Online catalog of world-wide test sites for the post-launch characterization and calibration of optical sensors

IAC Conference, Sept. 24-29, 2007

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U.S. Department of the Interior

U.S. Geological Survey

Outline

- Contextualization
- Site Selection Criteria
- USGS On-line Test Site catalog
- Provisional Calibration Site Categorizations
- Proposed Future Plans
- Some Sticky Points
- Summary

Contextualization

- **With television, weather channels, Google Maps™ mapping service, and other day-to-day uses, satellite imagery has clearly become part of mainstream information society**

- **Nevertheless, for most operational remote sensing applications, critical issues remain with respect to the:**
  - Reliability of supply
  - Consistent data quality
  - Plug-and-play capability

- **Consistent data quality implies the adherence of data to appropriate standards of fidelity to the underlying physical quantities that they measure**

Need for a Global, Integrated Network of Calibration Sites

- User communities increasingly rely on information products from multiple satellite sensors
- Better calibration can result from more post launch calibration, involving standardized measurement protocols, instrumentation, and processing
- Field measurements remain resource-intensive activities
- Less expensive complementary approaches can provide more frequent calibration updates and enable the monitoring of sensor performance trends, even without surface measurements
- Future global monitoring systems, using increasingly complex constellations of satellites with multiple sensors, such as the Global Earth Observation System of Systems (GEOSS), will amplify the need for this initiative to address global societal benefits

Well-Established Site Selection Criteria

- High spatial uniformity over a large area (within 3 %)
- Surface reflectance greater than 0.3
- Flat spectral reflectance
- Temporally invariant surface properties (within 2 %)
- Horizontal surface with nearly lambertian reflectance
- At high altitude, far from ocean, urban, and industrial areas
- In arid regions with low probability of cloud cover

Prime Candidate Earth Target Types

- **Including only playa (dry lakebed), salt flat, and desert sand sites**

- Snow fields are excluded primarily because high surface reflectances are more sensitive to variations in atmospheric particle size distribution and because they are usually located at latitudes characterized by high solar zenith angles

- Vegetation targets are excluded because they are subject to phenological changes as well as strong reflectance anisotropy effects

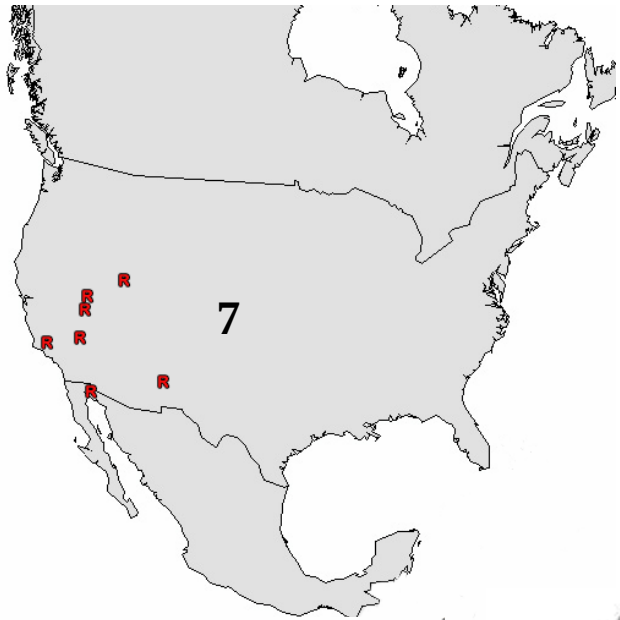
- Water targets are excluded because low surface reflectances are more sensitive to atmospheric path radiance and because of sun glint

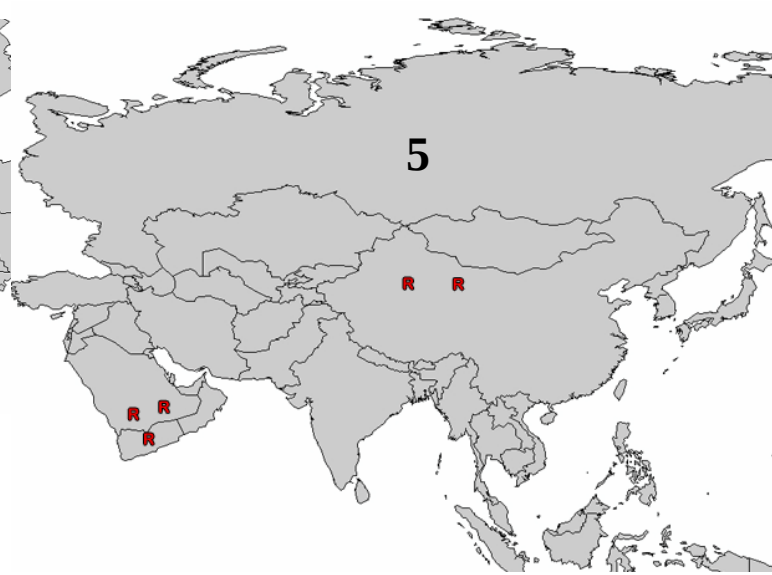
- Other target types (uniform cloud cover, atmospheric scattering, ocean glint) are excluded because more specialized analysis is required, not in keeping with operational use of benchmark test sites

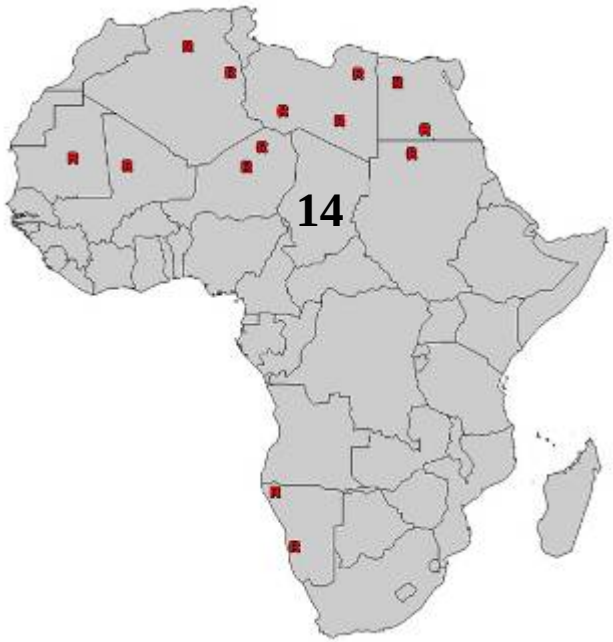
Initial List of 36 Test Sites for Consideration

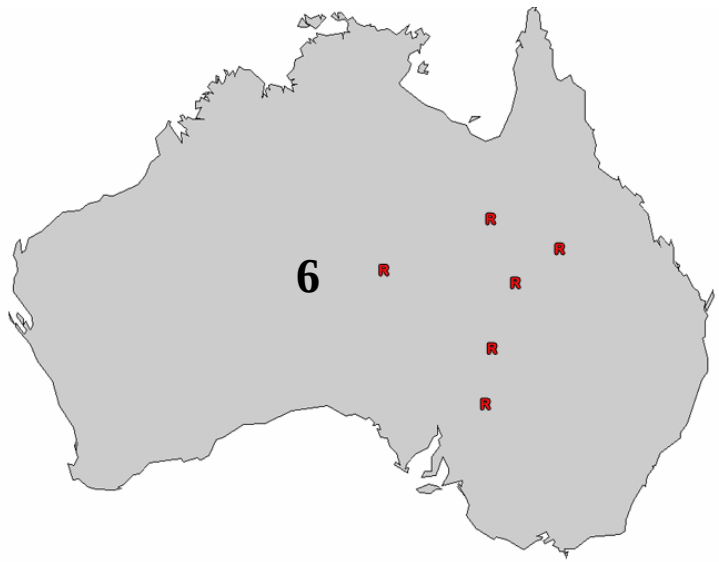
- Algeria 3
- Algeria 5
- Amburla
- Arabia 1
- Arabia 2
- Barreal Blanco
- Bonneville Salt Flats
- Dunhuang
- Dunrobin
- Egypt 1
- Egypt 2
- Ivanpah Playa
- La Crau
- Lake Frome
- Libya 1
- Libya 2
- Libya 4
- Lunar Lake Playa
- Mali 1
- Mauritania 1
- Namib Desert 1
- Namib Desert 2
- Niger 1
- Niger 2
- Railroad Valley Playa
- Rogers Dry Lake
- Sechura Desert
- Sonoran Desert
- Sudan 1
- Taklamakan Desert
- Tinga Tingana
- Uyuni Salt Flats
- Warrabin
- White Sands
- Winton
- Yemen Desert 1

Distribution of the 36 Radiometric Sites









USGS on-line test site catalog

- **The layout is set up to help the user quickly locate the needed information available on the site**
  - Drop-down menus list locations so the user may go straight to a specific site
  - A map with clickable links provides another way to go to sites
  - The maps include a world map, where the user selects a continent, and a map of each major continent
- **Each of the calibration site pages contains the same fields for easy review**
  - These fields include location, terrain elevation, center latitude/longitude, WRS-2 path/row, size of usable area, owner, researcher, purpose, description, support data, suitability, and limitations
- **Other features include**
  - a small image of the globe depicting the position of the site
  - satellite images of the test site
  - Sample Landsat images and Google KMZ files

http://calval.cr.usgs.gov/

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Remote Sensing Technologies - Satellite

Test Site Catalog

Catalog of World-wide Test Sites for Sensor Characterization

In an era when the number of Earth-observing satellites is rapidly growing and measurements from these sensors are used to answer increasingly urgent global issues, it is imperative that scientists and decision-makers rely on the accuracy of Earth-observing data products. The characterization and calibration of these sensors are vital to achieve an integrated Global Earth Observation System of Systems (GEOSS) for coordinated and sustained observations of Earth. The U.S. Geological Survey (USGS), as a supporting member of Committee on Earth Observation Satellites (CEOS) and GEOSS, worked with partners around the world to establish an online Catalog of prime candidate world-wide test sites for the post-launch characterization and calibration of space-based optical imaging sensors. The online Catalog provides easy public web site access to this vital information for the global community. Through greater access to and understanding of these vital test sites and their use, the validity and utility of information gained from Earth remote sensing will continue to improve.

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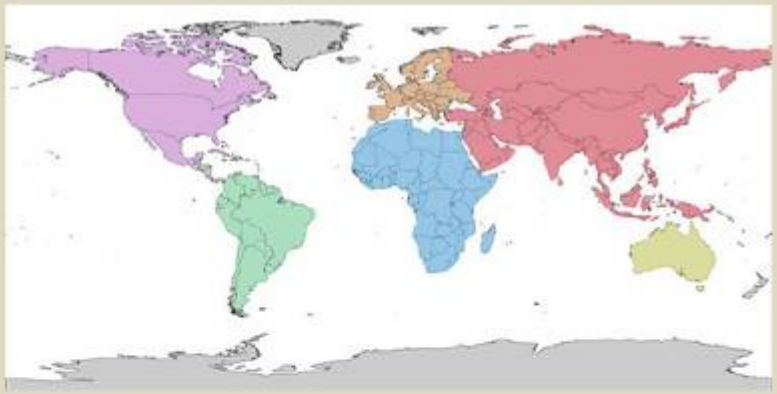

Choose A Radiometric St

Choose A Geometry St

World Map
North America
Africa
Europe
Asia
Australia
South America
Geometry Sites
Acronyms
References

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FirstGov

On-line Catalogue Example: Railroad Valley Playa, North America

Site Location: Railroad Valley Playa

Choose A Radiometric Site

Choose A Geometry Site

Radiometric

Location (City, State, Country):	Ely, Nevada, USA, North America
Altitude above sea level (meters):	1435
Center Latitude,Longitude (Degrees):	+38.5 , -115.69
Landsat WRS-2 Path/Row:	40 / 33
Size of Usable Area (km):	10 x 10
Owner:	Bureau of Land Management (BLM)
Researcher:	Dr. Kurtis J. Thome Email Researcher

Download L7_ETM+_GeoTiff Data

Download Google Earth KMZ File

View Additional Photos

World Map
North America
Africa
Europe
Asia
Australia
South America
Geometry Sites
Acronyms
References

Purpose:	Radiometric, vicarious calibration test site, with large homogenous regions
Description:	Dry-lake playa, spatially homogeneous, consisting of compacted clay-rich lacustrine deposits forming a relatively smooth surface compared to most land covers, although it has a lower spatial uniformity compared to the Ivanpah and Lunar Lake sites. The surface composition is comparable to those of Ivanpah and Lunar Lake; however, all three sites suffer from the presence of iron absorption (Fe3+) in the visible part of the spectrum, characteristic of playas in this region of the US. *Google Earth*: Slightly patchy (in colour and intensity) across the playa.
Support Data:	Strong linear road features and oil drilling structures (no lat/long available)
Suitability:	Recommended for 15m GSD and larger. Visible/UV to SWIR. Solar reflective and emissive. sub-meter to 2km GSD
Limitations:	Soft surface composition, spatial and spectral variation, possible hot spot effects, periodic snow and water, cloud cover increases in winter, remote location for ground-based studies

Return to Railroad Valley Playa

Choose A Radiometric Site

Choose A Geometry Site

World Map
North America
Africa
Europe
Asia
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South America
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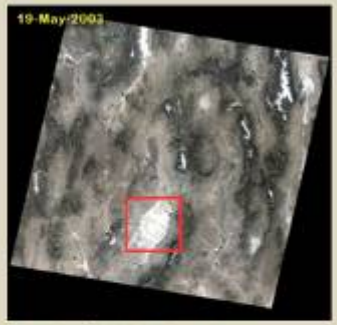
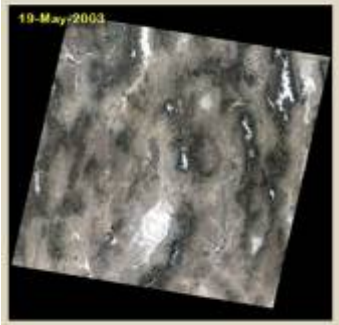
References

ETM+ Bands 321 Zoomed



ETM+ Bands 321 Site Parameters



ETM+ Bands 321

Google Earth Zoomed

Ground Picture 1

Ground Picture 2

On-line Catalogue Example: Libya 4, Africa

Site Location: Libya 4

Radiometric

Location (City, State, Country):	Libya, Africa
Altitude above sea level (meters):	118
Center Latitude,Longitude (Degrees):	+28.55 , +23.39
Landsat WRS-2 Path/Row:	181 / 40
Size of Usable Area (km):	75 x 75
Owner:	Unavailable
Researcher:	Unavailable

Download LT ETM+ GeoTiff Data

Download Google Earth KMZ File

View Additional Photos

Choose A Radiometric Site

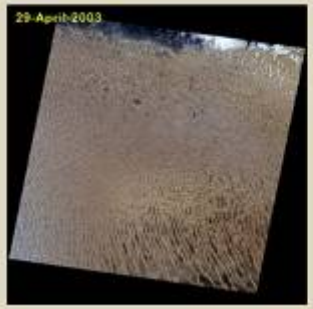
Choose A Geometry Site

World Map
North America
Africa
Europe
Asia
Australia
South America
Geometry Sites
Acronyms
References

Purpose:	TBD
Description:	South-west quadrant of Landsat WRS-2 181/40. Used by CNES (100 x 100 km) - smaller area would be better. *Google Earth :* Dunes at multiple scales, but large usable areas of 75 km x 75 km or more, especially north-west of centre coordinates. The surface varies slightly in intensity and colour across the area.
Support Data:	TBD
Suitability:	TBD
Limitations:	TBD

Return to Libya 4

ETM+ Bands 321 Zoomed



ETM+ Bands 321

Google Earth Ground Picture

Return to Libya 4

Acceptability of the site for radiometric calibration purposes

Calibration Site Categorizations

I: Among Best Sites with Routine Surface Measurements

II: Among Best Sites without Routine Surface Measurements

III: Other Potentially Good Sites

I

Dunhuang
Ivanpah Playa
La Crau
Railroad Valley
White Sands

II

Algeria 3
Algeria 5
Arabia 2
Barreal Blanco
Dunrobin
Egypt 1
Lake Frome
Libya 1
Libya 2
Libya 4
Lunar Lake Playa
Mauritania 1
Niger I
Rogers Dry Lake
Sonoran Desert
Taklamakan Desert
Uyuni Salt Flats
Warrabin

III

Amburla
Arabia 1
Bonneville Salt Flats
Egypt 2
Mali 1
Namib Desert 1
Namib Desert 2
Niger 2
Sechura Desert
Sudan 1
Tinga Tingana
Winton
Yemen Desert 1

Radiometric site categories

- **Absolute Calibration (A) -** An absolute calibration site is a location where in situ ground measurements of key physical parameters are acquired by calibrated ground instruments, allowing a detailed comparison of the ground instrument results to those of an orbiting sensor

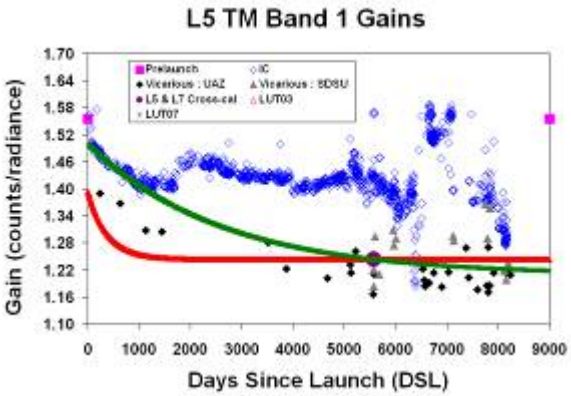
- **Pseudo-Invariant Calibration (I) -** A pseudo-invariant site is a location on the Earth's surface that is very stable both temporally and spatially over long periods of time and over significant spatial extent. These sites are typically located in desert regions that receive little rainfall and have few surface features

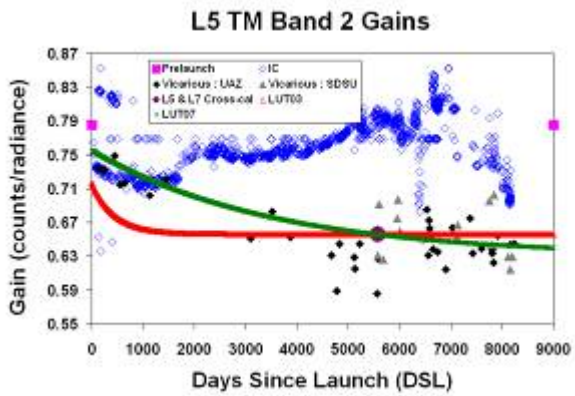
- **Cross-Calibration (X) -** A cross-calibration site is a location on the Earth's surface that contains large homogeneous regions that are viewable by two or more satellite sensors within a relatively short time period

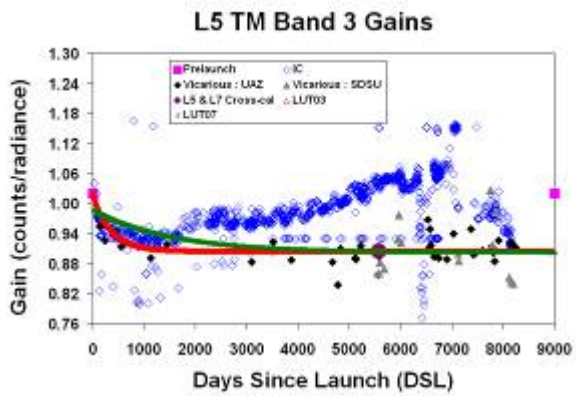
Provisional Calibration Site Categorizations
A=Absolute I=Pseudo-Invariant X=Cross-Calibration

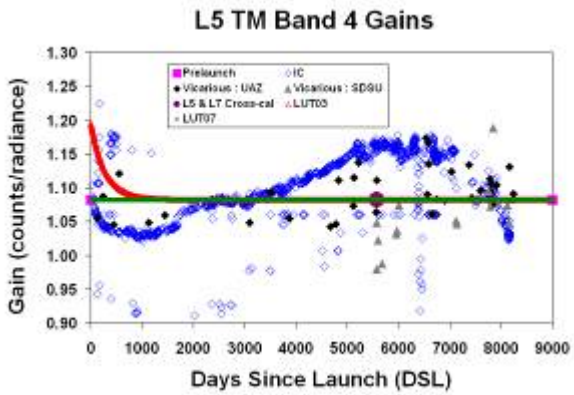
#	Site Name	WRS-2 Path	WRS-2 Row	Absolute Calibration (A)	Pseudo-Invariant Calibration (I)	Cross-Calibration (X)
1	Algeria 3	192	39		I	X
2	Algeria 5	195	39		I	X
3	Amburla	103	76	A		X
4	Arabia 1	164	47		I	X
5	Arabia 2	162	46		I	X
6	Barreal Blanco	232	82	A		X
7	Bonneville Salt Flats	39	32			X
8	Dunhuang	137	32	A		X
9	Dunrobin	94	76	A		X
10	Egypt 1	179	41		I	X
11	Egypt 2	177	44		I	X
12	Ivanpah Playa	39	35	A		X
13	La Crau	196	30	A		X
14	Lake Frome	97	81		I	X
15	Libya 1	187	43		I	X
16	Libya 2	182	43		I	X
17	Libya 4	181	40		I	X
18	Lunar Lake Playa	40	33	A		X
19	Mali 1	198	47			X
20	Mauritania 1	201	47		I	X
21	Namib Desert 1	179	77		I	X
22	Namib Desert 2	182	72		I	X
23	Niger I	189	46		I	X
24	Niger 2	188	45		I	X
25	Railroad Valley Playa	40	33	A		X
26	Rogers Dry Lake	41	36	A		X
27	Sechura Desert	10	64		I	X
28	Sonoran Desert	38	38		I	X
29	Sudan 1	177	45		I	X
30	Taklamakan Desert	146	32		I	X
31	Tinga Tingana	97	80	A		X
32	Uyuni Salt Flats	233	74		I	X
33	Warrabin	95	78	A		X
34	White Sands	33	37	A		X
35	Winton	96	76	A		X
36	Yemen Desert 1	164	48		I	X

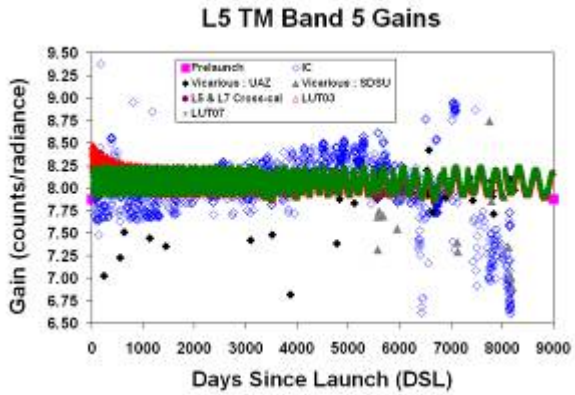
Comparison of L5 TM Radiometric Calibration Methods (Pre-launch, IC, Vicarious, LUT03, LUT07)

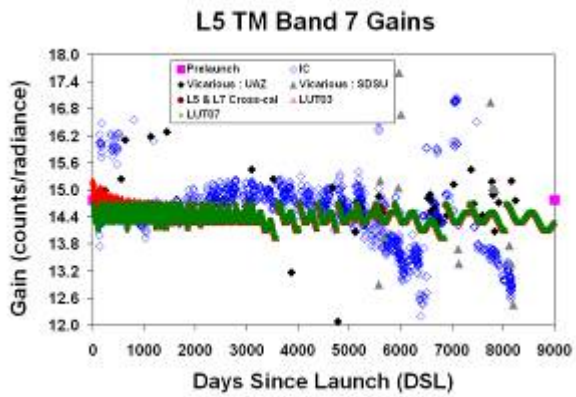












Proposed Future Plans

- Refine the selection of recommended primary sites
- Gather complete site characterization data and information
- Acquire and archive imagery of all primary sites
- Develop online calibration data access infrastructure
- Establish traceability chain for primary site data
- Develop guidelines and establish certification mechanisms for meeting calibration standards
- Endorse and advocate compliance with calibration standards

Some Sticky Points

- Global distribution of test sites uneven?
- What will be the traceable standards?
- Do sites have to be stationary?
- Key surface measurements and instruments needed?
- Ground truth data access?
- Do we need a certification/endorsement?
- What is the process for certification of test sites?
- Funding organizations?
- Who will do what, where, by when, and how?

GEO/CEOS workshop on Cal/Val processes Geneva October 2-4, 2007

- **To identify and scope key elements needed to develop and implement a "data quality strategy" as required by GEO task DA-06-02**
- **The Workshop will be organized by four main sessions**
  - **Cal/Val site characterization & classification**
  - Satellite and in situ Cal/Val data access
  - Methodology and guidelines for Cal/Val
  - Harmonization of quality information
- **Cal/Val site characterization & classification session**
  - This session will focus on the establishment, definition & characterization of calibration sites. Site characterization requirements will vary between expert groups but the desire is to establish a global set of CEOS-endorsed sources of cal/val data, which span all required disciplines, with the right to access and the guarantee of site maintenance

Summary

- This paper provides a comprehensive list of prime candidate terrestrial targets for consideration as benchmark sites for the post-launch radiometric calibration of space-based optical sensors
- The USGS test site online catalog provides easy public Web site access to this vital information for the global community
- The incompleteness of available information on even these prime test sites is an indication that much more coordination and documentation are still needed to facilitate the wider use of calibration test sites in remote sensing