Mountain Rain or Snow

Crowdsourced science for improving precipitation phase estimates

Sonia Nieminen | **Desert Research Institute**
sonia.nieminen@dri.edu

University of Nevada, Reno

Desert Research Institute

Lynker

NASA Partner

Have you ever noticed snow falling when the air temperature is above freezing?

Photo: Keith Jennings

Have you ever noticed snow falling when the air temperature is above freezing?

This poses a challenge for **estimating how much winter precipitation falls as snow.**

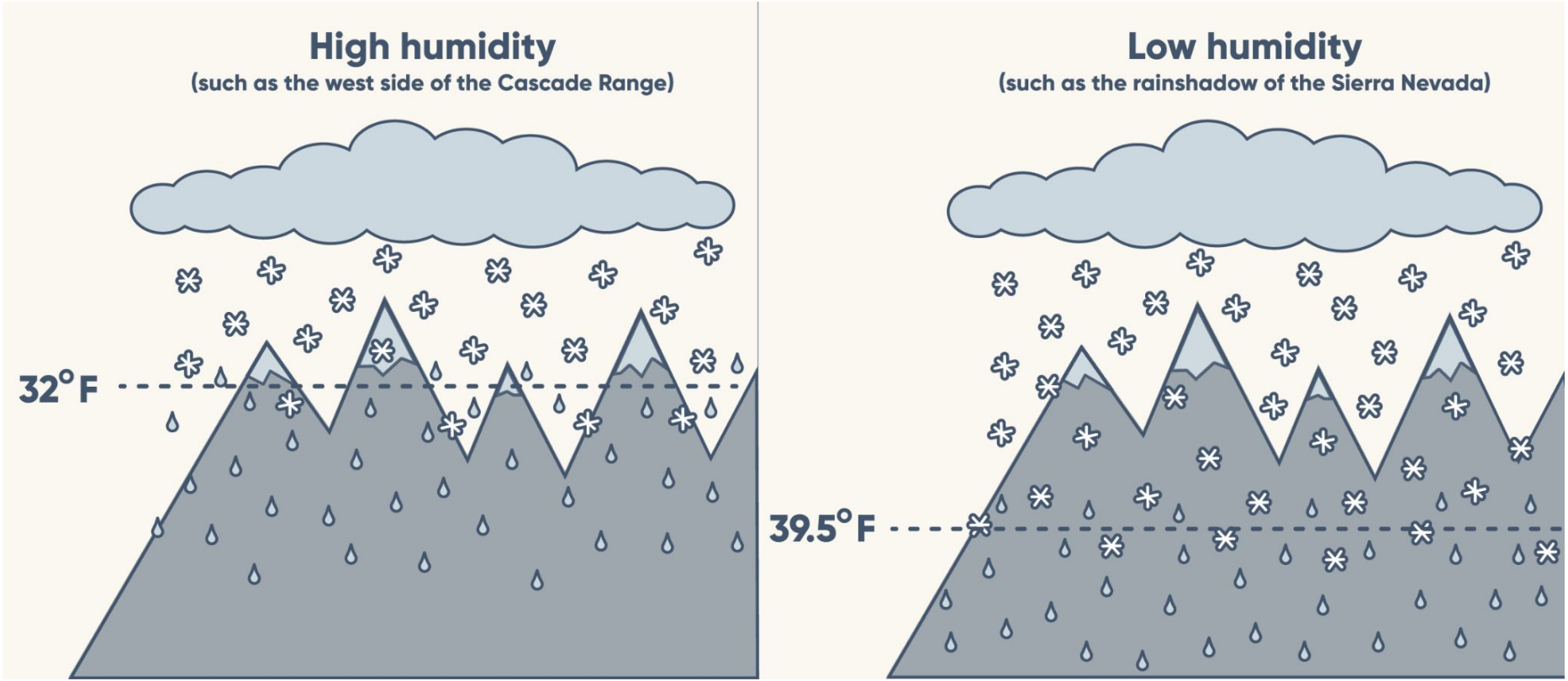
Photo: Keith Jennings

Mountain Rain or Snow

What’s the big deal?

Misidentifying the rain-snow transition affects our predictions of **flooding, snow accumulation, and avalanche hazard**.

Photo: Michael Fitzgerald



Graphic: Lindsey Funseth/DRI

Humid conditions influence the elevation of the rain-snow transition line.

Mountain Rain or Snow

Precipitation phase partitioning tools struggle the most when air temperature is near freezing.

Satellite tools for precipitation monitoring

Global Precipitation Measurement (GPM)

Joint NASA/JAXA mission

Graphic: NASA

Satellite tools for precipitation monitoring

Global Precipitation Measurement (GPM)

Joint NASA/JAXA mission

Global precipitation estimates are affected by GPM's assessment of phase.

Graphic: NASA

How can we improve estimates of winter precipitation phase?

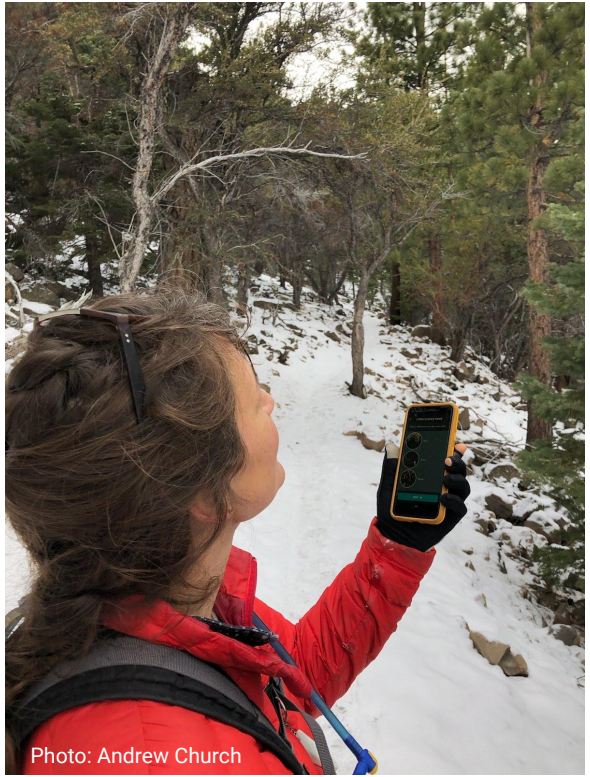
Photo: Gareth Blakemore

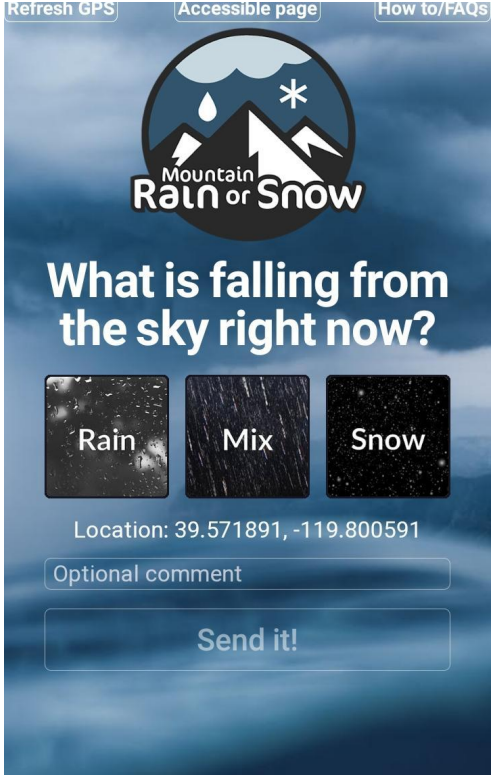
Mountain Rain or Snow's goal:

Ground-based, real-time observations of precipitation

Community-powered science

- Tahoe: Rain or Snow? *2019*
- National expansion *2021*
- 35,000+ observations and counting





Expansion allowed for regionally-specific analysis

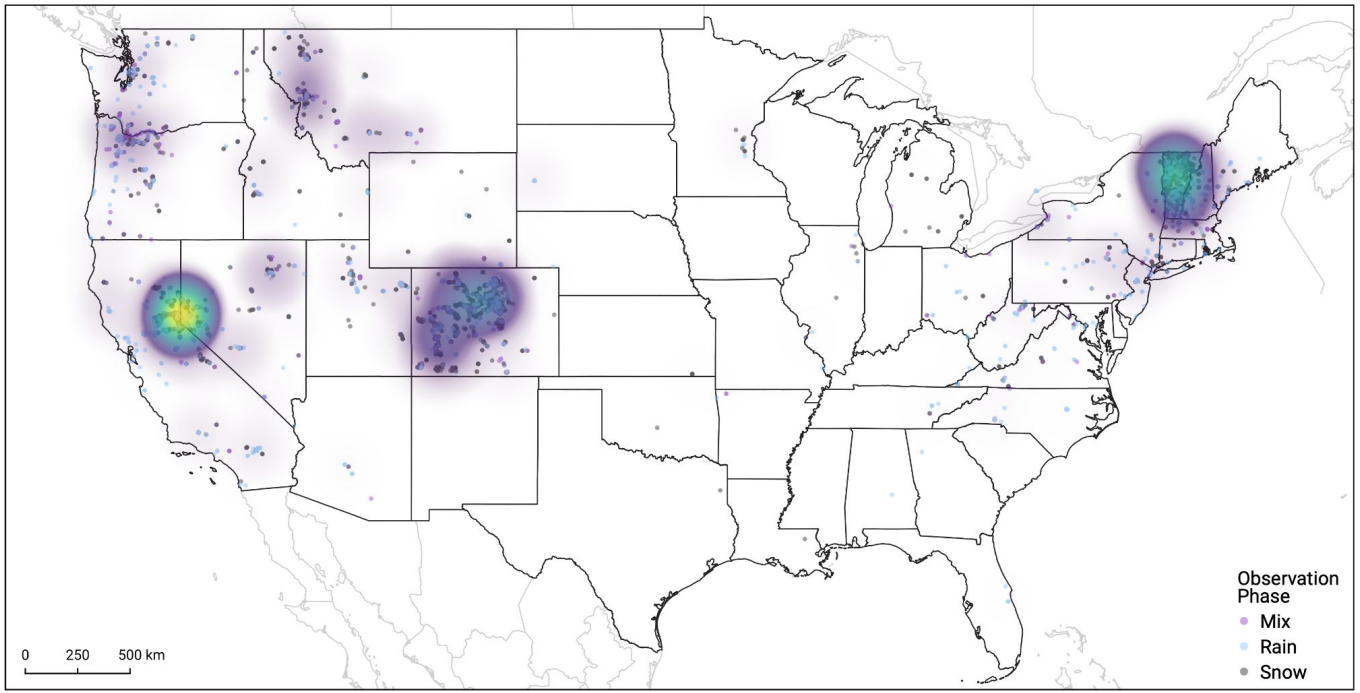


Figure: Nayoung Hur and Keith Jennings

Data collection and processing

Observer submits report of rain, snow, or mix (location + timestamp)

Learn more:
Jennings et al. (2023)
doi.org/10.1029/2022EA002714

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Determine elevation, relative humidity, and temperature

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Implement quality control procedure

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Analysis

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What have we learned so far?

The air temperature at which rain becomes more likely than snow varies by region.

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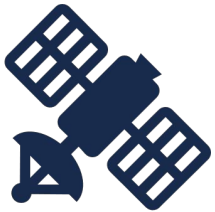

The success rates of NASA’s IMERG algorithm also vary by region.

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Snowfall probability curves
2020-present

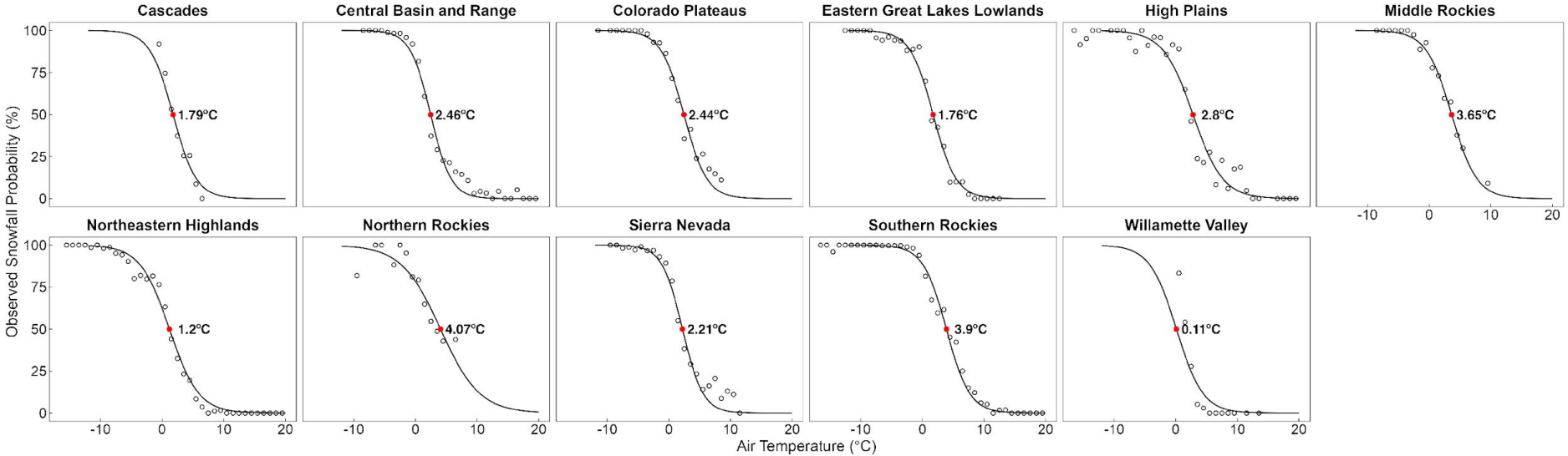
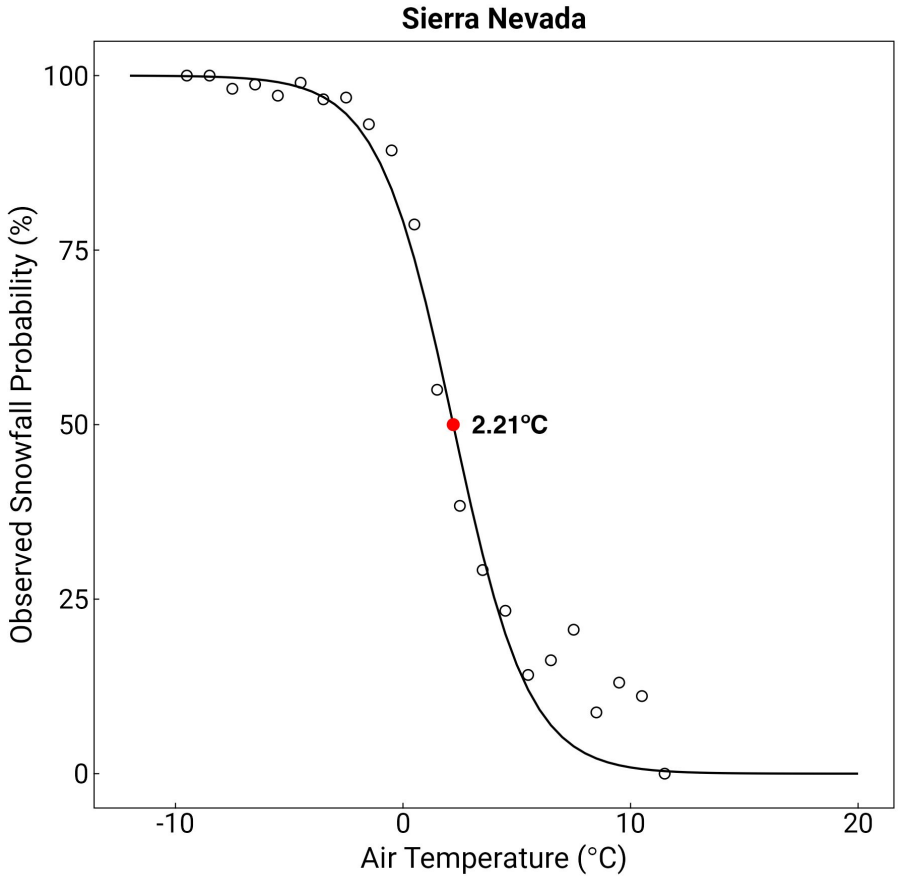


Figure: Nayoung Hur and Keith Jennings

Snowfall probability curve

2020-present



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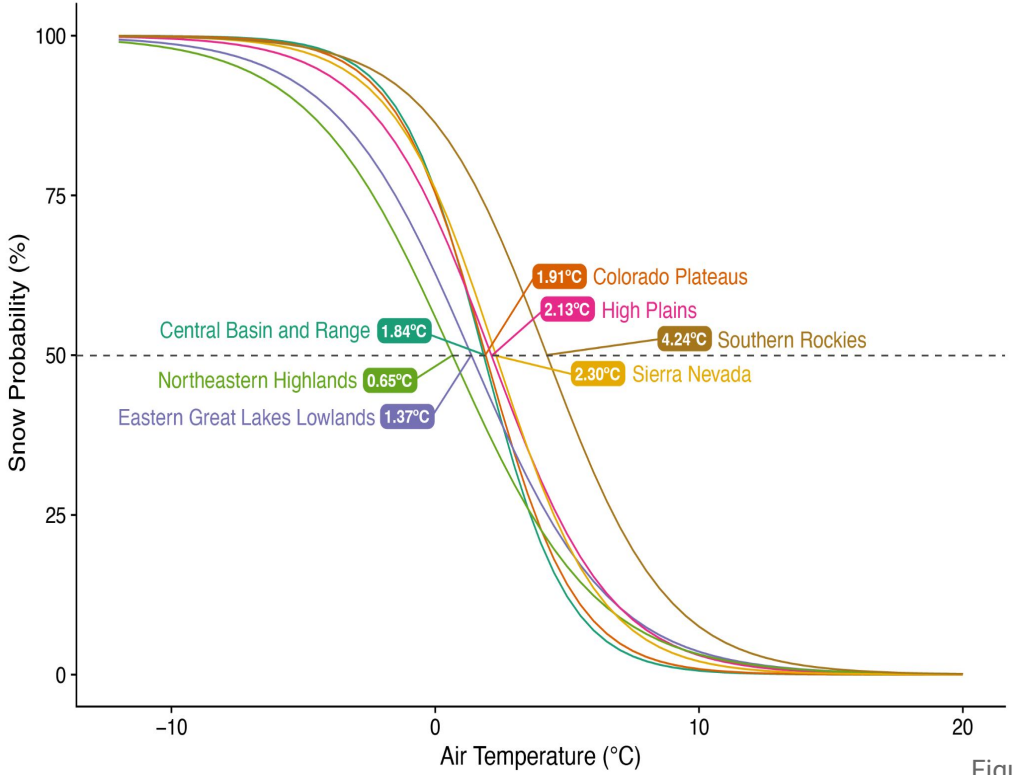
Snowfall probability curves

2021-2022 data



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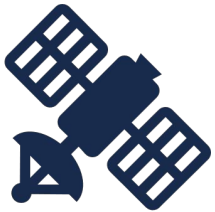

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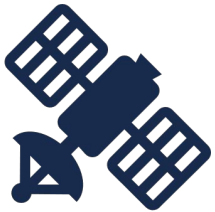

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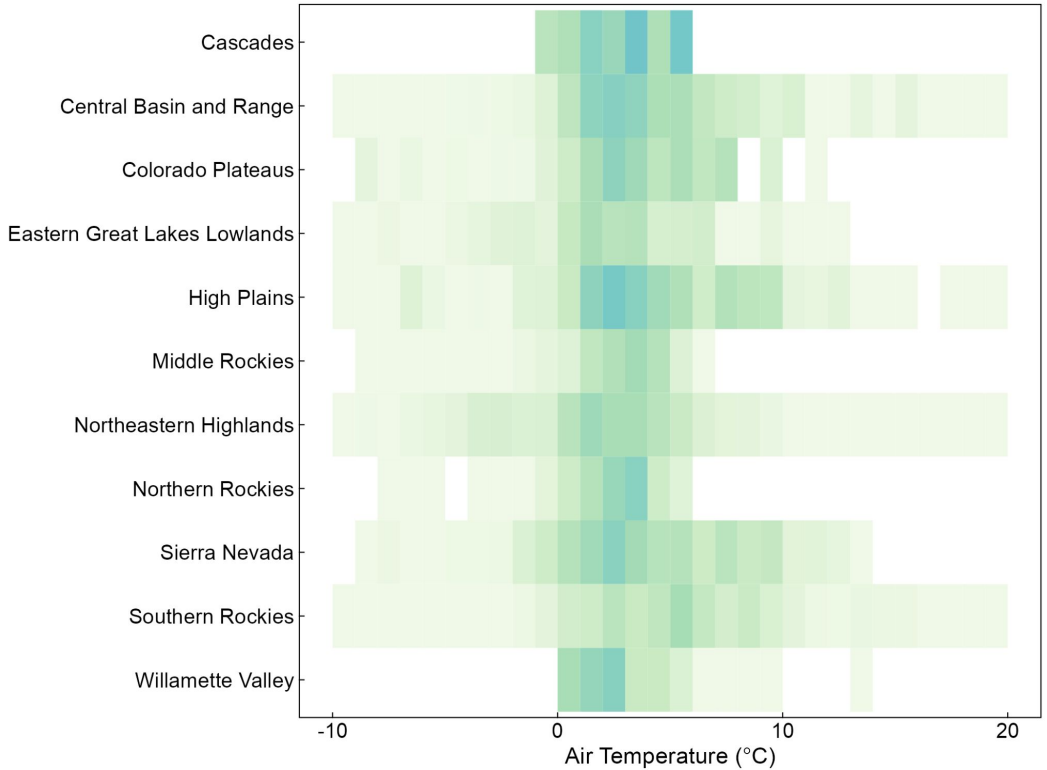
IMERG's success rates varied by region

2021-2023 data

IMERG:

Integrated Multi-satellitE Retrievals for GPM



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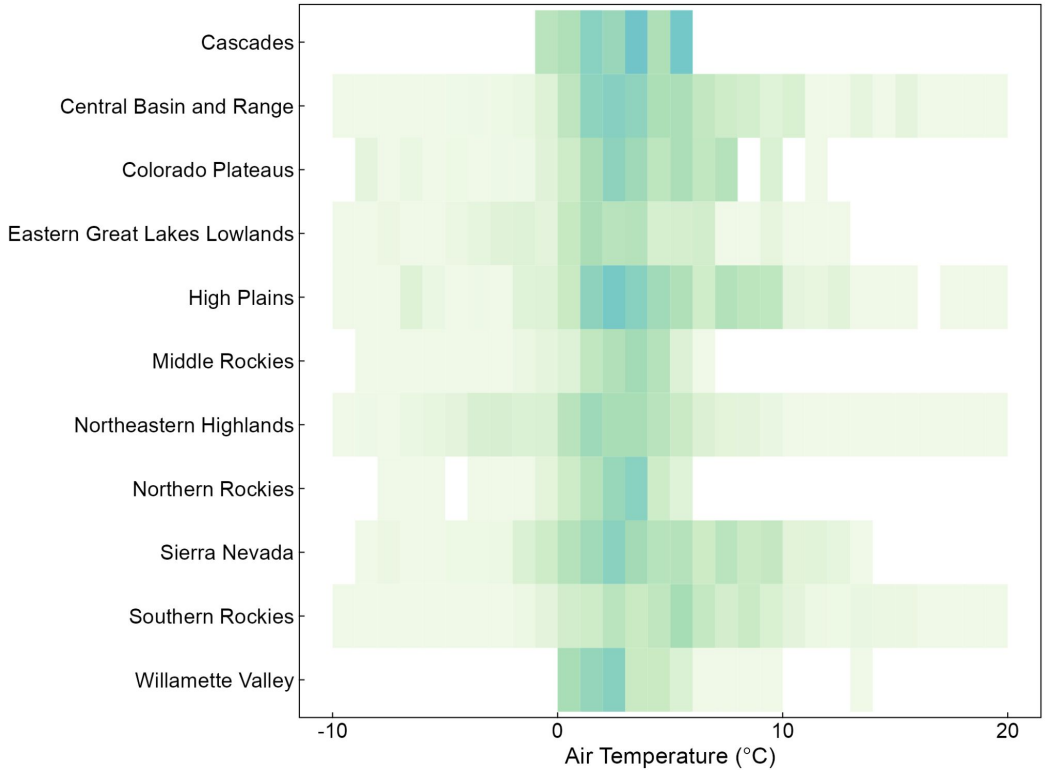
2021-2023 data

IMERG:

Algorithm that uses GPM satellite data to report precipitation rates

probabilityLiquidPrecipitation (pLP) data field



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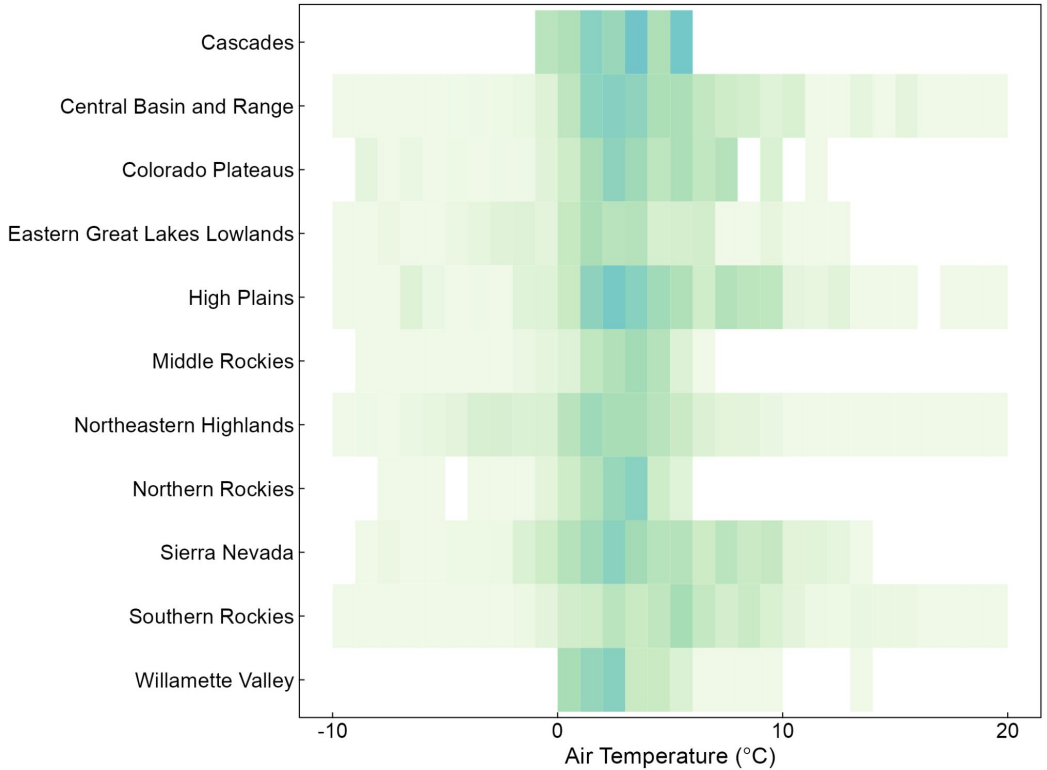

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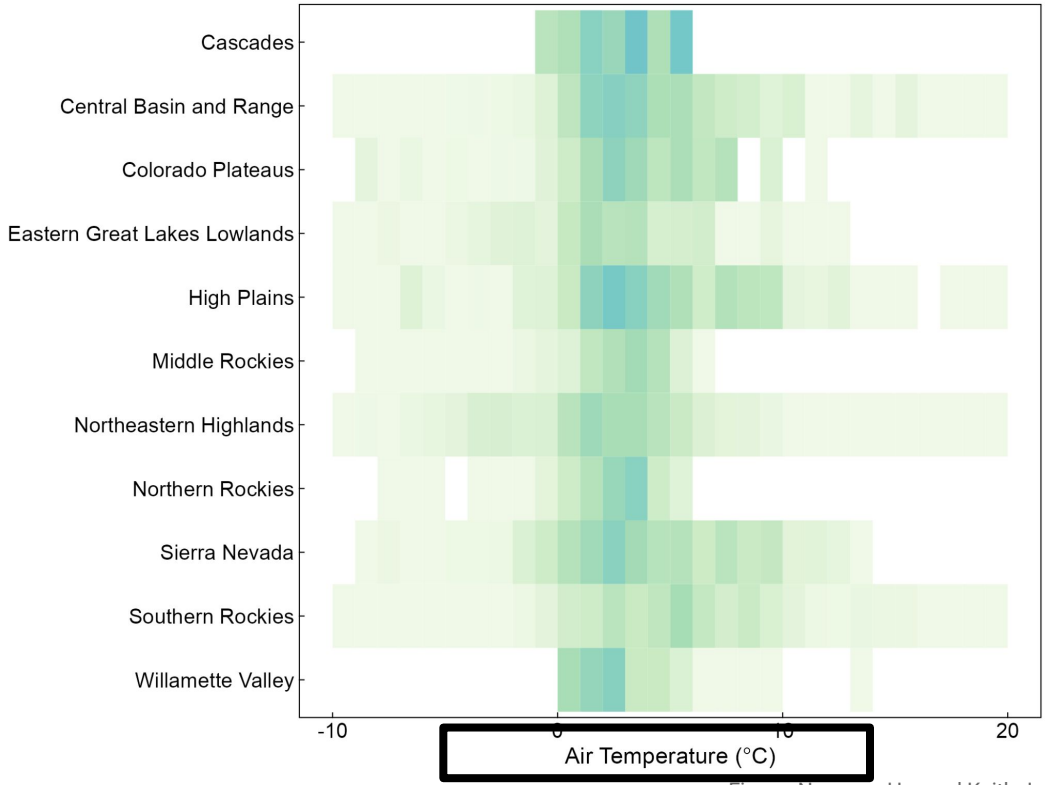

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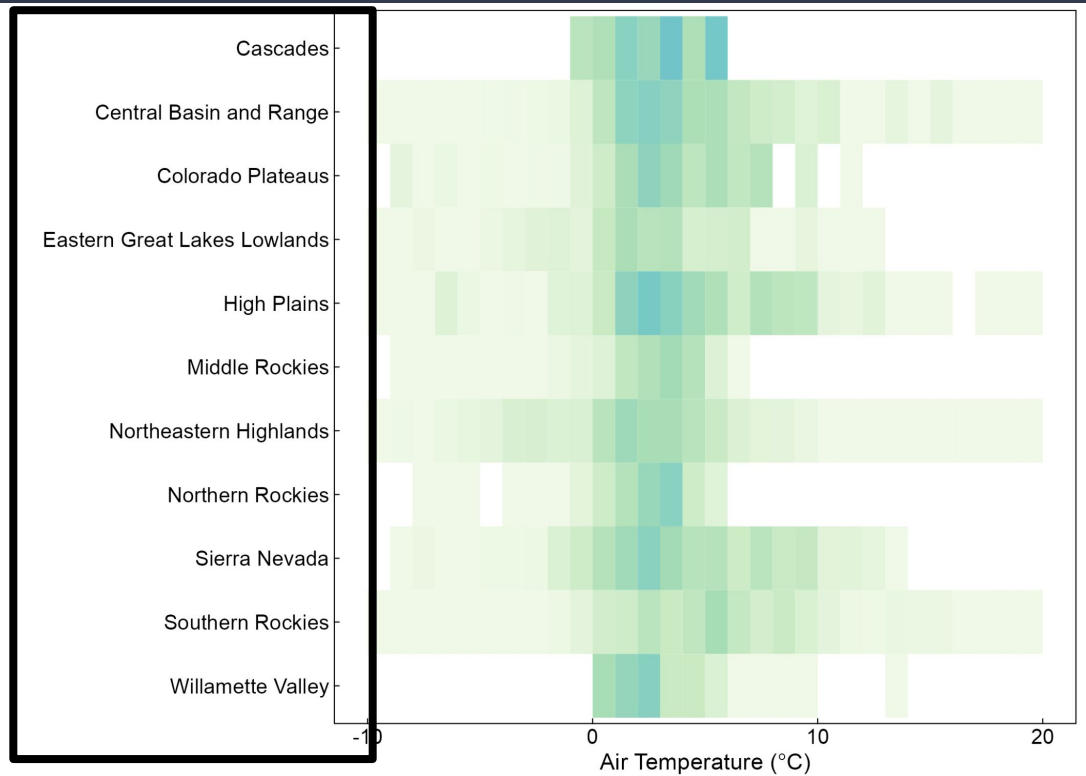

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IMERG's success rates varied by region

2021-2023 data

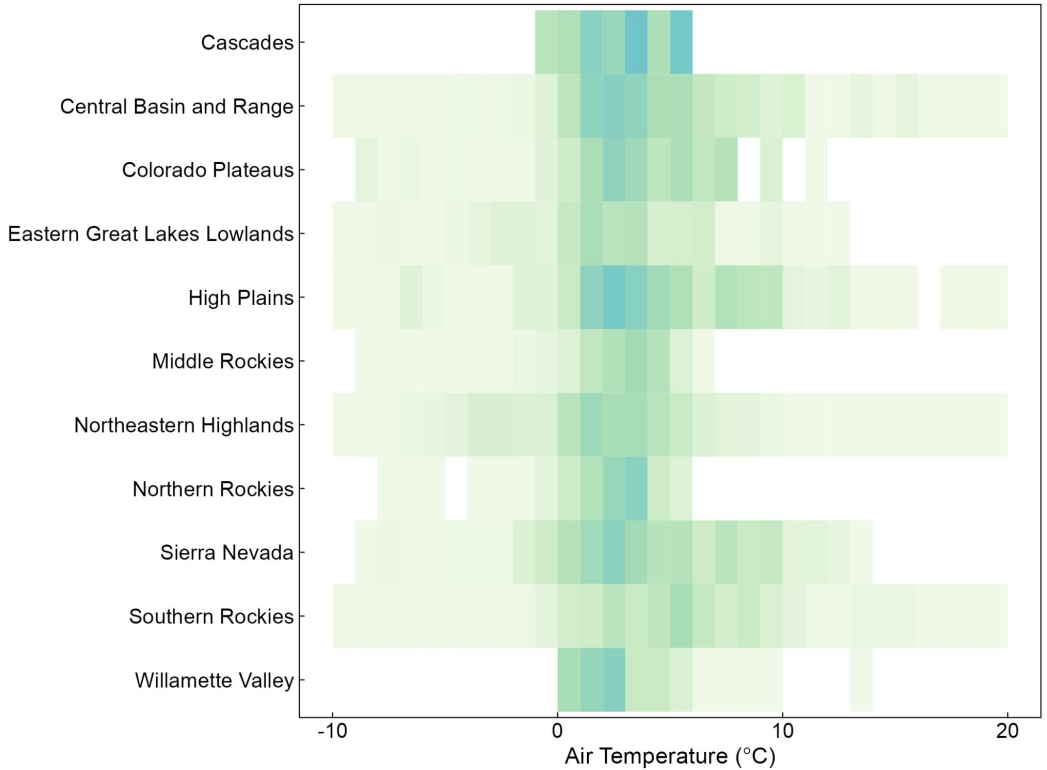
Success = **agreement** between satellite observations and your observations

IMERG Success Rate (%)

0 25 50 75 100

Darker blues = Low agreement

Lighter green = High agreement



Integrated Multi-satellitE Retrievals for GPM Level 3 v6 probabilityLiquidPrecipitation

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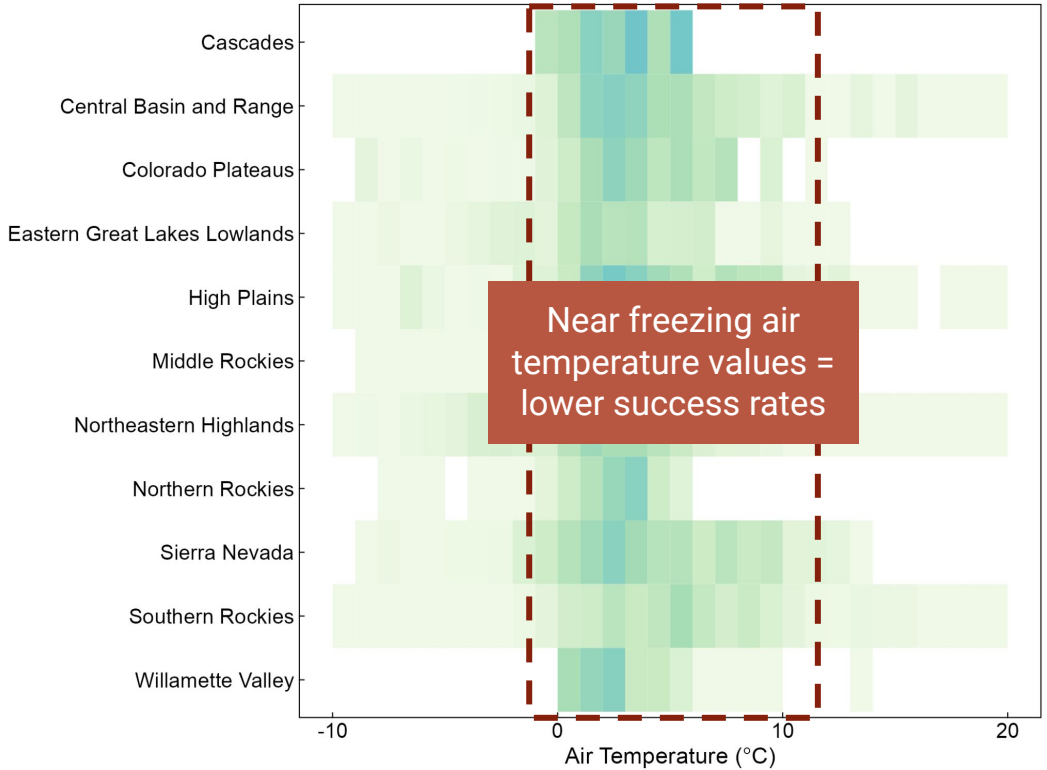

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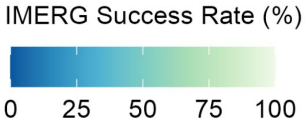

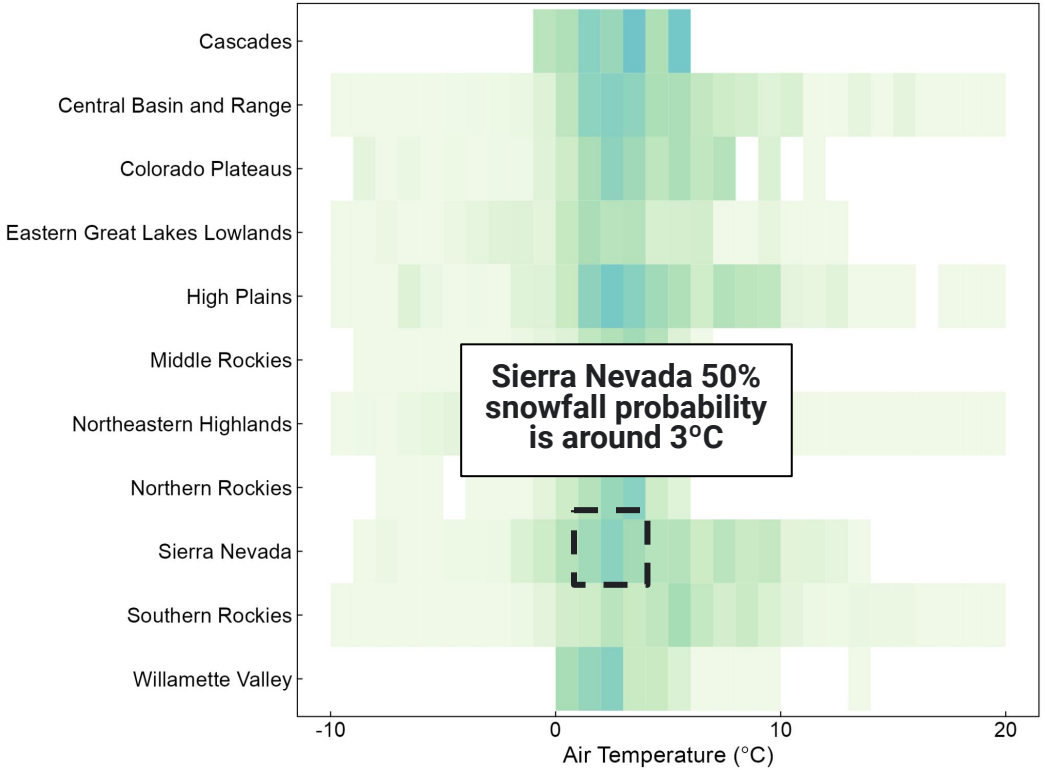

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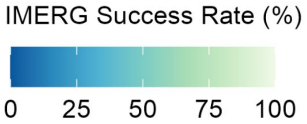

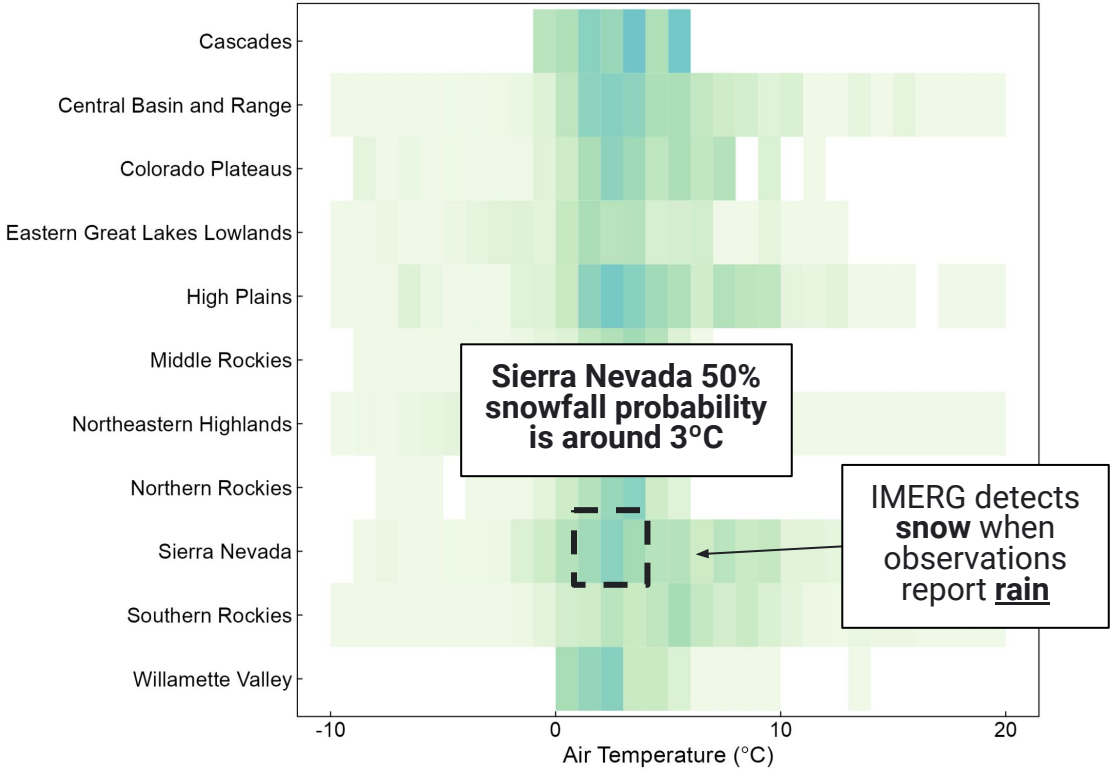

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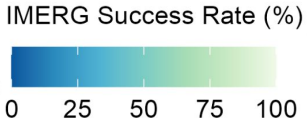

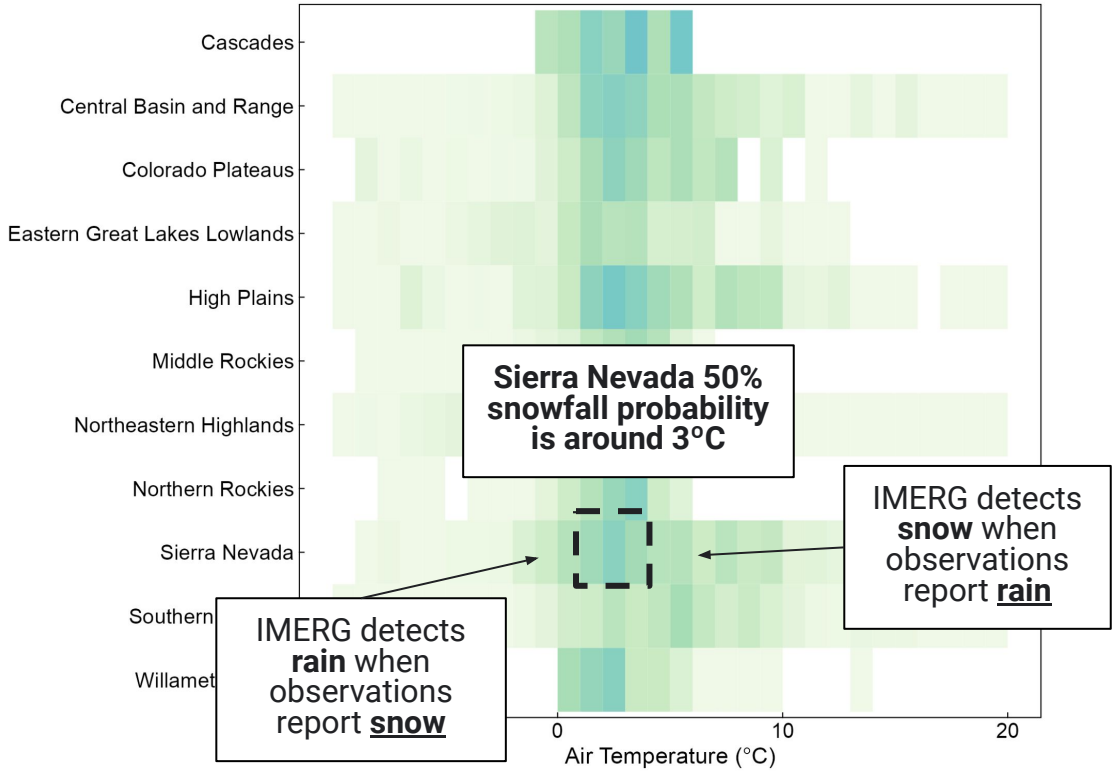

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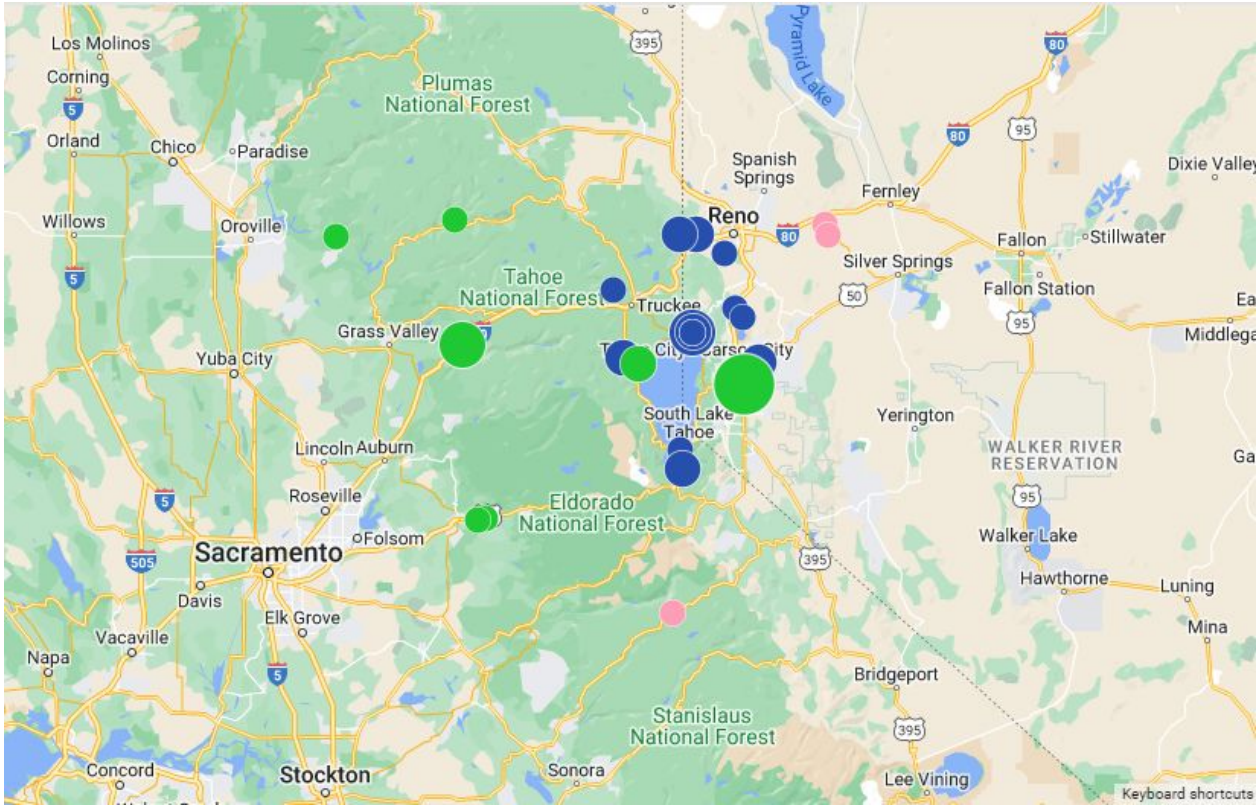
Next steps and future work

- IMERG & atmospheric rivers
- Compare other NASA tools
- Continued data collection
  - Geographic and climatic diversity

Real-time map for forecasters and emergency management groups

Request access:

RainOrSnow.org/request-map



We alert observers before important storms

“Showers are predicted on the western slope, snow over the Sierra crest, and…”

We alert observers before important storms

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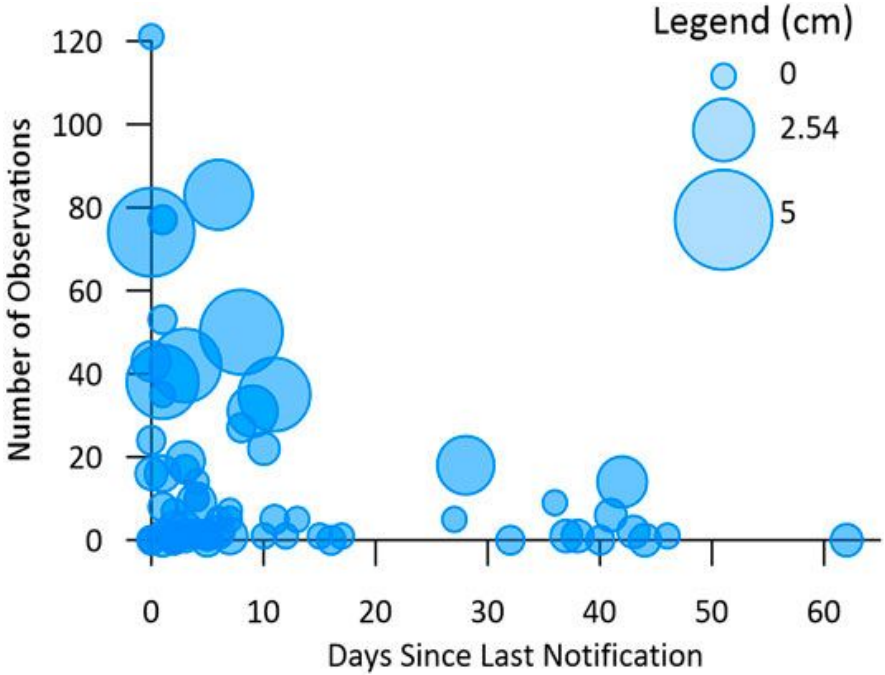


Arienzo et al. (2021)
doi.org/10.3389/feart.2021.617594

Get started!

Scan the QR code

or text **Winter**

to

855-909-0798

Different region? RainOrSnow.org/signup

How to reach us:

Text: 855-909-0798

Web: RainOrSnow.org

Email: RainOrSnow@dri.edu

Photo: Betty Copeland

Further reading about variability of precipitation phase partitioning tools

Jennings, K. S., Arienzo, M. M., Collins, M., Hatchett, B. J., Nolin, A. W., & Aggett, G. (2023). Crowdsourced data highlight precipitation phase partitioning variability in the rain-snow transition zone. *Earth and Space Science, 10*(3). https://doi.org/10.1029/2022EA002714

Further reading about engagement strategy

Collins, M., Arienzo, M. M., Nieminen, S., Hatchett, B. J., Nolin, A, & Jennings, K. S. (2023). Effective engagement while scaling up: Lessons from a citizen science program transitioning from single- to multi-region scale. *Citizen Science: Theory and Practice, 8*(1). https://doi.org/10.5334/cstp.622

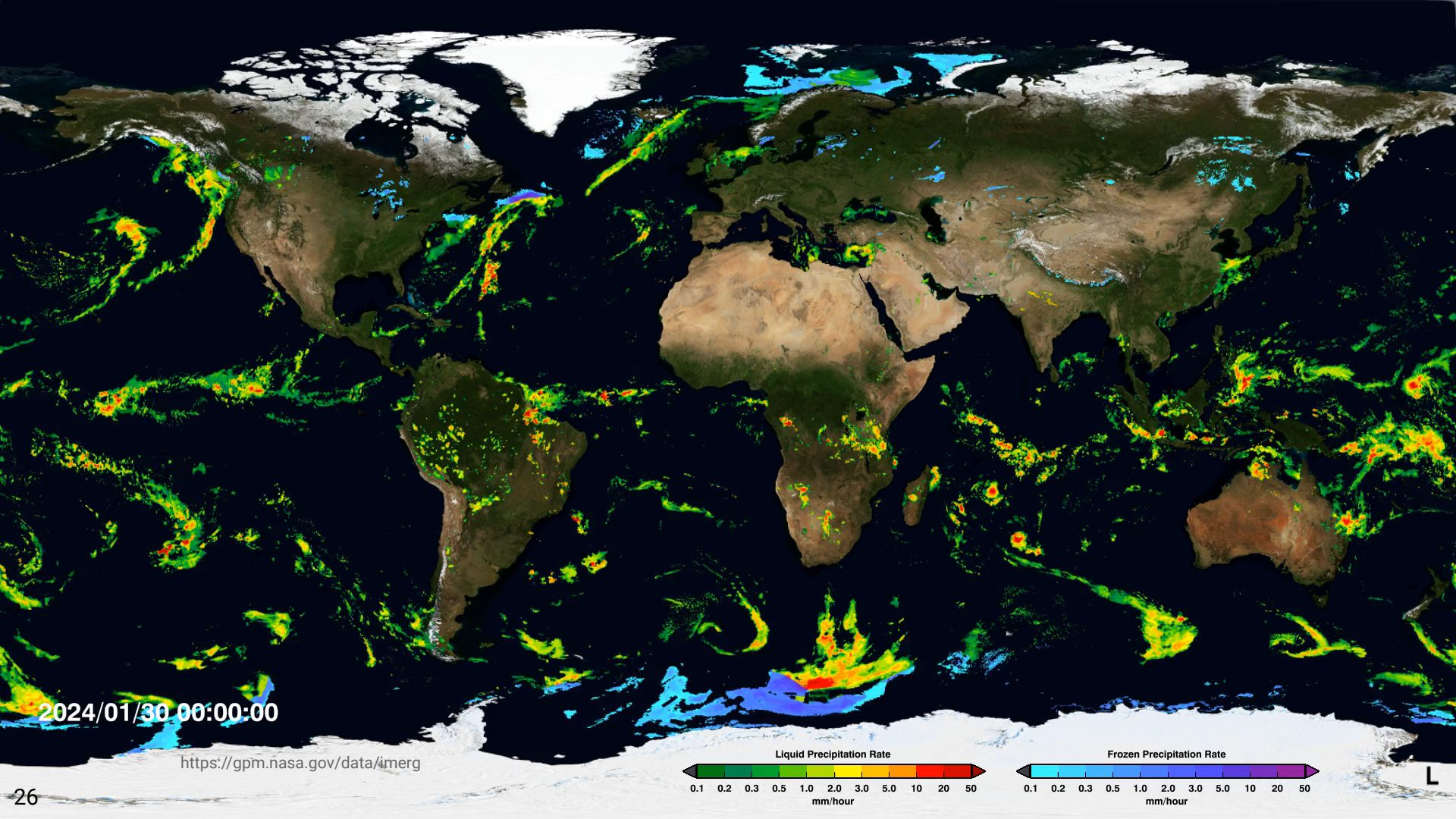
Further reading about participation analysis and project origin

Arienzo M. M., Collins, M., & Jennings, K. S. (2021). Enhancing engagement of citizen scientists to monitor precipitation phase. *Front. Earth Sci., 9.* https://doi.org/10.3389/feart.2021.617594

Quality control flags

- No precipitation recorded by nearby weather stations on the day of observation
- $T_{air} \leq -5°C$ for rain; $T_{air} \geq 10°C$ for snow
- Estimated Relative Humidity < 30%
- Average distance from meteorological stations > 100 km
- Duplicate timestamp

Jennings et al. (2023)
Section 2.2.3
doi.org/10.1029/2022EA002714


2024/01/30 00:00:00
https://gpm.nasa.gov/data/imerg
Liquid Precipitation Rate
0.1 0.2 0.3 0.5 1.0 2.0 3.0 5.0 10 20 50
mm/hour
Frozen Precipitation Rate
0.1 0.2 0.3 0.5 1.0 2.0 3.0 5.0 10 20 50
mm/hour
L

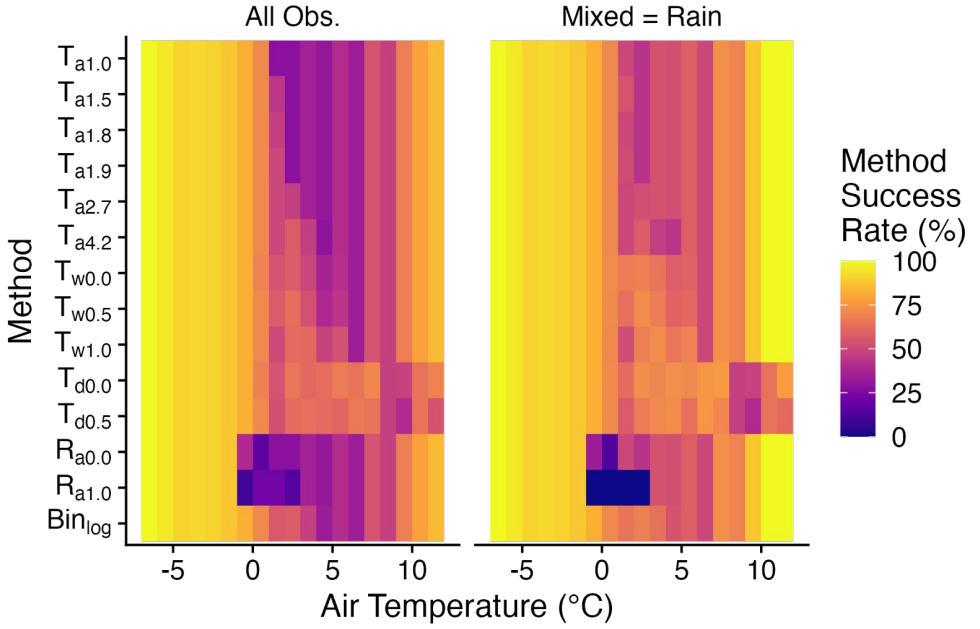
Partitioning tools' input and output differ

- Near-surface meteorology models
- NASA Global Precipitation Monitoring Products
  - Probability algorithm
  - Satellite data
- Ground-based radar

Near-Surface Meteorology	Binary Logistic Regression	Equation (Two Variables)
	Temperature Range	Air Temperature Range
	Temperature Threshold	Air Temperature
		Wet Bulb Temperature
		Dew Point Temperature

Models' performances varied widely

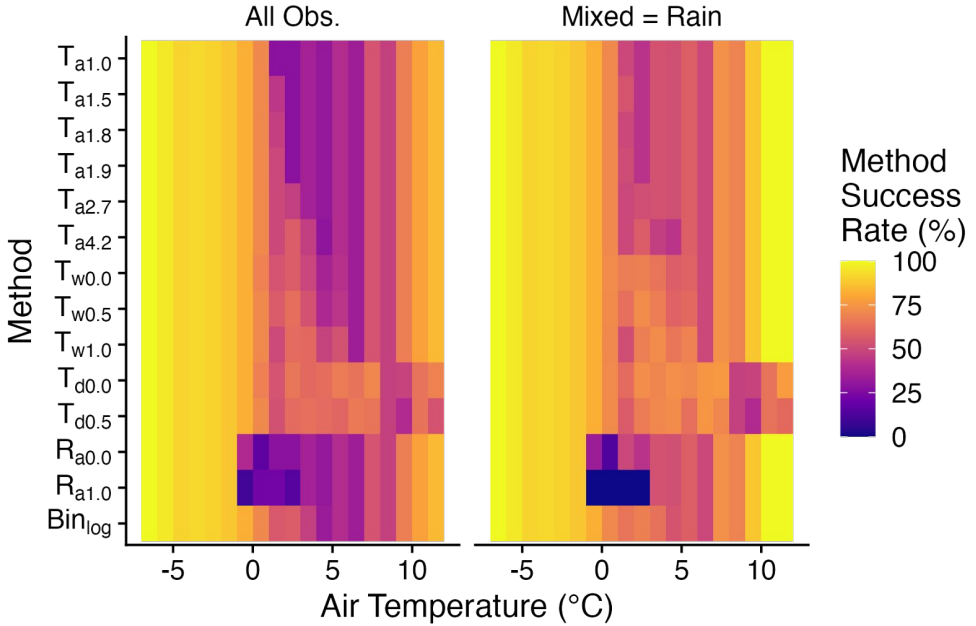
- Overpredicted rain



Jennings et al. (2023)

Models' performances varied widely

- Overpredicted rain
- Near-surface models had high variability
  - Humidity → Higher Success



Jennings et al. (2023)

Models' performances varied widely

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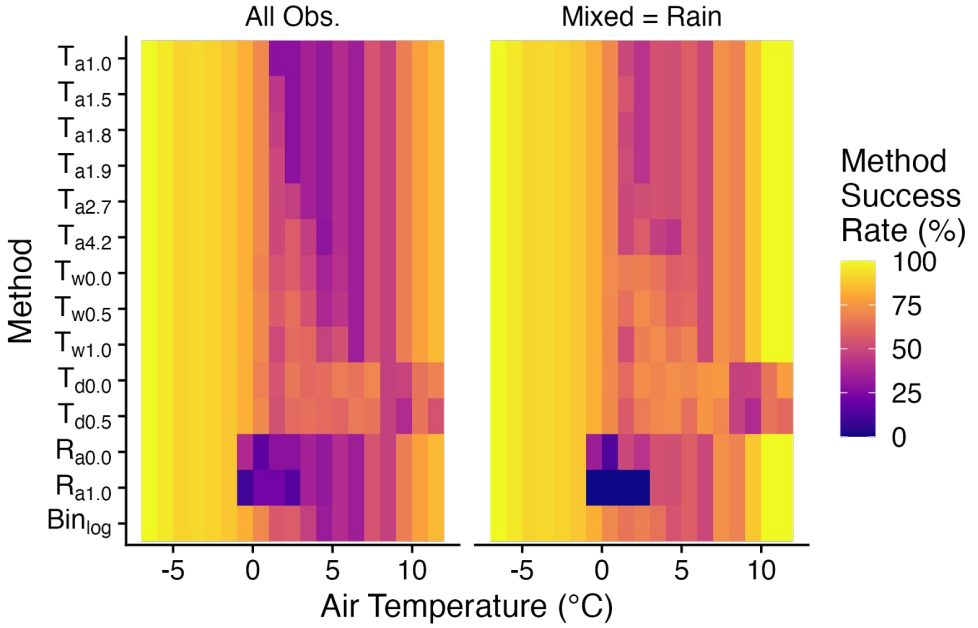
- 2020-2021 data – Sierra Nevada



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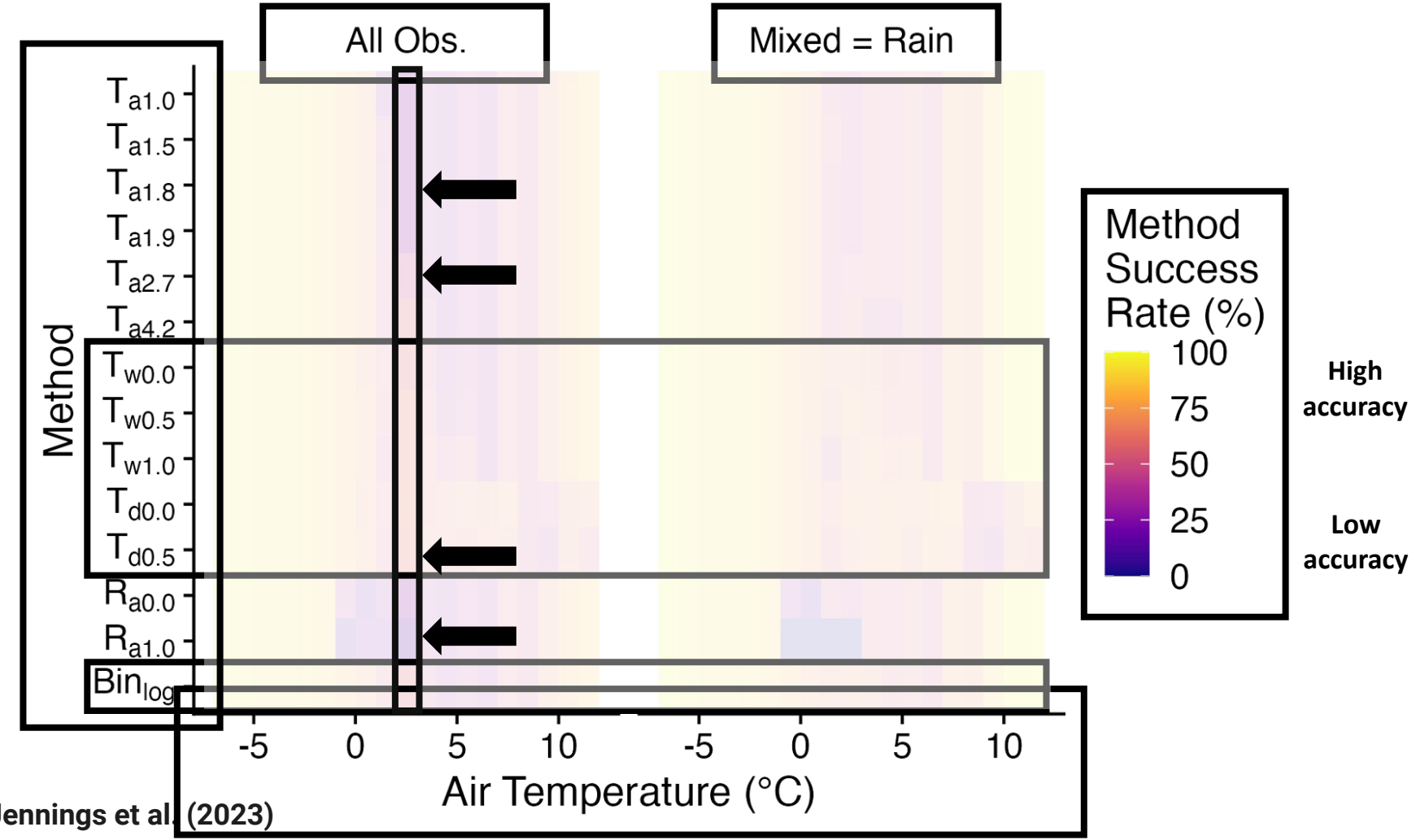


Jennings et al. (2023)

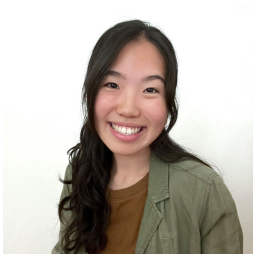
Our 2023-2024 Team

Keith Jennings
Lynker
Data analysis

Meghan Collins
DRI
Engagement strategy

Monica Arienzo
DRI
Engagement analysis

Anne Nolin
UNR
Hydroclimatology



Nayoung Hur
Lynker
Data & Engagement

Katherine Moore Powell
Lynker
Engagement

Guo Yu
DRI
Flood hydrology

Anne Heggli
DRI
Stakeholder & observer engagement

Sonia Nieminen
DRI
Engagement

Jessica Garrett
Lynker
Geospatial Developer

Not Pictured:

Dillon Ragar
Lynker

Brian Jenkins
UNR

Angus Watters
Lynker