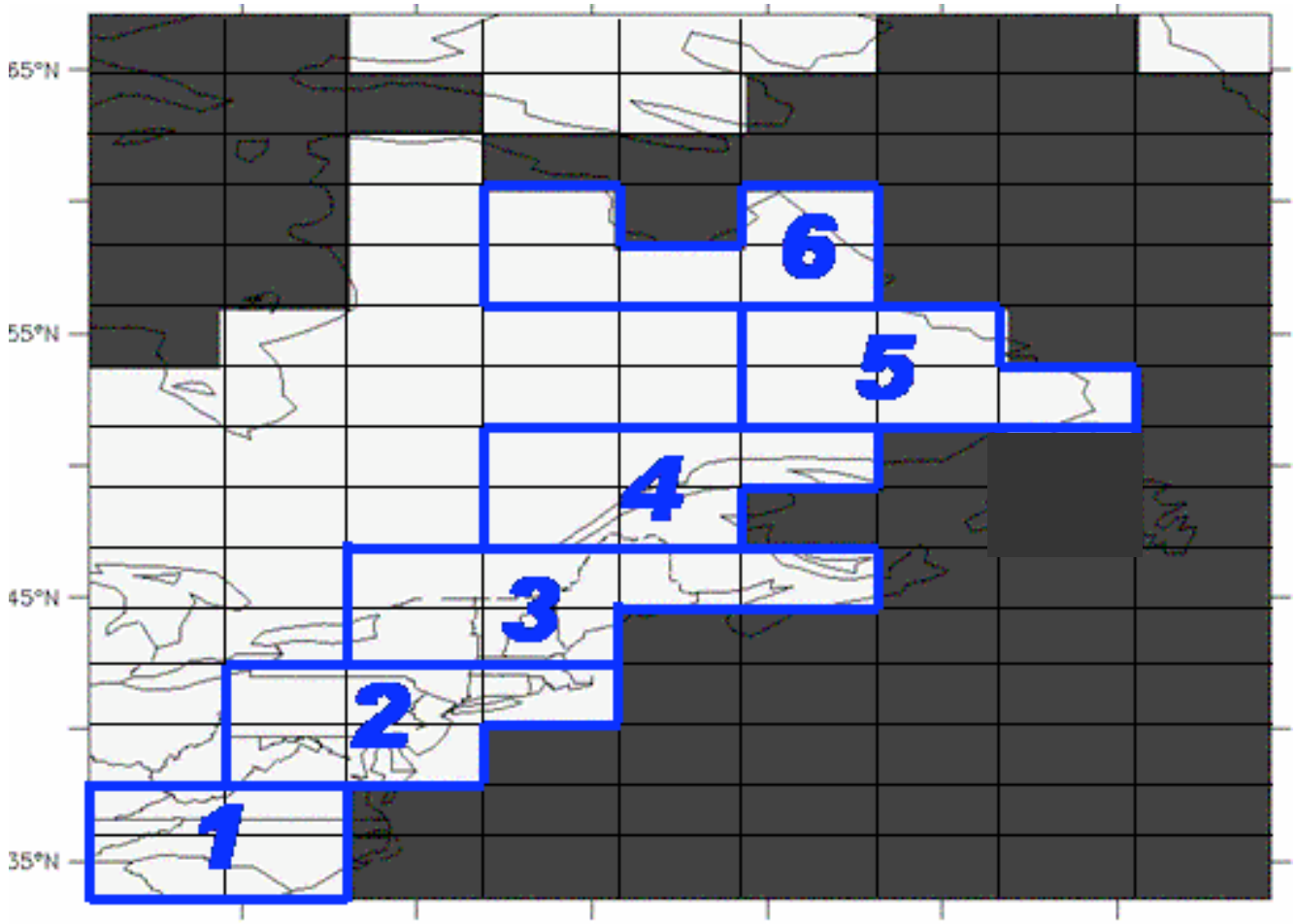
Snowfall Regions



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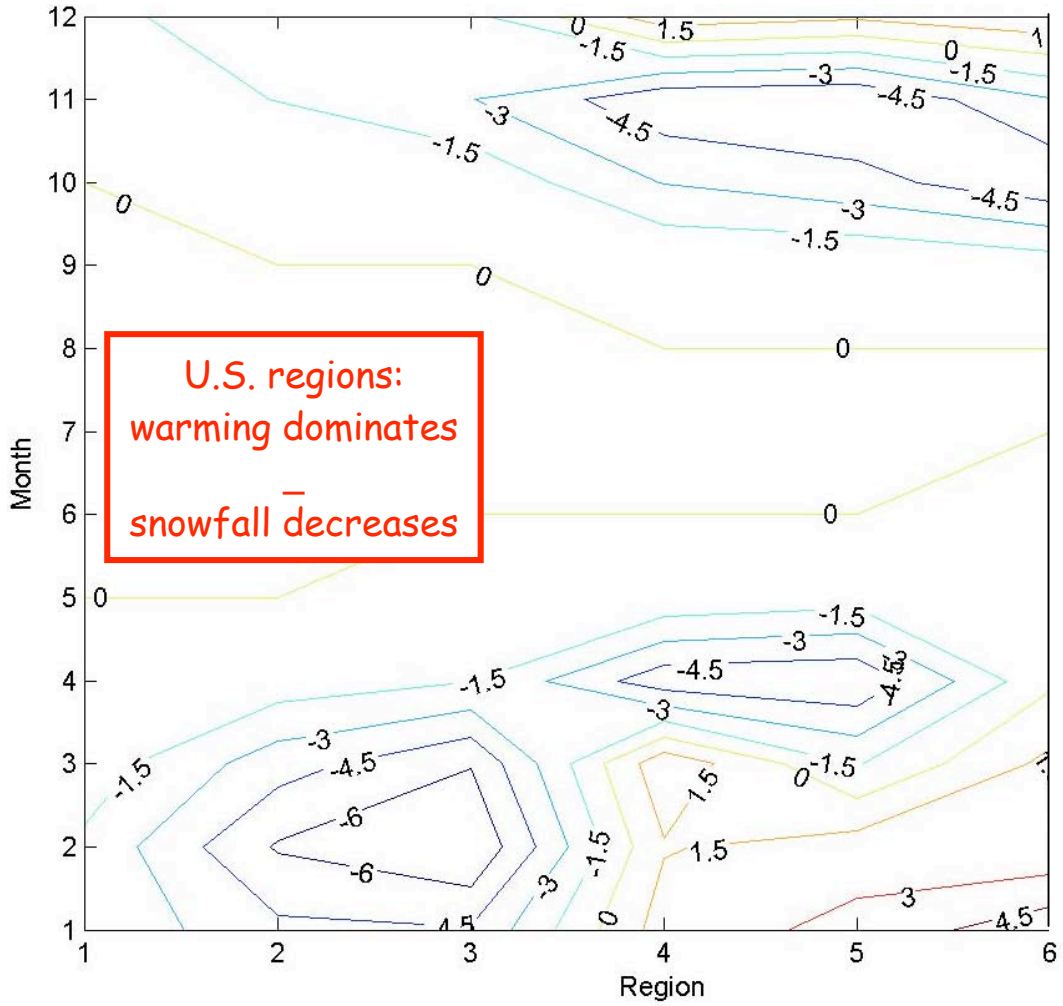
Regional Snowfall Trends [10^{-4} cm d^{-1} yr^{-1}]



U.S. regions:
warming dominates
snowfall decreases

Canadian regions:
warming dominates
in transition seasons
snowfall decreases

Canadian regions:
precip increase dominates
in midwinter
snowfall increases

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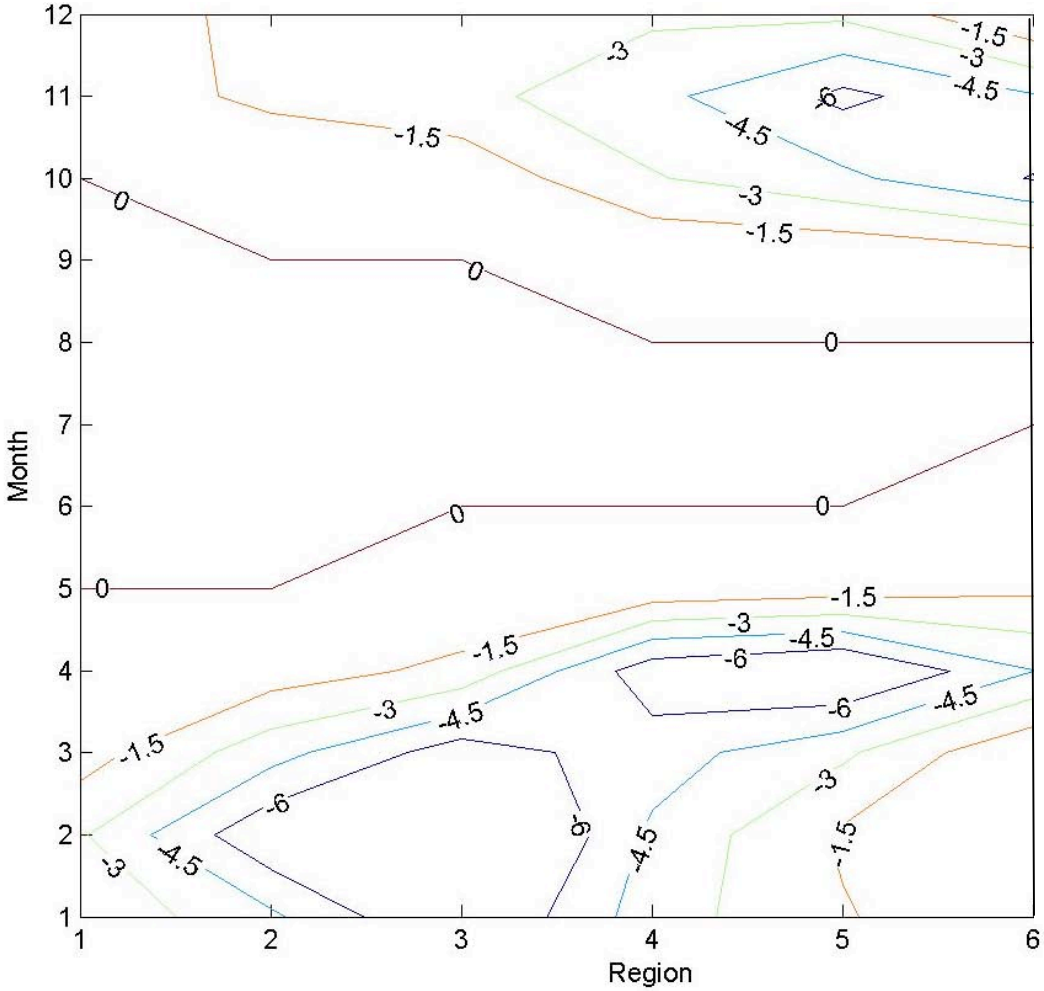
Snowfall Trends with Precipitation Held Constant [10^{-4} cm d^{-1} yr^{-1}]



Midwinter snowfall is less sensitive to temperature at higher latitudes

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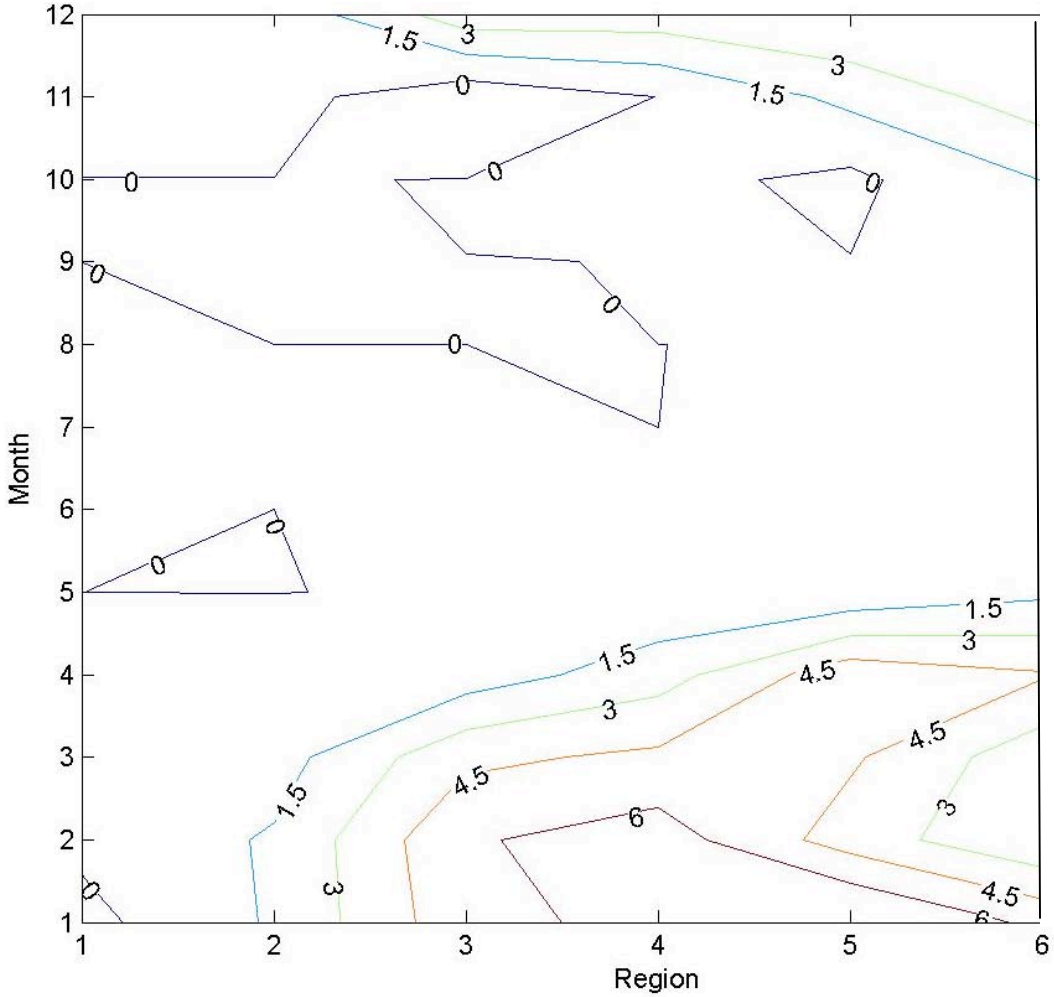
Snowfall Trends with Snow Fraction Held Constant [10^{-4} cm d^{-1} yr^{-1}]



Winter precipitation increases in eastern North America, with largest effect on snowfall in Canada

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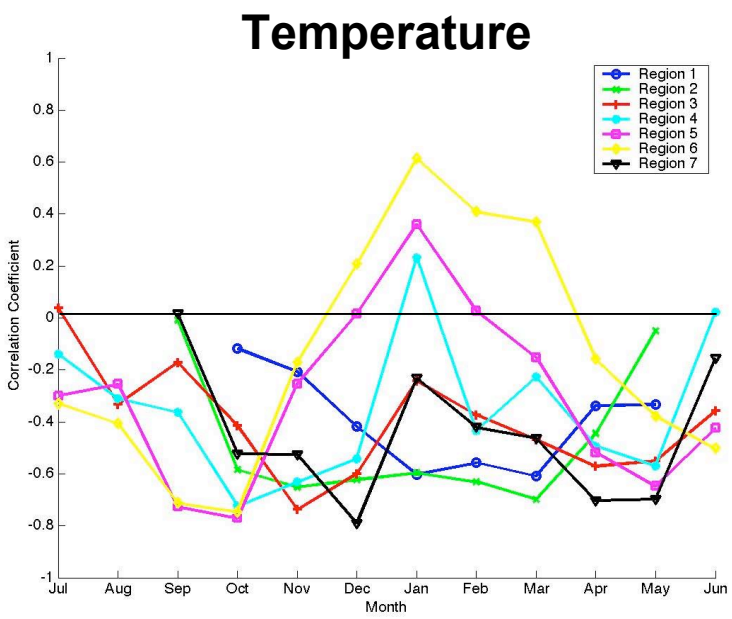
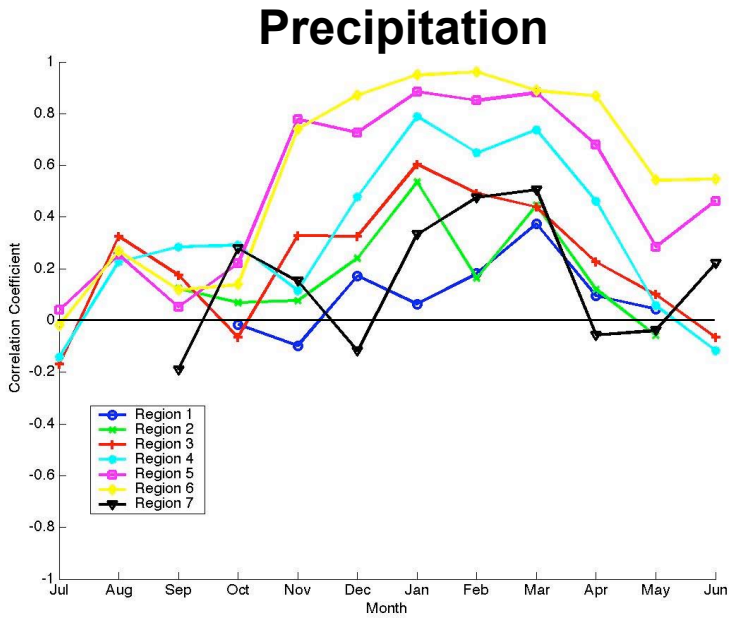
Observed Correlations of Snowfall with Temperature and Precipitation





Observed data based on a data set provided by Thomas Mote (University of Georgia), which consists of first-order and cooperative station data for U.S. and Canada optimally interpolated to a 1° x1° grid.

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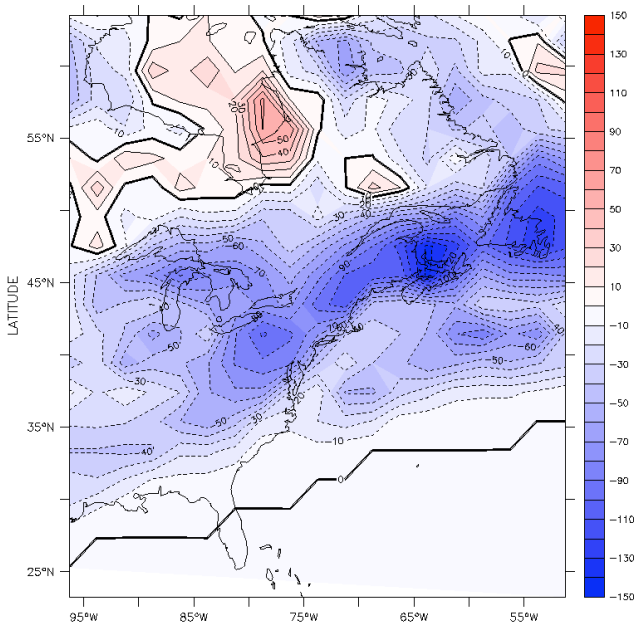
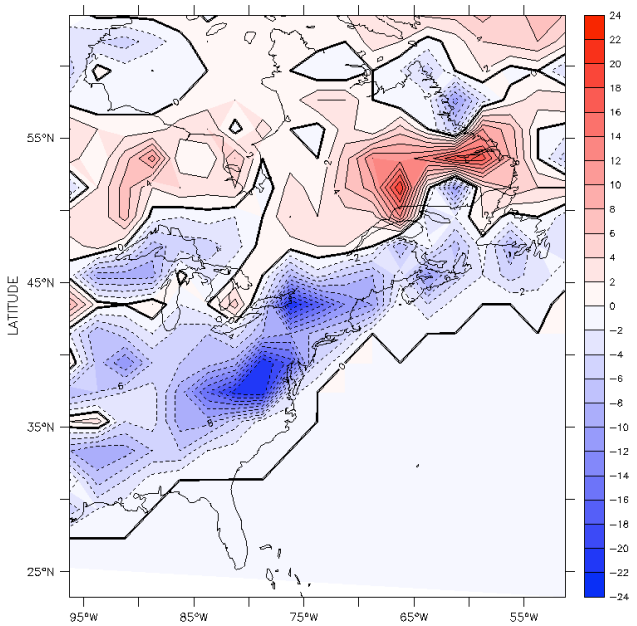
Changes in Frequency of Daily Snowfall Events (2081-2100) - (2001-2020)



Daily snowfall ≥ 5 cm



Daily snowfall ≥ 20 cm

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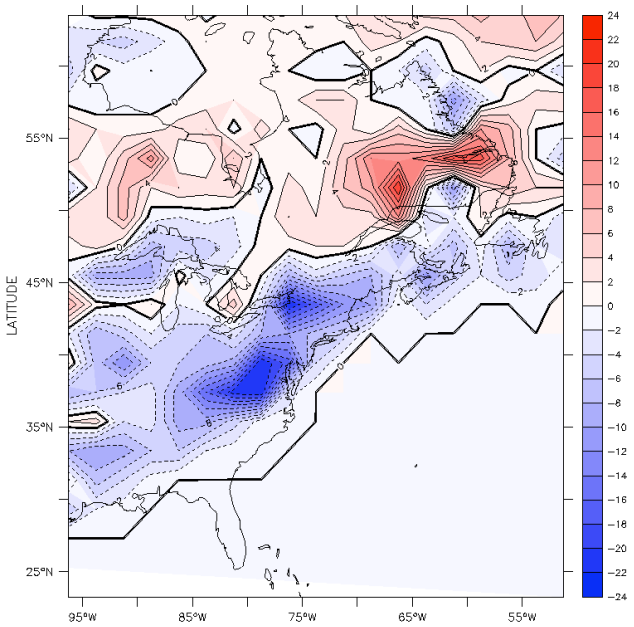
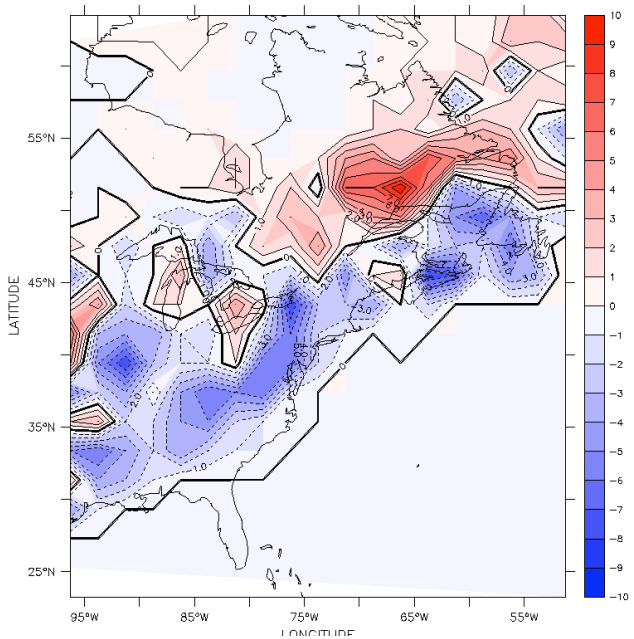
Changes in Frequency of Daily Snowfall Events ≥ 20 cm
(2081-2100) - (2001-2020)



All Months



January-February

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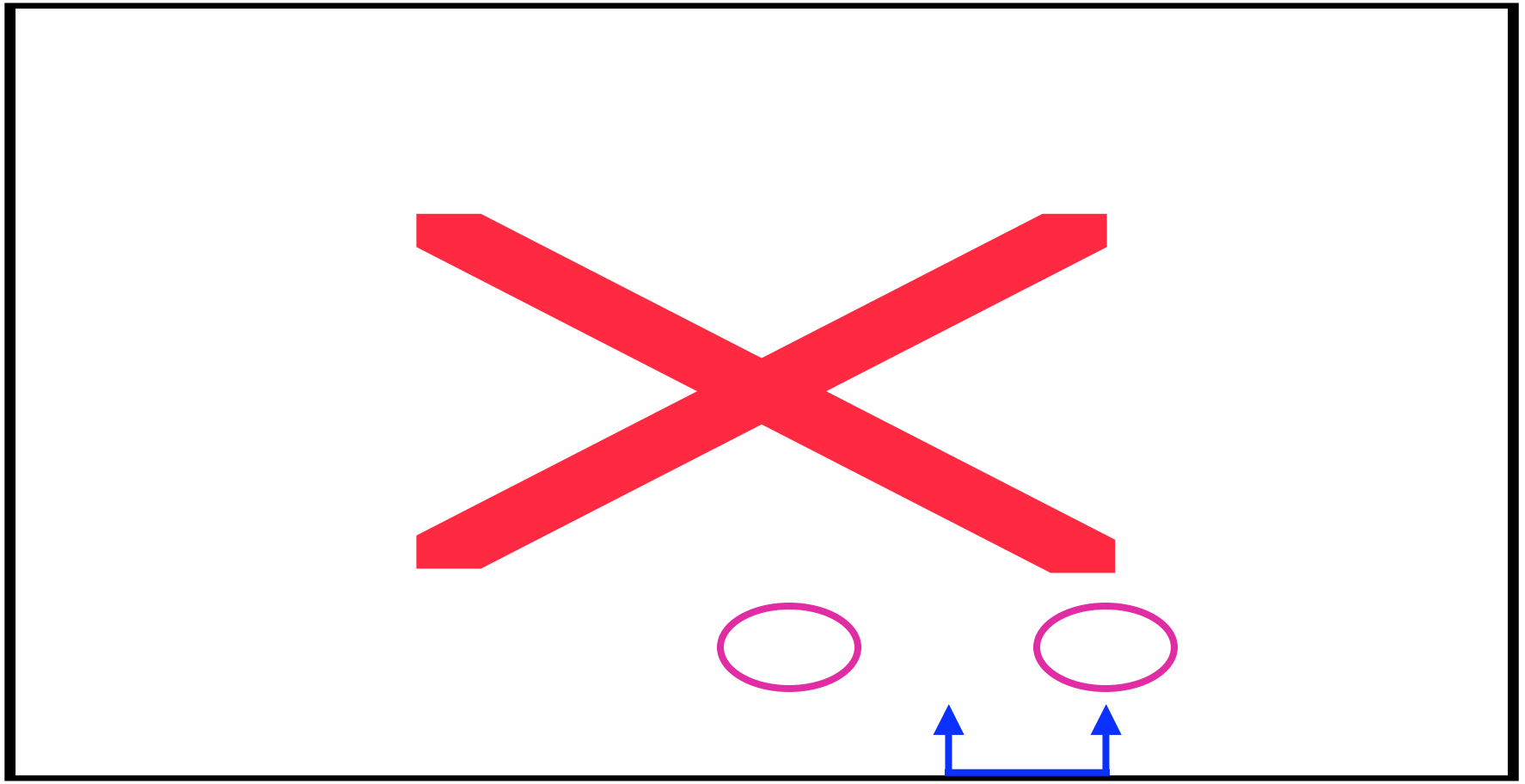
Do geographical and seasonal extreme values depend on climate sensitivity?

Methodology

- Analyze time-averaged, seasonally dependent response of a number of climate variables: *_X = f(location,season)*
- Express the frequency distribution of *_X* as a histogram.
- Examine geographical and seasonal extreme values (i.e., tails of the frequency distribution).

Variations of Climate Sensitivity in AM2



Mellor-Yamada to
Lock et al. PBL

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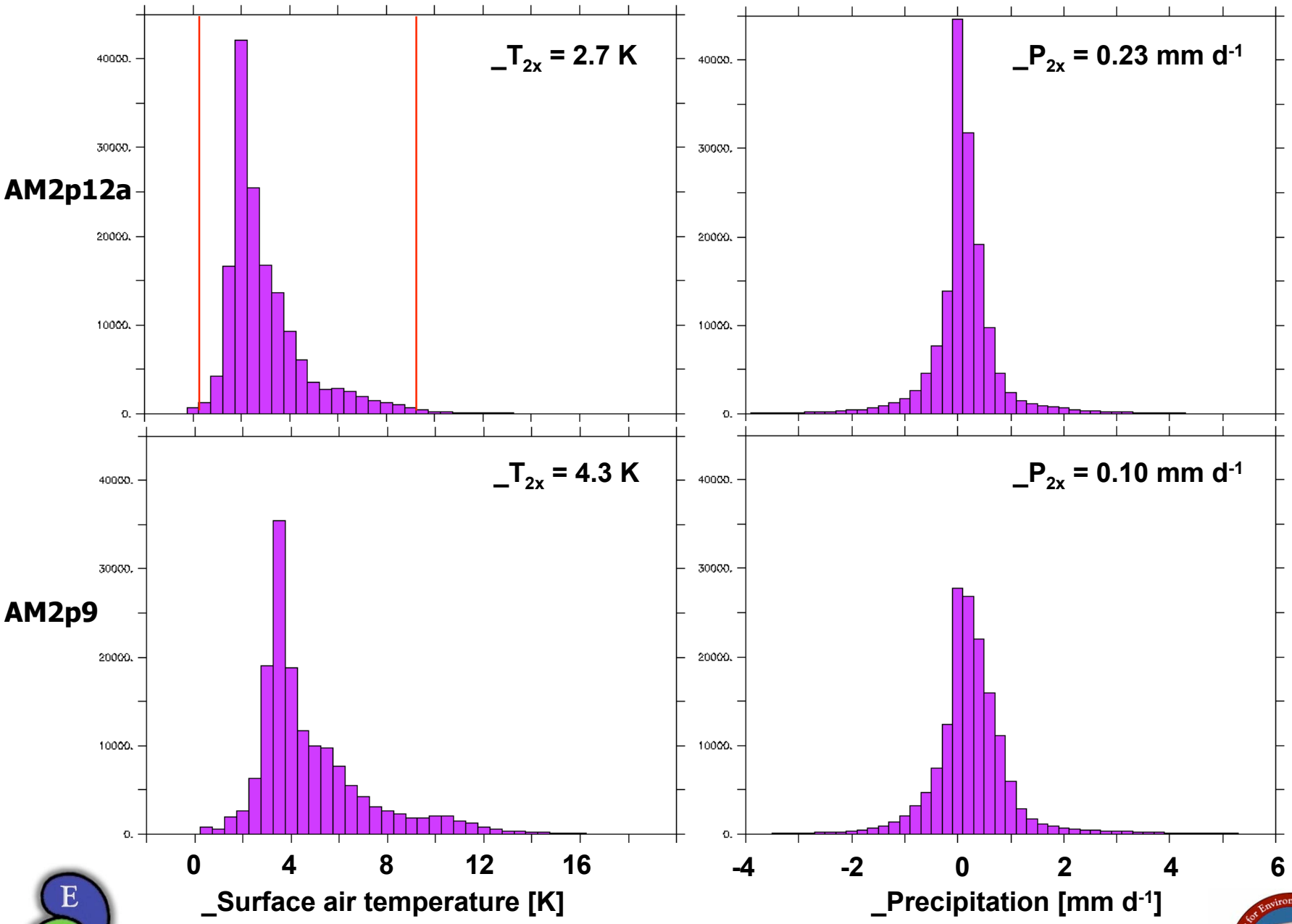

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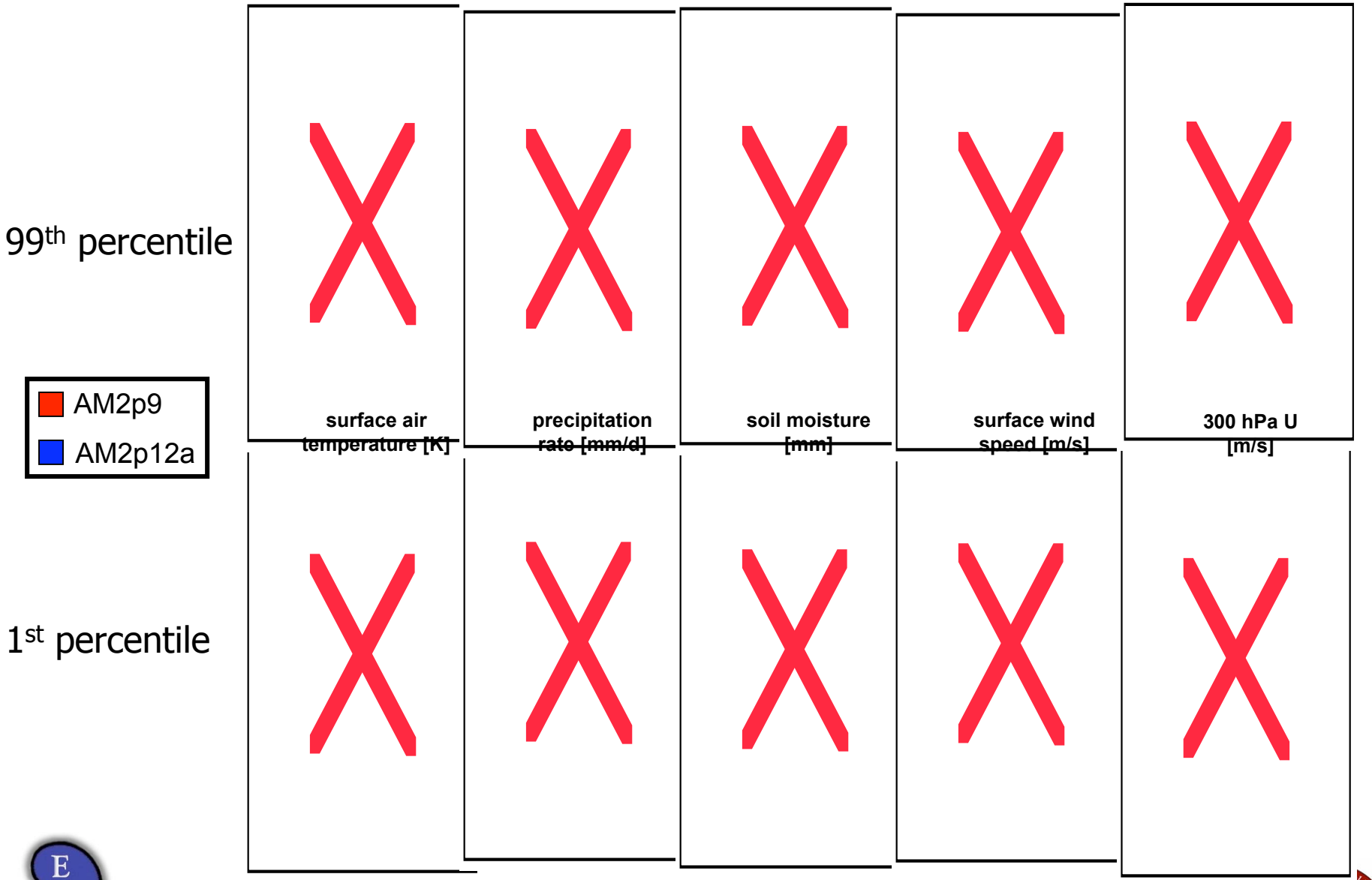

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Future Work

- This analysis should be extended to the temporal domain (i.e., extreme events) to determine the extent to which they are dependent on climate sensitivity.