Nitrogen budget in South America: observation and modeling

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Abstract
This paper, mirrored in the project report, presents a regional initiative, in South America, which aims to synthesize scientific information, acquire new data and informing the policy processes on the nitrogen budget and nutrient management in a broad region. The goal of this network is to examine human impact in natural and modified ecosystems across a wide range of climates, and ranging from direct measurements to regional modeling. The up-scaling of local nitrogen studies aims to constrain regional atmospheric chemistry and transport modeling, feeding global models, greatly enhancing our understanding of global patterns of alterations to the nitrogen cycle. In the study sites, defined according to physiographic and/or socio-economic attributes, the following inputs and outputs of nitrogen are being reviewed and analyzed: (i) Inputs: Natural-BNF and cultivation induced-BNF, fertilizer use, atmospheric deposition; (ii) Outputs: Net exports of agricultural products at regional level and estimates at site scale of gaseous emissions from land use (fertilizer volatilization, biogenic soil emissions and burning) and export of N to groundwater and surface waste (domestic, agricultural and industrial).

Key Words
Modelling, Agriculture, Nitrogen Deposition, Nitrogen biological fixation

Introduction
The network's ultimate goal is to have an integrated view of nitrogen management in the environment, maximizing N essential role in sustaining life and minimizing its environmental effects for Latin America. Some papers along these lines were published in the past year and will be outlined in this paper.

Results and Discussion
Soybean is one of the major crops been planned, usually in monocultures in the region. Crop rotations have been strongly suggested to replace soybean monocultures. Nitrogen fixation by soybean and other crops in the rotation have been scarcely studied under field conditions in the region. Natural abundance of nitrogen stable isotopes allow estimating nitrogen fixation with good accuracy. The concern with the expansion of soy in Bolivia is related to the extent of the expansion, the projected increase in fertilizer use in the next 10 years, and the degradation of soils in Bolivia. This work is a way of at determining the potential impact that the current agricultural practices could be having on nitrogen in waterways and what the impact could look like 10 years or 30 years into the future under current government plans to massively increase industrial scale agricultural activities.

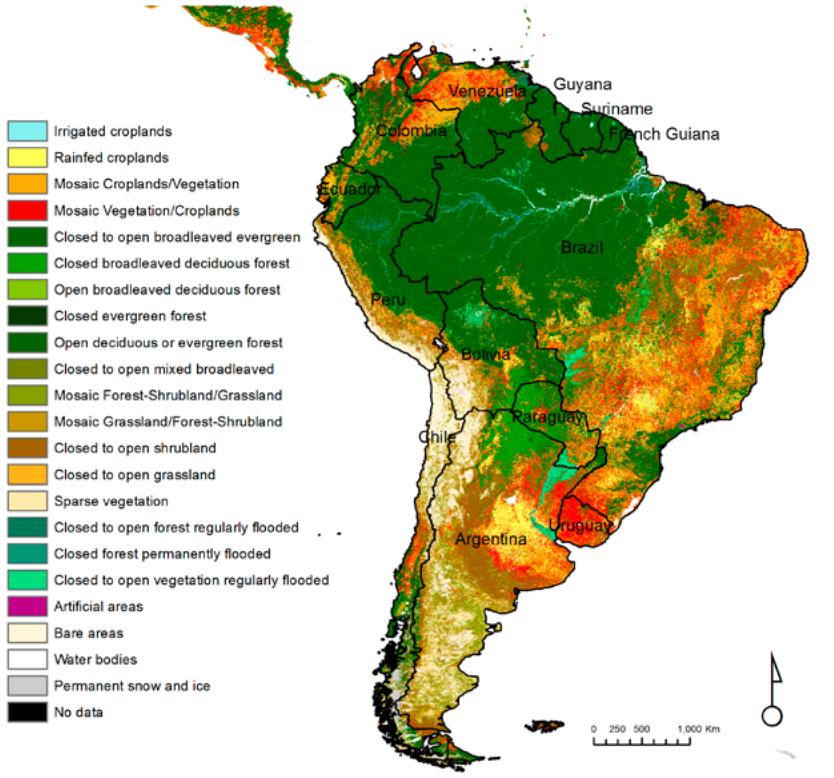


Figure 1. Land conver in South America (source: Pacheco, P. CIFOR, 2012)

Concerning the BNF the project group is working on systematize published information, promoting capacity building by interacting with students from the region on producing the data sets and attending workshop, adding new information from sampling sites within the network and consolidating information for publication. This was only possible due to the opportunity provided by the CRN3.

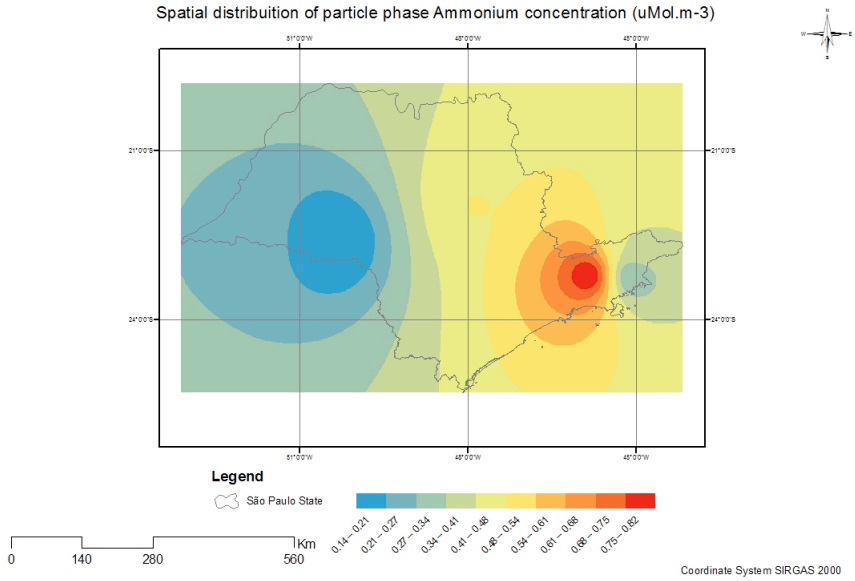
In relation to the depositions studies, it is critical to state that do not measure reactive nitrogen deposition directly, we do measure concentrations and these measurement have been scattered throughout Latin America. The studies use bulk and wet-only collectors in several sites. Within our network concept, we are setting all possible rainfall sites and advancing on having common sampling protocol. Ideally, we would have a deposition network based on NADP (US National Atmospheric Deposition Program) wet-only collector, however the costs are impractical. We designed, and are starting to use, wet-only collectors built in different institutions (e.g., in Argentina and Brazil) and having the official NADP collector to calibrate the ones built in our network. The information exchange with the NADP/NOAA group allowed us to look toward a common sampling protocol selecting the best sampler. Regarding the chemical analyses the protocols used are the ones recommended by the environmental agencies or international laboratory inter-calibration program such as QA/SAC-Americas.

Measuring gas-particle in atmosphere is more complex than collecting rainwater. Within the Nnet, a gas-particle measurement network is being established (as observed in the attached document) using the same protocols (sampler and chemical analyses). In this case, we adopted protocol used by the United Kingdom (DELTA System, Mark Sutton, Centre for Ecology & Hydrology; Sutton et al, 2007). We already have pilot network implemented successfully at São Paulo state (this is why we have a larger gas-particle sites network in this region). This is a partner initiative funded by FAPESP. This component of our project includes: (i) support to our collaborators to install a site for gas-particle measurement; (ii) capacity building through training activities on installing and system operation; although the infrastructure for these sites is simple, it requires special attention for the denuders and filters preparation and analysis and we cannot implement all at once.

The deposition is being calculated from the atmospheric concentration data (rainfall and gas-particle) with the proposed model, from which a map with the deposition values over the continent will be generate. This

spatial distribution of atmospheric reactive N deposition will be overlapped with the regional BNF interpolated map. A conceptual model based on the information generated by this spacialized analysis shall indicate the regional situation of the Ncycle regions with excess or shortage of Nr and its social and economic implications (in special related to agriculture demand and N pollution status of land and water bodies).

Figure 2. First results on ammonium gas phase concentration over the state of Sao Paulo, Brazil

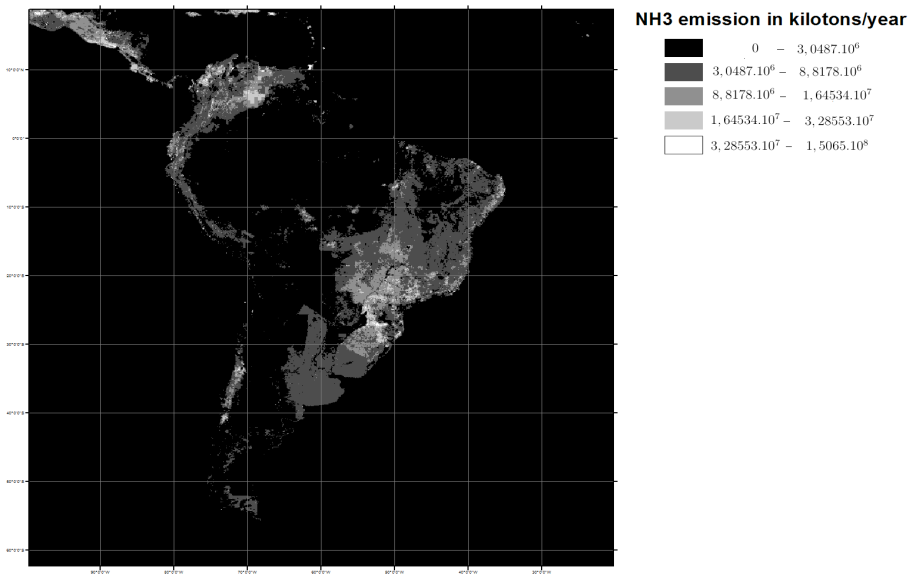


Also, N deposition rates of NO_3^-, SO_4^{2-}, and NH_4^+ gases and K^+, Na^+, Mg^{2+}, Ca^{2+}, NH_4^+, Cl^-, NO_3^- and SO_4^{2-} particles, all relevant to the N-cycle, will be calculated from the regionally measured data and will replace the standard deposition velocities described in the EURAD-IM model as part of the regionalization of the model to South America. Sensitivity tests of model simulations with the standard model deposition velocities of these species and regionalized adapted deposition velocities will be performed. Once the final deposition velocities are mapped for the region, based on the Nnet project's available observational data they will be extremely useful for future global modeling studies that seek to better understand the impact of South American N deposition on other region's N atmospheric concentrations.

The EURAD-IM modeling system is currently being adapted for South America, with special attention to improvement of emission inventories and deposition rates. The model system includes an advanced data assimilation routine that will help to improve simulations by introducing available observations directly into the model in the future. Presently, results for South America and a close-up over the state of São Paulo were included into the report, as observational data from the Nnet-framwork is becoming available to evaluate the model results. In future Nnet project modeling activities other regions containing observational data will gain more attention.

Emission data for South America are provided by different organizations in different data formats. For this work the emission data provided by the EDGAR inventory is used. The emission data consists in information on country code, year, Selected Nomenclature for Air Pollution (called SNAP), species, geographic coordinates, height, units, emission values and the grid structure.

Figure 3. NH3 emission, modeled with Eurad-Model (Source Silva C and Hoelzemann J)



The emissions are calculated for the different substances, such as direct greenhouse gases, ozone precursor gases, acidifying gases, primary particulates and stratospheric ozone depleting substances. For the calculation of emissions a technology based emission factor approach (compared to an average emission factor approach), spatial allocation of emissions to 0.1 degree grid cells and availability of annual emissions data is being used.

Conclusions

Lack of observational data, both historical or in representative spatial distribution, is the main obstacle to improve our understanding on continental scale N cycle in Latin America. This issue should be tackle in an integrated and interdisciplinary way, once nitrogen transposes boundaries of the biogeochemical world. Relevant social/economical questions are related to pollution of surface and ground water (due to untreated sewage dumped in surface waters and fertilizers leached to ground water), and also uneven distribution of fertilizer and the balance between food and biomass production.

References

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