# Soil Moisture Monitoring  Using Remote Sensing

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## Measurement of soil moisture

- **Direct observations of soil moisture are currently restricted to discrete measurements at specific locations, and such point-based measurements do not represent the spatial distribution because soil moisture is highly variable both spatially and temporally and are therefore inadequate to carry out regional and global studies.**

## Soil Moisture/Soil Water

- Soil  moisture is the water that is held in the spaces between soil particles and adsorbed by the colloidal surfaces
- Surface soil moisture is the water that is in the upper 10 cm of soil, whereas root zone soil moisture is the water that is available to plants, which is generally considered to be in the upper 200 cm of soil.

## Expression of soil water

- Gravimetric water content on mass (weight) basis: ratio of the mass of liquid phase to solid soil mass
- Volumetric water content on volume basis: ratio of the liquid phase in soil to total volume of the soil. Multiplied by density of water (1g/cc)

## Satellite remote sensing for soil moisture measurements

**Technological advances in satellite remote sensing have offered a variety of techniques for measuring soil moisture across a wide area continuously over time since the mid 1970's Numerous researchers have shown that near surface soil moisture content can be measured by optical, thermal infrared and microwave remote sensing techniques.**

**Optical to Mid-Infrared (0.4-3 µm)**

- Change of colour
- Water absorption bands at 1.4, 1.9 and 2.7 µm

**Thermal Infrared (7-15 µm)**

- Indirect assessment of soil moisture through its effect on the surface energy balance (temperature, thermal inertia, etc)

**Microwave (1mm-1m)**

Change of dielectric properties

**Dielectric properties-**

- Substances with large dielectric constant will tend to dissociate in water forming solutions containing ions.
- Water has high dielectric constant indicating that the force between the ions in a salt is very much reduced permitting the ions to dissociate.
- Separated ions are surrounded by the oppositely charged ends of the water dipoles and become hydrated

**Back scatter coefficient** –

- Measure of reflectivity of Earth's Surface
- Remote sensors do not measure soil moisture content directly
- Mathematical models describe the relation between the measured signal and soil moisture content
- Method is then developed for inverting the model by minimizing the residual error between the model simulated and sensor-measured values

## Optical Remote Sensing

- Remote sensing of soil moisture content using the solar domain with wavelengths between 0.4 and 2.5 µ m based on reflectance patterns
- Compared with microwave and thermal infrared domains that are most commonly used for soil moisture estimation, little attention has been paid to the use of the solar domain. However, many investigations have shown that the solar domain also provides the capability for soil moisture estimation.
- Several empirical approaches have been proposed to describe the relation between soil surface reflectance and moisture contents.

## Thermal infra red remote sensing

- **Thermal infrared remote sensing measures the thermal emission of the Earth with an electromagnetic wavelength region between 3.5 and 14 µm.**
- **The estimation of surface soil moisture using thermal wavebands primarily relies on the use of soil surface temperature measurements, either singly using the thermal inertia method or in combination with vegetation indices as the temperature/vegetation index method**

## Temperature-vegetation index method

- Vegetation and land surface temperature (LST) have a complex dependence on soil moisture.
- There is a unique relationship sometimes referred to as the “Universal Triangle” among soil moisture vs the normalized difference vegetation index (NDVI), and the LST for a given region. This method used for estimating soil moisture

## Microwave remote sensing

- Provides a unique capability for soil moisture estimation by measuring the electromagnetic radiation in the microwave region between 1mm and 1m.
- Fundamental basis of microwave remote sensing for soil moisture is the large contrast between the dielectric properties of water (~80) and soil particles (<4).
- As the moisture increases, the dielectric constant of the soil-water mixture increases and this change is detectable by microwave sensors.
- Microwave remote sensing techniques have demonstrated the most promising ability for globally monitoring soil moisture variations.

- These sensors measure the intensity of microwave emission from the soil, which is proportional to the brightness temperature, a product of the surface temperature and emissivity
- Emissivity is defined as the ratio of the energy radiated from a material's surface to that radiated from a blackbody (a perfect emitter) at the same temperature and wavelength and under the same viewing conditions.
- This observed emission is related to its moisture content because of the large differences in the dielectric constant of dry soil and water.
- Factors affecting accuracy
- Vegetation cover
- Most important, dense vegetation ( forest) can obscure soil surface
- Greater effect at shorter wave lengths
- Soil properties –Density, texture,Surface roughness


Thank You