Total Solar Eclipse 2017 Through the Eyes of NASA: Science in the Shadow of the Moon

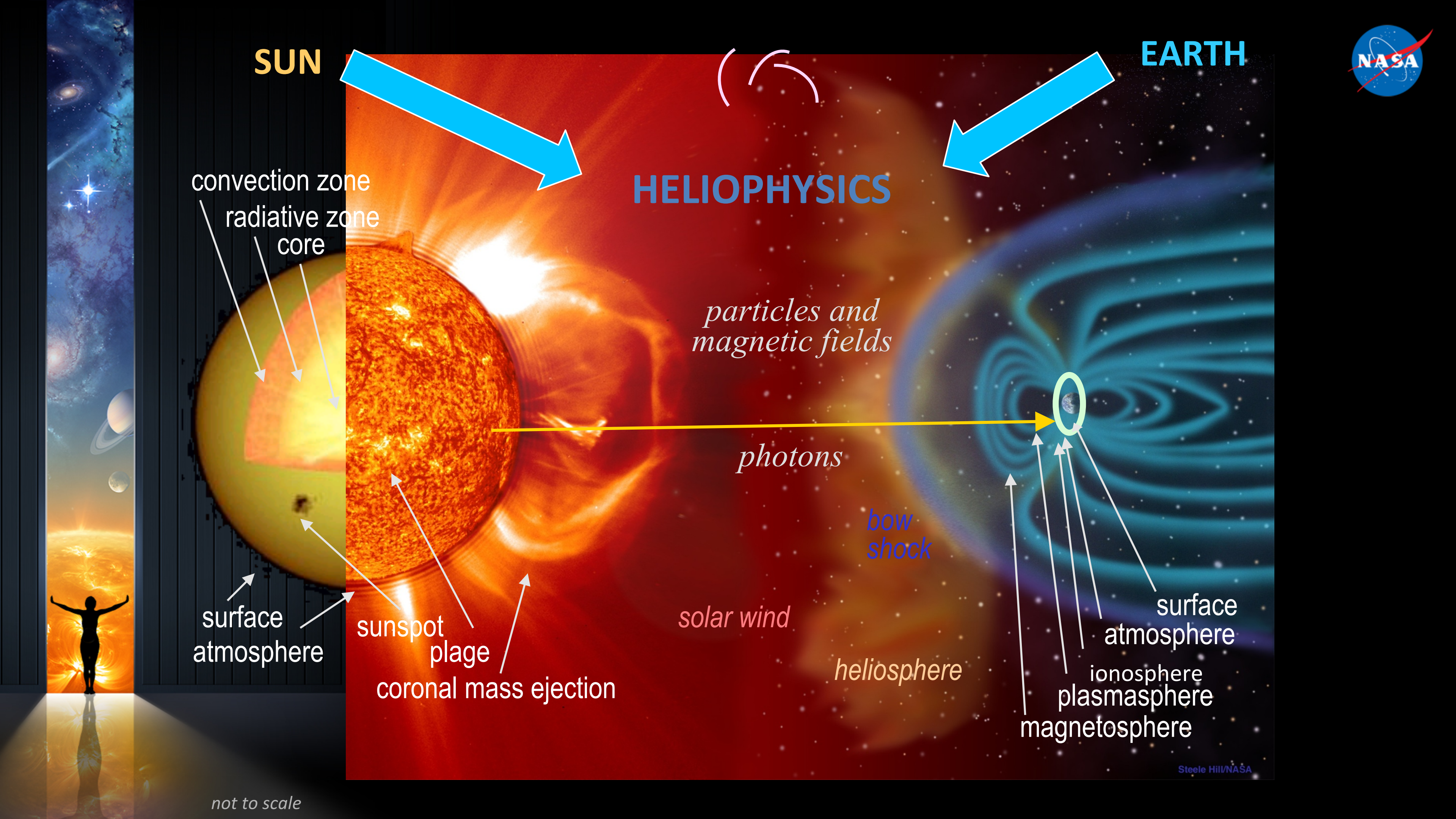
we're OUT there

"…The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space…" and to "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof…"

– 1958 NASA Space Act, as amended

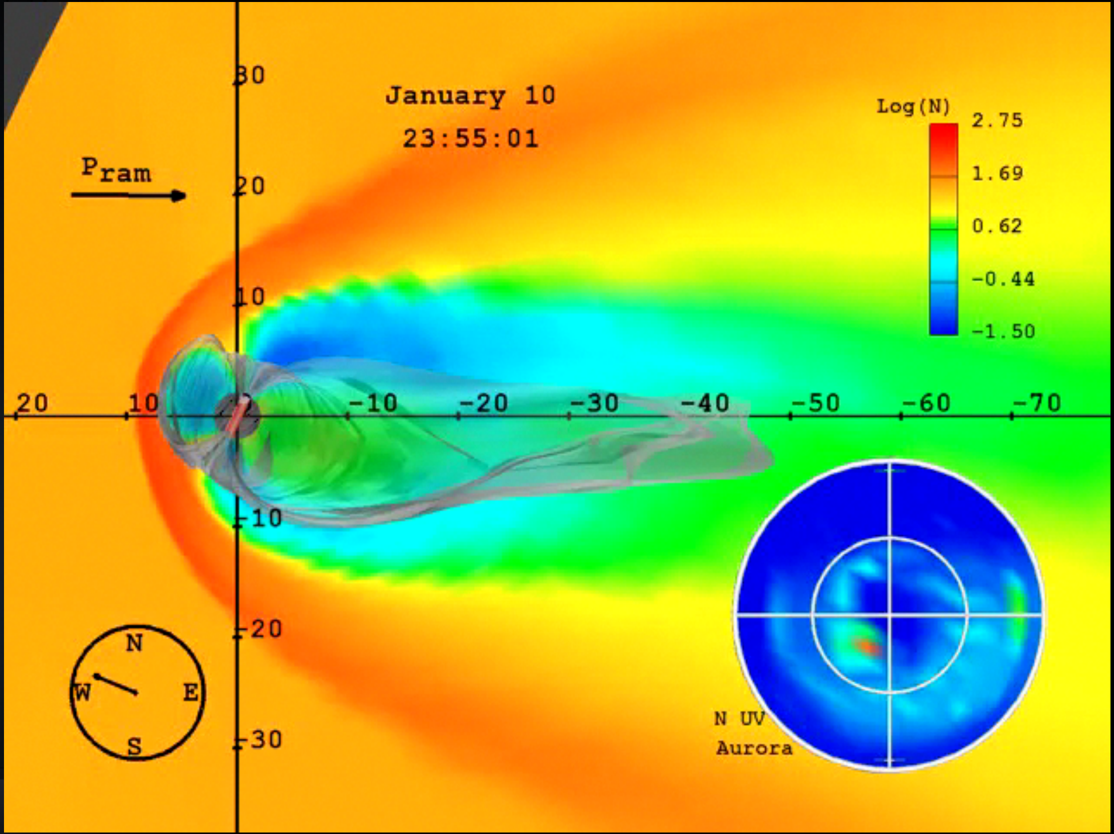
1. Safety – NASA's #1 core value and the #1 priority during any event
2. Science – Awareness of missions, science and return on investment
3. Education – Fundamental learning opportunity of nature's processes
4. Public Engagement – Unique opportunity for all U.S. to participate
5. Citizen Science – Several apps for citizens to gather data on nature's processes

Lika Guhathakurta
NASA ARC
August 8th, 2017
Heliophysics Summer School, Boulder, CO



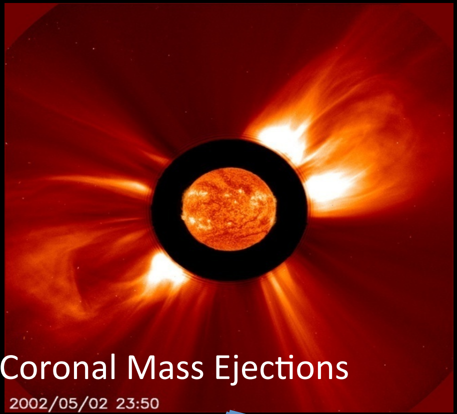
SUN
EARTH
HELIOPHYSICS
convection zone
radiative zone
core
surface
atmosphere
sunspot
plage
coronal mass ejection
particles and
magnetic fields
photons
bow
shock
solar wind
heliosphere
surface
atmosphere
ionosphere
plasmasphere
magnetosphere
Steele Hill/NASA
not to scale

The impacts on the Earth



Numerical simulation from Goodrich et al. Inset shows the resulting enhancement of energy going into Earth’s Polar region.

Three Basic Types of Solar Phenomena Affecting Earth & Creating Space Weather

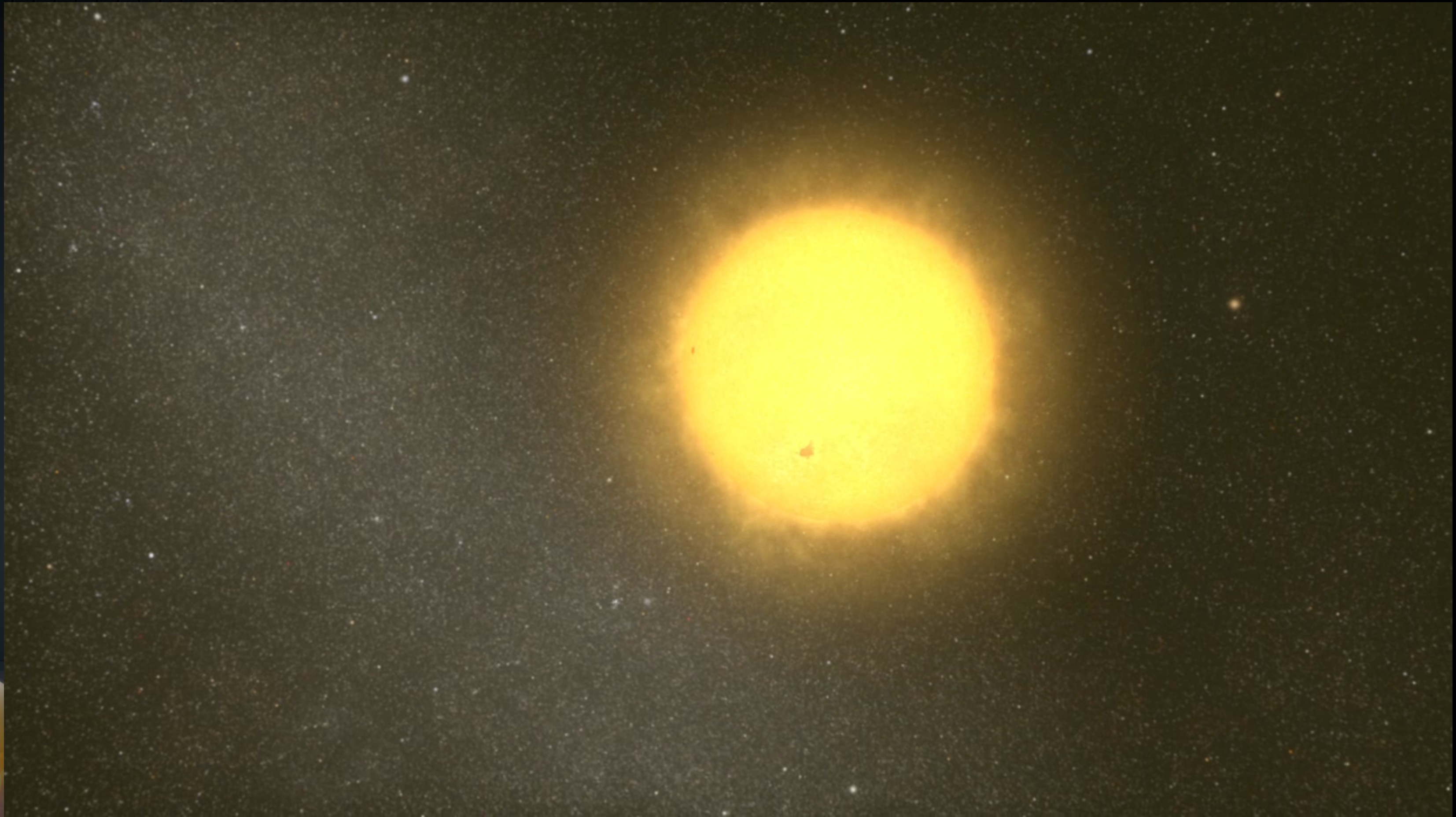


Radio Blackout

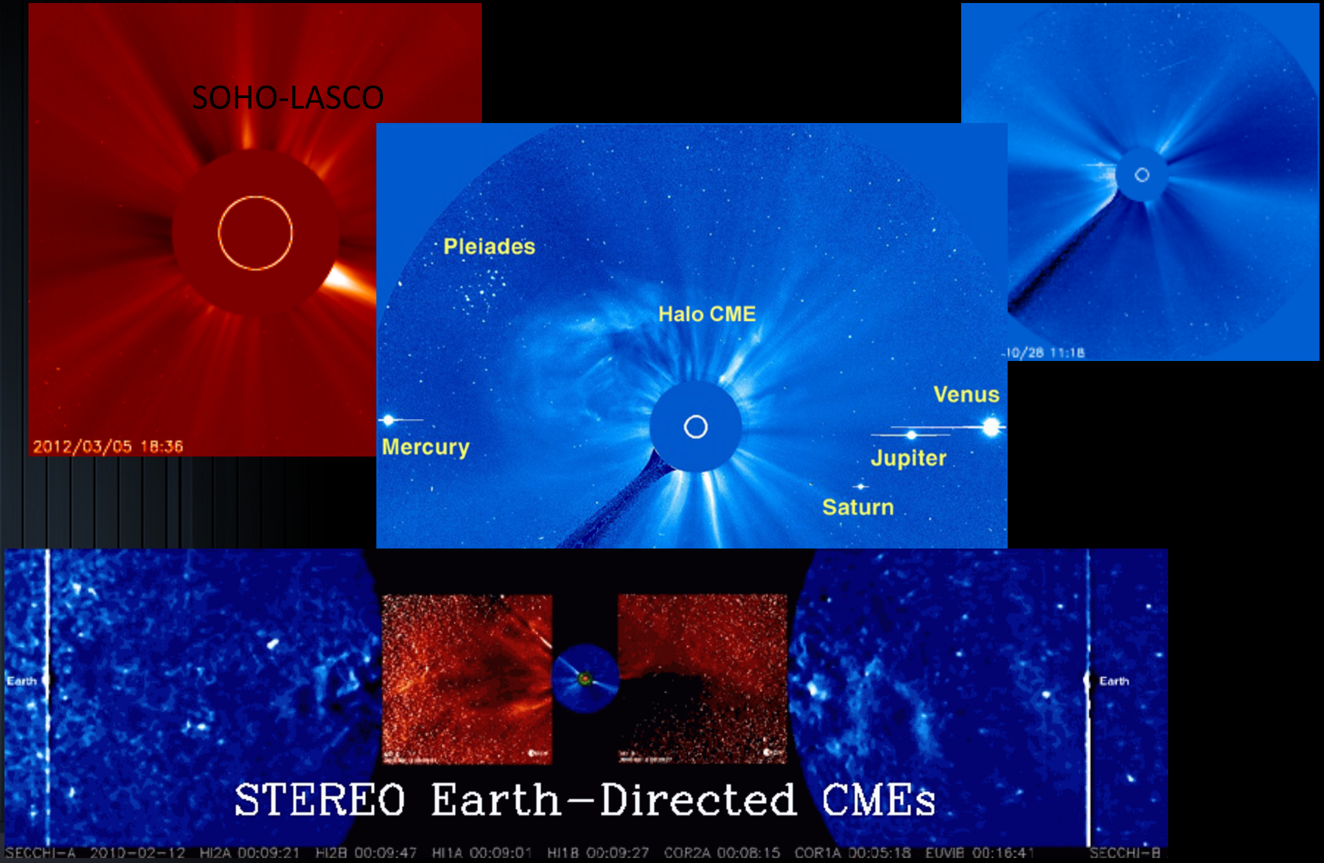
Radiation Storm

Geomagnetic Storm

The Corona Fills the Heliosphere

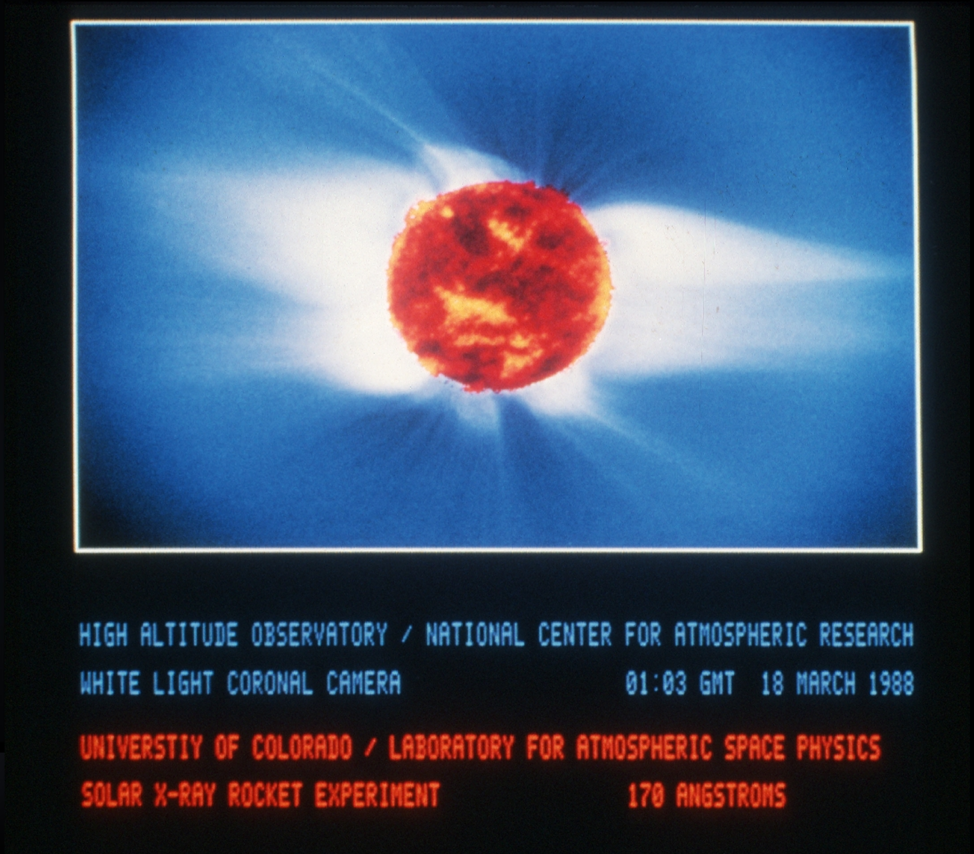


Entire Solar System Lives with the Star



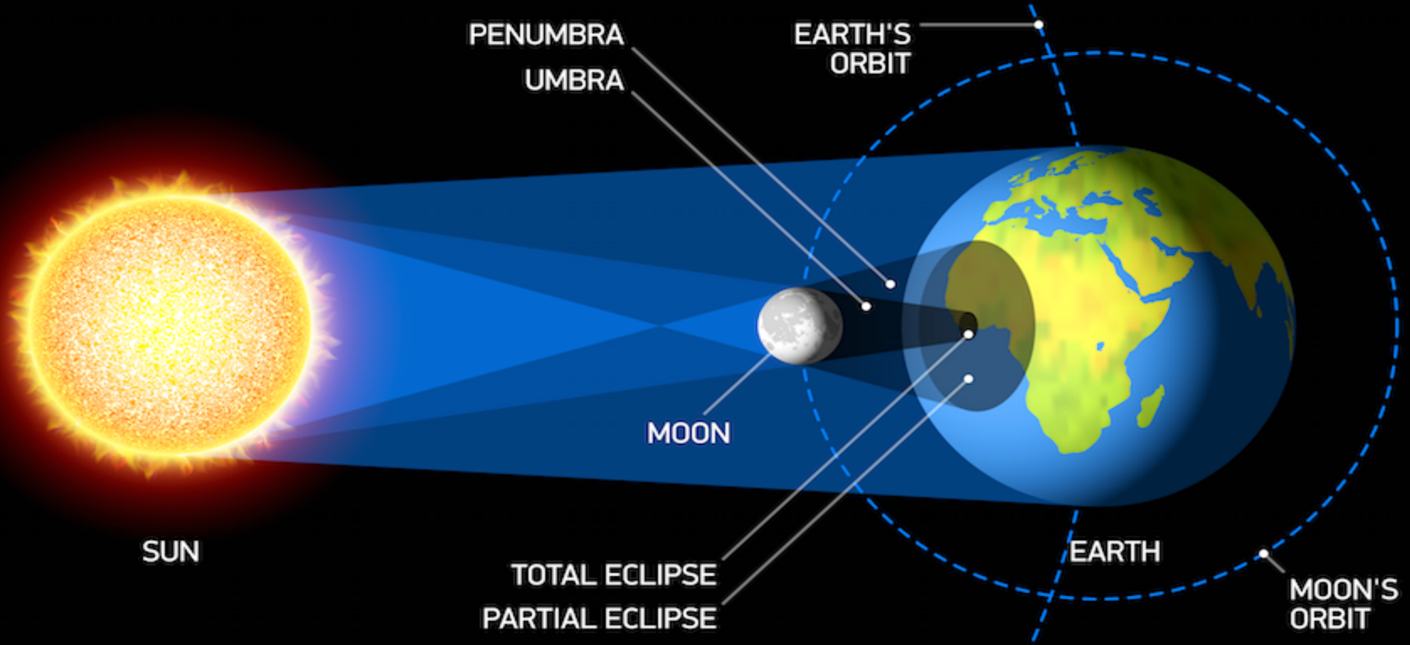
SOHO LASCO images and STEREO SECCHI images of coronal outflows and eruptions. (from SOHO website and Ying Liu, SSL (STEREO panorama))

A composite picture of the corona using soft-x-ray data and white light coronal observations (Eclipse March 17/18, 1988) from my thesis 3 decades ago!



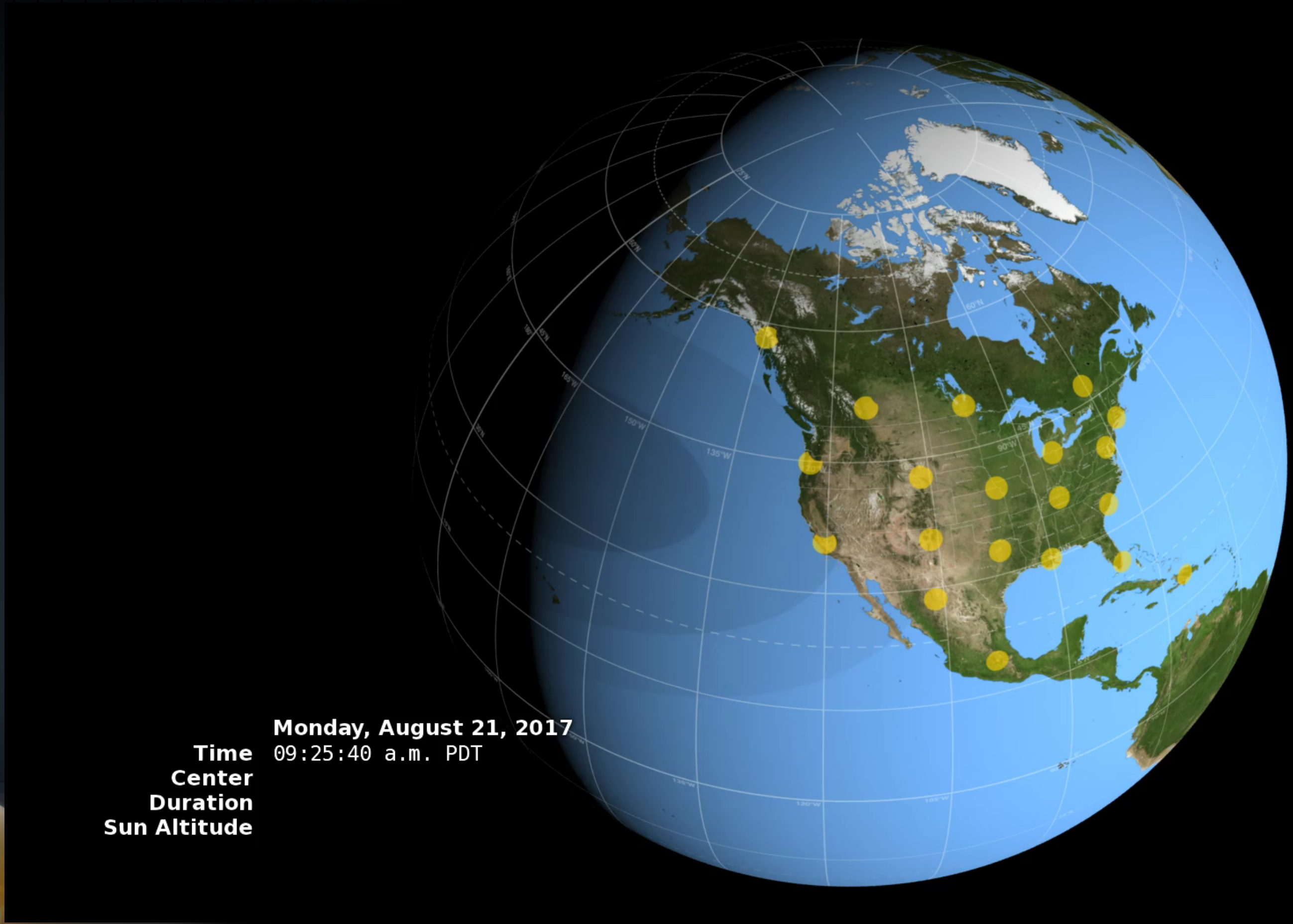
Time Magazine, 1988

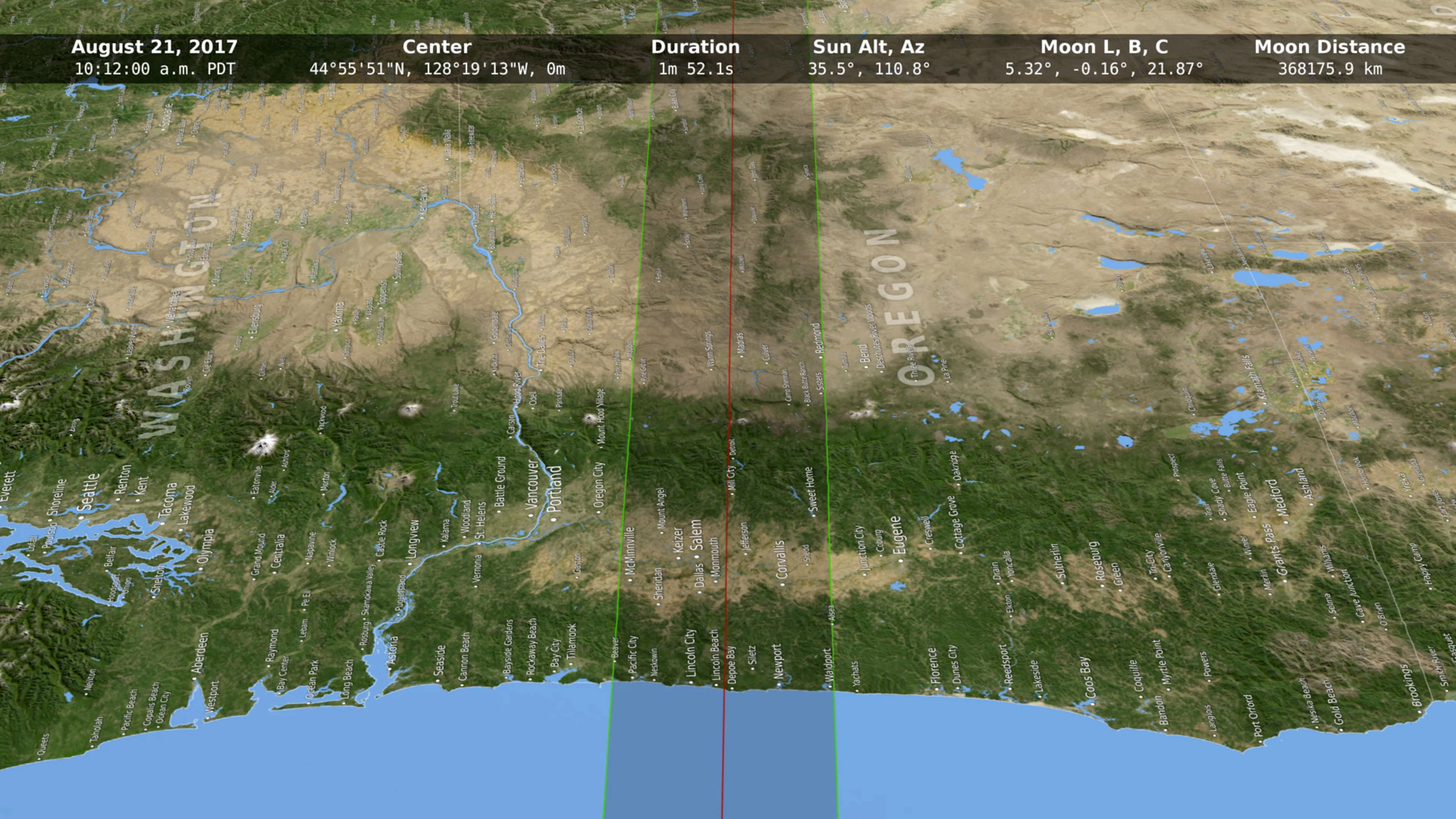
TOTAL SOLAR ECLISPE
Monday, August 21, 2017



Not to scale:
If drawn to scale, the moon would be 30 Earth diameters away.
The sun would be 400 times that distance.

GSFC Visualization/Erine Wright



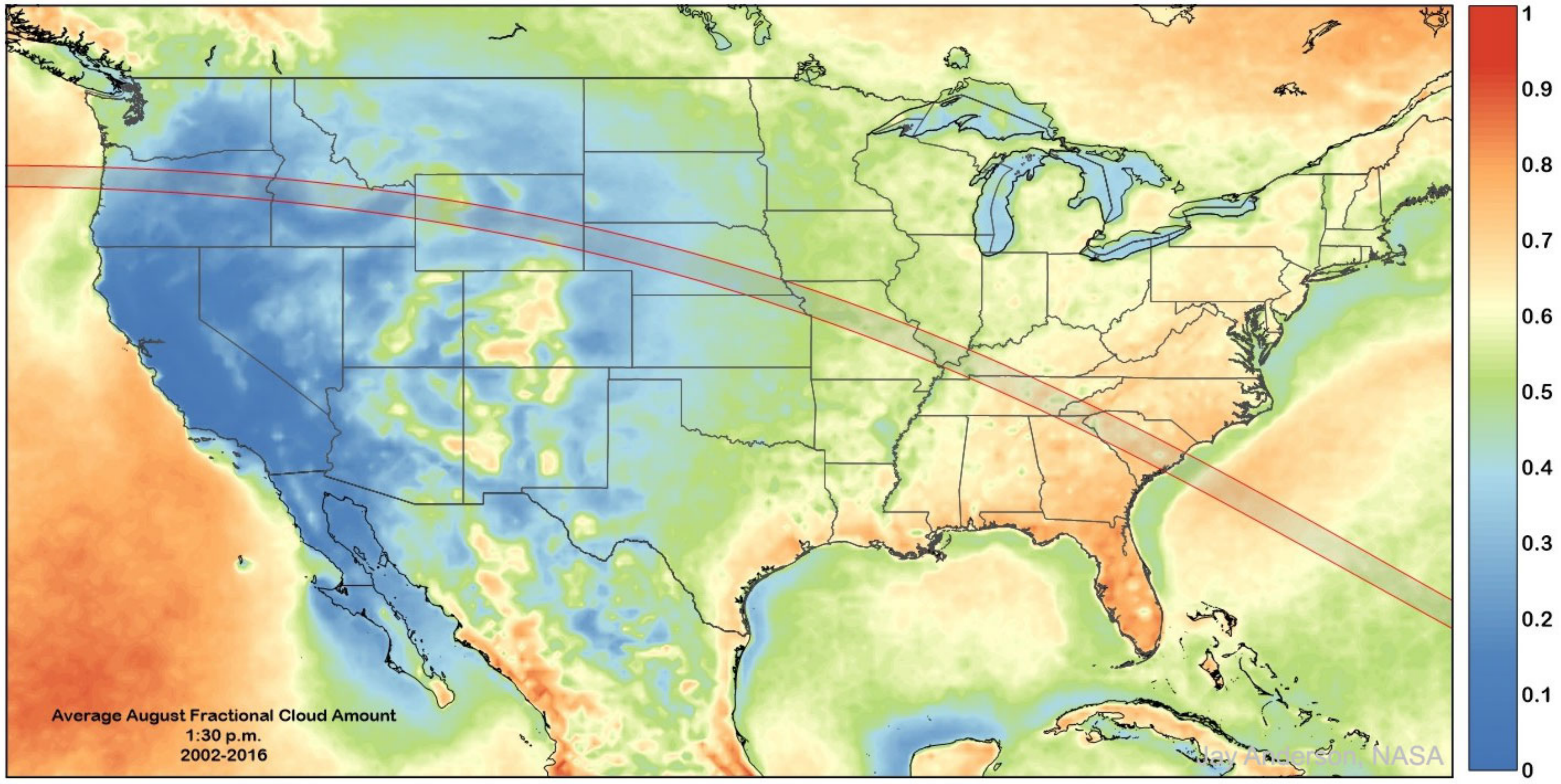

August 21, 2017
10:12:00 a.m. PDT
Center
44°55'51"N, 128°19'13"W, 0m
Duration
1m 52.1s
Sun Alt, Az
35.5°, 110.8°
Moon L, B, C
5.32°, -0.16°, 21.87°
Moon Distance
368175.9 km
WASHINGTON
OREGON
Seattle
Tacoma
Olympia
Longview
Vancouver
Portland
Oregon City
McMinnville
Salem
Corvallis
Eugene
Bend
Redmond
Newport
Lincoln City
Aberdeen
Astoria
Seaside
Florence
Coos Bay
Roseburg
Medford
Ashland
Grants Pass
Yakima
Ellensburg
Battle Ground
St. Helens
Kerzer
Dallas
Sweet Home
Mill City
Madras
Warm Springs
Junction City
Cottage Grove
Brookings
Gold Beach
Klamath Falls

12.2 MILLION AMERICANS

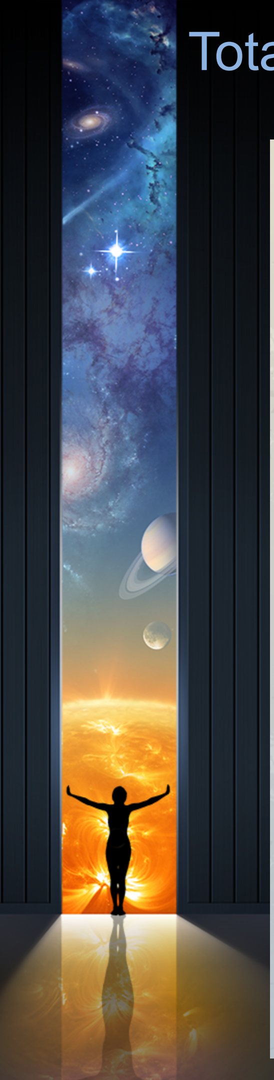
3.8% OF THE NATION

LIVES WITHIN THE PATH OF TOTAL SOLAR ECLIPSE

Great American Eclipse.com

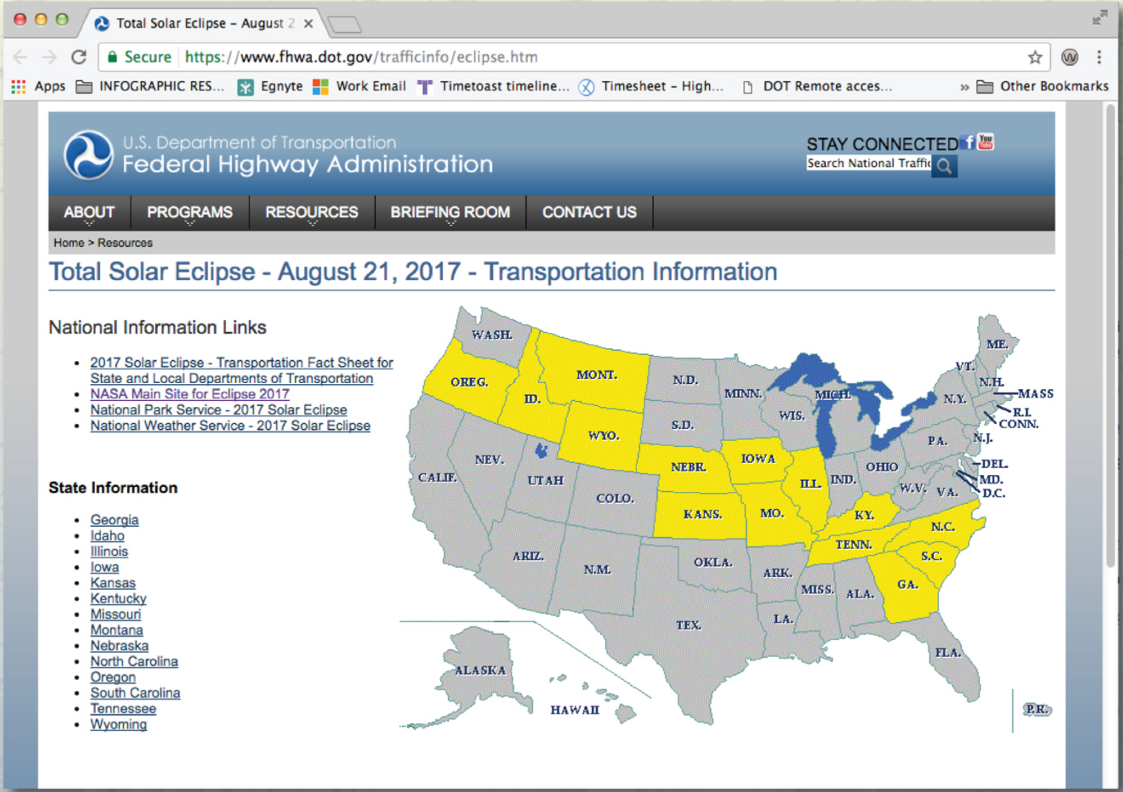

Average August Fractional Cloud Amount
1:30 p.m.
2002-2016
Jay Anderson, NASA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

Total Solar Eclipse – August 21, 2017 – Transportation Information



U.S. Department of Transportation
Federal Highway Administration

URL: https://www.fhwa.dot.gov/trafficinfo/eclipse.htm



Total Solar Eclipse – August 2

Secure https://www.fhwa.dot.gov/trafficinfo/eclipse.htm

Apps INFOGRAPHIC RES... Egnyte Work Email Timetoast timeline... Timesheet – High... DOT Remote acces... Other Bookmarks

U.S. Department of Transportation
Federal Highway Administration

STAY CONNECTED
Search National Traffic

ABOUT PROGRAMS RESOURCES BRIEFING ROOM CONTACT US

Home > Resources

Total Solar Eclipse - August 21, 2017 - Transportation Information

National Information Links

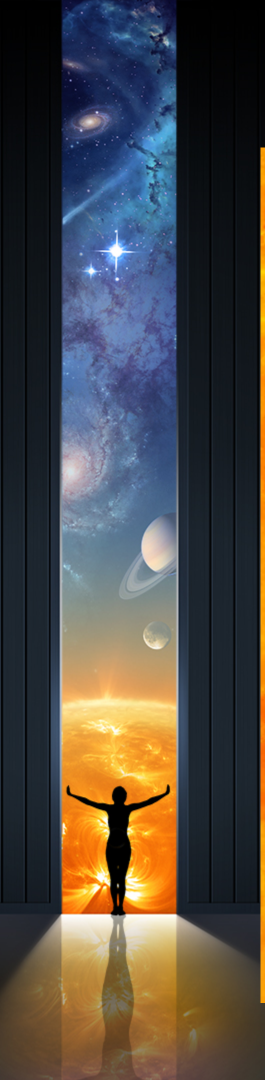
- 2017 Solar Eclipse - Transportation Fact Sheet for State and Local Departments of Transportation
- NASA Main Site for Eclipse 2017
- National Park Service - 2017 Solar Eclipse
- National Weather Service - 2017 Solar Eclipse

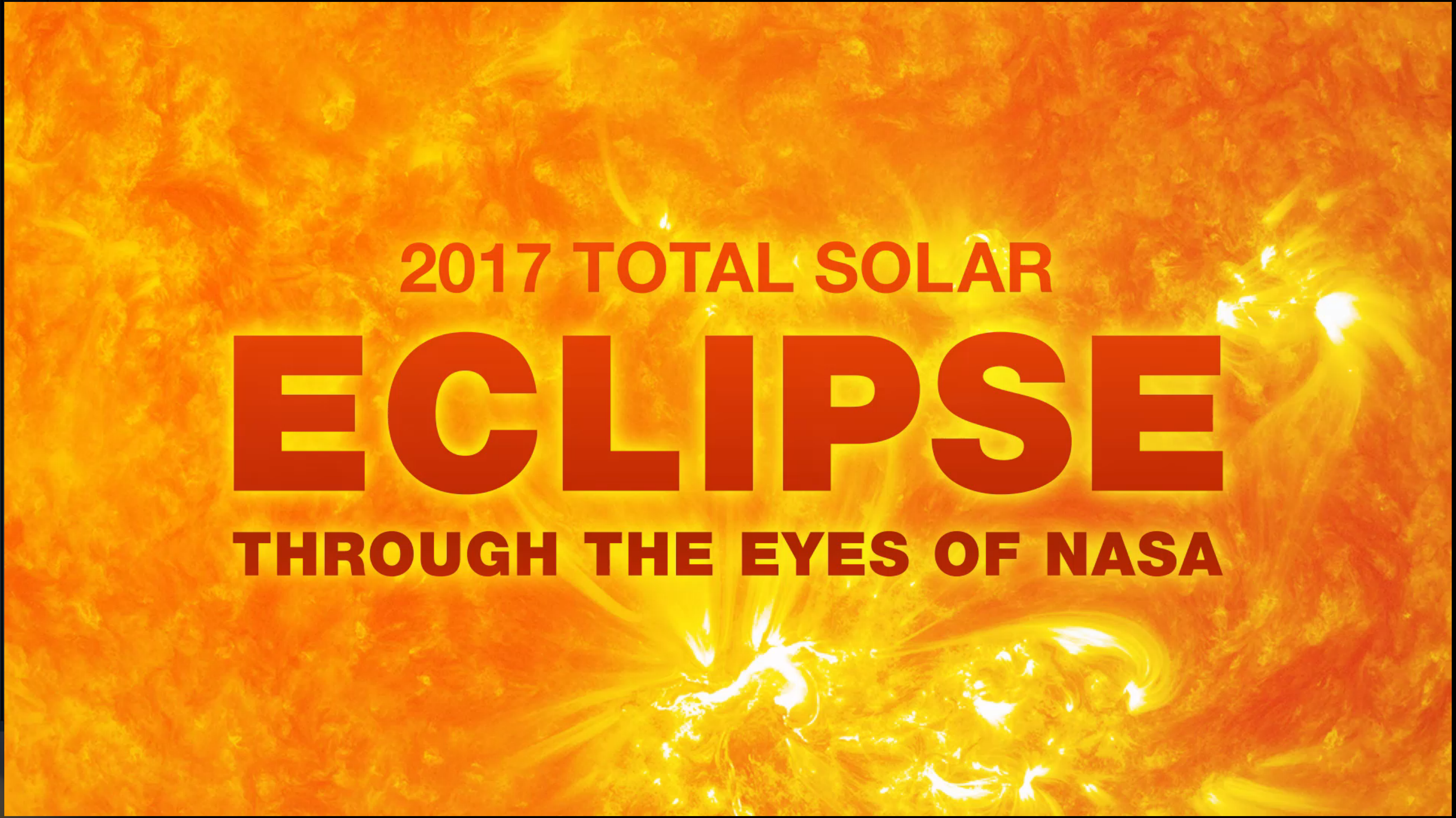
State Information

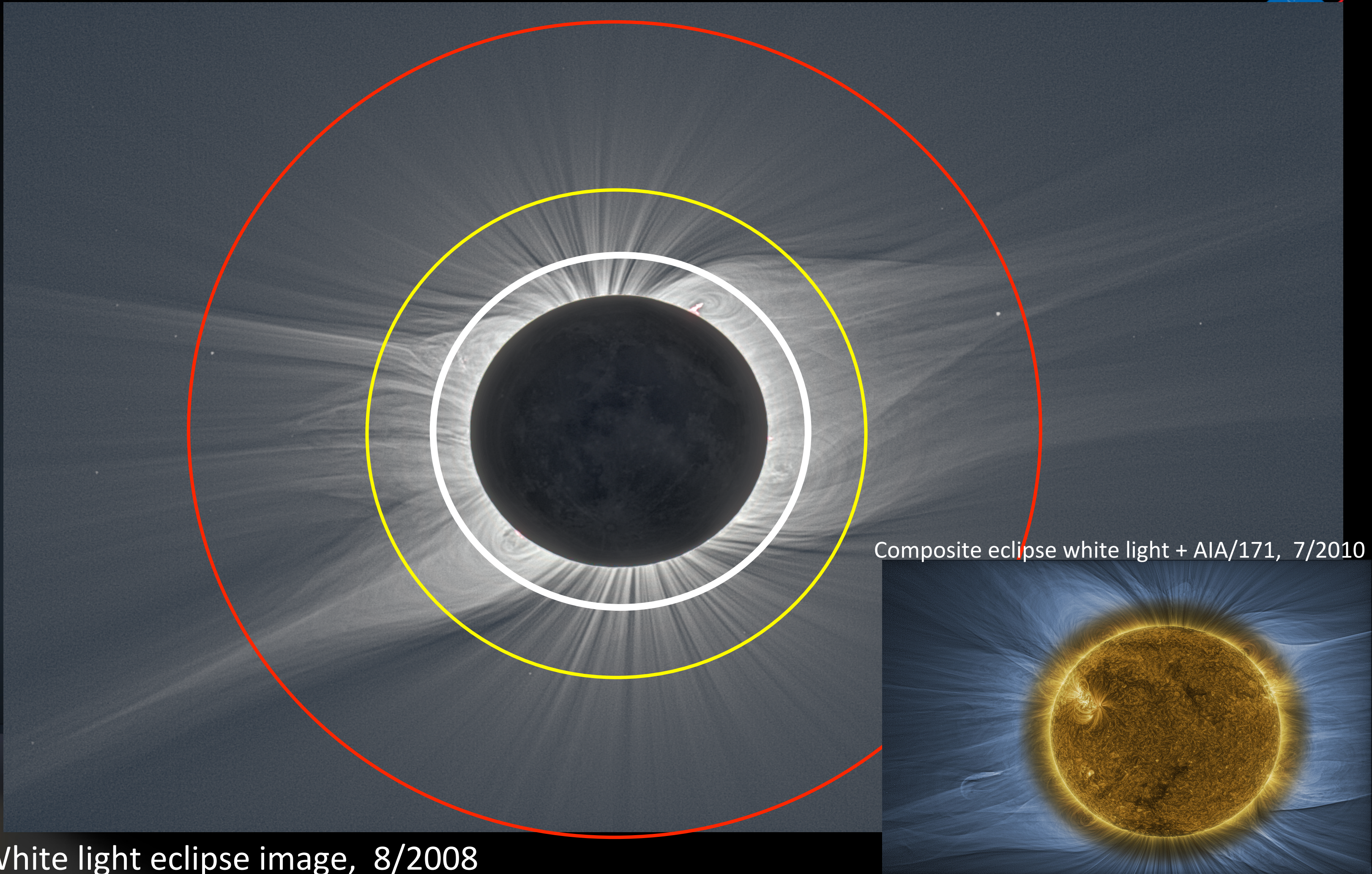
- Georgia
- Idaho
- Illinois
- Iowa
- Kansas
- Kentucky
- Missouri
- Montana
- Nebraska
- North Carolina
- Oregon
- South Carolina
- Tennessee
- Wyoming

total Eclipse AUGUST.21.2017
2017 Eclipse Path of Totality
10:10 PDT
10:2 PDT
11:30 MDT
11:40 MDT
11:50 MDT
1:00 CDT
1:10 CDT
1:20 CDT
1:30 CDT
2:40 EDT
2:50 EDT
75%
90%
90%
75%
25%
Chicago
Detroit
New York
Philadelphia
Baltimore
Washington
Boston
Cleveland
Indianapolis
Denver
Colorado Springs
Salt Lake City
San Francisco
San Jose
Sacramento
Fresno
Bakersfield
Los Angeles
San Diego
Las Vegas
Phoenix
Tucson
Albuquerque
El Paso
Lubbock
Amarillo
Dallas
Oklahoma City
Tulsa
Wichita
Kansas City
St. Louis
Nashville
Memphis
Little Rock
Atlanta
Charlotte
Raleigh
Virginia Beach
Richmond
Houston
San Antonio
Austin
Corpus Christi
New Orleans
Jacksonville
Orlando
Tampa
Miami
Minneapolis
Milwaukee
Des Moines
Fort Collins
Lincoln
Casper
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
MINNESOTA
WISCONSIN
MICHIGAN
OHIO
NEW YORK
NASA
ALL ECLIPSE COVERAGE

Eclipse 2017: Why NASA



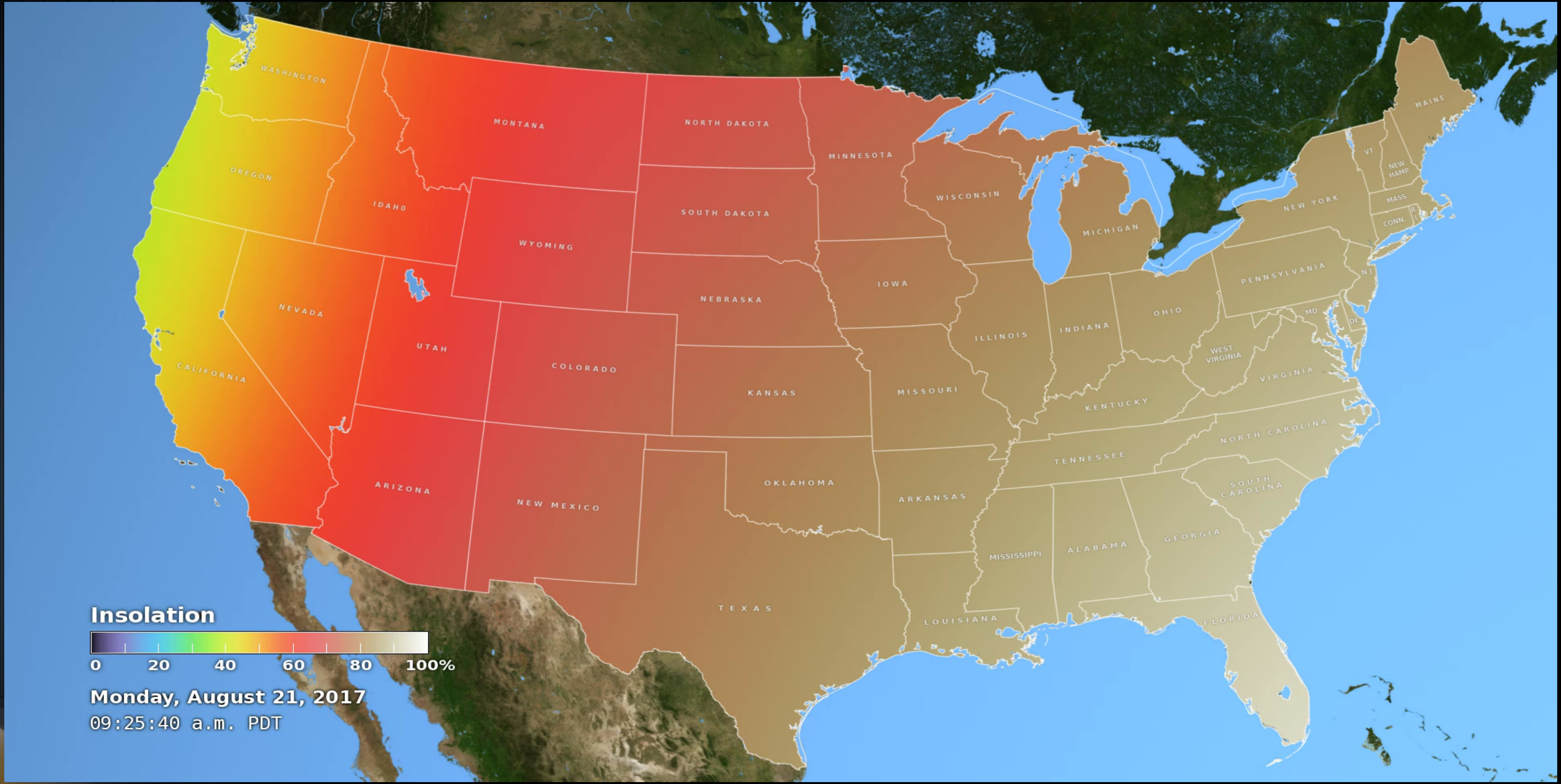




Composite eclipse white light + AIA/171, 7/2010

Background = White light eclipse image, 8/2008

A Vantage Point from Space



OBSERVING THE ECLIPSE FROM THE GROUND
NASA FUNDED PROJECTS

Total solar eclipses help us understand the sun-Earth connection. NASA is funding sun-focused and Earth-focused studies:

- Physics of the coronal plasma
- Measuring temperature and flow speed in the solar corona
- Interdisciplinary airborne science from NASA's WB-57
- Measuring the infrared solar corona
- Citizen science: measuring the polarization of solar corona
- Rosetta-stone experiments at infrared and visible wavelengths
- Induced changes in the ionosphere over the continental U.S.
- Contributions of ionization sources on the ionosphere
- Empirically-guided solar eclipse modeling
- Using spacecraft and ground-based instruments for radiative transfer
- Land and atmospheric responses

See more at:
http://go.nasa.gov/2kAbPzu

NASA Science from the Eclipse

The 2017 total solar eclipse on 21 August will be one of the best-observed solar eclipses to date. And NASA SMD will be taking full advantage of the opportunity to collect valuable data and observations to advance space science.

The 11 NASA-funded studies cross a range of disciplines, using the total solar eclipse to observe our sun and Earth, planet Mercury, test new instruments, and even leverage the skills of citizen scientists to expand our understanding of the sun-Earth system.

- **Exploring Coronal Physics through Imaging Spectroscopy**
- **Temperature and Flow Speed in the Solar Corona**
- **Interdisciplinary Airborne Science from NASA's WB-57**
- **Measuring the Infrared Solar Corona**
- **Citizen Science Approach to Measuring the Polarization of Solar Corona**
- **Rosetta-stone experiments at infrared and visible wavelengths**
- **Solar eclipse-induced changes in the ionosphere over the continental**
- **Ionization sources on the formation of the D-region ionosphere**
- **Empirically-Guided Solar Eclipse Modeling**
- **A 3-D radiative transfer closure experiment**
- **Land and Atmospheric Responses**

A broad range of institutes will facilitate this research, including the Universities of Hawaii, Colorado – Boulder, and Missouri; the University Corporation for Atmospheric Research, the Massachusetts' Institute of Technology, Virginia Tech, the Southwest Research Institute, the Space Sciences Institute and the NASA GSFC and JSC.

CHASING THE 2017 ECLIPSE: INTERDISCIPLINARY AIRBORNE SCIENCE FROM NASA's WB-57

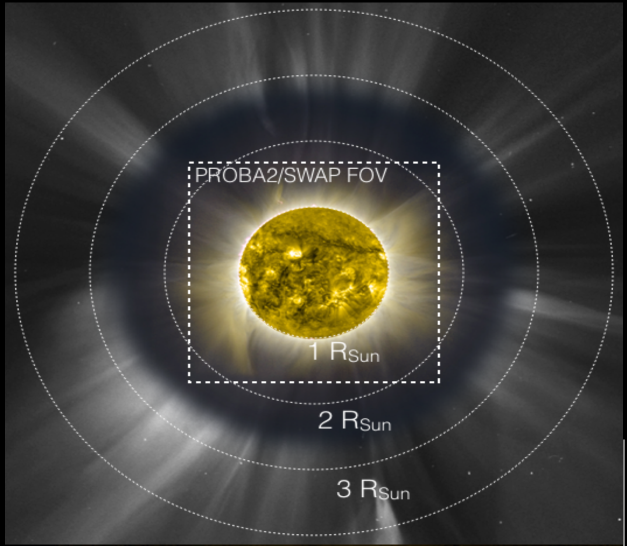
PI: Amir Caspi (SwRI)

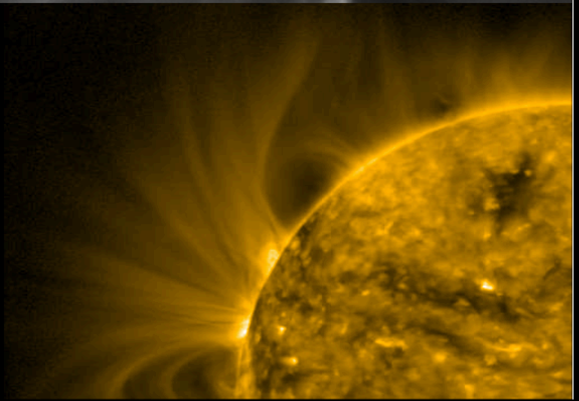
SOLAR SCIENCE:

- Small scale dynamics and coronal diffusivity:
  - Why do MHD models reproduce the corona well despite missing the microphysics?
  - Why is the corona smooth and organized, rather than matted and snarled?
  - ⇒ Nanojets can be resolved at scales below 10”

- Formation of small open regions:
  - Is there radial structure at scales down to ~6” that indicate small open regions within the “closed” corona?
  - ⇒ Nanojets can shed light on origins and acceleration of solar wind from these features

- Waves in the corona:
  - What role do Alfvén waves play in heating the corona?
  - Do Alfvén and fast magnetosonic waves contribute to solar wind acceleration?
  - ⇒ Wave trains can be resolved down to 6” spatial scales with up to 200 MHz frequencies





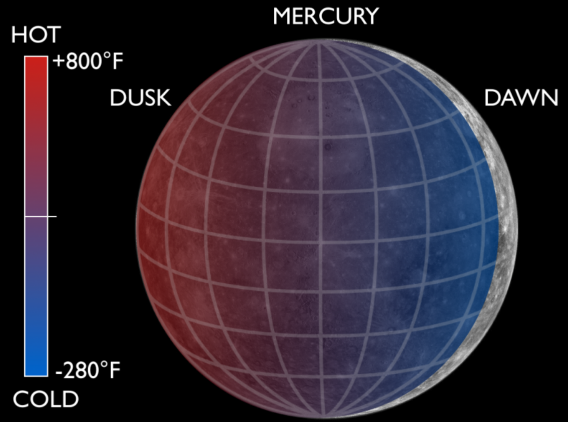
CHASING THE 2017 ECLIPSE: INTERDISCIPLINARY AIRBORNE SCIENCE FROM NASA's WB-57

PI: Amir Caspi (SwRI)

PLANETARY SCIENCE:

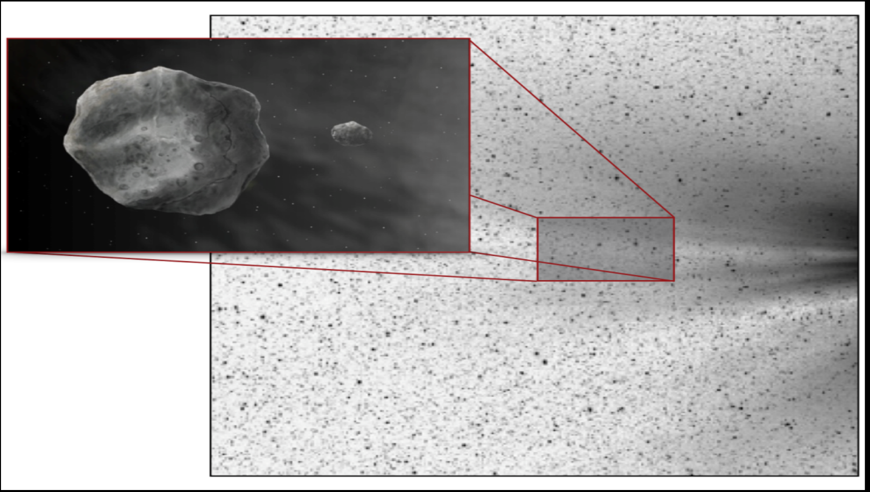
- **Mercury:**
  - Little is known about Mercury's subsurface (~few cm depth) density and composition
  - The diurnal cooling profile (temperature drop with local time) is a diagnostic of the regolith thermophysical properties
  - No multipixel thermal IR image of Mercury exists!

  ⇒ Our experiment attempts to make 3–5 μm "thermal" image of Mercury's nightside, the first time this will have ever been done



- **Vulcanoids:**
  - Theorized primordial asteroids within Mercury's orbit… not yet observed, but existence would impact understanding of solar system formation
  - Prior studies have placed constraints on size/brightness distribution of Vulcanoids, but were limited in sensitivity, by weather, etc.

  ⇒ "Free" opportunity to search for Vulcanoids and place more stringent constraints on size/brightness, in both visible *and* NIR simultaneously

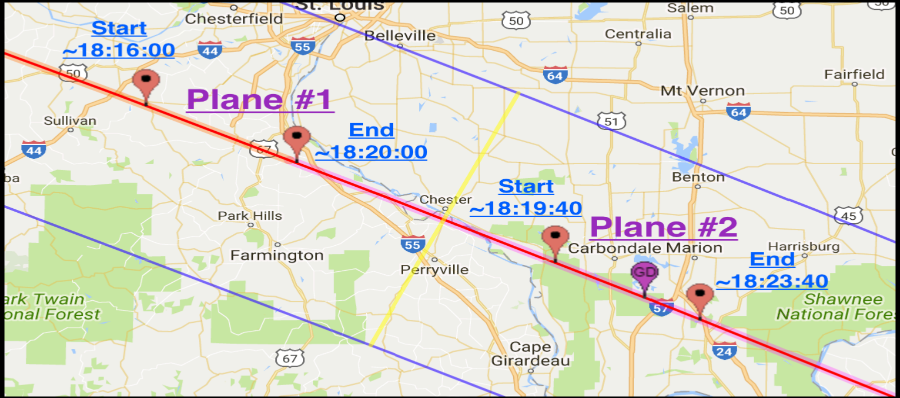


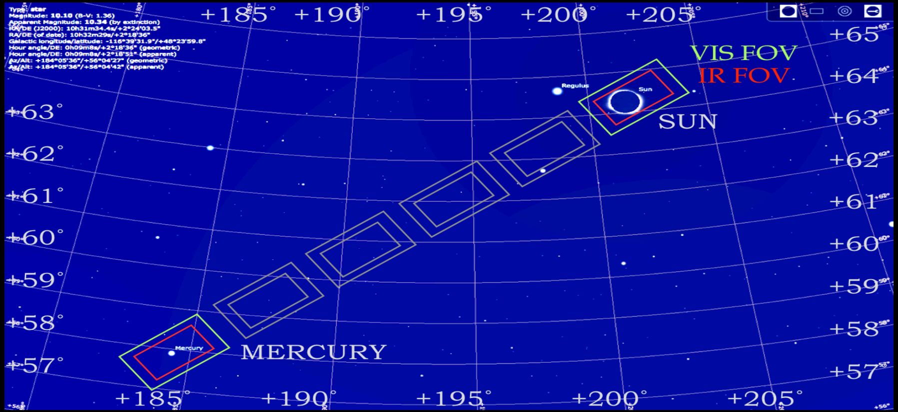
CHASING THE 2017 ECLIPSE: INTERDISCIPLINARY AIRBORNE SCIENCE FROM NASA's WB-57

PI: Amir Caspi (SwRI)

OBSERVING PLAN:

- Two WB-57 aircraft
  - Identically instrumented (DyNAMITE)
  - Visible camera: ±3 R_{sun} FOV, ~3”/pixel, green-line filter (10 nm bandwidth)
  - IR camera: ±2.75 R_{sun} FOV, ~3”/pixel, ~3–5 μm passband (lens coating)
  - 30 Hz frame rates on both cameras, with lossless recording
- Chasing the eclipse shadow
  - Yields ~4 min totality per plane
  - Tandem formation, ~50 mile separation, continuous totality coverage for ~8 min
- Mercury IR observations pre/post
  - ~15 min IR integrations during partial eclipse before and after totality
- Ground and in-flight calibrations
  - Ground calibration campaign quantifies noise, gain, etc. for VIS/IR cameras
  - Dark and flat-field frames acquired en route
  - Bright IR stars observed en route provide absolute flux calibration





Exploring the Physics of the Coronal Plasma through Imaging Spectroscopy during the 21 August 2017 Total Solar Eclipse, Shadia Rifai Habbal, U. Hawaii

Science Goals

Explore the physical properties of

- the coronal plasma
- the source regions of the solar wind
- coronal mass ejections

through imaging spectroscopy

Observations on 21 August 2017 will be acquired at

3 observing sites separated by 600 miles:

Alliance (NE), Mackay (ID) and Mitchell (OR)

with identical instrumentation, namely:

- white light imaging
- imaging in Fe XI (10^6 K) and Fe XIV ($2\ 10^6$ K)
- imaging spectroscopy with a triple channel spectrometer

Imaging spectroscopy will cover

- three different temperature regimes (10^5, 10^6 and > $2\ 10^6$K) over a projected area of 2.5 x 1.5 R_s^2, starting from the solar surface.
- Line intensities and profiles, as well as Doppler shifts when present

Thus will fully characterize the quiescent and dynamic state of the coronal plasma during totality.

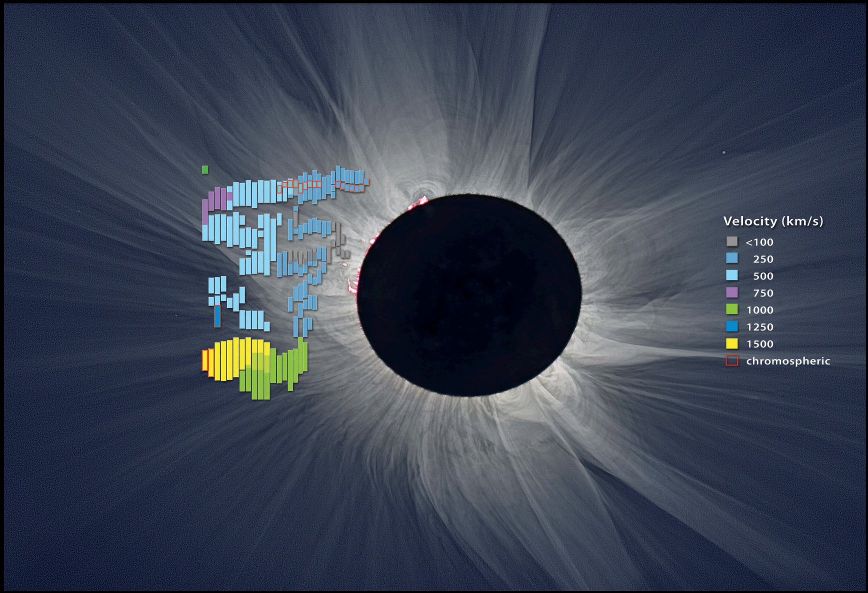
Background

- Imaging spectroscopy during the total solar eclipse of 20 March 2015, yielded plasma clusters of Doppler red-shifted coronal material, often accompanied by chromospheric material. Their complex distribution was akin to a complex CME with multi fronts.
- Inferred Doppler speeds of the cool-hot clusters reached up to 1500 km/s within a heliocentric distance of 2.5 R_s.
- No counterpart of these bulk motions was detected by LASCO/C2, in that region of the corona, consistent with the observed pure red-shifts.

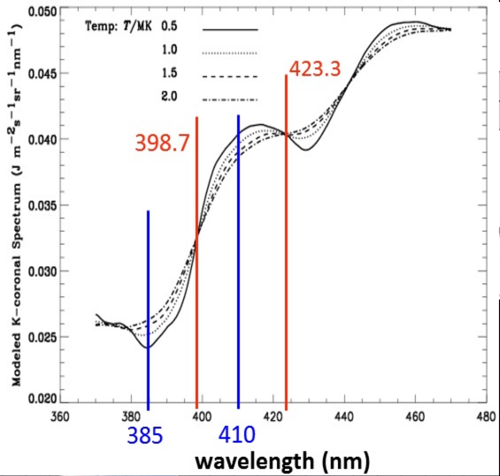
STEREO S/C were behind the Sun at the time

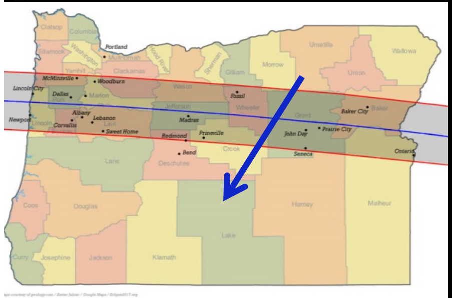
- Clusters of cool prominence material erupt together with their hot shrouds, preserving their identity as they propagate outwards into the solar wind.
- Presence of this cool chromospheric material provides the first corrobortaaion of the solar origin of reported netutral and low ionization state atoms in the solar wind

Mapping the Doppler Red-Shifted Emission in the Fe XIV channel



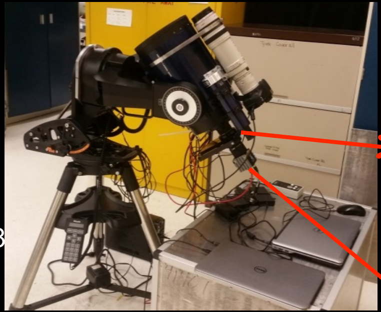
Temperature and Flow Speed in the Solar Corona
PI: Nat Gopalswamy, NASA/GSFC





www.eclipse2017.org

Madras, OR
lat: 44° 38' 00" N
lon:121° 07' 46" W
totality: 2m 2s
10:19:36 – 10:21:38

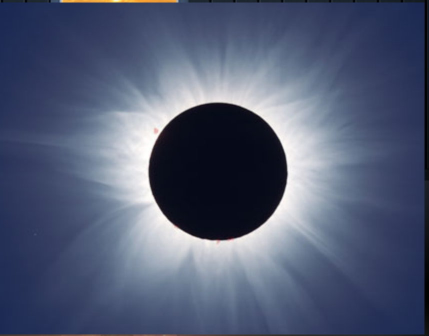


Filter wheel with 4 filters:
385 and 410 nm filters for 'Electron temperature'
399 and 423 nm filters for ,'Electron flow speed'

The NASA/GSFC team will observe from Madras, OR, at the Madras High School. The totality will be in the midmorning at 10:19:36 AM. Two Meade telescopes (F6.3 and F10) will be used. The F6.3 will be fitted with a polarization camera and a filter wheel for temperature and flow speed measurements; the F10 will be fitted with a high speed camera for dynamical changes.

Polarization camera

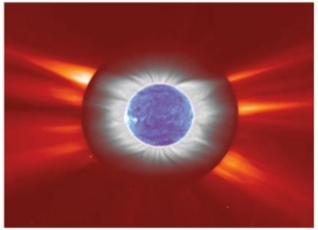
-Helps us to separate F and K corona
-We call K-corona information as 'signal'
-We call F-corona information as 'noise'
-Can record 30 images per sec at 8 MB per image
-The polarization camera can separate the K and F corona because the K-corona, is polarized, but the F-corona is un-polarized

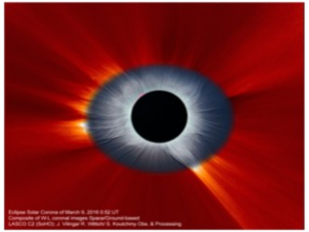


The corona will be imaged at four wavelengths centered on 385, 410, 399, and 423 nm. Intensity ratios obtained from these images provide information on the temperature and flow speed of the corona close to the solar surface. Demonstration of the use of the polarization camera will pave the way for using such a camera in balloon and spaceborne coronagraphs.

PACA Pol_Net: Measure Inner Solar Coronal Polarization
PI: Padma A. Yanamandra-Fisher/SSI

- Qs:Why is the solar corona hotter than the solar “visible” surface or photoshpere?
- Inner solar corona, 1.3 to 2.2 solar radii and polarized due to electron scattering, accessible during total solar eclipse.
- white-light polarimetric observations to map polarization brightness (pB) and degree of polarization (dolp) with Citizen CATE* telescope + white light polarimeter set-up (Daystar Filters)
- Two observation sites (shown in red on map) during the transcontinental US total solar eclipse 2017 (Tetonia, Idaho and Carbondale, Il), consistent with Citizen CATE project.



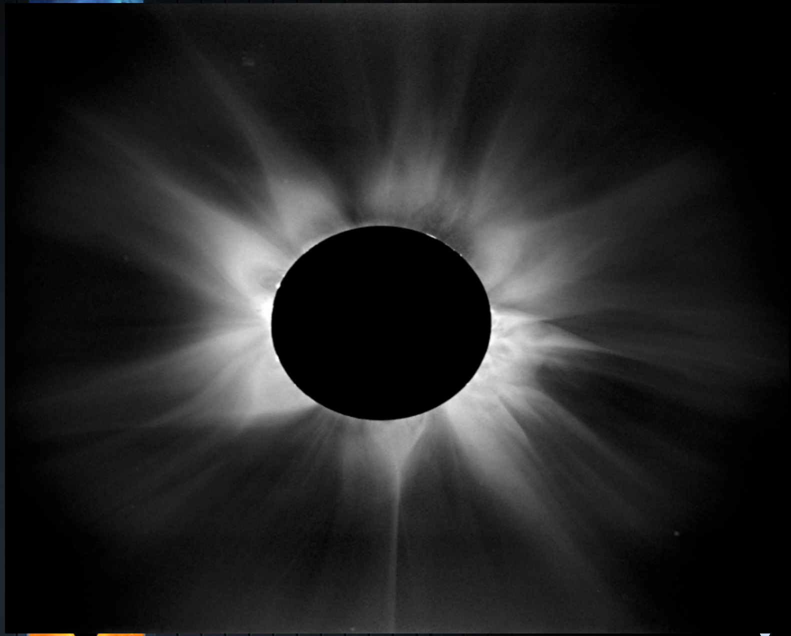


Composite images of the corona during total solar eclipses of 2006 (left; credit SOHO/LASCO, Johnson,Brown) and 2016 (right; credit SOHO/LASCO, Vilinga,Wittich). The outer corona (red) is imaged from space by NASA/SOHO/LASCO instrument; the inner solar corona (white) is from ground-based observers and the image of the sun is shown on blue (left image) and is occulted (black in the right image).

Citizen CATE sites for Eclipse 2017 (yellow dots) (credit: NSO, S&T,G. Dinderman)

- * Citizen CATE (NASA CAN, PI. M. Penn, NSO)

NCAR Airborne Interferometer (NAI
Scientific Motivation



The magnetic field of the solar corona drives the space weather phenomena that have a profound effect on life on Earth.

But because the corona is so tenuous and dim in comparison to the surface of the Sun, it is extremely difficult to measure.

A total solar eclipse gives a unique opportunity to perform such measurements without the overwhelming effects of the surface brightness.

The NAI will perform the *first ever* full spectral survey of the solar corona over the wavelength range of 2-12 microns.

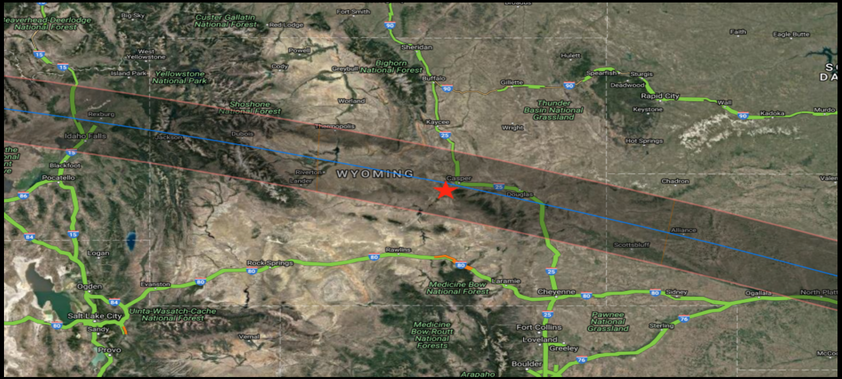
- The emission lines it will measure are sensitive to the magnetic field, so understanding their intensity and wavelength is crucial in being able to properly diagnose the coronal magnetic field and thus help predict space weather events.

NCAR Airborne Interferometer (NAI)

PI: Paul Bryans

- The NAI will be deployed from Camp Wyoba atop Casper Mountain, Wyoming.
- This high-altitude location is close to the center line of the eclipse, with 2.5 minutes of totality, and offers highly favorable weather conditions.
- The instrument is being built in Boulder, Colorado and will be installed in a scientific trailer for transportation

- The NAI is a Fourier Transform Infrared Spectrometer.
- It will measure the infrared spectrum of the solar corona from 2-12 microns.
- The instrument was initially designed to fly on NCAR's scientific aircraft – the ground-based instrument is being built to be compatible with future use on the aircraft as well as ground deployment for the eclipse.



Rosetta Stone: Scientific Motivtion

PI: Phil Judge

- Obtain unique data of IR emission lines of a quality that can only be obtained during an eclipse

- Identify optimal observations for future coronal magnetometry to further our understanding of coronal magnetic and thermal structure

- **Enhance understanding** of how the Sun generates **space weather**

- Implement +assess new camera technology **for astronomical polarimetry**

- Complement NSF GV aircraft and FTS 2017 eclipse experiments

- Benefits:
  - Leverages data from NASA's SDO and Hinode missions
  - New understanding for upcoming Solar Probe Plus mission

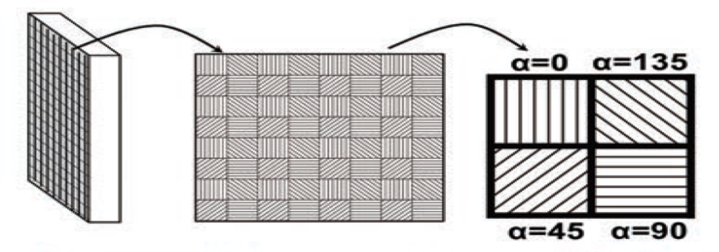
Rosetta Stone: Technical Approach

Judge, Tomczyk, Burkepile et al

The HAO team will operate 2 instruments co-mounted to a solar pointing platform, one at Visible wavelengths and the other in the IR

Eclipse will be observed from Casper Mountain, WY at an elevation of 2478 m, 9 km SW of eclipse centerline

Visible

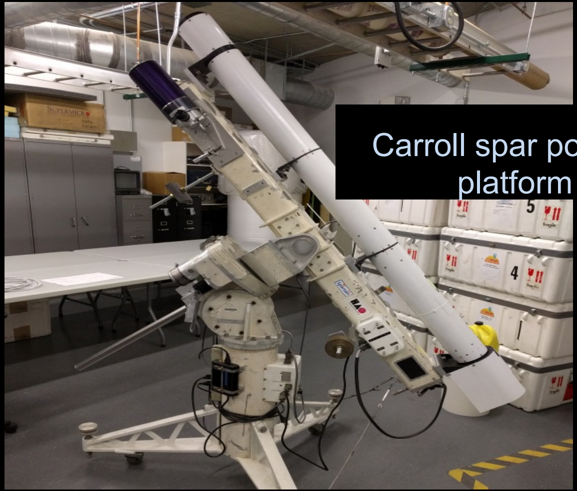


Novel detector with embedded micro-polarizer array will image the coronal intensity and polarization in FeXI 709 nm and FeXIII 1074 nm lines with a FOV of 6 Rsun

InfraRed

The corona will be imaged in the following IR emission lines over a FOV of 6 Rsun:

FeIX 2855 nm
MgVIII 3028 nm
SiIX 3935 nm



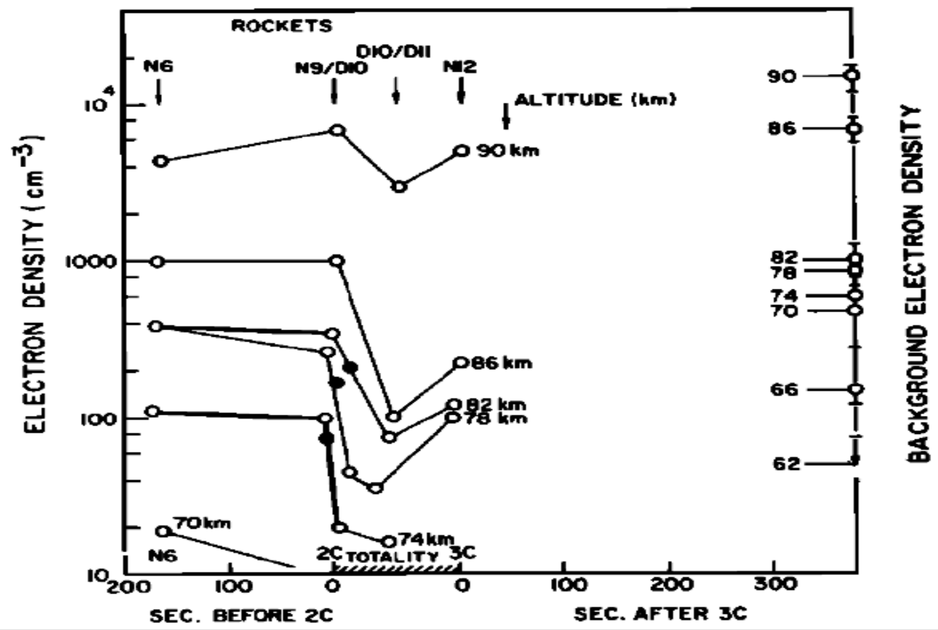
Carroll spar pointing platform

Quantifying the contributions of ionization sources on the formation of the D-region ionosphere during the 2017 solar eclipse

Robert Marshall, Aerospace Engineering Sciences, University of Colorado Boulder, Boulder, CO

Motivation

- The D-region ionosphere is particularly hard to measure: too low for spacecraft, too high for balloons, too tenuous for remote sensing
- D-region is important for long-range communications at VLF-HF frequencies
- D-region is produced primarily by solar Lyman alpha, EUV, and X-rays; highly sensitive to changes in X-ray flux
- **Eclipse 2017 provides a unique opportunity to study the D-region when the sun is "turned off"**
- **SQ: What are the contributions of solar Lyman-alpha, EUV, soft X-rays, and hard X-rays to the production of D-region**



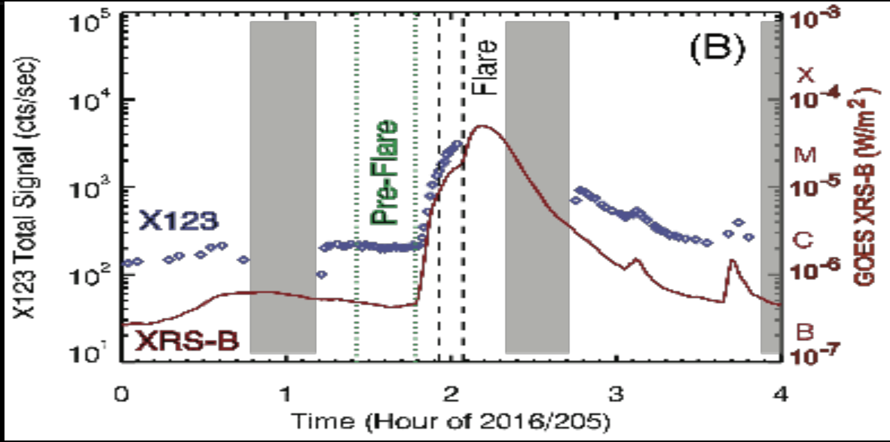
Previous eclipse study (1966): direct, in-situ measurements of the D-region with rocket experiments. Our approach in 2017 will be significantly lower cost, but also leverage new spacecraft data.

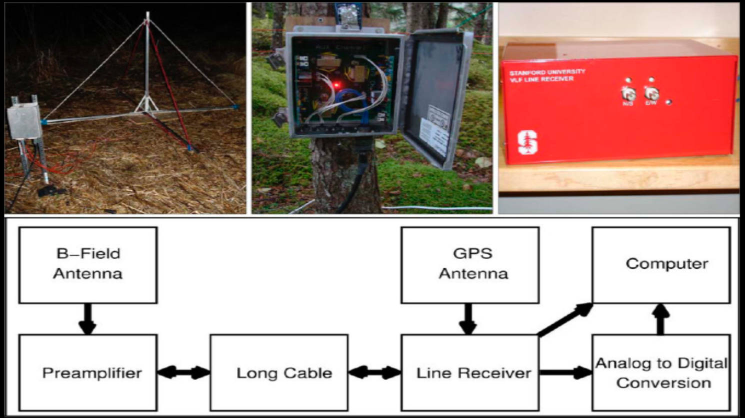
University of Colorado Boulder

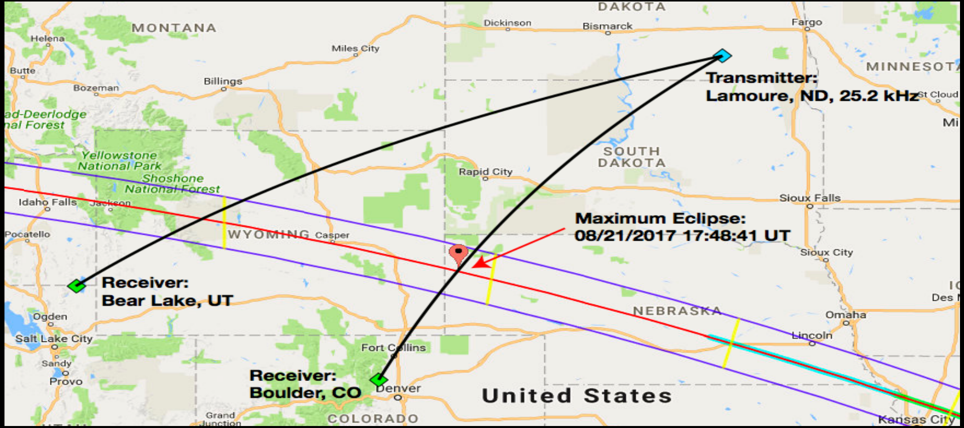
Robert A. Marshall

Approach: Ground and Spacecraft data

- Spacecraft data provides the inputs into the upper atmosphere responsible for creating the D-region: X-rays, EUV, and Lyman-alpha
- Ground-based VLF data observes changes to the D-region before, during, and after the eclipse along known transmitter-receiver paths

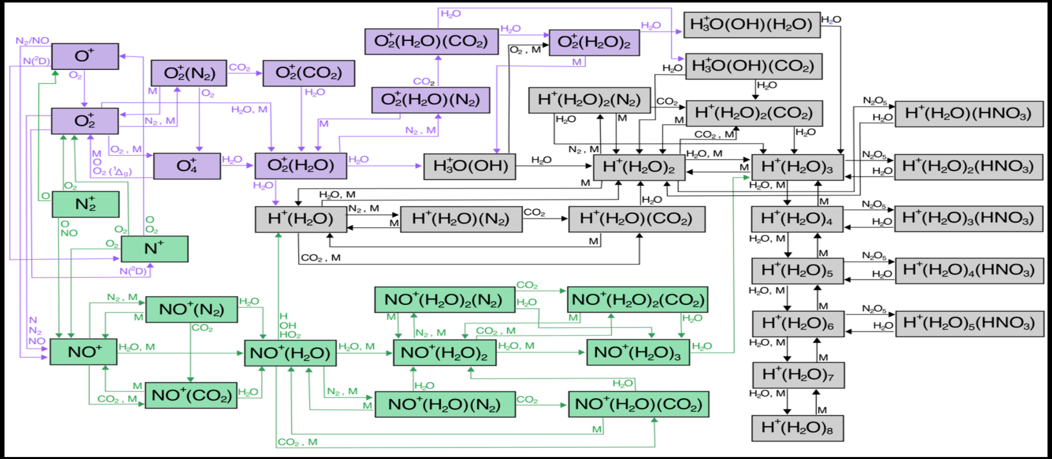




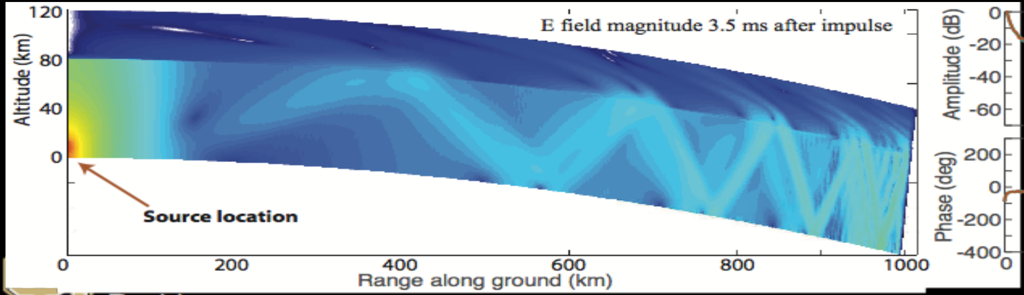


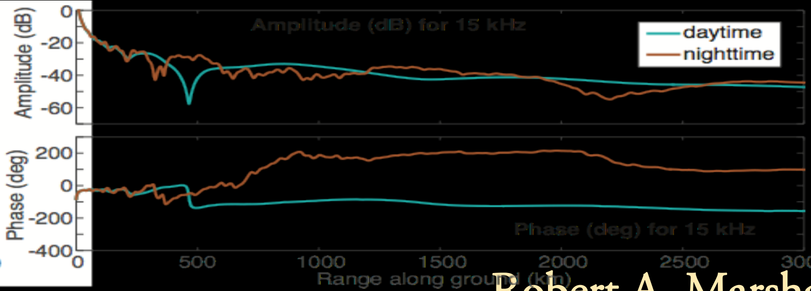
Modeling and Expected Results

- Solar flux measurements from spacecraft are input into a chemistry model of the D-region and middle atmosphere (right)
- Resulting electron / ion density profiles are used in VLF propagation model to predict amplitude / phase perturbations.
- Compare model results to VLF data; assess performance and adjust input parameters



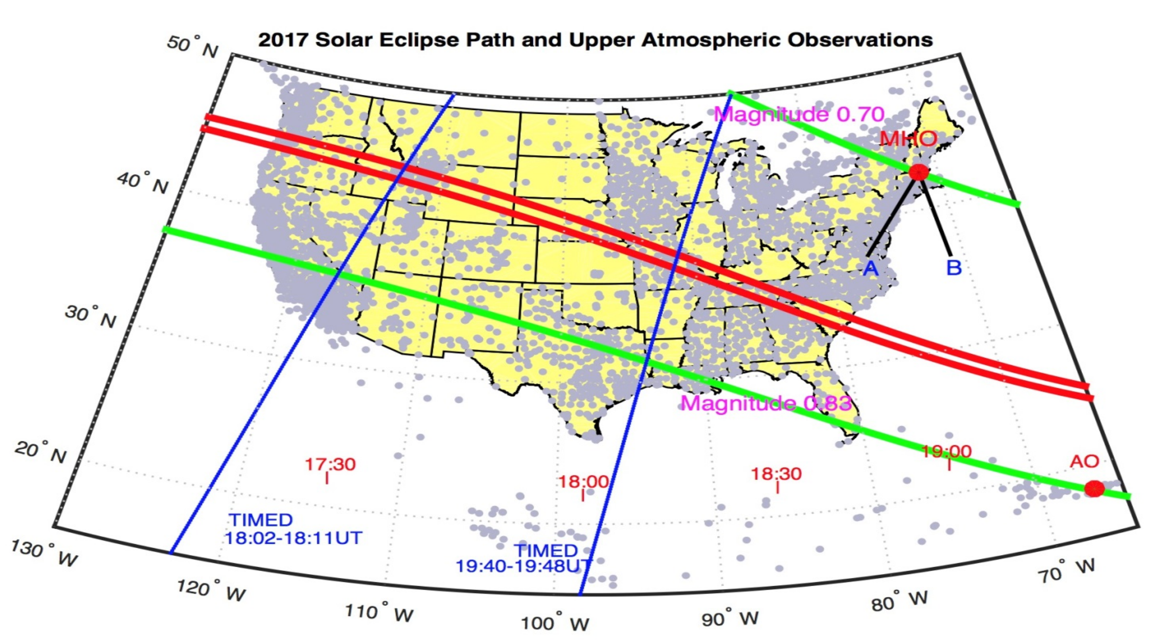
courtesy P. Verronen





Solar Eclipse-Induced Changes in the Ionosphere over the Continental US

PI: P. J. Erickson, MIT Haystack Observatory

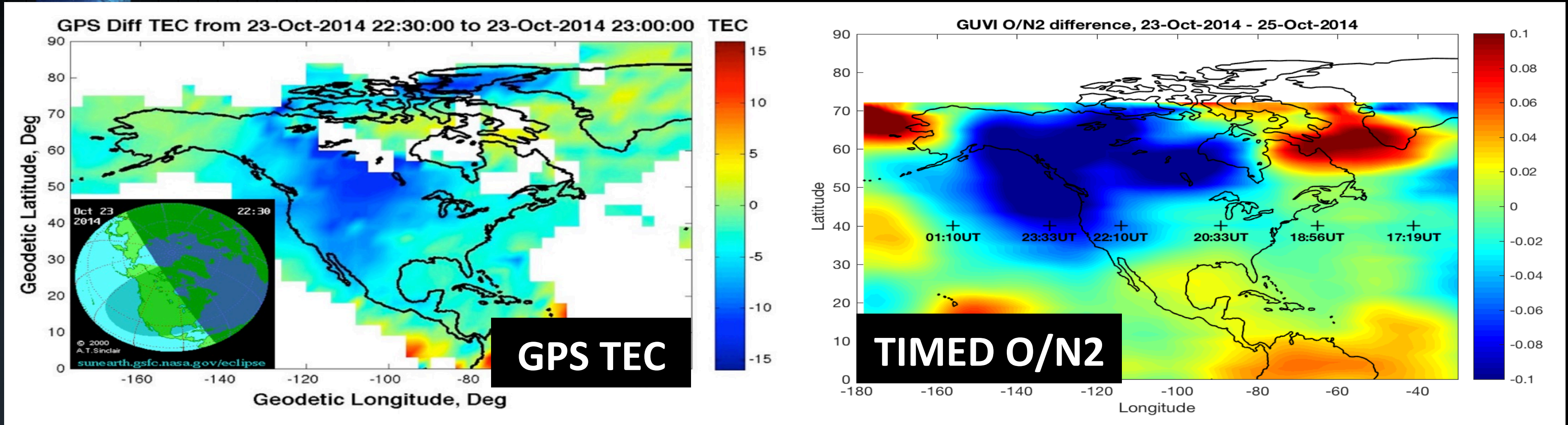


Instruments:

- GNSS
- Two ISRs
- TIMED
- DMSP

- What are the details of traveling ionospheric disturbances (TIDs) and atmospheric gravity waves (AGWs) triggered by the eclipse?
- What are the details of altitudinal and temporal ionospheric profile variations triggered by the eclipse?
- How widespread are spatial ionospheric variations associated with the eclipse?

Solar Eclipse-Induced Changes in the Ionosphere over the Continental US

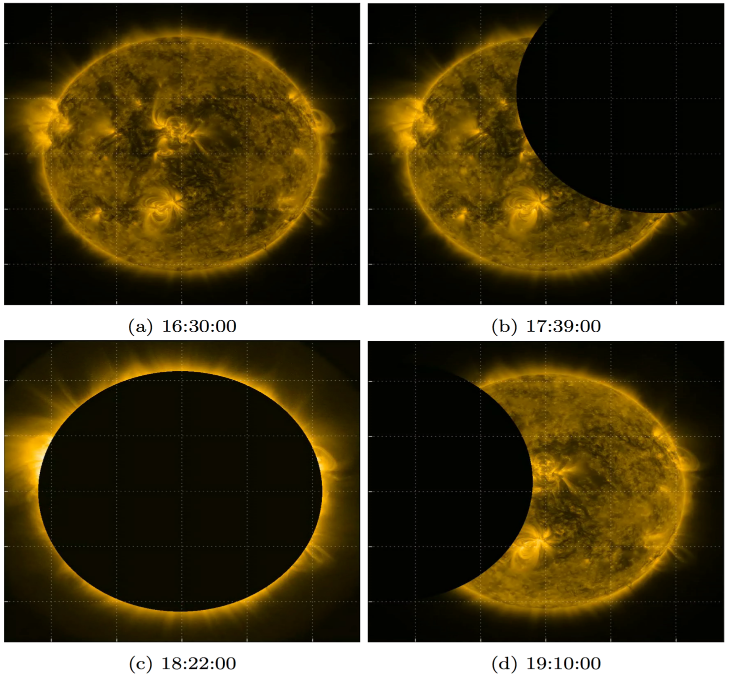


Ionospheric and Thermospheric Science from Eclipse Observations:

- Solar Eclipse-excited Traveling Ionospheric Disturbances and Atmospheric Gravity Waves (GNSS, ISR)
- High Accurate Temporal and Altitudinal Variation of the Whole Ionosphere over Partially Eclipsed Zones (Incoherent scatter radars)
- Temporal and Latitudinal Variation of the Ionosphere and Thermosphere Due to the Eclipse (GNSS, TIMED, DMSP)

Empirically-Guided Modeling of Solar Eclipse Effects

- The moon totally obscures the solar disk during the eclipse, but as much as 15-20% of the XUV/EUV solar flux originates from the solar corona and will not be obscured by the eclipse [Curto *et al., J. Geophys. Res., v. 111*, 2006].
- The net XUV/EUV solar flux varies non-uniformly across the solar disk due to the positions of active regions on the sun, as shown in the figure below.



(a) 16:30:00 (b) 17:39:00

(c) 18:22:00 (d) 19:10:00

Utilize both historical and real-time SDO images during the 2017 solar eclipse to accurately seed the SAMI-3 flux-tube coupled model with a time history of the XUV/EUV solar flux throughout the eclipse.

Empirically-Guided Solar Eclipse Modeling Study

G. D. Earle & L. Kordella
Virginia Tech
Space@VT Group

J. D. Huba and D. P. Drob
Space & Upper Atmospheric Research Div.
Naval Research Laboratory

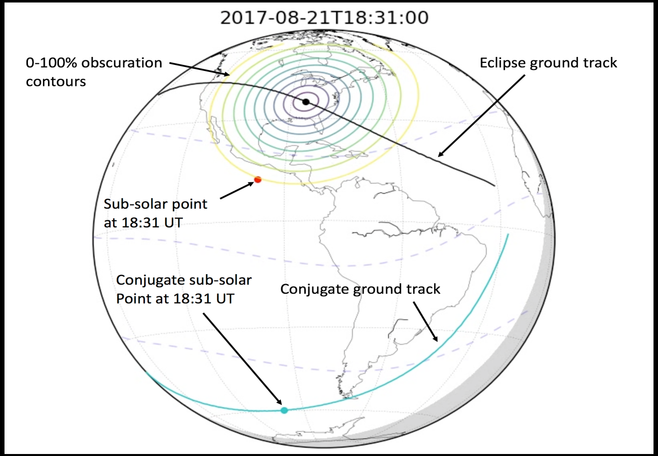
Background

- Virginia Tech (VT) has been funded by the NSF to carry out a ground-based study of eclipse effects on the high-altitude ionosphere.
- NASA is funding a companion project to enhance this effort using the SAMI-3 state-of-the-art modeling tools [Huba et al., Sp. Sci. Rev., submitted] and solar observations during the eclipse. The goals of this study are to:

- Study the effects of conjugate-hemisphere coupling, with constraints inferred from ground-based experiments.

- Apply the models to simulated eclipses at other latitudes and local times to determine the combined effects of geomagnetic latitude and flux tube coupling on eclipse-related plasma electrodynamics.

- Use the high-resolution version of the SAMI3 model to identify regions of instability and/or radio frequency scintillation effects along the eclipse track, as shown in the figure.



Modeling Approach

- The SAMI-3 model is a flux-tube-coupled PIC code that self-consistently solves the fluid equations including production and loss, so it is an ideal tool for studying cause-and-effect eclipse scenarios.
- Our ground-based dataset during the eclipse will included GPS-derived vertical TEC, coherent scatter HF radar data from the SuperDARN radars, and vertical incidence ionosonde data along the eclipse track. Using these datasets we will constrain the SAMI-3 and high-resolution SAMI3/ESF models to study:

  – Meso-scale (~100 km) ionospheric changes consistent with temporally and spatially modified EUV solar flux.

  – Higher resolution (~5 km) studies in a limited longitudinal range (12°) to assess smaller-scale effects such as instability onset and conjugate dynamics.

Conclusions

Through empirically constrained eclipse modeling studies determine the relationships between plasma density, temperature, and velocity within the eclipsed portion of the ionospheric plasma.

Once the physics of these processes are understood we will extend our results by using the model to extrapolate our results to other conditions, including:

Different magnetic latitudes, where the dip angle of the geomagnetic field may alter the ionospheric responses to an eclipse;

Different solar EUV flux conditions, because the EUV flux drives the ionization processes in the ionosphere.

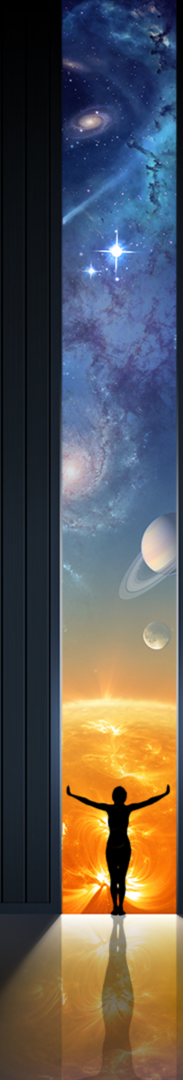
Finally, the results of our modeling work should help to predict &/or identify unstable regions within the eclipsed environment, where scintillation of RF signals may become significant.

Using the 2017 Eclipse viewed by DSCOVR/EPIC & NISTAR from above and spectral radiance and broadband irradiance instruments from below to perform a 3-D radiative transfer closure experiment

PI: Guoyong Wen, Morgan State University

Quantify the perturbation of TOA and surface shortwave radiation during 2017 eclipse. Use DSCOVR/EPIC & NISTAR observations from above and spectral radiance and broadband irradiance from below to perform a 3-D radiative transfer closure experiment.

- Deploy Pandora spectrometer systems (300 nm to 800 nm) and pyranometers to 3 locations in the umbra and penumbra region to collect radiance and irradiance measurements during the entire course of the 2017 eclipse. The ground-based observation will be the lower boundary condition for the closure experiment.
- NISTAR (broadband) and EPIC (narrowband) observations from DSCOVR will be used as constrains for upper boundary condition for the closure experiment.
- We will coordinate DSCOVR EPIC observations during the eclipse making sure that PEIC instrument will take images before, during and after the eclipse.



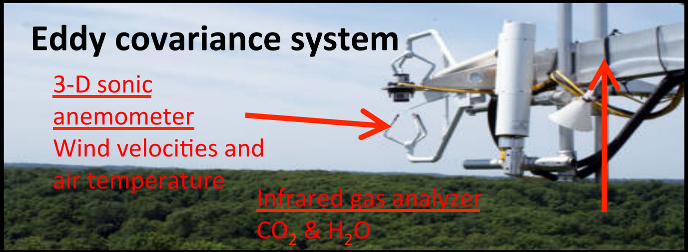
- Using MODIS observed cloud, aerosol, surface properties and water vapor amount as input to 3D (Monte Carlo) and 1D (Fu & Liou) codes to compute radiation changes in the the umbra and penumbra region.
- Using cloud properties derived from EPIC observations as input to radiation codes to compute the perturbation of shortwave radiation budget in the 2017 eclipse

Table I. Timeline of proposed research starting in June 2017 ended in May 2018

Task	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May
Pandora Systems and Pyranometers				
Preparation and Deployment				
Data Collection				
Data Analysis				
Analysis of DSCOVR Data				
EPIC Spectral Reflectance Data				
EPIC Cloud Optical Depth and Height				
NISTAR Radiation Budget				
Radiative Transfer Modeling				
Analysis of MODIS Data				
Umbra and Penumbra Radiation				
Global Average Radiation Budget				

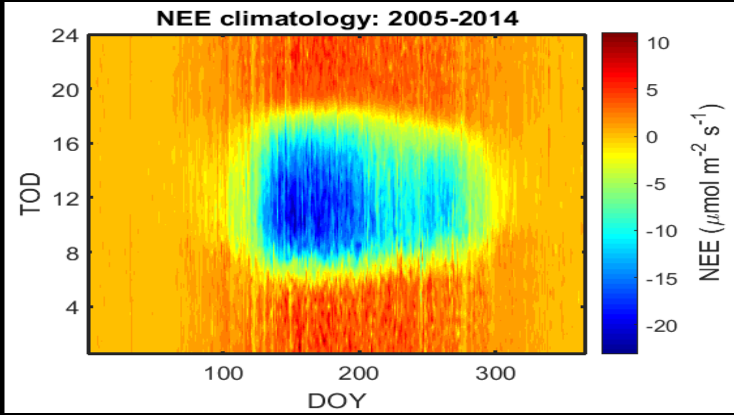
Land and Atmospheric Responses to the 2017 Total Solar Eclipse

B.M. Svoma, J. Wood, A. Speck, N. Fox, P. Market, A. Lupo, E. Sadler



The Eddy covariance (EC) systems measure horizontal and vertical wind, air temperature, and fluxes of carbon dioxide, water vapor, and sensible heat. Solar, longwave and photosynthetically active radiation are also measured. EC systems are also in agricultural lands north of the Missouri Ozarks AmeriFlux site (Oak-Hickory forest) to determine the eclipse effects over multiple ecosystems.

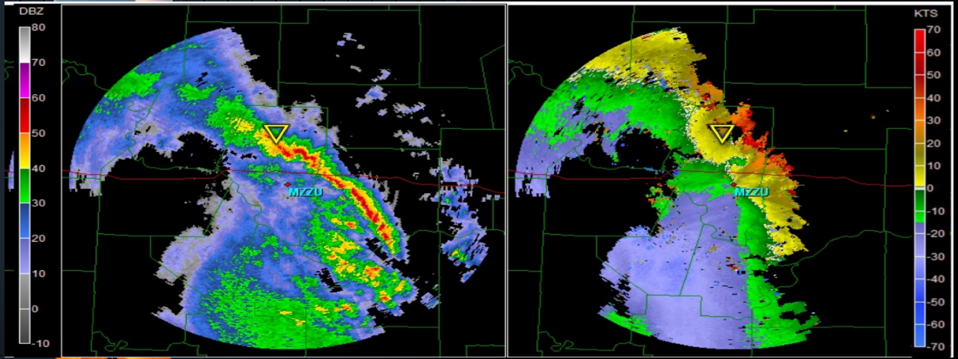
The Instrumentation Tower at the Missouri Ozarks AmeriFlux site (Oak-Hickory forest)



Lower Right: Sample of summarized EC data. Day of year (DOY) and Time of Day (TOD) averages of Net Ecosystem Exchange (NEE) in micromoles of carbon dioxide per square meter per second. Negative values represent net carbon uptake by the forest. The most carbon uptake is in late spring-early summer around mid-day (when the most water and solar radiation are typically available). Positive values at night are due to ecosystem respiration (loss of carbon from the surface).

Weather Balloon launch demonstration at the 10th annual South Farm showcase with the mobile rawinsonde system (http://cafnrnews.com/2016/10/a-diamond-in-the-rough/). This system will observe changes in the vertical wind, temperature, and humidity profiles due to the eclipse.

MZZU Research Radar will be used primarily to detect changes in wind fields due to the eclipse.



Sample of MZZU Research Radar data detecting a confirmed small tornado through identifying low-level wind rotation.

The Citizen Science campaign to measure air temperature response to the eclipse over a broader area (~50 volunteers anticipated). Air temperature sensors (DS 1922L-F5 Maxim Thermochron®iButtons®) and solar radiation shields constructed by students will be given to the volunteers to take ~5 days of observation approximately every minute.

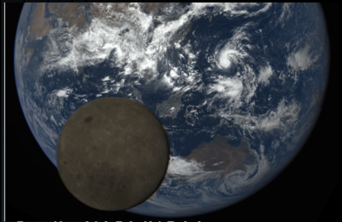
All instrumentation discussed above is near the center of the totality path.

Outreach Activities

- Make your own cardboard projector
- Mirror the solar eclipse image in an envelope
- Use 3-D printing to educate and excite
- Try the citizen explorer activities
- Google Science Journal
- Download more from the NASA eclipse website
- Additional resources for the eclipse and beyond

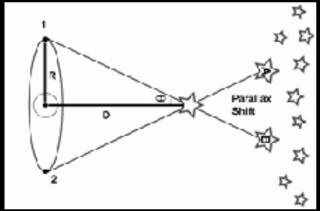
Citizen Explorers

Mass of the Earth



Credit: NASA/NOAA

Lunar Distance by Parallax



Credit: NASA

Diming of the Daylight

Credit: Olav Jon Nesvold/EPA

X Marks the Spot

Credit: NASA

Lunar Shadow Speed

Credit: MIR Cosmonauts

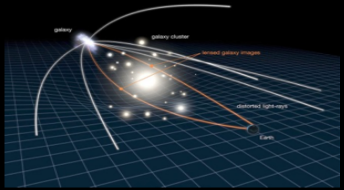
Measuring Temperature

Credit: NASA/GLOBE

Lunar Distance from Speed

Credit: Fred Espenak

Testing GR



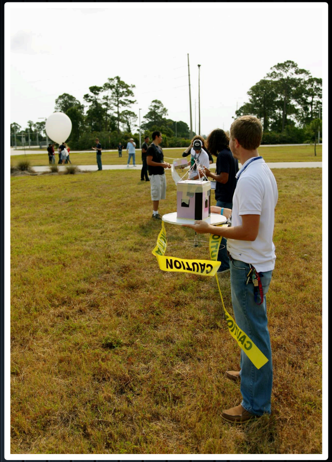
Credit: NASA/ESA

Shadow Bands

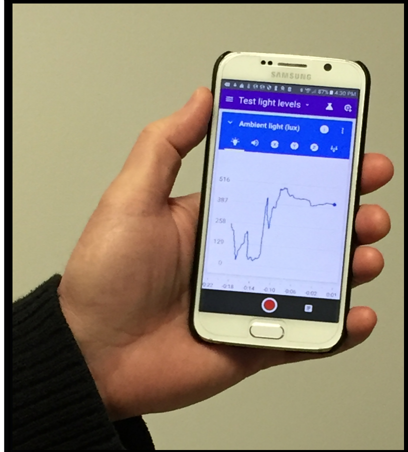
Credit: Karl Simmons, Mike Reynolds

https://eclipse2017.nasa.gov/citizen-explorers

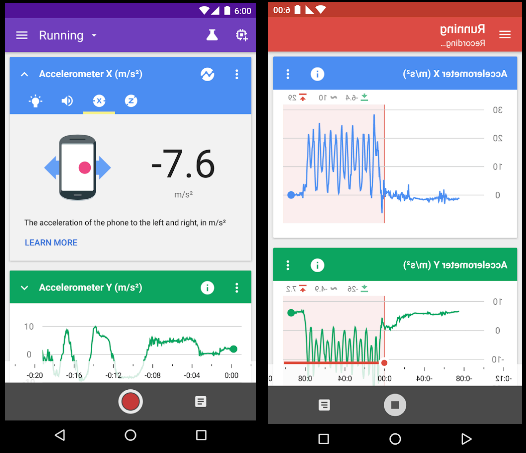
Google Science Journal



Credit: NASA KSC



Credit: NASA



Credit: Science Journal app store

- Collect data in the palm of your hand
- Use phone sensors as accelerometer, magnetometer, light and sound sensors
- Open source code
- Can attach external sensors
- Eclipse applications include light level and sound
- Find this free app from the appropriate Android store

NASA Eclipse Resources

Do you need ideas to engage your audiences? Try the following:

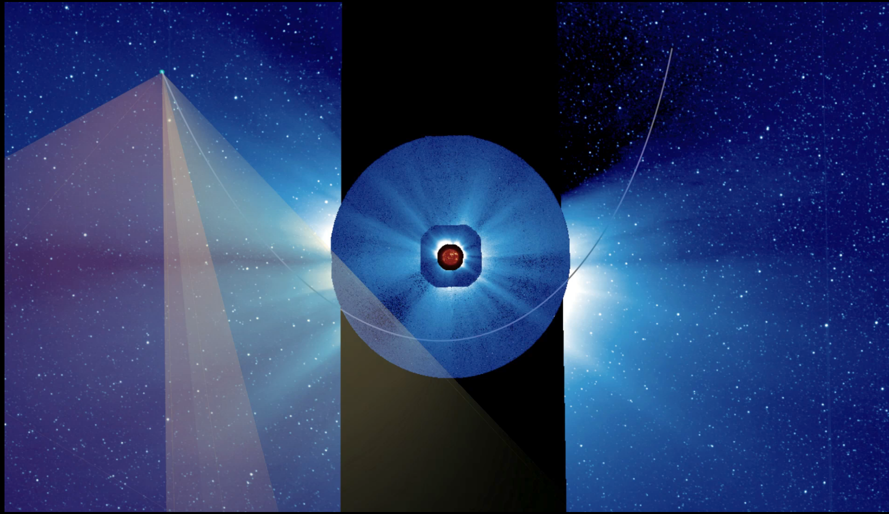
- Activities: try some for outdoor and indoor
  https://eclipse2017.nasa.gov/activities
- NASA's Eyes on the 2017 Eclipse: see a 3D simulation
  http://eyes.jpl.nasa.gov/eyes-on-eclipse.html
- Toolkit: watch videos, download banners, fact sheet, safety bulletin, star chart/bookmark, and tips to organize eclipse parties
  https://eclipse2017.nasa.gov/toolkit
- Event maps: find museums, libraries, parks and other organized eclipse events closest to you
  https://eclipse2017.nasa.gov/eclipse-maps

NASA Resources for Eclipse and Beyond

- Apply to become a Solar System Ambassador or invite one to your event
  http://solarsystem.nasa.gov/ssa/home.cfm
- NASA's Eyes on the Solar System -- learn about your home planet, our solar system, the universe beyond and the spacecraft exploring them
  https://eyes.nasa.gov/
- NASA's Night Sky Network -- join a nationwide coalition of amateur astronomy clubs
  https://nightsky.jpl.nasa.gov/
- Astronomical League -- find astronomy clubs near you and joint NASA observing challenges
  https://www.astroleague.org/
- Celebrate International Observe the Moon Night
  http://observethemoonnight.org/
- Learn more about NASA's science research and missions
  https://science.nasa.gov
- Find NASA visualizations, animations, and images by key words and topics

  https://svs.gsfc.nasa.gov

Parker Solar Probe Plus: Humanity’s First Voyage to a Star



First Ever Thermochromic Ink Stamp

Before

After

As a singular event of national scale and with a global audience, this event will rival the moon landing of 1969 as a landmark event for a new generation.