EvIDENz – Drought Hazard

Multi-Scale Drought Hazard Assessment

Cooperation: **ZFL**, UNU-EHS

Affiliated Partners: United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), Space Research Institute of Ukraine & University of the Free State, South Africa

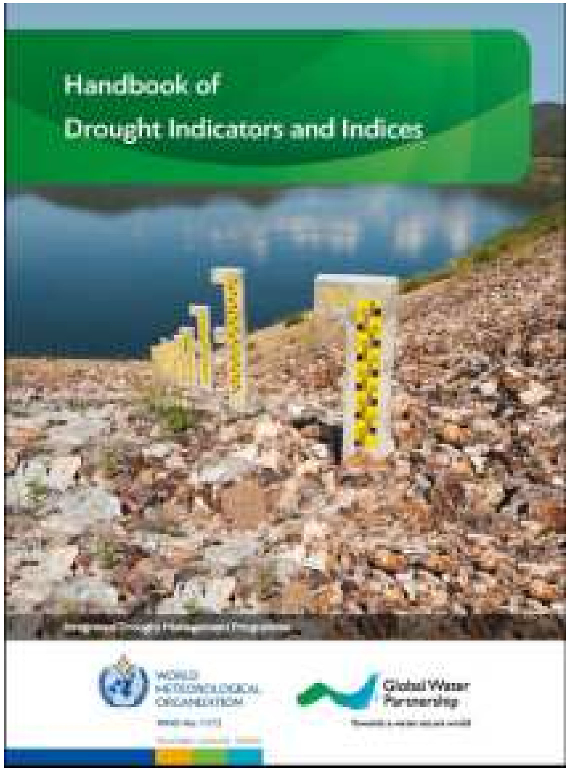
East London, 8th June 2018

Contents

1. Remote Sensing for Drought Monitoring

RS-based Drought Indices

- Normalized Difference Vegetation Index (NDVI)
- Enhanced Vegetation Index (EVI)
- Vegetation Drought Response Index (VegDRI)
- Temperature Condition Index (TCI)
- Normalized Difference Water Index (NDWI)
- Vegetation Health Index (VHI)
- Absolute Difference Normalized Difference Vegetation Index (ADVI)
- Standardized Vegetation Index (SVI)



- Satellite RS-based methods achieve much higher added value
  - good spatial resolution
  - temporal dynamic
  - consistent data

1. Remote Sensing for Drought Monitoring

Name	Acronym	Category	Inputs	Sensor(s)
Enhanced Vegetation Index	EVI	Vegetation	Sat	MODIS (+/- AVHRR)
Normalized Difference Vegetation Index	NDVI	Vegetation	Sat	AVHRR
Vegetation Condition Index	VCI	Vegetation	Sat	AVHRR
Vegetation Health Index	VHI	Vegetation	Sat	AVHRR
Soil Adjusted Vegetation Index	SAVI	Vegetation	Sat	MODIS
Temperature Vegetation Dryness Index	TVDI	Vegetation	Sat	MODIS
Optimized Vegetation Drought Index	OVDI	Vegetation/ Drought		
Vegetation Drought Response Index		Vegetation/ Drought	Sat+	
Evaporative Stress Index	ESI	Vegetation/ Water	Sat+	AVHRR
Water Requirement Satisfaction Index	WRSI	Vegetation/ Water	Sat+	NOAA Rainfall Estimates (RFE)+
Normalized Difference Water Index	NDWI	Vegetation/ Water	Sat	MODIS
Land Surface Water Index	LSWI	Vegetation/ Water	Sat	MODIS
Combined Drought Indicator	CDI	Drought	Sat+	MODIS (fAPAR)+
Perpendicuar Drought Index	PDI	Drought		
Modified PDI	MPDI	Drought		
Precipitation Condition index	PCI	Water		MODIS, TRMM
Soil Moisture Condition Index	SMCI	Water		
Optimized Meteorological Drought Index	OMDI	Water		
Temperature Condition Index	TCI	Temperature	Sat	AVHRR

1. Reviews of remote sensing vegetation indices remind us that there are quite a lot to choose from…

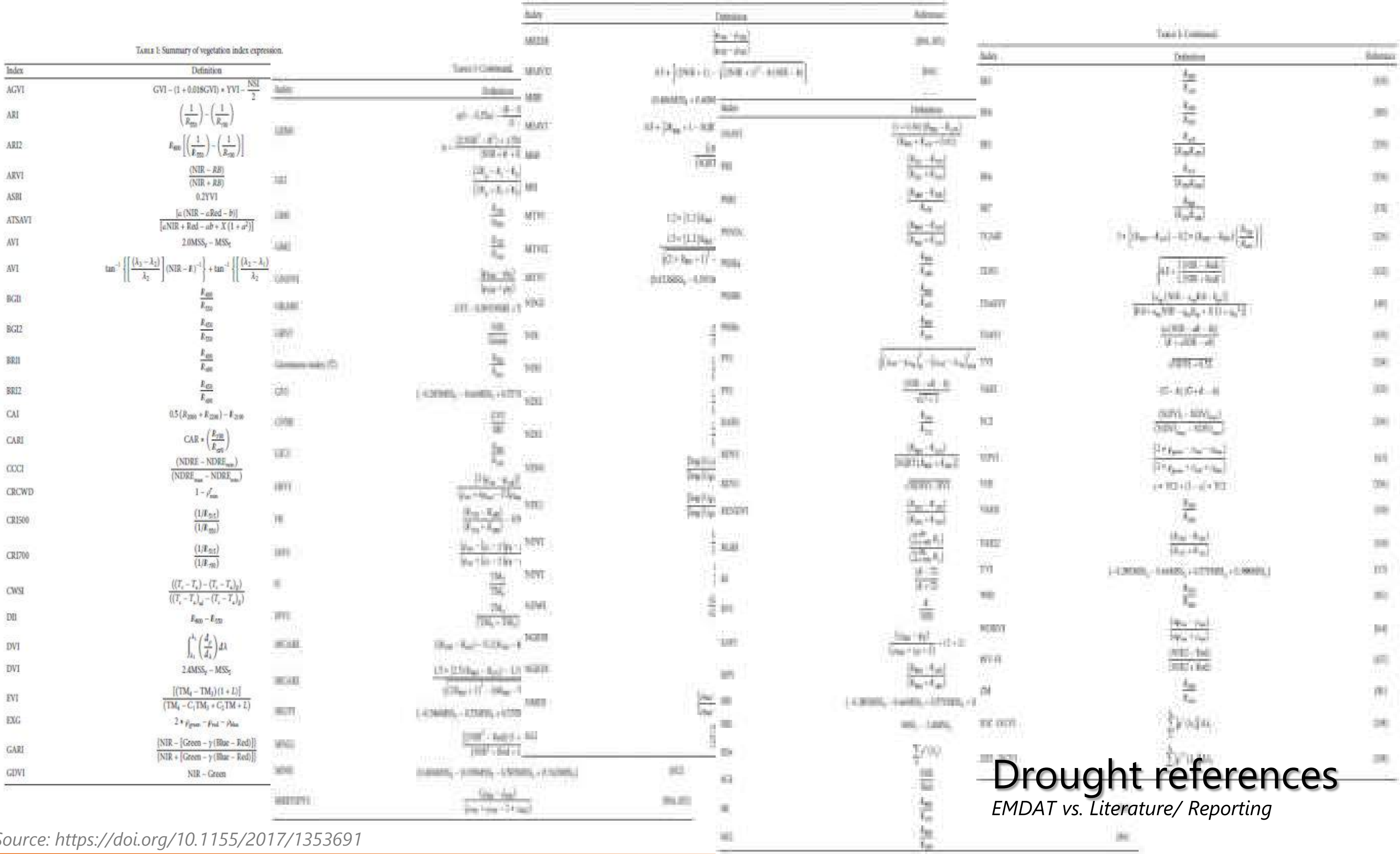


Table 1: Summary of vegetation index expression.

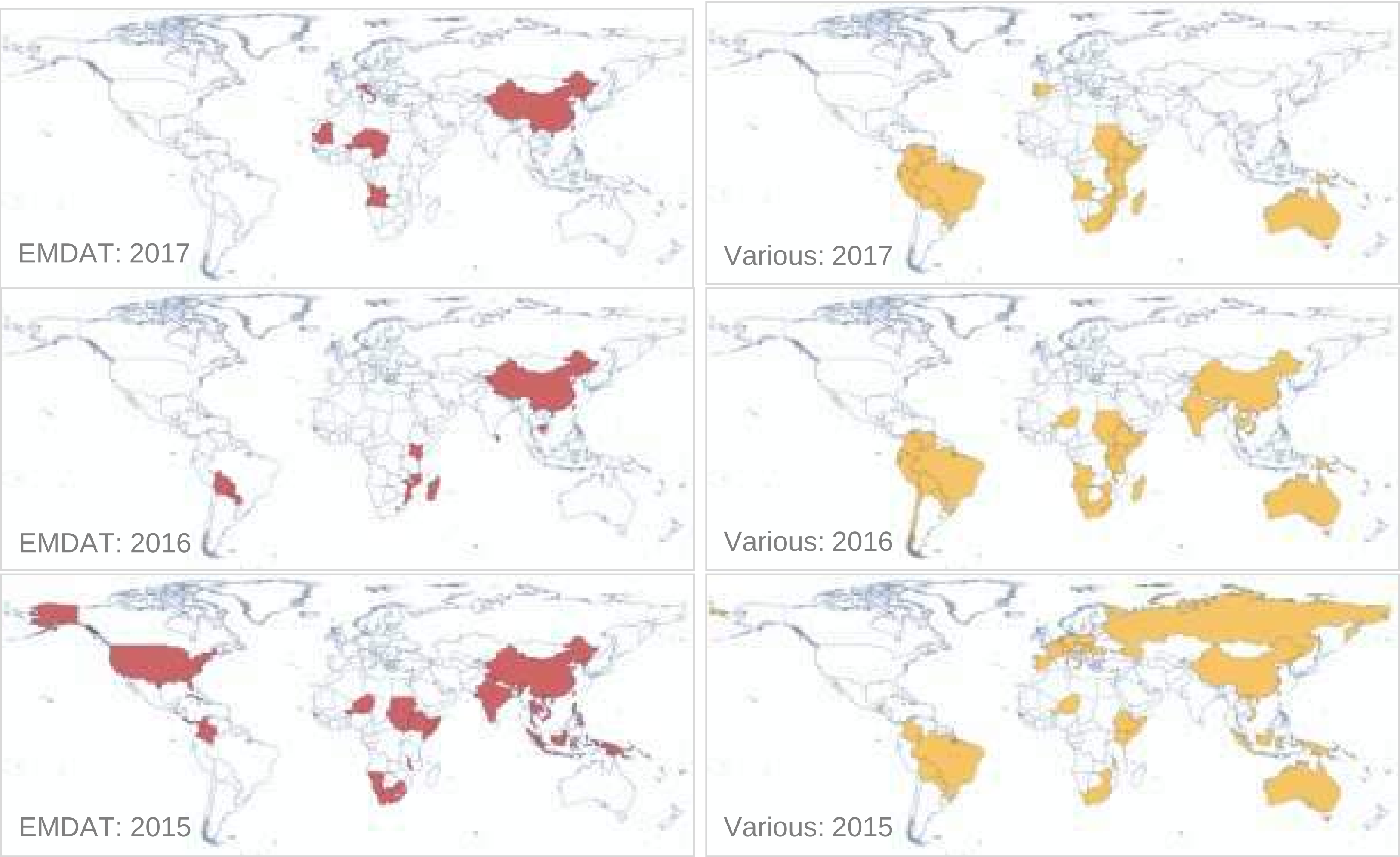
Index	Definition
AGVI	$GVI - (1 + 0.018GVI) \times YVI - \frac{NSI}{2}$
ARI	$\left(\frac{1}{R_{550}}\right) - \left(\frac{1}{R_{700}}\right)$
ARI2	$R_{800}\left[\left(\frac{1}{R_{550}}\right) - \left(\frac{1}{R_{700}}\right)\right]$
ARVI	$\frac{(NIR - RB)}{(NIR + RB)}$
ASBI	$0.2YVI$
ATSAVI	$\frac{a(NIR - aRed - b)}{[aNIR + Red - ab + X(1 + a^2)]}$
AVI	$2.0MSS_7 - MSS_5$
AVI	$\tan^{-1}\left\{\left[\frac{(\lambda_3 - \lambda_2)}{\lambda_2}\right](NIR - R)^{-1}\right\} + \tan^{-1}\left\{\left[\frac{(\lambda_2 - \lambda_1)}{\lambda_2}\right]\right.$ [illegible]
BGI1	$\frac{R_{400}}{R_{550}}$
BGI2	$\frac{R_{450}}{R_{550}}$
BRI1	$\frac{R_{400}}{R_{690}}$
BRI2	$\frac{R_{450}}{R_{690}}$
CAI	$0.5(R_{2000} + R_{2200}) - R_{2100}$
CARI	$CAR \times \left(\frac{R_{700}}{R_{670}}\right)$
CCCI	$\frac{(NDRE - NDRE_{min})}{(NDRE_{max} - NDRE_{min})}$
CRCWD	[illegible]
CRI500	$\frac{(1/R_{515})}{(1/R_{550})}$
CRI700	$\frac{(1/R_{515})}{(1/R_{700})}$
CWSI	$\frac{((T_c - T_a) - (T_c - T_a)_{ll})}{((T_c - T_a)_{ul} - (T_c - T_a)_{ll})}$
DII	$R_{800} - R_{550}$
DVI	$\int_{\lambda_1}^{\lambda_n}\left(\frac{d\rho}{d\lambda}\right)d\lambda$
DVI	$2.4MSS_7 - MSS_5$
EVI	$\frac{[(TM_4 - TM_3)(1 + L)]}{(TM_4 - C_1TM_3 + C_2TM + L)}$
EXG	$2 \times \rho_{green} - \rho_{red} - \rho_{blue}$
GARI	$\frac{[NIR - (Green - \gamma(Blue - Red))]}{[NIR + (Green - \gamma(Blue - Red))]}$
GDVI	$NIR - Green$

Drought references

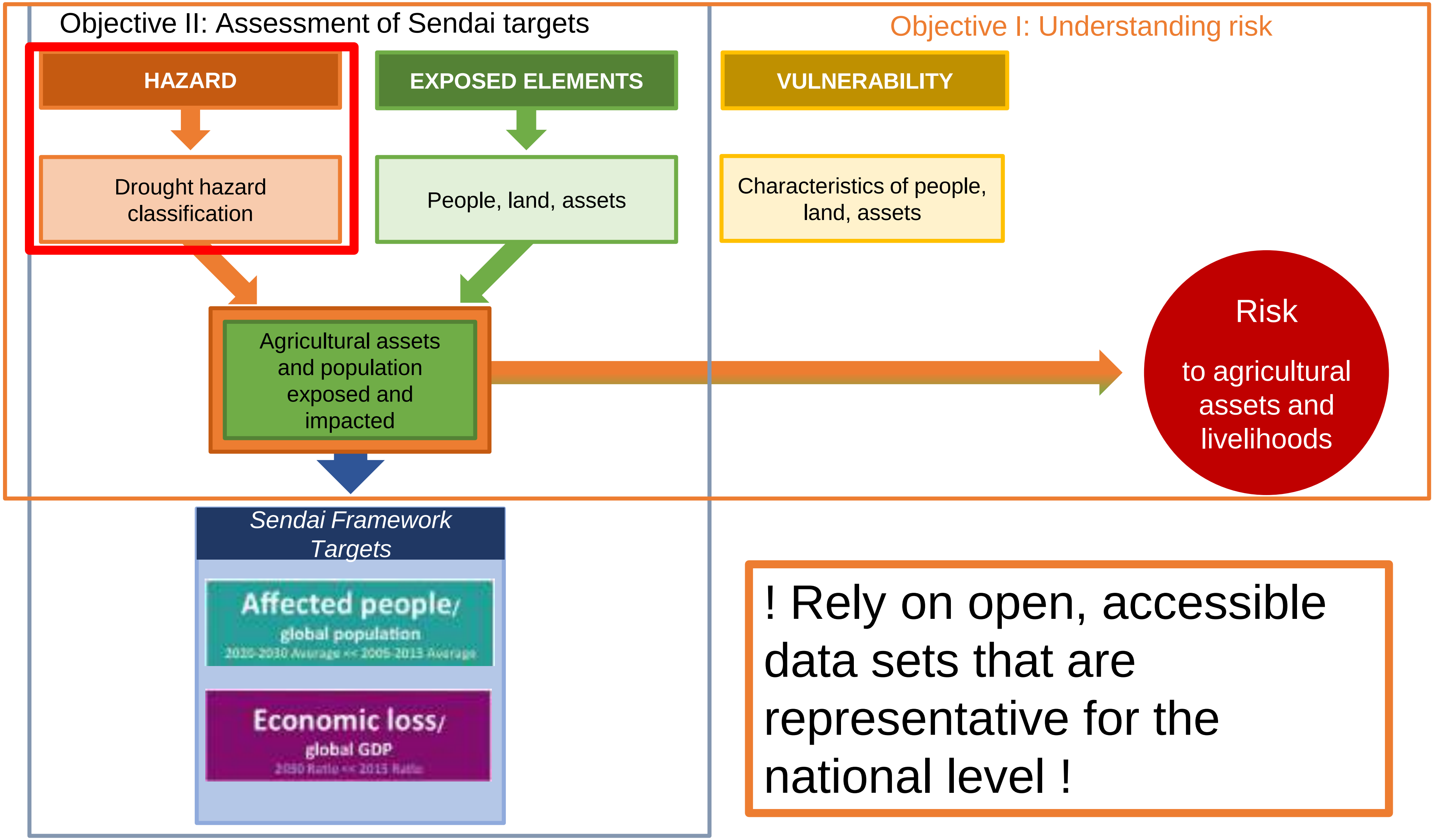
EMDAT vs. Literature/ Reporting

Source: https://doi.org/10.1155/2017/1353691

1. Drought Event Database



2. EvIDENz approach



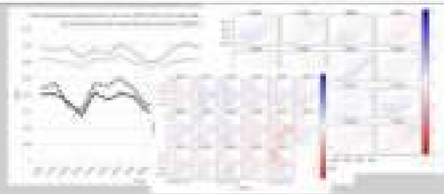
! Rely on open, accessible data sets that are representative for the national level !

2. Analysis

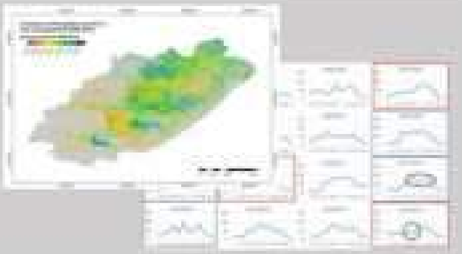
Moderate Resolution Data
(MODIS 250m, NOAA AVHRR 4km)

Vegetation | Temperature | Water

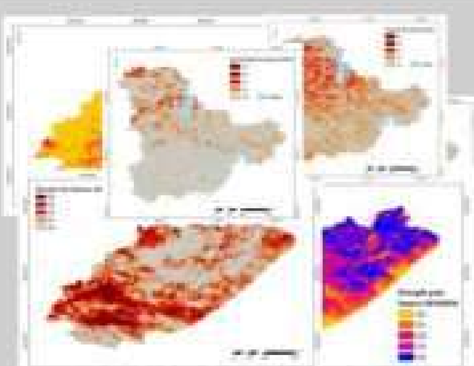
Productivity & Anomalies
(Detecting Drought Events)



Variable Complexity
Correlation, Cross-Correlation, Time Lags)



Drought Classification
(Predefined vs. Weighted classification)



High-Resolution Data
(Sentinel 1- 20m, Sentinel 2- 10-20m)

Vegetation | Temperature | Water

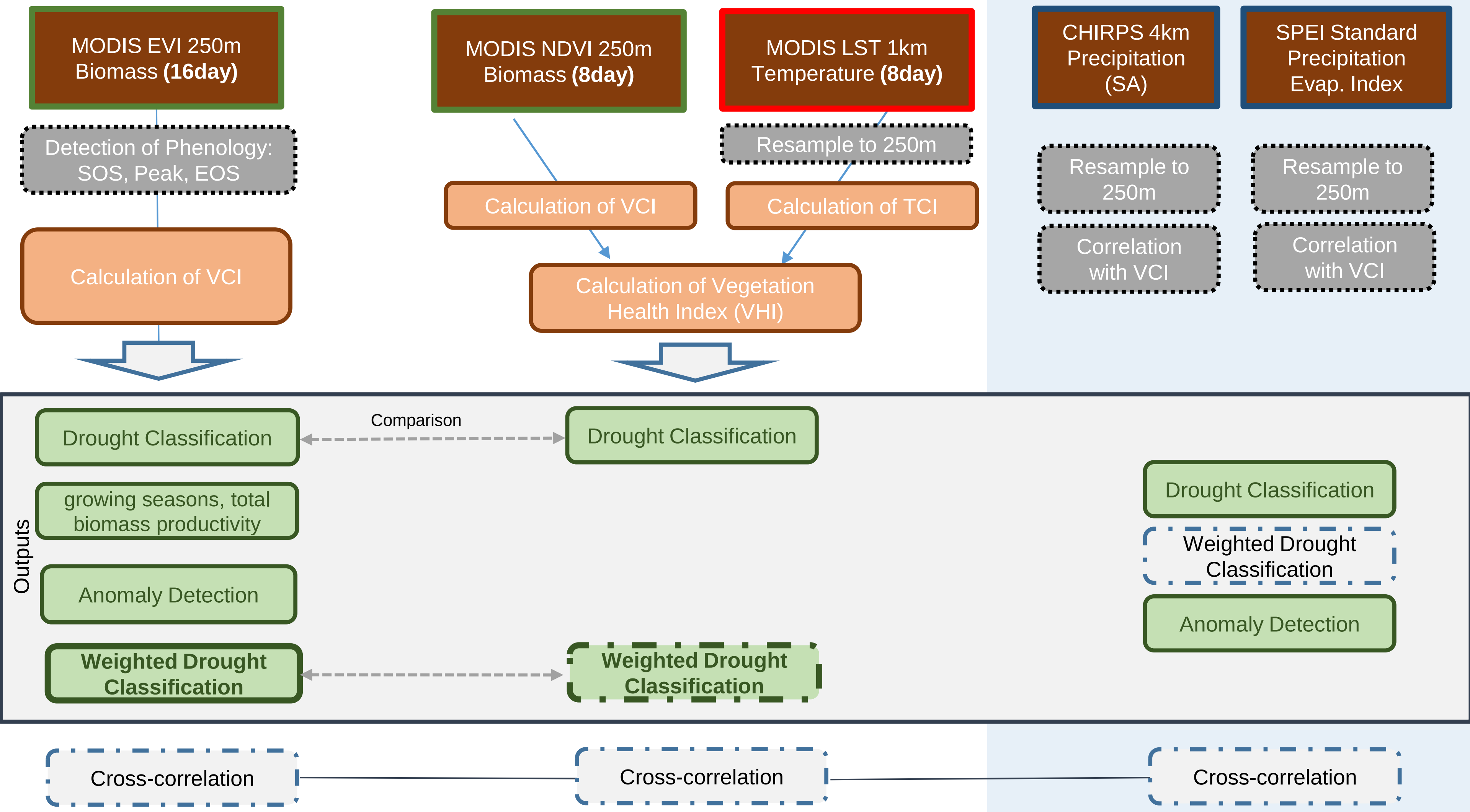
Crop Classification
(Drought Stress)

Variable Complexity

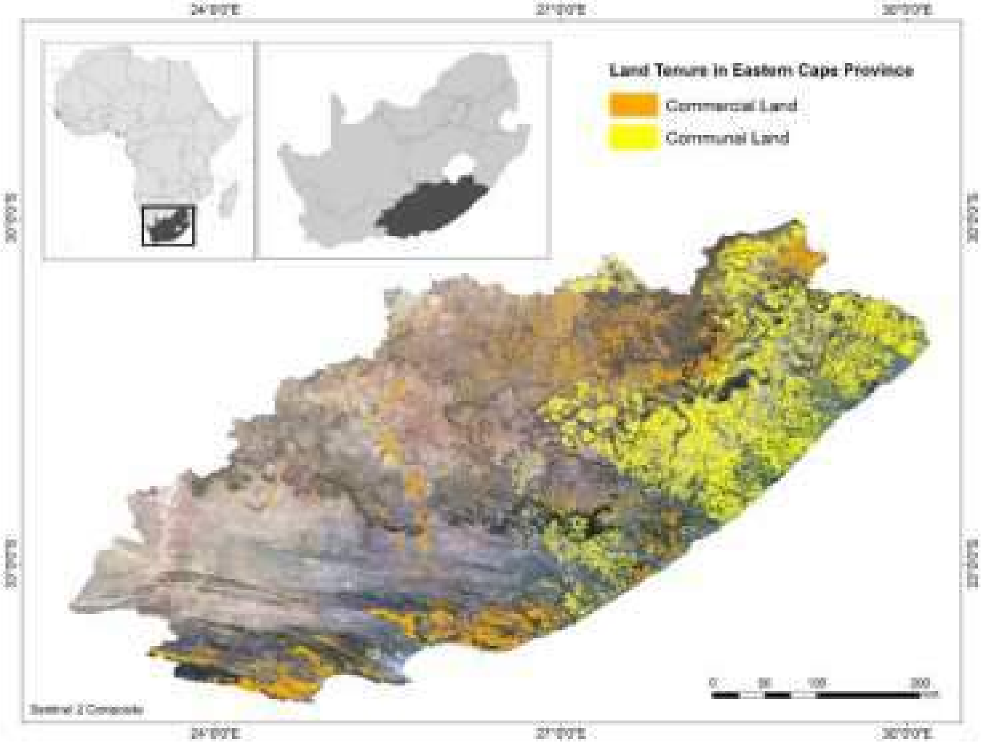
Drought Stress Detection

EVIDENZ

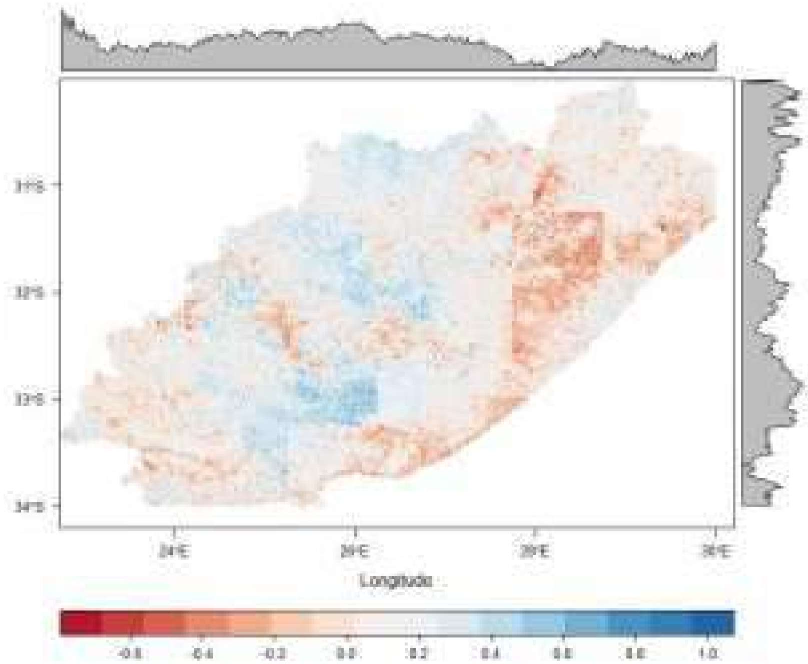
3. Data and Methods – moderate resolution



4. SPEI vs. VCI – Water vs. Vegetation? Hazard?



Drought Years 2014-2016



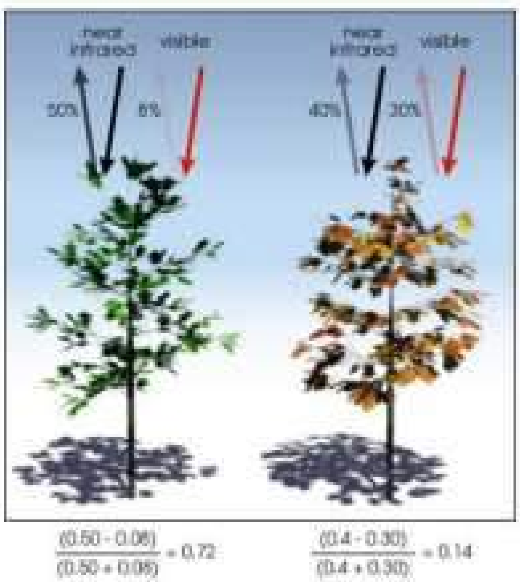
SPEI correlation with MODIS based vegetation index (here VCI), seasonal seasonal values

Response of Vegetation

- Agricultural productivity measured with Vegetation Condition
- How can we classify drought hazard?

EVI

Measuring Vegetation Performance with Remote Sensing (EVI/NDVI)



https://earthobservatory.nasa.gov/Features/MeasuringVegetation/

VCI

Vegetation Condition Index (VCI)

$$= \frac{EVI - EVI_{min}}{EVI_{max} - EVI_{min}} * 100$$

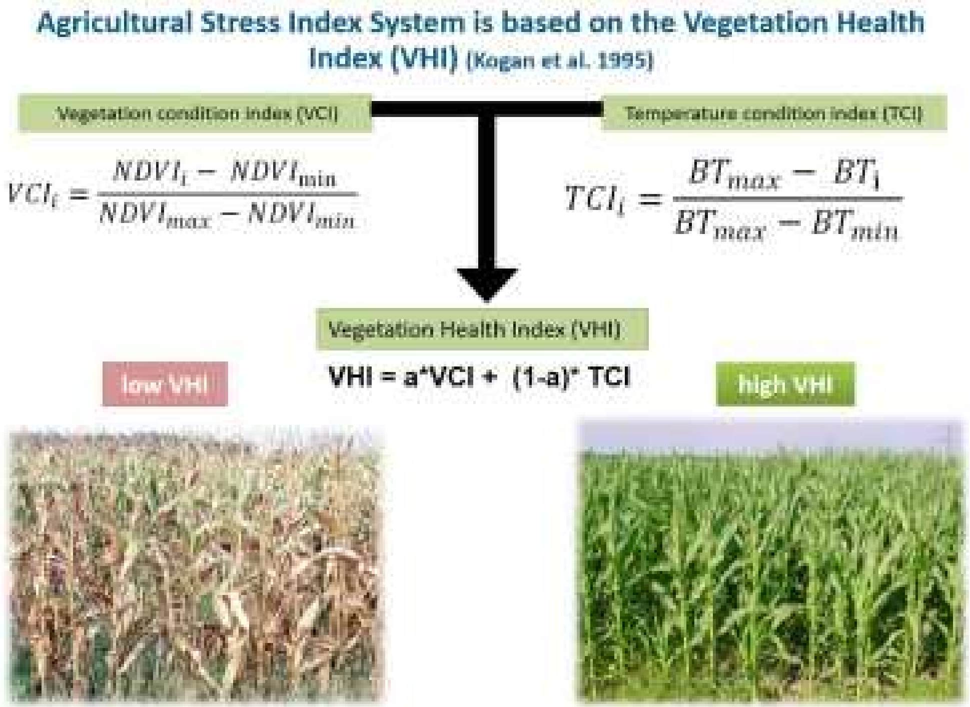
Classification for VCI (and VHI)

Drought hazard severity classes	VCI/VHI Values
No Drought	> 40
Mild Drought	30 - 40
Moderate Drought	20 - 30
Severe Drought	10 - 20
Extreme Drought	< 10

Kogan, 1998

3. Data and Methods – Drought Indices

Example: Agricultural Stress Index System (ASIS): Global and Local Analysis



Classification for VCI (and VHI)

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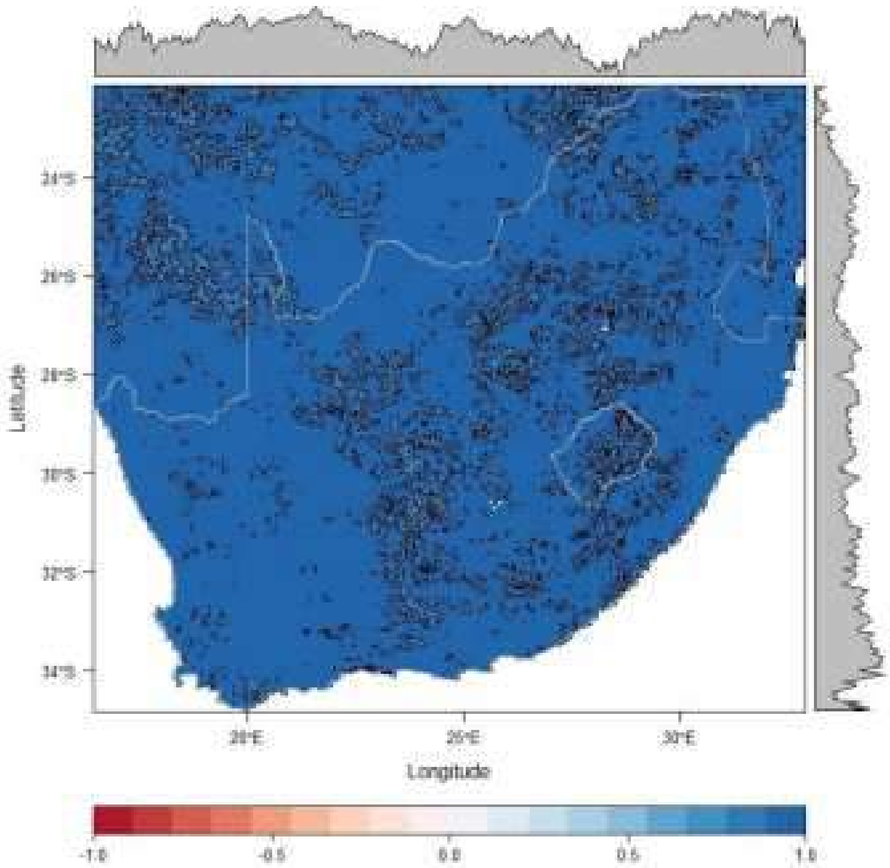
Kogan, 1998

Does remote sensing of vegetation support the detection of drought conditions?

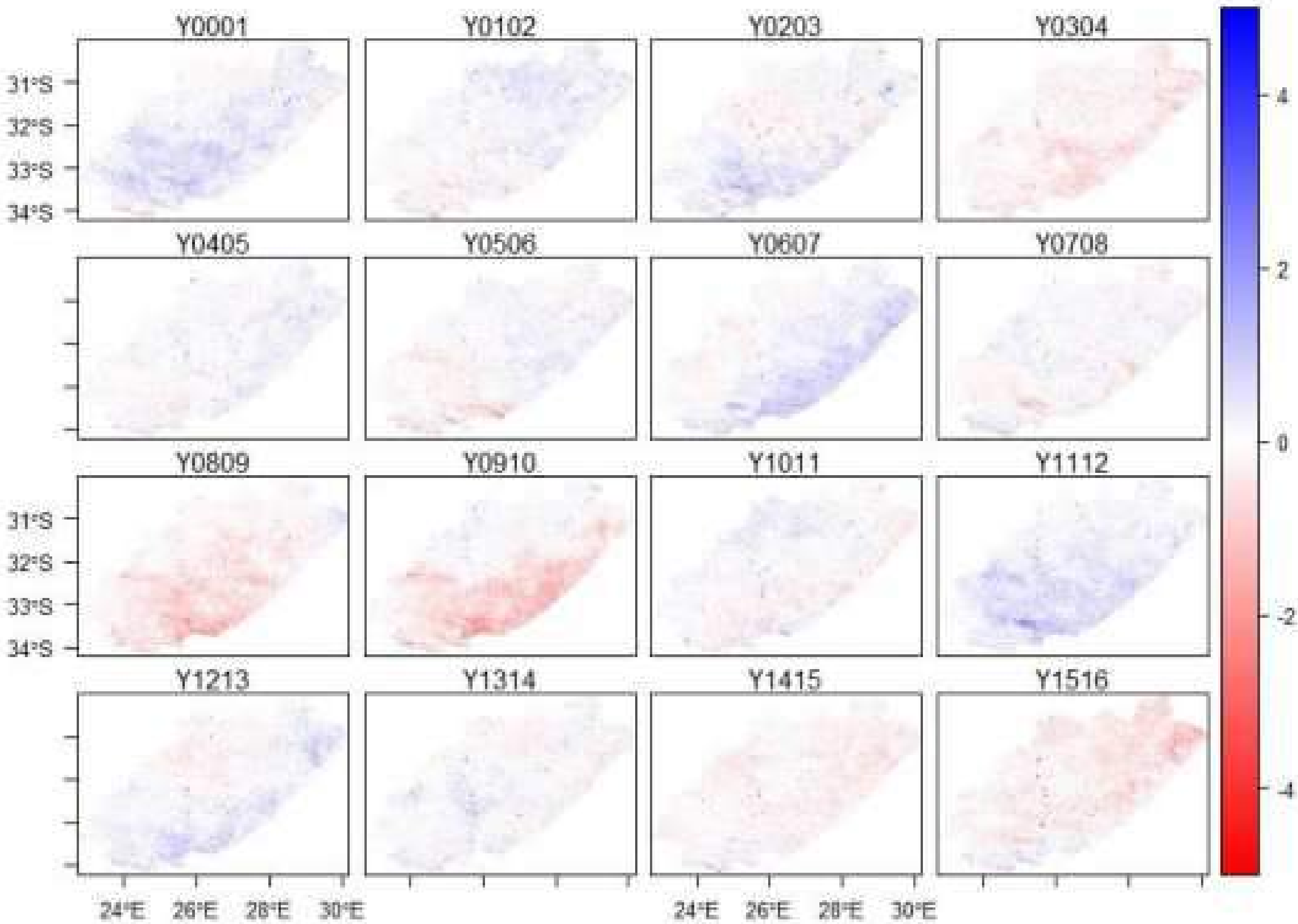
Vegetation Condition Index (VCI) vs. Vegetation Health Index (VHI)

- VHI integrates also Temperature
- Two most common used indices
- Same drought classifications

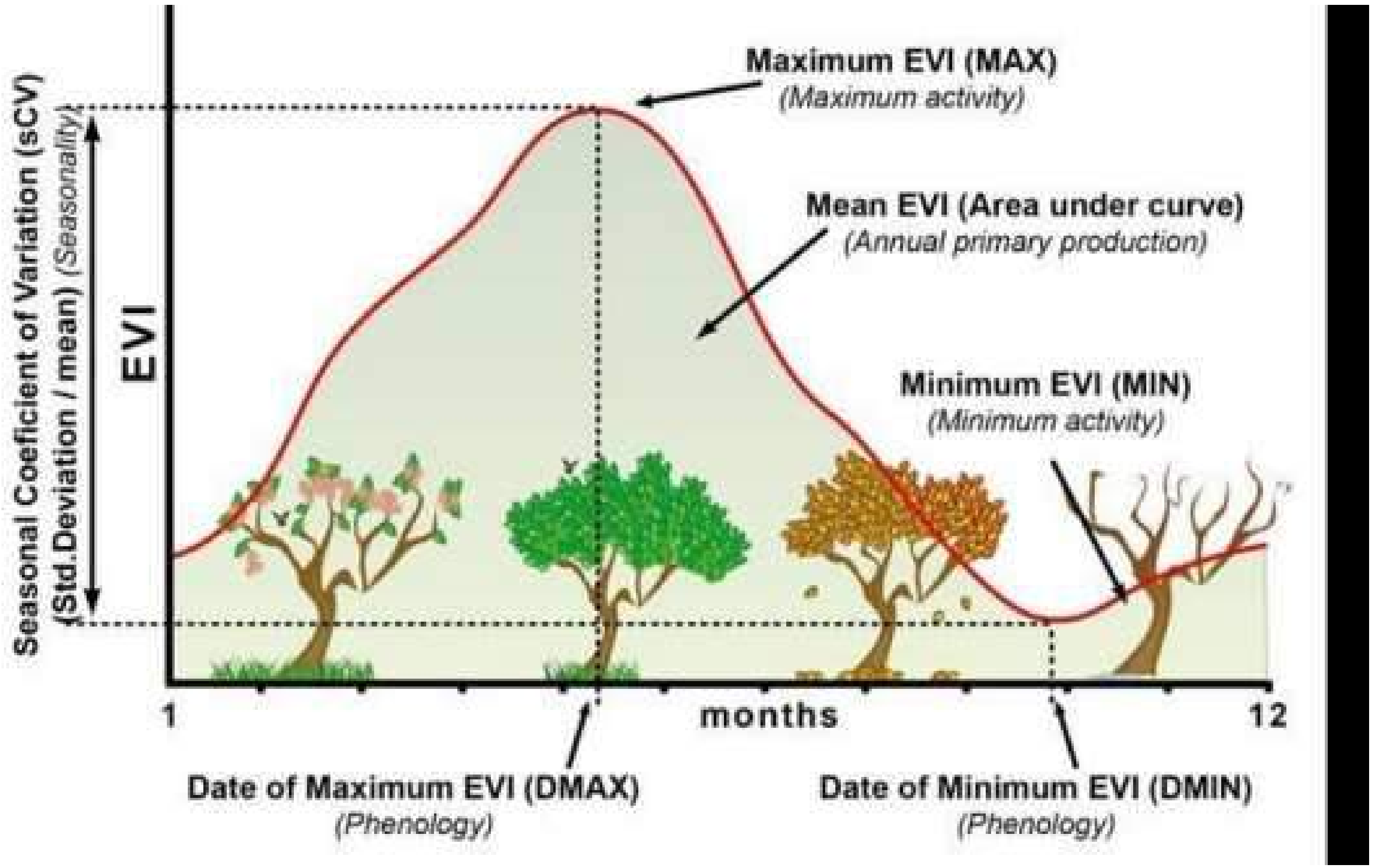


4. Drought Hazard Assessment – Anomalies in Productivity

Anomalies using annual ∑EVI



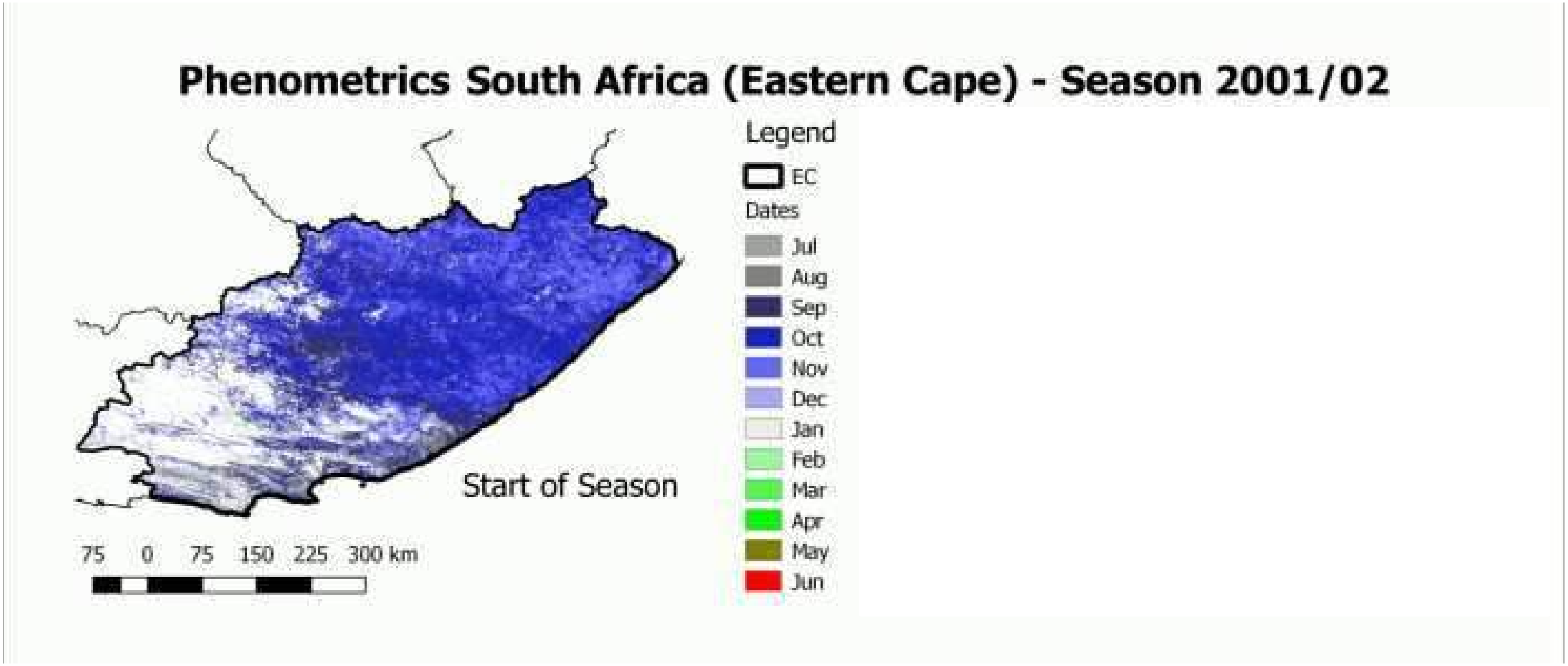
Seasonality Parameters – Vegetation Phenology



Lourenço (2015)

4. Drought Hazard – Timing matters …

When crops start to grow…



4. Drought Hazard – Timing matters …

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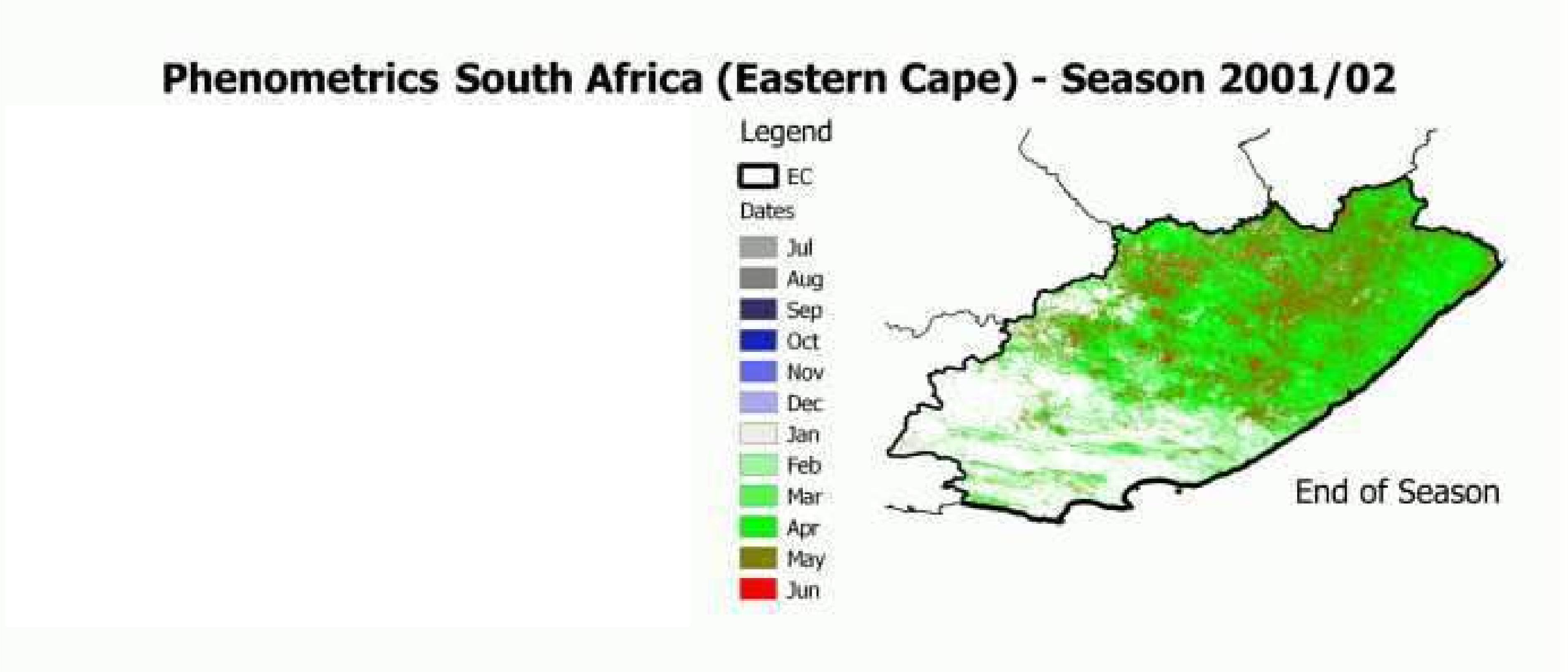
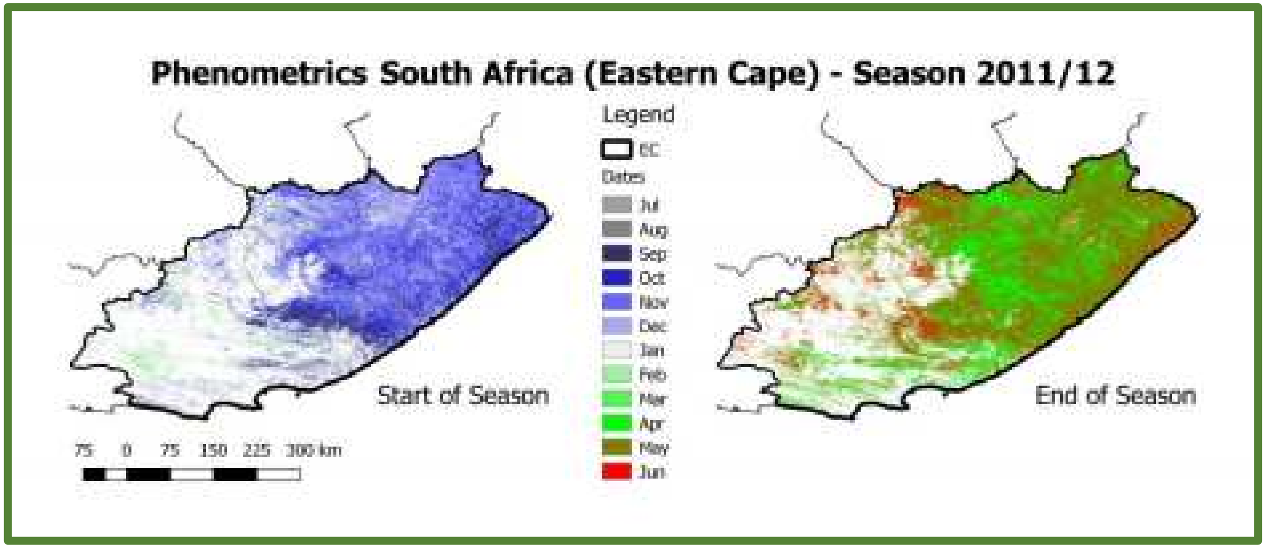


4. Timing matters: Drought vs. Non Drought Year

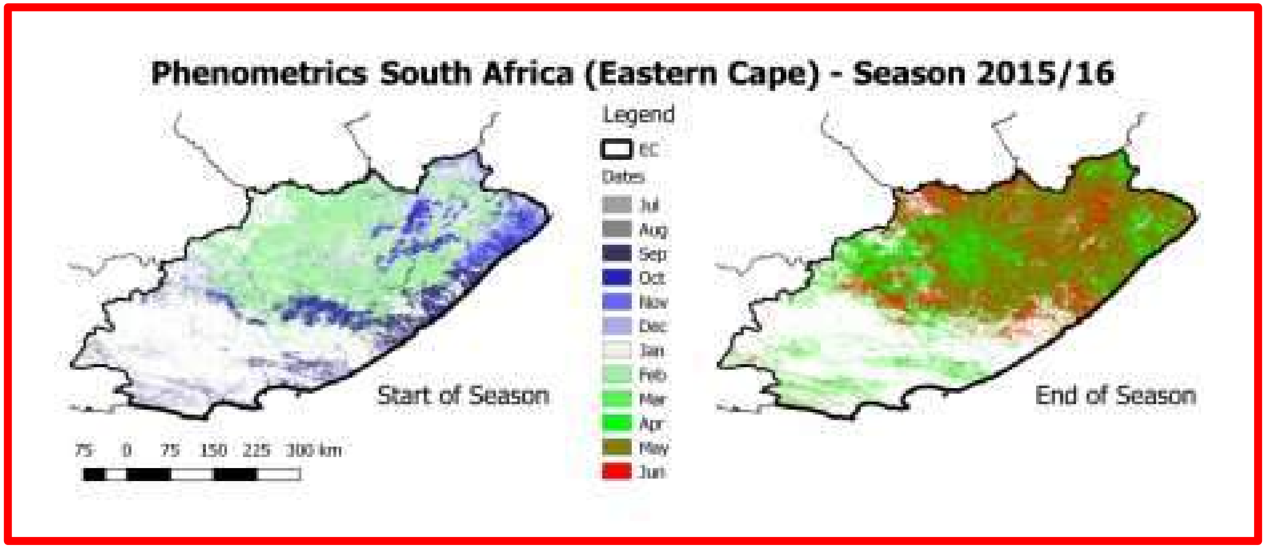
Start of Season (SOS)

- Can have huge impact – e.g. much later in 2015/2016 (drought year)



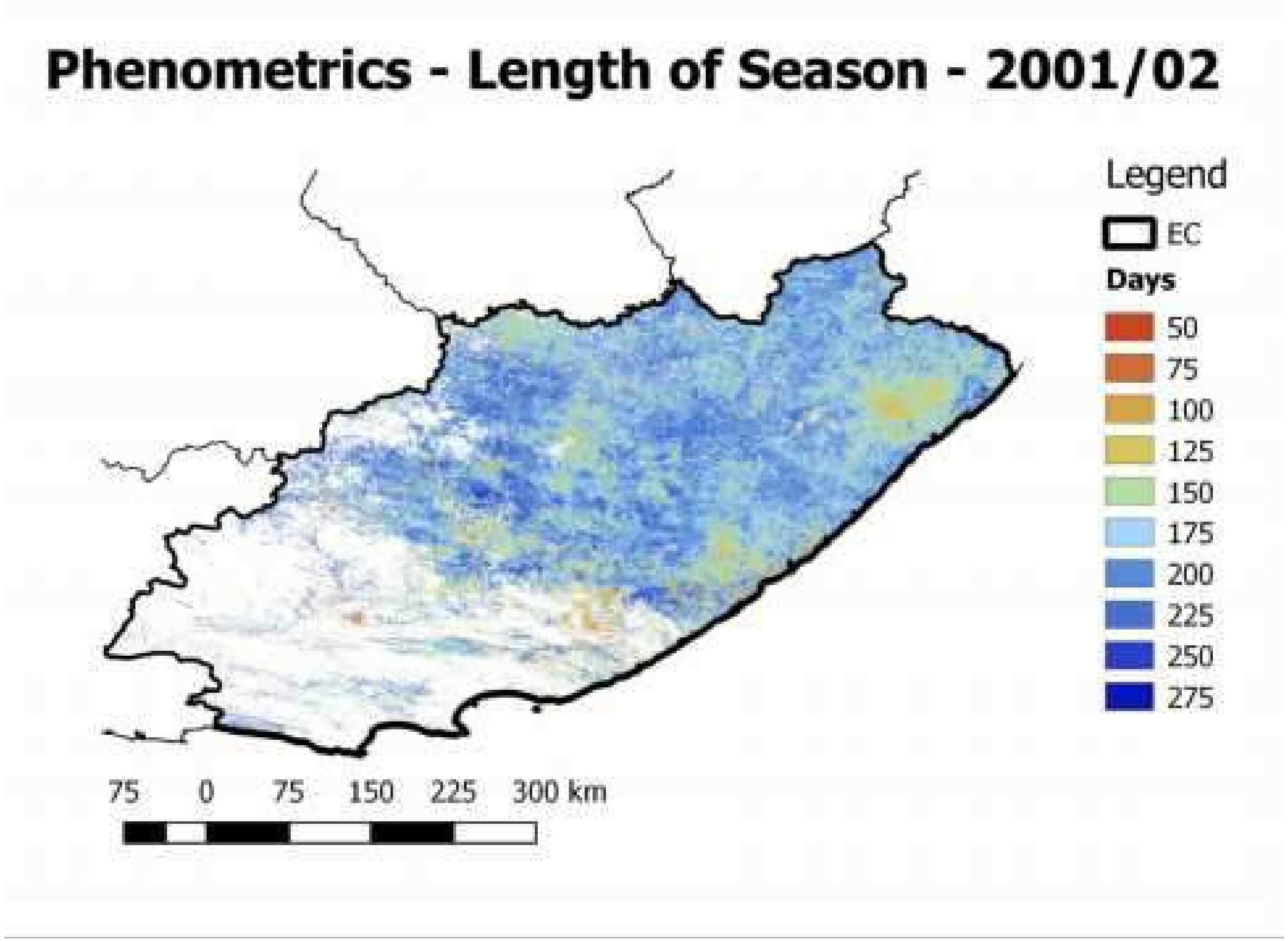
End of Season (EOS)

- effect not as different comparing different years



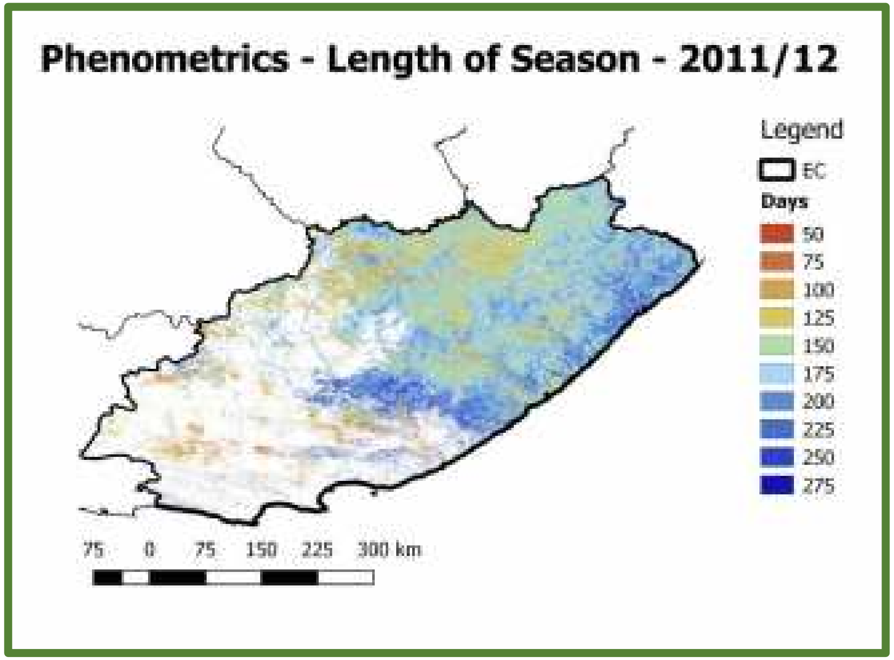
4. Drought Hazard – Timing matters …

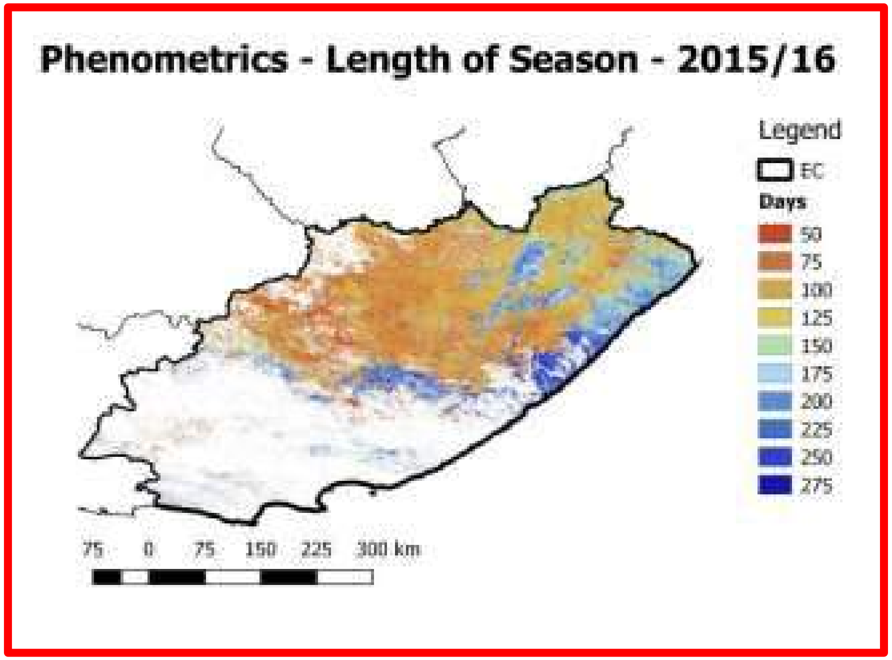
How much time is there for growing …



4. Timing matters: Drought vs. Non Drought Year

- SOS changes (later) – EOS stays almost the same = growing period much shorter
- Less time to provide harvests as expected





To be questioned

- Can a RS-based drought indicator represent agricultural drought conditions?
- What about drought conditions within different observation periods?

Characteristics

- to be operatable: it should be an index that could represent drought conditions
- No complicated index calculation but rather simple and representative
- Approach that can be adjusted for defined needs

Our Approach

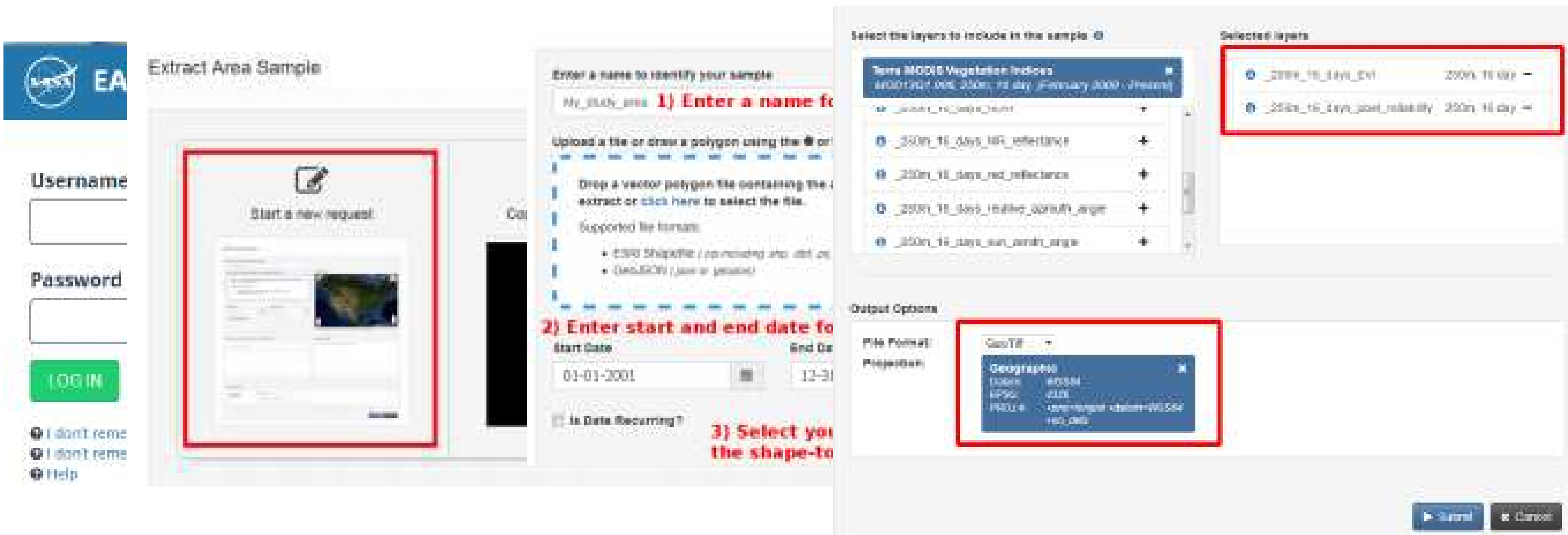
- VCI – an index that does not need a complex setting of input data but is still representative
- detect drought characteristics and drought severity

4. Drought Hazard – Insights in the workflow

Data acquisition

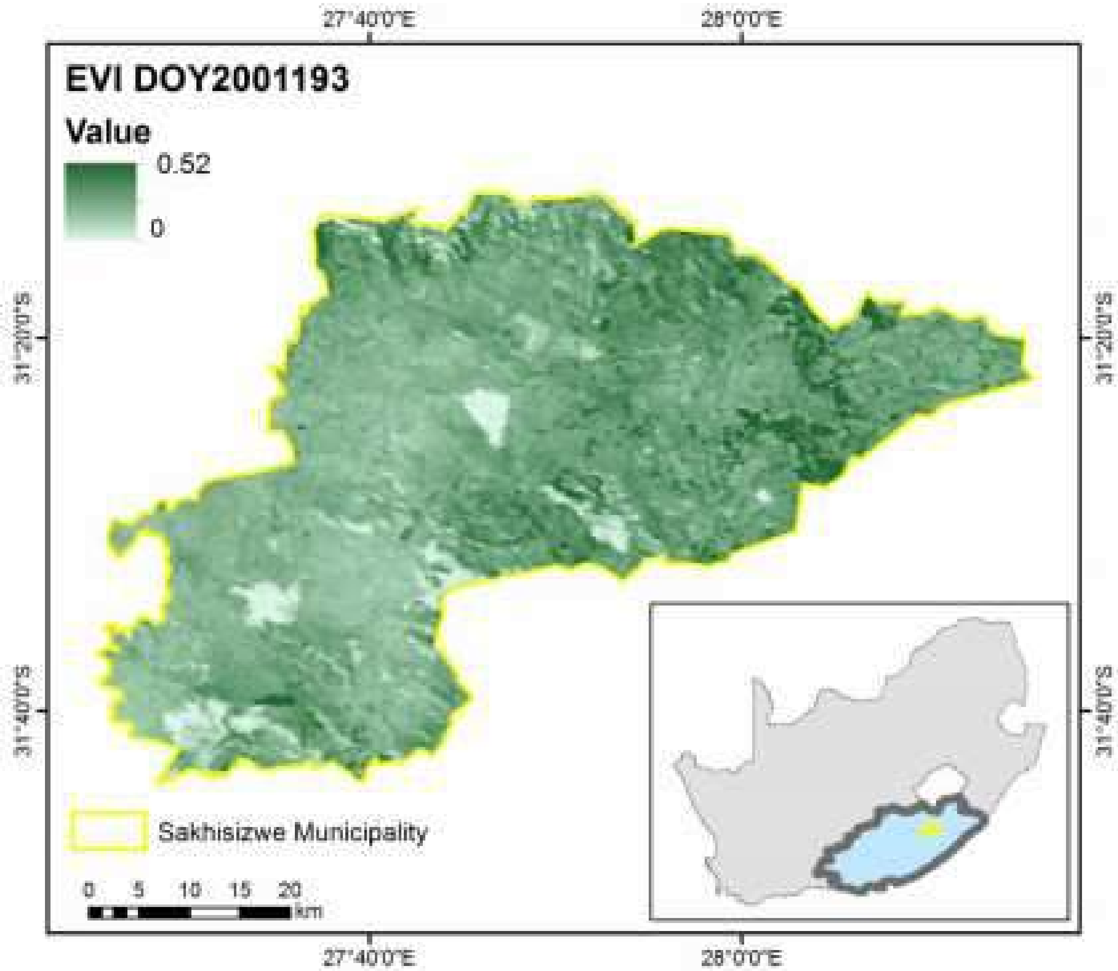
USGS appEEARS platform for data preparation

Data: EVI: Enhanced Vegetation Index

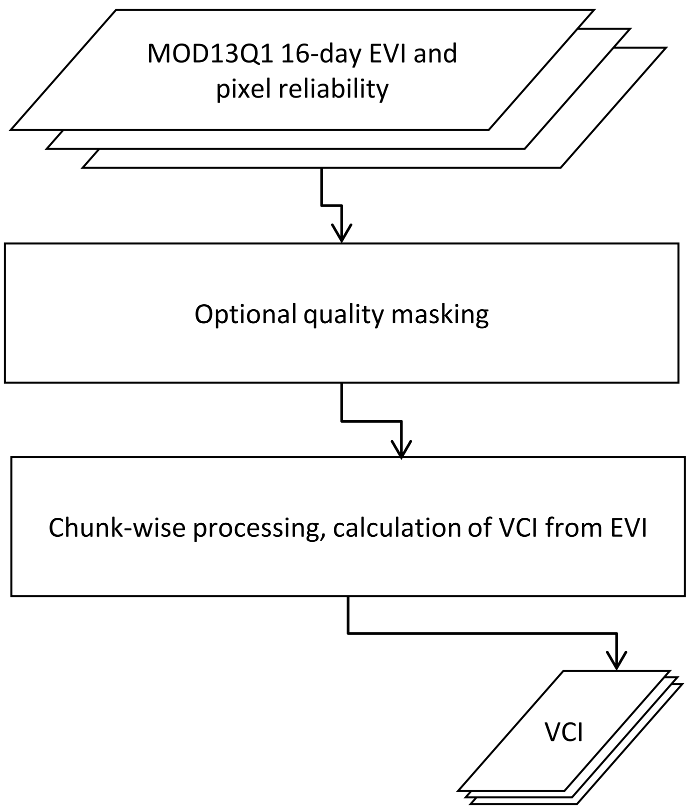


4. Drought Hazard – Study Site for Training

EVI Data 16 day, 250 m resolution



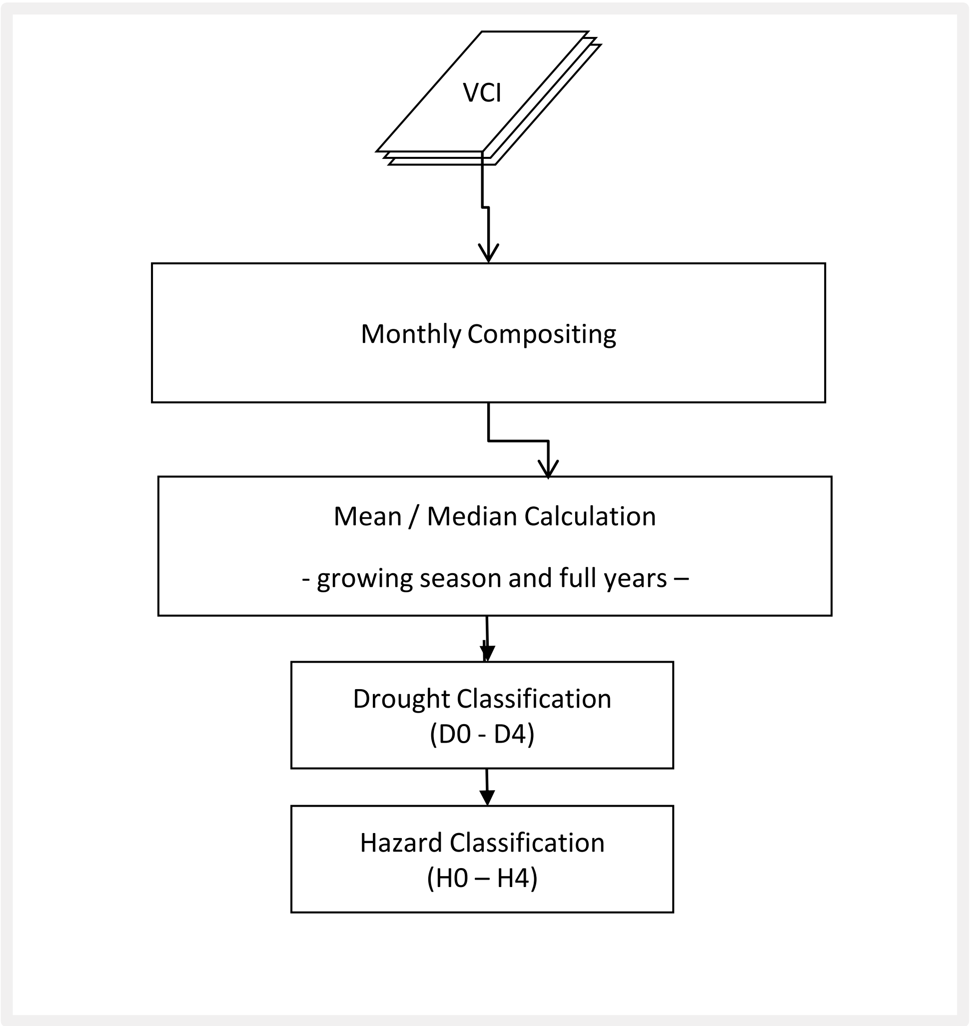
Calculating Vegetation Condition Index (VCI)

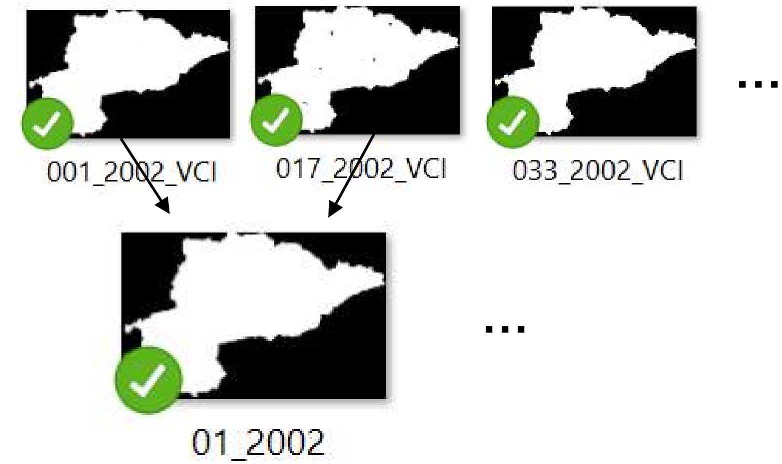


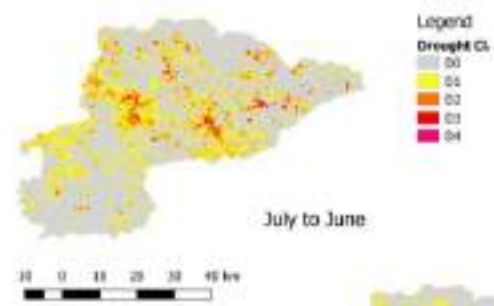
Pixel reliability: Quality of the data

VCI – Drought Index Calculation

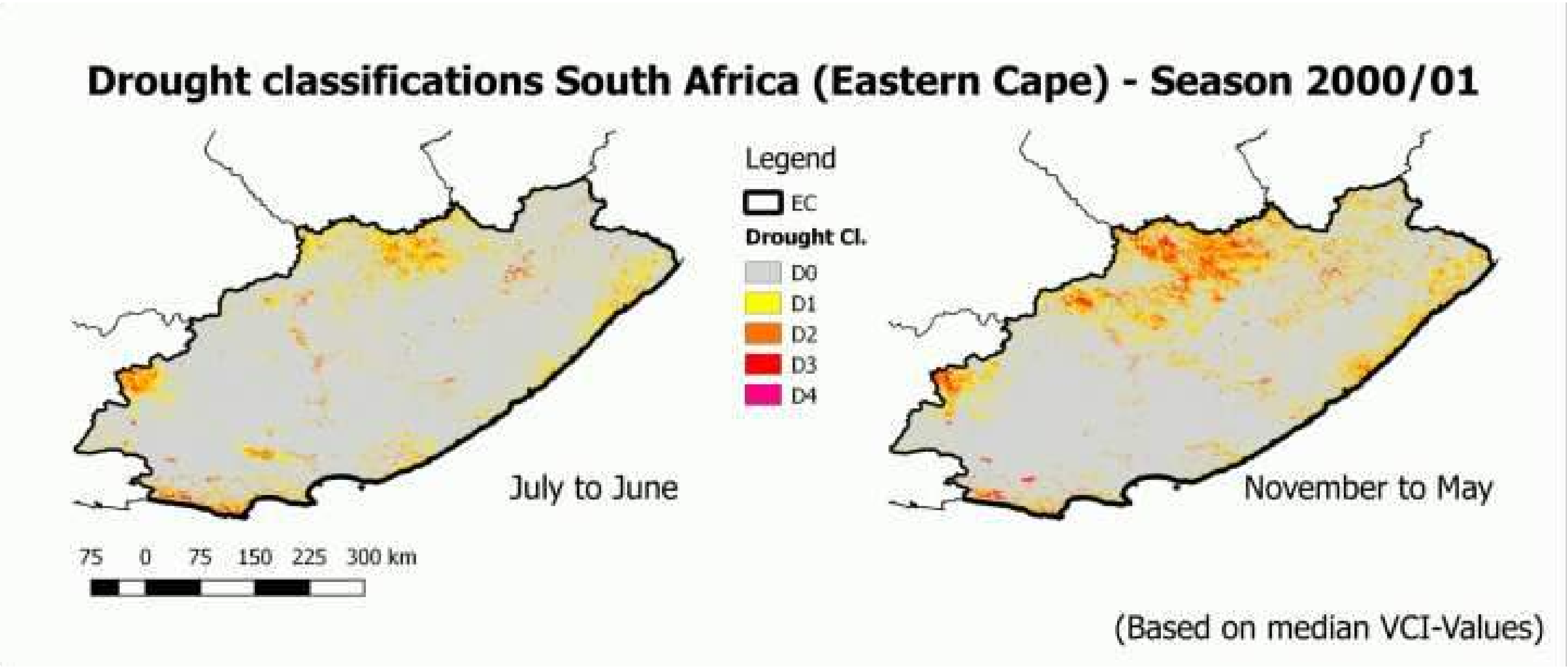
4. Preliminary Output





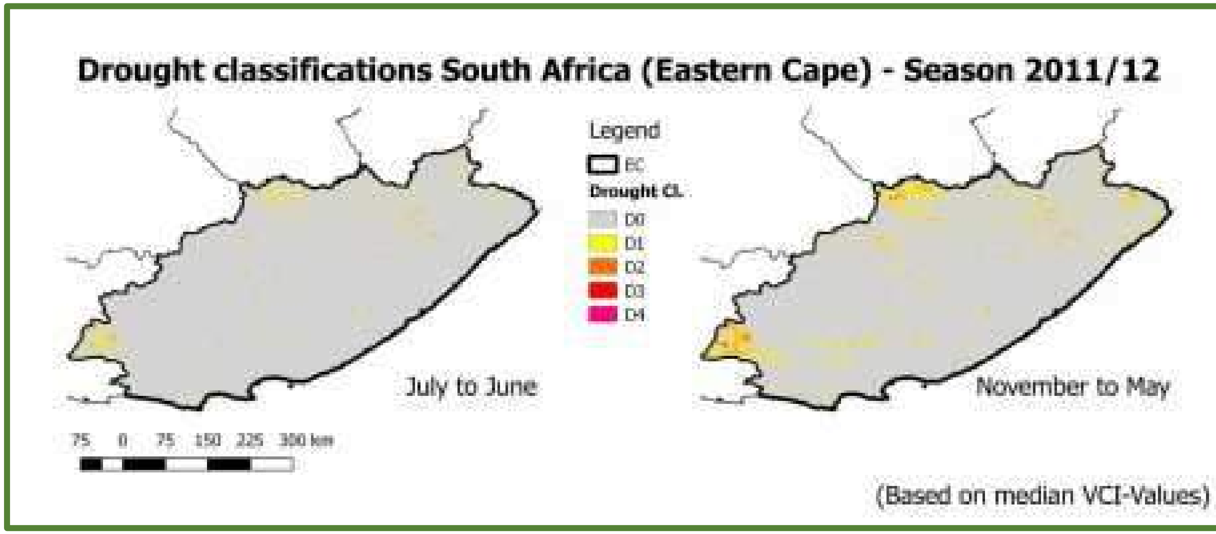


4. Preliminary Output – Conditions for a full year and for a season

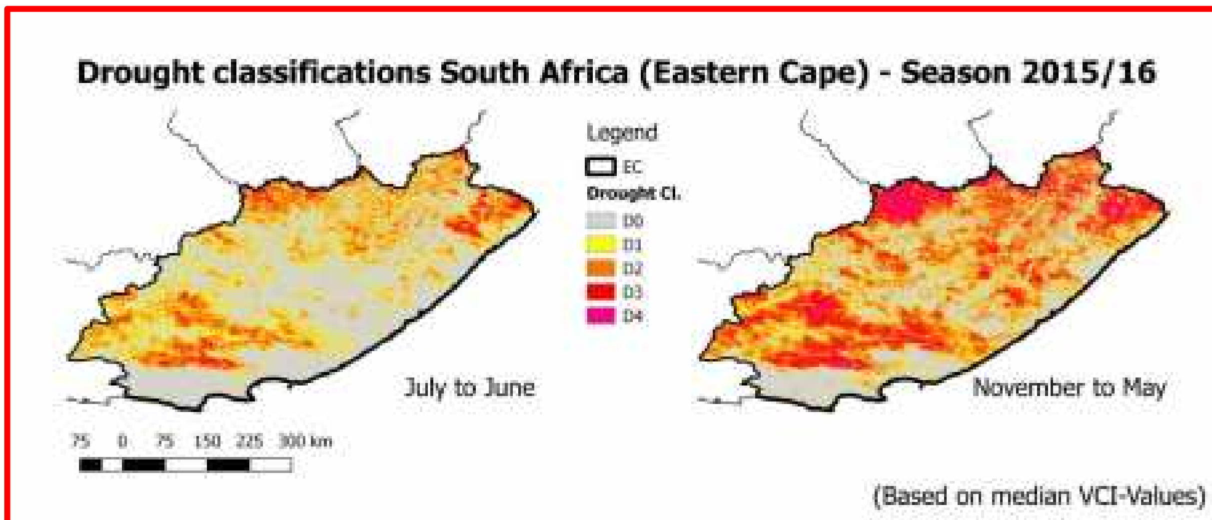


4. Preliminary Output – Conditions for a full year and for a season

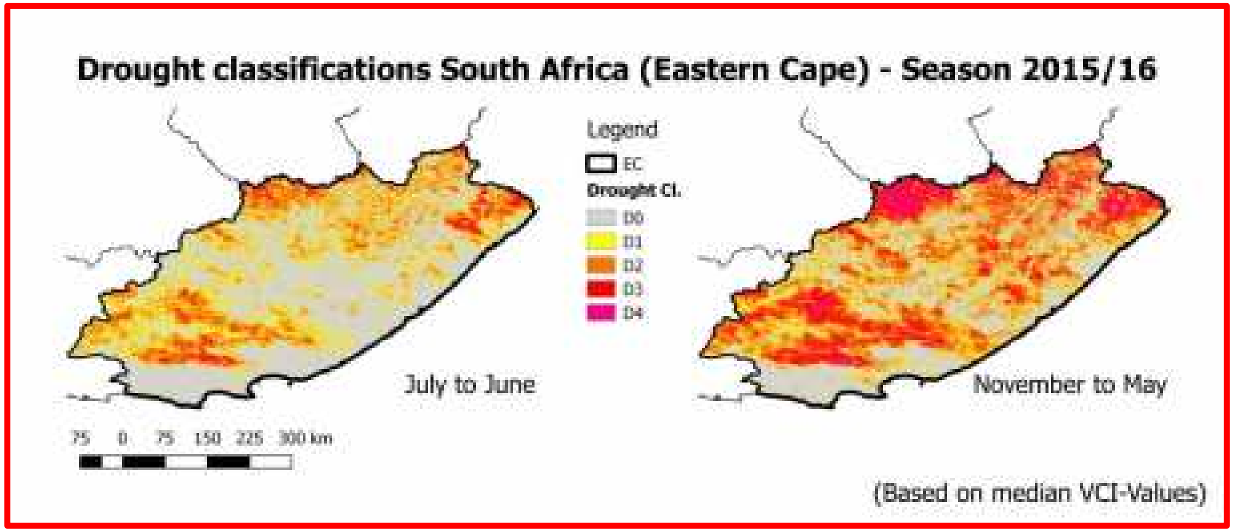
Normal/Non-Drought Year



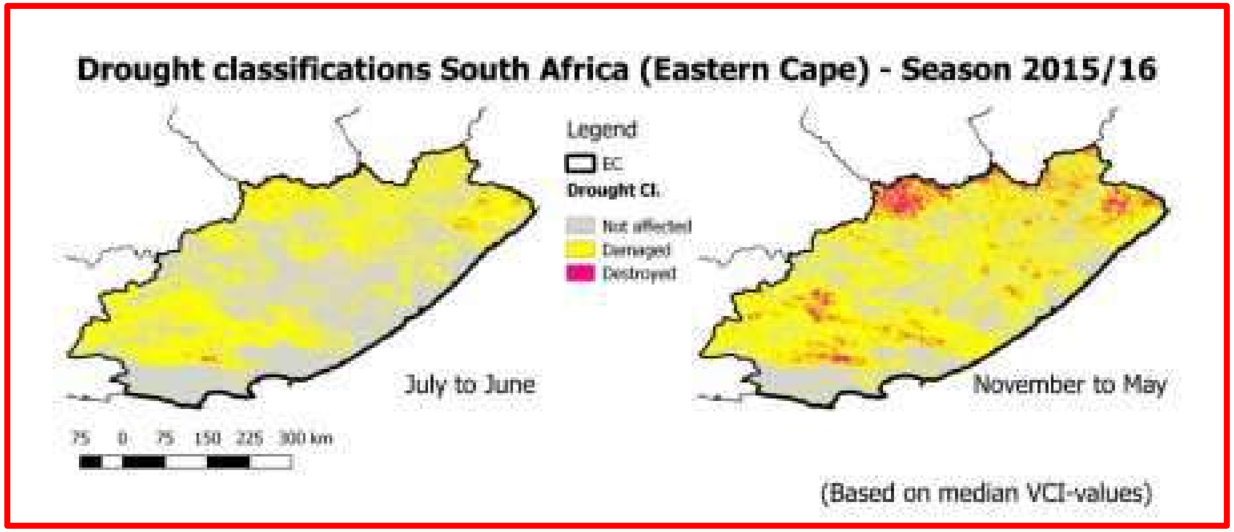
Drought Year



4. Drought Classification – Hazard Classification

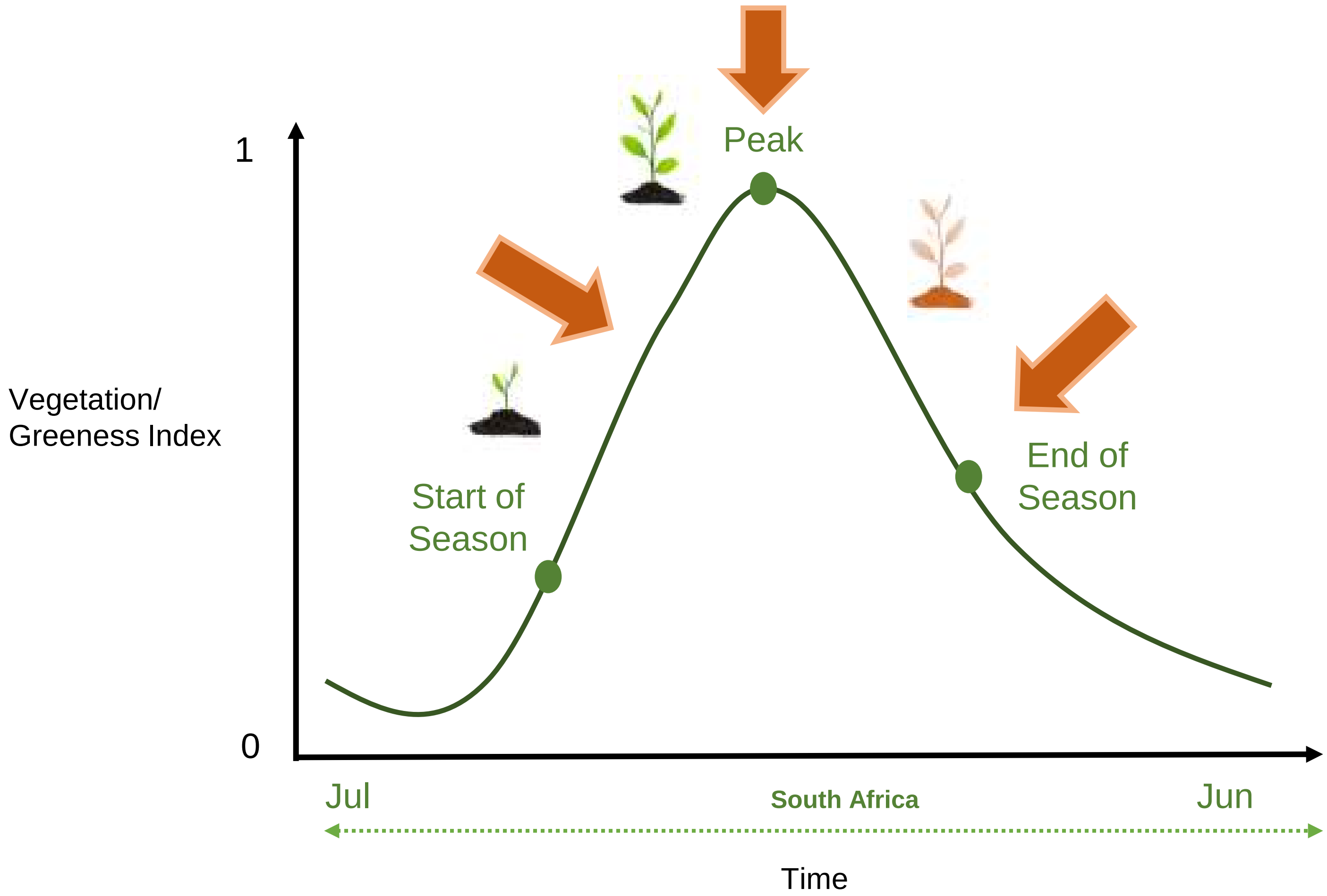


Drought Hazard Severity Classes	Value in final output	VCI Values (weighted over season)
No Drought (D0)	0	>40
Mild Drought (D1)	1	30–40
Moderate Drought (D2)	2	20–30
Severe Drought (D3)	3	10–20
Extreme Drought (D4)	4	<10



Vegetation condition	Value in final output	VCI Values (weighted over season)
Not affected (H0)	0	>40
Damaged (H1)	1	10–40
Destroyed (H2)	2	<10

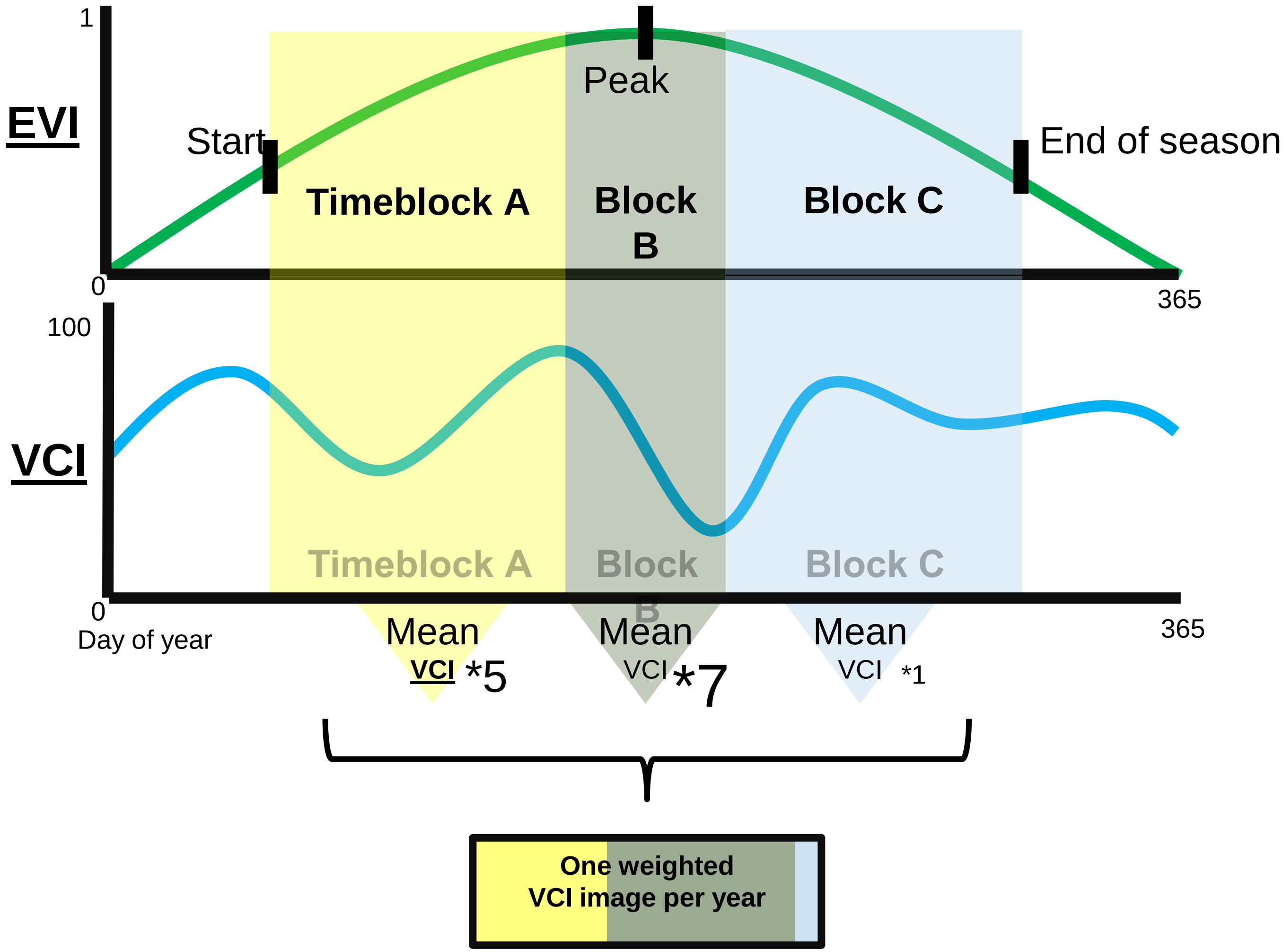
Seasonality Parameters – Vegetation Phenology



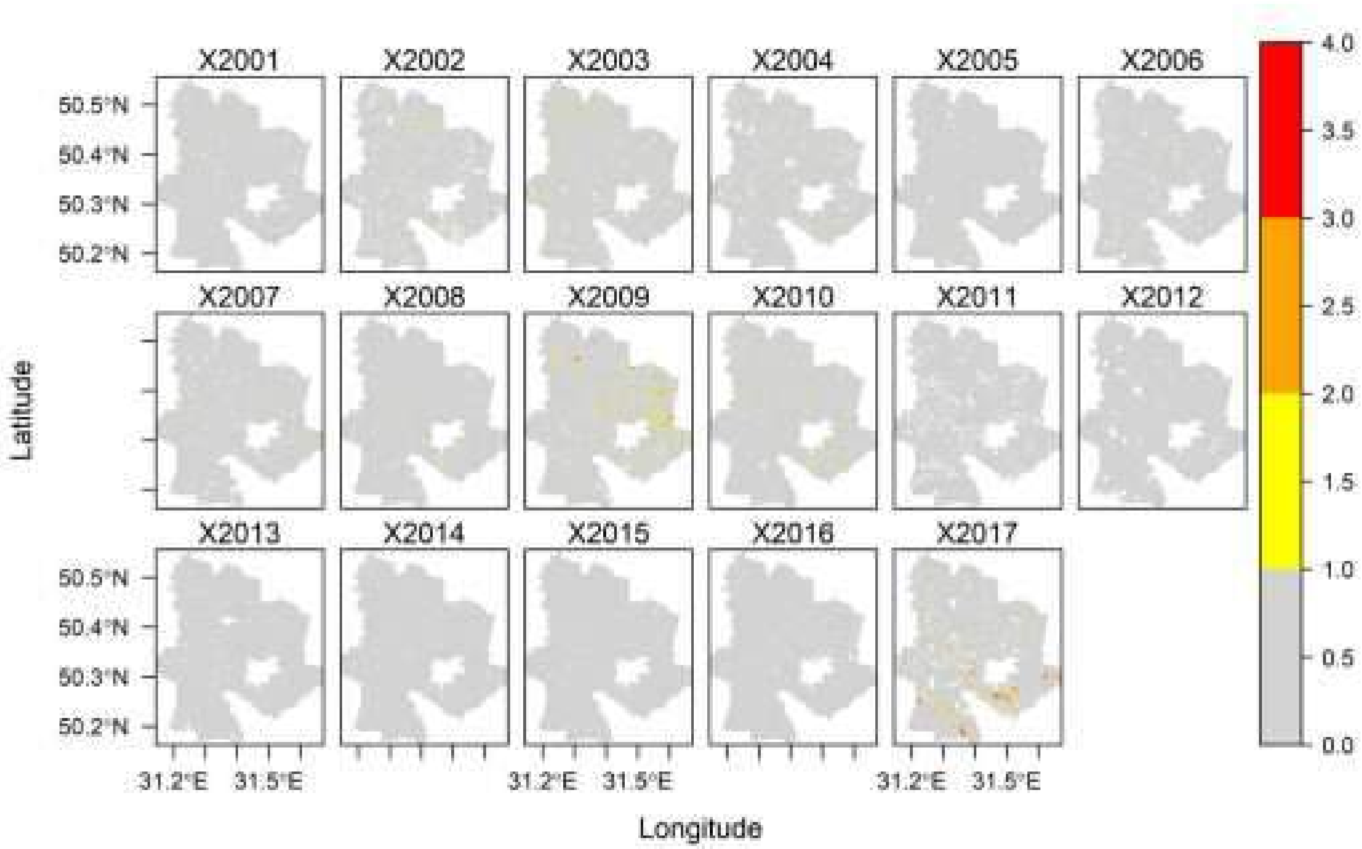
Drought Event

Timing
When does a drought occur?

5. Hazard Approach – Potential



5. Hazard Approach – Preliminary Results



5. Hazard Approach – Strengths and Weaknesses

Strengths

- free and open data
- simple index calculation
- adressing seasonality and allow focus on the growing season
- considering vulnerability stages during the phenological stages
- aiming at more accurate severity detection

Weaknesses

- Validation missing – drought event database
- Phenology detection needs to consider land cover – and has weak detection abilities over some land covers (e.g. Forest)
- Drought characteristics – move away from global approaches but locally applied ones needed

6. Discussion and Outlook

Final stage:

- Finalize Phenology detection and WLC
- Stress detection with actual temperature threshold passing

- Still in need of validation data

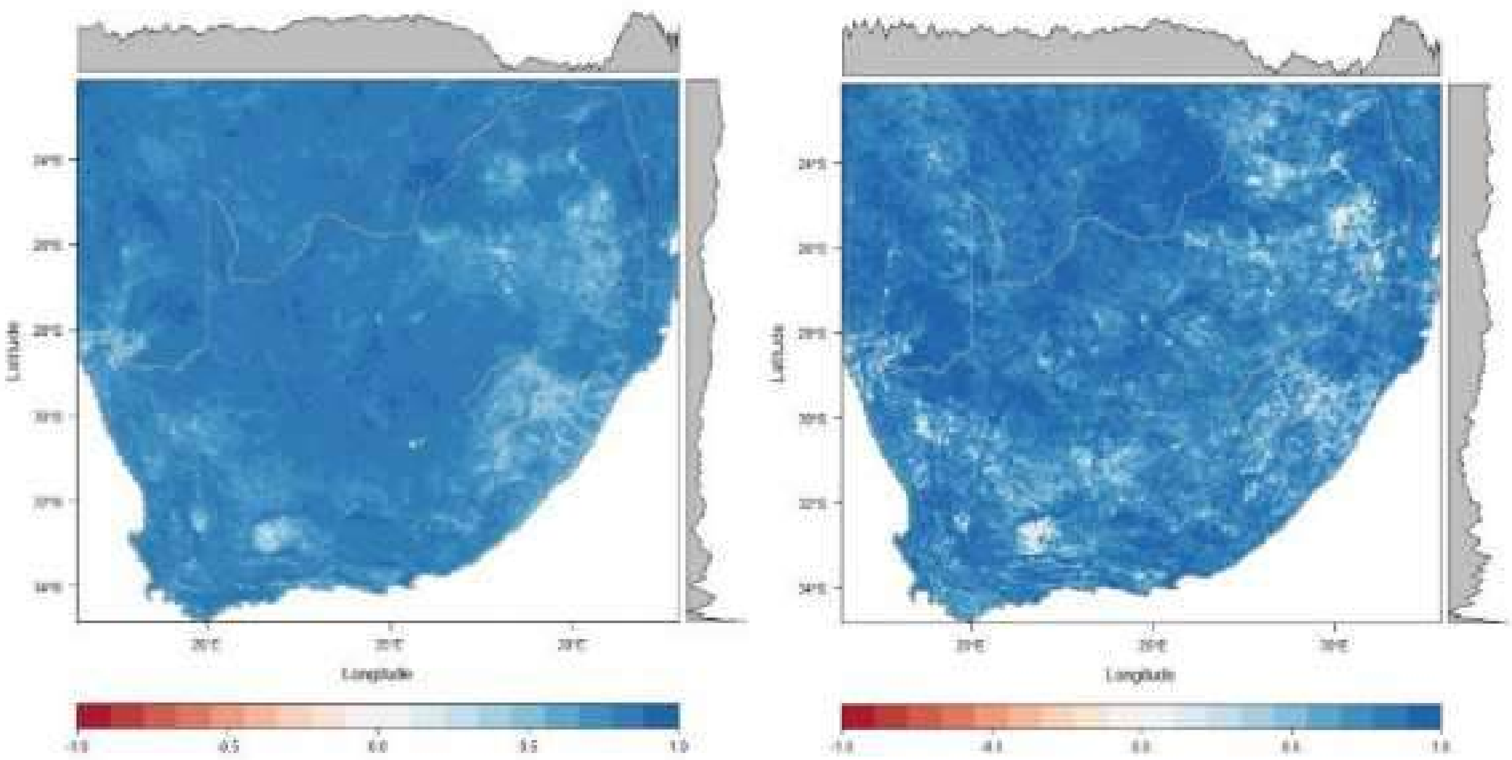
Ongoing

- Drought Monitoring with remote sensing on higher resolution scales (Sentinel 1 and 2 analysis currently under development for integration)
- We continue: ongoing /new project activitiy GlobeDrought
  → more impacts, more understanding, 5 countries
  → development of a drought information system

Thank you very much for your attention!

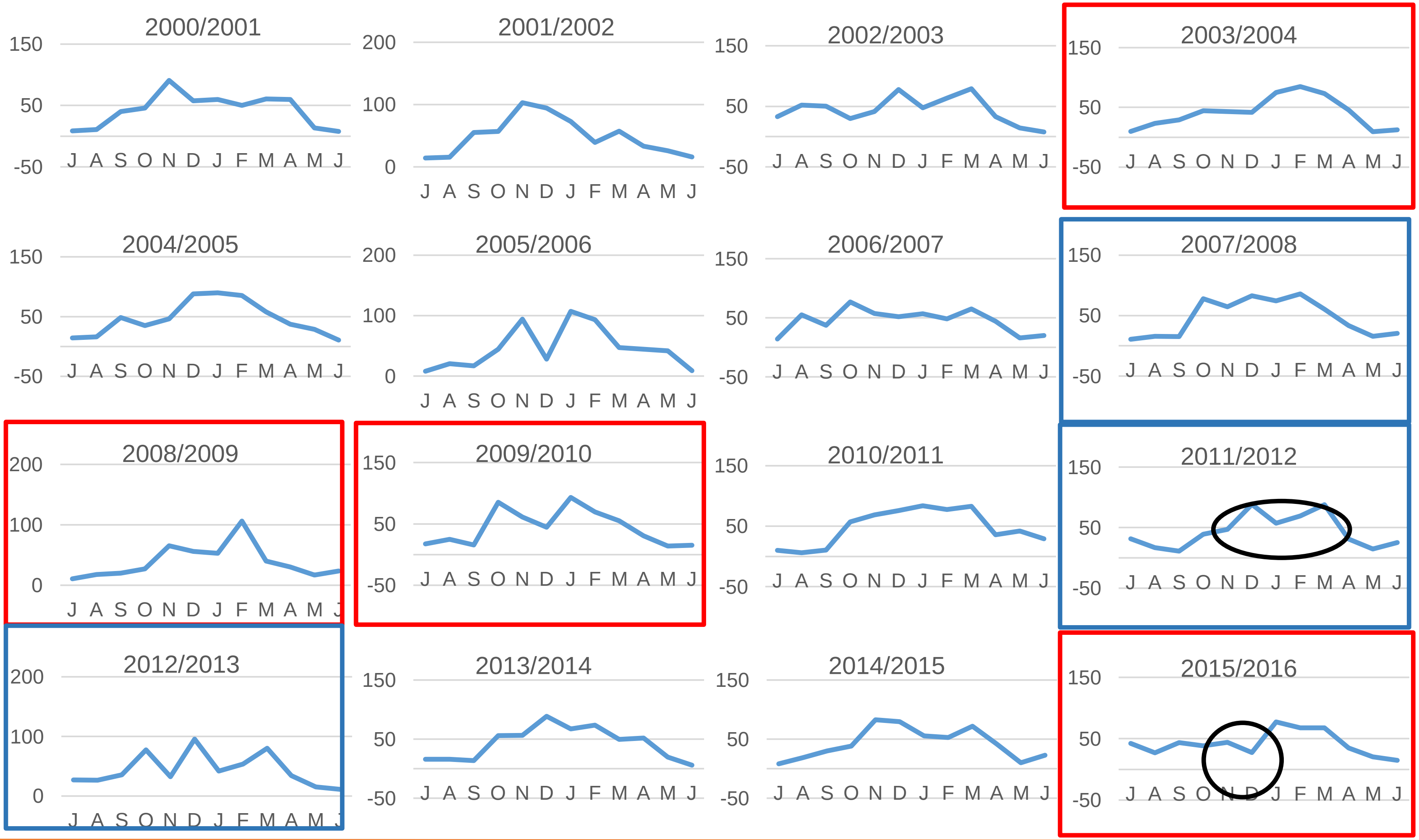
VCI (median) and ∑EVI Anomalies

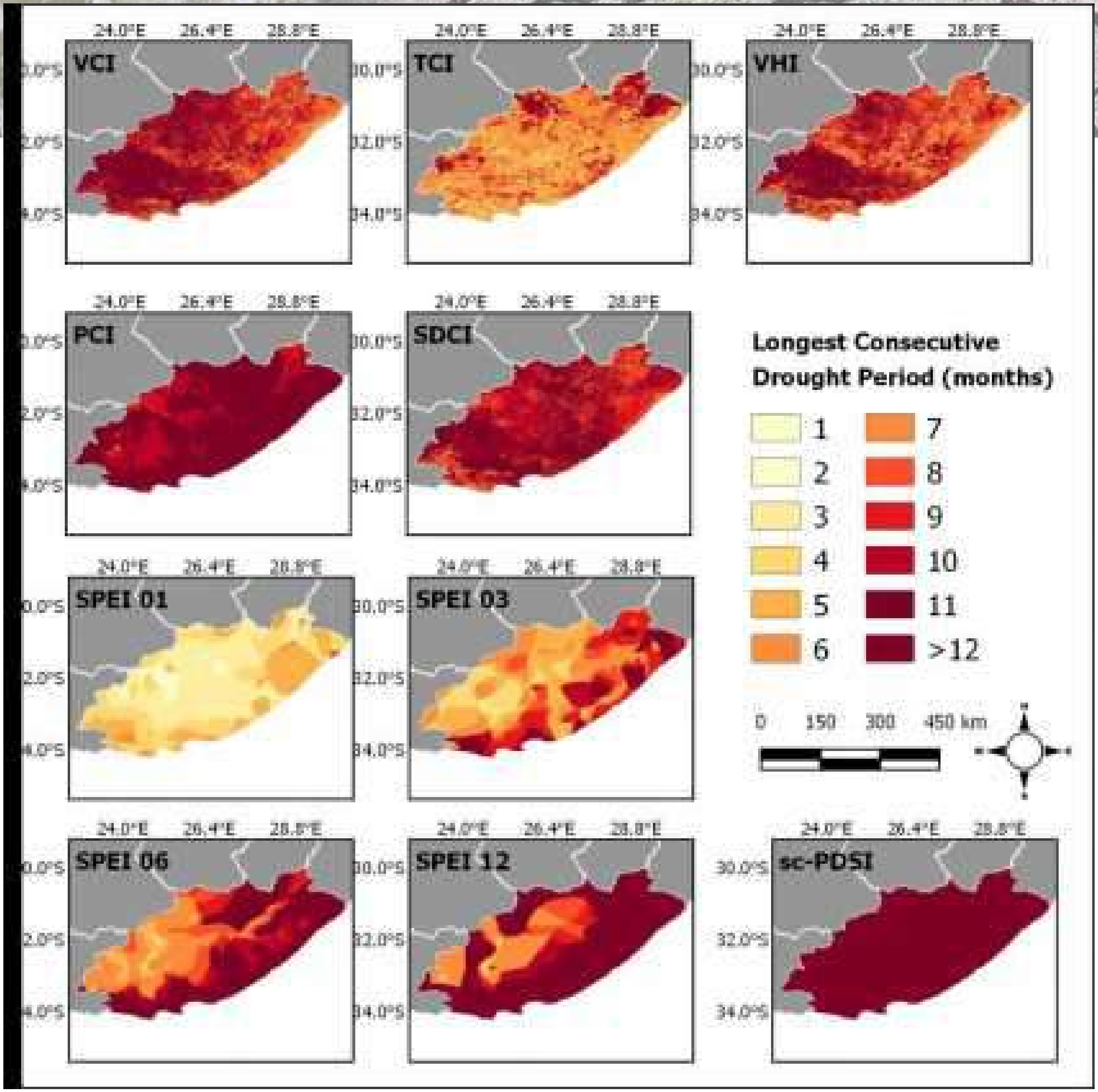
VHI (median) and ∑EVI Anomalies



4. Precipitation Profiles 2000-2016 – example Eastern Cape

Getting a better understanding …





"A project is never truly finished, you simply run out of time" (Peter Jackson)