Understanding the Gannon Storm by Harnessing the Power of Aurorasaurus Open Citizen Science

Feras Natsheh[1], Elizabeth MacDonald[2], Laura Edson[1], Vincent Ledvina[3], Matt Heavner[1]

1. New Mexico Consortium (NMC), 2. NASA Space Goddard Space Flight Center, 3. University of Alaska Fairbanks

ABSTRACT

Citizen scientists play a crucial role in advancing our understanding of space weather by contributing valuable observational data that complement traditional scientific methods. This poster presents ongoing efforts to clean, verify, and publish citizen science data collected through the Aurorasaurus participatory science project, ensuring their readiness for scientific use. Focusing on major auroral events such as the May and October 2024 geomagnetic superstorms, our work establishes protocols to enhance the quality and accessibility of these crowd-sourced observations.
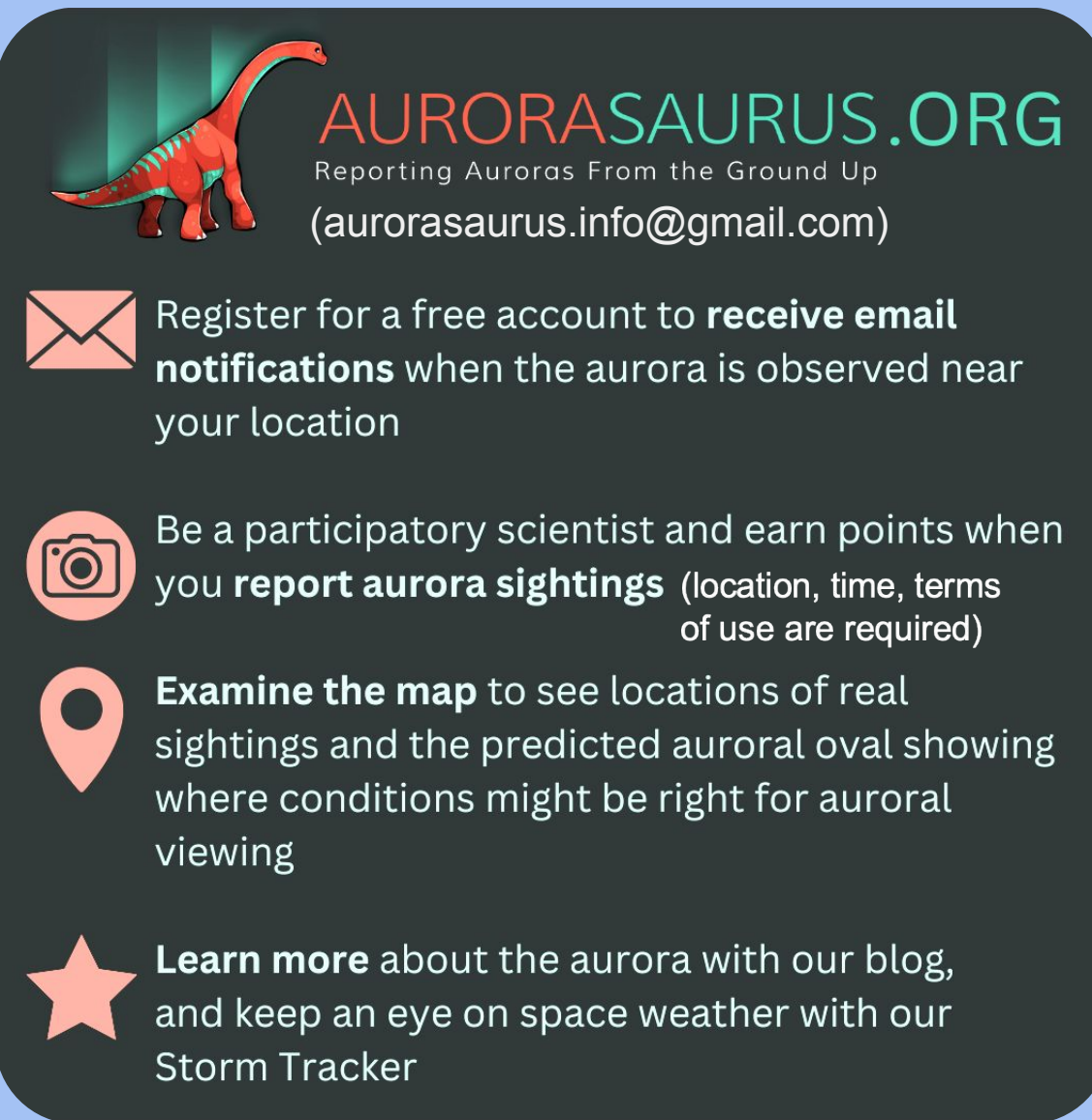
In addition, the Eclipse to Aurora Winter Field School, held in Fairbanks, Alaska, provided a transformative opportunity to expand this effort by incorporating optical and magnetometer measurements alongside citizen science auroral observations. Students and community members contributed scientifically valuable data that support the intercalibration of diverse datasets. These combined efforts highlight the agility and potential of citizen scientists to provide high-impact contributions to heliophysics education and space weather research.

By cleaning and analyzing 6000+ citizen science reports, and integrating them with heliophysics datasets, we demonstrate the reliability and scientific value of crowd-sourced observations during large, rare events. This highlights the importance of public engagement in space weather research, and showcases how these data can be utilized to study auroral activity at scale and at much lower than usual latitudes. This poster will detail the methodologies used for data verification, challenges in handling crowd-sourced heterogeneous data, and the contributions of citizen scientists and students to our understanding of exploring unusual aurora with new technologies.
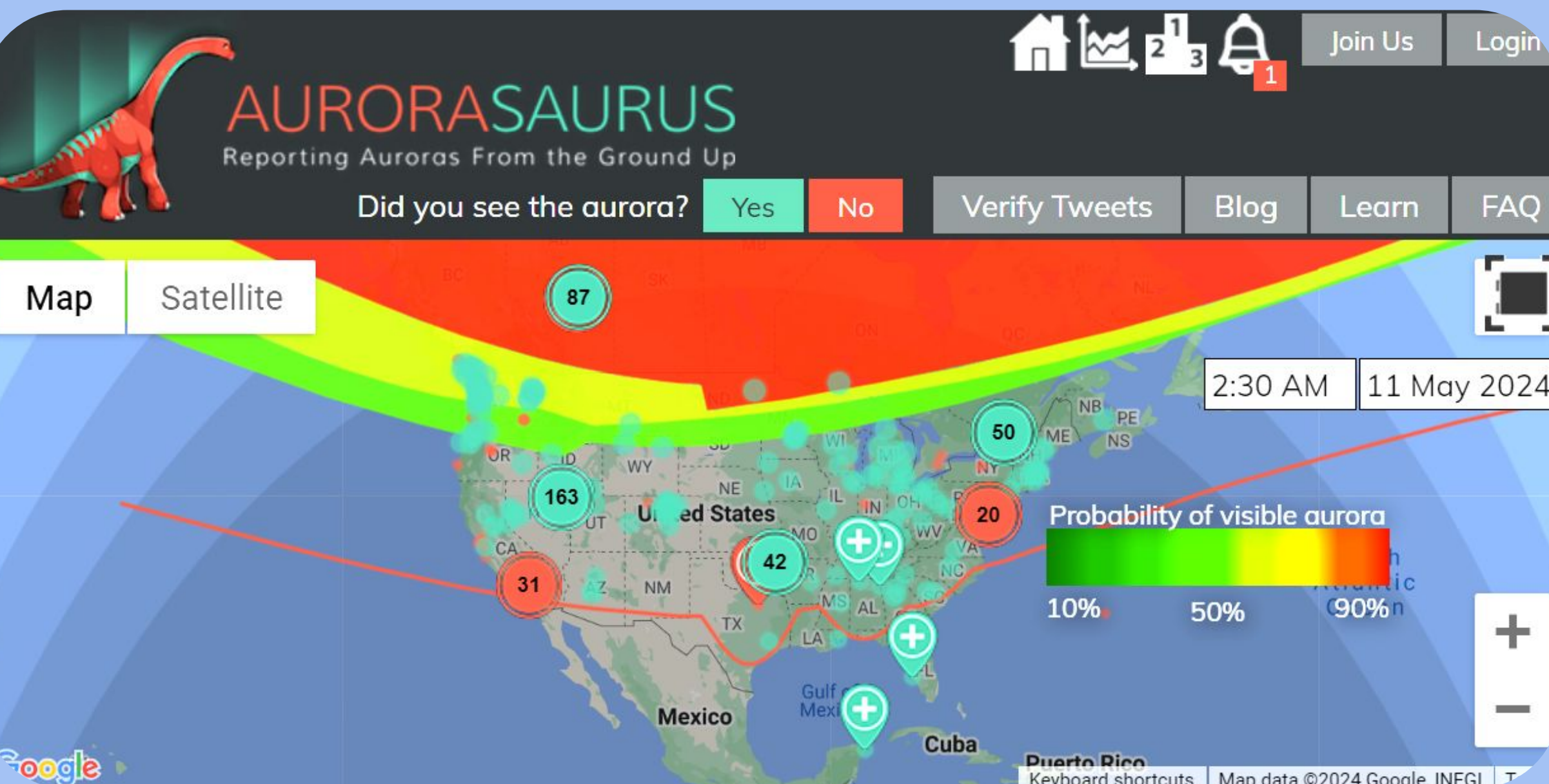
DATA-DRIVEN DISCOVERIES

The **Aurorasaurus project** harnesses public observations of the aurora, integrating them with scientific data to improve real-time aurora predictions and enhance space weather models

AURORASAURUS.ORG
(aurorasaurus.info@gmail.com)

- Register for a free account to **receive email notifications** when the aurora is observed near your location
- Be a participatory scientist and earn points when you **report aurora sightings** (location, time, terms of use are required)
- **Examine the map** to see locations of real sightings and the predicted auroral oval showing where conditions might be right for auroral viewing
- **Learn more** about the aurora with our blog, and keep an eye on space weather with our Storm Tracker

- Combining collaborative science reports with a traditional solar wind-driven auroral precipitation model enables greater spatial resolution of auroral visibility and the ability to generate localized alerts (Case et al., 2016a)
- A structure recognized by citizen scientists but unidentified by science associated with subauroral ion drift (SAID) is now known as Strong Thermal Emission Velocity Enhancement: STEVE (MacDonald et al., 2018; Hunnekuhl et al., 2020; Semeter et al., 2020)

OBJECTIVES

The Gannon Storm (May 10–11, 2024) was the strongest geomagnetic storm since 2003

- First major storm ever captured primarily by digital cameras, producing widespread auroral displays at unusually low latitudes
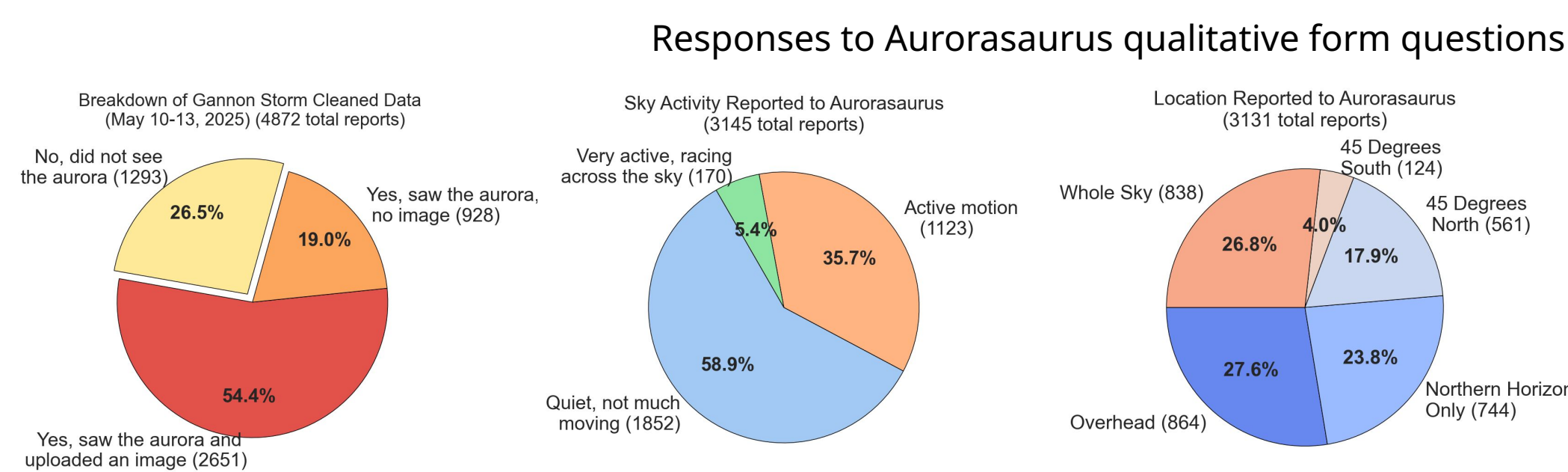
To maximize the scientific value of this dataset, a rigorous data cleaning and validation process was implemented:

- Filtered >6,000 citizen science reports from 55+ countries and 7 continents
- Removed duplicates and invalid entries
- Cleaned data can be used to improve auroral forecasting as well as to understand the forms of aurora during large events

Cleaned Aurorasaurus Reports from the Gannon Storm (May 10-13, 2024)

Saw Aurora?
- No (red)
- Yes (blue)

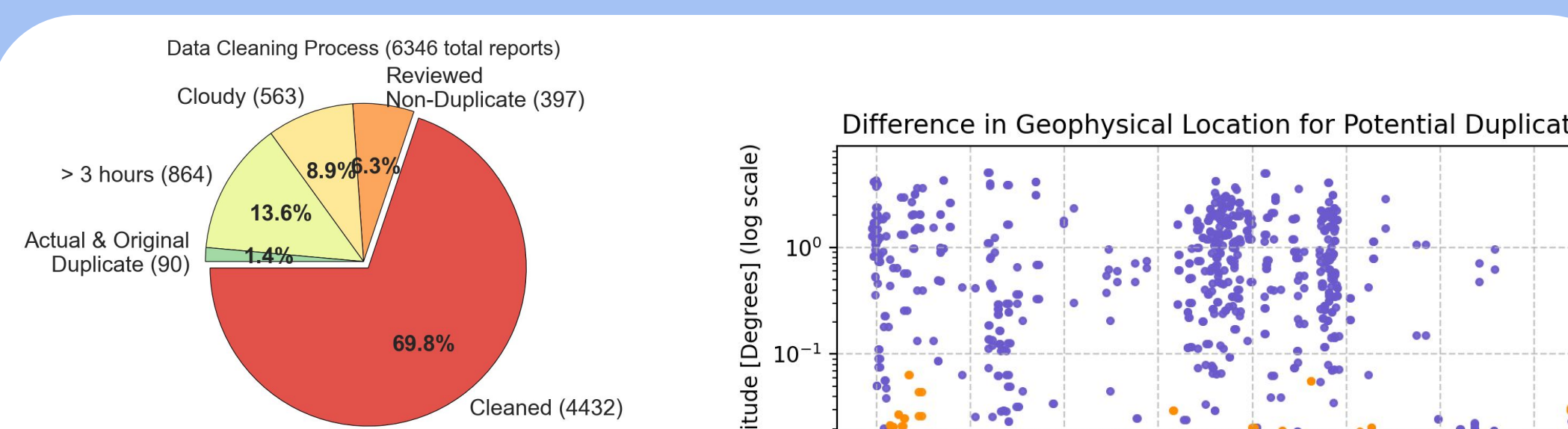Cleaned Hourly Reports on Aurorasaurus During the Gannon Storm (May 10-13, 2024)
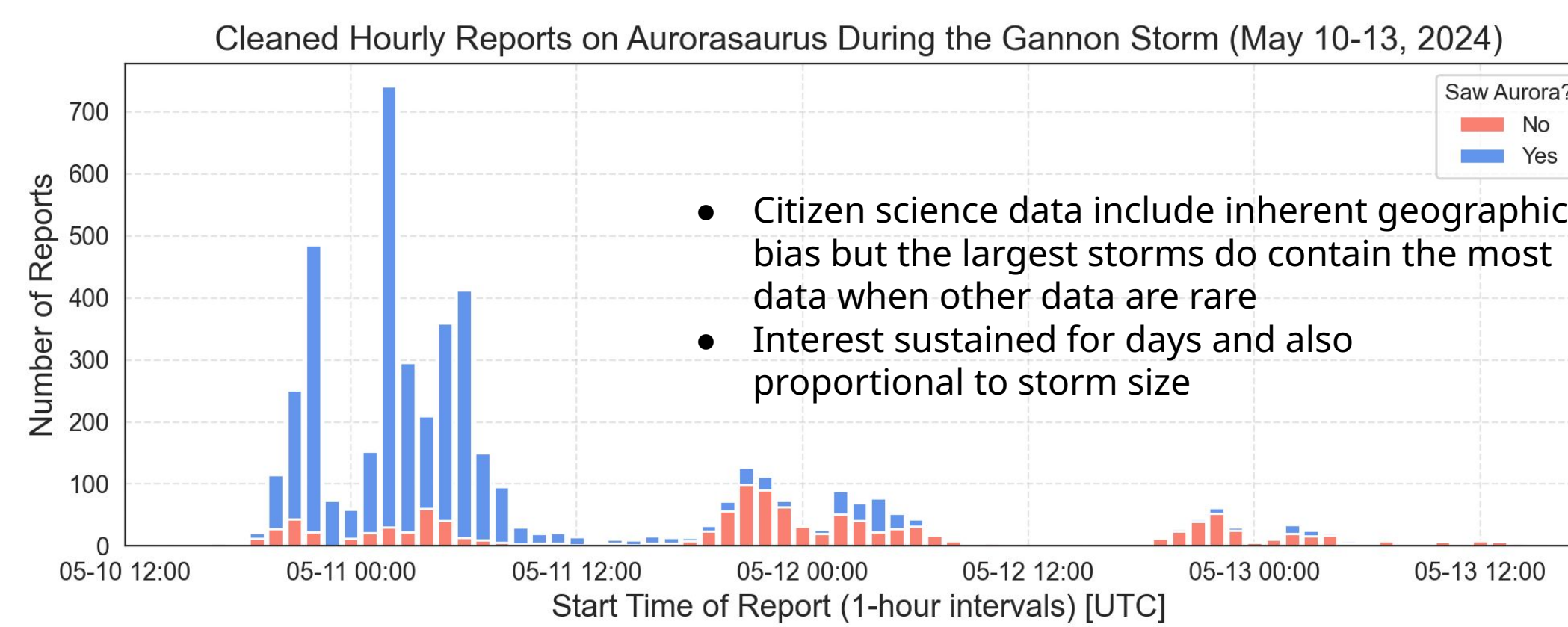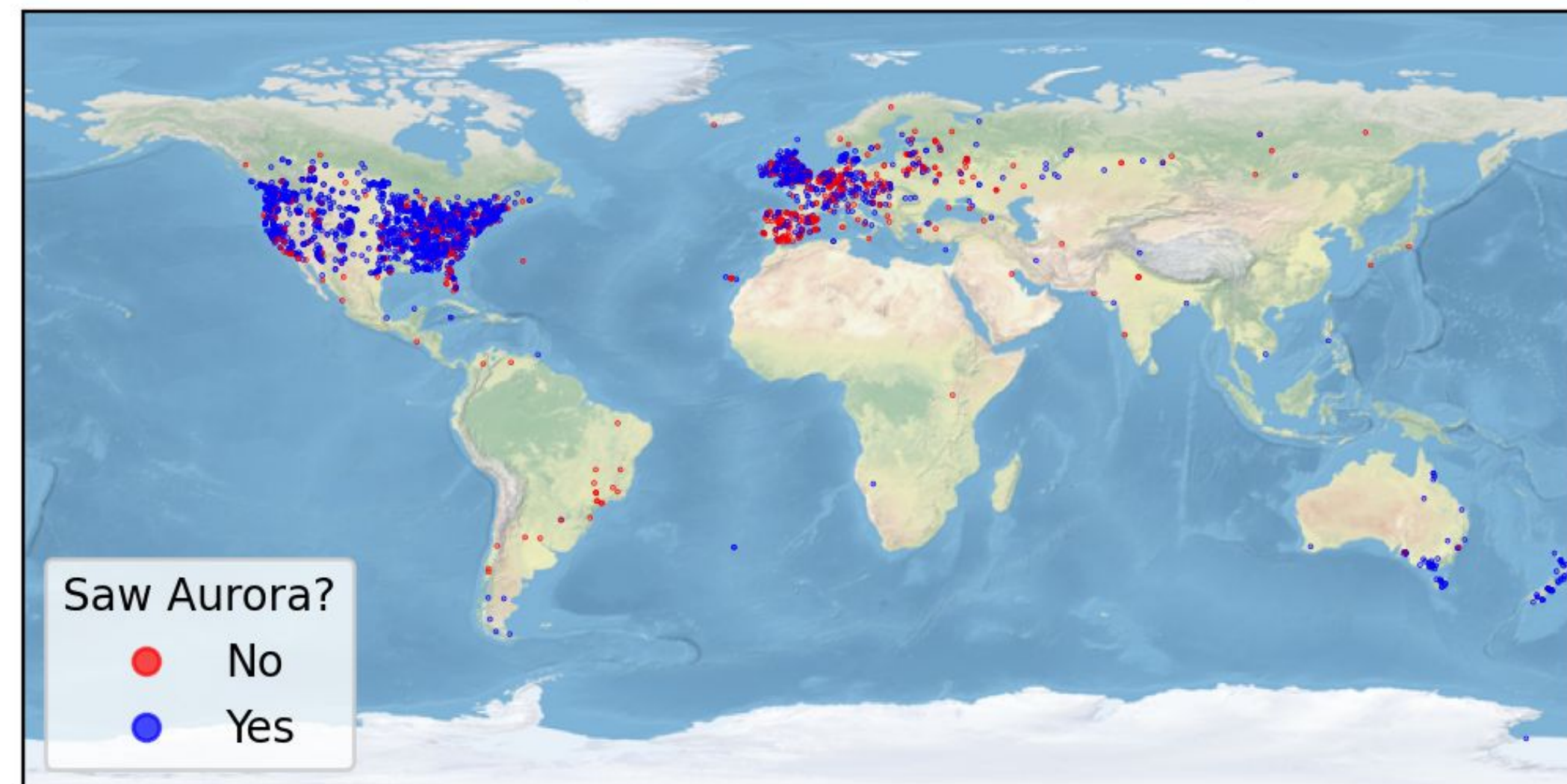
- Citizen science data include inherent geographic bias but the largest storms do contain the most data when other data are rare
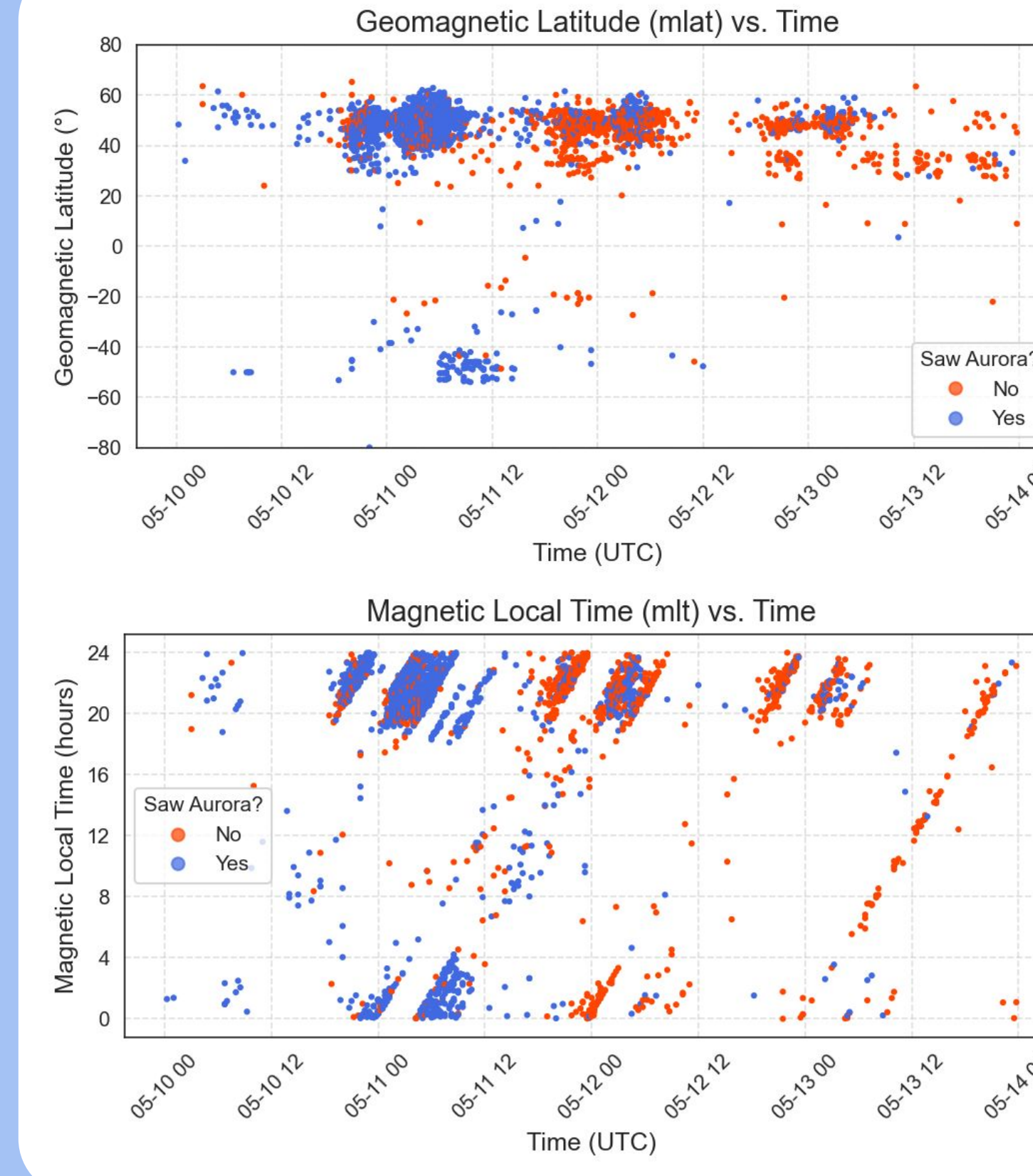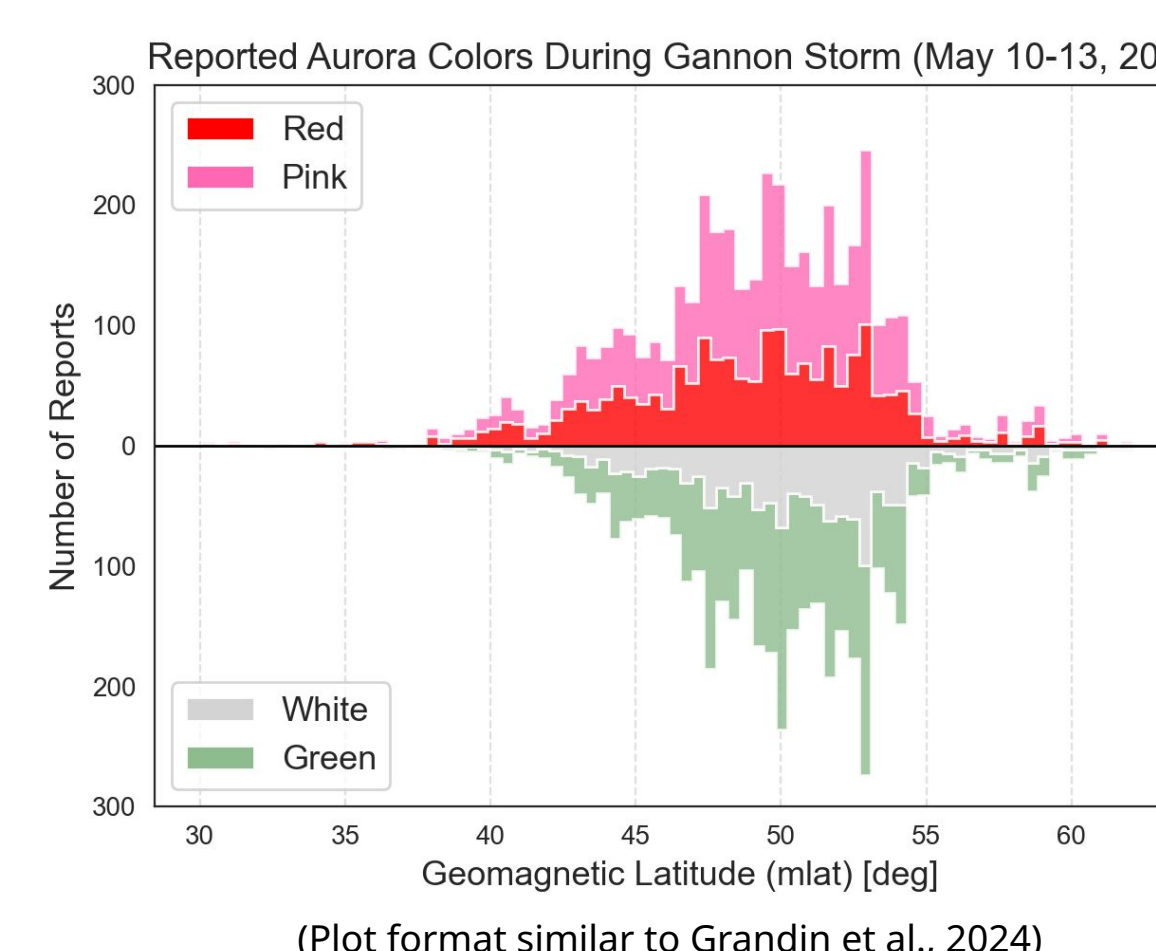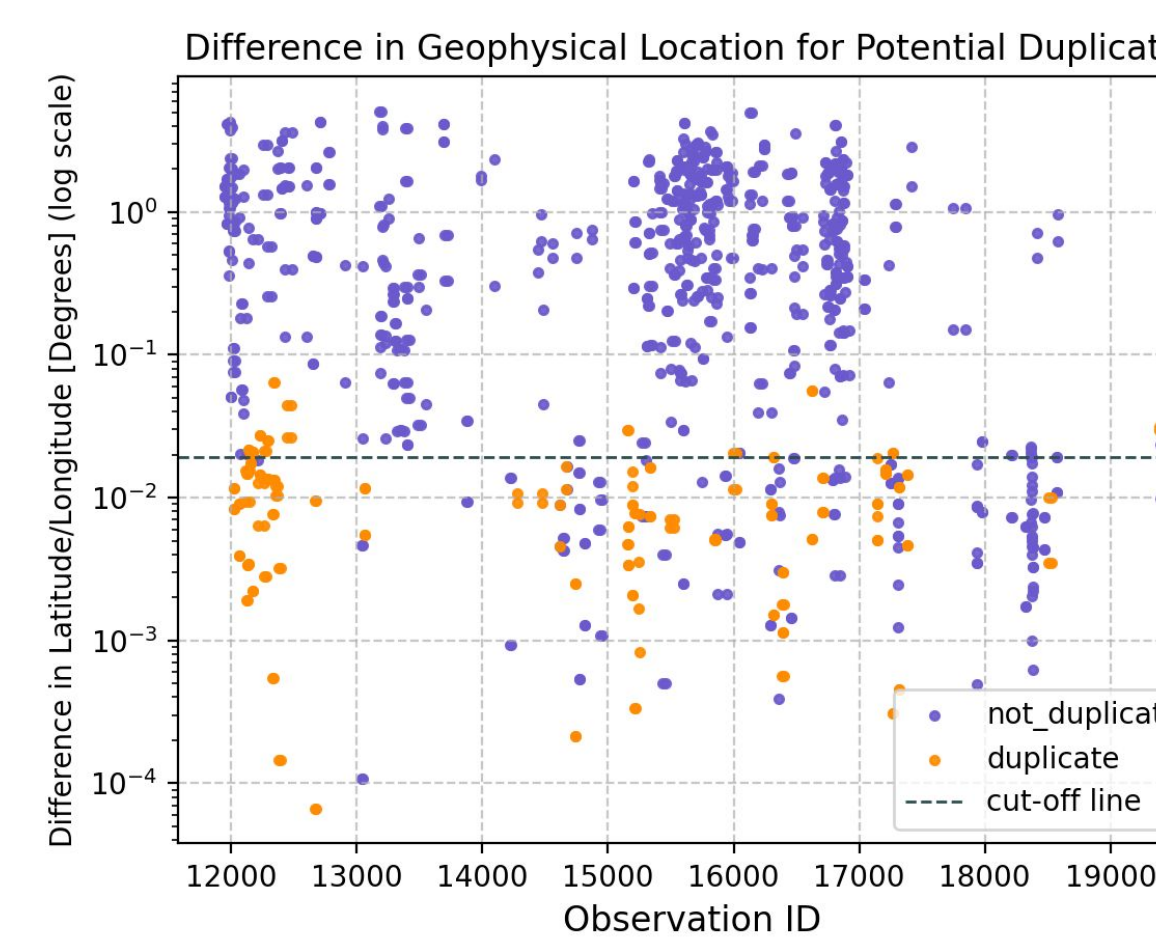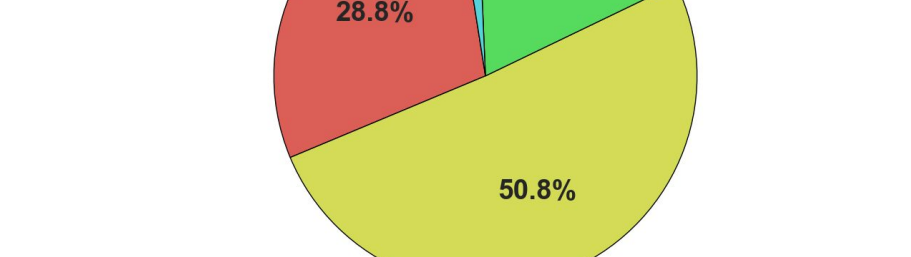- Interest sustained for days and also proportional to storm size

Responses to Aurorasaurus qualitative form questions

Breakdown of Gannon Storm Cleaned Data (May 10-13, 2025) (4872 total reports)
- No, did not see the aurora (1293): 26.5%
- Yes, saw the aurora, no image (928): 19.0%
- Yes, saw the aurora and uploaded an image (2651): 54.4%

Sky Activity Reported to Aurorasaurus (3145 total reports)
- Yes, very active, racing across the sky (170): 5.4%
- Active motion (1123): 35.7%
- Quiet, not moving (1852): 58.9%

Location Reported to Aurorasaurus (3131 total reports)
- Whole Sky (838): 26.8%
- 45 Degrees South (124): 4.0%
- 45 Degrees North (561): 17.9%
- Overhead (864): 27.6%
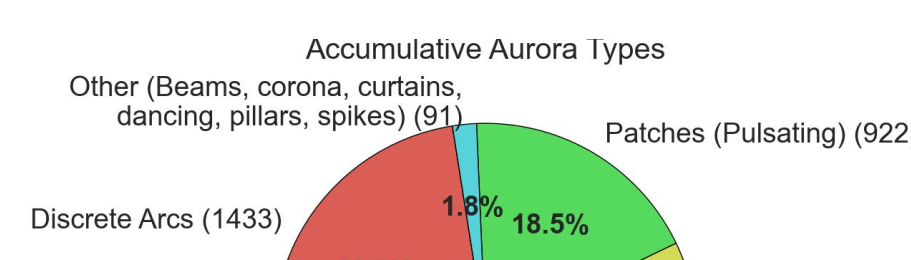- Northern Horizon Only (744): 23.8%

METHODOLOGY

- **Pre-processing:**
  - Standardized data, ensuring consistent formats
  - Extracted geolocation coordinates from the anonymized dataset
  - Filtered out incomplete or incorrectly formatted reports
- **Quality Filtering** (as in Kosar et al., 2018):
  - Removed duplicate reports
  - Filtered out reports with cloudy/obstructed conditions
  - Excluded long-duration observations (>3 hours)
- **Classification & Visualization:**
  - Labeled reports based on auroral visibility to identify trends
  - Resampled data into hourly intervals for time-based analysis
- **Final Dataset:**
  - Created a cleaned and structured dataset for scientific use
  - Prepared data for visualization and statistical analysis

Data Cleaning Process (6346 total reports)
- Cloudy (563)
- Reviewed Non-Duplicate (397)
- > 3 hours (864): 13.6%
- Actual & Original Duplicate (90): 1.4%
- Cloudy: 8.9%, 6.3%
- Cleaned (4432): 69.8%

Difference in Geophysical Location for Potential Duplicates

Difference in Latitude/Longitude [Degrees] (log scale) vs. Observation ID
- not_duplicate
- duplicate
- cut-off line

Responses to Aurorasaurus qualitative form questions

Accumulative Aurora Types
- Other (Beams, corona, curtains, dancing, pillars, spikes) (91): 1.9%
- Patches (Pulsating) (922): 18.5%
- Discrete Arcs (1433): 28.8%
- Diffuse Glow (2530): 50.8%

Accumulative Colors Reported to Aurorasaurus
- red (1959): 20.7%
- blue (223)
- purple (802)
- white (1266): 13.4%
- green (2709): 28.6%
- pink (2513): 26.5%

Reported Aurora Colors During Gannon Storm (May 10-13, 2024)

- Red
- Pink
- White
- Green
Number of Reports vs. Geomagnetic Latitude (mlat) [deg]
(Plot format similar to Grandin et al., 2024)

Analysis and Plans

Some advanced analysis has been carried out, with more to come:

- 77% of reports passed the cleaning criteria
- Automated duplicate screening procedures are largely sufficient, < 0.1% introduced error
- Plan to investigate auroral color/visibility changes with geomagnetic parameters
- Plan to update OpenSpace visualization which includes geophysical CCMC models

Geomagnetic Latitude (mlat) vs. Time

Saw Aurora? No / Yes

Magnetic Local Time (mlt) vs. Time

Saw Aurora? No / Yes

Visualization by Elon Olsson and Anders Lundkvist (CCMC, NASA GSFC), created using OpenSpace software in collaboration with Aurorasaurus

SUMMARY

- The Gannon Storm of May 10–11, 2024 produced the largest citizen science aurora dataset in recent years
- Initial data cleaning is complete and currently under review
- Data to be released on Zenodo along with updated description, terms of use, data paper, and Jupyter Notebooks to aid open science data exploration (target date: June 2025)
- Rigorous data cleaning improves data reliability and usability for scientific analysis
- Future work will focus on advanced analysis and visualization
- This study highlights the value of citizen science in contributing to space weather research of extreme events
- The Eclipses to Aurora Winter Field School demonstrated the power of combining citizen science with scientific instrumentation and educational outreach opportunities

Did We See STEVE This Storm?

Large storms are rare, and it is not known whether STEVEs occur in them:

- Quick check: 10 unique reports in the cleaned database mentioned STEVE, 7 included images
- Upon image examination, none were consistent
- Further investigation needed of images and red aurora (SAR features also)
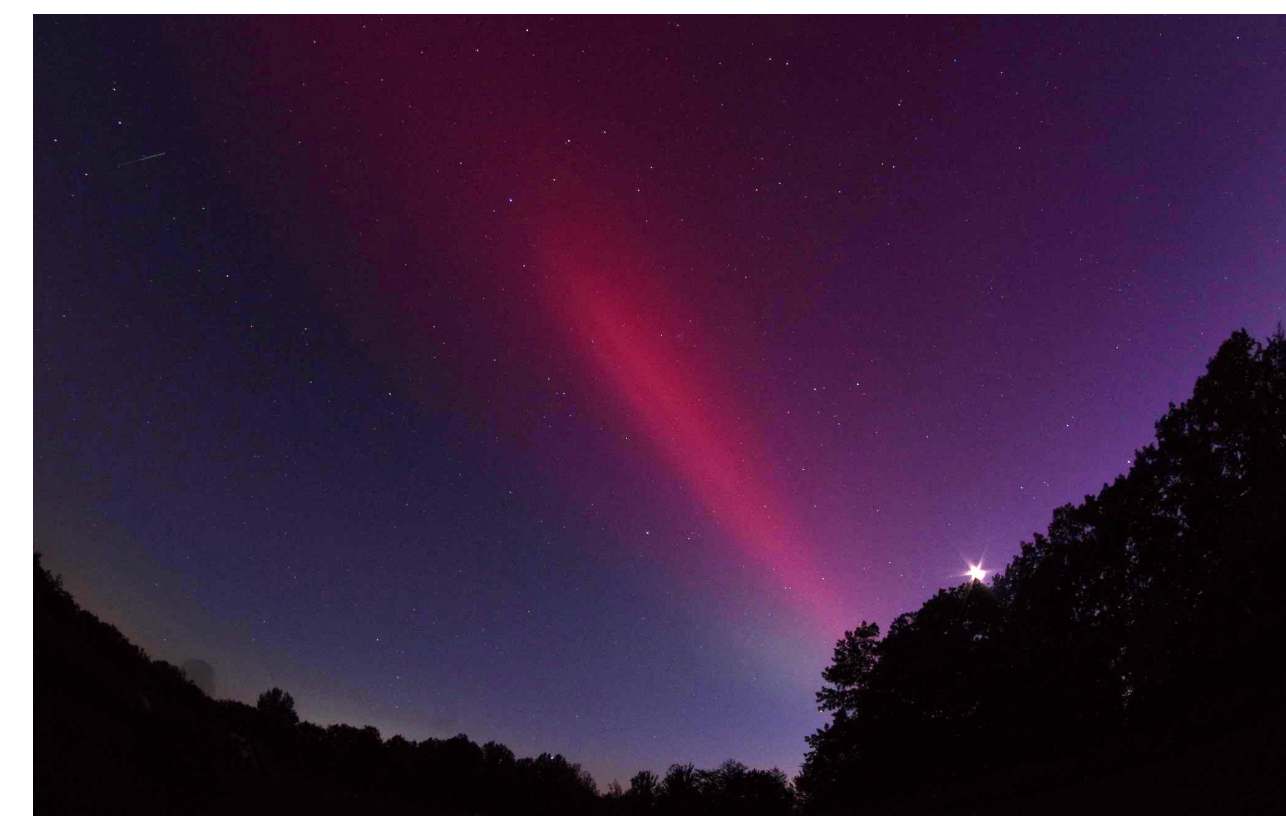

Photo Submission to Aurorasaurus from Tennessee, USA, May 11, 2024 1:45AM UTC
User said: "Was interested to know if one of the first things we saw was a Steve. Very persistent, more white to the eye but very red to camera. Amazing sight this far south. Eventually the aurora covered the sky." [Brightness adjusted for printing.]

The Eclipses to Aurora Winter Field School

Students, researchers, and citizen scientists in Fairbanks, AK

- Hands-on learning opportunities with Poker Flat Rocket Range, the Museum of the North, aurora chases, and more
- Active participation in citizen science data collection using a variety of instruments, including Aurorasaurus, EZIE-Mag, and AudioMoths

Winter Field School students and instructors. Photo: Andy Witteman

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