Diversity II – Preliminary Dryland Products

Booklet for Test Site 20 Southern Australia

Team

European Space Agency

Project requirement definition; user interface; EO data provision; project control

Brockmann Consult GmbH, Germany

Prime contractor; project management; algorithms for preprocessing including atmospheric correction over land and lakes; software and production

GeoVille, Austria

Drylands requirements analysis; algorithms for drylands; software and production

Brockmann Geomatics AB, Sweden

Biodiversity and user interface; algorithms for in-water retrieval and lake indicators; website, web GIS, communication and outreach

Research Centre in Biodiversity and Genetic Resources CIBIO, Portugal

Requirements engineering, validation

Consultants

Rasmus Fensholt (Uni Copenhagen)

Dr. Kurt Günther (DLR)

Table of Content

Introduction

With the Diversity II project (http://www.diversity2.info/) ESA aims at contributing with EO based methods to the strategic goals of the Convention on Biological Diversity (CBD), especially the supportive goal E: Enhance implementation through participatory planning, knowledge management and capacity building. Besides the CBD and other interested parties, also the UN Convention to Combat Desertification (UNCCD) is a major relevant and interested stakeholder and participating in the User Requirement compilations. The specific aim of this project is to set up an EO-based monitoring scheme for assessment of status, changes and trends of biodiversity and ecosystem NPP (Net Primary Production) in global drylands using moderate resolution EO data. The project is based on Envisat MERIS data and comprises a period of analysis from 2002-2012. Figure 1 gives an overview of the dry land sites which have been selected in the Diversity II project.

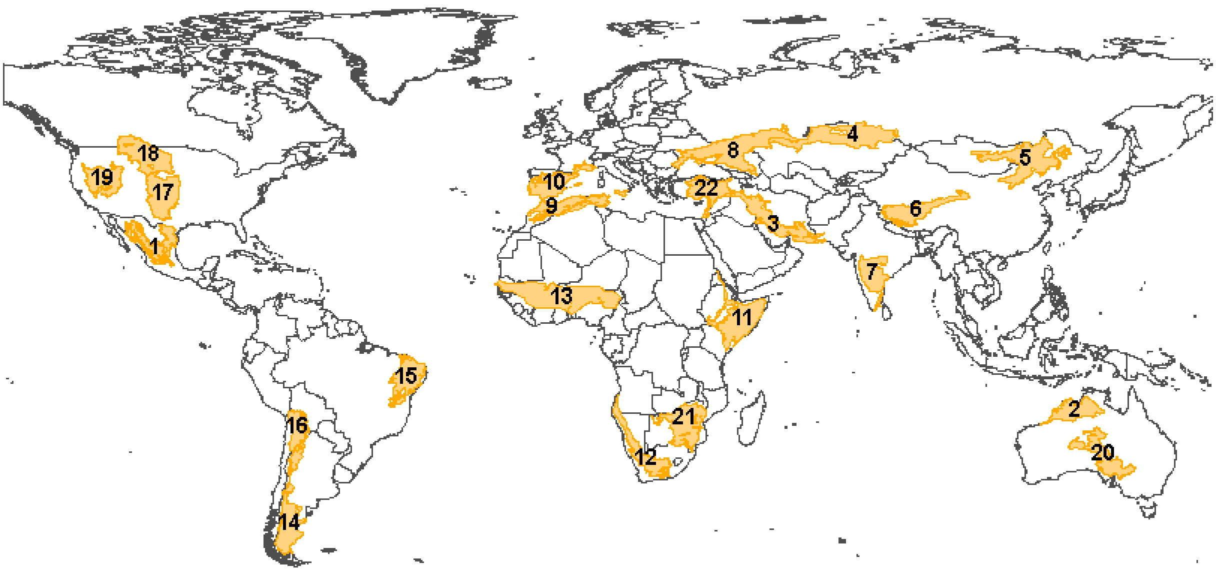


Figure 1: Distribution of global Diversity II dry land sites

Scope of the Preliminary Booklet

This booklet presents NPP proxy and Rain Use Efficiency (RUE) status, change and trend maps for study site 10, Southern Europe along with some basic background information. The booklet is in a preliminary stage and may be changed upon user request to include further or different results of the analyses. The booklets can be downloaded on http://www.diversity2.info/testsites/ppd/.

However, the focus of the booklet is on the most significant and important results of the studies, while complete documentations of methods, techniques and all results will be subject of the project reports. The presented maps can be downloaded via FTP (see page 10 for FTP access).

Up to now, only so-called "Level one" products are shown, i.e. descriptive maps of status and trends of NPP proxies and RUE. They will be supplemented with level-two products, which are currently under development and aim to present the results in more abstract and synthesised ways.

The booklet serves not only to present methods and results in a compact way to users, but also to elicit user feedback. At the end of the booklet (page 32), a short questionnaire is included, aiming at structuring the feedback along some general lines. However, for convenience we recommend to use the on-line questionnaire on http://www.diversity2.info/testsites/ppd/uq/

Overview of Test Site

The map in Figure 2 presents an overview of the study site 20 in the central southern part of Australia. The map on the left-hand side shows the GlobCover v. 2.3 2009 data, which were derived (http://due.esrin.esa.int/globcover/) based on ENVISAT MERIS FR (300m) reflectance data. The GlobCover map shows predominantly sparse vegetation with only minor areas of closed to open grassland or mosaic vegetation. Towards the centre of the test site vegetation becomes more and more sparse.

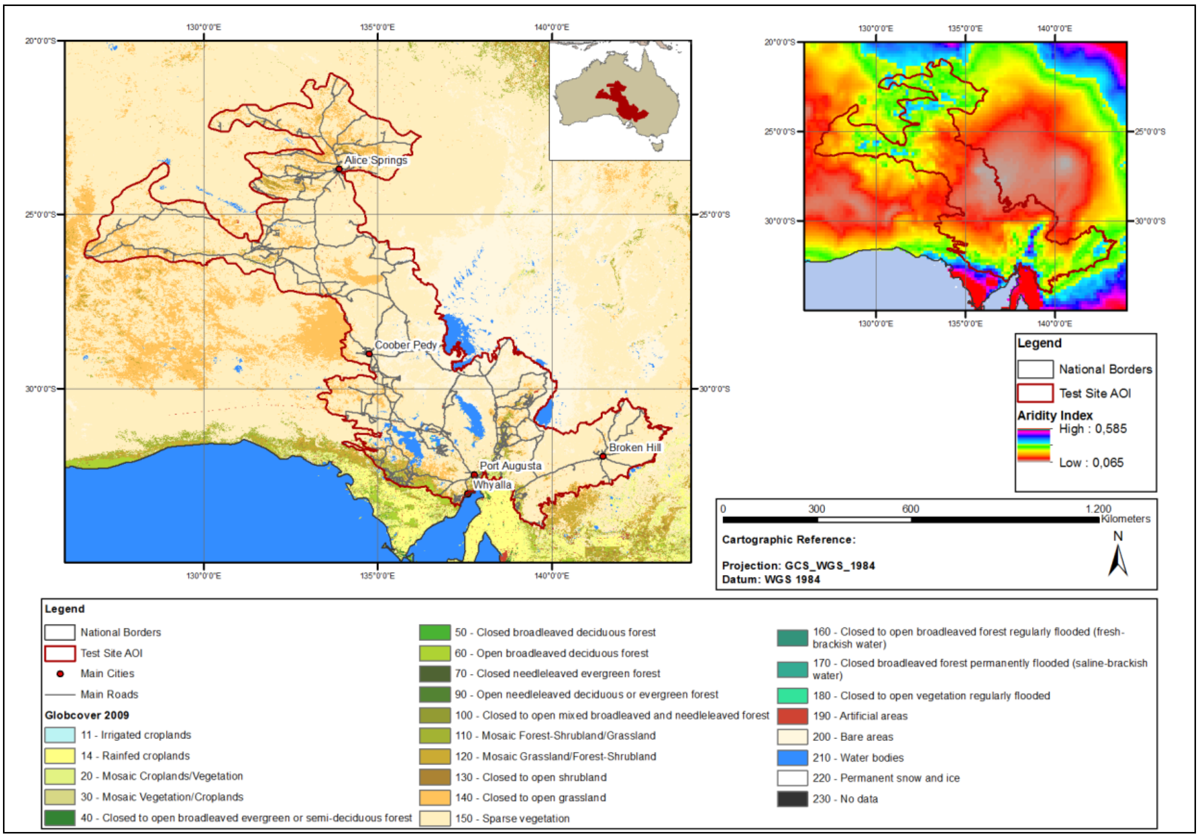


Figure 2: Overview of test site 20, Southern Australia, showing land cover from the GlobCover 2009 data set on the left-hand side and an aridity index map on the right-hand side derived from the CGIAR-CSI global aridity data base

However, the North and especially the South are characterized by denser vegetation cover, mainly closed to open grassland and, towards the South, mosaic vegetation and cropland. This pattern is clearly following the aridity index derived from the CGIAR-CSI global aridity data base (Zomer et. al, 2007, Zomer et. al, 2008) which is depicted on the right-hand side of Figure 2. The CGIAR-CSI global aridity index is computed as ratio of mean annual precipitation and mean annual potential evapotranspiration. Note that declining values indicate increasing aridity. The southern Australian test site comprises aridity values between 0,025 – 0,584 with the majority ranging between 0,025 and 0,2 (following the CGIAR-CSI classification scheme this corresponds to arid-hyperarid conditions).

Figure 3 shows two climographs of Central and Southern Australia, respectively. Both climographs exhibit a similar seasonal behavior. Note, however, that station Alice Springs exhibits a pronounced summer precipitation pattern while Woomera in the south is characterized by a rather equal distribution of rainfall throughout a year.

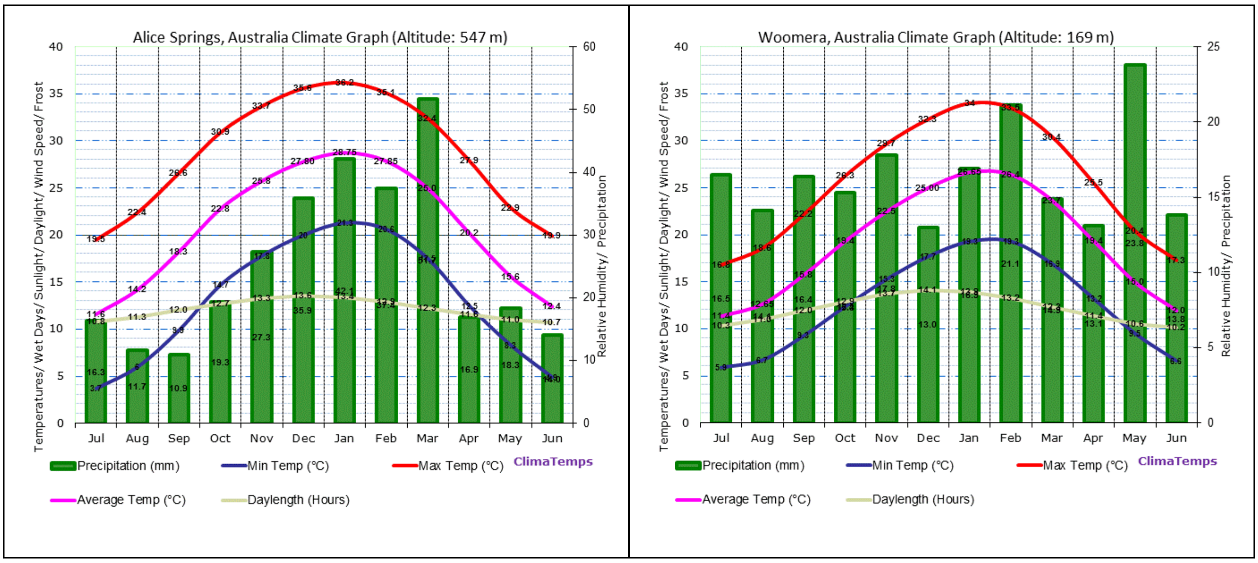


Figure 3: Climographs of Alice Springs (Central Australia) and Woomera (Southern Australia), sources: http://www.alice-springs-amo.climatemps.com/graph.php, http://www.woomera.climatemps.com/graph.php

The seasonal behaviour of the vegetation greenness and important water related parameters are shown in Figure 5. Figure 4 presents the locations of the time series data in all diagrams derived for test site 20, of which time series for location 26 and 30 are presented in Figure 5.

As NPP proxy the NOAA AVHRR GIMMS NDVI (http://gcmd.nasa.gov/records/GCMD_GLCF_GIMMS.html)were used, along with the corresponding rainfall (http://disc.sci.gsfc.nasa.gov/precipitation/documentation/TRMM_README/TRMM_3B42_readme.shtml), CCI soil moisture (http://www.esa-soilmoisture-cci.org/) and MODIS evapotranspiration (http://modis.gsfc.nasa.gov/data/dataprod/dataproducts.php?MOD_NUMBER=16) time series data. All these global data sets are available on the internet free of charge.

The two diagrams shown give an impression of both, the spatial and the temporal variability of rainfall and subsequently of soil moisture and vegetation. MODIS evapotranspiration follows this temporal pattern especially at location 30 that is more characterized by a seasonal pattern of precipitation.

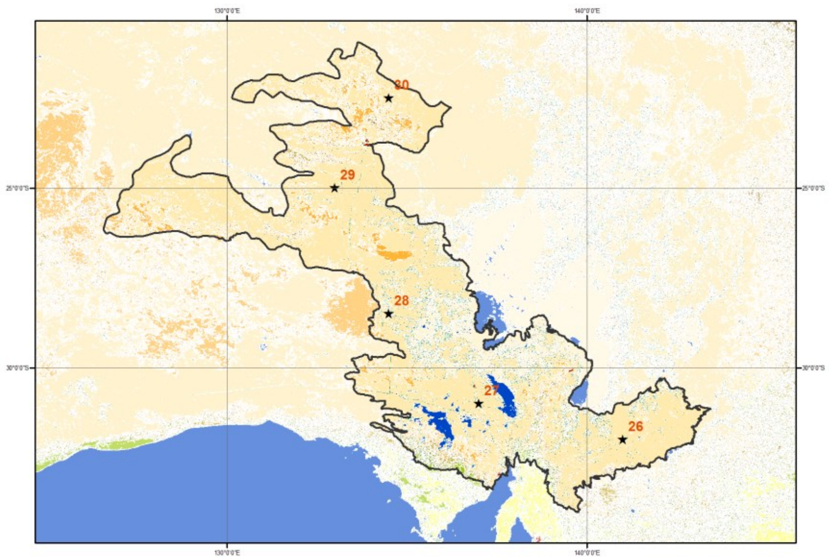


Figure 4: Locations of derived time series diagrams

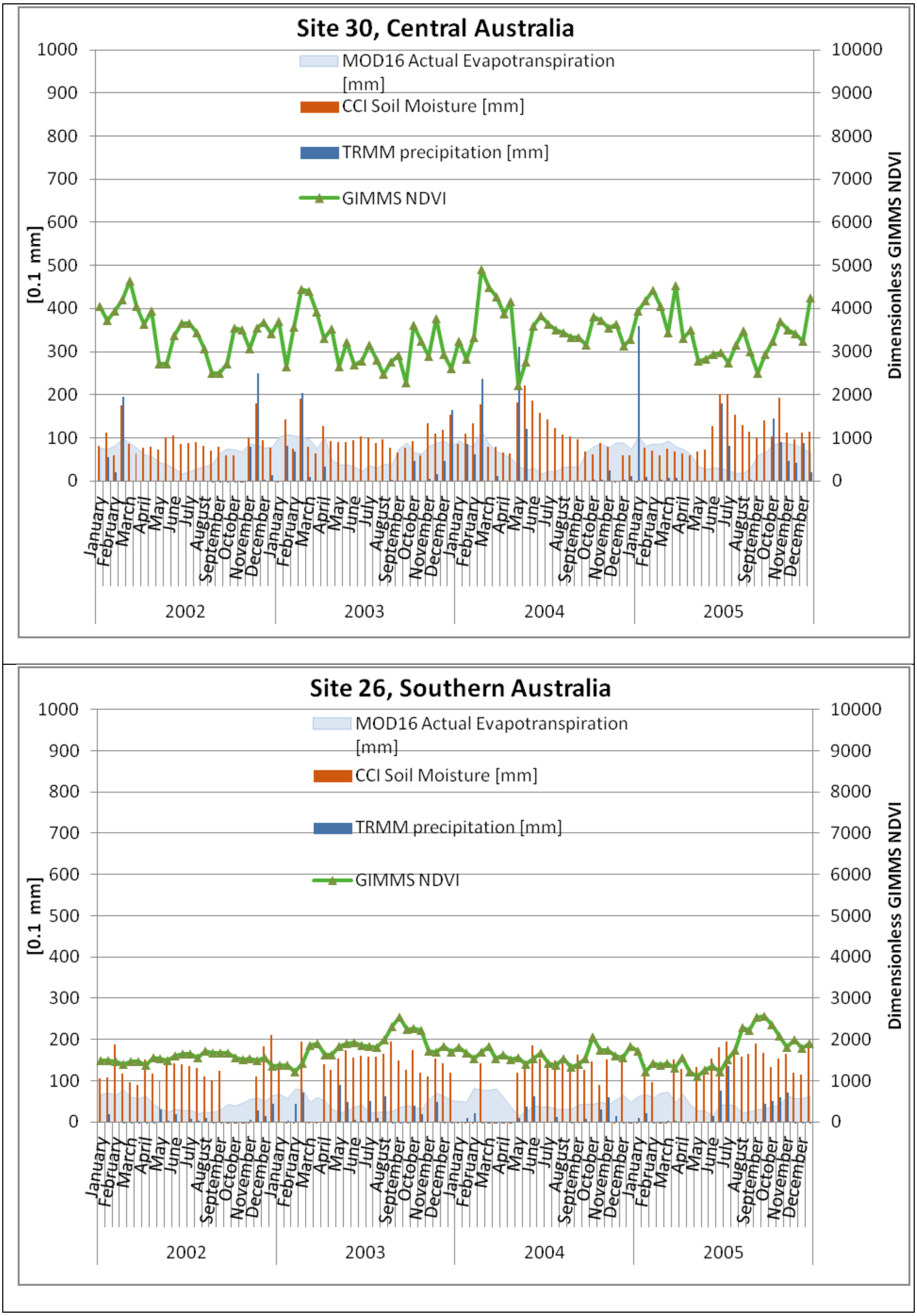


Figure 5: Time series diagrams for locations 30 and 26 in Figure 4

Underlying Data of the Generated Indicators

Based on ENVISAT MERIS FR (Full Resolution) data with a ground resolution of 300m, all NPP proxies presented here and the indicators derived therefrom originate from the fraction of absorbed photosynthetically active radiation (fAPAR) computed according to Gobron et al. 1999. The fAPAR values are compiled on a bi-weekly basis, resulting in time series data with 24 values per calendar year. In addition, TRMM 3b42 rainfall data were used to relate the productivity data to precipitation.

Generation of NPP-Proxies

In a first step, phenological descriptors and periods are derived individually for each year, as shown in Figure 6. The diagram in Figure 6 shows the temporal course of the NPP proxy data (here NOAA GIMMS NDVI) during a 3-years periods and the subdivision into different seasonal periods. The vegetation year includes the full yearly vegetation cycle starting at the end of the preceding dry season and ending at the end of the following dry season – or in case of several green seasons during a year – at or before the begin of the (statistically) dominant green season. The vegetation year length of a given year varies with possible shifts of the green season start time.

The ***vegetation year*** can be subdivided into different periods, limited by defined starting and ending points in time. The ***growing season*** includes ascending (green segment of the curve) and descending parts (brown part) and starts once a selected greenness threshold is surpassed on the way from the start of the vegetation year to the green peak. The brown part of the curve demarcates the ***senescence period***, which ends again once a defined lower fAPAR threshold is passed. The thresholds depend on the ranges between the fAPAR minima before and after the green peak, respectively, and the peak fAPAR value. Here, 10 percent of these ranges added to the respective minima define the thresholds. The ochre part of the vegetation curve constitutes the "***dry season***".

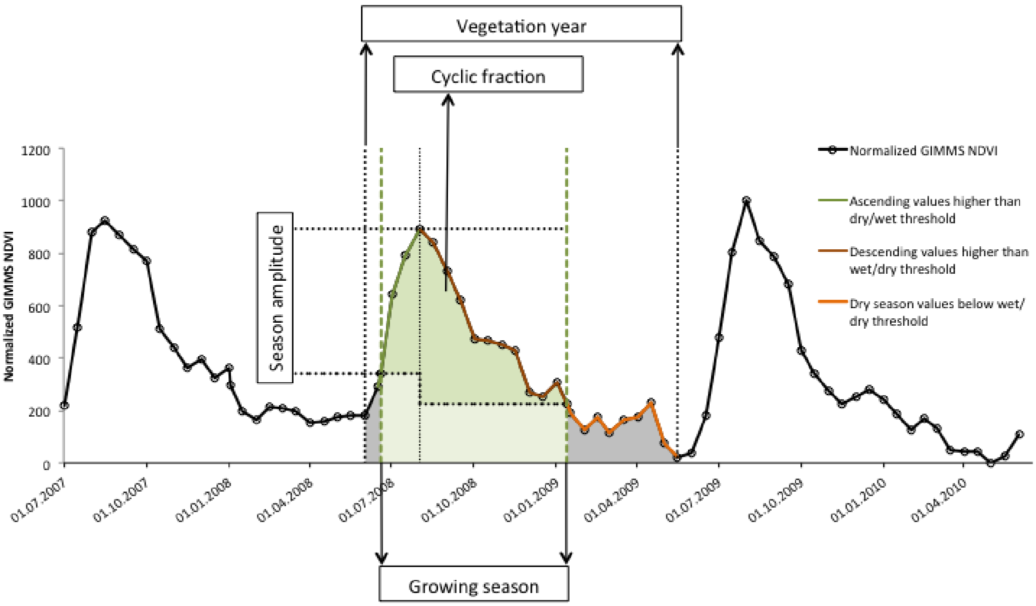


Figure 6: Scheme of the extracted phenological descriptors and periods . Note: the actual NPP proxies are derived based on MERIS fAPAR

For the above described phenological periods, the MERIS fAPAR values have been temporally integrated to either sum or average values, or in case of the season amplitude (figure 4), the difference between the fAPAR at the start of the growing season and the peak fAPAR is taken. The results are called "***NPP proxies***", and constitute yearly (one value per vegetation year) values. The indicator maps presented in this preliminary version of the booklet are based on the following NPP proxies:

- ***Average vegetation year fAPAR:*** Mean value of all fAPAR values within one full vegetation cycle, constituting a proxy for the annual NPP.

- ***Cyclic fraction fAPAR:*** The cyclic fraction of the vegetation comprises summed fAPAR values of the green peak(s) during a vegetation year, subtracting the non-cyclic base levels. The cyclic fraction fAPAR can be interpreted as the amount of NPP that is directly related to the annual cycle of the climatic vegetation growth factors, especially rainfall.

- ***Average dry season fAPAR:*** For the dry season the low fAPAR values after the green peak are taken, defined by a 10% amplitude threshold. The dry season greenness values reflect the portion of plants that remain green after senescence of the annual vegetation or grow new green leaves during the dry period. High dry season levels indicate the presence of shrubs, bushes and trees.

From Proxies to Indicators

By analyzing the annual NPP proxies and rainfall through time, a set of indicators for vegetation/ecosystem condition and change is derived. The indicators shown so far can be divided into status and trend type. Given the MERIS data period from June 2002 to March 2012 and the globally varying vegetation cycles, NPP proxy and Rain Use Efficiency indicators for a total of eight vegetation years could be extracted, starting in 2003/(2002) and ending in 2011/(2012).

Hence, the status and trend indicators cover worldwide eight vegetation years. Status indicators for this period include 8-year averages and the coefficients of variation. In addition, the 8-year period was subdivided into two epochs covering four vegetation years each. The corresponding epochal status maps and epochal difference maps are not shown in this booklet.

For the trend indicators, absolute and relative trends are shown. They were derived with the non parametric Theil Sen trend slope estimator (Theil 1950, Sen 1968) and limited with the Mann Kendall significance test (Kendall 1962) to trends with a probability greater than 0.95.

All indicator maps show distinct ranges of the original continuous values, using the same class intervals and colour scheme worldwide.

Maps of Indicators

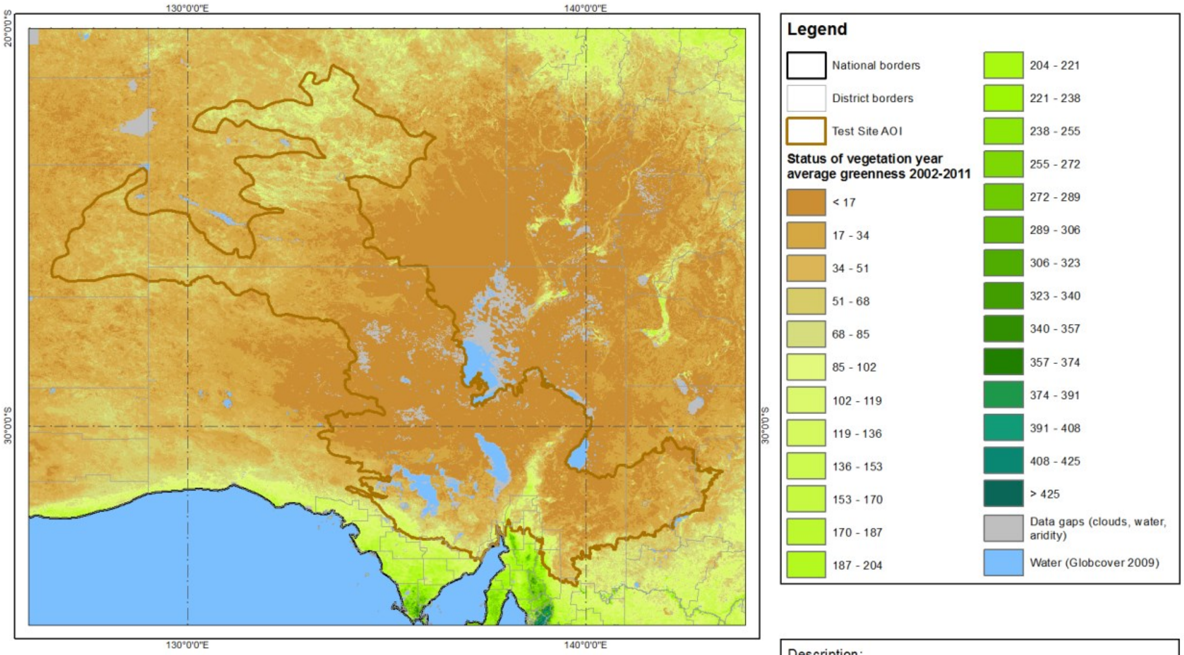
The following section contains maps for the entire test site and surrounding regions for each indicator product. The first two maps of each item depict status and variability maps while the third and fourth map show absolute and relative trends maps, respectively. An exception is the rainfall maps, where instead of the relative trend the difference between the two epochs (2002 – 2006 and 2007 – 2011, respectively) is shown. The maps are described with short product specifications.

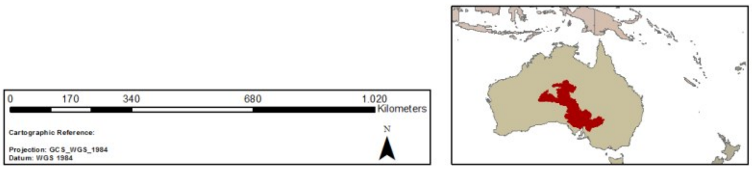
They can be downloaded from:

Domain: ftp.brockmann-consult.de

Username: diversity-pub
Password: dl&iw-usr

Average Vegetation Year Greenness

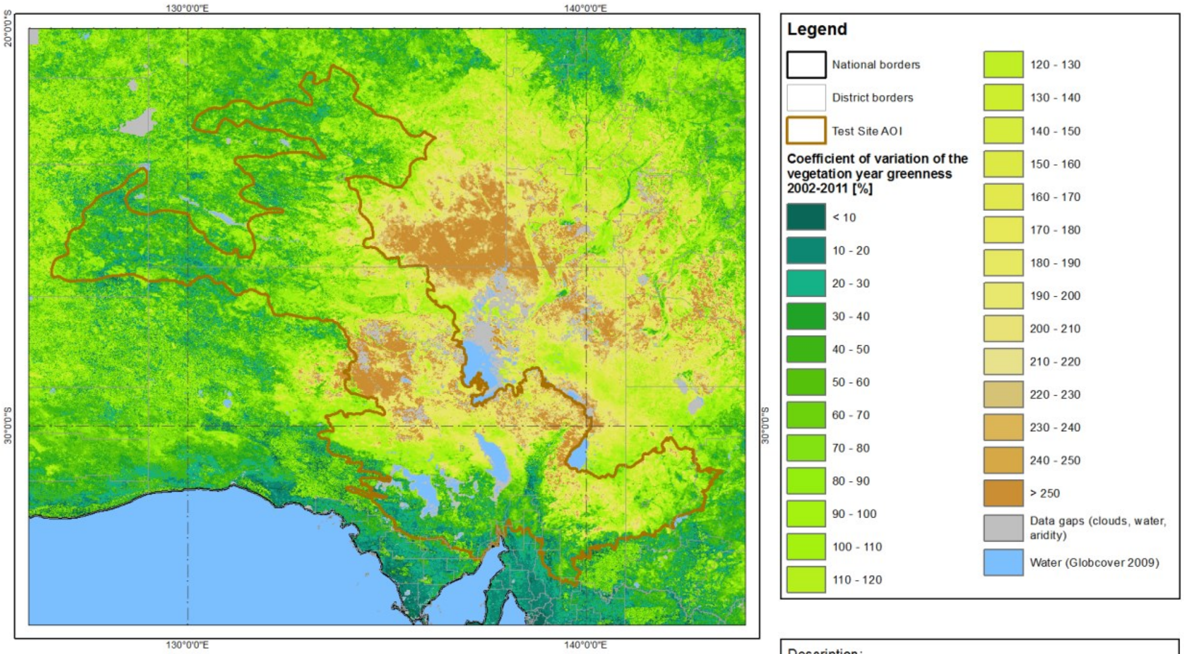


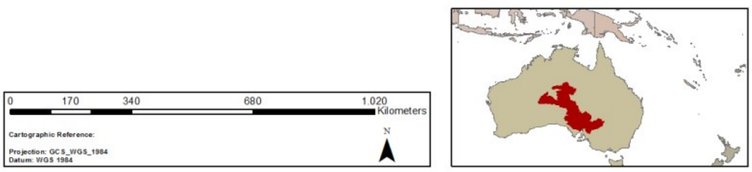


Description:

Status of ENVISAT MERIS fAPAR average vegetation year greenness, calculated as mean value for the period 2002-2011 in test site Southern Australia. One vegetation year comprises one full phenological cycle of the vegetation.

Vegetation Year Variability

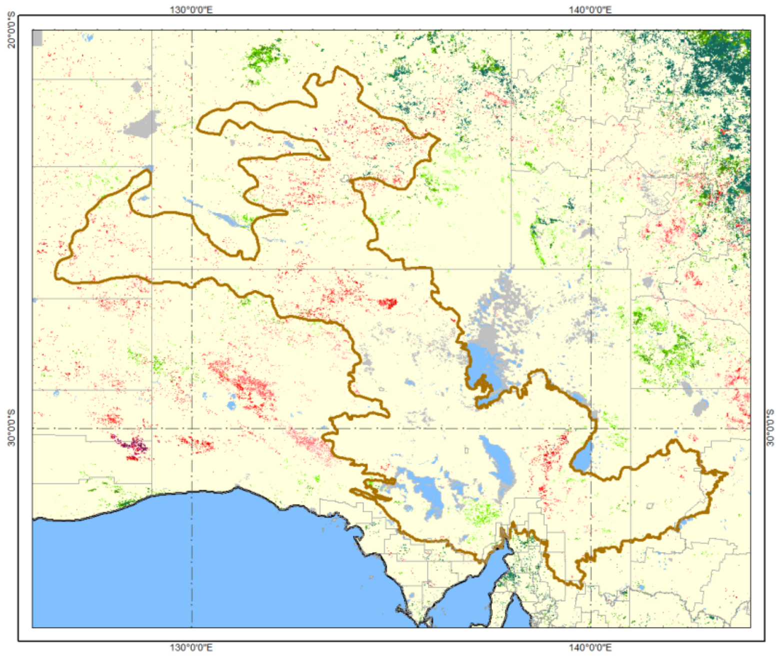


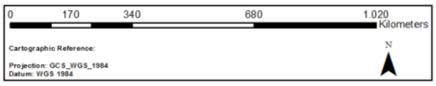


Description:

Variability of ENVISAT MERIS fAPAR vegetation year greenness expressed by the coefficient of variation for the period 2002-2011 in test site Southern Australia. One vegetation year comprises one full phenologic cycle of the vegetation.

Vegetation Year Greenness Trend (abs.)





Legend

- National borders
- District borders
- Test Site AOI

Absolute trend slopes of vegetation year average greenness 2002 – 2011

- yearly decrease > 15
- yearly decrease 12 - 15
- yearly decrease 9 - 12
- yearly decrease 6 - 9
- yearly decrease 3 - 6
- yearly decrease 1 - 3
- yearly increase 1 - 3
- yearly increase 3 - 6
- yearly increase 6 - 9
- yearly increase 9 - 12
- yearly increase 12 - 15
- yearly increase > 15
- Insignificant or trend < 1
- Data gaps (clouds, water, aridity)
- Water (Globcover 2009)

Description:

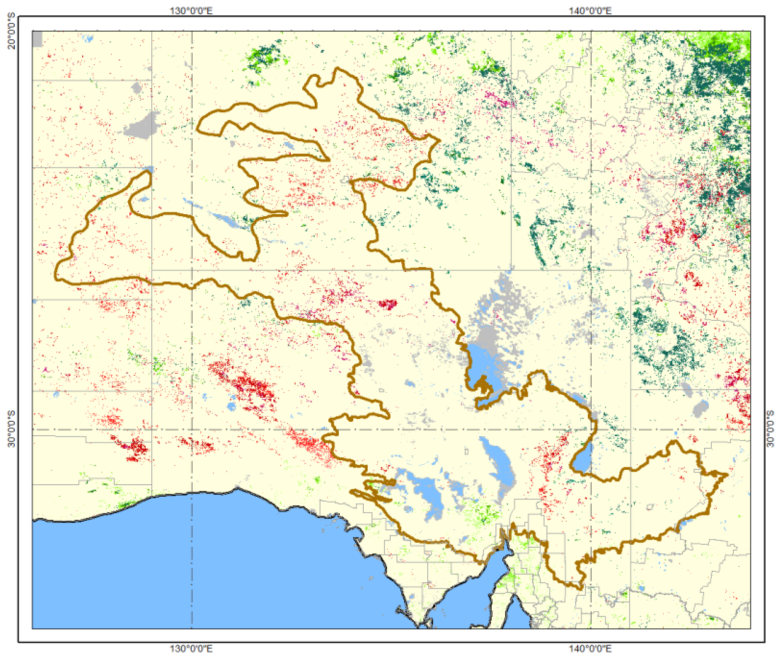
Slopes of absolute trends of ENVISAT MERIS fAPAR vegetation year averages in test site Southern Australia throughout the period 2002-2011. One vegetation year comprises one full phenological cycle of the vegetation and hence constitutes a proxy for the overall annual NPP. The vegetation year is defined to start at the onset of vegetation greening following first rainfalls and last until the end of the dry season. The actual start of each vegetation year is individually determined for each year.

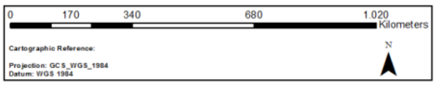
Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

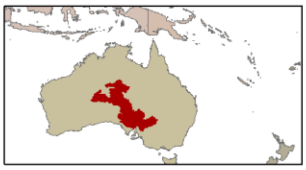
Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.

Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out.

Vegetation Year Greenness Trend (rel.)







Legend

- National borders
- District borders
- Test Site AOI

Relative trend of vegetation year average greenness 2002 – 2011

- yearly decrease > 15%
- yearly decrease 10 - 15 %
- yearly decrease 5 - 10 %
- yearly decrease < 5 %
- yearly increase < 10 %
- yearly increase 10 - 20 %
- yearly increase 20 - 30 %
- yearly increase 30 - 40 %
- yearly increase 40 - 50 %
- yearly increase 50 - 60 %
- yearly increase 60 - 80 %
- yearly increase > 80 %
- Insignificant or abs. trend < 0.5
- Data gaps (clouds, water, aridity)
- Water (Globcover 2009)

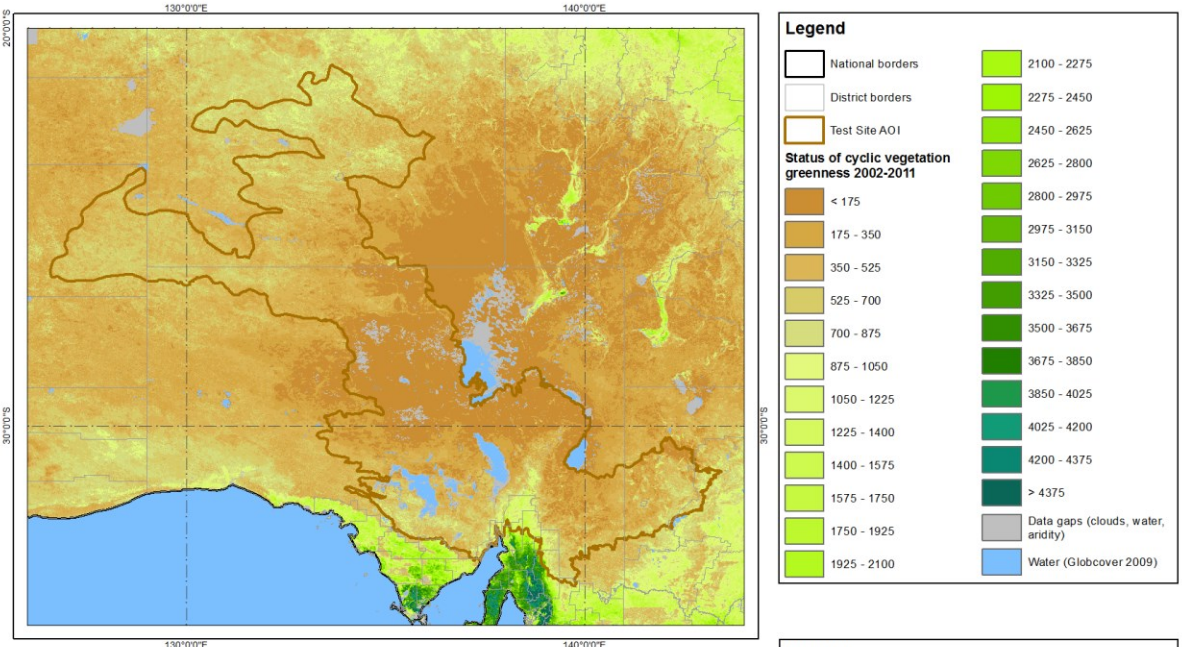
Description:

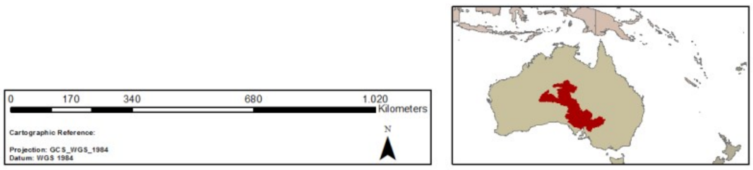
Relative yearly changes of ENVISAT MERIS fAPAR vegetation year averages in test site Southern Australia throughout the period 2002-2011. One vegetation year comprises one full phenological cycle of the vegetation and hence constitutes a proxy for the overall annual NPP. The vegetation year is defined to start at the onset of vegetation greening following first rainfalls and last until the end of the dry season. The actual start of each vegetation year is individually determined for each year.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Cyclic Vegetation Greenness

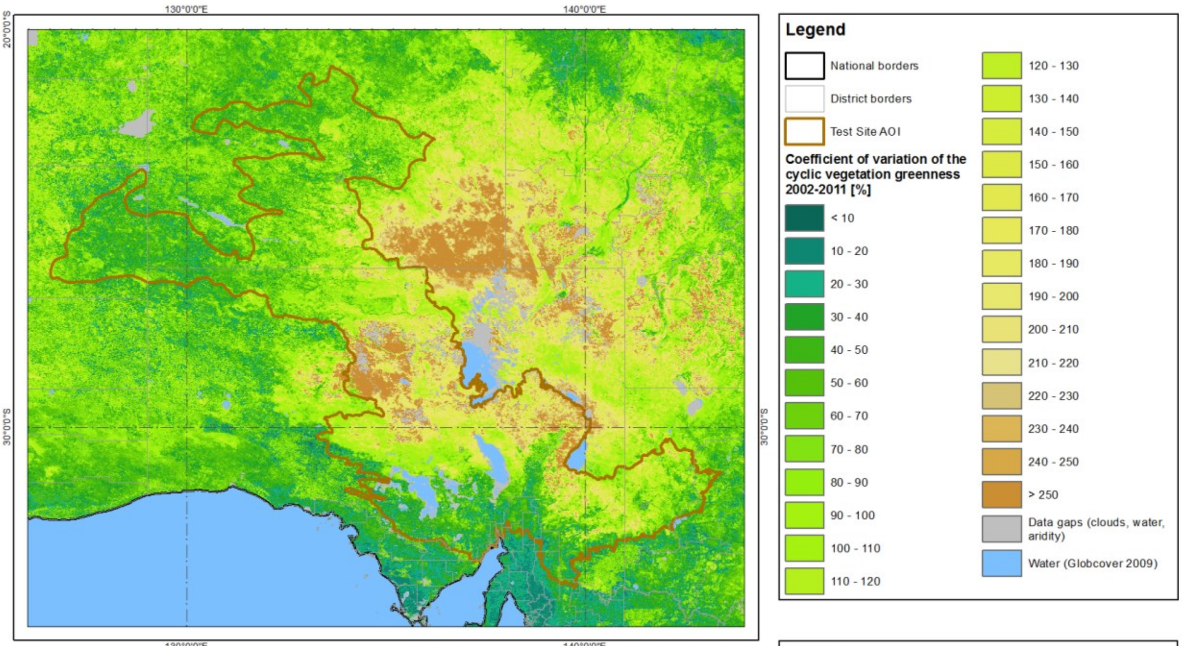


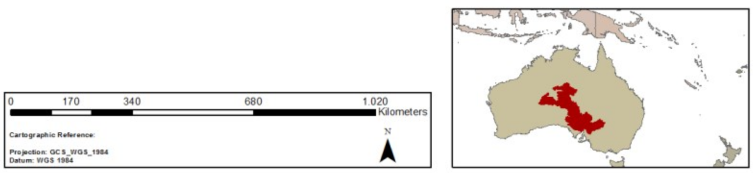


Description:

Status of ENVISAT MERIS fAPAR cyclic vegetation greenness calculated as mean value for the period 2002-2011 in test site Southern Australia. The cyclic fraction of the vegetation comprises summed fAPAR values of the green peak(s) during a vegetation year, subtracting the non-cyclic base levels.

Cyclic Vegetation Variability

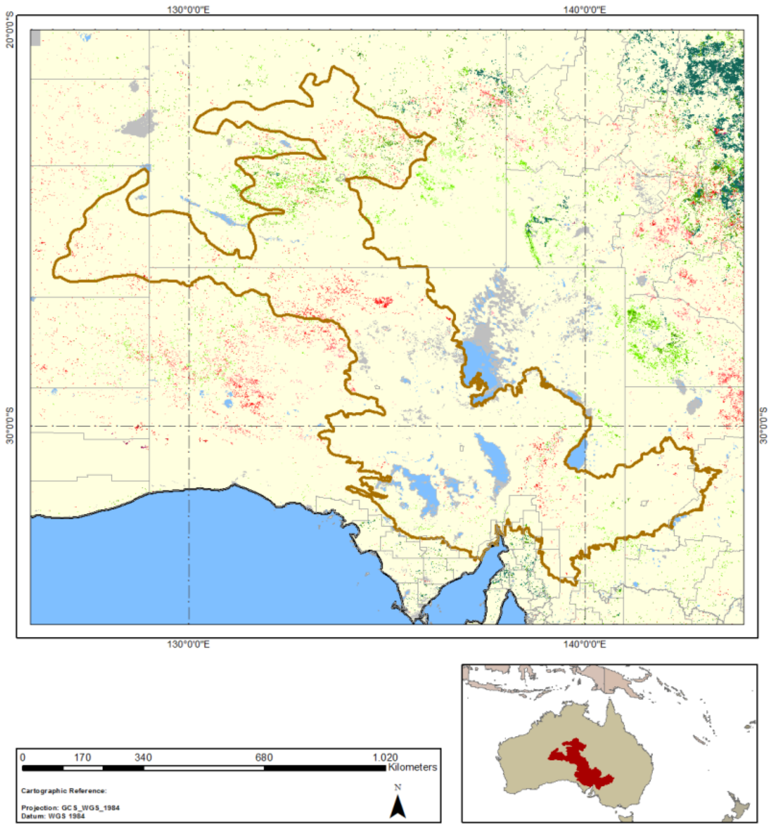


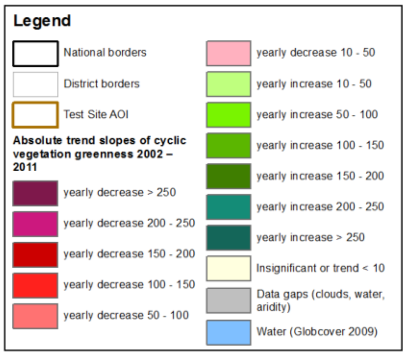


Description:

Variability of ENVISAT MERIS fAPAR cyclic vegetation greenness expressed by the coefficient of variation for the period 2002-2011 in test site Southern Australia. The cyclic fraction of the vegetation comprises summed fAPAR values of the green peak(s) during a vegetation year, subtracting the non-cyclic base levels.

Cyclic Vegetation Greenness Trend (abs.)





Description:

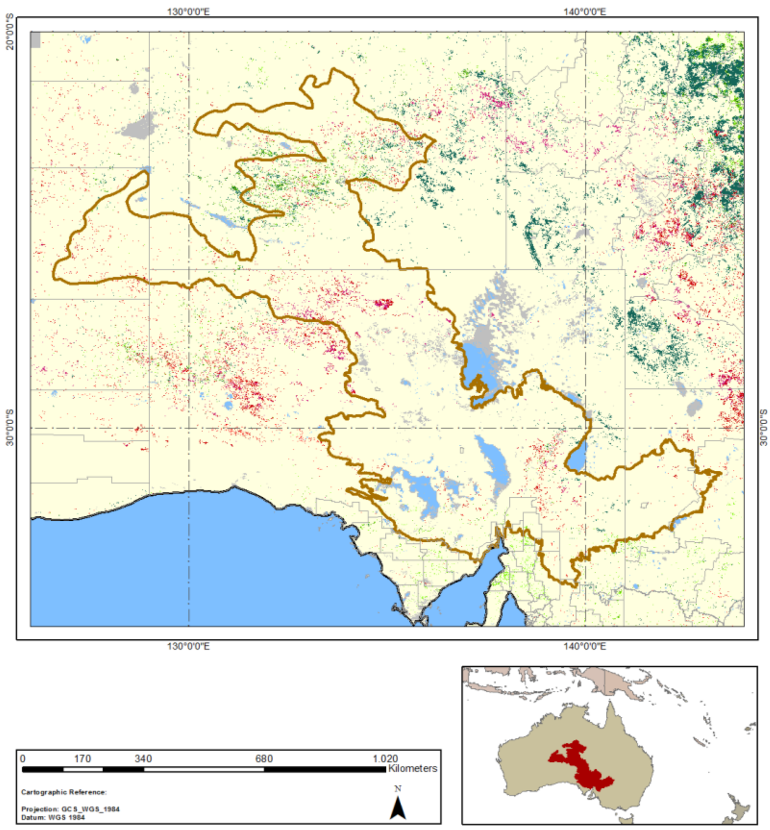
Slopes of absolute trends of ENVISAT MERIS fAPAR "cyclic fraction" values in test site Southern Australia throughout the period 2002-2011. The cyclic fraction of the vegetation comprises summed fAPAR values of the green peak(s) during a vegetation year, subtracting the non-cyclic base levels. The cyclic fraction fAPAR can be interpreted as the amount of NPP being directly related to the annual cycle of the climatic vegetation growth factors, especially rainfall.

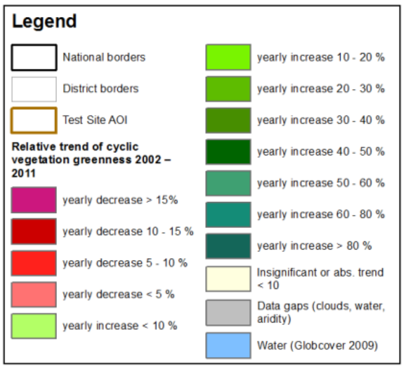
Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.

Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Cyclic Vegetation Greenness Trend (rel.)





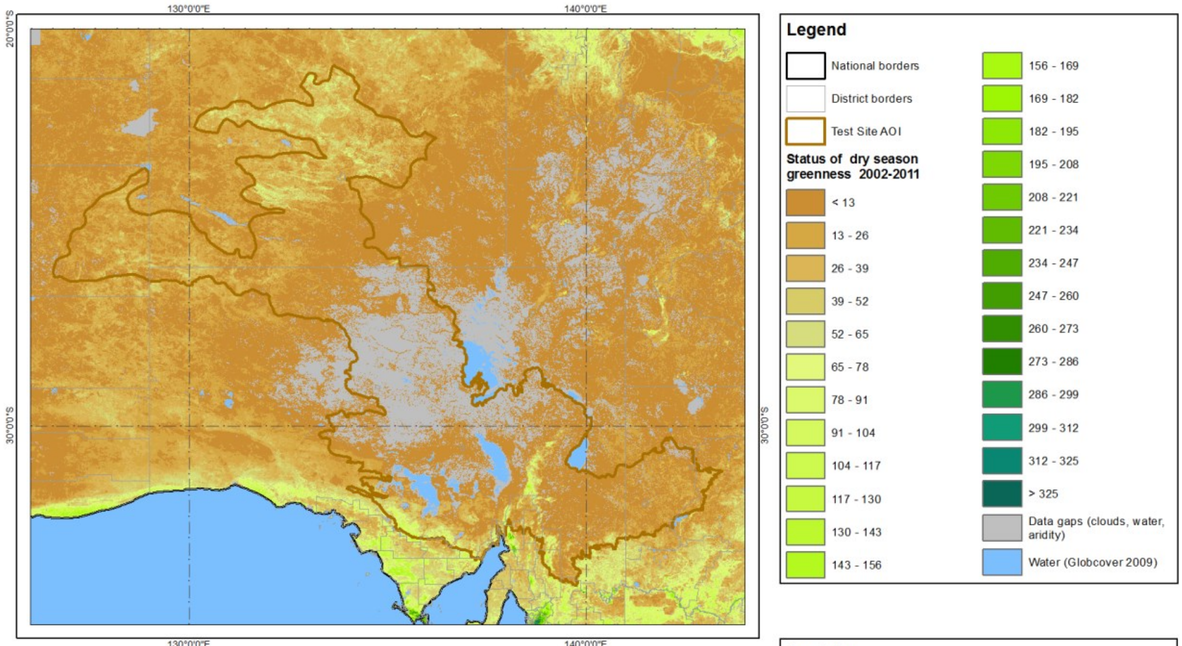
Description:

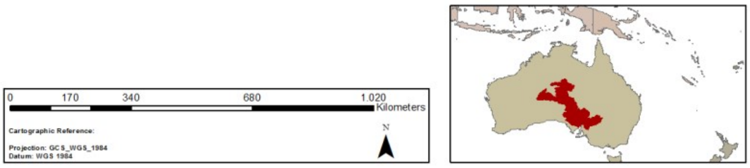
Relative yearly changes of ENVISAT MERIS fAPAR "cyclic fraction" values in test site Southern Australia throughout the period 2002-2011. The cyclic fraction of the vegetation comprises summed fAPAR values of the green peak(s) during a vegetation year, subtracting the non-cyclic base levels. The cyclic fraction fAPAR can be interpreted as the amount of NPP being directly related to the annual cycle of the climatic vegetation growth factors, especially rainfall.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Dry Season Greenness

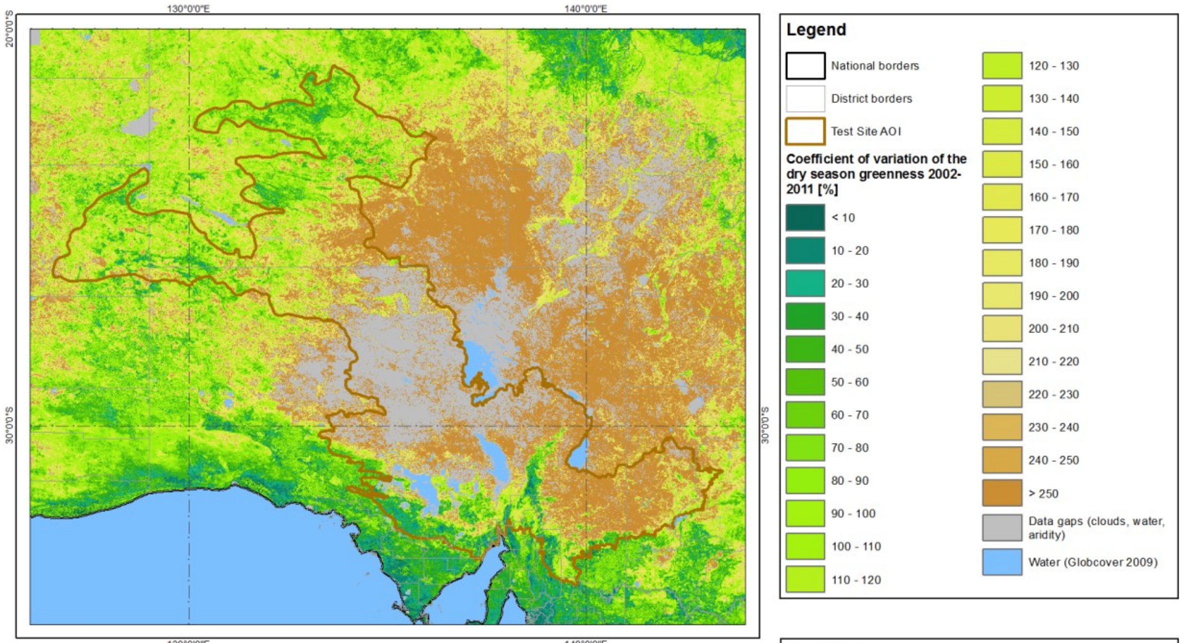


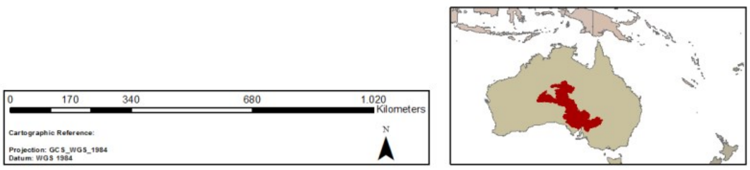


Description:

Status of ENVISAT MERIS fAPAR dry season greenness calculated as mean value for the period 2002-2011 in test site Southern Australia. The dry season greenness values reflect the portion of plants that remain green after senescence of the annual vegetation or grow new green leaves during the dry period.

Dry Season Variability

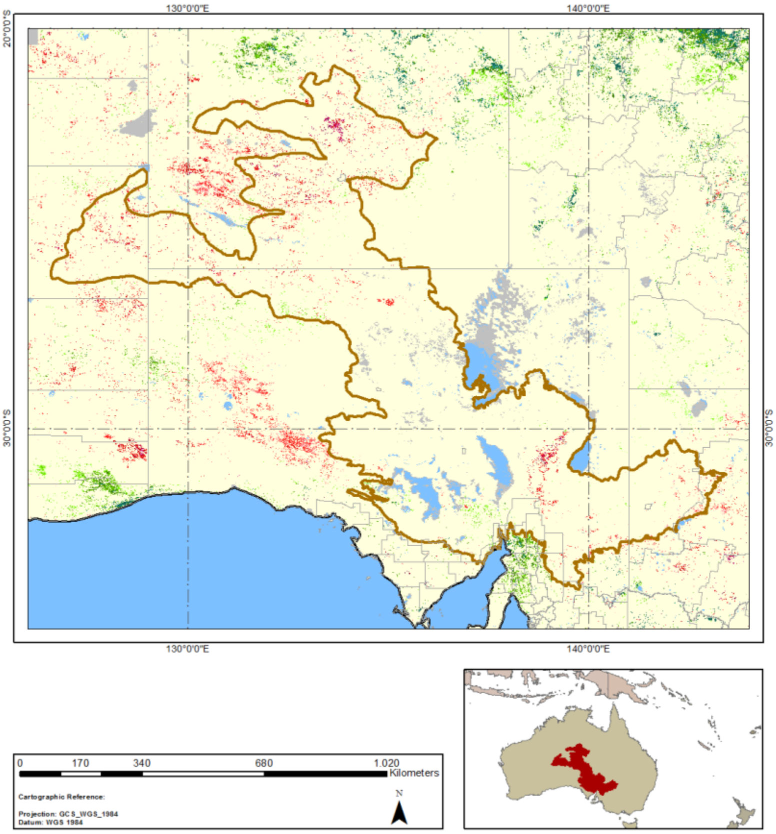




Description:

Variability of ENVISAT MERIS fAPAR dry season greenness expressed by the coefficient of variation for the period 2002-2011 in test site Southern Australia. The dry season greenness values reflect the portion of plants that remain green after senescence of the annual vegetation or grow new green leaves during the dry period.

Dry Season Greenness Trend (abs.)



Legend

- National borders
- District borders
- Test Site AOI

Absolute trend slopes of dry season greenness 2002 – 2011

- yearly decrease > 10
- yearly decrease 8 - 10
- yearly decrease 6 - 8
- yearly decrease 4 - 6
- yearly decrease 2 - 4
- yearly decrease 1 - 2
- yearly increase 1 - 2
- yearly increase 2 - 4
- yearly increase 4 - 6
- yearly increase 6 - 8
- yearly increase 8 - 10
- yearly increase > 10
- Insignificant or trend < 1
- Data gaps (clouds, water, aridity)
- Water (Globcover 2009)

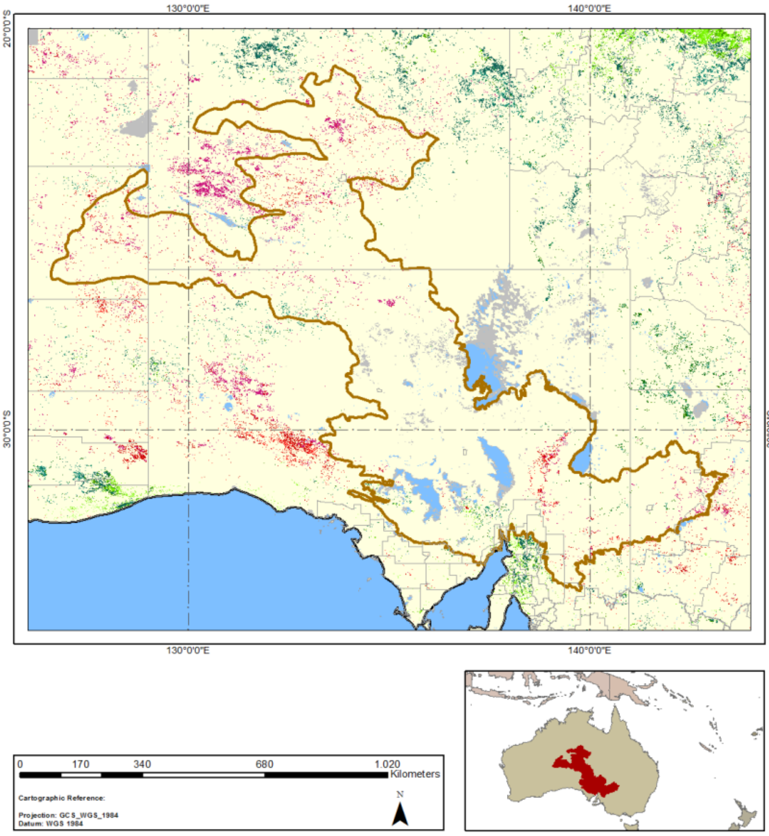
Description:

Slopes of absolute trends of ENVISAT MERIS fAPAR dry season averages in test site Southern Australia throughout the period 2002-2011. For the dry season the low fAPAR values after the green peak are taken, defined by a 10% amplitude threshold. The dry season greenness values reflect the portion of plants that remain green after senescence of the annual vegetation or grow new green leaves during the dry period.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).
Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.

Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Dry Season Greenness Trend (rel.)



Legend

- National borders
- District borders
- Test Site AOI

Relative trend of dry season greenness 2002 – 2011

- yearly decrease > 15%
- yearly decrease 10 - 15 %
- yearly decrease 5 - 10 %
- yearly decrease < 5 %
- yearly increase < 10 %
- yearly increase 10 - 20 %
- yearly increase 20 - 30 %
- yearly increase 30 - 40 %
- yearly increase 40 - 50 %
- yearly increase 50 - 60 %
- yearly increase 60 - 80 %
- yearly increase > 80 %
- Insignificant or abs. trend < 0.5
- Data gaps (clouds, water, aridity)
- Water (Globcover 2009)

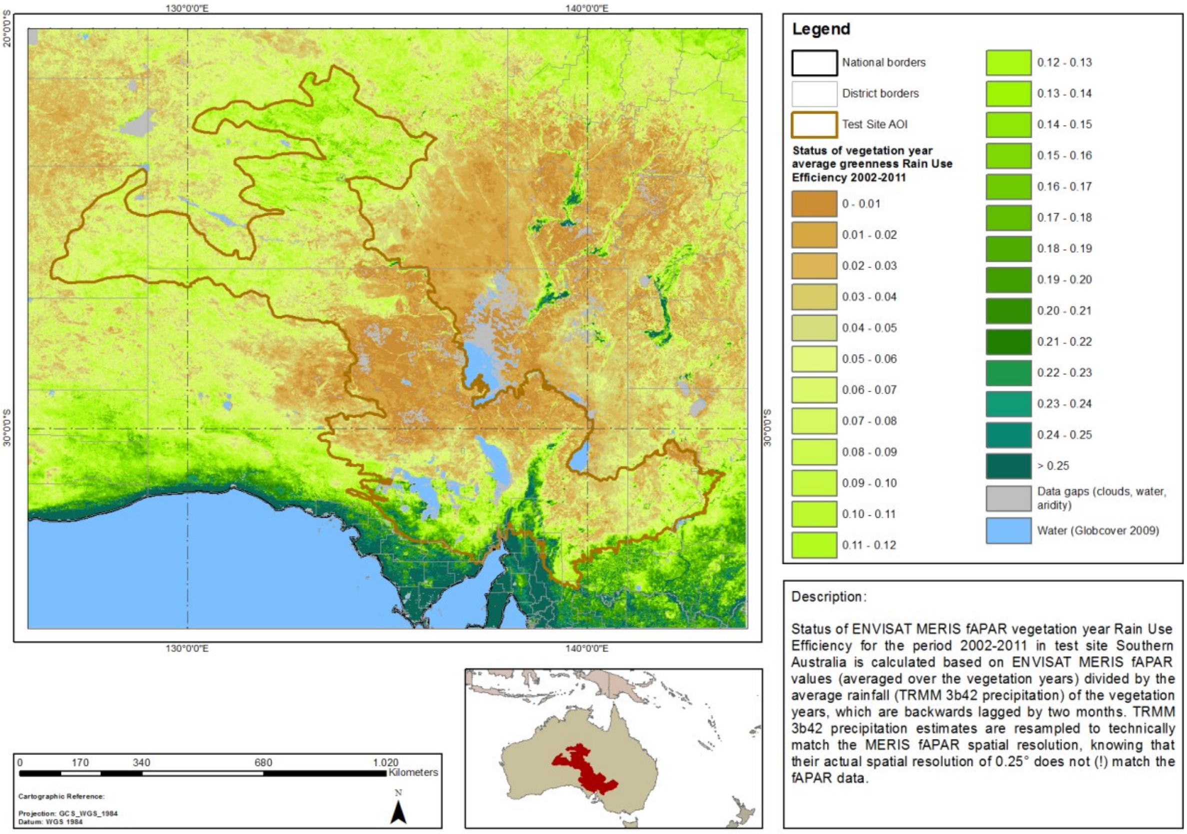
Description:

Relative yearly changes of ENVISAT MERIS fAPAR dry season averages in test site Southern Australia throughout the period 2002-2011. For the dry season the low fAPAR values after the green peak are taken, defined by a 10% amplitude threshold. The dry season greenness values reflect the the portion of plants that remain green after senescence of the annual vegetation or grow new green leaves during the dry period.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

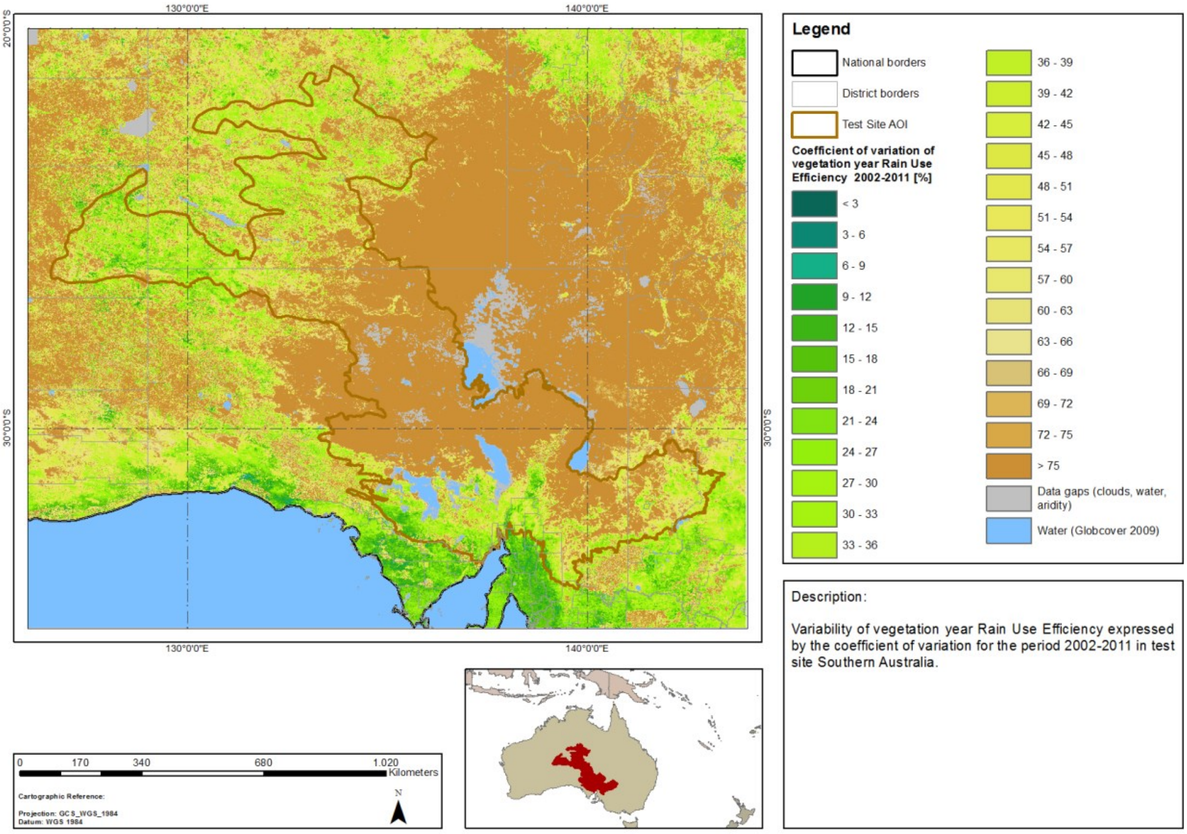
Average Vegetation Year Rain Use Efficiency Status



Description:

Status of ENVISAT MERIS fAPAR vegetation year Rain Use Efficiency for the period 2002-2011 in test site Southern Australia is calculated based on ENVISAT MERIS fAPAR values (averaged over the vegetation years) divided by the average rainfall (TRMM 3b42 precipitation) of the vegetation years, which are backwards lagged by two months. TRMM 3b42 precipitation estimates are resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

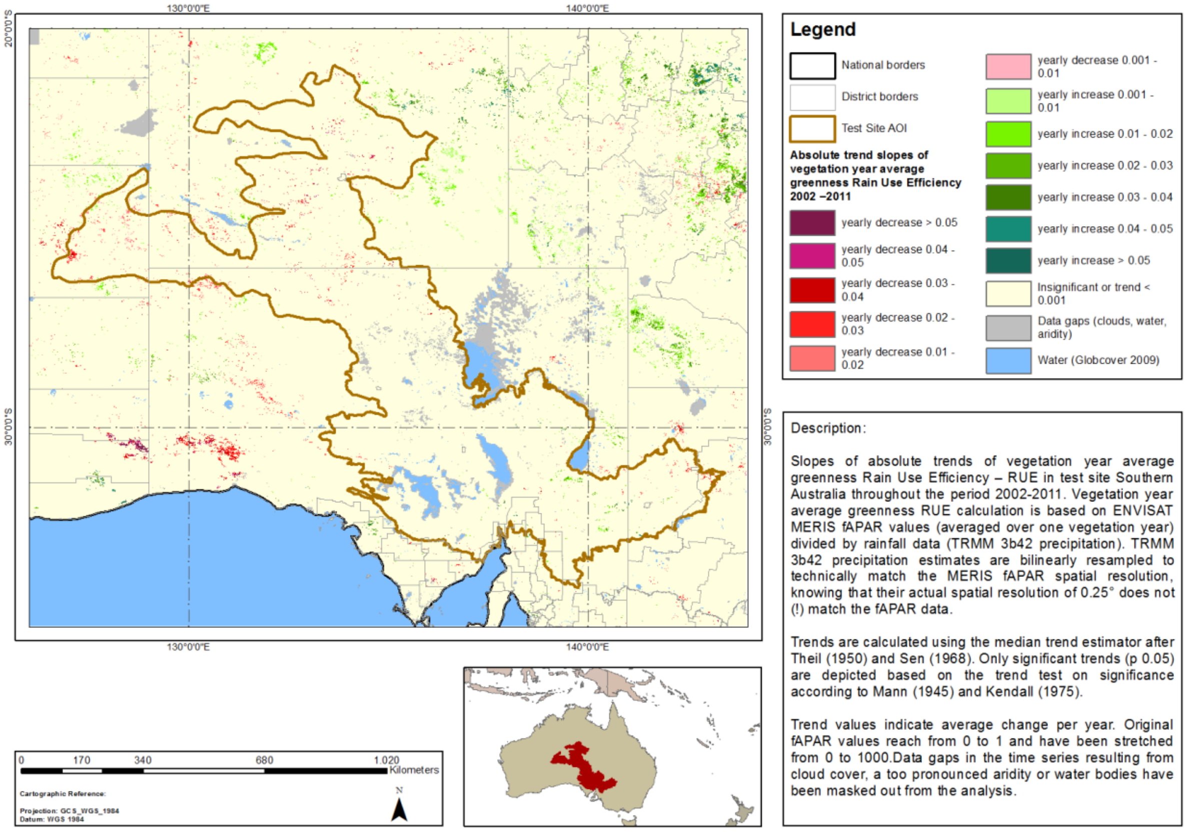
Vegetation Year Rain Use Efficiency Variability



Description:

Variability of vegetation year Rain Use Efficiency expressed by the coefficient of variation for the period 2002-2011 in test site Southern Australia.

Vegetation Year Rain Use Efficiency Trend (abs.)



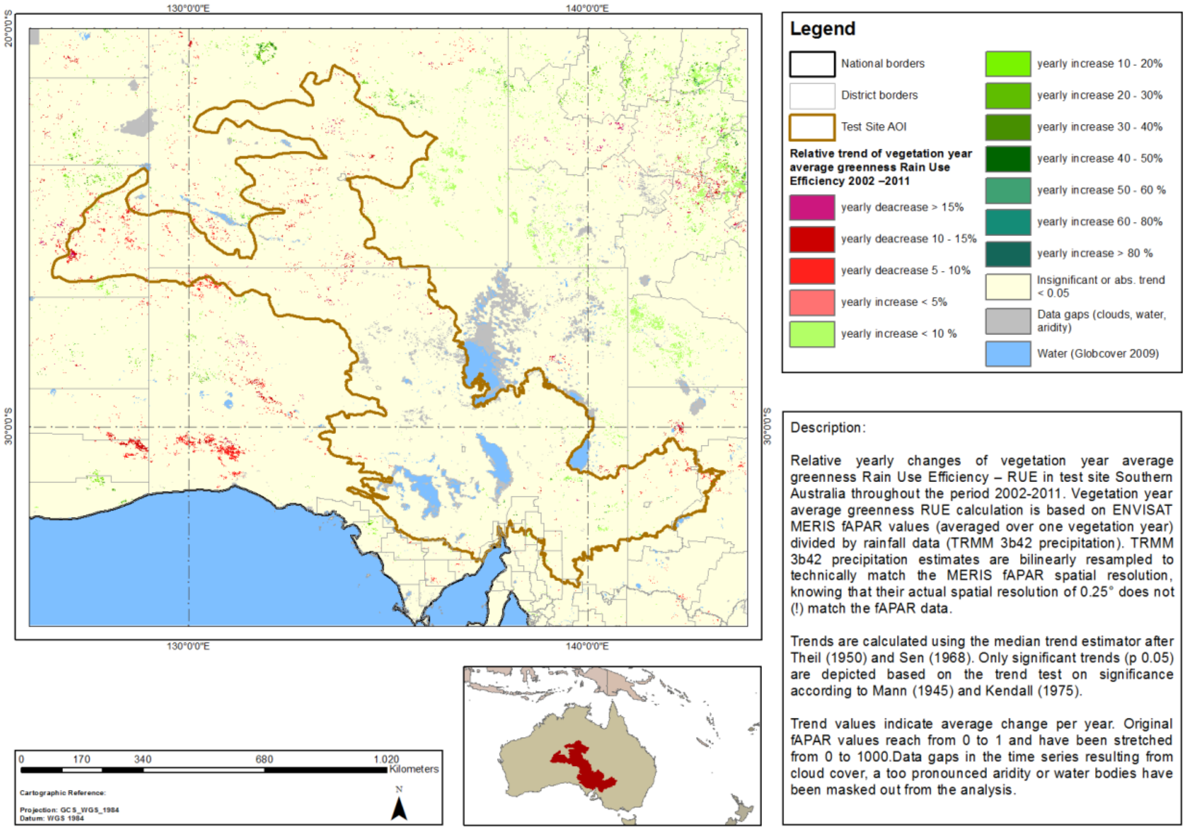
Description:

Slopes of absolute trends of vegetation year average greenness Rain Use Efficiency – RUE in test site Southern Australia throughout the period 2002-2011. Vegetation year average greenness RUE calculation is based on ENVISAT MERIS fAPAR values (averaged over one vegetation year) divided by rainfall data (TRMM 3b42 precipitation). TRMM 3b42 precipitation estimates are bilinearly resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Vegetation Year Rain Use Efficiency Trend (rel.)



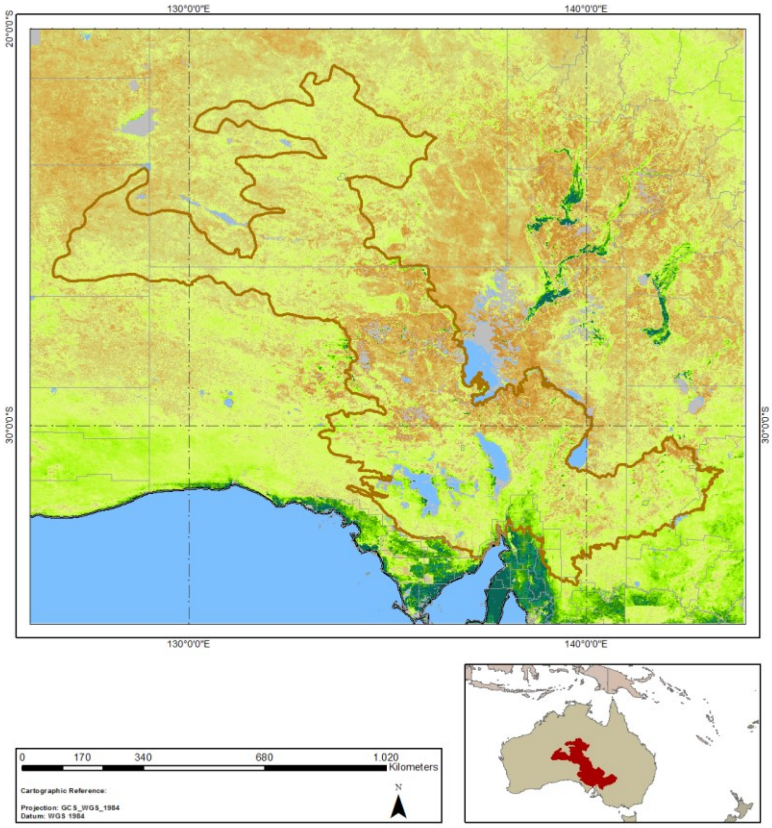
Description:

Relative yearly changes of vegetation year average greenness Rain Use Efficiency – RUE in test site Southern Australia throughout the period 2002-2011. Vegetation year average greenness RUE calculation is based on ENVISAT MERIS fAPAR values (averaged over one vegetation year) divided by rainfall data (TRMM 3b42 precipitation). TRMM 3b42 precipitation estimates are bilinearly resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Cyclic Vegetation Rain Use Efficiency Status



Legend

- National borders
- District borders
- Test Site AOI

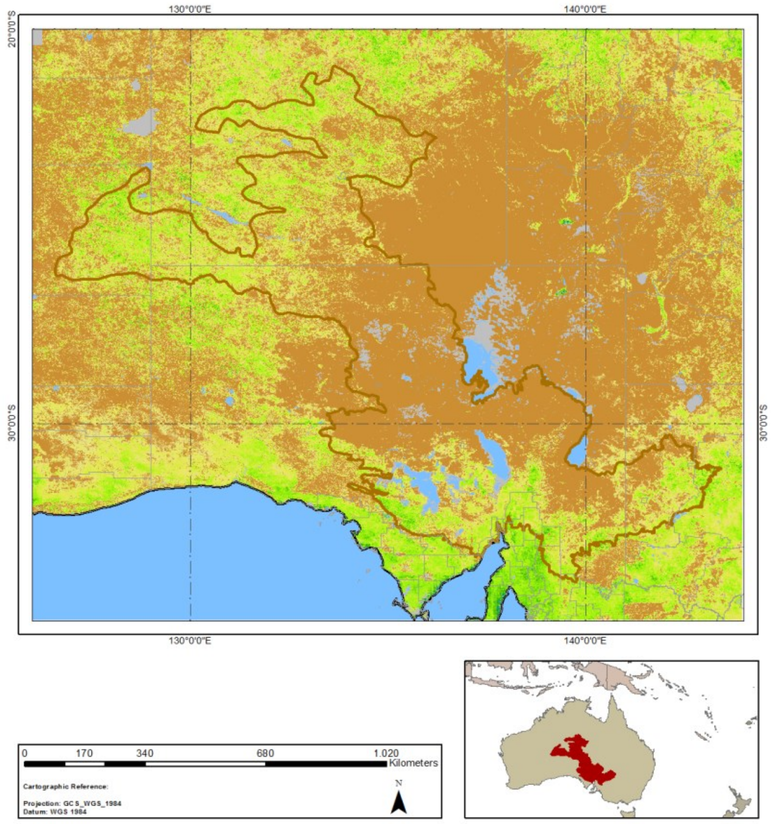
Status of cyclic vegetation Rain Use Efficiency 2002-2011

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- 6.0 - 6.5
- 6.5 - 7.0
- 7.0 - 7.5
- 7.5 - 8.0
- 8.0 - 8.5
- 8.5 - 9.0
- 9.0 - 9.5
- 9.5 - 10.0
- 10.0 - 10.5
- 10.5 - 11.0
- 11.0 - 11.5
- 11.5 - 12.0
- 12.0 - 12.5
- > 12.5
- Data gaps (clouds, water, aridity)
- Water (Globcover 2009)

Description:

Status of ENVISAT MERIS fAPAR cyclic vegetation Rain Use Efficiency for the period 2002-2011 in test site Southern Australia is calculated based on ENVISAT MERIS fAPAR values (averaged over the growing seasons) divided by rainfall data (TRMM 3b42 precipitation), that are starting two month prior to the growing season and ending with the growing season. TRMM 3b42 precipitation estimates are resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

Cyclic Vegetation Rain Use Efficiency Variability



Legend

- National borders
- District borders
- Test Site AOI

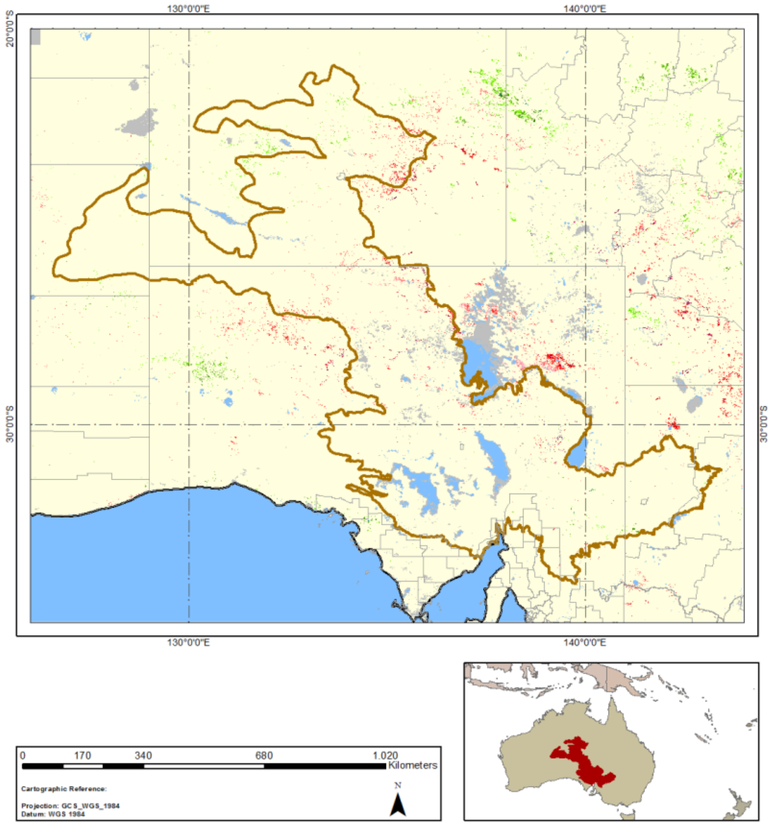
Coefficient of variation of the cyclic vegetation greenness 2002-2011 [%]

- < 3
- 3 - 6
- 6 - 9
- 9 - 12
- 12 - 15
- 15 - 18
- 18 - 21
- 21 - 24
- 24 - 27
- 27 - 30
- 30 - 33
- 33 - 36
- 36 - 39
- 39 - 42
- 42 - 45
- 45 - 48
- 48 - 51
- 51 - 54
- 54 - 57
- 57 - 60
- 60 - 63
- 63 - 66
- 66 - 69
- 69 - 72
- 72 - 75
- > 75
- Data gaps (clouds, water, aridity)
- Water (Globcover 2009)

Description:

Variability of ENVISAT MERIS fAPAR cyclic vegetation greenness expressed by the coefficient of variation for the period 2002-2011 in test site Southern Australia. The cyclic fraction of the vegetation comprises summed fAPAR values of the green peak(s) during a vegetation year, subtracting the non-cyclic base levels.

Cyclic Vegetation Rain Use Efficiency Trend (abs.)



Legend

- National borders
- District borders
- Test Site AOI

Absolute trend slopes of cyclic vegetation greenness Rain Use Efficiency 2002 –2011

- yearly decrease > 1.5
- yearly decrease 1.2 - 1.5
- yearly decrease 0.9 - 1.2
- yearly decrease 0.6 - 0.9
- yearly decrease 0.3 - 0.6
- yearly decrease 0.05 - 0.3
- yearly increase 0.05 - 0.3
- yearly increase 0.3 - 0.6
- yearly increase 0.6 - 0.9
- yearly increase 0.9 - 1.2
- yearly increase 1.2 - 1.5
- yearly increase > 1.5
- Insignificant or trend < 0.05
- Data gaps (clouds, water, aridity)
- Water (Globcover 2009)

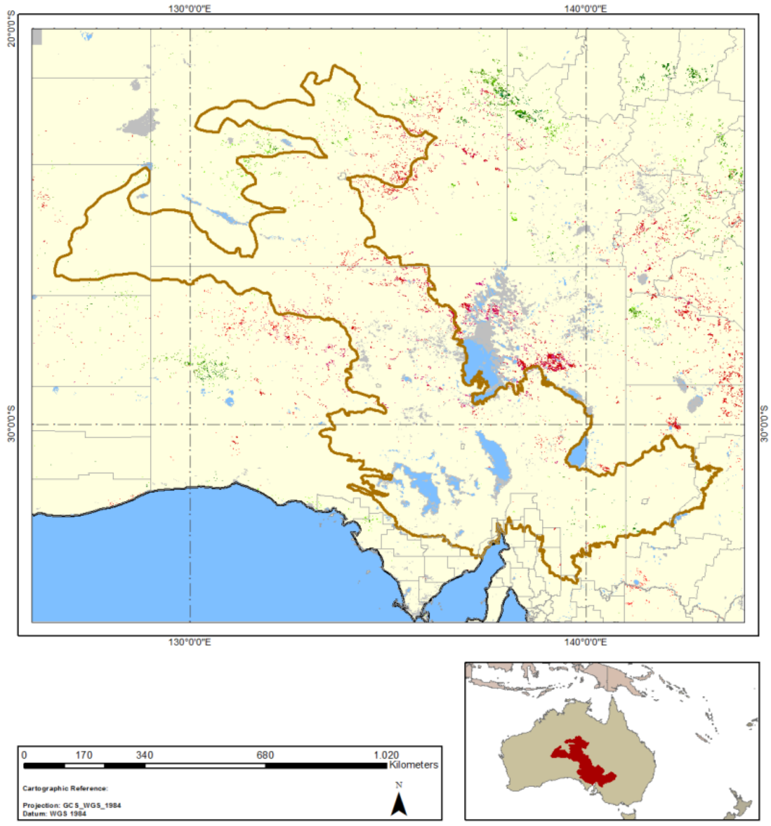
Description:

Slopes of absolute trends of cyclic vegetation greennness Rain Use Efficiency – RUE in test site Southern Australia throughout the period 2002-2011. Cyclic vegetation greenness RUE calculation is based on ENVISAT MERIS fAPAR values (of the green peak – "cyclic fraction") divided by rainfall data (TRMM 3b42 precipitation) TRMM 3b42 precipitation estimates are bilinearly resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Cyclic Vegetation Rain Use Efficiency Trend (rel.)



Legend

- National borders
- District borders
- Test Site AOI

Relative trend of cyclic vegetation greenness Rain Use Efficiency 2002 –2011

- yearly deacrease > 15%
- yearly deacrease 10 - 15%
- yearly deacrease 5 - 10%
- yearly increase < 5%
- yearly increase < 10 %
- yearly increase 10 - 20%
- yearly increase 20 - 30%
- yearly increase 30 - 40%
- yearly increase 40 - 50%
- yearly increase 50 - 60 %
- yearly increase 60 - 80%
- yearly increase > 80 %
- Insignificant or abs. trend < 0.05
- Data gaps (clouds, water, aridity)
- Water (Globcover 2009)

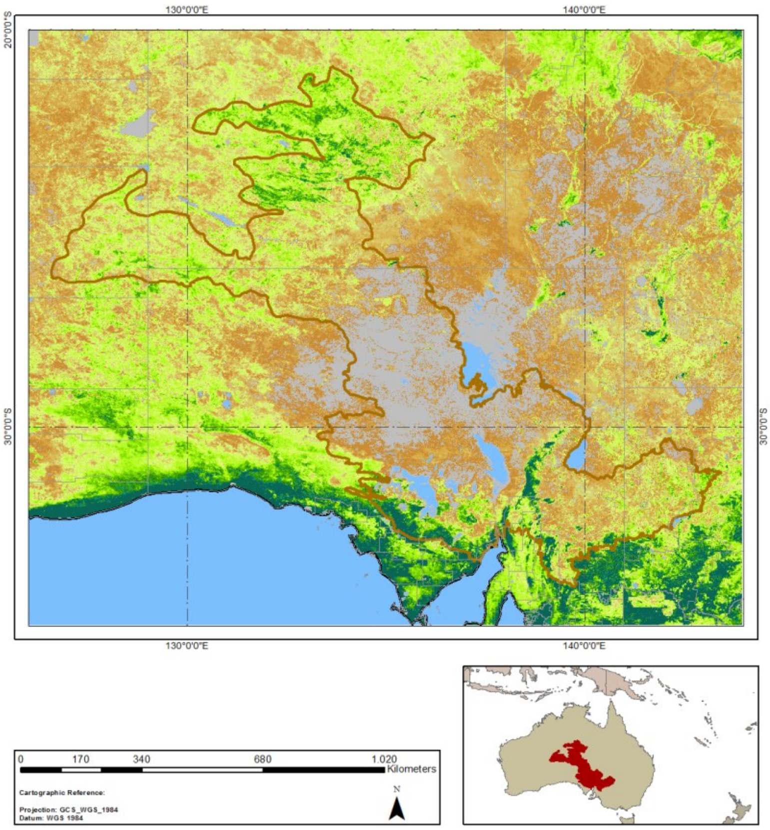
Description:

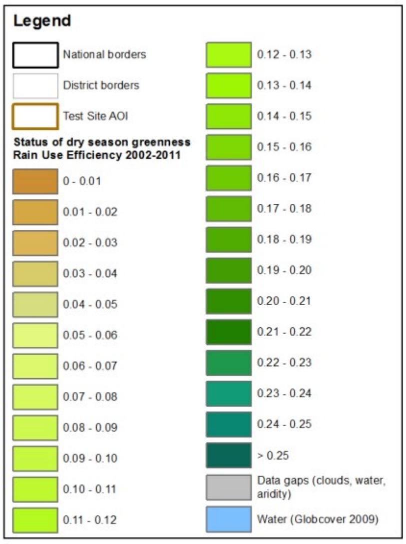
Relative yearly changes of cyclic vegetation greenness Rain Use Efficiency – RUE in test site Southern Australia throughout the period 2002-2011. Cyclic vegetation greenness RUE calculation is based on ENVISAT MERIS fAPAR values (of the green peak – "cyclic fraction") divided by rainfall data (TRMM 3b42 precipitation) TRMM 3b42 precipitation estimates are bilinearly resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Dry Season Rain Use Efficiency Status

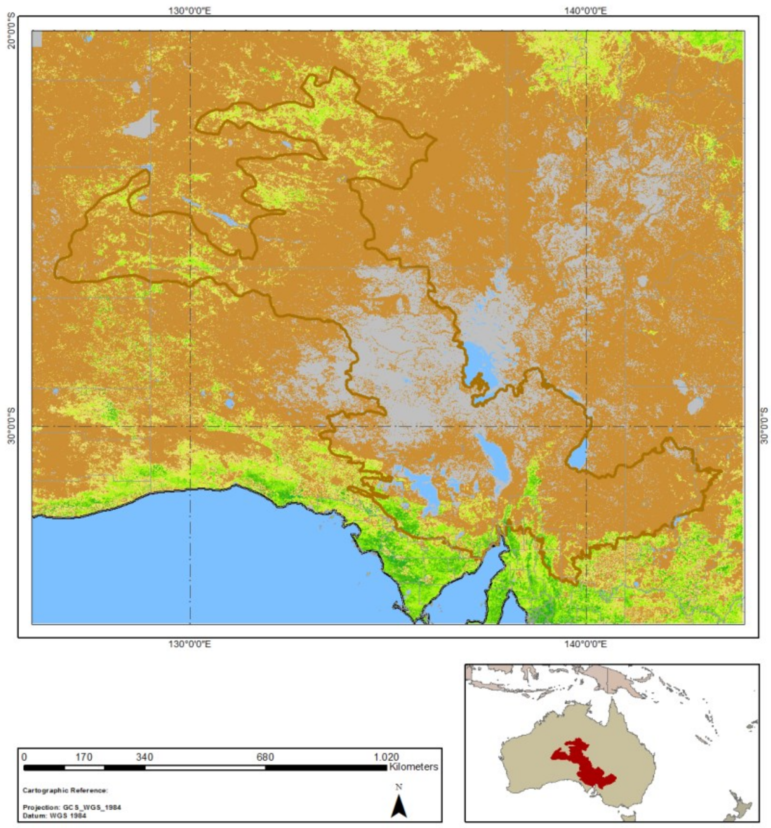


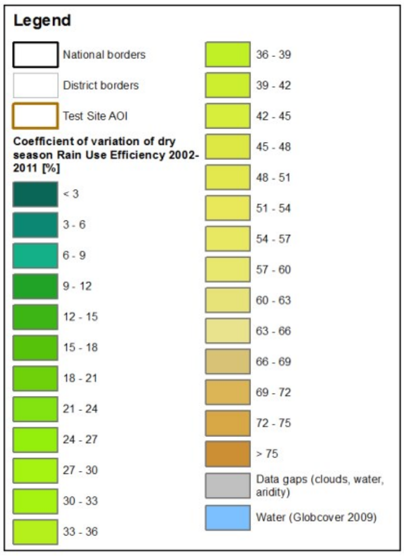


Description:

Status of ENVISAT MERIS dry season greenness Rain Use Efficiency for the period 2002-2011 in test site Southern Australia is calculated based on ENVISAT MERIS fAPAR values (averaged over the dry season after the green peak) divided by the averagerainfall (TRMM 3b42 precipitation) of the vegetation years, which are backwards lagged by two months . TRMM 3b42 precipitation estimates are bilinearly resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

Dry Season Rain Use Efficiency Variability

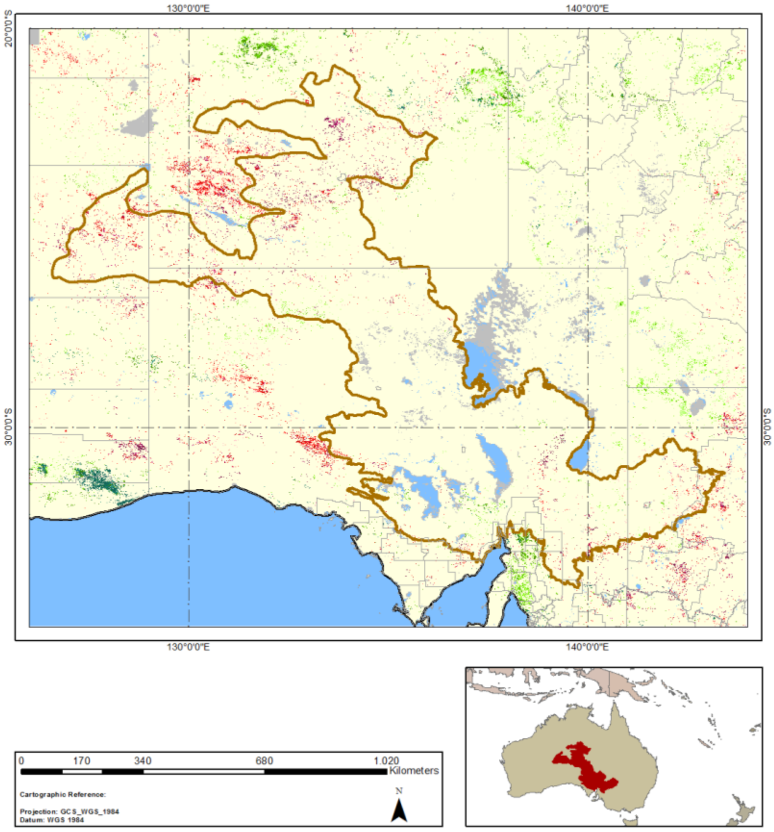


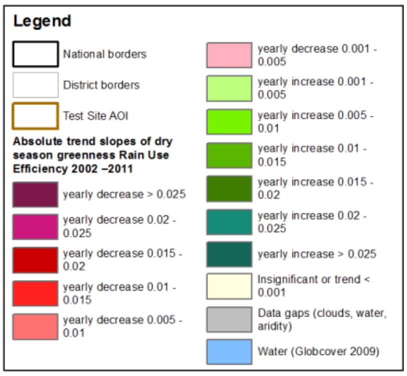


Description:

Variability of dry season Rain Use Efficiency expressed by the coefficient of variation for the period 2002-2011 in test site Southern Australia.

Dry Season Rain Use Efficiency Trend (abs.)





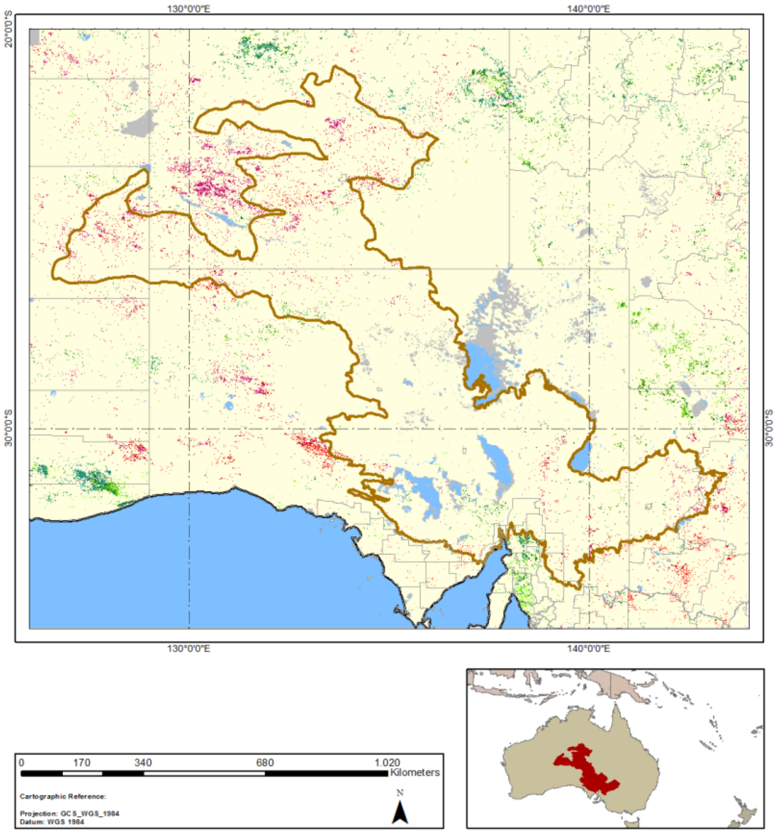
Description:

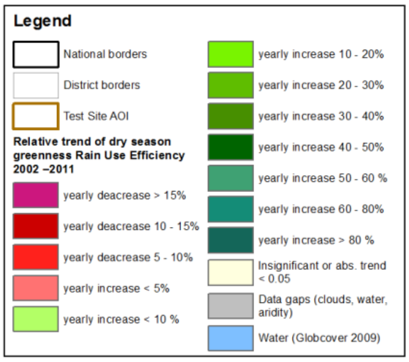
Slopes of absolute trends of dry season greenness Rain Use Efficiency – RUE in test site Southern Australia throughout the period 2002-2011. Dry season greenness RUE calculation is based on ENVISAT MERIS fAPAR values (averaged over the dry season after the green peak) divided by rainfall data (TRMM 3b42 precipitation). TRMM 3b42 precipitation estimates are bilinearly resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Dry Season Rain Use Efficiency Trend (rel.)





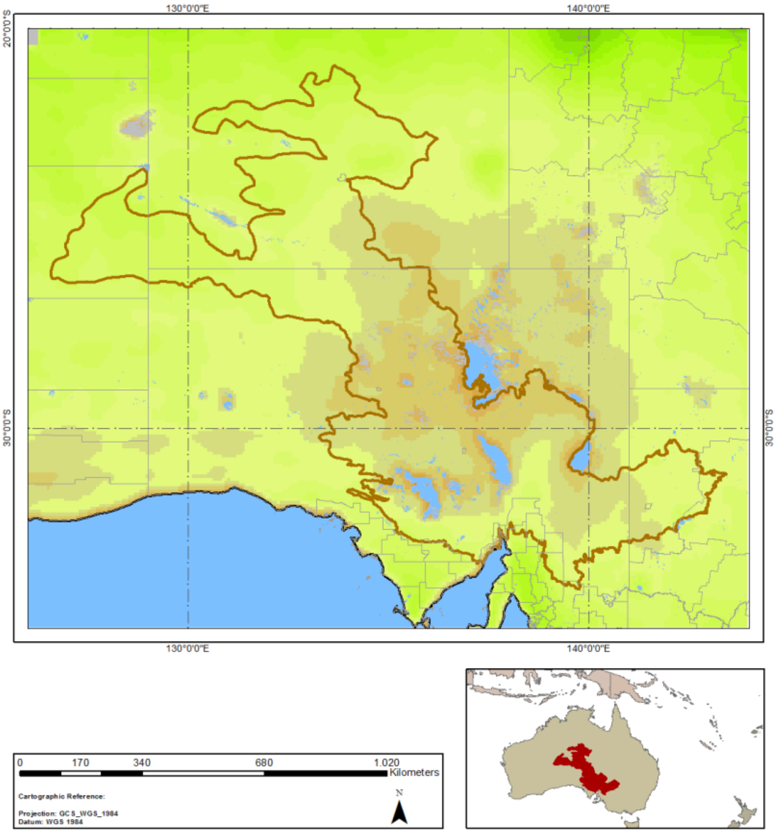
Description:

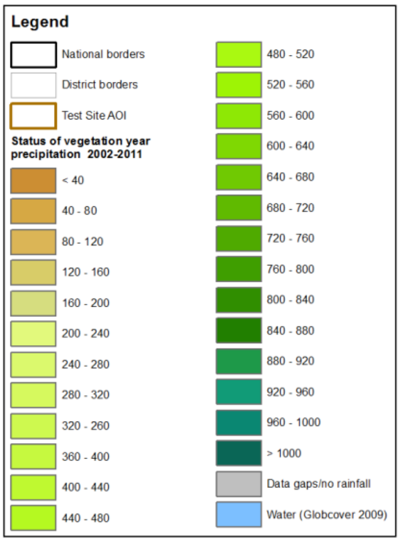
Relative yearly dry season vegetation greenness Rain Use Efficiency – RUE in test site Southern Australia throughout the period 2002-2011. Dry season vegetation greenness RUE calculation is based on ENVISAT MERIS fAPAR values (averaged over the dry season after the green peak) divided by rainfall data (TRMM 3b42 precipitation). TRMM 3b42 precipitation estimates are bilinearly resampled to technically match the MERIS fAPAR spatial resolution, knowing that their actual spatial resolution of 0.25° does not (!) match the fAPAR data.

Trends are calculated using the median trend estimator after Theil (1950) and Sen (1968). Only significant trends (p 0.05) are depicted based on the trend test on significance according to Mann (1945) and Kendall (1975).

Trend values indicate average change per year. Original fAPAR values reach from 0 to 1 and have been stretched from 0 to 1000.Data gaps in the time series resulting from cloud cover, a too pronounced aridity or water bodies have been masked out from the analysis.

Vegetation Year Precipitation Status

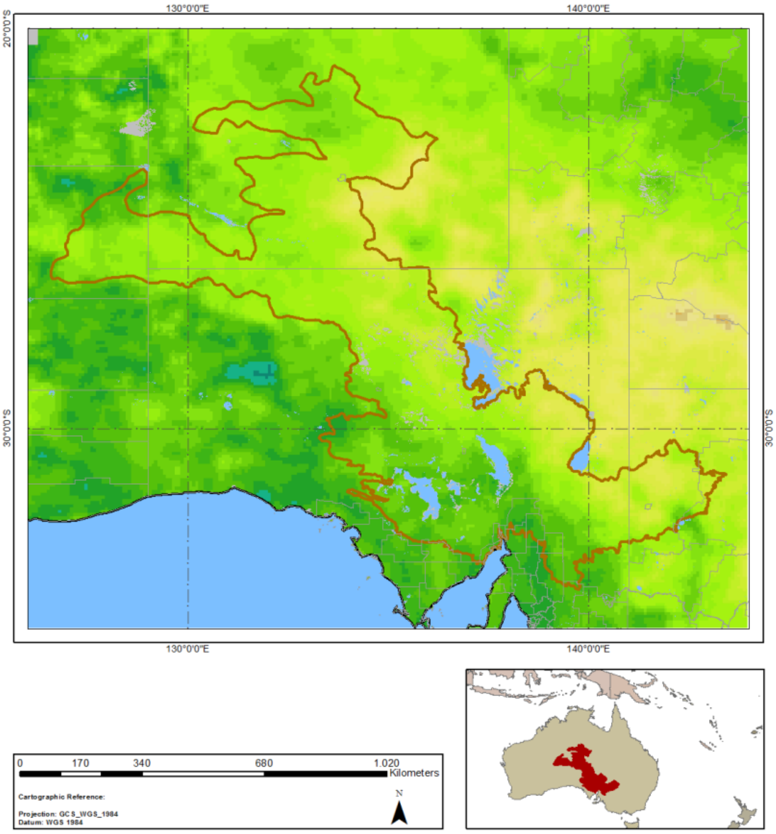


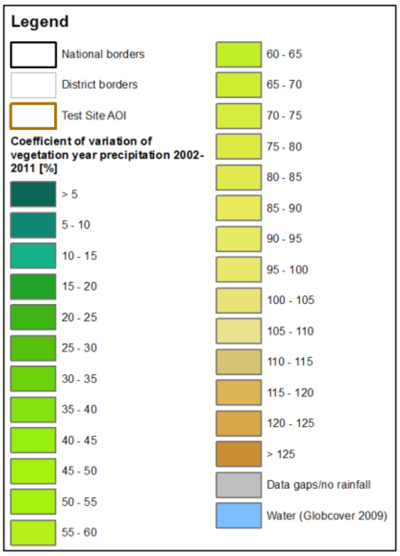


Description:

Status of TRMM 3b42 precipitation estimates summed over vegetation years calculated as mean value for the period 2002-2011 in test site Southern Australia. Yearly aggregation periods are derived from the corresponding vegetation year with a temporal backward shift of two months. Thus, each precipitation vegetation year starts and ends two months earlier than the corresponding vegetation year.

Vegetation Year Precipitation Variability

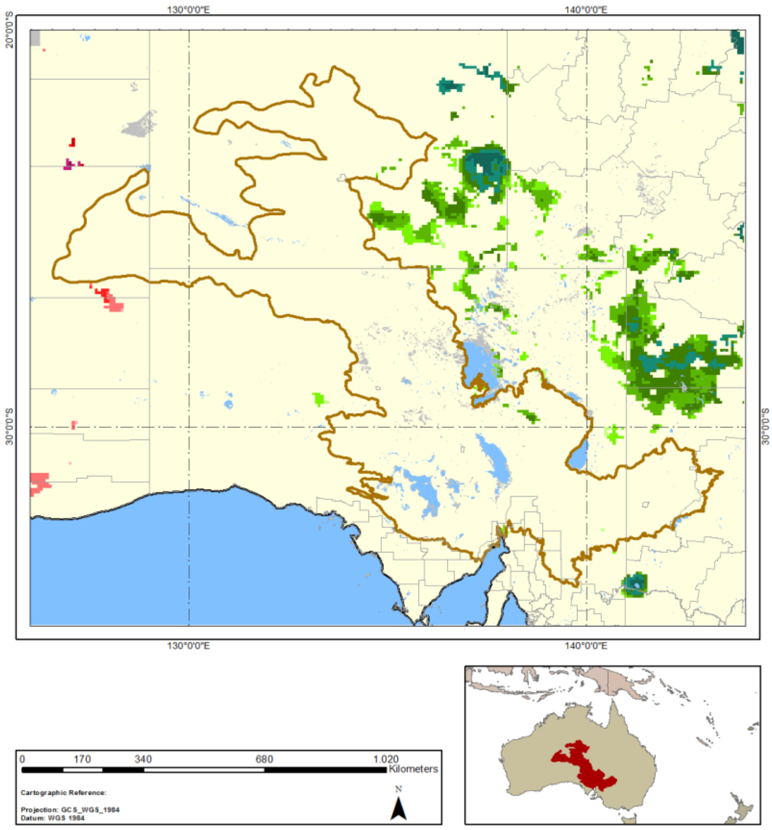


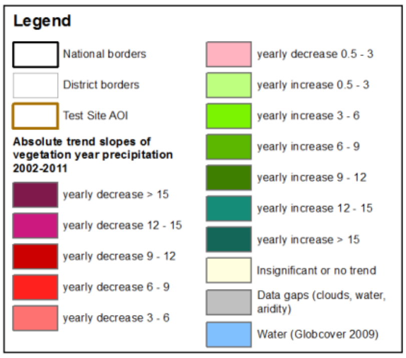


Description:

Variability of TRMM 3b42 precipitation estimates summed over vegetation years expressed by the coefficient of variation for the period 2002-2011 in test site Southern Australia. Yearly aggregation periods are derived from the corresponding vegetation year with a temporal backward shift of two months. Thus, each precipitation vegetation year starts and ends two months earlier than the corresponding vegetation year.

Vegetation Year Precipitation Trend (abs.)

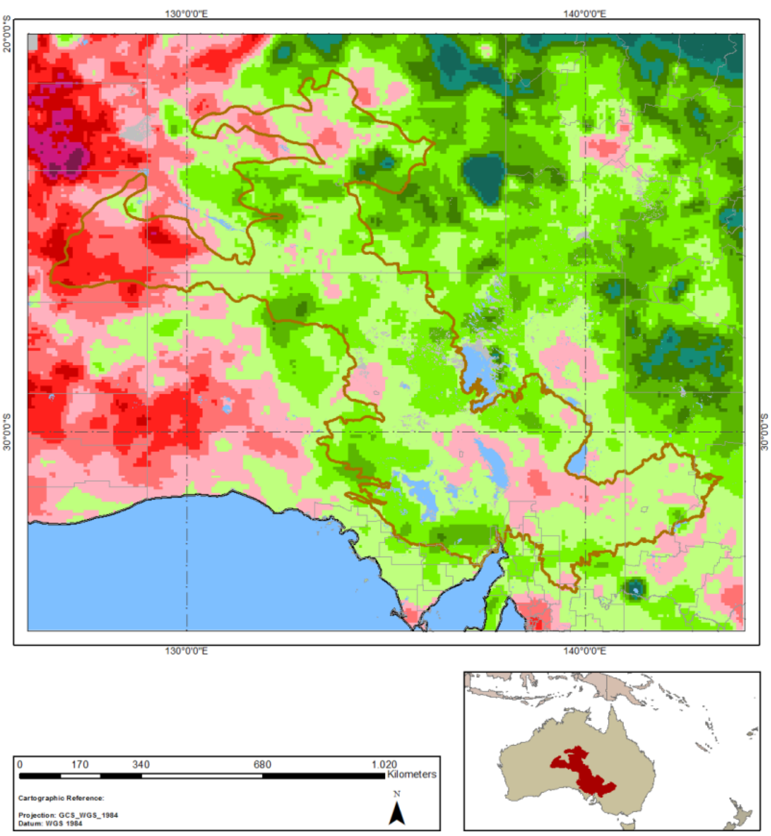


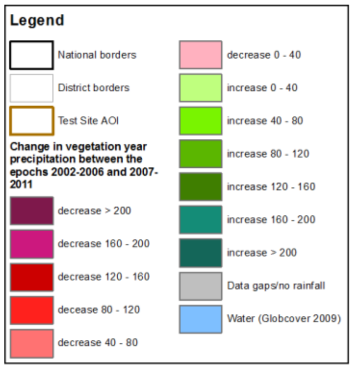


Description:

Slopes of absolute trends of TRMM 3b42 precipitation estimates summed over vegetation years in test site Southern Australia throughout the period 2002-2011. Yearly aggregation periods are derived from the corresponding vegetation year with a subsequent temporal backward shift of two months. Thus, each precipitation vegetation year starts and ends two months earlier than the corresponding vegetation year.

Vegetation Year Precipitation Change





Description:

Change in TRMM 3b42 precipitation estimates summed over vegetation years between the two epochs 2002-2006 and 2007-2011 in test site Southern Australia. The calculation of per-epoch precipitation is based on epoch median values. Yearly aggregation periods are derived from the corresponding vegetation year with a temporal backward shift of two months. Thus, each precipitation year starts and ends two months earlier than the corresponding vegetation year.

Generic Interpretation of the Maps with regard to Degradation and Potential Loss of Biodiversity

The maps that are so far shown in the booklet include phenologically differentiated NPP proxy (Net Primary Production) and RUE (Rain Use Efficiency) status and trend maps, as well as rainfall status, trend – and change maps.

Overall the status maps describe the amount and variability (coefficient of variation) of greenness (NPP proxy) in the differentiated phenological seasons, as well greenness in relation to the amount of rainfall (RUE).

While vegetation productivity obvious follows the rainfall gradients at the large scale (not considering temperature and radiation differences), the smaller scale differentiations exhibit the presence of further influences on vegetation growth at more local scales. These local and regional factors are especially land use, soil properties and topography and include also the protection status of areas. For instance many linear features with (mostly) higher NPP proxy and RUE values than their surroundings can be related to river valleys (often with only seasonal or ephemeral surface water).

Consequently, the spatial distribution of RUE varies not only with rainfall, but depends on the constellation of all these factors at various scales. Hence RUE status (average condition) values, even if stratified according to aridity, cannot directly be interpreted in terms of existing soil degradation or exposure to degradation or richness/poverty of biodiversity without knowledge about growth factors other than rainfall, and about bio-geographical properties.

Biomes with rich floristic biodiversity can be expected to exhibit higher NPP response to rainfall throughout the year as diverse plant communities may be characterised by a high phenological variability with optimised water exploitation. However, it is not known whether, where and to which degree this theory translates into measurable spatial differences of RUE. Here an assessment of the results by local experts and the usage of reference maps and information will help interpret the results. An example with an extended area of extraordinary high average RUE conditions is the Succulent Karoo biome in South Africa ("*The Succulent Karoo is notable for the world's richest flora of succulent plants, and harbours about one-third of the world's approximately 10,000 succulent species*" http://en.wikipedia.org/wiki/Succulent_Karoo).

The differentiation of the NPP and RUE indicators into phenological periods helps diagnose the seasonal behaviour of the vegetation and thus provides clues about the presence and dominance of evergreen perennial vegetation versus annual vegetation (e.g. annual grasses, crops). Accordingly, changes and trends of the phenological vegetation behaviour can be used as indicators for developments such as land use change and land cover change. For instance the worldwide observed phenomenon of bush encroachment (woody encroachment, woody thickening) in drylands (Ratajczak et al. 2011) will lead to a shift of vegetation phenology, where especially an increase of dry season greenness, possibly, but not necessarily combined with a decrease of the cyclic greenness can be expected.

Bush encroachment in drylands is often perceived as negative development, where the bushes lead to range land degradation by reducing grass cover and impeding the access of cattle to the remaining grass. Also impoverishment of biodiversity was frequently found as an effect of bush encroachment (Ratajczak et al. 2011). The greening trends especially in the dry season are indeed a widespread phenomenon in the derived NPP proxy maps (p. 16), possibly pointing to continued bush encroachment or enhanced growth and greening of existing bushes, partly related to rainfall increases. Dry season greening may also be caused by the plantation of (especially evergreen) woody plants and forests. In case of greening trends related to commercial forest plantations, the trends can also be interpreted as a biodiversity loss.

The “classical” degradation measure is exhibited by decreasing RUE trends, i.e. the decrease of NPP proxies in relation to rainfall, theoretically indicating the decreasing ability of the vegetation to exploit available water. In the test sites so far studied, RUE decreases are rarely observed for the cyclic vegetation of the growing season (p. 20). This means, the cyclic vegetation response to rainfall is not widespread diminished and degradation of soils leading to reduced usability of rainfall for vegetation growth seems to be hardly found in the test sites so far. Where it is found it seems to co-occur with regional rainfall increases, and may be interpreted as lacking ability of the vegetation to respond to apparently improved hydrologic growing conditions. Extended areas in South and East Portugal are an example for wide spread RUE decreases of the cyclic vegetation related to rainfall increase **Fehler! Textmarke nicht definiert.**without cyclic vegetation decrease. However, increased rainfall quantities may also come with higher rainfall intensities and may have also negative effects (increased runoff, more erosive power), and can be assumed to be not generally positively correlated with vegetation productivity.

RUE decreases are more frequently found when looking at the vegetation of the entire vegetation year (p. 18), and are also often related to rainfall increases, and not to greenness decreases. RUE decreases are not only indicating potential degradation developments (progressing degradation triggered e.g. by land over-utilisation), but may be as well related to land cover/use changes, such as the conversion of rangeland into cropland, deforestation (less important in dry lands), etc. Especially processes such as urbanisation or mining will lead to extreme NPP proxy and RUE decreases. Decreases of only the dry season RUE (p. 22) may in particular be related to conversion of rangeland into rainfed cropland, assuming a lower primary productivity of the cropland during the dry season. Also the clearing of shrubs, bushland and savannah vegetation may lead especially to dry season RUE decreases.

To summarize the observable NPP proxy and RUE trends cannot be directly interpreted as degradation or biomass losses, or, in case of positive trends, as land improvements. There are always multiple possible underlying causes and developments, hence in situ knowledge and information is indispensable for the interpretation of these developments, as well as for the average conditions expressed in the status maps. Especially the frequently found greening trends in the dry season, at first glance positive trends, may even be primarily related to adverse processes such as bush encroachment. However, caution is also necessary in this respect, as likewise range land improvement and tree planting activities may lead to diverse positive trends.

Finally it must me stated that the observation period is rather short, with several consequences for this study. The variability of rainfalls and subsequently vegetation greenness from year to year is so significant in drylands that it certainly hides trends, which in such a short period may be rare and not very pronounced. Trends must pass a high statistical significance threshold to be recognised as significant trends. There may be more relevant changes going on than the trend maps with only the highly significant trends can show, especially as many change events cannot be expected to exhibit gradual indicator developments. Also the rainfall trend maps (p. 24) show hardly any significant trends, while the rainfall change map between the two epochs shows large positive and negative change regions with partly big epochal rainfall differences.

On the other hand, the epochal change maps (differences between the means or median values of epochs, part of the overall products) are strongly influenced by variability and do certainly not only reflect “true” changes in the sense of concrete changes (e.g. land use change) or persisting developments (trends). Therefore these maps (that - except for rainfall - are not shown in the booklet) must be used with care.

Outlook

The phenologically differentiated analysis of NPP proxies and RUE so far performed will allow for a combination of the single results into integrated second order products. Their intention is to provide more evaluative assessments of the possible recent developments than the individual indicators. For instance, the occurrence of dry season greening in the absence of positive cyclic vegetation trends or in combination with negative cyclic vegetation trends may be derived as a an indicator for bush encroachment, either in the past and/or ongoing, where theoretically also the trend of the ratio of dry season to vegetation year greenness may support the diagnosis of increases of woody vegetation at the expense of grasses. The generation and/or interpretation of second order products may also be supported by means of land cover data.

Further on, CCI soil moisture (http://www.esa-soilmoisture-cci.org/) data, where available without greater data gaps, will be used as an additional and alternative measure for available water, and "Soil Moisture Use Efficiency" (SMUE) products analogue to RUE products will be derived thereof. Theoretically, soil moisture is the better suited water parameter for this purpose, as it almost directly constitutes the available water for plants, whereas rainfall only partly penetrates into the soil. The comparison of the SMUE with the RUE products will be of high interest.

Selected second order indicators will be added to these booklets, while the first order indicator maps may be reduced to keep the booklets focused on the most significant results. The results will be interpreted in terms of so-called "Biodiversity Stories", which will verbally highlight the most prominent and significant developments found in the data.

Description of Biodiversity of Test Site 20 Southern Australia

Under the Interim Biogeographic Regionalisation for Australia (IBRA) planning framework, an important part of the Australia's Strategy for the National Reserve System 2009-2030, the country's landscape has been divided into 89 bioregions (NRMMC 2009; IBRA 2012). The study area spans through four states, mostly in South Australia and Northern Territory but also smaller parts of New South Wales and Western Australia. The study area encompasses nine bioregions (from south to north): Flinders Lofty Block (FLB), Gawler (GAW), Broken Hill Complex (BHC), Stony Plains (STP), Simpson-Strzelecki Dunefields (SSD), Finke (FIN), Central Ranges (CER), MacDonnell Ranges (MAC) and Burt Plain (BRT) (Bastin & ACRIS 2008a,b,c,d,e,f,g,h,i). All these bioregions can be considered parts of the Tirari-Sturt Stony Desert. The combined area of the nine bioregions (and thus of the study area approximately) is of 933,550 km^2, with the SSD being the largest (272,920 km^2) and the MAC the smallest (39,290 km^2) (Bastin & ACRIS 2008a,b,c,d,e,f,g,h,i). All the bioregions are within the desert and xeric shrubland ecoregion of Australia, with predominant vegetation types being grass and shrubland, mulga (acacia) woodland and eucalyptus trees on hills and areas with higher rainfall (Bastin & ACRIS 2008a,b,c,d,e,f,g,h,i). The study area is subjected to a semiarid to arid climate, with sparse and unreliable rainfalls that tend to follow a decreasing gradient from south to north, ranging from 217 mm in FLB to 118 mm in STP (spatially averaged medians from 1890-2005), and high evapotranspiration rates. However, the landscape can also influence this pattern and for example rainfall in the MAC and BRT bioregions are of 228 and 243 mm, respectively, due to mountain ranges. Precipitation in the southern regions occurs mainly during winter, while summer storms dominate in the more northern reaches. Mean maximum temperatures during the summer range from 18 to 38°C, but can reach up to 50°C in the more central and arid regions (SSD and CER for example), while during winter it's common for temperature to range from 5 to 20°C (Bastin & ACRIS 2008a,b,c,d,e,f,g,h,I; ANRA 2013 a,b,c,d,e,f,g,h,I).

As one can imagine, the topography is very diverse, with successive mountain ranges, rocky hills, ridges, wide flat plains, sand dunes, salt lakes, watercourses, alluvial plains and springs. The geological background comprises mainly very old formations (Proterozoic and Palaeozoic) of metamorphosed sedimentary and igneous rock, among other later topographic features that span the entire geological time scale (ANRA 2013 a,b,c,d,e,f,g,h,I).

The study area holds an impressive biological diversity despite the harsh conditions. In terms of flora, all bioregions combined may hold over 2000 taxa, including many endemics and threatened species. The vegetation follows closely the topographic and climatic diversity. Within the FLB region's relatively more humid hills is common to find many species of eucalyptus (*Eucalyptus* spp.). As we move to more arid and flat regions the dominant types of vegetation become the mulga, chenopod and mallee woodlands with many acacias (*Acacia* spp.), grasses (*Astrebla* spp., *Danthonia* spp., *Stipa* spp., among others) and shrubs (*Atriplex* spp., *Maireana* spp., *Senna* spp., etc.) (Bastin & ACRIS 2008a,b,c,d,e,f,g,h,I; ANRA 2013 a,b,c,d,e,f,g,h,I).

The fauna in the region also presents a great species richness and endemicity, with around 20 amphibians, over 100 reptiles, up to 50 mammals and over 200 birds. Relevant herpetofauna examples include the streambank froglet (*Crinia riparia*), two agamid lizards (*Ctenophorusrufescens* and *C. maculosus*), a skink (*Lerista speciosa*) and a dtella or web-toed gecko (*Gehyravarifata*). Important mammal species include the yellow-toed (*Petrogale xanthopus*) and black-footed rock wallabies (*P. lateralis*), ghost bat (*Macroderma gigas*), dingo (*Canis lupus dingo*) and red kangaroo (*Macropus rufus*), among others, but common species are also the introduced European rabbit (*Oryctolagus cuniculus*) and red fox (*Vulpes vulpes*), besides feral domestic species like goats (*Capri hircus*), camels (*Camelus dromedarius*) and cats (*Felis cattus*). In relation to birds, key species include the Australian bustard (Ardeotis australis), the eyrean grasswren (*Amytornis goyderi*), scarlet-chested parrot (*Neophema splendida*), rufous-crowned emu-wren (*Stipiturus ruficeps*), grey falcon (*Falco hypoleucus*) and Wedge-tailed eagle (*Aquila audax*) (Bastin & ACRIS 2008a,b,c,d,e,f,g,h,I; ANRA 2013 a,b,c,d,e,f,g,h,I).

The main concerns in the study area are related with overgrazing and pest species. The region has been affected by intense pastoralism, especially by sheep and cattle. Rabbits and goats are also responsible for overgrazing, which exposes soils to erosion, reduces the recruitment rate of native plants and reduces the quality of habitat for native animals (DEH 2009; ANRA 2013 a,b,c,d,e,f,g,h,I). Many exotic plants are also present, up to 150, such as buffel (*Cenchrus ciliaris*) and couch grasses (*Cynodon dactylon*), mimosa bush (*Acacia farnesiana*), Bathurst burr (*Xanthium spinosum*) and athel pine (*Tamarix aphylla*) (ANRA 2013 a,b,c,d,e,f,g,h,I). The region also harbours mining explorations that can seriously transform and degrade the land (ANRA 2013 a,b,c,d,e,f,g,h,I). If we take into account the already arid climate, future climatic changes and the intense overgrazing, alteration and increase of severity of fire regimes poses also a very significant threat (Russel-Smith et al. 2003; DEH 2009).

Besides pastoral, agricultural and mining leases, the region also holds many extents of Aboriginal land, which is under less human pressure (Russel-Smith et al. 2003). Some bioregions are better covered by conservation reserves then others, but still most of the important biodiversity (as well as topographic) features are well represented, and many National Parks (NP) and reserves have been established, like the Sturt NP, Flinders Ranges NP, Lake Gairdner NP, Mootwingee NP, Simpson Desert Conservation Park and Innamincka Regional Reserve (ANRA 2013 a,b,c,d,e,f,g,h,I). Some IBAs are also located within the region (BirdLife International 2013).

References

ANRA (a) (Australian Natural Resources Atlas) *Rangelands overview: Broken Hill Complex*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/nsw/ibra-bhc.html (March 2013).

ANRA (b) (Australian Natural Resources Atlas) *Rangelands overview: Burt Plains*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/nt/ibra-brt.html (March 2013).

ANRA (c) (Australian Natural Resources Atlas) *Rangelands overview: Central Ranges*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/nt/ibra-cr.html (March 2013).

ANRA (d) (Australian Natural Resources Atlas) *Rangelands overview: Finke*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/nt/ibra-fin.html (March 2013).

ANRA (e) (Australian Natural Resources Atlas) *Rangelands overview: Flinders Lofty Block*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/sa/ibra-flb.html (March 2013).

ANRA (f) (Australian Natural Resources Atlas) *Rangelands overview: Gawler*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/sa/ibra-gaw.html (March 2013).

ANRA (g) (Australian Natural Resources Atlas) *Rangelands overview: MacDonnell Ranges*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/nt/ibra-mac.html (March 2013).

ANRA (h) (Australian Natural Resources Atlas) *Rangelands overview: Simpson-Strzelecki Dunefields*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/sa/ibra-ssd.html#tenure_and_use (March 2013).

ANRA (i) (Australian Natural Resources Atlas) *Rangelands overview: Stony Plains*. Retrieved from: http://www.anra.gov.au/topics/rangelands/overview/sa/ibra-stp.html (March 2013).

Bastin G. and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008a), *Rangelands 2008 –Taking the pulse, Supplementary reports: Bioregion – Broken Hill Complex*. ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

Bastin G. and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008b), *Rangelands 2008 – Taking the pulse, Supplementary reports: Bioregion – Burt Plain*. ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

Bastin G. and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008c), *Rangelands 2008 – Taking the pulse, Supplementary reports: Bioregion – Central Ranges*. ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

Bastin G. and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008d), *Rangelands 2008 – Taking the pulse, Supplementary reports: Bioregion – Finke*. ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

Bastin G. and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008e), *Rangelands 2008 – Taking the pulse, Supplementary reports: Bioregion*

– *Flinders Lofty Block*. ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

Bastin G. and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008f), *Rangelands 2008 – Taking the pulse, Supplementary reports: Bioregion – Gawler*. ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

Bastin G. and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008g), *Rangelands 2008 – Taking the pulse, Supplementary reports: Bioregion – MacDonnell Ranges.* ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

Bastin G and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008h).*Rangelands 2008 – Taking the pulse, Supplementary reports: Bioregion – Simpson-Strzelecki Dunefields*. ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

Bastin G. and ACRIS (Australian Collaborative Rangeland Information System) Management Committee (2008i), *Rangelands 2008 – Taking the pulse, Supplementary reports: Bioregion – Stony Plains*. ACRIS Management Committee, National Land & Water Resources Audit., Canberra.

BirdLife International (2013), Important Bird Areas. Retrieved from: http://www.birdlife.org (April 2013).

DEH (Department for Environment and Heritage) (2009), *South Australian Arid Lands Biodiversity Strategy – Channel Country Conservation Priorities*. South Australian Arid Lands NRM Board, Department for Environment and Heritage, 40 pp.

Gobron N., Pinty, B, Verstaete, M. and Govaerts, Y. (1999), The MERIS Global Vegetation Index (MGVI): description and preliminary application. *International Journal of Remote Sensing*, 9: 1917-1927.

IBRA (Interim Biogeographic Regionalisation for Australia) (2012), Retrieved from: http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html (March 2013).

Kendall, M.G. (1962), Rank Correlation Methods, Charles Griffin and Company: London.

NRMMC (Natural Resource Management Ministerial Council) (2009), *Australia's Strategy for the National Reserve System 2009-2030*. Australian Government, 74 pp.

Ratajczak, Z., Nippert, J.B. and Scott, L. (2011), The effects of woody encroachment on plant diversity in global grasslands and savannas: a meta-analysis. http://media.wix.com/ugd/d270f9_013ee3e8ed68377da3047468fb523488.pdf

Russel-Smith, J., Yates, C., Edwards, A., Allan, G.E., Cook, G.D., Cooke, P., Craig, R., Heath, B. and Smith, R. (2003), Contemporary fire regimes of northern Australia, 1997-2001: change since Aboriginal occupancy, challenges for sustainable management. *International Journal of Wildland Fire*, 12: 283-297.

Sen, P. K. (1968), Estimates of regression coefficients based on Kendall's tau. *J. Amer. Statist. Assoc.* 63: 1379–1389.

Theil, H. (1950), A rank-invariant method of linear and polynomial regression analysis" I, II and III, Nederl. Akad. Wetensch. Proc., 53.

Zomer, R.J., Bossio, D.A., Trabucco, A., Yuanjie, L., Gupta, D.C. & Singh, V.P. (2007), Trees and Water: Smallholder Agroforestry on Irrigated Lands in Northern India. Colombo, Sri Lanka.

International Water Management Institute. pp 45. (IWMI Research Report 122).

Zomer, R.J., Trabucco, A., Bossio, D.A., van Straaten, O., Verchot, L.V., (2008), Climate Change Mitigation: A Spatial Analysis of Global Land Suitability for Clean Development Mechanism Afforestation and Reforestation. *Agric. Ecosystems and Envir.* 126: 67-80.

User Questionnaire

You can find an on-line version of this questionnaire here:

http://www.diversity2.info/testsites/ppd/uq/

1. How do you judge the overall relevance and quality of the presented products?

2. Please comment shortly on the presentation of the methods and results

3. What further products (level one) would be interesting to you to have?

4. Do you have any suggestions concerning possible "second level" products, which are supposed to show the results in a more abstract and/or synthesised way?