SAMPLE

Earth's Dynamic Systems: Earth's Seasons

Why They Happen

Aira Astralis

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This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

A season is a division of the year based on changes in weather, ecology, and the number of daylight hours in a given region. On Earth, seasons arise because the planet's tilted axis keeps pointing the same way relative to the stars all year, so first one hemisphere and then the other leans into the sunlight. In temperate and polar regions, the seasons are marked by changes in the intensity of sunlight that reaches the Earth's surface, variations of which may cause animals to undergo hibernation or to migrate, and plants to be dormant.

Various cultures define the number and nature of seasons based on regional variations, and as such there are a number of both modern and historical definitions of the seasons. In temperate and sub-polar regions, four seasons based on the Gregorian calendar are generally recognized: spring, summer, autumn, and winter. Ecologists often use a six-season model for temperate climate regions which is not tied to any fixed calendar dates: prevernal, vernal, estival, serotinal, autumnal, and hibernal. Many tropical regions have two seasons: the rainy or wet monsoon season and the dry season. In India, from ancient times to the present day, six seasons or Ritu based on South Asian religious or cultural calendars are recognised and identified for purposes such as agriculture and trade.

It is Earth's axial tilt that causes the Sun to be higher in the sky during the summer months, which increases the solar flux. Because of seasonal lag, June, July, and August are the warmest months in the Northern Hemisphere while December, January, and February are the coldest, even though the solstices fall near their edges. Minor variation in the direction of the axis, known as axial precession, takes place over the course of 26,000 years, and therefore is not noticeable to modern human civilization. Regardless of the time of year, the Northern Hemisphere and Southern Hemisphere always experience opposite seasons: midsummer in one is midwinter in the other.

This book traces the story of Earth's seasons from their first recognition in ancient calendars to the modern precision with which astronomers now track the tilt of the axis, the wandering of the equinoxes, and the seasonal rhythms of other planets. It is a story that begins with farmers watching rivers rise and falls with stargazers measuring shadows, and it ends, for now, with numerical simulations that follow the Earth's tilted spin across billions of years.

Chapter 1: The Discovery of Earth's Seasons

Humanity did not discover the seasons the way it discovered a continent or a comet. The seasons were given before any theory existed: every culture that has left a record noticed that the Sun climbs higher in some months, that rain arrives with some moons and not others, and that the year has parts with distinct characters. What developed over millennia was not the observation but the reckoning: the business of naming the parts, fixing their boundaries, and finally explaining why they exist at all.

Some of the oldest seasonal calendars are also the most practical. Some examples of historical importance are the ancient Egyptian seasons, flood, growth, and low water, which were previously defined by the former annual flooding of the Nile in Egypt. Seasons often hold special significance for agrarian societies, whose whole cycle of sowing, tending, and harvesting was organized around them, and the Egyptian case shows how directly a calendar can follow a river: the "seasons" were simply the Nile's own behavior, formalized into a year of three parts, each of four months.

The classical world brought the seasons under astronomy. The four seasons have been in use since at least Roman times, as in the Rerum rusticarum of Varro, who wrote that spring, summer, autumn, and winter start on the 23rd day of the Sun's passage through Aquarius, Taurus, Leo, and Scorpio, respectively. Nine years before he wrote, Julius Caesar had reformed the calendar, so Varro was able to assign the dates of February 7, May 9, August 11, and November 10 to the start of spring, summer, autumn, and winter. Varro's reckoning was not decorative; he points out that the lengths of the seasons are not equal, being 91 (in non-leap years), 94, 91, and 89 days for spring, summer, autumn, and winter, respectively, and that the midpoints of these seasons, March 24 or 25, June 25, September 25 or 26, and December 24 or 25, sit near the equinoxes and solstices of his day.

Pliny the Elder, in his Natural History, mentions the two equinoxes and the two solstices and gives the lengths of the intervals, values which were fairly correct in his day but are no longer very correct because the perihelion has since moved from December into January. He then defines the seasons of autumn, winter, spring, and summer as starting half-way through these intervals, a midpoint reckoning that treats the solstice as the heart of winter rather than its beginning. He gives "the eighth day to the Kalends of January" (December 25) as the date of the winter solstice, though it actually occurred on the 22nd or 23rd at that time.

The seasonal markers were in the sky all along, and their names still show it.

The Tropic of Cancer takes its name from the constellation in which the Sun stood at the June solstice when Greek astronomers drew the line, and the Tropic of Capricorn from the solstice constellation of December; precession has long since moved the Sun out of both signs, but the lines on every map keep the antique coordinates. The zodiac itself was arranged as a calendar of solar stations, twelve constellations marking twelve months of the Sun's annual path, and the "tropics" of the globes are nothing more than the two places on Earth where that path can be directly overhead.

The deeper explanation took longer. Heliocentrism is the scientific model that first placed the Sun at the center of the Solar System and put the planets, including Earth, in orbit around it, and historically it stands opposed to geocentrism, which placed the Earth at the center. Aristarchus of Samos had already proposed a heliocentric model in the third century BCE, but it won few followers. In the sixteenth century, Nicolaus Copernicus' De revolutionibus presented a full discussion of a heliocentric model of the universe in much the same way Ptolemy had presented his geocentric model in the second century. This "Copernican Revolution" resolved the issue of planetary retrograde motion by arguing that such motion was only perceived and apparent: the planets, Earth among them, do not loop in their paths, but merely appear to as our moving platform overtakes them.

Once the Earth became a planet, its seasons became a planetary phenomenon, measurable with the same geometry used for any tilted, orbiting body. The ancient Greeks had good measurements of the obliquity, the tilt of the axis, since about 350 BCE, when Pytheas of Marseilles measured the shadow of a gnomon at the summer solstice. About 830 CE, the Caliph Al-Mamun of Baghdad directed his astronomers to measure the tilt afresh. During the Middle Ages, it was widely believed that both precession and Earth's obliquity oscillated around a mean value with a period of 672 years, an idea known as the trepidation of the equinoxes. The first accurate, modern, western observations of the obliquity were probably those of Tycho Brahe from Denmark, in about 1584, although observations by several others, including al-Ma'mun, al-Tusi, Purbach, Regiomontanus, and Walther, could have provided similar information.

The discovery of the seasons, then, is layered. First came the practical calendars of farmers and priests, then the astronomical reckoning of solstices and equinoxes, then the Copernican insight that made the Earth a tilted orbiting planet, and finally the measurements that fixed the tilt itself at a slowly changing value. Each layer kept the ones beneath it: the Egyptian farmer's three seasons and the Finnish meteorologist's thermal seasons and the astronomer's 23.44 degrees all describe the same underlying fact from

different distances.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.