SPECTRAL SIGNATURES

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Subjects Spectral Signatures

- Spectral signature (reflection)
- Temporal signature
- Vegetation indices
Reflective Optical Window

Wavelength

optical

reflective

human eye

lidar

photography

multispectral scanners

thermal scanners

microwave radiometry

radar

reflective effect of atmosphere

atmospheric transmittance

microwaves

UV VIS NIR MIR TIR

UV VIS NIR MIR TIR

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Source of EM radiation

curves for an “average” object on earth

radiation ($Wcm^{-2} \mu m^{-1}$)

reflected
solar radiation

emitted
thermal radiation

reflected thermal radiation

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Reflection

Reflection is the process of sending back EM radiation by an object

Reflectance factor [0,1]
-coefficient [0,1]
-percentage [0%,100%]

1) \( \rho(\lambda) = \frac{L_r(\lambda)}{L_i(\lambda)} \)
   = reflected divided by incoming radiation per wavelength \( \lambda \)
   or wavelength interval \( \Delta \lambda \)
Reflection

2) \[ \rho_{obj}(\lambda) = \frac{L_{obj}(\lambda)}{L_{ref}(\lambda)} \times \rho_{ref}(\lambda) \]

Reflectance factor: the radiance of an object in a certain direction under certain conditions of irradiation, relative to the radiance of an (ideal white) diffuse surface in the same direction and the same irradiation conditions.

3) Atmospheric correction model
Reference targets
Example influence of soil moisture content:

- Newtona silt loam
- Reflectance (%)
- Wavelength (µm)

Values:
- 0.8%
- 4.7%
- 8.3%
- 12.9%
- 16.9%
- 20.2%
Spectral Signatures: Leaf

- Absorptance (water)
- Absorptance (chlorophyll)
- Reflectance

Wavelength (µm)

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Spectral information of a leaf

Individual leaf

VIS $\rightarrow$ chlorophyll (absorptance)

NIR $\rightarrow$ cell walls - air transitions (reflectance)

MIR $\rightarrow$ water (absorptance)
Spectral Signatures: Leaf

Plant type

citrus
tomato
sorghum
cotton

Reflectance (%)

Wavelength (µm)

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Disease infection

Reflectance (%)

Wavelength (µm)

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Spectral Signatures: Vegetation

Reflectance (%)

Wavelength (µm)

barley

dry soil

wet soil

VIS_{veg.} \approx \frac{1}{2} \text{VIS}_{leaf}

NIR_{veg.} > \text{NIR}_{leaf}
Temporal signatures: Barley Crop

Reflectance (%%)

NIR
red
green

bare soil

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Field trial with barley
Single-engine aircraft for 70-mm photography
Mounts and cameras for 70-mm photography
Microlight aircraft for 70-mm photography
Camera mounts for the microlight
Spectral bands for multispectral photography

Reflectance (%)

Wavelength (µm)

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Green recording, 27 May
NIR recording, 27 May
True colour recording, 29 July
False colour recording, 29 July
Vegetation Indices:

simple band combinations in order to
- strengthen the spectral contribution of vegetation
- eliminate the disturbing influence of the atmosphere, soil, etc.

Example:

- simple ratio: NIR/Red

- “Normalized difference vegetation index”: NDVI = (NIR-Red) / (NIR+Red)
NOAA-NDVI image of Africa

March

June
Temporal signatures

Barley crop: Red, NIR

Reflectance (%)

WDVI (%)

Barley crop: WDVI

days after sowing

days after sowing

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\[ \text{LAI} = \frac{-1}{\alpha} \cdot \ln \left(1 - \frac{\text{WDVI}}{\text{WDVI}_\theta} \right) \]
NDVI = (NIR - Red) / (NIR + Red)

Relationship NDVI - LAI
### Example vegetation indices

NDVI = \( \frac{\text{NIR} - R}{\text{NIR} + R} \)

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