Modelling veld production using MODIS LAI – Phase 2

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Modelling the net primary production of arid and semi-arid rangelands in southern Africa using MODIS LAI and FPAR products – Phase 2

Water use efficiency (WUE) is one of several unifying concepts for comparing different rangeland condition classes and land-use options. These concepts can be used to evaluate the performance of landscapes relative to one another with the aim of selecting the most appropriate land-use option. Throughout southern Africa there are examples of places that are degraded due to over-grazing. With increasing levels of atmospheric CO2 and the recent COP21 agreement, it has become urgent to improve the efficiency of removing CO2 from the atmosphere, and to understand under what land-use conditions we are achieving increased efficiency of CO2 uptake. On intensively-grazed rangelands, the predominance of short green grass does not necessarily mean that an ecosystem is less efficient.

The WUE concept embodies the amount of water evaporated in order to capture carbon. In order for plants to capture CO2 from the atmosphere, they must open the stomata, and that results in water loss. It is therefore essential that plants control water loss by opening the stomata for just long enough to effect CO2 uptake. If the stomatal control is weak, water is lost through evapotranspiration and plants desiccate. Similarly, if the stomata are closed too much in the wet season, then the opportunity to capture CO2 is lost, and the plant starves. Achieving a balance between water loss and CO2 uptake is crucial to the success of crops and veld grasses. In this study, we defined WUE as the dry matter (kg) collected per mm of evapotranspiration (kg DM/ha/mm/year). It has been suggested that lower than expected WUE may reflect landscape-scale degradation or dys-functionality of a landscape. Satellite imagery enabled us to build models that accurately reflect the production and water use of the vegetation. The results of this study reflect the functionality of the ecosystems across RSA and we pronounce on the desirability of several land uses. This study reveals that high WUE values are experienced in the Kalahari region, through most of the Northern Cape and into the western Free State.

All MODIS LAI and fPAR data from the NASA Distributed archive has been downloaded up to December 2015. Data acquisition and archiving was extended to other MODIS products,

including the net primary production (NPP), gross primary production (GPP) and evapotranspiration (MOD16). Annual water use efficiency maps were prepared for 2000-2014. These results were presented at the Savanna Network Meeting in March 2015 (refer to the full report).

The co-operative project with US-funded START (indirect funding from Science Foundation) organization was undertaken in 2013 and 2014, with community engagement taking place with two villages on the Cape west coast (Ebenhaeser and Papendorp), near Vredendal. During the project, we held workshops with the farmers in the villages to determine their response to the climate change predictions for that region, where it is predicted to become hotter and drier. The funding for the START project was withdrawn prematurely by START and the community engagement was dis-continued. However, a BSc (Hons) project was completed using the field data on the relationship between MODIS LAI, fPAR and biomass in the villages. Farmers in Ebenhaeser and Papendorp were provided with support for their grazing capacity plan and with advice on how to adapt their grazing strategies to the deal with the climate change predictions for that region.

Two manuscripts have been published in the African Journal of Range and Forage Science in 2015, with two papers accepted for publication in 2016. These deal with the water use of South African grasslands and the modelling of rangeland production. The most recent paper, prepared in collaboration with researchers from Namibia, deals with the options for sequestration of carbon in semi-arid rangelands.

Scientific publications

Palmer, AR, Samuels I, Cupido C, Finca A, Kangombe F, Yunusa IAM, Vetter S and Mapaure I. 2016. Aboveground biomass production of a semi-arid southern African savanna: towards a new model. African Journal of Range and Forage Science. Published online 15 September 2015.

Samuels I, C Cupido, MB Swarts, AR Palmer, JW Paulse 2016. Feeding ecology of four livestock species under different management in a semi-arid pastoral system in South Africa. African Journal of Range and Forage Science. Published online 15 August 2015.

Palmer AR, Weideman C, Hannan N, Everson C, Finca A, Ellery W. 2015 Modelling annual evapotranspiration in a semi-arid, African savanna: functional convergence theory, MODIS LAI and the Penman-Monteith equation. African Journal of Range and Forage Science 32 (1): 33-39

Finca, A, Kakembo, V, Palmer AR. 2015. Exploring ground-based methods for the validation of remotely sensed evapotranspiration. African Journal of Range and Forage Science 32 (1). 41-50

Meissner, HH, Scholtz, MM, Palmer, AR. 2013. Sustainability of the South African Livestock Sector towards 2050. Part 1: Worth and impact of the sector. South African Journal of Animal Science 43 (3): 282-297

Conference presentations

Palmer, AR. 2015. A comparison of the trends in WUE between 2000 and 2013 in a range of land cover classes and land-use systems in South Africa. Savanna Network Meeting, Skukuza. March 6-9 2015.

Palmer, AR. 2013. Monitoring landscape changes using remote sensing technology in southern Africa. Proceedings of the 22nd International Grassland Congress, Sydney, Australia. 15-19 September 2013. 848-855.

Popular articles

Palmer, AR 2015. Drylands and rangelands across southern Africa: using earth observation to define the most water efficient regions. Grain SA. November 2015.