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High resolution surface radiation products for studies of regional energy, hydrologic and ecological processes over Heihe river basin, northwest China

Guanghui Huang[a,b,*], Xin Li[a,c], Mingguo Ma[d], Hongyi Li[a,b], Chunlin Huang[a,e]

[a] Key Laboratory of Remote Sensing of Gansu Province, CAREERI, CAS, Lanzhou 730000, China
[b] Cold and Arid Regions Remote Sensing Observation System Experimental Station, CAREERI, CAS, Lanzhou 730000, China
[c] CAS Center for Excellence in Tibetan Plateau Earth Sciences, Chinese Academy of Sciences, China
[d] Southwest University, No.2, Tiansheng Road, BeiBei District, Chongqing 400715, China
[e] Jiangsu Center for Collaborative Innovation in Geographical Information Resource Development and Application, Nanjing 210023, China

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ABSTRACT

This paper presents a framework to obtain high spatial resolution regional surface photosynthetically active radiation (PAR), solar radiation (SSR) and net radiation (NR) products through combining Geostationary Meteorological Satellite (GMS) data, polar-orbiting satellite Moderate Resolution Imaging Spectrometer (MODIS) products and ground meteorological sites' observations. Huang et al. (2011) approach was adopted and improved to directly retrieve instantaneous PAR and SSR from GMS data; while for NR the relationship between net radiation and net solar radiation was analyzed and calibrated using ground observations and Normalized Difference Vegetation Index (NDVI). Then these instantaneous estimates with temporal resolution of half hour would be averaged or integrated to acquire hourly and daytime accumulated PAR, SSR and NR. Taking Heihe river basin in northwest China, a typical oasis-desert area, as an example, the methodology was applied to produce year 2012 PAR, SSR and NR products. Ground measurements from Watershed Allied Telemetry Experimental Research (WATER, Li et al. (2009)) and Heihe Watershed Allied Telemetry Experimental Research (HiWATER, Li et al. (2013)) were used to perform the accuracy assessments. The results indicate highly reliable products at 1 km resolution have been produced over this basin, and are applicable to the researches of the regional surface energy, hydrological and ecological processes.

1. Introduction

Surface radiation budget (SRB) serves as a key driving force for many physical and biological processes such as evapotranspiration, photosynthesis, and heating of surface soil and air, and thus strongly affects land-atmosphere interaction, agricultural production, even the general atmospheric circulation pattern and the development of the planetary boundary-layer. Therefore, SRB and its components always are required by various applications including weather forecasting, climate monitoring and modelling, water resource planning and managing, as well as agricultural meteorology.

Currently, there are already some global and regional surface radiation data sets routinely produced and provided by different scientific groups and organizations. Famous ones include radiative flux profile data set provided by International Satellite Cloud Climatology Project (ISCCP-FD), surface and top-of-atmosphere (TOA) shortwave and longwave radiative fluxes produced by Global Energy and Water Exchanges Project (GEWEX-SRB), Clouds and the Earth's Radiant Energy System (CERES) TOA and surface fluxes data, and Global Land Surface Satellite (GLASS) shortwave radiation products (Huang et al., 2013; Liang et al., 2013; Wielicki et al., 1996; Zhang et al., 2013, 2004, 2006). However, the coarse spatial and temporal resolutions prevent these data sets from being further used in various complicated ecological, meteorological and hydrological researches and applications on watershed and even regional scales. Therefore, in this paper we present a framework of computing high resolutions surface photosynthetically active radiation (PAR), solar radiation (SSR) and net

* Corresponding author at: Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, 730000, China.
E-mail address: luckhgh@lzb.ac.cn (G. Huang).

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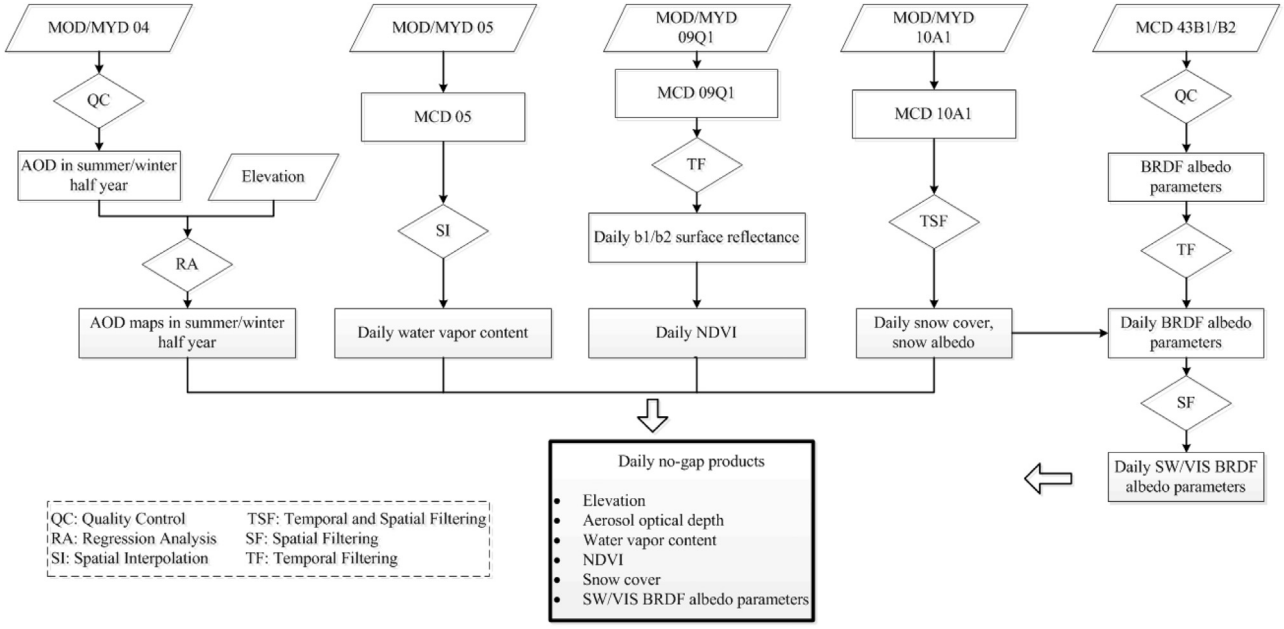

Fig. 1. Simplified flowchart of preparing surface and atmospheric state parameters required for estimating surface PAR, SSR and NR.

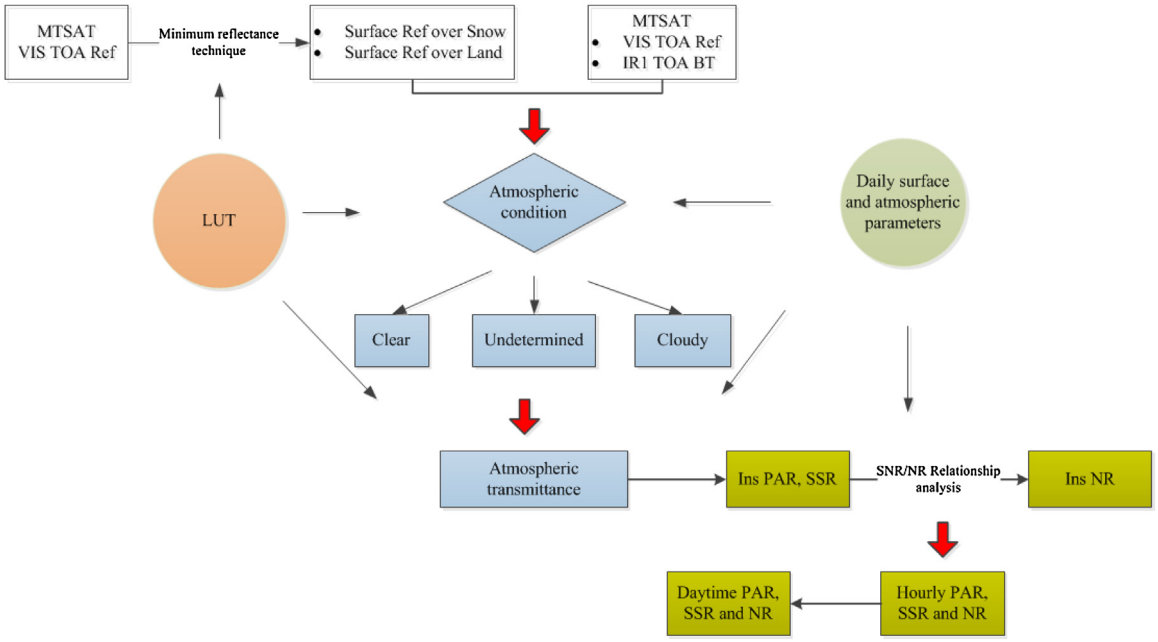

Fig. 2. Framework of estimating surface PAR, SSR and NR (instantaneous, hourly and daytime accumulated).

radiation (NR) and adopt it to produce the three main SRB component products in Heihe river basin, northwest China.

As primary SRB components, surface PAR and SSR had been explored and summarized in countless literatures, and many different types of approaches had been proposed from conventional meteorological parameterizations to retrieving algorithms based on satellite data (Deneke et al., 2008; Grant et al., 2004; Li et al., 2007; Liang et al., 2006; Liu et al., 2008; Lu et al., 2010; Pinker et al., 2007; Qin et al., 2011; Trnka et al., 2005; Yang and Koike, 2005; Zhang et al., 2006; Zheng et al., 2008). Due to being able to get rid of dependence on surface measurements, relatively complete spatial coverage and constantly appearances of new sophisticated satellite sensors, satellite remote sensing technique is playing a more important role in recent researches. A more detailed discussion on retrievals of PAR and SSR using satellite data had been summarized and given in our previous paper (Huang et al., 2011). Meanwhile, our previous research also demonstrated that considerable accuracy SSR could be estimated using the quantitative remote sensing technique by the synergy of geostationary meteorological satellite and polar-orbiting satellite over China. Therefore, in this study we still adopted the similar approach to estimate surface PAR and SSR, but some improvements had been imported to further polish the algorithm.

However, for the estimation of surface NR it is still very challengeable to only rely on satellite data, because not all of the components of SRB can be retrieved by satellite remote sensing technique. Conversely, the upward and downward longwave radiative fluxes are very difficult to accurately obtain from TOA

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