Air travel and climate: A potential new feedback?

July 13 2015

Boeing 737-700 jet airliner. Credit: Wikipedia/Arcturu

Global air travel contributes around 3.5 percent of the greenhouse gas emissions behind/driving anthropogenic climate change, according to the International Panel on Climate Change (IPCC). But what impact does a

warming planet have on air travel and how might that, in turn, affect the rate of warming itself?

A new study by researchers at the Woods Hole Oceanographic Institution and University of Wisconsin Madison found a connection between climate and airline flight times, suggesting a feedback loop could exist between the carbon emissions of airplanes and our changing climate. The study was published in this week's *Nature Climate Change*.

"Upper level wind circulation patterns are the major factor in influencing flight times," says lead author Kris Karnauskas, an associate scientist in WHOI's Geology and Geophysics Department. "Longer flight times mean increased fuel consumption by airliners. The consequent additional input of CO2 into the atmosphere can feed back and amplify emerging changes in atmospheric circulation."

The study began when co-author Hannah Barkley, a doctoral student in the MIT-WHOI Joint Program in Oceanography, asked Karnauskas a deceptively simple question. Barkley had noticed a direct flight she took from Honolulu back to the east coast—a route she has flown many times as field scientist—took far less time than expected, and she asked Karnauskas why that might be.

"The first thing that came to mind was, what did the flight-level winds look like that day," Karnauskas says.

They quickly queried a database of the winds on a NOAA website, selecting for the altitude jets fly at and plugging in the date of Barkley's flight, and saw that the jet stream that day was extra fast.

"There was just a big swath of extra-fast westerly winds stretching from Honolulu, Hawaii, to Newark," says Karnauskas. "It was just serendipitous, as if she was part of some kind of golden mileage club

where the atmosphere just opens up for you."

The finding piqued their curiosity about just how unusual Barkley's experience was, and the simple question led to a study of decades worth of data on flights between Honolulu and the North American West Coast (Los Angeles, San Francisco, and Seattle) by four different air carriers.

Through a database maintained by the Department of Transportation they were able to download departure and arrival data by each airline and the routes traveled—for every single flight that has occurred over the past 20 years. Because the upper level winds blow from west to east, the eastbound leg of a roundtrip flight is generally faster than the westbound leg. After quality controlling the data, Karnauskas plotted the differences in flight times for eastbound and westbound flights and noticed that regardless of the airline carrier, the difference for all the carriers looked the same, over the past 20 years.

"Whatever was causing these flights to change their duration, was the exact same thing, and it wasn't part of the airline's decision-making process," Karnauskas says. The hypothesis was born that climate variability (not just day-to-day weather) determines flight times.

He began digging into massive volumes of atmospheric data to assemble a "composite" snapshot of what the atmosphere looks like on days where the difference in flight times is large, versus small. When he overlaid the plots of the airlines's differences in flight times with graphs of wind variability at climatic time scales, Karnauskas says he "was pretty blown away." The plots were virtually identical.

Even after smoothing out the seasonal differences (the jet stream is always a little stronger in winter and weaker in summer), leaving him with the year-to-year variability, the match held up almost perfectly. Flight-level wind speed explained 91 percent of the year-to-year

variance. The result also pointed toward the influence of El Niño - Southern Oscillation (ENSO) - a phenomenon Karnauskas has studied extensively.

As the temperature of the equatorial Pacific Ocean rises and falls, like a pebble in a pond, atmospheric waves are set off toward the higher latitudes of both hemispheres, where they change circulation patterns.

"I came into this study, thinking this is going to be a weird junket that is totally unrelated to anything I do, but it really led me back to El Niño, which is what I do."

Karnauskas found that just by looking at the state of the tropical Pacific Ocean, he could predict what the airlines' ΔT had been. For this so-called hindcast, "we're talking about anomalies happening down at the equator that are affecting the atmosphere in such a spatially broad way, that it's probably influencing flights all around the world."

Their analysis also determined that the difference in flight times between eastbound and westbound flights on any given route didn't cancel each other out; rather there was a residual. In other words, when an eastbound flight became 10 minutes shorter, the corresponding westbound flight became 11 minutes longer.

According to Karnauskas, it took some "obsessive drilling into the data to find that residual, and at face value it seems very minor." The net additional flying time for a pair of eastbound and westbound flights between, for example, Honolulu and LA is only a couple minutes for every 10 mph speedup of the prevailing wind. But, he says, "the wind really fluctuates by about 40 mph, so multiply those couple of minutes by each flight per day, by each carrier, by each route, and that residual adds up quickly. We're talking millions of dollars in changes in fuel costs."

Once the researchers had proven that the atmospheric circulation affects how long planes are in the air, they began to wonder about the impact climate change would have on the airline industry.

According to the study, there are approximately 30,000 commercial flights per day in the U.S. If the total round-trip flying time changed by one minute, commercial jets would be in the air approximately 300,000 hours longer per year. This translates to approximately 1 billion additional gallons of jet fuel, which is approximately $3 billion in fuel cost, and 10 billion kilograms of CO2 emitted, per year.

"We already know that as you add CO2 to the atmosphere and the global mean temperature rises, the wind circulation changes as well—and in less obvious ways," says Karnauskas.

Based on what they had learned about the airlines' residual flight times, the researchers explored how climate models predict the atmospheric circulation to change and to make some estimates of how much more CO2 will be emitted by the airline industry in the face of those changes. Currently, global climate models to not incorporate inputs from air travel , so this potential feedback is missing from our state-of-the art models.

Karnauskas believes this information could be useful for the airline industry to more efficiently plan for future fuel costs, reallocate fuel resources, refine the predicted flight durations for their customers, and better manage all the inconveniences and manpower related to flight delays.

While this study focuses on a very small subset of the total global airline traffic, Karnauskas has plans to expand this study to include all US and European flights - a massive undertaking. To work with such large datasets, Karnauskas has been granted access to Azure, a powerful cluster of networked computers operated by Microsoft, under a special

research grant jointly offered between Microsoft Research and the White House Climate Data Initiative.

In reflecting on the findings of this project and the simple question Barkley had initially asked, Karnauskas says one of the biggest surprises is that the airline industry doesn't seem to be aware of the flight time patterns.

"The airline industry keeps a close eye on the day-to-day weather patterns, but they don't seem to be concerned with cycles occurring over a year or longer," he says. "They never say, 'Dear customer, there's an El Niño brewing, so we've lengthened your estimated flight duration by 30 minutes.' I've never seen that."

More information: *Nature Climate Change*, DOI: 10.1038/nclimate2715

Provided by Woods Hole Oceanographic Institution