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FIDUCEO Overview

C J Merchant & All

FIDUCEO

- **Ambition**: develop a widely applicable **metrology of Earth observation (EO)**
- **Motivation:** establish **traceable, uncertainty-quantified evidence** for climate and environmental change from space assets
- **High level objective:**
  - New means to enhance the trustworthiness of climate data from Earth Observations, demonstrated on challenging exemplars

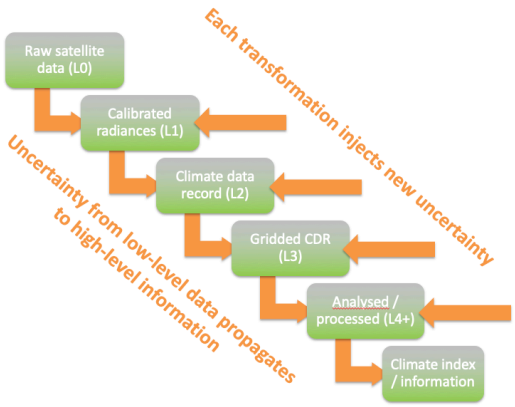
Specific objectives

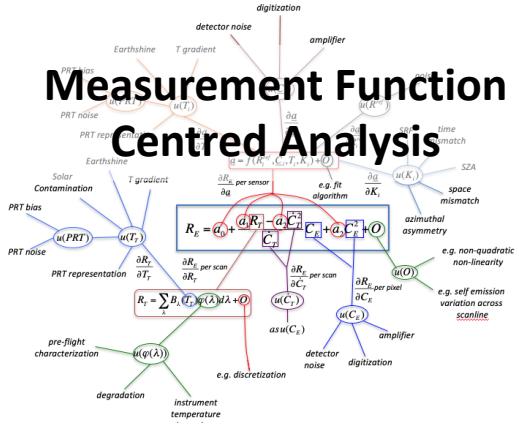
- New fundamental climate data records (FCDR)
  - uncertainty traceably quantified
- Advance the state-of-the-art of FCDR harmonisation
  - physics-based, linking sensors (inc. Copernicus)
- Advance the state-of-the-art for CDR
  - Derive climate data records (CDR) from FCDRs
    - examples of how to use new FCDR
    - traceable, uncertainty quantified
    - improved assessments of stability
- Maximise ease-of-use of advanced data sets
- Disseminate embodiments of best practice

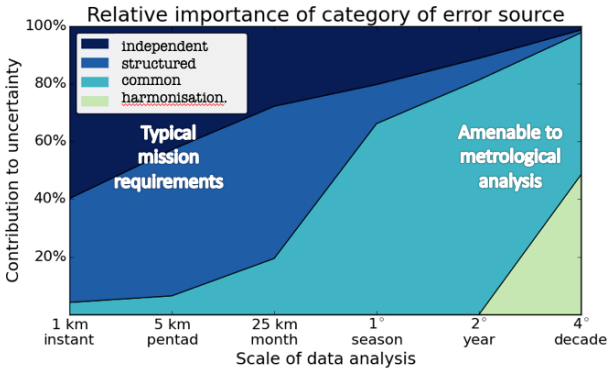
Overview of project

- Concepts
- Methods
- Exemplars
- Impact & Legacy

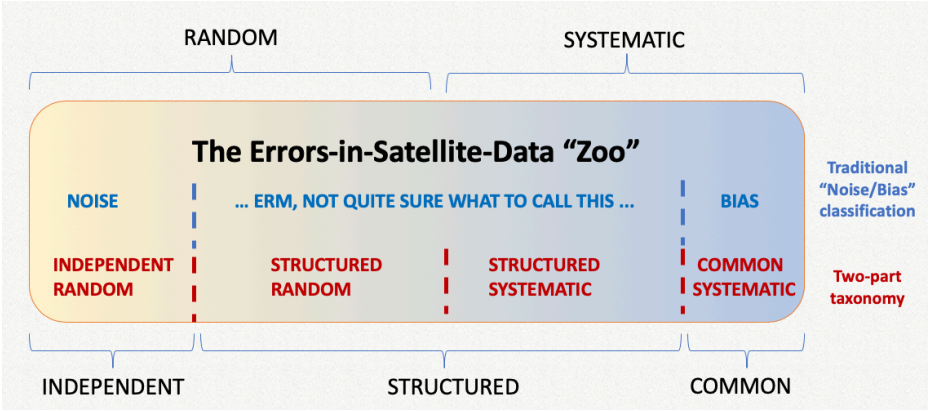
Concepts







	BIAS CORR.	RECALIB.
RESPECTING SRF	GSCIS Equiv Cal	**Harmon-isation**
ADJUSTING FOR SRF	GSCIS Ref Norm	Homogen-isation



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Methods: Uncertainty Analysis

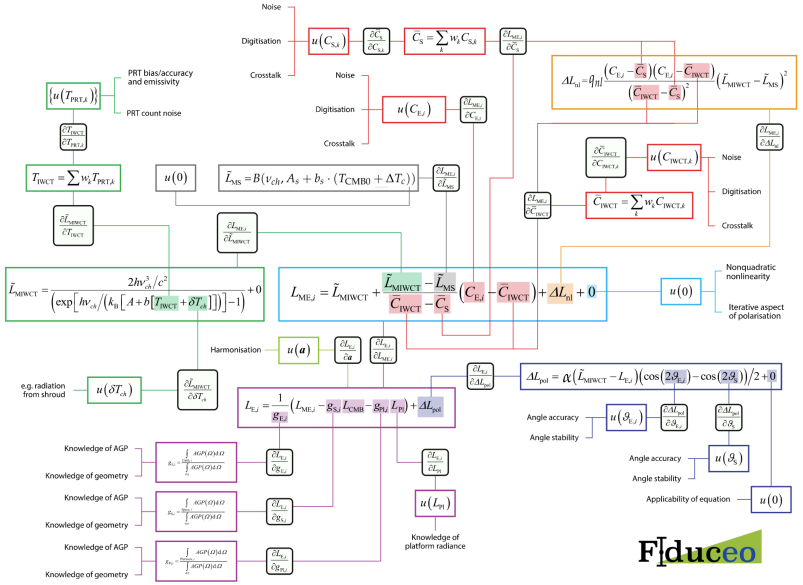

Table descriptor		Comments	Example
Name of effect		A unique name	Internal calibration target count noise
Affected term in measurement function		Name and standard symbol	$\tilde{C}_{\mathrm{ICT}}$
Instruments in the series affected		Identifier	All instruments all satellites
Correlation type and form	Pixel-to-pixel [pixels]	One of the types	Rectangular absolute
	from scanline to scanline [scanlines]		Triangular relative
	between images [images]		N/A for orbiting satellite
	Between orbits [orbit]		Random
	Over time [time]		Random
Correlation scale	Pixel-to-pixel [pixels]	As needed to define type	[-∞,∞] (fully correlated across scan)
	from scanline to scanline [scanlines]		n = 51 (51 scanlines averaged in rolling average)
	between images [images]		N/A for orbiting satellite
	Between orbits [orbit]		0
	Over time [time]		0
Channels/bands	List of channels / bands affected	Channel names	All channels
	Error correlation coefficient matrix	A matrix	Identity matrix (diagonal).
Uncertainty	PDF shape	Functional form	Gaussian
	units	Units	Counts
	magnitude		Given once per orbit file
Sensitivity coefficient		Value, equation or parameterisation of sensitivity of measurand to term	$\frac{\partial L_{\mathrm{E}}}{\partial \tilde{C}_{\mathrm{ICT}}}$

$$\boldsymbol{S}_e = \left\langle \sum_j \sum_{k|j} \boldsymbol{C}_e^{l,j} \boldsymbol{U}_e^{l,k} \boldsymbol{R}_e^{l,k} \boldsymbol{U}_e^{l,k} \boldsymbol{C}_e^{l,j} \right\rangle_l \qquad [\boldsymbol{U}]_{m,n} = \delta_{m,n} \sqrt{[\boldsymbol{S}]_{m,n}}; \quad [\boldsymbol{R}]_{m,n} = \frac{[\boldsymbol{S}]_{m,n}}{\sqrt{[\boldsymbol{S}]_{m,m}[\boldsymbol{S}]_{n,n}}}$$

Mittaz et al., 2019, 10.1088/1681-7575/ab1705
Merchant et al., 2019, doi.org/10.3390/rs11050474
Hans et al., 2019, 10.3390/rs11050548 & other examples

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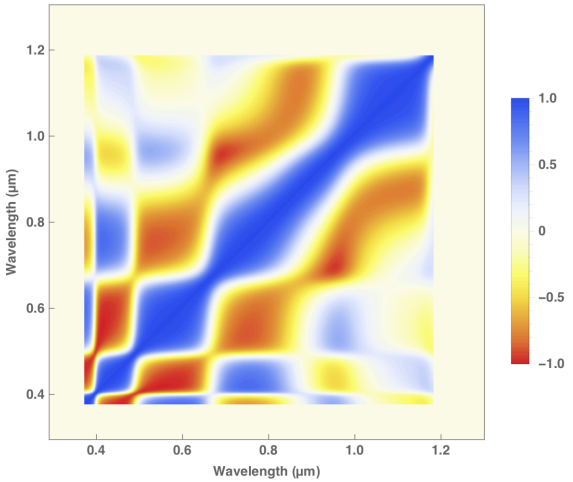
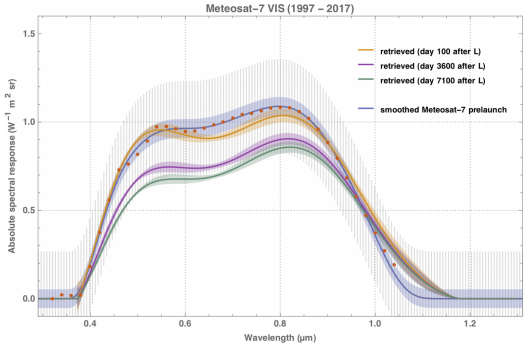
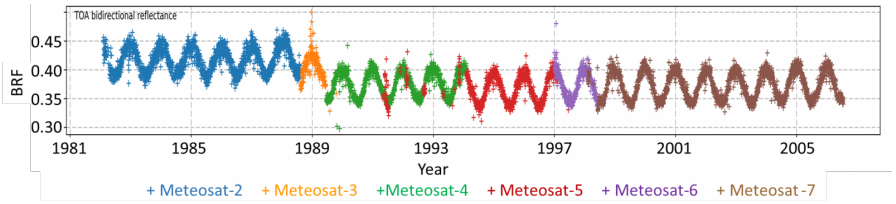
Methods: Harmonisation

- Recalibration respecting sensor differences
- ”Specific” methods

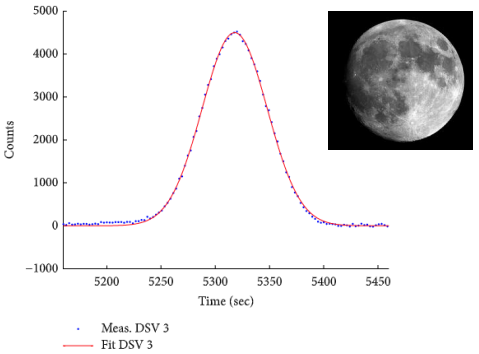






Harm. against Algerian desert

Quast et al, 2019, 10.3390/rs11050480
Rüthrich et al, 2019, 10.3390/rs11101165



Burgdorf et al., 2019, 10.1155/2019/2350476

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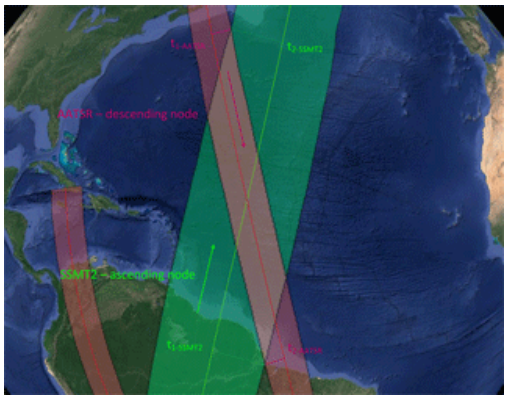
Methods: Harmonisation

- Recalibration respecting sensor differences
- General method for inter-sensor series

$$J(\boldsymbol{\alpha}) = \underbrace{\frac{1}{2}\sum_i \sum_{j>i} \left(\boldsymbol{d}^{ij}(\boldsymbol{\alpha}^i, \boldsymbol{\alpha}^j) - \boldsymbol{K}^{ij}\right)^{\mathrm{T}} \left(\boldsymbol{S}(\boldsymbol{d}^{ij}(\boldsymbol{\alpha}^i, \boldsymbol{\alpha}^j) - \boldsymbol{K}^{ij})\right)^{-1} \left(\boldsymbol{d}^{ij}(\boldsymbol{\alpha}^i, \boldsymbol{\alpha}^j) - \boldsymbol{K}^{ij}\right)}_{K\text{- residual term}}$$

$$+ \underbrace{\frac{1}{2}\sum_i \left(\boldsymbol{\alpha}^i - \check{\boldsymbol{\alpha}}^i\right)^{\mathrm{T}} \left(\boldsymbol{S}(\check{\boldsymbol{\alpha}}^i)\right)^{-1} \left(\boldsymbol{\alpha}^i - \check{\boldsymbol{\alpha}}^i\right)}_{\text{calibration prior term (optional)}} ,$$

Giering et al, 2019,
10.3390/rs11091002
Block et al, 2018,
10.5194/gmd-11-2419-2018



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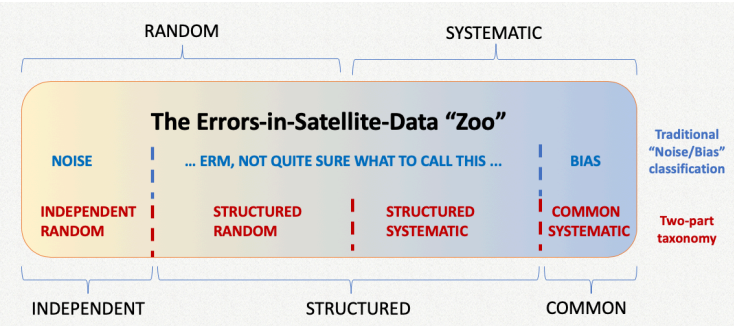
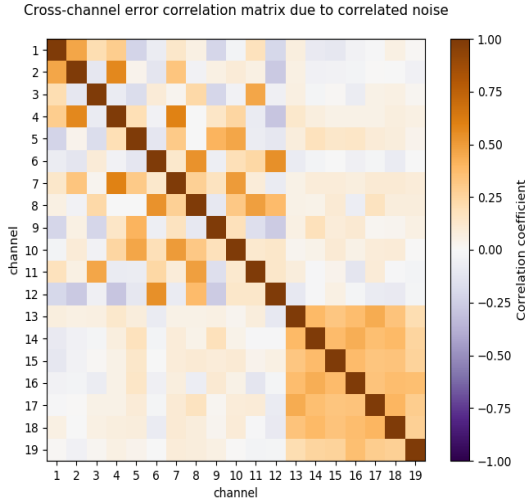
Methods: Encapsulating uncertainties

easyFCDR





Holl et al, 2019, 10.3390/rs11111337

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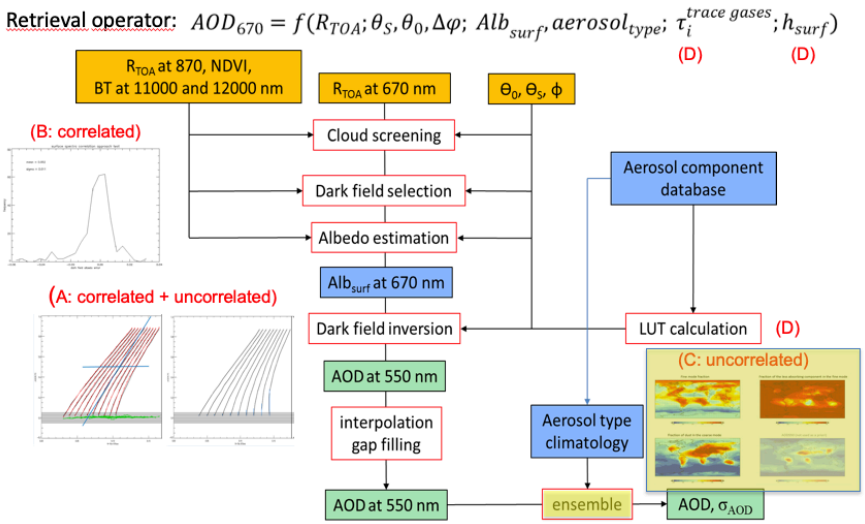
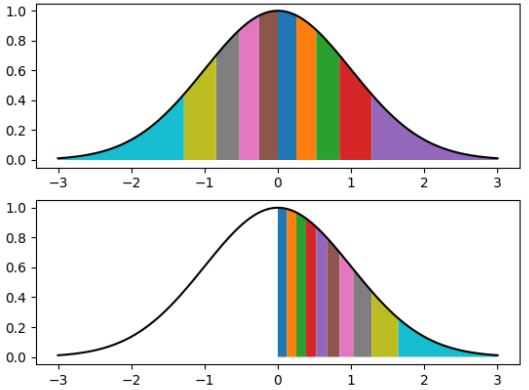
Methods: CDR uncertainty

- CDR-specific implementations of shared principles of propagation from FCDR

e.g., the uncertainty of aerosol type combined with other forms of uncertainty



e.g., ensemble CDR for sea and lake T



Easy-FCDR Radiance →

Retrieval Uncertainty Propagation Tool (1st workshop)

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Exemplars

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,…

Introducing the measurement function

FIDUCEO Vocabulary

This is the FIDUCEO draft vocabulary. We encourage comments on our definitions, please click on any word to comment.

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | ALL

AATSR

Advanced along track Scanning Radiometer

Absolute uncertainty

An uncertainty given in the same unit as the measured value. This is generally written as the standard uncertainty $u(x)$.

Accuracy

The closeness of agreement between a measured quantity value and a true quantity value of a measurand.

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 passive MW -	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 …

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Impact & Legacy

- In ESA
  - Climate Change Initiative
  - ESRIN (IDEAS++, FDR4ALT, etc)
  - ESTEC (HPCM)
- Wider EO
  - GSICS, CEOS, NASA, EUM, SAFs, GCOS
  - Uncertainty, stability, harmonisation are normal points of discussion in connection to many CDRs
- Legacy of website, papers, reports, workshops and datasets
- Copernicus – C3S, SLSTR, HPCM
- Metrology community