- *Radiative Forcing:* The major contributors from aircraft emissions to the radiative forcing, which is a measure of a change in climate, are carbon dioxide, ozone, methane (negative effect) and contrails, with minor contributions from water vapor, sulfate aerosols (negative effect) and soot. The contribution from cirrus clouds is projected to be positive and could be quite significant, but our current lack of scientific understanding precludes a quantitative assessment of its contribution. While the contributions from carbon dioxide, ozone, methane (opposite sign) and contrails are comparable in magnitude, the uncertainties associated with ozone, methane and contrails are much larger than those associated with carbon dioxide.

- *Current Impact of Aviation Emissions on Climate:* The best estimate of the radiative forcing in 1992 by aircraft is 0.05 Wm-2 (0.01 to 0.1 Wm-2) or about 3.5% of the total radiative forcing by all human activities. These estimates of forcing combine the effects of changes in all greenhouse gas concentrations, aerosols and line-shaped contrails, but do not include possible changes in cirrus.

- *Projected Impact of Subsonic Aviation Emissions on Climate*: For the reference scenario used in this assessment, the projected radiative forcing from subsonic aircraft emissions in 2050 is 0.19 Wm-2 or 5% of the radiative forcing in the mid-range IS92a scenario. For the full range of scenarios considered in the report, the radiative forcing is projected to grow to 0.13 to 0.56 Wm-2 in 2050, 2.6 to 11 times the value in 1992, and compares to the mid-range IS92a scenario of 3.8 Wm-2 in 2050.

- *Projected Impact of Supersonic Aviation Emissions on Climate*: One possibility for the future is the development of a fleet of second generation supersonic, high speed civil transportation aircraft. If a fleet of supersonic aircraft were developed to cruise at an altitude of about 19km, they would emit carbon dioxide, water vapor, oxides of nitrogen and sulfur, and soot directly into the lower stratosphere. Assuming a fleet of supersonic aircraft started operation in 2015, growing to a fleet of 1000 by 2040, displacing a portion of the subsonic fleet in the reference scenario, by 2050 the combined subsonic and supersonic fleet is projected to add a further 0.08 Wm-2 to the 0.19 Wm-2 radiative forcing projected for the reference scenario. Most of this additional forcing is due to the increased concentration of stratospheric water vapor.

- *Options to Reduce Aviation Emissions:* There is a range of options to reduce aviation emissions, including changes in aircraft and engine technology, fuel, operational practices, and regulatory and economic measures. While substantial aircraft and engine technology advances and air traffic management improvements are already incorporated in the aircraft emissions scenarios described above, further measures are feasible. However, it should be recognized that a number of factors will govern the rate at which technology advances and policy options related to technology can reduce aviation emissions: safety of operation, operational and environmental performance, cost, and the typical life expectancy of an aircraft of 25 to 35 years.

- *Conclusions and Issues for the Future:* The Report recognizes that there has been a steady improvement in characterizing the potential impacts of aviation on the global atmosphere,