# Climate Driven Changes in Snow Regime Classifications of the Continental United States


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## ABSTRACT


Much of the world's water resource infrastructure is experiencing rapid shifts in climate and snowmelt. Changing snowmelt regimes are responsible for rain-on-snow river flooding, putting communities at risk. Our study uses a new Snow Regime Classification system as a proxy for tracking climate driven changes in hydrology across the contiguous US over 40 years (1981-2020). Snow regimes are calculated annually, with changes evaluated across decadal and 30-year time scales. Our Snow Regime technique designates areas across CONUS as: (1) rain dominated (***RD***), (2) snow dominated (***SD***), (3) transitional (transient mix of rain and snow; ***R/S***), or (4) as perennial snow cover (***PS***). Class thresholding ratios involve snow water equivalent (SWE) over cumulative cool-season precipitation (October through March).


## BACKGROUND

- Snowmelt is a significant portion of streamflow across the U.S.
- Rain-on-Snow (RoS) events occur when warm storm systems deposit substantial rain on extensive snow cover.
- RoS events are responsible for some of the largest and most devastating floods in the US (e.g., 2019 Missouri River flood).
- Flood regimes in historically snow dominated watersheds are predicted to shift away from spring snow-melt and toward more rain-dominated winter floods (*Mussleman et. al., 2018; Arnell and Gosling, 2016; Freudiger et. al., 2014*).

## METHODS

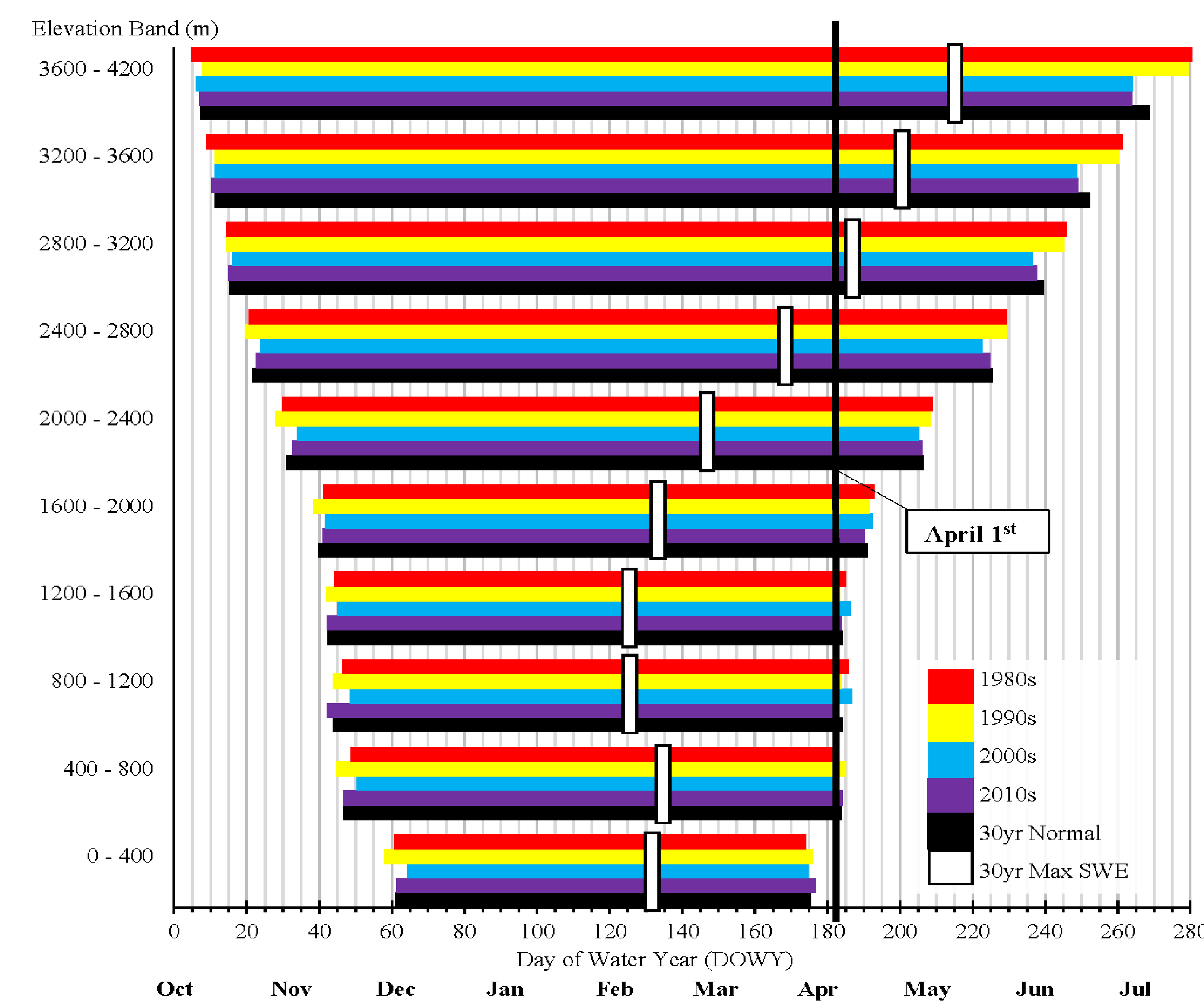
- Used daily PRISM precipitation and University of Arizona's Snow Water Equivalent (SWE) datasets
- Calculations and analysis using Google Earth Engine
- Inspected maximum SWE values and dates, start of snow accumulation, end of ablation (snowmelt), and snow cover duration
- Determined Snow Regime Classifications based on methodology from *Tohver et al. (2014)*

$$\text{Regime Ratio} = \frac{\textit{Maximum SWE}}{\textit{Cool Season Precipitation}}$$

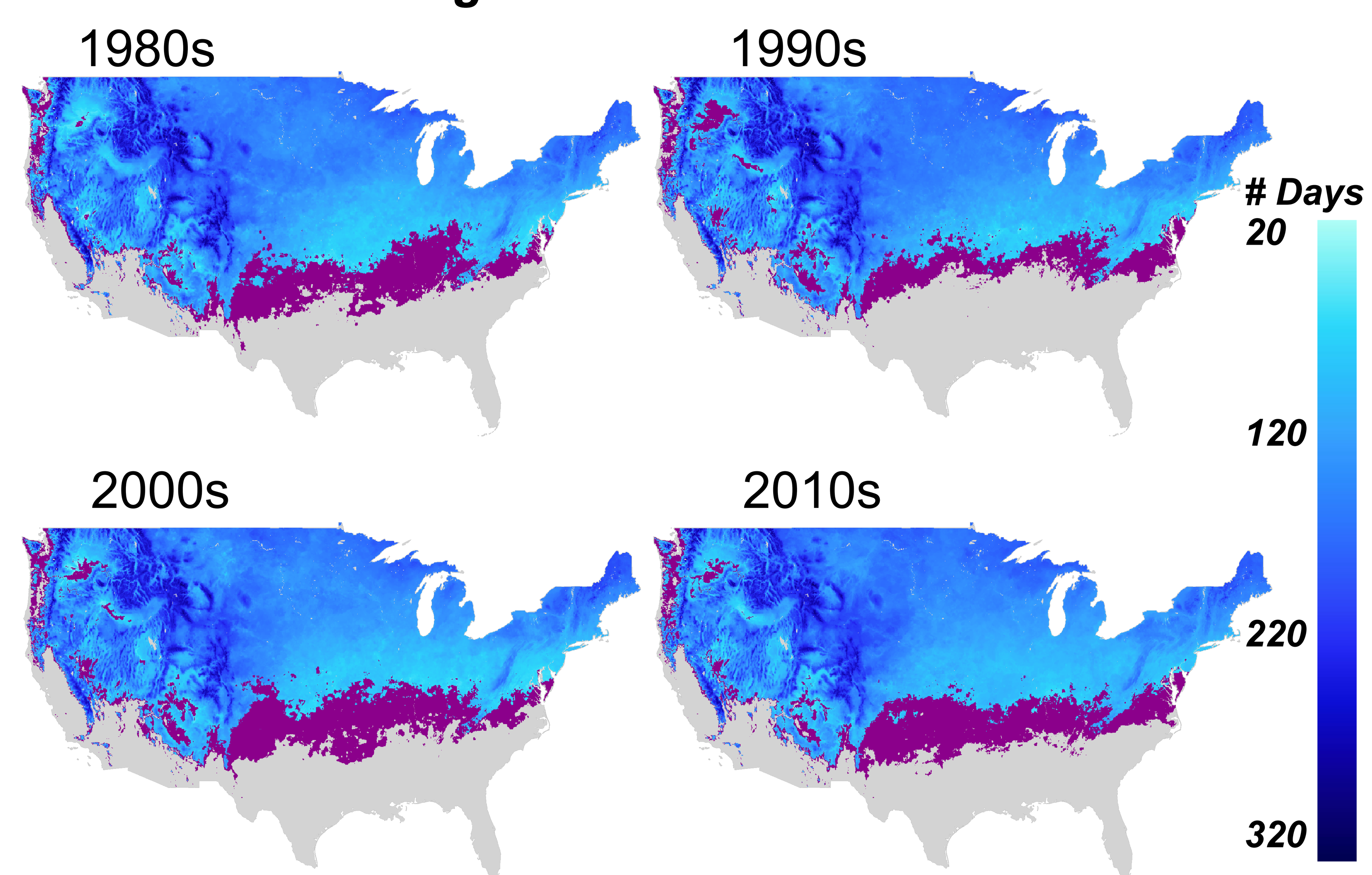
## CONCLUSIONS

- Generally, rain-dominated and transitional regimes are moving up in latitude and elevation.
- There is variability both temporally and spatially (i.e., the effects aren't uniform).
- These changes will affect both the timing and magnitude of snowmelt events.

## *Snow now dominates less of the country for less time than it did in the 20th Century*

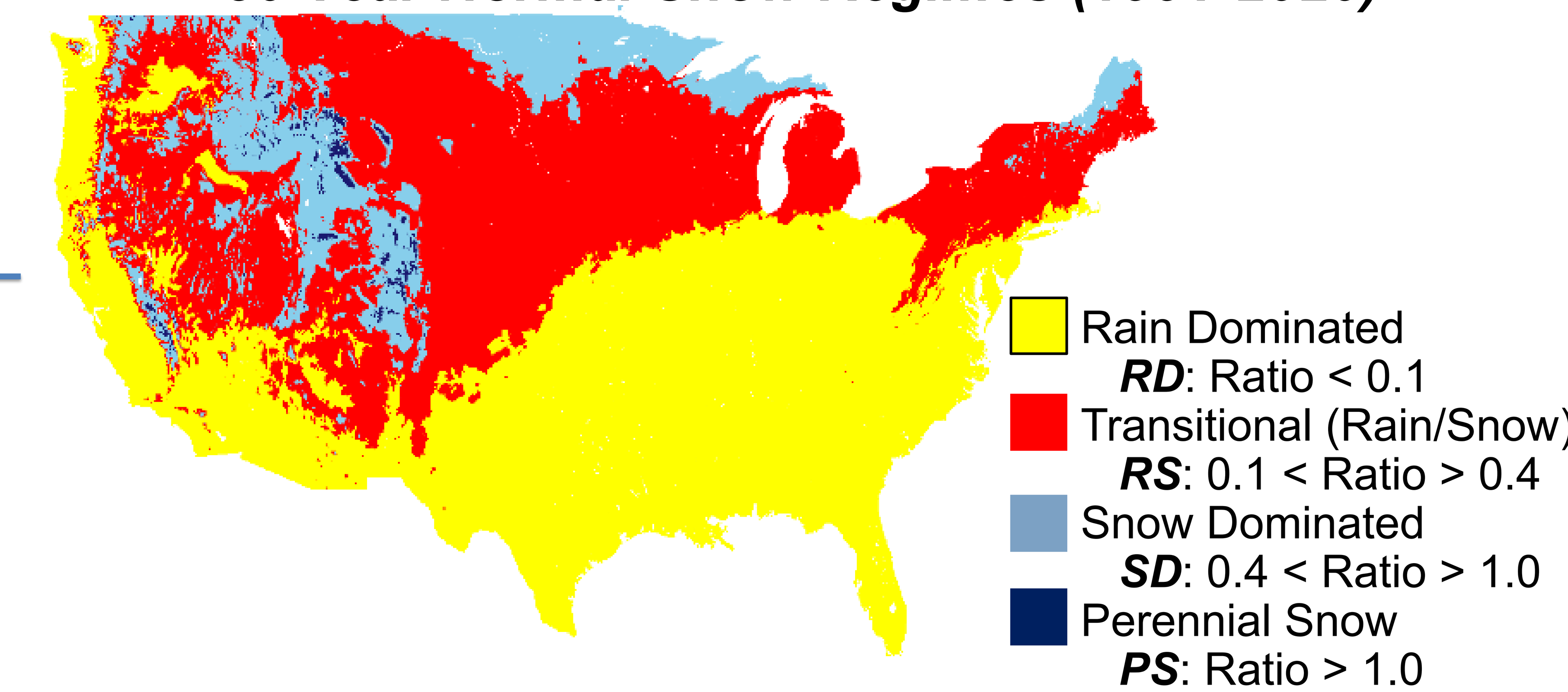



### *Average Snow Cover Duration*

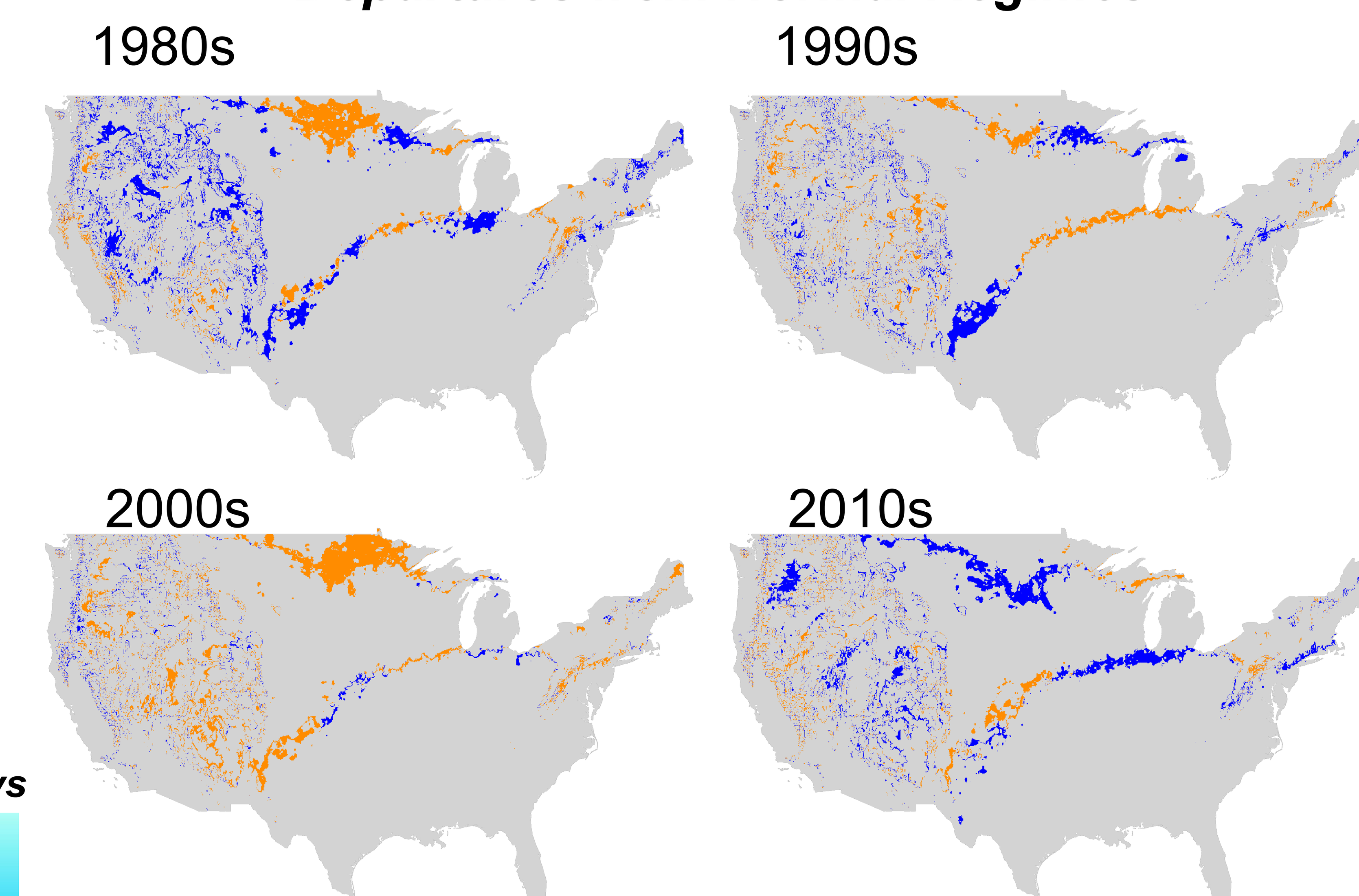



Negligible Snow Cover *(3 weeks or less SWE for all 10 yrs)*
Intermittent Snow Cover *(3 weeks or less SWE for 5-9 yrs)*

### *30 Year Normal Snow Regimes (1991-2020)*




### *Departures from Normal Regimes*




Liquid Precip **>** 30Yr Norm *(ratio decrease 1 or more class)*
Solid Precip **>** 30Yr Norm *(ratio increase 1 or more class)*

## REFERENCES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