Seasonal Variation of Carbon Dioxide Exchange in a Coniferous Forest in Korea

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- Forest influences climate through exchanges of energy, water, carbon dioxide and other chemical species with the atmosphere. Coniferous forest ecosystem is considered as a huge carbon sink.

- In Korea, a coniferous forest is one of the most important plant functional types, covering about 42% of the total forest areas of Korea (Forest Statistics, 2005).

- The influences of Monsoon climate on ecosystem carbon exchange are of great potential to the annual carbon balance (Yu et al., 2008; Hirata et al., 2008; Saigusa et al., 2008; Kato et al., 2008, Kwon et al., 2009).
The Objectives of the present study were to

(1) introduce the Gwangneung Coniferous site (GCK)

(2) characterize seasonality of net ecosystem exchange (NEE), gross primary production (GPP) and ecosystem respiration (RE) and

(3) quantify the annual carbon balance at the GCK site in 2008.
- Site name: KoFlux Gwangneung Coniferous site
- Lat. and long. & Elevation: 37° 45′ N, 127° 9′ E, 175 m.s.l
- Measurement: Nov 2006 - present
- Stand age: 93 yrs and planted
- Plant types: *Abies nephrolepis*, *A. Koreana* and *Pinus koraiensis*
- Canopy height: 23m
- Tower height: 40 m
- Soil type: Sandy loam
- Plant Area Index (PAI): 4 to 7.6
Measurements at GCK site

- Flux measurement: open path Eddy covariance system
- Vertical profile of CO$_2$ and H$_2$O concentration
- Low level eddy covariance system
- Various meteorological observations - Four components of solar radiations, Soil moisture, soil temperature, soil heat flux, precipitation
- Ecological measurements - Leaf Area Index, Leaf wetness
- Stable isotope measurements
GPP = - NEE + RE

Canopy Carbon/Water Budget

- Net Ecosystem Carbon Exchange
- Evapotranspiration
- Transpiration
  - Gross Photosynthesis
  - Leaf surface Evaporation
  - Dark and Photo Respiration
  - CO2 Storage
  - H2O

- Soil Evaporation
- Root respiration
- Microbial respiration
- Litter respiration
- Bole respiration
Evapotranspiration = Soil Evaporation + wet canopy evaporation + transpiration
Phenology Measurement: Plant area index

![Graph showing Phenology Measurement: Plant area index over DOY (Day of Year) from 2006 to 2009. The x-axis represents DOY from 0 to 360, and the y-axis represents PAI (Plant Area Index) from 0 to 10. The data points are color-coded by year: red for 2006, green for 2007, blue for 2008, and black for 2009.}
Daily energy balance closure

\[ R_n = LE + H + S + G \]

Where, \( R_n - G - S = A \) (available energy)
LE and H are latent and sensible heat fluxes
\( S = \) heat storage by trunk, leaves, biomass

\[ y = 0.9 \times x \]
\[ R^2 = 0.83 \]
Results - meteorological variables

Avg. annual Temp 11.3 °C
Annual sum PPT 1395 mm
Results - seasonal variations of NEE, GPP and RE

GPP = - NEE + RE

Source

Sink

Mid season depression of NEE
Results - seasonal variations of NEE, GPP and RE

NEE, GPP, RE (g C m\(^{-2}\) season\(^{-1}\))
Annual budget of NEE, GPP and Re

Cumulative NEE, GPP, RE (g C m$^{-2}$ yr$^{-1}$)

Day of Year (DOY)

-192 g C m$^{-2}$ yr$^{-1}$

1464

1273
Result – Mid season depression of Evapotranspiration
Relation between Environmental Variables and Carbon budget

\[ Y = 0.74x + 622.82 \quad R^2 = 0.60 \]

\[ Y = 0.46x + 654.41 \quad R^2 = 0.33 \]

\[ Y = -0.18x - 102.4 \quad R^2 = 0.47 \]

\[ Y = 0.74x + 622.82 \quad R^2 = 0.60 \]

\[ Y = 0.46x + 654.41 \quad R^2 = 0.33 \]

\[ Y = 0.46x + 654.41 \quad R^2 = 0.33 \]
The seasonality of the individual components (i.e., GPP, NEE and RE) showed clear variation with strong carbon uptake in spring.

The seasonal variation of GPP and NEE showed clear mid-season depression but RE did not.

Mid-season depression of GPP and NEE was attributed mainly by decreased in radiation. Thus ecosystem became carbon source in the middle of growing season.

The annual budget of GPP, NEE and RE were 1464, -192 and 1273 g C m$^{-2}$ yr$^{-1}$, respectively, and coniferous forest acted as a moderate carbon sink.

Future study

We will further examine interannual variability of carbon exchange under Asian monsoon climate and driving mechanism of interannual variability of carbon exchange.
Thank You!