

Trends in Annual and Seasonal Pan Evaporation in the Lower Yellow River Basin from 1961 to 2010

JI Xing-Jie, WANG Ji-Jun, GU Wan-Long, ZHU Ye-Yu, LI Feng-Xiu

Henan Climate Center, Henan Meteorological Bureau, Zhengzhou 450003, China

Abstract

The annual and seasonal trends in pan evaporation in the lower Yellow River Basin based on quality-controlled data from 10 meteorological stations in 1961–2010 are analyzed. The causes for the changes in annual and seasonal pan evaporation are also discussed. The results suggest that, despite the 1.15°C increasing in annual mean surface air temperature over the past 50 years (0.23°C per decade), the annual pan evaporation has steadily declined by an average rate of –7.65 mm per year. By comparison, this change is greater than those previously reported in China. Significant decreasing trends in annual pan evaporation have been observed at almost all stations. As a whole, seasonal pan evaporation decreased significantly, especially in summer, whereas seasonal temperature increased significantly, except in summer. Thus, the pan evaporation paradox exists in the lower Yellow River Basin. The trend analysis of other meteorological factors indicates significant decrease in sunshine duration and wind speed, but no significant variations in precipitation and relative humidity at annual and seasonal time scales. By examining the relationship between precipitation and pan evaporation, it did not show a concurrent decrease in pan evaporation and increase in precipitation. The partial correlation analysis discovered that the primary cause of decrease in annual and seasonal pan evaporation is the decrease in wind speed. A further examination using a stepwise regression shows that decrease in wind speed and sunshine duration, and increase in mean temperature are likely to be the main meteorological factors affecting the annual and seasonal pan evaporation in the lower Yellow River Basin over the past 50 years.

Keywords: lower Yellow River Basin; pan evaporation; trend; meteorological factors

Citation: Ji, X.-J., J.-J. Wang, W.-L. Gu, et al., 2012: Trends in annual and seasonal pan evaporation in the lower Yellow River Basin from 1961 to 2010. *Adv. Clim. Change Res.*, **3**(4), doi: 10.3724/SP.J.1248.2012.00195.

1 Introduction

It is believed that an increase in pan evaporation is one of the expected consequences of global warming. However, many observations across the world presented a significant rise in temperature but a significant decline in pan evaporation, which is known as the pan evaporation paradox. With increasing concerns of global warming, trends in pan evaporation have been investigated across the world over different climate regions resulting in diverse conclusions,

which showed that decreasing and increasing trends in pan evaporation are coexisting. Increasing trends have been reported in Israel's central coastal plain [Cohen et al., 2002], northeast of Brazil [Vicente and Rodrigues, 2004], and the Liaohe Delta in Northeast China [Ji and Zhou, 2011]. However, Many observations showed that measured pan evaporation has decreased over the past several decades in many countries, such as the USA and the former Soviet Union [Peterson et al., 1995; Golubev et al., 2001], Australia [Roderick and Farquhar, 2004], Japan [Jun et al., 2004], Thailand

Received: 21 May 2012

Corresponding author: JI Xing-Jie, jixingjie2004@yahoo.com.cn

[Taichi *et al.*, 2005; Limjirakan and Limsakul, 2012], Canada [Burn and Hesch, 2007], India [Jhaharia *et al.*, 2009], Italy [Moonen *et al.*, 2002], New Zealand [Roderick and Farquhar, 2005], and China [Qiu *et al.*, 2003; Liu *et al.*, 2010; Liu *et al.*, 2011; Shen *et al.*, 2010; Yang and Yang, 2012]. These trends are opposite to the expectation that the global warming will be accompanied by an increase in terrestrial evaporation, which is hypothesized to be related to rising temperature [Fu *et al.*, 2009]. Paradoxically, the observed trends across the world have been steadily decreasing over the last half century [Limjirakan and Limsakul, 2012]. This contrary fact between expected and observed trends of pan evaporation is known as the pan evaporation paradox. Up to date, this puzzling phenomenon has drawn great attention of many scientists to identify what meteorological factors have caused the observed decreasing trends despite the increase in temperature [Roderick *et al.*, 2007; Cong *et al.*, 2009; McVicar *et al.*, 2012; Yang and Yang, 2012]. It has been reported that the decrease in observed pan evaporation is not determined only by temperature [Ohmura and Wild, 2002; Limjirakan and Limsakul, 2012]. Recent studies have demonstrated major potential causes of the decrease in pan evaporation, which included the widespread decrease in solar radiation and wind speed [Jhaharia *et al.*, 2009; Roderick *et al.*, 2007; Cong *et al.*, 2009; Liu *et al.*, 2010; Limjirakan and Limsakul, 2012; McVicar *et al.*, 2012]. It could be concluded that the magnitude of the trends in pan evaporation and the determining factors vary greatly in different regions. Therefore, an additional analysis of existing pan evaporation data in different regions especially small scale region is undoubtedly important to better understand the trends in pan evaporation under global warming.

The Yellow River is the second largest river in China, and of great significance to the economy of the region and the whole nation. The lower Yellow River Basin is surrounded by the North China Plain in the north and west, by hills in the south, and by the Shandong Peninsula in the east. The regional climate is highly dependent on the surrounding climate systems from both high and low latitudes, being regarded as part of the warm temperate zone with

semi-arid to semi-humid monsoon climate. The lower Yellow River turned into a hanging river due to the slowing of the streamflow and the depositing of sediment [Cao *et al.*, 2005]. Because of the changes in land-use and the warming climate, the runoff into the river has decreased [Yang *et al.*, 2000; Xu and Zhang, 2006]. Meanwhile, agricultural and industrial water consumption has more than doubled with the development of the economy and society. The streamflow has reduced so much that no-flow and nearly no-flow events occur frequently [Yang *et al.*, 2000; Xu and Zhang, 2006]. Water availability in the lower Yellow River Basin is one of the most important factors determining the crop productivity (e.g., winter wheat) and local hydrological cycle of the whole region. The lower Yellow River Basin, as part of the Yellow River water irrigation district, often suffered droughts during the past several decades which regularly devastated the agricultural activities. Pan evaporation is one of the most important climatic parameters in the hydrological cycle, and is often applied to estimate terrestrial evaporation and water requirements. Influenced by changes in environmental conditions, changes in pan evaporation are affecting the balances of water and energy budget. Changes in annual and seasonal pan evaporation are of great significance in water resource planning, in estimating crop water requirements for irrigation, and in forecasting agricultural production [Jhaharia *et al.*, 2009; Lowe *et al.*, 2009; Wang *et al.*, 2009]. The objectives of this study are to discover the trends in pan evaporation in the lower Yellow River Basin and to identify the meteorological factors (temperature, humidity, wind speed, sunshine duration, and precipitation) which may cause the changes in pan evaporation. This will help to better understand the responses of pan evaporation to climate change and to provide suitable water regulations.

2 Study area and methods

2.1 Study area

The study area is located in the lower Yellow River Basin (113°32'–119°03'E, 34°50'–37°56'N) in eastern China, which covers an area of approximately 23,000 km² and takes up about 3% of the whole Yellow

Download English Version:

<https://daneshyari.com/en/article/4673551>

Download Persian Version:

<https://daneshyari.com/article/4673551>

[Daneshyari.com](https://daneshyari.com)