学 位 論 文 内 容 の 要 旨

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A Study on Process-based Modeling of Monoterpene Emission from Terrestrial Ecosystem
（陸域生態系からのモノテルペン排出量のプロセスベースモデルによる推定）

Globally, the emission of biogenic volatile organic compounds (BVOC) by plants represents the dominant source of volatile organic compounds emitted to the atmosphere. Monoterpenes, as the major BVOC group, can contribute to forming secondary organic aerosols and influence cloud properties. In this study, we developed a process-based monoterpene module in the Vegetation Integrative SImulator for Trace gases (VISIT) model by considering monoterpene production, storage, and emission as three main processes. We further evaluated the modeled monoterpene emissions against the ecosystem-level observation data at a half-hour scale at a Japanese larch (*Larix kaempferi*) forest site on Mt. Fuji, Japan. The VISIT model performed with relatively higher accuracy with Willmott's index of agreement at 0.61, a mean bias error (MBE) at 0.29, and a root mean squared error (RMSE) at 0.43, comparable to that of the Model of Emissions of Gases and Aerosols from Nature (MEGAN) model with Willmott's index of agreement at 0.63, a MBE at 0.40, and a RMSE at 0.54. In a long-term simulation under high CO_2 emission scenarios, the ratio between monoterpene emission and gross primary production strongly correlated with CO_2 concentration than temperature. This study provides a process-based modeling approach for more accurately simulating monoterpene emissions from Japanese larch.

Monoterpene emissions from litter contribute significantly to BVOC from the

soil layer, influencing atmospheric chemistry and ecosystem-climate interactions. However, the mechanisms and drivers of litter BVOC emissions remain poorly quantified in terrestrial ecosystem models. This study integrates laboratory-measured, in-situ observational data, for the boreal forest (Scots pine and Norway spruce) at Norunda and Hyltemossa sites and the process-based Lund–Potsdam–Jena General Ecosystem Simulator (LPJ-GUESS) model to calibrate and evaluate litter MT emissions module. We parameterized the model using observed MT emission rates from decomposition experiments and storage-based emission processes, incorporating environmental controls such as temperature and moisture. The model results are well reproduced and aligned with monthly observed MT observation results, with a weighted root mean square error (wRMSE) of 0.74 μg m^{-2} h^{-2}, a weighted mean absolute error (wMAE) of 0.59 μg m^{-2} h^{-2}, and a weighted relative root mean square error (wrRMSE) of 9.72%. In addition, modeling results show litter contributes 0.47% to 1.42% of the ecosystem-level monoterpene emission. Despite the achievement of modeling, uncertainties persist regarding the role of litter quality and soil organic matter dynamics in shaping emissions.

Overall, this thesis underscores the importance of integrating observational datasets with process-based models to enhance the predictive accuracy of BVOC emissions. It offers critical insights into their representation in Earth System Models (ESMs) and improves understanding of their role in global carbon and climate feedback.