FIDUCEO
(FIDelity and Uncertainty in Climate data records from Earth Observation)
EC Horizon 2020 submission

PI: Chris Merchant

University of Reading

Collaborating Organizations

National Physical Laboratory, EUMETSAT, DLR, University of Hamburg, University of Leicester, Rayference, FastOpt, Brockmann Consult, IPMA, CEDA, Assimilia

Metrology for EO

- Traceable Quality under QA4EO
  - All data and derived products must have associated with them a Quality Indicator (QI) based on documented quantitative assessment of its traceability to community agreed (ideally tied to SI) reference standards
  - Metrological traceability - property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty
  - Need traceable uncertainties for satellite data from Level 1 through to Level2-4
    - Technically traceability means pixel level
    - GHRSST has started for SSTs with pixel level SSESs but they don't (yet) have 'documented quantitative assessment of its traceability'
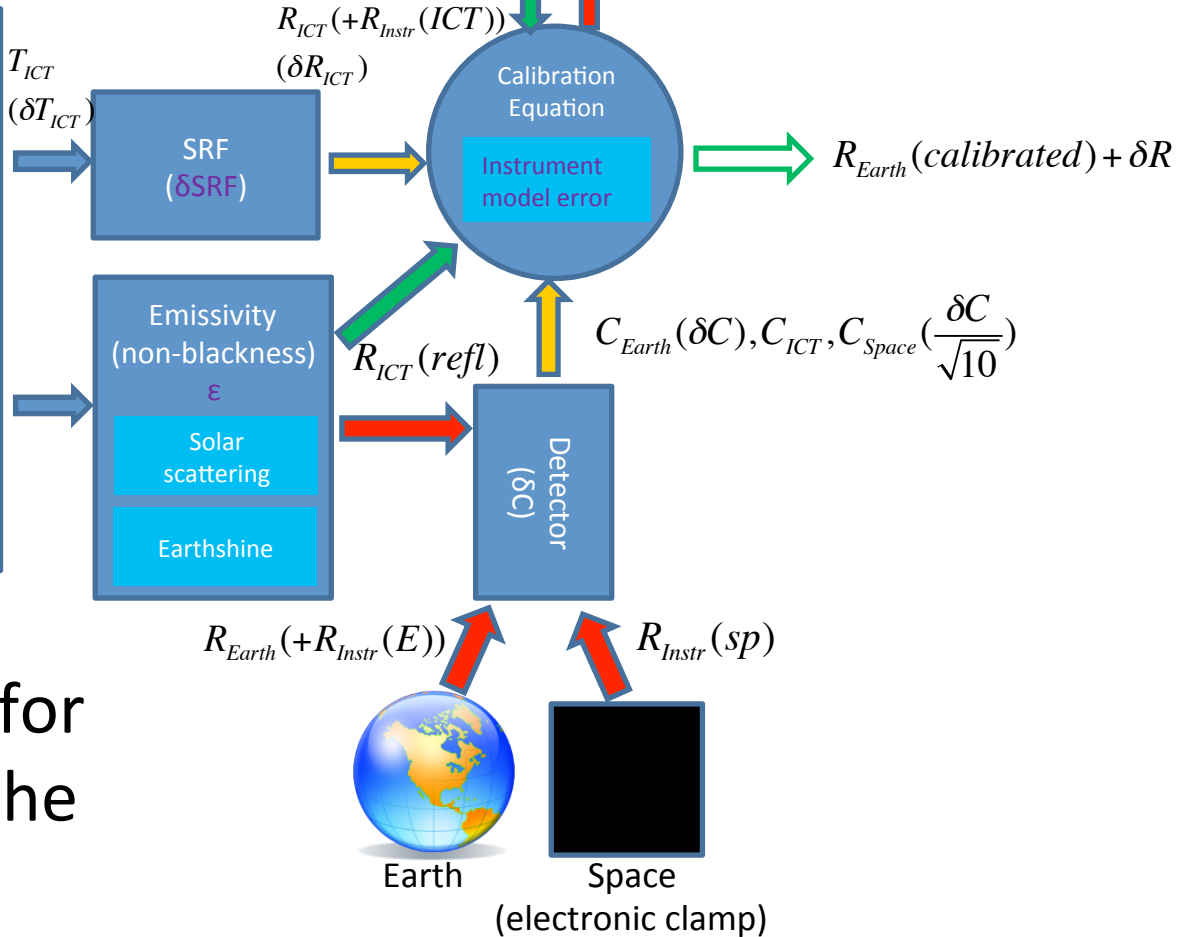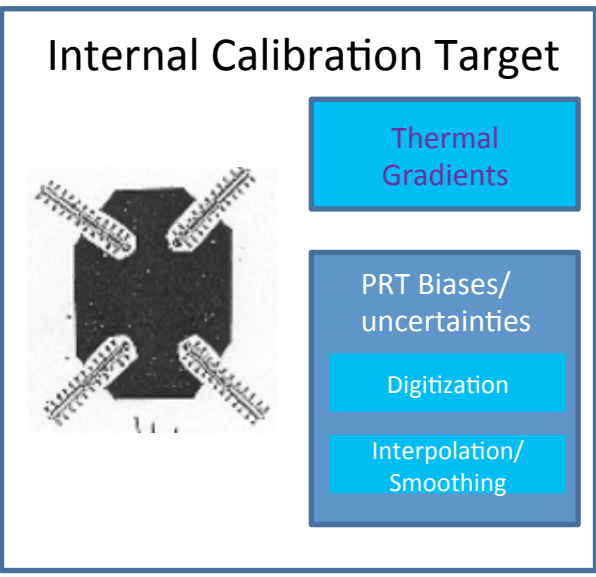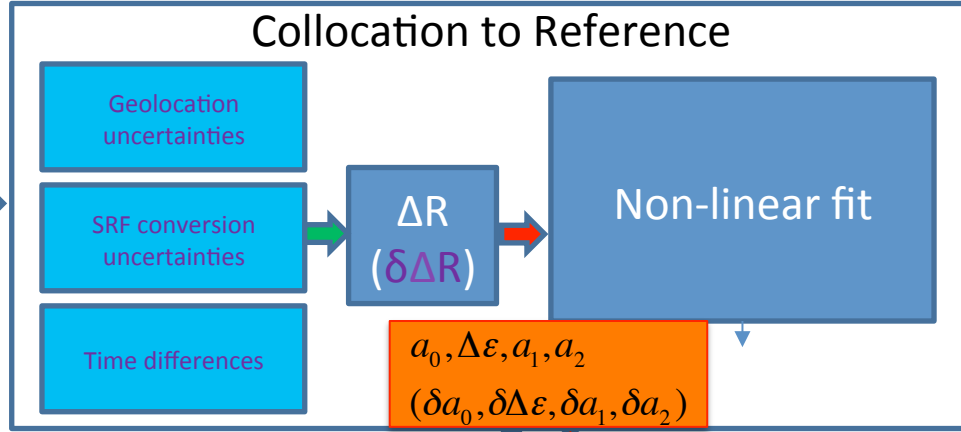
Traceability Chain for the calibration of the AVHRR

Traceable BT Uncertainties

Very preliminary Monte-Carlo simulation of AVHRR calibration traceability chain – almost realistic AVHRR uncertainties (but no instrument model/SRF/time dependent error yet). Note Monte-Carlo is a traceable method from the Guide to the Expression of Uncertainty in Measurement – GUM)

11µm
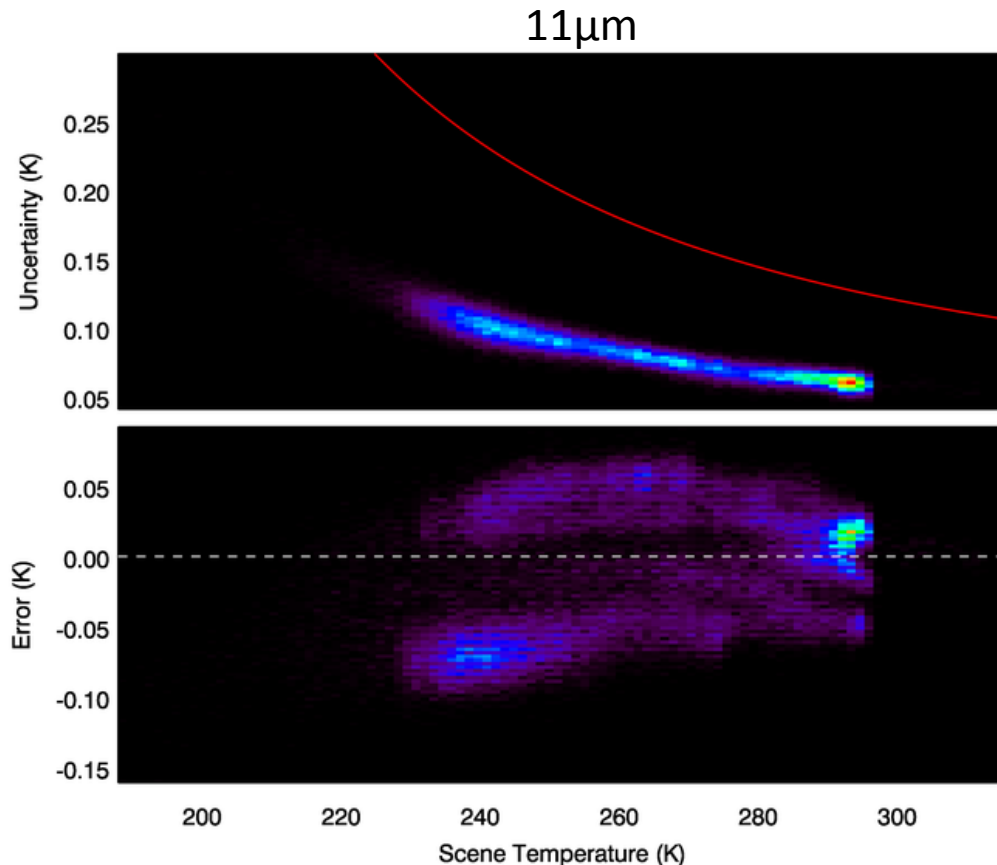
Red line : NeDT from KLM Guide

Input NeDT to model constant but effective NeDT varies (even in radiance space)
- NeDT modified by errors in calibration equations and variation in gain etc

Error likely day/night effect on AVHRR thermal state
- Real PRT measurements used in simulation

Traceable uncertainties have structure…

Towards metrologically robust CDRs

- Now a number of projects which are actively aiming to create datasets with traceable quality indices with the participation of NMIs which include
  - QA4ECV
    - Develop traceable quality assurance methods for ECVs,
    - Generate multi-decadal satellite-derived global ECV records, including multi-decadal Climate Data Records (CDR) for terrestrial ECVs and atmospheric ECV's precursors that are based on inter-satellite calibrated data, state of the art retrievals and are fully traceable with uncertainty metrics ready for ingestion into models
      - ECVs concentrate on Atmosphere and Land products
  - MetEOC (Metrology for Earth Observation and Climate)
    - Establish a European centre of excellence of Metrology to support Earth Observation and Climate as a 'one-stop-shop': enabling European calibration scientists and engineers to deliver cost effective, fit for purpose SI traceable solutions to meet the needs of industry, funding organisations and the user community.
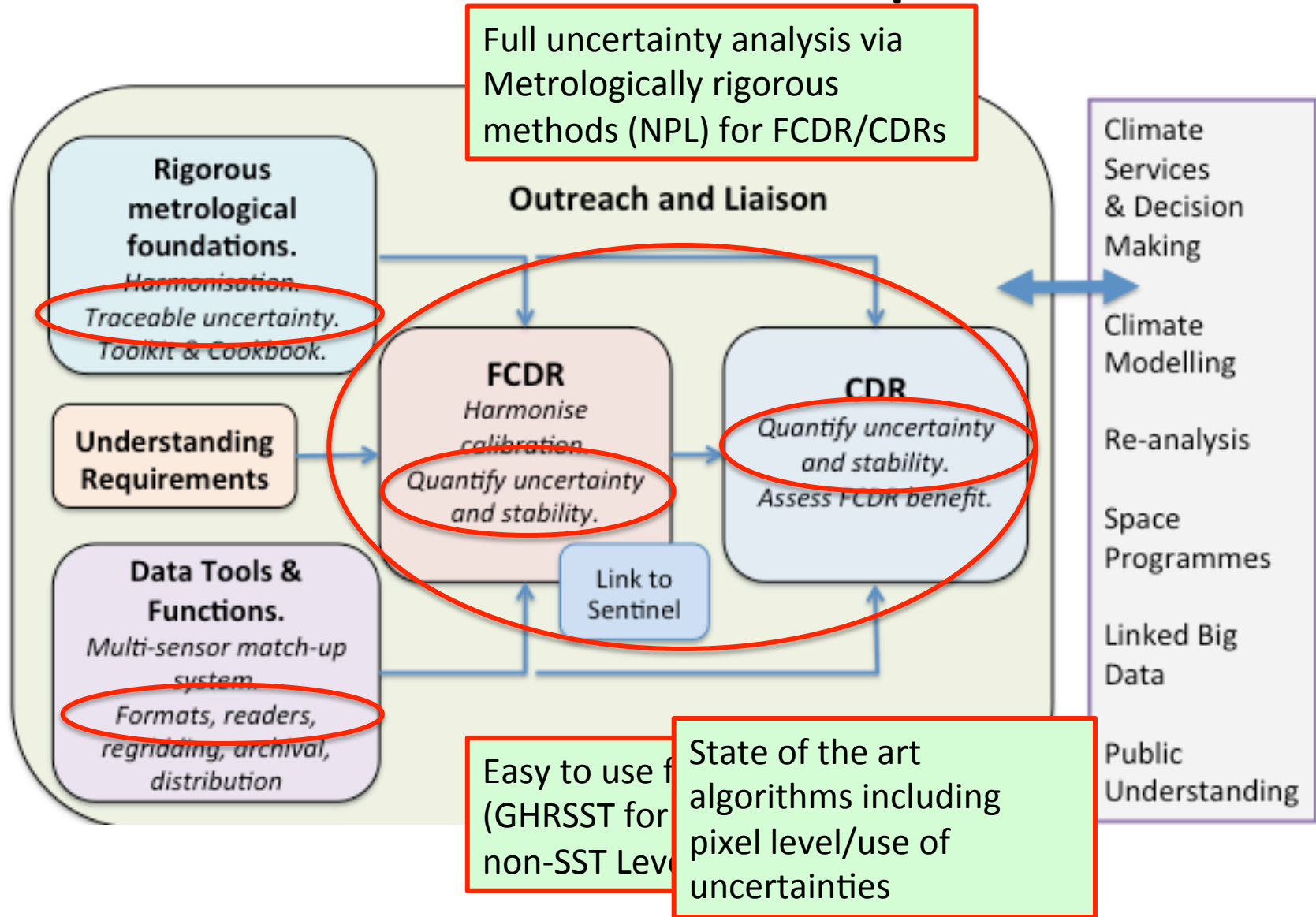
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- Many of the current NMI driven projects are tending to concentrate on Atmospheric/Land products
  - Dependent on expertise of participants including NMIs
  - Little effort on broad band IR sensors
    - (apart from me...)
  - Little effort on Microwave sensors
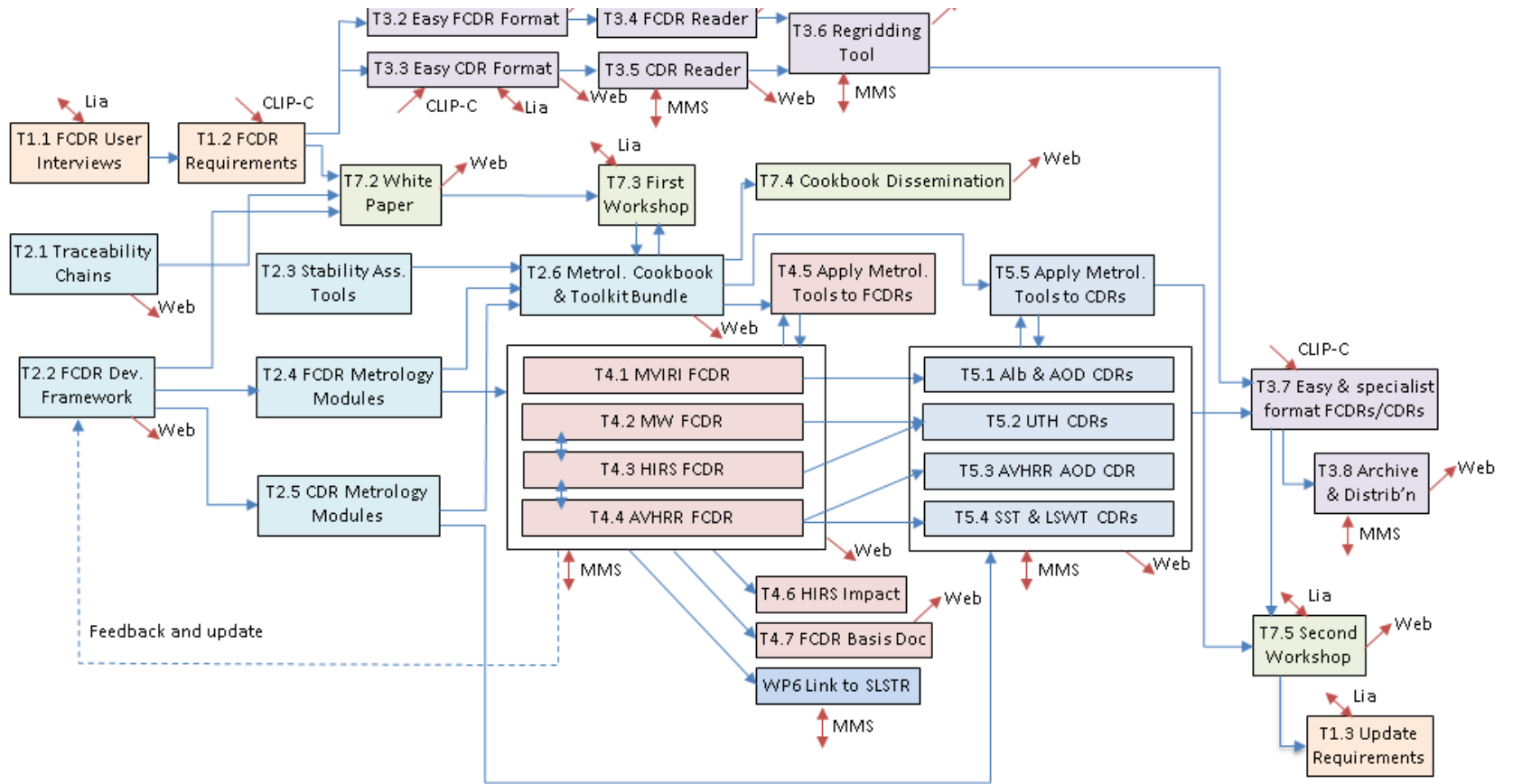- FIDUCEO tries to address the balance

EO-2-2014

- **Climate Change relevant space-based Data reprocessing and calibration**
  - Challenge
    - The data from past remote sensing missions must be made accessible in a way to establish seamless time series of similar observations, contributing to the generation of Climate Data Records across sensors and technologies over two decades and more.
    - The relevance of space derived variables and products needs to be critically examined, and enhanced to optimally fit the requirements arising from current policy issues in a variety of EU sectors
  - Scope
    - Produce the most reliable, accurate, stable and complete Climate Data Records.
    - Enable quick analyses, bulk reprocessing and wide access to different science and application communities. Interoperability of diverse observation collections (atmosphere and its boundary such as ice, fresh water, sea surface and land surface, tropospheric and stratospheric data, sensor calibration and sensor-to-sensor cross calibration) will have to be included, as well as estimates of the associated uncertainties, limits and biases.
    - Coordinate with ESA CCI and/or CEOS/GEO activities
  - Impact
    - Proposers should demonstrate how the work performed adds value to existing data repositories and efforts by the respective remote sensing data holding agencies. Best practices in combining data from different satellites and other sensor in consistent ways should be established and promoted.
- Total Budget
  - 5.5 million Euro s

Overall Concept

Full uncertainty analysis via Metrologically rigorous methods (NPL) for FCDR/CDRs

Outreach and Liaison

Rigorous metrological foundations.
Harmonisation.
Traceable uncertainty.
Toolkit & Cookbook.

Understanding Requirements

Data Tools & Functions.
Multi-sensor match-up system.
Formats, readers, regridding, archival, distribution

FCDR
Harmonise calibration.
Quantify uncertainty and stability.

Link to Sentinel

CDR
Quantify uncertainty and stability.
Assess FCDR benefit.

Easy to use f
(GHRSST for
non-SST Leve

State of the art algorithms including pixel level/use of uncertainties

Climate Services & Decision Making

Climate Modelling

Re-analysis

Space Programmes

Linked Big Data

Public Understanding

FIDUCEO WPs

FIDUCEO Objectives (FCDR)

- To create four FCDRs, for Meteosat, AVHRR, HIRS, and the microwave humidity sounder series (SSM/T2, AMSU-B, MHS), with
  - physics-based harmonisation of radiance calibration
    - Instrument models
  - traceable propagation of estimates of associated uncertainty components
    - Metrologically robust methods
  - a standard, convenient format for wider use.
    - NetCDF based with pixel level uncertainties **(GHRSST SSES for Level 1)**
- To develop and apply new harmonisation techniques across sensor-series and wavelength domains to maximise consistency of infra-red (AVHRR and HIRS) and microwave (SSM/T2, AMSU-B, MHS) FCDRs
- To link thermal infra-red FCDRs (AVHRR-, HIRS- and ATSR-series) to Sentinel 3 SLSTR

FIDUCEO Objectives (CDR)

- To derive CDRs/new datasets from the new FCDRs for four ECVs, as valuable exemplars
  - upper-tropospheric humidity (including joint evaluation of harmonised infra-red and microwave observations)
  - sea and lake surface temperature
  - surface albedo
  - aerosol optical depth
- In CDR generation, to set and apply new standards of quality, in relation to
  - exploitation of new FCDR uncertainty information
  - temporal resolutions
  - assessment of accuracy, and (crucial for CDRs) measurement stability
  - convenience of access and format
    - Easy to use format **(GHRSST for other Level 2 data)**

FIDUCEO FCDR/CDR Improvements

- Proposed improvements

Characteristic	Typical FCDR	FIDUCEO	Typical CDR	FIDUCEO
Ensemble spanning all forms of uncertainty	No	Yes	No	Yes
End-to-end traceability and propagation of uncertainty	No	Yes	No	Yes
Satellite-series harmonisation at radiance level based on rigorous physics	Some examples (e.g. MW); Others seem ad-hoc	Yes	Some examples	Yes
Uncertainty estimates for every pixel	No, usually generic values at best	Yes	Some examples	Yes
Uncertainty components support uncertainty propagation in aggregated data	No	Yes	One known example	Yes

FIDUCEO Objectives (Outreach)

- To provide the wider community with re-usable and adaptable embodiments of best-practice approaches to harmonisation and uncertainty estimation for FCDR/CDRs
  - open-source statistical toolkits (including uncertainty propagation and stability assessment)
  - open-access peer-reviewed publications
  - a "cookbook" guide: "Climate Data Records from Earth Observations: A Guide to Rigorous Practice"
- To publish FIDUCEO's CDRs in innovative ways that express both ECVs and their uncertainty in ways accessible to the general public and policy-makers

EC Review/Project Start

- Review of proposal within 5 months of submission
  - Should be completed by beginning of September
- Successful projects start 3 months after review
  - Possible FIDUCEO start Dec 2014/Jan 2015
- We have our fingers crossed…