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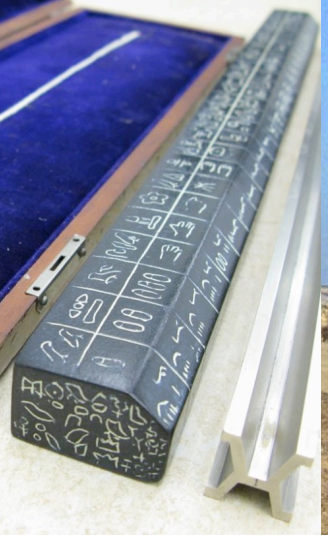
FIDUCEO workshop Lisbon 17-19th April 2018

Introduction to Metrology

Emma Woolliams



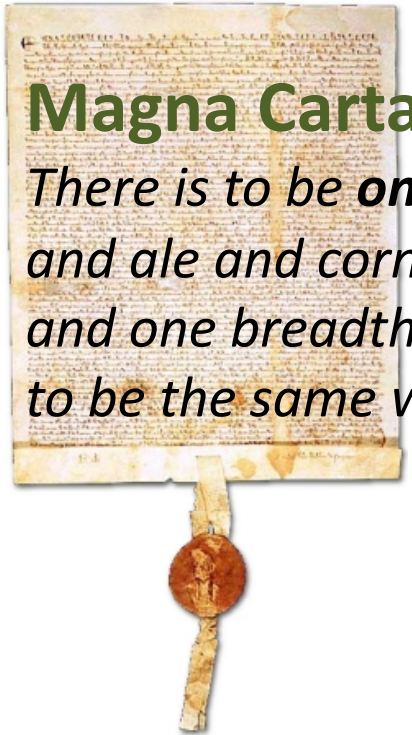
Ancient Egypt: **Death penalty** for **not calibrating** length standard each new moon

Differing weights *and differing measures, they are both alike an* ***abomination*** *to the LORD*

Hebrew Bible: Proverbs 20:10

Give full measure when ye measure, and ***weigh*** *with a balance that is* ***straight****; that is the most fitting and the* ***most advantageous*** *in the final determination*

Qu'ran Surah 17:35



Magna Carta (1215)

There is to be ***one measure of wine*** *and ale and corn within the realm, and one breadth of cloth, and it is to be the same with weights*

Organisation of World Metrology

- The Convention of the Metre (*Convention du Mètre*) 1875
- International System of Units (SI) (*Système International d'Unités)* 1960
- Mutual Recognition Arrangement (CIPM-MRA) 1999

Bureau International des Poids et Mesures

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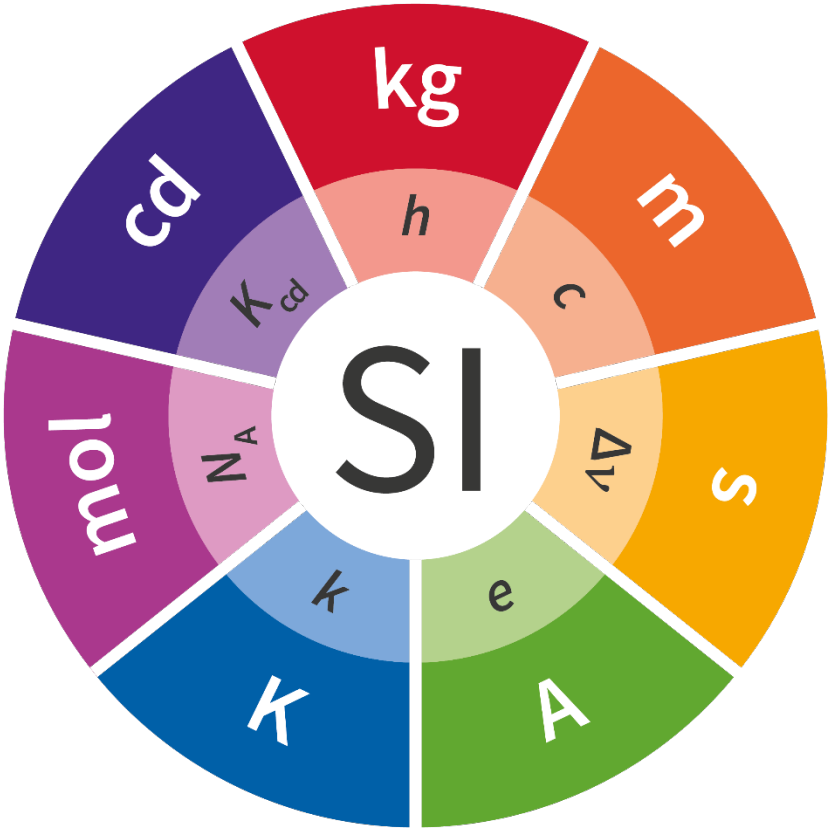
The SI



- Identical worldwide
- Century-long stability
- Absolute accuracy

… and updating 20 May 2019!

https://www.bipm.org/en/measurement-units/rev-si/

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- How do we make sure a wing built in one country fits a fuselage built in another?
- How do we make sure the SI units are stable over centuries?
- How do we improve SI over time without losing interoperability and stability?

Three principles

Traceability

Uncertainty Analysis

Comparison

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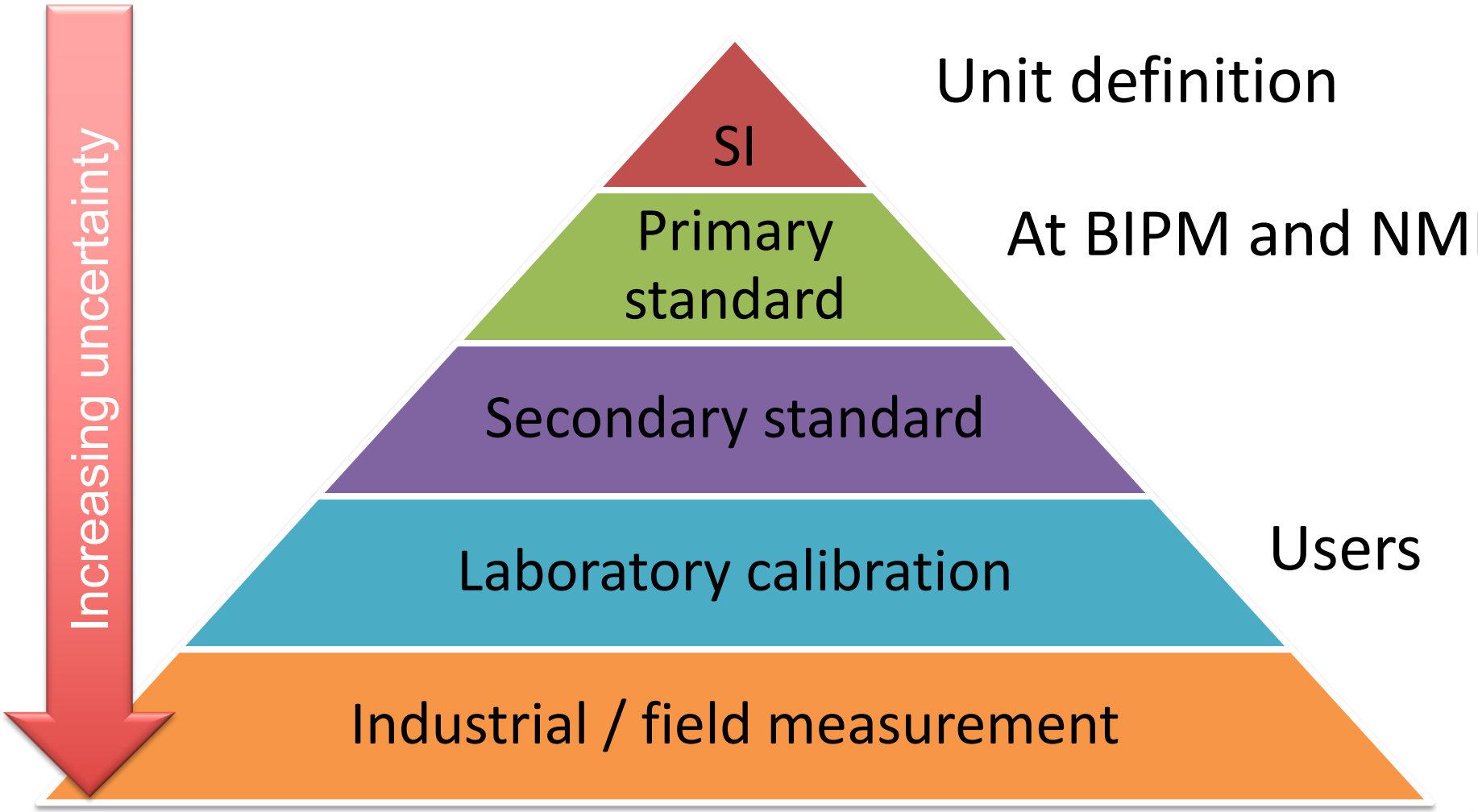
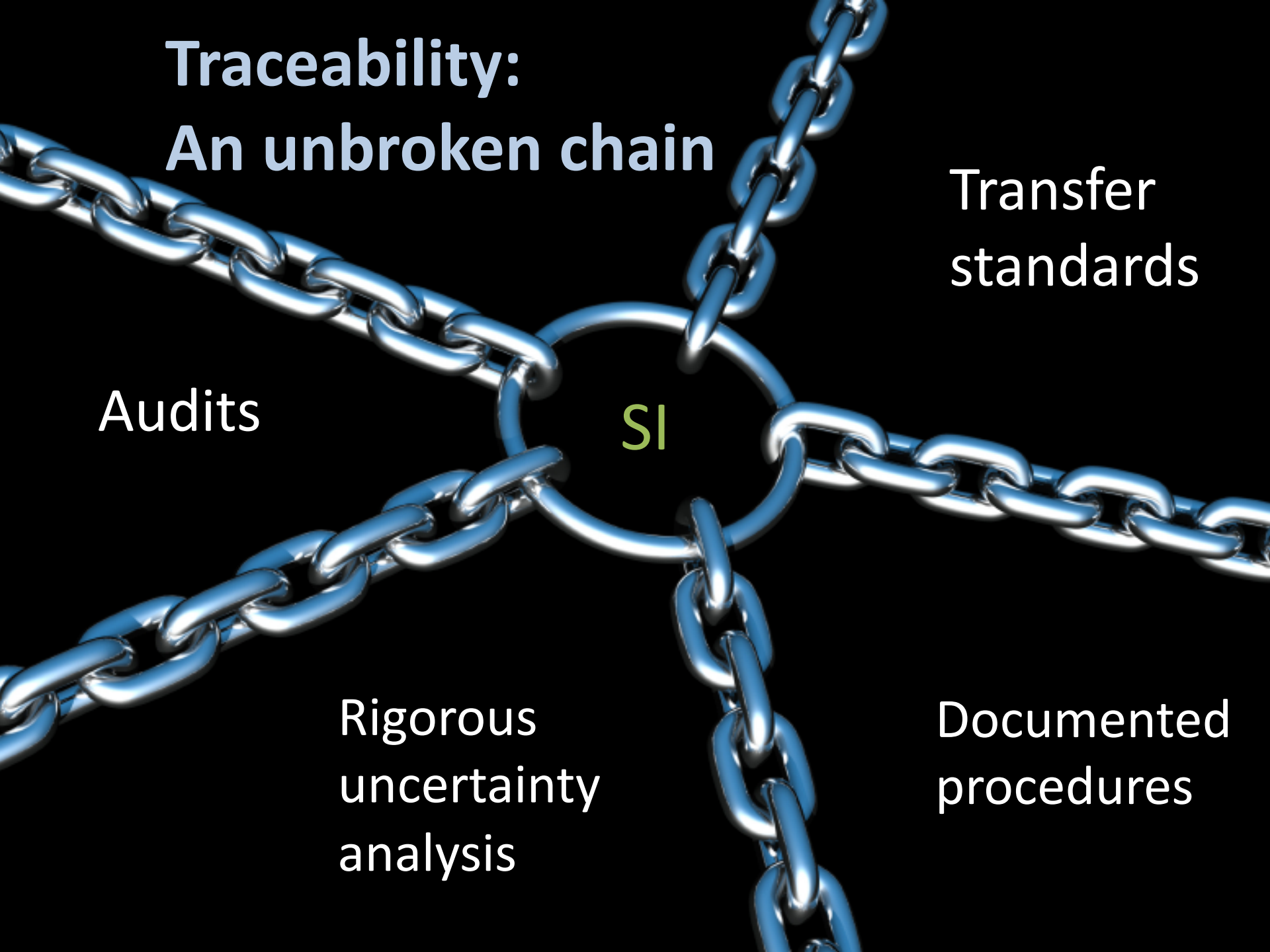
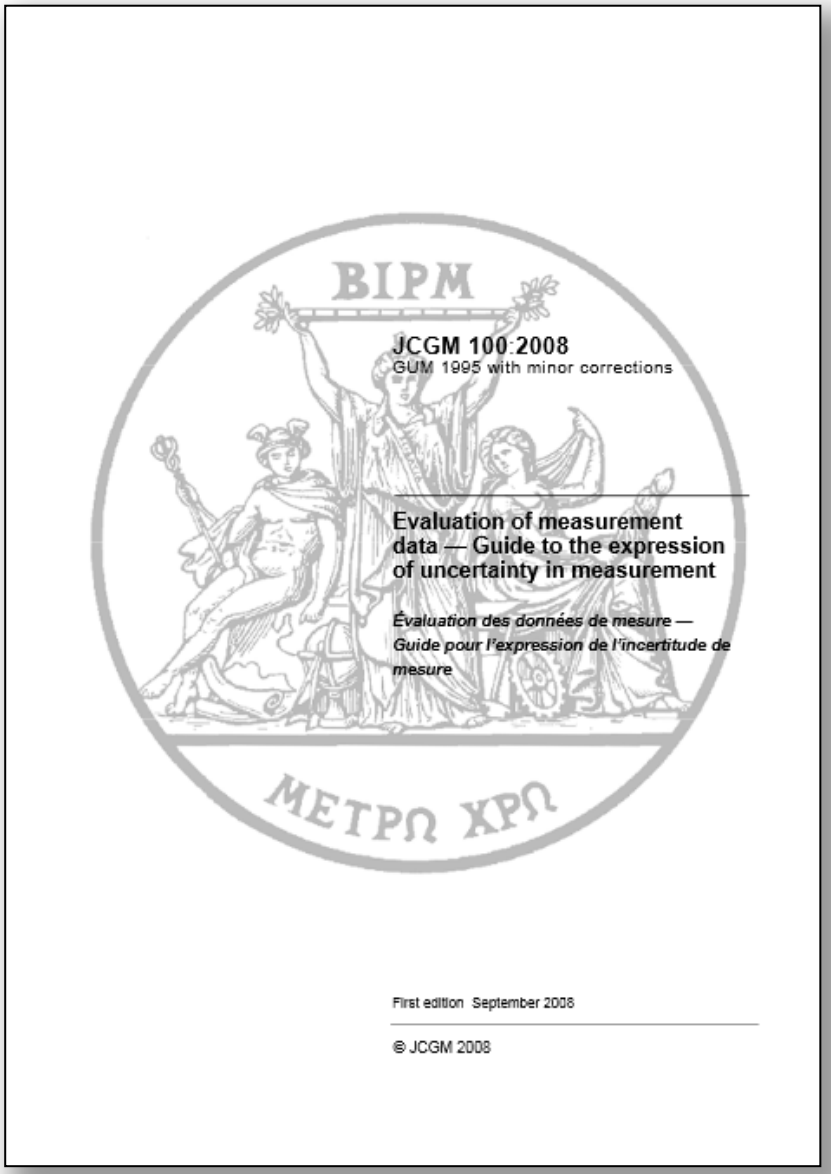
Traceability



Traceability: An unbroken chain



Rigorous Uncertainty Analysis



The Guide to the expression of Uncertainty in Measurement (GUM)

- The foremost authority and guide to the expression and calculation of uncertainty in measurement science
- Written by the BIPM, ISO, etc.
- Covers a wide number of applications
- Also a set of supplements

http://www.bipm.org/en/publications/guides/gum.html

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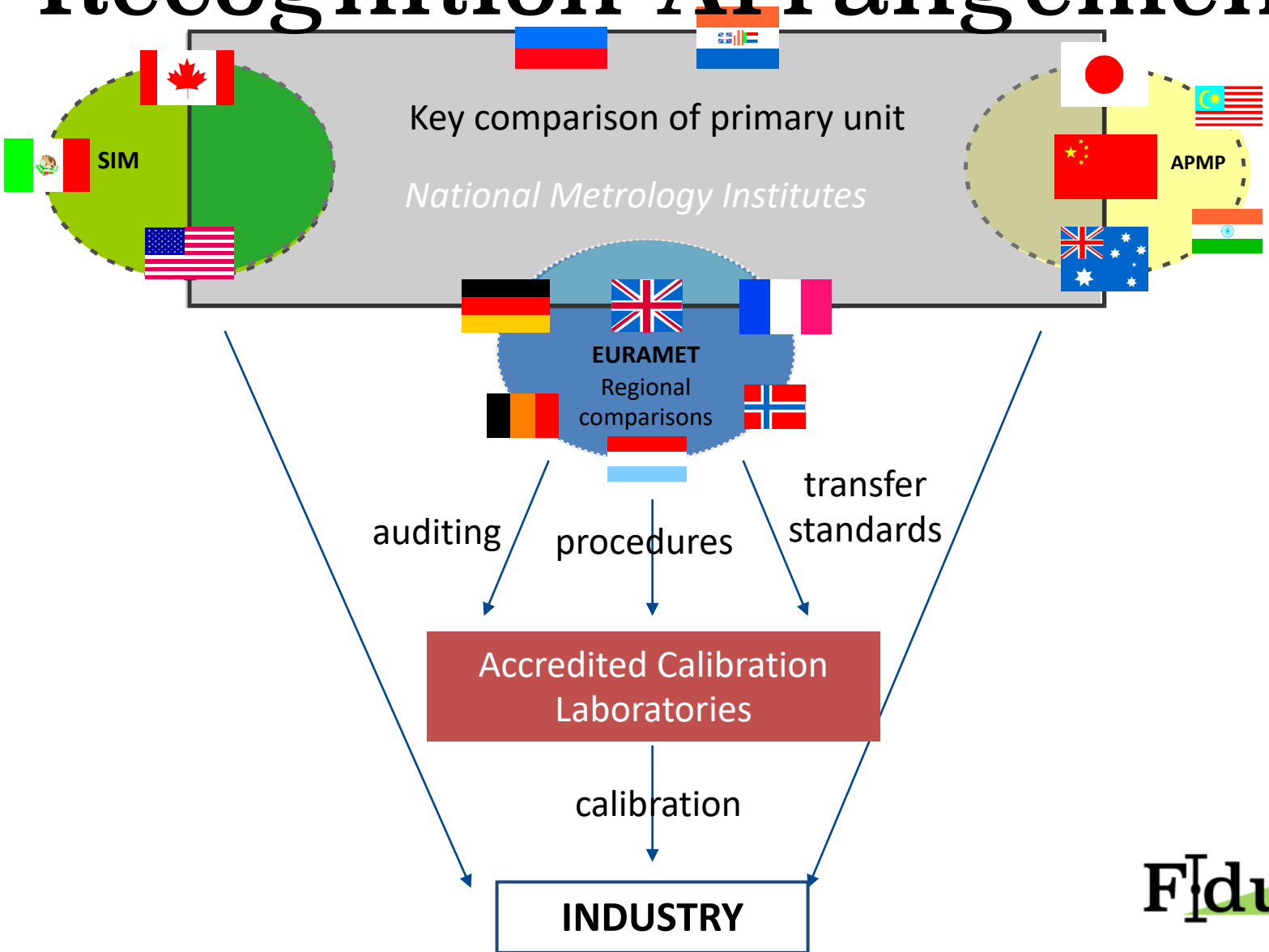
Comparison: The Mutual Recognition Arrangement



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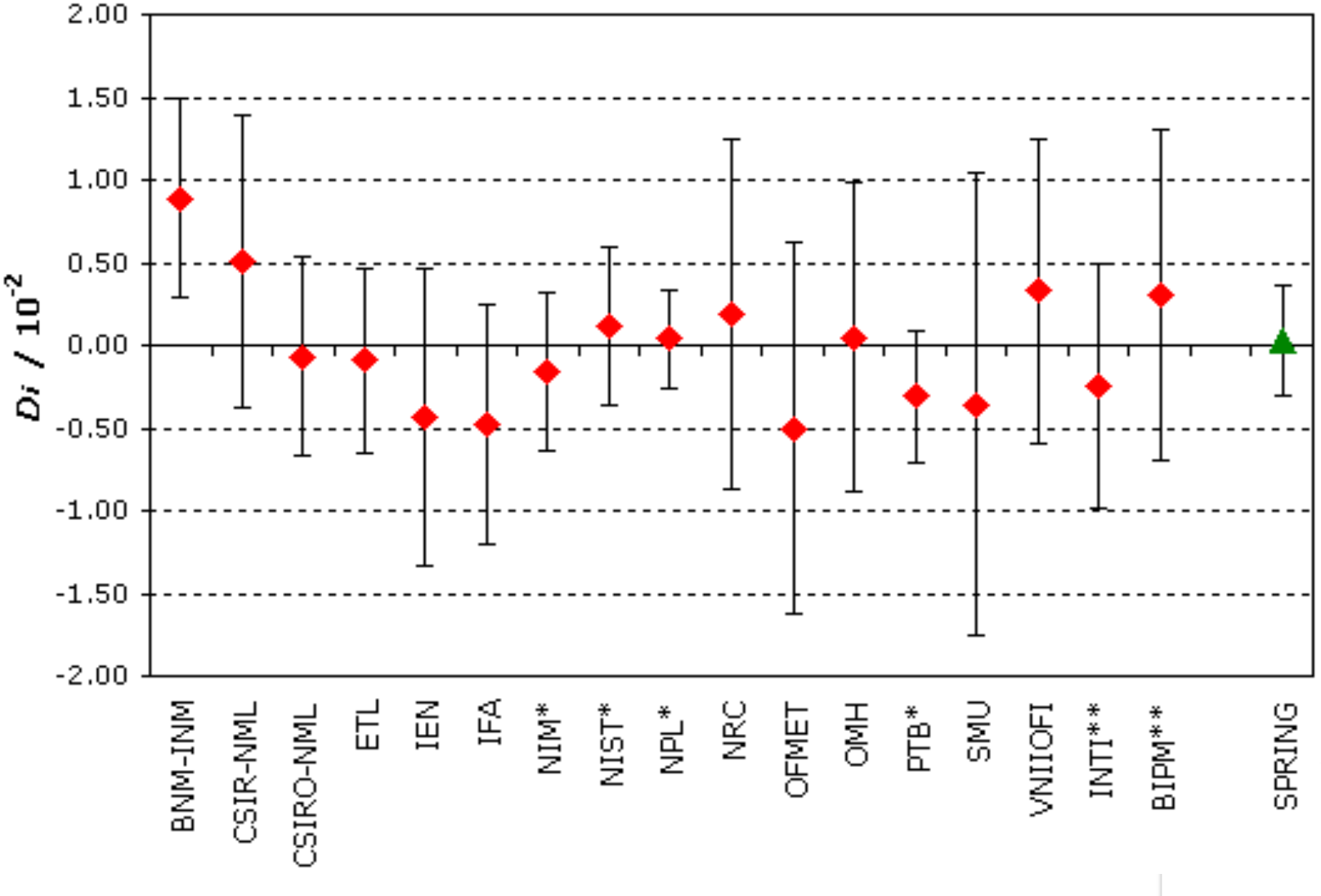
MRA Formal comparison
Luminous Intensity key comparison



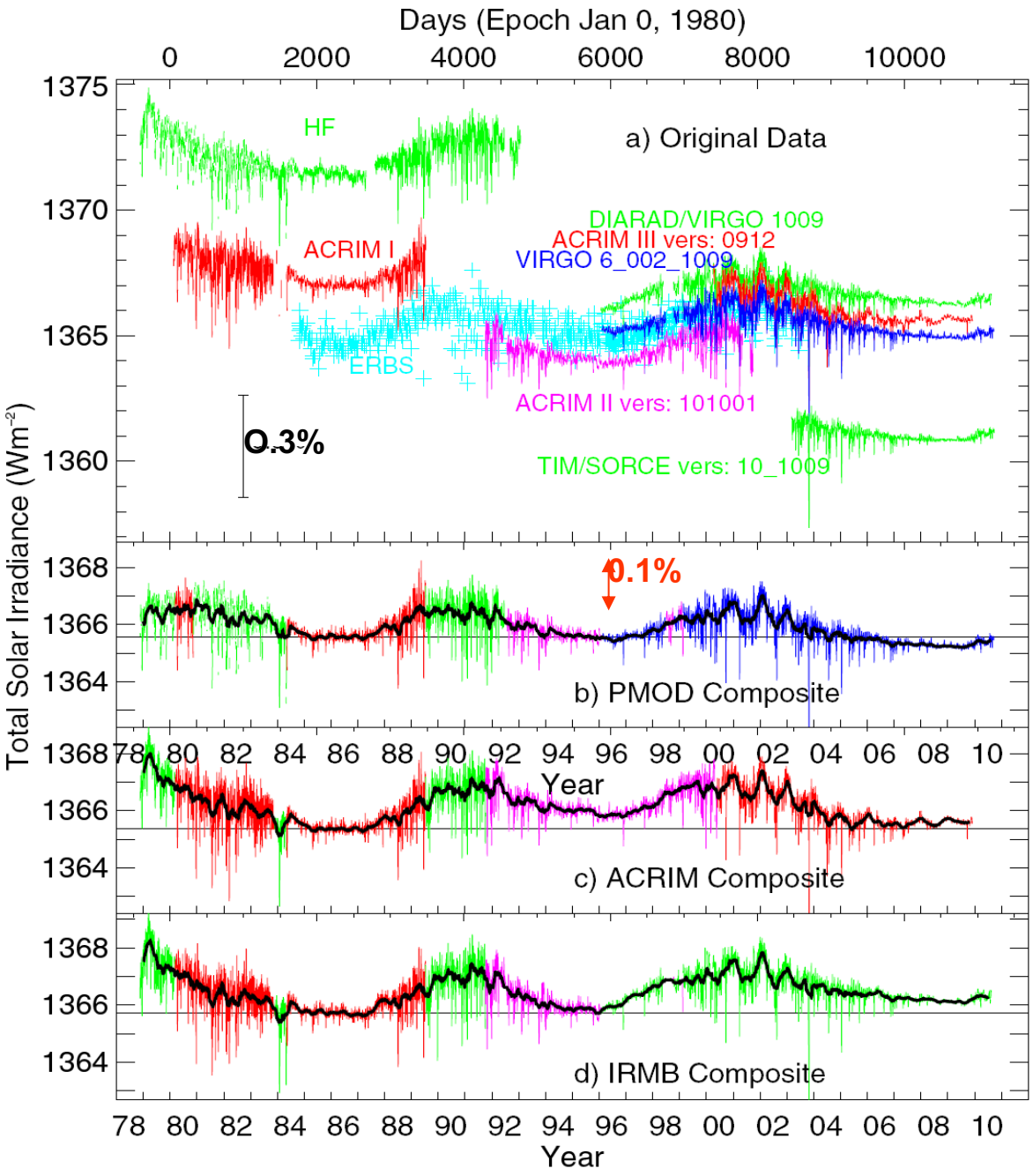
SI: Summary

- Identical worldwide
- Century-long stability
- Absolute accuracy

Achieved through:

- Traceability
- Uncertainty Analysis
- Comparison

How do we observe a climate signal reliably?



Total Solar Irradiance Composite

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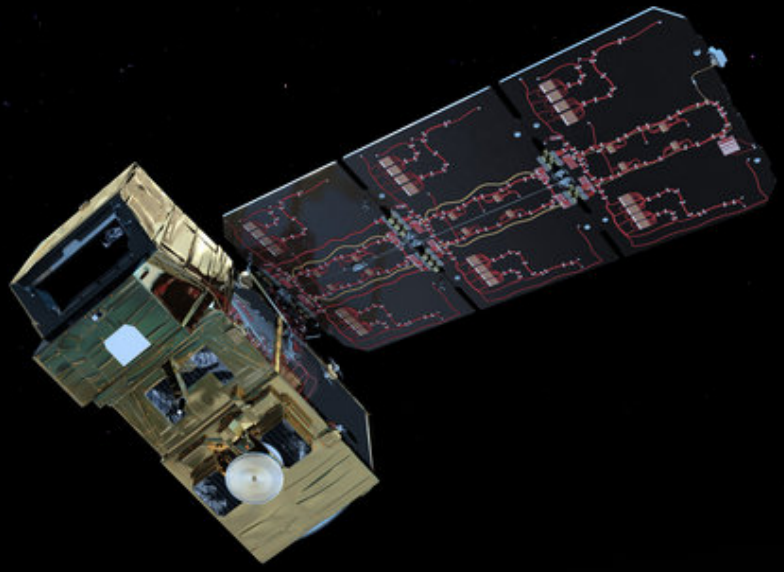

- Identical worldwide
- Century-long stability
- Absolute accuracy

Achieved through:

- Traceability
- Uncertainty Analysis
- Comparison

The traceability chain is broken

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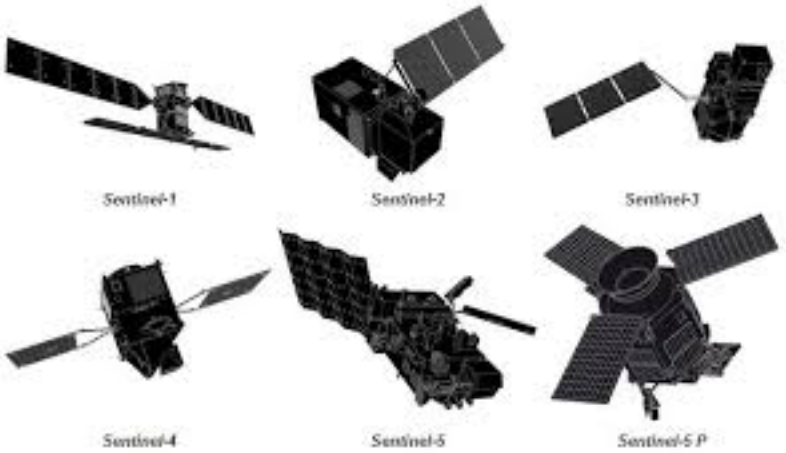
No reference in space …


No reference in space … yet
SI
www.npl.co.uk/truths

And for historical sensors it's even harder

But very worthwhile

A metrological approach can both give you an uncertainty and improve your data



Raw satellite data (L0)

Calibrated radiances (L1)

Climate data record (L2)

Gridded CDR (L3)

Analysed / processed (L4+)

Climate index / information

FIDUCEO addresses fundamental gaps in capability that prevent EO-based CDRs and climate information having traceable uncertainty

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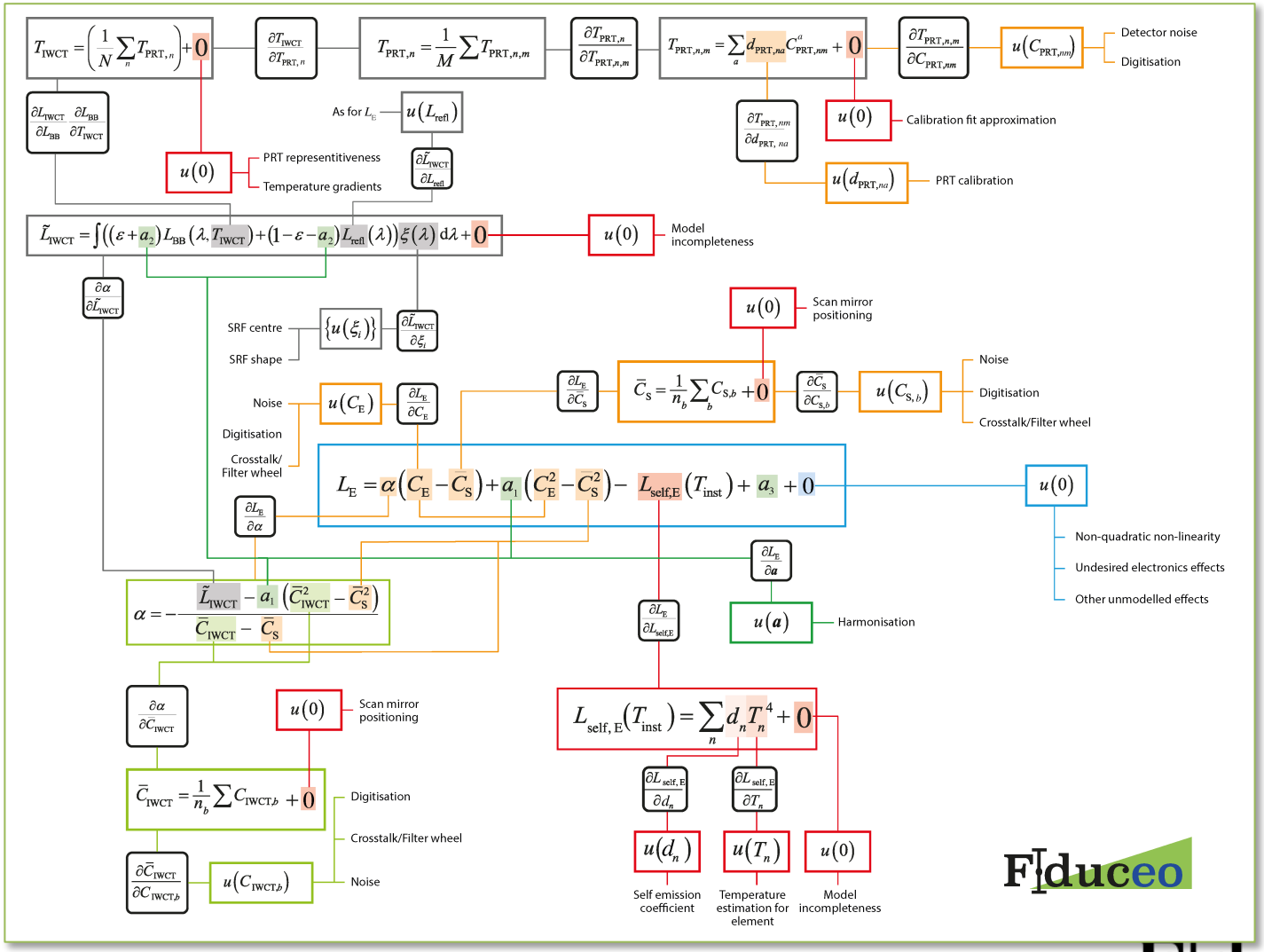
Traceability



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Uncertainty analysis

Table descriptor		Comments
Name of effect		A unique name
Affected term in measurement function		Name and standard symbol
Instruments in the series affected		Identifier
Correlation type and form	Pixel-to-pixel [pixels]	One of the types
	from scanline to scanline [scanlines]	
	between images [images]	
	Between orbits [orbit]	
	Over time [time]	
Correlation scale	Pixel-to-pixel [pixels]	As needed to define type
	from scanline to scanline [scanlines]	
	between images [images]	
	Between orbits [orbit]	
	Over time [time]	
Channels/bands	List of channels / bands affected	Channel names
	Error correlation coefficient matrix	A matrix
Uncertainty	PDF shape	Functional form
	units	Units
	magnitude	
Sensitivity coefficient		Value, equation or parameterisation of sensitivity of measurand to term

$$u_c^2(y) = \sum_{i=1}^{n} \left(\frac{\partial f}{\partial x_i}\right)^2 u^2(x_i) + 2\sum_{i=1}^{n-1}\sum_{j=i+1}^{n} \frac{\partial f}{\partial x_i}\frac{\partial f}{\partial x_j} u(x_i, x_j)$$

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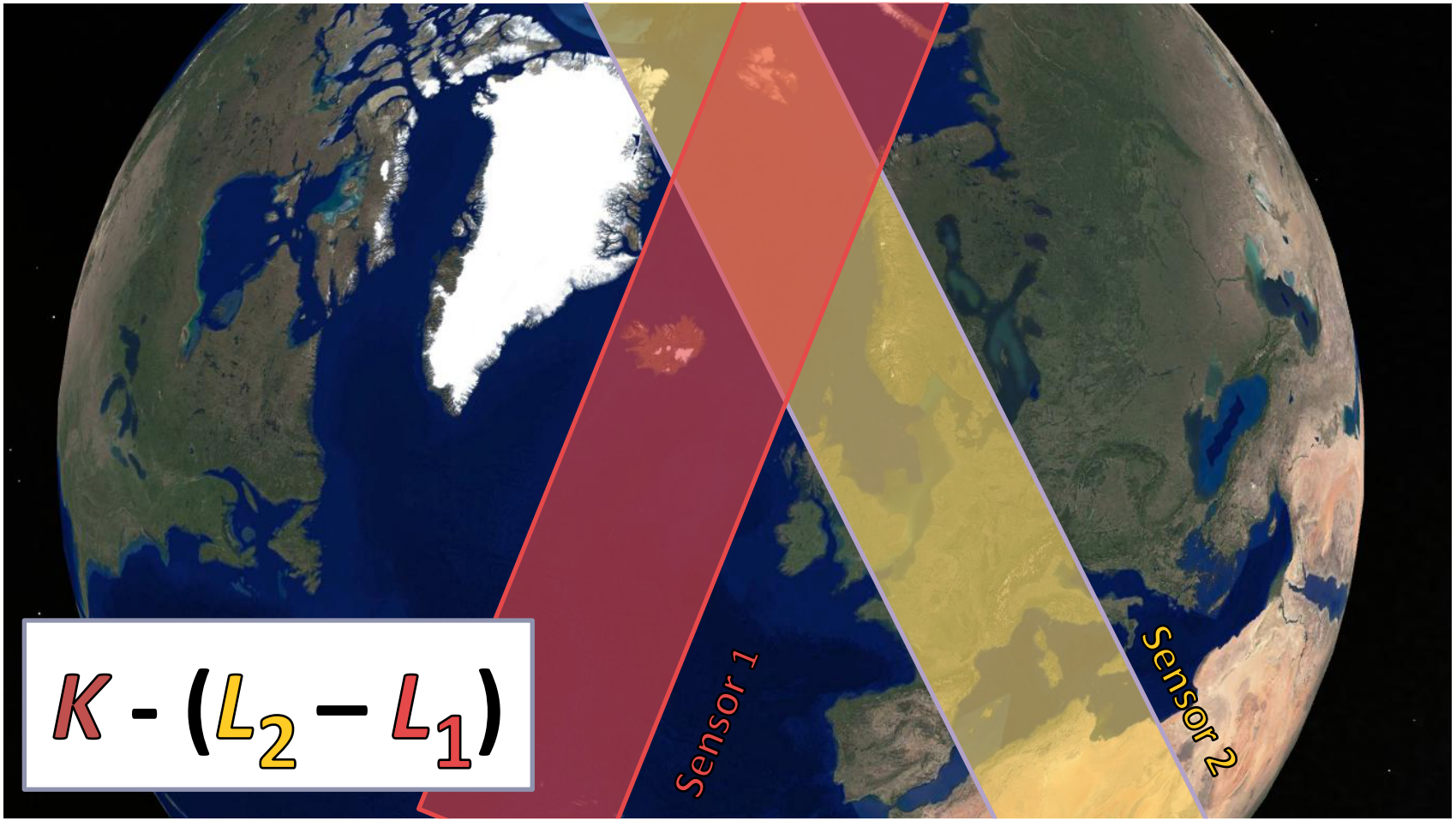
Comparison



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