# Slow-forming core could have fueled Ganymede's dynamo

Coalescing at a relatively low temperature may have helped the moon become the only one in the solar system to develop a magnetic field.

**By Alex Lopatka**

Of the hundreds of moons in the solar system, Jupiter's satellite Ganymede is the only one that's known to have an active dynamo. As liquid metal flows in the moon's core, circulating electric currents form and sustain a magnetic field. With just a handful of observations, modelers of Ganymede have conflicting assumptions about how the Jovian moon's core and dynamo formed. Now Kevin Trinh of Caltech and colleagues have reported simulations suggesting that Ganymede's dynamo began developing at a lower temperature than previously thought and, as a result, that the moon's core may be still slowly forming today.[1]

Magnetic field evidence of Ganymede's dynamo was first detected in the 1990s by NASA's *Galileo* spacecraft. The detection led many modelers to assume that similarly to how Earth's dynamo was generated, Ganymede's must have been generated after a hot core had fully formed. But Ganymede and other icy moons are much smaller than Earth, so they produce less gravitational heating. The icy moons form more slowly and thus have limited amounts of aluminum-26 and other short-lived, heat-producing radioactive isotopes that are necessary to sustain thermal convection and power a dynamo.

Ganymede, the largest moon in the solar system, was imaged by NASA's *Galileo* spacecraft in the 1990s. *Galileo*'s magnetic field measurements revealed that the moon has an active dynamo. (Image by NASA/JPL.)

To address the contradiction, Trinh and colleagues adapted a cold-start model that Trinh and another group had developed for the neighboring moon Europa.[2] The new Ganymede model starts with a mixed composition of rock, ice, and iron at 250 K. In that state, the mixture would have melted at temperatures lower than the melting point of pure iron. That would allow for Gany-

mede's core to form slowly. As the core differentiated from the rest of the mixture, the moon's interior temperature would have risen to 1250 K, and iron would then start to melt. The model shows that ongoing melting and core formation could sustain a dynamo whose properties are consistent with the *Galileo* magnetic field observations.

If Ganymede could start at a low temperature and sustain a dynamo, then why don't the neighboring Jovian moons of Callisto and Europa have dynamos? Trinh and others are still working on the answer to that question, and it may have to do with, among other factors, the moons' composition and tidal heating—the frictional heat that's dissipated when the moons expand and contract as they elliptically orbit Jupiter. Callisto, for example, has rock that's richer in water than Ganymede's and likely experienced less tidal heating, and those factors would have inhibited ongoing core formation. Answers may be forthcoming, as the European Space Agency's *Juice* (*Jupiter Icy Moons Explorer*) spacecraft, which is scheduled to enter orbit around Ganymede in 2034, will collect more observations of Jupiter and its moons. PT

## References


1. K. T. Trinh et al., "Powering Ganymede's dynamo with protracted core formation," *Sci. Adv.* **12**, eaed8021 (2026).
2. K. T. Trinh, C. J. Bierson, J. G. O'Rourke, "Slow evolution of Europa's interior: Metamorphic ocean origin, delayed metallic core formation, and limited seafloor volcanism," *Sci. Adv.* **9**, eadf3955 (2023).


# Wildfire emissions reverse declines in US surface ozone levels

A dataset of daily ozone concentrations with high spatial resolution enables researchers to identify the reversal.

**By Sarah Wells**

Created by a chemical reaction between nitrogen oxides and volatile organic compounds in the presence of sunlight, ground-level ozone can harm human health and vulnerable ecosystems. Since the establishment of regulations in the Clean Air Act, surface ozone levels in the US have declined from levels as high as 400 ppb in some areas in the 1970s to peak values of roughly 70–90 ppb today. (Current measurements represent a daily maximum ozone level recorded in an eight-hour period.) But a new analysis by Jun Wang of the University of Iowa and colleagues has shown that the trend has reversed in the past decade because of ozone produced during wildfires.[1] The researchers estimate