MODELING NET ECOSYSTEM PRODUCTIVITY
SCALE ISSUES AND REGIONAL APPLICATION TO THE IBERIAN PENINSULA

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ABSTRACT

Our research goal is to assess the regional vegetation dynamics in the Iberian Peninsula (IP). For this purpose, estimations of net ecosystem production (NEP) from a productivity ecosystem model, the Carnegie Ames Stanford Approach (CASA) model (Potter *et al.*, 1993), were compared with local CO_2 flux measurements. The CASA calibration process aimed the tuning of efficiency scalars directly related to net primary productivity and soil respiration calculations: maximum light use efficiency (*) and temperature effect on soil fluxes (Q_{10}), respectively. Local weather station data was used for climatic inputs, as well as remotely sensed leaf area index (LAI) and fraction of photosynthetically active radiation (FPAR) from the MODIS TERRA sensor. Firstly, NEP calculations were performed at different temporal resolutions, ranging from monthly to daily time steps, in order to assess the impact of temporal scales on productivity estimates. Both the calibration and validation procedures showed significant confidence, although the main processes behind vegetation carbon fluxes were best simulated at temporal scales ranging from 8 days to monthly. The impact of spatial scale was also analyzed on the NEP estimates. It was found that results accuracy was influenced by the data spatial resolution, and, furthermore, by the tree cover percentage of the aggregated cells. A correction method was implemented and a reduction of the spatial aggregation error up to 10% was obtained. The long term NEP analysis for the IP indicates statistically significant positive trends mainly related to solar radiation positive trends. A less significant negative trend was also found with a strong spatial autocorrelation behavior.

INTRODUCTION

NEP estimations play a key role in the terrestrial carbon cycle assessment, both at regional and global scales studies. Remote sensing data has improved NEP estimation methods and analysis, yet spatial and temporal resolution of sensors and remote sensing products often imply adjustments to NEP calculation methods. Regional scale productivity studies may induce an increase in confidence in global studies for the response of ecosystems to regionally heterogeneous stimuli, among which anomalies in climate fields and their effects on carbon fluxes are not predictable from global averages (Schimel *et al.*, 2001). The CASA model simulates plant and soil processes allowing the estimation of NEP through the difference between net primary productivity and soil respiration. In this study, we aim to use the CASA model on a regional scale, for the assessment of spatial and temporal scale issues through model calibration and validation, and to evaluate the NEP trends in the IP and its causes.

MODEL CALIBRATION AND VALIDATION

The calibration process consisted on the assessment of the fittest *and Q_{10}, through NEP monthly observations over a *Quercus ilex* and *Quercus suber* Mediterranean ecosystem. Vegetation biophysical properties data was acquired through remote sensing (TERRA MODIS LAI and FPAR products). All other input variables were obtained from the site data collection. The calibration process was carried through 2002 measurements and validation for 2003. The modeling efficiency results, through the Nash-Sutcliffe (*NS*) index (Janssen and Heuberger, 1995), revealed a very satisfactory (*NS*>0.5) model behavior (Quinton, 1997) in simulating the processes behind the ecosystem carbon fluxes. The estimated results obtained for *and Q_{10} are within referenced intervals found in previous studies (Ruymi *et al.*, 1994; Kirschbaum, 1995). The model validation results corroborated the calibration results, emphasizing the model's appropriateness to simulate ecosystem carbon fluxes.

TEMPORAL SCALE ANALYSIS

The calibration and validation processes were performed at different time intervals (16 days, 8 days and one day), in order to understand the impact of temporal scale on NEP estimates. The analysis' results indicate: (i) a constant *through the temporal scales range; (ii) a variable Q_{10} with a negative parabolic behavior; (iii) a statistical confidence in Person coefficient at all scales; and (iv) a satisfactory model efficiency index at 8 and 16 days. From this analysis, it can be concluded that the CASA model can be applied to shorter temporal scales - monthly to weekly - maintaining a significant confidence in explained variability as well as in the model efficiency.

SPATIAL SCALE ANALYSIS

The main goal of the spatial scale analysis was to find possible impacts of data aggregation over homogeneous land cover areas. NEP estimates were calculated from the MODIS continuous fields, LAI and FPAR finest spatial resolution (1km). NEP estimates were also modeled based on coarser scale MODIS inputs (4km, 8km and 0.25deg). The comparison between both methods revealed a systematic underestimation error, inversely proportional to the percentage of tree cover for annual NEP estimates. This error was corrected through: (i) a correction factor determined as a function of spatial aggregation scale and percentage of tree cover; (ii) intra annual outlier's correction of LAI and FPAR dynamics (Sellers *et al.*, 1996, Myneni *et al.*, 1997b, Asrar *et al.*, 1992).

NEP ESTIMATES FOR THE IBERIAN PENINSULA

Global scale vegetation studies have identified positive productivity trends in the Northern Hemisphere (Myneni *et al.*, 1997a; among others). NEP trends for the IP were analyzed accounting for the statistical confidence in pixel-by-pixel trends and for its spatial autocorrelation, allowing the identification of coherent regions of interest. CASA calibration and validation were again performed for 15 flux measurement stations used by the Advanced Terrestrial Ecosystem Analysis and Modelling (ATEAM) European project, representing about 60% of the IP land cover. The modeling inputs included: (i) AVHRR PATHFINDER LAI and FPAR (Myneni *et al.*, 1997b); AVHRR Percent Tree Cover (DeFries *et al.*, 2000); CRU TS 1.2 climate data; and European Soil Databases for soil texture and soil depth. A confident overall accuracy was obtained (*NS*: 0.55; *R*: 0.81). Through the local Moran's I (Anselin, 1995) analysis for NEP long term (1982-1999) trends, it was found that the positive and negative trend regions were autocorrelated areas. In regions of negative trends, located at Southern IP, although not statistically significant, the strong spatial autocorrelation may infer a non linear trend in this region. Positive trends, with a higher extension area than negative trends, are associated to solar radiation positive spatially coherent trends.

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