NPL

GEO, CEOS and the NMIs

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Chair IVOS sub group of CEOS WGCV

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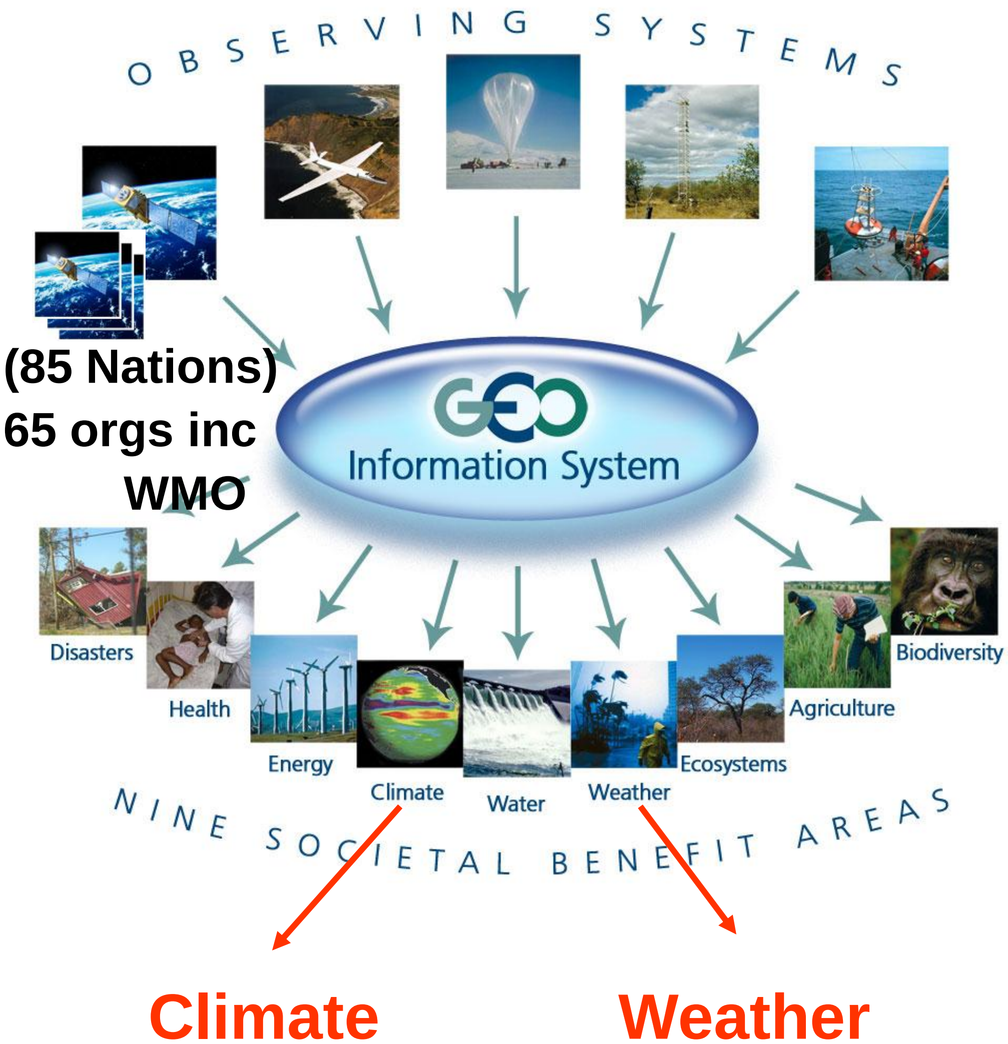
“Community” requirement



- **The Group on Earth Observations (GEO)’s (founded 2002) Global Earth Observation System of Systems (GEOSS) <u>must</u> deliver comprehensive “knowledge / information products” worldwide and in a timely manner to meet the needs of its nine “societal benefit areas”.**

- **This will be achieved through the synergistic use and combination of data derived from a variety of sources (satellite, airborne and *in-situ*) through the coordinated resources and efforts of the GEO members.**

- **Achieving this vision (2015) requires the establishment of an operational framework to facilitate interoperability and harmonisation.**

CEOS Organization

Committee on Earth Observation Satellites

- **Established 1984**
- **Now "space arm" of GEO**

Working Group on Calibration and Validation (WGCV)

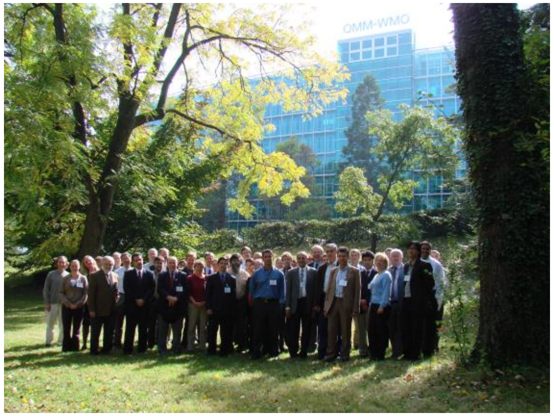
- **Atmospheric Composition (ESA)**
- **Infrared Visible & Optical Sensors (NPL)**
- **Land Product Validation (NASA)**
- **Microwave sensors (CSSAR)**
- **Synthetic Aperture Radar (DLR)**
- **Terrain Mapping (UCL)**

Tasked to: establish a QA strategy for GEO

Strategy development: community engagement

Strategy development led by small CEOS team through two community workshops, CEOS sub-groups and ad-hoc meetings

"GEO/CEOS workshop on quality assurance of calibration and validation processes":



"Guiding principles" (*Geneva Oct 07)*

"Establishing an operational framework" (*Washington May 08)*

QA4EO →

"Facilitating implementation" (*Antalya Oct 09)*

Inc WMO +

CEOS endorsed – Nov 08

Now evolving to meet all EO needs of GEO inc in-situ

GEO QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION CEOS

IVOS MISSION statement

Mission

"To ensure high quality calibration and validation of infrared and visible optical data from Earth observation satellites and validation of higher level products"

IVOS Terms of Reference

1. Promote international and national collaboration in the calibration and validation of all IVOS member sensors.

2. Address all sensors (ground based, airborne, and satellite) for which there is a direct link to the calibration and validation of satellite sensors;

3. Identify and agree on calibration and validation requirements and standard specifications for IVOS members;

4. Identify test sites and encourage continuing observations and inter-comparison of data from these sites;

5. Encourage the preservation, unencumbered and timely release of data relating to calibration and validation activities including details of pre-launch and in flight parameters.

6. In the context of calibration and validation encourage the full consideration of "traceability" in all activities involved in the end-to-end development of an EO product including appropriate models and algorithms.

IVOS

Operational framework:

Principles and scope (space example)

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All activities which contribute to the delivery of an end product derived from an input measurand

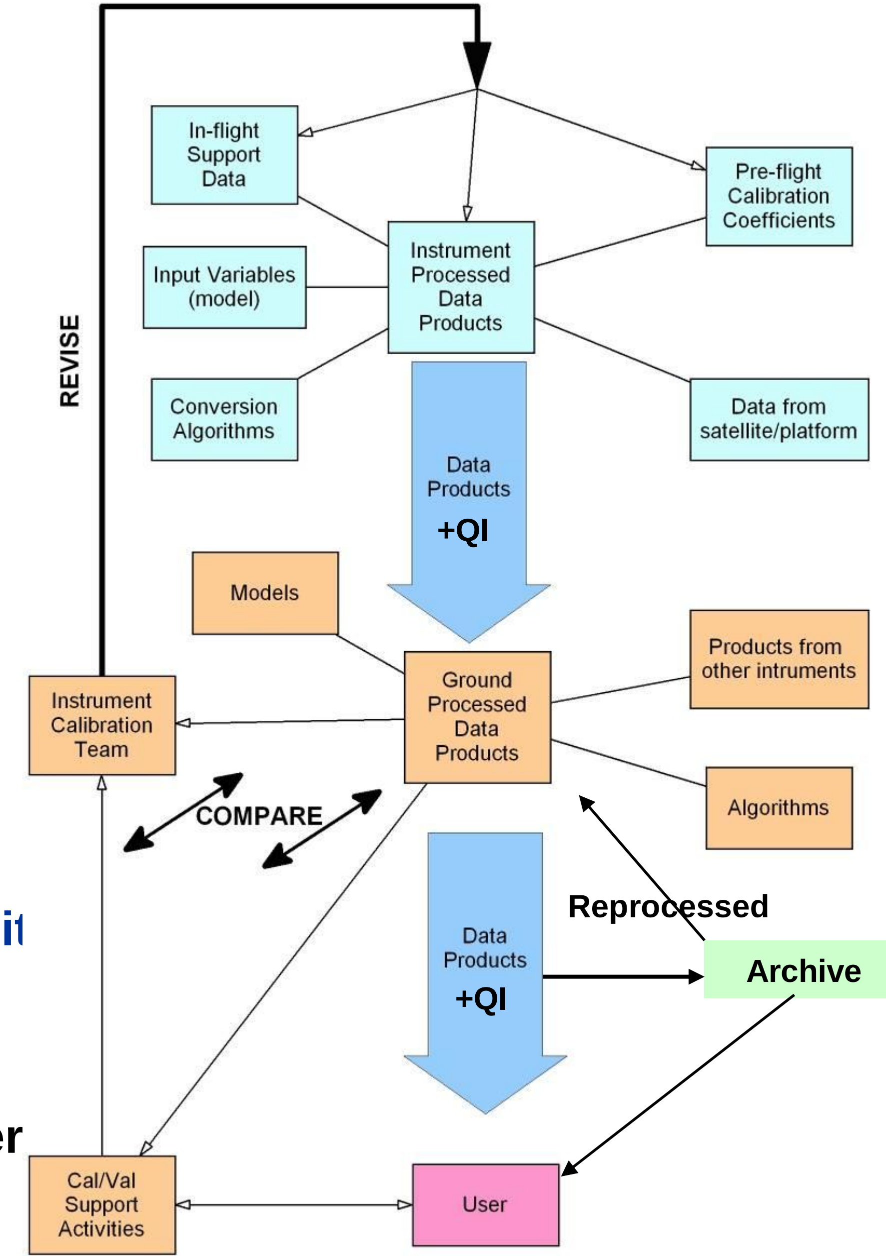
Pre-Flight

- **Requirement/Design Specification**
- **Instrument build: characterisation/calibration**
- **Data processing: algorithms, ref/support data,**

Post-Launch

- **Instrument performance**
- **Output data quality characteristics:**
  - **accuracy**
  - **equivalence to others (sensors/in-sit**
- **Processing – high level products**
- **Data distribution/archive …**

Collection – Processing – Validation - Deliver



Initiated (2008) by "space-community" on behalf of GEO to facilitate harmonisation and interoperability – Quality does not have to be "best" simply quantified

QA4EO Principle

Data and derived products shall have associated with them a fully traceable indicator of their quality

Quality Indicator

(QI)

Traceability

Data Quality guidelines: QA4EO-QAEO-GEN-DQK-….

…001: A guide to establishing a Quality Indicator on a satellite sensor derived data product

…002 A guide to content of a documentary procedure to meet the Quality Assurance requirements of GEO

largely based on formal ISO Quality management ISO 17025

…003 A guide to "reference standards" in support of Quality Assurance requirements of QA4EO

…004 A guide to comparisons – organisation, operation and analysis to establish measurement equivalence to underpin the Quality Assurance requirements of QA4EO Based on CIPM MRA (CCPR guidelines) http://www.bipm.org

…005 A guide to establishing validated software, algorithms and models to underpin the Quality Assurance requirements of QA4EO

…006 A guide to expression of uncertainty of measurements

GUM (ISO guide to uncertainty of measurement)

…007 A guide to establishing quantitative evidence of traceability to underpin the Quality Assurance requirements of QA4EO

CEOS WGCV:IVOS “instrumented sites” (LandNet)

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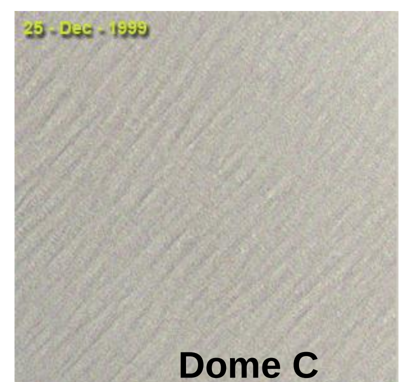
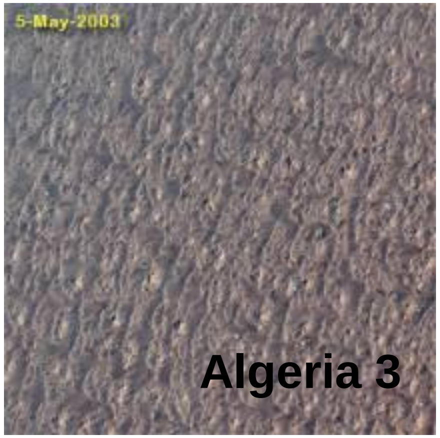
Reference stds for radiometric gain (land imagers) Ideally Need Ten!

- Spatially uniform, bright, large (pixels from 10’s to 100’s m)
- Standardised procedures to aid characterisation (and for new sites)
- Comparisons of “field measurement” instruments & techniques to ensure consistency and “traceability”



CEOS WGCV IVOS: “stability” Reference standards



Need wide range of Reference standards including “intrinsic standards” (methods) & transient stds

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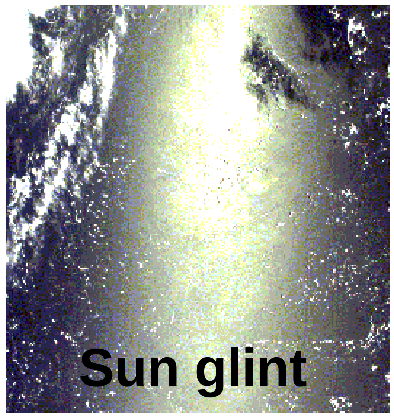
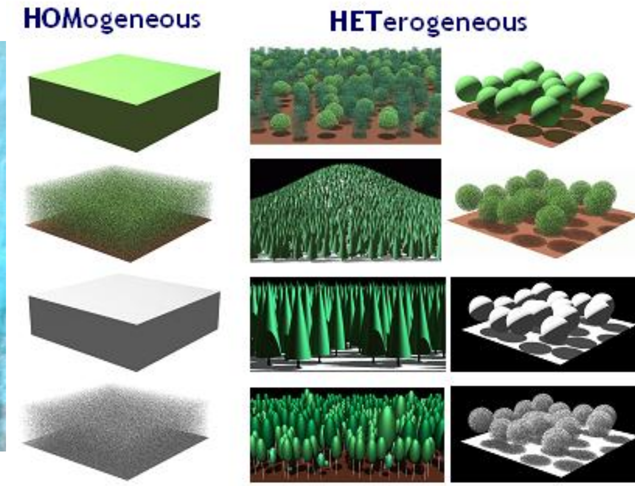
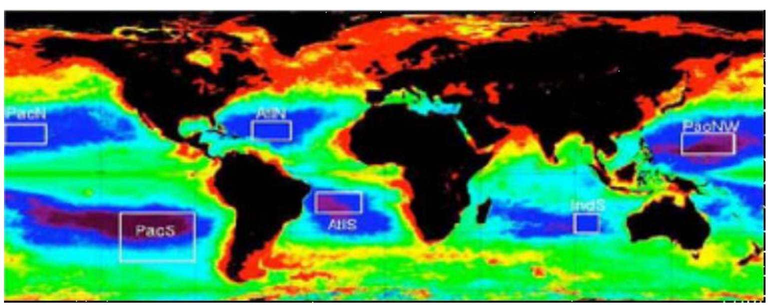




Radiation Transfer model intercomparison (RAMI) of JRC



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

Ocean buoys & ships

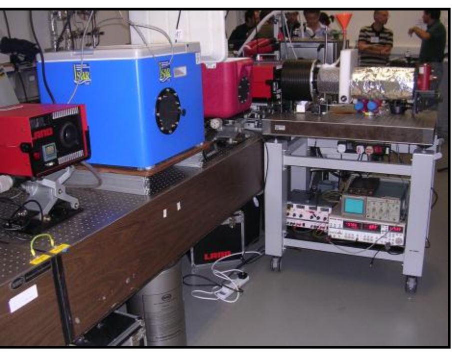
“test data sets” to evaluate models, algorithms and software

CEOS International comparisons to assess biases and develop "best practise"

see: ***http://calvalportal.ceos.org***

"Ocean Colour"

Land surface reflectance comparisons including BRDF with GRASS (hot and cold) also with sats



Sea surface temperature (Lab and Oceans)

Optical uncertainty requirements (GCOS) for decadal climate change UN Global Climate Observing System

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Objectives for SI traceability	Climate Requirement	Pre-flight	In-flight	Terrestrial	Primary
Solar Irradiance	0.01%	0.2%	?	0.2%	0.01%
Spectral radiance (clouds, albedo)	0.3%	2% - 5%	?	-1%	<0.05%
Water-leaving radiance (Ocean Colour)	1%	5%	-5%	-1%	<0.05%

"Strategy!": Need to monitor change – not necessarily absolute values

- Sensors only require "sensitivity" and stability (or means to check) and sufficient overlap with another sensor to avoid data gap

High risk: **- Guaranteed Data continuity - high cost – "data-gaps" likely**

- small drifts undetected - potential bias build-up with time

- discourages innovation

- sensitive to natural fluctuations (particularly during "overlaps")

SI Traceability (maintained in operation) – Flexible observing, innovation, coherence between methods (traceability routes) and observing systems

Towards a: European Metrology Centre for Earth Observation and Climate (EMCEOC) http://EMRP.org

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- Transfer standards
- Comparisons
- Innovation on techniques
- Measurement & test protocols
- International link
- Independence

Modelling & Data processing

Pre-flight

QA

Traceability

Advice

Audit

Validation

Calibration

Public sector

Private Industry

Academia

Funded partners: JRC,

+ NMIs of D, F, I, CH & Fi

Towards a "European Metrology Centre for Earth Observation and Climate" (EMCEOC)

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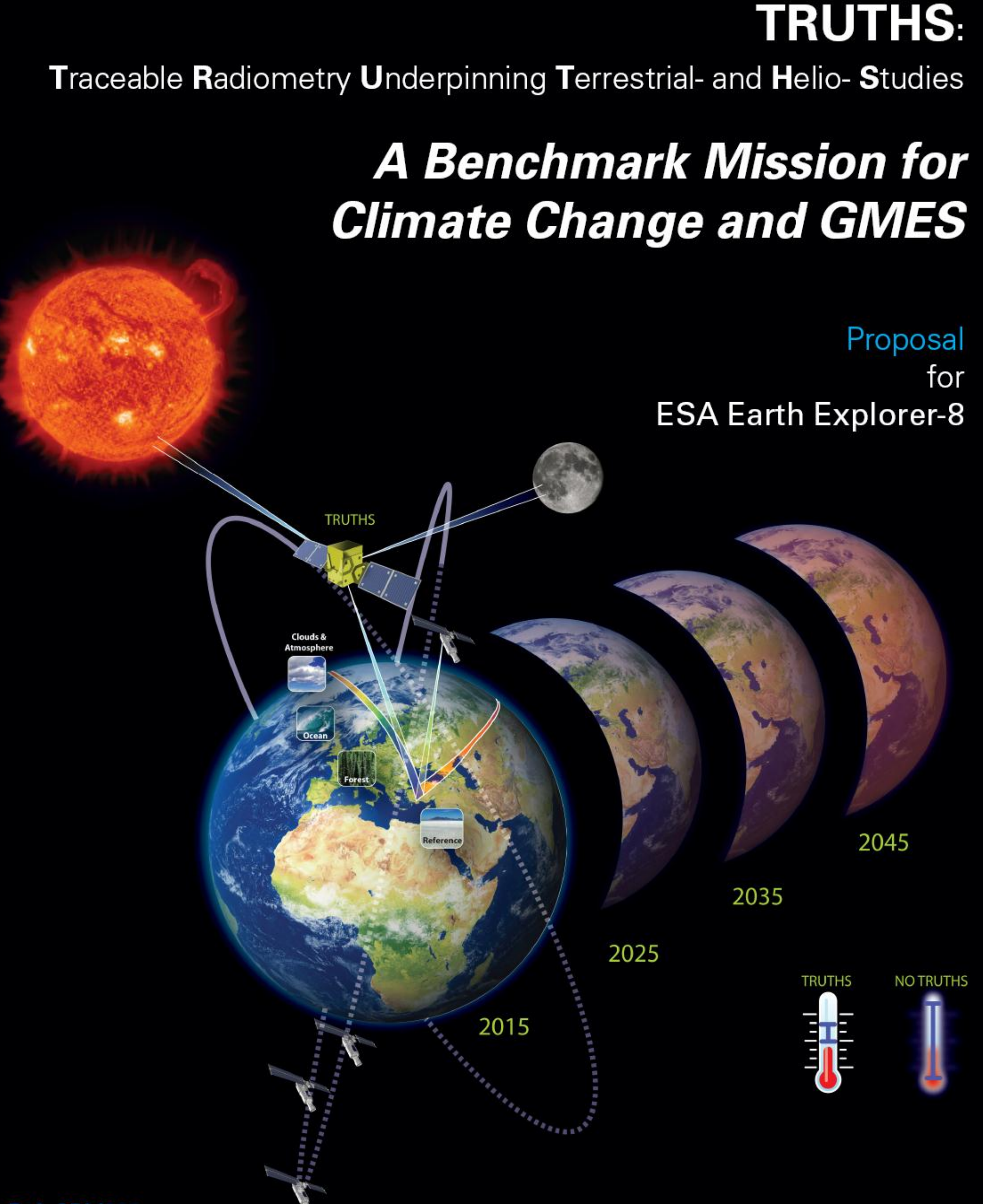
EU funded Project: ~40 MY over 3 yrs

Vision to be a "one-stop-shop" for EO metrology in Europe

Starts ~ Oct 2011

Case study projects: largely optical – illustrate range and scope

- **Pre-flight laboratory-based calibration standards and methodologies**
  in vacuum spectral radiance traceability, Stray light, linearity, microwave sounders
- **On-board calibration standards**
  Flat plate IR black bodies for limb sounders (accuracy ~0.1 K)
- **Recovering/establishing in-flight traceability through reference standard measurements and test-sites**
  Ocean Colour Cal/Val (target 1%), RT codes, field spectroscopy (leaf level) autonomous self-calibrating networks
- **Prototype in-flight SI traceability methodology - TRUTHS mission**
- **Supporting international QA and providing training**
  e.g. uncertainty/traceability of forest carbon



Ref: CRM329 Fox et al Phil. Trans. R. Soc. A (2011) 369, 4028–4063

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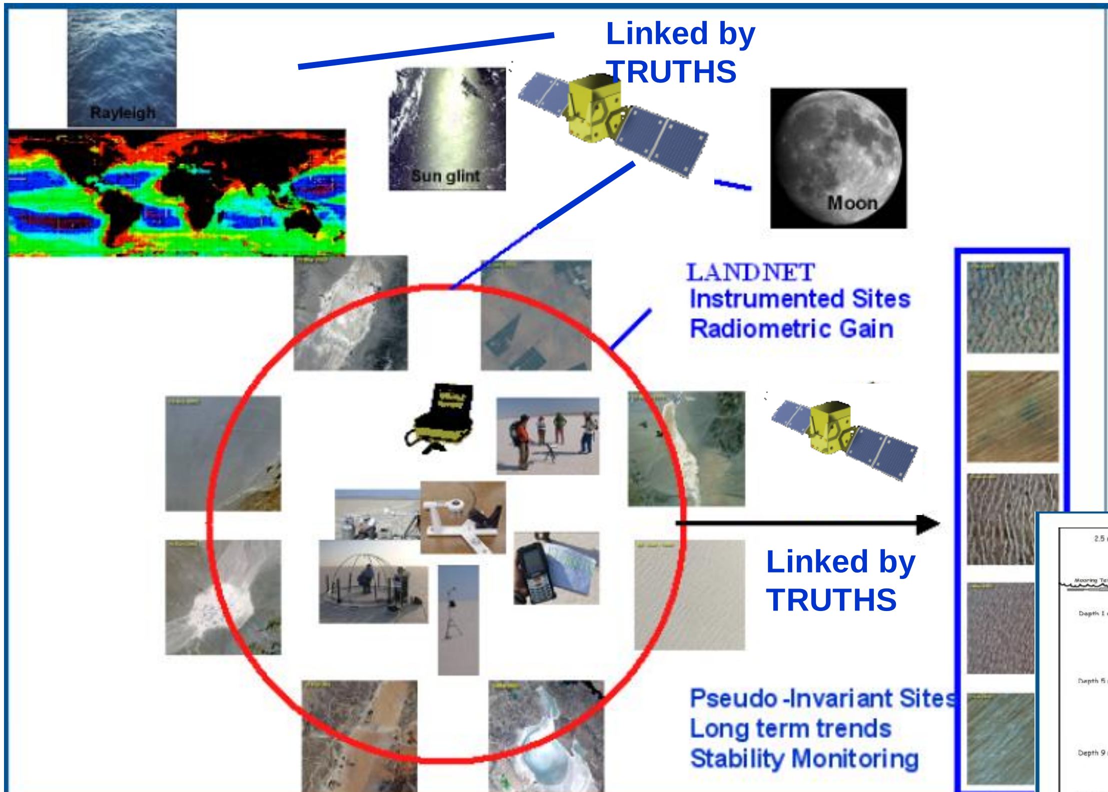
Climate studies require:

- **Global coverage**
  - ***observations (insensitive to time/location/scale)***
- **Decadal time scales**
- **Uncertainties close to primary SI standards/realisations**

EO “customers” (via GMES, GEOSS + £services) seek:

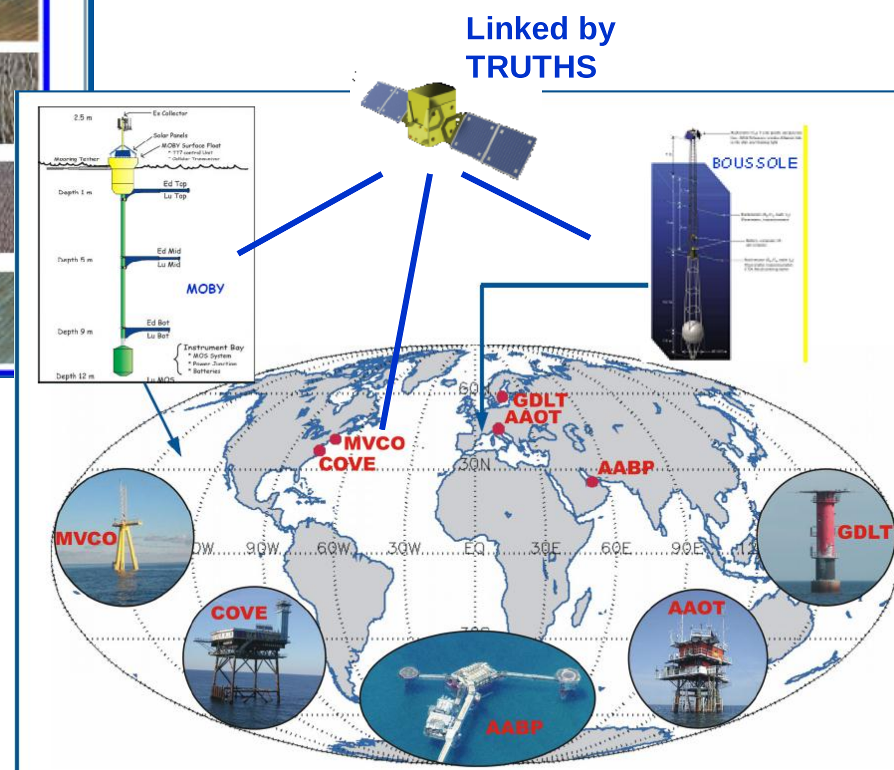
- **Timely, reliable & “fit-for-purpose” knowledge from:**
  - **integrated sources**
  - **international harmonised**
  - **affordable cost**
  - **(some) at climate quality**
- **Must have quality system**
  - **traceable uncertainty**
  - **e.g. QA4EO**

Operational calibration service through "CEOS standard" sites/methodologies



Networks of test sites and methodologies can become operational calibration service

Improved through use of reference standard SI traceable sensor e.g. TRUTHS



CEOS endorsed test sites for Land and Ocean can be used as standards to cross-compare between sensors and to ground data providing each site is compared to each other

Conclusion

- Earth observation (climate change) provides some of the biggest challenges to optical radiometry
- Close partnership between NMIs and EO expert community essential for long term success