MEAN AND DAYLIGHT TIME

by HR Suiter

People foam at the mouth when you mention daylight time. Standard Time arrives toward the end of October; around here an already short evening is converted into NO evening by the unwelcome change. Abruptly, it seems as if sunset is moved to before 5 PM and we are slapped suddenly in winter mode. People most commonly say we (that is, Panama City, FL) ought to be on Daylight time all the time (equivalent to Eastern Standard); people at the other end of time zones, of course, say it should always be Standard Time.

This is not going to be an editorial about the advantages and disadvantages of the daylight time system. Such arguments are usually based on the timing of TV programs or the desire to have extra mowing time in the summer evening. The reason this article is not an editorial advocating one position or another is because there is only one reason that the daylight savings time system is used, and there is nothing we can do about it. The shift happens so children will not be forced to wait for buses in the dimness before dawn. Buses now arrive not once, but in two or three waves, and some of the earliest waves happen before Daylight Time sunrise in the middle of the winter. So no matter what happens, we are probably stuck with the Standard Time shift. You could argue that it makes more sense to shift the schools schedules twice per year instead of the time system, but that's not the way the world works.

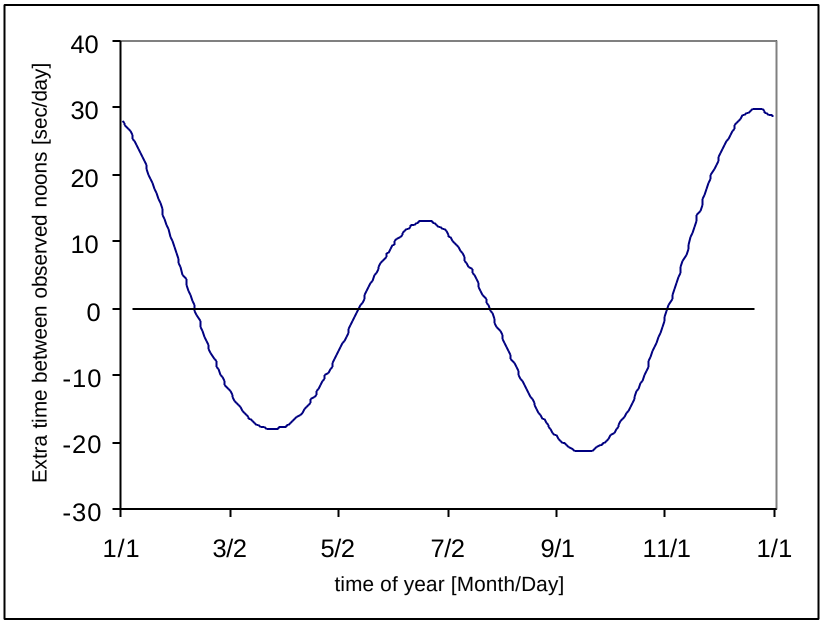
What we're going to be concerned with is the history of time measurement and the implications of having the sun and the clocks seem to run at slightly different rates.

First of all, the time zone is a human artifact. Back in the days of slow transport it was common to set the clock in every town to be different. Tallahassee would be about 6 minutes ahead of us and we would be about 6 minutes ahead of Pensacola. People could in principle travel overland about 100 miles a day, but then only by using stage coaches over the best roads. Less wealthy folk could only plod about 25 miles per day, and the four-day trip to either city could be detected only if their pocket watches were accurate to 1.5 minutes per day, a rare enough event in those days. (Although accurate portable chronometers were commercialized in the early 1800s, they cost three or four times the yearly income of a lower middle-class worker. Most pocket watches kept time abysmally.)

Then came railroads. Now you could easily move far enough to notice the time shifts on even an inaccurate watch. At the latitude of 40 deg N, a change of 1 hour was about 750 miles, and an express train moving at an average speed of 30 mph or so could traverse it in a single day. However, the advent of time zones had nothing to do with the accuracy of the customer's watches. It had to do with railroad scheduling. If a train had to move to a siding to allow another train to pass, the engineers of each train had better be carrying synchronized watches. Thus, the railroads started using a uniform time standard all over the US. They then broke up this one time standard into four zones extending approximately 15 degrees and used that to print schedules.

These four time zones, called Railroad Time, then crept into standard usage. Let's look at it this way. If you are a factory owner, do you want to make deliveries of your product to the train station on "Town Time" and then use a laborious conversion to actually find out when the train leaves? Of course not. You set your factory clock to Railroad Time. Then you set your pocket watch, and all of your clocks at home. You had the factory clock blow the whistle for the beginning of a shift, so that encouraged your workers to adopt Railroad Time, too. Soon, everyone was using Railroad Time and local time was a relic.

Local time even is messier than that. In the old days a lot of towns set their inaccurate clocks by using noon passage of the sun through the meridian. But the sun's apparent motion through the sky speeds up and slows down. This push-pull effect is caused by the elliptical orbit of the earth around the sun. The time between noons on successive days is plotted in the illustration below.

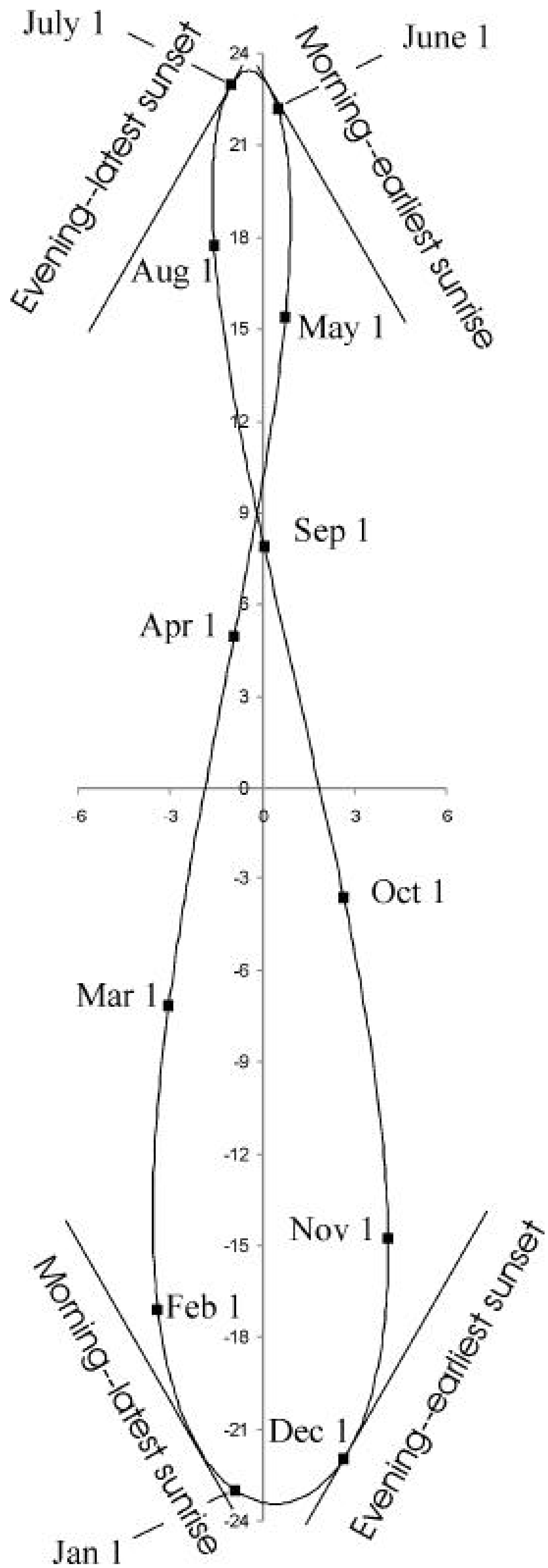


For example, noon of January 1 is separated from noon on January 2 by 24 hours plus 28 seconds. Now this statement contains an assumption already. We could have *defined* the time between noons as 1 day, as it was for thousands of years, but then our clocks would have to speed up and slow down too. We are now using some kind of weird time that moves uniformly. In fact, we are using a form of time defined by the flat line in the picture above, called *Mean Time*. "Mean" doesn't indicate "nasty," but rather "average." If you average all the rates for the whole year above, you get the flat line plotted to the left of 0 seconds.

We could have used solar time into the indefinite future without difficulty, but in the late 1600s to early 1700s, clockmakers began making pendulum clocks more accurate than the solar error of one day. They were confronted on one hand by the sensible habit of using the unsteady solar time (which meant that people rose and worked using the sun as a guide) and the necessity of making accurate instruments on the other. Making clocks that run steadily is hard enough; it is nearly impossible to make them run unsteadily in the precise manner of the rate graph above. Solar time suffered a quiet demise in most towns when good clockmakers came along. From then on it was Mean Time.

Think of the railroad problem. Some communities were still resetting their mean-time clocks occasionally at noon, other communities were using true local mean time. How could you print a table of departure times for each town? You couldn't. It is no wonder that railroads imposed time zones and it is also no wonder this time scale caught on. Finally, the state governments themselves signed up.

Consider the time between January 1 and January 2 again. Twenty eight seconds doesn't sound like a big deal, but this rate means that noon on Jan 3 is separated from noon on Jan 1 by 48 hours and 56 seconds, Jan 4 and Jan 1 by about 72 hours and 84 seconds or so, and so forth. The error builds up. You can find the mean time anywhere in half a solar-time hour (this is among the reasons sundials do such a poor job of matching clock time). If you plot the positional error of the sun against the sky at the **same time of day**, you plot a figure-8 type of thing that looks vaguely like a bowling pin. It is called the *analemma*.



Interesting note: The analemma is drawn on old world globes, usually somewhere around the Galapagos and Easter Islands, but has been omitted from modern ones. Hardly anyone knew what it was for, so globemakers stopped putting it on. The analemma is the graphical representation of something called the Equation of Time.

The analemma at left has horizontal and vertical axes measured in degrees. The horizontal axis is just the equator of earth projected into the sky. This celestial equator is elevated 90-latitude degrees in the south and passes through the east and west points at the horizon. The sun goes up to about 23.4 degrees declination in the summer and down to -23.4 degrees in the winter. This particular diagram has been plotted for the year 2000. The placement of dates varies somewhat, depending on whether there is a leap year. The precise shape may also vary in the long term with precession of the equinoxes.

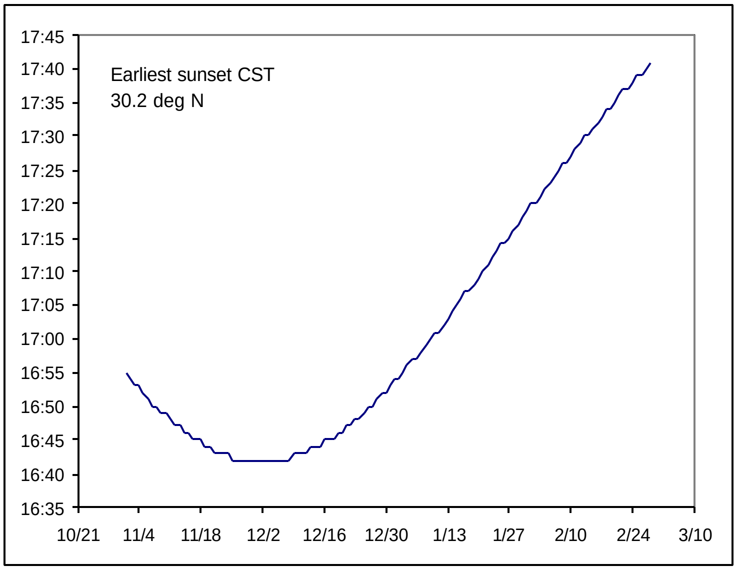
The mean-time sun slides around the analemma like a bead on a wire. The positions of the sun on the first days of the month are indicated by the little dark rectangles. When it's upright like in the figure to the left, it can be though of as the behavior at noon. But the analemma is valid at other times, too.

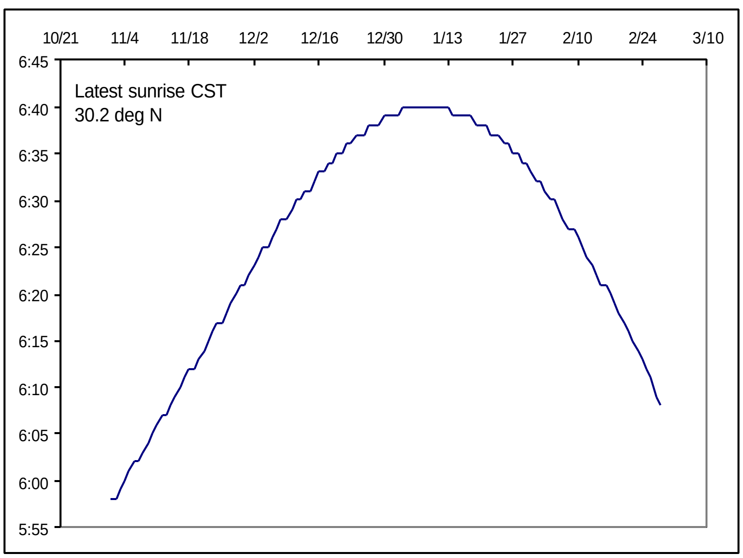
For example, we can slide the analemma around the sky until it touches the horizon like the line indicated by *Evening -- earliest sunset* (which indicates the horizon at sunset for 30 deg N latitude). Remember, the analemma indicates the same time of day. Therefore, all sunset times are later than that time because the **sun is always above the horizon at that time no matter where it is on the analemma during the year**. Thus, the earliest sunset will be around Dec 1 or Dec 2.

Now, I can hear you thinking "How can that be? The shortest day of the year is around December 21." True, but December 2 is not simultaneously the day of latest sunrise. That, as we read off the analemma figure, is around January 9th.

By the way, at the latitude of the equator the earliest sunset moves up to just after Nov 1 and the latest sunrise happens a week into February. But who cares on the equator? Every day is about 12 hours long anyway.

We see by the graph below that the earliest sunset happens about 4:41 PM or so CST on Hathaway Bridge. Conversely, the latest sunrise happens at about 6:40 AM. This is why we never will be on Central Daylight (or Eastern Standard) all the year long. Add an hour to 6:40, and you'll be forced to pick up some kids before sunrise.





If we take the difference between these two graphs, we'll find the shortest day right where we thought it should be at Dec 21, or thereabouts.

If we subtract or add 80 days to the January 9th latest sunrise, we get very near the late October / early April times that the Standard/Daylight times switch. That is part of the reason why the spring-forward and fall-back don't seem to balance with respect to the onset of spring or fall. This 80-day offset yields about an hour shift in sunrise, so we are approximately resetting to the same conditions. The lack of balance may also have something to do with temperatures.

The analemma chart shows that a similar effect prevails for the year 2000 summertime earliest sunrise (sunrise about 5:39 daylight time, June 9-10) and latest sunset (sunset about 7:48 pm CDT, June 30 -- that's why July 4th fireworks are so late). But people don't seem to notice these events like the case where the darkness is maximized.

In short, it seems incredible that a mysterious object like the analemma, which 99 out of 100 people probably couldn't name or recognize, so thoroughly rules our lives.

Calculations of sunset and sunrise times were done with Skymap Pro 6 planetarium simulator by Chris Marriott. The analemma and the solar rate were plotted using equations appearing or derived from those in the Explanatory Supplement to the Astronomical Almanac, *ed. by K Seidelmann.*