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# Validating CMIP6 Snowfall Simulations: A Grid-Point Comparison with Mount Washington Data (1980–1999)

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The Mount Washington Observatory is a private, nonprofit research and educational institution working to advance understanding of Earth's weather and climate.





#### WEATHER OPERATIONS

- Weather observations since 1932
- 23 mesonet stations around the White Mountains, NH

### SCIENTIFIC RESEARCH AND TECHNOLOGY

• In-house & university collaborations, instrument and other product testing

#### **RECREATION AND SAFETY**

- Higher Summits Forecast (5am, 5pm EST) EDUCATION AND OUTREACH
  - K-12 and adult audiences



# Introduction

#### **Key Points:**

•Extreme snowfall significantly impacts mountainous areas and nearby communities:

- Snow and water as a resource (recreation, water supply, etc).
- Flooding.
- Changes to snowpack stability (NSIDC).

•Limited research characterizes how mountainous extreme snowfall evolves in a warming climate.

#### **Objective:**

•Investigate changes in extreme snowfall over global mountain regions to bridge the gap from climate models to real-world weather impacts.

#### Importance:

•Warming climate could:

- Increase extreme precipitation (Donat et al. 2016; Tabari 2020).
- Reduce extreme snowfall by raising temperatures above freezing.



# Analyzing Mountain Snowfall with CMIP6

#### Approach:

- Verify CMIP6 estimates of extreme snowfall (1980 1999) using:
  - Observational data.
  - Reanalysis products.
- Assess the ability of simulations to capture:
  - Magnitude of mean and extreme snowfall.
  - Spatial distribution of snowfall patterns.

#### Data Source:

•Coupled Model Intercomparison Project Phase 6 (CMIP6) ensemble.

- Widely used for global extreme precipitation studies.
- NCEP Reanalysis

### **Region Definition:**

•Mountain regions identified using the Global Mountain Biodiversity Assessment (GMBA)/Mountain Inventory v2.0 (Snethlage 2022).



# Validating Snowfall Simulations Against Observations



Observations: 1980-1999 NCEP reanalysis products
Simulations: 1980-1999 CMIP6

outputs for mean daily snowfall and extreme events.

Validation Results: Simulations effectively capture:

- Magnitude of mean and extreme snowfall.
- Spatial distribution of snowfall patterns.

•Preliminary comparisons show good agreement, enabling confidence in using CMIP6 for future projections.



# 2080 – 2090 Simulations

Simulations effectively capture:

- •Magnitude of mean and extreme snowfall.
- •Spatial distribution of snowfall patterns.



180°W135°W 90°W 45°W 0° 45°E 90°E 135°E 180°E



<sup>180°</sup>W135°W 90°W 45°W 0° 45°E 90°E 135°E 180°E

- Northernmost mountain regions increase in mean and extreme snowfall.
- Mid-latitude mountain regions decrease in snowfall magnitude.



# **Comparison Characteristics**



- Resolution of 1.1°
- Lower than KMWN elevation

#### KMWN Observations:

- Latitude = 44.27 N
- Longitude = 71.30 W
- Elevation = 1917 m (6288 ft)

Charles and the state

• Tallest mountain in Northeast.

We don't expect great agreement from a point comparison, but lets see how we do...



# Point Comparison to Grid Box (Mean Daily Snowfall, mm)



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# Point Comparison to Grid Box (Consecutive Snow Days)



## Point Comparison to Grid Box (R130 mm)



- 10 mm (R130mm) 8 130 ٨I Average Annual Days with Snowfall 6 4 - 2

### Point Comparison to Grid Box (R90 mm)



- 10 mm (r130mm) 8 130 ٨ Snowfall 6 Average Annual Days with 4 - 2

MVOBS

# Point Comparison to Grid Box (r90 mm)



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# Point Comparison to Grid Box (r99 mm)



- 50

## Point Comparison to Grid Box (Daily Temp °C)



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### Point Comparison to Grid Box (Avg Snow Day Temp °C)



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# **Key Findings and Next Steps**

#### **Conclusions:**

#### •Validation Results:

 CMIP6 simulations (1980–1999) show better agreement in extreme snowfall metrics (r99, r1xday) compared to daily snowfall and temperature averages.

#### •Observed Patterns:

- Northernmost mountain regions: Increases in mean and extreme snowfall.
- Mid-latitude mountain regions: Decreases in snowfall magnitude.

#### •Grid Resolution Challenges:

 Point-location comparison to CMIP6 coarse grid boxes (~1.1° resolution) does not account for elevation variability.

#### **Future Work:**

#### •Resolution and Observations:

- Incorporate data from multiple observation stations across varying elevations.
- Use higher-resolution climate models to better capture localized snowfall patterns.

#### •Analysis of Dynamics:

- Investigate thermodynamic and dynamic processes driving snowfall trends.
- Explore why and how the magnitude of extreme snowfall will evolve over mountain ranges.



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