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学 位 論 文 審 査 の 要 旨

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学 位 論 文 題 名

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）

This doctoral thesis consists of 4 chapters, including 68 pages, 18 figures (including 2 figures in appendix), 4 tables (including 1 table in appendix) based on 1 reference paper. This study aims to improve the representation of monoterpene (MT) emissions from both vegetation and litter in terrestrial ecosystem models by integrating these processes into a modeling framework. It is divided into two main sections: (1) modeling MT emissions from vegetation using the Vegetation Integrative SImulator for Trace gases (VISIT) model, focusing on simulating emissions at a half-hourly scale, assessing their sensitivity to environmental conditions, and evaluating future climate impacts in a Japanese larch forest ecosystem; and (2) modeling MT emissions from litter within the Lund–Potsdam–Jena General Ecosystem Simulator (LPJ-GUESS) framework, incorporating laboratory and site-based observations to quantify litter emission capacity, analyze its dependence on temperature and moisture, and link it to vegetation and soil biogeochemical processes.

This study develops and evaluates process-based models to improve the simulation of MT emissions from vegetation and litter. A module for vegetation-derived MT emission simulation was implemented in the VISIT model, incorporating production, storage, and emission processes. The model was evaluated based on the observational data from a Japanese larch forest and demonstrated comparable performance to an existing emission model. Long-term simulations revealed that MT emissions were more strongly influenced by CO_2 concentration than temperature under high-emission CO_2 scenarios.

Additionally, the study integrated observational data from boreal forest sites with the LPJ-GUESS model to simulate litter-derived monoterpene emissions. By incorporating environmental factors such as temperature and moisture, the model effectively captured seasonal variations in emissions. Results indicated that litter contributes a small but non-negligible fraction of ecosystem-level MT emissions. Despite improvements in model accuracy, uncertainties remain regarding the role of litter quality and soil organic matter dynamics. This research underscores the importance of integrating observational data with process-based models to enhance the representation of BVOC emissions in Earth System Models.

Chapter 1 illustrates the development of modeling BVOCs emission processes from both vegetation and soil, emphasizing their role in atmospheric chemistry and climate interactions. Vegetation BVOC emissions, influenced by environmental factors, are commonly modeled using empirical and process-based approaches to predict their impact under future climate scenarios. While soil BVOC emissions are less studied, they play a significant role in ecosystem interactions, microbial processes, and atmospheric composition. Understanding and integrating both vegetation and soil BVOC emissions into terrestrial models is essential for improving predictions of climate-ecosystem feedback.

Chapter 2 presents the simulation of MT emissions at the Fuji Hokuroku (FHK) site using the VISIT model, comparing it with The Model of Emissions of Gases and Aerosols from Nature (MEGAN) to assess performance. The VISIT model was enhanced with an MT emission module incorporating production, storage, and release processes. Model calibration optimized vegetation parameters and storage dynamics, achieving realistic ecosystem activity indicators, and MT emission trends. Compared to MEGAN, VISIT better captured seasonal and diurnal variations. Future projections (2015–2100) using the sixth version of the Model for Interdisciplinary Research on Climate dataset (MIROC6) climate data suggest that MT emissions are influenced by temperature, photosynthetic activity, and CO_2 levels, providing insights into BVOC-climate feedback mechanisms.

Chapter 3 investigates MT emissions from litter in Swedish forests, focusing on the Norunda and Hyltemossa sites. Using flux-based measurements and litterfall data, it models (by LPJ-GUESS) MT emissions through microbial-decomposition-based and storage-based MT emissions. The study develops a process-based model that incorporates temperature, moisture, and biochemical factors, yielding a good match to observed emissions. Key findings highlight the influence of litter quality, temperature, and water content on MT emission dynamics, with temperature and moisture showing significant impacts on the emission rates. The results suggest that the litter contribution to MT emissions is highly dependent on water conditions in soil.

Chapter 4 summarizes the thesis, which focuses on process-based modeling of M) emissions in forest ecosystems. The thesis improves the VISIT model to simulate MT emissions from a Japanese larch forest, emphasizing the role of temperature and CO_2. Moreover, this study explores litter-derived MT emissions in Swedish boreal forests, highlighting the need for further research into litter quality and vegetation dynamics. This thesis demonstrates the value of combining models with observational data to better understand BVOC emissions and predict future ecosystem-atmosphere interactions.

Overall, this doctoral thesis presents significant advancements in process-based modeling of monoterpene emissions from vegetation and litter, integrating observational data with ecosystem models to improve the representation of BVOC emissions and enhance predictions of future climate-ecosystem interactions.

よって，審査員一同は，陳　展 灼が博士（食資源）の学位を受けるのに十分な資格を有するものと認めた。