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Validation of CRE based on multisource evapotranspiration data at Yongdam dam basin

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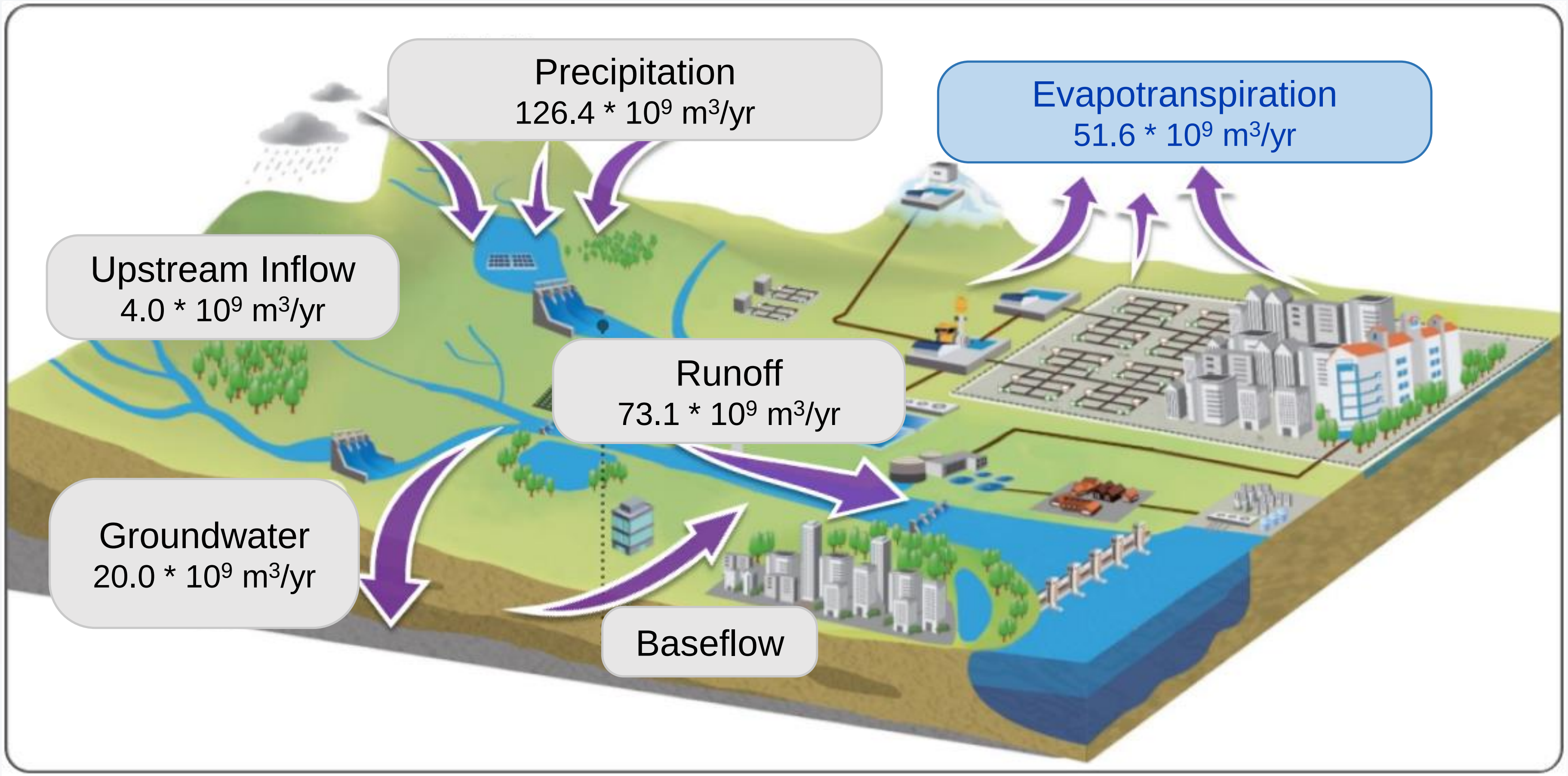
Content

- Background
- Study area and datasets
- Methodology
- Result
- Conclusion

Background

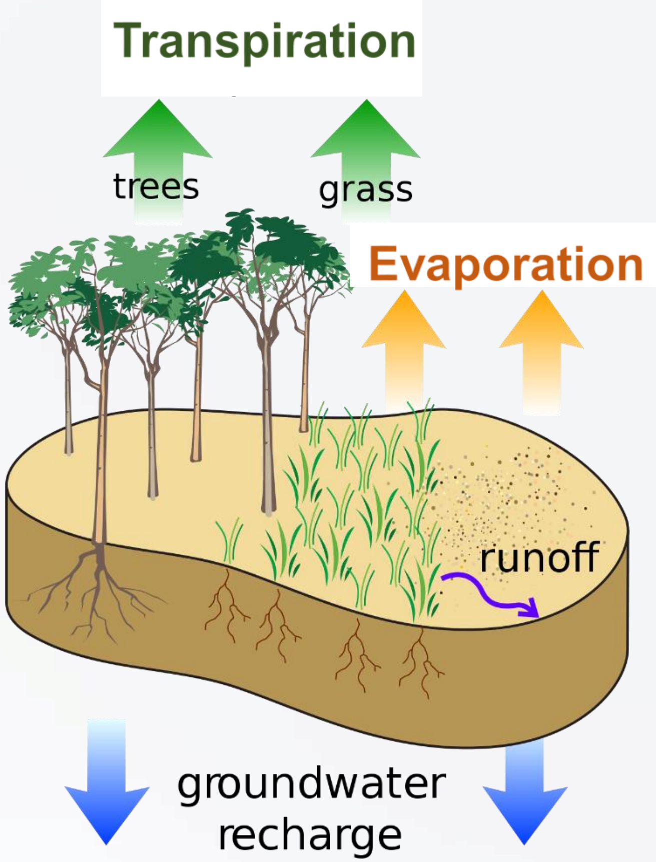
- Evapotranspiration accounts for 40.8% of precipitation in South Korea's water cycle.
- It is an essential factor for the water supply plan of drought season.



<Major components of the water cycle in South Korea>

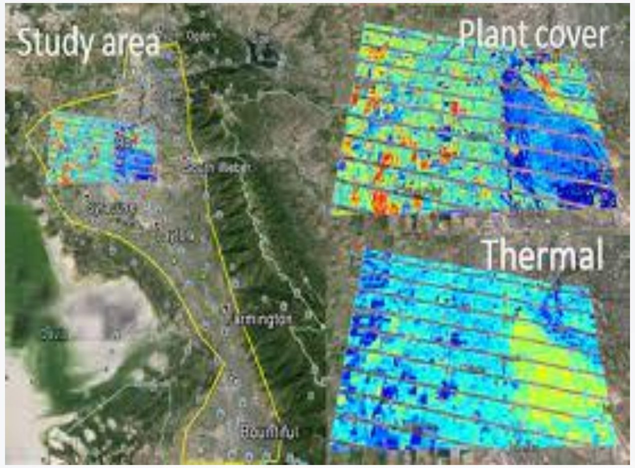
Background

Evapotranspiration = Transpiration + Evaporation



- Evaporation is mainly measured by the evaporation pan.
- Evapotranspiration is estimated using flux equipment or satellites.

➔ Measuring evapotranspiration is a complex and difficult task.



Study area and Datasets

❑ Study area : Yongdam Dam basin

- Total : 930 km^2
- Surface area of dam : 36.2 km^2

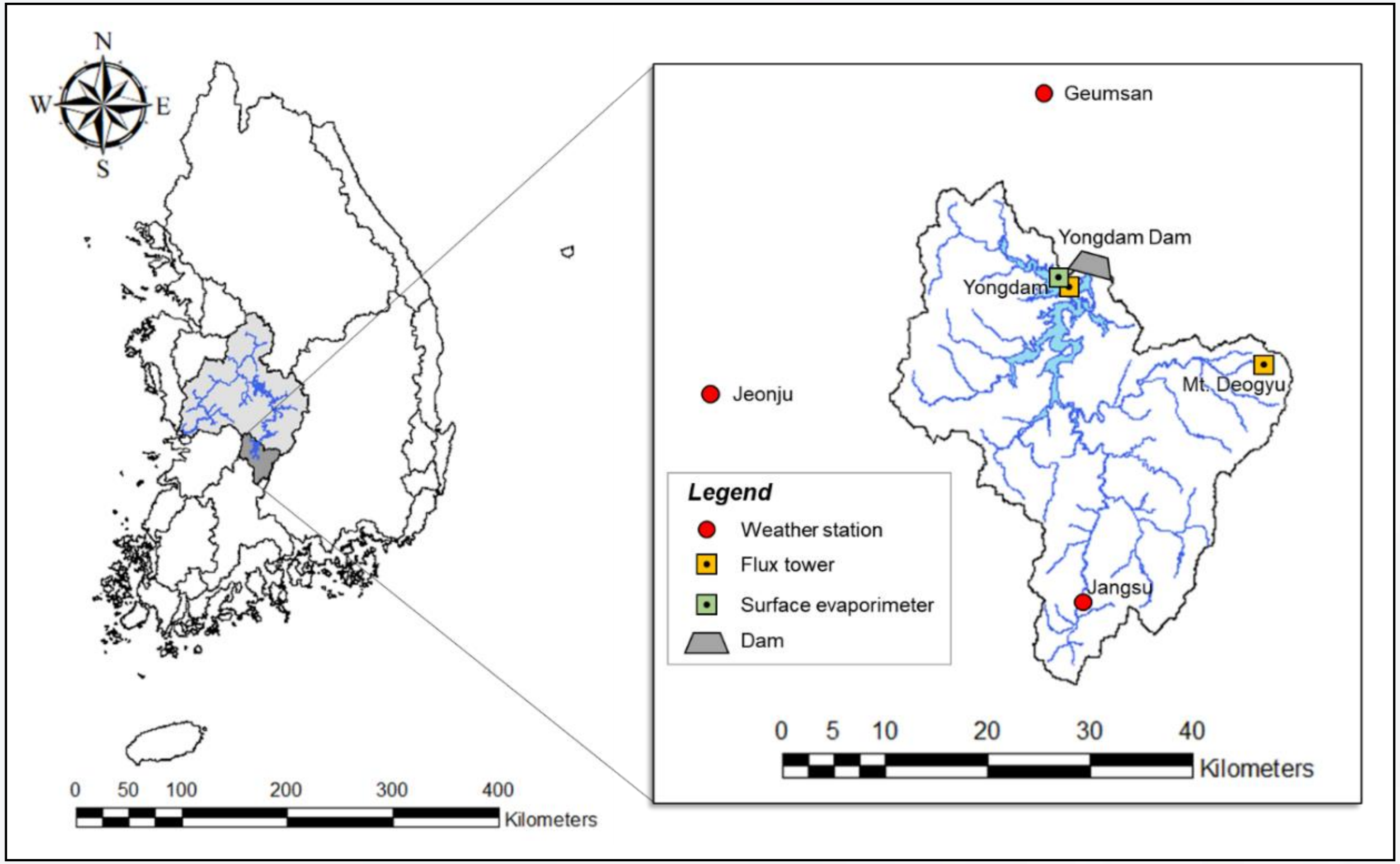
❑ Datasets (2011~2020)

➢ Meteorological data

- Temperature (℃)
- Wind speed (m/s)
- Relative humidity (%)
- Radiation (MJ/m^2)
- Atmospheric pressure (hPa)
- Actual vapor pressure (hPa)
- Pan evaporation (mm/day)

➢ Flux measurements

- Evapotranspiration (mm/day)



<Location of Yongdam Dam basin and observatories>

Methodology

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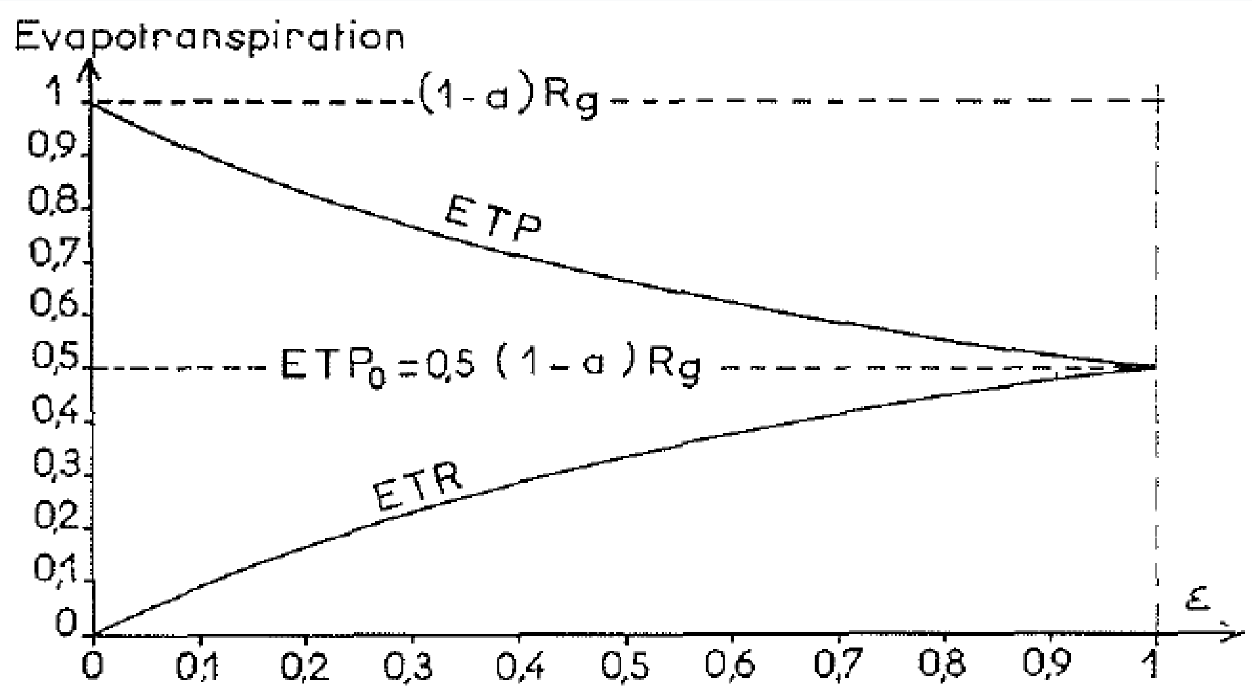
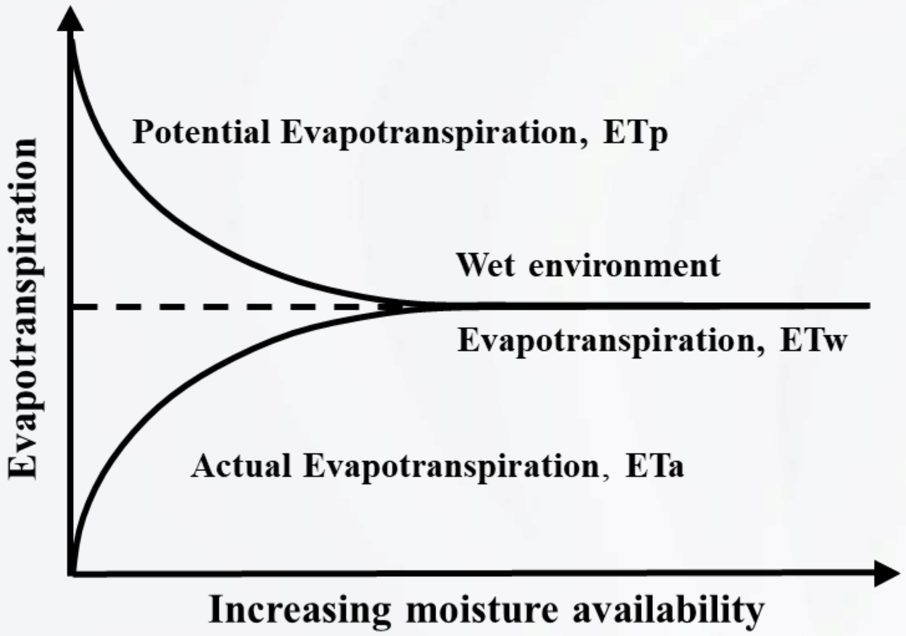
❑ Complementary Relationship of Evapotranspiration (CRE)

➢ Bouchet's hypothesis (1963)

- Actual evapotranspiration (AET) and potential evapotranspiration (PET) have a complementary relationship.
- Depending on the water vapor supply situation, as AET increases, PET decreases.



<Bouchet's complementary relationship>



<Complementary relationship of between ETP and ETA>

Methodology

❑ Complementary Relationship of Evapotranspiration (CRE)

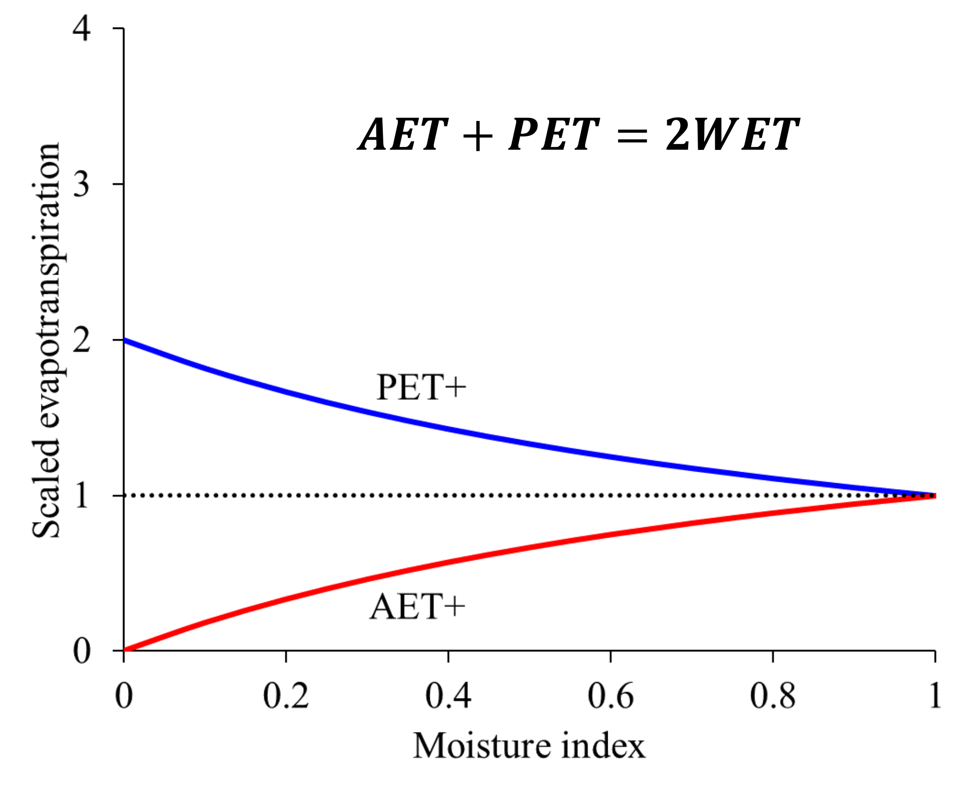
➢ Variables

$$MI = \frac{AET}{PET}$$

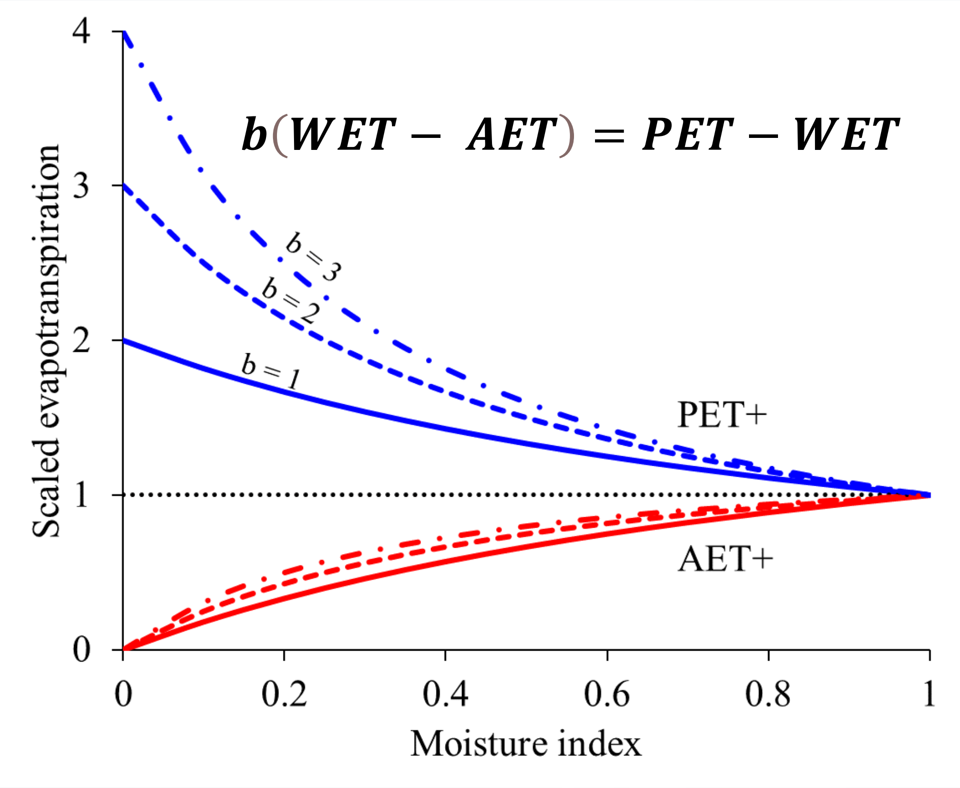
$$PET+ = \frac{PET}{WET}$$

$$AET+ = \frac{AET}{WET}$$

➢ Graphical representation



<Symmetric CRE>



<Asymmetric CRE>

Methodology

❑ FAO Penman-Monteith Equation

(Allan et al., 1998)

$$PET = ET_{FAO\ P-M} = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273.3} u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

PET = Potential evapotranspiration (mm/day)

R_n = Net radiation at the crop surface (MJ/m^2/day)

G = Soil heat flux density (MJ/m^2/day)

T = Mean daily air temperature at 2m (℃)

u_2 = Wind speed at 2m (m/s)

e_s = Saturation vapor pressure (kPa)

e_a = Actual vapor pressure (kPa)

$e_s - e_a$ = Saturation vapor pressure deficit (kPa)

Δ = Slope vapor pressure curve (kPa/℃)

Γ = Psychrometric constant (kPa/℃)

❑ Priestley-Taylor Equation

(Priestley and Taylor, 1972)

$$WET = ET_{P-T} = \alpha \frac{\Delta(R_n - G)}{\Delta + \gamma}$$

WET = Wet evapotranspiration (mm/day)

α = Priestley-Taylor coefficient (=1.26)

R_n = Net radiation at the crop surface (MJ/m^2/day)

G = Soil heat flux density (MJ/m^2/day)

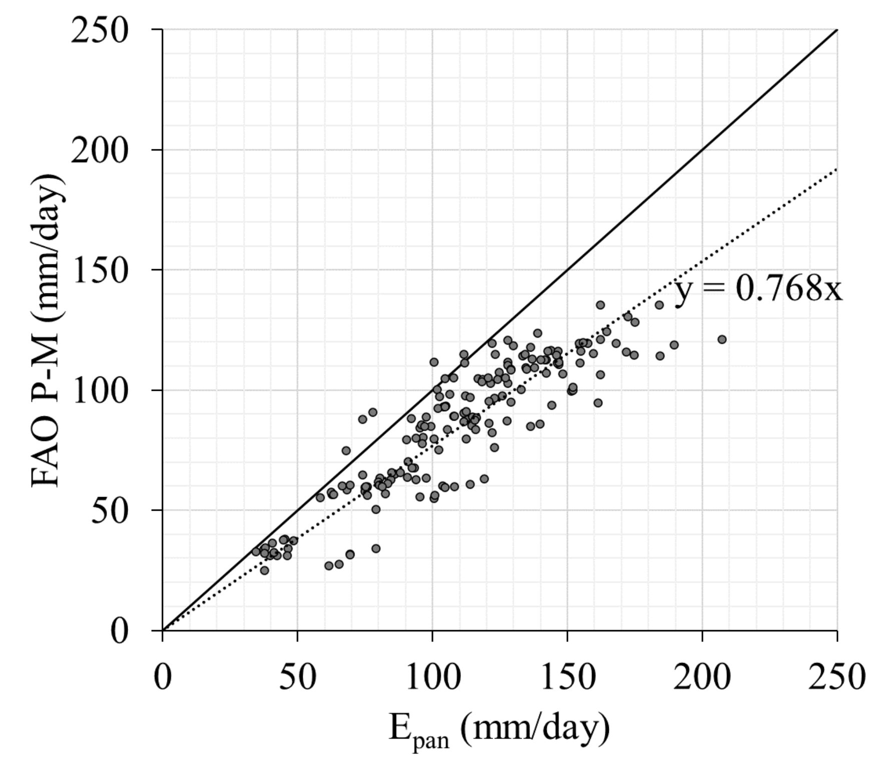
Δ = Slope vapor pressure curve (kPa/℃)

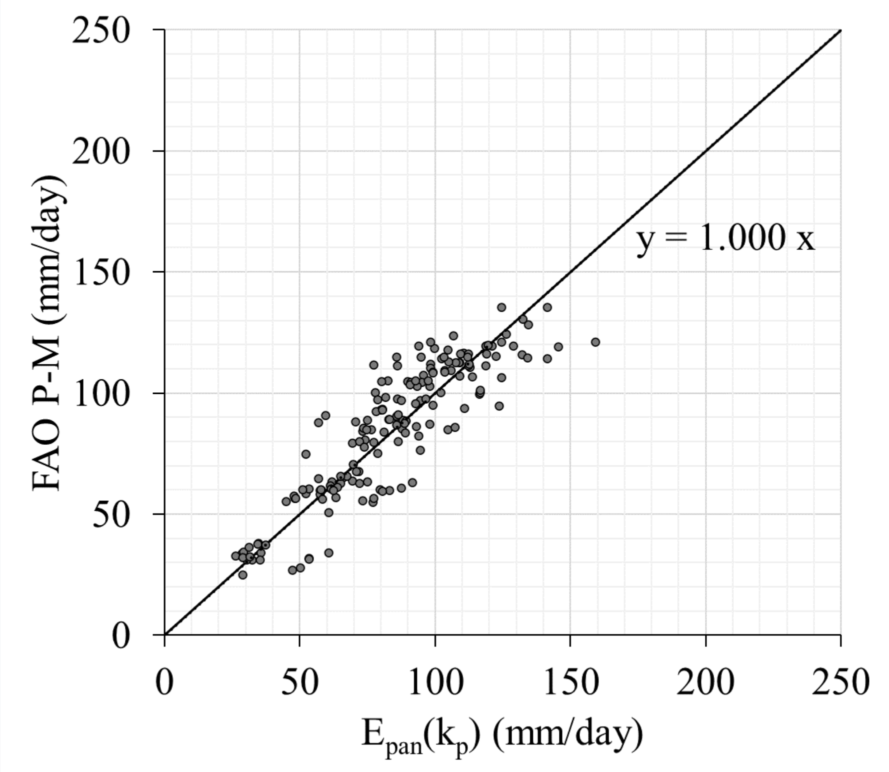
Γ = Psychrometric constant (kPa/℃)

Results

❑ Pan evaporation (E_{pan}) Calibration

- The pan evaporation is calibrated by applying the calibrating coefficient k_p.
- The k_p is estimated using the ETP from FAO P-M equation.





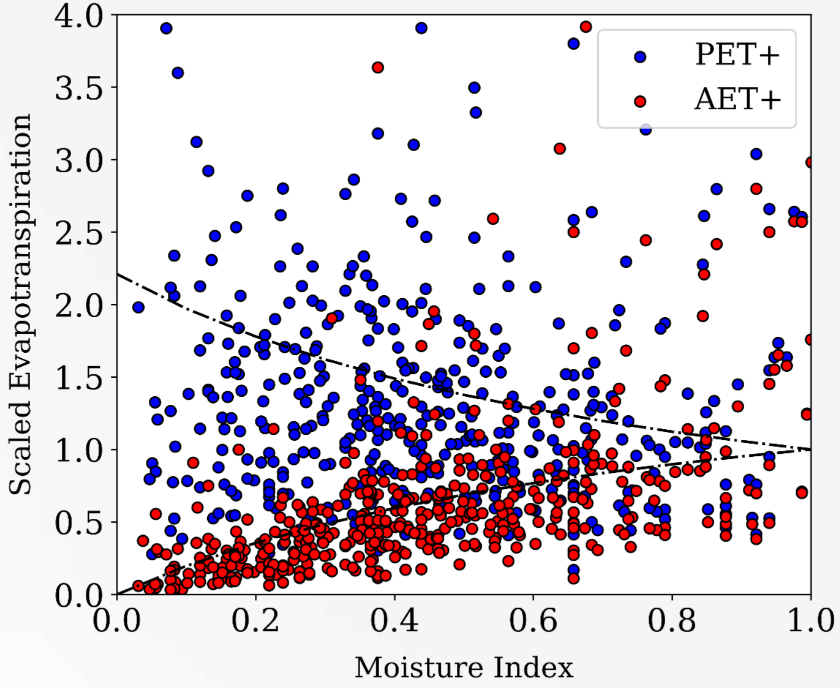
<Comparison before (left) and after (right) application of k_p>

Results

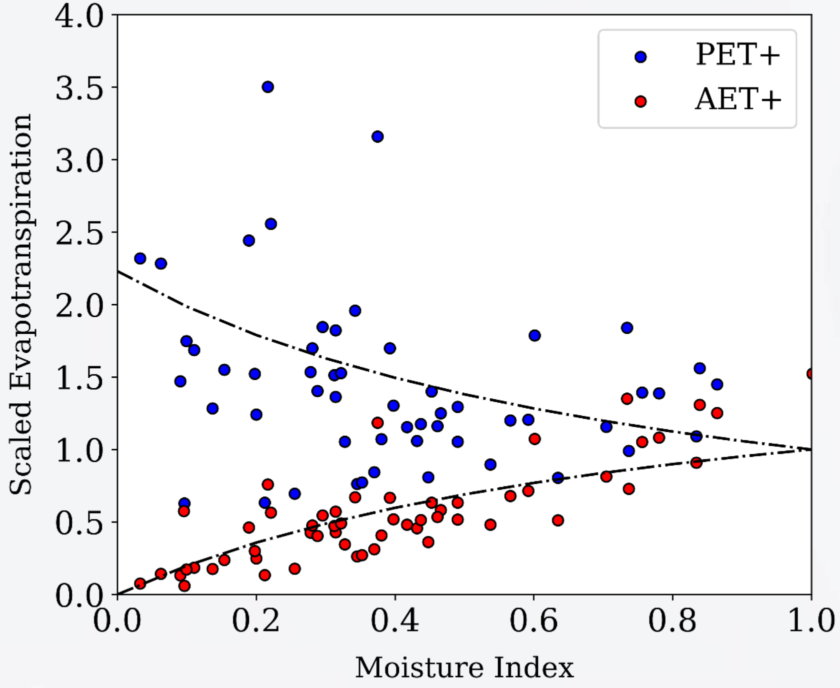
❑ Validation of CRE

- The CRE hypothesis was verified using pan evaporation applied k_p, flux evapotranspiration of Deogyu, and pan evapotranspiration of the reservoir surface.

* PET → E_{pan} AET → E_{flux} WET → E_{res}



<Daily (b=1.2)>



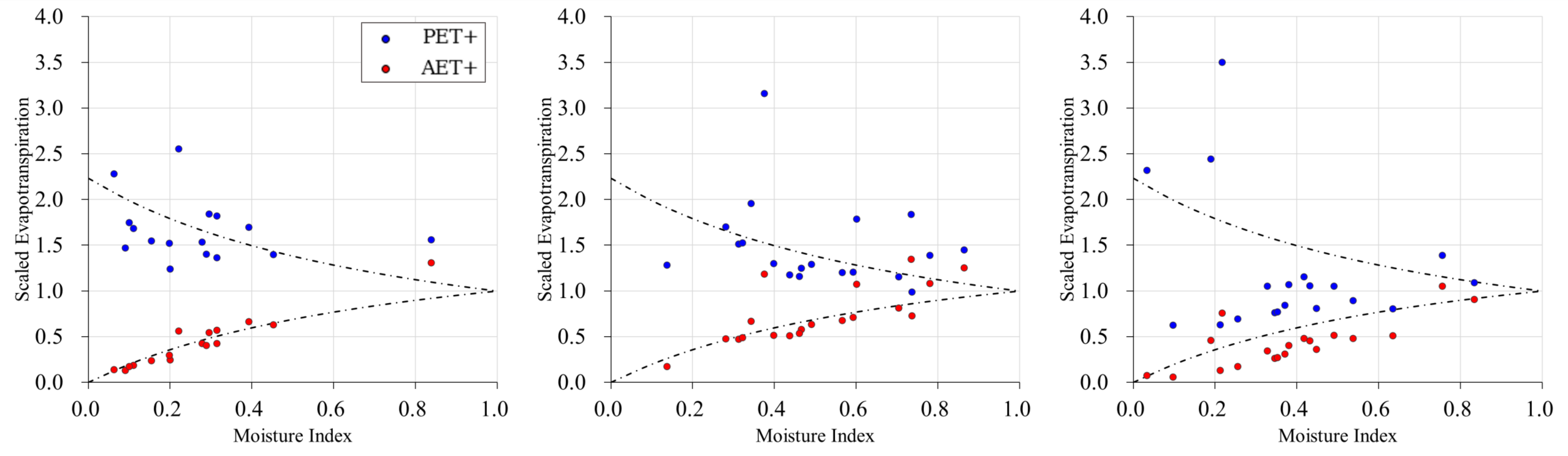
<Monthly (b=1.3)>

➲ The asymmetry coefficient b=1.3 calculated using monthly data is reasonable. (R^2=0.627)

Results

❑ Seasonal CRE

- MI varies by season and represents CRE well except for the autumn season (Sep to Nov).
- In the case of SON, the difference between AET+ and PET+ is the smallest.



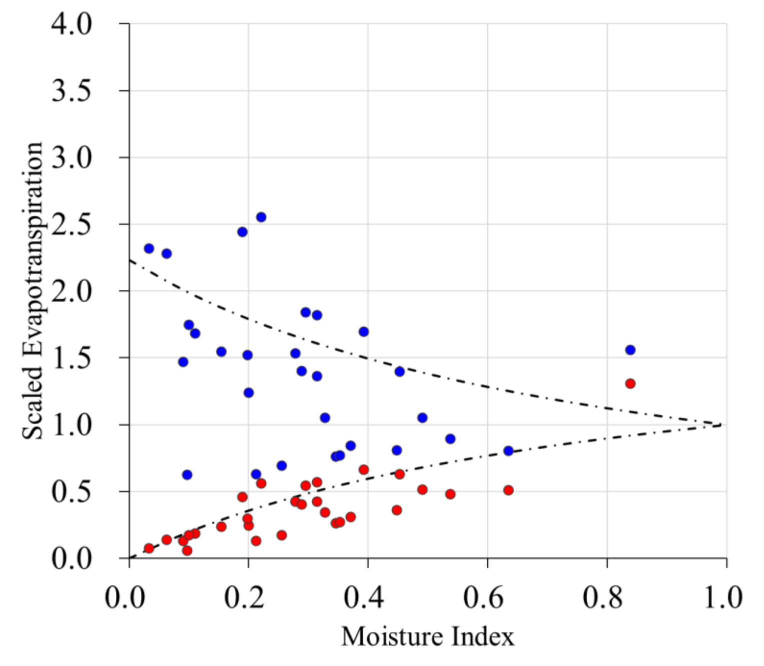
(a) MAM (b) JJA (c) SON

<Comparison of CRE by season (Monthly)>

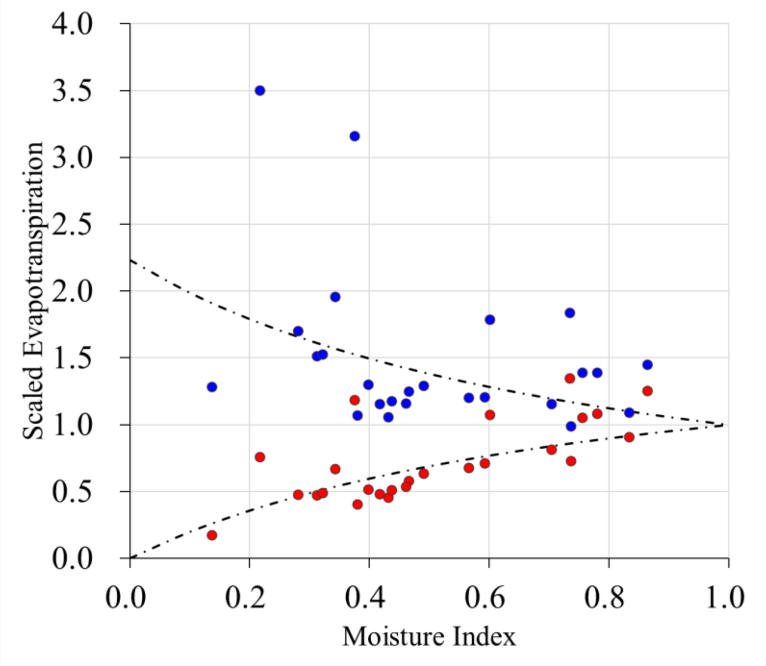
Results

❑ CRE of Flood/Non-flood season

- There are many values where PET is smaller than WET without following a complementary relationship.
- The moisture index is higher in the flood season compared to the non-flood season.



(a) Non-flood season



(b) Flood season

< Comparison of CRE by flood and non-flood periods(Monthly)>

Results

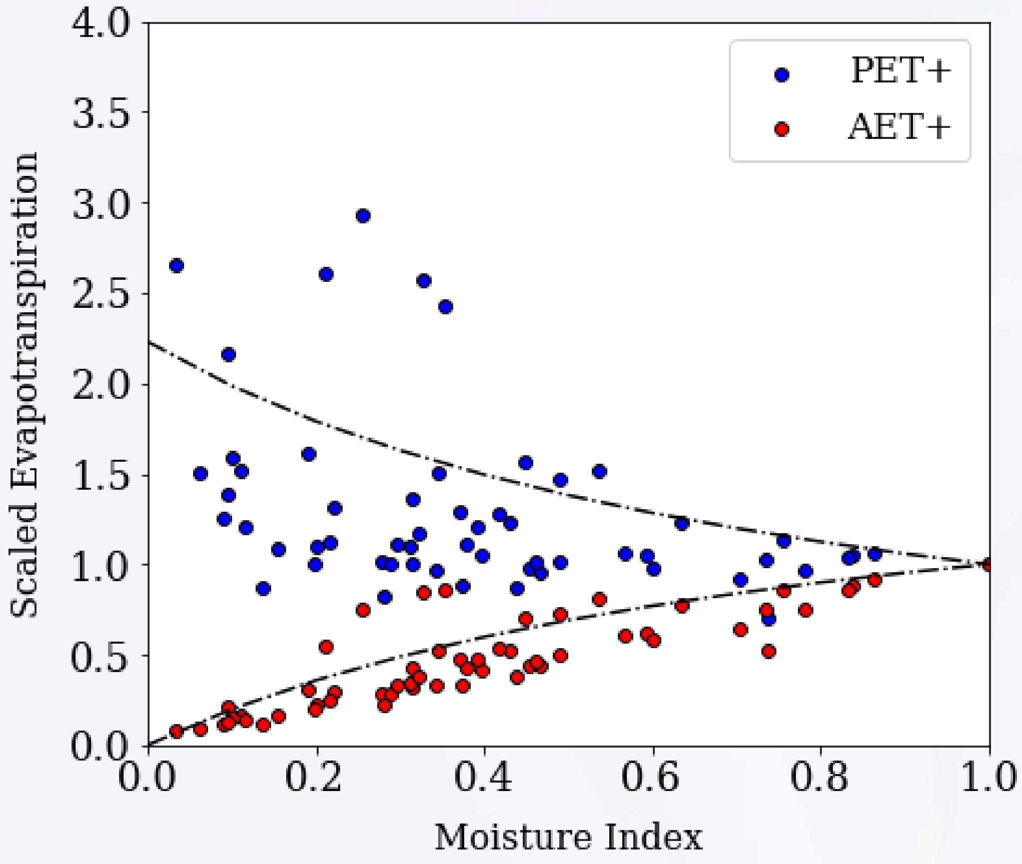
❑ Priestley-Taylor coefficient using CRE

- Since evaporation observations of reservoir surface are very in South Korea, WET must be calculated using the Priestley-Taylor equation.

$$WET = \alpha \frac{\Delta(R_n - G)}{\Delta + \gamma}$$

- Determine the α value that satisfies the CRE by using the WET through the P-T equation.

⇒ Priestley-Taylor coefficient (α) = 1.17



< CRE using WET applied by the P-T equation (Monthly)>

Conclusion

- The objective of this study is to verify the hypothesis of CRE at the basin level through various evapotranspiration observation data located in the Yongdam Dam basin.
- Despite various limitations, such as not much available data on evapotranspiration and the use of pan evaporation data located outside the basin, it satisfies the CRE hypothesis by using observational data.
- Since the pattern of evapotranspiration varies depending on the observation point, the characteristics of the observation data must be identified to determine actual evapotranspiration (AET), potential evapotranspiration (PET), and wet evapotranspiration (WET).
- The CRE hypothesis covered in this study has limitations in accurately capturing phenomena that occur at a local scale, but it can be expected to be used in the future when simulating long-term runoff considering actual evapotranspiration and establishing water resources plans of watersheds.

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Thank you for your attention

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