

# Earth Has Tilted 31.5 Inches. That Shouldn't Happen.

Can we fix it back?



BY TIM NEWCOMB PUBLISHED: JUL 13, 2023 12:00 PM EST

Popular Mechanic



- Humans pumping groundwater has a substantial impact on the tilt of Earth's rotation.
  - Additionally, a new study documents just how much of an influence groundwater pumping has on climate change.
  - Understanding this relatively recent data may provide a better understanding of how to help stave off sea-level rise.
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Water has power. So much power, in fact, that pumping Earth's groundwater can change the planet's tilt and rotation. It can also impact sea-level rise and other consequences of climate change.

Pumping groundwater appears to have a greater consequence than ever previously thought. But now—thanks to a new study published in the journal *Geophysical Research Letters*—we can see that, in less than two decades, Earth has tilted 31.5 inches as a result of pumping groundwater. This equates to .24 inches of sea level rise.

"Earth's rotational pole actually changes a lot," Ki-Weon Seo, a geophysicist at Seoul National University and study lead, says in a statement. "Our study shows that among climate-related causes, the redistribution of groundwater actually has the largest impact on the drift of the rotational pole."

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With the Earth moving on a rotational pole, the distribution of water on the planet impacts distribution of mass. "Like adding a tiny bit of weight to a spinning top," authors say, "the Earth spins a little differently as water is moved around."

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Thanks to a study from NASA [published](#) in 2016, we were alerted to the fact that the distribution of water can change the Earth's rotation. This new study attempted to add some hard figures to that realization. "I'm very glad to find the unexplained cause of the rotation pole drift," Seo says. "On the other hand, as a resident of Earth and a father, I'm concerned and surprised to see that pumping groundwater is another source of sea-level rise."

The study included data from 1993 through 2010, and showed that the pumping of as much as 2,150 gigatons of [groundwater](#) has caused a change in the Earth's tilt of roughly 31.5 inches. The pumping is largely for irrigation and human use, with the groundwater eventually relocating to the oceans.

In the study, researchers modeled observed changes in the drift of Earth's rotational pole and the movement of water. Across varying scenarios, the only model that matched the drift was one that included 2,150 gigatons of groundwater distribution.

Surendra Adhikari, a research scientist at NASA's Jet Propulsion Laboratory who was involved in the 2016 study, says the additional research is important. "They've quantified the role of groundwater pumping on polar motion," he says in a [news release](#), "and it's pretty significant."

Where the water moves from—and to—matters. Redistributing water from the midlatitudes makes the biggest difference, so our intense water movement from both western North America and northwestern India have played a key role in the [tilt](#) changes.

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## DIVE DEEPER

[Earth Has Tilted 31.5 Inches—But Should We Care?](#)

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Now that the impact of water movement is known for such a short—and relatively recent—time, digging through historical data may help show trends and provide greater depth to the understanding of groundwater movement effects.

“Observing changes in Earth’s rotational pole is useful,” Seo says, “for understanding continent-scale water storage variations.”

This data may also help conservationists understand how to work toward staving off continued sea level rise and other climate issues. Hopefully,



TIM NEWCOMB

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# How AI is helping airlines mitigate the climate impact of contrails

We worked with the airline industry to use AI and satellite imagery to reduce the warming effects of contrails

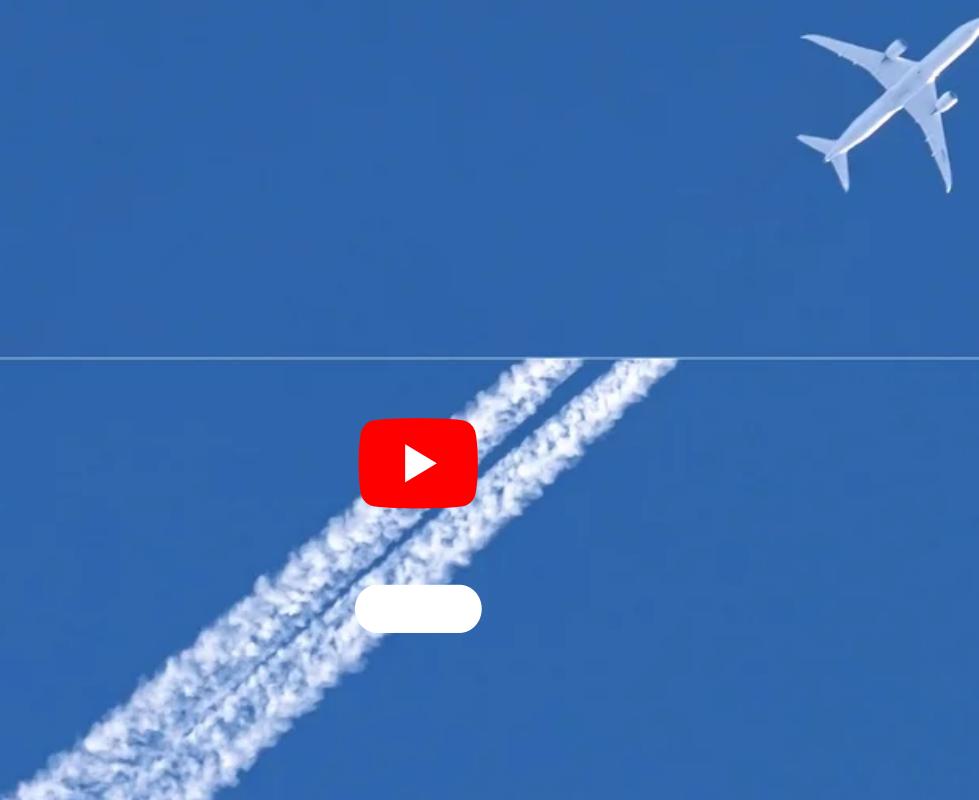
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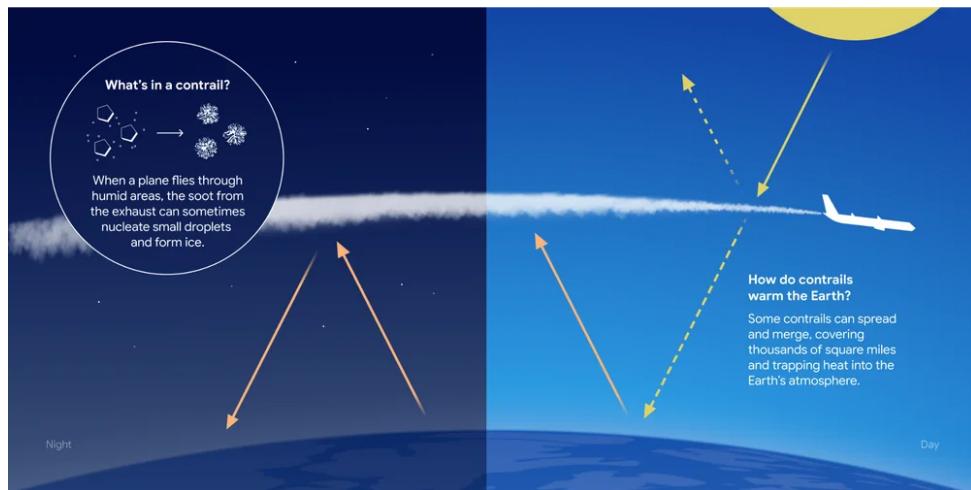


Dinesh Saneikommu



Contrails – the thin, white lines you sometimes see behind airplanes – have a surprisingly large impact on our climate. The 2022 IPCC report noted that clouds created by contrails account for roughly 35% of aviation's global warming impact,

over half the impact of the world's jet fuel. Google Research teamed up with American Airlines and Breakthrough Energy to bring together huge amounts of data — like satellite imagery, weather and flight path data — and used AI to develop contrail forecast maps to test if pilots can choose routes that avoid creating contrails.



Visual explanation of nighttime and daytime contrail radiative effects. Nighttime contrails are often more warming than daytime contrails because they exclusively trap heat.

Contrails form when airplanes fly through layers of humidity and they can persist as cirrus clouds for minutes or hours depending on the atmospheric conditions. While these extra clouds can reflect sunlight back into space during the day, they also trap large amounts of heat that would otherwise leave the Earth's atmosphere. This creates a net warming effect. Avoiding flying through areas that create contrails can reduce warming. The challenge is knowing which flight routes will create contrails.

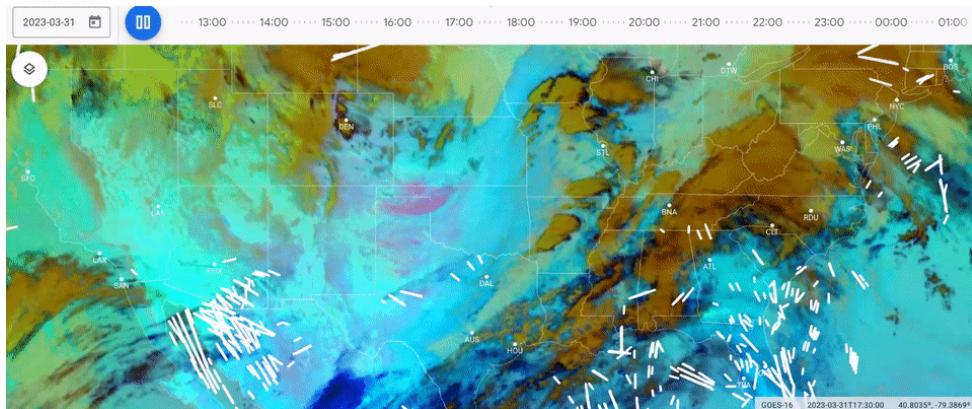
## Reducing the warming impact of contrails

A group of pilots at American flew 70 test flights over six months while using Google's AI-based predictions, cross-referenced with Breakthrough Energy's [open-source contrail models](#), to avoid altitudes that are likely to create contrails. After these test flights, we analyzed satellite imagery and found that the pilots were able to reduce contrails by 54%. This is the first proof point that commercial flights can verifiably avoid contrails and thereby reduce their climate impact.



American Airlines Managing Director of Flight Operations, Captain John P. Dudley (right), and First Officer, Tammy Caudill (left), from the flight deck of the first contrail avoidance flight, who used our predictions in PACE's FPO application to avoid contrails.

The other significant finding of our test with American is the flights that attempted to avoid creating contrails burned 2% additional fuel. Recent studies show that a small percentage of flights need to be adjusted to avoid the majority of contrail warming. Therefore, the total fuel impact could be as low as 0.3% across an airline's flights.<sup>2</sup> This suggests that contrails could be avoided at scale for around \$5-25/ton CO<sub>2</sub>e (carbon dioxide equivalent) using our existing predictions, making it a cost-effective warming-reduction measure, and further improvements are expected.



Contrails detected over the United States using AI and GOES-16 satellite imagery.

# What's next?

Contrail avoidance has the potential to be a cost-effective, scalable solution to reduce the climate impact of flying. We will continue research and development to automate avoidance, target the highest impact contrails and improve satellite-based verification. We're committed to working across the aviation industry to use AI to make contrail avoidance a reality over the coming years.

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## More Information



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- 2 Teoh, R., Schumann, U., Gryspeerdt, E., Shapiro, M., Molloy, J., Koudis, G., Voigt, C., and Stettler, M. E. J.: Aviation contrail climate effects in the North Atlantic from 2016 to 2021, *Atmos. Chem. Phys.*, 22, 10919–10935, <https://doi.org/10.5194/acp-22-10919-2022>, 2022.

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