The Metrology of Earth Observation

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Fiduceo

Fidelity and Uncertainty in Climate Data Records from Earth Observations

www.fiduceo.eu

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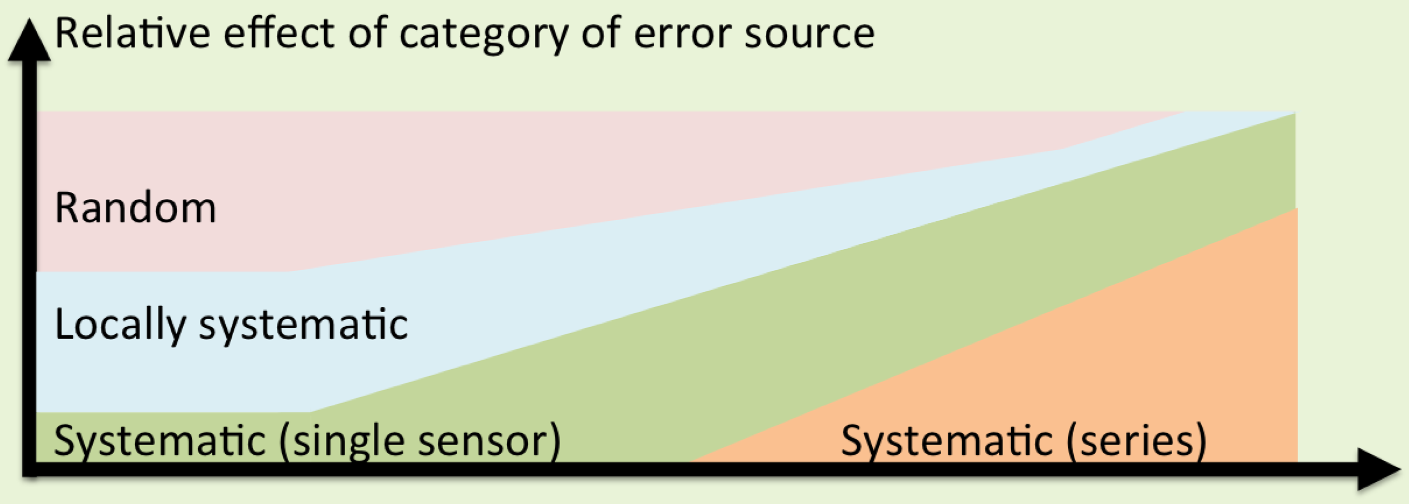
Metrology is the science of measurement, and delivers the references on which all quantitative natural science is based . The H2020 project, FIDUCEO, will apply the insights and techniques of metrology systematically to Earth Observation, to demonstrate the trustworthiness of satellite-derived climate data records.

Well-characterised uncertainties are crucial if Climate Data Records (CDRs) are to be properly exploited. Our understanding of CDR uncertainties is, however, currently limited.

For example, how trustworthy is the uncertainty on a given measurement of a climate variable? If we compare a measurement now with one obtained a few decades earlier, how uncertain is the apparent change? To what extent do instrumental and multi-mission (in)stability limit the conclusions that can be drawn about climatic trends?

The FIDUCEO project will adapt insights and techniques from metrology to deliver trustworthy, traceable uncertainty information. This will be demonstrated across microwave, infra-red and visible domains.

Rigour in considering every effect that causes error is demanding, but necessary for CDRs, because different errors dominate at the many different scales on which data are analysed for climate science.



L2	|	L3	|
full res	hi res		global
instant	daily		decadal
total u			stability

Error is not uncertainty.
Systematic error is not simply bias.

Uncertainty:
Describes the spread of a probability distribution i.e. standard deviation
- Uncertainty is the doubt you have on the value

Error:
Difference from truth
- Result of measurement imperfections
- From random and systematic effects

DATASET	NATURE	POSSIBLE USES
AVHRR FCDR	Harmonised infra-red radiances and best available reflectance radiances, 1982 - 2016	**SST, LSWT, aerosol**, LST, phenology, cloud properties, surface reflectance …
HIRS FCDR	Harmonised infra-red radiances, 1982 - 2016	**Atmospheric humidity**, NWP re-analysis, stratospheric aerosol …
MW Sounder FCDR	Harmonised microwave BTs for AMSU-B and equivalent channels, 1992 – 2016	**Atmospheric humidity**, NWP re-analysis …
Meteosat VIS FCDR	Improved visible spectral response functions and radiance 1982 to 2016	**Albedo, aerosol**, NWP re-analysis, cloud, wind motion vectors,…

New uncertainty-quantified Fundamental Climate Data Records

det. noise, digitisation …	L0 ↓	
calibration, geolocation …	L1 ↓	
propagation (random, systematic), inversion	L2 ↓	
propagation (rand., syst., locally syst.), sampling	L3 ↓	
extra-/interpolation, smoothing	L4	

Techniques to trace the uncertainty from each effect causing error through data levels to CDRs.

DATASET	NATURE	USE
Surface Temperature CDRs	Ensemble SST and lake surface water temperature	Most of climate science … model evaluation, re-analysis, derived/synthesis products ..
UTH CDR	From HIRS and MW, 1992 - 2016	Sensitive climate change metric, re-analysis …
Albedo and aerosol CDRs	From M5 – 7 (1995 – 2006)	Climate forcing and change, health …
Aerosol CDR	2002-2012 aerosol for Europe and Africa from AVHRR	Climate forcing and change, health …

New uncertainty-quantified CDRs, traceable to the FCDRs, via documented propagation of uncertainty.

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

Adding in quadrature

Sensitivity coefficient times uncertainty

Correlation term

Sensitivity coefficients times covariance

2 because symmetrical

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