



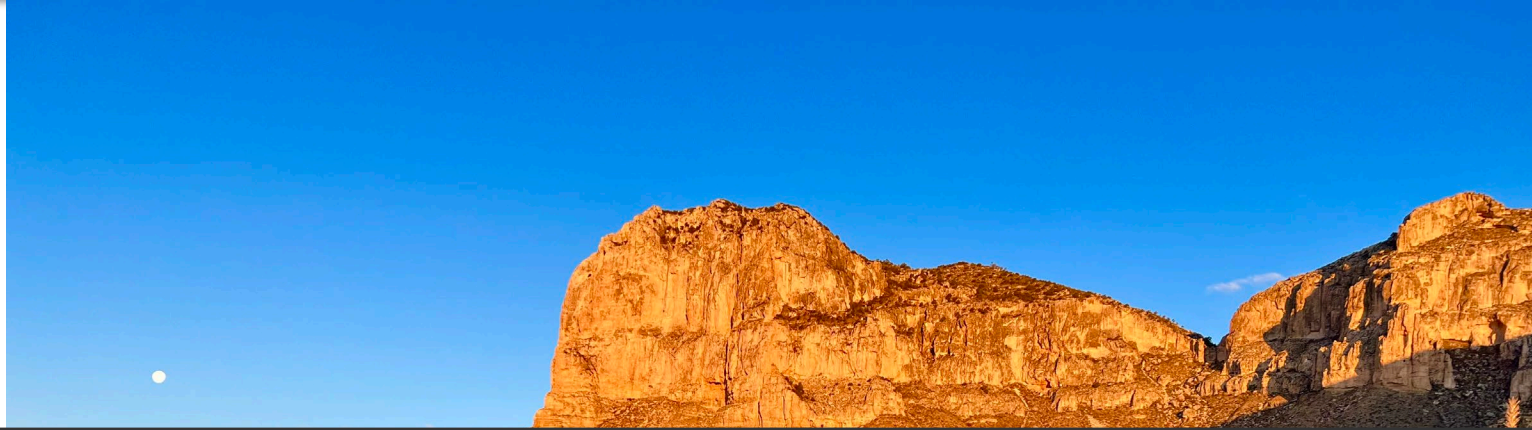
# Leveraging Variable-Resolution CESM to Understand the Drivers of a Historic Rain-on-Snow Flooding Event in Glacier National Park

**Wednesday June 11, 2025**

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# Why do we care about flooding in National Parks?



National Parks **provide** physical, emotional, cultural, and economic benefits. But for most, realizing these benefits **requires** roads, trails, and facilities





# November 2006: Glacier NP Rain-on-Snow (ROS) Flooding Event

## What Happened?

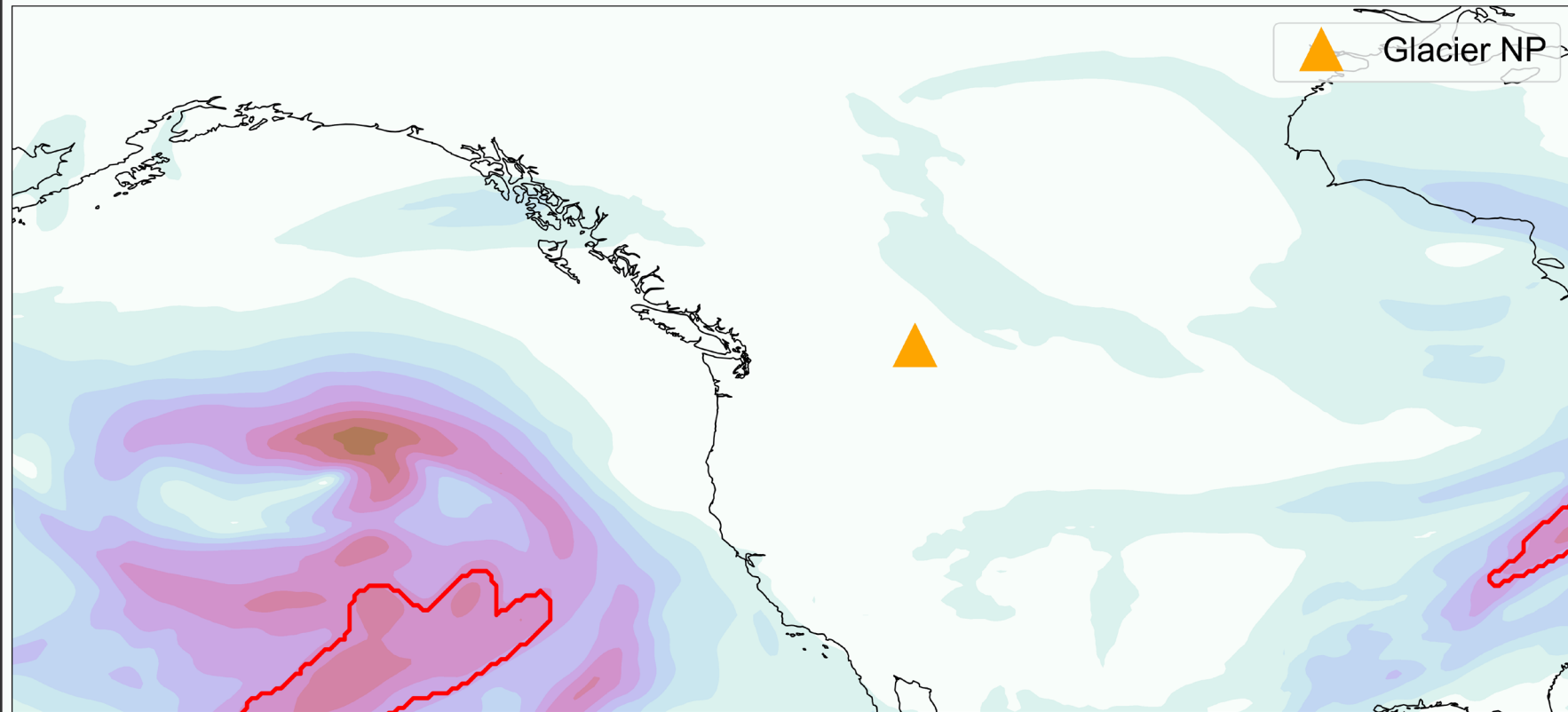
- A strong atmospheric river (AR)
  - Heavy precipitation
  - High temperatures
- Extensive damage:
  - Going-to-the-Sun Road
  - Many Glacier Hotel
- **\$5 million of damages, with emergency funding from the Federal Highways Administration**

“It’s a big, big hole...It’s significant because there’s no material. Everything’s gone.” – Ranger Matt Graves reporting on road damage near Logan Pass

Excessive rainfall caused Swiftcurrent Lake to overflow and damage the road to Many Glacier Hotel

# Family of atmospheric rivers drove ROS flooding

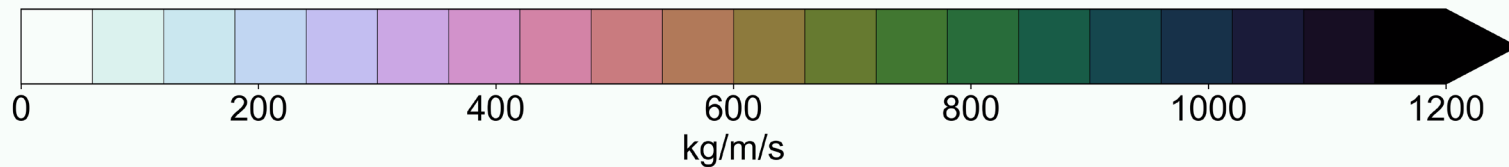
IVT at 2006-11-01-00



Red outline  
is AR  
detected by  
objective  
algorithm

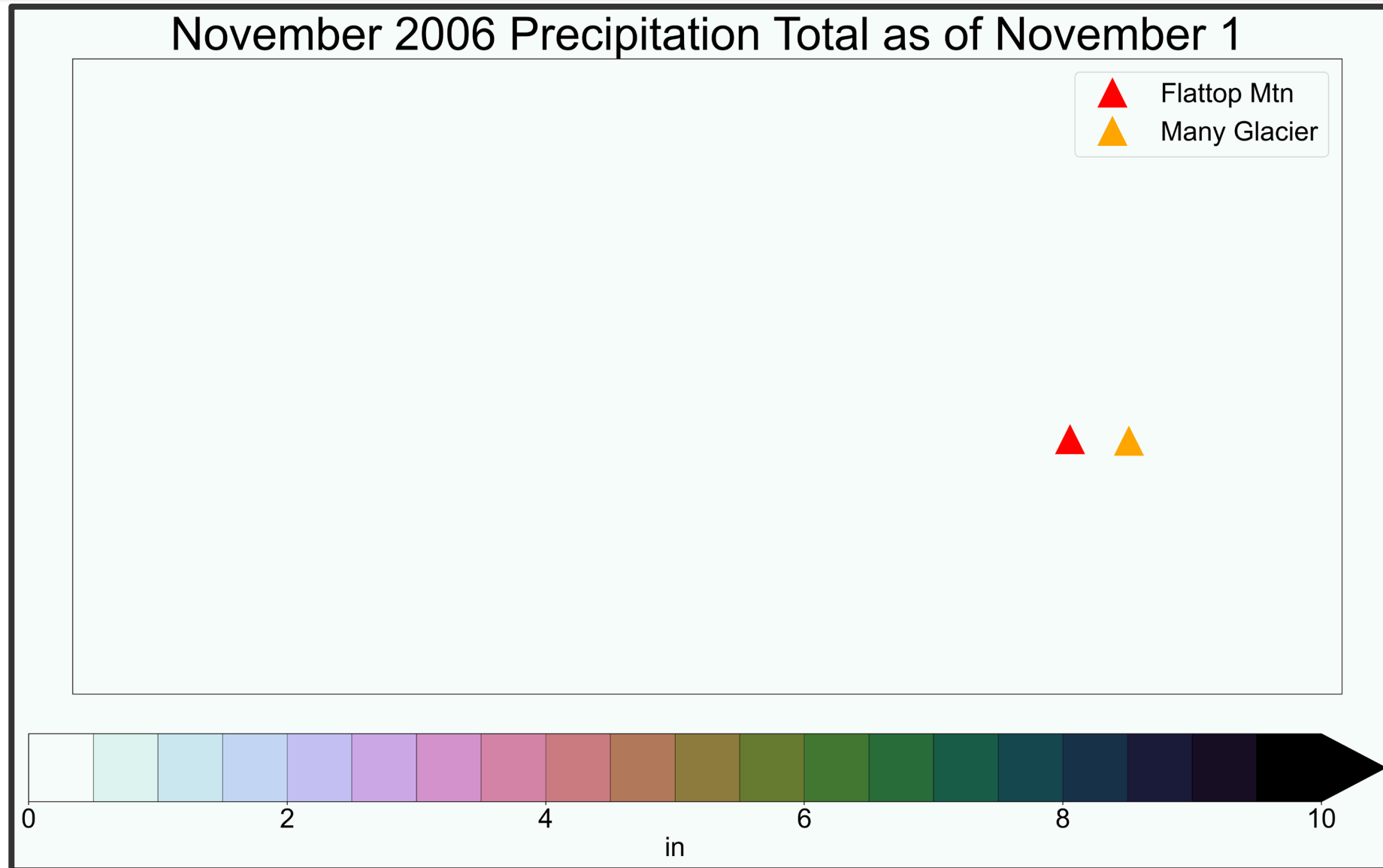
IVT =  
integrated  
water vapor  
transport

IVT from  
ERA5



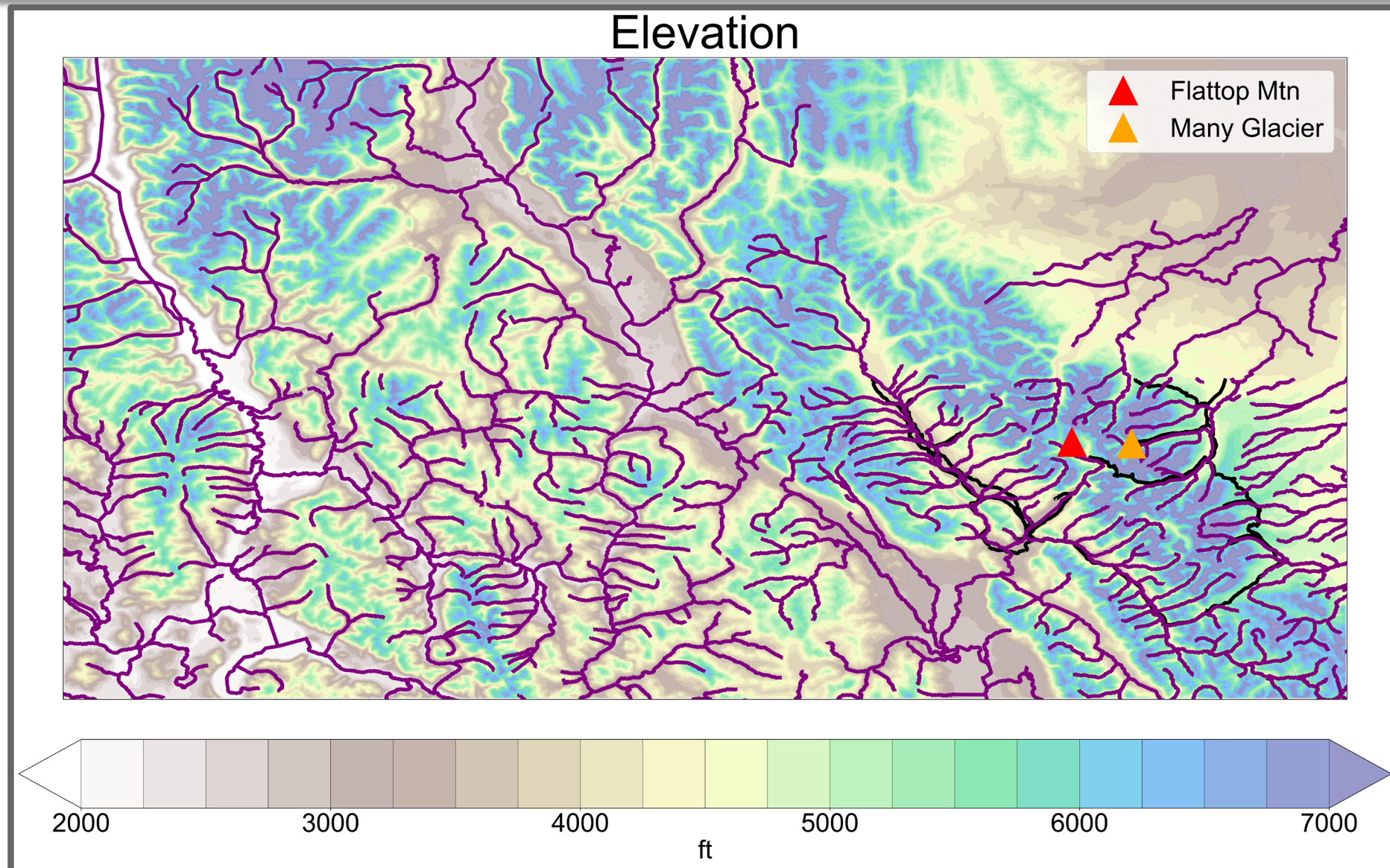


# Excessive precipitation accumulated over first days of November



1-km Daily  
Precipitation  
Data from  
CHELSA

# Glacier National Park Characteristics

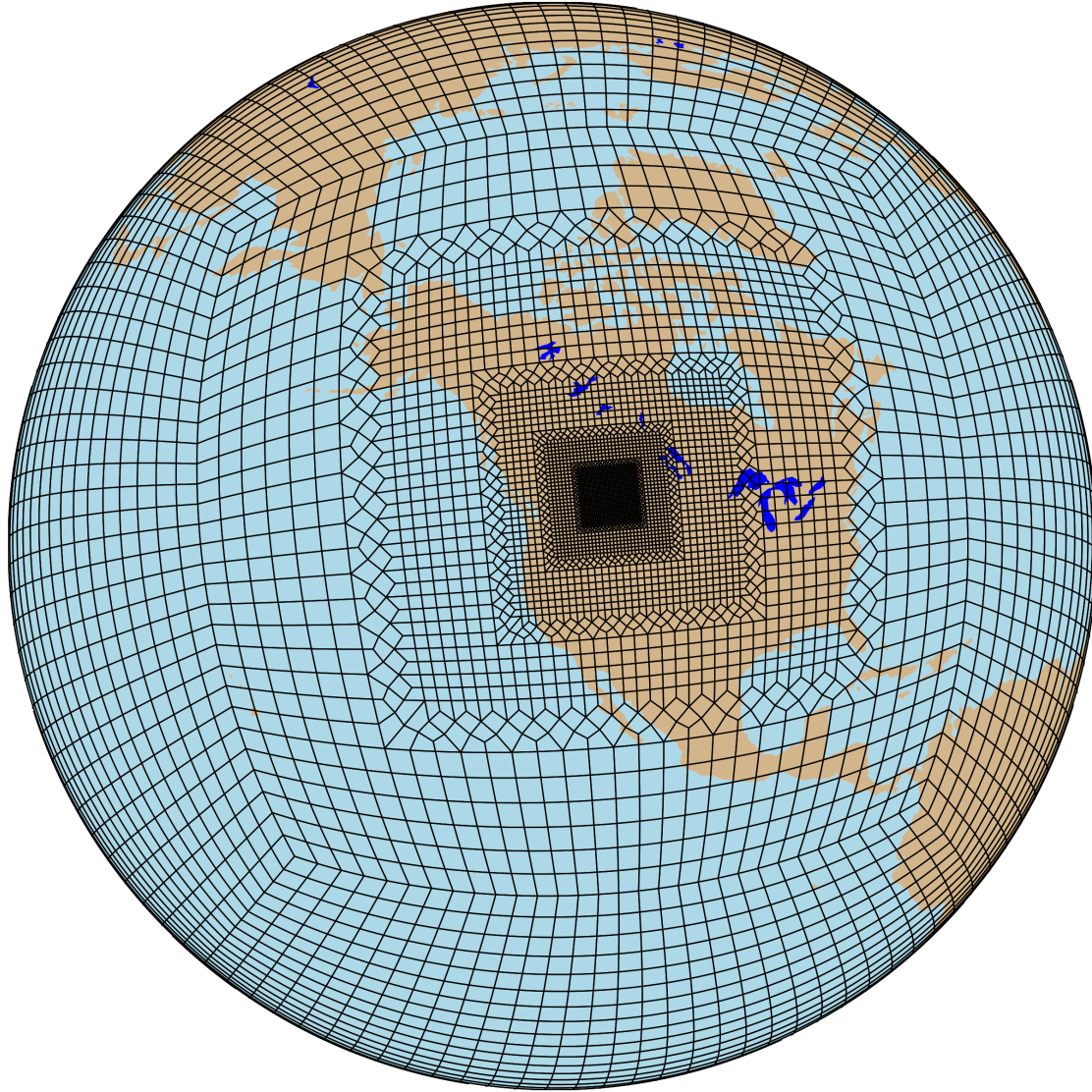




# How can we better prepare for these ROS events?

- 1. How well does CESM re-create key physical processes driving this ROS event?**
  - ARs, precipitation, temperature, snowmelt, runoff
- 2. Can we use CESM to give us a range of plausible outcomes for similar ROS events in the future?**
  - What would this storm look like in the future?  
(Goal for down the road)

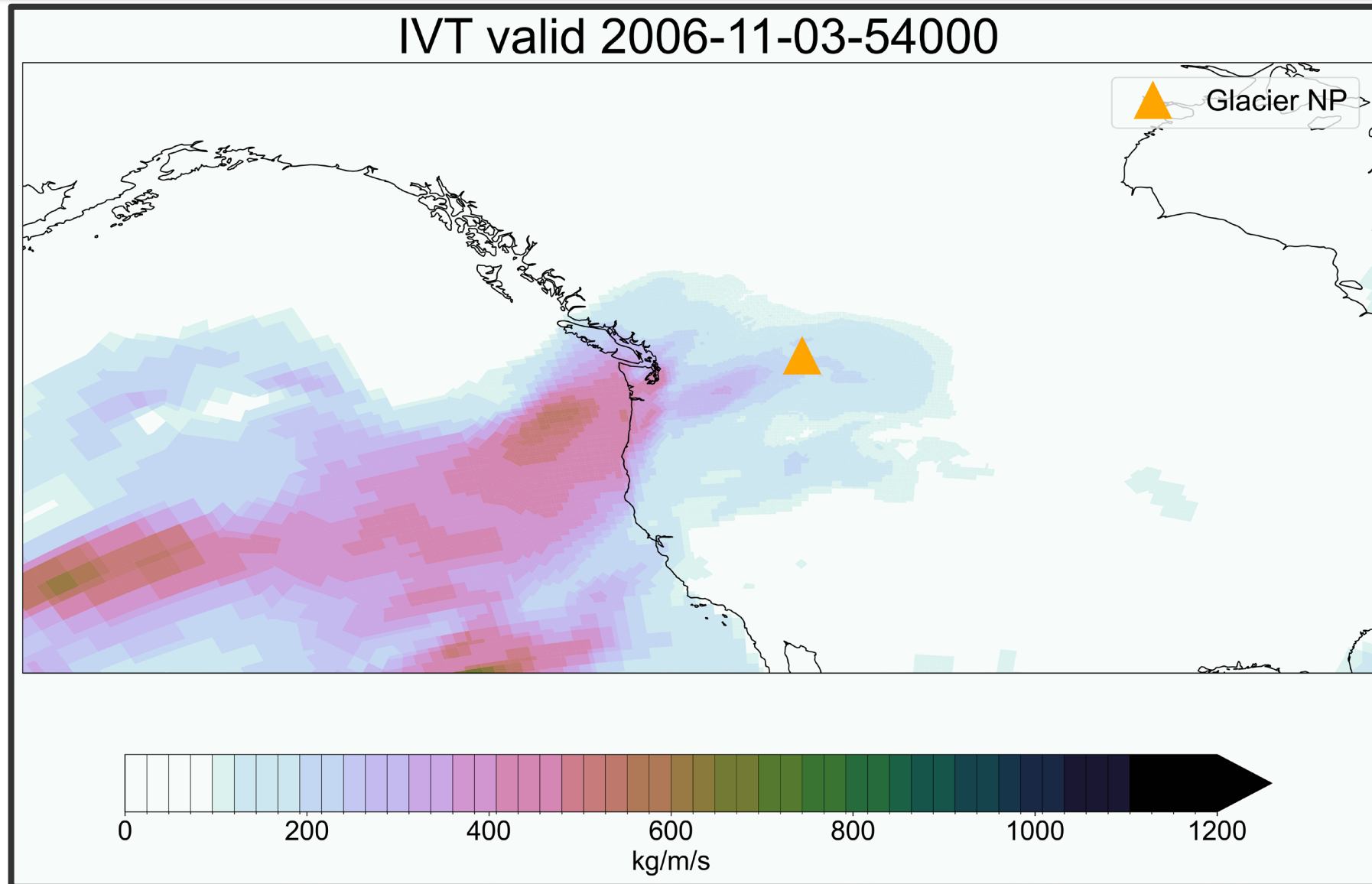
# What tools can we use to test CESM's capacity to recreate this event?



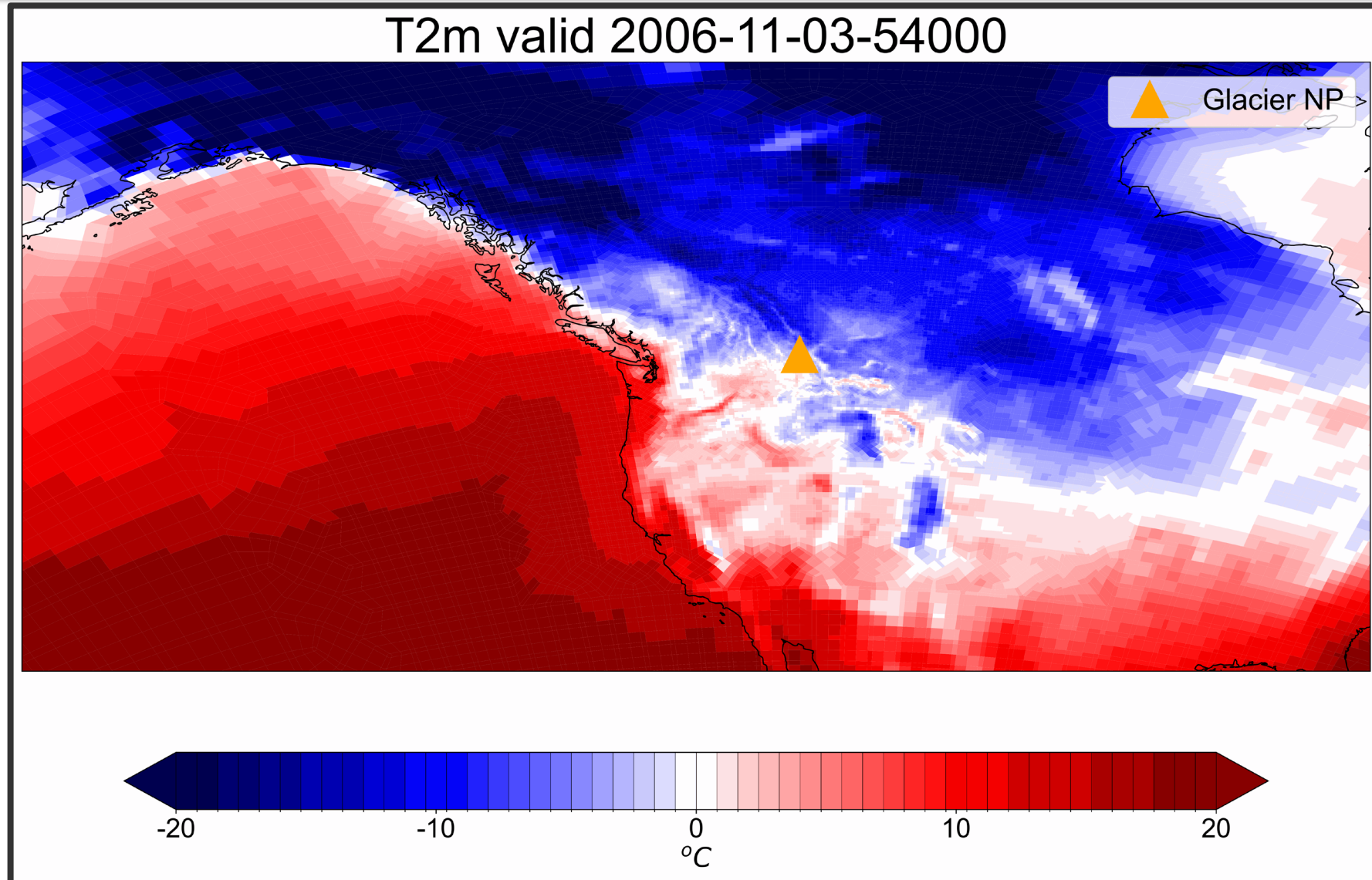
- CESM3 (cesm3\_0\_beta05)
  - CAM7 + CTSM6
  - Prescribed SSTs
- Variable-Resolution
  - 1 degree globally
  - refinement to 1/16<sup>th</sup>-degree over Glacier
  - 58 vertical levels
- “Betacast” framework
  - 12Z on November 3, 2006
  - initialize atm with ERA5
  - initialize ocean with NOAA OI SST V2
- Land spinup
  - run land-only config for preceding 12 months
  - atmospheric forcing from ERA5



# CAM7 depicts the AR family, but characteristics are important

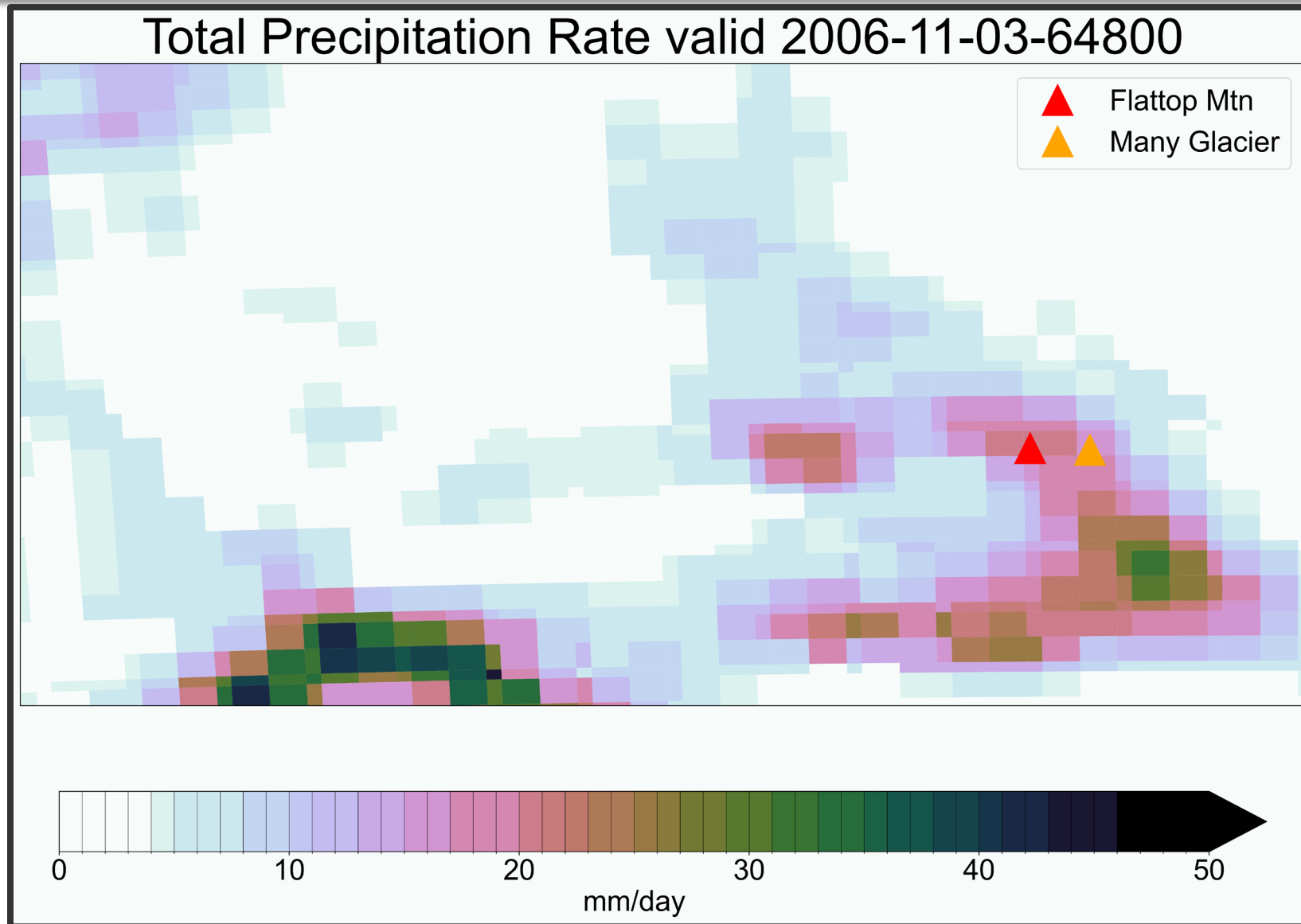


# Modeled AR family brings anomalously warm weather to the West

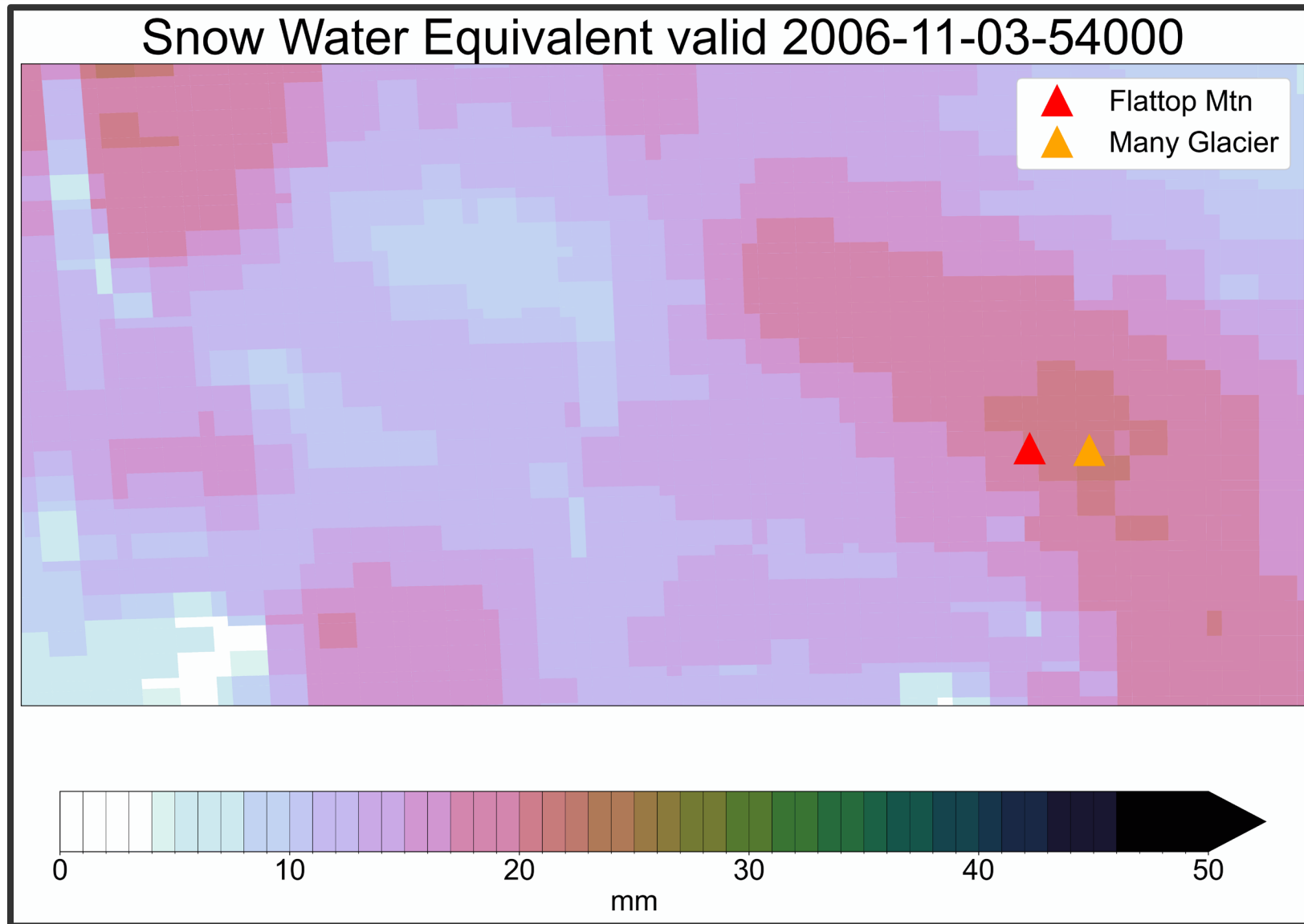




# AR family also brings periods of heavy precipitation to the region



# Warm temperatures and heavy precipitation reduce snowpack



# What are we evaluating with this configuration?

## What we have so far:

- Stable configuration with several different grid variations
- AR family, warm anomalies, and broad snowmelt

## What we're evaluating:

- How well does the model depict precipitation from AR family?
- Does the model accurately depict snow-loss amount and runoff?

## Things we're trying:

- Identify tunable parameters to better depict precip and snowmelt
- Different procedures to initialize the land surface



# Summary

**Why we're here:** To improve our understanding of, and preparedness for, the damaging effects of ROS flooding events on public lands and neighboring communities

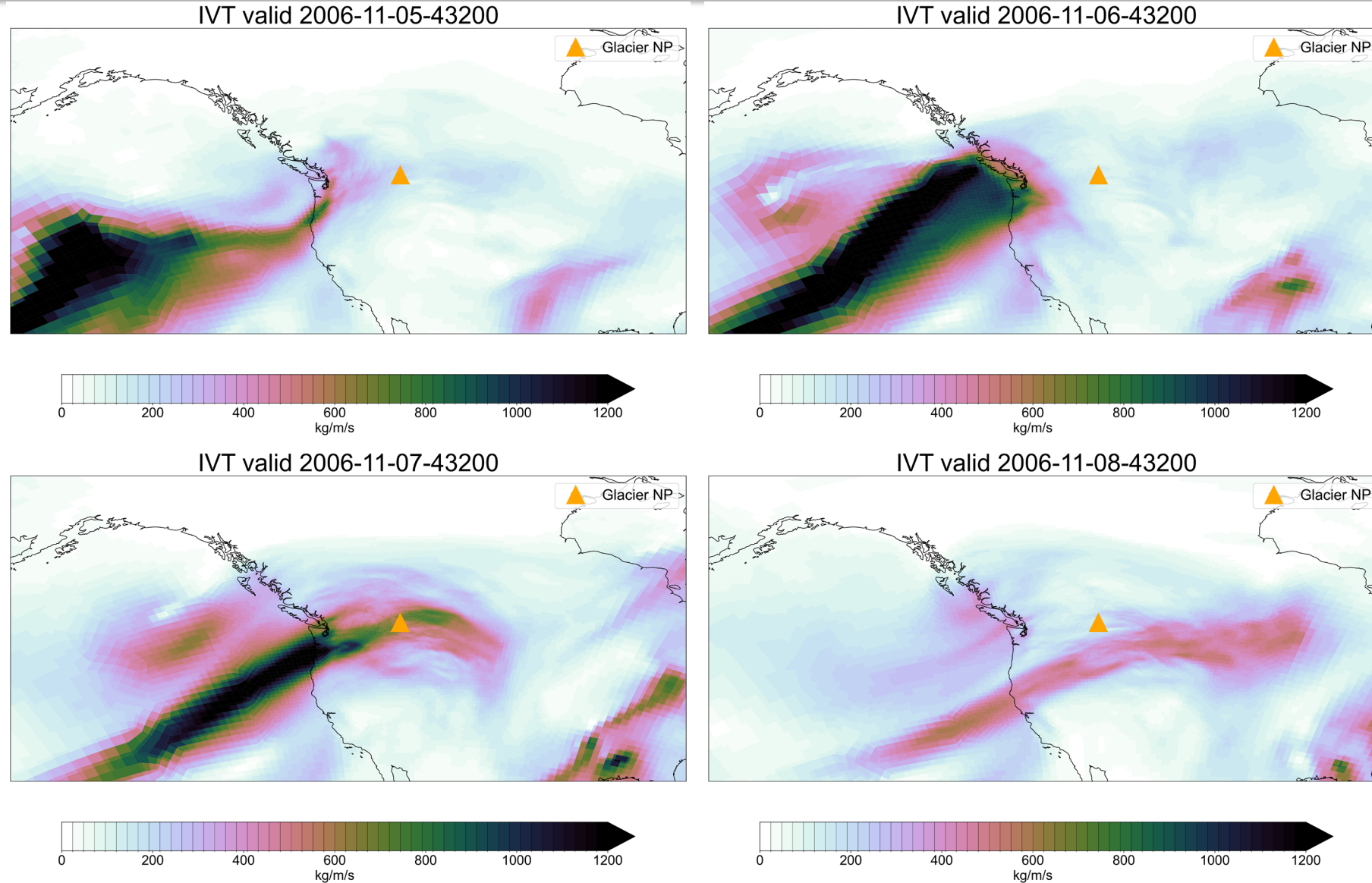
**What we're doing:** Applying a variable-resolution version of CESM to a case study of the November 2006 Glacier National Park ROS flooding event – Can the model depict the key drivers?

**Where we're going:** Use CESM to tell a story about how this event, and others, may affect public lands under a range of plausible future climate scenarios



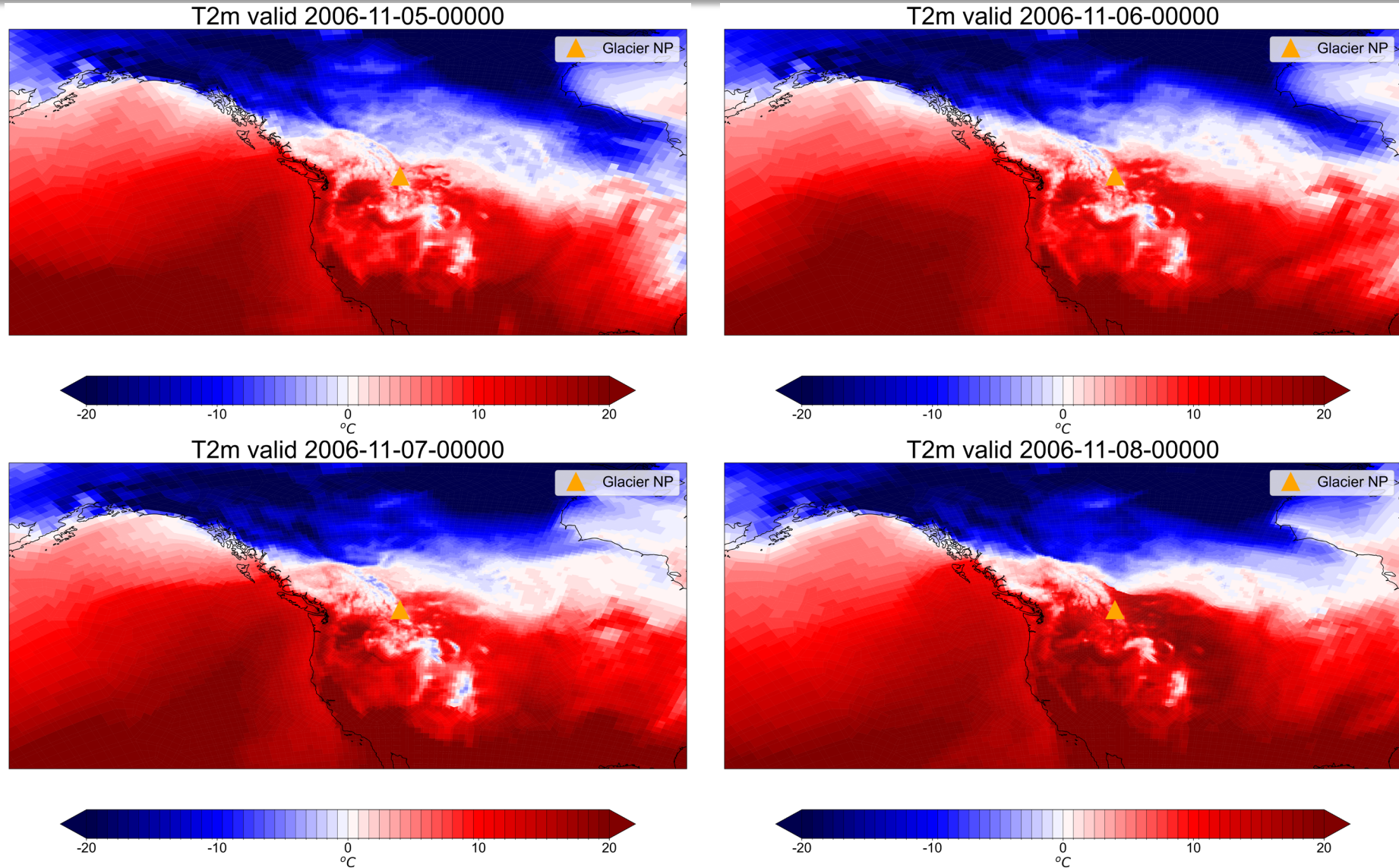
# Extra Slides

# CAM7 depicts the AR family, but characteristics are important

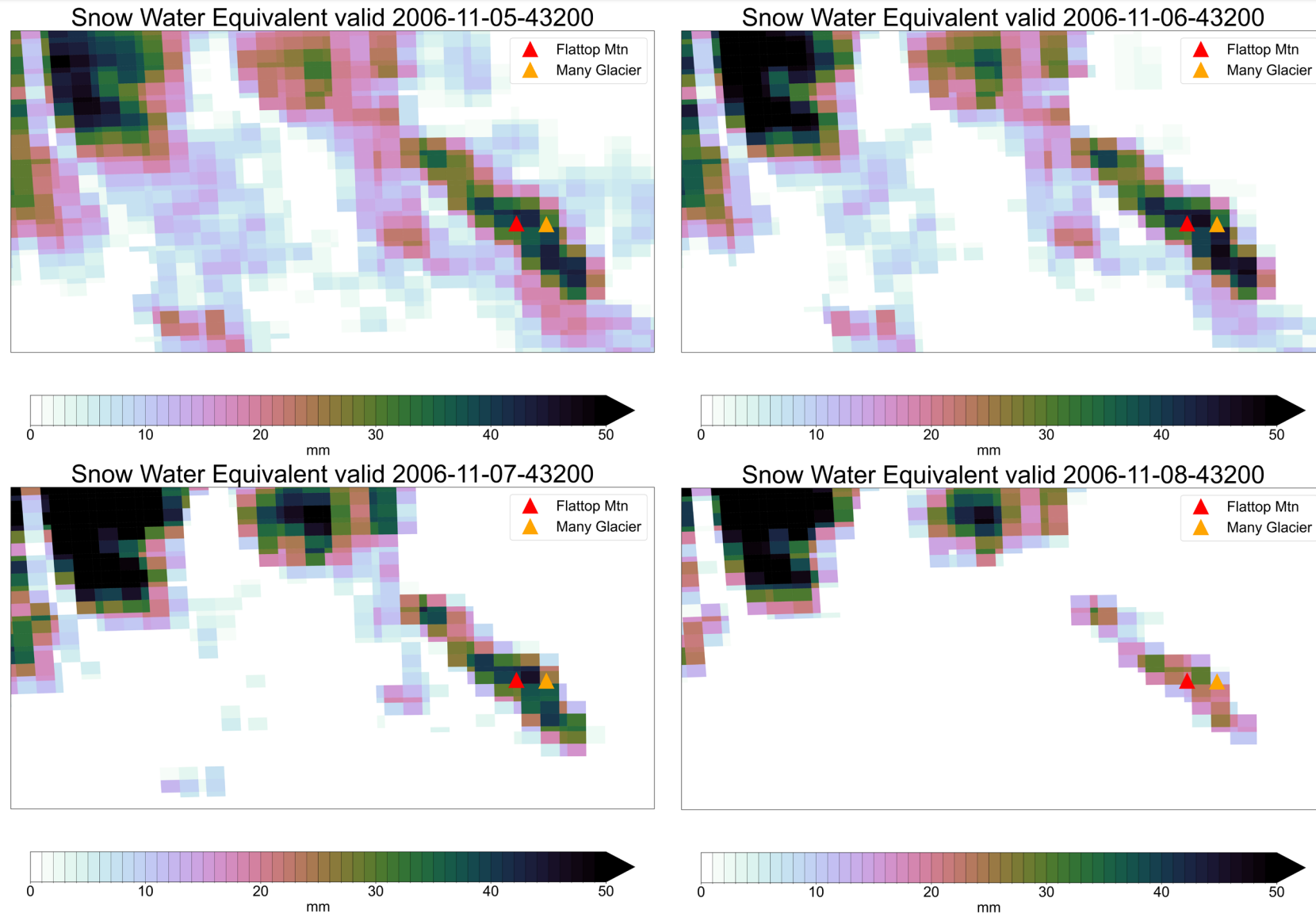




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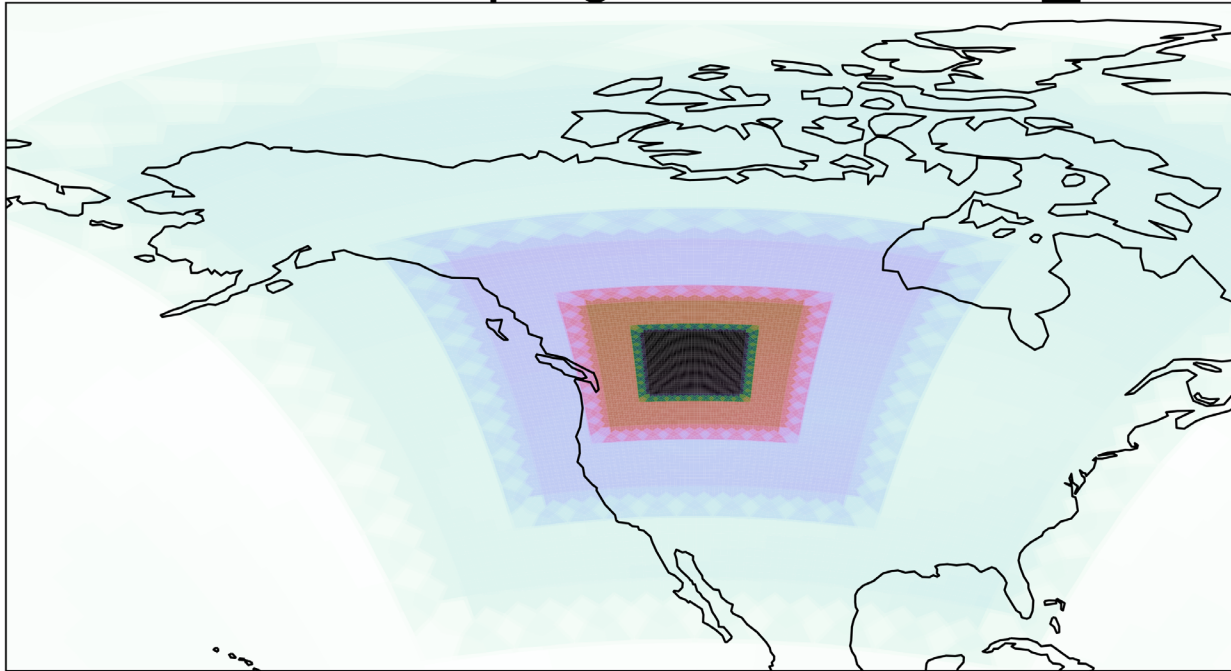


# Warm temperatures and heavy precipitation reduce snowpack

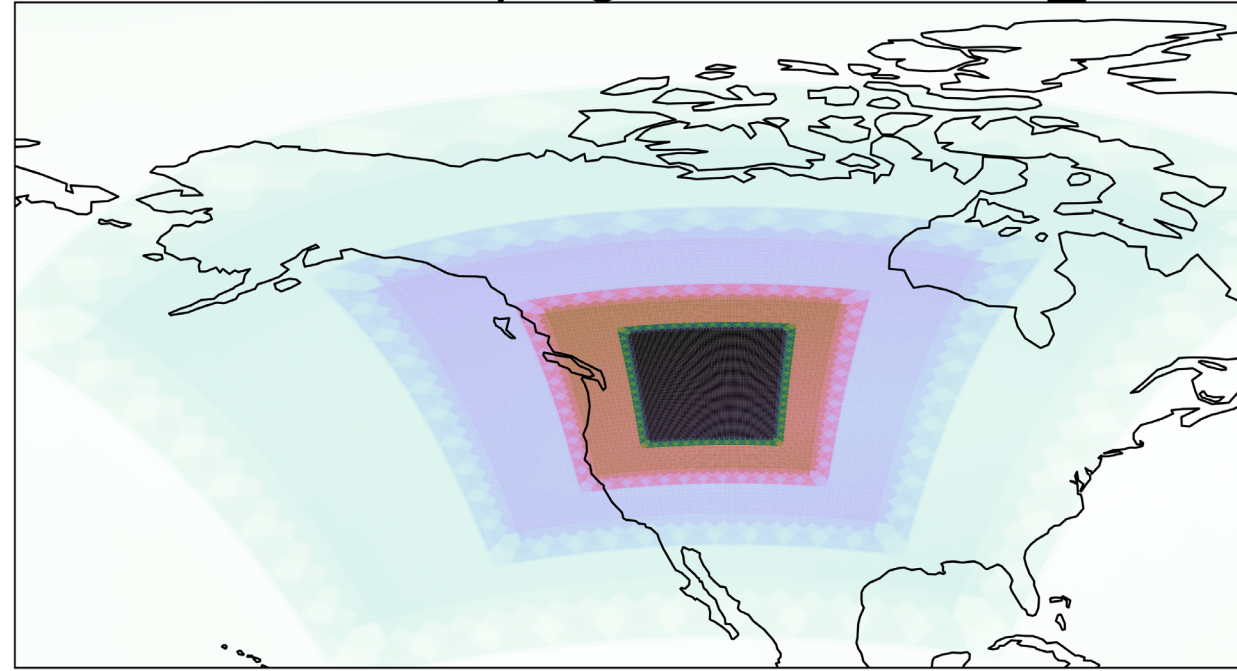


# Currently Testing: Experimenting with Different Meshes

RRFAC ne0np4.glacier.ne30x16\_v1



RRFAC ne0np4.glacier.ne30x16\_v3



Testing a new variable-resolution grid with

- 1) Greater coverage surrounding Glacier National Park and
- 2) Higher resolution upstream over the Pacific Ocean