

A satellite view of Earth from space, showing a vast expanse of blue oceans and white clouds. The horizon is visible at the top of the frame, and the curvature of the planet is evident. The text is overlaid on this background.

WRF PGW Simulations of Prairie Future Hail and Severe Weather Environment

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Objective

- Investigate the sensitivity of future changes in hail (and potentially heavy rain) and severe weather environment to thermodynamic variations using the PGW approach

Data & Methods

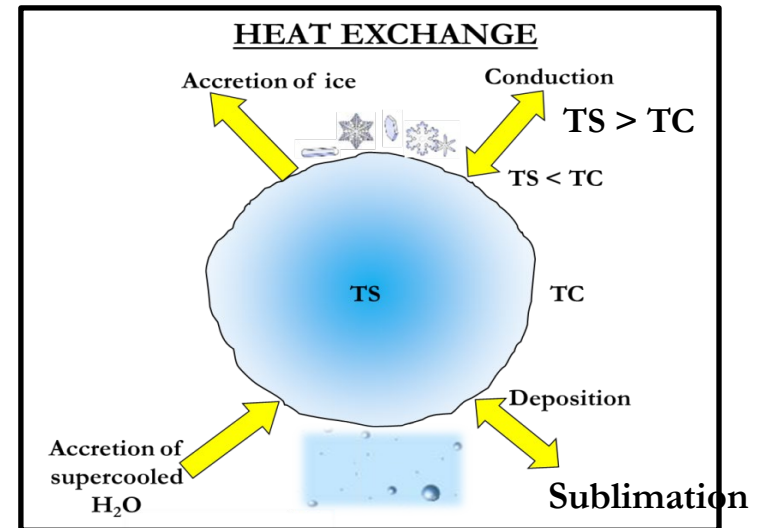
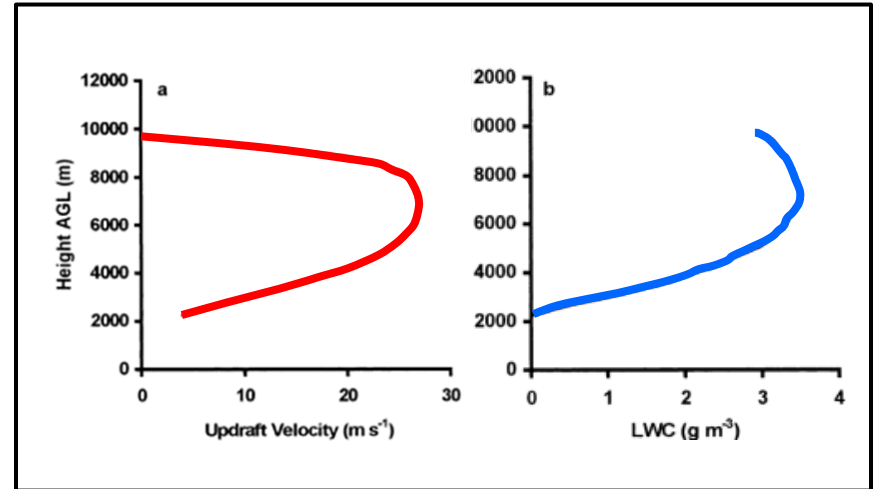
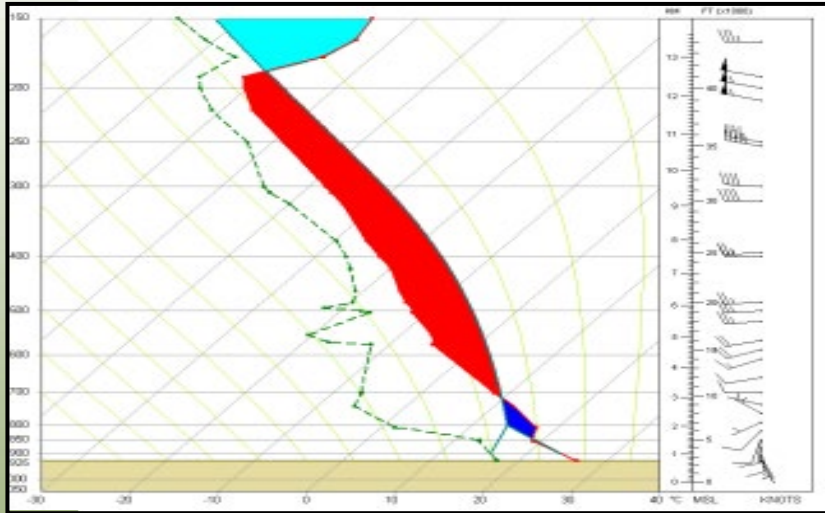
- **NCAR WRF historic and PGW simulations 2001 – 2013 (Liu et al 2017)**

$$\text{WRF}_{\text{input}} = \text{ERA-Interim} + \Delta_{\text{RCP8.5}}^{\text{CMIP5}} \quad \text{where } \Delta_{\text{RCP8.5}}^{\text{CMIP5}} \text{ is the 95-year CMIP5 multi-model}$$

ensemble-mean change under the RCP8.5 emission scenario: $\Delta_{\text{RCP8.5}}^{\text{CMIP5}} = \text{CMIP5}_{2071-2100} - \text{CMIP5}_{1976-2005}$

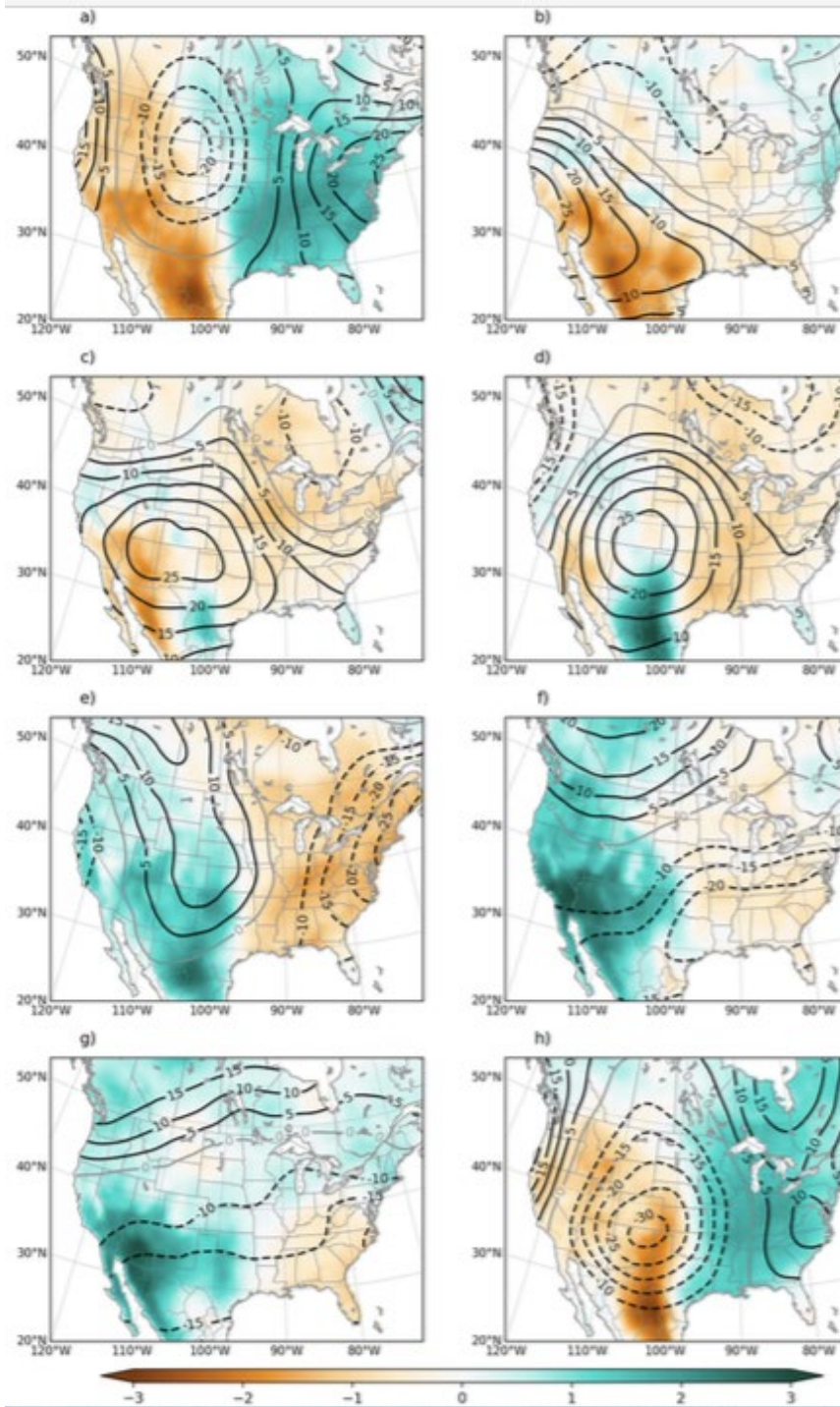
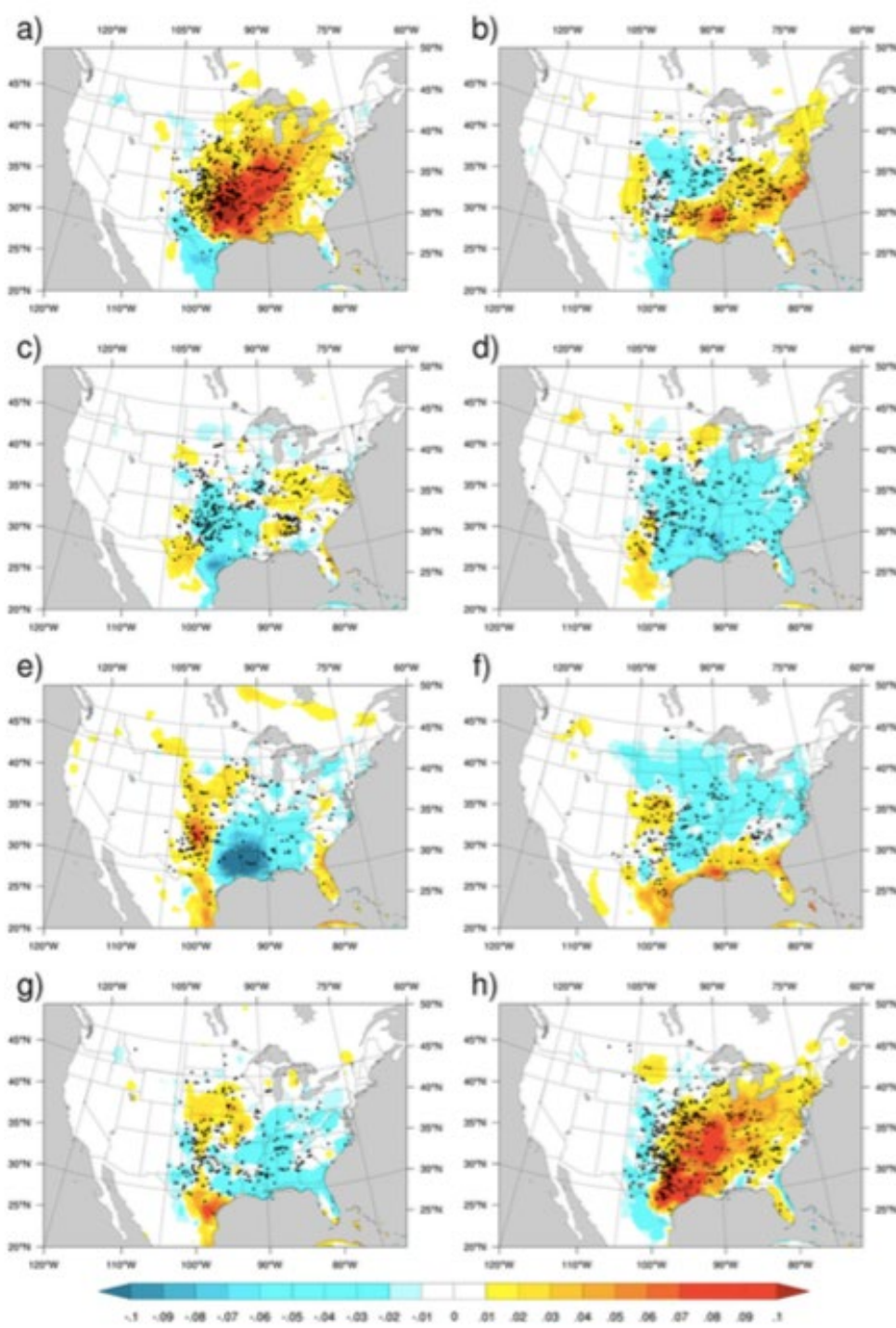
- **Perturbed fields: horizontal wind, geopotential height, temperature, specific humidity, sea surface temperature, soil temperature, sea level pressure, and sea ice.**
- **Ran Hailcast model and severe weather scripts using WRF-PGW output**
- **Yanping Li & Zhenhua Li – getting hailcast and severe weather scripts working from WRF output – massive effort**
- **Applied to Canadian Prairies and bordering U.S. states; due to data volumes and computational limitations**
- **Focusing on 1800 – 0300 UTC time period**

Old Tool (Hailcast) Used Today



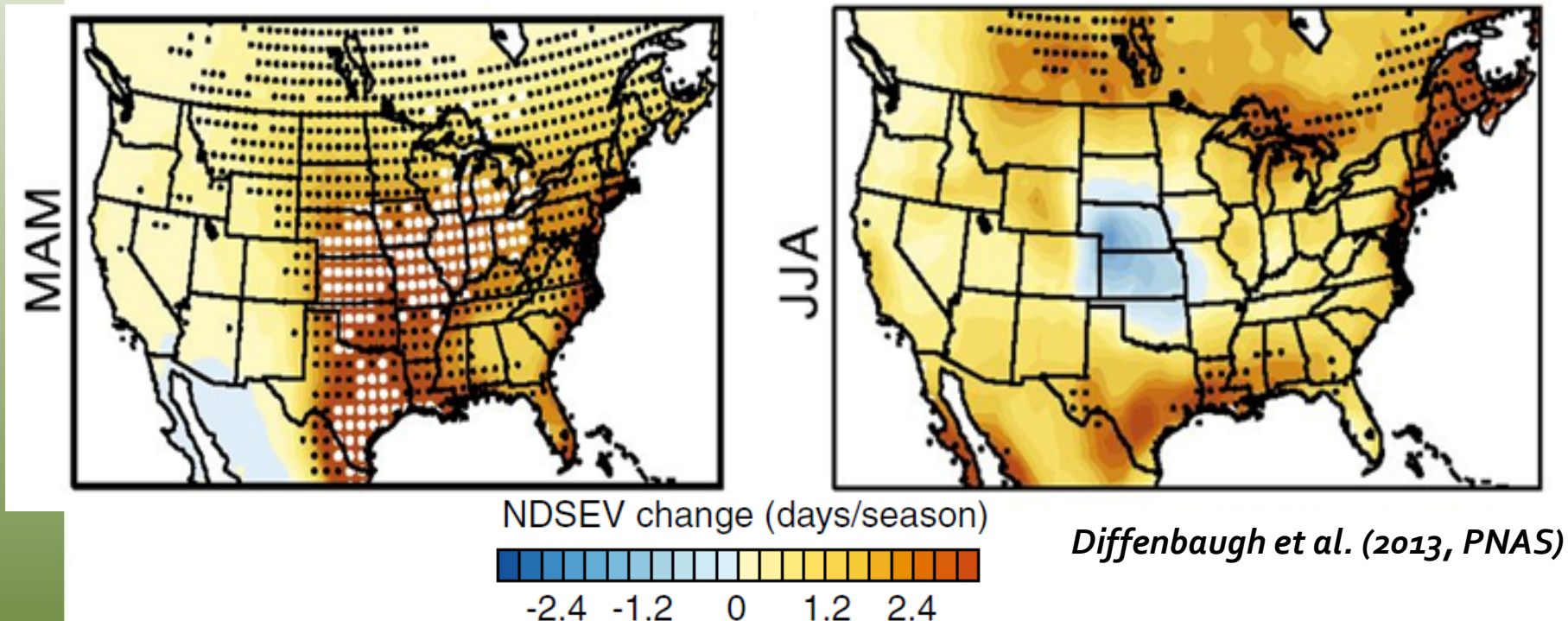
Some Previous Research

- Most work has focused on historical aspects
- e.g. Gensini and Allen, GRL, 2018



Some Previous Research

- Research on the response of severe storms to ACC has focussed on CAPE-Shear phase space
- Greater the CAPE and Shear => greater potential for severe storms



- No research to date has *explicitly* modelled the response of hail to ACC
- Empirical relationships derived for the current climate between atmospheric parameters and damaging hail days => applied to future

Some Previous Research

Paquin et al. 2014, AO

Prairies, ON & S. QC

- CAPE will increase and shear will slightly decline in future
- Effect of CAPE increases severe threats
- Frequency and intensity of convective extremes expected to increase

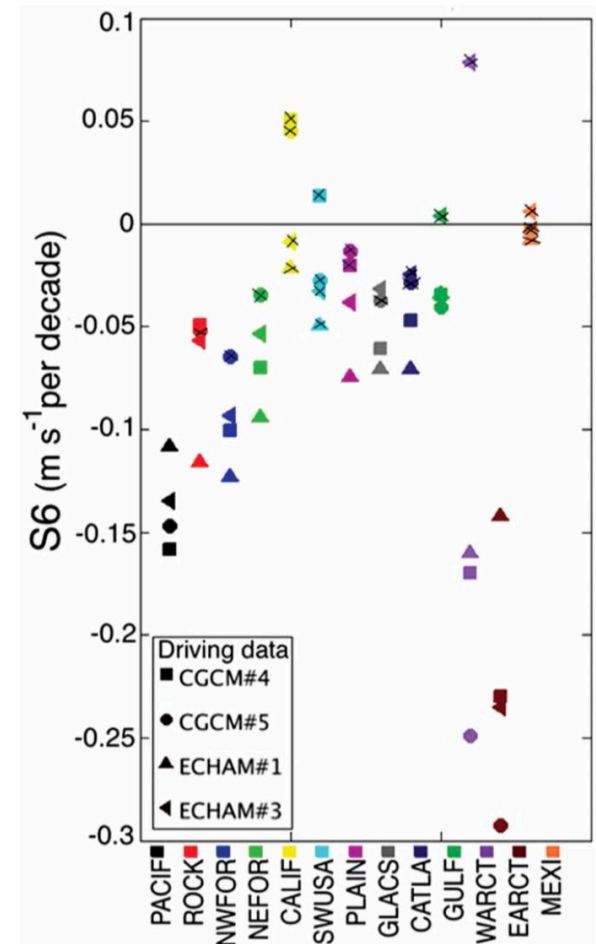
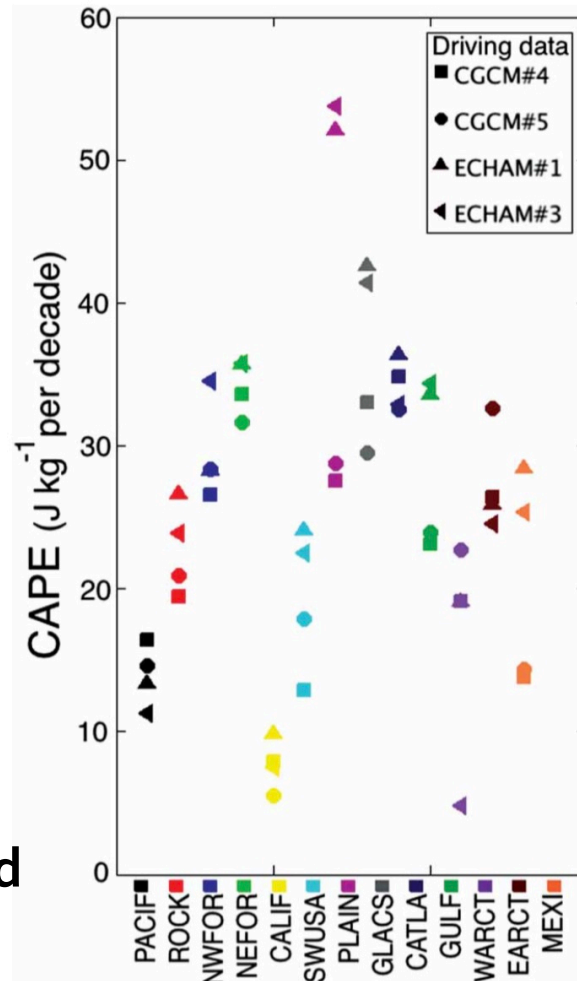
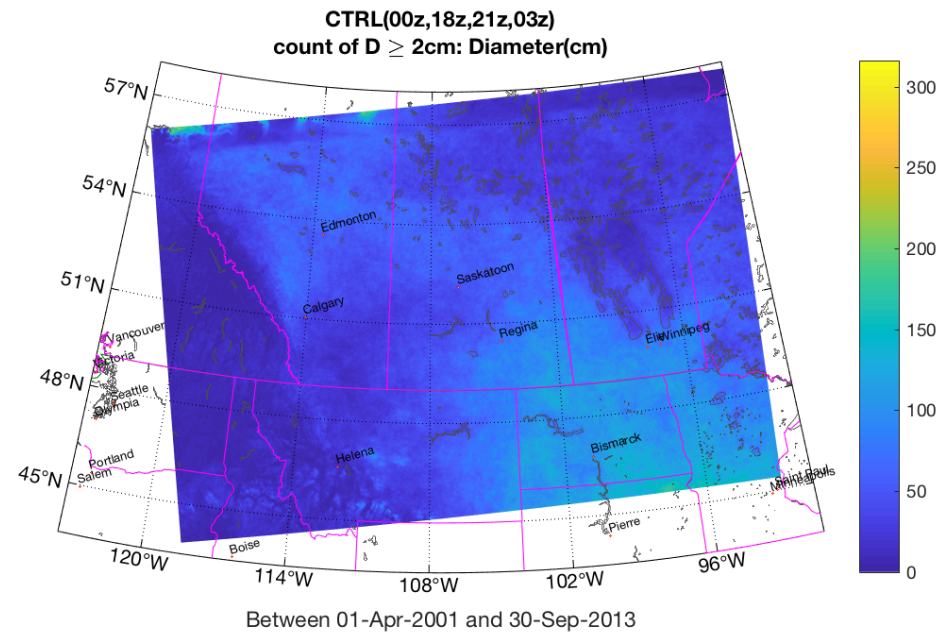
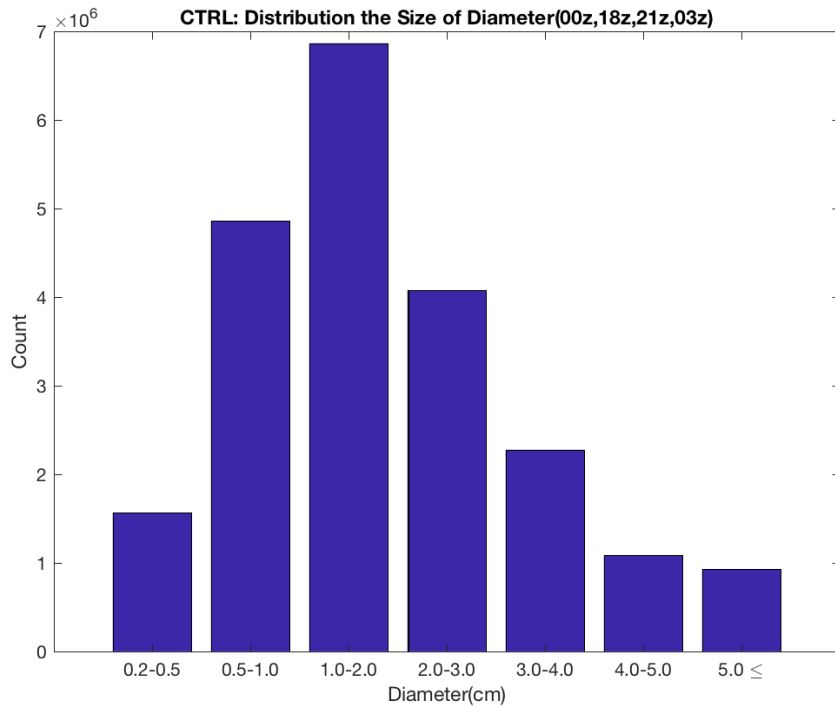


Fig. 10. As in Fig. 9 but for S6 (m s⁻¹ per decade).

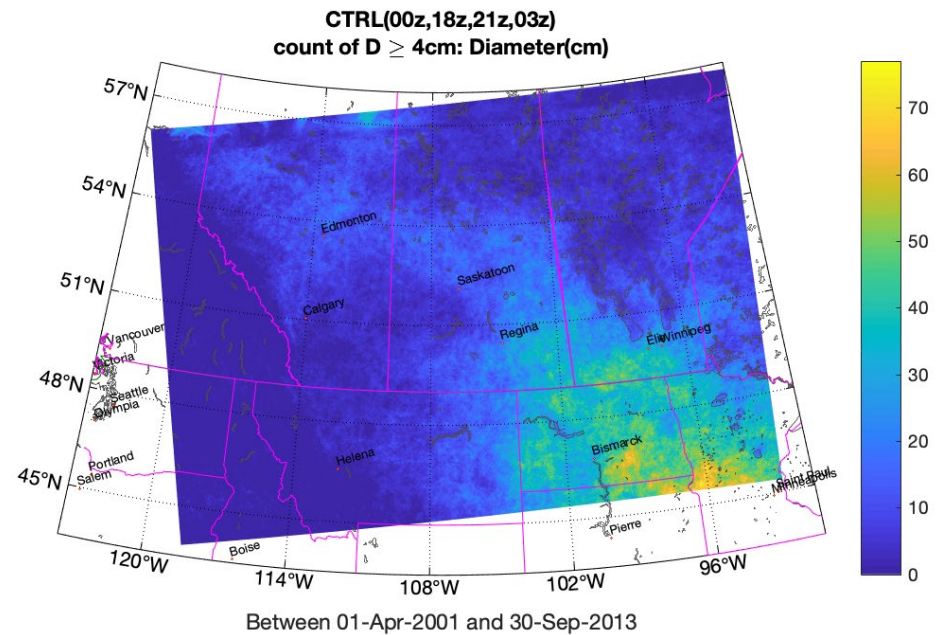
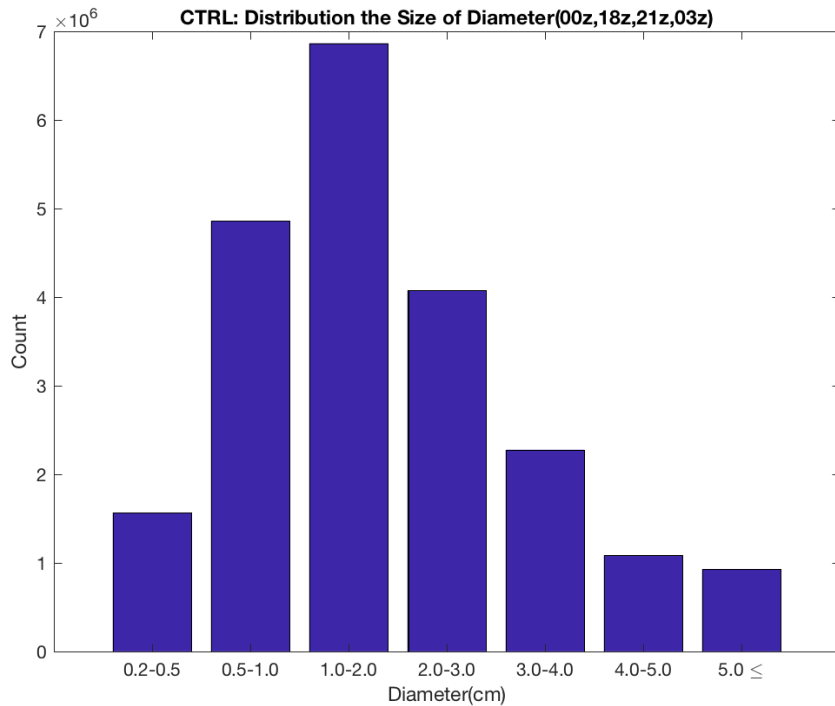
Results: Climate Verification

CTRL Hail ge 2 cm & 4 cm



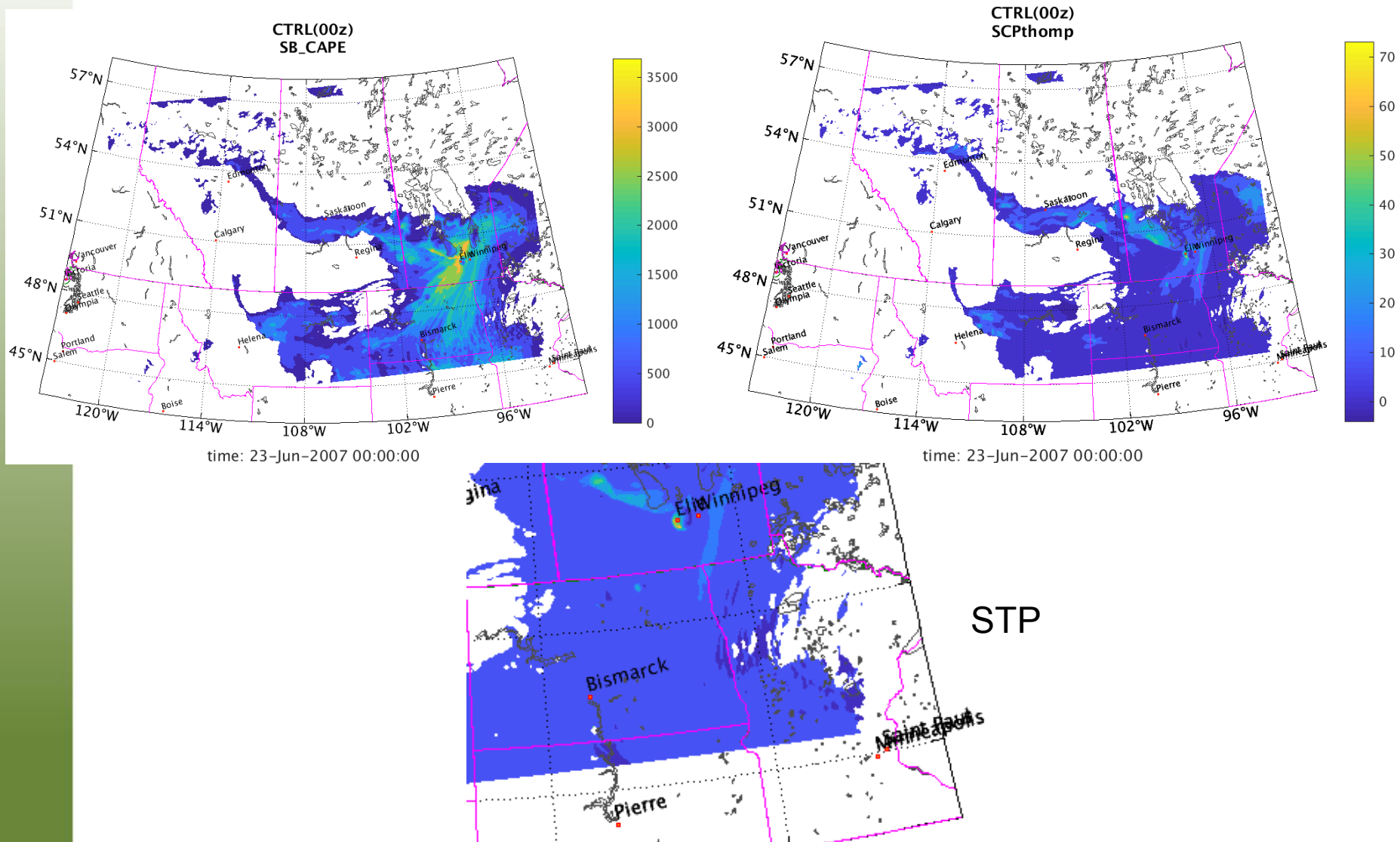
Results: Climate Verification

CTRL Hail ge 2 cm & 4 cm

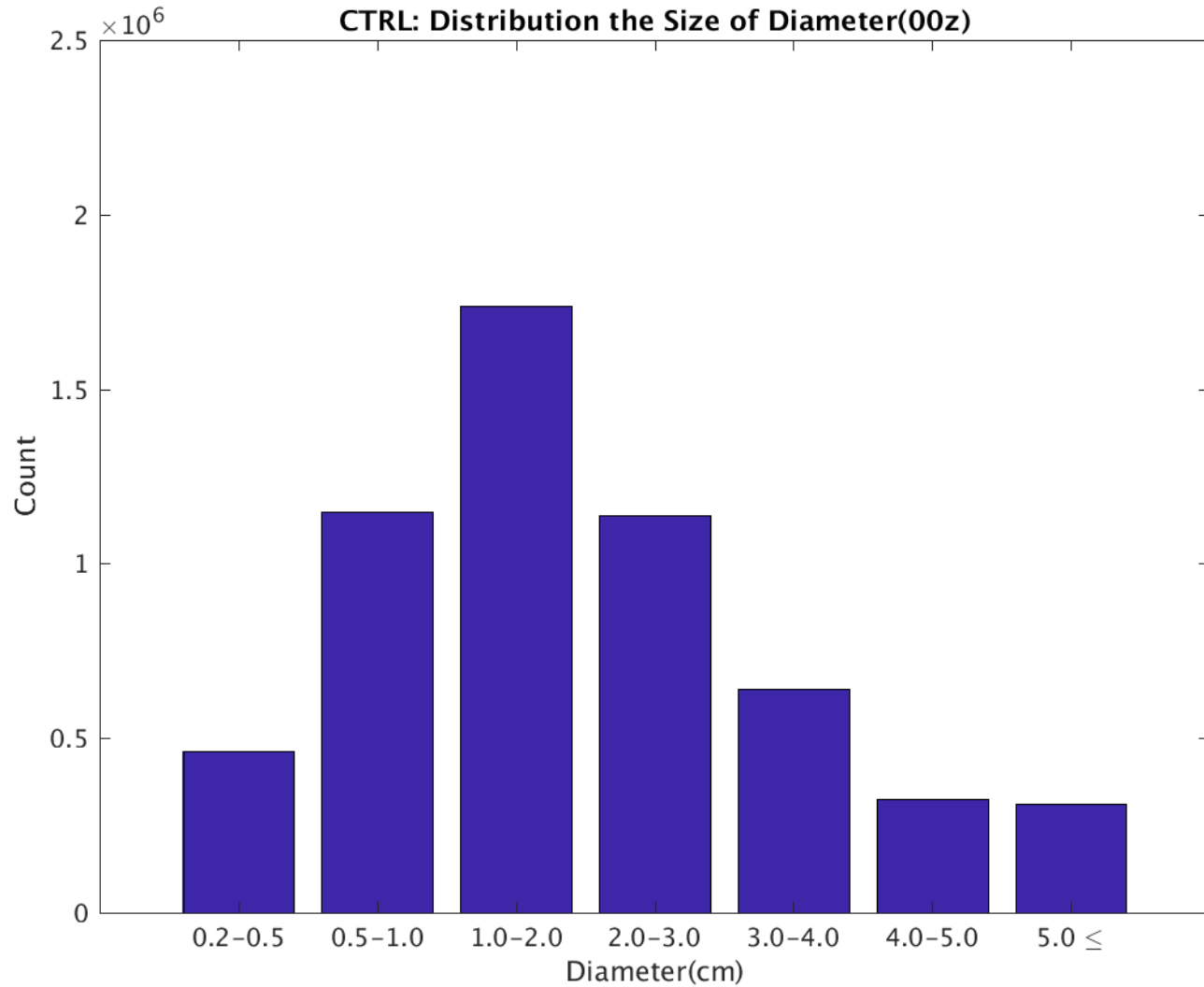


Results: Case Study Verification

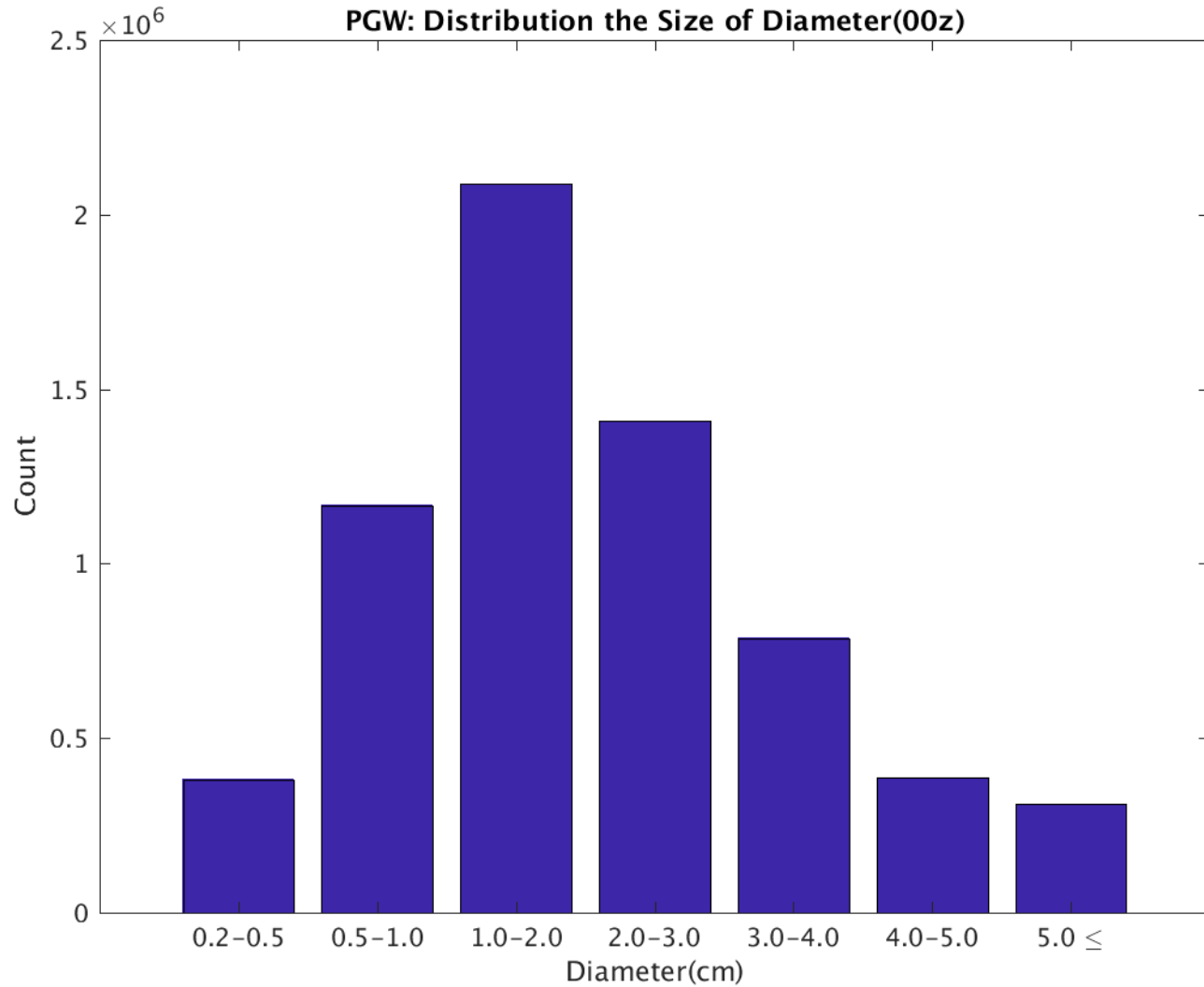
Elie, MB Tornado and Hail – June 22, 2007



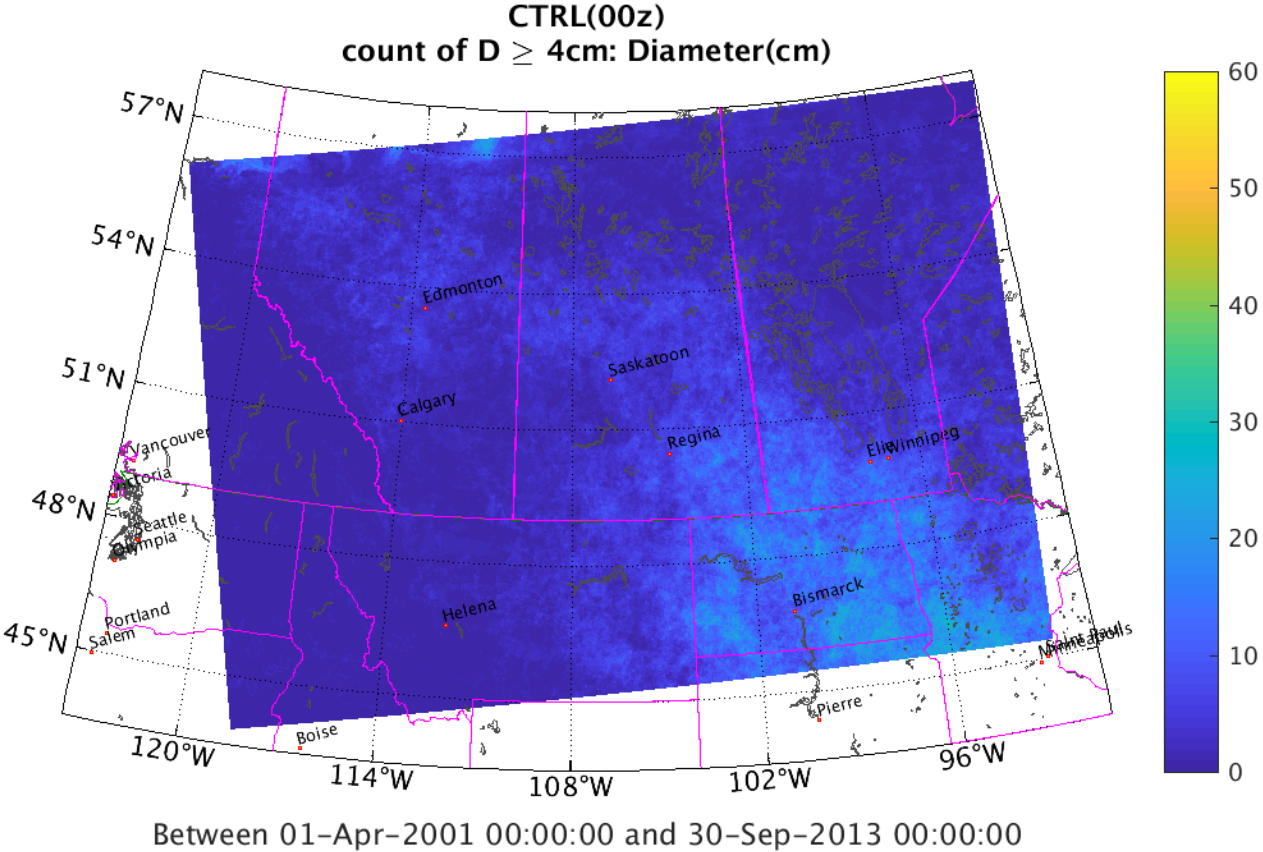
Results: PGW vs CTRL



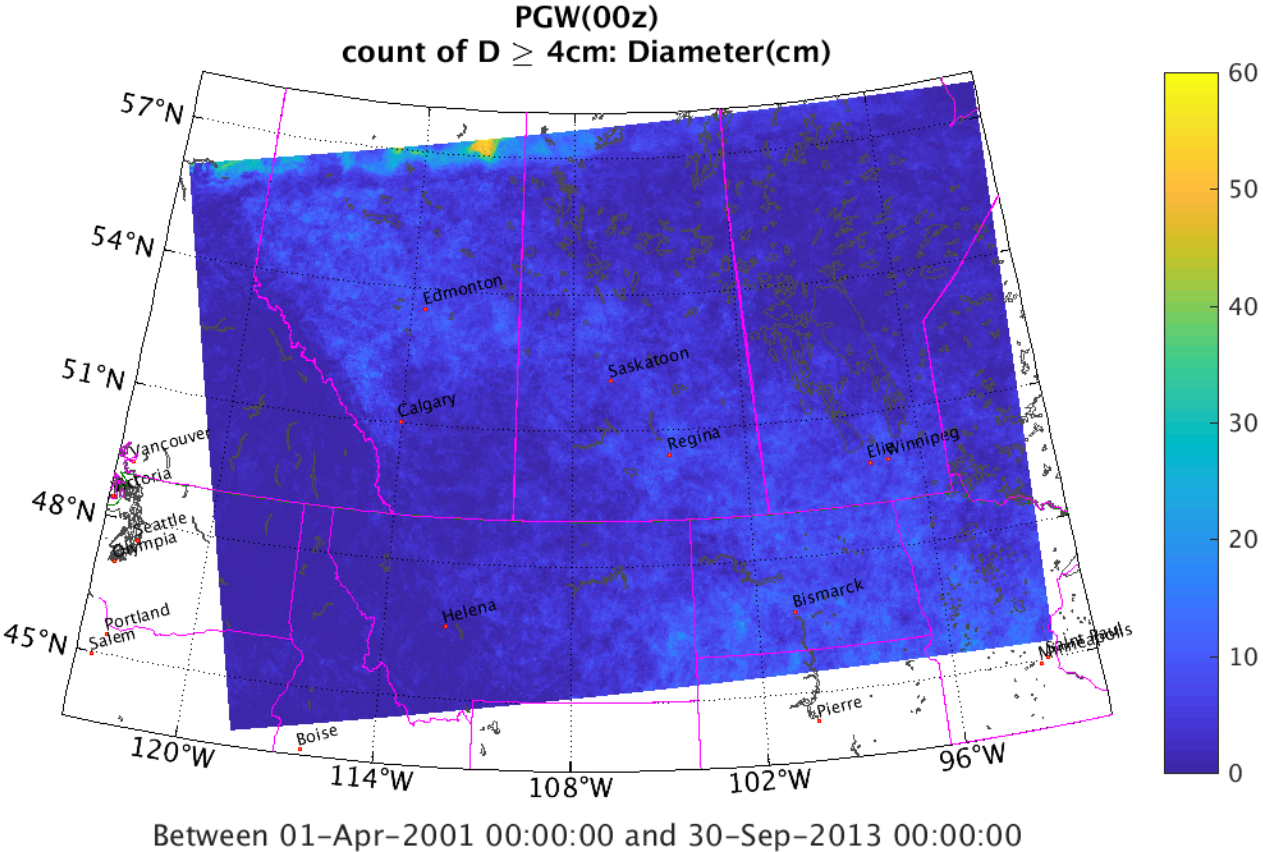
Results: PGW vs CTRL



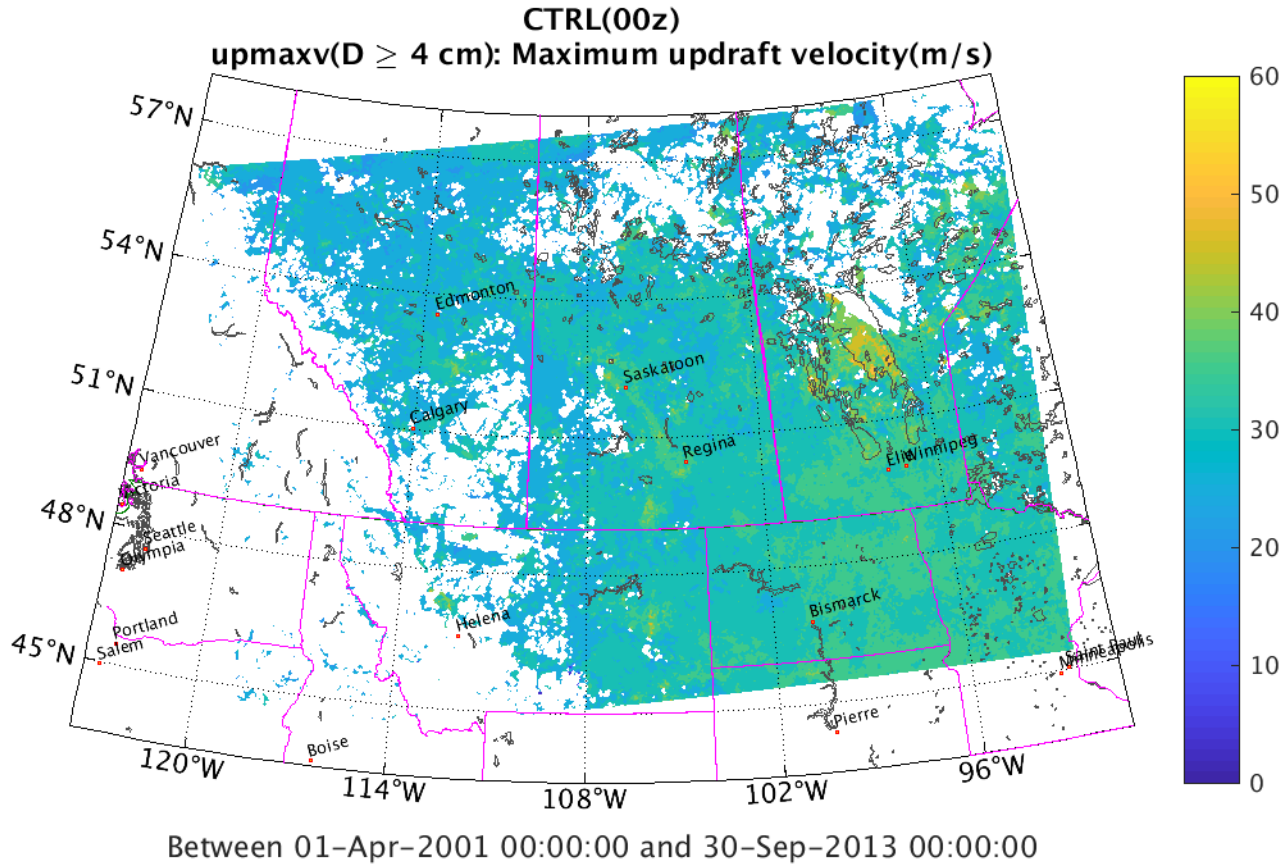
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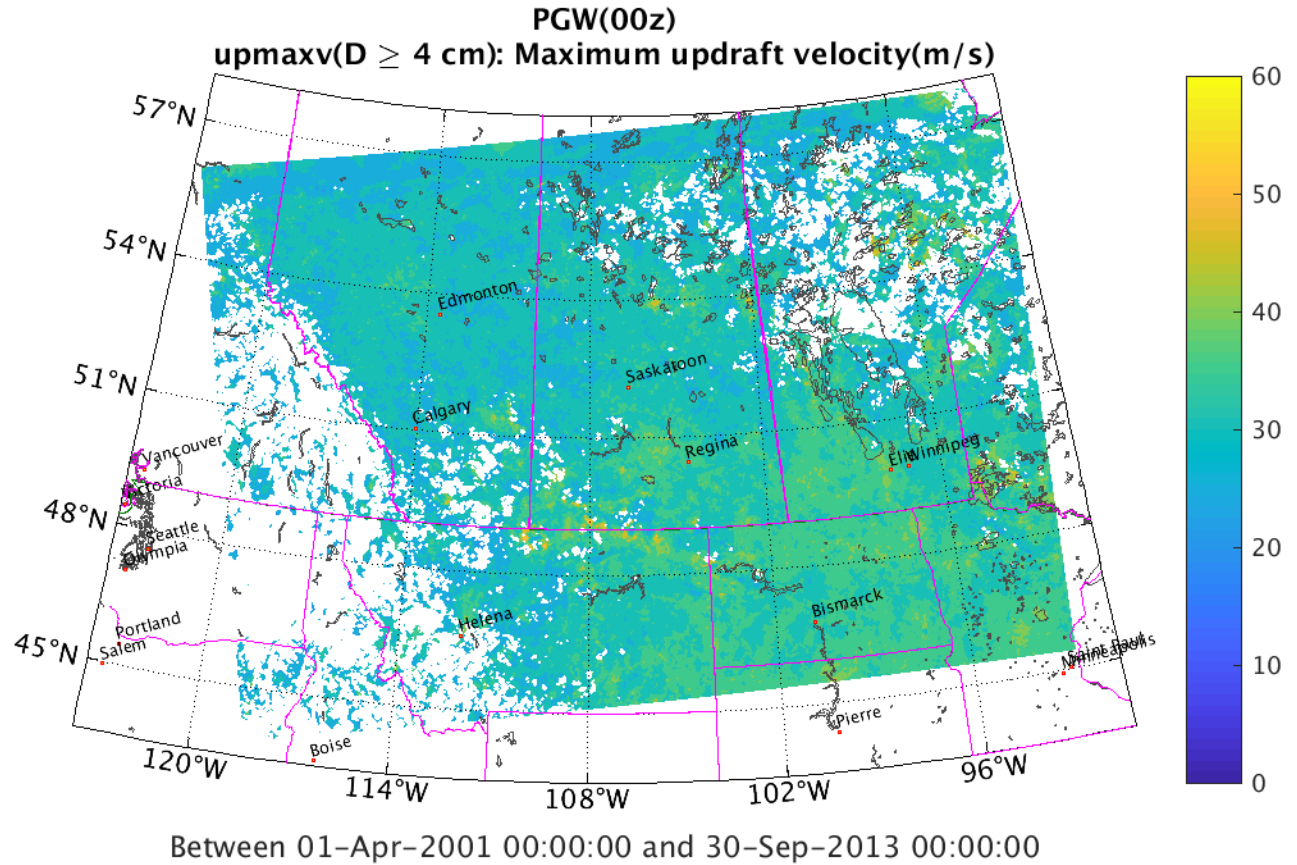
Results: PGW vs CTRL



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Results: PGW vs CTRL



Next Steps

- We are pretty confident in WRF simulations to reproduce hail & severe weather climatology
- Complete PGW – CTRL analysis of key variables
- Working with Mary Kelly and Laura Twidle to gather significant insurance related events – use this for analysis below
- Examine future changes in hail, heavy rain and severe weather :
 - occurrence changes (over entire domain & specific areas)
 - distribution of hail size and heavy rain amount (histograms)
 - changes in case studies (events)
 - create diagrams/plots useful to partners

Acknowledgements

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- **Nicole Loeb, Jennifer Bruneau (plotting)**



Cianne McLean