Collaborative use of solar eclipses to study the ionosphere

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13 October 2017

This material is based upon work supported by the National Science Foundation under Grant Nos. 1638685 and 1638697
and NERC Knowledge Exchange Fellowship

Outline

Historical Background

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Conclusions

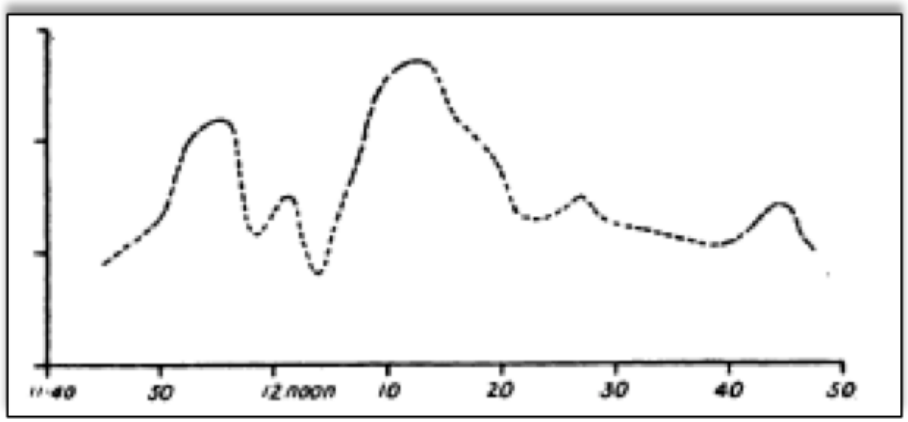
Historical Background

First use of solar eclipse to study ionosphere

- During the eclipse on 17 April 1912, William Henry Eccles (23 August 1875 – 29 April 1966), a prominent British electrical engineer and scientist, recorded discharges - clicks - strays.

- Wavelength 5,500 meters (frequency approximately 54.5 kHz)

- Published in Nature, 1912, Vol 89 (2217)



Nature, 1912, Vol 89 (2217)

NASA image

First multiple reception reports for same transmitter

- Data from the 1912 solar eclipse was also collected in France, Denmark and Germany using the transmitter at the Eiffel Tower in Paris.
- The transmitter had a frequency of 115 kHz (wavelength approximately 2,610 meters).
- UK study was done at 54.5 kHz and French, Danish and German studies were done at 115 kHz, difficult for data comparison.

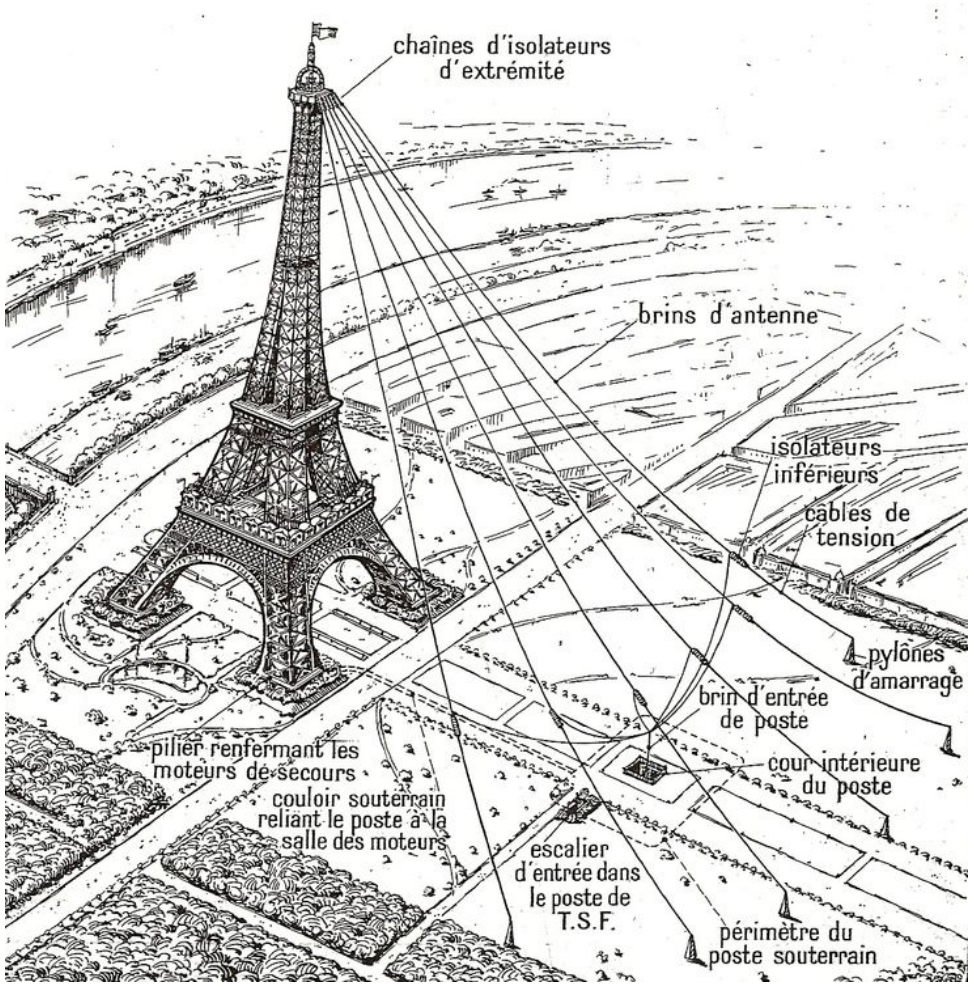


image from de.wikipedia.org

First Attempt at Group Data Collection

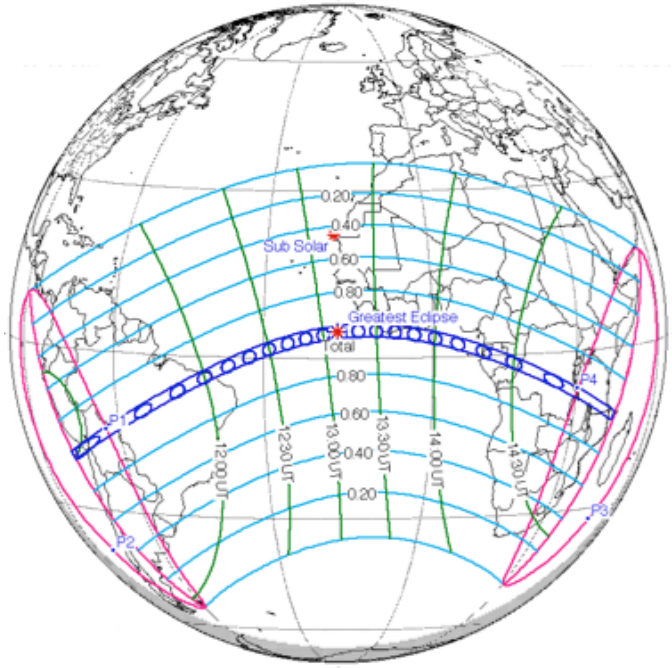
- Planned for 21 August 1914
- Group activity envisioned early on
- WWI impacts data collection and analysis

http://astro.ukho.gov.uk/eclipse/0311914/S1914Aug21.pdf

Second Try

- During the solar eclipse on 29 May 1919, increased signal strength was noticed in daytime between Meudon, Paris and Ascension
  - Wavelength 4,700 meters (approximately 63.8 kHz)
- Hypothesis: increased signal strength was due to the diminishing effect of solar radiation

- No particular change in intensity was noticed for most transmit/receive pairs
- Many different receivers coupled with different transmitters
- Only anecdotal reporting!

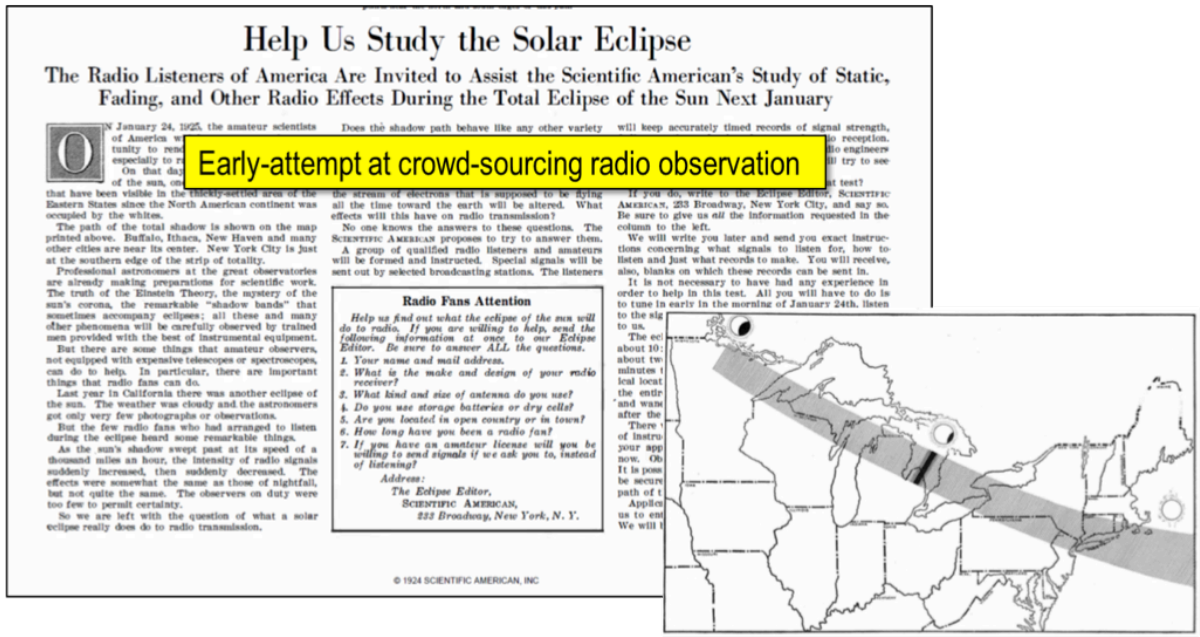


NASA image

Early Crowdsourcing Effort

25 January 1925 Solar Eclipse

- Scientific American and ARRL Efforts
- Close to 2,000 AM broadcast and 150 Amateur Radio reports
- Noticed 75 meter daytime signals arrived with intensity associated with nighttime signals
- AM broadcast and Amateur Radio reports contained many errors[1]



Help Us Study the Solar Eclipse

The Radio Listeners of America Are Invited to Assist the Scientific American's Study of Static, Fading, and Other Radio Effects During the Total Eclipse of the Sun Next January

Early-attempt at crowd-sourcing radio observation

Radio Fans Attention

Help us find out what the eclipse of the sun will do to radio. If you are willing to help, send the following information at once to our Eclipse Editor. Be sure to answer ALL the questions.

1. *Your name and mail address.*
2. *What is the make and design of your radio receiver?*
3. *What kind and size of antenna do you use?*
4. *Do you use storage batteries or dry cells?*
5. *Are you located in open country or in town?*
6. *How long have you been a radio fan?*
7. *If you have an amateur license will you be willing to send signals if we ask you to, instead of listening?*

Address:
The Eclipse Editor,
SCIENTIFIC AMERICAN,
233 Broadway, New York, N. Y.

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[1]Reports in Scientific American and QST

Reports of 75 kHz reception during 1999 solar eclipse

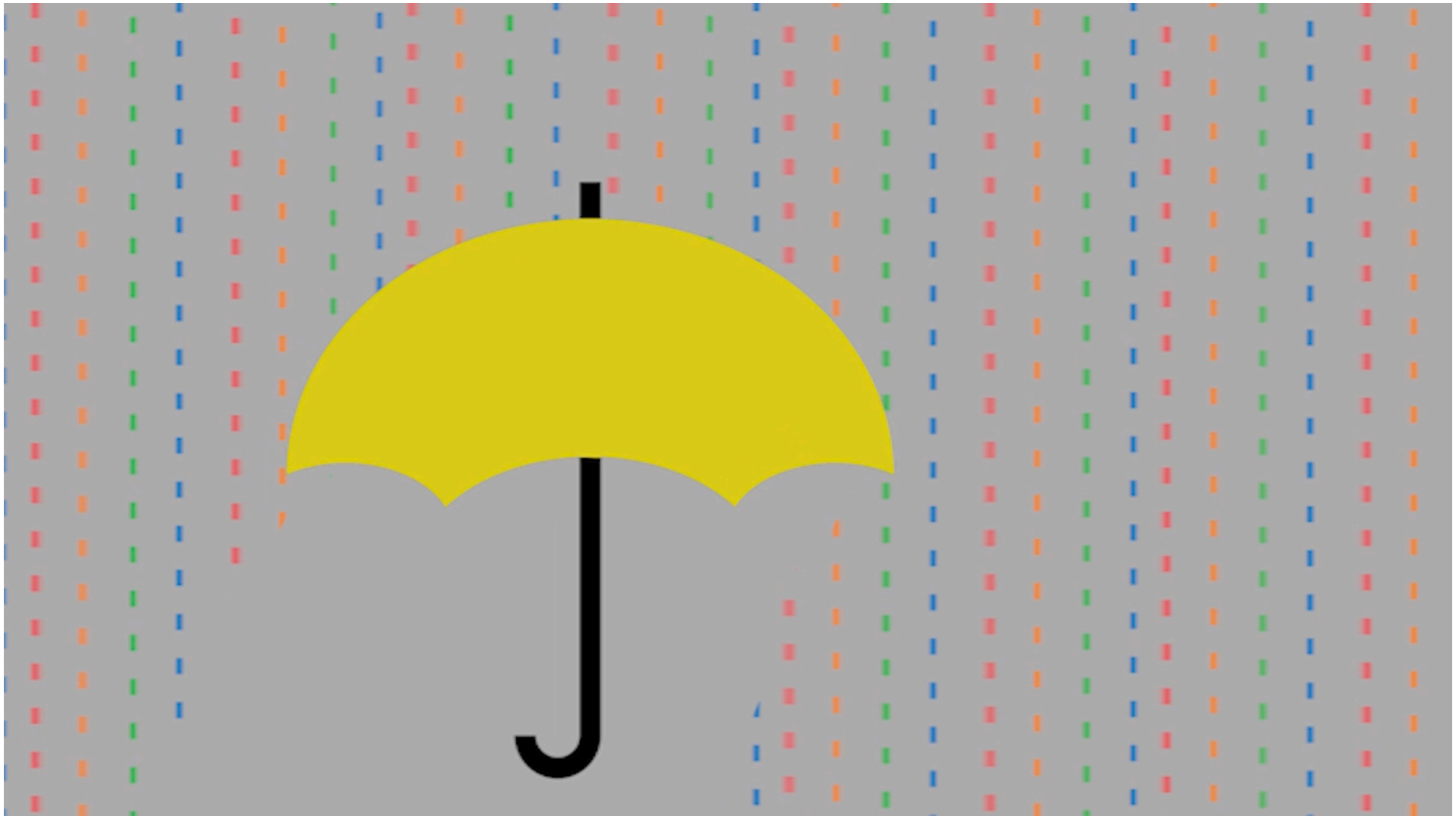
Graphics can be seen at URL listed below.

M. Sanders, 1999. "Solar eclipse effect on the propagation of LF radio signals" from 3 December 1999, available at URL:http://www.xs4all.nl/misan/eclipse.htm.

Ionosphere Ionization Experiment

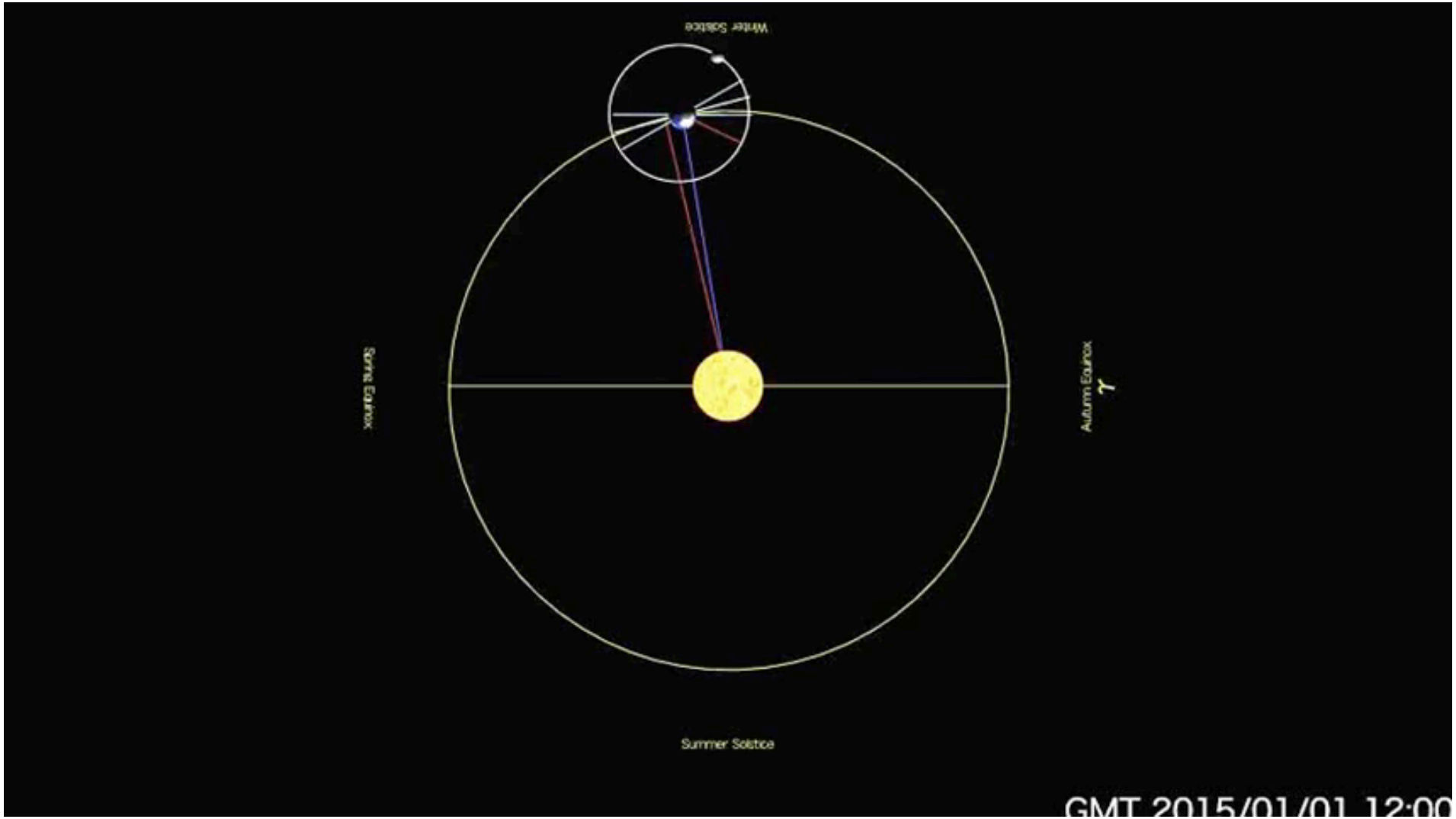
- In the 1920s, it was understood that the sun caused the ionization of the ionosphere. Two possible mechanisms were hypothesized:
    1) electromagnetic waves emitted by the sun
    2) neutral particles emitted by the sun
- Edward Appleton proposed an experiment where the moon during a solar eclipse would stop both the electromagnetic waves and the particles
- Particles travel approximately 1,000 to 2,000 km/sec vs. the speed of electromagnetic waves (300,000 km/sec)
- Solar eclipses of 1932, 1933 and 1934 were studied by 26 teams

Particle Path Being Obstructed



Graphics by Carrie Lemaster

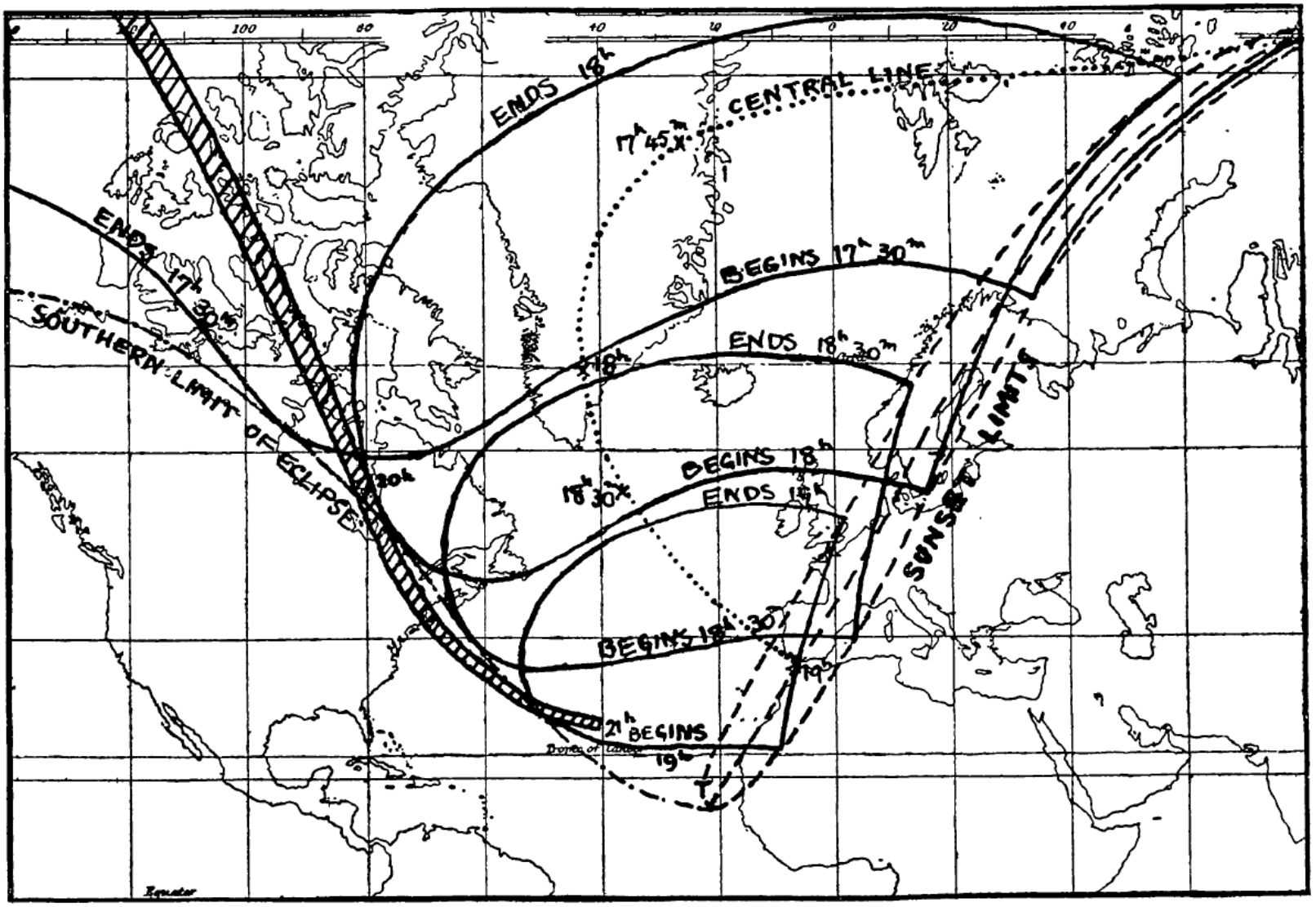
Motion of Earth and Moon



https://www.youtube.com/watch?v=2Z0CfNoDu_o

Animation by AstroSimulator

Corpuscular Eclipse Track

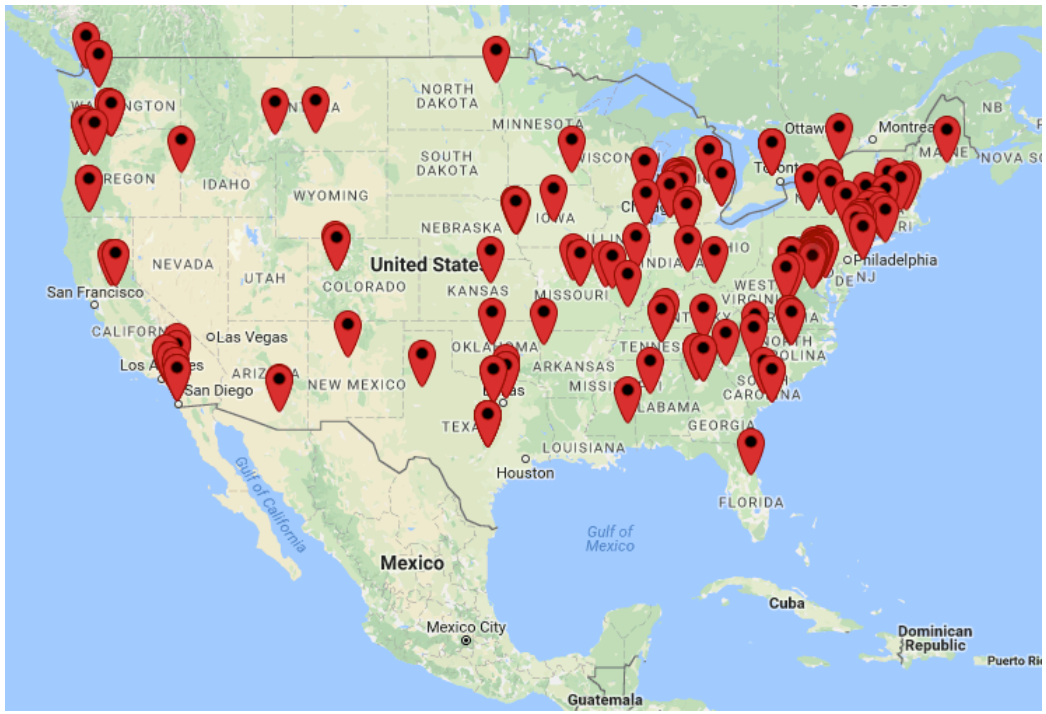


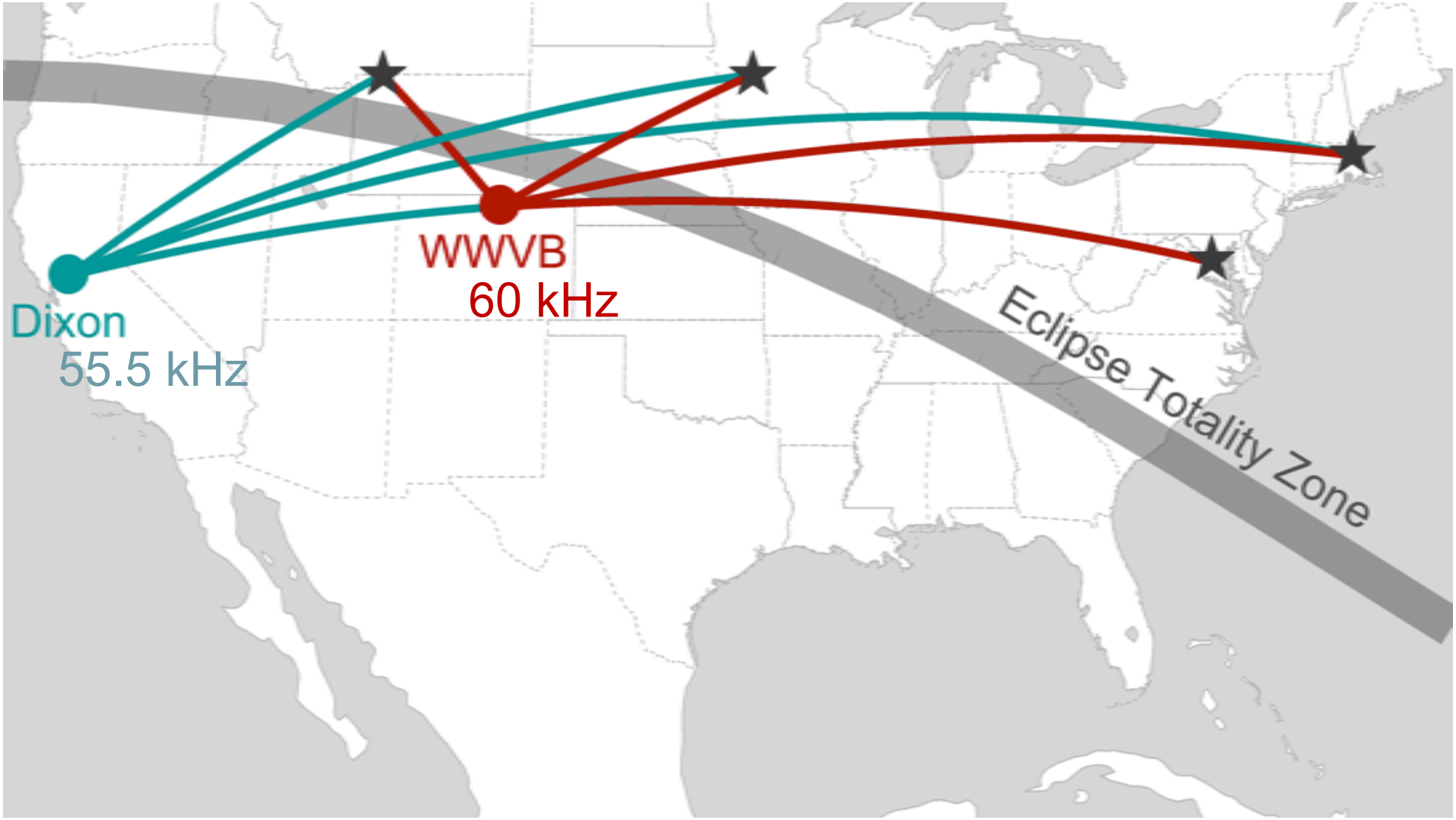
J. C. P. Miller, "Map of the corpuscular eclipse track of 1932 August". MNRAS, Vol 32, p. 421, 1932

EclipseMob Effort

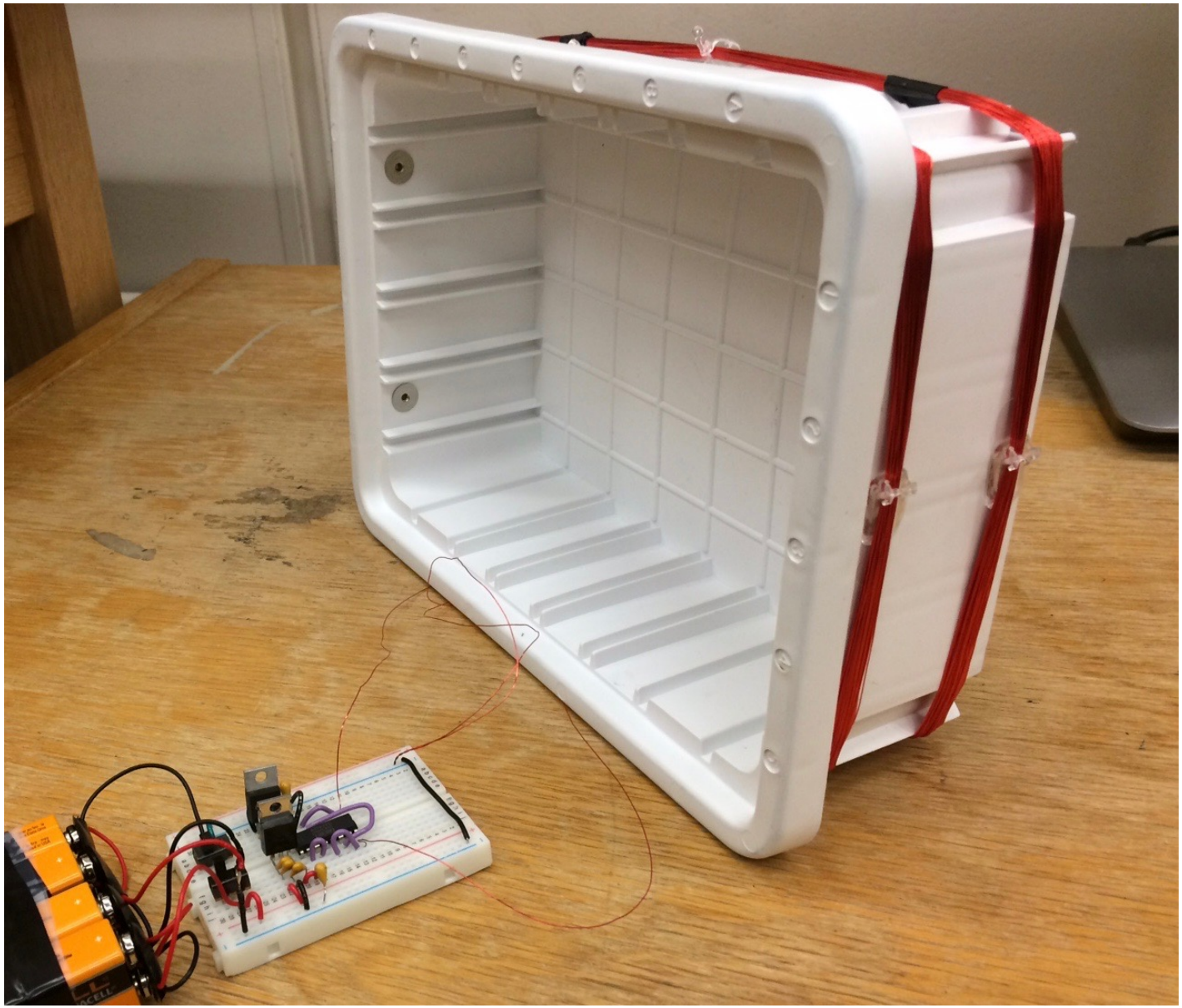
What is EclipseMob?

A collaborative effort to conduct a nationwide crowdsourced measurement of LF radio wave propagation during the 21 August 2017 solar eclipse




WWVB
60 kHz
Dixon
55.5 kHz
Eclipse Totality Zone

Assembled Kit and Antenna Minus Smartphone



Conclusions

What Didn't Work and How To Do Better

EclipseMob kit and app delivery were repeatedly delayed, frustrating participants who had to test their receivers without the app

How to do better

- Start early to allow more testing time
- Avoid using students for critical tasks like app development
- Centralize/systematize project management

Web and social media communication was labor intensive

How to do better

- Plan for this when staffing project
- Use a ticket system to track responses

What Didn’t Work

EclipseMob data may be degraded

- Incorrect impedance to phone line in (found after eclipse data received)
- Some initial positive test results differed from actual data collected. Did line in signal leak through onboard mic pathway? Were both active?
- Can some data be salvaged anyway?

Lessons Noted from Group Experiments

Lots of interest from the public

- Received twice as many requests for kits than were initially available, had to make a second batch
- Received approximately 500 uploads

Crowdsourcing concept and DIY circuit

- Citizen scientist tasks are often very simple, not much science involved
- People were perfectly capable of assembling the kit when following the instructions

Reporting specification for experiment distributed and agreed on early on

Thank You

"We are deeply grateful to all of [our] collaborators. They have sent us data of great value. We hope that the knowledge of a good job well done will prove to them a satisfactory reward for their effort and time."

Scientific American Eclipse Party, "The Effects of the Eclipse on Radio," *Scientific American*, April 1925

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