TATA CONSULTANCY SERVICES
Experience certainty.

Interpretation of Remote Sensing Data

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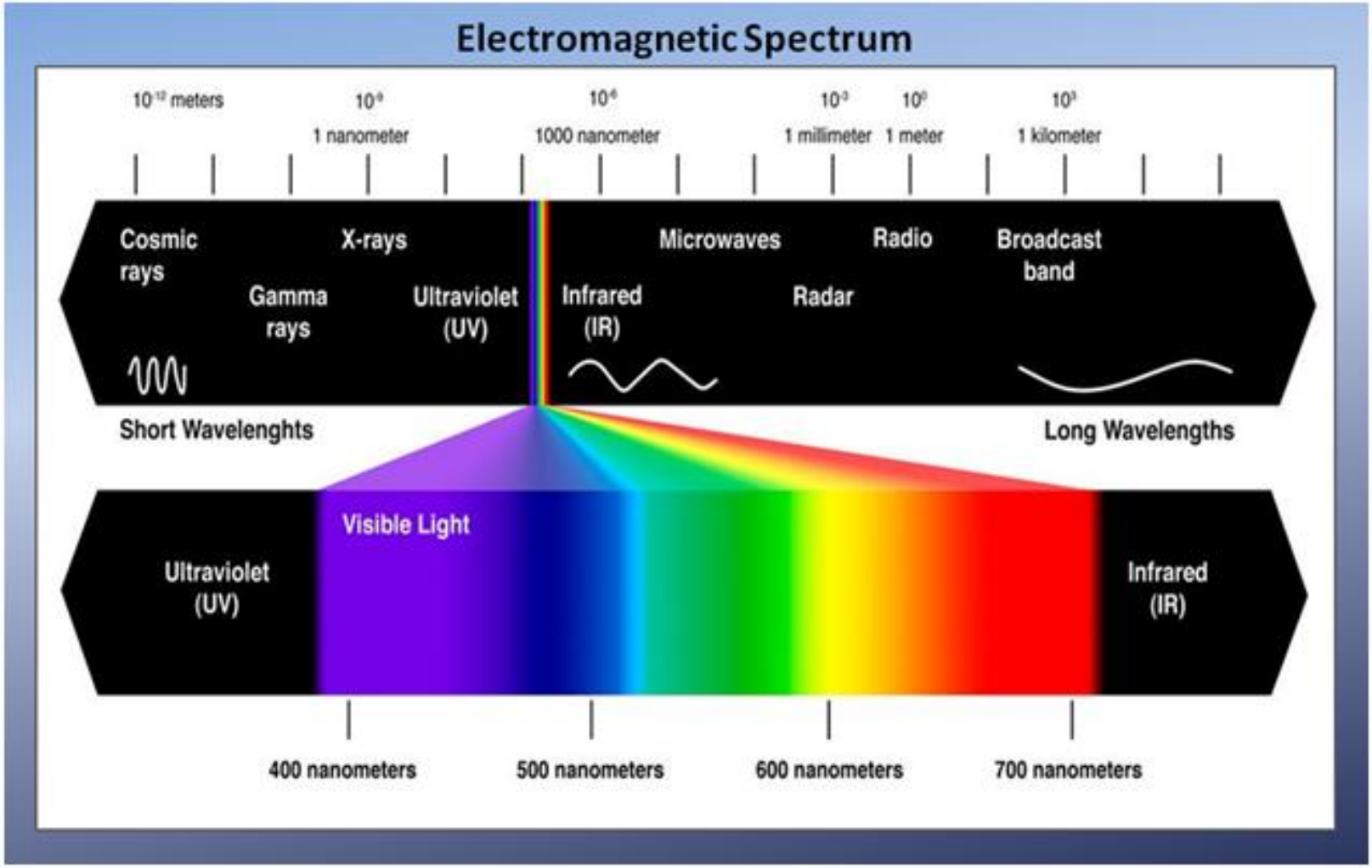
Spectral Imaging

- Measuring electromagnetic energy at varying wavelengths as it interacts with materials
- The nature of the material causes electromagnetic energy to be reflected, refracted or absorbed in a way that is unique to each material
- These interactions when plotted form a unique shape that is called the spectral signature of the material
- Vegetation interacts with solar radiation in a different way than other natural materials

The Electromagnetic Spectrum

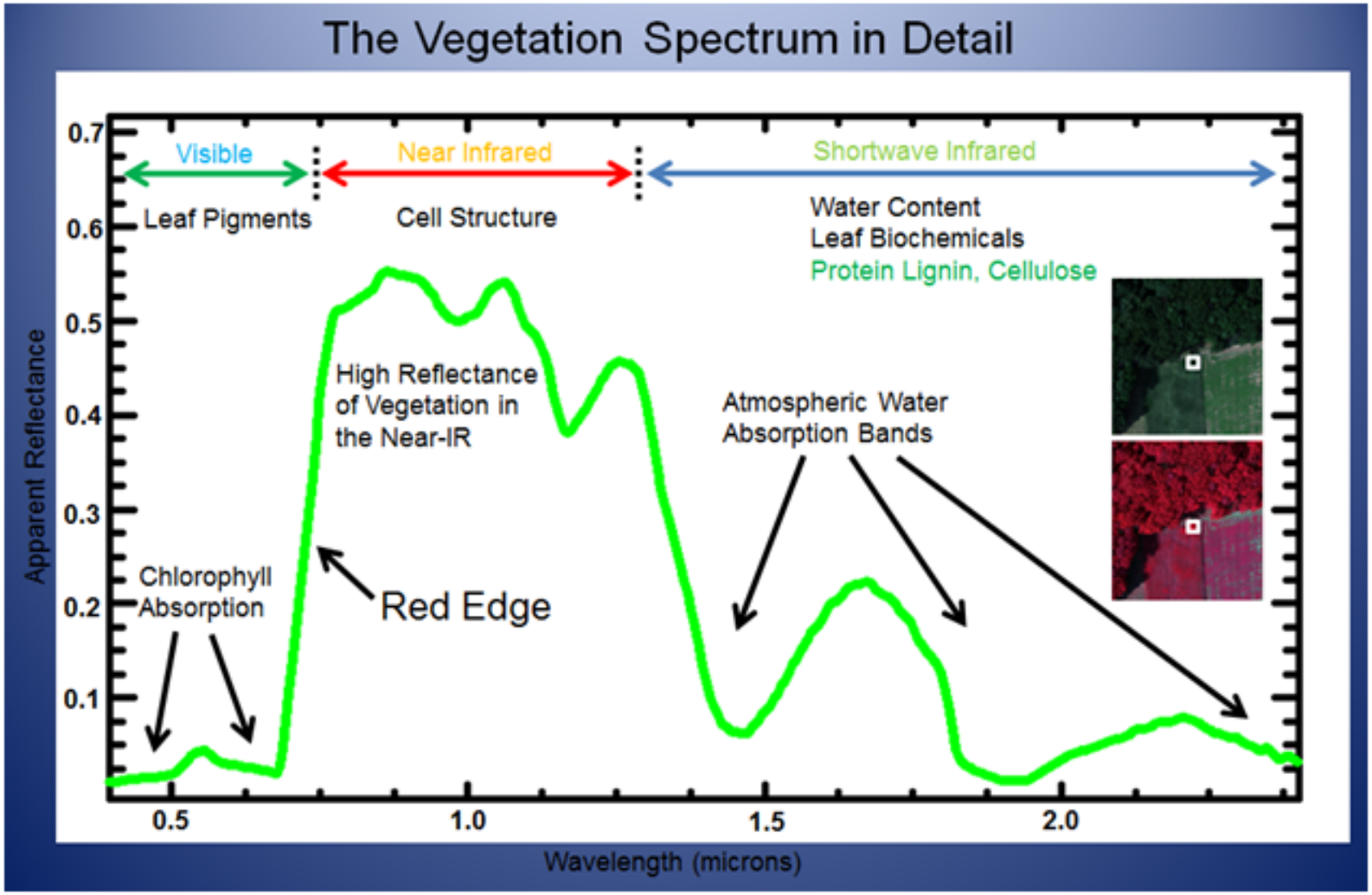


* Images downloaded from multiple websites

The Infra-Red Spectrum

Division	Wavelength	Frequency	Characteristics
Near infra-red	0.75 to 1.4 um	214 to 400 THz	Atmospheric water absorption
Short wave infra-red	1.4 to 3 um	100 to 214 THz	Atmospheric water absorption increases significantly at 1.45 um. 1.53 to 1.56 um is used in long distance communication
Medium wave infra-red	3 to 8 um	37 to 100 THz	Heat seeking missiles are designed to work in this spectrum
Long wave infra-red	8 to 15 um	20 to 37 THz	Thermal imaging region

The Vegetation Spectrum 1/2



* Images downloaded from multiple websites

The Vegetation Spectrum 2/2

- Strong absorption in red and blue wavelength
- Reflects in green wavelength
- Strong reflectance in near Infra-red wavelength
- Strong absorption in wavelengths where atmospheric water is present
- Different plant materials, water content, pigments, carbon and nitrogen content cause further variation across the spectrum

Sensor Considerations 1/2

- Solar reflected optical spectrum spans 0.4 um to 2.5 um
- This is readily measured by most satellites and airborne sensors
- Partitioned into 4 distinct wavelength ranges
  - Visible: 400 to 700 nm
  - Near infra-red: 700 to 1300 nm
  - Shortwave infra-red 1: 1300 to 1900 nm
  - Shortwave infra-red 2: 1900 to 2500 nm
- Transition from NIR to SWIR1 is marked by 1400 nm atmospheric water absorption
- Transition from SWIR1 to SWIR2 is marked by 1900 nm atmospheric water absorption

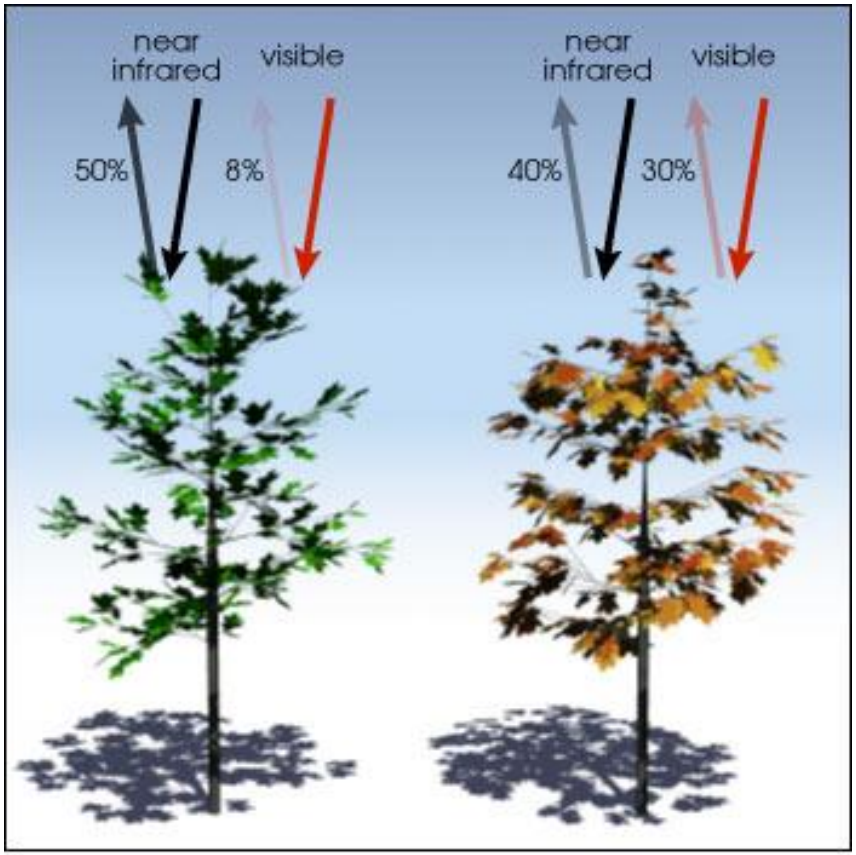
Sensor Considerations 2/2

- Near infra-red (0.7 to 1.0 um): Silicon
- Short wave infra-red (1 to 3 um): InGaAs covers up to 1.8 um
- Medium wave infra-red (3 to 5 um): InSb, HgCdTe, PbSe
- Long wave infra-red (7 to 15 um): HgCdTe and microbolometers

Vegetation Indices

- Broadband greenness
  - Measure of the vigor or health of green vegetation
  - Sensitive to chlorophyll concentration, leaf area, foliage clumping, canopy architecture
  - Exploit the strong reflective property in NIR and strong absorption in red wavelengths
  - Examples are NDVI, SRI, EVI, ARVI and SGI

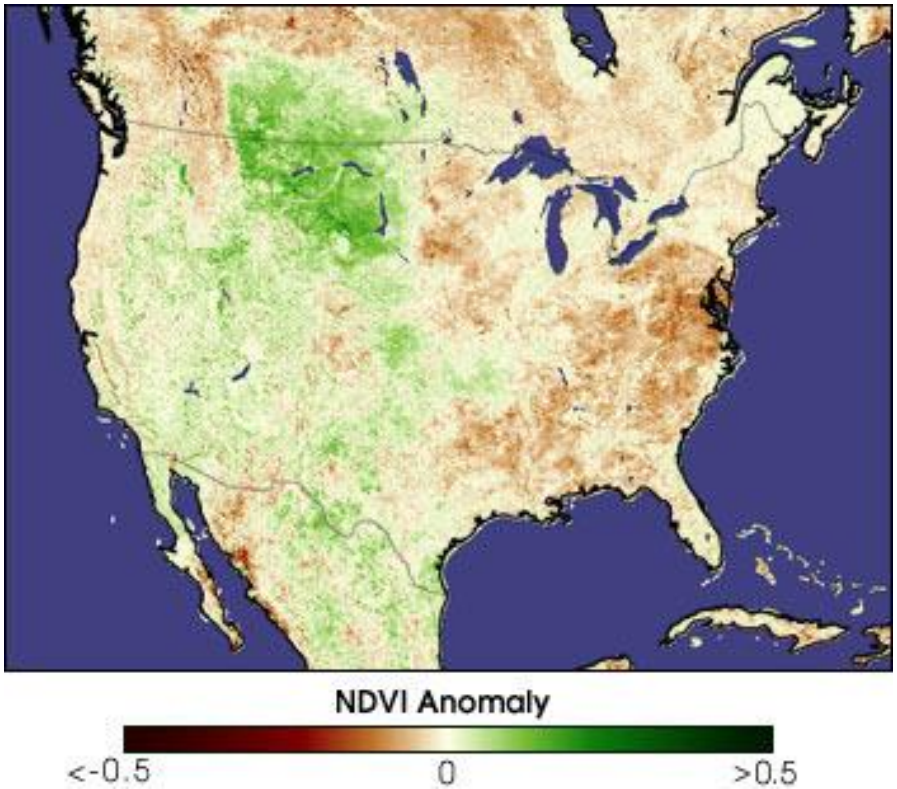
NDVI (Normalized Difference Vegetation Index)



- NDVI = (NIR + VIS) / (NIR – VIS)
- Fraction of reflected light needs to be calculated
- Need to know the amount of incident light
- Values are between -1 and 1
- Healthy vegetation falls between 0.2 and 0.8.
- Absolute and relative NDVI
- Can use Red instead of VIS

* Images downloaded from multiple websites

NDVI as an Indicator of Drought

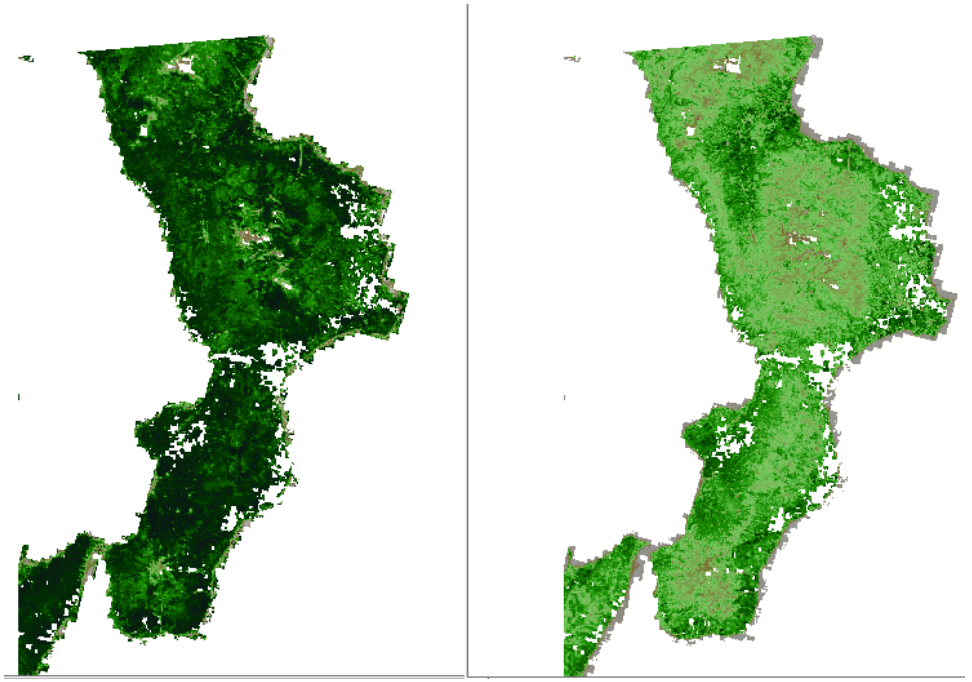


- NDVI Anomaly; diff between current NDVI and average NDVI over long time period
- Exceptionally lush vegetation in Aug 1993 over Northern Great Plains due to flooding of Missouri river
- Very low rainfall in Eastern US resulted in a strong negative anomaly

* Images downloaded from multiple websites

Enhanced Vegetation Index (EVI)

- NDVI can get saturated when there is too much chlorophyll as in Evergreen forests
- NDVI is also influenced by reflectance from soil and particles in air
- EVI corrects for the above errors; EVI = 2.5[(NIR – RED) / (NIR + 6RED – 7.5BLUE +1)]



* Images downloaded from multiple websites

Other Broadband VIs

- ARVI (Atmospherically Resistant Vegetation Index)
  - Corrects for aerosols in the atmosphere
  - Uses reflectance measurement in blue to correct for scattering effects
  - ARVI = (NIR – (2RED – BLUE)) / (NIR + (2RED – BLUE))
- SGI (Sum Green Index)
  - Detects changes in vegetation greenness
  - Useful for detecting forest disturbances as it is highly sensitive to canopy opening
  - Mean reflectance across 500 nm to 600 nm
  - Value ranges from 0 to 50 %
  - Common range for green vegetation in 10 to 25 % reflectance

Narrowband Greenness

- Similar to broadband greenness; measure of overall amount and quality of photosynthetic material in vegetation
- Uses reflectance in red-edge region; between 690 and 740 nm
- Using red-edge makes these VIs more sensitive to smaller changes in vegetation health than broadband greenness
- Intended to be used with high resolution imagery like those from advanced multi-spectral or hyperspectral cameras
- Red Edge NDVI, Modified Red Edge Simple Ratio, Modified Red Edge NDVI, Vogelmann Red Edge Index 1,2,3, Red Edge Position Index

Common Narrowband Greenness VIs

- Red Edge NDVI: (750nm – 705nm) / (750nm + 705nm)
  - Makes use of the sensitivity of Red Edge to canopy foliage content, gap fraction and senescence
  - Values range from -1 to 1
  - Common range for green vegetation in 0.2 to 0.9
- Modified Red Edge Simple Ratio Index:
  - = (750nm – 445nm) / (705nm – 445nm)
  - Uses Red Edge and incorporates correction for leaf specular reflection
  - Values range from 0 to 30
  - Common range for green vegetation is 2 to 8

Common Narrowband Light Use Efficiency VIs

- Light Use Efficiency: Quantifies vegetation's ability to use incident light for photosynthesis
- Photochemical Reflectance Index:
  - Exploits role of Xanthophylls in photoprotection
  - (530nm – 570nm) / (530nm + 570nm)
  - Values range from -1 to 1
  - Healthy vegetation falls between -0.2 and 0.2
  - Indicates light use efficiency and stress; more specifically drought or nitrogen stress
  - Highly affected by LAI; cannot be used when LAI is > 4
  - Low chlorophyll content results in high PRI
  - High chlorophyll content results in low PRI when LAI is high

Normalized Difference Nitrogen Index

- High reflectance at 1510nm indicates high nitrogen concentration and high biomass
- Reflectance at 1680nm is due to biomass without Nitrogen influence
- This property is exploited in NDNI
  - log (1/1510nm) – log (1/1680) / log (1/1510nm) + log (1/1680nm)
  - Values range from 0 to 1
  - Common range for green vegetation is 0.02 to 0.1

Senescence related VIs

- Levels of lignin and cellulose increase just before senescence
- Lignin and cellulose are flammable
- Normalized Difference Lignin Index
  - log (1/1754nm) – log (1/1680nm) / log (1/1754nm) + log (1/1680nm)
  - Values range from 0 to 1
  - Common range for healthy green vegetation in 0.005 to 0.05
- Cellulose Absorption Index
  - Quantifies exposed surfaces that contain dried plant material
  - Strong absorption in 2000nm and 2200nm indicate high concentration of cellulose
  - Used in crop residue monitoring
  - = 0.5 (2000nm + 2200nm) – 2100nm

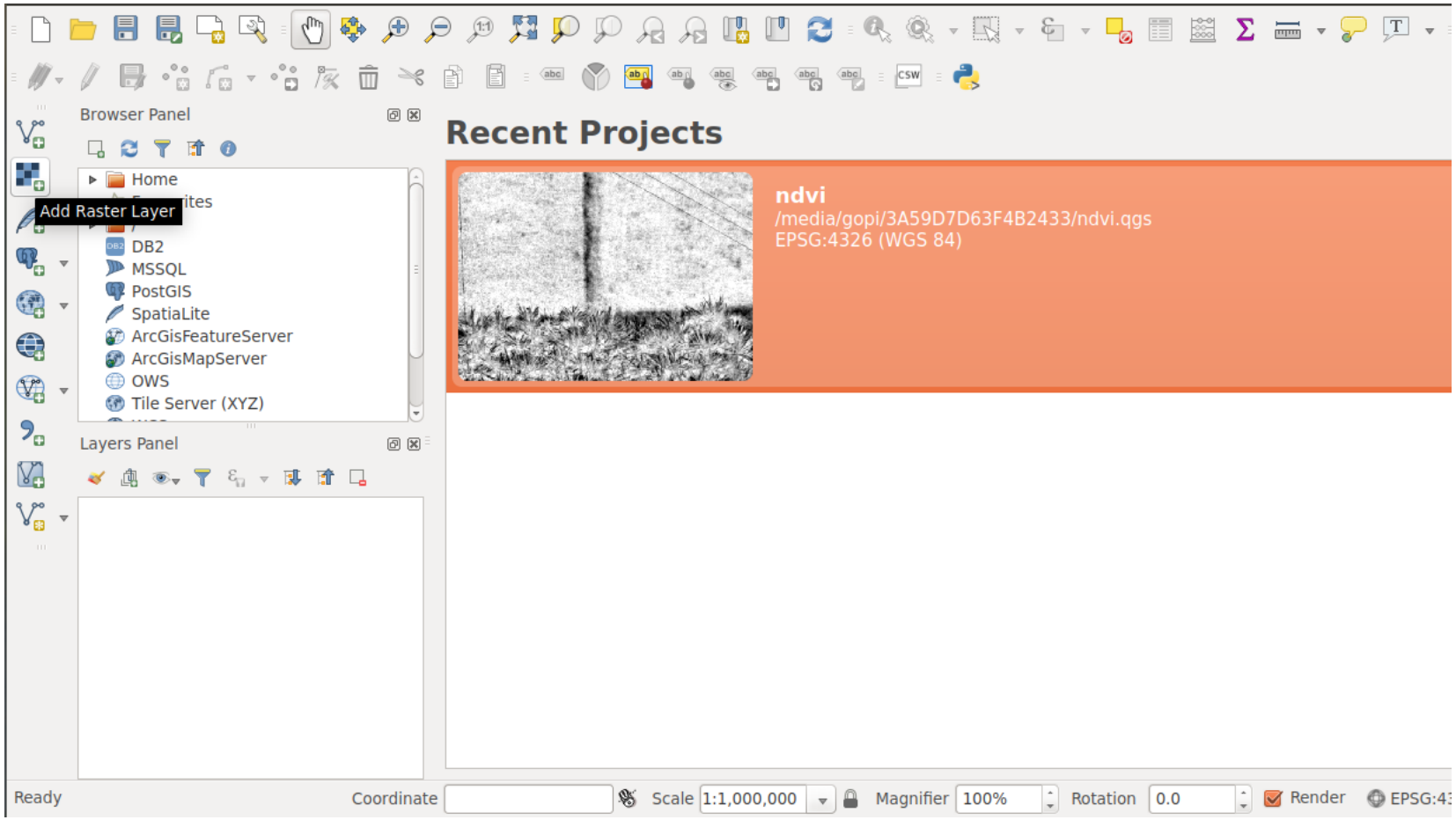
- Plant Senescence Reflectance Index
  - Exploits ratio of carotenoids to chlorophyll that indicates canopy stress, canopy senescence and fruit ripening
  - = (680nm – 500nm) / 750nm
  - Values range from -1 to 1
  - Common range for green vegetation is from -0.1 to 0.2

Canopy Water Content

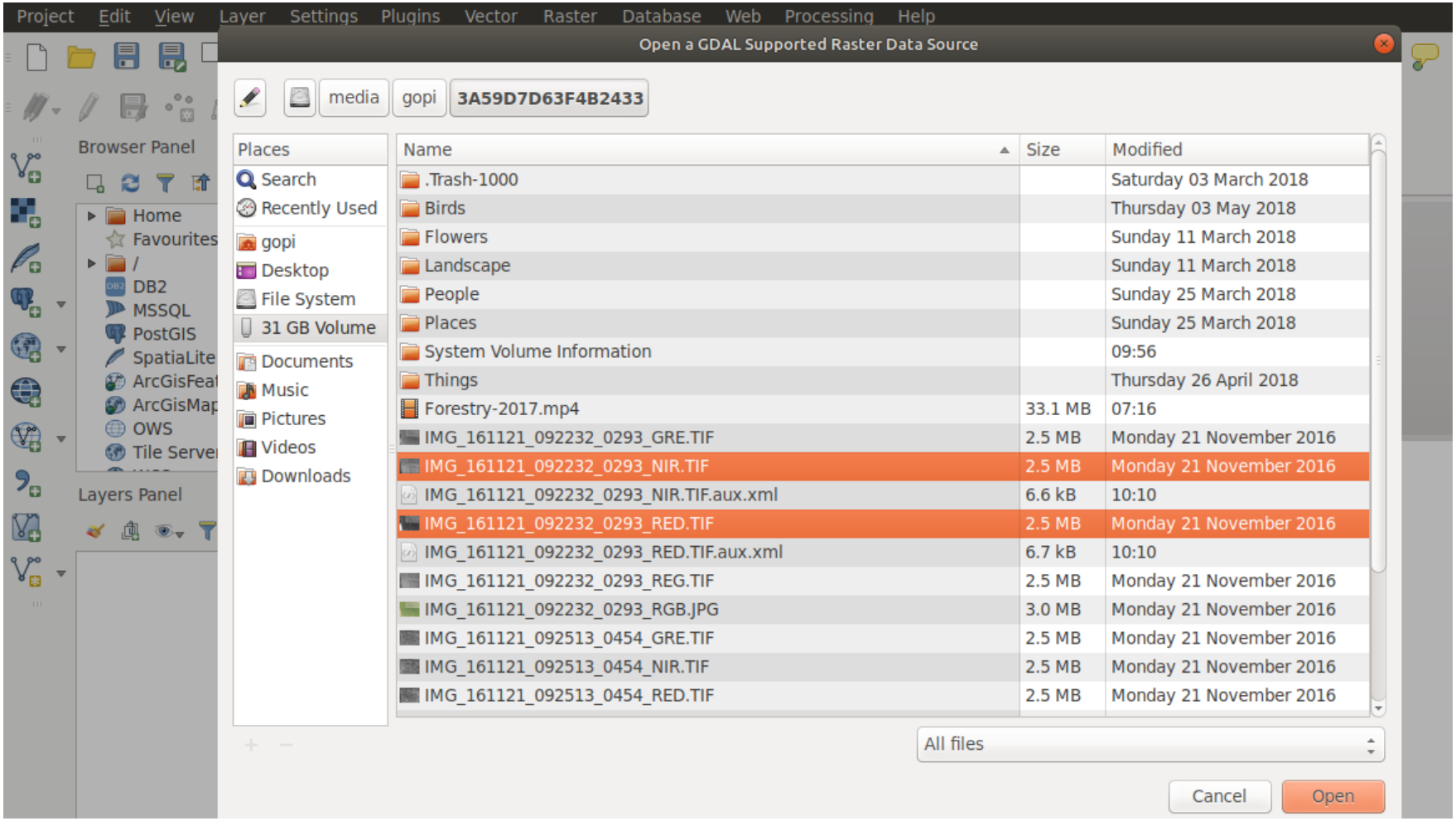
- Provides measure of water content in foliage
- Higher water content often indicates healthier vegetation and fire resistance
- Water Band Index
  - 900nm / 970nm
  - Common range of green vegetation is 0.8 to 1.2
- Normalized Difference Water Index
  - = (857nm – 1241nm) / (857nm + 1241nm)
  - Values range from -1 to 1
  - Common range for green vegetation is -0.1 to 0.4

Using QGIS for NDVI

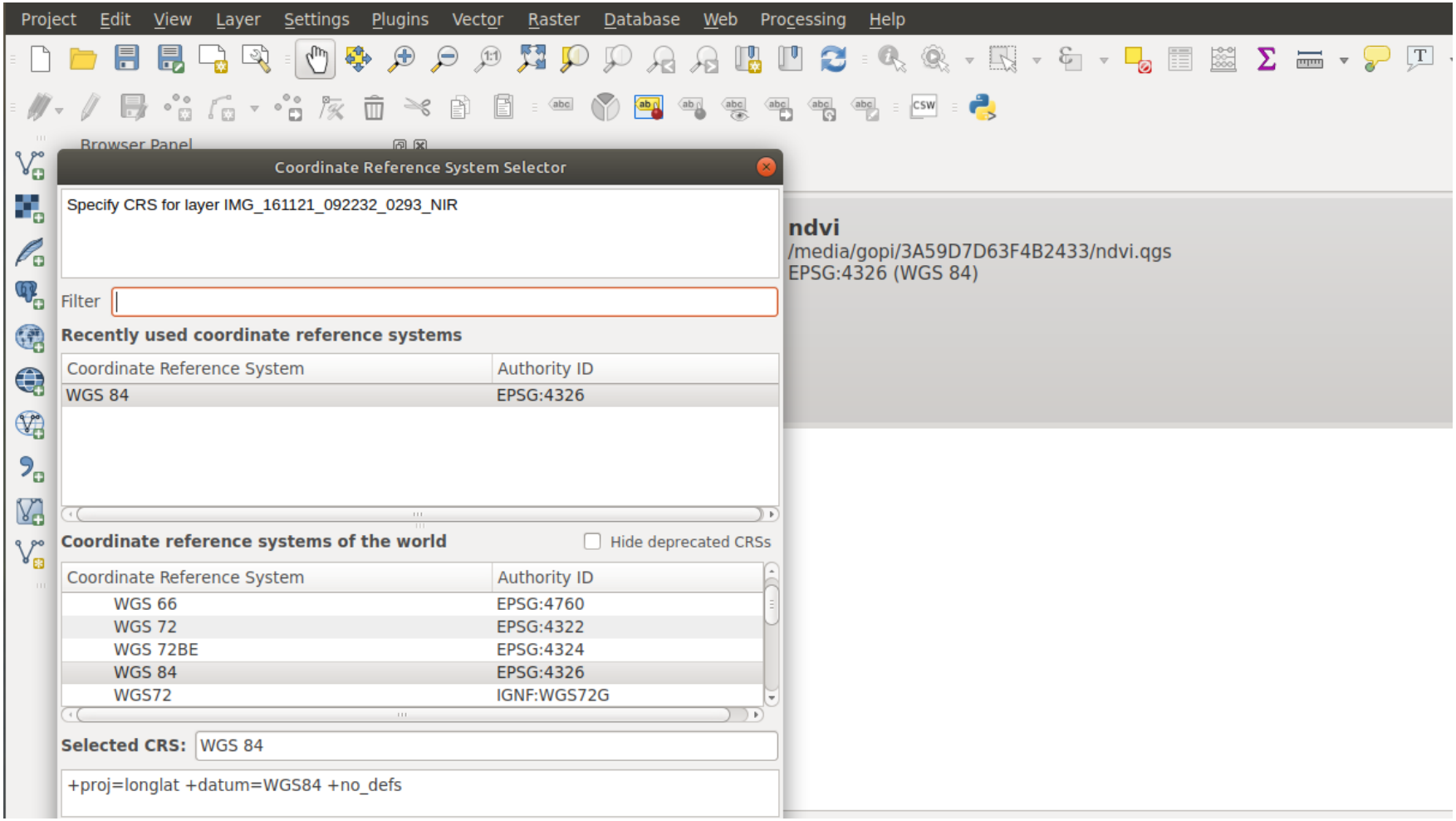
- Add multi-spectral images using “Add Raster Layer”



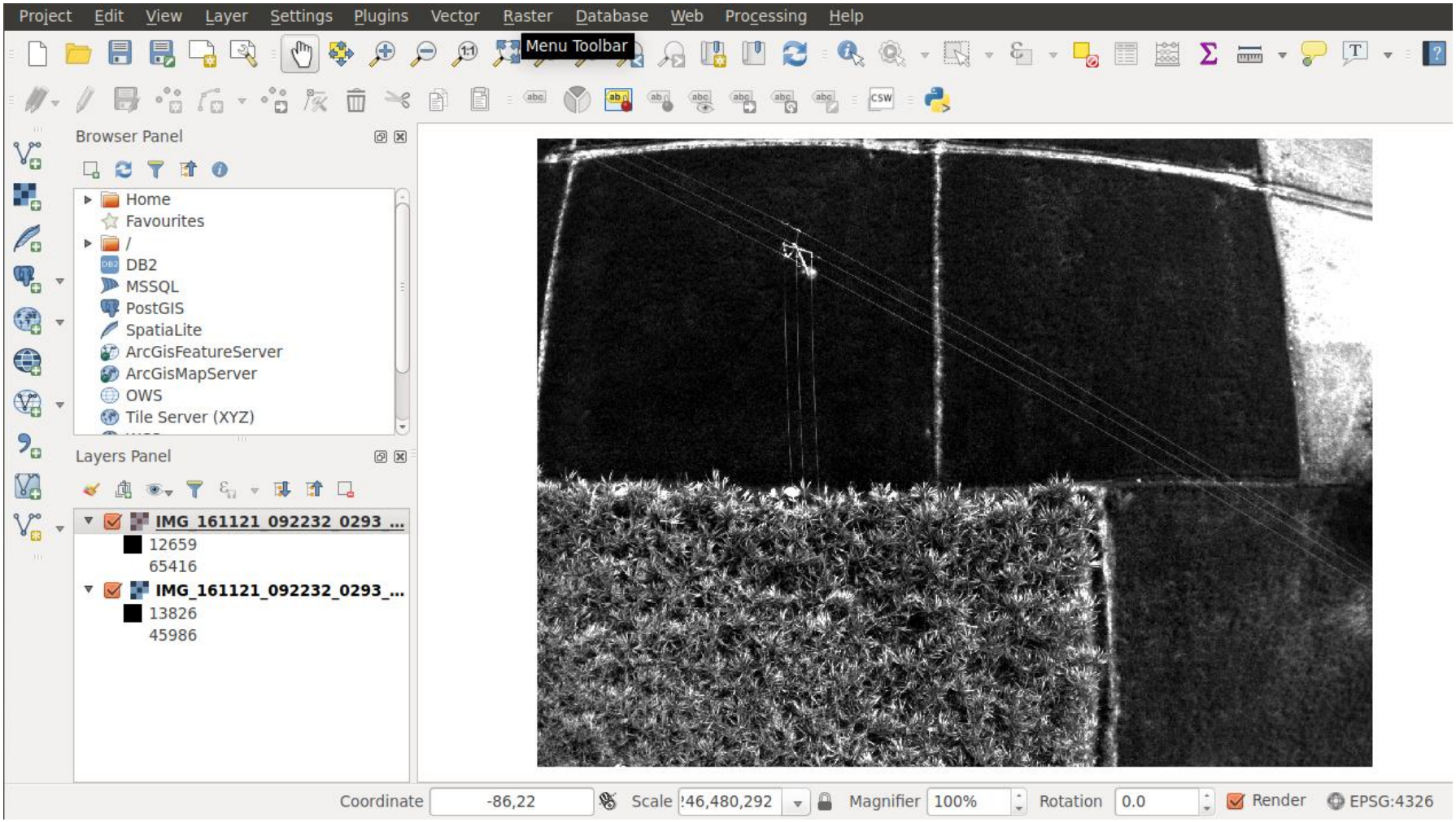
- Add Red and NIR images



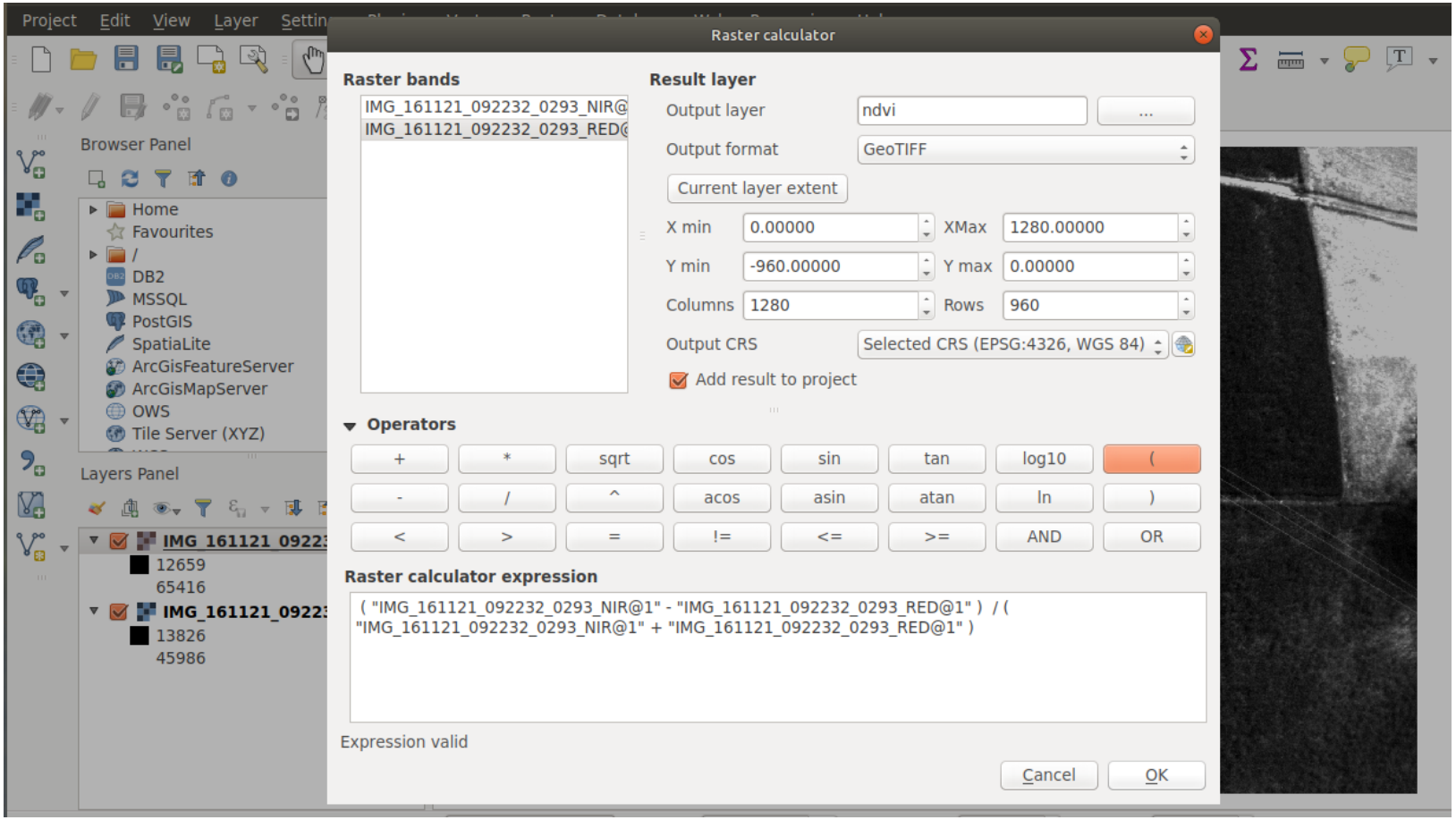
- Specify coordinate system



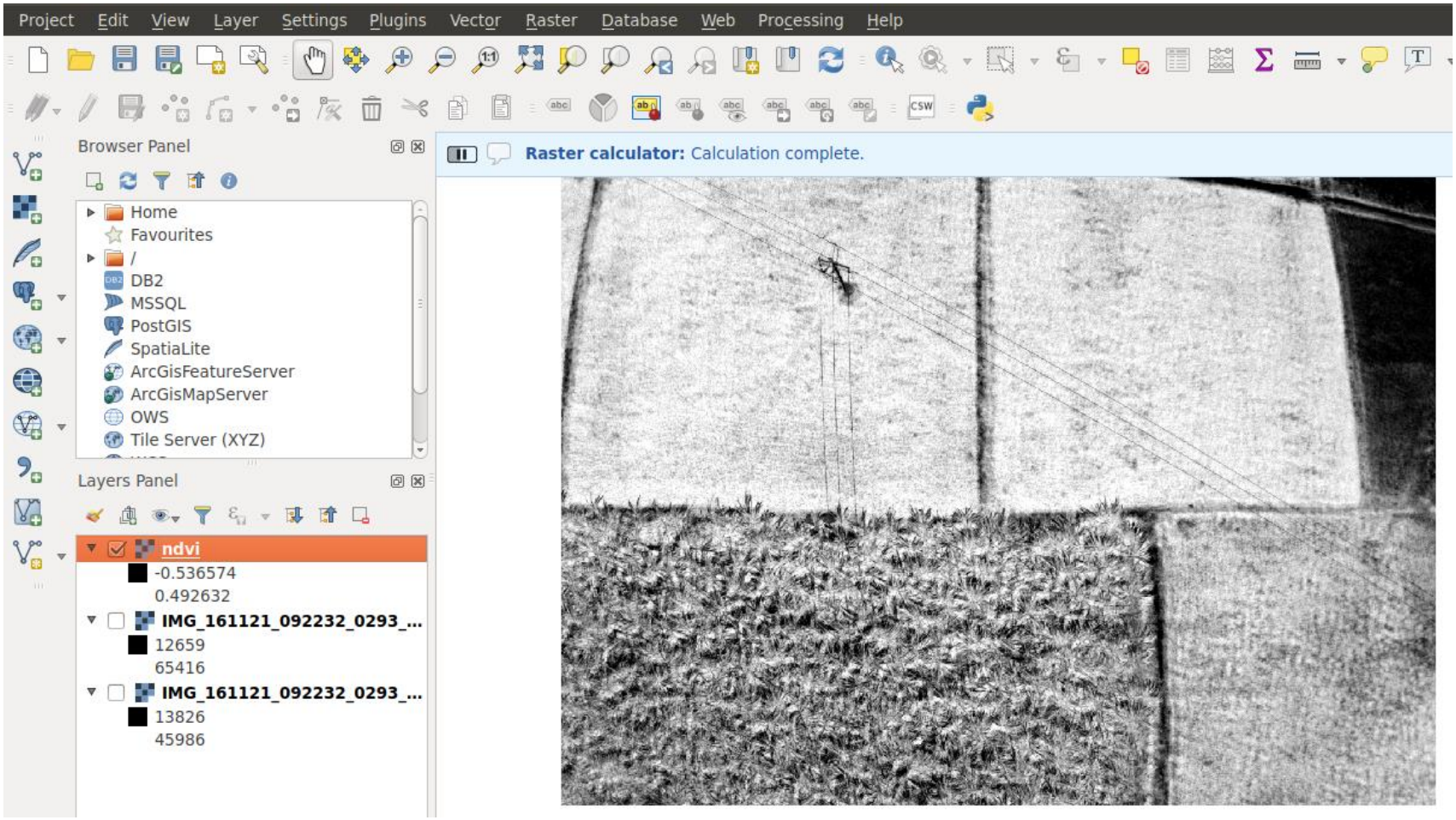
- Both layers loaded and selected



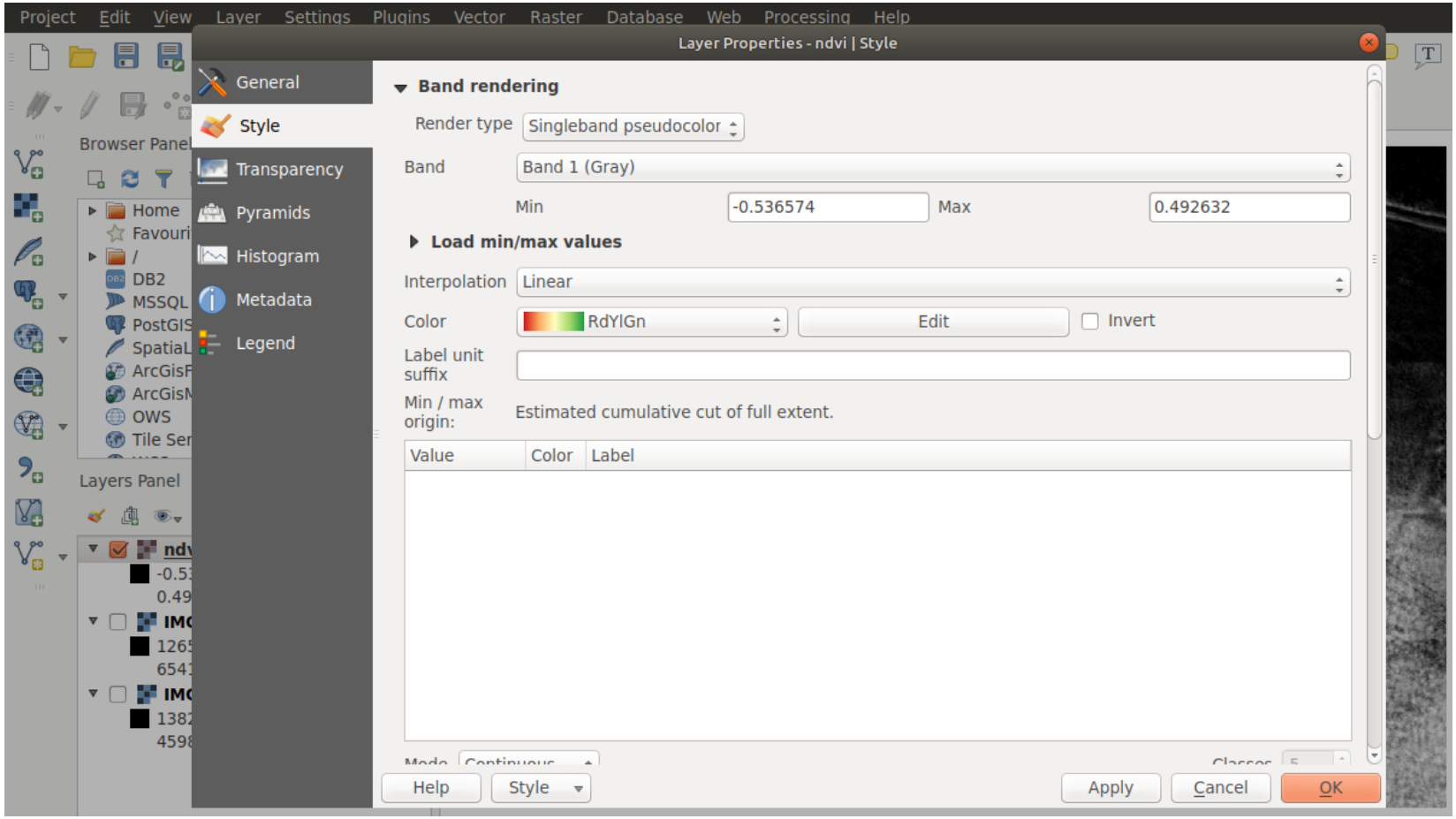
- Open Raster Calculator
- Calculate NDVI using formula NDVI = (NIR – R) / (NIR + R)



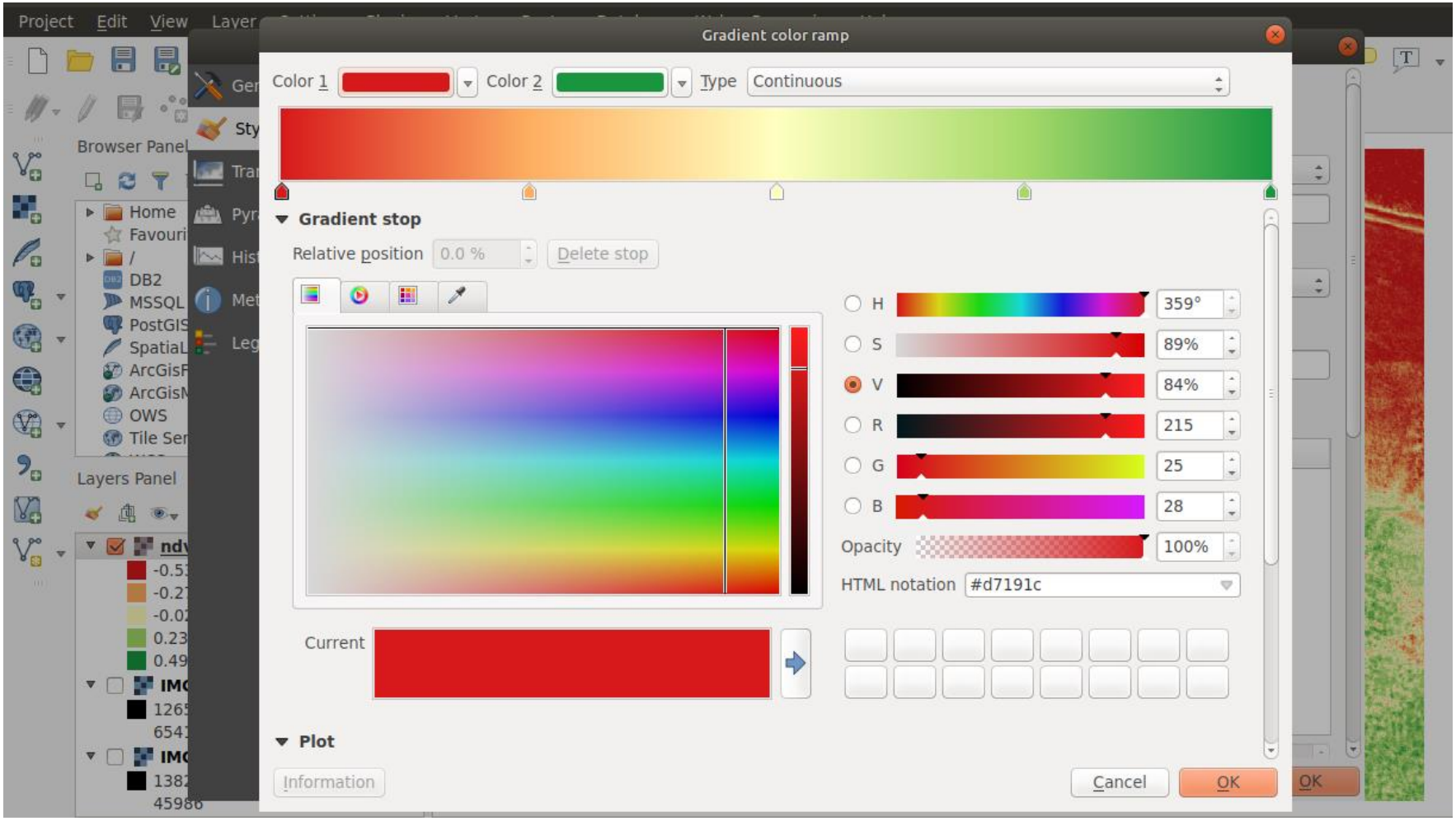
- Output is in grayscale



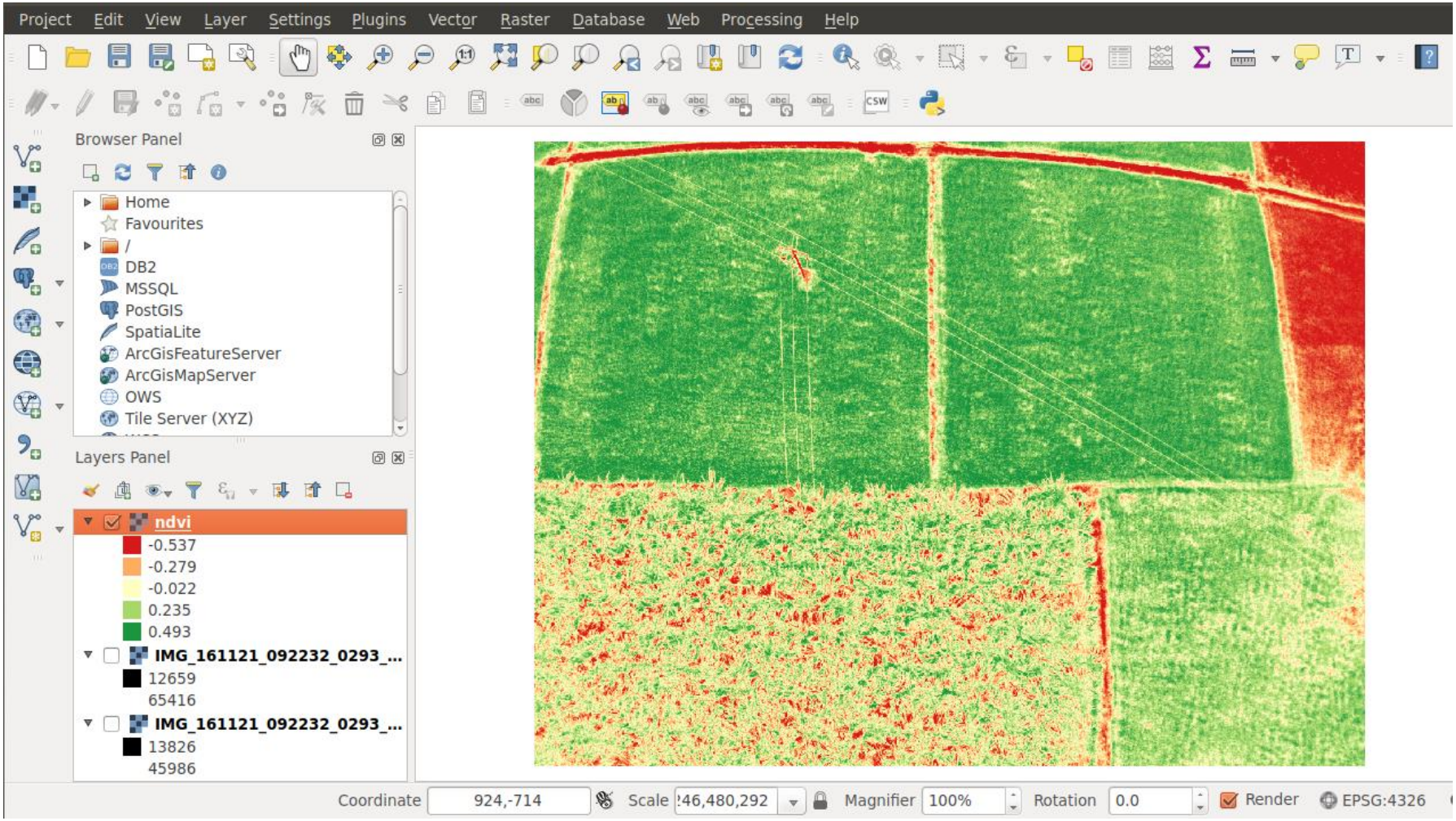
- Change color scheme; right click on “ndvi” layer and select properties



- Select Singleband Pseudocolor and edit the color scheme

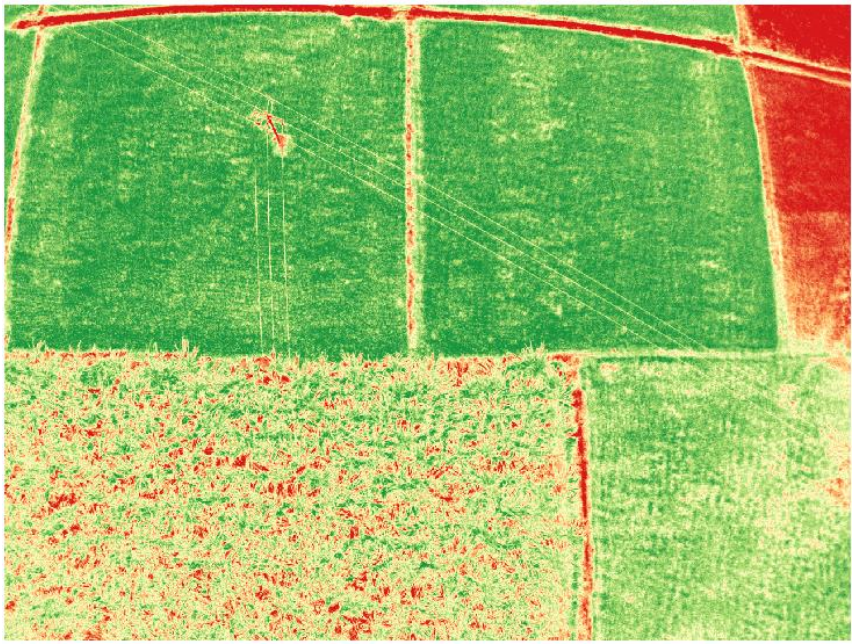


- False color NDVI final image

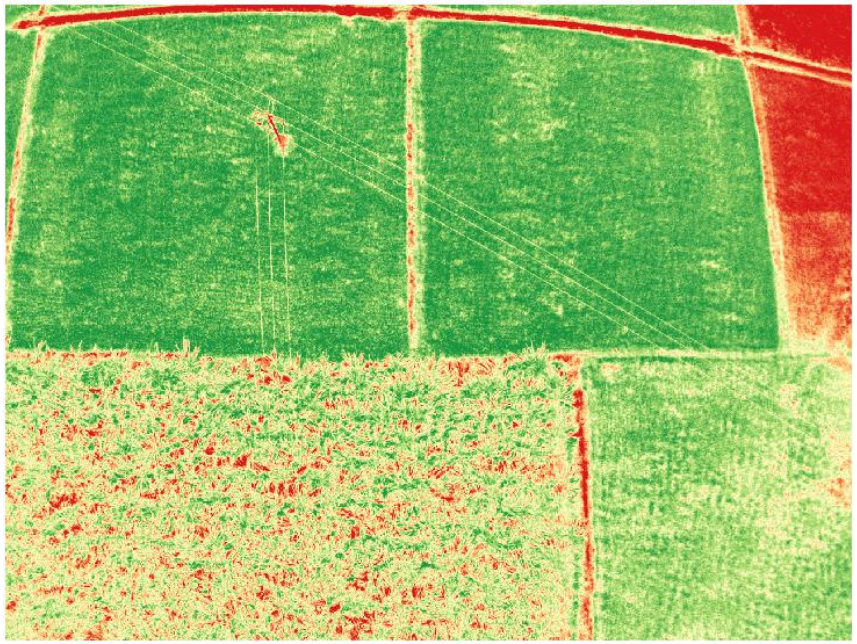


RGB

NDVI



NDVI



EVI