4–9 Mechanism of Greenhouse Gas Emission from Rice Paddy

— Simulation of Atmospheric Ammonia Exchange Using the Land Surface Model for Transport of Radioactive Materials —

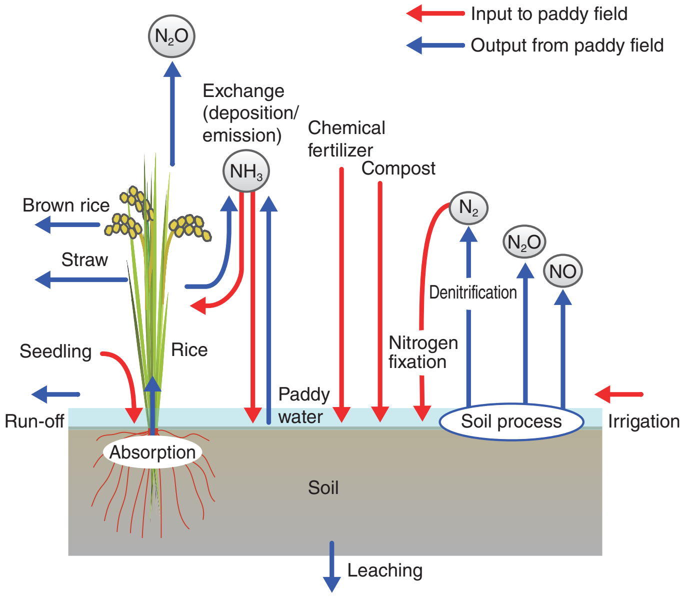

Fig.4-21 Nitrogen cycling at rice paddy
Greenhouse gases, such as nitrous oxide, relate to various processes. Bidirectional NH_3 exchange (deposition and emission) between the atmosphere and the rice paddy is hard to accurately be quantified.

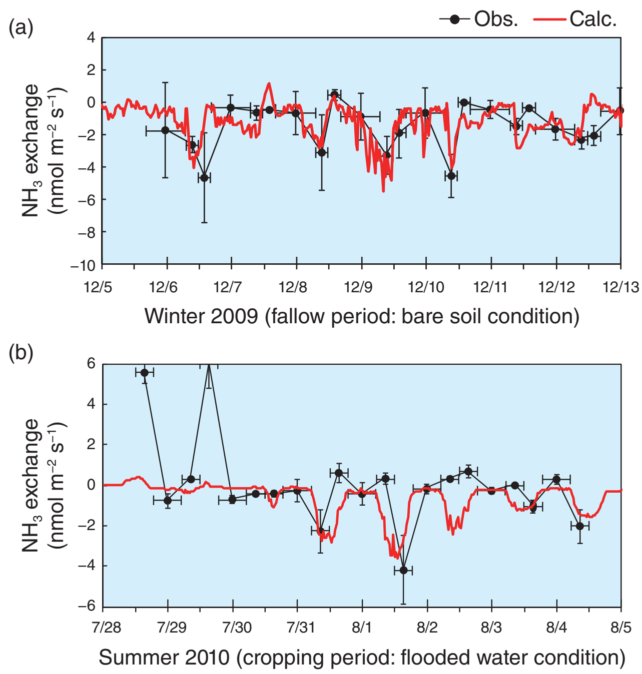

Fig.4-22 SOLVEG simulation of NH_3 exchange over rice paddy (a) during fallow period and (b) cropping period
Upon incorporating NH_3 exchange process into SOLVEG, the model reproduced the dynamics observed in NH_3 exchange (positive: emission, negative: deposition) between the atmosphere and the rice paddy.

To develop the model for various environmental material-transport studies, we applied the SOLVEG (Multi-layer Atmosphere-SOiL-VEGetation Model) to those studies, which is the land surface model for prediction of radioactive materials transfer between atmosphere and land surface. In the present study and in cooperation with National Institute for Agro-Environmental Sciences, Japan, we newly modeled ammonia (NH_3) exchange process above rice paddy fields.

Rice paddies are not only the major arable ecosystems providing the staple food in Asia, but also substantial sources of greenhouse gases such as nitrous oxide (N_2O). The emission of greenhouse depends on complicated processes of nitrogen cycling between the atmosphere, rice paddies and soil (Fig.4-21). NH_3 in the atmosphere above paddy fields is absorbed by the stomata of rice foliage and/or is dissolved by paddy water (NH_3 deposition). However, NH_3 is often emitted from the paddy when nitrogen fertilizer is provided (NH_3 emission). The accurate estimate of this bidirectional NH_3 exchange (the difference between NH_3 emission and deposition) is not straightforward and remains a key issue in the prediction of the greenhouse gas emission from rice paddies.

Hence, we developed new modules for SOLVEG to predict the paddy water temperature and the NH_3 concentrations in the foliage and at the surface of paddy water or soil. The modified SOLVEG model reproduced the observed NH_3 exchange rate at the Mase rice paddy site in Ibaraki, Japan (Fig.4-22). We also investigated how amount of NH_3 is exchanged during rice growth. The result revealed that the recapture by the foliage of NH_3 from the surface of the paddy water (NH_3 recapture) tends to increase with rice growth. Once maturity is reached, most volatilized NH_3 is recaptured in rice canopies and no longer transfers to the atmosphere. By allowing the reduction of the vaporization loss of NH_3 to the atmosphere, this result is useful for managing supplemental fertilization of rice paddies.

The present study was partly supported by Japan Society for the Promotion of Science (JSPS) KAKENHI Grant-in-Aid for Scientific Research (A) (No.22248026).

Reference

Katata, G. et al., Coupling Atmospheric Ammonia Exchange Process over a Rice Paddy Field with a Multi-Layer Atmosphere-Soil-Vegetation Model, Agricultural and Forest Meteorology, vol.180, 2013, p.1-21.