Nitrogen and Global Change - Preface

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Preface

"Nitrogen & Global Change"

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Human alteration of the nitrogen cycle represents a major driver of global environmental change. Since the invention, a century ago, of industrial methods to fix atmospheric dinitrogen (N_2), the production of reactive nitrogen (N_r) has roughly doubled at the global scale and tripled in Europe (Erisman et al., 2008; Galloway et al., 2008; Sutton et al., 2011a). The main use of this deliberate anthropogenic N_r production has been to produce fertilizers to increase crop production, allowing the world's human population to increase, as well as for people to eat richer diets, with a larger fraction of animal products.

In parallel, increased rates of fuel combustion have caused an additional inadvertent rise in anthropogenic N_r production and release to the atmosphere. This has especially been the result of greater use of high temperature combustion processes in vehicles, electricity generation and other industries, which oxidize atmospheric N_2 to nitrogen oxides (NO_x). In addition, low temperature combustion processes, from domestic burning of coal, wood, dung and burning of forests and other land, have led to an increase in both NO_x and ammonia (NH_3) emissions. Together with the emissions of N_r from agricultural systems in the form of NH_3, NO_x, nitrous oxide (N_2O), nitrates (NO_3) and many organic nitrogen forms, this human alteration of the nitrogen cycle is causing multiple effects on global change.

The consequences include pollution of air, soil and water, alteration of the climate balance and threats to biodiversity. While some policies have already been enacted in Europe and elsewhere, N_r pollution represents a still largely unsolved problem. Many details of the science remain uncertain, while levels of N_r pollution are causing major threats across Europe and other industrialized and agricultural areas of the world. The complexity is illustrated by the way in which N_r emissions alter climate balance. The recent European Nitrogen Assessment (ENA) estimates that N_r emissions may be having a net cooling effect on climate, as aerosol N_r effects and forest fertilization from atmospheric N_r deposition tend to outweigh the warming effects of N_2O emissions and the N_r contribtion to O_3 formation (Butterbach-Bahl et al., 2011). However, the cooling components of N_r have even bigger estimated societal costs than their climate benefits, as aerosols affect human health and N_r deposition threatens biodiversity. Overall, the ENA estimates a societal damage cost of between 70 billion to 320 billion per year across the European Union (Brink et al., 2011; Sutton et al., 2011c). Even from this limited set of interactions, it is clear that human alteration of the nitrogen cycle is a highly complex issue, with major economic consequences. Advances in the underlying science are needed using new measurement methods and models, as a basis to

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inform policies that maximize the intended benefits of N_r, while minimizing its environmental threats.

These issues have been addressed by concerted efforts in Europe over the last 5 years, as a number of projects have contributed to the global ambitions of the International Nitrogen Initiative (INI), a joint project under the International Geosphere Biosphere Programme (IGBP) and the Scientific Committee on Problems of the Environment (SCOPE). The European collaboration has linked closely to the efforts of the NitroEurope Integrated Project, a consortium of 62 institutes funded by the European Union 6th Framework Programme to examine the effect of nitrogen on the European greenhouse gas balance (Sutton et al., 2007, 2011b). Several of the outcomes have already been reported in earlier special issues (Reis et al., 2009; Beier et al., 2010; Ambus et al., 2011).

In order to increase the scientific scope, NitroEurope has worked closely with the Nitrogen in Europe (NinE) framework networking programme of the European Science Foundation (Bleeker et al., 2008), allowing an increased focus on interactions with biodiversity, water quality, policy and economic issues. In parallel, the COST Action 729, "Assessing nitrogen fluxes in the atmosphere biosphere system", has added to the critical mass through workshops to stimulate collaborative activities, including a major focus on the interaction between nitrogen deposition and the Natura 2000 network, protected under the EU Habitats Directive (Hicks et al., 2011; Bleeker and Erisman, 2011).

These combined efforts have come to fruition in the presentations and discussions at the international science conference *Nitrogen & Global Change* (NEU, 2011), held in Edinburgh from 11–15 April, 2011. The conference launched the European Nitrogen Assessment, including the key messages (Sutton et al., 2011a, b), with an emphasis on improving public awareness of the nitrogen (see NinE, 2011, plus numerous press reports).

This special issue now reports the detail of the scientific findings discussed at the *Nitrogen and Global Change* conference. The papers discuss key aspects of N_r in the environment, including – but not limited to – the relevance of nitrogen for climate change and air quality, for food and energy security and for biodiversity and ecosystem health. While the focus is on Europe and terrestrial ecosystems, papers addressing issues from other parts of the world are represented, as well as contributions discussing the role of nitrogen in freshwater and marine environments. The submitted papers under discussion here in *Biogeosciences* thus reflect the full breadth of societal challenges related to human perturbation of the nitrogen cycle. As will be seen, the contributions are also broad in nature, covering the full suite of approaches, from measurement and modelling techniques, process understanding, temporal and spatial upscaling, to analysis of policy options and N_r biogeochemistry-economic interactions.

Finally, in addition to this special issue and the other products, the conference agreed "The Edinburgh Declaration on Reactive Nitrogen" (Nitrogen and Global Change Conference, 2011). This short statement highlights the need for further scientific efforts to understand the ways in which nitrogen is both causing global change and being impacted by it. At the same time, it illustrates how continued integration between disciplines – a key theme of this special issue – will be essential to develop future solutions at local, European and global scales.

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