Development of gross primary production algorithm based on plant's photosynthesis capacity and a canopy conductance index using flux and global observing satellite data

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Backgrounds

GCOM-C1 (Global Change Observation Mission -Climate 1) by JAXA un 2016.
SGLI (Second generation Global Imager)
SGLI : 250m spatial resolution of 380, 412, 443, 530, 670, 763, and 865 nm
We have a plan to estimate GPP using GCOM-C1/SGLI data with the method based on satellite observation

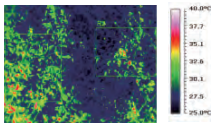
Framework of GPP estimation algorithm

Algorithm characteristics
Correspond to photosynthesis process
Photosynthesis velocity = Capacity x Depression
Use light response curves
Estimate directly GPP, not use LAI

stomatal opening and closing
GPP with less stress

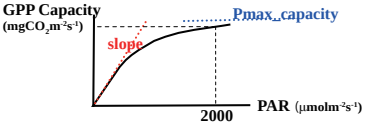
GPP depression estimation with thermal image

Measurements in the fields
Leaf: photosynthesis velocity
stomatal conductance
leaf brightness temperature
Canopy: Canopy temperature using thermal imager



GPP capacity estimation algorithm

[Thanyapraneedkul et. al, 2013]

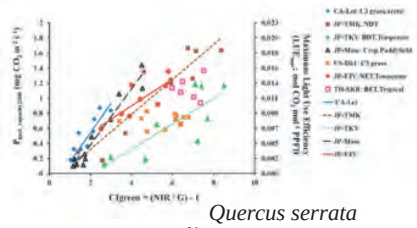


$$GPPcapacity = \frac{slope \times P_{max\_capacity} \times PAR}{1 + slope \times PAR}$$

Plant functional type	Flux site	α_{slope}	a	b
Needleleaf deciduous trees	JP_TMK	0.0016	0.232	-0.148
Broadleaf deciduous trees, temperate	JP_TKY	0.0023	0.169	-0.351
Needleleaf evergreen trees, temperate	JP_FJY	0.0014	0.180	0.183
C3 grass, arctic	CA_Let	0.0029	0.435	-0.255
Crops (paddy field)	JP_Maize	0.0017	0.371	-0.359

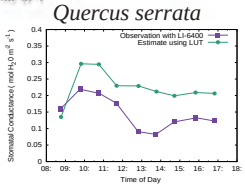
GPPcapacity_2000=a×CIgreen+b
CIgreen＝NIR/Green -1

[Gitelson et. al, 2006]



For a leaf
Stomatal conductance estimation
using Baldocchi(1994) model.
calculate thermal balance (leaf temperature) --> stomatal conductance, photosynthesis velocity
Make Look Up Tables using Baldocchi(1994) model
input : Leaf temperature, PAR
VPD (or Air temperature, Humidity)
output: Stomatal conductance

Quercus serrata



Daily change patterns : O.K.
Absolute values had pedestals.

How to solve the problem of the pedestal and to develop scaling up method for a canopy, and, How to estimate GPP from GPP capacity with conductance information.

Data Used in this study

i) Flux data in 2007 Open shrubs: US-Ses:

GPP capacity estimation formula of open shrub was the same as that of Grass.

US-Ses: Desert shrub land
Open shrub land(IGBP)

ii) Satellite data
MODIS reflectance data (MOD09A1) in 2007
(MODIS Land Subsets)

Methods

GPP capacity calculation from MODIS and PAR data
The grass formula was used.
For Grass: Pmax_capacity2000= 0.435× CIgreen −0.255, slope=0.0029

Canopy conductance from Flux data

[Penman-Monteith Eq. (Monteith, 1973)]

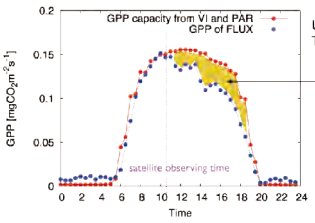
$$\lambda E = \frac{\Delta(R_n - G) + \rho C_p g_a (e_s(T_a) - e_a)}{\Delta + \gamma\left(1 + \frac{g_a}{g_c}\right)}$$

g_a:boundary layer conductance
g_c:Canopy conductance
$es(Ta)$: saturated steam pressure at air temperature Ta
es:air steam pressure
Δ:the slope of the saturated steam pressure curve
Rn: net radiation
G: soil Flux
ρ: air density
Cp:specific heat at constant air pressure
γ:the dryness and moisture coefficient

Results

i) GPP capacity and GPP

AmeriFlux US-Ses site, 2007 May 16-31



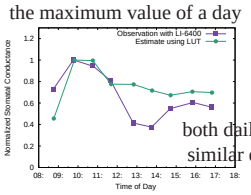
Until 10:30 : almost same values
Then GPP was depressing

16% of GPP capacity

The condition of less stress
GPP capacity :
the first approximation
of GPP

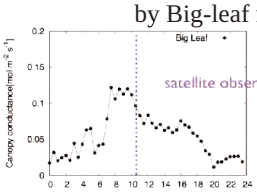
ii) Stomatal conductance

The stomatal conductance was normalized using the maximum value of a day



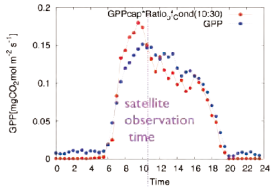
both daily changes were similar each other

iii) Canopy conductance by Big-leaf model



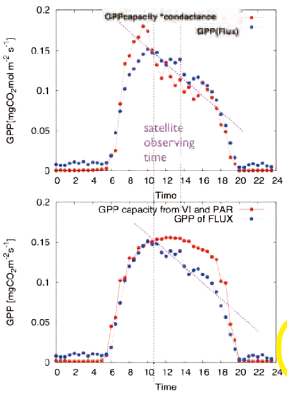
Canopy conductance normalized using the value at satellite obserbation time: Conductance factor

GPP capacity×Conductance factor was compared with Flux's GPP.



Discussions

Canopy conductance index
for scale-up to satellite level



MODIS observes
at around 10:30 and 13:30.
Surface temperature.

the conductance factor
at 10:30 and 13:30 of satellite observation time
—> slope of the conductance factor

The slope and GPP capacity
-> GPP will be able to estimate.

The slope :
"Canopy conductance index"

Conclusions:

GPP capacity multiplied by the "canopy conductance factor" was compared with GPP of Flux. The slope of canopy conductance factor at 10:30 to 13:30 → "canopy conductance index" It is needed to develop the method to calculate LUT for canopy conductance index.

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Flux site data was provided by AmerFlux on US-Ses site.