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机载激光雷达森林叶面积指数反演研究

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Forest leaf area index (LAI) inversion using airborne LiDAR data

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摘要

叶面积指数(LAI)是分析冠层结构最常用的参数之一,它控制着植被的生物物理过程,如光合、呼吸、蒸腾、碳循环和降水截获等,因此快速、可靠和客观地评价LAI非常重要.本文发展了激光穿透指数(LPI)的简化计算方法,首次利用校正后的回波强度计算出LPI,以LPI为变量基于Beer-Lambert定律实现了甘肃大野口研究区森林LAI反演,并且与原始回波强度和回波数反演LAI的精度进行对比,结果发现通过距离和角度校正后的回波强度值能提高LAI反演精度.为了评价模型的可靠性和泛化性能,用留一法交叉验证程序(LOOCV)对最佳反演模型进行了验证,表明该模型没有过度拟合,具有很好的泛化能力.最后,用没有参加建模的16个实测LAI对预测值进行精度验证($R^2=0.810$,RMSE=0.198),发现校正后的回波强度反演山区森林LAI精度较高.本文还对激光雷达LAI反演结果与传统光学TM影像的反演结果进行了对比分析,结果表明机载激光雷达反演LAI精度($R^2=0.825$,RMSE=0.165)高于光学TM遥感数据($R^2=0.605$,RMSE=0.257),因此,可用激光雷达数据实现研究区的高精度LAI反演,为生态环境研究提供可靠的基础数据.

关键词 激光雷达, 叶面积指数, 穿透指数, 回波强度, 森林植被

Abstract：

Leaf Area Index(LAI)is one of the most important parameters,which controls biological and physical processes associated with vegetation on the Earth's surface, such as photosynthesis, respiration, transpiration, carbon and nutrient cycle, and rainfall interception. Therefore, rapid, reliable and objective estimations of LAI are essential. In this study, we developed a new approach for laser penetration index (LPI) estimation from LiDAR data, and first computed LPI based on corrected echoes intensity. Using the variable of LPI, we built LAI estimation model based on Beer-Lambert law. This approach was applied on a forest area in Dayakou, Gansu Province. The accuracy of the corrected intensity-derived LAI inversion model was compared with that of uncorrected intensity-derived and echoes counts-derived model. The study found that corrected echoes intensity can improve the accuracy of LAI inversion. To assess validity and generalization of the model, we validated the optimum model via the Leave-One-Out Cross-Validation (LOOCV) procedure, and the result showed that the model had no overfitting and was more general. Finally, we validated the accuracy of predicted LAIs with 16 field-measured LAIs which were not involved in the modeling process and found that LAI estimation accuracy is high in mountains area by corrected echoes intensity. The LiDAR-derived LAI ($R^2=0.825$,RMSE=0.165) was compared with the LAI from Landsat TM images ($R^2=0.605$, RMSE=0.257), the accuracy of the former is far higher than that of the latter. This study indicates that airborne LiDAR data can be used to obtain high-accuracy LAI estimation and can provide reliable data for ecological environment research.

Keywords LiDAR, LAI, Laser penetration index, Echoes intensity, Forest vegetation

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