Remote Sensing of Soil Moisture for Agriculture

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Background Information: As defined by the AMS Glossary of Meteorology, soil moisture is "the total amount of water, including the water vapor, in an unsaturated soil." Soil moisture is a critical aspect of agriculture; a shortage or overabundance of water may cause plants to wilt and die. Soil moisture helps to regulate soil temperature, breaks down nutrients and minerals in the dirt necessary for plant growth, and is used directly as an ingredient in photosynthesis.

Remote Sensing: Traditionally, soil moisture is measured by weighing wet soil sampled in the field, drying it in an oven, and then weighing the dry soil. However, this method is expensive, time-consuming, and inefficient. Remote sensing satellites provide accurate soil moisture measurements continuously over large areas. NASA's Soil Moisture Active Passive (SMAP) satellite and ESA's Soil Moisture Ocean Salinity (SMOS) satellite pick up faint L-Band microwave emissions from Earth's surface to globally map soil moisture levels in the top 5 cm of soil.

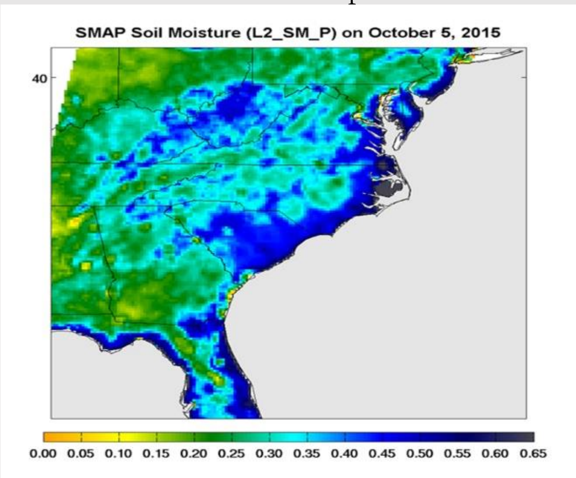

Figure 1. SMAP Soil Moisture Map[1]

Moisture decreases the emissivity of soil, and thereby affects microwave radiation emitted from the surface of the Earth. The SMAP satellite measures the microwave temperature of the land surface; within the L-Band water appears relatively cold and dry soil appears relatively warm.[2] The SMOS satellite uses interferometry to map soil moisture by measuring the phase difference of incident radiation at two or more receivers at a known distance apart.[3]

Soil Moisture Anomaly: Soil moisture has high spatial and temporal variability due to differences in soil properties, topography, land use, vegetation, and atmospheric conditions. Because of this variability, the same absolute soil moisture value can indicate normal soils in one region and serious drought in another.

This is combatted by mapping Soil Moisture Anomalies, which measures the degree of dryness or saturation of the soil compared to normal conditions. These anomalies can then be used to determine and forecast the start and duration of agricultural drought and flood conditions long before plants begin to suffer.

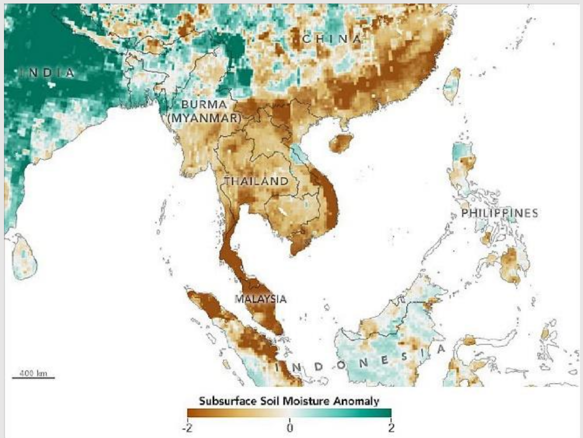

Figure 2. SMAP Soil Moisture Anomaly Map[4]

Irrigation: Satellite imagery can be used to estimate evapotranspiration rates, which is useful in determining the duration and frequency of irrigation needed for plant growth as a function of water availability. Better estimation of irrigation needs will help with water conservation in arid regions.

Crop-Yield: The U.S. Department of Agriculture uses Soil Moisture measurements from the SMAP and SMOS satellites to improve the accuracy of their crop-yield forecasts.[5] These predictions are used to make decisions about when to plant and harvest crops, to anticipate equipment, fuel, labor, and storage needs, and make early marketing decisions, hence the accuracy of these predictions is critical in assuring food security.

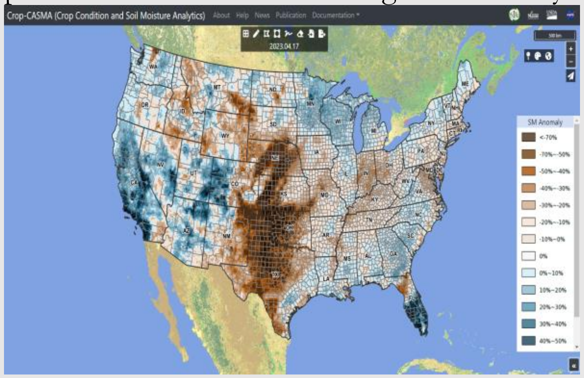

Figure 3. USDA's Crop Condition and Soil Moisture Analytics (Crop-CASMA)[6]

References and Relevant Websites:

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