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Research Progress on Quantitative Inversion of Evapotranspiration based on Remote Sensing Technology

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Abstract

Evapotranspiration (ET) is the link between water circulation and energy exchange in the hydrosphere, atmosphere and biosphere. At the global scale, ET accounts for about 60% of the total land precipitation. With the development of flux observation technology, the global long-term continuous observation data can be acquired and shared, and the remote sensing inversion method of ET based on remote sensing technology has made good progress in recent years. In this paper, the existing research progress of remote sensing inversion method for ET is sorted out, summarized, and concluded from the aspects of domestic and international research progress, technical challenges and solutions, application areas, and future development trends. In the future, it is still necessary to carry out research on remote sensing ET inversion methods with high spatial and temporal resolution, effectively consider important information such as surface temperature and soil moisture that can indicate short-term changes in surface ET, and at the same time, strengthen the combination of process-driven physical models and data-driven models, so that the two types of models can complement each other and give full play to each other, which will jointly promote the research level of remote sensing inversion of ET.

Keywords

Evapotranspiration; Remote Sensing; Quantitative Inversion; Flux Observation Technology.

1. Introduction

Surface evapotranspiration (ET) is a process in which surface water absorbs solar radiation energy and vaporizes it for transmission to the atmosphere [1], including evaporation of surface water [2] and transpiration of vegetation [3-4]. Studies have shown that more than 60% of the precipitation that reaches the earth's surface through condensation is vaporized into the atmospheric water vapor through surface moisture and vegetation transpiration, and this proportion can be as high as 90% or more due to the lower precipitation and larger evapotranspiration in arid regions [5]. As the second largest component of the land surface water cycle after precipitation, evapotranspiration is the most difficult component of the water cycle to estimate [6]. With the development of satellite remote sensing technology, surface temperature, vegetation index, soil moisture and other surface parameters closely related to surface water heat fluxes can be obtained by remote sensing inversion, and remote sensing inversion of ET has become an effective method to obtain the temporal and spatial distributions of ET on the regional and global scales with high precision and high time. ET is a key link in the surface water cycle and energy exchange, which is of great significance to the understanding of

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climate change, water resource management, agricultural yield estimation and ecosystem health.

2. Basic Principles of Remote Sensing Inversion of ET

Evapotranspiration is the process by which surface water enters the atmosphere through evaporation and plant transpiration. Remote sensing inversion of ET is usually based on the principle of surface energy balance, through the measurement of surface temperature, vegetation index, short-wave radiation, long-wave radiation, soil moisture and other parameters, combined with the corresponding models and algorithms, to estimate the amount of ET.

3. Overview of Domestic and Overseas Research Progress

3.1. Overseas Progress

(1) Satellite product development Internationally, NASA and NOAA have developed several ET remote sensing products, such as MODIS (Moderate Resolution Imaging Spectroradiometer) and VIIRS (Visible Infrared Imaging Radiometer Suite) data. Imaging Radiometer Suite) data. These products are widely used in global and regional scale hydrological and ecological studies.

(2) Innovations in models and algorithms Internationally, researchers have developed a variety of empirical and process models to invert evapotranspiration, such as the SEBAL (Surface Energy Balance Algorithm for Land), SEBS (Surface Energy Balance System), and SEBI (Surface Energy Balance Index) models. Energy Balance Index) models. These models combine the principle of energy balance and remote sensing data to improve the accuracy of ET estimation.

(3) Data assimilation techniques Data assimilation techniques optimize ET estimation by combining observational data and model simulations. For example, using methods such as the ensemble Kalman filter, multi-source remote sensing data can be effectively integrated to improve the accuracy and reliability of ET estimation.

3.2. Domestic Progress

(1) Application of Remote Sensing Data Domestic researchers have utilized domestically produced satellite data, such as FY-3 (Fengyun-3) and GF-1 (Gaofen-1), to carry out remote sensing inversion studies of ET. These data have high spatial resolution and provide strong support for regional-scale ET studies.

(2) Model Localization Improvement In response to the complex topography and diverse climatic conditions in China, researchers in China have localized and improved the existing ET models to adapt to the hydrological and ecological characteristics of different regions.

(3) Development of Data-Driven Methods With the development of big data and machine learning technologies, Chinese researchers have begun to explore data-driven ET inversion methods. These methods improve the efficiency and accuracy of ET estimation by analyzing a large amount of remotely sensed data and ground observation data to build a prediction model.

4. Technical Challenges and Solutions

(1) Cloud Shading Problem Cloud shading is one of the main factors affecting the accuracy of remote sensing inversion of ET. Internationally, researchers have overcome this problem by developing cloud identification algorithms and utilizing microwave remote sensing data.

(2) Spatial resolution limitation Remote sensing data with high spatial resolution can help improve the accuracy of ET estimation, but the spatial resolution of existing data is often limited. This problem can be solved to some extent by data fusion techniques and spatial interpolation methods.

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(3) Time Scale Extension Remote sensing data are usually instantaneous or short time scales, while ET studies often require data on daily or monthly scales. Researchers convert instantaneous data to daily scale data through time scale extension methods, such as fixed evaporation fraction method and variable body resistance method.

5. Areas of Application

5.1. Water Resources Management

ET inversion techniques play an important role in water resources assessment and management, helping decision makers to understand the distribution and trends of water resources.

5.2. Agricultural Estimates

ET data are used to assess crop water demand and irrigation management, which is important for improving crop yields and water use efficiency.

5.3. Ecosystem Health

ET is one of the important indicators for assessing ecosystem health. By monitoring changes in ET, the water status and ecological processes of an ecosystem can be understood.

6. Future Trends

6.1. High-resolution Remote Sensing Data

With the progress of remote sensing technology, more high-resolution and high-frequency remote sensing data will be available for ET inversion in the future.

6.2. Intelligent Models

With the combination of artificial intelligence and machine learning technologies, future ET inversion models will be more intelligent and able to automatically adapt to different environmental conditions and data characteristics.

6.3. Multi-source Data Fusion

Multi-source data fusion technology will be further developed to integrate optical, microwave, radar and other remote sensing data to improve the accuracy and robustness of ET estimation. d. Global monitoring network The establishment of a global monitoring network will help to build a global monitoring network.

6.4. Global Monitoring Network

A global-scale ET monitoring network will be constructed to realize real-time monitoring and analysis of the global water cycle and energy exchange.

7. Conclusion

Remote sensing ET inversion technology has made remarkable progress at home and abroad, but still faces some technical challenges. In the future, with the development of remote sensing technology, data assimilation methods and intelligent models, the remote sensing inversion of ET will be more accurate and efficient, and provide strong support for global change research and resource management.

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