

Research on Surface Fuel Moisture Content Retrieval Model Based on Satellite Remote Sensing and Machine Learning

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Abstract: Forest fires are significant natural disasters worldwide, causing severe impacts on the ecological environment and socioeconomic development. Accurate prediction of forest fire risk levels and timely implementation of effective measures are crucial for preventing forest fires and ensuring ecological security. Traditional forest fire warning systems primarily rely on meteorological factors, neglecting the critical factor of fuel moisture content, resulting in limited warning accuracy. This study leverages machine learning algorithms and satellite remote sensing data to invert the surface dead fine fuel moisture content, exploring a more precise forest fire warning method. The research findings indicate: (1) Four machine learning models (Linear Regression, Random Forest, Convolutional Neural Network, XGBoost) were employed to construct a surface dead fine fuel moisture content (DFFMC) inversion model. Model training results demonstrate that the XGBoost model performs best, with an R^2 of 0.8228, MAE of 0.0613, and RMSE of 0.0845. (2) Ground validation of the model was conducted by comparing the inverted DFFMC data with real-world measurements from 10 validation sites in the Greater Khingan Mountains. The results show that the XGBoost model exhibits a good fit across different sites, with an average R^2 of 0.6178, surpassing other machine learning models. (3) A daily DFFMC dataset for the Greater Khingan Mountains region was constructed by integrating SMAP soil moisture data, EAR5 meteorological data, and the XGBoost model. This dataset can be utilized in forest fire warning systems, providing vital data support for fire prevention and control. This study provides an effective method and technical support for inverting DFFMC based on microwave remote sensing, offering crucial scientific evidence for forest fire prevention and control. It also lays a foundation for further enhancing the accuracy and timeliness of forest fire warnings.