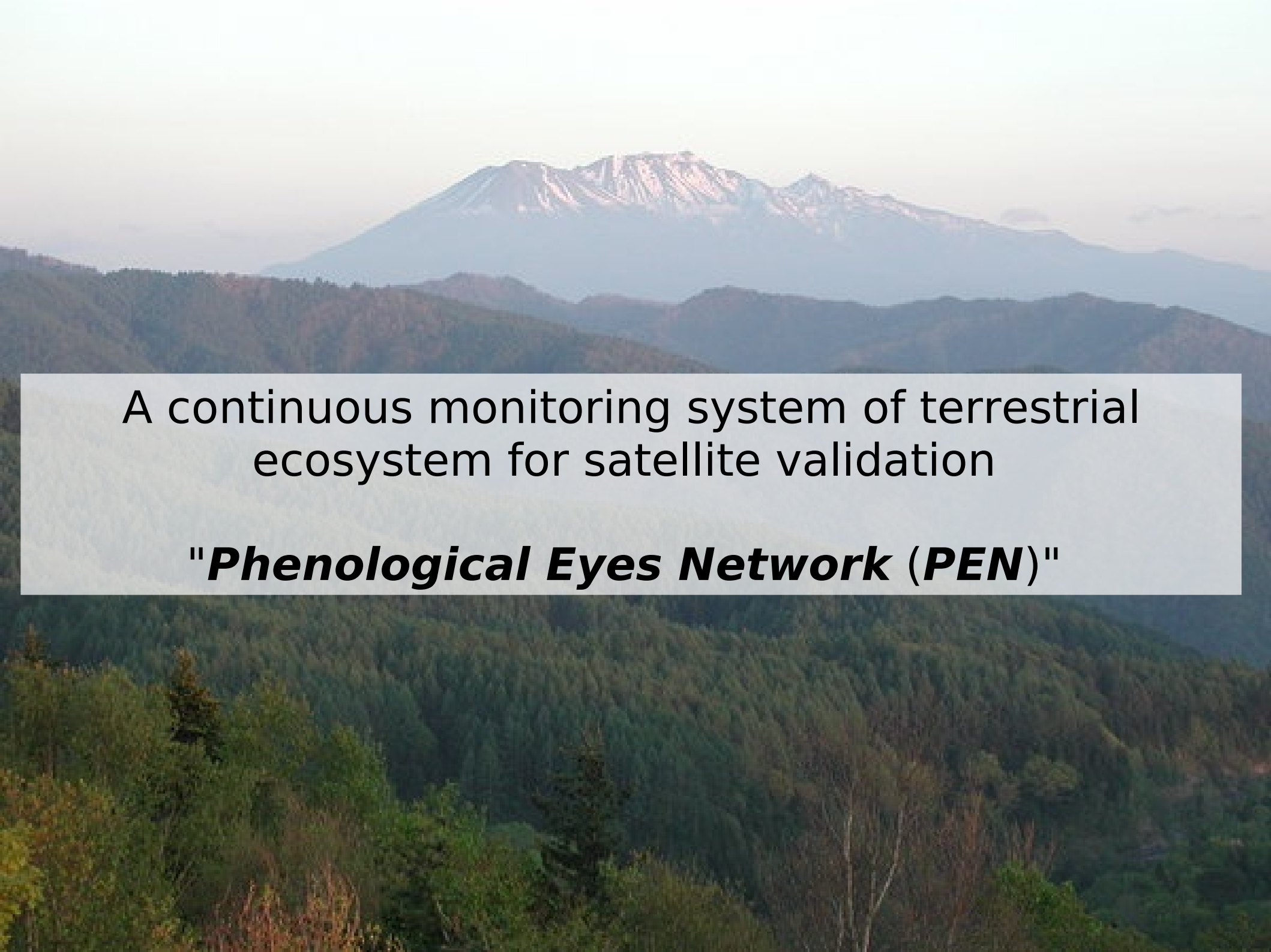
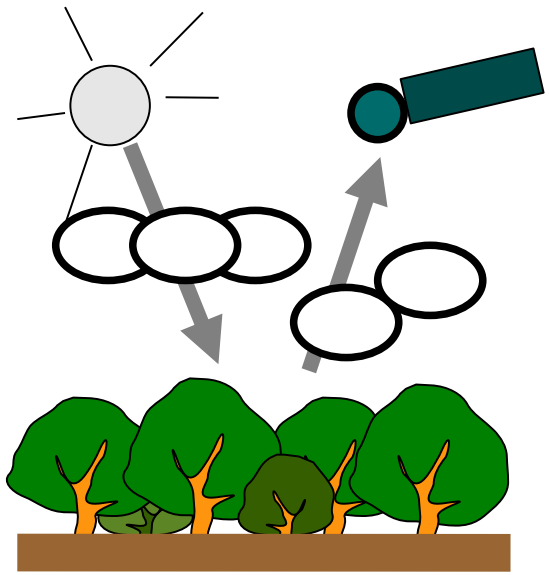


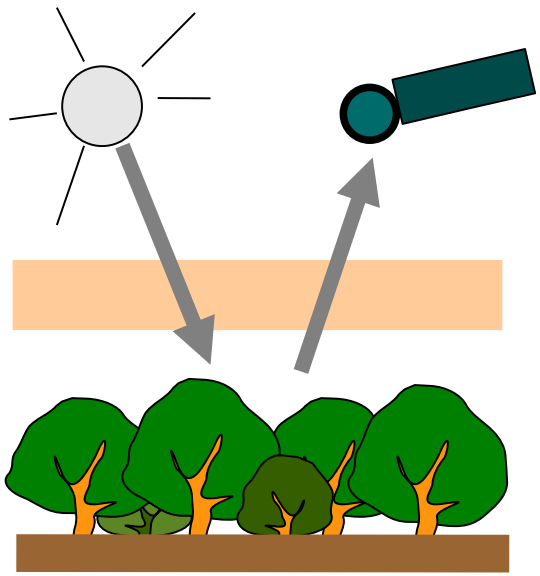
A continuous monitoring system of terrestrial ecosystem for satellite validation

"***Phenological Eyes Network*** (***PEN***)"

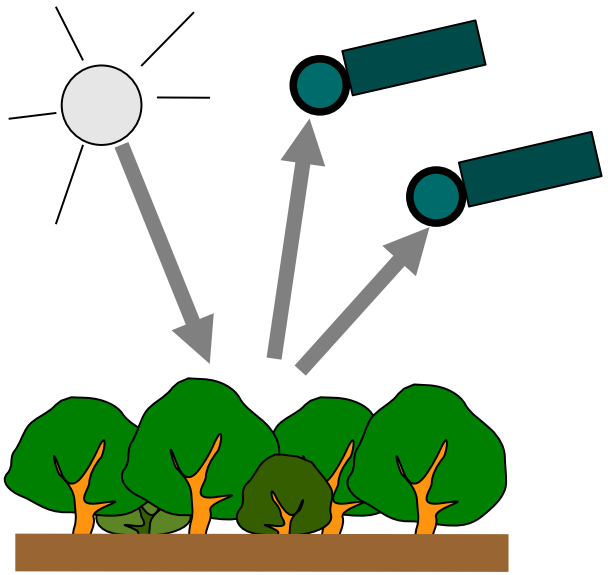
# Noise factors for satellite data



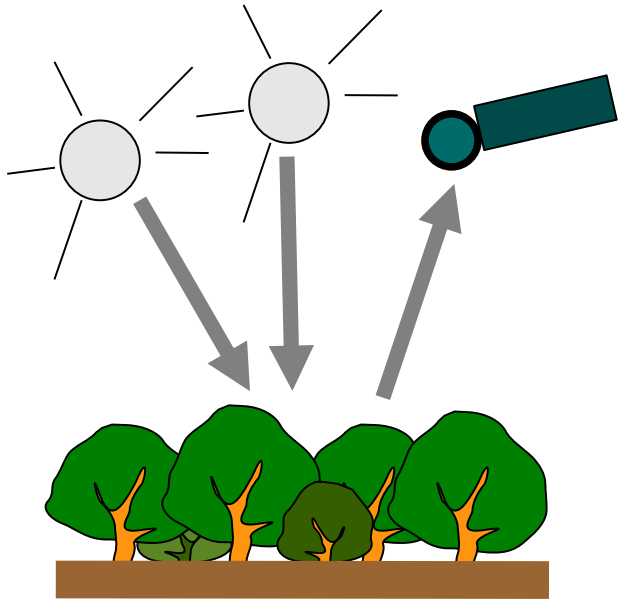
clouds!



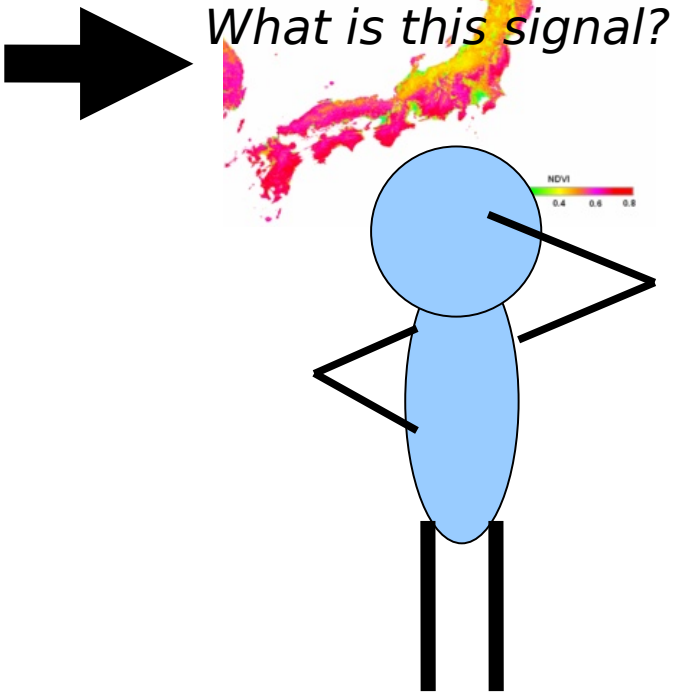
aerosols!



Different view angle!

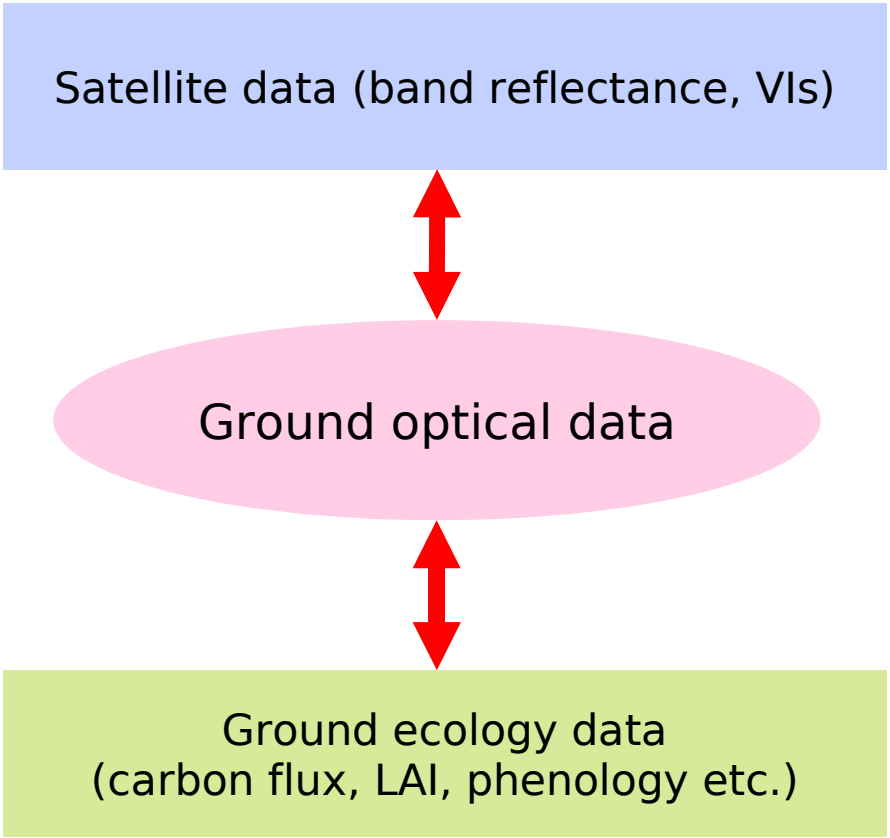


Different sun angle!



# Phenological Eyes Network (PEN)

We need ground data for validation of ecology remote sensing.




Systematic error due to cloud, aerosol, sensor angle, sun angle, etc., within a single satellite sensor.

Difference in overpass-time, band setting, etc. among multiple sensor.

We need stable, long-term, multi-site ground datasets to mitigate these problems.

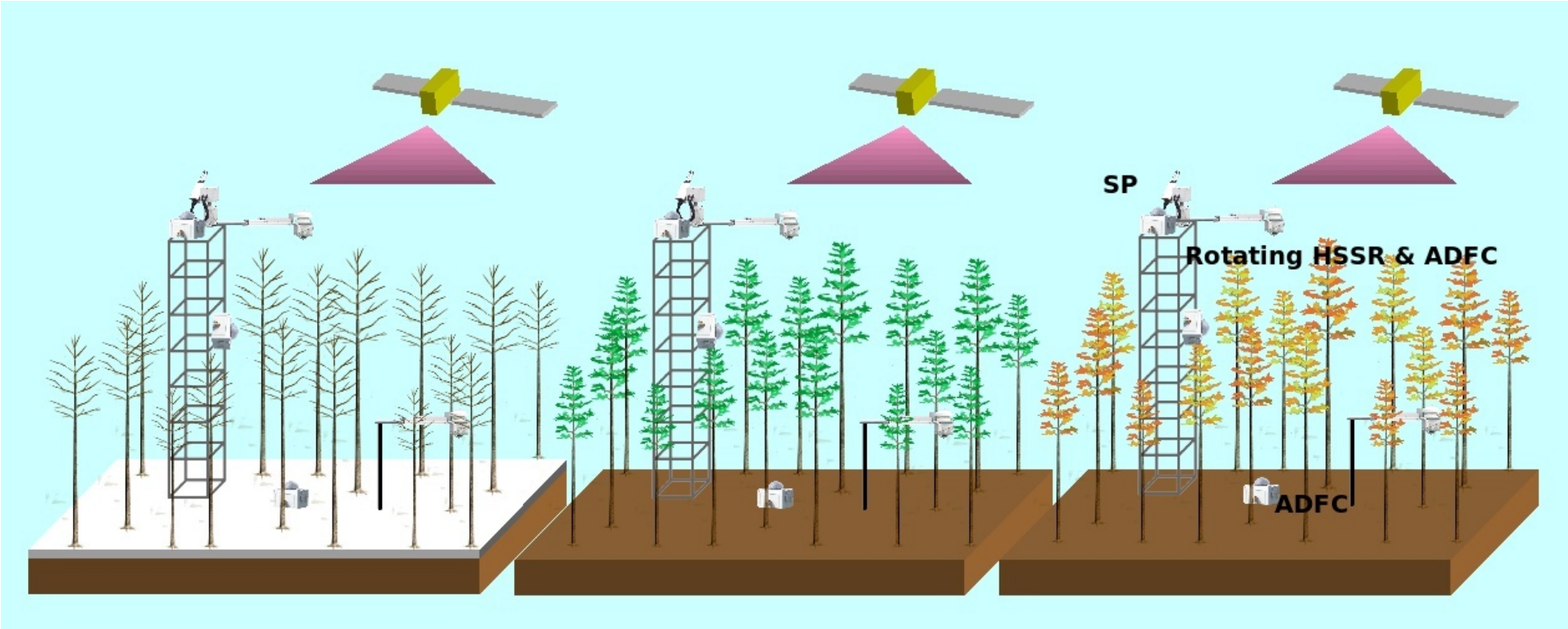
Because ecosystem is always changing!

A network of the ground sites for data collection of these purposes:

||

"***Phenological Eyes Network (PEN)***"

# We need “Ground truth” for ecology remote sensing.




Long-term ... Because ecosystem is always changing!
Multiple-site ... Because there are many types of ecosystems!
Hyper-spectrum ... Because there are many satellite sensors!
Biophysical ... Because we want to estimate LAI, NPP, GPP, etc.

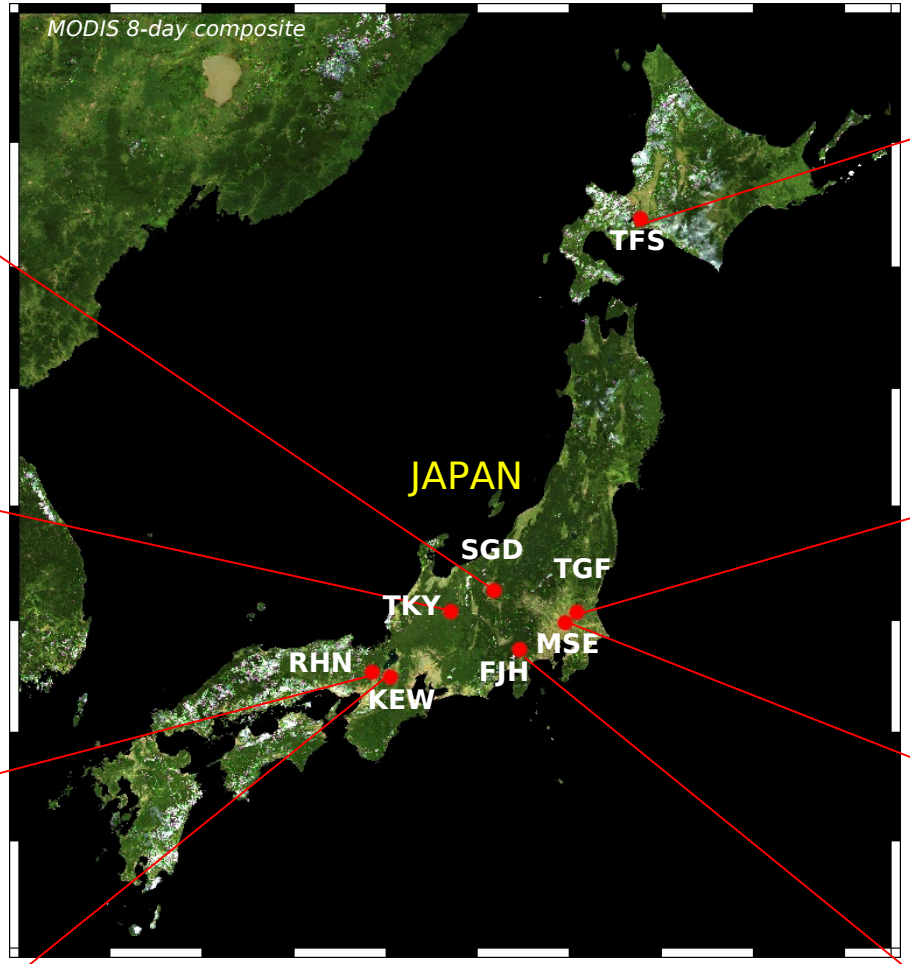
II

"***Phenological Eyes Network (PEN)***" Since 2003

# PEN Sites












Most of the PEN sites are located at the AsiaFlux sites. AsiaFlux is a monitoring network of carbon, water and energy fluxes between ecosystems and the atmosphere.

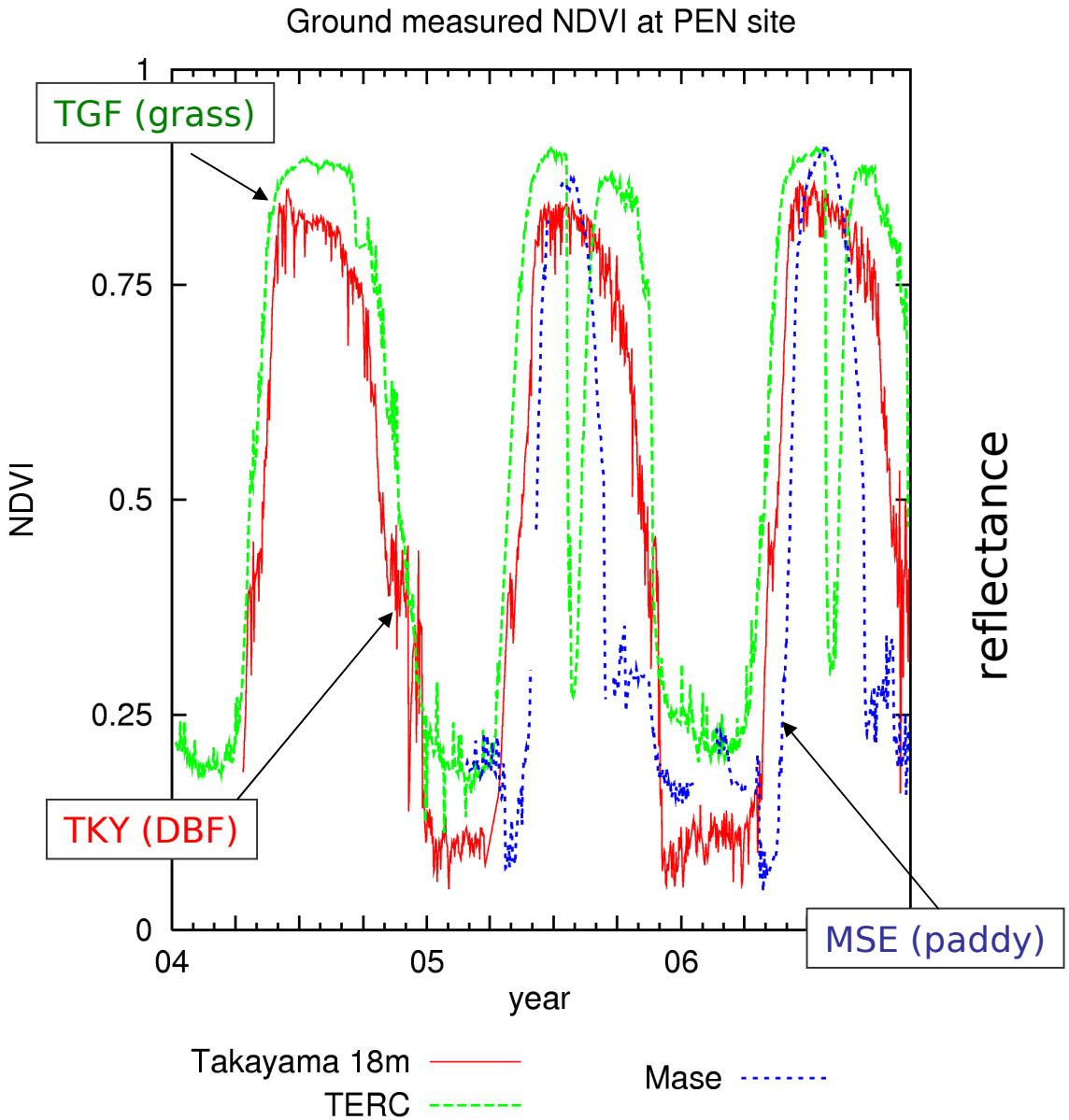
* TFS and RHN stopped operation in September, 2004 and February 2006, respectively.

New sites:

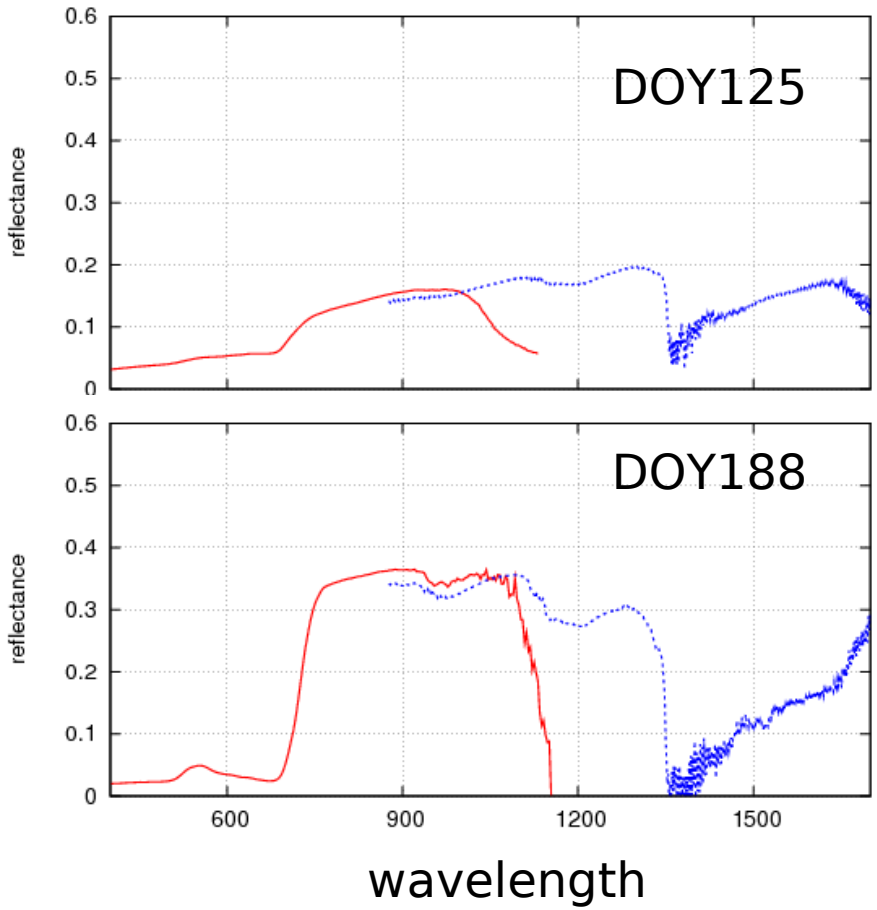
Mt. Tsukuba 筑波山 (DBF; Japan; 2007-)
Gwangneung 光陵 (DBF; Korea; 2009-)
Alice Holt (DBF; England; 2009-)

# PEN Device: HSSR

HemiSpherical Spectro-Radiometer




reflectance spectrum (TKY)



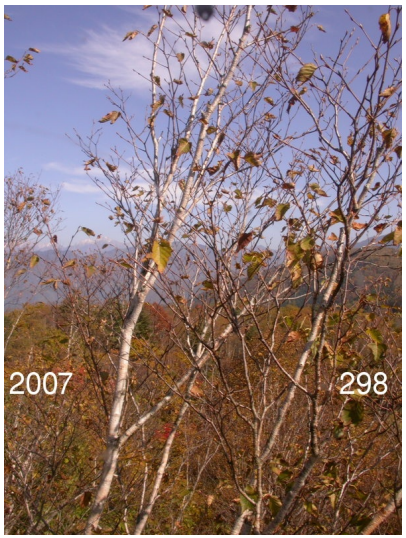
# PEN Device: ADFC

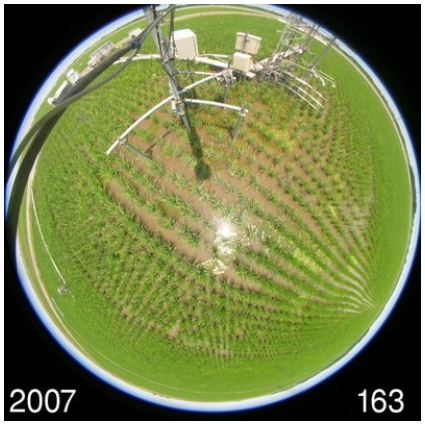
## Automatic Digital Fish-eye Camera)

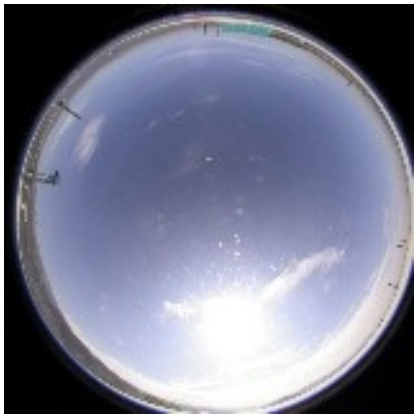
Nikon CoolPix4500 + fisheye FC-E8

Phenology, LAI, sky condition (cloud cover), snowpacks.

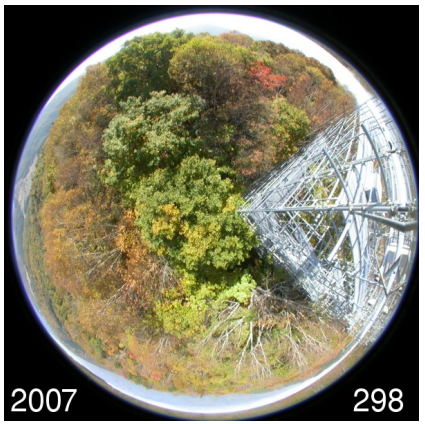
11 sites, 34 cameras, 2.3 million digital pictures so far.



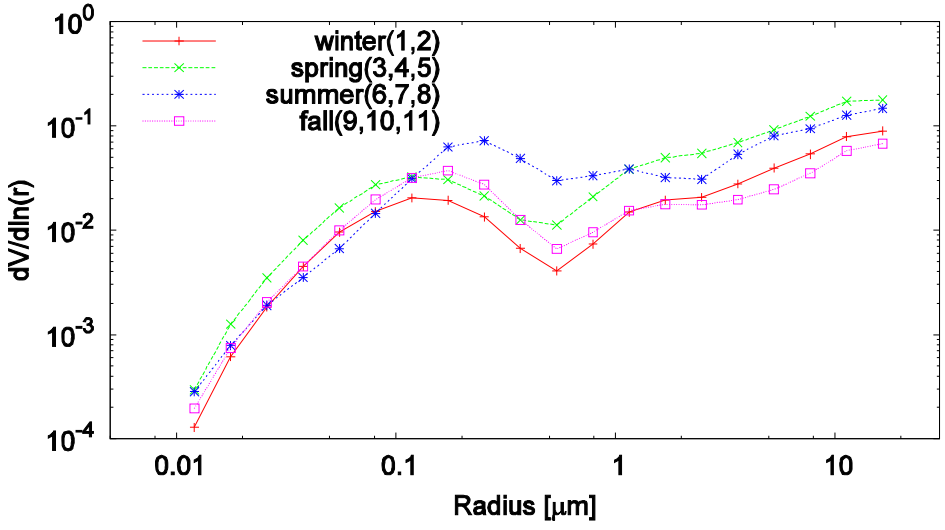




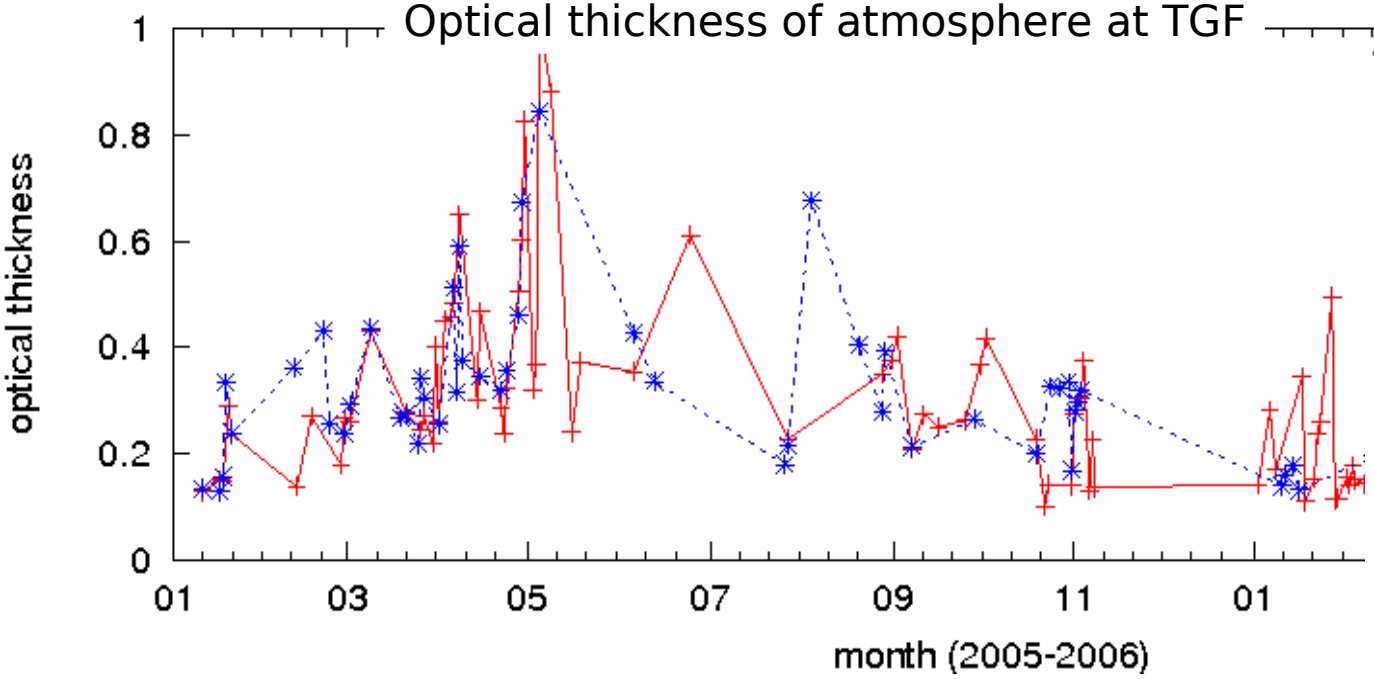
# Phenological Eyes Network (PEN)

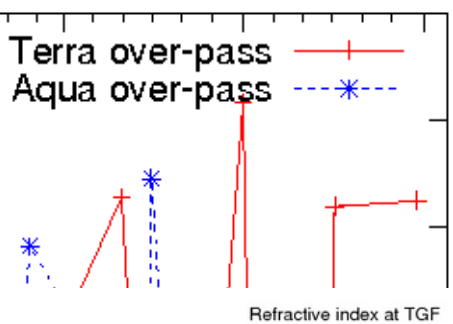
## Skyradiometer (sunphotometer)

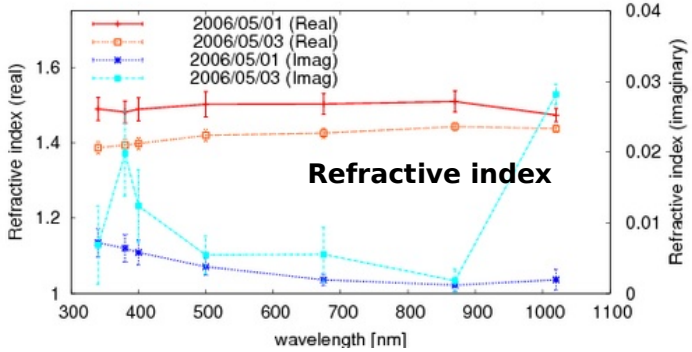
aerosol particle size at TGF (2005)



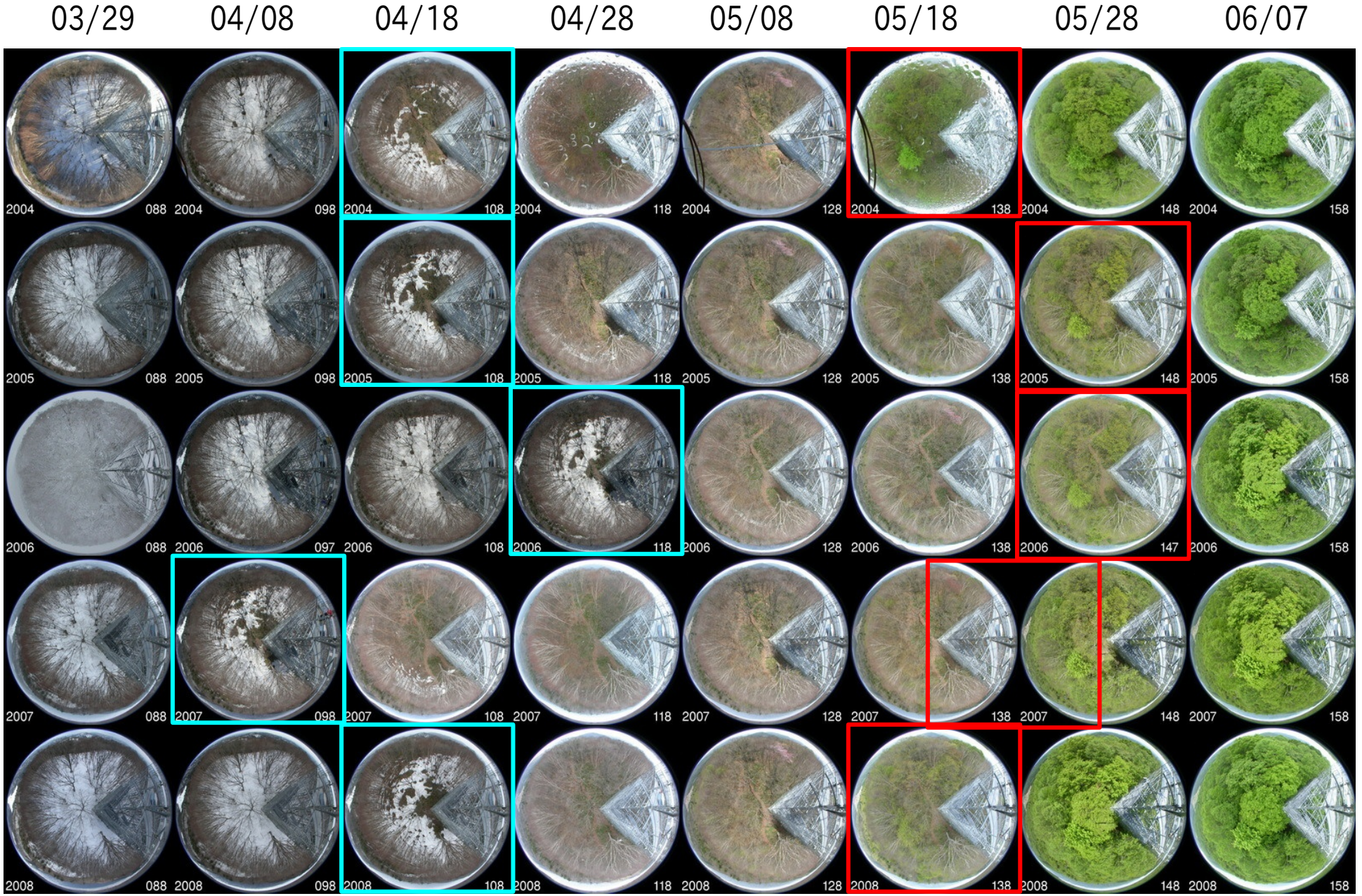

Optical thickness of atmosphere at TGF



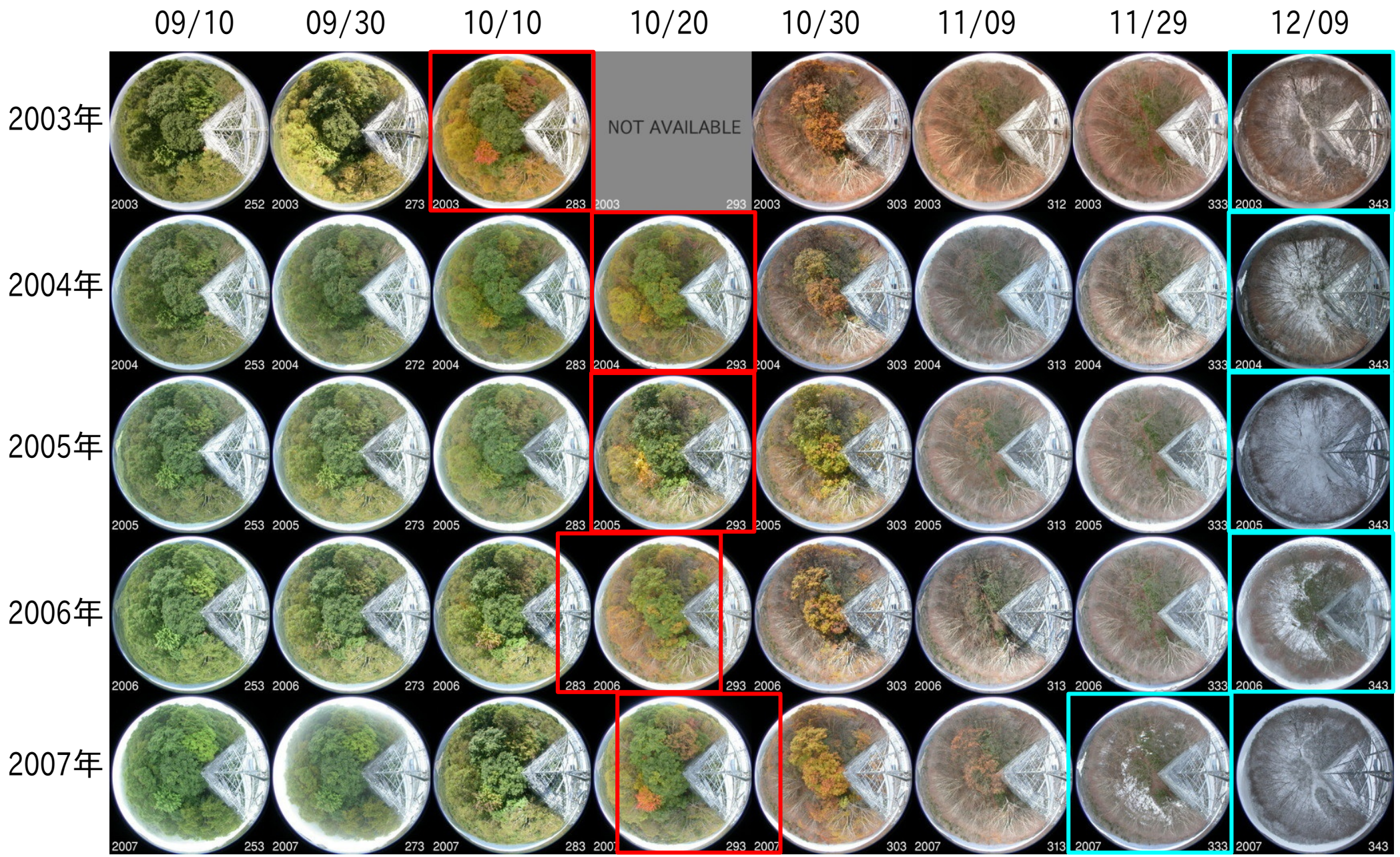



# Spring phenology (TKY) ... 10-day summary



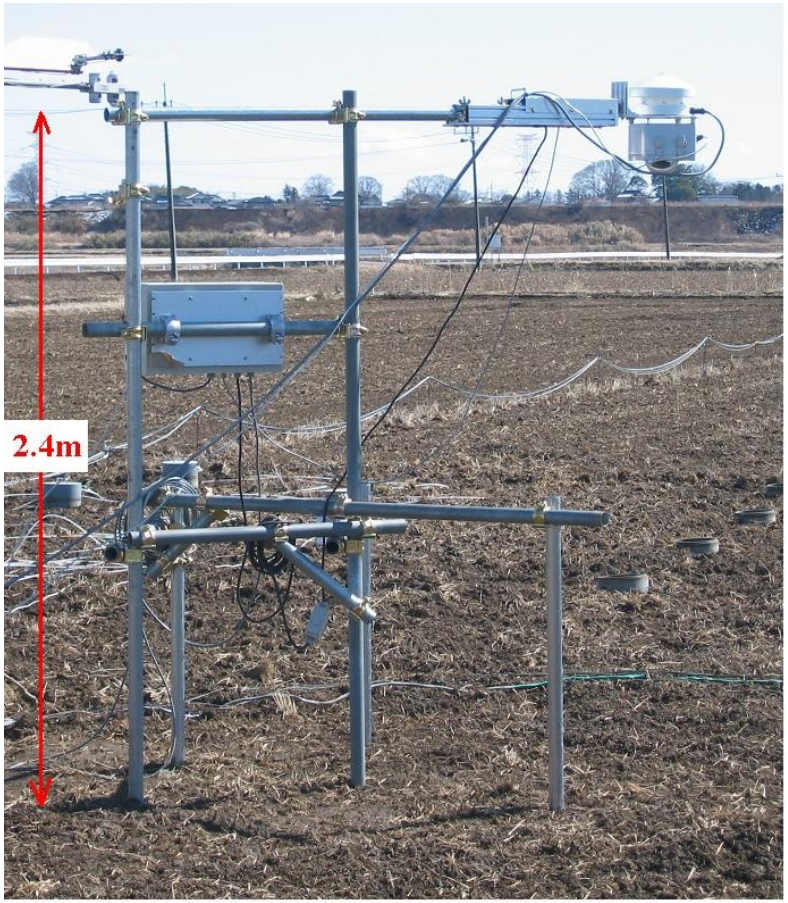

Timing of snow melt and budburst do not correlate.

# Autumn phenology (TKY) ... 10-day summary



# Phenological Eyes Network (PEN)

Installation in MSE



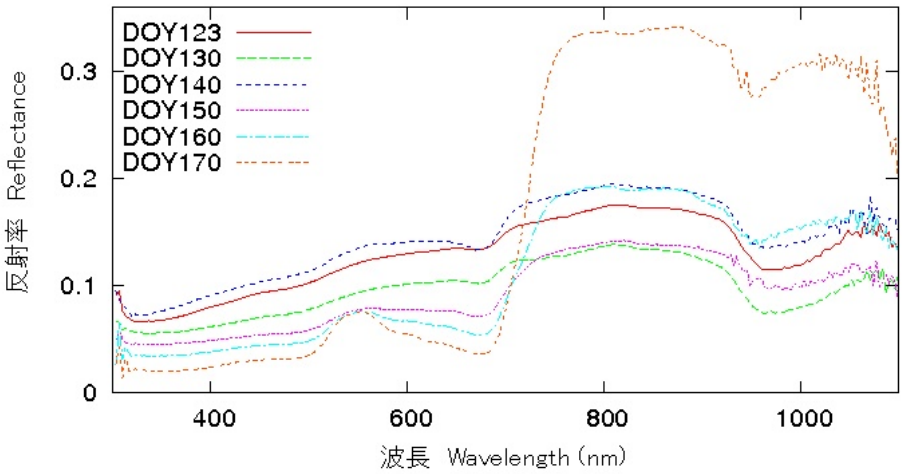

**Automatic-capturing Digital Fish-eye Camera (ADFC)**

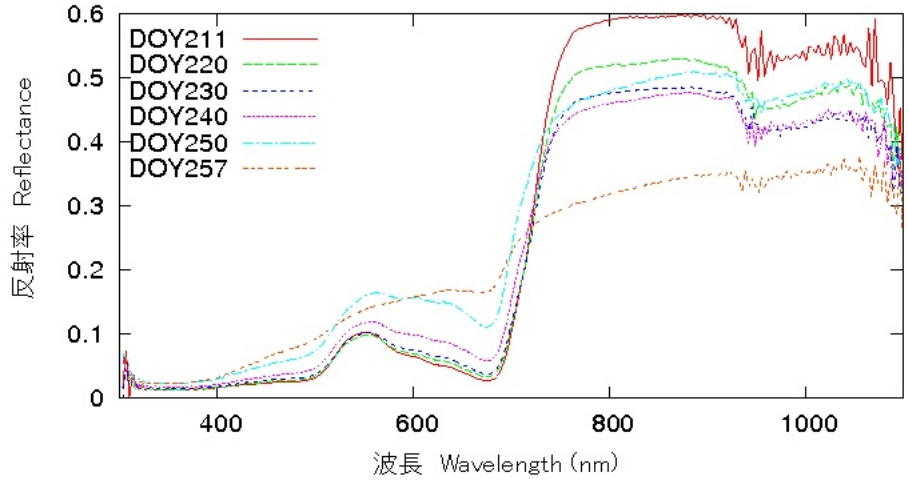
(NIKON Coolpix4300 + FC-8 Fisheye Converter)

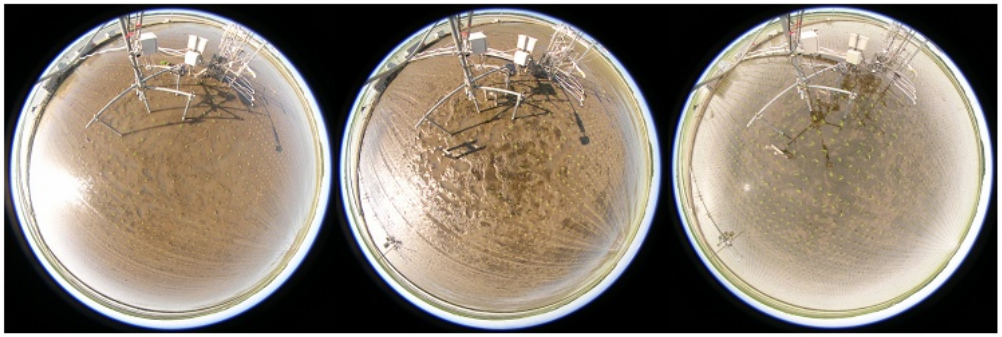

**Hemispherical Spectro-radiometer (HSSR)**

(Eko MS-700; 350nm-1100nm; 256bands)

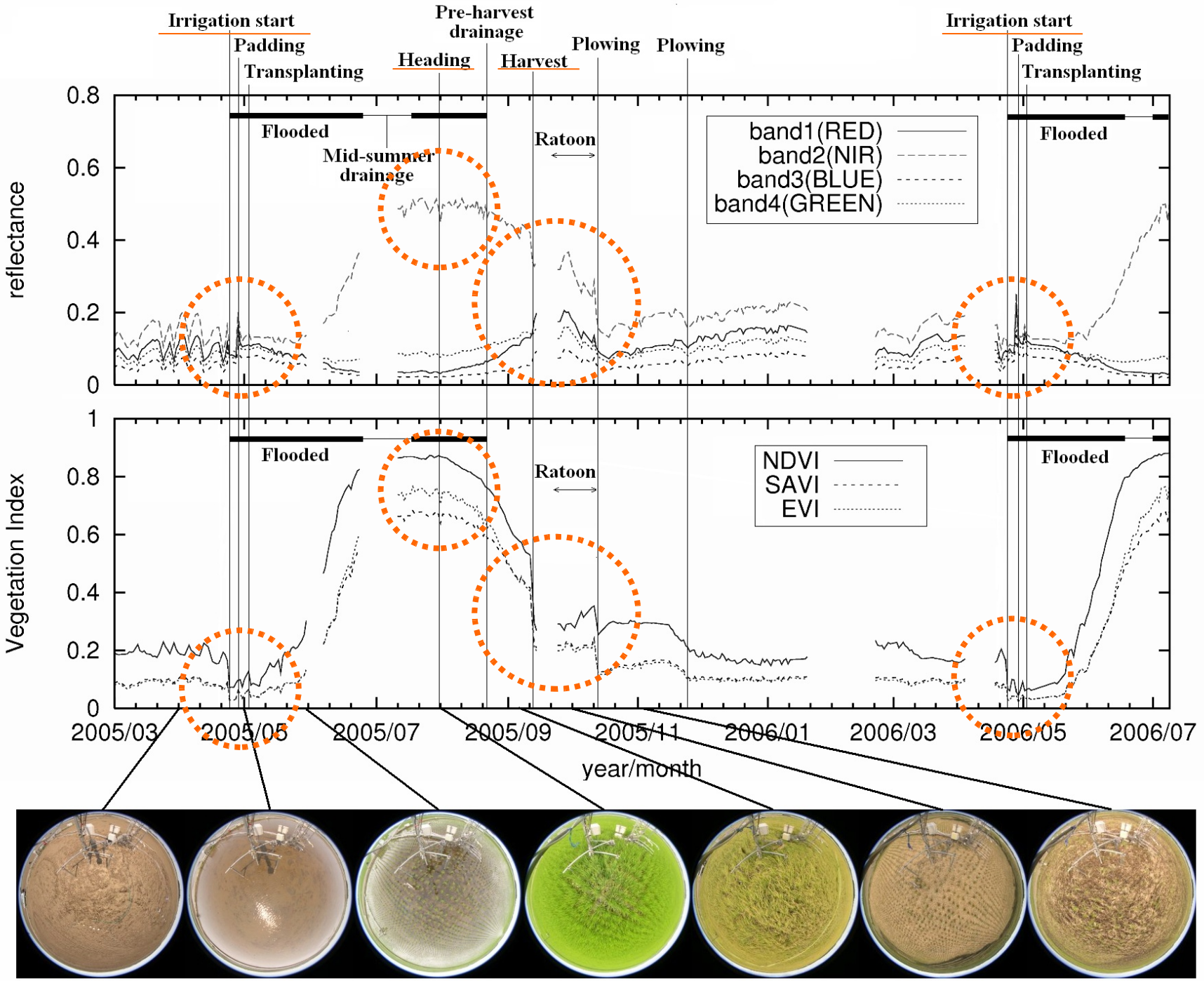
# Example: Mase site (paddy), 2005



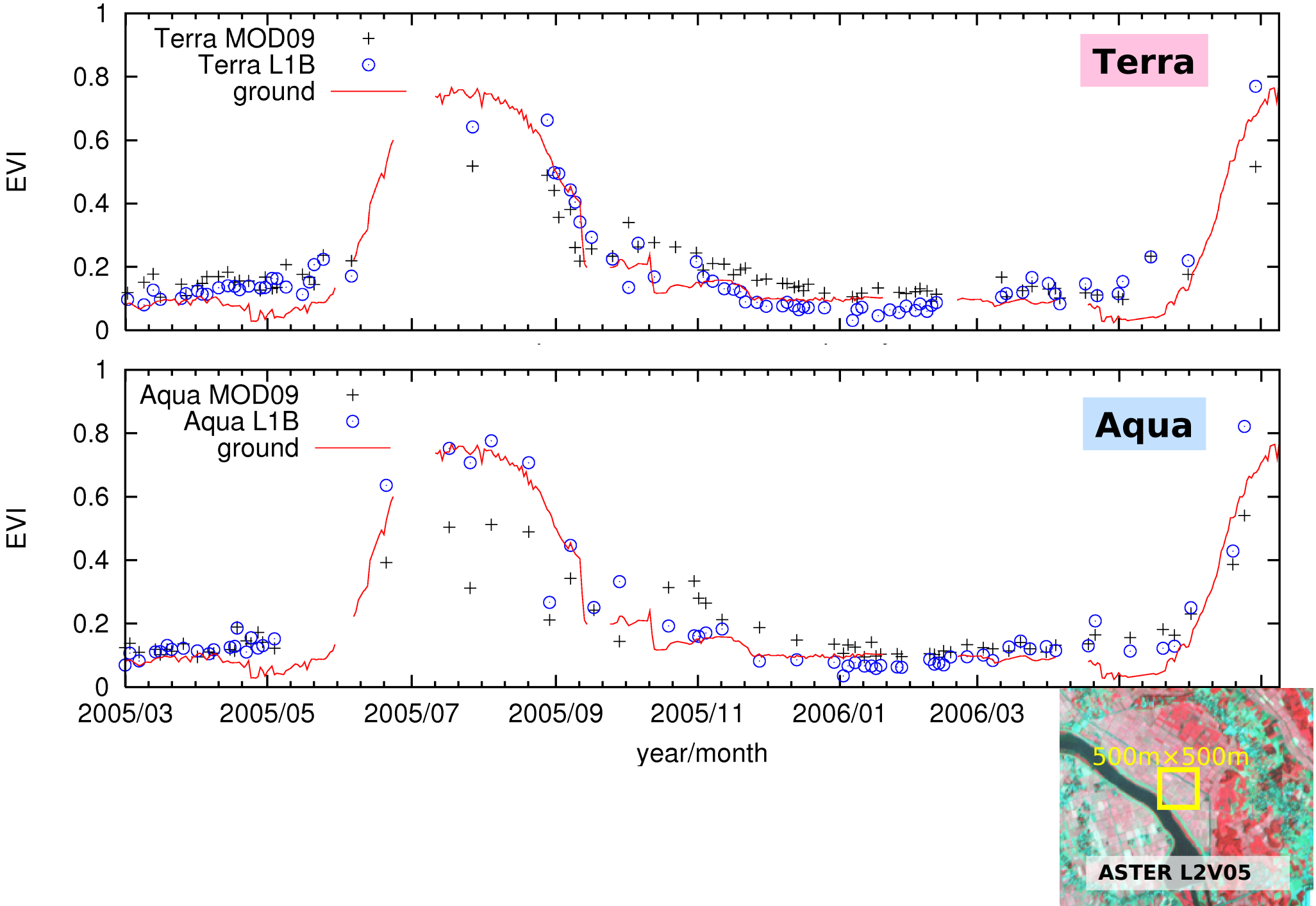



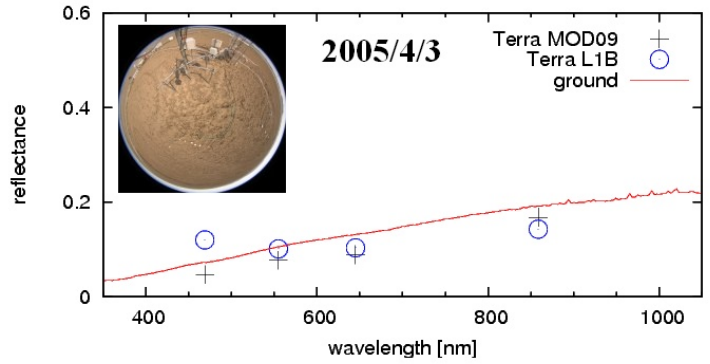

# Example: Mase site (paddy), 2005-2006

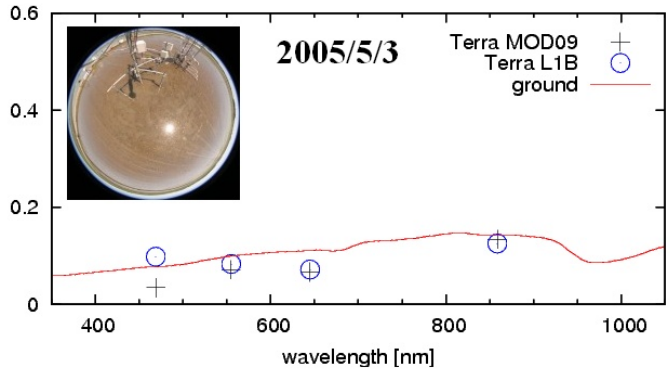


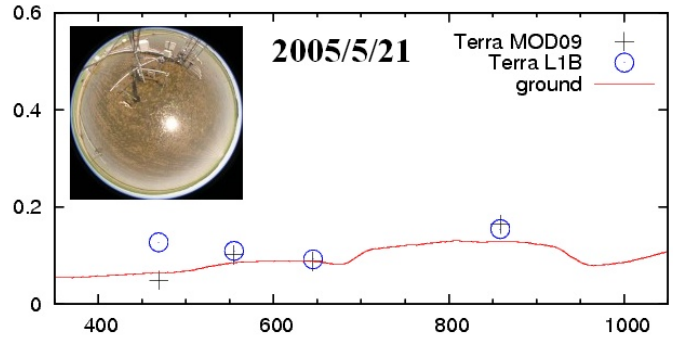
# Example: check of satellite index at Mase site (paddy)

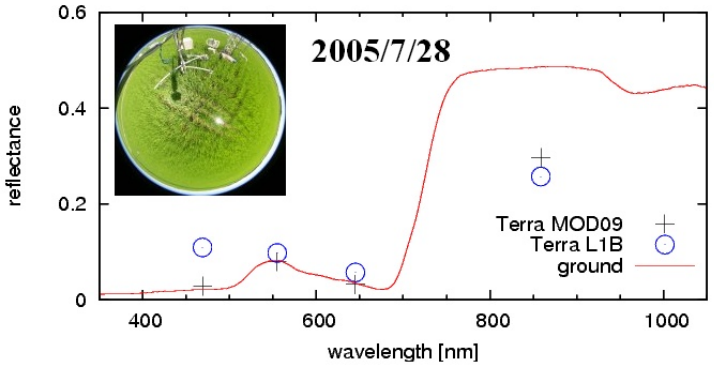


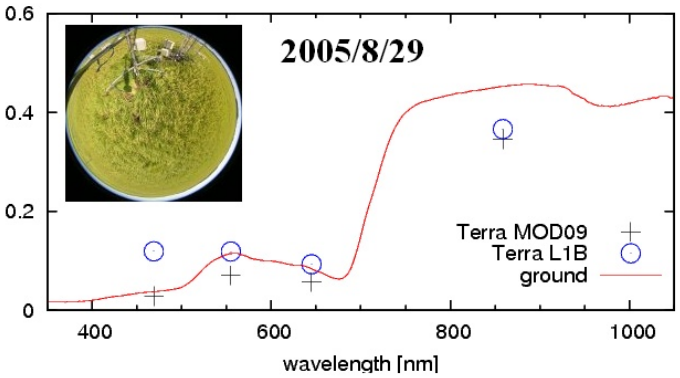
# MODIS data vs. ground data: spectrum

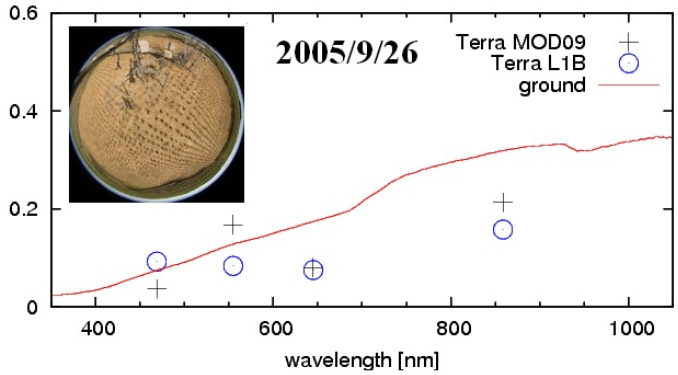


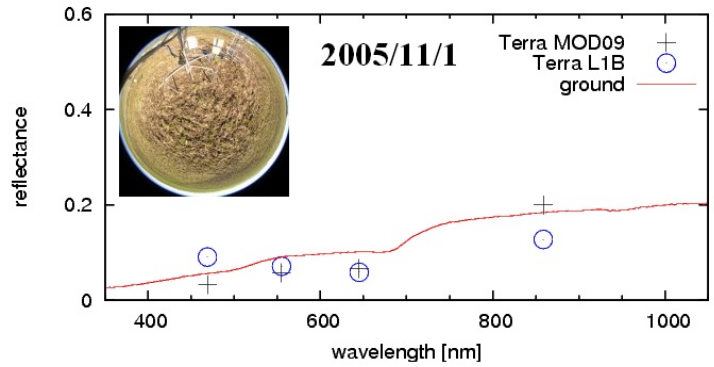



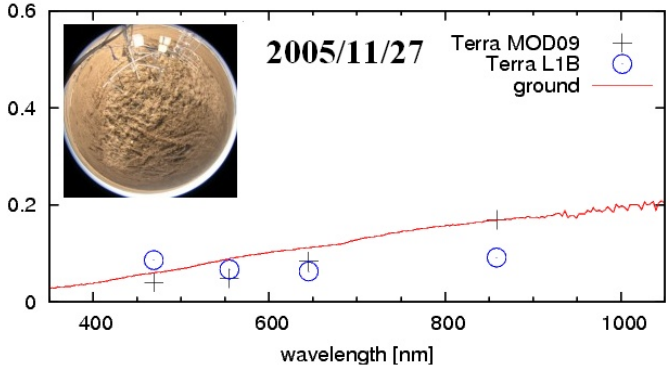



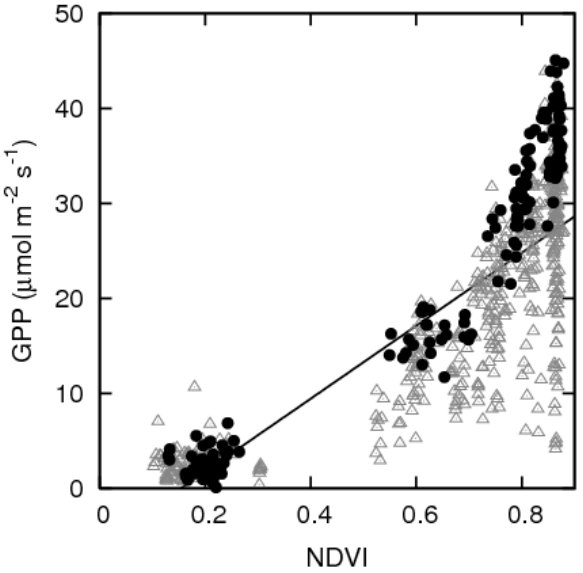



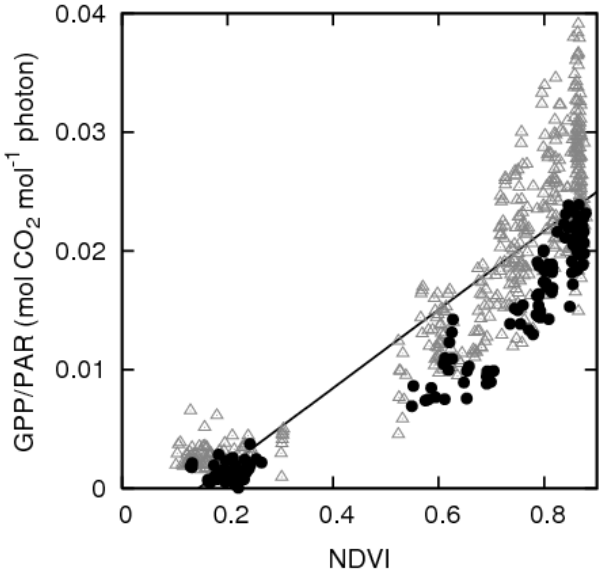



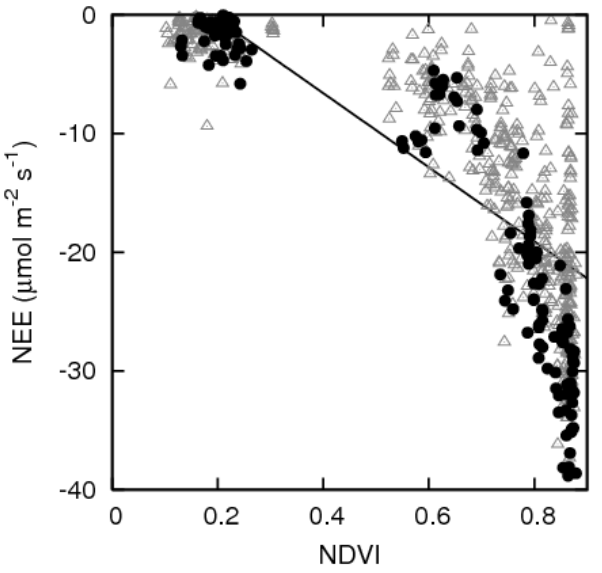
# Spectral index vs. Carbon flux

Flux data: courtesy of NIAES group (A. Miyata)

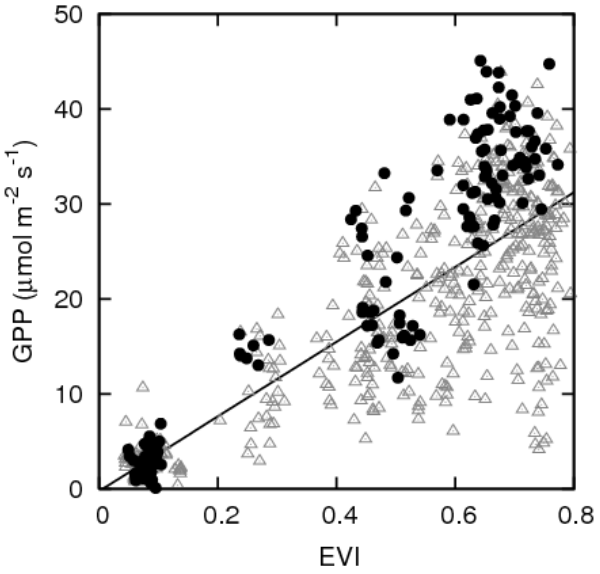
(a) NDVI

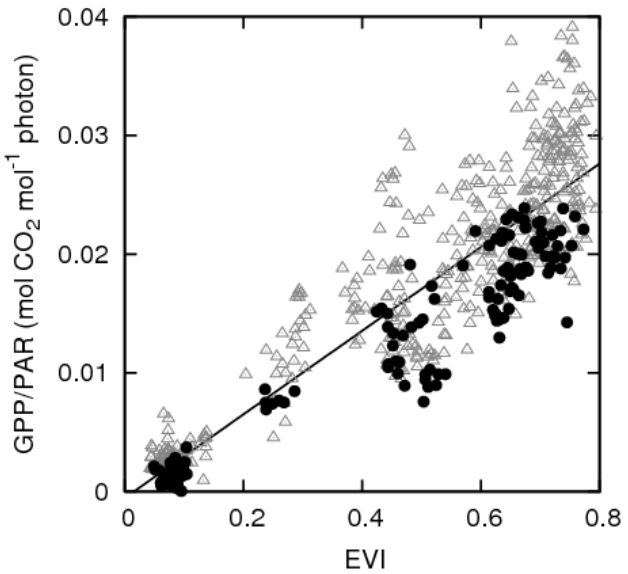


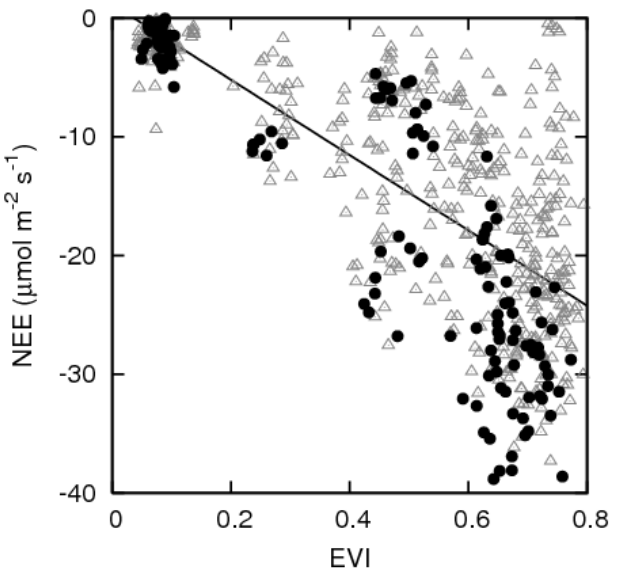




(b) EVI



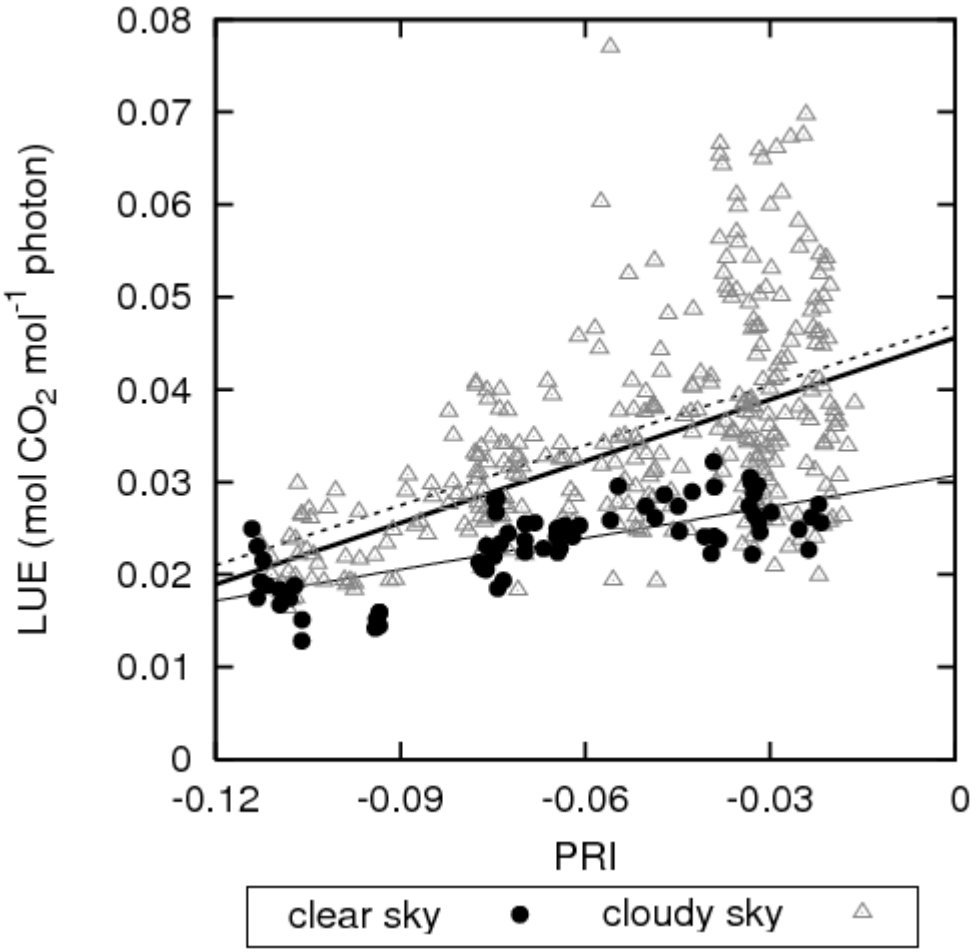




clear sky ● cloudy sky △

MSE (paddy)

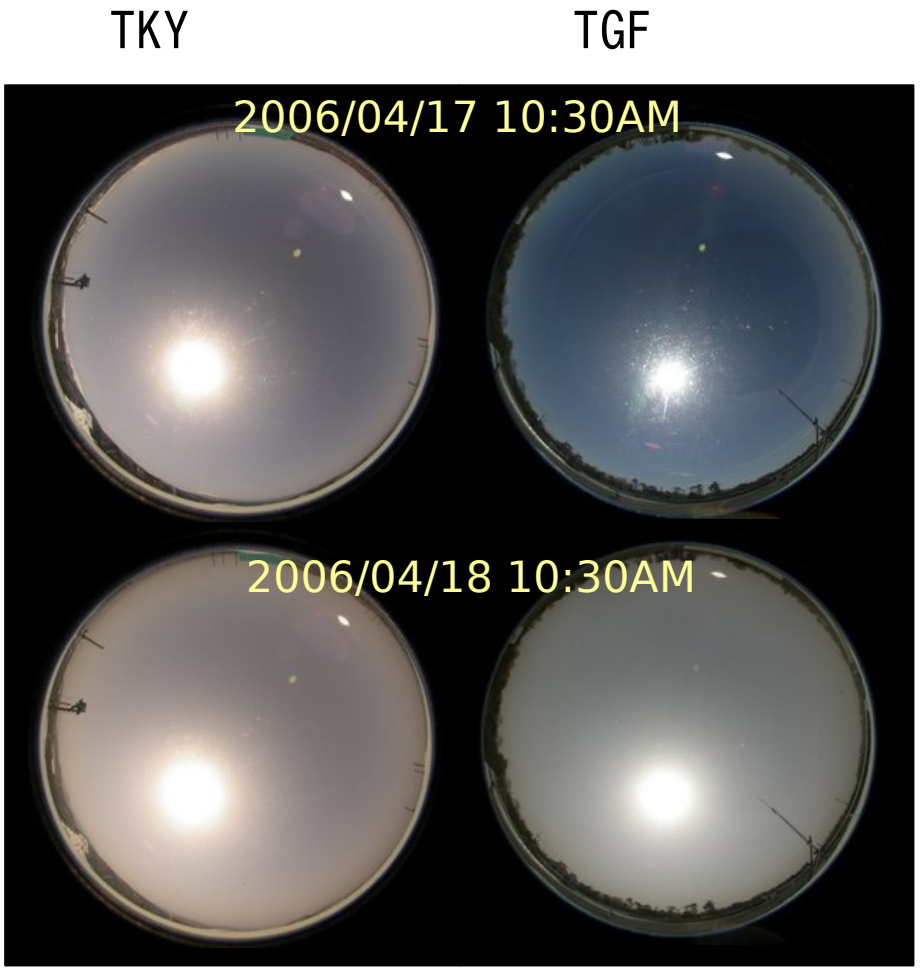
# PRI ... photochemical reflectance index

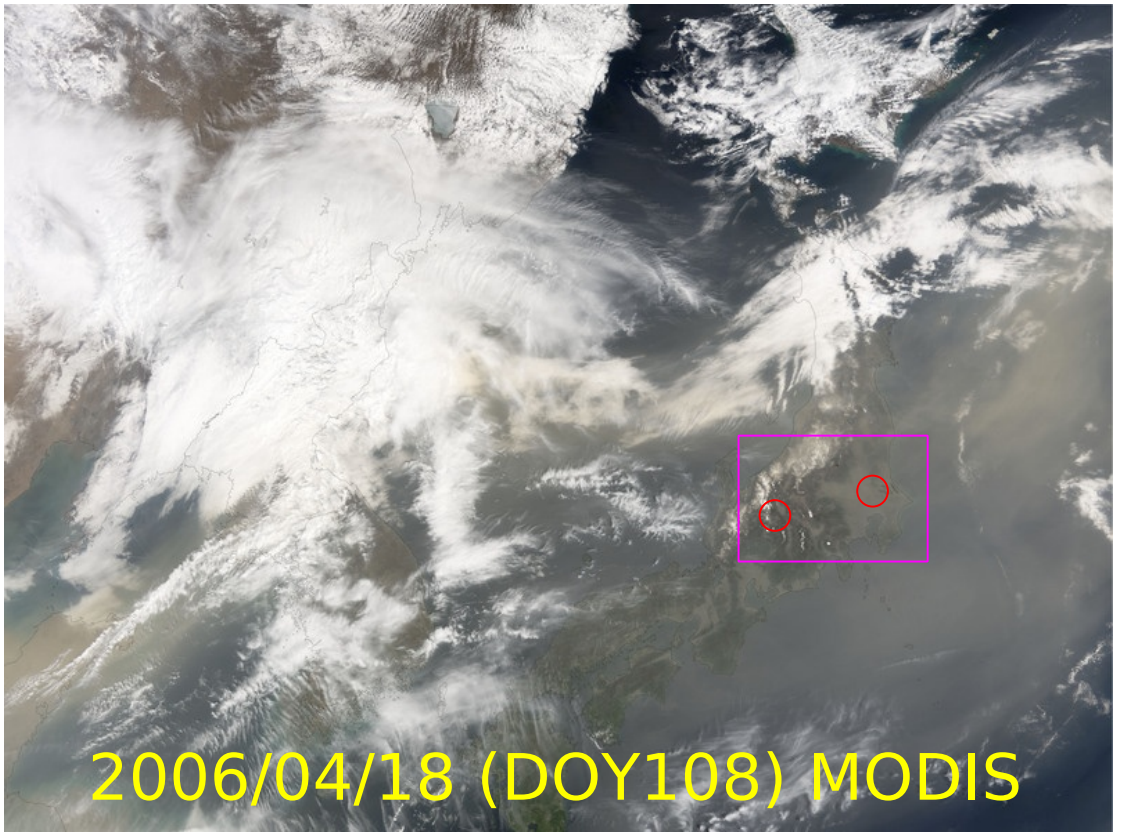
Flux data: courtesy of NIAES group (A. Miyata)

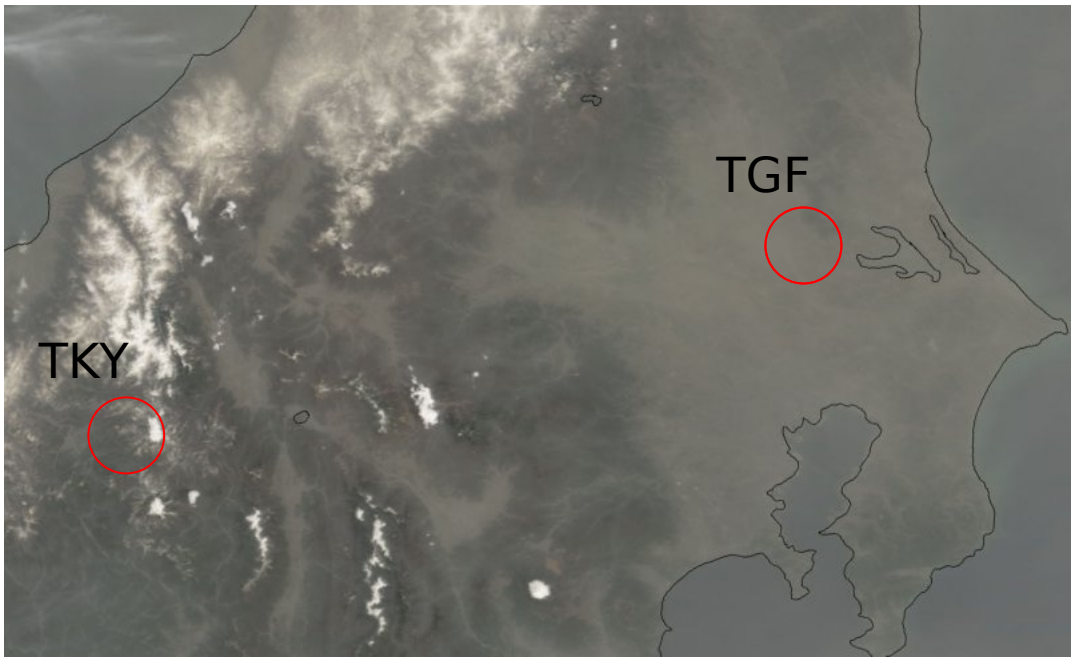



| VI | Sky condition | LUE | | |
|---|---|---|---|---|
| | | $r^2$ | $A$ | $B$ |
| PRI | All condition | 0.212 | 0.223 | 0.0456 |
| | Clear sky | 0.517 | 0.113 | 0.0307 |
| | Cloudy sky | 0.184 | 0.217 | 0.0470 |

# Yellow sands captured by PEN



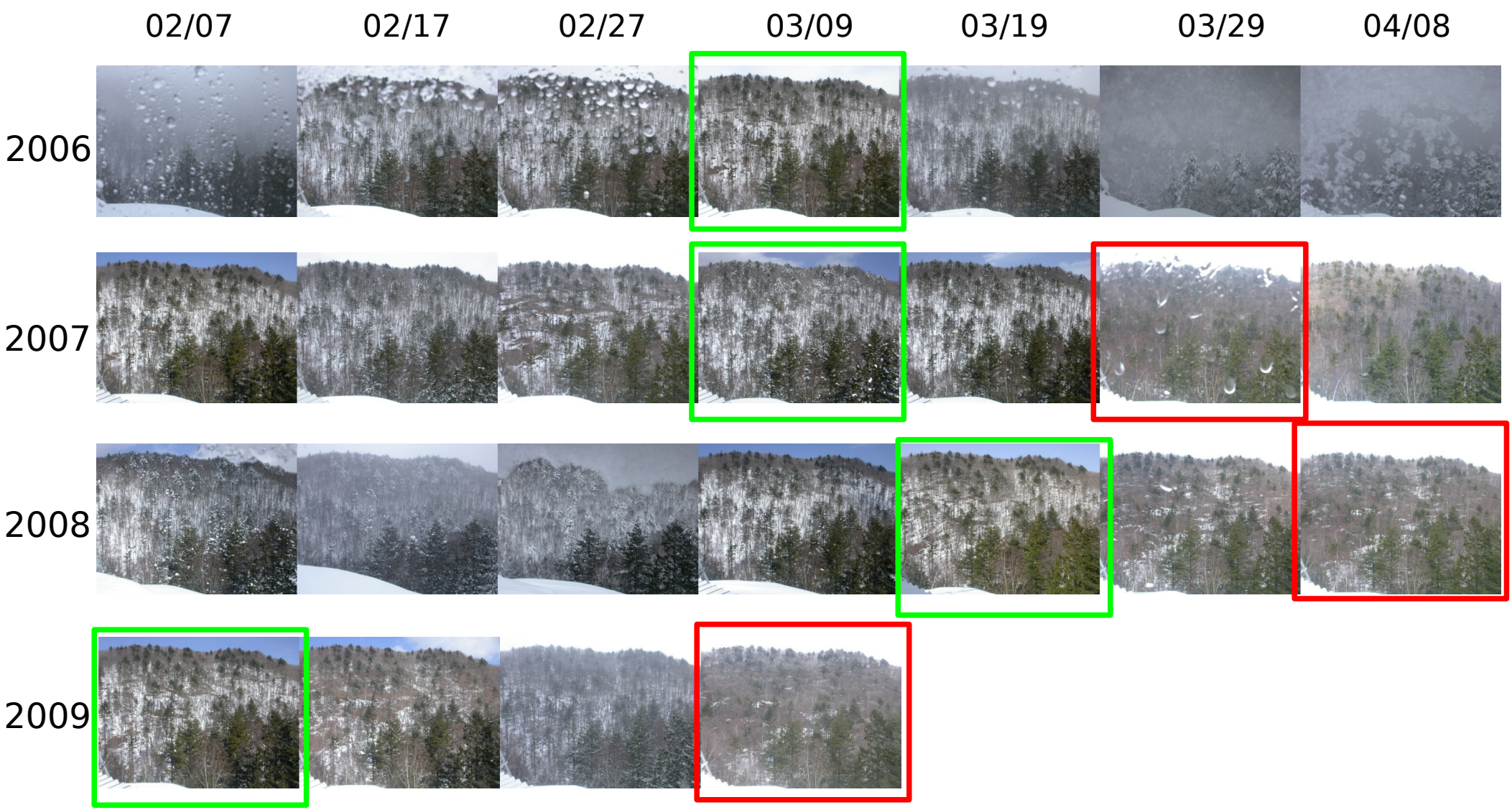




From 4/17 to 4/18, visibility decreased sudenly.

Influence was bigger in TKY than TGF, because TKY is closer to the Chinese continent.

# Snow melt (TKY)




Snowmelt in 2009 is 20-30 days earlier than other years!

# Manual observations

## Leaf area index (LAI):

litter traps

LAI-2000

TRAC

## Monitoring of shoots and leaves

phenology

leaf spectrum

leaf physiology

# Conclusion

Phenological Eyes Network (PEN) is accumulating long-term ground data for ground-truth of satellite remote sensing.

Ground truth by PEN:
- Cloud-screening
- Band reflectance, NDVI, EVI.

New algorithms by PEN:
- phenology detection
- LAI estimation
- carbon budget estimation (LUE, GPP)