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Estimation of near-surface soil moisture based on MODIS data over Taklamakan's Oases – China

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Soil moisture is the most important factor that shapes the biotic and aboitic properties of the soil. Crop yielding is more often determined by the availability of soil moisture rather than deficiency of other nutrients. Hence, soil moisture management is imperative for sustainable food production and water supply; it also controls the response and feedback mechanisms between land surface and atmospheric processes and has been widely recognized in numerous environmental studies. However, spatially and temporally limited in-situ field observations are not appropriate to describe spatial variations of soil moisture over large areas. Consequently, there is a great need for satellite remote sensing to estimate and monitor the spatial and temporal variations of soil moisture.

Recent advances in remote sensing have shown that soil moisture can be estimated by a variety of methods using visible bands (VIS), thermal infrared (TIR) and microwave imaging systems. Particularly optical remote sensing provides fine to moderate spatial resolution for near surface soil moisture estimation. In that context, MODIS data are a well-suited source for soil moisture estimation on a moderate-scale of spatial domain.

The main objective of this work is to estimate the near-surface soil moisture (the "surface wetness") of some oases located in Taklamakan Desert (Xinjiang Uygur Autonomous Region, Northwest China) using MODIS data in combination with in-situ (field) observations. The Taklamakan Desert encloses many oases of different sizes, where key oases (watered by rainfall and irrigation) are Awati, Kuqa, and Turpan in the north, Milan, Ruoqiang, Waxxari, Qiemo, Minfeng, Yutian and Hotan in the south, and Shache in the west.

This study uses the triangular (or trapezoid) method based on land surface temperature and vegetation index (Ts/VI) feature space. For the period 28 July to 29 August 2010, Ts and VI were derived from MODIS (day/night) land surface temperature (MOD11A2- 8 days) and NDVI (MOD13A1- 16 days). Firstly, we scaled NDVI data and calculated the fractional vegetation cover (fr) to avoid the great spatial heterogeneity due to large differences of surface energy exchange between bare soil and vegetation. Next, we gap-filled Ts no-data pixels using the Delaunay triangulation surface fitting. Secondly, we normalized Ts and adjusted its temporal resolution to be compatible with the NDVI data (16 days). Thirdly, we inspected the Ts/VI feature space to obtain the minimum and maximum values of NDVI and Ts, respectively. Finally, we estimated the near-surface soil moisture by the calculation of TVDI (Temperature Vegetation Dryness Index) for DOYs 209-225 (28.07-12.08.2010); 225-241 (13.08-28.08.2010); and 241-257 (29.08-14.09.2010).

Validation of the results produced from this study was performed using in situ observations of soil moisture at 0.025 m depth, obtained from three oases, namely Milan, Kuqa, and Sache. By knowing the upper (θmax, at field capacity) and lower (θmin, wilting point) limits of surface volumetric soil moisture, the TVDI index at any given time could be converted to an absolute value of volumetric surface soil moisture (θv).