Inversion of Soil Salinity in Baicheng City, Jilin Province Based on Sentinel-2A Remote Sensing Data (Postprint)

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Abstract

Based on Sentinel-2A remote sensing data, combined with laboratory-measured total salt content values from surface soil samples in Baicheng City, and utilizing statistical and fitting analysis methods, a remote sensing monitoring model for soil salinization was established to conduct inversion analysis of surface soil salt content in the study area. The results show that: The reflectance of soil in the study area is positively correlated with salt content, with the correlation coefficient reaching its maximum value at Sentinel-2A band 5 (center wavelength 0.705 m) as r=0.902. The soil salt content inversion model established using band 5 reflectance is TSC=50.776R5-8.262, with a coefficient of determination R 2=0.813 and a root mean square error of RMSE=0.814 g · kg-1 for the validation samples; After performing mathematical transformations such as exponential, power, and S-curve on the reflectance, the fitting accuracy can be significantly improved. Among these, the single-band inversion model for soil salt content established after power function transformation of band 8 reflectance, TSC=77.51x2.346, achieves the best accuracy, with a coefficient of determination R 2=0.888; Using the method of multiple stepwise regression analysis, a multi-band inversion model for soil salt content was established: TSC=-13.810+38.973R5-14.122eR5+23.896R82.248+1.743ln(R9), with a coefficient of determination of R2=0.924 and a root mean square error of RMSE=0.736 g · kg-1 for the validation samples.

Full Text

Preamble

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Inversion of Soil Salt Content Based on Sentinel-2A Remote Sensing in Baicheng City, Jilin Province

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Abstract

Soil salinization represents one of the primary forms of land degradation and constitutes a worldwide challenge for resources and ecology. The western region of Jilin Province encompasses China' s largest area of soda saline soil. Real-time monitoring of soil salt content is critically important for the prevention and control of soil salinization, protection of regional soil ecological environments, and sustainable development of agricultural economies. Based on Sentinel-2A remote sensing imagery for Baicheng City, this study established a remote sensing monitoring model for soil salinization through statistical and fitting analysis, and analyzed the salt content of topsoil in the study area.

First, radiometric correction and atmospheric correction were performed to eliminate the effects of atmospheric water vapor, methane, and ozone on remote sensing image processing. Second, reflectance was transformed using reciprocal, logarithmic, exponential, power, and S-function transformations to reduce noise influence in the remote sensing images. Finally, sensitive bands for soil salinity in the study area were identified through correlation analysis, and a soil salinity inversion model was established using multiple stepwise regression analysis.

The results demonstrate that soil reflectance is positively correlated with soil salt content, with the correlation coefficient reaching its maximum in Sentinel-2A band 5 (center wavelength 0.705 m), where r = 0.902. Using band 5 reflectance, the soil salt content inversion model TSC = 50.776R5 - 8.262 was established, with a coefficient of determination $R^2 = 0.813$ and root mean square error RMSE = 0.814 $g \cdot kg^{-1}$.

Model fitting accuracy can be significantly improved by transforming reflectance into exponential, power, and S-functions. The single-band soil salinity inversion model TSC = $77.51x^{2 \cdot 346}$ achieves the best precision after transforming the eighth-band reflectance into a power function, yielding a model coefficient of determination $R^2 = 0.888$.

The correlation between soil salinity and reflectance can be substantially enhanced through reflectance transformation using exponential, power, and S-curve functions. A multivariate stepwise regression method was employed to establish the following soil salinity inversion model: TSC = -13.810 + 38.973R5 - 14.122eR5 + 23.896R2.2488 + 1.743ln(R9). This model achieved a coefficient

of determination $R^2 = 0.924$, with a root mean square error of RMSE = 0.736 $g \cdot kg^{-1}$ for the test sample. Redundant bands were eliminated while ensuring model accuracy.

Keywords: Sentinel-2A; remote sensing; quantitative inversion; saline soil; Baicheng City; Jilin Province

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Note: Figure translations are in progress. See original paper for figures.