QA4EO | A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

Catalog of Worldwide Test Sites for Sensor Characterization

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GEO Task: DA-09-01a_2 Lead

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Outline

- Introduction
- Site Selection Criteria
- Online Test Site catalog
- CEOS Reference Standard Test Sites
- 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 central 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 of 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
- Stability
- MTF
- Uniformity (Flat field)
- Stray light (Adjacency effects)
- Polarization
- Spectral
- SNR
- Algorithms
- Geolocation
- Camera model
- Band-to-band
- Internal Geometry
- Temporal effects

Well-Established Site Selection Criteria for Radiometry Test Sites

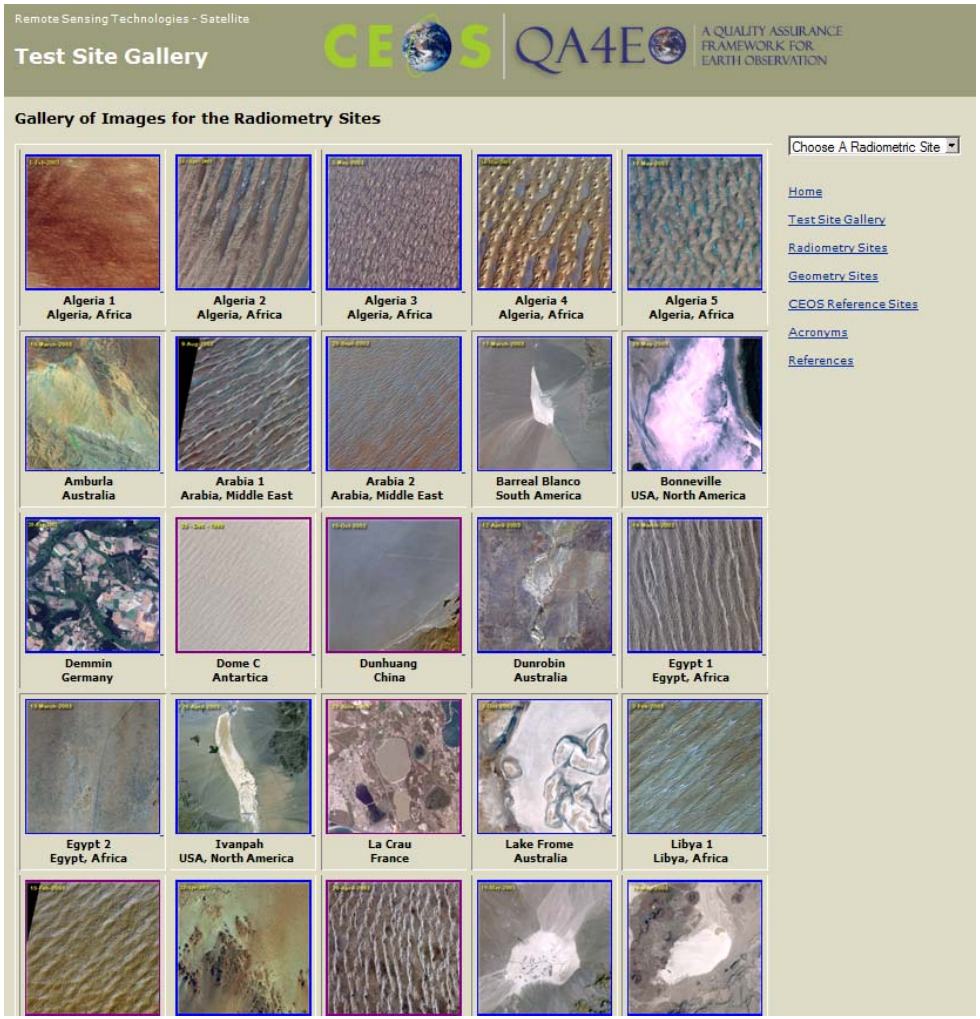
- **High spatial uniformity over a large area (within 3%)**
  - Minimize misregistration and adjacency effects
- **Surface reflectance greater than 0.3**
  - To provide higher SNR and reduce uncertainty due to atmosphere
- **Flat spectral reflectance**
  - Reduce uncertainties due to different RSR
- **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

Online Test Site Catalog

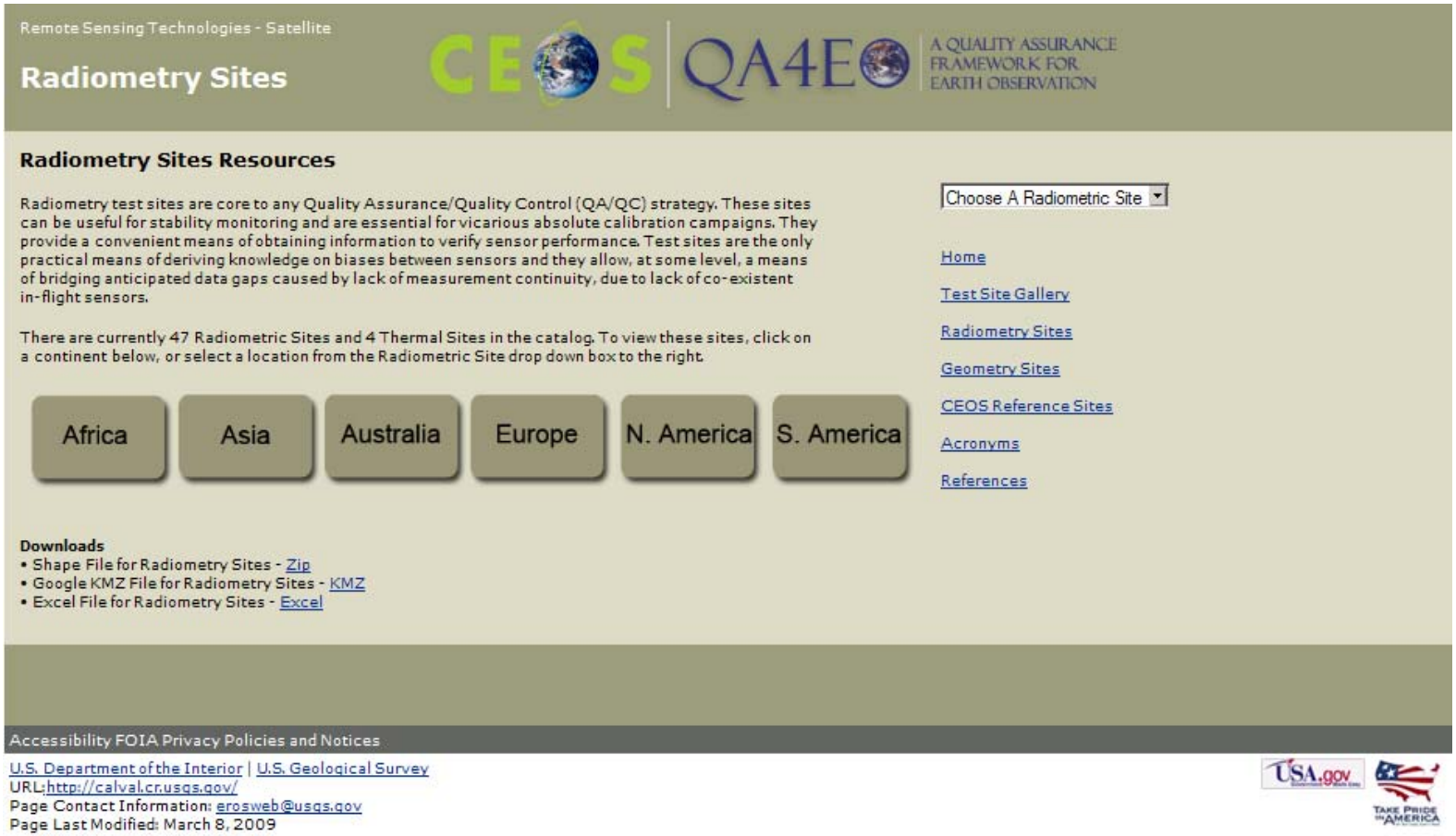
- **The layout is set up to help the user quickly locate the needed information available on the site**
  - Drop-down menus list locations so the user may go straight to a specific site
  - A map with clickable links provides another way to go to sites
  - The maps include a world map, where the user 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



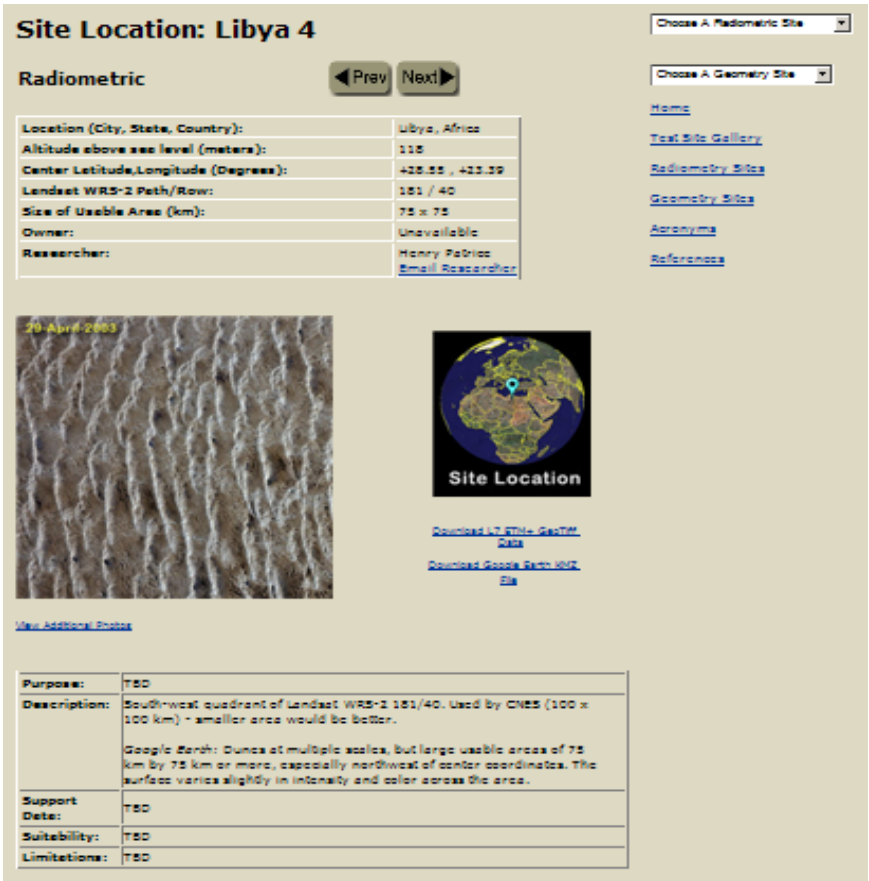
Radiometry Sites

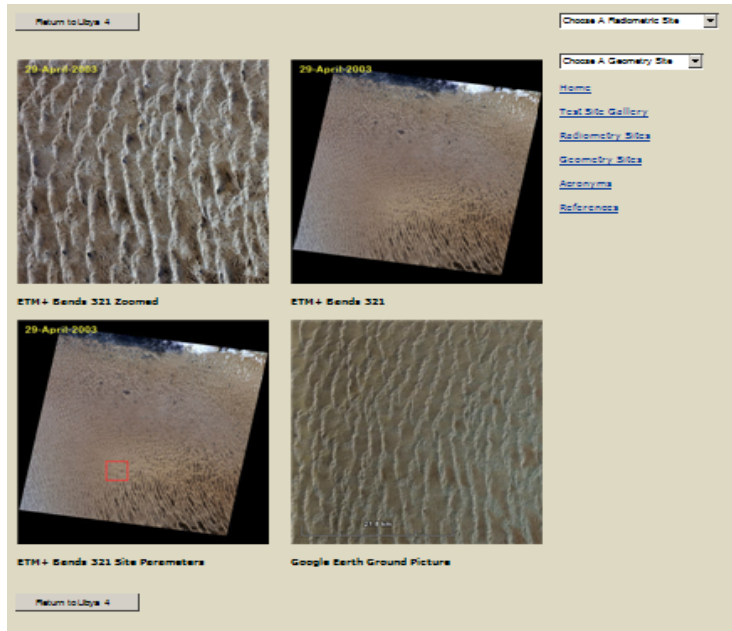


Radiometry Sites

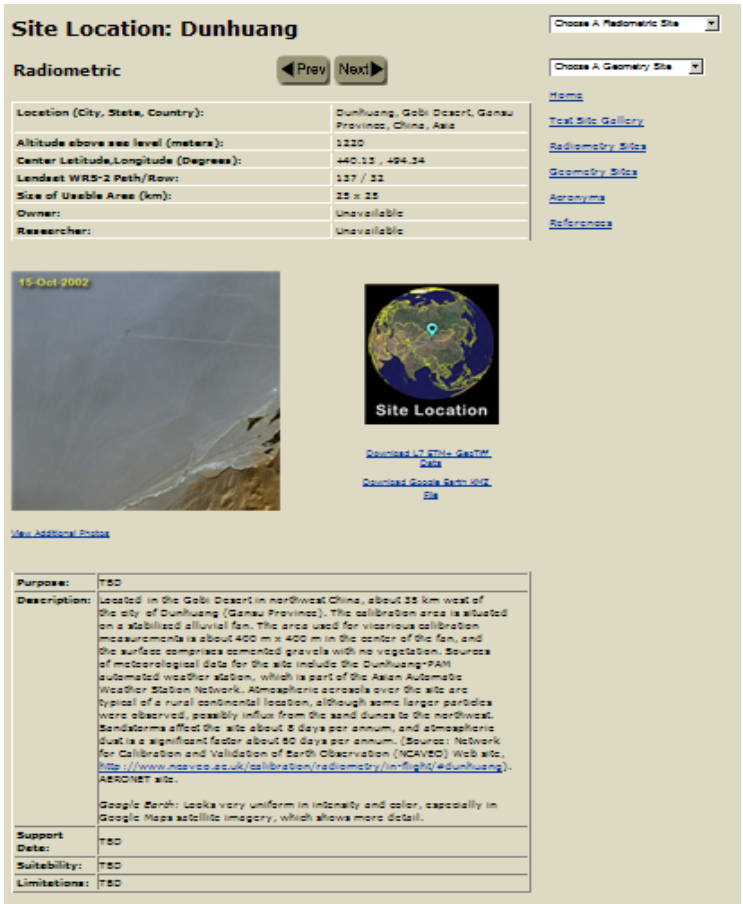
Online Catalog Example: Railroad Valley Playa, North America

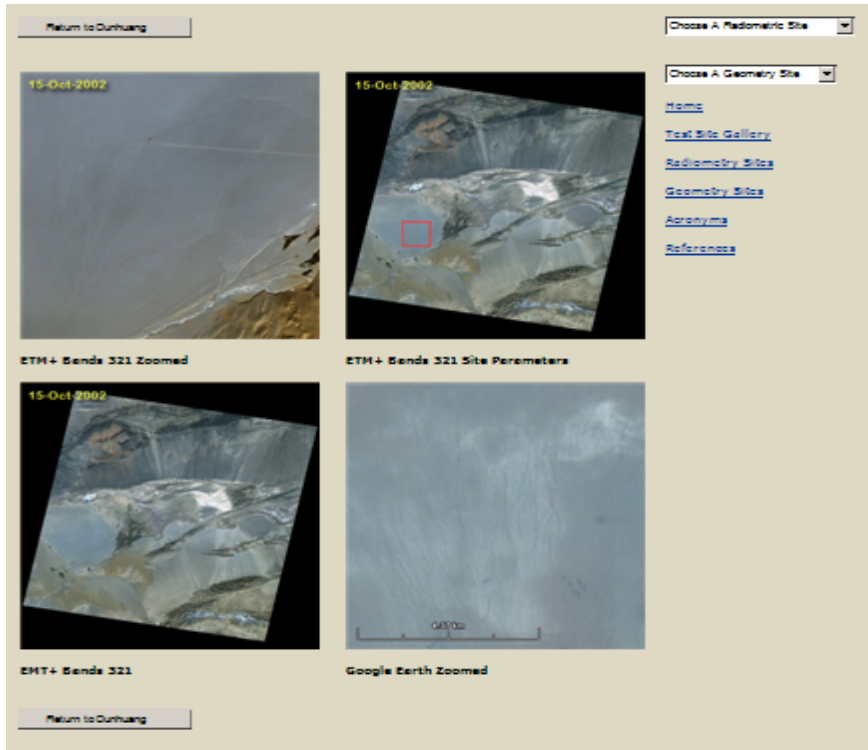
Online Catalog Example: Libya 4, Africa





Online Catalog Example: Dunhuang, Asia





Online Catalog Example: Amburla, Australia

Site Location: Amburla

Radiometric

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Choose A Radiometric Site

Choose A Geometry Site

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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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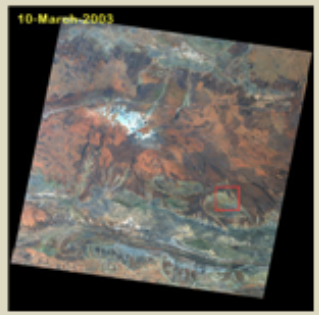
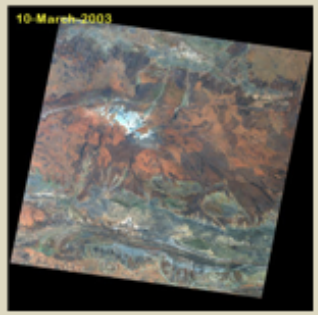
ETM+ Bands 321 Zoomed



ETM+ Bands 321 Site Parameters



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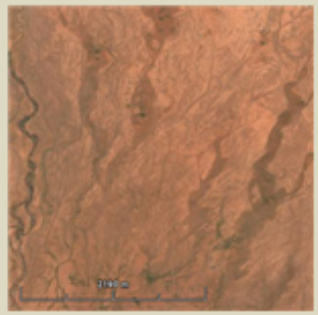

Google Earth Zoomed

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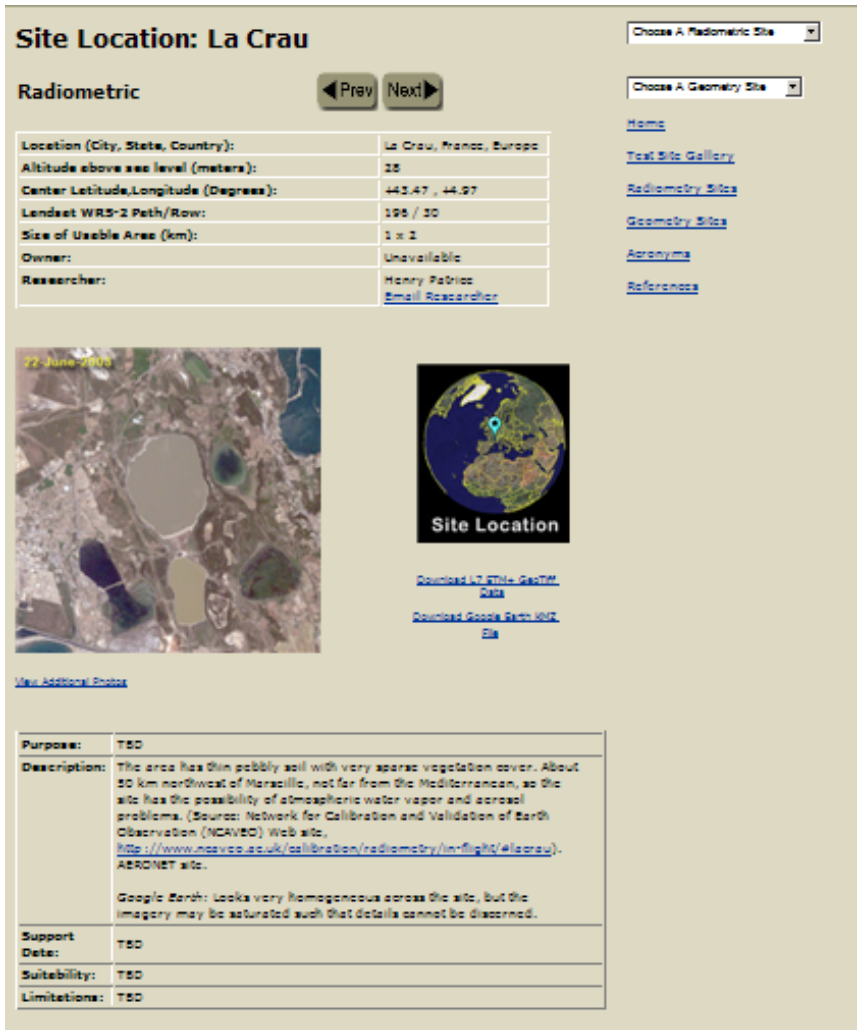
A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

Online Catalog Example:
La Crau, Europe



Site Location: La Crau

Radiometric

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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:	195 / 30
Size of Usable Area (km):	1 x 1
Owner:	Unavailable
Researcher:	Henry Patrice Email Researcher

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22-June-2003

Site Location

Download L7 ETM+ GeoTIF Data

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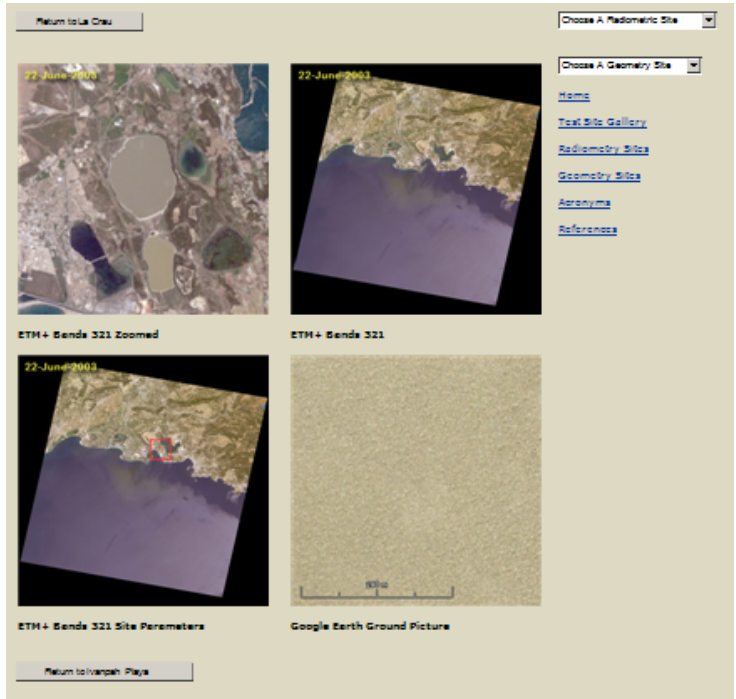
Purpose:	TBD
Description:	The area has thin pebbly soil with very sparse vegetation cover. About 50 km northwest of Marseille, not far from the Mediterranean, so the site has the possibility of atmospheric water vapor and aerosol problems. (Source: Network for Calibration and Validation of Earth Observation (NCAVEO) Web site, http://www.neavco.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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ETM+ Bands 321 Site Parameters

Google Earth Ground Picture

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Online Catalog Example:
Barreal Blanco, South America

Site Location: Barreal Blanco

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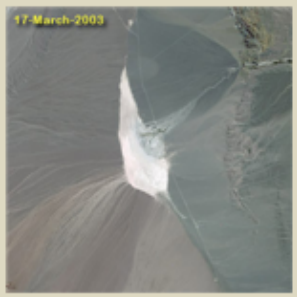
Location (City, State, Country):	Barreal Blanco, San Juan, Argentina, South America
Altitude above sea level (meters):	1572
Center Latitude,Longitude (Degrees):	-31.65 , -69.45
Landsat WRS-2 Path/Row:	232 / 82
Size of Usable Area (km):	0.5 x 0.5
Owner:	Unavailable
Researcher:	Unavailable



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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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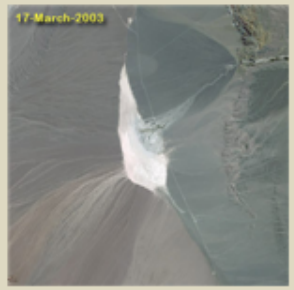
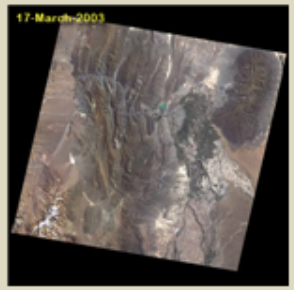
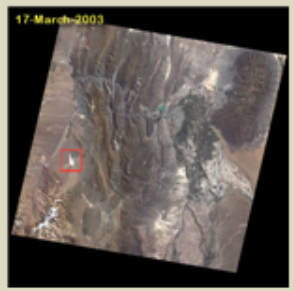


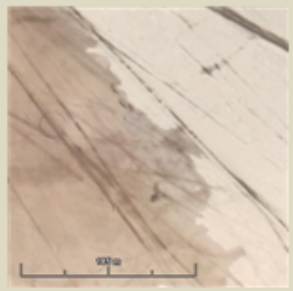
ETM+ Bands 321 Zoomed



ETM+ Bands 321



ETM+ Bands 321 Site Parameters



Google Earth Ground Picture

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Geometry Sites

Remote Sensing Technologies - Satellite

Medium Resolution Geometry Sites

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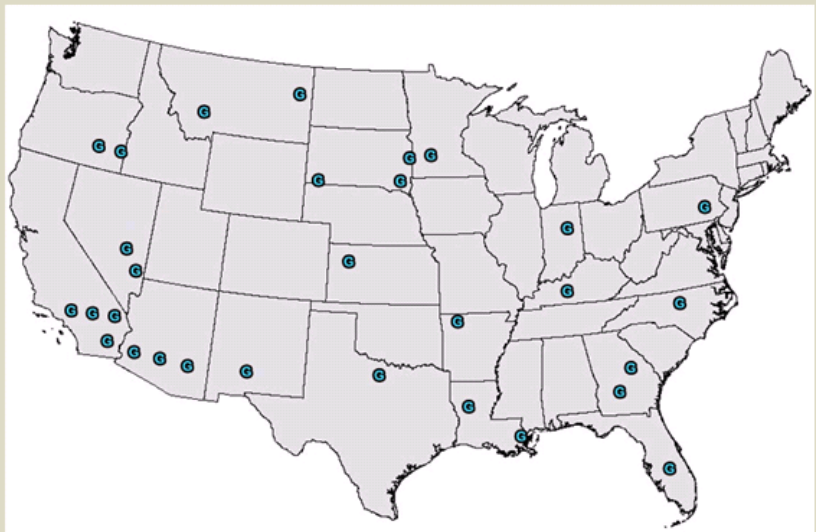
The geometric supersites are all built by mosaicking panchromatic Digital Orthophoto Quadrangles (DOQs) that have been reduced in resolution from 1 meter to 15 meters to match that of the ETM+ PAN band. DOQs themselves are designed to meet the national map accuracy standards at 1:24,000-scale and have 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 Medium Resolution Geometric Sites in the catalog. To view these sites, click on a hyperlink (G) below. At this time, the geometry sites are only over the continental United States, CONUS.

Medium Resolution | High Resolution



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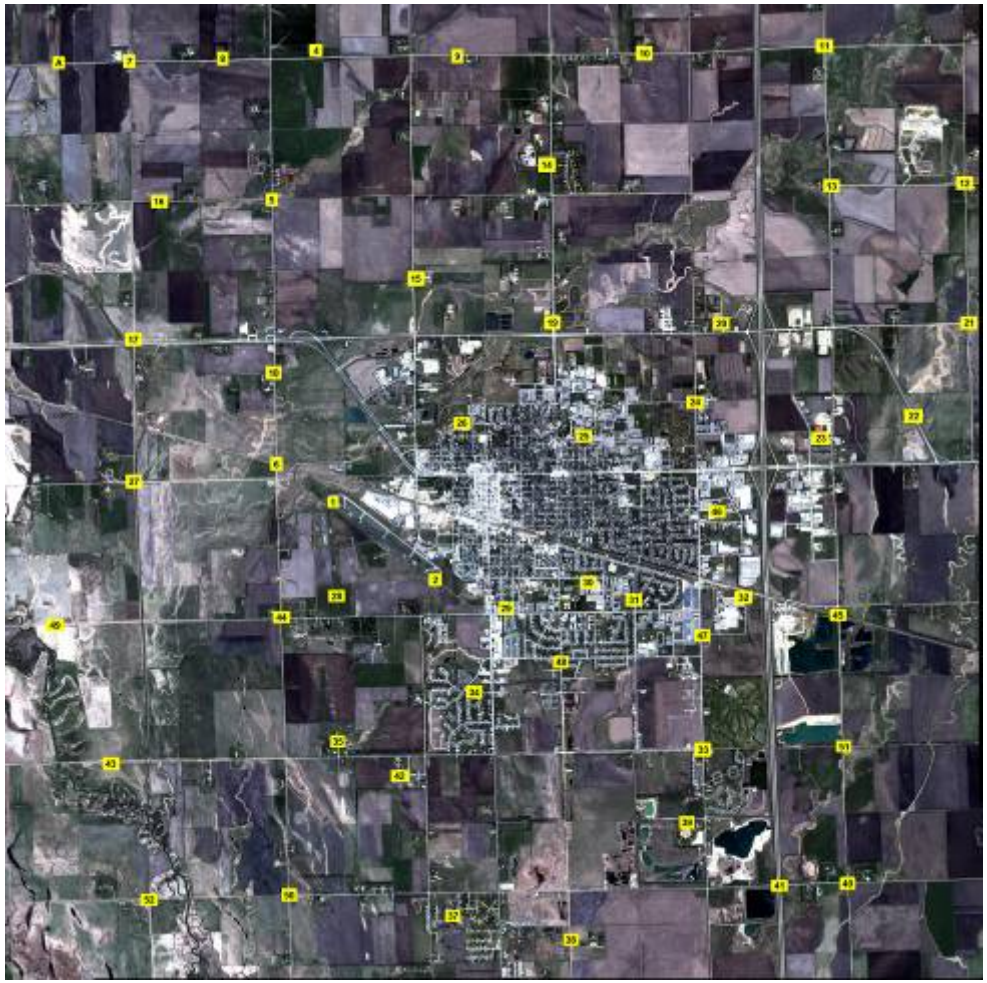
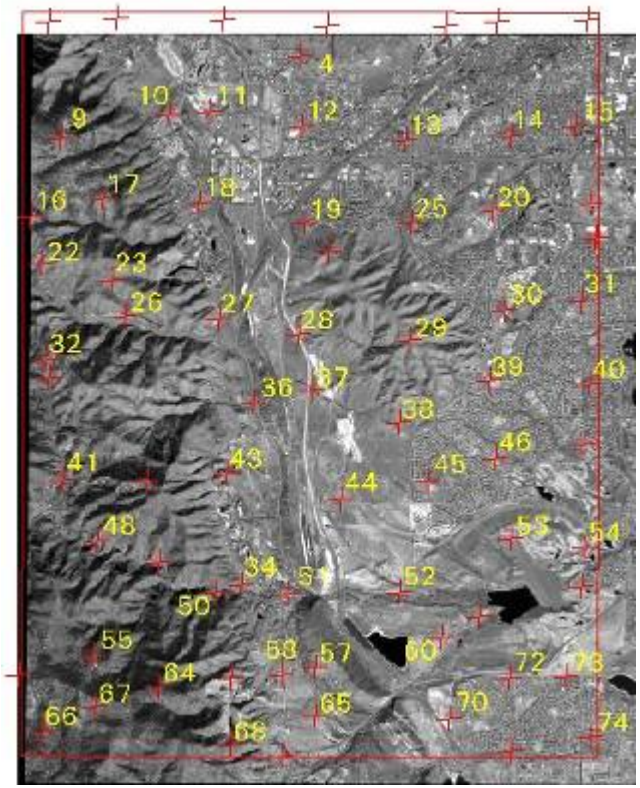
Ground Control Points (GCP)



51 GCPs selected over Brookings, SD area



72 GCPs selected over Morrison, CO area

Acronyms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QA4EO
A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION
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
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Page Last Modified: March 8, 2009
USA.gov
TAKE PRIDE IN AMERICA

References

References

- Bannari, A., K. Omari, P.M. Teillet, and G. Fedosejevs (2005). Potential of Getis Statistics to Characterize the Radiometric Uniformity and Stability of Test Sites Used for the Calibration of Earth Observation Sensors, IEEE Transactions on Geoscience and Remote Sensing, 43(12): 2918-2926, PDF
- Biggar, S.F., K.J. Thome, and W. Wisniewski (2003). Vicarious Radiometric Calibration of EO-1 Sensors by Reference to High-Reflectance Ground Targets. IEEE Transactions on Geoscience and Remote Sensing, 41(6): 1174-1179. PDF
- Black, S.E., D.L. Helder, and S.J. Schiller (2003). Irradiance-based cross-calibration of Landsat-5 and Landsat-7 Thematic Mapper sensors. International Journal of Remote Sensing, 24(2): 287-304. PDF
- Butler, J.J., L. Wanchoo, L. Truong (2001). CEOS Database of World-wide Calibration Facilities and Validation Test Sites. Sensors, Systems, and Next-Generation Satellites IV, 4: 202 - 208. PDF
- Cabot, F., O. Hagolle, C. Ruffel, and P. Henry (1999). Use of remote sensing data repository for in-flight calibration of optical sensors over terrestrial targets. Proceedings of SPIE Conference 3750 on Earth Observing Systems IV, Denver, Colorado, pp. 514-523. PDF
- Cabot, F., Hagolle, O., and Henry, P. (2000). Relative and multi-temporal calibration of AVHRR, SeaWIFS, and Vegetation using POLDER characterization of desert sites. Proceedings of the International Geoscience and Remote Sensing Symposium (IGARSS), 5: 2188-2190. PDF
- Chander, G., Christopherson, J.B., Stensaas, G.L., Teillet, P.M., "Online Catalogue of World-wide Test Sites for the Post-Launch Characterization and Calibration of Optical Sensors," in Proc. IAC Int. Symp. , Hyderabad, India, 2007. (In press) PDF
- Chander, G., "Catalog of World-wide Test Sites for Sensor Characterization," in Proc. JACIE, The Civil Commercial Imagery Evaluation Workshop, Fairfax, Virginia, March 25-27, 2008. PDF
- Cosnefroy, H., M. Leroy, and X. Briottet (1996). Selection and characterization of Saharan and Arabian Desert sites for the calibration of optical satellite sensors. Remote Sensing of Environment, 58(1): 101-114. PDF
- Fox, N., J. Aiken, J.J. Barnett, X. Briottet, R. Carvell, C. Frohlich, S.B. Groom, O. Hagolle, J.D. Haigh, H.H. Kieffer, J. Lean, D.B. Pollock, T. Quinn, M.C.W. Sandford, M. Schaepman, K.P. Shine, W.K. Schmutz, P.M. Teillet, K.J. Thome, M.M. Verstraete, and E. Zalewski, 2002. "Traceable Radiometry Underpinning Terrestrial- and Helio- Studies (TRUTHS)", Proceedings of SPIE Conference 4881 on Sensors, Systems, and Next-Generation Satellites VIII, Heraklion, Crete, Greece, 12 pages. PDF
- Gu, X.F., G. Guyot, and M. Verbrugghe (1992). Evaluation of measurement errors in ground surface reflectance for satellite calibration. International Journal of Remote Sensing, 13(14): 2531-2546, PDF
- Hill, J., and D. Aifadopoulou (1990). Comparative analysis of Landsat-5 TM and SPOT HRV-1 data for use in multiple sensor approaches. Remote Sensing of Environment, 34: 55-70. PDF
- Iwabuchi, H. (2003). Calibration of the visible and near-infrared channels of NOAA-11 and -14 AVHRRs by using reflections from molecular atmosphere and stratus cloud. International Journal of Remote Sensing, 24(24): 5367-5378. PDF
- Kaufman, Y.J., and B.N. Holben (1993). Calibration of the AVHRR visible and near-IR bands by atmospheric scattering, ocean glint and desert reflection. International Journal of Remote Sensing, 14: 21-52. PDF
- Koepke, P. (1982). Vicarious satellite calibration in the solar spectral range by means of calculated radiances and its application to Meteosat. Applied Optics, 21(15): 2845-2854. PDF

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References

- Loeb, N.G (1997). In-flight calibration of NOAA AVHRR visible and near-IR bands over Greenland and Antarctica. International Journal of Remote Sensing, 18: 477-490. PDF
- Martiny, N., R. Santer, and I. Smolskaia (2005). Vicarious calibration of MERIS over dark waters in the near infrared. Remote Sensing of Environment, 94(4): 475-490. PDF
- Nieke, J., T. Aoki, T. Tanikawa, H. Motoyoshi, and M. Hori (2004). A satellite cross-calibration experiment. IEEE Geoscience and Remote Sensing Letters, 1(3): 215-219. PDF
- Ohring, G., J. Tansock, W. Emery, J. Butler, L. Flynn, F. Weng, K. St. Germain, B. Wielicki, C. Cao, M. Goldberg, J. Xiong, G. Fraser, D. Kunkee, D. Winker, L. Miller, S. Ungar, D. Tobin, J. G. Anderson, D. Pollock, S. Shipley, A. Thurgood, G. Kopp, P. Ardanuy, and T. Stone (2007). Achieving Satellite Instrument Calibration for Climate Change, Eos Trans. AGU, 88(11), 136. PDF
- Rao, C. R. N., and Chen, J. (1995). Inter-satellite calibration linkages for the visible and near-infrared channels of the Advanced Very High Resolution Radiometer on the NOAA-7, -9, and -11 spacecraft. International Journal of Remote Sensing, 16: 1931-1942. PDF
- Rao, C. R. N., and Chen, J. (1999). Revised post-launch calibration of the visible and near-infrared channels of the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA-14 spacecraft. International Journal of Remote Sensing 20: 3485-3491. PDF
- Rao, C.R.N., Cao, C., and Zhang, N. (2003). Inter-calibration of the Moderate-Resolution Imaging Spectroradiometer and the Along-Track Scanning Radiometer-2. International Journal of Remote Sensing, 24(9): 1913-1924. PDF
- Rondeaux, G., Steven, M. D., Clark, J. A. and Mackay, G. (1998). La Crau: A European test site for remote sensing validation. International Journal of Remote Sensing, 19: 2775-2788. PDF
- Santer, R., and N. Martiny (2003). Sky radiance measurements for ocean colour calibration-validation. Applied Optics, 42(6): 896-907, PDF
- Santer, R., X. F. Gu, G. Guyot, J. L. Deuzé, C. Devaux, E. Vermote, and M. Verbrugghe (1992). SPOT calibration at the La Crau test site (France). Remote Sensing of Environment, 41(2-3): 227-237, PDF
- Schiller, S.J. (2003). Technique for estimating uncertainties in top-of-atmosphere radiances derived by vicarious calibration. Proceedings of SPIE Conference 5151 on Earth Observing Systems VIII, SPIE Volume 5151, San Diego, California, Ed. W.L. Barnes, pp. 502-516. PDF
- Six, D., M. Fily, S. Alvain, P. Henry, and J.-P. Benoist (2004). Surface Characterisation of the Dome Concordia Area (Antarctica) as a Potential Satellite Calibration Site, Using SPOT 4/VEGETATION Instrument. Remote Sensing of Environment, 89: 83-94. PDF
- Slater, P.N., Biggar, S.F., Holm, R.A., Jackson, R.D., Mao, Y., Moran, M.S., Palmer, J.M. and Yuan, B. (1987). Reflectance- and Radiance-Based Methods for In-Flight Absolute Calibration of Multispectral Sensors. Remote Sensing of Environment, 22: 11-37. PDF
- Smith, D.L., C.T. Mutlow, and C.R.N. Rao (2002). Calibration monitoring of the visible and near-infrared channels of the Along-Track Scanning Radiometer-2 by the use of stable terrestrial sites, Applied Optics, 41(3): 515-523, PDF
- Tahnk, W. R., and Coakley, J. A. (2001). Updated calibration coefficients for NOAA-14 AVHRR channels 1 and 2. International Journal of Remote Sensing, 22(15): 3053-3057. PDF
- Teillet, P.M., Barsi, J. A., Chander, G., Thome, K. J., "Prime Candidate Earth Targets for the Post-Launch Radiometric Calibration of Satellite Sensors," in Proc. SPIE Int. Symp. , San Diego, CA, 2007. PDF
- Teillet, P.M., P.N. Slater, Y. Ding, R.P. Santer, R.D. Jackson and M.S. Moran (1990). Three Methods for the Absolute Calibration of the NOAA AVHRR Sensors In-Flight. Remote Sensing of Environment, 31: 105-120. PDF
- Teillet, P.M., G. Fedosejevs, and R.P. Gauthier (1998). Operational Radiometric Calibration of Broadscale Satellite Sensors Using Hyperspectral Airborne Remote Sensing of Prairie Rangeland: First Trials. Metrologia, 35:639-641. PDF
- Teillet, P.M., G. Fedosejevs, R.P. Gauthier, N.T. O'Neill, K.J. Thome, S.F. Biggar, H. Ripley, and A. Meygret (2001c). A Generalized Approach to the Vicarious Calibration of Multiple Earth Observation Sensors Using Hyperspectral Data, Remote Sensing of Environment, 77(3): 304-327. PDF
- Teillet, P.M., G. Fedosejevs, D. Gauthier, M.A. D'Iorio, B. Rivard, P. Budkewitsch, and B. Brisco (1995). Initial Examination of Radar Imagery of Optical Radiometric Calibration Sites, Proceedings of SPIE Conference 2583 on Advanced and Next-Generation Satellites, Paris, France, pp. 154-165. PDF
- Teillet, P.M., G. Fedosejevs, K.J. Thome, and J.L. Barker (2007). Impacts of spectral band difference effects on radiometric cross-calibration between satellite sensors in the solar-reflective spectral domain", Remote Sensing of Environment, in press. PDF
- Teillet, P.M., G. Fedosejevs, F.J. Ahern and R.P. Gauthier (1994). Sensitivity of Surface Reflectance Retrieval to Uncertainties in Aerosol Optical Properties, Applied Optics, 33 (18): 3933-3940, PDF
- Teillet, P.M. (1997). A Status Overview of Earth Observation Calibration/Validation for Terrestrial Applications. Canadian Journal of Remote Sensing, 23(4): 291-298. PDF
- Template for information regarding the prime CEOS WGCV Cal/Val site for the post-launch characterization and calibration of optical sensors. PDF
- Thome, K., S. Schiller, J. Conel, K. Arai, and S. Tsuchida (1998). Results of the 1996 Earth Observing System vicarious calibration joint campaign at Lunar Lake Playa. Metrologia, 35: 631-638, PDF
- Thome, K. J., Crowther, B.G., and Biggar, S.F. (1997). Reflectance- and Irradiance-Based Calibration of Landsat-5 Thematic Mapper. Canadian Journal of Remote Sensing 23: 309-317, PDF
- Thome, K.J. (2001). Absolute Radiometric Calibration of Landsat 7 ETM+ Using the Reflectance-Based Method. Remote Sensing of Environment, 78(1-2): 27-38. PDF
- Thome, K.J., J. Czapla-Myers, and S. Biggar (2003a). Vicarious calibration of Aqua and Terra MODIS. Proceedings of SPIE Conference 5151 on Earth Observing Systems VIII, SPIE Volume 5151, San Diego, California, Ed. W.L. Barnes, pp. 395-405. PDF
- Thome, K.J, S.F. Biggar, and W. Wisniewski (2003b). Cross Comparison of EO-1 Sensors and Other Earth Resources Sensors to Landsat-7 ETM+ Using Railroad Valley Playa. IEEE Transactions on Geoscience and Remote Sensing, 41: 1180-1188, PDF
- Vermote, E.F., and Kaufman, Y.J. (1998). Absolute Calibration of AVHRR Visible and Near-Infrared Channels Using Ocean and Cloud Views. International Journal of Remote Sensing, 16(13): 2317-2340, PDF
- Wheeler, R. J., LeCroy, S. R., Whitlock, C. H., Purgold, G. C. and Swanson, J. S. (1994). Surface characteristics for the alkali flats and dune regions at White Sands Missile Range, New Mexico. Remote Sensing of Environment, 48: 181-190. PDF
- Wu, D., Yin, Y., Wang, Z., Gu, X., Verbrugghe, M. and Guyot, G. (1997). Radiometric characterisation of Dunhuang satellite calibration test site (China). Physical Measurements and Signatures in Remote Sensing, Eds. Guyot, G. and Phulpin, T. Rotterdam, Balkema, 1: 151-160.

CEOS Reference Standard Test Sites

- **The IVOS sub-group members established a set of CEOS reference standard test sites**
  - Based on the decision from the CEOS IVOS-19 meeting, there are 8 instrumented sites and 5 pseudo-invariant sites

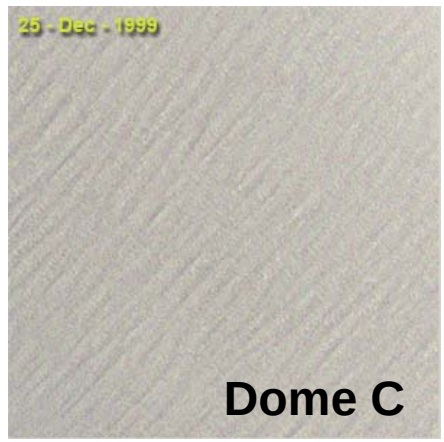
CEOS Reference Standard Test Sites						
#	Site Name	Center Latitude	Center Longitude	POC	Affilation	Email
Instrumented Sites						
1	Railroad Valley Playa	38.50	-115.69	Kurtis J. Thome	NASA/GSFC	kthome@email.arizona.edu
2	Ivanpah Playa	35.57	-115.40	Kurtis J. Thome	NASA/GSFC	kthome@email.arizona.edu
3	Lspec Frenchman Flat	36.81	-115.93	Carol J. Bruegge	NASA/JPL	Carol.J.Bruegge@Jpl.Nasa.Gov
4	La Crau	43.56	4.86	Patrice Henry	CNES	patrice.henry@cnes.fr
5	Dunhuang	40.13	94.34	Xiuqing Hu	NSMC/CMA	huxq@cma.gov.cn
6	Negev, Southern Israel	30.11	35.01	Arnon Karnieli	Ben Gurion University	karnieli@bgu.ac.il
7	Tuz Golu	38.83	33.33	Selime Gurol	TUBITAK UZAY	selime.gurol@uzay.tubitak.gov.tr
8	Dome C	-74.50	123.00	Stephen Warren	University of Washington	sgw@atmos.washington.edu
Pseudo-Invariant Test Sites						
1	Libya 4	28.55	23.39	Patrice Henry	CNES	patrice.henry@cnes.fr
2	Mauritania 1	19.40	-9.30	Patrice Henry	CNES	patrice.henry@cnes.fr
2	Mauritania 2	20.85	-8.78	Patrice Henry	CNES	patrice.henry@cnes.fr
3	Algeria 3	30.32	7.66	Patrice Henry	CNES	patrice.henry@cnes.fr
4	Libya 1	24.42	13.35	Patrice Henry	CNES	patrice.henry@cnes.fr
5	Algeria 5	31.02	2.23	Patrice Henry	CNES	patrice.henry@cnes.fr

CEOS Reference Standard Test Sites

- **The CEOS instrumented sites are provisionally being called "Landnet"**
  - These instrumented sites are primarily used for field campaigns to obtain radiometric gain and these sites can serve as a focus for international efforts, facilitating traceability and cross-comparison to evaluate biases of in-flight and future sensors in a harmonized manner

- **The pseudo-invariant desert sites have high reflectance and are usually made up of sand dunes with low aerosol loading and practically no vegetation**
  - Consequently, these pseudo-invariant reference standard test sites can be used to evaluate the long-term stability of a sensor and to facilitate cross-comparison of multiple sensors

“Instrumented” Sites (Total=8)



“Pseudo-Invariant” Sites (Total=5)

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

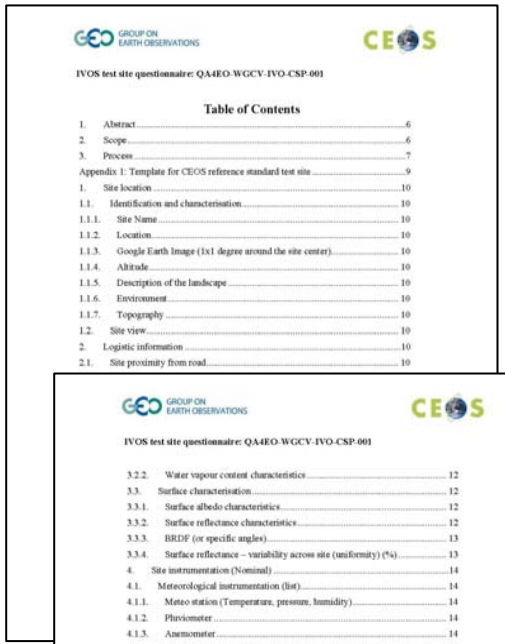
Questionnaire for Information Regarding the Cal/Val Test Sites

GROUP ON EARTH OBSERVATIONS CEOS

QA4EO

Questionnaire for information regarding the CEOS WGCV IVOS subgroup Cal/Val test sites for land imager radiometric gain

QA4EO-WGCV-IVO-CSP-001



GROUP ON EARTH OBSERVATIONS CEOS

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

Table of Contents

GROUP ON EARTH OBSERVATIONS CEOS

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

1. Abstract

This document provides the template to collect and present information to describe the characteristics of a Land based test site suitable for calibrating and validating the radiometric gain of an inflight satellite/aircraft imaging optical sensor. The template is structured as a series of questions to describe the sites, accessibility as well as its physical characteristics and their derivation. Test sites with varying characteristics have been used for many years for a variety of applications, however this template has been specifically designed for sites which are regularly instrumented and are or seek to be endorsed by the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV) as "reference standards". At present there are eight such sites but more are required to ensure a robust system to reliably underpin the needs of the Earth Observation (EO) community in the longer term. The template contained in this document should be completed by anyone seeking to have a site endorsed by CEOS to join this group. The current eight **CEOS instrumented reference standard test sites** are:

- **Railroad Valley Playa**, NV, USA, North America
- **Ivanpah**, NV/CA, USA, North America
- **Lspec Frenchman Flat**, NV, USA, North America
- **La Crau**, France, Europe
- **Dunhuang**, Gobi Desert, Gansu Province, China, Asia

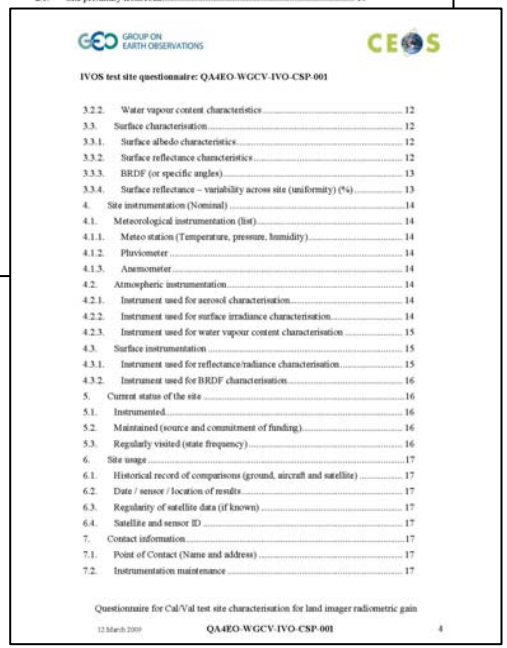
GROUP ON EARTH OBSERVATIONS CEOS

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

Questionnaire for information regarding the CEOS WGCV IVOS subgroup Cal/Val test sites for land imager radiometric gain

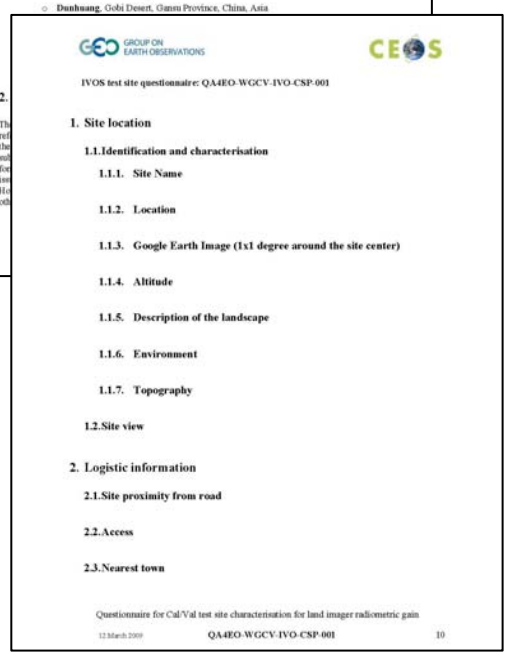
Author: Gyanesh Chander
E-mail: gchander@usgs.gov
Issued under Authority of: CEOS

Issue no: Version 1.1
Date of issue: 18 February 2009



GROUP ON EARTH OBSERVATIONS CEOS

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001



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IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

GEO QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION CEOS

La Crau, France

GROUP ON EARTH OBSERVATIONS CEOS

QA4EO

Questionnaire for information regarding the CEOS WGCV IVOS subgroup Cal/Val test sites for land imager radiometric gain

QA4EO-WGCV-IVO-CSP-001

Name of site: La Crau

GROUP ON EARTH OBSERVATIONS CEOS

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

1. Site location

1.1. Identification and characterisation

1.1.1. Site Name

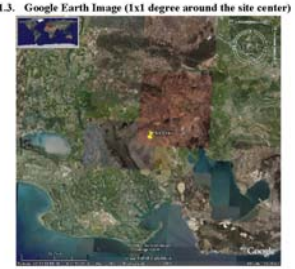
La Crau

1.1.2. Location

Latitude 43° 33'N

Longitude -4° 51'W

1.1.3. Google Earth Image (1x1 degree around the site center)



1.1.4. Altitude

18 m

Questionnaire for Cal/Val test site characterisation for land imager radiometric gain

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GROUP ON EARTH OBSERVATIONS CEOS

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

3. Site Climatology

3.1. General atmospheric conditions: Meteorological conditions

3.1.1. Annual pluviometry

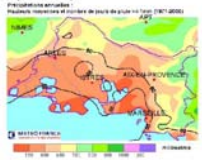

Figure 3: Pluviometry

GROUP ON EARTH OBSERVATIONS CEOS

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

3.3.3. BRDF (or specific angles)

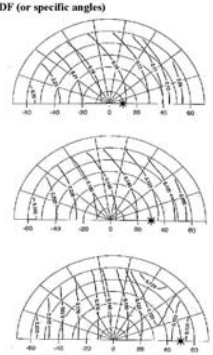

Figure 7: Polar diagram of the La Crau reflectance at 650 nm at three solar angles. Solar position is reported on the x-axis (R. Santer)

The La Crau BRDF substantially departs from a Lambertian surface with a quite strong specular effect at low solar elevations.

3.3.3.1. Instrument used

Questionnaire for Cal/Val test site characterisation for land imager radiometric gain

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IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

Figure 8: Cimel instrument

4.2.1.2. Route of traceability

4.2.1.3. Measurement protocol

4.2.1.3.1. Scanning mode

As soon as the air mass reaches m=5, then the scanning protocol, illustrated in figure 2, begins:

GROUP ON EARTH OBSERVATIONS CEOS

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

6.2. Date / sensor / location of results

6.3. Regularity of satellite data (if known)

6.4. Satellite and sensor ID

ALOS data base in the calval portal

7. Contact information

7.1. Point of Contact (Name and address)

Patrice HENRY
CNES - DCT/SI/MO
18 av. Edouard Belin
31401 Toulouse Cedex 4
FRANCE
Tel: +33 561 274 712
Fax: +33 561 273 633
Email : patrice.henry@cnes.fr

7.2. Instrumentation maintenance

Questionnaire for Cal/Val test site characterisation for land imager radiometric gain

12 March 2009 QA4EO-WGCV-IVO-CSP-001 26

GEO QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION CEOS

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

- **Gather complete site characterization data and information**
  - Define core measurements (eg. Instruments)
  - Develop protocols and fund pilot projects
  - Create an operational network of land sites (“Landnet”)

- **Encourage agencies to acquire, archive, and provide data to the Cal/Val community over CEOS sites**
  - Use radiometric gain and stability as an immediate priority
  - Develop online calibration data access infrastructure
  - Create tools to identify the potential co-incident image pairs (NASA SEO)

- **Integrate the catalog into the CEOS EO Cal/Val portal**

- **Establish traceability chain for primary site data & “best practice” guidance on site characterization and its use**

Back-up Slides

Radiometry Sites

		Center		Upper Left Corner		Upper Right Corner		Lower Left Corner		Lower Right Corner		Landsat WRS-2	
#	Site Name	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Path	Row
1	Algeria 3	30.32	7.66	31.24	5.96	31.27	8.33	29.31	6.02	29.35	8.34	192	39
2	Algeria 5	31.02	2.23	31.25	1.36	31.25	3.72	29.33	1.40	29.34	3.71	195	39
3	Amburla	-23.39	133.12	-22.16	131.62	-22.19	133.77	-24.04	131.57	-24.07	133.75	103	76
4	Arabia 1	18.88	46.76	19.73	46.59	19.70	48.69	17.86	46.57	17.83	48.65	164	47
5	Arabia 2	20.13	50.96	21.17	49.97	21.17	52.11	19.28	49.98	19.28	52.10	162	46
6	Barreal Blanco	-31.86	-69.45	-30.79	-69.98	-30.79	-67.62	-32.71	-70.00	-32.70	-67.59	232	82
7	Bonneville Salt Flats	41.00	-113.57	41.27	-114.96	41.34	-112.22	39.31	-114.85	39.37	-112.18	39	32
8	Dunhuang	40.13	94.34	41.30	93.75	41.25	96.41	39.39	93.73	39.35	96.31	137	32
9	Dunrobin	-22.67	146.13	-22.17	145.51	-22.17	147.68	-24.06	145.49	-24.06	147.69	94	76
10	Egypt 1	27.12	26.10	28.37	25.39	28.38	27.67	26.46	25.41	26.47	27.66	179	41
11	Egypt 2	22.94	28.79	24.06	27.48	24.04	29.65	22.18	27.47	22.16	29.62	177	44
12	Ivanpah Playa	35.57	-115.40	37.01	-116.07	36.96	-113.58	35.11	-116.09	35.07	-113.66	39	35
13	La Crau	43.56	4.86	44.16	3.44	44.11	6.24	42.24	3.43	42.20	6.14	196	30
14	Lake Frome	-30.85	139.67	-29.34	139.00	-29.35	141.31	-31.23	138.96	-31.25	141.32	97	81
15	Libya 1	24.42	13.35	25.48	12.34	25.51	14.57	23.58	12.38	23.60	14.58	187	43
16	Libya 2	25.05	20.48	25.49	20.07	25.49	22.29	23.59	20.09	23.59	22.27	182	43
17	Libya 4	28.55	23.39	29.82	22.69	29.77	24.96	27.95	22.66	27.90	24.89	181	40
18	Lunar Lake Playa	38.40	-115.99	39.86	-116.82	39.83	-114.21	37.95	-116.82	37.92	-114.29	40	33
19	Mali 1	19.12	-4.85	19.72	-5.97	19.74	-3.84	17.81	-5.94	17.83	-3.83	198	47
20	Mauritania 1	19.40	-9.30	19.73	-10.62	19.73	-8.49	17.83	-10.60	17.84	-8.50	201	47
21	Namib Desert 1	-24.98	15.27	-23.61	13.84	-23.61	16.04	-25.50	13.82	-25.50	16.06	179	77
22	Namib Desert 2	-17.33	12.05	-16.42	10.93	-16.39	13.04	-18.33	10.95	-18.29	13.08	182	72
23	Niger I	19.67	9.81	21.17	8.26	21.17	10.40	19.28	8.27	19.28	10.38	189	46
24	Niger 2	21.37	10.59	22.61	10.18	22.58	12.32	20.73	10.16	20.70	12.28	188	45
25	Railroad Valley Playa	38.50	-115.69	39.86	-116.82	39.83	-114.21	37.95	-116.82	37.92	-114.29	40	33
26	Rogers Dry Lake	34.96	-117.86	35.56	-119.60	35.59	-117.10	33.63	-119.54	33.66	-117.10	41	36
27	Sechura Desert	-5.90	-80.43	-4.85	-80.75	-4.84	-78.75	-6.73	-80.75	-6.72	-78.74	10	64
28	Sonoran Desert	32.35	-114.65	32.70	-115.64	32.66	-113.29	30.82	-115.67	30.78	-113.37	38	38
29	Sudan 1	21.74	28.22	22.61	27.16	22.59	29.31	20.72	27.15	20.71	29.28	177	45
30	Taklamakan Desert	39.83	80.17	41.29	79.77	41.29	82.47	39.36	79.81	39.36	82.43	146	32
31	Tinga Tingana	-29.00	139.86	-27.91	139.38	-27.92	141.67	-29.81	139.35	-29.82	141.68	97	80
32	Uyuni Salt Flats	-20.38	-66.95	-19.29	-68.55	-19.28	-66.42	-21.20	-68.55	-21.18	-66.39	233	74
33	Warrabin	-26.28	143.65	-25.05	143.29	-25.09	145.49	-26.91	143.23	-26.95	145.46	95	78
34	White Sands	32.92	-106.35	34.12	-107.64	34.15	-105.19	32.20	-107.58	32.22	-105.18	33	37
35	Winton	-22.52	142.94	-22.18	142.39	-22.14	144.59	-24.09	142.41	-24.06	144.64	96	76
36	Yemen Desert 1	16.87	47.55	18.29	46.29	18.27	48.38	16.42	46.28	16.40	48.34	164	48
37	Dome C	-74.50	123.00	-73.47	118.25	-73.49	127.08	-75.86	117.46	-75.88	127.76	89	113
38	Tuz Golu	38.83	33.33	39.88	31.39	39.88	34.27	37.91	31.43	37.91	34.24	177	33
39	Algeria_1	23.80	-0.40	24.08	-1.91	24.04	0.47	22.18	-1.93	22.14	0.42	196	44
40	Algeria_2	26.09	-1.38	26.96	-2.80	26.94	-0.37	25.04	-2.81	25.02	-0.41	197	42
41	Algeria_4	30.04	5.59	31.29	4.46	31.24	6.98	29.39	4.43	29.34	6.91	193	39
42	Niger_3	21.57	7.96	22.63	6.98	22.64	9.35	20.69	7.01	20.71	9.35	190	45
43	Libya_3	23.15	23.10	24.08	22.82	24.03	25.17	22.18	22.79	22.13	25.11	180	44
44	Mauritania_2	20.85	-8.78	21.19	-10.33	21.19	-7.99	19.26	-10.32	19.27	-8.00	201	46
45	Makhtesh Ramon	30.59	34.84	31.28	33.80	31.24	36.34	29.37	33.78	29.34	36.27	174	39
46	Lspec Frenchman Flat	36.81	-115.93	38.45	-117.30	38.42	-114.50	36.50	-117.30	36.48	-114.56	40	34
47	Negev	30.11	35.01	31.28	33.80	31.24	36.34	29.37	33.78	29.34	36.27	174	39
48	Thar Desert	27.63	71.86	28.40	70.17	28.36	72.63	26.49	70.15	26.45	72.57	150	41

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

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

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

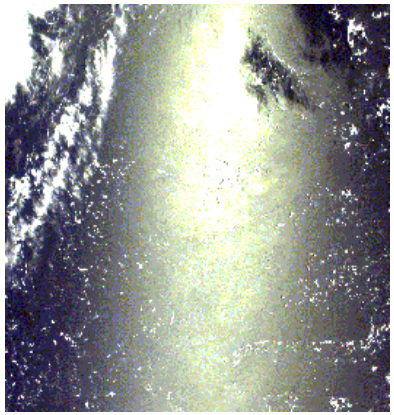
#	Site Name	WRS-2 Path	WRS-2 Row	Absolute Calibration (A)	Pseudo-Invariant Calibration (I)	Cross-Calibration (X)
1	Algeria 3	192	39		I	X
2	Algeria 5	195	39		I	X
3	Amburla	103	76	A		X
4	Arabia 1	164	47		I	X
5	Arabia 2	162	46		I	X
6	Barreal Blanco	232	82	A		X
7	Bonneville Salt Flats	39	32			X
8	Dunhuang	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

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**

Special Methods

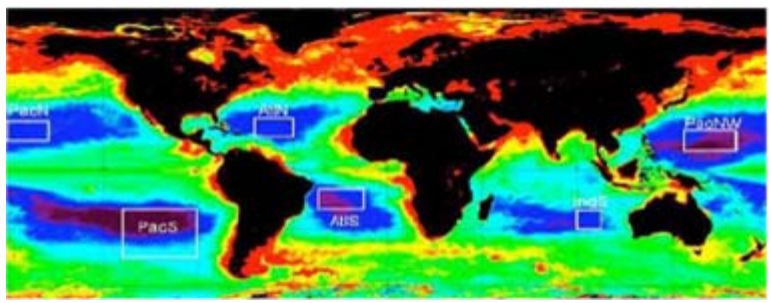
Moon



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)

Template for information regarding the CEOS IVOS Cal/Val Test Sites

Template for information regarding the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV) Infrared and Visible Optical Sensors (IVOS) Cal/Val sites

1. **Purpose of the Site**

2. **Core Site**
   - Need a conventional name.
   - Location (City, State, Country)
   - Altitude above sea level (meters)
   - Centre Latitude/Longitude (degrees)
   - Size/shape of usable area (meters) – indicate North direction and major and minor dimensions as appropriate
   - Point Of Contact (POC): name, address, email, phone and fax

3. **Description of Site**
   - Percent vegetated
   - Percent water cover
   - Vegetation types
     - Light scrub / heath
     - Grassland
     - Wood / forest
     - Mixed
   - Soil type
     - Desert
     - Playa
     - Dunes
     - Salt flat
     - Snow field
     - Stony
   - Water type
     - Ocean
     - Coastal
     - Lake
   - Other types
     - Urban
     - Asphalt
     - Concrete

4. **Picture(s) Including Surroundings**
   - Google (to be updated regularly if necessary)
   - Digital topographic data screenshots (SRTM/GTOPO30)
   - Moderate and high resolution data screenshots (Landsat/SPOT/DMC)

5. **Current Status of the Site**
   - Instrumented
   - Maintained
   - Regularly visited (state frequency)
     - Human
     - Satellite
     - Aircraft
     - Automated
   - Source of funding for maintenance
   - Open access (to other teams)

Please send any comments to Gyanesh Chander (gchander@usgs.gov) 1

6. **Surface Measurements**
   - Meteorological instrumentation (list)
   - Historical record of site from (year)
   - Average number of days with clear skies
   - Seasonal constraints

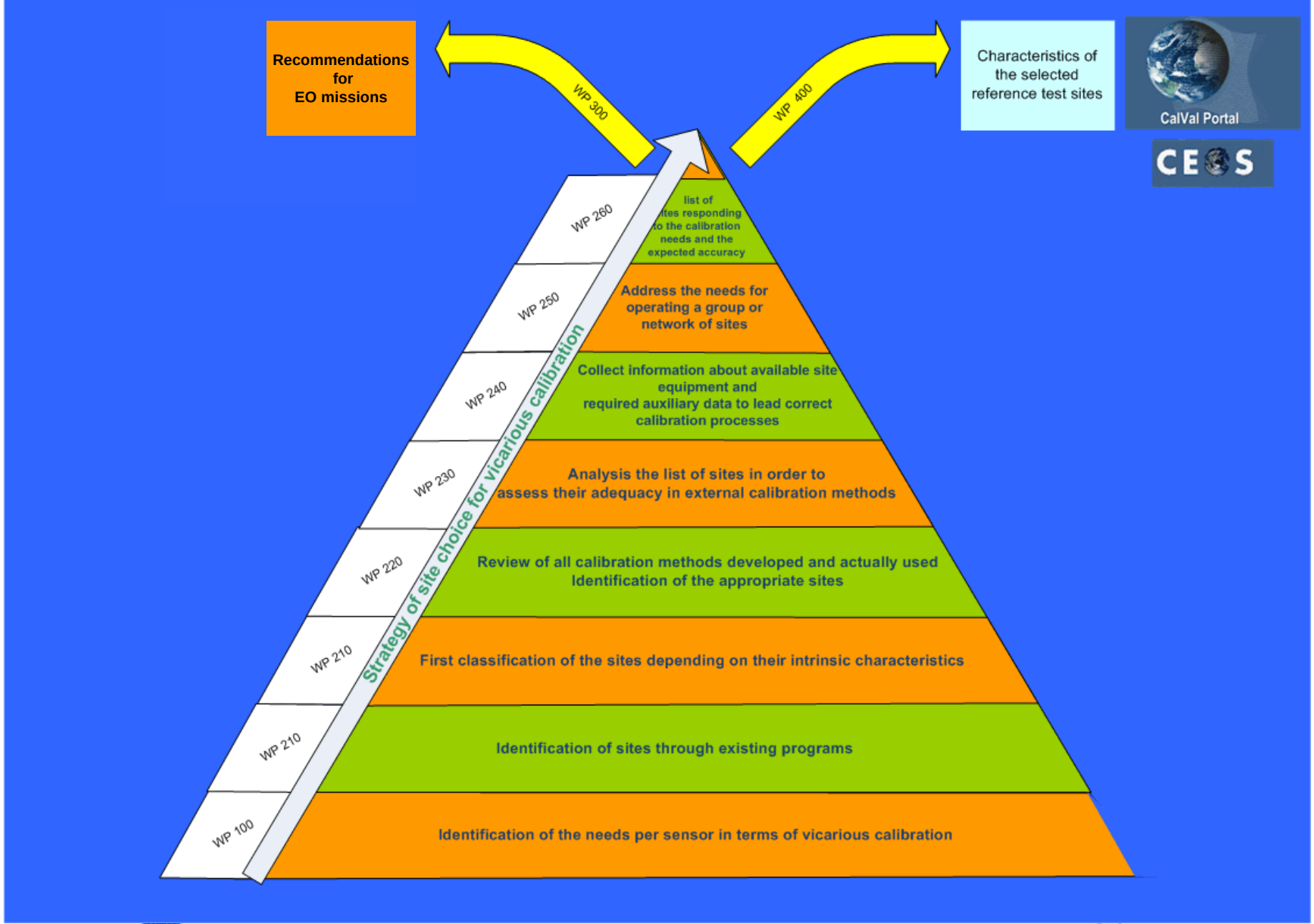
7. **Data Policies (in-situ and/or satellite)**
   - Data availability
   - Data format
   - Data access
   - POC
   - Data tractability

8. **Surface Characteristics – Surface Measurements**
   - Instrumentation description used by site "owner"
     - Route of traceability
     - Estimated uncertainty of reflectance/radiance at surface
       - Public reference / evidence / uncertainty breakdown
     - Estimated uncertainty of reflectance/radiance at TOA
       - Public reference / evidence / uncertainty breakdown
   - Sampling strategy
   - Surface reflectance – variability across site (uniformity) (%)
   - Average site reflectance plot (calibration site)
     - At nadir
     - BRDF (or specific angles)
   - Principal site reflectance plots (validation site)
     - At nadir
     - BRDF (or specific angles)
   - Site stability (measurement variability)
     - Visit-to-visit
     - Long term
   - Surface elevation and slope (angle and direction) - DEM
   - Atmospheric stability (aerosol loading and water vapor content)
   - Number and availability of well surveyed points

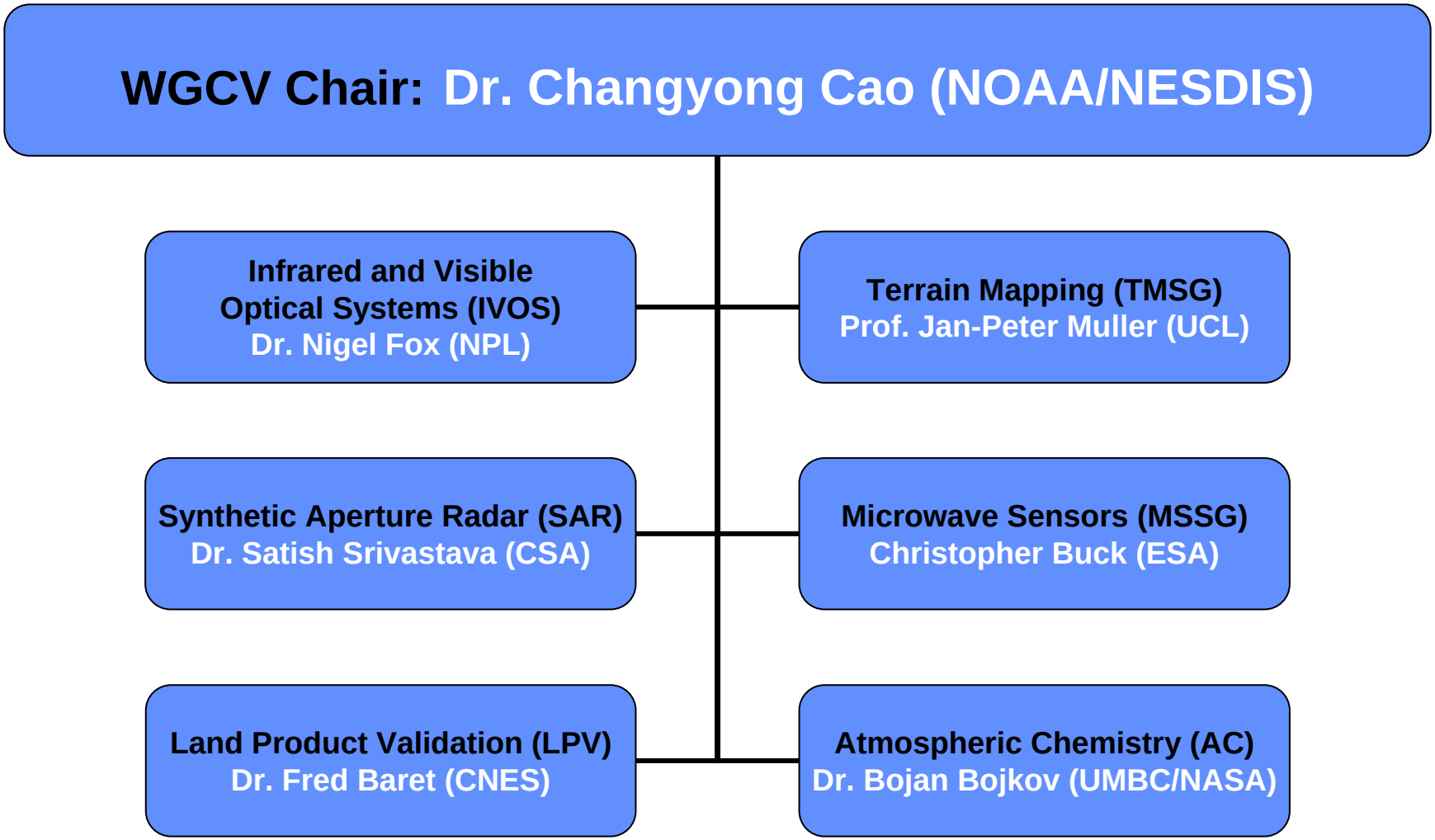
9. **Site Usage**
   - Historical record of comparisons (ground, aircraft and satellite)
     - Dates / sensors / location of results
   - Regularity of satellite data (if known)
     - Satellite and sensor ID

10. **Auxiliary Data**
    - Landsat WRS2 Path/Row
      - NW Corner Latitude/Longitude (degrees)
      - NE Corner Latitude/Longitude (degrees)
      - SW Corner Latitude/Longitude (degrees)
      - SE Corner Latitude/Longitude (degrees)
    - Polygon Vertices

Please send any comments to Gyanesh Chander (gchander@usgs.gov) 2


Recommendations for EO missions
WP 300
WP 400
Characteristics of the selected reference test sites
CalVal Portal
CEOS
Strategy of site choice for vicarious calibration
WP 260
WP 250
WP 240
WP 230
WP 220
WP 210
WP 210
WP 100
list of sites responding to the calibration needs and the expected accuracy
Address the needs for operating a group or network of sites
Collect information about available site equipment and required auxiliary data to lead correct calibration processes
Analysis the list of sites in order to assess their adequacy in external calibration methods
Review of all calibration methods developed and actually used
Identification of the appropriate sites
First classification of the sites depending on their intrinsic characteristics
Identification of sites through existing programs
Identification of the needs per sensor in terms of vicarious calibration

CEOS WGCV Subgroups



Terrain Mapping Subgroup (TMSG)

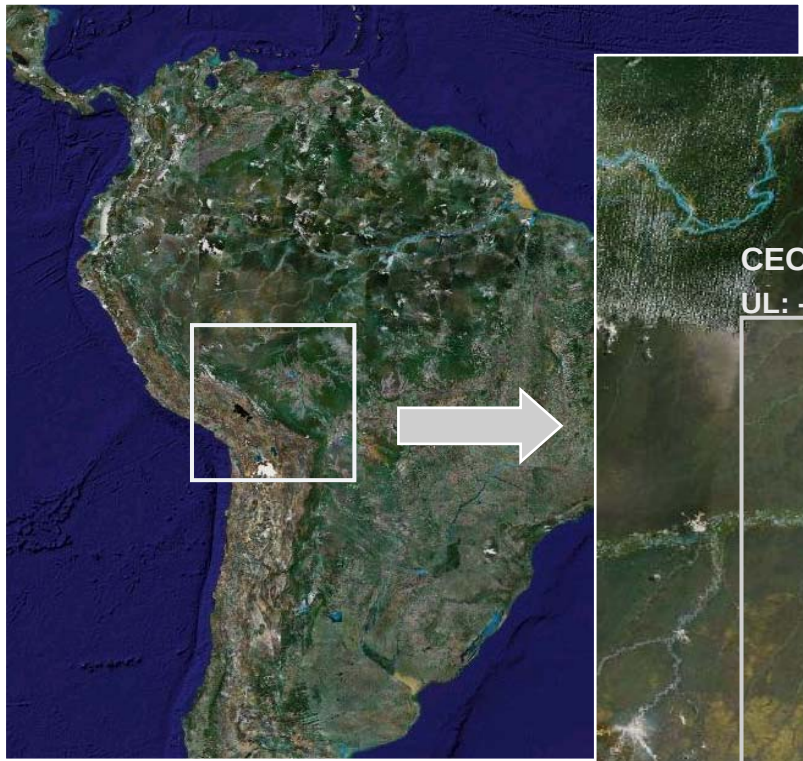
- **Montagne Sainte-Victoire**
  - France referred to as Aix-en-Provence
  - 5.528-5.685ºE, 43.502-43.560ºN
  - mixed arable, forest, limestone
- **Barcelona, Spain**
  - 1.5-2.75ºE, 41.25-41.82ºN
  - urban, mixed arable, forest
- **North Wales,**
  - UK3-5ºW, 52-53.5ºN
  - urban, pasture, forest
- **Three 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

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**

SAR Cal/Val Test Site: Amazon Rainforest



CEOS WGCV 2004

UL: - 5.03, - 65.67; LR - 9.12, - 69,64 deg

Isotropy
Temporal stability
Spatial uniformity

Well characterized radiometrically

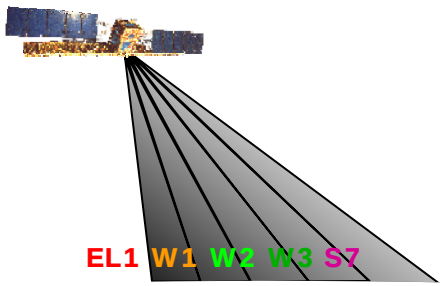
1978 Seasat (L)
1985 SIR-B (L)
1991 ERS-1 (C)
1992 ERS-2 (C)
1994 SIR-C (X)
1992 JERS-1 (L)
1996 RADARSAT-1 (C)
2002 ENVISAT (C)
2006 PALSAR (L)
2008 RADARSAT-2 (C)

CSA Amazon Data Record: 10 years
(1600 RADARSAT-1 acquisitions to date)

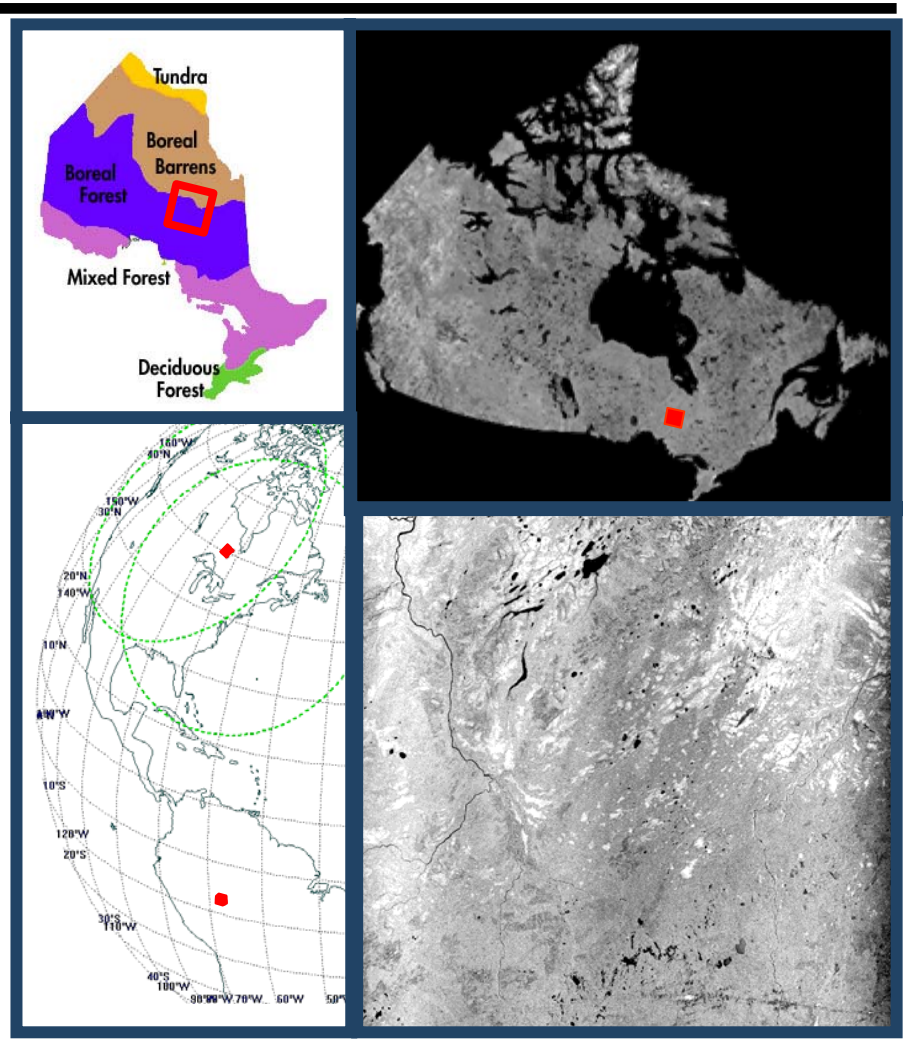
QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

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

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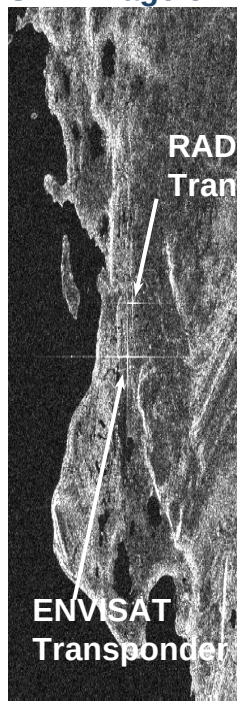
C-Band Transponder Sites in Canada: from CSA-only to CSA/ESA Sites

- Another Envisat ASAR Transponder was relocated in Ottawa in 2007, again in vicinity of a RADARSAT Transponder

- 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

ENVISAT ASAR Image of Resolute



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

(RADARSAT-1, Envisat and RADARSAT-2)

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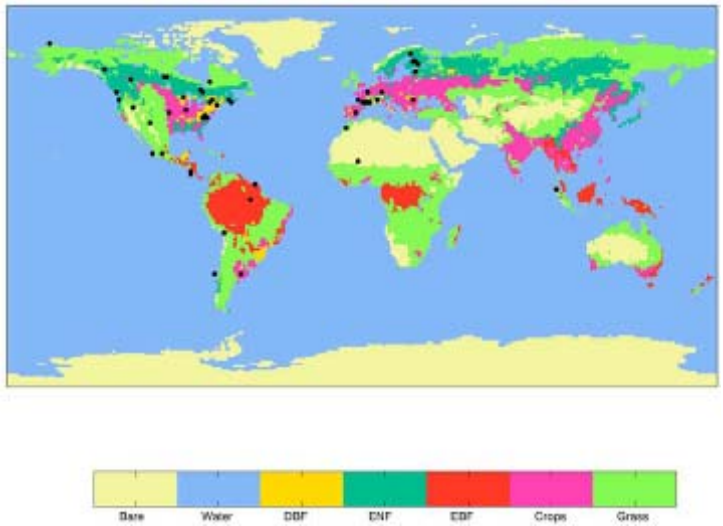
Microwave Sensors Subgroup (MSSG)

- **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/**

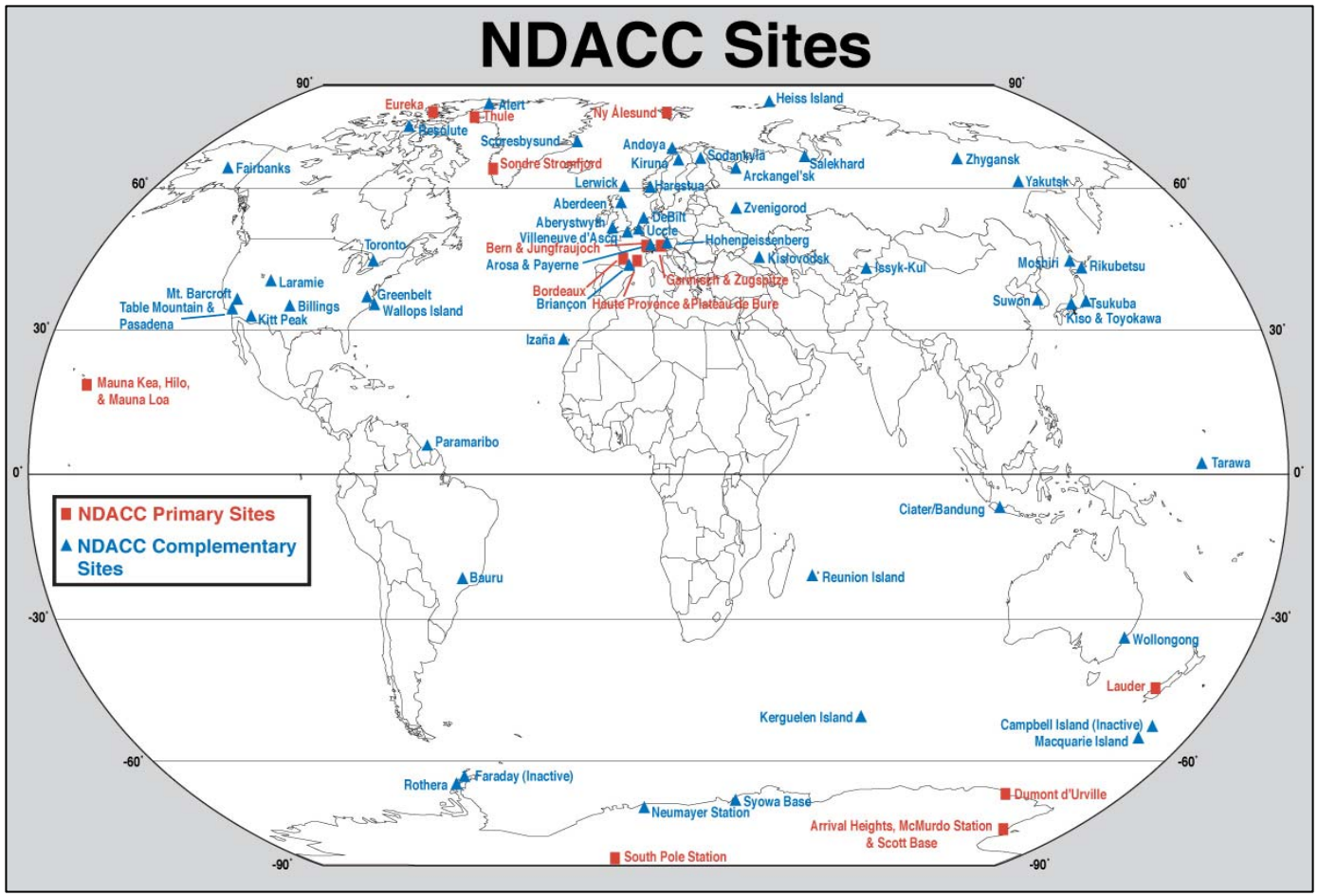


- **Map of sites covered by the groups represented in this paper (given on a global map of dominant surface types in each 1 x 1 cell (bare soil, water bodies, deciduous broadleaf forest, evergreen needleleaf forest, evergreen broadleaf forest, crops, grass)**

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)



QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION