Metrology for Climate Action: a perspective developed over 50 years

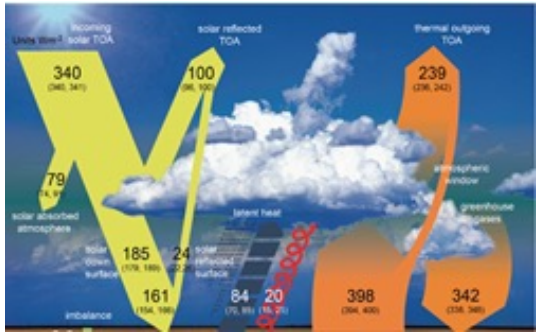
Bruce W Forgan
VP WMO Infrastructure Commission (INFCOM)

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

To Measure Is To Know



USA National Research Council

"When the global climate record emerges as a significant contributor to public policy (societal) decisions, that record will be attacked relentlessly. If the climate record cannot stand up to those attacks, the record cannot effectively serve society."

Charles Keeling's Axioms

Without a SI traceable measurement, time works ***against*** you
With a SI traceable measurement, time works ***for*** you

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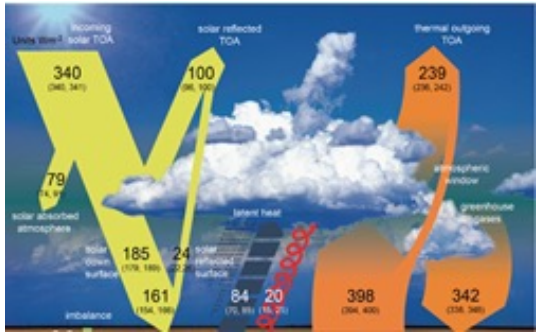
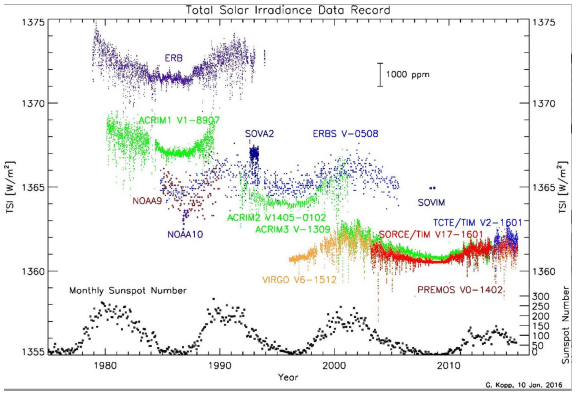
Environmental Metrology – My Milieu





Environmental Measurements → Models → Societal Benefit

So what men knew about seasons was true and sometimes not; it was questionable but not knowable, discernible by its origins but obscure in its presence and in its moment of ending. It was like so many things men accepted without wonder. Yet in that uncertainty lay the pivot point of existence.

Fortress of Eagles

C J Cherryh

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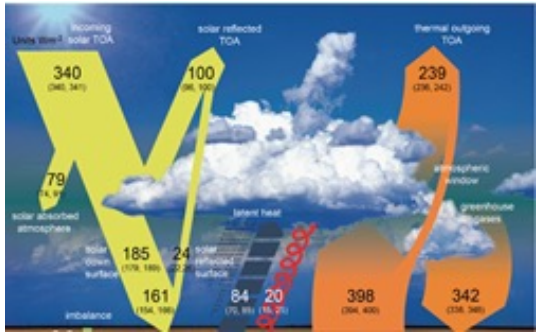
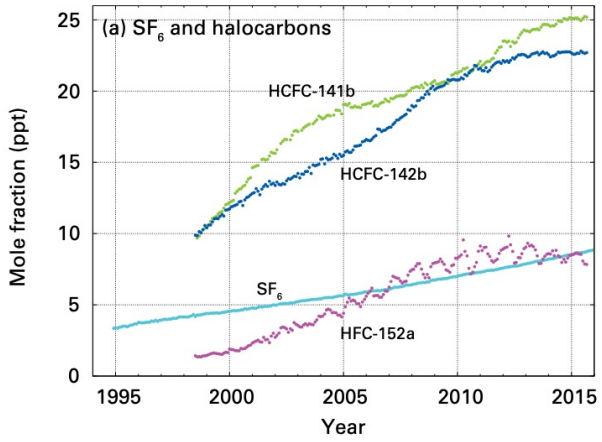
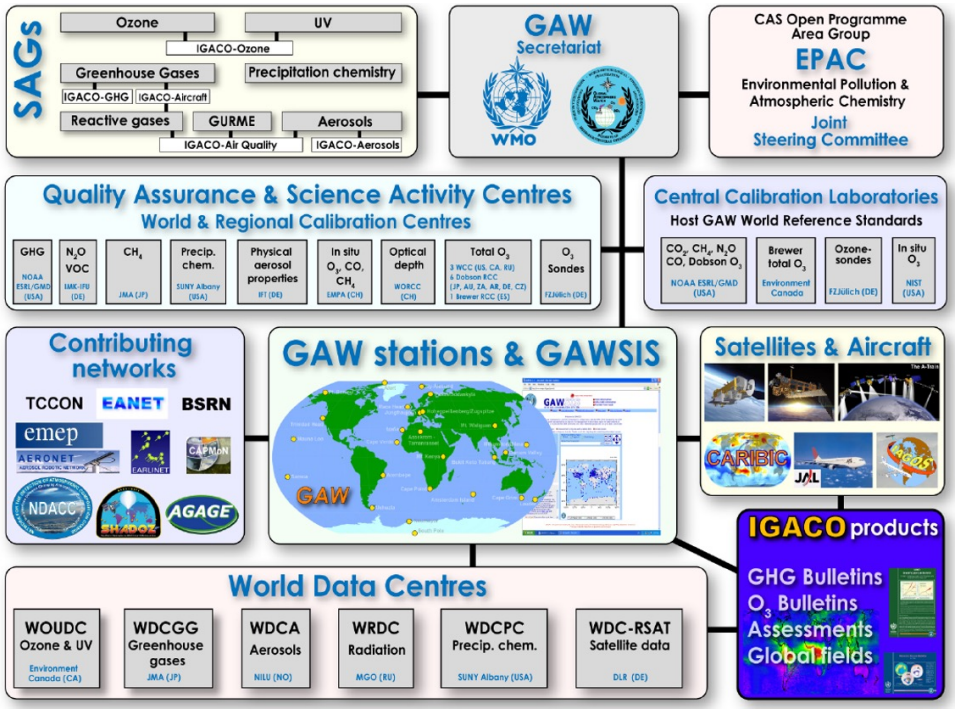
Where Metrology has Improved Environmental Information 1



Chemical Composition of the Atmosphere





WMO, BIPM and others,
Integrated Global Greenhouse Gas Information System (IG3IS)

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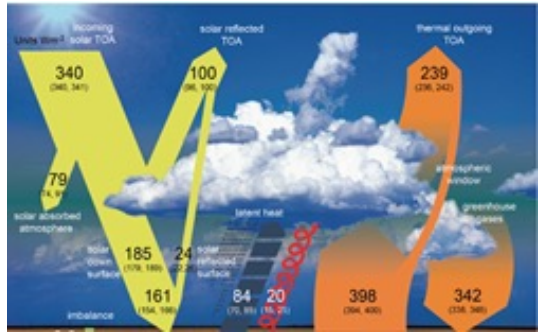
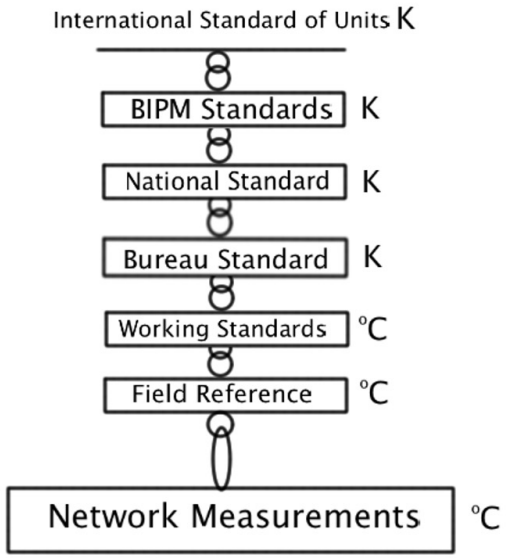
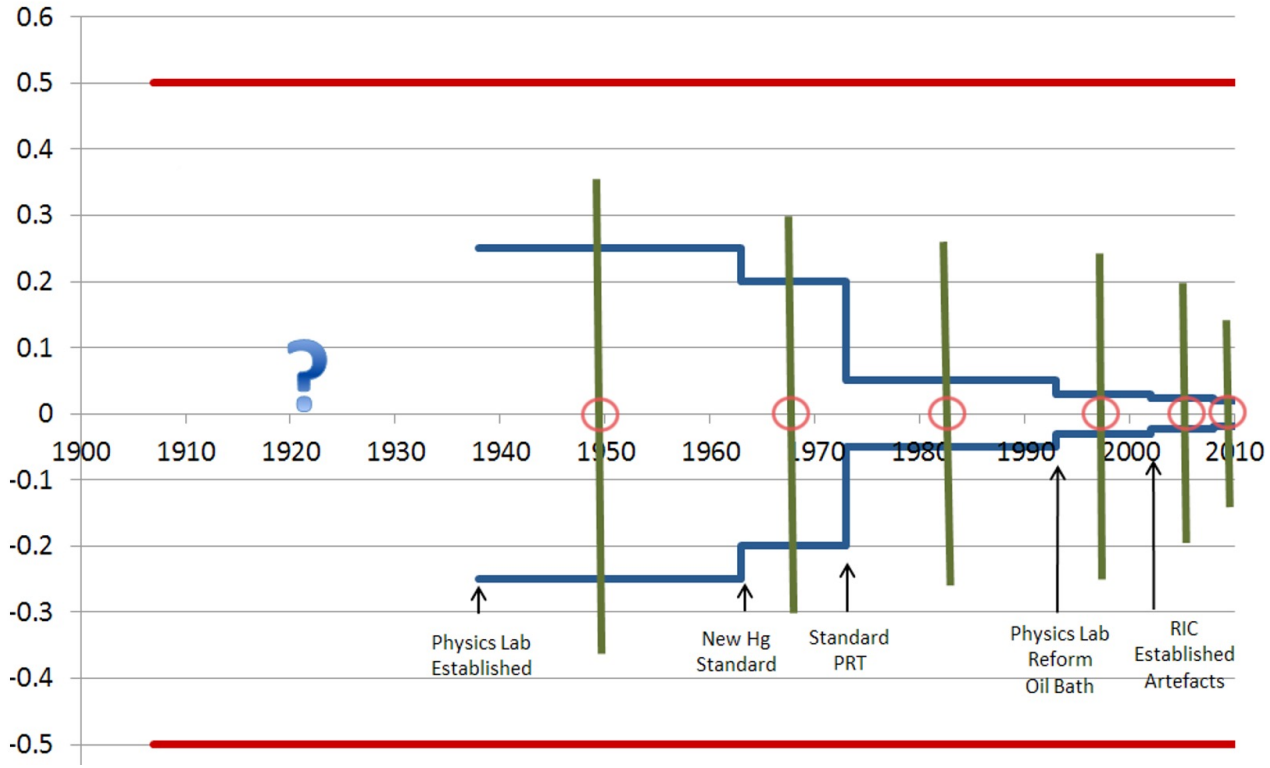
Where Metrology has Improved Environmental Information 2



Australian Climate Observations Reference Network – **Surface Air Temperature** (ACORN-SAT)





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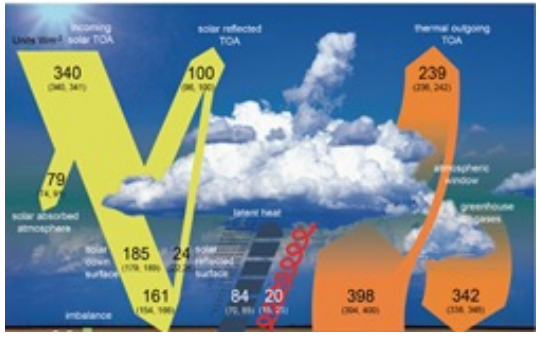
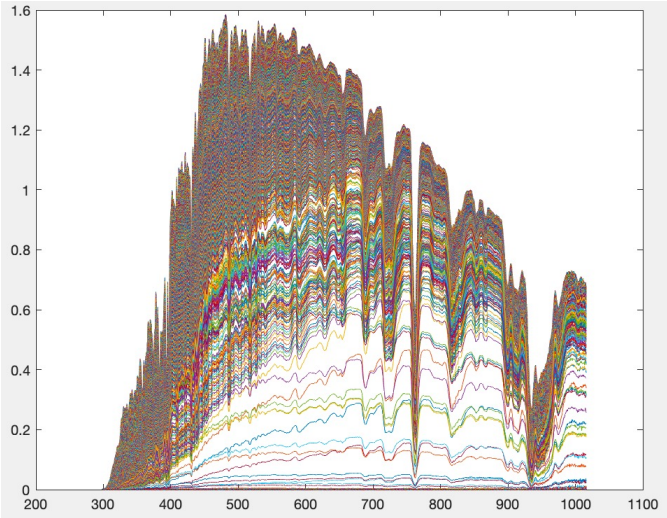
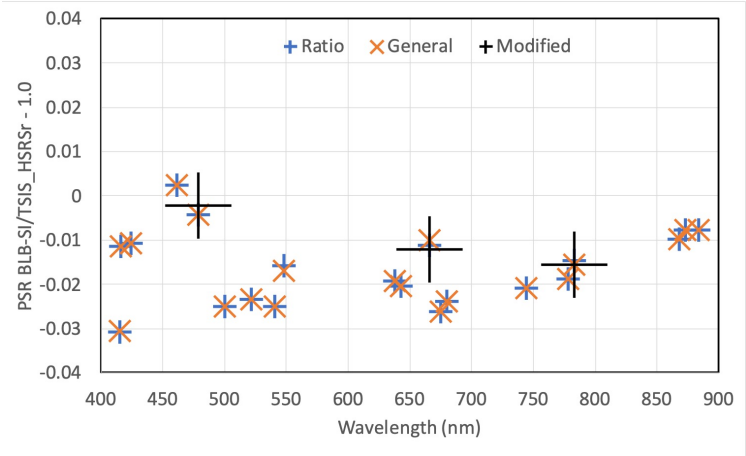
Potential impact of metrology currently in development 1







- Solar Spectral Irradiance (from space)
  - . ATLAS-3 (SI)
  - . TSIS-HSRSr (SI)
  - . TSIS-2 (SI)
  - . NIST/PTB High Temperature BB for SI
- Transitioning from relative interpolation to SI for Total Atmospheric Column constituents e.g.
  - Aerosol optical depth
  - Total column ozone
  - CO_2 .....
- Requirements
  - Improved spectral irradiance in space and in atmosphere including spectral wide-band TSI in-situ
  - $U_{95} < 0.005$ of Top of Atmosphere Solar Spectral Irradiance
  - Improved absorption cross-sections!

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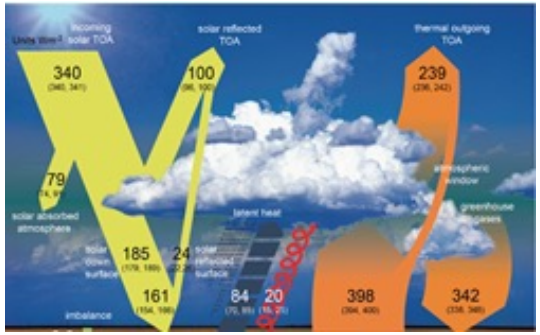
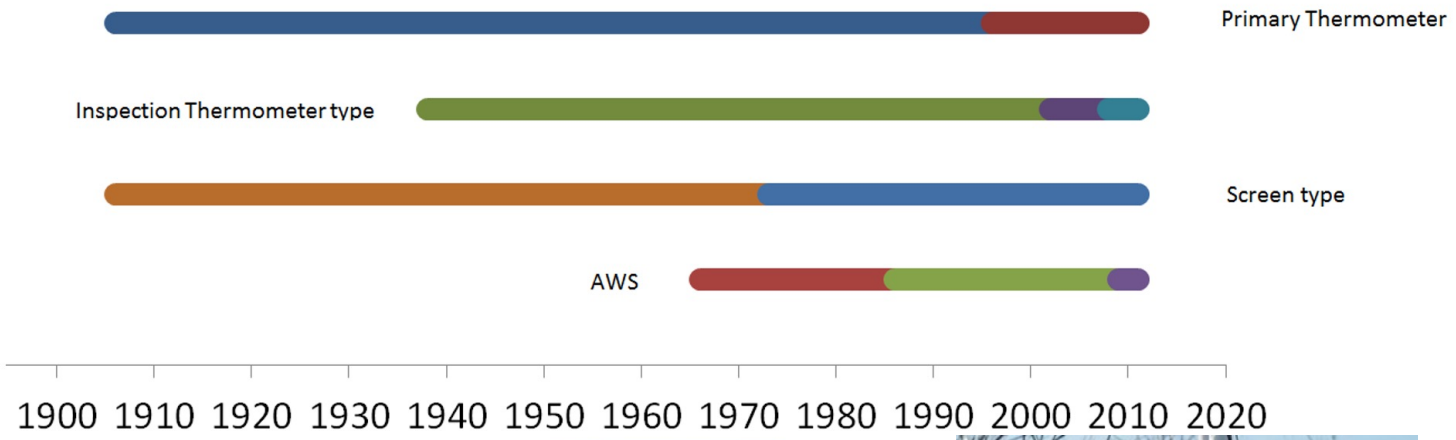
Potential impact of metrology currently in development 2



When the Measurand changes is it still the same ”Air Temperature”?



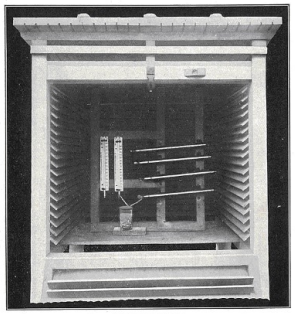


PLATE A.—FIG. 8.
ARRANGEMENT OF THERMOMETERS IN THE SCREEN.

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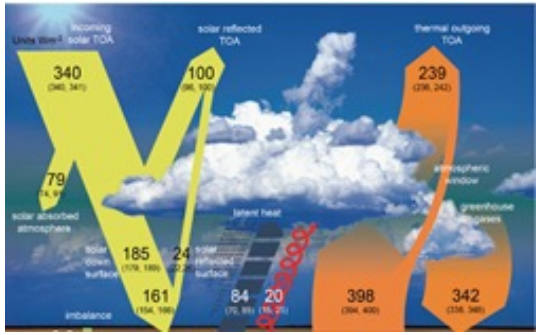
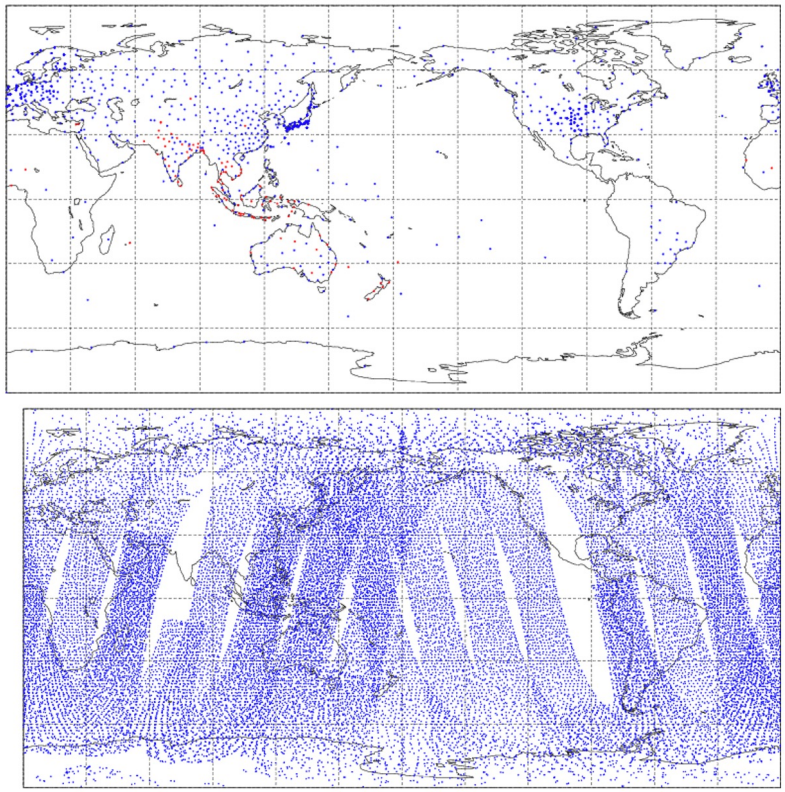
Areas of focus for improving the quality system of climate science 1+++ !!



Improving the traceability of space-based solar and earth measurements



Sturgeon's Law

99% of everything is @#$!! (i.e. problematic)

99.9%+ environmental numerical input values are from satellite sensors.

However, traceability and hence uncertainty (not accuracy!) needs some work.

We need to merge vertical profiles from space-based and surfaced-based remote sensing to measure continuously from the boundary layer to the stratosphere *and in SI*

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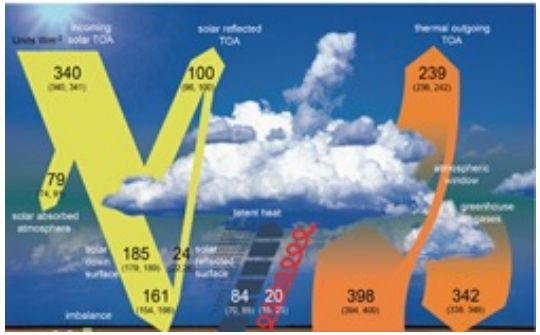
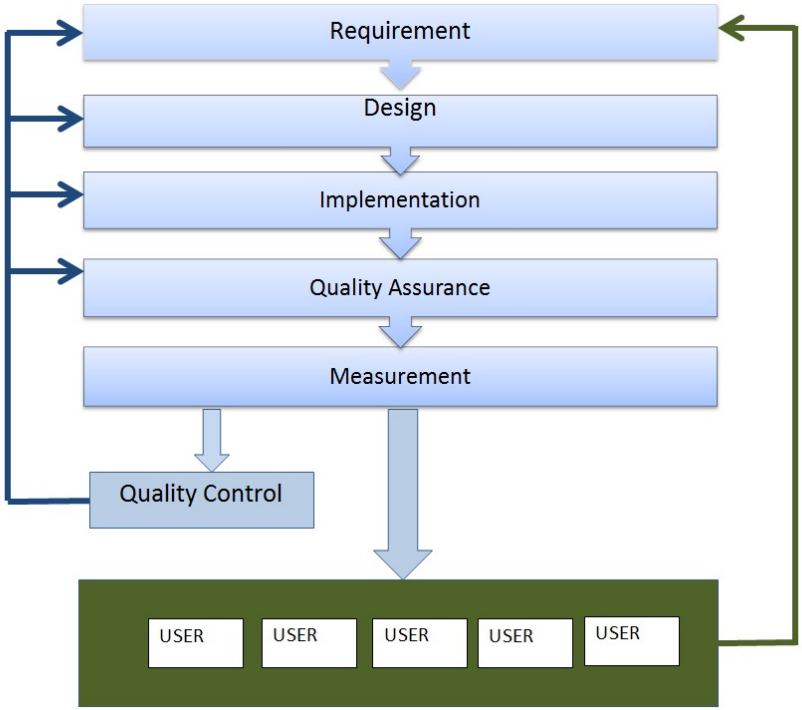
Areas of focus for improving the quality system of climate science 2



Metrology and specifically uncertainty analysis as a tool for instrument and network design



Metrology has direct input to and impact on:

- Design
- Implementation
- Quality Assurance
- Measurement
- Quality Control
- User Confidence

- ISO GUM move to probability – great! But now largely incomprehensible to the non-metrologists and and most network managers.

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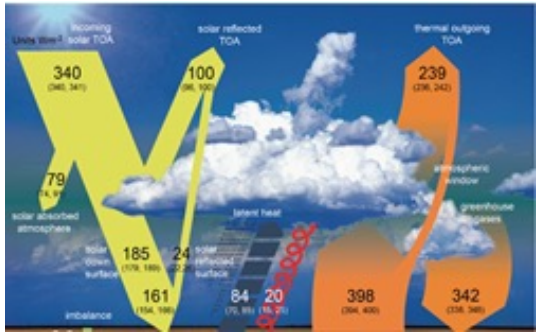
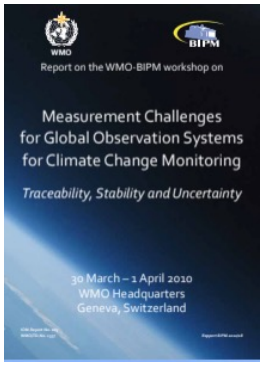
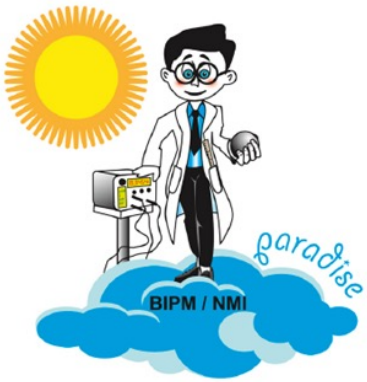
Areas of focus for improving the quality system of climate science 3



Increased collaboration between Metrologists and Environment Measurement Network Operators





Linkages to BIPM increased since 2010

- Contributions to the WMO Guide
- Climate Commission
- CIMO

WMO Significant Re-organization 2019-20

8 Commissions now down to 2 + 1

- Services
- Infrastructure
- Research Board (*including GAW monitoring*)

- Insufficient NMI metrologists in all areas
- Agreements on representation mechanisms need reworking to allow more detailed communication on middle level issues
- Metrologists secondment to environmental agencies and visa versa should be considered

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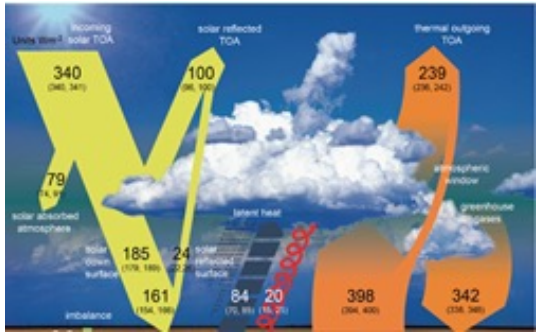
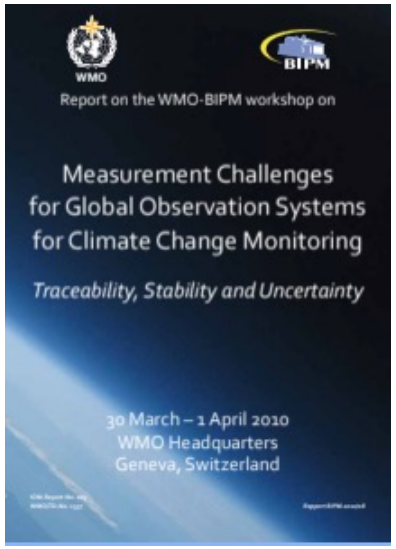
Areas of focus for improving the quality system of climate science 4



When will Metrologists and Environmental Scientists use the same measurement vocabulary?



"Recommendation 4
Knowledge transfer activities between the metrology and meteorology communities, including recommendations to:
...
Publish a joint paper by practitioners from both communities explaining differences in vocabularies used."

But .....

OSCAR
Observing Systems Capability Analysis and Review Tool

The "uncertainty" characterizes the estimated range of observation errors on the given variable, with a 68% confidence interval (1 σ).

OSCAR is a comprehensive WMO tool for network administrators, listing environmental variables, but metrologists have difficulty understanding its context. Vocabulary remains a significant issue.

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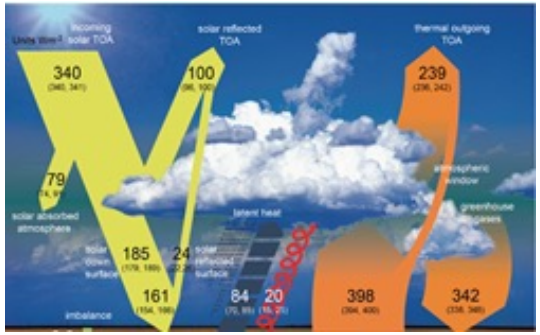
Areas of focus for improving the quality system of climate science 5



Educating and Informing Government Leaders and Agency heads

As environmental monitoring and climate prediction becomes more important it is essential that the top tiers of both government and environmental agencies have an understanding of the importance of environmental metrology and information traceable to SI.

Out world's future leaders need to understand that while a measurement program for climate is costly, a good traceability foundation reduces the total operational cost significantly, and increases the benefit to cost ratio and utility.

A key strategy of WMO's measurement community is to educate agency leaders on traceability and utility of uncertainty in infrastructure development.

E.g. 10 minute video (https://vimeo.com/164968933) on the International Pyrheliometric Comparison, International Pyrgeometer Comparison and Filter Radiometer Comparison. *Is a combined WMO-BIPM strategy possible?*

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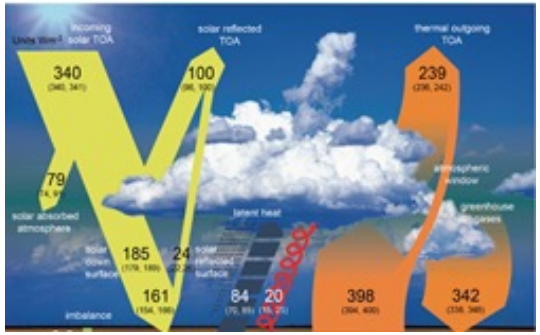
Areas of focus for improving the quality system of climate science 6



Metrology Education in Environment focussed Higher Education

There are an increasing number of papers in respected journals involving environmental measurements that contradict a simple uncertainty analysis, the conservation of energy, radiative transfer and basic sampling theory to name a few measurement/metrology issues.

- BIPM and WMO need to encourage NMIs and environmental agency metrologists to be involved as reviewers for environmental measurement journals.
- BIPM and WMO need to work with the academic community, and environmental agencies to ensure educators have and support core of metrology expertise.
- BIPM encourage local metrological societies to actively engage with meteorological, oceanographic and hydrological societies.

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WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

Thank you
Merci

The Moving Finger writes; and having writ
Moves on: nor all your Piety nor Wit
Shall lure it back to cancel half a Line
Nor all your Tears wash out a Word of it.

Quatrain 51
The Rubaiyat, Omar Khayyam
(1st Trans. Edward Fitzgerald)

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