Understanding Water Balances in Korea Landscapes

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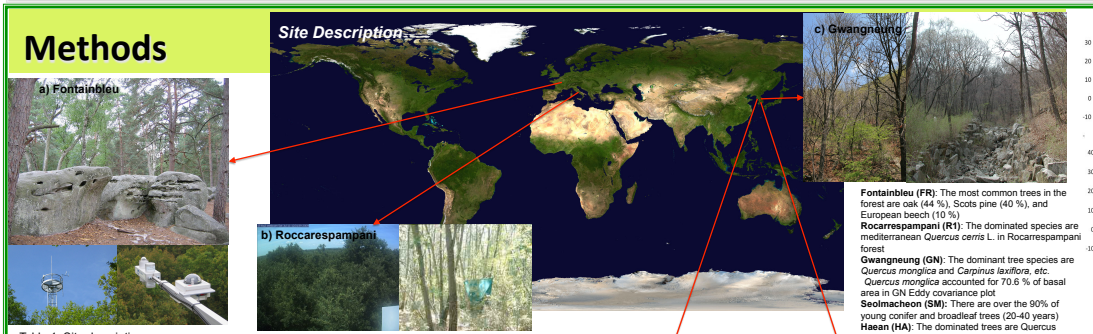
Introduction

In forest ecosystems, the water balance depends on topographic gradients that affect precipitation, evapotranspiration and runoff, both directly and indirectly through modifications in forest structure and function. As a first step in understanding the water balance in the forested watershed in Haean Basin in Gangwon Province of S. Korea, water vapor and CO_2 exchange characteristics of deciduous forest, which make up ca. 50% of the land cover of the basin, have been defined by combining information from KoFlux forest site measurements including eddy covariance data, from local sapflow measurements, with remote sensing data, and with process-based simulation models. While eddy covariance measurements at flux tower sites provide much new information about micrometeorology and ecosystem function, generalization of the data for use in spatial models is an important spin-off from land surface flux network measurements.

Forest water use at the Seolmacheon mixed forest site (ca. 20-30 years average tree age) and Gwangneung old natural deciduous forest site (ca. 90-200 years average tree age) are compared with estimates in the Haean Basin, adjusting for the cooler highland climate. Accurate estimation of forest water use in the Haean Basin is extremely important in order to aid in calibration of basin hydrological models. Canopy CO_2 exchange from two KoFlux sites is characterized by inverting the single layer process-based canopy model PIXGRO with respect to eddy covariance data and local climate, in order to obtain the seasonal course of carboxylation capacity (Vc_{uptake}). It is related to Haean Basin by consideration of probable differences in water use efficiency. Remote sensing data are being examined in order to adjust gas exchange characteristics along the elevation gradient within the Haean Basin, and to obtain independent estimates of canopy water use and carbon uptake via remote sensing algorithms.

Methods



Fontainbleu (FR): The most common trees in the forest are oak (44 %), Scots pine (40 %), and European beech (10 %)
Rocarrespampani (R1): The dominated species are mediterranean *Quercus cerris* L. in Rocarrespampani forest
Gwangneung (GN): The dominant tree species are *Quercus monglica* and *Carpinus laxiflora, etc. Quercus monglica* accounted for 70.6 % of basal area in GN Eddy covariance plot
Seolmacheon (SM): There are over the 90% of young conifer and broadleaf trees (20-40 years)
Haean (HA): The dominated trees are Quercus dentata, QuercusMongolica, Betula davurica and Tilia amurensis, etc.

Table 1. Site description

Site	Fontainbleu	Roccarespampani	Gwangneung	Seolmacheon	Haean
Location	Ile-de-France, France	Viterbo, Italy	Pocheon-gun, Gyeonggi-do, South Korea	Paju-si, Gyeonggi-do, South Korea	Yanggu-gun, Kangwon-do, South Korea
Latitude	48°28'	42°24'	37°45'	37°56'	38°17'
Longitude	2°46'	11°55'	127° 9'	126°54'	128° 8'
Altitude	100m	234m	340m	120m	660m
Ecosystem	Oak forest	Deciduous broadleaf forest	Old natural deciduous forest	Young mixed forest	Mixed forest
Mean Annual Temperature	10.2°C	15.2°C	11.3°C	11.7°C	9.9°C
Annual Precipitation	720mm	876mm	1300-1400mm	1100-1200mm	1100-1200mm

Figure 1. a)-e) The photos and location of eddy covariance measurement site in Europe and South Korea

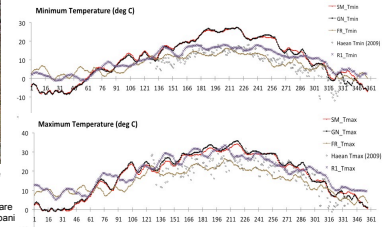


Figure 2. The weather condition in 5 study site. Fontainbleu, Roccarespampani, Gwangneung and Seolmacheon show minimum and maximum temperature in 2008, Haean shows air temperature in 2009. The sites located in S.Korea have frozen winter season and not shown in this results but also drought in spring time.

Definition of Water Use Efficiency and Radiation Use Efficiency

The mount of carbon gained per unit of water loss in ecosystem level, Ecosystem Water Use Efficiency (WUE) (*Beer et al.*, 2009);

$$GPP/ET$$

The mount of carbon gained per unit of absorbed radiation, Radiation Use Efficiency (RUE);

$$GPP/Radiation$$

Results and Discussion

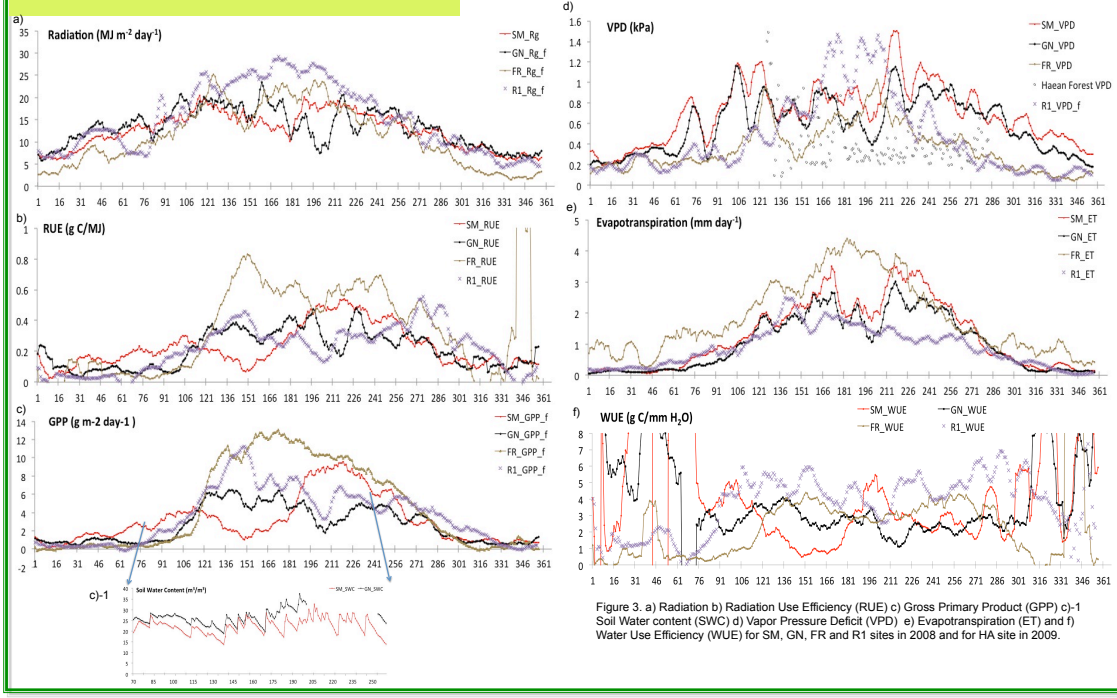


Figure 3. a) Radiation b) Radiation Use Efficiency (RUE) c) Gross Primary Product (GPP) c)-1 Soil Water content (SWC) d) Vapor Pressure Deficit (VPD) e) Evapotranspiration (ET) and f) Water Use Efficiency (WUE) for SM, GN, FR and R1 sites in 2008 and for HA site in 2009.

The observation by eddy covariance measurement of radiation, GPP and RUE in the European forests are higher than in Korea forests. Radiation input at R1 was higher than at FR, however RUE in the oak forest (FR) have the highest values. The amount of evapotranspiration (ET) is similar during the growing season between R1, SM and GN, but ET in FR is higher than at the other sites. And, GPP is strongly related to total water use by the ecosystem.

During the springtime in Seolmacheon, GPP rapidly decreased with SWC. As compared to the GN site, soil moisture in SM was relatively low, with high VPD at the same time. The young forest appears more sensitive than the old forest with respect to water limitations. WUE explains the link between carbon assimilation and water use though stomatal control by the plant. Increasing WUE in SM and GN during the monsoon season (180-220 DOY) occurs, which may relate to decreases in vpd, increased radiation use efficiency and aspects of stomatal control.

The comparison of water balances between European and South Korean oak dominated forests provides a perspective that helps to develop a general understanding of function in Asian deciduous forests, as well as potential variations in the possible controls that occur in carbon and water exchange. Further work should allow for appropriate parameterization of forest water use which aid in quantifying overall landscape water balances, as well as the links between water use and carbon gain.

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