From soil - plant interactions to satellite imagery: integrating disciplines and scales in process based simulation models

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Introduction

Decisions for conservation of biodiversity and sustainable management of natural resources are typically related to large scales, i.e. the landscape level. However, understanding and predicting the effects of land use and climate change on scales relevant for decision making requires to include both, large scale vegetation dynamics and small scale processes, such as soil-plant interactions. Integrating results of multiple BIOTA subprojects enabled us to include necesseray data of soil science, botany, socio-economics and remote sensing into a high resoluted, process based and spatially explicit model. **On the example of a sustainable used research farm and a communally used and degraded farming land in semi-arid southern Namibia we show the power of simulation models as a tool to integrate processes across disciplines and scales.**

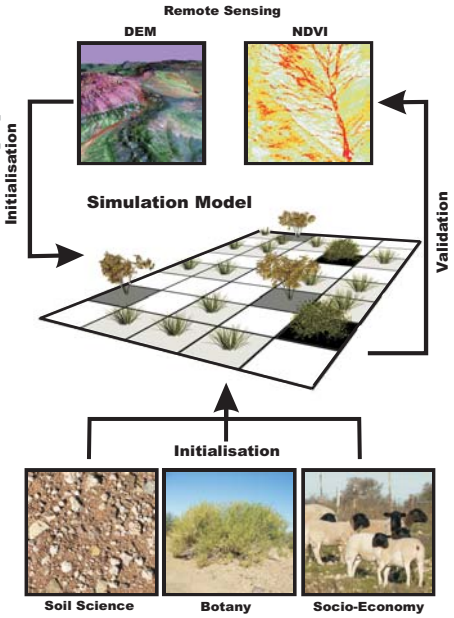

Figure 1

Methods

Based on the concept of State-and-transition the grid based landscape model simulates dynamics of most abundant vegetation types and interlinked hydrological processes of a dwarf shrub savannah with distinct topography.

Data and information for the landscape scale are derived by a small-scaled and spatially explicit simulation model.

Surface run-off is included by incorporating spatial interaction of neighbouring cells and initialising the topografical information for the simulation model with the help of digital elevation models (DEM).

Landuse is considered by livestock type and density as well as palatability of the different vegetation types.

Soil texture and vegetation composition affect local infiltration and evaporation rates.

Simulated annual biomass production is compared with remotely sensed estimates of annual total biomass production (NDVI) for the sustainable used research farm Gellap and the overgrazed communal farming land at Nabaos.

Results

Data and information from different disciplines and scales could successfully be intergrated to simulate landscape dynamics. Fig. 2 demonstrates how vegetation composition and productivity depend on rainfall and land use type. In contrast to Gellap where perennial grass receives largest share in productivity, communal farming at Nabaos led to a dominance of shrubs and annual forbs.

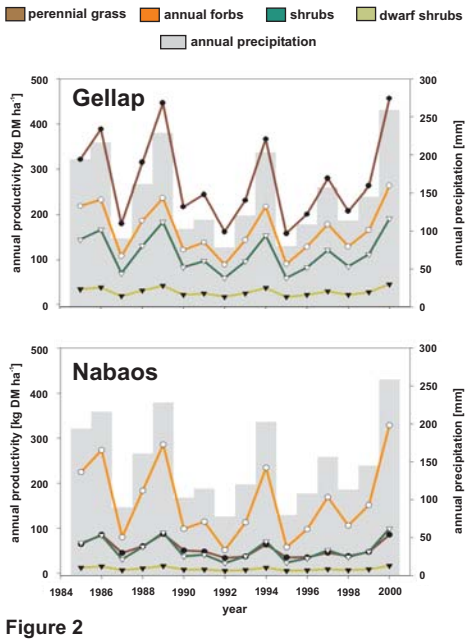

Figure 2

Spatial interactions, in this case overland transport of water by run-off can have strong impact on vegetation dynamics (Fig. 3). At light grazing intensities (Gellap), spatial exchange of water among vegetation patches increases biomass production. High share of run-on cells indicates a diverse set of hydrological enhanced islands where high values of run-on due to high infiltration capacities lead to high levels of water input. In contrast, disturbance in the form of overgrazing (Nabaos) destabilizes positive soil-plant mechanisms and decreases the number of hydrological sinks. Low numbers of run-on cells linked with low mean run-on increase run-off. Water quits the system and causes artificial droughts.

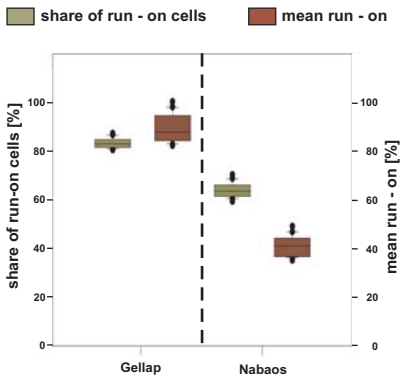

Figure 3

Validation

Linear regression (Fig, 4) shows strong correlation between simulated and remotely sensed biomass (I-NDVI).

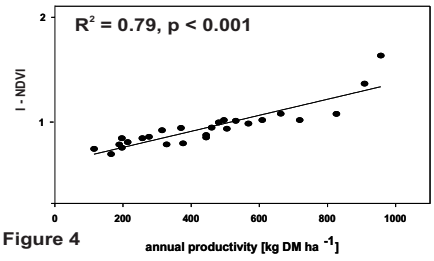

Figure 4

Discussion

One aim of this study was to present a method which has the power to transfer and integrate existing information between spatial scales. We combined technologies of remote sensing, GIS and stochastic modelling to adress landcover change in arid landscapes. The simulation results show that spatial interactions, in this case the overland transport of water by run-off, can have strong impact on vegetation dynamics, composition and productivity. Improved forecasts and management decisions will arise from incorporation of a landscape linkages approach dealing with complex systems that exhibit nonlinear dynamics. Currently we are llinking the vegetation model with a socio-economic decision model.

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