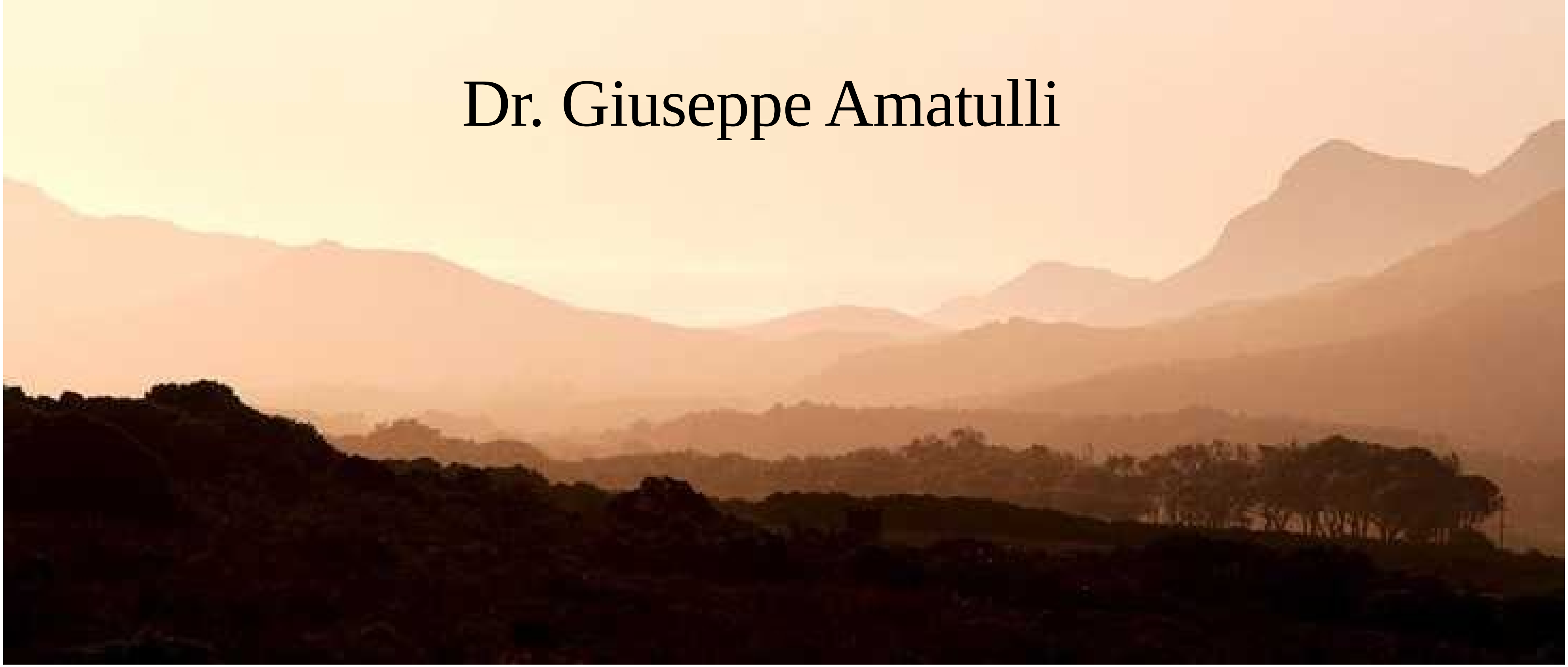
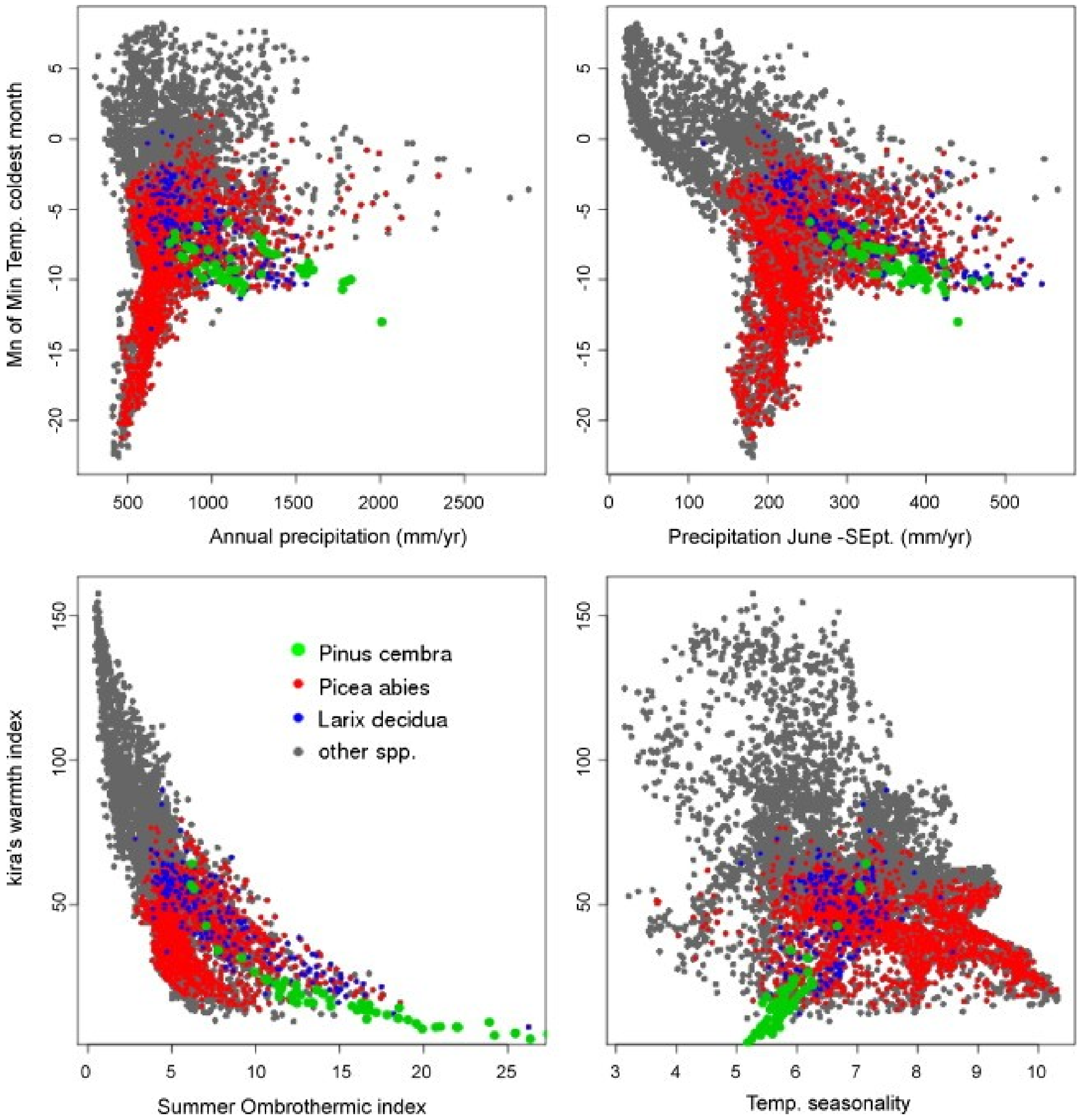
GIS and RS for Biodiversity
Biodiversity $\sim f$ (environment)

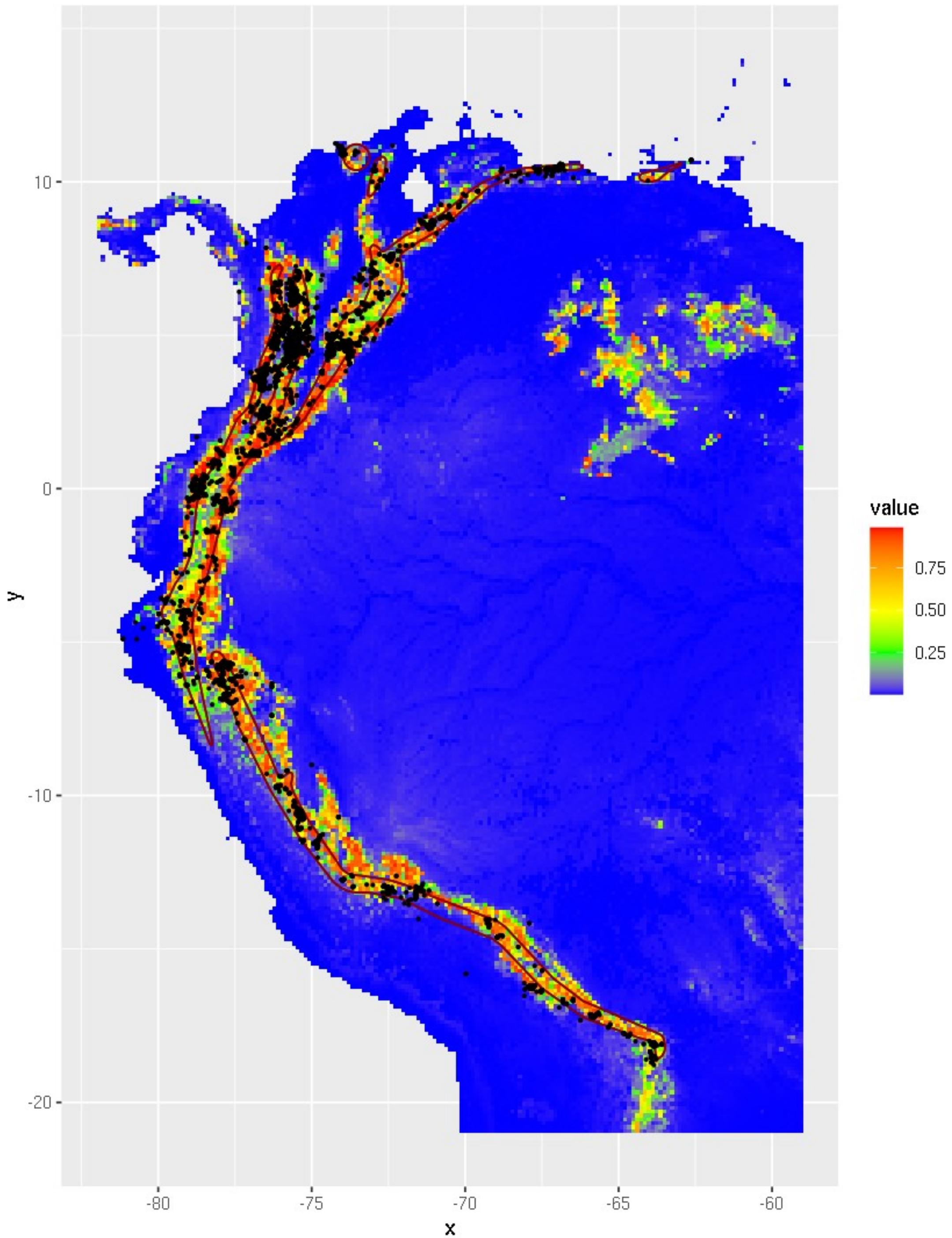


Dr. Giuseppe Amatulli

Biodiversity ~ *f* (environment)



Biodiversity ~ f (environment)



Objectives

Biodiversity $\sim f$(**environment**)

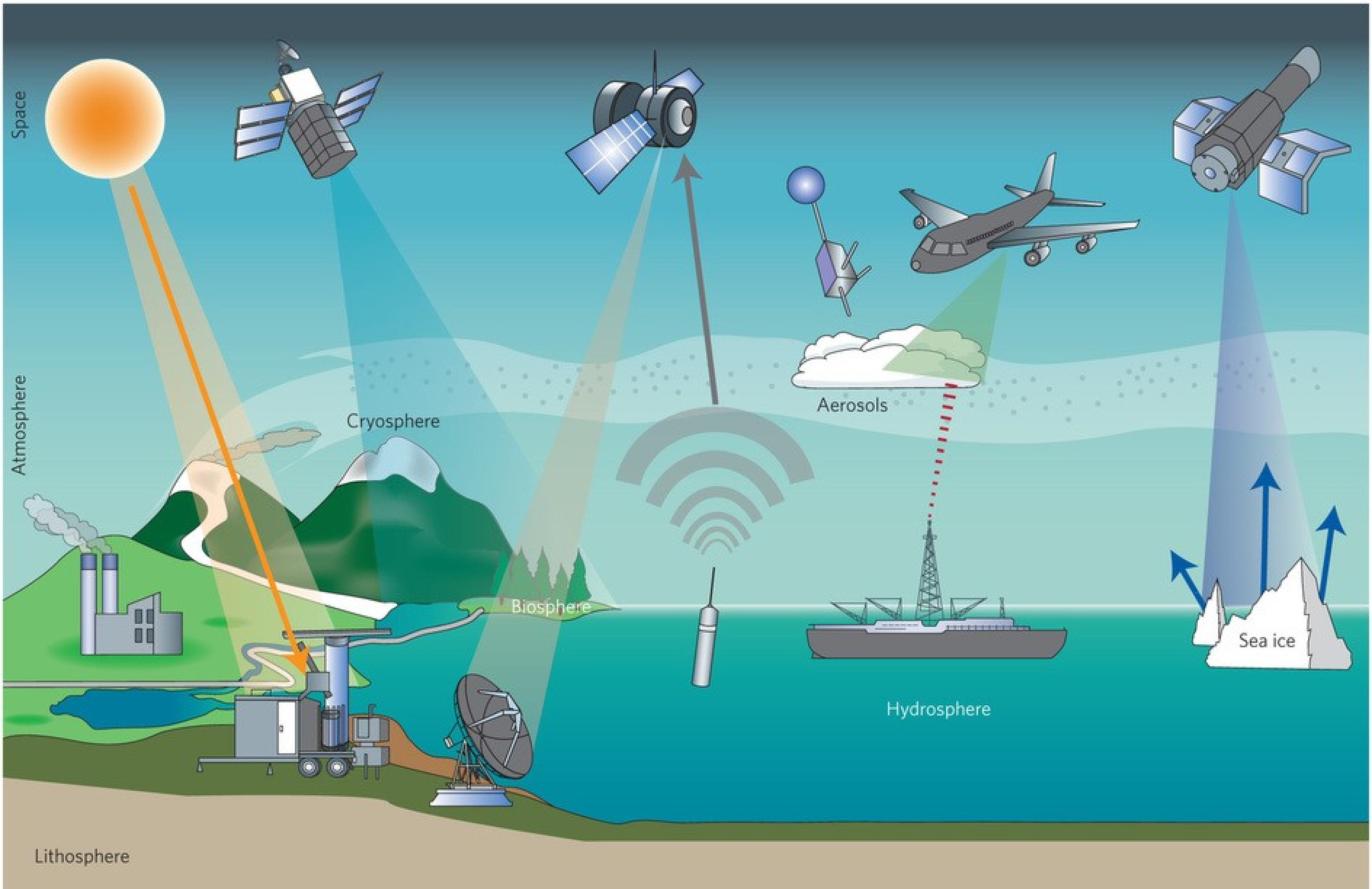
A whirlwind tour of environmental data:

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

Key take-home messages:

1. Data deluge → incredible opportunities
2. Data complexity → biogeographers must be vigilant

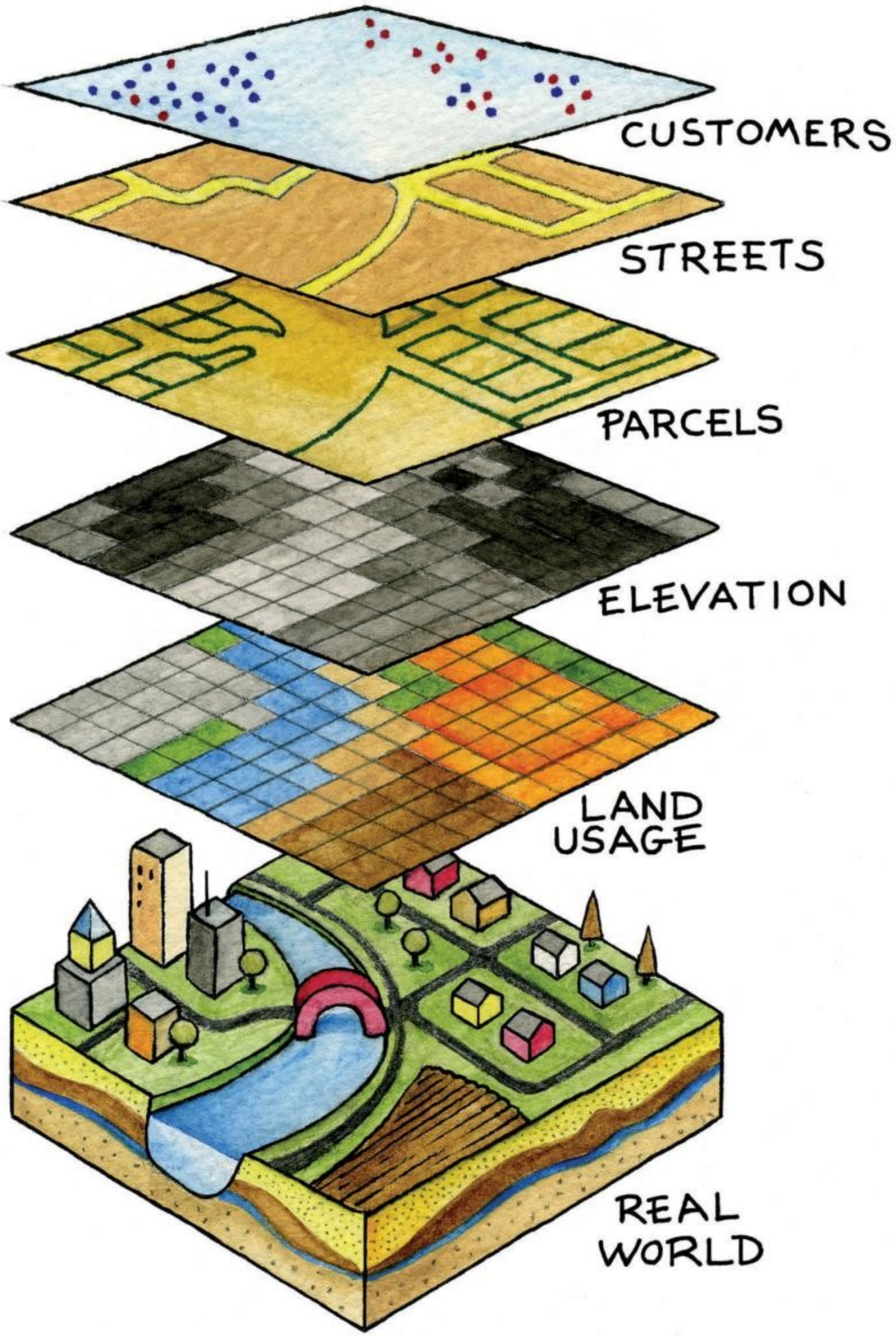
Remote sensing



Geographic
Information System

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

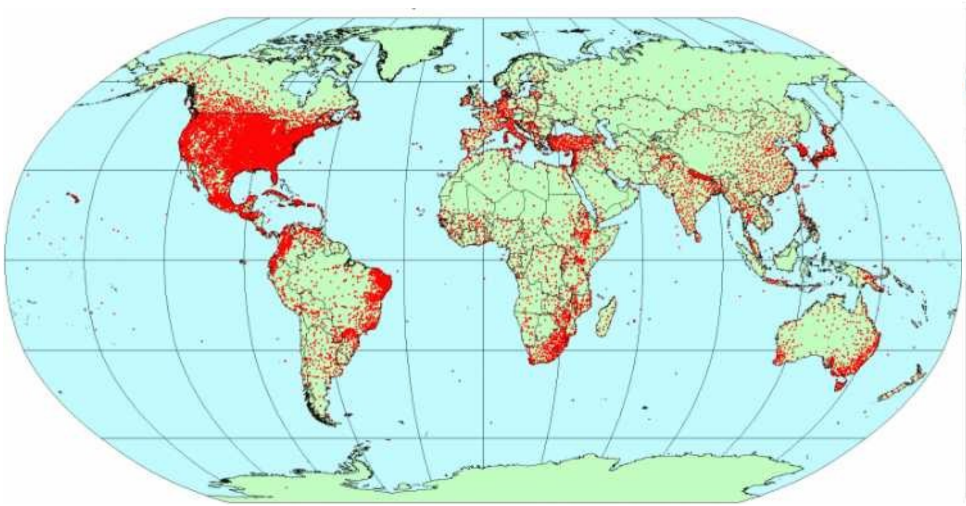
Modeling

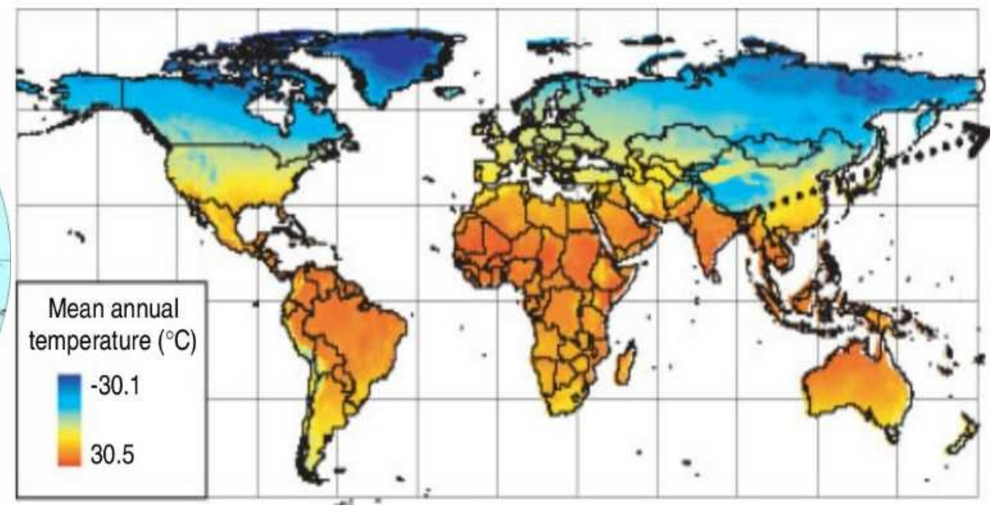


Climate

WorldClim https://worldclim.org
Chelsa https://chelsa-climate.org

Station Locations → Continuous Grid





- Global ≈1km 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/

MERIT DEM

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER

10.1002/2017GL072874

A high-accuracy map of global terrain elevations

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

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

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

MERIT Hydro

AGU100 ADVANCING EARTH AND SPACE SCIENCE

Water Resources Research

RESEARCH ARTICLE

10.1029/2019WR024873

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

Dai Yamazaki[1,2], Daiki Ikeshima[2], Jeison Sosa[3], Paul D. Bates[3], George H. Allen[4], and Tamlin M. Pavelsky[5]

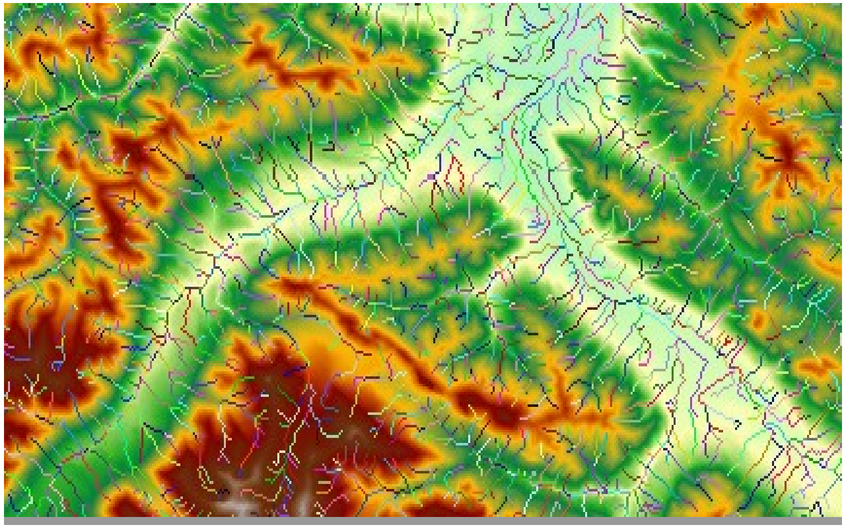
[1]Institute of Industrial Science, The University of Tokyo, Tokyo, Japan, [2]Department of Civil and Environmental Engineering, Tokyo Institute of Technology, Tokyo, Japan, [3]School of Geographical Sciences, University of Bristol, Bristol, UK, [4]Department of Geography, Texas A&M University, College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

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

- 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



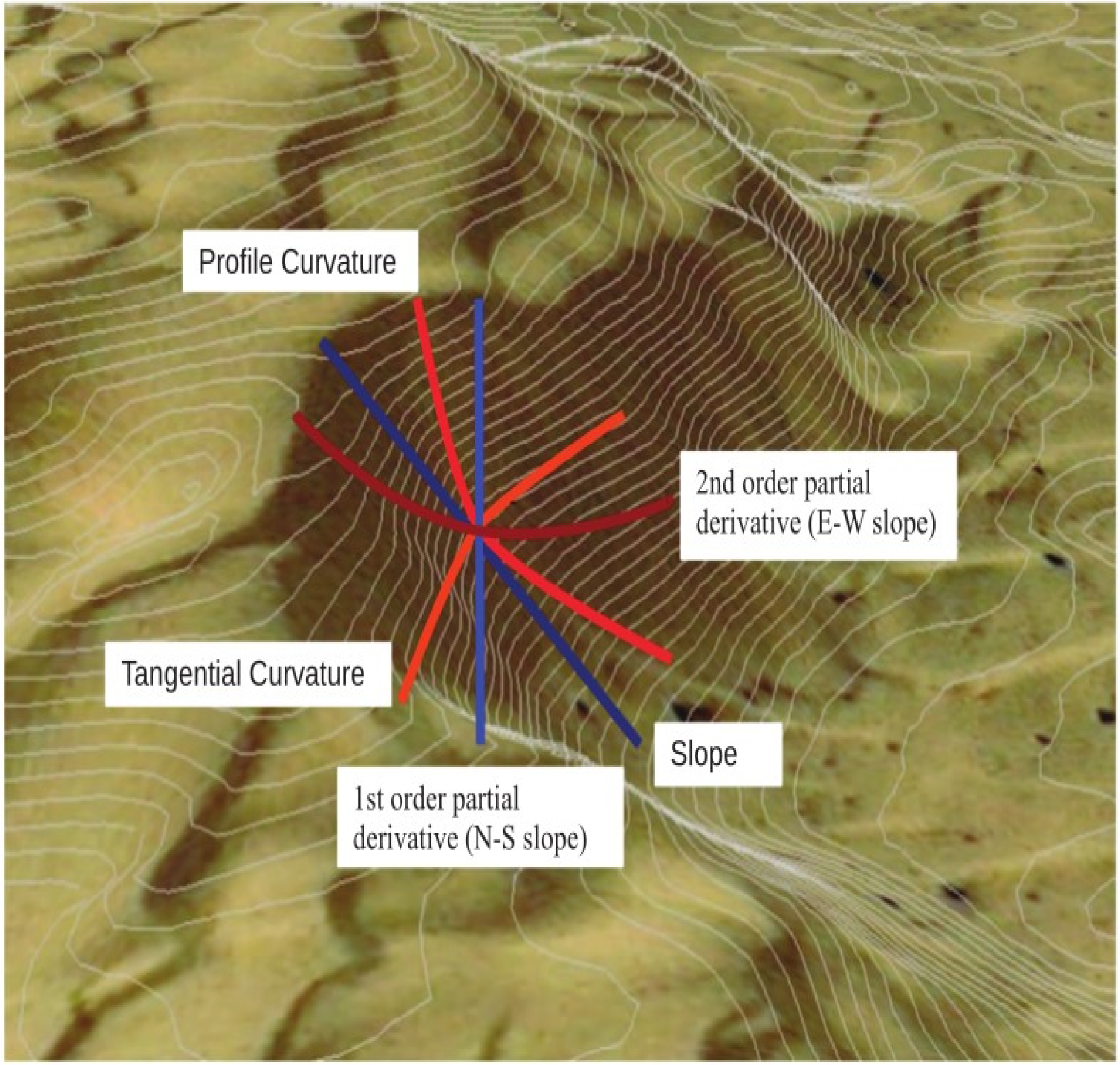
- Hydrographic features
  19 layers (streams slope/distance/length, outlet distance, etc.)
  Hydrography90m: Amatulli et al., 2022

Topography complexity
(geomorphometry/geomorphology analysis)





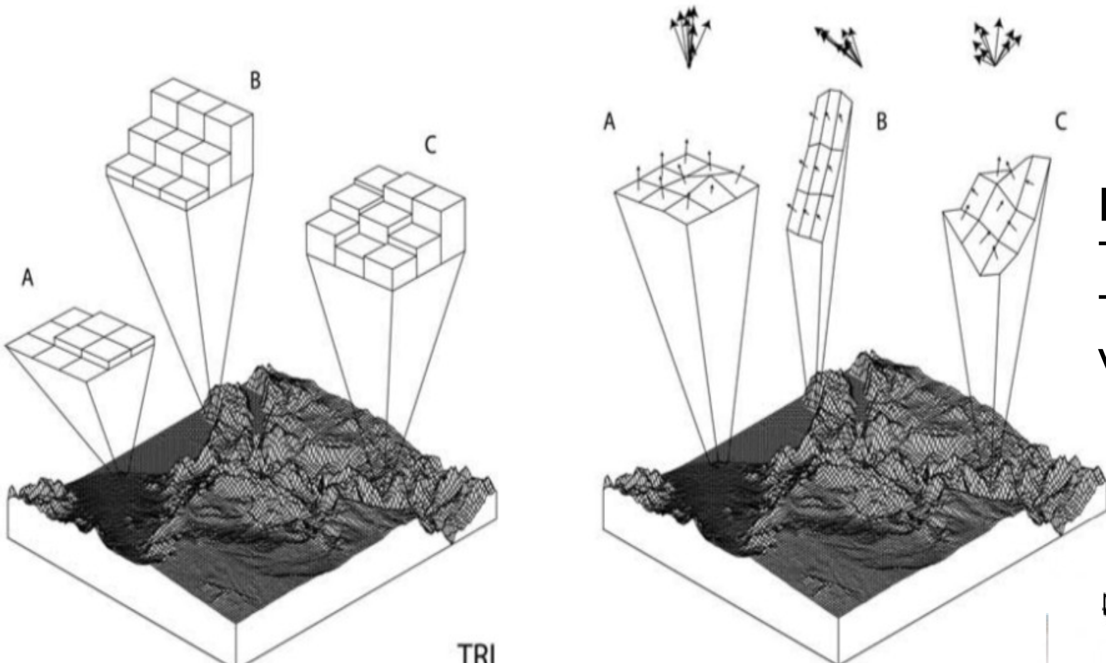

Topographic variation underpins a myriad of patterns and processes in hydrology, climatology, geography and ecology, and is key to understanding the variation of life on the planet (Amatulli et al. 2018).



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)



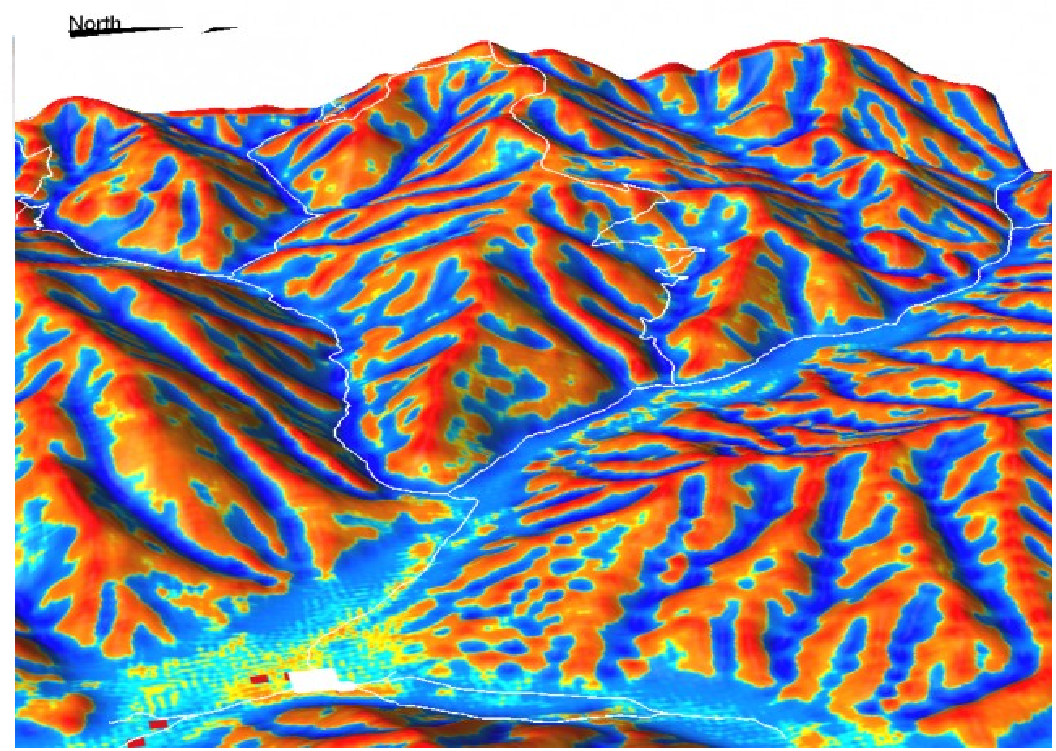
Sappington et al. (2007)

Roughness indices

Roughness - Median / SD
Topographic Position Index - Median / SD
Terrain Ruggedness Index - Median / SD
Vector Ruggedness Measure - Median / SD

Curvature

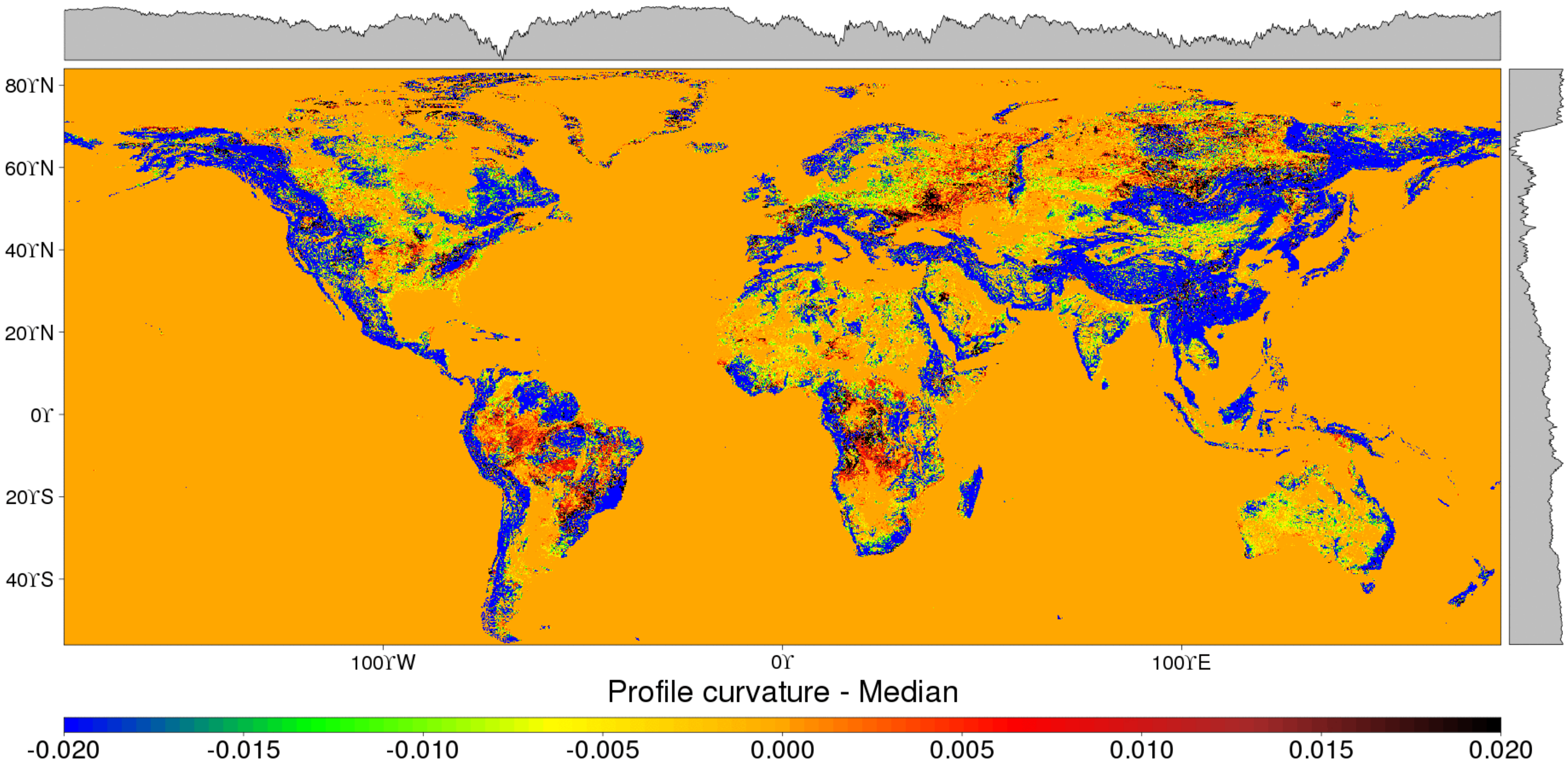
Profile curvature - Median / SD
Tangential curvature - Median / SD



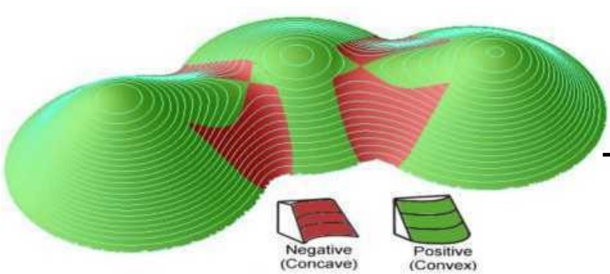
Topography complexity layers

(surface roughness and geo-morphology analysis)

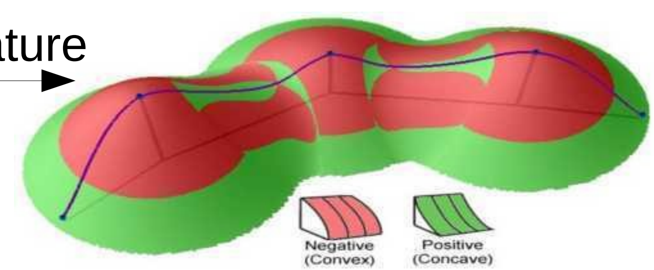
Curvature



Profile curvature



Tangential curvature



Hydrography90m

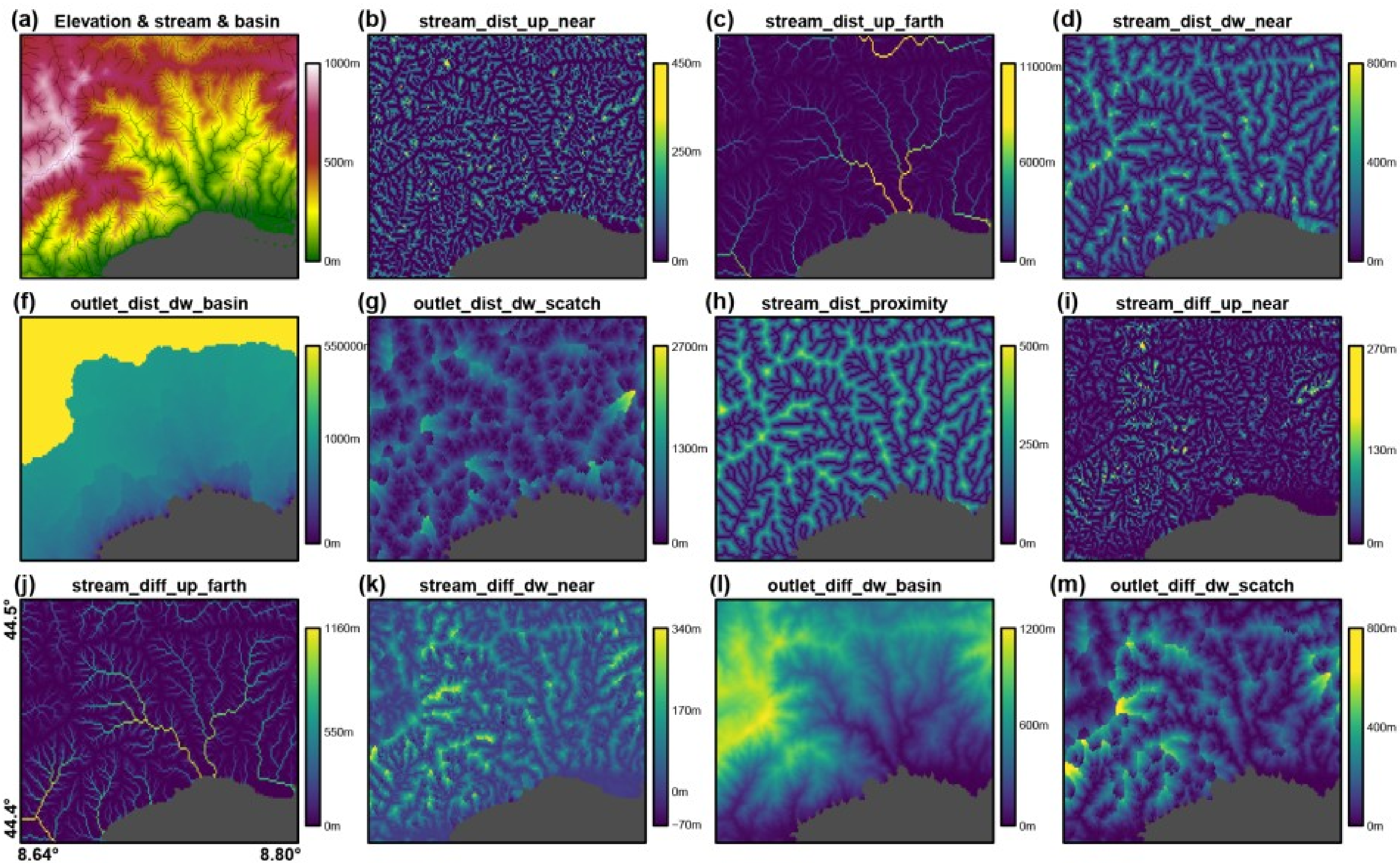
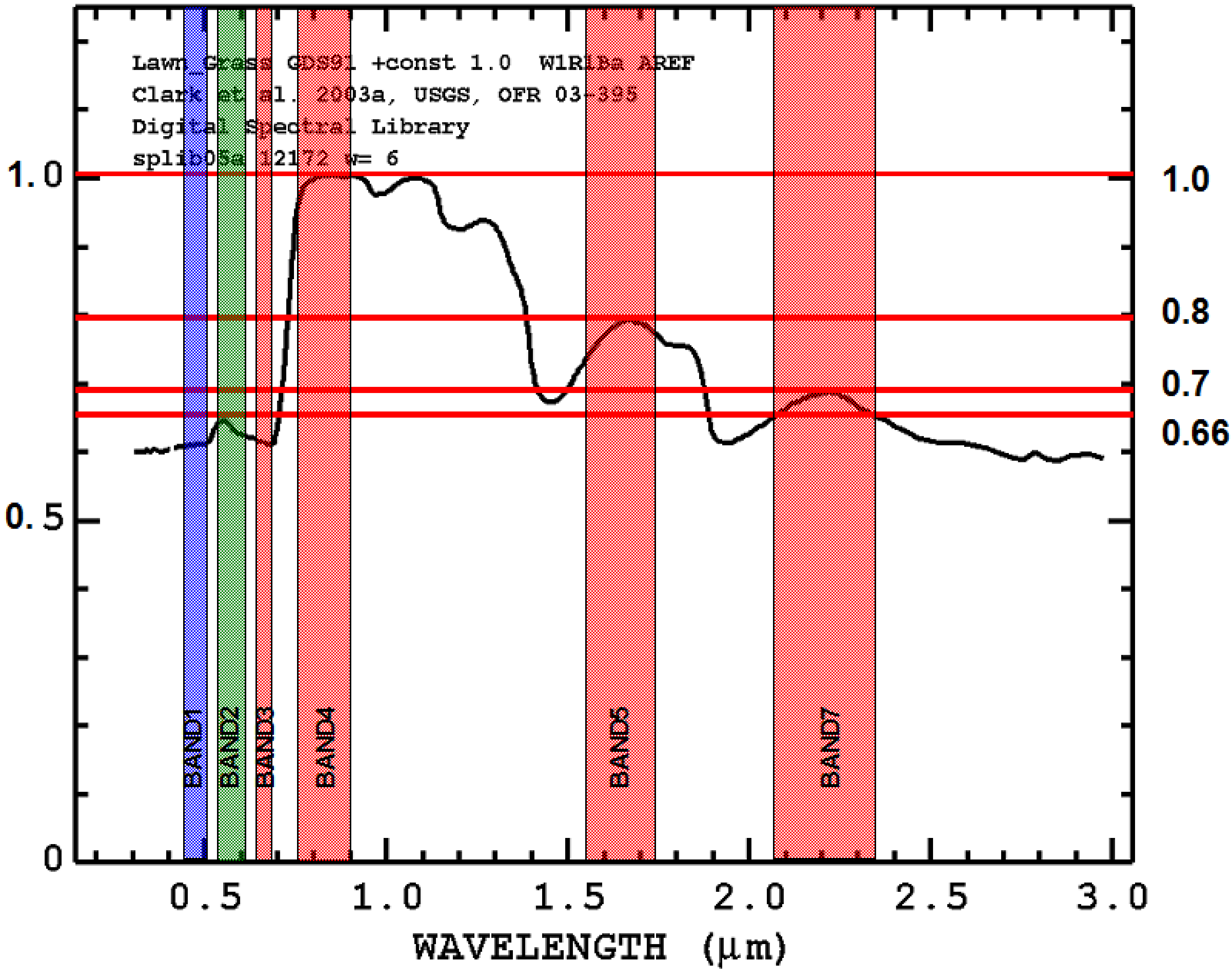


Figure 12. Map **(a)** shows the stream channels and drainage basins derived from the elevation layer. Maps **(b)**–**(m)** show, for the same area, the distance and elevation difference attributes of each land grid cell to the stream channels, outlets, or stream nodes using the *r.stream.distance* GRASS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

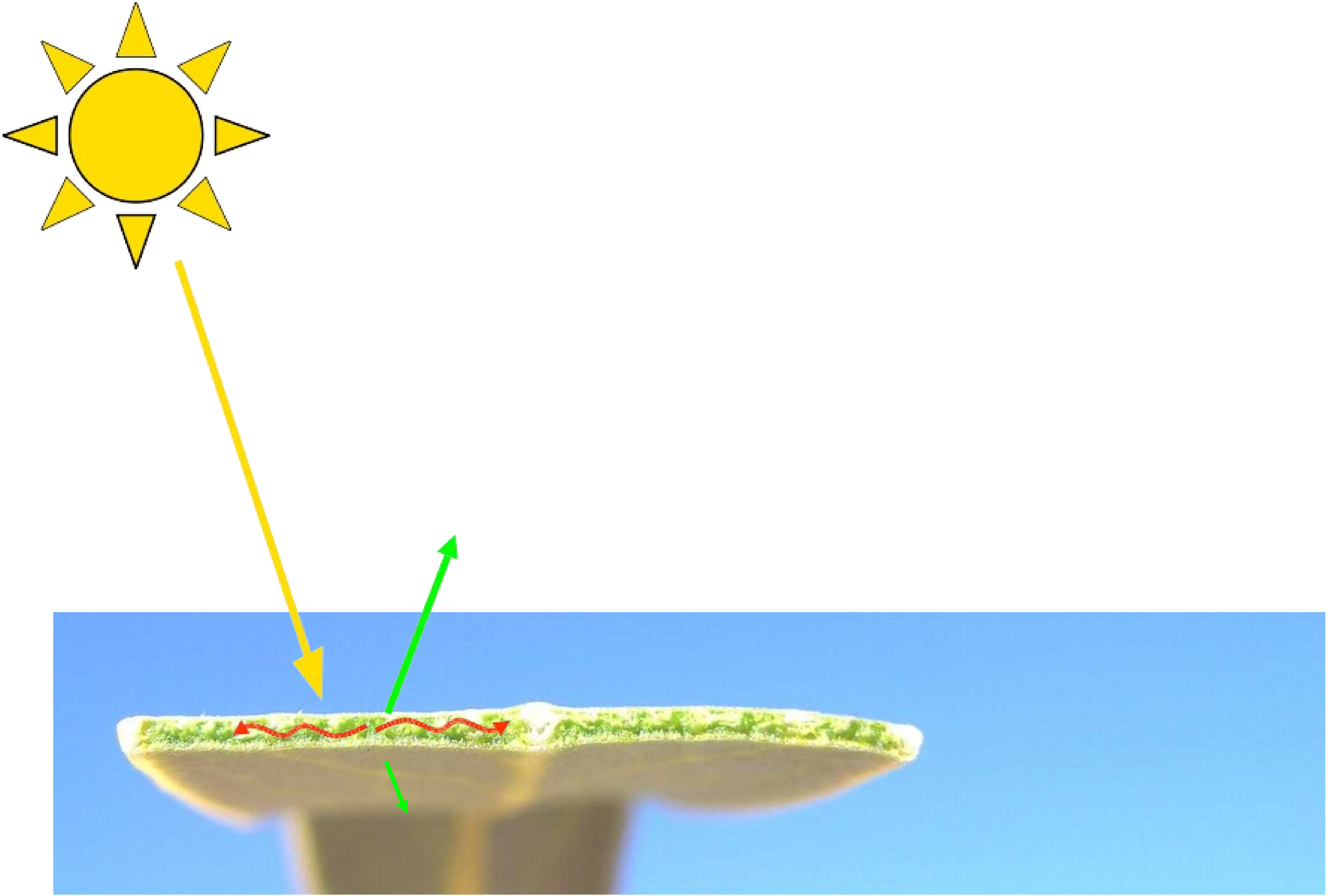
Satellite spectral images

Landsat Multispectral Satellite Image

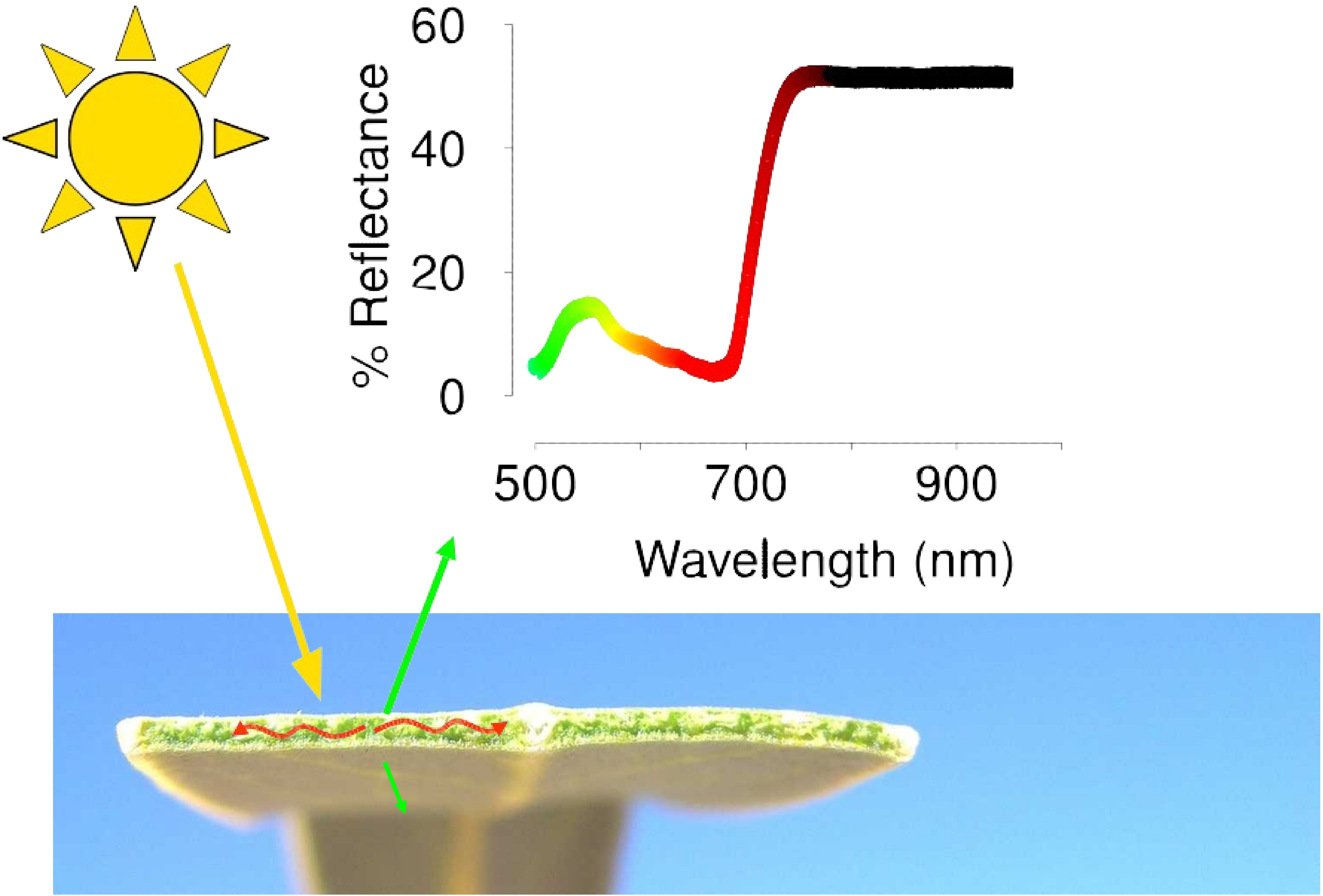


https://glad.geog.umd.edu/book/glad-landsat-ard-tools

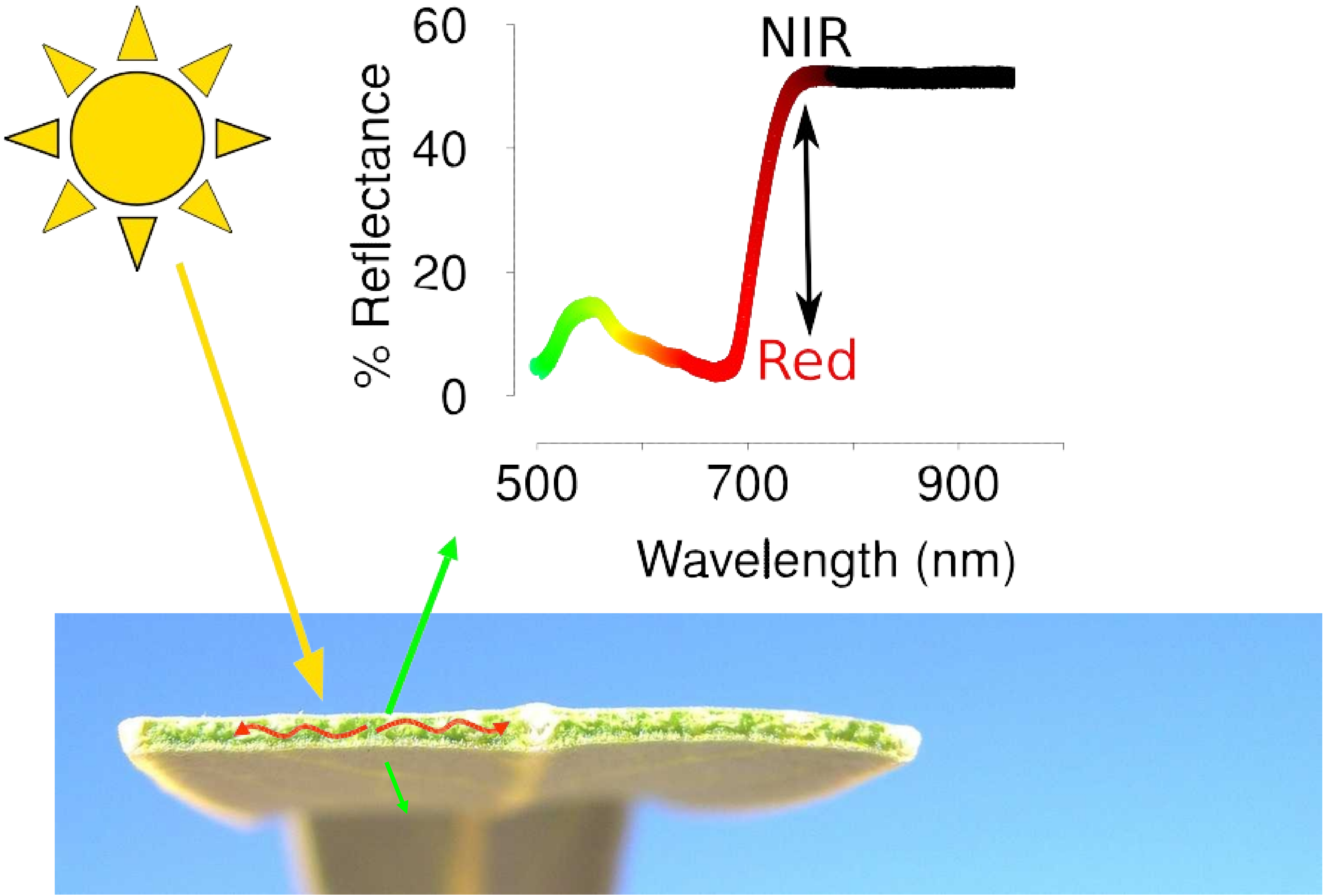
Vegetation Indices: NDVI



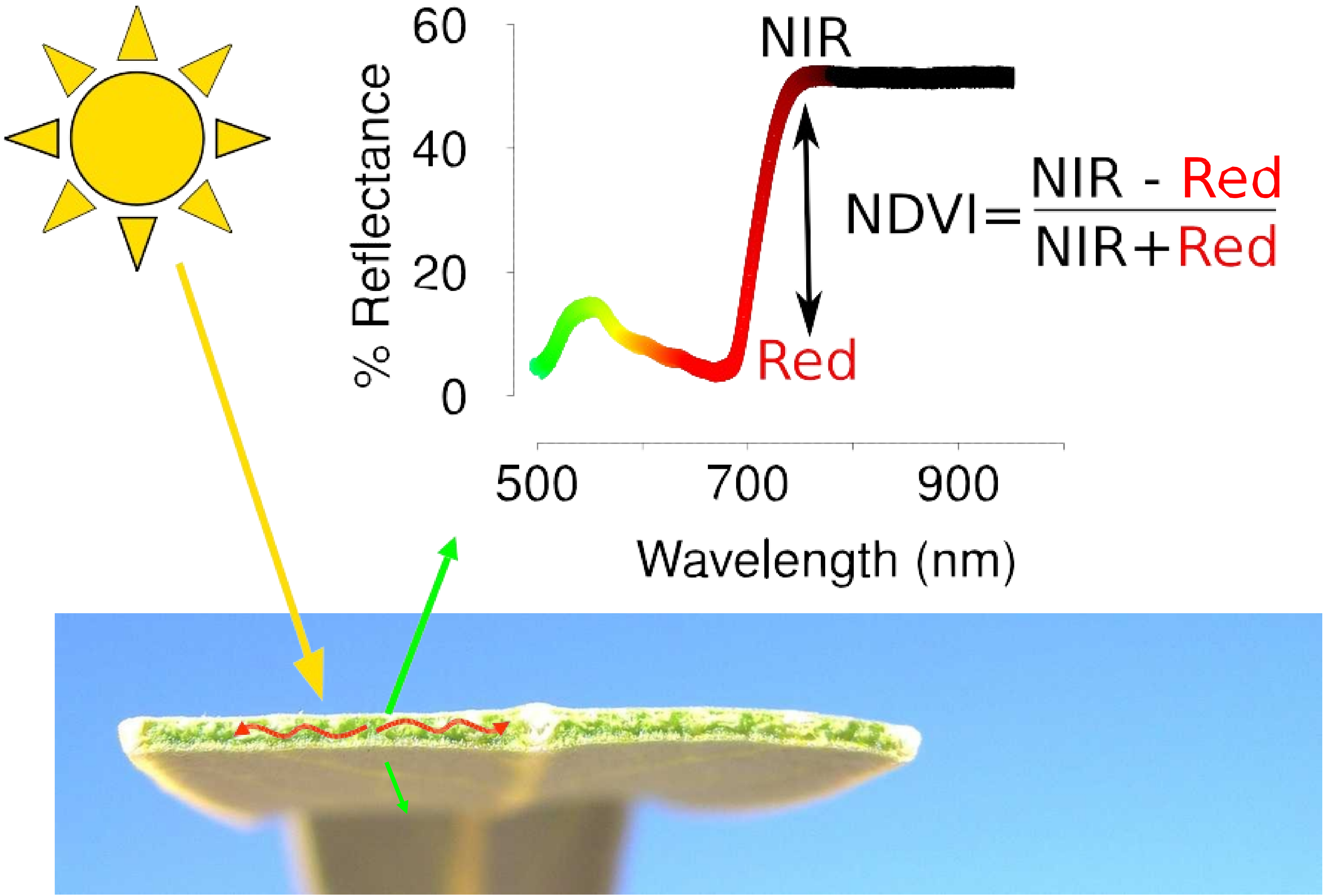
Vegetation Indices: NDVI



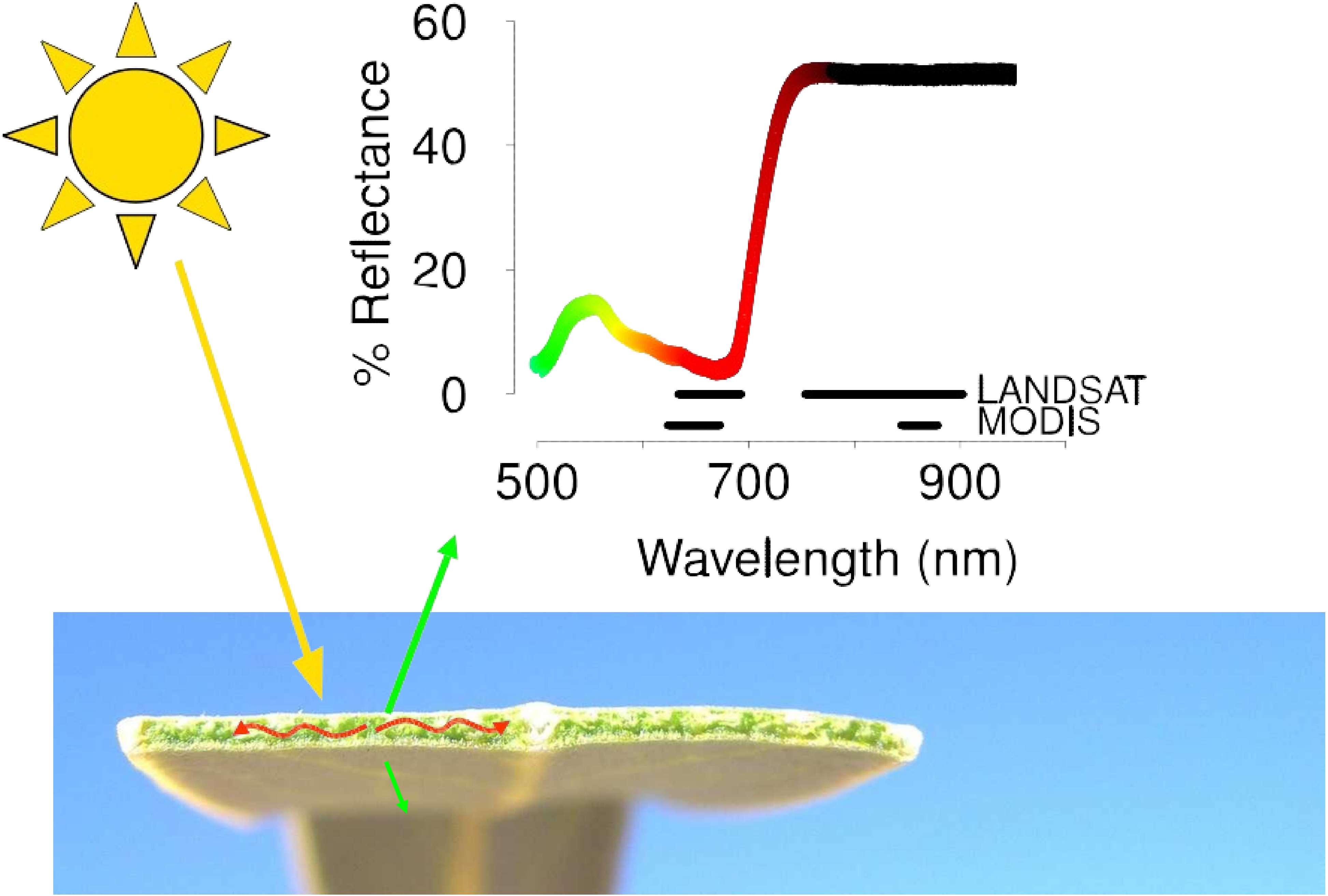
Vegetation Indices: NDVI



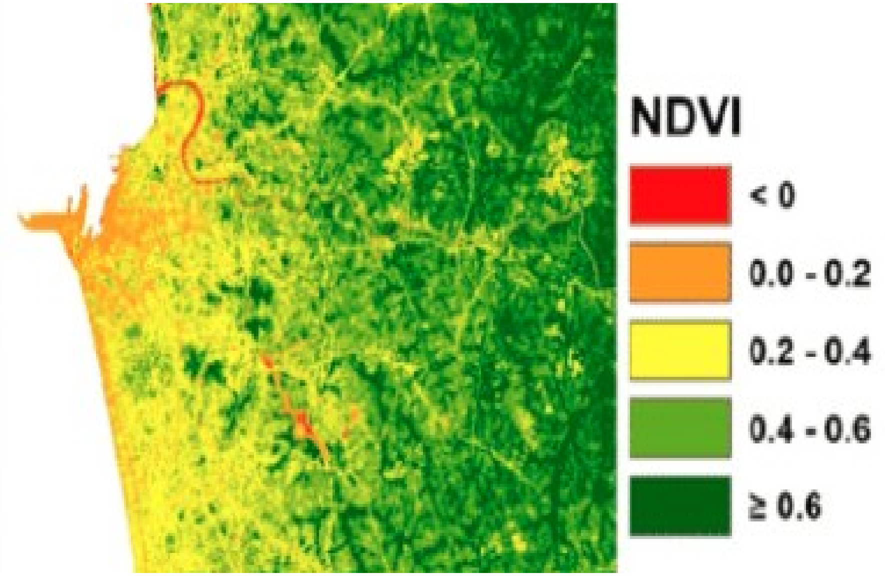
Vegetation Indices: NDVI



Vegetation Indices: NDVI



Spectral Indices with multispectral satellite data



- Vegetation features

3 layers derived from sentinel.

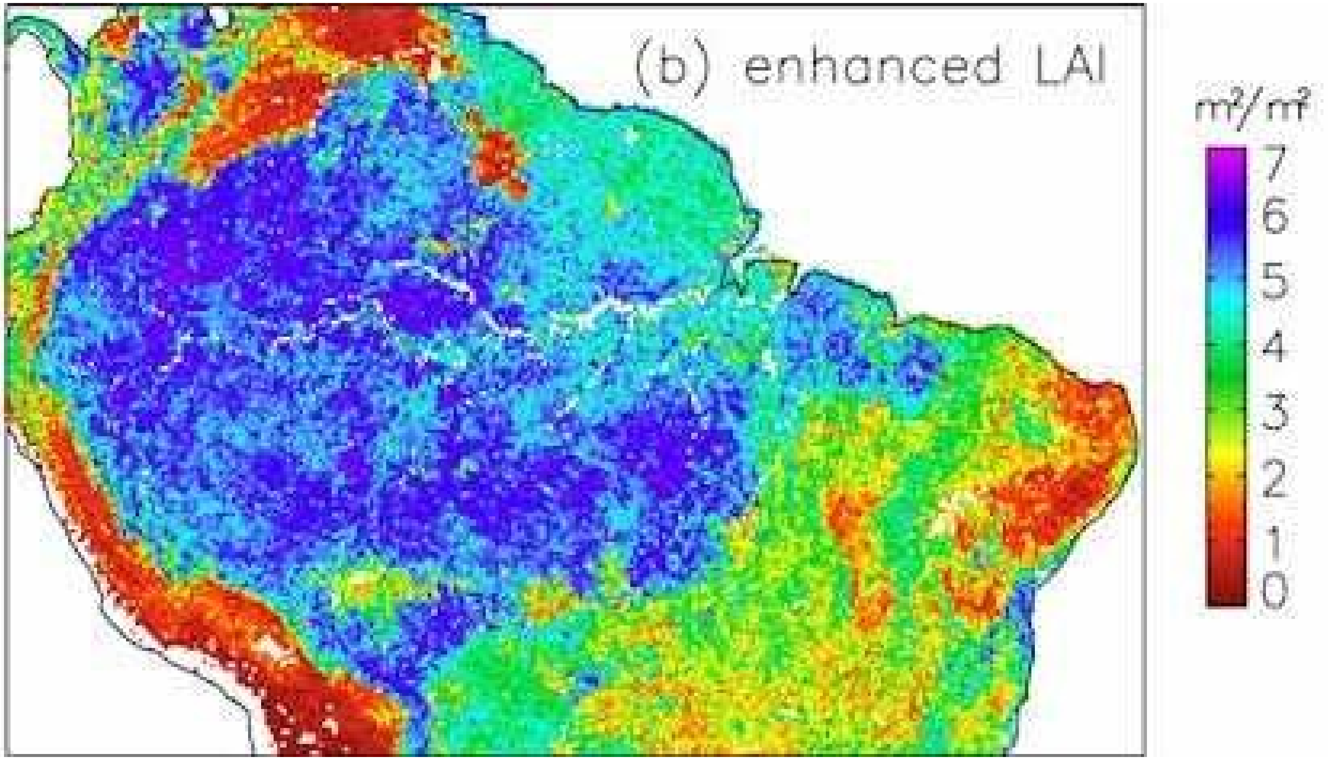
Normalized Difference Vegetation Index(NDVI)
Normalized Difference Water Index (NDWI)
Normalized Difference Turbidity Index (NDTI)

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

Derived MODIS Metrics: LAI, fPAR, NPP

- Leaf Area Index ($\frac{m}{m^2}$)[12]: Reflectance + Biome Coefficients
- Net Primary Productivity (NPP)[13]: 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).

[12] http://modis.gsfc.nasa.gov/data/dataprod/dataproducts.php?MOD_NUMBER=15

[13] http://modis.gsfc.nasa.gov/data/dataprod/dataproducts.php?MOD_NUMBER=17

https://ghsl.jrc.ec.europa.eu/download.php?ds=compositeS2

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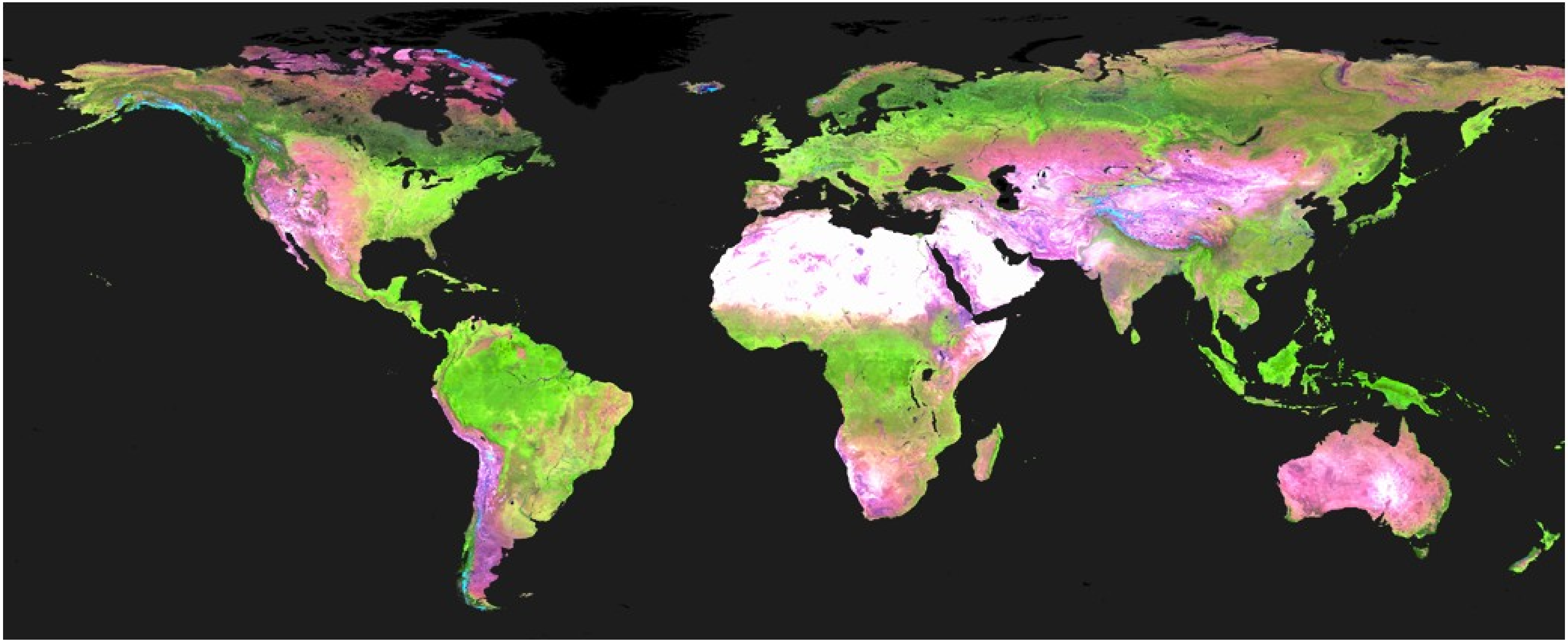
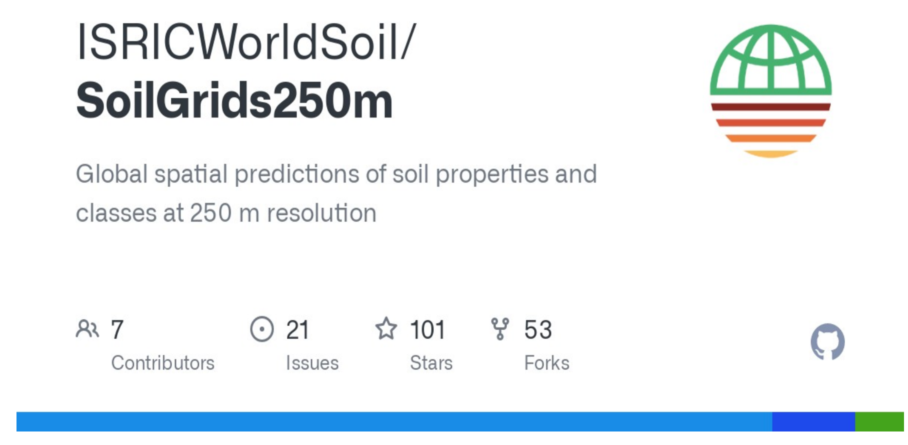
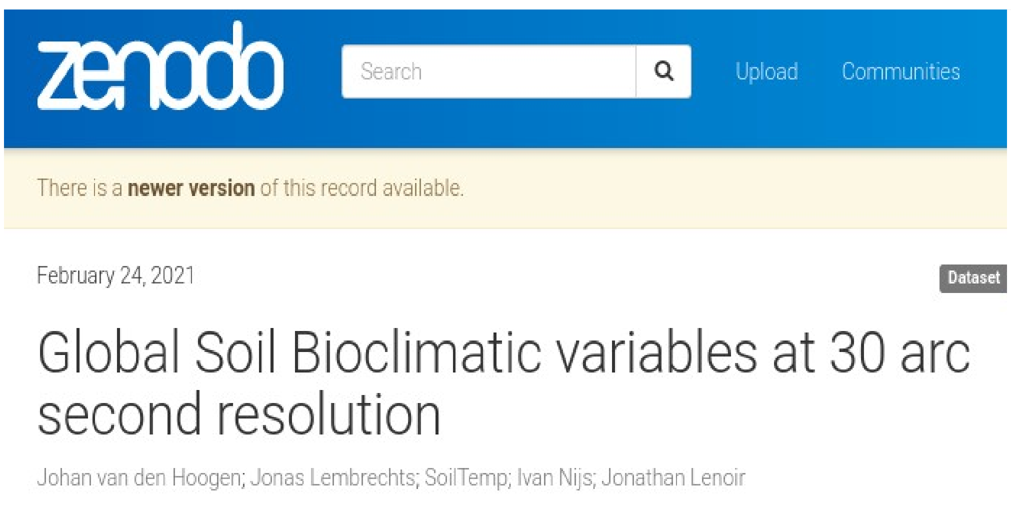
https://glad.geog.umd.edu/book/glad-landsat-ard-tools



Soil



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

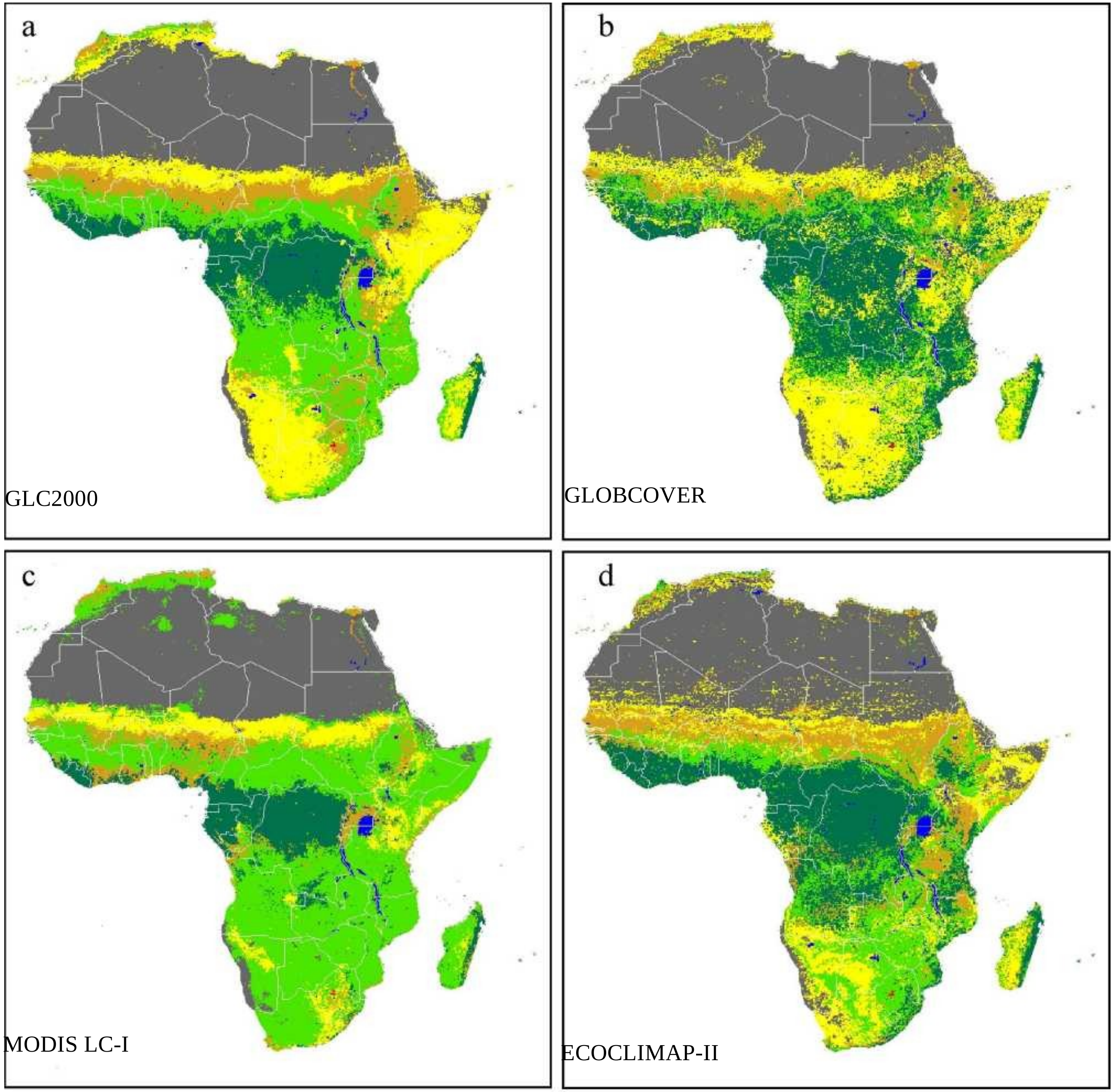


- Soil climatic features
  48 layers (temperature at n depth etc.)
  Jonas J. Lembrechts et al., 2022

Land Cover

LULC: Products Matter

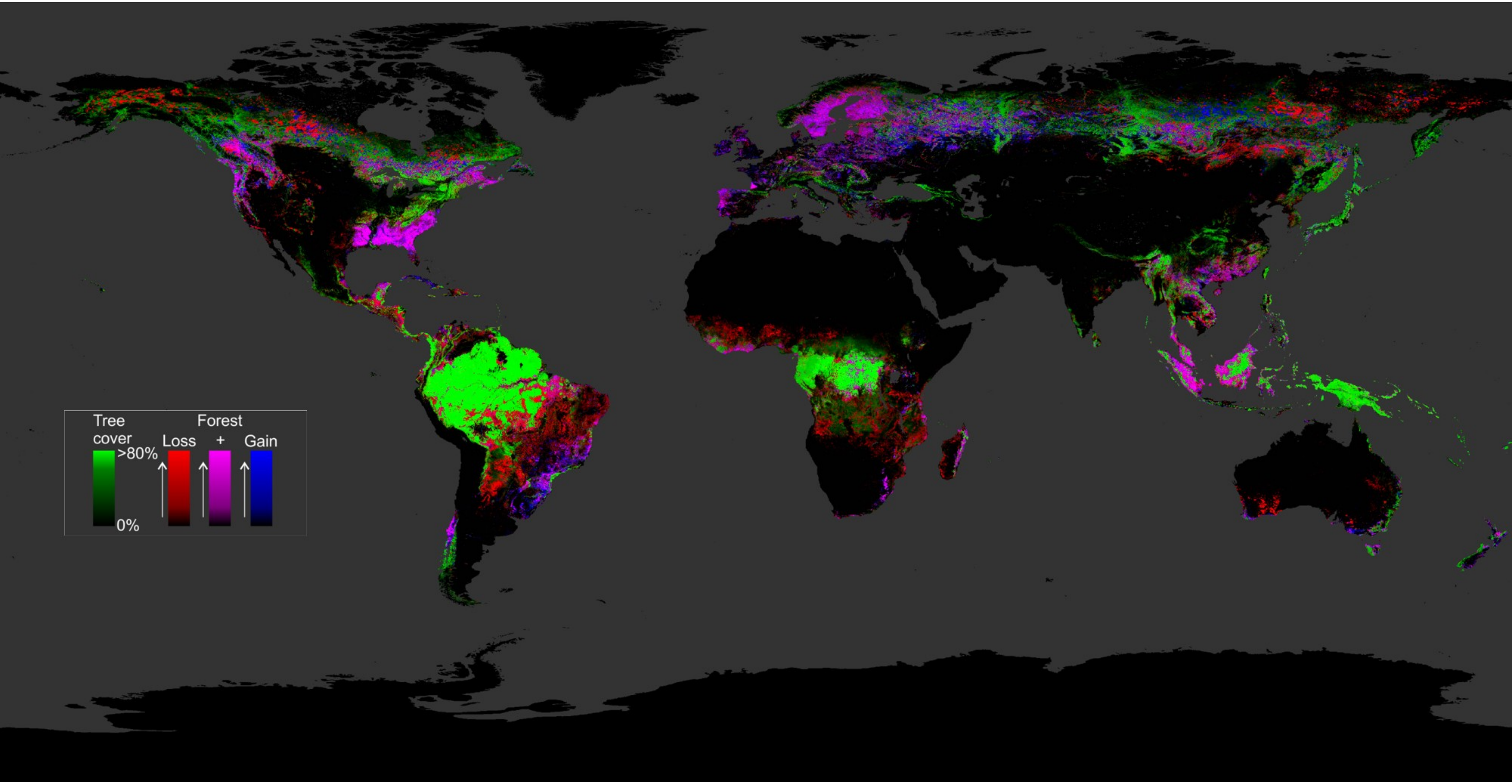
Comparison of four land cover maps for Africa[15]



Forest
Woodland/Shrubland
Cropland
Grassland Bare
Land Water Urban

[15] *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/

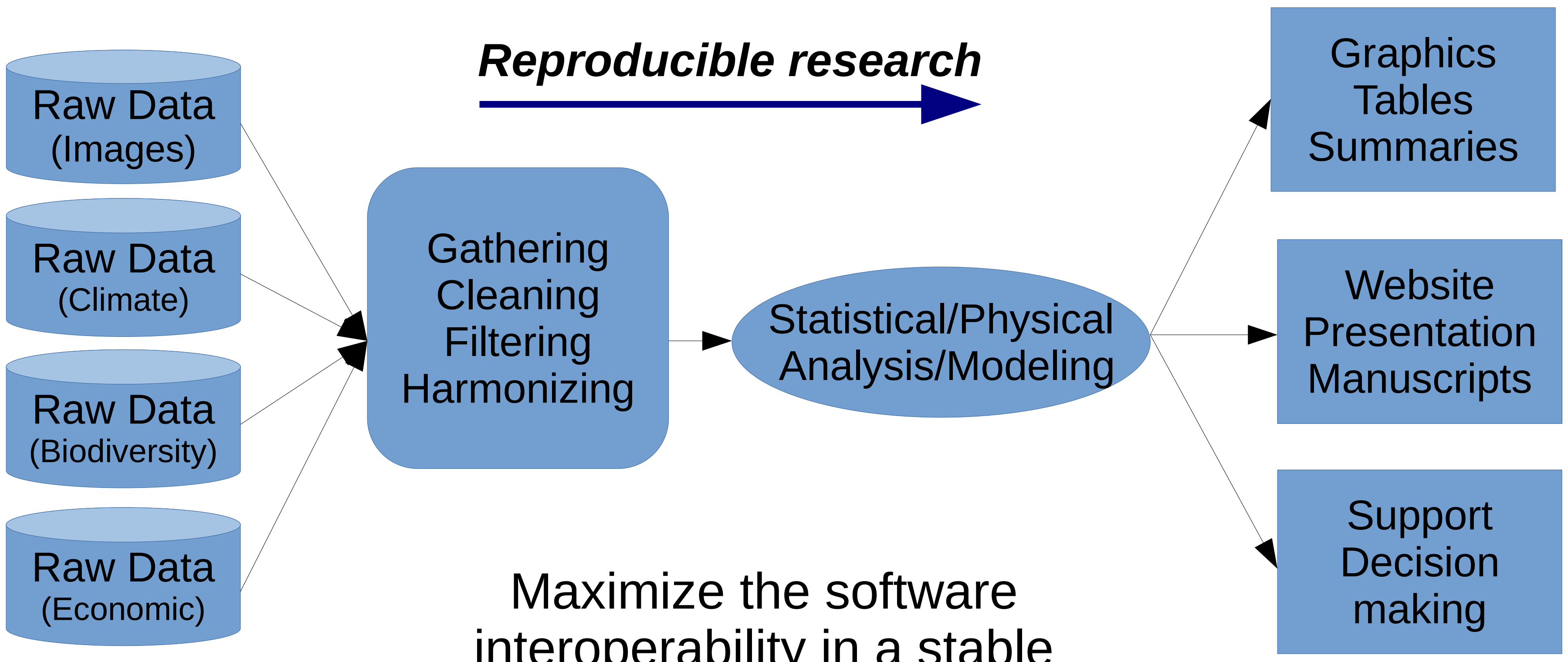
Livestock

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

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**



Maximize the software interoperability in a stable Operating System