



**United Nations  
Environment  
Programme**



Distr.  
GENERAL

UNEP/OzL.Pro/WG.1/19/2/Add.1  
18 May 1999

ORIGINAL: ENGLISH

NINETEENTH MEETING OF THE OPEN-ENDED  
WORKING GROUP OF THE PARTIES  
TO THE MONTREAL PROTOCOL ON  
SUBSTANCES THAT DEplete  
THE OZONE LAYER  
Geneva, 15-18 June 1999

Addendum

PRESENTATION OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE  
(IPCC)/SCIENTIFIC ASSESSMENT PANEL SPECIAL REPORT ON AVIATION  
AND THE GLOBAL ATMOSPHERE

Note by the Secretariat

INTRODUCTION

1. The present note summarizes the issues addressed in the 1999 special report on aviation and the global atmosphere. The Summary for Policymakers (SPM) of the special report has been communicated to all the Parties. The Special Report on Aviation and the Global Atmosphere has been published by Cambridge University Press and is being distributed to all Parties. The Parties should study the full report, which contains valuable information not included in the present summary, which briefly reviews a number of the issues calling for the consideration of the Working Group.

I. BACKGROUND

2. The Special Report on Aviation and the Global Atmosphere was requested pursuant to decision VII/34, paragraph 3 (b), by which the Seventh Meeting of the Parties decided that the major emphasis of the 1998 scientific assessment should include:

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"An assessment of other aspects of ozone changes, such as the impacts of aircraft emissions, and the role of ozone changes in the alteration of the global climate system, with particular attention to the need for adequate information in the southern hemisphere. The Panel is requested to work as appropriate with the International Civil Aviation Organization and the Intergovernmental Panel on Climate Change."

3. The report assesses the effects of aircraft on climate and atmospheric ozone. It was prepared by the Intergovernmental Panel on Climate Change (IPCC) in collaboration with the Scientific Assessment Panel of the Montreal Protocol and the International Civil Aviation Organization (ICAO).

4. The report examines the effects of current aviation activity and a range of unconstrained growth projections for aviation (which include passenger, freight, and military), including the possible effects of a fleet of second-generation, commercial supersonic aircraft. The report also describes current aircraft technology, operating procedures, and options for mitigating the future impact of aviation on the global atmosphere.

5. The Summary for Policymakers (SPM) of the special report, which will be translated into all United Nations languages, represents the formally agreed statement of the IPCC concerning current understanding of aviation and the global atmosphere.

## II. FINDINGS OF RELEVANCE TO THE OZONE LAYER

6. Some of the report's findings relevant to the ozone layer are that:

(a) Aircraft emit gases and particles directly into the upper troposphere and lower stratosphere where they have an impact on atmospheric composition;

(b) Aircraft-emitted nitrogen oxides (NO<sub>x</sub>) participate in ozone chemistry;

(c) Subsonic aircraft fly in the upper troposphere and lower stratosphere (at altitudes of about 9 to 13 kilometres), whereas supersonic aircraft cruise several kilometres higher (at about 17 to 20 km) in the stratosphere. In the upper troposphere and lower stratosphere, ozone is expected to increase in response to increases in nitrogen oxides, and methane is expected to decrease;

(d) At higher altitudes however, increases in nitrogen oxides lead to decreases in the stratospheric ozone layer. Ozone precursor (NO<sub>x</sub>) residence times in these regions increase with altitude and hence perturbations to ozone by aircraft depend on the altitude of NO<sub>x</sub> injection and vary from regional in scale in the troposphere to global in scale in the stratosphere;

(e) Water vapour, sulphur oxides (SO<sub>x</sub>) and soot (these last two are both examples of aerosols) emitted by aircraft play both direct and indirect roles in climate change and ozone chemistry;

(f) Aircraft sulphur and water emissions in the stratosphere tend to deplete ozone, partially offsetting the NO<sub>x</sub>-induced increases in tropospheric ozone. The degree to which this occurs is, as yet, unquantified. The special report concluded that the impact of subsonic aircraft emissions on stratospheric ozone requires further evaluation;

(g) One possibility for the future is the development of a fleet of second-generation supersonic civil transport aircraft. These supersonic aircraft are projected to cruise at an altitude of about 19 km, about 8 km higher than subsonic aircraft, and to emit carbon dioxide, water vapour, nitrogen oxides, sulphur oxides, and soot into the stratosphere. The nitrogen oxides, water vapour, and sulphur oxides from supersonic aircraft emissions all contribute to changes in stratospheric ozone. The effect of introducing a civil supersonic fleet of 1,000 aircraft (one scenario considered) would be a reduction in stratospheric ozone;

(h) Flying higher leads to larger ozone-column decreases, while flying lower leads to smaller ozone-column decreases and may even result in an ozone-column increase for flight in the lowermost stratosphere. In addition, emissions from supersonic aircraft in the northern hemisphere stratosphere may be transported to the southern hemisphere where they cause ozone depletion.

### III. FINDINGS OF RELEVANCE TO CLIMATE CHANGE

7. Some of the findings relevant to climate change are that:

(a) The gases and particles emitted by the aircraft alter the concentration of atmospheric greenhouse gases, including carbon dioxide (CO<sub>2</sub>), ozone (O<sub>3</sub>), and methane (CH<sub>4</sub>), trigger the formation of condensation trails and may increase cirrus cloudiness, all of which contribute to climate change;

(b) Emissions of carbon dioxide by aircraft were 0.14 carbon gigatons a year in 1992. This is about 2 per cent of total anthropogenic carbon dioxide emissions in 1992 or about 13 per cent of carbon dioxide emissions from all transportation sources;

(c) According to the range of scenarios considered in the report, aircraft emissions of carbon dioxide will continue to grow and by 2050 will be between 0.23 and 1.45 carbon gigatons a year, in other words, between 1.6 and 10 times the 1992 value;

(d) The emissions of nitrogen oxides are expected to decrease the concentration of methane, in fact these reductions tend to cool the surface of the Earth. The effect of subsonic aircraft water emissions is less than that of other aircraft emissions such as carbon dioxide and nitrogen oxides;

(e) In 1992, aircraft line-shaped condensation trails (contrails) were estimated to cover 0.1 per cent of the Earth's surface on an annually averaged basis with larger regional values. Contrails tend to warm the Earth. The contrail cover was projected to grow to 0.5 per cent by 2050 in the reference scenario of the report;

(f) The climate impacts of different anthropogenic emissions can be compared using the concept of radiative forcing <sup>1/</sup> which is a measure of the importance of a potential climate change mechanism. The best estimate of the radiative forcing in 1992 by subsonic aircraft was 0.05 watts per square metre or about 3.5 per cent of the total radiative forcing by all anthropogenic activities;

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<sup>1/</sup> Radiative forcing is a measure of the importance of a potential climate change mechanism. It expresses the perturbation or change to the energy balance of the Earth-Atmosphere system in watts per square metre. Positive values of radiative forcing imply a net warming, while negative values imply cooling.

(g) The report used seven future global aircraft scenarios. The reference scenario assumed a 3.1 per cent average traffic growth per year and a 1.7 per cent average annual growth rate of fuel burn from 1990 to 2050, a 2.9 per cent economic and a 1.4 per cent population average annual growth for 1990-2025, a 2.3 per cent economic and a 0.7 per cent population average annual growth for 1990-2100, a 6.4 ratio of traffic (2050/1990) and a 2.7 ratio of fuel burn (2050/1990). According to one scenario, a combined fleet including 1,000 supersonic aircraft, replacing 11 per cent of the current subsonic fleet in emissions terms, 2/ is projected to add 0.08 watts per square metre (42 per cent) to the 0.19 watts per square metre radiative forcing of the reference scenario in 2050. Most of the additional forcing would be due to accumulation of stratospheric water vapour.

#### IV. OPTIONS TO REDUCE EMISSIONS AND IMPACTS

8. The report presents a range of options for reducing the impact of aviation emissions:

(a) Changes could be made to aircraft and engine technology;

(b) Sulphur content in fuel could be reduced and improvements could be made to air traffic management and other operational procedures;

(c) Regulatory, economic and other options could be explored. Policy options to further reduce emissions include more stringent regulations on aircraft engine emissions, removal of subsidies and incentives that have negative environmental consequences, market-based options such environmental levies (charges and taxes) and emissions trading, voluntary agreements, research programmes, and replacement of aviation by rail and bus travel.

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2/ The civil subsonic fleet comprised 12,000 aircraft in 1997.