# UM researcher helps NASA get the dirt on soil moisture

January 15 2015

SMAP's liftoff will look very similar to the liftoff of an earlier NASA Delta II Mission from Vandenberg AFB, in Jun. 2011. The Delta II vehicle pictured is the same type and configuration that will be used for SMAP and will be launched from the same pad (Space Launch Complex 2W) at Vandenberg AFB. Credit: NASA

During the early-morning hours on Tuesday, Jan. 29, NASA will launch a satellite that will peer into the topmost layer of Earth's soils to measure the hidden waters that influence our ecosystems weather and climate.

University of Montana Professor John Kimball is among the team of researchers involved in the project. He developed algorithms that will digest the vast amount of data collected by the satellite and spit them into a software platform that estimates and monitors global land-atmosphere carbon dioxide exchange, ecosystem productivity and underlying environmental controls.

"We've been working with NASA for almost a decade to develop methods for effective global monitoring of surface soil moisture and freeze-thaw status from satellites," Kimball said. "These parameters are very dynamic and strongly impact weather, climate and ecosystem processes, including vegetation growth."

The Soil Moisture Active Passive, or SMAP, mission will produce the most accurate, highest-resolution global maps ever obtained from space of the moisture present in the top 2 inches of Earth's soils. It also will detect and map whether the land surface is frozen or thawed.

Kimball and his team hope to reduce uncertainty regarding the status and potential vulnerability of the global carbon sink, and better understand relationships between global water, carbon and energy cycles. These new observations will benefit a variety of applications, including regional assessment and monitoring of vegetation productivity and health, and drought impacts to forests, rangelands and agricultural systems.

"With data from SMAP, scientists and decision makers around the world will be better equipped to understand how Earth works as a system and how soil moisture impacts a myriad of human activities, from floods and drought to weather and crop-yield forecasts," said Christine Bonniksen, SMAP program executive with the Science Mission Directorate's Earth Science Division at NASA Headquarters in Washington, D.C. "SMAP's global soil moisture measurements will provide a new capability to improve our understanding of Earth's climate."

Globally, the volume of soil moisture varies between 3 and 5 percent in desert and arid regions, to between 40 and 50 percent in saturated soils. In general, the amount depends on such factors as precipitation patterns, topography, vegetation cover and soil composition. There are not enough sensors in the ground to map the variability in global soil moisture at the level of detail needed by scientists and decision makers. From space, SMAP will produce global maps with 2- to 6-mile resolution every two to three days.

Researchers want to better measure soil moisture and its freeze/thaw state for numerous reasons. Plants and crops draw water from the soil through their roots to grow. If soil moisture is inadequate, plants fail to grow, which over time can lead to reduced crop yields. Also, energy from the sun evaporates moisture in the soil, cooling surface temperatures and also increasing moisture in the atmosphere, allowing clouds and precipitation to form more readily. In this way, soil moisture has a significant effect on both short-term regional weather and longer-term global climate.

In summer, plants in Earth's northern boreal regions - the forests found in Earth's high northern latitudes - take in carbon dioxide from the air and use it to grow, but lay dormant during the winter freeze period. All other factors being equal, the longer the growing season, the more carbon plants take in and the more effective forests are in removing carbon dioxide from the air. Since the start of the growing season is marked by the onset of seasonal thawing of soils and vegetation in the spring, mapping the freeze/thaw state of soils with SMAP will help scientists more accurately account for how much carbon plants are removing from the atmosphere each year. This information will lead to better estimates of the carbon budget in the atmosphere and, hence, better assessments of future global warming.

Kimball said, SMAP data will enhance our confidence in projections of how Earth's water cycle will respond to climate change.

"It will advance our ability to monitor droughts, predict floods and mitigate the related impacts of these extreme events," Kimball said.

It will allow the monitoring of regional deficits in soil moisture and provide critical inputs into drought monitoring and early warning systems used by resource managers. In addition, the mission's high-resolution observations of soil moisture will improve flood warnings by providing information on ground saturation conditions before rainstorms.

SMAP's two advanced instruments work together to produce soil moisture maps. Its active radar works much like a flash camera, but instead of transmitting visible light, it transmits microwave pulses that pass through clouds and moderate vegetation cover to the ground and measures how much of that signal is reflected back. Its passive radiometer operates much like a camera, capturing natural Earth light emissions from the land without transmitting a pulse. Unlike traditional cameras, however, SMAP's images are in the microwave range of the electromagnetic spectrum, which is invisible to the naked eye. Microwave radiation is sensitive to how much moisture is contained in the soil.

The two instruments share a large, lightweight reflector antenna that will be unfurled in orbit like a blooming flower and before spinning at about 14 revolutions per minute. The antenna will allow the instruments to collect data across a 621-mile swath, enabling global coverage every two to three days.

SMAP's radiometer measurements extend and expand on soil moisture measurements currently made by the European Space Agency's Soil Moisture Ocean Salinity mission, launched in 2009. With the addition of a radar instrument, SMAP's soil moisture measurements will be able to distinguish finer features on the ground.

SMAP will launch from Vandenberg Air Force Base on a United Launch Alliance Delta II rocket and maneuver into a 426-mile altitude, near-polar orbit that repeats exactly every eight days. The mission is designed to operate at least three years.

Provided by University of Montana