Land Cover Change / Fractional Vegetation Cover

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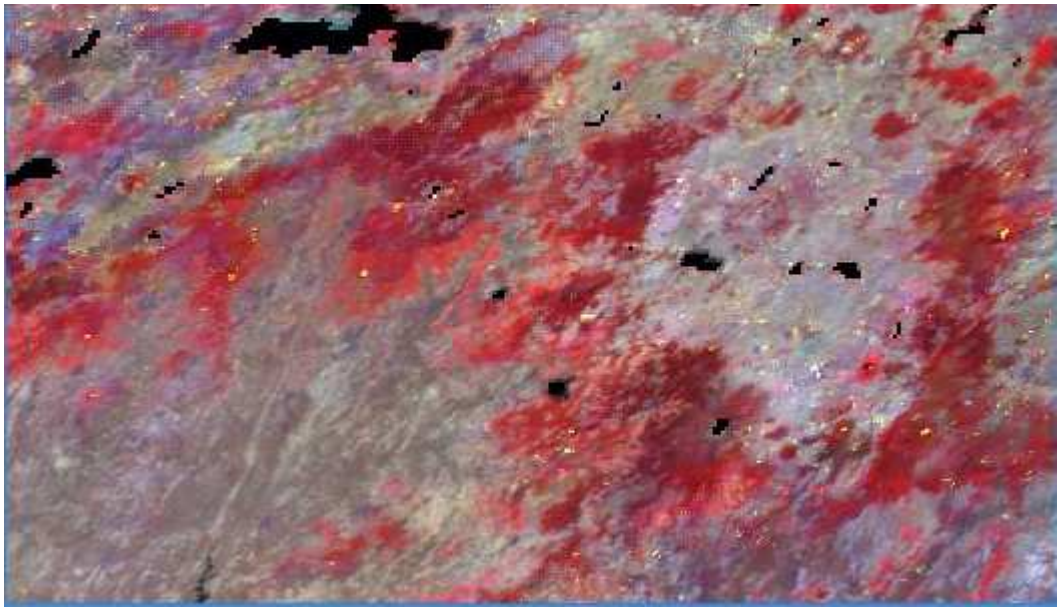
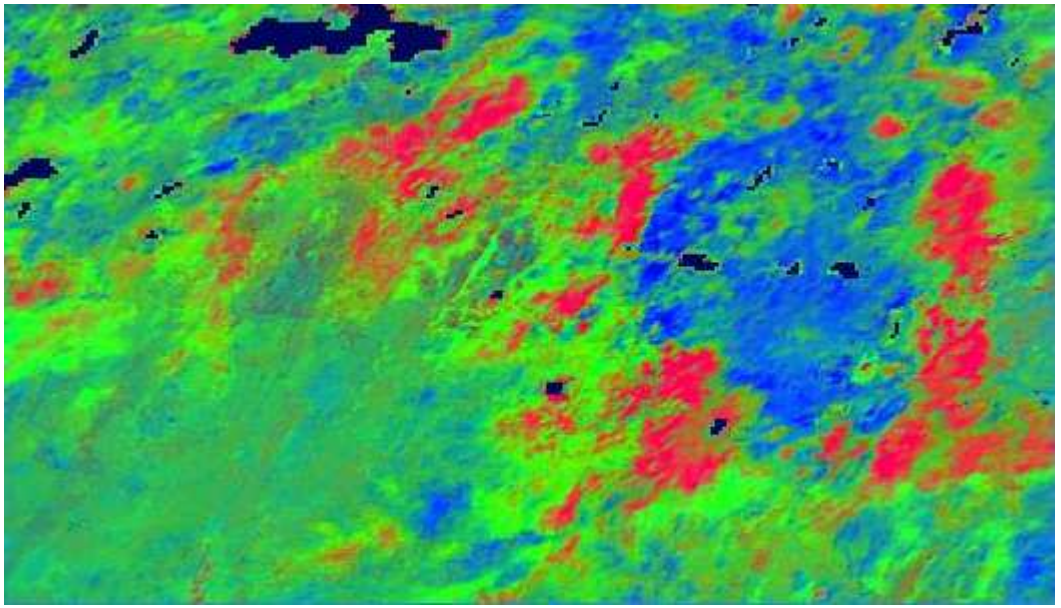
Comisión nacional para el conocimiento y uso de la biodiversidad - CONABIO
Deutsches Zentrum für Luft- und Raumfahrt - DLR-DFD





Land and Vegetation Direct Readout Workshop
October 10, 2007, Mexico City

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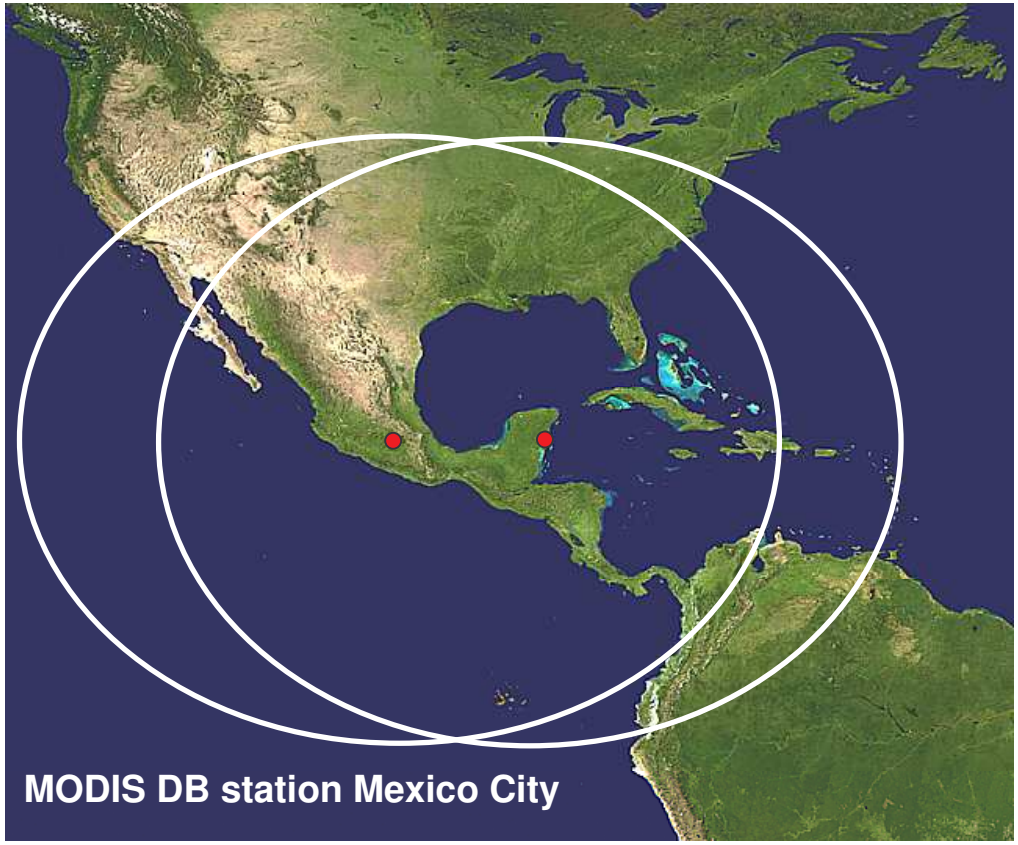


Moderate resolution imaging spectroradiometer (MODIS) since 2002

- 36 bands
- 250m - 500m - 1 km resolutions

Advanced Very High Resolution Radiometer (AVHRR) since 2001

- 5 bands
- 1.1 km resolution

Ecosystem applications terrestrial studies

Wild fire detection

Vegetation monitoring

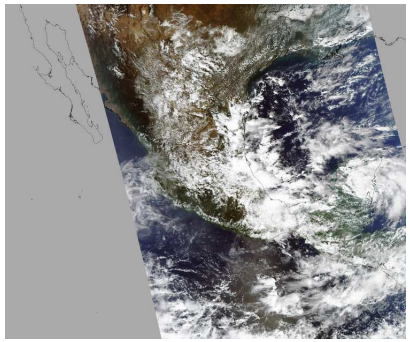
Land cover & change detection studies

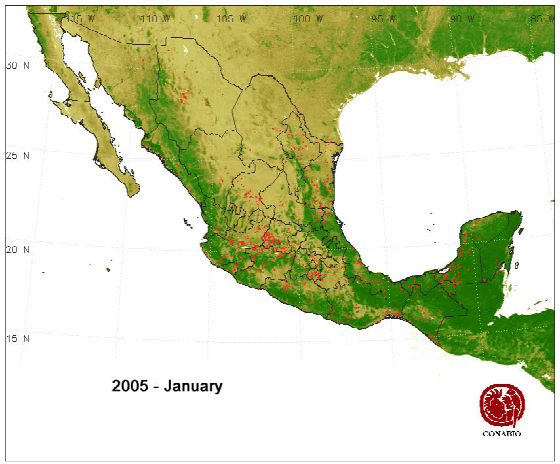
Mangrove National Inventory

Oceanic studies

Sea Surface Temperature (climate change)

Chlorophyll -a concentration (ocean colour)





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Introduction

Land cover monitoring

- Land cover monitoring is a major topic for different tasks like landscape management or biodiversity assessment in order to define environmental policies.

- Land cover / land use mapping requires resource intensive procedure to extract valid information from remote sensing data.

- For better understanding of land surface dynamics, frequently identification of land cover changes per year are required.

- Atmospheric conditions are the most limiting factor in using optical remotely sensed data.

- Up to now almost all land cover approaches focus on discrete instead of continuous classifications.

Development of an automated operation chain using hypertemporal MODIS data for land cover processes monitoring

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Objectives

Hypertemporal MODIS framework

- Centralised data storage of "unlimited" raster data using MySQL database for distributed processing capabilities (**grid processing**)
- Based on MODIS reflectance product for using multispectral information
- Filtering of clouds and bad angle data for extracting consistent surface information
- Interpolation of gaps for monthly analysis
- Classification of dataset, continuous surface classes (fraction of trees, shrubs and bare soil).

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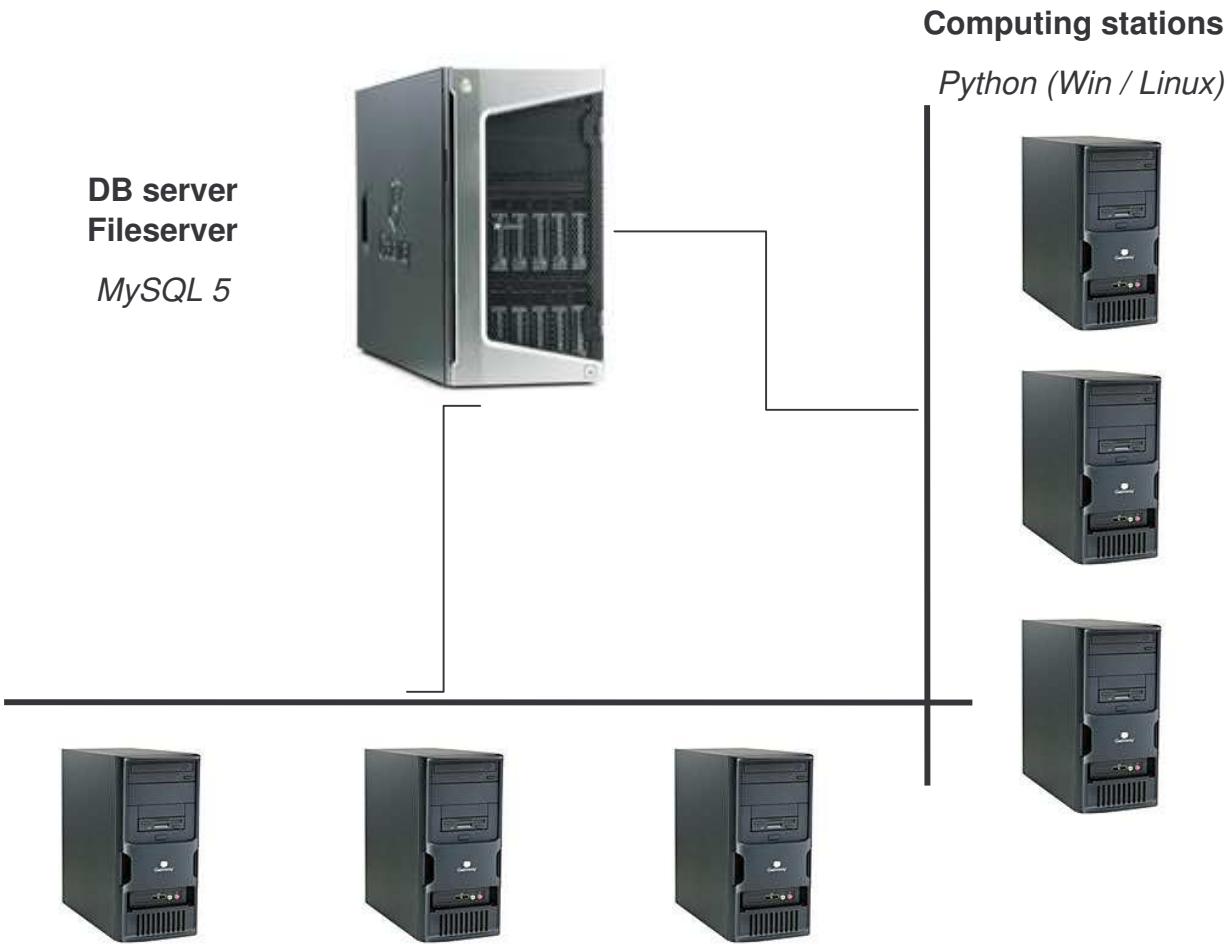
System components



- **Data import**
  - MySQL, MySQLdb, GDAL, Python, HDF library, gnosis (Python XML processing)
- **Data filtering**
  - MySQL SP's
- **Interpolation**
  - Python, NumPy, gnosis
- **Classification**
  - Python, NumPy, gnosis, LIBSVM

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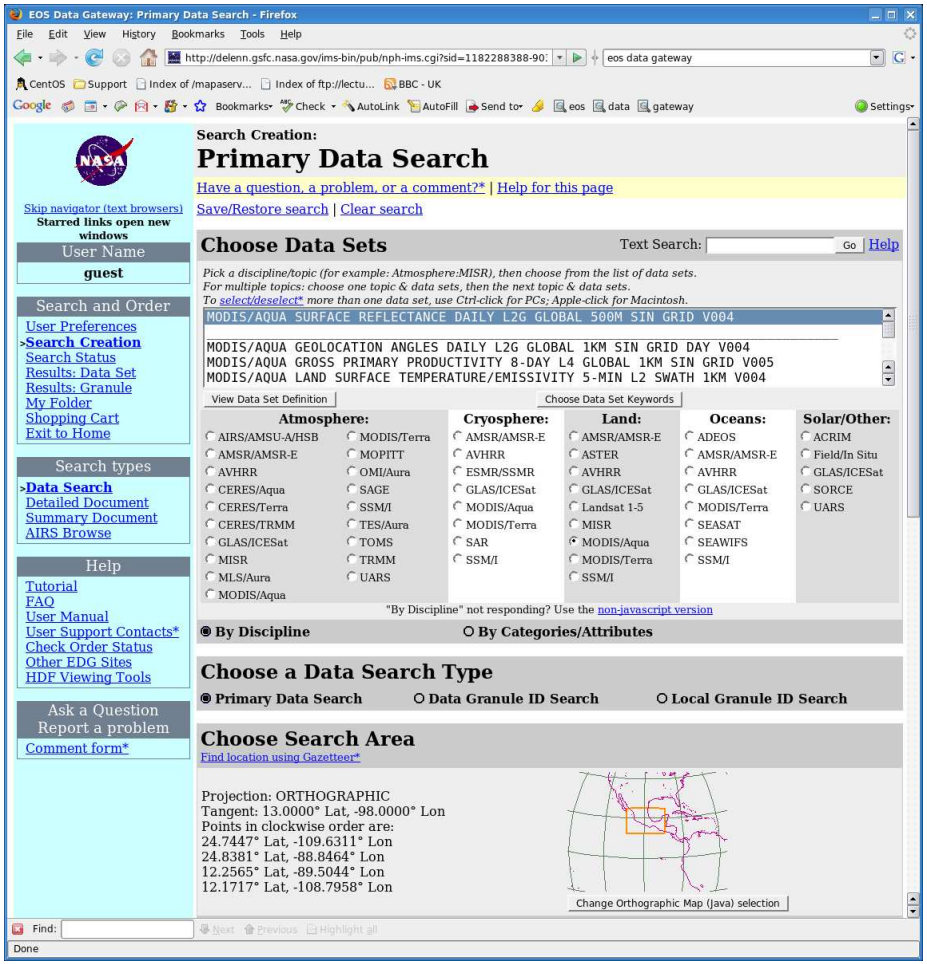
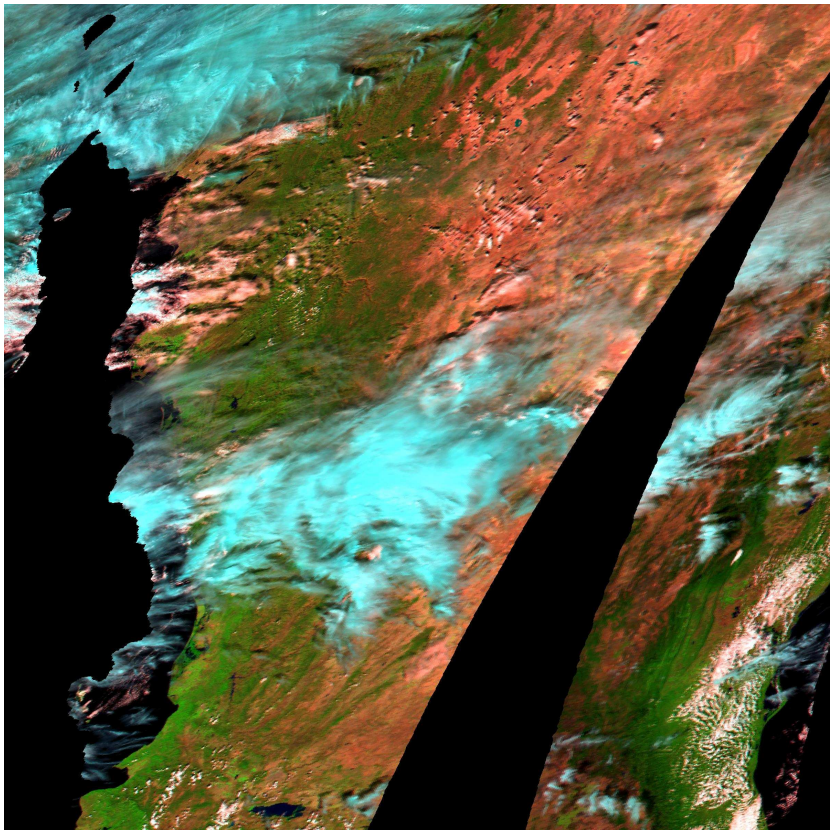
MODIS data



Earth Observing System Data Gateway



MODIS/Aqua, Surface Reflectance Daily L2G Global 500m Sinusoidal grid, V004

- One daily image per tile ~ **147 MB**
- One year per tile ~ **54 GB**
- Mexico requires ~ 7 tiles ~ **378 GB**

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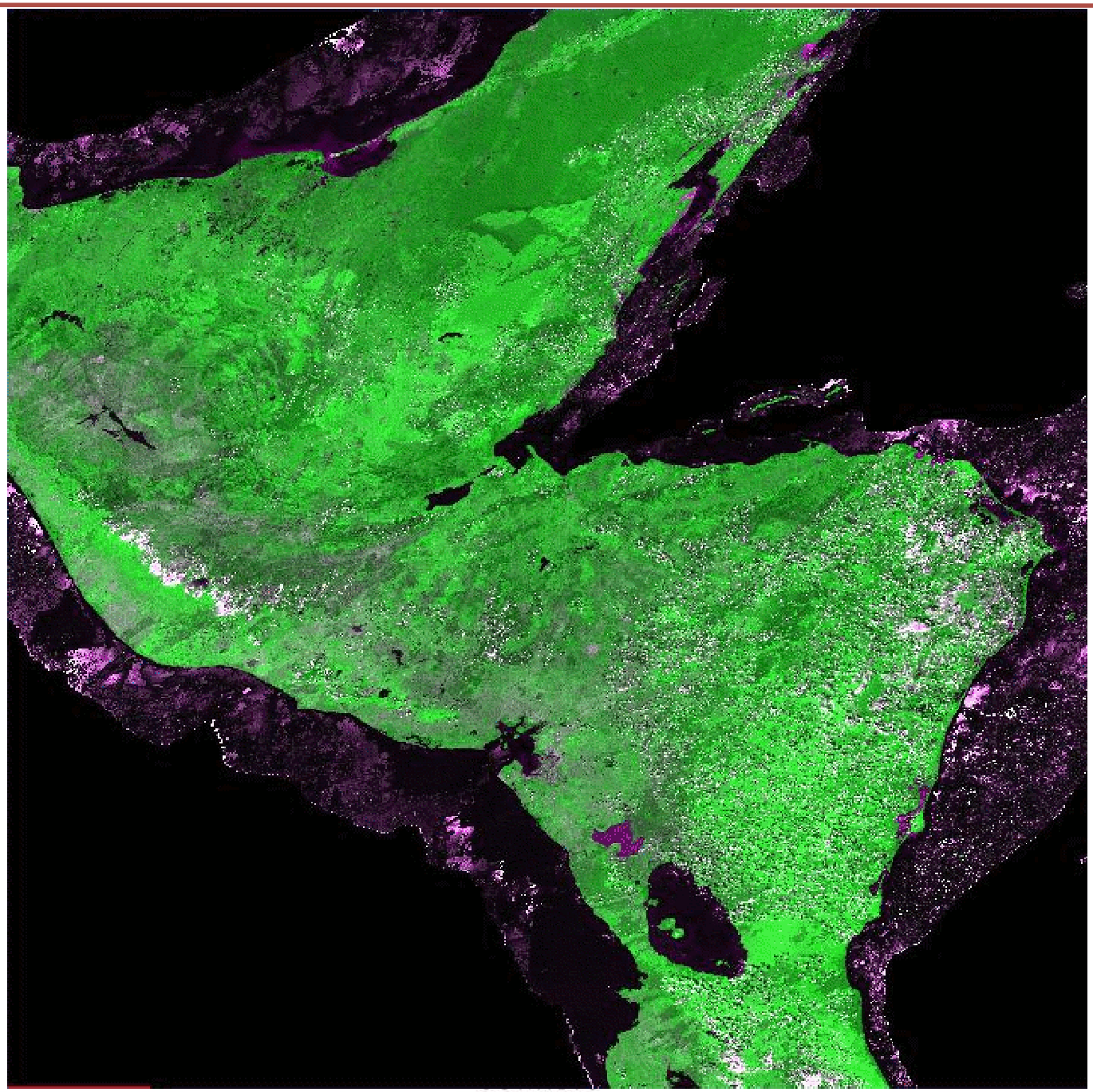
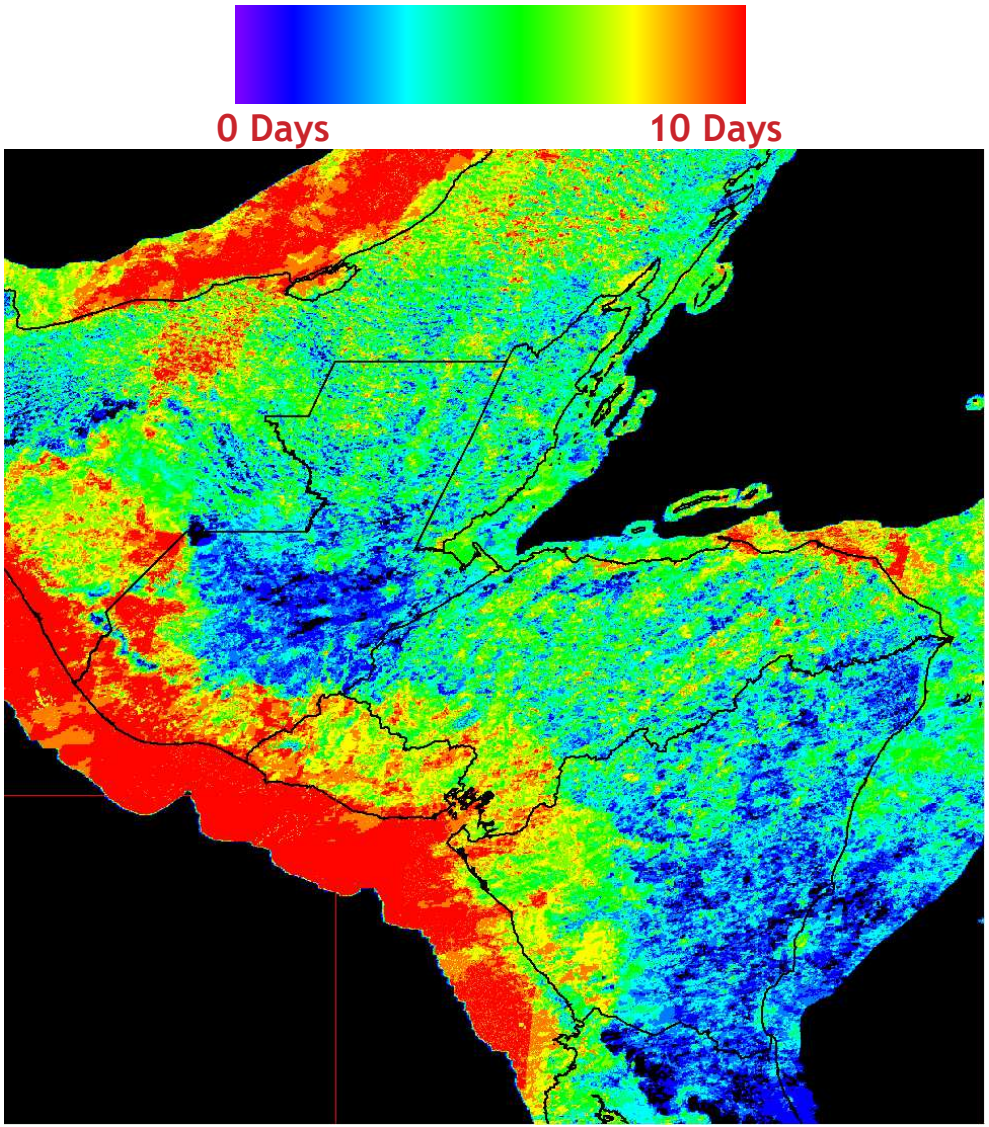
MODIS data preprocessing – original data set



MODIS data preprocessing – data filtering

MOD09GST – Data availability for best pixels



Filtering by best QA

- QA (Quality Assessment) objective is to evaluate scientific quality of products products generated from MODIS data

- Resampling QA from 1km to 500m and filter MOD09 using following criteria:

  - Bits 0-1, Cloud state=00, clear
  - Bits 3-5, Land/Water mask flag=100, land
  - Bits 6-7, Aerosol quality=00 or 01 or 10, climatology or low or average.

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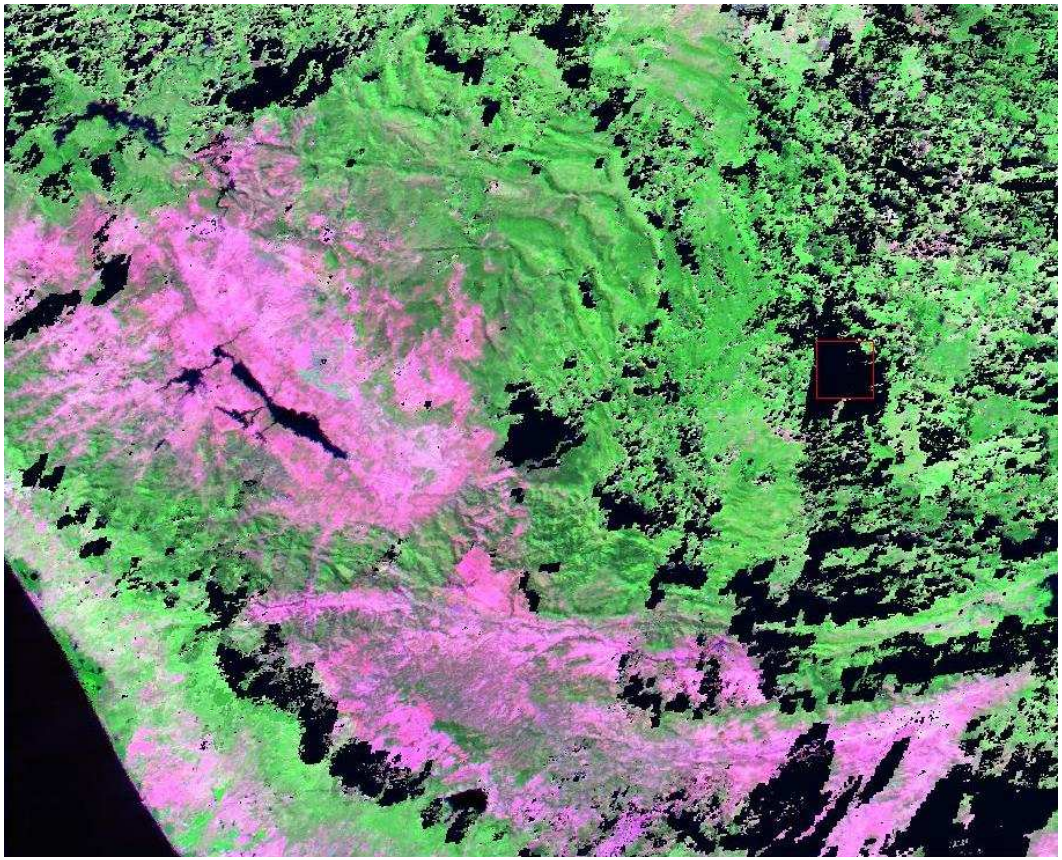
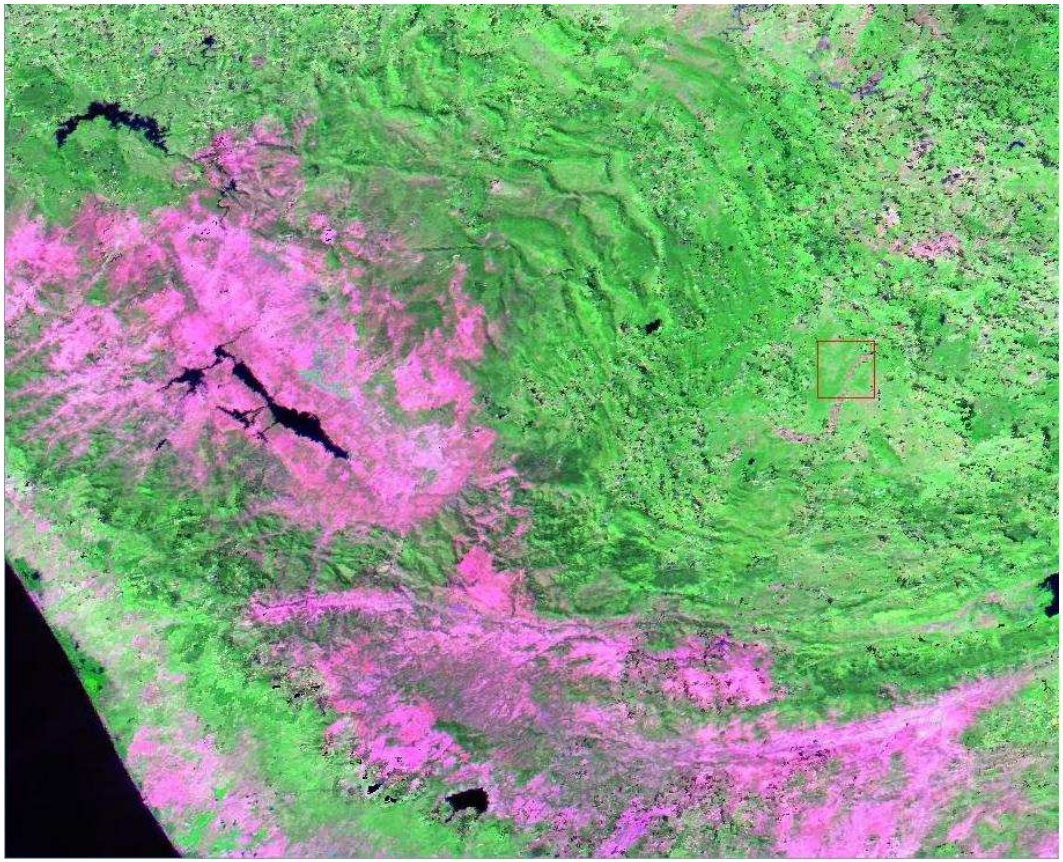
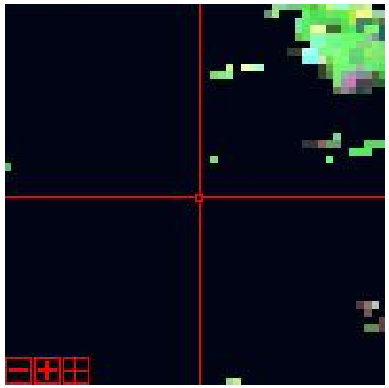
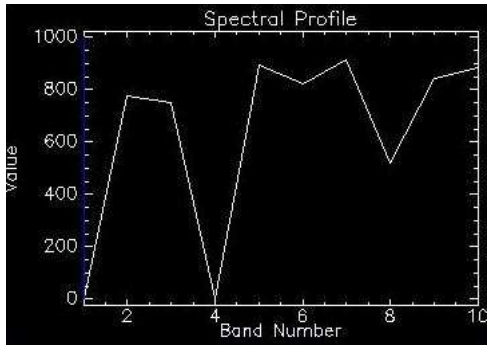
MODIS data preprocessing - data filtering

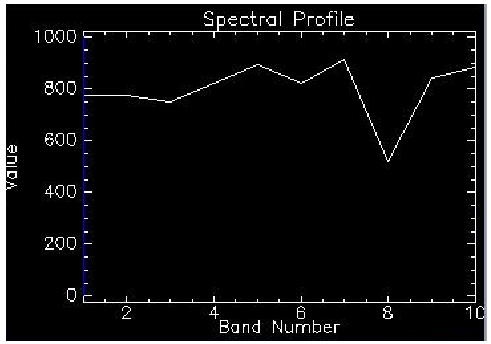
Gap filling using simple interpolation processing

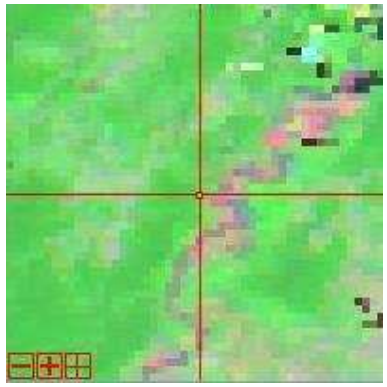












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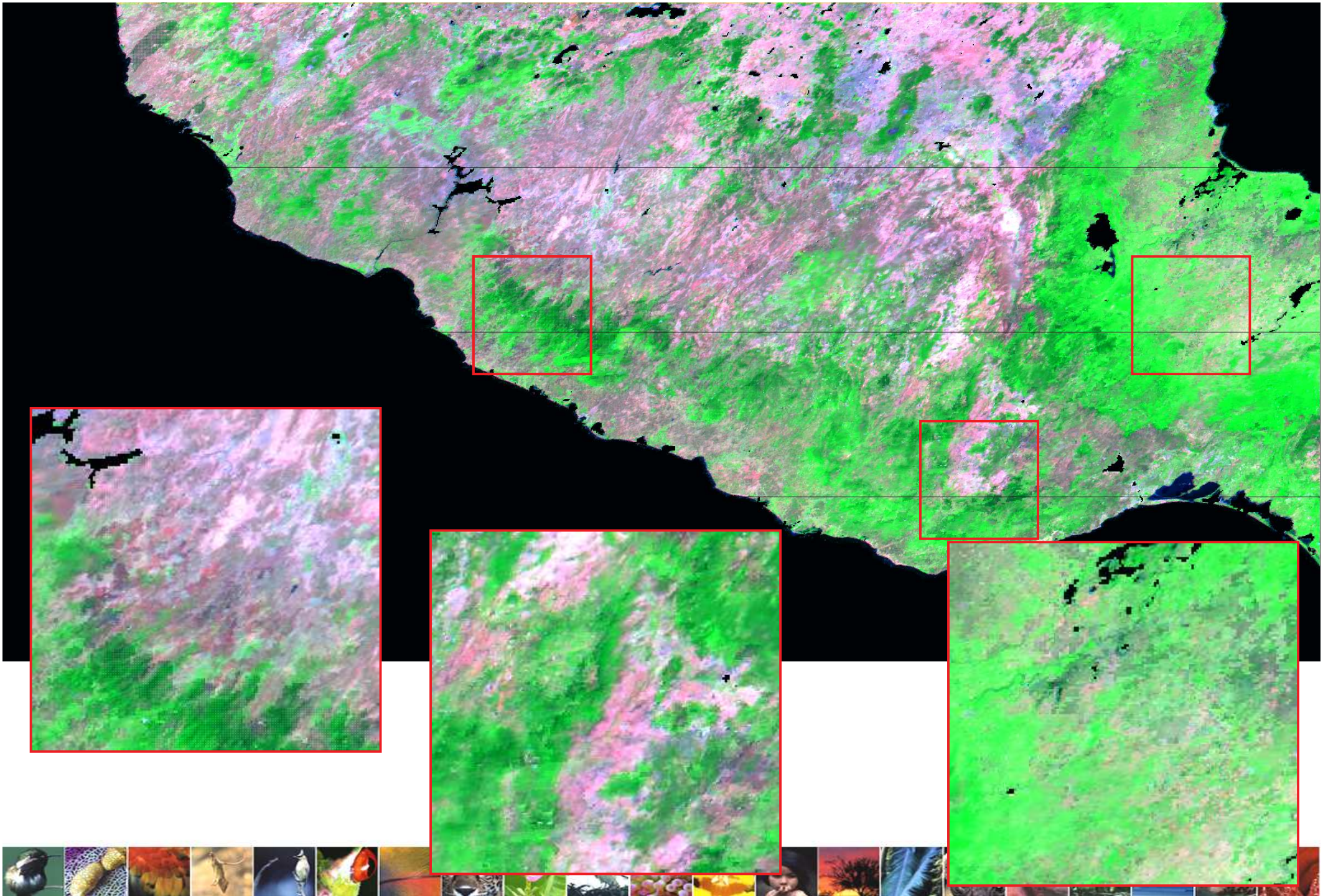
MODIS data preprocessing – quality of interpolated data



Classification of daily data

Support vector machines

.Approach can be used for the extraction of discrete **and** continuous land cover classes (Classification and regression)

.SVM are Non-parametric classifiers like artificial neuronal networks or decision tree classifiers, Non-parametric models differ from parametric models in that the model structure is not specified a priori but is instead determined from data

.No problems with overfitting and designing network topologies

.Part of machine learning SVMs are used for classification tasks based on statistical learning theory

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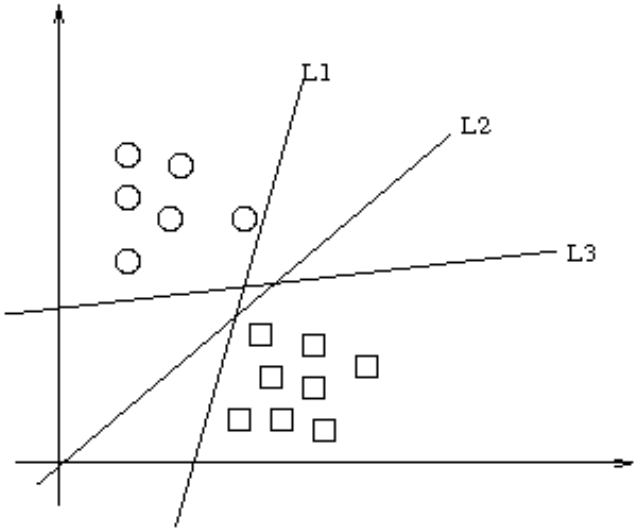
Identification of continuous/discrete fraction data

Support Vector Machines / Support Vector Regression

- Supervised learning method for classification and multivariate regression
- Considered a linear classificator useable also for non-linear classifications using a kernel trick
- Maximizes distances between hyperplanes.

LIBSVM – Open source library for SVMs. Chih-Chung Chang and Chih-Jen Lin



$$\{(\mathbf{x}_1, c_1), (\mathbf{x}_2, c_2), \ldots, (\mathbf{x}_n, c_n)\}$$

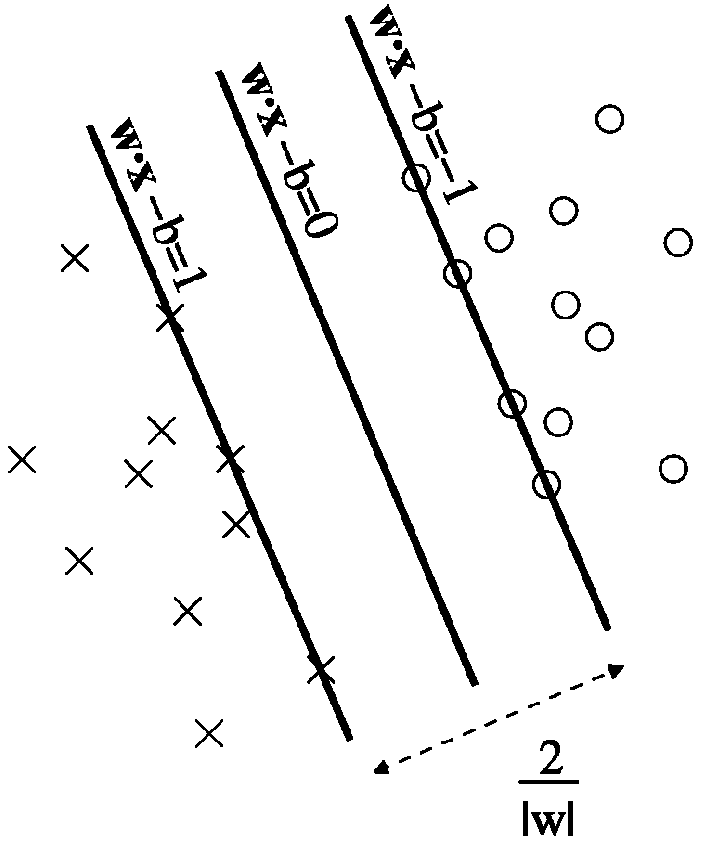
Hiperplane

$$\mathbf{w} \cdot \mathbf{x} - b = 0.$$

W vector points perpendicular to Hyper-plane which divides classes.

If training data has linear separability It is possible to maximize the distance between the hyper-planes $2/|\boldsymbol{w}|$, therefore we want to minimize $|\boldsymbol{w}|$

$$\mathbf{w} \cdot \mathbf{x_i} - b \geq 1 \quad \text{or}$$
$$\mathbf{w} \cdot \mathbf{x_i} - b \leq -1$$



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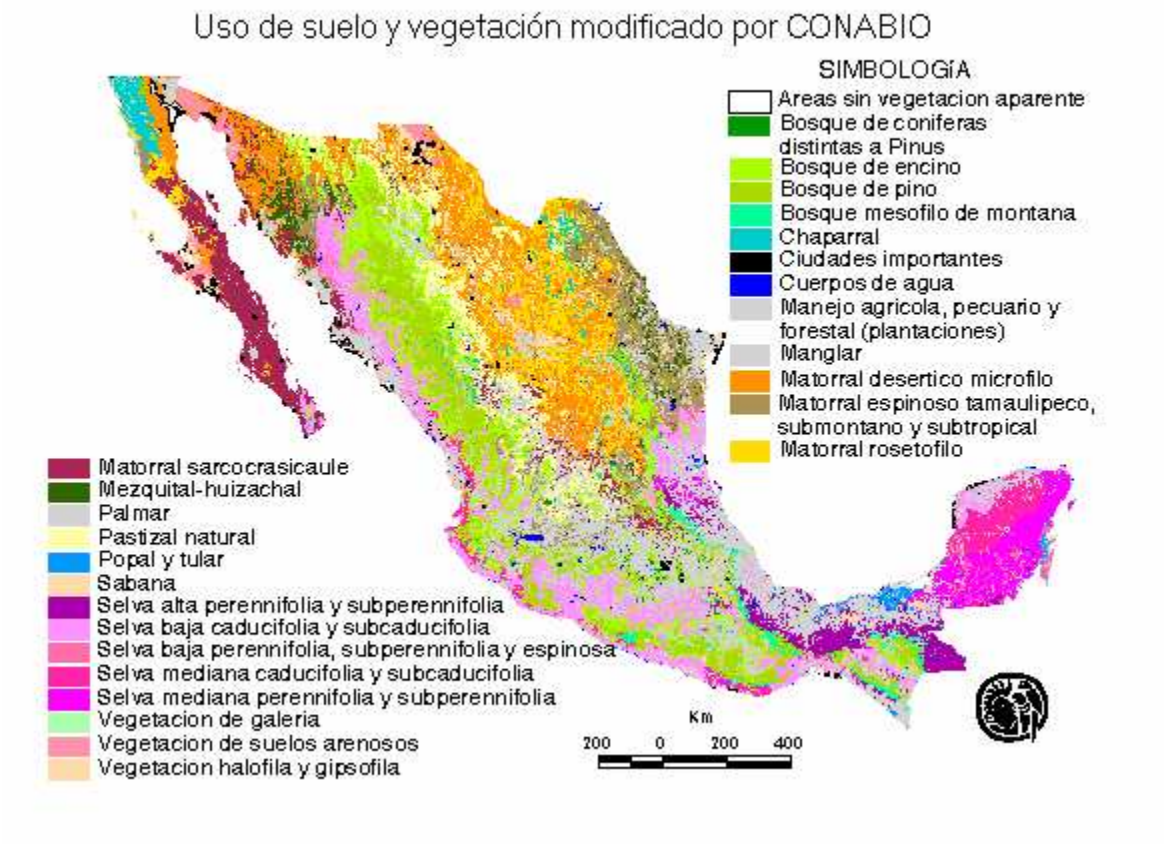
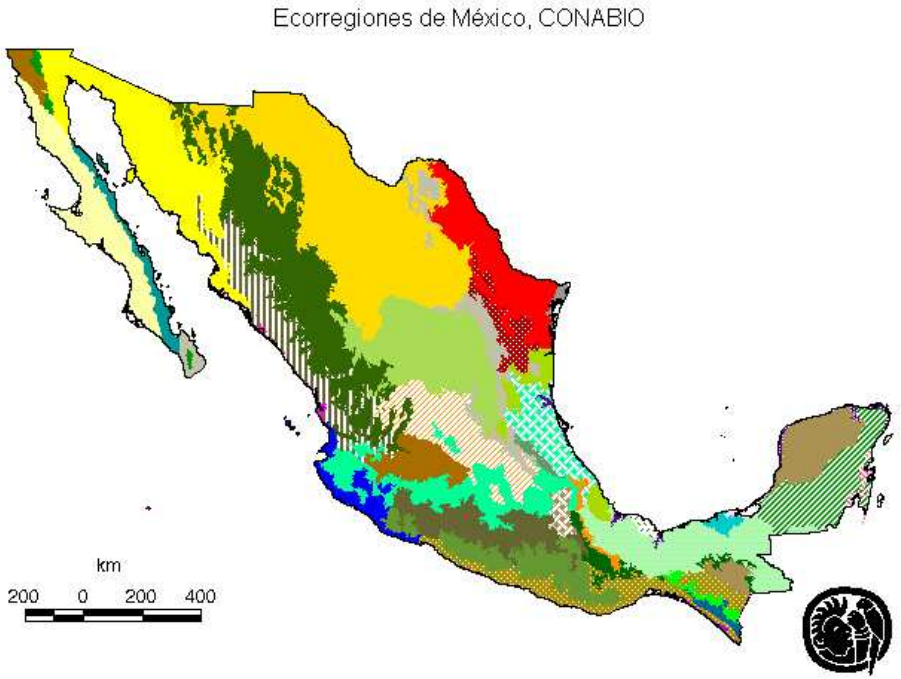
Goal is extraction of INEGI classes





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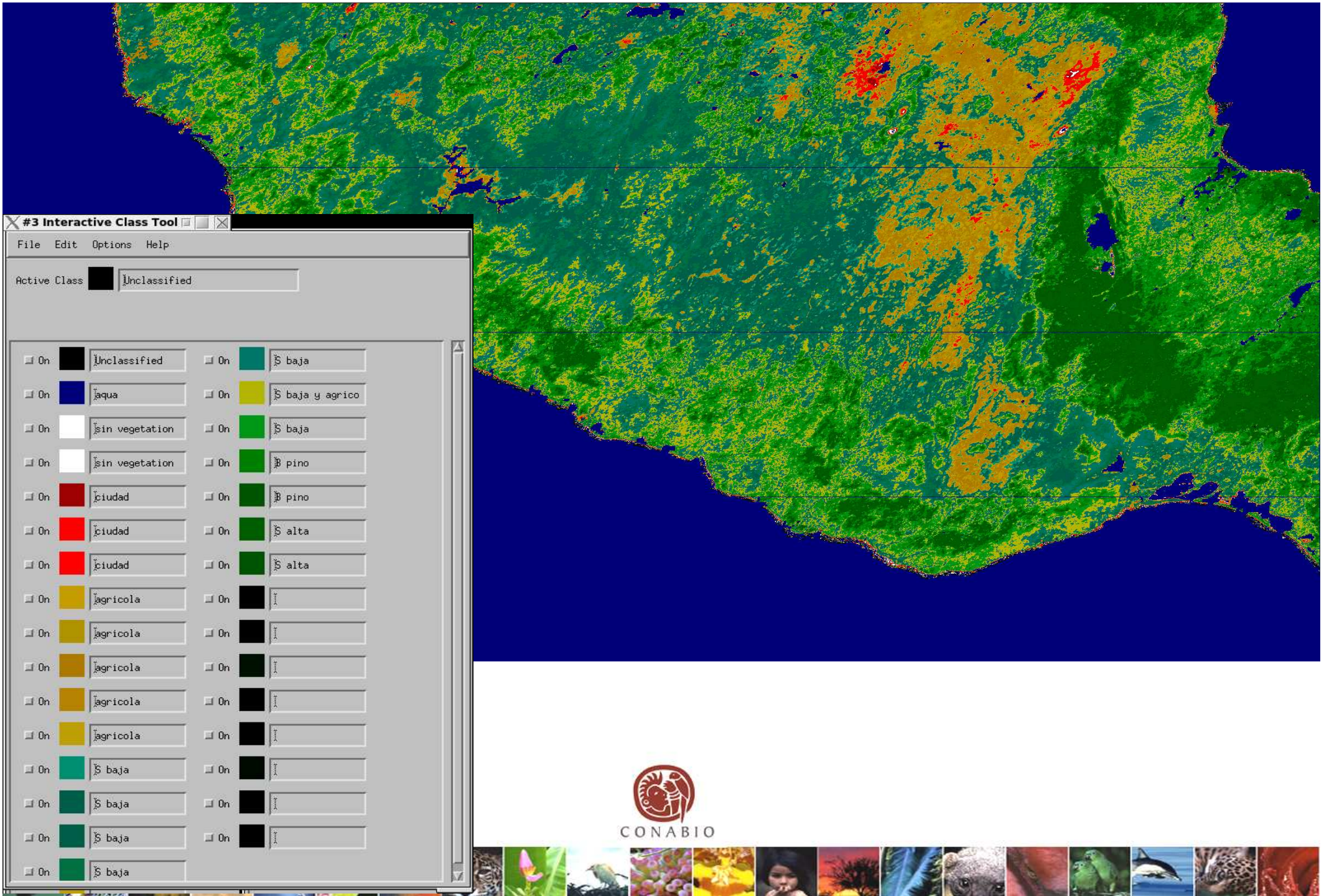
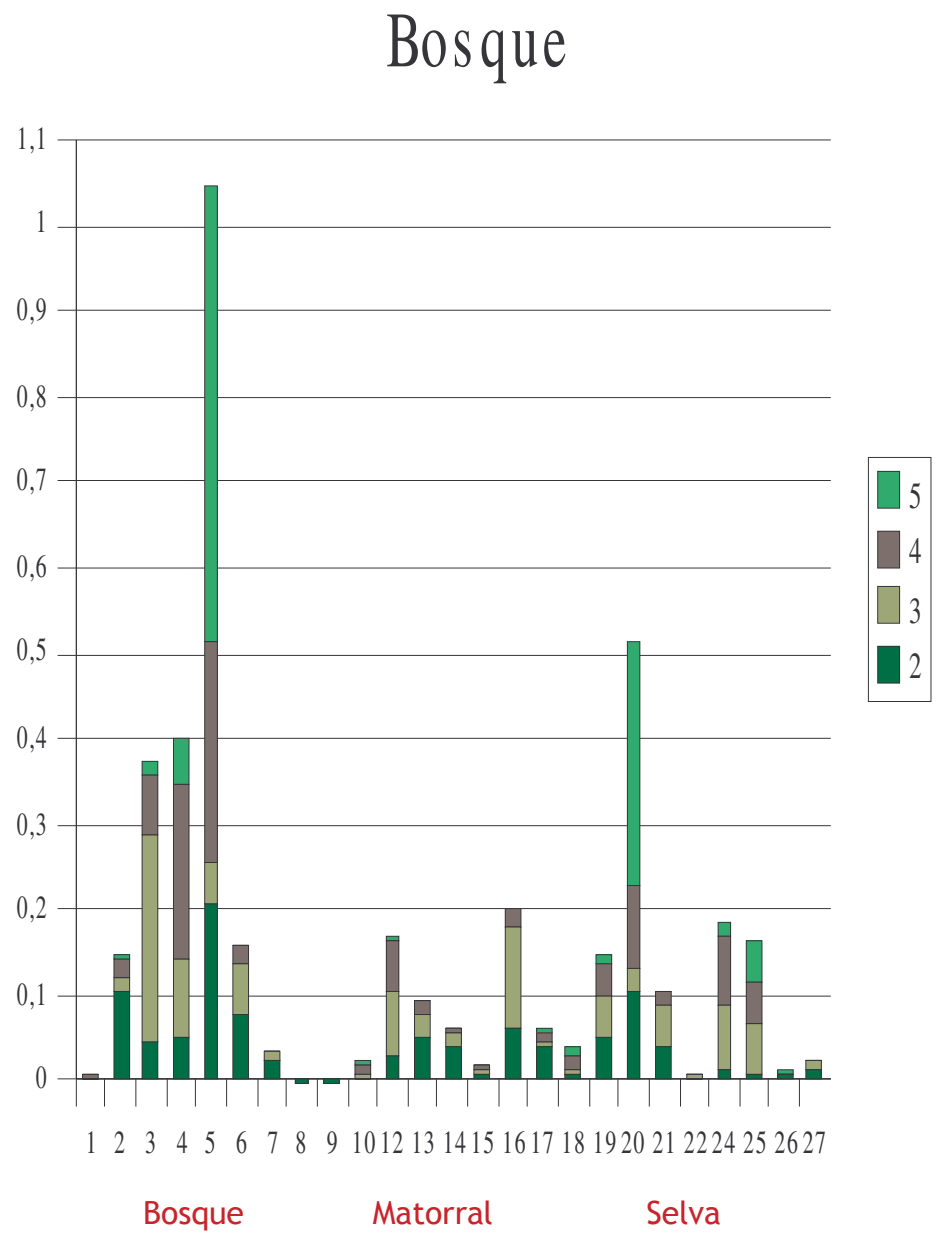
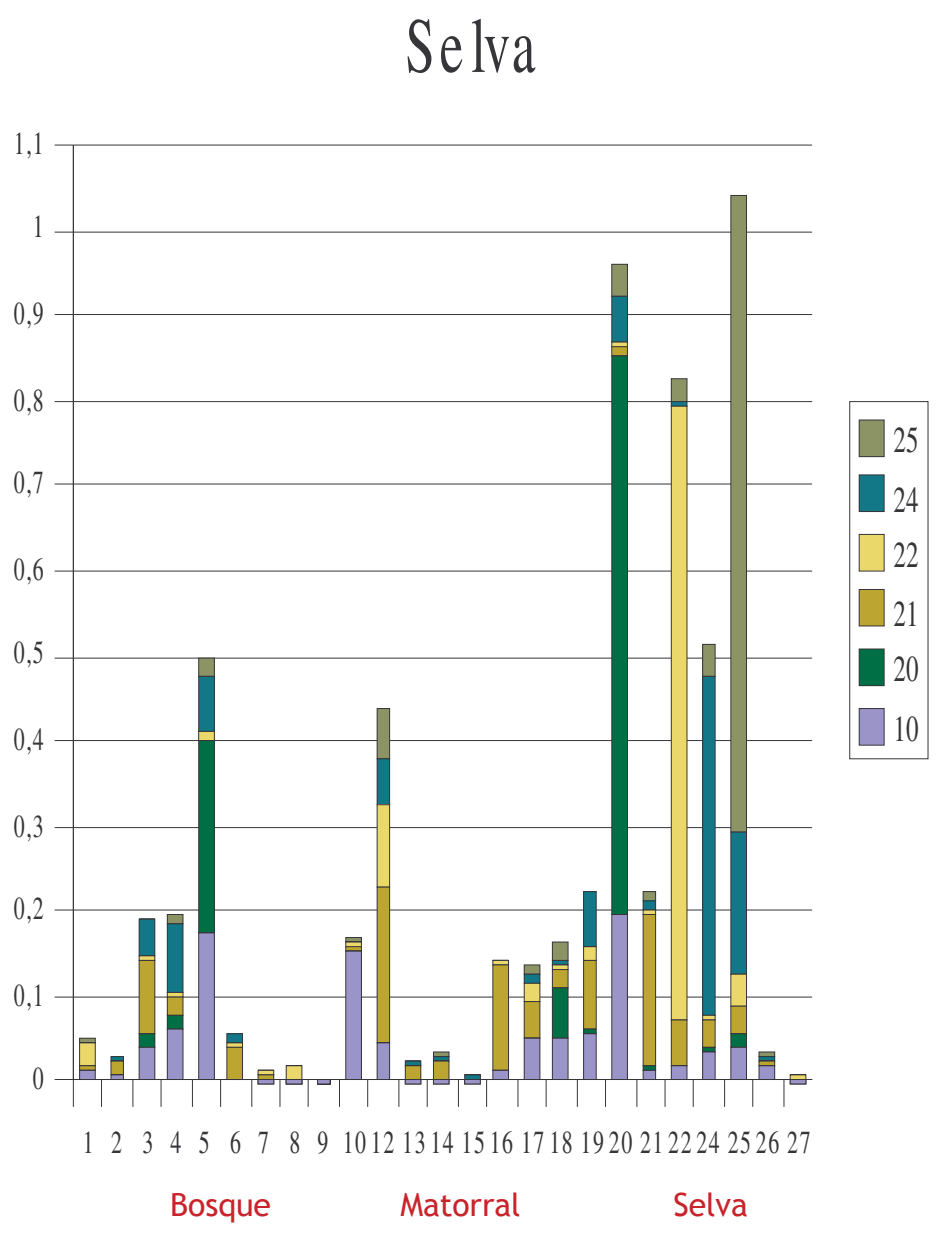
Unsupervised classification based on phenology 2005



Analysis of class composition





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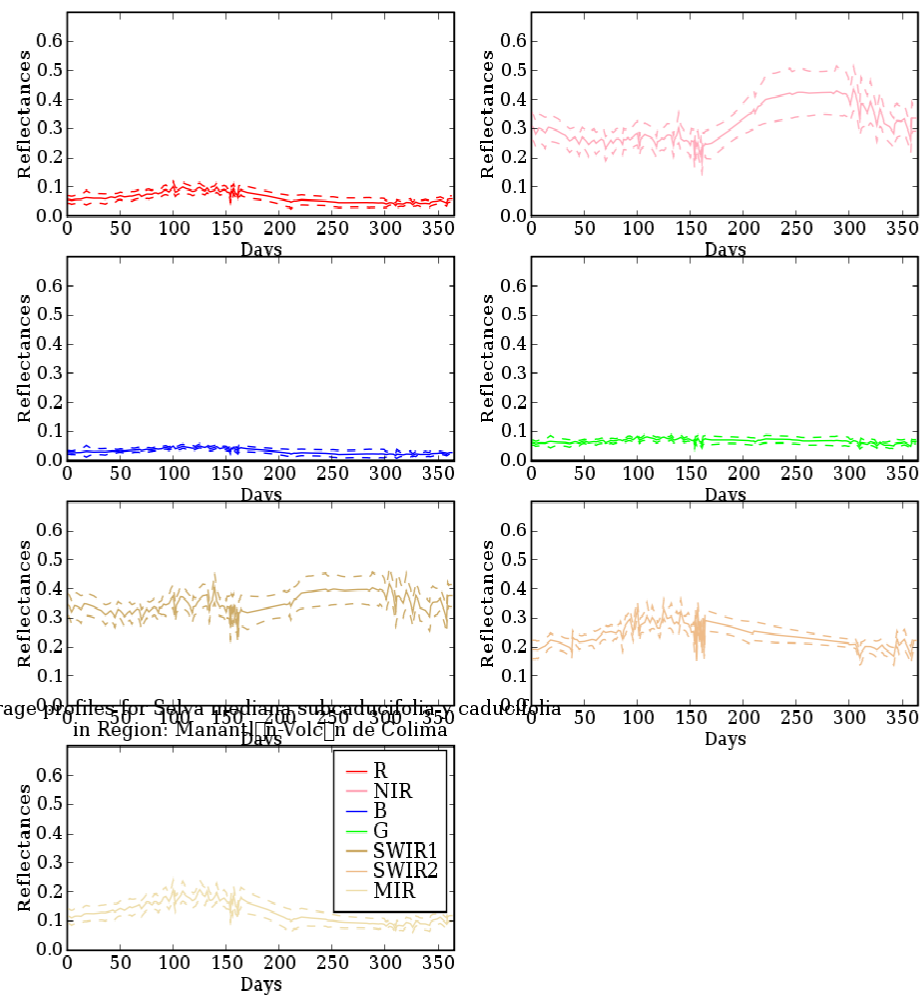
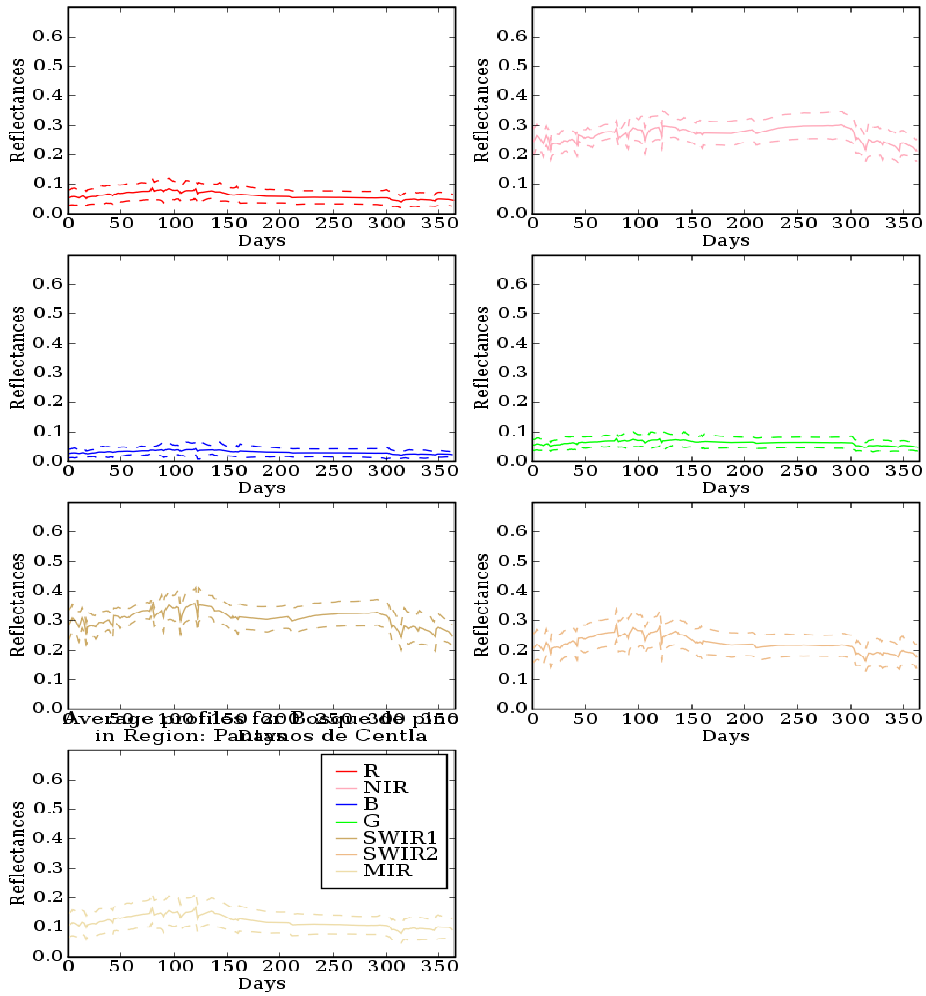
Analysis of temporal characteristics



Selva mediana subcaducifloa



Bosque de pino

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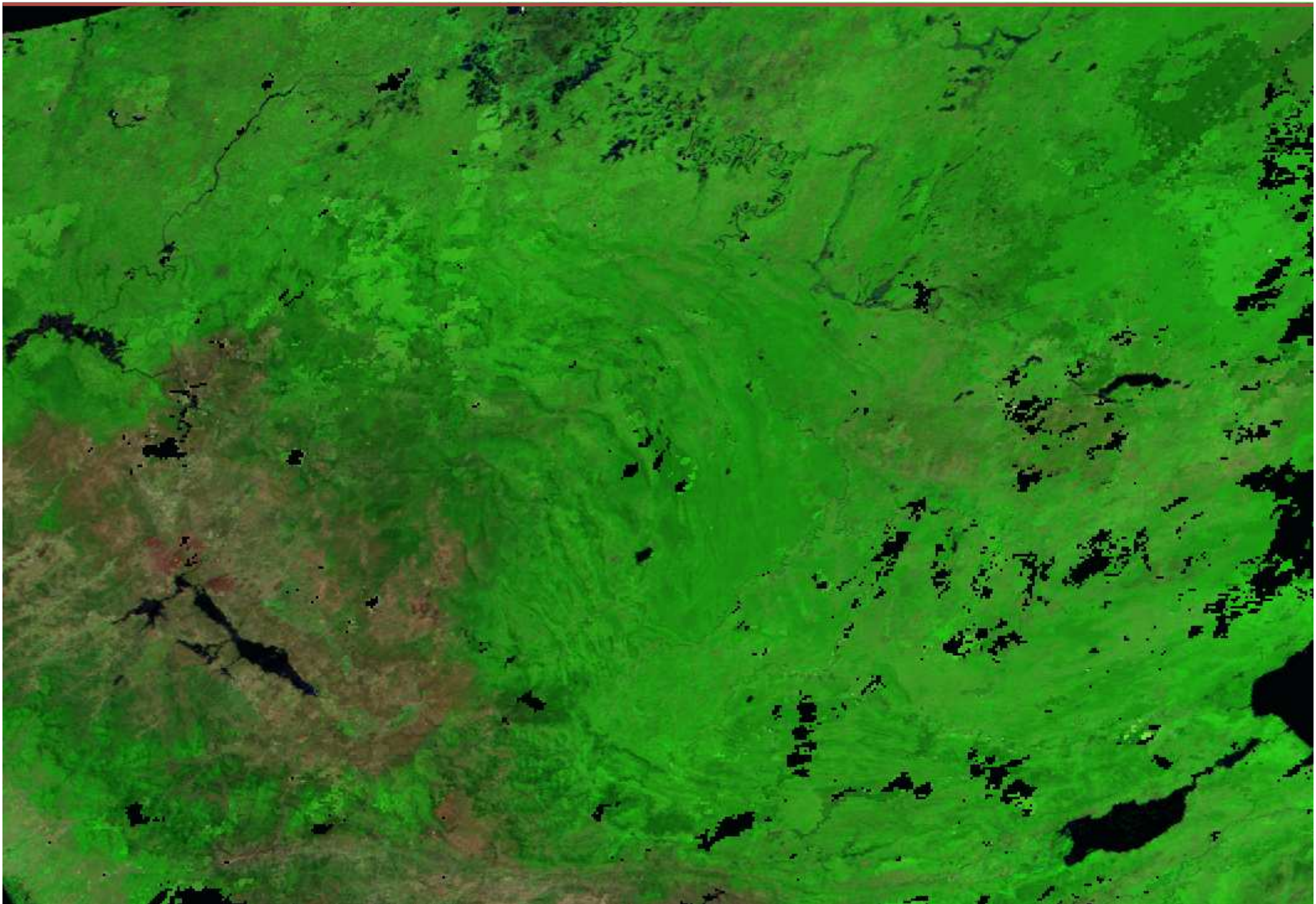
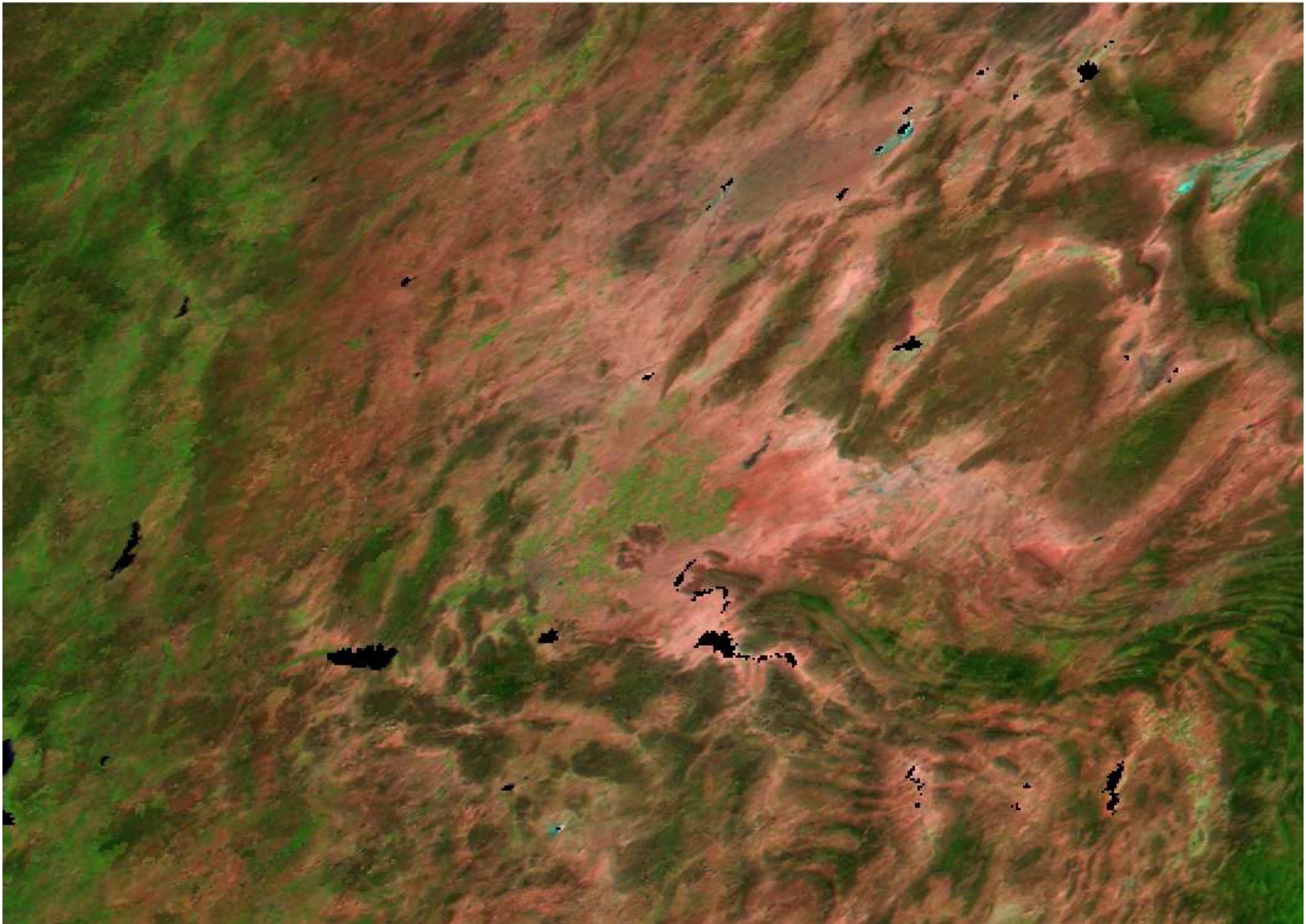
MODIS data preprocessing – composite creation

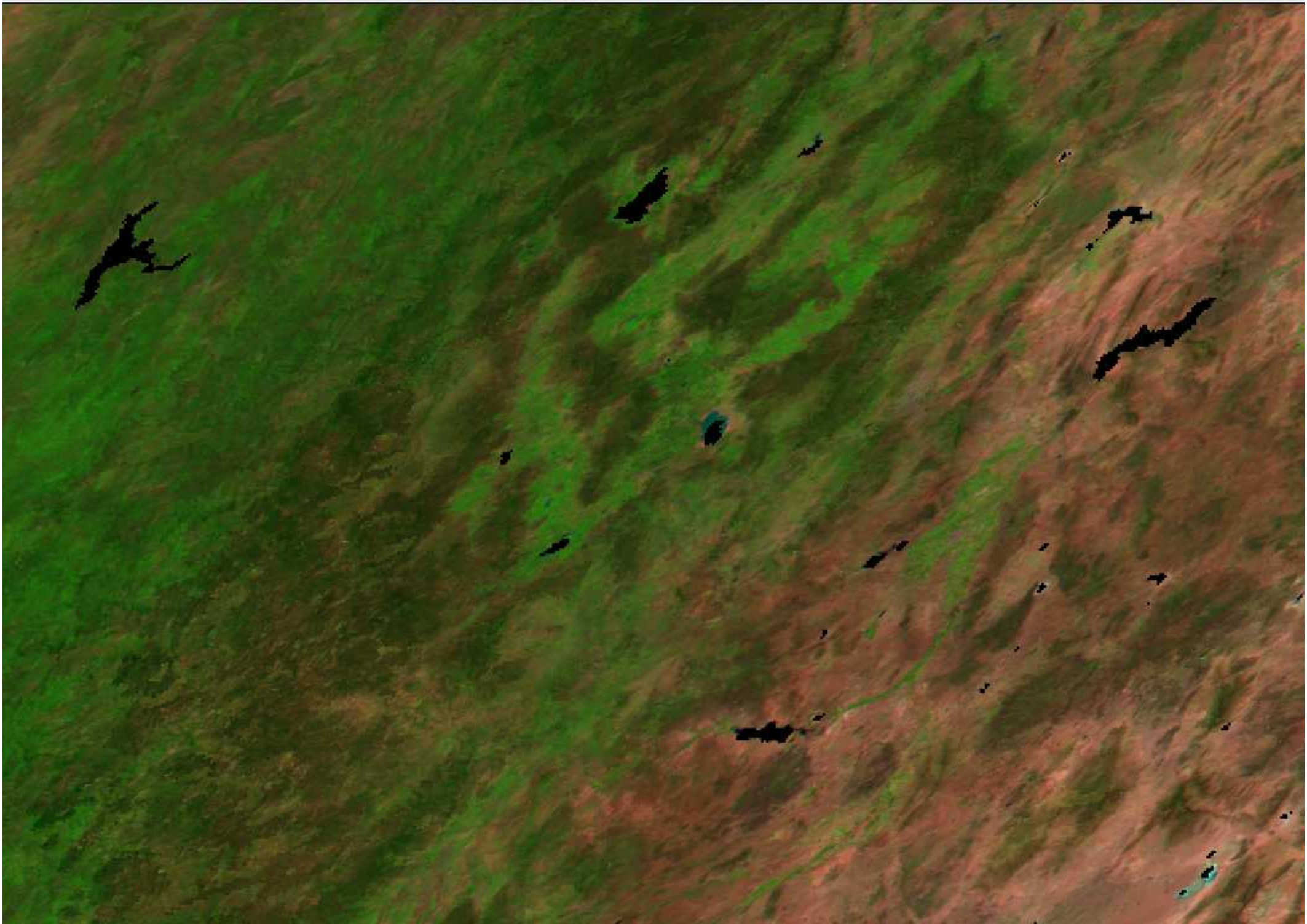
MODIS data preprocessing – composite creation (500m 721 RGB)



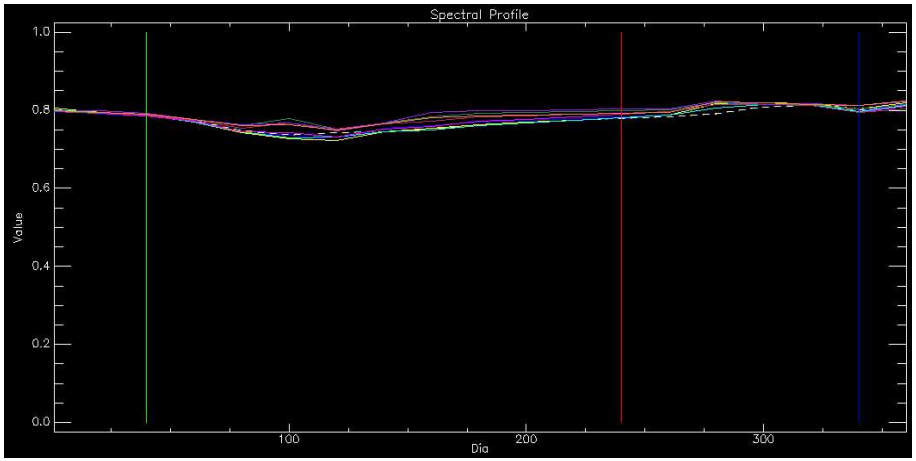
MODIS surface reflectance (500m 721 RGB)



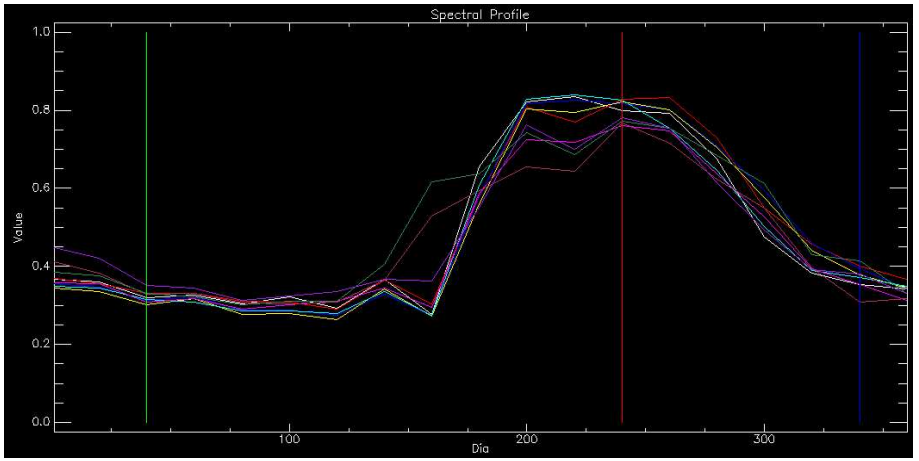
MODIS surface reflectance (500m 721 RGB)



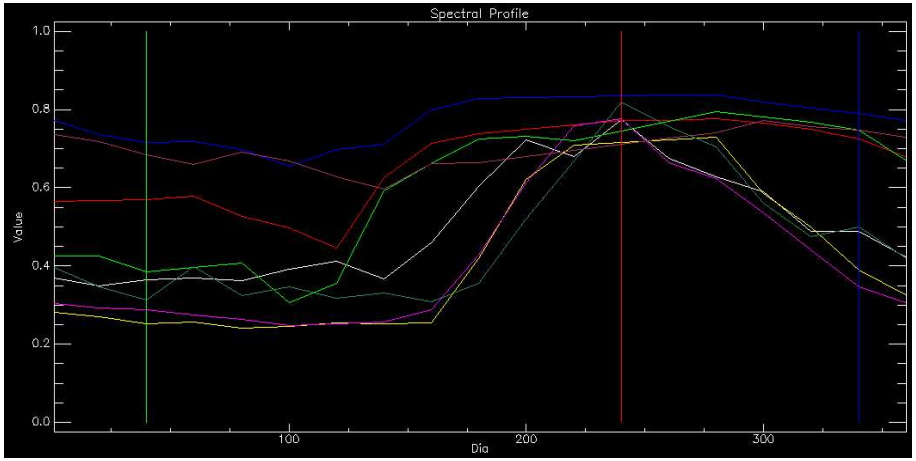
Characteristics of hypertemporal Data



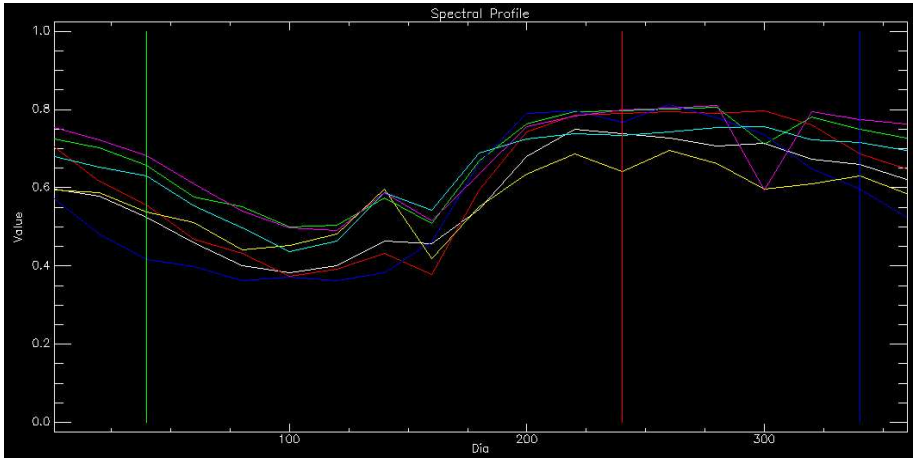
Tropical evergreen rain forest



Tropical deciduous forest



Agricluture



Oak forest

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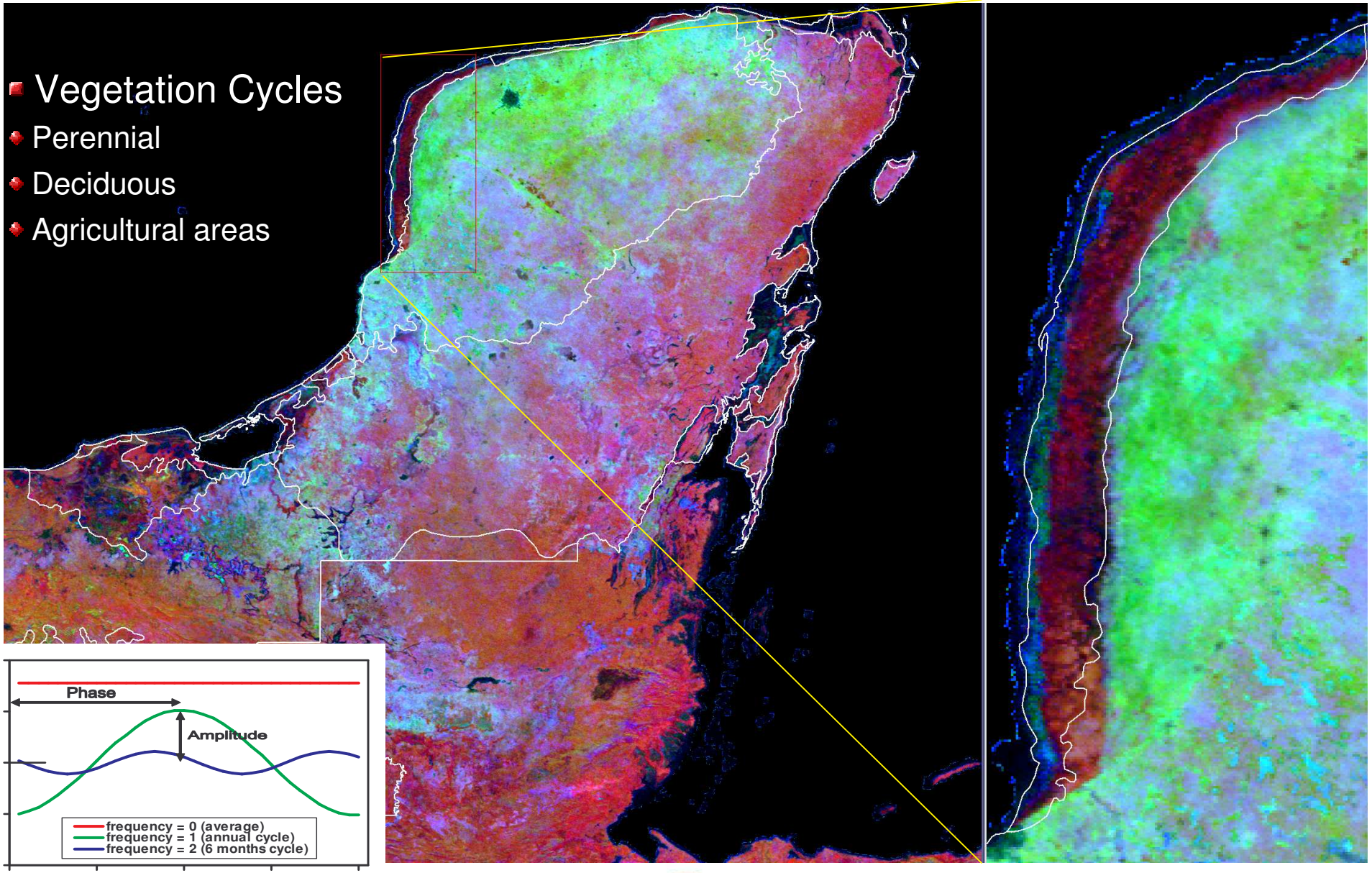
Characteristics of hypertemporal data



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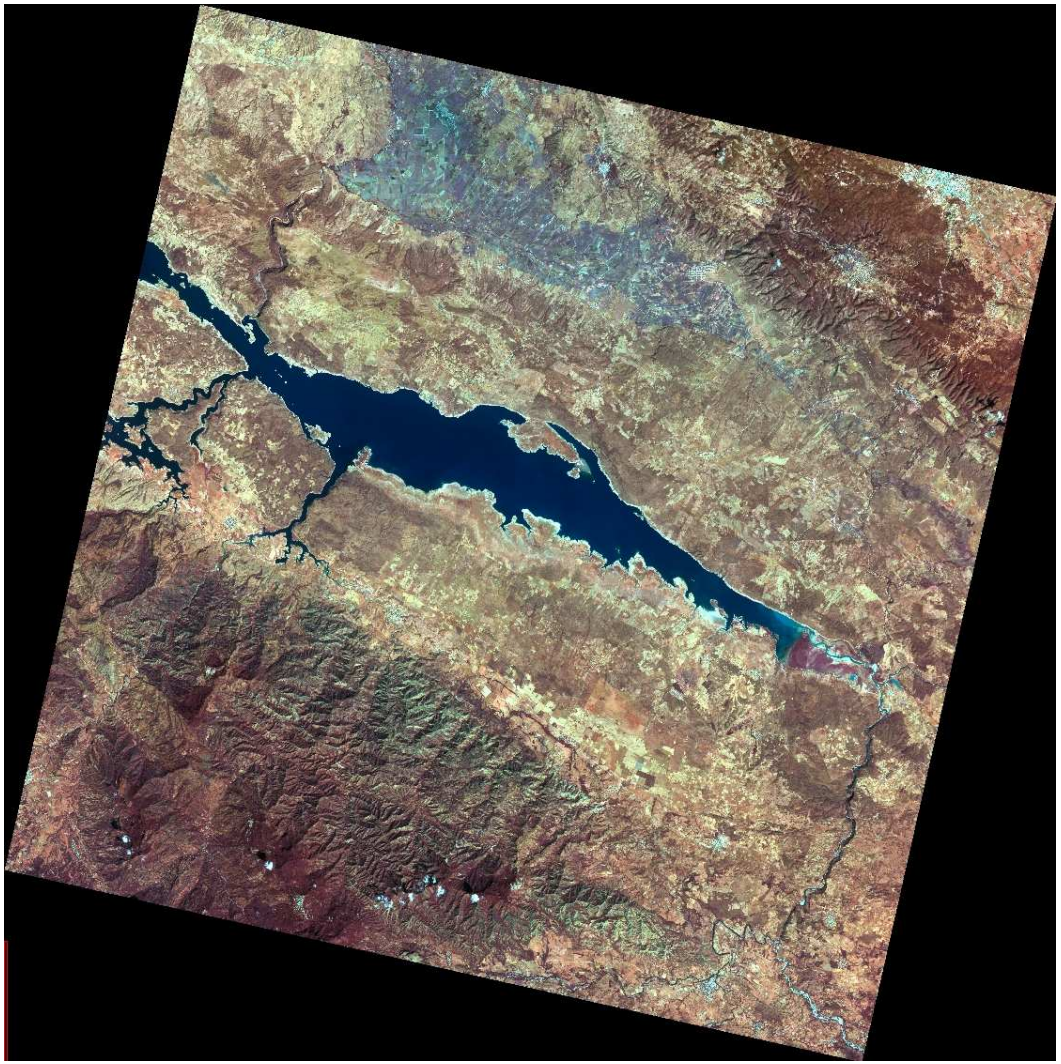
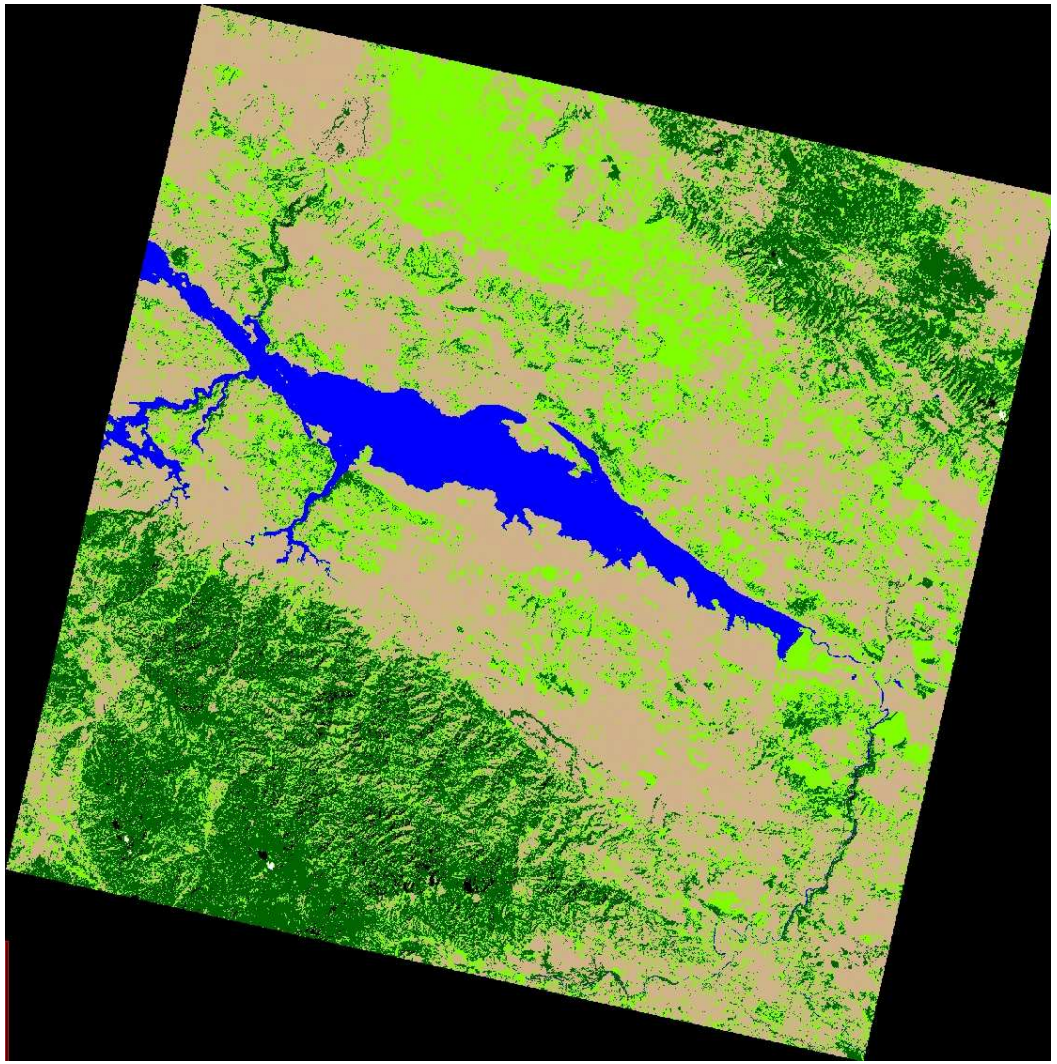
Extraction of continuous fraction data

High resolution training data – SPOT 10 m





4 classes: herbaceous/shrubs, trees, bare soil, others: water, clouds, shadows, etc.

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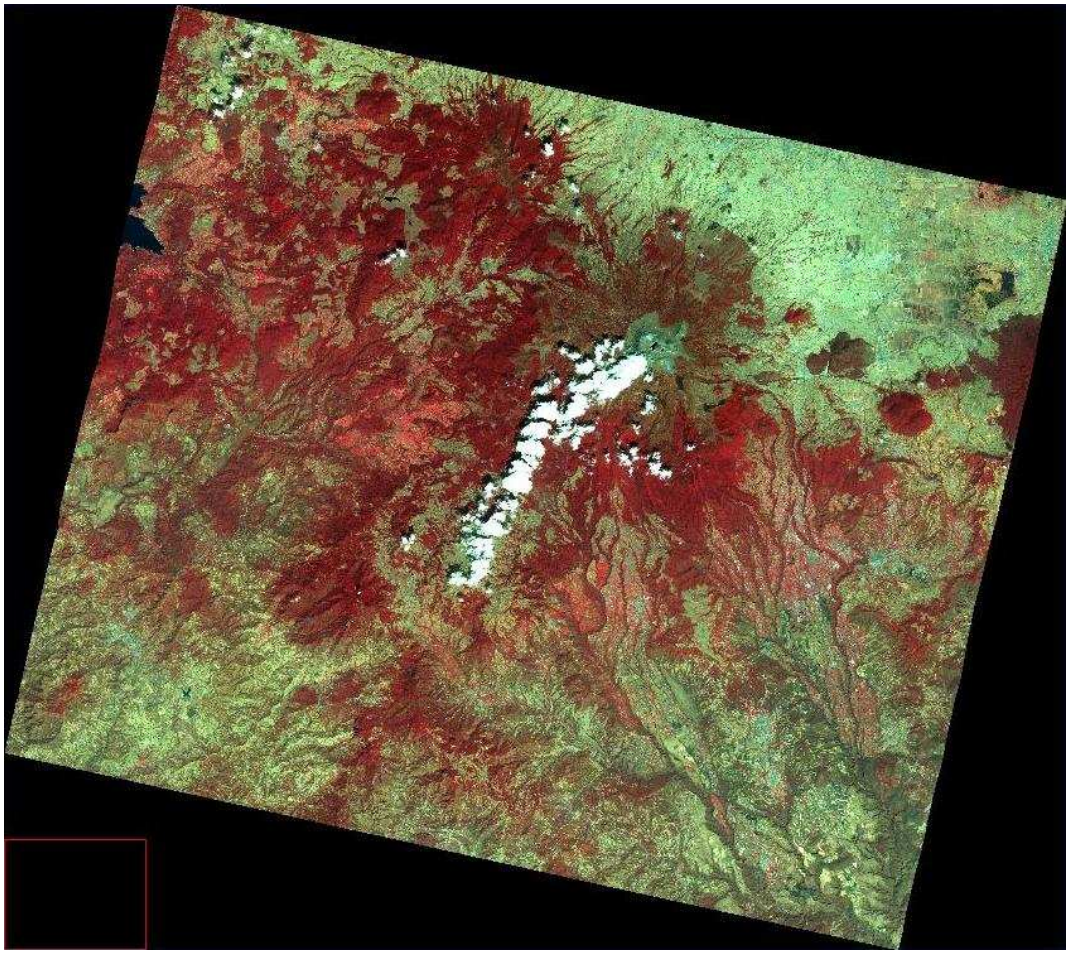
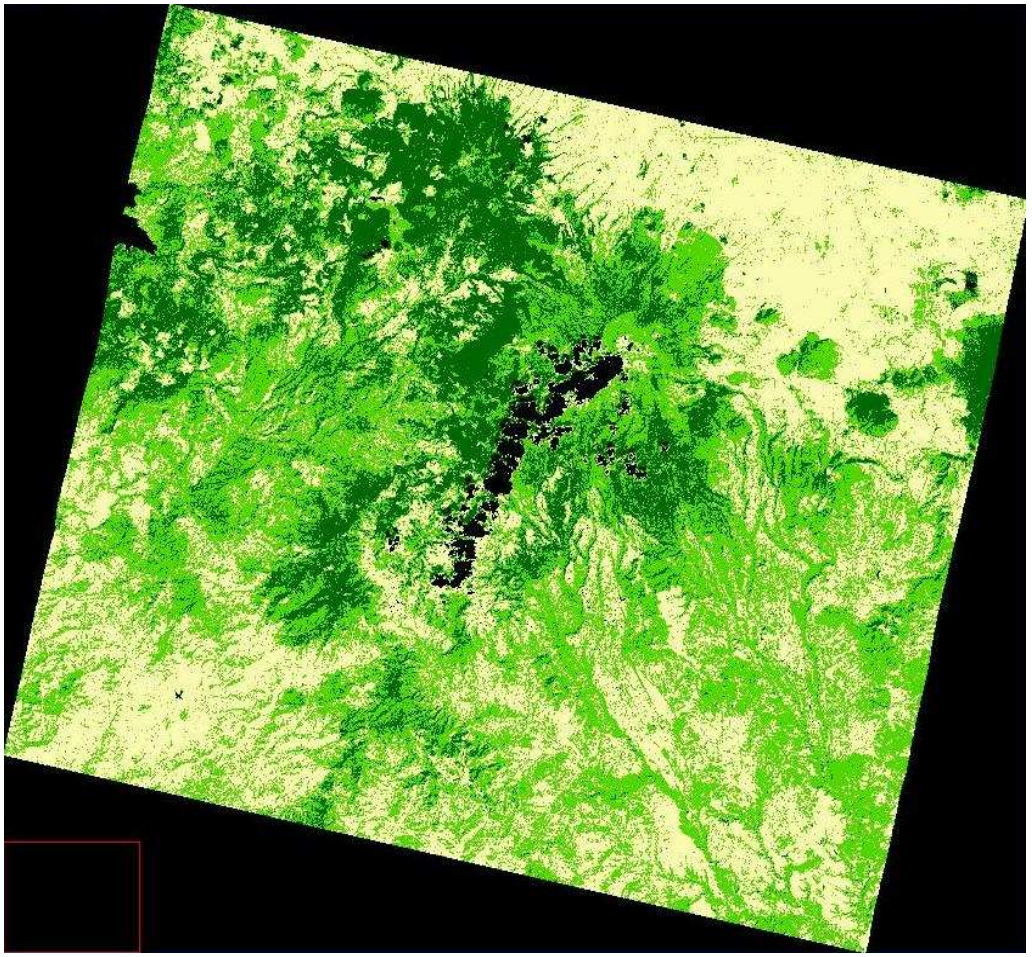
Extraction of continuous fraction data

High resolution training data – SPOT 10 m





4 classes: herbaceous/shrubs, trees, bare soil, others: water, clouds, shadows, etc.

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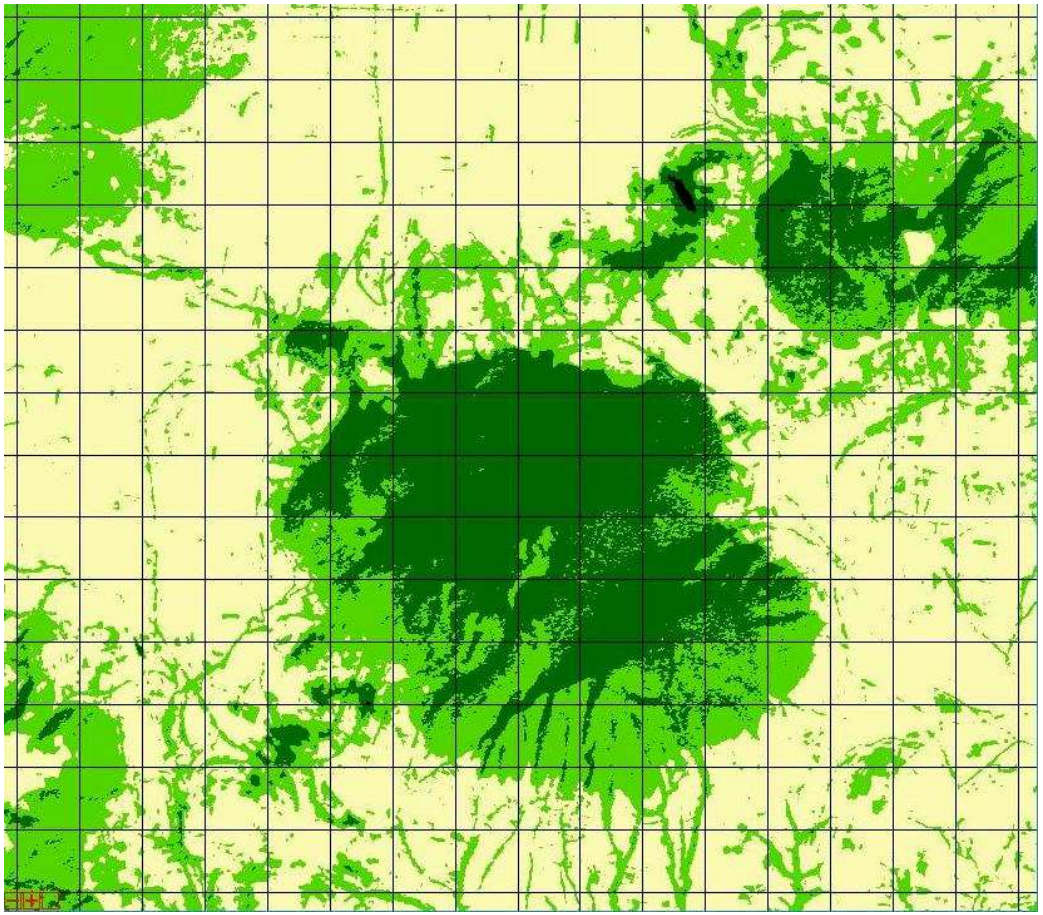
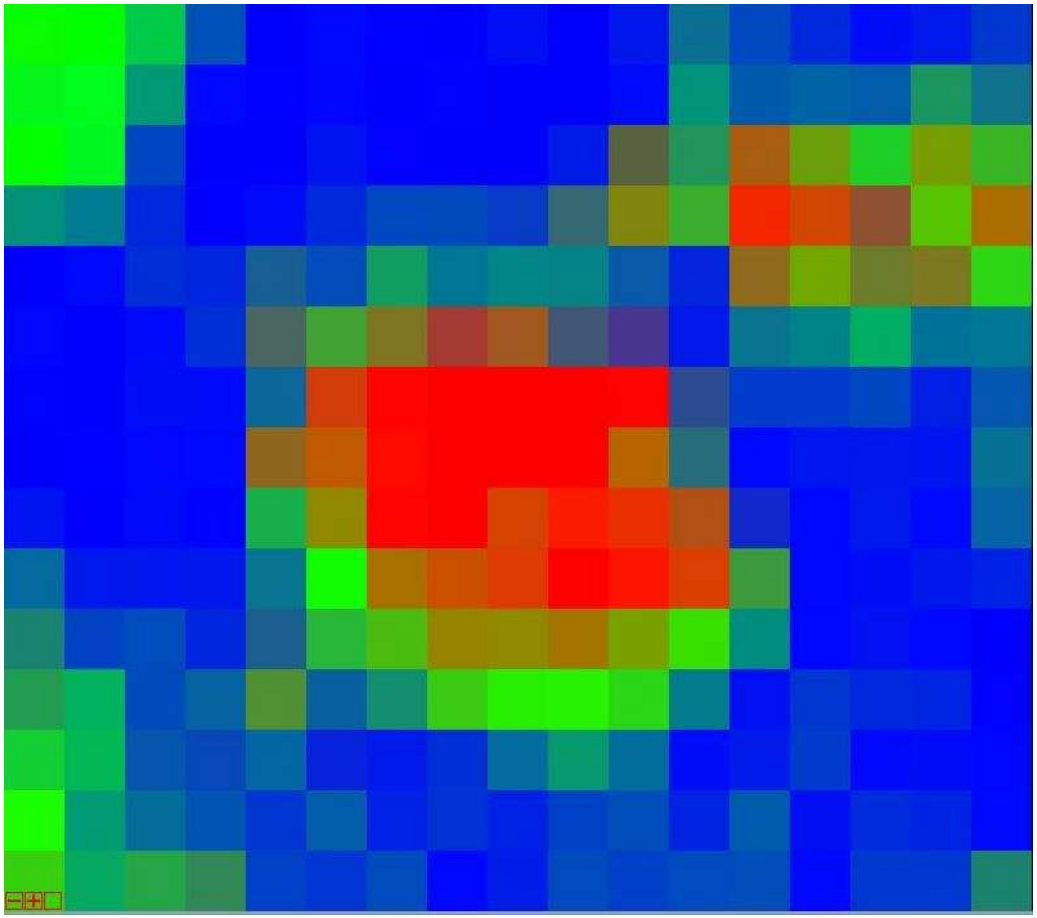
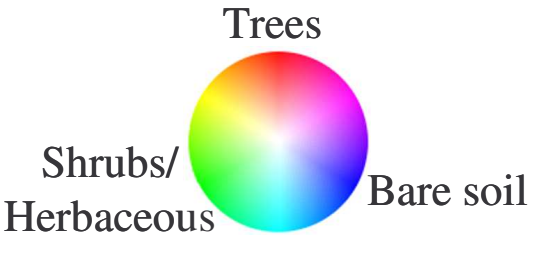
Extraction of continuous fraction data

Land cover fraction from SPOT data adjusted to MODIS resolution







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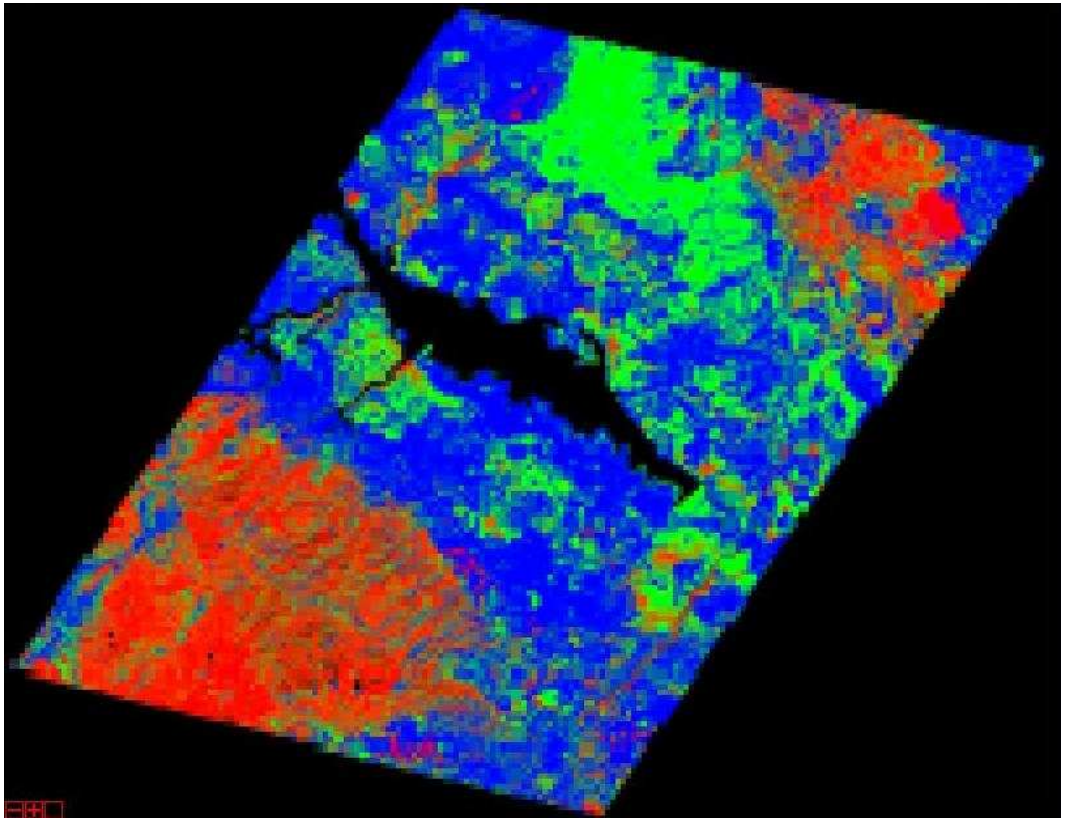
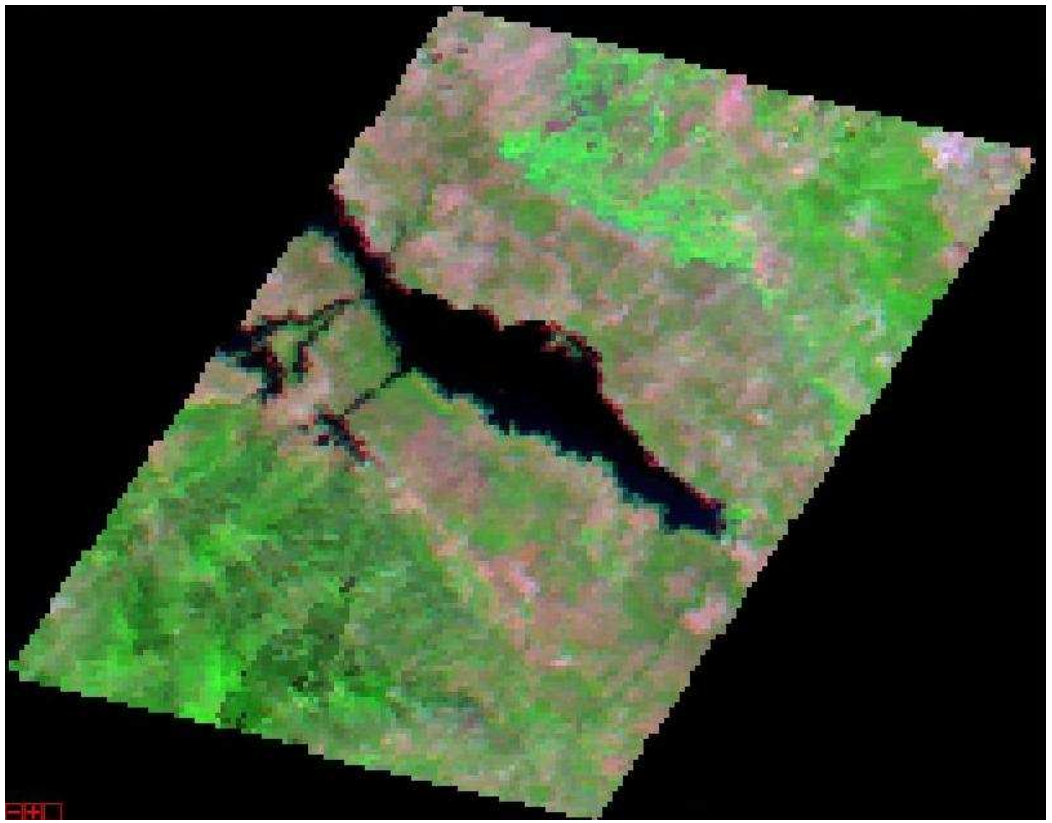
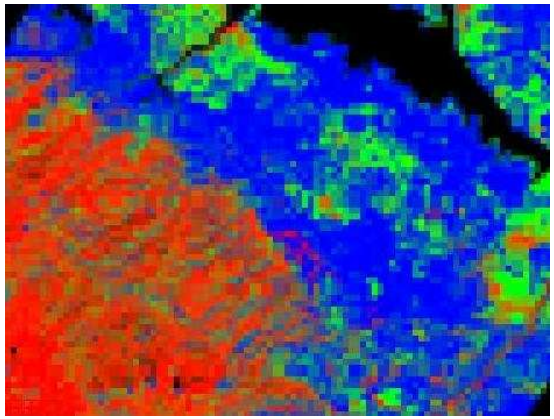
Extraction of continuous fraction data – using SVR

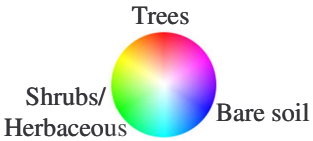
Apply algorithm for regression - SVR

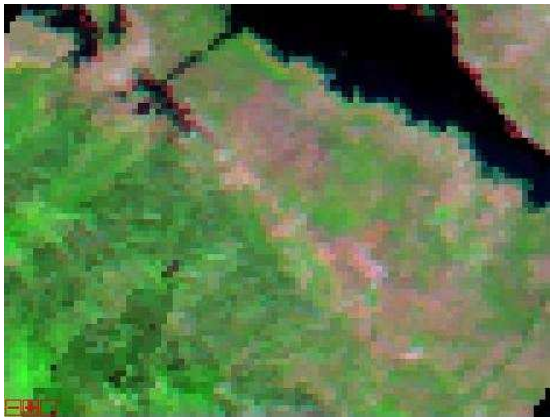




Training data derived from SPOT data 500 m







MODIS MOD09 500 m

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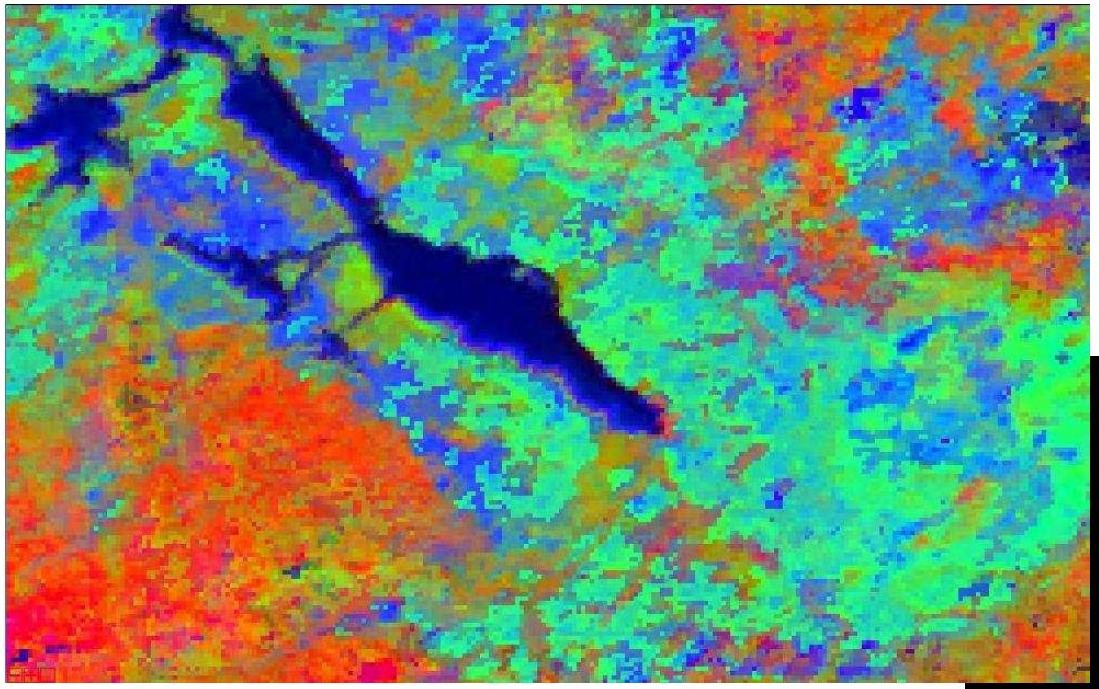
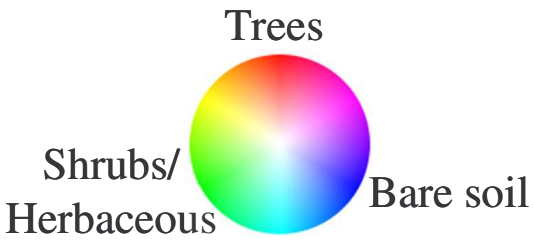
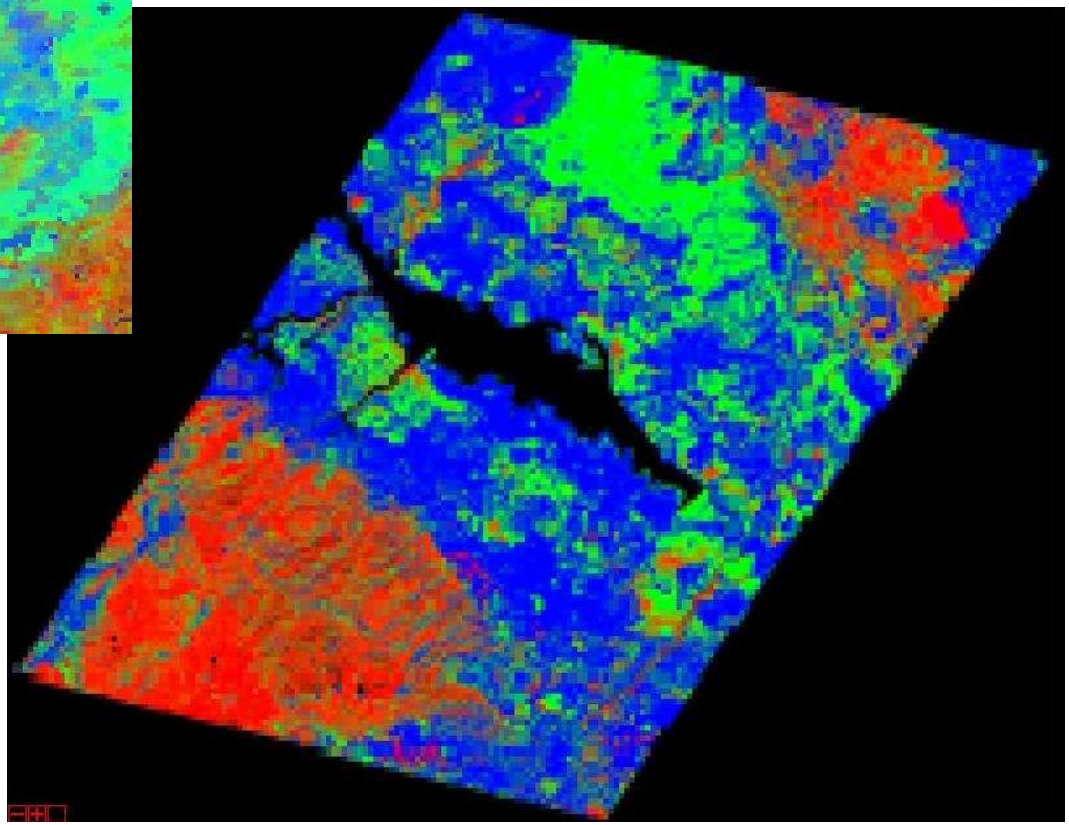
Extraction of continuous fraction data – using SVR



•Preservation of structures



•Original training data



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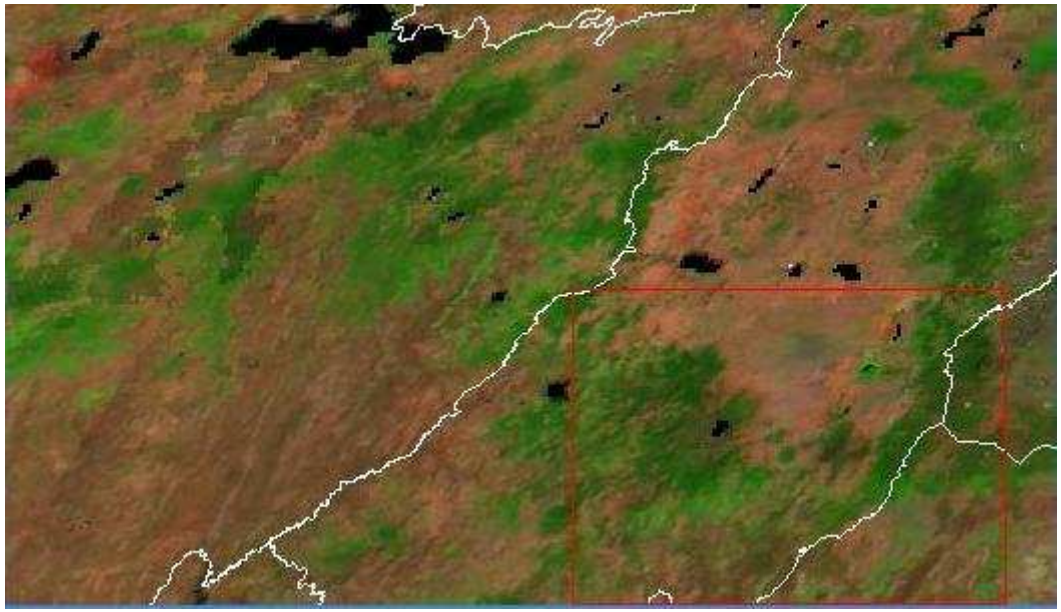
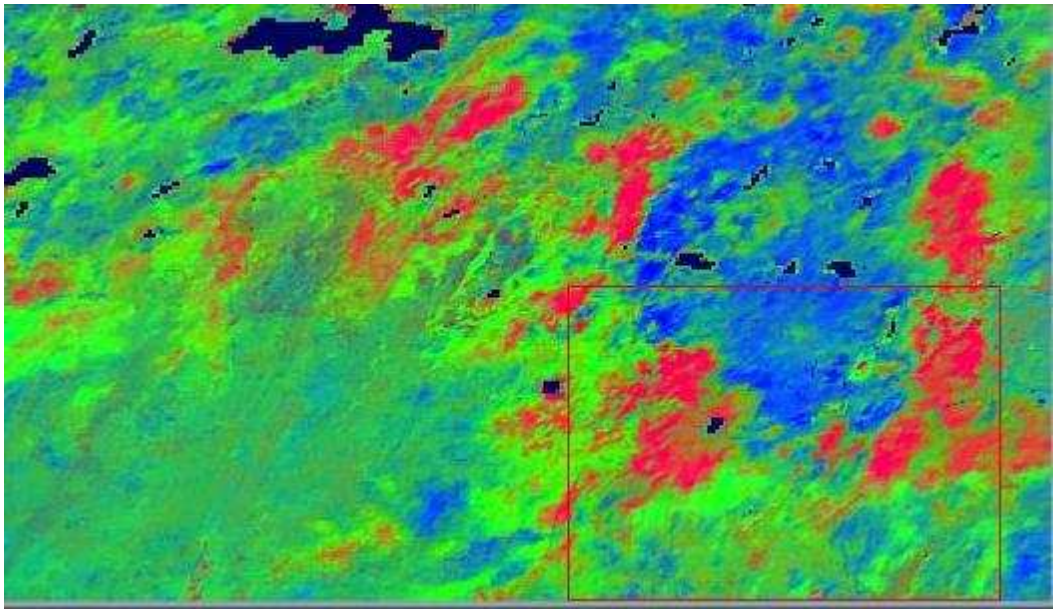
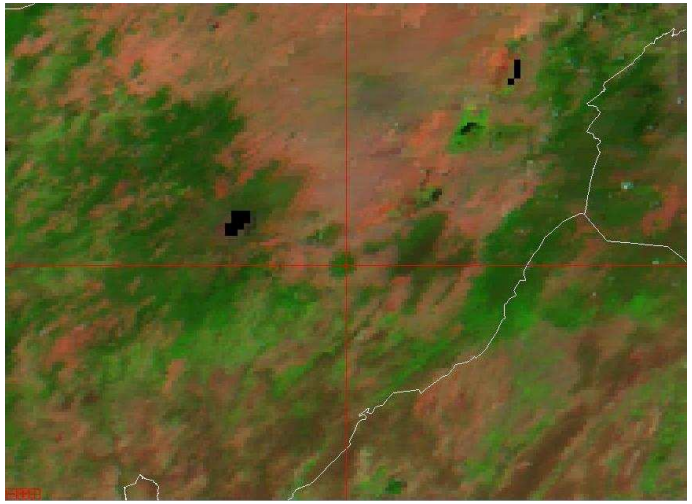
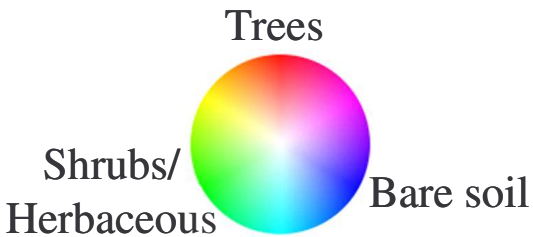
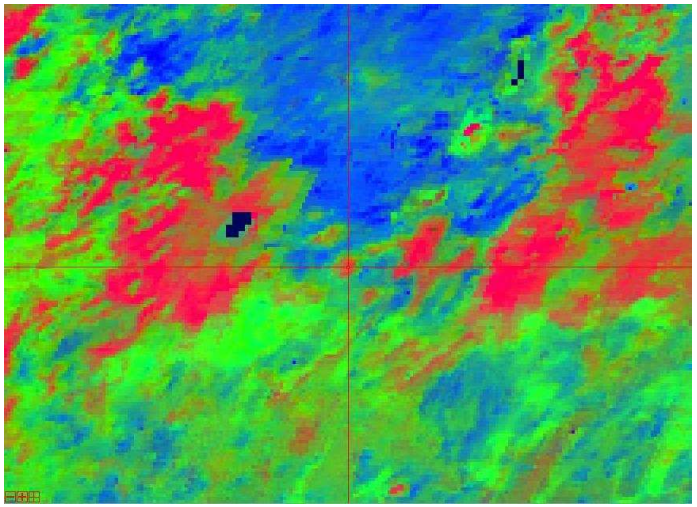
Extraction of continuous fraction data using SVR











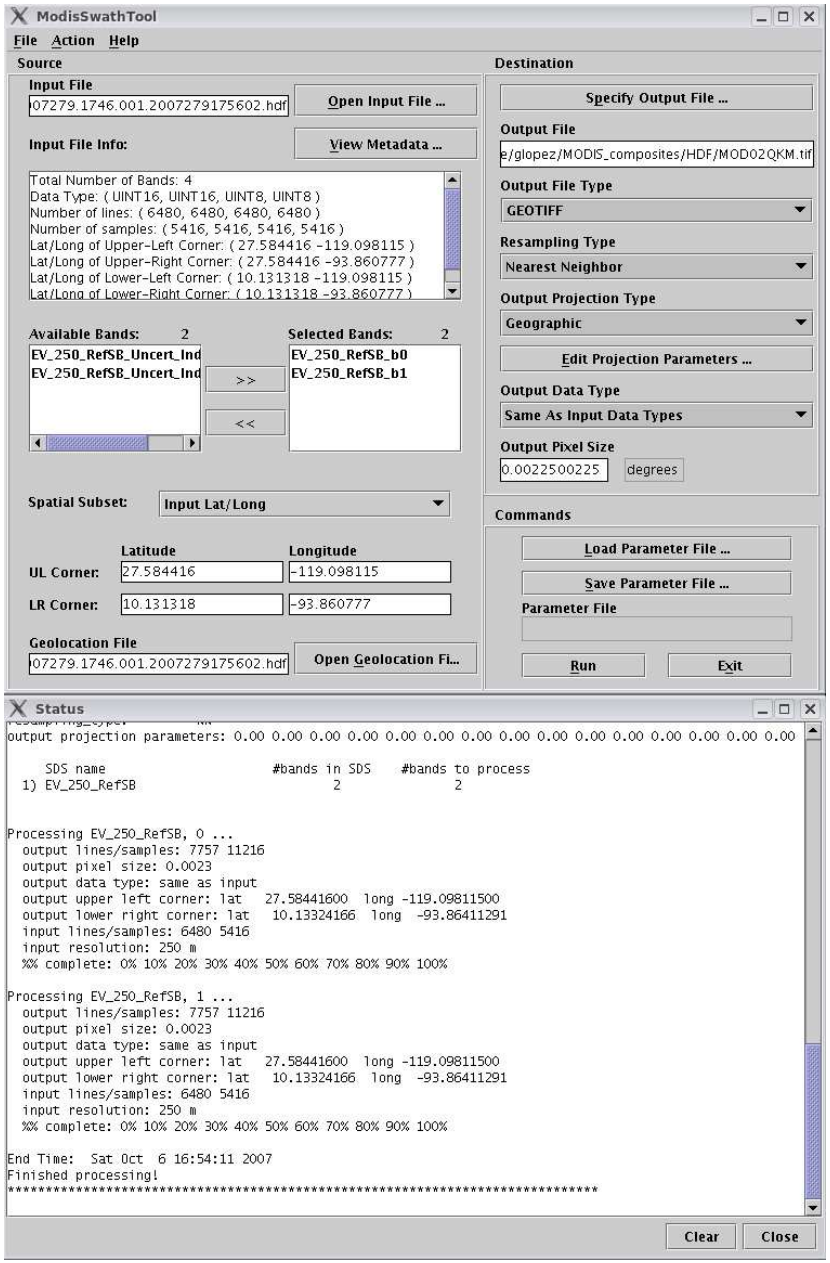
CONABIO

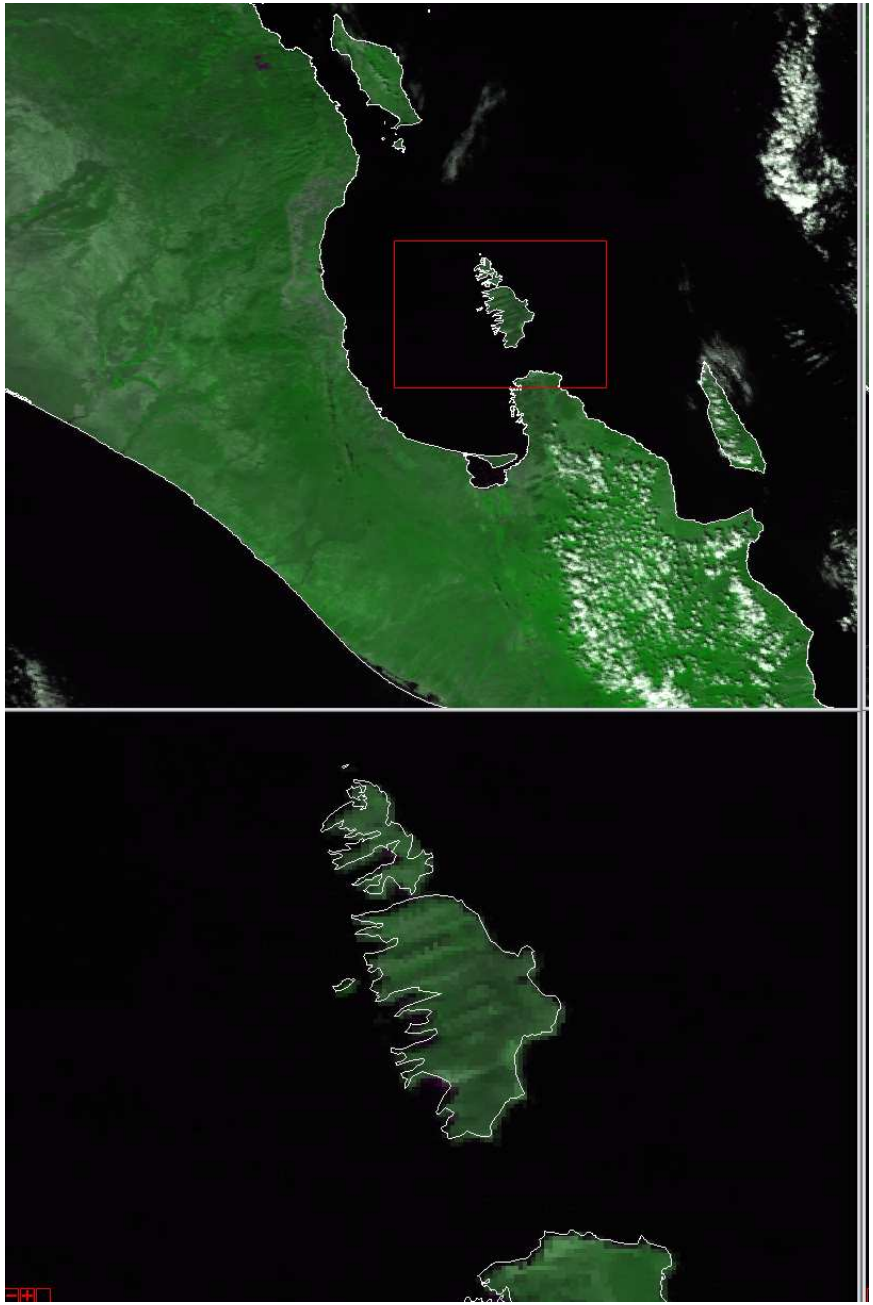
Status

- Framework is developed in Python, MySQL as DBMS
- **Implemented functionalities**
  - Data import, filtering (QA and angles) and linear interpolation
  - Dynamic composite creation
  - Profile generation
  - Regression (still file based)

CONABIO

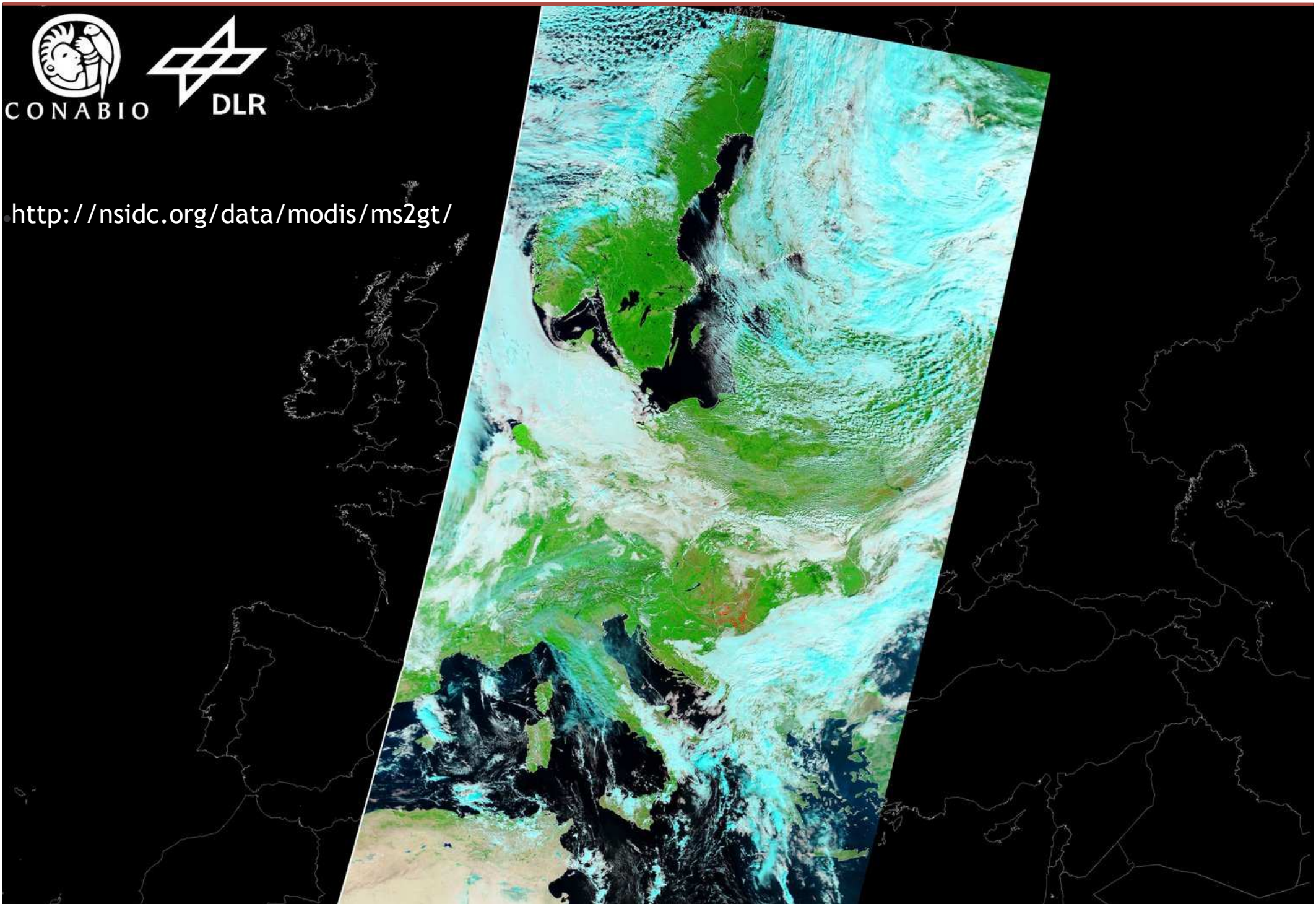
MODIS Swath data reprojection



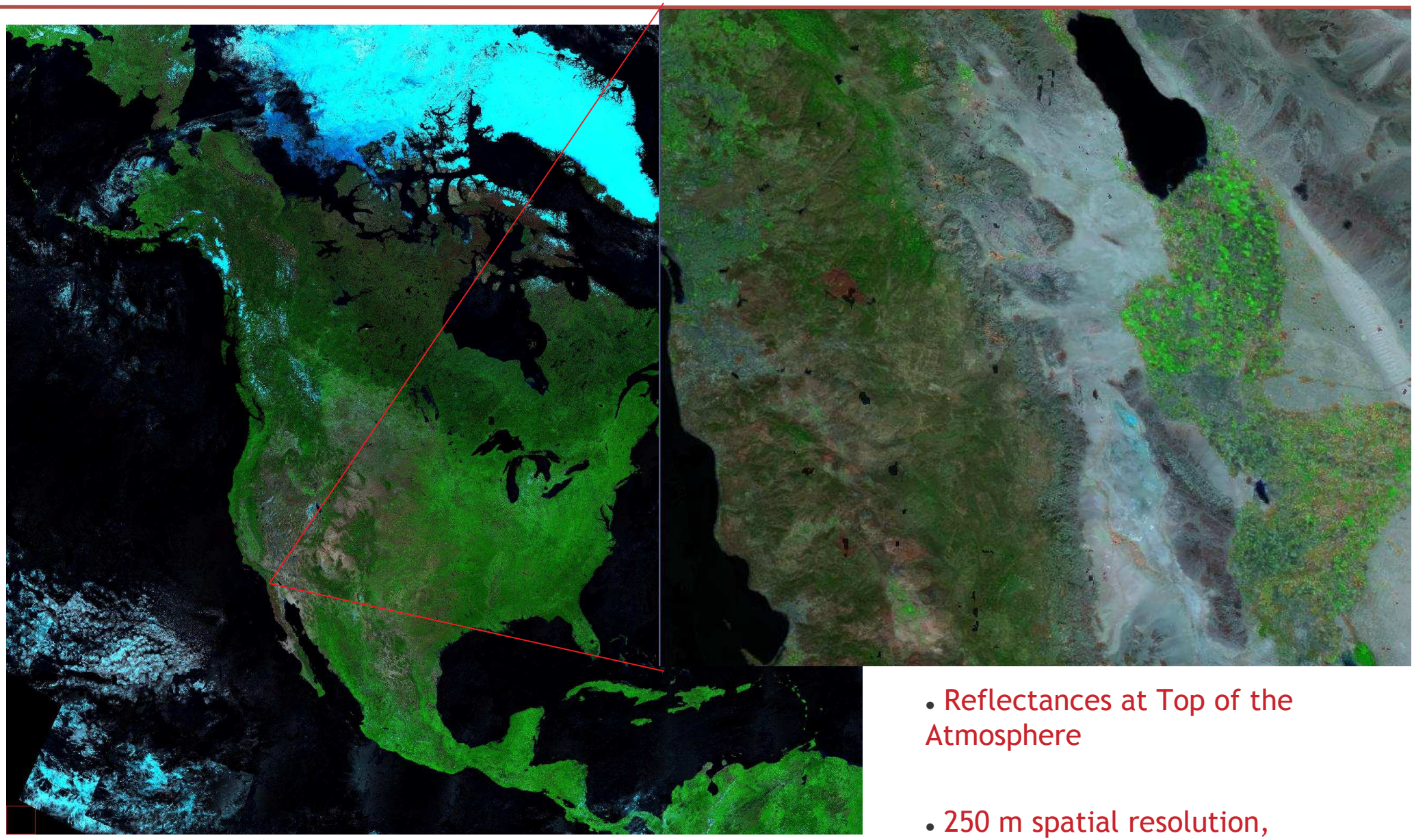


CONABIO

MS2GT: The MODIS Swath-to-Grid Toolbox



NALCMS – CCRS monthly MODIS composite



- Reflectances at Top of the Atmosphere

- 250 m spatial resolution, downscaling for bands 3-7 ()

CONABIO

Summary and outlook

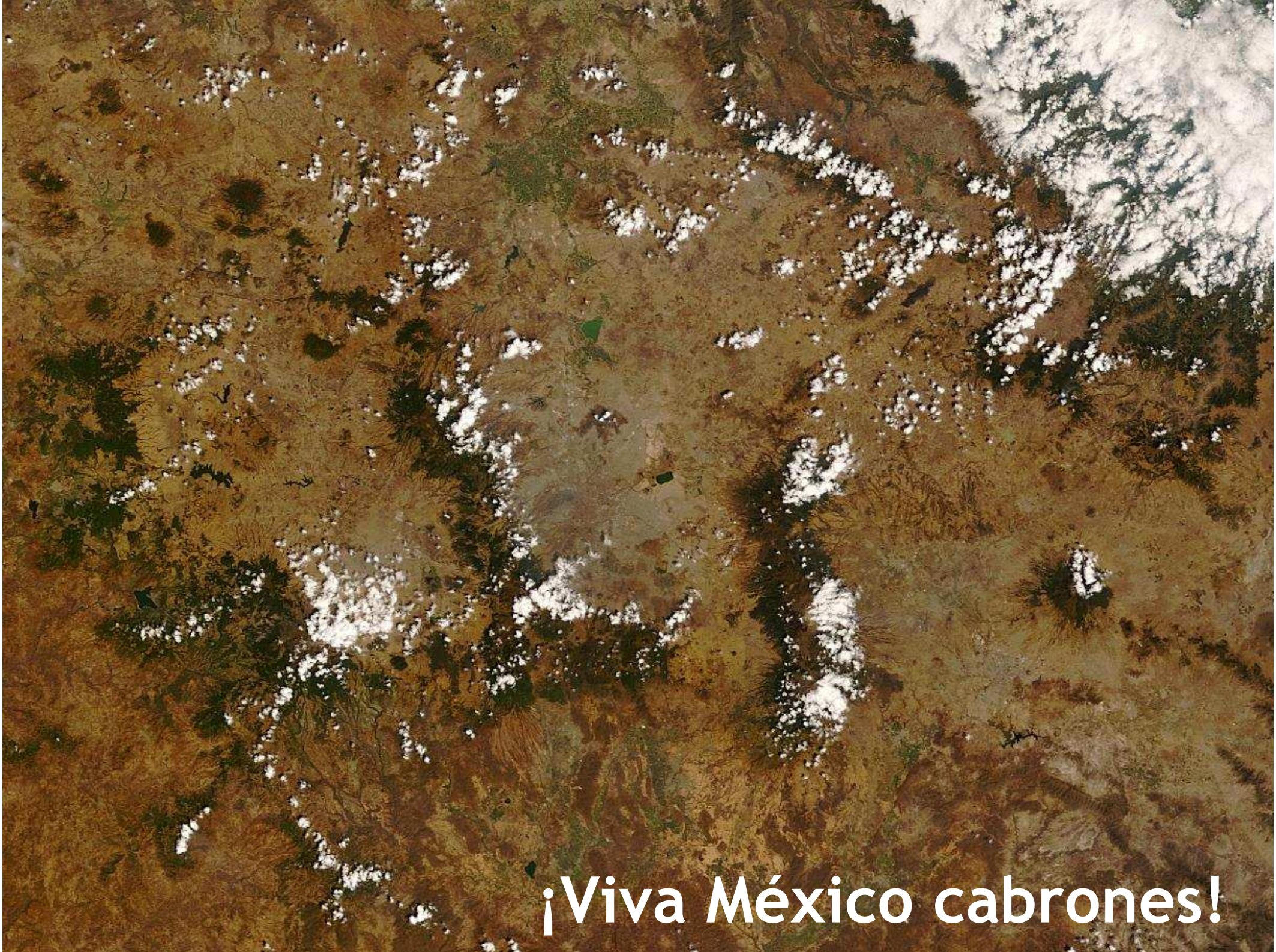
Framework

- Adapt import function to swath data, ingesting MOD09 and correct BRDF
- Test prototype and fix bugs
- Implement regression functionality to database system
- Enhance filtering algorithms for small clouds and cloud shadows

Analysis

- Enhance the basis of training samples, maybe use field data, why not?
- Design classification scheme for classes with dynamic spectral behaving
- Validate results with high resolution (SPOT / IRS) data

CONABIO


¡Viva México cabrones!