**Major satellite/sensor providing vegetation data**

NOAA/AVHRR
(1981〜)

Landsat /TM,ETM+
(1972〜)

ALOS/PALSAR
(2006〜)

SPOT/VEGETATION
(1998〜)

Terra/MODIS,ASTER
(2000〜)
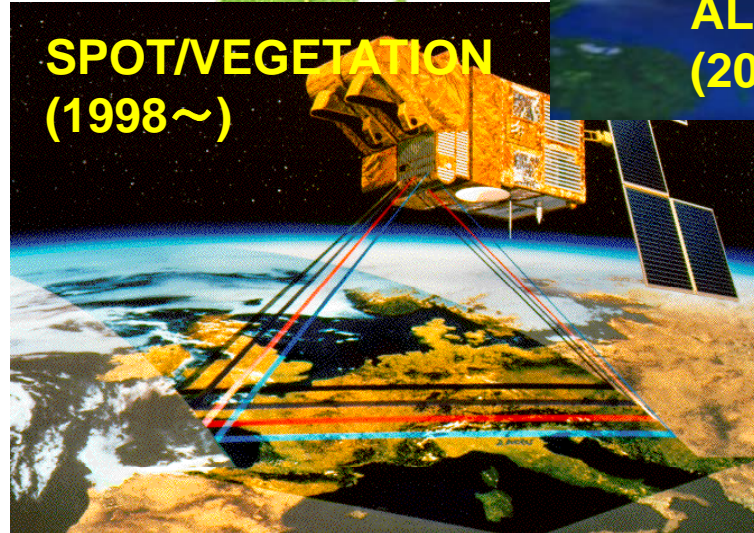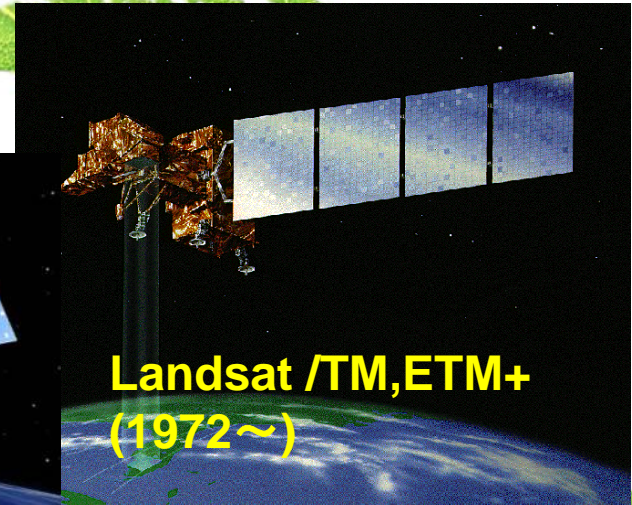
# Carbon cycle between biosphere and atmosphere, and major remote sensing



optical sensor (visible and NIR)

greenness (vegetation index, etc) and estimated vegetation physical properties (LAI, fPAR, NPP, land cover, structure)

atmosphere

photosynthesis

respiration

**CO$_2$ cycle**

*biomass*

biosphere

biomass, tree stand height, land cover, structure

microwave radar, lidar
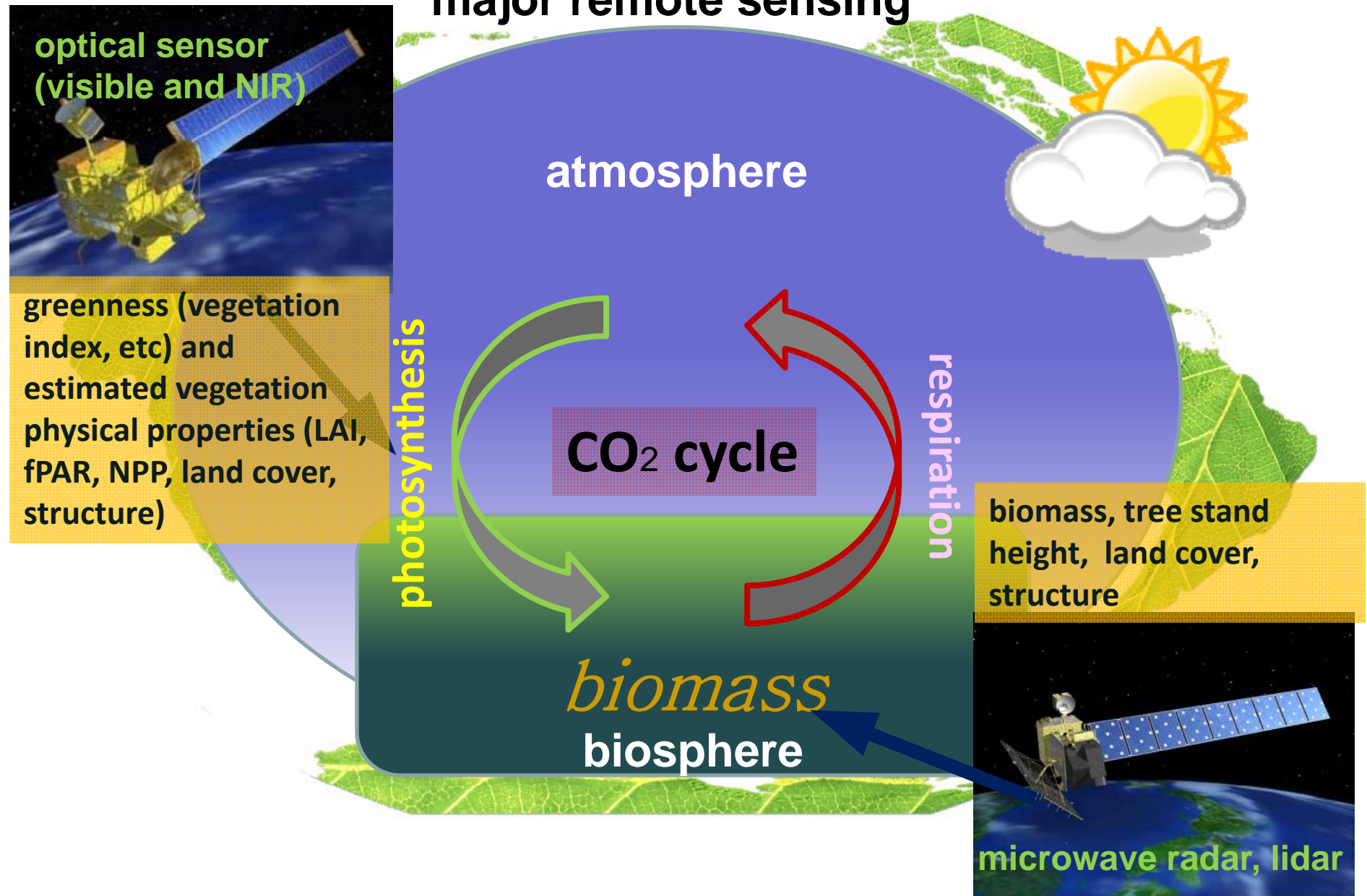
| **Ecosystems** Table 4.7.5 **Observational Requirement** | **Societal Benefit Subtopic** | | |
|---|---|---|---|
| | A | B | C |
| | Land, River, Coast & Ocean Management | Agriculture, Fisheries, Forestry | Carbon Cycle |
| **Ecosystem extent and composition** | | | |
| 1 **Extent and location of ecosystem and habitat types** | 1 | 1 | 1 |
| 2 **Fragmentation of ecosystems** | 2 | 2 | 2 |
| 3 **Community composition （including benthos）** | 2 | 2 | 2 |
| **Ecosystem structure and function** | | | |
| 4 **Leaf Area Index or greenness** | 1 | 1 | 1 |
| 5 **Ocean, freshwater water color and chlorophyll content** | 1 | 1 | 1 |
| 6 **Canopy architecture: height, cover** | 2 | 2 | 2 |
| 7 **Biomass per unit area** | 2 | 2 | 2 |
| 8 **Carbon fluxes: NPP, NEE and Respiration** | 3 | 3 | 3 |
| 9 **Water fluxes: evaporation** | 2 | 2 | 2 |

"GEOSS 10-year Implementation Plan"

4. Societal benefits, requirements, and earth observation systems

4.7. Improving the management and protection of terrestrial, coastal and marine ecosystems

4.7.5. Observation requirement table

0 – Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.

1 – Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.

2 – Not yet widely available or not yet globally monitored, but could be with two years.

3 – Only locally available or experimental; could be available in six years.

4 – Still in research phase; could be available in ten years.

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**An example of satellite-derived terrestrial vegetation greenness**
**– fundamental satellite-derived information of vegetation –**



Applicable to studies on spatio-temporal variation of vegetation, phenology, NPP, LAI, land cover, agriculture, forestry, etc

Enhanced Vegetation Index (EVI)

0    0.2    0.4    0.6  0.8 1.0
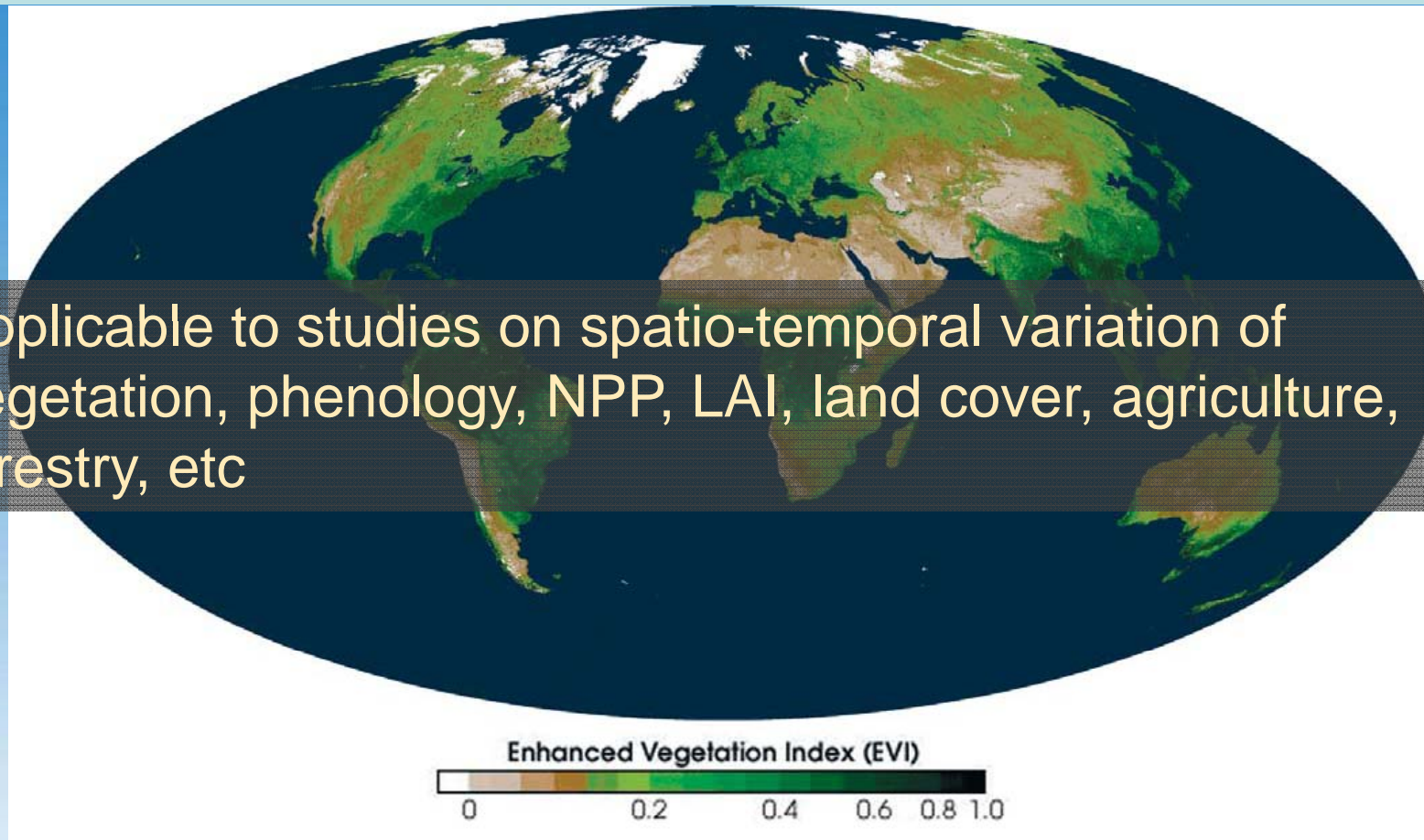
**Enhanced Vegetation Index (EVI):** Satellite measurements can be used to quantify the concentrations of green-leaf vegetation around the world, allowing scientists to monitor major fluctuations and understand how they affect, and are affected by, regional climate trends (from GEOSS 10-year Implementation Plan)

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# An example of satellite-derived Leaf Area Index (LAI)
## (opened and shared)



LAI distribution in June 2000 by Myneni's group
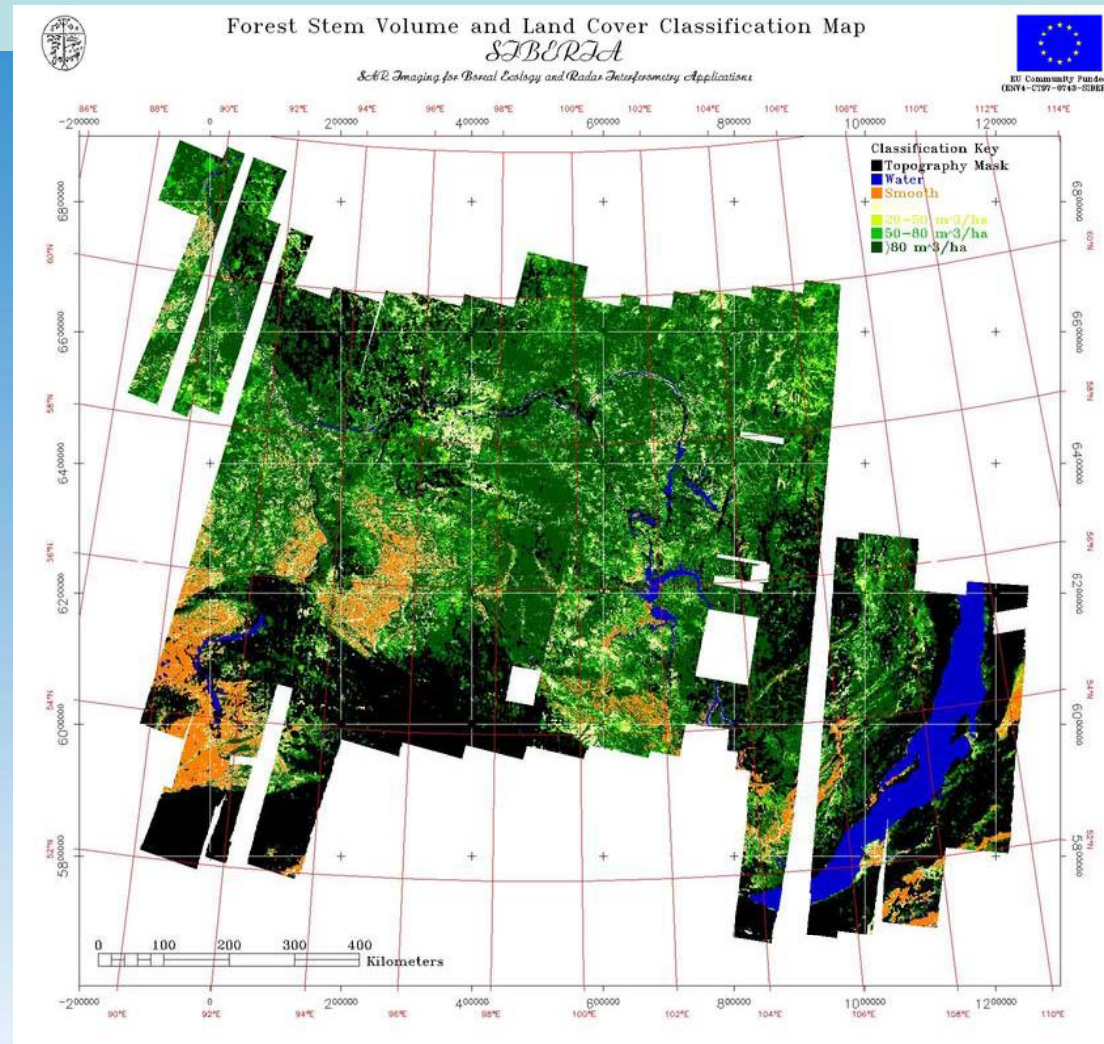fetched from the website on January 21, 2007
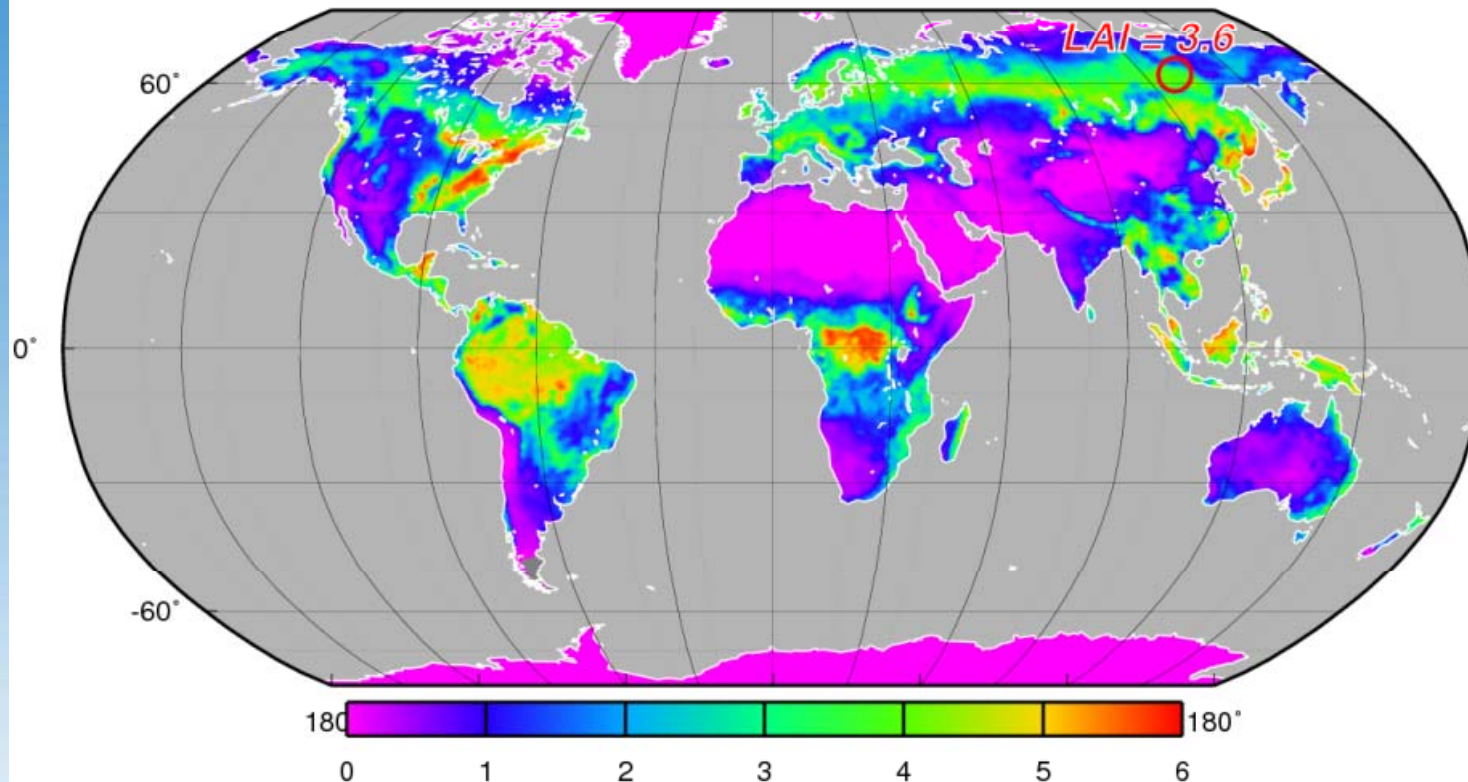
**Global Leaf Area Index (LAI) distribution in June, 2000 estimated by MODIS (MOD15 Correction 4)**
*ftp://primavera.bu.edu/pub/datasets/MODIS/MOD15_BU/C4.1/LAI/*

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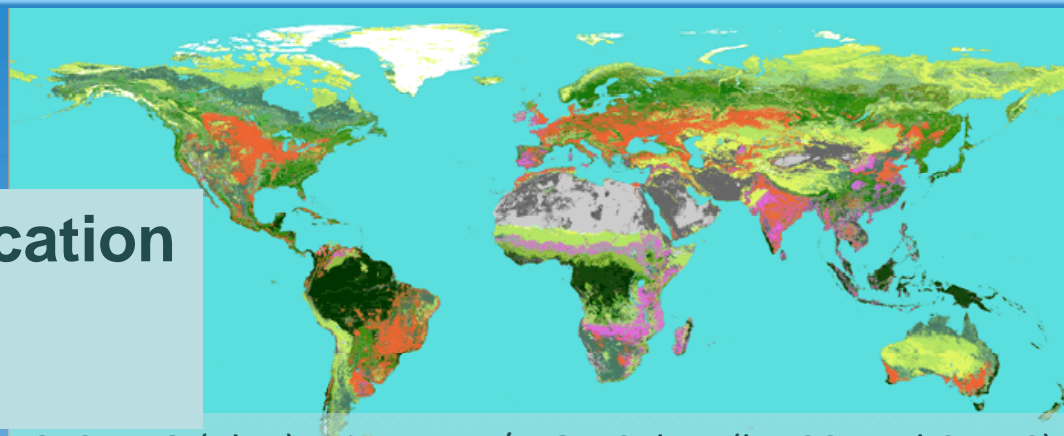# Remote sensing of above-ground forest biomass by microwave radar



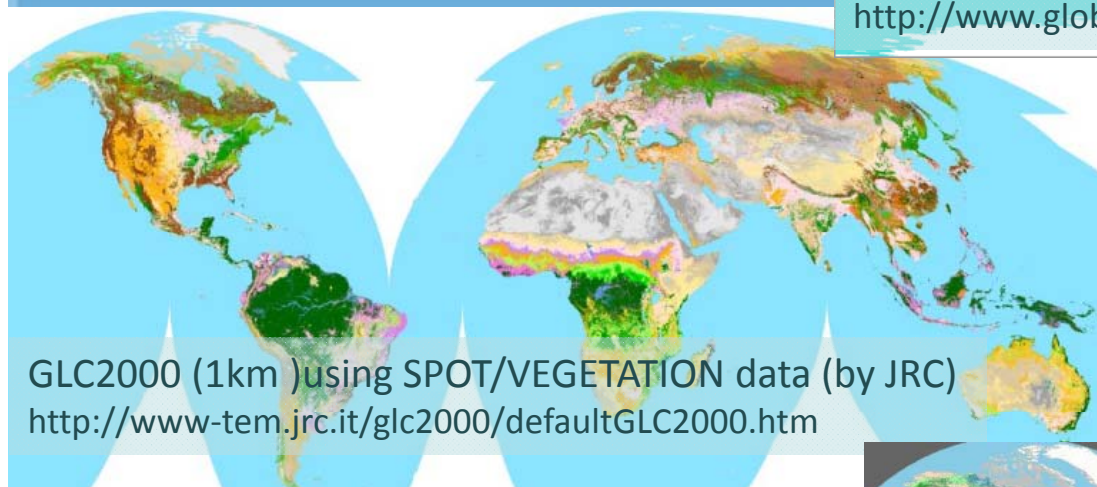**Above-ground biomass distribution estimated by JERS-1 and ERS observations by Siberia-II.**

*http://www.gofc-gold.uni-jena.de/sites/data/siberia.htm*

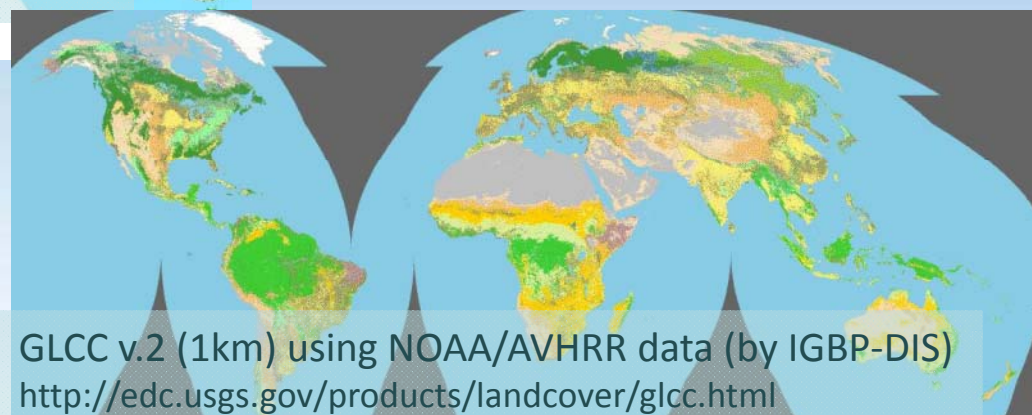GEOSS-AP at Kyoto, February 4-6, 2009

**Global land cover classification by satellite data**
**(opened and shared)**

GLCNMO (1km) using Terra/MODIS data (by GSI and CEReS)
http://www.globalmap.org/cd_j/index.html

GLC2000 (1km )using SPOT/VEGETATION data (by JRC)
http://www-tem.jrc.it/glc2000/defaultGLC2000.htm

GLCC v.2 (1km) using NOAA/AVHRR data (by IGBP-DIS)
http://edc.usgs.gov/products/landcover/glcc.html

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**Increasing requirement of ground truth data for remote sensing**

# Development of estimation algorithm for above-ground forest biomass by microwave remote sensing (Suzuki, Kim, and Ishii)



ALOS/PALSAR image (HV) along the Trans-Alaska Pipeline in July and August, 2007
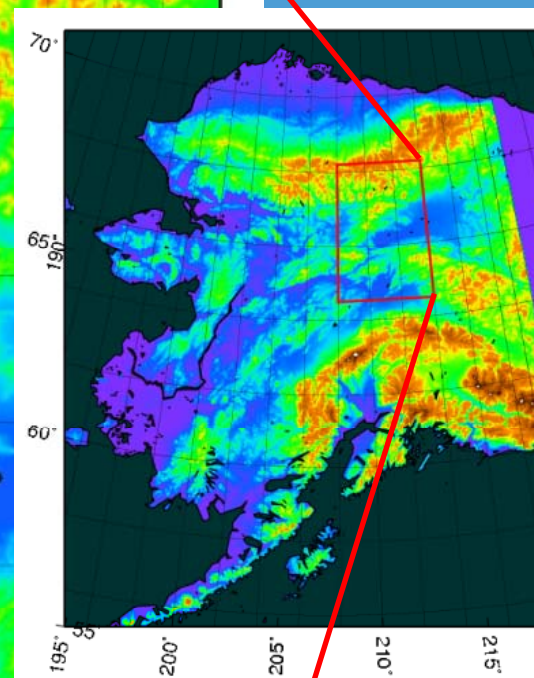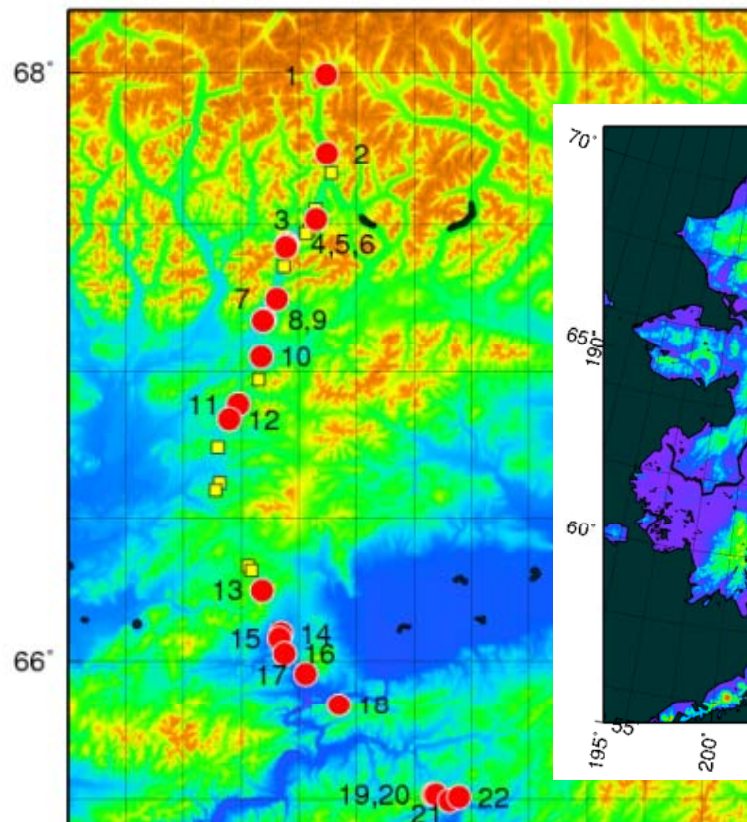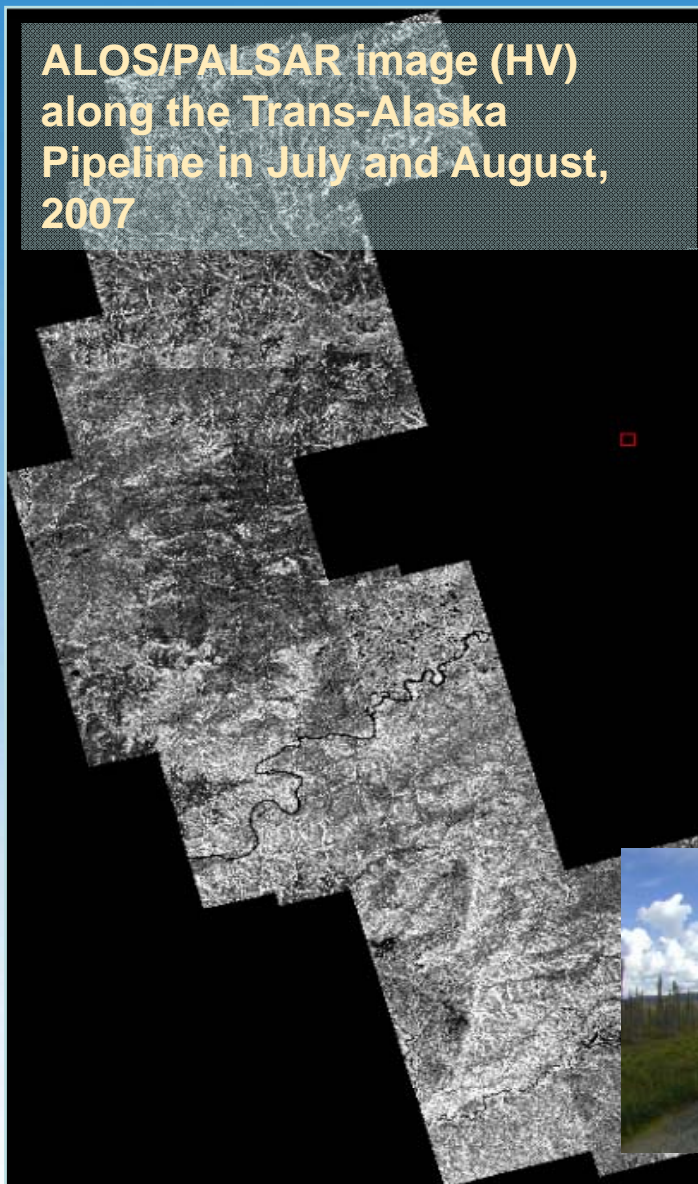
Ecotone from boreal forest to tundra along Dalton Highway

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# Biomass（t/ha）of 29 forests in Alaska（July, 2007）

| | | | | | |
|---|---|---|---|---|---|
| R7-01 4.7 | R7-02 31.9 | R7-03 27.5 | R7-04 25.5 | R7-05 2.2 | R7-06 20.9 |
| R7-07 5.9 | R7-08 22.4 | R7-09 35.0 | R7-10 12.4 | R7-11 4.35 | R7-12 69.8 |
| R7-13 24.9 | R7-14 7.3 | R7-15 12.6 | R7-16 115.8 | R7-17 81.9 | R7-18 30.9 |
| R7-19 67.0 | R7-20 36.1 | R7-21 40.1 | R7-22 16.3 | R7-23 100.2 | R7-24 92.4 |
| R7-25 15.3 | R7-26 50.7 | R7-27 6.6 | R7-28 12.7 | R7-29 12.8 | Rikie Suzuki |

# A concept of ecosystem dataset construction derived from satellite remote sensing

## OBSER-VATION

**satellite obs.**

*hopefully coordinated*

**field obs.**

## ANALYSIS & DATA SET CREATION

**satellite data**
- optical (ex. NDVI)
- microwave (ex. $\sigma_0$)

**analysis**

**ecosystem physical data**
(land cover type, LAI, biomass, fire, pest, structure)

**ground truth data**
(vegetation type, forest census, land cover, LAI, biomass, fire, pest, structure)

## APPLICATION
- monitoring
- earth system models
- prediction
- decision support

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# Recommendations for GEOSS

1. To construct and distribute satellite remote sensing data (both spatially high resolution data and <span style="color:red">globally-covered data</span>).
2. To coordinate and enhance domestic and international networks for field surveys (e.g. LTER, FLUXNET) for exchanging and archiving the ground truth data for the remote sensing (forest census, LAI, biomass).
3. To digitize and archive of the land cover maps of each country as the ground truth information for the remote sensing.
4. To open and share above data sets.
5. RS potential for biodiversity monitoring --> immature