平成２８年度　環境科学院　修士論文内容の要旨

Spatial modelling of Mongolian permafrost using statistical and stochastic approaches

（モンゴルにおける統計的及び確率論的手法を用いた永久凍土の空間分布モデリング）

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Introduction

The permafrost occurrences in Mongolia, the southern fringe of the Siberian permafrost, are highly dependent on the diverse local geographic factors such as elevation, slope orientation and aspect, soil wetness and types of land cover. The conventional permafrost map published by the International Permafrost Association has many issues on understanding permafrost states, since this map shows areal extent of permafrost in very rough and less quantified forms (i.e., continuous, discontinuous and sporadic), so that this map still remains ambiguities in understanding concurrent and future states of permafrost and regional ecosystem services over permafrost. This study aims to evaluate statistical correlations between the permafrost states (temperature and probability of permafrost existence) and local geographic factors, and to generate permafrost maps in more quantified, detailed and diverse forms.

Study areas and methods

The study areas are Altai Mountains, sporadic to continuous permafrost zones, Hovsgol area, continuous permafrost, and Khangai Mountains, sporadic to continuous permafrost zones. The analytical methods used are statistical and stochastic approaches, in which multiple explanatory and objective variables are correlated quantitatively. As the objective variables 1m-deep ground temperatures, which reflect the occurrences of deeper permafrost, were measured at 56, 57 and 68 points in Altai Mountains, Hovsgol Area and Khangai Mountains, respectively, in summers, 2012, 2015 and 2016. The explanatory variables were taken from digital elevation model for estimating topographic parameters, Landsat OLI/TIRS image for calculating NDVI (Normal Difference Vegetation Index) and ESACCI (European Space Agency Climate Change Initiative) land cover datasets for categorizing land cover types. Multiple regression analysis correlated 1m-deep ground temperatures with multiple geographical factors. The best model for each study areas was selected through step-wise model reduction method. Probability of permafrost existence was evaluated by logistic regression analysis, in which the objective variables at 1m-deep ground temperature measurement points were categorized into either permafrost presence or absence on the basis of threshold values estimated by referring to deeper ground temperatures at other sites. The best combination of explanatory variables was determined by step-wise method and nonparametric test.

Result and discussion

The multiple regression analysis found that the elevation primarily determines the ground temperatures in Altai and Khangai Mountains. In Khangai Mountains, the potential solar radiation and topographic wetness were also significantly correlated with ground temperature. On the other hand, the land cover types such as presence of forest cover, pasture and mosaic cropland, and latitude were equivalently important factors determining ground temperature in Hovsgol area. The logistic regression analysis achieved excellent discriminations (Area Under the Receiver-Operating Characteristic > 0.8) and revealed that the permafrost probabilities were directly correlated with elevation and NDVI in Altai Mountains, and elevation and forest cover in Khangai Mountains. Meanwhile, presence of pasture, topographic wetness and latitude were the most important factors governing permafrost existence in Hovsgol area.

The regional maps showing distribution of 1m-deep ground temperature and permafrost probability for three areas are all with sufficient statistical significance and high spatial resolution, potentially providing much information on permafrost states and ecosystem services over permafrost.