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Globe Drought

GRoW - GlobeDrought
Characterizing drought risk and impact

Federal Ministry of Education and Research

Detecting Drought and Vegetation Health with Remote Sensing

Olena Dubovyk, Gohar Ghazaryan

With contribution of Javier González, Valerie Graw, Joans Schreier, Johannes Loer and Simon König

AIMS

- Overview of Remote Sensing (RS) data for vegetation monitoring
- Drought hazard, impact and health – case studies
- RS perspective of risk assessment based on parametrization with yield

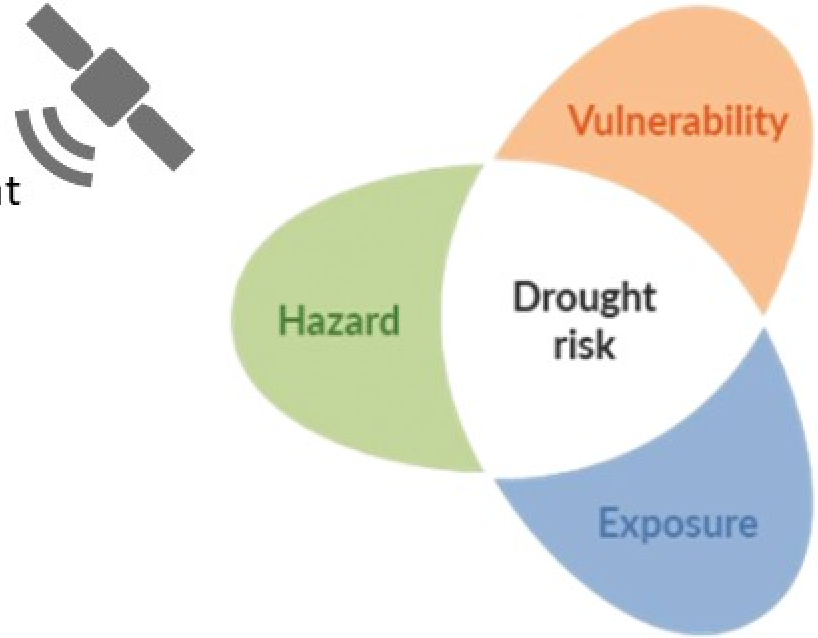
INTRODUCTION

Drought – a global problem

- Droughts affect millions of people and cause significant damages all over the world:
  - Over the **United States**, droughts resulted in over **$200 billion** costs during **1980-2014** (NCDC, 2015)
  - **In Europe,** the damages of droughts over **the last 30 years** are at least **€100 billion** (CEC, 2007)
  - **In North Africa**, the droughts in 2000-2011 brought **about 3 million people** in extreme poverty and wiped out **80–85 % of herd stock** (UN-DESA, 2013)

INTRODUCTION: Terms and concepts

- **Drought events** that may have adverse effects on vulnerable and exposed elements



modified from IPCC, 2014

Impact

Social *Environmental* *Economic*

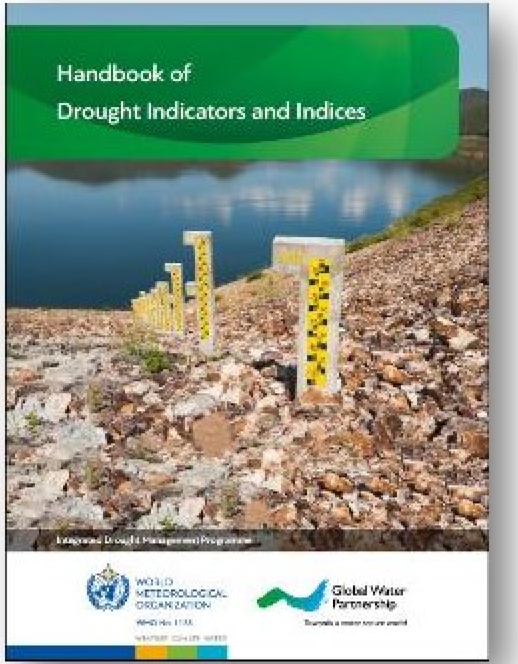
- **Predisposition of exposed elements** to suffer adverse effects when impacted by a drought event

- An **inventory of elements**, such as population, its livelihoods and assets, in an **area** where **drought events** may occur

METHODS: Drought assessment

Drought hazard indicators

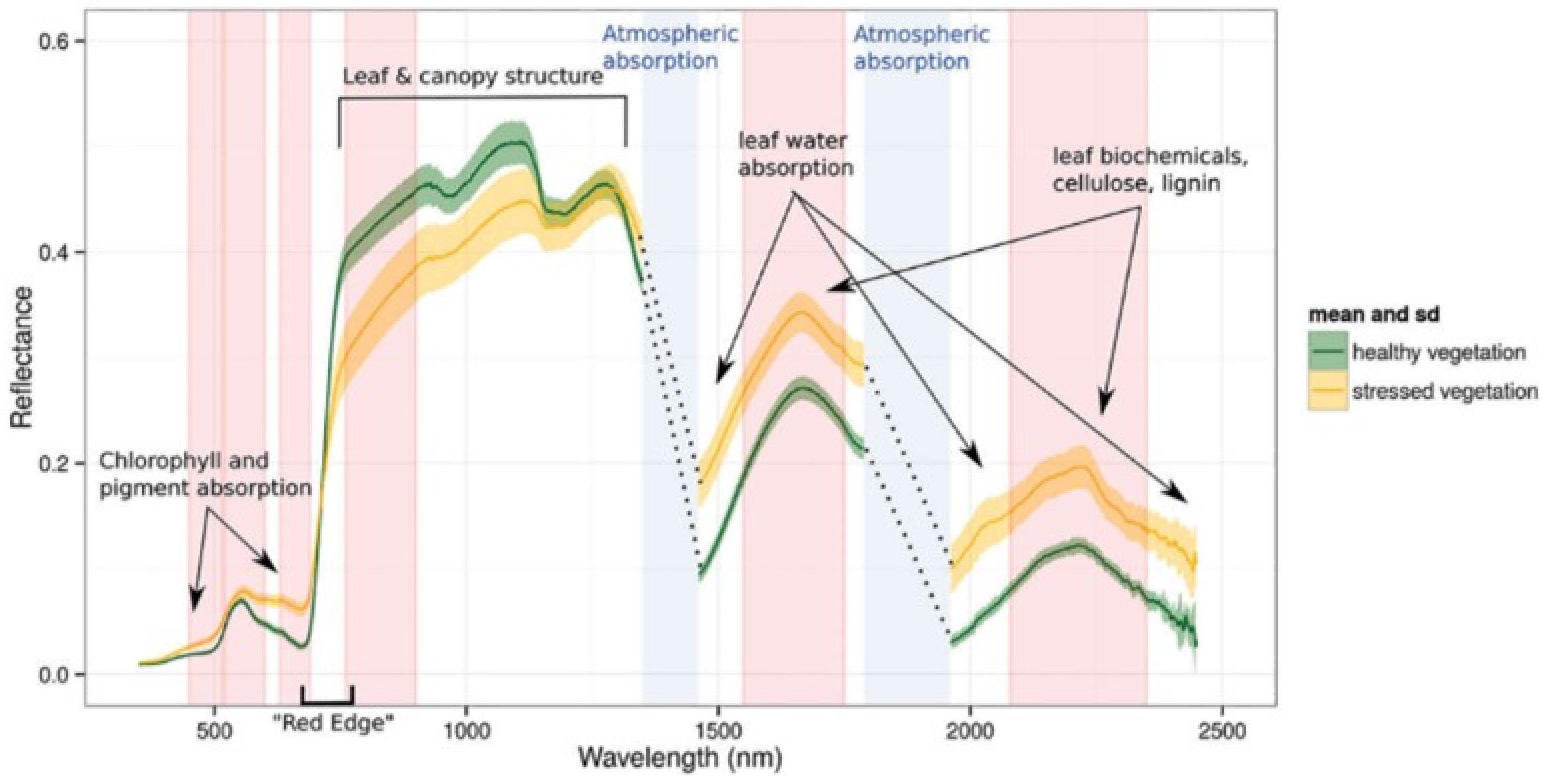
- Drought indicators are used to provide quantitative assessment of the different characteristics of drought events (**severity, location, timing and duration)**
- Categories: (a) meteorology, (b) soil moisture, (c) hydrology, (d) remote sensing and (e) composite or modelled
- Drought hazard assessment is conducted:
  - Using a single indicator
  - Using multiple indicators



WMO (2016)

METHODS

Remote Sensing based vegetation condition monitoring

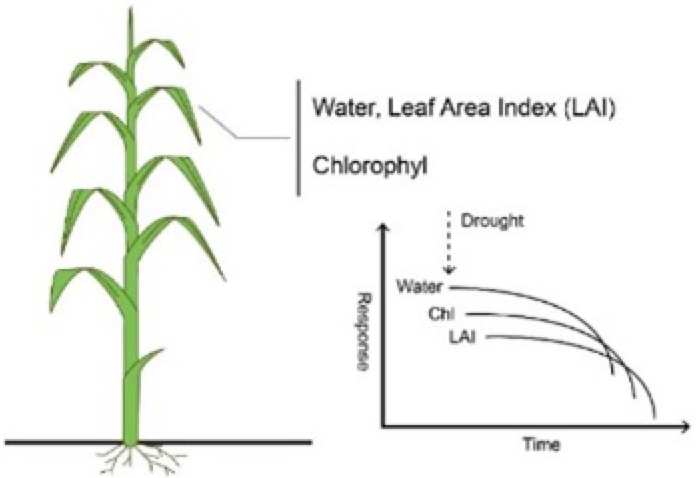


Spectral reflectance of vegetation

Source: Remote Sensing and GIS for Ecologists

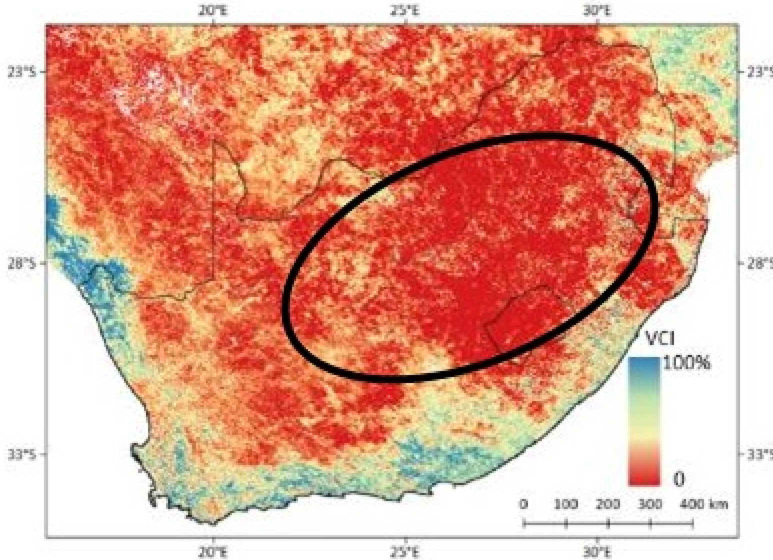
METHODS

Remote Sensing based vegetation condition monitoring



Primary proxies for vegetation stress

Maize in the mid-growing season (March 2007)



Large scale assessment based on Remote sensing (March 2007)

METHODS

Some selection..

Name	Acronym	Inputs
Enhanced Vegetation Index	EVI	Sat
	NDVI	Sat
Soil Adjusted Vegetation Index	SAVI	Sat
Evaporative Stress Index	ESI	Sat +
Water Requirement Satisfaction Index	WRSI	Sat +
Normalized Difference Moisture Index	NDMI	Sat
Combined Drought Indicator	CDI	Sat +
Precipitation Condition index	PCI	Sat +

$$\text{NDVI} = \frac{\text{NIR} - \text{R}}{\text{NIR} + \text{R}}$$

$$\text{Vegetation Condition Index (VCI)} = \frac{\text{EVI} - \text{EVI}_{min}}{\text{EVI}_{max} - \text{EVI}_{min}} * 100$$

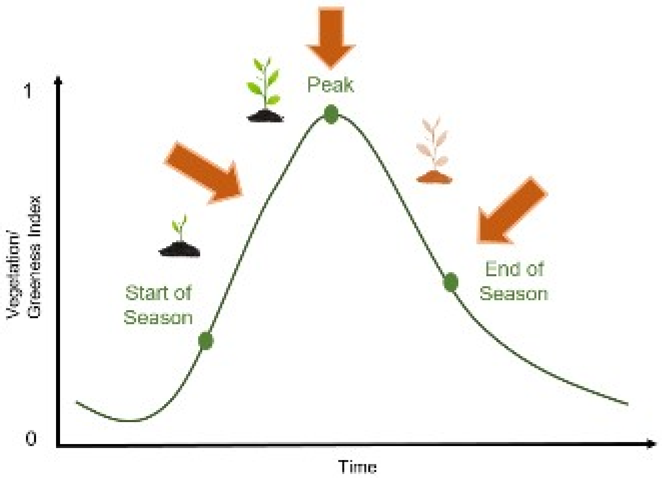
$$\text{ESI} = \text{AET}/\text{PET}$$

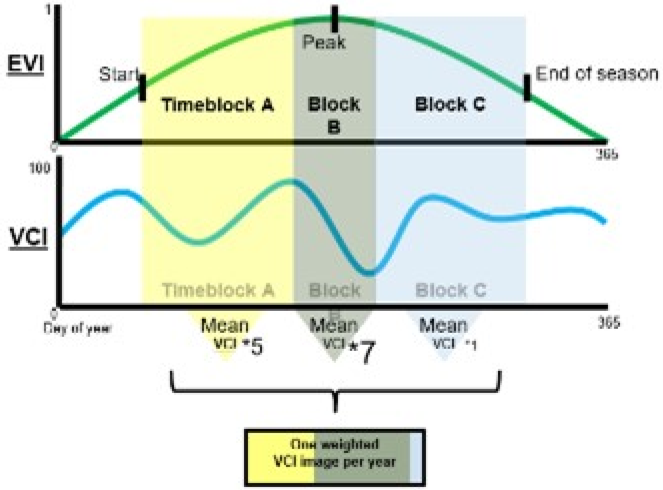
$$\text{NDMI} = \frac{\text{NIR} - \text{SWIR}}{\text{NIR} + \text{SWIR}}$$

$$\text{Temperature Condition Index (TCI)} = \frac{\text{TEMP}_{max} - \text{TEMP}}{\text{TEMP}_{max} - \text{TEMP}_{min}}$$

CASE STUDY 1: South Africa

Drought dynamics and vegetation condition in Eastern Cape

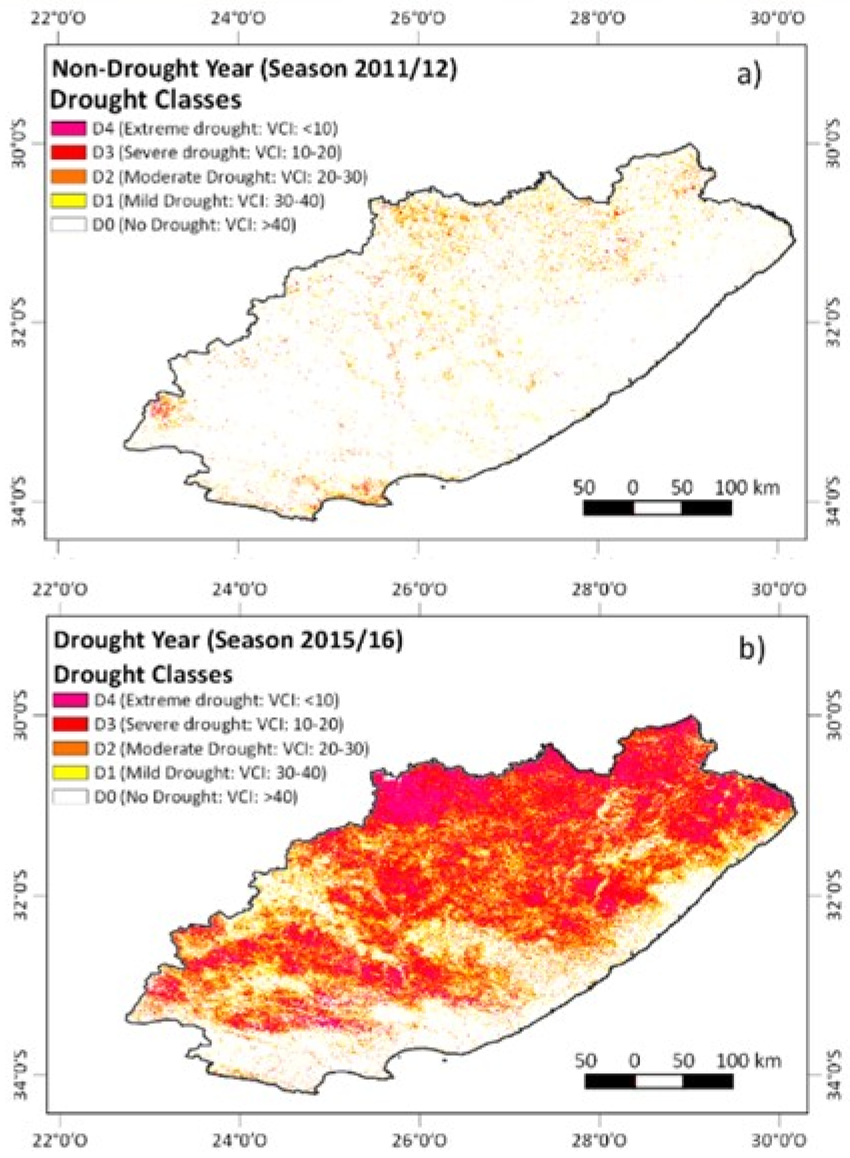




Classification for VCI

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

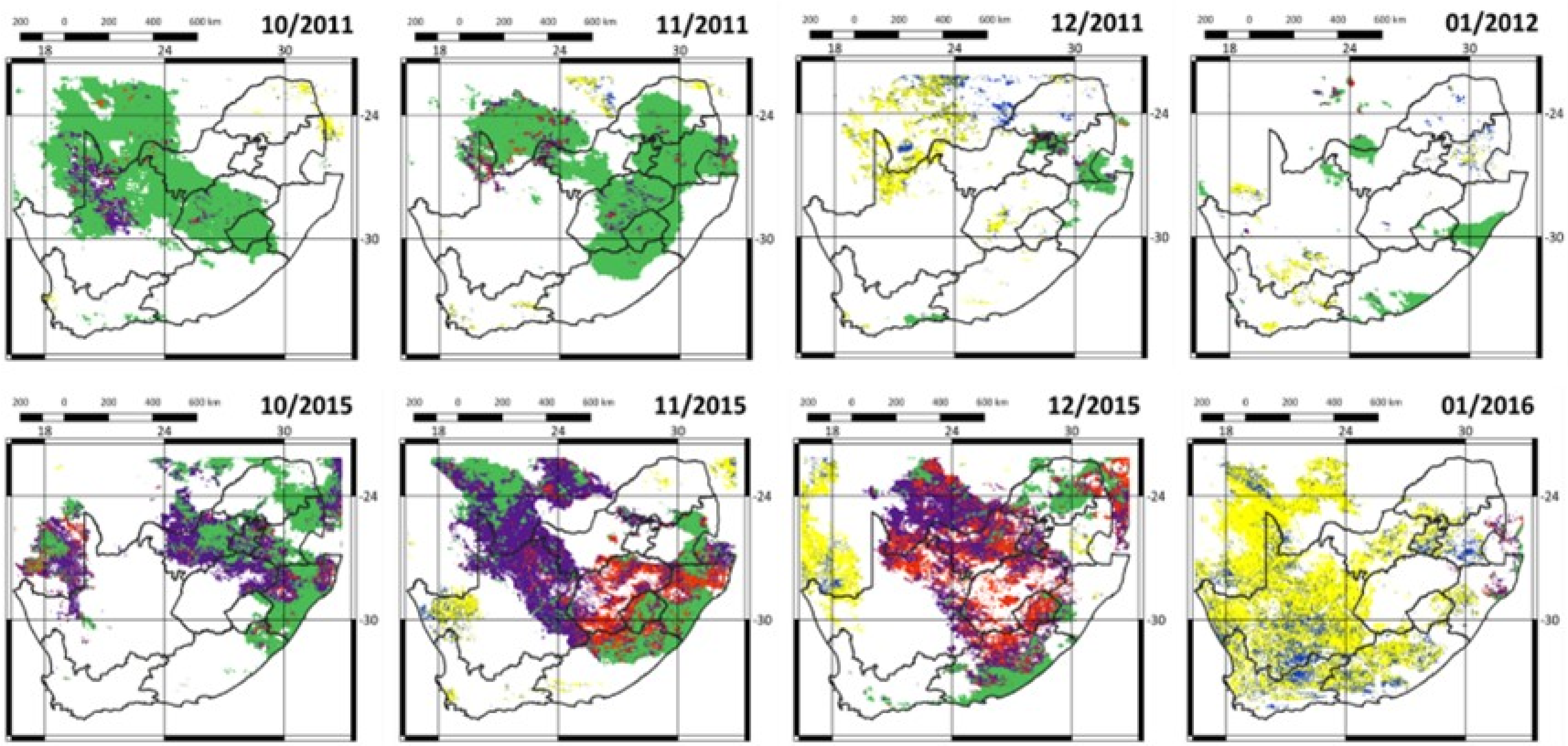
Kogan, 1998



Graw et al 2018, Graw et al, 2020 (In press)

CASE STUDY 1: South Africa

Interplay of different drought indicators



SPI/VCI/TCI overlap

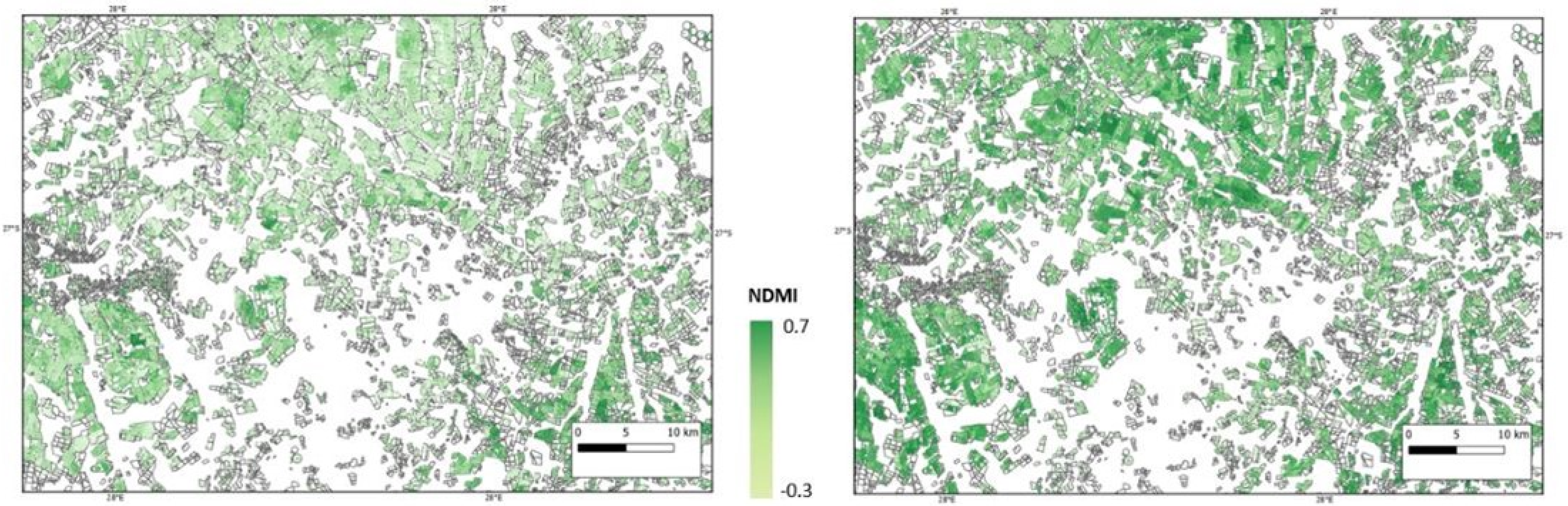
- SPI >0, VCI <30
- SPI <(-1), VCI >30
- SPI <(-1), VCI <30
- SPI >0, VCI <30, TCI <40
- SPI <(-1), VCI <30, TCI <40
- (None of the above)

General limitation for drought indices usage: Validation!

CASE STUDY 1: South Africa

Finer resolution analysis based on Landsat-8

- Growing Season maximum NDMI (November-May)

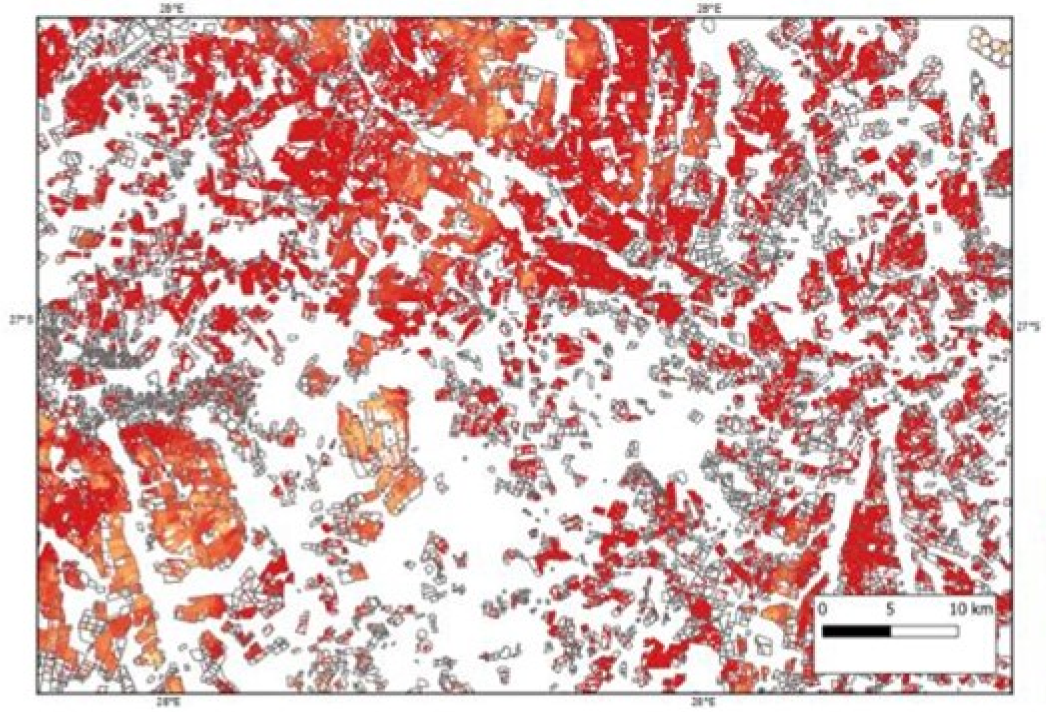


2015-16 **2017-18**

CASE STUDY 1: South Africa

Finer resolution analysis based on Landsat-8

- Land Surfance Temperature



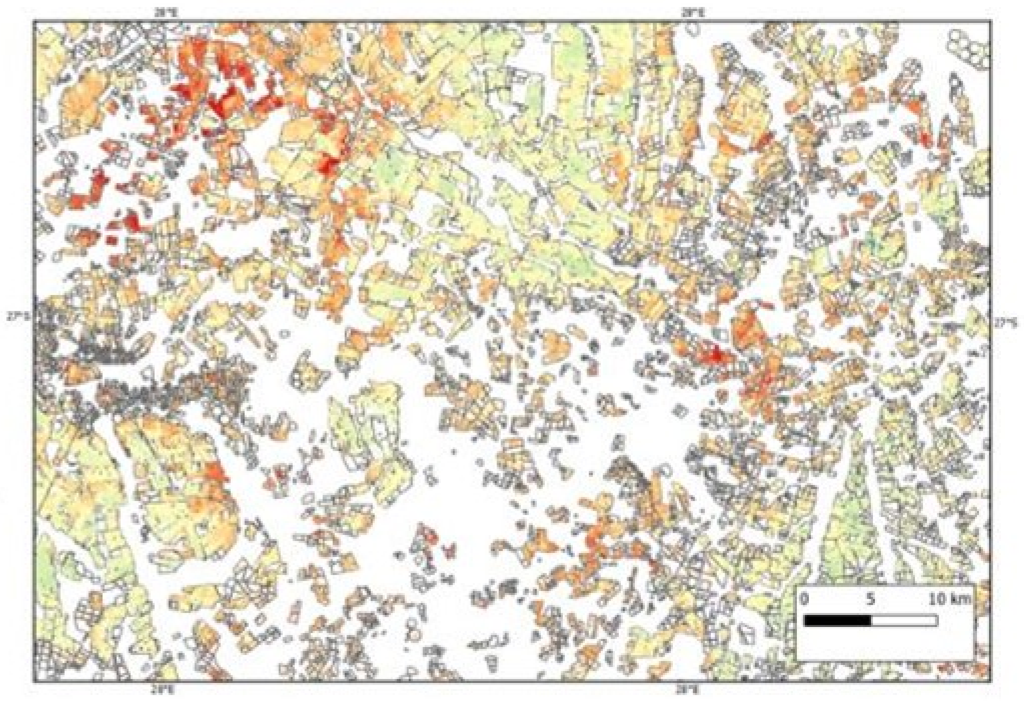
LST °C

>34

29

24

20



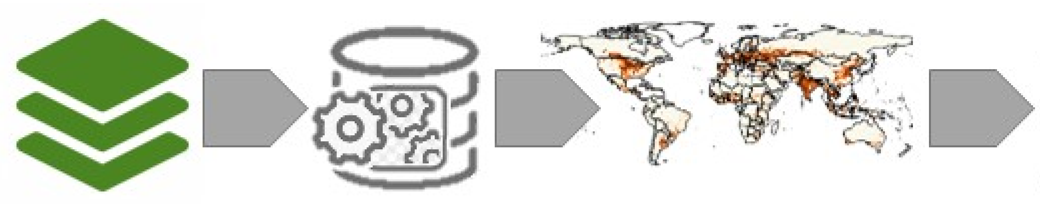
2016, February

2018, February

CASE STUDY 2: Global analysis

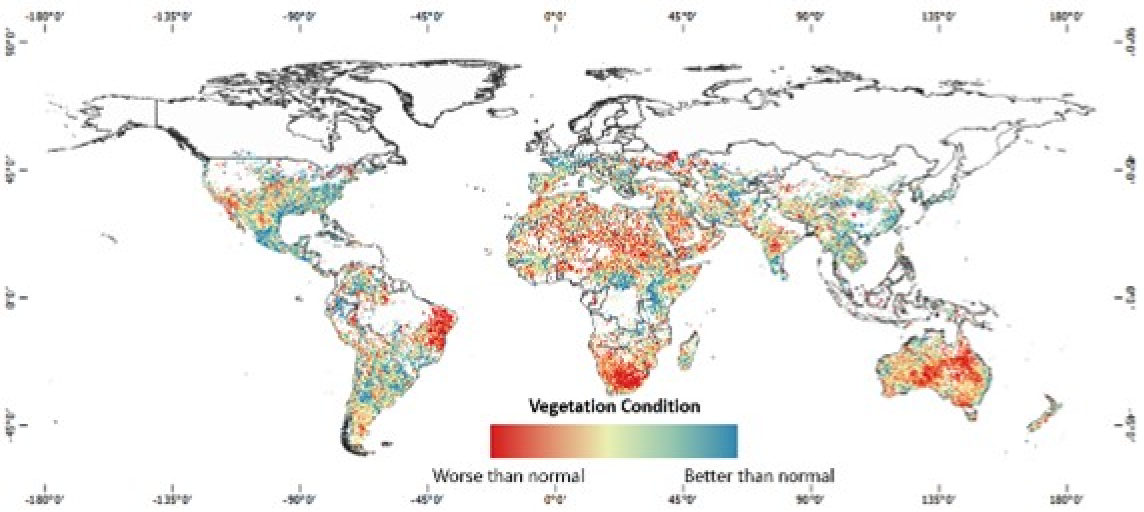
Drought impact on agricultural systems

Time series | **Preprocessing** | **Cropland mask**



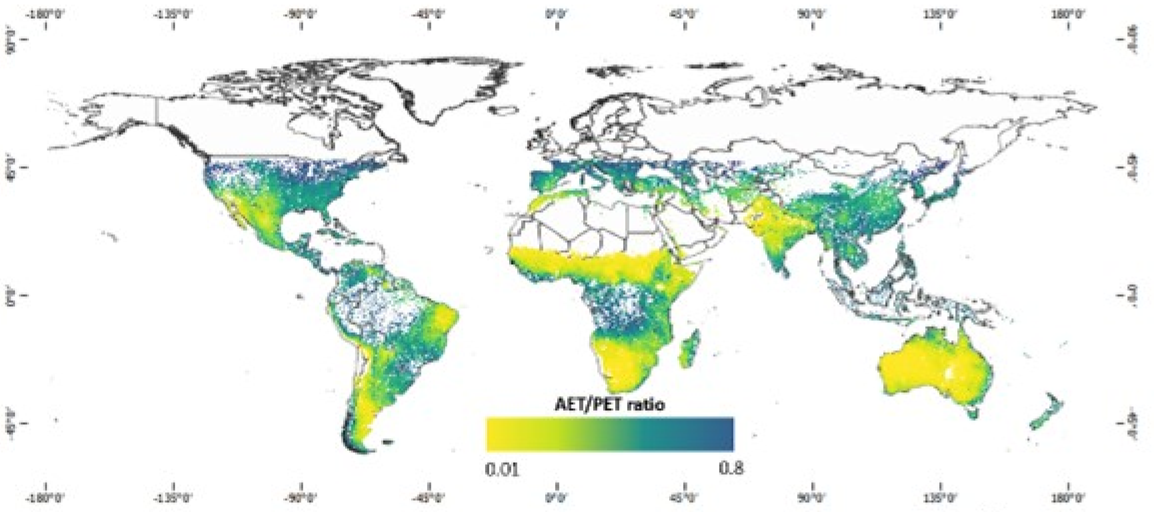
Time series analysis

- Anomalies
- VCI
- AET/PET



Highlights (2015, December):

- Unfavorable conditions in South Africa, including the maize growing area.
- Some missing information, because of cloud cover (e.g. Northern regions).



CASE STUDY 2: Global analysis

Drought impact on agricultural systems

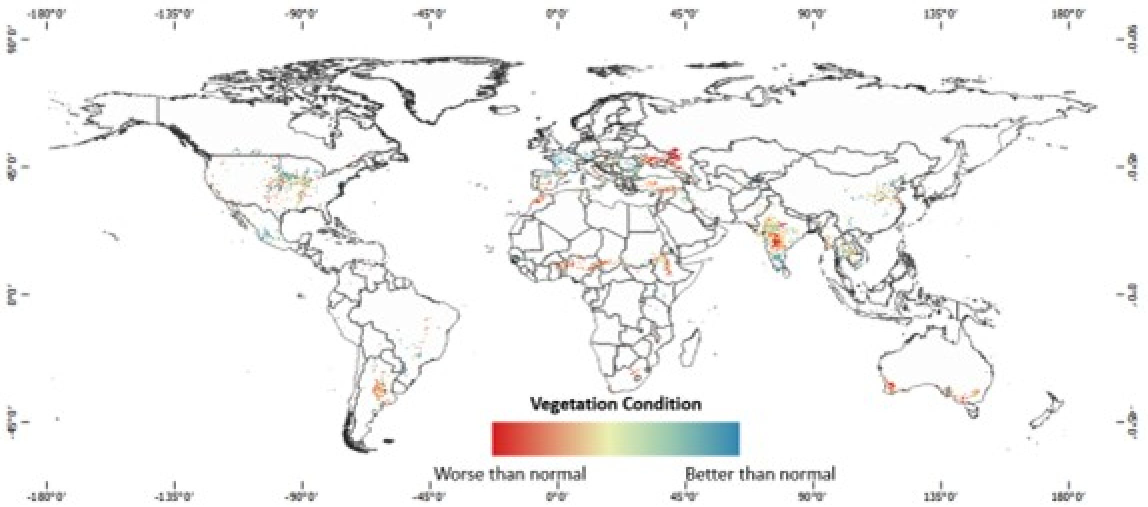
Time series

Preprocessing

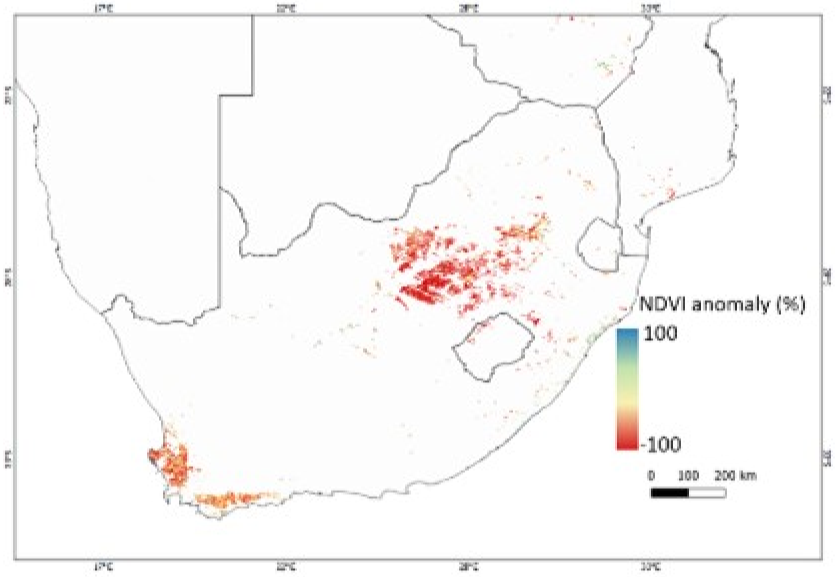
Cropland mask

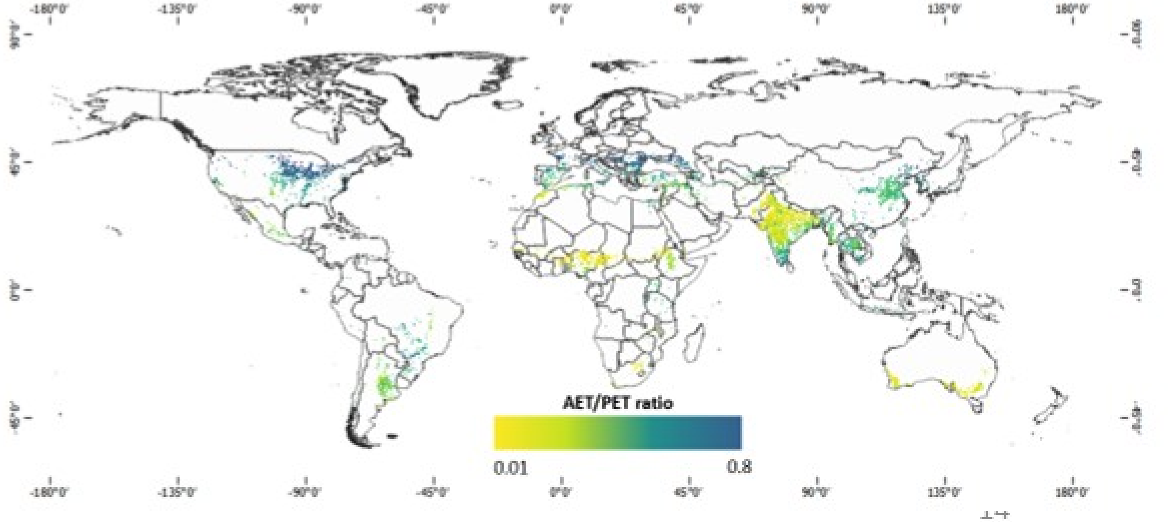
Time series analysis

- Anomalies
- VCI
- AET/PET



2015, December

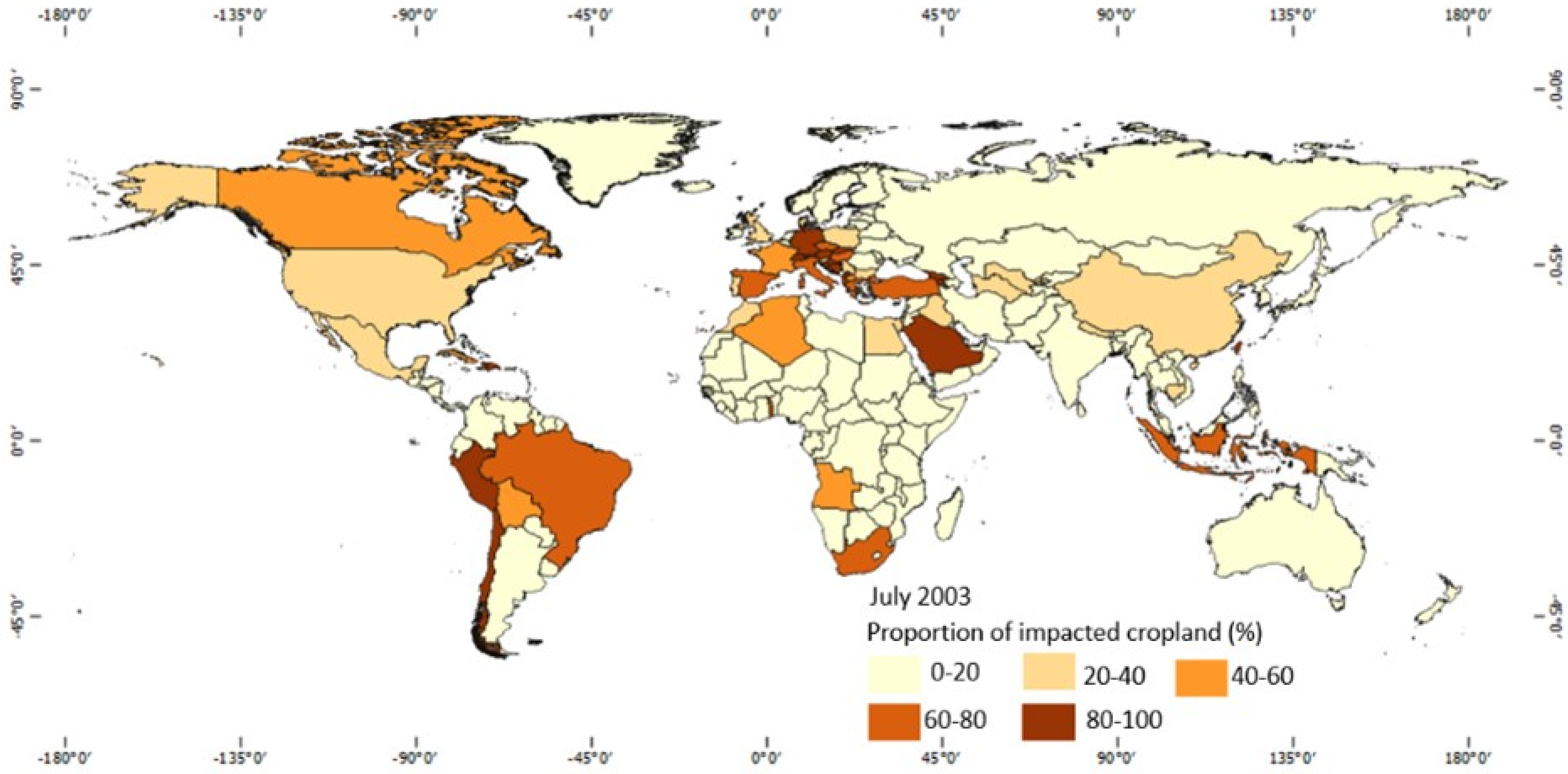




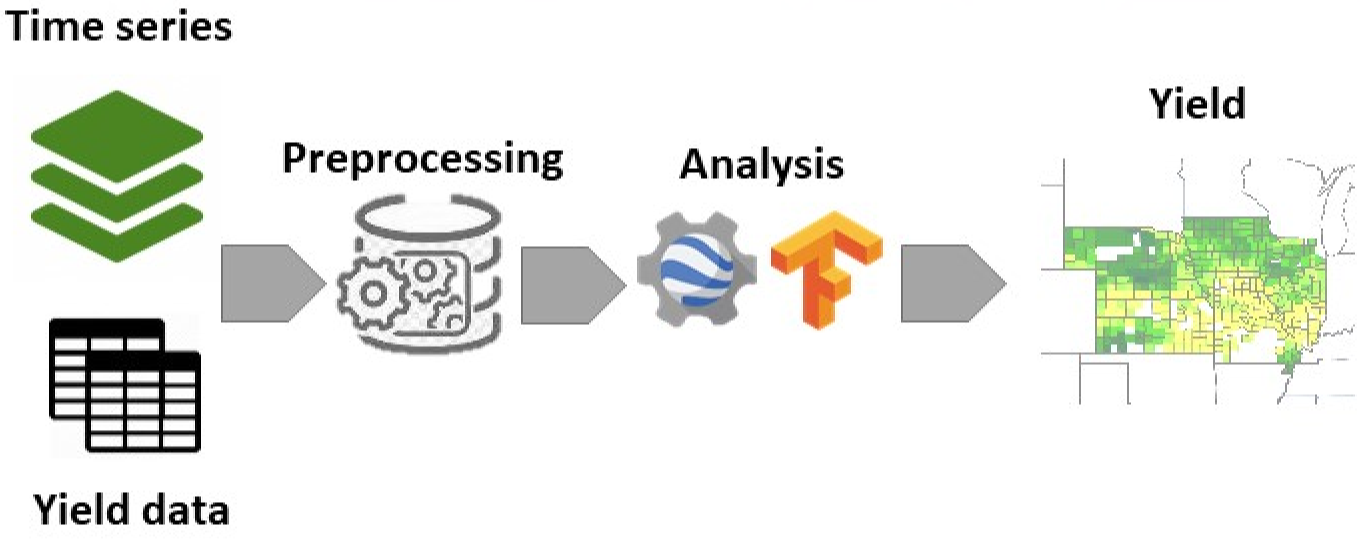
CASE STUDY 2: Global analysis

Drought impact on agricultural systems

Reference period: 2001-2018 – aggregate over the country



CASE STUDY 3: Yield estimation

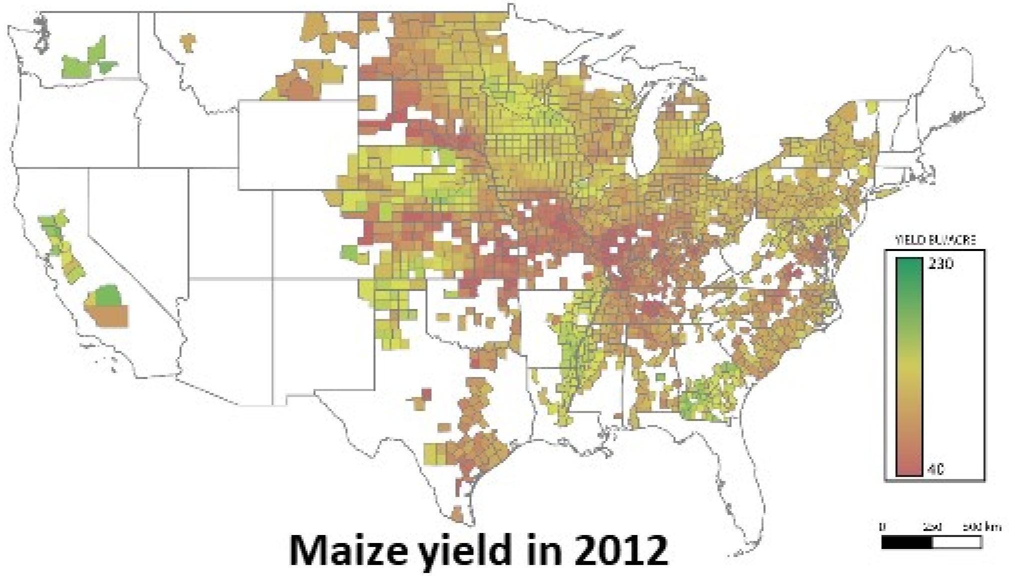


Remote Sensing based input

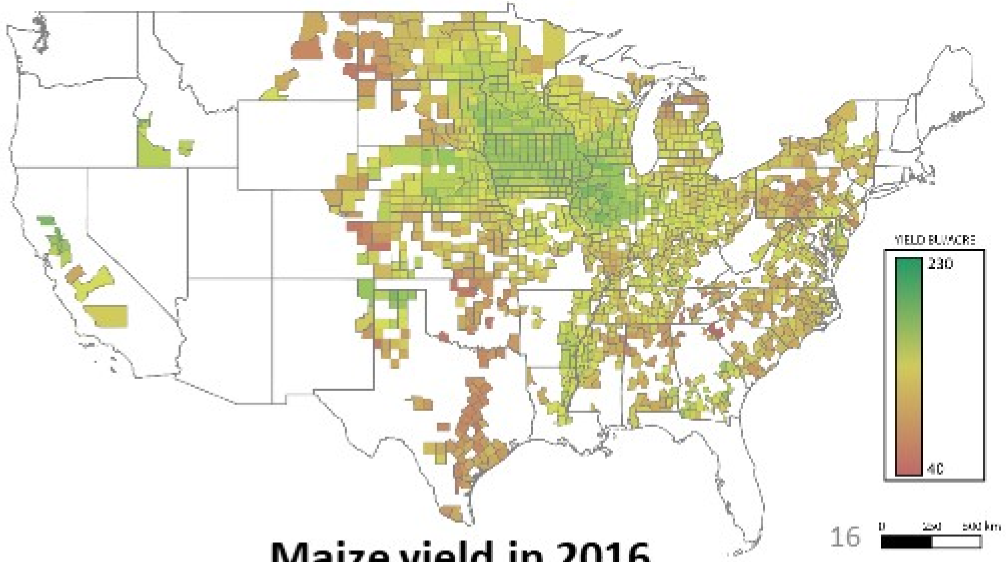
- MODIS 8-Day 500m surface reflectance (MOD09A1)
- MODIS 8-Day 1km Land Surface Temperature (MOD11A1)
- MODIS 8-Day 500m Evapotranspiration (ET) (MOD16A2)

Methods

- Convolutional neural network (CNN)
- CNN followed by long-short term memory (LSTM)



Maize yield in 2012



Maize yield in 2016

Ghazaryan et al, in prep.

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THANK YOU

We thank BMBF for funding the GlobeDrought (grant no. 02WGR1457F)

odubovyk, gghazary @uni-bonn.de

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