Inter-annual comparisons of water and carbon flux dynamics between temperate natural mixed forest and Korean pine plantation

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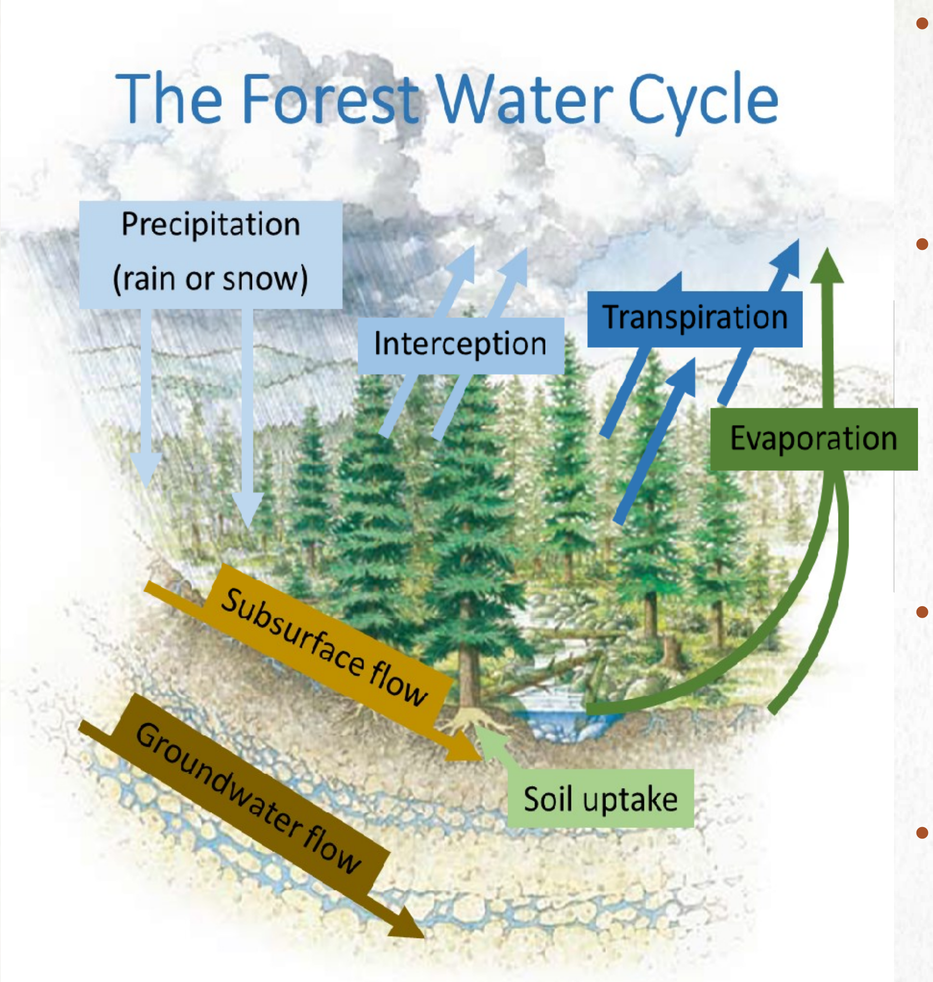
Introduction

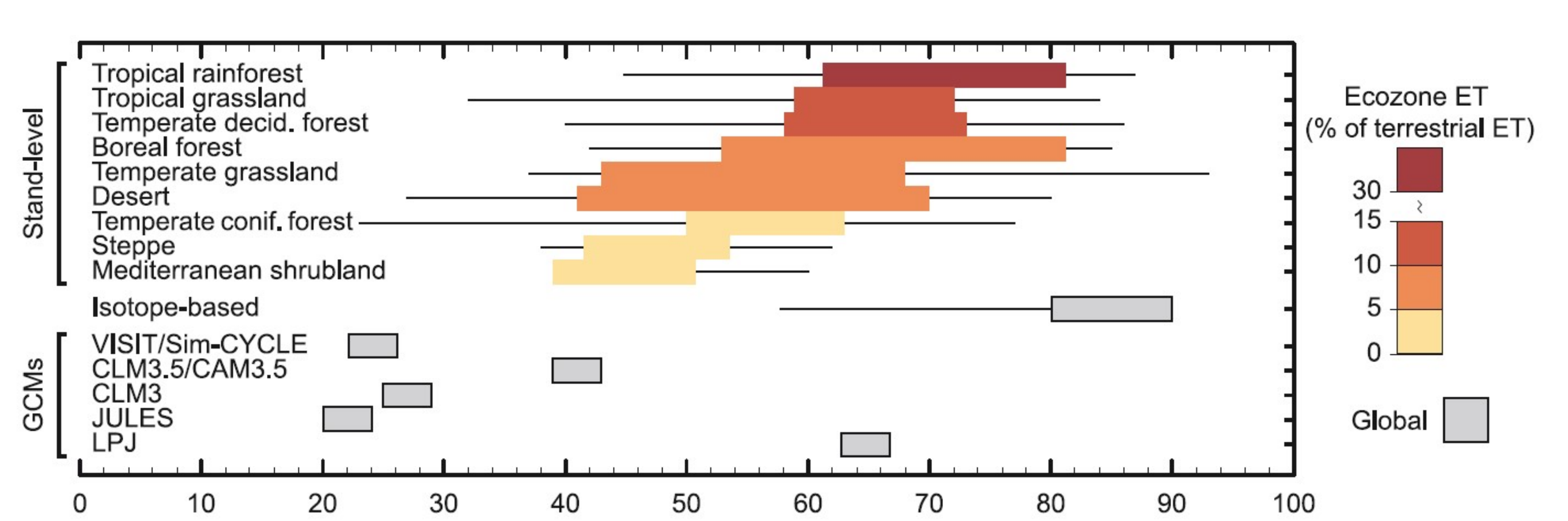


The Forest Water Cycle (From US Forest Service)

- **Forest plays a major role in regulating the global carbon and hydrological cycles.**
- **As a major components of hydrological cycle evapotranspiration (ET) accounts for 60 – 95% of precipitated water in terrestrial ecosystems.** (Ford et al., 2007; Jasechko et al., 2013; katul et al., 2012)
- **ET is partitioned in to evaporation from surface, and transpiration through the stomata of plants.**
- **The fraction of ET attributed to plant transpiration (E_t) is an important source of uncertainty in water flux and land surface modeling.** (Lawrence et al., 2007; Miralles et al., 2011)

Introduction

- E_t vs. ET related to net ecosystem production and carbon cycling.

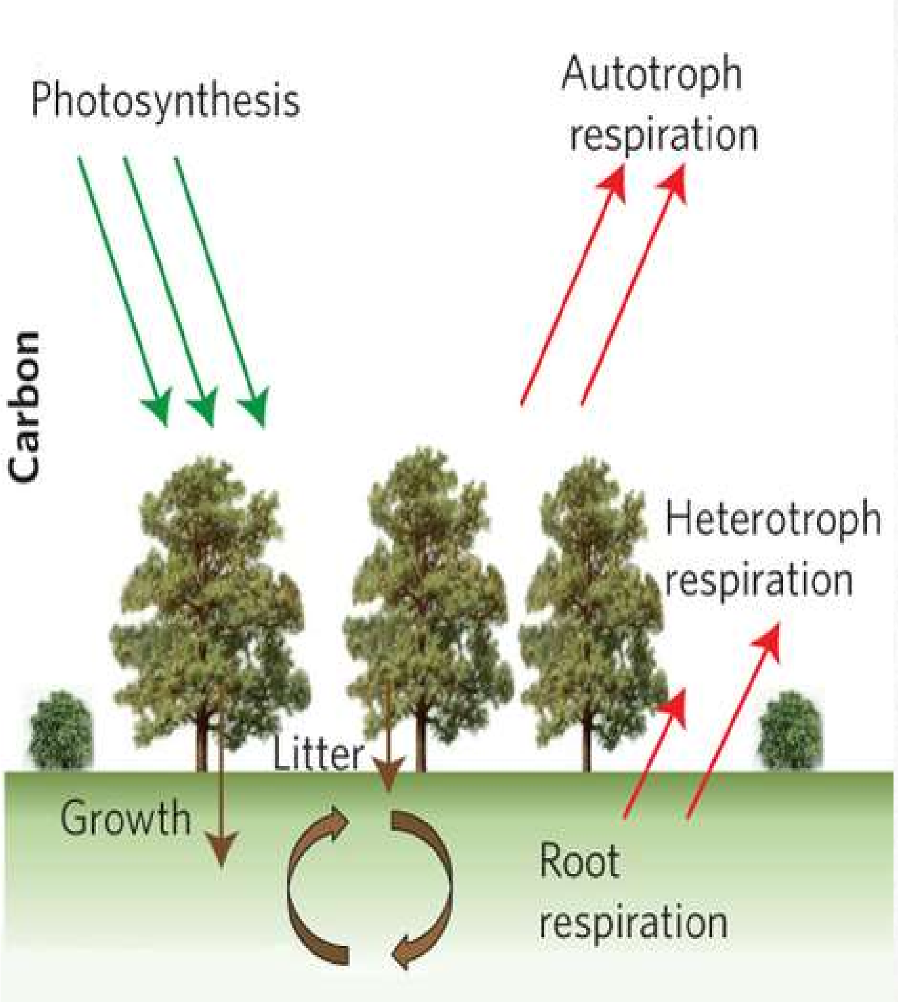


The ratio of transpiration to evapotranspiration. (Schlesinger et al. 2014)

- Understanding the partitioning of ET helps to identify the influence of biotic and abiotic factors that are involved in the evaporation pathway of the hydrological cycle.

Introduction

Carbon cycle in forest ecosystems

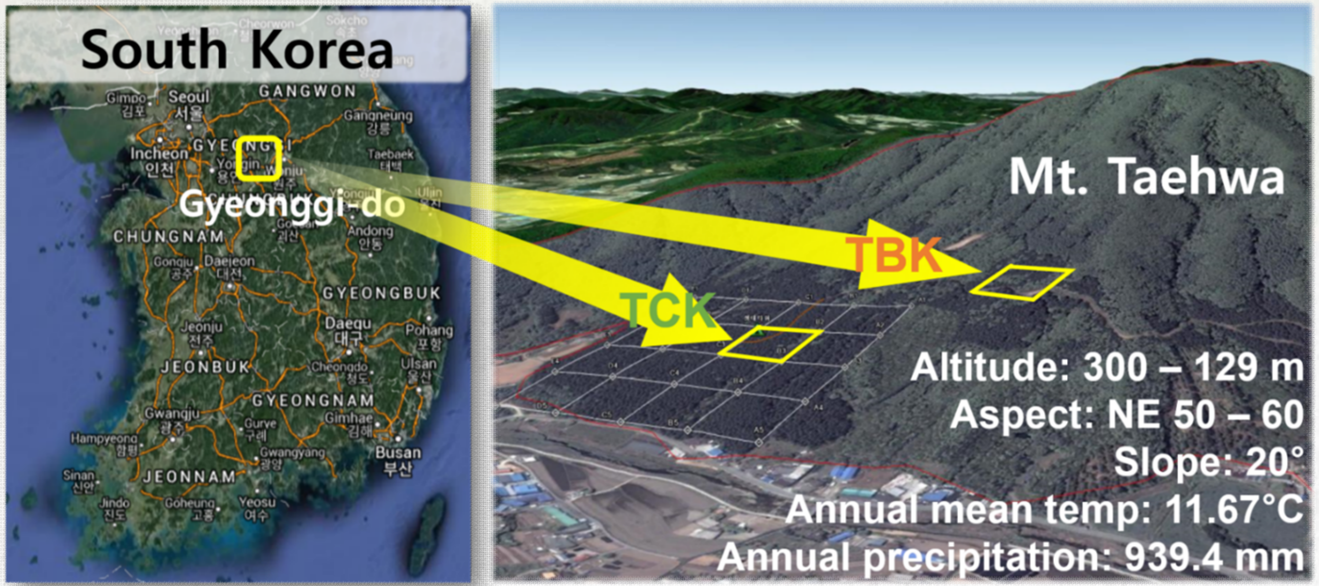


- Forests ecosystem is the important component of global carbon cycle with respect to both fluxes and pools.
- The best way to manage forests to store carbon and to mitigate climate change is hotly debated.
- In Europe, the absorption of carbon did not increase by replacing broadleaved forests with conifers forests. (Naudts et al., 2017)
- Forest management is an important activity that affects the forest carbon stock, and therefore needs to be studied to further understand how its different in greenhouse gas reduction efforts.

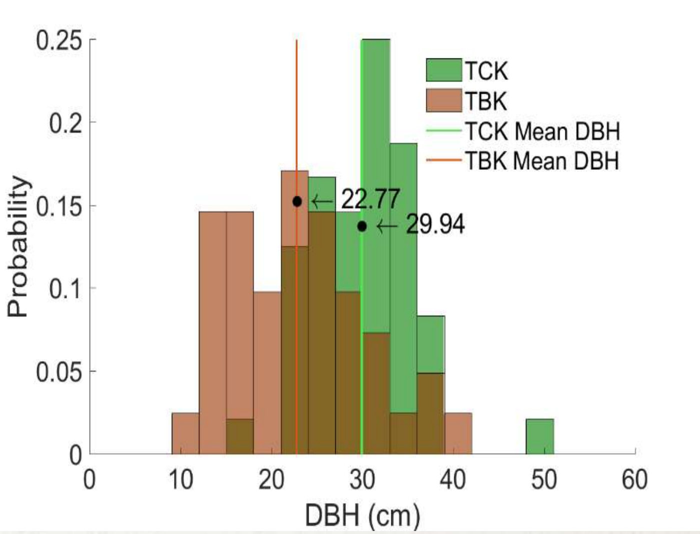
Objectives of the Study

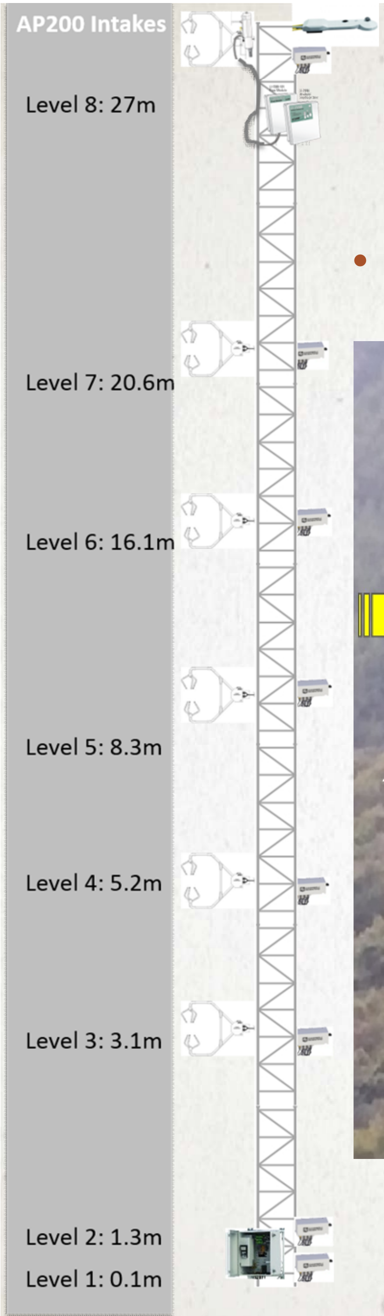
1) To compare the carbon and water use between two nearby and similar aged forests (young natural mixed broadleaved forest, TBK vs. properly managed 50-year-old *Pinus koraiensis*, TCK).
2) To compare the carbon absorption and water use efficiency between TCK and TBK.

Study sites



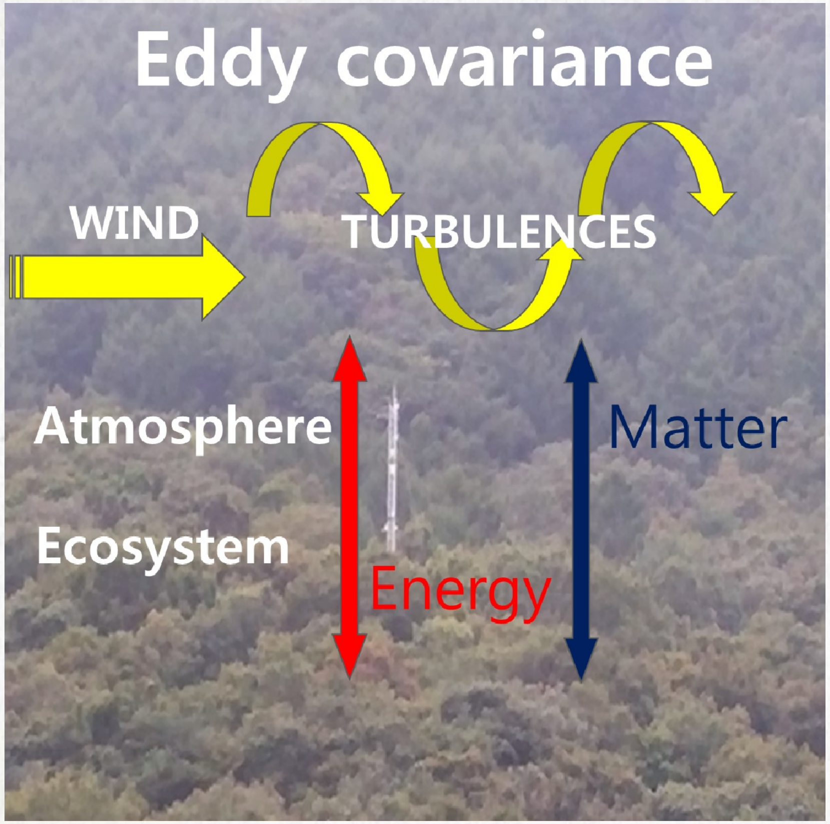
Stand type	Conifer stand (TCK)	Mixed stand (TBK)
Species	*Pinus koraiensis*	*Pinus koraiensis, Quercus mongolica, Quercus variabilis,* Others
LAI_{max}	4.7	5.2
Height (m)	21	20
DBH (cm)	29.9	22.8
Stand density (tree ha^{-1})	450(750)	738(1135)





Experimental Design

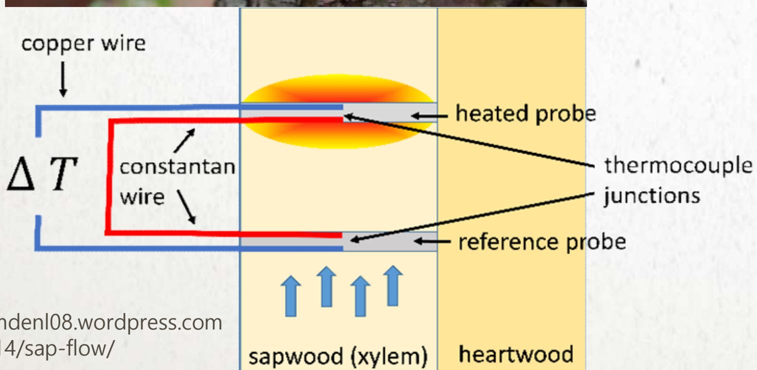
- Water/carbon flux using eddy-covariance system



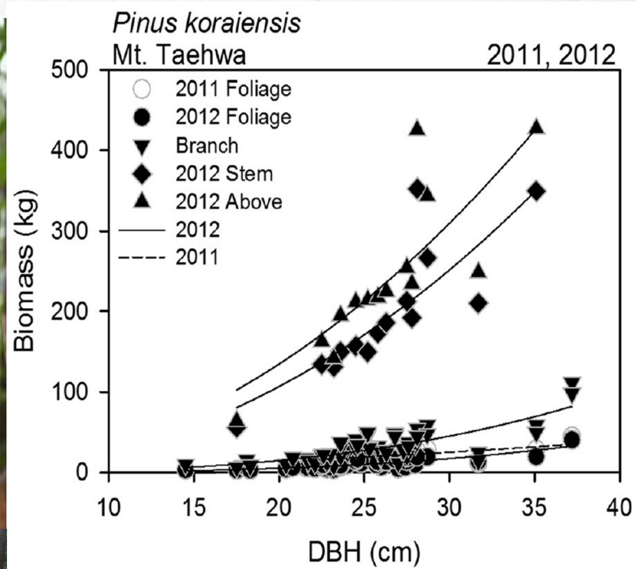
- Our data processed in KoFlux standardized program.
- Flux data was corrected the nighttime NEE using three different methods (i.e., U* correction, light response curve, and van Gorsel methods), and partition NEE in to GPP and R_e.
- WUE was calculated GPP divided by ET.

Experimental Design

- **Sapflow monitoring using Granier type sensor**
- **Tree biomass change estimated using allometric equations**



https://camdenl08.wordpress.com
/2014/04/14/sap-flow/



Ryu et al., (2014).

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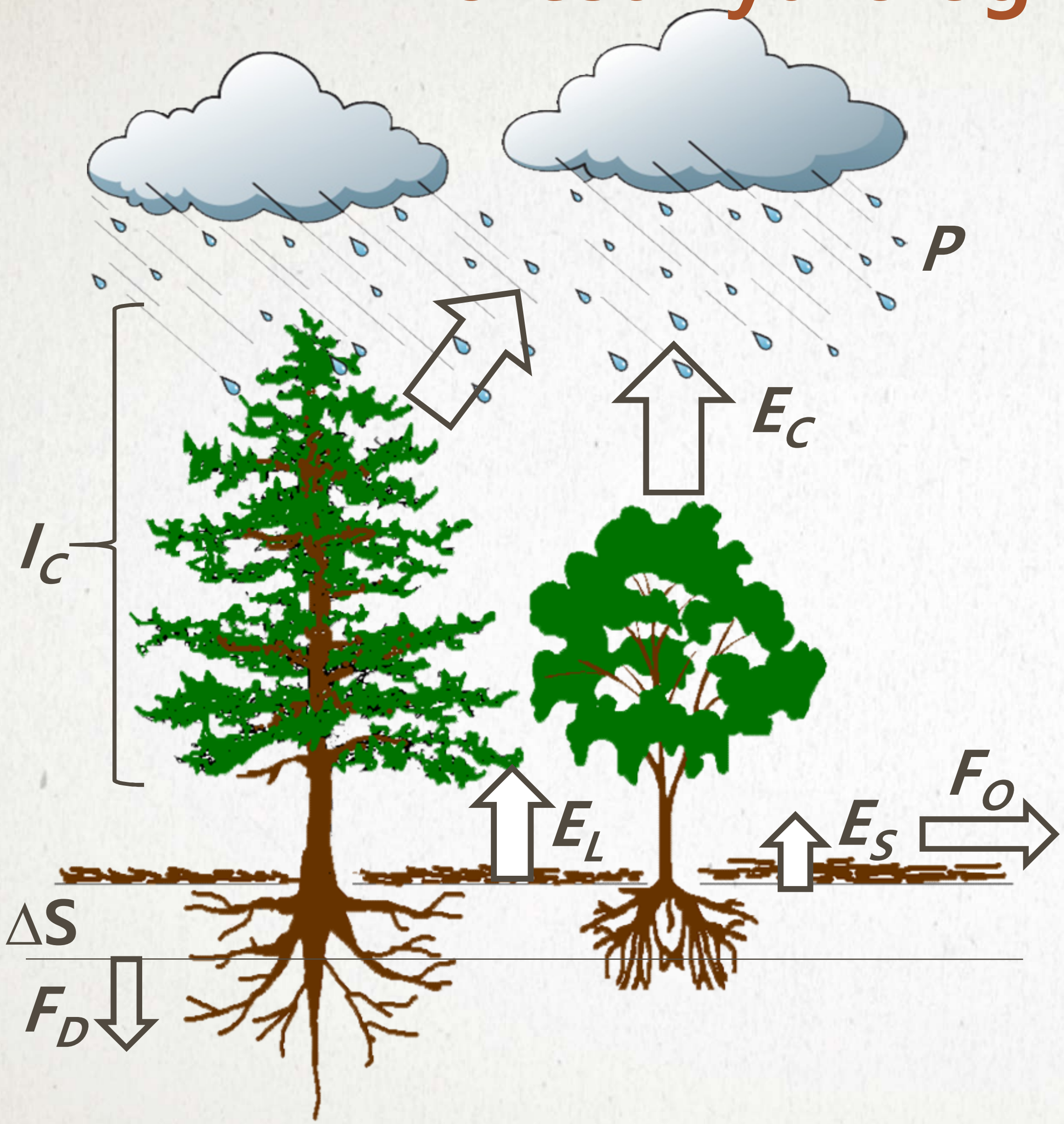
Carbon Emission Factors and Biomass Allometric Equations by Species in Korea (2014)

Forest hydrologic budget



- $P = I_C + E_C + E_L + E_S + F_O + F_D + \Delta S$

P: precipitation

I_C: precipitation interception,

E_C: canopy transpiration,

E_L: litter layer evaporation

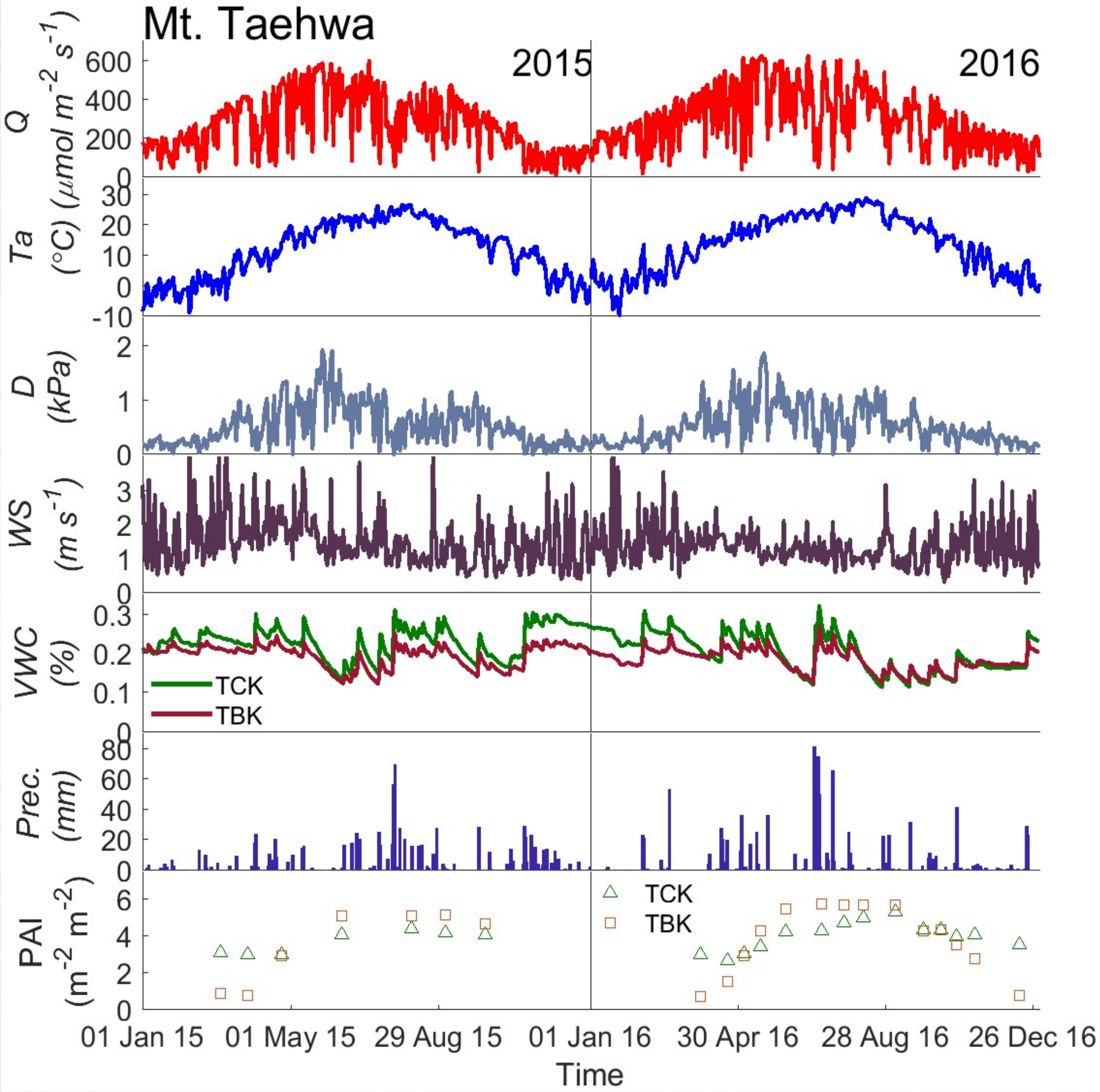
E_S: soil evaporation

F_O: overland flow,

F_D: drainage flow,

ΔS: change in the soil moisture

Results – Environmental variables

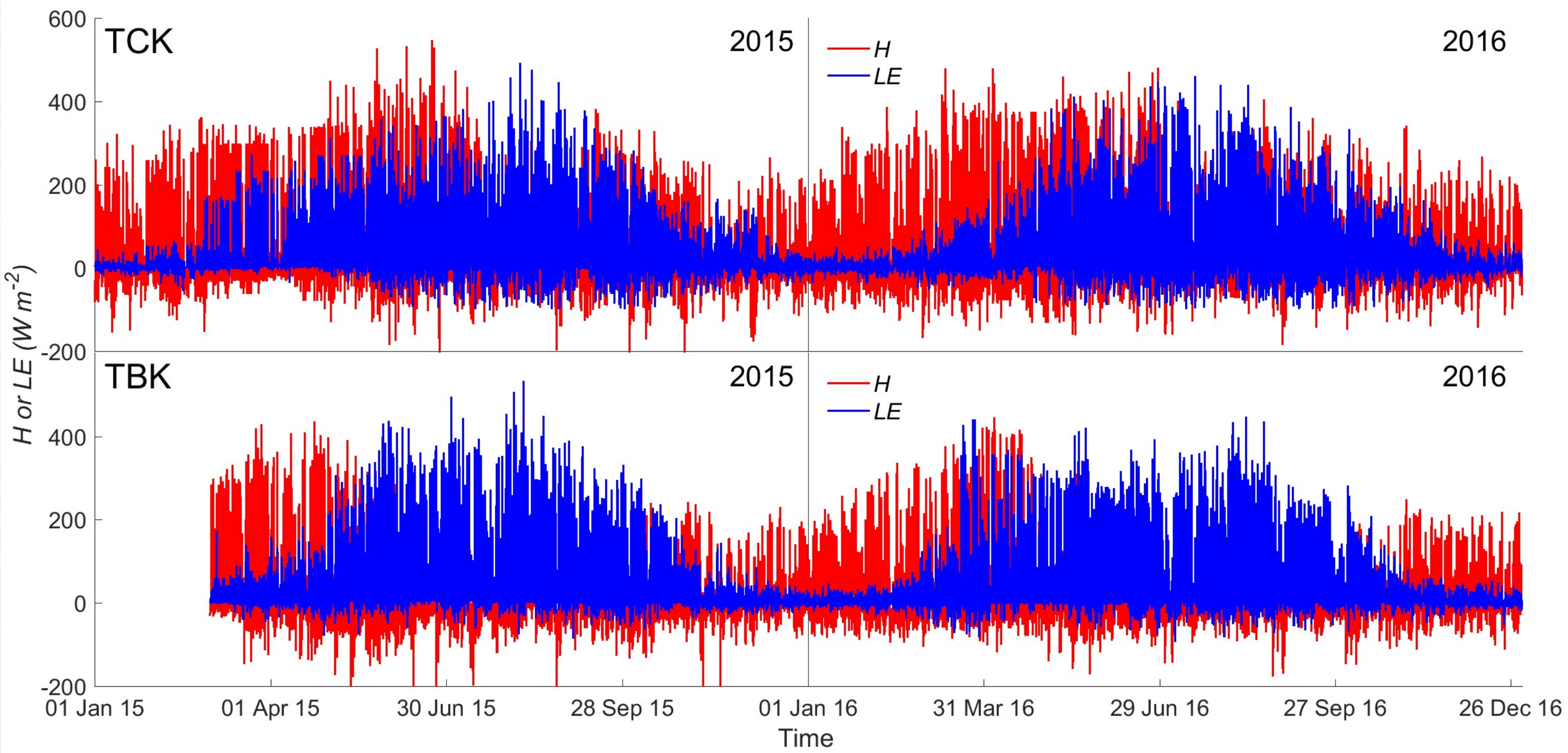


Mt. Teahwa		2015	2016
Q (μmol m^{-2} s^{-1})		274.62 ± 7.83	302.14 ± 7.92
Mean air temp (℃)		11.67 ± 0.49	11.67 ± 0.54
VPD (kPa)		0.53 ± 0.02	0.53 ± 0.02
Wind speed (m s^{-1})		1.52 ± 0.04	1.39 ± 0.03
VWC (%)	TCK	23.18 ± 0.21	20.36 ± 0.26
	TMK	19.58 ± 0.15	18.43 ± 0.15
Prec. (mm)		939.4	928.2

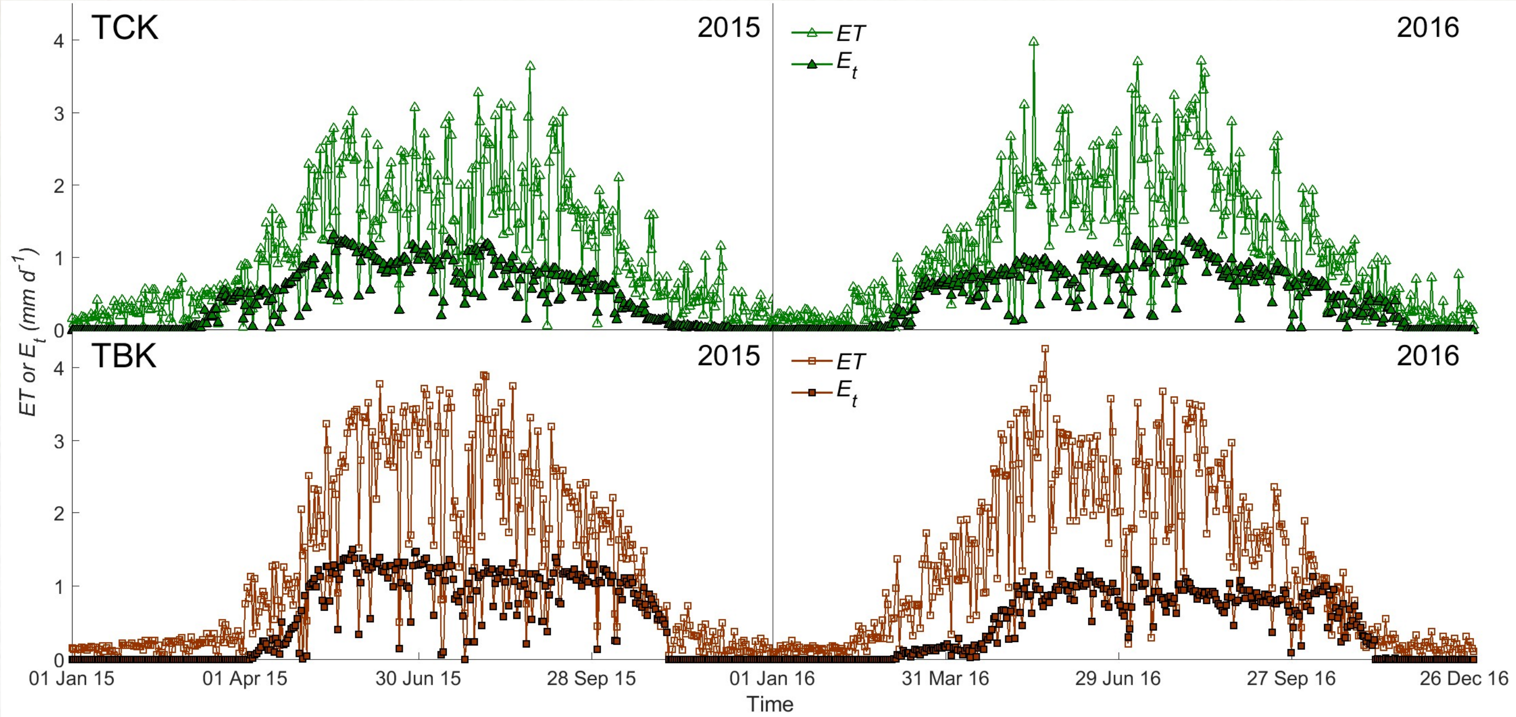
Results – Sensible & Latent heat flux

- The sensible heat flux (*H*) of TCK was higher than TBK in both year. TCK were 33.86, 32.21 W m^{-2} and TBK were 19.53, 18.46 W m^{-2} in 2015 and 2016.

- The latent heat flux (*LE*) of TCK were 35.01, 32.29 W m^{-2} and TBK were 44, 37.02 W m^{-2} in 2015 and 2016.



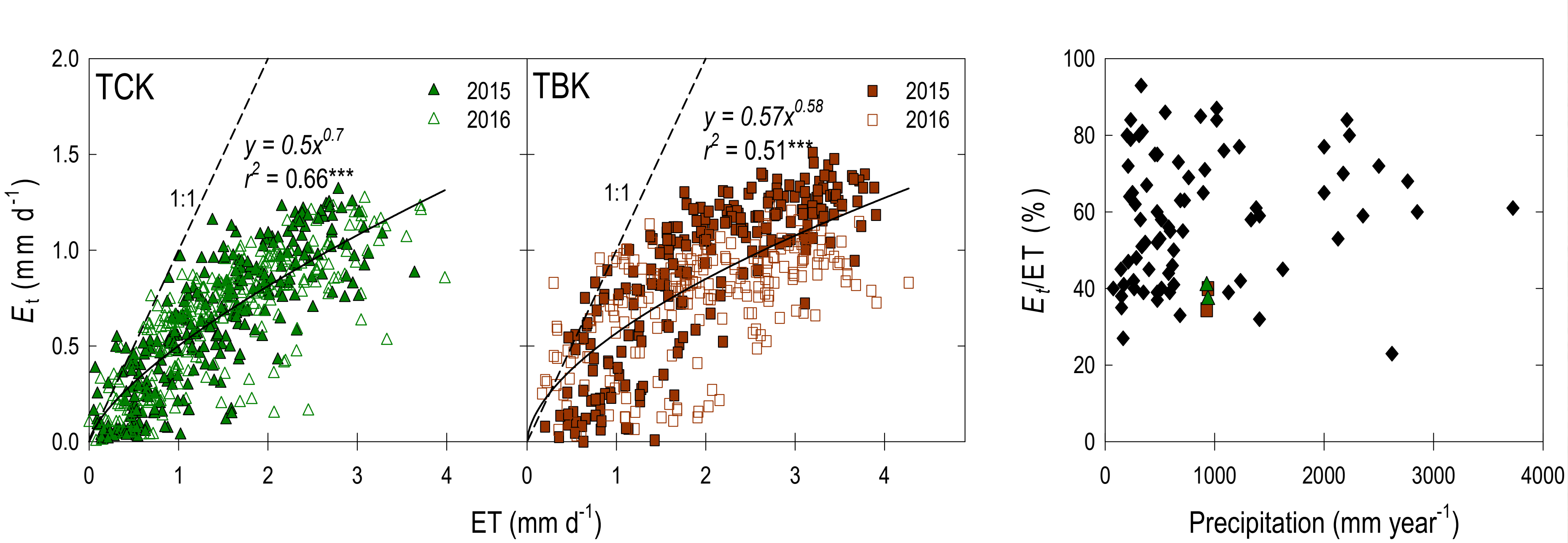
Results – Evapotranspiration & Transpiration



Year	Site	E_t (mm)	ET (mm)	E_t/ET
2015	TCK	163.78	406.53	40%
	TBK	196.51	479.23	41%
2016	TCK	175.47	431.3	41%
	TBK	166.18	482.26	34%

Results – Evapotranspiration & Transpiratoin

Stand level E_t/ET values in relation to precipitation amount



(Schlesinger et al. 2014)

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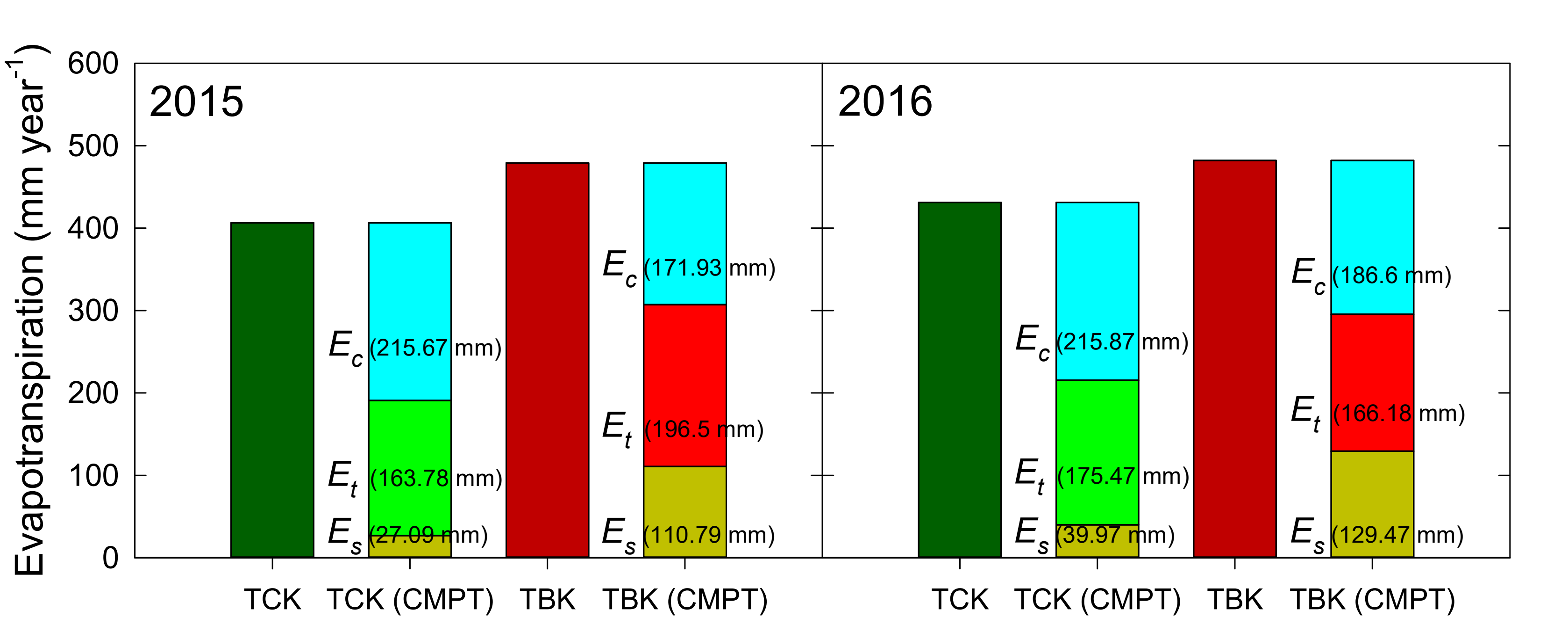
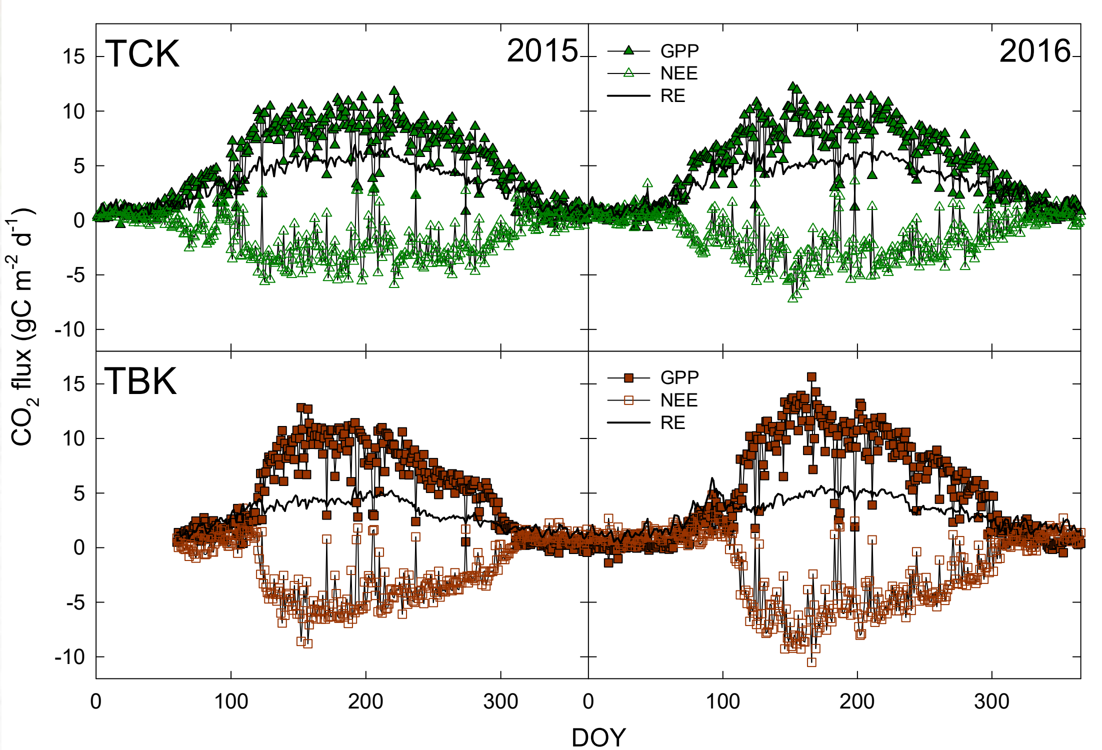
Results – Evapotranspiration components

Stand level ET components



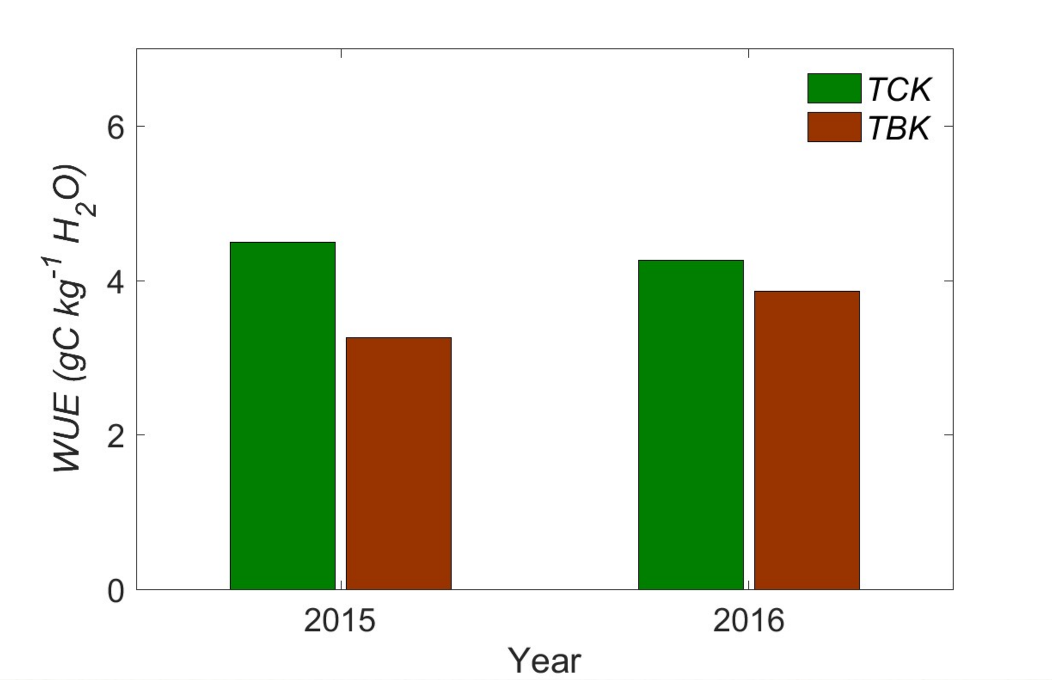
Results – NEE, Re, GPP



Year	Site	GPP (gC m^{-2} y^{-1})	NEE (gC m^{-2} y^{-1})	RE (gC m^{-2} y^{-1})	ANPP (gC m^{-2} y^{-1})
2015	TCK	1800.43	-524.75	1275.74	363.95
	TBK	1531.79	-610.18	923.63	386.08
2016	TCK	1836.61	-531.31	1305.48	369.61
	TBK	1862.93	-674.4	1191.57	364.86

Results – Water use efficiency

- The WUE of TBK were 3.26, 3.86 gC Kg^{-1} H_2O in 2015 and 2016. TCK were 4.49, 4.26 gC Kg^{-1} H_2O in TCK.
- The water use efficiency of TCK was higher than TBK in both year, however, the gap of WUE was smaller in 2016.



Summary

- The total amount of ET of coniferous plantation was lower than natural mixed forest in both years.
- In contrast to the water use, the GPP estimate of plantation forest were similar to that of natural forest in both year.
- As results, the WUE of managed plantation forest were higher than nearby natural mixed forest.

Thank you!

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