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Editorial: Terrestrial Ecosystem Nitrogen Fluxes *via* the Atmosphere-Land System

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Editorial:

Terrestrial Ecosystem Nitrogen Fluxes via the Atmosphere-Land System

Increased Nitrogen (N) deposition associated with industrial activities, construction, vehicle emissions and agricultural practices has contributed to the acidification of terrestrial ecosystems and has been related to adverse effects on forests, and soil condition worldwide (Norton et al., 2004; De Schrijver et al., 2006; Galloway et al., 2014). Although in recent decades atmospheric concentrations of major anthropogenic air pollutants have greatly decreased due to emission abatement policy in Europe and North America, mitigation strategies have not been equally effective with reactive N and the over-emission of N to the environment is still an unsolved problem (García-Gómez et al., 2014). Anthropogenic disturbance of the global N cycle has more than doubled the amount of reactive N circulating in the terrestrial biosphere. Despite the positive effect of N as an essential macro-nutrient on plant growth rates, a potentially toxic effect at sites with high N deposition has been recognized at a continental scale in Europe (Etzold et al., 2020). Exceedance of N input can increase both the risk of groundwater contamination due to elevated nitrate leaching from soil (Rabalais, 2002; Cecchini et al., 2021) and the extent of N_2O soil emissions, a powerful greenhouse gas (Crutzen et al., 2008). Other consequences of excessive reactive N compounds in the environment are polluted air, depleted soil quality, and reduced ecosystem functioning and biodiversity (Aber et al., 1998; Fenn et al., 1998).

Disentangling the complexities of N transformations and transport is of interest to understand the cause-effect mechanisms that determine changes in its fluxes through the atmosphere-land system. The awareness of the reductionisms of "simple" predictive models has boosted research activity in measuring and modeling the open system extending from the top of the canopy to the base of groundwater, using a large range of explanatory factors and their interactions at various temporal and spatial scales.

In this general context, the present Research Topic (RT) was launched with the purpose to provide an opportunity to integrate studies from different background knowledge and expertise with the aim of capturing the complexity and tracking the fluxes of N across the atmosphere-soil system. The RT seeks to improve our understanding of how the intensification of reactive N affects the pools and fluxes of N in the terrestrial ecosystem. We especially encouraged studies from underrepresented areas in literature such as the Mediterranean Basin and Tropical and Subtropical areas to enlarge our comprehension of N fate in environments within different deposition loads and climate conditions (Gerosa et al., 2009; Lequy et al., 2012; Cecchini et al., 2019).

The RT was intended to attract articles describing:

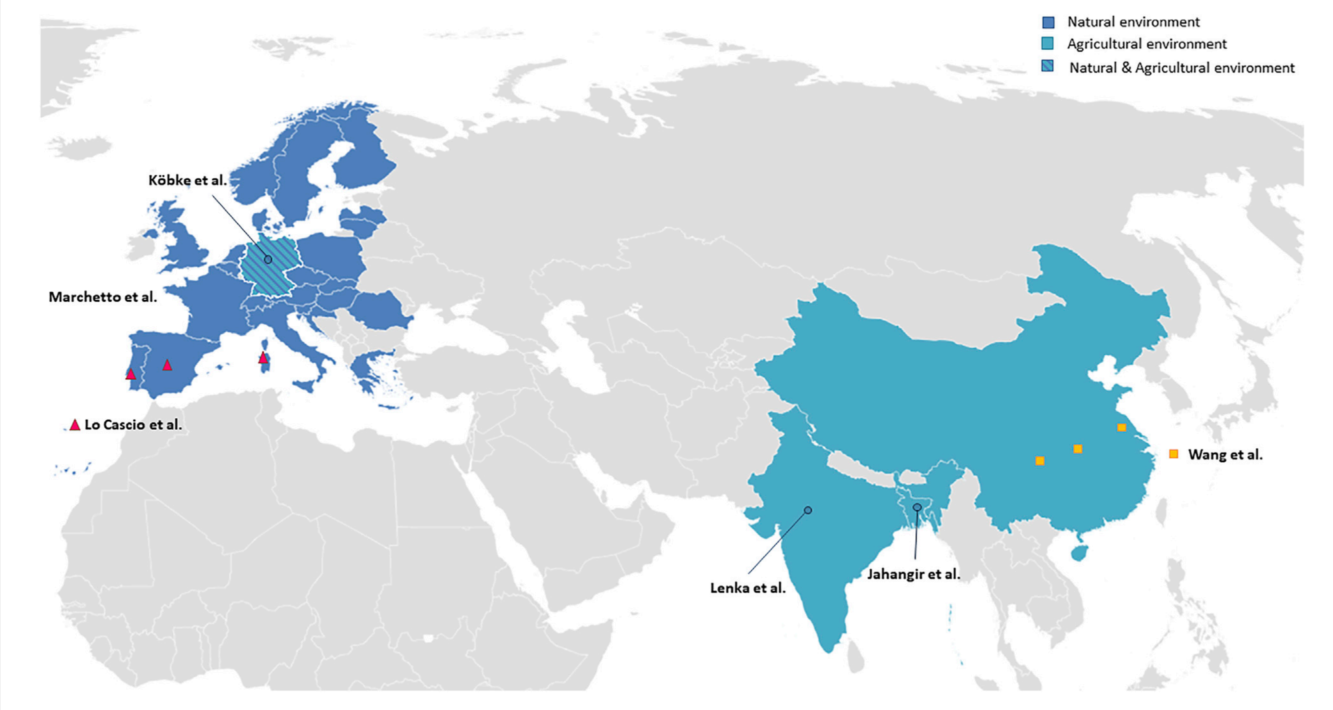

FIGURE 1 | Geographical distribution of contributions in the Research Topic.

- Long time series of measurements on deposition, nutrient bioavailability and soil properties.
- Experimental and modeling approaches that cover microbes-mediated and physico-chemical transformations.
- Measuring and modeling of terrestrial water and N fluxes across the air-land continuum from local to global scales.
- Interactions of N with other elemental cycles

The six articles that constitute this RT describe original research. Two of them deal with natural environments, while the other four focus on agricultural practices (**Figure 1**). Among the natural-oriented ones, Lo Cascio et al. used a network of long-term N addition experimental sites in the Mediterranean Basin to assess the effects of N addition on ecosystem properties associated with litter decomposition, soil physical-chemical properties, soil extracellular enzymatic activity and microbial abundance. Although all sites were representative of Mediterranean shrublands, they showed a wide range of values for soil parameters. This heterogeneity overruled the effect of the supplied N suggesting that the responses of soil functioning to N deposition are site-dependent and contributing to explain contrasting ecosystem responses to N additions based on single field experiments.

Field experiments are crucial not only for direct observation of N fluxes and effects, but also to feed and validate models. Marchetto et al. compared sulphur and N deposition estimates obtained using a Eulerian model (EMEP MSC-W) with the measurements performed by two large independent networks covering most of Europe, the EMEP and the ICP Forests monitoring networks. Authors found a good agreement between modeled and measured depositions on a continental scale confirming the suitability of models for estimating general patterns and trends in deposition. However, despite the improved accuracy of these estimates in recent years, local measurements and calculations of deposition are still required when more precise estimates are needed.

Agricultural practices are one of the main causes of water and soil contamination. Conservation agriculture has been proposed as a tool to increase soil organic matter and reduce soil erosion. Jahangir et al. investigated if these new technologies applied to wetland rice production may mitigate greenhouse gas emissions. They found that the adoption of conservation agriculture with high and low residue levels reduced CH_4 and N_2O emissions respect the current management practices, pointing at the need to deepen our knowledge in the field. N_2O emission was also tested by Lenka et al. in response to crop residue return, focusing on the role of crop residue type, soil moisture and nutrient management in Vertisol of subtropical India. The results suggested that nutrient addition could modulate magnitude and direction of soil N_2O flux, possibly through influencing the underlying soil microbial processes of the carbon and N cycle. Deepening into the N fluxes through soil-atmosphere, Köbke et al. performed a 2-years field experiment to identify the regulating factors of N cycling with emphasis on N_2O emissions during the post-harvest period. In agreement with Lenka et al., they found that soil moisture, precipitation, and high temperature are relevant factors for N_2O production even under field conditions.

Improving N fertilizer use efficiency is another relevant facet of N impact reduction. Wang et al. carried on research in the Yangtze River Basin to test the effects of reduced and more efficient fertilizer inputs on crop yields. The authors found that a 50% reduction of the N applied to wheat and vegetables maintained the wheat yields in two out of three sites analyzed. However, agricultural infrastructure and management had substantial effects on the yield suggesting that multiple factors must be considered to optimize the production system.

Globally, the RT points out the importance to take into consideration the effects of multiple biotic/abiotic factors, multi-year experiments, climatic variables, and climate change on the agricultural systems to implement more efficient agricultural practices and mitigation strategies.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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