South African Land Degradation Monitor (SALDi) – A new German – South African SPACES collaboration to advance land degradation assessments

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Land degradation is an important issue in South Africa, partly due to the high variability of the climatic conditions, the strong population growth and economic demands. It has been linked to the terms *veld degradation* and *soil degradation* and has been addressed by numerous measures. But there is still uncertainty on the extent of human induced land degradation as compared to periodic climate induced land surface changes.

In cooperation with South African institutions and stakeholders, the overarching goal of SALDi is to implement novel, adaptive, and sustainable tools for assessing land degradation in multi-use landscapes. Building upon the state of the art in land degradation assessments, the project aims to advance current methodologies by innovatively incorporating inter-annual and seasonal variability in a spatially explicit approach. SALDi takes advantage of the emerging availability of high spatio-temporal resolution Earth observation data, growing sources of in-situ data and advancements in modelling approaches. Particularly, SALDi aims to:

i) develop an automated system for high temporal and spatial resolution change detection monitoring of ecosystem service dynamics,

ii) develop, adapt and apply a Regional Earth System Model (RESM) to South Africa and investigate the feedbacks between land surface properties and the regional climate,

iii) advance current soil degradation process assessment tools for soil erosion.

Here we introduce the new three-year research project to the Global Change community and seek further opportunities for collaboration.

Keywords: Veld degradation, soil erosion, remote sensing, in-situ observations, collaboration with stakeholders

1. Introduction

Since the middle of the 20th century, the issue of land degradation in South Africa has been linked to the terms *veld degradation* and *soil degradation* and has been addressed by numerous measures (Hoffman and Ashwell 2001). The first national survey was conducted by Hoffman *et al.* (1999) based on expert interviews at the district level. Other milestones were the national GLADA (Bai and Dent 2007) and LADA (Lindeque 2009) reports, the country-wide RUSLE-based estimation of soil erosion by water (Le Roux *et al.* 2008), and the remote sensing-based land cover change analysis between 1995 and 2005 (Schoeman *et al.* 2010, 2013).

The ARC ISCW (2017) recently presented an assessment of land degradation change for the period 2009-2013. Water and wind erosion, soil salinization and acidification, hydro-climatic parameters, land cover and the loss of biodiversity were taken into account when calculating the Land Degradation Index (LDI). Accordingly, South Africa is greatly affected by land degradation, partly due to the high variability of its climatic conditions and the strong population growth. The LDI spatial variation, depicted in Figure 1, illustrates its relation to climatic conditions, biome distribution (Rutherford 1997) and land use (DEA 2015).

Measures to combat land degradation have led regionally to well established soil-conserving agriculture. A preliminary data analysis on the development of water storage volumes and reservoir siltation in South Africa (DWS 2017, status: ~2005) indicates, that these measures possibly led regionally to a deceleration of reservoir siltation and thus to an improvement in aquatic ecosystem services. In other parts of the country, the fight against land degradation has been less successful. Here, the LDI increased between 2009 and 2013 (ARC-ISCW 2017).

Consequently, FAO & ITPS (2015) attest South Africa poor soil conditions and an overall continuing negative trend. However, there is still uncertainty on the extent of human induced land degradation as compared to periodic climate induced land surface changes, e.g. the impact of the last drought. A new German – South African SPACES Collaboration, the South African Land Degradation Monitor (SALDi) addresses these uncertainties. Here we introduce this new three-year cooperative research project to the Global Change community and seek new opportunities for collaboration.

2. SALDi Aims

In cooperation with South African institutions and stakeholders, the overarching goal of SALDi is to implement novel, adaptive, and sustainable tools for assessing land degradation in multi-use landscapes in South Africa. At this stage institutions involved in this project include the Agricultural Research Council (ARC-ISCW), Council for Scientific and Industrial Research (CSIR NRE (EO)), South African National Parks (SANParks), the South African National Space Agency (SANSA), Stellenbosch University and University of the Free State, Equispectives Research and Consulting Services as well as the Planning and GIS division of Eskom.

Building upon the state of the art in land degradation assessments (e.g. Lindeque 2009, Wessels *et al.* 2012) the project aims to advance current methodologies by innovatively incurporating inter-annual and seasonal variability in a spatially explicit approach. SALDi takes advantage of the emerging availability of high spatio-temporal resolution Earth observation data (e.g. ESA Sentinels, DLR TanDEM-X, Landsat program), growing sources of in-situ data and advancements in modelling approaches. Particularly, SALDi aims to:

i) develop an automated system for high temporal frequency (bi-weekly) and spatial resolution (10 to 30 m) change detection monitoring of ecosystem service dynamics,

ii) develop, adapt and apply a Regional Earth System Model (RESM) to South Africa and investigate the feedbacks between land surface properties and the regional climate,

iii) advance current soil degradation process assessment tools for soil erosion, as this process represents an intrinsic limiting factor for biomass production and other regulating, supporting and provisioning ecosystem services.

Thus, SALDi is committed to contribute to a number of cross-cutting knowledge challenges identified in the Global Change Grand Challenge National Research Plan, South Africa (van Wilgen 2009), e.g. the under-standing of the processes, the adaption to them and the innovations for sustainability.

3. SALDi study sites

SALDi focuses on six 100 x 100 km² study regions across South Africa (Figure 1). These regions represent a major climate gradient, from the high winter rainfall region in the SW across dry summer rainfall to high summer rainfall regions around the escarpment in the NE. The fact that large reservoirs do not exist in all areas, illustrate the climatic contrasts in southern Africa. The regions cover also different geological conditions and represent landscapes with varying land degradation status in 2013 and different agricultural practices. These include commercial, rain-fed and irrigated cropland, free range cattle, sheep and game farming, as well as communal and subsistence farming. These considerable differences in land use and ownership structure reflect further factors influencing land degradation (Meadows & Hoffman 2002). Thus, the sites basically represent the climatological, ecological, socio-economic and cultural diversity of South Africa. Furthermore, sites were selected in a way to take into account the incisive biome changes expected under the predicted global climate change (Driver *et al.* 2011).

At these sites, the three major scientific objectives, i.e. spatio-temporal monitoring, land-atmosphere and erosion modelling, and the updated land degradation assessment, are being investigated based as well on in situ measurements. Protected areas, e.g. National Parks, within our study regions represent benchmark sites, providing a foundation for Baseline Trend Scenarios, against which climate-driven ecosystem service dynamics of multi-used landscape (cropland, rangeland, forests) will be evaluated.

The methodological developments concerning the Earth Observation-based land degradation monitor as well as the ground validation works and the improvements in the assessment of soil erosion focusses on all six sites. At two sites, socio-economic investigations on land degradation and the final evaluation of the SALDi products concerning their applicability at the local stakeholder scale will take place. Compared to this, the modelling exercise with a fully coupled Regional Earth System Model (Arnault *et al.* 2016) WRF-Hydro applies to the whole southern African region shown in Figure 1.

The Earth Observation-based investi-gations will use the latest frequently acquired high temporal and spatial resolution remote sensing data (e.g. ESA Sentinels) to build up a time series data cube starting in July 2015. This will enable SALDi to investigate not only the land surface dynamics and land degradation processes for a period of 5+ years, but as well the recovery of the South African landscape from the 2015 drought being considered the worst drought since rainfall records began in 1904 (Joubert 2016). We should thus be

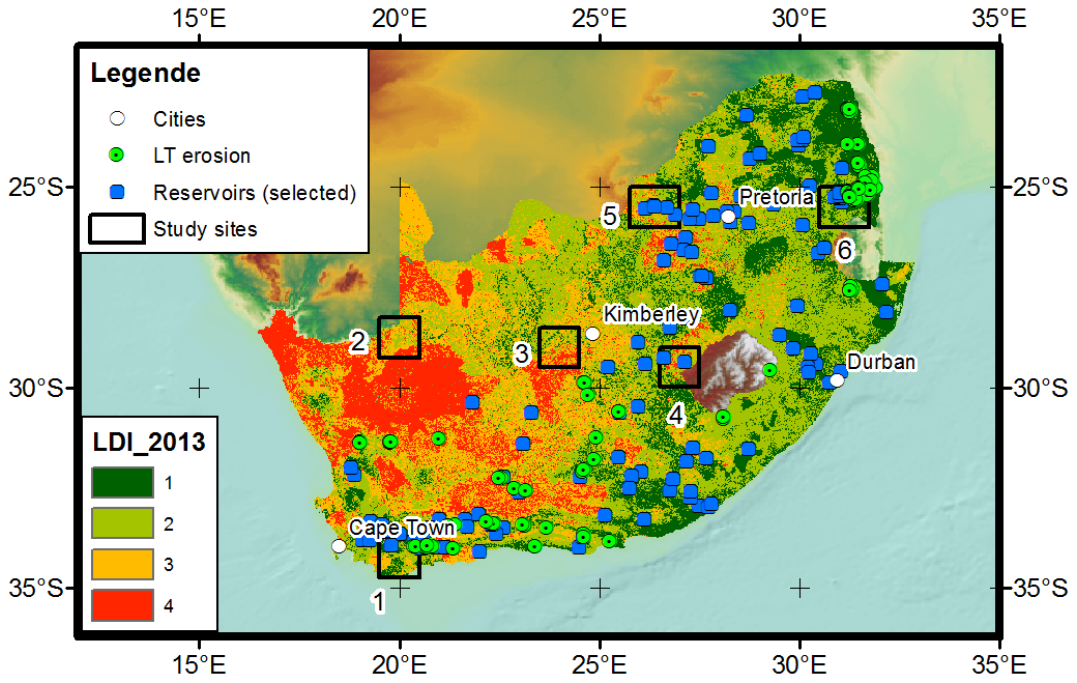

Figure 1. SALDi study sites

The map shows the proposed study sites based on the Land Degradation Index map 2013 (LDI_2013, 1 = slight to 4 = severe, from: ARC-ISCW 2017), the selected dams for an update of the reservoir siltation and sediment yield assessment of Rooseboom 1992, as well as the currently available data on long-term erosion rates derived from cosmogenic isotope analysis ((LT erosion) (Data sources: LT erosion: own compilation, Rooseboom 1992, ARC ISCW 2017, NOAA 2006)

able to document and better understand land surface dynamics under the anticipated trend towards more extreme conditions (e.g. Scholes *et al.* 2015)

4. SALDi outreach and outcome evaluation

SALDi is committed to make the results freely available to all stakeholders in Southern Africa for non-commercial use. Thus, our South African partners can use the developed processors, algorithms and models for long-term monitoring. In particular, the SALDi Data Cube will be exchanged with SANSA and the SASSCAL Open Access Data Center (OADC). The South African partners will use the results to improve land and soil degradation management in politics, communal and agricultural planning and to apply SALDi's findings and insights in their university teaching. In order to ensure that the developed tools will be applicable at the local stakeholder level, the socio-economic dimension of land degradation and a validation of the usefulness of the monitoring products to local farmers is an important goal of the investigations. It is particularly this local scale outcome evaluation where we seek the support of the Global Change community. So, if you are engaged in land surface change studies or land degradation amelioration work in one of our six study regions, please get in touch with us.

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