HIGH RESOLUTION MAPPING OF SOIL MOISTURE WITH SMAP RADAR AND RADIOMETER IN SUPPORT OF NEW APPROACHES TO WATER CYCLE SCIENCE AND APPLICATIONS

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1. INTRODUCTION

The Soil Moisture Active and Passive (SMAP) mission is being developed by NASA for launch in early 2013. SMAP is one of four first-tier missions recommended by the U.S. National Research Council Committee on Earth Science and Applications from Space in 2007. SMAP builds on concept development and risk-reduction studies carried out for the earlier Hydros ESSP mission. The primary science objectives of SMAP are to enhance understanding of land surface controls on the water, energy and carbon cycles, and to determine their linkages. SMAP high-resolution soil moisture mapping additionally has practical applications in agriculture, human health, drought and flood decision support. In this paper we focus on the potential impact of SMAP data products on agriculture and human health decision support systems that are currently operational across Africa. We will describe the potential for enhanced services and discuss some of the challenges in making the transition from research to applications.

2. HIGH RESOLUTION SOIL MOISTURE MAPPING

The SMAP mission makes simultaneous active (radar) and passive (radiometer) measurements in the 1.26-1.43 GHz range (L-band) from a sun-synchronous low-earth orbit. Measurements will be obtained across a wide swath (1000 km) using conical scanning at a constant incidence angle (40°). The radar resolution varies from 1-3 km over the outer 70% of the swath to about 30 km near the center of the swath. The radiometer resolution is 40 km across the entire swath. The radiometer measurements will allow high-accuracy but coarse resolution (40 km) measurements. The radar measurements will add significantly higher resolution information. The radar is however very sensitive to surface roughness and vegetation structure. The combination of the two measurements allows optimal blending of the advantages of each instrument. SMAP will be able to provide 10 km blended radar-radiometer soil moisture data with 2 to 3 day refresh rate. Soil-vegetation freeze/thaw products in boreal latitudes will be provided at 3 km resolution with 1-2 day revisit.

3. WATER CYCLE AND NATURAL HAZARDS APPLICATIONS

The combined radar-radiometer SMAP retrievals of soil moisture will allow the scientific community to address some of the scientific challenges in water cycle science. Characterizing the water cycle in the climate system poses some grand challenges in understanding climate variability and climate change impacts. The SMAP 10 km soil moisture data product will be particularly valuable where water is often a limiting resource. In this paper we present the scientific and practical applications of SMAP-quality data to support water-related decision-support tools now currently implemented in Africa. In the presentation we draw case studies from the European Space Agency TIGER and United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) initiatives aimed at helping African

societies to use satellite measurements for water-related applications. In this context we focus on two major applications: 1) Agriculture and drought, and 2) human health.

3.1. Agriculture and Drought

Agricultural productivity decision support systems are used to forecast seasons-ahead crop harvest anomalies for both commerce and disaster relief preparedness. Agricultural droughts that affect dryland agriculture – the main agricultural practice in Africa - are the major concern of these decision support systems. So-called "agricultural drought" or "hydrological drought" can be established even without a deficit in precipitation (or "meteorological drought"). For this reason ecosystem services require direct monitoring of soil moisture rather than precipitation to assess ecosystem and agricultural productivity.

3.2. Human Health

There are two major human health hazards that are significantly influenced by soil moisture: 1) heat stress, and 2) some vector-borne diseases. Heat-induced casualties and reduced productivity occur with excessive exposure to persistent warm days. Anomalous degree-days (cumulative temperatures) are sensitive to antecedent soil moisture. Seasonal climate prediction models have been used to show that with realistic soil moisture initialization the heat wave forecast accuracies are significantly enhanced. The second major area in human health where soil moisture is a controlling factor is vector-borne diseases. This principally refers to viral and bacterial diseases that are transmitted through insects such as mosquitoes. Soil moisture has two principal influences on the mosquito life cycle: 1) humid conditions enhance mosquito flight activity and host-seeking behavior, and 2) moisture pools alter the abundance and type of aquatic habitats where the early stages of mosquito breeding takes place. Where there is high soil moisture there is an associated increase in biting rates (malaria varieties). The prediction of biting rates has higher skill when soil moisture rather than precipitation is the predictant. This is due to the fact that the cumulative effects of precipitation and evaporation, i.e. the formation of aquatic and local environments for breeding, is better reflected in soil moisture. Several studies shows that soil moisture explains 30%-60% of biting rate two-four weeks. Using precipitation data the explained variance is below 10%. Furthermore soil moisture also affects the survival rate of mosquito eggs.

3. RESEARCH TO APPLICATIONS: THE CASE OF SOIL MOISTURE REMOTE SENSING

In this paper we will present the mechanisms and partnerships necessary to transition soil moisture remote sensing data from the research arena to the practical natural hazards mitigation context. We will do so by introducing case studies of current and potentially enhanced applications. The upstream flow of measurement requirements and the downstream flow of measurements to decision support systems will be outlined. The challenges of developing working interfaces and the issue of timeliness of the data will be addressed.