Accuracy Assessment of the Evapotranspiration over the Tibetan Plateau Based on the REOF-3T Model for 2008-2018

Lu Li[1,2], Xiaohua Dong[1,2]*, Chong Wei[1,2], Huijuan Bo[1,2], Bob Su[4], Yaoming Ma[3]

[1] College of Hydraulic & Environmental Engineering, China Three Gorges University, Yichang 443002, China

[2] Engineering Research Center of Eco-environment in Three Gorges Reservoir Region, Ministry of Education, Yichang 443002, China

[3] Land-Atmosphere Interaction and its Climatic Effects Group, State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources (TPESER), Institute of Ti-betan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China

[4] Faculty of Geo-Information Science and Earth Observation, University of Twente, Enschede 7500 AE, The Netherlands

ABSTRACT

Accurate calculation of evapotranspiration at the basin scale can provide the information for dynamic analysis of the hydrological cycle within the basin. In this study, The Qinghai-Tibet Plateau (TP) , consisting of 12 watersheds, was used as the study area. The process of realization of the medium-scale evapotranspiration calculation by the REOF-3T model can be generalized as follows. Each watershed was divided into several subregions based on the analysis results of the rotated empirical orthogonal function (REOF) method for 10a downward shortwave radiation. Compared with the original 3T model, the simulated values of the improved 3T model are closer to the observed values over the TP sites, except NADORS station.

INTRODUCTION

The 3T model proposed by Qiu(Qiu et al., 1996a), having a small number of parameters and a profound physical foundation, is a two-source model. The 3T model comprises two consumptions. One is proposing a reference pixel for the canopy and soil pixel respectively, and the reference canopy and soil have no evapotranspiration. The other is the reference pixel shares the same dynamics resistance with the target pixel, which indicates the radiation and terrain of the reference pixel and target pixel are very approximate. Comparing with other ET method, the 3T model avoids complicated and cumbersome process to confirm the aerodynamic resistance.

METHODS

1. The REOF-3T model

1.1 Rotated empirical orthogonal function (REOF)

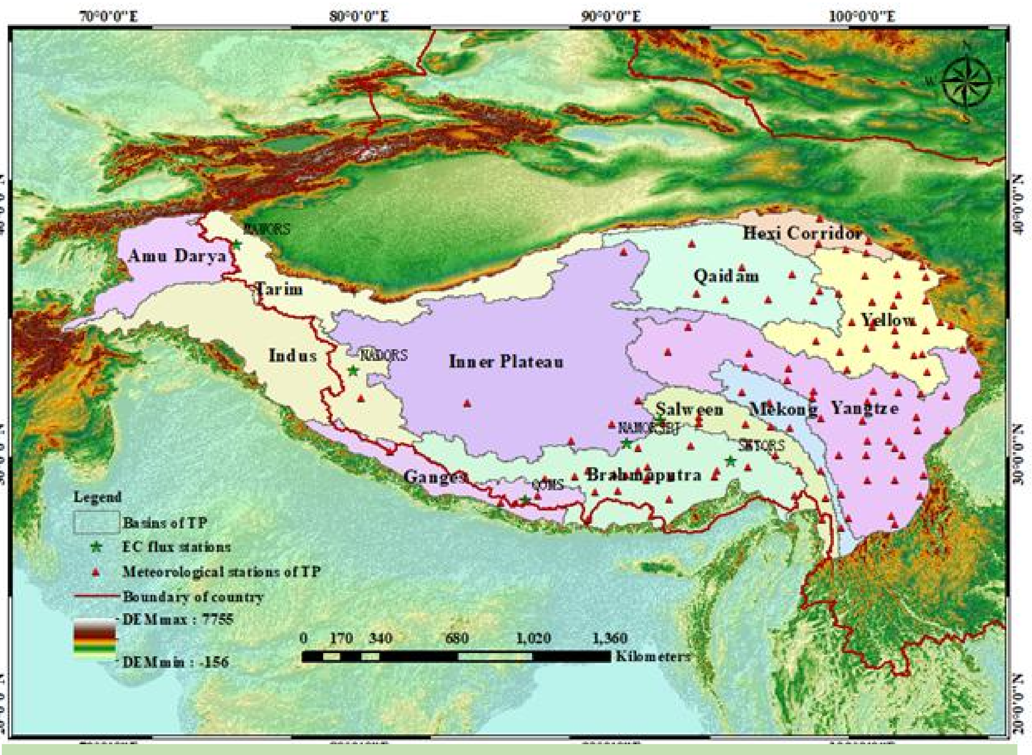

Figure 1 The location of the TP, the geographical distribution of EC flux towers and conventional meteorological stations.

1.2 the modified Three Temperature(3T) Model

1. The spatial pixels are divided into two categories by fractional vegetation cover (Fc).

$$Fc = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

2. the reference pixel selection for soil and canopy pixels

$$T_{sr} - Ta_{sr} = \max\{(T_{si} - Ta_i),(T_{smi} - Ta_i)\}$$

$$T_{cr} - Ta_{cr} = \max\{(T_{ci} - Ta_i),(T_{cmi} - Ta_i)\}$$

3. the ET in the mixed pixel is the sum of ET in bare soil and vegetation

$$LE_s = Rn - Gs - (Rn_{mr} - Gs_{mr})\frac{T_s - Ta}{T_{mr} - Ta_{mr}}, \text{mixed}$$

$$LE_c = Rn - Rn_{mr}\frac{T_c - Ta}{T_{mr} - Ta_{mr}}, \text{mixed}$$

$$LE_m = LE_s + LE_c, \text{mixed}$$

Highlights

The selection of reference points is complicated. The vegetation and soil parts are respectively retrieved from the mixed pixels.There is a big difference between the surface temperature of some vegetation in mixed pixel and that of pure vegetation pixel, and the same situation also appears in soil pixel.it is necessary to screen reference points not only for pure vegetation pixels and pure soil pixels, but also for mixed vegetation and soil pixels.

In this paper, it is considered that the maximum surface temperature should not be used as the sole basis for selecting reference pixels. Under the premise that the solar radiation is basically the same, the maximum difference between surface temperature and air temperature should be selected.

Forcing datasets

Variable	Resolution	Source
LST	1 km 8-day	MOD11A2
NDVI	1 km 8-day	MOD13A2
T_a R_{swd} R_{lwd}	0.1° daily	CMFD
sur_refl_b01-07	500 m daily	MOD09GA1
Day view time	500 m daily	MOD11A2
Emis_31/32	500 m daily	MOD11A2

Validation datasets

Variable	Resolution	Time period
EC observation	In-situ daily	2012-2018
EVP	In-situ daily	2010-2018
origion 3T	0.1° daily	2010-2018
MOD16A2	500 m 8-day	2000-2014
GLASS V42	1 km 8-day	2000-2016

REOF

Downlward radiadtion

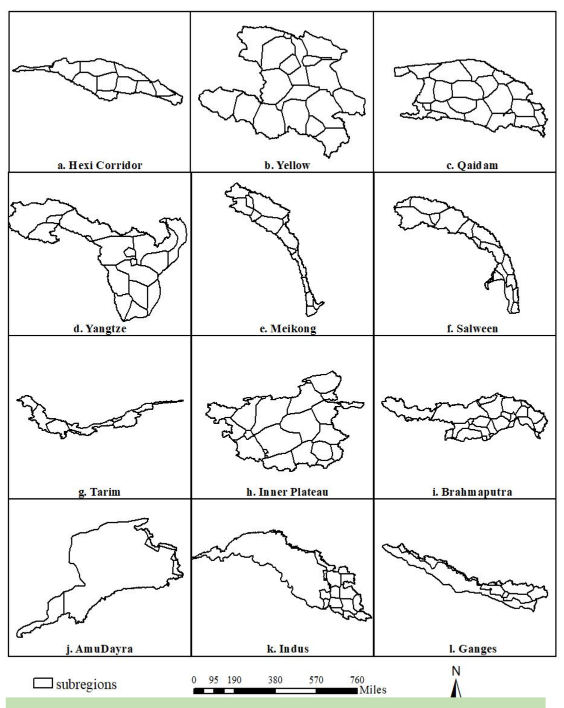

Figure 2. Subregions of each basin derived from the REOF method

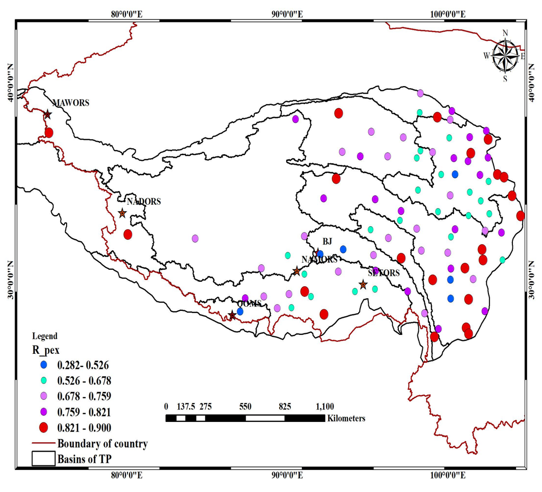

Figure 3. the average correlation coefficient of estimated ET (REOF-3T model) and the observed ET (water evaporation) in 93 conventianal stations from 2008 to 2018

RESULTS

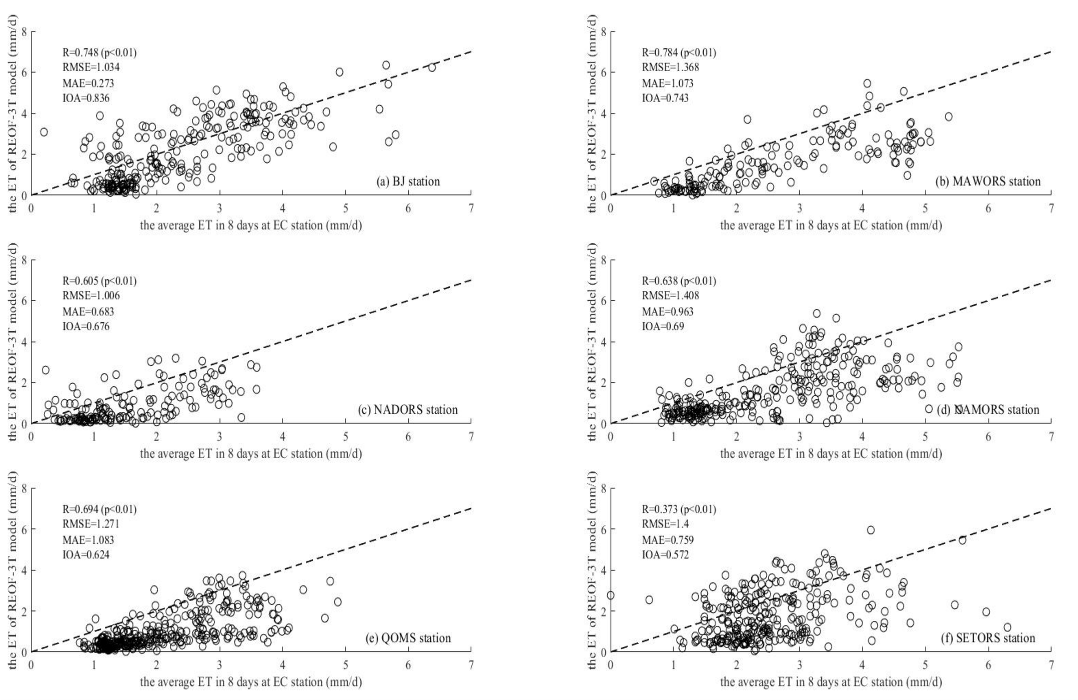

Figure 4. Comparison of the estimated (REOF-3T model) and the observed (EC tower) average ET in 8-days at six stations

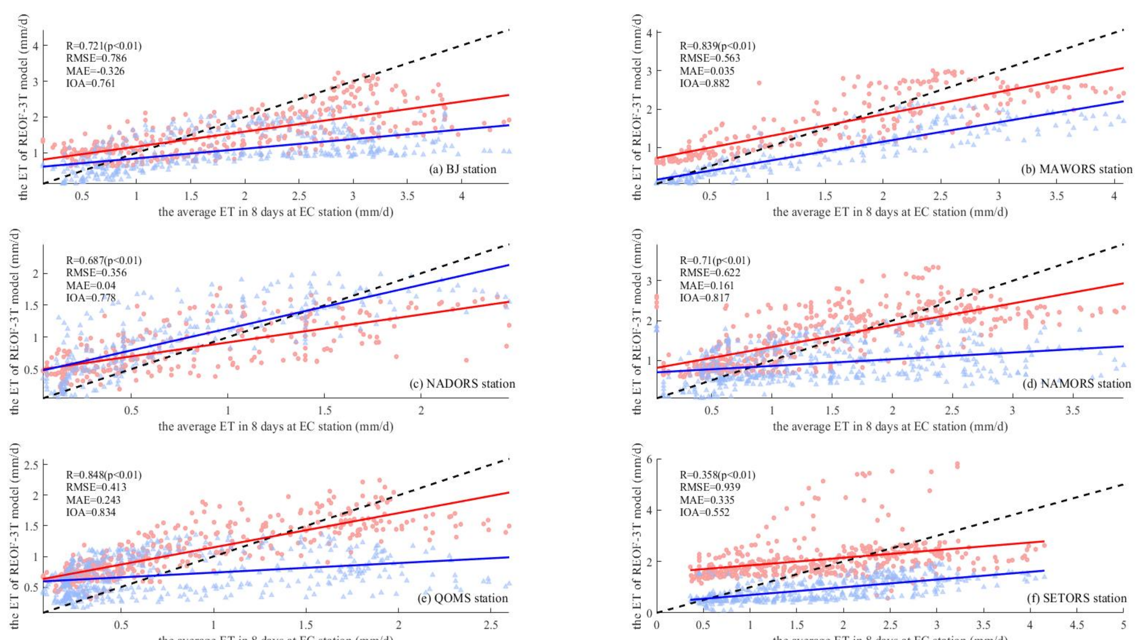

Figure 5. Comparison of the estimated (REOF-3T model) and the origional 3T model average ET in 8-days at six stations

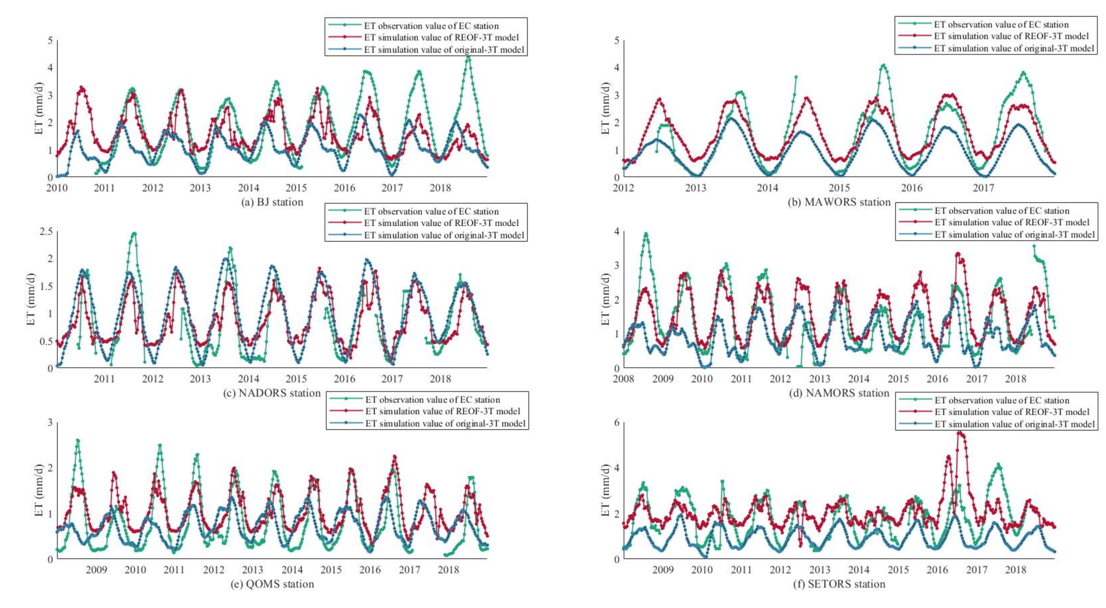

Figure 6. the comparison curve of REOF-3T model estimated, the original 3T estiated and EC observed average ET in 8 days at six stations

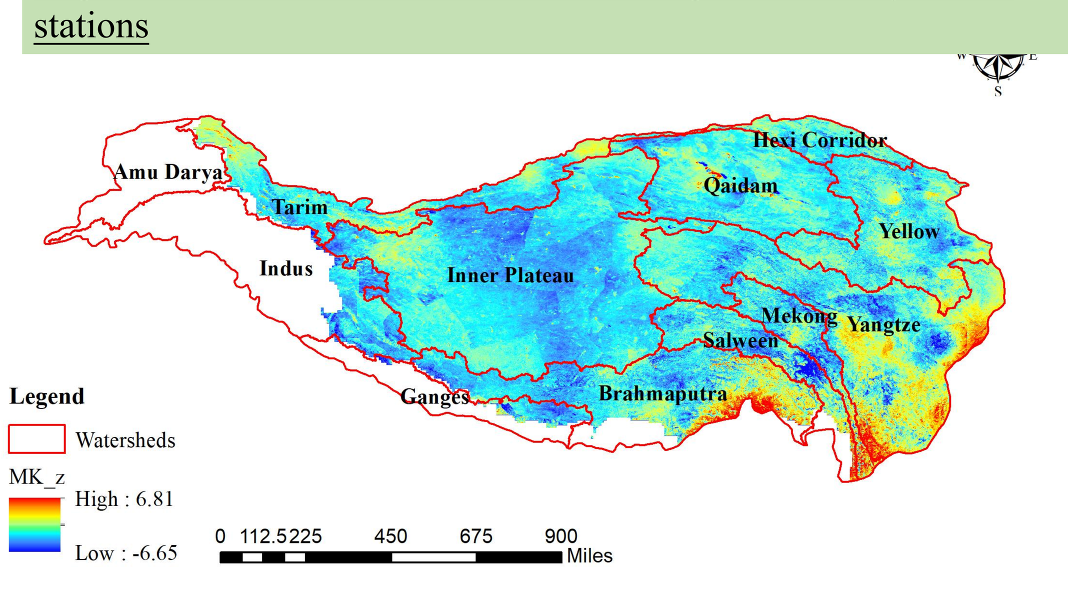

Figure 7. the MannKendall (MK) trends of monthly ET over the Qinghai-Tibet Plateau from 2008-2018

The REOF-3T estimated results and the observed average ET in 8-days at six stations from 2008-2018 were shown in Figure 3. In general, the paired ET values between the REOF-3T model and EC observations is on the right-hand side of the 1:1 line, which indicated that the REOF-3T model overestimated the ET in daily scale. The Pearson's correlation coefficient R mainly ranged from 0.61 to 0.78 (P<0.01),, except the SETORS station whose R lower than 0.6. The root-mean square error (RMSE) ranged from 1.006 mm/d to 1.408 mm/d.

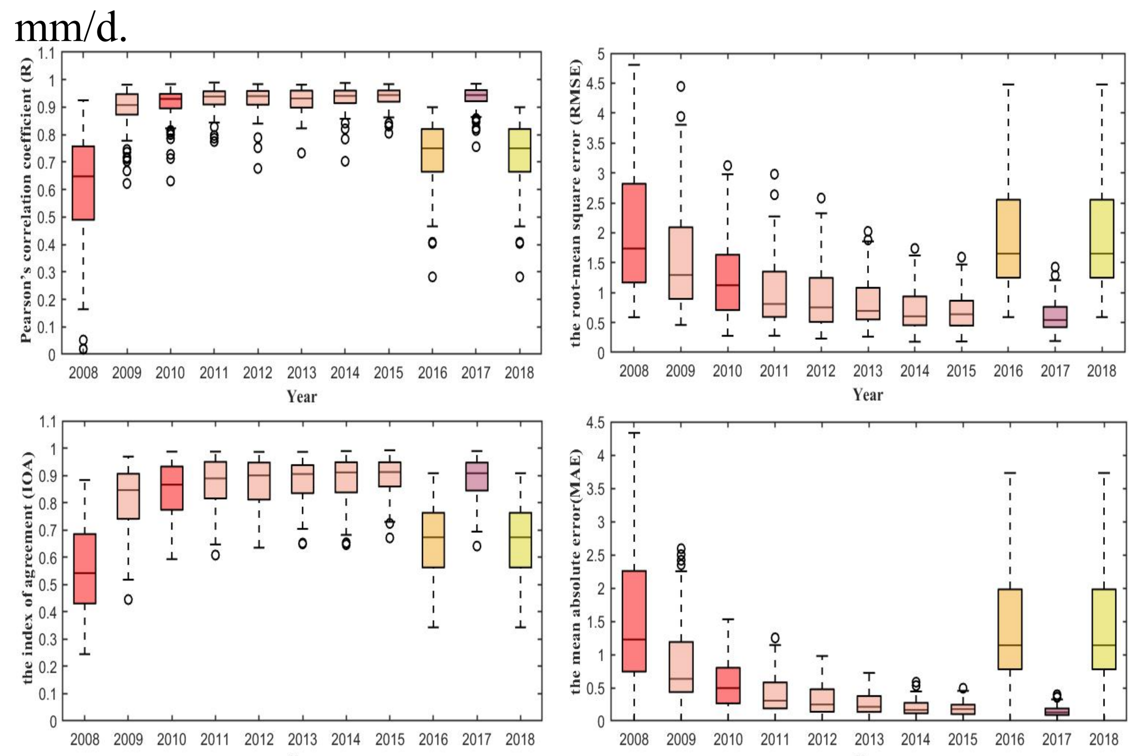

Figure 8. the R, RMSE, MAE, IOA of the estimated (REOF-3T model) and observed (water evaporation) ET in each year

Multi-year (2008-2018) average 8 day ET values for 93 meteorological stations were obtained with the REOF-3T model and compared to water evapotranspiration ET (ETw) data. Figure 5 shows the REOF-3T model performance in each year of the 93 meteorological stations in terms of RB, RMSE, MAE and IOA. The R values in nearly 70% stations exceeded 0.85. The simulated(REOF-3T) and observed water evaporation(ETw) values are very close within all years except 2008, 2016 and 2018.

CONCLUSIONS and DISCUSSION

- An evapotranspiration(ET) production of 8-Day 1km resolution over the TP during 2008 - 2018 is calculated in this study, which based on the REOF-3T model.
- To validate the accuracy of ET product, site observations and other remote sensing products were compared to the calculated ET series. The results showed that the REOF-3T model has a significant correlation with the average ET in 8 day of six eddy covariance flux stations over the TP.
- The estimated ET (REOF-3T model) also displayed a good consistency with the observed ET (water evaporation) in 93 meteorological stations during 2008 – 2018. More than 93% of sites have R-values over 0.6. The average annual R in 93 stations exceeded 0.9, except for 2008, 2016, and 2018.
- There is an increasing trend of ET in the southwestern of TP, especially in the upper Yangtze River basin. While the north and northwest are on a downward trend.

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三峡大学