**The role of soil moisture in water and carbon cycle interactions and modulating feedbacks to weather – an integrated modeling and satellite data approach**

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With data from the Soil Moisture Active-Passive (SMAP), in conjunction with data from the Orbiting Carbon Observatory (OCO-2) mission, the opportunity for new hydrometeorology and terrestrial ecosystem science that bridges water and carbon cycles is imminent. ***We propose to integrate SMAP soil moisture and other satellite data to evaluate and improve land surface model soil moisture and carbon flux estimates, with emphasis on carbon flux sensitivity to moisture deficits and impacts to weather/climate prediction. We will investigate broad-scale relationships between soil moisture and carbon dynamics.*** To link soil moisture and ecosystem properties with process-level mechanistic upscaling, we will employ a unique data integration setup—an integrated biosphere model (Simplified Simple Biosphere Model, SSiB) and dynamic global vegetation model (Top-down Representation of Interactive Foliage and Flora Including Dynamics, TRIFFID) coupled to a Weather Research and Forecasting (WRF) model. The phenological processes in TRIFFID are emphasized in this project. This model setup is especially relevant to this NASA Call because SSiB and TRIFFID are sensitive to soil moisture in terms of the impacts on carbon balance and weather feedbacks to WRF.

This proposed activity encompasses a number of objectives that build on one another:

1. Set up SSiB/TRIFFID to ingest remotely SMAP-sensed soil moisture and update model runs to coincide with available SMAP data;

2. Evaluate the impact of modeled soil moisture on ecosystem carbon dynamics, leveraging observations from OCO-2, with different Plant Functional Types (PFTs) with and without SMAP constraints using standalone model runs;

3. Conduct regional coupled WRF/SSiB and WRF/SSiB/TRIFFID model runs over North America with/without SMAP soil moisture as a constraint. The soil moisture and gross primary productivity (GPP) coupling will be assessed, as well as the impact due to introducing these two data sets on the weather predictions, especially on flood and drought events.

In this project, we will test the hypotheses: (a) **Aboveground variability and trends in GPP are strongly correlated with soil moisture variability, particularly soil moisture extremes;** (b) **Variability through soil moisture and GPP coupling significantly controls weather feedbacks through controls over evapotranspiration, vegetation phenology, and surface energy balance;** and, (c) **a fully coupled biophysical/carbon/ecology/weather processes model will better reproduce the satellite-observed hydrology and carbon variability than a model with only specified vegetation conditions.**

This proposal aims to respond to this NASA announcement by ingestion of the SMAP satellite products to develop quantitative scientific knowledge and models to “enabling advances in the study of the water, carbon, and energy cycles, especially on those topics that deal with the intersections of these cycles” and “exploring the impact of soil moisture variability on weather and climate” (This NASA Announcement). The Decadal Survey (2007) has indicated that “variations in soil moisture affect the evolution of weather and climate over continental regions” and “soil moisture and its freeze-thaw state are also key determinants of the global carbon cycle.” This proposal responds to these scientific objectives by using the SMAP data to model these processes and to understand how perturbations in one cycle affect the rates of the other cycles.