# Seasonal Evapotranspiration and its Sensitivity to Climatic Parameters in Cold Region Watershed of Fukushima, Japan

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## BACKGROUND AND OBJECTIVES

Estimation of reference evapotranspiration (ETo) is important in management of water resources, hydrological and ecological modelling. As climate change is said to be occurring, it becomes necessary to understand the effect of climate change to climatic parameters effecting ETo. In this study, focus is put in estimating seasonal ETo and sensitive climatic parameters to ETo in cold region watershed of Mishima, Fukushima Prefecture, Japan. The climate of this area fluctuates during seasons, with winter season having high amount of snowfall. This, fluctuations makes this and similar watersheds vulnerable to climate change disrupting hydrological cycle. Therefore, understanding sensitive climatic parameters to ETo has high significance for effective future planning and management of water resources.

## METHODOLOGY

- Research site: Mishima, Fukushima prefecture, Japan.
- Seasonal ETo was calculated using FAO Penman Montieth Method (Allen et al., 1998).
- Climatic data from 2018/1 to 2021/1, was obtained from weather station in the study site, which was used for ETo daily calculation.
- Relation between climatic variables and ETo were analyzed using Pearson correlation coefficient.
- A Multi regression model was developed to analyze the sensitivity of ETo and climatic parameters. This was evaluated using Adjusted $R^2$, Root Mean Square Error (RMSE) and Nash Sutcliffe Efficiency (NSE).

## RESULTS AND DISCUSSION

### Variation in seasonal Evapotranspiration

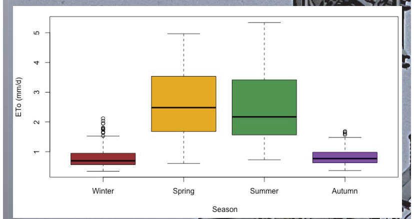
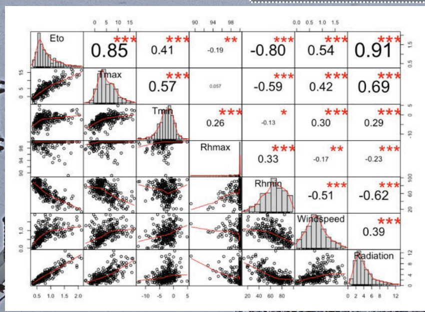



**Fig.1 Variation in seasonal transpiration**

ETo was high in spring and summer season compared to winter and autumn. However, extreme fluctuations were observed for winter and autumn seasons as seen by presence of outliers (Fig. 1).

Radiation and maximum temperature effected ETo the most for all the seasons. Other than those wind speed was the most dominant factor in determining ETo. (Fig 2 to fig. 5)

### Correlation between ETo and climatic parameters




Significance difference at *p<0.05, **p<0.01, ***p<0.001

**Fig. 2 Pearson correlation matrix for ETo and climatic parameters for winter season**

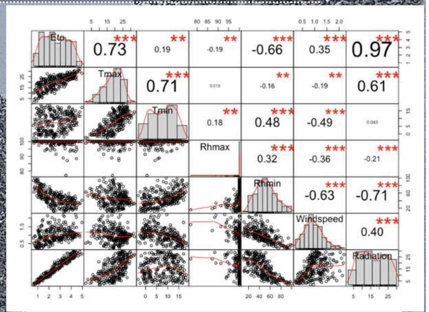



**Fig. 3 Pearson correlation matrix for ETo and climatic parameters for spring season**

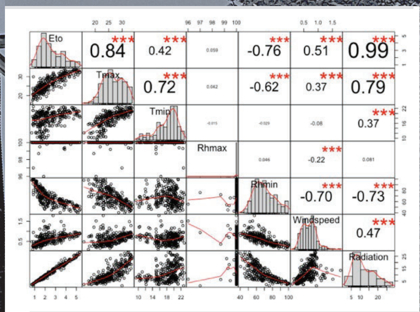



**Fig. 4 Pearson correlation matrix for ETo and climatic parameters for summer season**

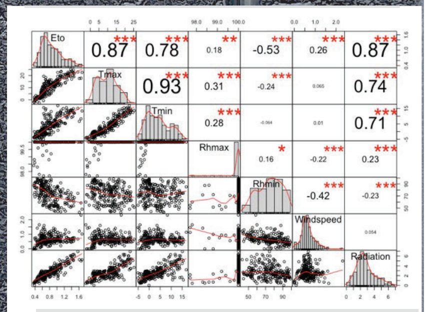



**Fig. 5 Pearson correlation matrix for ETo and climatic parameters for autumn season**

### Regression model developed and its evaluation

**Table 1 Regression model for each season**

| Season | Regression equation | Adjusted $R^2$ | RMSE (mm/d) | NSE |
|---|---|---|---|---|
| Winter (n=271) | 0.29+0.037*Tmax+0.093*R+0.004*WS | 0.91 | 0.10 | 0.90 |
| Spring (n=273) | -0.03+0.039*Tmax+0.116*R+0.0002*Tmin+0.003*WS | 0.97 | 0.16 | 0.97 |
| Summer (n=276) | -0.58+0.04*Tmax+0.15R | 0.99 | 0.13 | 0.98 |
| Autumn (n=276) | 0.28+0.037*Tmax+0.111*R | 0.84 | 0.14 | 0.89 |

*Note : Tmax, R, Tmin, WS represents maximum temperature, minimum temperature, radiation and wind speed respectively, n = cumulative no. of days*

According to regression model, maximum temp., radiation and wind speed, were sensitive climatic parameters for winter. For spring, maximum temp. , minimum air temp., radiation and wind speed, were sensitive. Summer had maximum temp. and radiation as sensitive parameters. Lastly, for autumn maximum temp., radiation, were the sensitive parameters. According to the results, it was observed that radiation and maximum temperature were the most dominant climatic parameters effecting ETo in the study area.

### Performance of the regression model

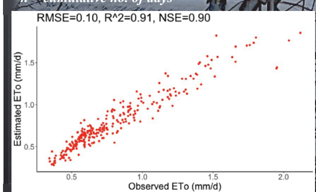



**Fig. 6 Relation between observed and estimated ETo for winter season**

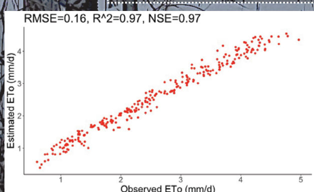



**Fig. 7 Relation between observed and estimated ETo for spring season**

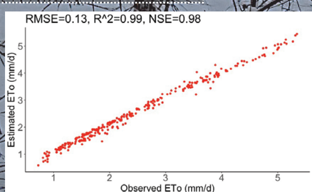



**Fig. 8 Relation between observed and estimated ETo for summer season**

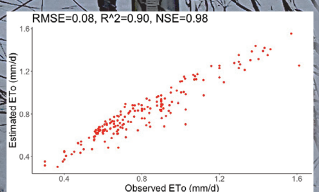



**Fig. 9 Relation between observed and estimated ETo for autumn season**

Adjusted $R^2$, RMSE and NSE values had satisfactory results for relation between estimated and observed values verifying the performance of regression model developed in this study

## CONCLUSION

This study was conducted to estimate seasonal ETo and sensitivity of climatic parameters to it in cold region watershed of Mishima, Japan. The results showed that ETo was high during spring and summer season, when maximum air temperature and radiation were high. Autumn and winter season had less ETo losses, however daily fluctuations were observed. It was seen that radiation and maximum air temperature had highest sensitivity to ETo losses in the study area. Whereas wind speed and minimum air temperature also contributed in some extent. The regression model developed had satisfactory results when comparing the estimated and observed values. Although, evapotranspiration is a complex phenomena, it was concluded that maximum air temperature and radiation are two significant climatic parameters effecting evapotranspiration. Therefore, this finding could be of great help for effective future planning of water resources with respect to climatic parameters which are vulnerable to climate changes.