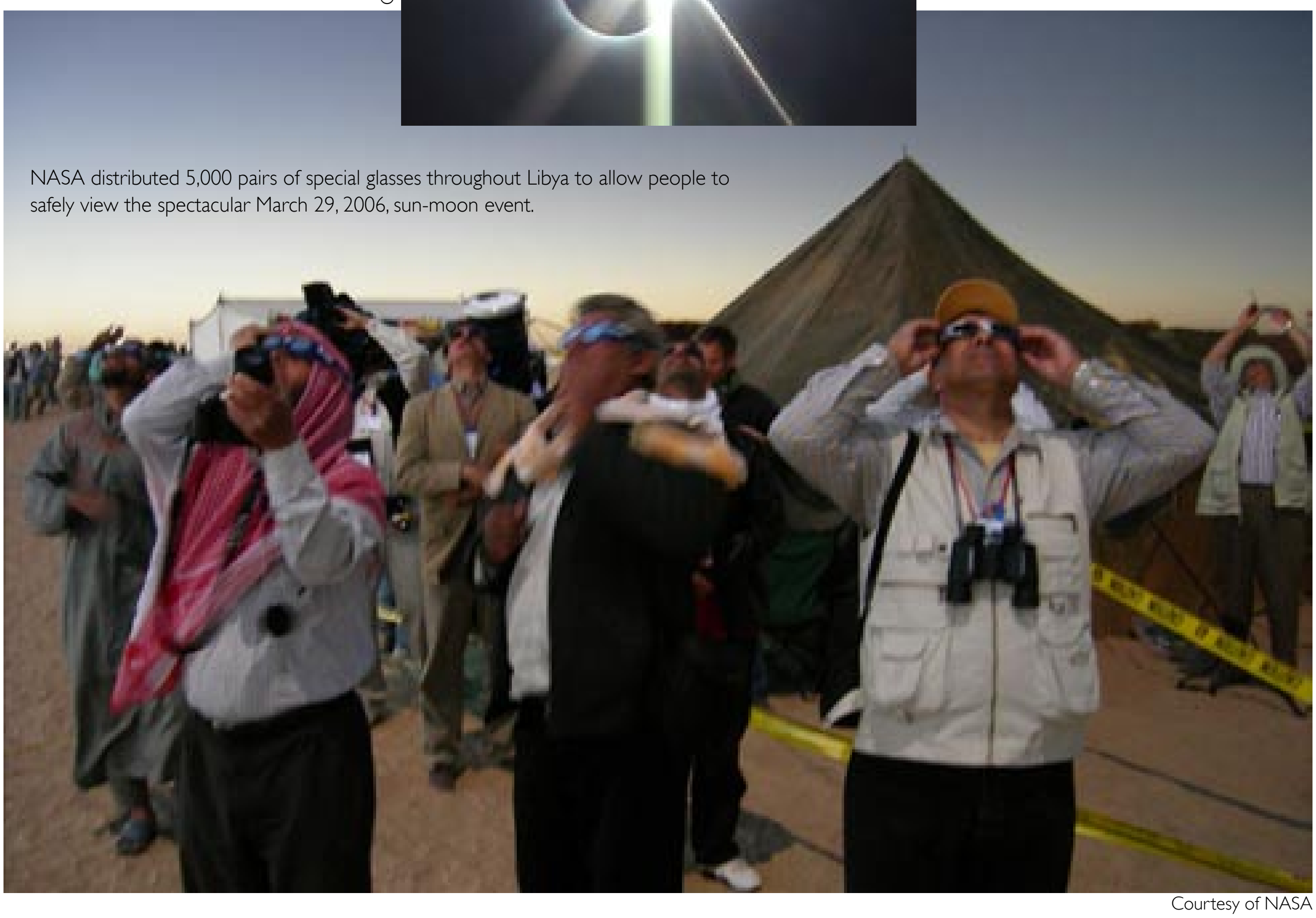
# Total Eclipse Cooperation

Joseph Davila, PhD

Courtesy of Nat Gopalswamy, PhD

Near the beginning and end of a total solar eclipse, the sun's edge seems broken into beads of light, called Baily's beads after British astronomer Francis Baily's 1836 discovery. The beads occur because the moon's edge is jagged with mountain peaks. When one bead is visible, the effect resembles a diamond ring. This effect was captured after totality, from Anatolia in southern Turkey.



NASA distributed 5,000 pairs of special glasses throughout Libya to allow people to safely view the spectacular March 29, 2006, sun-moon event.

Courtesy of NASA

Courtesy of Joseph Davila, PhD

Joseph Davila

*Joseph Davila, PhD, is an astrophysicist in the Heliophysics Division at NASA's Goddard Space Flight Center in Maryland. His research interests include wave/particle interactions on the sun, the three-dimensional structure of the sun's corona, and the sun's magnetic field.*

In March 2006, during a rare four-minute total solar eclipse, astrophysicists from NASA and scientists from research institutions in Libya collaborated for the first time in this North African country on joint scientific activities. Traveling to Libya's ancient southern desert in search of the best eclipse visibility, the scientists studied the sun's corona and helped broadcast the event to people around the world.

Total solar eclipses happen about once a year, on average, somewhere on Earth. On March 29, the four-minute, six-second total solar eclipse occurred when, from Earth's perspective, the moon passed in front of the sun and seemed to be about the same size as the sun. Over the past 50 years, scientists have learned a lot about the sun's corona—where its energy comes from and how it attaches to the rest of the interplanetary medium—but many details are still mysterious.

What many people don't realize is that the sun doesn't end at the yellow ball. The atmosphere of the sun extends all the way through the solar system. Earth travels through the sun's atmosphere, which ends at a region called the heliopause boundary—the outer limits of the sun's magnetic field and outward flow of the solar wind—between 18 billion and 22 billion kilometers from the sun.

The next total eclipse, on August 1, 2008, will be seen in northern Canada, Greenland, Siberia, Mongolia, and northern China. It will last about two minutes. One of the longest eclipses on record will take place July 22, 2009, when totality will last for more than six minutes as seen from a spot in the Pacific Ocean.

Predicting eclipses is easier than predicting space weather, which is similar to Earth weather but originates on the sun. Activity on the sun's surface, like solar flares, can cause high levels of radiation in space that can appear as plasma (particles) or electromagnetic radiation (light). On Earth, space weather can interfere with shortwave radio transmission and electric power grids. In space, space weather can cause satellite orbits to decay and can be a radiation hazard for satellites and astronauts during some phases of space missions.

In studying the sun and the corona, we'd like to develop our science to be comparable with today's weather observations and forecasts, so when people or robots go into space, we can predict what the weather will be. To do that takes a lot more information than we currently have. Right now, we have broad sketches of how things work, so it's not mysterious from that point of view. But in terms of making actual predictions about what's going to happen in space tomorrow, we're not very good at that yet.

The eclipse is special for us because it gives us a chance on Earth to test instruments in conditions that are similar to space. It's much cheaper for us to go to an eclipse observation site and test these instruments than it is to build a spacecraft and test them in space. You're talking about hundreds of millions of dollars in space and tens of thousands of dollars for one of these trips. Neither one is cheap, but this is much cheaper than going to space with a brand new instrument.

Courtesy of NASA

In Libya's Al-Fateh University, where 7,000 students study nearly every engineering and science discipline, NASA's Joseph Davila (left) presents Dr. Hadi A.A. Omar, dean of the faculty of science, with a book about the history of NASA spaceflight for the university library.

After Portuguese explorer Ferdinand Magellan first sailed around the world, the world got smaller and people suddenly needed a science of oceans, ocean currents, jet streams, large-scale winds, and trade winds. People needed to know about the large-scale features in Earth's atmosphere because they were traveling through that atmosphere. It's similar in space. We've just kind of stuck our toe into space, but maybe in the next 50 to 100 years, people will be traveling in space, so we're going to need to know more about the space environment.

To demonstrate new techniques for observing the sun's atmosphere and prototype instruments for future space missions, we and our Libyan collaborators performed two experiments during the eclipse.

In one experiment, we set up a small telescope with a camera that uses filters to capture light from the sun's corona and separate it into different colors of the spectrum. Another experiment—called MACS, for multi-aperture coronal spectrometer—uses a spectrograph to separate the light into individual colors. The filter approach is simpler to implement, but the spectrograph is more accurate. We will compare the two techniques when the data gathering is complete. Much analysis is needed before results can be released to the scientific community, but the results so far are very promising.

By doing these experiments, we're able to measure properties of the electrons that are scattering the light—the density, the temperature, and the flow speed of electrons in the corona. That's information we need to improve computer models of the solar system.

The day after the eclipse, I traveled to Sebha University, 800 kilometers south of Tripoli, to discuss scientific participation in programs related to the International Heliophysical Year 2007, an international program to unite the world's science community from all 191 United Nations member states for scientific collaboration to study the Earth, sun, and solar system as one system.

Throughout the Libyan trip, the people's response to us was overall very positive. Young people were very interested in talking to us and were very friendly. Some of the older people were more wary, but everyone knew NASA and everyone wanted something with the NASA logo on it. We gave away all of our pens, buttons, and NASA stickers.

The photos below and on the following pages show various aspects of our visit to Libya. ■

Courtesy of NASA

After giving a presentation on space weather, NASA solar science, and the sun's influence on Earth's environment, the NASA team lunches with Al-Fateh University faculty, university officials, and visitors. Afterward, NASA and faculty scientists discussed potential areas of scientific cooperation.

Courtesy of NASA

The NASA-Libyan science team arrived by helicopter at Eclipse City, at Waw an Namus near the southwest city of Awbari in Libya's southern desert, three days before the eclipse.

Hundreds of kilometers into the Sahara Desert, scientists from universities and research organizations in the United States, Libya, Switzerland, Italy, France, and Germany participated in the International Symposium on Solar Physics and Solar Eclipses. The International Heliophysical Year, the Libyan government, and the Institute of Astronomy of the Swiss Federal Institute of Technology in Zurich sponsored the conference.

Courtesy of NASA

Courtesy of NASA

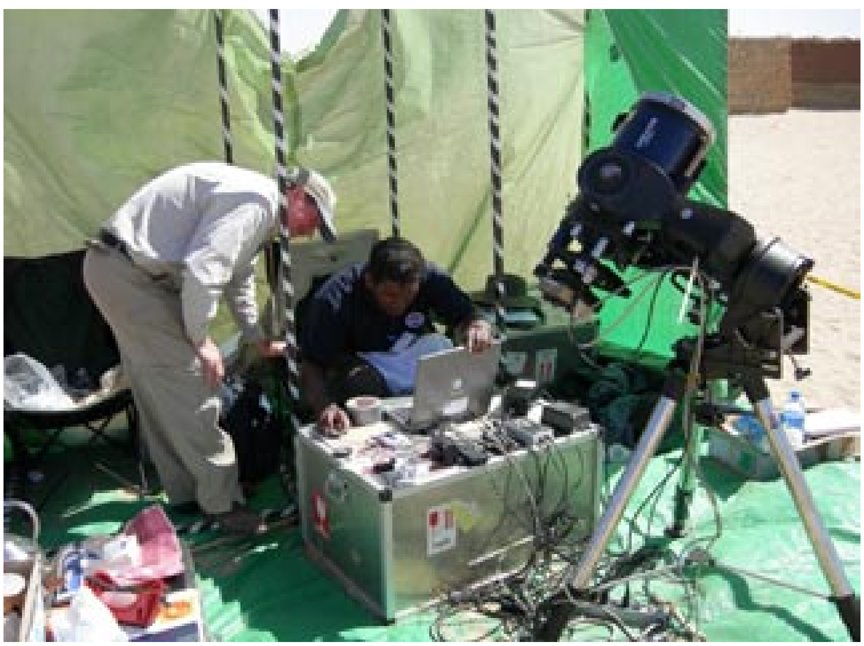
Eclipse City, two years in planning and construction, was a temporary base camp and headquarters provided by the Libyan government. More than 150 scientists and support personnel lived on site. The main tents, dining tents, a community area, and sleeping accommodations are on the right. Tents for soldiers from the Libyan Army, who maintained a security perimeter around the camp, are on the left.

Courtesy of NASA

The temporary tent city had showers, toilets, refrigerated food storage, a gift shop, kitchen and dining tents, and satellite communications. Housing consisted of finely crafted straw huts with carpeting and thick foam mattresses.

Courtesy of NASA

Joseph Davila: "The Libyan government provided telephone service and wireless Internet access, and a communications tent housed equipment that linked us to the rest of the world by satellite. A separate link from Libya Television allowed images from the eclipse site to be transmitted to NASA in the United States and around the world. Libya Television broadcast news from the encampment to the Libyan population."

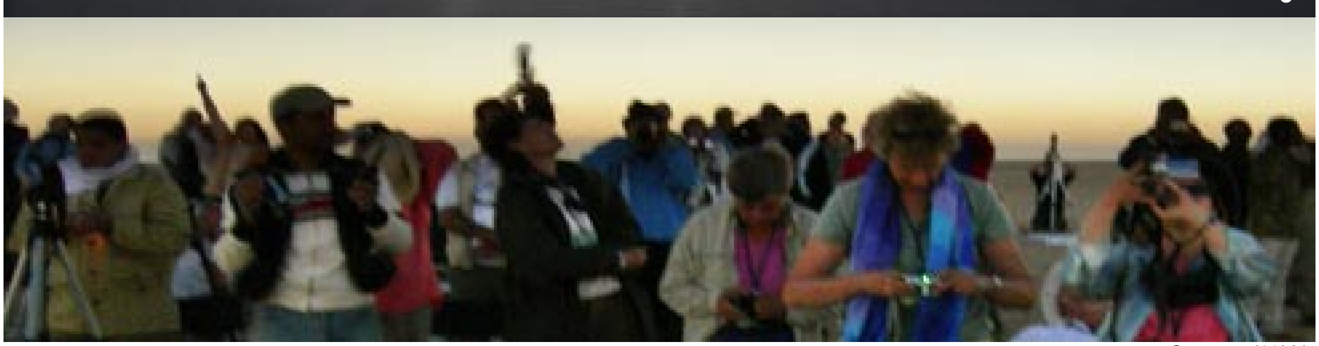


Courtesy of NASA

Orville Chris St. Cyr (left), an astrophysicist in the NASA Solar Physics Branch at Goddard Space Flight Center, and Nelson Reginald, assistant research professor of physics in the Institute for Astrophysical and Computational Sciences at Catholic University of America in Washington, D.C., set up one of two experiments to demonstrate new techniques for observing the sun's atmosphere.

Totality.

Courtesy of Olivier Garde, Grenoble, France



Courtesy of NASA

The U.S. Department of State Office of Science and Technology Cooperation, NASA, and the government of Libya worked in concert to make possible the historic solar eclipse expedition.