Gross primary production algorithm development and validation

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Framework of GPP estimation

Characteristics of the algorithm

Correspond to photosynthesis process

- Photosynthesis velocity = Capacity x depression
- Use light response curves
- Estimate directly GPP, not use LAI

stomatal opening and closing

Photosynthesis process:
only the light exposure area

photosynthesis process

Light reaction

light → chlorophyll → Chemical energy

~ amount of absorbed light

chlorophyll contents, light intensity

plant physiological parameter

related to color

$f_{capacity}$ (PAR, chlorophyll)

Carbon fixation

Calvin cycle → Carbon fixation

stomata ← CO_2

~ amount of absorbed CO_2

stomatal opening and closing, Weather, soil moisture

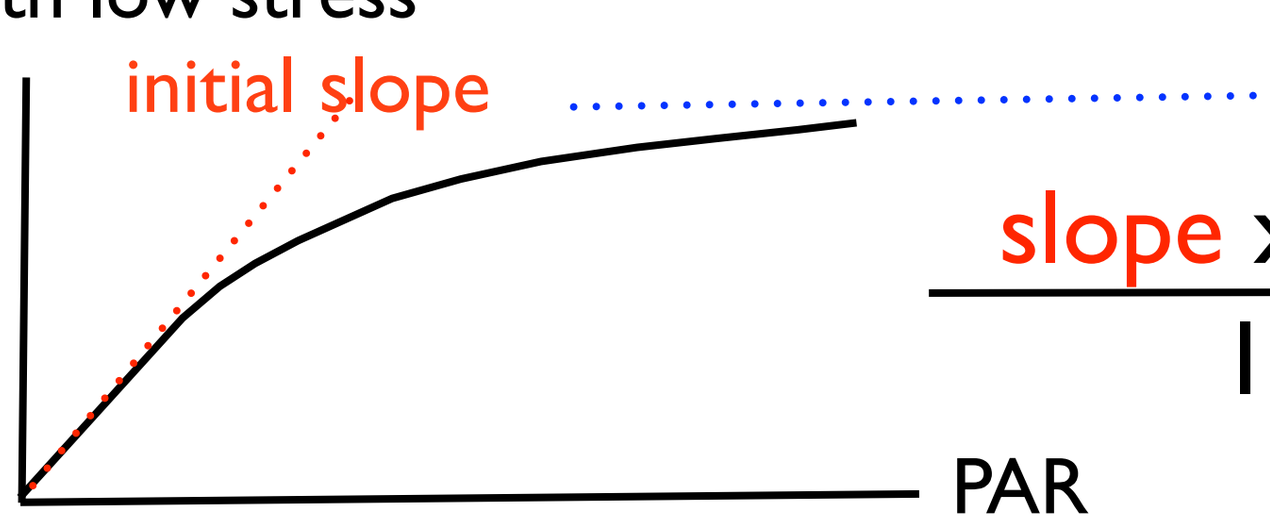
plant physiological actions

gas exchange is controlled

$f_{stomata}$ (xxx, xxx, •••)

GPP capacity estimation framework

photosynthesis
velocity with low stress



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

From the plant physiological study
For a leaf
Initial slope: efficiency of light conversion to carbon
related to chlorophyll contents
$P_{max\_capacity}$: volume of chloroplasts [Ono et. al, 1995, Oguchi 2003]

$P_{max\_capacity}$ related to chlorophyll contents ↔ CIgreen=G/NIR -1.

[Gitellson et. al, 2006]

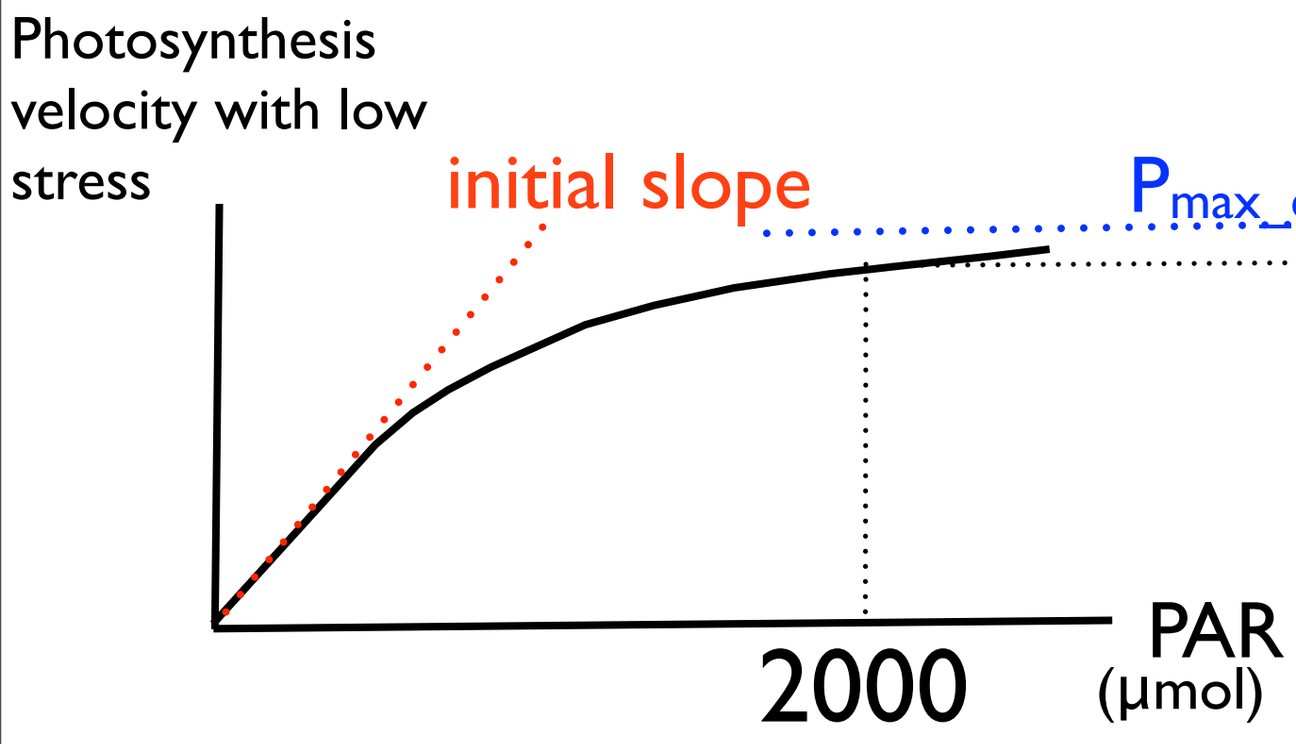
Characteristics of CI_{green}(=NIR/G-1)

Results from Previous study

i) High sensitivity to Chlorophyll contents：Green＞Red

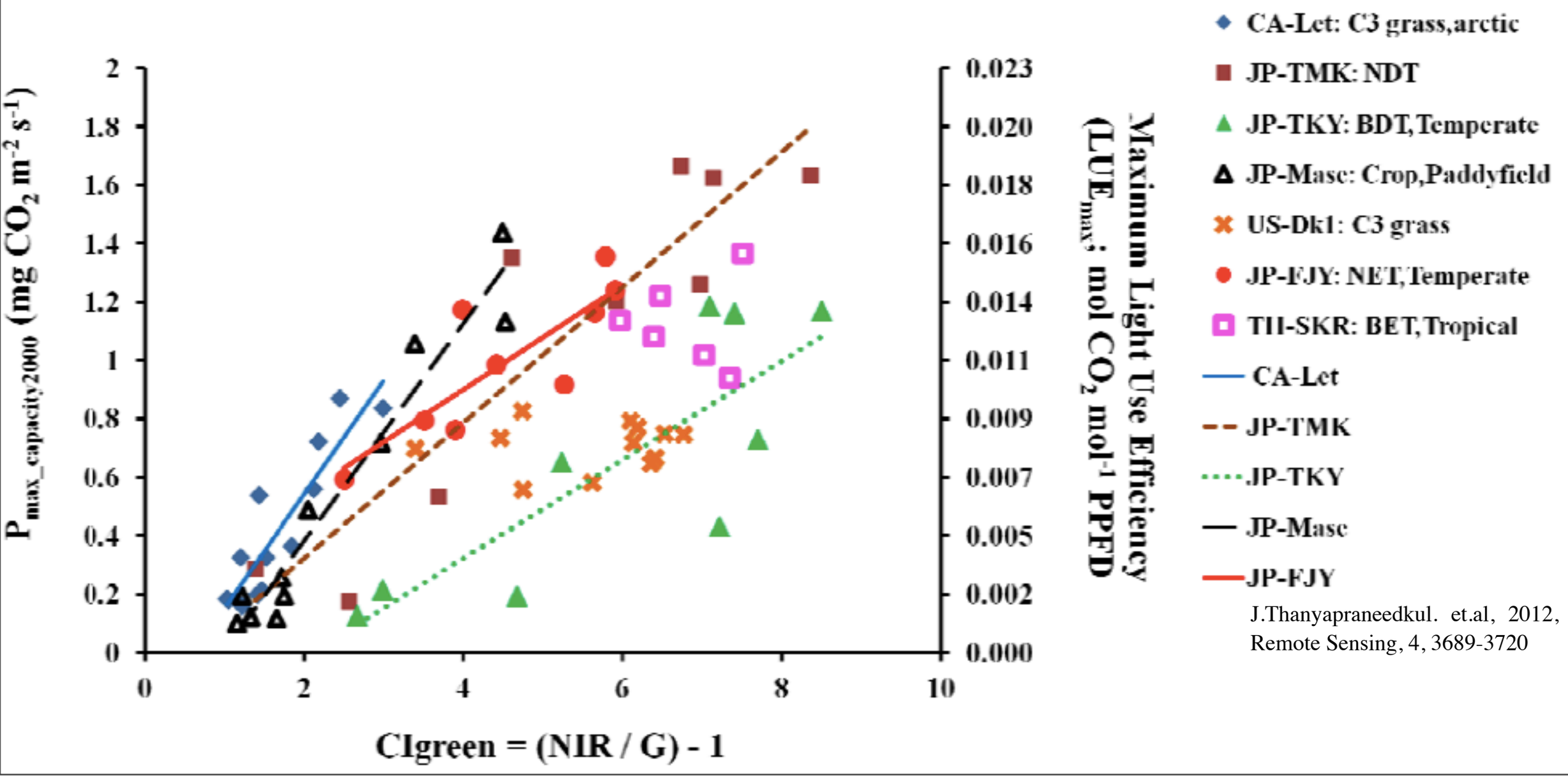
ii) Linear relationship with Chlorophyll contents of a leaf

iii) Linear relationship with Pmax_capacity_2000



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

Previous study
Pmax_capacity2000 vs. CIgreen
for each vegetation functional types



J.Thanyapraneedkul. et.al, 2012, Remote Sensing, 4, 3689-3720

GPP capacity estimation :

Class	
Water	
Evergreen Needleleaf Forest	
Evergreen Broadleaf Forest	
Deciduous Needleleaf Forest	
Deciduous Broadleaf Forest	
Mixed Forests	
Closed Shrublands	
Open Shrublands	
Woody Savannas	
Savannas	
Grasslands	
Permanent Wetlands	
Croplands	
Urban and Built-Up	
Cropland/Natural Vegetation Mosaic	
Snow and Ice	
Barren or Sparsely Vegetated	
IGBP Water Bodies	
Tundra	
Unclassified	
Fill Value	

EF

DNF

DBF

DBF

Grass ???

PF

Parameters determined mainly using Japan FLUX

Use Grass parameters

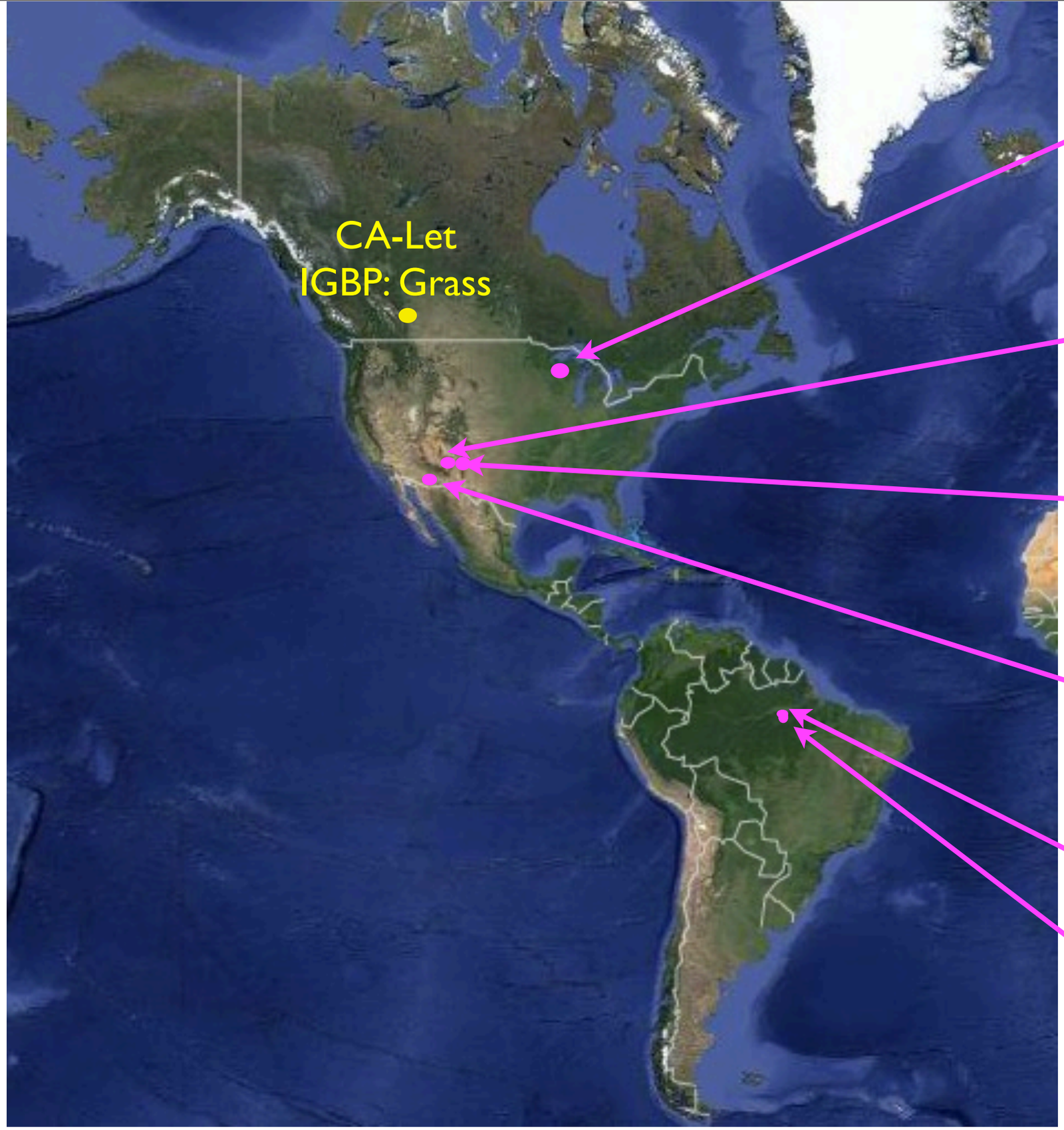
Open Shrub ?

Closed Shrub ?

Evergreen Broad Leaf forests ?

Amazon

Study site , this year



US-Los: ハンノキ,湿地

IGBP: Closed shrub bland

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

US-Wjs: Savanna（EGF）

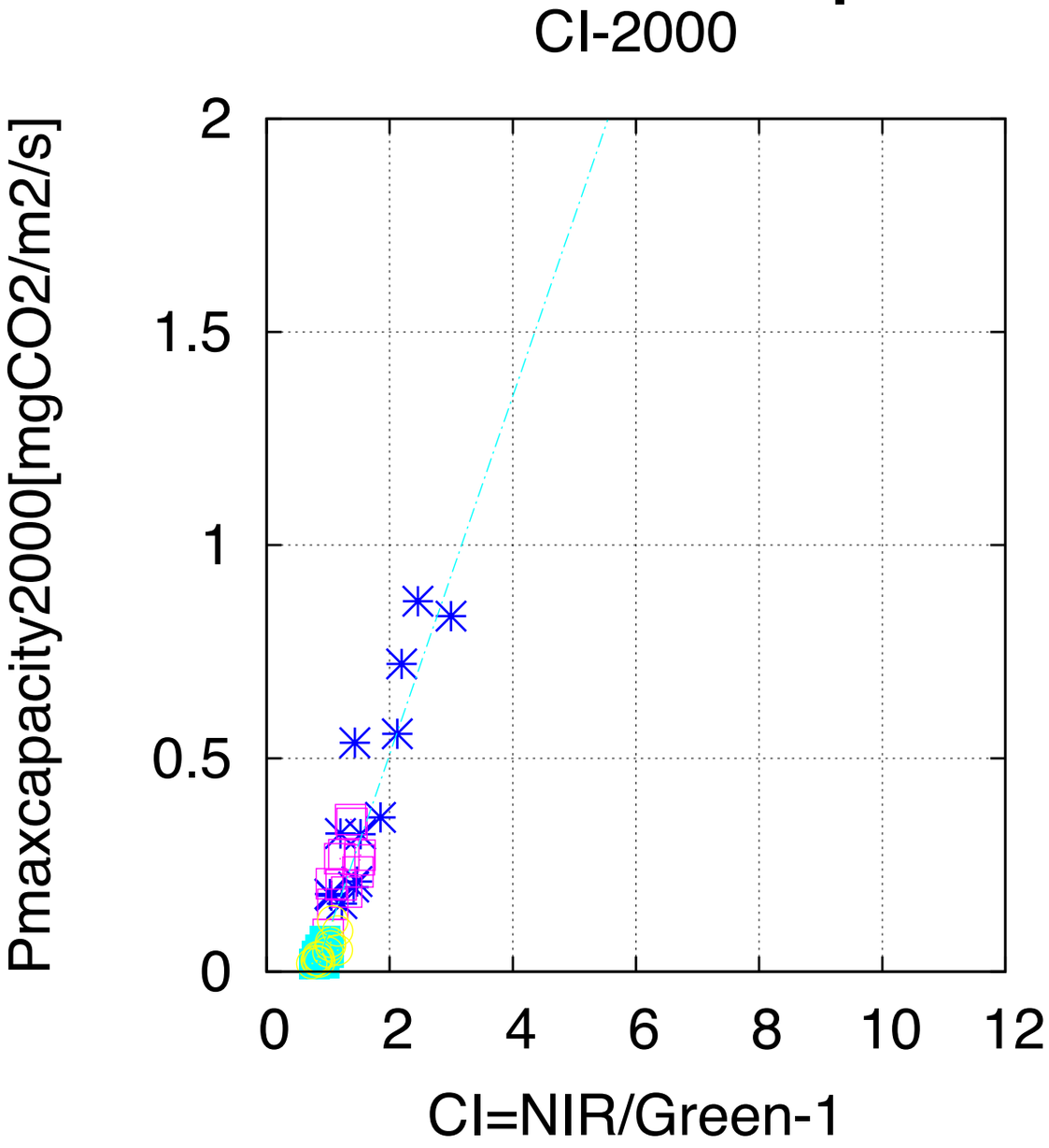
IGBP: Open shrub land

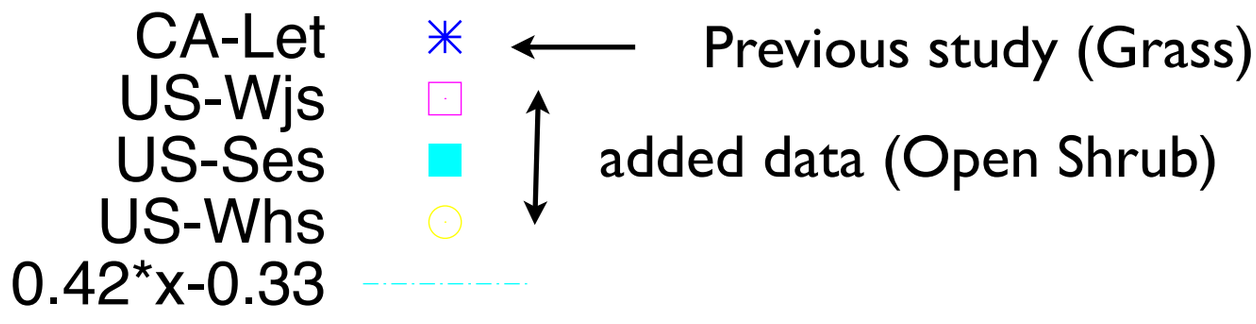
US-Whs: Grazing area
IGBP: Open shrub land

Km67: natural Forest
IGBP: EBF

Km83: Logged Forest
IGBP: EBF

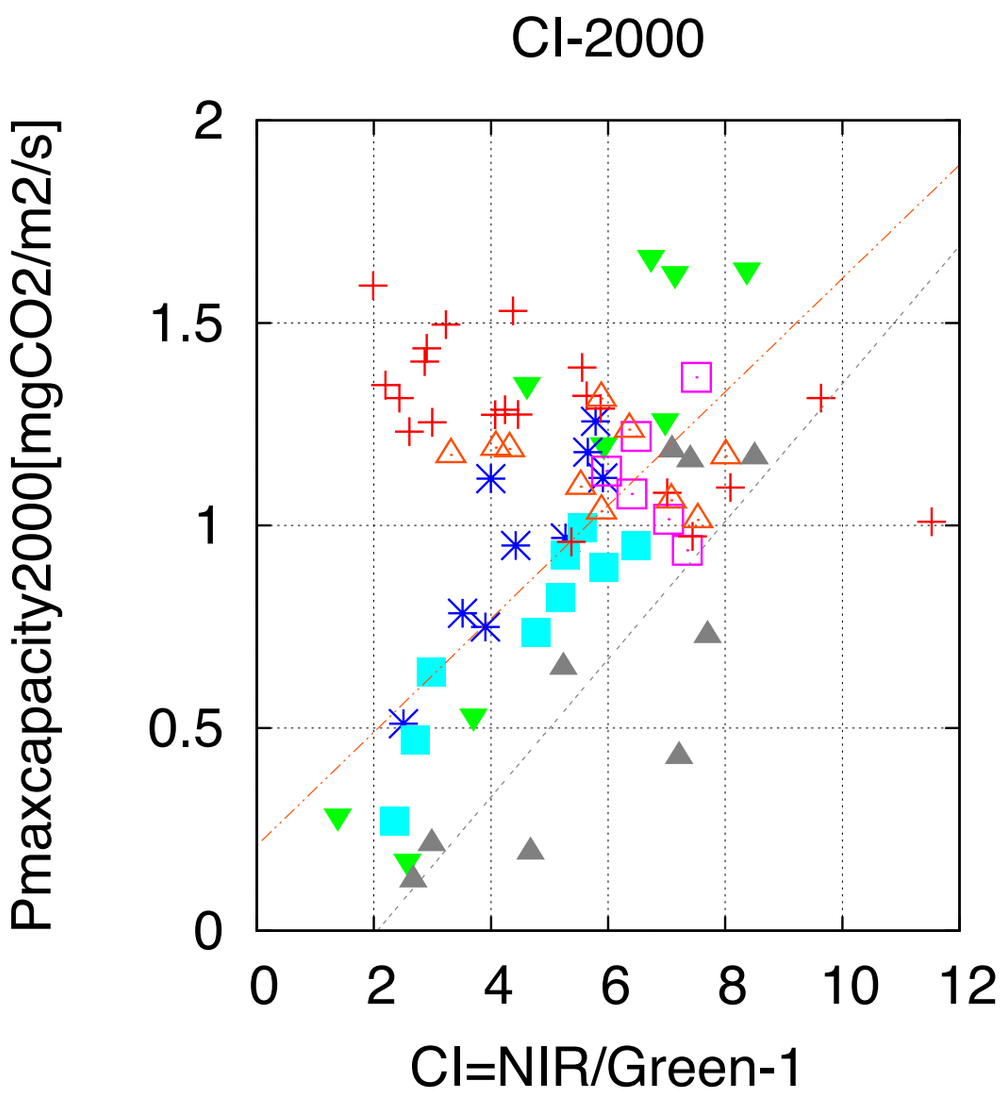
Open shrub and GRASS

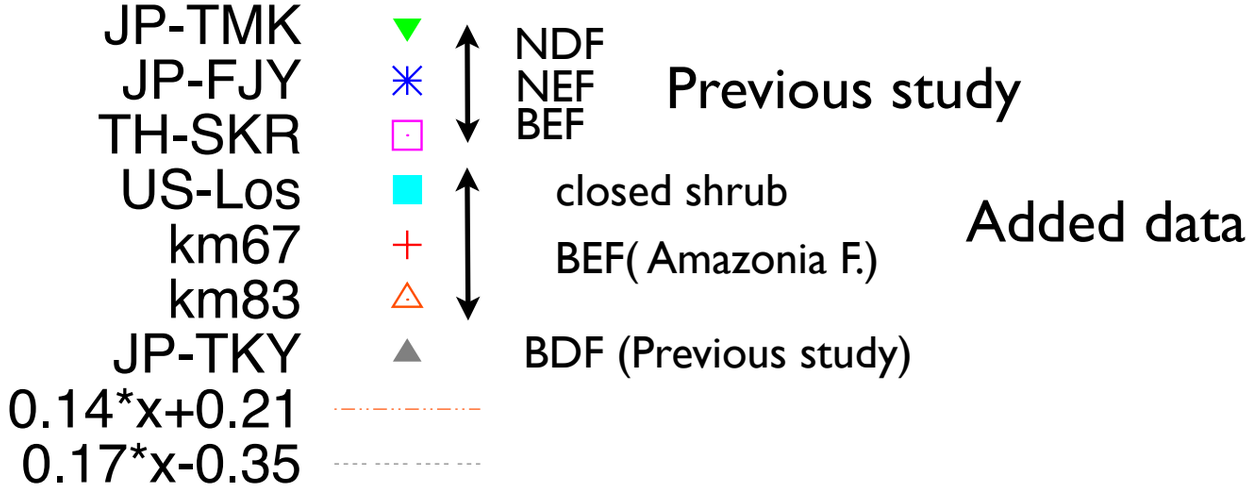




Grass (CA-Let) and Open shrubs (US-Wjs, US-Ses, US-Whs)
On the same line

Closed shrub and Amazonia Forest (EBF)





Amazonian Forest:　Pmax_capacity_2000 has almost constant value

Except for Amazonian Forest

On the same line

US-Los(Closed shrub), JP-FJY(ENF), JP-TMK (DNF), TH-SKR(EBF)

Another line

JP-TKY

Slopes of them are the almost same value

The relationship between CI vs. Pmax_capacity_2000
Three vegetation groups

1) Grass and Shrubs
2) Woody plant except for Amazonian Forest
3) Amazonian Forest

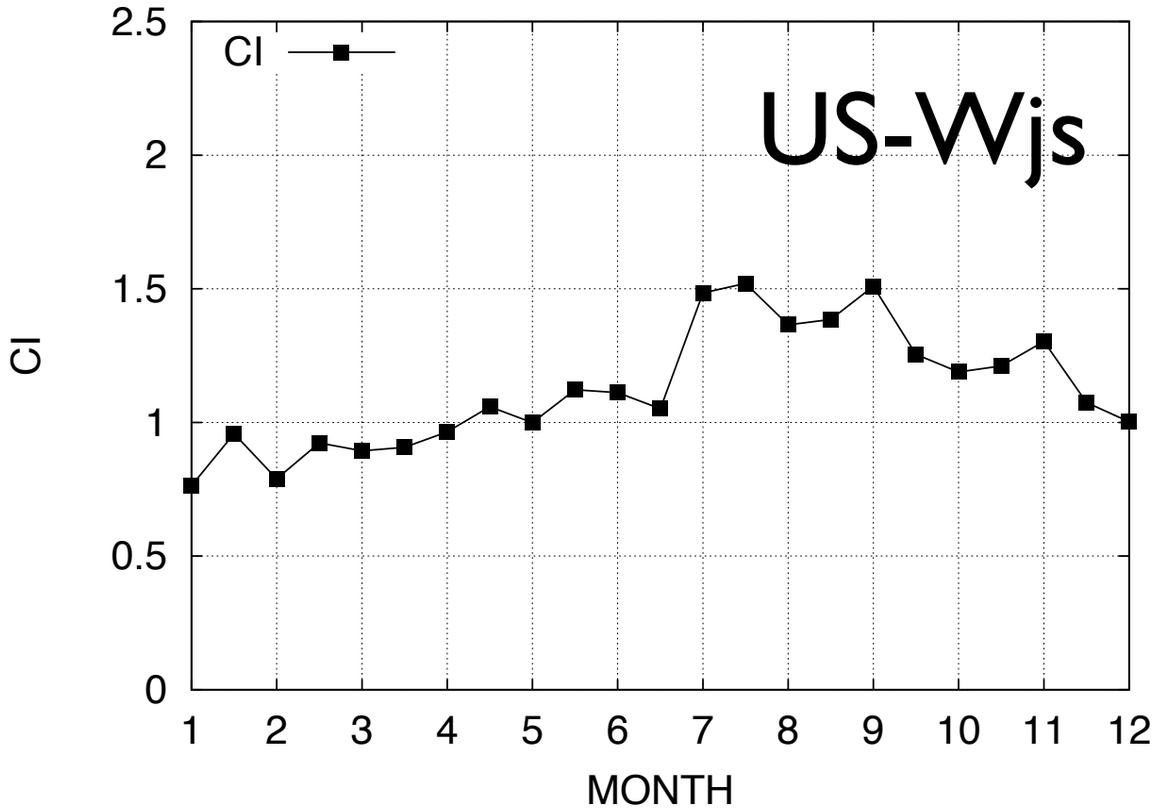
In the same group:

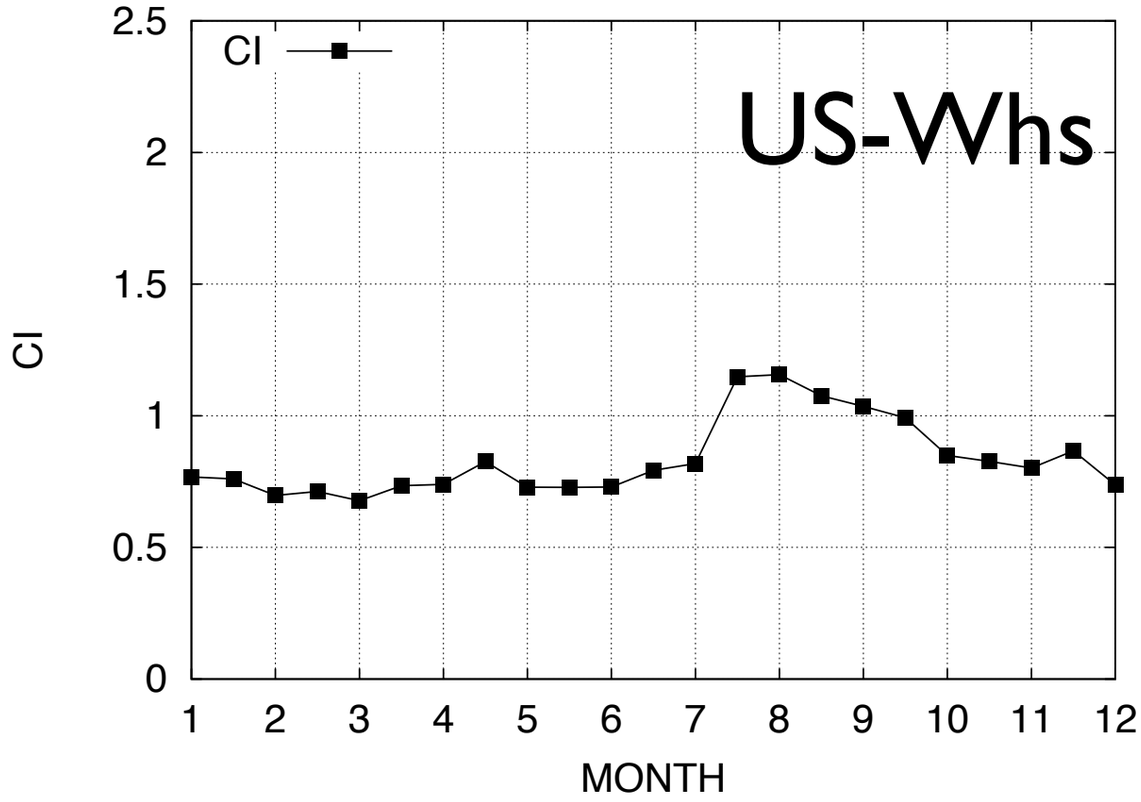
The slope are almost same values

↓

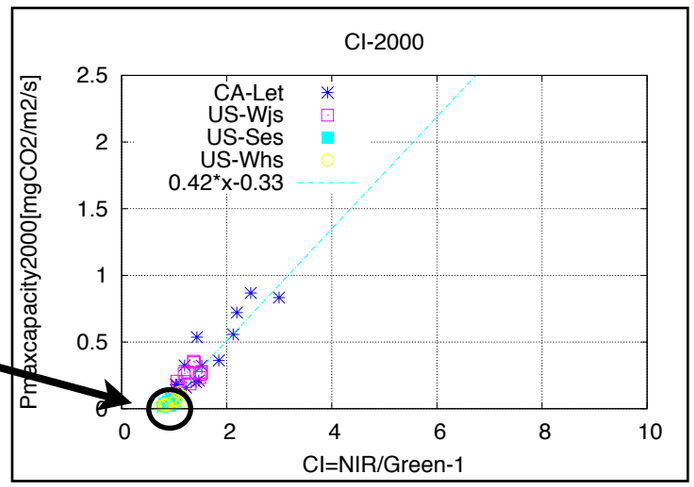
If there is the determination rule of the intercept,
determination of parameters can be generalized.

CI seasonal changes of Shrubs



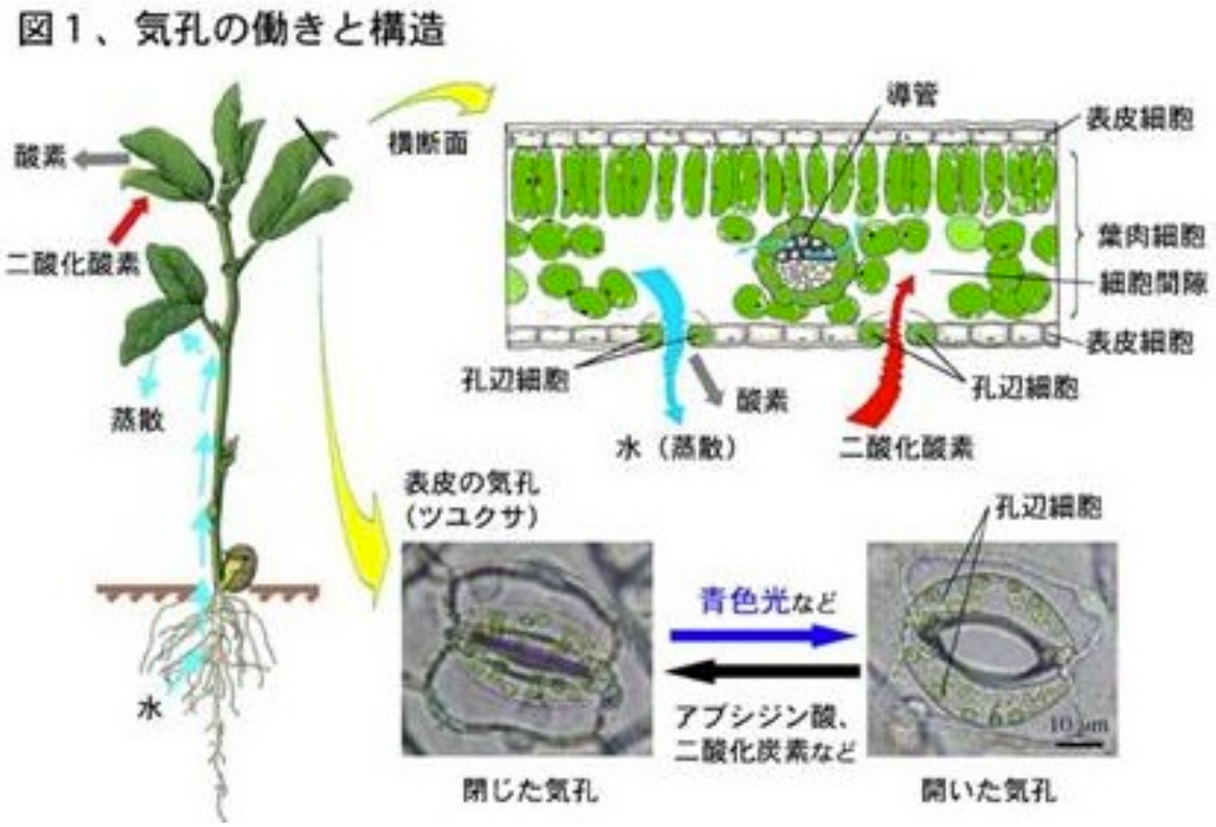


Not growing season's CI value is this start point



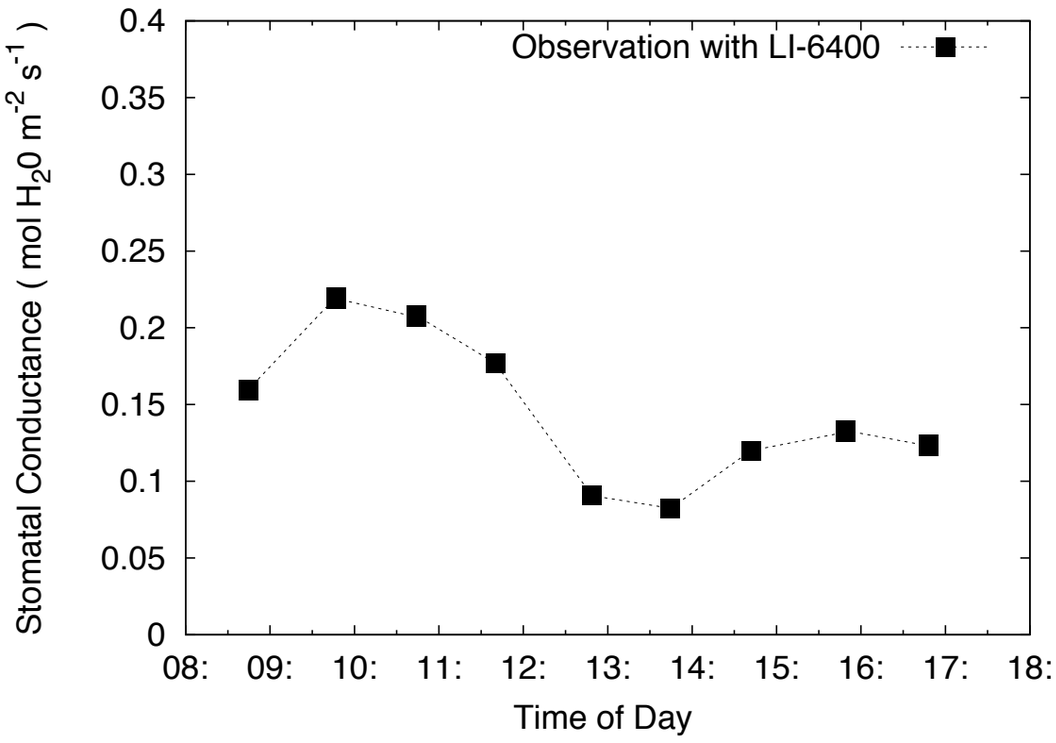
For Woody plant group: considering

Stomata opening closing



http://www.jspp.org/17hiroba/kaisetsu/kinoshita.html

Daily change of stomatal conductance



Gas exchange is controlled by stomata opening and closing.

When absorbing CO_2, H_2O is evapolated

→ Leaf temperature rising is suppressed

At Takayama (Gifu, Pref.) and Ymashiro (Kyoto Pref.) site

For three vegetation species: ミズナラ•ダケカンバ•コナラ

Quercus crispula, Betula ermanii, Quercus serrata

Leaf : Measurements

Photosynthesis

Leaf Temperature :

Thermal imager

Brightness thermometer

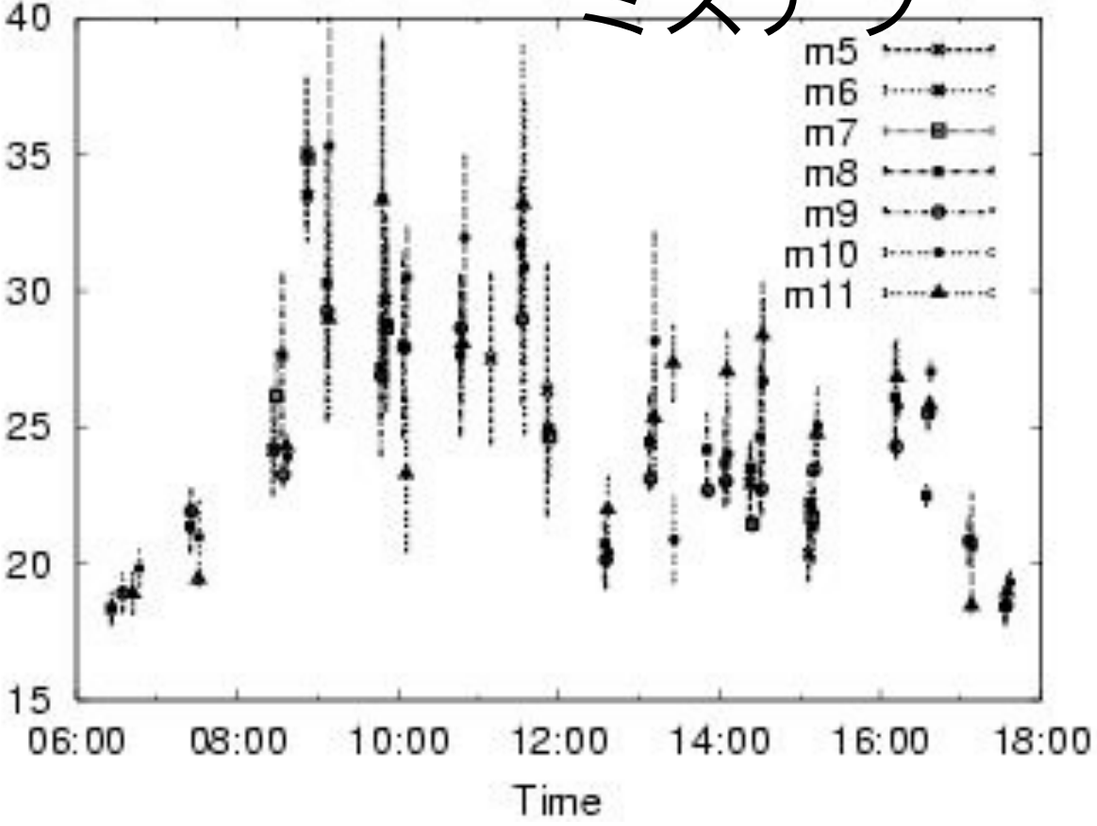
Canopy: Measurements

Canopy temperature:

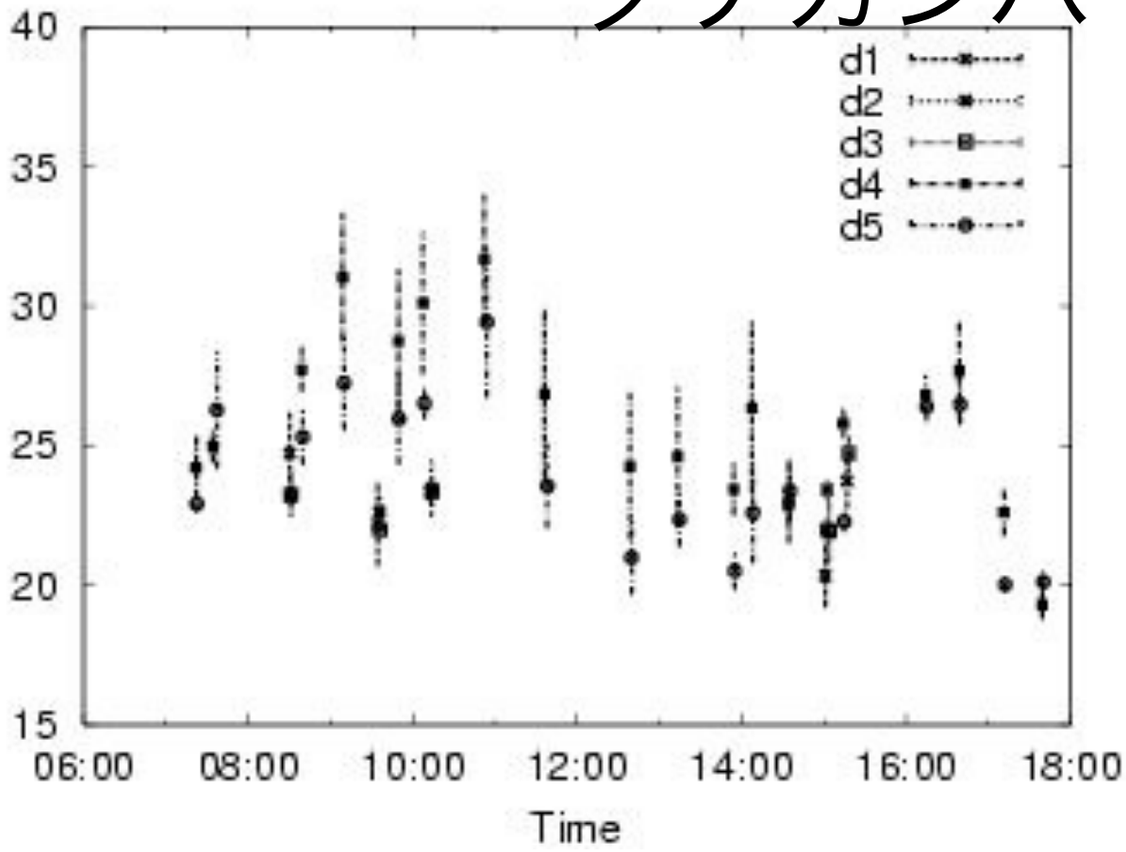
Thermal imager

Daily change of leaf temperature

Quercus crispula
ミズナラ



Betula ermanii
ダケカンバ



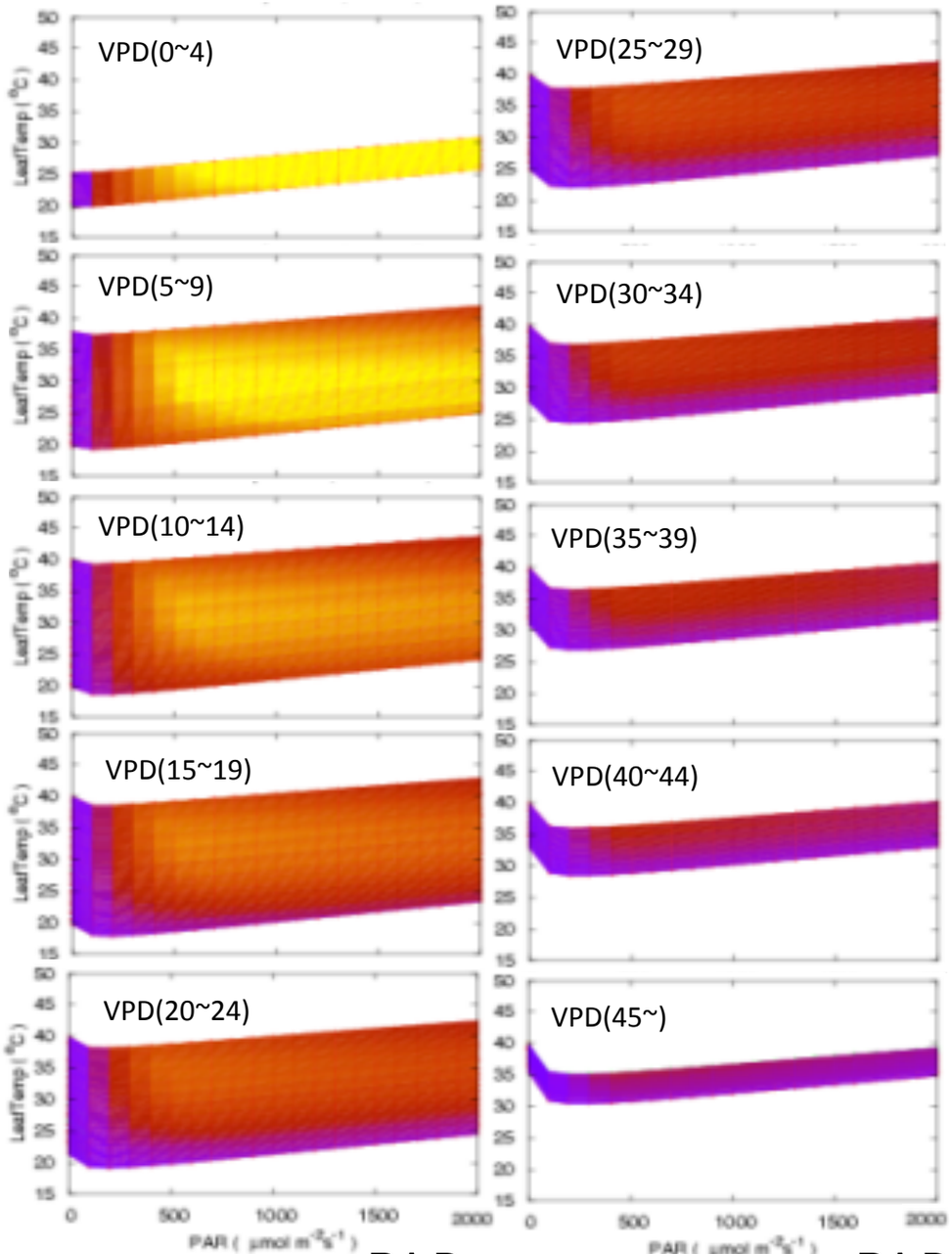
The relationship among conductance, leaf temperature, weather conditions (air temperature, humidity, solar radiation)

Calculate LUT using the moel[Baldocchi,1994]

LUT

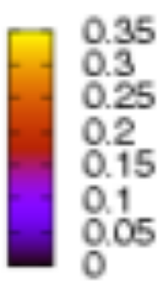
VPD:Vapor pressure deficit (kPa)

quercus serrata コナラ

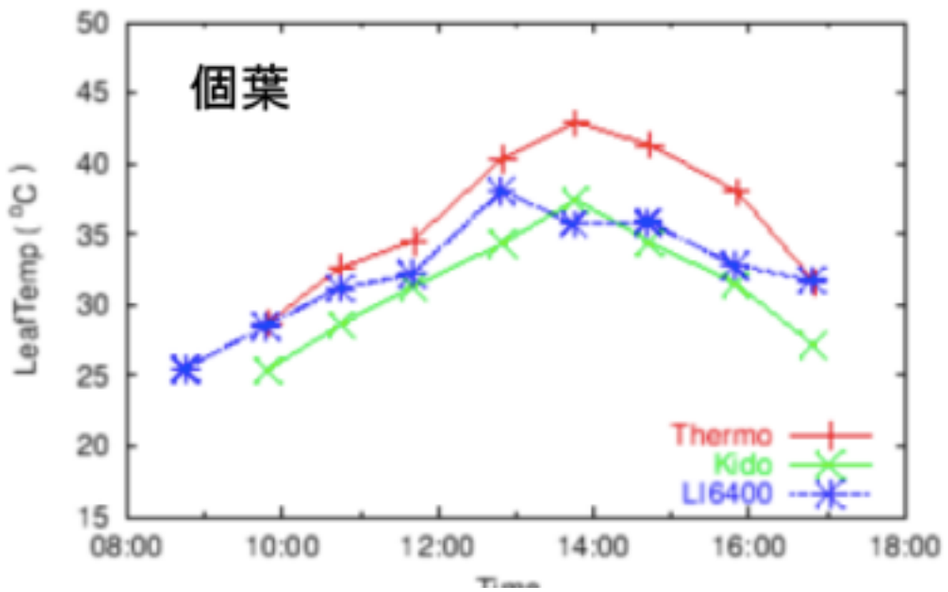


PAR PAR

stomata conductance
(mol $H_20m^{-2}s^{-1}$)

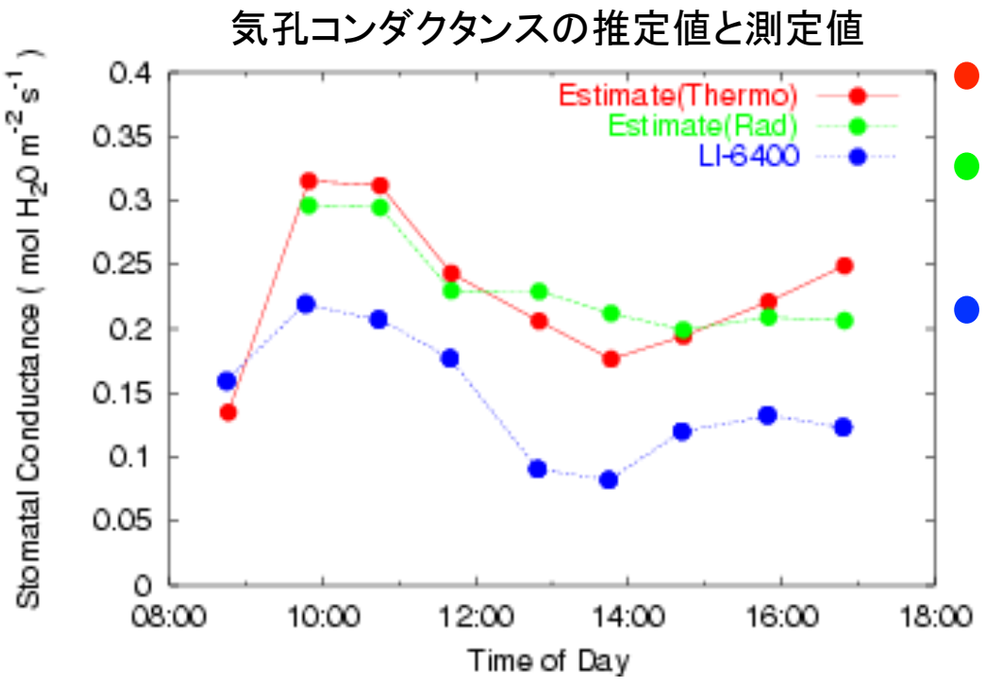


Leaf temperature



- Thermal imager
- Brightness thermometer
- Thermocouple (LI6400)

Estimation results of stomatal conductance



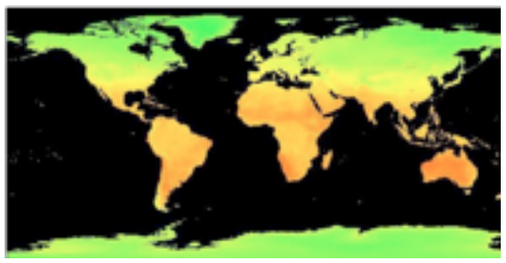
- Thermal imager
- Brightness thermometer
- Measurements (LI6400)

Pattern : O.K.
Absolute values: Calibration

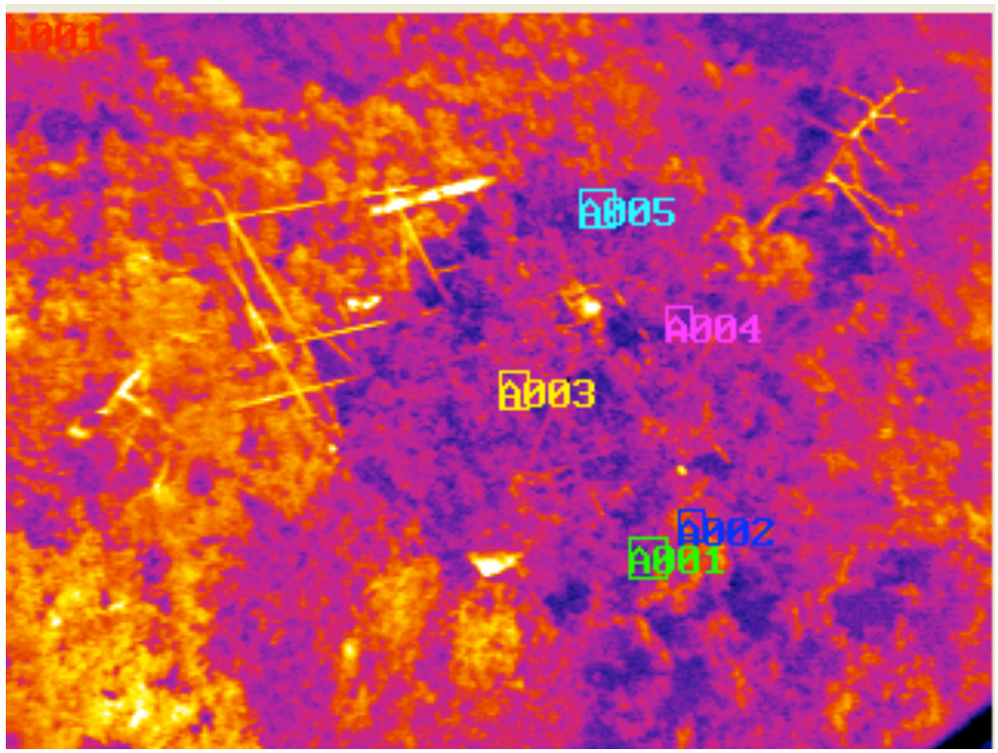
This year:

Continue the field measurements
for scaling up from leaf to canopy
at Takayama and Yamashiro site

MODIS data analysis
for scaling up from canopy to satellite
Using MODIS11C3 products
(monthly averaged daily LST data)

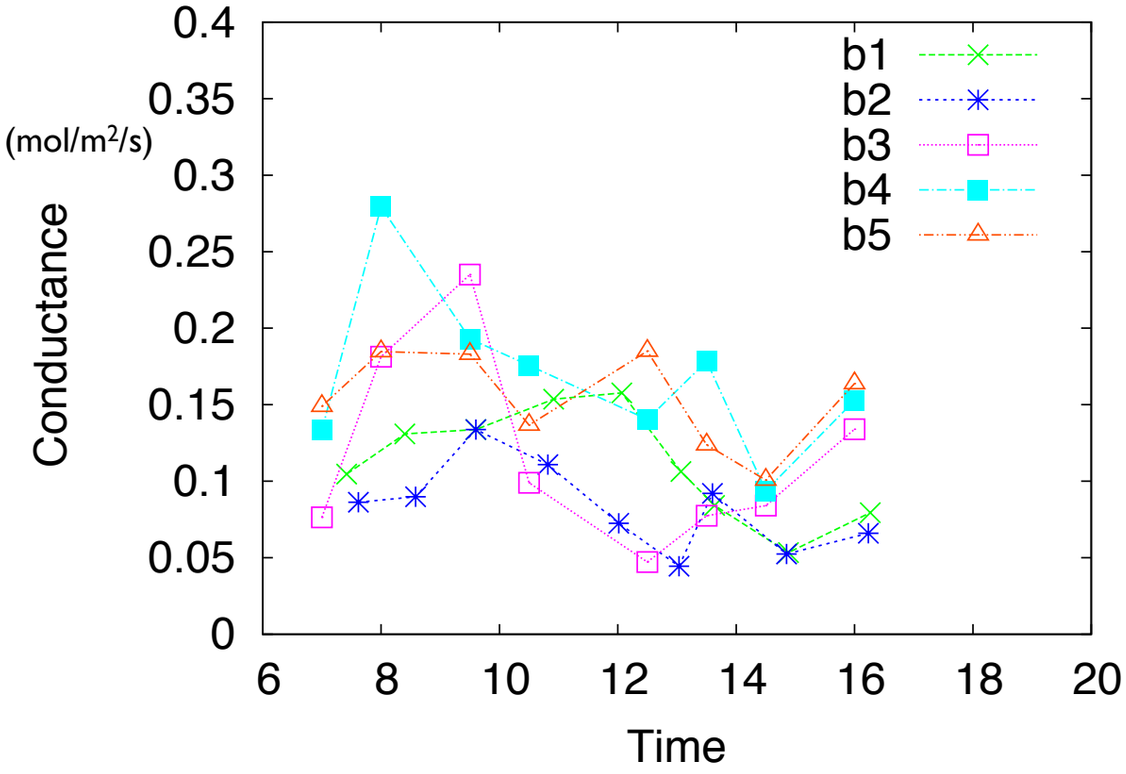


Example of field measurements at Yamashiro site

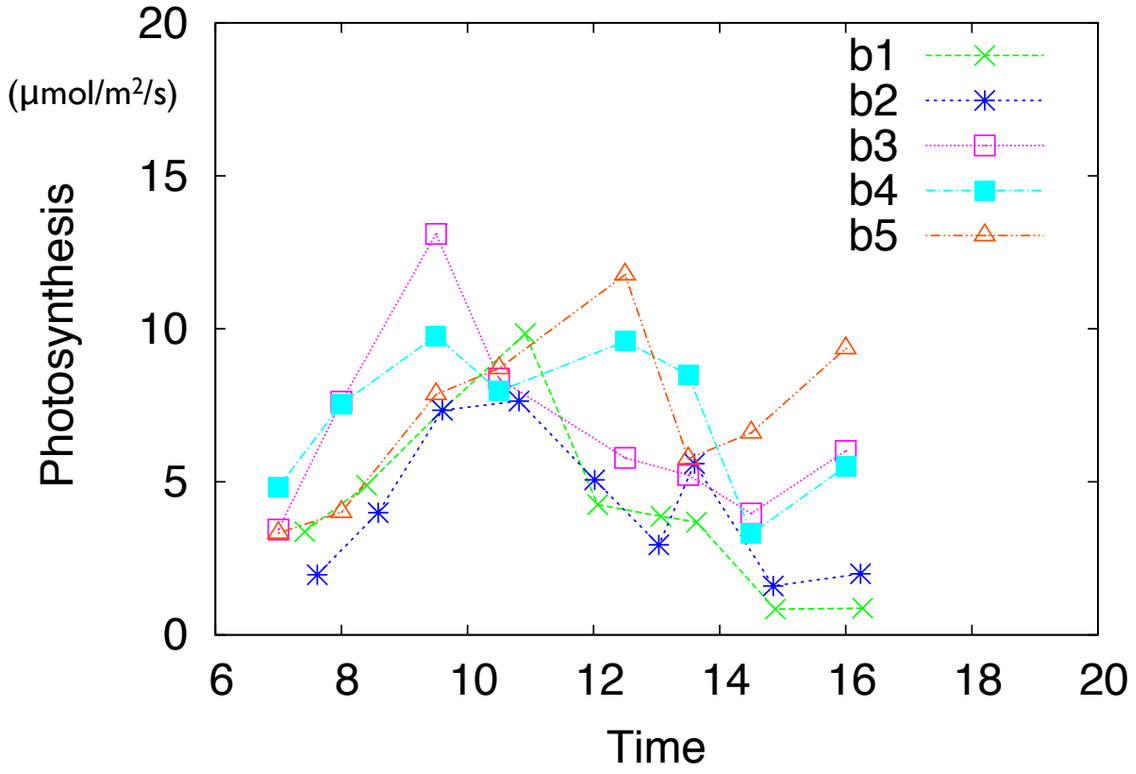


5 branches:
daily change of photosynthesis measurement

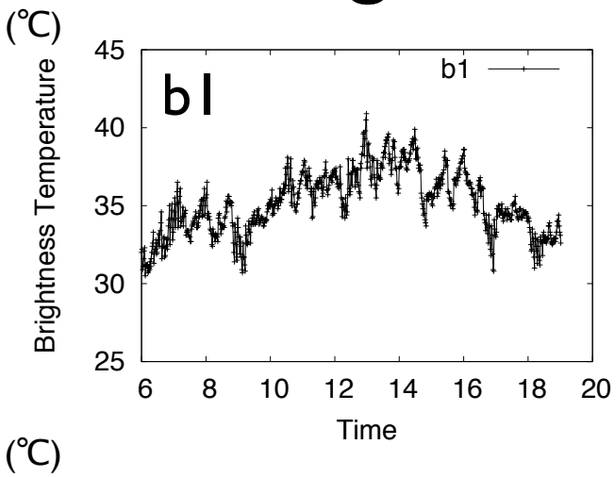
Stomatal conductance

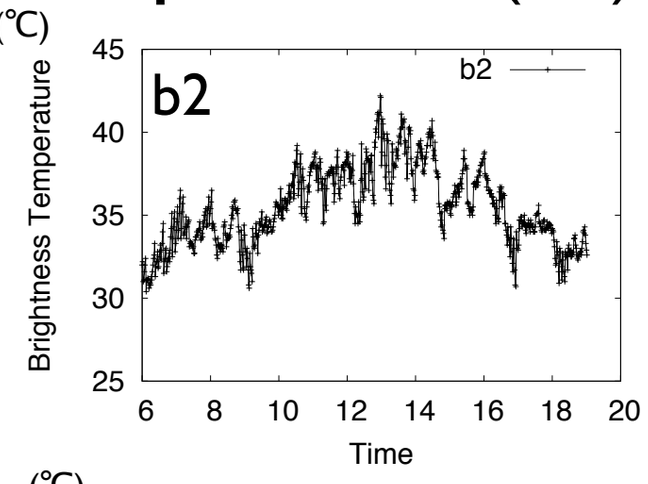


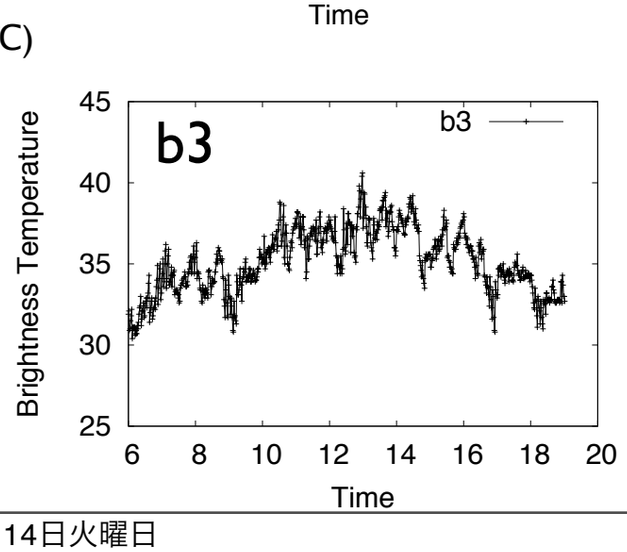
photosynthesis

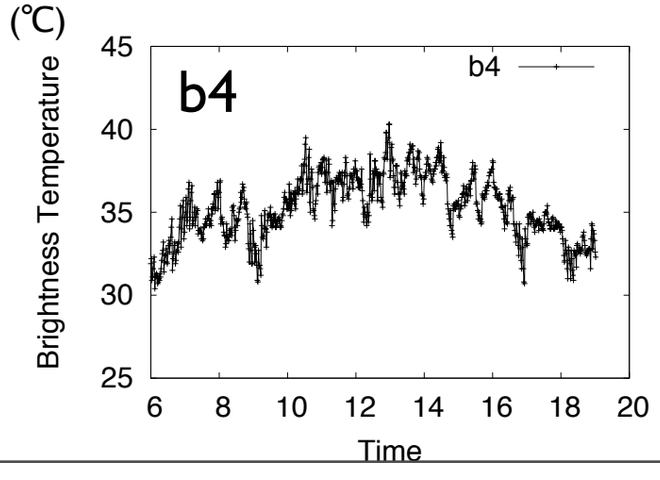


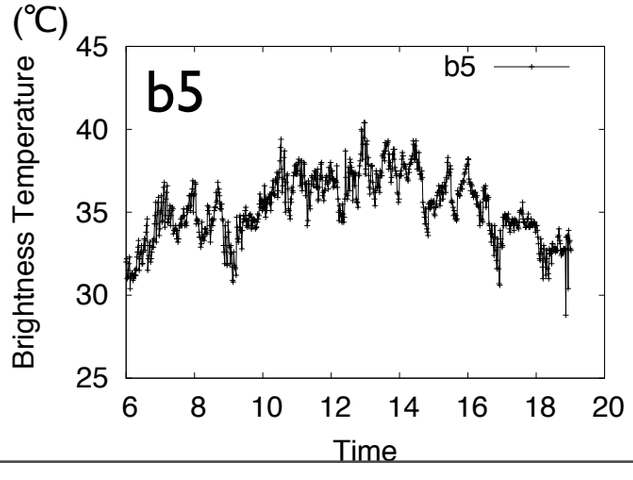
Brightness Temperature (℃)











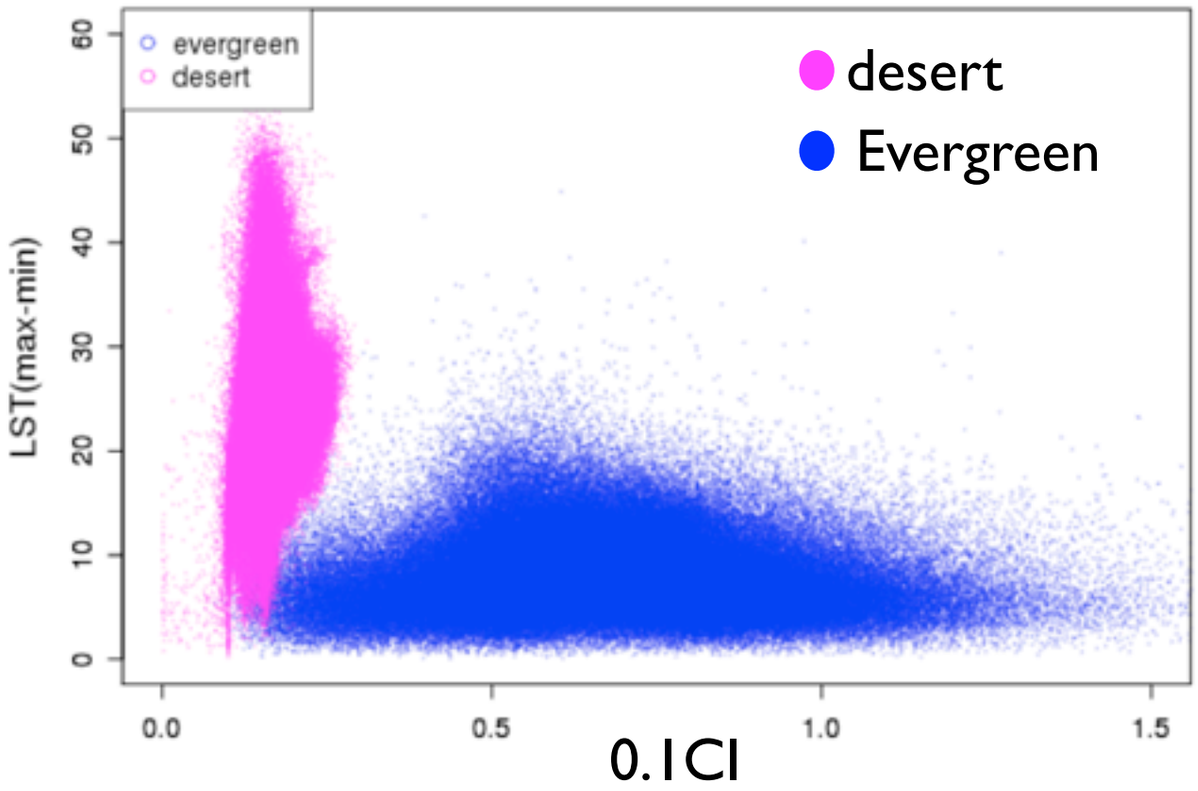
LUT is checked using these data.

MODIS data analysis

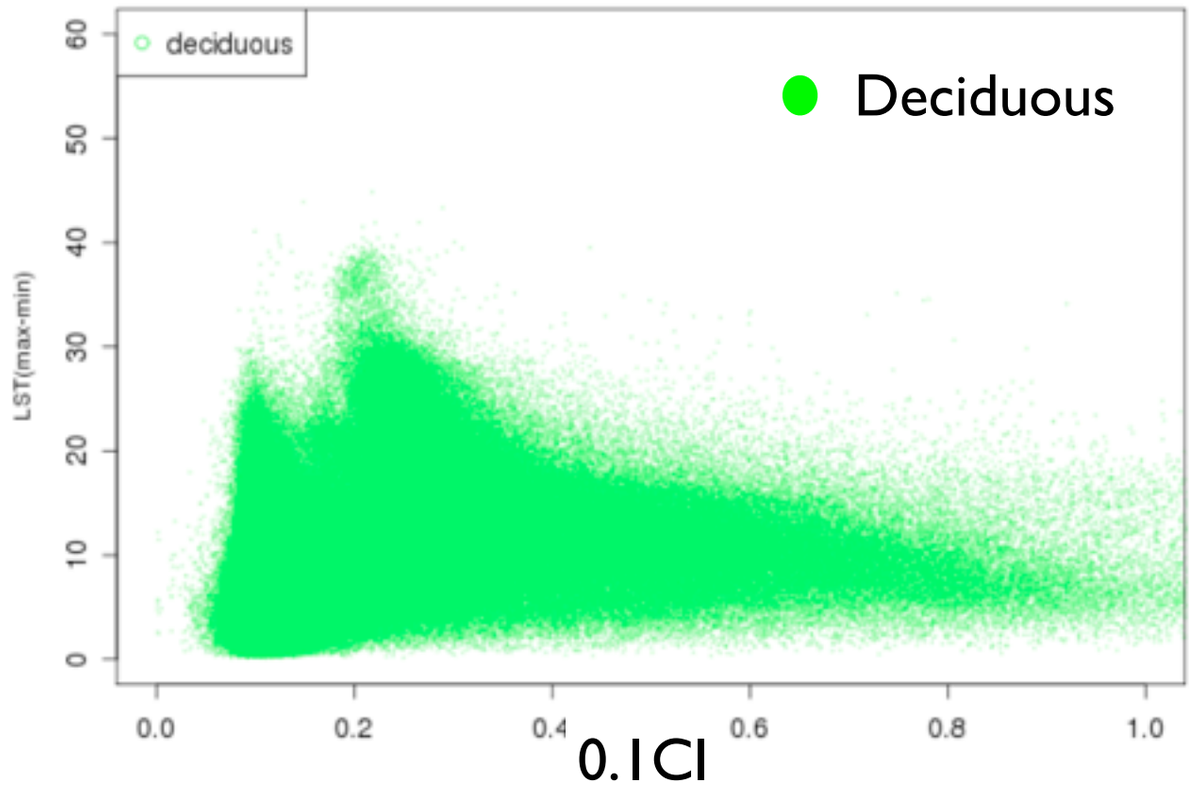
study the daily variation range of surface temperature for evergreen and deciduous types

MODIS daily variation of LST(max.-min.) vs. CI

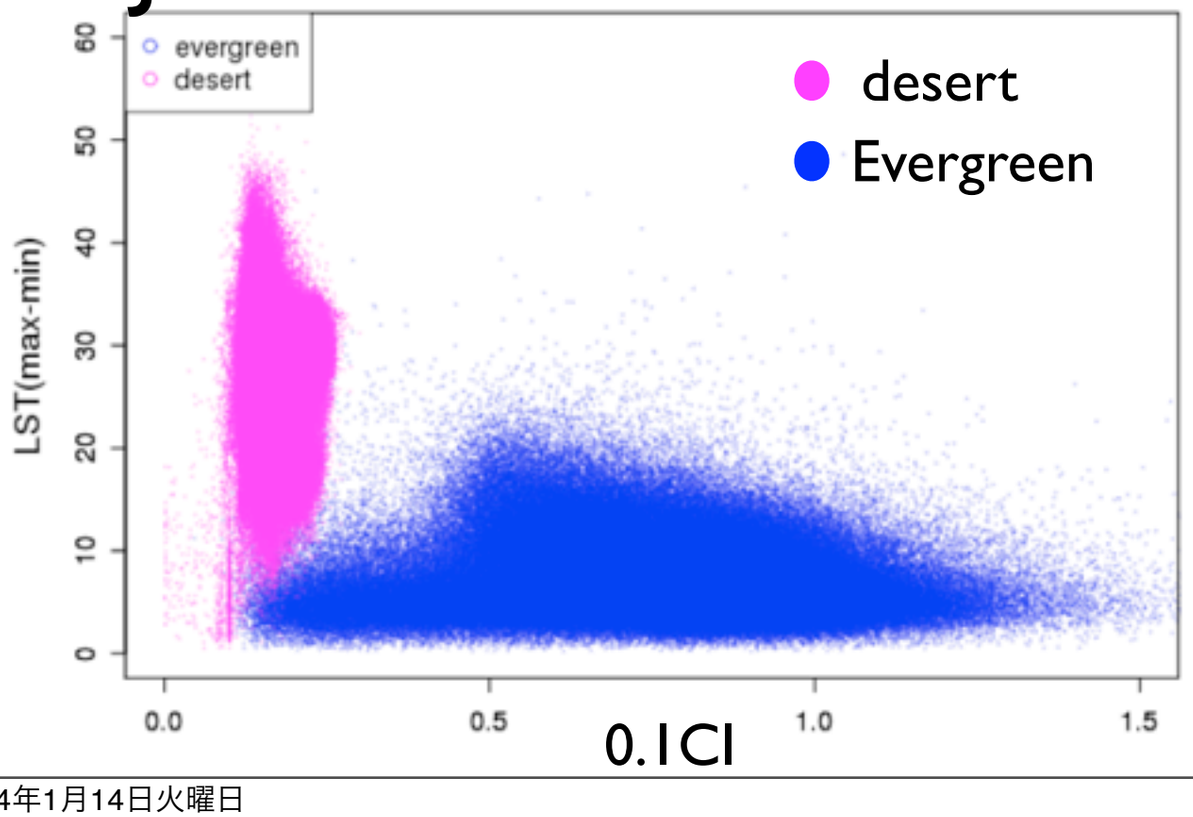
Jan.



Jan.



Jul.



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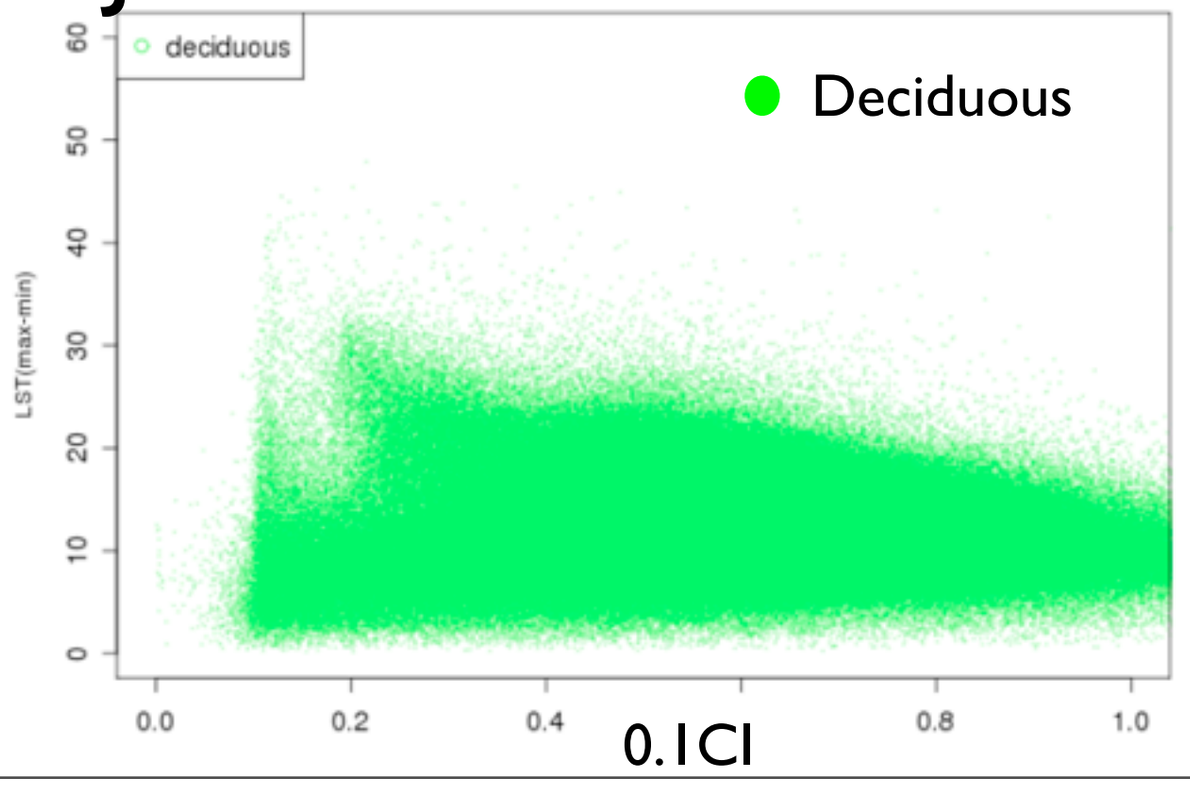

Study Plan

- GPP capacity estimation
  - Another vegetation types : FLUX site
  - consider the generalized rule for the estimation formula
- Stomatal opening and closing
  - Consider scaling up method (LUT for global study)

Preparation for Validation

- Collect the validation data
  - FLUX data sets
    - find the available (we can use) data
    - Calculate typical value of the site
  - Ground observation data sets
    - Nara prefecture forest, Yatsugatake site,,,
    - Ecological study sites : Nasahara-san G


Thank you!