Workshop on Land Productivity Indicators for Drylands

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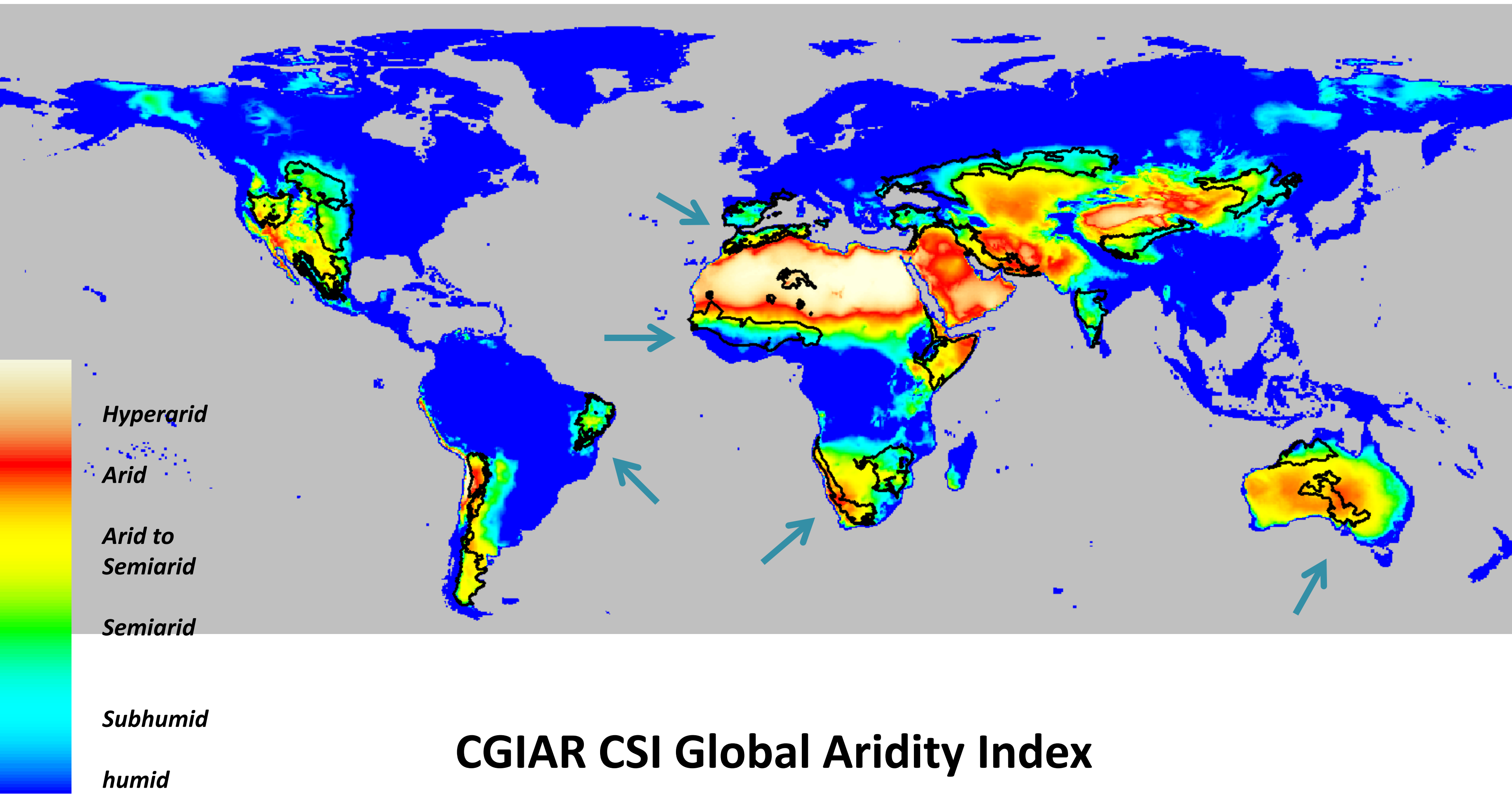
Presentation Overview

1. Dryland testsites
2. Technical production environment at Brockmann Consult and GeoVille
3. Earth Observation data used
4. Applied methods
5. EO time series data issues
6. First order products
7. Preliminary booklets , downloads

diversity drylands

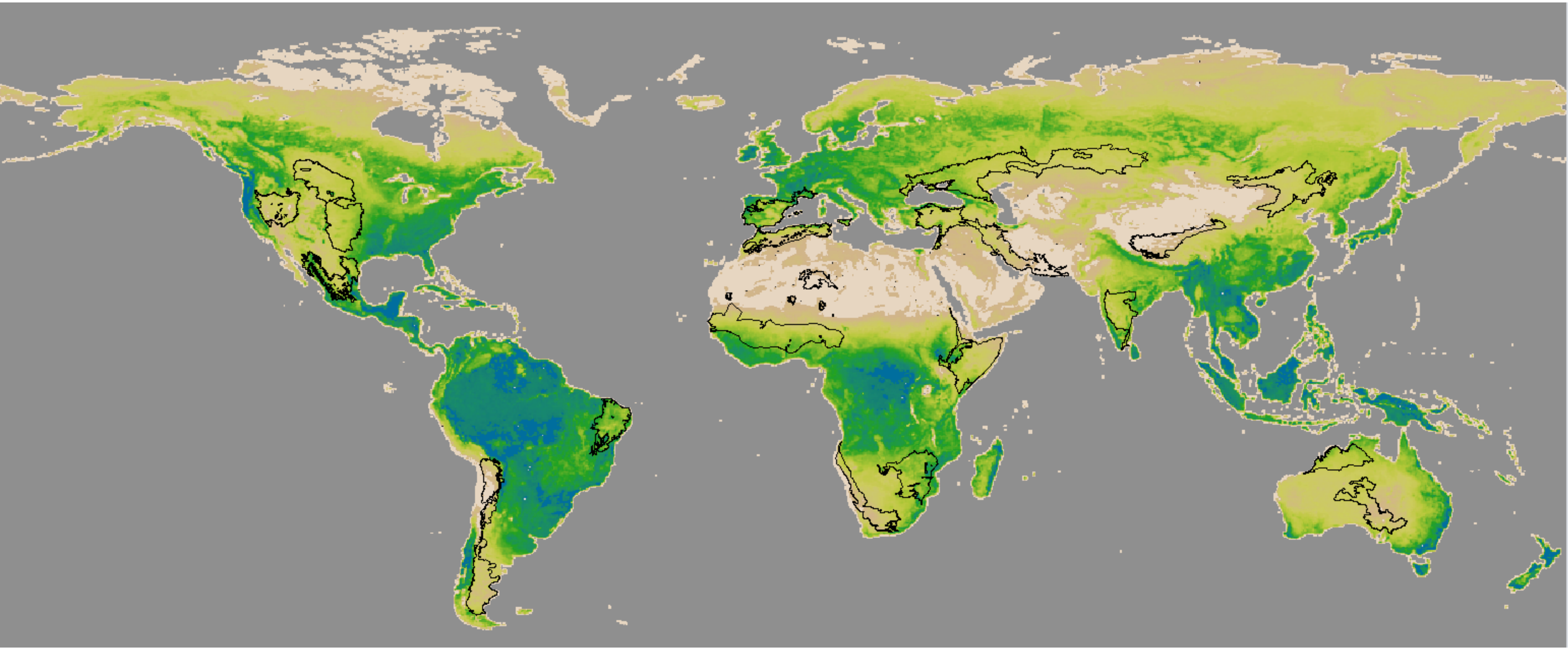
diversity inland waters

Distribution of the 23 testsites



CGIAR CSI Global Aridity Index

GIMMS NDVI Average Vegetation Year 1982 - 2010



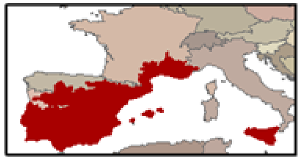
Properties of the five validation sites

Nr	Dryland geographical area (WWF ecoregion no.)	Size Country	Aridity Index WWF Info	Diversity Hotspot (Global 2000)	Other criteria
10	S-Europe: Iberian conifer forests, Northeastern Spain and Southern France Mediterranean forests (PA1208), Iberian sclerophyllous and semi-deciduous forests (PA1209), Southwest Iberian Mediterranean sclerophyllous and mixed forests (PA1221), Northwest Iberian montane forests (PA1216), Tyrrhenian-Adriatic Sclerophyllous and mixed forests (PA1222), South Appenine mixed montane forests (PA1218), Southeastern Iberian shrubs and woodlands (PA1219)	524.698 km^2 Portugal, Spain, France, Italy	AI 0,21 – 1,78 Mediterranean forests, woodlands, and shrub	Part of Mediterranean Forests, Woodlands and Scrub (G200_NUM 123)	Area contains two Centres of Plant Diversity and Transboundary Protected Areas WRI Major Watersheds: Parts of Rhone, Garonne, Ebro, Douro-Duero, Tagus, Guadiana and Guadalquivir

Cabo de Gata Natural Park, Andalusia, Spain. @ C.Michael Hogan

http://www.eoearth.org/view/article/156156/

Southeastern Spain. Source: Pedro Regato / WWF MedPO)



Coto Dorana National Park, Spain. (Photograph by WWF-Canon / Michel Gunther)

http://en.wikipedia.org/wiki/Portugal

Properties of the five validation sites

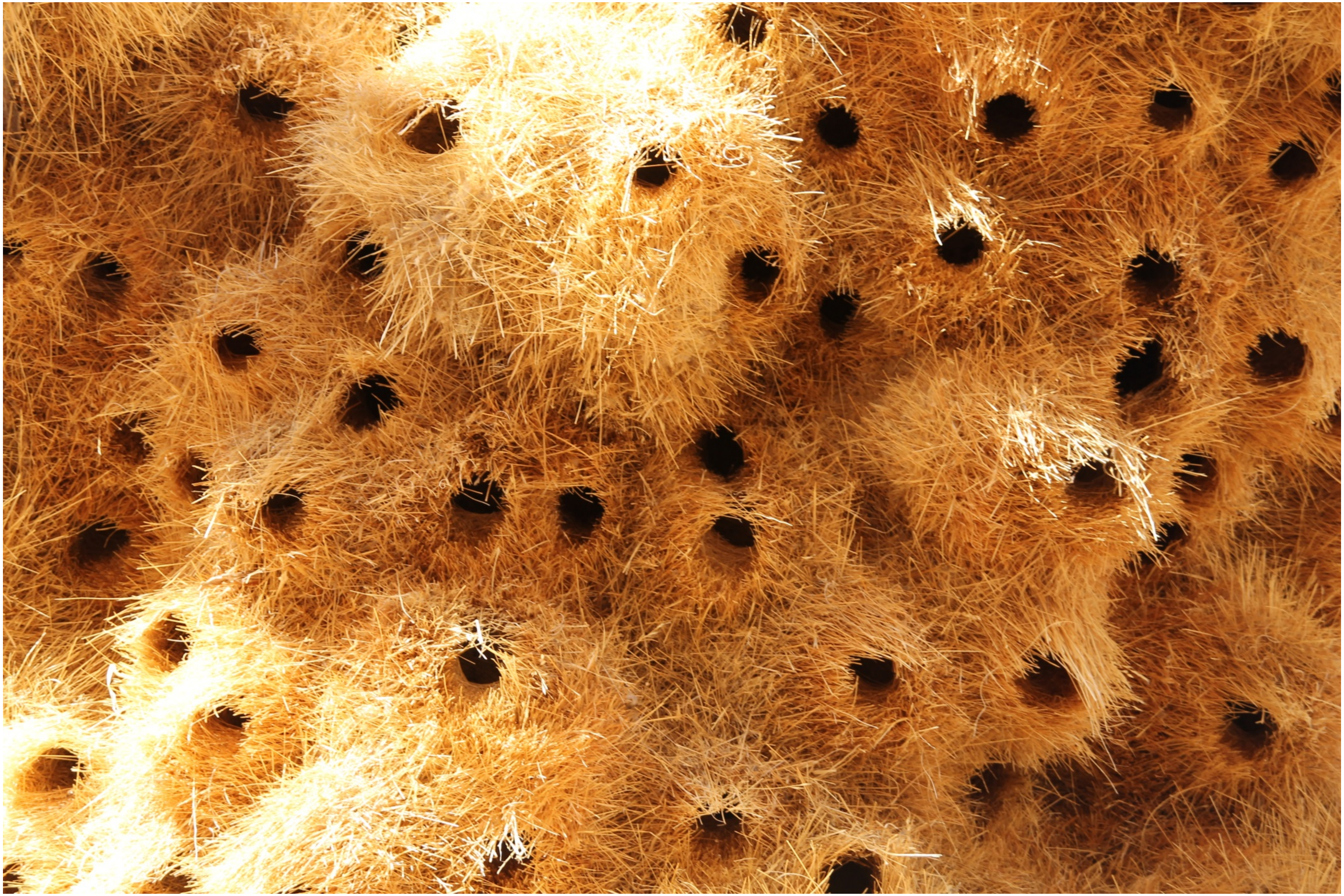
Nr	Dryland geographical area (WWF ecoregion no.)	Size / Country	Aridity Index / WWF Info	Diversity Hotspot (Global 2000)	Other criteria
12	S-Africa: Namibian savanna woodlands (AT1316), Nama Karoo (AT1314)	576.085 km^2 Angola, Namibia, South Africa	AI 0,02 – 0,58 Deserts and xeric shrublands	Biodiversity Hotspot (**The Succulent Karoo**, one of only two hotspots that are entirely arid (the other being the newly recognized Horn of Africa)	Part of Namib-Karoo-Kaokoveld Deserts and Shrublands (G200_NUM 124)

Large Euphorbia and other succulent Karoo, Lapalala River basin. @ C.Michael Hogan

http://www.miningsafety.co.za/newscontent/154/Succulent-Karoo-biome,-ecological-hotspot-at-risk

Weaver birds in Namibia

Weaver bird nest holes in Namibia

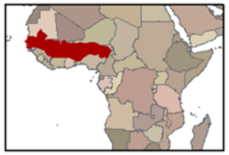


Properties of the five validation sites

Nr	Dryland geographical area (WWF ecoregion no.)	Size / Country	Aridity Index / WWF Info	Diversity Hotspot (Global 2000)	Other criteria
13	West Sudanian savannah (AT0722)	1.641.911 km² Senegal, Mali, Guinea, Cote d'Ivoire, Ghana, Burkina Faso, Togo, Benin, Niger, Nigeria	AI 0,17 – 1,08 Tropical and subtropical grasslands, savannas, and shrublands	No hotspot, but the entire Sudanian area has e.g. more than 1000 endemic plants. The total area of protected lands is over 90,000 km² (6.7 %)	Part of the Sudanian regional center of endemism

http://www.fredhoogervorst.com/photo/02436/

http://savannaenvironment.files.wordpress.com/2008/04/acacia.jpg



http://www.connect4climate.org/blog/terrafrica-as-part-of-the-solutions

Properties of the five validation sites

Nr	Dryland geographical area (WWF ecoregion no.)	Size Country	Aridity Index WWF Info	Diversity Hotspot (Global 2000)	Other criteria
15	Caatinga (NT1304)	718.135 km² Brazil	AI 0,2 – 1,03 Deserts and xeric shrublands	No hotspot, but: Caatinga is unique to Brazil yet only 1% of its habitats are protected; Several ongoing protection activities	Most populated semi-arid region in the world

http://www.nature.org/ourinitiatives/regions/southamerica/brazil/placesweprotect/caatinga.xml

Village of Aprazível, in the state of Ceará, in a photo by Deltafrut/Otávio Nogueira/Flickr

http://deepbrazil.com/2012/11/11/worst-drought-in-50-years-in-the-northeast-of-brazil/

Properties of the five validation sites

Nr	Dryland geographical area (WWF ecoregion no.)	Size Country	Aridity Index WWF Info	Diversity Hotspot (Global 2000)	Other criteria
20	Australien: Tirari-Sturt stony desert (AA1309), Central Ranges xeric scrub (AA1302)	660.019 km² Australia	AI 0,06 – 0,24 Deserts and xeric shrublands	Part of Great Sandy-Tanami-Central Ranges Desert (G200_NUM 129)	Area contains a Centre of Plant Diversity and Protected Areas WRI Major Watersheds: Part of Murray-Darling


Near Coober Peddy, South Australia Photograph by Gerhard Ortner


Coober Pedy, Australia. Photograph by Dr. Tim Berra


The Australian bustard. Source: Glen Fergus

http://www.eoearth.org/view/article/177278/

Dryland Processing Components:
Hardware and Processing Infrastructure

GeoVille infrastructure for Dryland Processing:

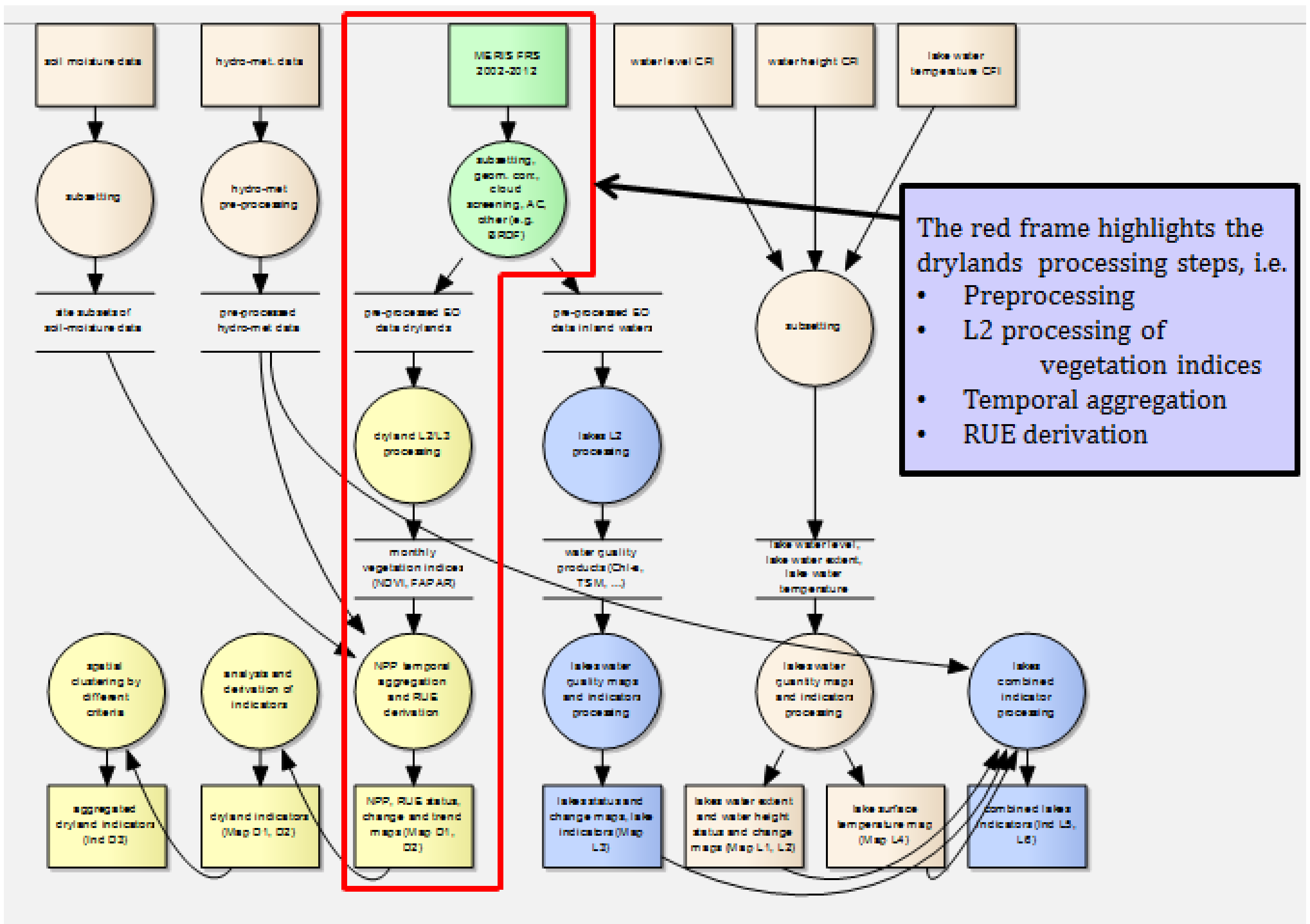
- Storage capacity of data servers currently ca. 45 TB
- Ca. 20 workstations (with 4 + 1 ERDAS licenses) equipped with
  - Xeon processors (quad-core)
  - Up to 16 GB RAM
  - Up to 3 TB local storage (including some SSD)
  - nVidia graphics cards
- Network with 1 GBit/sec for fast internal data exchange
- Fiber optic Internet with 30 GBit/sec for rapid external data exchange

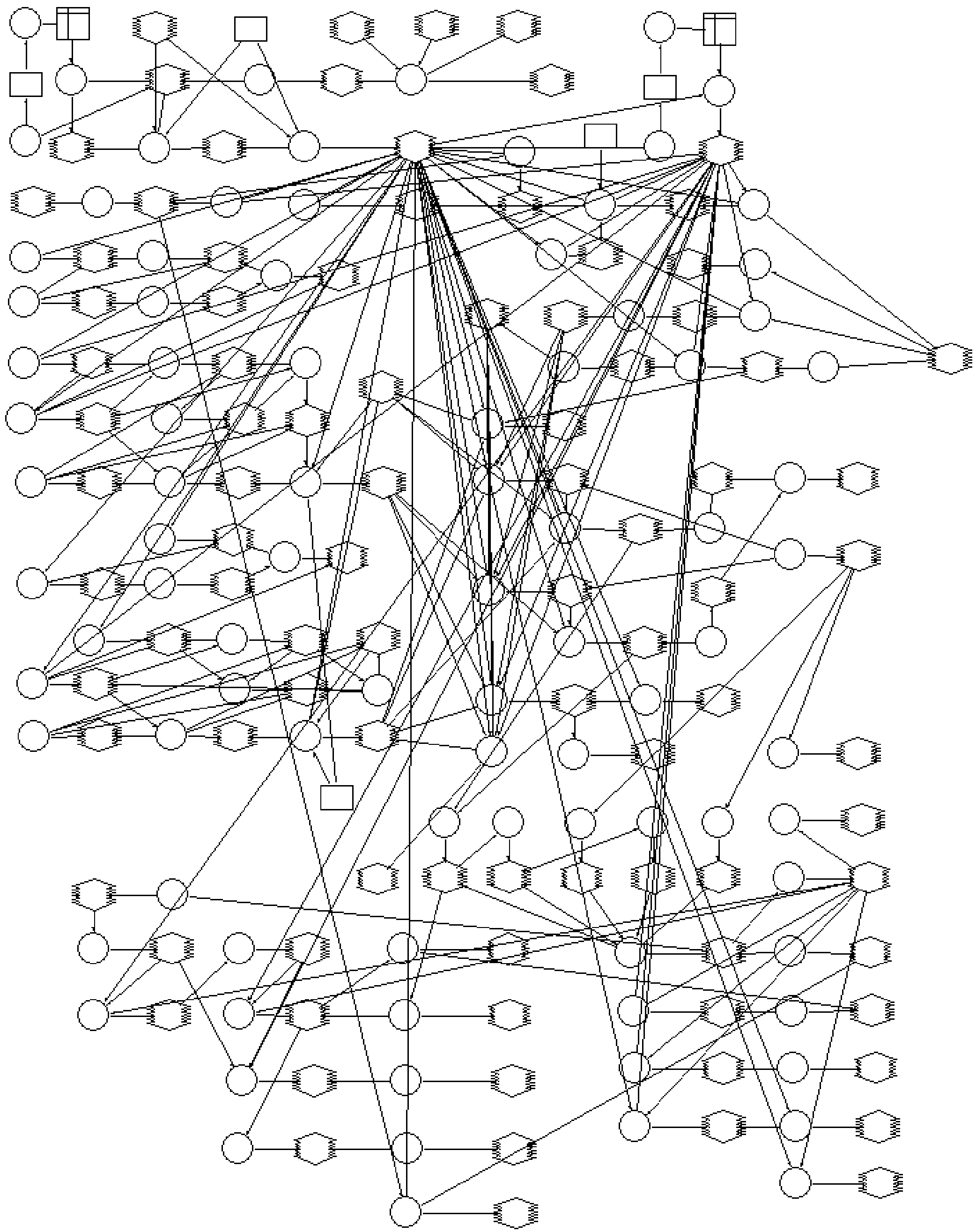
Dryland Processing Components:
Software Systems

Software Systems for Dryland Processing:

- ERDAS 2011/2013/2014
- ArcGIS 9.3/10.2
- Timesat 3.2
- QGIS 2.2
- R environment v. 3.0.2

Overall Diversity II production scheme





One of teh developed ERDAS models, in this case for the ***derivation of phenological and productivity parameters***,

Currently being translated into the newer ERDAS Spatial Modeler and from there to Python

Input and Test Data

1. MERIS FR, RR fAPAR and NDVI (2002 – 2012)
2. GIMMS NDVI (1982 – 2011)
3. Rainfall data: GPCP (from 1979), TRMM (from 1997), CMORPH (from 2002)
4. Soil Moisture data: CCI Soil Moisture (from 1979)
5. NCEP temperature – not yet used
6. (MODIS Evapotranspiration)
7. CGIAR CSI Aridity Index map

NPP Proxies - fAPAR

- fAPAR directly expresses a canopy's energy absorption capacity
- fAPAR is the index ***most directly related to loss of plant productive capacity*** and it is the core variable used in models of primary production in terrestrial ecosystems (GEO BON, 2011)
- The fAPAR has been recognized as one of the fundamental Essential Climate Variable (ECV) by Global Terrestrial Observing System (GTOS) and Global Climate Observing System (GCOS 2003)
- The systematic observation of fAPAR is suitable to reliably monitor the seasonal cycle and inter-annual variability of vegetation photosynthetic activity over terrestrial surfaces (GTOS 2009)

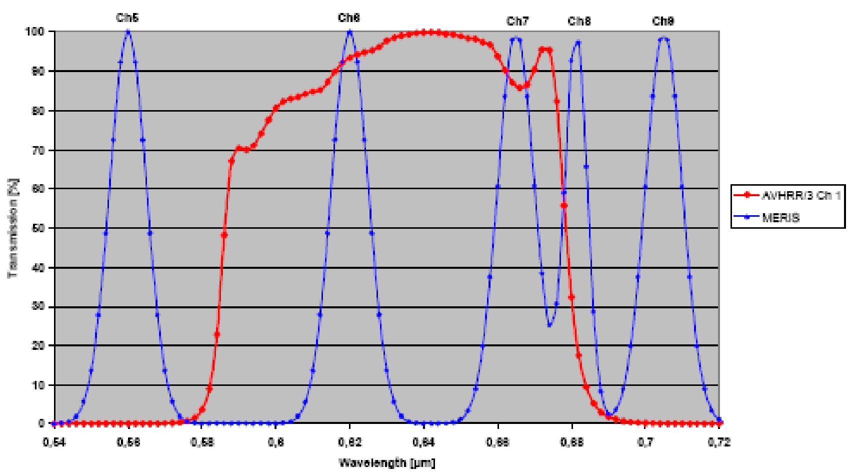
MERIS fAPAR

- fAPAR assessments from space remote sensing platforms are retrieved by numerically inverting physically-based models.
- The design of the fAPAR algorithm (MGVI – MERIS Global Vegetation Index) is based on the following procedure (Gobron et al. 2006):

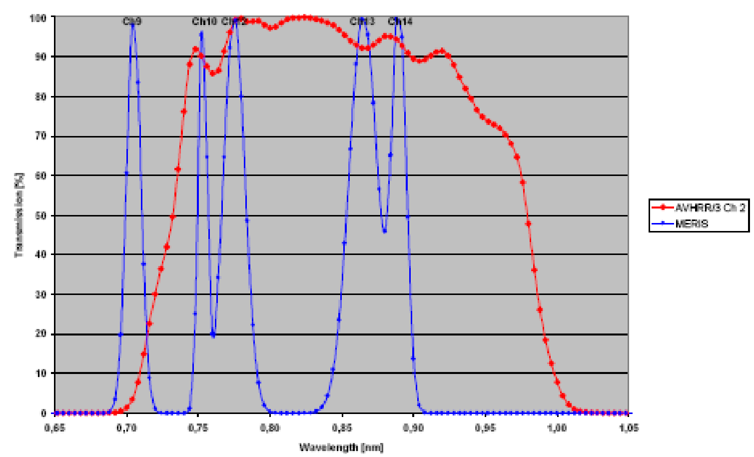
1. Input data are MERIS Level 1 data, i.e. Top Of Atmosphere (TOA) Bidirectional Reflectance Factors (BRFs)
2. First the spectral reflectances measured in the red and near-infrared bands are rectified in order to ensure their 'decontamination' from atmospheric and angular effects and,
3. second combined together in a mathematical formula to generate the fAPAR value.

NDVI from MERIS (will be used for comparison to fAPAR)

- Prince et al. (2009) like many other authors take the NDVI as a surrogate for NPP and state that ***there is a near-linear relationship between NPP and ΣNDVI in tropical grassland, cropland and sparse woodland*** *and light use efficiency has been shown not to improve accuracy* (Fensholt et al., 2006)*"*.
- As the MERIS NDVI will be computed to compare it with the longer time series of the AVHRR GIMMS NDVI, a thorough band selection of the MERIS bands has to be performed for NDVI calculation.



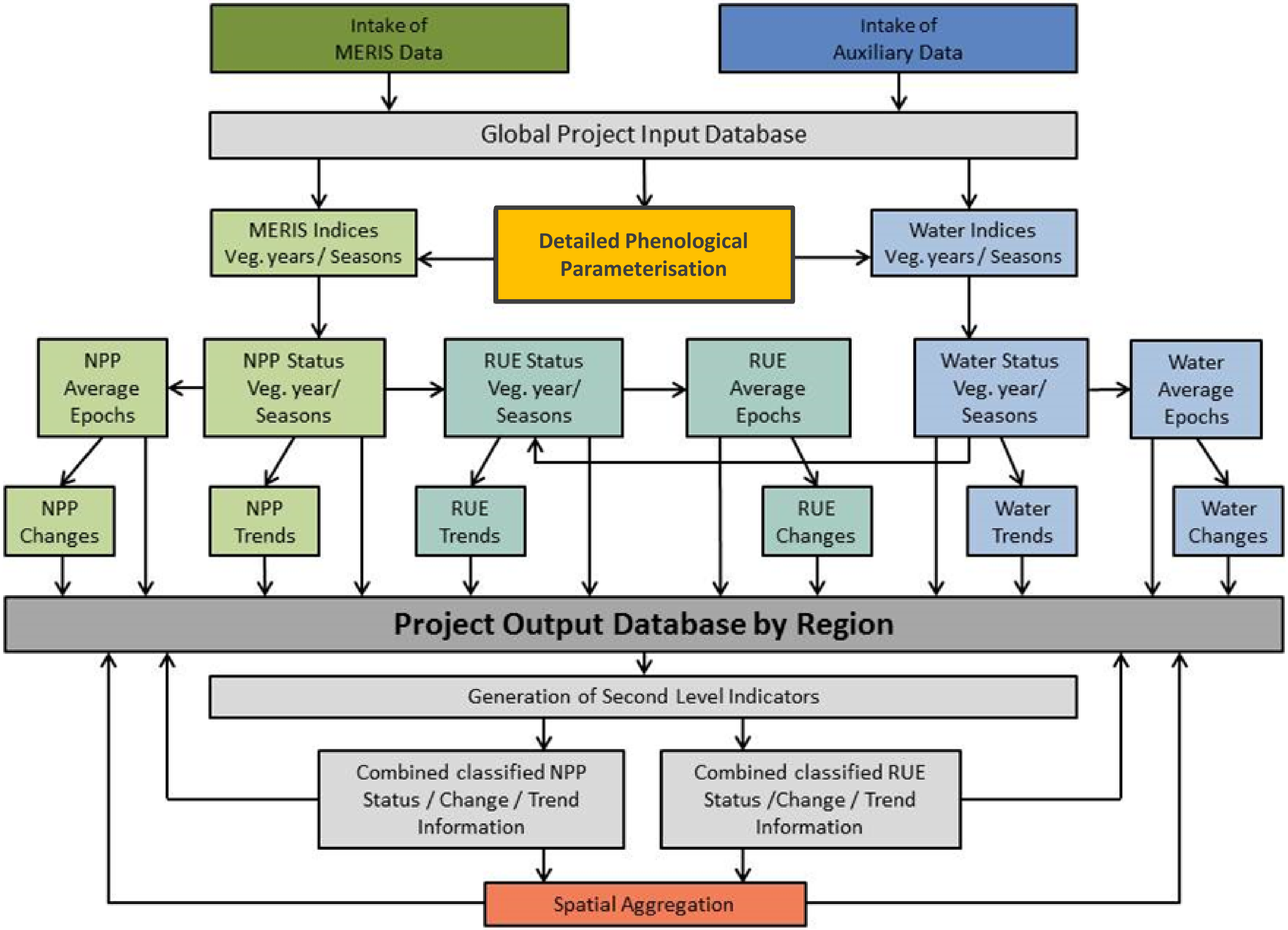
$\rho_1 = \alpha * (\rho_6^* + \rho_7^*)$



$\rho_2 = \beta * (\rho_{10}^* + \rho_{12}^* + \rho_{13}^* + \rho_{14}^* + \rho_{15}^*)$

- The MERIS NDVI will be modeled by deriving weighted sums of the MERIS bands that correspond to the red and NIR bands of the AVHRR (Günther and Maier 1999, AVHRR Compatible NDVI)

Overall dryland processing chain

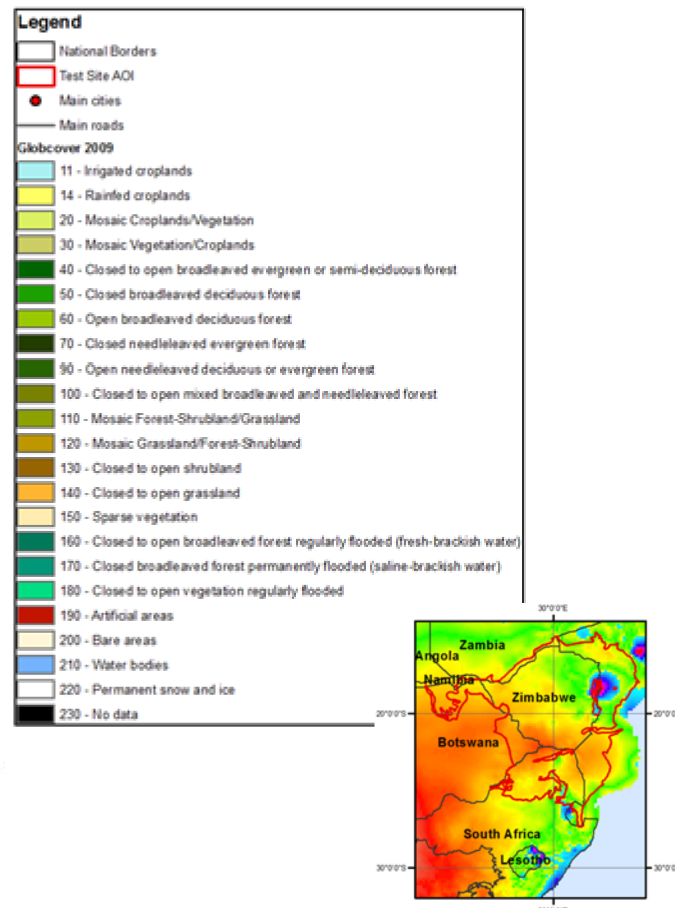


Why detailed phenological and productivity parameters of drylands?

- As phenology varies between years, it must be taken into account when making year to year comparisons of VI data and analyses involving yearly trends
- Only when considering the growing season fraction of vegetation development can we derive the direct response of vegetation to rainfall
- A lack of direct response of the vegetation to rainfall is our „classical“ measure for potentially degraded land in this context (RUE)
- They can provide indirect information to broad categories of land cover when we put the vegetation greenness of the different seasons in relation to each other
- Shifts and changes of pheno-production parameters can thus give clues about land cover changes, and to trends of the functional vegetation composition

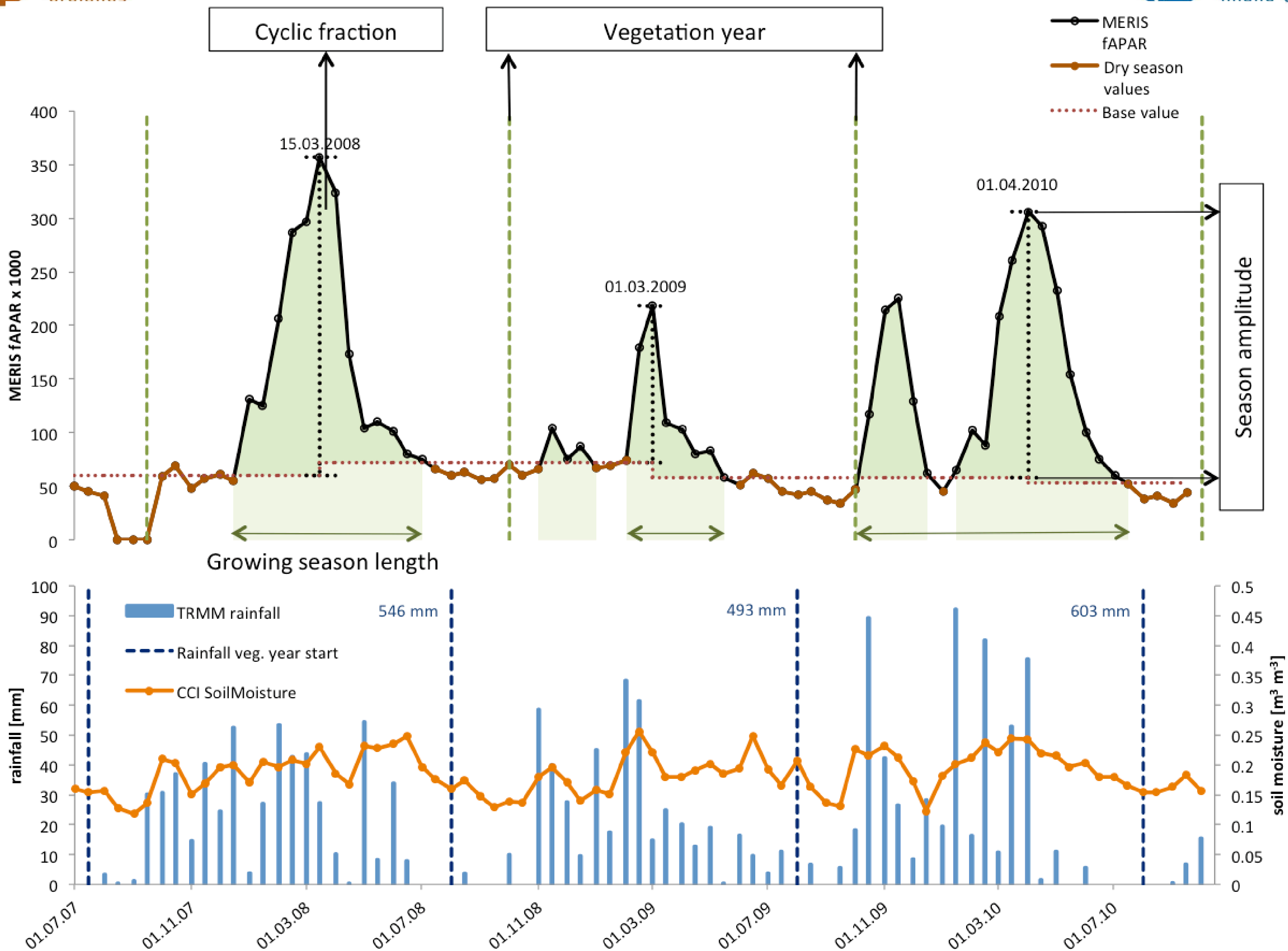
Testsite Southern Africa East

21	Zimbabwe: Zambezian and Mopane woodlands (AT0725), Southern Miombo woodlands (AT0719), Zambezian Baikiaea woodlands (AT0726), Southern Africa bushveld (AT0717)	870.742 km² Zimbabwe, Zambia, Mozambique, Botswana, South Africa, Malawi	AI 0,19 – 1,81 Tropical and subtropical grasslands, savannas, and shrublands	Part of Central and Eastern Miombo Woodlands (G200_NUM 88)	Area contains Protected Areas and Transboundary Protected Areas WRI Major Watersheds: Parts of Zambezi, Okavango, Limpopo and Save



Location of derived time series diagram

Phenological and Productivity Parameters



Phenological and Productivity Parameters

Based on Vegetation Year time series

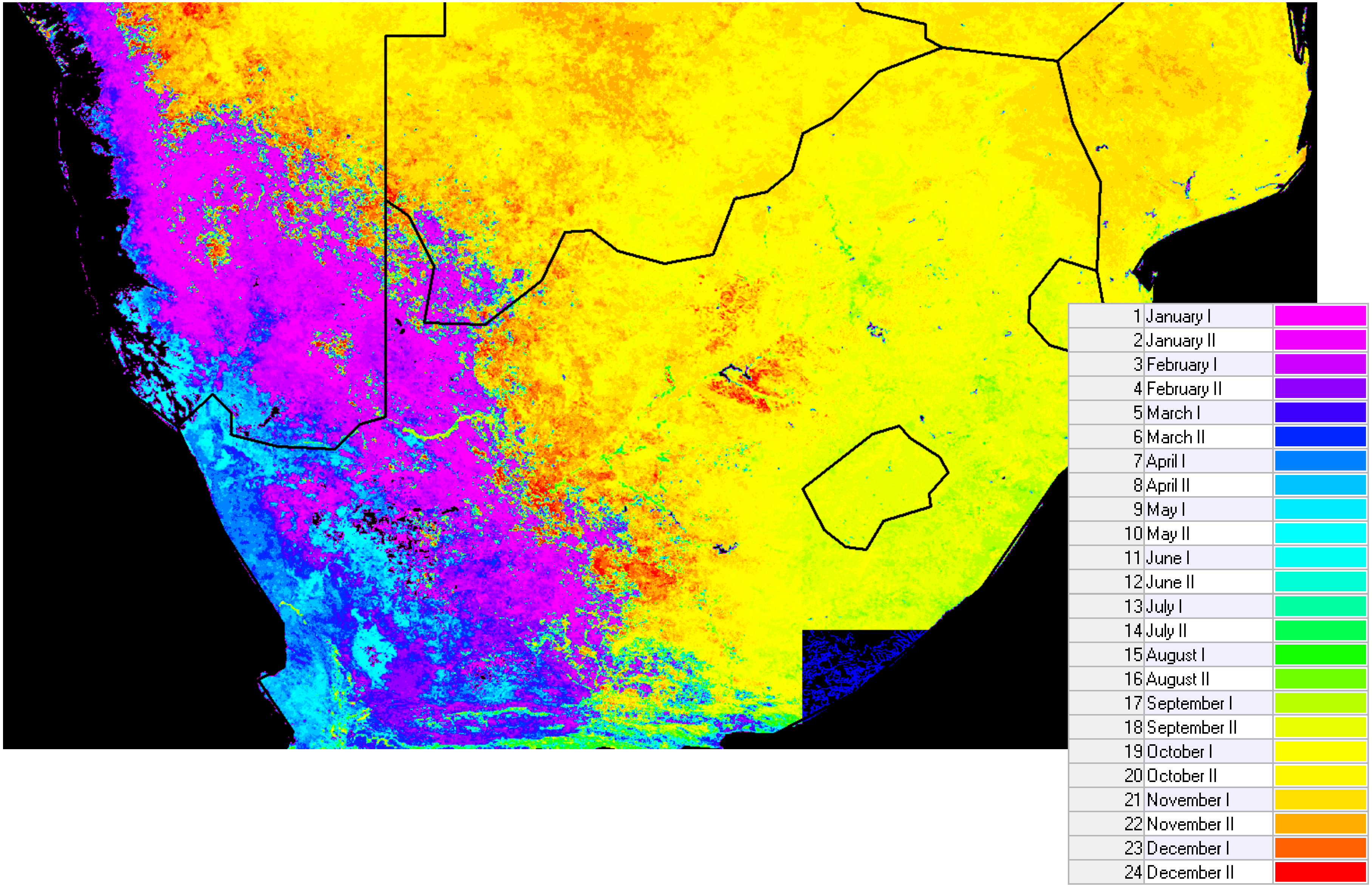
Phenological Parameters

1. Dominant start time of vegetation year
2. Start time of growing season
3. End time of growing season
4. Length of growing season including all peaks
5. Length of growing season excluding small/short peaks (2 variants)
6. Time of maximum
7. Number of peaks within growing season separated by values below base value
8. Overall number of peaks in vegetation year

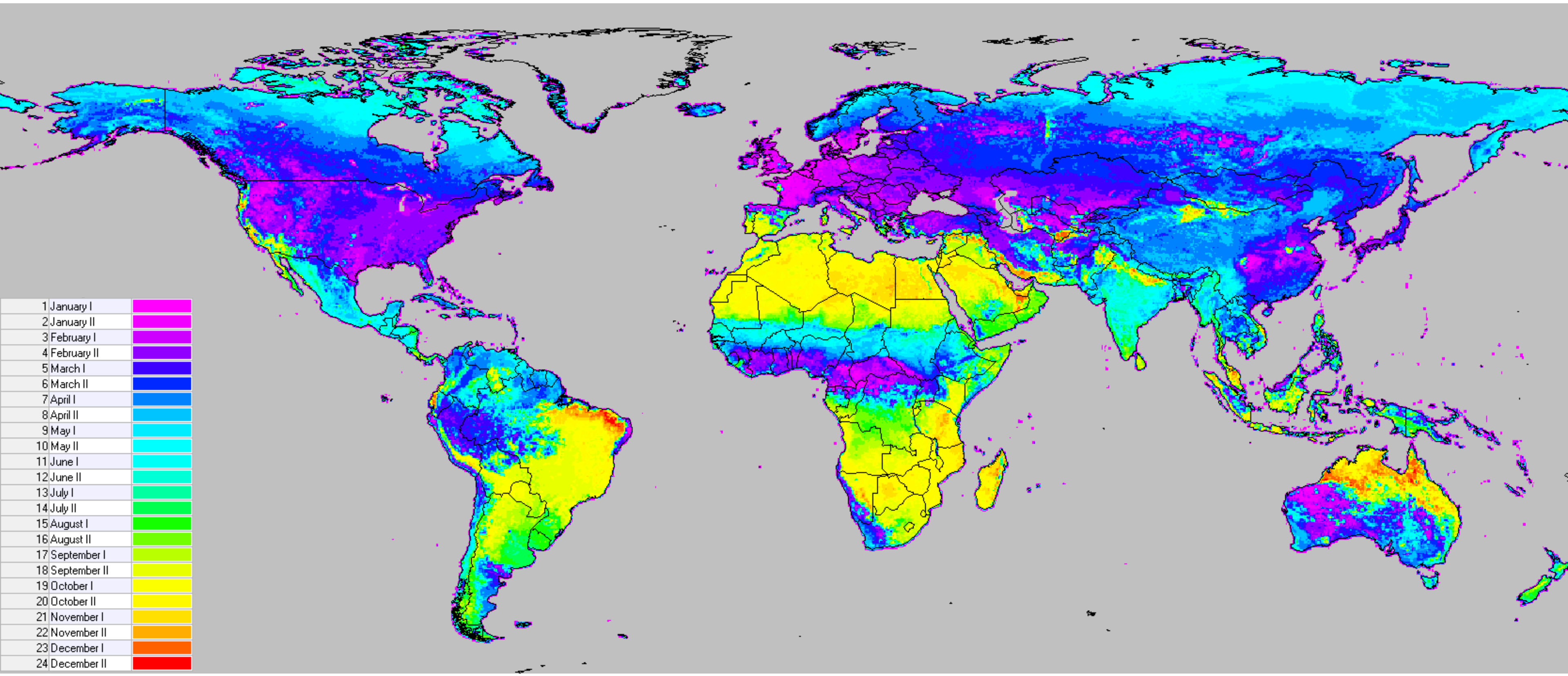
Productivity Parameters

1. Base values (separate growing season from dry season)
2. Maximum
3. Amplitude
4. Cyclic fraction (all)
5. Cyclic fraction (excluding short/small peaks)
6. Dry season average
7. Dry season average (including short/small peaks)
8. Peak values

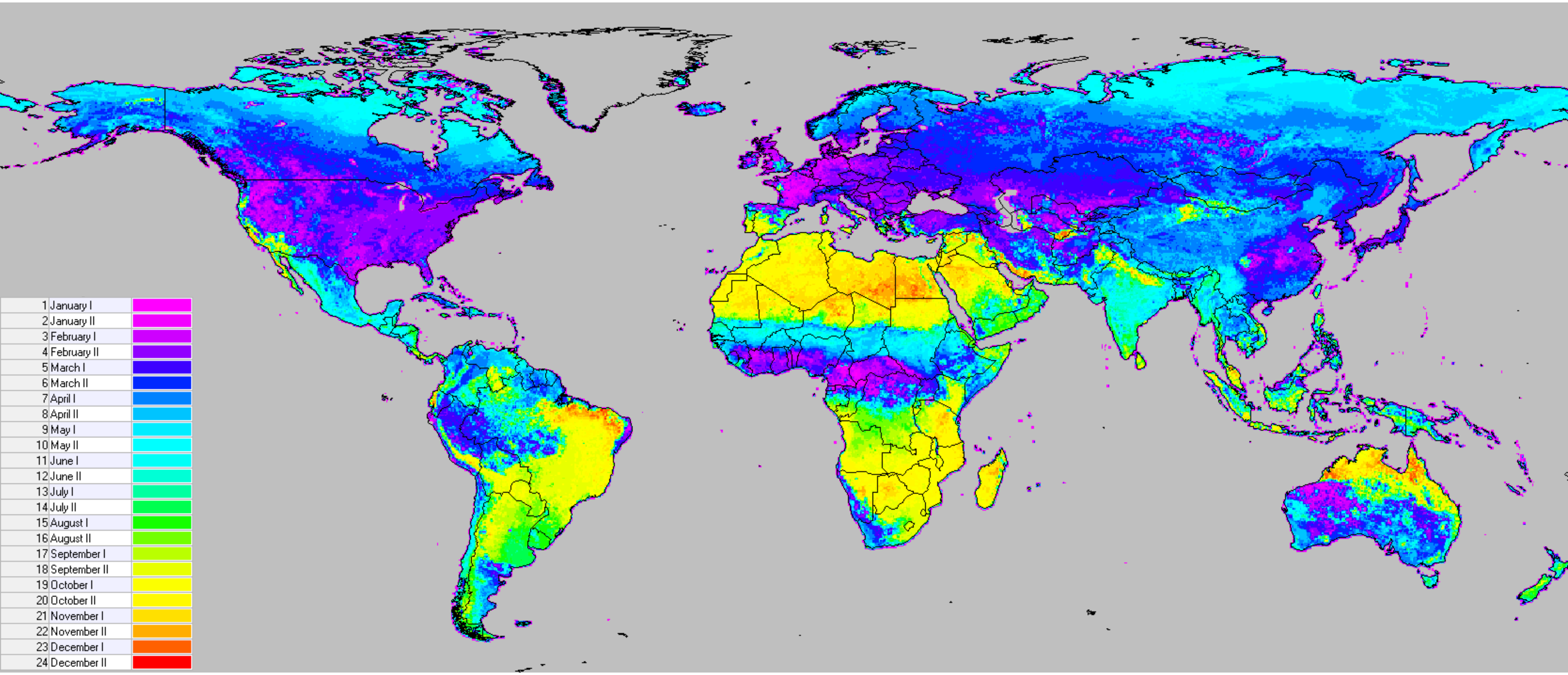
Start of Vegetation Year (Median 2003 – 2010)



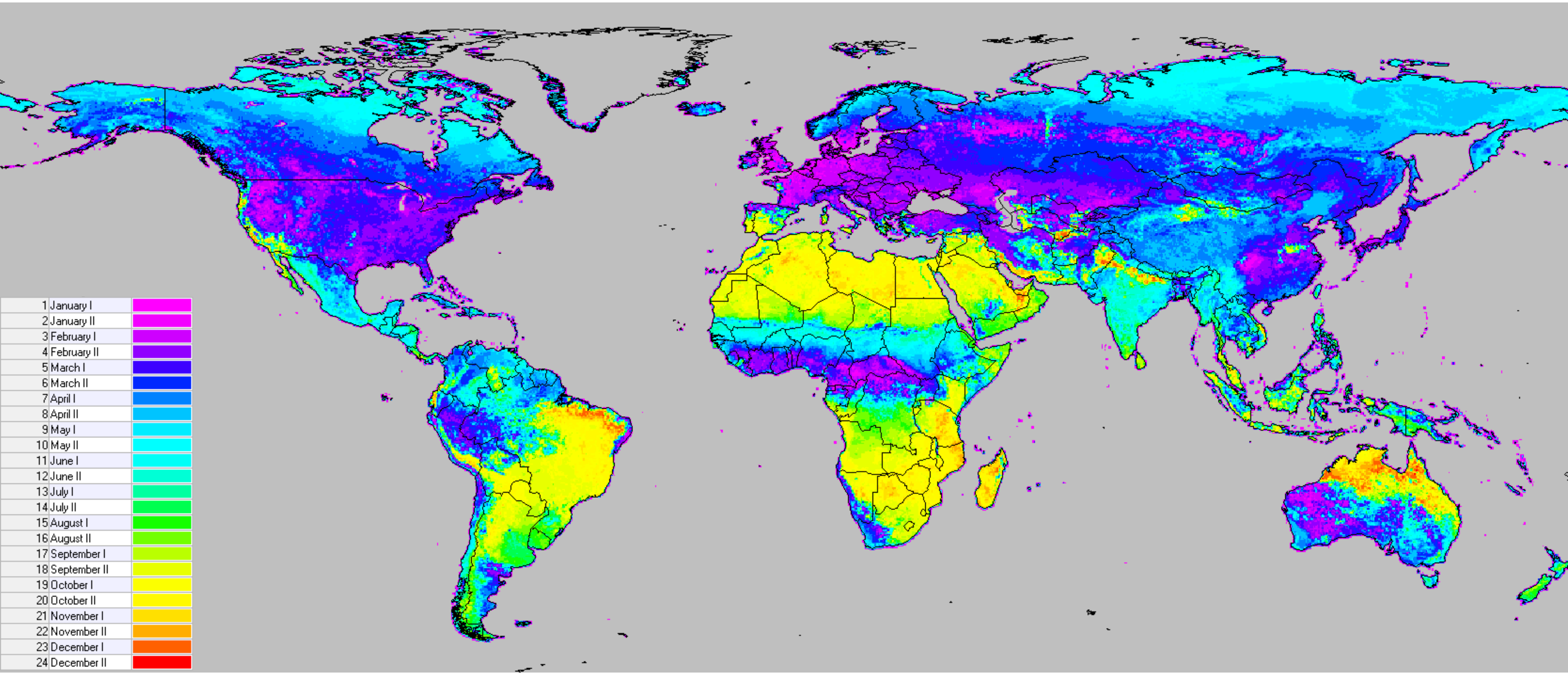
NOAA GIMMS median of dominant start of vegetation year 1982 - 2011



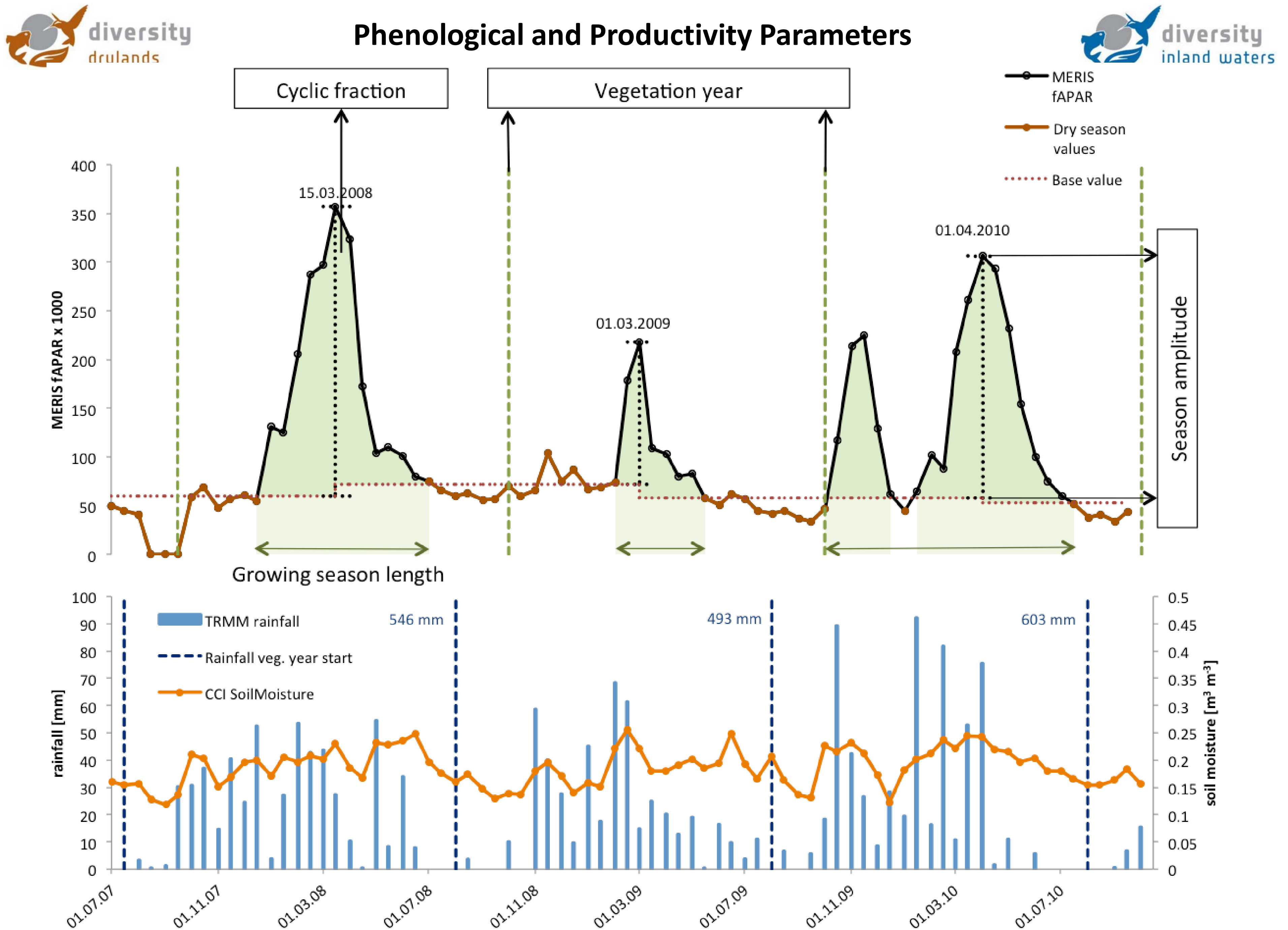
NOAA GIMMS median of dominant start of vegetation year 1982 - 1991



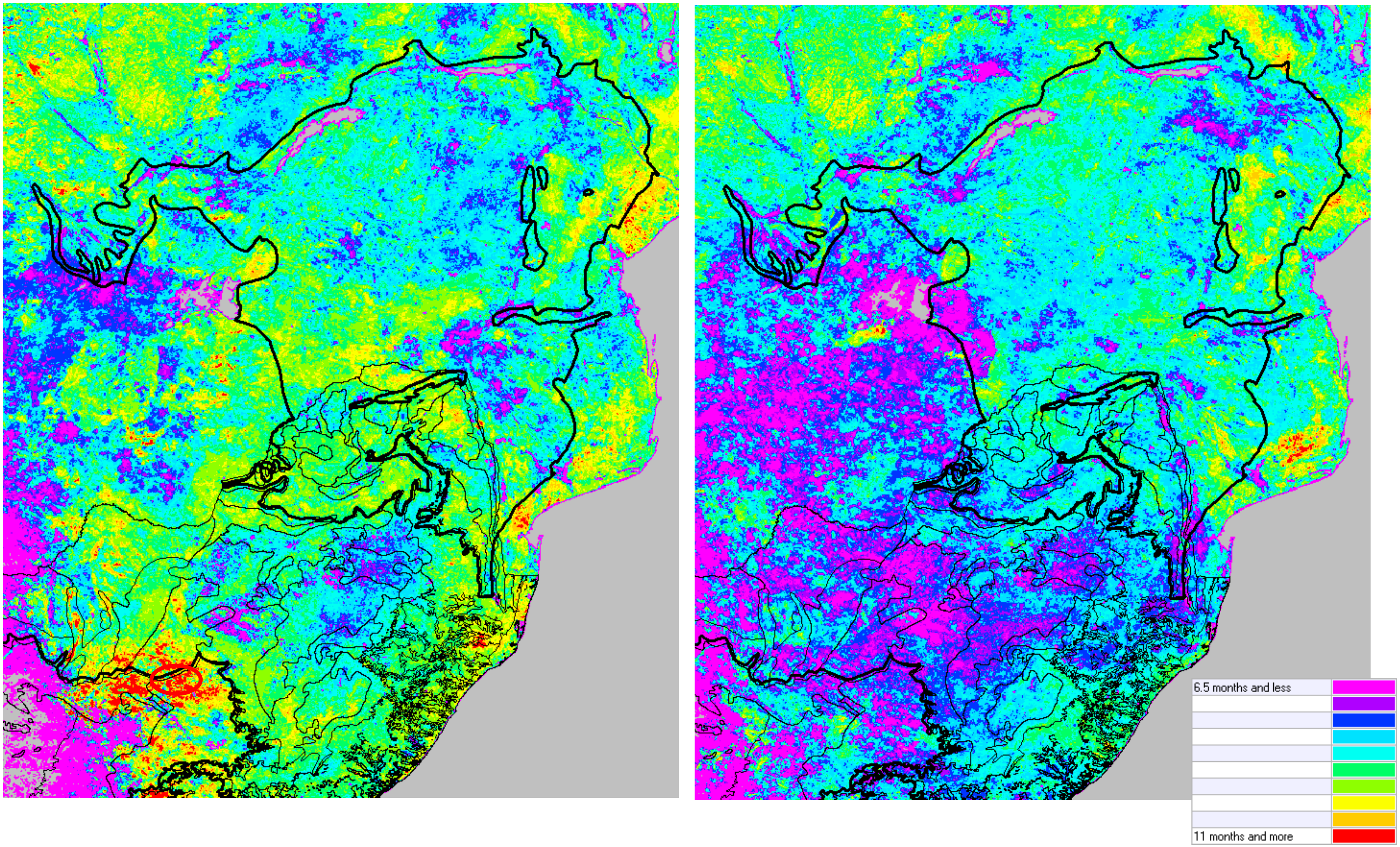
NOAA GIMMS median of dominant start of vegetation year 2002 - 2011



Phenological and Productivity Parameters



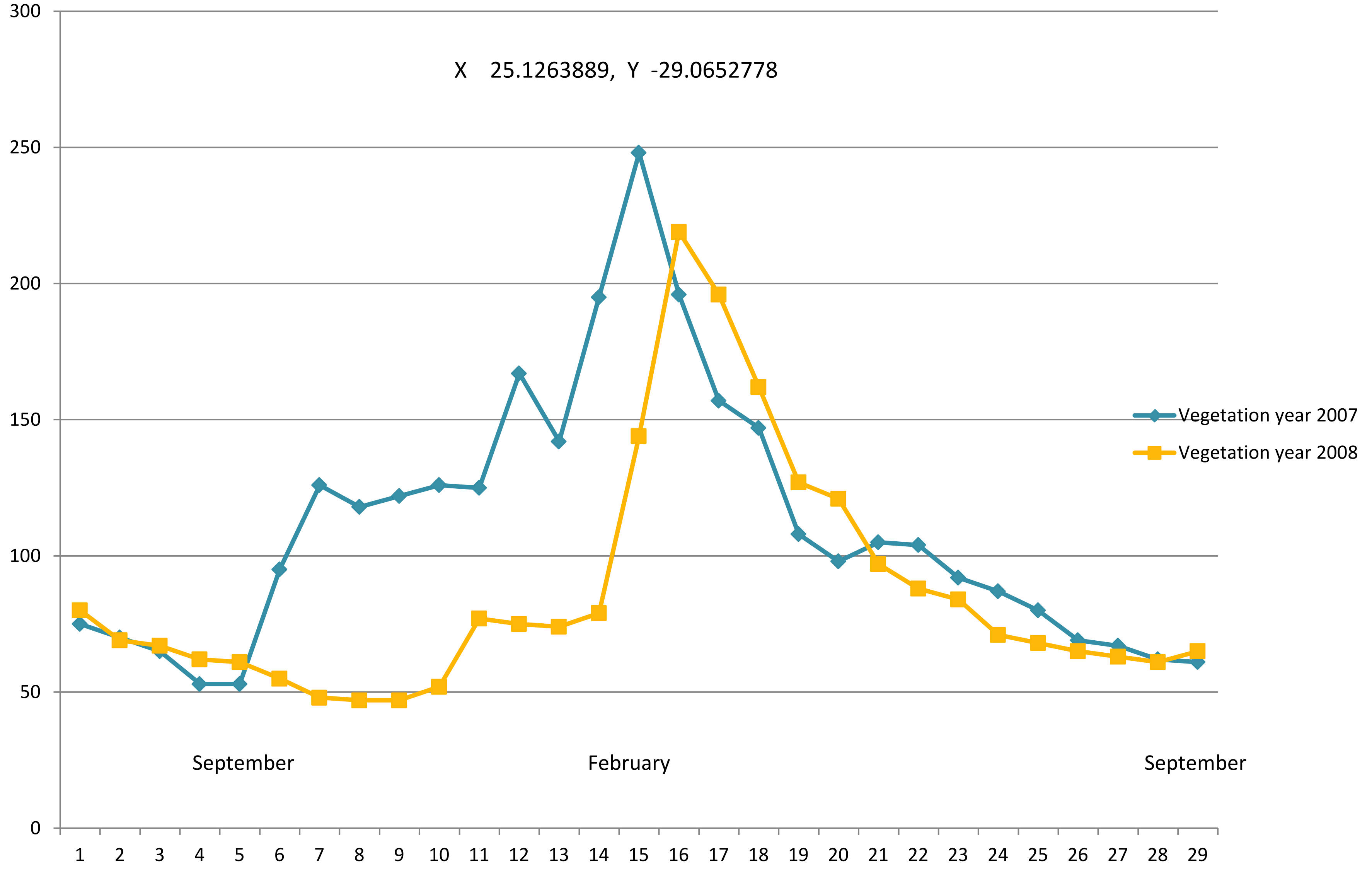
Length of growing season 2007 vs. 2008 (right)



diversity drylands

Length of growing season 2007 vs. 2008 (ye

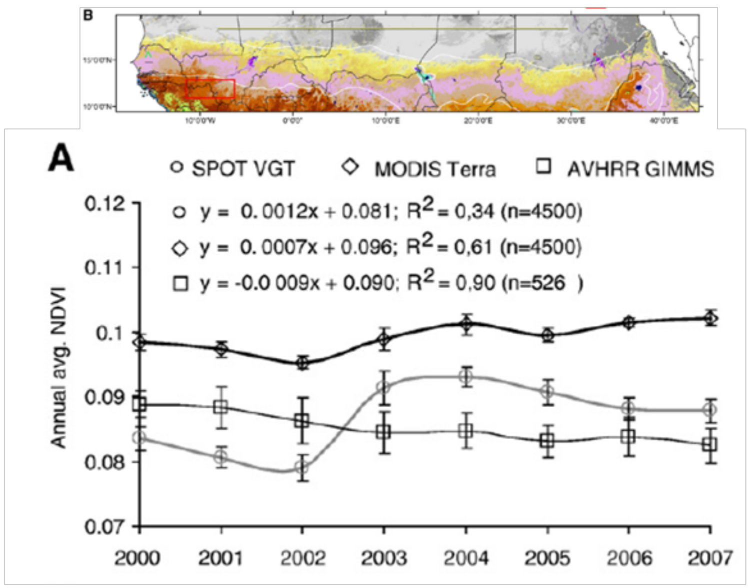
diversity inland waters

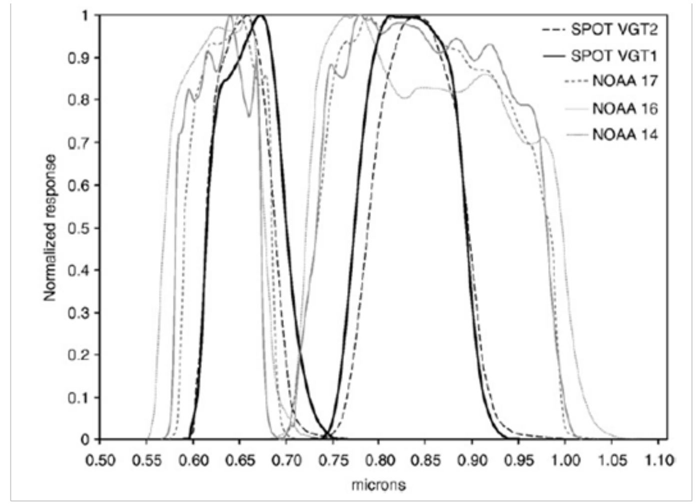


EO time series data issues

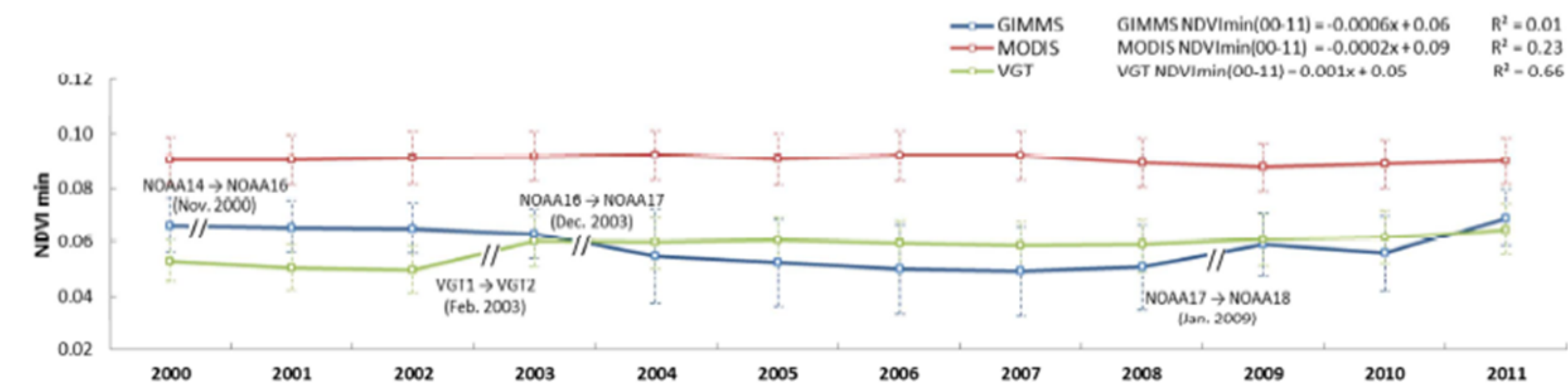
- NOAA GIMMS
- Rainfall data (GPCP, TRMM, CMORH)
- Soil moisture data (surface soil moisture TU Vienna)

Shift in AVHRR-sensor configuration



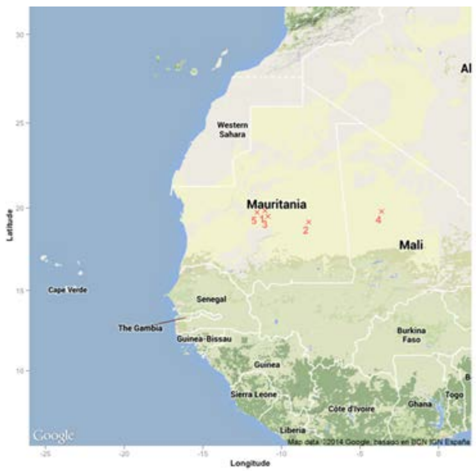


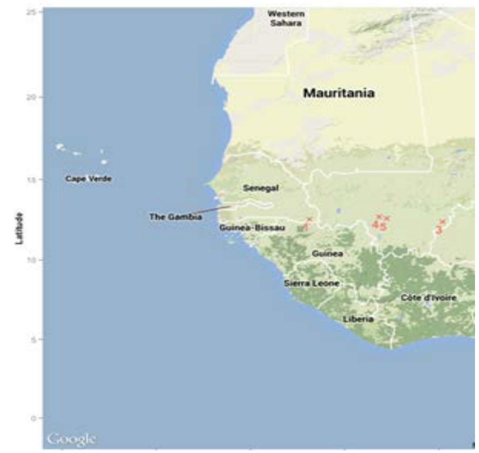
Fensholt et al., 2009

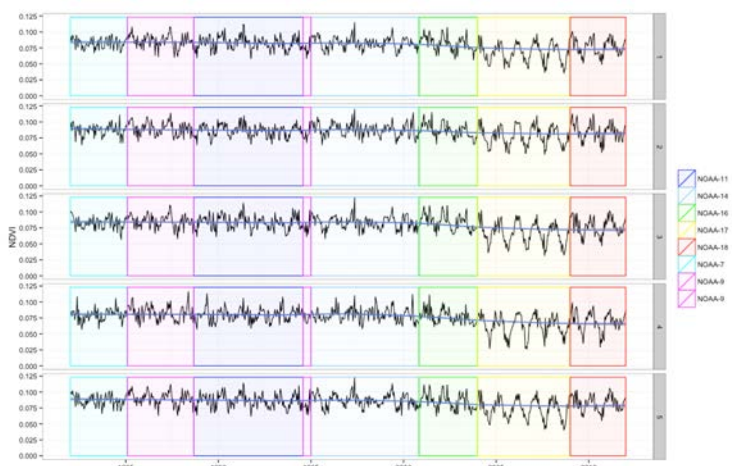


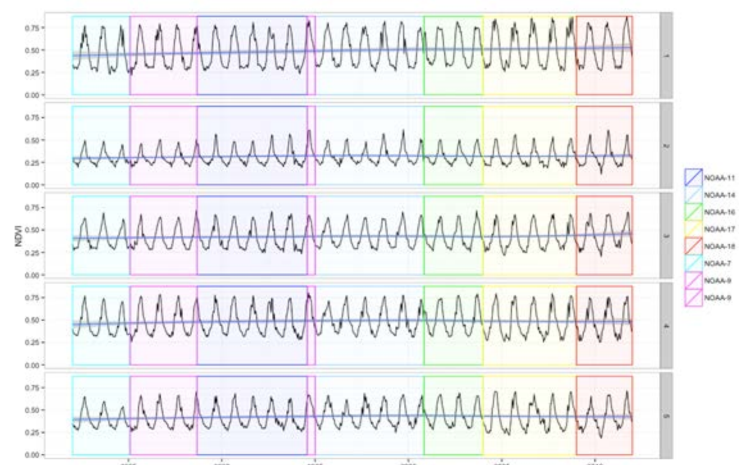
Horion et al., in press

Possible effects of AVHRR sensor degradation

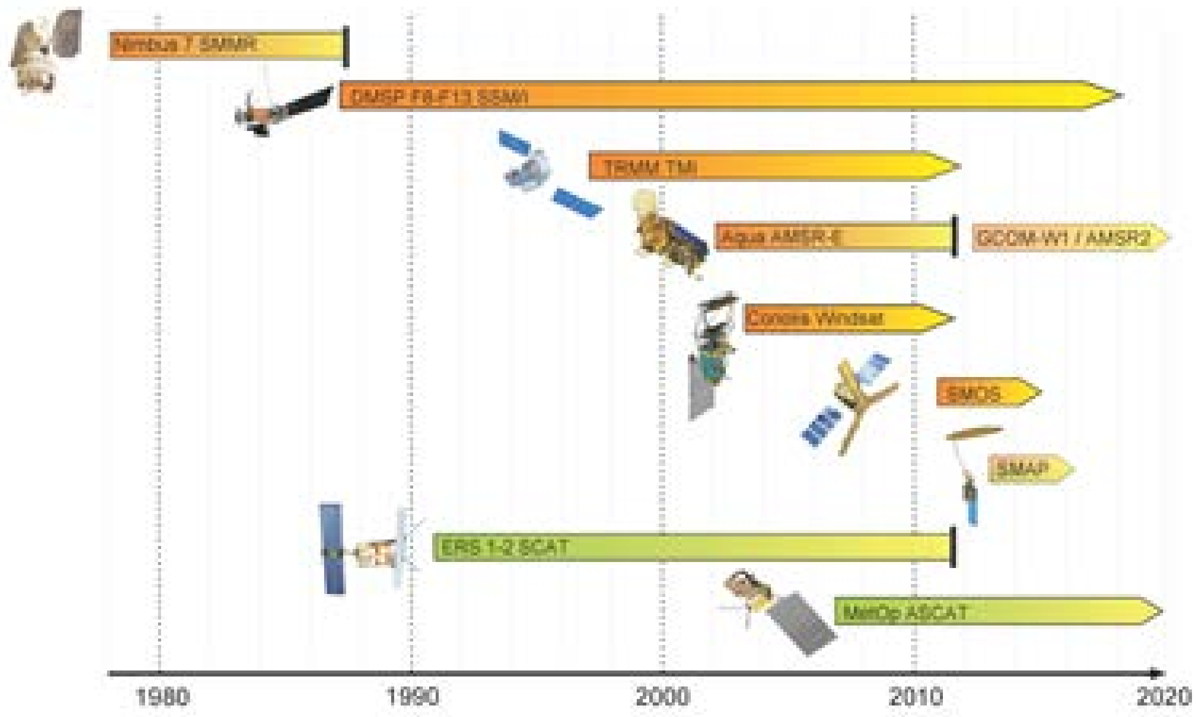




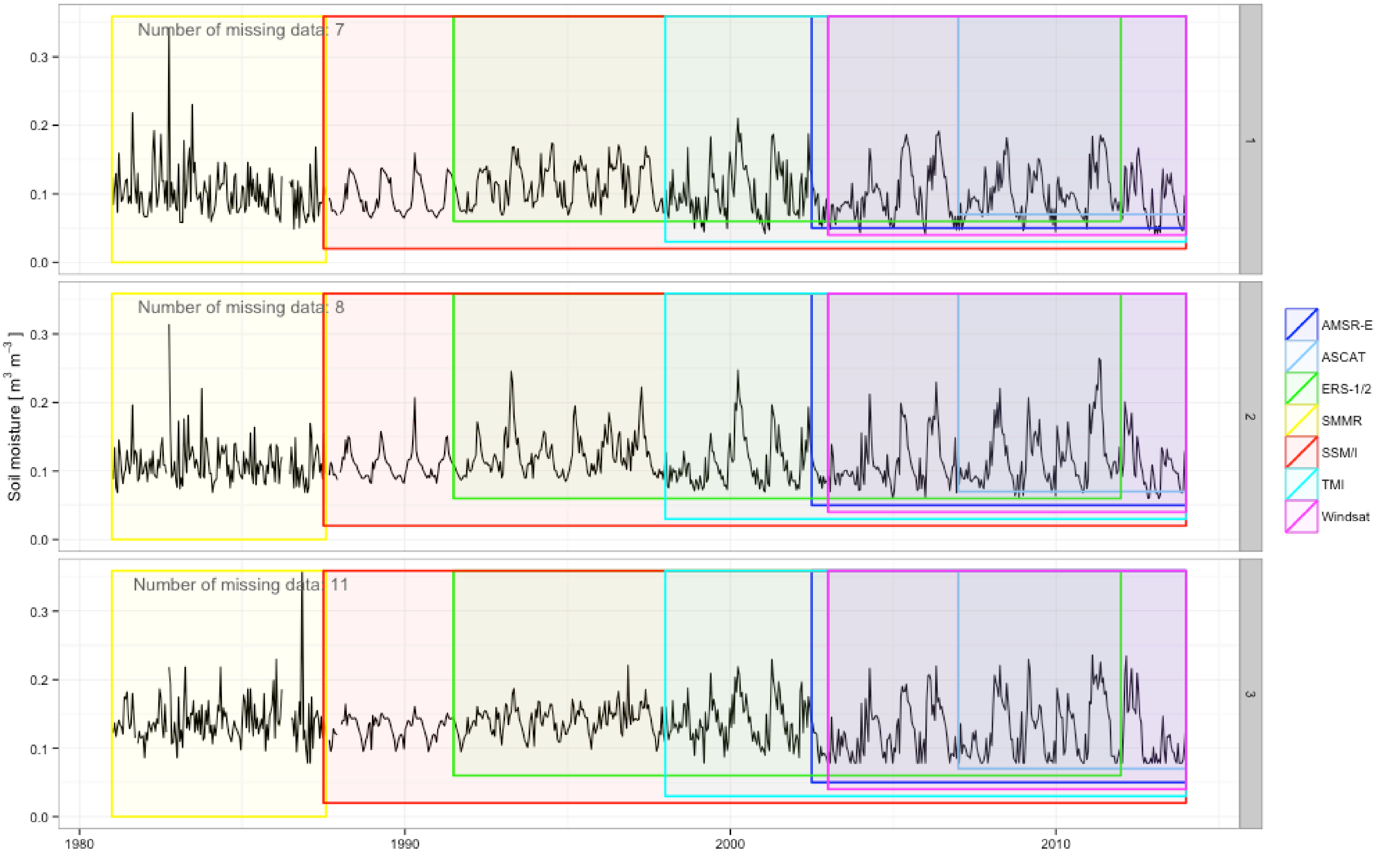




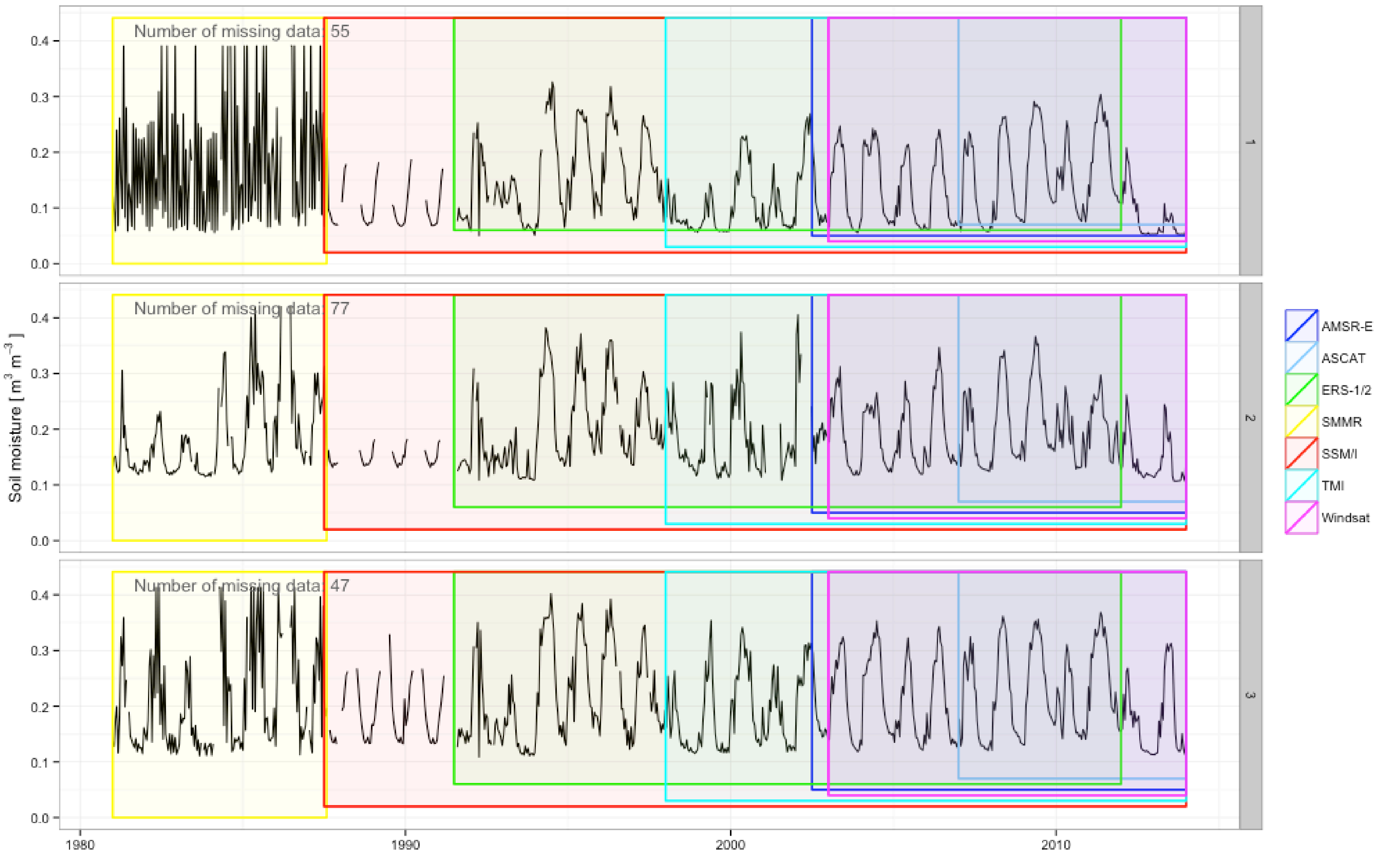
Passive/Active Sensors of the CCI Soil Moisture product



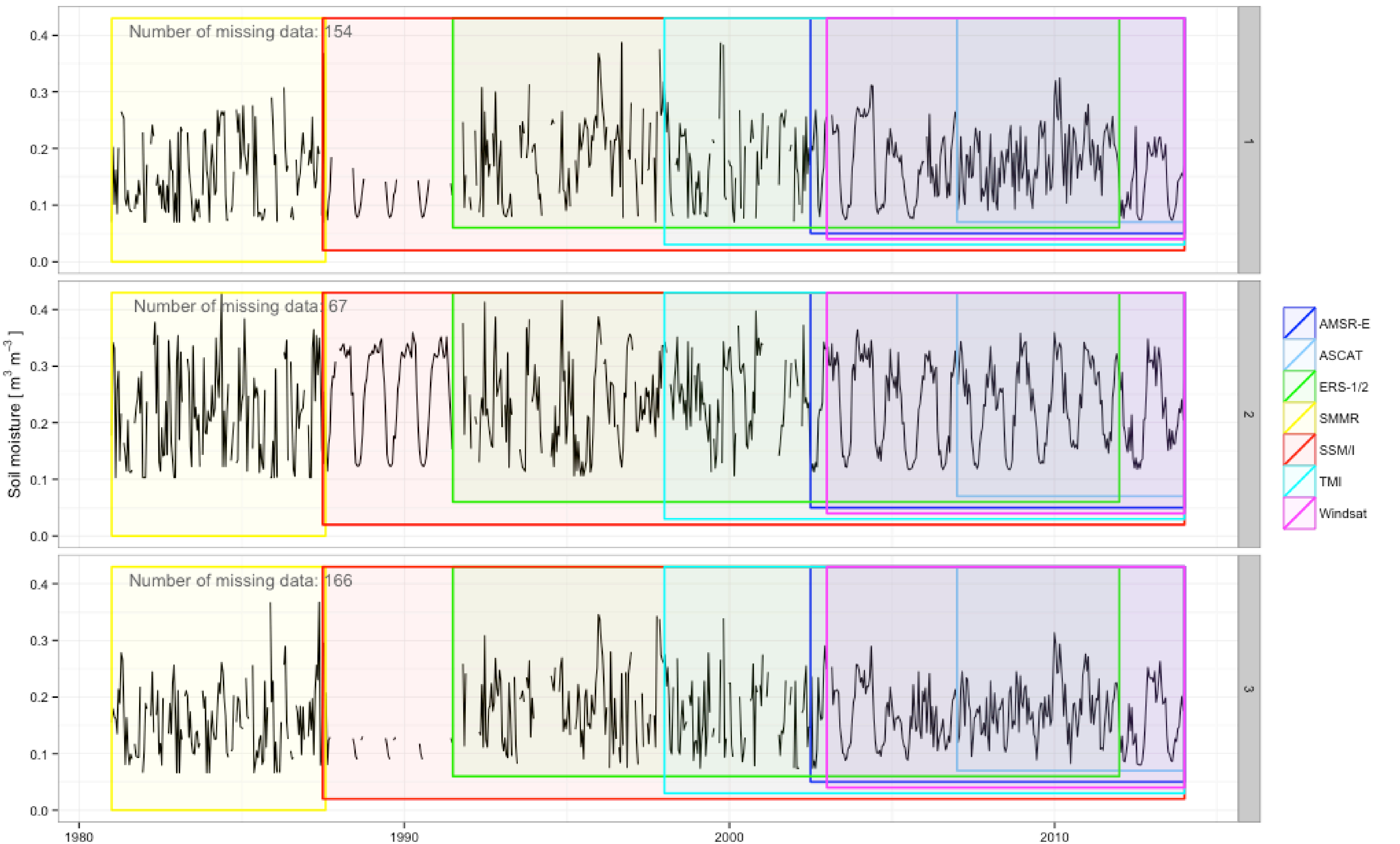
CCI Soil Moisture Time Series 1978 – 2013 Southern Namibia



CCI Soil Moisture Time Series 1978 – 2013 Caatinga



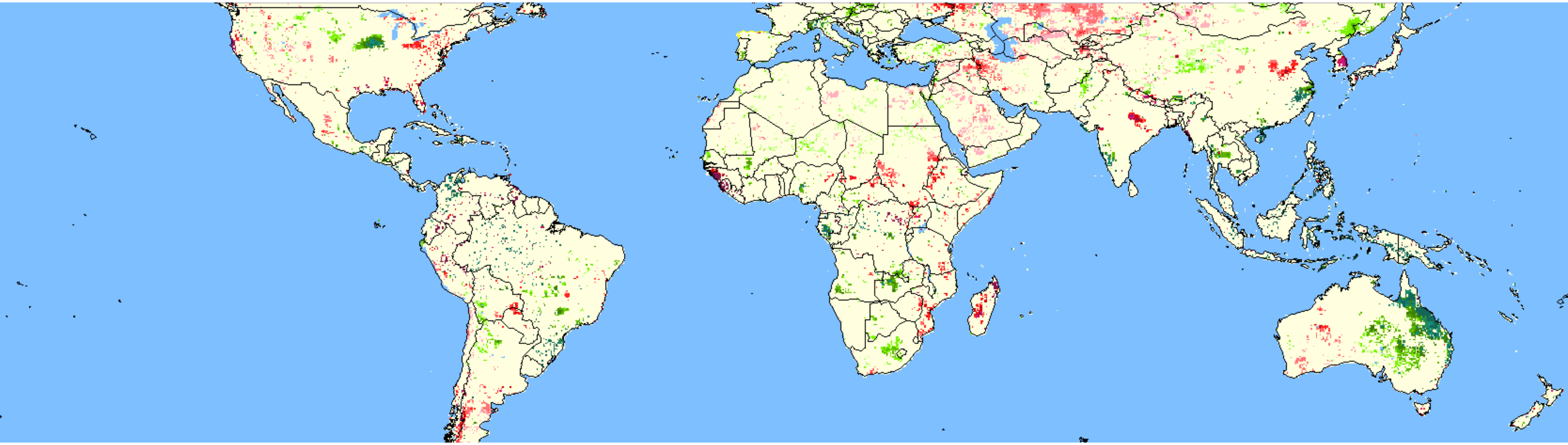
CCI Soil Moisture Time Series 1978 – 2013 Southern Spain



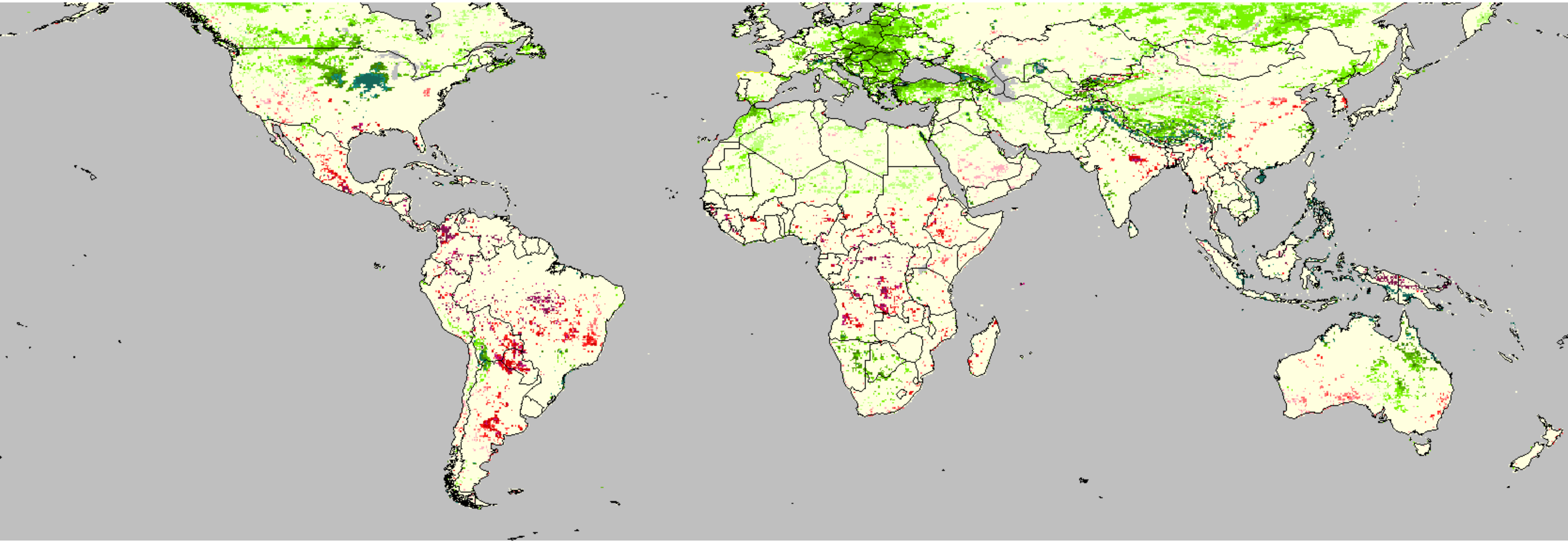
Preliminary Conclusions regarding the Soil Moisture Data

- Long term time series may be affected by sensor related shifts and derived trends may therefore not be valid
- The MERIS period seems to be less or not affected by those shifts
- First visual inspections of the raster images show that the data availability becomes better towards more recent times
- This also positively effects the usage of the SM data for MERIS based efficiency indices

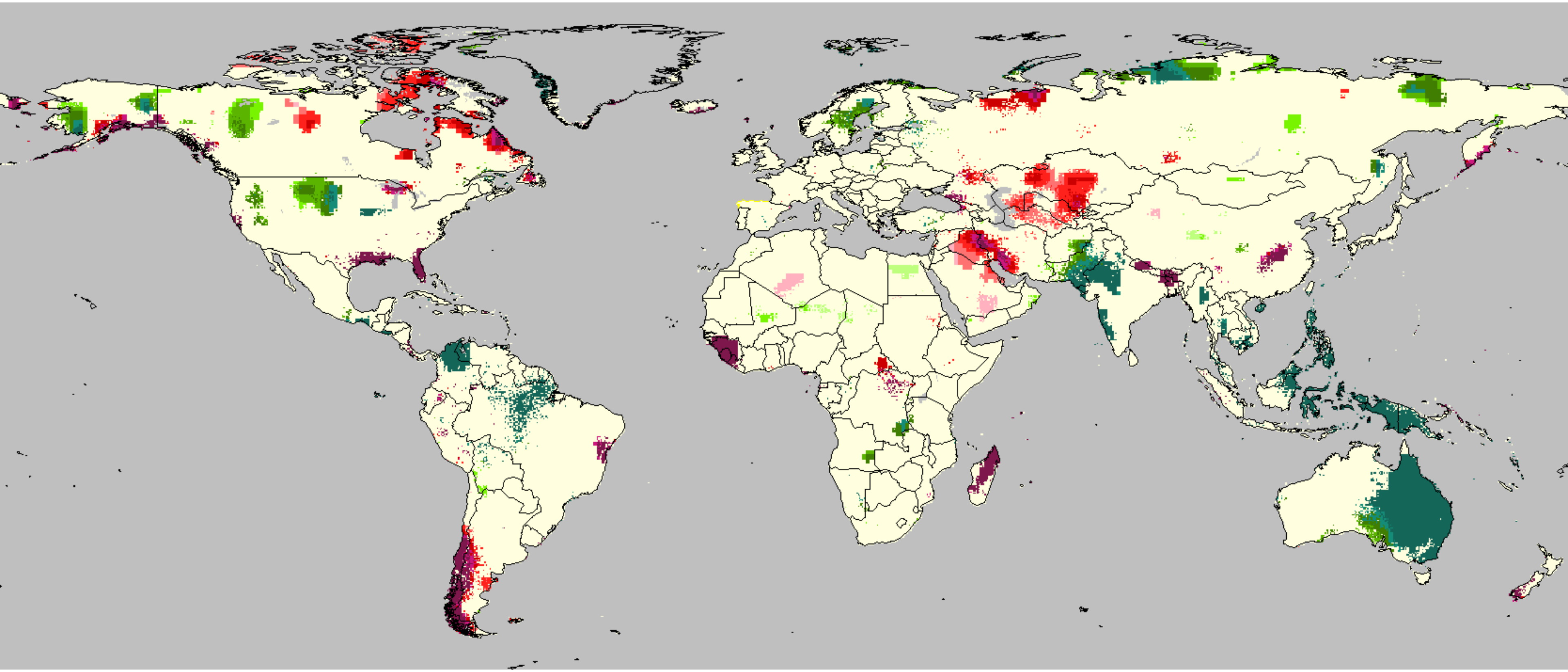
TRMM rainfall trends 2003 – 2010
p: 0.05



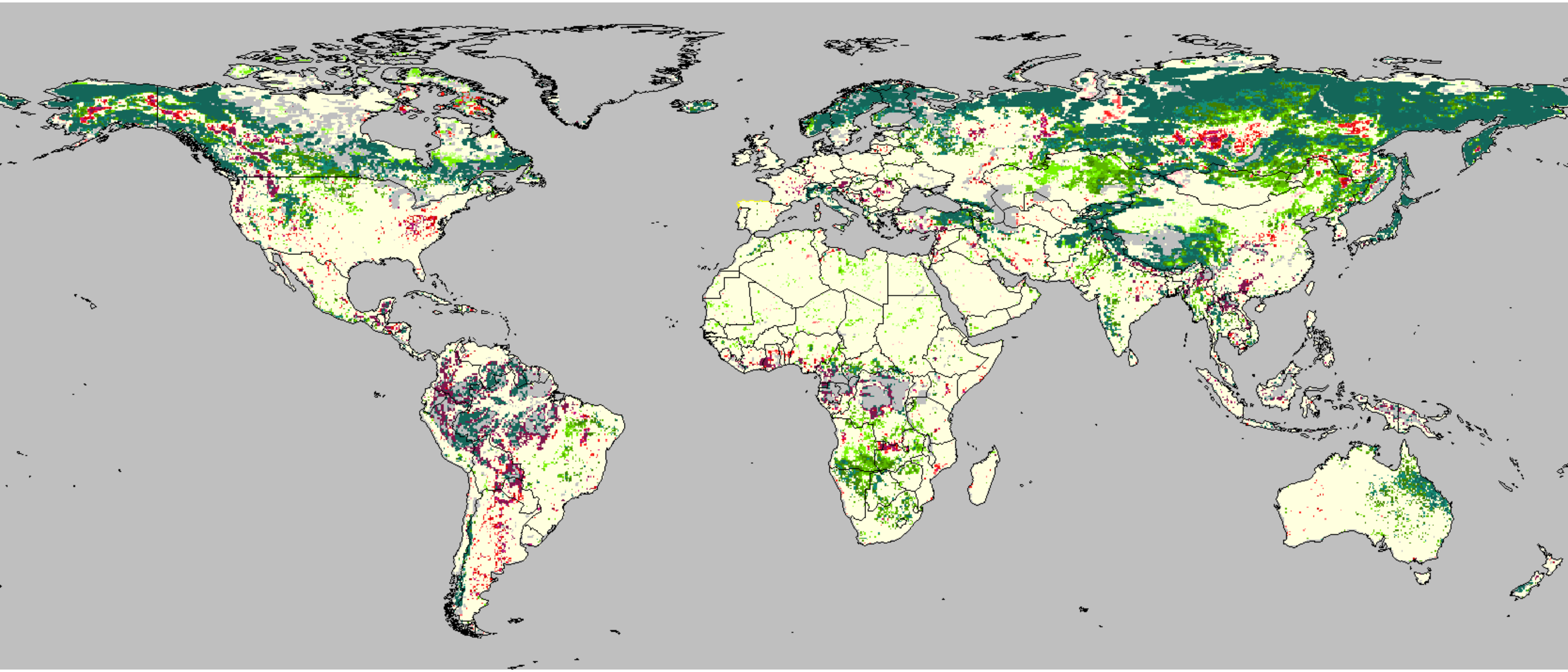
CMORPH rainfall trends 2003 – 2010
p: 0.05



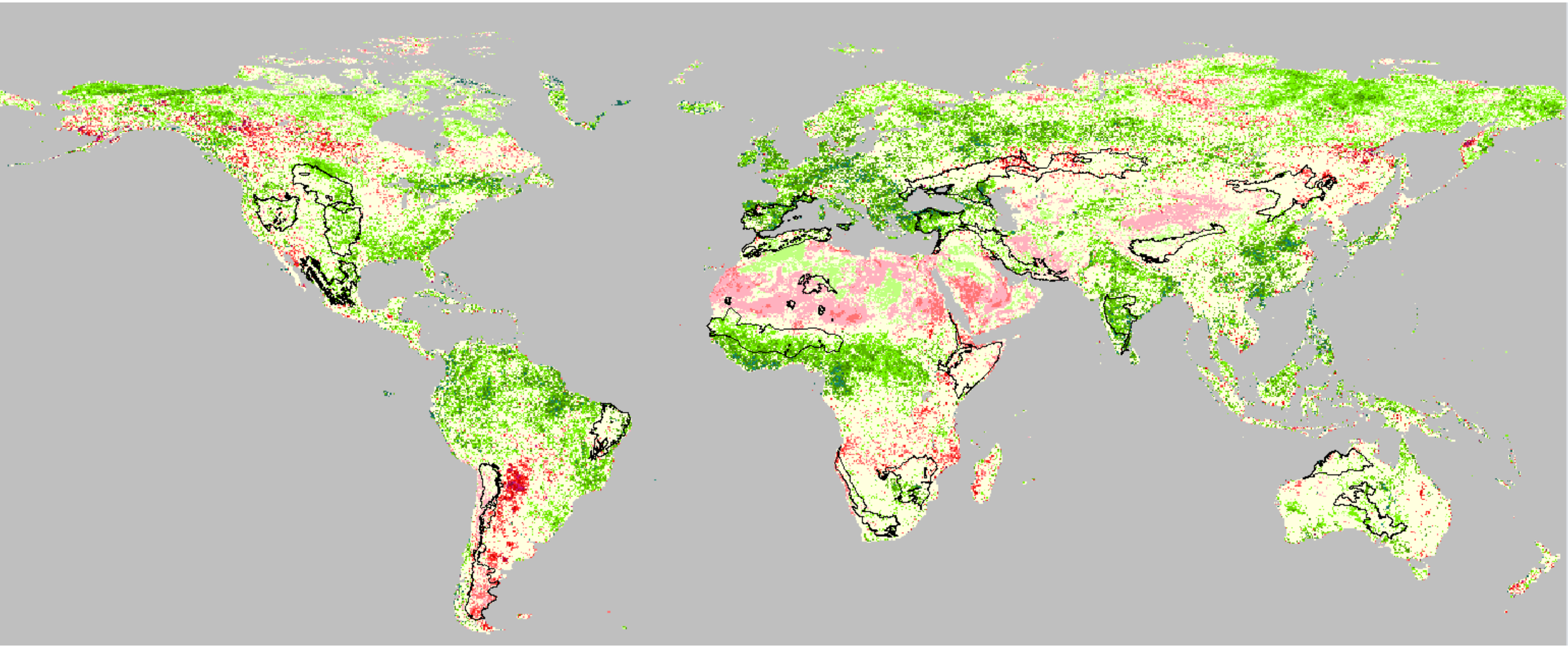
GPCP rainfall trends 2003 – 2010
p: 0.05



Surface soil moisture trends 2003 – 2010
p: 0.05

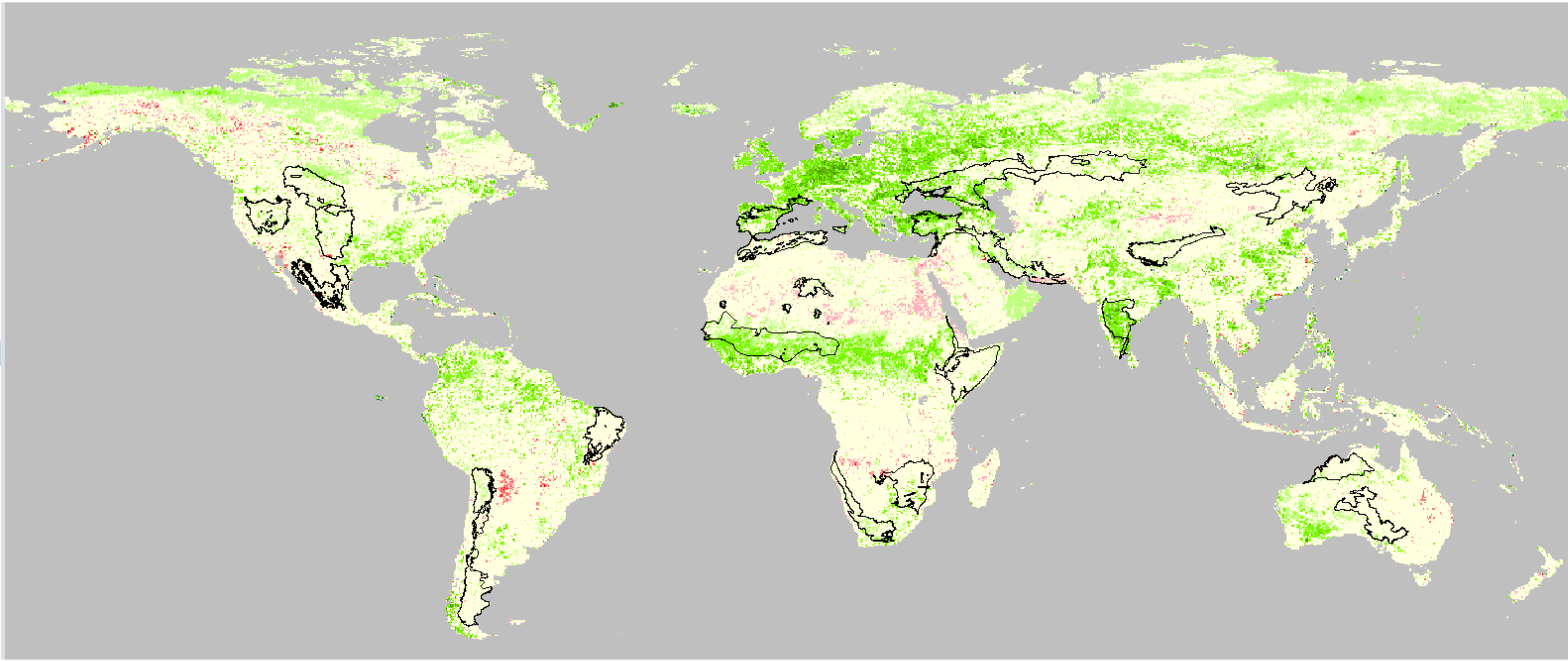


GIMMS NDVI Vegetation Year Trends 1982 - 2010



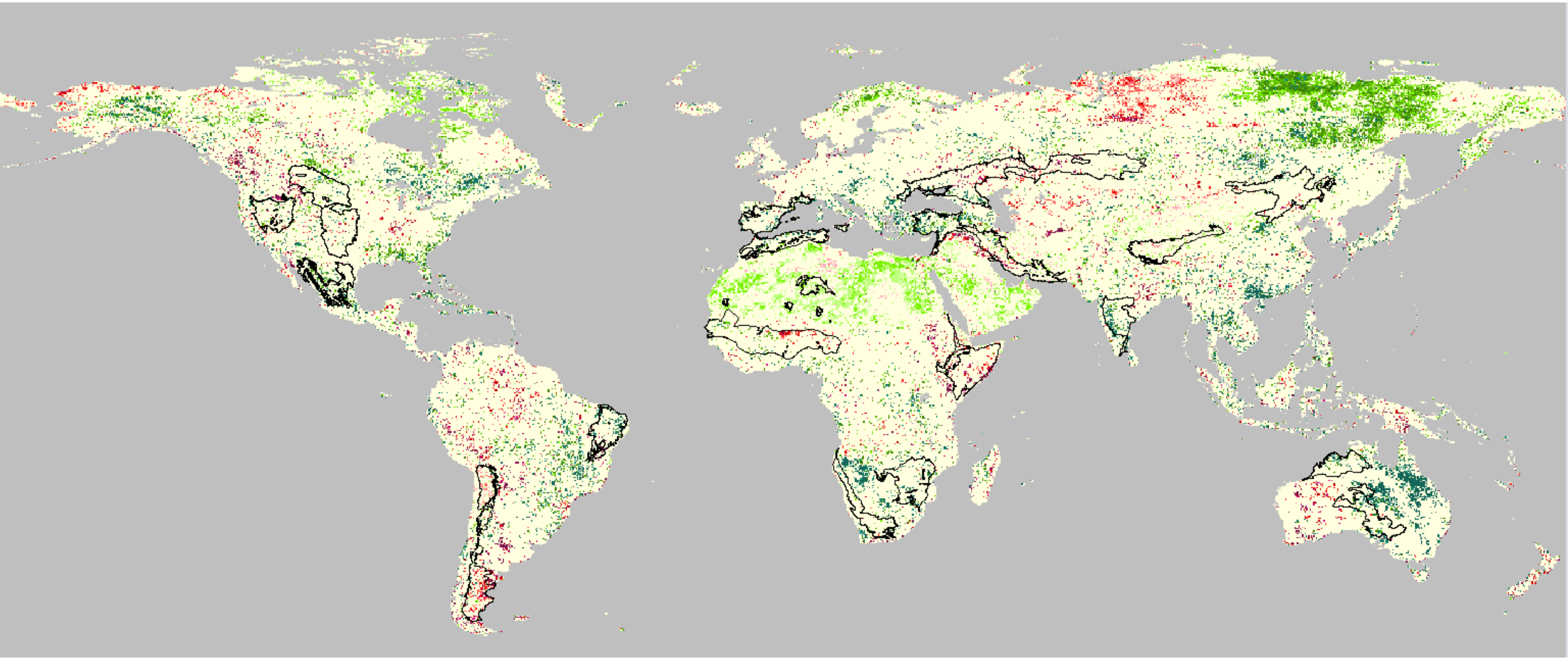
Threshold for significant pearson r: 0.367 (p: 0.05)

GIMMS NDVI Vegetation Year Trends 1982 - 2002



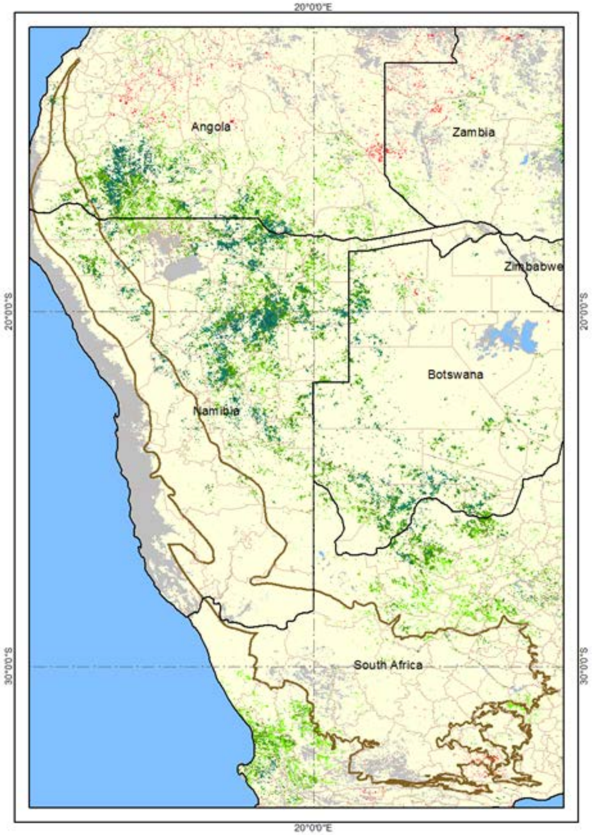
Threshold for significant pearson r: 0.433 (p: 0.05)

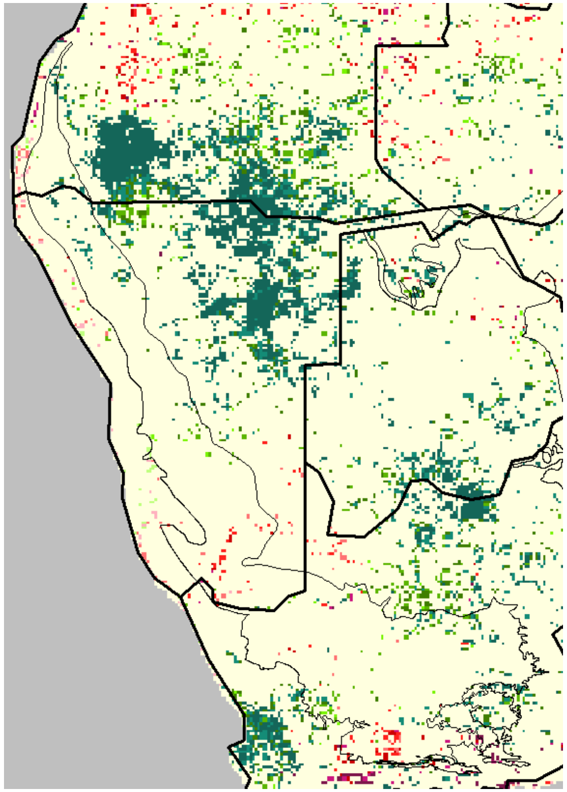
GIMMS NDVI Vegetation Year Trends 2003 - 2010

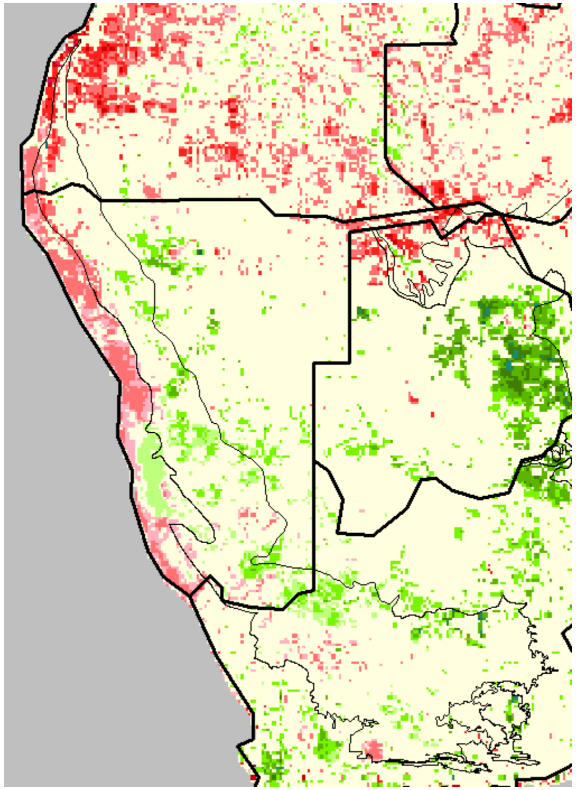


Threshold for significant pearson r: 0.707 (p: 0.05)

MERIS fAPAR trends versus GIMMS trends



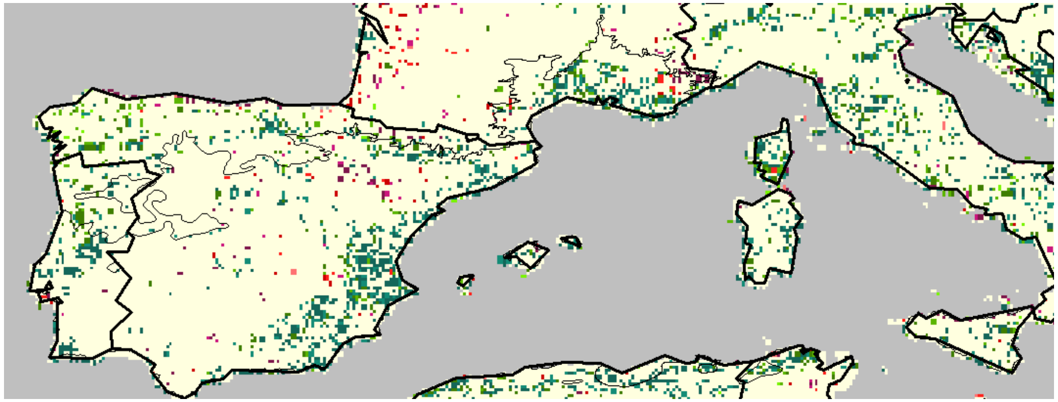




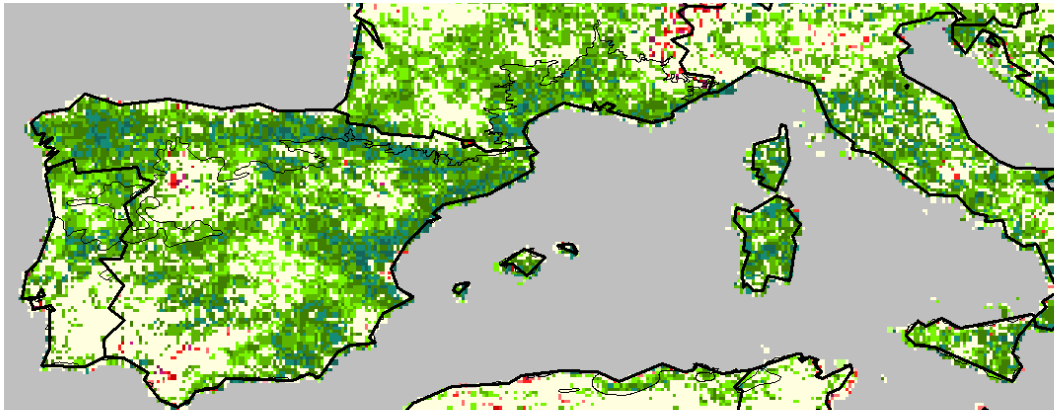
MERIS fAPAR 2003 – 2010 GIMMS NDVI 2003 – 2010 GIMMS NDVI 1982 - 2010

MERIS fAPAR trends versus GIMMS trends

MERIS fAPAR 2003 – 2010

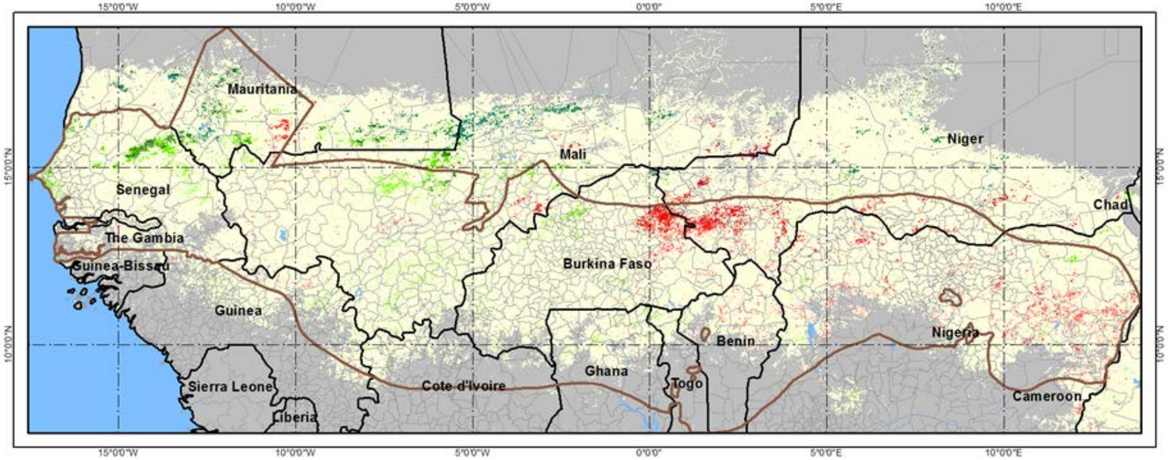


GIMMS NDVI 2003 – 2010

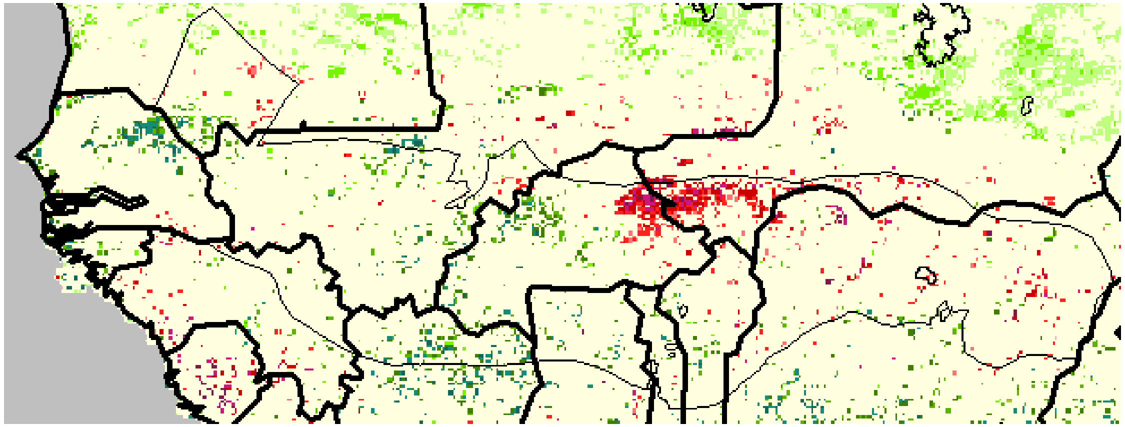


GIMMS NDVI 1982 - 2010

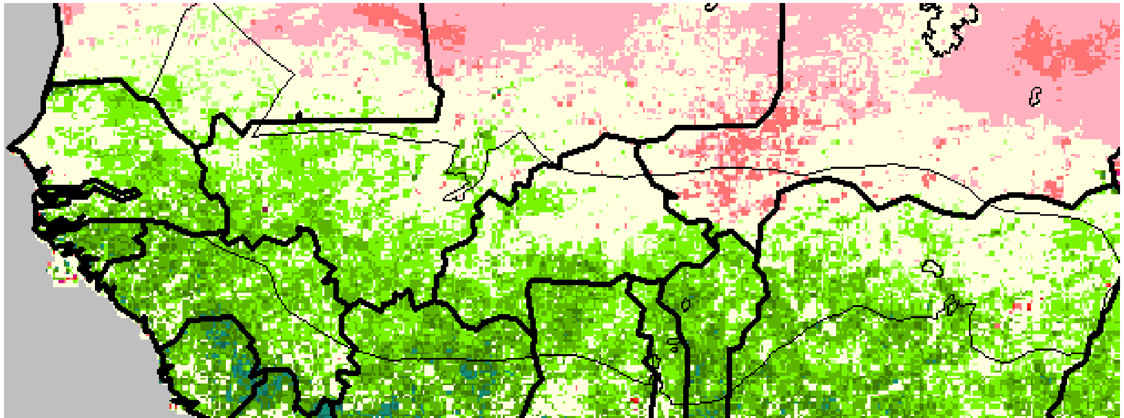
MERIS fAPAR trends versus GIMMS trends



MERIS fAPAR 2003 – 2010

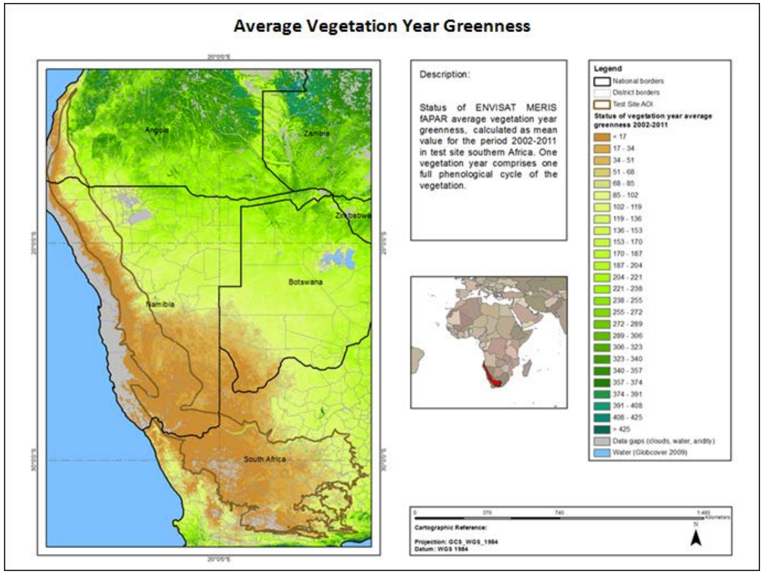


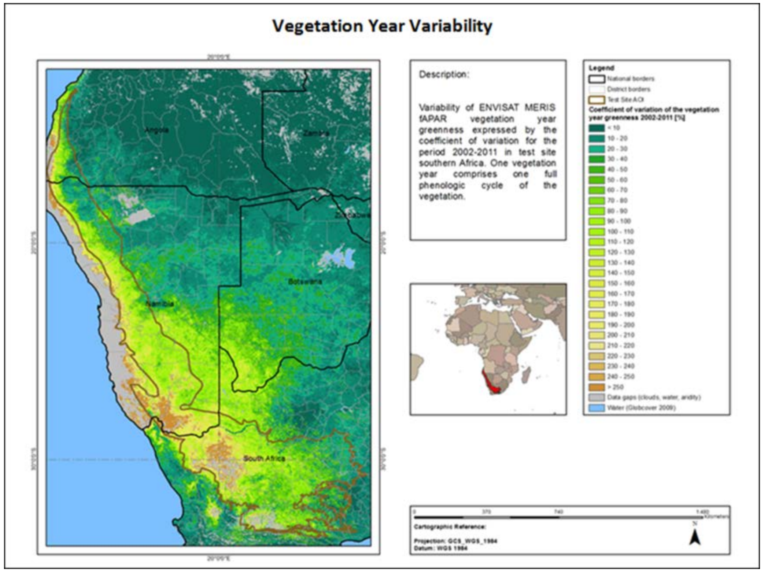
GIMMS NDVI 2003 – 2010

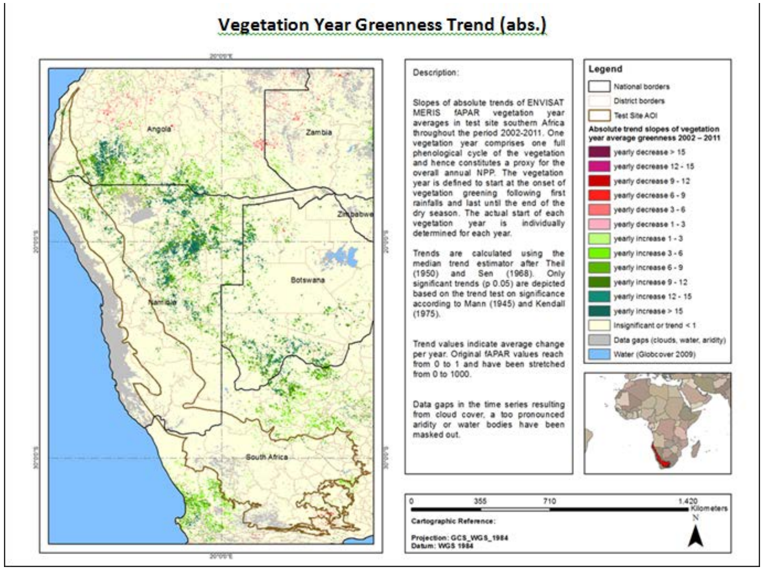


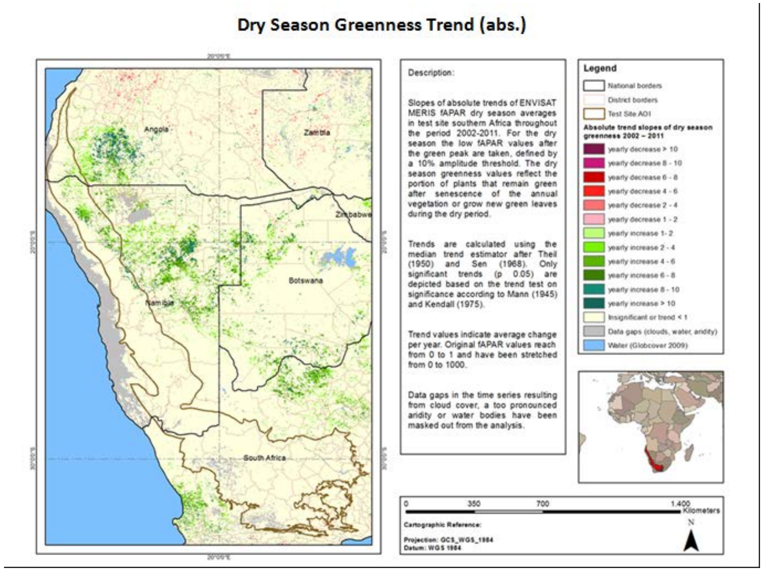
GIMMS NDVI 1982 - 2010

First order product examples: Southern Africa West

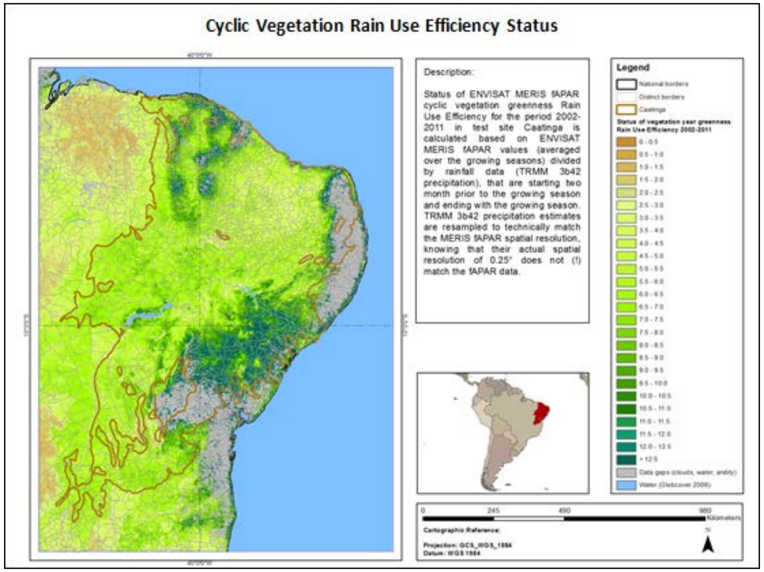


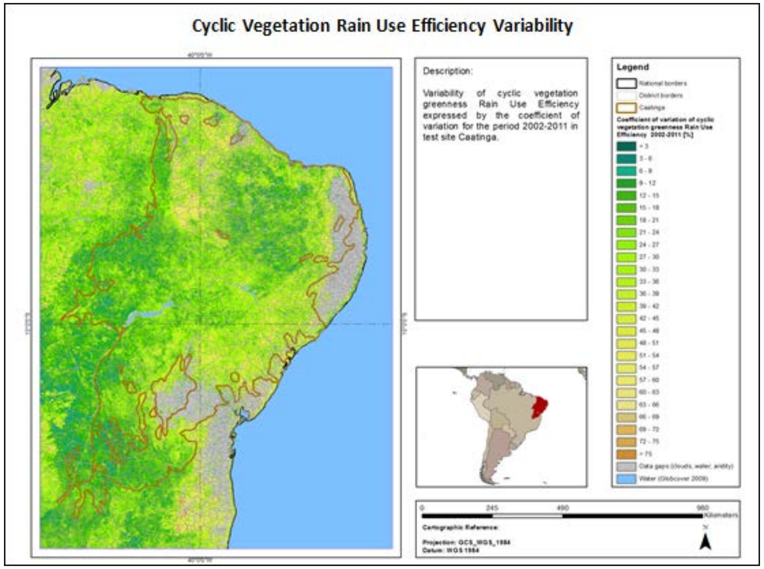


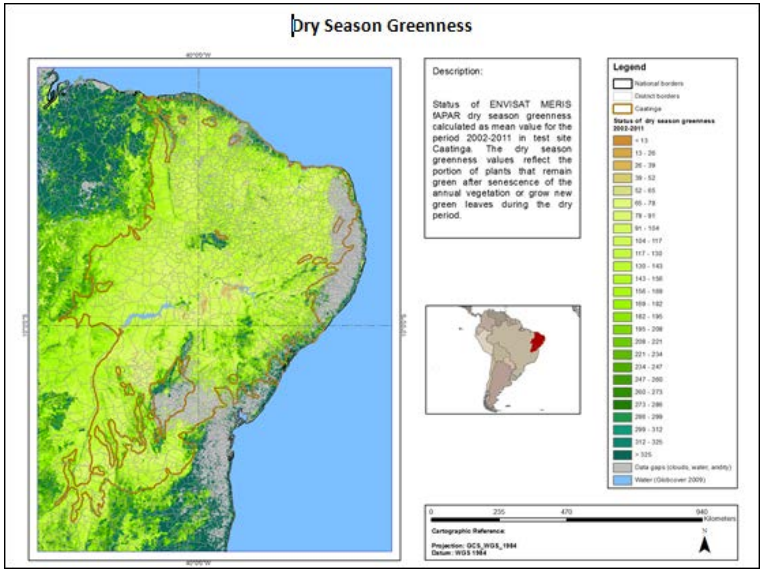


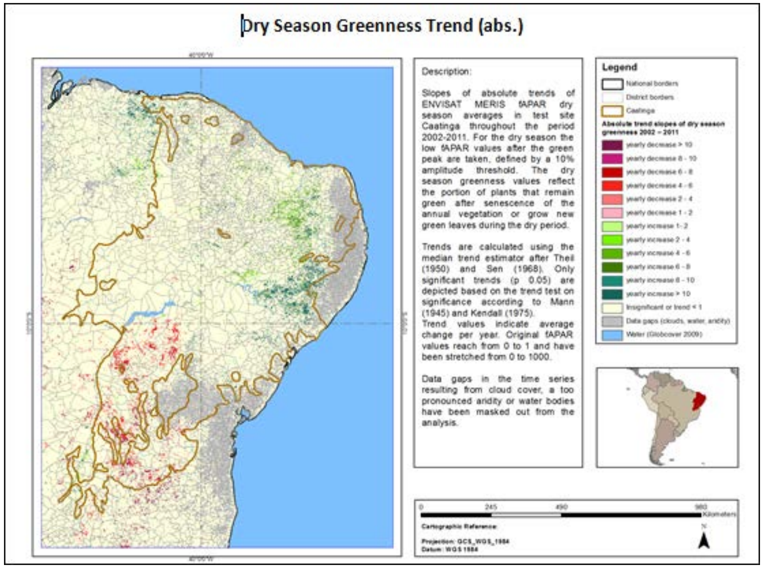


First order product examples: Caatinga, Brazil

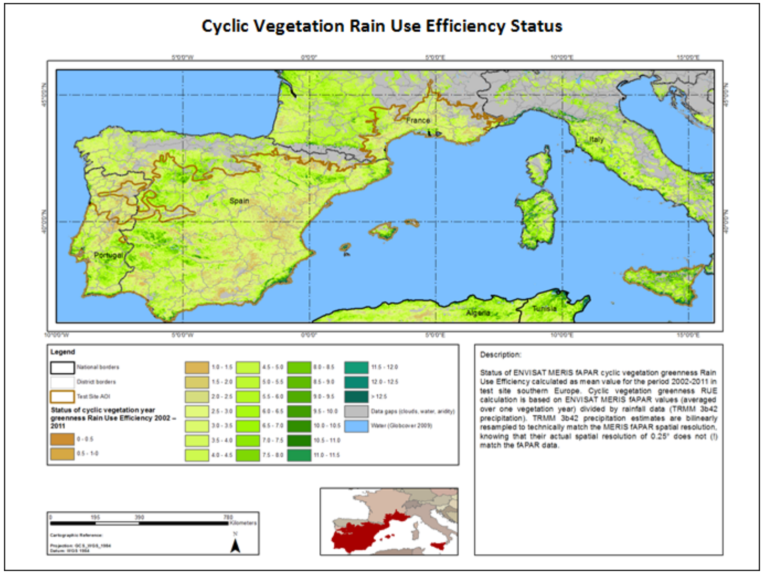


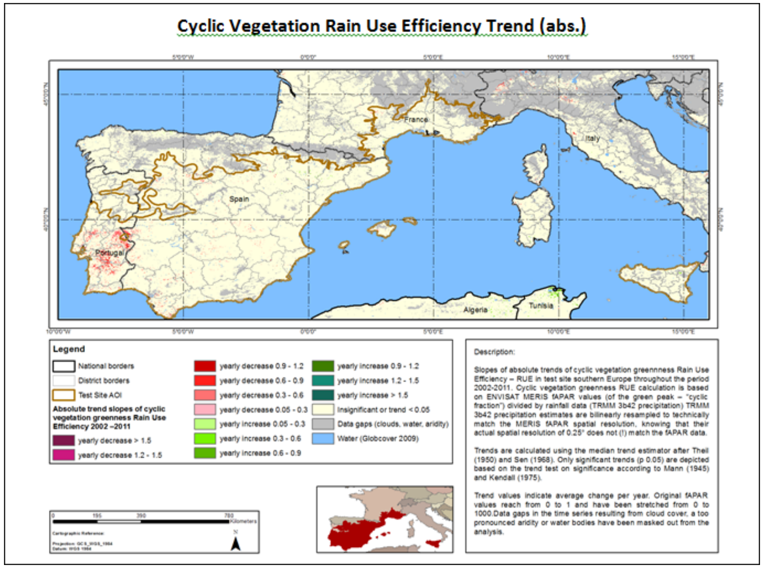


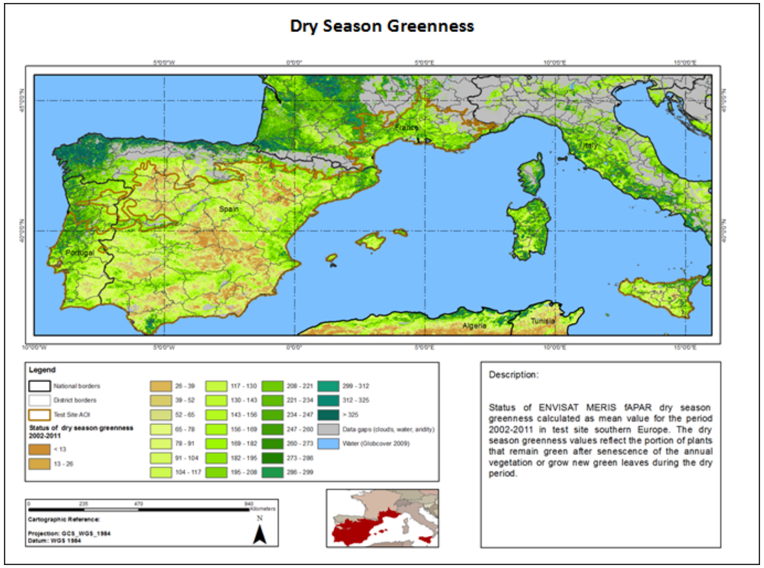


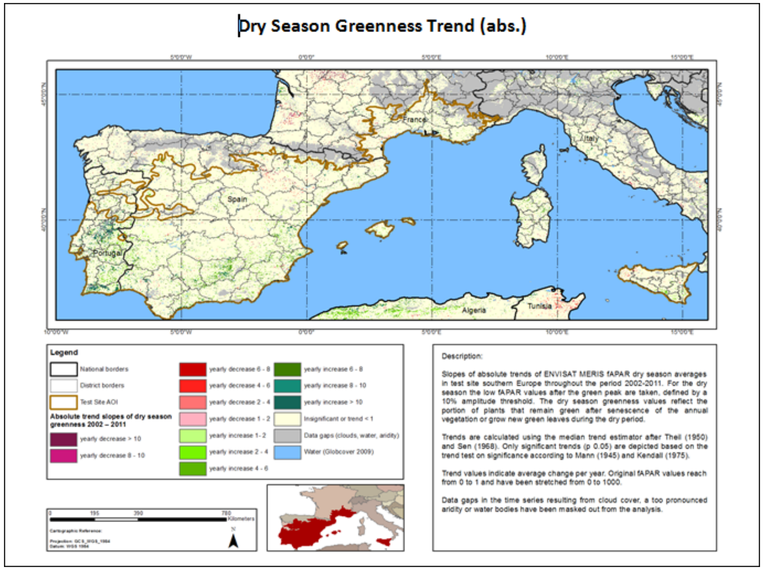


First order product examples: Southern Europe

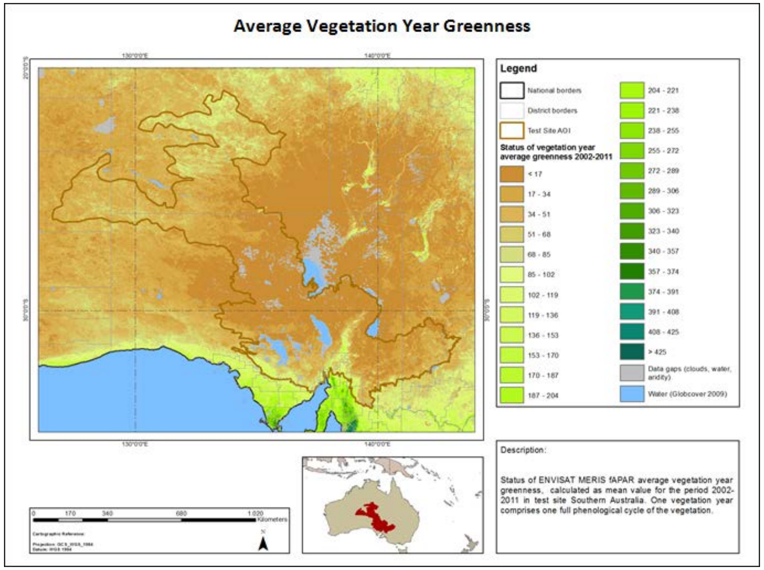


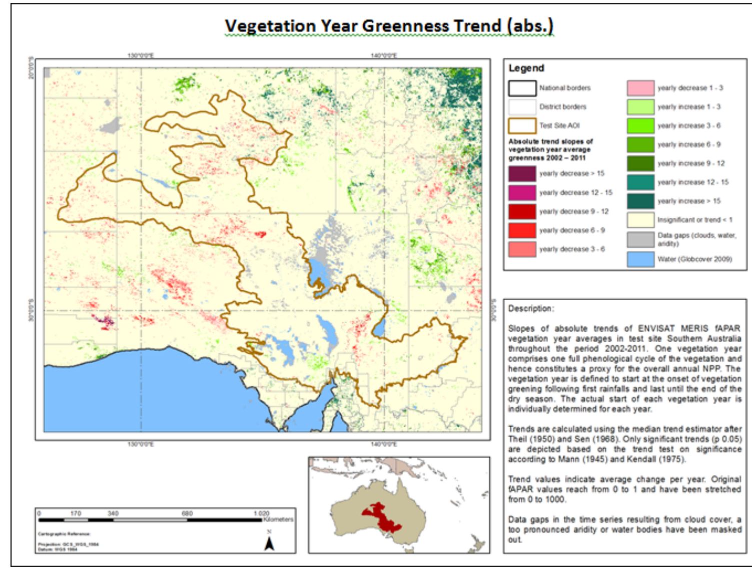


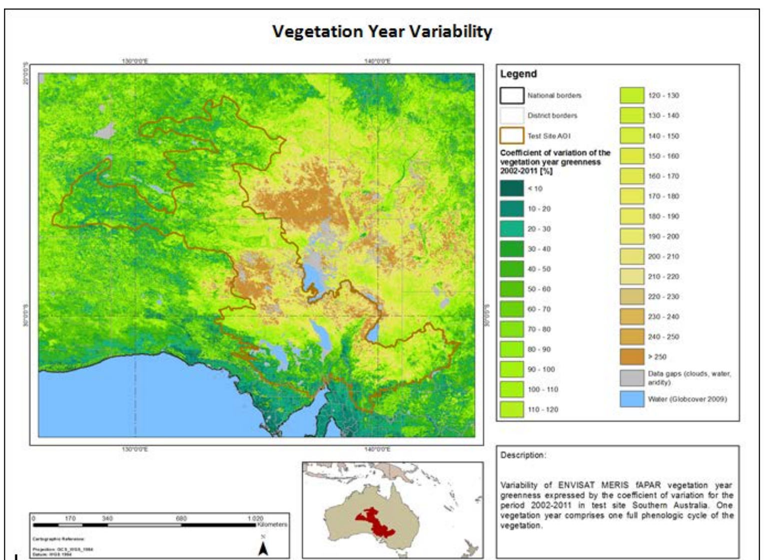


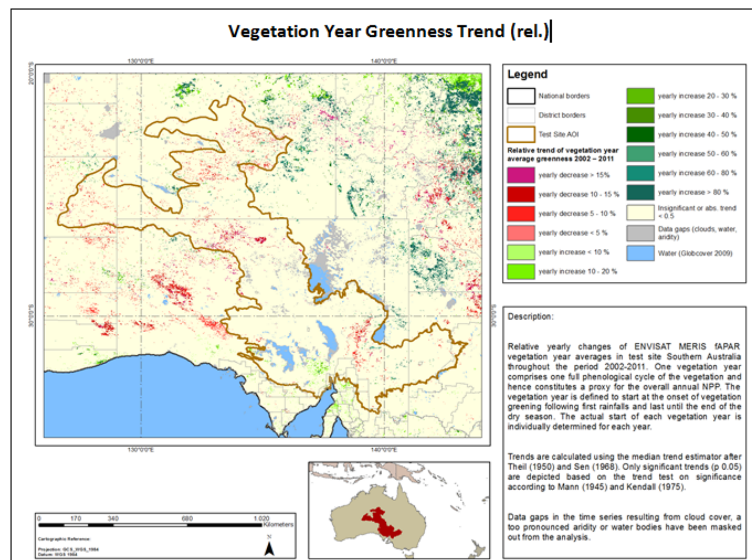


First order product examples: Southern Australia

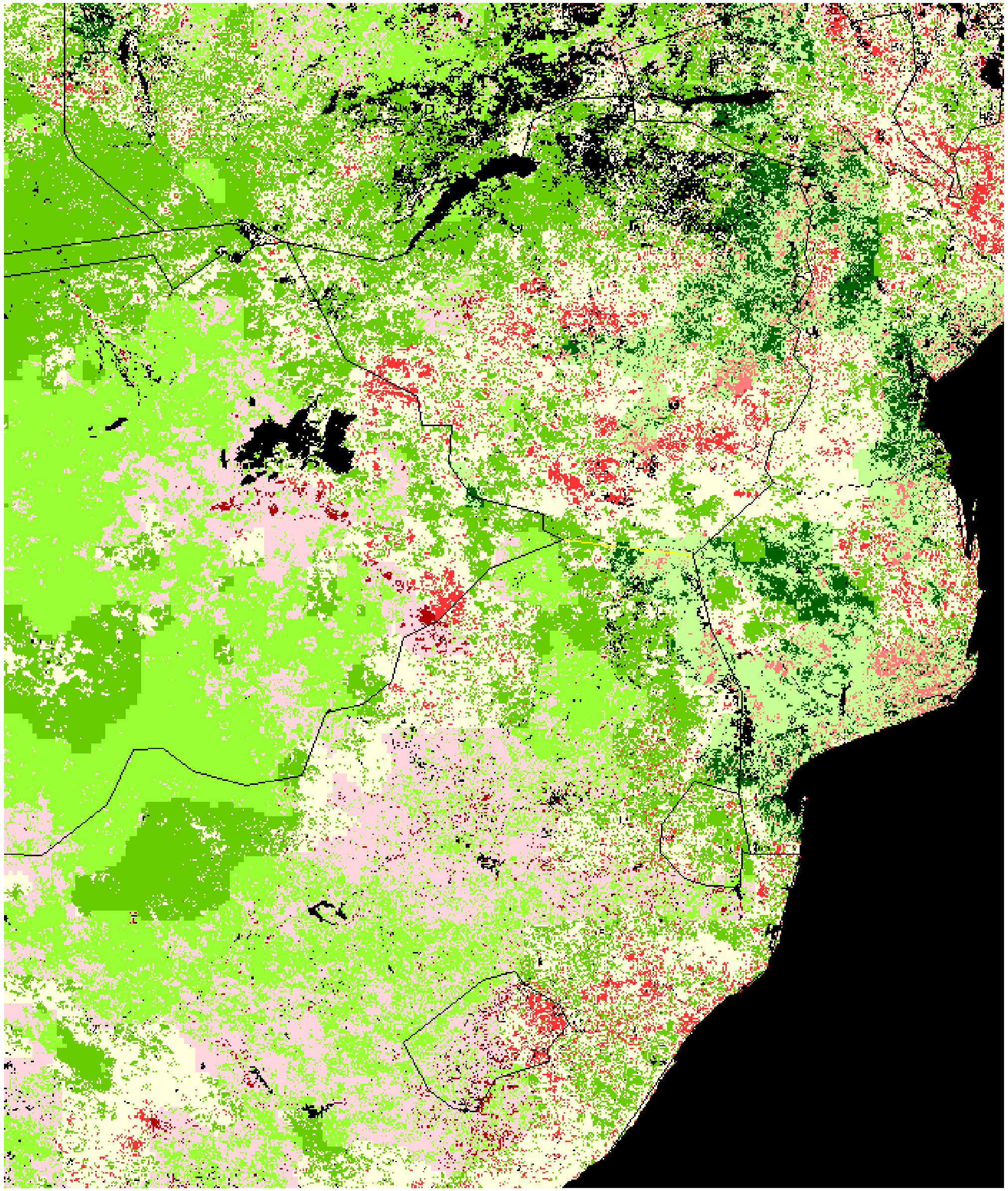








Direct NPP Proxy – rainfall relation



- rain pos., veg. neg.
- rain no (sig.) trend, veg. neg.
- rain neg. veg. neg.
- rain pos., veg. no (sig.) trend
- rain neg., veg. no (sig.) trend
- rain pos., veg. pos.
- rain no (sig.) trend, veg. pos.
- rain neg., veg. pos.
- rain and veg. no (sig.) trend
- water, ice, no data

Thank you for your attention !