SI-Traceable Satellite (SITSat) Task Group

(supported by WGCV and GSICS members)

Co-lead : Nigel Fox (UKSA) (NPL)
Yolanda Shea (NASA)

Committee on
Earth Observation Satellites

Global Space-based
Inter-Calibration System

Background

Achieving Satellite Instrument Calibration for Climate Change (ASIC³)

Report of a Workshop Organized by

National Oceanic and Atmospheric Administration
National Institute of Standards and Technology
National Aeronautics and Space Administration
National Polar-orbiting Operational Environmental Satellite System-Integrated Program Office
Space Dynamics Laboratory of Utah State University

At the National Conference Center, Lansdowne, VA, May 16-18, 2006

Edited by George Ohring

Contributors

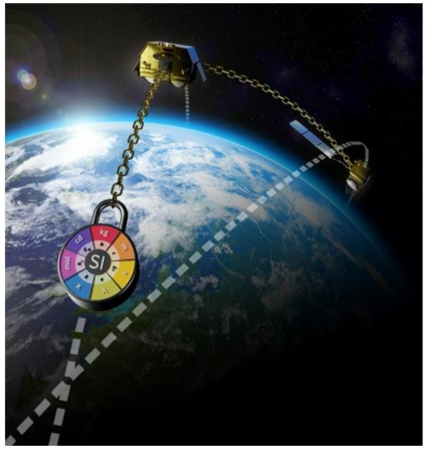
James G. Anderson	Philip Ardanuy	Gail Bingham
James Butler	Changyong Cao	Raju Datla
John Dykema	William Emery	Lawrence Flynn
Gerald Fraser	Mitchell Goldberg	Greg Kopp
Toshio Iguchi	David Kunkee	Stephen Leroy
Laury Miller	David Pollock	Hank Revercomb
Scott Shipley	Karen St. Germain	Tom Stone
Joe Tansock	Alan Thurgood	David Tobin
Stephen Ungar	Bruce Wielicki	David Winker
Jack Xiong	Fuzhong Weng	

2007

Strategy Towards an Architecture for Climate Monitoring from Space

SI-Traceable Space-based Climate Observing System: a CEOS and GSICS Workshop National Physical Laboratory, London, UK, 9-11 Sept. 2019

SITSCOS Workshop Report



Editors: Nigel Fox, Tim Hewison, Greg Kopp, Bruce Wielicki

International activities around SI-Traceable data for Climate Monitoring from Space, including plans to launch SITSats

What is a SITSat ?

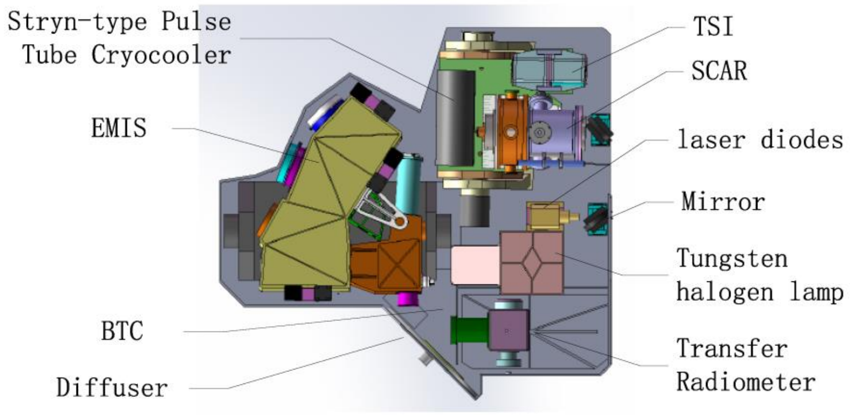
A SITSat is a satellite-based sensor which can provide and verifiably evidence, in a fully open and transparent manner, all significant contributions to the uncertainty of its measurements, **metrologically traceable** to the international system of units, SI, at **the location and time from where they are made**. In addition, this uncertainty must be at a level that is considered by the community to be **of 'Fiducial reference' quality**, i.e., that for a defined spectral domain/application it can be considered 'state-of-the-art' and able to unequivocally serve as a **reference** for similar measurements from other sensors. The uncertainty of a SITSat should be expected to reach or at least approach that required for **key climate science objectives** such as those identified in the "SI-Traceable Space-based Climate Observing System: a CEOS and GCICS Workshop" (https://doi.org/10.47120/npl.9319). When used as a reference a SITSat would be expected to have a **measurement uncertainty of <0.5 compared to that of its non-SITSat peers**.

Note:
1/ If used as a reference, the method used to compare with other sensors and its associated uncertainty to SI, should also be fully documented and evidenced.
2/ The nominal threshold uncertainty to be considered a SITSat for a particular type of measurement/application may increase or reduce over time commensurate with scientific consensus, currently this requires 2-10x improvement over current sensors. Although desirable in the long-term, it is not essential to have a SITSat for all applications and sensor domains and thus the assignment of the classification to a sensor should only be made when the maturity and technology of a particular domain justifies it.
3/ A SITSat peer group would constitute ALL sensors making similar measurements (e.g., spatial and spectral range)

SITSats in Development

CLARREO PATHFINDER - NASA

TRUTHS - ESA



LIBRA - CMA

Motivation for SITSats

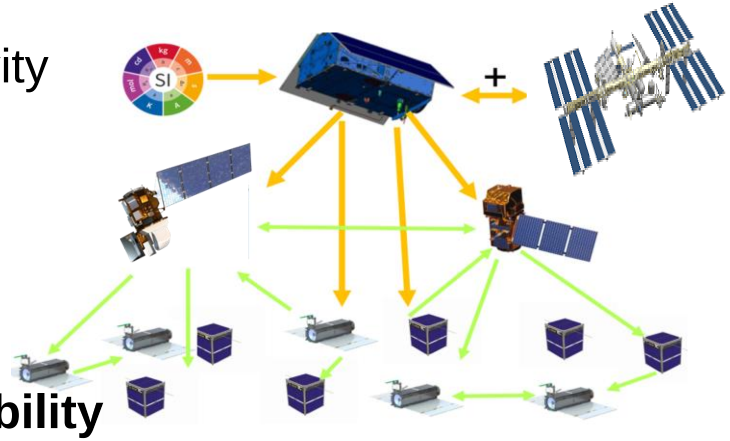
- **Desire for ‘Reference/Fiducial’ data that enable unequivocal change detection in relatively short time-scales and mitigate ‘data gaps’ (*particularly for climate*)**
  - Robust, transparent quantified evidence of traceability to a reference (ideally SI) - ‘QA4EO’
  - Small comprehensively evaluated uncertainties
    - Allowing ‘stability’ criteria for climate to be robustly tied to invariant reference (SI)

- ‘**System of systems’ Integrated EO data, interoperable/harmonised knowledge of/removal of biases**
  - ARD
  - SI-Traceability provides unambiguous trust, space agency agnostic, longevity

- **New space – reliance on post-launch calibration, no on-board calibration**
  - Reduced cost, complementary observations (*temporal/spatial coverage*)
  - Level playing field, maximal utilisation of investments and assets

- **CEOS/GSICS initiatives to establish international references and SI-Traceability**
  - Coherent, comprehensive/flexible, reliable anchor to well-established methods
  - Mimics calibration methodologies of all terrestrial ‘industries’
  - Provides a clear label of a specific sensor property but generic to ‘application’

Space-based Intercalibration



Rationale for Task Group

- **Recognition, visibility of the new class of Instrument to senior levels in space agencies & EO community**
  - Noting at least 3 SITSats are currently under-development from different continents

- **Similar to CEOS-VCs – coordinate, where appropriate, to facilitate commonality of purpose (shared vision)**
  - Maximal utilisation of resources
  - Continuity of 'service' (data, coordination of launches)
  - Internationally integrated 'users', data source agnostic tools
  - Advocacy from an international 'multi-agency' perspective
  - Lessons learnt – enabling new missions/agencies
  - Value > sum of parts

- **Establish an agreed minimal set of definitions and principles to distinguish SITSats and their utilisation**
  - Independent of application domain or technology

- **Seek to build a common user/customer base, transcending individual missions**
  - Value/necessity for achieving GEOSS 'fit for purpose' solutions to needs of climate & society

Task Group Objectives

- Establish clear definitions of what constitutes a SITSat and the minimal requirements needed to evidence this status

- Serve as a forum for agencies developing/planning SITSat missions to share experiences and knowledge

- Discuss collaboration opportunities, joint cal/val activities, campaigns, and data sharing

- Provide an opportunity for mission coordination, gap analyses, efficient tasking, and acquisition planning

- Facilitate coordination on technical topics, reporting of uncertainty and traceability information, interoperability, and methods of dissemination

- Aim for a systems-based approach along the lines of a CEOS Virtual Constellation, rather than missions being developed and operated in isolation

Task Group Deliverables

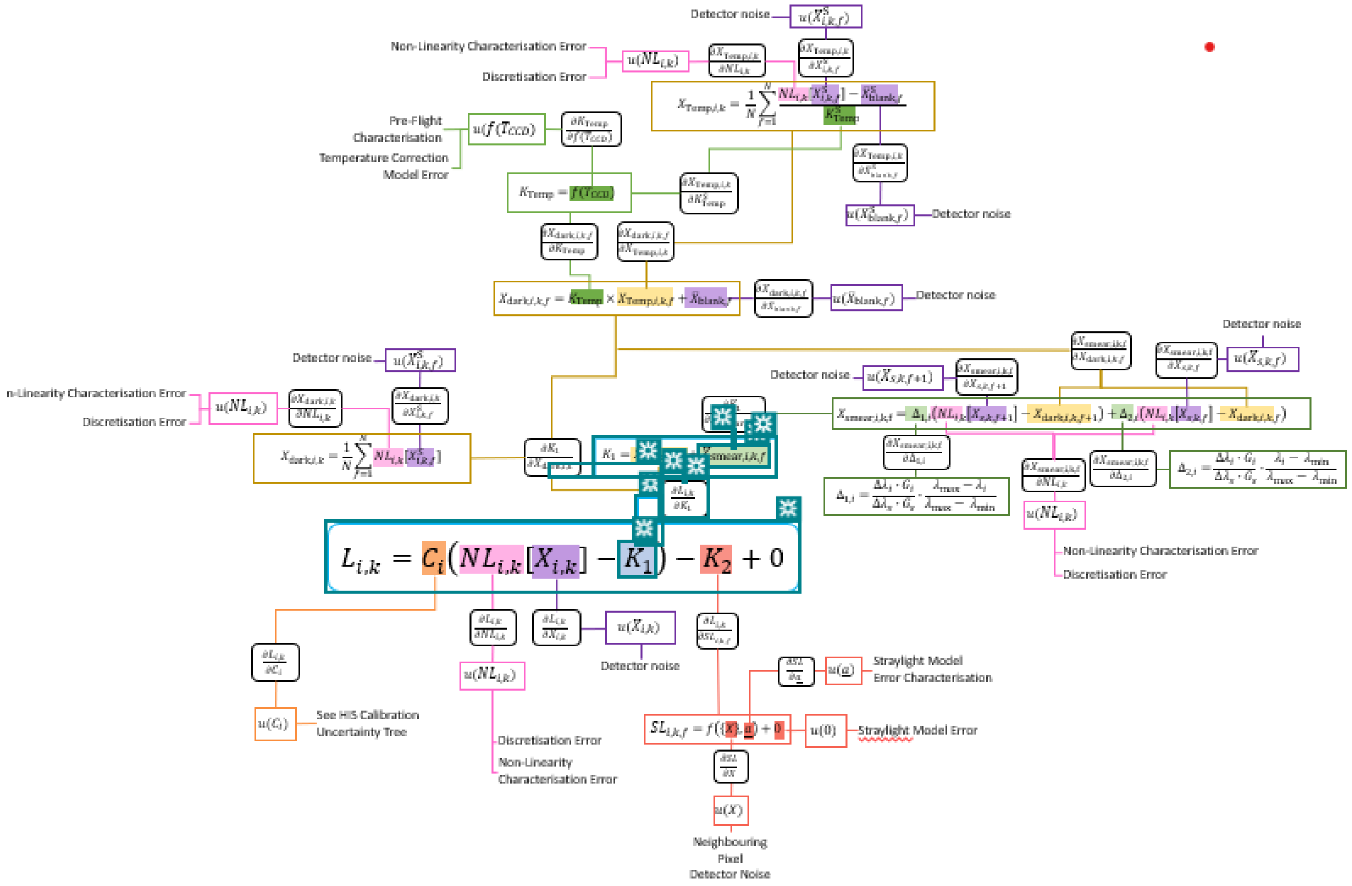
- **Establish a <u>clear definition</u> of what constitutes a SITSat and minimal requirements needed to evidence this status**
  - How and what to present as Uncertainty/SI-traceability evidence (standardized content and/or format)

- **Develop a <u>roadmap</u> (whitepaper) of what a SITSat enabled observing system looks like**

- **<u>Data sharing</u> based on a systems approach**
  - **Common (interoperable?) reporting/archive grid for climate? (Spectral/spatial)**
  - **Common Grid for S2S calibration?**
  - **Format – what info to report and how?**
  - **Mirrored data stores/access?**
  - **Minimal set of common ‘targets’ (comparison/gap filling etc)**

- **<u>Communications strategy</u>** for awareness raising / key messages / utility for observing system / integrated multi-SITSat observing system

FIDUCEO-like – TRUTHS Radiance



TRUTHS HIS Earth Radiance Uncertainty Tree

CSAR power correction						
Name of effect		Cavity temperature characterisation error (Shuttered)	Cavity temperature characterisation error (open)	Sensor reference resistor voltage fluctuation error	Reference resistor characterisation error	Cavity sensitivity characterisation error
Affected term in measurement function		$T_{cav,\,c}$	$T_{cav,\,i}$	$V_{r\_cav,i}$	$R_{r\_h\_cav}$	S_{cav}
Image error-correlation type, form and scale	Across track (k)	Systematic	Systematic	Random	Systematic	Systematic
	Along track (f)	Systematic	Systematic	Systematic	Systematic	Systematic
	Between spectral pixels (i)	Systematic	Systematic	Systematic	Systematic	Systematic
Uncertainty	PDF shape	Rectangular	Rectangular	Gaussian	Rectangular	Rectangular
	units	K	K	V	Ω	KV^{-1}
	magnitude	TBD	TBD	TBD	TBD	TBD
Source						
Sensitivity coefficient		$\frac{\partial L_{i,k}}{\partial T_{cav,\,c}}$	$\frac{\partial L_{i,k}}{\partial T_{cav,\,i}}$	$\frac{\partial L_{i,k}}{\partial V_{r\_cav,i}}$	$\frac{\partial L_{i,k}}{\partial R_{r\_h\_cav}}$	$\frac{\partial L_{i,k}}{\partial S_{cav}}$

‘effects table’ for each error source

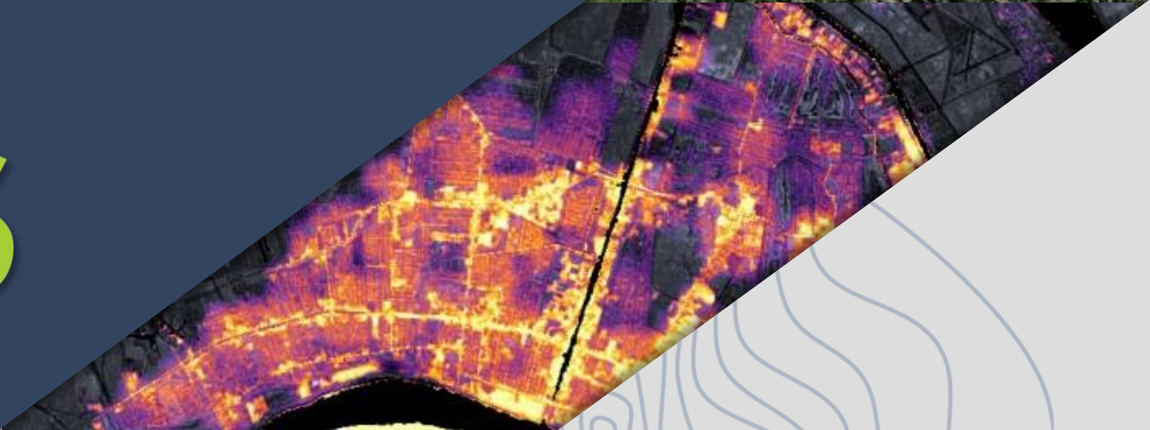
Fiduceo like analysis of end to end traceability and uncertainties – an exemplar for other missions

Task Group Members

Nigel Fox	UKSA
Scott (Xiuqing) Hu	CMA
Yolanda Shea	NASA
Kurt Thome	NASA
Medhavy Thankappan	GA
Thorsten Fehr	ESA
Philippe Goryl	ESA
Cody Anderson	USGS
Mounir Lekouara	EUMETSAT

Akihiko Kuze	JAXA
Martin Bachmann	DLR
Santhisree	ISRO
Cheng-zhi Zou	NOAA
Jason (Taeyoung Choi)	NOAA
Lawrence Flynn	NOAA
Ruben Urraca	EC
Jack Xiong	NASA
Manik Bali	NOAA
Lingling MA	AIRCAS

Thank you



Committee on
Earth Observation Satellites