

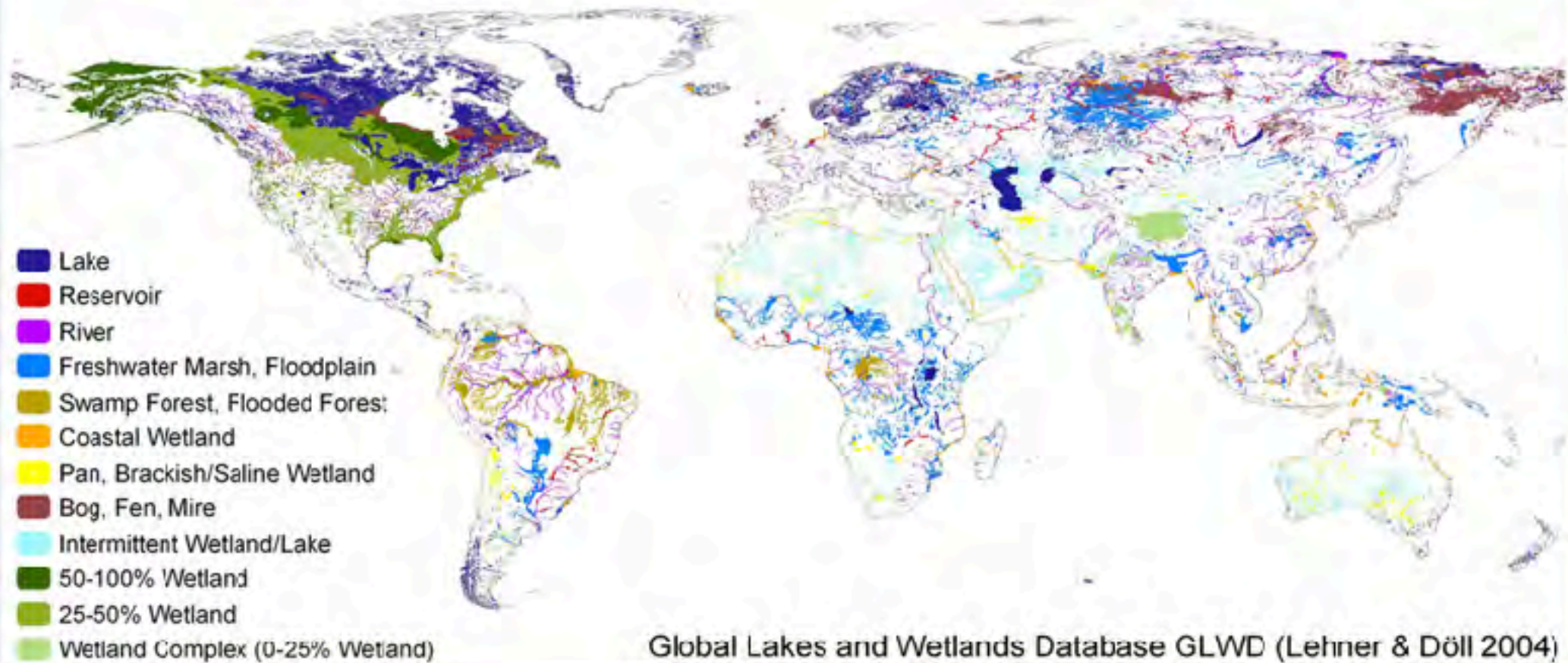
Mapping carbon content of global tropical wetlands

1. Finding the wetlands (today)
2. Getting the volumes (in August?)
3. Estimating carbon content (in August?)

An apology

I am very, very rusty when it comes to presentations, and I get very nervous in the beginning (it runs in the family). But do not feel sorry, and do not hesitate to ask – it makes it easier for me as well if you ask. For me having a presentation is like you would feel being dumped in a cave with snakes. Even if they tell you that the snakes are not dangerous, it will take a while to get used to them.

Global wetlands



Why are wetlands important?

- Carbon storage
- Organic matter resource
- Hydrological regulator
- Landscape kidney

Constraints – time (not money)

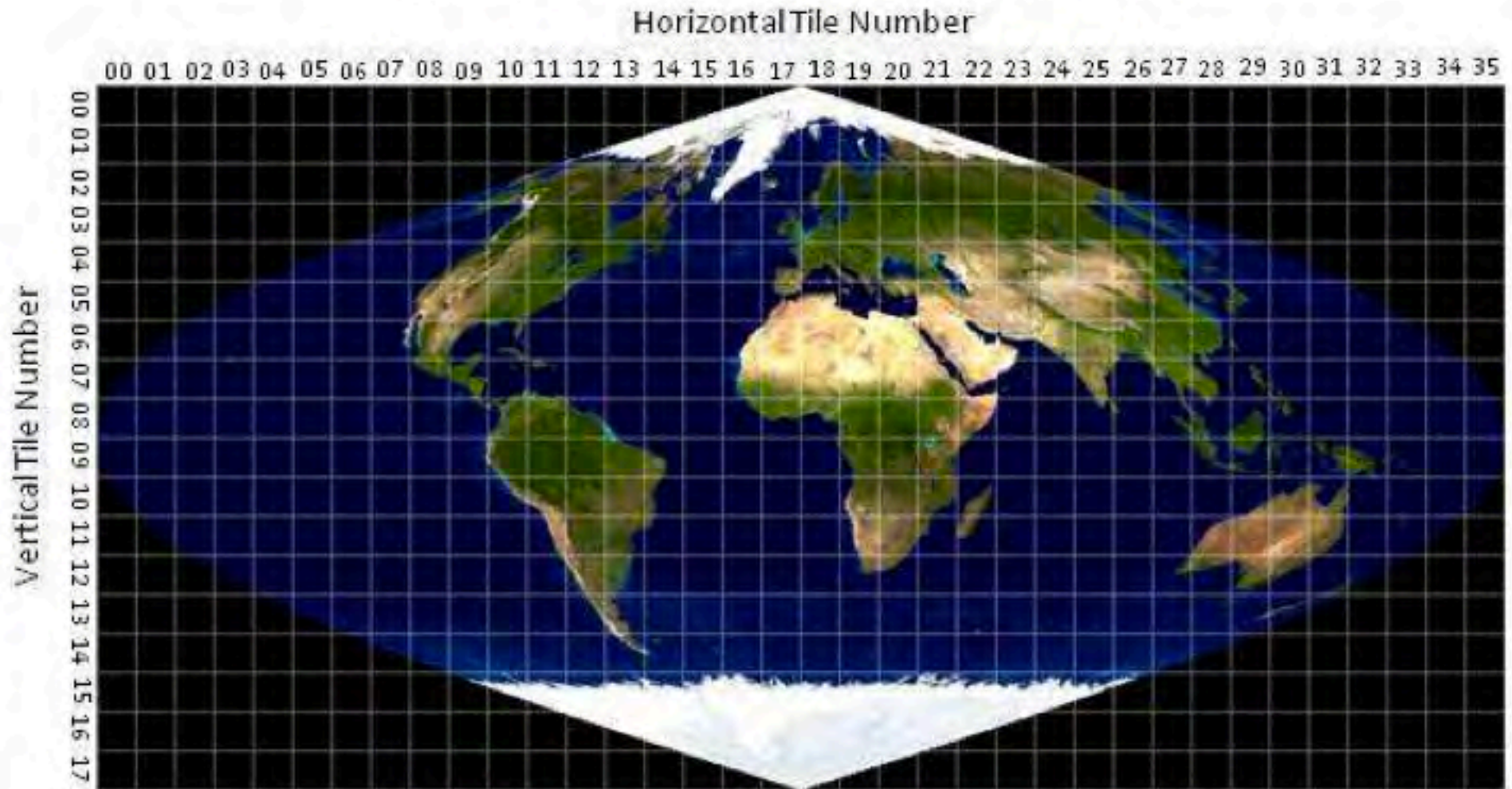
Finding the worlds global tropical wetlands in a consistent manner calls for the adoption of remotely sensed data – satellite images. A range of passive (optical) and active (radar) sensors are suitable. Given the time limit and the requirements we chose to use the MODIS sensor in this first approach. Other options are available, but would have demanded longer time (and more money).

Why use MODIS?

- Operational for more than 10 year
- Two replicas of the sensor available
- Daily coverage of the Earth's surface
- Pre-processed into tiles
- Easy to access (open FTP)
- Comes with premade products to use as ancillary layers in the analysis
- A compromise between spatial detail and processing time

MODIS coverage

MODIS Land Sinusoidal Mapping Grid



MODIS tiles for this study

- MOD13Q1 (16 day vegetation indexes - 2011)
- MOD13Q1 (16 day reflectance - 2011)
- MCD12Q1 (annual land cover - 2009)
- Total number of input tiles: 3,640
- Total number of input layers: 24,700
- Total number of cells to process: 2 billion
- I did not know the word for 2 billion * 3,640 – but that has to pass the processor in several loops

Pre-processing steps

- Automated FTP download (expect/TCL)
- Automated organization in folder system (applescript)
- Registering in PostgreSQL database (applescript)
- Extraction of useful data layers (applescript/MRT)
- Reprojection to more common projection (the MODIS SIN-grid is esoteric and few softwares can handle it) – but the free MODIS Reprojection Tool (MRT) can do it (on any platform)

Ancillary data – why?

Satellite images alone is not enough to find the world's global wetlands. Ancillary data hinting us about where to look is important. Ancillary data is also important for determining wetland types, geomorphology and wetland depth at later stages.

Ancillary data – which

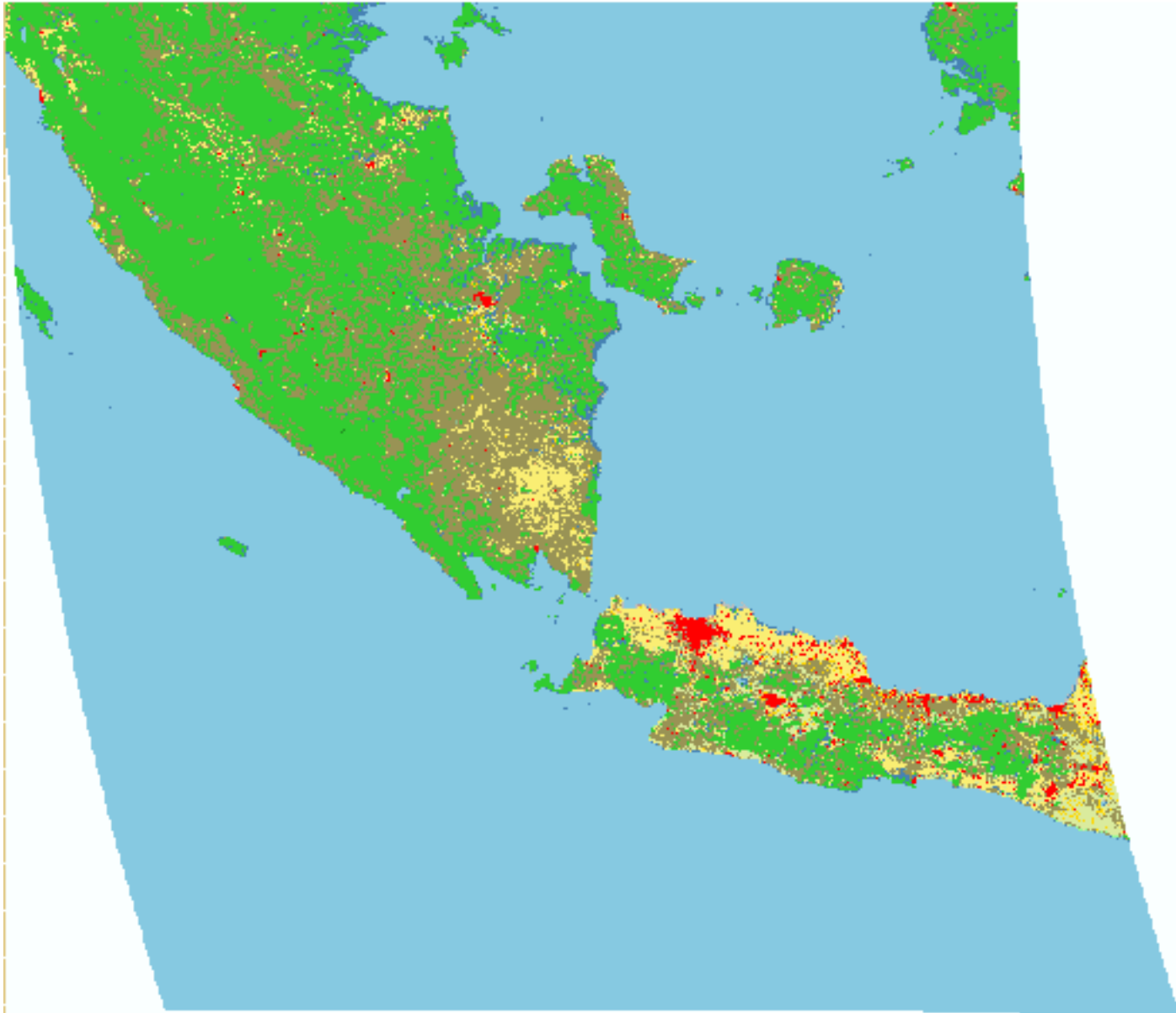
For this study the following ancillary data was captured:

- SRTM (Shuttle Radar Topography Mission) Digital Elevation Data
- HWSD (Harmonized World Soil Database) soil map and attribute database
- Worldclim monthly climate data (1950-2000)

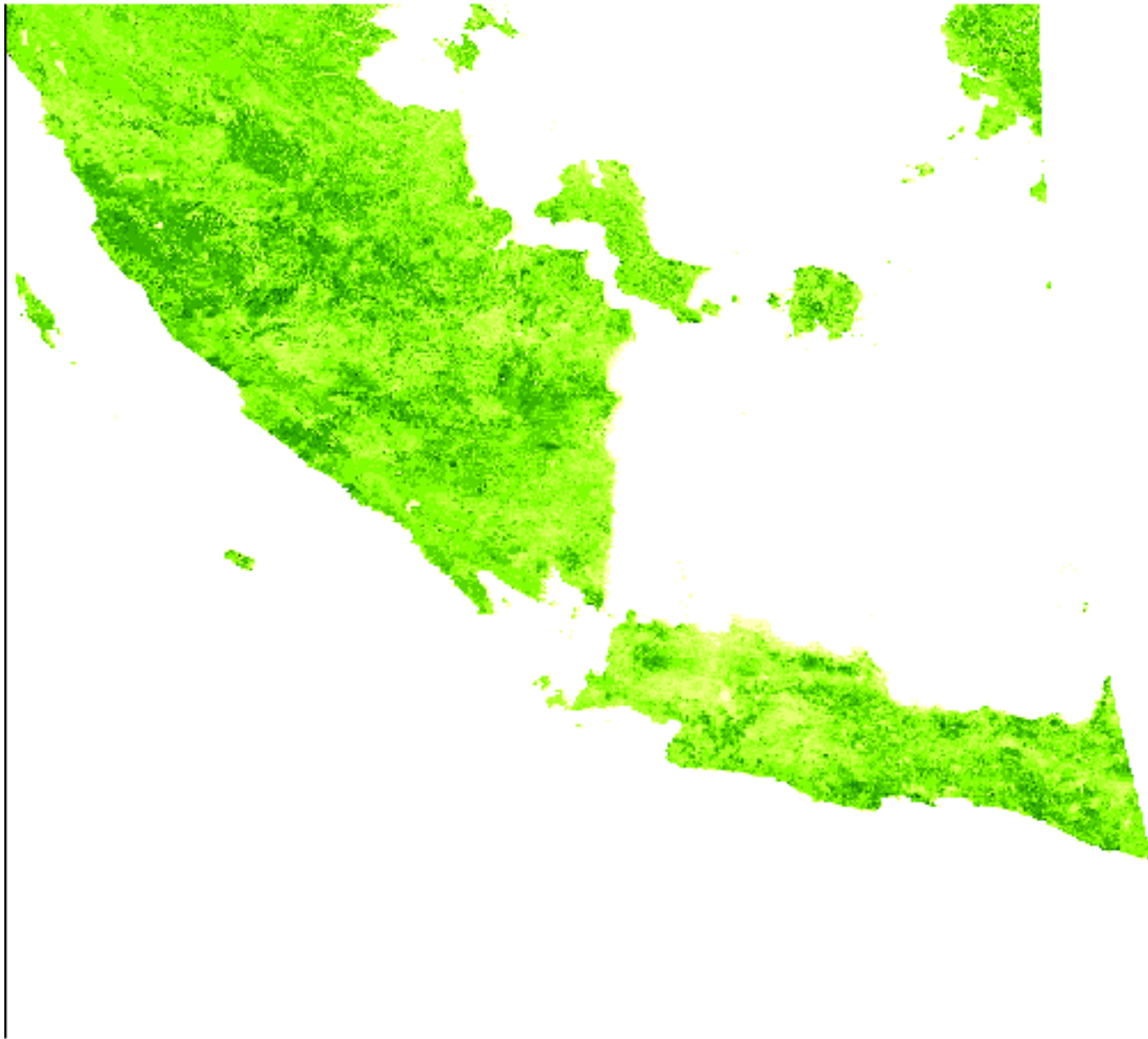
Ancillary data – preprocessing

The MODIS Reprojection Tool (MRT) can handle any raster/grid spatial dataset. All the preprocessing of the ancillary data was hence done in MRT – and reprojected to fit with the MODIS data itself.

MODIS data – land cover



MODIS data – vegetation (EVI)



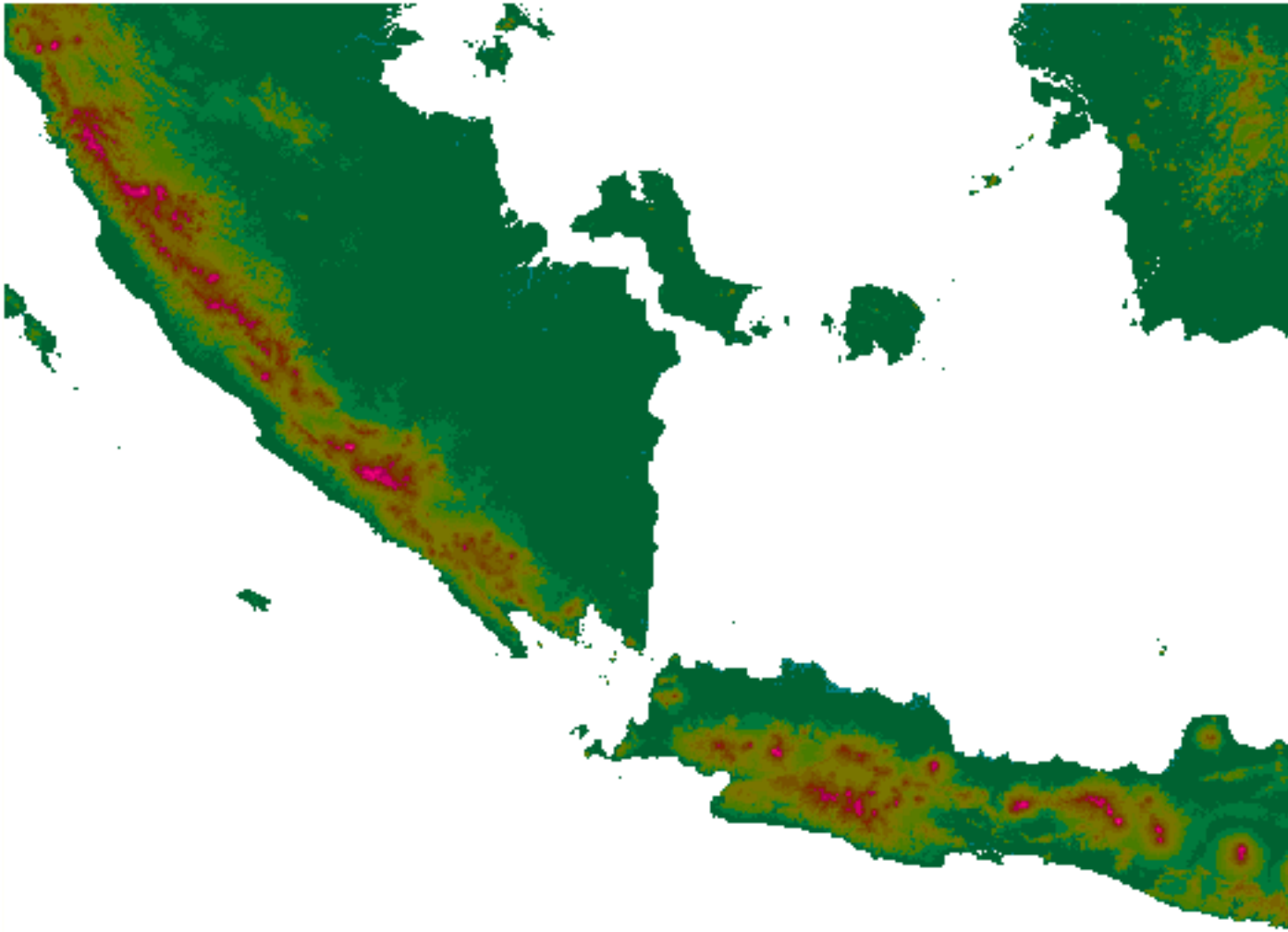
MODIS data – MIR reflection



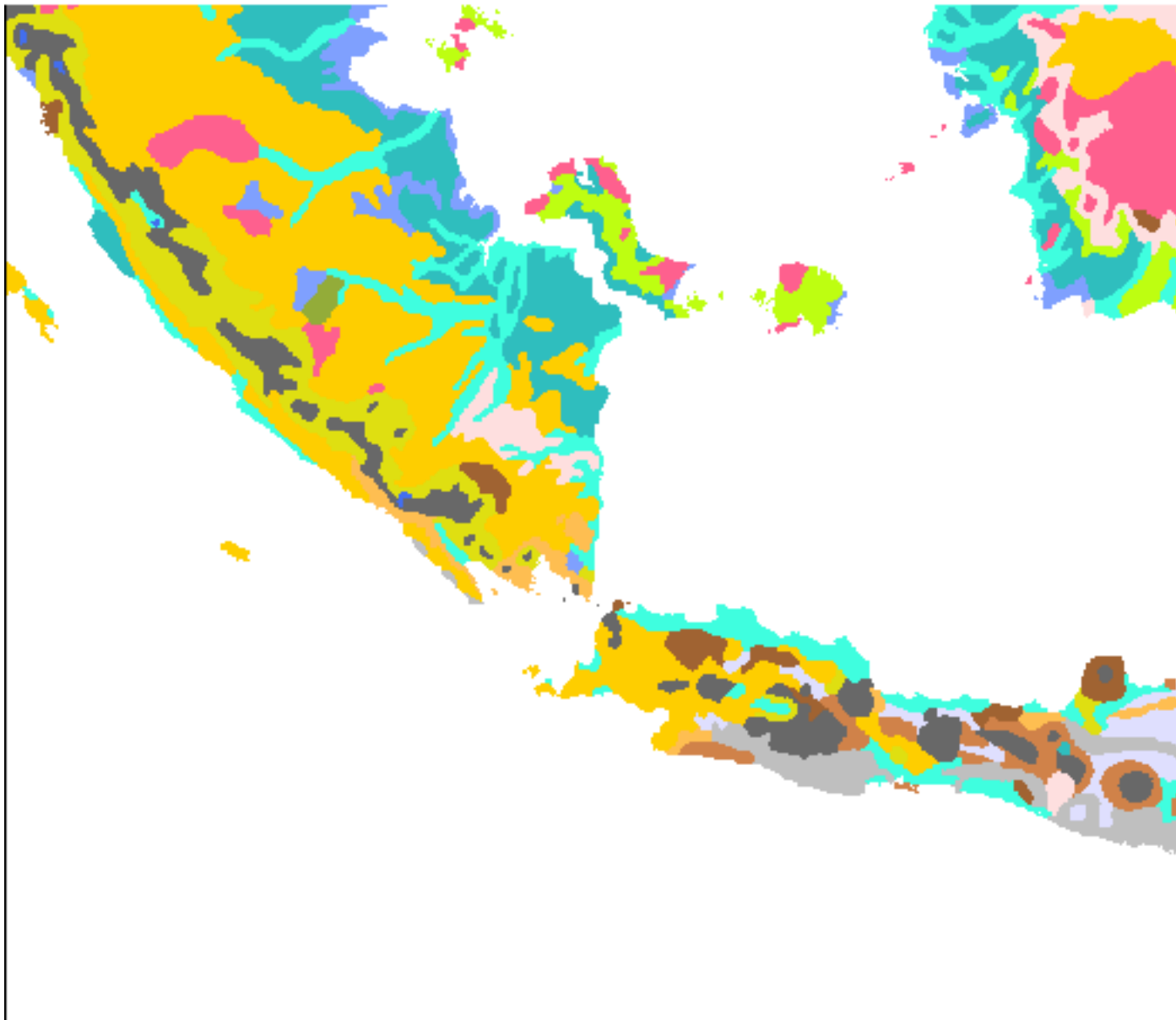
MODIS data – NIR reflection



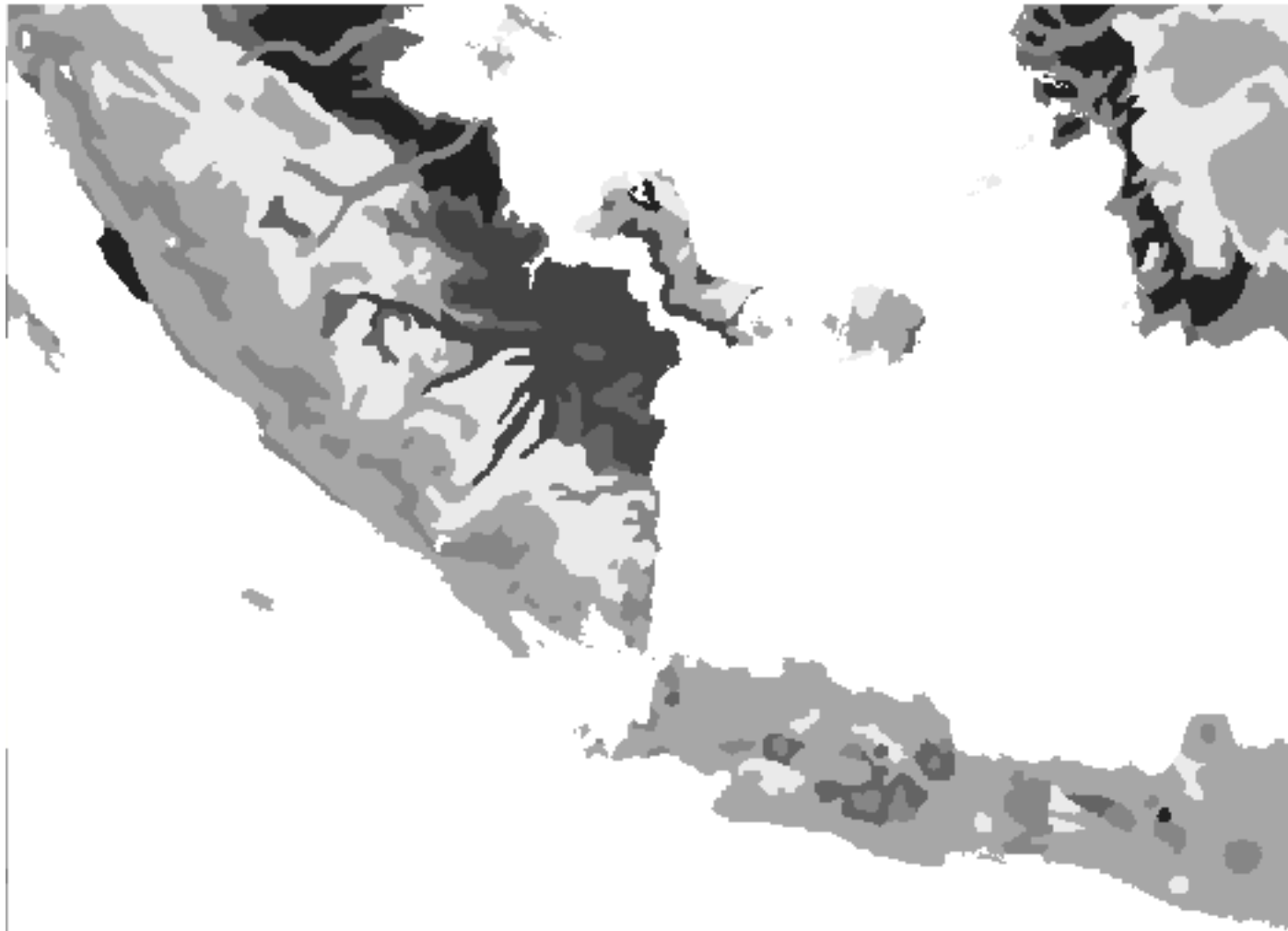
Ancillary data - SRTM



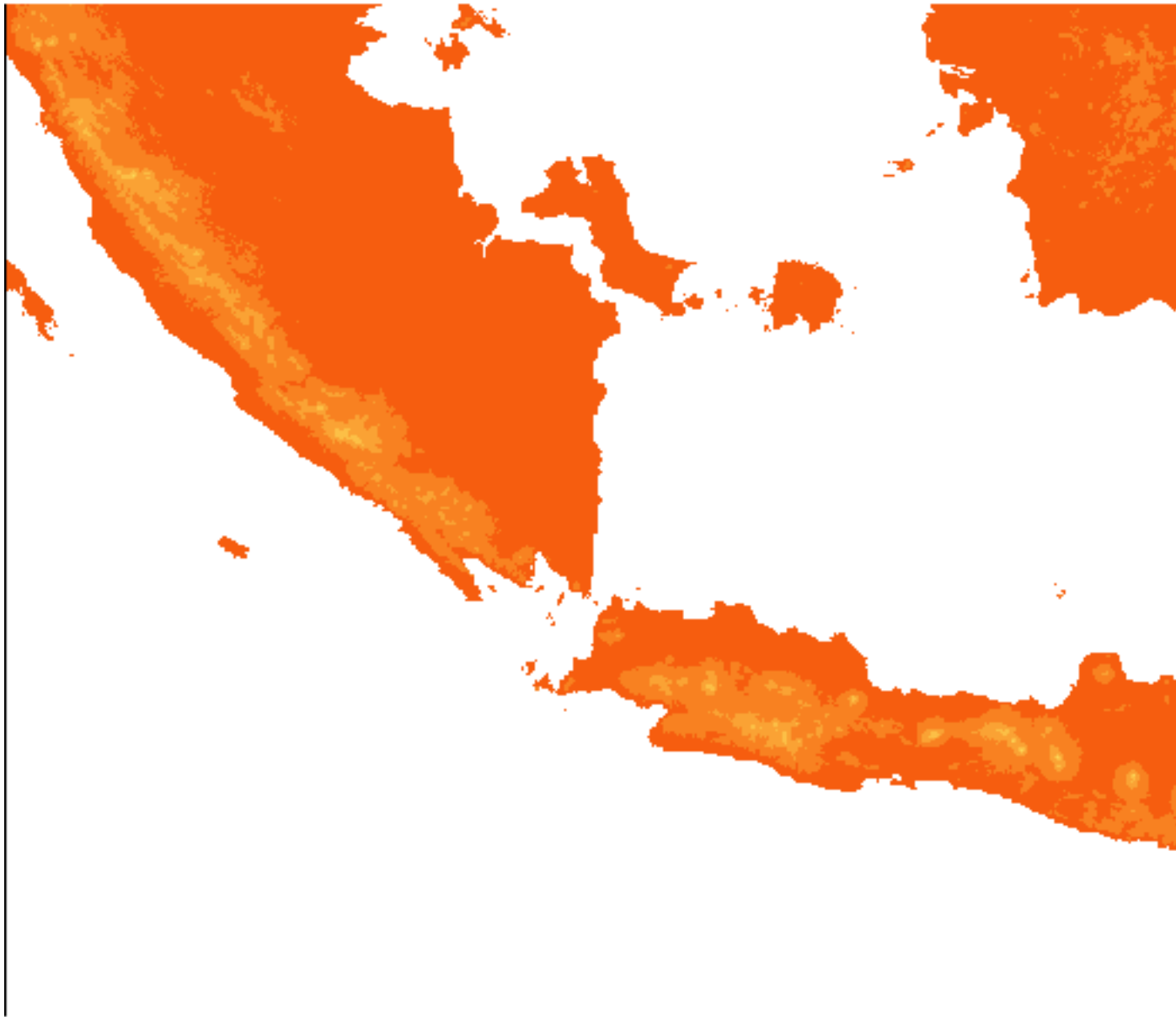
Ancillary data – dominating soil



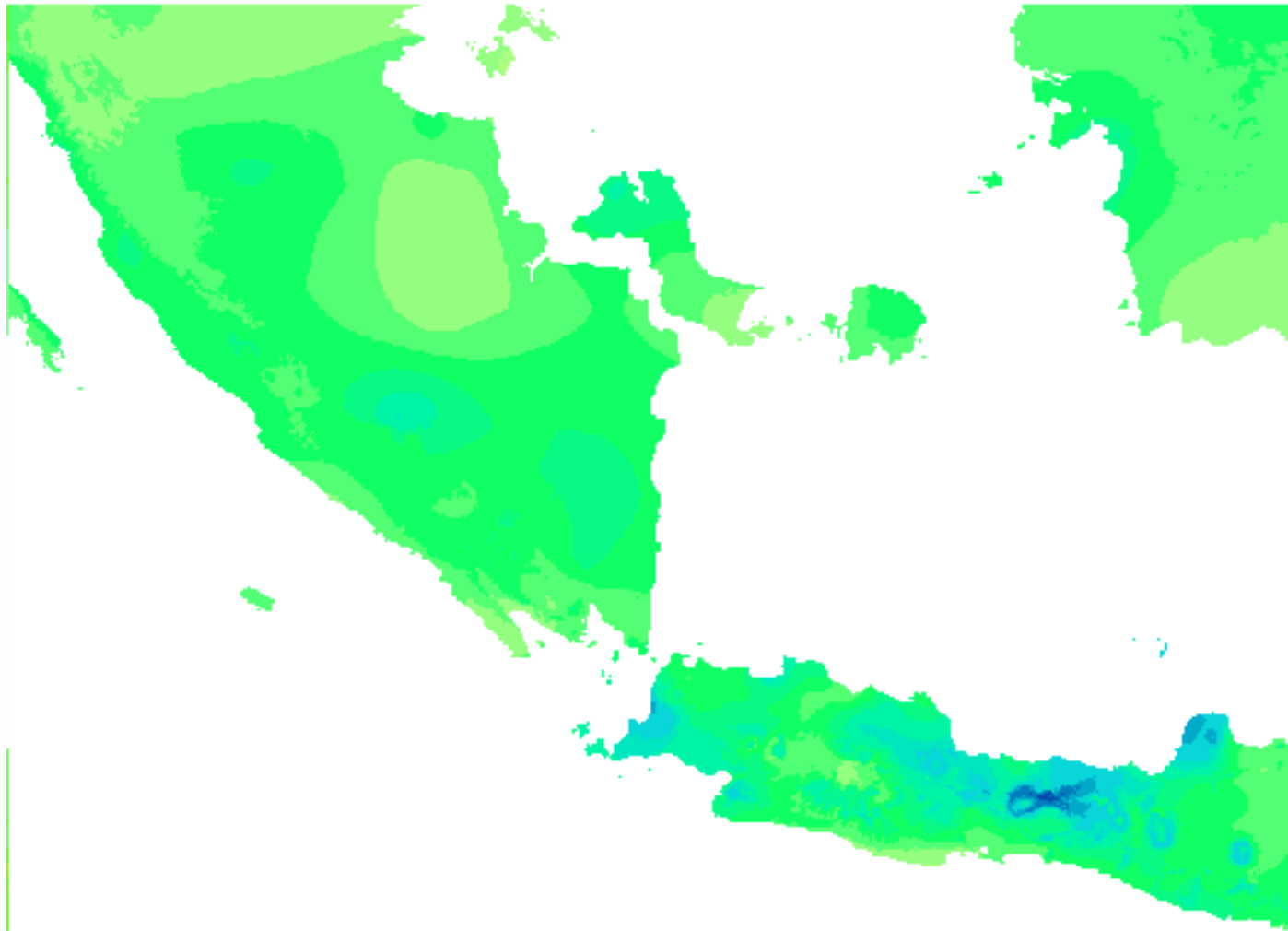
Ancillary data – top soil TOC



Ancillary data – temperature



Ancillary data – precipitation



MODIS data – processing

OK, if the film in the previous slide worked, you would have noticed how vegetation cover seemed to fluctuate wildly over the annual cycle.

This is an artefact of cloud and aerosol disturbance. Luckily the reliability and disturbance (quality) of each pixel in each MODIS scene is recorded. And can be used to clean the data from errors.

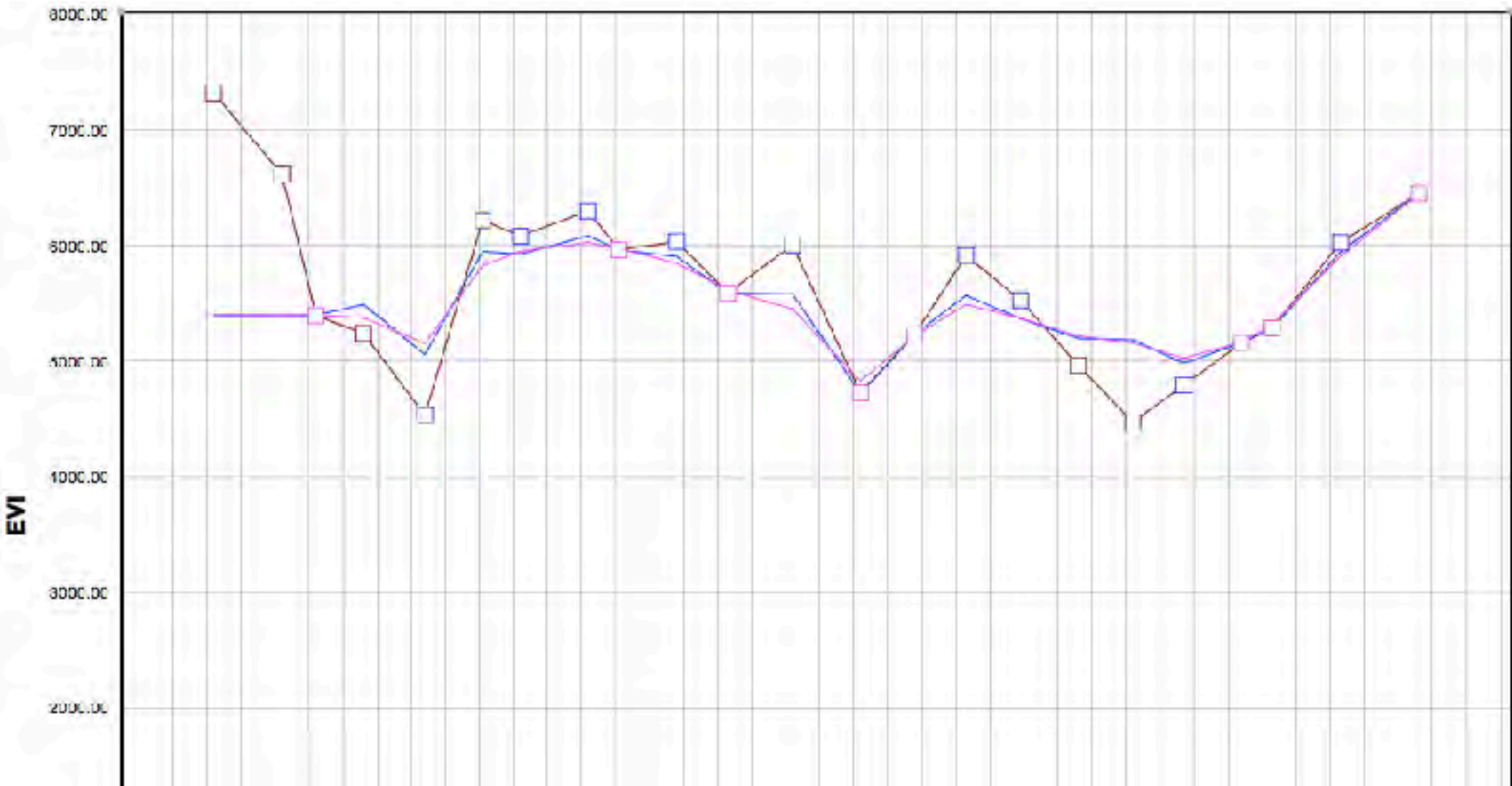
MODIS data – data cleaning

The data cleaning is done assuming that vegetation and reflectance are moderately slowly changing variables. The average time difference between 2 MOD13Q1 (vegetation) products is 16 days. Tiles with recorded errors (or poor data) are interpolated (corrected) using adjacent dates with perfect data. Simple as that. But it takes a very very long time. The 2 billion * 3,640 cells have to be passed over several times.

MODIS data – data smoothing

To get rid of small (deemed artificial) fluctuations, a smoothing filter is applied to the cleaned time series. As a compromise between processing speed and accuracy, the smoothing is done as a local regression (LOESS) keeping the x-value (day of year of recording) constant. A distance decay functions assigns higher weights to dates closer to the pixel (picture element) to be smoothed.

MODIS data – cleaning/smoothing



Finding the wetlands – next steps

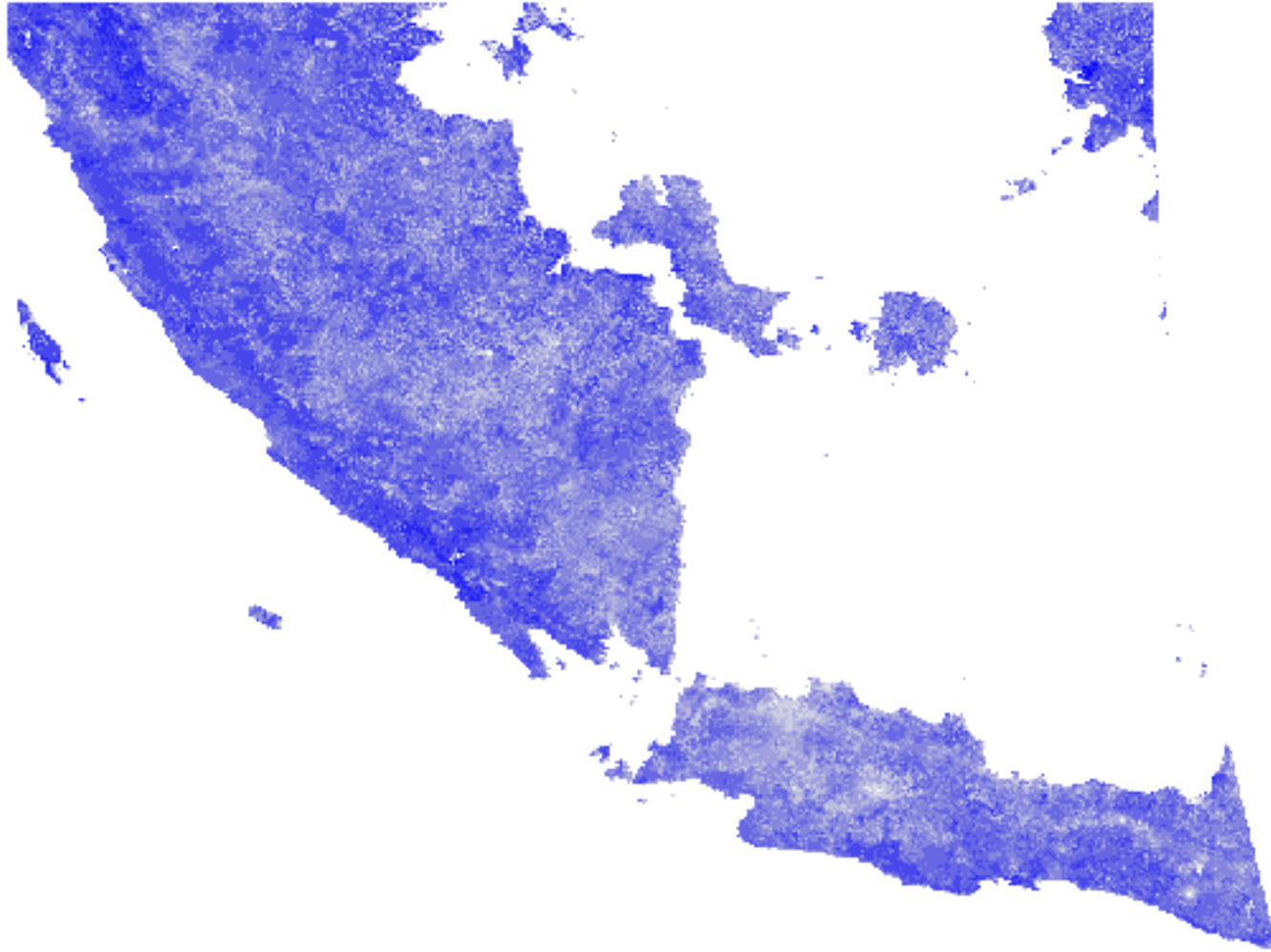
This is about how far I am right now. Once the cleaning/smoothing is done I will use the EVI vegetation data to try to identify wetlands directly. But perhaps the larger potential is to use the EVI data for pixel unmixing the reflectance data. By doing a forward driven pixel unmixing I can divide the reflection in each pixel in 2 components – one for vegetation and for the ground.

Finding the wetlands – next steps

Using only the ground component I can then calculate a Normalized Difference Wetness Index (NDWI) for each pixel:

$$\text{NDWI} = (\text{NIR} - \text{MIR}) / (\text{NIR} + \text{MIR})$$

Finding the wetlands – NDWI



Finding the wetlands - alternatives

There are better wetness indexes than the NDWI – but they demand reflectance data also from other bands. These bands are not available from the MOD13Q1 product, and demand more complicated pre-processing. MOD09A1 could be used to construct a Tasseled Cap (PCA) derived wetness index for example. In very cloudy locations (like here in Indonesia) turning to radar data could be an alternative.

Getting the volumes

I intend to use the SRTM and ASTER-DEM global data to estimate the volumes of the wetlands I find. This can be done by geospatial interpolation of the land surface surrounding each wetland. But I believe it must also consider geomorphology and wetland idiotyping.