Spatial Mapping of Actual Evapotranspiration with MODIS products and Landsat TM data in the Songnen Plain during the growing season

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Spatial knowledge of land surface evapotranspiration is of prime interest for environmental applications, such as optimizing irrigation water use, irrigation system performance, crop water deficit, drought mitigation strategies and accurate initialization of climate prediction models especially in arid and semiarid catchments where water shortage is a critical problem. According to some research, water productivity and irrigation performance in the Songnen Plain in Northeast China is grossly under-performing and a major reason for increasing ecological problems in the region. Yet, this generalized statement is based upon inconsistent and unreliable data provided by different administrations or research organizations. Remote sensing may help filling this gap by improving the understanding and assessment of the water using efficiency and productivity at different spatial scales and may contribute to better-informed decision-making of water resources management. Especially performance indicators based on an accurate estimation of the actual amount of water consumption for different land use types derived from remote sensing data have been found useful to assess the major principles of irrigation management, adequacy, equity, reliability, productivity, and sustainability.

This study aims to investigate the evapotranspiration (ET) characterization in the Songnen Plain which represents one agricultural commodity grain base for the country suffering from the water scarcity and inconsistency of data for strategic and operational water management. As a consequence, the area is characterized by advancing soil degradation and salinity, owing to overgrazing, improper agricultural practice and water table decreasing problem. The specific objectives of this study were (i) to quantify evapotranspiration over different ecosystem in the Songnen Plain (ii) to compare the ET mapping accuracy with both MODIS products and Landsat TM data over different complex, and (iii) to explain ET mapping for the potential water management within the Songnen Plain. To achieve these objectives, the relative ET, revealing the adequacy of water distribution, have been addressed with both satellite acquired imagery data and ground based climate data. The present study focused on the regional scale and combined land use/cover and actual evapotranspiration (ETact) derived from MODIS and Landsata TM remote sensing records.

The Songnen Plain located in the central part of Northeast China, between 121°38′—127°30′ E and 43°59′—48°18′N, and situated on a transitional belt between the agricultural region and the pastoral region, with an area of about 192, 897 km2 . Its elevation is between 110 and 350 m. The study area is characterized by a temperate, semi-humid and semi-arid continental monsoon climate. Seasons alternate between dry and windy springs, humid and warm summers with intensive rainfall, windy and dry autumns and long, cold dry winters. Air temperature spatially increases from north to south with a mean annual value of 2-6℃. Precipitation varies greatly within and between years of which eighty percent of total precipitation occurs between the middle of June to mid-August. Precipitation decreases from

520-640 mm in the east to 350-420 mm in the west. Evaporation increases from 700-900 mm in the east to 900-1100 mm in the west. Land use practices have significantly changed and modified the original land cover in past decades and the main annual crops are maize, rice, and soybean.

MODIS remote sensing data products distributed by the NASA (http://redhook.gsfc.nasa.gov/ ~imswww/pub/imswelcome/) were utilized to model agricultural land use and ETact. Time series of 250 m normalized difference vegetation index (NDVI) derived from 8-day MODIS reflectance data facilitated to classify agricultural land use, in particular corn, soybean, rice, wetland, forest, grassland. Temporal NDVI signatures showed patterns of vegetation cover and greenness of vegetation throughout the season and therefore disclosed crop phonological trend.

The Surface Energy Balance Algorithm for Land (SEBAL, Bastiaanssen et al., 1998) allowed for modelling ETact solving the surface energy balance:

$$\lambda ET = R_n - G - H \tag{1}$$

which enabled calculating latent heat flux (λET) by subtracting ground heat flux (G) and sensible heat flux (H) from the available energy (net radiation, Rn). It was successfully applied on MODIS and Landsat TM overpass thermal data to model seasonal ETact of the growing period (April 20th to Oct 20th) of 2001. Monthly and seasonal ETact resulted from linear interpolation of the relationship between ETact and reference ET which was calculated with Penman-Monteith suggested by FAO 56.

In this research, the ET estimation results were compared between MODIS products and Landsat TM imagery based SEBAL model on the overpass time of August 11th, 2001. Our result indicated that: (1) the ET value over the Songnen Plain during the growing season is about 130~1200mm; (2) there is an obvious variable spatial pattern of the ET over the study area, it decreased gradually from northeast to southwest, and this pattern is inverse to the reference ET calculated with ground measured meteorological data using Penman-Monteith equations; (3) our result also showed that ET estimation derived from MODIS products is a little bit lower than that from Landsat TM with an average value of 0.4mm/d for the whole region, and（4）compared with ET mapping result derived from MODIS products, result based on TM tend to underestimate ET over water body, grassland and salinity affected land (barren or semi-barren land), however, it tend to overestimate ET over forest, wetland and cropland. This is only a gross result, much work still need to be carried out to the refine the result, and efforts also need to be done to validate the result with ET derived from eddy flux measurement, and finally sort out which imagery data source is more reliable for ET estimation and what is the suitable scale for various satellite imagery data source to carry out ET mapping with remotely sensed data.

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