

The Ecological Context Built from Satellites

Summer course on Movement and Population data management and analysis

Duccio Rocchini

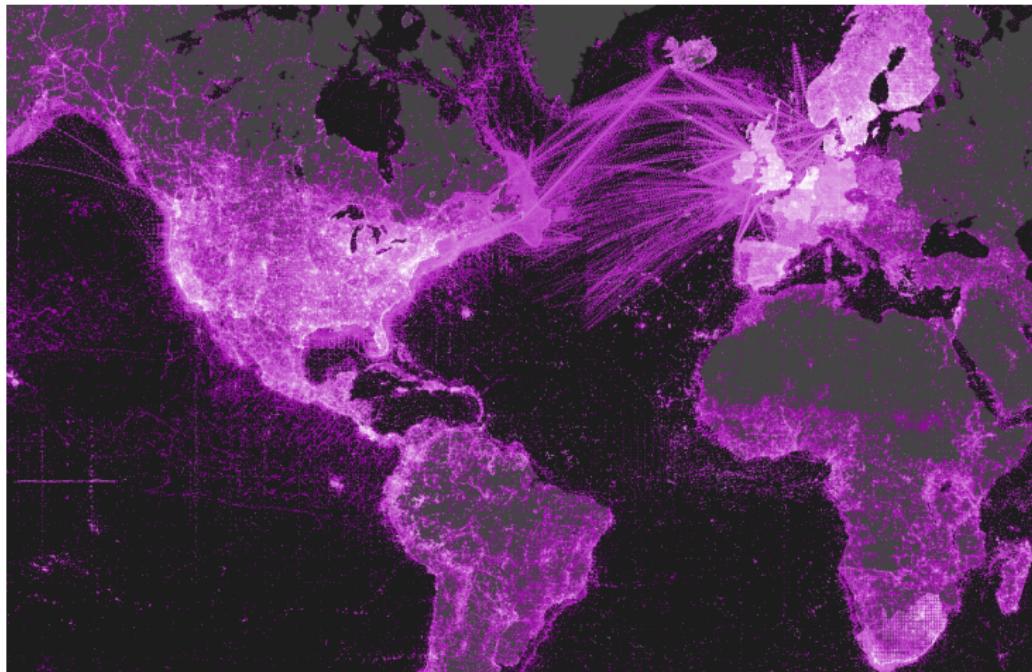
University of Trento

Center Agriculture Food Environment
Centre for Integrative Biology
Fondazione Edmund Mach

Outline

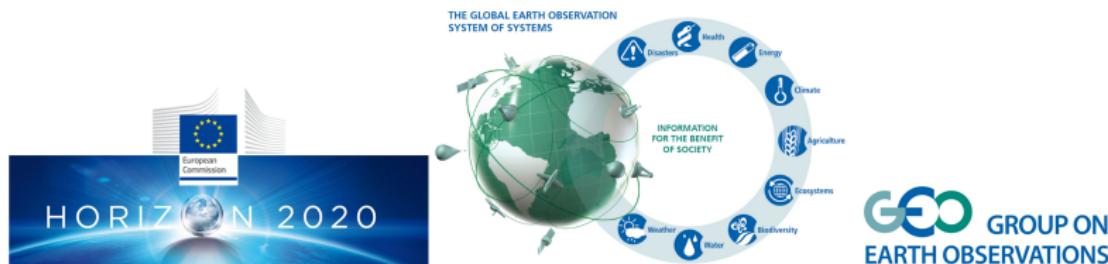
- 1 Introduction
- 2 Basics on satellite images
- 3 Ecological satellite remote sensing
- 4 Population and community Ecology

The Global Biodiversity Information Facility [GBIF]



<http://www.gbif.org/>

GEOSS - Global Earth Observation System of Systems



- The Commission is committed to implement GEOSS
- GEO Strategic Plan 2016-2025
- Increasing capacity to observe the planet at different scales

GEOSS - Global Earth Observation System of Systems



Ecological Informatics for robust and reproducible analysis



Letter

Cell
PRESS

Let the four freedoms paradigm apply to ecology

Duccio Rocchini and Markus Neteler

Fondazione Edmund Mach, Research and Innovation Centre, Department of Biodiversity and Molecular Ecology, Via E. Mach 1,
38010 S. Michele all'Adige (TN), Italy

In our view, the explicit use of Free and Open Source Software (FOSS) with **availability of the code** is essential for **completely open science**: 'scientific communication relies on evidence that cannot be entirely included in publications', but '**anything less than the release of source programs is intolerable for results that depend on computation**' [3].

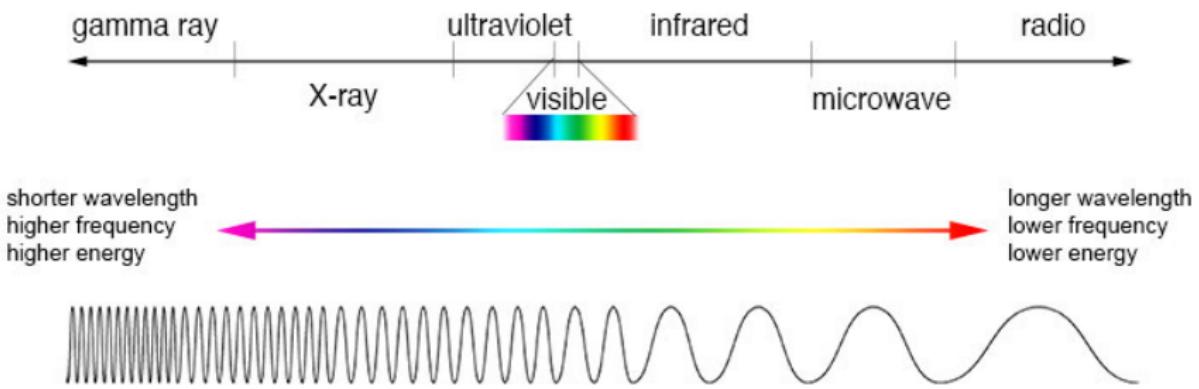
My aim

“Once a map is drawn people tend to accept it as reality” (Bert Friesen)

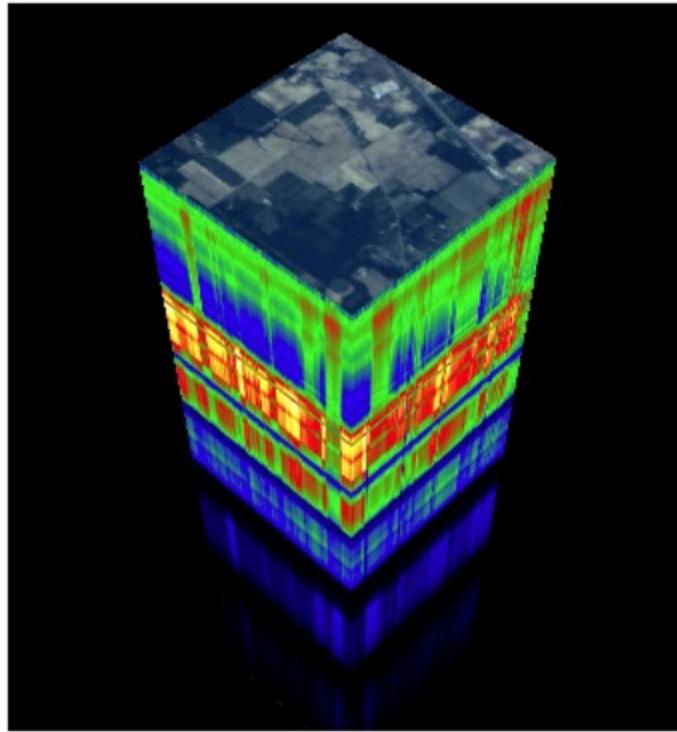
Outline

- 1 Introduction
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Satellite images - electromagnetic spectrum



Satellite images - Multi- or Hyper-cubes



Satellite images as matrices of numbers



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NASA site

 **MODIS**
MODERATE RESOLUTION IMAGING SPECTRORADIOMETER

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Data

- Data Products
- Algorithms
- Direct Broadcast



Dust storm in the Sahara
01-12-2015



Phytoplankton Bloom in the Bering Sea
09-04-2014

Home >> Data >> Data Products >> MODIS Vegetation Index Products (NDVI and EVI)

MODIS Vegetation Index Products (NDVI and EVI)

Overview

MODIS vegetation indices, produced on 16-day intervals and at multiple spatial resolutions, provide consistent spatial and temporal comparisons of vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure. The vegetation indices are derived from the MODIS-derived reflectance in the red, near-infrared, and blue wavebands; the normalized difference vegetation index (NDVI), which provides continuity with NOAA's AVHRR NDVI time series record for historical and climate applications, and the enhanced vegetation index (EVI), which minimizes canopy-soil variations and improves sensitivity over dense vegetation conditions. The two products more effectively characterize the global range of vegetation status and processes.

The vegetation indices are retrieved from daily, atmosphere-corrected, bidirectional surface reflectance. The VI's use a MODIS-specific compositing method based on product quality assurance metrics to remove low quality pixels. From the remaining good quality VI values, a constrained view angle approach then selects a pixel to represent the compositing period (from the two highest NDVI values it selects the pixel closest to the mean). Because the MODIS sensor observes the Earth approximately once per day, the VI algorithm generates each 16-day composite eight days apart (phased products) to permit a higher temporal resolution product by combining both data records. The MODIS VI product suite is now used successfully in all ecosystem, climate, and natural resources management studies and operational research as demonstrated by the ever increasing body of peer publications.

Product Information

- Product PI: Kamel Didan
- Validated Stage: Stage 3
- PI Product Page URL
- User Guide Download
- ATBD

Product Details

ndvi

Highlight All Match Case 1 of 1 match

Terra Prod Aqua Prod

<https://earthdata.nasa.gov/> - NASA [National Aeronautics and Space Administration]
MODerate resolution Imaging Spectroradiometer



The USGS site

The screenshot shows the USGS Earth Explorer search interface. On the left, there is a sidebar with search criteria fields for Address/Place, Coordinates, Date Range, and Data Sets. The main area features a world map centered on Europe and Africa, with a search summary overlay. The summary includes a map view, coordinates (58° 05' 36" N, 047° 29' 24" E), and options for Options, Overlays, Map, and Satellite. At the bottom of the map, there is a Google logo and a link to the Terms of Use.

USGS science for a changing world

EarthExplorer

Home

Search Criteria Data Sets Additional Criteria Results

Page Expires in 1:59:31 C

1. Enter Search Criteria

To narrow your search area: type in an address or place name, enter coordinates or click the map to define your search area (for advanced map tools, view the [help documentation](#)), and/or choose a date range.

Address/Place PathRow Feature Circle

Show Clear

Coordinates Predefined Area Shapefile KML

Degree/Minute/Second Decimal

No coordinates selected.

Use Map Add Coordinate Clear Coordinates

Date Range Result Options

Search from: mm/dd/yyyy to: mm/dd/yyyy

Search months: (all)

Data Sets a Additional Criteria a Results a

Search Criteria Summary (Show)

(58° 05' 36" N, 047° 29' 24" E) Options Overlays Map Satellite

Map data ©2015 Google. Imagery ©2015 NASA, TerraMetrics | 1000 km | Terms of Use

<http://earthexplorer.usgs.gov/>



The Global Land Cover Facility

Global Land Cover Facility
www.landcover.org



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Welcome

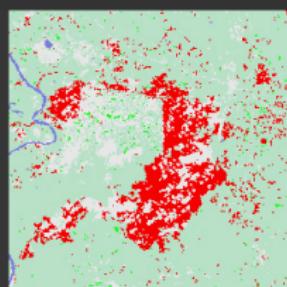
The GLCF is a center for land cover science with a focus on research using remotely sensed satellite data and products to access land cover change for local to global systems.



2000
Path: 118 Row: 061 Borneo
Landsat TreeCover
[Data](#) [Gallery](#)



2005
Path: 118 Row: 061 Borneo
Landsat TreeCover
[Data](#) [Gallery](#)



2000-2005
Path: 118 Row: 061 Borneo
Landsat Forest Cover Change
(Red-Loss; Green-Gain)
[Data](#) [Gallery](#)

Download Data

ESDI 

GLS Data 

Quick Links

- FIRST TIME TO GLCF?
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- GOFC-GOLD
- GOFC-GOLD Reports
- IGOL
- Landsat GeoCover
- SRTM DEM GeoTIFFs
- Rapid Response

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<http://glcf.umd.edu/>

The Global Land Cover Facility

Global Land Cover Facility
www.landcover.org



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Data & Products

Imagery and products can be accessed from this list or using the [Earth Science Data Interface](#). Users are also asked to consider GLCF data policies, especially providing appropriate citations when displaying imagery or products downloaded from this site.

Satellite Imagery

ASTER L1B Imagery	Ikonos Fine Resolution Imagery	Quickbird Fine Resolution Imagery	Orbview Fine Resolution Imagery
Landsat Landsat ETM+ Landsat MSS Landsat TM GeoCover Global Land Survey Surface Reflectance	MODIS 32-day Composites 16-day Composite	SRTM 30m Elevation Imagery 90m Elevation Imagery 1km Elevation Imagery	

Products Derived from Satellite Imagery

Landsat Forest Change Products Amazon Basin Central Africa Paraguay	MODIS Albedo Broadband Emissivity Downward Surface Shortwave Radiation	AVHRR Albedo Burned Areas In Russia GloPEM Land Cover Classification	Special Collections 2008 China quake Hurricane Katrina Hurricane Rita 2004 Tsunami
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<http://glcf.umd.edu/>

Download Data

ESDI 

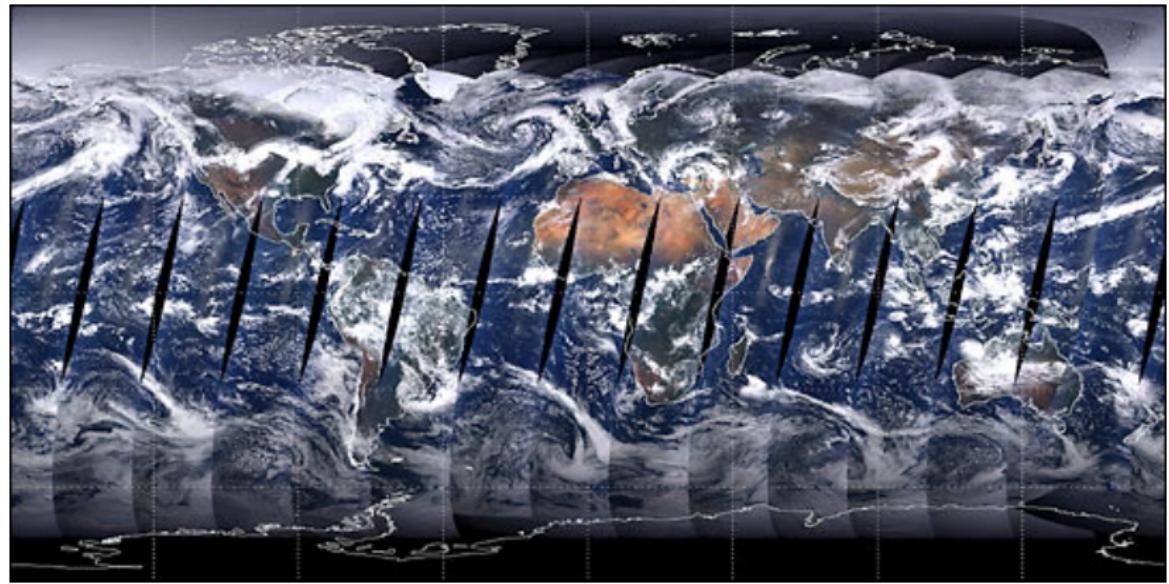
Data & Products

- Data Contributions
- Data Guides
- Data Policies
- Restricted Access

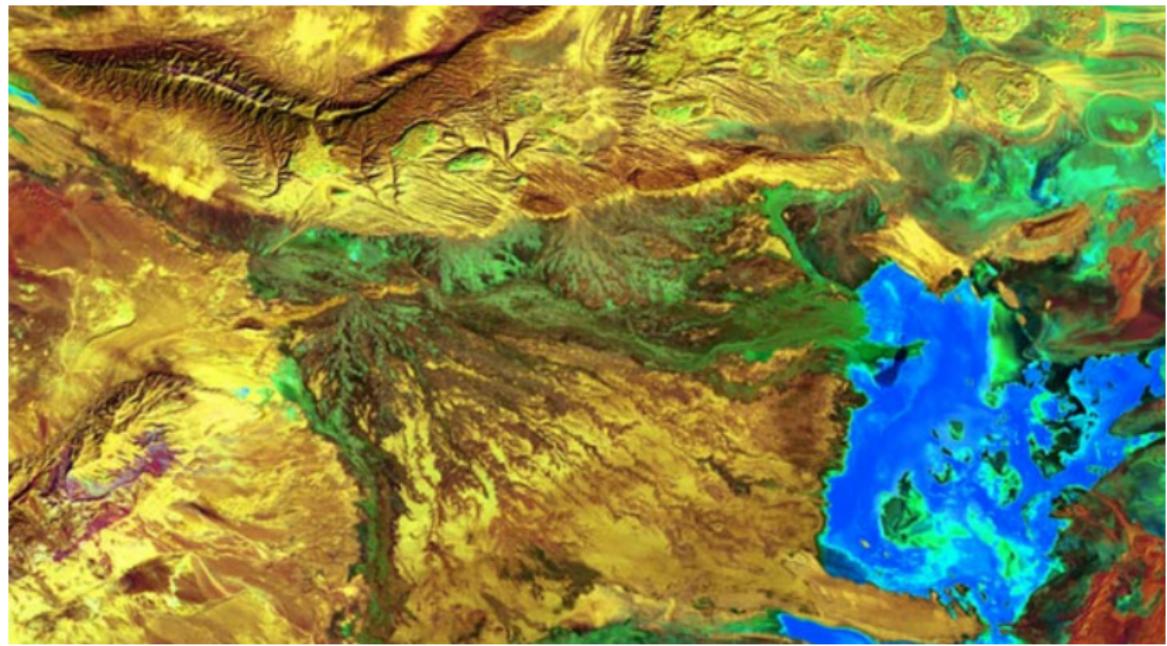
Quick Links

- EROS Data Center
- Global Change Master Directory
- MODIS Rapid Response
- MODIS-Terra Data in MODAPS
- USGS Global Visualization Viewer

Different types of sensors...the MODIS program



Different types of sensors...the Landsat program



Different types of sensors...the Landsat program



grass gis

Bringing advanced geospatial technologies to the world

Different types of sensors...the Landsat program



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LANDSAT

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- [2 Modules overview](#)
 - [2.1 Generic modules applicable to Landsat](#)
 - [2.2 Landsat specific modules](#)
 - [2.3 Landsat specific GRASS AddOns](#)
- [3 Pre-Processing](#)
 - [3.1 Overview](#)
 - [3.2 Importing data](#)
 - [3.2.1 Notes](#)
 - [3.2.2 Hint: Minimal disk space copies](#)
 - [3.2.3 Automated data import](#)
- [4 Post-Processing](#)
 - [4.1 Natural color composites](#)
 - [4.2 Create a MASK to only show data where coverage exists for all bands](#)
 - [4.3 Calculate Top-of-Atmosphere Reflectance and band-6 Temperature](#)
 - [4.4 Haze removal](#)
 - [4.5 Atmospheric correction](#)
 - [4.6 Cloud identification](#)
- [5 Download sample data](#)
 - [5.1 Preprocessed Landsat-7 data for North Carolina](#)

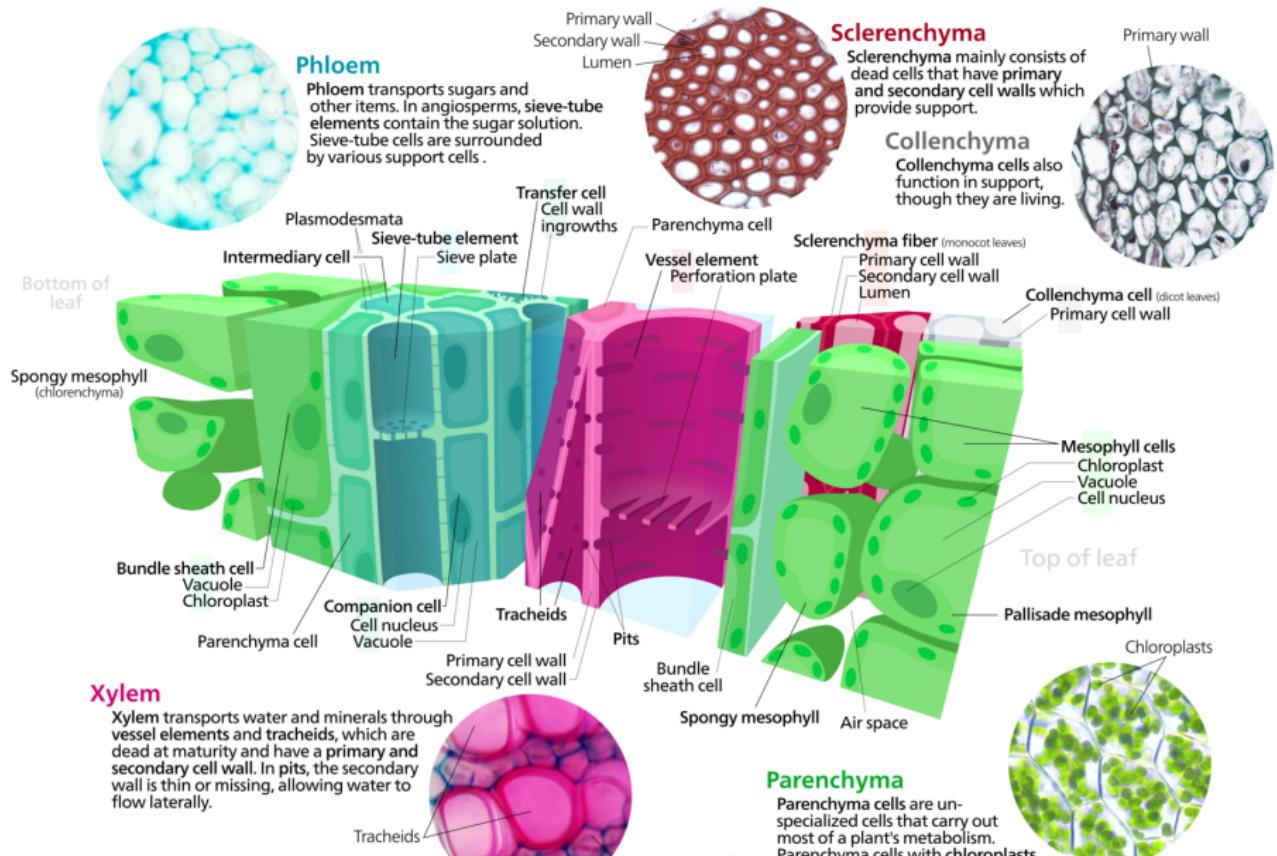
Different types of sensors....Quickbird



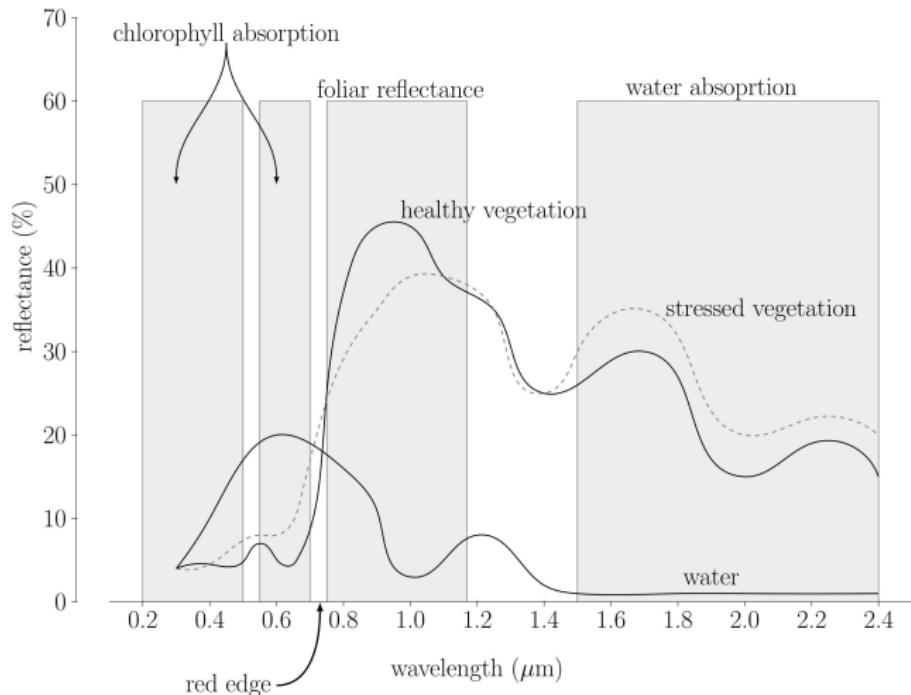
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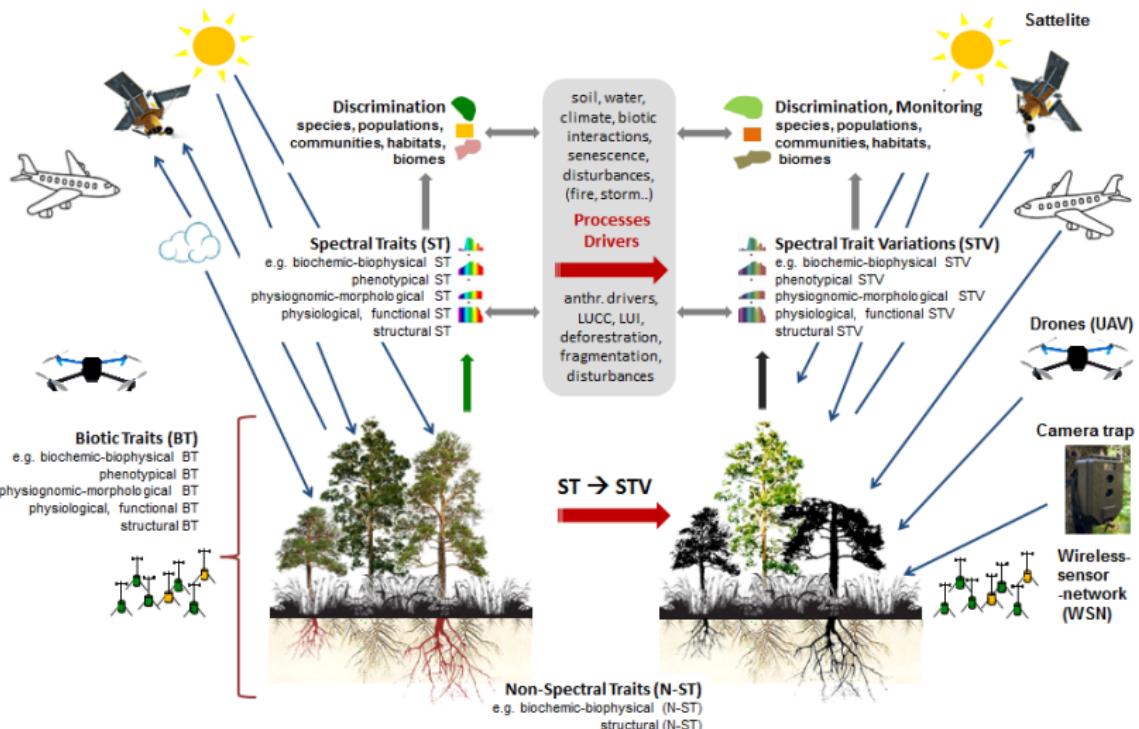
Ecosystem structure



Spectral signatures

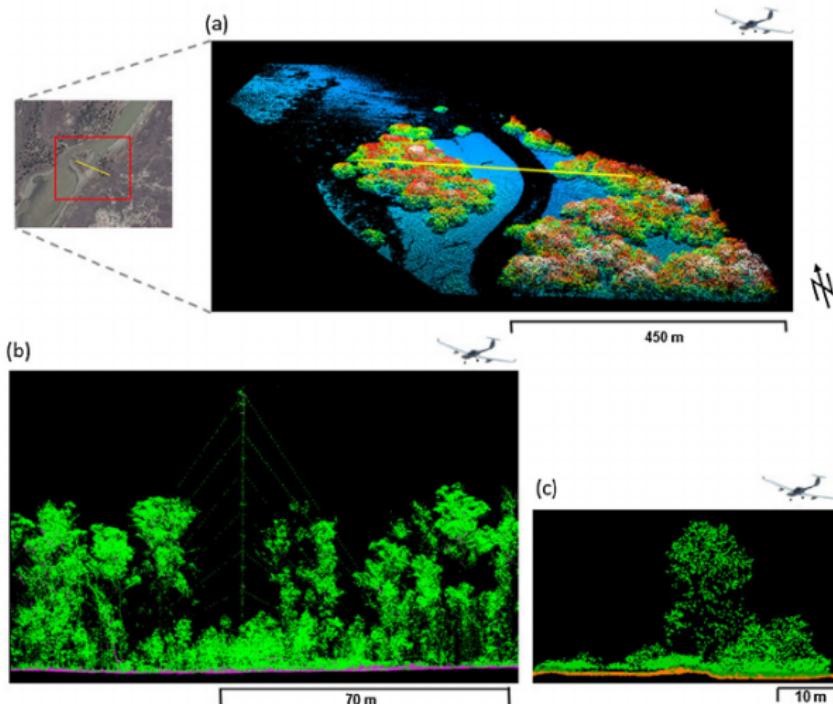


Ecosystem structure



Lausch et al. (Ecol. Indic., 2016)

Ecosystem structure



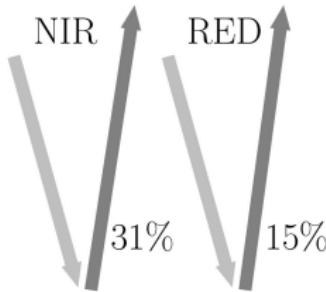
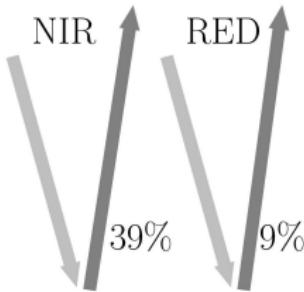
Lausch et al. (Ecol. Indic., 2016)

Vegetation indices

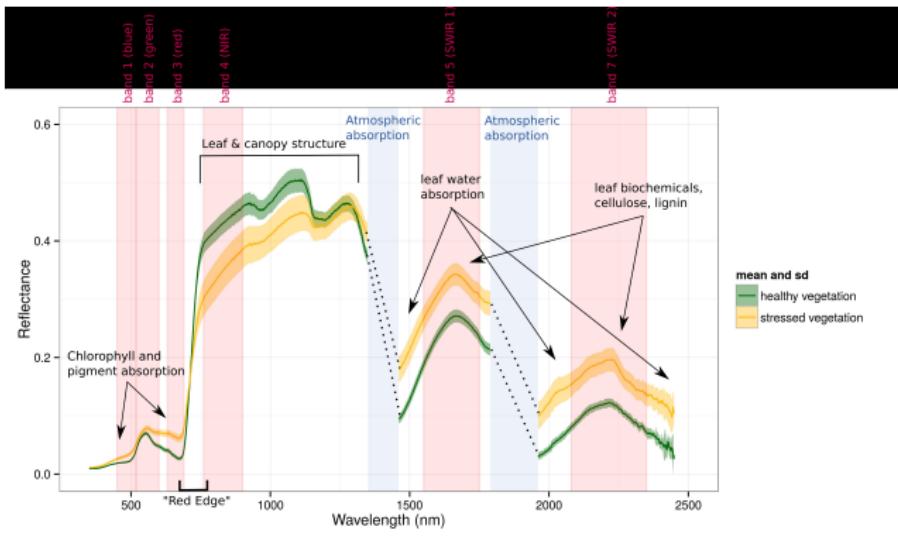
$$\frac{NIR - RED}{NIR + RED} = \text{NDVI}$$

$$\frac{0.39 - 0.09}{0.39 + 0.09} = \mathbf{0.63}$$

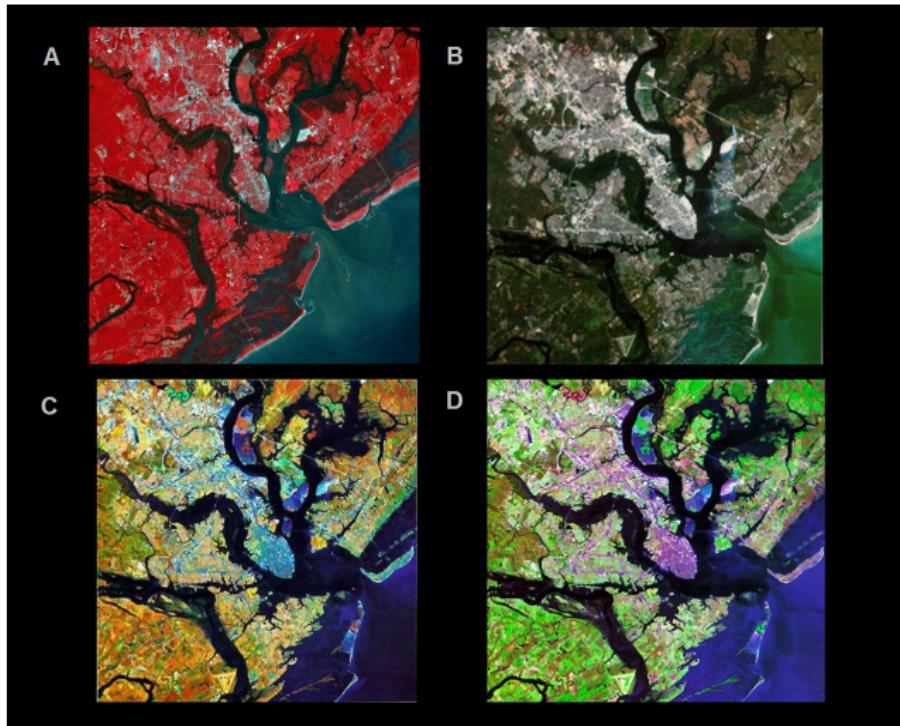
$$\frac{0.31 - 0.15}{0.31 + 0.15} = \mathbf{0.35}$$



Monitoring changes in ecosystem structure in time



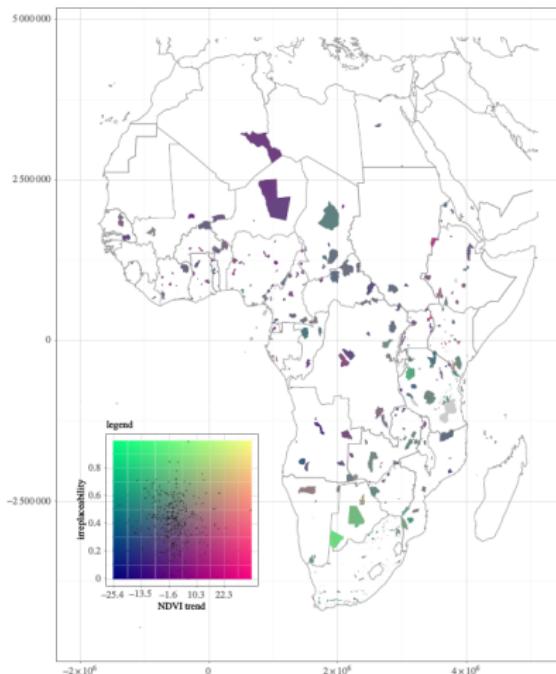
Colour composites



Outline

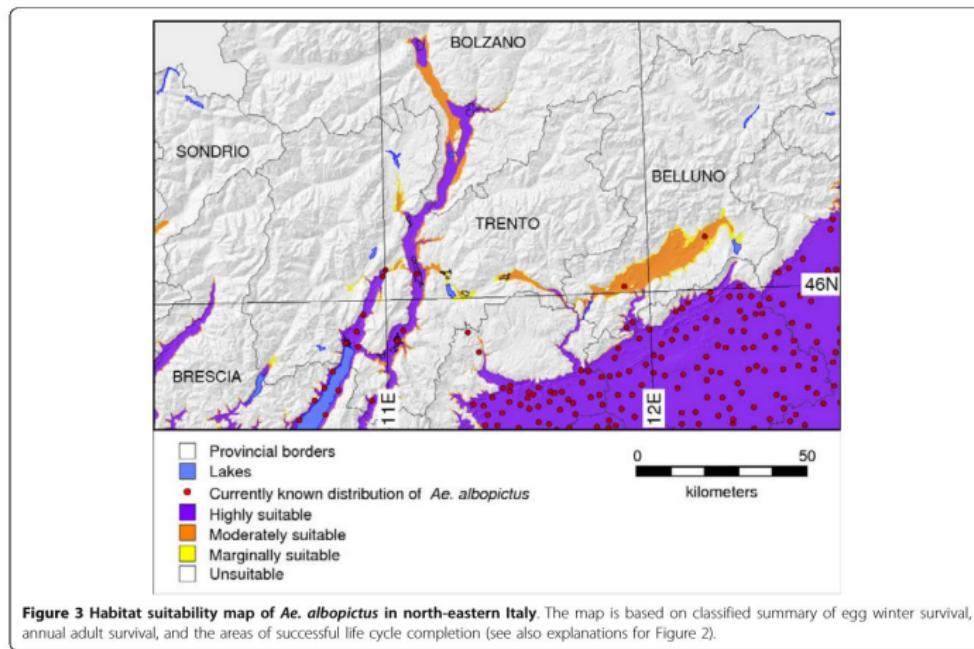
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Indirect RS: ancillary data



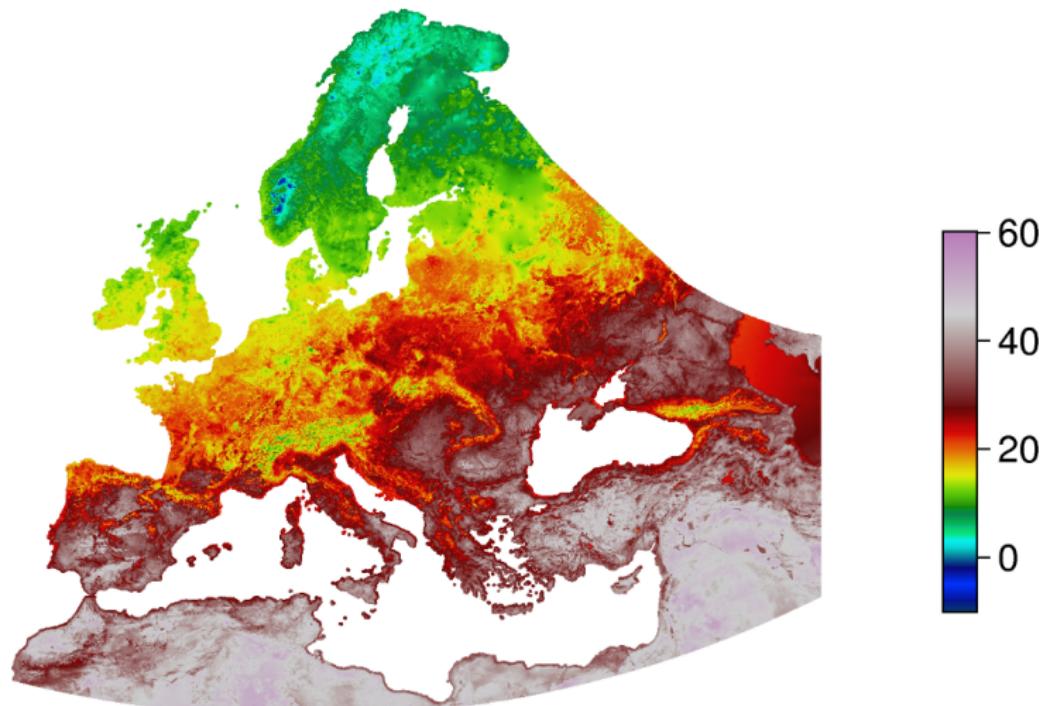
Wegmann, M., Santini, L., Leutner, B., Safi, K., Rocchini, D., Bevanda, M., Latifi, H., Dech, S., Rondinini, C. (2014). Role of African protected areas in maintaining connectivity for large mammals. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 369: 20130193.

Tiger mosquito spread



(Neteler et al., Int. J. Health Geogr., 2011)

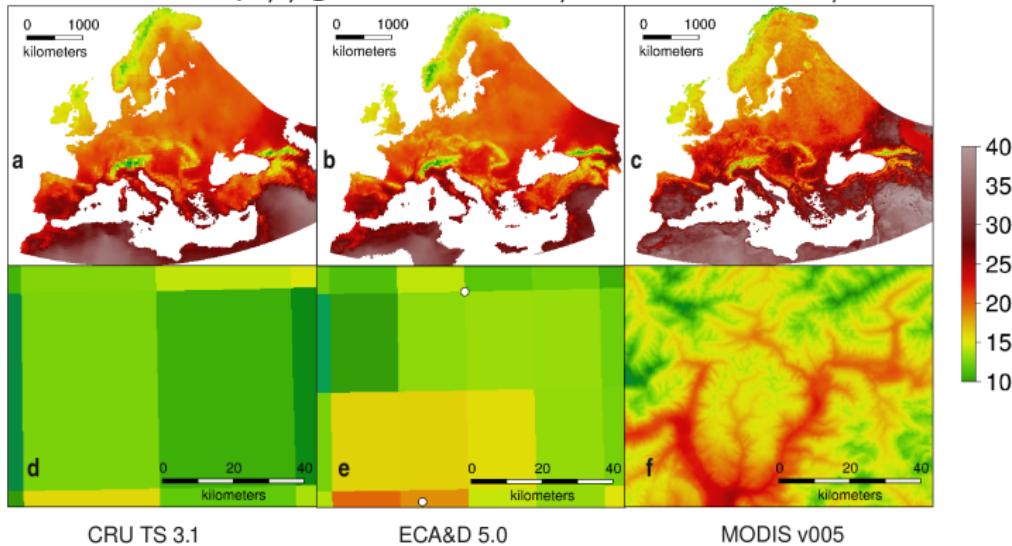
MODIS daily temperatures



Metz, M., Rocchini, D., Neteler, M. (2014). Surface Temperatures at the Continental Scale: Tracking Changes with Remote Sensing at Unprecedented Detail. *Remote Sensing*, 6: 3822-3840.

MODIS daily temperatures

<http://gis.cri.fmach.it/eurolst-bioclim/>



Metz, M., Rocchini, D., Neteler, M. (2014). Surface Temperatures at the Continental Scale: Tracking Changes with Remote Sensing at Unprecedented Detail. *Remote Sensing*, 6: 3822-3840.

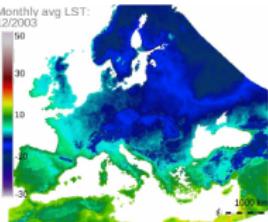
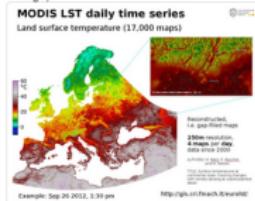
LST site

EuroLST

a seamless and gap-free daily European maps of temperatures

The new EuroLST dataset is **seamless and gap-free with a temporal resolution of four records per day and enhanced spatial resolution of 250 m**. This newly developed reconstruction method has been applied to Europe and neighbours countries, resulting in complete daily coverage from 2001 on. To our knowledge, this new reconstructed LST time series exceeds the level of detail of comparable reconstructed LST datasets by several orders of magnitude. Studies on emerging diseases, parasite risk assessment and temperature anomalies can now be performed on the continental scale, maintaining high spatial and temporal detail. In their paper, the authors provide examples for implications and applications of the new LST dataset, such as disease risk assessment, epidemiology, environmental monitoring, and temperature anomalies.

Reconstructed MODIS Land Surface Temperature Dataset, at 250m pixel resolution (click figure to enlarge):



Article and data citation:

EuroLST product of FEM-DBEM based on gap-free daily MODIS LST (Product of NASA) maps.

<http://www.geodati.fmach.it/eurolst.html>

Land use data and their potential in ecology



Mapping the spatial distribution of plant diversity indices in a tropical forest using multi-spectral satellite image classification and field measurements

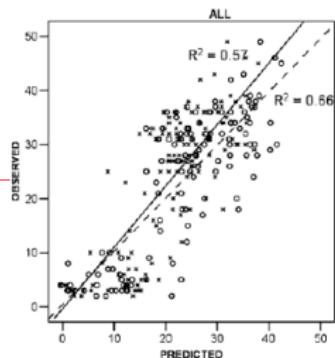
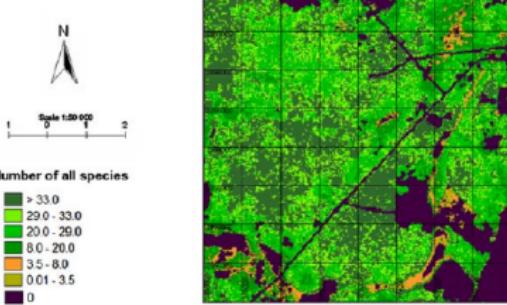
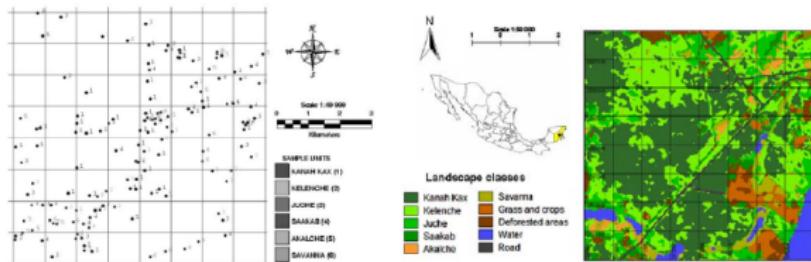
J. LUIS HERNANDEZ-STEFANONI¹ and RAUL PONCE-HERNANDEZ^{1,2,*}

Biodivers Conserv (2007) 16:3817–3831
DOI 10.1007/s10531-007-9182-6

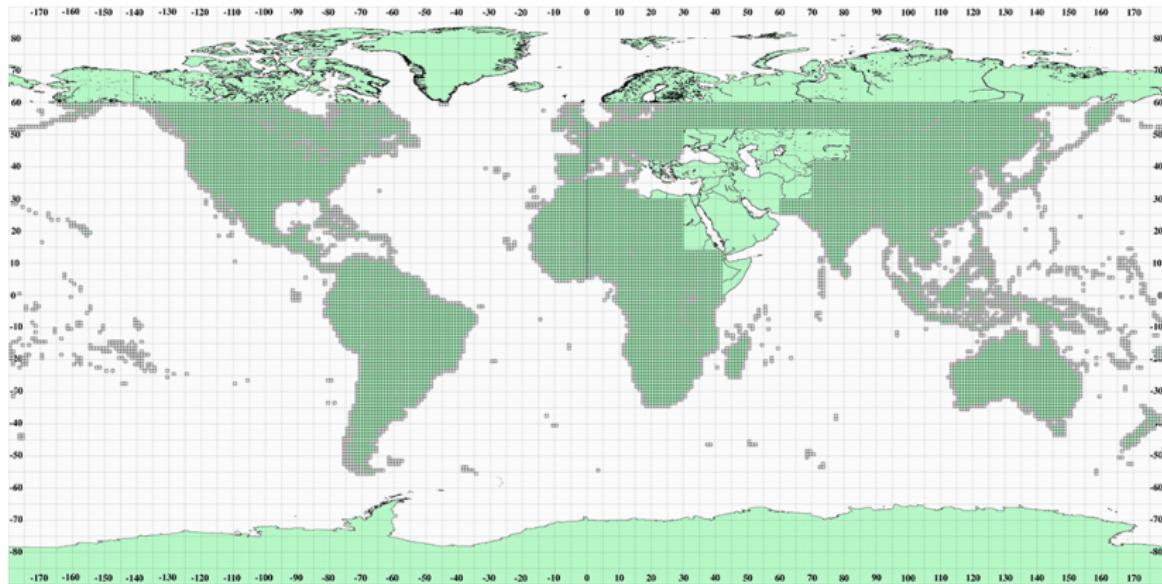
ORIGINAL PAPER

Mapping species density of trees, shrubs and vines in a tropical forest, using field measurements, satellite multispectral imagery and spatial interpolation

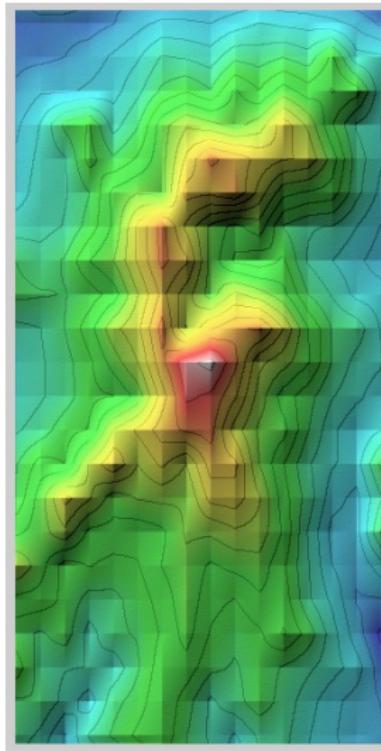
J. Luis Hernández-Stefanoni - Juan Manuel Dupuy



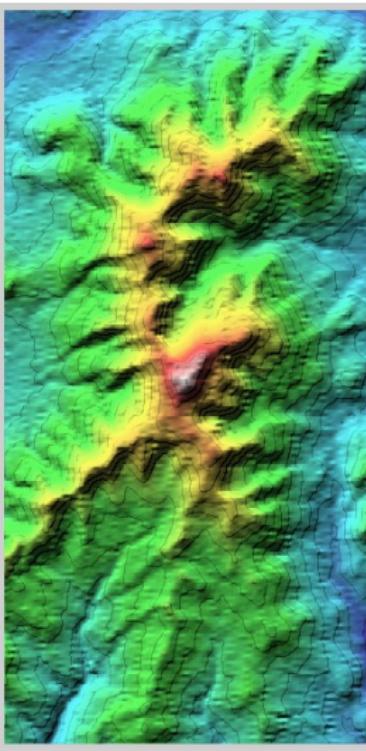
Deriving elevation from RS data: the Shuttle Radar Topography Mission (SRTM)



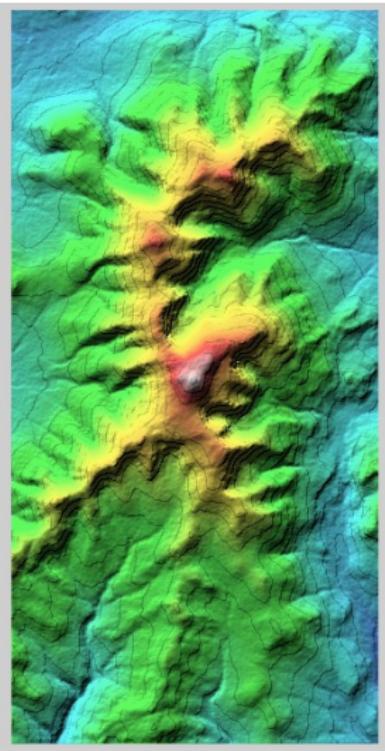
Deriving elevation from RS data: the Shuttle Radar Topography Mission (SRTM)



GTOPO30 (30 arcsec)



DEM250 (3 arcsec)



SRTM (1 arcsec)

RS heterogeneity

Ecological Indicators 85 (2018) 983–990



Contents lists available at ScienceDirect

Ecological Indicators

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

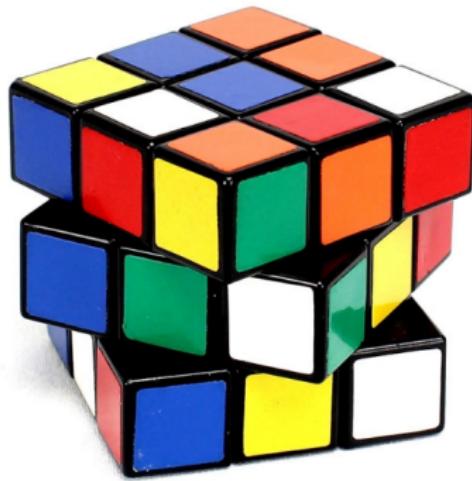
Brief article

Remotely sensed spatial heterogeneity as an exploratory tool for taxonomic and functional diversity study



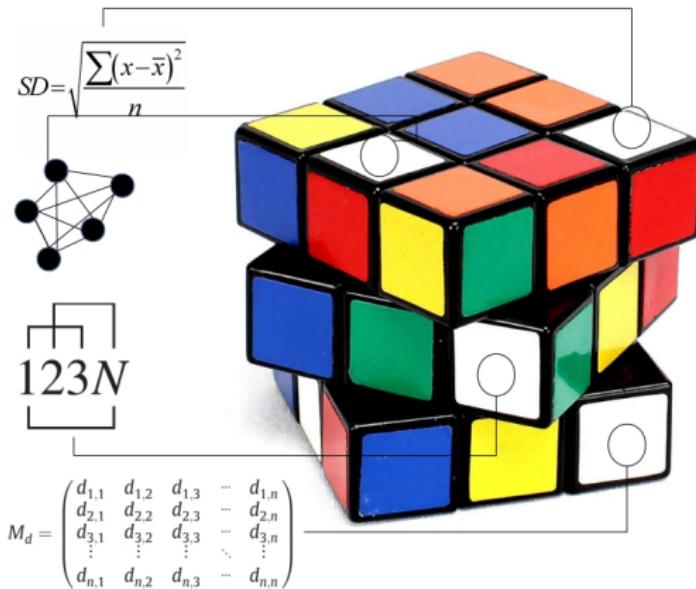
Duccio Rocchini^{a,b,c,*}, Giovanni Bacaro^d, Gherardo Chirici^e, Daniele Da Re^d, Hannes Feilhauer^f, Giles M. Foody^g, Marta Galluzzi^e, Carol X. Garzon-Lopez^h, Thomas W. Gillespieⁱ, Kate S. He^j, Jonathan Lenoir^k, Matteo Marcantonio^l, Harini Nagendra^m, Carlo Ricottaⁿ, Edvinas Rommel^o, Sebastian Schmidlein^p, Andrew K. Skidmore^{q,r}, Ruben Van De Kerchove^s, Martin Wegmann^t, Benedetto Rugani^u

RS heterogeneity



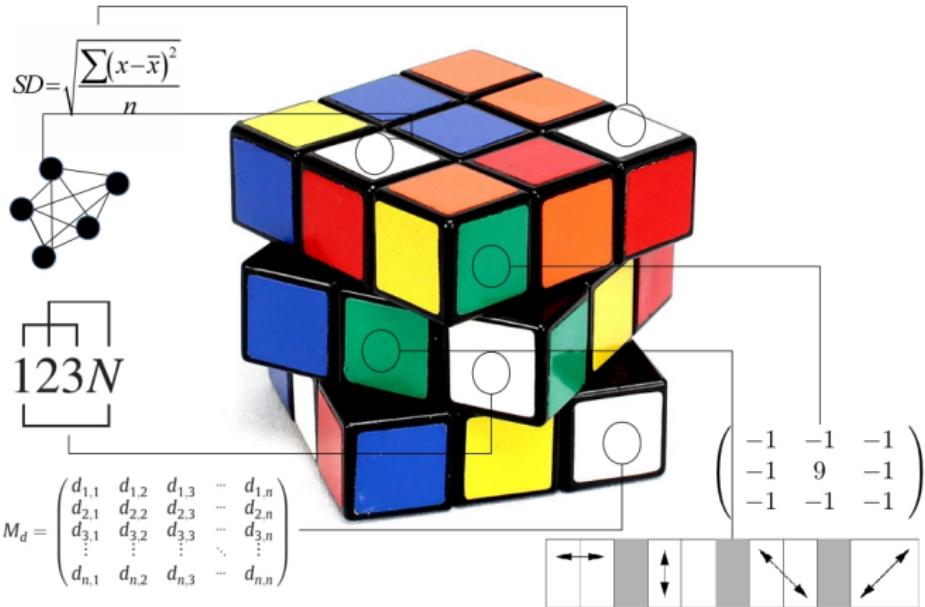
RS heterogeneity

DISPERSION MEASURES



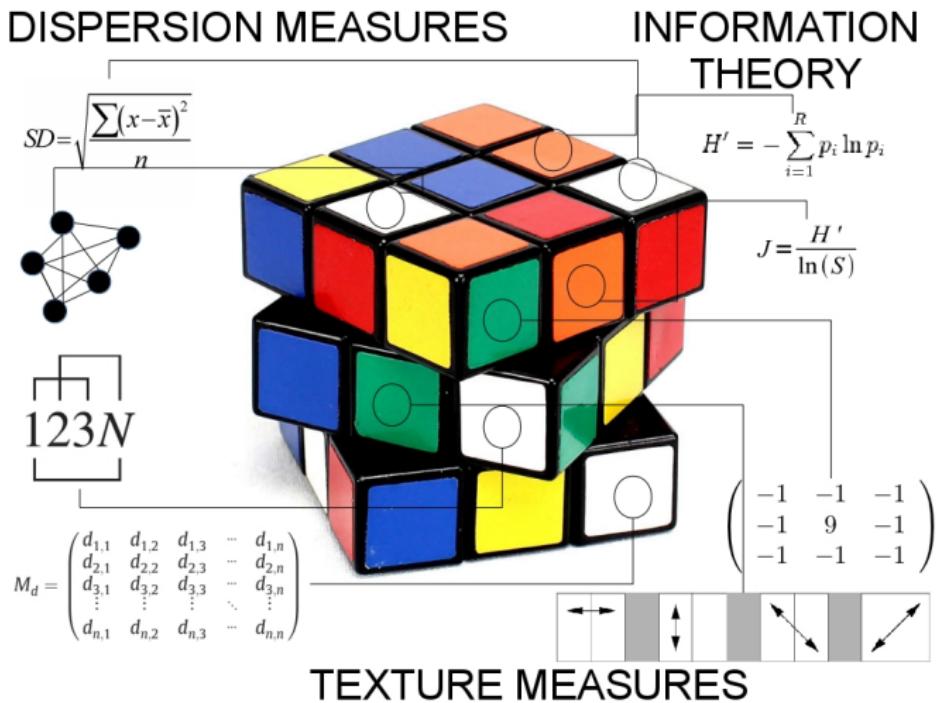
RS heterogeneity

DISPERSION MEASURES

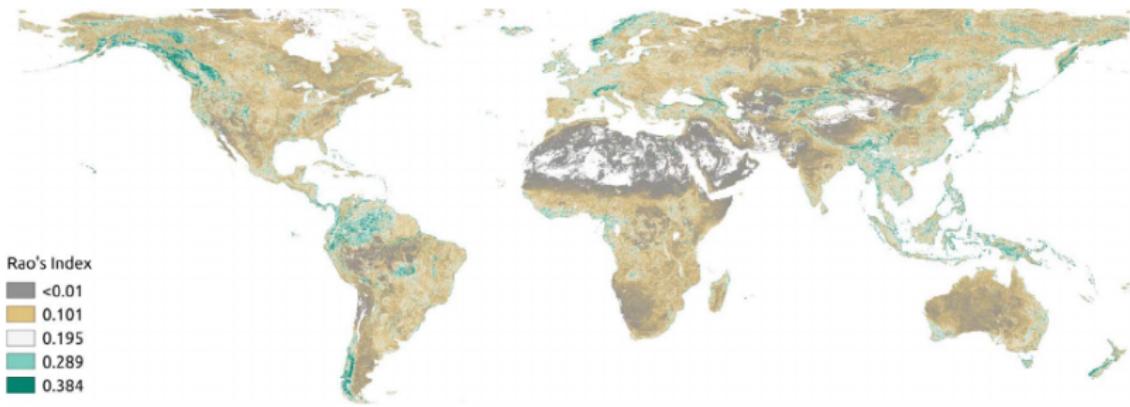


TEXTURE MEASURES

RS heterogeneity



RS heterogeneity



Coding

R code

Introduction to remote sensing and GIS for
ecological applications

Duccio Rocchini

May 21, 2018

Coding

```
####— Functions: 1
https://github.com/bleutner/RStoolbox/tree/master/R 3

####— Data: 5
http://book.ecosens.org/software/rstoolbox/

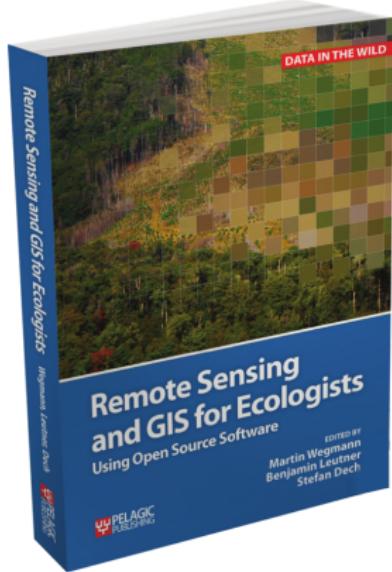
####— Landsat bands 7
https://landsat.usgs.gov/what-are-band-designations-landsat-satellites 9

####— Code 11
install.packages("raster") #—— do the same for all packages to
  be recalled later on by library () 13

library(raster)
library(rgdal) 15
# Geospatial Data Abstraction Library
library(RStoolbox) 17
library(ggplot2)
library(hexbin) 19

# 2011 image 21
p224r063_2011m <- brick("~/grassdata/data_book/raster_data/final/
  p224r63_2011_masked.grd") 23
```

Coding



Contacts



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University of Trento
duccio.rocchini@unitn.it