SPACES II

Science Partnerships for the Adaptation to Complex Earth System Processes in Southern Africa

Research Programme Newsletter

Welcome to the fifth SPACES II Newsletter!

As the first Newsletter of 2021 comes out, most projects would – in normal circumstances – be wrapping up their final results. Under the second wave of the pandemic, most of us are planning project extensions instead, trying to reach crucial project deliverables in spite of continuing lockdowns.

On a positive note, our joint open-access book 'Sustainability of southern African ecosystems under global change: Science for management and policy interventions' is gaining momentum. Following very positive reception from Springer Publishers, around 40 SPACES II author teams are working on the book that we believe will be of high value to an audience of policy makers and those working in the science-policy interface.

This Newsletter covers SPACES II research topics from human-elephant coexistence to the detection of land degradation via remote sensing, and introduces an experimental study on drought recovery. Our field work section focusses in multifunctional landscapes, while the stakeholder part features livestock farmers in the Karoo. Finally, a highlighted publication establishes a 3D model to study the shading impact of trees in agroforestry systems.

Thanks for your contributions and enjoy reading!

Mari Bieri (SPACES II Board / External Communications)

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ESSA 2021—22nd Congress of the Entomological Society of Southern Africa (Abstract submission deadline 19.3.)

The 22nd Biennial ESSA Congress will be held from 28 June to 1 July 2021 at the Forever Resort Thipise in Limpopo Province, South Africa.

The congress will provide an overview of advances in entomology, and is open to all professional and amateur entomologists. The Conference is chaired by Stefan Foord (University of Venda), and it hosts a variety of international keynote speakers. Read more: http://savetcon.savetcon.co.za/essa21-cfa/

EGU 2021 - SALDi session on "Land degradation in savanna environments - assessments, dynamics and implications" (Friday, 30th Apr 13:30 - 14:15)

Convener: Jussi Baade (FSU Jena, Germany)

Co-Conveners: Hilma Sevelia Nghiyalwa (FSU Jena), J.J. Le Roux (University of the Free State, RSA), T. Morgenthal (DALRRD/DAFF, RSA)

The European Geosciences Union (EGU) General Assembly 2021 will take place online between the 19th and 30th April. Early registration rates apply until the end of March!

SALDi organizes a special session on "Land degradation in savanna environments - assessments, dynamics and implications". The aim of this session is to explore the wide range of methodological approaches to assess land degradation and its dynamics over various spatial and temporal scales as well as the implications for society and the interaction with the different spheres of the Earth. There are currently 11 impulse presentations on different land degradation related topics, such as detection of gullies with digital elevation models, vegetation trends in savannas, atmospheric-hydrological modeling, shrub encroachment as well as developing an Earth observation data cube for land degradation monitoring. The presentations are followed by breakout groups for further discussions and scientific exchange between the presenters and the audience.

Limited open access special issue in African Journal of Range & Forage Science: Montane Rangelands in a Changing World

A special issue of the African Journal of Range & Forage Science is dedicated to mountains, which comprise a significant proportion of rangelands.

This special issue is available open access for a limited period of time, access here: https://www.tandfonline.com/toc/tarf20/current

Academic Exchange

A call for short-term-scientific-missions (STSMs) in the framework of agroforestry research

What is an STSM?

An exchange visit aimed at supporting researchers' individual mobility, strengthening existing networks and fostering collaboration with the possibility to:

- **Collect data in a specified study region, near or afar.**
- **Establish new partnerships, learn new techniques, gain access to specific data, instruments or methods not available in your own institution.**

STSMs are open to Master, PhD students and Early Stage "Post-Doc" Researchers.

Applicable for research performed within or relevant to agroforestry in SADC countries.

Funding is available to cover travel costs (local/long-distance), research supplies, COVID-19 PPE and other necessary expenses relevant to your application.

Full rules and guidance given in the funding documentation.

For full guidance on the application process please visit the ASAP website

www.agroforestry-africa.org

or write to

asap@agroforestry-africa.org

Deadline for applications

30th April 2021

Applications will be reviewed as received until the deadline date

What's needed to apply:

- Applicant CV & motivation letter.
- Letter of recommendation from home institution.
- CV and contact details of host supervisor & letter of support.
- Detailed research proposal.

Full details and guidance given in the STSM funding documentation

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QUEST article shows recently published Sentinel-1 derived woody cover map from the SALDi team

In the current QUEST magazine (Vol. 16, No. 4, 2020), Dr. Izak Smit explains how LiDAR (Light Detection and Ranging) has been used for environmental monitoring and landscape mapping in the Kruger National Park. He highlighted and emphasized the importance of Earth observation data products such as the recently published wall-to-wall woody cover map at 10 m spatial resolution by the SALDi team (Urban et al. 2020 - https://doi.org/10.4102/koedoe.v62i1.1621).

SALLnet researcher presents results in Farmer's weekly

Valerie Linden has been interviewed by the journal "farmer's weekly". In this article she presents important insights into her research on bats and their pest control abilities for macadamia. Even though increased pest control application and insect pest damage to South Africa's macadamia industry relates to a declining number of bats, these mammals have a great potential of effective natural pest control. Linden aims to create awareness on how management practices affect natural predators and gives advice how to increase the presence of bats.

Read more here.

EMSAfrica stakeholder workshop in the Eastern Karoo - transferring project outputs to sustainable land management

Mari Bieri[1], Justin du Toit[2], Thomas Clemen[3]
[1]Thünen Institute of Climate-Smart Agriculture, Braunschweig
[2]Grootfontein Agricultural Development Institute, Middelburg
[3]Hamburg University of Applied Sciences

EMSAfrica
Ecosystem Management Support for Climate Change in Southern Africa

EMSAfrica focuses on the impacts of climate change and land use on the structure and function of South African terrestrial ecosystems. Two of our six core research sites are situated in Eastern Karoo, allowing comparison between lenient grazing and overgrazing.

As an important part of EMSAfrica's stakeholder activities, we organise workshops with local land-owners and land managers at our core research sites. These meetings emphasise two-way knowledge exchange, and aim to jointly find ways in which the data, products and knowledge produced by the combination of approaches in EMSAfrica could be used and further developed to provide value for land-use decision making at the local level.

On the 18th November, Justin du Toit, representing the project group due to Covid-19 travel restrictions, organised a workshop for our Eastern Karoo stakeholders in Middelburg. The invitation covered interested farmers of livestock and wild game, researchers, educators, as well as representatives of eco-tourism and conservation organisations. First part of the discussions focussed on introducing the project and the various approaches and tools, mapping the main challenges of the stakeholders, relevant products used, and linkages to the work of EMSAfrica. The latter part of the meeting was dedicated to collecting a "wish list" from the stakeholders to the EMSAfrica team - the kinds of data, outputs, and services that could be jointly developed to respond to the local needs. These were further distinguished into short-term and long-term needs, with the aim to link stakeholders more strongly in future proposals.

The farms in the area are typically large, and in the semi-arid environment, challenges are related with animal management, such as identifying best areas for grazing and the most water-stressed sites. EMSAfrica's remote sensing team at FSU Jena has a key role here as the developer of products that help in assessing ecosystem productivity and land cover; these products are of equal interest to the researchers and conservationists in the area. Training workshops in the use and interpretation of drone and satellite imagery are also under planning.

Another topic that came up in the discussions was the dissemination of the results produced by the two eddy covariance flux towers, which help to understand the impact of different intensities of livestock grazing on carbon balance. These results were seen as valuable to the efforts to develop sustainable farming practices, and potentially link to carbon credits or tax schemes in the future.

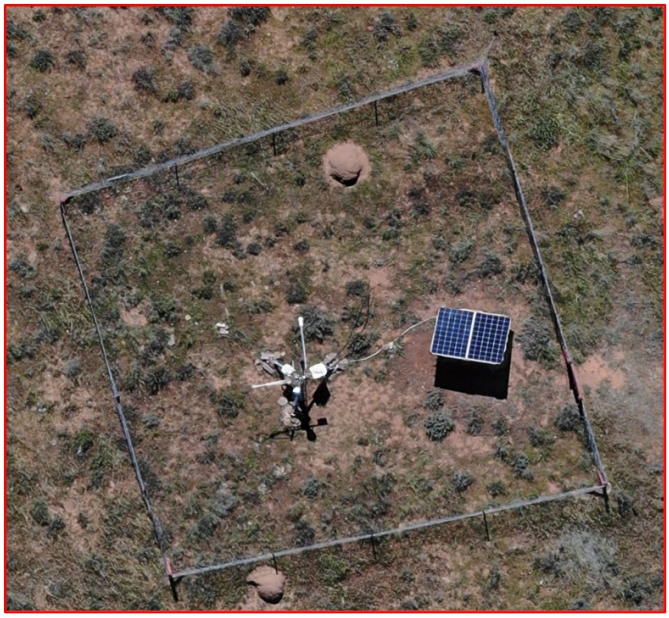

***Figure 1 (right)**. RGB orthomosaic of a drone flight at the Middelburg flux tower on 20th March 2020 with a spatial resolution of approx. 1.5 cm; (above) typical livestock (sheep) grazing.*

Finished ORYCS master's thesis: Landscape permeability for elephant movement

Ronja Kraus[1], Robert Luetkemeier[1,2], Morgan Hauptfleisch[3], Stefan Liehr[1,2]

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[3]NUST – Namibia University of Science and Technology, Windhoek, Namibia

According to a Namibian stakeholder who lives in coexistence with elephants, fences and elephants were incompatible. This is a remarkable statement considering the multitude of game-proof fences in the freehold farmland area south of Etosha National Park (Kunene Region, Namibia), a landscape that is inhabited by several elephant herds. Indeed, fences are a common infrastructure in southern Africa, while their cumulative impact on elephant movement is still not well understood. In order to contribute to this field of science, we investigated the interaction of human land use and infrastructure with elephant movements.

As a starting point, we conducted interviews with freehold farmers around Kamanjab and experts from the human-wildlife interface (government officials, conservationists, representatives from non-governmental organizations and associations) in 2019. We complemented the respondents' knowledge of the area by GPS records from elephants that were collared by the Ministry of Environment, Forestry and Tourism (MEFT) of Namibia, satellite data and self-collected information on the location of game-proof fences and on the applied farm management. We then used this large bundle of information to identify potentially suitable habitats and to conduct a least-cost corridor analysis using Linkage Mapper by McRae et al. (2017; see https://circuitscape.org/linkagemapper).

Our analyses with different scenarios of modified landscapes including land management and fencing strategies show, first, the cumulative impact of these socio-economic infrastructures and activities on the permeability of the landscape for elephant movement. Second, they demonstrate a strong need for a landscape-wide management plan including coordinated measures. These results are important because currently, boundary fences are constructed on the basis of individual decisions by landowners, and therefore without scientifically sound knowledge of the wide-ranging impacts. Knowledge about the impact on movement patterns and the possible emergence of conflicts is needed to support long-term and sustainable landscape management in an area where farmers and elephants coexist and rely on the same natural resources.

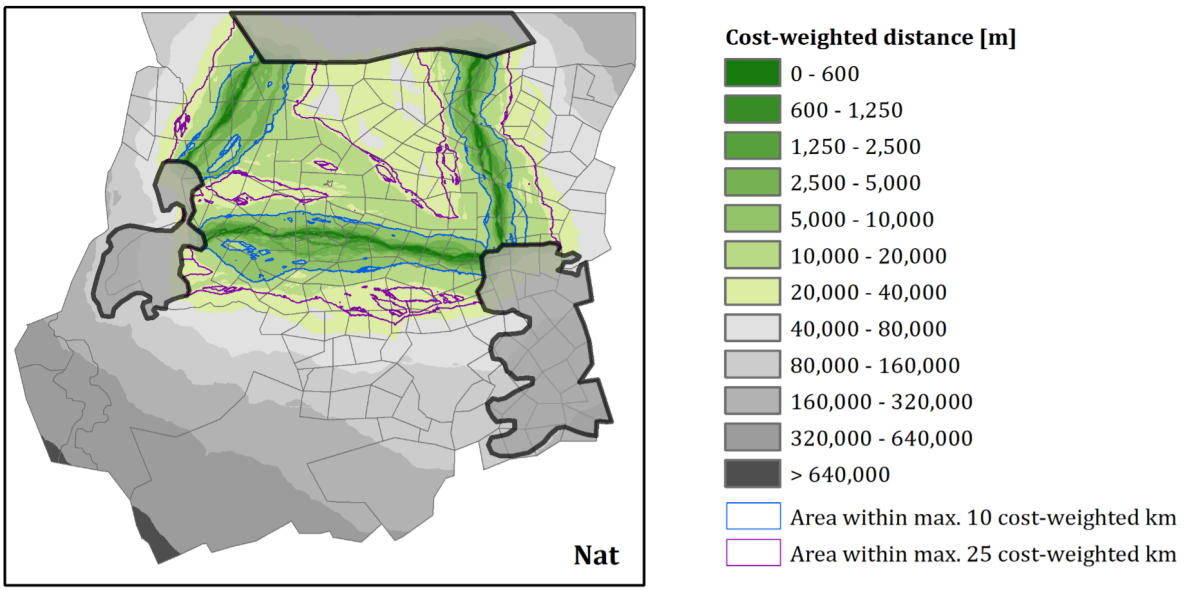

Figure 1: Example of a least-cost corridor analysis in the study area without fences and without considering land management types (Master's Thesis Ronja Kraus, Dec 2020).

SALLnet field work on arable lands, rangelands, and tree orchards

Rangelands, arable lands and orchards are very common land-use types in southern Africa. In their specific spatial arrangements, they constitute multifunctional landscapes that provide essential ecosystems services, which are increasingly threatened by climate change and strong population increases. Therefore, SALLnet focuses on how the resilience of the multi-functional landscapes in southern Africa can be enhanced. To do so, we are developing and testing new approaches and methods for more sustainable land-use, with a focus on the interactions between the connected land-use types: arable lands, rangelands and tree orchards.

Arable experimental trials to overcome climate variability, and Covid-19 disruptions

Arable experiments are key for several SALLnet activities. However, in one of SALLnet's work packages, in which researchers from the Universities of Göttingen, Venda and Limpopo collaborate, they are carried out by South African early career scientists, who run and analyse the trials. These activities do not only train young South African scientists, but the data generated from them feeds crop simulation models (CSM) for calibration and validation purposes. The use of CSM enables us to upscale field-based investigations, which assess the effect of management interventions on arable cropping systems, as well as ecosystem services. Once CSMs are validated by experimental data, they are used to generate input for several SALLnet work packages. The studies conducted by four South Africa students, as described below, are the foundation of a substantial amount of SALLnet's output.

Students based at the Universities of Venda and Limpopo assess several climate smart agricultural approaches, including:

- Cowpea variety trials and rotational impacts on maize production
  Musumuvhi Thabelo, PhD student, University of Venda
- Maize-lablab intercropping, using several lablab cultivars
  Sophy Thaba, MSc student, University of Venda
- Groundnut variety trials
  Mulaudzi Ntakadzeni Rose, MSc student, University of Venda
- Sorghum-cowpea intercropping under different tillage methods
  Mogale Tlou Elisabeth, PhD student, University of Limpopo

All students were awarded grants in 2020 to visit TROPAGS, University of Göttingen to advance their experience with the CSM APSIM. Restrictions meant they could not travel to Göttingen, but were instead given the opportunity to take part in an online workshop in August, called: APSIM Advanced and Dynamic Vegetation Modelling.

These experiments assess yield production as well as soil water, nitrogen, and carbon dynamics at a field scale and were set up in multiple locations and over several years, starting with the Nov-2018 to April-2019 season.

Figure 1. *Groundnut trials (four cultivars) and soil sampling, University of Venda, 2019-20. Photos: Mulaudzi Ntakadzeni Rose*

While in the first season all samples could be gathered, the following one (2019-2020) was dramatically disrupted by Covid-19 travel restrictions and lockdowns. Around the 2020 harvest period, students were not granted access to experimental stations to harvest crops and sample at key stages. The 2019-2020 experiments largely failed due to this but were been reinitiated in autumn 2020 to produce this much needed data. Soil analysis, key for CSM setups, was also delayed as the necessary equipment could not be delivered. A joint effort of TROPAGS, University of Göttingen and the University of Venda secured the funding, purchase and safe delivery of vital soil lab equipment, which is now in South Africa and due to be installed over the coming months and used to analyse the backlog of soil samples.

Figure 2. *Maize-lablab intercropping trial (left), lablab pods and seeds (right), University of Venda, 2019-20. Photos: Sophy Thaba*

The delay of experimental trial data collection has knock on effects for several work packages. With plans in place to ensure the collection of field trial data for the 2021 harvest, our work package dealing with the "Effect of climate change and management interventions on ecosystem services of arable land and macadamia plantations in Limpopo region" looks forward to two full years of experimental data.

Grasses, Forbs or Shrubs: What do cattle eat in a dry savanna?

SALLnet's work package "Rangelands and agroforestry" focuses on the delivery of multiple ecosystem services (ESs) of Limpopo's rangelands and agroforestry systems, and evaluates ecosystem stability in the face of climate change. To better understand seasonal differences in cattle diet in a South African savanna, an international team investigates forage provision and consumption. Plant samples and cattle dung were collected in different seasons. The field work was done on the research farm of the University of Limpopo, South Africa, in April 2019 (rainy season), October 2019 (dry season) and concluded in December 2020 (early rainy season). Analyses are currently done via DNA-Metabarcoding and stable isotope analysis. One main question is if cattle resort to forbs and shrubs during times when grasses are scarce e.g. in early rainy season. The results will eventually contribute to improved concepts for grazing management and for compensation of seasonal nutritional deficits. The research is led by the SALLnet work package "Rangelands and agroforestry" in close collaboration with work package "Arable lands". It includes researchers from the Universities of Potsdam, Göttingen and Bonn in Germany and the University of Limpopo and the North-West University in South Africa.

Figure 3. *Collection of cattle dung in April 2019 (left), Vegetation assessment and biomass collection in December 2020 (middle and right). Photos: Vincent Mokoka (left), Charity Selaphelo (middle), João Silva (right)*

Pollinator and Predator Trials in Macadamia Orchards

SALLnet's work package "Orchards" examines the effects of landscape composition and altitudinal gradients: Considering current land use and climate change we are investigating two ecosystem services (ESs) and their potential trade-offs (pollination and biocontrol) in macadamia systems, which are located along an elevation gradient. Our project is led by researchers at the University of Göttingen and carried out in close collaboration with our colleagues from the Universities of Venda and of the Free State. In our project the provisioning of biological control by bats and birds as well as pollination services by insects are manipulated experimentally during flowering and fruit ripening to assess their relative importance and potential interactions for yield quantity and nut quality.

Figure 4. *Macadamia orchard (left), bird and bat exclusion cage around two macadamia trees (right). Photos: Mina Anders*

Dr. Valerie Linden and Prof. Peter Taylor (University of the Free State) are recording bat and bird activity using passive acoustic monitoring. 40 AudioMoth recorders are being deployed in the orchards every six weeks for two days and nights, autonomously recording either sound or ultrasound. Additionally, Samson Mulaudzi, a local bird guide, has been employed to do visual bird counts (local ornithologist www.birdingsoutpansberg-venda.co.za). Moreover, nut set and final yields and kernel quality is monitored throughout the upcoming growing season. Since the field trip of Mina Anders (PhD student, University of Göttingen) had to be cancelled, due to the Corona pandemic, two students from the University of Venda, Vusani Mphethe (PhD student) and Lorraine Ramotjiki (MSc and new field assistant), took over the fieldwork until January. They conducted pollinator observations and pollinator exclusion experiment in the macadamia orchards, as well as the nut set monitoring. The macadamia nuts are developing and will be mature soon, so that we can start harvesting and subsequently perform the quality analysis of the nuts. From February onwards, a group led by Dr. Lourens Swanepoel (www.aice.org.za) takes over the maintenance of the experimental setup and the data collection on site.

The rain has been generous in our study area this winter and temperatures have been favorable during flowering. Unfortunately, the rain has become excessive in the last weeks causing flooding in some parts of the area and hampering the fieldwork. Still, the climatic comparisons between the two field seasons will be interesting, with the first one having been very dry and hot, causing an overall low yield for all of South Africa.

First results indicate that feral and managed honeybees, which are evenly distributed along the elevation gradient, dominate pollinator communities in macadamia orchards. However, remnants of natural bush have a positive effect on bat activity and biological control resulting in enhanced yields and nut quality.

Figure 5. *Pollination exclusion by a mesh bag around a macadamia inflorescence (left), a honeybee pollinating a macadamia flower (middle), a raceme with immature macadamia nuts (right). Photos: Mina Anders*

Breakpoint Detection using Sentinel-1 Time Series as part of the South African Land Degradation Monitor

South African SALDi Land Degradation Monitor

Marcel Urban[1], K. Heckel[1], T. Morgenthal[2], B. Mogonong[3], G. Feig[3], A. Ramoelo[4,5], H. S. Nghiyalwa[1], J. Baade[6] & C. Schmullius[1]

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[2]Department of Agriculture, Land Reform and Rural Development (DALRRD), Pretoria
[3]South African Environmental Observation Network (SAEON), Arid Land Node, Kimberley
[4]Scientific Services, South African National Parks (SANParks), Pretoria
[5]Department of Geography, Geoinformatics & Meteorology, University of Pretoria
[6]Department of Physical Geography, Friedrich Schiller University Jena (FSU)

Due to its high spatial and temporal resolution, Sentinel-1 radar time series data holds large potential for detecting anomalies and breakpoints to monitor land surface changes and dynamics. Within the South African Land Degradation Monitor (SALDi), our aim is to identify regions, where land degradation processes take place, such as land use changes susceptible for erosion (e.g. clearings for macadamia plantations), disused fallow farmland, shrub encroachment, fire disturbances or water level fluctuations in reservoirs. Likewise, agricultural dynamics can be identified to draw conclusions about harvest cycles and their changes.

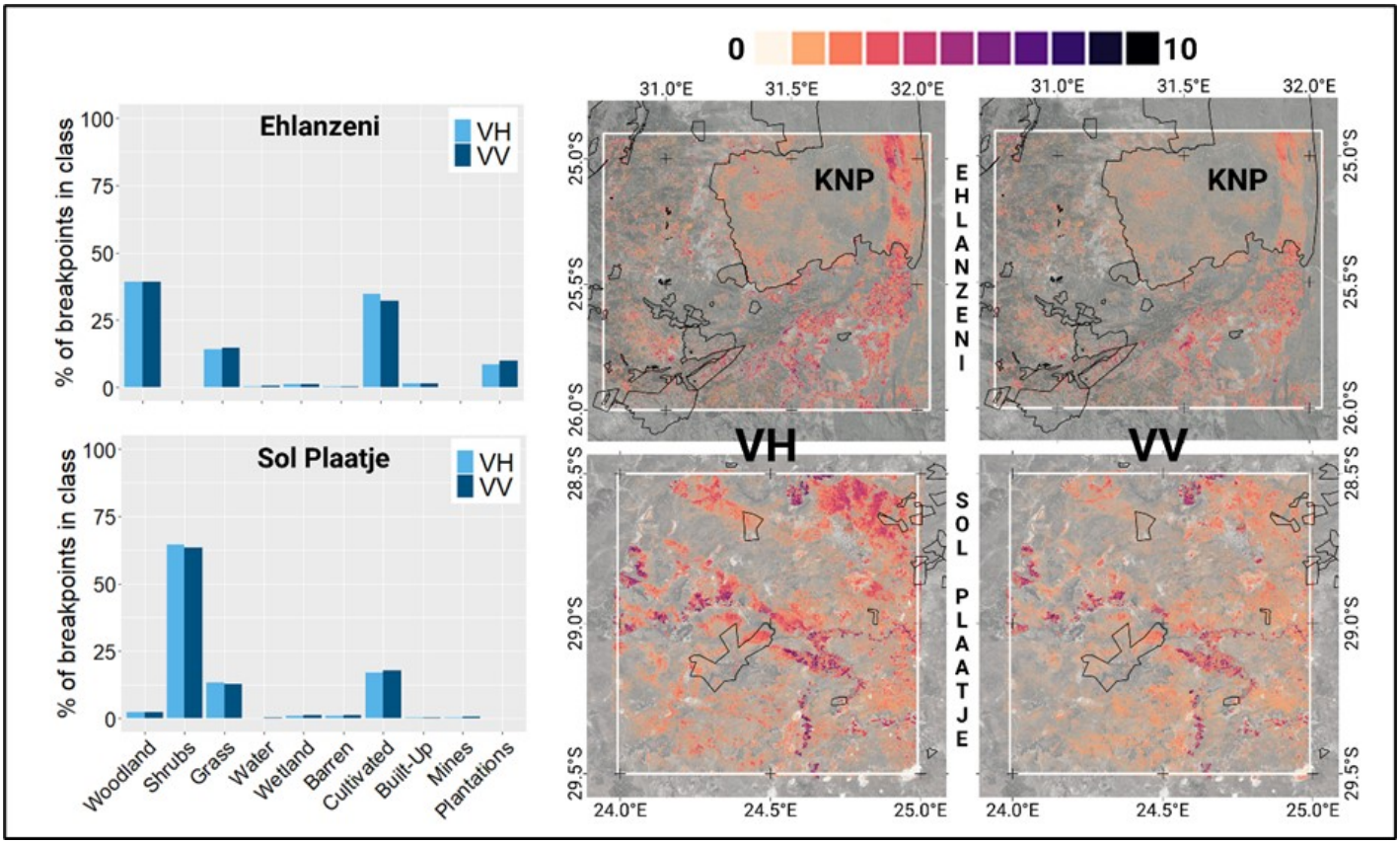

***Figure 1**. Sentinel-1 VV and VH derived breakpoints per land cover class (in %) (International Land Resources 2018) (left). Number of breakpoints in the Sentinel-1 time series (2015 - 2020) for Ehlanzeni (the southern part of the Kruger National Park is located in the northeast) & Sol Plaatje (black outline shows the protected areas (DEA 2020)) (right) (contains modified Copernicus Sentinel data [2015 - 2020]) (Urban et al. 2021).*

For this study we used BanDiTS (Müller & Ziemer 2020), which detect breakpoints in Sentinel-1 time series, utilizing filtering methods, statistical functions and parallel processing capabilities. Figure 1 (previous page; left) shows the amount of breakpoints (in %) in Sentinel-1 VV (co-polarization, vertical-vertical) and VH (cross polarization - vertical-horizontal) time series between 2015 and 2020 in our SALDi study areas Ehlanzeni and Sol Plaatje with respect to land cover classes (International Land Resources 2018). In general, the Sentinel-1 VH is more sensitive to volumetric scattering (e.g. vegetation), the VV signal exhibits surface moisture conditions as well as surface roughness. The results show that arable lands and woodlands in Ehlanzeni as well as shrublands in Sol Plaatje have the highest number of breakpoints.

The number of breakpoints in the SALDi study area Ehlanzeni and Sol Plaatje are visualized in Figure 1 (previous page; right). The majority of breakpoints in Ehlanzeni are found south of the Kruger National Park (KNP), where large areas are covered by sugarcane fields. However, some regions in the eastern part of the KNP are also highlighting some breakpoints, which were most likely caused by fires (FIRMS 2021). In Sol Plaatje, the breakpoint detection indicates the shrublands to have the highest dynamics, especially in the north east of the study area. The validation of the findings will be carried out in close cooperation with our local stakeholders during upcoming field trips. Future work will concentrate on the evaluation of the synergetic potential of Sentinel-1 and Sentinel-2 time series data (Urban et al. 2021).

References:

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Reporting on the progress of the SALDi Data Cube

Insa Otte[1], P. Kluter[1], S. Hill[1], A. Hirner[2], M. Urban[3], A. Mlisa[4], N. Mashiyi[4], J. Eberle[2], M.Schwinger[2], U. Gessner[2], C. Schmullius[3], J. Baade[5]
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[4]South African National Space Agency

The SALDi data cube from optical and radar satellite data includes all necessary pre-processing steps and is generated to monitor vegetation dynamics of five years for six focus areas. Intra- and interannual variability in both, a high spatial and temporal resolution will be accounted for monitor land degradation. Therefore, spatial high resolution earth observation data from 2016 to 2021 from Sentinel-1 (C-Band radar) and Sentinel-2 (optical) will be integrated in the SALDi data cube for six research areas of roughly 100 x 100 km. Additionally, a number of vegetation indices will be implemented to account for explicit land degradation and vegetation monitoring. Spatially explicit query tools will enable users of the system to focus on specific areas, like hydrological catchments or blocks of fields.

So far the following products are already ingested into the SALDi data cube:

- 2015-2020: Sentinel-1 (Gamma Naught RTC backscatter, 10 m x 10 m)
- 2016-2018: Sentinel-2 (L2A scenes processed, 10 m, 20 m and 60 m)
- DEMs (Copernicus DEM GLO-30 / Digital Elevation Model, 30m resolution)
- 2013-2014: NLC DEA (72 Class GTI South African National Land Cover Dataset)

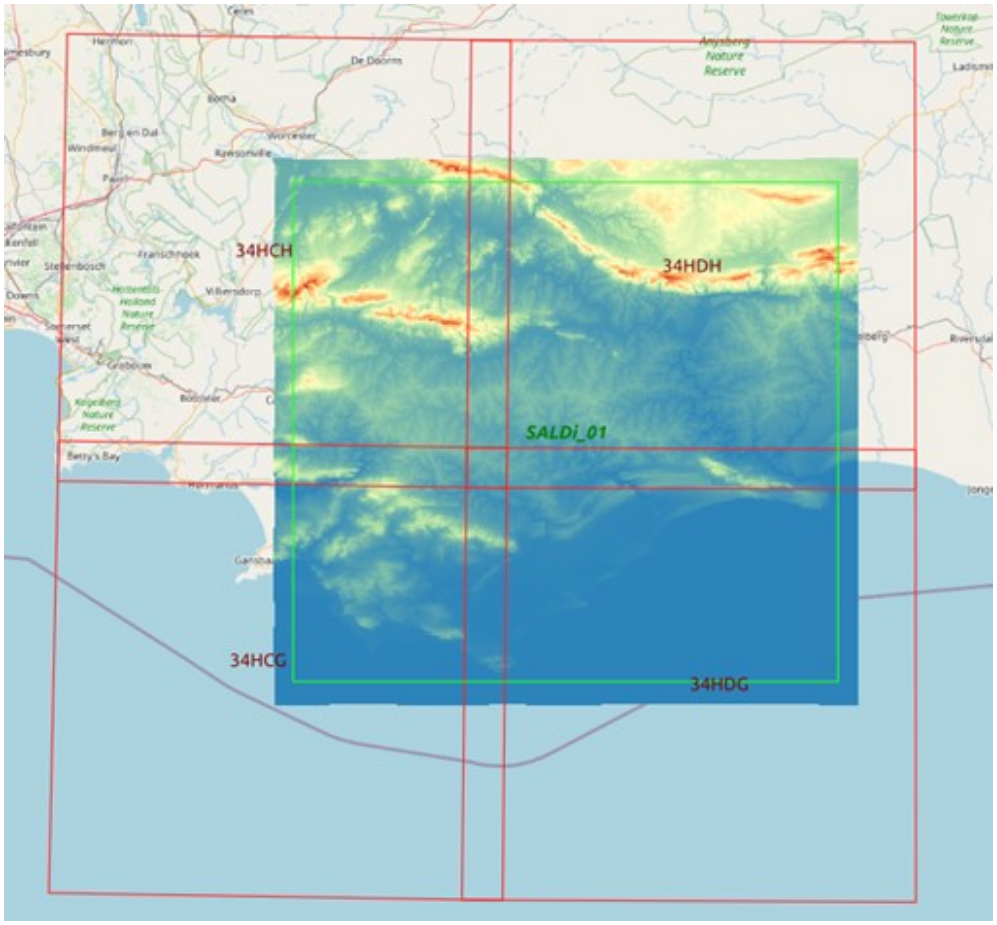

Figure: *Copernicus DEM GLO-30 readily ingested into the SALDi data cube, here displayed for the SALDi study site 1, situated in close vicinity to Cape Town in South Africa. To our knowledge, this is the first time a Copernicus DEM has been ingested and used in an EO data cube.*

Sallnet DroughtAct experiment: After six extreme drought years, the focus is now on recovery processes

After six years of experimental drought in the DroughtAct experiment situated in a dry savanna in South Africa's Limpopo province, plots under drought treatment turned to bare ground (Figure 1). Before the growing season 2020/2021 an important treatment change was initiated: The six-year drought was ended and now the post-drought recovery processes in vegetation and soil will be investigated in the coming years.

Results from the past years show a collapse of annual net primary production (ANPP) in the drought plots, both under grazing and resting conditions (Figure 2). Relative reduction of ANPP in drought plots increased with the length drought (Figure 3), indicating of decreasing rain use efficiency and therefore a degradation of vegetation. While we found the vegetation to be relatively resistant and resilient to a 2-years drought, we expect a lengthy recovery process after a 6-years drought.

***Figure 1**: Core treatments of DroughtAct in the sixth observation year (2020). Pictures: Vincent Mokoka*

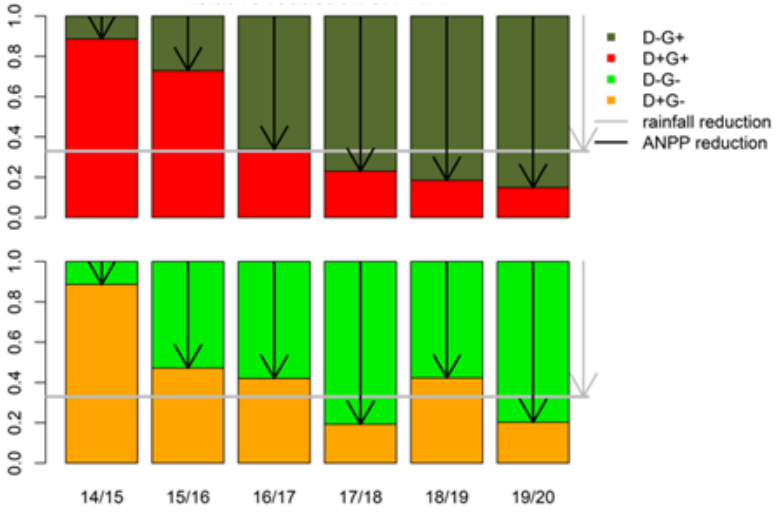

***Figure 2:** Comparison of ANPP (in g/m²) between drought (D+) and ambient rainfall conditions (D-) both under grazing (G+) and resting (G-) conditions. Asterisks indicate a significant difference between D+ and D- at p<0.05.*

The DroughtAct experiment was established in 2014 following a pre-treatment year in the context of the Spaces I: Limpopo Living Landscapes (LLL) project. The main aim of the experiment was to understand the combined effects of a centennial-scale drought and grazing on a dry savanna ecosystem, using a full-factorial design. With continuous data collection until today, DroughtAct has become a long-term experiment and an integral part of the SALLnet subproject "Rangelands and Agroforestry" led by Prof. Dr. Anja Linstädter. With the end of the SALLnet project, DroughtAct will be handed over to the working group of Prof. Dr. Kingsley Ayisi at the University of Limpopo for further investigations of ecosystem recovery.

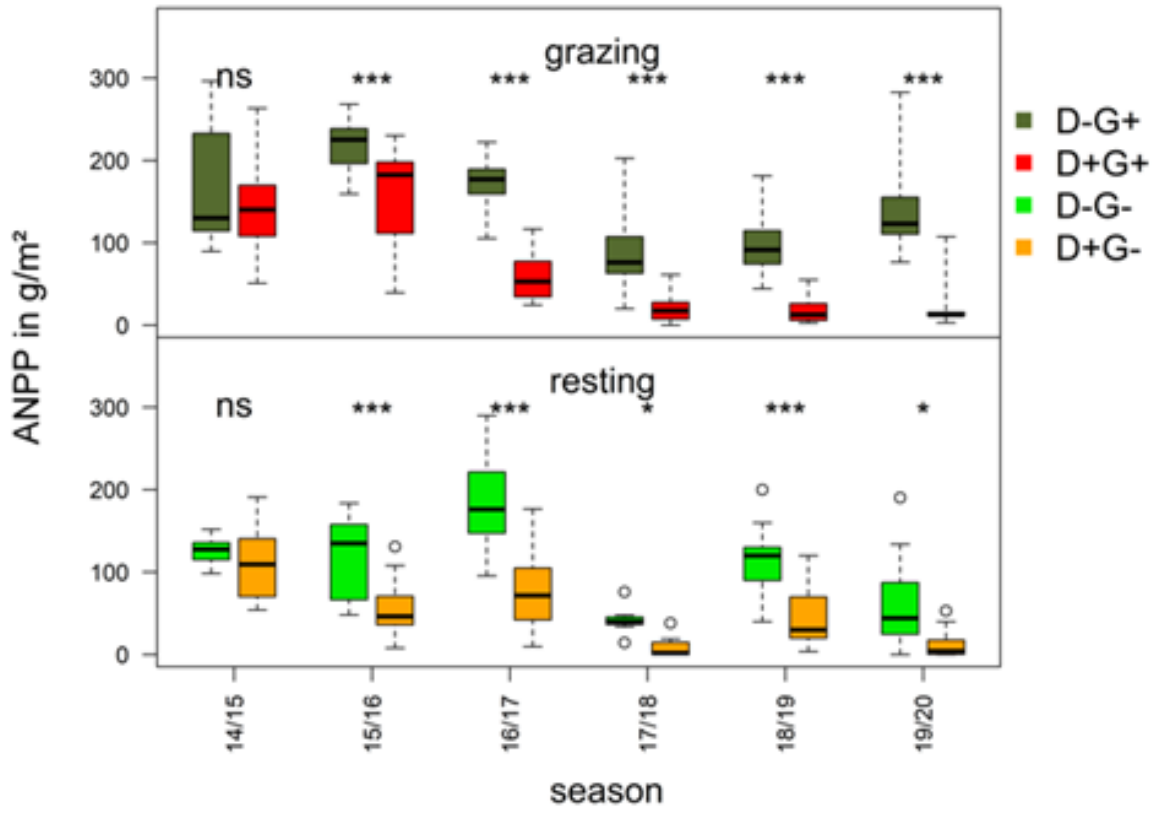

***Figure 3**: Response ratio of Drought (D+) compared to ambient rainfall conditions (D-). The black arrow indicates the relative reduction of ANPP in the D+ plots compared to D- plots, while the grey line indicates the relative rainfall in the D+ plots (33% of the ambient rainfall).*

Fine resolution for fine details: The perception of trees as competitors for light resources in agricultural fields has to change

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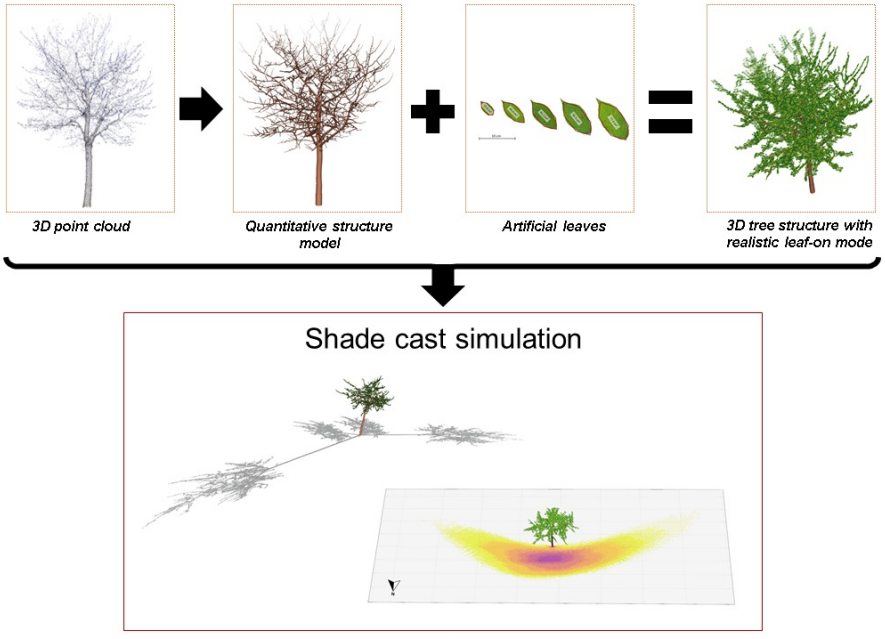
Should we add trees to convert agricultural fields in agroecosystems? What are the likely trade-offs of having trees growing alongside crops and or livestock? How is the structure of the trees shaping the availability of resources within a productive system over time?

ASAP's newest article **"Modelling and Comparing Shading Effects of 3D Tree Structures with Virtual Leaves"** (Bohn Reckziegel et al. 2021) does not answer all these questions, but aims to enhance our perception of scattered trees in the agricultural landscape by investigating a fine scale assessment of solar energy reduction on the ground as a result of trees in agroforestry systems acting as physical barriers to incoming solar radiation.

For years, the assessment of the shade cast by trees has been reduced to the utilisation of simplified geometric structures representing the tree and its crown (e.g. cones, spheres). Using Wild Cherry (*Prunus avium* L.), growing in Germany as a test case, we couple Terrestrial LiDAR, as a tool for digitalisation of landscapes, with a cylinder-fitting algorithm, to produce measurable 3D models of trees of known topology and structure. The derived cylinder models are populated with virtual leaves, realistically representing leaf morphology and distribution in order to refine the estimations of solar insolation on the ground at any point in time and space as a function of tree size, tree attributes and architecture.

The results provided evidence that the shadow model is a suitable tool for a detailed quantification of the shading effects of single trees, as it focuses on the particularities of the tree structures derived from the LiDAR data. However, the method still demands relatively high computational resources. Our findings can be utilised to support decision-making by land managers, in agricultural and established agroforestry systems, or even to facilitate the inclusion of trees in urban areas, as a strategic public health measure. We foresee the use of the shadow model as a tool for defining tending operations to woody perennials, as a possibility to manage light, and its reduction, around trees or at stand level and of particular importance to areas where light, (and thus also, other related factors such as water management) are of upmost importance.



Bohn Reckziegel, R.; Larysch, E.; Sheppard, J.P.; Kahle, H.-P.; Morhart, C. Modelling and Comparing Shading Effects of 3D Tree Structures with Virtual Leaves. Remote Sens. 2021, 13, 532. https://doi.org/10.3390/rs13030532