

Environmental Physics Day

series and from scientific profiling flights over the period from the late 1950s up to 2011 have shown that there has been a clear 55% increase in the CO₂ seasonal change amplitude at latitudes above 45° N. This pattern relates to a large increase in seasonal carbon exchange in northern ecosystems, particularly in boreal forests. Current models used by the IPCC underestimate the change in CO₂ amplitude at 6 km altitude north of 45°N. This is not yet explained but could involve changing forest composition, changing forest age from disturbance and land-use soil dynamics.



The final talk, by **Dr Paul Williams** of Reading University, described how and why flights are likely to get bumpier through climate change. Aviation turbulence is a serious problem for aircraft and in the US alone causes 40 fatalities, hundreds of injuries and millions of dollars of damage annually. In particular, clear air turbulence (CAT), is difficult to detect and avoid, and computer simulations at the height resolution required to predict it are infeasible. Models for the causes of CAT take account of height stratification, which has a stabilising effect, as well as wind shear, which has a destabilising effect.

A phenomenon called Kelvin-Helmholtz instability occurs if the ratio of these two effects drops below a threshold value, causing the observed turbulence. The tropopause, the boundary between the troposphere and the stratosphere and above which most commercial aircraft fly, varies in height between the equator and the poles and CO₂ in the atmosphere cools the stratosphere but warms the troposphere. Satellite observations show that the lower stratosphere has cooled by around 1 degree over the past few decades. CAT is linked to upper-level jet streams, which are projected to be strengthened by anthropogenic climate change, and this is borne out by the increases in a number of CAT diagnostics by 40-90% over the period 1958-2001 in the North Atlantic, USA, and European sectors. The overall prediction is therefore that transatlantic flights are indeed likely to become bumpier by the middle of the century.



Dr Hugh Deighton