Anticipation of research development on the atmosphere-land interactions of the terrestrial nitrogen cycle

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The Haber–Bosch process established in the early 20th century enables artificial creations of ammonia (NH_3) from dinitrogen (N_2). Artificially created reactive nitrogen (Nr: nitrogen species other than N_2) from NH_3 as the commencing material provides great benefits for human, ca. 80% of which is used for chemical fertilizer of crop production. The enhanced capacity of crop production has also increased livestock production providing feed crops, and then fed the global population growth since the 20th century. However, the nitrogen use efficiency of food production is low, that is, ca. 50% and 10% for crop and livestock production, respectively, as global mean. The remain is eventually lost to the environment as Nr and N_2. The Nr lost to the environment moves over the environmental media changing its physicochemical forms and provides a variety of effects according to its properties such as global warming, ozone destruction, air pollution, water pollution, eutrophication, and acidification until finally converted to N_2 again, which is known as the nitrogen cascade. Thus, the nitrogen use by human is a tradeoff between the benefit as fertilizer to earn food and the threat as various environmental impacts, which is called as the nitrogen issue. To cope with the nitrogen issue, quantitative information of Nr flows between human sector and environmental media and that within the environment is indispensable.
Hereafter the topic is narrowed into the Nr impacts on terrestrial ecosystems. There are various and active exchange processes of nitrogen between land and the atmosphere, even involving the inert N_2. For example, biological nitrogen fixation (BNF) and nitrogen deposition (wet and dry deposition of Nr) are key fluxes from the atmosphere to land, and gas emissions with denitrification (N_2 and nitrous oxide [N_2O]), NH_3 volatilization, and gas and particle emissions with wildfire are key fluxes from the land surface to the atmosphere. The N_2 flows with BNF and denitrification are large in quantity, and the Nr flows with nitrogen deposition, NH_3 volatilization, and N_2O emissions are particularly important in terms of environmental impact.
Numerical model and satellite remote sensing are advantageous to grasp the atmosphere–land exchanges of nitrogen in regional and global scales. Flux observation research at the ground surface has an important role that provides verification data to model and remote sensing research. The observation research is further indispensable for elucidating unknown mechanisms of nitrogen cycling in terrestrial ecosystems. Regular monitoring networks of atmospheric deposition are relatively common, whereas only accumulated respective studies are available for other processes. A wide-area expansion of nitrogen exchange observation research in collaboration with model and satellite sensing research has not been realized yet. In this presentation, cropland N_2O emissions are highlighted with particular interest. According to the Global N_2O Budgets (Tian et al., 2020), agricultural land is the biggest anthropogenic emitter of N_2O accounting for 52% from 2007 to 2016 on average, and its emissions have been increasing in contrast with the decreasing trends in other anthropogenic sources. Considering that the world population and food demand will continuously increase, it is required that effective measures to reduce the agricultural N_2O emissions are introduced and their effects are evaluated correctly. Furthermore, the effects of increased atmospheric CO_2 levels and climate change on the nitrogen cycle and N_2O emissions are unknown. Observational research is an important approach that brings flux data and elucidation of the mechanism. Therefore, in this presentation, the presenter will show an idea of efficiently developing observational research on N_2O. It is hoped that a chance for its realization will be created though discussion with participants.

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