

Use of BIOME-BGC to simulate water and carbon fluxes within Mediterranean macchia

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The biogeochemical model BIOME-BGC is capable to estimate the main eco-physiological processes characterising all terrestrial ecosystems. To this aim it needs to be properly adapted to reproduce the behaviour of each biome type through a calibration phase. The aim of this paper is to adapt BIOME-BGC to reproduce the evapotranspiration (ET) and photosynthesis (GPP) of Mediterranean macchia spread all over Italy. Ten different sites were selected in the Centre-South of Italy and their gross primary production (GPP) was estimated by applying a parametric model, C-Fix, based on remotely sensed data for ten years (1999-2008). These monthly data were then used to calibrate BIOME-BGC through an iterative process which led to reproduce the spatial and temporal GPP variations found by C-Fix. The calibrated model was then applied to simulate the ET and GPP of two Italian sites characterised by the presence of an eddy flux tower; its performances were evaluated against ground data by common statistics. The results obtained indicate that, after a proper calibration phase, BIOME-BGC can be applied to estimate the evapotranspiration and photosynthesis of Mediterranean macchia with a good accuracy, strictly dependent on the input data utilised.

Keywords: Evapotranspiration, Gross primary production, C-Fix, E-OBS dataset

Introduction

One of the most important research themes in global ecology is related to the study of water and carbon fluxes within terrestrial ecosystems. This is fundamental to understand the effects of global change on vegeta-

tion and consequently apply sustainable management practices (Waring & Running 2007). Several studies have been carried out on this subject concerning in particular forest ecosystems (e.g., Cramer et al. 1999, Yang et al. 2007).

As reported by IPCC (2007), quantifying the amount of forest carbon pools and their variation during time is of fundamental importance in the Mediterranean area, which is one of the most vulnerable to global change. Mediterranean macchia is a particular biome type which is spread all around the Mediterranean basin. In Italy it covers wide areas in the centre and in the south and is therefore a potential carbon sink, but little is known about its capacity to store carbon. These areas are potentially characterised by consistent changes in time; the surface covered by macchia is supposed to increase as a response to land abandonment and, in some cases, forest degradation and to decrease when evolving towards different forest types in successional ecosystems trends (ISPRA 2010).

To quantify the water and carbon fluxes within terrestrial ecosystems on a regional scale, the most common approach is based on the use of models of ecosystem processes, often integrated with remotely sensed data (e.g., Matsushita & Tamura 2002, Corona 2010). Among these simulation models, BIOME-BGC was largely applied to simu-

late the behaviour of different forest types for monitoring and predicting purposes (e.g., Chiesi et al. 2010). In general, this model was chosen for its suitability to provide information on water, carbon and nitrogen cycles within forest and non-forest ecosystems and for its relative simplicity in reproducing vegetation processes based on biome-types (Running & Hunt 1993, White et al. 2000).

So far, BIOME-BGC has never been applied to simulate the behaviour of Mediterranean macchia. Therefore, its operational application for estimating the water and carbon fluxes of macchia requires a preliminary calibration procedure to adapt the model to this new biome type. Following Chiesi et al. (2007), this operation can be carried out using monthly photosynthesis (GPP) estimates derived from an NDVI-based parametric model (Modified C-Fix), which was recently demonstrated to accurately depict productivity features of existing Italian forests (Veroustraete et al. 2002, Maselli et al. 2009).

The current paper aims at adapting BIOME-BGC to simulate the main processes of Mediterranean macchia. The paper first describes the study areas and data considered. Next, the properties of BIOME-BGC are briefly introduced together with the data processing steps applied. In particular this section is divided into:

1. the calibration phase, conducted with the objective of identifying the optimal model configuration for Mediterranean macchia;
2. the validation phase, consisting in applying the original and the calibrated versions of BIOME-BGC in two additional sites for which independent data of evapotranspiration (ET) and GPP exist. These are used to test the accuracy of the model estimates.

The paper finally illustrates the problems encountered and discusses future perspectives of the work.

Study areas

Italy is geographically situated between 36° and 47°30' North latitude and between 5°30' and 18°30' East longitude. Its orography is irregular and characterised by the presence of two main mountain chains, the Alps in the north and the Apennines in the centre-south. The climate is variable following the latitudinal and altitudinal gradients and the distance from the sea: in general, it ranges from Mediterranean Warm to Temperate Cool (Blasi 2005). Following the above gradients, also the land cover is changing, ranging from agricultural areas to forests and pastures.

As regards Mediterranean macchia (Fig. 1), this is spread all over Italy especially in the centre and in the south. Its presence is linked to particular ecological conditions (e.g., rocky soils, warm climate) and/or past utili-

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