MODELING VEGETATION DYNAMICS AND SOIL WATER BUDGET OF A WATER-LIMITED MEDITERRANEAN ECOSYSTEM: THE FLUMENDOSA BASIN CASE STUDY

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Key-words: land surface model, vegetation dynamics, LAI, Mediterranean ecosystem, soil moisture

Objective of the study
The structure and function of the vegetation regulates the exchange of mass, energy and momentum across the biosphere-atmosphere interface. Vegetation dynamics are usually neglected, other than seasonal phenology, in land surface models (LSMs). However, changes in vegetation densities, influencing the partitioning of incoming solar energy into sensible and latent heat fluxes, can result in long-term changes in both local and global climates (e.g., precipitation and temperature), which in turn will feedback to affect the vegetation growth. In semi-arid regions, this may result in persistent drought and desertification, with substantial impacts on the human populations of these regions through reduction in agricultural productivity and reduction in quantity and quality of water supply.

The objective of this study is to find a simple vegetation dynamic model (VDM) that, coupled with a LSM, is able to simulate land-surface fluxes and leaf area index (LAI) dynamics of the main competing plant functional types of a water-limited Mediterranean ecosystem.

Materials and Methods
VDMs of different level of complexity (e.g., including or not the modeling of the root biomass or the modeling of the dead biomass) are developed and compared. The VDMs compute the change in biomass over time as difference between the rate of production (e.g., photosynthesis) and the rate of destruction (e.g., respiration and senescence). The VDMs incorporates two plant functional types (grass and woody vegetation), using basic rules regarding competition for a limiting resource. The VDMs are coupled to a LSM, with the vegetation models providing the green biomass and the LAI evolution through time, and the LSM using this information in the computation of the land surface fluxes and updating the soil water content in the root-zone.

The case study is a Mediterranean water-limited field in Orroli, situated in the mid-west of Sardegna within the Flumendosa river watershed, which is considered one of the most important water supply resources to the island. The landscape is a mixture of Mediterranean patchy vegetation types: trees, including wild olives and cork oaks, different shrubs and herbaceous species. An extensive field campaign started in April 2003. Land-surface fluxes and CO2 fluxes are estimated by an eddy correlation technique based agro-meteorological tower, equipped with a Campbell Scientific CSAT-3 sonic anemometer and Licor-7500 infrared gas analyzer. Three infrared transducers were used to measure the surface temperature of the different land cover elements (i.e. bare soil or grass, tree and composite surface), while incoming and outcoming shortwave and longwave radiation components were
measured by the CNR-1 (Kipp & Zonen) integral radiometer positioned at 10 m with a hemispherical field of view. Photosynthetic active radiation (0.4 to 0.7 mm) was also measured using a Quantum sensor positioned at 5 m above the ground, and soil heat flux were also measured. Soil moisture profiles were continuously estimated using seven - frequency domain reflectometer probes (CS615 soil moisture probes of Campbell Sci.), and periodically LAI estimates of both plant types are made using the Accupar LP-80 ceptometer by Decagon Devices Inc.

Results
Results show that the use of a simple VDM, which simulates the living aboveground green biomass only (i.e., with low parameterization and computational efforts), allows to accurately estimate soil, vegetation and atmosphere dynamic interactions and LAI dynamics for a grass cover type but not for the woody vegetations (trees and shrubs). Only the use of a more sophisticated VDM allows to simulate well the LAI dynamics of the woody vegetation species, because the VDM simulates the complex interactions between roots and shoots (e.g. biomass translocation from root to shoots), allowing to model the strong tolerance to water drought of these resistant Mediterranean plants.