

Five Millennium Catalog of Solar Eclipses: –1999 to +3000 (2nd Edition)
Fred Espenak and Jean Meeus

Preface – 1st Edition

Solar eclipse canons have traditionally been publications offering maps of past and future eclipse paths using the best ephemerides of their day for calculating the positions of the Sun and Moon. The first major work of this kind was Theodor von Oppolzer's 1887 *Canon der Finsternisse* (Translated as *Canon of Eclipses*, Gingerich, 1962). It stands as one of the greatest achievements in computational astronomy of the 19th century and contains the elements of all 8,000 solar eclipses (and 5,200 lunar eclipses) occurring between the years –1207 and +2161 (1208 BCE and 2161 CE, respectively), together with maps showing the approximate positions of the central lines. To accomplish this remarkable feat, a number of approximations were used in the calculations and maps. Consequently, the eclipse paths often differ by hundreds of miles compared to rigorous predictions generated with modern ephemerides. Furthermore, the 1887 canon took no account of the shifts imparted to ancient eclipse paths as a consequence of Earth's variable rotation rate and the secular acceleration of the Moon. Nevertheless, Oppolzer's canon remained the standard reference for nearly a century.

With the arrival of the electronic computer, the *Canon of Solar Eclipses* (Meeus, Grosjean, and Vanderleen, 1966) contains the Besselian elements of all solar eclipses from +1898 to +2510, together with central line tables and maps. The aim of this work was to provide data on future eclipses.

In comparison, the *Canon of Solar Eclipses, –2003 to +2526* (Mucke and Meeus, 1983) was intended primarily for historical research, serving as the modern day successor of Oppolzer's great canon. The Mucke-Meeus publication included Besselian elements and maps of all 10,774 solar eclipses during this time interval. Each orthographic map was oriented to show the day-side hemisphere of Earth. In this projection, the path of the Moon's penumbra and the central axis of the shadow cone could be approximated by straight lines.

Several other special canons have been produced. *Atlas of Historical Eclipse Maps, East Asia 1500 BC – AD 1900* (Stephenson and Houlden, 1986) provides the path maps of all total and annular eclipses visible from China. The *Fifty Year Canon of Solar Eclipses: 1986–2035* (Espenak, 1987) contains individual detailed maps and central path data for all solar eclipses from 1986 through 2035.

Without exception, all solar eclipse canons produced during the latter half of the 20th century were based on Newcomb's tables of the Sun (1895) and Brown's lunar theory (1905), subject to later modifications in the *Improved Lunar Ephemeris* (1954). These were the best ephemerides of their day, but they have all been superseded.

The recently published *Five Millennium Canon of Solar Eclipses: –1999 to +3000* (Espenak and Meeus, 2nd Edition 2021) contains individual maps for each of the 11,898 solar eclipses occurring over this period. The following points highlight the features and characteristics of this work.

- Based on modern theories of the Sun and the Moon constructed at the *Bureau des Longitudes* of Paris rather than the older Newcomb and Brown ephemerides.
- Ephemerides and eclipse predictions performed in Terrestrial Dynamical Time.
- Covers historical period of eclipses, as well as one millennium into the future.
- Global maps for each eclipse depict the actual northern and southern limits of the Moon's penumbral and umbral or antumbral shadows, as well as the sunrise and sunset curves.
- Maps include curve of eclipse magnitude 0.5.
- Maps include continental outlines with contemporary political boundaries and are large enough to identify geographic regions of eclipse visibility.
- Maps are based of the most current determination of the historical values of ΔT .
- Estimates of eclipse path accuracy based on the uncertainty in ΔT (i.e., standard error in ΔT)

A primary goal of this work is to assist historians and archeologists in the identification and dating of eclipses found in references and records from antiquity. This is no easy task because there are usually several possible candidates. Accurate maps using the best available values of ΔT coupled with estimates in the standard error of ΔT , are critical in discriminating among potential eclipse candidates. Ultimately, historical eclipse identification can lead to improved chronologies in the timeline of a particular culture.

The *Canon* is of value to educators, planetariums, and anyone interested in knowing when and where past and future eclipses occur. The general public is fascinated by eclipses. With each major eclipse, the question always

arises as to when a particular location experienced its last and next eclipses. The maps presented in the *Canon* are ideally suited to addressing such queries.

To supplement the 11,898 eclipse maps in the *Five Millennium Canon of Solar Eclipses*, we offer the following catalog. It includes additional information for each eclipse that could not be included in the original 664-page publication because of size limits. The data tabulated for each eclipse include the catalog number, canon plate number, calendar date, Terrestrial Dynamical Time of greatest eclipse, ΔT , lunation number, Saros number, eclipse type, Quincena Lunar Eclipse parameter, gamma, eclipse magnitude, geographic coordinates of greatest eclipse (latitude and longitude), and the circumstances at greatest eclipse (i.e., Sun altitude and azimuth, path width, and central line duration).

The *Canon* and the *Catalog* both use the same solar and lunar ephemerides as well as the same values of ΔT . This 1-to-1 correspondence between them will enhance the value of each. The researcher may now search, evaluate, and compare eclipses graphically (*Canon*) or textually (*Catalog*).

— Fred Espenak and Jean Meeus, 2009 January

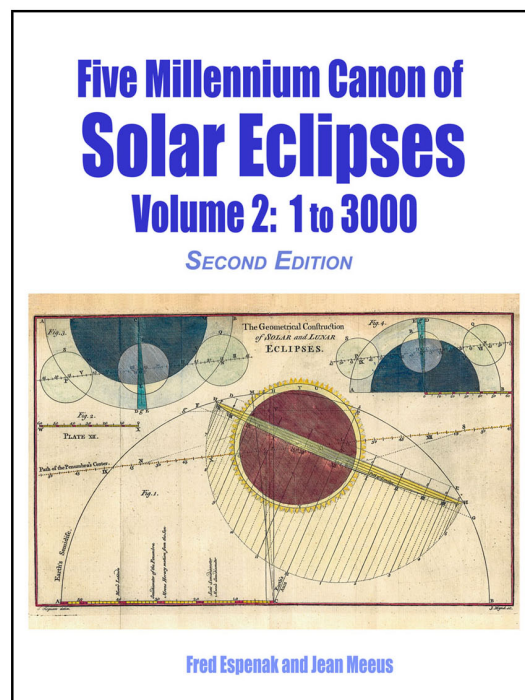
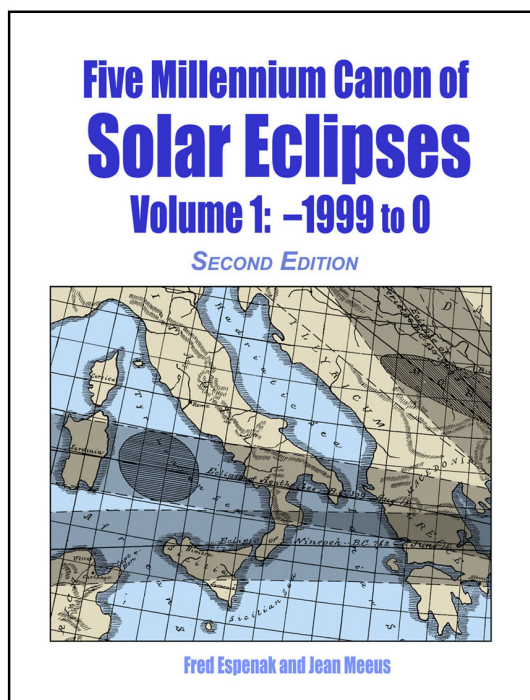
Preface – 2nd Edition

The *Five Millennium Catalog of Solar Eclipses: -1999 to +3000* was first published in January 2009 (NASA TP-2009-214174). As a NASA Technical Publication it had a limited publication run and distribution. The available supply of hard copies was depleted within 12 months of publication although the PDF version continues to be available,

A decade later, the *Five Millennium Catalog of Solar Eclipses* is available again in hard copy in this Second Edition through Astropixels Publishing. The *Catalog* serves as a supplement to the 2-volume *Five Millennium Canon of Solar Eclipses* which contains a map of every eclipse. The *Canon* and the *Catalog* both use the same solar and lunar ephemerides and the same value of ΔT .

A new section (Section 4: Eclipses and the Moon's Orbit) has also been added to this second edition.

— Fred Espenak and Jean Meeus, 2021 July



See: <http://astropixels.com/pubs/5MCSE2.html>