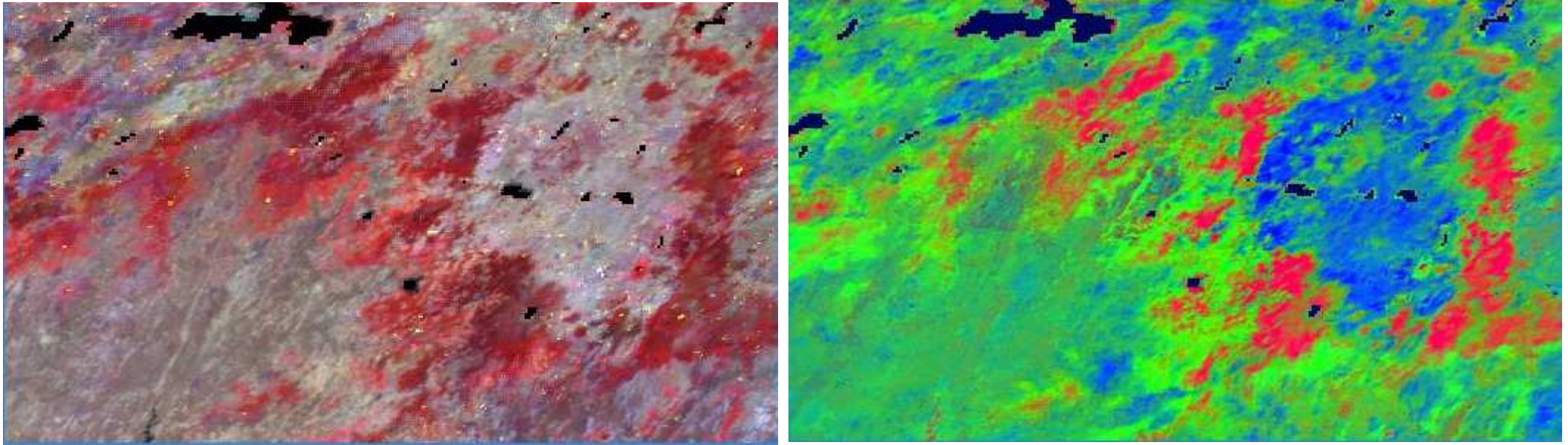


Land Cover Change / Fractional Vegetation Cover

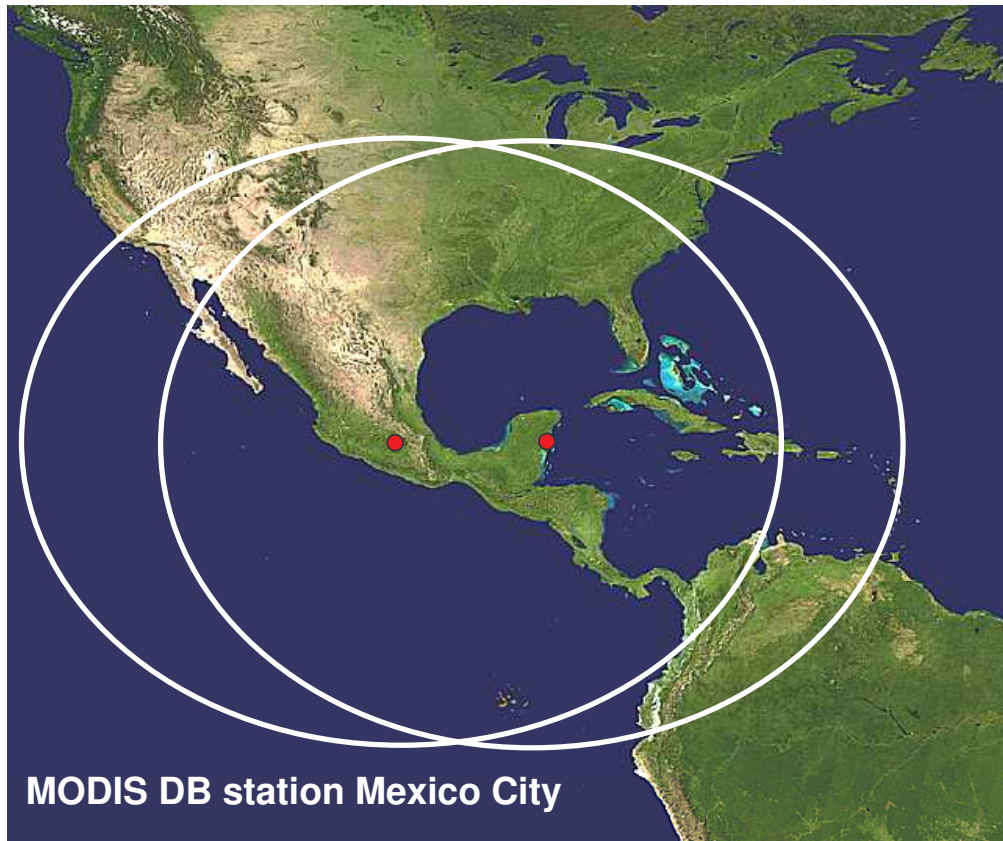
Gerardo López Saldaña, Thilo Wehrmann

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





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

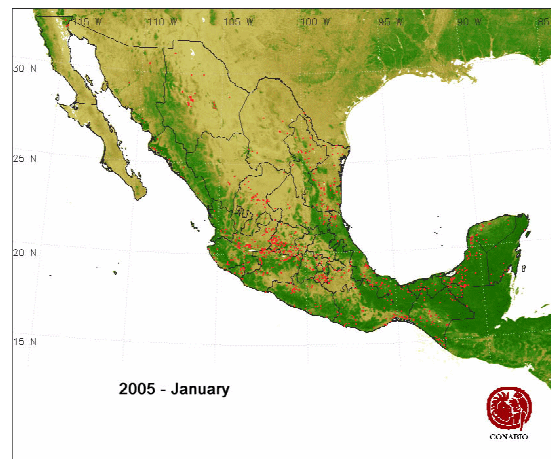
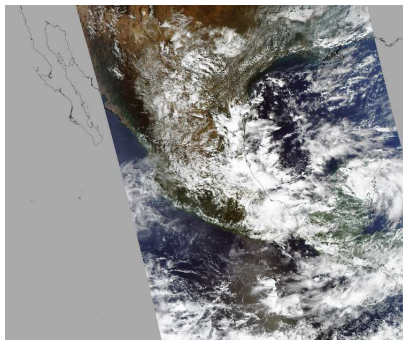
Land cover & change detection studies

Mangrove National Inventory

Oceanic studies

Sea Surface Temperature (climate change)

Chlorophyll -a concentration (ocean colour)



CONABIO



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



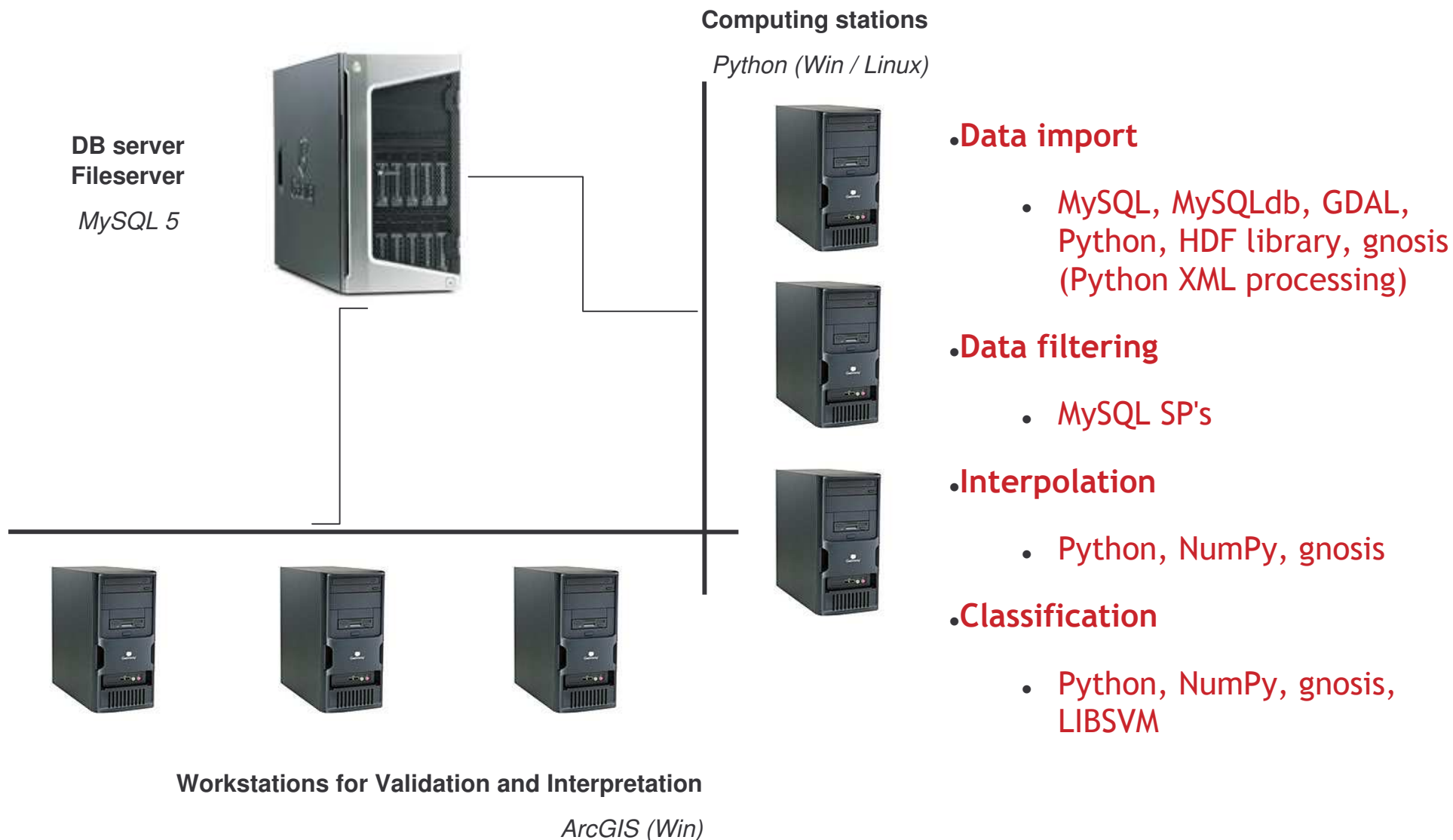
Objectives

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).



System components



MODIS data

EOS Data Gateway: Primary Data Search - Firefox

http://deleann.gsfc.nasa.gov/ims-bin/pub/nph-ims.cgi?sid=1182288388-90: eos data gateway

Search Creation: **Primary Data Search**

Have a question, a problem, or a comment? | Help for this page

Save/Restore search | Clear search

Choose Data Sets Text Search: Go Help

Pick a discipline/topic (for example: Atmosphere:MISR), then choose from the list of data sets.
For multiple topics: choose one topic & data sets, then the next topic & data sets.
To select/deselect more than one data set, use Ctrl-click for PCs; Apple-click for Macintosh.

MODIS/AQUA SURFACE REFLECTANCE DAILY L2G GLOBAL 500M SIN GRID V004

MODIS/AQUA GEOLOCATION ANGLES DAILY L2G GLOBAL 1KM SIN GRID DAY V004
MODIS/AQUA GROSS PRIMARY PRODUCTIVITY 8-DAY L4 GLOBAL 1KM SIN GRID V005
MODIS/AQUA LAND SURFACE TEMPERATURE/EMISSIONIVITY 5-MIN L2 SWATH 1KM V004

View Data Set Definition Choose Data Set Keywords

Atmosphere:	Cryosphere:	Land:	Oceans:	Solar/Other:
☐ AIRS/AMSU-A/HSB	☐ AMSR/AMSR-E	☐ AMSR/AMSR-E	☐ ADEOS	☐ ACRIM
☐ AMSR/AMSR-E	☐ MOPITT	☐ ASTER	☐ AMSR/AMSR-E	☐ Field/In Situ
☐ AVHRR	☐ ESMR/SSMR	☐ AVHRR	☐ AVHRR	☐ GLAS/ICESat
☐ CERES/Aqua	☐ GLAS/ICESat	☐ GLAS/ICESat	☐ GLAS/ICESat	☐ SORCE
☐ CERES/Terra	☐ SSM/I	☐ MODIS/Aqua	☐ MODIS/Terra	☐ UARS
☐ CERES/TRMM	☐ TES/Aura	☐ MODIS/Terra	☐ MISR	
☐ GLAS/ICESat	☐ TOMS	☐ SAR	☐ Landsat 1-5	
☐ MISR	☐ TRMM	☐ SSM/I	☐ MODIS/Aqua	
☐ MLS/Aura	☐ UARS	☐ MODIS/Terra	☐ SEASAT	
☐ MODIS/Aqua		☐ SSM/I	☐ SEAWIFS	

"By Discipline" not responding? Use the [non-javascript version](#)

☒ By Discipline ☐ By Categories/Attributes

Choose a Data Search Type

☒ Primary Data Search ☐ Data Granule ID Search ☐ Local Granule ID Search

Choose Search Area

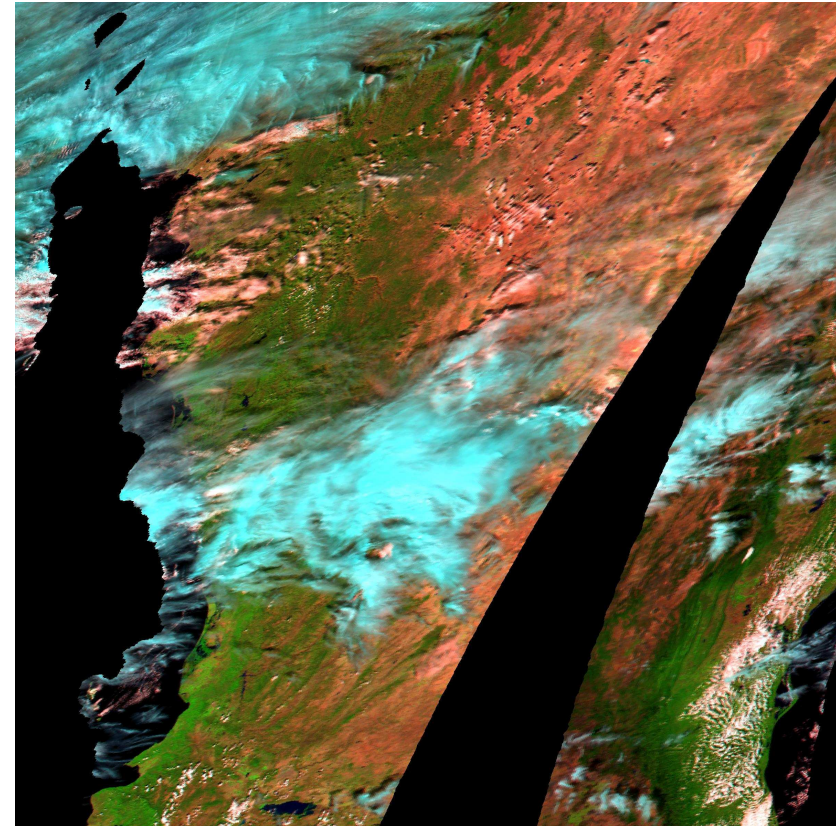
Find location using Gazetteer*

Projection: ORTHOGRAPHIC
Tangent: 13.0000° Lat, -98.0000° Lon
Points in clockwise order are:
24.7447° Lat, -109.6311° Lon
24.8381° Lat, -88.8464° Lon
12.2565° Lat, -89.5044° Lon
12.1717° Lat, -108.7958° Lon

Change Orthographic Map (java) selection

Find: Next Previous Highlight all

Done



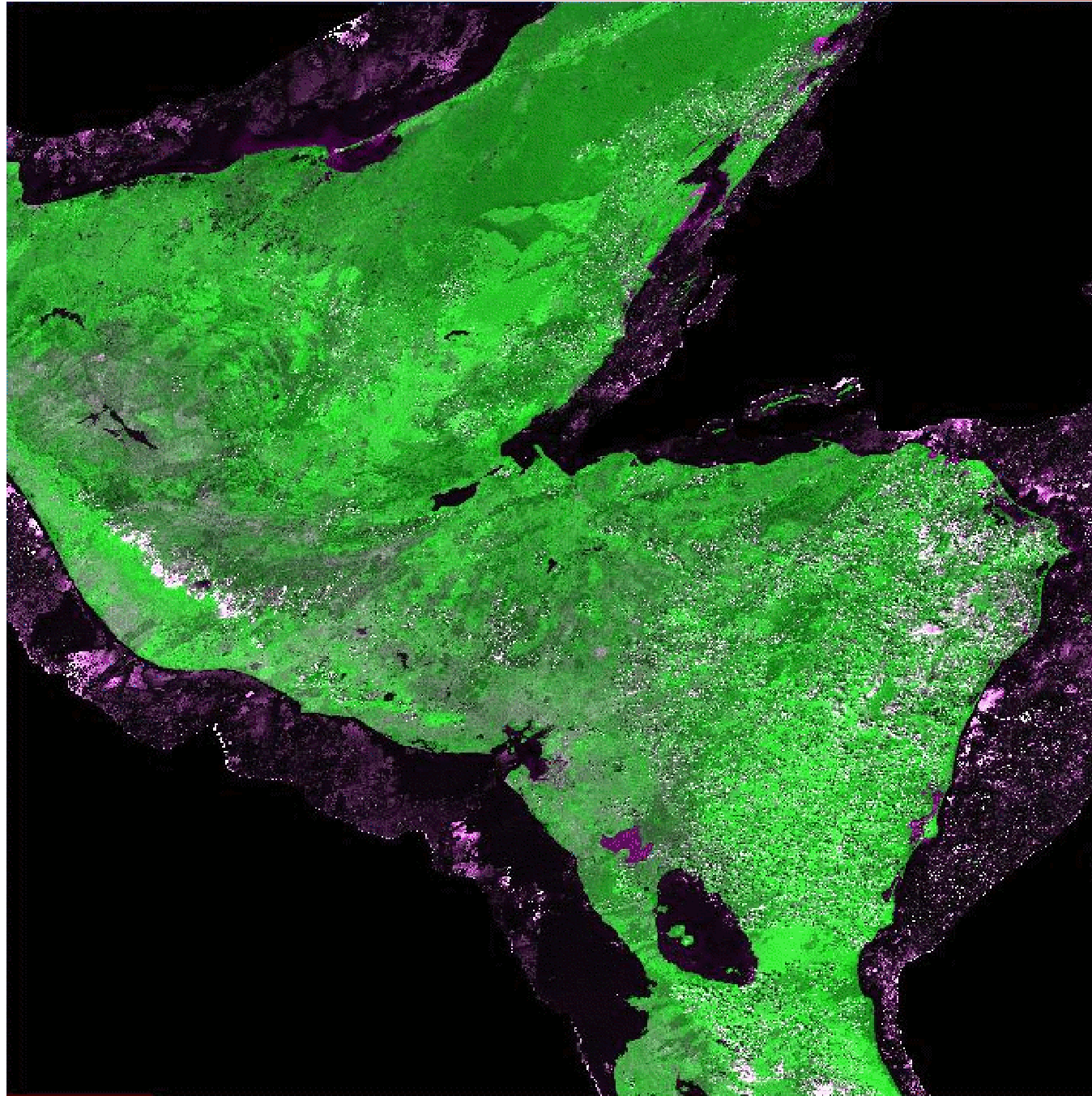
MODIS/Aqua, Surface Reflectance Daily L2G Global 500m Sinusoidal grid, V004

Earth Observing System Data Gateway

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



MODIS data preprocessing - original data set



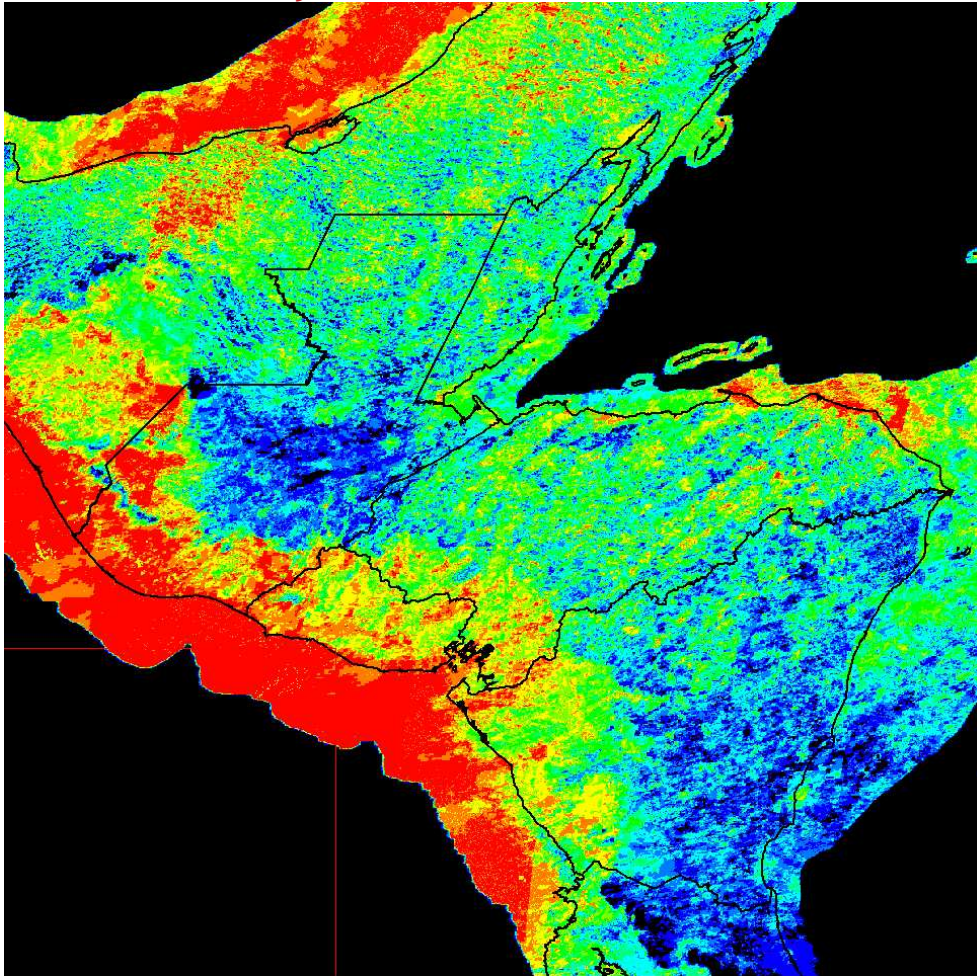
MODIS data preprocessing - data filtering

MOD09GST - Data availability for best pixels



0 Days

10 Days



Filtering by best QA

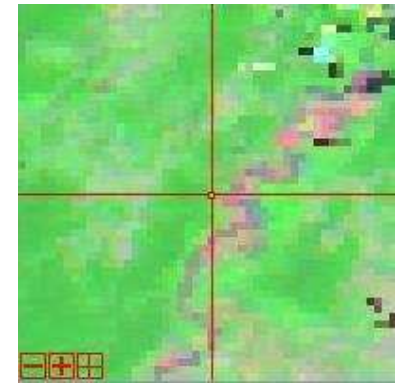
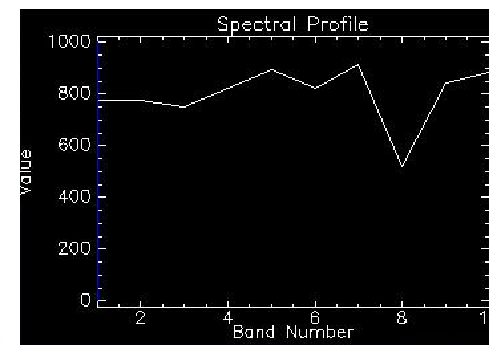
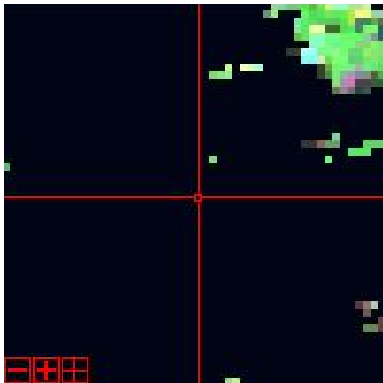
- QA (Quality Assessment) objective is to evaluate scientific quality of products generated from MODIS data
- Resampling QA from 1km to 500m and filter MOD09 using following criteria:
 - Bits 0-1, Cloud state=00, clear
 - Bits 3-5, Land/Water mask flag=100, land
 - Bits 6-7, Aerosol quality=00 or 01 or 10, climatology or low or average.

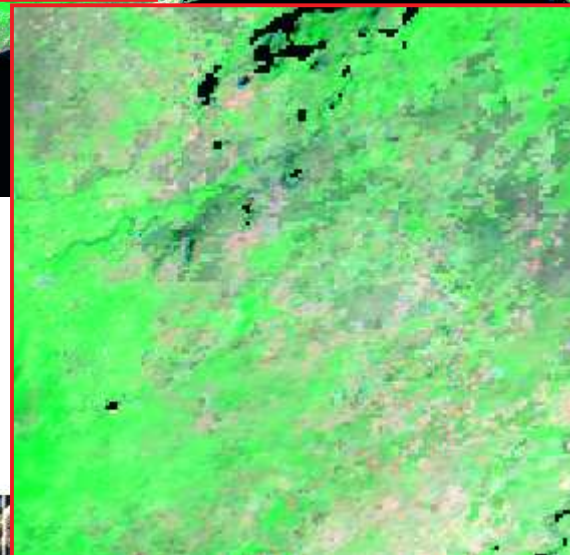
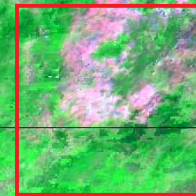
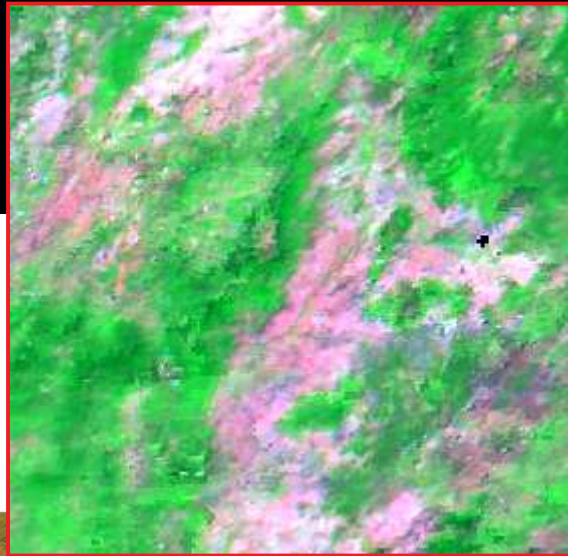


CONABIO



Gap filling using simple interpolation processing





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

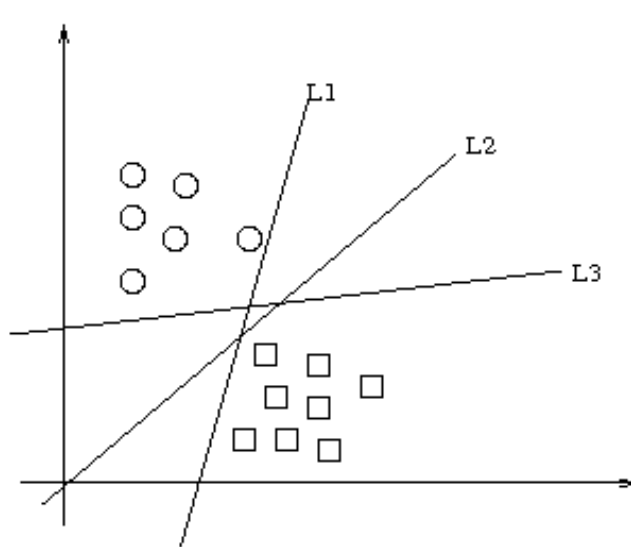


Identification of continuous/discrete fraction data

Support Vector Machines / Support Vector Regression

- Supervised learning method for classification and multivariate regression
- Considered a linear classifier 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



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

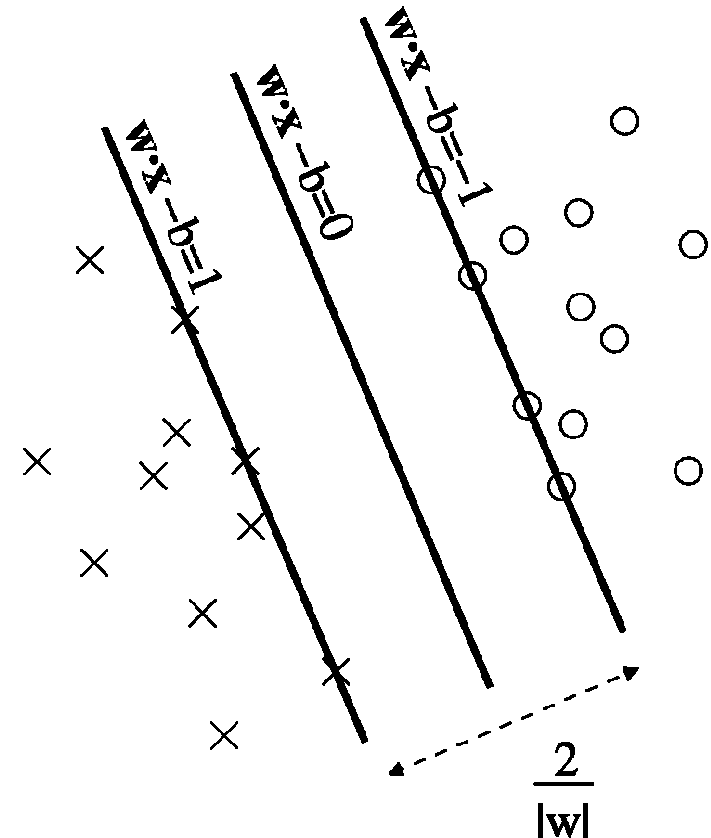
Hiperplane

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

$\mathbf{W}$ vector points perpendicular to Hyper-plane which divides classes.

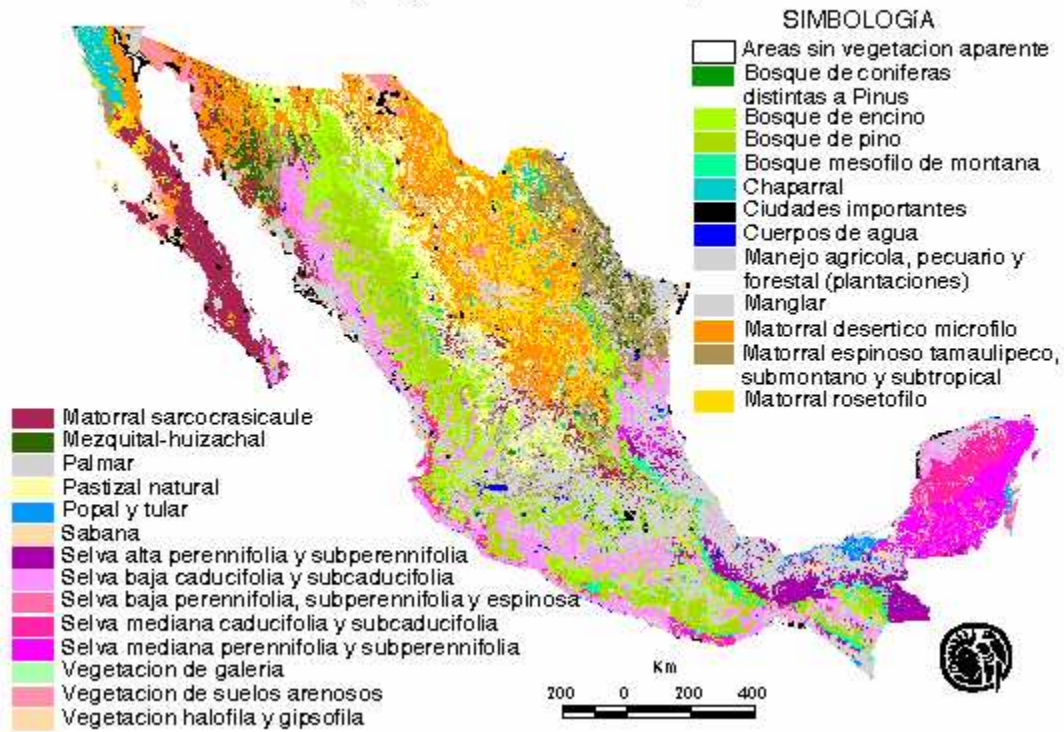
If training data has linear separability
It is possible to maximize the distance
between the hyper-planes $2/|\mathbf{w}|$,
therefore we want to minimize $|\mathbf{w}|$

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

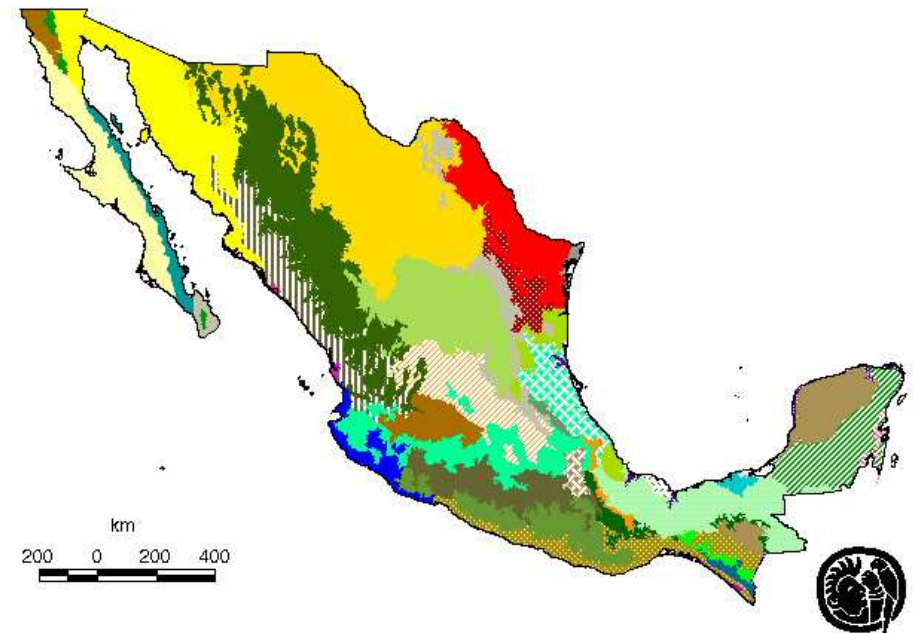


Goal is extraction of INEGI classes

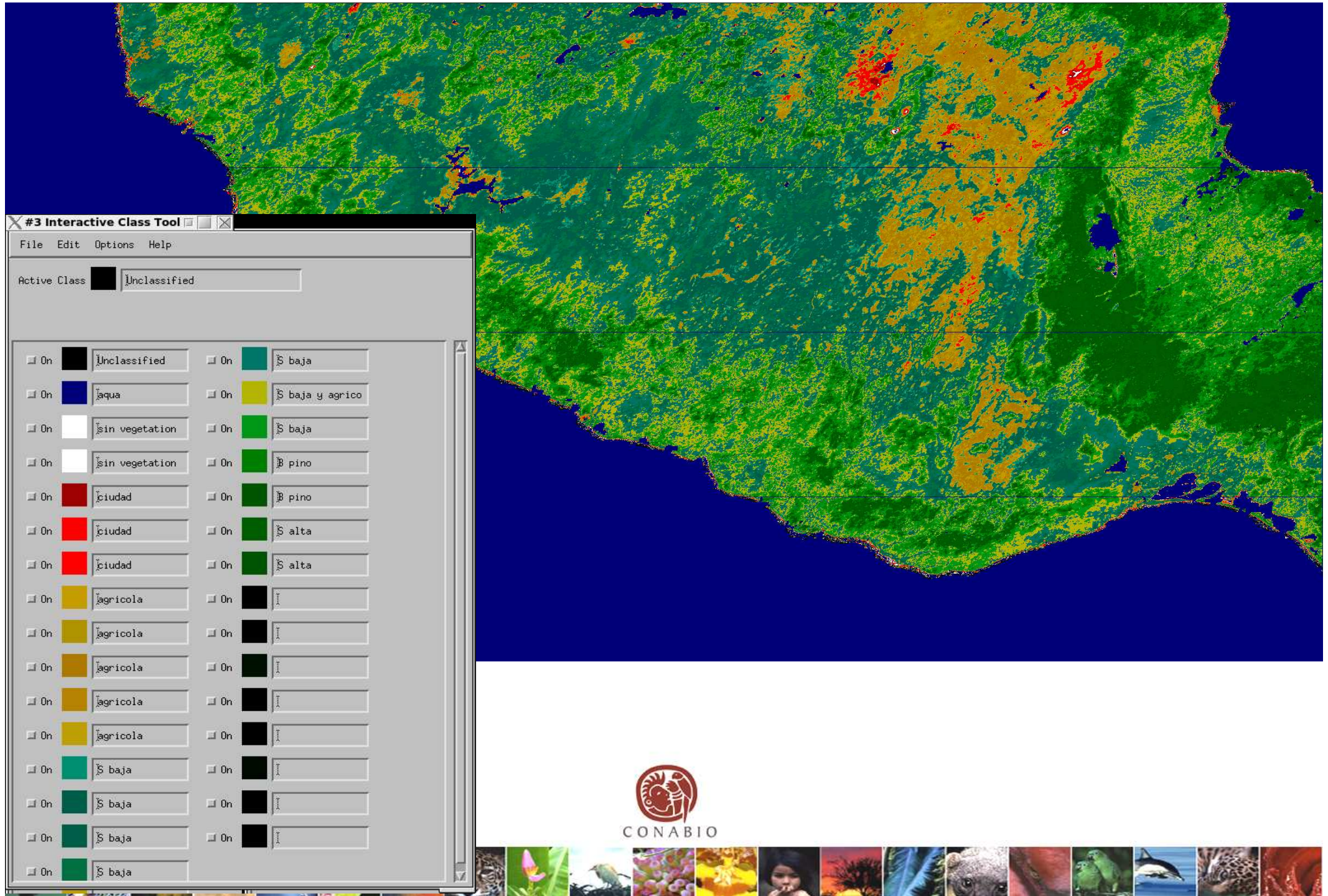
Uso de suelo y vegetación modificado por CONABIO



Ecorregiones de México, CONABIO

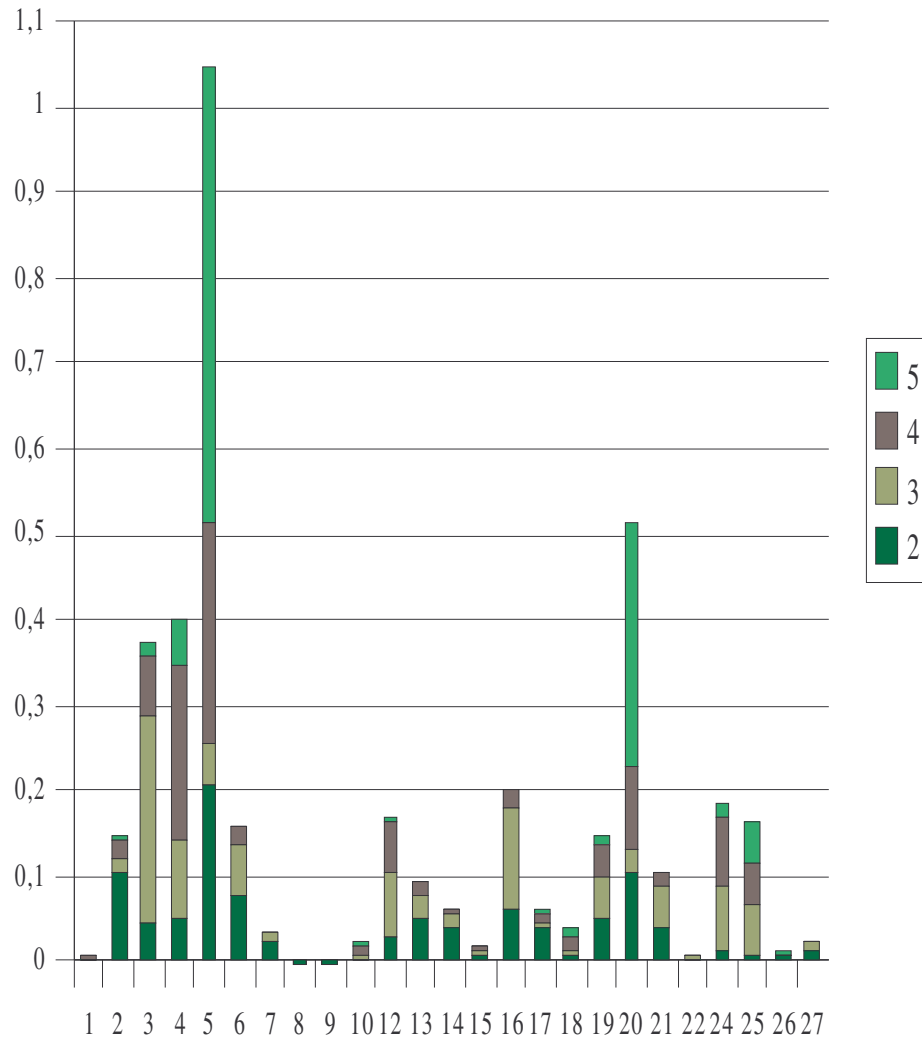


Unsupervised classification based on phenology 2005



Analysis of class composition

Bosque

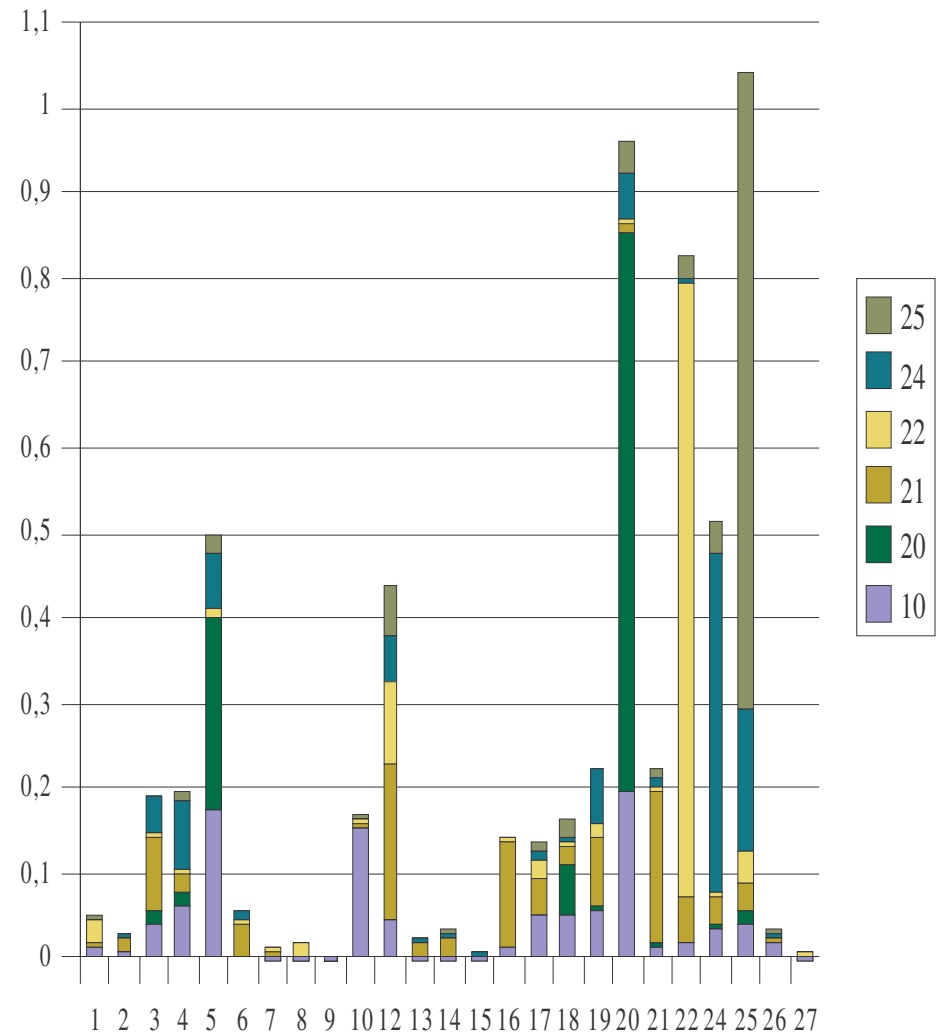


Bosque

Matorral

Selva

Selva



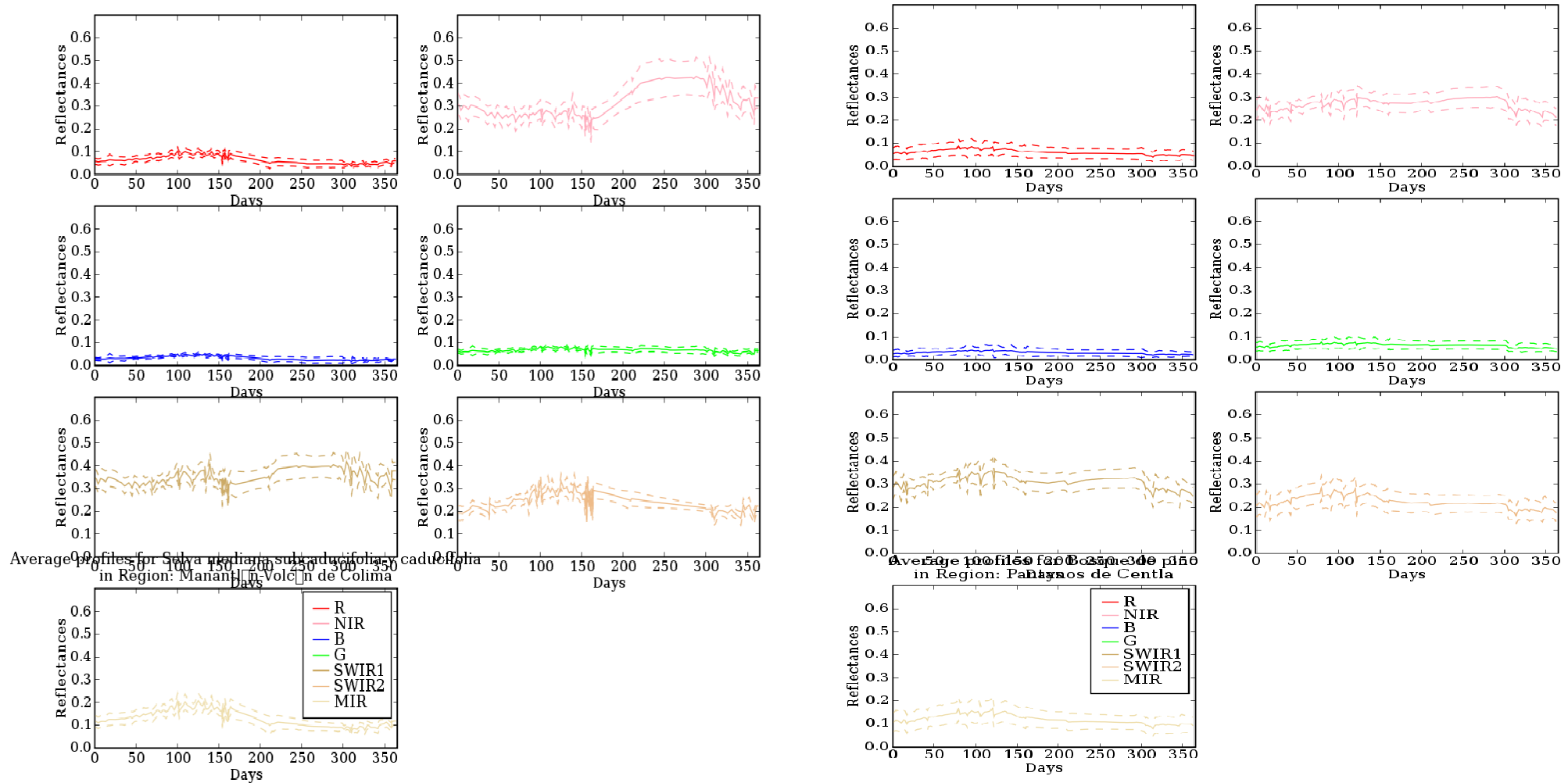
Bosque

Matorral

Selva



Analysis of temporal characteristics



Selva mediana subcaducifloa

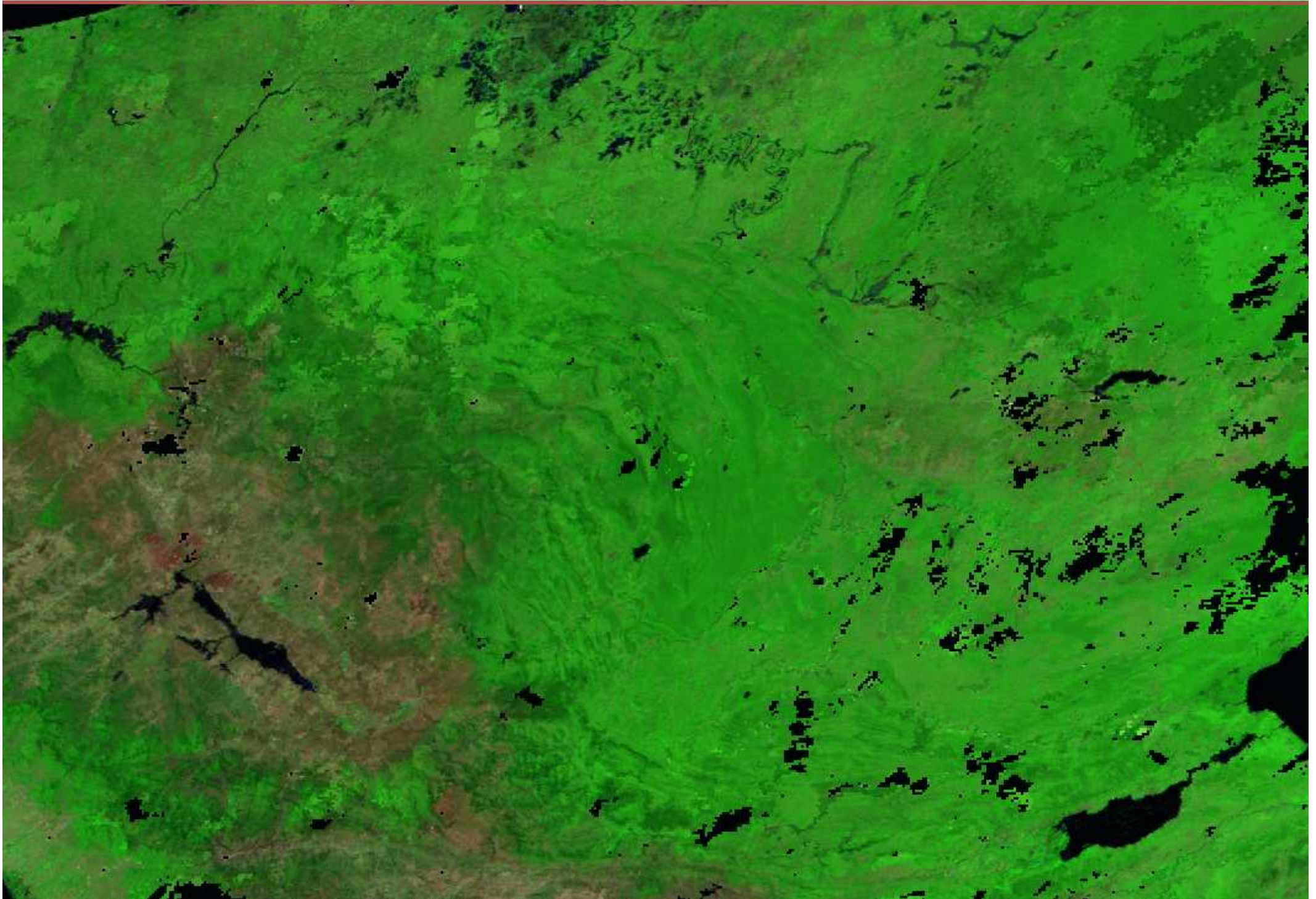
Bosque de pino



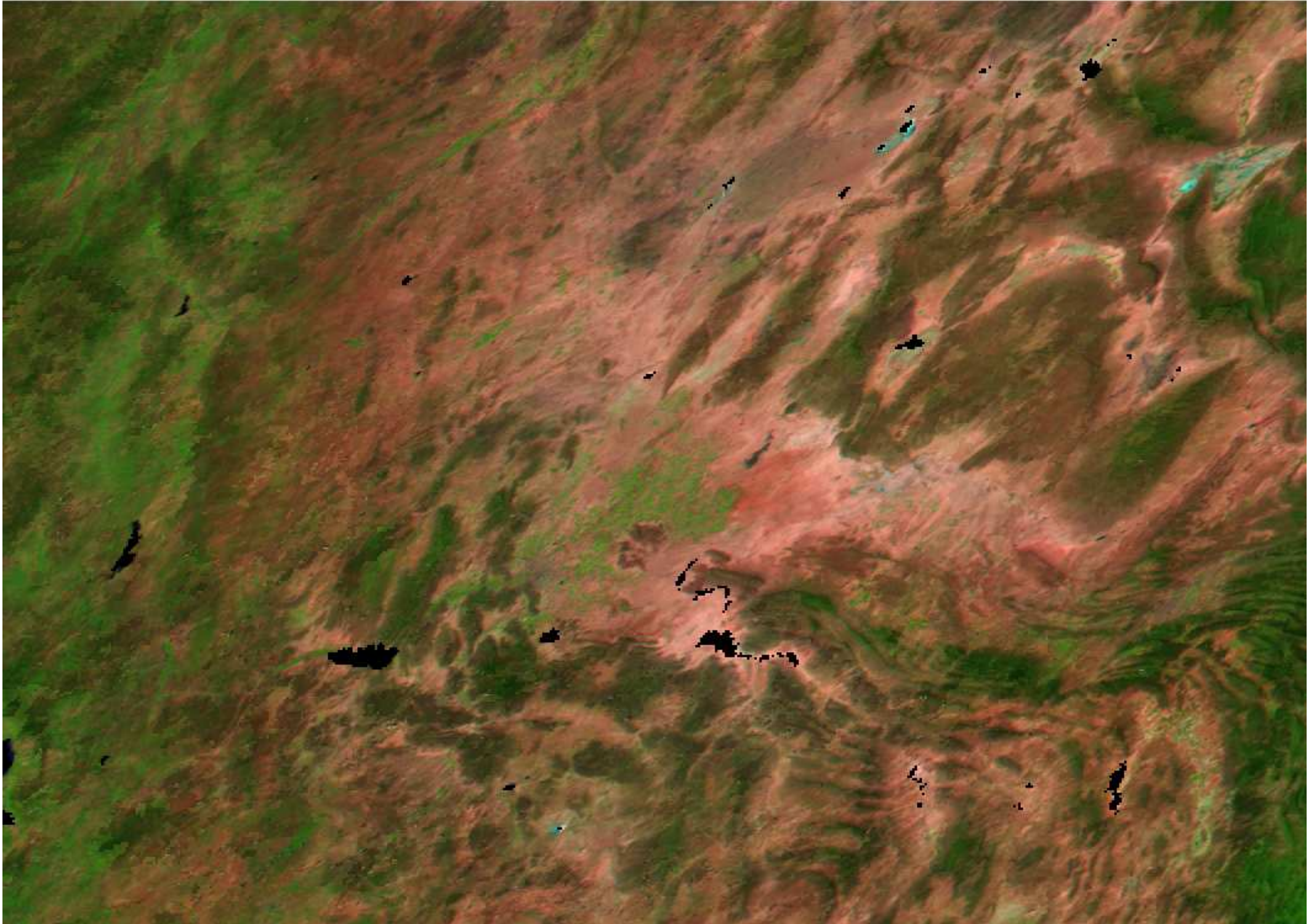
MODIS data preprocessing - composite creation



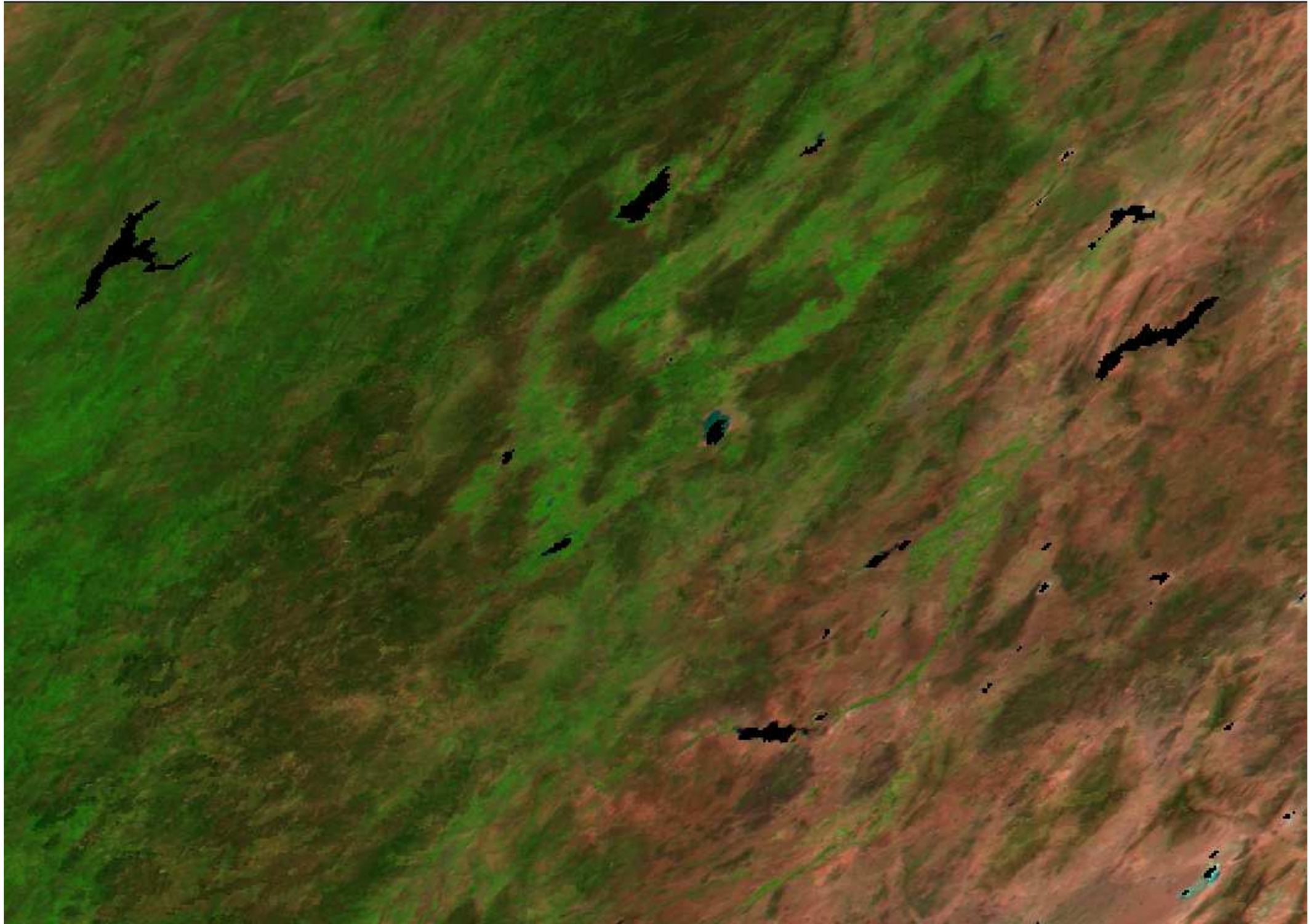
MODIS data preprocessing - composite creation (500m 721 RGB)



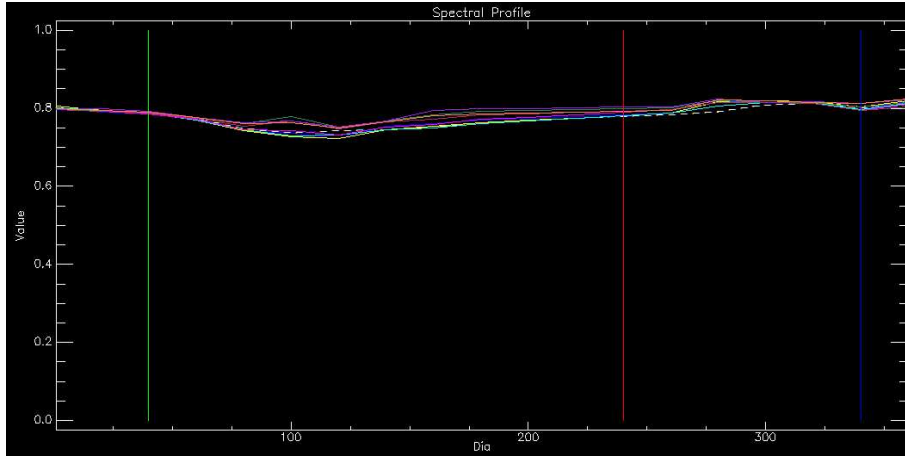
MODIS surface reflectance (500m 721 RGB)



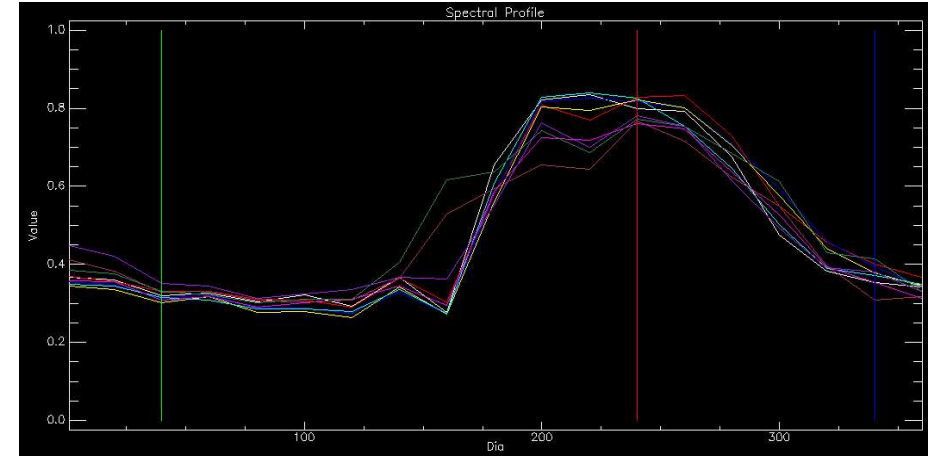
MODIS surface reflectance (500m 721 RGB)



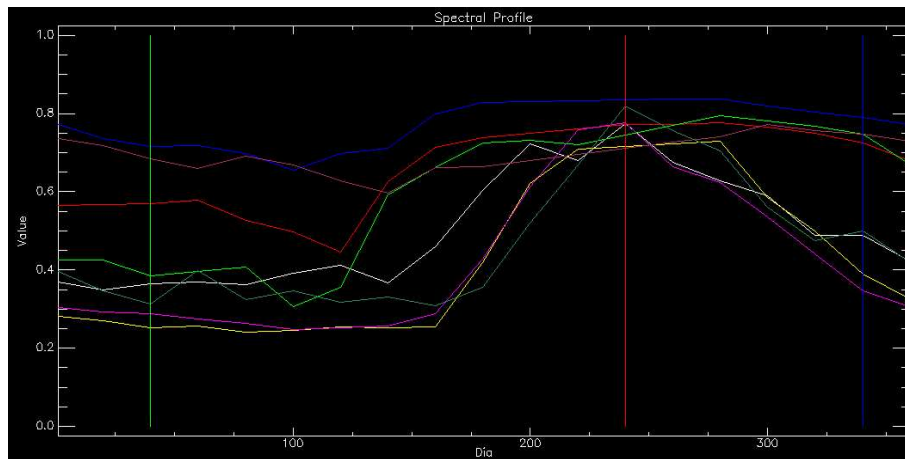
Characteristics of hypertemporal Data



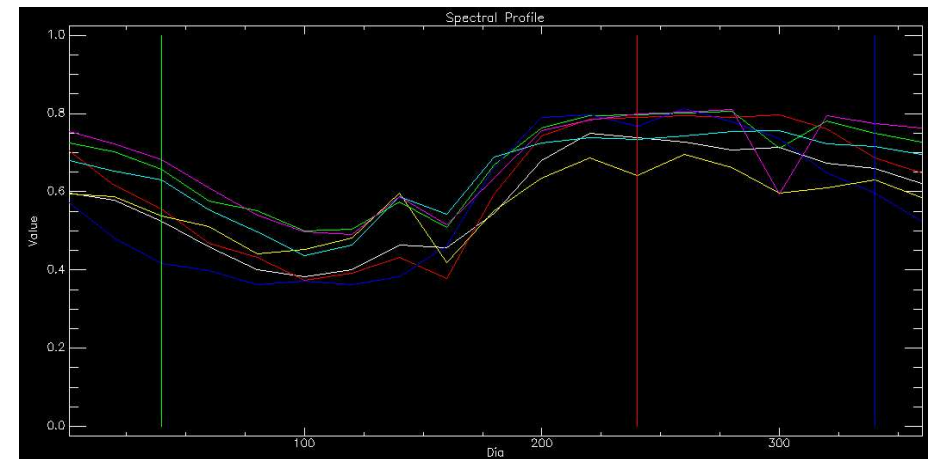
Tropical evergreen rain forest



Tropical deciduous forest



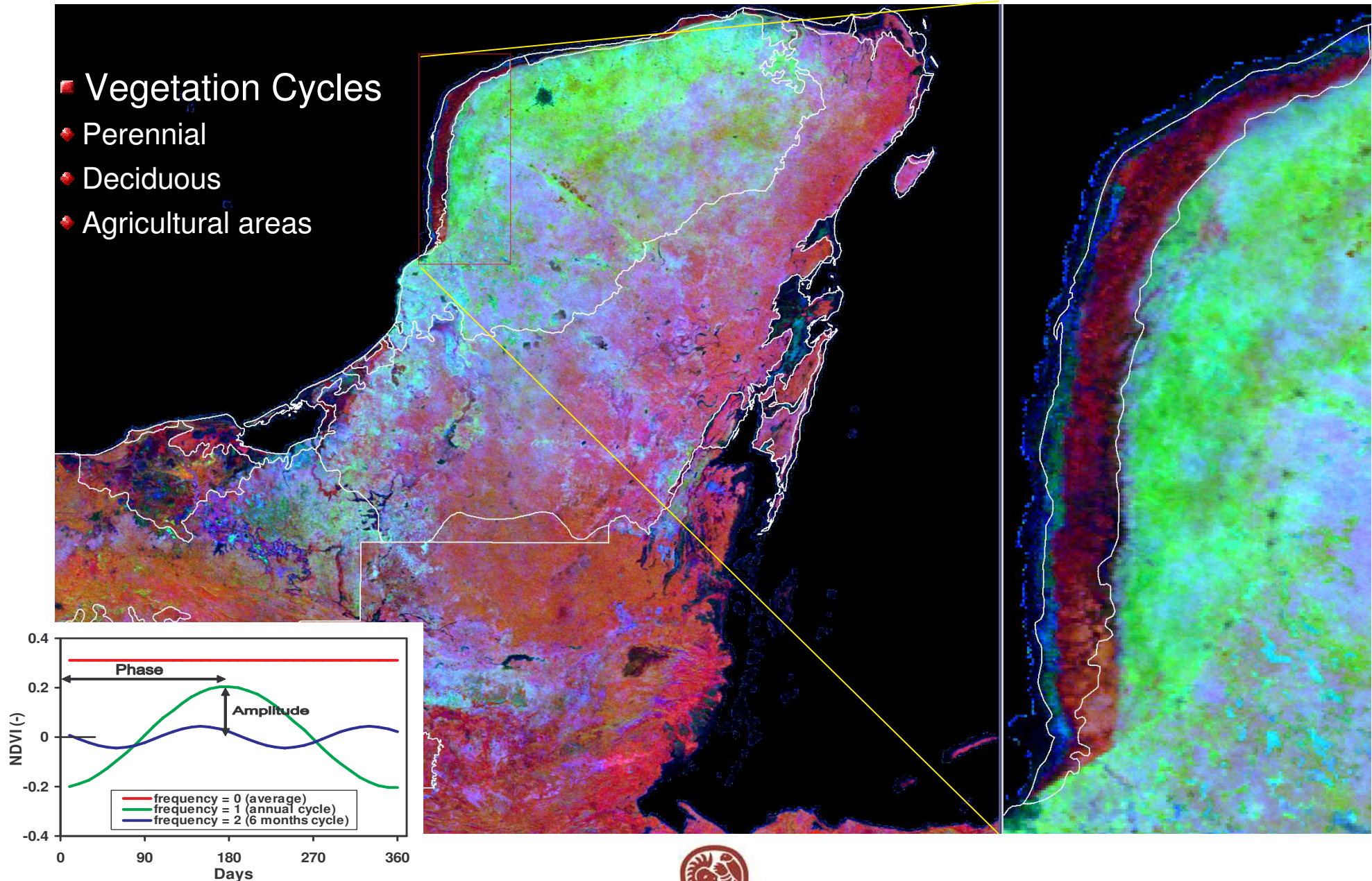
Agriculture

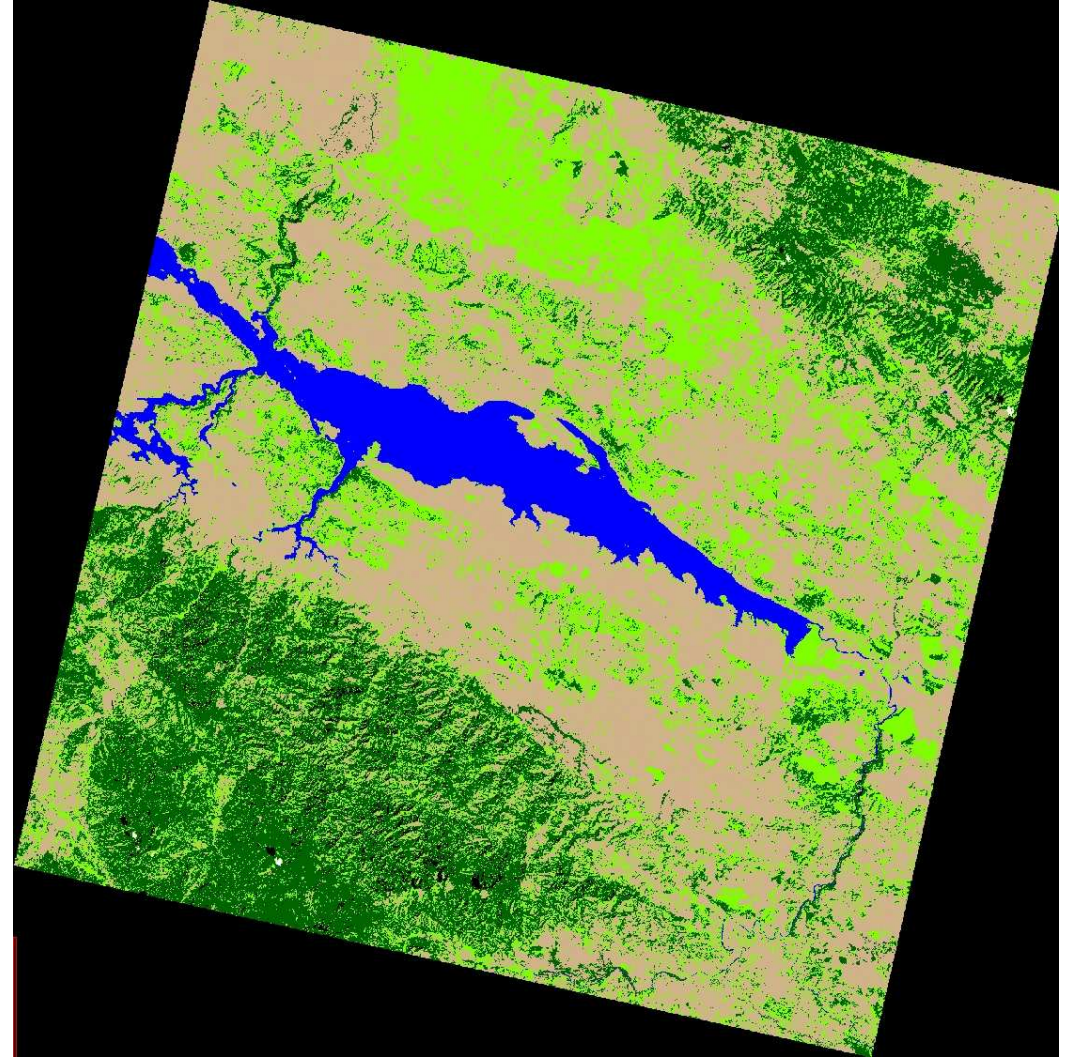
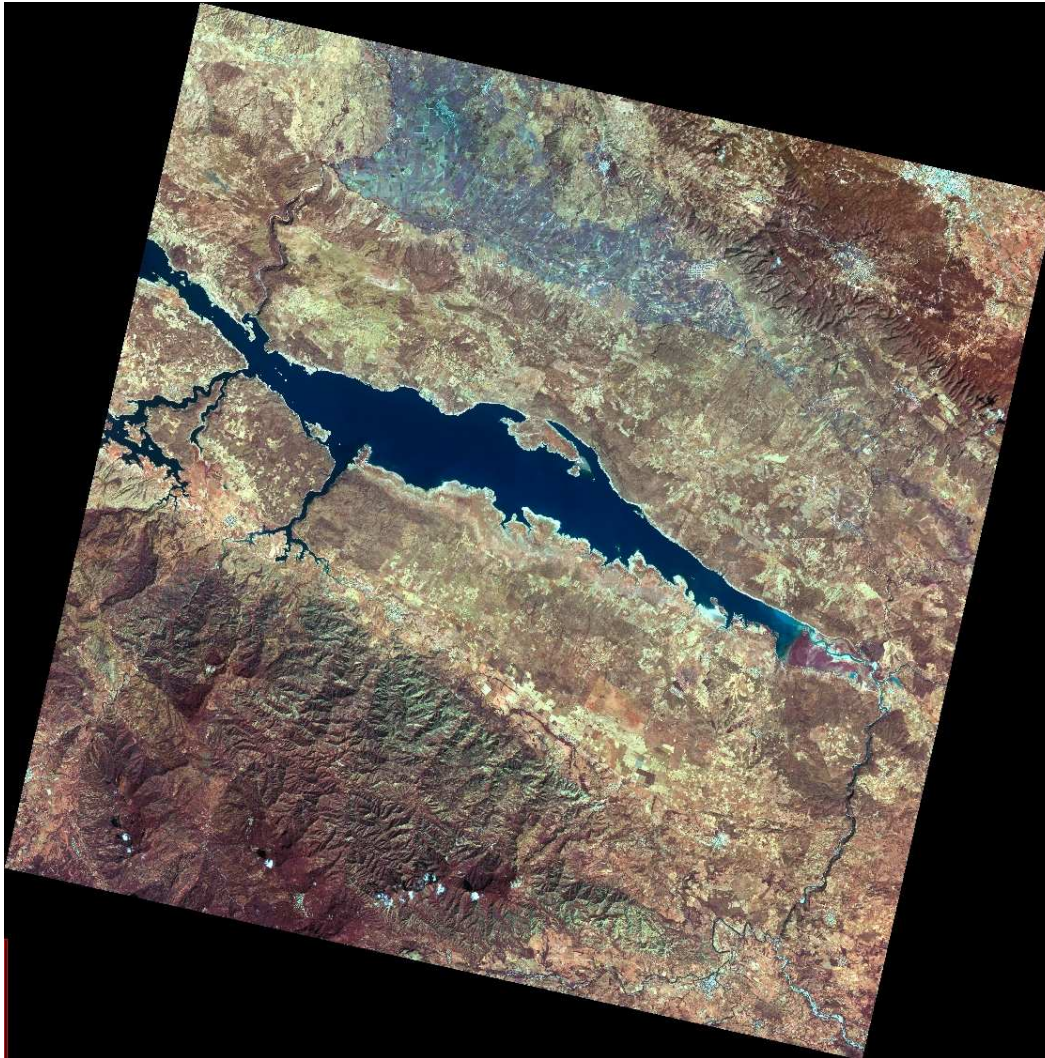
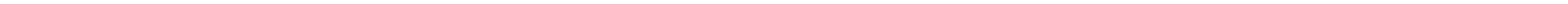


Oak forest



Characteristics of hypertemporal data



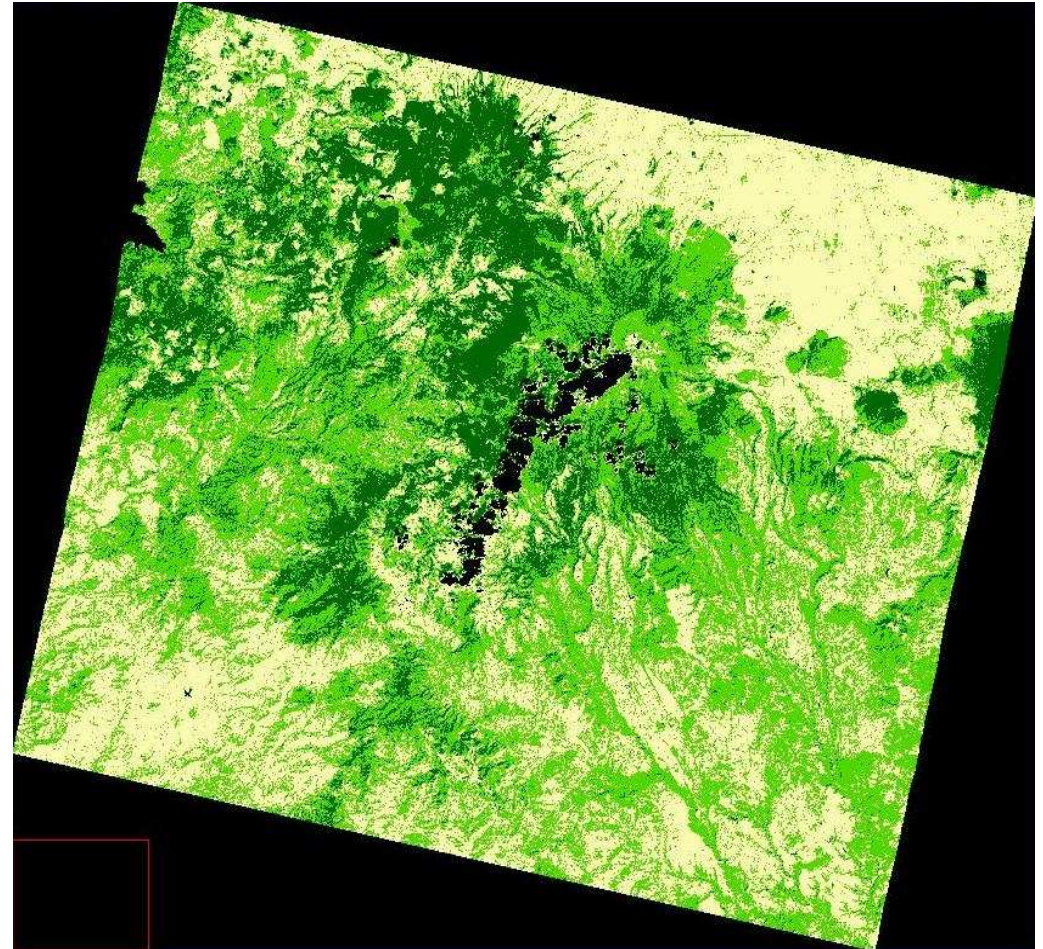
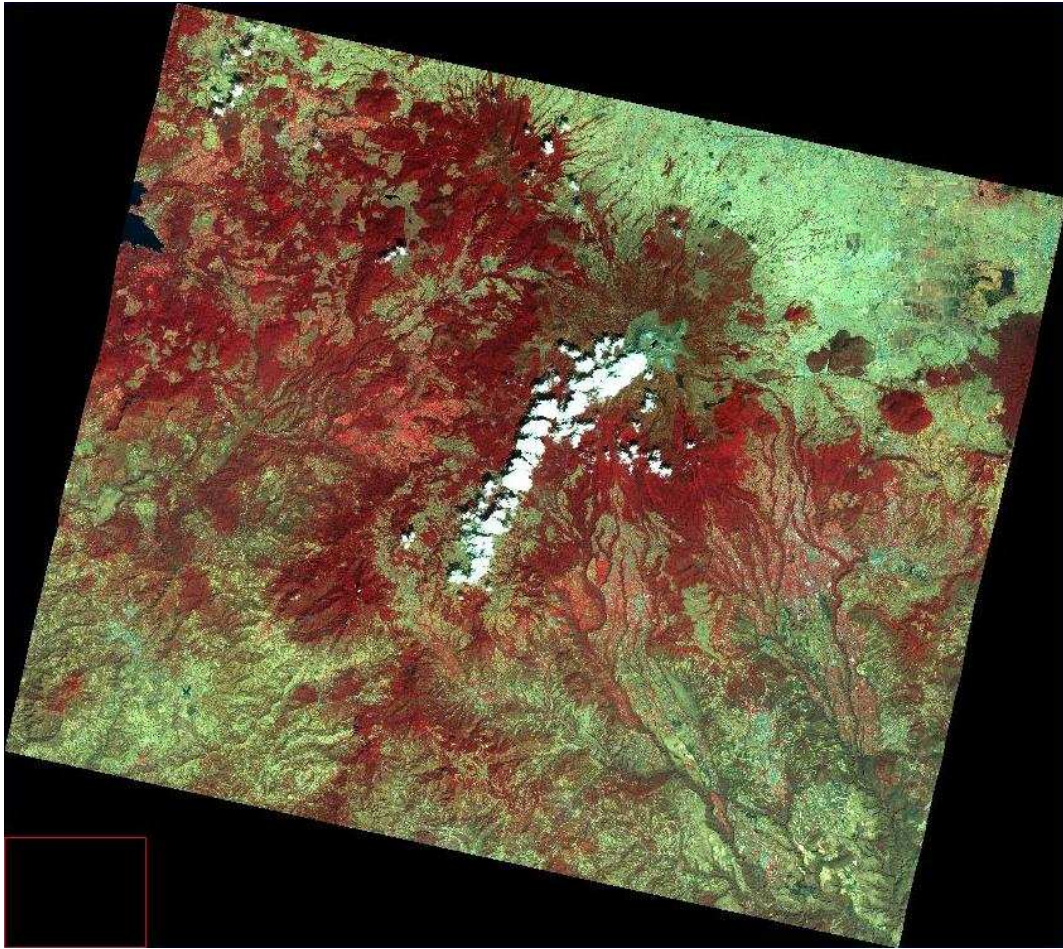


4 classes: herbaceous/shrubs, trees, bare soil, others: water, clouds, shadows, etc.



Extraction of continuous fraction data

High resolution training data – SPOT 10 m

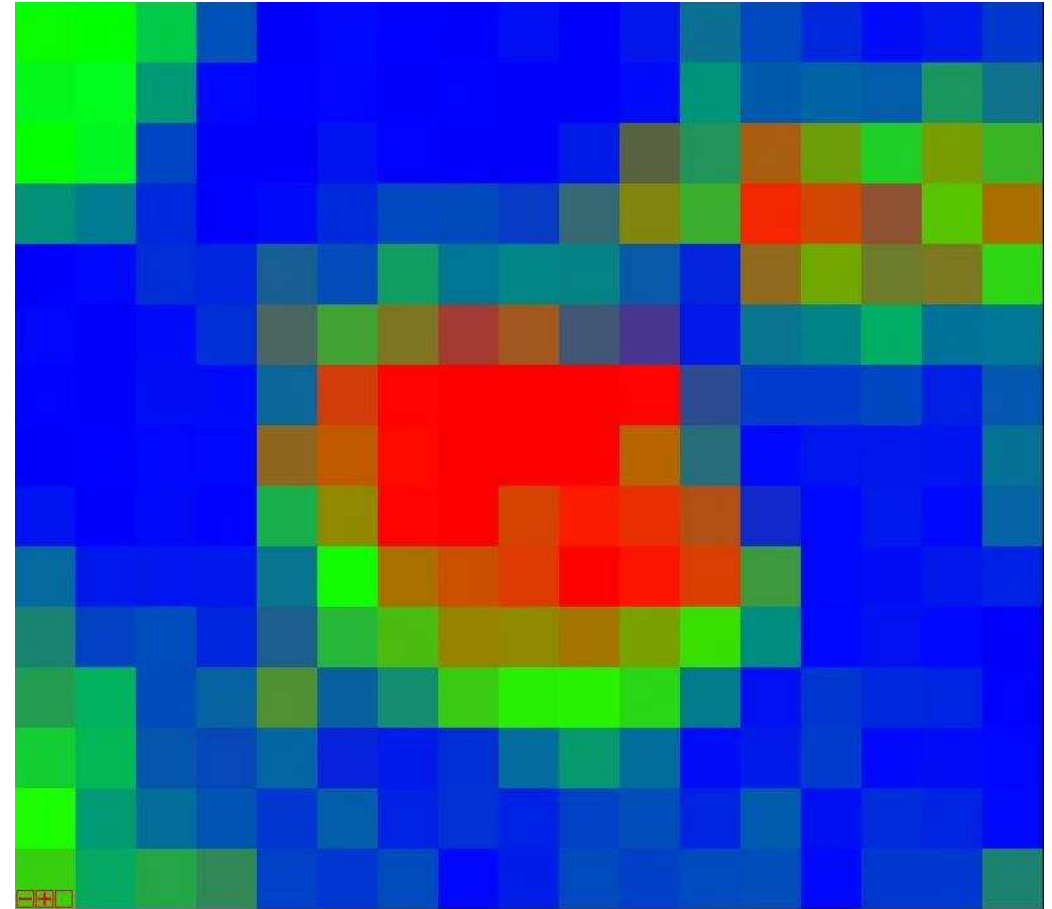
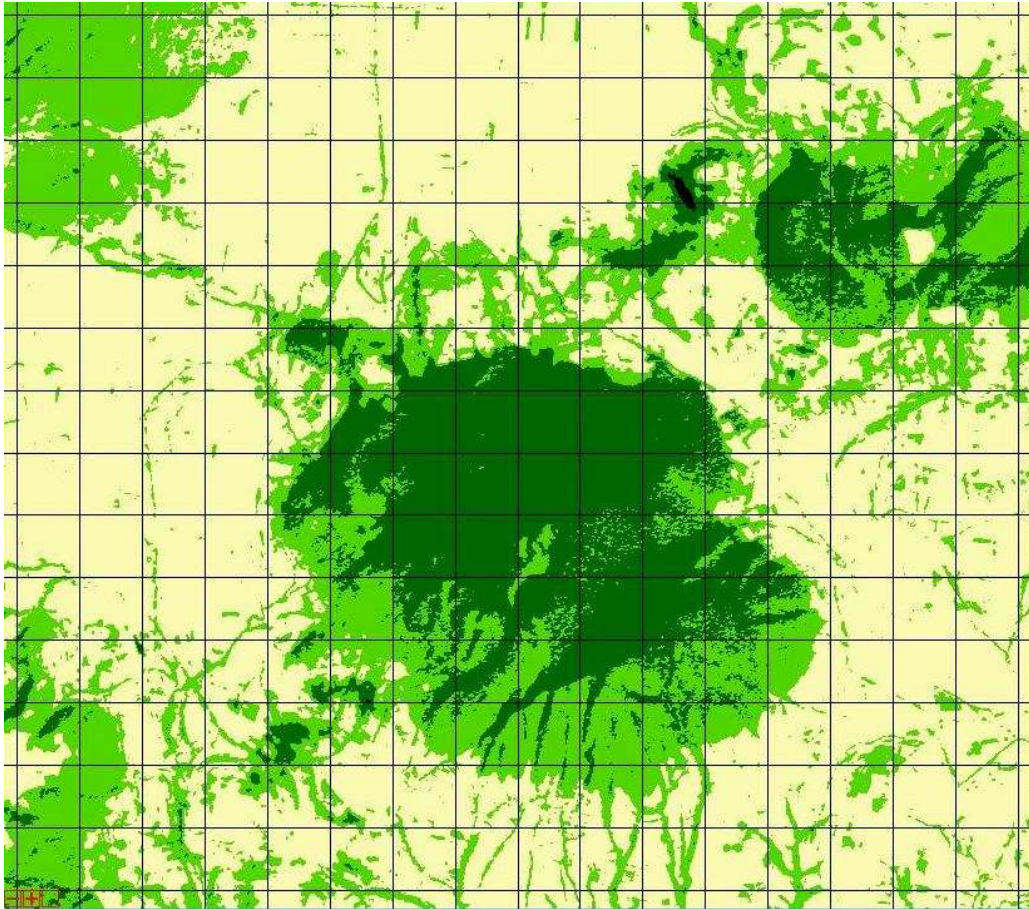


4 classes: herbaceous/shrubs, trees, bare soil, others: water, clouds, shadows, etc.



Extraction of continuous fraction data

Land cover fraction from SPOT data adjusted to MODIS resolution



Trees

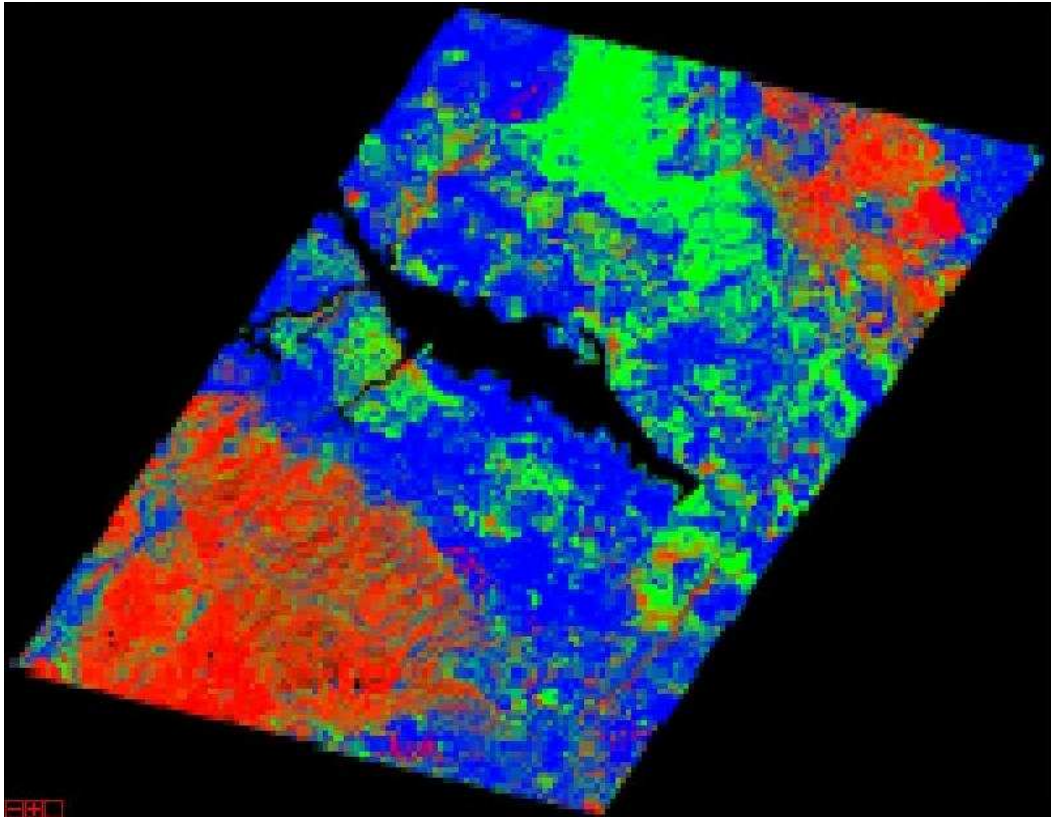
Shrubs/
Herbaceous

Bare soil

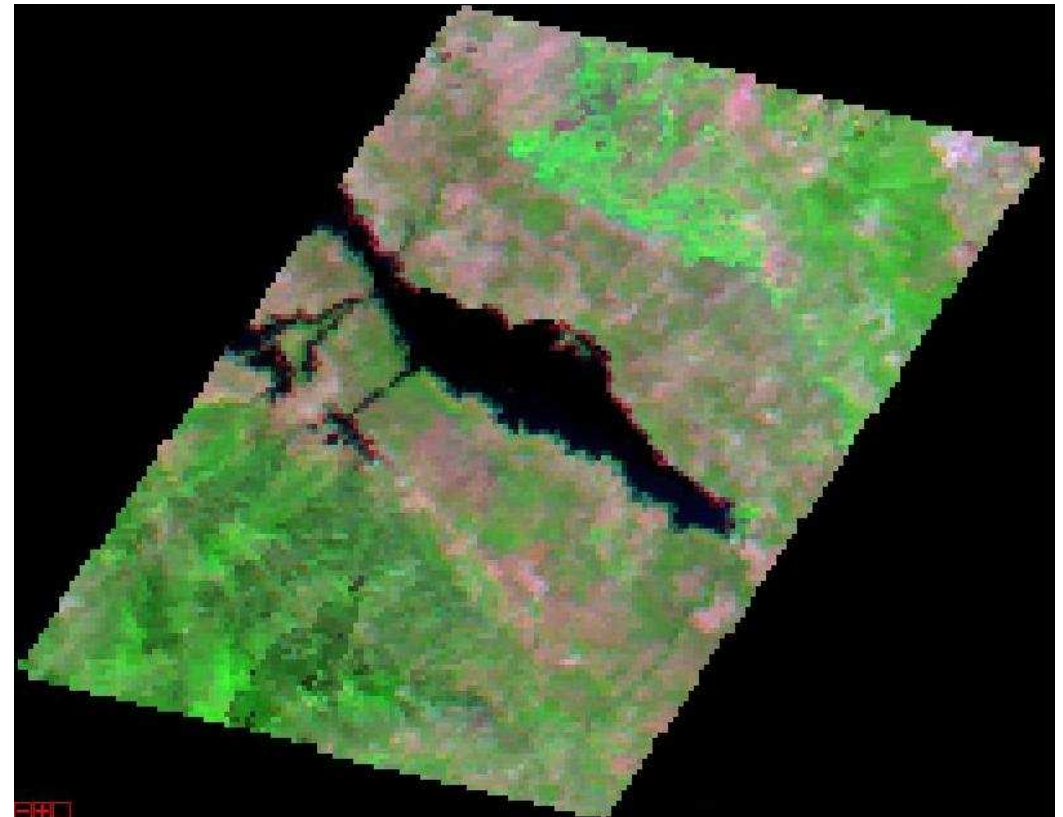
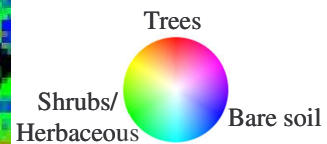
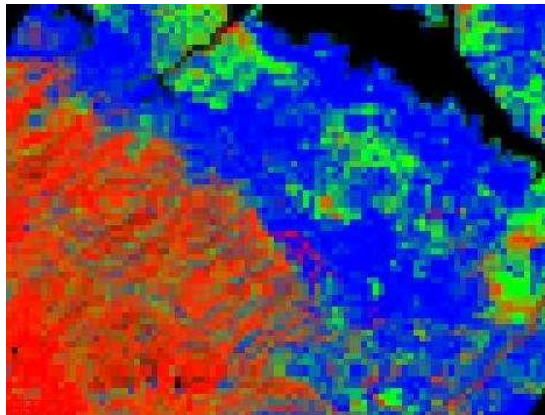


Extraction of continuous fraction data - using SVR

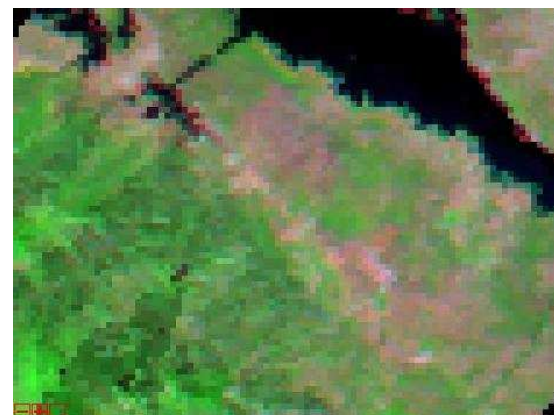
Apply algorithm for regression - SVR



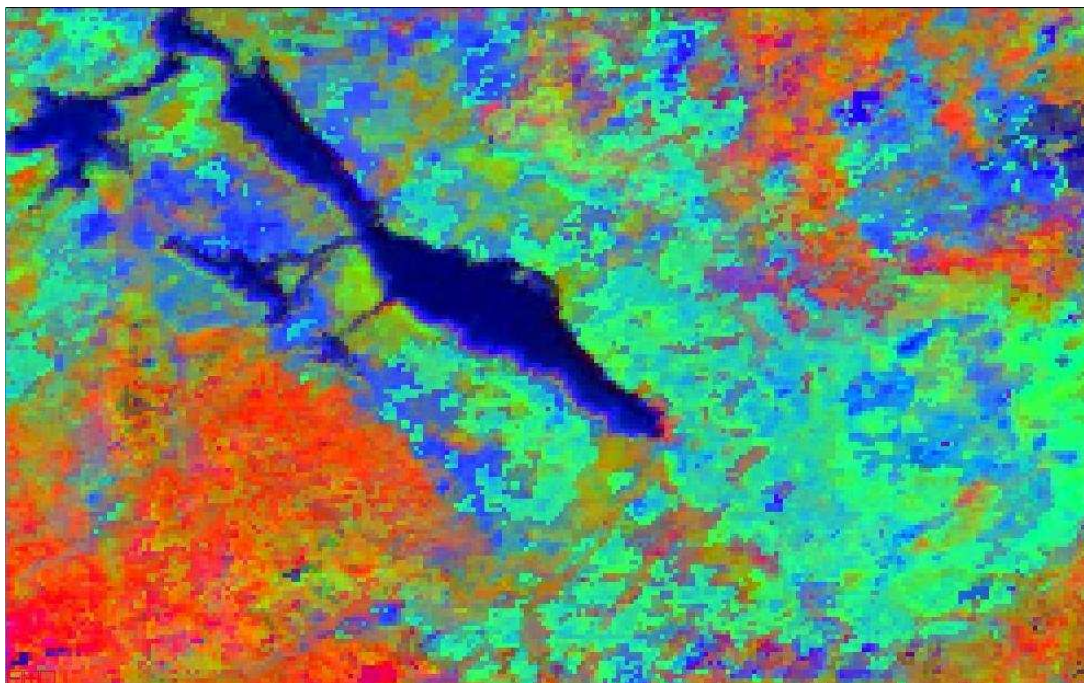
Training data
derived from
SPOT data
500 m



MODIS
MOD09
500 m

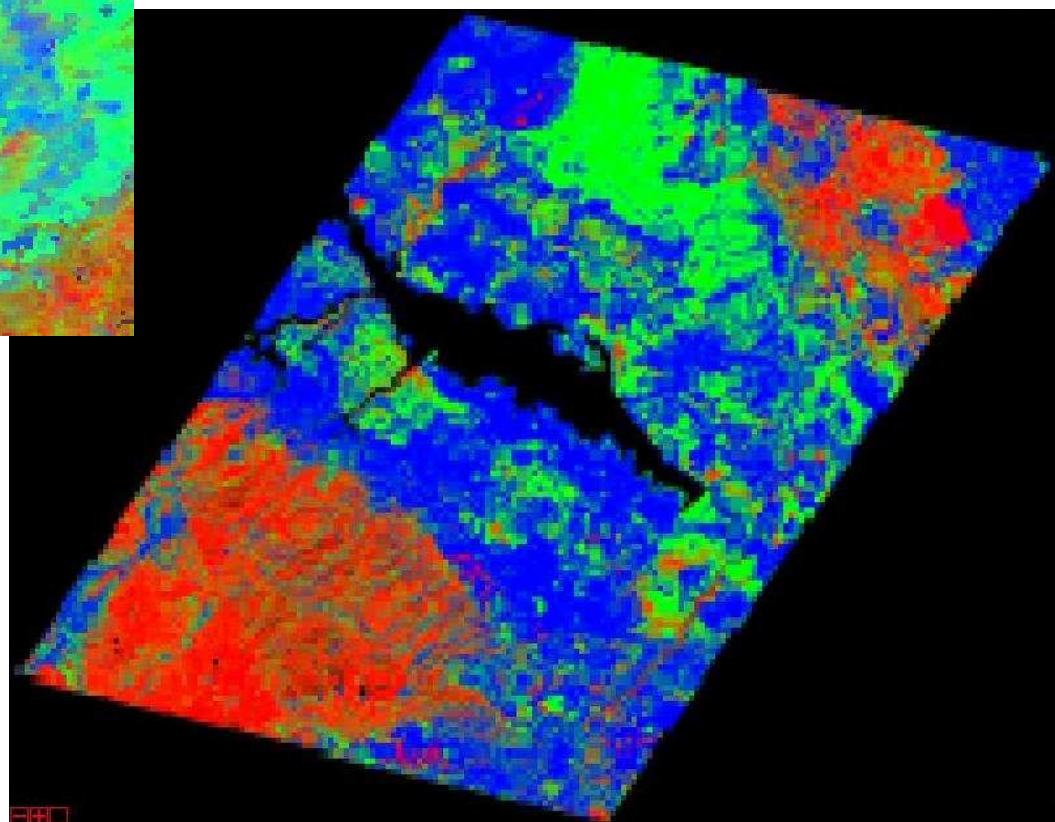
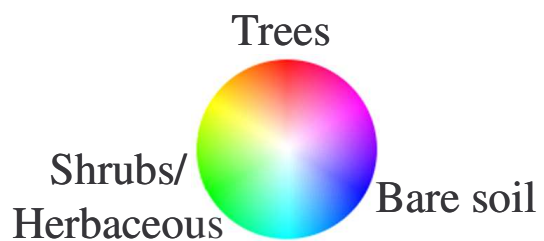


Extraction of continuous fraction data - using SVR

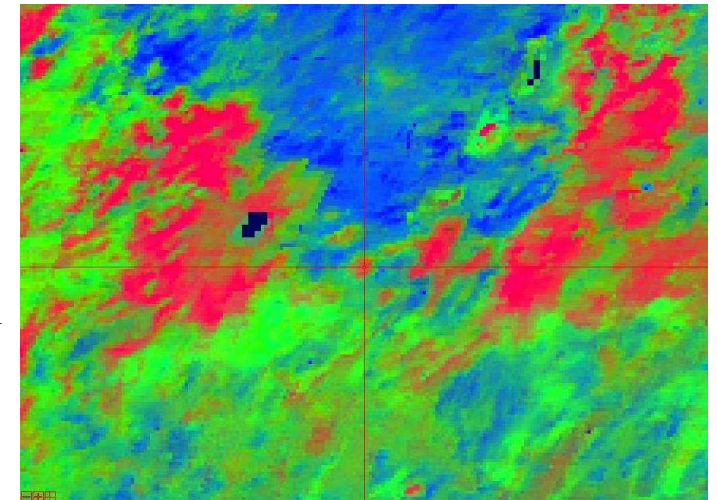
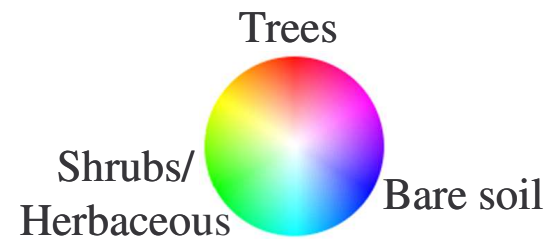
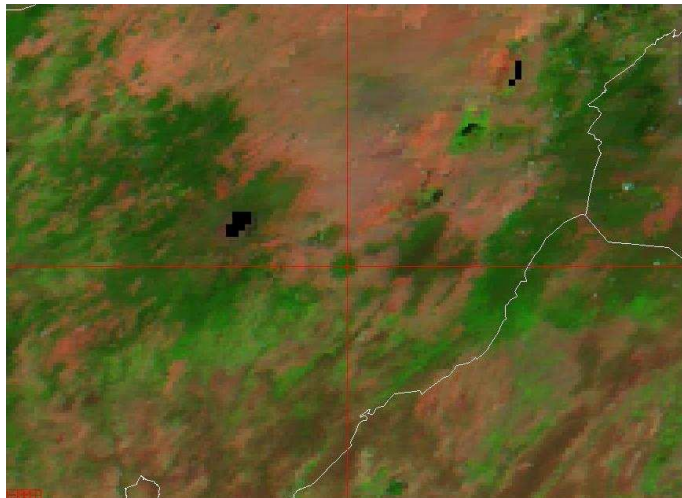
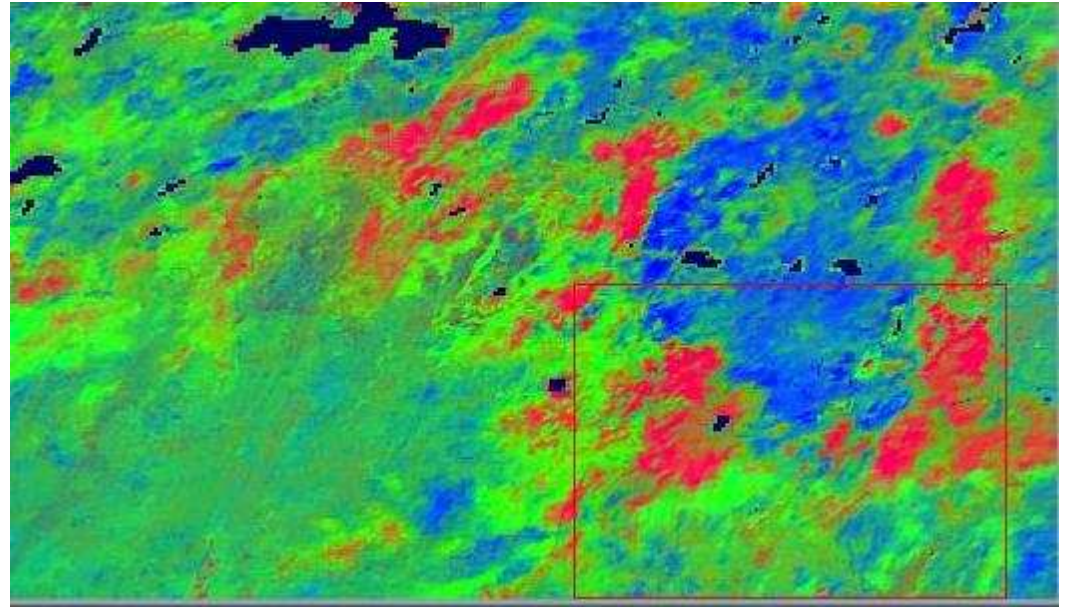
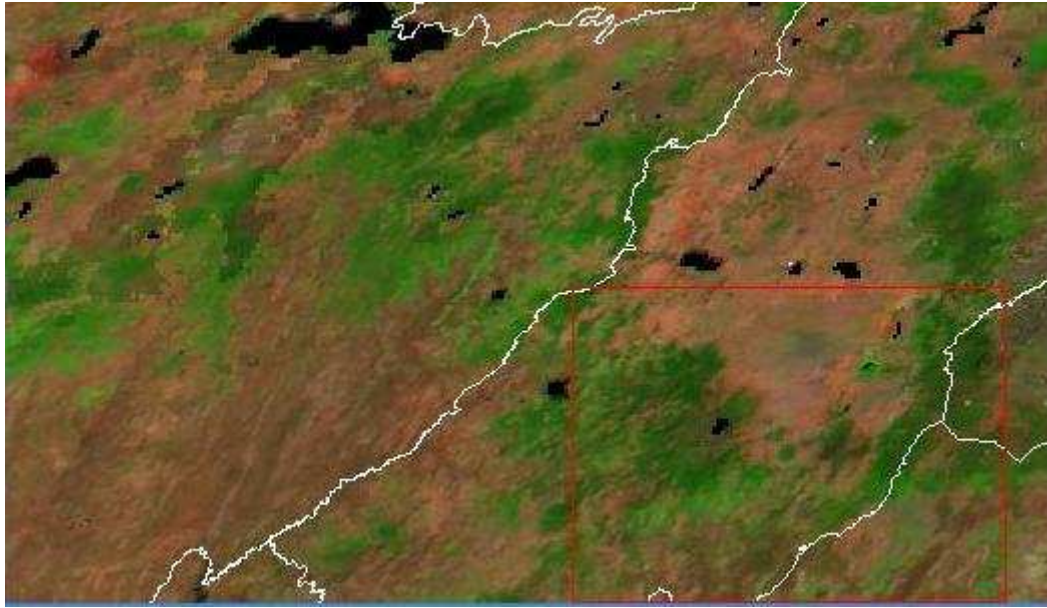


•Original training data

•Preservation of structures



Extraction of continuous fraction data using SVR



Status

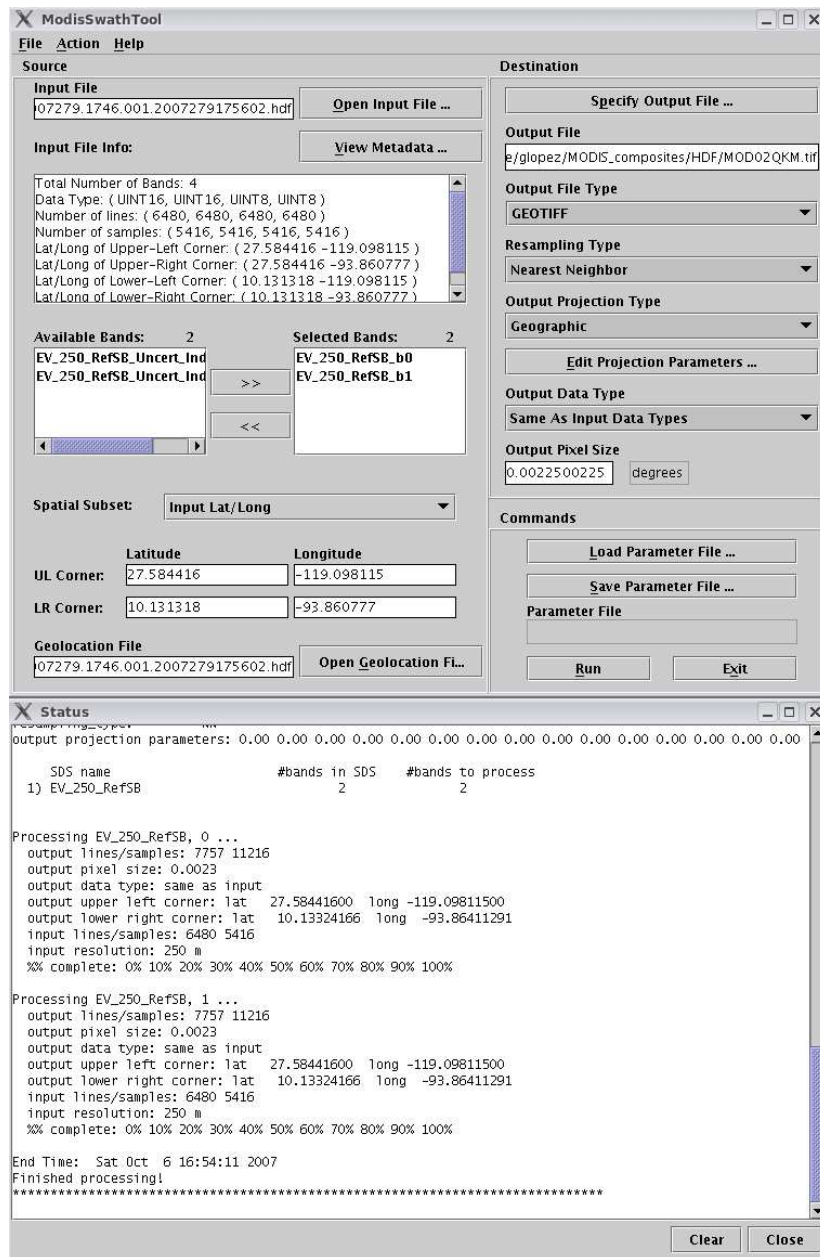
- Framework is developed in Python, MySQL as DBMS

- **Implemented functionalities**

- Data import, filtering (QA and angles) and linear interpolation
- Dynamic composite creation
- Profile generation
- Regression (still file based)



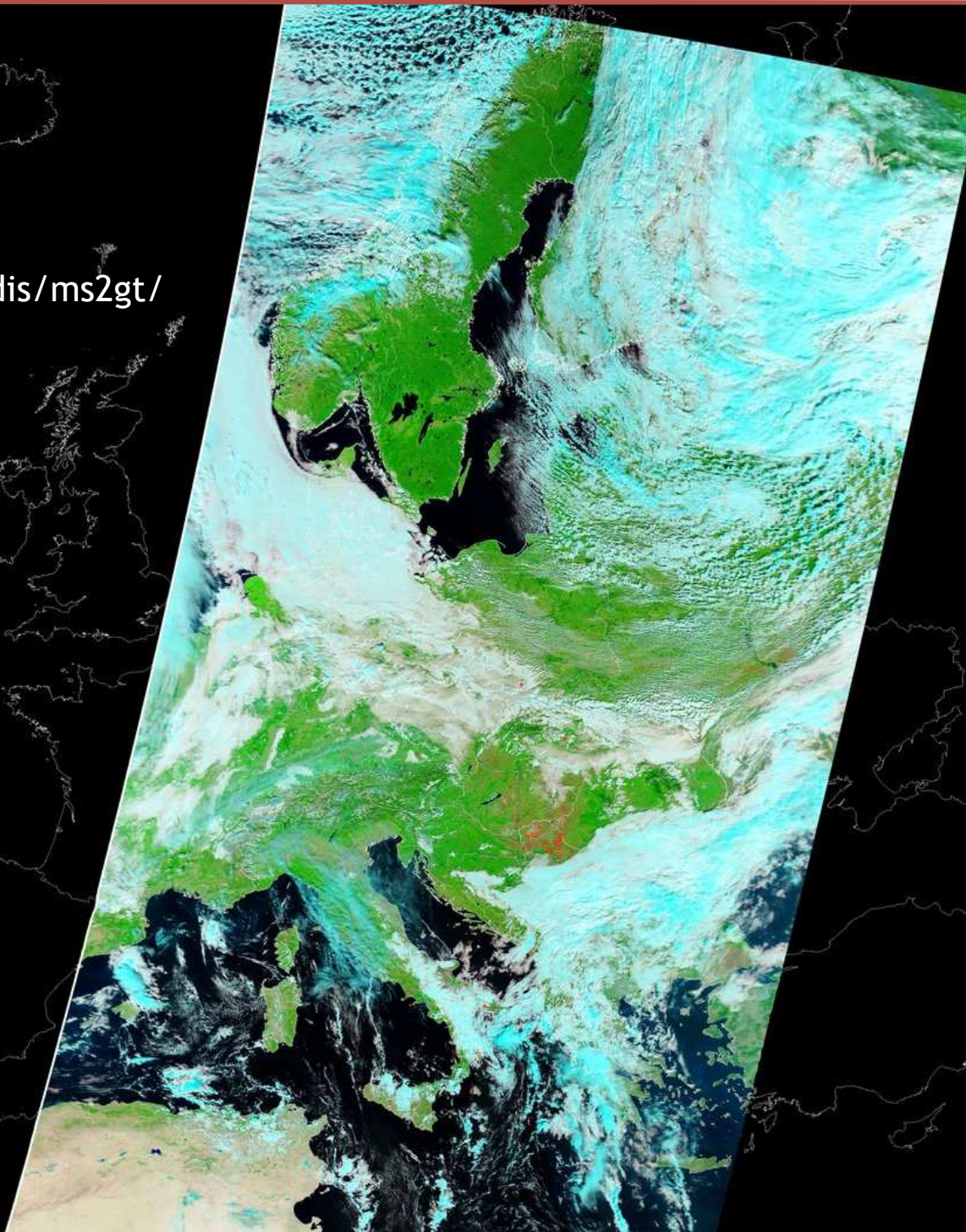
MODIS Swath data reprojection



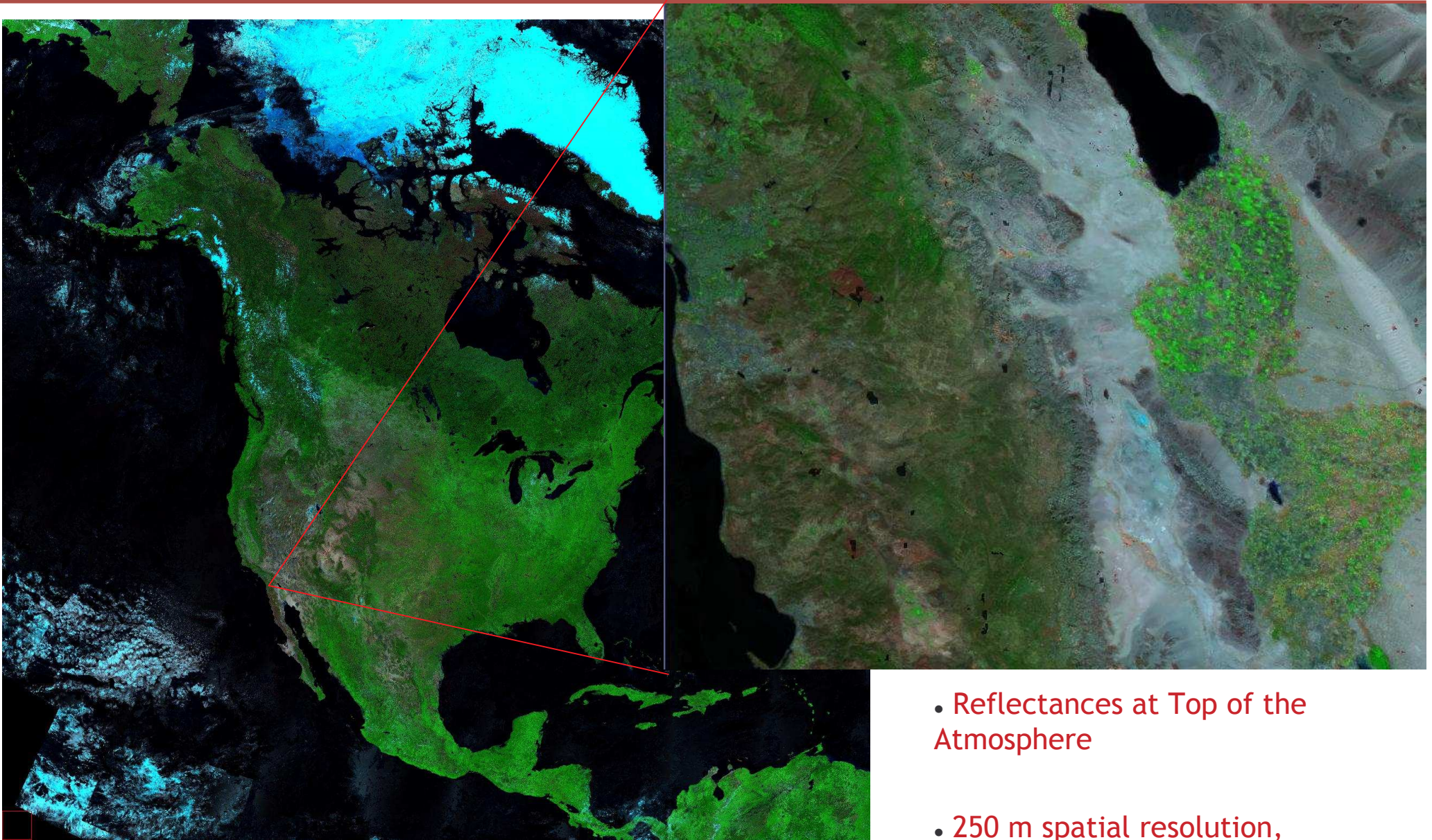
MS2GT: The MODIS Swath-to-Grid Toolbox



• <http://nsidc.org/data/modis/ms2gt/>



NALCMS - CCRS monthly MODIS composite



- Reflectances at Top of the Atmosphere
- 250 m spatial resolution, downscaling for bands 3-7 ()



Summary and outlook

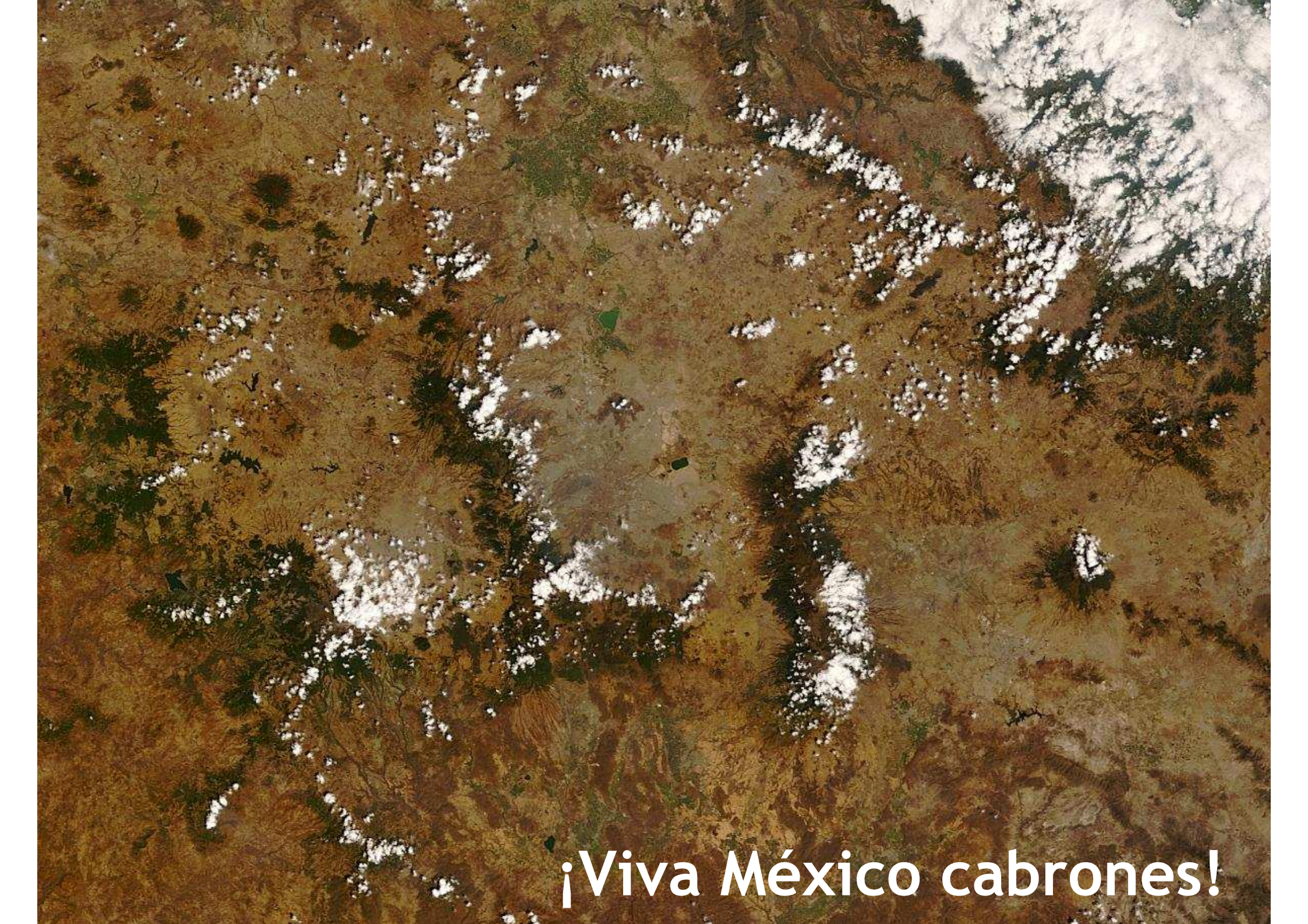
Framework

- 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



An aerial photograph of a vast, arid landscape. The terrain is a mix of brown and tan hues, indicating dry earth and sparse vegetation. Numerous irregular patches of white, likely snow or ice, are scattered across the surface, particularly along the edges of the land and in some central areas. The overall texture is rough and uneven.

¡Viva México cabrones!