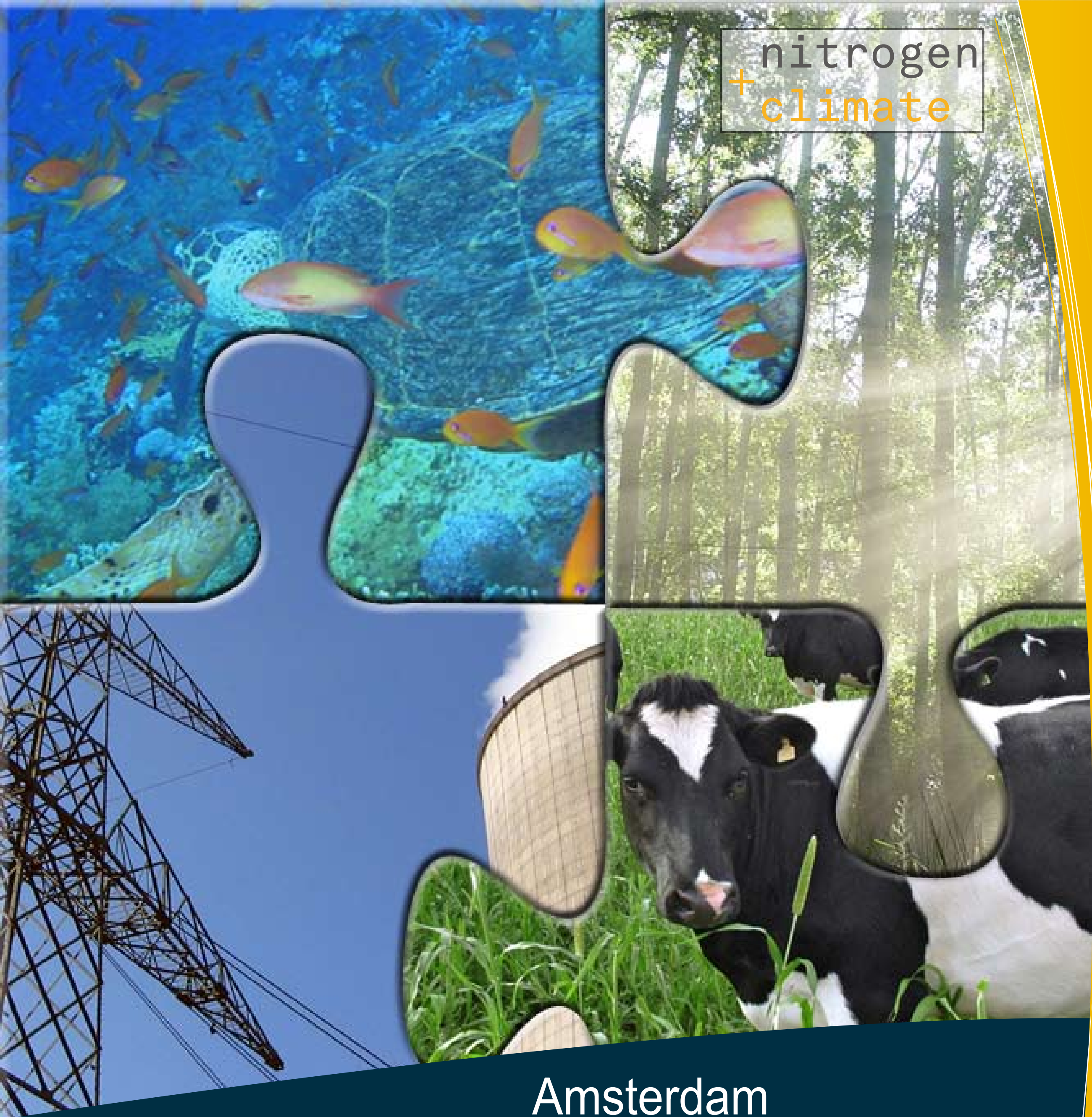

Amsterdam

31 October - 1 November, 2011

Workshop report on
Nitrogen and Climate

Interactions of reactive nitrogen with climate change and opportunities for integrated management strategies

TFRN LRTAP
Long-range Transboundary Air Pollution

ipcc
INTERGOVERNMENTAL PANEL ON climate change
Working Group II (WG II) – Impacts, Adaptation and Vulnerability

Workshop on Nitrogen and Climate

Interactions of reactive nitrogen with climate change and opportunities for integrated management strategies

Workshop report prepared by:
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Workshop report reviewed by the workshop participants

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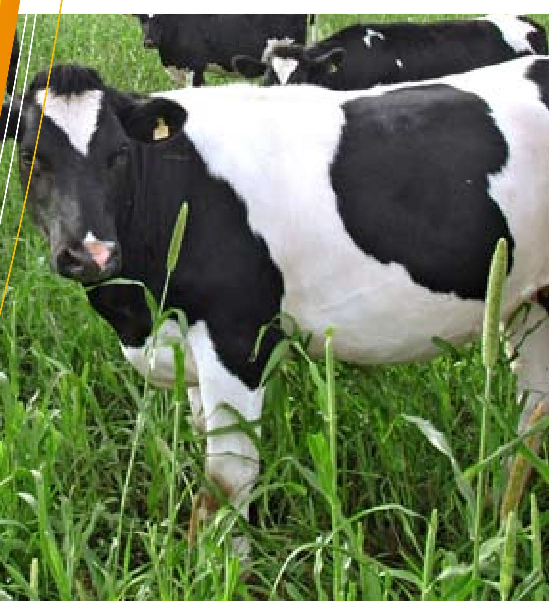
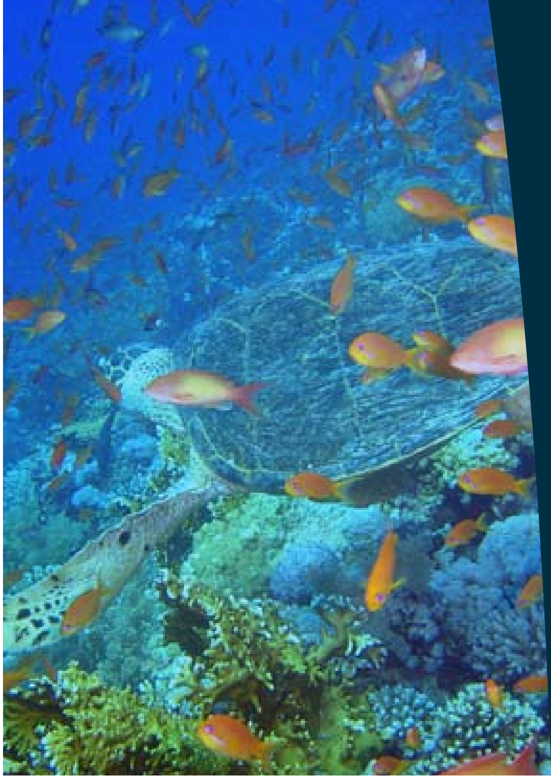


Background

At the 15th Conference Of Parties of the United Nations Framework Convention on Climate Change (Copenhagen 7-18 December, 2009) a Nitrogen Side Event was organized at the U.S. Center on *Options for including Nitrogen Management in Climate Policy Development*. The event highlighted the importance of nitrogen and its management in relation to climate change. It proposed the drafting of a report on Nitrogen and Climate and the organization of a workshop under the IPCC flag to inform the 5th Assessment Report.

A workshop was organized in Amsterdam, 31 October-1 November 2011 by the Expert Group on Nitrogen and Climate of the Task Force on Reactive Nitrogen (TFRN) under the UNECE



Convention on Long Range Transboundary Air Pollution, co-sponsored by the IPCC WGII. IGBP, INI, ESF-NinE and the Ministry of Infrastructure and the Environment of the Netherlands. The workshop brought together 21 experts from 9 countries, being authors of the relevant chapters of the 5th Assessment Report of the IPCC and scientists working on the relation between nitrogen (N) and climate change. It also sought to discuss how the relation between N and climate, and the nitrogen management options for climate change abatement, could be fully reflected in AR5. The report on *Interactions of reactive nitrogen with climate change and opportunities for integrated management strategies* (www.nitrogenweb.info) served as background material and input to the workshop.

WORKSHOP STRUCTURE

Day 1 (31 October)

Welcome, opening, workshop introduction

Introduction of the Participants

Session I
Nitrogen and the 5th Assessment Report
chaired by Mark Sutton

Session II
Modelling Nitrogen in relation to Climate
chaired by Oene Oenema

Session III
General Nitrogen issues in relation to Climate
chaired by Eric Davidson

Workshop dinner

Day 2 (1 November)

Session IV
Nitrogen policies in relation to Climate
chaired by Jan Willem Erisman

General Discussion on N / C interaction in AR5

Synthesis of Discussions and Next Steps

Closing remarks

Outcome of the workshop

General

The workshop was divided in sessions that dealt with different Nitrogen/Climate topics: N and the 5th Assessment Report; Modeling N in relation to Climate; General N issues in relation to Climate; N policies in relation to Climate. Each session was introduced by means of expert presentations, followed by discussions on the state of science and the main messages. A synthesis of these discussions was made at the end of the workshop. The following paragraphs give an overview of the different findings of the workshop. These findings are listed according to 'Drivers', 'Impacts & Vulnerabilities' and 'Mitigation and Adaptation'. We propose that these findings find their way into the AR5 process, supported by the relevant background peer-reviewed literature.

Drivers

1. When considering the N and Climate Change interactions, we have to be aware of the difference between short and long-term effects:

- N_2O has a long-term warming effect
- C sequestration due to N enrichment in the biosphere has a long-term cooling effect, but the sequestration potential is likely to become saturated, and the sequestered carbon pools are vulnerable to climate change and land use change
- NOx (sum of NO and NO_2) contributes to tropospheric O_3 formation, which has a strong, but short-term warming effect
- NOx and NH_3 contribute to particle formation, which has a strong, but short-term cooling effect

2. There are also interactions of N with CH_4 production and consumption, but the magnitude of these effects is small relative to those listed above.

3. The net effect of all of the above is probably a modest cooling effect, although the uncertainty associated with this estimate implies that the warming and cooling effects could cancel each other.

4. However, because N_2O has an atmospheric half-life of >100 years and because the permanence of C sequestration is uncertain, the long-term warming effect merits considerable concern and attention.

5. Nitrogen is a key input for boosting the necessary food production, with significant climate change effects, in part through increased trade of food, feed and fuel, which lead to depletion of nutrients in one part of the world, and to accumulation of nutrients in other parts, and thereby to inefficient nitrogen use.

6. According to a recent HSBC bank study we will see a 10 fold increase of the trade between countries in the Southern Hemisphere in the next 4 decades (until 2050). In terms of changing patterns (flows of money, material, N), this will be the region in the world where 'everything' will happen in the next decades.

Impacts and Vulnerabilities

1. Climate smart agriculture could gain very much by including sound nutrient management. Crops that are deficient in nutrients are more vulnerable to climatic variability, especially drought in the developing world. Improper nutrient management can reduce the effectiveness of irrigation and efforts to improve water use efficiency. However, where farmers have access to abundant use of fertilizers, they often use excess fertilizers to provide some protection from climatic variation, which leads to inefficient use of nutrients and runoff problems. This response of farmers could become more common as climate becomes more variable and extreme.

2. Formation of tropospheric ozone is affected by concentrations of NOx, VOCs, and temperature, and it has undesirable effects on both human respiratory health and crop and forest productivity. Hence the impacts of climate change on human health and crop production cannot be fully understood without knowledge of NOx production and dynamics.

3. Ammonia emissions are temperature dependent and they affect the formation of aerosols, which have climate feedback effects as well as harmful effects on human respiratory health and on downwind ecosystem health.

4. Perturbations of either climate or nutrient enrichment are known to reduce biodiversity in both terrestrial and aquatic ecosystems. Much less is known about the multiple stresses of simultaneous climate and N perturbations.

5. Eutrophication of estuaries and fresh water bodies results from nutrient enrichments (mostly N and P), and climate change can exacerbate this effect. Climate change may also accelerate the release of nutrients from soils and sediments, with a range of consequences from enhanced carbon sequestration (nutrient limited) to toxification and loss of diversity (nutrients in excess or imbalanced). Quantification of these processes and thereby the effect of N on the carbon cycle remains highly uncertain.

6. The tropics contain a large carbon stock. Although it is assumed that phosphorous limitation is dominating carbon sequestration in the tropics, N dynamics may also be very important, and the effect of both increased N availability and climate change needs to be quantified.

7. The formation and removal of nitrate in soils, groundwater, rivers, lakes, and estuaries is partly temperature dependent. Meeting WHO or other drinking water standards for nitrate and avoiding undesirable eutrophication of aquatic ecosystems will require better understanding of the interactions of the relevant processes in the N cycle with changing temperature and precipitation.

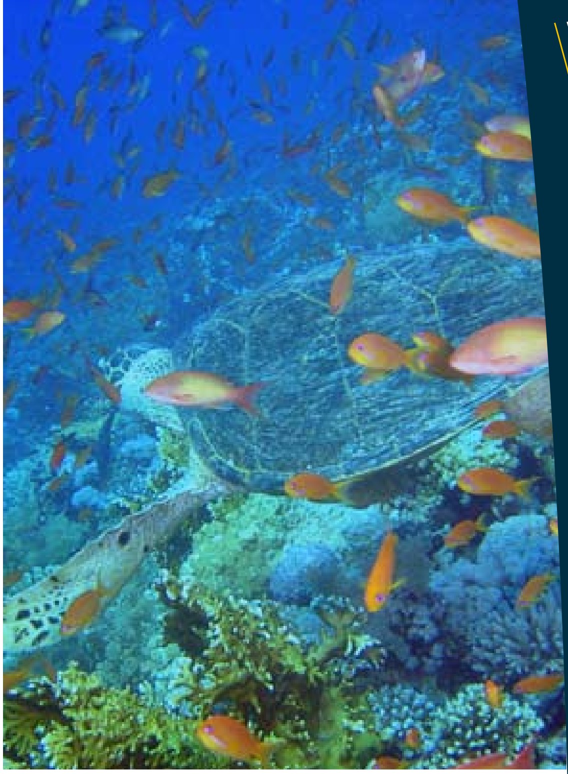
Mitigation and adaptation

1. N_2O mitigation must include improvements in agricultural efficiencies throughout the world and perhaps also changes in dietary habits in the developed world. The need to produce more food as human populations grow and as nutrition improves in the developing world will make N_2O mitigation especially challenging. The AR5 RCPs for N_2O properly express the large range of possibilities, from continuously increasing atmospheric N_2O at present rates under RCP8.5 with little improvement of agricultural efficiencies, to declining N_2O concentrations later this century under RCP3PD. The latter possibility would require several highly effective mitigation efforts in all sectors as well as reduced per capita meat consumption in the developed world.

2. Improvement of Resource use efficiency is not relevant to reduce N_2O emissions, but is the key to mitigating all N emissions.

3. Great progress has been made in NOx mitigation in the developed world, although further improvements are needed and possible. NOx mitigation is urgently needed in many developing world countries, especially emerging market countries. Due to the interactions of temperature, NOx concentration, and VOC concentration, the effectiveness of NOx mitigation to reduce harmful ozone and particulate matter concentrations is climate-sensitive, making effective NOx mitigation for ozone reduction more difficult in a warmer world.

4. The effectiveness of carbon sequestration in forests and soils will depend upon C-N interactions. Estimates of carbon sequestration at present and in the future will be inaccurate unless these interactions are properly accounted for.



5. The below ground N cycle is poorly modeled, while at the same time models are very sensitive to how N is modeled.

6. The CO_2 fertilization effect is likely overestimated by models that do not include reactive N (N_r) and progressive N limitation is likely to cause a diminished CO_2 fertilization effect in the future. Including N in carbon models will, therefore, result in higher projected CO_2 concentrations in 2100, compared to using carbon models alone.

7. We know that global biogeochemistry models get incorrect answers if they do not include N, but our skill at modeling C-N interactions at global scales is still poor. This also holds for the modeling of the relationship and feedbacks from the phosphorus cycle and hydrology.

8. Much of the scenario work builds on the available RCPs. However, these RCPs do not cover the full range of possible futures. Instead, they focus mainly on 'desired' air pollution futures. The different RCPs seem not to be internally consistent (especially the combination of different components show an inconsistent picture), but the extent to which this is the case is difficult to judge since the underlying assumptions and their consequences (financial, social) are not clear. From an N point of view, and especially the N_r production and ammonia emissions, we might be coming up with RCPs different from the current ones. Establishing and elaborating the RCPs need to be given more attention from an N point of view.

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GLOBAL IGBP CHANGE International Geosphere-Biosphere Programme

NinE

INI International Nitrogen Initiative

Ministry of Infrastructure and the Environment

ECN Energy research Centre of the Netherlands