CARBON FLUX BASELINE ESTIMATION FOR RUBBER PLANTATION BY UPSCALING EDDY COVARAINCE MEASUREMENT WITH SATELLITE-BASE INDICATOR

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Introduction

The need for information on the amount of carbon emission and removal in different regions is pervasive across various domains. Therefore, reliable and precise estimations of carbon emission and removal are required. In Thailand, the world's largest rubber producer, the rubber plantation area increased from 2.95 to 3.52 million ha from 2011 to 2022. This rapid expansion of rubber plantations has significantly changed the ecosystem-based carbon sink which may have an impact on carbon treading and the ability to mitigate climate change. Net ecosystem exchange (NEE) of CO_2 using the eddy covariance (EC) technique is an indicator of net carbon balance of the ecosystem. However, the EC technique only provide integrated CO2 flux measurements over tower footprints with sizes and shape that vary with tower height, canopy physical characteristics and wind velocity. Scaling up beyond the tower footprint to large areas is critically important in the quantification of net CO_2 exchange over regions.

Satellite remote sensing provides ecosystem observations with spatio-temporal coverage and is an attractive tool for up-scaling carbon fluxes. This study has utilized a combination of EC technique micrometeorological methods and satellite remote sensing data for quantifying NEE to determine the sink–source status and upscale NEE from the tower footprint scale to the continental scale.

Materials and Methods

Direct measurement of NEE variations with ground-based system

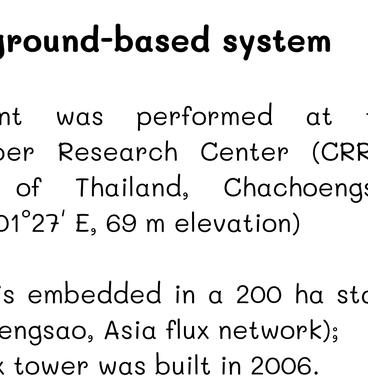
The experiment was performed at the Chachoengsao Rubber Research Center (CRRC), Rubber Authority of Thailand, Chachoengsao province (13°34′ N, 101°27′ E, 69 m elevation) in eastern Thailand.

The 6 ha plot is embedded in a 200 ha stand (Rubber Flux Chachoengsao, Asia flux network); a 25 m high eddy-flux tower was built in 2006. A 3-D sonic anemometer-thermometer (CSAT3) and an open-path infrared gas analyzer (LI7500) were installed at a height of 27.5 m.

Net Ecosystem Exchange (NEE) was calculated from half-hourly measurements of the net exchanges of CO_2 and water vapor between the rubber stand and the atmosphere. CO_2 and H_2O fluxes were obtained from the eddy covariance between the fluctuations of vertical wind speed and air CO_2 concentration and water vapor measured at 20 Hz, 6 m above the canopy.

Monitoring NEE variations from ecosystem scale to regional scales OCO-2 SIF products: Solar Induced Fluorescence

- An emerging remote sensing approach to investigate the photochemical component of photosynthesis
- During photosynthesis, a portion of absorbed solar energy is emitted as fluorescence.
- Provides a signal directly linked to photosynthesis that can be detected from proximal and remote platforms.
- OCO-2 Satellite: Orbiting Carbon Observatory 2 , higher resolution (16-day, 1.3 km × 2.25 km); with two bands: 757nm; 771nm.



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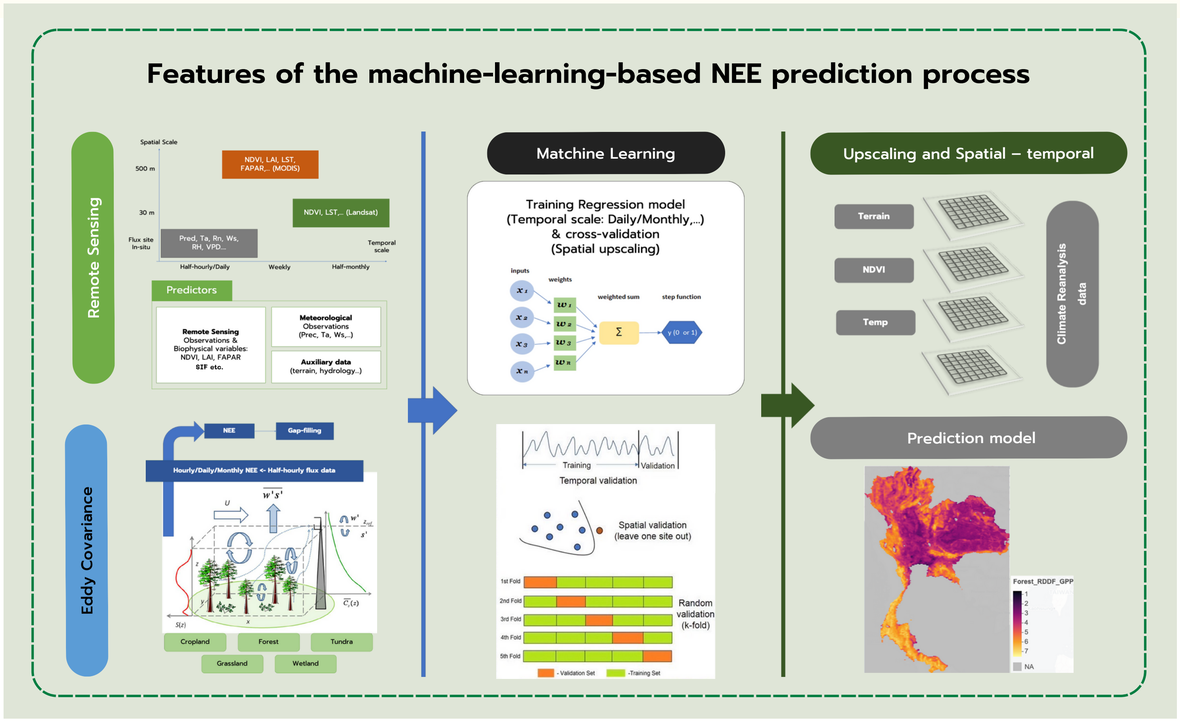

Fig1. Flow chart of the upscaling of EC with satellite remote sensing.

Carbon Fluxes Measured by the EC Tower vs. SIF

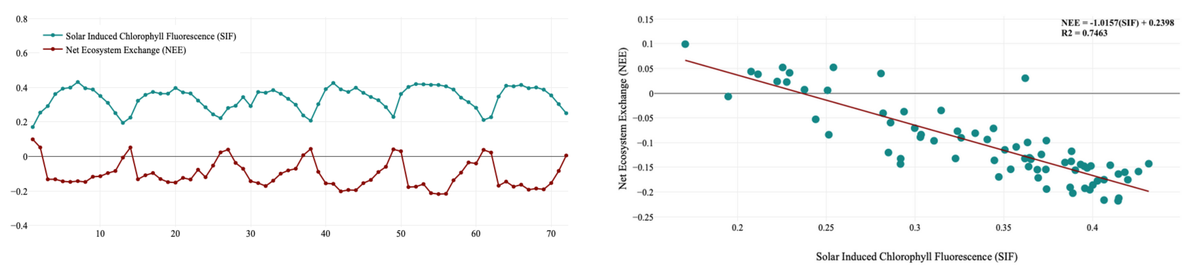

Fig.2 Comparison between satellite-derived SIF and NEE from EC observations (right). Their relatipnship and the coefficient of determination (left).

The daily net ecosystem exchange (NEE) dynamic of rubber plantation ecosystem showed a single peak curve in all seasons covering the period from 2015-2019. The diurnal NEE variation in the year showed a likely U shape curve. The total annual NEE of rubber plantation ecosystem was -42.8 tCO_2 /ha /y , and its capacity of carbon sequestration is very strong. Spatial patterns in climatological SIF and NEE are very similar across large scales, resulting in correlation coefficients of >0.7 (N = 75).

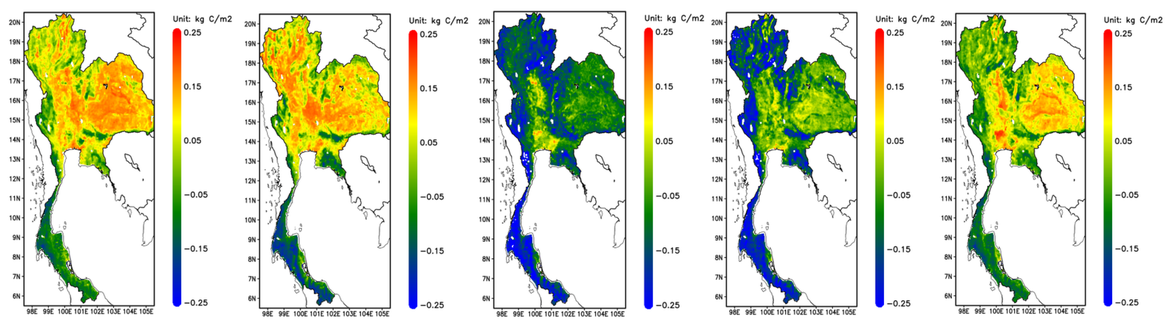

Fig.3 The spatial pattern of mean monthly NEE (kg C / m^2). By convention, a negative NEE flux indicates a transfer CO_2 into the ecosystem as carbon sink. Conversely, a positive NEE flux indicates a transfer CO_2 into the atmosphere as carbon source.

Conclusions

1. The carbon balance process of the rubber plantation system was first systematically studied, which can evaluate the carbon sink benefits of the rubber plantation system scientifically, and provide basic data for government decision-making and carbon trade.
2. Regional NEE map would be an interesting factor alongside with the emission generation and transfer data as well as local economic levels to be considered in carbon allocation policy.
3. OCO-2 SIF products had significant linear correlations with daily NEE over rubber plantation. SIF performed well in predicting CO_2 emission and removal.