National Aeronautics and Space Administration

917 GLOBE Eclipse: Citizen Scientist Measurements of Atmospheric Changes During Astronomical Events

Ashlee Autore[1,2], Marilé Colón Robles[1,2], Kristen Weaver[3,4], Tina Rogerson[1,2], Jessica Taylor[2], Holli Kohl[3,4]

(1) ADNET Systems, Inc., Hampton, VA (2) NASA Langley Research Center, Hampton, VA (3) Science Systems and Applications, Inc., Lanham, MD (4) NASA Goddard Space Flight Center, Greenbelt, MD

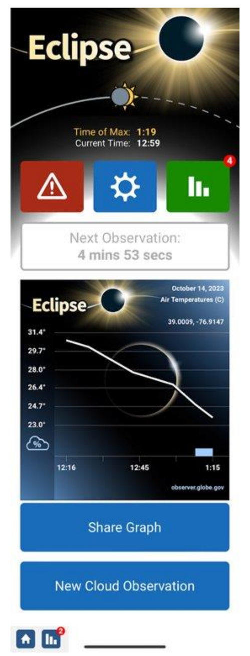
Introduction

The GLOBE (Global Learning and Observations to Benefit the Environment) Program is an international citizen science (CS) and education program. The program's GLOBE Observer app guides participants to collect cloud and air temperature observations during solar eclipses. The participants are prompted to collect:

- Air temperature every 10 minutes and then every 5 minutes 30 minutes before/after maximum.
- Cloud information (cover, type, and height) every 15 to 30 minutes.
- A land cover observation the day of the eclipse (new in 2023).

This research explores:

- The importance of citizen science.
- The effects of the solar eclipse on clouds.

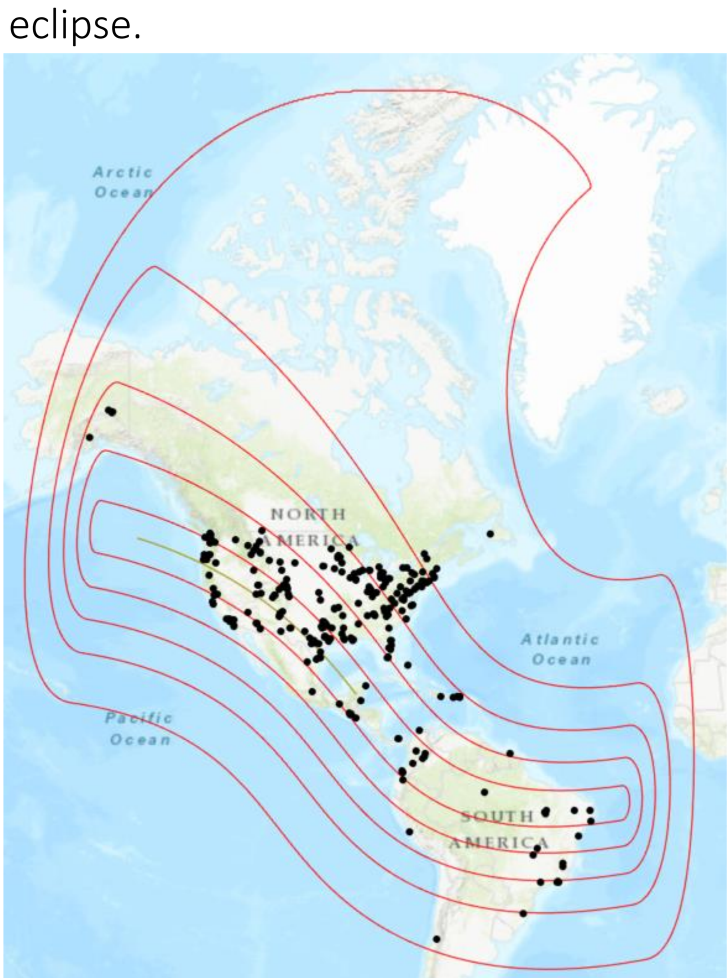


Download the app:

observer.globe.gov/get-the-app

October 2023 Annular Eclipse

GLOBE collected more than 2300 cloud observations on 14 October 2023, across the world. The eclipse was seen in North, Central, and South America, and lasted about 6 hours, with most places experiencing the eclipse for 2 hours. Below is a map of observations collected by GLOBE (black points), with red lines representing percent totality, in increments of 20%. Some observations were collected outside the spatial range of the eclipse, but they are not included in this research project. The yellow line represents the center path of the solar eclipse.



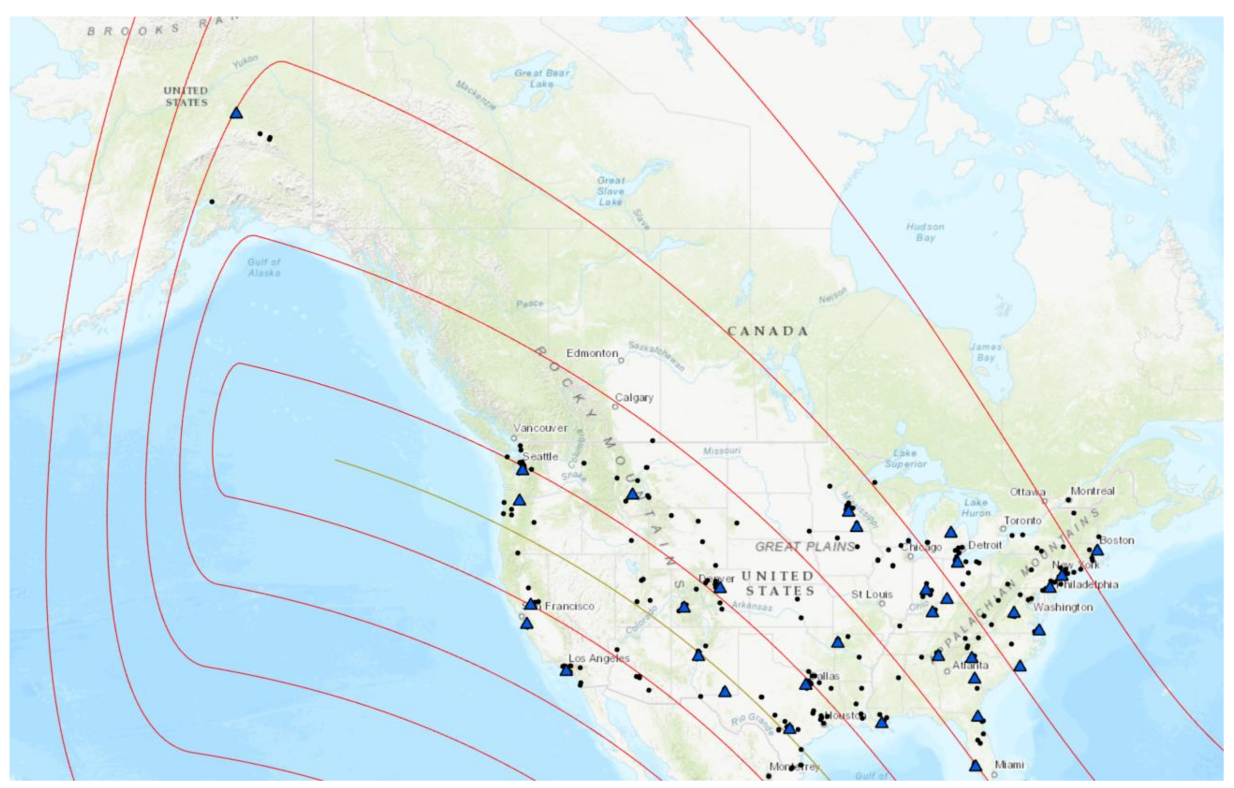
Data & Methodology

Just over 2000 collected observations were within the eclipse path, representing 606 locations. The coordinates of each observation were rounded to the nearest 0.01 degree to allow for grouping and better analysis, as many locations only had 1 observation reported. This produced 389 different locations in the eclipse path. Of these, 311 were in the USA. Only USA locations were considered because of the availability of ASOS stations and data. The analysis of each site included:

1. Gathering local eclipse start, maximum, and end times
2. Organizing GLOBE observations at each site by collection time
   - Cloud cover observations from 1 hour before the local eclipse began until 1 hour after the local eclipse ended were analyzed
3. Gathering 5-min ASOS cloud data from select sites
   - Cloud cover observations from 1 hour before the local eclipse began until 1 hour after the local eclipse ended were analyzed
4. Mapping each CS and ASOS site with eclipse percent totality and U.S. climate zones
5. Grouping ASOS and CS sites based on spatial distance
   - CS sites up to 204 km from the ASOS site were compared to it
6. Analysis of data in each group

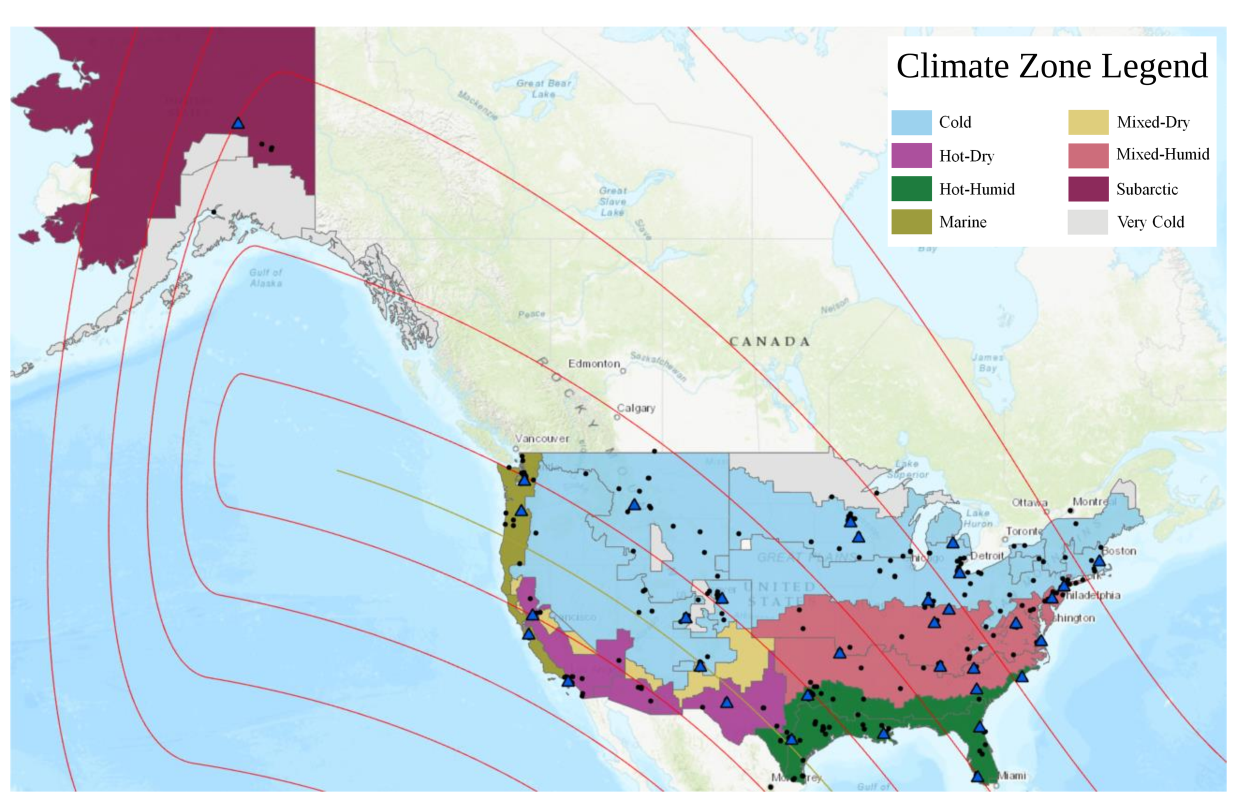
% Totality	# of CS sites that agree w/ closest ASOS site
<20	0/4
20-39.9999	24/41
40-59.9999	17/36
60-79.9999	12/53
>79.9999	3/70

Climate Zone	# of CS sites that agree w/ closest ASOS site
Cold	23/68
Hot-Dry	4/21
Hot-Humid	15/36
Marine	1/25
Mixed-Dry	5/11
Mixed-Humid	18/41
Very Cold	0/2
Subarctic	N/A



Map displaying the 311 CS observation sites (black points), 33 ASOS sites (blue triangles), percent totality in increments of 20% (red lines), and eclipse center path (yellow line).

% Totality	# of ASOS Sites	# of CS Sites (within 204 km of ASOS)
<20	1	4
20-39.9999	7	41
40-59.9999	10	36
60-79.9999	7	53
>79.9999	8	70

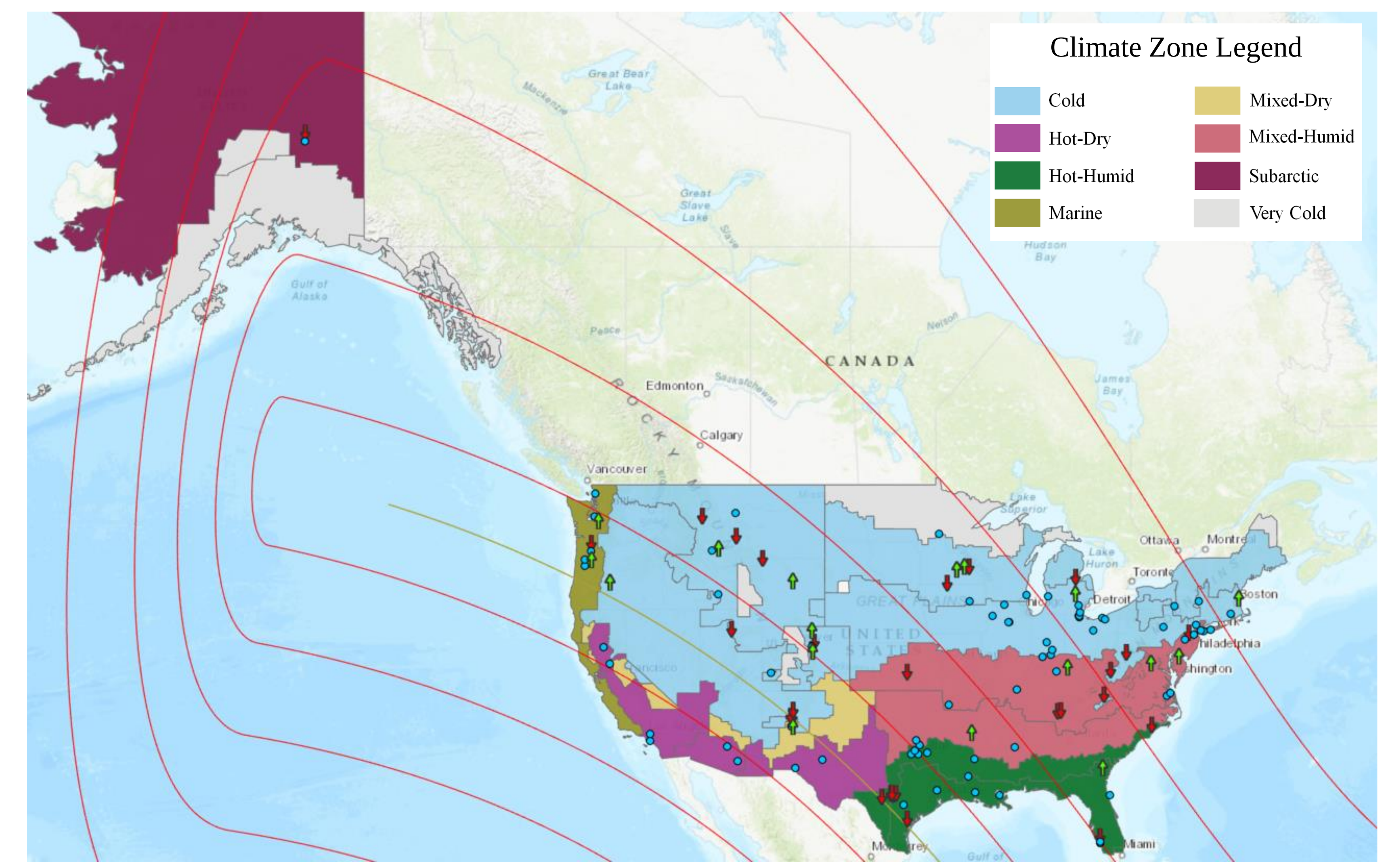


Map displaying the 311 CS observation sites (black points), 33 ASOS sites (blue triangles), climate zone (see legend), percent totality in increments of 20% (red lines), and eclipse center path (yellow line).

Climate Zone	# of ASOS Sites	# of CS Sites (within 204 km of ASOS)
Cold	9	68
Hot-Dry	3	21
Hot-Humid	6	36
Marine	3	25
Mixed-Dry	1	11
Mixed-Humid	10	41
Very Cold	0	2
Subarctic	1	0

Some Cities with Best CS-ASOS Agreement:

ASOS Site	Cloud Coverage Change	Climate Zone	% Totality
Toledo, OH	no change	cold	20-39.9999
Newark, NJ	no change	mixed-humid	20-39.9999
Philly, PA	no change	mixed-humid	20-39.9999
Indianapolis, IN	no change	cold	40-59.9999
Minneapolis, MN	increase	cold	40-59.9999
Chattanooga, TN	decrease	mixed-humid	40-59.9999
Greenville, SC	decrease	mixed-humid	40-59.9999
Los Angeles, CA	no change	hot-dry	60-79.9999
Fort Myers, FL	decrease	hot-humid	60-79.9999
New Orleans, LA	increase	hot-humid	60-79.9999
Carlsbad, NM	no change	hot-dry	>79.9999
Dallas, TX	no change	hot-humid	>79.9999
San Antonio, TX	decrease	hot-humid	>79.9999
Albuquerque, NM	decrease	mixed-dry	>79.9999



Map displaying overall cloud change at the 311 CS observation sites, with climate zone (see legend), percent totality in increments of 20% (red lines), and eclipse center path (yellow line). Red arrows indicate a decrease in cloud coverage, green arrows an increase, and blue dots no change.

Societal Impact

Does the solar eclipse affect cloud coverage? From these data it's hard to tell. 23/33 ASOS sites had most CS observations in agreement with them on how cloud coverage changed during the eclipse. More observations would strengthen the CS impact and produce results. Having 50 observations per group is preferred to make a statement about the relationship between cloud coverage and the eclipse[1]. Satellite images show large areas of the U.S. experienced cloudy conditions during the eclipse, as well as cold fronts, also impacting the sky conditions. Many of the CS observations did not contain enough data (i.e., not multiple observation times) to form conclusions about cloud change. The 2017 total solar eclipse received many more observations from citizen scientists, almost 10 times more. It is possible that people were not aware of the 2023 annular eclipse, resulting in so few observations. GLOBE aims to have more observations for the 2024 total solar eclipse, to study the change before and after maximum eclipse, as done in 2017.

Why do we want citizen science data? Citizen science observations are important because they can provide more spatial coverage than weather stations, they can yield higher temporal resolution, and they bring science to the community, helping people learn by doing. As more people become aware of the opportunities GLOBE provides, we can achieve higher quantity and quality of observations. In turn, this will provide insight into more localized atmospheric phenomena.

Citations

1. Dodson, J. B., M. C. Robles, J. E. Taylor, C. C. DeFontes, and K. L. Weaver, 2019: Eclipse across America: Citizen Science Observations of the 21 August 2017 Total Solar Eclipse. *J. Appl. Meteor. Climatol.*, **58**, 2363–2385, https://doi.org/10.1175/JAMC-D-18-0297.1.