SPACES II

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

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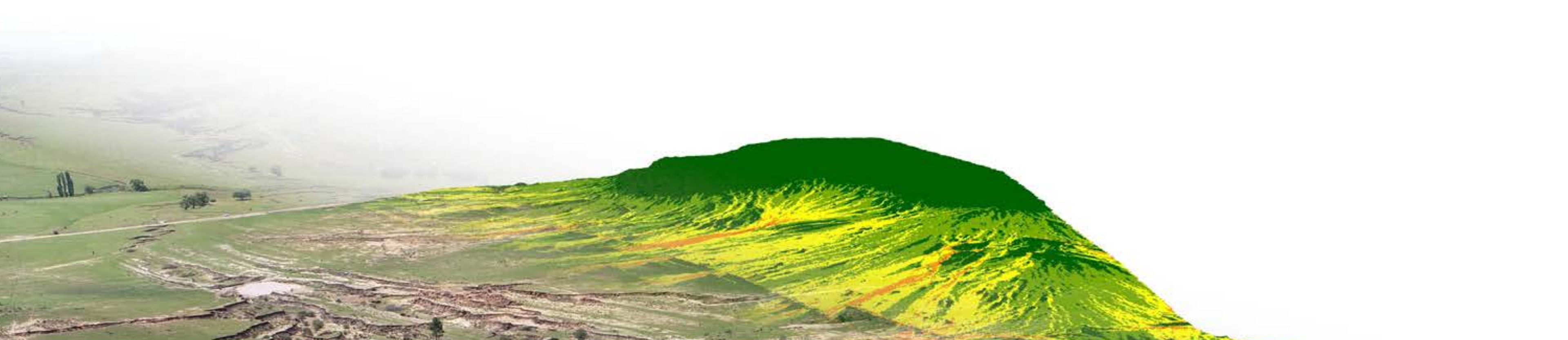
SALDi – South African Land Degradation Monitor
Project Status Report 2018-2020

Additional material

Prepared by SALDi Consortium Team Members

Photo: M. Geissler 2019



2 Focus 1: Soil Erosion Assessment

with contributions from

A. Kaiser[1], M. Geißler[1], J. Le Roux[2], M.Stander[2], G. van Zijl[3], Z. Zhang[4,5], P. Laux[4,5], H. Kunstmann[4,5], T. Strydom[6], I. Smit[6], C. Glotzbach[7] & J. Baade[1]

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[5] Institute of Meteorology and Climate Research (IMK-IFU), Karlsruhe Institute of Technology, Campus Alpin, Garmisch-Partenkirchen, Germany
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2.1 Content

2.2 Rainfall simulations

2.3 Soil erosion model tests

2.4 Reservoir surveys

2.5 UAV surveys

2.6 Long-term erosion

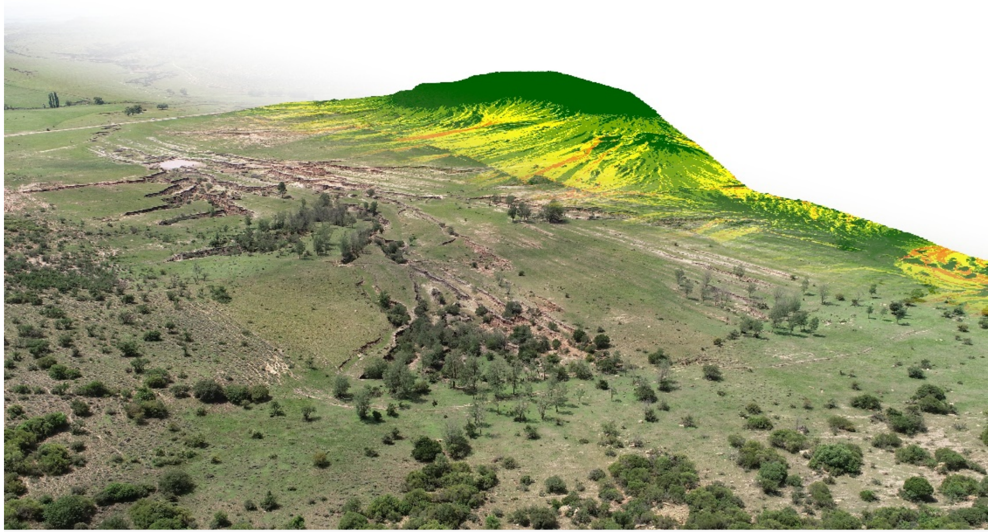
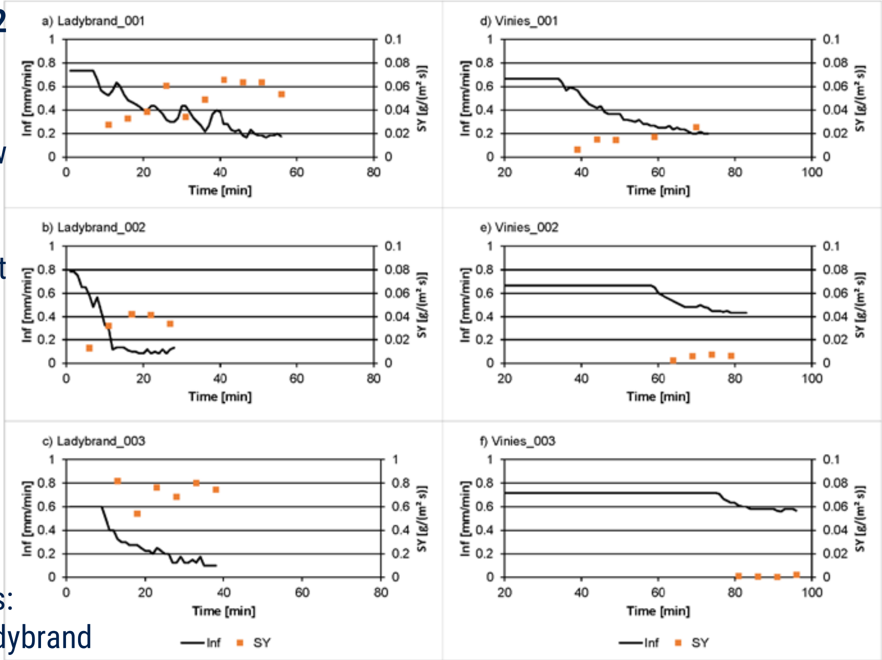


Fig. 2.1: Overlay of model results and aerial image of the research catchment Manyatseng near Ladybrand

2.2 Rainfall simulations

Fig. 2.2



Rainfall experiment results from the Free State. Graphs show infiltration rates vs. time [mm/min]. a) to c) show results from a degraded catchment, d) to f) results from a conservation tillage site. Squares indicate sediment yield (SY).

Fig. 2.3
Some locations of the rainfall experiments:
Top: Manyatseng research catchment, Ladybrand
Middle: Conservational tillage at Vinies
Bottom: Macadamia plantation in Mpumalanga

2.3 Soil erosion model tests

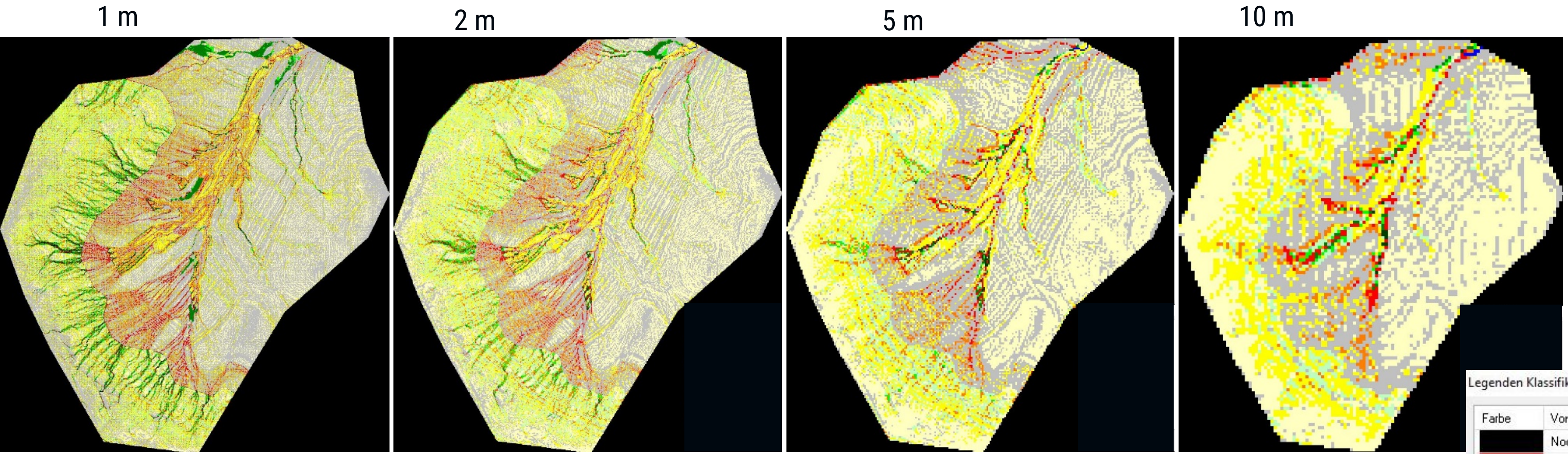


Fig. 2.4 Model runs with varying DEM resolutions

Legenden Klassifikation kg/m²

Farbe	Von (>=)	Bis (<)
black	Nodata	Nodata
red	-20000,000	-25,000
orange	-25,000	-2,500
yellow	-2,500	-0,250
light yellow	-0,250	-0,001
grey	-0,001	0,001
light green	0,001	0,250
green	0,250	2,500
dark green	2,500	25,000
very dark green	25,000	20000,000

Parameters adjusted during testing:
- Skinfactor
- DEM resolution
- DEM resampling method
- Filtering approach

2.4 Reservoir surveys

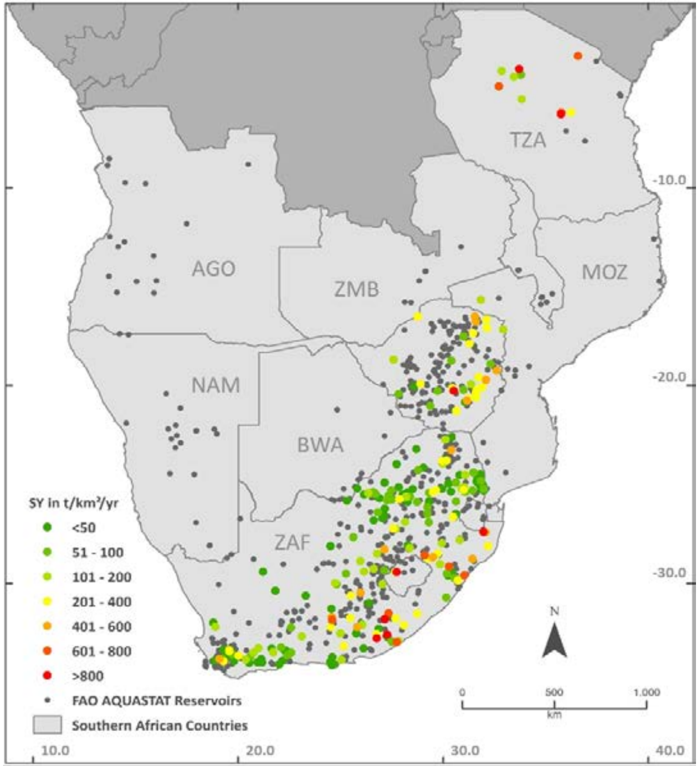


Fig. 2.5 Map of Southern Africa showing all surveyed reservoirs in graduated colors, from green (lowest SY values) to red (highest SY values). The same classes have been used by Rooseboom et al. (1992). Grey points show all medium and large reservoirs listed by the FAO (2016).

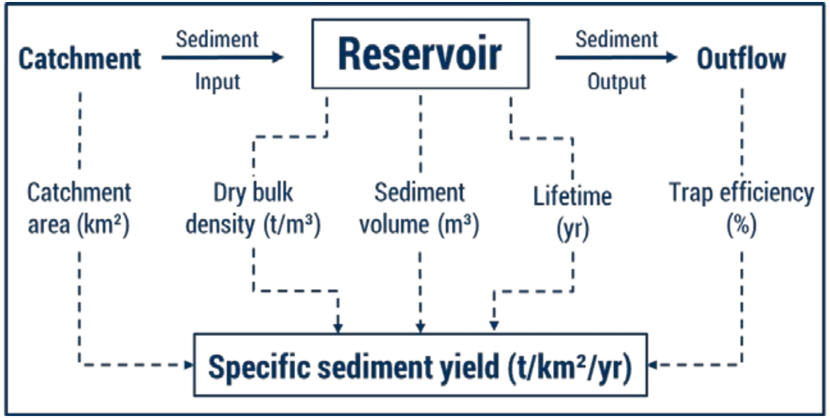


Fig. 2.6 Schematic description of parameters needed to calculate the specific sediment yield (SY) from reservoir sedimentation data

2.4 Reservoir surveys

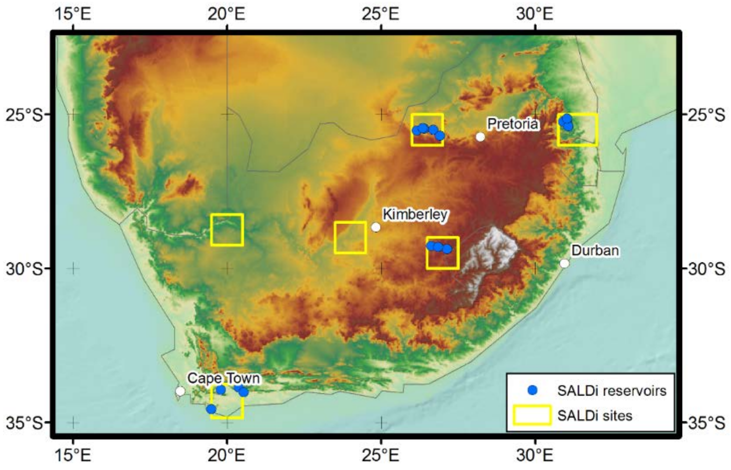


Fig. 2.7 Map of South Africa with the SALDi study sites and the 16 reservoirs to be studied

Goals:
- Analyze DWS (2019) reservoir data for sediment yield trends over time
- Relate these trends to influencing catchment parameters

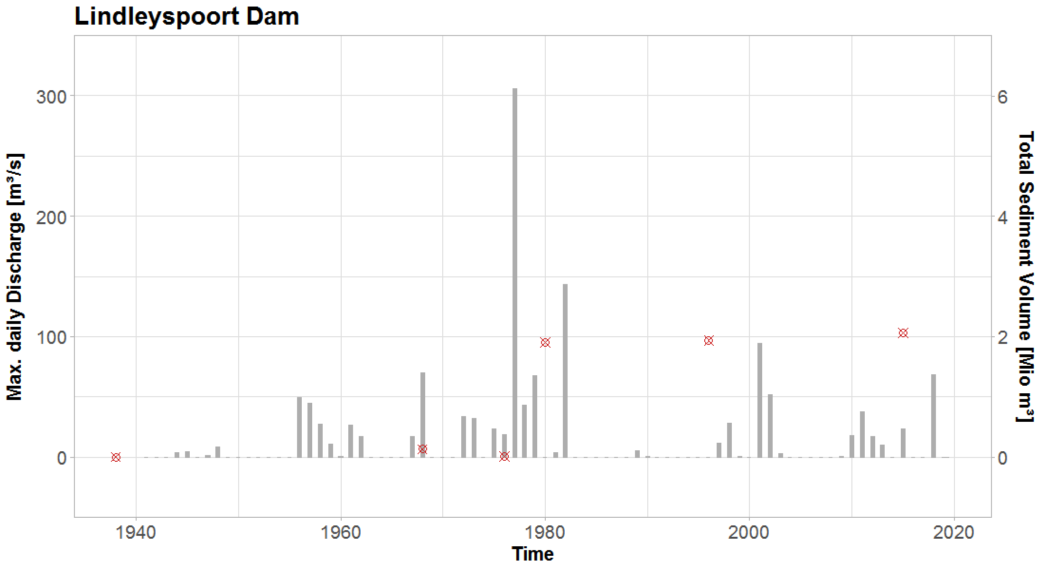


Fig. 2.8 Maximum daily discharge per year for the Lindleyspoort Dam (grey bars) and the sediment volumes derived for six measurement timesteps

2.4 Reservoir surveys

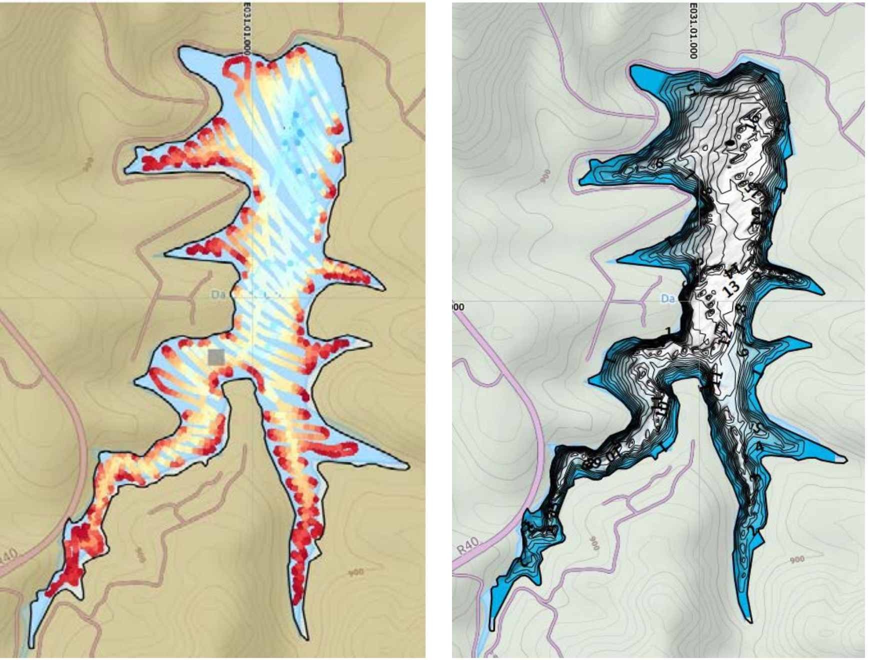


Fig. 2.9 Echo sounder mapping of DaGama Dam (Hazyview,, Mpumalanga). Left: the track of the survey boat, Right: bathymetric map of the reservoir.

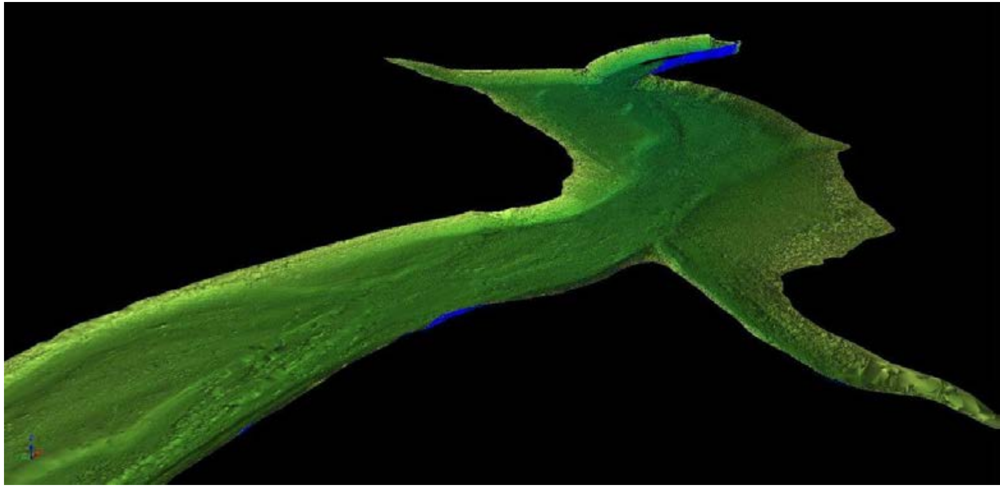


Fig. 2.10 Results from terrestrial laser scanning at almost dried out Klipberg Dam close to Robertson, Western Cape.

2.5 SALDi-UAV surveys

Fig. 2.11 Overview of SALDi-UAV flights for mapping, monitoring and modelling

- a total of 26.04 km² covered
- 25 campaigns, ~56 lift-offs
- ground resolution orthophotos 0.4 – 5.7 cm
- ground resolution elevation models 0.8 – 12cm
- 162,8 GB of raw image data
- Two campaigns for sister project EMSAfrica and one for collaboration partners at University of the Free State, Bloemfontein

→ with support from SA-licensed pilots, UAV industries, Cape Town

UAV INDUSTRIES
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2.5 SALDi-UAV surveys

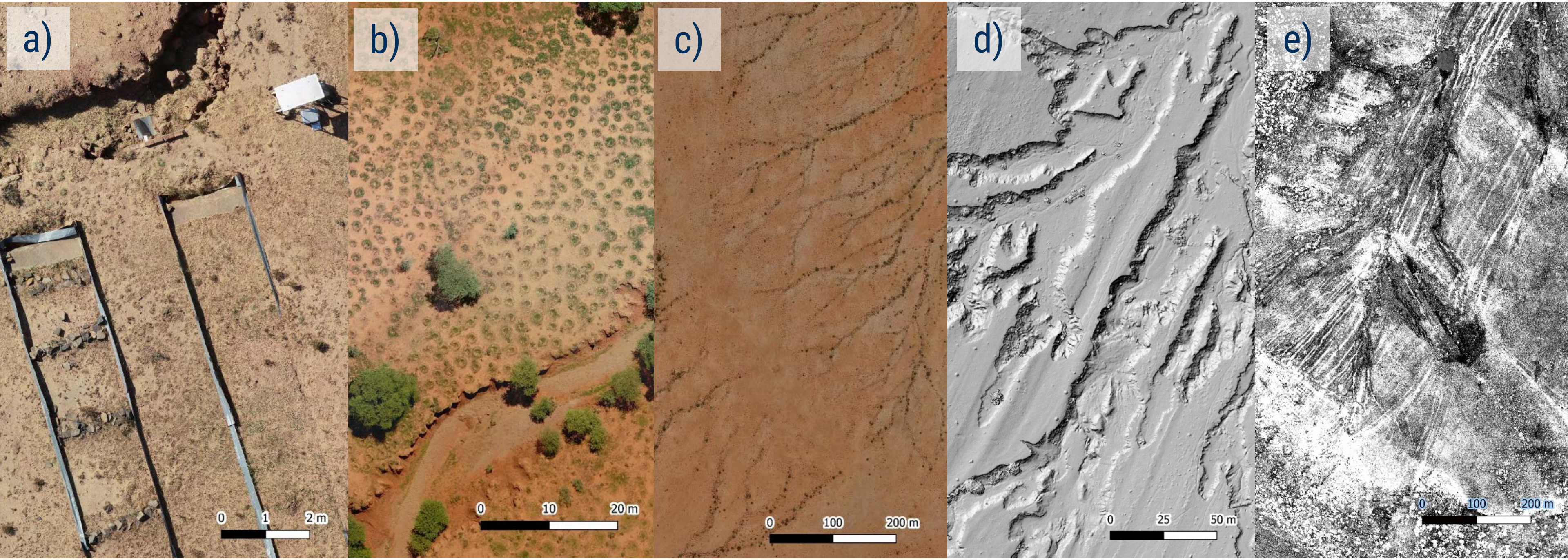


Fig. 2.12 Examples of different datasets showing results in different resolutions. a) high detail of old erosion research plots in Manyatseng research catchment; b) 'ponding' as a runoff control measure in Mokala NP; c) large-scale rill monitoring in Augrabies NP; d) digital surface model of a gully in Manyatseng research catchment, Free State; e) additional products: excess green index of Manyatseng catchment, Free State.

2.6 Long-term erosion

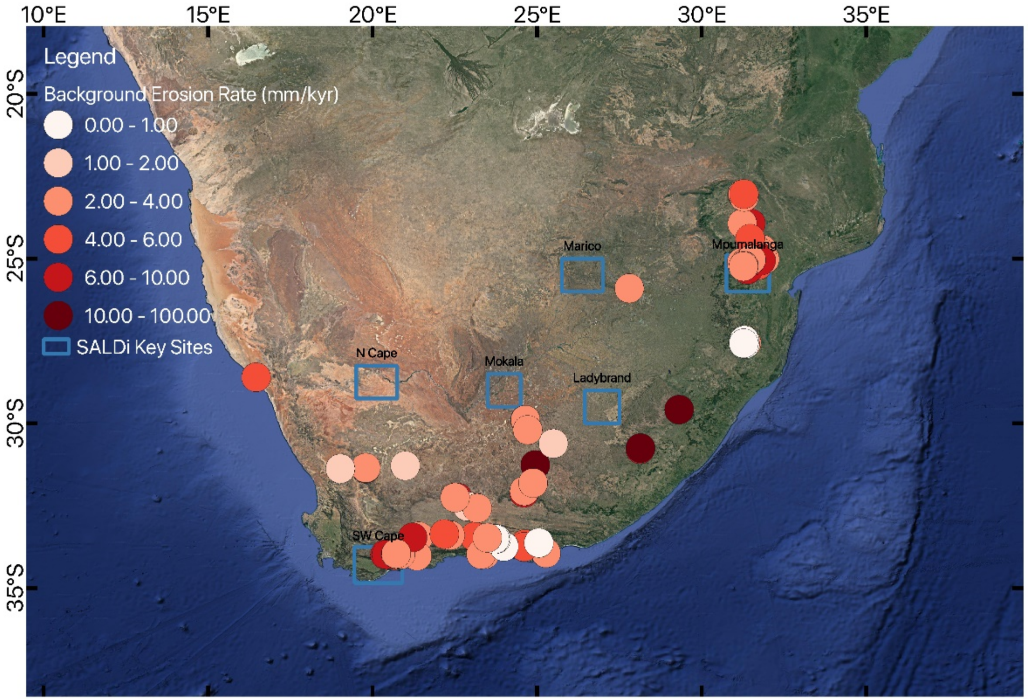


Fig. 2.13 Overview of currently available asessments of long-term ersoion rates (N = 138) in South Africa.

2.6 Long-term erosion

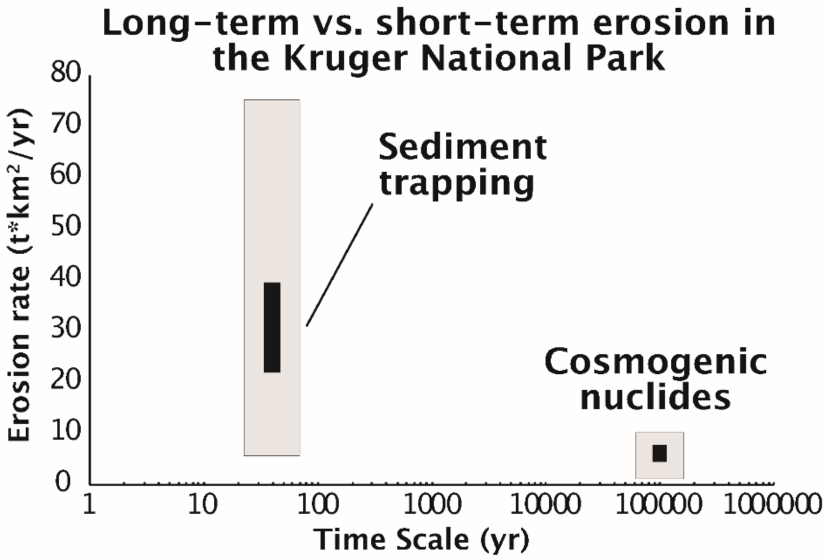


Fig. 2.14 Comparison of long-term erosion rates based on cosmogenic nuclides with those measured by sediment trapping from the same catchments in the Kruger National Park, South Africa (unpublished).

2.6 Long-term erosion

Fig. 2.15 Long-term erosion rate assessment work flow including a) sampling of river deposits (Photo: J. Baade 2019), b) preparation of targets for AMS measurements (Photo: C. Glotzbach 2020), c) determination of beryllium concentrations with an accelerator mass spectometer (AMS), here the facility at iThemba LABS in Johannesburg (Photo: J. Baade 2015).

3 Focus 2: Land surface dynamics

with contributions from

M. Urban[1], A. Hirner[2], C. Schmullius[1], U. Gessner[2] K. Heckel[1], K. Schellenberg[1], T. Strydom[3], I. Smit[3], T. Morgenthal[4], G. Feig[5], J. Henschel[6], B. Mogonong[6], W. Lück[7], J. Eberle[2], S. Hill[8], N. Mashiyi[9], A. Mlisa[9], Z. Zhang[10], P. Laux[10] & J. Baade[11]

[1] University of Jena, Department for Earth Observation, Jena, Germany, [2] German Aerospace Center, Oberpfaffenhofen, Germany, [3] Scientific Services, South African National Parks, Skukuza, South Africa, [4]Department of Agriculture, Forestry and Fisheries (DAFF) - Directorate: Land Use and Soil Management, [5]EFTEON Manager at the South African Environmental Observation Network (SAEON), [6] South African Environmental Observation Network (SAEON), Arid Land Node, [7]PCI Geomatics, [8]University of Würzburg, Germany, [9]SANSA, South Africa, [10]University of Augsburg, Germany, [11]University of Jena, Department for Physical Geography, Jena, Germany

3.1 Content

3.2 Soil Moisture Monitoring

3.3 High-Resolution Digital Surface Models

3.4 Slangbos Monitoring

3.5 Woody Cover Classification

3.6 Trend Analysis & Change Detection

3.7 Data Cube

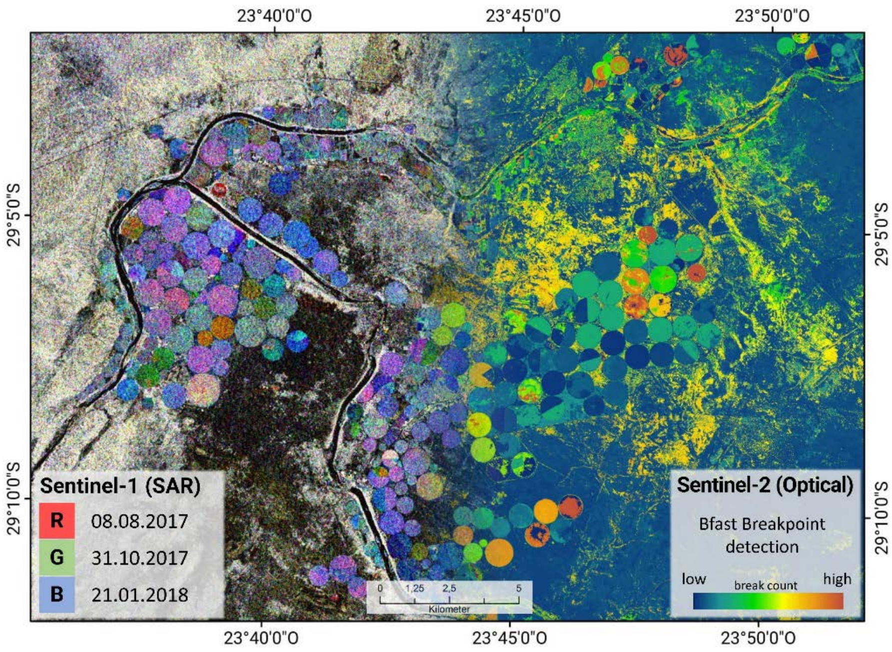


Fig. 3.1: Synergistic combination of Sentinel-1 and Sentinel-2 data to derive surface products for Land Degradation Monitoring.

3.2 Soil Moisture Monitoring

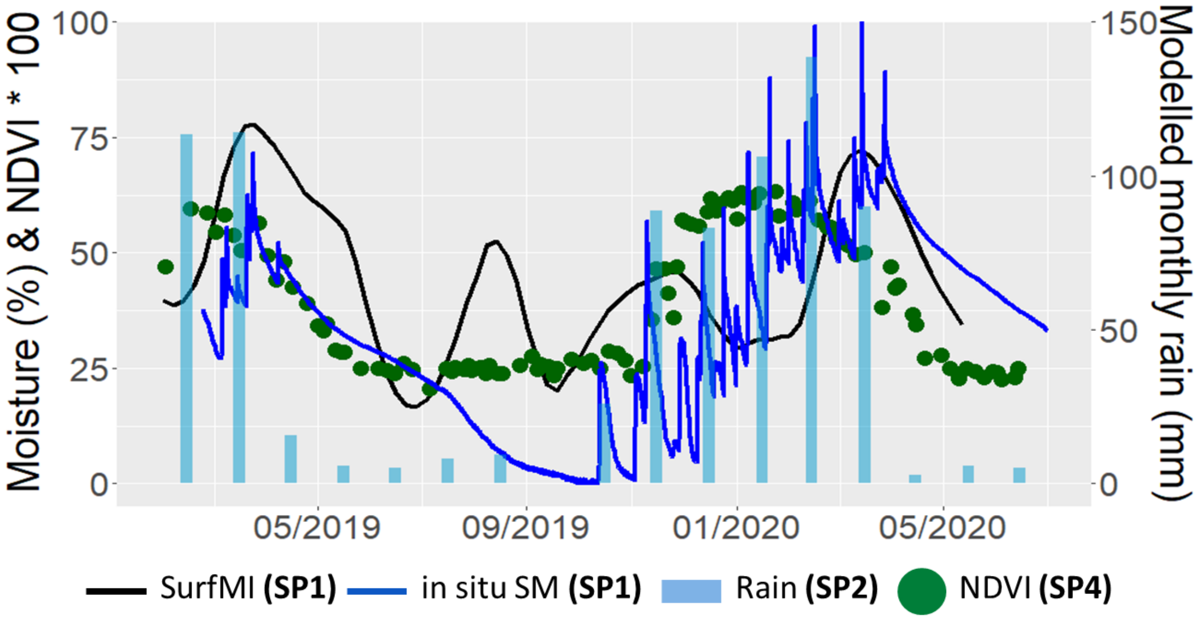


Fig. 3.2: Soil Moisture time series from in situ measurements in the Mantsopa project region in comparison with SurfMI derived from Sentinel-1, modelled precipitation from CHIRPS as well as NDVI from Sentinel-2.

3.3 High-Resolution Digital Surface Models

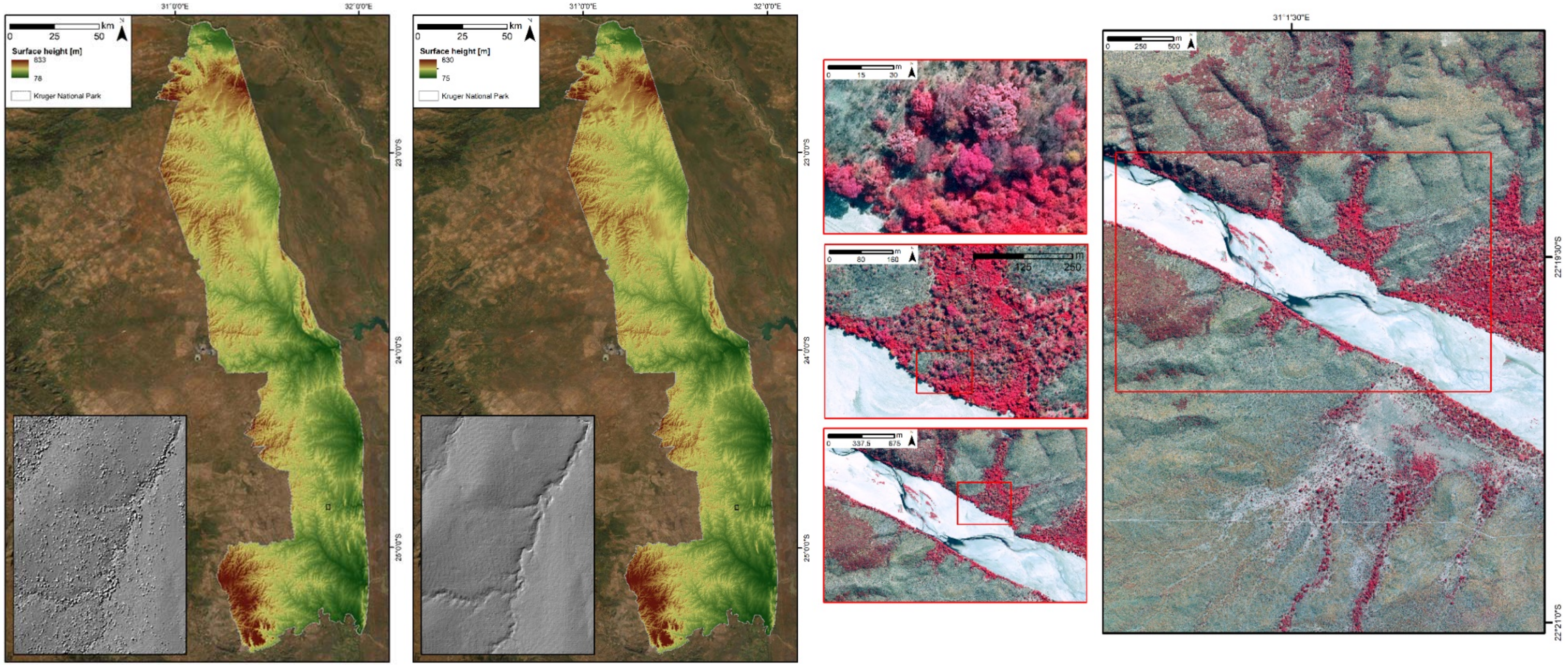
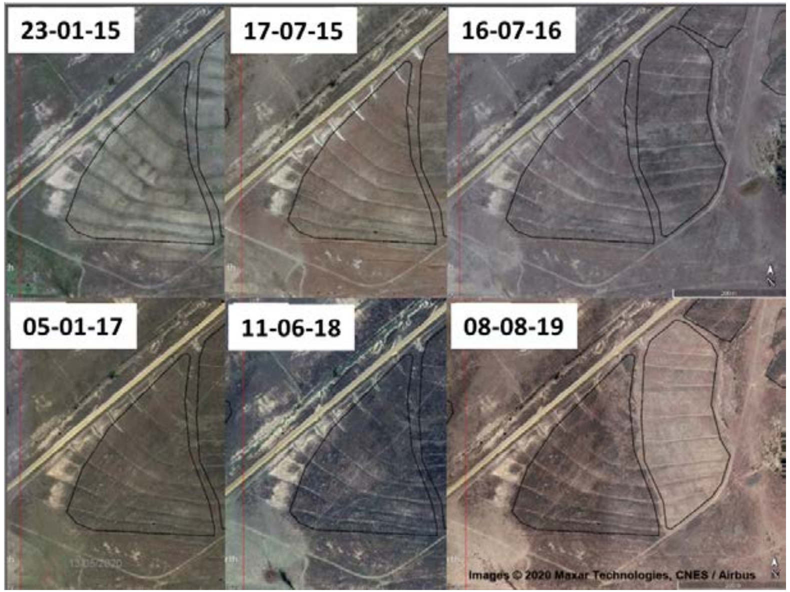


Fig. 3.3: High resolution Digital Surface Model (**left**), Digital Terrain Model (**middle**) as well as orthophotos (**right**) derived from Digital Mapping Camera imagery (© NGI) for the Kruger National Park at 25 cm spatial resolution (Heckel et al. in prep.)).

3.4 Slangbos Monitoring



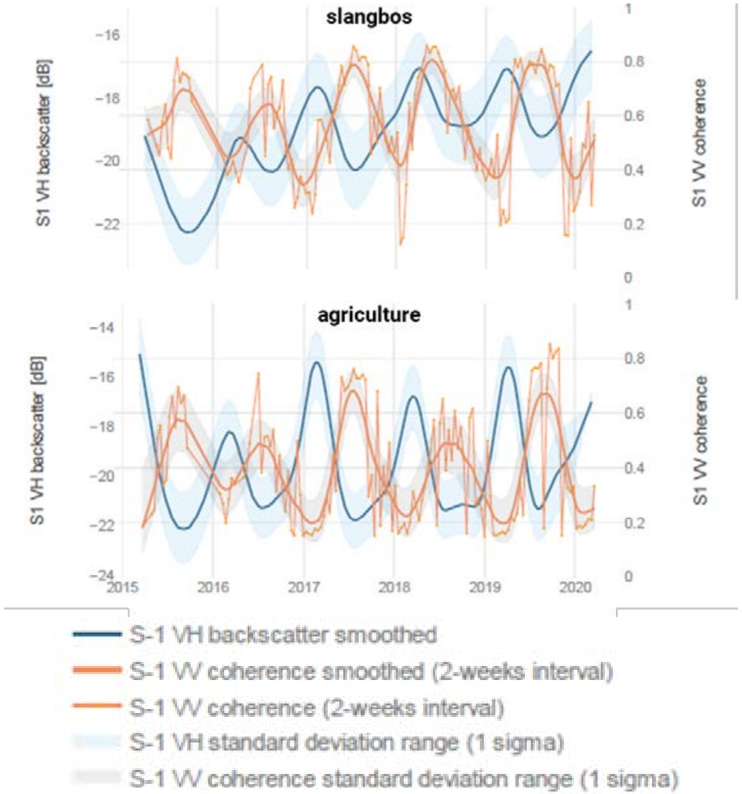
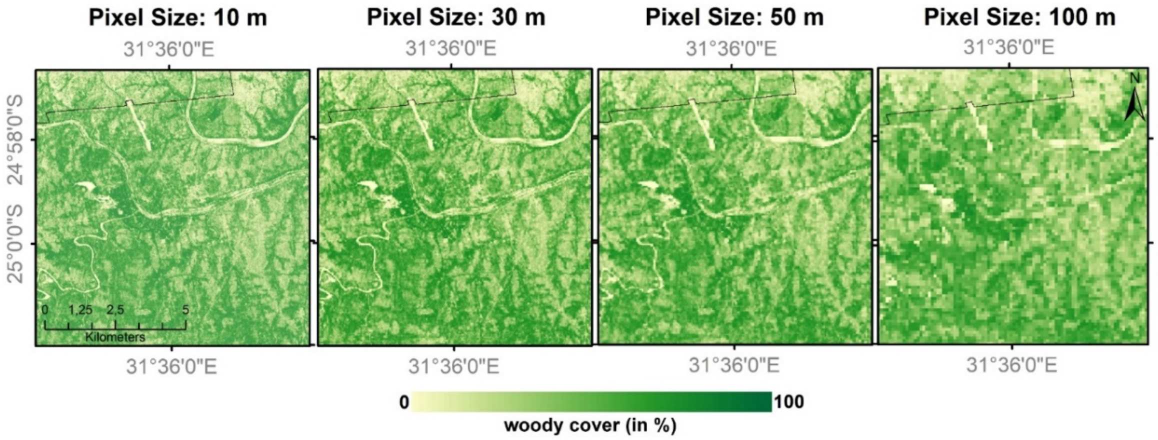


Fig. 3.5: (above). High-resolution satellite data illustrating Slangbos encroachment in the Mantsopa project region (Source: Google Earth). (right) Sentinel-1 backscatter and coherence time series 2015-2020 for the above fields (Urban et al., in prep.).

3.5 Woody Cover Classification



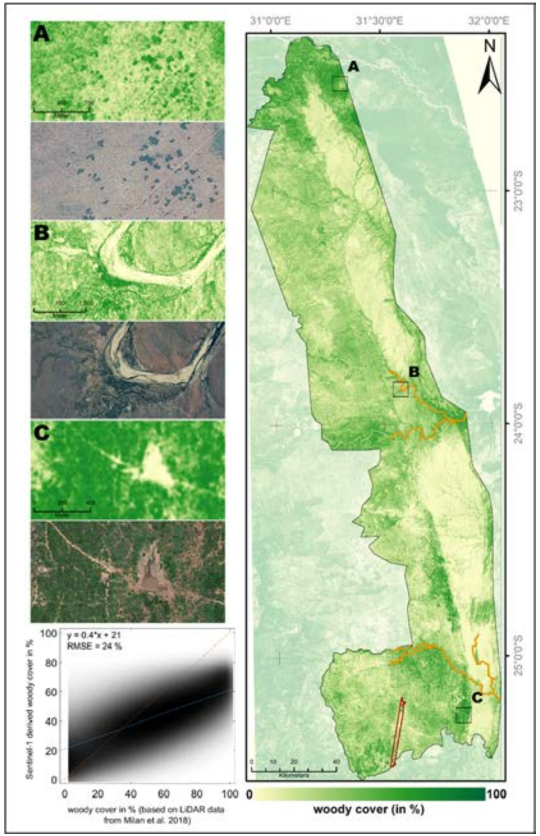


Fig. 3.6: (above) Woody cover map of Kruger National Park for 2016/17 (area between Skukuza and Skukuza Airport – 10 m to 100 m pixel size (left to right)). Spatial cross-validation: 10m - RMSE = 22.8 %, 30 m - 15.8 %, 50m - 14.8 %, 100 m - 13.4 %. (right) Woody cover map of the KNP at 10 m pixel size. Red stripe represents airborne LiDAR training data. Locations A-C show Google Earth comparisons. The scatterplot illustrates correlation to in situ data (from: Urban et al. 2020).

Data/scripts are freely available: https://doi.org/10.5281/zenodo.3728186

3.5 Woody Cover Classification

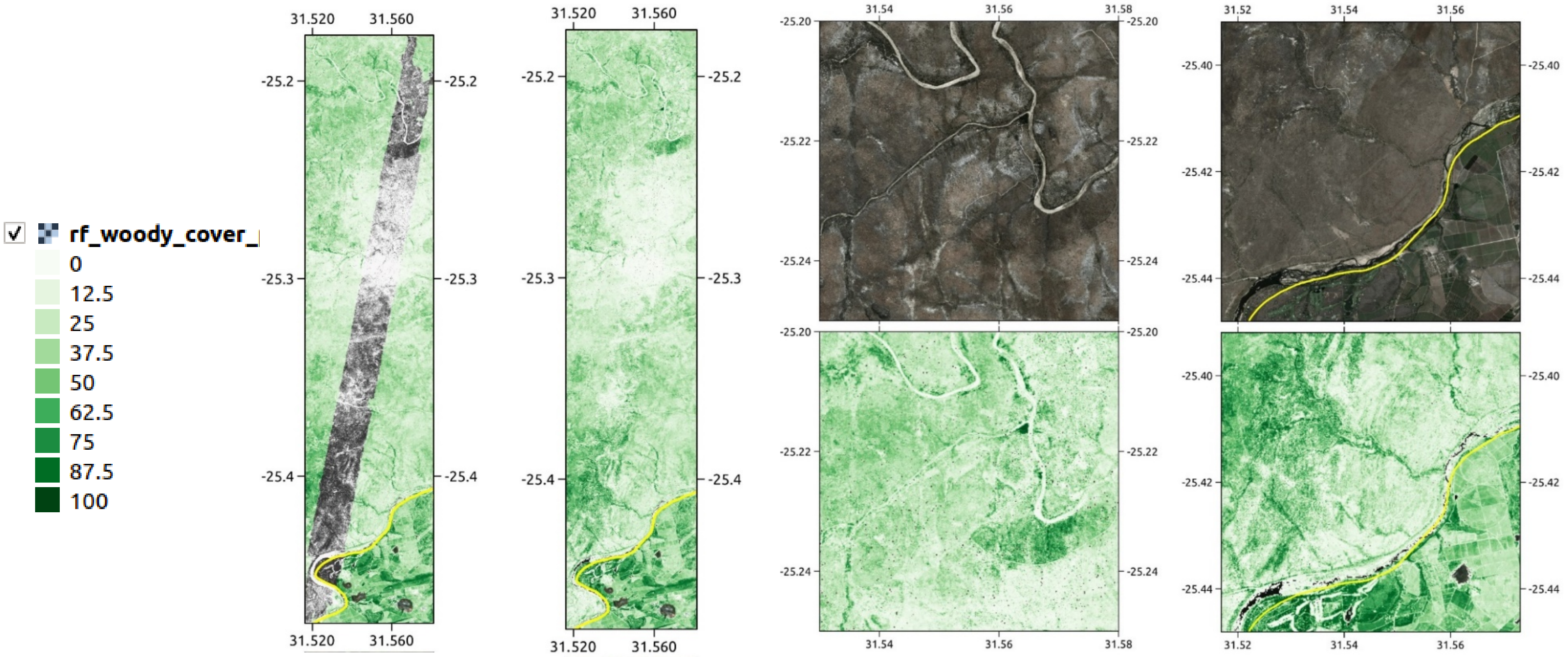


Fig. 3.7: (**left**) first results of a woody cover map derived from Sentinel-2 time series in southern Kruger National Park. (**right**) Enlarged comparisons of Google Earth images and derived maps illustrating qualitative agreement of retrieval results.

3.6 Trend Analysis & Change Detection

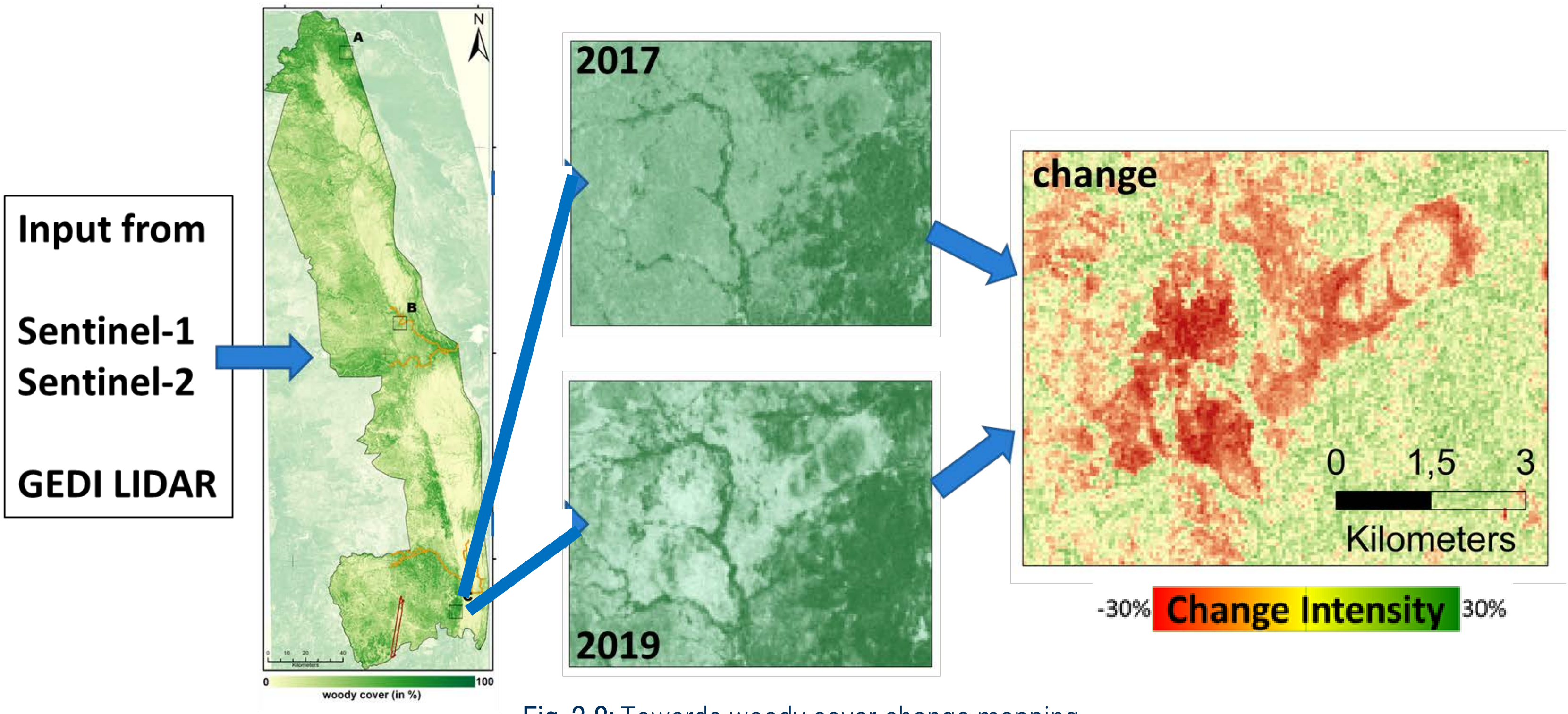


Fig. 3.8: Towards woody cover change mapping.

3.6 Trend Analysis & Change Detection

Sentinel-1 (Recurrence Matrix Analysis - Anomalies)

Sentinel-2 (Bfast)

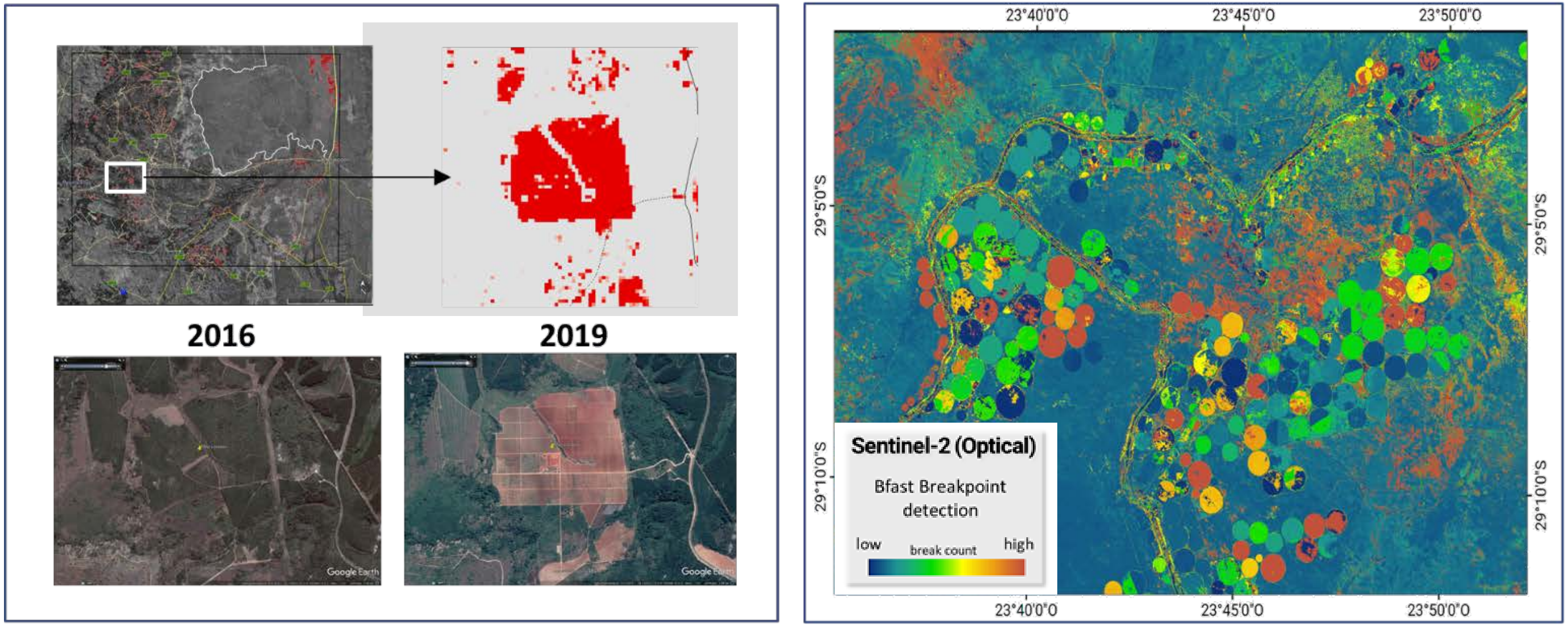


Fig. 3.9: (**left**) Mapping surface changes using automatic Sentinel-1 retrieval: change in red (subset of white rectangle), and below in Google Earth images. (**right**) Mapping surface dynamics with Sentinel-2 time series, here number of crop changes using the Bfast-algorithm.

4 Focus 3:
Land-Atmosphere-Interaction

with contributions from

Z. Zhang[1,2], P. Laux[1,2], J. Baade[3], A. Kaiser[3] & H.Kunstmann[1,2]

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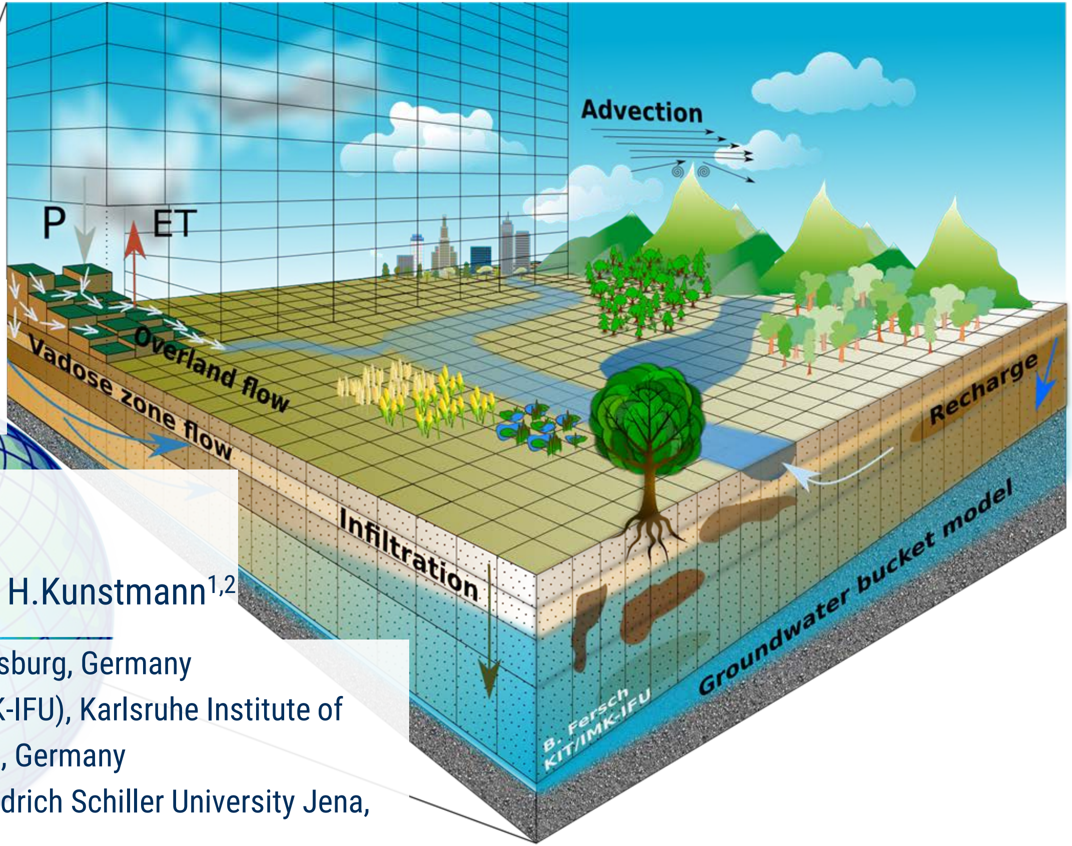
[2] Institute of Meteorology and Climate Research (IMK-IFU), Karlsruhe Institute of Technology, Campus Alpin, Garmisch-Partenkirchen, Germany

[3] Department of Geography, Physical Geography, Friedrich Schiller University Jena, Germany



4.1 Content

4.2 Regional Earth System Modeling - fully coupled WRF-Hydro

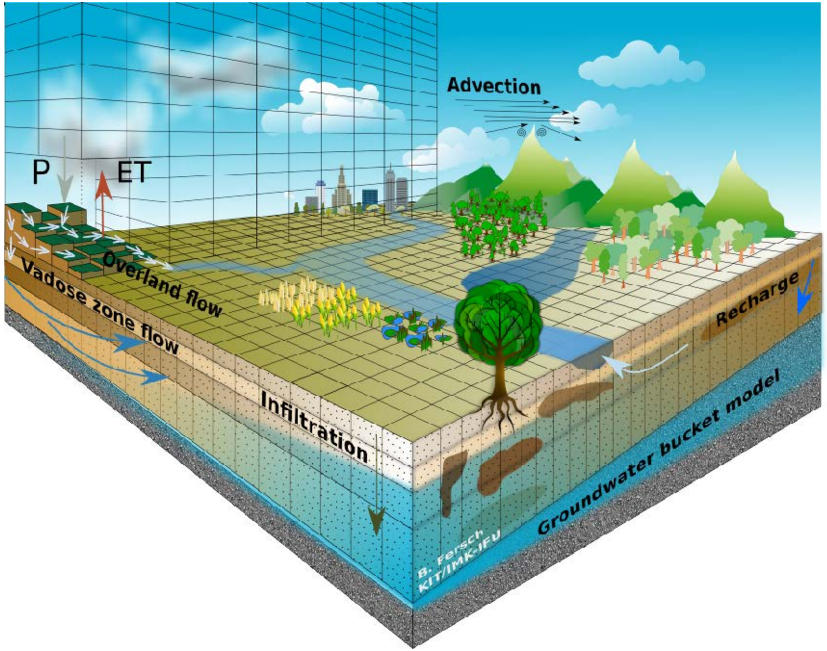
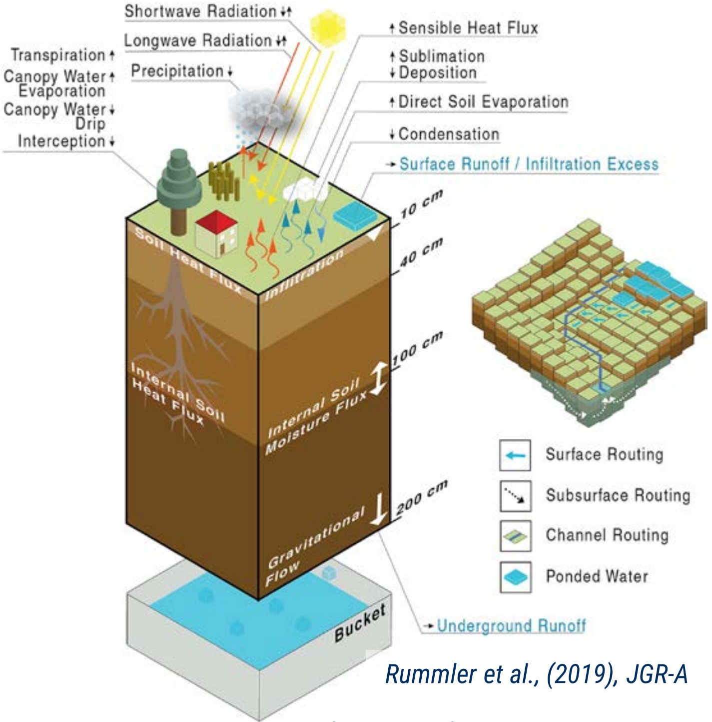


Fig. 4.1 Coupled atmosphere-hydrology modeling framework



Rummler et al., (2019), JGR-A

Fig. 4.2 Schematic illustration of land surface hydrological processes in WRF-Hydro

4.2 Regional Earth System Modeling - fully coupled WRF-Hydro

Fully coupled WRF-Hydro model setup:

- Input data: 3-hourly ERA5 reanalysis.
- Atmospheric grid: 650×500 @ 4km, convection permitting, covering southern Africa
- Atmospheric setting: WSM6 microphysics, YSU PBL, RRTM radiation
- NOAH-MP LSM, with lateral terrestrial water routing.
- Hydrological grid: 6500×5000 @ 400m
- Simulation period: Year 2000 - 2020

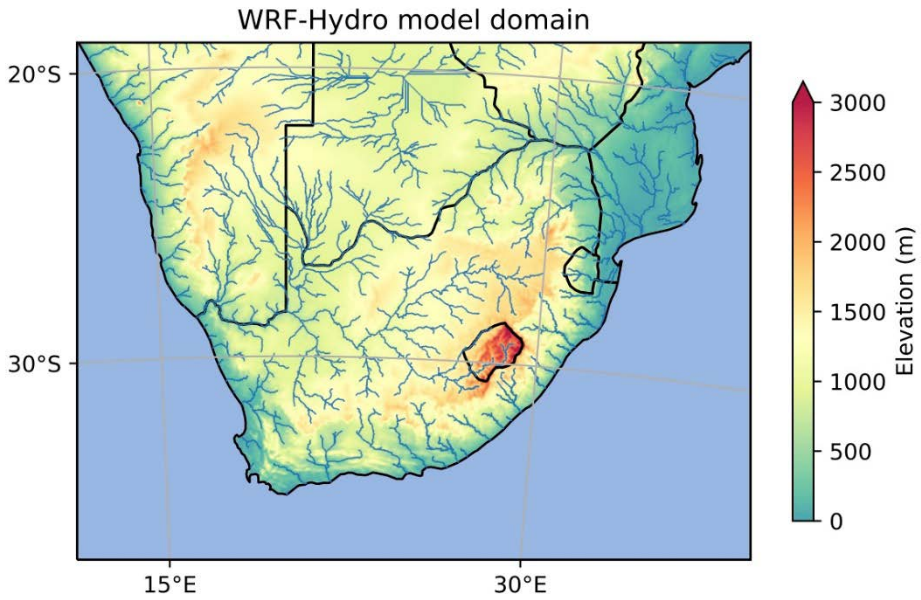


Fig. 4.3 Model domain location and river channels in the modeling

4.3 Comparison of modeling results

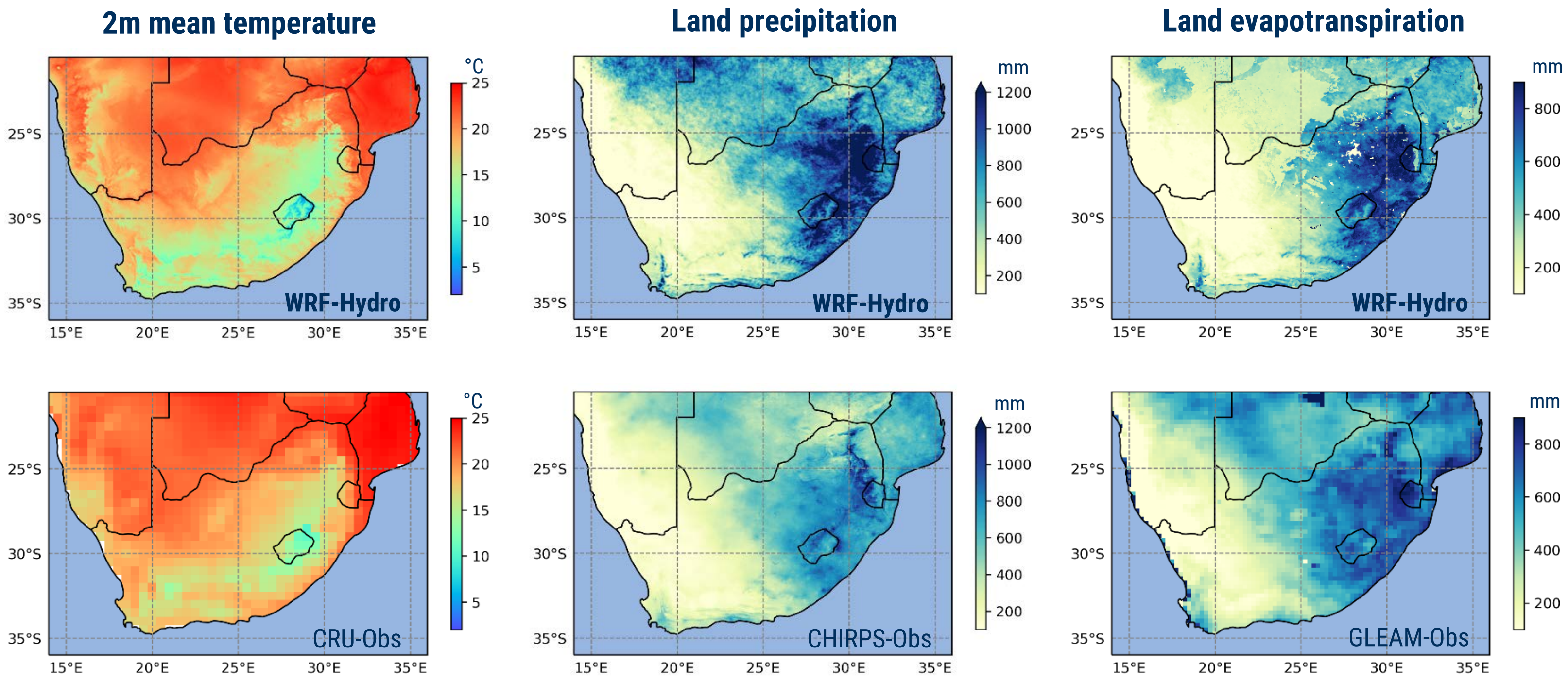


Fig. 4.4 Spatial comparison of simulated hydrometeorological fields with observational grided dataset for the year 2010

4.3 Comparison of modeling results

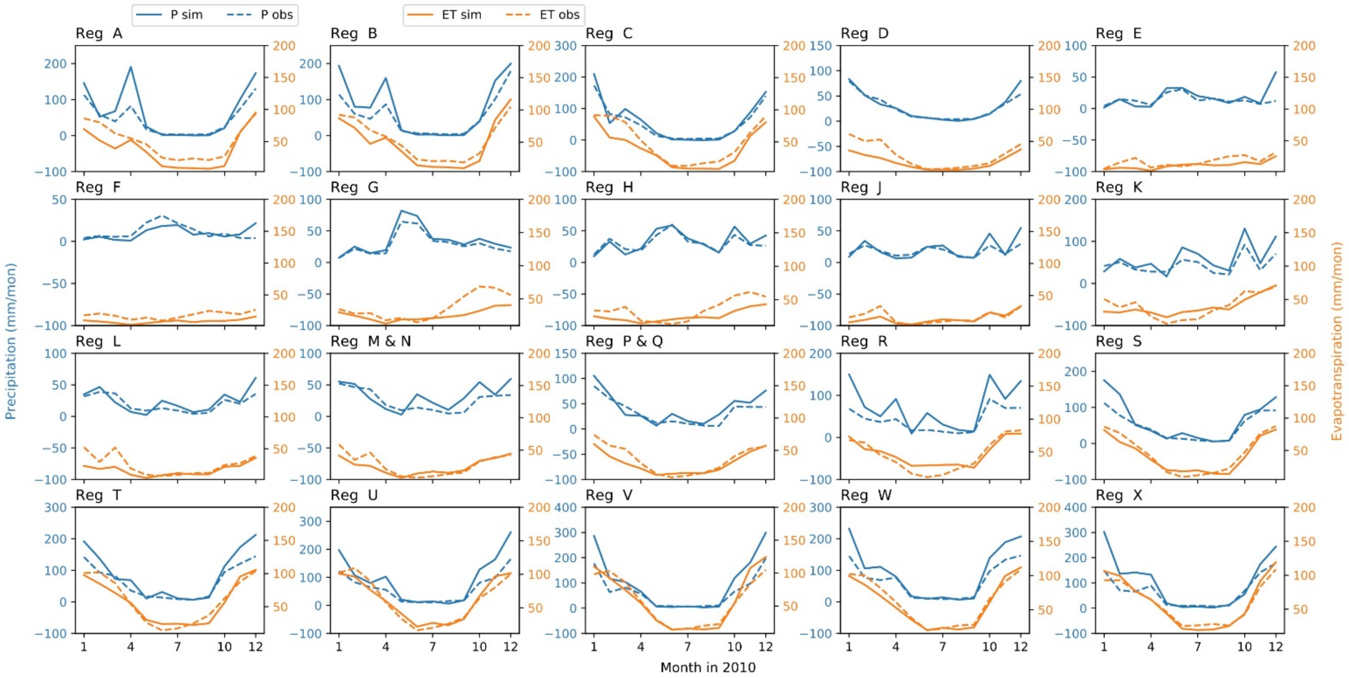


Fig. 4.6 Simulated and observed monthly precipitation and evapotranspiration comparation for 22 primary drainage regions

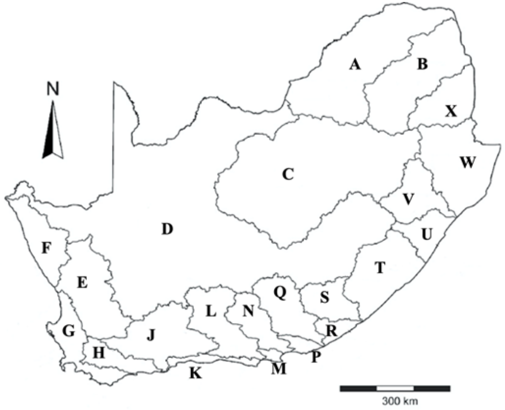


Fig. 4.5 Location of the 22 primary drainage regions in South Africa (Huizenga et al. 2013)

4.4 Preliminary results of regional water balance investigation

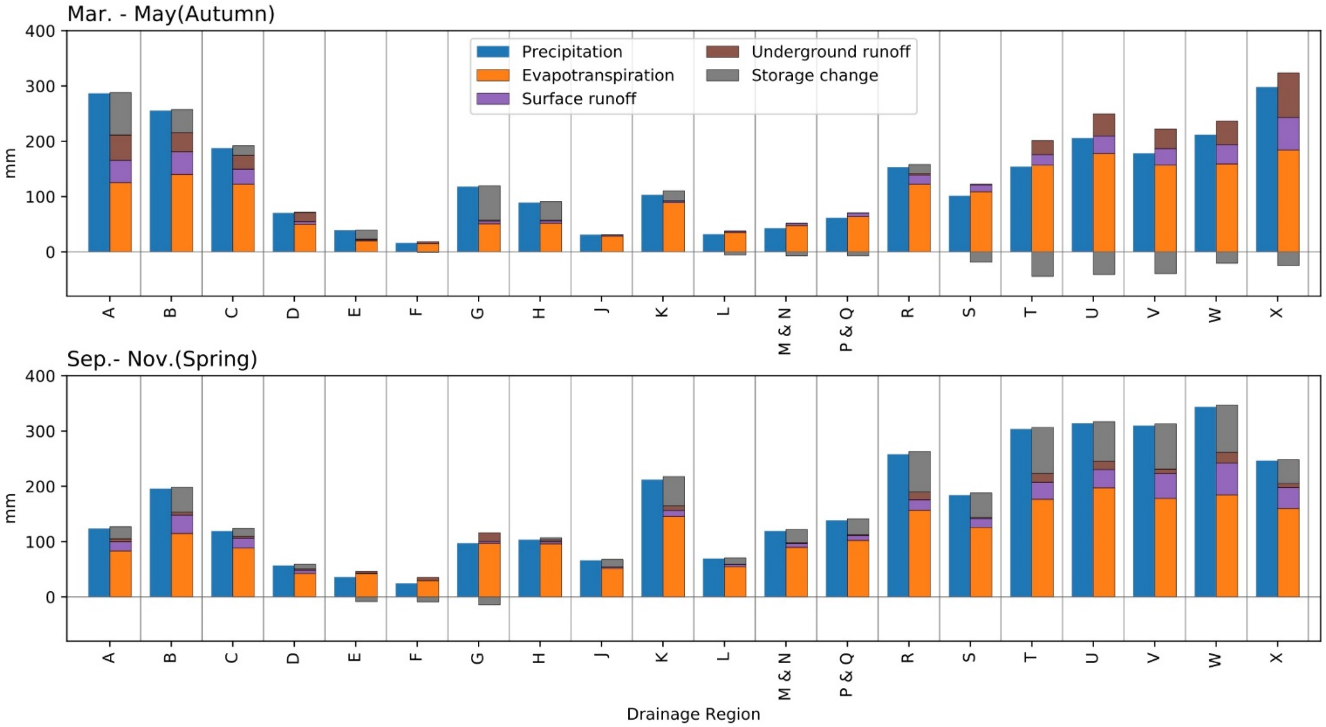


Fig. 4.7 Seasonal water balance simulated by coupled WRF-Hydro for 22 primary drainage regions

5 Summary

- SALDi has established strong ties with > 30 partners and stakeholders in RSA
- SALDi is on a solid track to reach the major envisaged scientific outcomes
- COVID-19 has interrupted field work, delayed capacity building and necessary scientific exchange by ~ 1 year
- An extension is needed to reduce the COVID-19 impact and to ensure the proposed implementation of the SALDi Land Degradation Monitor

Acknowledgements

Participants in the SALDi Kick-off Meeting at ARC-ISCW in Pretoria in March 2019

We like to thank all our partners and collegues and the unnamed supporters and helpers in the field in South Africa. Without their contribution these achieve-ments would not have been possible. The same applies to the funding agencies:

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