

Outcome of Workshop on SI-Traceable Space-based Climate Observing System (SITSCOS)

Tim Hewison, *EUMETSAT, Germany*
Nigel Fox, *National Physics Laboratory, UK*
Bruce Wielicki, *retired NASA Langley*
Greg Kopp, *CU-LASP*

*A CEOS and GSICS
International Workshop*

held at the
*National Physical Laboratory
London, UK*

2019-09-09/11





SITSCOS Workshop Overview

- ~ 100 international participants
- Space-based climate observations
- Relevant SI-traceable climate change accuracy requirements
- Current/future accuracy + stability capabilities
 - for satellite sensors
 - Ground-based metrology laboratories
 - pre- and post-launch calibration
- ~200 page Workshop Report
 - using input from the presentations, discussions, and participants' written contributions.
 - set of recommendations was developed as part of the report



Group Photo of SITSCOS Workshop, NPL 2019

Workshop Report, Agenda and Presentations can be found at the CEOS Cal/Val Portal:
<http://calvalportal.ceos.org/sitscos-ws>

- <https://doi.org/10.47120/npl.9319>



SITSCOS Workshop Report Structure

1. Executive Summary

Bruce Wielicki , Tim Hewison, Nigel Fox, Greg Kopp

- 26 page summary
- Distributable as a stand-alone document



SITSCOS Workshop Report Structure

1. Executive Summary

2. Societal Need for an Advanced Climate-Observing System

B. Wielicki, R. Cooke

- Current space-based observations are typically factors of 5 to 10 less accurate than climate-change science requirements
- An advanced climate observing system (*including SITSats*) could reduce trend-detection uncertainties by 15 to 30 years from current approaches
- Cost of delay in establishing an adequate climate observing system is 50x that of the investment

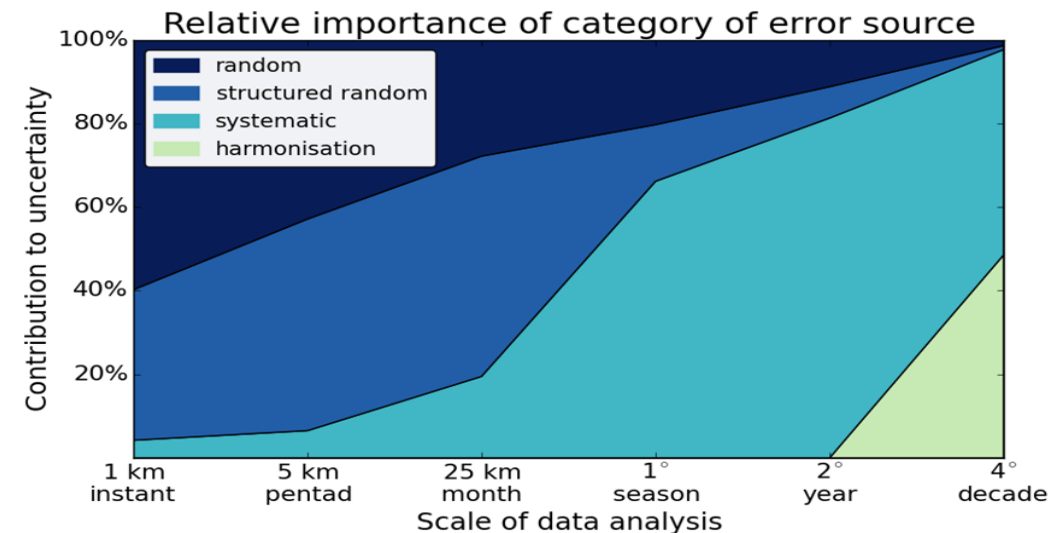


SITSCOS Workshop Report Structure

1. Executive Summary
2. Societal Need for an Advanced Climate-Observing System
3. **Metrology and CDRs**

S. Hunt, E. Woolliams, J. Mittaz, C. Merchant

- Rigorous metrology in the development of climate data records is crucial to ensure datasets produced are of irrefutable credibility and are stable at a level that justifiably permits the evaluation of climatic trends





SITSCOS Workshop Report Structure

1. Executive Summary
2. Societal Need for an Advanced Climate-Observing System
3. Metrology and CDRs
4. **SI-Traceable Calibrations**

N. Fox, P. Green, S. Devlin

- International metrology laboratories and space agencies have developed and demonstrated new technologies to provide space-based SI-traceable reference instruments to achieve climate-change accuracy requirements

The seven defining constants of the SI and the seven corresponding units they define:

Defining constant	Symbol	Numerical value	Unit
hyperfine transition frequency of Cs	$\Delta\nu_{\text{Cs}}$	9 192 631 770	Hz
speed of light in vacuum	c	299 792 458	m s^{-1}
Planck constant	h	$6.626\,070\,15 \times 10^{-34}$	J s
elementary charge	e	$1.602\,176\,634 \times 10^{-19}$	C
Boltzmann constant	k	$1.380\,649 \times 10^{-23}$	J K^{-1}
Avogadro constant	N_{A}	$6.022\,140\,76 \times 10^{23}$	mol^{-1}
luminous efficacy	K_{cd}	683	lm W^{-1}



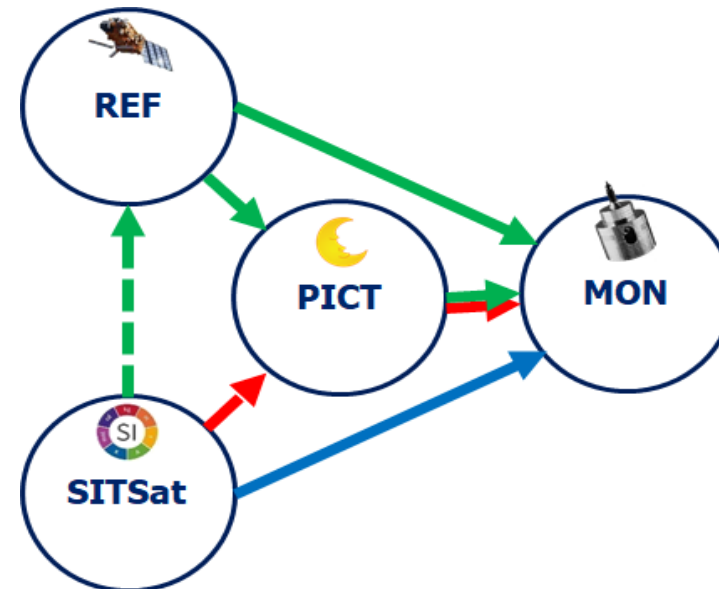


SITSCOS Workshop Report Structure

1. Executive Summary
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3. Metrology and CDRs
4. SI-Traceable Calibrations
5. **Extending GSICS to an Absolute Scale**

*T. Hewison, D. Doelling, C. Lukashin, D. Tobin, V. John,
X. Hu, L. Wang, D. Coppens*

- Global Space-based Inter-Calibration System
- See poster



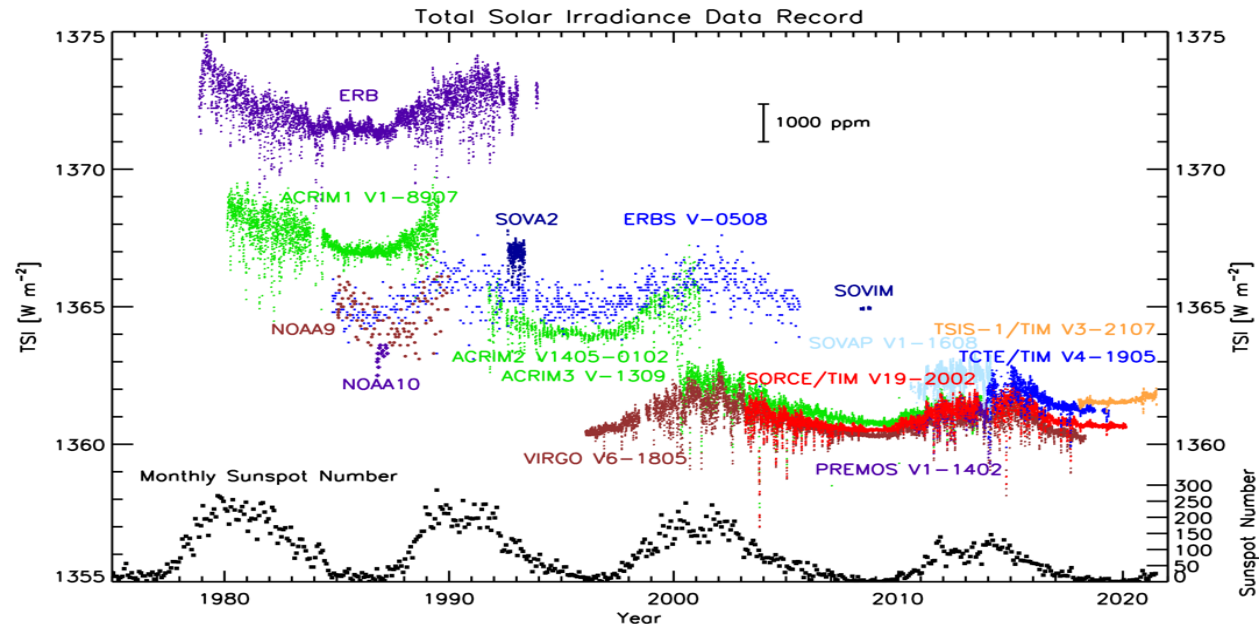


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6. **Earth Radiation Budget**

G. Kopp, X. Ye, X. Zhang, X. Yi, C. Lin, and L. Wang, E. Richard, O. Coddington, P. Pilewskie, M. Mlynczak,

- Outgoing Earth radiation budget measurements complete the energy-balance assessment
- Continuity provides record of net incoming energy





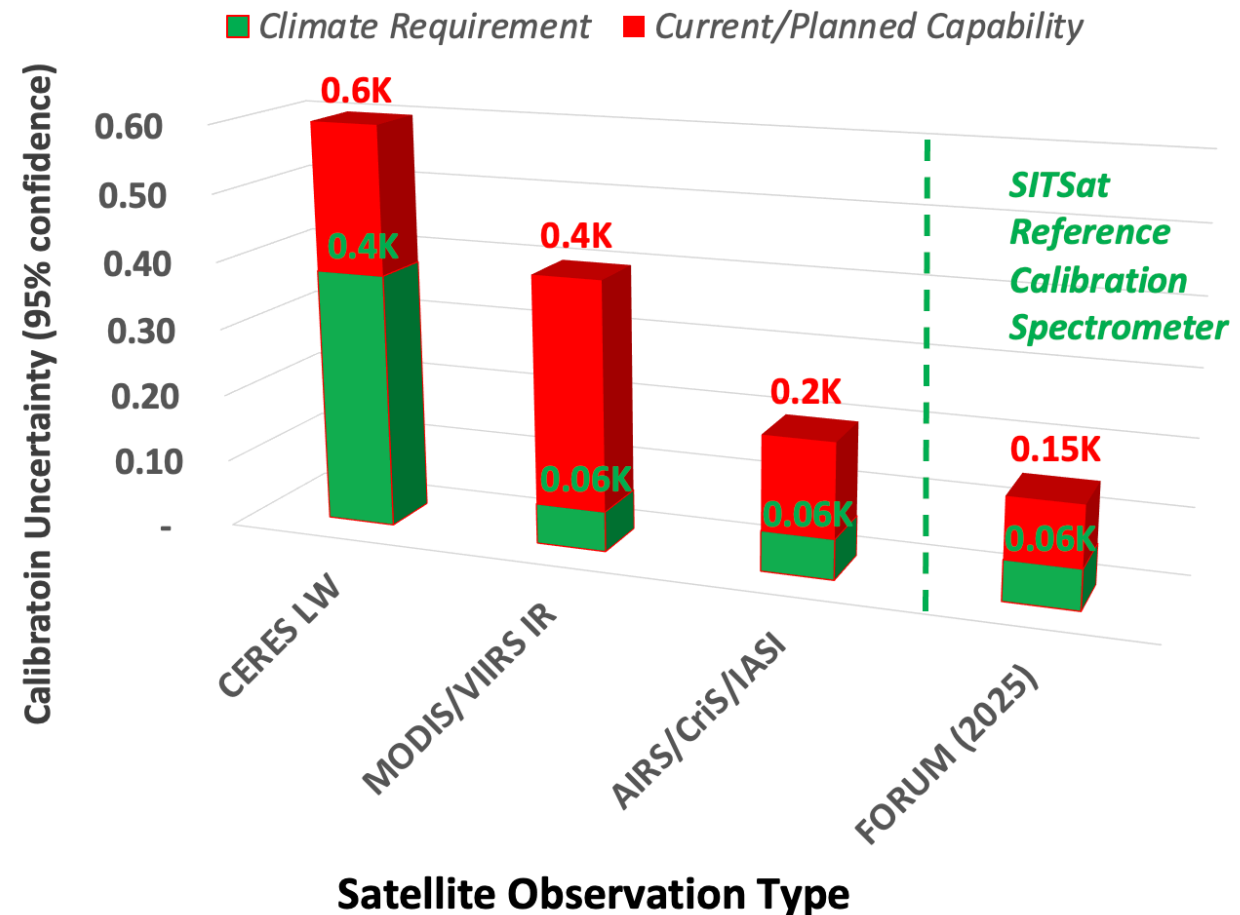
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6. Earth Radiation Budget
7. Thermal Infrared

D. Smith, D. Peters, T. Nightingale, J. Pearce, R. Veltcheva, X. Xiong, J. Butler, T. S. Pagano, E. M. Manning, S. E. Broberg, H. Aumann, S. Ray, E. Fetzer, J. Teixeira, L. Strow, H. Revercomb, F. Best, D. Tobin, J. Taylor, J. Gero, R. Knuteson, D. Adler, C. Pettersen, M. Mulligan, R. Holz, F. Nagle

- Designs to realise a SITSat in IR exist and are virtually ready to fly

Infrared Current Capabilities versus SI Climate Requirement





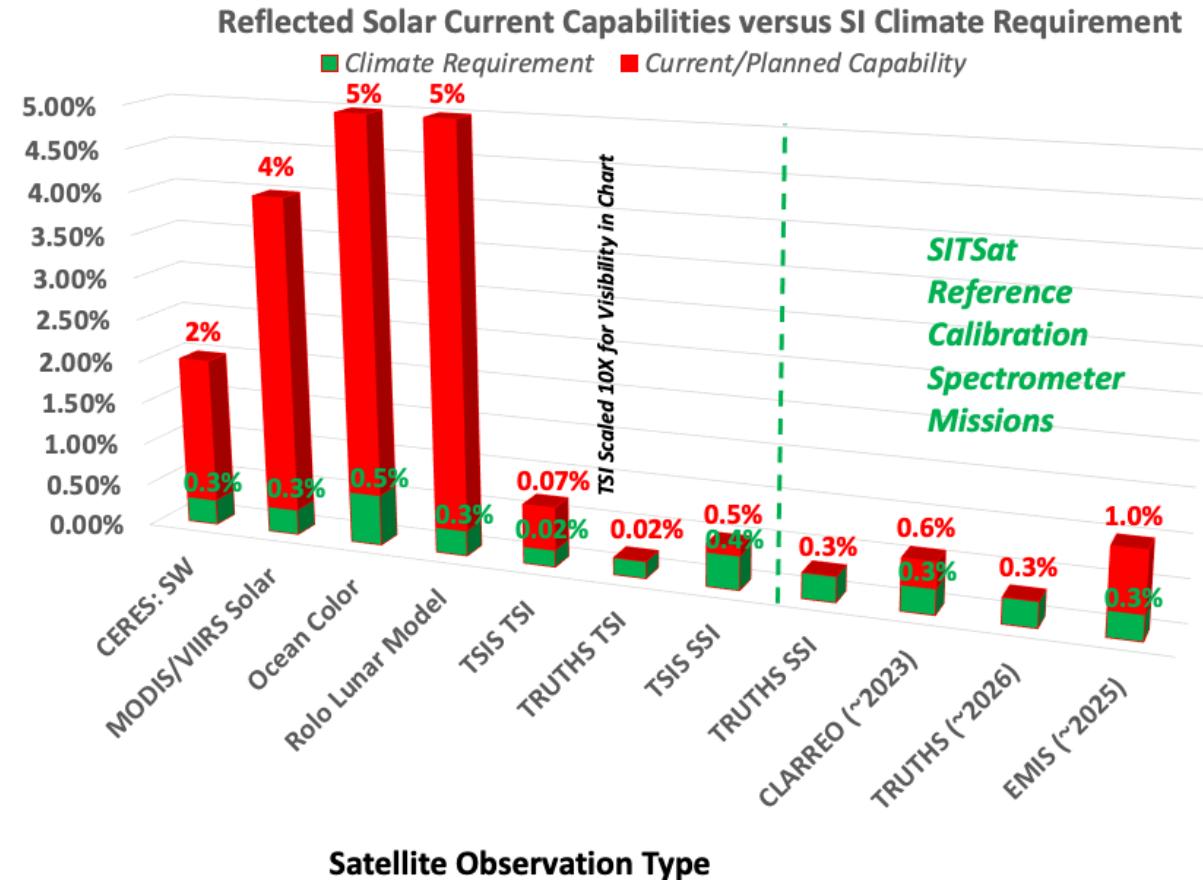
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7. Thermal Infrared
8. Reflected Solar Measurements

X. Xiong, J. Butler, T. C. Stone, C. Lukashin, K. Turpie,
D. Helder, W. Sun, Y. Shea, B. A. Wielicki, R. R. Baize,
G. A. Fleming

- Reviewed calibration of current operational VIS/NIR sensors compared to climate reqs.

Calibration Uncertainty (95% confidence)





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9. Microwave

*D. Houtz, P. Rosenkranz, H. Yang, M. Burgdorf,
R. V. Leslie, W. Blackwell, E. Kim,*

- Microwave sounders provide high impact observations for NWP
- Current satellite sensors are optimized for weather, not climate
- Further calibration improvements would bring large benefits



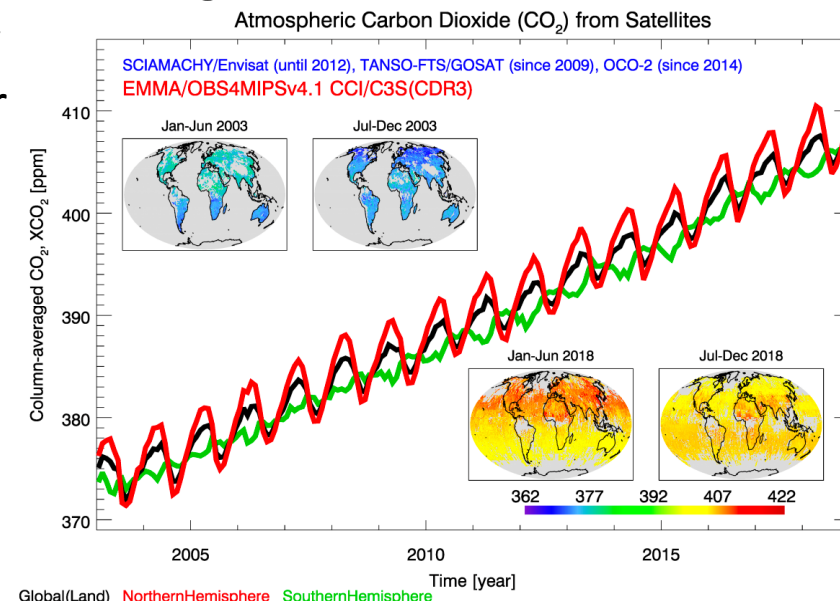


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10. Additional Applications

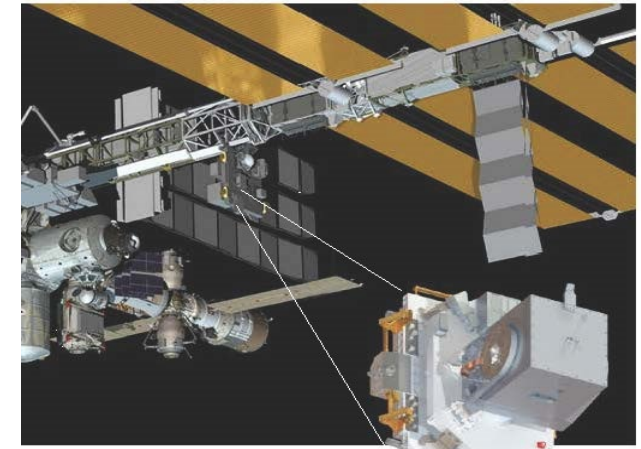
F. Carminati, C. Harlow, Y. Shea, D. Helder, S. Simis, T. Jackson, G. Zibordi, H. Boesch, T. Trent

- Reviewed benefits of applying SITSats to:
- Numerical Weather Prediction
- Cloud Radiative Forcing
- Land Imaging
- Ocean Colour
- Trace Gases





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10. Additional Applications
11. SITsats in Development

G. Kopp, P. Pilewskie, P. Smith, B. Wielicki, C. Lukashin, G. Fleming, C. Currey, D. Goldin, C.M. Roithmayr, Y. Shea, W. Sun, K. Thome, A. Wu, X. Xiong, N. Fox, P. Green, X. Ye, X. Zhang, X. Yi, C. Lin, L. Wang, H. Brindley, R. Bantges, L. Palchetti, S. Buehler, B. M. Dinelli, L. Labonnote, Q. Libois, M. Mlynczak, H. Oetjen, M. Ridolfi, M. Riese, R. Saunders,

- NASA CLARREO Pathfinder on ISS
- ESA TRUTHS
- Chinese Space Agency CSRB
- ESA FORUM
- Chinese Space Agency LIBRA
- **Multiple independent sensors for verification (as for international metrology standards)**



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10. Additional Applications
11. SITSats in Development

12. Conclusions

Bruce Wielicki , Tim Hewison, Nigel Fox, Greg Kopp

- 3 page conclusions
- Including Recommendations of Workshop...



SITSCOS Workshop Report: Recommendations 1

- **Space agencies should plan a long-term operational SI-traceable climate observing system, building on the currently planned SITSats**
 - Overlapping continuity improves sensitivity monitoring climate change due to natural events
 - With SI traceability, gaps in observations may not compromise long-term data record
- **NASA should plan for CLARREO Pathfinder to intercalibrate additional sensors and surface sites**
 - Should also extend the mission operations plan to five years to enable overlap with the TRUTHS and CSRB SITSats
- **Encourage U.S. to add IR SITSat spectrometer**
 - to reach required goals from independent sensors through entire thermal-infrared spectrum
 - The complimentary FORUM mission covers the far-infrared
 - Chinese LIBRA mission aims to achieve those goals through improvement of multiple missions



SITSCOS Workshop Report: Recommendations 2

- **Use the Moon to improve reflected-solar sensors' calibration accuracies and stabilities**
 - Lunar observations enable stabilities of < 0.1 %/decade
 - Further improvements in the accuracy of lunar irradiance models are required
- **Passive microwave instruments require further work on SI-traceability**
 - for climate-change accuracies of calibration references
 - to demonstrate reference calibration sensors in orbit
- **FRM surface measurements complement SITSats**
 - Integrate to further improve models and understanding of processes and Earth cycles
- **Plan follow-on SITSCOS workshop for 2026 to consider early results and status of SITSat missions**
 - Include progress and plans for SI traceability of microwave, polarimeter, and active satellite sensors

Where to Find the Report: CEOS Cal/Val Portal

CEOS Cal/Val Portal SITSCOS WS

esa /sitscos-ws

search... Everything

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- WGCV 46
- WGCV 47

SITSCOS WS

- Report and Actions
- WS Materials

Contacts



SI-Traceable Space-based Climate Observing System Workshop (SITSCOS) - Event Dates: 9-11 September, 2019 - National Physical Laboratory in London, UK

The SI-Traceable Space-based Climate Observing System Workshop (hereafter denoted SITSCOS) was hosted by the National Physical Laboratory in London, UK, 9-11 September 2019 and sponsored by the UK Space Agency. The workshop was organized under the auspices of the Global Space-based Inter-Calibration System (GSICS) and the Committee on Earth Observation Satellites - Working Group on Calibration and Validation (CEOS-WGCV). The goal of the workshop was to quantify the benefits and resulting requirements of a space-based climate observing system and produce this [Workshop Report](#) summarizing current measurement capabilities, climate-based needs, and future plans for implementation. The international workshop included about 100 attendees and spanned users, satellite instrument designer/builders, metrologists, and space agencies with expertise across a wide range of applications and technologies.



Group photo at the SITSCOS Workshop. NPL UK Sept 2019

Please visit the [Workshop Report and Actions page](#)