Land Surface Imaging (LSI) Constellation Study Team

Co-Leads: *U.S. Geological Survey (USGS), Indian Space Research Organization (ISRO), and the Instituto Nacional de Pesquisas Espaciais (INPE)*

LSI Constellation and LSI Portal

LSI Constellation:

- **Goal 1:** establish agreements, among space agencies currently operating mid--resolution land surfacing imaging satellite systems, to cooperate more closely together to operate those systems as a real prototype Land Surface Imaging Constellation;
- **Goal 2**: develop preliminary guidelines for a mid--resolution Land Surface Imaging Constellation; and
- **Goal 3**: meaningfully contribute to the production of a fundamental climate data records by providing mid-resolution LSI data to support GEO and CEOS priorities.

LSI Constellation Portal:

Mid-Resolution Optical Land Surface Imaging Satellite Systems - Information and Enhanced Data Access

http://wgiss.ceos.org/lsip

Co-Chaired by:

U.S. Geological Survey (**USGS**),

Indian Space Research Organization (**ISRO**),

Instituto Nacional de Pesquisas Espaciais (**INPE**)

LSI Constellation Meeting

- **3rd Land Surface Imaging Virtual Constellation Study Team Meeting (approximately 20 participants)**
  - INPE Headquarters, São José dos Campos, Brazil
  - 22-23 February 2010
- **Purpose**
  - 2009 Activities - Work Plan Accomplishments
  - GEO Forest Carbon Tracking Initiative
    - 2009 Accomplishments and 2010 Requirements.
  - Look Strategically at LSI Constellation Activities.
    - How do we better organize ourselves to accomplish the work?
    - Can we better utilize WGCV, WGISS, SEO, etc.?
  - Define our 2010 Work Plan.

LSI Constellation Meeting Recommendations to SIT-25

- **LSI-3-9:** LSI team to recommend to GEO, through SIT-25, the use of all sources/types FCT task data for demonstration of agricultural research.

- **LSI-3-11:** Terminate the Working Group on Regional Data Set Compilation in favor of FCT requirements.

- **LSI-3-12:** Inform SIT-25 of the LSI Constellation decision to terminate the Working Group on Radar and refer broader issues of SAR mission coordination back to the SIT .

- **LSI-3-13:** LSI present its plans for its 2010 work to the SIT, and seek SIT participants' committed support. This support would include **proper membership composition and active participation** in its future meetings.

LSI Constellation Study Team - 2009

CEOS Agency Members

- USGS: **Co-Chair**, Tom Holm (new 2009)
- ISRO: **Co-Chair**, V. Hegde (new 2009)
- INPE: **Co-Chair**, Julio Dalge (new 2009)
- INPE: João Vianei Soares
- EC: Herve JeanJean
- ESA: Michael Berger
- CSA: Daniel DeLisle
- CONAE: Ana Medico
- JAXA: Takeo Tadono
- NOAA: Kevin Gallo
- NASA: Garik Gutman
- NRSCC: Yonghong Zhang
- CRESDA: Xiaohua Yi
- GISTDA: Phuriwaj Ruengnaowaroj
- CNES: Aurelie Sand
- CDTI: Mónica Lopez

CEOS WG Members

- WGCV (NASA): Stephen Ungar
- WGCV (USGS): Greg Stensaas

User Community Members

- USGS: Brad Reed
- JRC: Alan Belward
- JPL: Mike Abrams
- Nagoya U.: Yasushi Yamaguchi
- BGS: Stuart Marsh
- U. Maryland: J. Townshend
- CSIRO: Alex Held

Actions by CEOS Agencies needed to involve more Agencies / Missions and better coordinate the plans of future missions to fill potential data gaps or to improve the accuracy of products – “Ivan”

2010 LSI Constellation Priorities

- **LSI Web-Based Tools**
  - INPE has the lead – SPRING (ortho-rectification plug-in)
- **LSI Portal Enhancements**
  - Working with CEOS WGISS – Add additional data sets and develop a prototype using the CEOS WGISS Integrated Catalog (CWIC) tool.
- **LSI Mid-Resolution Optical Guidelines Document**
  - Develop preliminary guidelines for a mid--resolution Land Surface Imaging Constellation.
- **Continue support to the GEO Forest Carbon Tracking Task**
  - Coordinated satellite data acquisition effort by CEOS agencies in 2009 with continued support in 2010.

Back-up Slides

LSI Web-Based Tools

- Complete development of web-based services and/or freeware (INPE)
  - **Image format converter tool to GeoTIFF** – **closed action**.
    - Agencies are capable of providing products in geotiff format – no longer a requirement.
    - As an alternative, INPE released Marlin (www.dgi.inpe.br/CDSR) as open source. Marlin is a tool for image visualization and analysis. It's the tool INPE uses to test radiometry and geometry of CBERS image data.
  - **Ortho-rectification tool for Level 1 mid-resolution data:**
    - INPE now plans to use an ongoing GIS software project, SPRING (www.dpi.inpe.br/spring) and add to its functions menu an ortho-rectification plug-in based on RPC (rational polynomial coefficients). The plan is to have this included in a new version of SPRING in 2010.

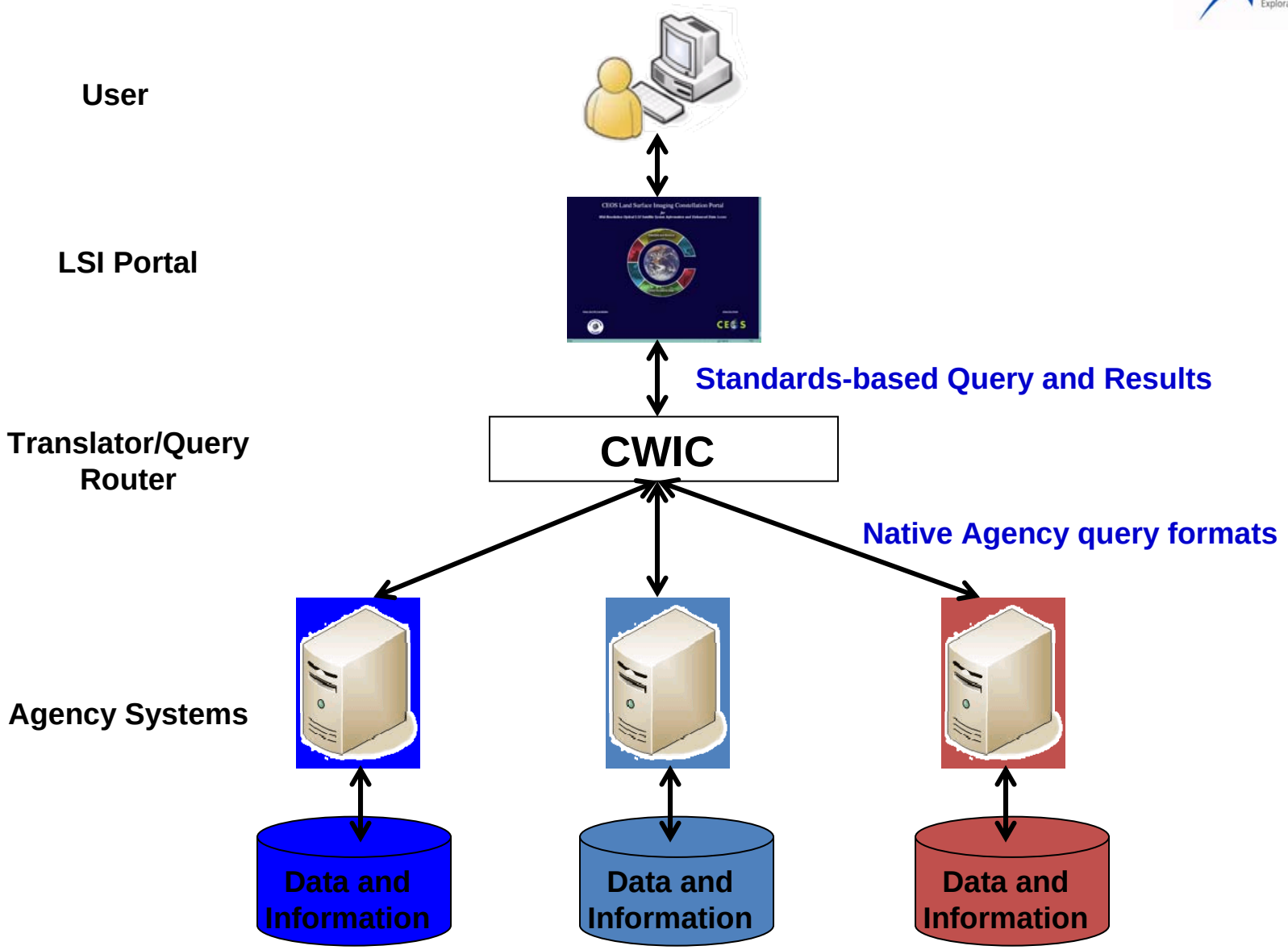
LSI Portal Enhancement Proposals

- **Options under consideration:**
  - Addition of **new data types** or descriptive information
    - Expanding the data set, sensor, and platform information as well as links to order/access systems for other optical land imaging systems such as MODIS and/or high resolution systems.
  - **Expand functionality** to include cross-system, granule-level, search and data retrieval
    - Expand the functionality to go beyond directory and metadata about sensors and platforms to being able to initiate a granule-level search across multiple LSI member systems to select and obtain individual data granules directly through a single portal without having to be linked or handed off to other member portals or web sites.
    - Develop a prototype using the CEOS WGISS Integrated Catalog (CWIC) tool.

LSI Portal Enhancement Proposals

- **CWIC Capabilities**
  - CWIC will provide an **access point** for major CEOS agency catalog systems.
  - CWIC will interface to user interface clients by using the **GEO standards.**
  - CWIC will send directory/collection searches to the International Directory Network.
  - CWIC will distribute inventory/product searches to the CEOS agency inventory systems **using the agency systems native protocol**.
  - CWIC will be offered as the CEOS community catalog as **part of the GEO common infrastructure.**

LSI Portal Enhancement Proposals



LSI Mid-Resolution Optical Guidelines

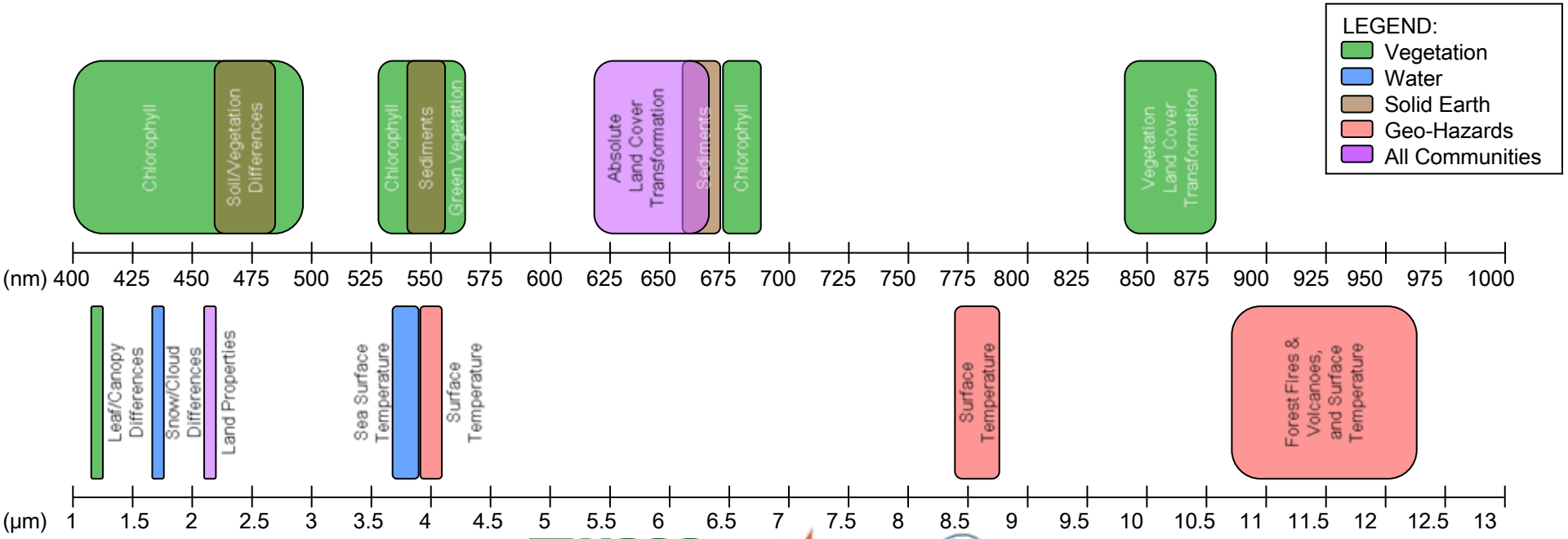
- In 2008, the LSI Constellation initiated an effort to define guidelines that **define a set of ideal or optimal guidelines for mid-resolution optical mission, instrument, and data policy characteristics.**
- It is recognized that no single mission or ground segment would be expected to meet all of these guidelines. Instead, the overall virtual constellation of LSI would together achieve these goals through the combination of their specific subset of specialties and foci.
- Guidelines to be **based on the needs of the land imaging user communities** (vegetation, solid earth, water, geo-hazards).
- **Systems Engineering Office has been supporting the LSI Constellation**
  - Multiple iterations worked with LSI Co-Chairs
  - An assessment of the currently flying instruments and their spectral band coverage is in progress to determine what is already being measured

LSI Mid-Resolution Optical Guidelines

- LSI Community broken into four user communities:

Vegetation | Water | Solid Earth | Geo-Hazards

- An initial look at how various spectral regions could support these communities
- The regions designated below for each user community are based on the MODIS band applications.



LSI Mid-Resolution Optical Guidelines

- A list of currently flying and planned mid-resolution optical LSI missions. Below is a sample of this data.

	Mission	Instrument	Country or Organization	Launch	Spatial Resolution (meters)	Number of Bands	Spectrum (um)	Swath Width (km)
Currently Flying or Past	CBERS-1	HRCC	CAST-China/INPE-Brazil	1999	20	5	0.45-0.89	113
	CBERS-1	IRMSS	CAST-China/INPE-Brazil	1999	80-156	4	0.5-12.5	120
	Terra	ASTER	NASA-USA/METI-Japan	1999	15-90	14	0.52-11.65	60
	Landsat 7	ETM+	USGS-USA	1999	15-60	8	0.45-12.5	185
	SAC-C	HRTC	CONAE-Argentina	2000	35	1	0.4-0.9	90
	EO-1	ALI	NASA/USGS-USA	2000	30	10	0.433-2.35	37
	EO-1	Hyperion	NASA/USGS-USA	2000	30	242	0.356-2.577	7.5
	PROBA	CHRIS	ESA	2001	18-36	81	0.4-1.05	14
	SPOT-5	HRS	CNES-France	2002	10	1	0.49-0.69	120
	SPOT-5	HRG	CNES-France	2002	20	4	0.5-1.75	60
	Alsat-1	2 Imagers	CNTS-Algeria	2002	32	3	0.5-0.8	600
	UK-DMC	DMC Imager	BNSC-UK	2003	32	2	VIS, NIR	600
	CBERS-2	HRCC	CAST-China/INPE-Brazil	2003	20	5	0.45-0.89	113

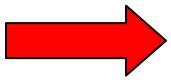
- The spectral bands of these missions have been overlaid with the spectral regions of interest mentioned on the previous slide.

LSI Mid-Resolution Optical Guidelines

Use Case 1: A new instrument

- A CEOS agency would like to build an instrument to achieve LSI goals. The instrument design team goes to the guidelines document to see what the instrument characteristics should be.

- **This would require the document to include detailed instrument design characteristics like these**



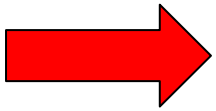
Orbit	Orbit type
	Altitude
	Equatorial Crossing
Spectral Bands (each value captured for every band of interest)	Band Range Minimum
	Band Range Maximum
	Band Shape
	Spectral Uniformity
	Spectral Stability
	Spectral Simultaneity
Spatial Resolution	Spatial Edge Response
	Aliasing
	Internal Scattering
	Ghosting
Radiometric Accuracy	Absolute Radiometric Uncertainty
	Signal-to-Noise and Uniformity
	Saturation Radiances
	Polarization Sensitivity
	Radiometric Stability
	Image Artifacts
Geolocation Accuracy	Band-to-Band Registration Accuracy
	Image-to-Image Registration Accuracy
	Geodetic Accuracy
	Geometric Accuracy
Coverage	Swath Width
	Revisit Time
	Type of Coverage (global, regional, local, …)
Ground Segment, Data Policy, and Operations	Processing Level Provided
	Plans to Archive the Data
	Search and Order Method
	Metadata and Formatting Standards
	Product Delivery
	Data Timeliness
	Data Use Restrictions
	Distribution Policies (including pricing)
	Acquisition Strategy

LSI Mid-Resolution Optical Guidelines

Use Case 2: A new partner

- A CEOS agency has an instrument already built that they feel will benefit the LSI Community. They go to the guidelines document to learn about where they would fit with other LSI instruments and to determine if they are filling a needed niche.

- **This would require the document to include mission design details like these**



Missions List
Timelines
Mission Planning Data
Satellite Orbit
Spatial Resolution
Spectral Bands
Sampling Schemes
Swath Width
Coverage Maps
Coverage Details

LSI Mid-Resolution Optical Guidelines

Where this document could lead…

- Once guidelines are established these can be translated through a gap analysis into a powerful decision tool that **can show the Constellation where gaps in capabilities exist currently or will in the future**.
- Analyses such as these have been completed by the SEO for segments of the Atmospheric Composition Constellation. Below is an example for carbon dioxide.

Mission	Accuracy	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Nadir Absorption, Total Troposphere Columns weighted to the Lower Troposphere																		
ENVISAT	3.6% (14 ppm)									GAP								
GOSAT	1% (4 ppm)																	
OCO-2	0.25% (1 ppm)																	
ASCENDS	0.25% (1 ppm)																	
Nadir Emission, Total Troposphere Columns weighted to the Mid-Troposphere and Upper-																		
EOS-AQUA	0.4% (1.5 ppm)																	
EOS-AURA																		
Metop (A,B,C)	0.5% (2 ppm)																	
METOP and NOAA	1% (4 ppm)	5	5	5	5	4	4	3	3	2								
FY-3 (C,D,E,F,G)	0.5% (2 ppm)						2	2	3	2	3	2	3	2	2			
NPOESS (1,3,4)	0.5% (2 ppm)										2	2	3	2	2	2	2	2
Limb Viewing, Stratosphere Profiles																		
SCISAT-1																		
ENVISAT																		
SCISAT-2														GAP				
ENVISAT																		
PREMIER																		

LSI Mid-Resolution Optical Guidelines

- **Next Steps:**
  - Document **initial CEOS SEO findings** and start preliminary standards document
  - To create a document that is meaningful to you as the land surface imaging community and will be utilized in the future

- **Milestones:**
  - **Nov-2010**: Final Report for Plenary 2010

CEOS SEO Points of Contact:
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Brian Killough (Brian.D.Killough@nasa.gov)

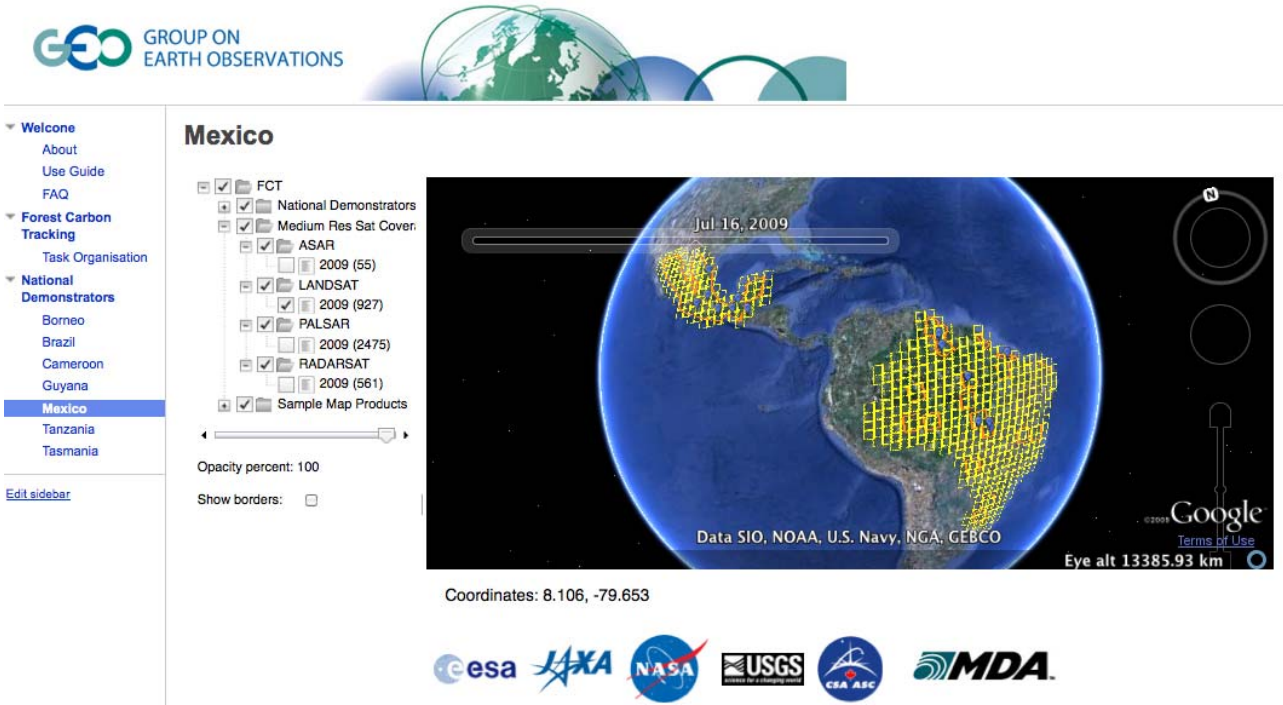
GEO Forest Carbon Tracking

GEO FCT Background

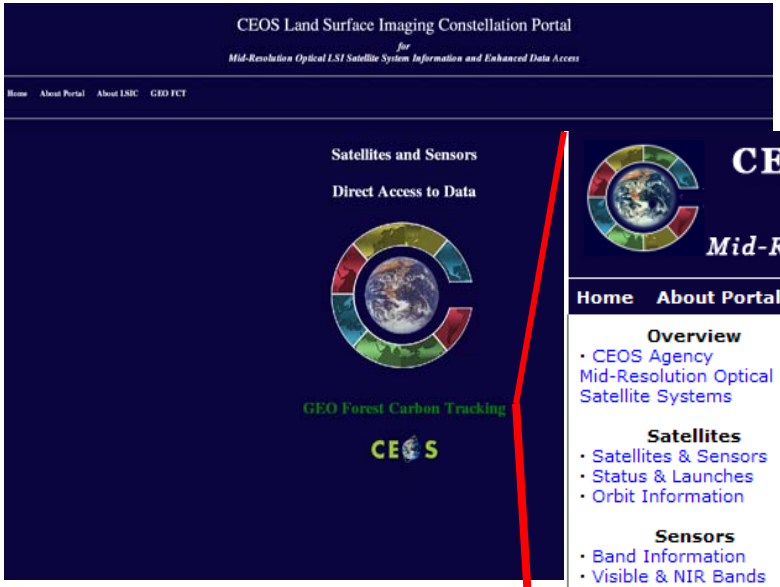
- The GEO Forest Carbon Tracking initiative seeks to develop a global framework for a system of national systems for forest carbon tracking in support of the inclusion of forests in a post-Kyoto climate agreement
- Satellite and in-situ data are an essential element of the Monitoring, Reporting and Verification (MRV) systems that will be employed in the regulatory framework for such an agreement

CEOS role

- CEOS is demonstrating that the technical capacity and institutional frameworks are in place to ensure continuity of the required satellite observations in support of post-Kyoto regulatory frameworks
- 7 National Demonstrator countries have been the subject of a coordinated satellite data acquisition effort by CEOS agencies in 2009 – with complete coverage achieved for both radar and optical data
- A demonstrator portal showing available data and forest carbon datasets has been developed: portal.geo-fct.org



GEO Forest Carbon Tracking Task



CEOS Land Surface Imaging Constellation Portal

for

Mid-Resolution Optical LSI Satellite System Information and Enhanced Data Access

Home **About Portal** **About LSIC** **GEO FCT** **Contact**

Overview
- CEOS Agency Mid-Resolution Optical Satellite Systems

Satellites
- Satellites & Sensors
- Status & Launches
- Orbit Information

Sensors
- Band Information
- Visible & NIR Bands
- SWIR Bands
- Thermal Bands
- Panchromatic Bands
- Hyperspectral Bands
- Radiometric & Geometric Characteristics
- Geographic Characteristics

Data
- Data Access
- Documentation

GEO Forest Carbon Tracking Initiative

CEOS Role

- CEOS, with the support of the LSI Constellation, is demonstrating the technical capacity and institutional frameworks to support continuity of the required satellite observations in support of post-Kyoto regulatory frameworks.

- 7 National Demonstrator countries have been the subject of a coordinated satellite data acquisition effort by CEOS agencies in 2009 - with complete coverage achieved for both radar and optical data (LSI contributions).

- A demonstrator portal showing available data and forest carbon datasets has been developed:

Link to GEO Forest Carbon Tracking Portal: portal.geo-fct.org

GROUP ON EARTH OBSERVATIONS

- In addition, the Landsat contributions for the 7 National Demonstrator countries are searchable through the USGS:

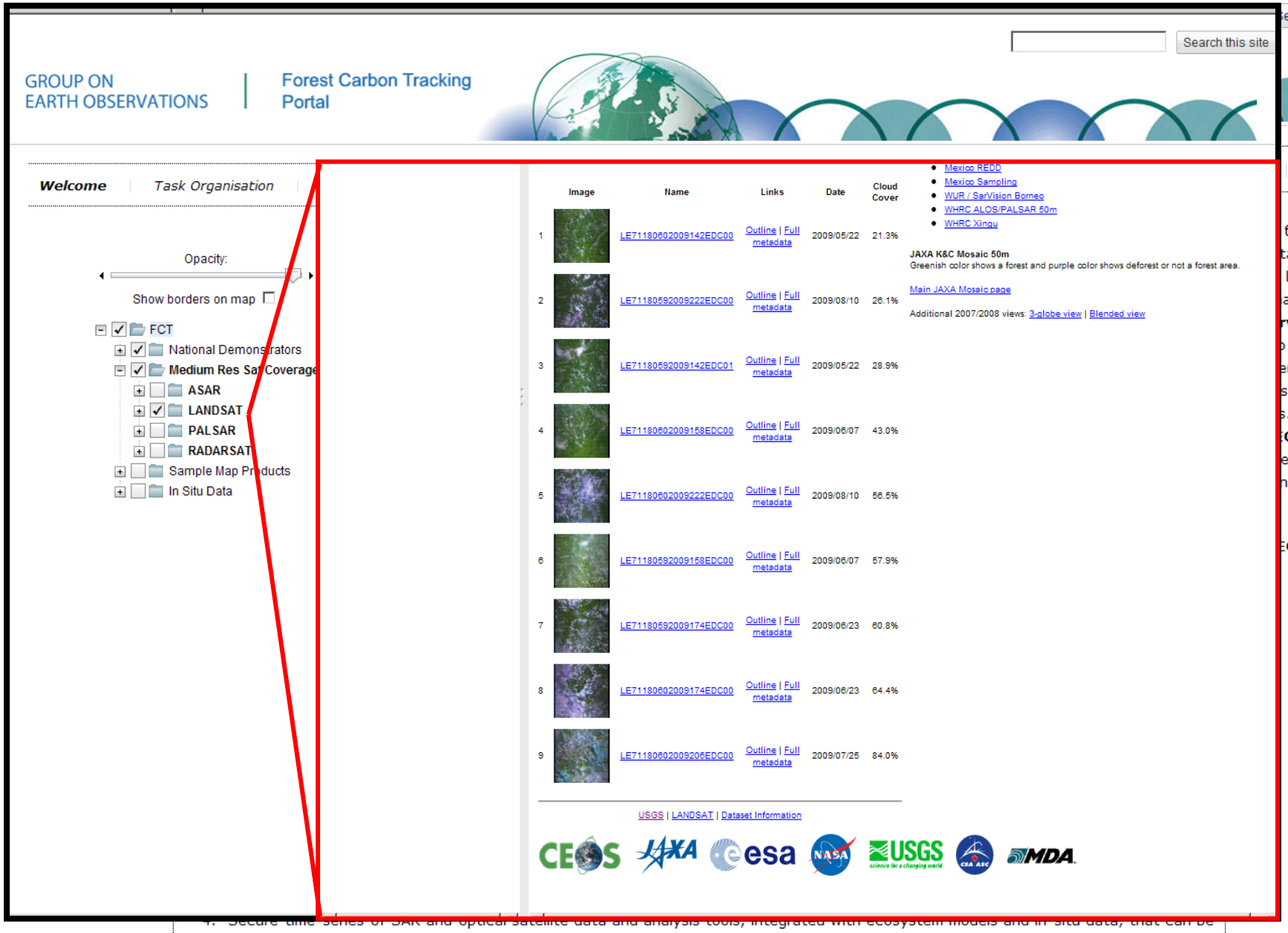
Link to Earth Explorer - Forest Carbon Sites: earthexplorer.usgs.gov

USGS science for a changing world

Forest Carbon Tracking Goals:

Demonstrate that coordinated Earth observations, validated by in situ measurements and properly linked to forest models, can provide reliable information of suitable consistency, accuracy and continuity to support forest carbon Monitoring, Reporting and Verification leading to eventual establishment of a network of **national** forest and carbon monitoring systems.

Define a set of standards and interoperability requirements and methodologies to provide the most accurate results relying on the full potential of existing observational and processing capabilities.



used interoperably and in complementary ways to support the information needs of MRV systems for FCT.

5. Appropriate international institutional frameworks, and supporting data policies allowing open access and application of the supporting satellite datasets will be essential to secure the sustained supply of information in support of MRV requirements.

Forest Carbon Tracking: Status of LSI Optical Support - 2009

ND Sites / Source	Brazil	Guyana	Mexico	Cameroon	Tanzania	Borneo	Tasmania
Landsat 5/7 USGS	Acquired	Acquired	Acquired	Acquired	Acquired	Acquired L1T gen.	Acquired L1T gen.
Landsat 5/7 IC's	Acquired INPE	Acquired INPE	Acquired CONABIO Grnd Station	Not feasible No IGS	Feasible CSIR SAC & ASI (Kenya)	Feasible GISTDA	Acquired CSIRO
IRS: AWIFS	2010 INPE	2010 INPE	Feasible ISRO	Feasible ISRO	Feasible ISRO	Feasible ISRO	Feasible ISRO
IRS: LISS-III	2010 INPE	2010 INPE	Feasible ISRO	Feasible ISRO	Feasible ISRO	Feasible ISRO	Feasible ISRO
CBERS2B: CCD	Acquired INPE	Acquired INPE	Not feasible in 2009	Not feasible in 2009	Not feasible in 2009	Not feasible in 2009	Not feasible in 2009
AVNIR-2	Investigated ESA	Investigated ESA	Investigated ESA	Investigated ESA	Investigated ESA	Investigated ESA	Investigated ESA
SPOT 4	Feasible ESA 940 scenes	Feasible ESA 940 scenes	Feasible ESA 940 scenes	Feasible ESA 940 scenes	Feasible ESA 940 scenes	Feasible ESA 940 scenes	Feasible ESA 940 scenes
SPOT 5	Not feasible 2009 Congo - 2010	Not feasible 2009 Congo - 2010	Not feasible 2009 Congo - 2010	Not feasible 2009 Congo - 2010	Not feasible 2009 Congo - 2010	Not feasible 2009 Congo - 2010	Not feasible 2009 Congo - 2010
Kompsat-2	Not feasible in 2009	Not feasible in 2009	Not feasible in 2009	Not feasible in 2009	Not feasible in 2009	Not feasible in 2009	Not feasible in 2009

Status of LSI Optical Support - 2010

Area	Brazil (parts)	Guyana	Mexico	Cameroon	Tanzania	Borneo	Tasmania
Landsat	2443	173	1732	230	253	320	129
SPOT	TPM by ESA, but restrictions related to repatriation			Congo Basin 2010		TPM by ESA, but restrictions related to repatriation	
CBERS	full coverage	full coverage					
IRS	acquired at INPE	acquired at INPE					

o.k.	some restrictions
not feasible	under discussion