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9 Raster Analysis

a) Vegetation Indices

Learning Objectives

Understand the concept of vegetation indices and their applications

Explain the mathematical principles behind NDVI, NDMI, NDWI

Compare different indices and their suitability for specific environmental applications

Recognize the limitations and potential sources of error in vegetation index calculations

Vegetation Indices

Definition

- Vegetation indices (VIs) are mathematical combinations of spectral bands that enhance vegetation signals in satellite imagery
- Derived from reflectance properties of vegetation in different parts of the spectrum

Why do we use them?

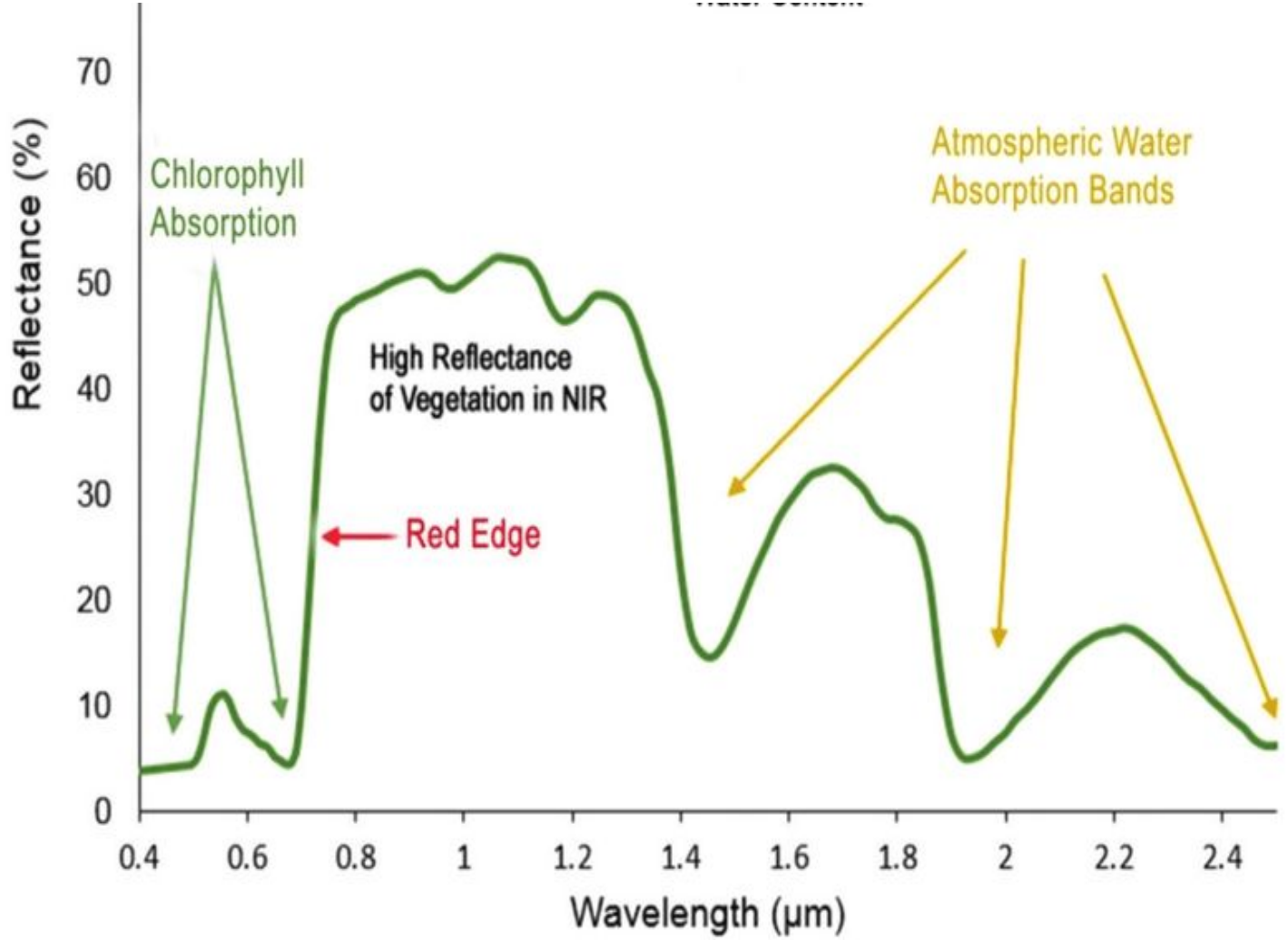
- Enhance detection of vegetation health, biomass, and water stress
- Reduce the impact of atmospheric effects by standardizing values
- Useful for agriculture, forestry, climate studies, and land use monitoring

Spectral Properties of Vegetation

Vegetation Reflectance Behavior

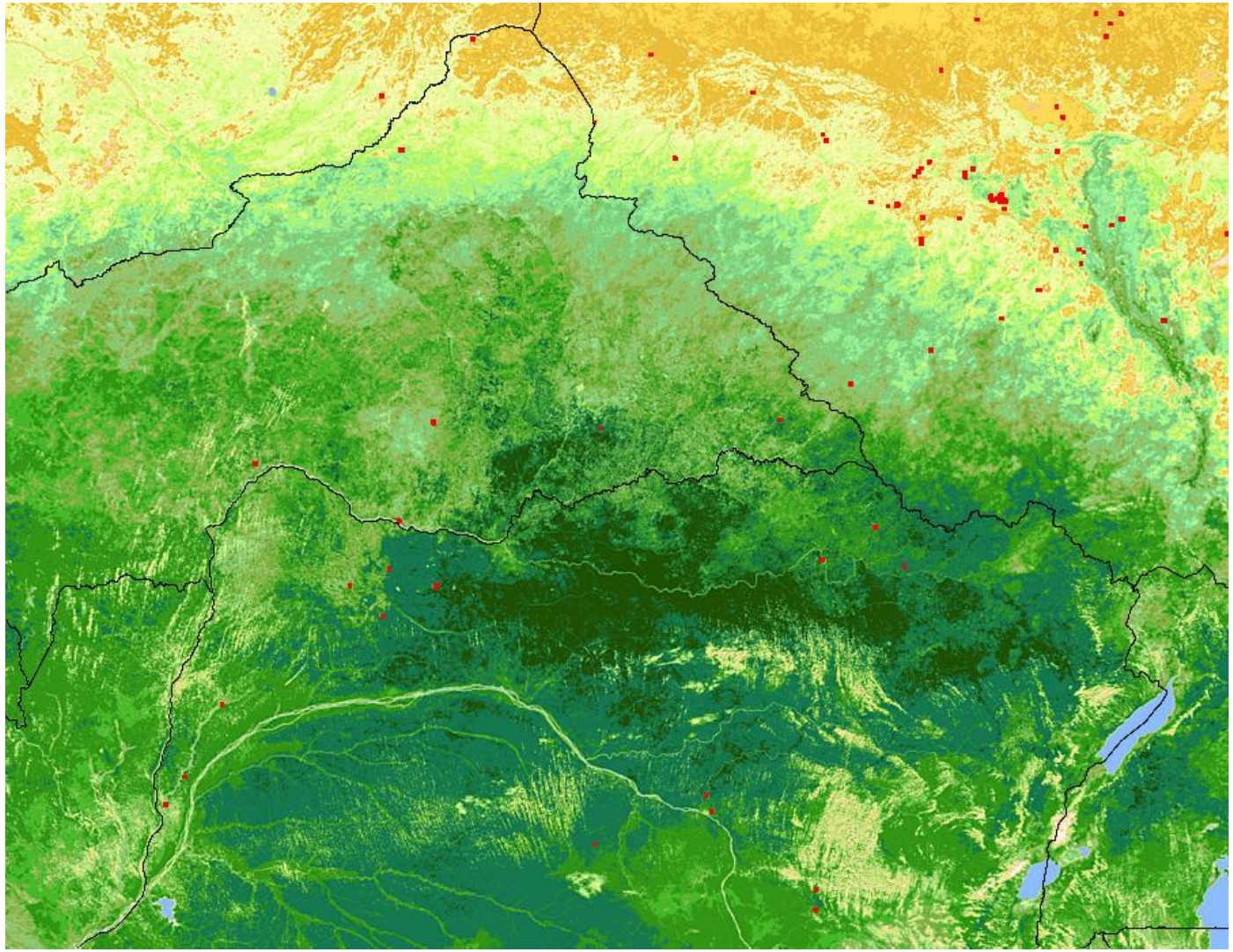
- Healthy vegetation absorbs blue and red light (chlorophyll absorption)
- Healthy vegetation reflects green light (why leaves appear green)
- Near-infrared (NIR) is strongly reflected by healthy leaves but absorbed by unhealthy or sparse vegetation
- Shortwave infrared (SWIR) helps in detecting plant water content

Spectral Properties of Vegetation



(Roman/Ursu 2016)

NDVI – Normalized difference Vegetation Index



(Descloitres 2004)

Describe what you see!

What could the red spots mean?

NDVI – Normalized difference Vegetation Index

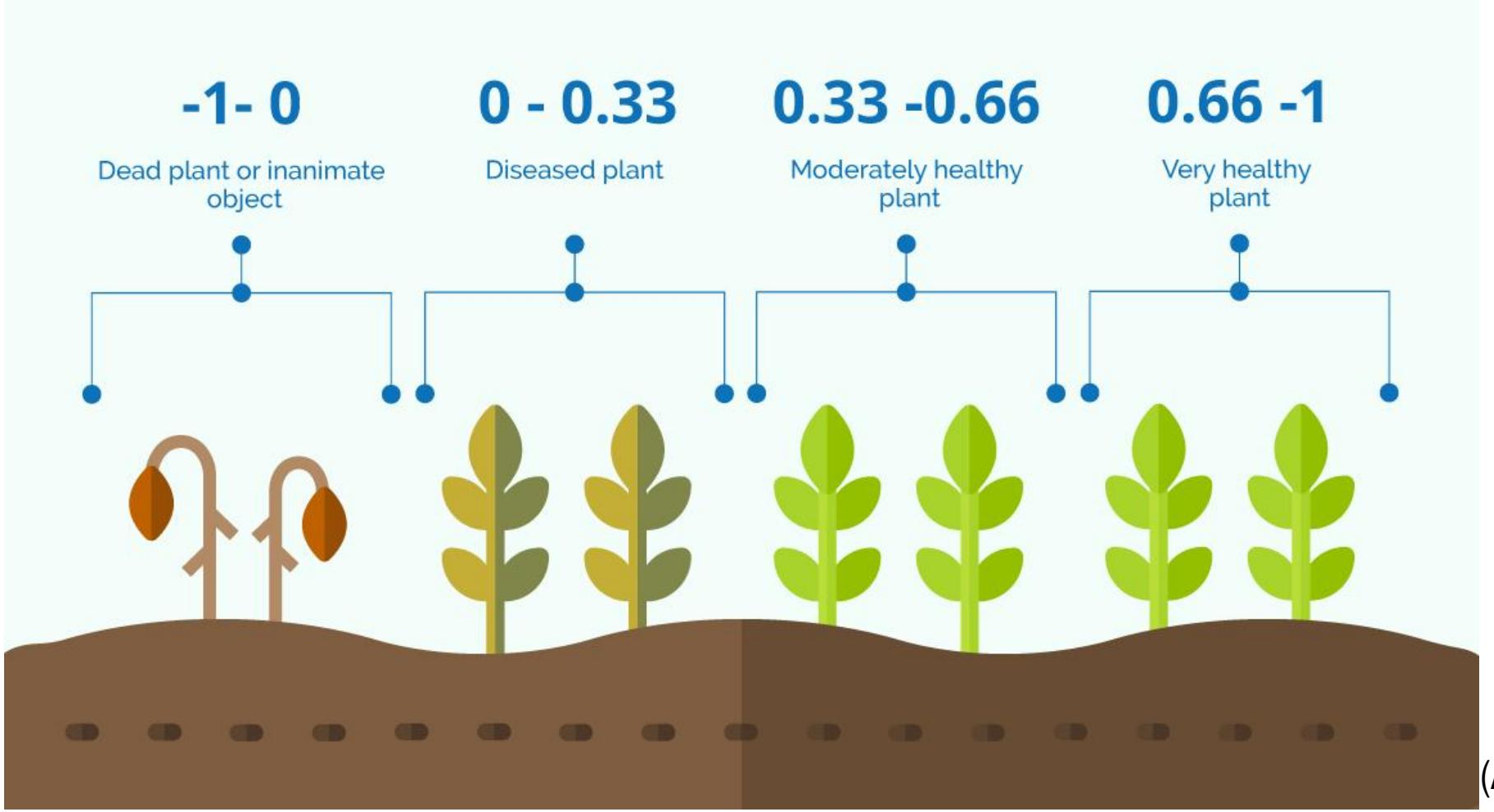
Key Use Cases

- Crop health monitoring
- Deforestation analysis
- Burned area assessment

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

NDVI – Normalized difference Vegetation Index

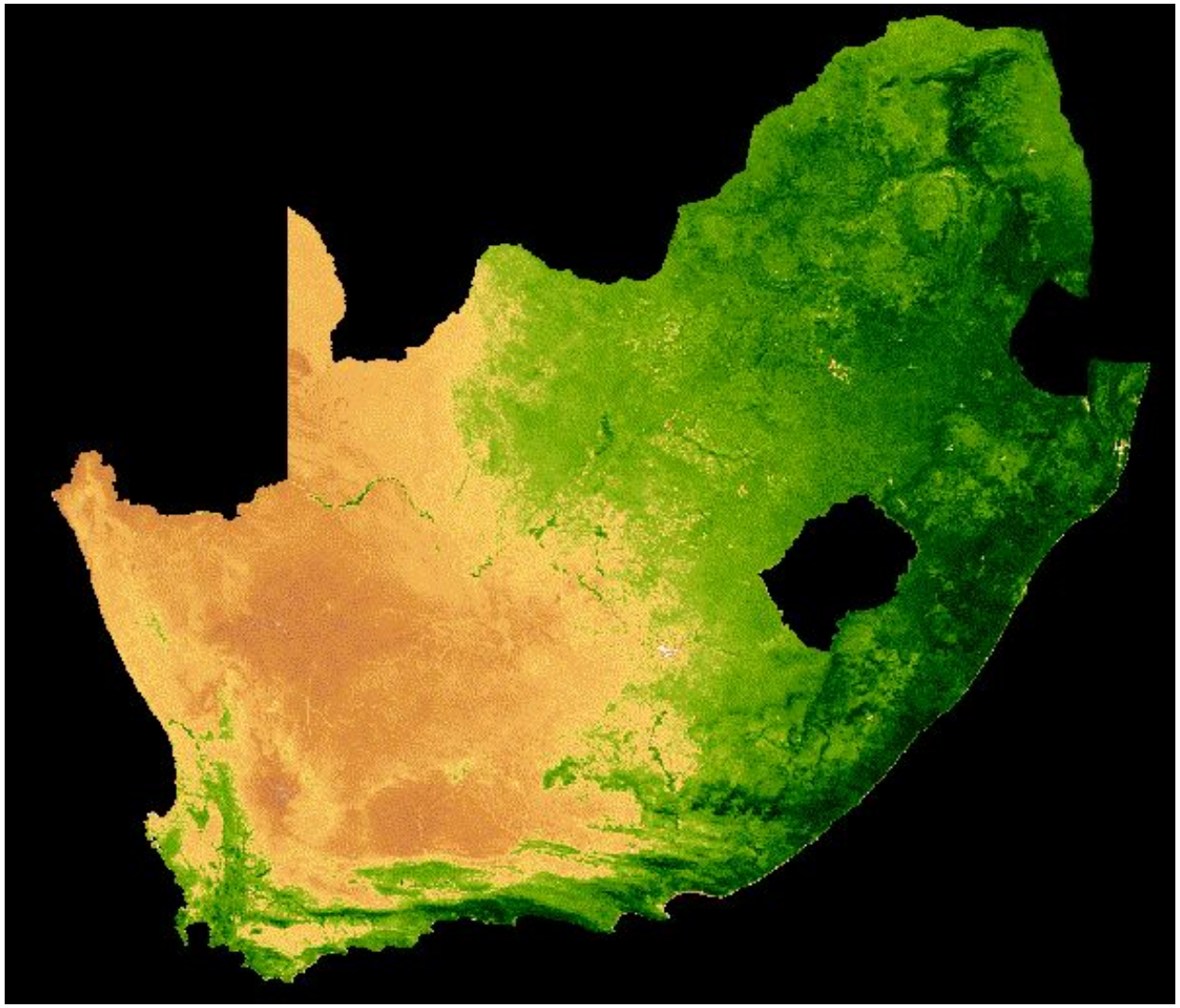
Interpretation:



(Auravant 2021)

NDVI – Normalized difference Vegetation Index

Time Series Analysis
South Africa

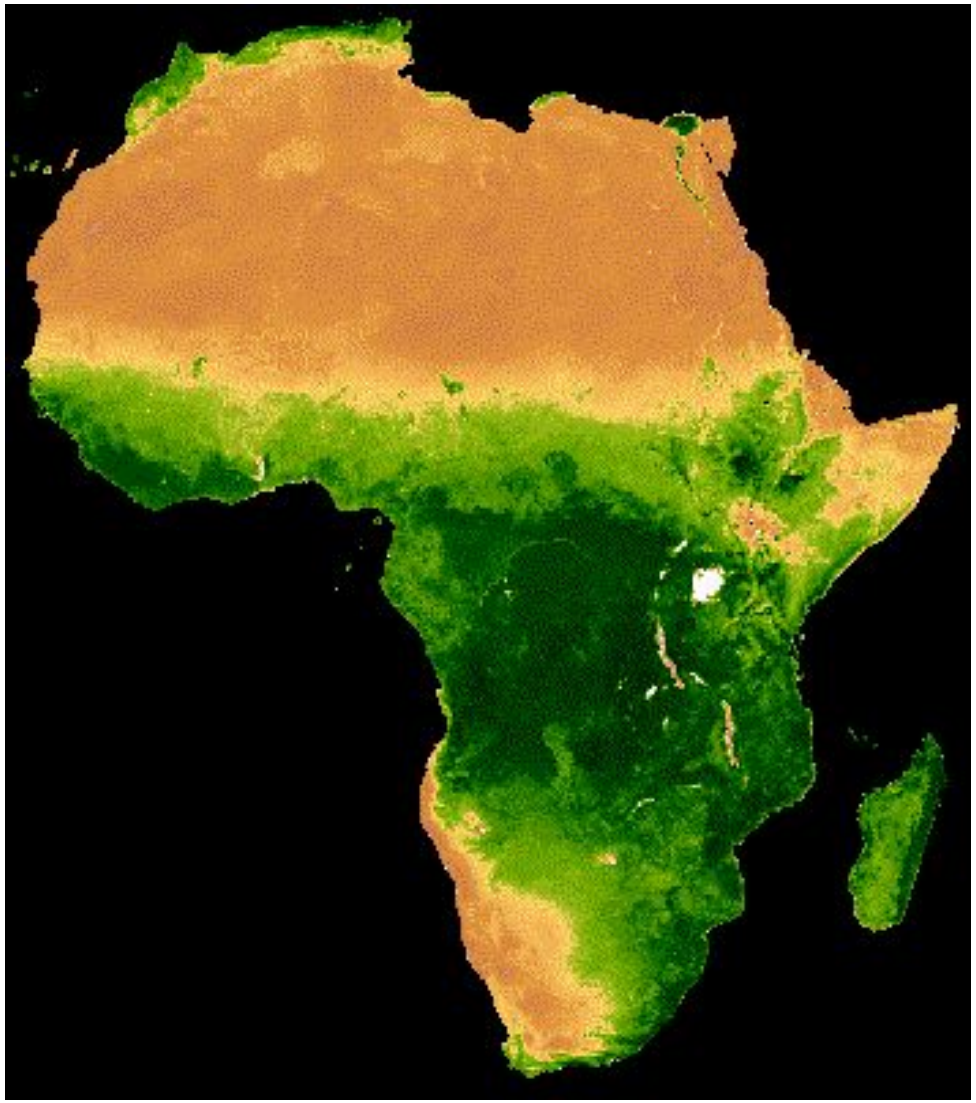


(White 2022)

NDVI – Normalized difference Vegetation Index

Time Series Analysis - African continent

What advantages does a temporal NDVI analysis have?

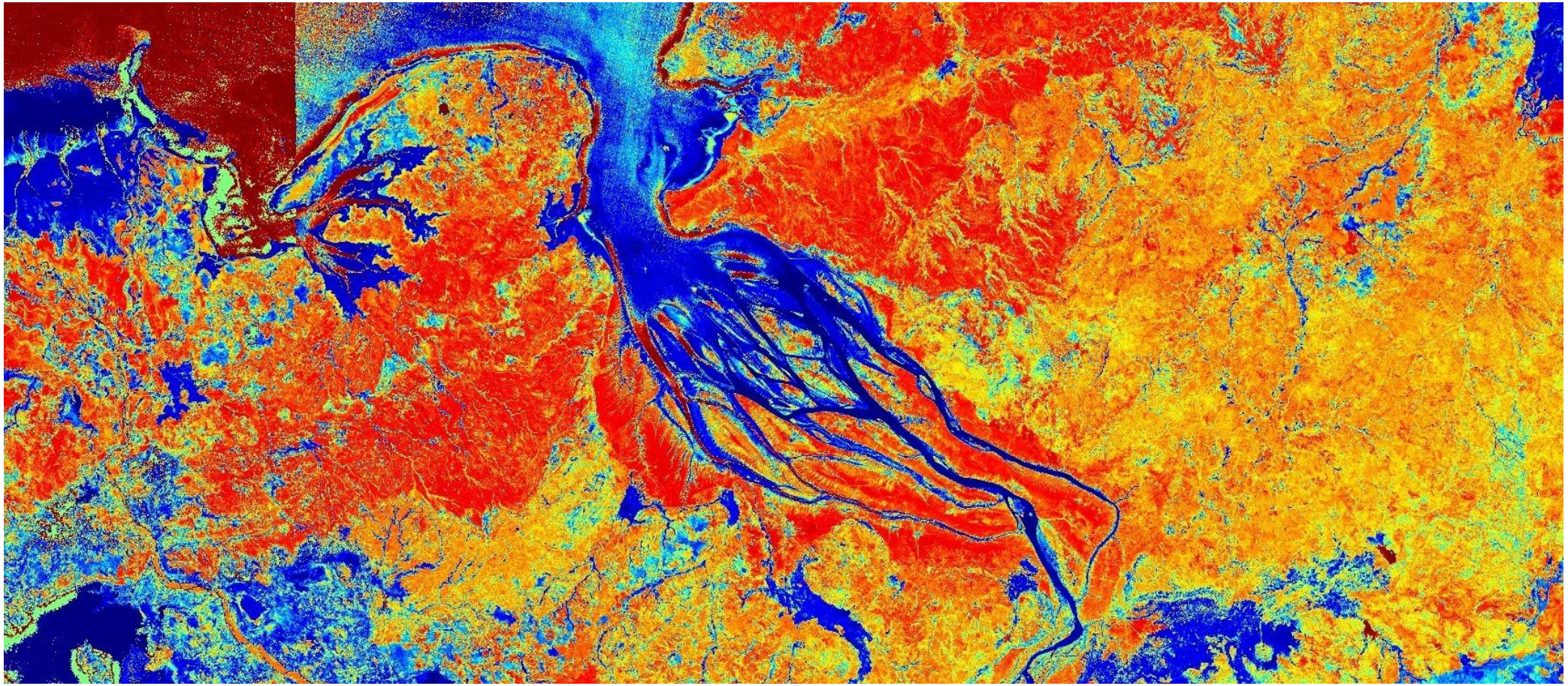


(Google Earth Engine Community n.d.)

NDMI – Normalized difference Moisture Index

Describe what you see!

(Sentinel Hub a n.d.)



NDMI – Normalized difference Moisture Index

$$NDMI = \frac{NIR - SWIR}{NIR + SWIR}$$

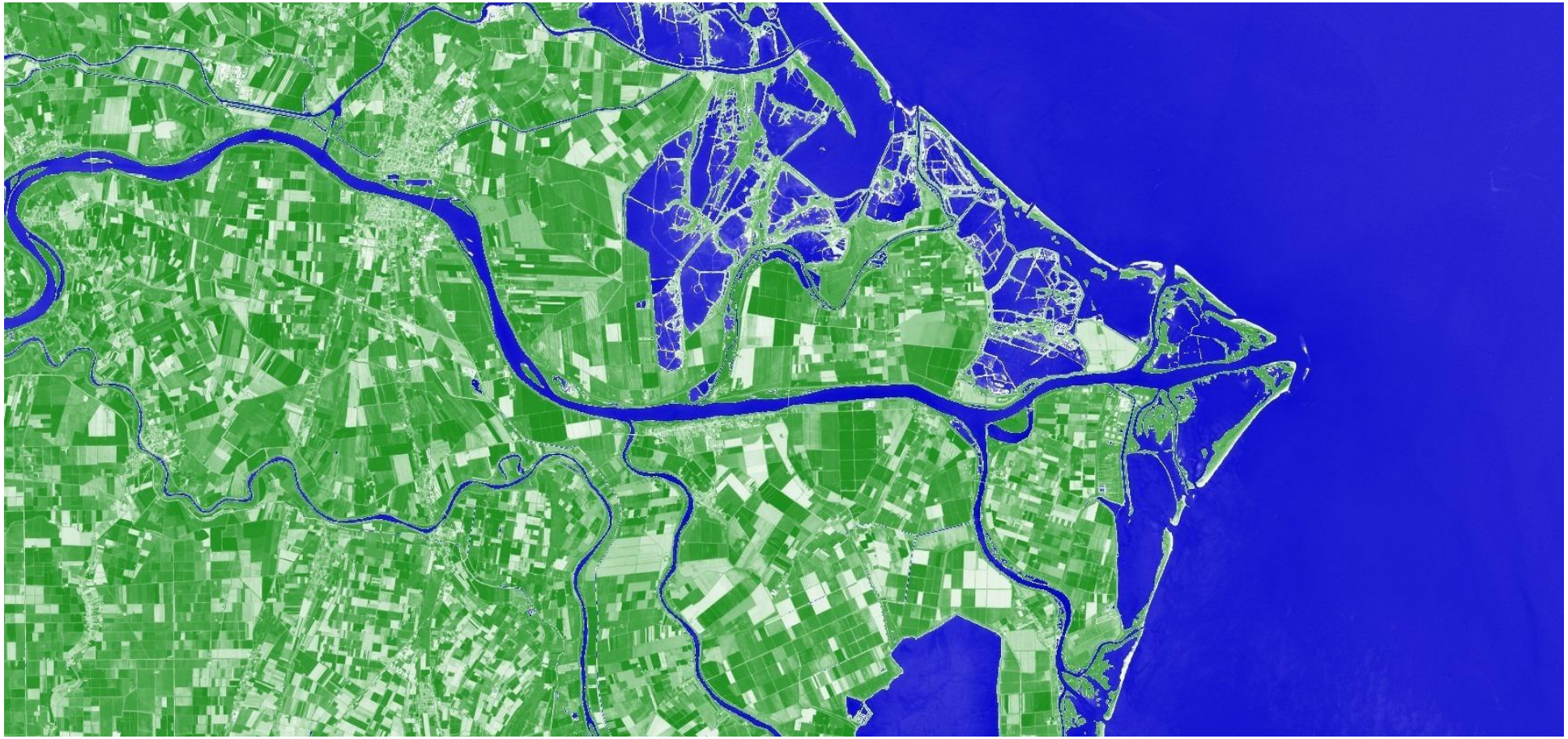
Key Use Cases

- Used to measure vegetation water content and drought stress
- Sensitive to moisture changes in leaves

NDWI – Normalized difference Water Index

Describe what you see!

(Sentinel Hub b n.d.)



NDWI – Normalized difference Water Index

$$NDWI = \frac{Green - NIR}{Green + NIR}$$

Key Use Cases

- Enhances water bodies in satellite images
- Useful for flood mapping and wetland monitoring

Choosing the right Vegetation Index

Index	Input Bands	Best Use Case	Limitations
NDVI	Red, NIR	Vegetation health	Affected by soil brightness
NDMI	NIR, SWIR1	Drought monitoring	May confuse wet soil with vegetation
NDWI	Green, NIR	Water detection	Can mix vegetation with water

Sources of Errors in Index Calculations

Common Challenges

- Atmospheric interference (aerosols, clouds, haze)
- Soil background effects (NDVI can misclassify bright or dark soils)
- Mixed pixels in heterogeneous landscapes
- Sensor differences (e.g., Sentinel-2 vs. Landsat band configurations)

Solutions

- Apply radiometric corrections
- Use cloud masking techniques
- Use multiple indices for validation

Summary & Key Takeaways

Vegetation indices **enhance** specific spectral properties of vegetation

NDVI is the most widely used but has **limitations**

NDMI & NDWI are useful for **water stress and wetland mapping**

Preprocessing steps (e.g., atmospheric correction) improve accuracy

Sources

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Thank you for your attention!

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