

基于星载 ICESat-2/ATLAS 数据的 天然林郁闭度空间异质性研究

余金格¹ 舒清态^{1*} 胥丽¹ 罗绍龙¹ 国朝盛¹ 王书伟¹ 周文武¹

(1. 西南林业大学 昆明 650224)

摘要:【目的】星载激光雷达能够提供全球尺度的采样观测,借此机会,本研究基于高密度的 ICESat-2/ATLAS 采样足迹,探讨香格里拉市天然林郁闭度的空间异质性及其与地形因子的关系,为科学经营管理天然林提供参考。【方法】本研究以香格里拉天然林为研究对象,基于 ICESat-2/ATLAS 数据,结合 51 块实测样地,采用四种机器学习算法(k-NN、SVM、RF、GBRT)构建光斑尺度的郁闭度估测模型,选择性能最优的模型预测天然林地内的 1100 个光斑足迹郁闭度,通过采用空间自相关分析、变异函数分析、相关性分析、方差分析、地理加权回归等方法,对光斑足迹内的郁闭度空间异质性及其与地形因子的关系进行研究。【结果】四种机器学习(KNN、SVM、GBRT、RF)算法中,GBRT 模型具有最好的预测精度($R^2 = 0.94$, $RMSE = 0.041$);研究区天然林郁闭度的空间变异最适合用指数模型来描述,郁闭度在 0~10200 m 范围内存在强烈的空间自相关;基于 Co-Kriging 的光斑郁闭度空间插值具有良好的精度($R^2 = 0.59$, $RMSE = 0.07$);地形在一定程度上解释了天然林郁闭度的空间变异,海拔对空间变异的影响较大。【结论】天然林郁闭度在一定的空间尺度上显示出较强的异质性,且会由于地形因子的变化产生差异,在影响程度方面,海拔最大,坡度次之,坡向最小。

关键词: 郁闭度;天然林;激光雷达;地形因子;空间异质性

Spatial heterogeneity of natural forest canopy cover based on spaceborne ICESat-2/ATLAS data

Abstract: 【Objective】 Spaceborne LiDAR can provide global scale sampling and observation. Based on the high-density ICESat-2/ATLAS sampling footprint, this study explores the spatial heterogeneity of natural forest canopy cover (NFCC) in Shangri-La and its relationship with topographic factors, so as to provide references for scientific management of natural forests. 【Method】 This study takes Shangri-La natural forest as the research object. Based on ICESat-2/ATLAS data and combined with 51 measured plots, a machine learning model is built and 1100 light spot footprints in natural forest land are predicted. Spatial autocorrelation analysis, variance analysis, correlation analysis, geographical weighted regression and other methods are adopted. The spatial heterogeneity of canopy in light spot footprint and its relationship with topographic factors were studied. 【Result】 Among the four machine learning algorithms (KNN, SVM, GBRT, RF), GBRT model has the best prediction accuracy ($R^2 = 0.94$, $RMSE = 0.041$). The spatial variation of natural forest canopy density in the study area is best described by the exponential model, and there is a strong spatial autocorrelation in the range of 0~10200 m. The spatial interpolation of spot density based on Co-Kriging has good accuracy ($R^2 = 0.59$, $RMSE = 0.07$). The spatial variation of natural forest canopy density in the study area is best described by the index model.

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作者简介: 余金格(1999-), 男, 云南楚雄, 研究方向为 3S 技术在林业上的应用。Email: yjg721@swfu.edu.cn

*通讯作者: 舒清态(1970-), 男, 湖北武汉, 教授, 主要从事林业 3S 技术应用研究。Email: shuqt@163.com

Topography explains the spatial variation of natural forest canopy to a certain extent, and elevation has a greater effect on the spatial variation. 【Conclusion】 The NFCC showed strong heterogeneity on a certain spatial scale, and the difference is caused by the change of topographic factors. In terms of the impact degree, the altitude is the largest, followed by the slope, and the slope direction is the least.

Key words: forest canopy cover; natural forest; spaceborne LiDAR; topography factor; spatial heterogeneity.