UNIVERSITY OF TWENTE.

RETRIEVAL OF LEAF AREA INDEX FROM REMOTE SENSING DATA

STATISTICAL APPROACH - PART I: VEGETATION INDICES

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CONTENT

- Remote sensing role
- Retrieval of vegetation indices
- Statistical approach
- Why vegetation indices?
- Ratio based indices
- Soil based indices
- Narrowband indices

LEARNING OBJECTIVES:

- To familiarize with main types of RS VI
- What are the shortcomings and advantages
- To familiarize with estimation of LAI from VI

REMOTE SENSING ROLE

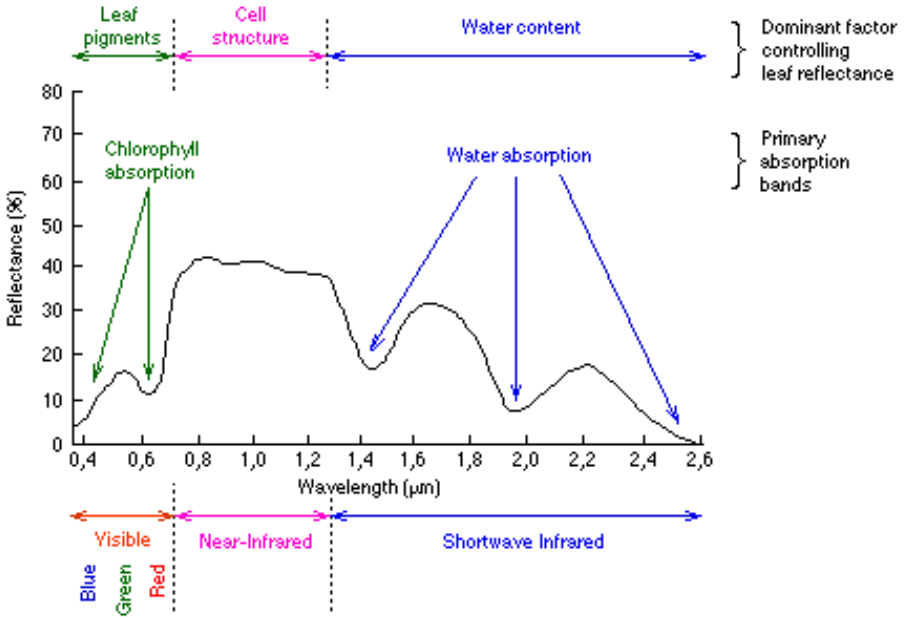
- Utilizing remote sensing, implies that the knowledge of vegetation type, species, growth, health and productivity is obtained from their spectral signatures.

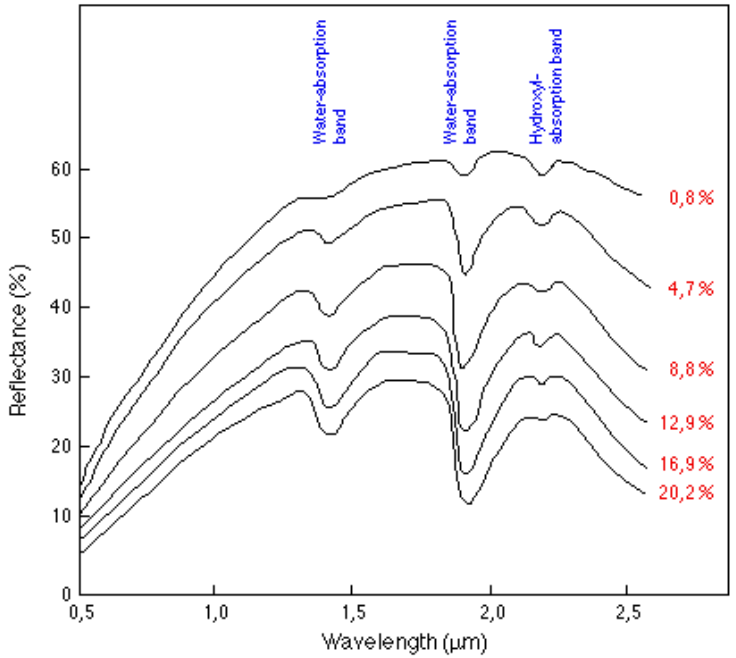
- Neglecting exterior factors such as soil background and atmosphere, **plant traits are the main features** affecting the spectral signature of vegetation.

- Understanding the **link between these traits** and **plant's spectral signature**, as well as **how they interact** and **how the combined interaction** will affect the spectral signature is crucial.

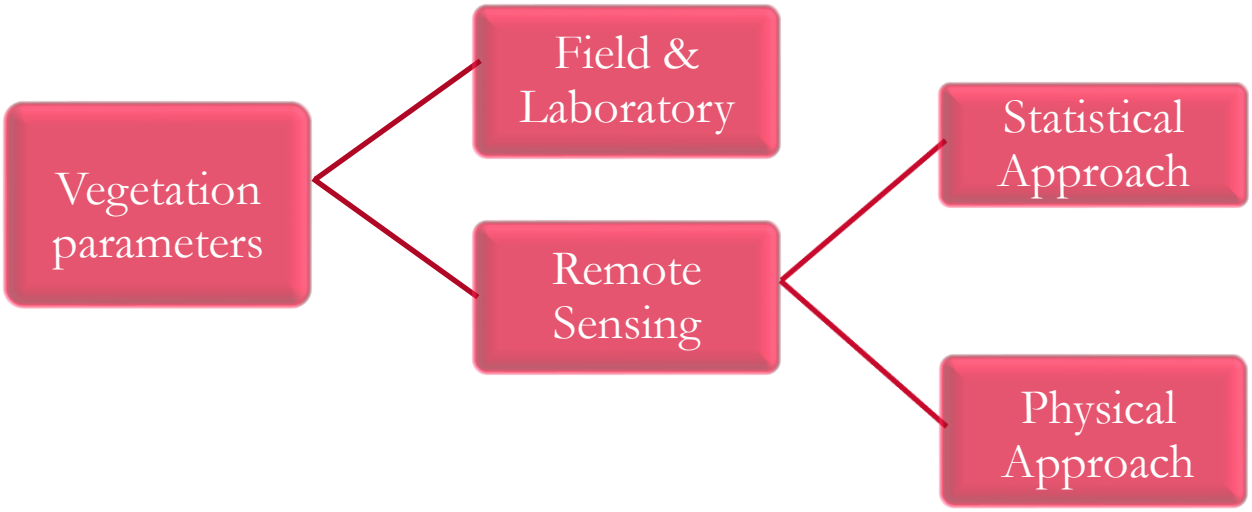
VARIATION IN REFLECTANCE

- (bio)chemical & structural properties
  - Chlorophyll concentration in vegetation
  - soil - minerals/ water/ organic matter





RETRIEVAL OF VEGETATION TRAITS



STATISTICAL APPROACH

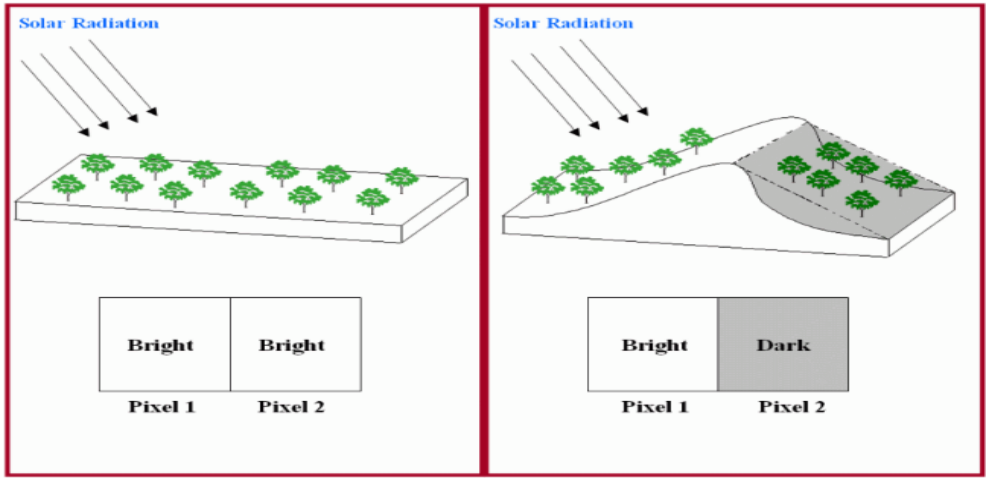
Search for a meaningful relationship between the spectral signature of an object (plants leaves/canopy), or its derivatives and the biophysical variable/plant trait of interest (LAI)

- Lack generalization and transferability
- sensor-specific (spectral characteristics and resolutions)
- site and sampling conditions (soil, observation geometry, canopy structure, species variation)

WHY VEGETATION INDICES?

- Simplicity in computation
- Normalize the undesired effects by considering the most relevant wavelengths

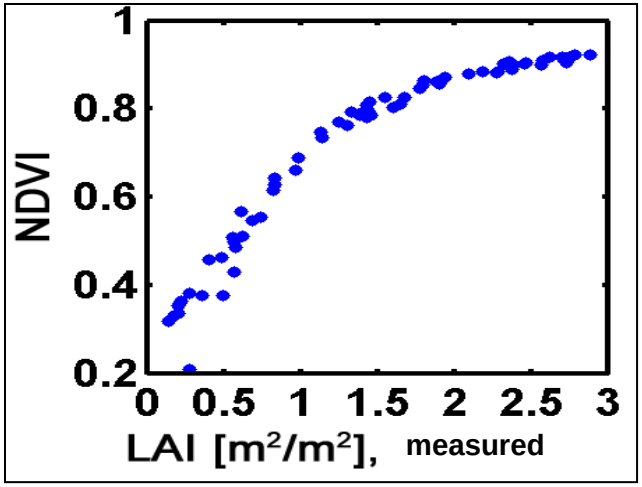
- Soil /background reflectance
- Atmosphere composition
- Observation (Sun and view) geometry



VEGETATION INDICES

- Distinct reflectance in red, NIR and SWIR as well as relevant absorption peaks
- Sensitivity to the biophysical properties can be explained by physical laws to an extent

- Ratio based
- Soil based
- Narrow bands



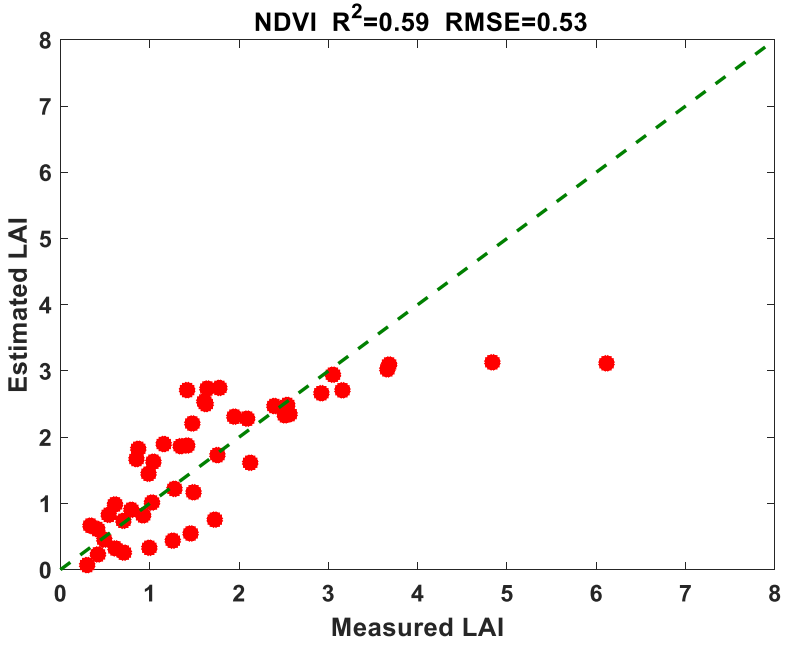
FORMS OF RATIO BASED INDICES

- Ratio vegetation index (RVI) (Pearson and Miller 1972)

$$RVI = \rho_{\lambda 1} / \rho_{\lambda 2}$$

- Normalized difference vegetation index (NDVI) (Rouse et al. 1974)

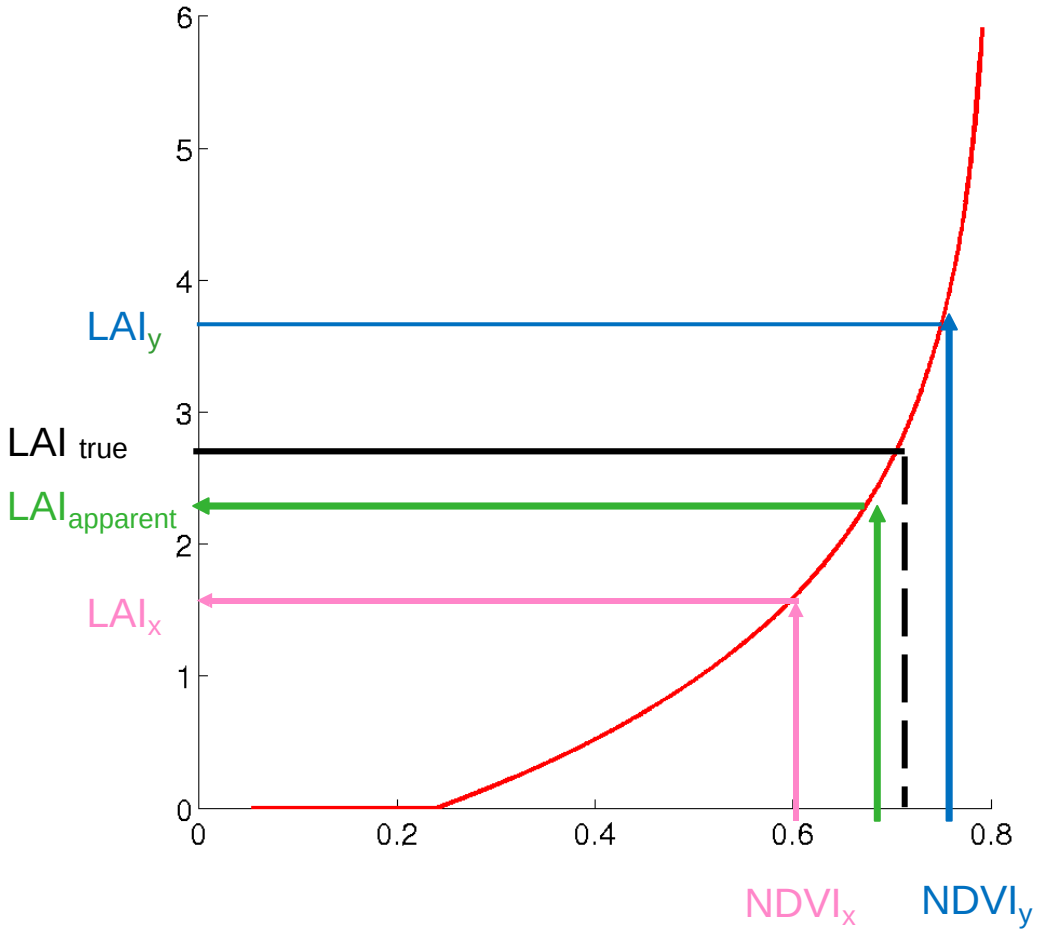
$$NDVI = \frac{\rho_{\lambda 1} - \rho_{\lambda 2}}{\rho_{\lambda 1} + \rho_{\lambda 2}}$$



Non-linearity with Indices results bias (underestimation)

LAI=f(NDVI)

True LAI: (1.8+3.8)/2=2.8



CLUMPING EFFECT ON LAI

- In a clumped canopy (e.g. Conifer canopies), leaves are hiding each other with larger gaps in between.
- More light reaching the ground as compared to a canopy with a random leaf distribution (e.g. broad leaves).
- The obtained LAI (un-destructively) is based on light transmission therefore, underestimated.
- The apparent LAI or effective LAI is lower than the true LAI.
- The ratio LAIe/LAI is called Ω (omega).

CLUMPING EFFECT ON LAI

- Ω determine which part of the light from the sky is coming through larger gaps and which part is coming through the canopy.

- Leaves are all clumped near the top of the tree stems and leave large gaps in between. For example if LAI estimated with the assumption of a random canopy would be 2.3 (LAIe).
- Taking the gap structure into account result a higher estimate 3.6 (Ω = 0.64).

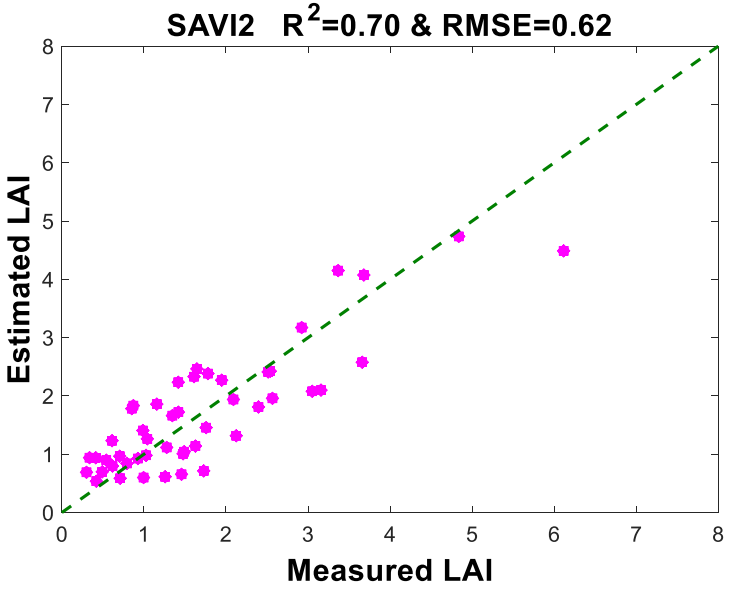
FORMS OF SOIL BASED INDICES

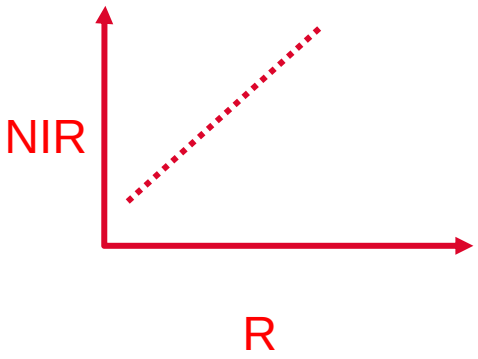
- Second soil- adjusted vegetation index (***SAVI2)*** (Major et al., 1990)

$$SAVI2 = \frac{\rho_{\lambda 1}}{\rho_{\lambda 2} + (b/a)}$$

- perpendicular vegetation index (PVI) (Richardson and Wiegand 1977)

$$PVI = \frac{\rho_{\lambda 1} - a\rho_{\lambda 2} - b}{\sqrt{1 + a^2}}$$





Enhanced Vegetation Index

$$EVI = \frac{\rho_{NIR} - \rho_{red}}{L + \rho_{NIR} + C_1 \rho_{red} + C_2 \rho_{blue}} * G$$

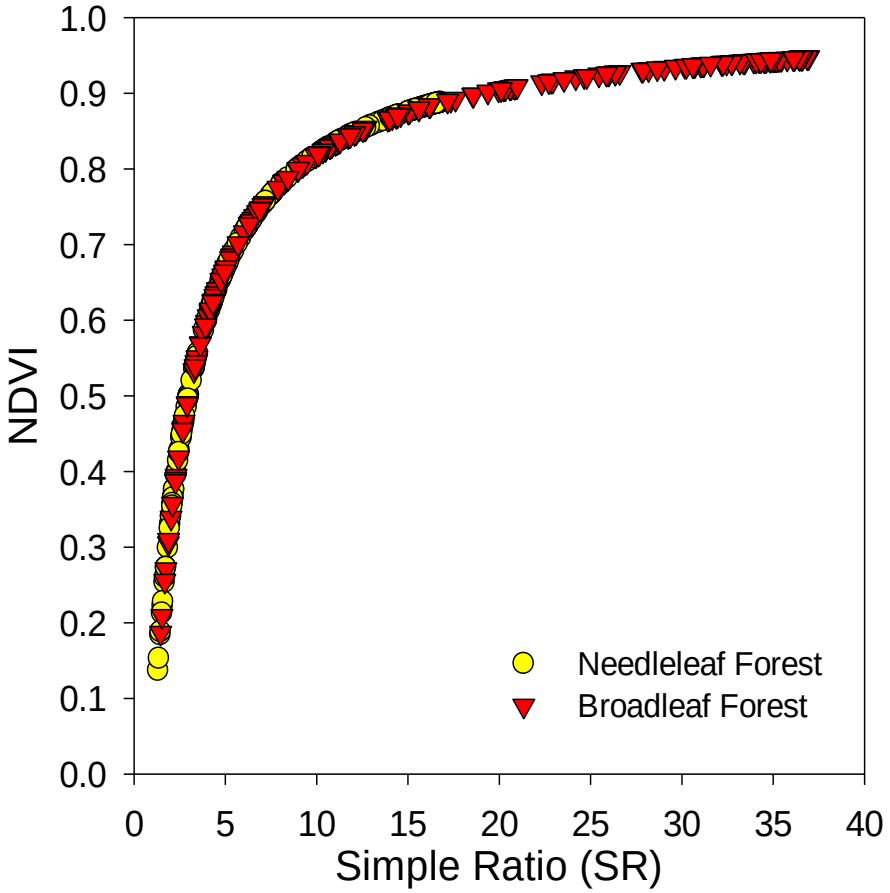
- L = canopy background adjustment,
- C_1 and C_2 are coefficients for aerosol correction

- Reduces atmosphere and canopy background contamination
- Increased sensitivity at high vegetation cover (less saturation)

INTER-RELATIONSHIPS AMONG SPECTRAL VI'S

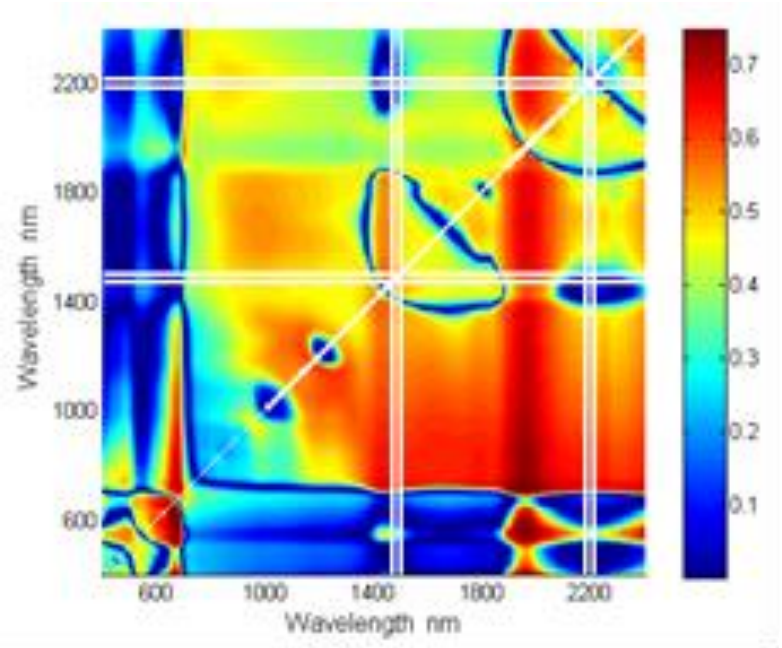
- VI's behave similarly to each other under a 'constant' set of conditions,
- NDVI and SR have non linear relationships.
- If soils are not varying then NDVI and SAVI are well correlated,
- If aerosol differences are minimal, then similarly there is minimal difference between EVI and SAVI.

INTERRELATIONSHIP OF INDICES



NARROW BAND INDICES (HYPERSPECTRAL INDICES)

- Narrow band vegetation indices utilize spectral data of narrow bands obtained from hyperspectral sensors.
- To find the optimum bands for a specific index, usually all possible two band combinations are used for calculating vegetation index.



Summary

Why we use VI

- Ratio based vegetation indices
- Soil based vegetation indices
- Narrowband vegetation indices