A Penman Monteith-based model for the evaluation of daily remotely sensed evapotranspiration

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Objectives

Evapotranspiration (ET) is the main parameter for energy and water balance in land surface systems. Accurately assessing ET is foundation for climate change, water resource management , irrigation management and food production. However, available ET products cannot meet high spatial and temporal resolutions. For example, GLASS ET products have a temporal resolution of 8 days and a spatial resolution of 1km or 5km; MOD16 is an 8-day product with a spatial resolution of 1km.This study employs a FAO-PM formula-based inversion model to evaluation remotely sensed ET. The model combines FAO-PM formula, meteorological reanalysis data and high resolution Sentinel-2 emissivity data.

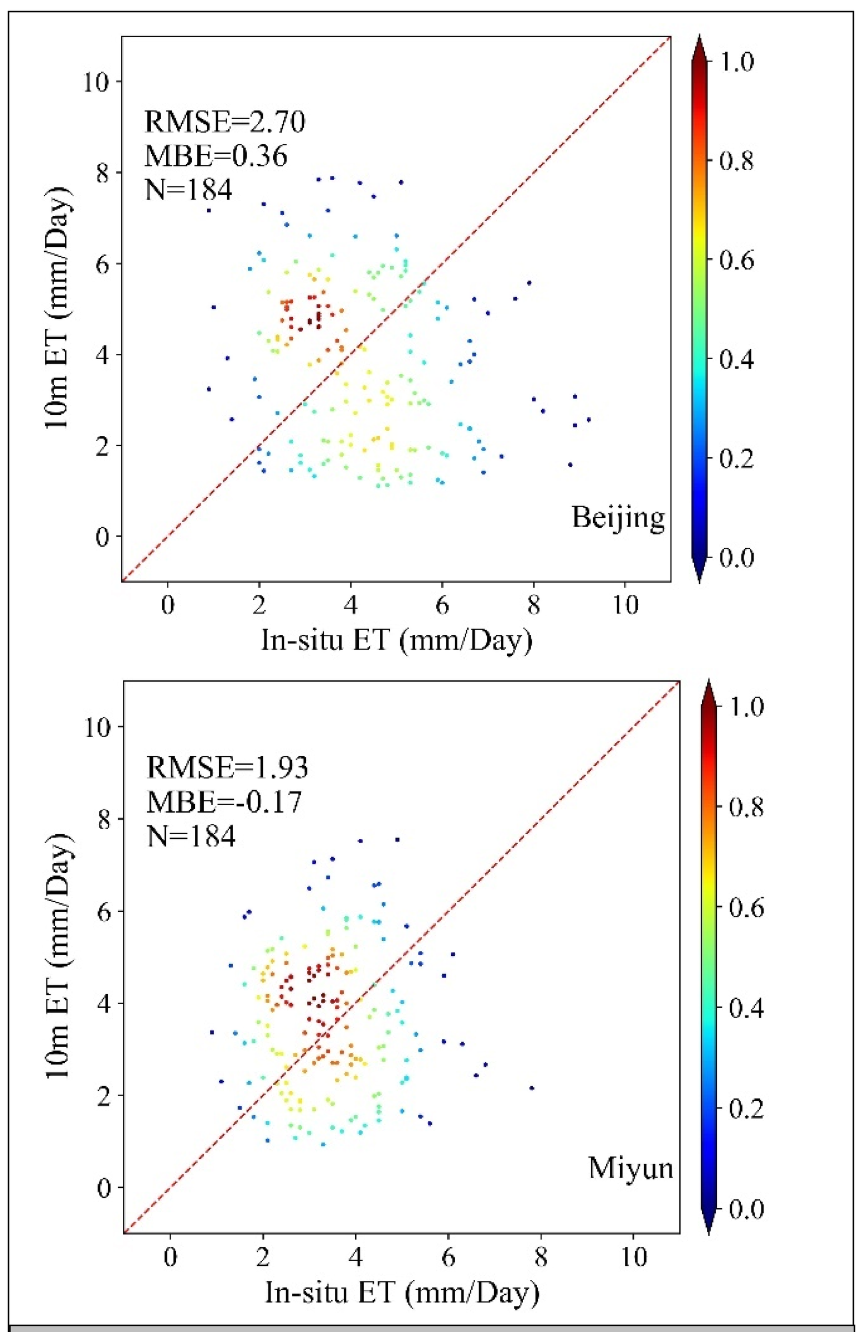

Fig1. Comparison between the model 10m ET and actual ET

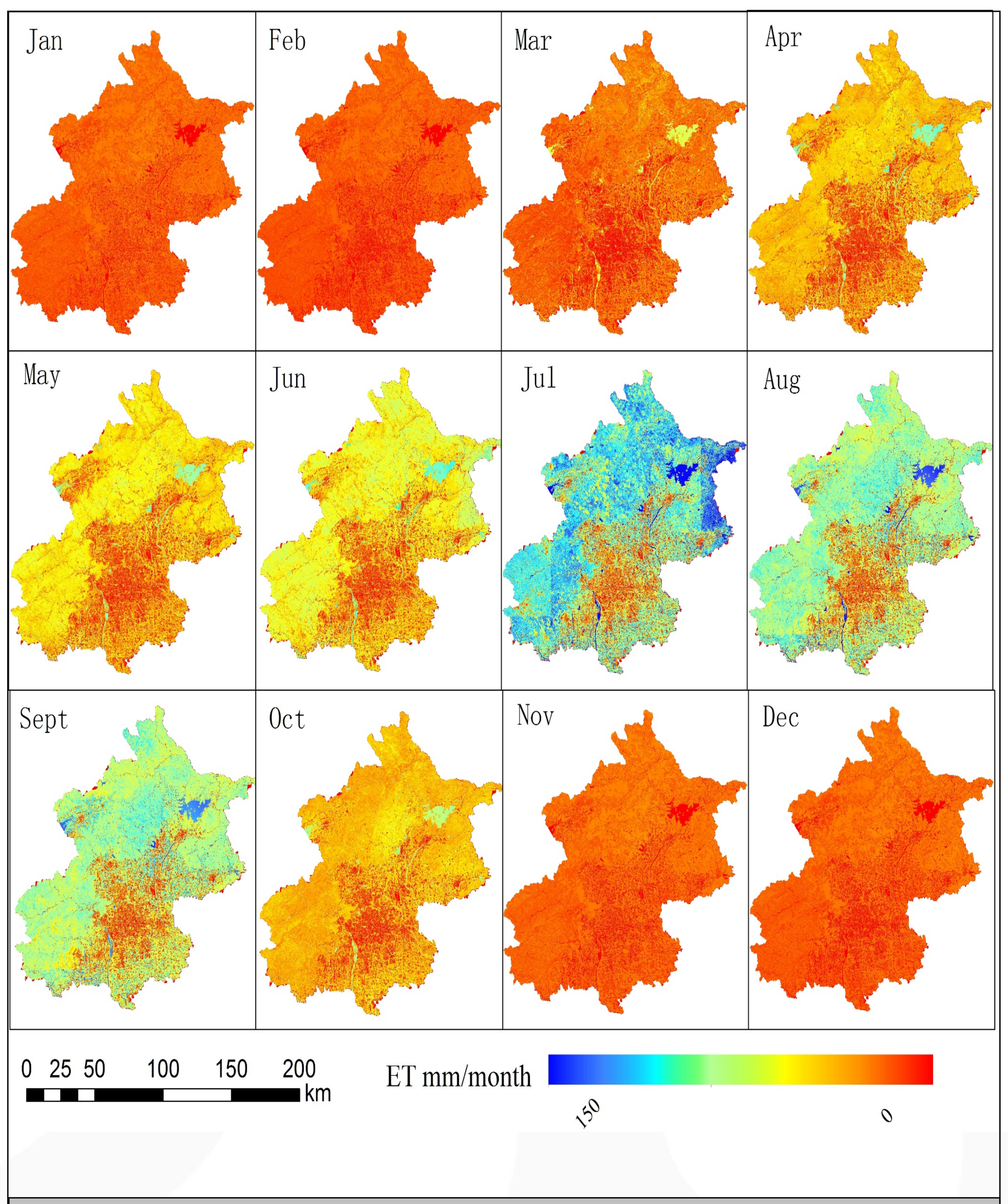

Fig2. Spatial distribution of the total ET in Beijing at 2022

Methods

The model in this study mainly includes the following steps:

(1) The Normalized Difference Vegetation Index (NDVI) is computed by NIR band and Red band from Sentinel-2:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

(2) The 6.25km reference evaporation ET_0 is calculated by FAO P-M formula, and it was resampled to a resolution of 10m:

$$ET_0 = \frac{0.408(R_n - G) + r\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + r(1 + 0.34u_2)}$$

Temperature, pressure, solar shortwave radiation, and wind speed is from daily 6.25km meteorological reanalysis data.

(3) By establishing a correspondence between the crop coefficient Kc values and the NDVI of Sentinel-2 based on 10m land use data in Beijing, the resolution of 10m daily evapotranspiration can be estimated:

$$ET = K_c \cdot ET_0$$

Results

The models were validated by observed ET in Beijing Station, Miyun Station. As shown in Fig.1, the mean bias error(MBE) and root mean square error(RMSE) at Beijing station and Miyun Station show that the model has a higher precision in evaluating ET. The MBE at the scales was 0.36mm/day and -0.17mm/day, and the RMSE reached up to 2.70mm/day and 1.43mm/day, respectively.

The annual average ET in Beijing is 539mm, and the distribution of monthly ET shows seasonal variation(Fig.2), which is basically consistent with the vegetation growth season. The ET shows the high in the northeast and southwest and low in the west. The monthly ET distribution curve shows a single peak, with ET reaching its peak at summer. The maximum ET in July is 83mm, and the minimum ET in February is 11mm.

Conclusions

The ET of Miyun Reservoir, Wenyuhe Park (the underlying surface is grassland), farmland, and ecological forest have different characteristics(Fig.3). It can be seen from the figure that the ET of Miyun Reservoir(water body) is always higher than that of other underlying surfaces. The ET of ecological forest is the higher because the ET of forest land is higher than that of the grass in Wenyuhe Park and the farmland. The ET of the grassland and farmland have similar characteristics from March to July, while the ET of grassland is higher than that of the farmland from July to October.

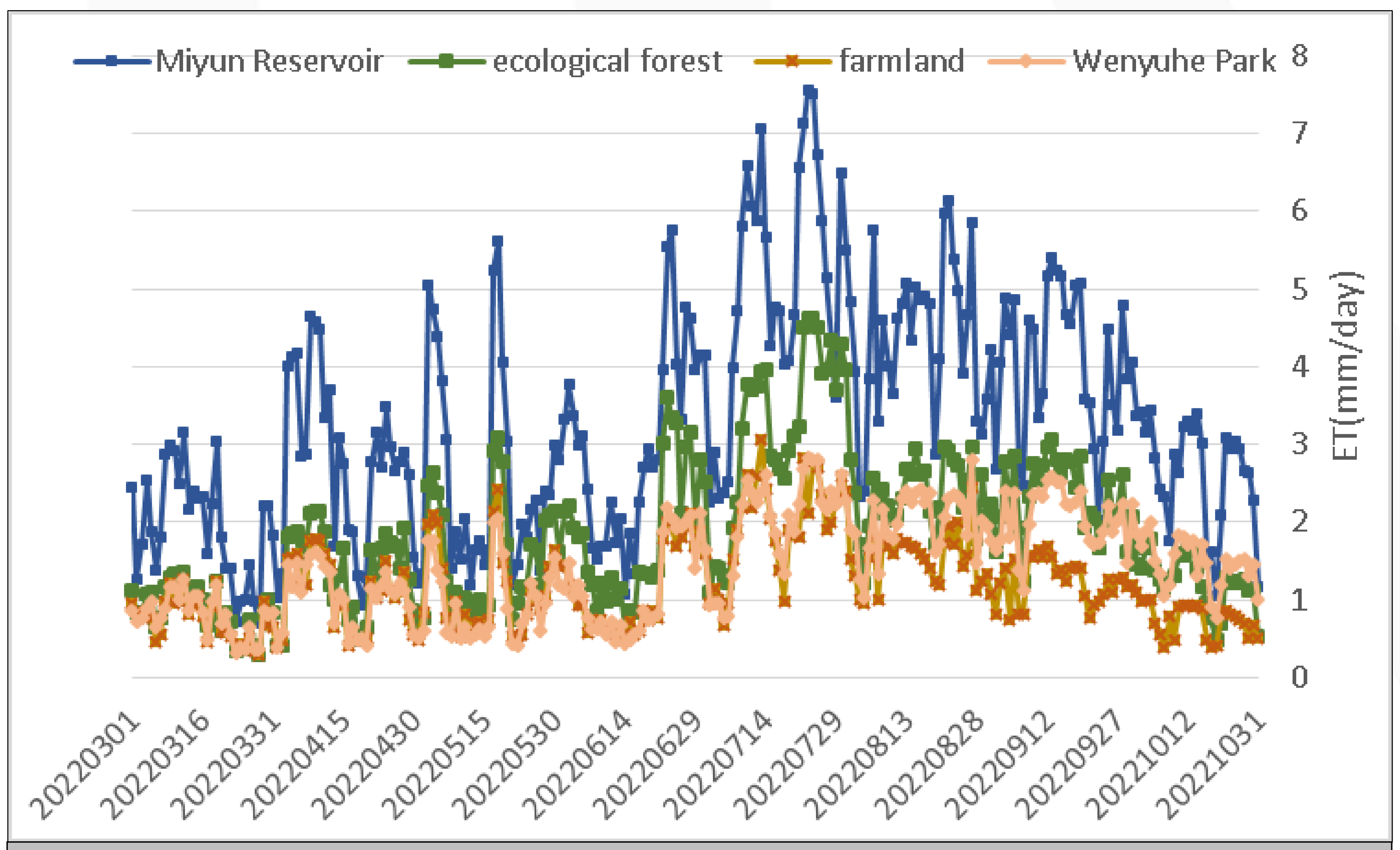

Fig 3. Temporal variation of ET on typical underlying surfaces