Practical Use of Remote Sensing Data in Agriculture

Training course for IAEA

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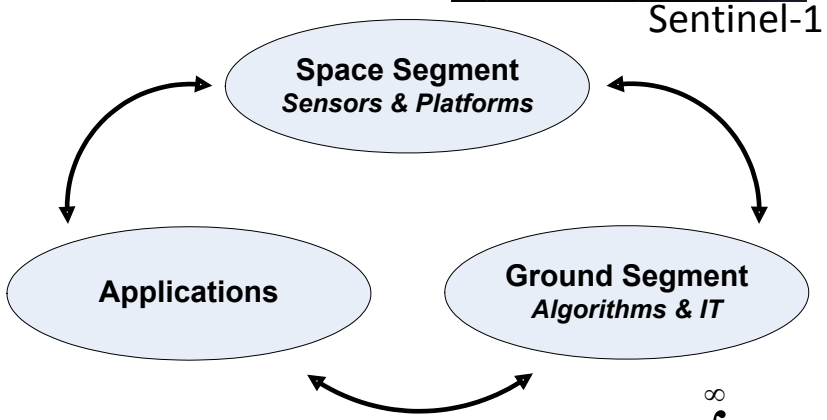
Data → Applications → Decisions

Sentinel-1



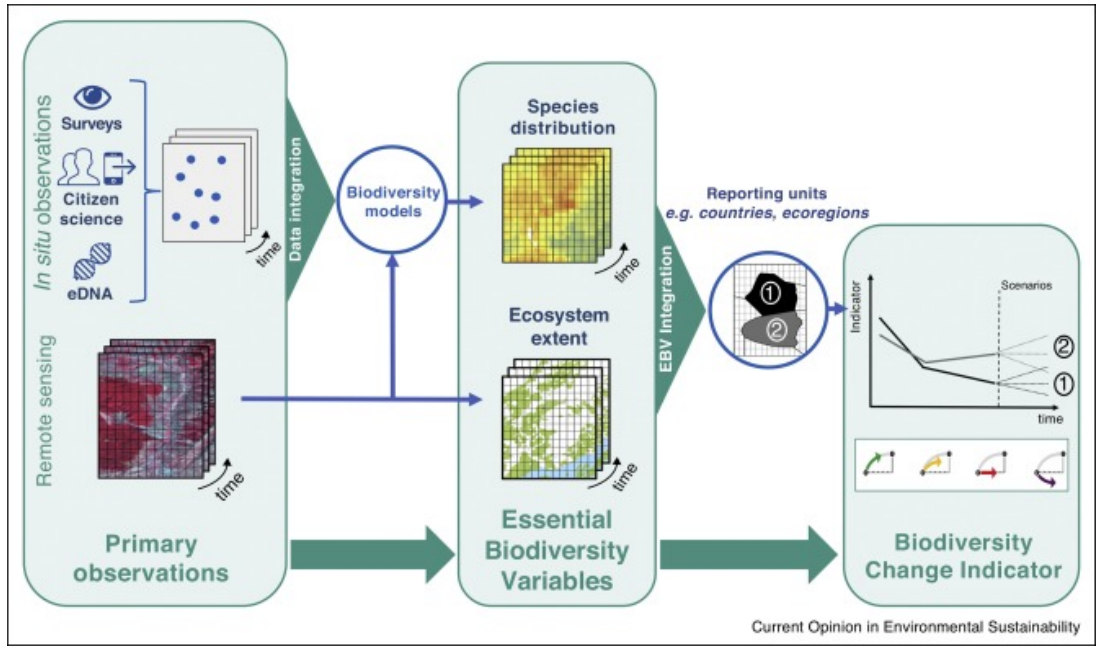
Flood Forecasting

$$\Phi = \int_0^{\infty} x \exp(-x\xi) dx$$

Geometric Models

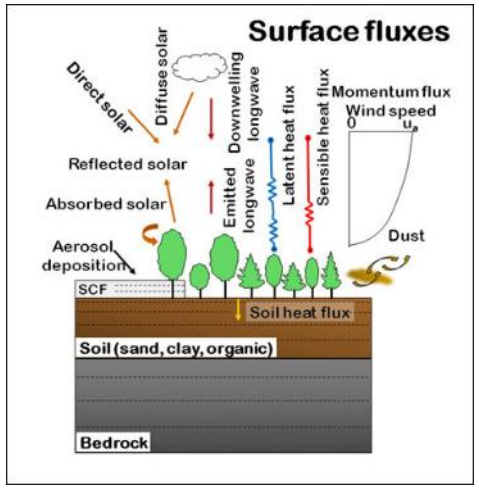
Physical Models

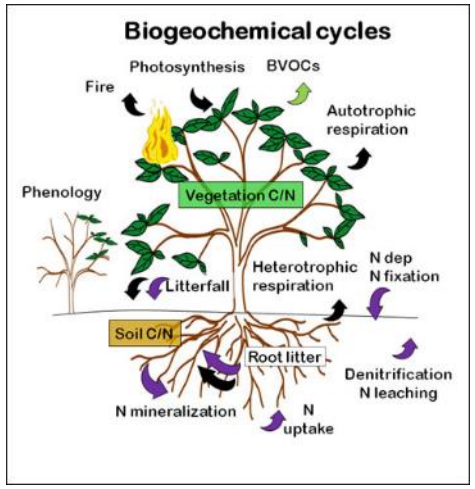
Data Processing

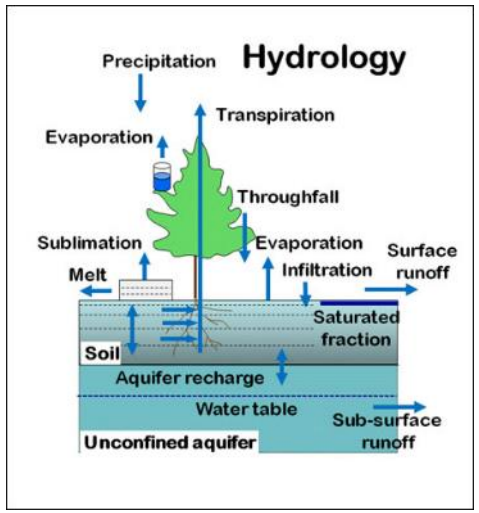


Source: Navarro et al. (2017)

Environmental Monitoring Requires a Holistic View

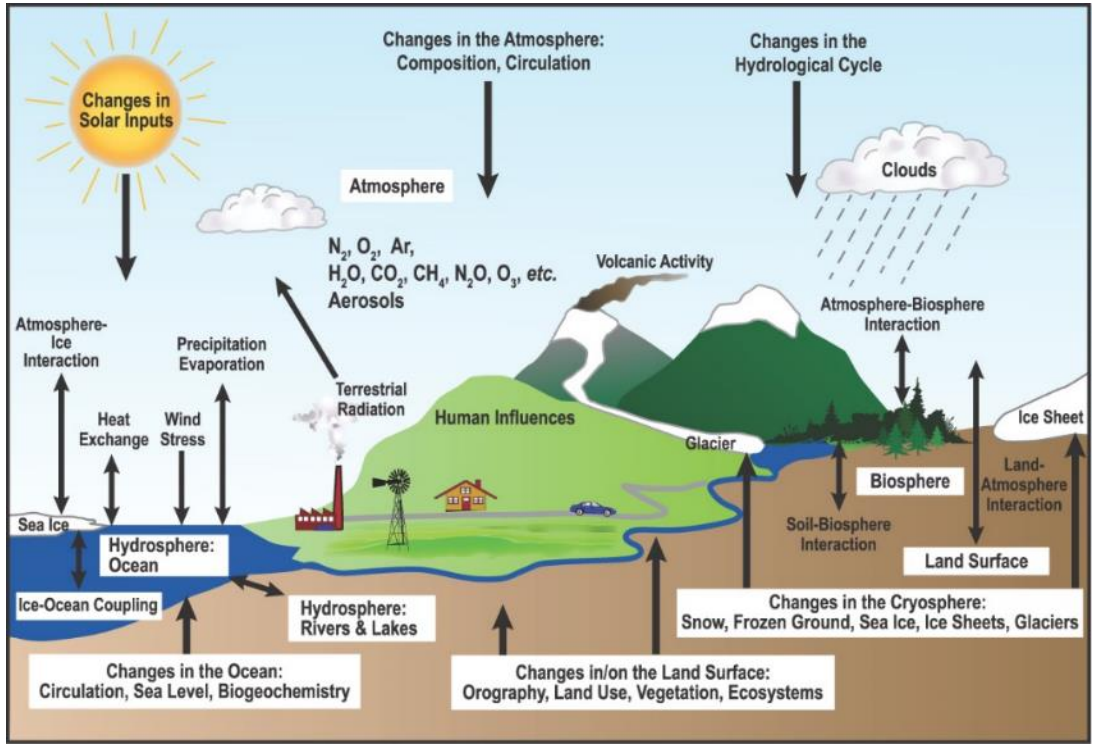






Schematic diagram depicting processes represented in the Community Land Model (http://www.cesm.ucar.edu/models/clm/)

Source: Lawrence and Fisher (2013)

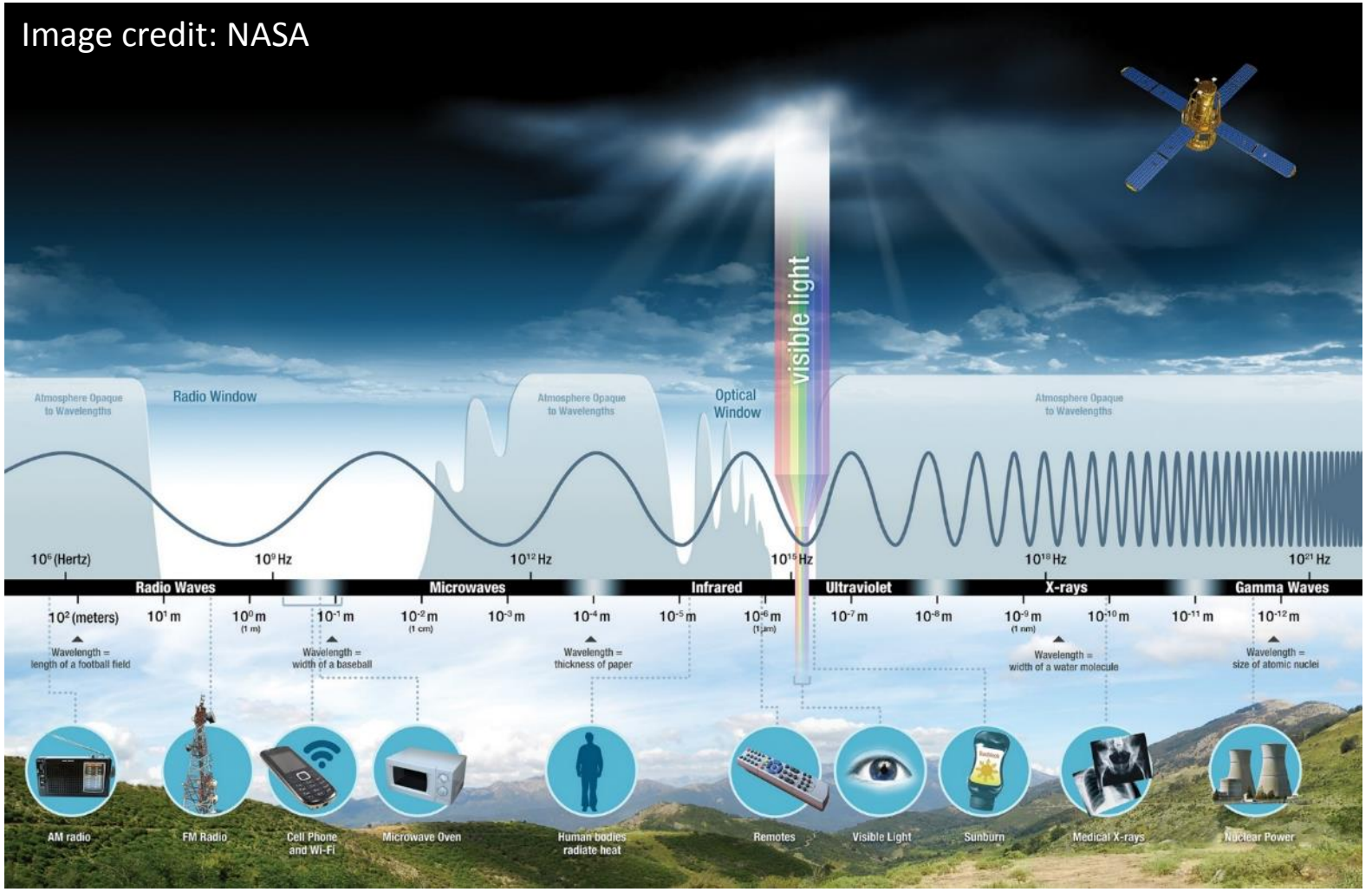


Global Climate Observing System

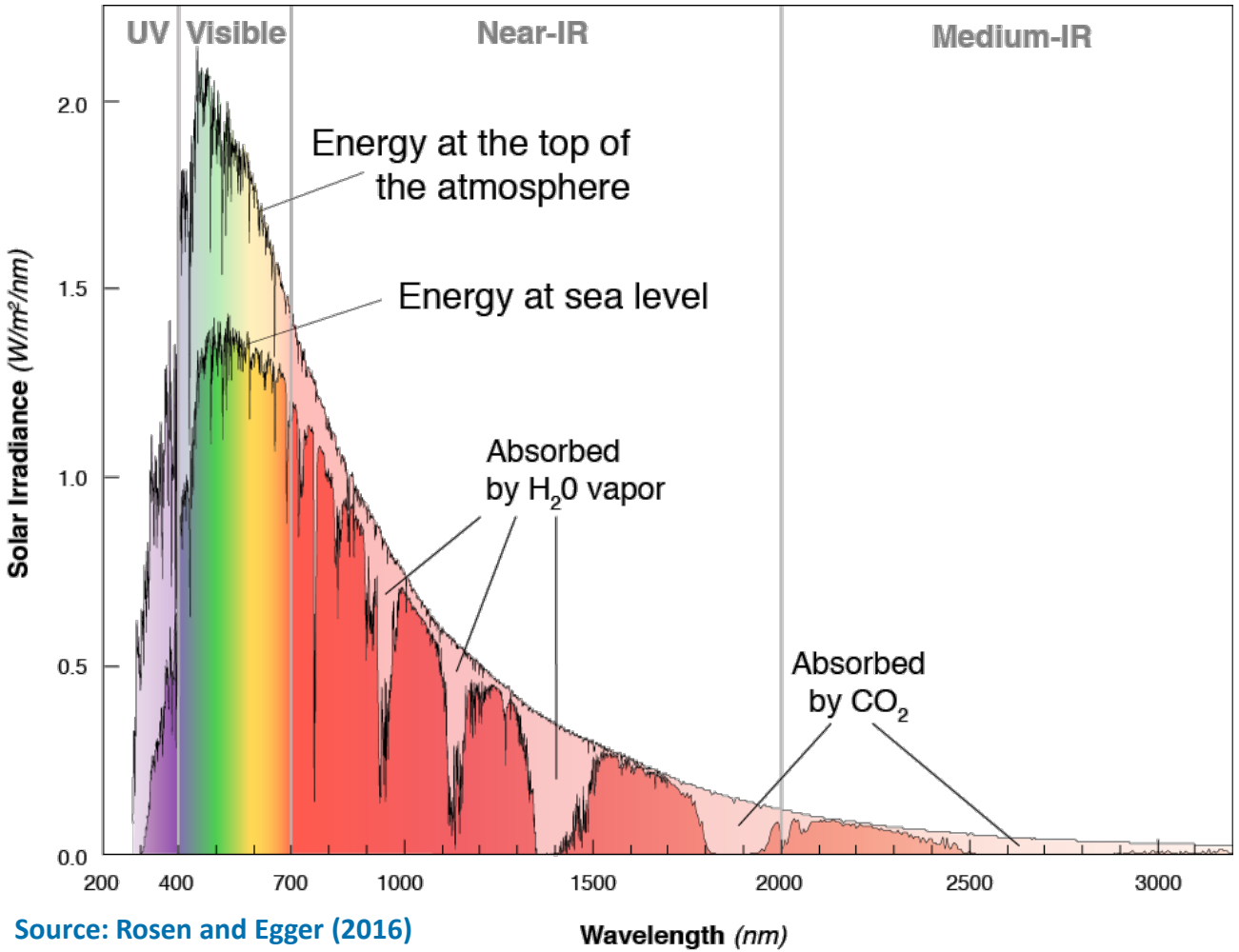
Measurement domain	Essential Climate Variables (ECVs)
Atmospheric	Surface: air temperature, wind speed and direction, water vapour, pressure, precipitation, surface radiation budget Upper-air: temperature, wind speed and direction, water vapour, cloud properties, Earth radiation budget, lightning Composition: carbon dioxide (CO_2), methane (CH_4), other long-lived greenhouse gases, ozone, aerosol, precursors for aerosol and ozone
Oceanic	Physics: temperature: sea surface and subsurface; salinity: sea surface and subsurface; currents, surface currents, sea level, sea state, sea ice, ocean surface stress, ocean surface heat flux Biogeochemistry: inorganic carbon, oxygen, nutrients, transient tracers, nitrous oxide (N_2O), ocean colour Biology/ecosystems: plankton, marine habitat properties
Terrestrial	Hydrology: river discharge, groundwater, lakes, soil moisture Cryosphere: snow, glaciers, Ice sheets and Ice shelves, permafrost Biosphere: albedo, land cover, fraction of absorbed photosynthetically active radiation, leaf area index, above-ground biomass, soil carbon, fire, land surface temperature Human use of natural resources: water use, greenhouse gas fluxes

https://gcos.wmo.int/

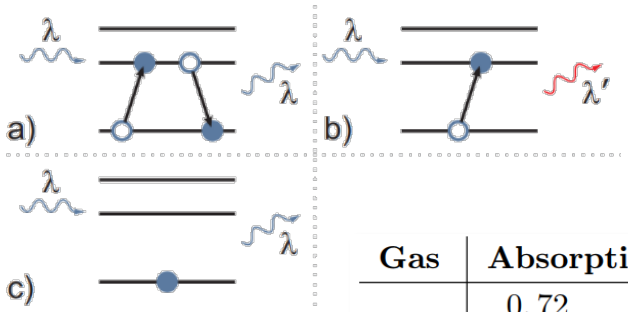
Basics: Electromagnetic spectrum



Absorption by Atmospheric Constituents



Source: Rosen and Egger (2016)



Gas	Absorptionsbanden $[\mu m]$		
H_2O	$0,72$	$0,82$	$0,94$
	$1,1$	$1,38$	$1,87$
	$2,7$		
CO_2	$1,4$	$1,6$	$2,0$
	$2,7$		
O_3	$0,25$	$0,33$	$0,73$
O_2	$0,14$	$0,22$	$0,63$
	$0,69$	$0,76$	$1,06$
	$1,27$	$1,58$	
CH_4	$1,66$	$2,2$	$2,37$
CO_2	$2,34$	$2,75$	
NO_2	$0,5$		

Source: Schramm (2010)

Spectral resolution

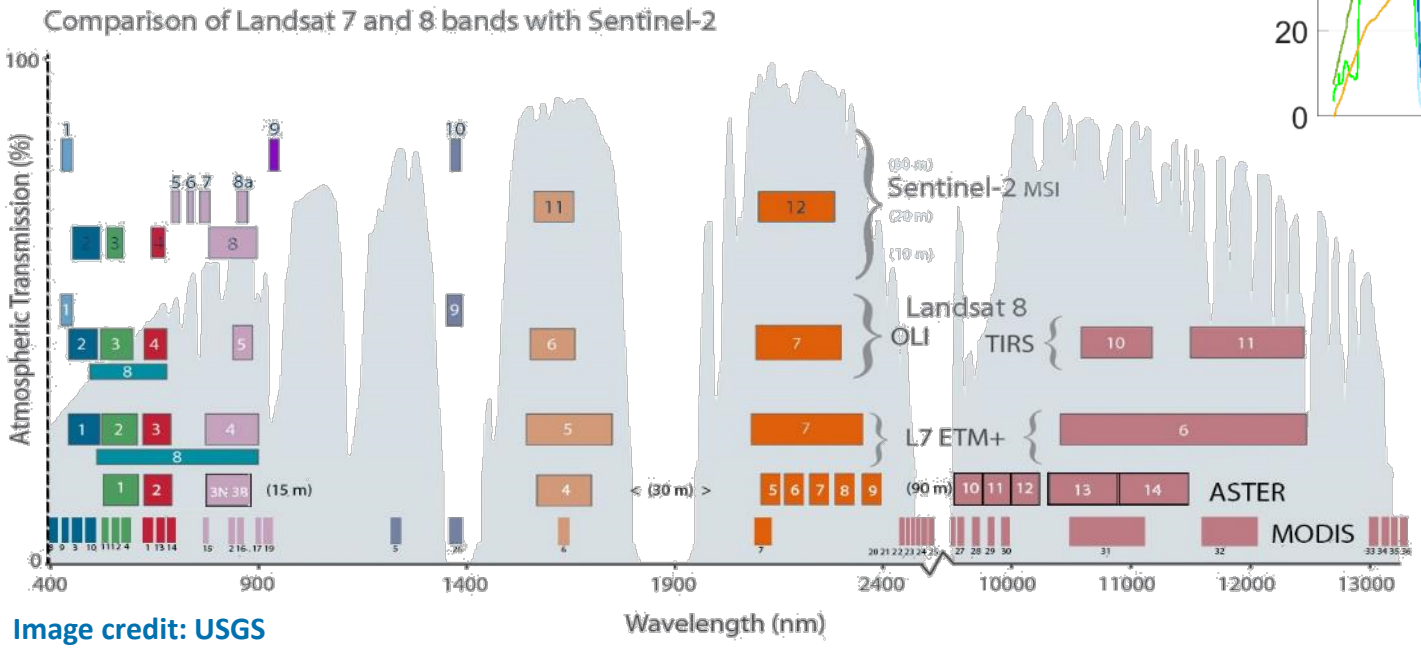
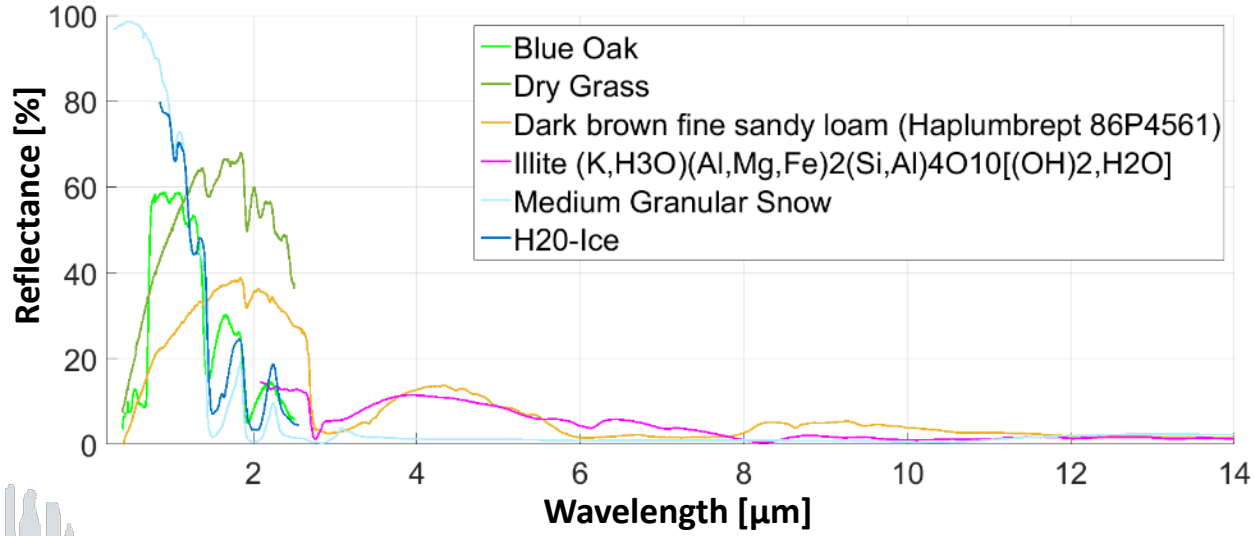
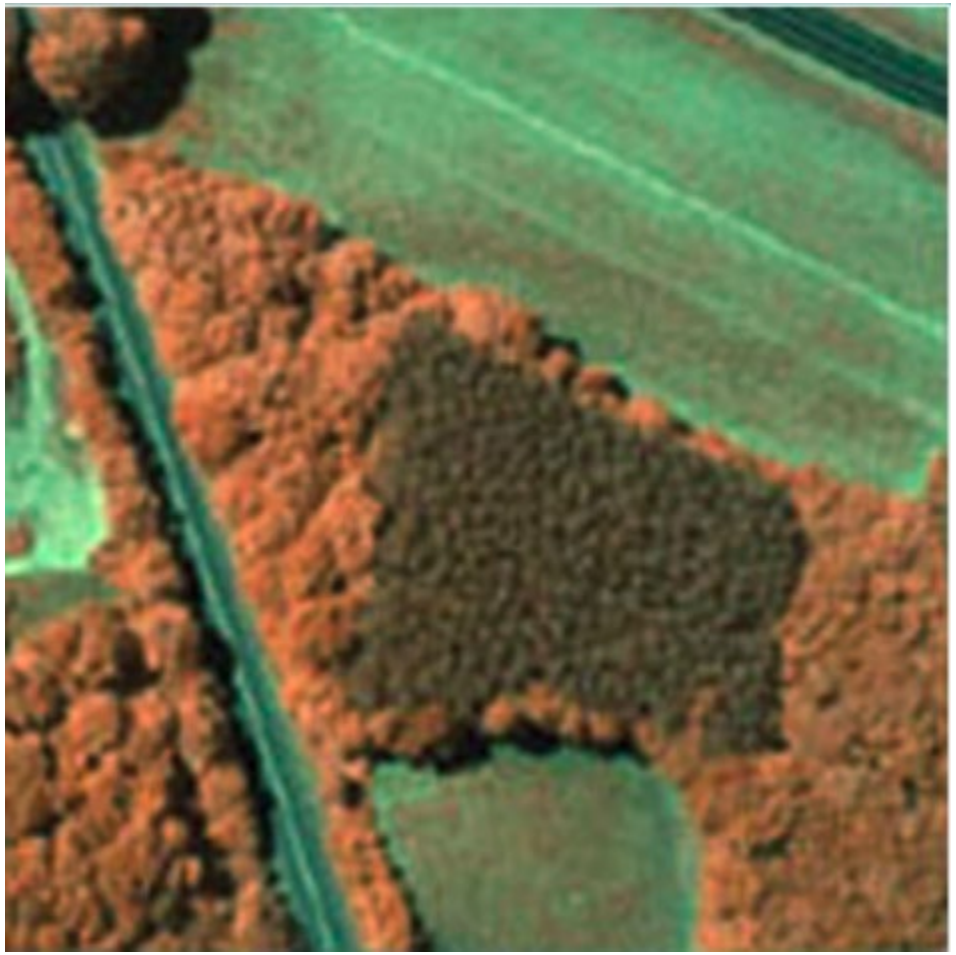


Image credit: USGS



Source: Clark et al. (2007), Baldridge et al. (2009)

Spectral resolution



- Deciduous vs. Coniferous Forest
- 1x1m
- Spatial Emerge Digital Camera
- Bands: NIR,R,G

Source: Jensen (2005)

Geometric resolution

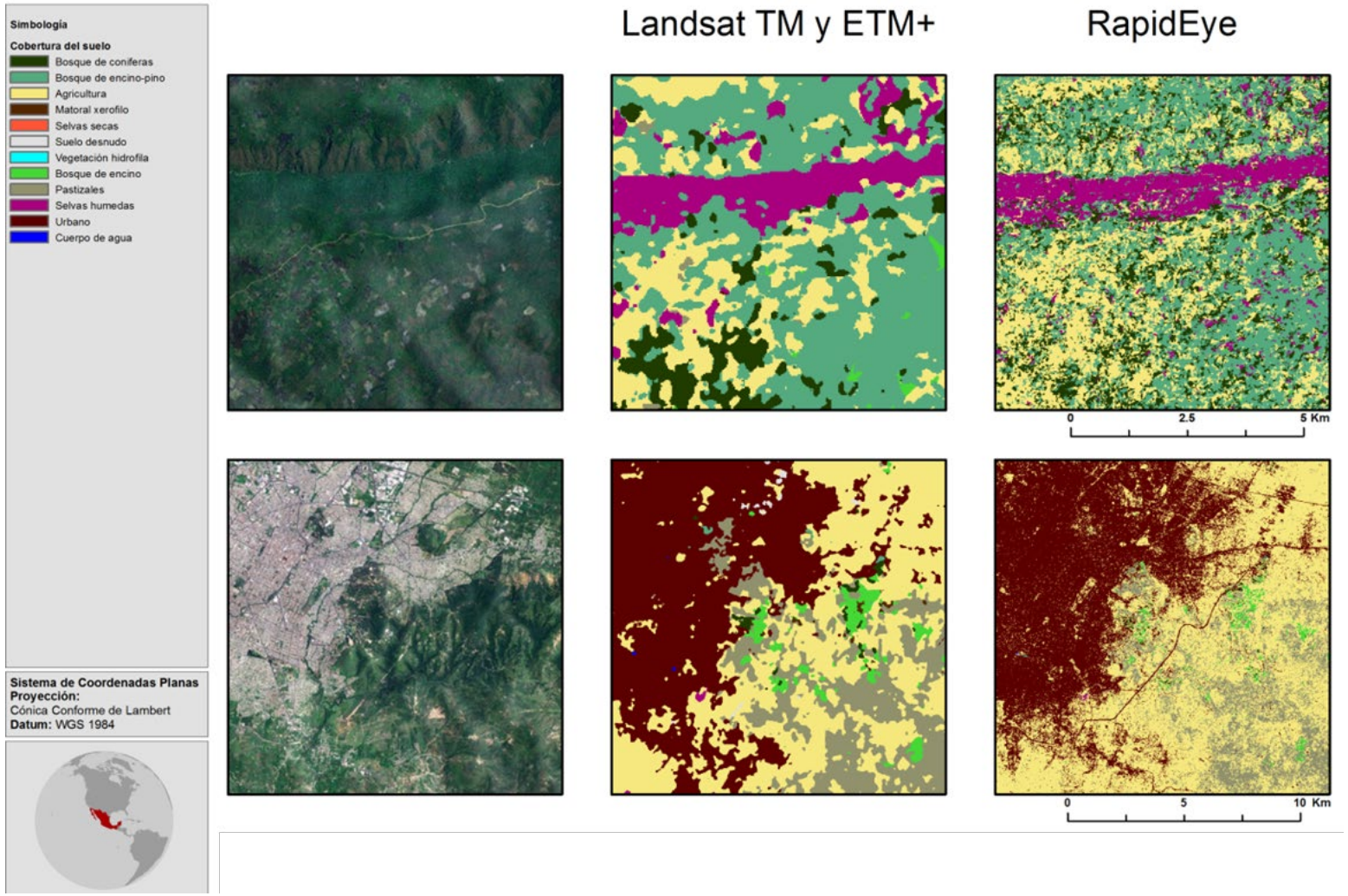
a. Landsat ETM+

b. ATLAS

c. QuickBird

Image Credit: NASA

Geometric resolution



Source: Schramm, 2014

Basics: temporal resolution

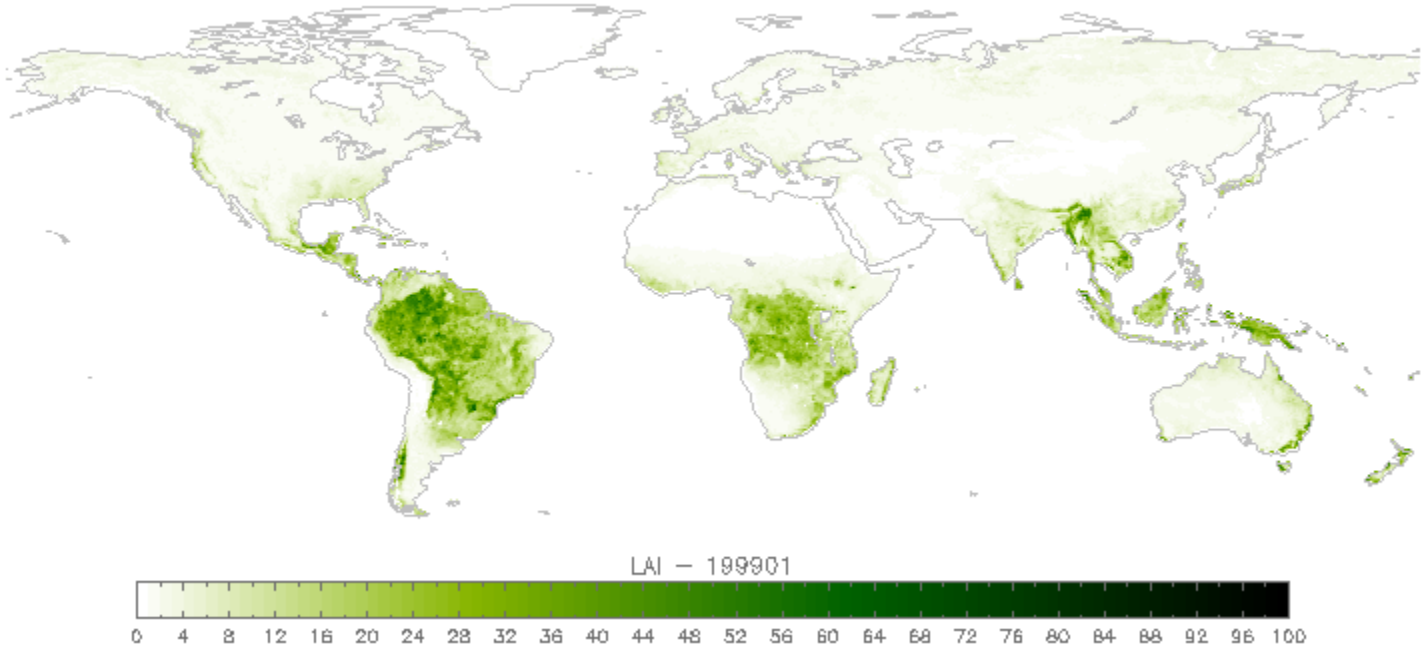
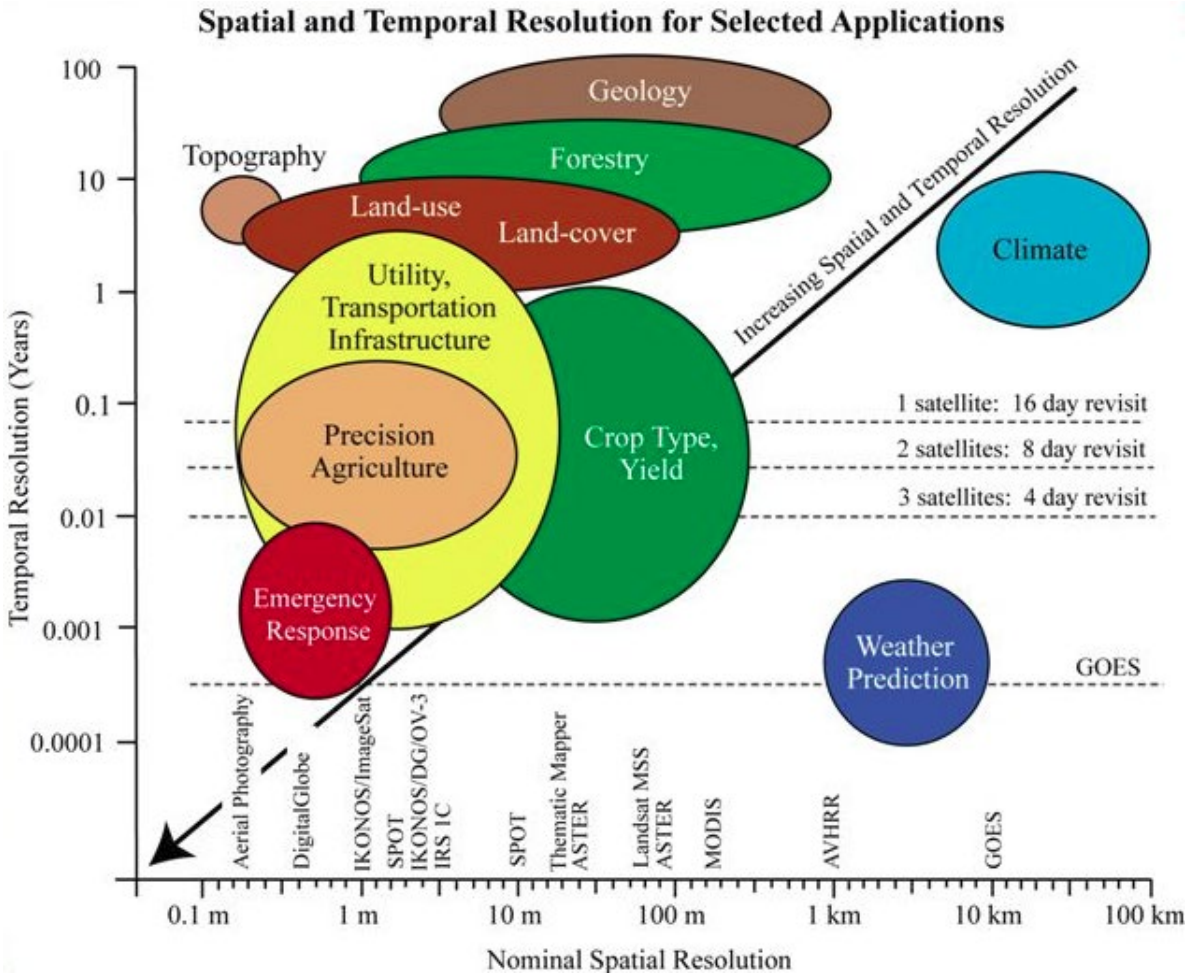


Image Credit: ESA

- Animation based on GLOBCARBON data
- Changes in worldwide leaf area index (LAI)
- 1999 – 2002

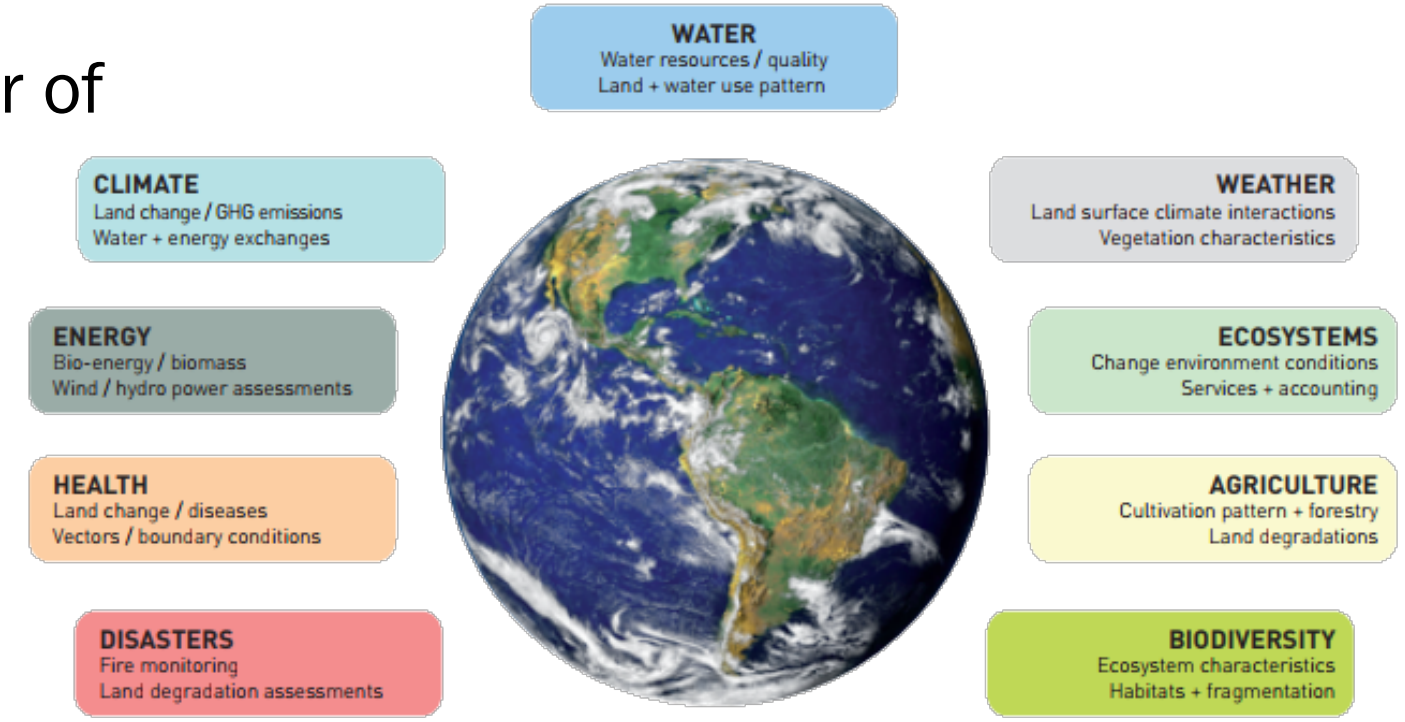
Required resolution



Source: Jensen (2005)

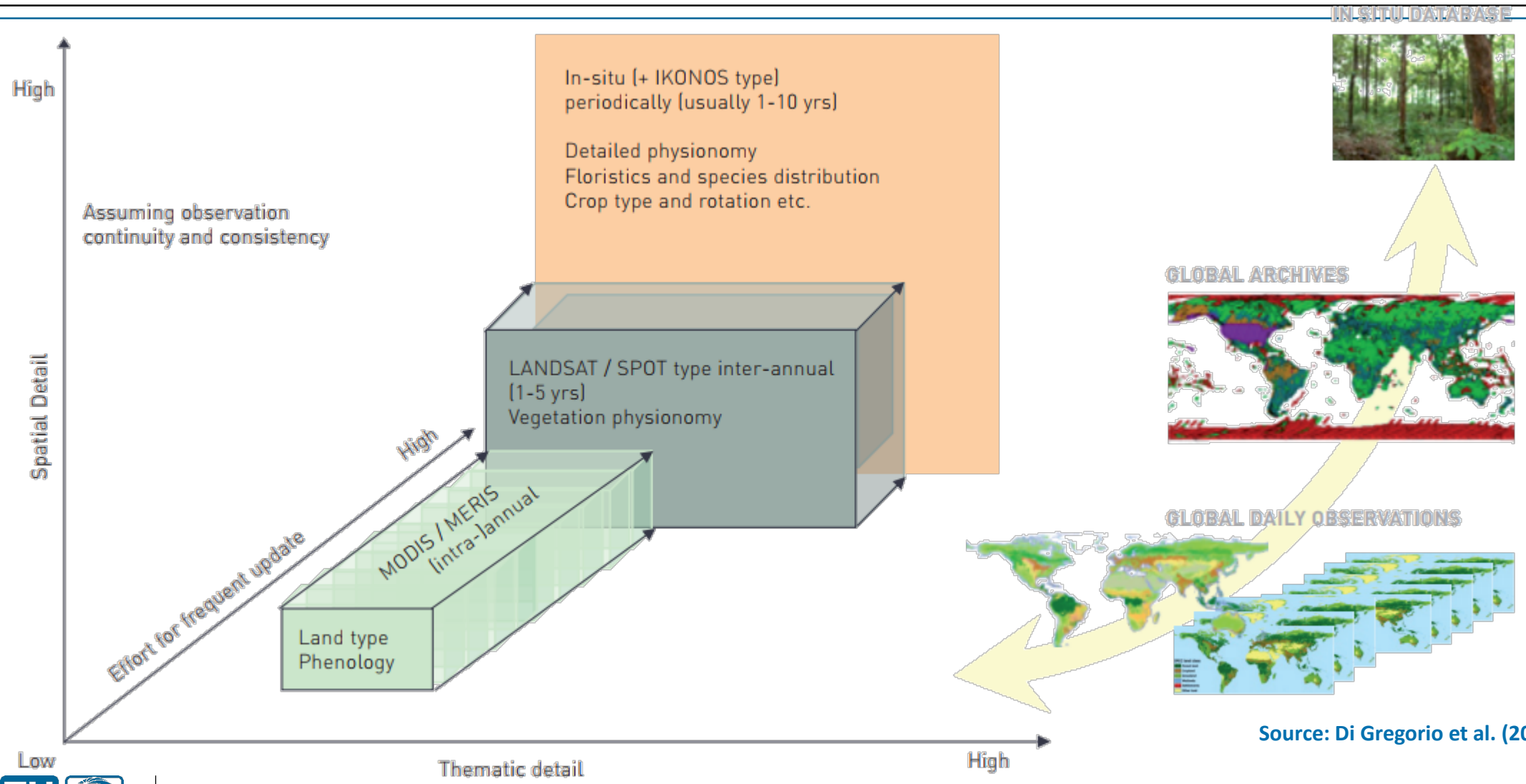
Land Cover (LC) / Land Cover Change

- Observed (bio) physical cover of the earth's surface
- Synthesis of all processes taking place on the land
- Reflects land occupation / transformation by natural, modified, artificial systems
- To detect dynamics / human intervention on land



Source: Herold et al. (2012)

Land Cover (LC) / Land Cover Change



Source: Di Gregorio et al. (2016)

CORINE Land Cover

Level 1	Level 2	Level 3
1 Artificial surfaces	11 Urban fabric	111 Continuous urban fabric
		112 Discontinuous urban fabric
	12 Industrial, commercial and transport units	121 Industrial or commercial units
		122 Road and rail networks and associated land
		123 Port areas
		124 Airports
	13 Mine, dump and construction sites	131 Mineral extraction sites
		132 Dump sites
		133 Construction sites
	14 Artificial, non-agricultural vegetated areas	141 Green urban areas
		142 Sport and leisure facilities
2 Agricultural areas	21 Arable land	211 Non-irrigated arable land
		212 Permanently irrigated land

CORINE Land Cover

Level 1	Level 2	Level 3
2 Agricultural areas	21 Arable land	211 Non-irrigated arable land
		212 Permanently irrigated land
		213 Rice fields
	22 Permanent crops	221 Vineyards
		222 Fruit trees and berry plantations
		223 Olive groves
	23 Pastures	231 Pastures
	24 Heterogeneous agricultural areas	241 Annual crops associated with permanent crops
		242 Complex cultivation patterns
		243 Land principally occupied by agriculture, with significant areas of natural vegetation
		244 Agro-forestry areas

CORINE Land Cover

Level 1	Level 2	Level 3
3 Forest and semi natural areas	31 Forests	311 Broad-leaved forest
		312 Coniferous forest
		313 Mixed forest
	32 Scrub and/or herbaceous vegetation associations	321 Natural grasslands
		322 Moors and heathland
		323 Sclerophyllous vegetation
		324 Transitional woodland-shrub
	33 Open spaces with little or no vegetation	331 Beaches, dunes, sands
		332 Bare rocks
		333 Sparsely vegetated areas
		334 Burnt areas
		335 Glaciers and perpetual snow
4 Wetlands	41 Inland wetlands	411 Inland marshes
		412 Peat bogs

CORINE Land Cover

Level 1	Level 2	Level 3
4 Wetlands	41 Inland wetlands	411 Inland marshes
		412 Peat bogs
	42 Maritime wetlands	421 Salt marshes
		422 Salines
		423 Intertidal flats
5 Water bodies	51 Inland waters	511 Water courses
		512 Water bodies
	52 Marine waters	521 Coastal lagoons
		522 Estuaries
		523 Sea and ocean

Other common legends

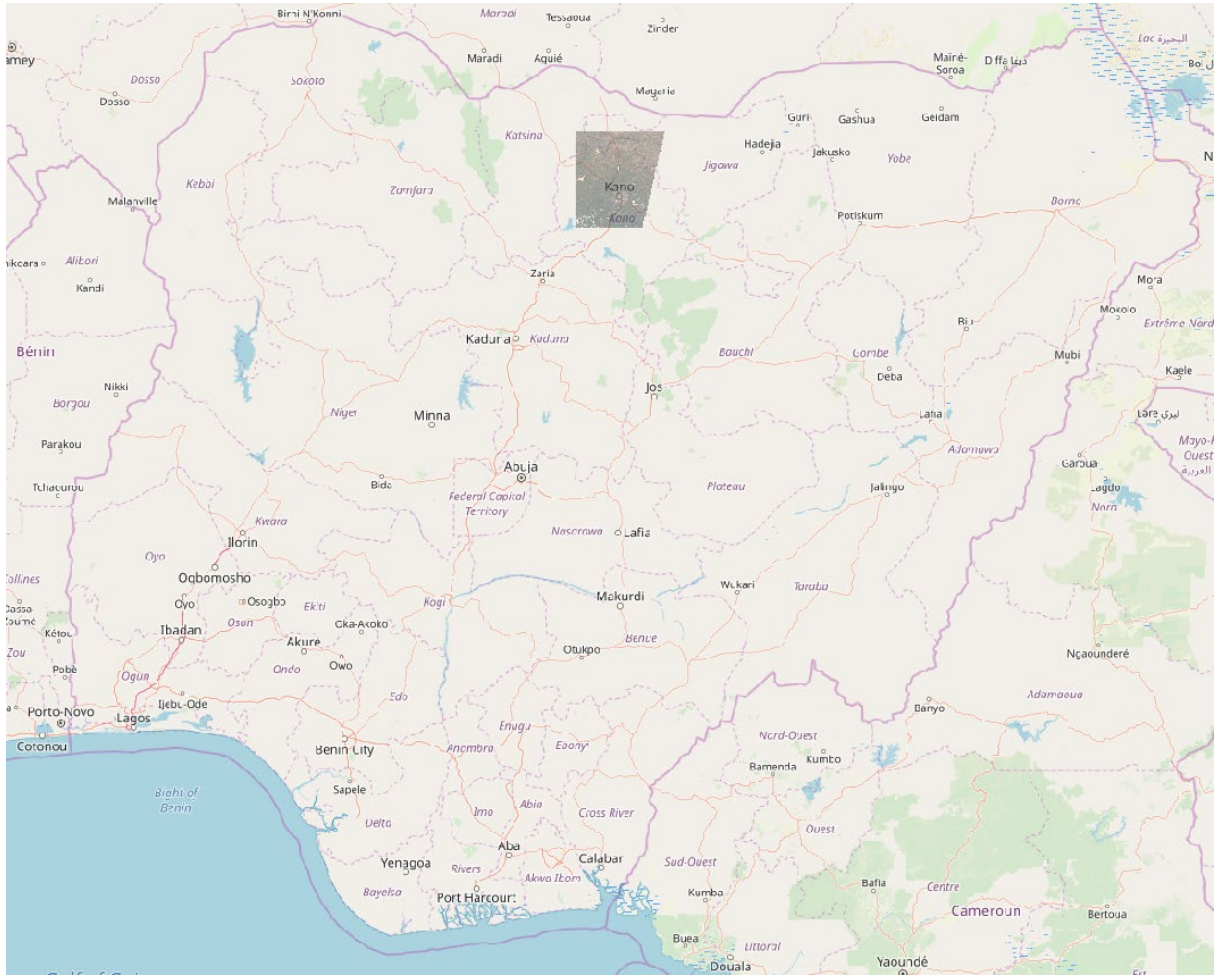
- UN Land Cover Classification System (LCCS)
- GLC2000
- GlobCover 2009
- FAO FRA

FRA2000 Class	FAO Definition	Representative land cover
Closed forest	Land covered by trees with a canopy cover of more than 40 percent and height exceeding 5 meters. Includes natural forests and forest plantations.	• Tropical/subtropical moist forest • Temperate broadleaf mixed forest • Subtropical/temperate conifer plantation • Boreal conifer forest
Open or fragmented forest	Land covered by trees with a canopy cover between 10 and 40 percent and height exceeding 5 meters (open forest), or mosaics of forest and non-forest land (fragmented forest). Includes natural forests and forest plantations.	• Northern boreal/taiga open conifer or mixed forest • Southern Africa woodland • Tropical fragmented/degraded forest
Other wooded land	Land either with a 5-10 percent canopy cover of trees exceeding 5 meters height, or with a shrub or bush cover of more than 10 percent and height less than 5 meters.	• Mediterranean closed scrubland • Tropical woody savanna
Other land cover	All other land, including grassland, agricultural land, barren land, urban areas.	• Grassland, cropland, non-woody wetland, desert, urban
Water	Inland water	• Inland water

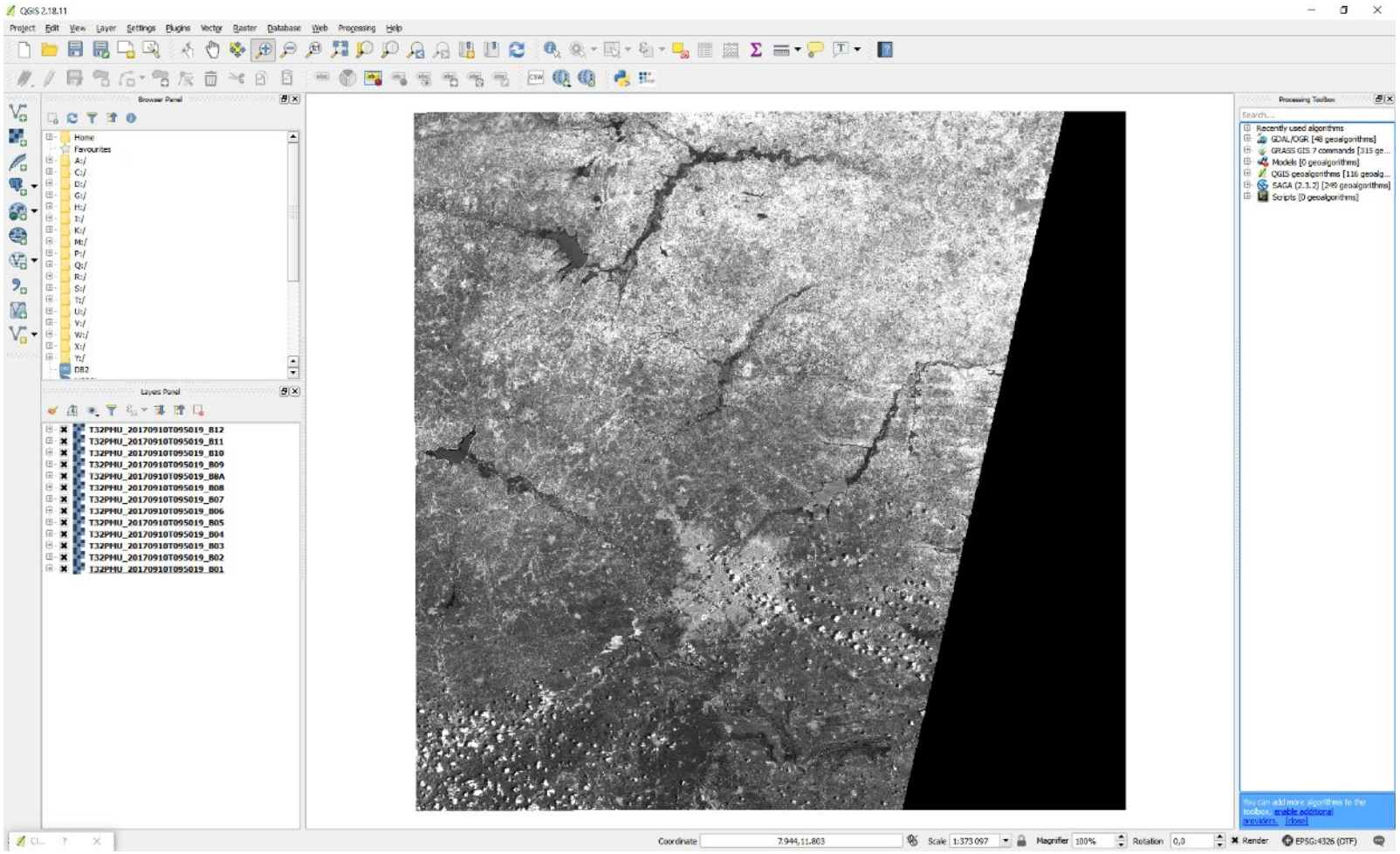
QGIS Example

1. Visualizing Sentinel 2 Data (raster dataset)
2. Masking clouds
3. Loading Aivian Influenca (vector dataset; csv)
4. Clipping them together
5. Calculation NDVI
6. Zonal Statistics

QGIS Example

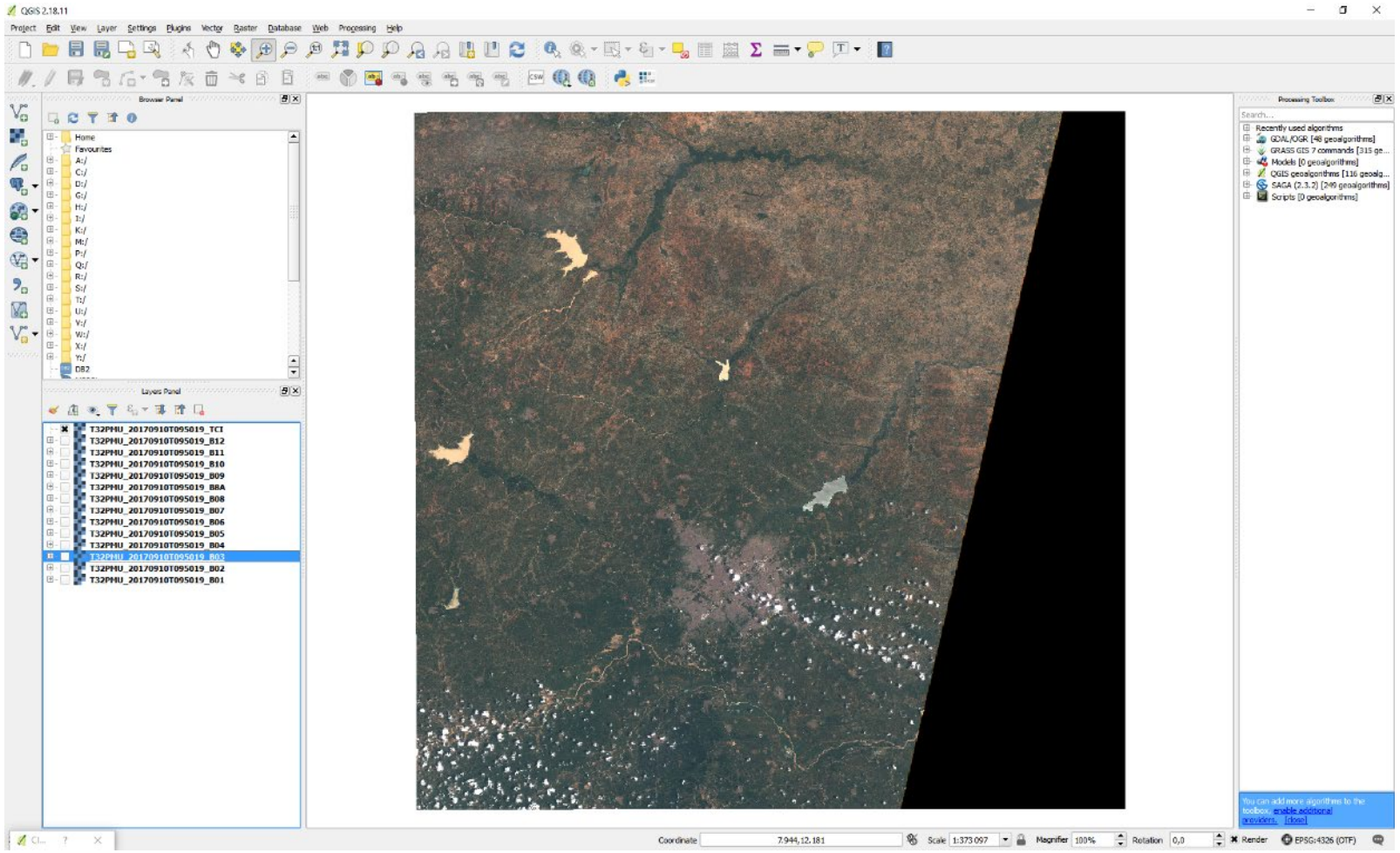


Visualising Sentinel-2 Data



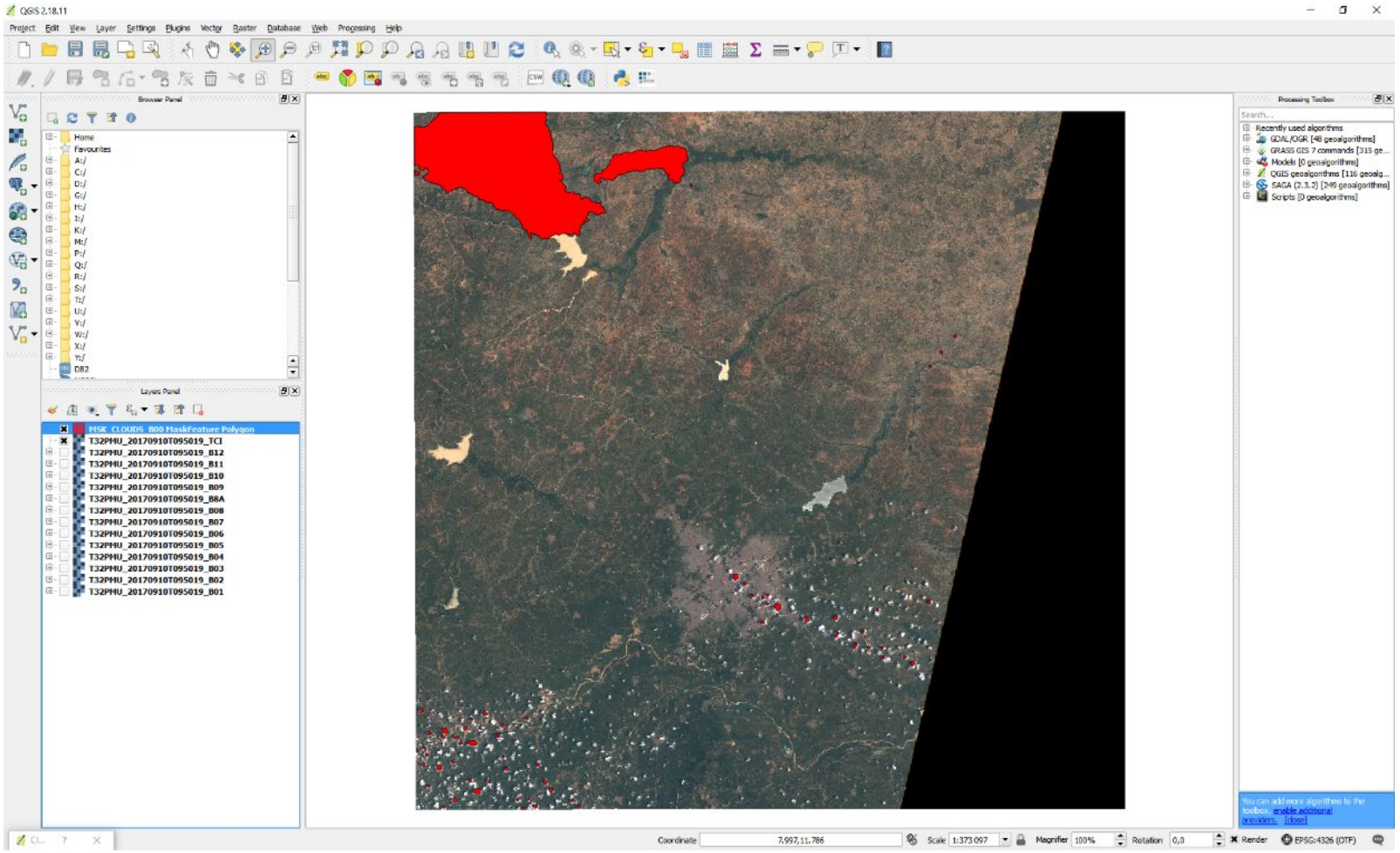
- Each band a single data file

Visualising Sentinel-2 Data



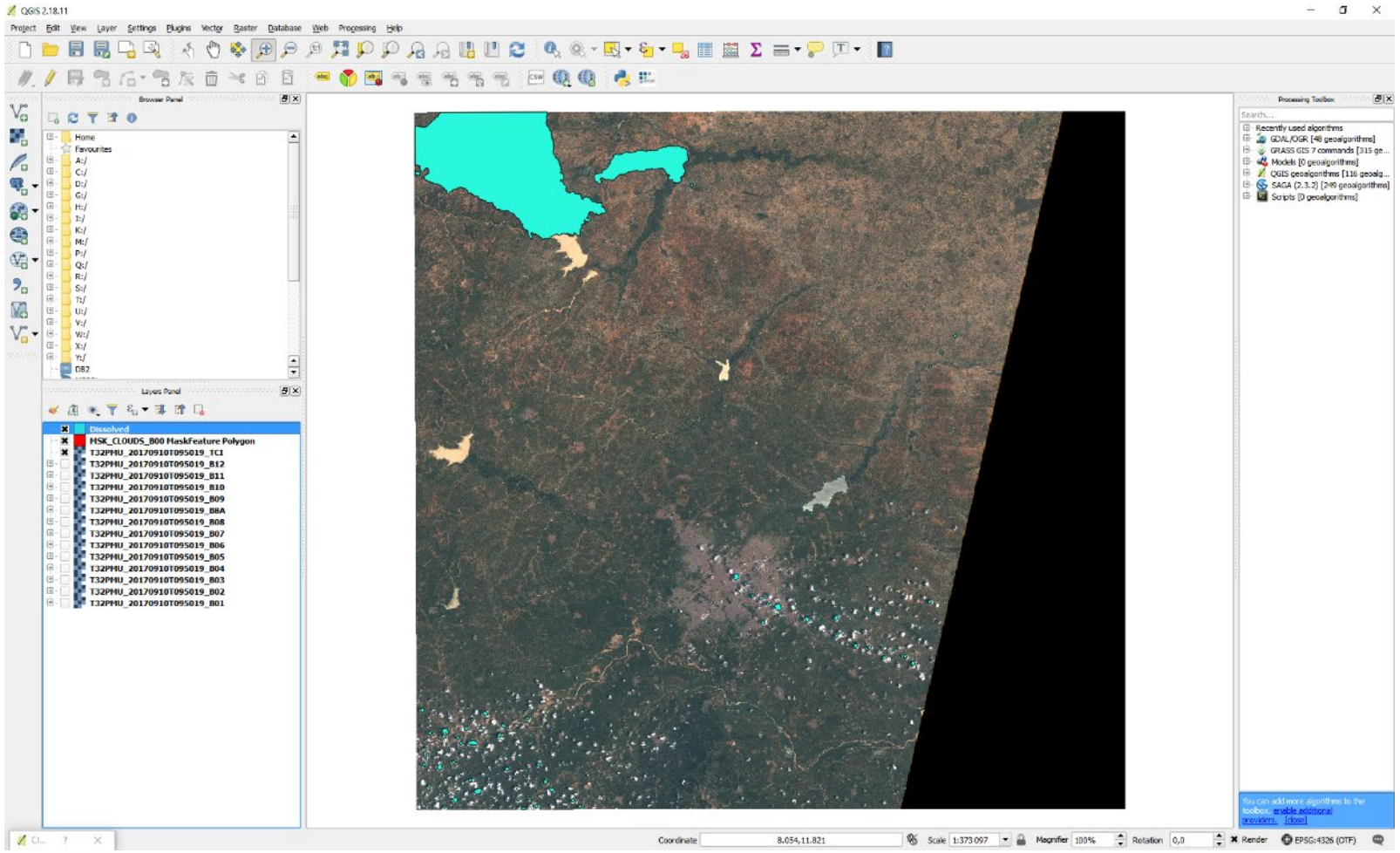
- True color image
  - T32PMU_ … _TCI.jp2
  - Consists of Bands 4,3,2 (Red, Green, Blue)

Masking Clouds



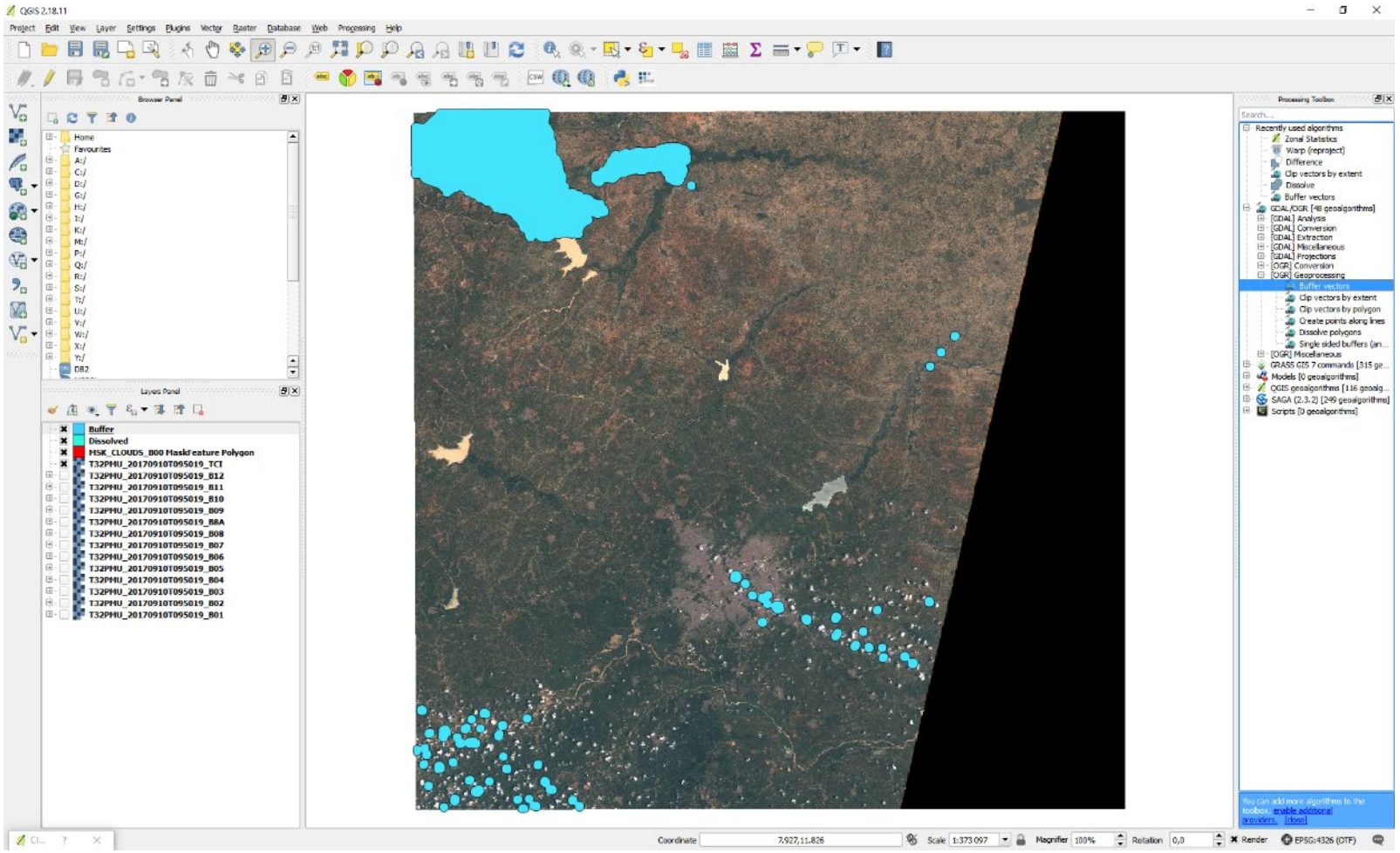
- Cloud mask
  - Layer available for S-2 data (vector data)
  - Not all clouds, not complete, some areas wrongly detected

Masking Clouds



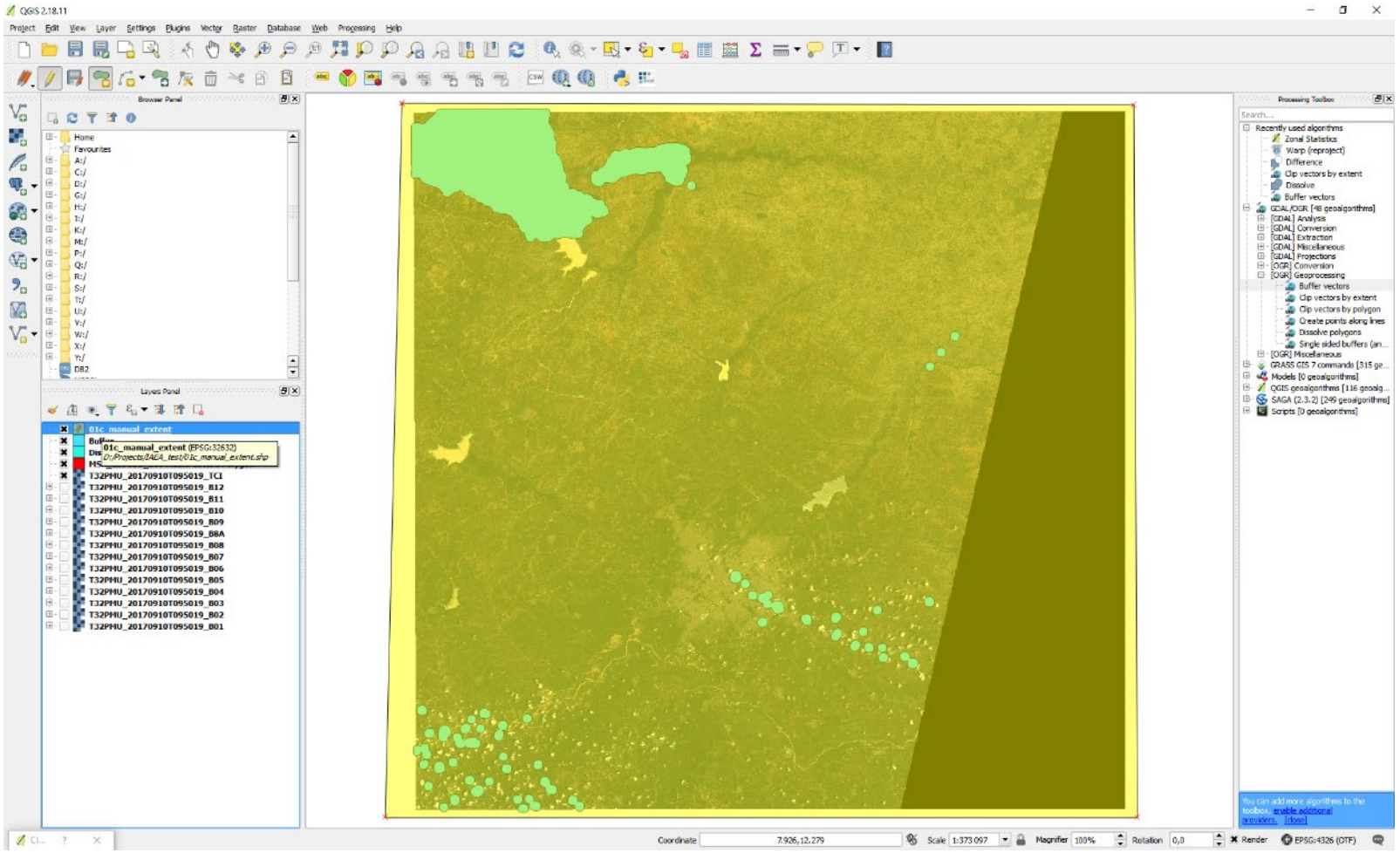
- Buffering clouds
  1. Dissolving cloud data to one single multi-polygon
     - Vector → Geoprocessing Tools →Dissolve

Masking Clouds



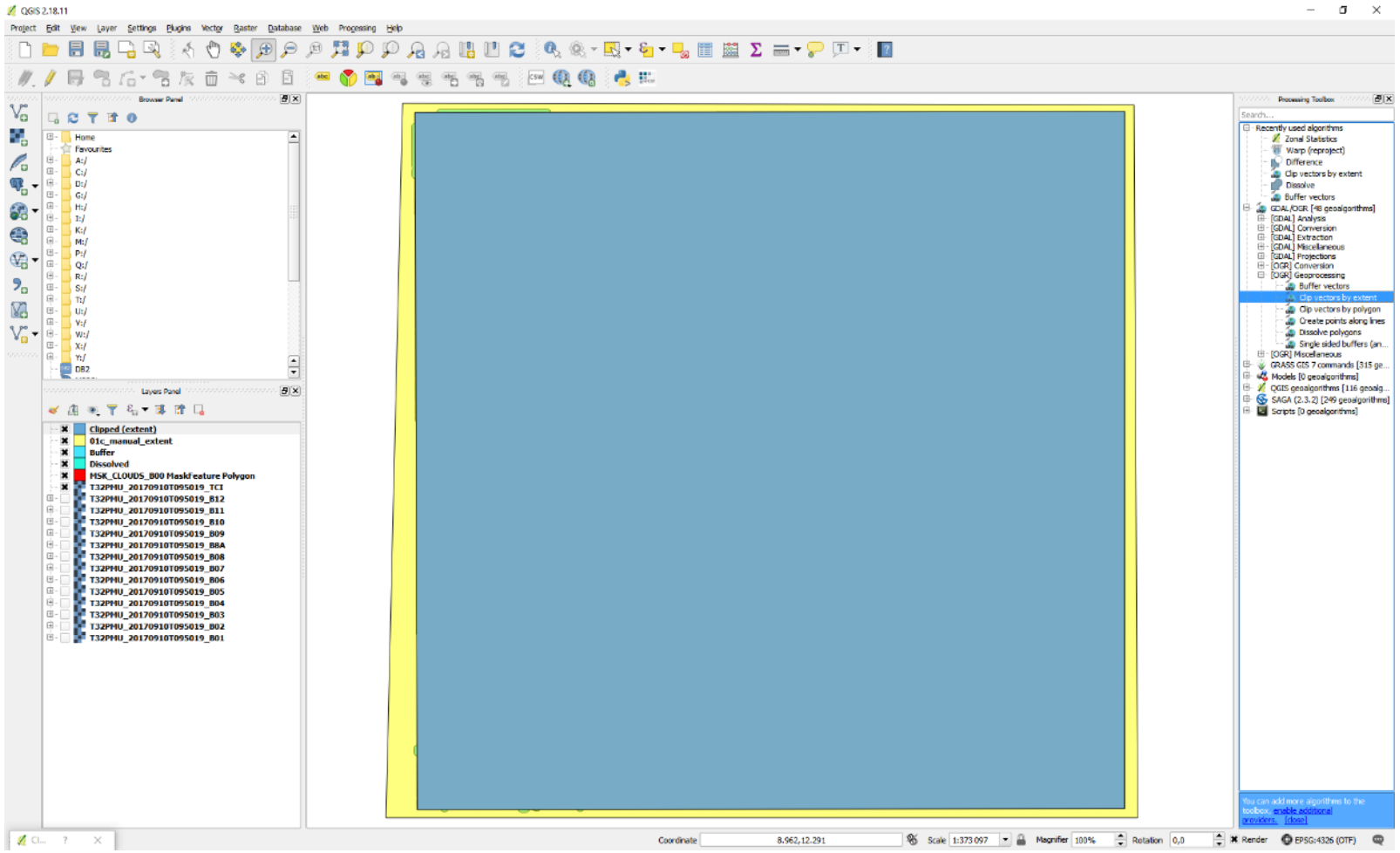
- Buffering clouds
  2. Buffering process
     - In Processing toolbox
     - GDAL/OGR → [OGR] Geoprocessing → Buffer vectors)

Masking Clouds



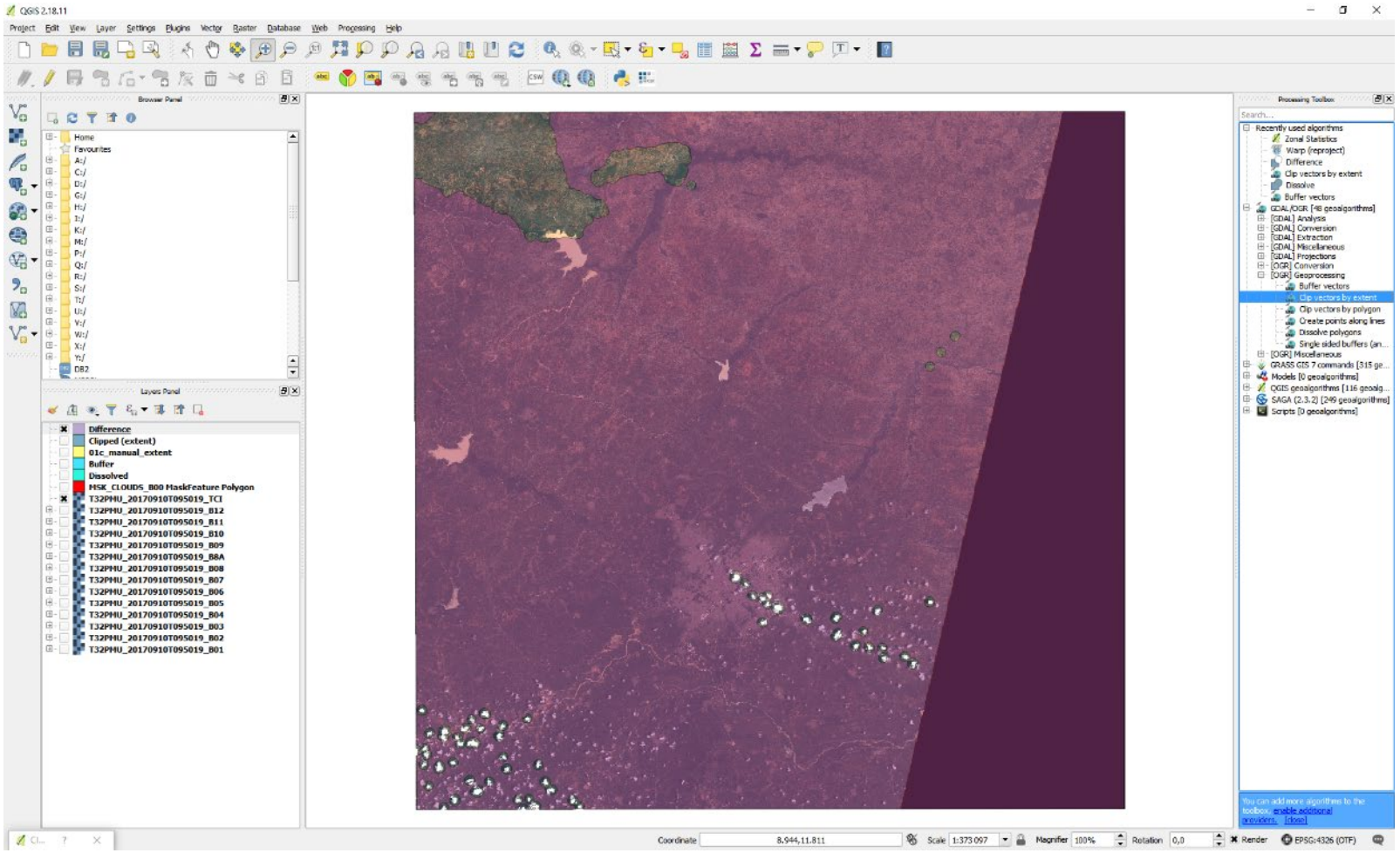
- For using only pixels, which are no cloud:
  1. Create manual shapefile
     - Layer → Create Layer → New Shapefile Layer
       - choose Polygon
     - Right click → Toggle Editing
       - Create box manually
     - Reproject to raster projection
       - Save as; choose CRS

Masking Clouds



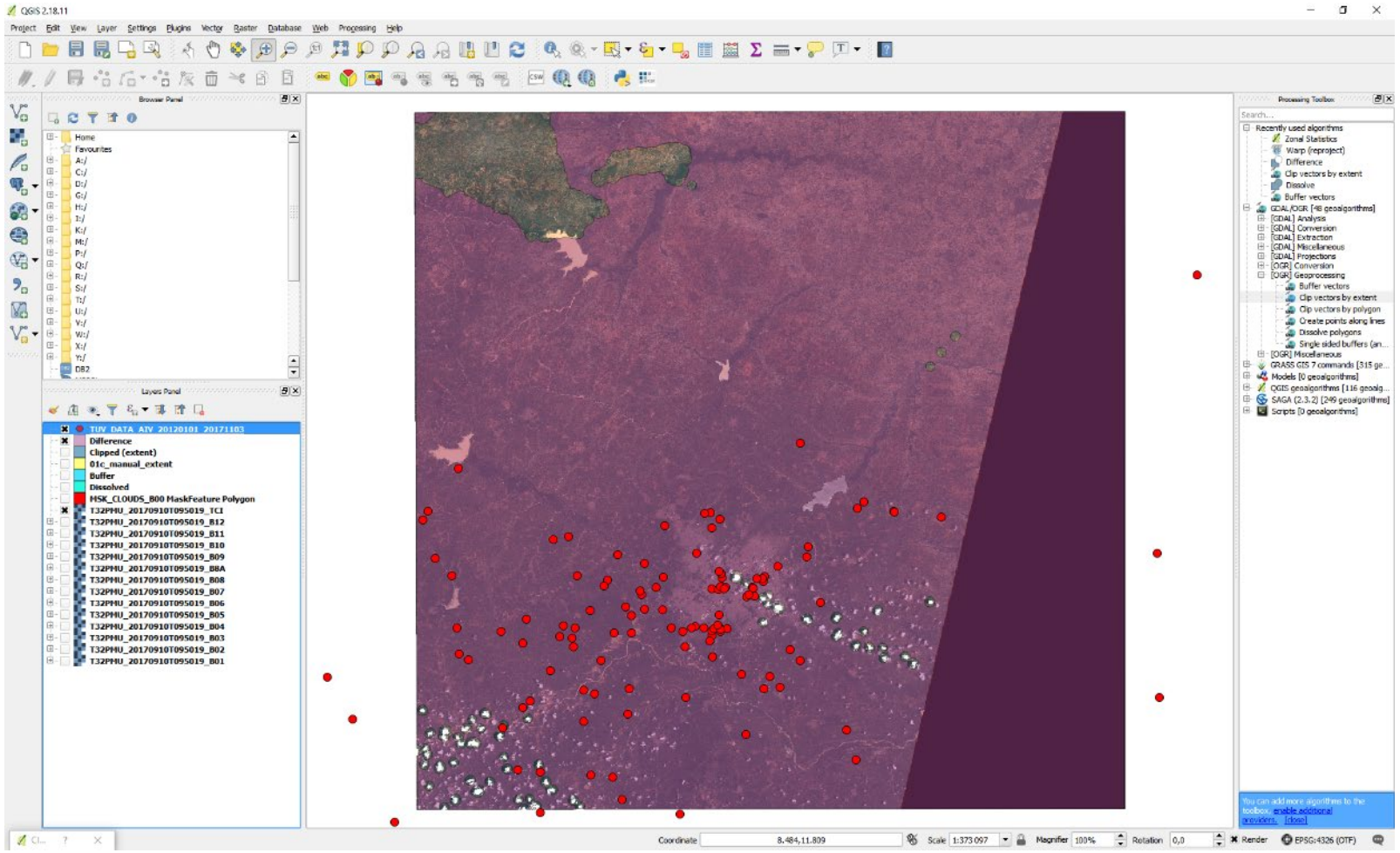
- For using only pixels, which are no cloud:
  2. Clip shapefile to raster
     - Processing toolbox → GDAL/OGR → [OGR] Geoprocessing → Clip vectors by extent
     - Clip extent → … → Use layer / canvas extent
       - must have same CRS as Polygon

Masking Clouds



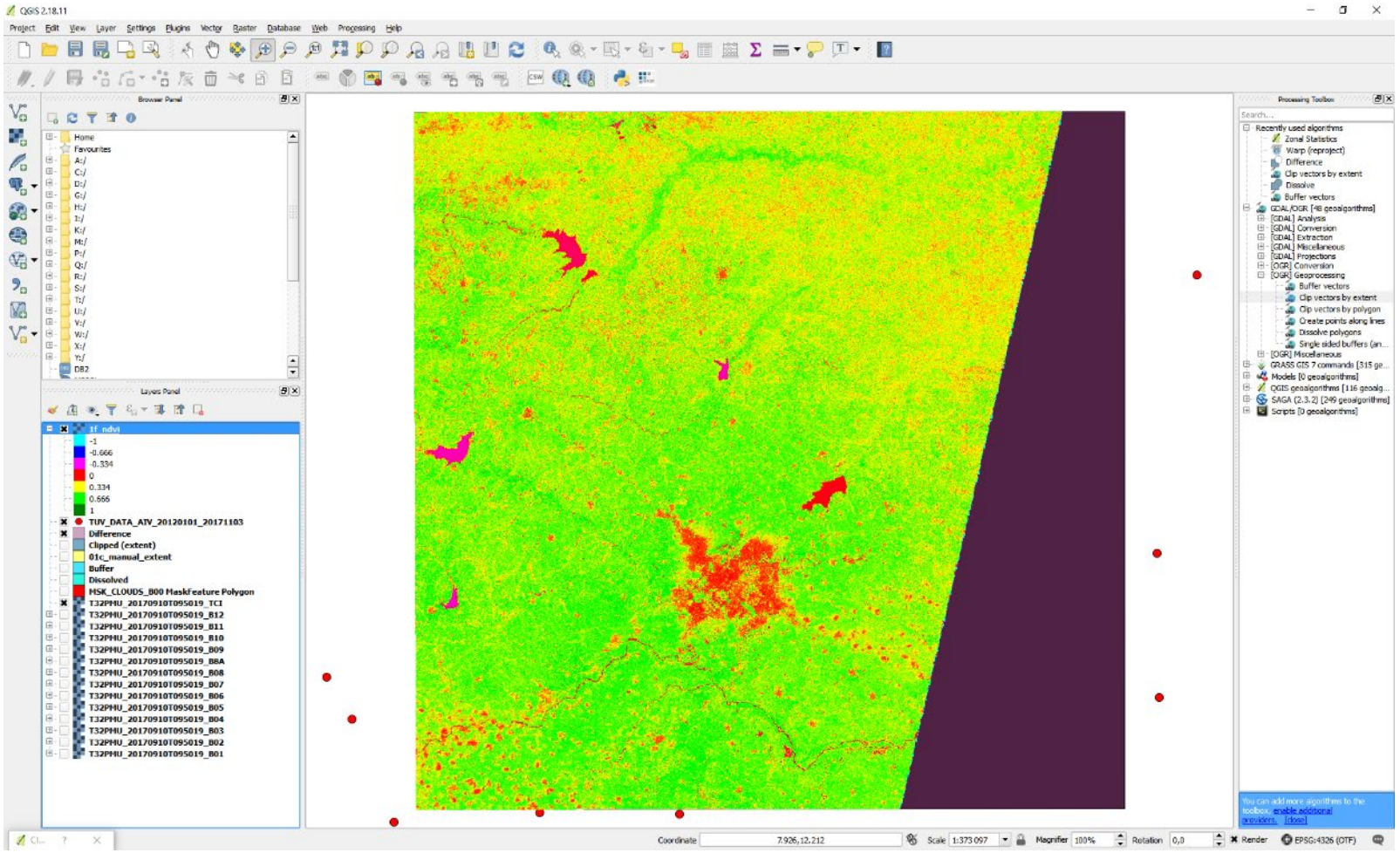
- For using only pixels, which are no cloud:
  3. Invert buffered cloud mask
     - Geoprocessing Tools → Difference

Loading Aivian Influenca



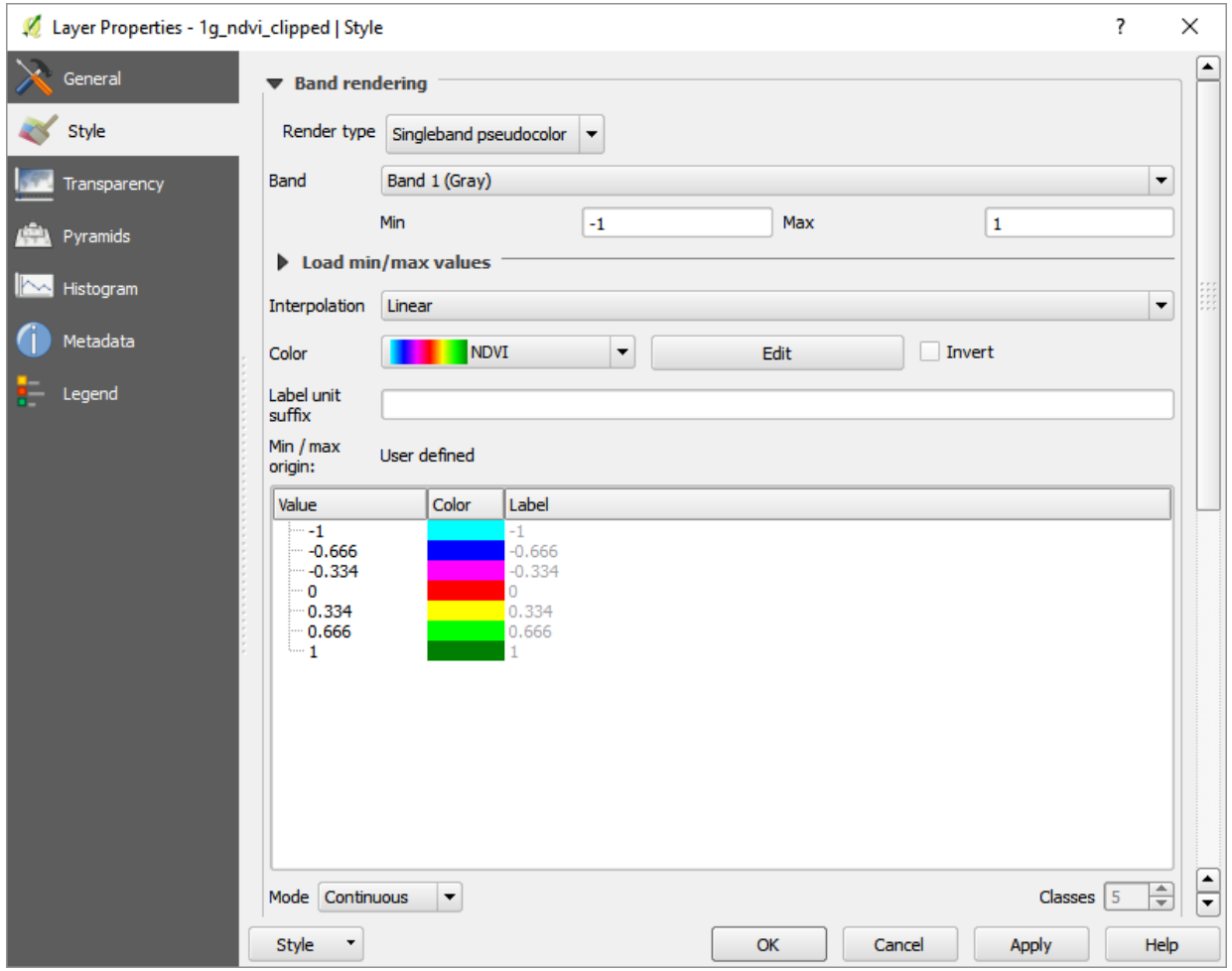
- Adding vector data from CSV file
  - Layer → add Layer → add delimited text layer

NDVI - Normalized Difference Vegetation Index



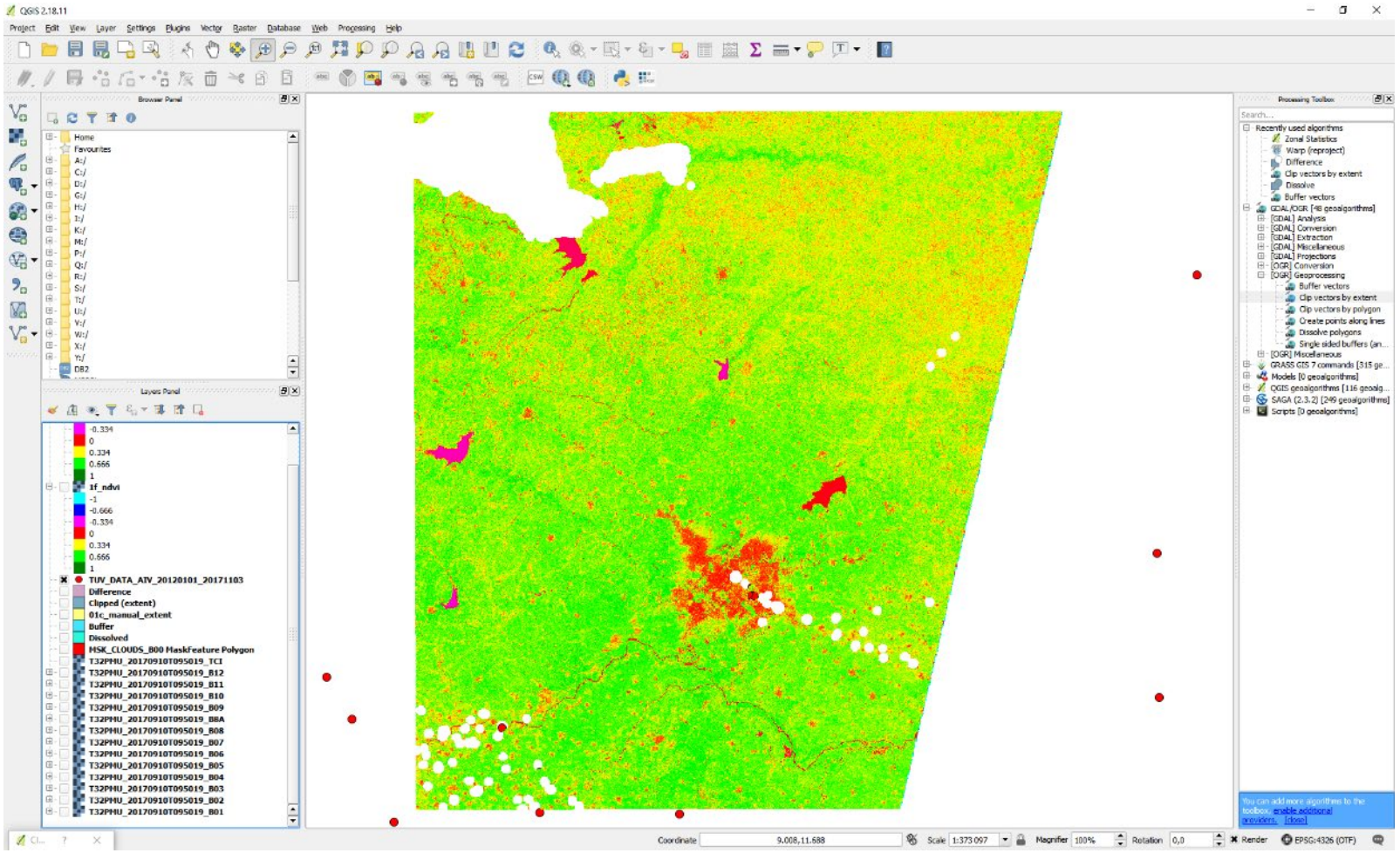
- (NIR-Red)/(NIR+Red)
  - (B08-B04)/(B08+B04)
  - Values from -1 to +1
  - Information about vegetation
- Raster →Raster Calculator

NDVI - Normalized Difference Vegetation Index



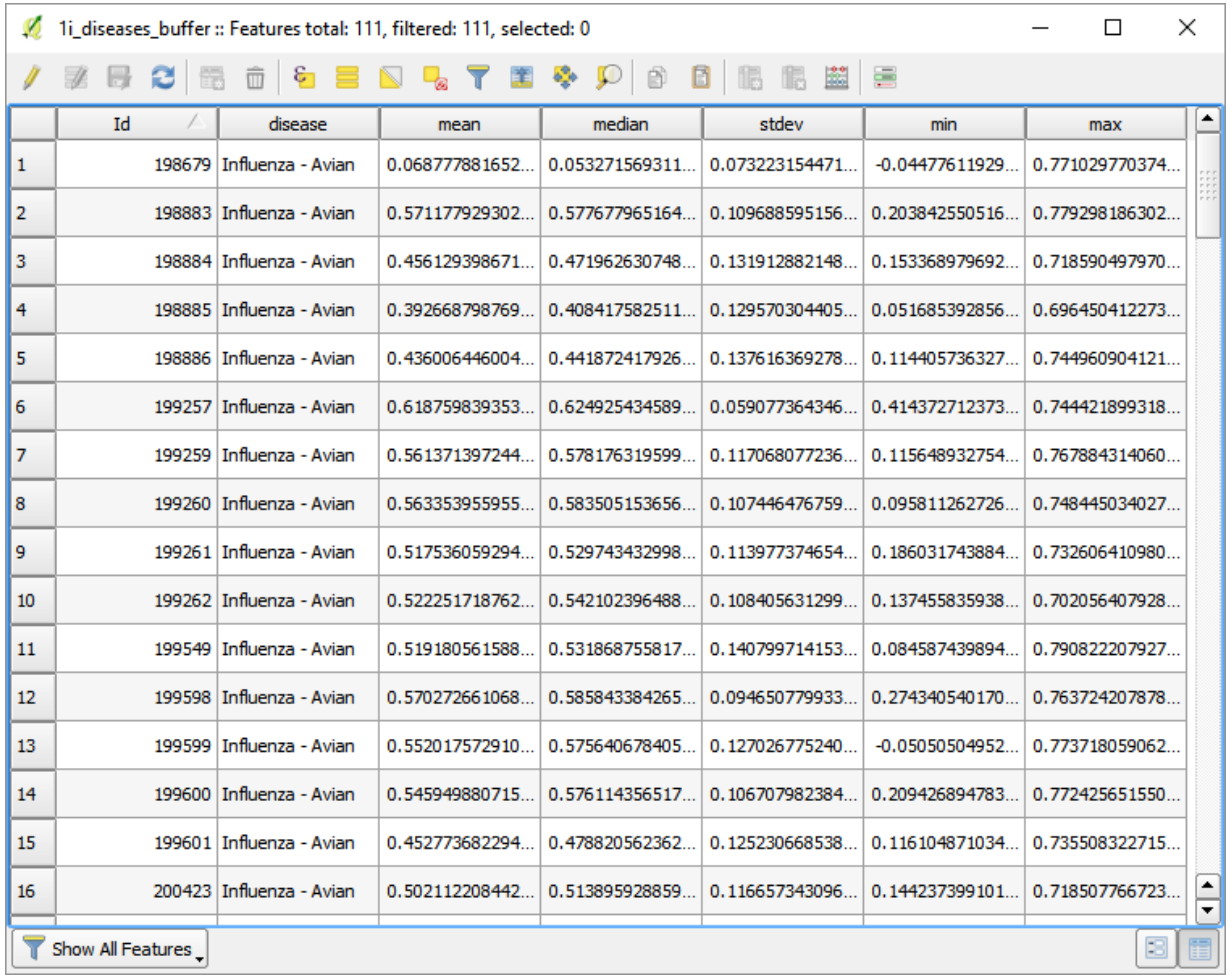
- Adapt Legend
  - Right mouse click → Properties

Masking Clouds



- Clipping Raster to Vector
  - Raster → Extraction → Clipper
  - NDVI raster and non cloud vector mask

Zonal Statistics



	Id	disease	mean	median	stdev	min	max
1	198679	Influenza - Avian	0.068777881652...	0.053271569311...	0.073223154471...	-0.04477611929...	0.771029770374...
2	198883	Influenza - Avian	0.571177929302...	0.577677965164...	0.109688595156...	0.203842550516...	0.779298186302...
3	198884	Influenza - Avian	0.456129398671...	0.471962630748...	0.131912882148...	0.153368979692...	0.718590497970...
4	198885	Influenza - Avian	0.392668798769...	0.408417582511...	0.129570304405...	0.051685392856...	0.696450412273...
5	198886	Influenza - Avian	0.436006446004...	0.441872417926...	0.137616369278...	0.114405736327...	0.744960904121...
6	199257	Influenza - Avian	0.618759839353...	0.624925434589...	0.059077364346...	0.414372712373...	0.744421899318...
7	199259	Influenza - Avian	0.561371397244...	0.578176319599...	0.117068077236...	0.115648932754...	0.767884314060...
8	199260	Influenza - Avian	0.563353955955...	0.583505153656...	0.107446476759...	0.095811262726...	0.748445034027...
9	199261	Influenza - Avian	0.517536059294...	0.529743432998...	0.113977374654...	0.186031743884...	0.732606410980...
10	199262	Influenza - Avian	0.522251718762...	0.542102396488...	0.108405631299...	0.137455835938...	0.702056407928...
11	199549	Influenza - Avian	0.519180561588...	0.531868755817...	0.140799714153...	0.084587439894...	0.790822207927...
12	199598	Influenza - Avian	0.570272661068...	0.585843384265...	0.094650779933...	0.274340540170...	0.763724207878...
13	199599	Influenza - Avian	0.552017572910...	0.575640678405...	0.127026775240...	-0.05050504952...	0.773718059062...
14	199600	Influenza - Avian	0.545949880715...	0.576114356517...	0.106707982384...	0.209426894783...	0.772425651550...
15	199601	Influenza - Avian	0.452773682294...	0.478820562362...	0.125230668538...	0.116104871034...	0.735508322715...
16	200423	Influenza - Avian	0.502112208442...	0.513895928859...	0.116657343096...	0.144237399101...	0.718507766723...

- Disease csv saved as point shapefile
- Clipped to NDVI raster
- Buffer with size 500m
- Zonal statistics
  - QGIS Plugin ‘Zonal Statistics’
  - Raster → Zonal Statistics → Zonal Statistics
- Right mouse click → Attribute table

Zonal Statistics

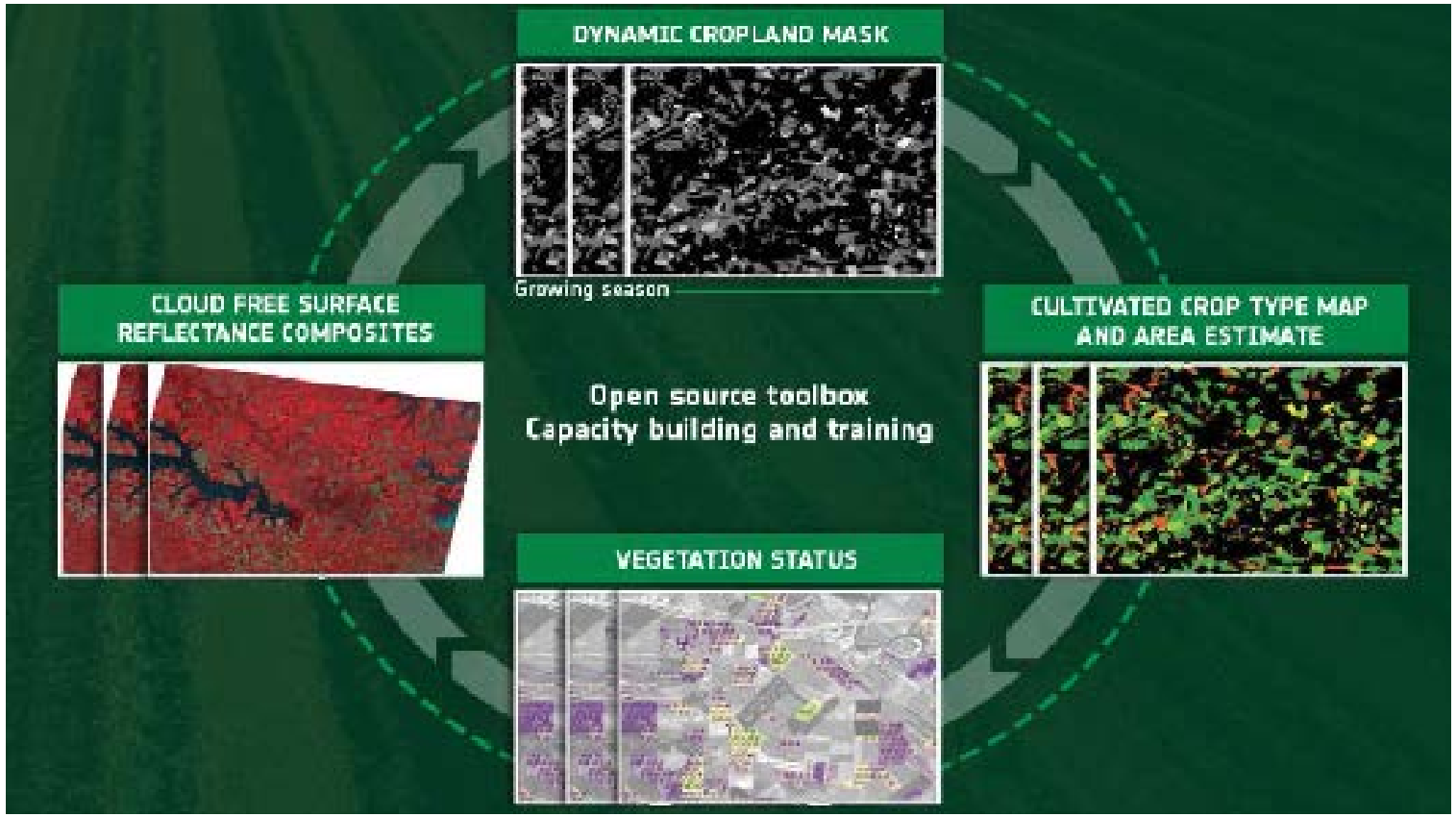
ARVI2	Atmospherically Resistant Vegetation Index 2	−0.18+1.17((NIR−RED)/(NIR+RED))
EVI	Enhanced Vegetation Index	2.5(NIR−RED)/[(NIR+6RED−7.5BLUE)+1]
GVMI	Global Vegetation Moisture Index	[(NIR+0.1)−(SWIR+0.02)]/[(NIR+0.1)+(SWIR+0.02)]
MSAVI	Modified Soil Adjusted Vegetation Index	[2NIR+1−SQRT((2NIR+1)²−8(NIR−RED))] / 2
NDVI	Normalized Difference Vegetation Index	(NIR-RED)/(NIR+RED)

Sen2Agri

- Sentinel-2 for Agriculture
- Funded by ESA / Copernicus
- 4 validated EO products
  - Cloud-free surface reflectance composites
  - Dynamic cropland masks
  - Cultivated crop type maps
  - Crop status
- Objective: develop open source processing system for national scale agriculture monitoring at field scale based on multitemporal Sentinel-2 and Landsat-8

Sen2Agri

- Connect to Copernicus Sci-Hub and USGS EROS
- Operational processes, steered by user
- Runs on CentOS 7



http://www.esa-sen2agri.org

Literature

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Questions ?

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