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Acidification interacting with global changes: research to manage drifting systems

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Abstract

A comparison is made between acidification and the climate change problems. The common cause and the variety of effects with an impact on many different ecosystems and aspects of society are discussed. A number of specific aspects of environmental pollution research are highlighted. For the Dutch Climate Change Program 1995-2000, a more system-oriented approach in stead of an effect-oriented approach is chosen. Research should determine the degrees of freedom the society has to manage these different systems.

1. Acidification and global change

Air pollution has many negative effects, both on our natural environment as on our health and well-being. Since the industrial revolution, fossil fuel has provided the energy for a spectacular improvement of human welfare. In the mean time, all combustion products were emitted to the atmosphere where they were supposed to infinitely dilute.

Certain emissions like dust and heavy metals, do not travel a long distance and have to be sanitated in an early stage. A number of compounds, like the acidifying ones, travel across the national border and international negotiations are needed to abate these emissions. Last but not least, the lightest gases like CO_2 and CH_4 travel around the world and still proved to have an impact on the emitting societies by influencing the climate system in different ways.

The major and common cause to both acidification and climate change is the *emission of fossil fuel combustion products* to the atmosphere. Besides, NH_3 emission from manure also causes acidification, and land cover change, e.g. in the tropics, causes climate change. The direct relation that exists between human welfare, energy consumption and air pollution, implies that all three increase exponentially and that a clean environment can only be achieved by adopting a less materialistic life style.

2. Emissions, effects and impact

By burning fossil fuel a variety of compounds are emitted: H_2O, CO_2, CO, SO_2, NO_x, VOC, etc. Each compound has a specific atmospheric chemistry, transport rate, residence time and thus dispersal over the globe and, finally, deposition rate.

A first category of effects of their deposition are of (bio-)chemical nature:
- acidification
- oxidation
- intoxication
- fertilisation

The second category has to do with the physics of the atmosphere:
- radiative forcing by reflection of the earth's emitting infra-red radiation back to earth, resulting in global warming (Houghton et al. 1992),
- regional cooling because of reflection of solar radiation by aerosols (Taylor & Penner 1994)
- absorption/transmittance of UV radiation (De Backer 1994)

These effects act on the earth and may induce *secondary effects*:
- sea level rise
- more frequent extreme weather (drought, heavy rain, storm, ...)
- large scale biotic feedbacks to the climate system because of increased nutrient levels (CO_2, N) and improved water efficiency (Goudriaan 1992).

All these effects have an impact on a wide variety of ecosystems that are of importance to man, and also directly on the human populations and societies. Ecosystems touched by these environmental changes are both terrestrial (forests, lakes, crop lands and non-woody systems like prairies, savannah, tundra, etc.) and marine (coastal shelf systems, open ocean, (ant-)arctic systems.

Human society is also directly touched by these effects. Health is threatened: respiratory problems by smog, loss of immunity and skin cancer by UV radiation, etc. Man's security against floods and extreme weather is endangered. On a global scale, also food security may be in danger. This may lead to migration and subsequent political instability.

A much greater variety of systems is subject to global change research than to acidification research. This also means that the available research funds are to be shared between much more disciplines.

3. Aspects of environmental pollution research

A number of aspects makes environmental pollution research particulary difficult, and should be considered when defining future research programmes on these problems.

As indicated above, the geographic scale of each pollutant and its effects may differ considerably. Consequently, there is a need for georeferenced modelling that can handle different scale levels or resolutions simultaneously (Alcamo et al. 1994, Leemans et al. 1994).

From a more conceptual point of view, there is a need to attain a higher level of aggregation.

The environment is permanently changing and adapted research methods are needed to study this "moving target". In most cases there is a lack of a reference state or control which underwent no treatment. Also modelling exercises are embarrassed by the permanent drift of the object of study, making validation difficult. Ecological sciences need to adapt their concepts to this situation.

The policy makers ask environmental scientists for predictions of future evolutions and possible damage or risk. This aspect of scanning the future often forces the scientist to pronounce his expert guess beyond the scientifically certain conclusions of his research work.

A last but major aspect of this kind of research is the complexity of the systems under study and the chaotic behaviour of these systems. Biosphere, atmosphere and hydrosphere have plenty of feedback mechanisms and multi-factor interactions which make single effect of single factors difficult to separate out. Non-linear relationships result in multi-equilibrium systems, difficult to model or predict.

4. Approach of NRP 1995-2000

Based on the experience gained in the first phase of NRP (1990-1994), the Dutch National Research Programme on Global Air Pollution and Climate Change, NRP, has chosen the following approach:

- from effect-oriented to system-oriented research
In the first phase many projects focussed on dose-effect relationships. Many climate variables may be considered and almost any system is sensitive to change of one of those. To concentrate research efforts on the problematic cases of climate change, we invited research proposals using a system-oriented approach by selecting a system under study, e.g. the Rhine river basin or the Wadden Sea, and then situating possible impact of climate change against other antropogenous changes affecting the system.

- assess the system's vulnerability and adaption capacity
Given the uncertainty and the lack of detail in the prediction of future climate, it is not desirable to consider the impact of only one possible scenario. By assessing the system's vulnerability to climate change, many possible future climate states are considered. At the same time the severity of the damage to the system or its eventual collapse is also assessed. Both natural systems and society are able to adapt to climate change and research should be focussed on adaption capacity and adaptation rates versus climate change rates.

- determine degrees of freedom to manage the drifting system
As the NRP is a policy oriented research programme, research is also invited in the domain of human induced adaptation. All the knowledge on foregoing aspects should be used for a wiser management of the environment for present and future generations.

5. Message for the acidification research community

I conclude that the environmental problem of acidification shows many interactions with global environmental changes such as climate change. To pick up the shift in public and policy maker interest towards global change, I suggest the research community the following:
- for atmospheric chemists and physicists:
Switch compounds and include all elements present in the atmosphere in the modelling work

- for stress ecologists:
Include the climate factors when studying plant and ecosystem response. Try to shift from plant to ecosystem level and even to biome level.

- for modellers:
Introduce a georeferenced framework in the modelling work. Solve the time and space scale problems. Apply a whole system approach and provide handles for management.

This conference addressed the question whether we have enough answers in the domain of acidification research?. After this overview of global change problems, one might ask: *Don't we have enough problems left?*

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