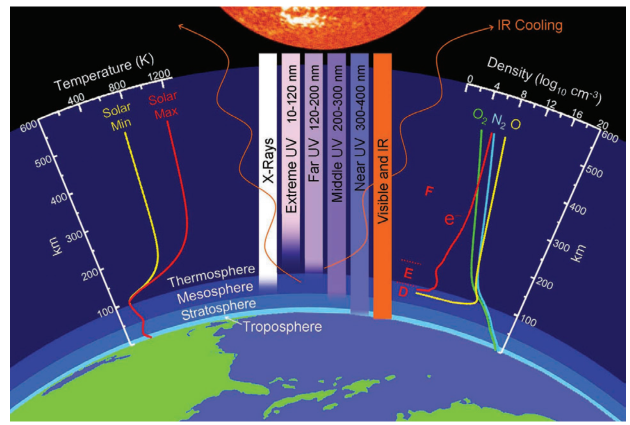
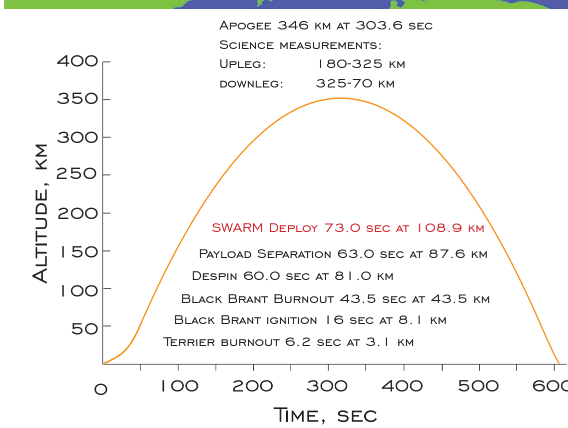
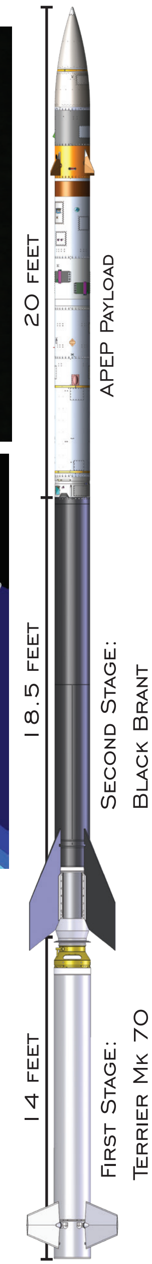
National Aeronautics and Space Administration

Atmospheric Perturbations around Eclipse Path (APEP) Sounding Rockets to study the ionosphere during Solar Eclipses







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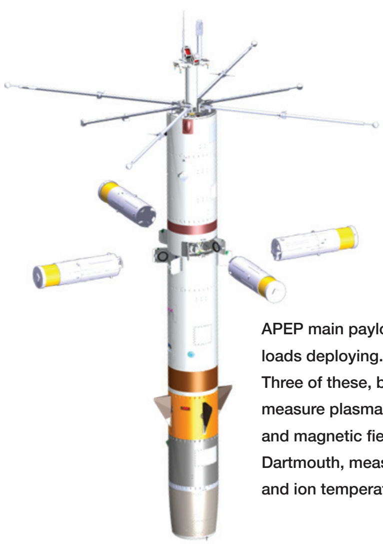
Sounding rockets are well suited to study the dynamics of Earth's ionosphere and a unique opportunity to do so is presented by the Annular Solar Eclipse on October 14, 2023 when three Black Brant IX sounding rockets will be launched from White Sands Missile Range, NM to study the ionosphere before, during, and after the peak eclipse.

Three additional rockets, with similar instrumentation, will be launched from Wallops Island, VA during the Total Solar Eclipse on April 8, 2024.

The mission is called Atmospheric Perturbations around Eclipse Path or APEP. The acronym was chosen because Apep is also the name of the serpent god from ancient Egyptian cosmology, who pursued the sun god Ra and every so often nearly consumed him, resulting in an eclipse.

The APEP payloads

APEP will detect changes in the ionosphere using instruments such as Langmuir probes, electric field probes, magnetometers, ionization gauges, and accelerometers. Simultaneous multipoint measurements will be achieved by ejecting four instrumented deployables from each payload. Springs are used to deploy the ejectables at a velocity of 3 m/s and they will take data for about 7 to 8 minutes. This allows taking measurements in a larger volume of space.



APEP main payload model with subpayloads deploying.
Three of these, built by Embry-Riddle, measure plasma density, neutral density and magnetic field. The fourth, built by Dartmouth, measures plasma density and ion temperature.

The Ionosphere and APEP science

The ionosphere is a region of the Earth's atmosphere between 90 and 500 km altitude, where solar radiation ionizes gases, i.e. strips molecules and atoms of their electrons, creating ions and free electrons. This state of matter is called plasma. The ionosphere is affected by Earth's gravity, earth's magnetic field, the solar wind, the Interplanetary Magnetic Field (IMF), solar flares, terrestrial weather and various other processes, and is a very dynamic environment.

Eclipses present a unique opportunity to study the effects of a supersonic cooling shadow of the Moon as it moves across the ionosphere and its effect on the structure and energetics of the ionosphere-thermosphere system.

An eclipse is a rapid sunset and sunrise in the span of roughly 90-120 minutes while the rest of the surrounding ionosphere is still under full sunlight. Launching the rockets and instruments during a solar eclipse allows scientists to study the ionosphere during a simulated day/night cycle, where nighttime conditions are created by the Moon eclipsing the Sun and altering the radiation environment.

The first rocket, launched approximately 35 minutes before the local peak eclipse measures the ionosphere as the eclipse is starting. The second rocket is launched during the peak eclipse period when the ionosphere has the maximum shielding from solar radiation. Approximately 35 minutes after the eclipse, when solar radiation again reaches the ionosphere, the third rocket is launched.

An eclipse creates waves in the ionosphere as the supersonic cooling shadow races across the ionosphere. The situation gets further complicated because most of the time there are already existing waves in the ionosphere due to terrestrial weather or an ongoing space weather event, such as a flare hitting Earth, especially during the ongoing Solar Max. Visualize this as a motorboat racing across a disturbed ocean which already has waves and tides.

Scientists want to understand how the ionosphere responds to all these disturbance activities because all satellite communications go through the ionosphere before they reach Earth. And as society gets more dependent on space based assets, such as GPS and satellite based communications, we need to understand and consequently model all perturbations and irregularities in the ionosphere.

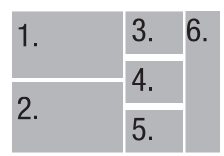
Recent studies, especially after the 2017 great American eclipse, have shown that physical processes perturbed by an eclipse extend well beyond the path of totality into the penumbra and appear across vast geographical expanse and disrupt communication paths.

Ripples and disturbances and irregularities in the ionosphere happen horizontally as well as vertically. Rockets are the best way to look at the vertical dimension at the smallest possible spatial scales. Ground based remote sensing assets, such as ionosondes and Incoherent Scatter Radar (ISR), can also be used but do not offer the small spatial resolution of rocket based instruments. They can be targeted for the right moment and go where satellites can't and they measure at scales that ground based remote sensing assets can't.

The Investigators

The Principal Investigator for APEP is Dr. A. Barjatya from Embry-Riddle Aeronautical University. Co-Investigator institutions include Air Force Research Labs, Dartmouth College, Massachusetts Institute of Technology, and University of Colorado-Boulder.

ABOUT THE IMAGES



1. Payload integration activity. Payload is being prepared for pre-flight testing.
2. Paths of the 2023 and 2024 eclipses. Visit: https://solarsystem.nasa.gov/eclipses/home/
3. Annular Eclipse May 20, 2012. Credits: NASA/Bill Dunford
4. Graphic of the Ionosphere and Earth's atmosphere. Credit: John Emmert/Naval Research Lab
5. Sounding Rocket flight profile for the APEP rockets.
6. Terrier-Black Brant Sounding Rocket with APEP payload.