The Impacts of Aviation on the Atmosphere, (in the Context of Climate Change)

Background Information

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Sources of information:

The Environmental Effects of Civil Aircraft in Flight - Special Report published by the Royal Commission on Environmental Pollution on 29th November 2002
http://www.rcep.org.uk/avreport.htm

The Future of Air Transport - White Paper - published by Department for Transport on 16th December 2003
http://www.dft.gov.uk/stellent/groups/dft_aviation/documents/divisionhomepage/029650.hcsp

Aviation and the Global Atmosphere – published by the Intergovernmental Panel on Climate Change (IPCC) report in 1999

Any other sources of information are quoted in the text.

Aircraft Emissions

During flight, aircraft engines emit carbon dioxide, oxides of nitrogen, oxides of sulphur, water vapour, hydrocarbons and particles - the particles consist mainly of sulphate from sulphur oxides, and soot. These emissions arise from the combustion of aviation fuel, kerosene.

This cocktail of aircraft emissions contributes to climate change by warming the atmosphere at a magnitude that is approximately 3 times stronger than carbon-dioxide alone (ie its 'radiative forcing' is 3 times greater). This is due to their overall effect, by absorption and reflection, on the balance of incoming solar (shortwave UV) radiation and outgoing thermal (longwave infrared) radiation back to the upper atmosphere:

Carbon-dioxide and water vapour are greenhouse gases ie they absorb thermal radiation being emitted from the Earth's surface, thus warming the near-surface of the Earth;

The oxides of nitrogen take part in reactions that produce or destroy ozone, (depending on where they are emitted in the atmosphere, see below) and reductions in methane. Both ozone and methane are greenhouse gases and thus absorb thermal radiation being emitted from the Earth's surface;

The particles of sulphate, sulphur oxides and soot act as surfaces for the water vapour to condense onto when the hot air from the engines hits the cold ambient air at height.

In this way contrails are formed (condensation trails) and if the air is moist, these can form cirrus clouds. Contrails and cirrus clouds absorb thermal radiation emitting it back downwards, thus warming the Earth's surface. They also reflect some solar radiation therefore causing a cooling effect but this is less than the warming effect. There is thus increasing evidence that aviation-induced cirrus clouds and contrails contribute to global warming.

The effect of altitude and location on the impact of emissions

The impact of aircraft emissions on the atmosphere can be very different depending on the height and latitude at which they are emitted. Overall, emissions have more damaging impact at altitude.

Such scientific understanding of the processes involved and their impact is important because re-routing of aircraft may be able to reduce the impact of the emissions on the atmosphere:

Subsonic aircraft fly at a height of about 9-13km so the majority of aircraft emissions occur at this altitude. This height is close to what is known as the 'tropopause' - the sharp transition between the troposphere and the stratosphere. (The troposphere is that turbulent part of the atmosphere from the Earth's surface to about 10km, where most weather processes occur. The stratosphere above it is relatively stable).

Whether or not an aircraft is flying in the troposphere or stratosphere will depend on the latitude, the weather and the time of year. In the tropics the height of the tropopause is higher than the range of subsonic cruise altitudes but in polar regions it is usually lower.

If oxides of nitrogen are emitted into the turbulent troposphere they will undergo reactions to *produce* the greenhouse gas, ozone, which absorbs thermal radiation, heating the surface of the Earth and contributing to global warming.

However, if oxides of nitrogen are emitted into the stable stratosphere they will react to *destroy* ozone in the stratosphere, leading to increased surface UV radiation at the Earth's surface. The projected changes in damaging UV radiation are, however, very small and unless there is a major increase in the number of supersonic aircraft cruising in the stratosphere, the change is surface UV associated with aircraft, is unlikely to be a problem.

The troposphere naturally contains more water vapour than the stratosphere so that water vapour emissions from the aircraft, in terms of their radiative forcing, become negligible if aircraft fly in the troposphere. However, if particles are present in the emissions then contrails and cirrus clouds may form which *do* have significant impact on the radiative forcing.

Contrails and cirrus clouds are formed when there is enough moisture in the ambient air and saturation occurs. Scientists (Professor David Lee at Manchester Metropolitan University – meeting organiser) have found that by flying aircraft at lower altitudes -

6,000 feet lower than normal, in areas where there is higher ambient air temperatures and less moisture - it is possible to reduce the occurrence of contrails by 47%.

Modern weather forecasting techniques can predict the height of the tropopause and the regions of likely saturation in the upper troposphere, days in advance. With more scientific understanding of the various elements involved in climate impact due to aviation, it should be possible to route aircraft away from the most sensitive areas, reducing climate impact.

Facts and Figures

Aircraft emissions (carbon dioxide, oxides of nitrogen, oxides of sulphur, water vapour, hydrocarbons and particles) contribute to climate change by warming the atmosphere with a radiative forcing that is approximately 3 times stronger than carbon-dioxide alone.

The government has pledged to reduce UK carbon-dioxide emissions by 60% from current levels by the year 2050.

But, air travel has increased five-fold in the UK over the past 30 years and demand is projected to be between two and three times current levels by 2030.

Therefore, to meet demand, the UK will need 5 times as many aircraft flying in 2050, compared to today. The government, in its White paper, has supported the building of new runways at Stansted, Heathrow, Gatwick and Birmingham airports.

If the UK reduces carbon-dioxide emissions from ground-level activities in line with its pledge, then air travel will become one of the major sources of anthropogenic climate change by 2050. By 2030 aviation is likely to be contributing 25% of the UK carbon-dioxide emissions.

Half the population of the UK now flies at least once a year and 97% of UK air transport is international.

One return flight from the United Kingdom to Florida produces as much carbon dioxide as a year's driving by the average British motorist (report 'Aviation and Global Climate Change', by the Aviation Environment Federation, the National Society for Clean Air and Friends of the Earth).

The huge expansion of 'no-frills' carriers has contributed to the growth in air transport.

Aviation fuel, kerosene, is exempt from fuel tax. According to Friends of the Earth, the absence of fuel duty effectively gives the industry a £9 billion subsidy.

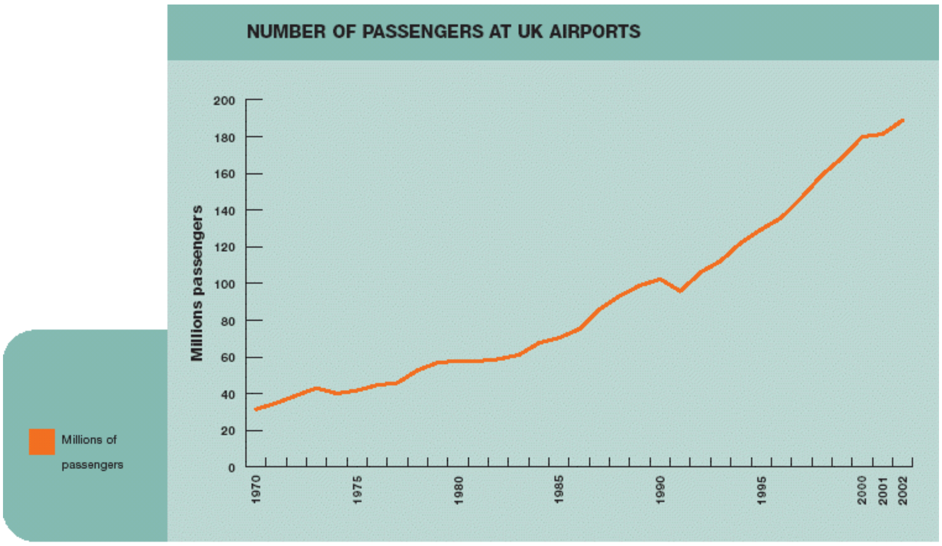
International aviation emissions were omitted from the Kyoto protocol. Domestic air transport is, however, included in the Kyoto protocol.

The government believes that the best way of ensuring that aviation contributes towards the goal of climate stabilisation, is through a well-designed emissions trading regime. It believes that an international trading regime is the best solution. The government has pledged to work with the EU, using the UK G8 Presidency in 2005, to ensure inclusion of aviation in The EU Emissions Trading Scheme, due to come online from 2008. The government is pressing the International Civil Aviation Organisation (ICAO) for the development and implementation of an open emissions trading system for international aviation. The ICAO supports this idea but has no powers of enforcement.

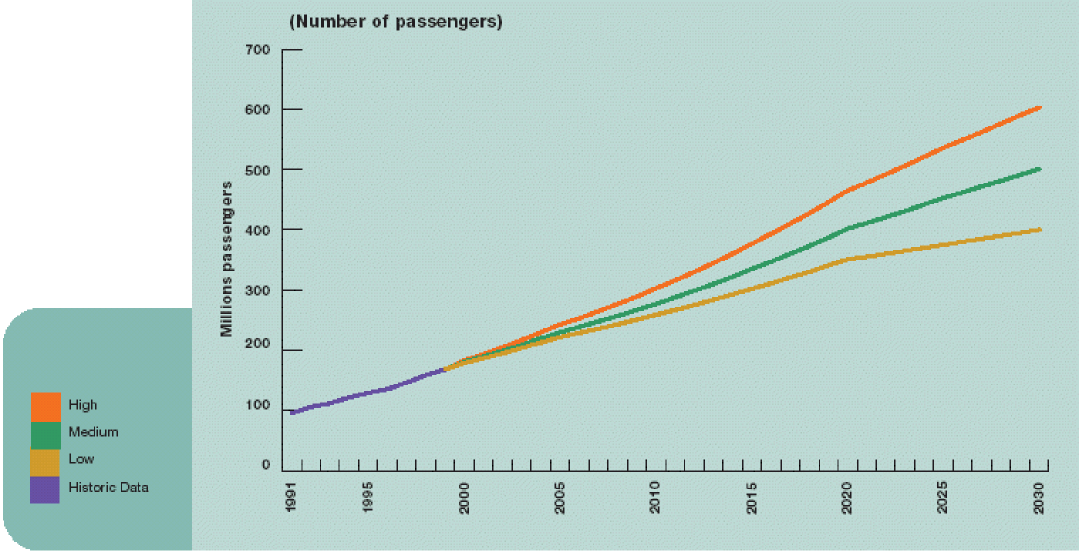
RCEP support emissions trading however they warn that any scheme will have to take account of the fact that the total radiative forcing of aviation is about 3 times that of carbon-dioxide emitted alone. Aviation emissions will need to be accounted to reflect their true contribution to climate change. This would require that the aviation industry should acquire 3 carbon emission permits for each unit of carbon that it actually emits.

RCEP report that whilst there are considerable opportunities for improvements to the environmental performance of individual aircraft, these will not offset the effects of growth. Radically new airframe designs, with improved fuel efficiency and possibly lower emissions and will create a significant change, but this change will not be seen for decades and then only for long-haul aircraft. Kerosene will remain the fuel of choice in the foreseeable future.

Source of Figures below: *The Future of Air Transport* - White Paper published by Department for Transport on 16th December 2003
http://www.dft.gov.uk/stellent/groups/dft_aviation/documents/divisionhomepage/029650.hcsp



ACTUAL AND FORECAST (UNCONSTRAINED) DEMAND AT UK AIRPORTS 1990 TO 2030



UK AVIATION'S FORECAST CARBON DIOXIDE EMISSIONS[1]

UK Aviation's forecast Carbon Dioxide Emissions (DfT forecast based on an assumption of three new runways in the South East and does not reflect any impact of economic instruments - hence it represents a slight over-estimation).