

Exploring the trio of Iberian eclipses (2026-2028) using the "Solar Eclipse Maps" application in Google Earth Engine (GEE)

Between 2026 and 2028, the Iberian Peninsula will be the stage for an exceptional astronomical phenomenon: a "trio" of solar eclipses. Specifically, we will experience two total eclipses (August 2026 and August 2027) and one annular eclipse (January 2028). To help observers, educators, and enthusiasts prepare for this historic event, a new computational tool has been created: "Solar Eclipse Maps."

Developed entirely on the Google Earth Engine (GEE) platform, this interactive application allows any user to check whether eclipses will be visible from a specific location and obtain a detailed breakdown of the local circumstances. The application is available for free at the following link:

<https://gee-astrolab.users.earthengine.app/view/solar-eclipse>

The engine of the application is based on the rigorous astronomical algorithms of Jean Meeus and uses Besselian elements provided by NASA. All the geometric computational load—from the calculation of the shadow's path to the generation of the umbra and penumbra— was processed in real time on Google's servers, allowing for a smooth experience without overloading the user's device. Although the tool does not seek to replace the millimeter precision of space agencies (NASA) or the National Geographic Institute of Spain (IGN-Spain), its main strength lies in the integration of environmental and topographic geospatial data into a single platform. It is an application designed by and for planning astronomical observations in the field and scientific outreach.

To ensure its international reach, the interface is completely translated into Spanish, English, French, and Italian. The application panel is structured into different functional modules that guide the user from a global view of the event to the local details of their observation site. Below, we explore its main functions in detail.

Time selection and control module

The application header acts as the main control panel. Here, the user selects which of the three eclipses they want to simulate (i.e., 2026, 2027, or 2028). Once chosen, a time slider allows the simulation to be advanced or rewound chronologically. The playback speed can be adjusted to see how the Moon's shadow crosses the map at high speed or to find the moment of the "Local Maximum" with a single click.

Visual layers control module

This panel allows the customization of the information overlaid on the cartographic map. The user can turn the central path line, umbra, and penumbra regions on or off. In addition, it dynamically shows the terminator, which is the line that separates day from night globally, as the event progresses.

Orographic shadows and historical cloud cover

This is one of the greatest advantages of using the GEE. The app incorporates a digital elevation model (SRTM) that projects orographic shadows in real time according to the altitude of the sun at that exact moment. In addition, a historical cloud cover layer can be activated (based on the EarthEnv MODCF catalog), which shows the average probability of finding overcast skies in that month, a critical factor in choosing the optimal location for observation.

Global data and ephemeris module

Before analyzing a specific point, the app displays the global data for the selected eclipse. It reports the Julian date, the Saros cycle to which it belongs, the gamma metric, and the maximum worldwide duration. Furthermore, a solar and lunar ephemeris submodule calculates the sunrise and sunset times, Moon's illuminated phase, and Equation of Time for that day.

Local circumstances

This is the heart of our application. By clicking on any point on the Iberian map, the system extracts the coordinates and terrain elevation and calculates the exact distance to the center line of the totality. In just a couple of seconds, it returns a dynamic results panel that indicates whether the eclipse has started, if it is total, partial, or if, on the contrary, the Sun has already set. Within this panel, the observer obtains vital technical data: the eclipse magnitude, the percentage of obscuration of the solar disk, and the apparent size ratio between the Moon and the Sun. Of vital importance are the precise calculations of the times of the "Contacts" (C1, C2, Maximum, C3, and C4), provided in Official Peninsular Time (CEST).

Topographic visibility profile

To avoid last-minute surprises, the application draws a visibility profile within a 10-kilometer radius from the chosen point in the direction of the sun. Through an area chart intersected with the line of sight, the app evaluates the surrounding orography and issues a clear verdict: it confirms whether the eclipse will be visible or warns whether the Sun will be hidden behind a mountain before reaching totality.

Celestial path of the eclipse

For enthusiasts of celestial mechanics, a Cartesian diagram is generated, showing the exact path that the Sun will trace in the sky (altitude vs. azimuth). In this curve, the exact points of contact are marked with different colors, visually allowing you to see at what height above the horizon the most spectacular phase of the event will occur.

Data export

Finally, considering offline planning, the application features export options. All astronomical and location data for a specific point can be dumped into a plain text format (TXT) to copy to the clipboard or automatically downloaded as a spreadsheet file (CSV) for later empirical analysis.

Sources, Bibliography and Complementary Tools

To provide the application with academic rigor and offer users a solid starting point for delving deeper, a detailed fundamental bibliography module was incorporated. This compendium includes key works on calculating ephemerides and algorithms, highlighting irreplaceable texts such as "Astronomical Algorithms" by Jean Meeus and the "Five Millennium Canon of Solar Eclipses" by Fred Espenak and NASA. Likewise, references are made to popular science studies, historical works, and observation guides recently published specifically for the trio of Iberian eclipses, including publications from the Spanish National Research Council (CSIC) and the National Geographic Institute (NGI).

Aware that astronomical observation thrives on collective effort, the tool was created as complementary support to large institutional resources, which it provides direct access to from its help panel. From there, direct links are provided to the official website of the Trio of Eclipses of the Government of Spain and to the detailed views of IGN-Spain. To contrast data at an expert level, it also links to the celebrated interactive cartographies of Xavier Jubier, Jay Anderson, and Fred Espenak, as well as to valuable related projects and applications within the community, weaving a comprehensive network of information for the observer.

Discussion and conclusions

The arrival of the "triad of eclipses" in Spain (2026, 2027, and 2028) is an event that goes beyond mere anecdote to become an unparalleled opportunity for citizen science, education, and fieldwork planning. The simulator developed in Google Earth Engine (GEE) was designed to bridge the gap between the complex algorithms of celestial mechanics and the end user. By transforming mathematical equations into visual and interactive layers,

the tool democratizes access to astronomical information, allowing anyone to prepare their observations independently.

From an educational perspective, this application is presented as an invaluable virtual laboratory for classrooms and outreach centers. Educators can use dynamic time control to illustrate how the orbital movements of the Earth and Moon interact, showing tangible concepts that are often abstract, such as the geometry of the umbra, the expansion of the penumbra, or the influence of atmospheric refraction. Observing the speed at which the shadow moves across the Iberian geography helps students assimilate the true cosmic scale of these phenomena.

In the practical field of observation, the simulator tackles head-on two of the biggest challenges faced by any eclipse chaser: meteorology and orography. By integrating satellite data to map historical cloud cover and trace transverse elevation profiles, the user obtains much more than just contact times. The difference between a resounding success and a disappointment may lie in the ability to anticipate, thanks to the app, if a mountain range will block the view of the eclipsed Sun right near the horizon, which is a critical and decisive factor for the impending 2026 eclipse.

In conclusion, beyond the numerical solvency that supports the ephemeris system, the true achievement of this platform is its ability to empower observers. Whether for an astrophotographer looking for the perfect topographic framing, an eclipse chaser recording contact data, or a citizen eager to experience an amazing moment, this tool provides the precision and context necessary to choose the optimal time and place, transforming planning into the first great step of an astronomical journey.

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