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The climate issue

Present state of knowledge

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THE CLIMATE ISSUE: PRESENT STATE OF KNOWLEDGE

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SUMMARY OF RECENT FINDINGS

The IPCC Supplement Report 1992, summarizes the present state of knowledge of the climate issue. This report has been written and reviewed by the majority of climate researchers throughout the world, and should therefore represent the present knowledge in the area well. The following presentation gives a short description of our understanding of the climate issue.

Measurements of the most important greenhouse gases from man made sources show that there is a continued increase of these gases in the atmosphere. With the exception of the CFCs, there are no major changes in the estimates of emissions of these gases. Emissions of CFCs are reduced markedly over the last few years. This marked reduction in emissions result in a slower growth of the atmospheric concentrations. The reduction is, however, not sufficient to lead to a levelling off of the atmospheric concentrations of the CFCs.

Climate models predict an increase in the global mean temperature in the future of 1.5 to 4.5 degree Celcius for a doubling of CO₂. Analysis of global temperatures indicate an increase over the last 100 years of 0.3 to 0.6. The high mean temperatures which were observed during the 1980s continue into the 1990s. 1990 and 1991 were the two warmest years ever observed. The temperature increase is found in both hemispheres.

The observed temperature increases broadly in agreement with calculated temperature increases. However, too strong conclusions should not be drawn from these comparisons. The increase is of the same order as the observed variation in temperature. The possibility that the observed increases are due to natural causes can not be disregarded.

Observed ozone reductions in the stratosphere are estimated to have reduced the heating at high latitudes significantly. The reduction in ozone has been particularly large during the last decade, and is found over large areas in the Northern and the Southern Hemispheres at mid- and high-latitudes. The significance for the climate is because the reductions occur in the lower stratosphere (15 to 25 km), where ozone is a strong climate gas. There are now increasing indications that the ozone loss observed in the Northern Hemisphere is due to CFC releases. The CFCs are therefore expected to have an indirect effect through its impact on ozone which substantially reduces its role as a greenhouse gas.

Ozone increases in the troposphere over the last two decades at heights up to approximately 10 km is estimated to have led to significant increases in surface temperatures. The increase in tropospheric ozone is regional in extent. The climate impact is therefore estimated to be regional in nature.

Emission of sulfur in the Northern Hemisphere can have led to significant cooling at northern latitudes. This could have counteracted the temperature increase from CO₂ and other greenhouse gases. Sulfur has a short lifetime in the atmosphere, the greenhouse effect from sulfur is therefore first of all a regional problem, while the effect from CO₂ and most of the other greenhouse gases are global. Observations indicate that sulfur emissions in the Southern Hemisphere are small, and that the impact on climate is negligible.

Models which calculate the time dependent temperature changes at the Earth's surface from the greenhouse gases give smaller temperature increases over oceans in the North Atlantic, and in the south close to the Antarctic than in other areas. Some of the main features in calculated climate changes are: Temperature increases are larger over land than over oceans. The precipitation increases at high latitudes, in the monsoon region of Asia, and at midlatitudes during the winter. The soil is dryer at mid latitudes during the summer. These conclusions are based on time dependent calculations which simulate the temperature development for a

time period of 100 years.

Global Warming Potentials (GWP) for the greenhouse gases are calculated and found to be approximately the same as given earlier. Particular interest has been given to the indirect effect of the greenhouse gases. This occurs through chemical interactions in the atmosphere. Methane has been pointed out as a gas where the indirect effect is of great importance. The indirect contribution will add to its climate effect. The CFCs could also have a significant indirect effect through their impact on stratospheric ozone. The indirect effect will counteract the direct effect. The indirect effects are at present difficult to calculate.

The impact on surface temperatures of sulfate particles in the troposphere and reduced ozone in the stratosphere has probably masked the expected temperature increase due to CO₂ and other greenhouse gases. The observed surface temperatures increase at high- and mid- latitudes.

Changes in tropospheric ozone and in the distribution of sulfate particles vary strongly from region to region. Their contribution to the global warming will therefore show a different regional pattern than the contribution from well mixed gases like CO₂ and methane. It is therefore difficult to compare future contribution from tropospheric ozone and sulfate particles with the contribution from CO₂.

One important aspect in the context of global warming is that sulfate has short lifetime in the atmosphere; any reduction in the emission will lead to an immediate reduction in the abundance of sulfate in the atmosphere. CO₂ on the other hand has a very long lifetime in the atmosphere. Its atmospheric concentration will therefore react very slowly to changes in emission. Furthermore, emission has to be reduced strongly (approximately 60%) before concentrations are stabilized. Due to the different climate impact of CO₂ and sulfate particles, decisions on climate regulations should not be based on the assumption that the effects of sulfate will compensate for the CO₂ impact.

Global Warming Potentials (GWP), which give the relative importance of the greenhouse gases, is a helpful tool for making a first comparison between the different greenhouse gases. However, estimates of the indirect greenhouse effects, which is believed to be important for several of the greenhouse gases (e.g. CH₄), are difficult to quantify at present. The uncertainties are connected to the uncertainties in quantifying the chemical processes.

There has been a considerable development of climate models over the last years. The models have a more realistic description of the interaction between the atmospheres and the oceans. The water cycle is also described in a more realistic way than previously. The results of model calculations are

more accurate than previously. However, it is realized that there are still significant uncertainties connected with model calculations, particularly the estimates of the interaction of climate with clouds.

Up to recently, the climate models considered the impact of greenhouse gases that was well mixed in the atmosphere (CO_2 , CH_4 , N_2O and CFCs). Since it now has become obvious that tropospheric ozone and sulfate particles are effecting the radiative balance of the atmosphere, the regional impact is becoming important. Their distributions have regional patterns, and focus of the climate studies in connection with tropospheric ozone and sulfate should be on the regional impact.

Estimates of future climate changes are connected with uncertainties due to the adopted emission scenarios. The future emissions of many greenhouse gases are difficult to assess due to factors like economical and technical development, political decisions and international regulations. However, unless there are significant reductions in the emission of the major climate gases (CO_2 , CH_4 , CFCs and others), the current understanding of the climate processes points to a significant climate impact in the future.