Climate Change Research: Evaluation and Policy Implications
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Discussion on the NRP assessment report "Greenhouse gases"

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Introduction (J. Slanina)
The uncertainties in the global CO_2 budget were discussed, in particular the relation between the fluxes of CO_2 between the various compartments, i.e. oceans, atmosphere and terrestrial biosphere. Reduction of the CO_2 emissions from fossil fuel combustion is necessary to stabilize the atmospheric CO_2 concentration. The percentage reduction of the current emission depends on the amount of CO_2 that is taken up by the world's oceans and the terrestrial biosphere (the CO_2 fertilization effect). The uncertainties in these sinks is of great importance for future mitigation policies.

The major global sources and atmospheric destruction of CH_4 are still very uncertain. Regarding the emission estimates, the major source of uncertainty is in the extrapolation of measurements to larger scales. In the past generally point measurements made at one or a few sites were used to calculate the regional, continental or global emission. Recent extrapolation techniques develop towards validation of flux measurements at regional scales to arrive at more reliable source estimates.

The most recent IPCC global N_2O budget shows that the uncertainty in the various source estimates is very uncertain, and there may yet be unidentified sources. The trends in the concentrations of CO_2, CH_4 and N_2O have changed in recent years. The global increase of the mean CO_2 and CH_4 concentrations were lower in the early 1990s than in the 1980s, and the trend in N_2O in 1992 was about half that in the 1980s. For N_2O the global observed temperature decrease caused by aerosols from the eruption of Mount Pinatubo may have lead to a decrease in biogenic emissions from soils and oceans. For the other gases it is more difficult to explain the observed changes in atmospheric growth rates.

The major criteria used in the programming of the three clusters were:

- The relative *importance* of a source of emissions, both now and in the future
- The range of *uncertainty* in the available estimates (in the Dutch inventory, by Van den Born et al., 1991)
- Availability of techniques or policies to *reduce emissions*
- Availability of specific *experience* in The Netherlands.

Theme "Greenhouse Gases" of the Dutch National Research Programme on Global Air Pollution and Climate Change consisted of five clusters. Three clusters concentrated on fluxes of CO_2, CH_4 and N_2O. The two other clusters, database development and social causes of climate change, were not discussed during this session. An overview of the CO_2, CH_4 and N_2O clusters was given during this session. The individual projects, institutes and project leaders are listed in the assessment report of Theme B (Berdowski et al., in prep.), and will not be given in this report.

The CO_2 cluster (J. Slanina)
The research in the CO_2 cluster concentrated on the exchange of CO_2 between terrestrial ecosystems and the atmosphere, with a focus on grasslands. Grassland cover about one-third of the Netherlands. Moreover, grasslands have received much less research attention regarding CO_2 exchange than e.g. forests.

Research topics
The research topics in the CO_2 cluster included:

- Inventory of carbon stocks in Dutch forests
- The mechanism of soil carbon (C) accumulation in sand, clay and peat soils, using labelled $^{14}CO_2$ as a tracer to study the distribution of carbon in vegetation and soil.
- Development of models describing the exchange of CO_2
- Validation of models at different scales, on the basis of aircraft measurements using eddy correlation techniques, towers (gradient technique) and concentration measurements and determination of the isotopic composition of atmospheric CO_2.
- Integration of results.

Results
An inventory was made of the current stocks of C in living biomass and soils for Dutch forests. One of the conclusions was that Dutch forests are currently taking up 0.33×10^{12} g C yr^{-1}.

The mechanistic research showed that retention of C in clay and sand soils was higher than in peat soils. The difference between measured and modelled CO_2 exchange between the grassland and the atmosphere was attributed to oxidation of the peat. The CO_2 fluxes at the scale of a hectare were estimated with the gradient technique at Cabauw. Net uptake occurred in March-May, while a net emission to the atmosphere occurred in all other months. The estimated annual net emission was 3000 kg C ha^{-1}. Most of this is caused by peat oxidation.

Aircraft measurements are not applicable to Dutch conditions. The heterogeneity of the landscape makes it very difficult to attribute fluxes to a certain area or component of the landscape. It was noted that in places with vast areas with homogeneous landscape and vegetation, aircraft measurements may be successful, as shown in e.g. the U.S.A.

Low ground water tables cause oxidation of the peat material. The total historic C-loss resulting from peat oxidation in The Netherlands is of the same order of magnitude as the total historic C-injection into the atmosphere by Dutch fossil fuel combustion. By implementing higher water tables in the Dutch peat soils the loss of C can be halted and soils may even become a net sink by C accumulation. However, as was noted in the CH_4 and N_2O clusters, changes in the water table has important consequences for fluxes of all trace gases, where fluxes of one gas may decrease while the emission of another gas increases.

The CH_4 cluster (J. Berdowski)

Research topics

The programming of the CH_4 cluster was based on the results of a Dutch inventory of sources (Van den Born et al., 1991). The research on CH_4 sources concentrated on the following sources:

- Rice fields
- Grasslands on organic soils (integrated CH_4 grassland project)
- Landfills
- Exploration of oil and gas
- Evaluation and validation

Not all the projects have been completed. The results of the different projects were briefly discussed.

Results

Research on CH_4 from rice fields paddies carried out in the Philippines has concentrated on soil factors influencing fluxes of CH_4 from irrigated rice fields. The effect of additions of gypsum was given special attention. The general conclusion was that soil parameters need to be included in global estimates of CH_4 from rice paddies. The sulphate added in the form of gypsum causes a reduction of CH_4 emission, caused by competition between sulphate reducing bacteria and methanogens.

The integrated CH_4 grassland project consisted of different projects, investigating CH_4 formation, CH_4 oxidation, modelling of CH_4 fluxes and effects of soil and water management on CH_4 fluxes. The conclusion drawn on the basis of the results of this project was that CH_4 emission from intensively managed grasslands on peat soils is lower than for extensively managed systems. The major cause of lower fluxes in intensively managed systems is the lower ground water table. This causes a more extensive oxic layer in the peat surface soil, with higher oxidation of CH_4 than in soils with high ground water tables.

The major sources of methane from oil and gas exploration in The Netherlands include the venting of gas, chronic leaks during collection and transport. Testing of wells is probably a moderate to major source in The Netherlands.

The evaluation and validation studies included permanent measurement of the atmospheric concentration of CH_4, modelling of air trajectories and estimation of urban sources of CH_4. Permanent ground based (20 m) measurements are made in

Delft, Arnhem, Kolummerwaard and Amsterdam. Measurements at 200m are done at Cabauw. The measurements show a background concentration of about 2 ppm, but very high peaks occur occasionally. In the Northern part of The Netherlands these peaks are associated with fluxes from gas fields during exploration. Observations of peak CH_4 concentrations correspond to SE winds, indicating a source SE of The Netherlands. The modelling of air trajectories and backcalculation of emissions resulted in estimates that are consistent with the inventory of CH_4 emissions.

The N_2O cluster (A.F. Bouwman)

Research topics
For the N_2O cluster two preparatory studies were carried out, i.e. an inventory of Dutch N_2O emissions and a comparison of measurements techniques. Based on these studies, the following sources were selected for further research:

- Mobile and stationary combustion
- Aquatic sources
- Sewage water treatment plants
- Integrated N_2O grassland project
- Global N_2O inventory and validation

The results of the N_2O cluster were used to compile a new inventory and scenarios of Dutch emissions in the Background document on N_2O (Kroeze, 1994) (part of the cluster on Social Causes).

Results
Various types of vehicles and engines with/without catalysts were included in the study on mobile N_2O sources. Cars equipped with catalysts emit more N_2O than cars without catalysts. The N_2O emission increases along with the age of the catalyst. At present mobile combustion contributes about 10% to Dutch emissions. With increasing automobility and further penetration of catalyst equipped cars, the importance of mobile combustion will increase in the future. Measurements carried out in Dutch power plants, chemical industries, an oil refinery, waste incineration plant indicate that stationary combustion is a minor direct source in The Netherlands. Indirect emissions from soils induced by NO_x emission and deposition may be more important.

Measurements in the Indian Ocean indicated very high fluxes from upwelling zones. The calculated fluxes from the North Sea were much lower. In the Scheldt estuary a close relation was found between N concentrations in the water and N_2O fluxes. Two different sewage water treatment plants were studied, representing the major types of installations in the Netherlands. Literature research and measurements indicate that N_2O fluxes from these treatment installations are much lower than assumed previously (Van den Born et al., 1991).

The integrated grassland N_2O project included flux measurements, modelling and studies on the effects of management, and focused on grasslands on peat soils. The results indicate that intensively managed grasslands on peat soils show much higher N_2O emissions than mineral soils. As was found in the preparatory inventory, grasslands form the major individual source of N_2O in The Netherlands. The N_2O emission associated with food production makes up about 50% of Dutch emissions. Reduction of emissions from soils is possible by implementing higher ground water tables and by reducing N inputs. However, this will induce higher CH_4 emissions. The overall result of extensification of grasslands on peat soils based on Global Warming Potentials (GWP) has not been estimated yet. The global inventory indicates that 2/3 of the global increase of atmospheric N_2O is associated with food production, with an important part from animal production.

It was noted that at the Kolummerwaard station the N_2O concentrations are fairly constant. This is seen in all monitoring stations where N_2O is measured worldwide. The explanation may be that N_2O fluxes are negligible relative to the background concentration, so that variation in emission has hardly any effect on the air concentration.

References

Berdowski, J.J.M., A.F. Bouwman, J. Slanina and W.M. Kieskamp (in prep.) Assessment report, Theme B, "The Causes", Dutch National Research Programme on Global Air Pollution and Climate Change.

Van den Born, G.J., A.F. Bouwman, J.G.J. Olivier and R.J. Swart, 1991. The emission of greenhouse gases in The Netherlands. Report 222901003, National Institute of Public Health and Environmental Protection, Bilthoven.

Kroeze, C., 1994. Background document N_2O. Report 222901003, National Institute of Public Health and Environmental Protection, Bilthoven.