Simultaneous observations of solar-induced chlorophyll fluorescence and atmospheric CO_2 dynamics by GOSAT

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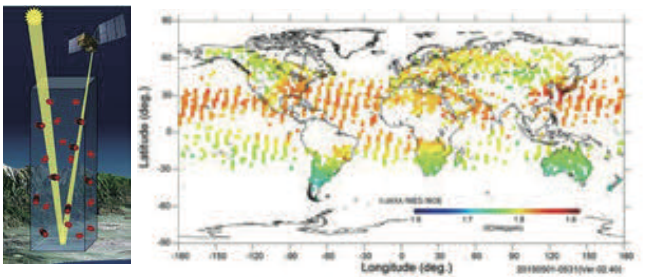
In these decades, global warming has progressed owing to increase of greenhouse gases (GHGs) such as CO_2 and CH_4. To deal effectively with this issue by mitigation and adaptation, it is necessary to monitor (1) atmospheric concentrations of GHGs and (2) emission and sequestration of GHGs with their underlying mechanisms including biogeochemical processes and human activities.

Monitoring of GHGs concentrations



GOSAT L2 XCO_2
Monthly mean values in 2.5° × 2.5° grid in May 2015

Our challenge in GOSAT and GOSAT-2 project

In-situ measurement by high-resolution wavelength spectroradiometer

Ecophysiological experiments in a laboratory

Consequence between SIF and photosynthetic parameters based on the ecophysiological mechanisms

Data from
- Flux measurement sites
- LTER sites

Analysis of GOSAT (and GOSAT-2) SIF data

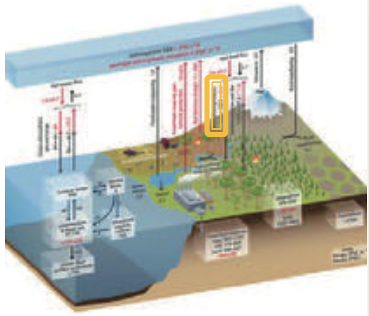
Ecosystem model

Accurate estimation of carbon sequestration by terrestrial ecosystems

- Mitigation to climate change
  e.g., REDD+
- Adaptation to climate change
  e.g., ecosystem services

Monitoring of carbon sequestration

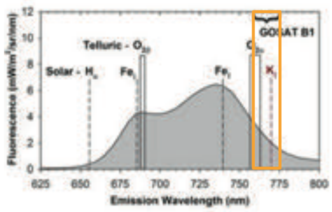
Terrestrial ecosystem, which is the large carbon sink, absorbs 123 Pg carbon per year through plant photosynthesis (IPCC 2014).
Remote sensing by satellite, e.g., Terra, Land Sat, etc., has been used to monitor the spatial and temporal dynamics of terrestrial ecosystems that are responsible for such photosynthetic CO_2 absorption.



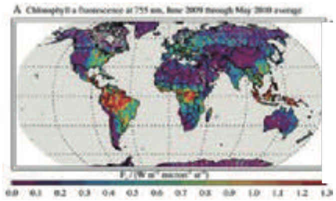
Such observation provides us with geographical information on the potential distribution of carbon sequestration. However, since the photosynthetic rate is quite sensitive to climate conditions (e.g., radiation, temperature and soil moisture), it is necessary to observe the photosynthetic activity to understand the effects of climate.

SIF (Solar-Induced chlorophyll Fluorescence)
— New remote-sensing index for the photosynthetic activity

Joiner et al. (2011) and Frankenberg et al. (2011) have suggested that TANSO-FTS could detect overlapping part of chlorophyll fluorescence*, induced by solar radiation and Fraunhofer line (the dark lines in the spectrum of the solar radiation).



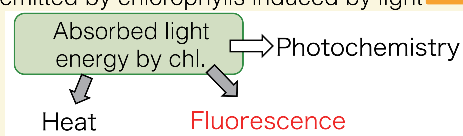
Spectrum of chlorophyll fluorescence and Fraunhofer lines.
Joiner et al. (2011)



Annual average chlorophyll fluorescence on a 2°× 2° grid.
Frankenberg et al. (2011)

SIF remote sensing has been drawn considerable attention as a new technic to observe the photosynthetic production of terrestrial ecosystem. However the consequence between SIF data and photosynthetic activity is not well understood.

* Chlorophyll fluorescence;
photons of red and far-red light that emitted by chlorophylls induced by light



Chlorophyll fluorescence has been a biophysical index to examine the photosynthetic responses to environmental stresses (e.g., drought and heat) in plant ecophysiological studies. In general, it is difficult to detect the fluorescence under natural condition because it is so weak light.