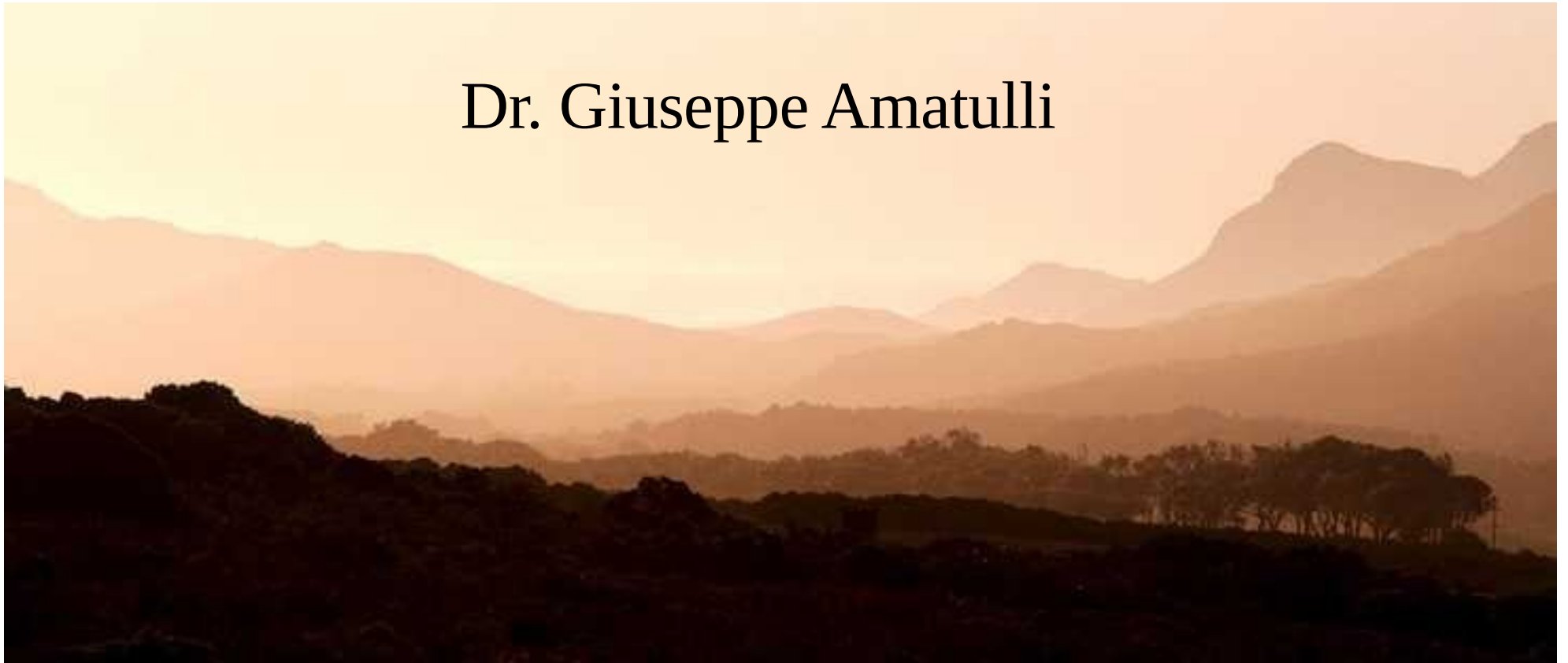


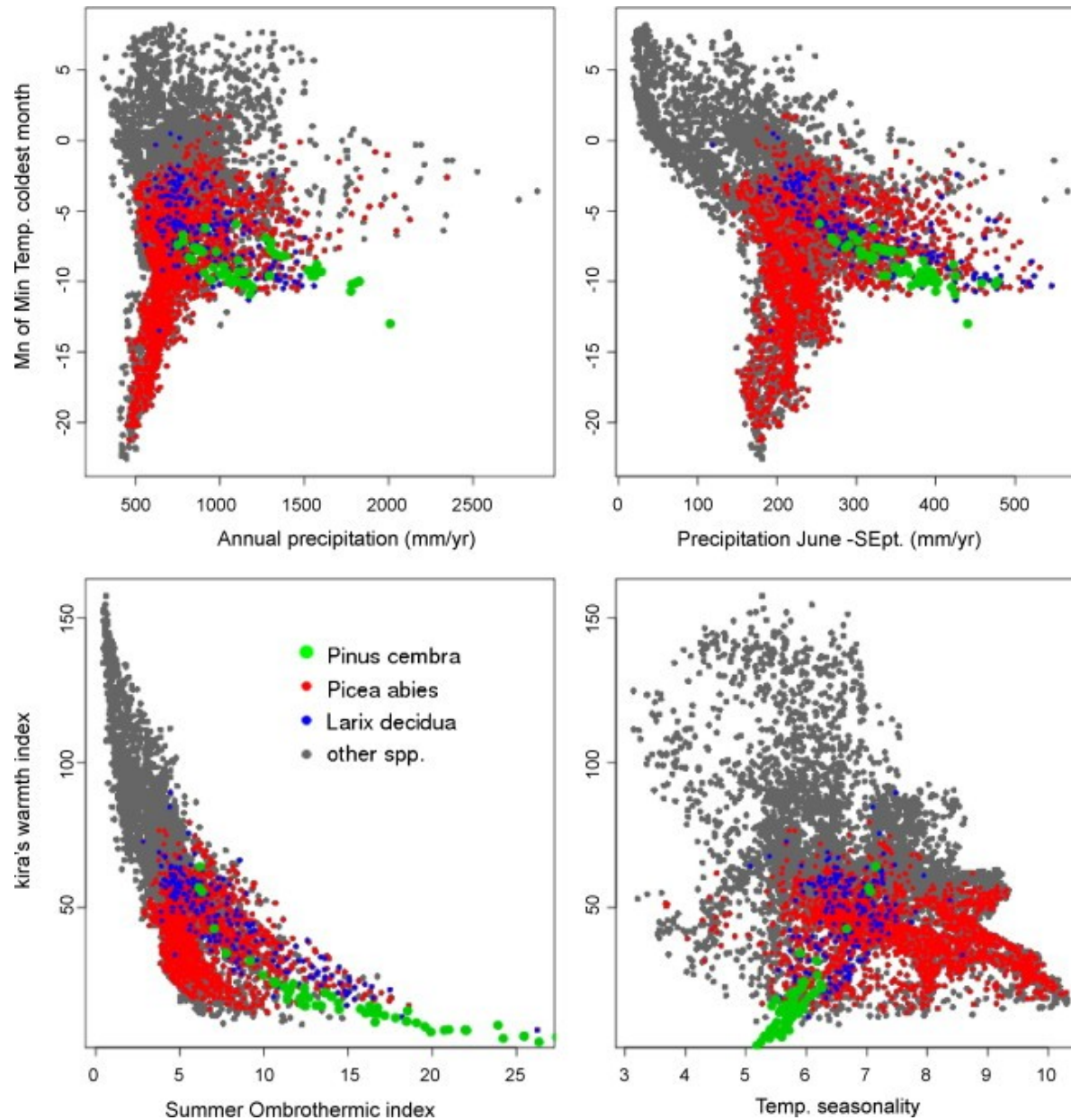
# GIS and RS for Biodiversity

Biodiversity  $\sim f(\text{environment})$

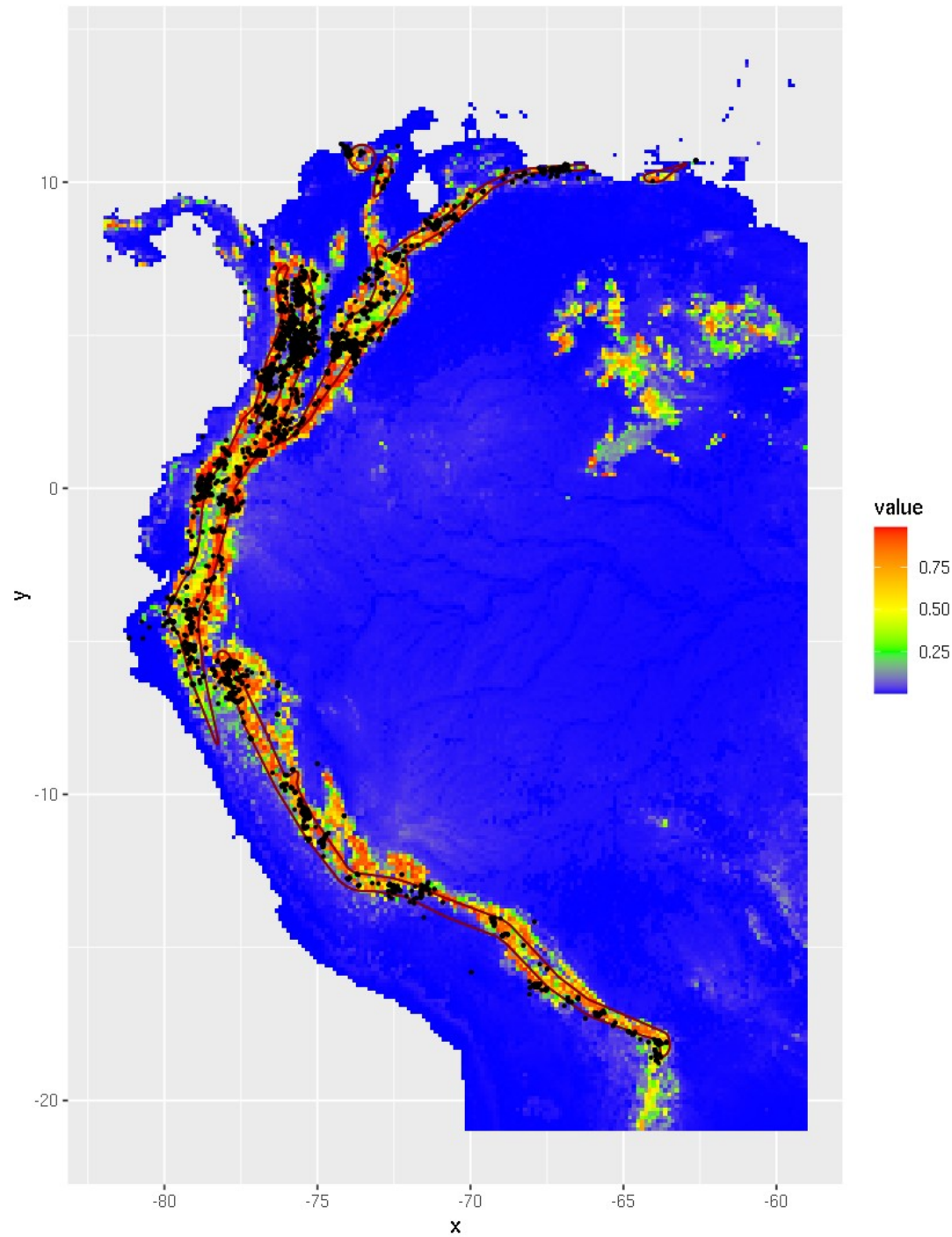
Dr. Giuseppe Amatulli



# Biodiversity $\sim f(\text{environment})$



Biodiversity  $\sim f(\text{environment})$



# Objectives

Biodiversity  $\sim f(\text{environment})$

A whirlwind tour of environmental data:

- Climate (past & future)
- Topography & Hydrography
- Soil
- Land Cover
- Satellite images  $\rightarrow$  vegetation/water index
- Human population density
- Livestock density.

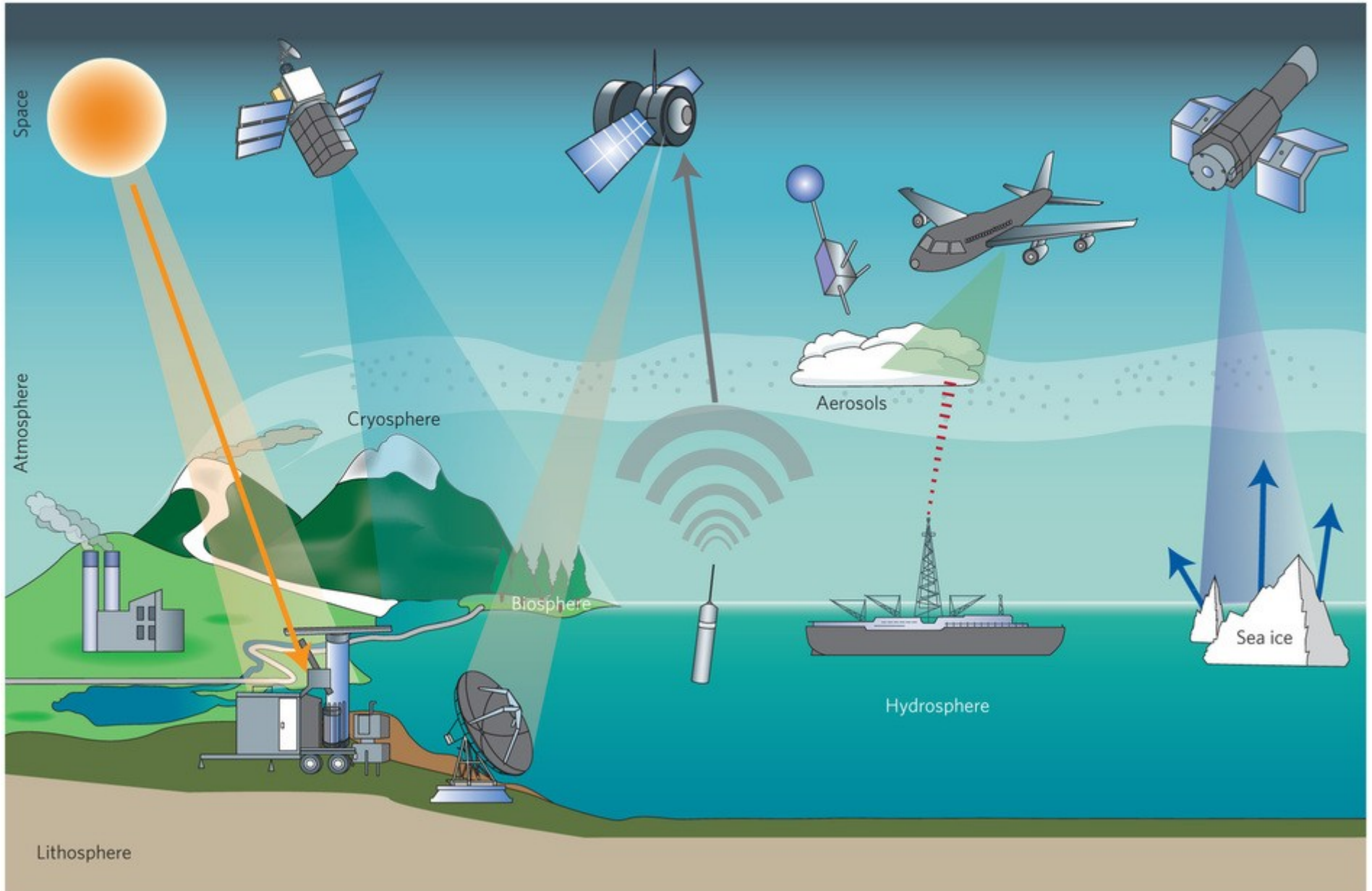


Key take-home messages:

1. Data deluge  $\rightarrow$  incredible opportunities
2. Data complexity  $\rightarrow$  biogeographers must be vigilant



# Remote sensing



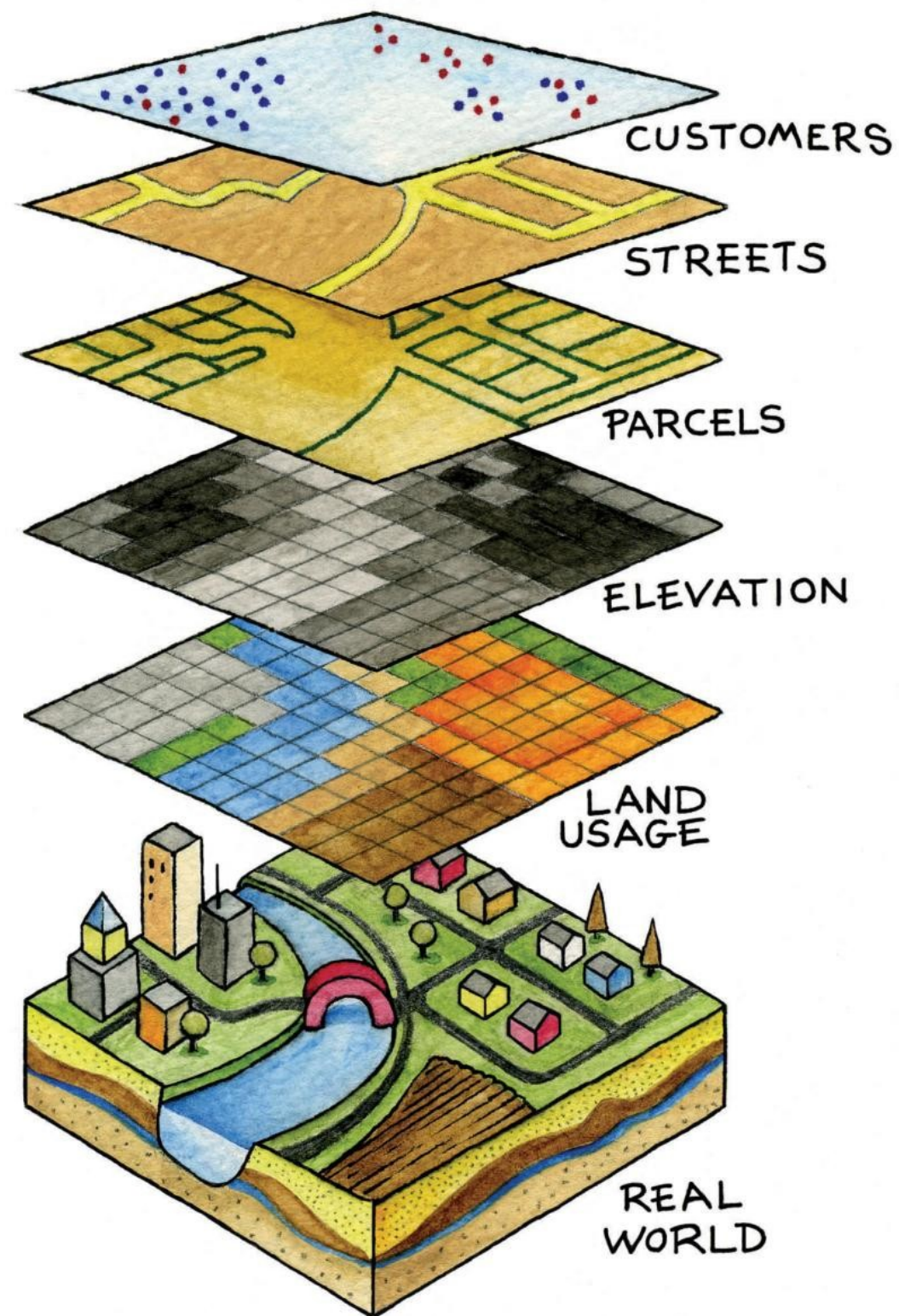
# Geographic Information System

Combine:

- satellite information,
- ground true
- gps device data,
- station data



## Modeling



Climate



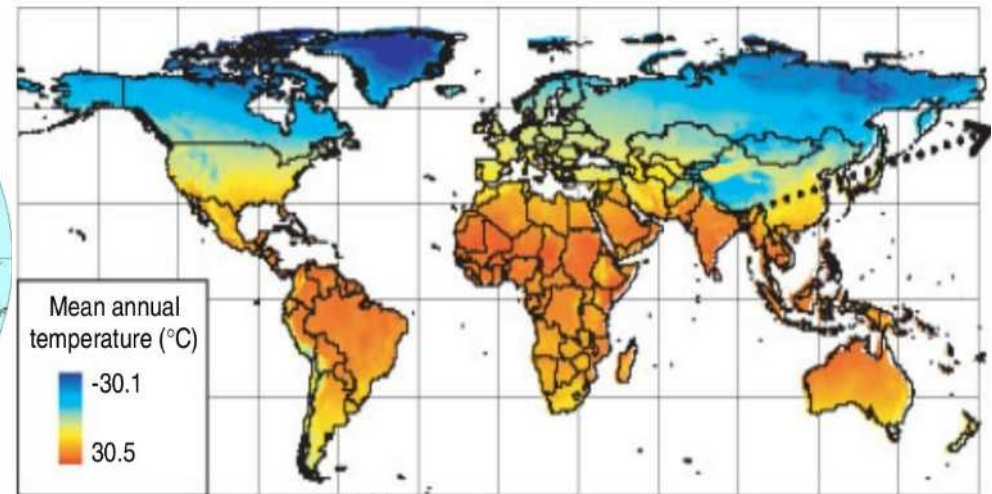
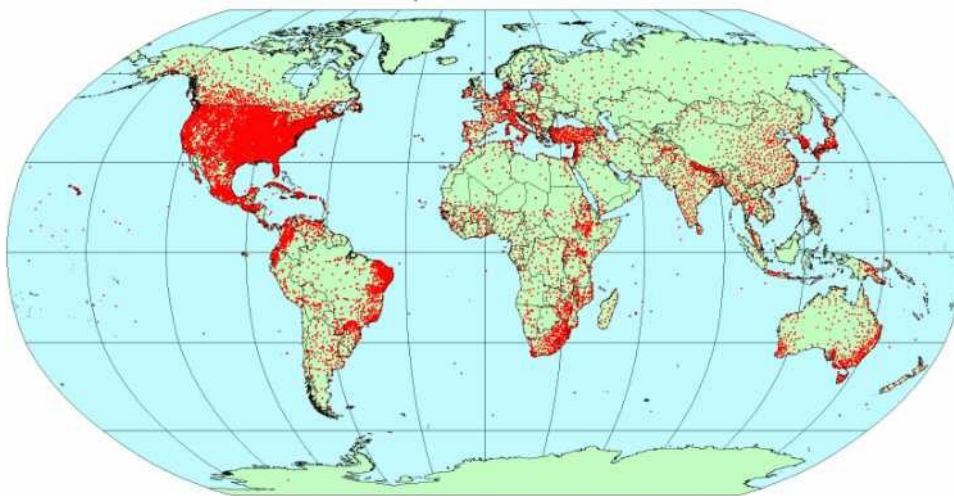
WorldClim  
Chelsa

<https://worldclim.org>  
<https://chelsa-climate.org>

Station Locations

→

Continuous Grid



- Global  $\approx 1\text{km}$  resolution monthly  $T_{max}$ ,  $T_{min}$ , and Precipitation.
- Thin-plate splines (latitude, longitude, and elevation).
- No pixel-by-pixel metrics of uncertainty



# Topography & Hydrography

# Multi-Error-Removed Improved-Terrain DEM

[http://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT\\_DEM/](http://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT_DEM/)



## Geophysical Research Letters



### RESEARCH LETTER

10.1002/2017GL072874

#### Key Points:

- A high-accuracy global digital elevation model (DEM) was developed by removing multiple height error components from existing DEMs
- Landscape representation was improved, especially in flat regions where height error magnitude was larger than actual topography variation

### A high-accuracy map of global terrain elevations

Dai Yamazaki<sup>1,2</sup> , Daiki Ikeshima<sup>3</sup> , Ryunosuke Tawatari<sup>3</sup> , Tomohiro Yamaguchi<sup>4</sup> ,  
Fiachra O'Loughlin<sup>5</sup> , Jeffery C. Neal<sup>6</sup> , Christopher C. Sampson<sup>7</sup> , Shinjiro Kanae<sup>3</sup> ,  
and Paul D. Bates<sup>6</sup>

<sup>1</sup>Department of Integrated Climate Change Projection Research, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan, <sup>2</sup>Institute of Industrial Sciences, University of Tokyo, Tokyo, Japan, <sup>3</sup>Department of Civil and Environmental Engineering, Tokyo Institute of Technology, Tokyo, Japan, <sup>4</sup>Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagami-hara, Japan, <sup>5</sup>UCD School of Civil Engineering, University College Dublin, Dublin, Ireland, <sup>6</sup>School of Geographical Sciences, University of Bristol, Bristol, UK, <sup>7</sup>SSBN, Bristol, UK



## Water Resources Research



### RESEARCH ARTICLE

10.1029/2019WR024873

#### Key Points:

- A global hydrography map was generated using the latest topography dataset
- Near-automatic algorithm applicable for global hydrography delineation was developed
- Adjusted elevation and river width layers consistent with flow direction map are provided

### MERIT Hydro: A High-Resolution Global Hydrography Map Based on Latest Topography Dataset

Dai Yamazaki<sup>1,2</sup> , Daiki Ikeshima<sup>2</sup> , Jeison Sosa<sup>3</sup> , Paul D. Bates<sup>3</sup> , George H. Allen<sup>4</sup> ,  
and Tamlin M. Pavelsky<sup>5</sup>

<sup>1</sup>Institute of Industrial Science, The University of Tokyo, Tokyo, Japan, <sup>2</sup>Department of Civil and Environmental Engineering, Tokyo Institute of Technology, Tokyo, Japan, <sup>3</sup>School of Geographical Sciences, University of Bristol, Bristol, UK, <sup>4</sup>Department of Geography, Texas A&M University, College Station, TX, USA, <sup>5</sup>Department of Geological Sciences, University of North Carolina, Chapel Hill, NC, USA

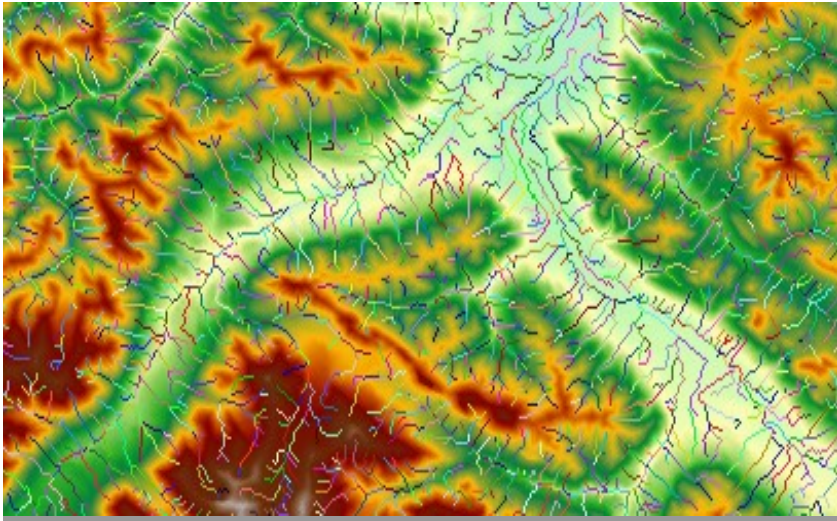
# MERIT DEM

# MERIT Hydro

- GIS layers predictors able to capture the ecological needs of the blackfly



- Geomorphometric features  
24 layers (slope, aspect, curvature, etc.)  
**Geomorpho90m**: Amatulli et al., 2020



- Hydrographic features  
19 layers (streams slope/distance/length, outlet distance, etc.)  
**Hydrography90m**: Amatulli et al., 2022



# Topography complexity

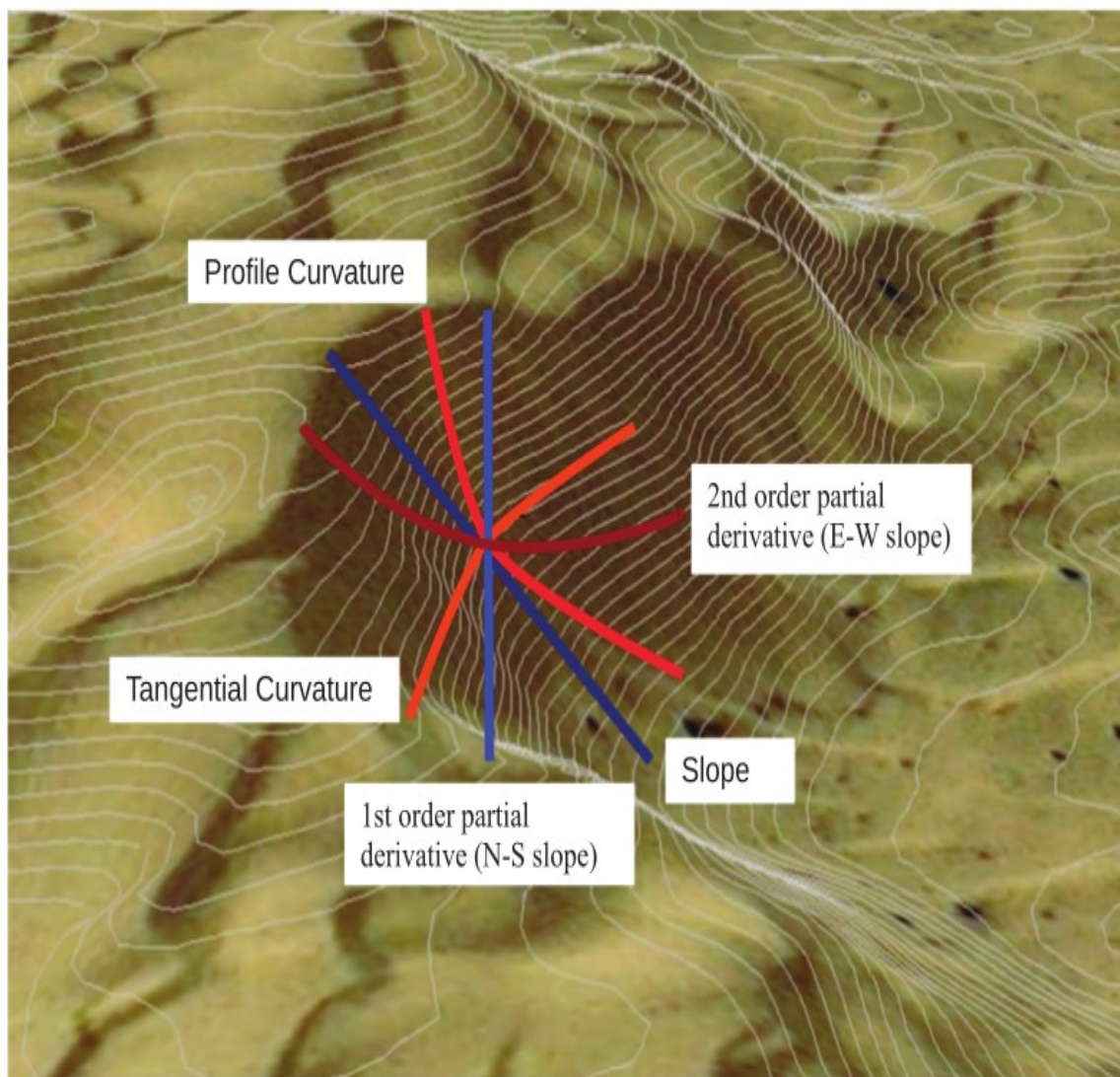
(geomorphometry/geomorphology analysis)



**Topographic variation underpins a myriad of patterns and processes in hydrology, climatology, geography and ecology, and is key to understanding the variation of life on the planet (Amatulli et al. 2018).**



Amatulli *et al.* 2018  
DOI:  
10.1038/sdata.2018.  
40

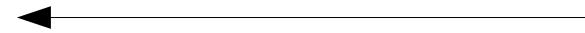


**Figure 2.** Graphical representation of landform shapes based on slope and curvature. Slope is the rate of change of elevation in the direction of the steepest descent, whereas the second order partial derivative (N-S slope) is the slope in the North-South direction. The profile and tangential curvatures identify concavity and convexity in the direction of the slope, or perpendicular to the slope. The second order partial derivatives (E-W slope) identify the curvature in the East-West direction.

# Topography complexity layers

(Surface roughness and terrain forms analysis)

## Roughness indices

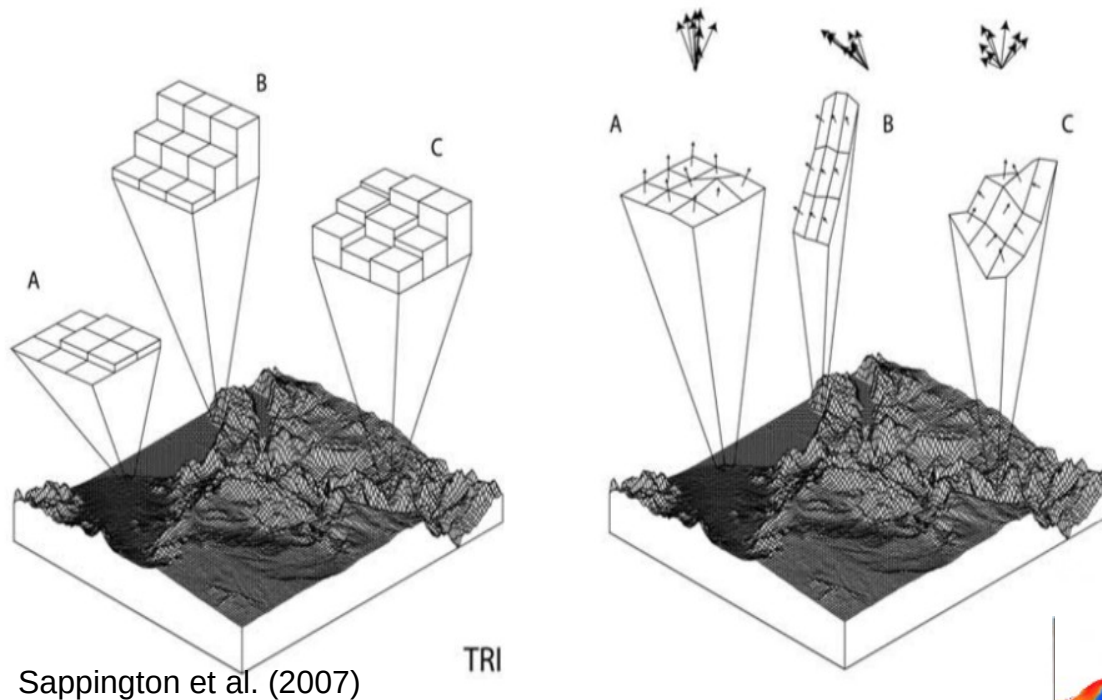


Roughness - Median / SD

Topographic Position Index - Median / SD

Terrain Ruggedness Index - Median / SD

Vector Ruggedness Measure - Median / SD



Sappington et al. (2007)

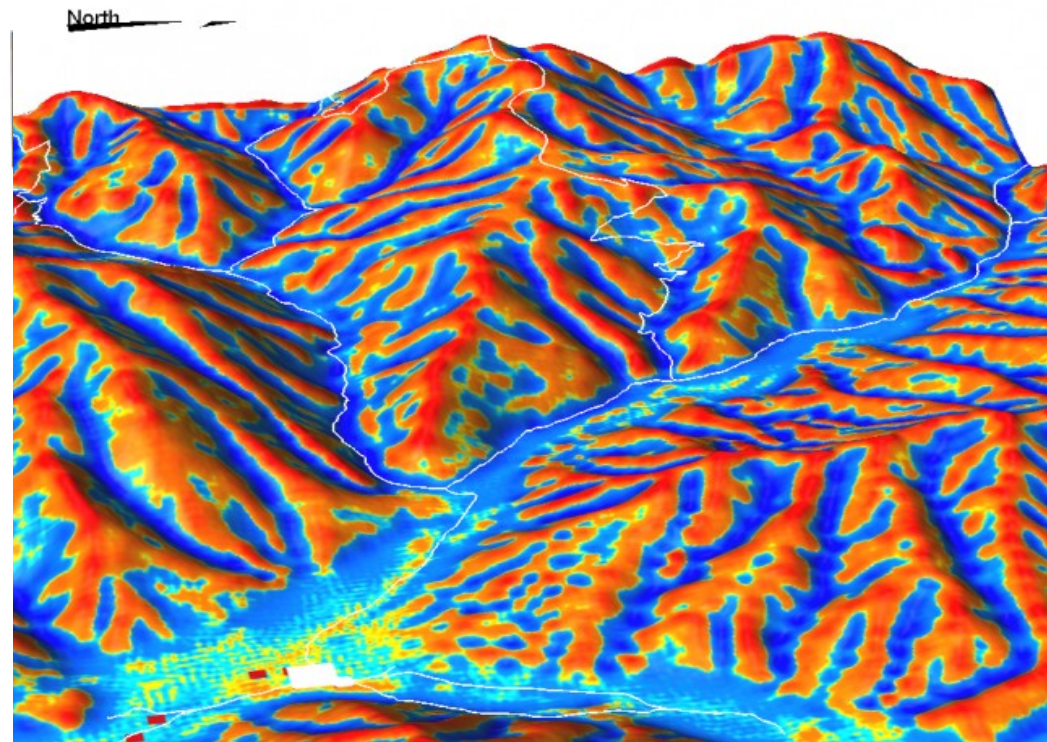
TRI

## Curvature



Profile curvature - Median / SD

Tangential curvature - Median / SD

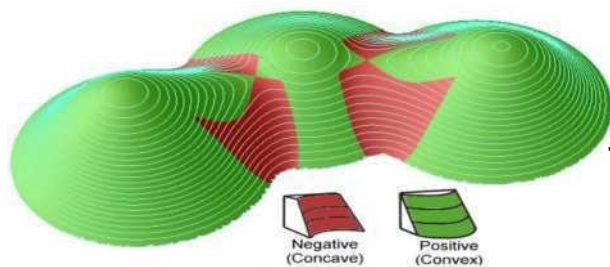
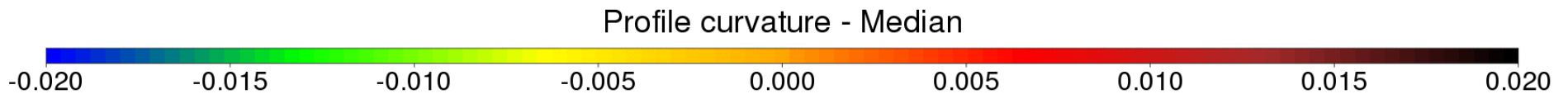
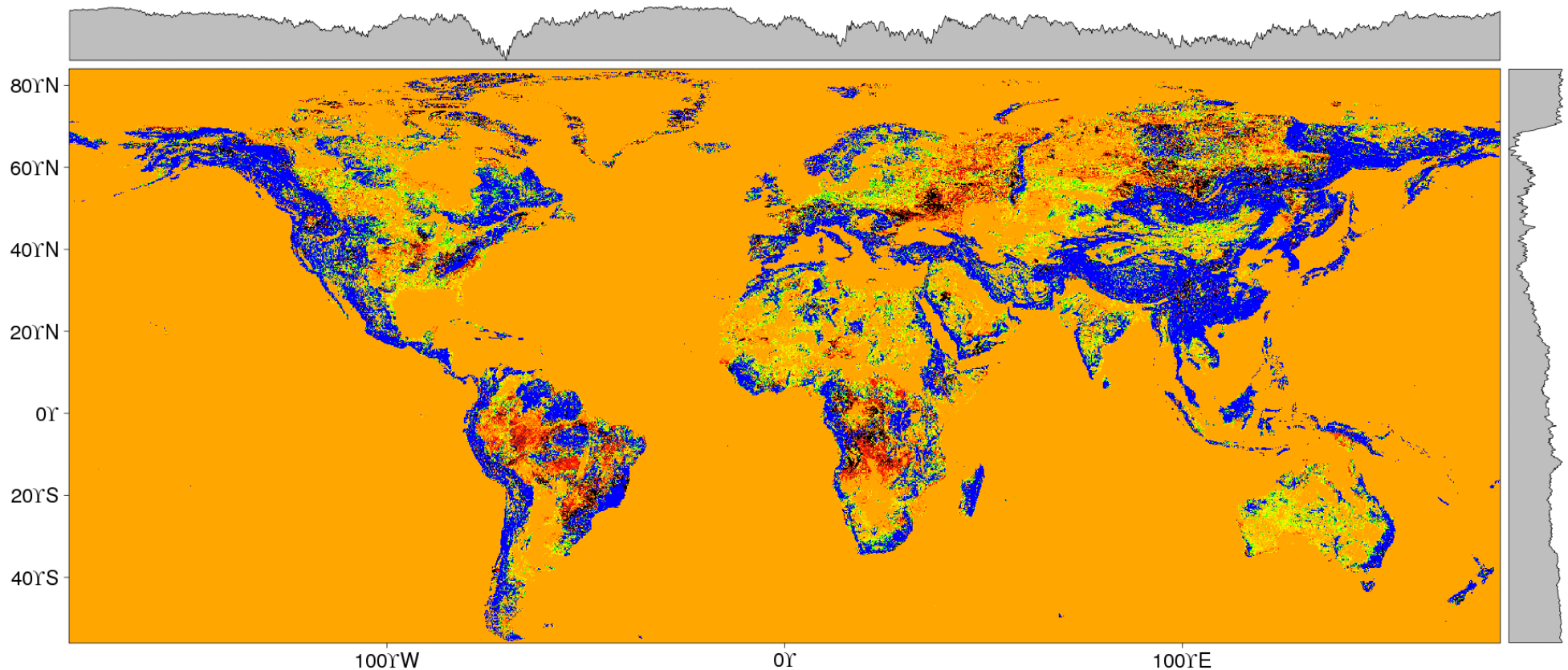




# Topography complexity layers

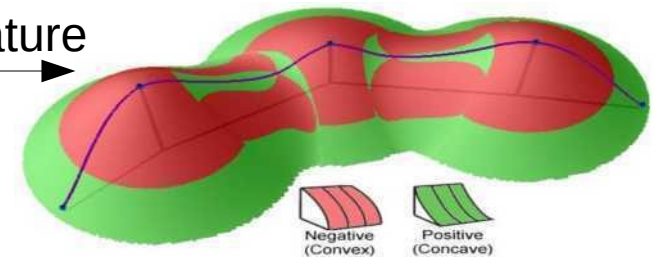
(surface roughness and geo-morphology analysis)

## Curvature

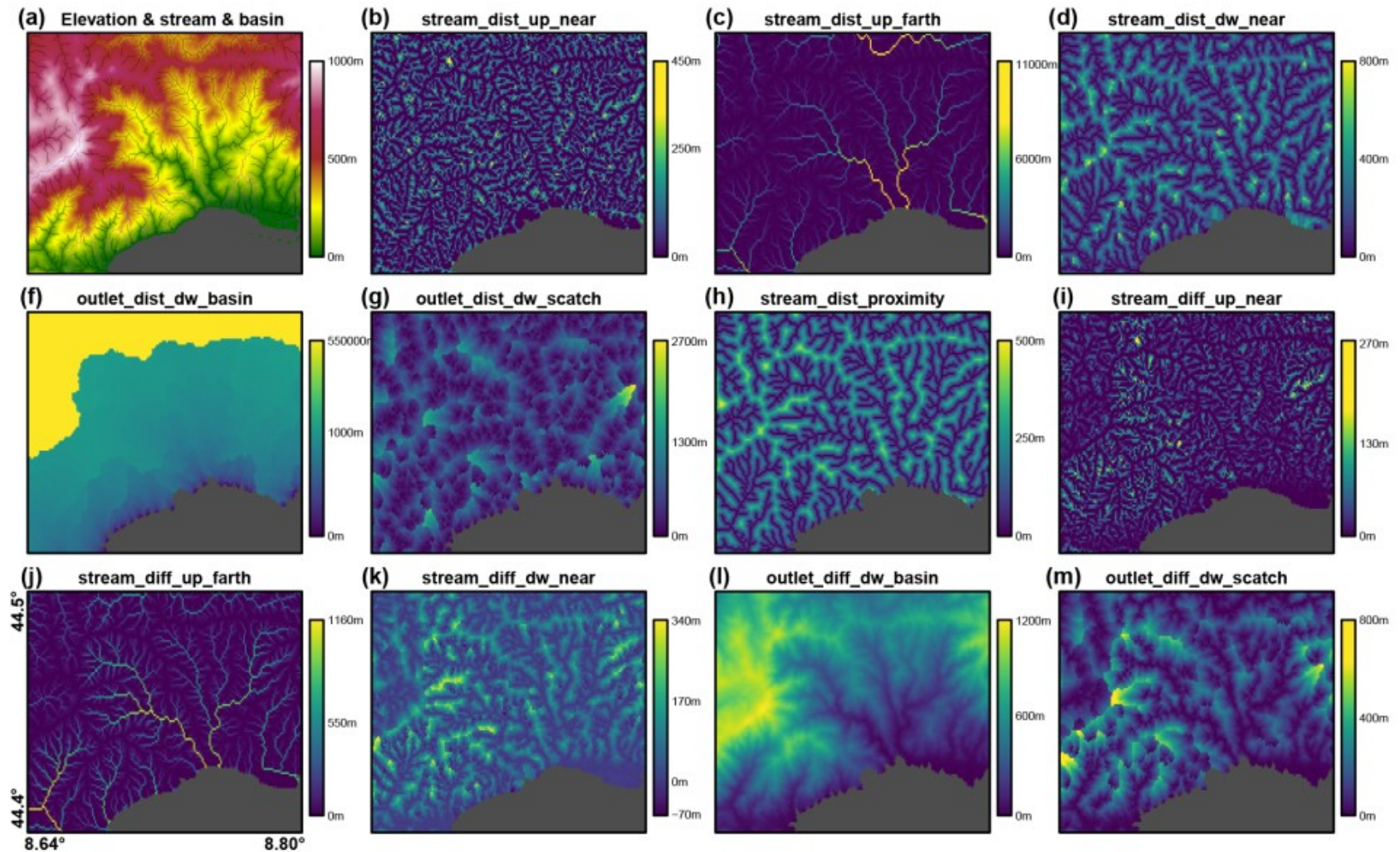


Tangential curvature

Profile curvature



# Hydrography90m

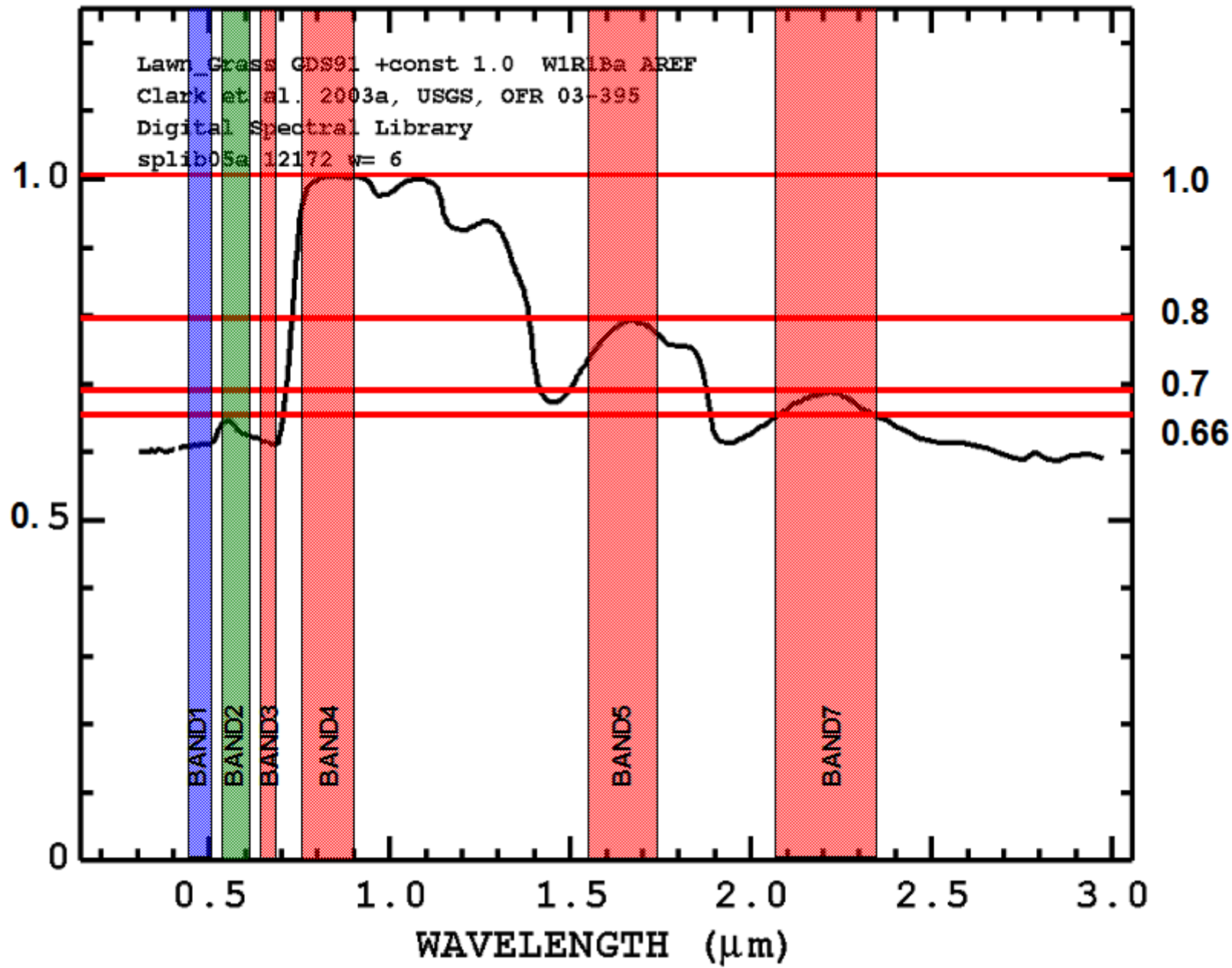


**Figure 12.** Map (a) shows the stream channels and drainage basins derived from the elevation layer. Maps (b)–(m) show, for the same area, the distance and elevation difference attributes of each land grid cell to the stream channels, outlets, or stream nodes using the *r.stream.distance* GRASS GIS module. The panel letters correspond to those in Table 4.

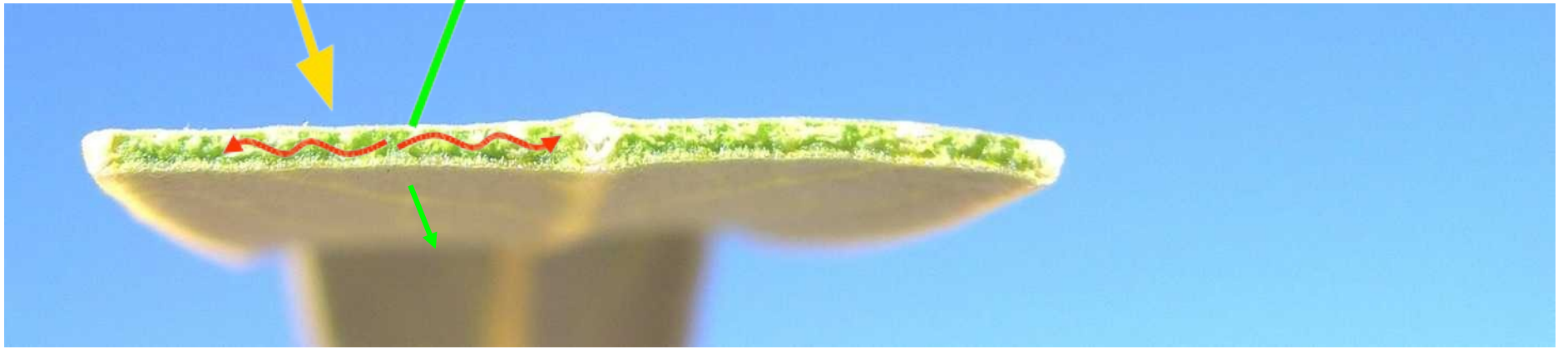


# Satellite spectral images

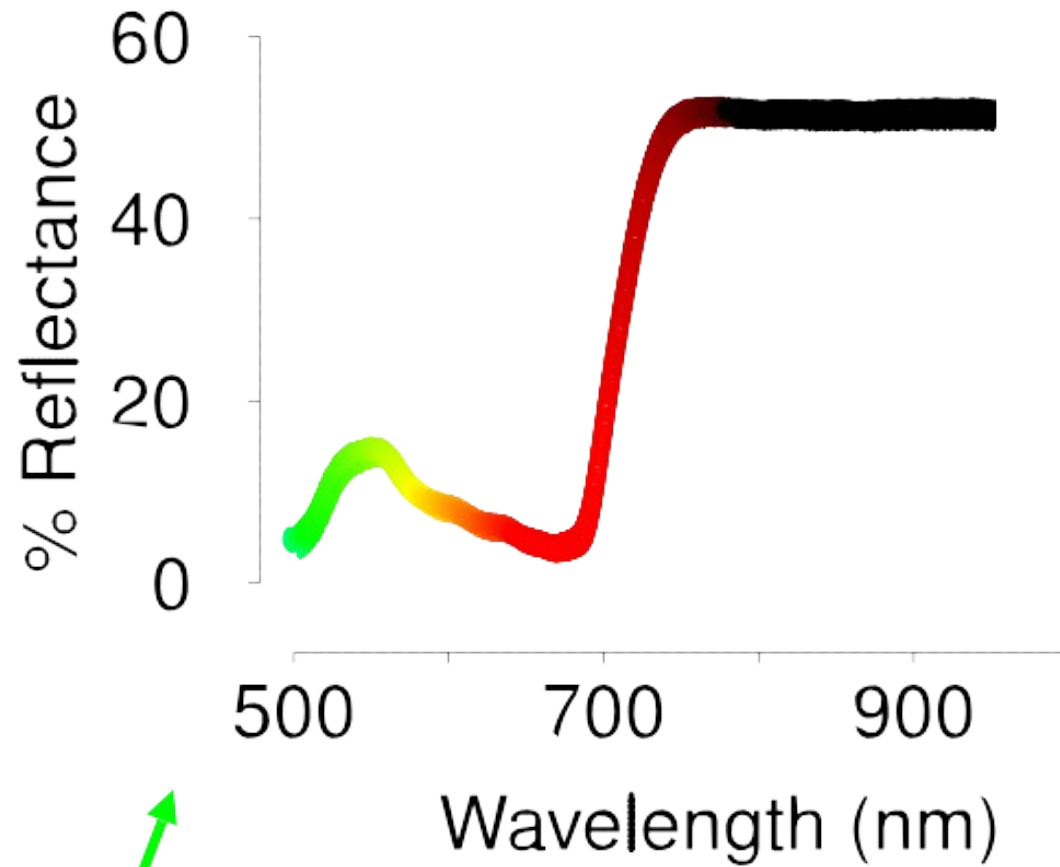
# Landsat Multispectral Satellite Image



## Vegetation Indices: NDVI

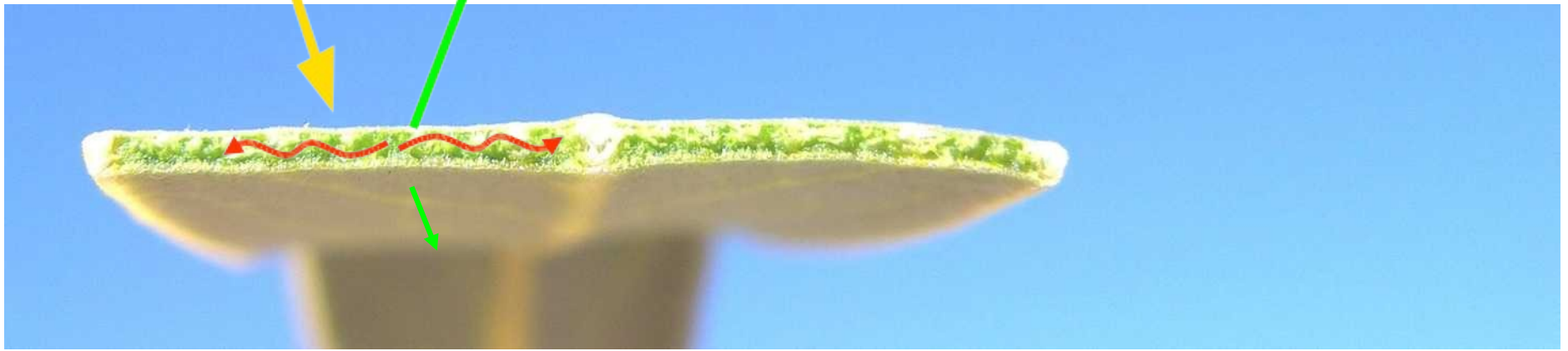
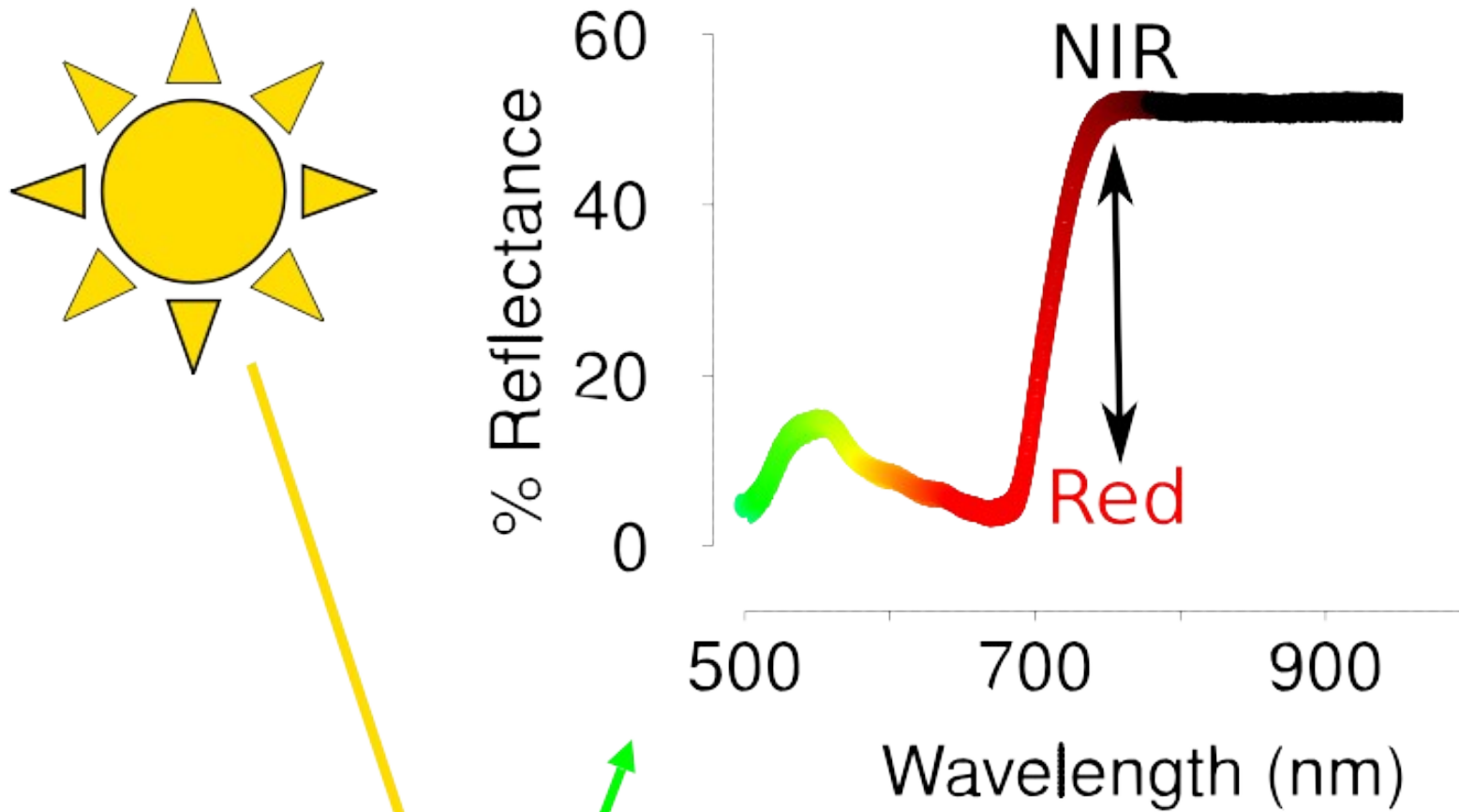


## Vegetation Indices: NDVI

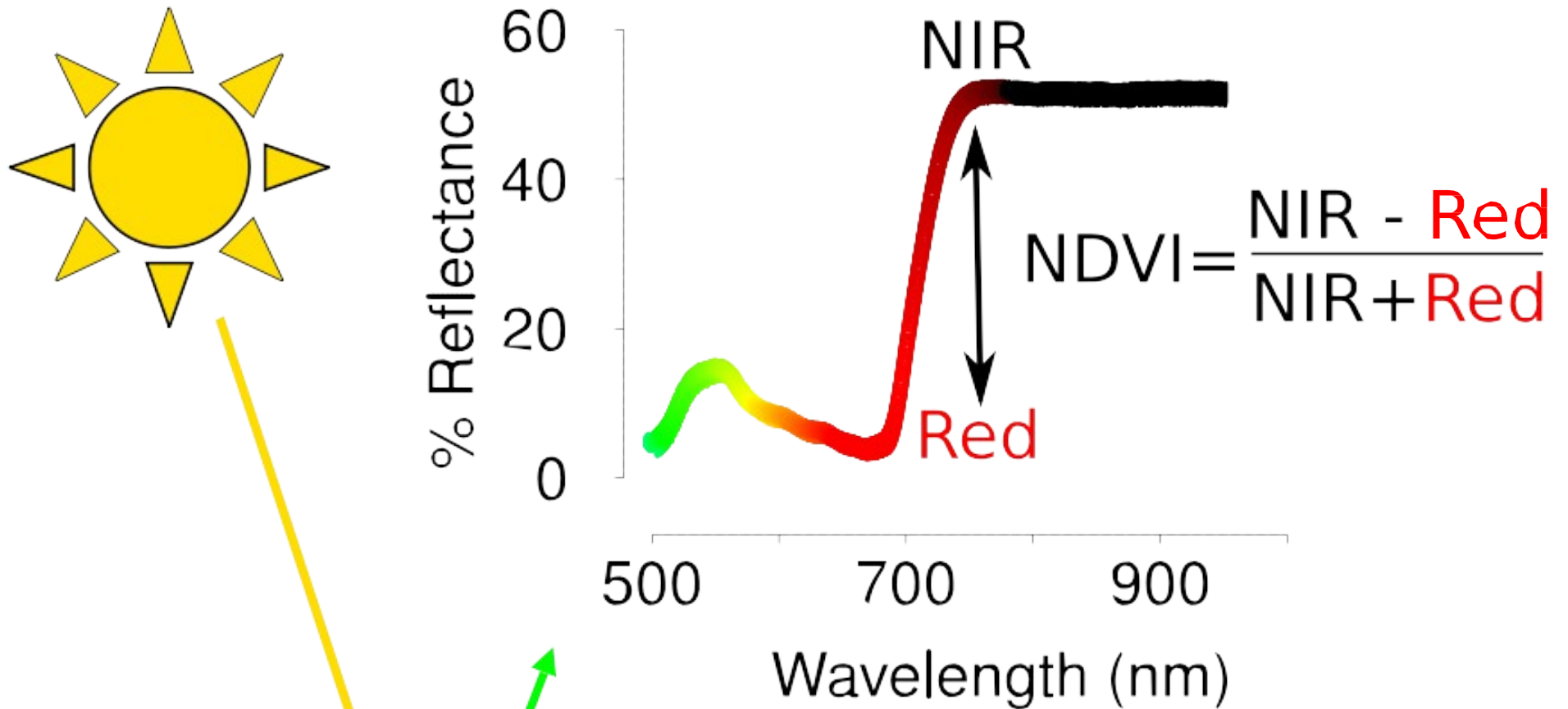




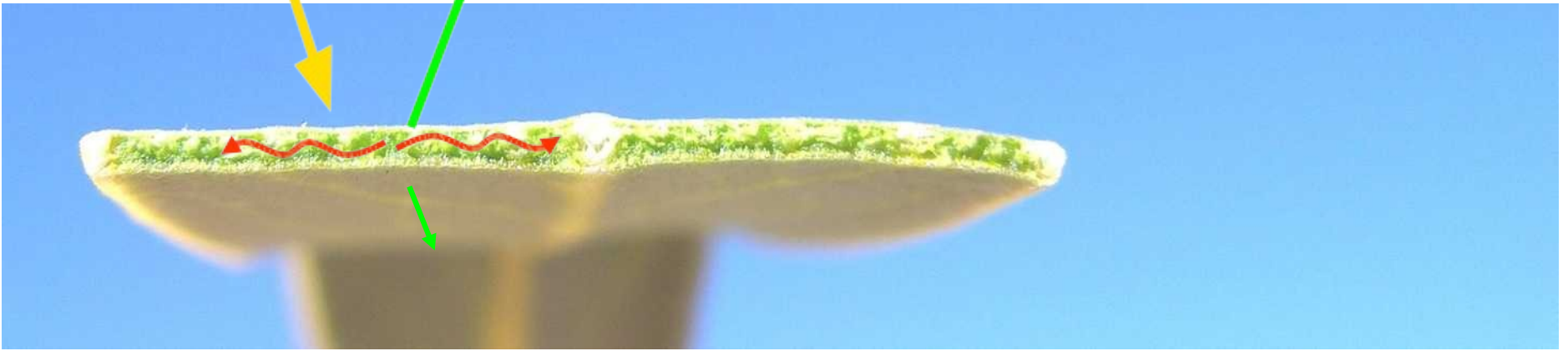
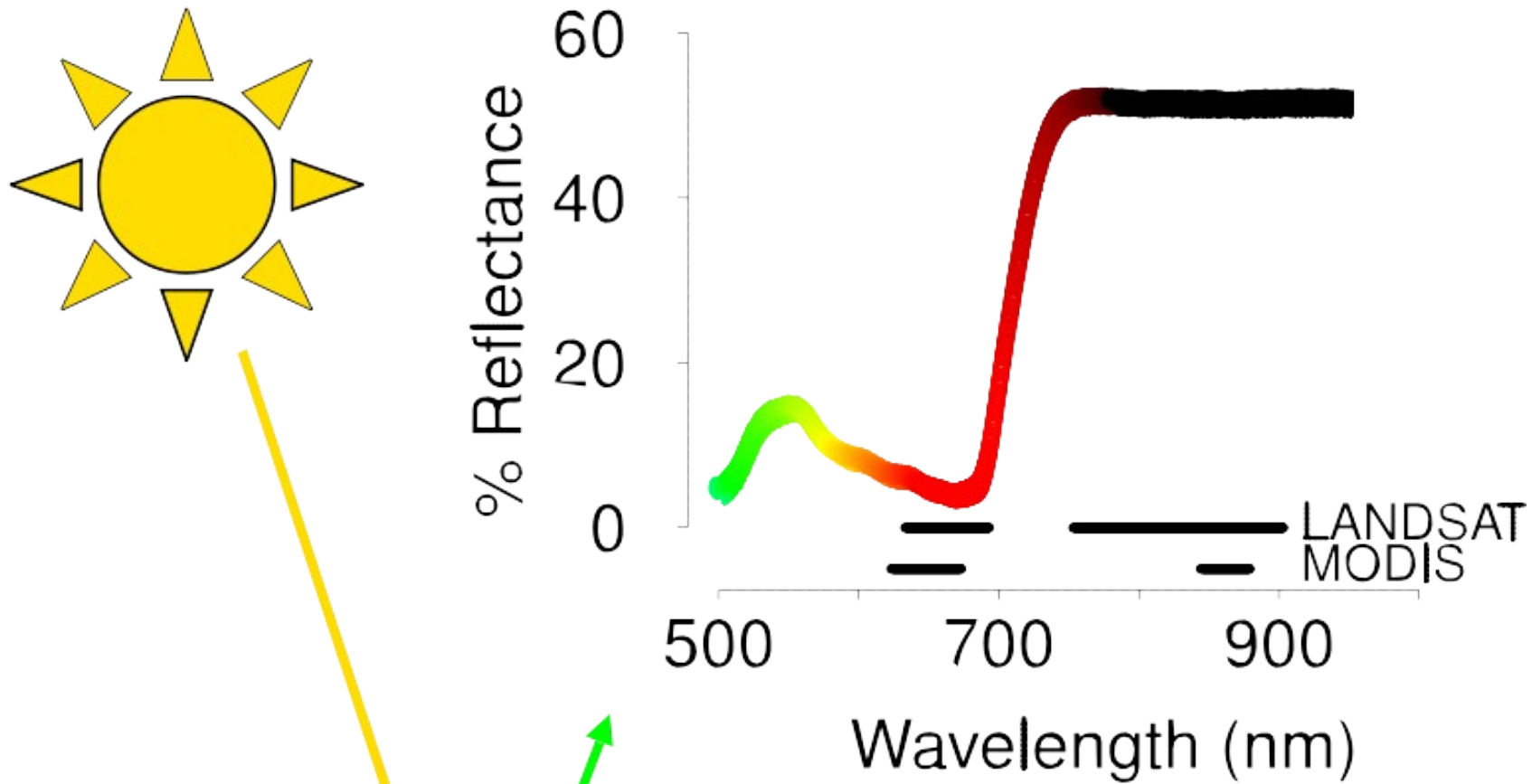
## Vegetation Indices: NDVI



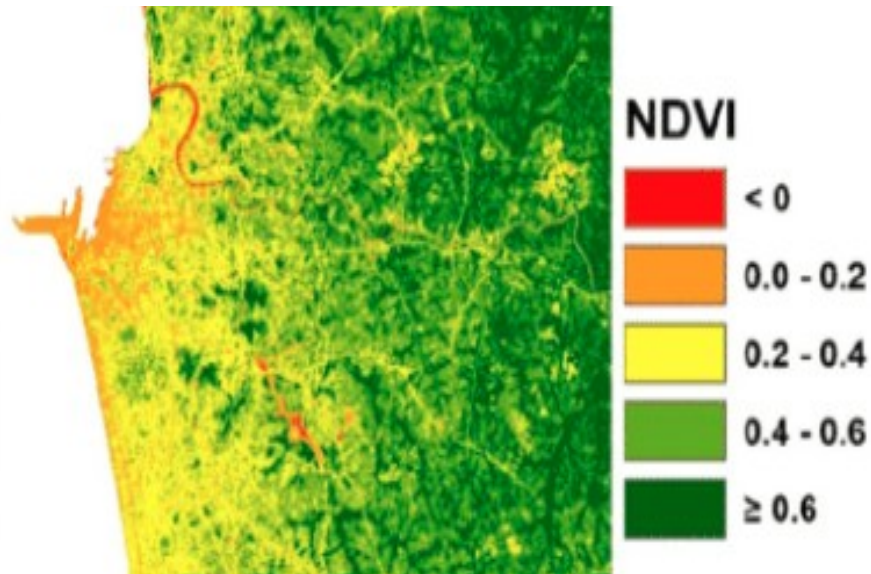
## Vegetation Indices: NDVI



## Vegetation Indices: NDVI



# Spectral Indices with multispectral satellite data



## - Vegetation features

3 layers derived from sentinel.

Normalized Difference Vegetation Index (NDVI)

Normalized Difference Water Index (NDWI)

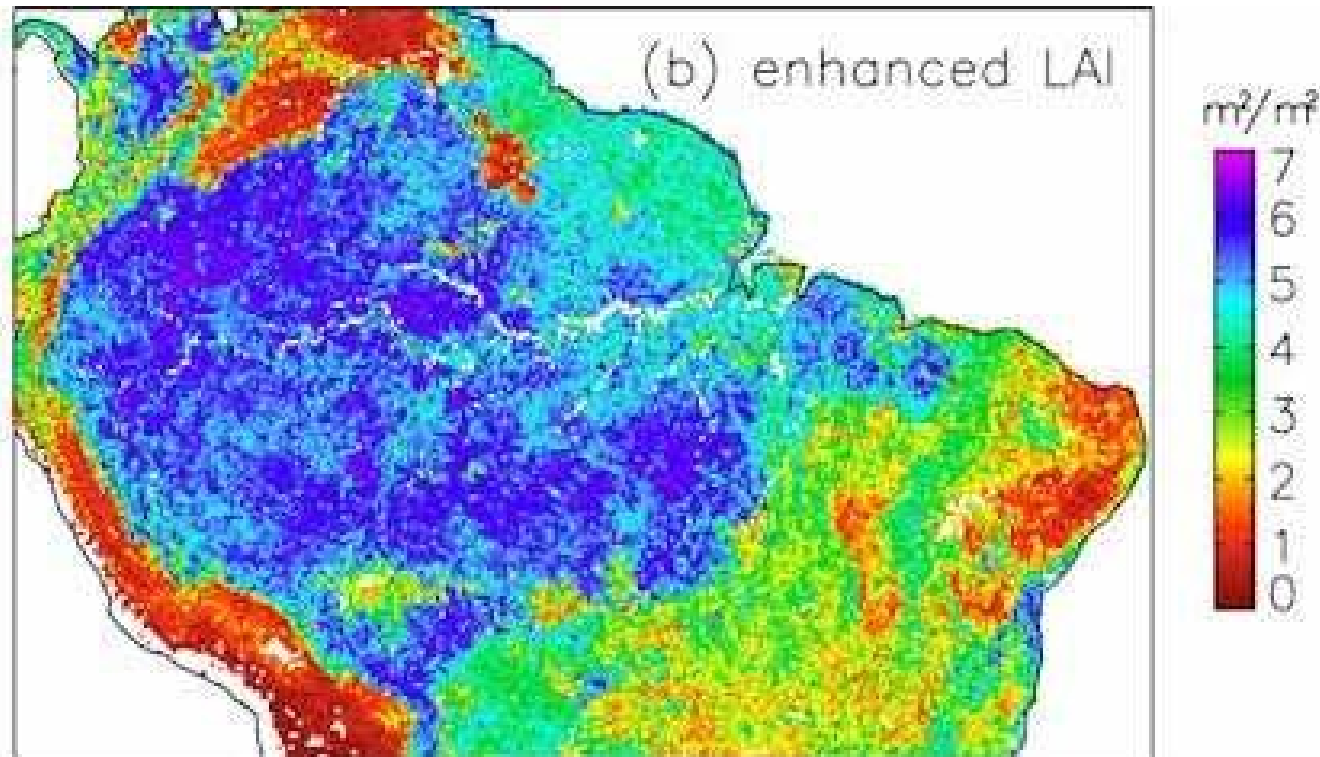
Normalized Difference Turbidity Index (NDTI)

<https://www.geo.university/pages/blog?p=spectral-indices-with-multispectral-satellite-data>



## Derived MODIS Metrics: LAI, fPAR, NPP

- Leaf Area Index ( $m^2$ )<sup>12</sup>: Reflectance + Biome Coefficients
- Net Primary Productivity (NPP)<sup>13</sup>: fPAR + LAI + Biome Parameters + Temperature  
(fPAR = Fraction of Absorbed Photosynthetically Active radiation)



Both LAI and FPAR have been used extensively for calculation of photosynthesis, evaporation and transpiration of water, and Net Primary Productivity (NPP, which estimates how much carbon is taken in by vegetation).

<sup>12</sup> [http://modis.gsfc.nasa.gov/data/dataproduct/dataproducts.php?MOD\\_NUMBER=15](http://modis.gsfc.nasa.gov/data/dataproduct/dataproducts.php?MOD_NUMBER=15)

<sup>13</sup> [http://modis.gsfc.nasa.gov/data/dataproduct/dataproducts.php?MOD\\_NUMBER=17](http://modis.gsfc.nasa.gov/data/dataproduct/dataproducts.php?MOD_NUMBER=17)

## Product



## Epoch

2030	2025	2020
<b>2018</b>	2015	2011
2010	2005	2000
1995	1990	1985
1980	1975	

## Resolution

2m	<b>10m</b>	100m
1km	3 arcsec	
30 arcsec		

**NOTE:** The download server might currently be under maintenance, should you experience issues in downloading a product, please try again later.

Thanks for the patience.

## Sentinel-2 global pixel based image composite from L1C data for the period 2017-2018

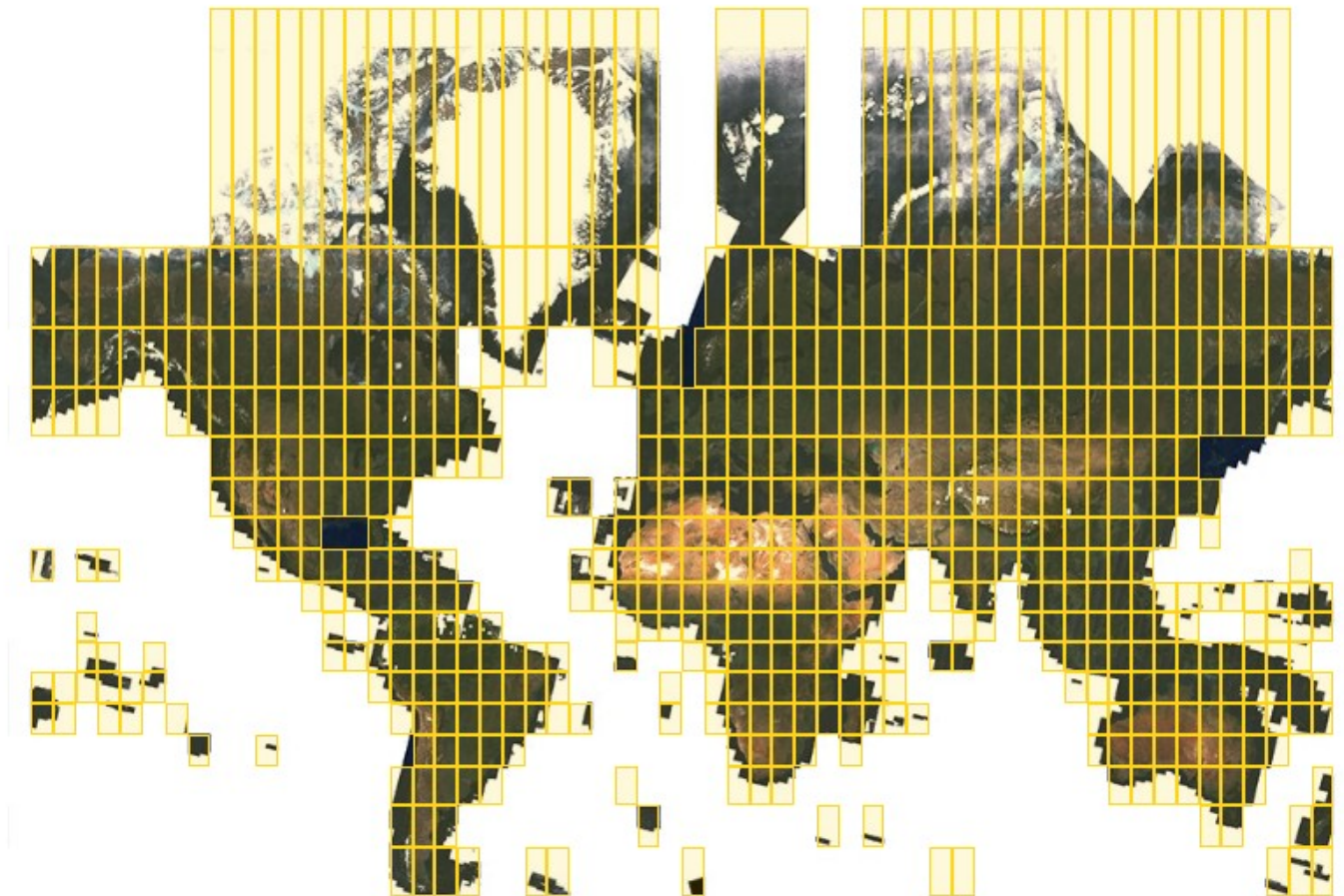
[Read the technical details for this product](#)

### Current selection:

Product: **compositeS2**, epoch: **2018**, resolution: **10m**, coordinate system: **UTM**

*To be noted that some variation might be available only for a certain product (e.g. the 30m resolution is only available for the GHS-BUILT multi-temporal classification)*

**Download by tiles** (click on each box to download a single tile):



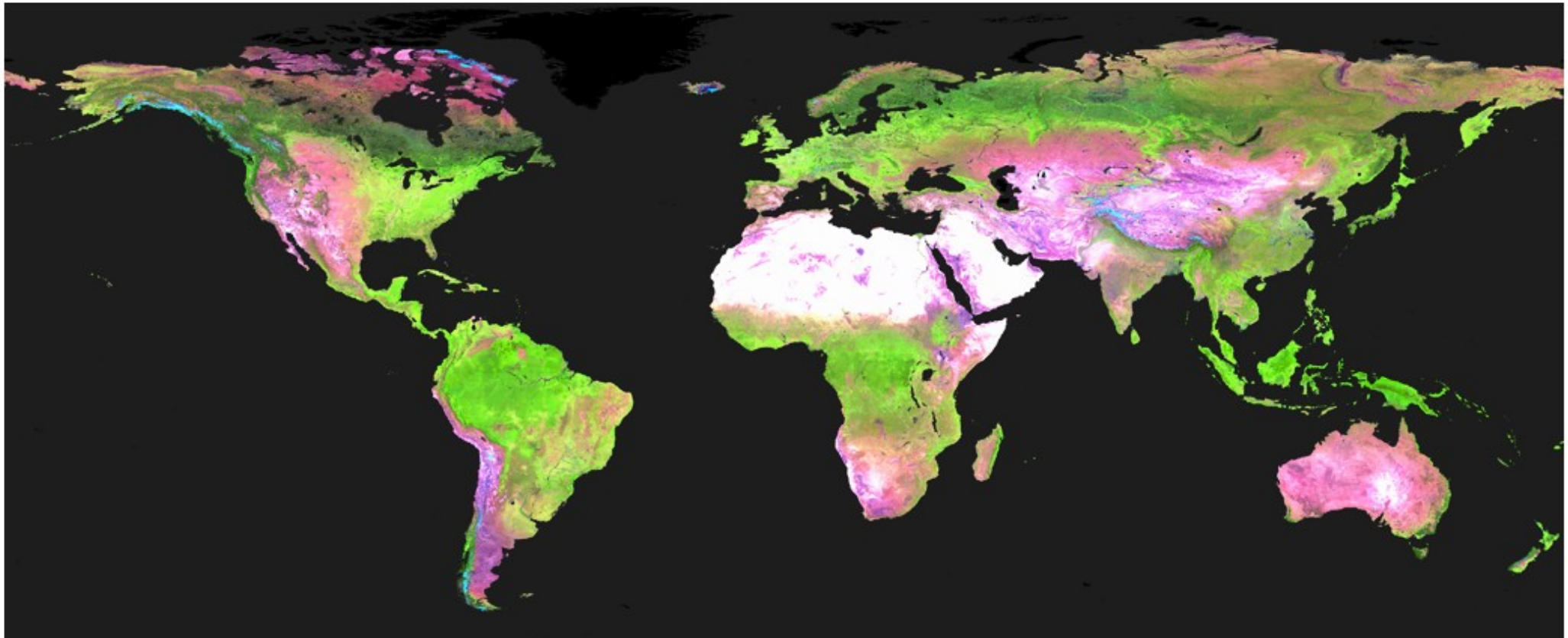
Home

# GLAD Landsat ARD Tools

[Home](#) [Software Download](#) [User Registration](#) [User Manual](#) [License and Disclaimer](#)

## GLAD Landsat ARD Tools V1.1

<https://glad.geog.umd.edu/book/glad-landsat-ard-tools>



Soil



## ISRICWorldSoil/ SoilGrids250m

Global spatial predictions of soil properties and classes at 250 m resolution



7  
Contributors

21  
Issues

101  
Stars

53  
Forks



### - Soil features

16 layers (ph, clay, silt, carbon, etc)  
SoilGrid250m Hengl et al., 2017

zenodo



Upload

Communities

There is a **newer version** of this record available.

February 24, 2021

Dataset

## Global Soil Bioclimatic variables at 30 arc second resolution

Johan van den Hoogen; Jonas Lembrechts; SoilTemp; Ivan Nijs; Jonathan Lenoir

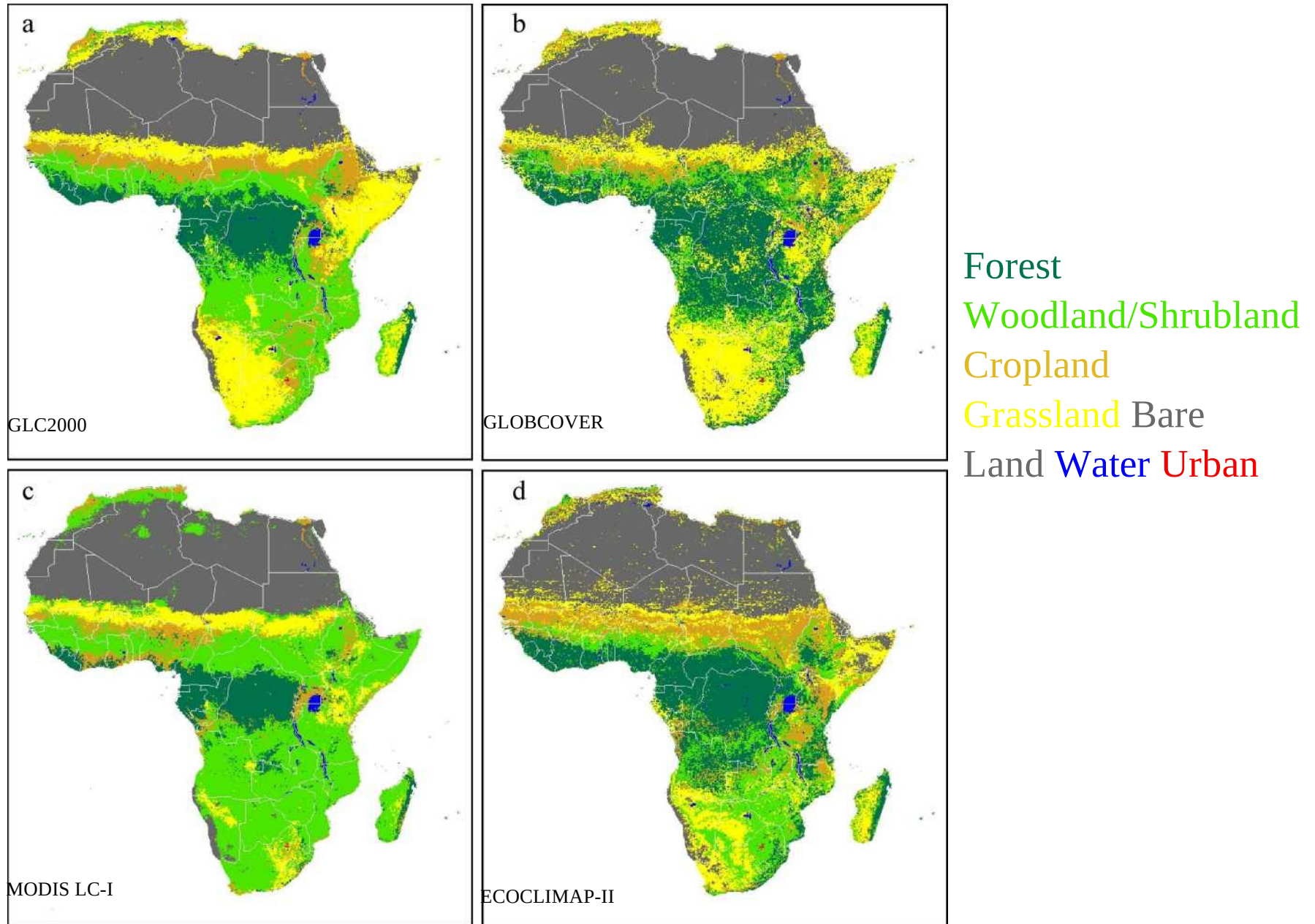
### - Soil climatic features

48 layers (temperature at n depth etc.)  
Jonas J. Lembrechts et al., 2022

# Land Cover

# LULC: Products Matter

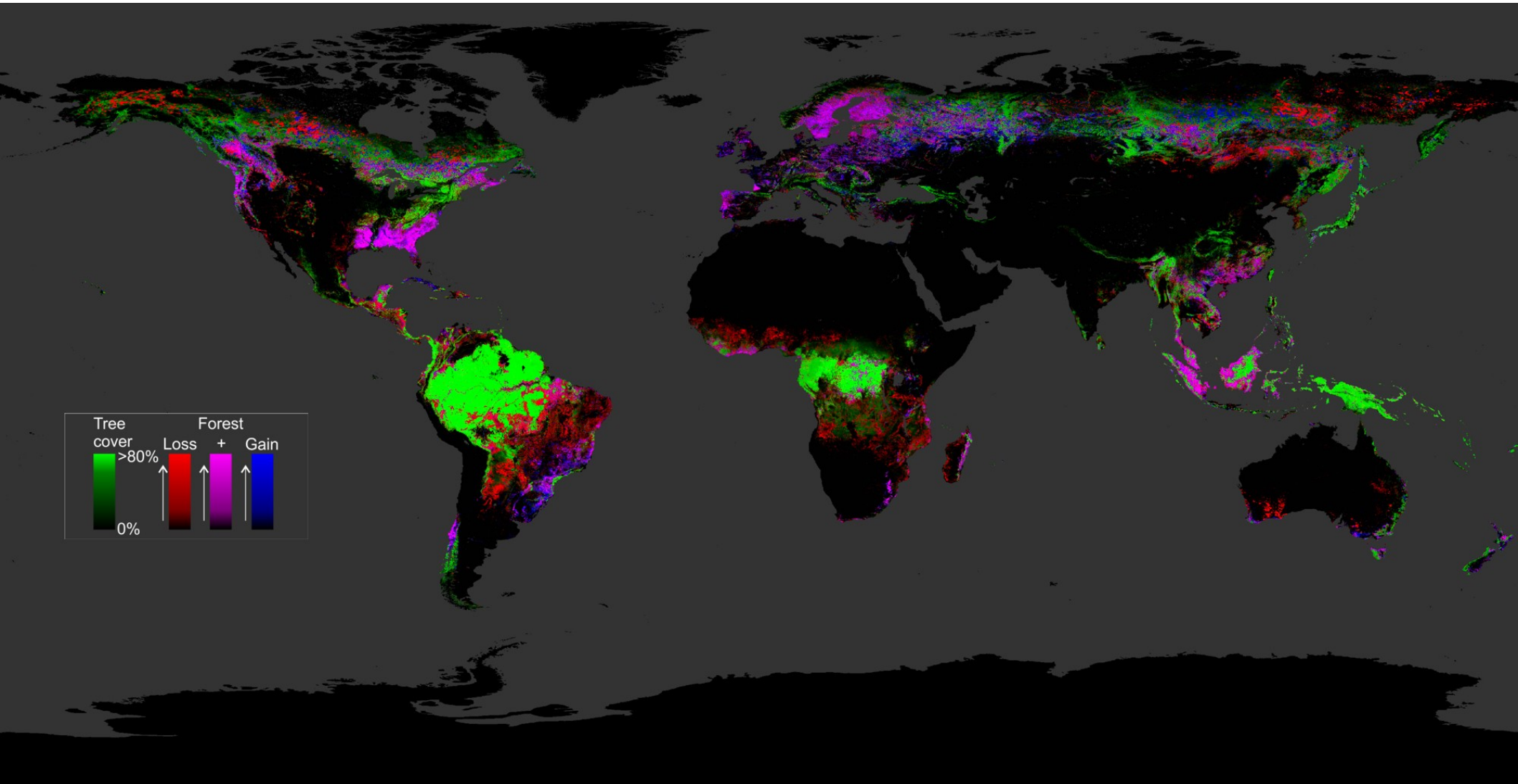
## Comparison of four land cover maps for Africa<sup>15</sup>



<sup>15</sup>Intl J of Appl Earth Observation & Geoinformation (2011) 13(2): 207–219

# Global Forest Cover Change

<https://glad.umd.edu/projects/quantifying-global-forest-cover-change>





# How to search for geographic data

Raw data (satellite images, LiDAR)  
Sensor Products (LandCover, DEM)

NASA Products  
MODIS Products  
LANDSAT Products  
Copernicus Products

<https://datasetsearch.research.google.com/>

# Livestock

<https://data.apps.fao.org/catalog/iso/15f8c56c-5499-45d5-bd89-59ef6c026704>

**Food and Agriculture Organization  
of the United Nations**

ENHANCED BY Google

العربية 中文 English Français Русский Español

## Livestock Systems

[Home](#) [Global distributions](#) [Production systems](#) [Resources](#)



[Buffaloes](#)

[Cattle](#)

[Chickens](#)

[Ducks](#)

[Horses](#)

[Goats](#)

[Pigs](#)

[Sheep](#)

### Cattle



Cattle (*Bos indicus* and *B. taurus*) are the most common and widespread species of large ruminant livestock and are raised primarily to produce milk, meat and hides and to provide draft power. In grass-based systems they play an important role in nutrient recycling and convert human-inedible plant matter into protein. Cattle are raised in diverse production systems ranging from capital-intensive, specialised beef and dairy grass-based and feed-lot systems; through multi-purpose cattle in labour-intensive, mixed crop-livestock systems; to extensive pastoral and agro-pastoral systems.

Number of cattle per square kilometre in 2010



Dataset



Global distribution of cattle in 2010

Related documents

- Global livestock distribution data for cattle, buffaloes, horses, sheep, goats, pigs, chickens and ducks in 2010 (GLW 3)
- Using random forest to improve the downscaling of global livestock census data
- Mapping the global

# Why use Open Source Software?

## Scientific/Technical aspects: data flow

**Codes that are easily published** > no license constraints

**Complex work-flows** > integrate different data analysis methods

