"Desertification; what can we learn from time series of Earth Observation data?"

Rasmus Fensholt
Department of Geosciences and Natural Resource Management
Section of Geography
University of Copenhagen

"Desertification; what can we learn from time series of Earth Observation data?"

Outline:

- Intro and definitions of desertification
- EO-based Indicators of degradation
- Understanding drivers
- The importance of spatial scale
- Conclusions and recommendations

Desertification intro:

- The UN Conference on Desertification (1977)
- The Rio Conference (1992) and the ’UN Convention to Combat Desertification’ (1994/96)
- UNEP/NASA/World Bank (1998): ”Desertification and land degradation result from poor land management, which can be exacerbated by climatic variations”

UNCCD

United Nations Convention to Combat Desertification

Climate change or human mismanagement ?

The concepts of desertification and land degradation

The UNCCD text:

"Desertification" means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities

"Land degradation" means reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as:

(i) soil erosion caused by wind and/or water;

(ii) deterioration of the physical, chemical and biological or economic properties of soil; and

(iii) long-term loss of natural vegetation;

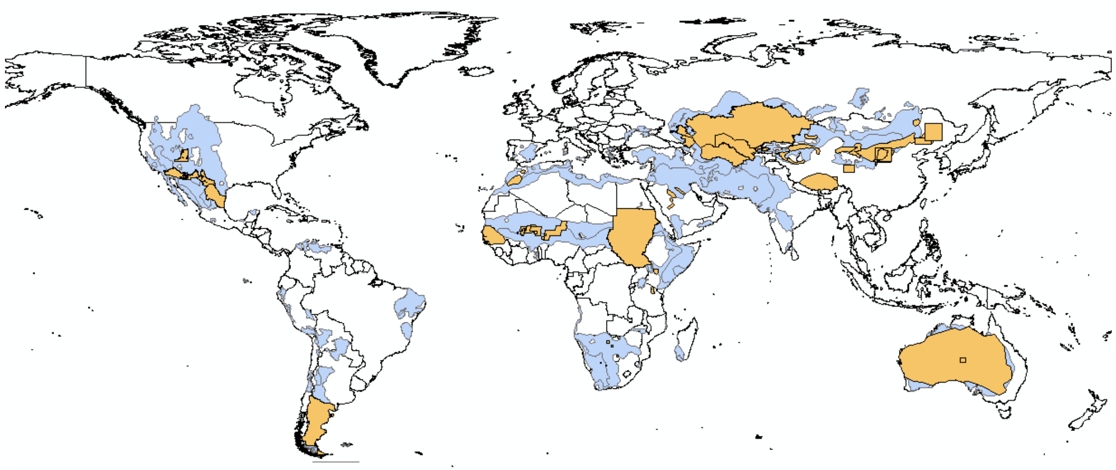
Dynamic Causal Patterns of Desertification

2004

HELMUT J. GEIST AND ERIC F. LAMBIN

Using a meta-analytical research design, we analyzed subnational case studies (n = 132) on the causes of dryland degradation, also referred to as desertification, to determine whether the proximate causes and underlying driving forces fall into any pattern and to identify mediating factors, feedback mechanisms, cross-scalar dynamics, and typical pathways of dryland ecosystem change. Our results show that desertification is driven by a limited suite of recurrent core variables, of which the most prominent at the underlying level are climatic factors, economic factors, institutions, national policies, population growth, and remote influences. At the proximate level, these factors drive cropland expansion, overgrazing, and infrastructure extension. Identifiable regional patterns of synergies among causal factors, in combination with feedback mechanisms and regional land-use and environmental histories, make up specific pathways of land change for each region and time period. Understanding these pathways is crucial for appropriate policy interventions, which have to be fine-tuned to the region-specific dynamic patterns associated with desertification.

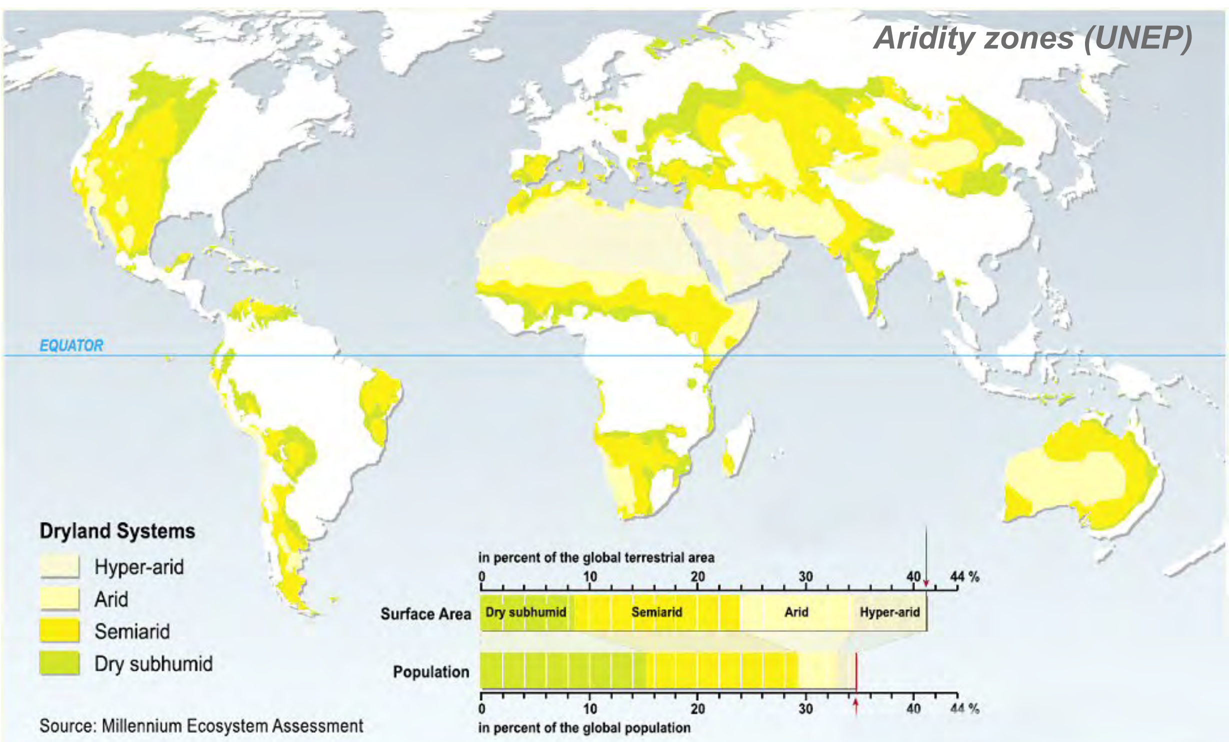
Keywords: desertification, dryland degradation, feedbacks, pathways, causes

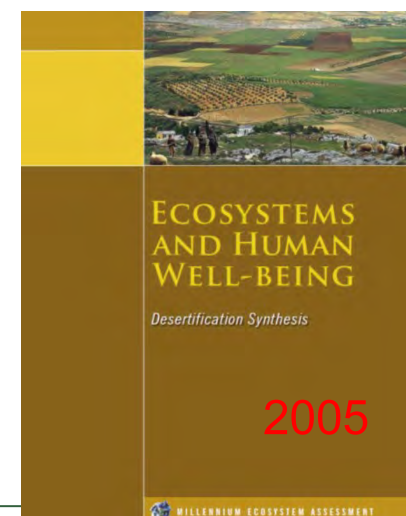


Millennium Ecosystem Assessment - Desertification synthesis (2005):

- **10–20% of drylands already degraded (high uncertainty exists).**

- **Need for scientifically robust methods to identify regions and extent .**





Land degradation:
Problems of operationalizing the definition

UNCCD
United Nations Convention to Combat Desertification

1. Land Degradation may be the result of many different processes, not necessarily operating in parallel

2. Possible indicators of Land Degradation
    1. Biological productivity: NPP: kg/ha, J/ha
    2. Economic productivity: USD/ha
    3. Complexity: Measures of species diversity

3. What time-scales and spatial scales should be considered ?

Needed:

- *Improved methods for monitoring the global dryland carbon cycle and land degradation → including a better understanding of the drivers of changes.*

- *Clarification on what part/kind of the degradation (definition) is being monitored*

"Desertification; what can we learn from time series of Earth Observation data?"

EO-based indicators:
Trends in biological productivity: NPP: kg/ha

- NDVI
- fAPAR
- LAI
- GPP
- NPP…

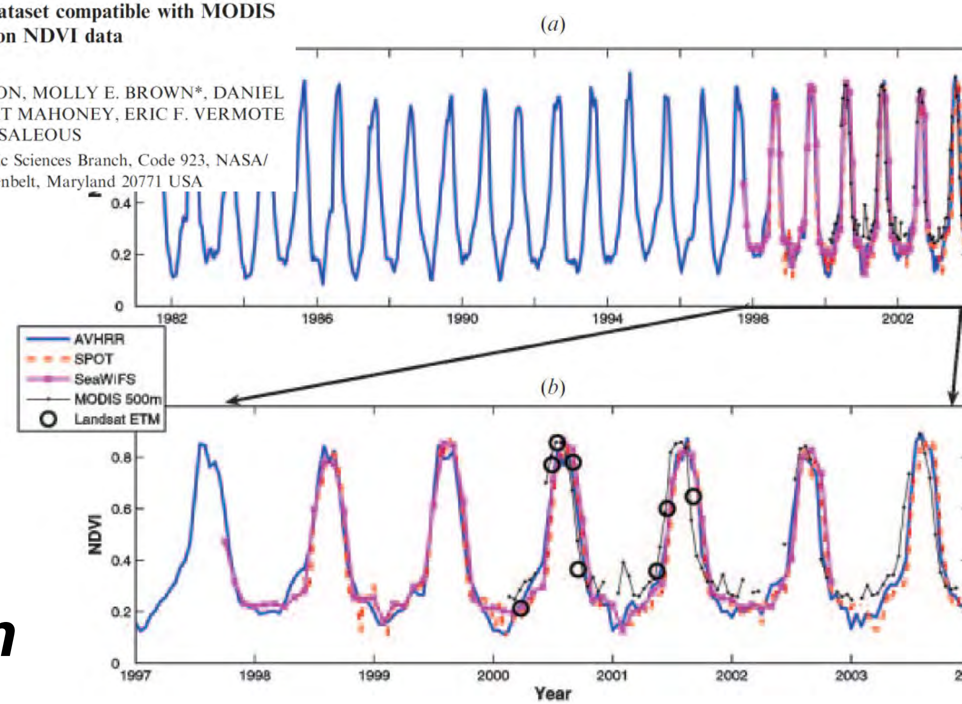
The AVHRR archive

Global Inventory Monitoring and Modeling System (GIMMS) project – 30 years and counting

International Journal of Remote Sensing
Vol. 26, No. 20, 20 October 2005, 4485–4498
Taylor & Francis
Taylor & Francis Group

An extended AVHRR 8-km NDVI dataset compatible with MODIS and SPOT vegetation NDVI data

COMPTON J. TUCKER, JORGE E. PINZON, MOLLY E. BROWN*, DANIEL A. SLAYBACK, EDWIN W. PAK, ROBERT MAHONEY, ERIC F. VERMOTE and NAZMI EL SALEOUS
Laboratory for Terrestrial Physics, Biospheric Sciences Branch, Code 923, NASA/ Goddard Space Flight Center, Greenbelt, Maryland 20771 USA



SPOT VGT
MODIS
MERIS

Trend analysis/
Epoch changes

Shorter time series – improved spatial resolution

Re

journ

Greenness in semi-arid area
Satellite based analysis of tr

Rasmus Fensholt [a,*], Tobias Langanl
Compton Tucker [c], Robert J. Scholes
Howard Epstein [l], Andrea E. Gaugha
Christian Schweitzer [m], Jonathan Se

Changes in greenness for se

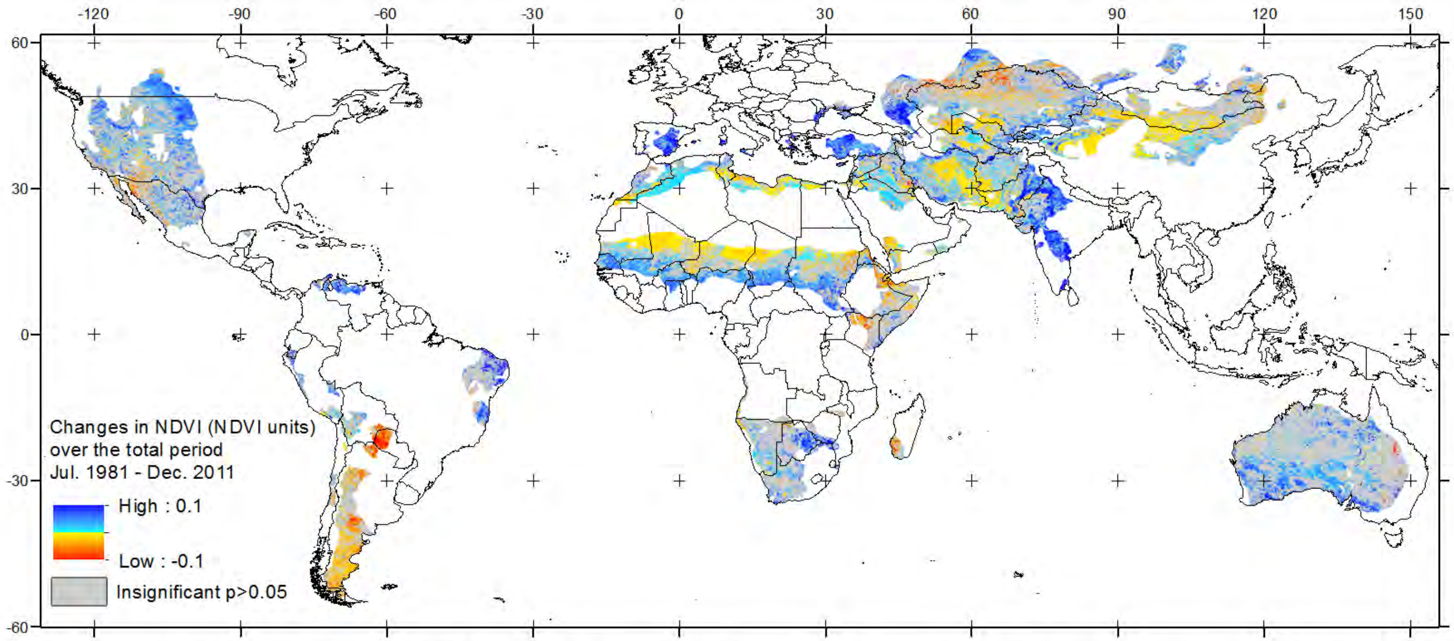
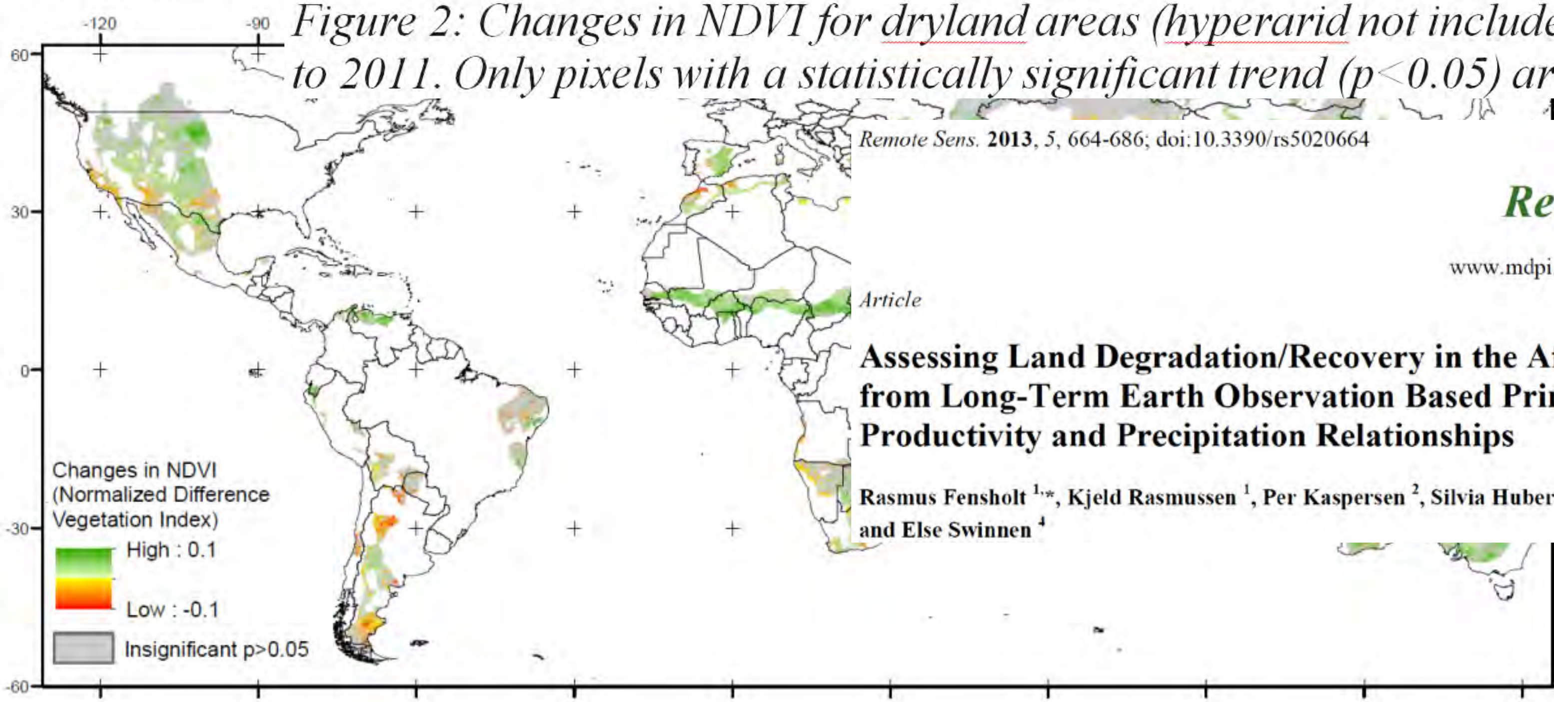


Figure 2: Changes in NDVI for dryland areas (hyperarid not included) from 1981 to 2011. Only pixels with a statistically significant trend (p<0.05) are shown.



Remote Sens. **2013**, *5*, 664-686; doi:10.3390/rs5020664

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Remote Sensing

ISSN 2072-4292

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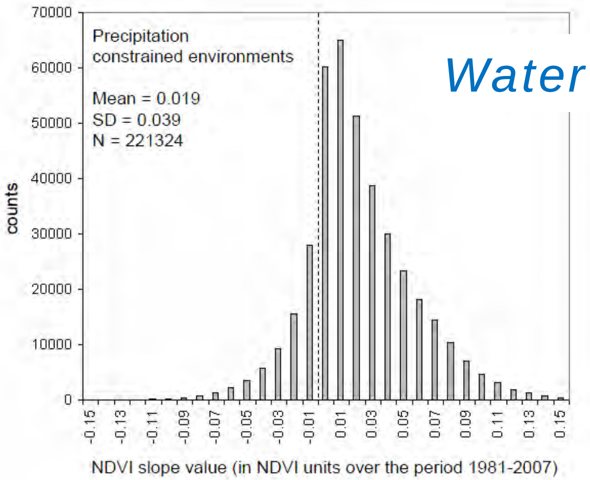
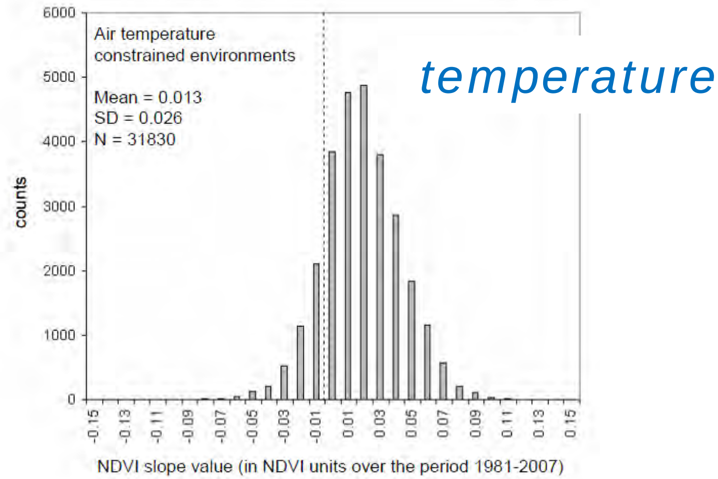
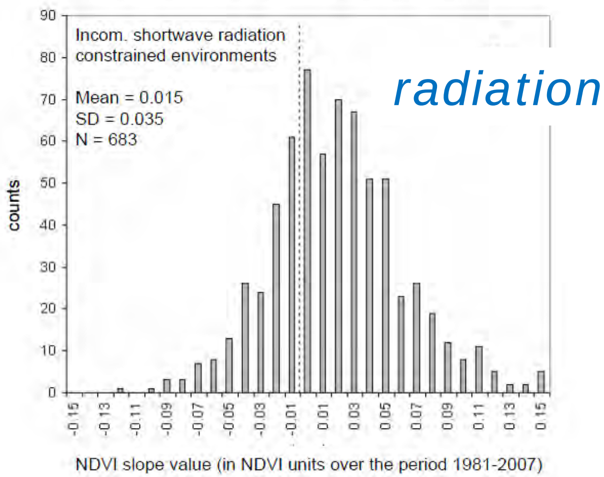
Article

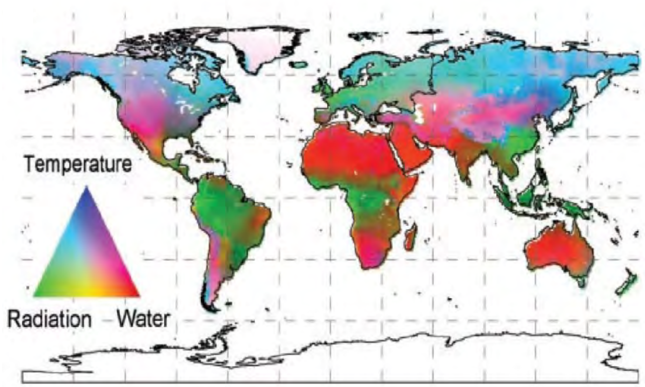
Assessing Land Degradation/Recovery in the African Sahel from Long-Term Earth Observation Based Primary Productivity and Precipitation Relationships

Rasmus Fensholt [1,*], Kjeld Rasmussen [1], Per Kaspersen [2], Silvia Huber [3], Stephanie Horion [1] and Else Swinnen [4]










Remote Sensing of Environment 121 (2012) 144–158

Contents lists available at SciVerse ScienceDirect

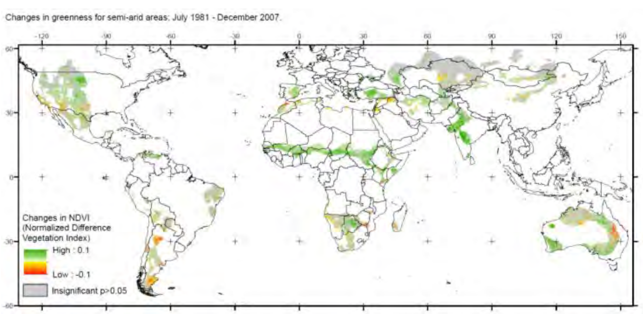
Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

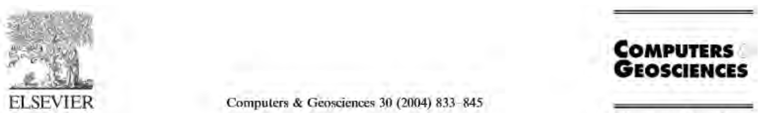
ELSEVIER

Greenness in semi-arid areas across the globe 1981–2007 — an Earth Observing Satellite based analysis of trends and drivers

Rasmus Fensholt [a,*], Tobias Langanke [a], Kjeld Rasmussen [a], Anette Reenberg [a], Stephen D. Prince [b], Compton Tucker [c], Robert J. Scholes [d], Quang Bao Le [e,f], Alberte Bondeau [g,o], Ron Eastman [h], Howard Epstein [i], Andrea E. Gaughan [j], Ulf Hellden [n], Cheikh Mbow [k], Lennart Olsson [n], Jose Paruelo [l], Christian Schweitzer [m], Jonathan Seaquist [n], Konrad Wessels [d]



Refining the indicators…
NDVI time series parameterization


ELSEVIER

Computers & Geosciences 30 (2004) 833–845

COMPUTERS & GEOSCIENCES

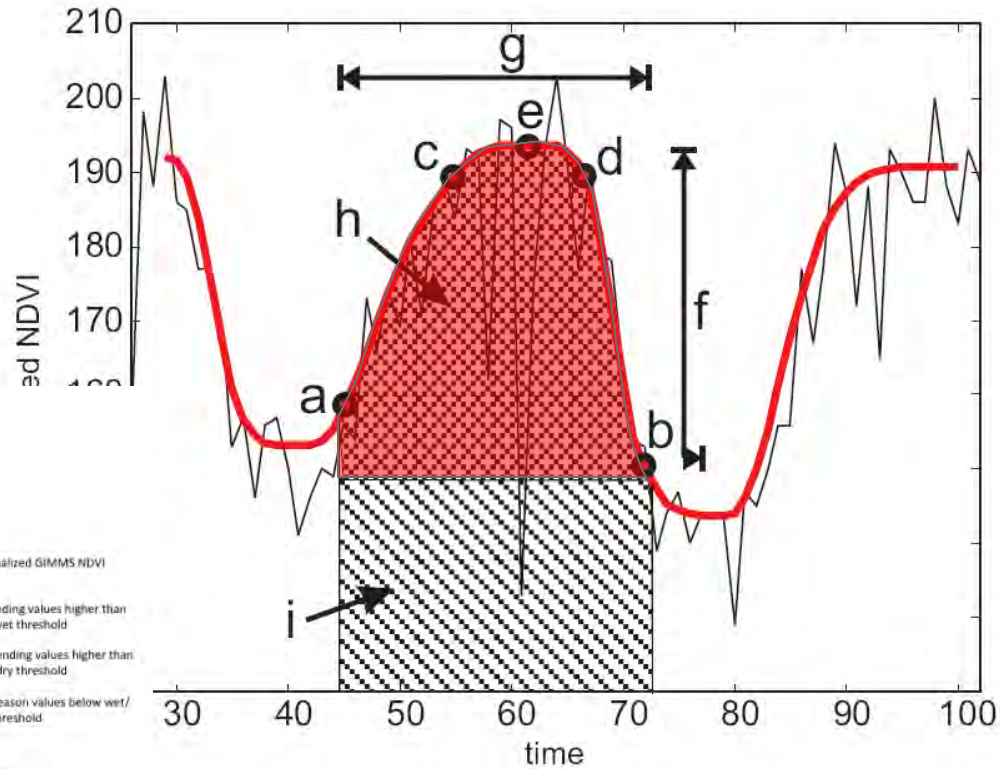
www.elsevier.com/locate/cageo

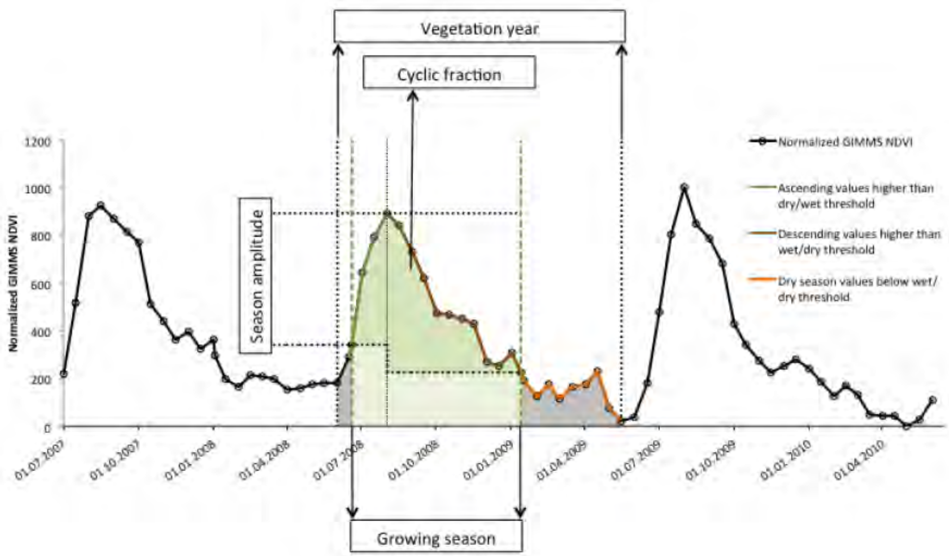
TIMESAT—a program for analyzing time-series of satellite sensor data☆

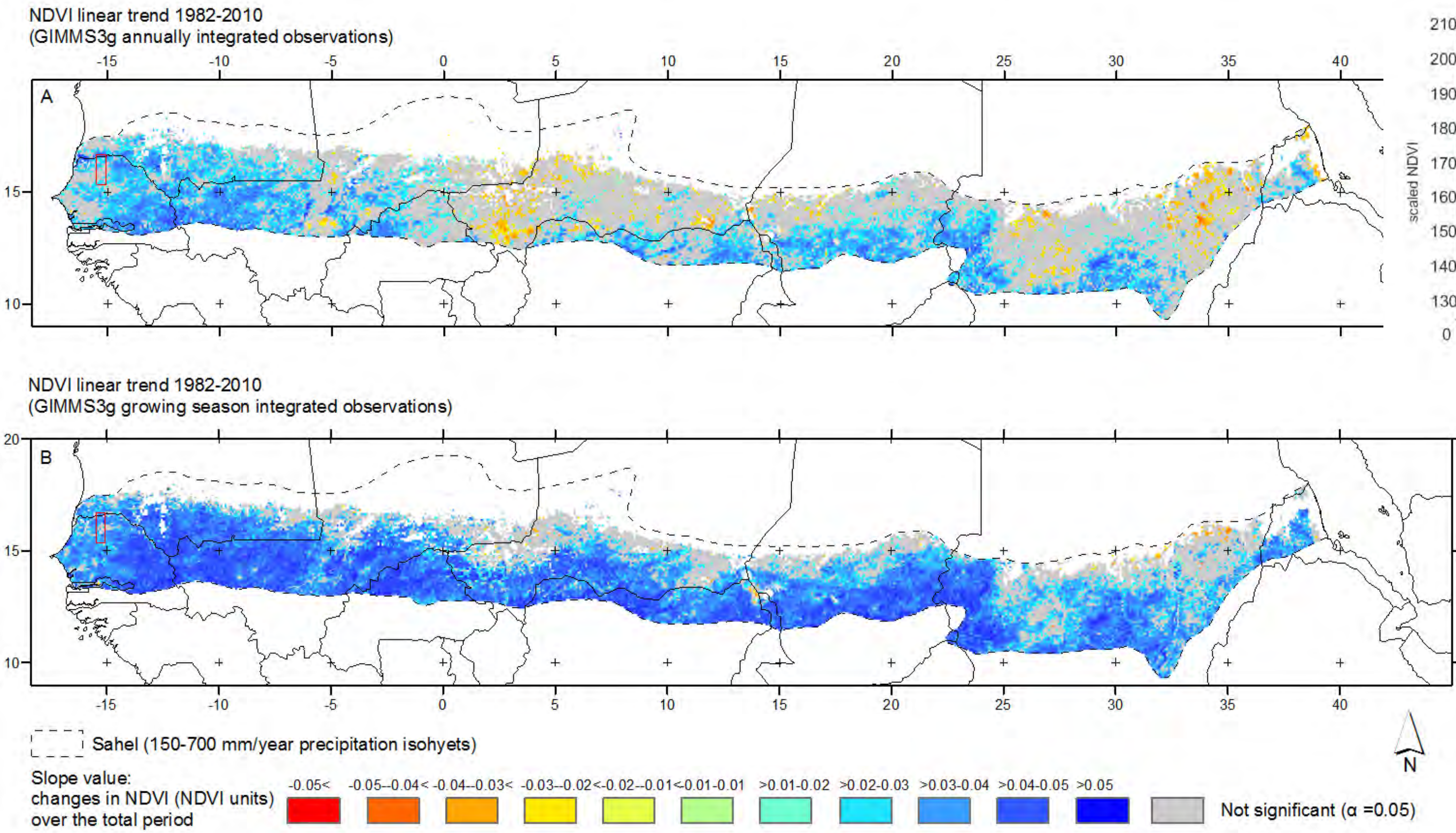
Per Jönsson[a,b,*,1], Lars Eklundh[c,1]

[a] Division of Mathematics, Natural Sciences and Language, Malmö University, Malmö, Sweden
[b] Department of Physics, Lund University, Lund, Sweden
[c] Department of Physical Geography and Ecosystems Analysis, Lund University, Lund, Sweden

Received 3 March 2003; received in revised form 14 April 2004; accepted 1 May 2004







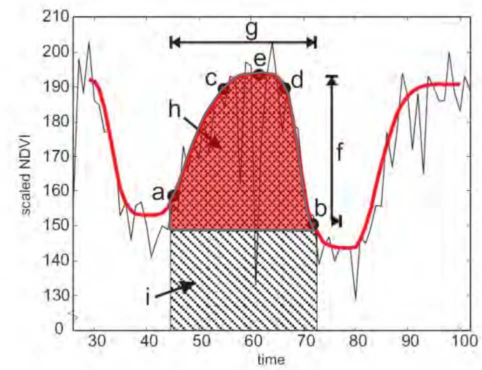


Figure 3: GIMMS3g NDVI linear trend 1982–2010 based on (A) annually integrated NDVI and (B) growing season NDVI integral estimated from TIMESAT parameterization.

Remote Sens. **2013**, *5*, 664-686; doi:10.3390/rs5020664

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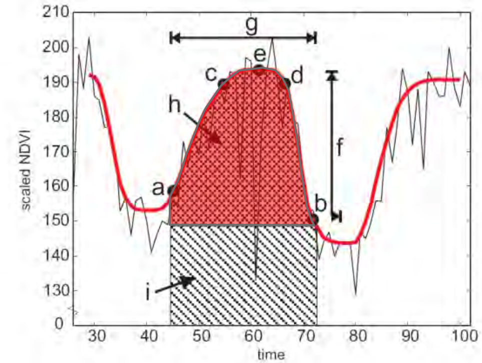
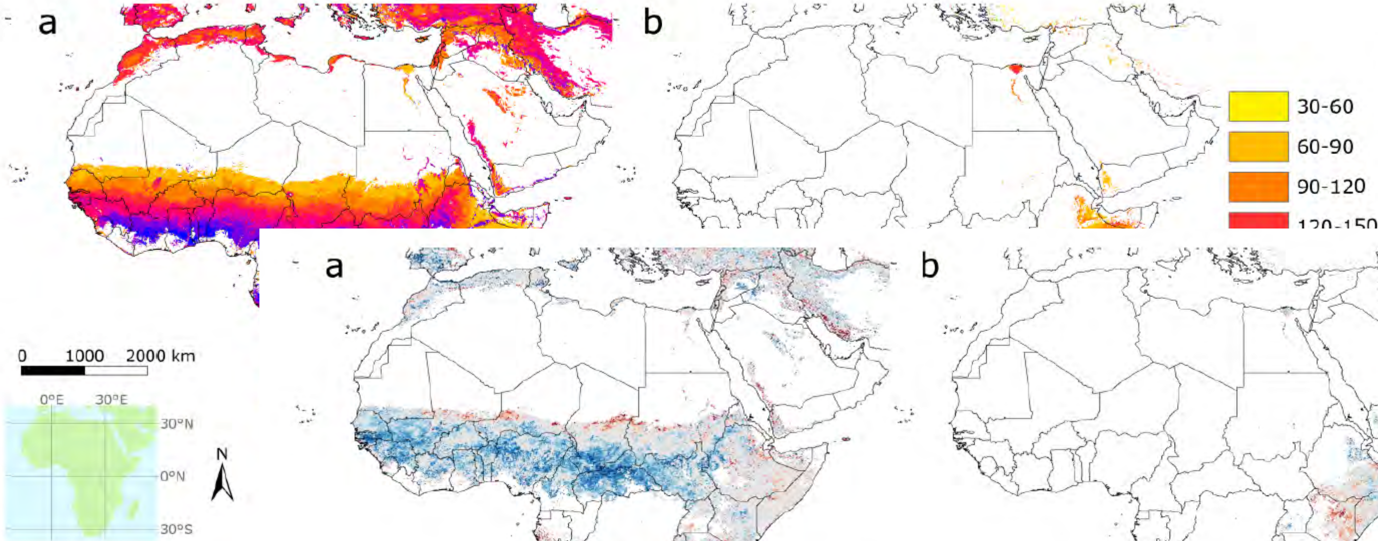
Article

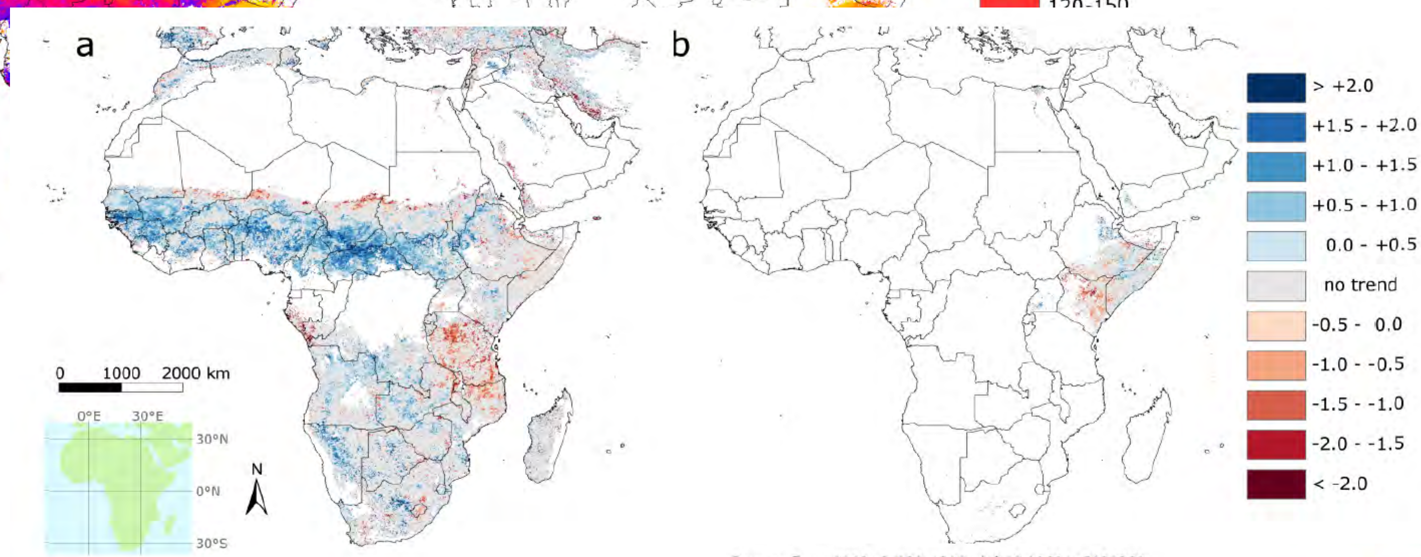
Assessing Land Degradation/Recovery in the African Sahel from Long-Term Earth Observation Based Primary Productivity and Precipitation Relationships

Rasmus Fensholt [1,*], Kjeld Rasmussen [1], Per Kaspersen [2], Silvia Huber [3], Stephanie Horion [1] and Else Swinnen [4]

Figure 2. (**a**) Average length of growing period (in days) for the first season in calendar year. (**b**) Average length of growing period for areas with a second season. Note that cloud-contaminated areas along the Guinea Coast that were identified as bimodal (Figure 1) are masked out.







Remote Sens. **2013**, *5*, 982-1000; doi:10.3390/rs5020982

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ISSN 2072-4292

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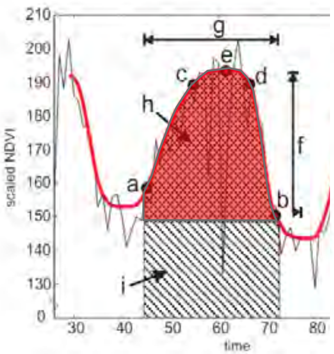
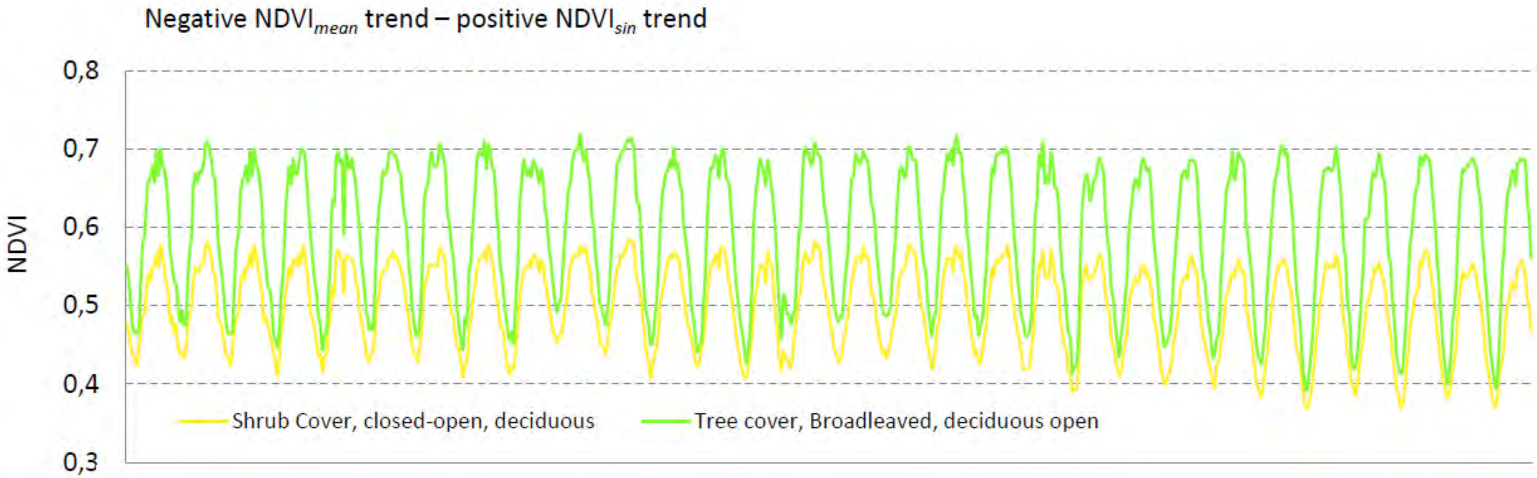
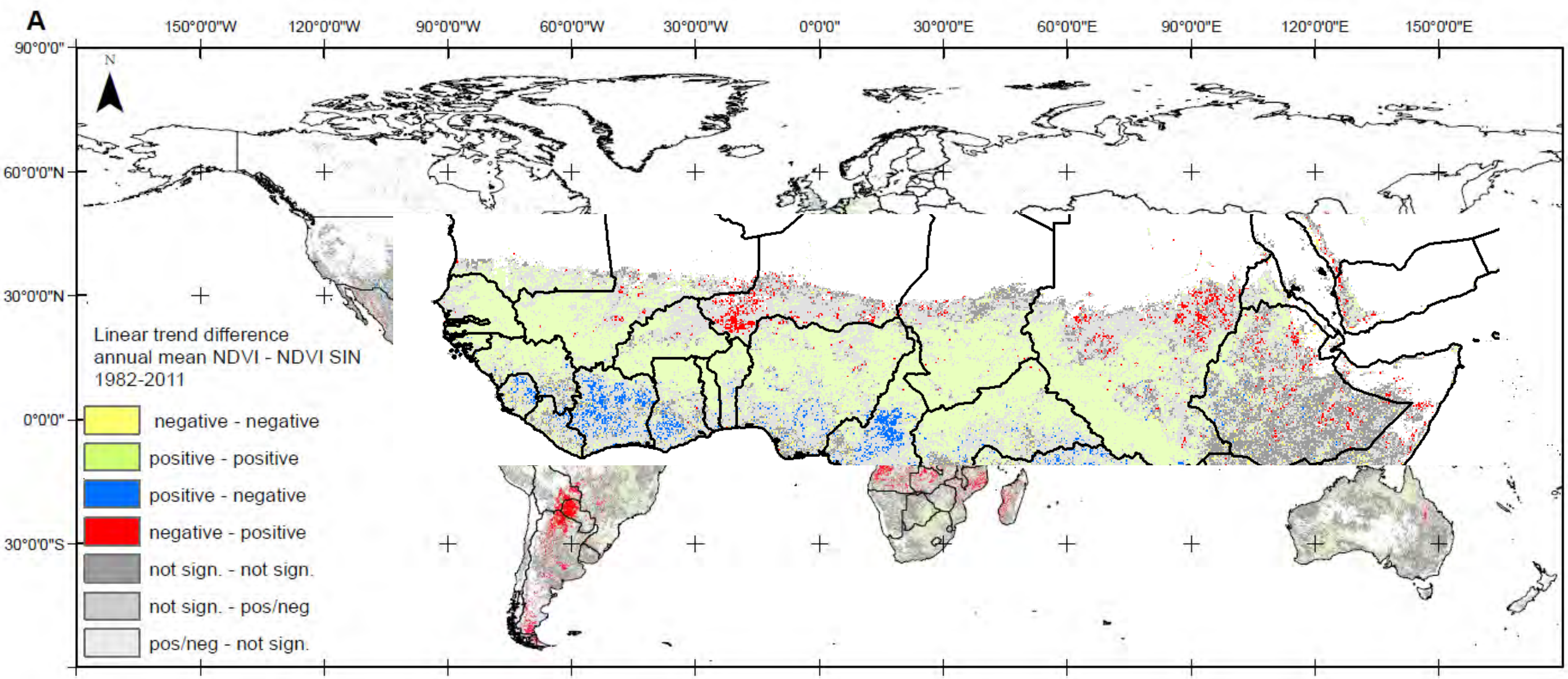
Article

Length of Growing Period over Africa: Variability and Trends from 30 Years of NDVI Time Series

Anton Vrieling [1,*], Jan de Leeuw [2] and Mohammed Y. Said [3]


scaled NDVI
time
210
200
190
180
170
160
150
140
130
0
30
40
50
60
70
80
a
b
c
d
e
f
g
h
i


Negative $NDVI_{mean}$ trend – positive $NDVI_{sin}$ trend
NDVI
0,8
0,7
0,6
0,5
0,4
0,3
Shrub Cover, closed-open, deciduous
Tree cover, Broadleaved, deciduous open


A
150°0'0"W
120°0'0"W
90°0'0"W
60°0'0"W
30°0'0"W
0°0'0"
30°0'0"E
60°0'0"E
90°0'0"E
120°0'0"E
150°0'0"E
90°0'0"
60°0'0"N
30°0'0"N
0°0'0"
30°0'0"S
N
Linear trend difference
annual mean NDVI - NDVI SIN
1982-2011
negative - negative
positive - positive
positive - negative
negative - positive
not sign. - not sign.
not sign. - pos/neg
pos/neg - not sign.

EO productivity indicators

Greening ⟷ desertification/land degradation ?

Why discrepancy between global EO/field based assessment?
Can we have degradation despite ongoing greening?

We need to know more about

- The drivers (changes in precipitation, temperature, CO_2, antropogenic)?
- Whats behind this greening (changes in LUCC, biodiversity/”green deserts”)?
- The impact from ”scale of observations”

How to explain the greening trend global drylands

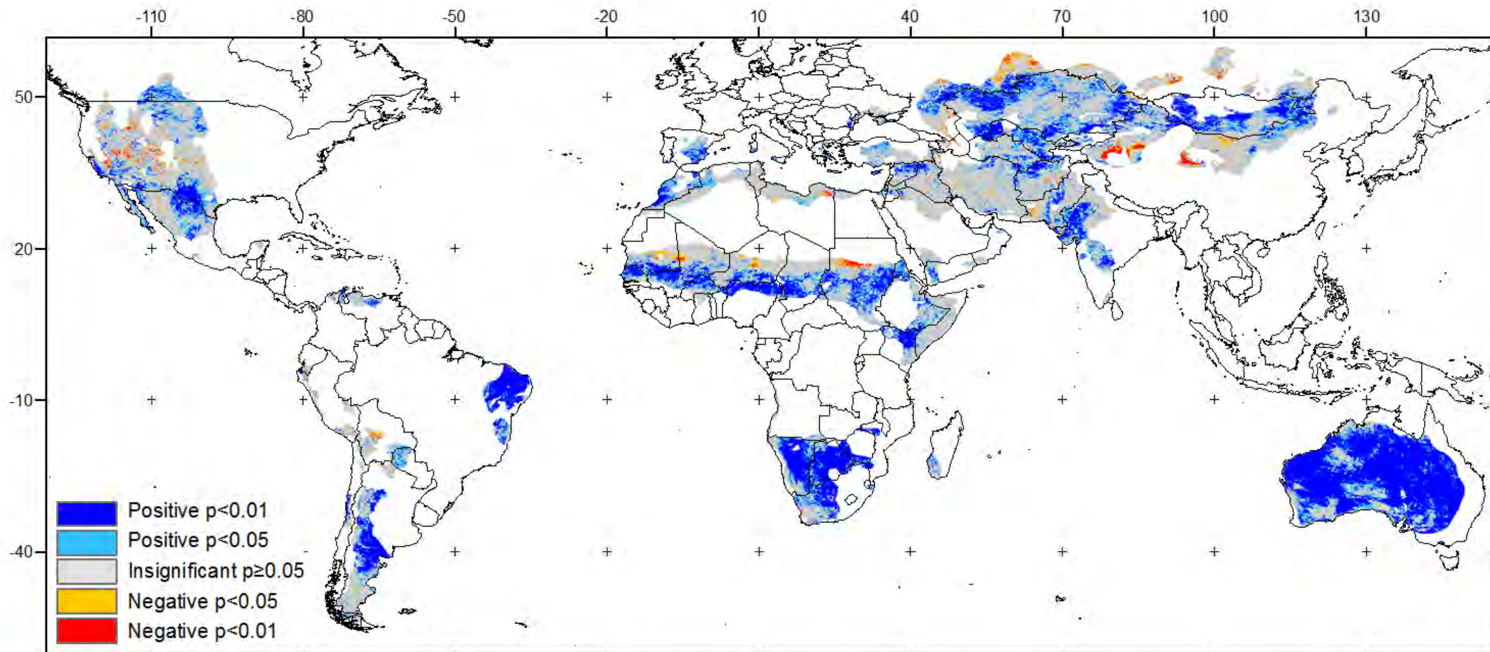
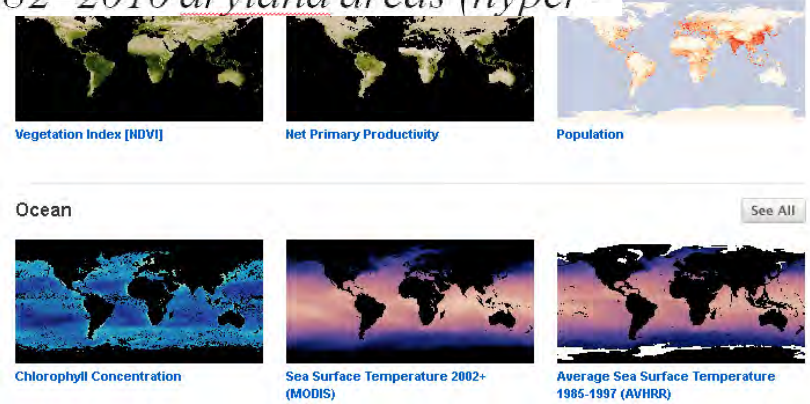


Figure 1: Significance of linear correlation between annual integrated GIMMS3g NDVI and annual summed CMAP precipitation 1982–2010 dryland areas (hyper-



Land degradation – normalizing for rainfall variability

Higher order indicators:

Rain Use Efficiency (standing biomass produced per mm rainfall)

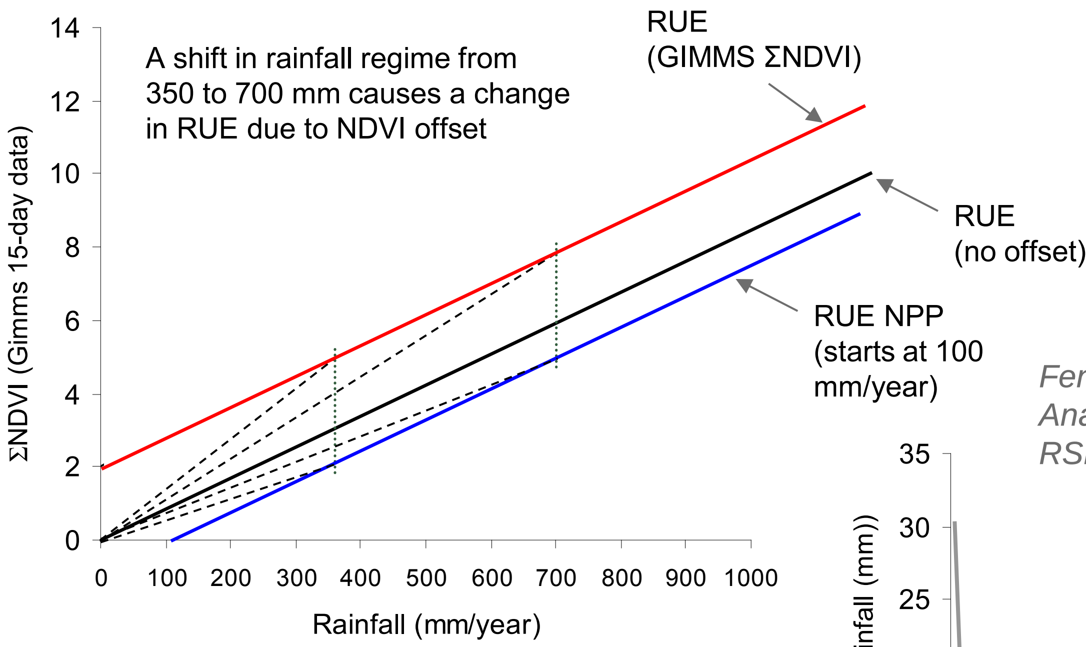
- In the absence of degradation temporal trends in RUE is assumed constant for semi-arid areas

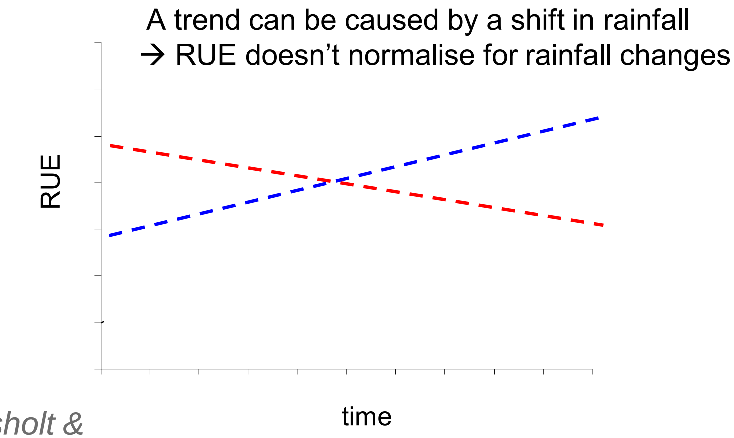
- *A decrease in RUE over time indicates ongoing land degradation not caused by rainfall (anthropogenic influence)*
- *A decrease in RUE over space indicates ongoing land degradation not caused by rainfall (anthropogenic influence) if normalised for climate (different Et regimes)*

NOTE - for biophysical reasons RUE should be constrained to water limitated environments – otherwise the assumption of constant RUE for varying rainfall breaks down

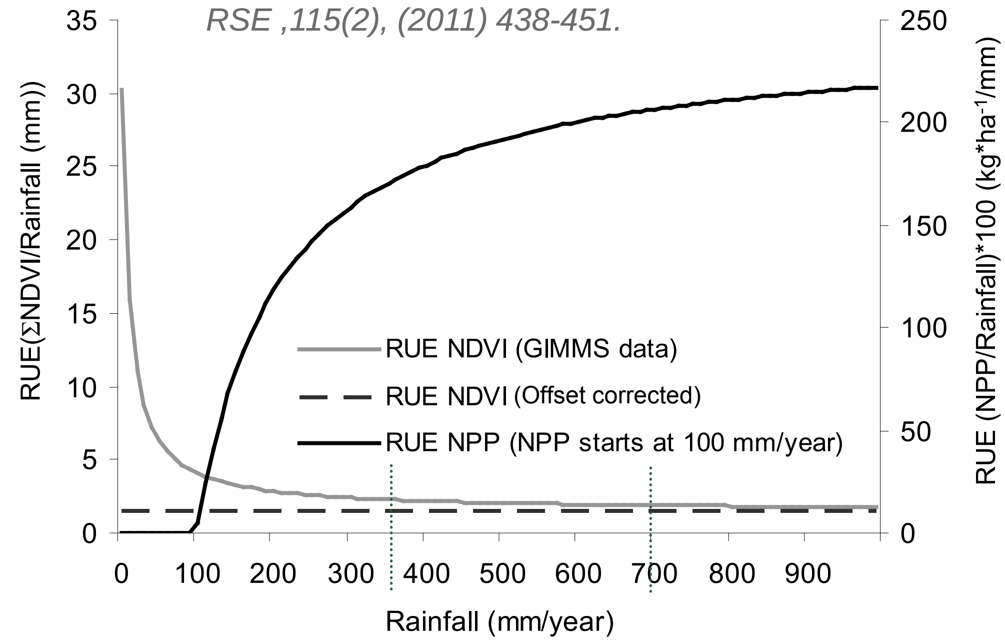
Rain Use effficience - temporal interpretation

- For mathematical reasons; RUE should be used with caution when substituting NPP by NDVI (..... the assumption about a constant RUE ratio)





Fensholt & Analysis of trends in the Sahelian 'rain-use efficiency' RSE ,115(2), (2011) 438-451.



Linearity

But no proportionality !!

Rain Use effficience - spatial interpretation

Remote Sensing for Science, Education, and Natural and Cultural Heritage
Rainer Reuter (Editor)
EARSeL, 2010

Integrating MODIS-EVI and Gridded Rainfall/temperature Fields for Assessing Land Degradation Dynamics in Horqin Sandy Lands, Inner Mongolia (China)

Joachim HILL[a,1], Claudia DACH[a], Gabriel DEL BARRIO[b], Marion STELLMES[a], Ulf HELLDÉN[c], and WANG Changyao[d]
[a] *Environmental Remote Sensing, University of Trier,*
[b] *CSIC, Estacion Experimental de Zonas Aridas, Alm*

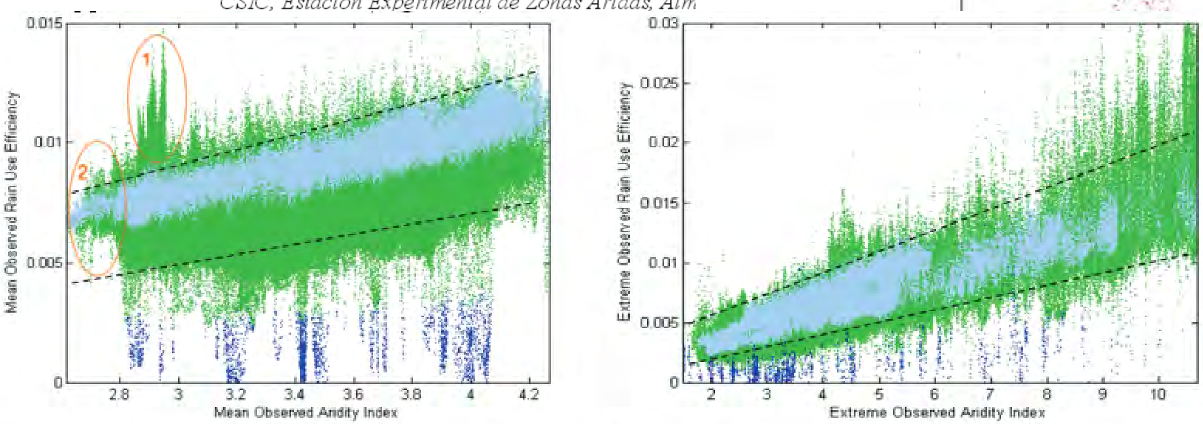
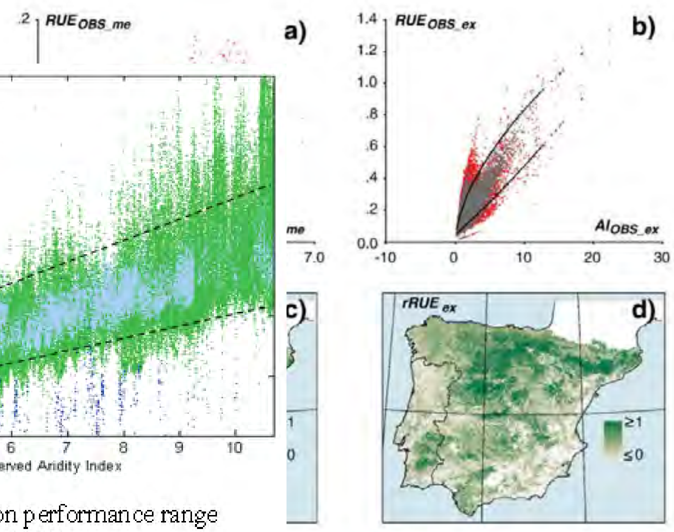


Figure 2. RUE vs. AI scatter plots used for defining the lower and upper vegetation performance range (5 - 95 percentiles) for long-term (left) and short-term response to rainfall

Remote Sensing of Environment 114 (2010) 1817–1832
Contents lists available at ScienceDirect
Remote Sensing of Environment
journal homepage: www.elsevier.com/locate/rse

Assessment and monitoring of land condition in the Iberian Peninsula, 1989–2000

Gabriel del Barrio[a,*], Juan Puigdefabregas[a], Maria E. Sanjuan[a], Marion Stellmes[b], Alberto Ruiz[a]
[a] *Estacion Experimental de Zonas Aridas (CSIC), Sacramento Road, 04120 La Cañada de San Urbano, Almeria, Spain*
[b] *Remote Sensing Department, FB VI Geography/Geosciences, University of Trier, D-54286 Trier, Germany*



...d as the inter-annual mean of each location over the full period (*a* and *c*), and for the six-month period preceding the time when maximum vegetation density was detected at each location (*b* and *d*). Empirical boundary functions fitted to the scatterplots of observed RUE over aridity (*a*: RUE_{OBS_me} vs. AI_{OBS_me} ; *b*: RUE_{OBS_ex} vs. AI_{OBS_ex}) define the potential limits of expected RUE for any aridity level. Only locations of rainfed natural and seminatural vegetation (grey dots) were used to fit the boundaries, whilst irrigated crops and other surfaces not responding to climate (red dots) are shown for information. Relative RUE (*c*: $rRUE_{me}$; *d*: $rRUE_{ex}$) is then computed for each location as the position of its observed RUE within the referred limits.

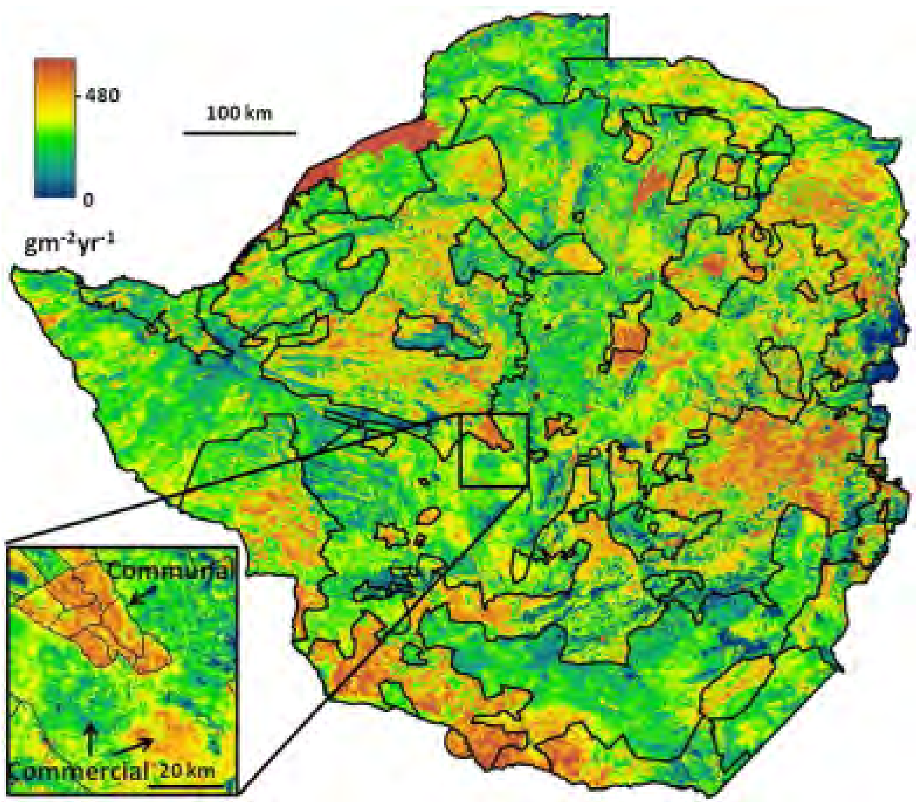
Challenges: impacts from
- spatial variability in soil type
- spatial variablility in slope (run on/off

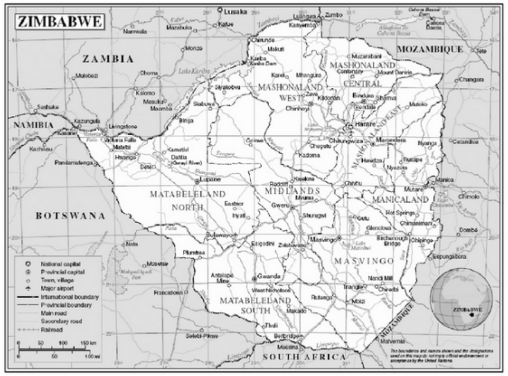
≈ Local NPP Scaling (LNS)

Remote Sensing of Environment
Volume 113, Issue 5, 15 May 2009, Pages 1046–1057

Detection and mapping of long-term land degradation using local net production scaling: Application to Zimbabwe

S.D. Prince, I. Becker-Reshef, K. Rishmawi





Local NPP Scaling (LNS) of Zimbabwe using the ZSOL soils map and precipitation (ZSOL–PPT) *land capability classification*.

Communal and Commercial area boundaries shown in black.

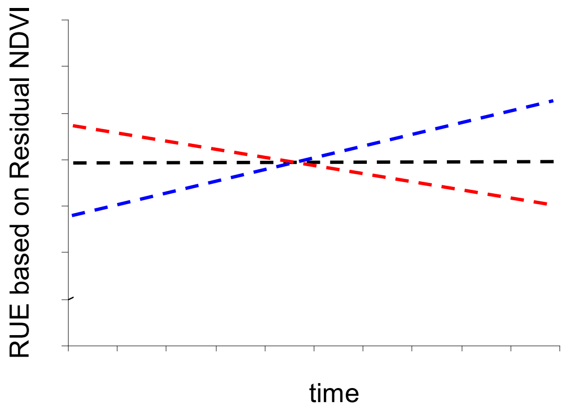
Inset, higher resolution segment showing communal area degradation (top left) and commercial area degradation (lower right)...

→ The residual NDVI trend approach (RESTREND)

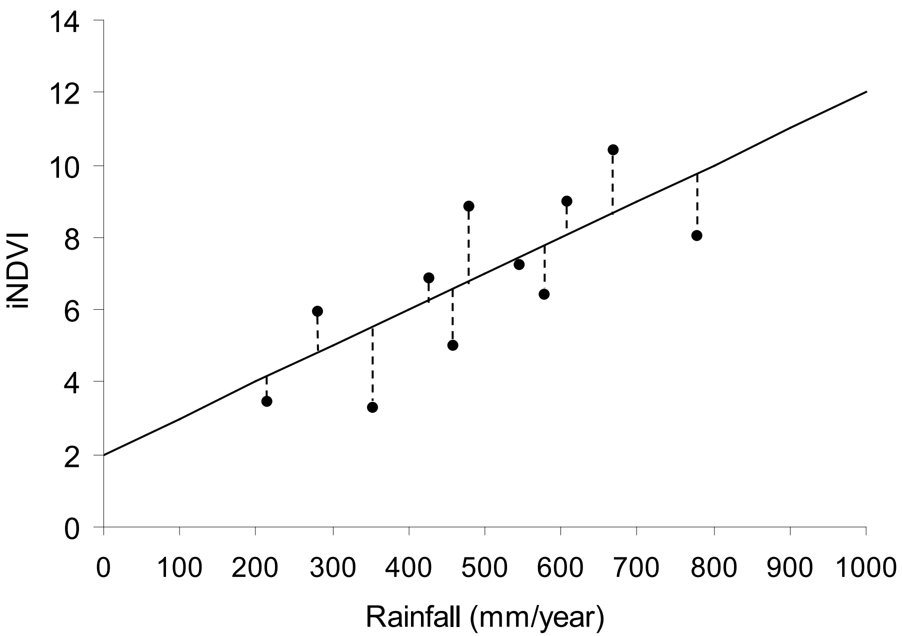
Wessels et al.,
Can human-induced land degradation be distinguished from the effects of rainfall variability?
Journal of Arid Environments, 68, (2007) 271–297.

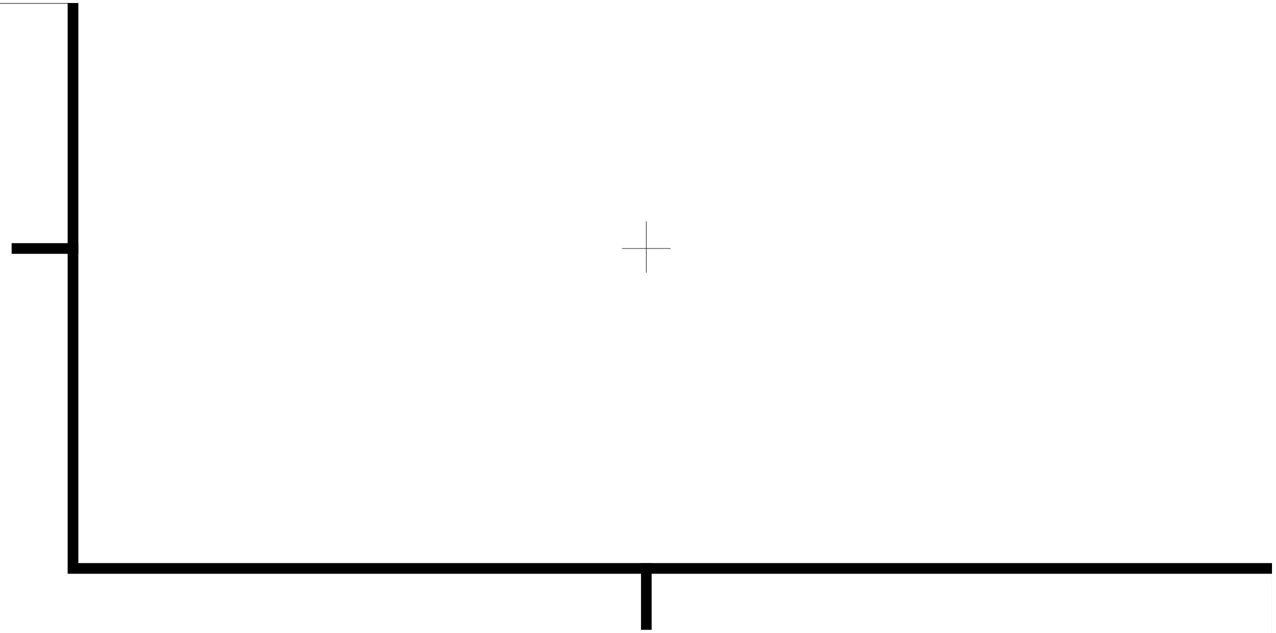
Per-pixel residual NDVI is estimated from differences between the observed and predicted NDVI

A trend cannot be caused by a shift in rainfall
→ RUE normalises for rainfall changes



Per-pixel relation





Requires strong per-pixel linear correlation

- tends to disappear for an area exposed to to land degradation

→ trend estimates become uncertain for degraded areas

ELSEVIER
Remote Sensing of Environment
Volume 125, October 2012, Pages 10–22

Limits to detectability of land degradation by trend analysis of vegetation index data

K.J. Wessels[a, b], F. van den Bergh[a], R.J. Scholes[c]

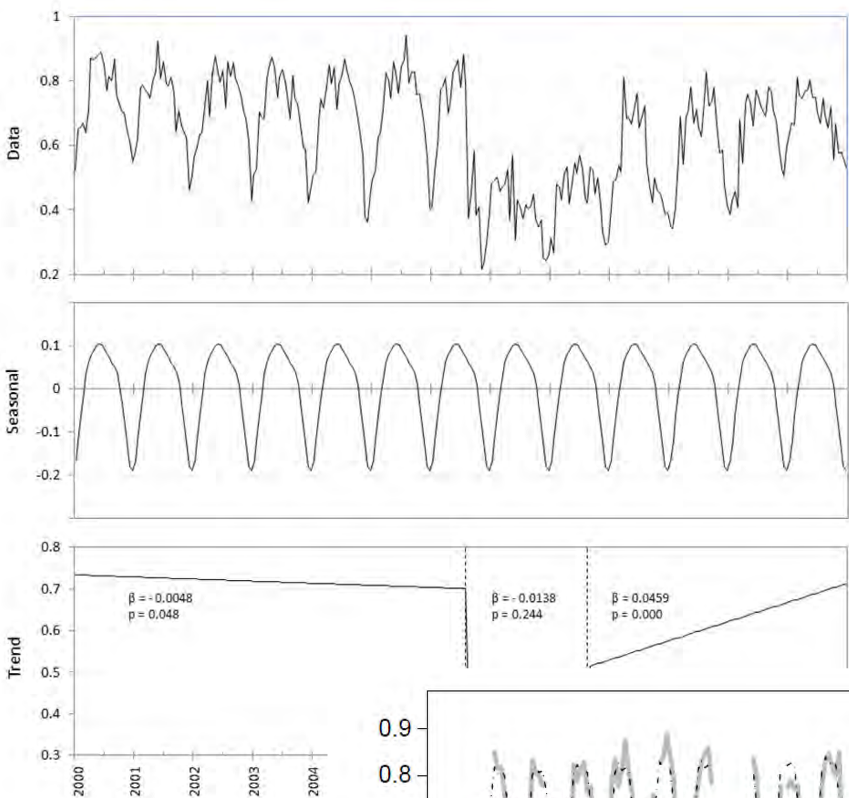
"The RESTREND method became unreliable when degradation reduces ΣNDVI by 20% or more, as the ΣNDVI–rainfall relationship breaks down as a result of degradation, i.e. reductions in ΣNDVI.

Unless a confirmed non-degraded reference period is available to establish the expected ΣNDVI–rainfall relationship for an area, the RESTREND method will suffer from this inherent limitation.

Correcting for rainfall trends and variability therefore remains one of the biggest challenges when monitoring land degradation".

Assumptions of linearity/proportionallity between rainfall and productivity (constant RUE for varying rainfall)
→ breaks down when introducing degradation in a time series

Refining the (Higher order?) indicators… breaks in time series



Remote Sens. **2013**, *5*, 1117-1133; doi:10.3390/rs5031117

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Remote Sensing

ISSN 2072-4292

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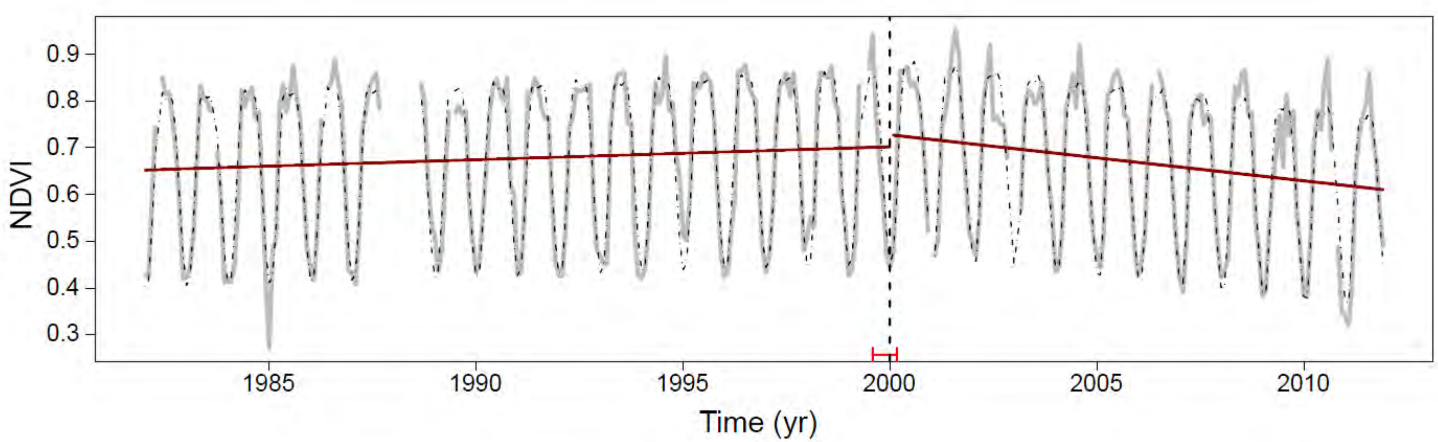
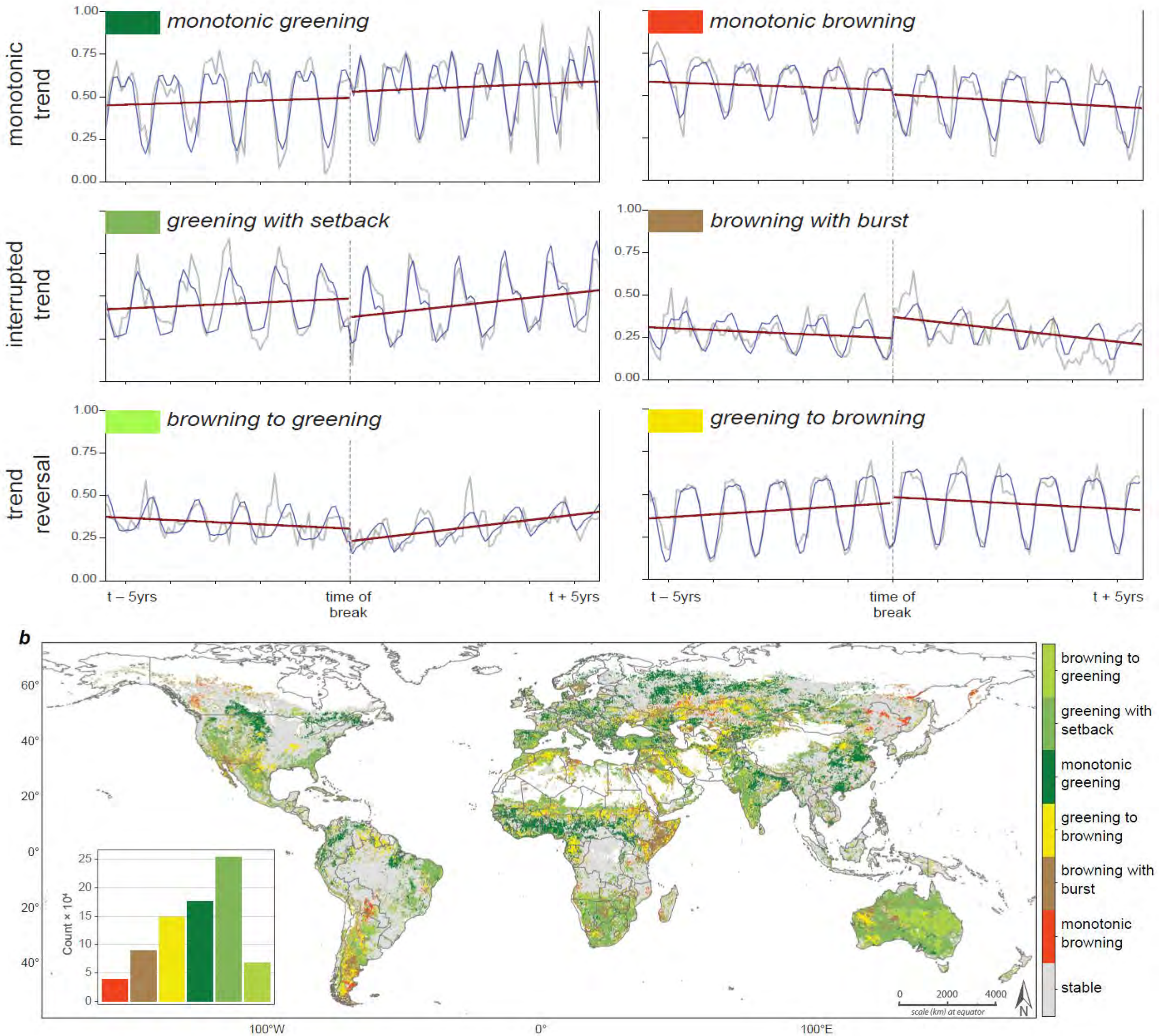
Article

Shifts in Global Vegetation Activity Trends

Rogier de Jong [1,*], Jan Verbesselt [2], Achim Zeileis [3] and Michael E. Schaepman [1]

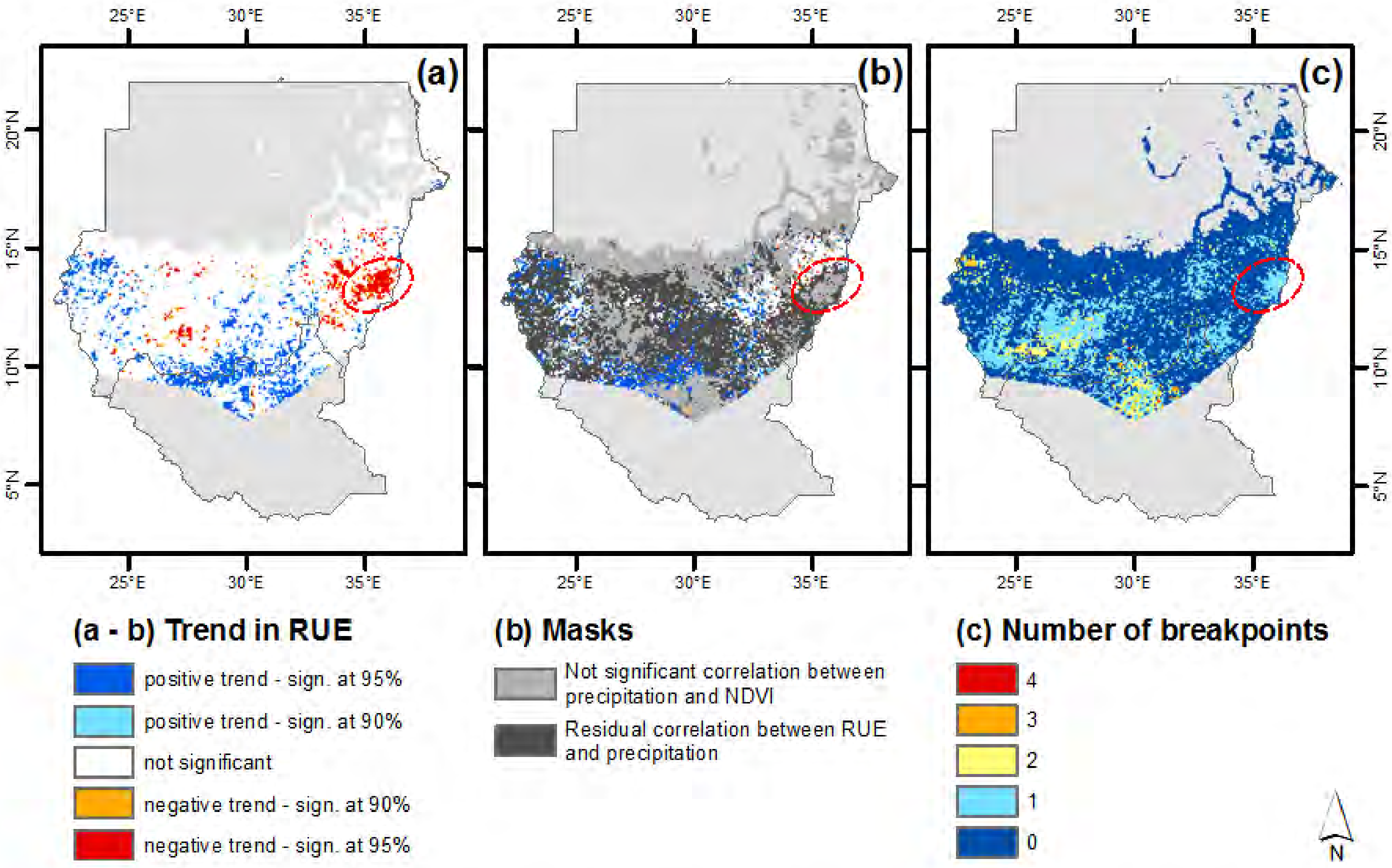
BFAST
Breaks For Additive Season and Trend





Greening

browning

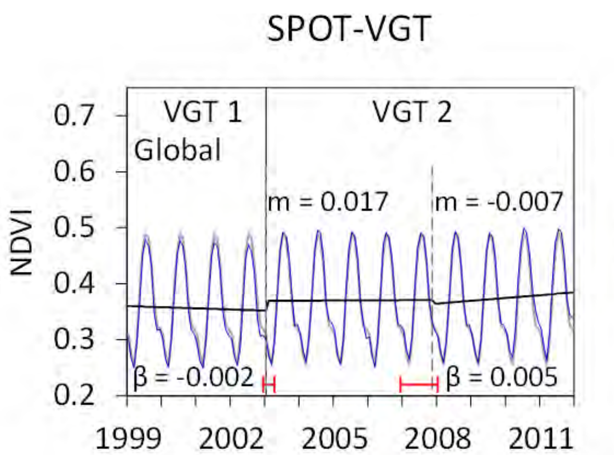


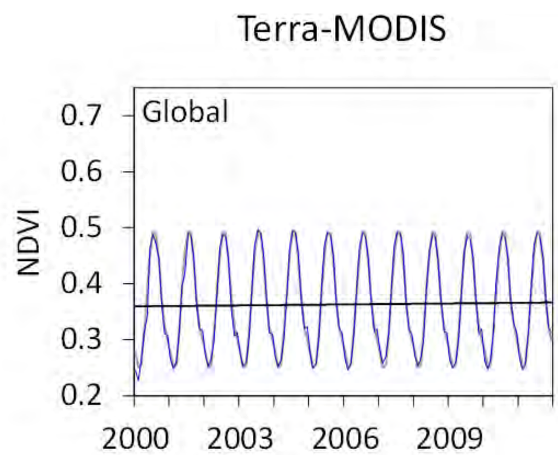
Horion, S., work in progress

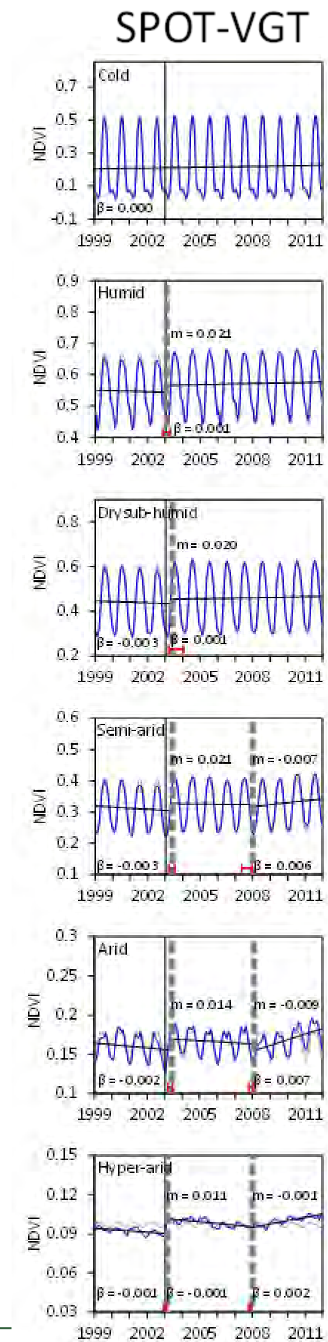
Figure 6: (a) Direction and significance of 1982-2011 trends in Rain-Use Efficiency derived from the GIMMS3g NDVI and the GPCP yearly totals for dryland areas of Sudan. Non vegetated areas were masked out (light grey). (b) As in (a) but superimposed by pixels being masked due to lack of correlation between rainfall and NDVI (medium grey) and residual correlation between RUE and rainfall (dark grey).(c) Number of break points in Rain-Use Efficiency identified by BFAST between 1982-2011.

Time series – data quality?

BFAST
Breaks For Additive Season and Trend

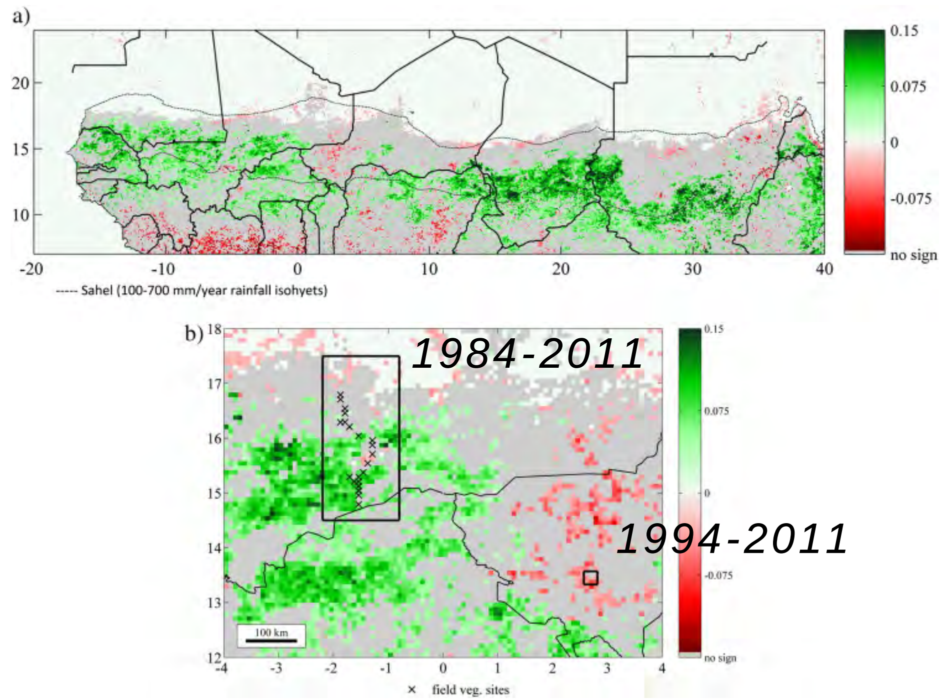






Tian, F.,
Submitted (RSE)

Ground validation…



Remote Sensing of Environment 140 (2014) 350–364

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Re-greening Sahel: 30 years of remote sensing data and field observations (Mali, Niger)

C. Dardel [a,*], L. Kergoat [a], P. Hiernaux [a], E. Mougin [a], M. Grippa [a], C.J. Tucker [b]

[a] Geosciences Environnement Toulouse (GET), Observatoire Midi-Pyrénées, UMR 5563 (CNRS/UPS/IRD/CNES), 14 Avenue Edouard Belin, 31400 Toulouse, France
[b] NASA Goddard Space Flight Center, Mail Code 610.9, Greenbelt, MD 20771, USA

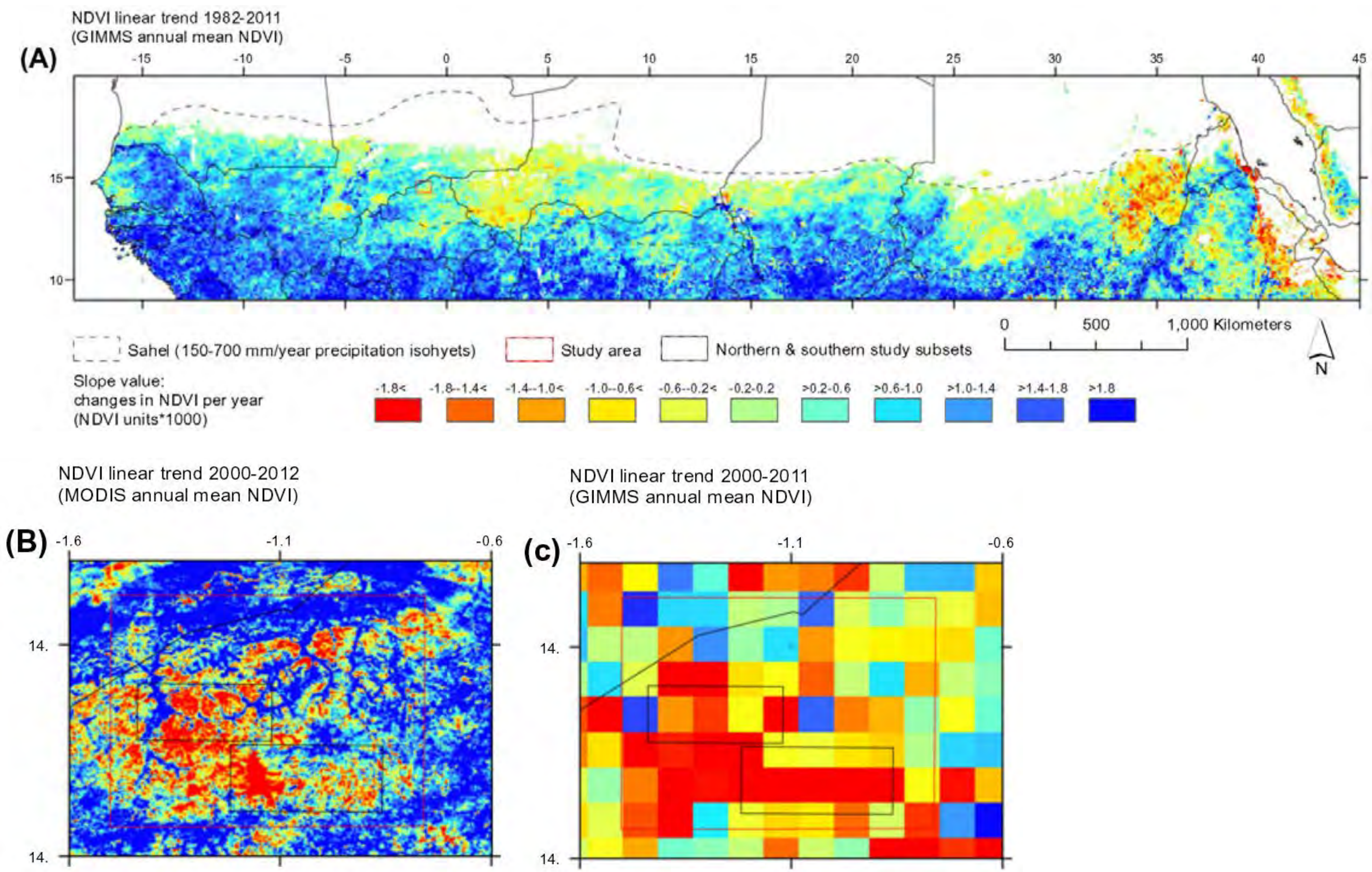
Scale of analysis

Geografisk Tidsskrift-Danish Journal of Geography, 2014
Vol. 114, No. 1, 17–24, http://dx.doi.org/10.1080/00167223.2014.890522
Taylor & Francis

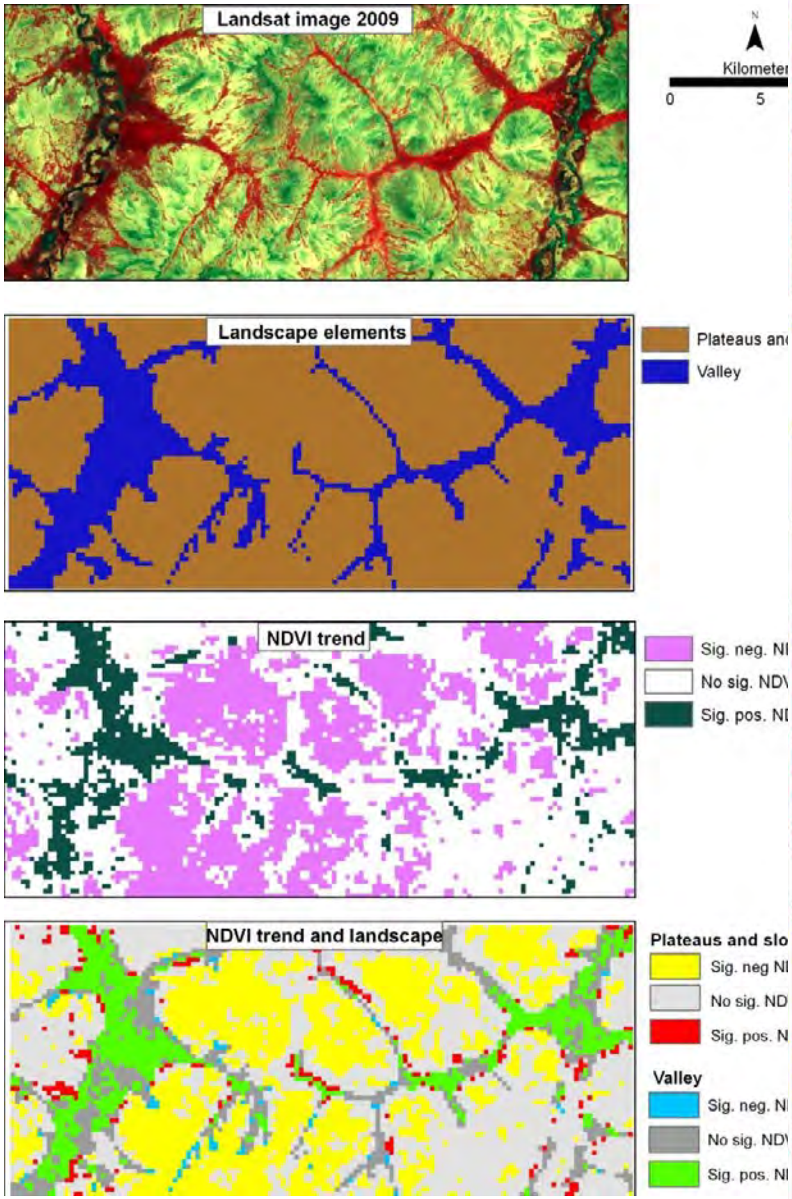
Explaining NDVI trends in northern Burkina Faso

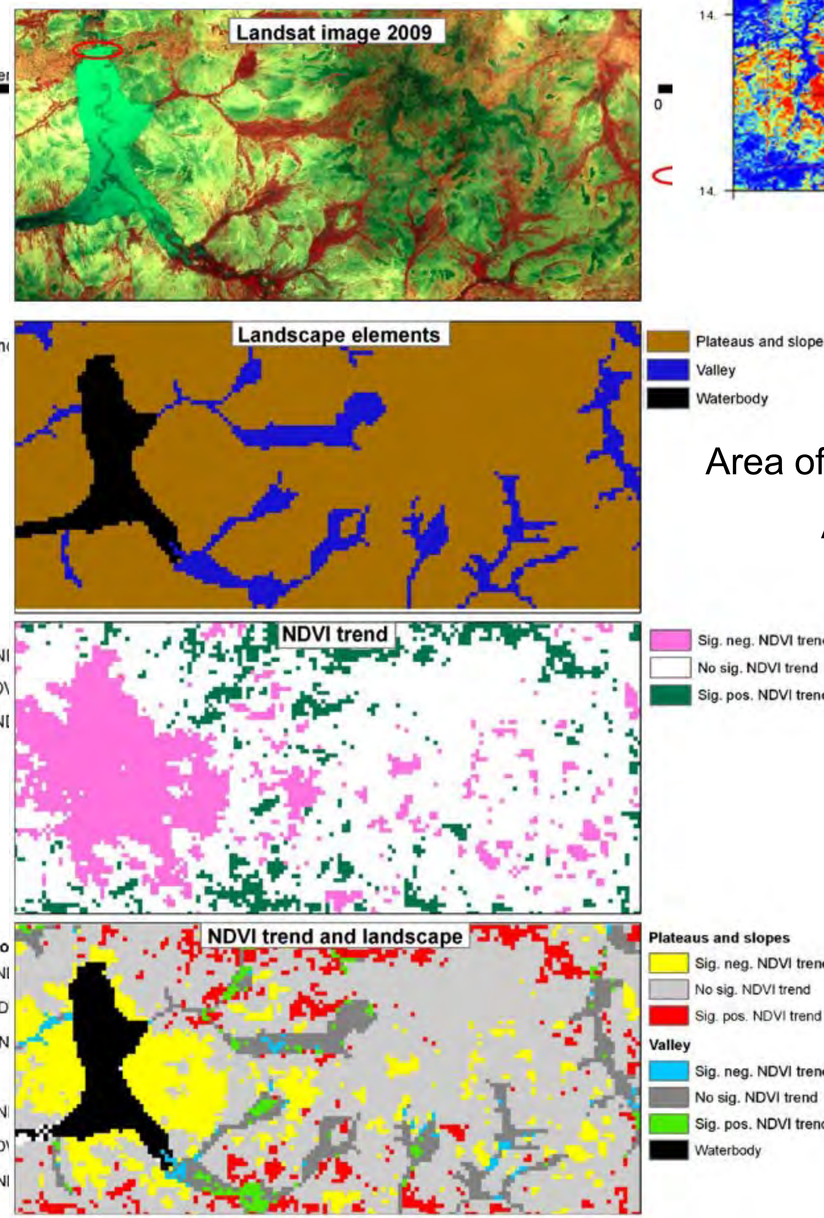
Kjeld Rasmussen[a*], Rasmus Fensholt[a], Bjarne Fog[a], Laura Vang Rasmussen[a] and Isidore Yanogo[b]
[a]*Department of Geosciences and Natural Resource Management, University of Copenhagen, Øster Voldgade 10, Copenhagen DK-1350 Denmark;* [b]*Department of Geography, University of Ouagadougou, Ouagadougou, Burkina Faso*

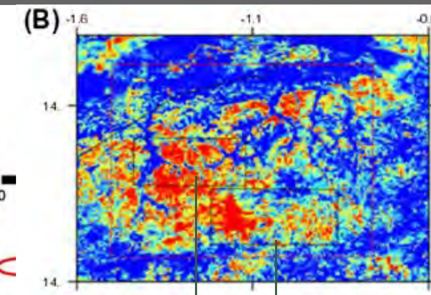
(*Received 12 November 2013; accepted 29 January 2014*)



Scale of analysis







Area of pastoralism

Area of farming

Scale of analysis

Global Environmental Change 21 (2011) 413–420

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Can a 25-year trend in Soudano-Sahelian vegetation dynamics be interpreted in terms of land use change? A remote sensing approach

Agnès Bégué [a,*], Elodie Vintrou [a], Denis Ruelland [b], Maxime Claden [c], Nadine Dessay [d]

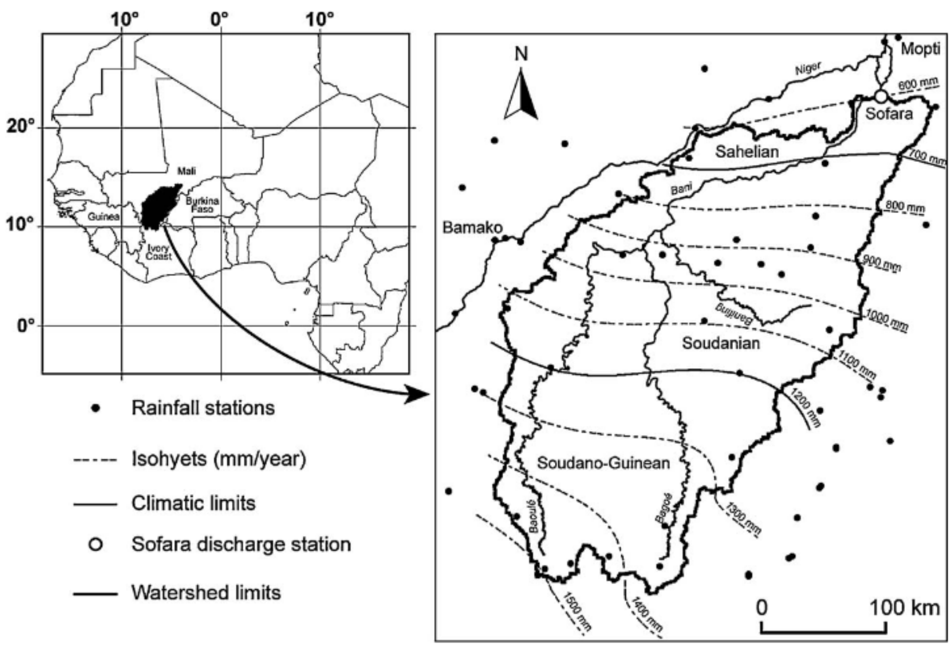


Fig. 1. Location of the Bani catchment.

Landsat scale analysis for LUCC

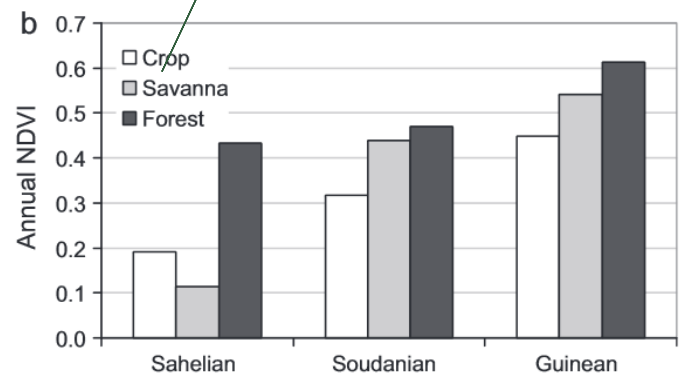


Fig. 4. Landsat NDVI values for the three dominant land cover types in the Bani catchment (crops, savanna and forest). (a) Seasonal variation in the Sahelian region (2002). (b) Comparison of the mean NDVI (June–October) in the three eco-climatic zones.

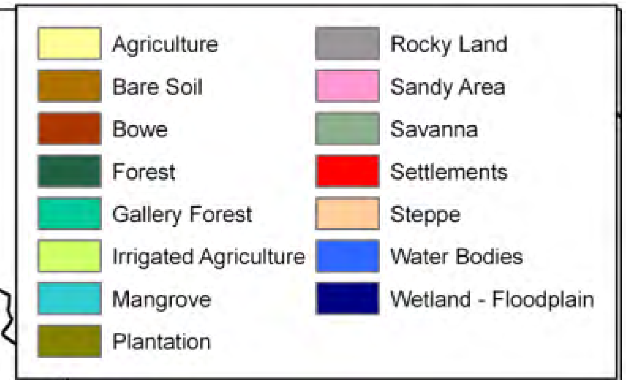
During 1985–2000; cropped land increased from 13% to 23% of the Bani catchment

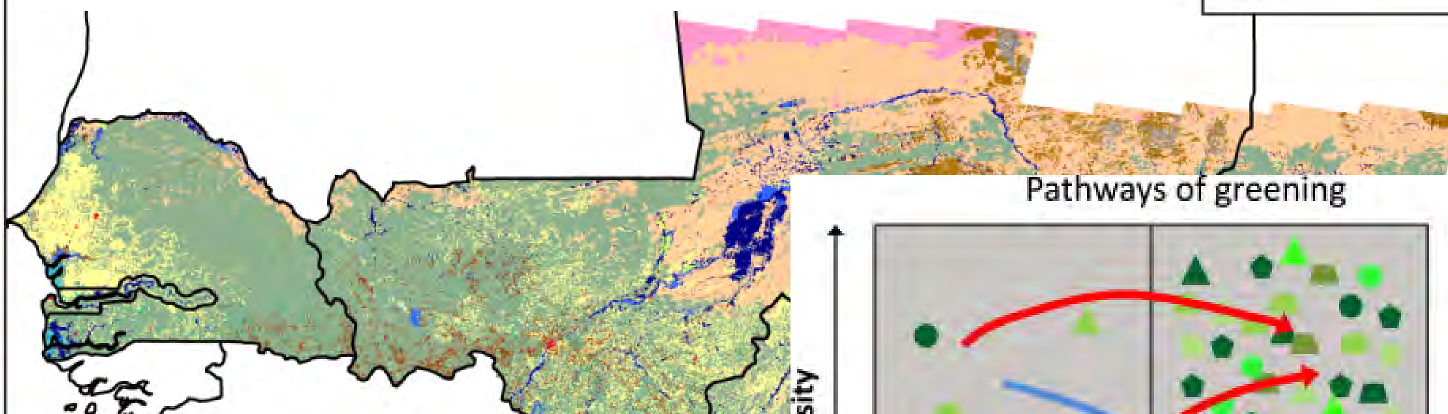
Scale of analysis

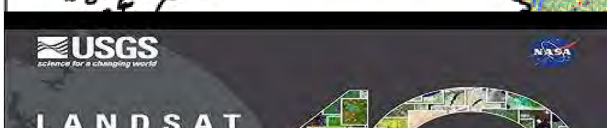
Changes in Land use/cover (LUCC)
Importantant implications for understanding of:

- *Changes in economic productivity*
- *Changes in biodiversity*

United Nations Convention to Combat Desertification







Journal of Arid Environments 90 (2013) 55–66

Contents lists available at SciVerse ScienceDirect

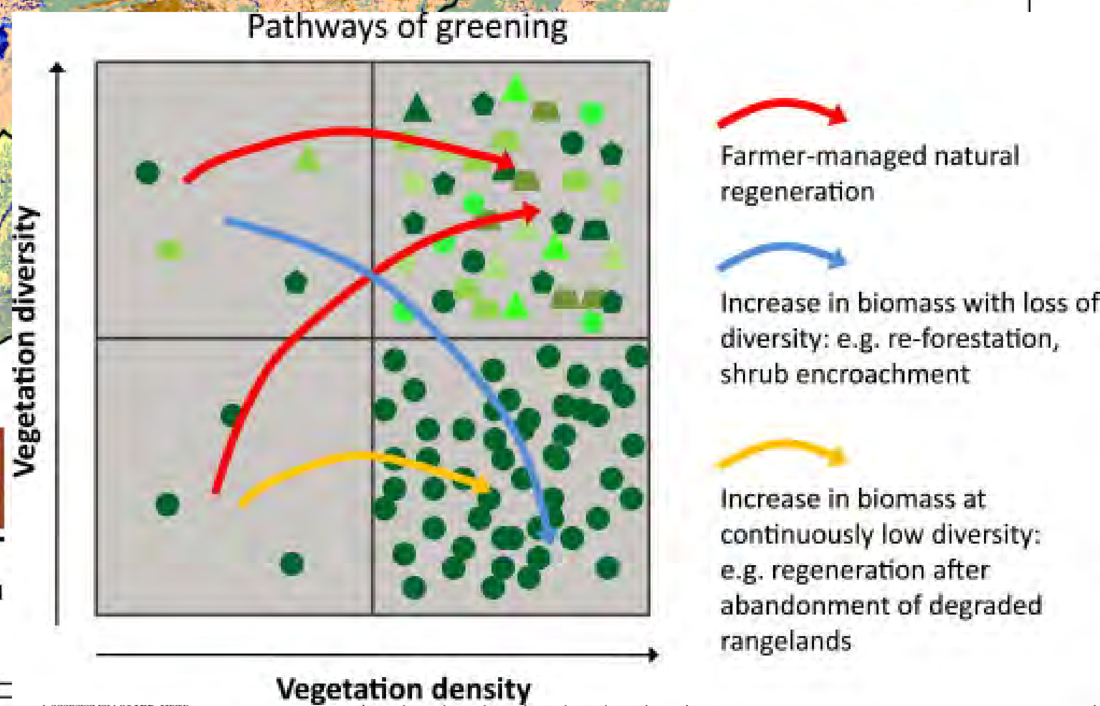
Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Vegetation impoverishment despite greening: A case study from central Senegal

S.M. Herrmann [a,*], G.G. Tappan [b]

[a] The University of Arizona, School of Natural Resources and the Environment (SNRE), Office of Arid Land Studies (OALS), 1955 E. Sixth St., Tucson, AZ 85719, USA
[b] US Geological Survey (USGS), Earth Resources Observation Systems (EROS), Data Center Sioux Falls, SD 57198, USA

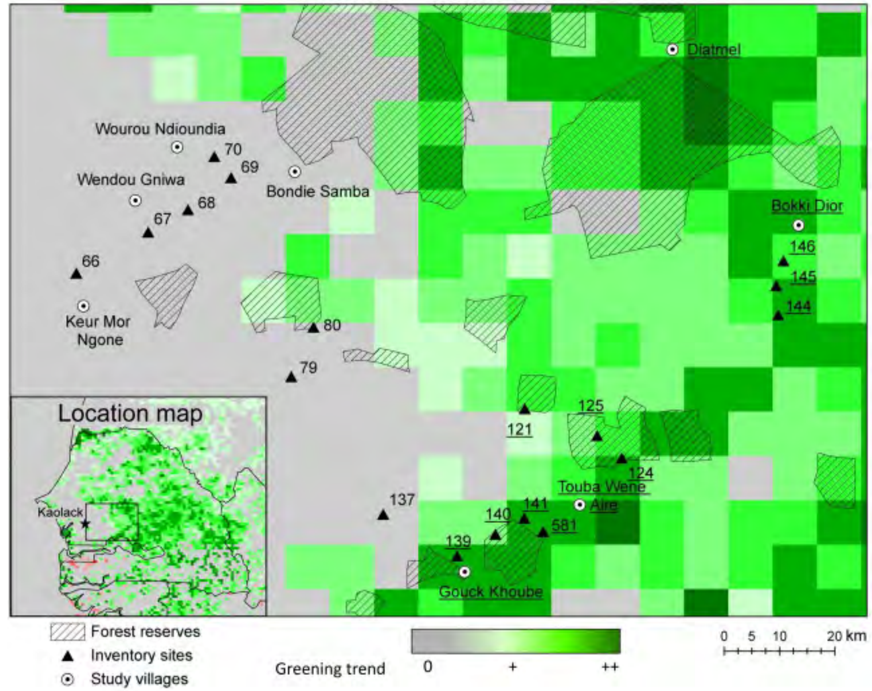


Scale of analysis

Combining EO/ground observation for improved understanding

Increase in biomass (kg/ha) but decrease in biodiversity
→known as "green deserts"

Land degradation??



Journal of Arid Environments 90 (2013) 55–66

Contents lists available at SciVerse ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

ELSEVIER

Vegetation impoverishment despite greening: A case study from central Senegal

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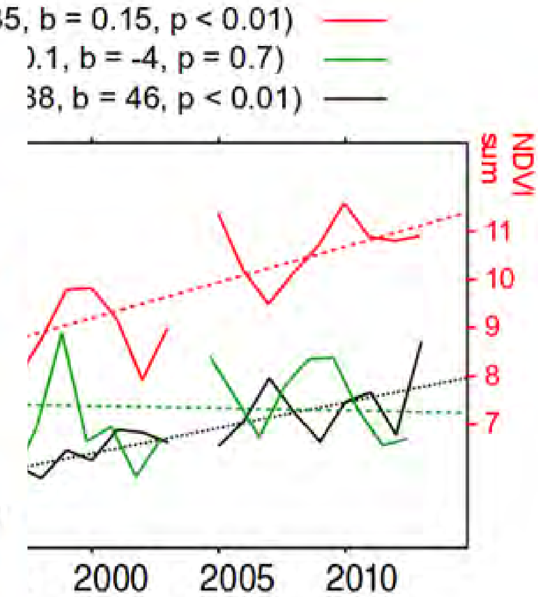
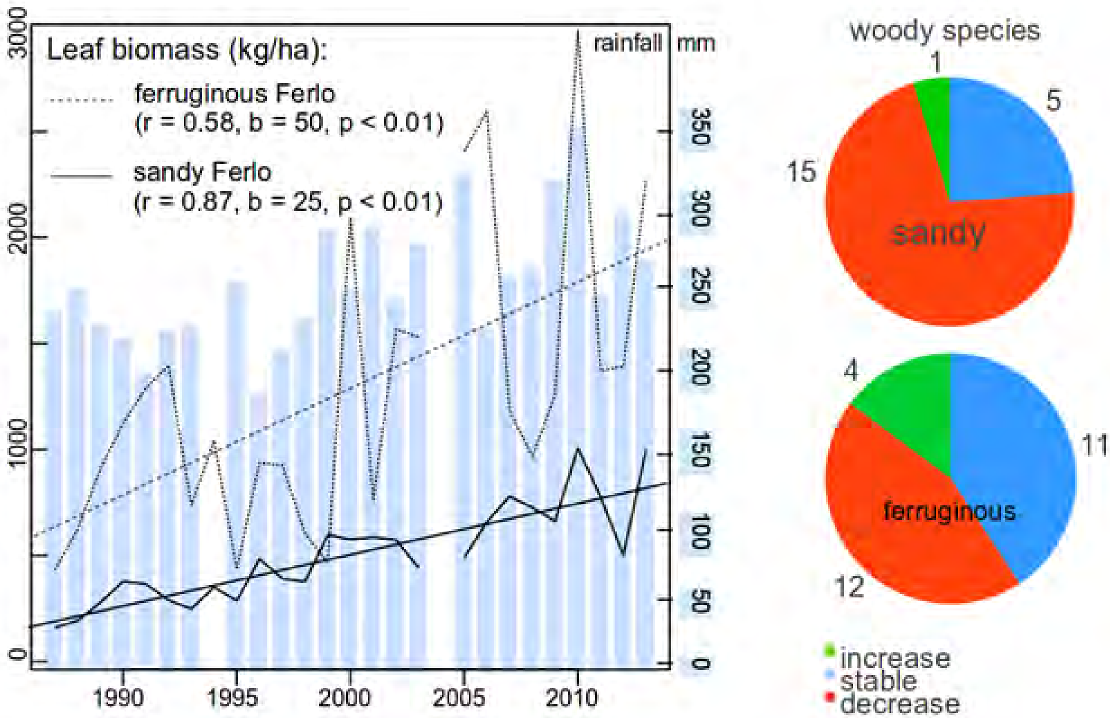
Scale of analysis

Combining EO/ground observation for improved understanding

Brandt, M. et al., Submitted (PNAS)





987-2013) of 23 monitoring sites demonstrate a clear
5 kg/ha/year) and annual NDVI (slope b = 0.15
served in herb biomass (slope b = -4 kg/ha/year). Tab. 2
:.

Figure 5:

Woody vegetation change in the Sahel: the temporal profiles show the leaf biomass of the Sahelian monitoring sites separated in sandy and ferruginous Ferlo. Although the rainfall regime is similar, the soil and vegetation composition has a significant impact on the leaf biomass production and inter-annual variability. The diagrams show a drastic shift in biodiversity of woody species from 1983-2013, especially in the sandy Ferlo.

"Desertification; what can we learn from time series of Earth Observation data?"

Conclusions & recommendations:

- Trend/Epoch based analysis of vegetation productivity indicators works well
  - no signs of widespread global ongoing land degradation (kg/ha)
- Importance of spatial scale of analysis
  - complementary EO/ground observation –data need for in-depth understanding of the drivers of observed changes
- Be careful how to use and interpret higher order indicators of land degradation
- Contrasting empirical evidence of land degradation could be reduced if
  - more explicit reference to (which part of) the UNCCD definition is applied
  - spatial and temporal scale of observations are explicitly considered

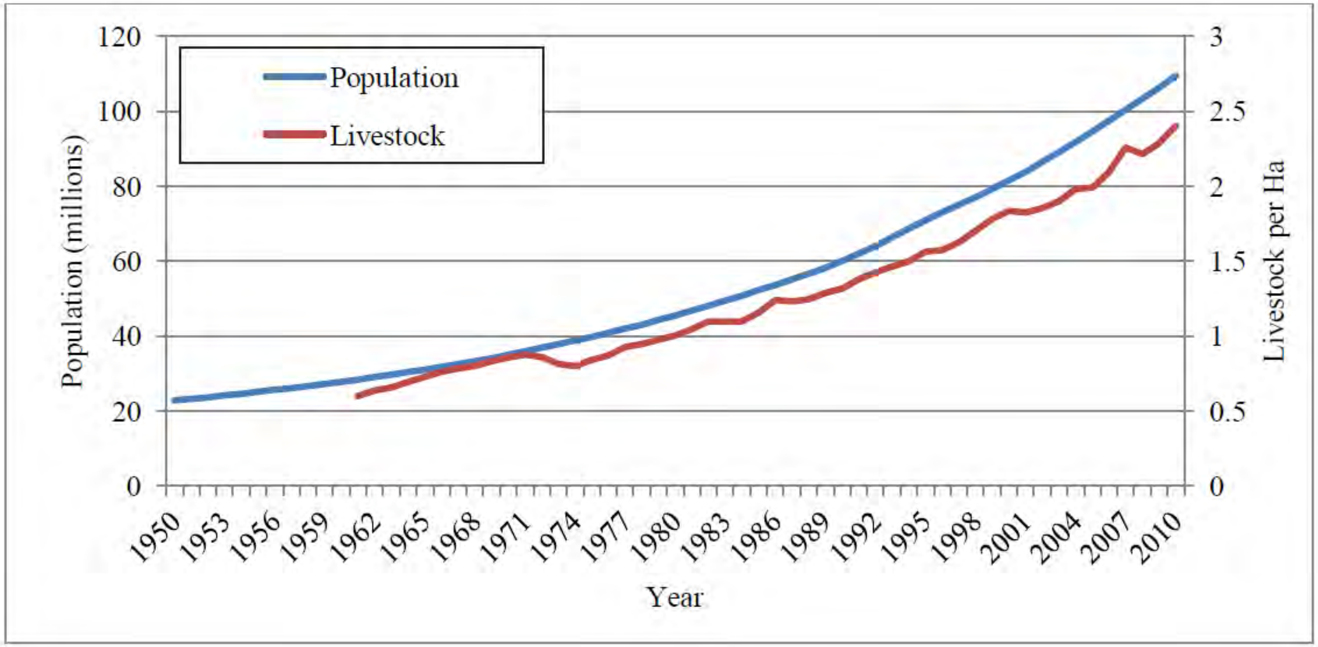
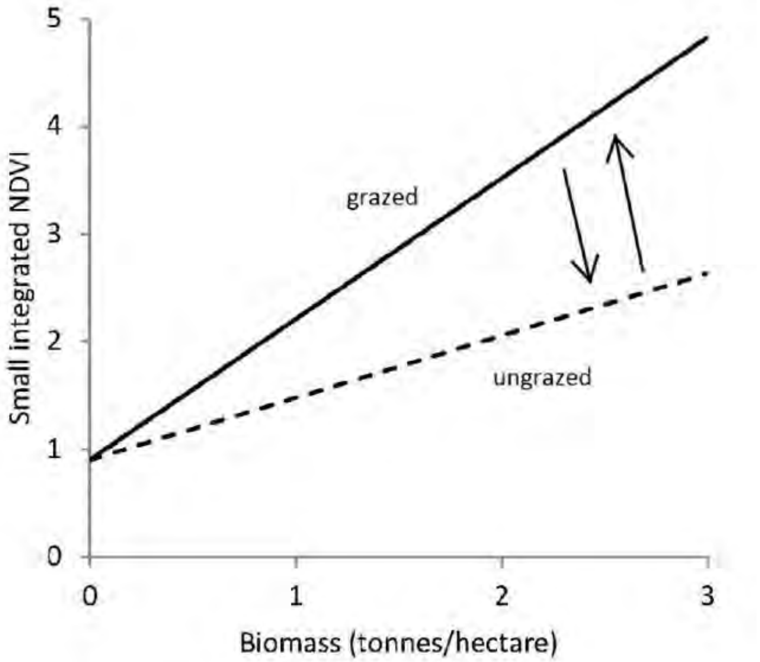

Population
Livestock
Population (millions)
Livestock per Ha
Year
120
100
80
60
40
20
0
3
2.5
2
1.5
1
0.5
0
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010

Table 4: Correlation coefficients between *in situ* measurements of biomass and satellite based growing season parameters derived from MODIS NDVI product with: A) relative amplitude dependent thresholds. B) Thresholds set to absolute values. Coefficients marked with * represent significant relations ($p < 0.05$) and coefficients marked in grey represent highly statistically significant relations ($p < 0.005$).

A)	Excluded (n = 28)	Controlled (n = 49)	Communal (n = 28)
Amplitude	0.71	0.77	0.79
End	-0.29	-0.55	-0.45*
Large int.	0.56	0.40	0.53
Length	-0.17	-0.36*	-0.29
Max	0.72	0.78	0.80
Small int.	0.79	0.76	0.81
Start	0.03	0.12	0.10

B)	Excluded (n = 28)	Controlled (n = 49)	Communal (n = 28)
Amplitude	0.61	0.77	0.79
End	0.72	0.42	0.41
Large	0.76	0.68	0.69
Length	0.63	0.39	0.41*
Max	0.61	0.78	0.80
Small	0.80	0.78	0.81
Start	-0.32*	-0.29*	-0.25
Sum+	0.67	0.72	0.77

+: Thresholds not relevant



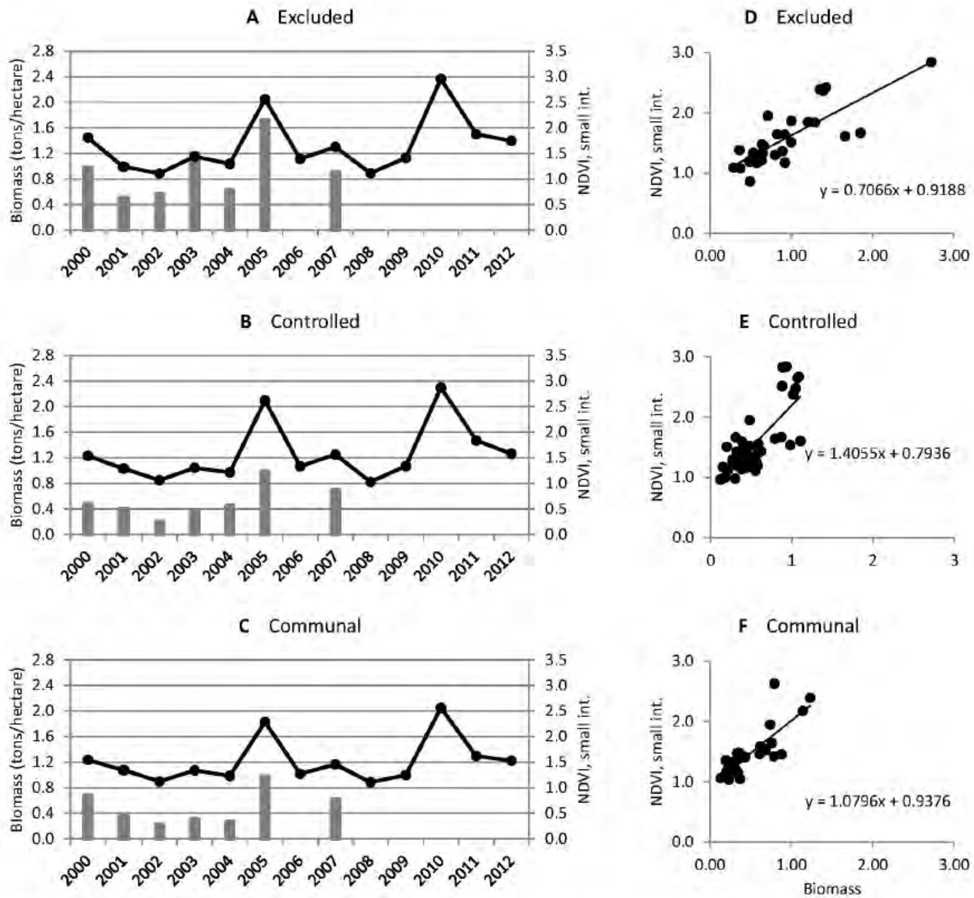
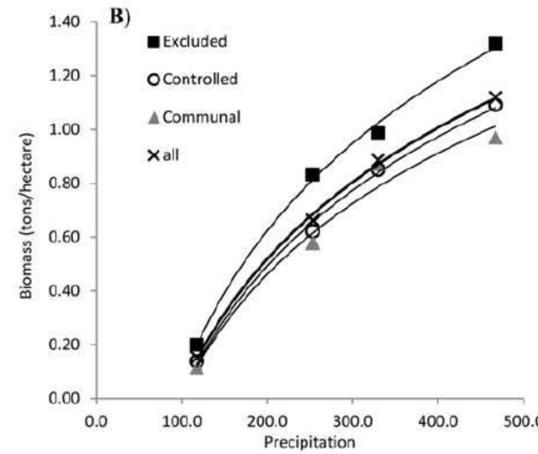
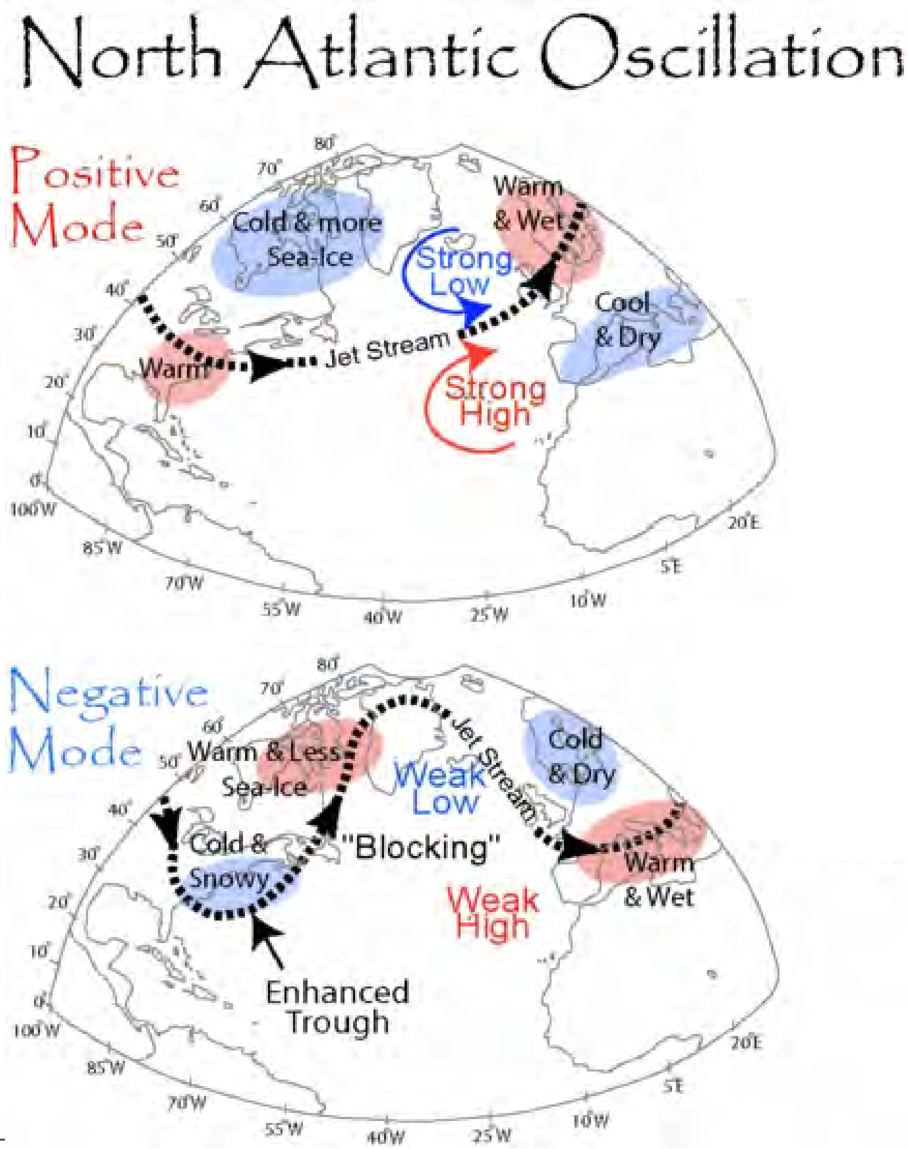


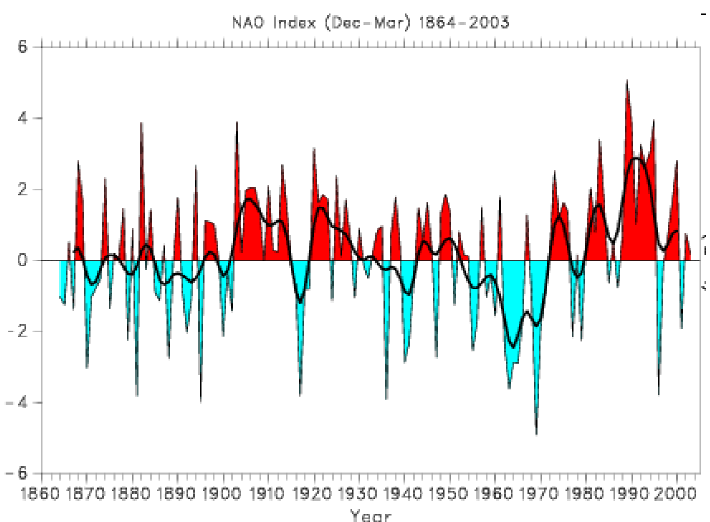
Figure 5: A, B and C: Black lines showing annual values of MODIS NDVI small integrals for pixels covering vegetation sampling plots, averaged for each grazing regime. Grey bars showing standing crop biomass averaged by grazing regime. D, E and F show relations between individual measurements of plot biomass and MODIS NDVI small integrals.



How to explain the greening trend of Sahel - Teleconnections?



Influence on the Sahel rainfall



Correlation between SST anomalies and gimms NDVI anomalies for the Sahel (July-September)

How to explain the greening trend of Sahel - Teleconnections?

March-May

Jan-March

r value

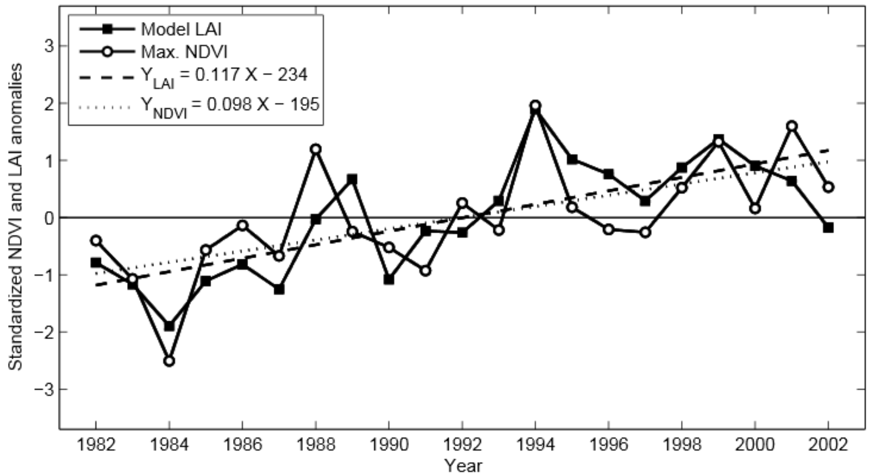
Not significant (p≥0.05)


Remote Sensing of Environment 115 (2011) 3276–3285
Contents lists available at SciVerse ScienceDirect
Remote Sensing of Environment
journal homepage: www.elsevier.com/locate/rse

Analysis of teleconnections between AVHRR-based sea surface temperature and vegetation productivity in the semi-arid Sahel

Silvia Huber *, Rasmus Fensholt
Dept. of Geography and Geology, University of Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen, Denmark

How to explain the greening trend of Sahel…



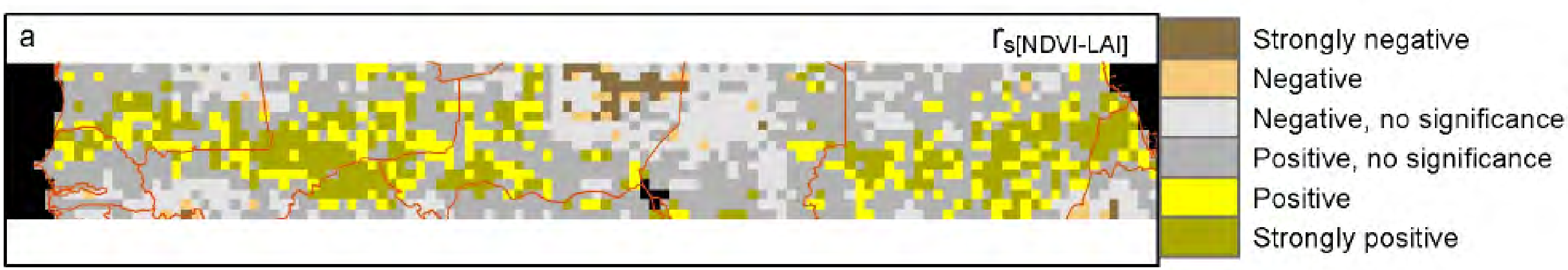
Biogeosciences, 6, 469–477, 2009
www.biogeosciences.net/6/469/2009/

Biogeosciences

Disentangling the effects of climate and people on Sahel vegetation dynamics

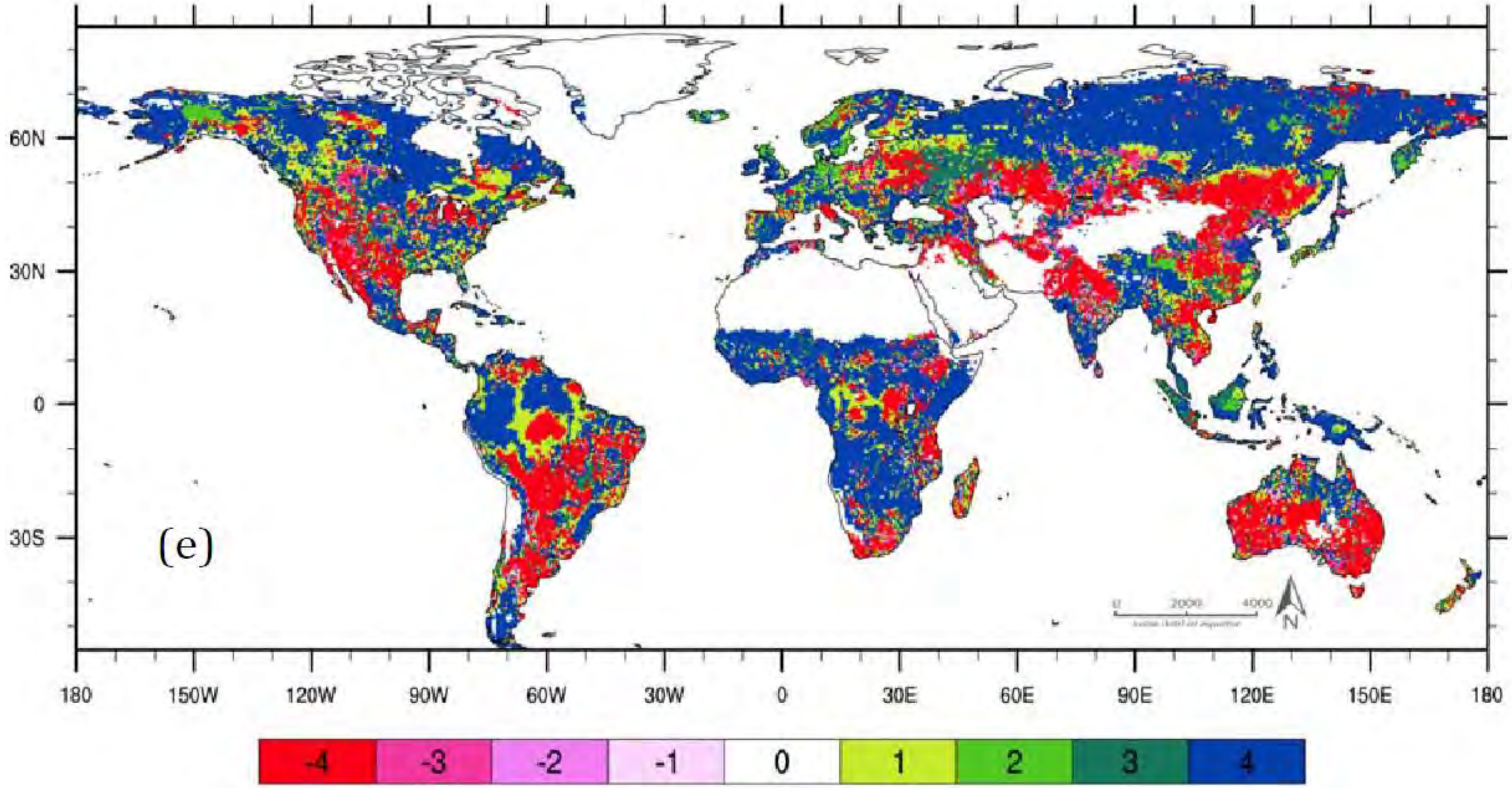
J. W. Seaquist[1], T. Hickler[1], L. Eklundh[1], J. Ardö[1], and B. W. Heumann[2]

[1]Department of Physical Geography and Ecosystems Analysis, Geobiosphere Science Centre, Lund University, Sölvegatan 12, 223 62, Lund, Sweden
[2]Department of Geography, University of North Carolina at Chapel Hill, Saunders Hall, Campus Box 3220, Chapel Hill, NC 27599-3220, USA



Process-based vegetation model vs. Satellite based
LPJ-Dynamic Global Vegetation Model & GIMMS NDVI)

How to explain the greening trend global drylands



-4 decrease due to Climates
-3 decrease due to LULCC
-2 decrease due to N Dep
-1 decrease due to CO2
0 no trend
1 increase due to CO2
2 increase due to N Dep
3 increase due to LULCC
4 increase due to Climates

OPEN ACCESS
Remote Sensing
ISSN 2072-4292
www.mdpi.com/journal/remotesensing

Article

Global Latitudinal-Asymmetric Vegetation Growth Trends and Their Driving Mechanisms: 1982–2009

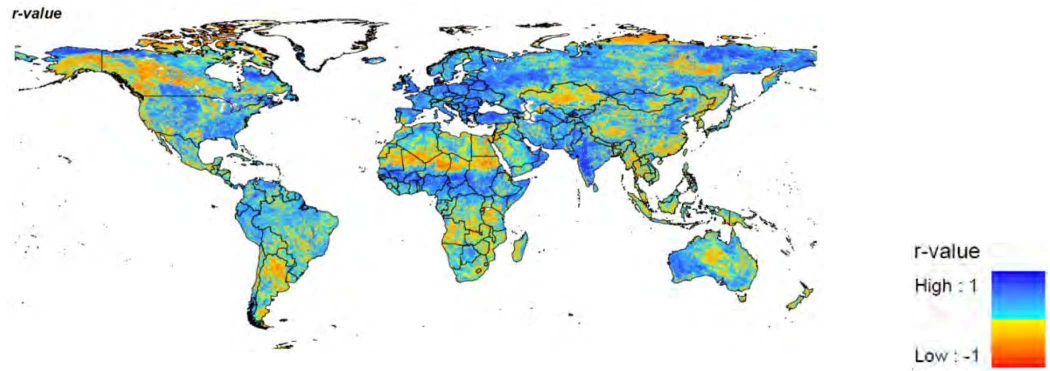
Jiafu Mao [1,*], Xiaoying Shi [1], Peter E. Thornton [1], Forrest M. Hoffman [2], Zaichun Zhu [3] and Ranga B. Myneni [3]

Summing up…

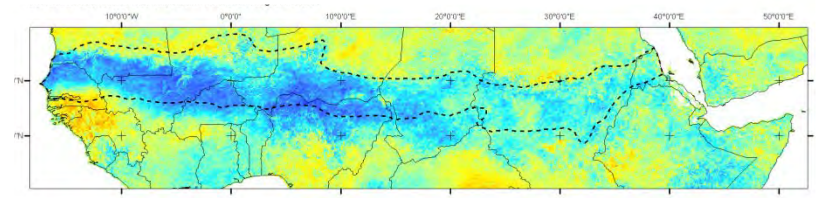
Improved understanding of dryland dynamics:

what's causing changes in vegetation productivity & land degradation?

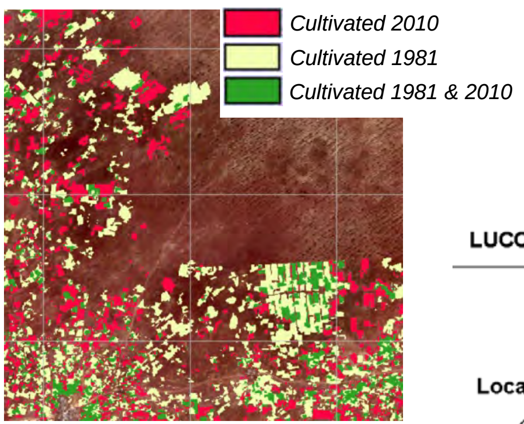
Vegetation trends (30 years)

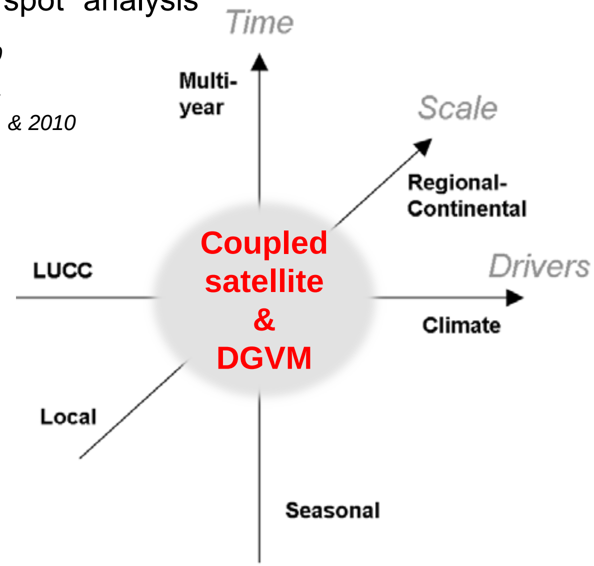


Vegetation dependency on rainfall (30 years)

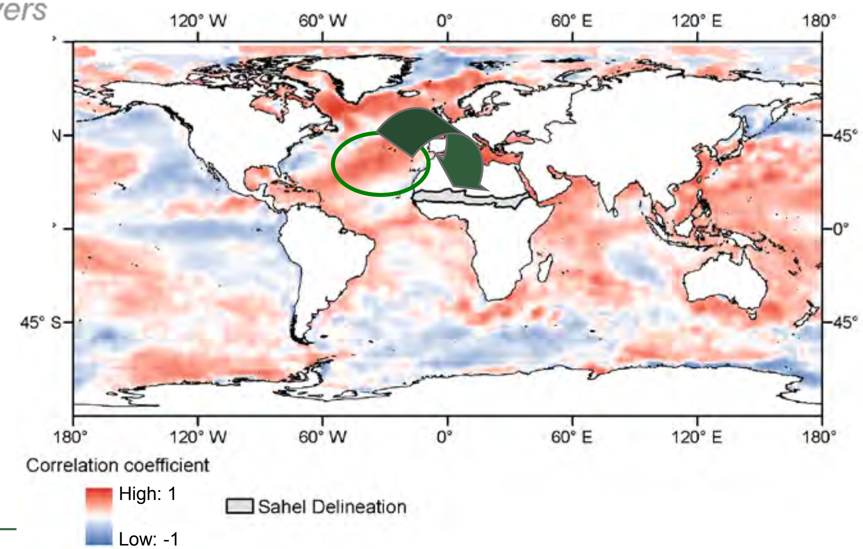


Land Use Cover/Change – ”hot spot” analysis

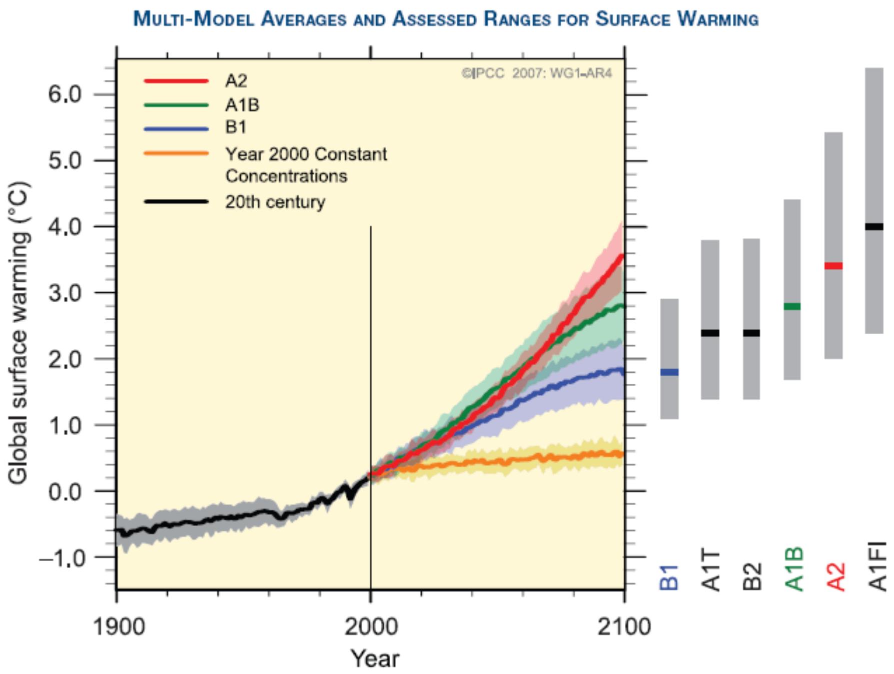




Vegetation dependency on ocean temperatures (30 years)



Summing up…



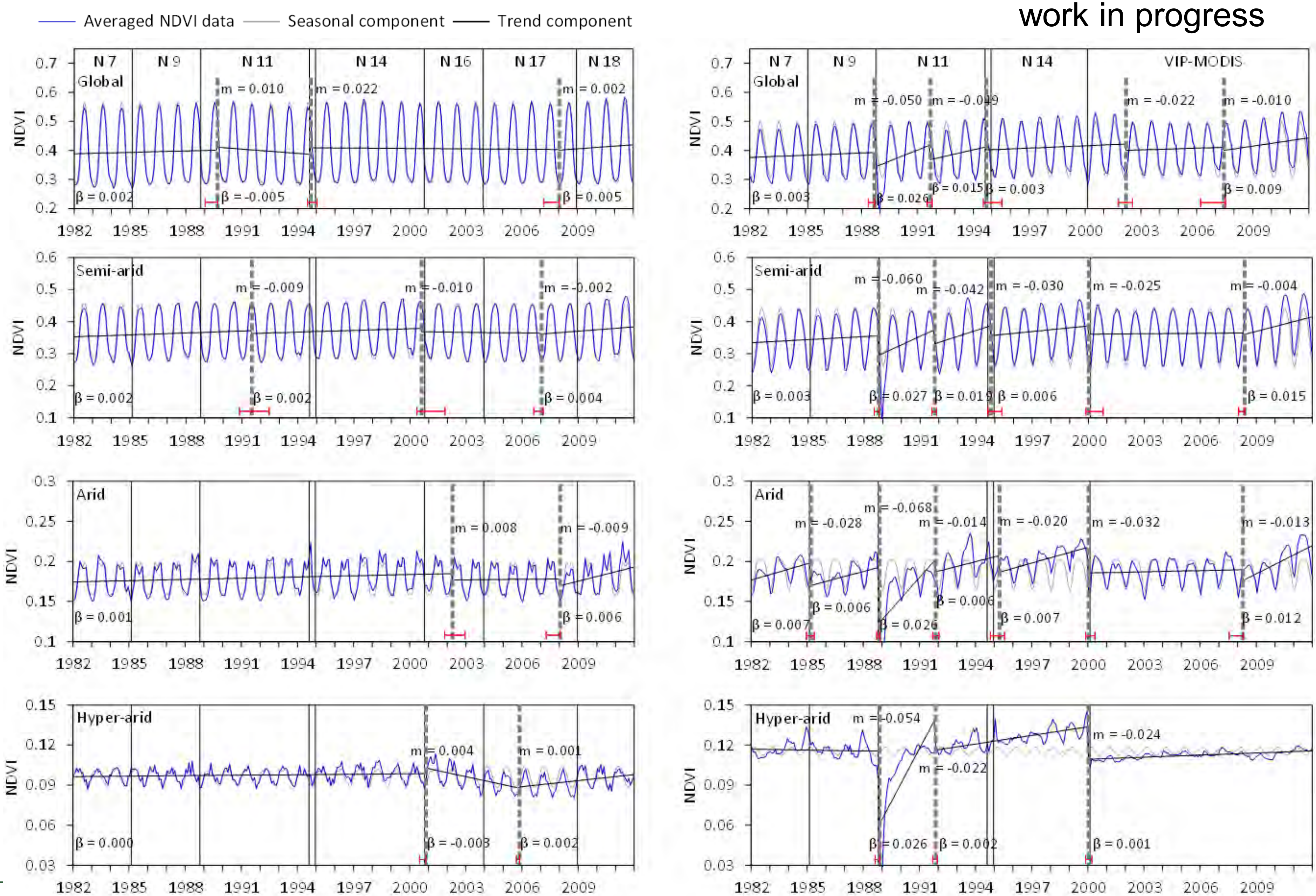
Predictions for global drylands???

strategies for climate adaptation and mitigation

GIMMS3g

VIP3

Tian, F.,
work in progress



AVHRR LTDR 4 - Eric Vermote or Sadashiva Devadiga