Sri Lanka Journal of Food and Agriculture (2016)
Suthakar *et al*. 2(2): 45-49
ISSN 2424-6913
http://doi.org/10.4038/sljfa.v2i2.34

Short Communication

Estimation of large scale surface soil moisture using remote sensing approach

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Abstract: The surface soil moisture of three districts namely Bulandshar, Gazjiabad and Goutam Buddha Nagar of India was estimated using remote sensing approach during the Rabi season (October–March) in 2009 and 2010. The daily evapotranspiration (ET) at the satellite passing date was in between 0.0 and 6.7 mm/day in 2009 (CV=57%) and between 0.0 and 6.81 mm/day in 2010 (CV=39%) while the variations in the surface soil moisture map in the whole region developed from optical remote sensing using SEBAL were between 1.5% and 45.7% in 2009 (CV=40%) and between 8.5% and 33.4% in 2010 (CV=34%). Further improvement of the prediction model would help in decision making by farmers in agricultural operations.

Keywords: surface soil moisture, remote sensing approach, India

Introduction

Improved soil moisture management will help farmers to achieve food security through enhanced productivity (FAO, 2003). Many factors determine the availability of water in soil. Soil moisture must be at the desired level to satisfy the evapotranspiration in order to achieve better crop management. Different approaches have been used to estimate soil moisture using remote sensing (RS). The RS techniques have made progress in assessing spatial and temporal variations of soil moisture.

Soil moisture controls the surface energy balance and partitioning between infiltration and surface runoff. Many attempts have been reported to retrieve the soil moisture data from air-borne and space-borne multispectral measurements (Bastiaanssen, 1998). Evaporative fraction is estimated from the different fluxes derived from SEBAL, and then the surface soil moisture could be determined up to a certain depth (Mobin and Bastiaanssen, 2003).

Materials and Methods

The study area was located in the north-west part of Uttar Pradesh in India covering three districts namely Bulandshar, Gazjiabad and Goutam Buddha Nagar, covering a high potential area for agricultural production. Geographically it the sampling area extended between the latitude 28° 00’ 59.93” N to 28° 41’ 40.20” N and longitude 77°

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24’ 26.13” E to 78° 07’ 24.63” E (Figure 1). The terrain was almost flat. The soil was alluvial and tends to be a lighter-textured loam with some occurrences of sandy soil. The climate was predominantly subtropical but weather conditions changed significantly with location and season. The MODIS satellite data 09A1, 11A1, 13A1, 43B3 and Aerosol Optical Density for consequent pre-winter season 2009 and 2010 were retrieved.

Figure 1. Study area districts in Uttar Pradesh, India

Ground-truthing was done during pre-sowing period of *Rabi* (October-March) in 2009 and 2010 for *in-situ* soil moisture measurements synchronizing with the satellite passing over agricultural bare fields. In SEBAL, all energy balance fluxes were estimated. The instantaneous evaporative fraction was estimated from the estimated fluxes. An empirical relationship (Equation 1) was developed between fraction of soil moisture content and evaporative fraction by Bastiaanssen *et al.* (1998);

$$VMC = EXP(\Lambda - a)/b \qquad \text{(dimensionless)} \qquad \text{(Equation 1)}$$

where, VMC = fraction of volumetric moisture content (dimensionless), Λ = evaporative fraction (dimensionless), and ‘a’ and ‘b’ are coefficients. Instantaneous evaporative fraction determination was usually done using sensible heat flux and latent heat flux. The instantaneous evaporative fraction was approximately equal to the daily evaporative fraction (Saha, 2004). Daily evapotranspiration was estimated from evaporative fraction and daily net radiation. In both years, this value was in pre-sowing period.

Results and Discussion

The daily evapotranspiration (ET) at the satellite passing date is in between 0.0 and 6.7 mm/day in 2009 (CV = 57%, Figure 2) and between 0.0 and 6.81 mm/day in 2010 (CV=39%; Figure 2). In 2009, nearly 50% of area ET was between 5 and 6 mm/day, with only 2% of area having an ET below 5 mm/day. In the case of 2010, approximately 35% of the area ET was in between 5 and 6 mm/day, while about 22% of the area was below 5 mm/day. In both years, a similar equal trend was observed in ET.

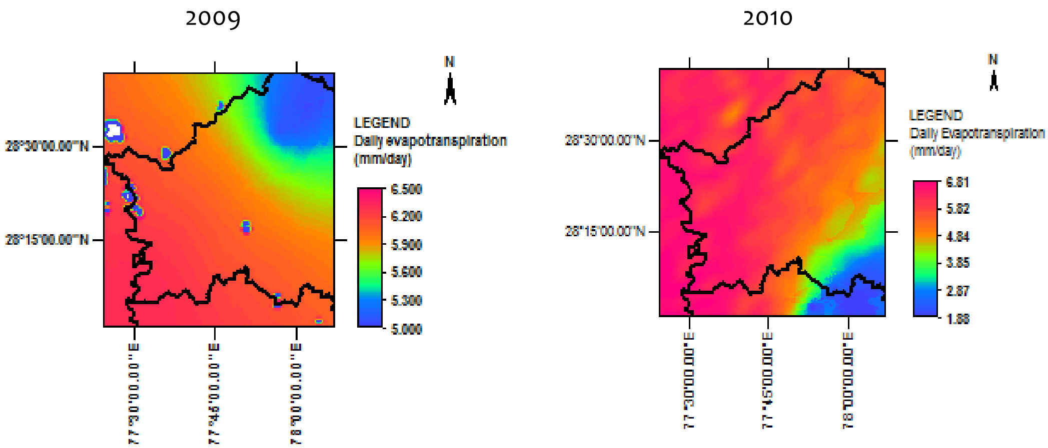

Figure 2. Daily evapotranspiration in mm/day

The relationship between evaporative fraction and fraction of volumetric soil moisture content was developed by Mobin and Bastiaanssen (2003) for different locations globally. The gravimetric moisture content percentage was between 1.5% and 45.7% (CV=40%; Figure 3), in 2009 and between 8.5% and 33.4 % in 2010 (CV=34%; Figure 3). From 2009 data validation, coefficients derived were a=0.869 and b=0.625. The same 2009 coefficients were used to estimate the moisture content of 2010, and validated through ground truthing. The validation process revealed that R^2=77% (Figure 4) and RMSE=0.07 (g/g). Therefore, the coefficients could be used for this region to estimate the surface soil moisture content from evaporative fraction.

The variations in the surface soil moisture map in the whole region developed from optical remote sensing using SEBAL were between 1.5% and 45.7% in 2009 (CV=40%) and between 8.5% and 33.4% in 2010 (CV=34%). The high variability in surface soil moisture in this region was due to that the farmers' fields in the study area were in different stages of seedbed preparation for growing *Rabi* crops. Further improvement of prediction model can be attempted using moderate and high resolution data for timely decision-making on sowing and other crop establishment practices.

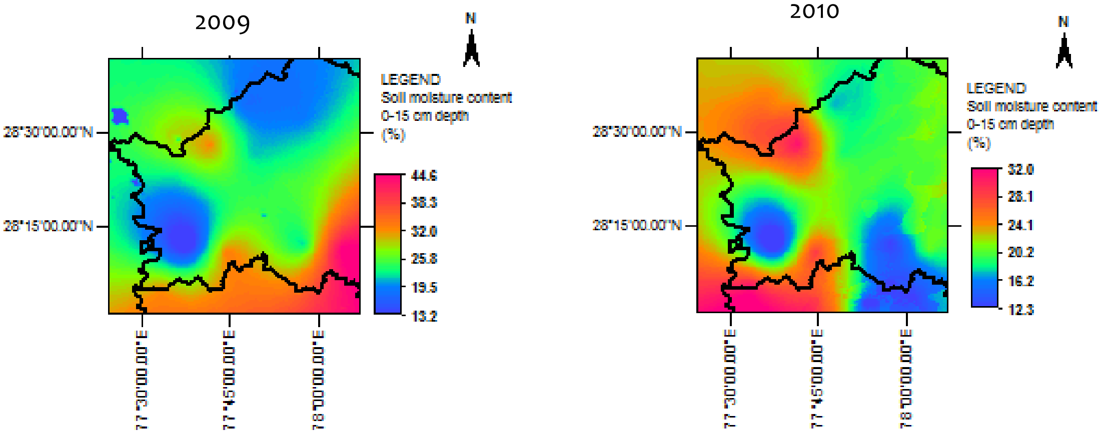

Figure 3. Surface soil moisture (%)

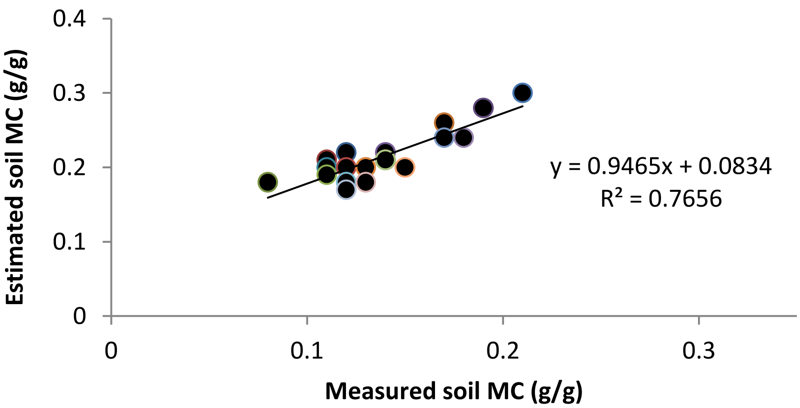

Figure 4. Validation of surface soil moisture content with derived moisture content from MODIS

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