VOL. 101 | NO. 3
MARCH 2020

Eos

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Ancient Assyrian Aurorae Illuminate Solar Activity

On a dark spring night, the sky blanketing the Neo-Assyrian Empire turned red. The red glow was taken as an ominous sign—one important enough that the Assyrian court scribe Issār-šumu-ēreš carved an official record of the event into a clay tablet.

Although the event, which we know today as the aurora borealis, or northern lights, wouldn't have affected the course of nature at the time, it is now helping astronomers understand our Sun and may even help protect astronauts and assets in space.

The Assyrian record is one of the earliest known observations of aurorae, dating to around 660 BCE. Aurorae are created by high-energy particles launched from the Sun, and historical records offer a way to study conditions on the Sun long before the invention of telescopes.

"Direct observations [of the Sun] span some 400 years with sunspot observations, and ground-based instrument observations are mostly within 200 years," said Hisashi Hayakawa, lead author of a new study and an astronomer at Osaka University in Japan and the Rutherford Appleton Laboratory in the United Kingdom. "To discuss the kind of less frequent, but more hazardous events [coming from the Sun], we need to expand the data coverage, like with historical documents."

This Neo-Assyrian tablet from the Library of Ashurbanipal provided researchers with what may be one of the earliest descriptions of the aurora borealis. Credit: Trustees of the British Museum, CC BY-NC-SA 4.0 (bit.ly/ccbyncsa4-0)

Blasts in the Past

Hayakawa and his colleagues identified the records by examining ancient cuneiform tablets held in the British Museum. These tablets were carved by Assyrian court scribes, whose job was to document important happenings in the empire. They often included accounts of celestial appearances, like comets (*ṣallummû*), meteors (*kakkabu rabû*), and lunar and solar halos (*tarbāṣu*), which were thought to be omens of the future. Although most Assyrian and Neo-Assyrian tablets aren't explicitly dated, their authorship gives scholars a close idea of when the tablet was written—usually within a decade.

In the tablets studied, researchers found two references from Nineveh (a city near current-day Mosul, Iraq) and one from Babylon (built along Iraq's Euphrates River) that describe red aurorae, using terms like *akukūtu,* meaning red glow, or stating, "red covers the sky." Using the authorship of the tablets, researchers think the events happened sometime between 680 BCE and 650 BCE, a century earlier than previous records of aurorae.

Documenting aurorae helps astronomers understand patterns of solar activity. Magnetic storms on the Sun can release giant plumes and jets of materials, some of which fall back into the Sun and some of which are ejected and spewed across the solar system. Particles that make it to Earth can be funneled along magnetic field lines into Earth's upper atmosphere, where they strike atmospheric particles, causing them to glow. Red aurorae, like the ones seen in ancient Assyria, are typically caused by low-energy electrons.

Because they follow magnetic field lines, aurorae are most commonly seen near the poles. But strong solar events can make aurorae visible at lower latitudes. Although today it is rare to see an aurora in the Middle East, 2,000 years ago the magnetic North Pole was much closer to Mesopotamia, hovering over the Norwegian archipelago of Svalbard instead of at its current location just 4° south of the geographic North Pole.

The newly identified records also match indirect evidence of solar activity. Since 2012, several studies have found isotope data of carbon-14 levels recorded in tree rings that suggest a strong burst of solar activity during the same time period. By adding Assyrian observational evidence to these natural archival data, scientists are better able to confirm that the event was truly a space weather event caused by an extreme solar storm.

"Comparing these data from natural archives to real historical records made by contemporary astrologers at the time is very important," said Ilya Usoskin, a space physicist at the University of Oulu in Finland who was not involved with the new research. "From it, we know that we are on the right track, because the two records match each other."

Dangerous Beauty

Although solar energetic particles can create beautiful aurorae, they can also fry electronics in telecommunications satellites and harm astronauts in space. The distance from the pole to where the ancient Assyrian observations of aurorae were made is similar to that of an event in 1989 when the power grid in all of Quebec was knocked out.

"It is likely that the [ancient] storms were considerably large," Hayakawa said. "Storms with similar intensity [today] would be harmful to modern technological infrastructures."

Understanding the historical frequency of solar storms and learning how to predict such big events are important for mitigating their effects on our tech-based society. The historical data can help astronomers model how often such extreme events occur and better assess the probability of similar extreme events.

"Direct observations from the last decades are not very useful here because they just cover too short a period of time," Usoskin said. "Such historical records are very helpful because now we know that during the last, say, 3,000 years, there were three events of that magnitude, which means that on average, we may expect such disasters to occur a few times per millennia."

Hayakawa and his colleagues recently published their analysis of the Assyrian tablets in *Astrophysical Journal Letters* (bit.ly/solar-activity-660-BCE).

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