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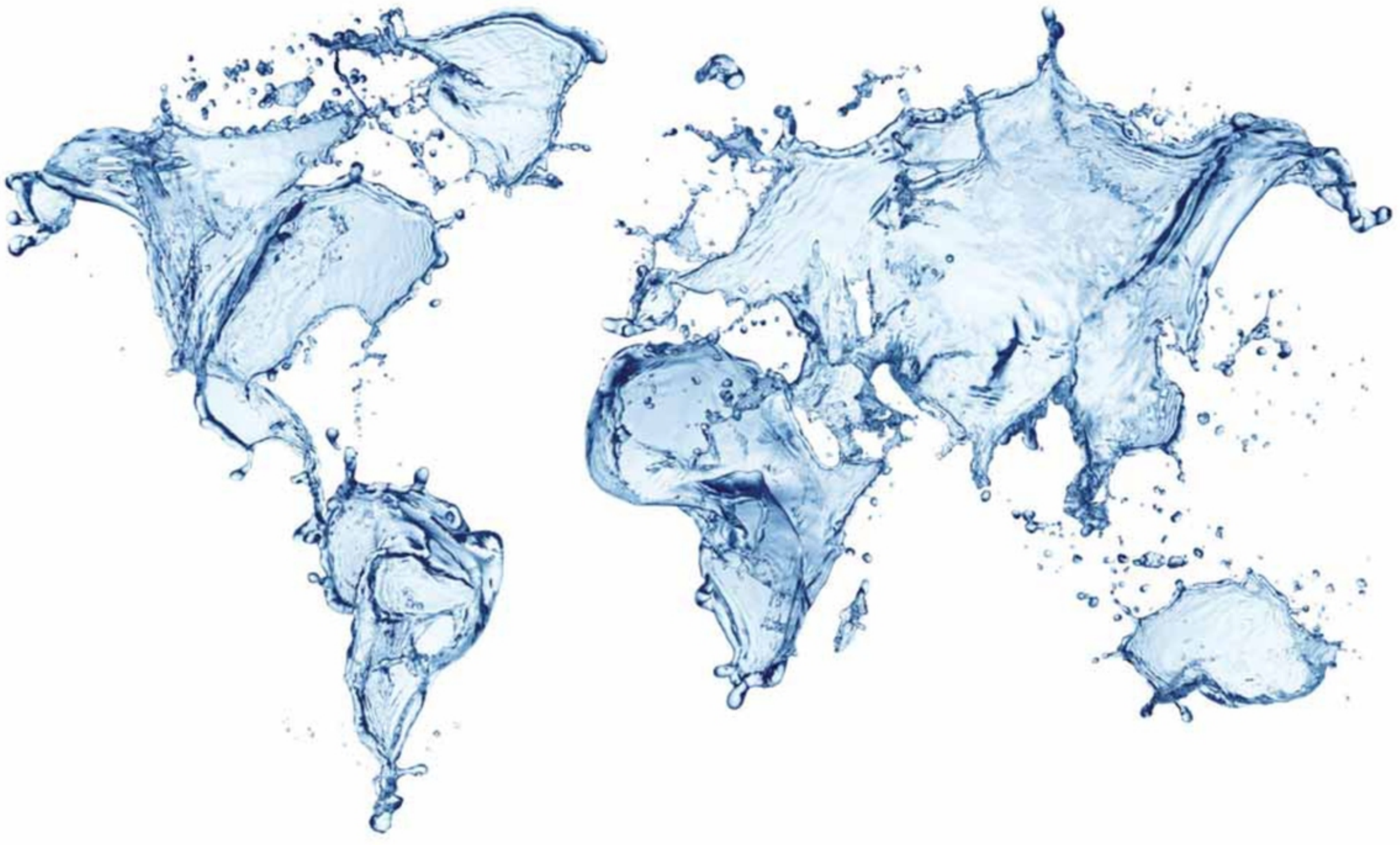

The fourth phase of water - is the world ready?

One man's mission to overcome scepticism and put water research back on the map p22

the BIG ask

Transatlantic airline passengers may soon be in for a bumpier ride according to research into the effects of climate change and turbulence. But why might this be the case? We catch up with Dr Paul Williams, Royal Society University Research Fellow at the University of Reading and the National Centre for Atmospheric Science to find out

LN First of all, could you give us a brief explanation of what clear-air turbulence is and what causes it?
We call it "clear-air" turbulence to distinguish it from the turbulence experienced when planes fly through clouds. Clear-air turbulence occurs at cruising altitudes, high above clouds and weather systems. At these altitudes, the wind speeds can exceed 100 mph and can vary with height. If these variations are strong enough, the situation becomes unstable and turbulence breaks out. Invisible atmospheric fluctuations push up and down on the wings of the plane, causing a bumpy flight.

LN Your research suggests that turbulence will worsen with climate change. But why will climate change affect this?
That's a good question. We mostly associate climate change with the warming of the lowest part of the atmosphere. However, changes are occurring higher up in the atmosphere, too. Planes fly at altitudes of about 35,000 feet, where the east–west winds are expected to get stronger because of an increased temperature difference the equator and the poles. These increased wind speeds will make it easier for turbulence to form.

LN What techniques did you use to figure this out?
We analysed supercomputer simulations of the atmospheric winds at typical cruising altitudes over the North Atlantic Ocean. We chose this airspace because it is one of the world's busiest flight corridors, with 600 planes crossing the North Atlantic every day. We focused on winter, which is when clear-air turbulence is strongest. We calculated 21 different estimates of turbulence, each based on a unique mathematical formulation. The different estimates generally agreed that turbulence would increase in strength and frequency.

LN How accurate is the model that you used?
We used one of the world's best climate models, developed by Princeton scientists. Simulations with this model have been shown to agree well with observations of the present-day upper-atmospheric winds. The response of the winds to greenhouse gases in this model is consistent with what is seen in other state-of-the-art climate models.

LN Why hasn't a correlation between climate change and turbulence been looked into before?
Two previous studies have looked at historic data and found suggestions of an increase in turbulence. However, there were question marks at the time over whether these apparent trends were real and significant or just artefacts of the data. Our study is the first to make a direct comparison between a pre-industrial simulation and a climate-change simulation. The turbulence increases we have found are highly statistically significant.

LN How much bumpier do you think flights are going to get and when can we expect this by?
Our study found that, if the amount of CO_2 in the atmosphere were doubled, then the chances of encountering significant turbulence would increase by between 40% and 170%. The most likely outcome was a doubling of the airspace containing significant turbulence at any time. The average strength of turbulence would increase by between 10% and 40%. Exactly when the amount of CO_2 will reach twice its pre-industrial level depends upon future anthropogenic emissions. The middle-of-the-road scenarios put it sometime around the 2050s.

LN What will be the consequences of this added turbulence?
We can expect transatlantic flights to become bumpier and less comfortable, at least in the winter months. On a typical flight, the 'fasten seatbelt' sign might be illuminated for perhaps twice as long. If patches of turbulence become stronger, as projected, then pilots may increasingly choose to divert around them, raising journey times and fuel costs. More research is needed to find out exactly what the detailed consequences would be.

LN What will pilots and engineers have to do to overcome these problems?
Planes are designed and built to withstand even the strongest turbulence. It is very rare for turbulence to cause serious structural damage. That having been said, turbulence does contribute to the general wear-and-tear on planes. The engineering aspects and the implications for the fatigue life of planes are outside my expertise, but may be something for aircraft manufacturers to consider.

Dr Paul Williams