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Something Was Messing With Earth's Axis. The Answer Has to Do With Us.

Scientists knew the planet's centerline could move. But it took a sharp turn sometime around the start of the 2000s.

By Raymond Zhong

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Around the turn of the millennium, Earth's spin started going off-kilter, and nobody could quite say why.

For decades, scientists had been watching the average position of our planet's rotational axis, the imaginary rod around which it turns, gently wander south, away from the geographic North Pole and toward Canada. Suddenly, though, it made a sharp turn and started heading east.

In time, researchers came to a startling realization about what had happened. Accelerated melting of the polar ice sheets and mountain glaciers had changed the way mass was distributed around the planet enough to influence its spin.

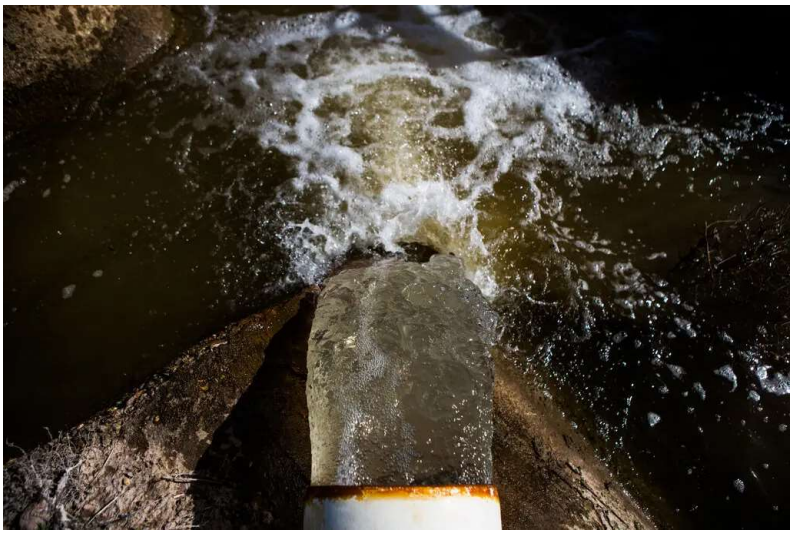
Now, some of the same scientists have identified another factor that's had the same kind of effect: colossal quantities of water pumped out of the ground for crops and households.

"Wow," Ki-Weon Seo, who led the research behind the latest discovery, recalled thinking when his calculations showed a strong link between groundwater extraction and the drifting of Earth's axis. It was a "big surprise," said Dr. Seo, a geophysicist at Seoul National University.

Water experts have long warned of the consequences of groundwater overuse, particularly as water from underground aquifers becomes an increasingly vital resource in drought-stressed areas like the American West. When water is pumped out of the ground but not replenished, the land can sink, damaging homes and infrastructure and also shrinking the amount of underground space that can hold water thereafter.

Between 1960 and 2000, worldwide groundwater depletion more than doubled, to about 75 trillion gallons a year, scientists estimate. Since then, satellites that measure variations in Earth's gravity have revealed the staggering extent to which groundwater supplies have declined in particular regions, including India and the Central Valley of California.

"I'm not surprised that it would have an effect" on Earth's spin, said Matthew Rodell, an earth scientist at NASA's Goddard Space Flight Center. But "it's impressive they were able to tease that out of the data," Dr. Rodell said, referring to the authors of the new research, which was published this month in the journal Geophysical Research Letters. "And that the observations they have of the polar motion are precise enough to see that effect."



Pumped groundwater pouring into an irrigation ditch in Fabens, Texas. Max Whittaker for The New York Times

Earth's axis hasn't been wandering enough to affect the seasons, which are determined by the planet's tilt. But fine patterns and variations in the planet's spin matter hugely to the satellite-based navigation systems that guide planes, missiles and map apps. This has helped motivate researchers to try to understand why the axis moves and where it might be headed next.

You can't feel it, but our planet's rotation is nowhere near as smooth as that of the globe on your desk.

As it moves through space, Earth wobbles like a poorly thrown Frisbee. This is partly because it bulges at the Equator and partly because air masses are constantly whirling through the atmosphere and water is sloshing around in the oceans, pulling the planet ever-so-slightly this way and that.

And then, there's that wandering axis.

One main cause is that Earth's crust and mantle are springing back after being covered for millenniums by gigantic ice sheets, rebounding like a mattress unburdened of a sleeper. This has been steadily changing the balance of mass around the planet.

More recently, the balance has also been altered by factors more closely linked to human activity and the global climate. These include the melting of mountain glaciers and the Greenland and Antarctic ice sheets, changes in soil moisture, and our impounding of water behind dams.

Another big factor, according to the study by Dr. Seo and his colleagues, is groundwater depletion. In terms of the effect on Earth's axis, pumping up water from underground was second in magnitude, between 1993 and 2010, only to the post-glacier adjustment of the planet's crust, the study found.

Other forces might also be pulling Earth's axis in its new direction but aren't yet fully understood, said Clark R. Wilson, a geophysicist at the University of Texas at Austin and another author of the study. "It's possible, for example, there's something in Earth's fluid core that's going on, that's contributing as well," he said.

Even so, the latest discovery points to new possibilities for using information about Earth's spin to study the climate, Dr. Wilson said.

Because scientists have collected highly precise data on the position of Earth's axis during much of the 20th century, they might be able to use it to understand shifts in groundwater use that took place before the most modern and reliable data became available.

It is a possibility Dr. Seo says he has already begun to explore.

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