Past, Present, and Future Postlaunch Cal/Val

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Past, Present, and Future Postlaunch Cal/Val: A Personal View

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Overview of Presentation

- **Past: Some History**
- **Present: The Workshop**
- **Future: Some Thoughts**

Some History (1/8)

- **Initial examinations of the reflectance and other properties of land surfaces now used to greatest effect for vicarious calibration began in the 1950s and 1960s. Examples:**
  - **1956 (Ashburn and Weldon)**
  - **1968 (Salomonson and Marlatt)**
  - **1971 (Molineux et al.)**

- **Initial examinations of suitable terrestrial targets for the postlaunch radiometric calibration of satellite sensors took place in the 1970s and 1980s. Examples:**
  - **1972 (Coulson and Jacobowitz)**
  - **1982 (Kastner and Slater)**

Some History (2/8)

- **Early experience with onboard calibration systems. Examples:**
  - **1970s Landsat MSS (Markham and Barker)**
  - **1980s Landsat TM (LIDQA; Markham and Barker)**
  - **1980s SPOT HRV (Begni et al.)**

- **Early research on surface and airborne measurement methodologies focused to a considerable extent on White sands, New Mexico in the 1980s. Examples:**
  - **1984 (Castle et al.)**
  - **1985 (Smith et al.)**

Some History (3/8)

- Vicarious calibration methodologies were developed in the 1980s to provide mission-specific radiometric calibration updates. Examples:
  - 1982 Meteosat (Koepke)
  - 1985 NIMBUS-7 CZCS (ocean) (Mueller)
  - 1986 NOAA AVHRR (Staylor; Frouin and Gautier)
  - 1987 Landsat TM (Slater et al.
- Aspects of calibrated NOAA AVHRR usage. Examples:
  - 1990s ISLSCP, NAC, GXOS, G1K
  - 1990s Internet dissemination of calibration coefficients

Some History (4/8)

- Other deserts and playas considered/used as reference standard sites in the late 1980s and 1990s include the following examples:
  - 1988 La Crau, France (Xing-Fa et al.)
  - 1994 Saharan and Arabian Deserts (Cosnefroy et al.)
  - 1994 Australian sites (Graetz et al.)
  - 1994 Dunhuang, China (Wu et al.)
  - 1996 Railroad Valley Playa, USA (Scott et al.)
  - 1996 Ivanpah Playa, USA (Thome et al.)
  - 1997 Negev Desert, Israel (Bushlin et al.)
  - 1998 Lunar Lake Playa, USA (Thome et al.)

Some History (5/8)

- Other target types used to provide radiometric calibration performance checks include the following examples:
  - 1992 Atmospheric molecular scattering (Vermote et al.)
  - 1993 Cloud tops (Desormeaux et al.)
  - 1995 Oceans (Vermote et al.)
  - 1996 The Moon (Kieffer and Wildey)
  - 1997 Snow/ice fields (Loeb)

Some History (6/8)

- **Some key pioneers/players:**

AFGL	INRA	NPL
BNSC	ISPRS	ONERA
CCRS	ISRO	RAL
CEOS	JAXA	RIT
CNES	JRC	SDSU
CRESDA	LOA	UM
CSIRO	NASA	USDA
DLR	NERC	USGS
ESA	NIST	UAZ
INPE	NOAA	UZ

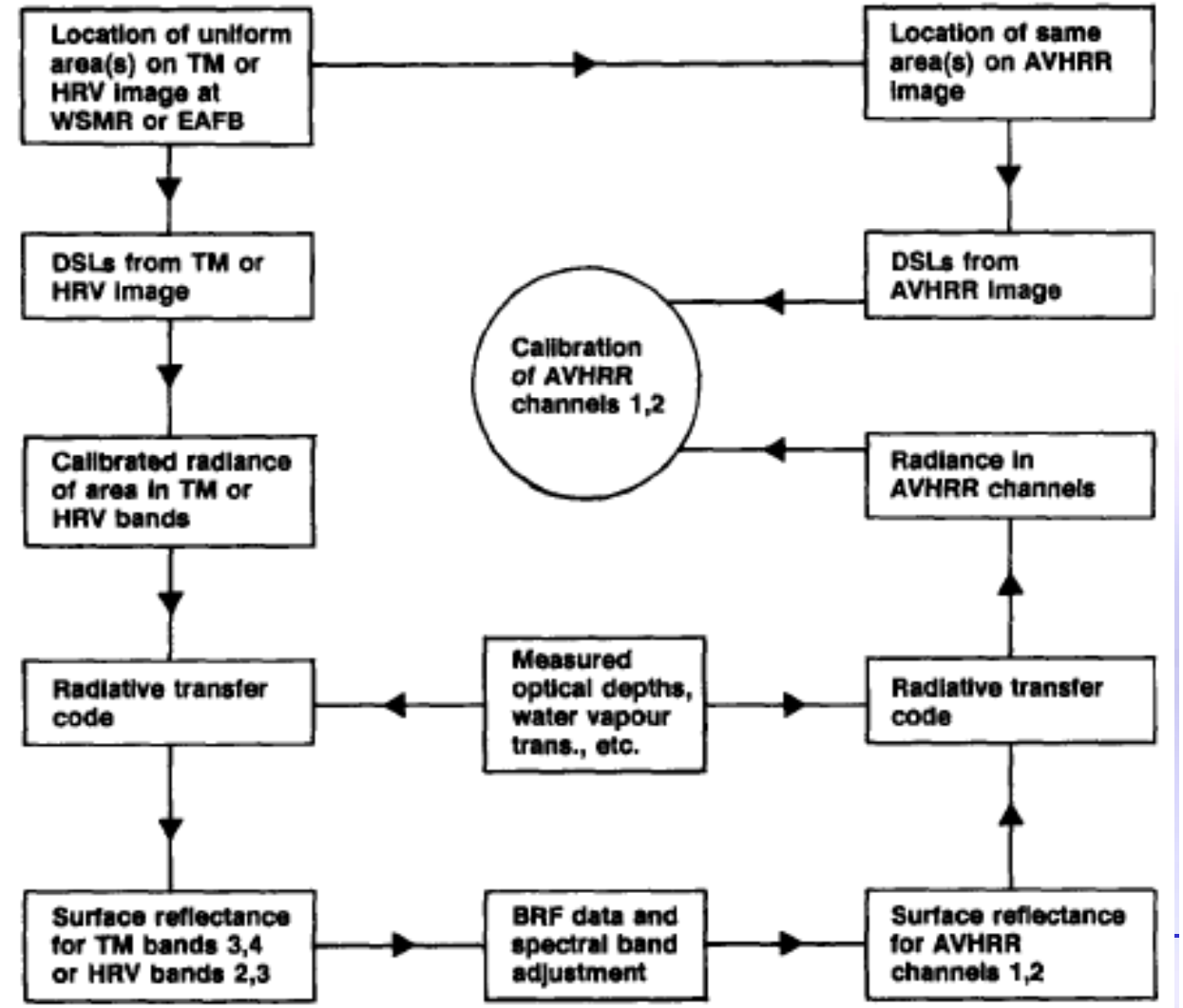
Some History (7/8)

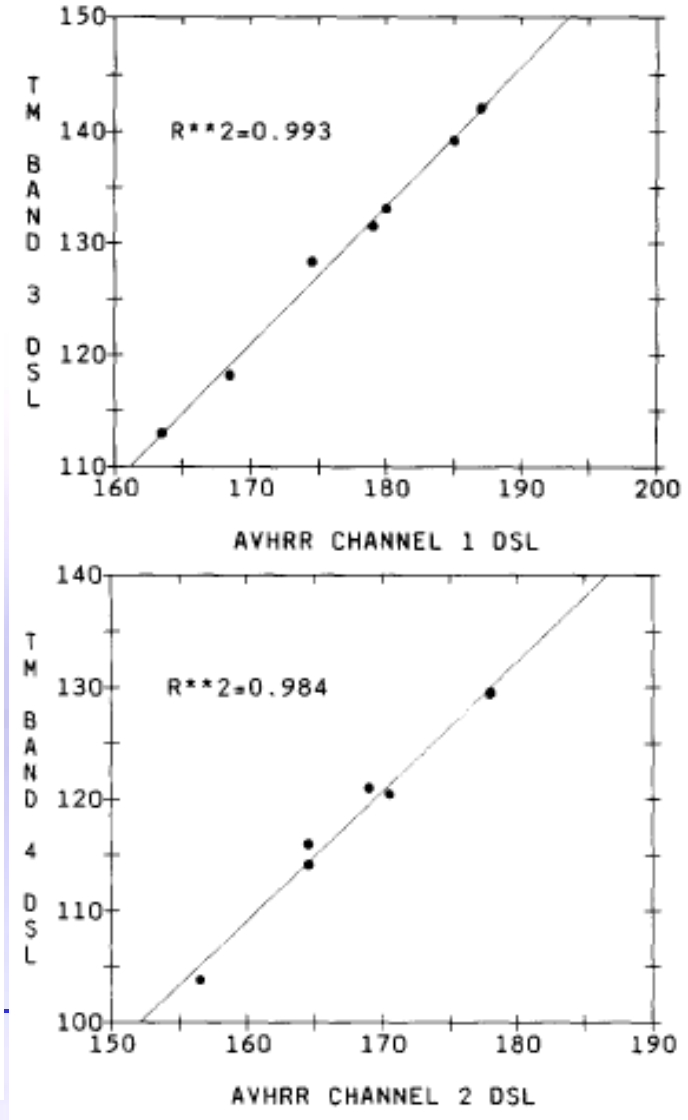
- **Special concepts and initiatives:**
  - **1980 Slater's book published**
  - **1980s SADE database (CNES)**
  - **1980s CEOS WGCV started (CNES)**
  - **1990 AVHRR cross-calibration methodologies (Teillet et al.)**
  - **1990s CEOS WGCV revived (CCRS)**
  - **1990s Calibration inter-comparisons (CEOS)**
  - **1990s MODIS MCST (Guenther) and Calibration (Slater)**
  - **1990s Envisat calibration plan**
  - **1993 AERONET initiated (Holben et al.)**
  - **1994 ROSAS initiated at La Crau (CNES)**
  - **1995 EOS Calibration (Butler) and Validation (Starr) Scientists**
  - **1998 Generalization via hyperspectral (Teillet et al.)**

Some History (8/8)

- **Special concepts and initiatives:**
  - **1999 Climate Monitoring Principles (GCOS)**
  - **2001 Global network of test sites concept (Teillet et al.)**
  - **2002 TRUTHS mission concept (Fox et al.)**
  - **2007 GEOSS calibration for climate change (Ohring et al.)**
  - **2007 CLARREO mission (NRC decadal survey; UMd workshop)**
  - **2007 Core site selection (Teillet et al.)**
  - **2007 Core site cataloguing (Chander et al.)**
  - **2007 Cal/Val Portal (CEOS)**
  - **2008 QA4EO (Fox et al.)**
  - **2009 Concatenation of core site campaigns (Teillet and Fox)**

AVHRR Cross-Calibration with Respect to Landsat TM and SPOT HRV (1988)





Reflectance-Based Approach to Vicarious Calibration (Thome, GSFC)

Measure site: reflectance data

Measure site: atmospheric data

Radiative Transfer Code

Compute top-of-atmosphere radiance

Average site DNs derived from image data

Calibration of sensor's spectral bands

Workshop Objectives

- **Bring together the world's cal/val experts related to "land and ocean solar reflected" sensors (post-launch) to review and consolidate the state-of-the-art and develop a coordinated prioritised strategy for the future.**
- **Establish an internationally consistent & "fit-for-purpose" means to enable full interoperability between sensor observations and resultant products through coordinating resource and expertise of CEOS members.**
- **Identify and quantify biases (Largely Level 1) between sensors (TOA), between sensors (BOA), and between "true-value"**
- **Establish "uncertainties" in measurements and means to assess**
- **Develop consensus on methodologies to use and their capabilities (intrinsic methods, "reference standards")**
- **"Operational" system for implementation**

Specific Recommendations

- Increase the number of core reference standard sites
- Gather more complete characterization data and information for the core reference standard sites
- Define a recommended standard set of core measurements
- Create an operational network of land sites
- Organize local, regional, national, and international field campaigns at the CEOS-endorsed reference sites
- Acquire and archive imagery of the core reference standard sites on an ongoing basis
- Develop online calibration data access infrastructures
- Continue to improve vicarious calibration methodologies
- Establish traceability chains for core reference standard site data
- Endorse and advocate compliance with calibration standards.

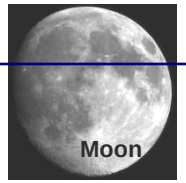
Some Thoughts (1/2)

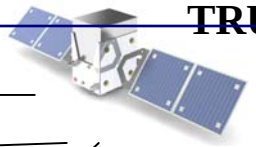
- "Seeking robust challenge to status quo" (Fox)
- Future pool of people with in-depth experience
- "Most important person on campaigns is the note-taker (Thome)": automation?
- Model-based QA of validation protocols for land products (Widlowski): explore further for radiometric calibration
- "Important to understand requirements" (Vermote)

Some Thoughts (2/2)

- **Is Frenchman Flat still a core site? Do we need more non-USA sites?**
- **More effort on the use of data at wavelengths outside the solar-reflective spectrum to help characterise reference standard sites used for optical sensor calibration**
- **Roadmap**
- **Optimum operational network: How? Who?**

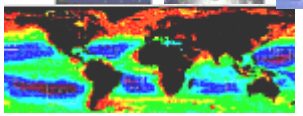
Optimum Operational Network (IVOS)





TRUTHS

Absolute sensor



SNO

+ SADE / CNES

Pseudo-Invariant Sites
Long term trends
Stability Monitoring

Instrumented Sites / Radiometric Gain

Thank You!

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"The power of technological convergence will bring measurable benefits to each and every individual." *Our Molecular Future*, Douglas Mulhall (2002)

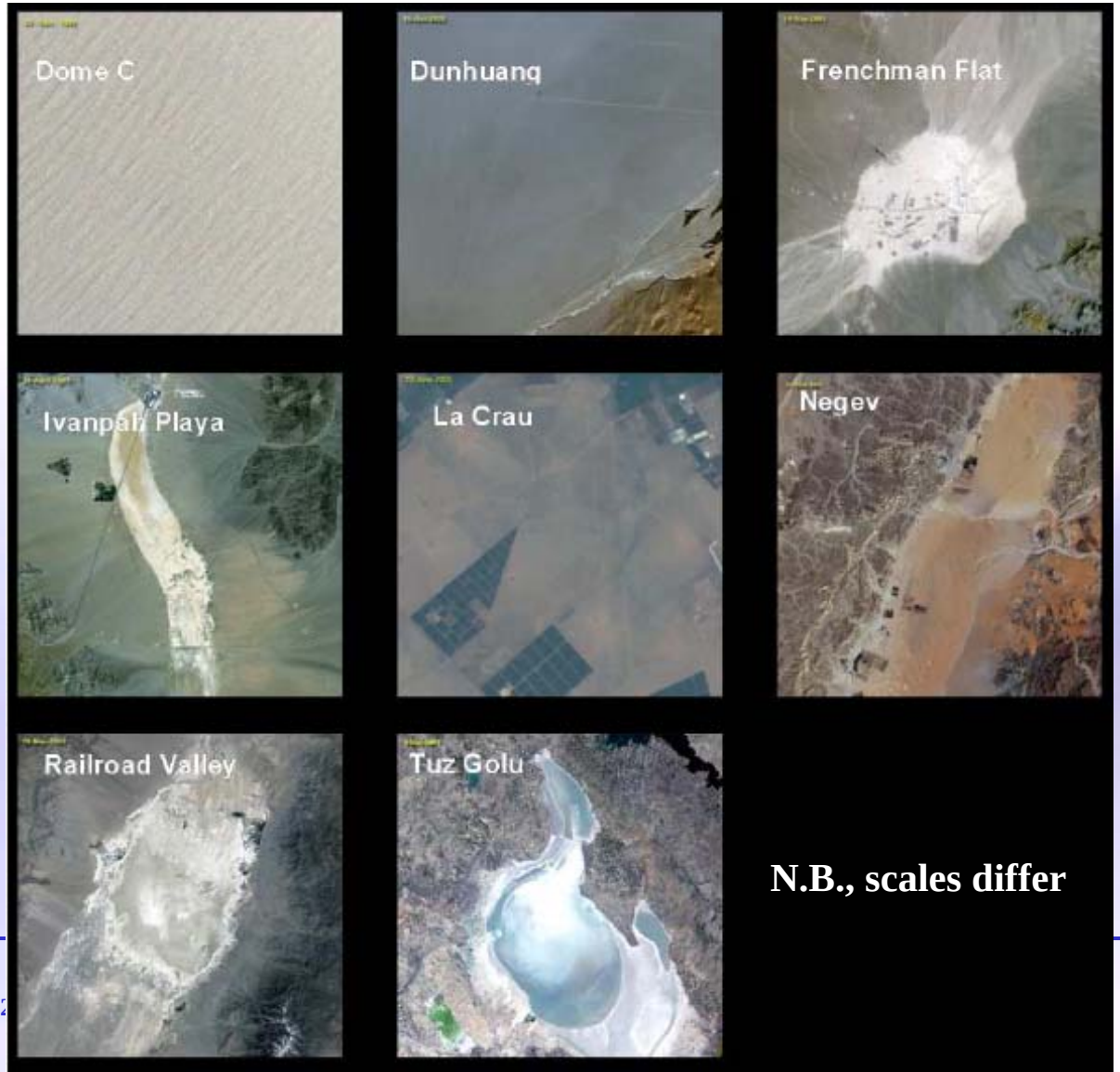
Spares

Distribution of 36 Candidate Radiometric Sites

Core Set of CEOS-Endorsed Reference Standard Test Sites

#	Site	WRS-2 Path/Row	Centre Latitude (Degrees), Longitude (Degrees), and Altitude ASL (m)	Point of Contact
1	Dome C, Antarctica	88-89-90/113	-74.50, +123.00, 3215	Stephen Warren University of Washington, USA
2	Dunhuang, China	137/32	+40.13, +94.34, 1220	Xiuqing Hu National Satellite Meteorological Center, China
3	Frenchman Flat, USA	40/34	+36.81, -115.93, 940	Carol J. Bruegge NASA Jet Propulsion Laboratory, USA
4	Ivanpah Playa, USA	39/35	+35.5692, -115.3976, 813	Kurtis J. Thome NASA Goddard Space Flight Center, USA
5	La Crau, France	196/30	+43.47, +4.97, 28	Patrice Henry Centre National d'Etudes Spatiales, France
6	Negev Desert, Israel	174/39	+30.11, +35.01, 334	Arnon Karnieli Ben Gurion University, Israel
7	Railroad Valley Playa, USA	40/33	+38.50, -115.69, 1435	Kurtis J. Thome NASA Goddard Space Flight Center, USA
8	Tuz Golu, Turkey	177/33	+38.83, +33.33, 905	Selime Gurol Tubitak Uzay (Space Technologies Research Institute), Turkey

CEOS-Endorsed Core *Instrumented* Reference Standard Sites



CEOS-Endorsed Core *Pseudo-Invariant* Reference Standard Sites

N.B., scales differ

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

Ground Photograph 1

Ground Photograph 2