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论文

光合有效辐射总量及其散射辐射比例变化对 森林*GPP*影响的模拟

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摘要:

研究利用基于冠层辐射传输与植物生理过程的MAESTRA模型,结合中国东部鼎湖山、千烟洲及长白山3个典型森林生态系统的CO_2通量观测数据,对光合有效辐射(Photosynthetically Active Radiation, *PAR*)总量及其散射辐射比例变化影响下生态系统总初级生产力(Gross Primary Productivity,*GPP*)的变化进行了模拟与敏感性分析,从而探讨这两者的变化对森林生态系统*GPP*的综合影响。研究结果表明:*PAR*总量变化对*GPP*的影响程度由*PAR*总量变化幅度以及*GPP*对*PAR*总量变化的敏感程度所决定,较低的*PAR*总量与较高的温度条件下*GPP*对*PAR*总量变化较敏感;散射辐射比例增大可以提高森林冠层对入射*PAR*的吸收和利用效率,其对*GPP*的影响程度由散射辐射量的变化以及散射辐射与直射辐射在吸收与利用效率上的差别所决定,较高温度与叶面积条件下该差别较大;*PAR*总量与散射辐射比例共同变化对*GPP*的综合影响取决于上述两个过程的抵消结果,入射*PAR*较强时两者抵消作用通常更明显,在全年总量上,散射辐射比例变化对*GPP*的影响能抵消*PAR*总量变化影响的1/3~1/2。

关键词: 碳循环 *GPP* 生态系统模拟 光合有效辐射 散射辐射比例 森林生态系统 MAESTRA

Modeled Effects of Changes in the Amount and Diffuse Fraction of PAR on Forest GPP

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Abstract:

The scattering and absorption of solar radiation by anthropogenic aerosols reduce the amount of photosynthetically active radiation (PAR) reaching the earth's surface and increase the fraction of PAR that is diffuse (FDIFF), with the counteracting effects on plants photosynthesis which determines terrestrial ecosystem's gross primary production (GPP). For the complex interactions among the total PAR amount, FDIFF, temperature and humidity, it's difficult to derive the quantitative relationship between FDIFF and GPP from present field and experimental measurements, leading to substantial uncertainty and dispute about the projection of the production and carbon assimilation of terrestrial biosphere influenced by emissions of anthropogenic aerosols. Using a process-based canopy photosynthesis model (MAESTRA), we explored respective and combined effects of changes in PAR amount and the FDIFF on GPP in three typical forests among the North-South Transect of Eastern China (NSTEC). The results showed that the responses of GPP to PAR amount changes were consistently positive in all three sites, while the magnitudes of GPP change were determined not only by the degrees of PAR amount change but also the sensitivity of GPP to these changes, which was generally depressed to nearly naught by higher PAR amount and/or lower temperature from about 0.6 g C mol^{-1} when incident PAR was lower and temperature was not limited. The increase of FDIFF stimulated absorption and use efficiencies of incident PAR in the three forests, as a result of the difference, which was depressed by lower temperature and/or fewer leaf area, between the efficiencies of direct and diffuse PAR, leading to the magnitudes of GPP change responding to FDIFF changes were also influenced by the temperature and leaf area as well as the degree of FDIFF changes and the total PAR amount. Investigating the relations between the changes of diffuse PAR and total amount was necessary in quantifying the combined effects of these changes on GPP, which were generally the

consequence of the counteraction of respective effects of the changes. In our results, the counteraction was usually significant under conditions with greater PAR amount, but the direction of GPP changes was still mainly controlled by the changes of PAR amount. The year-around offset was about 1/3 — 1/2 of the degree of the effect of total amount changes.

Keywords: carbon cycle GPP ecosystem modeling PAR fraction of diffuse radiation forest ecosystem MAESTRA

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