SURFACE SOIL MOISTURE ESTIMATION FROM SEVIRI DATA ONBOARD MSG SATELLITE

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Surface soil moisture is an important component controlling surface energy partition and water vapor flux at the land surface/atmosphere interface. It is also one of the crucial parameters in hydrological process in the land surface. Consequently, accurate estimation of soil moisture is very useful in weather forecast modeling, climate modeling and global change study.

Monitoring soil moisture content from remote sensing technique using optical data dates back to 1970s, and it mainly relies on the magnitude of surface temperature change. It is a challenging problem due to the mutual interaction among soil, vegetation and atmosphere. Theoretically, soil moisture directly influences soil temperature by increasing the specific heat, thermal conductivity and thermal inertia of soils. Thermal inertia derived from the change of soil surface temperature between day and night has been found to be highly correlated with the surface soil moisture content. However, it is only applicable in the regions with no or little vegetation cover. Vegetation and land surface temperature are both dependent on soil moisture. To retrieve soil moisture under vegetation cover, the triangle method was proposed. Numerous studies have found that a scatter plot of remotely sensed surface temperature (Ts) and vegetation index (VI) often formed a triangular shape or a trapezoid shape if a full range of fractional vegetation cover and soil moisture contents exist in the study area [1], and soil moisture can be determined by analyzing the position of data distribution in surface temperature and vegetation index or fraction cover (Fr) space.

In this study, on the basis of the Ts-VI triangle method, an estimation of surface soil moisture from SEVIRI data onboard the Meteosat Second Generation (MSG) satellite is accomplished for the Iberian Peninsula region from July to August in 2006.

The MSG-SEVIRI sensor represents a new type of geostationary satellite with 12 channels and high temporal resolution (15 min interval). These characteristics enable it capturing the diurnal variation of land surface temperature accurately. From model simulation, Wetzel et al. [2] found that the land surface temperature increased linearly in the mid-morning and the slope of the rise of land surface temperature in that period was closely correlated with soil moisture content. Later, Wetzel and Woodward [3] used the slope of temperature change in the morning to estimate soil moisture from GOES-VIISSR infrared data and found that the soil wetness could be well distinguished and high morning rise in surface temperature corresponded to low soil water content and vice versa.. Stisen et al [4] also concluded that the morning rise in surface temperature was a strong proxy for total daytime sensible heat flux, In order to improve soil moisture estimation with Ts-VI triangle method, the mid-morning rising rate (RT) of surface temperature is studied in this work.

Firstly, cloud-free area should be extracted to get rid of cloud influence. In clear day, the optical spectral radiance observed at the satellite exhibits sinusoidal/cosine variation with time. However, for cloudy or partly cloudy conditions, the radiance increases greatly due to the high reflectance of cloud and the time variation of spectral radiance has a zigzag shape (Fig.1). Consequently, according to both the time variation shape and the magnitude of the optical spectral radiance, daytime cloud-free data/area can be selected.

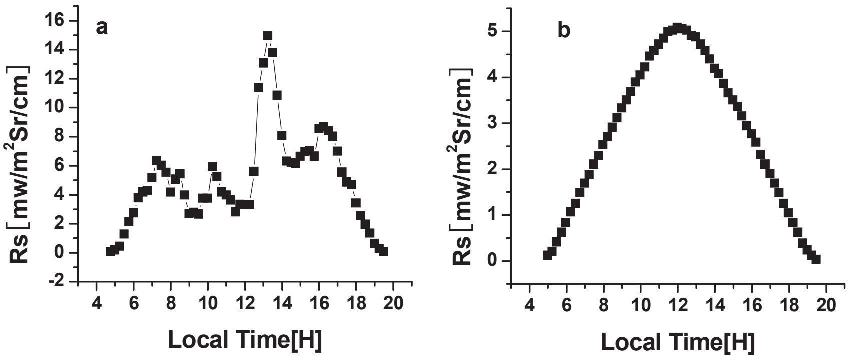

Fig. 1. MSG-SEVIRI channel 1 daytime shortwave spectral radiance under cloudy (a) and clear sky (b) conditions.

Then the RT in function of the normalized difference vegetation index (NDVI) is displayed in Fig.2. In this RT-NDVI space, the highest RT (RTmax) along the dry edge represents the driest surface soil conditions, while the wettest soil conditions correspond to the wet edge. Under the assumption that soil moisture availability varies linearly from the dry edge to the wet edge. A soil wetness index (RSWI) is defined as:

$$RSWI = \frac{RT_{\max(i)} - RT_{(i)}}{RT_{\max(i)} - RT_{\min}}$$

where RT(i) is the mid-morning rising rate of surface temperature for pixel *i*, RT_{min} is the minimum RT in the triangle that defines the wet edge, $RT_{max(i)}$ is the maximum RT for pixel *i* at $NDVI_i$.

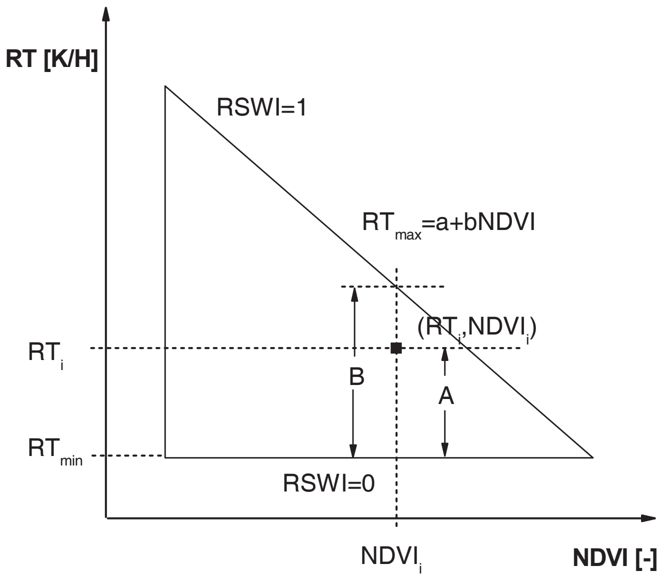

Fig. 2. Definition of the RSWI. For a given pixel i ($NDVI_i/RT_i$), RSWI is estimated to be the proportion between lines A and B

To validate the surface soil moisture derived from SEVIRI-MSG data, precipitation data of several sites have been downloaded from the European Climate Assessment and Dataset. The anticipant precipitation index (API) which indirectly implies soil moisture condition is calculated. Comparison between API and surface soil moisture estimated from SEVIRI data for two months shows that these two indices are highly correlated, and RSWI is suitable to retrieve regional surface soil moisture from SEVIRI-MSG data.

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[2] P.J. Wetzel, D. Atlas, and R.H. Woodward, “Determining Soil Moisture from Geosynchronous Satellite Infrared Data: A Feasibility Study,” *J. Appl. Meteor.*, vol. 23, pp. 375–391, 1984.

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