

# Spatio-temporal monitoring of vegetation structure and surface moisture within four SANParks regions

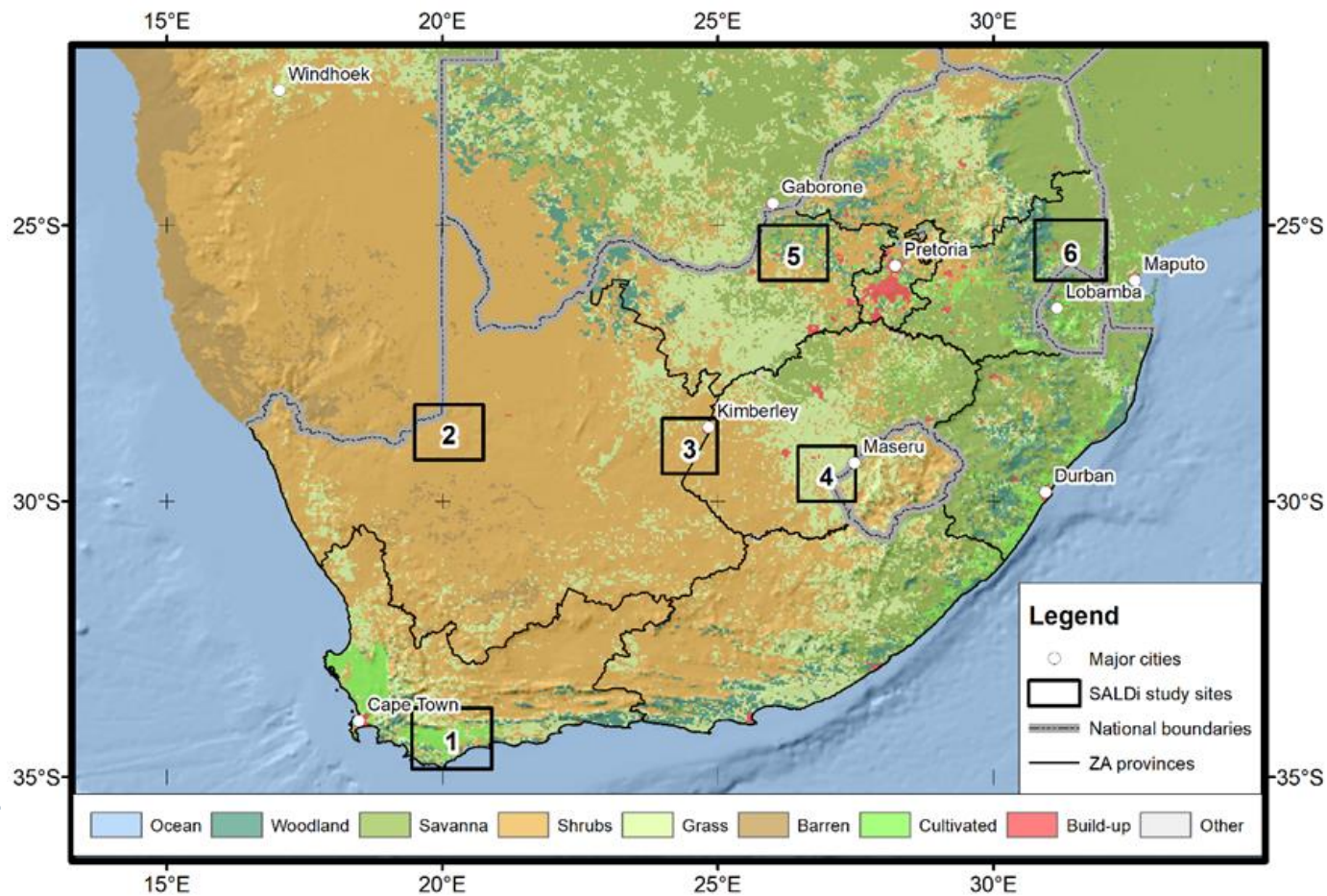
## Result Updates from Sentinel-1 and -2 Time-Series



**Fig.: Land cover in SALDi study areas**

- 1: Overberg
- 2: Kai !Garib
- 3: Sol Plaatje
- 4: Mantsopa
- 5: Bojanala Platinum
- 6: Ehlanzeni

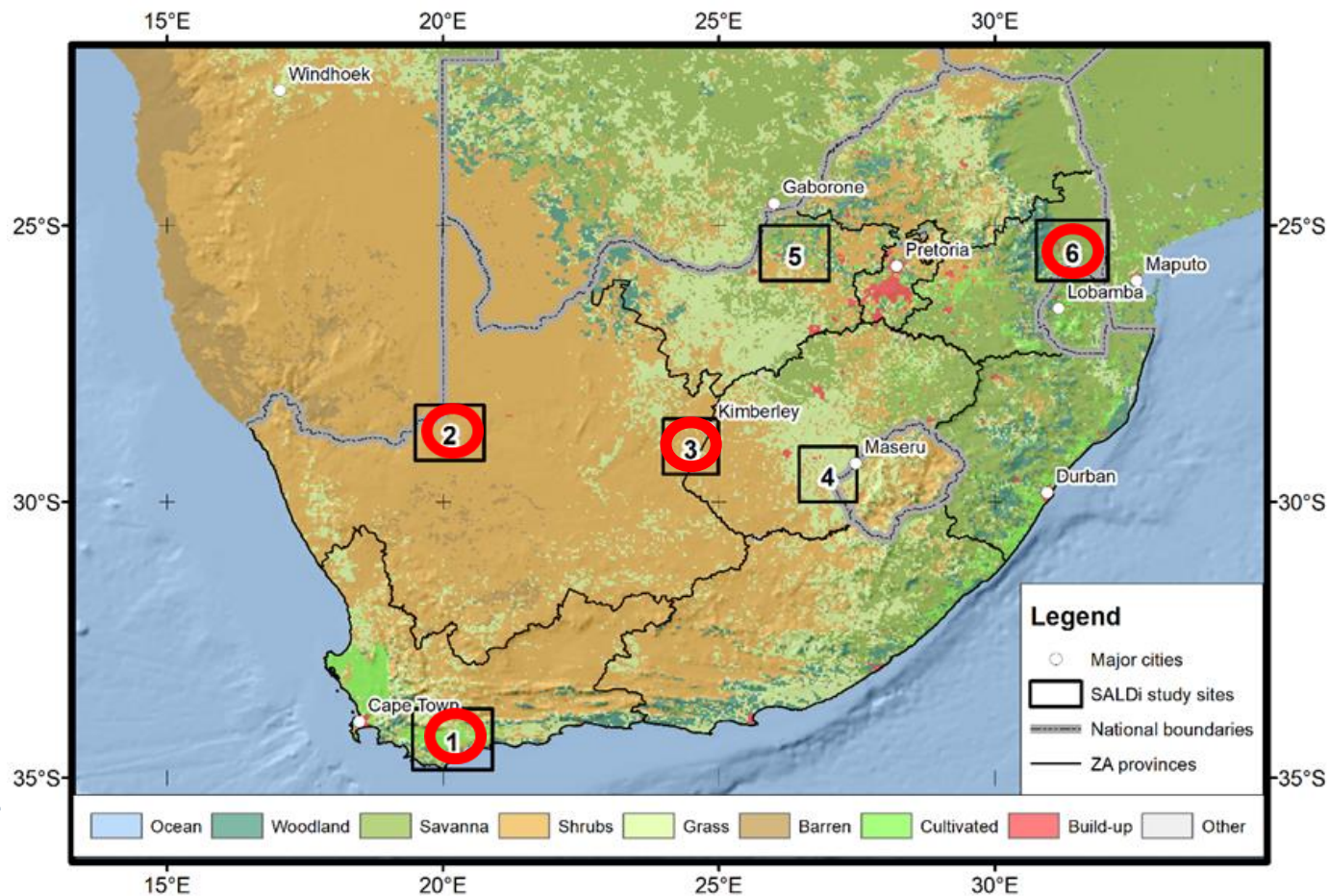
(data source: ESRI 2013, simplified MODIS Land Cover cf. FRIEDL et al. 2010)



**Fig.: Land cover in SALDi study areas**

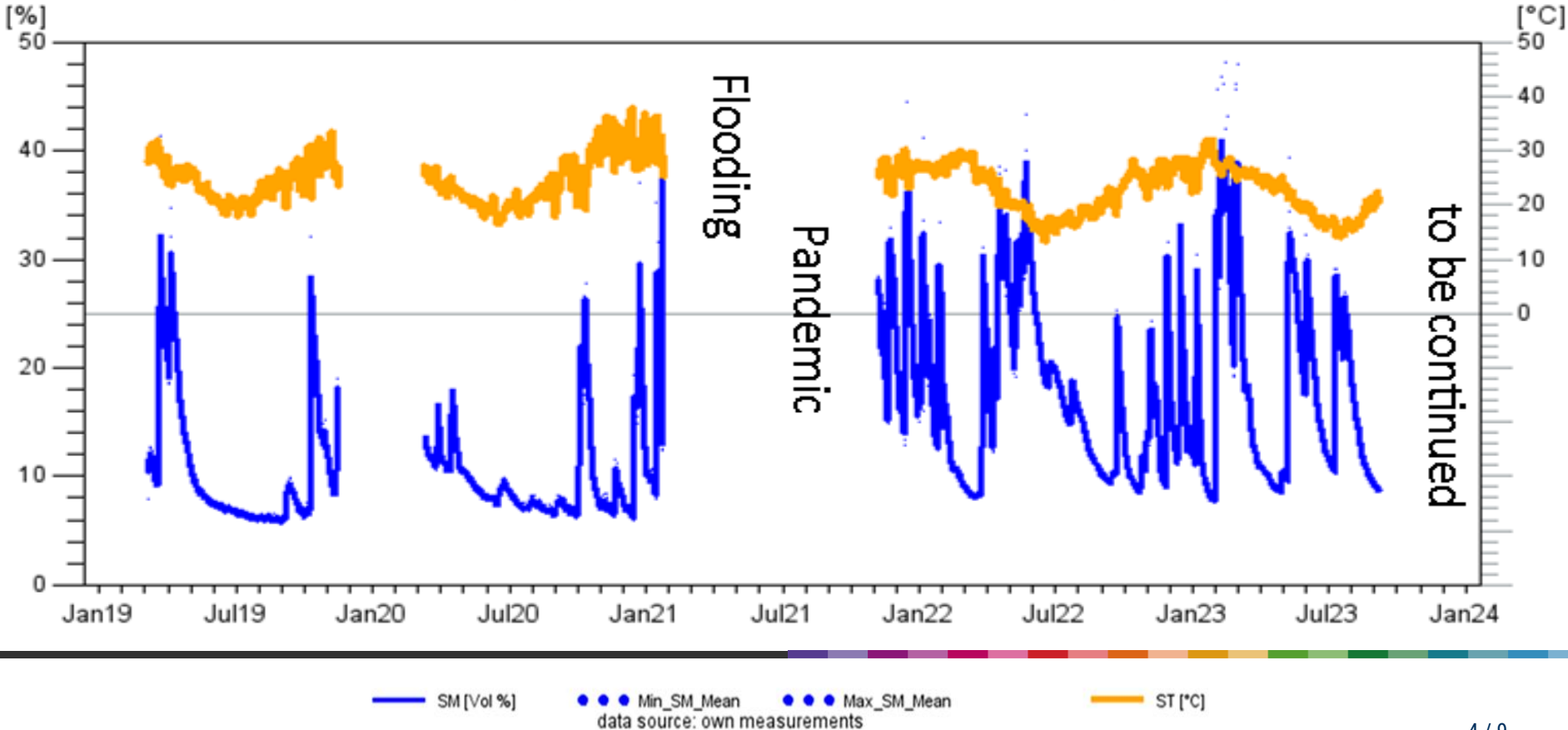
- 1: Overberg
- 2: Kai !Garib
- 3: Sol Plaatje
- 4: Mantsopa
- 5: Bojanala Platinum
- 6: Ehlanzeni

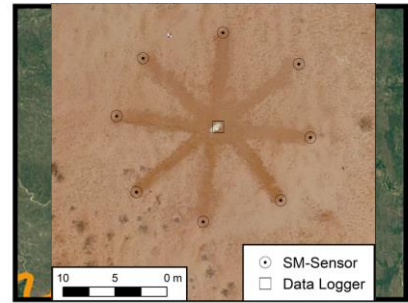
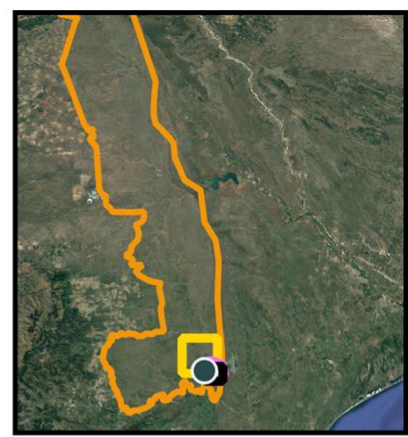
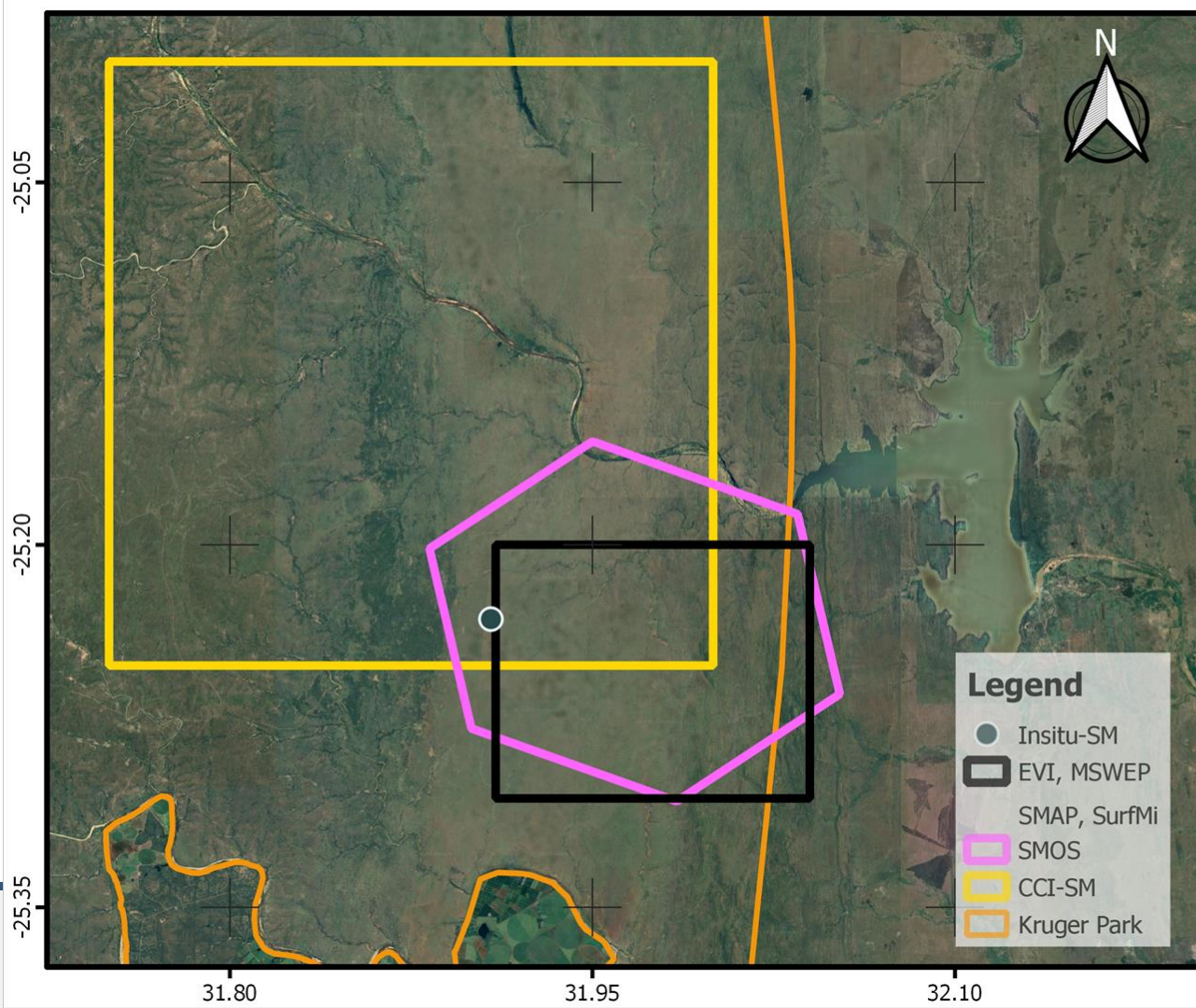
(data source: ESRI 2013, simplified MODIS Land Cover cf. FRIEDL et al. 2010)



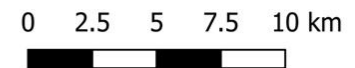
SALDi06 (KNP Lower Sabie) SM\_mean & ST\_mean  
01/2019 - 01/2024

See Poster Baade et al.: Status of ongoing soil moisture measurements in contrasting landscapes across South Africa!

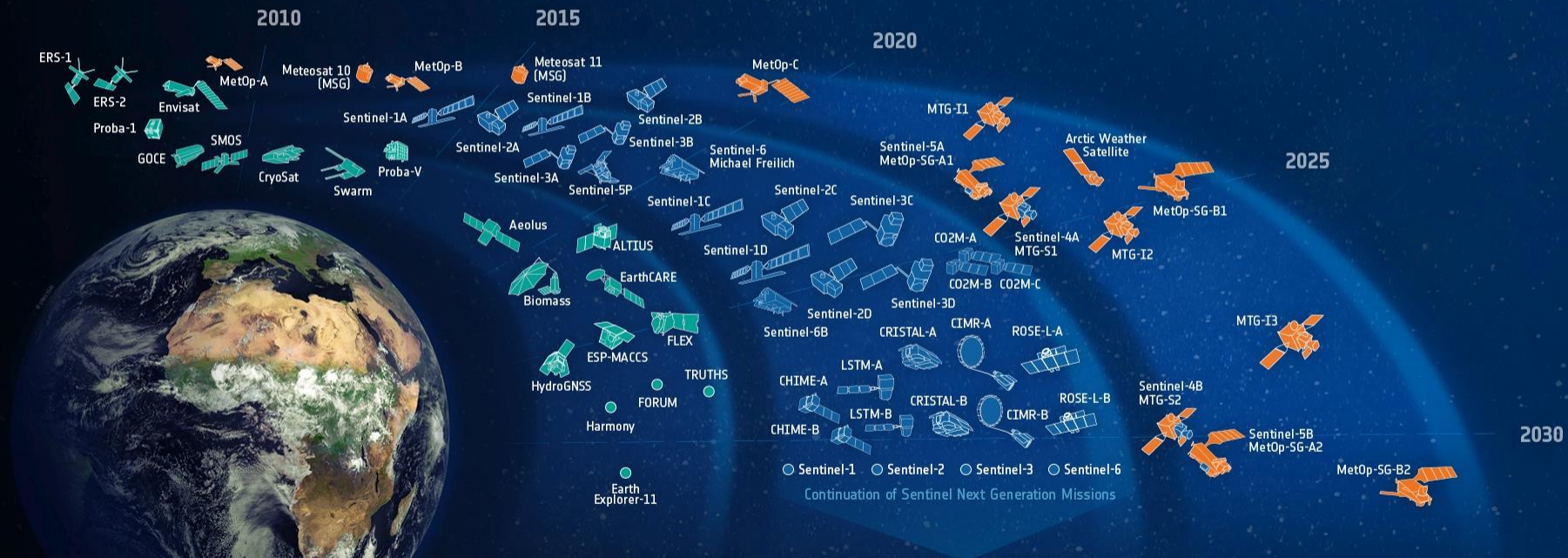




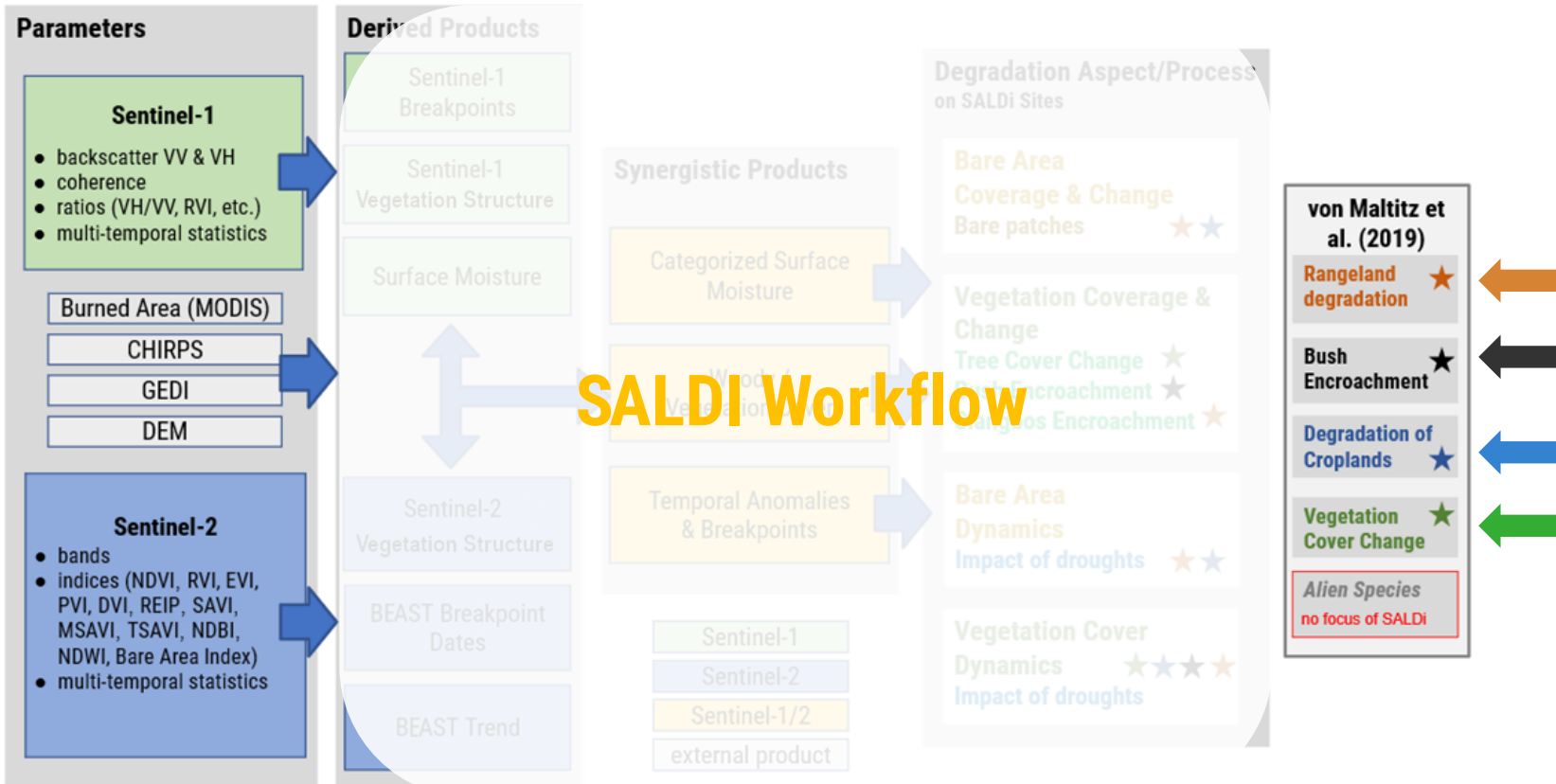
Date: 29.01.2024  
 Author: Schubert, Stumpf  
 Basemap: © 2023 Maxar Technologies, CNES/Airbus via Google Maps  
 Datasource: SDC  
 EPSG: 4326



# ESA-DEVELOPED EARTH OBSERVATION MISSIONS



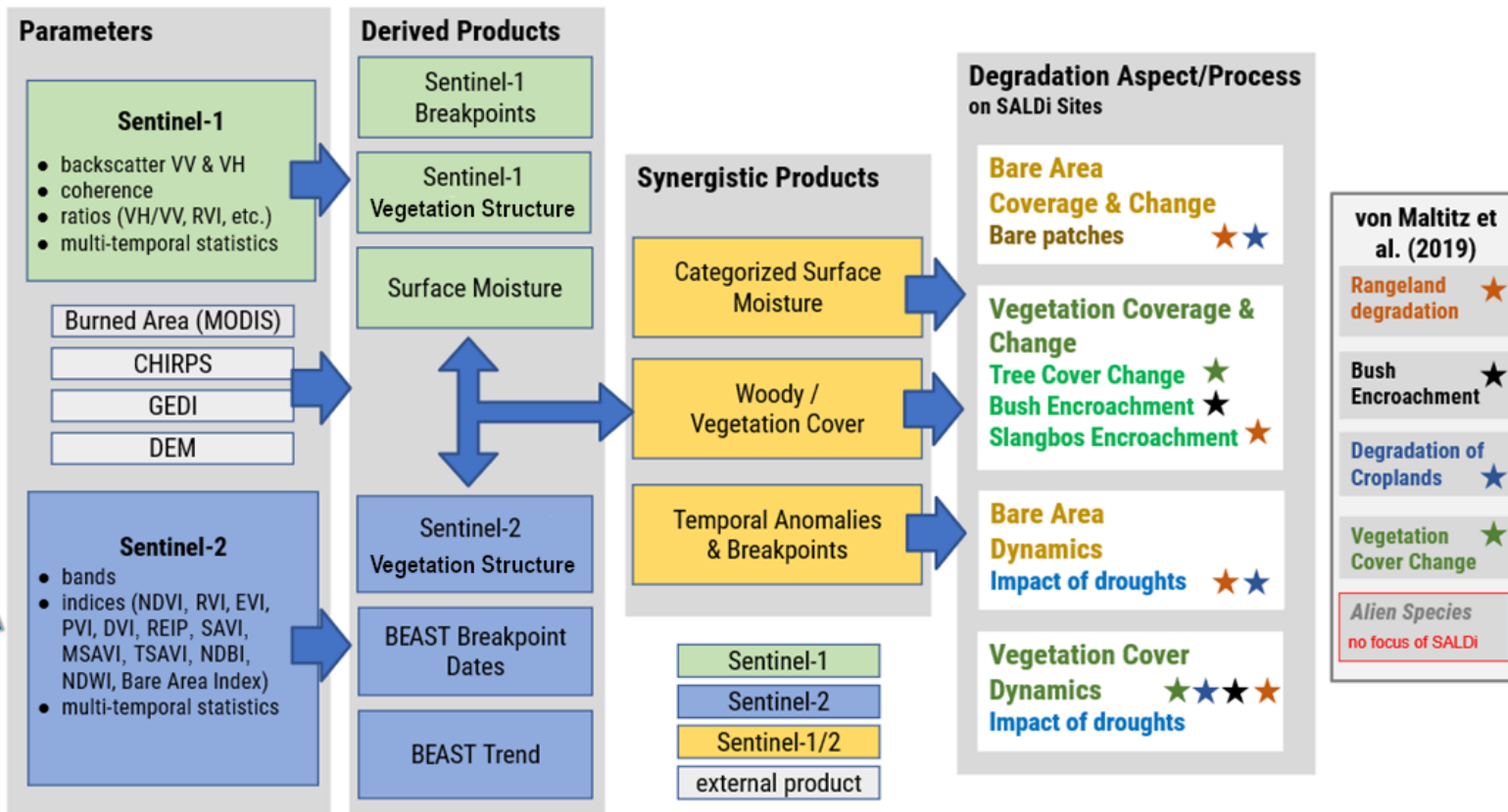
# Land Surface Dynamics – Earth Observation Concept



# Land Surface Dynamics – Earth Observation Concept

Radar

Optical



## Development of EO Data Cubes for monitoring land degradation processes in South Africa

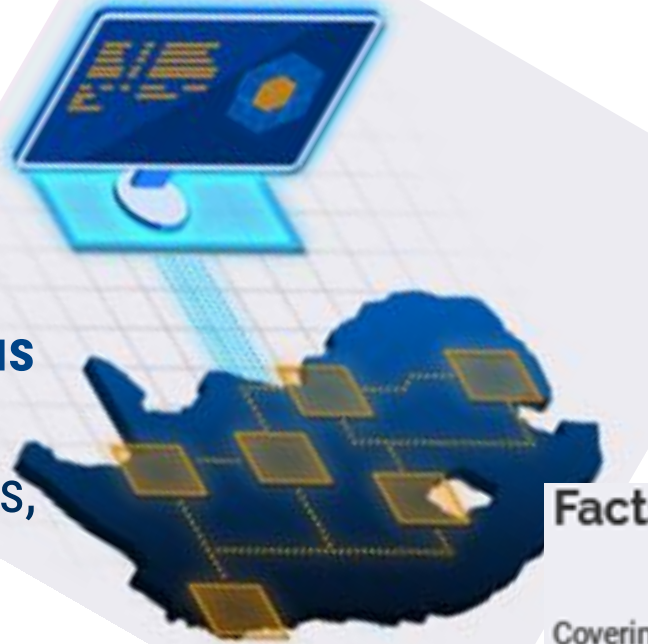
Six **SALDi Data Cubes** ready for exploration, including a **github repository with various Jupyter-Notebooks** for time-series analyses, classification, woody cover and surface moisture modelling.



Illustrations: Uni Würzburg

## Development of EO Data Cubes for monitoring land degradation processes in South Africa

Six **SALDi Data Cubes** ready for exploration, including a **github repository with various Jupyter-Notebooks** for time-series analyses, classification, woody cover and surface moisture modelling.



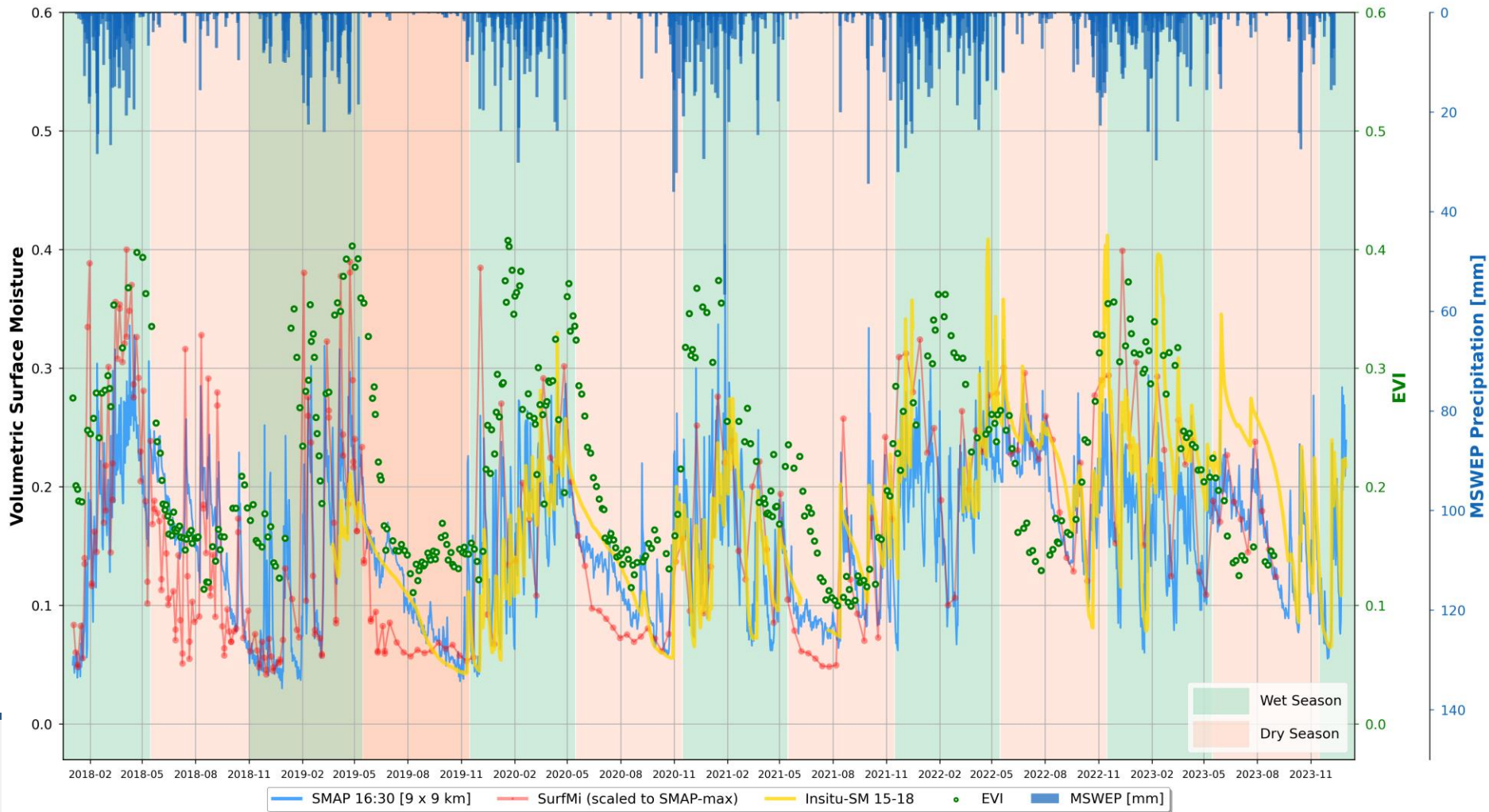
Illustrations: Uni Würzburg

### Facts and Figures

Covering six SALDi sites, this Data Cube is constructed with:

- ca. **8500** Sentinel-1 RTC images between 2018/01 - 2023/12
- ca. **8500** Sentinel-2 L2A images between 2018/01 - 2023/12
- additional products: in-situ moisture, SANLC, GEDI, Copernicus DEM
- about **19 TerraBytes** of data in total.

# SALDi Site 6 [5x5 SurfMi Pixel]



**Spatio-temp.  
Vegetation  
Structure  
Monitoring  
with Sentinel-1**

K-Means Clustering to 3 distinct vegetation clusters

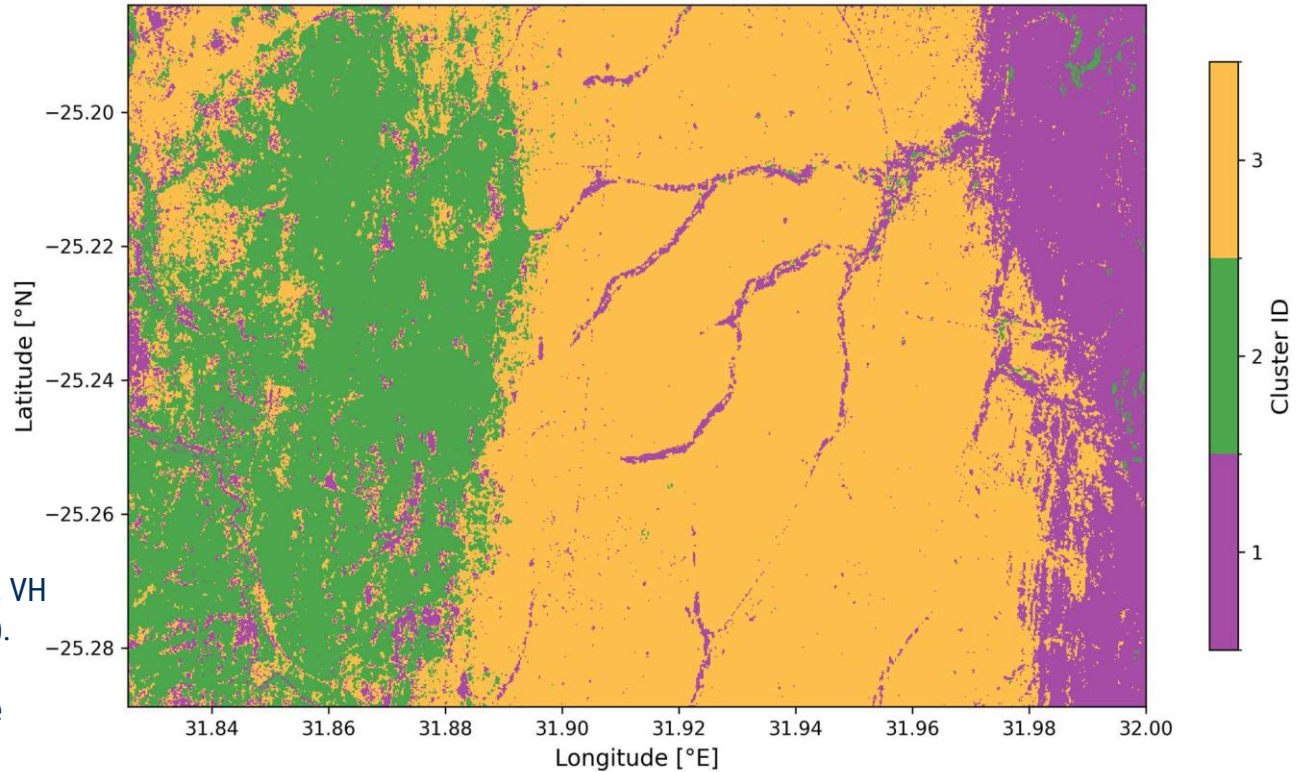


Figure: K-means clustering of Sentinel-1 VV, VH and RVI data aggregated over time (median). Data source: Based on modified Copernicus Sentinel Data [2018-2023], SALDi Data Cube

11/2023

S82

S28

S82

S28

Comondwane Rd

Comondwane Rd

Comondwane Rd

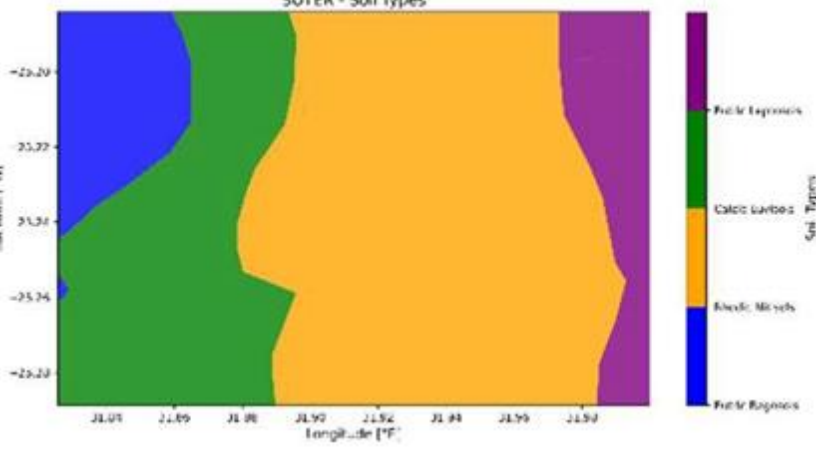
Comondwane Rd

Comondwane Rd

Image © 2025 Airbus  
Image © 2025 Maxar Technologies

Google Earth

Bildaufnahmedatum: 11/12/2023 25°14'02.57" S 31°55'27.43" O Höhe 0 m sichthöhe 15.04 km



## K-Means Clustering to 3 distinct vegetation clusters

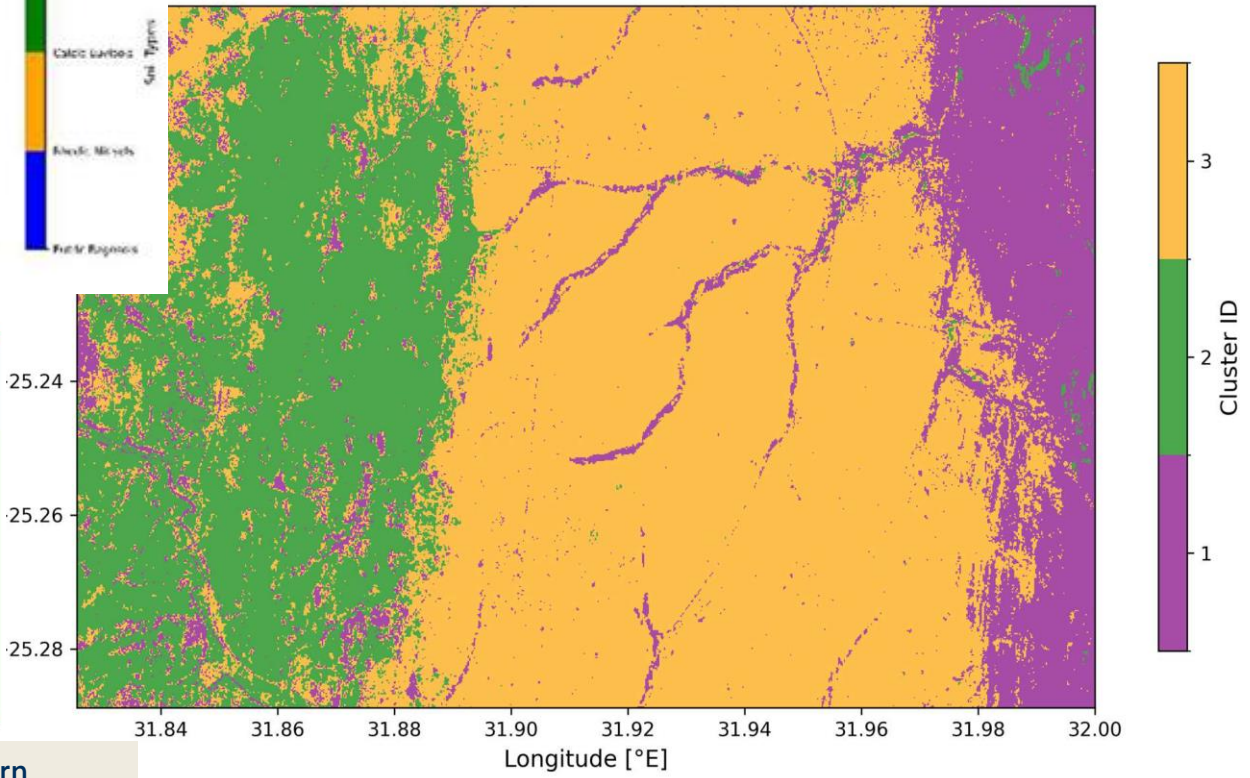
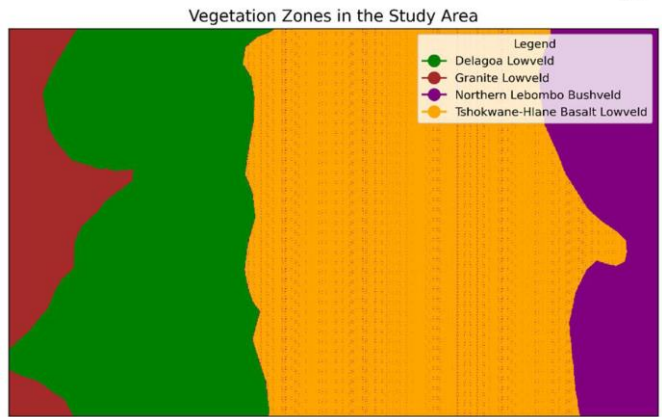
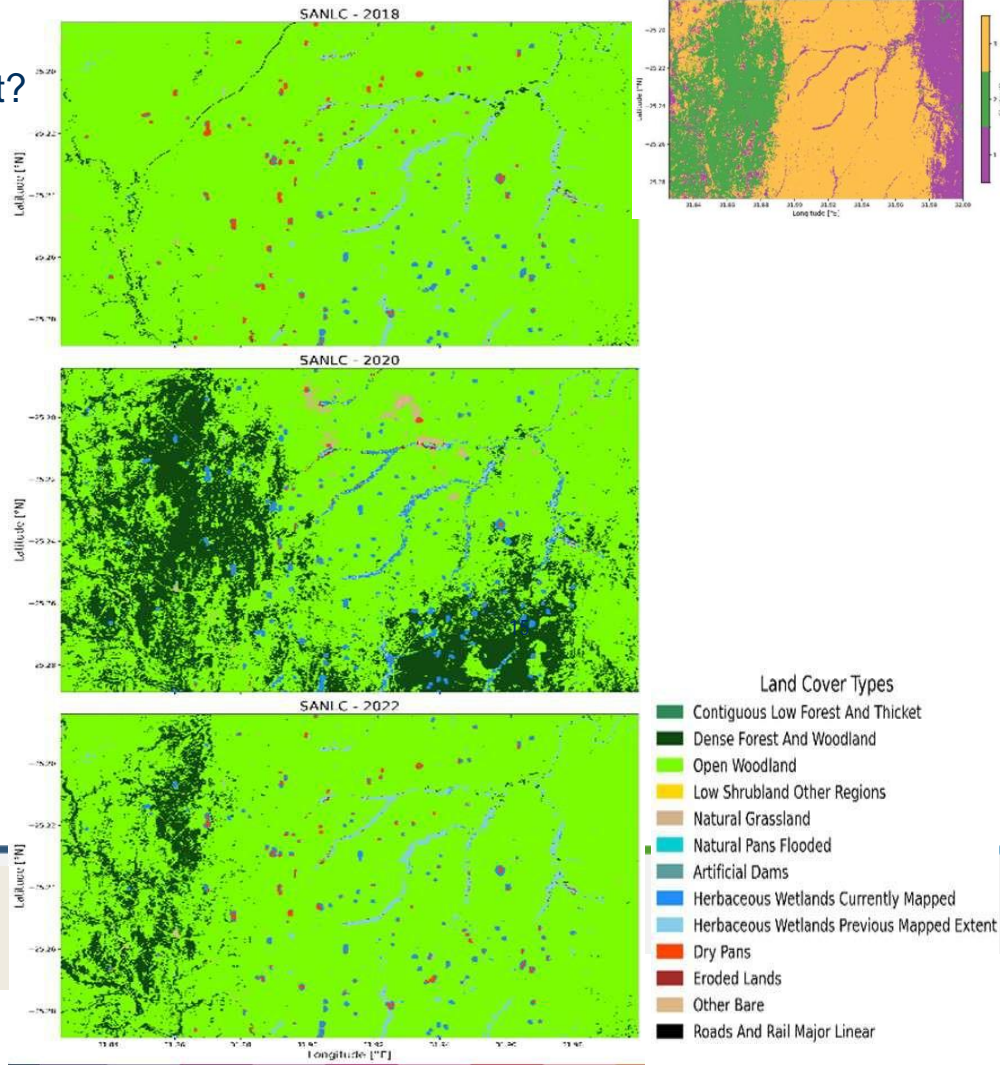


Figure: *above* - SOTER Soil types (Divjkshoorn 2003) *below* - vegetation types within the study area (Datasource: SANBI, Mucina & Rutherford, 2011)

# Why is this radar-retrieved vegetation map relevant?



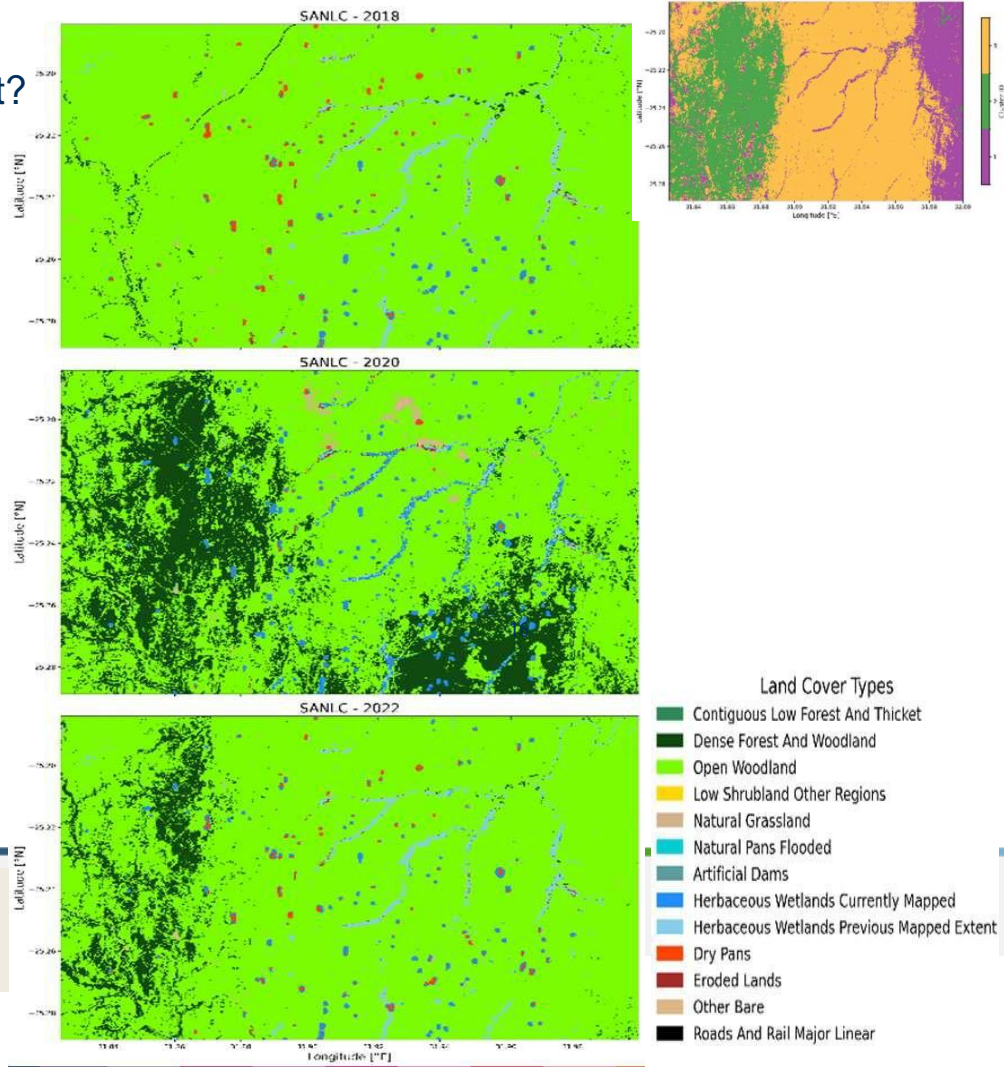
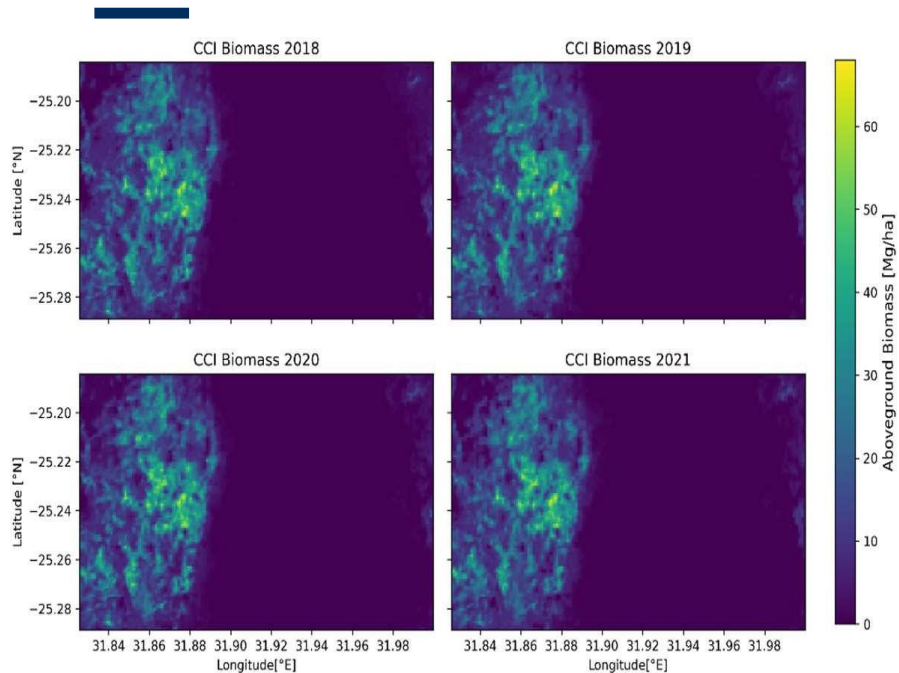
## Data sources:

Above - CCI Biomass: Santoro & Cartus 2024

Right - SANLC: DFFE (2018-2022)

Gerrit Eisele, GEO 402 – Uni Jena, 2025

# Why is this radar-retrieved vegetation map relevant?



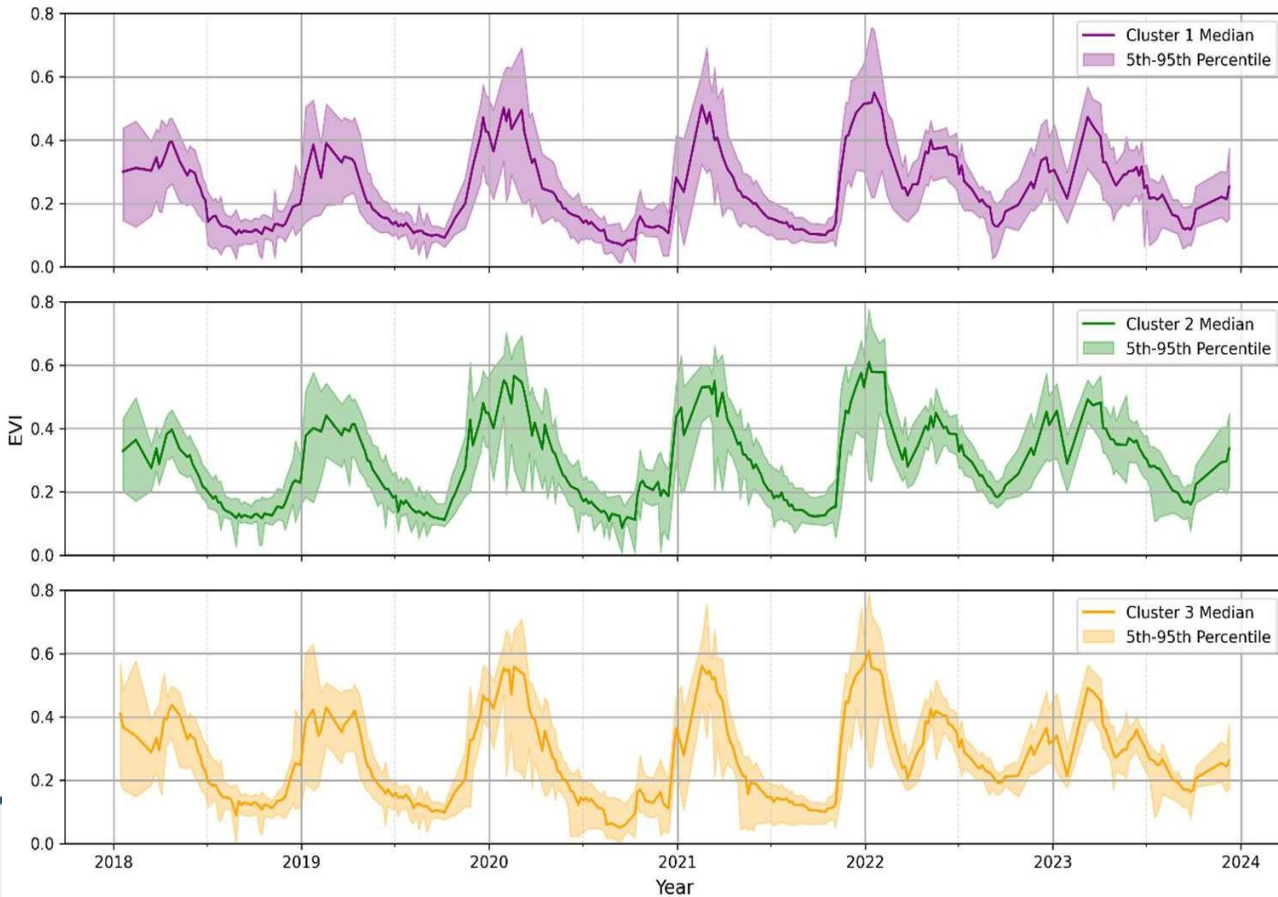
## Data sources:

Above - CCI Biomass: Santoro & Cartus 2024

Right - SANLC: DFFE (2018-2022)

Gerrit Eisele, GEO 402 – Uni Jena, 2025

### EVI for Seperate Cluster



### - EVI per Cluster

$$EVI = G \times \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + (C_1 \times \rho_{red} - C_2 \times \rho_{blue}) + L}$$

(Huete 1997, Venter et al. 2020)

- $G = 2.5$ ,  $C_1 = 6$ ,  $C_2 = 7.5$ ,  $L = 1$
- Small differences, like NDVI

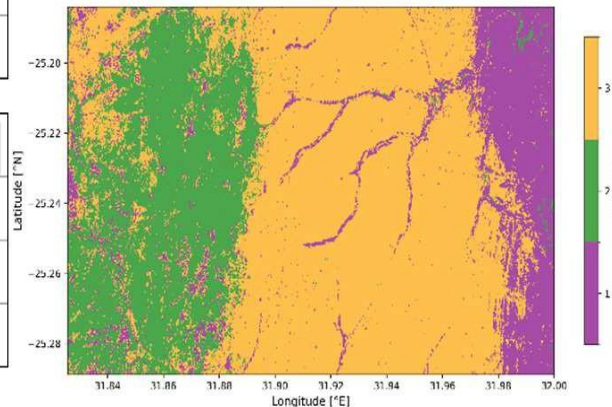
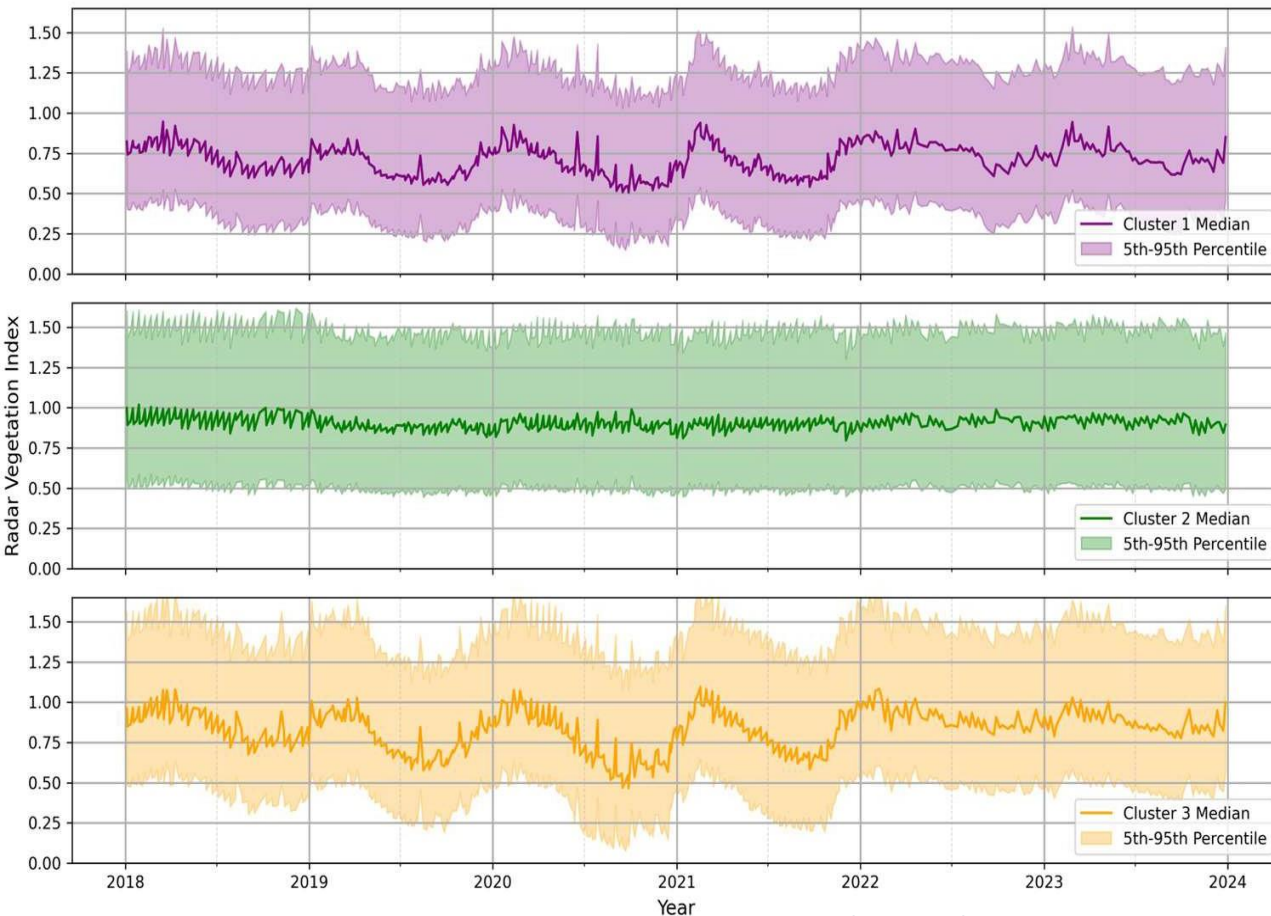


Figure: EVI median time series per cluster with 5<sup>th</sup> and 95<sup>th</sup> percentile range. Data Source: Contains modified Copernicus Sentinel Data [2018-2023], SALDi Data Cube  
Gerrit Eisele, GEO 402 – Uni Jena, 2025

RVI for Different Clusters



- Radar Vegetation Index (RV) per Cluster

$$RVI = \frac{4\sigma_{VH}^0}{\sigma_{VV}^0 + \sigma_{VH}^0}$$

(Birth & McVey 1968, Charbonneau et al. 2005)

- Measure VH backscatter relative to total backscatter
- Indicator of vegetation-related volume scattering

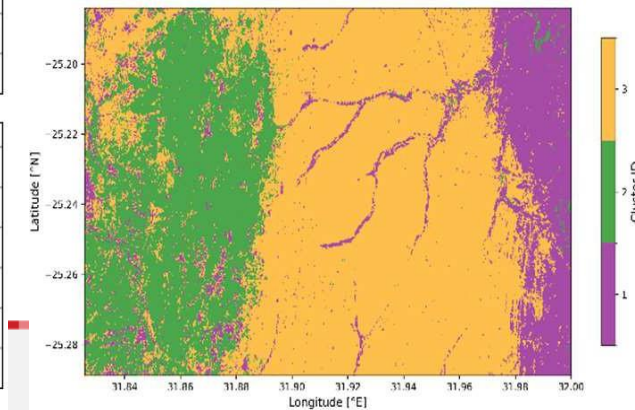
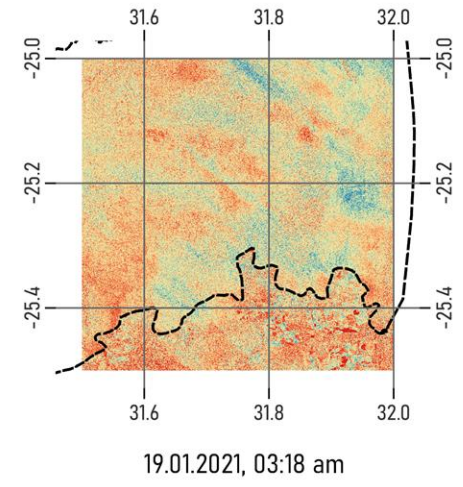
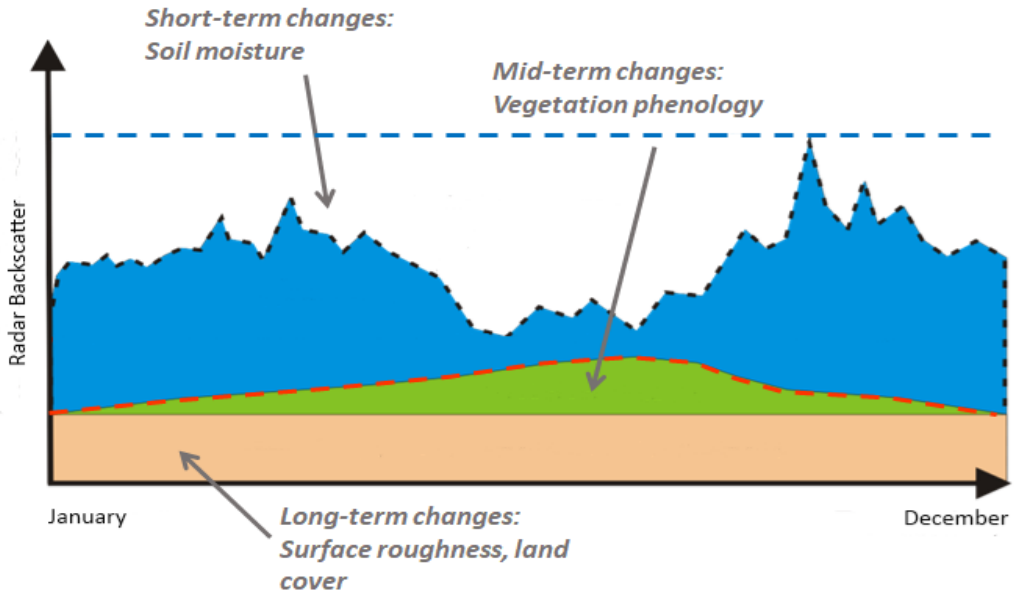
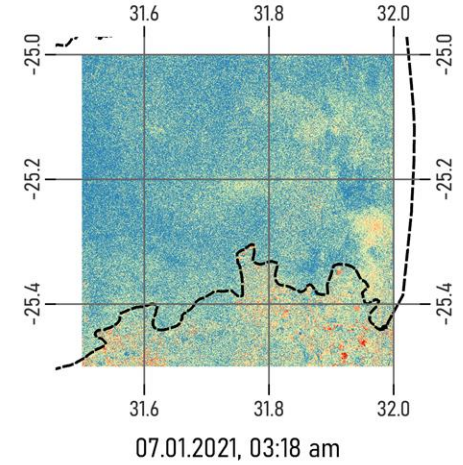
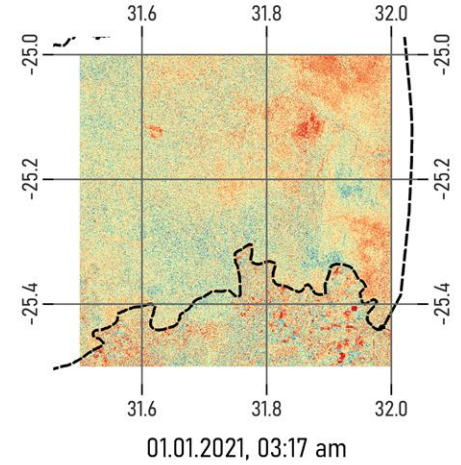
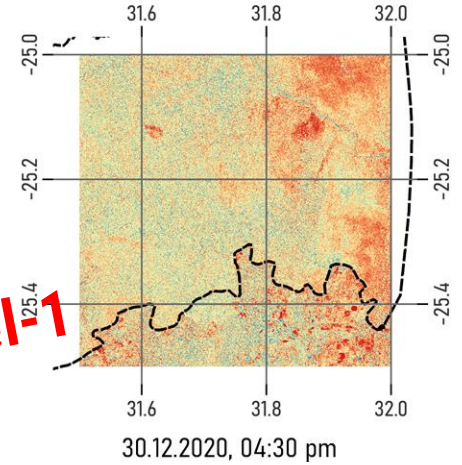
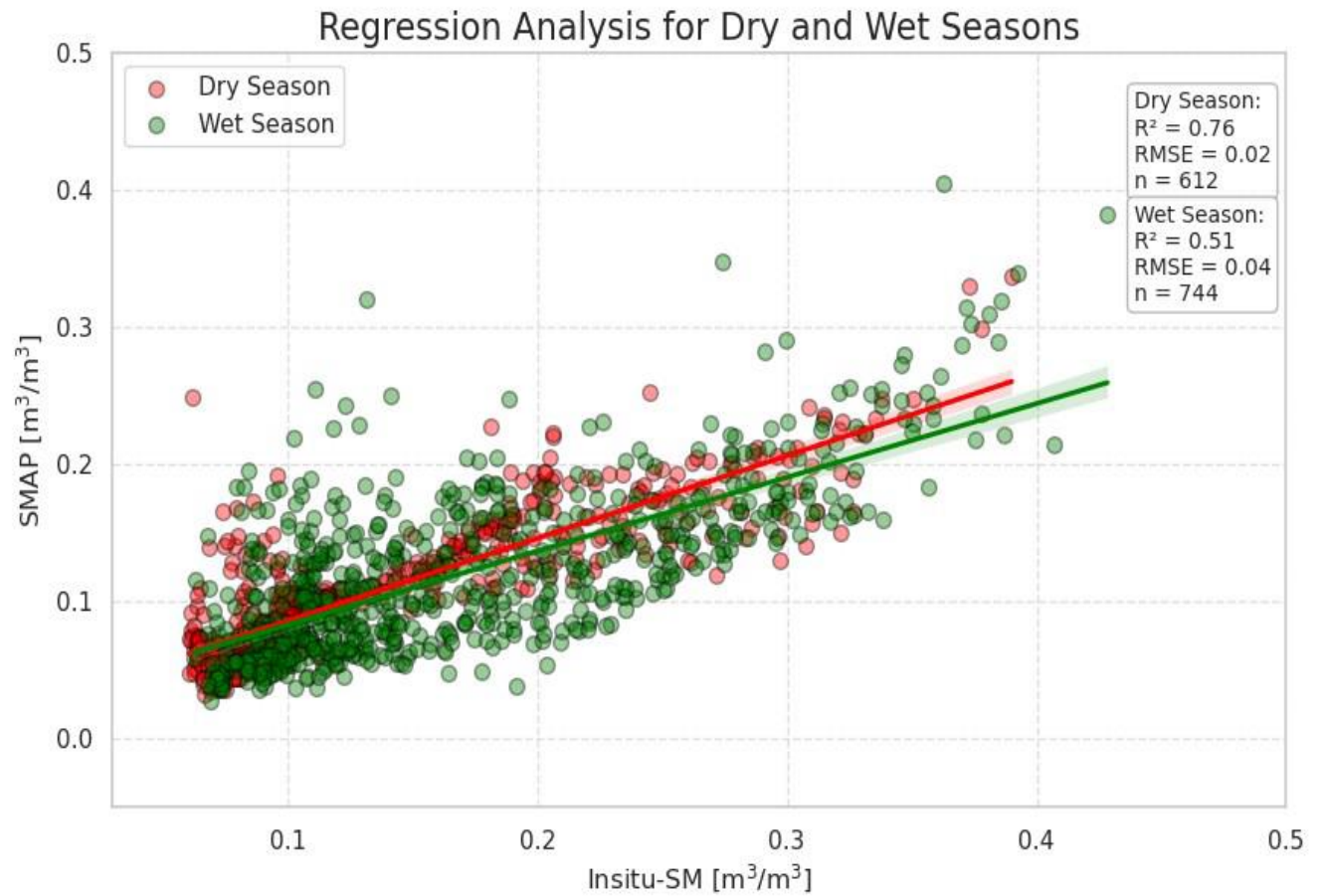


Figure: Sentinel-1 based median RVI time series per cluster with 5<sup>th</sup> and 95<sup>th</sup> percentile range. Data Source: Contains modified Copernicus Sentinel Data [2018-2023], SALDi Data Cube

# Spatio-temp. Surface Moisture Monitoring With Sentinel-1



**Spatio-temp.  
Soil Moisture  
Monitoring  
With NASA  
SMAP**



# Map of the 5-year **vegetational trend** based on EVI maxima for Mokala National Park

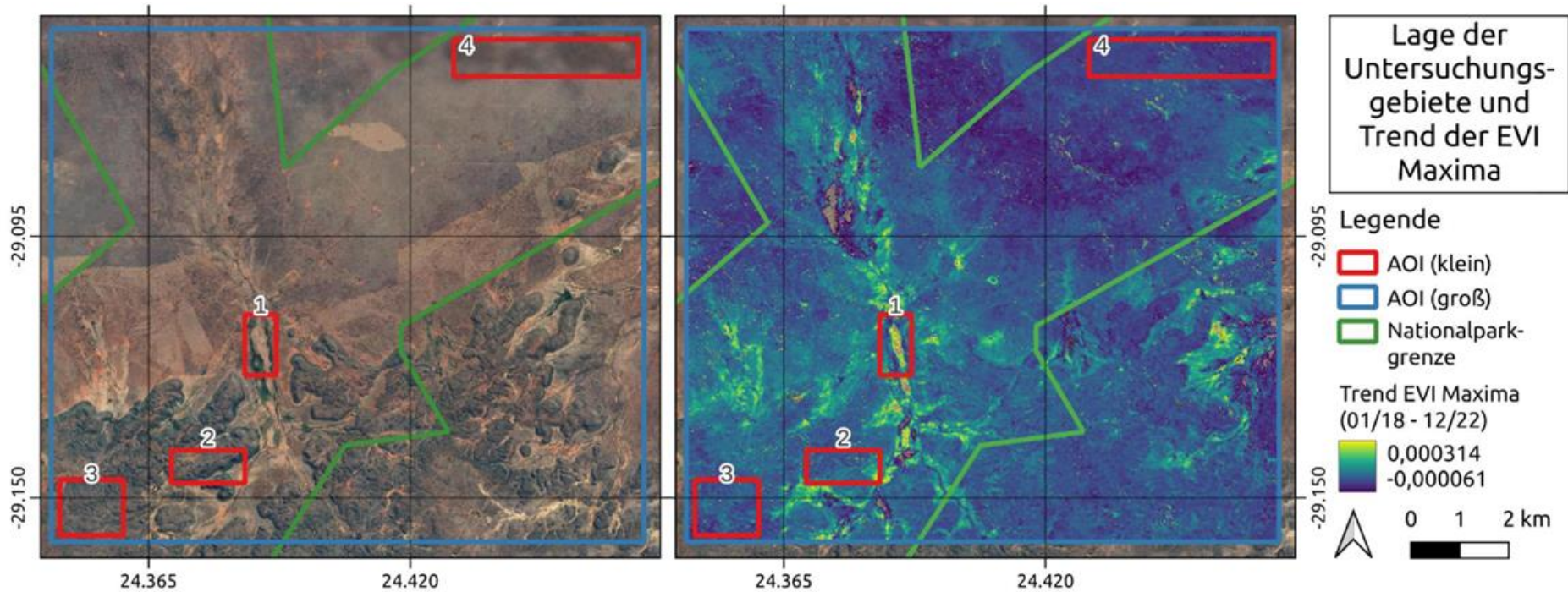


Abb. 59: Lage der Untersuchungsgebiete (l.) und Trend der saisonalen EVI Maxima von 2018 bis 2022 (1.-99. Perc.) (r.) (CRS: WGS84; Daten: SANLC 2020, enthält modifizierte Copernicus Sentinel Daten 2018-2022)

# Trend analyses over 5 years for grassland using maxima and phenological phases

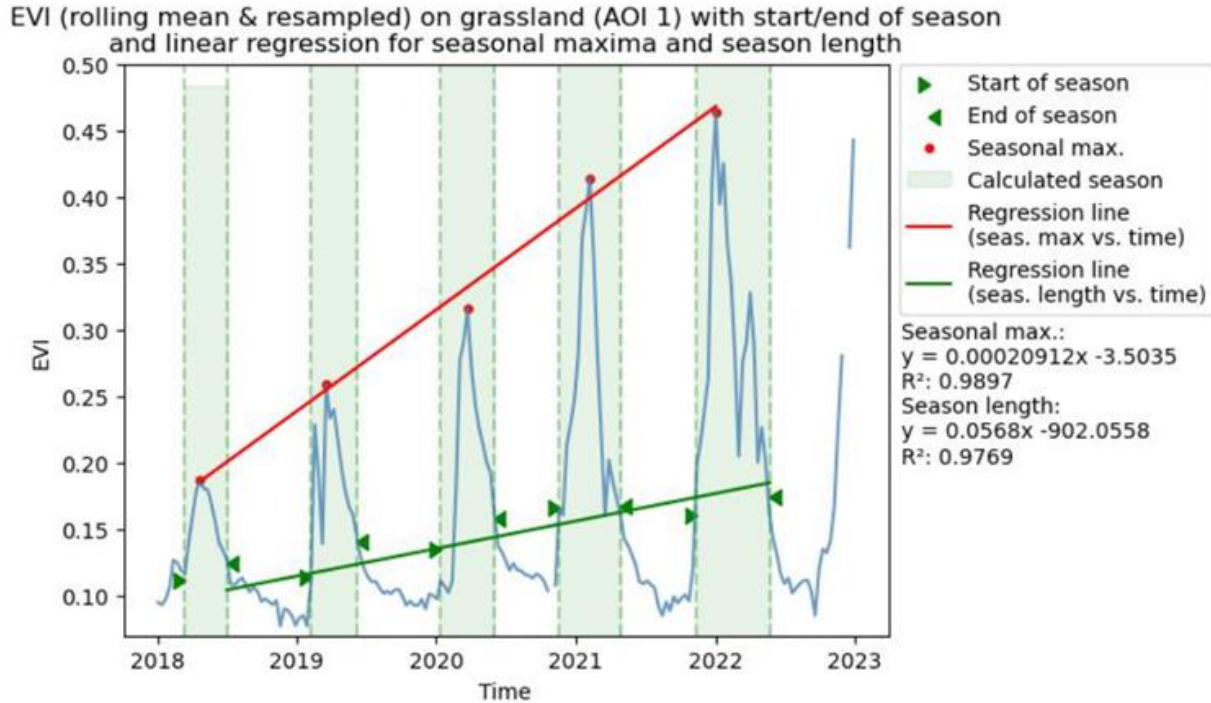
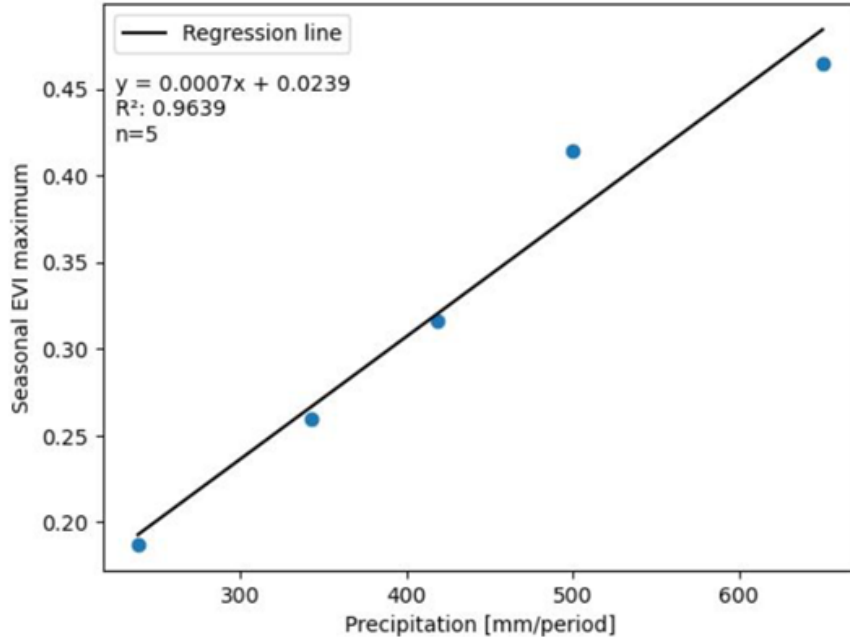


Abb. 10: EVI, Phänologie und Regressionsgeraden der EVI Maxima und der Vegetationsperiodendauer auf Grasland im Untersuchungsgebiet 1 (Daten: SANLC 2020, enthält modifizierte Copernicus Sentinel Daten 2018-2022)

# Proving the impact of precipitation on grasland in Mokala National Park

Seasonal EVI maximum vs. precipitation per period on grassland (AOI 1)



Season length vs. precipitation per period on grassland (AOI 1)

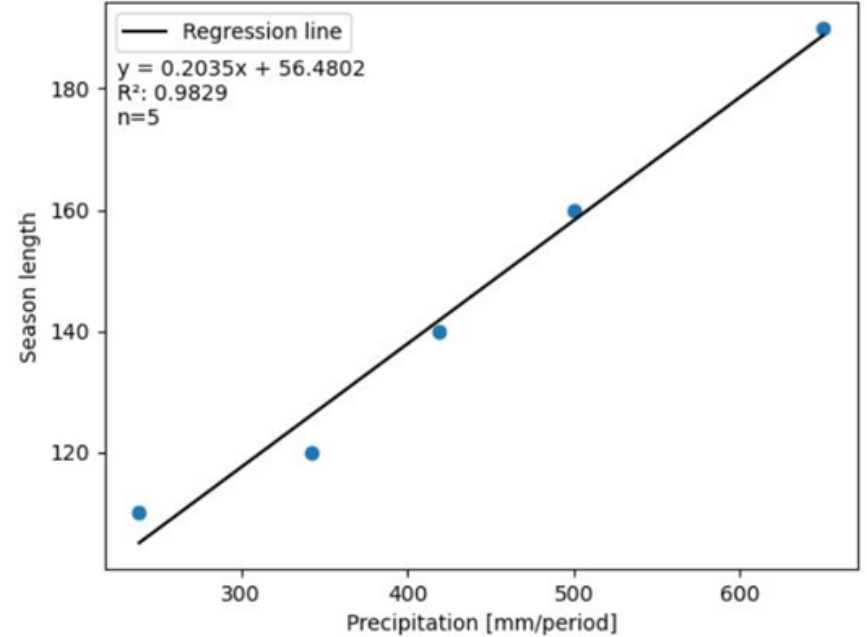


Abb. 10 & 11: Regressionsgeraden von EVI Maxima und Vegetationsperiodendauer gegen Niederschlagsmenge pro Periode auf Grasland im Untersuchungsgebiet 1 (Daten: SANLC 2020, GloH2O MSWEP, enthält modifizierte Copernicus Sentinel Daten 2018-2022)

# Visual Summary

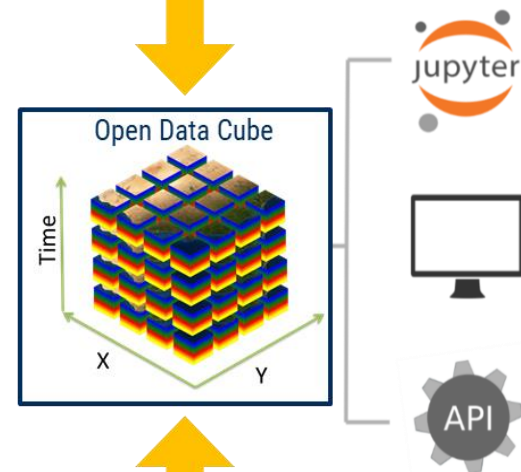
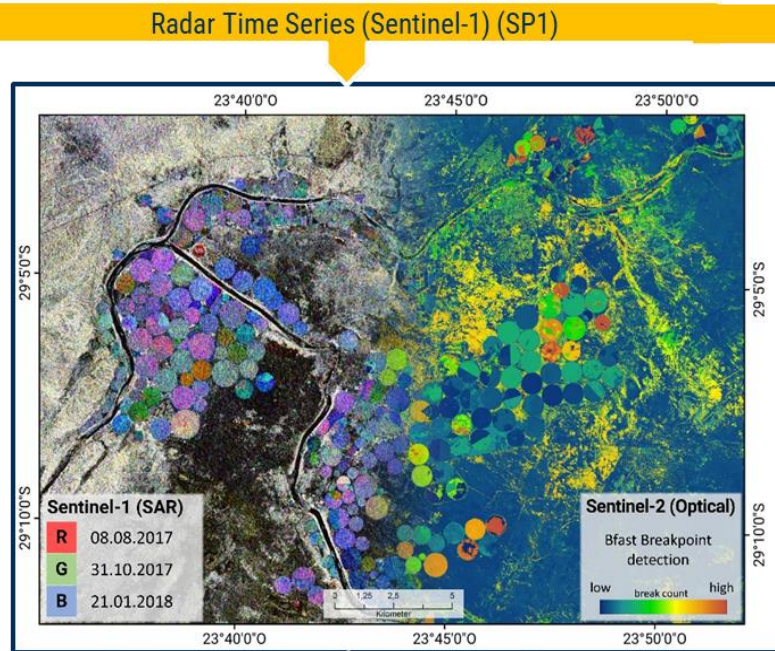
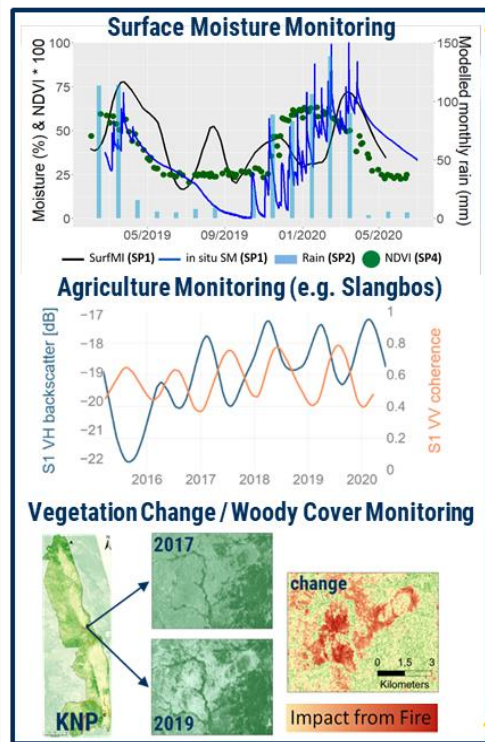








Figure: The Open Data Cube is a cloud-based platform for an efficient and user-oriented analysis of land surface dynamics.

Graham P. von Maltitz · Guy F. Midgley ·  
Jennifer Veitch · Christian Brümmer ·  
Reimund P. Rötter · Finn A. Viehberg ·  
Maik Veste *Editors*

# Sustainability of Southern African Ecosystems under Global Change

Science for Management and Policy  
Interventions

## A New Era of Earth Observation for the Environment: Spatio-Temporal Monitoring Capabilities for Land Degradation

Christiane Schmallius , Ursula Gessner , Insa Otte ,  
Marcel Urban , George Chirima, Moses Cho, Kai Heckel,  
Steven Hill, Andreas Hirner , Pawel Kluter, Nosiseko Mashiyi,  
Onesimo Mutanga, Carsten Pathe, Abel Ramoelo, Andrew Skowno,  
Jasper Slingsby, and Jussi Baade 

**Open access !** <https://link.springer.com/book/10.1007/978-3-031-10948-5>

OPEN ACCESS

 Springer

SSNM 2025



FRIEDRICH-SCHILLER-  
UNIVERSITÄT  
JENA

**FONA**  
Research for sustainability



# Thank You for Your Attention !

## Acknowledgments

Kruger National Park Scientific Services Staff,  
SANParks Section Ranger & Game Guards

SANParks Project Ref. No.: BAAJ1519

Federal Ministry of Education and Research (BMBF)

SPACES Grants: 01LL1701 A-D, 01LL1801D