

Remote Sensing meets Future Earth

～衛星リモセンはFEに何をどう
やって貢献できるか～

楊 偉

千葉大学
環境リモートセンシング研究
センター



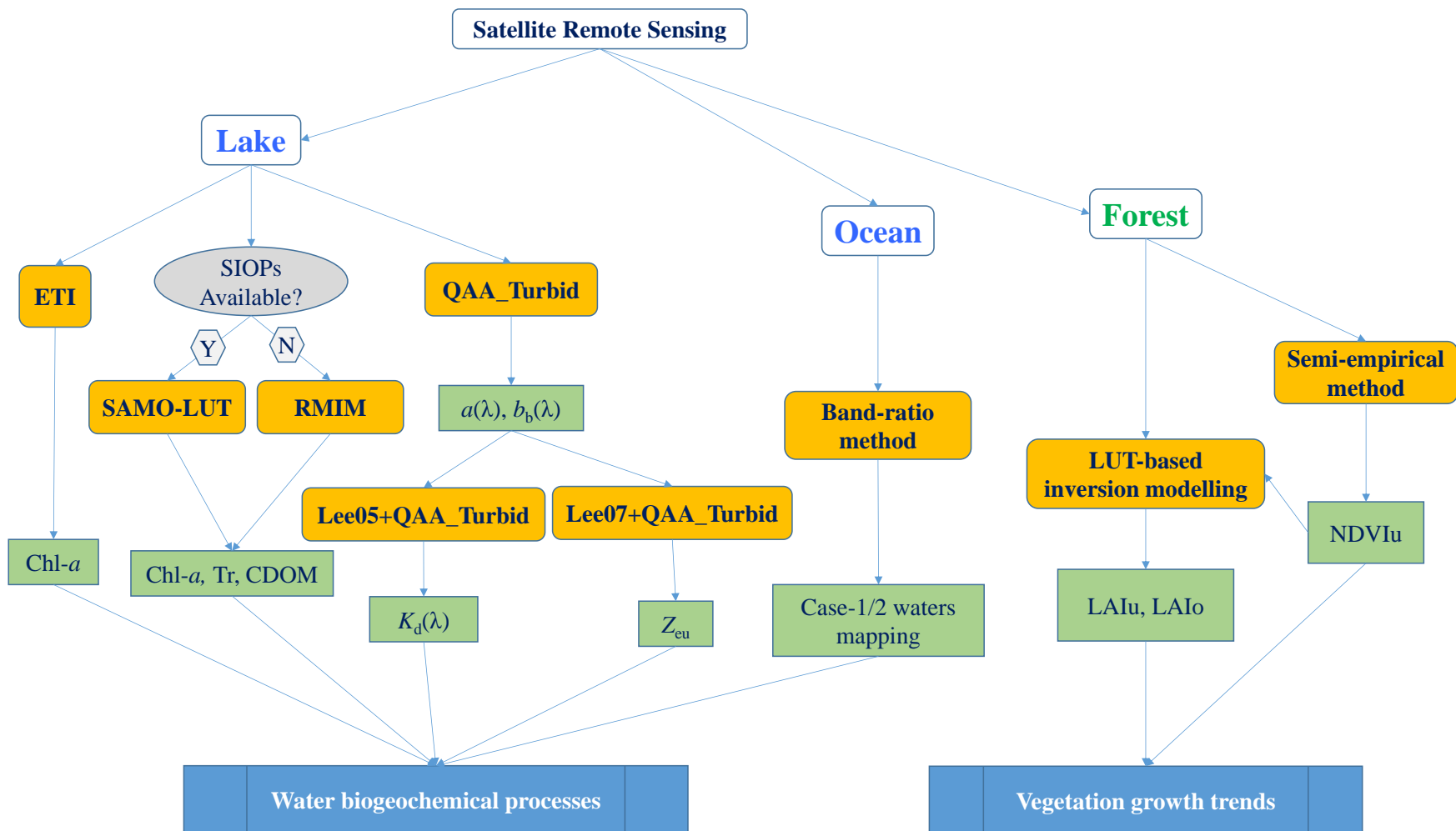
目次

- 自分の研究分野・研究内容
- 衛星リモセンとF Eの連結

定量的衛星リモートセンシング

- 物理や経験的なモデルに基づき、様々な数学手法を用いて衛星観測データから地球表面における生物・化学・物理パラメータを抽出する
- 対象地域：陸域生態系、特に湖沼と植生
- 放射伝達モデル + 推定アルゴリズム + 衛星データ

今まで開発したアルゴリズム



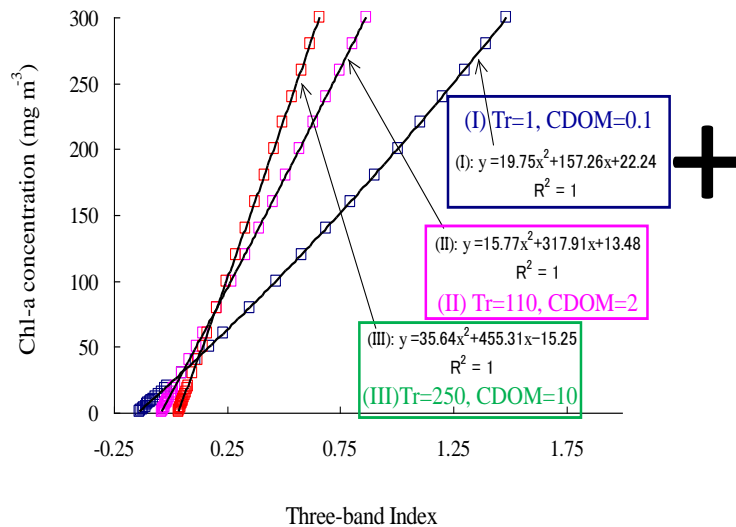
Semi-Analytical Model Optimizing and Look-up Table (SAMO-LUT) method

(Yang et al., 2011, RSE)

クロロフィル濃度

MODLE OPTIMIZING

LOOK-UP TABLE

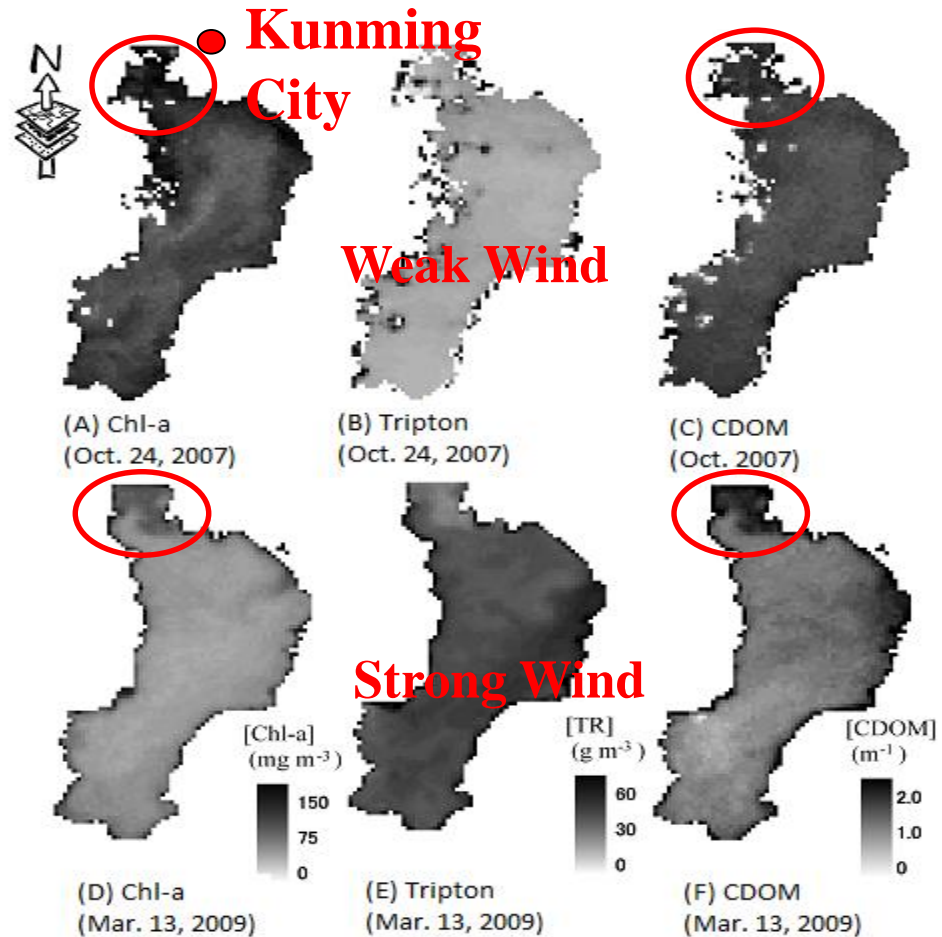


CDOM (m^{-1})	Trypton (g m^{-3})			
	1	2	...	...
0.1	($p_{1,1}; q_{1,1}; r_{1,1}$)	($p_{1,2}; q_{1,2}; r_{1,2}$)	...	...
0.2	($p_{2,1}; q_{2,1}; r_{2,1}$)	($p_{2,2}; q_{2,2}; r_{2,2}$)	...	...
0.3	($p_{3,1}; q_{3,1}; r_{3,1}$)	($p_{3,2}; q_{3,2}; r_{3,2}$)	...	...
...
...
9.9	($p_{99,1}; q_{99,1}; r_{99,1}$)	($p_{99,2}; q_{99,2}; r_{99,2}$)	...	...
10	($p_{100,1}; q_{100,1}; r_{100,1}$)	($p_{100,2}; q_{100,2}; r_{100,2}$)	...	...

- The basic idea of SAMO-LUT is an imaginary case-2 waters, in which only one water constituent concentration is changing, the other two are constrained as constant.
- SAMO-LUT yields acceptable accuracy for water quality parameters with relative errors $\pm 30\%$.

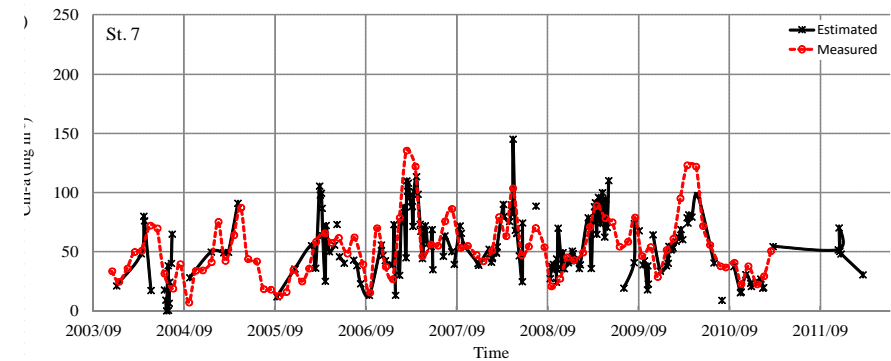
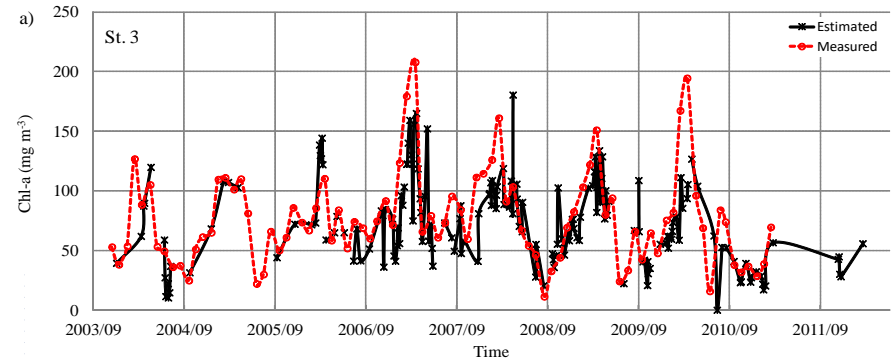
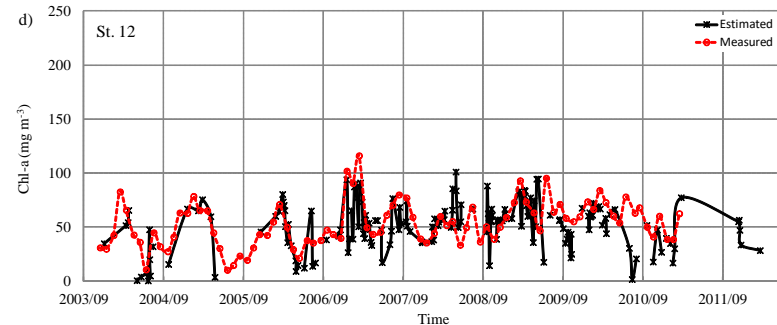
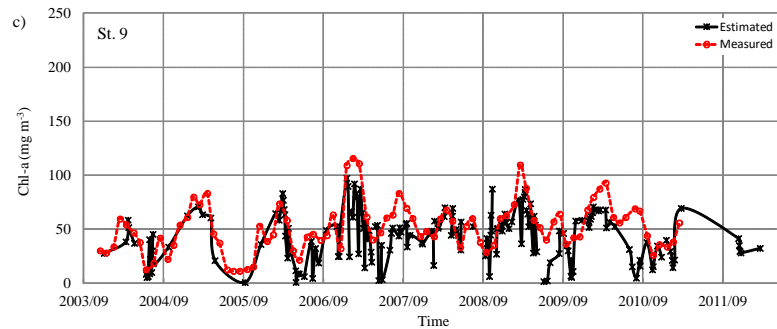
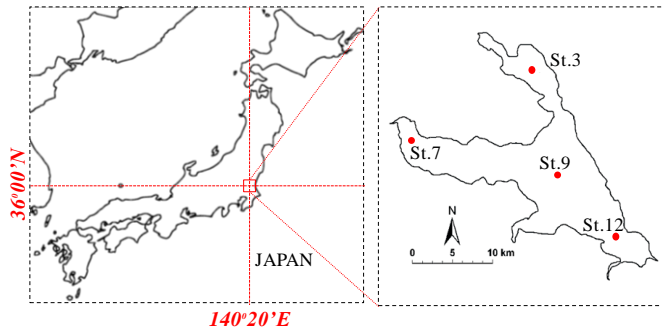
研究結果の例-水質：

□中国の滇池の水質パラメータ



霞ヶ浦における長期モニタリング (MERIS)

(Matsushita, Jaelania, Yang et al., 2015, RSSJ)



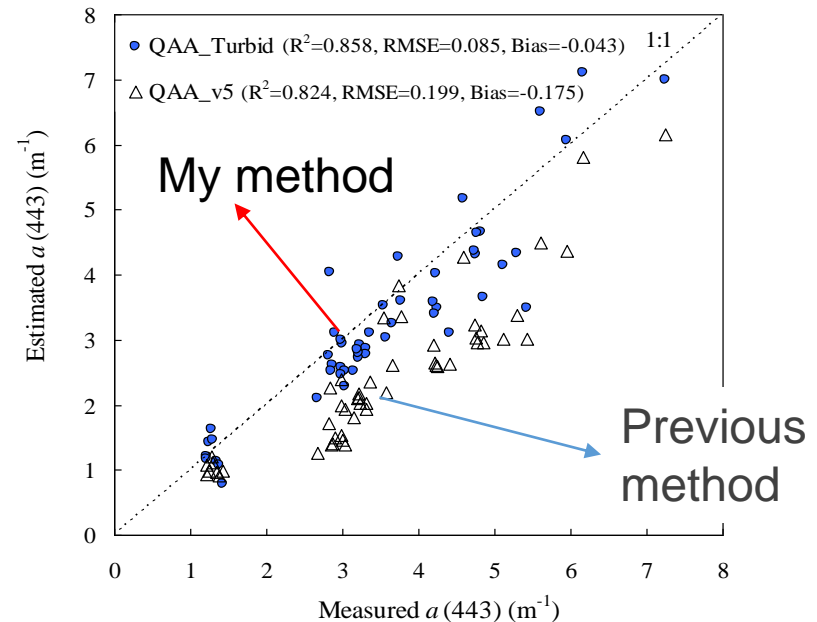
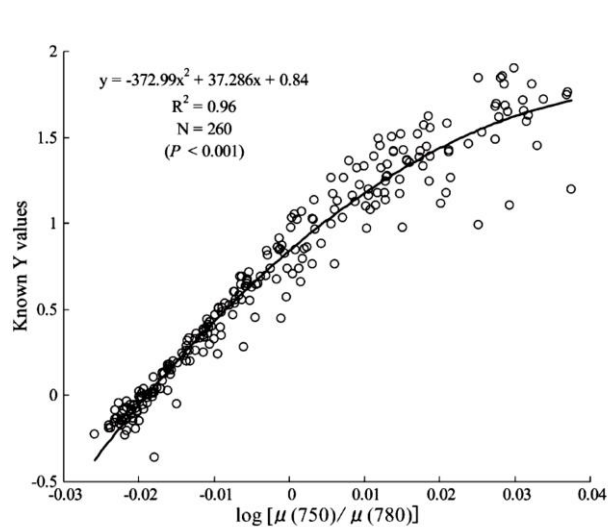
Time-series of satellite estimation show high agreements with field measurements.

Quasi-analytical approach for turbid waters (QAA_Turbid)

(Yang et al., 2013, IEEE TGRS)

□ Estimate of *inherent optical properties*, 吸收 · 散乱系数

Idea: using longer reference bands and proposing new model of backscattering spectral shape.



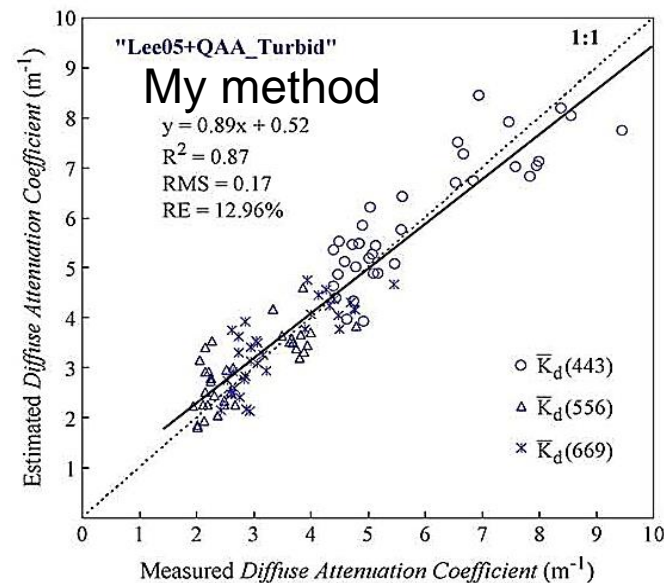
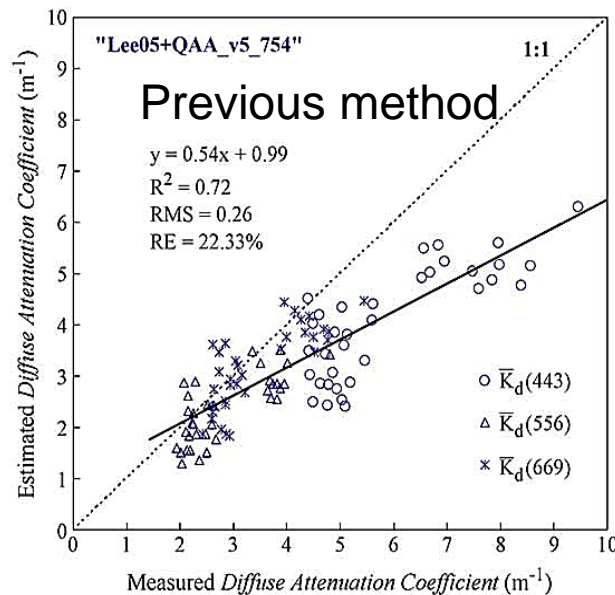
□ QAA_Turbid outperforms the original QAA significantly in inland lakes.

Lee05+QAA_Turbid model

(Yang et al., 2014, IEEE GRSL)

□ Estimate of *diffuse attenuation coefficient*, 消散係数

Idea: use of the retrieved $a(\lambda)$, $b_b(\lambda)$ from QAA_Turbid as input in the Lee05 model



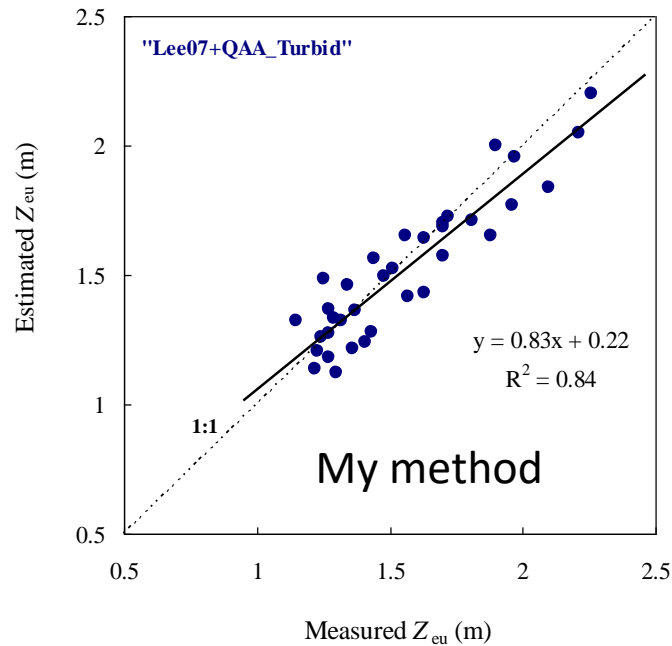
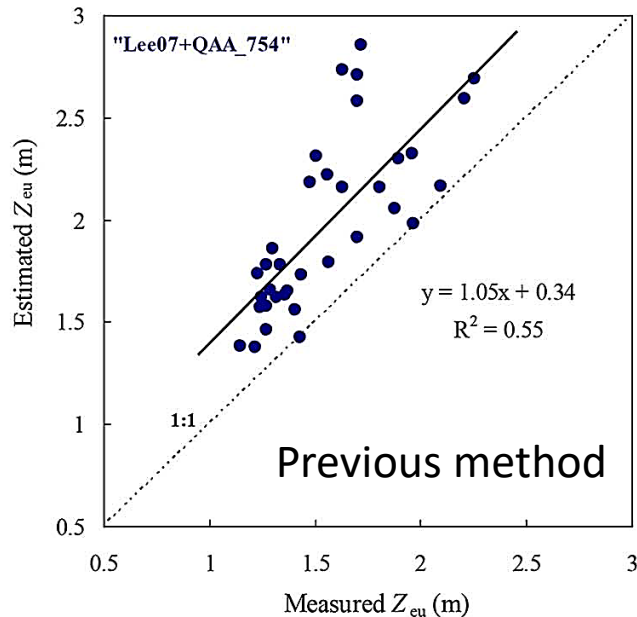
□ The proposed method yields remarkably higher accuracy than previous methods.

Lee07+QAA_Turbid model

(Yang et al., 2015, IEEE JSTASRS)

□ Estimate of *Euphotic zone depth*, Z_{eu} 、真光層

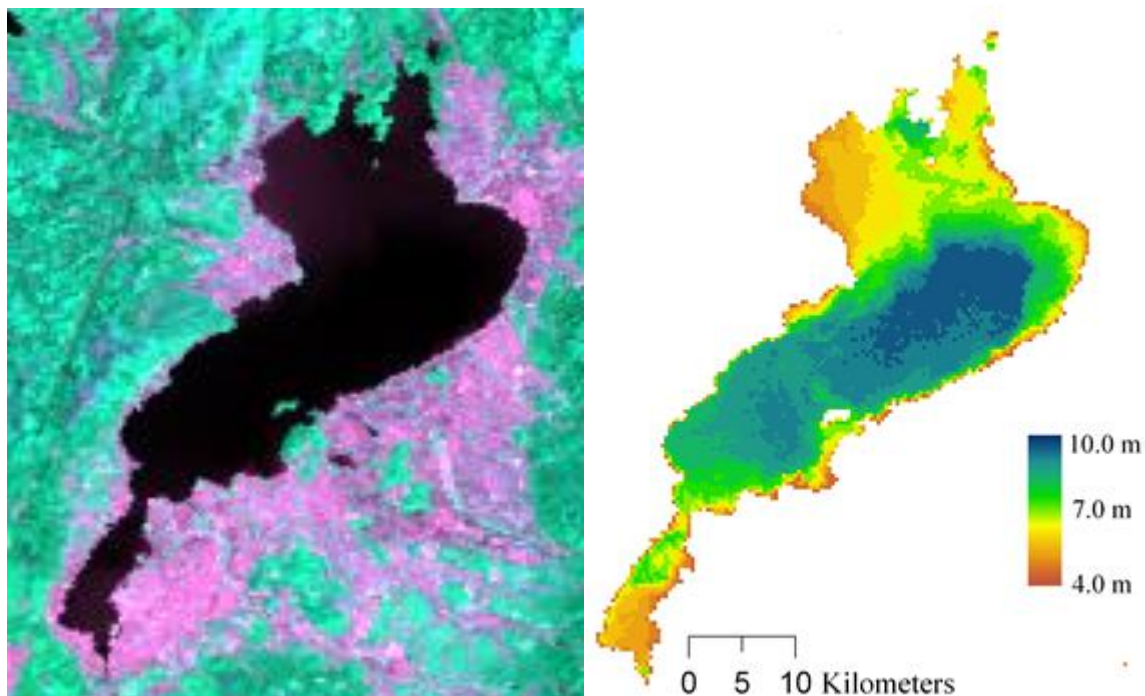
Idea: use of the retrieved $a(490)$, $b_b(490)$ from QAA_Turbid as input in the Lee07 model



□ The proposed method shows noticeably better performance than previous methods.

研究結果の例-透明度：

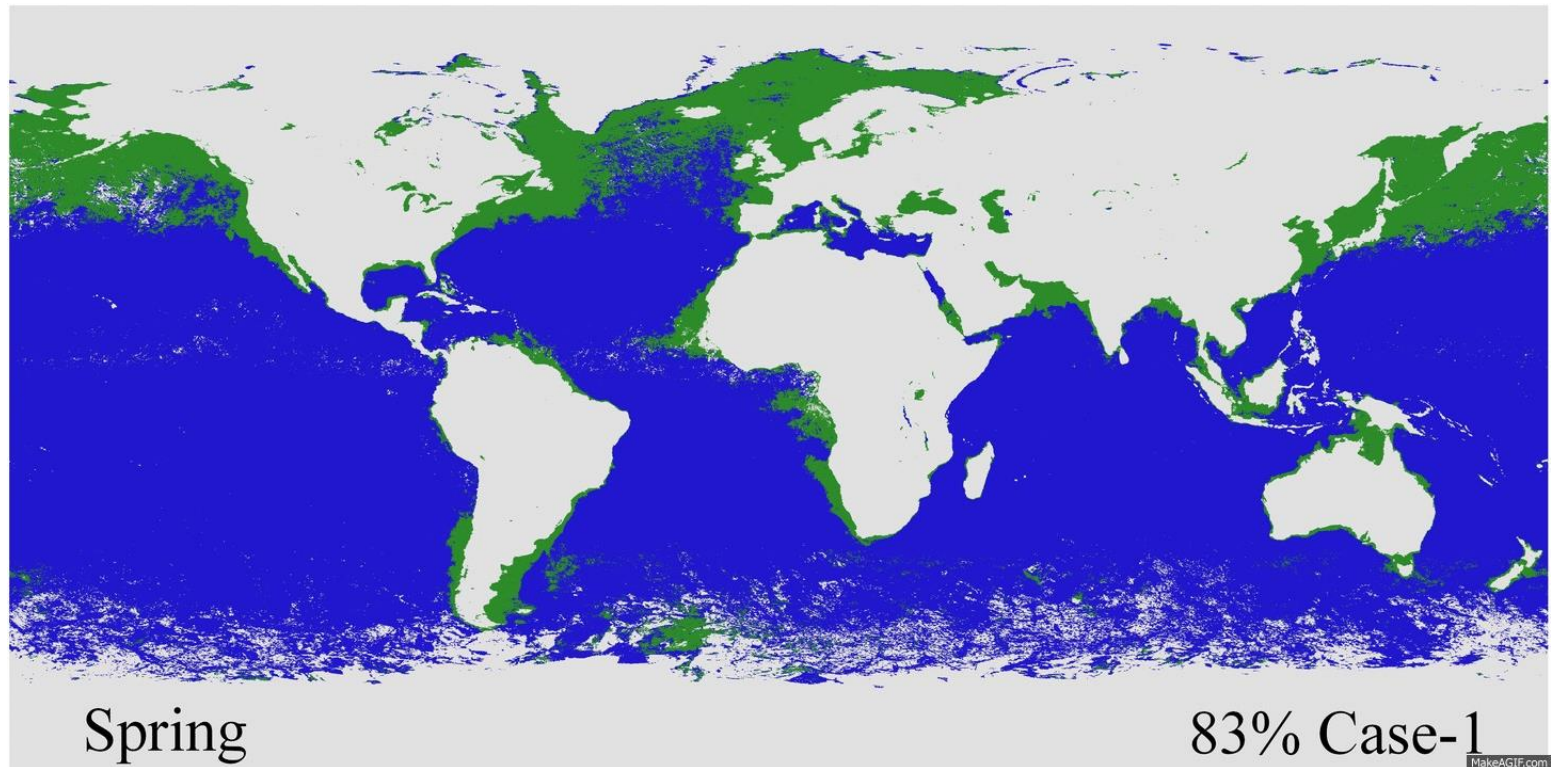
□琵琶湖の透明度のマッピング



- ✓ MERIS-based transparency for Lake Biwa, Japan

研究結果の例-沿岸水域：

□ 全球的なCase-1とCase-2 水域の空間分布



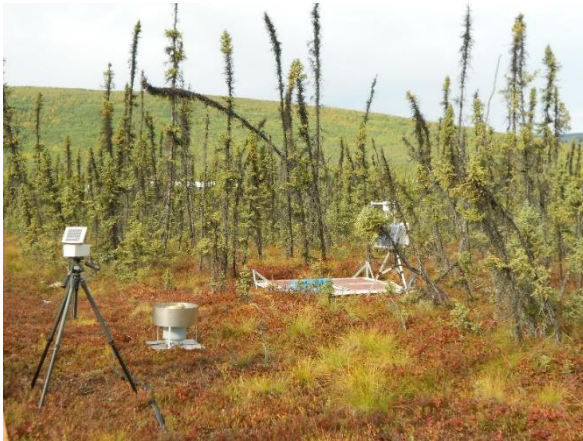
- The oceanic satellite products can be optimized by selecting appropriate algorithms for Case-1 and Case-2 waters, respectively.

林床植生を注目している

1). Carbon fixed through net primary productivity (NPP) has **different residence times** for different components in forest ecosystems (Vogel & Gower, 1998; Rentch et al., 2003).

✓ In **carbon cycle modeling**, overstory and understory vegetation need to be treated differently.

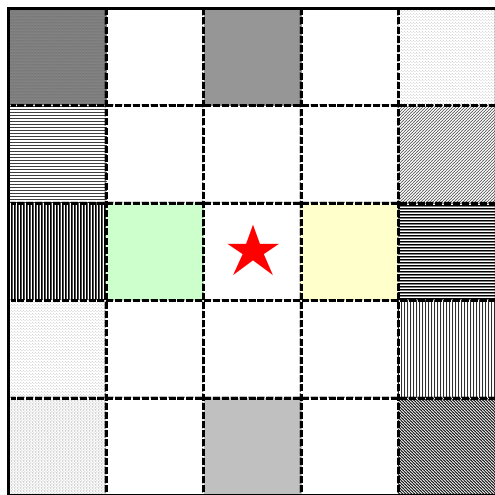
2). In boreal forests, understory is often exposed to satellite observation:



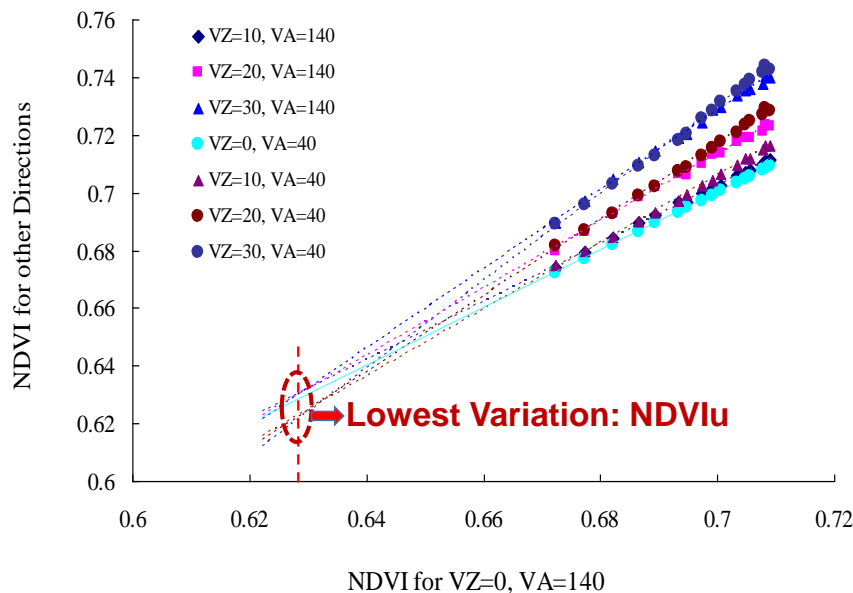
林床植生指数NDVIの推定アルゴリズム

(Yang et al., 2014, Remote Sens.)

CANDIDATE PIXELS



REGRESSION ANALYSIS



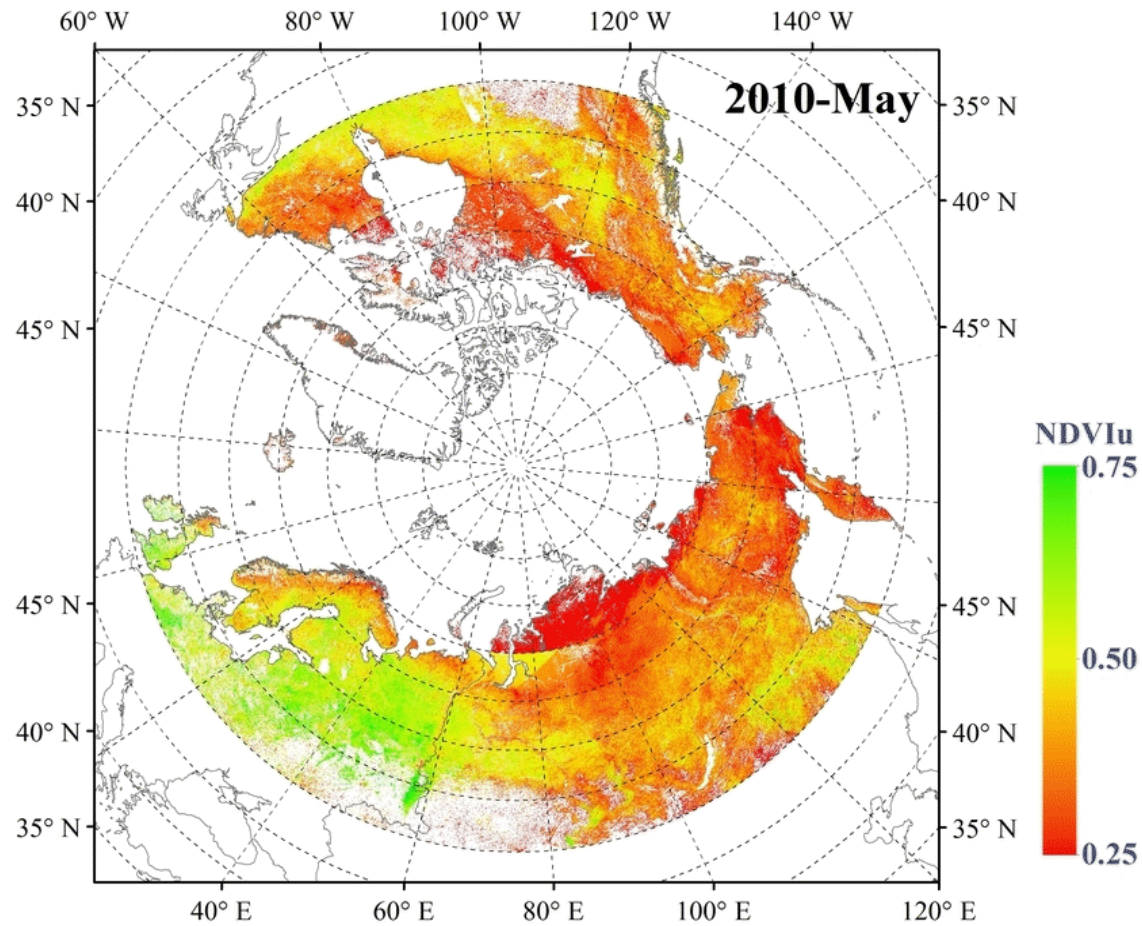
Assumptions:

(1) Identical Understory

(2) Identical vegetation properties but different overstory LAI

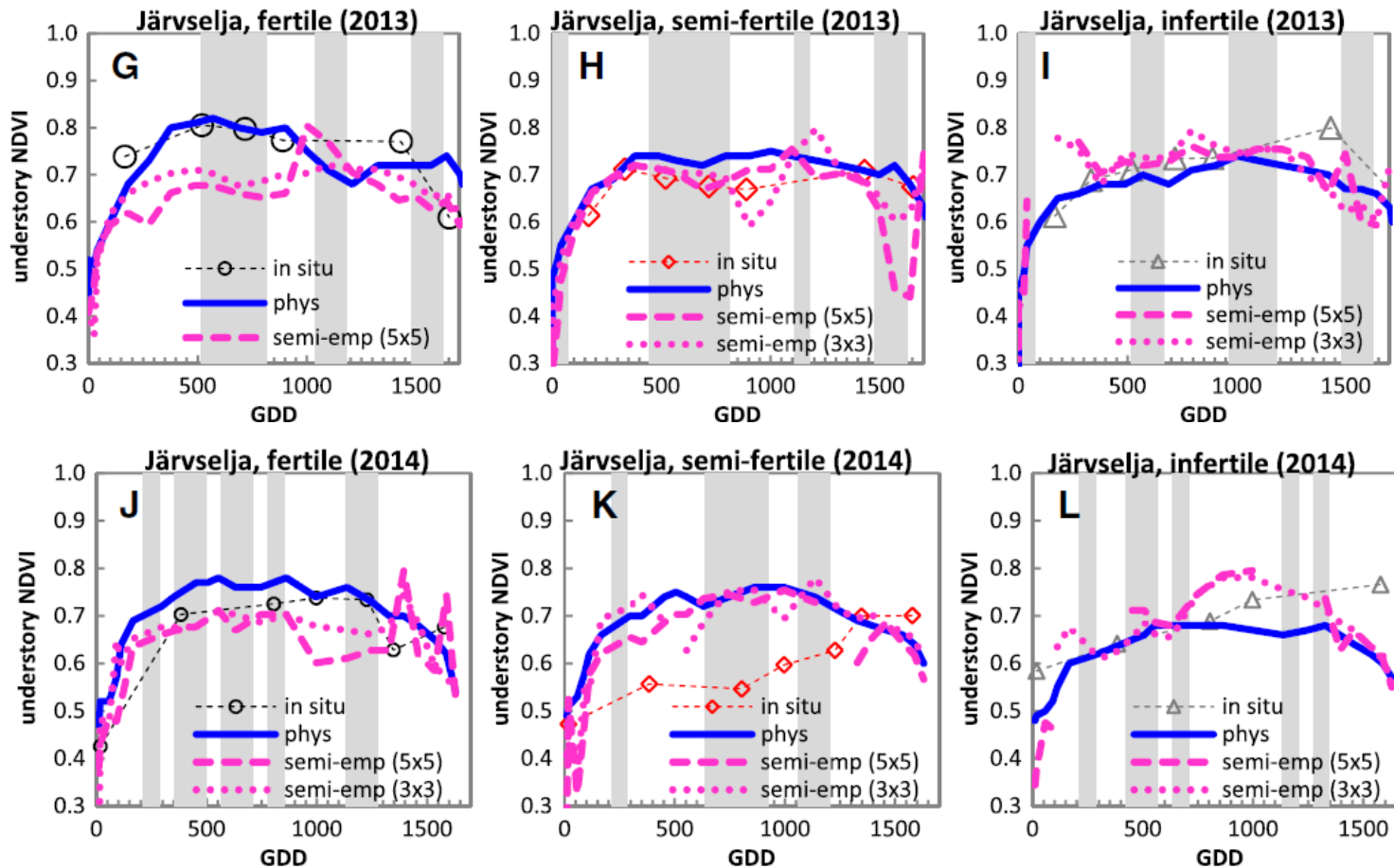
Retrieved understory NDVI in Boreal forests

(Yang et al., in prep.)



- ❑ The seasonal changes of NDVIu can be tracked.

Validations in European boreal forests

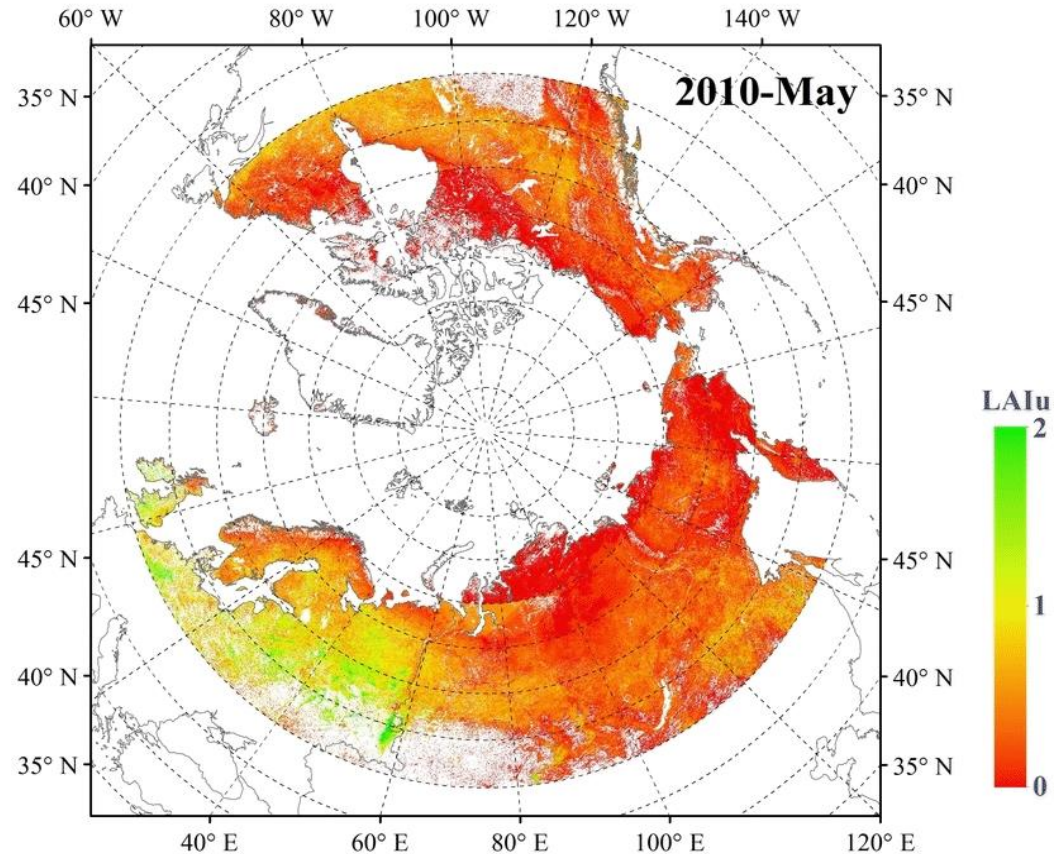
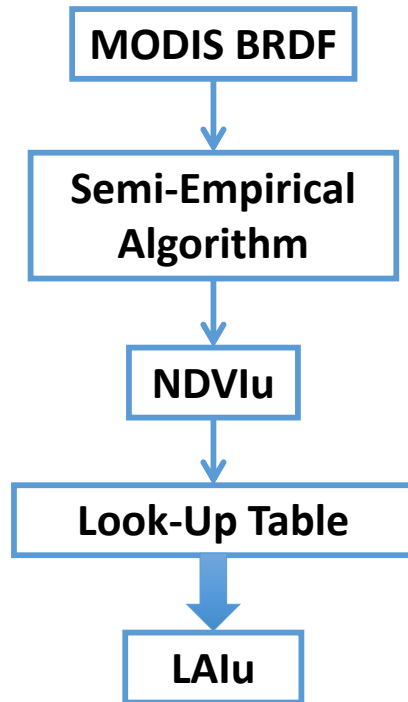


□ Satellite estimates of NDVIu show high agreement with *in situ* measurements.

(Pisek et al., 2015, RSE)

Estimated understory LAI in Boreal forests

(Yang et al., in prep.)



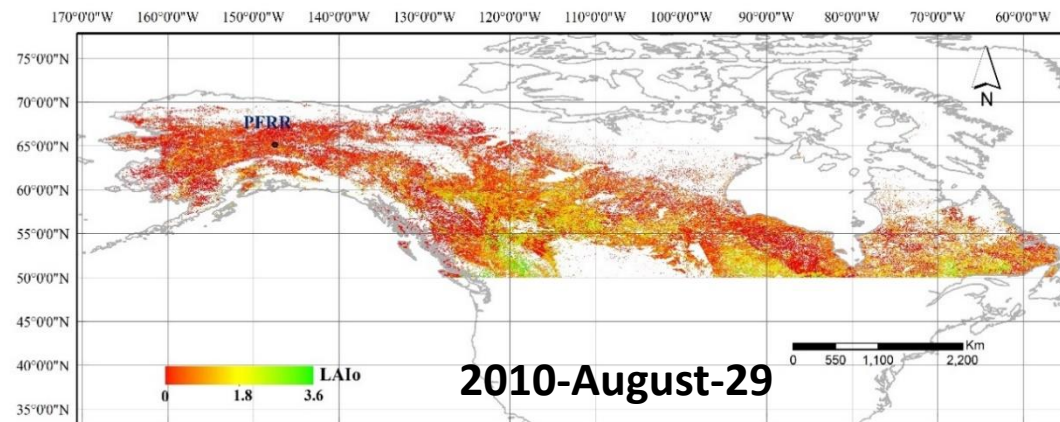
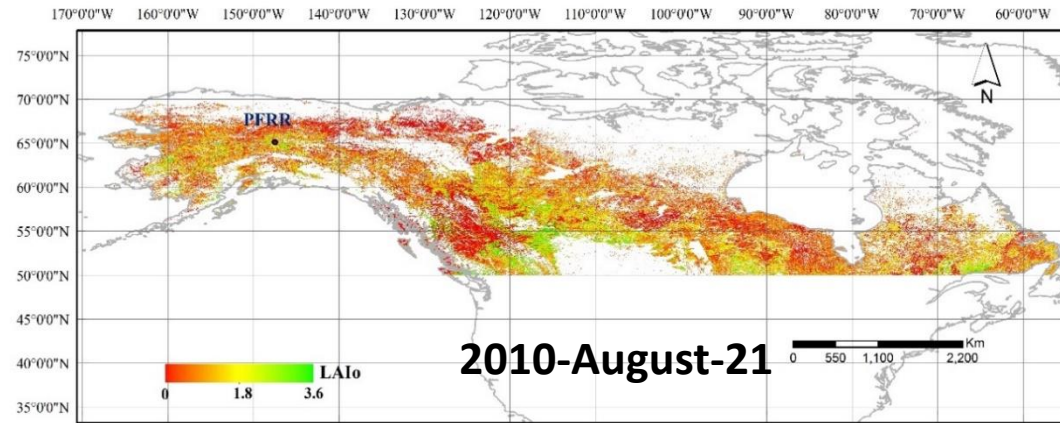
- Estimated LAIu show reasonable magnitudes (0~2.0) and seasonal patterns.

Estimated overstory LAI of boreal Evergreen Needleleaf Forest

(Yang et al., in prep.)

- 1). Forest Structure Model
- 2). Optical Parameters

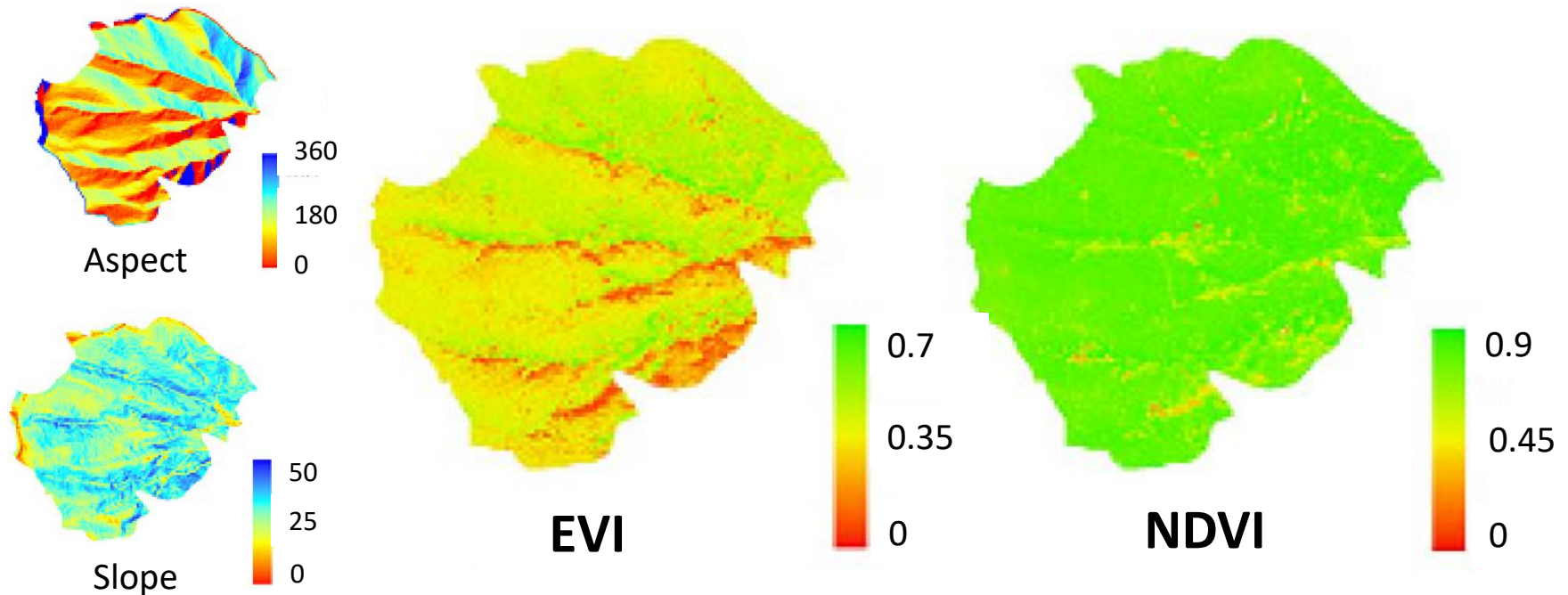
Look-Up Tables
(FLIES)



□ Reasonable magnitudes (0~3.6) and spatial patterns of LAI_o.

Sensitivity of NDVI and EVI to topographic effect

(Matsushita, Yang et al., 2007, Sensors, 50 times cited)



研究地域：高知の人工林

- **Finding:** NDVI is less sensitive to topographic conditions than is the EVI.
- It has been widely used in others' studies to explain the performances of EVI, or NDVI, such as Mildrexler, Zhao, & Running (2009, RSE).

現地調査の様子：湖沼



Diffuse attenuation coefficient,
Euphotic zone depth



**OCR 500 Multispectral
Radiometer**

A combination of precision optics and high p
microelectronics which can be operated as a
or in a networked environment as a part of a

現地調査の様子：森林



衛星リモセンとF Eの連結

～Pure Scientistの立場で自分の理解だけで～

衛星リモセンの役割

- **データ**：長期的・広域的な観測データ、特に全球・大陸的なスケールで
 - 例えば土地利用・土地被覆、森林被度、水質パラメータ、.....
- **情報**：環境変動の歴史;リアルタイム・モニタリング
 - 従来の環境はどうして今日の環境になった？



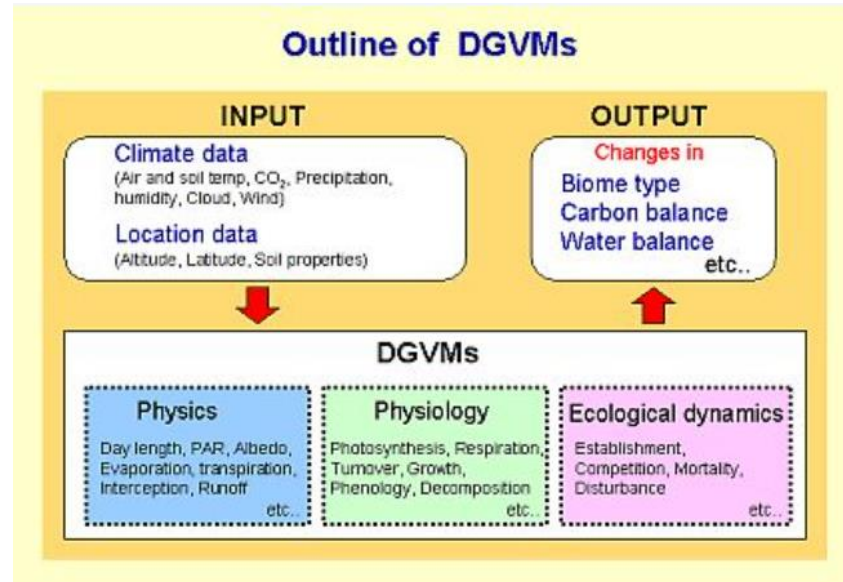
地球科学(Geoscience)

地球科学(Geoscience)の役割

- FUTURE of the Earth
- 従来の環境現象とその要因を理解する上で、
将来の環境を予測する。
- モデルを用いる

従来型のモデルの枠組み

- 例としてのDynamical Global Vegetation Model



- ✓ 気候変数：降水量、気温、湿度、風速など
- ✓ 人間活動：土地利用変動のみ

↓
詳細化は可能？

F E の枠組みで、モデルの高度化

- 人間活動 = ステークホルダーの活動
- ステークホルダーの詳細化とモデル化
- モデル化の為に、ステークホルダーを区別する必要性

ステークホルダーの二種類

- Type 1: 対象環境に影響する人
- Type 2: 対象環境に影響される人
- 人文系・社会系など知識を用い、ステークホルダー種類毎の将来性を予測する

取り組む目標

- 気候についての予測 + 人間についての予測 =
未来環境の予測
- No matter what kinds of situations are encountered, scientists should predict the future environments neutrally and accurately.

ご清聴ありがとうございました