**Remote sensing live vegetation cover and health**

- Most plant cover/condition remote sensing use Normalized Difference Vegetation Index (NDVI):
  \[
  \text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}
  \]

- NDVI not overly sensitive to chlorophyll.

- The position of the Red Edge can indicate nitrogen stress conditions.

- Red edge indices are sensitive to chlorophyll (bands shown are for Sentinel-2):
  \[
  \text{Red EdgeNDVI} = \frac{\text{R}_{705} - \text{R}_{740}}{\text{R}_{705} + \text{R}_{740}}
  \]

- **MTCI** is a linear relationship between Red edge NDVI, Red edge EVI, Red edge EVI:
  \[
  \text{MTCI} = \frac{\text{R}_{705} - \text{R}_{740}}{\text{R}_{705} + \text{R}_{740}}
  \]

- Red Edge indices require at least one band at 720 nm (WorldView-2, RapidEye), plus red, NIR bands.

- The MERIS Terrestrial Chlorophyll Index (MTCI) least affected by soil.

- Red Edge is better imaged with bands at 705 and 740 nm:
  - Sentinel-2 mean soil MTCI = 0.82, std. dev. = 0.29, N = 4257
  - WorldView-2 (one band at 720 nm) mean soil MTCI = 0.93, std. dev. = 3.29

**Remote Sensing of Canopy Water and Evapotranspiration**

- Soil moisture deficiencies cause leaf stomata to close up:

- Evapotranspiration and photosynthesis decrease;

- Vegetation heats up;

- Yields can be negatively impacted.

- NIR and SWIR band at 1610 – 1650 nm can be used to estimate canopy water content:
  - SWIR band reflectance inversely related to leaf water content.

- LDCM's split thermal infrared (TIR) bands (10.8 and 12.0 μm) will allow for estimation of canopy evapotranspiration (ET).

- Additional thermal bands at 8.6 and 9.1 μm will help improve emissivity estimation.

**Remote sensing dry biomass**

- Dry biomass (senescent vegetation) serves a number of purposes:
  - As crop residues left on a surface for conservation tillage practices
  - As a feedstock for cellulosic biofuels
  - As an indicator of rangeland health and grazing
  - As fuel for wildfires.

- Below 2000 nm, dry biomass and soils can be spectrally similar.

- Broad Landsat TM bands cannot discriminate narrow spectral features of dry vegetation components.

- Cellulose Absorption Index (CAI) ideal for sensing dry vegetation:
  \[
  \text{CAI} = 100 \left( \frac{\text{R}_{905} - \text{R}_{810}}{\text{R}_{905} + \text{R}_{810}} \right)
  \]

- CAI targets an absorption occurring at 2100 nm present for all sugars, including cellulose.

- Most soil minerals do not have absorptions in this relationship.

- CAI has a linear relationship between bare soil, 100% dry biomass cover.

**Spectral bands: visible through SWIR**

- Spectral bands: visible through SWIR

**Spectral bands: TIR**

- Emissivity Response and Spectra

**What would an ideal agricultural satellite look like?**

- Temporal resolution requirements: < 7 days, 5 day or better ideal.

- Pixel size: 60 m max. visible through SWIR (VSWIR), 100 m TIR;

- 20 m ideal VSWIR, 60 m TIR.

- Nadir looking.

- Swath width constrained to a maximum of 20° off-nadir view angle:
  - Minimizes BRDF problems;
  - Minimizes obscuration of soil by canopy residue;
  - Ensures radiometric accuracy in TIR.

- Quantization > 12 bits.

- Signal-to-Noise Ratio (SNR) requirements: >250.

- Narrower ASTER-type bands in SWIR to discriminate cellulose absorption.