

THE LAST WORD

4-3

BUMPY RIDE

Question: Why do airliners bump and bounce even when flying through clear sky? Often it's like driving along a bumpy road, but sometimes it is much more violent. What causes this to happen? It sometimes seems associated with passing through sections of cloud but at other times it occurs in clear sky and it seems to happen more at high altitudes.

Answer: There are several reasons why you might get a bumpy ride while flying in apparently clear air. These include wake turbulence—the lift that other aircraft generate—as well as clear air turbulence (CAT) and other meteorological conditions. The air in the atmosphere is constantly changing and moving to a greater or lesser degree, so things are rarely still even if there is no cloud.

Clouds are visible forms of water vapour which occur when saturated air condenses. The actual nature of the cloud and its size depends on numerous factors including the moisture content and stability of the air. Aircraft motion can be affected by clouds but, as we can see below, clouds are only the most easily noticeable of the many atmospheric factors.

All aeroplanes produce lift through their wings in order to fly. Once air has passed over the wings, it flows towards the wing tips to produce two counter-rotating funnels of air—one per wing—trailing behind and slightly below the aircraft.

Generally, the bigger the aircraft the greater the turbulence in its wake. This wake can continue for some distance behind the aircraft, and while you may feel nothing in the aircraft in which you are travelling, passengers in another aircraft passing through the same altitude may fly through your wake and feel some turbulence.

Pilots and air traffic controllers are aware of wake turbulence and that it can lead to accidents. For example, a small aircraft that is following too closely behind a big jet on a final landing approach may fly into the jet's wake and encounter vortices so strong that it loses control. The worst conditions for wake turbulence are stable air and light winds. Strong winds help to disperse the wake.

Clear air turbulence occurs in clear air above the friction layer, at around 600 metres, where the effects of surface friction are noticeably reduced. It is invisible and cannot be detected by conventional aircraft weather radar. CAT is often associated with jet streams—narrow bands of high-altitude winds that occur at around 10 to 12 kilometres, depending on the season and latitude.

Near parts of a jet stream there are areas of strong vertical and horizontal wind shear (rapid changes in wind speed over a short distance), leading to CAT. Jet streams and CAT can be forecast and appear on the meteorological forms given to aircrews at pre-flight briefing.

Other meteorological conditions also help cause bumpy rides. Turbulence occurs in the friction layer and is caused by thermals and surface winds blowing around obstacles such as buildings and hills. This is why there often seems to be much more turbulence during takeoff and landing, a phenomenon which is frequently triggered by conditions that develop around mid-afternoon.

Mountain or standing waves can occur when a strong wind blows at right angles to a range of hills or mountains. Providing the air is stable, this can create strong updraughts and downdraughts which in turn produce further oscillations downwind and

high in the atmosphere.

I would recommend *Meteorology For Pilots* by Mike Wickson, published by Airline (ISBN 1853103160), for anybody who is interested in reading more about turbulence and its effects on aircraft.
Richard Heaton
Solihull, West Midlands

Answer: Based on 14 years' experience of flying gliders, I am very familiar with the air currents below and within the cloud base. Below the cloud base, these can be caused by convection currents from the warming effects of the Sun's rays.

The rising vertical pockets of warm air will produce a cloud at the appropriate level if the conditions are right. These rising currents continue within the cloud and were frequently used by the early gliding pilots when they were attempting to set altitude records—often accidentally within thunder clouds.

There will also be descending areas of air as well. Close to the surface, perhaps up to 300 metres on occasion, turbulence—that is, rising and falling air—can be caused by the contours of the terrain that lies below. At higher altitudes turbulence can be found to the lee of high ground. This is caused by the air "bouncing" off or following the contours of the hills below.

These areas of rising and falling air are smooth, but where the two types interact, the air can become very agitated indeed. This effect is called rotor and it refers to the rapid rotation of the air.

All of the vertical movements will produce clouds if the moisture content is such that condensation will occur when the temperature falls at altitude. If the air is dry, cloud will not form.

Philip Walker
by e-mail, no address supplied

RUSTLE RIDDLE

Question: What generates the energy that makes thin, white supermarket bags so noisy?

Answer: The energy is generated mostly by you, because the bag will not rustle by itself. The noise is caused by sharp movements of the kind you get when a stiff plate buckles or gets rubbed. The bags are made of polyethylene film which, untreated, is waxy and floppy and not very noisy. It is elastic rather than plastic, so it absorbs stresses quietly.

However, to make the bags, the film is stretched to get it thin enough to be convenient to handle and cheap enough to give away with the goods. This partly aligns its molecules into stiffer sheets. To make the bags look better and the contents more anonymous, manufacturers add fillers for colouring and further stiffening. The result is a bag which audibly protests every crinkle, crumple and abrasion.

Jon Richfield
Dennesig, South Africa

This week's questions

Chameleon clothes: During long hours spent ironing I have noticed that when I am using a hot iron some of the colours change shades when heated. This happens mostly with reds and blues. What is the change, chemical or otherwise, that causes this to happen?

Elena Lambea
London

Sharp fruit: I thought fruit were supposed to attract animals. So what is the point of lemons tasting so sour? Are there any animals, apart from my brother, who actually like the taste? Did we breed lemons from ones that were sweeter? Or do animals have a different sense of taste?
Hannah Cheverton (aged 10)
Oakham, Rutland

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