Comprehensive MRV System in Tropical Peatland Ecosystem

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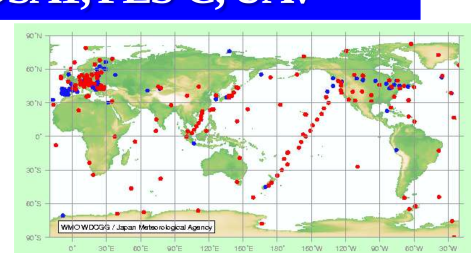
Reducing **E**missions from **D**eforestation and forest **D**egradation **(REDD-plus)** mechanism is expected to generate new incentive with co-benefit to tropical peatland ecosystems. Multi-temporal, multi-satellite sensors and multi-methods approach for establishment of reliable MRV system is a key of successful REDD-plus implementation. The group of Hokkaido University and Indonesian Institutes concluded that eight key elements are essential to establish reliable and comprehensive MRV system based on more ten years-long term ground observation data in peatland of Central Kalimantan, Indonesia.

[Eight key elements] (1) CO_2 concentration, CO_2 flux rate, (2) Hotspots detection, (3) Forest degradation and species mapping, (4) Deforestation, forest biomass changes, (5) Water level and soil moisture, (6) Peat dome detection and peat thickness, (7) Peat-subsidence, and (8) Water soluble organic carbon (Fig.1). These are obtained by advanced technology of remote sensing sensors loaded in GOSAT, ALOS/PALSAR, TERRA/ASTER, HISUI and others.

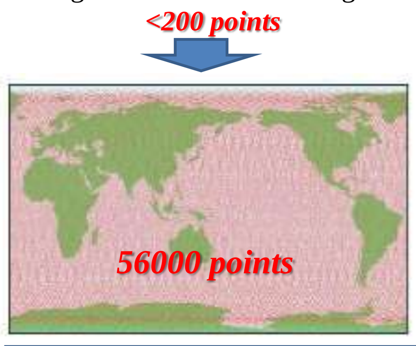
(1) CO_2 Concentration Estimation by GOSAT, FES-C, UAV

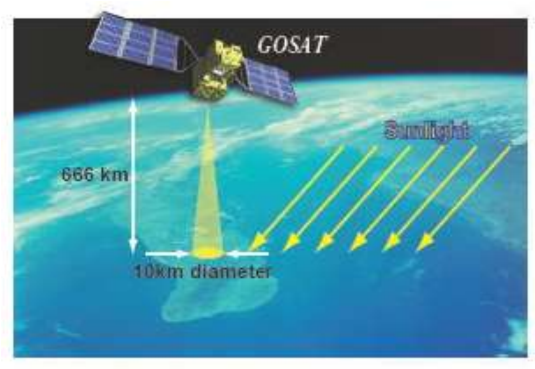
The Greenhouse Gases Observing Satellite (GOSAT) is the world's first spacecraft to measure the concentrations of green house gasses (GHGs) such as carbon dioxide (CO2) and methane (CH4) in atmosphere. It enables to map the CO2 concentration with data observed by CO2 flux tower and simulated model on CO2 concentration related with soil moisture in peatland.

GOSAT flies at an altitude of approximately 666 km and completes one revolution in about 100 minutes. The satellite returns to the same point in space in three days (Figure in next slide). The observation instrument onboard the satellite is the Thermal And Near-infrared Sensor for carbon Observation (TANSO). TANSO is composed of two subunits: the Fourier Transform Spectrometer (FTS) and the Cloud and Aerosol Imager (CAI).



Current ground-based monitoring stations
<200 points





Up: schematic illustration of how GOSAT makes observations.
Upper left: locations of ground-based monitoring stations (source: World Data Centre for Greenhouse Gases).
Left: GOSAT's footprint in three days
(http://www.gosat.nies.go.jp/eng/gosat/)

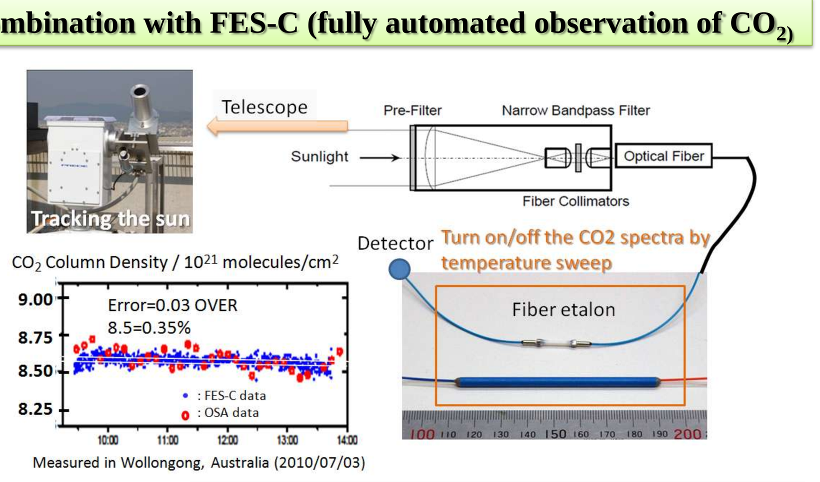
Specifications of FTS

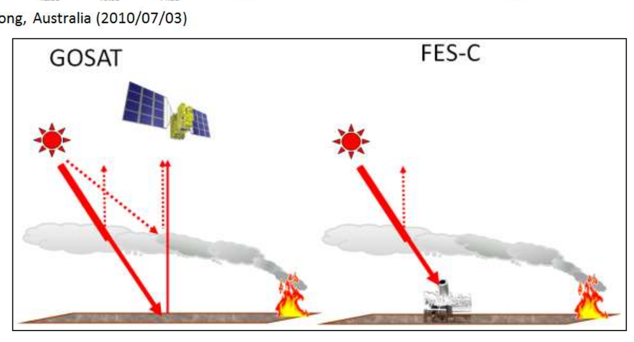
	Band 1	Band 2	Band 3	Band 4
Spectral coverage (μm)	0.758-0.775	1.56-1.72	1.92-2.08	5.56-14.3
Spectral resolution (cm^{-1})	0.2	0.2	0.2	0.2
Polarized light observation	Performed	Performed	Performed	Not Performed
Targeted gases	O_2	$CO_2 \cdot CH_4$	$CO_2 \cdot H_2O$	$CO_2 \cdot CH_4$
Angle of instantaneous field of view	15.8 mrad.(corresponds to 10.5 km when projected on the earth's surface)			
Time necessary for a single scanning (sec.)	4.0 , 2.0 , or 1.1 (depending on the scanning mode being used)			

Specifications of CAI

	Band 1	Band 2	Band 3	Band 4
Spectral coverage (μm)	0.370-0.390 (0.380)	0.664-0.684 (0.674)	0.860-0.880 (0.870)	1.56-1.65 (1.60)
Targeted substances	Cloud and aerosol			
Swath (km)	1000	1000	1000	750
Spatial resolution at nadir (km)	0.5	0.5	0.5	1.5

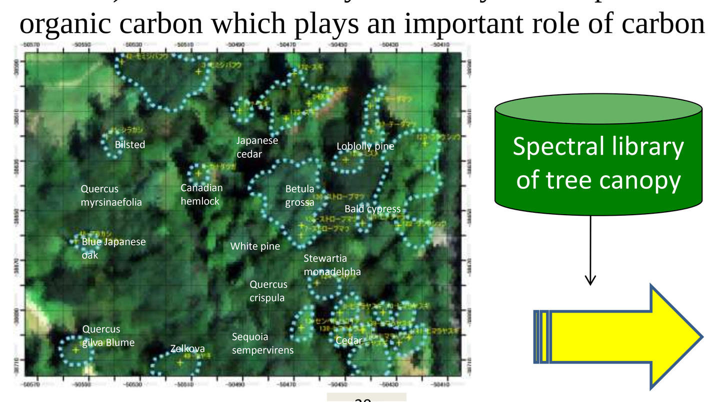
Combination with FES-C (fully automated observation of CO_2)



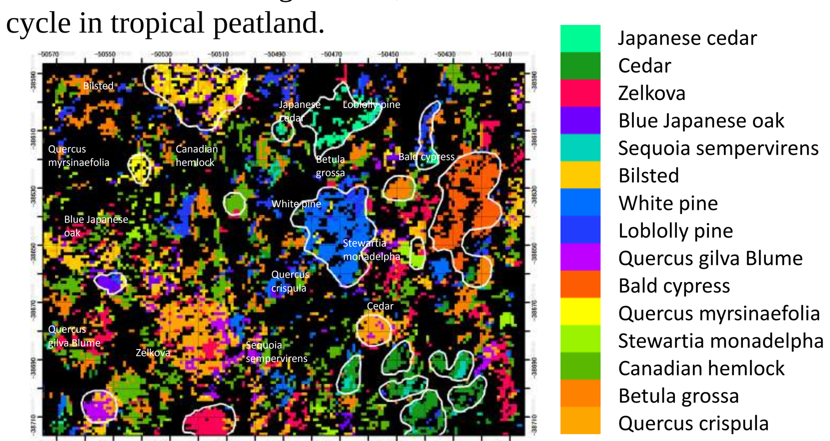


(3) Forest Degradation and Species Mapping by HISUI

Ministry of Economy, Trade and Industry (METI), Japan is developing a Hyper-spectral Imager SUIte (HISUI) which will be launched in 2014. It has 185 bands (57 bands in VNIR, 128 bands in SWIR) with narrow spectral resolutions (10-12.5nm). It allows not only to classify forest species and to evaluate forest degradation, but also to estimate water soluble organic carbon which plays an important role of carbon cycle in tropical peatland.



Site: Tokyo, Japan
Data: CASI (2004/9/1) [413-1053nm, 72bans, 1x1m]



Specification of HISUI *(http://www.ersdac.or.jp)*

Parameter		Requirement
Resolution, Swath		30 m and 30 km
Spectral	Bands	185 (VNIR:57 SWIR:128)
	Range	VNIR:0.4-0.97 µm SWIR:0.9-2.5 µm
	Resolution	10 nm (VNIR), 12.5 nm (SWIR)
Dynamic Range		12bit
Pointing Capability		≈ ±3° (±30 km)

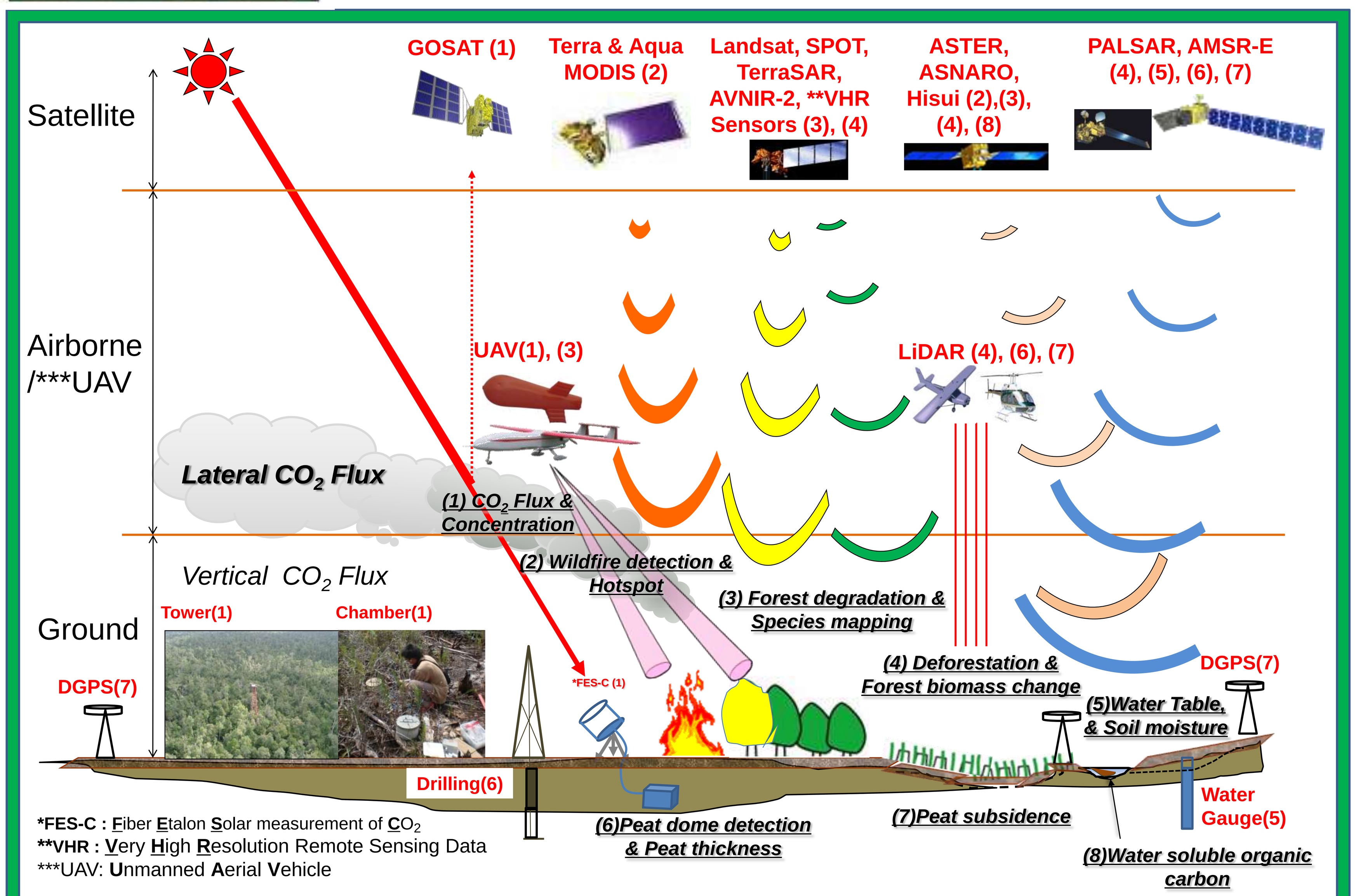
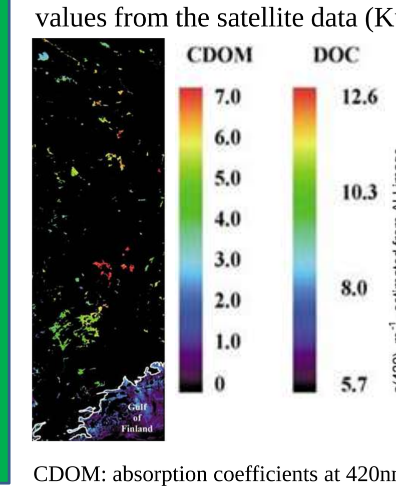


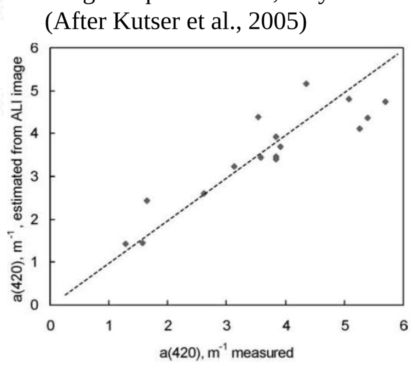
Fig.1 Key Elements of comprehensive MRV system in peatland

(8) Water soluble organic carbon estimation by HISUI

Dissolved Organic Carbon (DOC) is identified as the most significant form of carbon export from peatlands, and it has been found to be between 51 to 88% of fluvial carbon export (e.g. Hope et al., 1997; Dawson et al., 2002). Thus, monitoring DOC is an essential process to estimate dynamic carbon flux in a peatland ecosystem. As concentrations of colored dissolved organic matter (CDOM) and DOC are strongly correlated (Tranvik 1990; Kortelainen 1993; Kallio 1999), CDOC enables to estimate DOC values from the satellite data (Kutser et al.,2005).



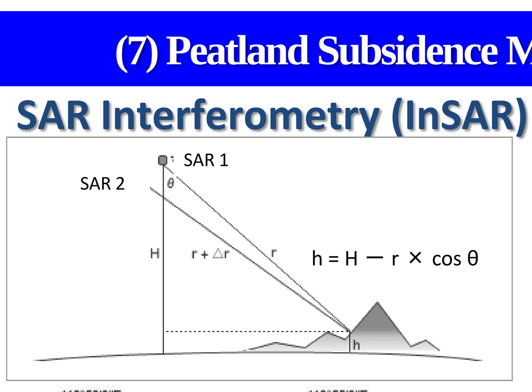
Example of DOC using ALI image acquired on 14, July 2002 (After Kutser et al., 2005)

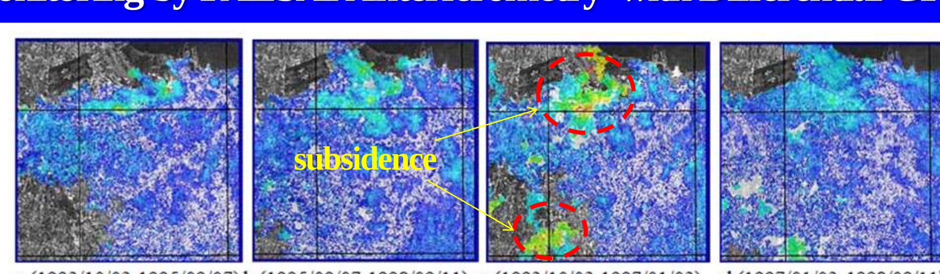


CDOM: absorption coefficients at 420nm(m-1), DOC: mg/L-1 calculated by CDOM

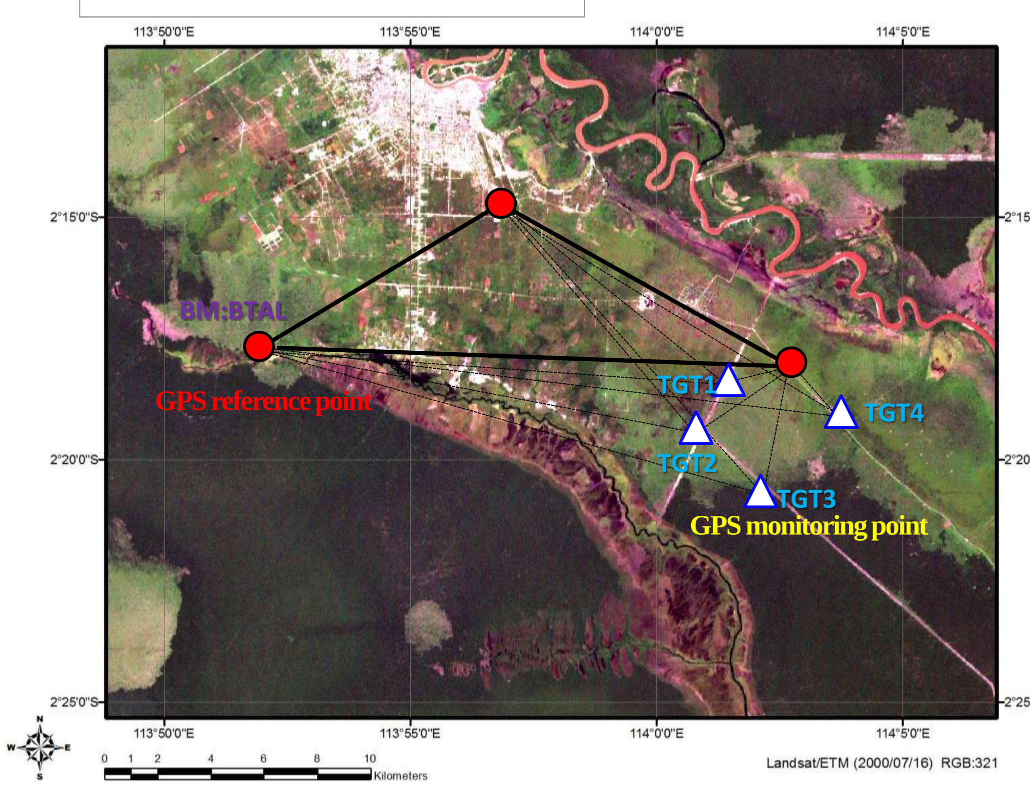
(7) Peatland Subsidence Monitoring by PALSAR Interferometry with Differential GPS Survey

SAR Interferometry (InSAR)

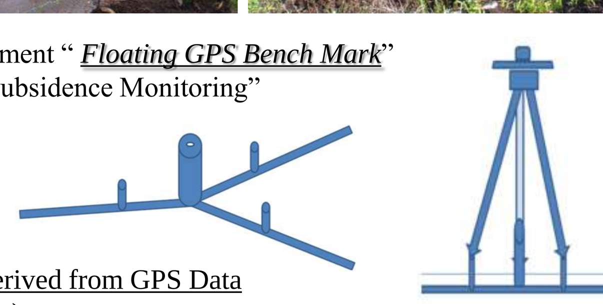




Example of InSAR subsidence monitoring in Jakarta (Hirose et al., 2001)



Special Equipment "*Floating GPS Bench Mark*" for Peatland Subsidence Monitoring"



GPS Data Processing

Characteristics of Baseline		Note
Baseline Length	<10 km	Radial from 3 reference station
Number of Baseline	12	Linear combination was used
Observation Length	~1 day hr	
Epoch Interval	30 sec	
Elevation Mask	15°	
GPS Data	L1 and L2	

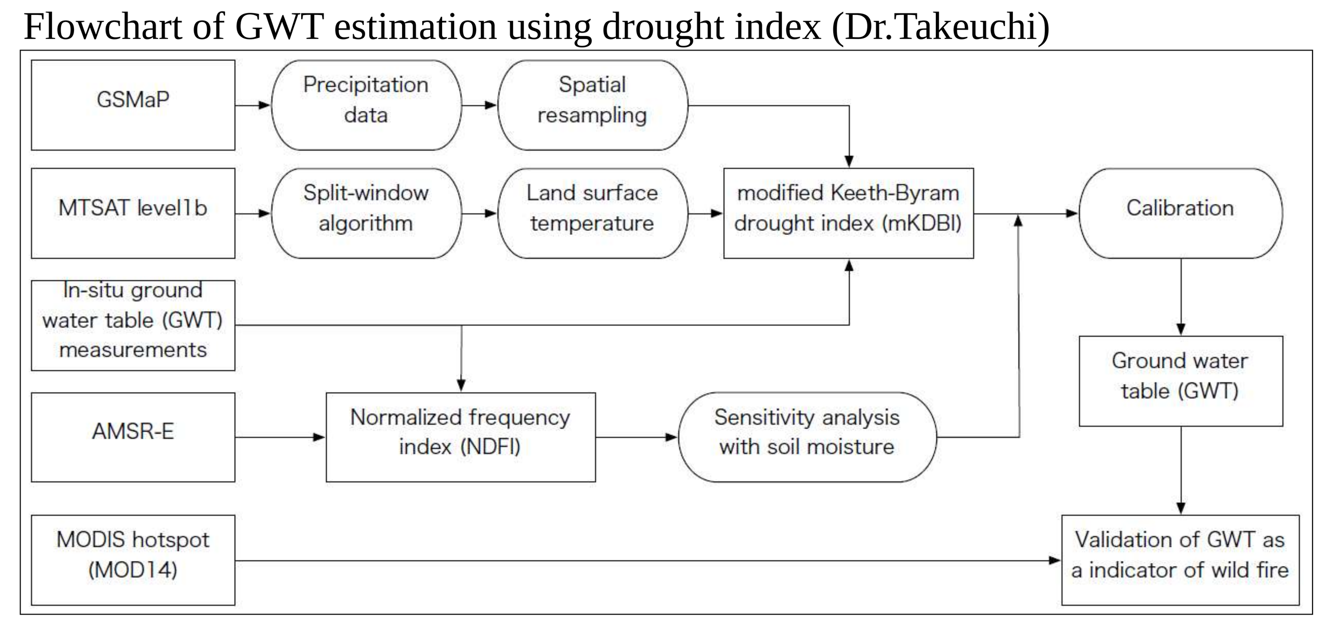
GPS Biases and Errors	Reduction Strategy
Ephemeris	Differencing and Precise Ephemeris
Ionosphere	Differencing and Estimated
Troposphere	Differencing and Estimated
Cycle Ambiguity	Quasy Ionospheric Free Method
GPS Biases and Errors	Reduction Strategy

Result of Peatland Subsidence derived from GPS Data
(Nov. 2010 – July 2011: 8 months)

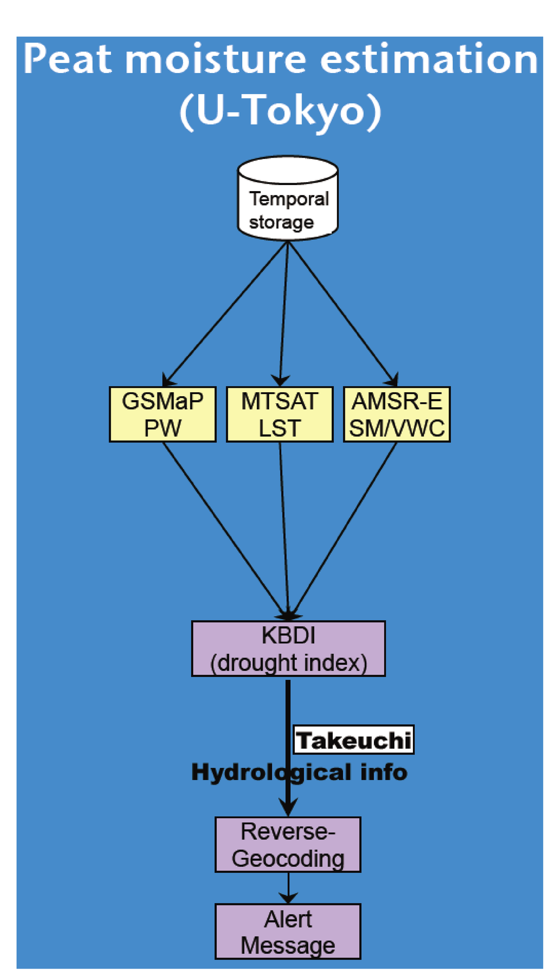
No	GPS Station	H ellipsoid (m) Nov 2010 (Wet Season)	H ellipsoid (m) July 2011 (Dry Season)	Subsidence (m)
1	TGT1	51.2958	51.2863	-0.0095
2	TGT2	50.7925	50.7951	0.0026
3	TGT3	50.6332	50.5993	-0.0339
4	TGT4	49.7986	49.7901	-0.0085

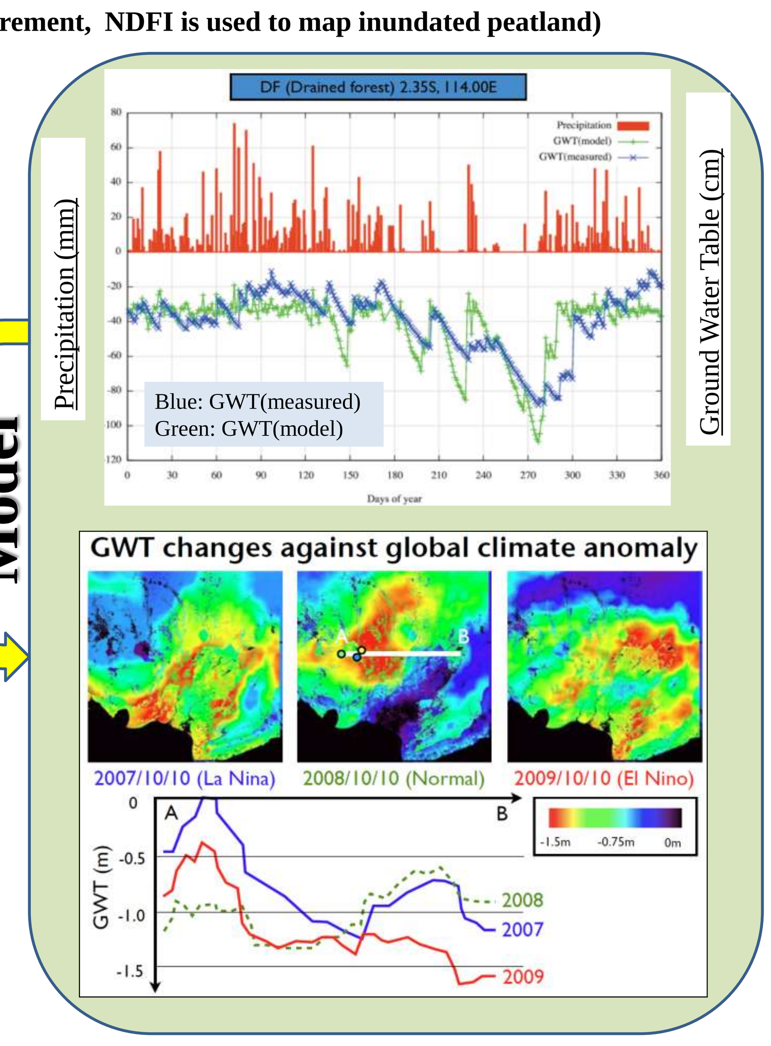
(5) Ground Water Table (GWT) and Soil Moisture Estimation

Flowchart of GWT estimation using drought index (Dr.Takeuchi)



(mKBDI is calibrated suitable for peatland measurement, NDFI is used to map inundated peatland)





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