Catalog of World-wide Test Sites for Sensor Characterization

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Gyanesh Chander

SGT, INC.*, contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD

*Work performed under USGS contract 08HQCN0005

Telephone: 605-594-2554, E-mail: gchander@usgs.gov

U.S. Department of the Interior

U.S. Geological Survey

Outline

- Introduction
- Site Selection Criteria
- Online Test Site catalog
- Provisional Calibration Site Categorizations
- Summary
- Proposed Future Plans

Context

- **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 (reflectance, temperature, etc.) that they measure**

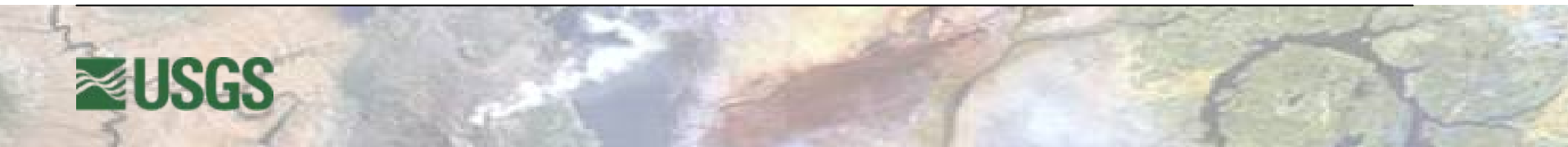
- **These well-calibrated data then assure the accuracy and enhance the intercomparability that enables the use of advanced Earth observation technologies to address societal benefits**

Scope of test sites

- Test sites are core to any future QA/QC strategy
- Test sites provide a convenient means of obtaining information to verify sensor performance
- Test sites are the only practical means of deriving knowledge on biases between sensors
- Test sites allow, at some level, a means of bridging anticipated data gaps caused by lack of measurement continuity, due to lack of co-existent in-flight sensors

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 postlaunch 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



Characteristics of sensors which can benefit from test sites

- Gain
- Linearity
- Stability
- MTF
- Uniformity (Flat field)
- Stray light (Adjacency effects)
- Polarization
- Spectral
- SNR
- Algorithms
- Geo location
- Camera model
- Band-to-band

Test site as a reference standard!

- **For example in the context of radiometric gain: Internal Calibrator, Solar Diffuser, Rayleigh scattering, clouds, sun-glint are all equally applicable methods**
  - Test sites and their use is really a methodology which in turn is one of many potential methods
- **In that context, test sites become a means to achieve an objective and should really be defined as "reference standards" to facilitate an activity**

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

Well-Established Site Selection Criteria

- **High spatial uniformity over a large area (within 3 %)**
  - Minimize misregistration and adjacency effects
- **Surface reflectance greater than 0.3**
  - To provide higher SNR and reduce uncertainty due to atmosphere
- **Flat spectral reflectance**
  - Reduce uncertainties due to different RSR
- **Temporally invariant surface properties (within 2 %)**
  - To reduce BRDF, spectral, surface reflectance effects
- **Horizontal surface with nearly lambertian reflectance**
  - Minimize uncertainty due to different solar illumination and observation geometry
- **At high altitude, far from ocean, urban, and industrial areas**
  - Minimize aerosol loading and atmospheric water vapor
- **In arid regions with low probability of cloud cover**
  - Minimize precipitation that could change soil moisture

Initial List of 36 Test Sites for Consideration

1) Algeria 3
2) Algeria 5
3) Amburla
4) Arabia 1
5) Arabia 2
6) Barreal Blanco
7) Bonneville Salt Flats
8) Dunhuang
9) Dunrobin
10) Egypt 1
11) Egypt 2
12) Ivanpah Playa
13) La Crau
14) Lake Frome
15) Libya 1
16) Libya 2
17) Libya 4
18) Lunar Lake Playa
19) Mali 1
20) Mauritania 1
21) Namib Desert 1
22) Namib Desert 2
23) Niger 1
24) Niger 2
25) Railroad Valley Playa
26) Rogers Dry Lake
27) Sechura Desert
28) Sonoran Desert
29) Sudan 1
30) Taklamakan Desert
31) Tinga Tingana
32) Uyuni Salt Flats
33) Warrabin
34) White Sands
35) Winton
36) Yemen Desert 1

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Distribution of 36 Radiometric Sites

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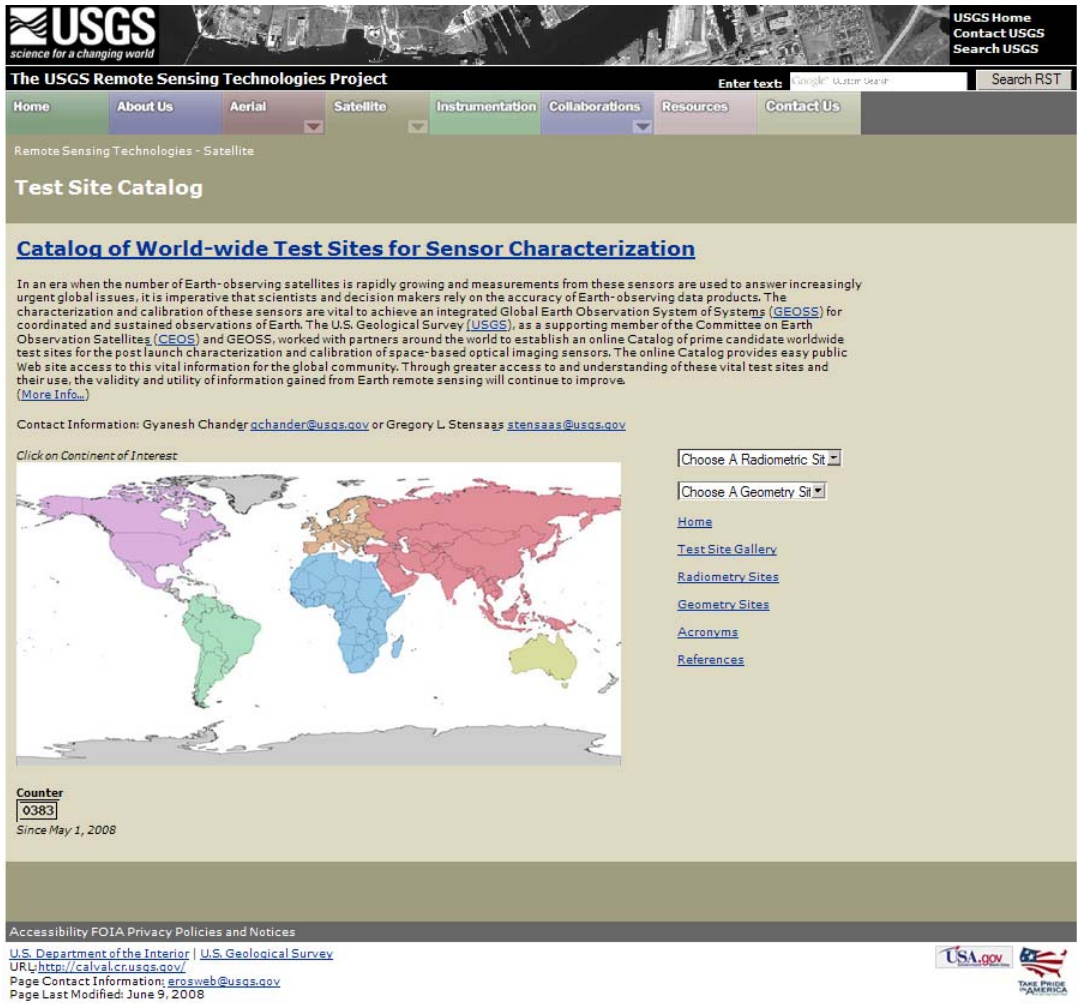
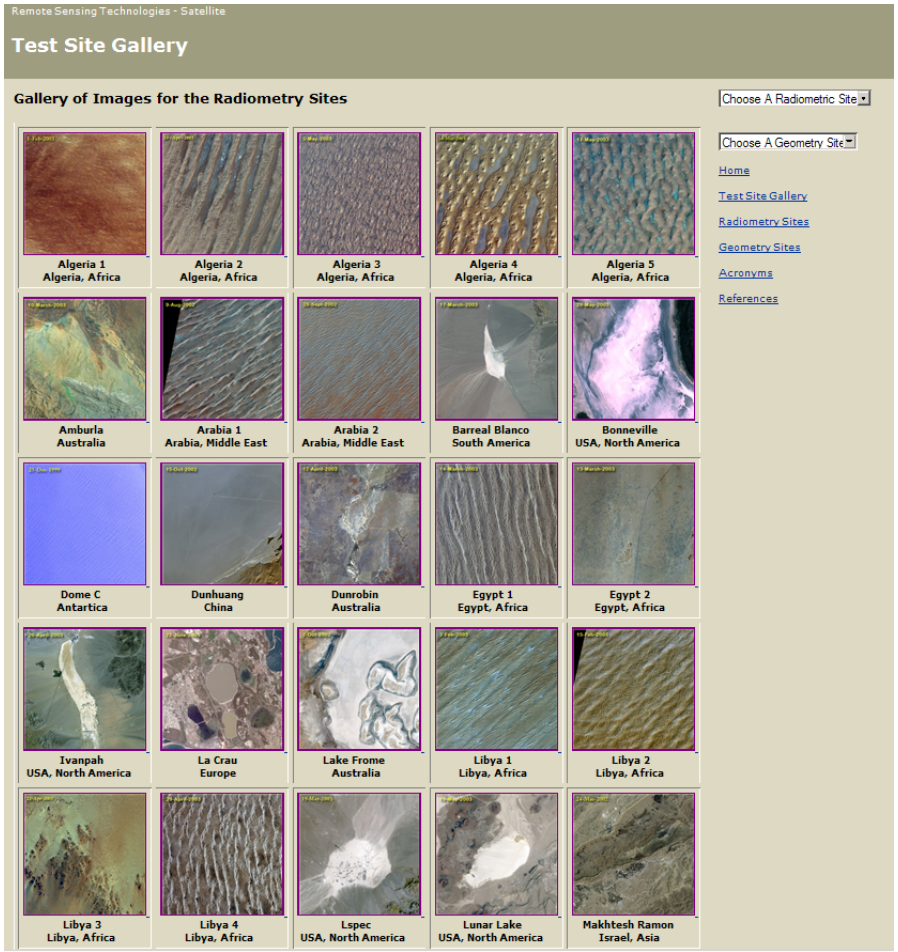
Online test site catalog

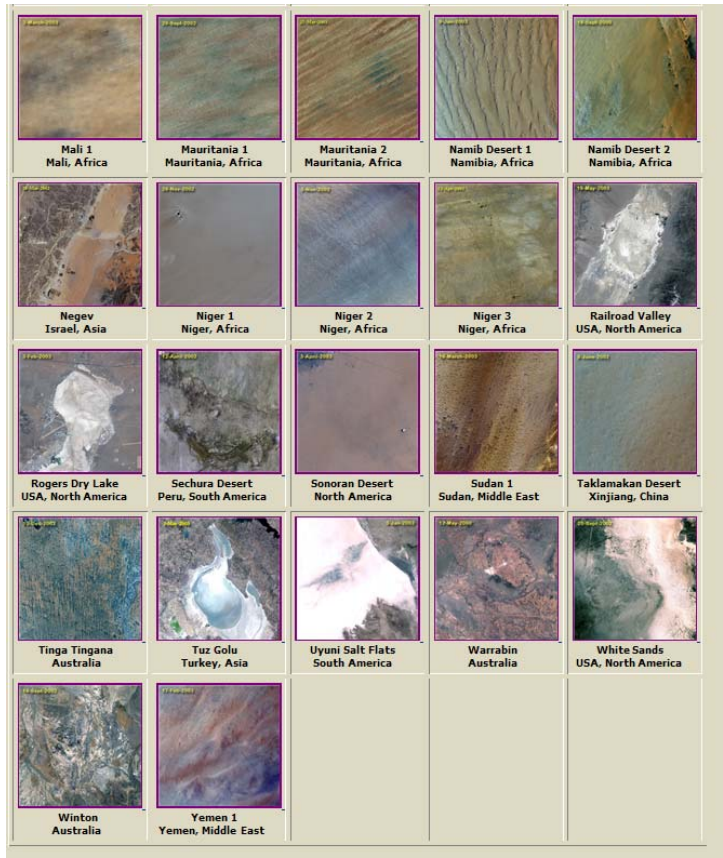
- **The layout is set up to help the user quickly locate the needed information available on the site**
  - Drop-down menus list locations so the user may go straight to a specific site
  - A map with clickable links provides another way to go to sites
  - The maps include a world map, where the user 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
  - previous/next button
  - sample Landsat images and Google KMZ files

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



Test Sites Gallery





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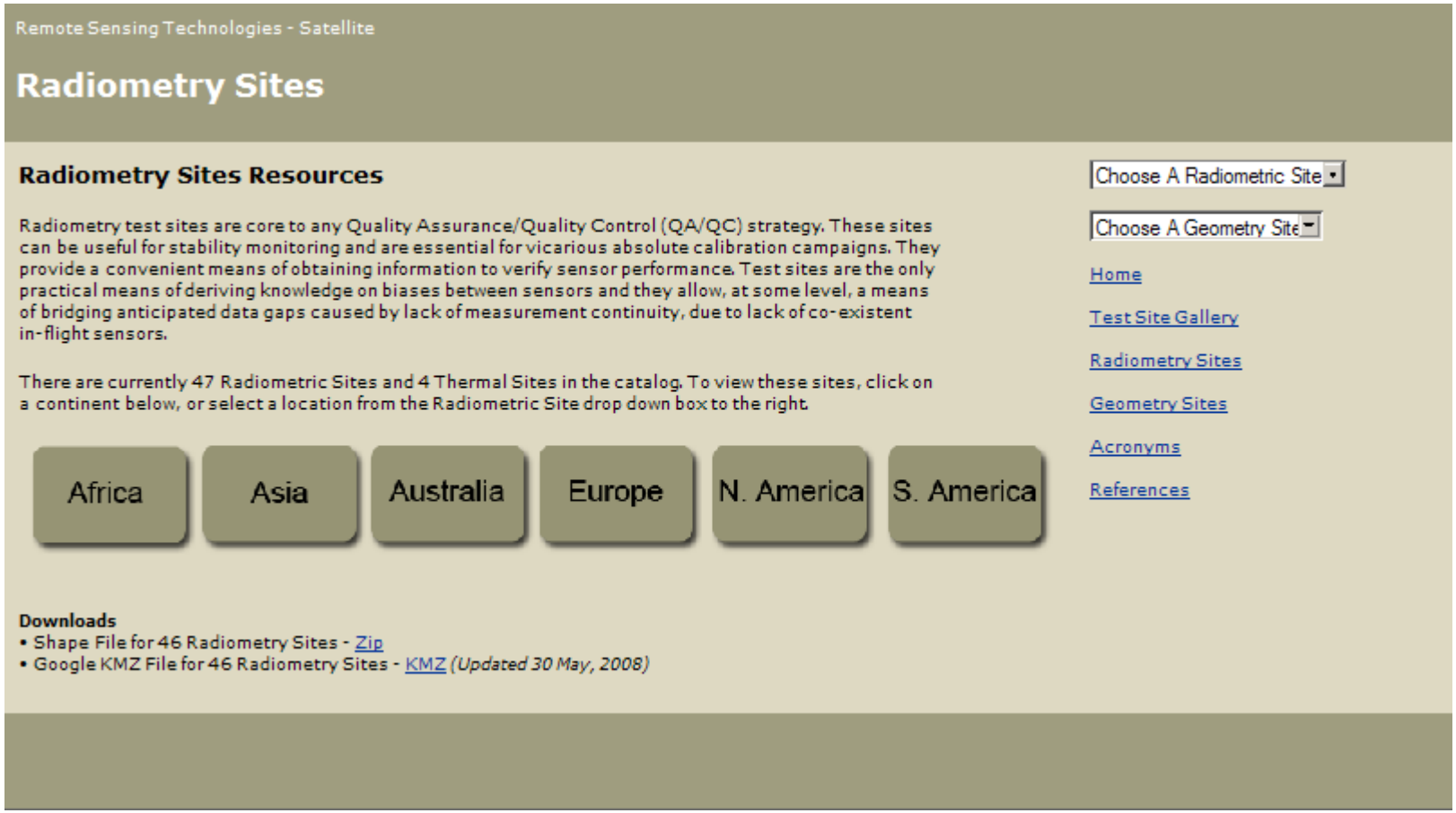
Radiometry Sites



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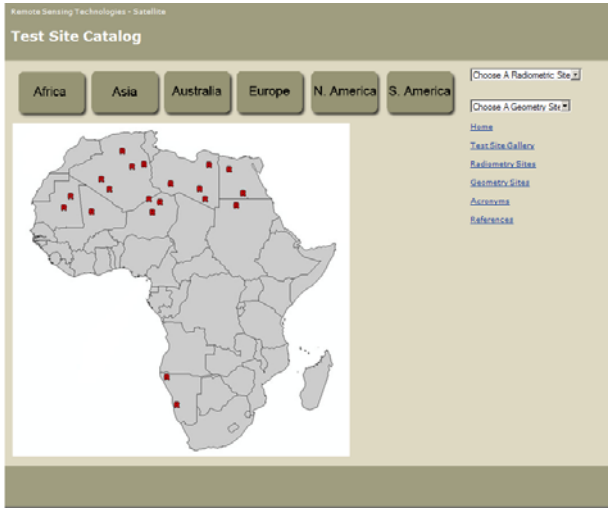
Radiometry Sites

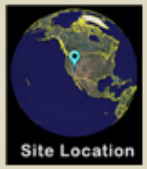


Online Catalogue Example: Railroad Valley Playa, North America

Site Location: Railroad Valley Playa

Radiometric ◀Prev Next▶

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 Useable Area (km):	10 x 10
Owner:	Bureau of Land Management (BLM)
Researcher:	Dr. Kurtis J. Thome Email Researcher



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Purpose:	Radiometric, vicarious calibration test site with large homogenous regions
Description:	Dry-lake playa, spatially homogenous, 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 (Fe^{3+}) in the visible part of the spectrum, characteristic of playas in this region of the United States. Google Earth: Slightly patchy (in color and intensity) across the playa.
Support Data:	Strong linear road features and oil drilling structures (no lat/long. available)
Suitability:	Recommended for 15-m GSD and larger; VisibleUV to SWIR. Solar reflective and emissive, sub-meter to 1-km 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

Choose A Radiometric Site

Choose A Geometry Site

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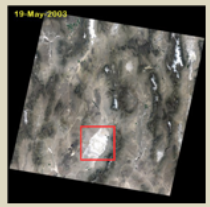
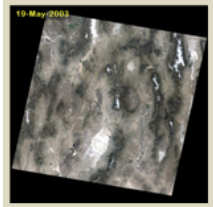
ETM+ Bands 321 Zoomed



ETM+ Bands 321 Site Parameters



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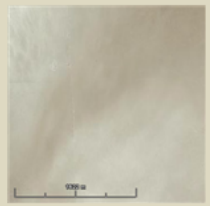
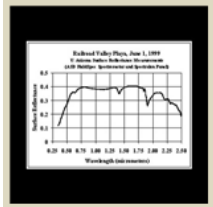

Google Earth Zoomed


Ground Picture 1


Ground Picture 2


Railroad Valley Reflectances

Online Catalogue Example: Libya 4, Africa

Site Location: Libya 4

Radiometric

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Location (City, State, Country):	Libya, Africa
Altitude above sea level (meters):	115
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:	Henry Patrick Email Researcher

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Purpose:	TBD
Description:	Southwest quadrant of Landsat WRS-1 181/40. 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 by 75 km or more, especially northwest of center coordinates. The surface varies slightly in intensity and color across the area.
Support Data:	TBD
Suitability:	TBD
Limitations:	TBD

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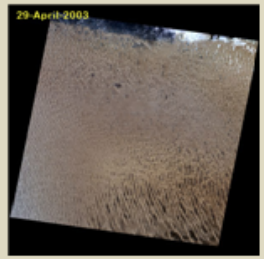

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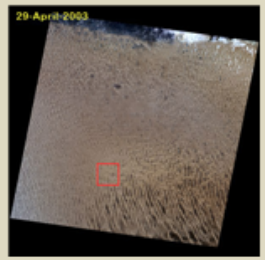

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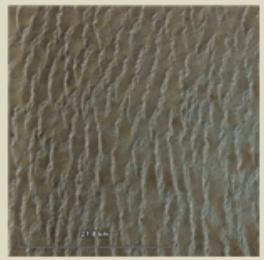

Google Earth Ground Picture

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Online Catalogue Example: Dunhuang, Asia

Site Location: Dunhuang

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Location (City, State, Country):	Dunhuang, Gobi Desert, Gansu Province, China, Asia
Altitude above sea level (meters):	1220
Center Latitude,Longitude (Degrees):	440.13 , 494.34
Landsat WRS-2 Path/Row:	137 / 32
Size of Usable Area (km):	25 x 25
Owner:	Unavailable
Researcher:	Unavailable

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Purpose:	TBD
Description:	Located in the Gobi Desert in northwest China, about 35 km west of the city of Dunhuang (Gansu Province). The calibration area is situated on a stabilized alluvial fan. The area used for vicarious calibration measurements is about 400 m x 400 m in the center of the fan, and the surface comprises cemented gravels with no vegetation. Sources of meteorological data for the site include the Dunhuang-PAM automated weather station, which is part of the Asian Automatic Weather Station Network. Atmospheric aerosols over the site are typical of a rural continental location, although some larger particles were observed, possibly influx from the sand dunes to the northwest. Sandstorms affect the site about 5 days per annum, and atmospheric dust is a significant factor about 80 days per annum. (Source: Network for Calibration and Validation of Earth Observation (NCAVEO) Web site, http://www.neaveo.ac.uk/calibration/radiometry/in-flight/4dunhuang). AERONET site. Google Earth: Looks very uniform in intensity and color, especially in Google Maps satellite imagery, which shows more detail.
Support Data:	TBD
Suitability:	TBD
Limitations:	TBD

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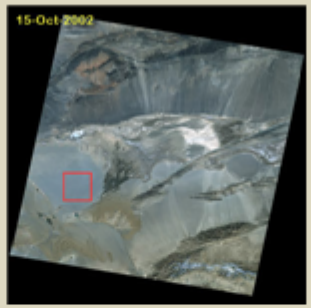

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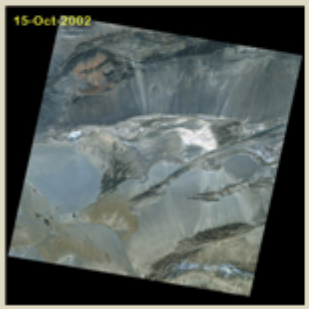

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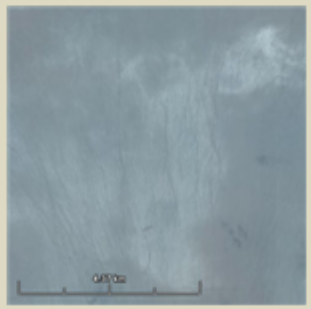

Google Earth Zoomed

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Online Catalogue Example: Amburla, Australia

Site Location: Amburla

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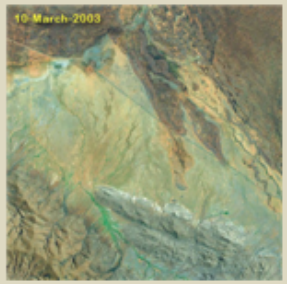
Location (City, State, Country):	Amburla, Tanami Desert, 100 km NW of Alice Springs, Northern Territory, Australia
Altitude above sea level (meters):	626
Center Latitude,Longitude (Degrees):	-23.385 , +133.119
Landsat WRS-2 Path/Row:	103 / 76
Size of Usable Area (km):	1 x 2
Owner:	Unavailable
Researcher:	Unavailable



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Purpose:	TBD
Description:	An arid desert site located on a long flat plain characterized by a red soil with a sparse cover of Mitchell grass. Used for cattle and camel grazing. Ephemeral vegetative growth following heavy tropical thunderstorm activity or slow-moving rainband activity may be significant but is uncommon. The site has moderate column amounts of water vapor (typically 5 to 40 kg m-1) and aerosol optical depth (typically 0.03 at 0.5 micron). The site is instrumented to monitor continuously the surface radiation budget and meteorological parameters at several points. (Source: AATSR Validation Implementation Plan PO-PL-GAC-AT-005 (3), http://www.icess.ac.uk/AATSR/Downloads/AATSR_VIP_Version3.pdf). *Google Earth:* Various drainage patterns, small ranges of colors and intensities. The most useable part is limited to a small area about 1 km (E-W) by 2 km (N-S).
Support Data:	TBD
Suitability:	TBD
Limitations:	TBD

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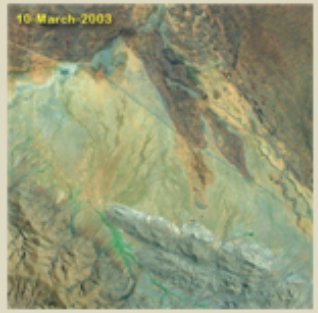

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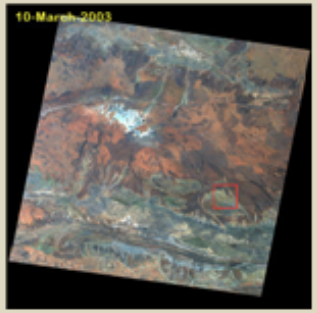
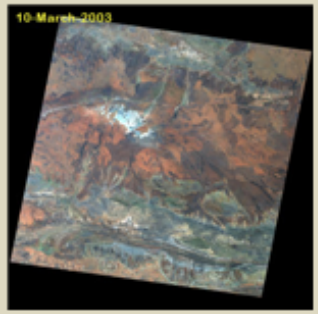


ETM+ Bands 321 Site Parameters



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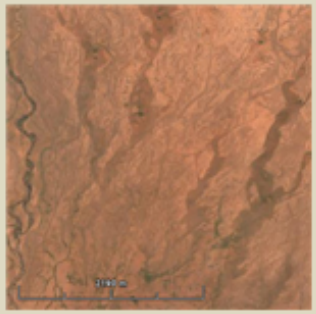

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Online Catalogue Example: La Crau, Europe

Site Location: La Crau

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Location (City, State, Country):	La Crau, France, Europe
Altitude above sea level (meters):	25
Center Latitude,Longitude (Degrees):	43.47 , 4.97
Landsat WRS-2 Path/Row:	196 / 30
Size of Useble Area (km):	1 x 1
Owner:	Unavailable
Researcher:	Henry Patrice Email Researcher

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Purpose:	TBD
Description:	The area has thin pebbly soil with very sparse vegetation cover. About 50 km northwest of Marseille, not far from the Mediterranean, so the site has the possibility of atmospheric water vapor and aerosol problems. (Source: Network for Calibration and Validation of Earth Observation (NCAVEO) Web site, http://www.ncaveo.ac.uk/calibration/radiometry/in-flight/#lacrau). AERONET site. *Google Earth*: Looks very homogeneous across the site, but the imagery may be saturated such that details cannot be discerned.
Support Data:	TBD
Suitability:	TBD
Limitations:	TBD

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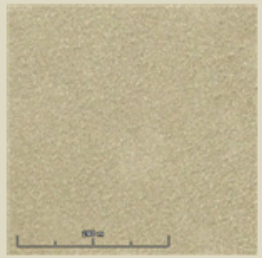

Google Earth Ground Picture

Return to Ivanpah Playa

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Online Catalogue Example: Barreal Blanco, South America

Site Location: Barreal Blanco

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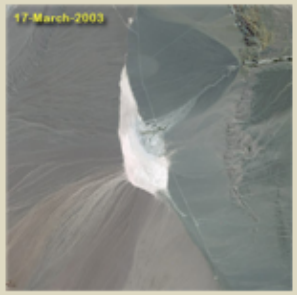
Location (City, State, Country):	Barreal Blanco, San Juan, Argentina, South America
Altitude above sea level (meters):	1572
Center Latitude,Longitude (Degrees):	-31.65 , -69.45
Landsat WRS-2 Path/Row:	232 / 82
Size of Usable Area (km):	0.5 x 0.5
Owner:	Unavailable
Researcher:	Unavailable



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Purpose:	TBD
Description:	Located in northwest Argentina in Provincia de San Juan. Used on a joint campaign with Argentina's CONAE to calibrate the satellite instruments EO-1 ALI and Hyperion as well as Landsat 7's ETM+ and Terra's ASTER. The EO-1 and ASTER site measured 16x4 30-m pixels on a 100-180 axis. ETM+ consisted of a 16x4 30-m pixel site on a 010-190 axis. The site was chosen because there was a need to calibrate the instruments aboard EO-1 immediately after the January launch, and weather conditions are favorable in the Southern Hemisphere in January. *Google Earth*: Small homogeneous bright site. May be prone to saturation at high sun. Uniform areas are limited to 0.5 km by 0.5 km or less, but there are several such areas.
Support Data:	TBD
Suitability:	TBD
Limitations:	TBD

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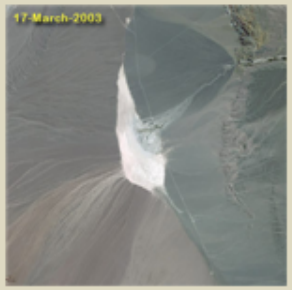

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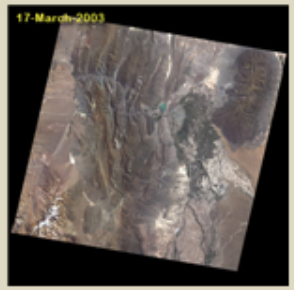

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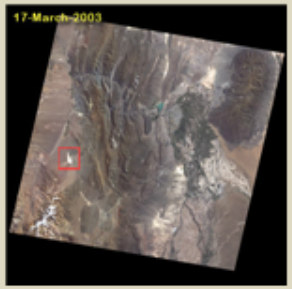
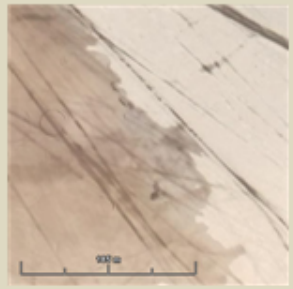


ETM+ Bands 321 Site Parameters



Google Earth Ground Picture

Return to Barreal Blanco

USGS

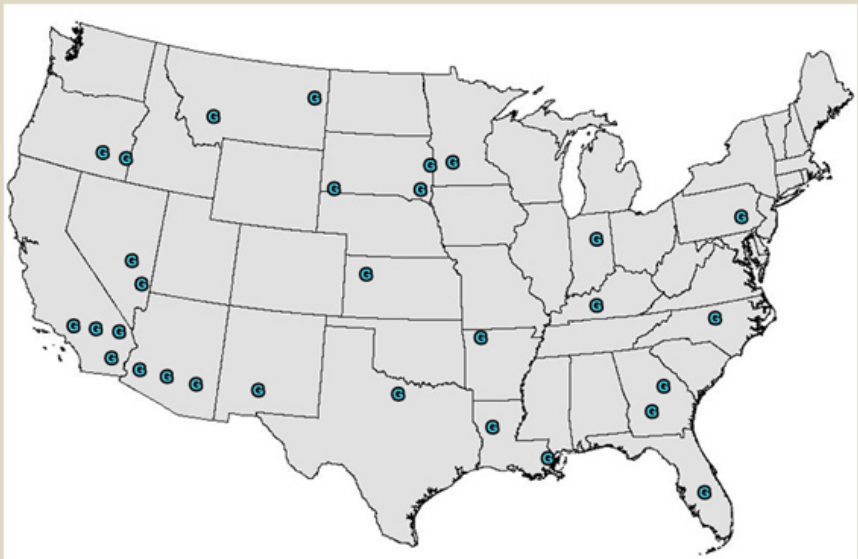
Geometry Sites

Remote Sensing Technologies - Satellite

Geometry Sites

The geometric supersites are all built by mosaicking panchromatic Digital Orthophoto Quadrangles (DOQs) that have been reduced in resolution from 1 meter to 15 meters to match that of the ETM+ PAN band. DOQs themselves are designed to meet the national map accuracy standards at 1:24,000-scale and have a horizontal root-mean-square accuracy of approximately 6 meters. The term supersite is one the Landsat geometric Image Assessment System (IAS) team has given to any WRS-2 path/row in which wall-to-wall coverage of DOQs have been assembled for geometric characterization and calibration purposes.

There are currently 30 Geometric Sites in the catalog. To view these sites, click on a hyperlink (G) below, or select a WRS-2 path/row from the Geometry Site drop down box to the right. At this time, the geometry sites are only over the continental United States, CONUS.



Choose A Radiometric Site

Choose A Geometry Site

Home

Test Site Gallery

Radiometry Sites

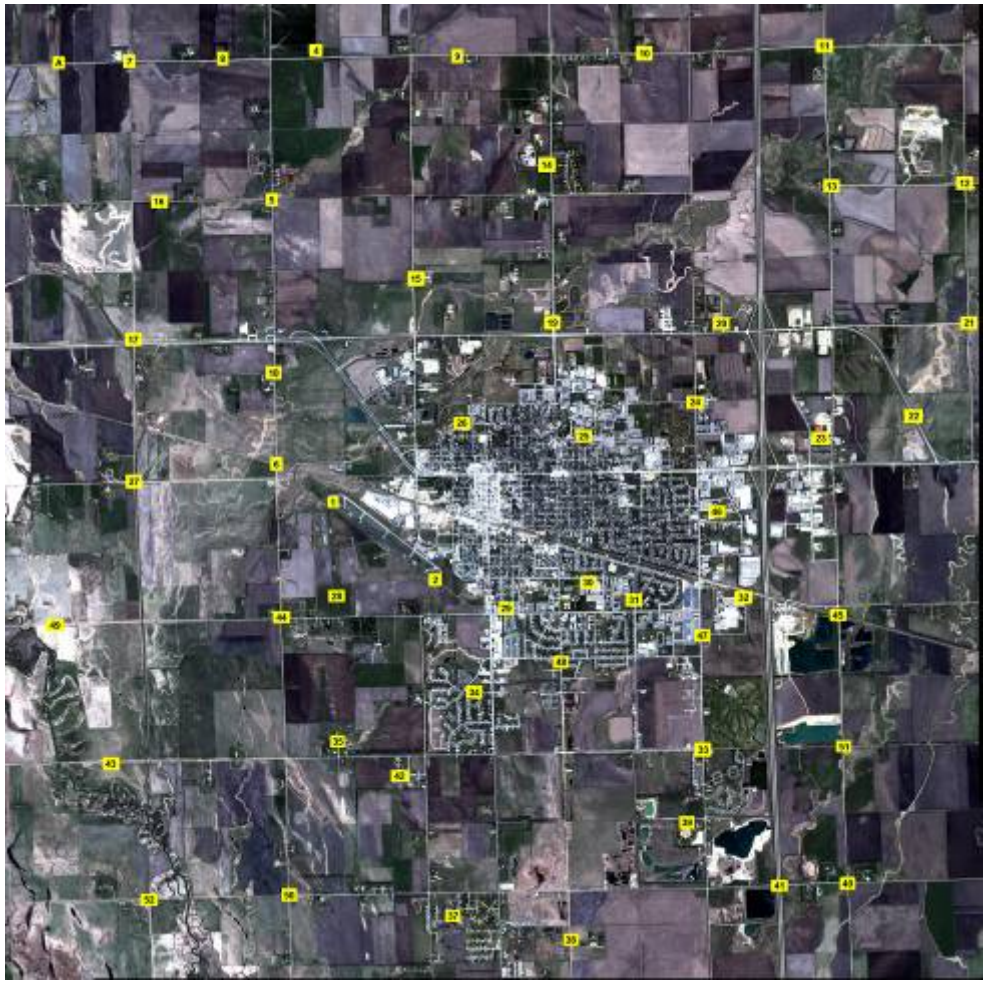
Geometry Sites

Acronyms

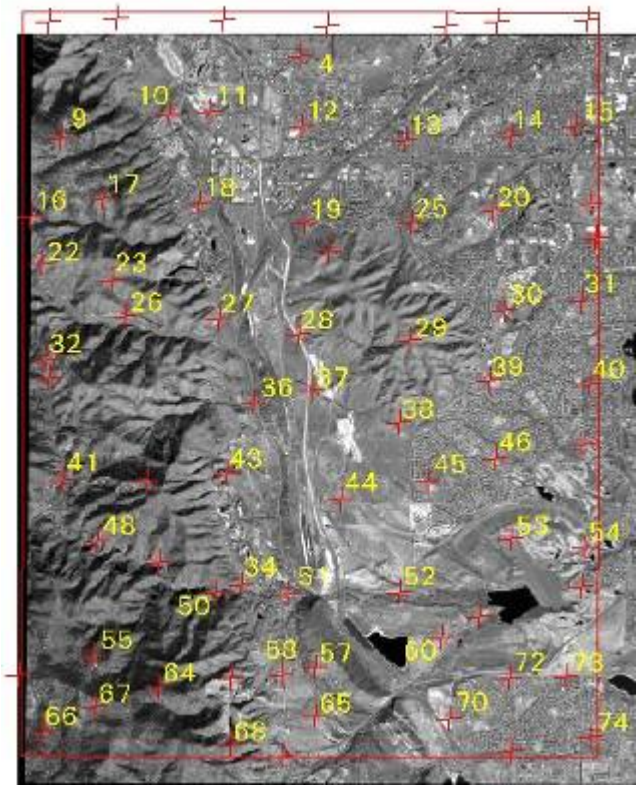
References

USGS

GCPs

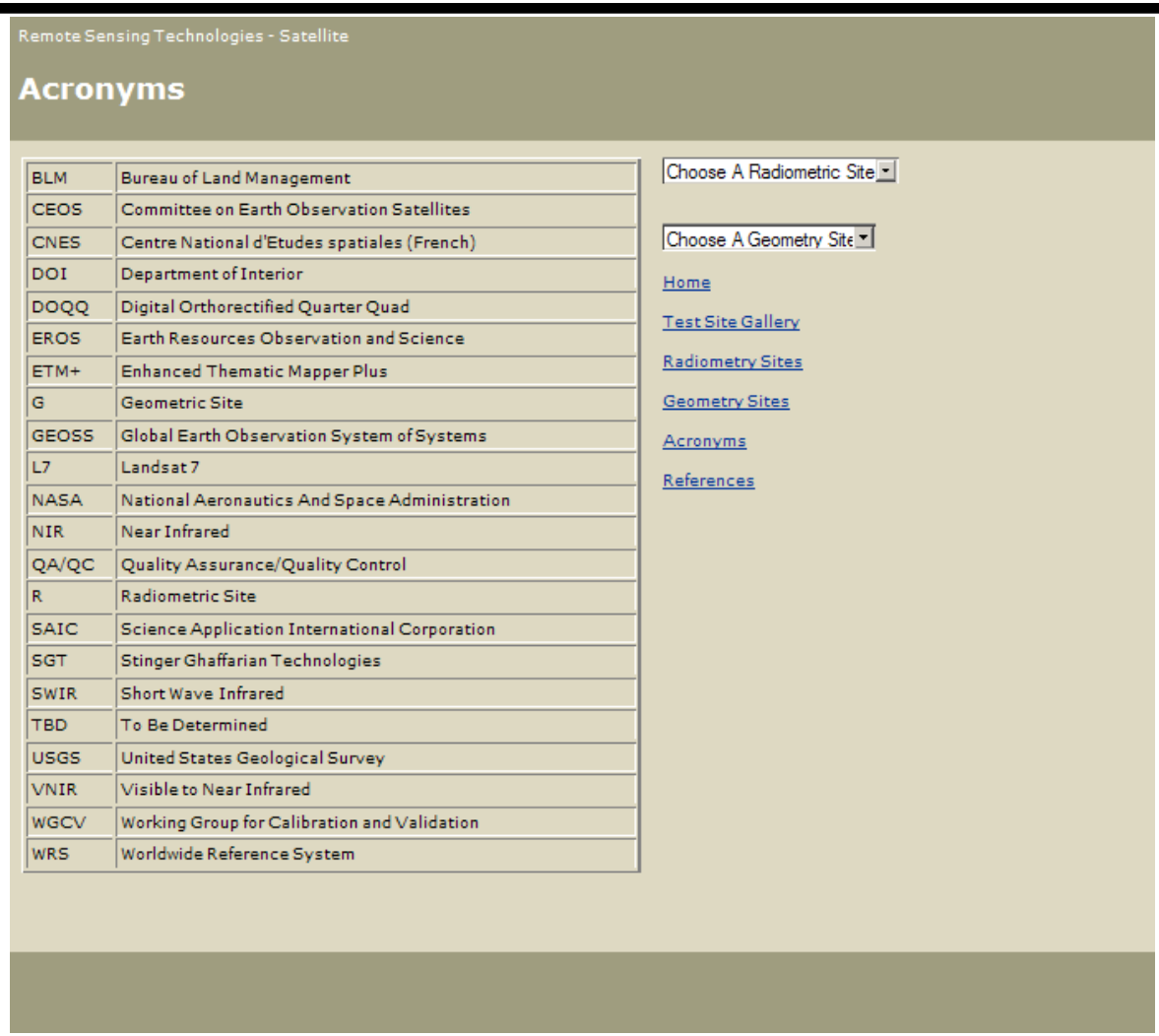


51 GCPs selected over Brookings, SD area



72 GCPs selected over Morrison, CO area

Acronyms



BLM	Bureau of Land Management
CEOS	Committee on Earth Observation Satellites
CNES	Centre National d'Etudes spatiales (French)
DOI	Department of Interior
DOQQ	Digital Orthorectified Quarter Quad
EROS	Earth Resources Observation and Science
ETM+	Enhanced Thematic Mapper Plus
G	Geometric Site
GEOSS	Global Earth Observation System of Systems
L7	Landsat 7
NASA	National Aeronautics And Space Administration
NIR	Near Infrared
QA/QC	Quality Assurance/Quality Control
R	Radiometric Site
SAIC	Science Application International Corporation
SGT	Stinger Ghaffarian Technologies
SWIR	Short Wave Infrared
TBD	To Be Determined
USGS	United States Geological Survey
VNIR	Visible to Near Infrared
WGCV	Working Group for Calibration and Validation
WRS	Worldwide Reference System

References

Remote Sensing Technologies - Satellite

References

Choose A Radiometric Site

Choose A Geometry Site

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Test Site Gallery

Radiometry Sites

Geometry Sites

Acronyms

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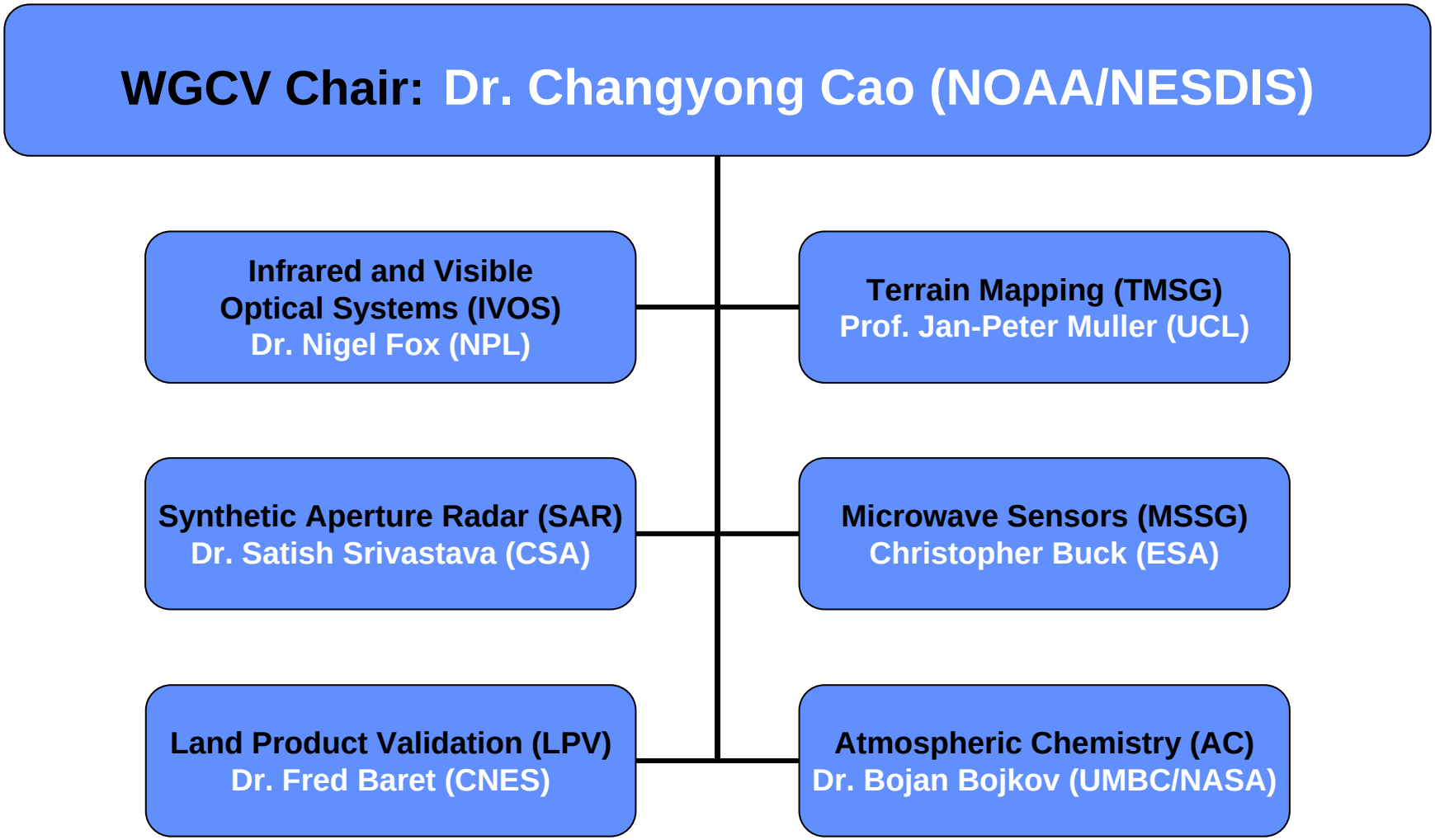
CEOS WGCV Subgroups



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CEOS IVOS-19 Test sites Discussion Summary

Invariant Sites			
#	Site Name	Center Latitude	Center Longitude
1	Libya 4	28.55	23.39
2	Mauritania 1	19.40	-9.30
2	Mauritania 2	20.85	-8.78
3	Algeria 3	30.32	7.66
4	Libya 1	24.42	13.35
5	Algeria 5	31.02	2.23
Core Instrumented Sites			
1	Railroad Valley Playa	38.50	-115.69
2	Ivanpah Playa	35.57	-115.40
3	Lspec Frenchman Flat	36.81	-115.93
4	La Crau	43.47	4.97
5	Dunhuang	40.13	94.34
6	Negev, Southern Israel	30.11	35.01
7	Tuz Golu	38.83	33.33
8	Dome C	-74.50	123.00

Mauritania (consider as one site)

Core "Instrumented" IVOS Sites (Total=8) LANDNET

1. **Railroad Valley Playa, NV, USA, North America**
   - Dr. Kurtis J. Thome (kthome@email.arizona.edu) – University of Arizona, USA
2. **Ivanpah, NV/CA, USA, North America**
   - Dr. Kurtis J. Thome (kthome@email.arizona.edu) – University of Arizona, USA
3. **Lspec Frenchman Flat, NV, USA, North America**
   - Mark C. Helmlinger (mark.helmlinger@ngc.com) – NGST, USA
4. **La Crau, France, Europe**
   - Patrice Henry (patrice.henry@cnes.fr) – CNES, France
5. **Dunhuang, Gobi Desert, Gansu Province, China, Asia**
   - Fu Qiaoyan (fqy@cresda.com) – CRESDA, China
6. **Negev, Southern Israel, Asia**
   - Arnon Karnieli (karnieli@bgu.ac.il) – Ben Gurion University, Israël
7. **Tuz Golu, Central Anatolia, Turkey, Asia**
   - Selime Gurol (selime.gurol@uzay.tubitak.gov.tr) – TUBITAK UZAY, Turkey
8. **Dome C, Antartica**
   - Dr. Stephen Warren (sgw@atmos.washington.edu) – University of Washington, USA

Core “Instrumented” IVOS Sites (Total=8)

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“Invariant” IVOS Sites (Total=5)

- Libya 4
- Mauritania 1/2
- Algeria 3
- Libya 1
- Algeria 5

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Terrain Mapping Subgroup (TMSG)

- **Montagne Sainte-Victoire**
  - France referred to as Aix-en-Provence
  - 5.528-5.685ºE, 43.502-43.560ºN
  - mixed arable, forest, limestone
- **Barcelona, Spain**
  - 1.5-2.75ºE, 41.25-41.82ºN
  - urban, mixed arable, forest
- **North Wales,**
  - UK3-5ºW, 52-53.5ºN
  - urban, pasture, forest
- **Three Gorges, China**
  - 108.252-111.302ºE, 30.638-31.229ºN
  - forest, arable, limstone shales
- **Puget Sound, WA, USA**
  - -121.397 to -123.897ºW, 46.364-48.864ºN
  - forest, urban, wetlands

N.B. screenshots from ICEDS extracts

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Synthetic Aperture Radar (SAR)

- **International Amazon Rainforest Site**
  - A CEOS radiometric calibration reference site
  - Data routinely collected and analyzed for calibration monitoring of SAR satellites including RADARSATs
  - Radiometry of the site remains stable
- **Canadian Boreal Forest Site**
  - Radiometric characterization completed at C-band using RADARSAT-1 data
  - Site seasonally dependent
  - Can be used as a complimentary site to the Amazon but with reduced radiometric accuracy
- **Calibration Transponder Sites**

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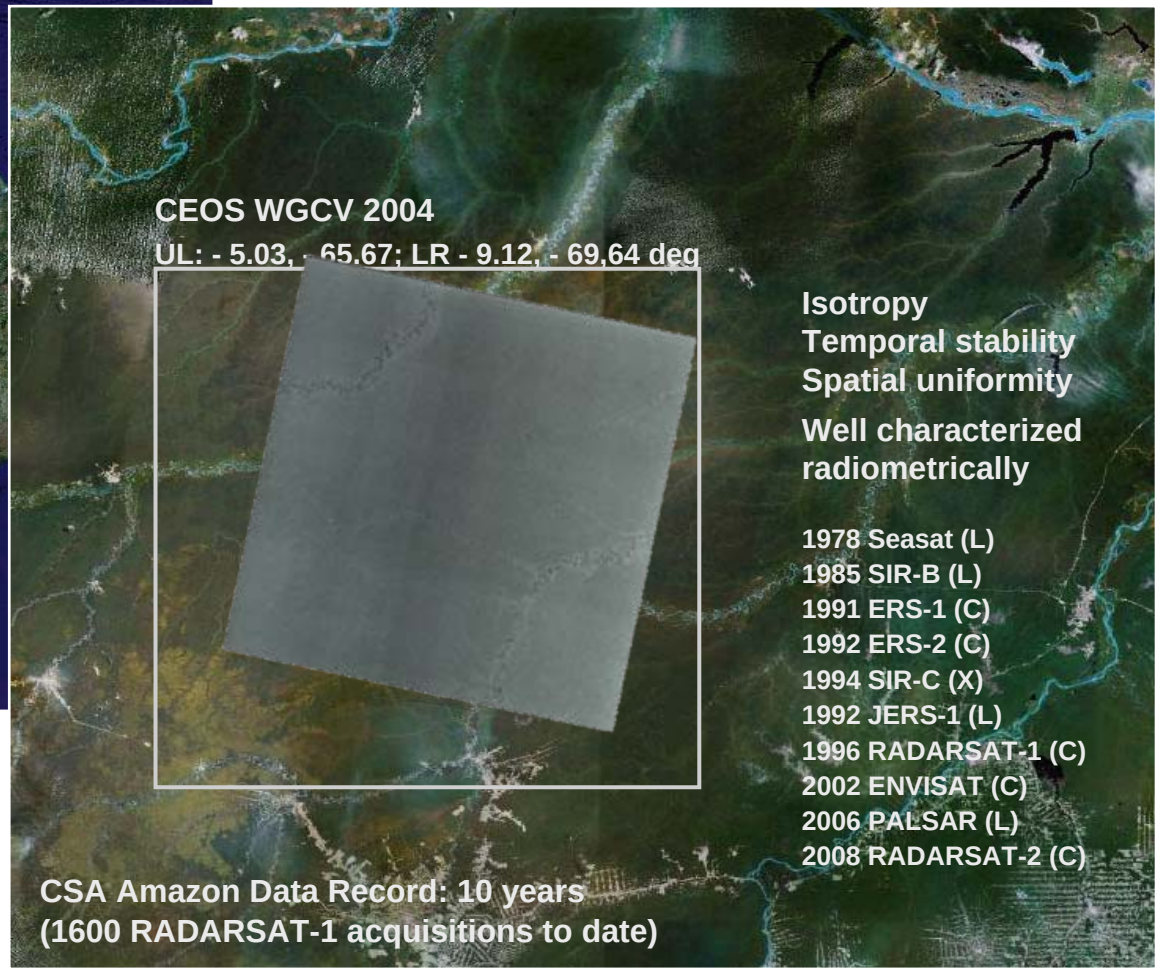
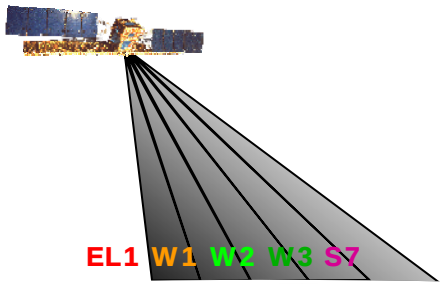
SAR Cal/Val Test Site: Amazon Rainforest



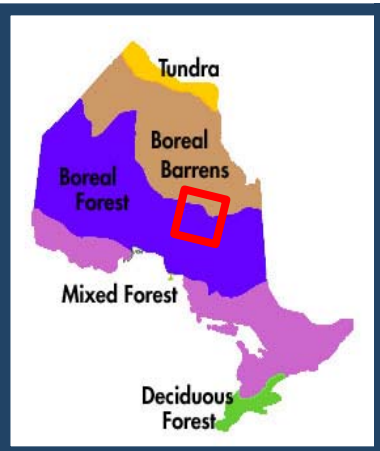
Experimental SAR Cal/Val Test Site: Boreal Forest, Canada

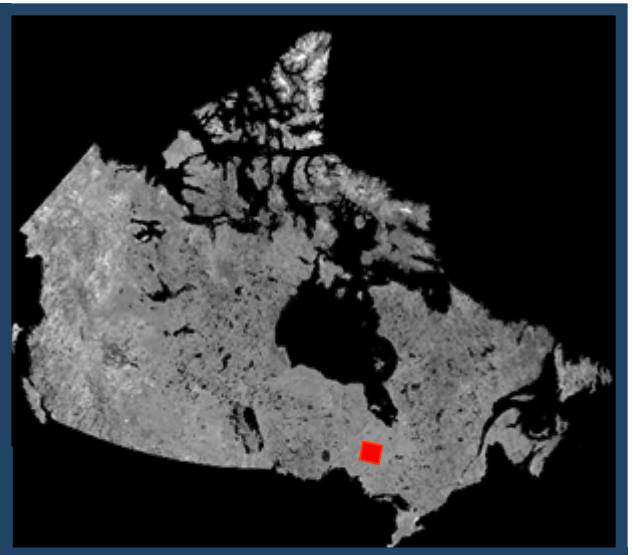
- CSA campaign started Jan 2003
- Elevation beam pattern extractions began Dec 2004 using seasonal γ references for summer and winter

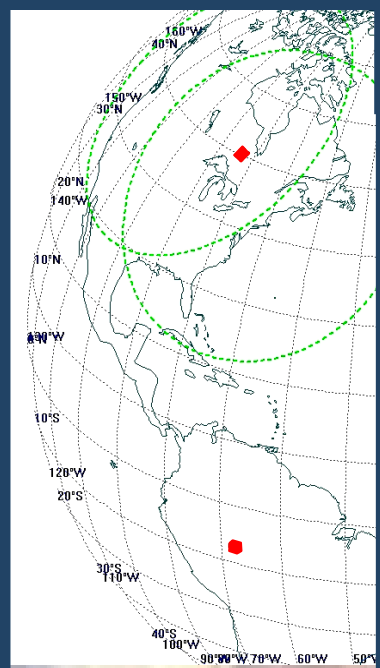


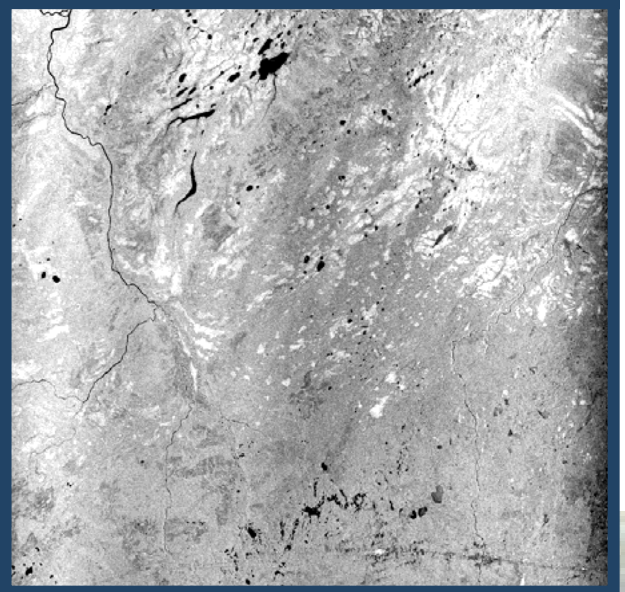
- Support for prime calibration area (Amazon) with non-OBR, real-time acquisitions
- Allows frequent calibration assessments (higher latitude)
- Used for W2 recalibration in 2006

- CEOS SAR Workshop 2006, "RADARSAT-1 Elevation Beam Pattern Extraction using the Canadian Boreal Forest: Update and Application", S. Cote, P. Le Dantec, T.I. Lukowski, R. K. Hawkins, S. K. Srivastava





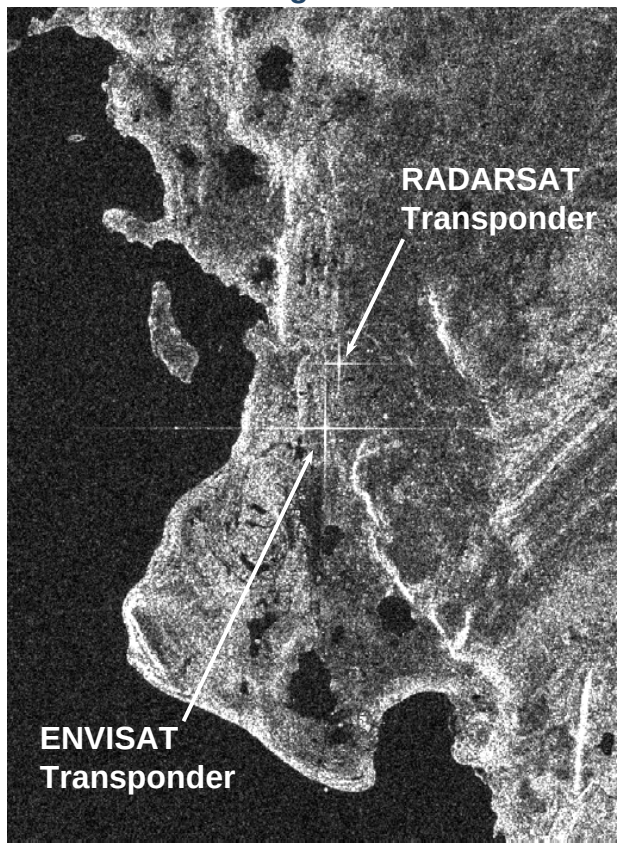




C-Band Transponder Sites in Canada: from CSA-only to CSA/ESA Sites

- In Fall 2006, ESA relocated an Envisat ASAR Transponder in Resolute Bay in vicinity of the RADARSAT Transponder
- Both transponders can be used simultaneously by Envisat
- Another Envisat ASAR Transponder was relocated in Ottawa in 2007, again in vicinity of a RADARSAT Transponder

ENVISAT ASAR Image of Resolute



Two potential sites in Canada for inter-sensor comparisons for C-band SARs

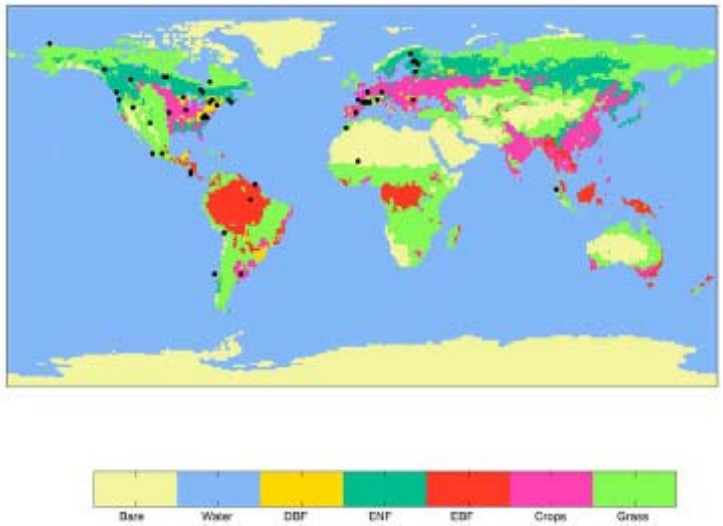
(RADARSAT-1, Envisat and RADARSAT-2)

Microwave Sensors Subgroup (MSSG)

- **Sandy desert (e.g. Sahara)**
  - Deep penetration depth, temporal stability of the Tb, underground structure TBD
- **Rocky/mixed desert (e.g. Gobi)**
  - Shallow penetration depth, azimuthal effects and vegetation
- **Rainforest (Amazon)**
  - Volume scatter, effects of rain cells on the canopy equivalent moisture TBD
- **Stable ocean areas**
  - Effects of the wind/salinity at L-band TBD
- **Antarctica**
  - Dry atmosphere, large penetration depth & temporally stable, low azimuthal anisotropy

Land Product Validation (LPV)

- **CEOS Benchmark Land Multisite Analysis and Intercomparison of Products (BELMANIP) - http://lpvs.gsfc.nasa.gov/**

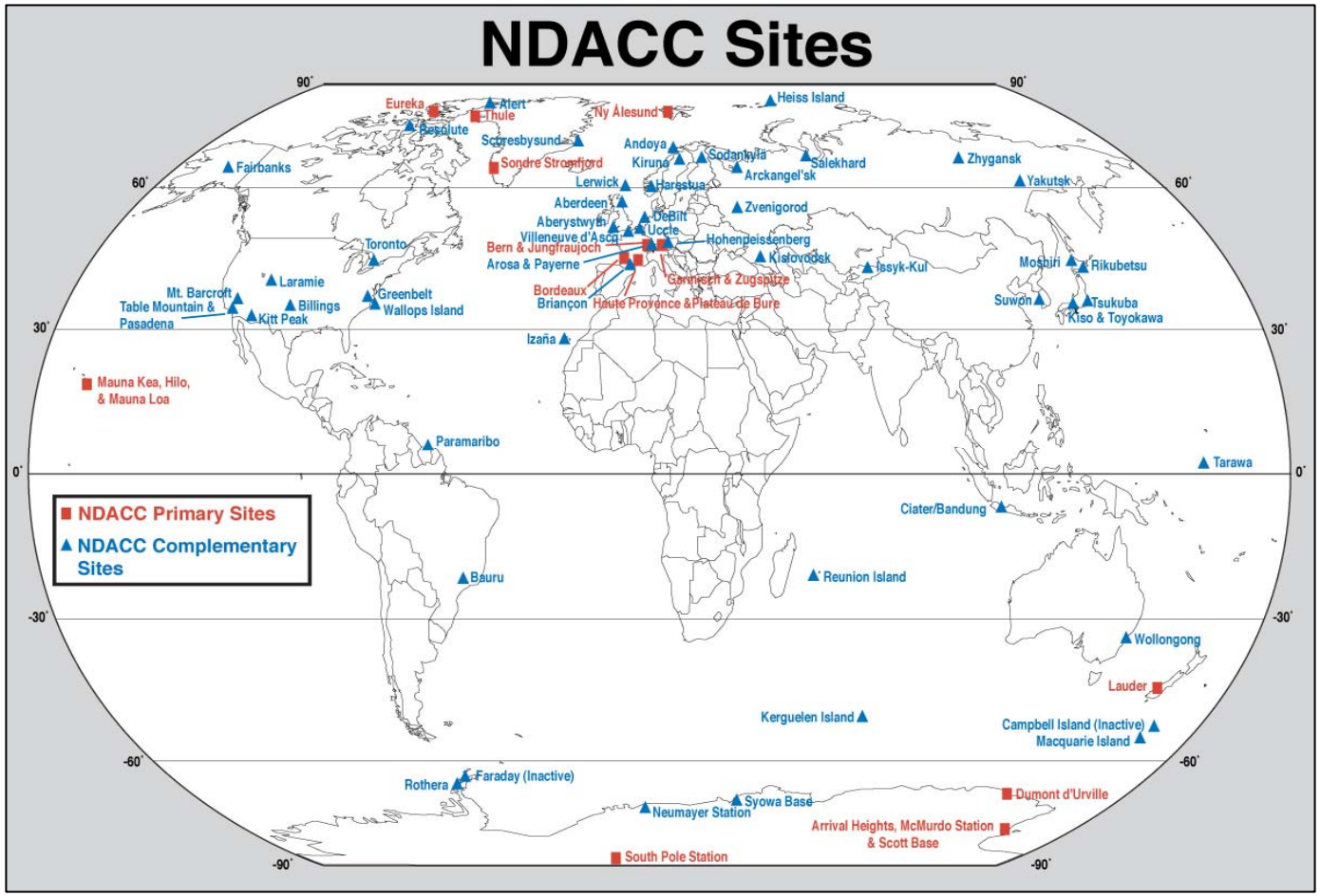


- **Map of sites covered by the groups represented in this paper (given on a global map of dominant surface types in each 1 x 1 cell (bare soil, water bodies, deciduous broadleaf forest, evergreen needleleaf forest, evergreen broadleaf forest, crops, grass)**

Land Product Validation (LPV)

- **CEOS Benchmark Land Multisite Analysis and Intercomparison of Products (BELMANIP)**
- **'Direct' sites**
  - No necessity for high spatial homogeneity (non linearity as a function of heterogeneity), but homogeneity at medium resolution (geometrical accuracy, PSF)
  - Flat site
  - Element of an ensemble to sample different vegetation types and conditions
  - Currently about 100 sites identified, but only a fraction with accessible information… List under compilation
- **'Intercomparison' sites**
  - Homogeneity at medium spatial resolution
  - Flat site
  - Sampling all conditions (BELMANIP accessible at LPV web site, but must be revised)

Atmospheric Chemistry (AC)



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Summary

- **The test site catalog provides a comprehensive list of prime candidate terrestrial targets for consideration as benchmark sites for the postlaunch radiometric calibration of space-based optical sensors**

- **The online test site 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**

Proposed Future Plans

- **Refine the selection of recommended primary sites**
  - Gather complete site characterization data and information
  - Define core measurements (eg. Instruments)
  - Develop protocols and fund pilot projects
  - Create a “calnet” or “landnet”
- **Agencies should acquire and archive imagery of all primary sites**
  - Develop online calibration data access infrastructure
  - Create tools to identify the potential co-incident image pairs
- **Extend the list to include snow fields, vegetation targets and water targets**
- **Integrate the catalog into the CEOS EO Cal/Val portal**
- **Establish traceability chain for primary site data**

Back-up Slides

Calibration Site Categorizations

- **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**

Radiometry Sites

		Center	
#	Site Name	Latitude	Longitude
1	Algeria 3	30.32	7.66
2	Algeria 5	31.02	2.23
3	Amburla	-23.39	133.12
4	Arabia 1	18.88	46.76
5	Arabia 2	20.13	50.96
6	Barreal Blanco	-31.86	-69.45
7	Bonneville Salt Flats	41.00	-113.57
8	Dunhuang	40.13	94.34
9	Dunrobin	-22.67	146.13
10	Egypt 1	27.12	26.10
11	Egypt 2	22.94	28.79
12	Ivanpah Playa	35.57	-115.40
13	La Crau	43.47	4.97
14	Lake Frome	-30.85	139.67
15	Libya 1	24.42	13.35
16	Libya 2	25.05	20.48
17	Libya 4	28.55	23.39
18	Lunar Lake Playa	38.40	-115.99
19	Mali 1	19.12	-4.85
20	Mauritania 1	19.40	-9.30
21	Namib Desert 1	-24.98	15.27
22	Namib Desert 2	-17.33	12.05
23	Niger I	19.67	9.81
24	Niger 2	21.37	10.59
25	Railroad Valley Playa	38.50	-115.69
26	Rogers Dry Lake	34.96	-117.86
27	Sechura Desert	-5.90	-80.43
28	Sonoran Desert	32.35	-114.65
29	Sudan 1	21.74	28.22
30	Taklamakan Desert	39.83	80.17
31	Tinga Tingana	-29.00	139.86
32	Uyuni Salt Flats	-20.38	-66.95
33	Warrabin	-26.28	143.65
34	White Sands	32.92	-106.35
35	Winton	-22.52	142.94
36	Yemen Desert 1	16.87	47.55
37	Dome C	-74.50	123.00
38	Tuz Golu	38.83	33.33
39	Algeria_1	23.80	-0.40
40	Algeria_2	26.09	-1.38
41	Algeria_4	30.04	5.59
42	Niger_3	21.57	7.96
43	Libya_3	23.15	23.10
44	Mauritania_2	20.85	-8.78
45	Makhtesh Ramon	30.59	34.84
46	Lspec Frenchman Flat	36.81	-115.93

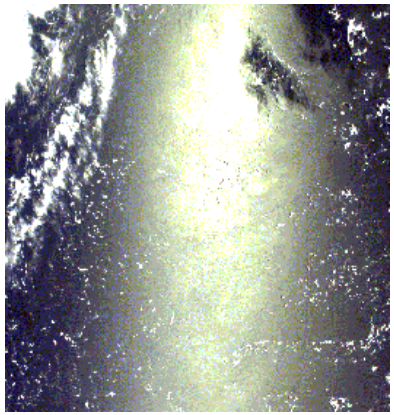
Provisional Calibration Site Categorizations
A=Absolute I=Pseudo-Invariant X=Cross-Calibration

#	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

USGS

Special Methods

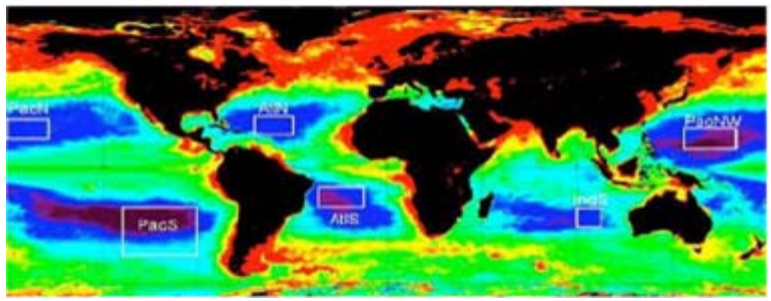
Moon



Sun glint

Rayleigh

Clouds



Rayleigh Calibration Sites – Choice of oligotrophic areas with 2 years of SeaWiFS data made in 2001 with ACRI and LOV (CLIMZOO zones)