NASA PUNCH Outreach: *Birthday Sunrises on a Chaco Canyon Horizon*

Guide for Self-Directed Engagement

1. What is a *Horizon Calendar*?

The location of sunrise (and sunset) on the horizon changes a little bit each day over the course of a year. There are no big jumps. The Sun rises directly in the east and sets directly in the west *only* near the days of Fall and Spring Equinoxes (~September 21st and ~March 21st). Every other time of year the sunrises occur northward or southward of due east, and the sunsets occur northward or southward of due west. Our Sun-watching ancestors could use this fact to track time and seasons by observing sunrises or sunsets on a familiar horizon from a consistent viewing place. We call this using a *Horizon Calendar*. This ancient, nature-based technology helped (and still helps) to determine appropriate times for important seasonal activities.

Before reading ahead, study the dates on the horizon calendar below and make **a first *estimate* of where the Sun rises on your birthday.** Then whatever your birth month, make an estimate of **where the Sun rises in January.** This is *not* a test, it is an exploration. Most of us have lost touch with this knowledge. You can change your answers as you learn more. **Please read on!**

2. Where is the *Horizon Calendar* in the poster located?

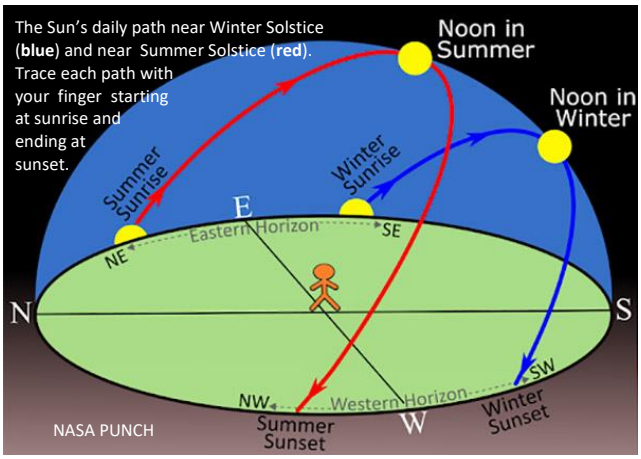
This horizon is in a **World Heritage Park** located within **Chaco Canyon** in northwestern **New Mexico** (yellow star on the map). The large, round, sandstone building is a ceremonial structure called a **Kiva** (pronounced KEE-vuh) built by Ancestral Puebloan people almost one thousand years ago. The Kiva is more than sixty feet wide and precisely aligned to the cardinal directions (E, S, W, N). Its architecture also interacts with solar and lunar cycles in ways still celebrated by contemporary people, including the descendants of the Chaco builders who continue to live in the southwestern US. We chose this marvel of ancient astronomical alignment in Chaco Canyon as a meaningful context to learn about horizon calendars. However, **anyone can create their own local horizon calendar closer to home**.

3. *How* does the sunrise change location on the horizon over a year's time?

The Sun's daily path traces parallel arcs across the sky whose rising points depend on the date. Everyone in the northern hemisphere has experienced less daylight in December (winter) and more daylight in June (summer). The solar path diagram below shows us how our lived experience corresponds to the changing location of sunrise on the eastern horizon.

In **Winter months**, the sunrises occur in the *southeast* (SE) and travel lower daily paths across the sky (**blue arc**). The Sun's shorter time above the horizon leads to our experience of *fewer* daylight hours and *colder* temperatures during the winter.

In **Summer months**, the sunrises occur in the *northeast* (NE) and travel higher daily paths across the sky (**red arc**). The Sun's longer time above the horizon leads to our experience of *more* daylight hours and *warmer* temperatures during the summer.



Near both the **Fall and Spring** equinoxes (arc not shown) the Sun rises due east (E) and travels a middle path across the sky, setting due west (W). Hours of daylight and darkness are equal.

4. Does the sun ever rise outside the solstice extremes?

Nope. The winter solstice sunrise in December occurs at the southernmost extreme on the horizon and defines the days of the year with the least amount of daylight. In January, we begin to notice more hours of daylight again, and so the position of sunrise must have reversed course! Yes, the sunrise occurs at the solstice extreme for a few days, and then slowly moves back northward along the horizon causing the amount of daylight to slowly increase. **The winter and summer solstices are turning points – places where the sunrise position pauses and then turns back to proceed in the opposite direction.** This means the sunrise positions during January are the same as for November. Now try pointing to sunrises for ***all*** months of the year. **Does this change your answer for where the Sun rises on your birthday?**

5. *Why* does the sunrise change location on the horizon over a year's time?

Earth orbits the Sun once per year with its rotation axis tilted 23.5 degrees from being straight-up-and-down. If the Earth axis *were* straight-up-and-down, then the Sun would always rise due east, and we would have equal daylight and darkness every day of the year. But because the axis *does* have a steady tilt toward a distant star called Polaris, our orientation to the Sun changes as Earth goes around it (diagram). When Earth is at a place in its orbit where the tilted rotation axis leans *away* from the Sun, the Sun rises south of east and follows a lower path in the sky (less daylight, wintertime). Six months later Earth arrives at a place where the rotation axis (with the unchanged tilt toward Polaris) now leans *toward* the Sun. Here the Sun rises north of east and follows a higher path in the sky (more daylight, summertime). At the equinoxes, the tilted Earth is neither leaning toward nor away from the Sun, so the Sun rises directly in the east and there are equal hours of daylight and darkness.