The Global Terrestrial Observing System

and

Terrestrial Carbon Observations (TCO)

Alos meeting

Tokyo

1-2 november 2001

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GTOS Programme director

Mission statement:

To provide policy makers, resource managers and researchers with access to the data they need to detect, quantify, locate, understand and warn of changes (especially reductions) in the capacity of terrestrial ecosystems to support sustainable development.

Five issues of global concern:

1. changes in land quality
2. freshwater resources
3. loss of biodiversity
4. climate change
5. pollution and toxicity

Terrestrial carbon observation project

1. **By 2005, demonstrate the capability** to estimate annual net land-atmosphere fluxes at a sub-continental scale with an accuracy of +/- 30% globally, and a regional scale (10^6 km^2) over areas selected for specific campaigns with a similar or better accuracy.

2. **By 2008, improve** both the spatial resolution (10^6 km^2 globally) and accuracy (+/- 20%).

3. In each case, **produce sink/source maps with the highest spatial resolution** enabled by the available satellite-derived and other input products (~ 1 km^2 or less).

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TCO Partners

IGOS
Integrated Global Observing Strategy

NASDA

ICSU

FAO
FIAT PANIS

cnes

GLOBAL CHANGE
IGBP

CEOS

GCOS
IOC WMO ICSU UNEP
GLOBAL CLIMATE OBSERVING SYSTEM

NASA

UNEP

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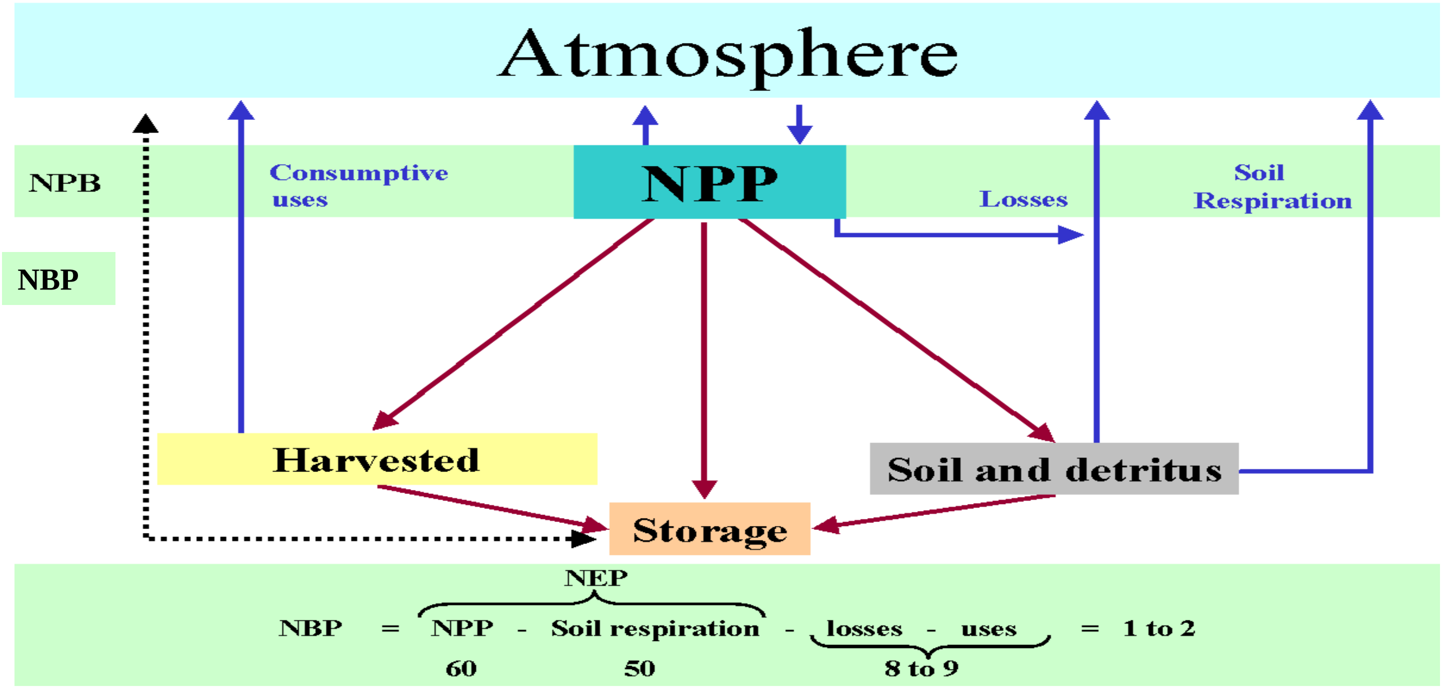
Dual-constraint approach

Atmospheric observations → Atmospheric tracer models → Global - regional C sources, sinks

Analysis, consistency, interpretation

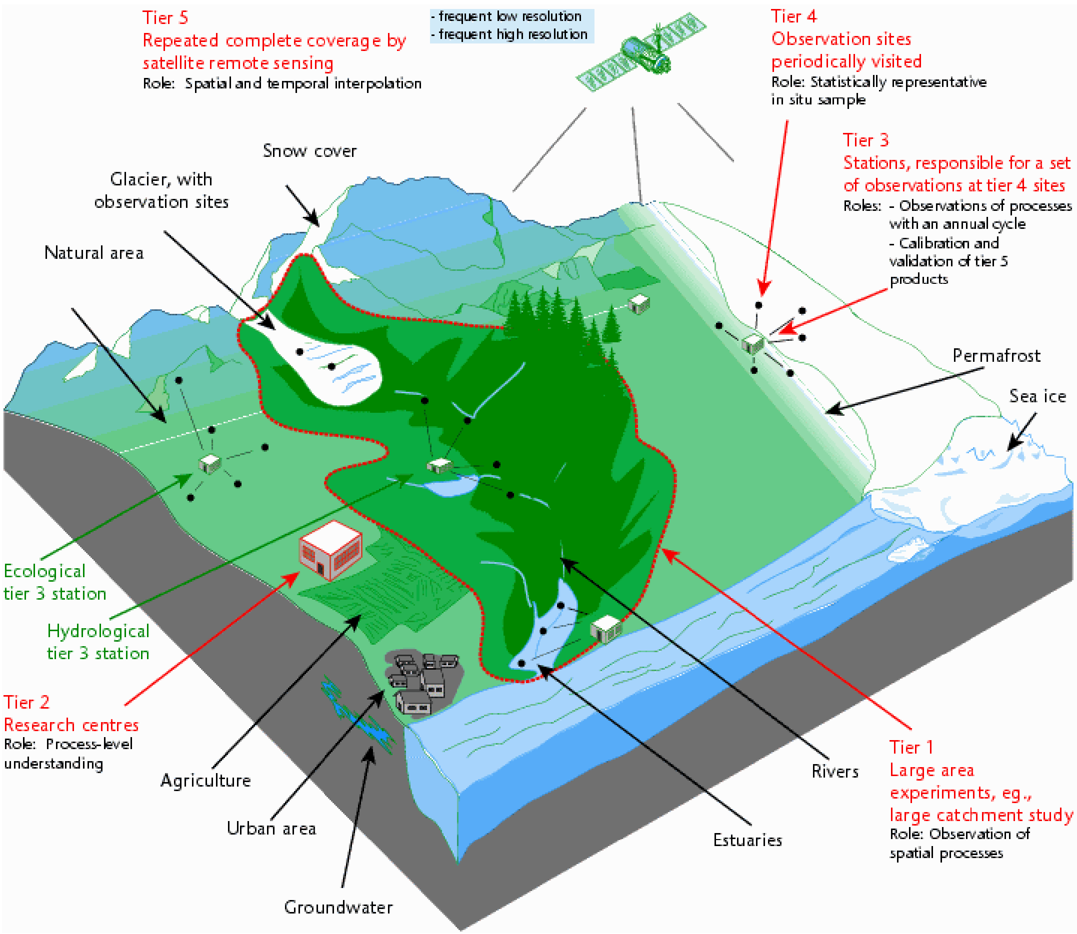
Ecosystem observations → Ecosystem models → Local - regional C sources, sinks

Terrestrial carbon balance



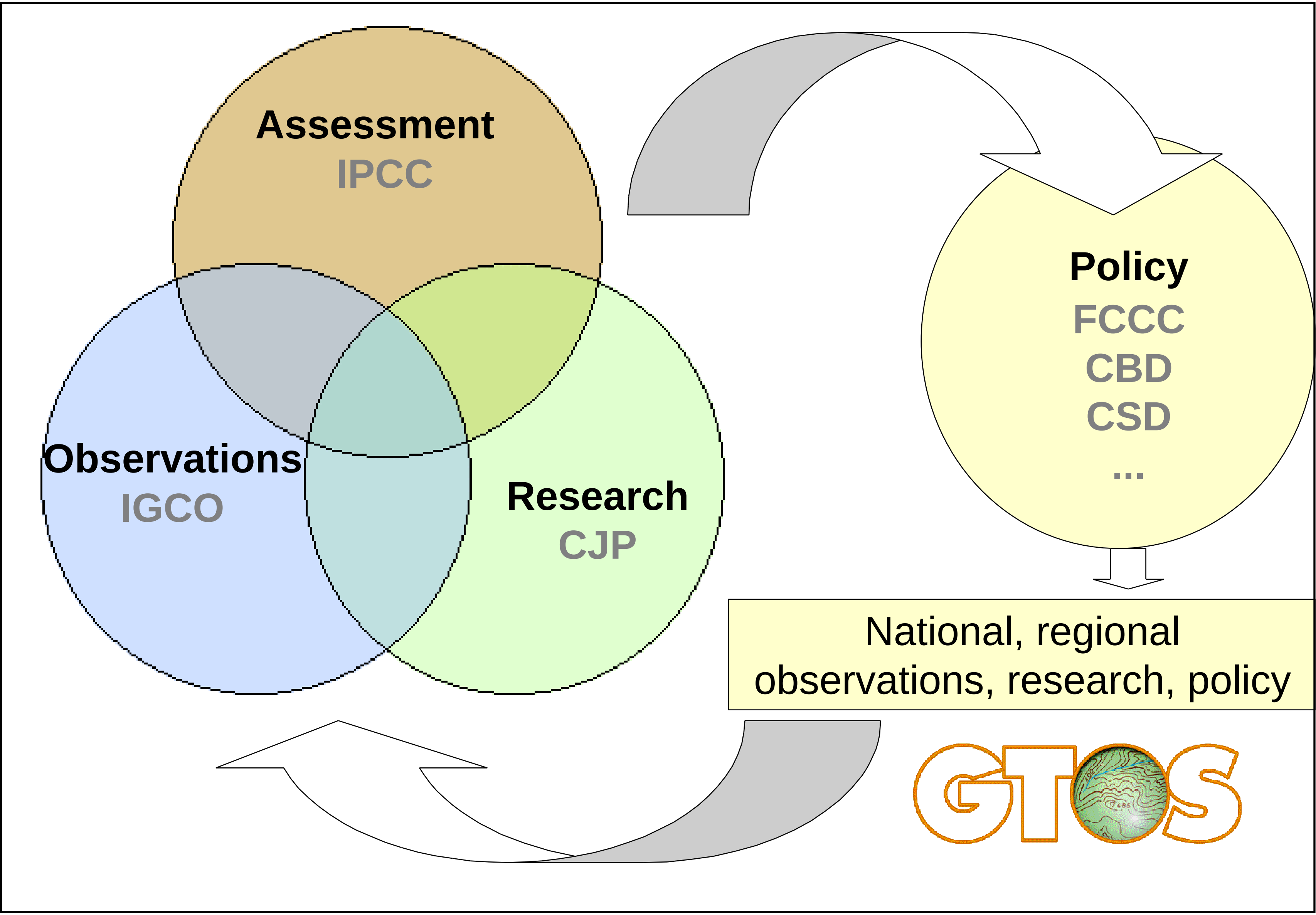
GtC/year

Global Hierarchical Observing Strategy (GHOST)



TCO observation requirements

- land cover and use
- biomass, leaf area
- fire
- radiation
- atmospheric column (CO_2, CH_4)
- near surface GHG concentrations
- surface fluxes
- C pools and changes


Assessment
IPCC
Observations
IGCO
Research
CJP
Policy
FCCC
CBD
CSD
...
National, regional
observations, research, policy
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TCO products for initial period (3-5 years)

Category	Products (georeferenced)	Spatial extent	Temporal frequency
Land cover	Land cover types and change	Global, Continental	Annual, seasonal, 5 yr.
Land cover	Continuous fields	Global,	Annual
Biomass	Biomass density	Region, Biome-specific	Annual
Seasonal growth	Leaf area index	Region, site-specific campaigns, Global	Sub-seasonal
Seasonal growth	Growing season duration	Region, site-specific campaigns, Global	Annual
Fires	Burned area	Continental, Global	Annual
Fires	Burned biomass	Continental, Global	Annual
Solar radiation	SW solar irradiance	Global	Daily
Surface atmos. fluxes	CO2 flux, tower measurements	Network of sites	Sub-daily
Atmospheric CO2	Trace gas concentration	Network of sites	Weekly (or less)
Ecosystem	NPP	Region, site-specific campaigns, Continental Global	Annual
Ecosystem	NEP	Region site-specific campaigns, Continental, Global	Annual

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TCO Satellite-based data requirements
Specifications of TCO variables for CEOS - SIT[1]

VARIABLE	OPTIMIZED				THRESHOLD			
	Hor Res	Cycle (d,m,y)	Timelines (d,m,y)	Accuracy	Hor Res	Cycle (d,m,y)	Timelines (d,m,y)	Accuracy
Target variables								
Albedo satellite	1km	10d	30d	+ 2%	4km	30d	60d	+ 7%
Carbon dioxide flux (CO2)	Tier 1,2 (100 sites globally)	Continous	Continous	+ 5%	TBD	TBD	TBD	TBD
Radiation – outgoing long wave satellite	50km	20d	1m	+ 2%	100km	60d	3m	+ 10%
Land cover	0.1km	1y	3m	50 classes	1km	10y	1y	20
Land use	0.1km	1y	6m	>100 classes	1km	10y	1y	5 classes
Net Ecosystem productivity (NEP)	1km	1d	annually	+10% for annual budget	1km	1y	3y	+20%
Net Primary Productivity (NPP) satellite	0.1km	1d	10d	+10%	1km	10d	1y	+30%
Canopy conductance maximum	1km	10y	1y	+ 10%	1km	20y	2y	+20%
Biogeochemical transport from land to oceans	10km	1q	10d	+10%	100km	1y	1y	+30%
Biomass – total	0.1km	1y	3m	+5%	1km	10y	1y	+20%
Dissolved C, N, and P in water (rivers and lakes)	10km	1d	river dependent	+5%	100km	1y	1y	+30%
Dry deposition of NO3, SO4	1km	1m	7d	+10%	50km	1y	1y	+30%
Emissions of CO2, Nox, Sox from combustion of fossil fuels	10km	1m	1y	+10%	country	4y	4y	+20%

[1] Based on TOPC recommendations (Corvallis, 1998, annex 6) and subsequent TCO meetings (Ottawa, Lisbon, Durham, Frascati).

Fire area	0.1km	10d	1m	+10%	1km	1y	3m	+20%
Fire intensity	0.1km	10d	1m	+20%	1km	1y	3m	+40%
Methane flux (CH4), modelled	0.1km	1d	6m	+15%	10km	1y	1y	+30%
Ground water storage fluxes	Tier 1,2,3,4,	1y	Annually	1% of true depth	Tier 1,2,3,4	1y	Annually	+10%
Soil moisture	Tier 1,2,3	1d	3d	+2%	Tier 1,2,3	5d	5d	+10%
Surface water flow – discharge	Tier 1, 2,3 ,4	0.01d	1d	+5%	Tier 1,2,3	30d	30d	+20%
Input variables								
Albedo in situ	Tier 1,2,3	0.01d	7d	+3%	Tier 1,2,3	0.04d	1m	+5%
Precipitation - accumulated (solid	1km	0.04d	1d	<+0.1mm	10km	0.05d	1d	+0.1mm
Radiation – fraction of photosynthetically active radiation (FPAR)	0.1km	10d	10d	+0.05	2km	30d	10d	+0.1
Radiation - incoming short-wave satellite	50km	10d	10d	+2%	100km	40d	1m	+7%
Radiation – outgoing long-wave in situ	Tier 1,2,3	0.01d	1d	+1%	Tier 1,2,3	10 miute mean	5d	+2%
Relative humidity (atmospheric water content near the surface)	Tier 1,2,3 & weath.sta'ns	0.04d	1d	+1%	Tier 1,2,3 and weather stations	0.04d	3d	+2%
Temperature - air	Tier 1,2,3 & weath.sta'ns	0.02d	1d	+0.2C	Tier 1,2,3 and weather stations	0.5d	2d	+0.5C
Biomass – above ground	0.1km	1y	3m	+5%	1km	710y	1y	+20%
Land cover	0.1km	1y	3m	50 classes	1km	10y	1y	20 classes
Leaf area index (LAI)	0.1km	10d	10d	+0.2	1km	10d	1y	+1
Net primary productivity (NPP) in situ biomass sampling	Tier 1,2,3	10d	3m	+10%	1km	1y	2m	+10%
Peak leaf biomass of nitrogen-fixing plants	Tier 1,2,3	1y	3m	+5%	Tier 1,2,3	5y	1y	+15%
Spectral vegetation	0.1km	1d	1d	+1%	2km	1d	10d	+3%

greenness index								
Vegetation structure	Tier 1,2, 3	1y	6m	+ 5%	Tier 1,2,3	10y	1y	+ 10%
Soil surface state	Tier 1,2,3,4	1y	6m	+ 5%	Tier 1,2,3,4	10y	1y	+ 10%
Ancillary variables								
Aerosols (total column)??or transmissivity measurements?	1km	1d	10d	TBD	4km	2d	1m	TBD
Aerosols In situ	Tier 1,2,3	continuous	1d	+5%	Tier 1,2,3	Hourly	5d	TBD
Radiation –incoming short-wave in situ	Tier 1,2,3	continuous	1d	+ 1%	Tier 1,2,3	0.01d	30d	+ 1%
Radiation - reflected short-wave in situ	Tier 1,2,3	continuous	1d	+ 1%	Tier 1,2,3	0.01d	30d	+ 1%
Snow surface state	10km	1d	2d	6classes	25km	3d	3d	2 classes
Snow water equivalent (SWE) in situ	Tier 1,2,3, surface network	1d	2d	+ 5%	Tier 1,2,3, surface network	30d	3d	+ 15%
Vegetation hydric stress index	0.1km	0.04d	1d	+10%	4km	1d	2d	+ 20%
Decomposition rate	Tier 1,2,3	30d	30d	+10%	Tier 1,2,3	60d	30d	+ 15%
Fire type	0.25km	1y	1m	6classes	1km	3y	3m	2classes
Measured variables								
Microwave backscatter	0.01km	1d	1d	+0.2dB	1km	2d	10d	+ 0.6dB
Radiation - reflected short-wave satellite (multispectral)	0.01km	1d	1d	TBD	1km	2d	1m	TBD

"Target, Input, Ancillary, Measured": as defined by GOSSP, Paris, 1997
"Optimized, Threshold" and "Parameters (Horizontal Resolution, Cycle, Timeliness, Accuracy)": as defined by GOSSP, Paris, 1997

Definitions of Variables

(Intended for use with the CEOS database of satellite data requirements)

Roles of SAR data in TCO (Cihlar)

Information requirements – most important:
Biomass and biomass change (above ground)
Land cover and LC change (disturbances,..)
[together: spatial, temporal rates of biomass loss/increase]
Wetlands: water level dynamics → GHG emission rates (CH_4)
Freeze/thaw timing → phenology

Geographic windows (broadly):
Forests, wetlands, cloudy areas, cold areas with C & seasonal dynamics

Temporal windows (broadly):
Wet-dry contrasts, cold/warm contrasts

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PALSAR (Cihlar)

Information potential:

PALSAR an important information source for TCO

- Biomass change and biomass in forests
- Land cover change in forested areas
- Wetlands distribution and seasonal dynamics (treed, with shrubs, herbaceous types)

Geographic windows:

- Forest biome
- Areas with rapid land cover change (clearing, afforestation)
- Wetlands (natural, managed - e.g. paddies)

PALSAR (Cihlar)

Planning data acquisition:

- Systematic global acquisition essential (in space and time)
- Consider in context of other satellite data acquired (at the same time and previous/follow-on missions)
- Link to *in situ* observation networks
- Tightly inked to research programs (C processes and retrieval algorithms/models)

Specifics (areas, etc.):

- The ALOS analysis (May, 2001) a good starting point
- Need to refine in relation to the above considerations and recent knowledge of PALSAR data capabilities

Important to keep in mind (Cihlar):

- SAR part of a ‘system solution’ (other sensors + *in situ* obs’ns + models)
  → PALSAR in context of overall TCO system.
- Satellite data acquisition must be coordinated with *in situ* acquisition and with research programs/activities – need to plan for this.
- Need products, not (raw) data: product generation, validation and quality control an integral part of satellite mission – a challenge for NASDA.
- Ongoing engagement of the scientific community (>>EO community) very important, ALOS should promote this engagement.

TCO next steps

- Complete the TCO implementation plan.
- Engage the key partners (in situ->space, science->policy).
- Rationalise the flux networks.
- Harmonise forest inventories.
- Compile regional land use histories.
- Expedite improved atmospheric concentration measurements.
- Improve tools for studying interaction between top-down and bottom-up approaches.
- Build data archive and analysis centres.