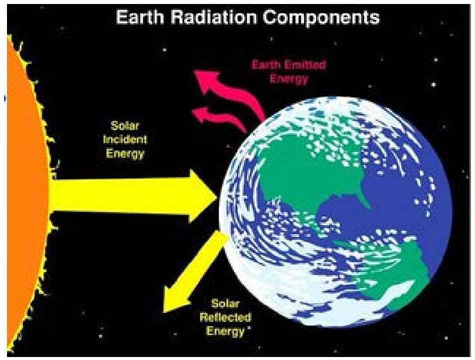
ENVIRONMENT

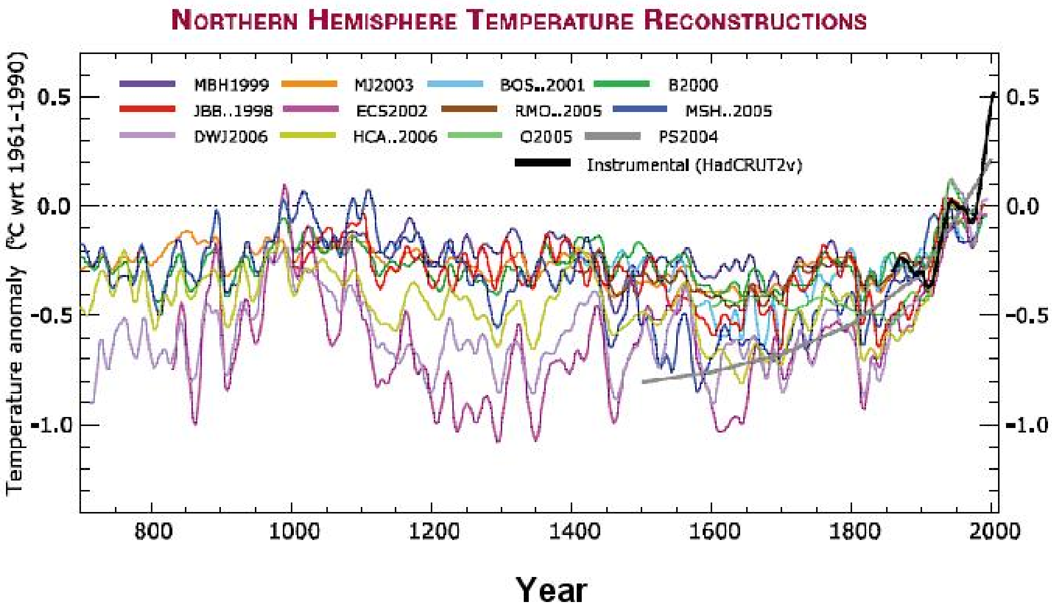
CHALLENGES FOR EURAMET TO MEET THE NEEDS OF EARTH OBSERVATION AND CLIMATE

Marek Smid

TC-PR EURAMET Chair

Climate Change - one of the most important question and meteorology challenge



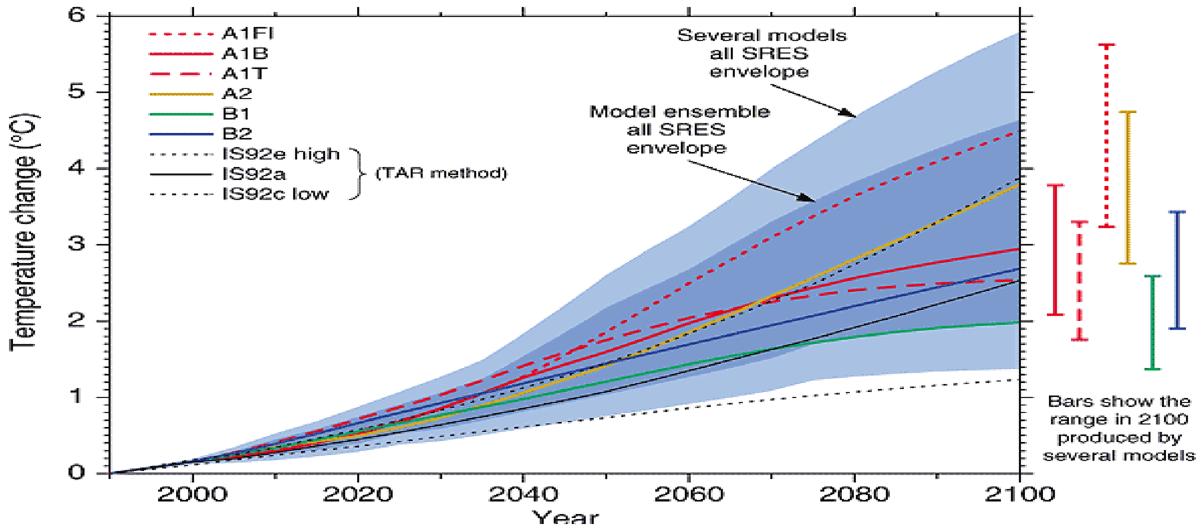


Key Societal Questions

- Is the Earth warming ?
- If so how much ?
  - And by when?
  - What will this mean?
- What is the cause ?
- Can we detect it ?
- Can we stop it ?
- Can we adapt?
- ..
- Do we care ?

“A warming Earth” - How Much?

All climate models reliably predict the past (nearly) but provide wide variances in their prediction of the future.



IPCC Emission scenarios

Uncertainty in data/feedbacks limits ability to discriminate trends to ~ 30+ yrs!!

Strategic decisions need sronger evidence - Need to test and constrain models with data more accurate than natural variability.

(85 Nations)
65 orgs inc WMO

Decadal timescales

Small trends from background of weather

WMO defined set of key parameters- 50 Essential Climate Variables (ECV)

GCOS

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

IMPLEMENTATION PLAN FOR THE
GLOBAL OBSERVING SYSTEM FOR CLIMATE
IN SUPPORT OF THE UNFCCC

(2010 UPDATE)

Global climate observing system
ECV's of WMO-GCOS

50 ECV's with monitoring requirements,

Domain	GCOS Essential Climate Variables
Atmospheric (over land, sea and ice)	**Surface:**[1] Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. **Upper-air:**[2] Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance). **Composition:** Carbon dioxide, Methane, and other long-lived greenhouse gases[3], Ozone and Aerosol, supported by their precursors[4].
Oceanic	**Surface:**[5] Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton. **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers.
Terrestrial	River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture.

Pronounces the need to detect small decadal trends from background of natural variability (weather)

Requires trustworthy global observations over decades

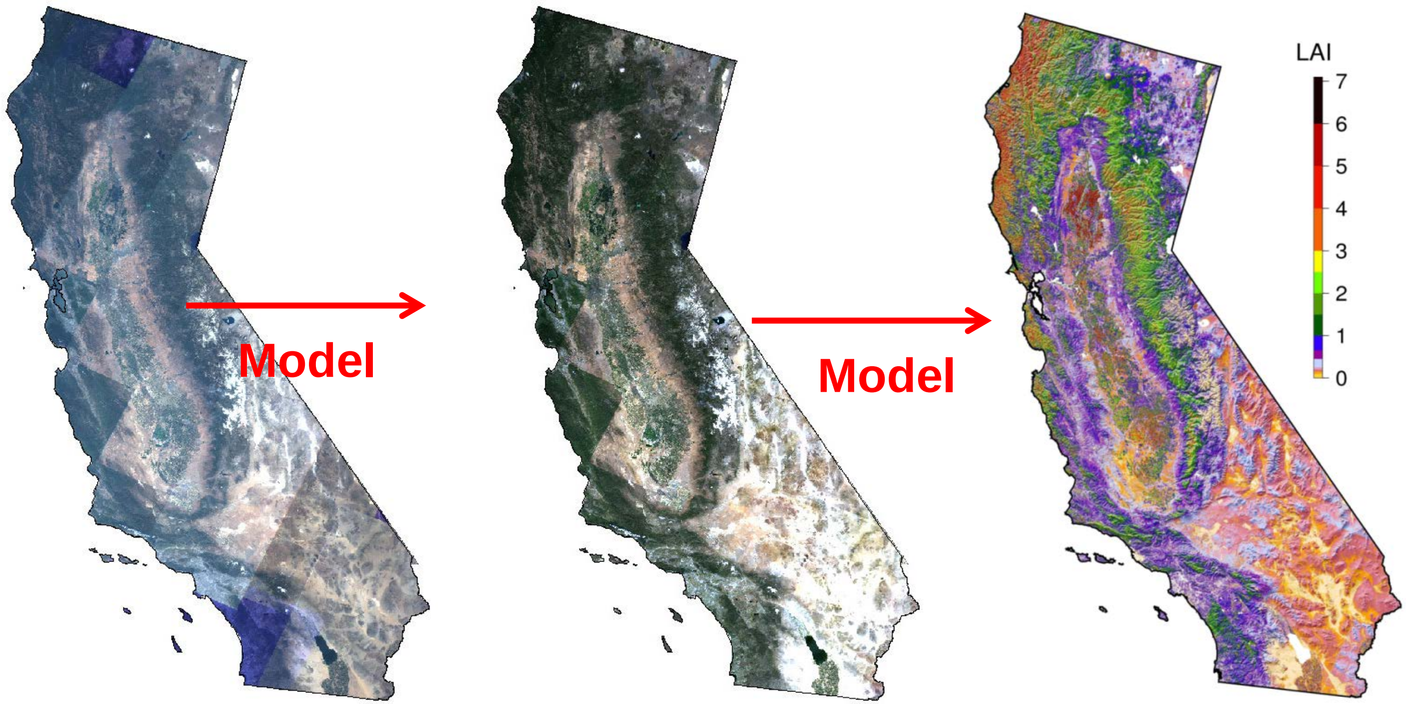
NEEDS:

- **Satellites**
- **In-situ validation**
- **Interdependent measurands/algorithms**
- **SI TRACEABILITY**

http://www.wmo.int/pages/prog/gcos/Publications/gcos-138.pdf

Measured quantity to required Information

L1T At-sensor Radiance (FCDR) | **Surface Reflectance (TCDR)** | **Leaf Area Index (ECV)**



Courtesy Rama Nemani, NASA Ames

- **Many (ECV's) are bio-geo physical parameters**
- **=> Measured quantity is first step to desired measurand**

Defining the measurand:
How to measure the ECV Sea Surface Temperature (SST)

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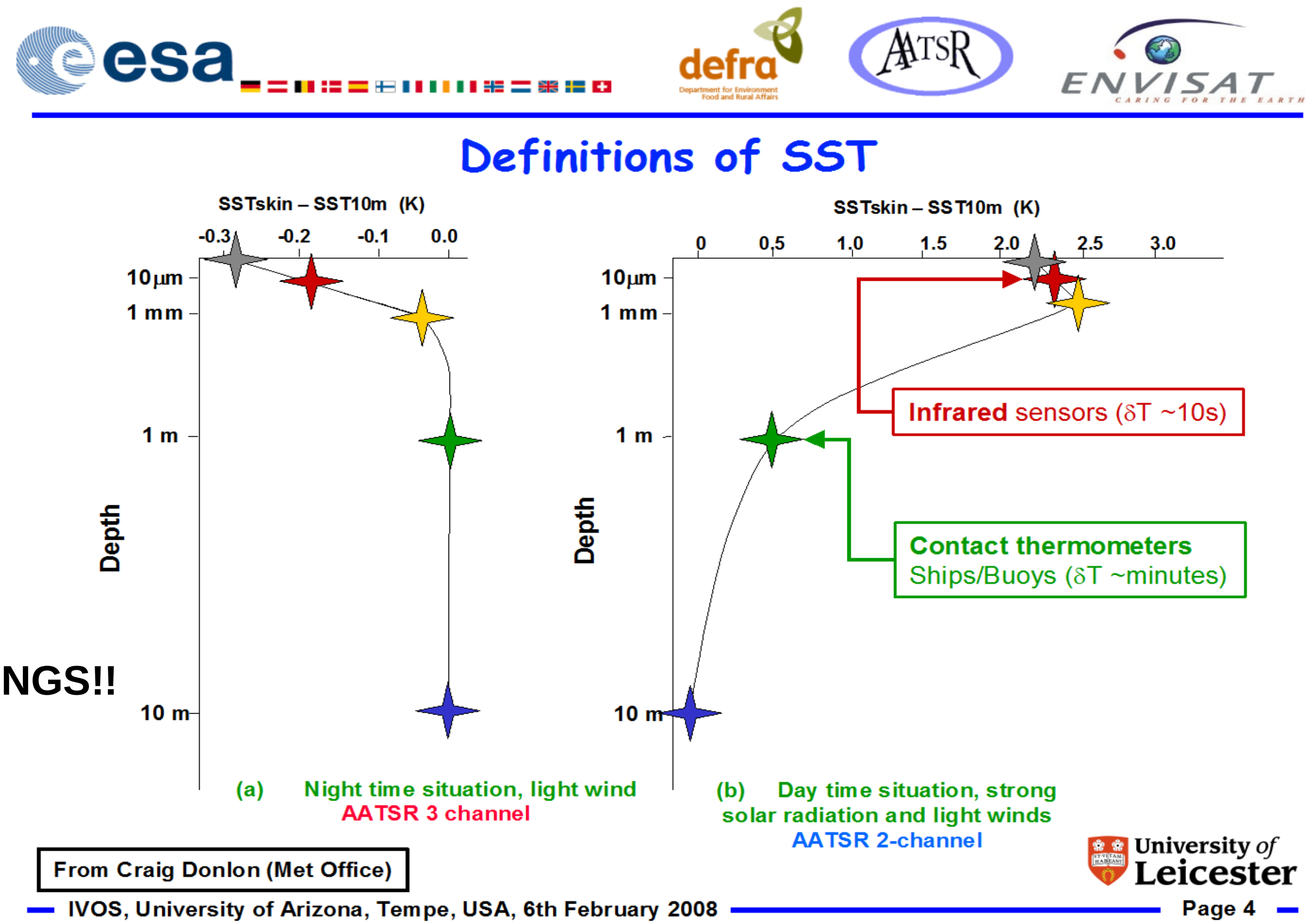
Oceans big heat sink of energy - temperature rise slow and indicative of Climate warming – leads to expansion & sea level rises etc:

Climate models predict SST to change ~0.2 K per dec

How is measured?

- Ships sampling
  - Buckets
  - Hull thermometers
  - Radiometers
- Ocean buoys
  - Drifting
  - Tethered
  - Robotic
- Satellites

ALL MEASURE DIFFERENT THINGS!!



What is Earth Observation?

Remote sensing of the Earth from Space: (utilising full EM spectrum)

But also In-situ

>100 civilian EO satellites launched in 2000 – 2010

>200 expected to be launched in current decade at a cost of $20B

Operated by > 34 countries   Surface resolutions <1 m

Quality of Data to Decision

Old philosophy:

"Only need to measure change, therefore only need sensitivity and overlaps!"

High Risk

- **Guaranteed continuity of data**
- **Small drifts may propagate undetected**
- **Natural variability during overlaps**

.. emphasis on heritage not innovation

Metrology community must show benefits of SI Traceability

Key metrology challenges of GEOS – top level

- **Robust complete End to End (SI) traceability chains for parameters**
- **Representativeness of measurement**
  – sampling, environmental effects (lab/field/space)
- **Tailored transfer standards/methodologies to EO community**
  - accuracies close to primary realisations
  - challenging instruments (size, vacuum?, 'in-field', non-returned,….)
  -Need to establish with community e.g. WMO/ESA 'test-sites' with SI traceability

    Natural targets e.g. deserts/snow, networks of Ocean buoys, mountain top Observatories of the atmosphere, ….

  -…
- **Consistent use and understanding of terminology** (Error vs Uncertainty)
- **NMIs need close interaction with EO/climate community & organisations**

http://www.bipm.org/utils/common/pdf/rapportBIPM/2010/08.pdf

Key metrology challenges of GEOS – measurement areas

Microwave sensors (sounders/imagers)

- NMIs to support traceability and QA specifications

Atmospheric composition/GHGs

- Need new primary reference standards (range of species) for instrument validation and associated sites (including mitigation needs)
- Improved spectroscopic reference data for various species (lab and atmos)

Surface temperature

- Improve accuracy and traceability of Ocean buoys and linkage with other systems

Radiation Balance

- Need high accuracy long term measurement of incoming and outgoing radiation from space through - In-orbit SI traceable standards of sufficient accuracy e.g. CLARREO/TRUTHS
- Improve traceability of ground networks UV to IR include replace WRR with SI e.g. CSAR

Surface properties (via reflected solar)

- Needs robust broader traceability of algorithms back to sensor

Ocean Salinity

- Standards/methods for PH
- Standardise reference equations used across discipline/communities

JRP: Metrology for Earth Observation and Climate (MetEOC):

Project coordinator: Nigel Fox, NPL

Partners:

NPL National Physical Laboratory

PTB

INRIM Istituto Nazionale di Ricerca Metrologica

pmod wrc

MIKES

LNE

European Commission Directorate-General Joint Research Centre

Jülich Forschungszentrum

Bergische Universität Wuppertal

DLR

Geodetiska Institutet

A!

Collaborators:

esa

EUMETSAT

Surrey Satellite Technology Ltd

CEOS

cnes

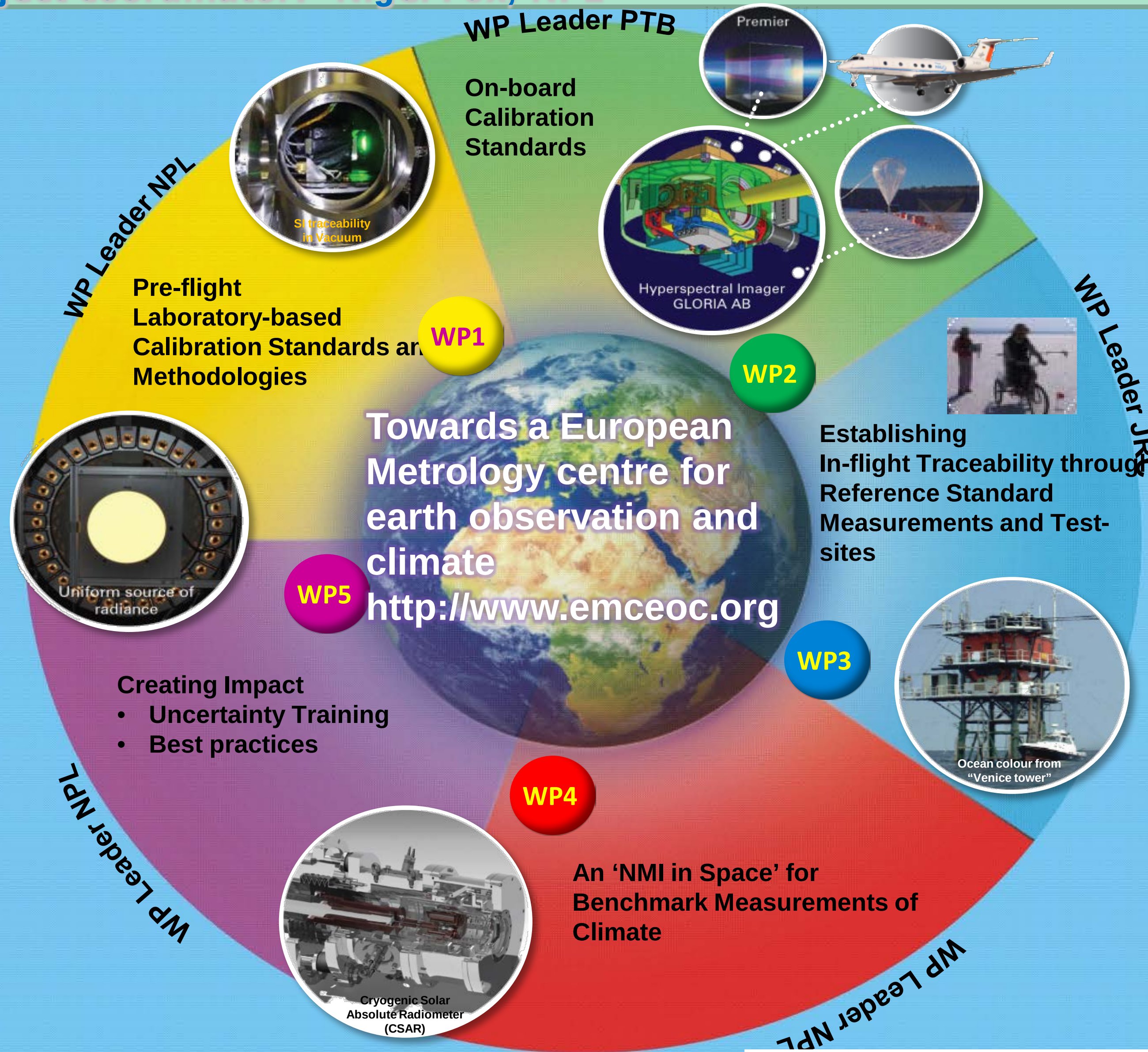
KIT Karlsruhe Institute of Technology

GEO

ECMWF

Science & Technology Facilities Council Rutherford Appleton Laboratory

QA4EO A Quality Assurance Framework for Earth Observation



MetEOC-2: Metrology for Earth Observation and Climate

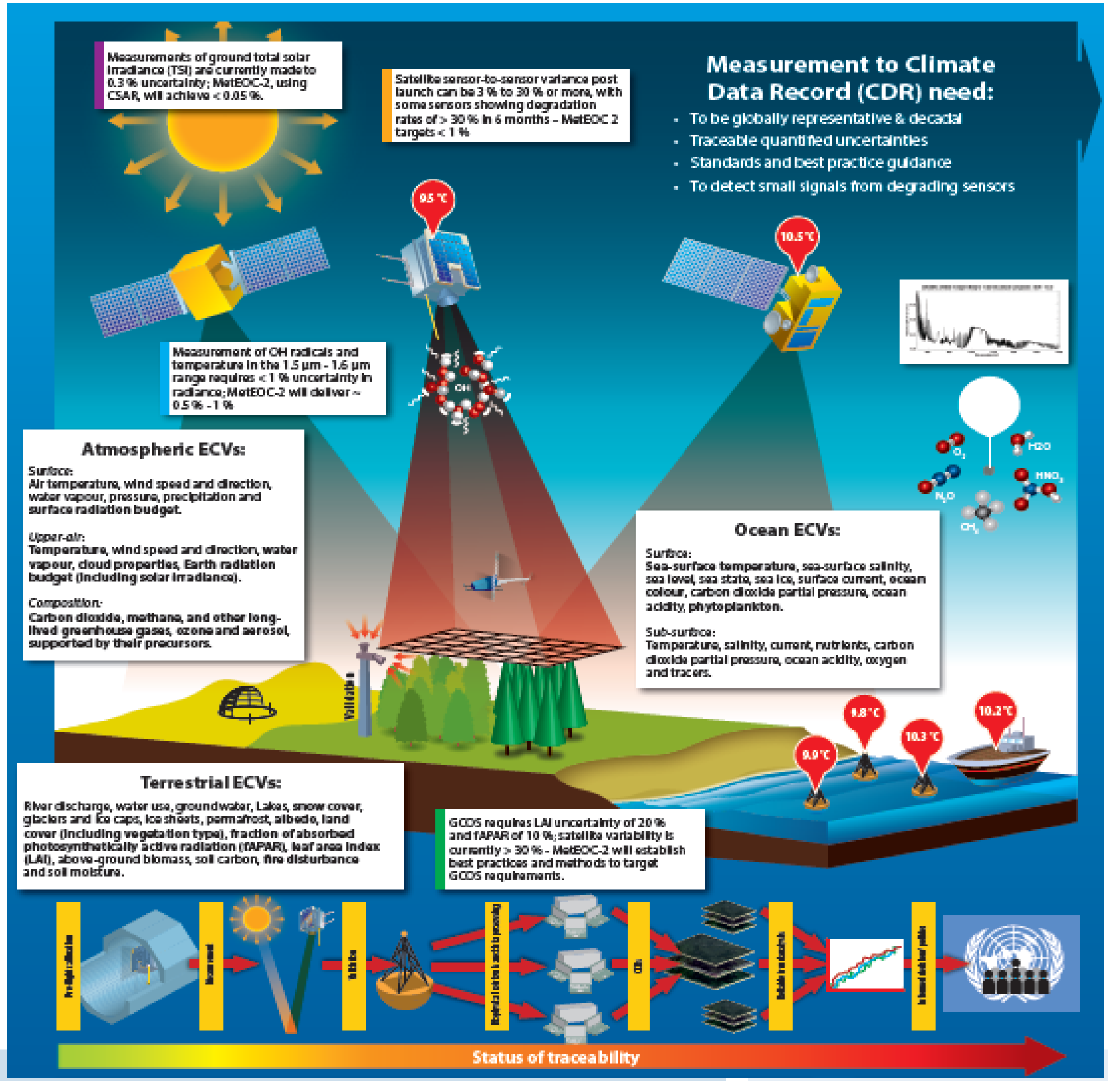
EURAMET
European Association of National Metrology Institutes

Will start in Sept. 2014
~ 40 man years of effort
- aligned to WMO, CEOS, GEO, ESA, etc ~15 collaborators

- **NMIs from, UK, F, D, Fi, I, NL, Cz, Sp, CH**
  + RAL, DLR, FGI, BUW, Ujul. UCL

MetEOC 1: resolved most critical pre-flight Cal needs of EO sector

- **Concentrates on Post-launch**
- **End to End Traceability & ECVs**
- **Seek to establish virtual centre of excellence**
- **Addresses ~15 ECVs in Land, Atmosphere, Ocean, Radiation**
- **Stakeholder support from industry , academia, international orgs**



HIGHGAS:
Metrology for high impact greenhouse gases

EURAMET
European Association of National Metrology Institutes

Metrology in chemistry addressing WMO ECVs

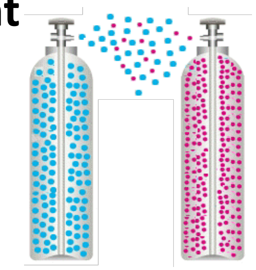
NPL National Physical Laboratory · VSL Dutch Metrology Institute · LNE · PTB · CMI · MIKES · DFM · EMPA · FINNISH METEOROLOGICAL INSTITUTE

June 2014

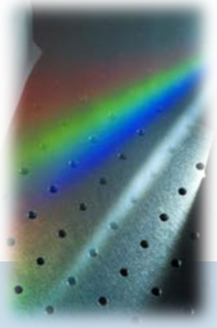
Metrology for high impact greenhouse gases

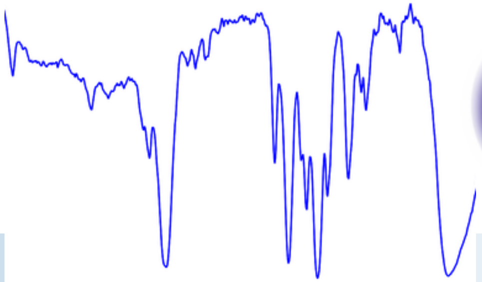
To deliver High accuracy primary reference gas mixtures

To develop dynamic methods for trace amount fractions and disseminate them to the field



To develop novel spectroscopic methods for isotopic composition measurements and deliver transfer standards for in-field measurements





In conclusion ..

- Climate Change is most critical issue facing mankind, dealing with requires global observations of the Earth
- Observing the Earth Is relatively easy
- Using EO Data for quantitative applications particularly long-term studies (Climate change) requires:
  - SI Traceable, Validated measurement systems, including models, with quality indicators (uncertainties)
- But it is hard!
- And involves rocket science …

I acknowledge the contributions of Dr. Nigel Fox, head of Earth Observation and Climate at NPL and the other EURAMET TC Chairs

Thank you!