GLOBE Eclipse: Citizen Scientist Measurements of Atmospheric Changes during Astronomical Events

Marilé Colón Robles, NASA LaRC/ADNET

GLOBE Clouds Team

Jessica Taylor
Principal Investigator

Tina Rogerson
Data Manager

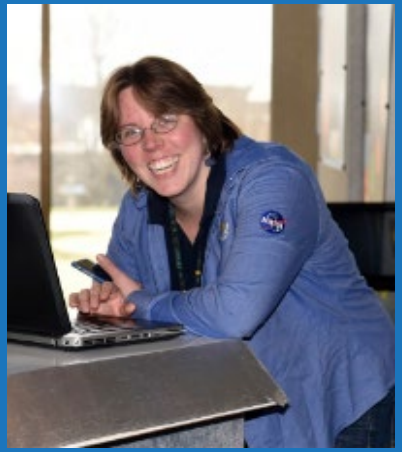
Rosalba Giarratano
Education Specialist

Marilé Colón Robles
Project Scientist

Ashlee Autore
Research Support

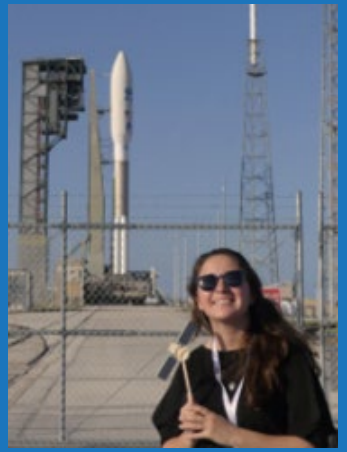
GLOBE Observer Team

Holli Kohl
Project Coordinator



Kristen Weaver
Deputy Project Coordinator

Autumn McMartin
Communications Director



Heather Mortimer
Graphic Designer

David Overoye
Lead Data Information Systems Team

The GLOBE Program

- Since 1995
- 127 countries
- 50+ science protocols
- 400+ publications
- 35k+ schools
- 244k+ citizen scientists
- 3M+ cloud observations

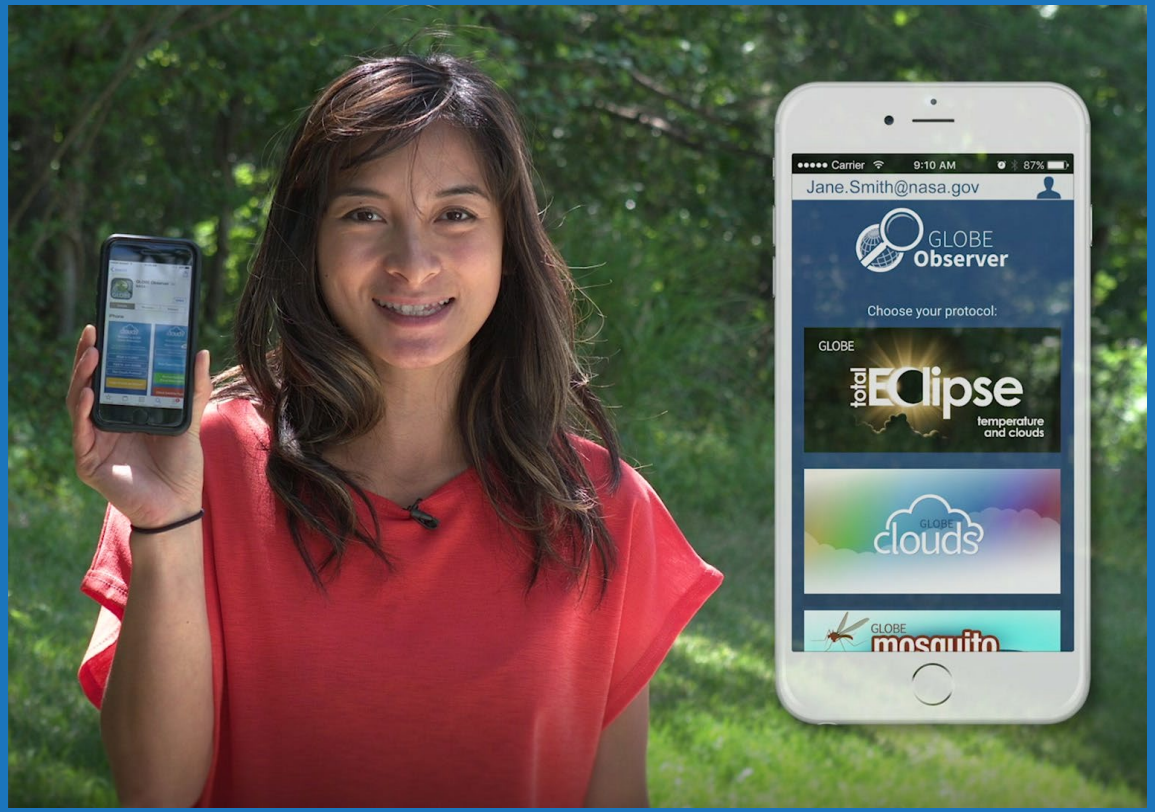
THE GLOBE PROGRAM

Global Learning and Observations to Benefit the Environment (GLOBE)

Sponsored by: NASA

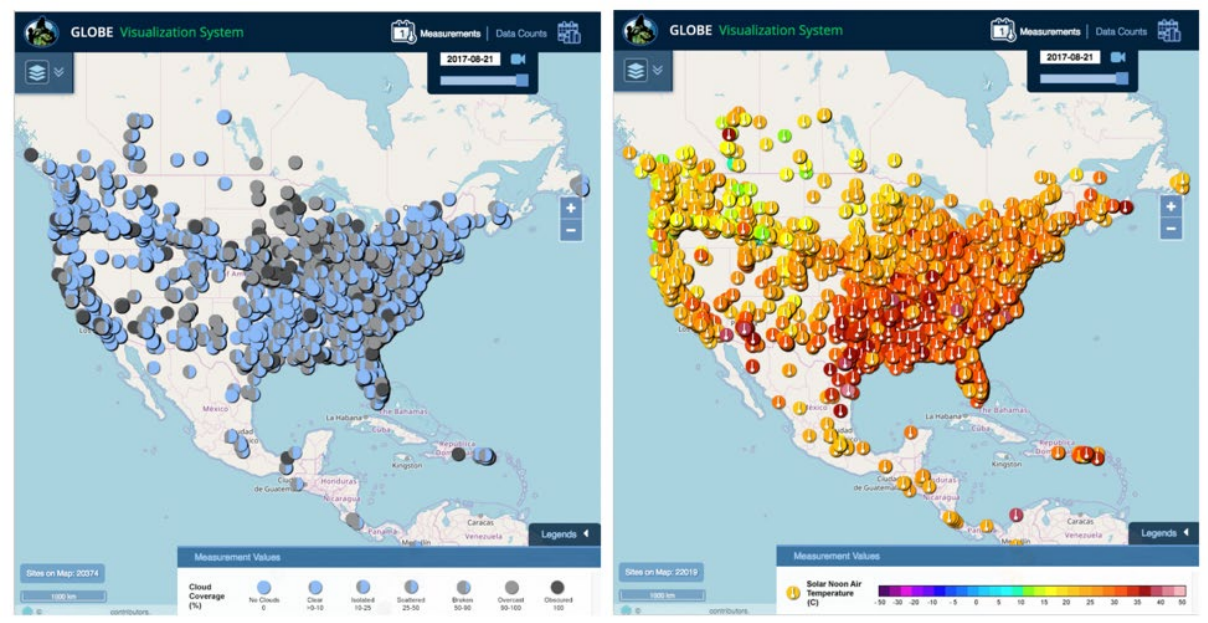
Supported by: NOAA, NSF, Department of State

Launch of The GLOBE Program's GLOBE Observer app



- Launch of GLOBE Eclipse tool in 2017
- On 21 August 2017
  - 80K air temperature
  - 20K cloud and sky
  - 60K photographs

Total Solar Eclipse 2017

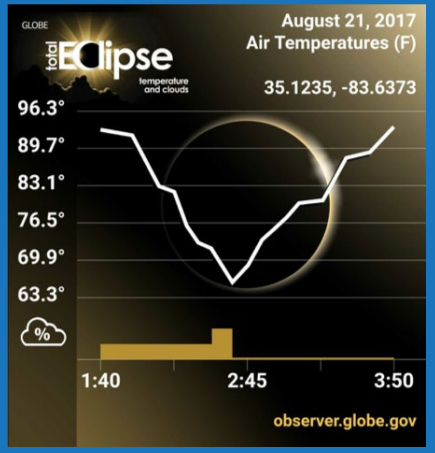


Dodson et al., 2019 found correlation between the total cloud cover and its impact on the coolness reported.

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.

Solar Eclipses 2023 and 2024 Data Collection

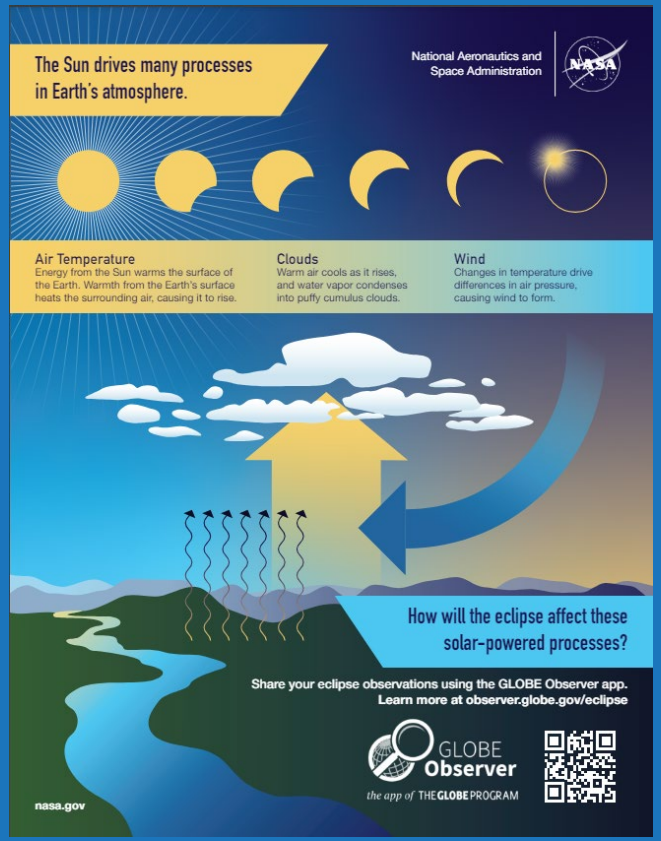
14 October 2023 (annular) and 8 April 2024 (total)



In the Eclipse Tool: Participants collect air temperature and clouds before and after maximum.

*Dodson et al., 2019, Eclipse Across America: Citizen Science Observations of the 21 August 2017 Total Solar Eclipse https://doi.org/10.1175/JAMC-D-18-0297.1

GLOBE Eclipse Challenge: Clouds and Our Solar-Powered Earth



15 March – 15 April 2024

Collected:

- 23,000 cloud observations
- 25,444 satellite comparisons

With observations from over 90 countries

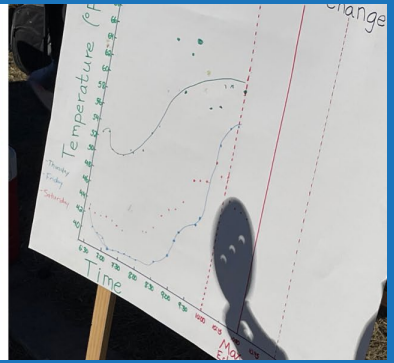
POWER

Prediction Of Worldwide Energy Resources

Annular Solar Eclipse – 14 October 2023

The team was part of the NASA footprint at the 2023 Albuquerque Balloon Fiesta event (900,000 people) during the Annular Solar.

Air temperature measurements: 17,000
Cloud measurements: 2,100



Total Solar Eclipse – 8 April 2024

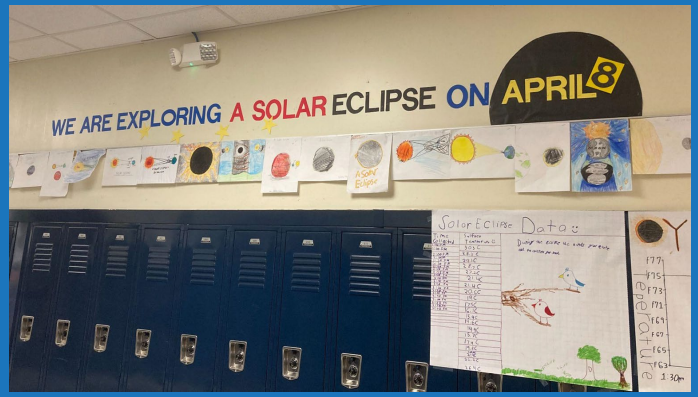
Events and Engagements

- Products and Videos in English and Spanish
- Scientific Presentations (poster and NASA Hyperwall talks) at the American Meteorological Society's Annual Meeting
- 5-week GLOBE Eclipse Workshop for U.S. Educators

Participants

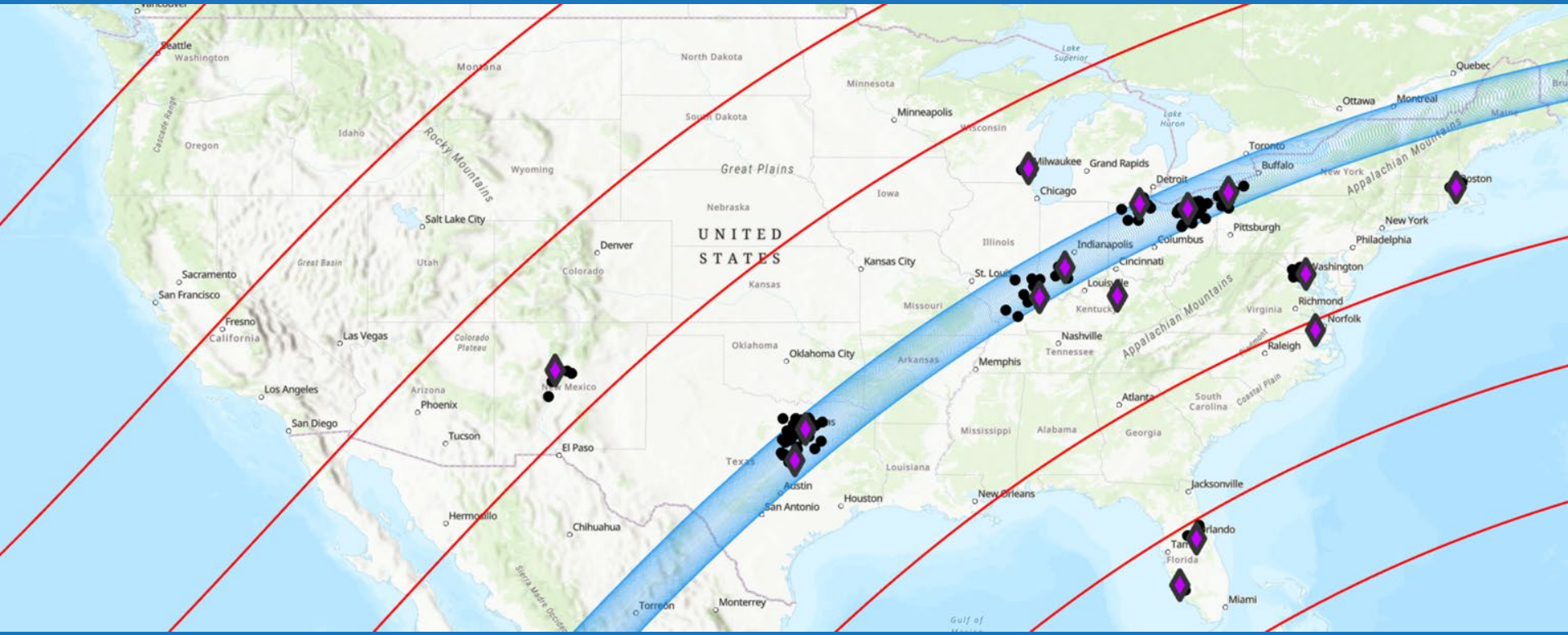
- Air Temp Measurements:
  - **34K+ (2.3 times the previous 3-day average)**
- Clouds Measurements:
  - **10K+** (13 times the previous 3-day average)
- ***Accounts for over half of all the data contributed to NASA citizen science projects!***

Credit: NASA



Credit: NASA/Marilé Colón Robles

Observation Locations



= % totality lines, 20% increments

= path of totality

= GLOBE Observation site

= city study sites/ASOS stations

Datasets

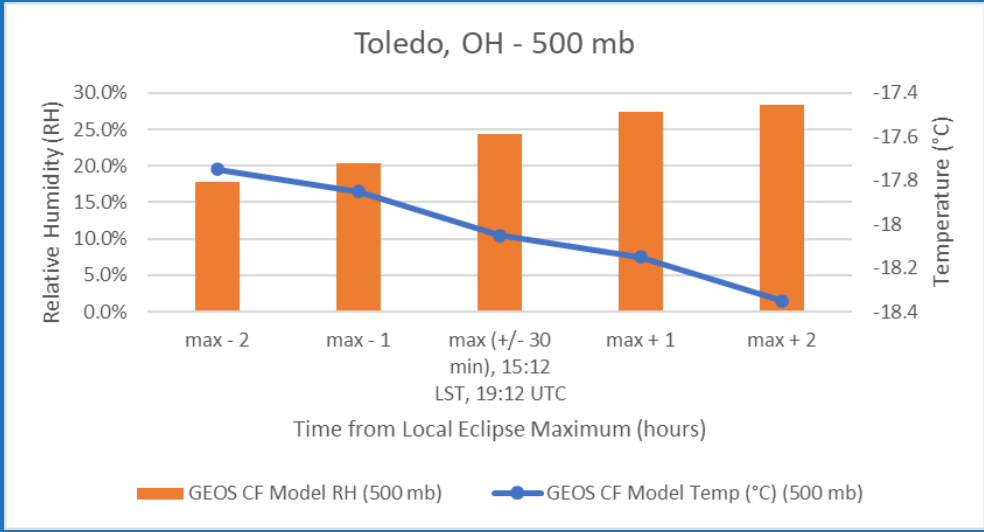
- GLOBE citizen science (CS) observations
- GLOBE satellite match reports (GOES-16 and GOES-18)
- 5-min ASOS
- GEOS-CF model (replay)
- CustomWeather hourly reports
- TimeandDate.com local eclipse times

Images:

- GOES-16
- EarthCam.com
- GLOBE CS observations

Analysis

- Analysis on high (500 mb), mid (700 mb), and low (800 mb) level clouds using citizen science observations, satellite match reports, and GEOS-CF model replay
  - used 5-min ASOS and hourly weather reports as available
  - GEOS-CF model replay provided hourly relative humidity & temp
- Compared RH and temp changes with CS observations and satellite match reports
  - 2 hours before local eclipse max to 2 hours after



Results

Overall:

- Mostly reported high-level clouds in all climate zones
- Before local eclipse max:
  - 10/15 cities reported a decrease or no change in cloud coverage
  - 11/15 cities reported increase in contrails
  - 7/15 cities modeled an increase in 500 mb RH
- After local eclipse max:
  - 11/15 cities reported a decrease or no change in cloud coverage
  - 12/15 cities reported increase in contrails
  - 11/15 cities modeled an increase in 500 mb RH
- 2 cities reported approaching cumulonimbus clouds after max
  - both reported increase in contrails after max

Contrail Imagery Collected by GLOBE Volunteers

Waco, TX; during partial, before local max

Waco, TX; same location, 30 min later, 25 min before max

Toledo, OH; during partial, before local max. Red circle highlighting a contrail

Toledo, OH; after local max

Toledo, OH; after local max, 25 min after previous image &same location

Results

Cold/Humid Continental:

- 3/5 cities reported increase in contrails before max
  - other 2 were the only ones to experience 500 mb temperature increase
- 5/5 cities reported increase in contrail reports after max

Mixed-Dry/Cold Semi-Arid:

- Albuquerque, NM
- Increase in spreading contrails before max
- Increase in cumulonimbus and contrails after max
- Increase in RH

Results

Mixed-Humid/Humid Subtropical:

- More reports of mid-level clouds than the previous climate zone
- 4/6 cities reported increase in contrails before max
  - of the other 2, 1 saw temp increase before max and 1 had no temp change
- 5/6 cities reported overall decrease in contrails after max
  - 6/6 reported decrease in short-lived contrails

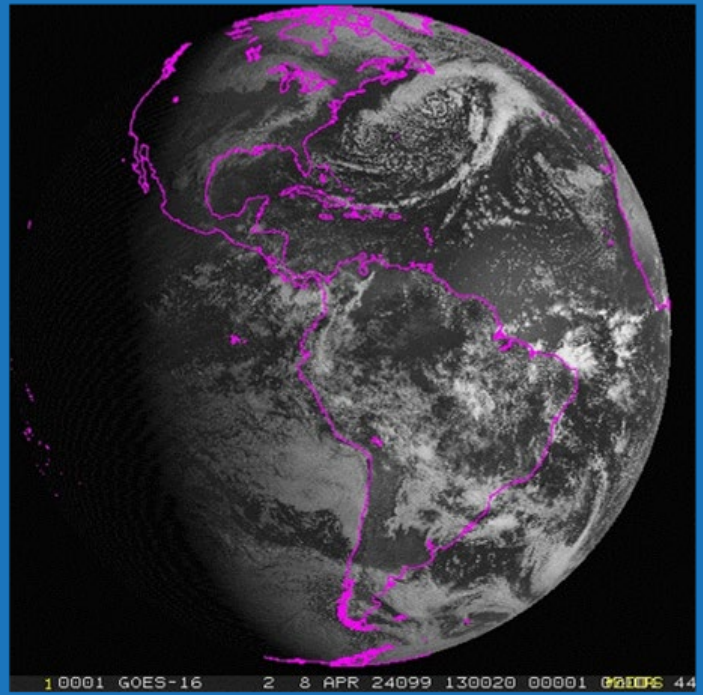
Hot-Humid/Humid Subtropical:

- 3/3 cities reported increase in overall contrails before and after max
- Cape Coral, FL reported cumulonimbus clouds after max
  - reported increases in all 3 types of contrails
- 2/3 cities have model data showing general decrease in RH
  - Cape Coral, FL only city with model data showing consistent increase in RH

Other Findings/Conclusions

- Locations most commonly experienced high-level clouds
  - cirrus most-reported cloud type
- Resulting decrease in solar radiation from eclipse may have affected upper-air RH, therefore affecting contrails
- Citizen science observations and satellite match reports typically agreed, except for +/- min of local eclipse max
  - satellite likely couldn't see the clouds
- ASOS most often reported skies as clearer than the other weather datasets
  - typically doesn't reach high enough to report high-level clouds
- Hourly-scale data cannot properly capture these small-scale phenomena

Weather Imagery

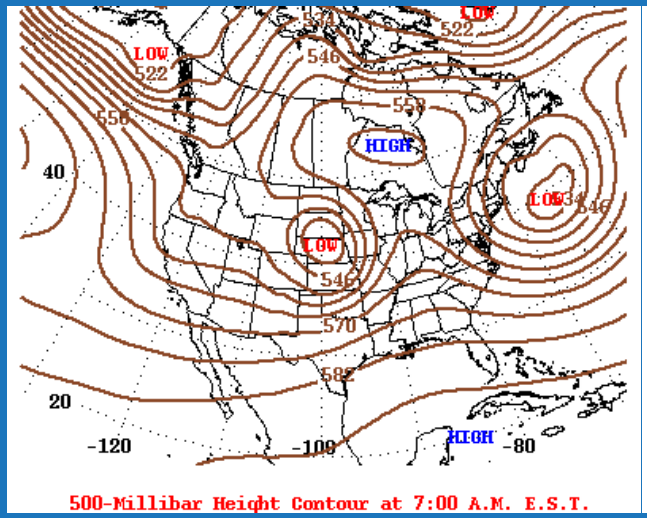


GOES-16 cloud coverage over the continental U.S. during the eclipse, from 1300 UTC to 2100 UTC, band 2. Note the visible shadow from the eclipse.

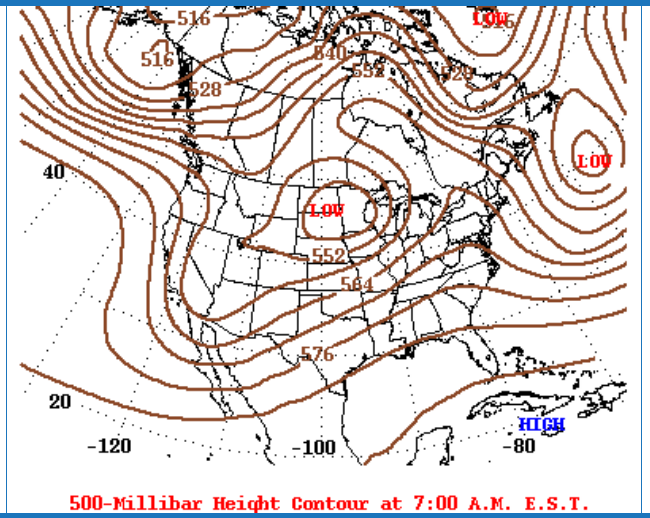
EarthCam overlooking Washington, D.C. from the Washington Monument. Exact times unknown, but relative times can be assumed to be mid-morning, local eclipse time, then sunset.

EarthCam overlooking Naples, FL from the Naples Pier (near Cape Coral, FLt. Exact times unknown, but relative times can be assumed to be mid-morning, local eclipse time, late-afternoon, then sunset.

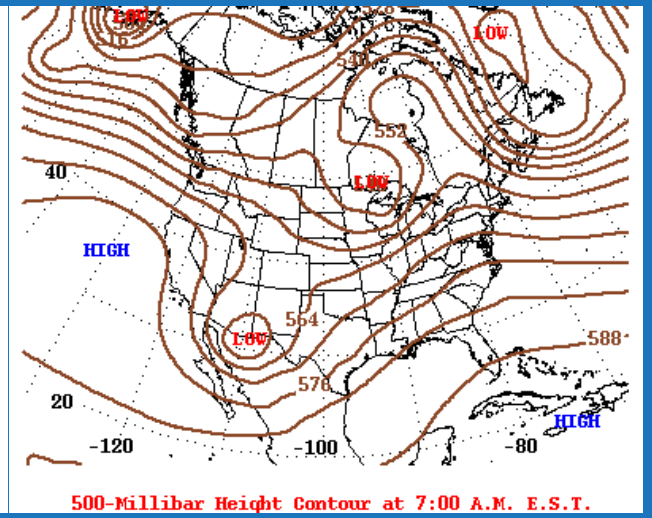
500 mb Weather Maps



7 April 2024 500 mb height contour, 1200 UTC



8 April 2024 500 mb height contour, 1200 UTC



9 April 2024 500 mb height contour, 1200 UTC