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Design Snow Water Equivalent and Snowmelt

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NH Climate Summit

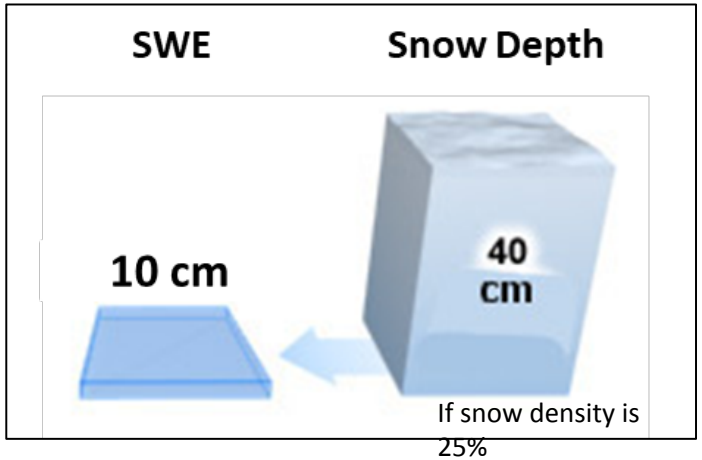
May 26, 2020 (Thursday)

Background Snow-driven Extreme Events in U.S. and Canada

- Snow and snowmelt driven extreme events can have large societal and economic consequences. Extreme snow can ***damage infrastructure*** *(e.g. dams)* ***and buildings***.
- Snow meltwater with rain-on-snow event is a dominant driver of ***severe spring floods*** in the north-central and -eastern U.S. and southern Canada.
- The current and future snowpack and snowmelt extreme design maps are very limited ***due to the lack of reliable long-term snow data***.

Background Importance of snow water equivalent (SWE)

Exceeded design values of snow loads on building roof



Accurate, spatially distributed SWE data are important to develop design extreme SWE and snowmelt maps

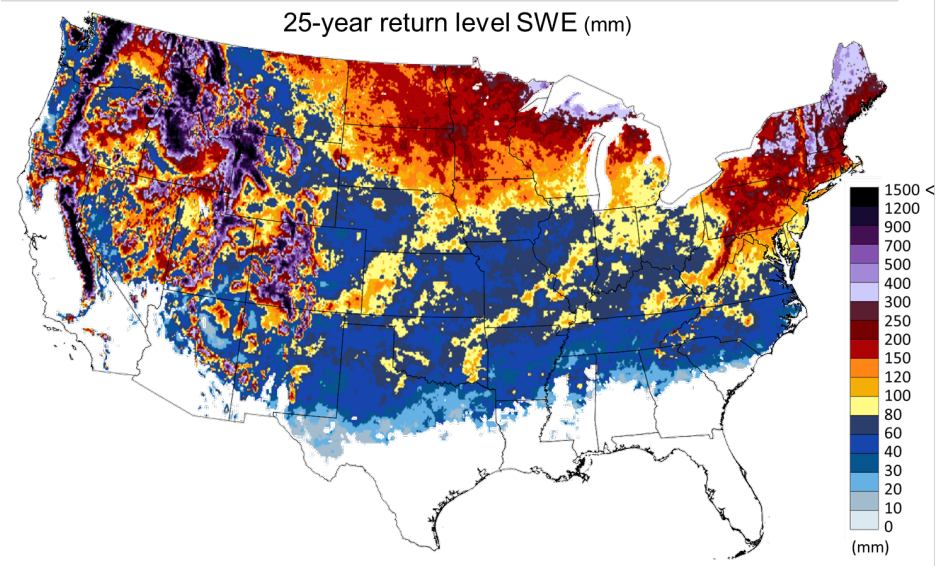
Motivation & Research Questions

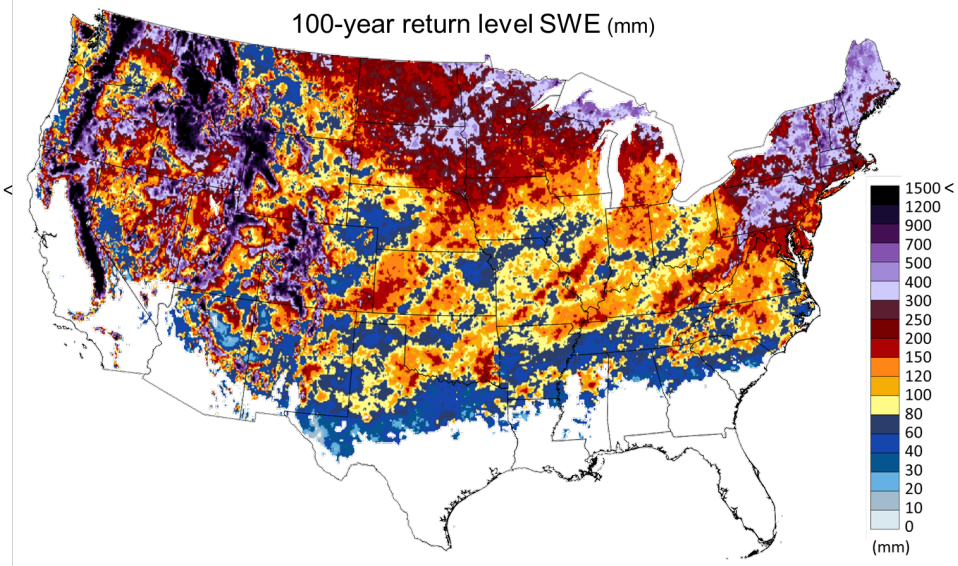
The "current" U.S. government standard design precipitation maps (e.g. NOAA Atlas 14) are based on liquid precipitation data with ***very limited guidance on snowmelt-driven floods.***

Q1. How different are design extreme SWE and snowmelt using the current available long-term SWE datasets from the NOAA Atlas 14 design standard map?

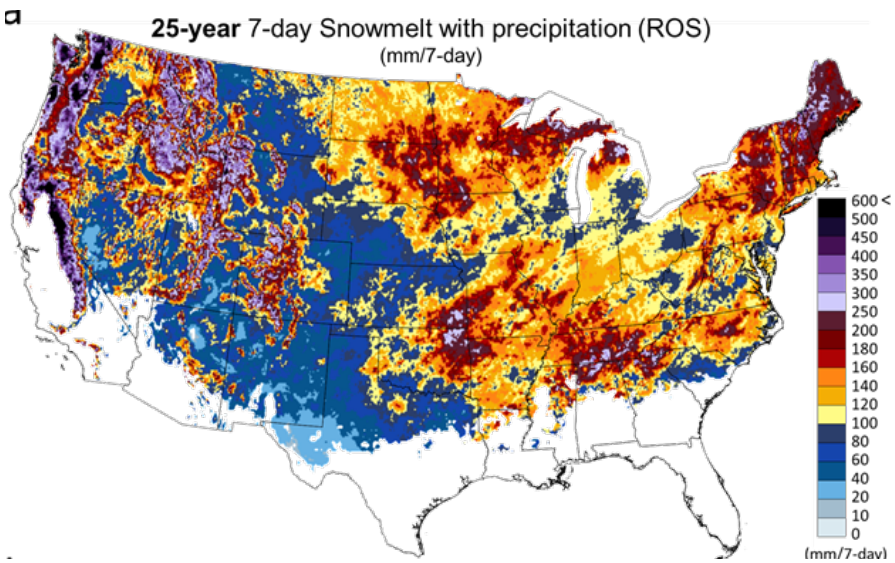
Q2. Which regions are vulnerable to extreme snowmelt events if infrastructures were designed based on the Atlas 14 standard values?

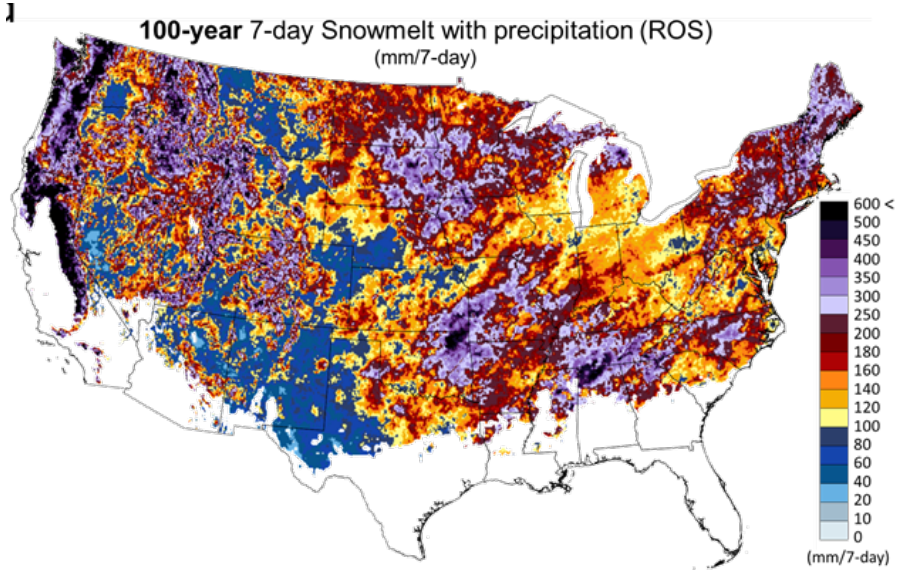
Result 1 25- and 100-year Return Level SWE



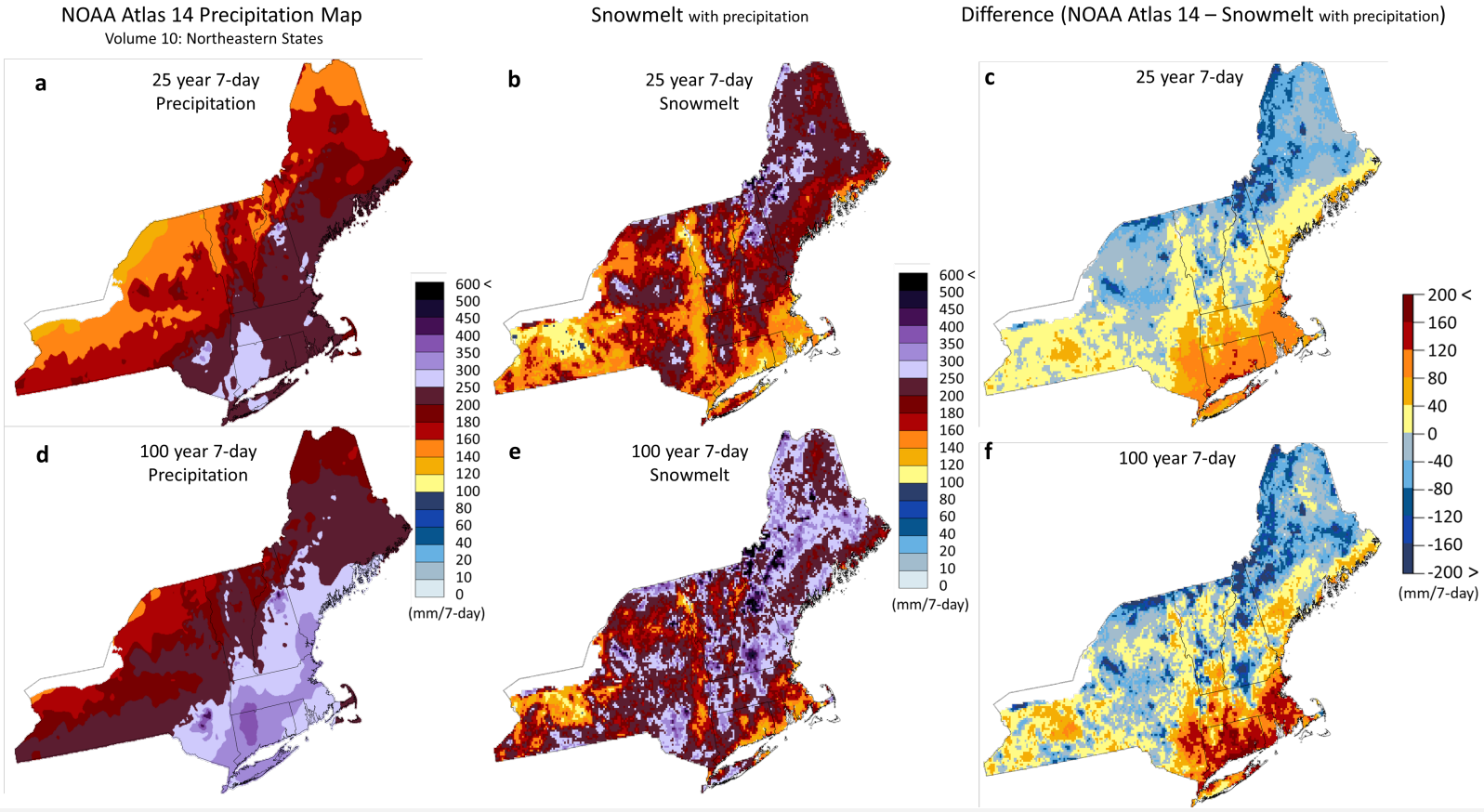


Result 1 25- and 100-year Snowmelt with precipitation





Result 2 NOAA Atlas 14 maps vs. snowmelt with precip. Maps for New England



Conclusion 1

Q1. How different are design extreme SWE and snowmelt using the current available long-term SWE datasets from the NOAA Atlas 14 design standard map?

✓ The **7-day extreme snowmelt values** exceed the Atlas 14 standard design values in **23% of the total extent**.

Q2. Which regions are vulnerable to extreme snowmelt events if infrastructures were designed based on the Atlas 14 standard values?

✓ In the **northeastern U.S.** near the Canadian border, the **north central** U.S. where just 10 cm of SWE can cause spring flooding, and the western mountainous U.S., **design snowmelt substantially exceeds the Atlas 14 design values**.

Additional Question

However…
Hydrologists and water resources engineers are still challenged to plan and design infrastructure for ***the "future" SWE & snowmelt extremes in a changing climate****.*

- ✓ Q3. How much will snow-related extreme values (1. **Snowpack**, 2. **Snowmelt**, and 3. **Runoff Potential** *[snowmelt + precipitation]*) be changed in the mid-century and late-century from the current condition?

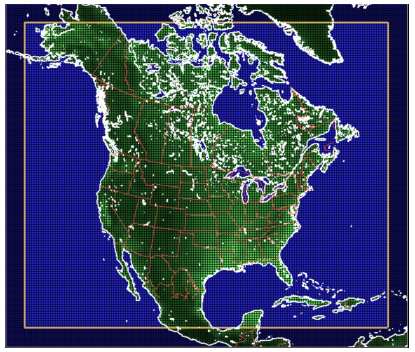
NA-CORDEX SWE data

- ***North America COordinated Regional Downscaling Experiment (NA-CORDEX)*** regional climate model (RCM) ensemble.
- Multiple RCMs are used to dynamically downscale multiple CMIP5 global climate models (GCMs).
- 25km resolution SWE simulations (3 RCMs, 7 GCMs, **9 Simulations**)

- **Study period**
- **Historical (1976 – 2005)**
- **Mid-century (2040 – 2069)***
- **Late-century (2070 – 2099)***

*Future runs follows **RCP8.5** emissions scenario

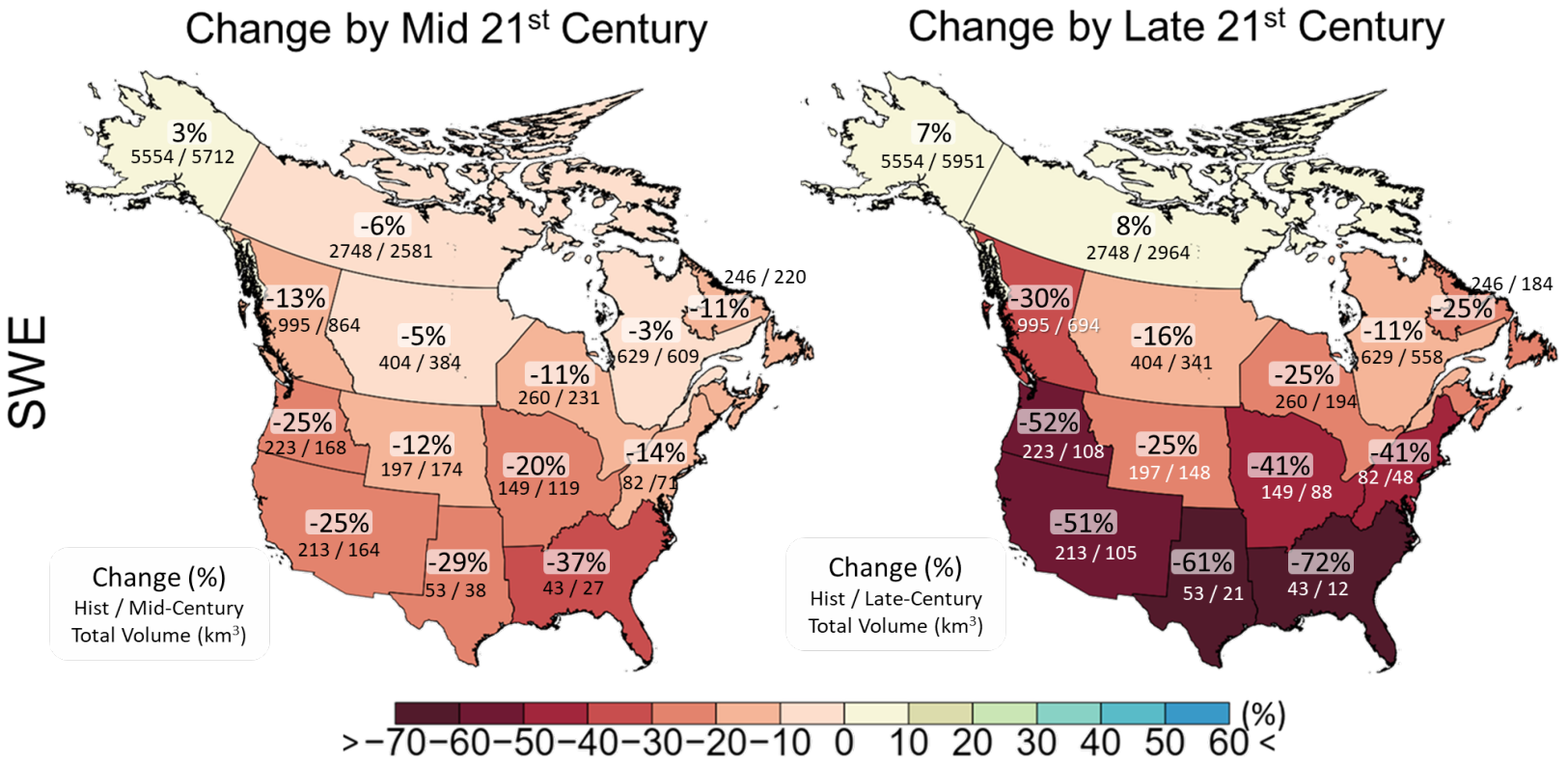
Full NA-CORDEX Domain



GCMs \ RCMs	CRCM5 (UQAM)	RegCM4	WRF	CanRCM4
HadGEM2-ES		X	X	
CanESM2	X			X
MPI-ESM-LR	X	X	X	
MPI-ESM-MR	X			
GFDL-ESM2M		X	X	
GEMatm-Can	X			
GEMatm-MPI	X			

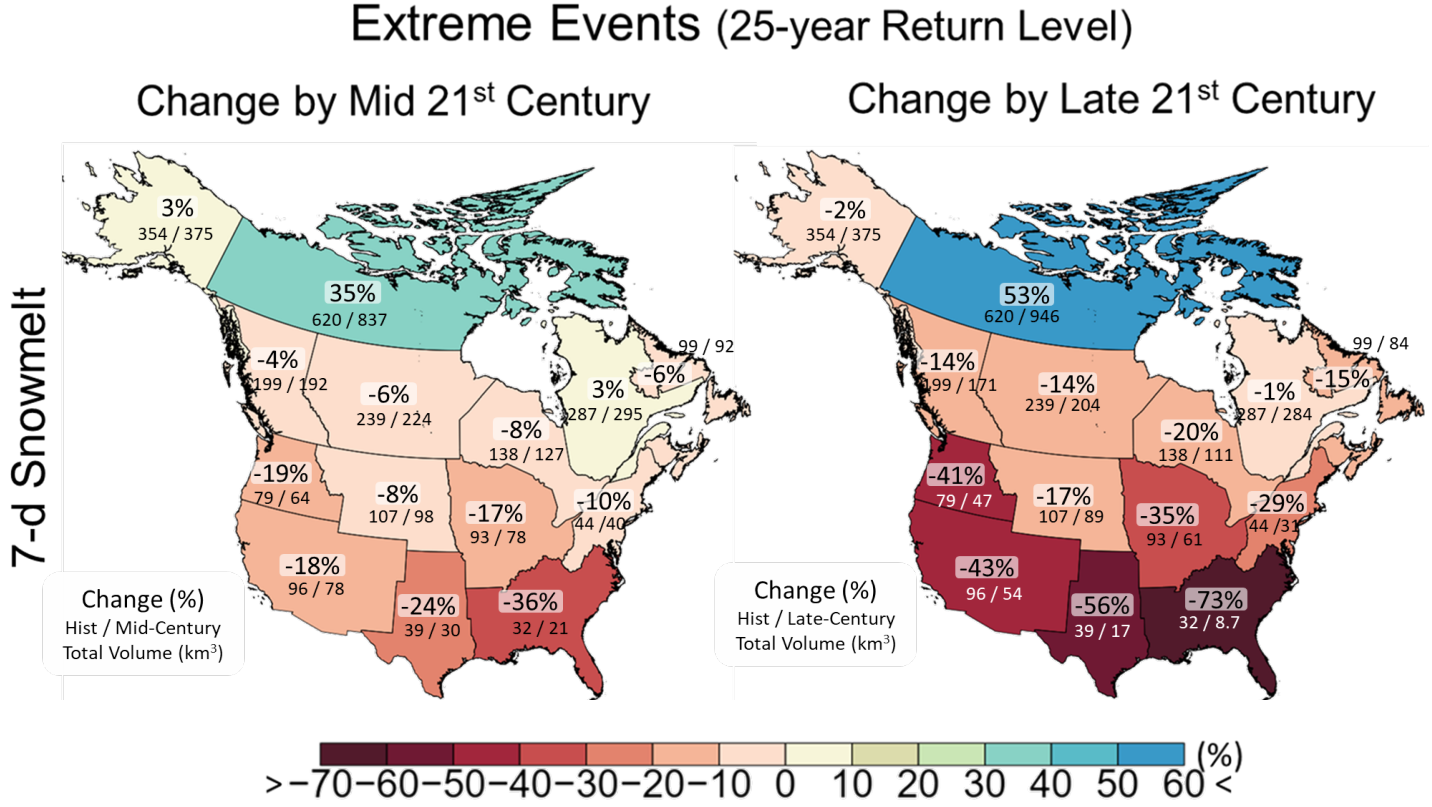
* RegCM4 models are excluded due to unrealistic wet estimates & numerical problems with snow.

Result 3 – Future Changes in SWE by regional boundaries

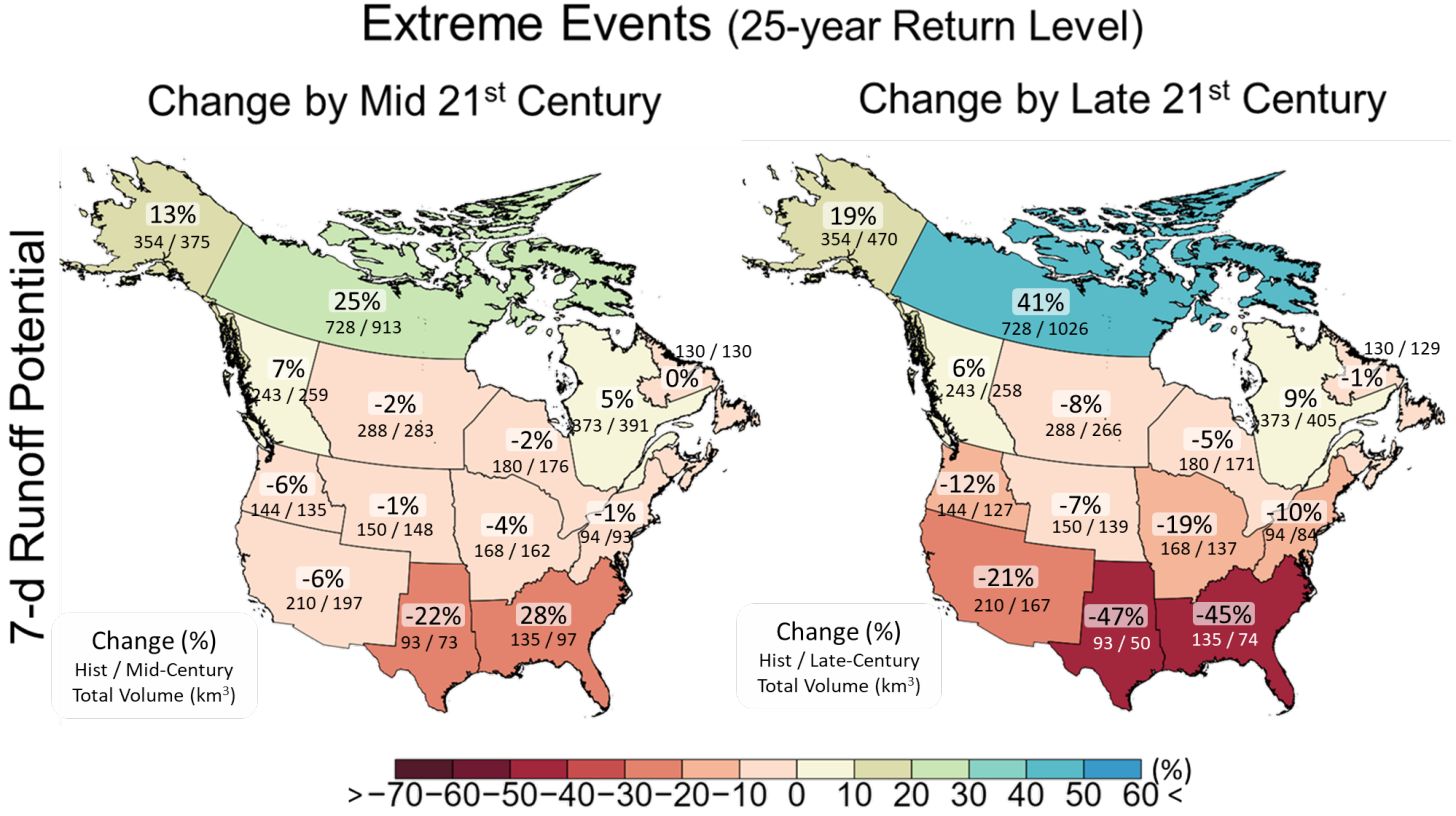


**US National Climate Report & Canada's Changing Climate Report*

Result 2 – Future Changes in Snowmelt by regional boundaries



Result 2 – Future Changes in RP by regional boundaries



Conclusion 2

Q3. How much will snow-related extreme values be changed in the mid-century and late-century across the north America?

1. **Extreme SWE values will decrease** by up to 150 mm (mid-century) and 500 mm (late-century) respectively over the US, **but increase in the Alaska and northern Canada**

2. Similarly, **7-d snowmelt will decrease** by 50 and 100 mm over U.S. but **increase in the Alaska and northern Canada**.

Thank you for listening, Questions?

If you have additional questions or comments, feel free to email me!

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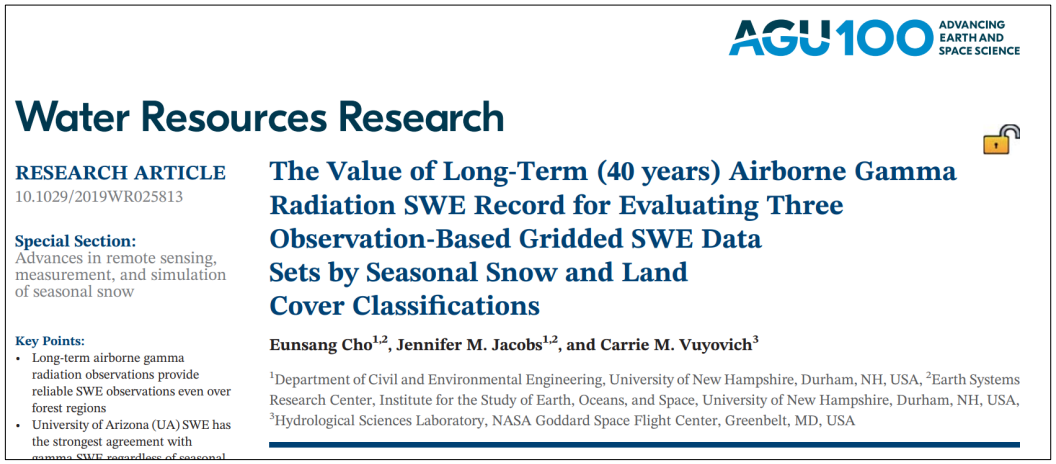
Supplementary Information

Relevant References

Cho, E., J.M. Jacobs, C. Vuyovich (2020) The value of long-term (40 years) airborne gamma radiation SWE record for evaluating three observation-based gridded SWE datasets by seasonal snow and land cover classifications, ***Water Resources Research,*** ***featured in AGU EOS Research Spotlight!***
Also awarded as 2020 AGU WRR Editor's Choice Award yesterday!



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Water Resources Research

RESEARCH ARTICLE
10.1029/2019WR025813

Special Section:
Advances in remote sensing, measurement, and simulation of seasonal snow

Key Points:
- Long-term airborne gamma radiation observations provide reliable SWE observations even over forest regions
- University of Arizona (UA) SWE has the strongest agreement with

The Value of Long-Term (40 years) Airborne Gamma Radiation SWE Record for Evaluating Three Observation-Based Gridded SWE Data Sets by Seasonal Snow and Land Cover Classifications

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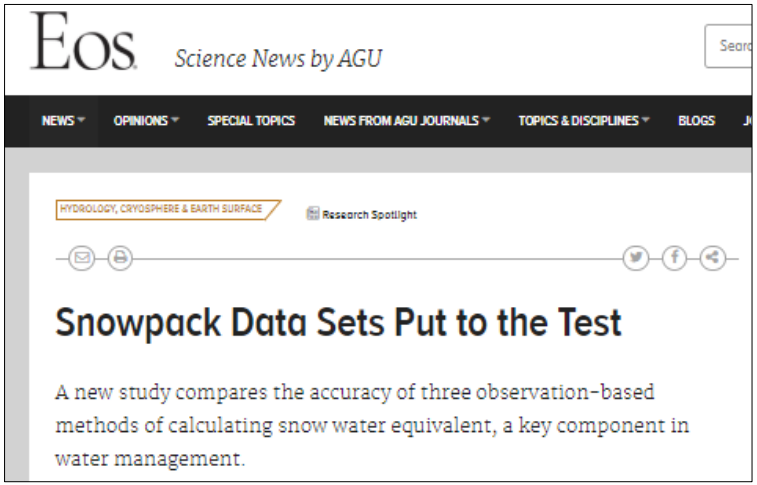

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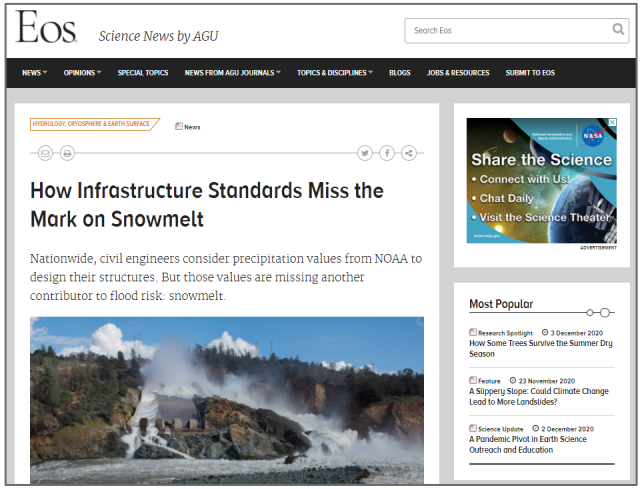
Snowpack Data Sets Put to the Test

A new study compares the accuracy of three observation-based methods of calculating snow water equivalent, a key component in water management.

Relevant References

Cho, E., & Jacobs, J. M. (2020). **Extreme Value Snow Water Equivalent and Snowmelt for Infrastructure Design over the Contiguous United States**. *Water Resources Research*. ***featured in AGU EOS Science News!***

Cho, E., Rachel R. McCrary, Jennifer M. Jacobs **Future Snow Water Equivalent and Snowmelt Extremes from Regional Climate Model Ensembles** *Earth's Future (in prep.)*



Water Resources Research

RESEARCH ARTICLE
10.1029/2020WR028126

Key Points:
- The 25- and 100-year design extreme SWE and snowmelt maps were developed by GEV probability distribution using the UA and SNODAS SWE
- The 7-day snowmelt exceeds the NOAA Atlas 14 standard design precipitation in 23% of the CONUS

Extreme Value Snow Water Equivalent and Snowmelt for Infrastructure Design Over the Contiguous United States

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