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# Why are flights getting bumpier?

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## Abstract

Have you ever ridden on an airplane? If so, was there a moment when it suddenly started to shake? That unpleasant and sometimes scary shaking is called turbulence. If there is no storm, or even clouds, it can seem to come out of nowhere!

We wanted to find out whether clear-air turbulence has increased over the past 40 years. We analyzed data from 1979 to 2020 and found a big increase over the midlatitudes. The skies that most planes fly through are bumpier now than four decades ago. In fact, over the North Atlantic, severe turbulence increased by 55%. Our findings are important because they show that we are already seeing the impacts of climate change in unexpected ways.

## Introduction

As your seat begins to shake, the pilot announces: "We are experiencing some **turbulence**. Please stay in your seat with your seatbelts fastened." But what causes this bumpy ride? Turbulence can strike when a plane flies through sections of air of changing direction and speed. Pilots know that mountain ranges and storms create turbulence, so they can usually try to avoid it. However, another type of turbulence, called **clear-air turbulence**, is invisible and difficult to predict.

Turbulence isn't just annoying. Over time, airplanes can get worn down or damaged by turbulence. Sometimes turbulence can even cause injuries to people on flights. This happens when loose objects move around or when a person bumps against something inside the plane. Airplane damage, hospital fees, and related costs add up to around $200 million every year in the US alone!

Maybe you've heard about heat waves, droughts, and other extreme weather events happening more often. This is because the Earth's climate is changing. As people burn fossil fuels for energy, more carbon dioxide is released into the atmosphere. Carbon dioxide and other gases trap the sun's heat and cause the Earth to warm up (Figure 1). This changes our weather patterns.

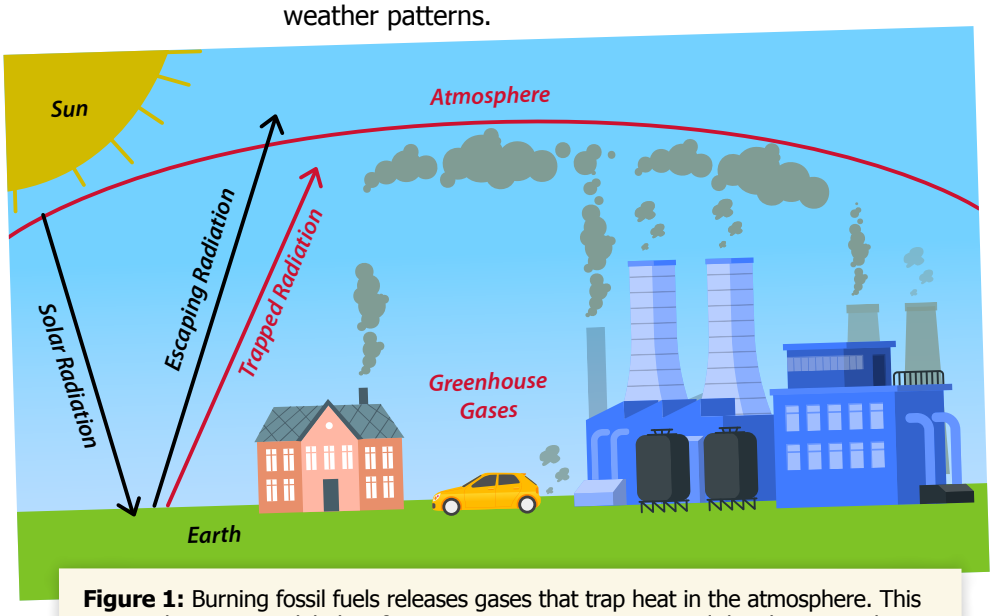



**Figure 1:** Burning fossil fuels releases gases that trap heat in the atmosphere. This causes the average global surface temperature to increase and the climate to change.

Previous studies have predicted that clear-air turbulence is likely to get worse over time because of climate change. We wanted to find out if this is already happening. Understanding how clear-air turbulence has already changed can help us predict and avoid it in the future.

## Methods

We looked at a global dataset gathered from many sources, including satellites, weather balloons, and planes. It had data about wind speed and air temperature from January 1979 to December 2020. The data came from the **troposphere** and **stratosphere**, the layers of atmosphere closest to the Earth. We focused our attention on data from the height where planes spend most of their time flying.

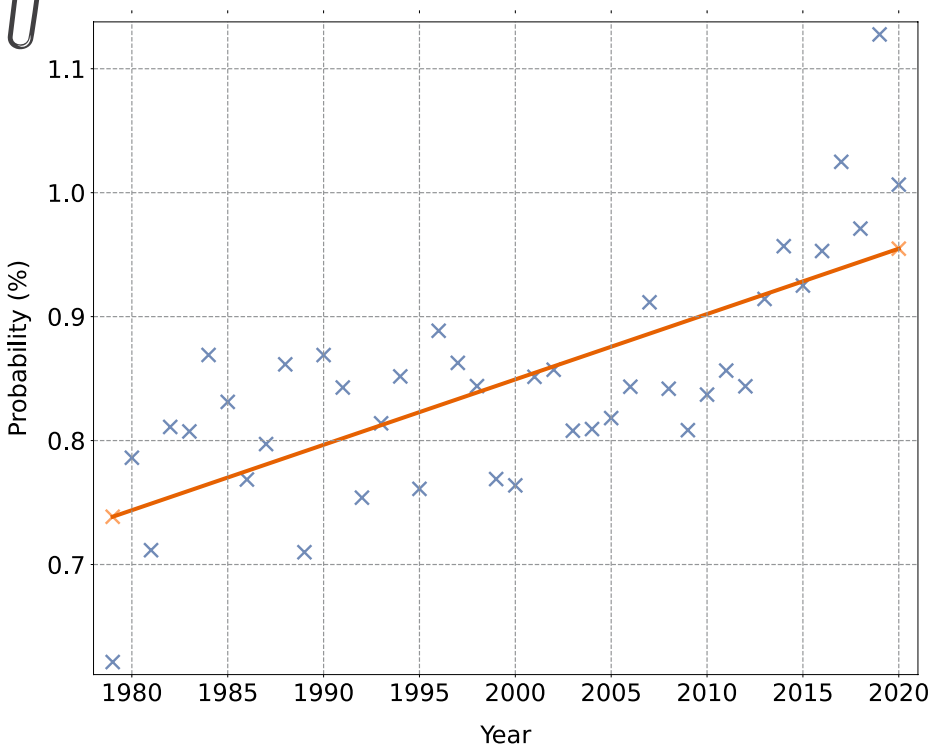
We used 21 different calculation methods to relate wind speed and temperature to turbulence. We averaged these together for each location on the globe in each season and year. If the average was very high, it indicated that the location was turbulent at that time.

We then used simple statistics to look at how the probability of clear-air turbulence changed over the 42 years.

## Results

Our research showed that clear-air turbulence increased significantly over the **midlatitudes** from 1979 to 2020 (Figure 2). We also found some interesting trends.

- The Northern Hemisphere has almost twice as much turbulence as the Southern Hemisphere.
- Increases in clear-air turbulence were highest over the North Atlantic and the USA. In the North Atlantic, there were 26 more hours of moderately strong turbulence in the year 2020 than in the year 1979, which is an increase of 37%. The USA had 19 more hours of moderately strong turbulence in this period, an increase of 29%.
- Areas over mountains have a higher probability of turbulence. That matches what we know about other types of turbulence.
- Autumn and winter have more clear-air turbulence than spring and summer.




Which year showed the highest probability of clear-air turbulence? Which had the lowest?

**Figure 2:** The probability of moderately strong clear-air turbulence over the USA from 1979 to 2020. What does it mean when clear-air turbulence is moderately strong? That's when loose objects move around and people have a hard time getting around inside the cabin. Each cross represents the yearly average probability using 21 calculation methods. The solid line shows how clear-air turbulence changed over time.

# Discussion

Our study shows that clear-air turbulence has increased in the past four decades over the midlatitudes. Some of the globe's busiest flight paths are in the fastest changing areas. This has serious consequences for airlines. Every additional minute spent in turbulence causes extra wear on the plane. It also increases the chance of injuries to passengers and flight attendants during a flight.

Other studies from our research group have used computer models to create forecasts about increasing clear-air turbulence for the period 2050-2080. Our results indicate that these increases have already begun. We can continue to improve our understanding of clear-air turbulence by using the most accurate data available. With better weather monitoring technology, we can understand and model clear-air turbulence. And pilots can try to avoid it.

# Conclusion

The increase in clear-air turbulence should not make you afraid to fly. Although it's uncomfortable when it does occur, the chances of injury are still very low. Here are some ideas to help you stay safe when traveling by plane:

- Keep your seatbelt fastened whenever you're seated.
- Avoid having too many loose items out. Keep anything you aren't currently using in your bag, and keep your bag under the seat in front of you or up in the overhead compartment.
- Listen to announcements from the pilot or flight attendants and follow their instructions.

## Glossary of Key Terms

**Clear-air turbulence** – invisible air movement that doesn't show up with any visual clues (like clouds). It occurs when a large mass of moving air meets another air mass that's moving at a different speed, for example when jet streams meet slower moving air. (Jet streams are fast-moving currents of air that flow high above certain areas from west to east, for example from the US to Europe. Many planes flying that route 'hitch a ride' on a jet stream to get to their destination faster using less fuel.)

**Midlatitudes** – areas in the temperate parts of the globe, 30-60°N and 30-60°S of the Equator.

**Stratosphere** – the second closest layer of atmosphere to the Earth's surface. It contains the ozone layer and reaches from the top of the troposphere to about 30 miles (50 km) above the surface of the Earth.

**Troposphere** – the closest layer of atmosphere to the Earth's surface. This is where most weather occurs. It ranges in thickness from 4 to 11 miles (6 to 18 km) above the surface of the Earth.

**Turbulence** – chaotic flow in a liquid or gas that is difficult to predict in detail.

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# Check your understanding

1 How could you explain turbulence to someone who has never flown in a plane before?

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2 Which area of the world saw the largest increase in moderately strong clear-air turbulence?

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3 The USA saw an additional 19 hours of moderately strong clear-air turbulence over the study period. Using this information, how much did it increase on average each year? Hint: Your answer should be in minutes per year.

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4 A friend of yours is worried about running into turbulence when they fly to visit family during the summer vacation. What could you tell them to help them feel more confident?

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5 Our research shows that clear-air turbulence is getting worse, likely because of the increasing carbon dioxide in our atmosphere. What steps can you take to help solve the environmental problem of climate change?

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