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Workpackage 2

Emma Woolliams

National Physical Laboratory

WP2

WP2 will set out a philosophy of how to develop FCDRs and CDRs in a way that is

- *rooted in the physics of the sensor measurements,* and
- *based on sound metrological principals*.

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But mostly it's about a dialogue between EO and Metrology

T4.5
T5.5

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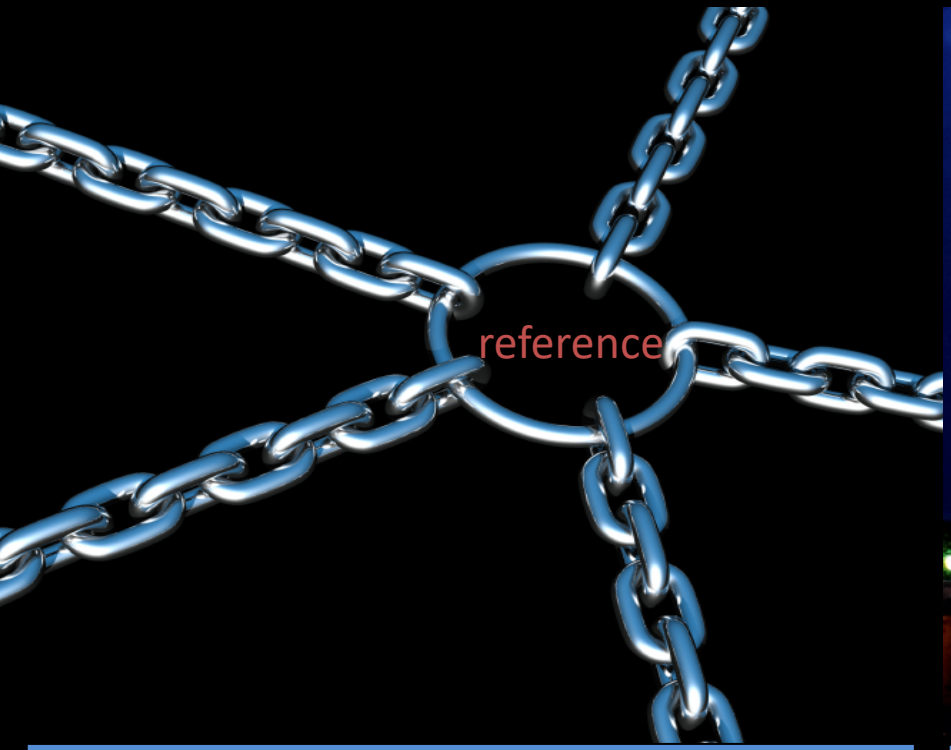
Metrology



Traceability

Uncertainty Propagation

Establishing the dialogue

…

The first steps

- Developing traceability chains (T2.1)
  - NPL led
- Writing a development framework (T2.2)
  - University of Reading led

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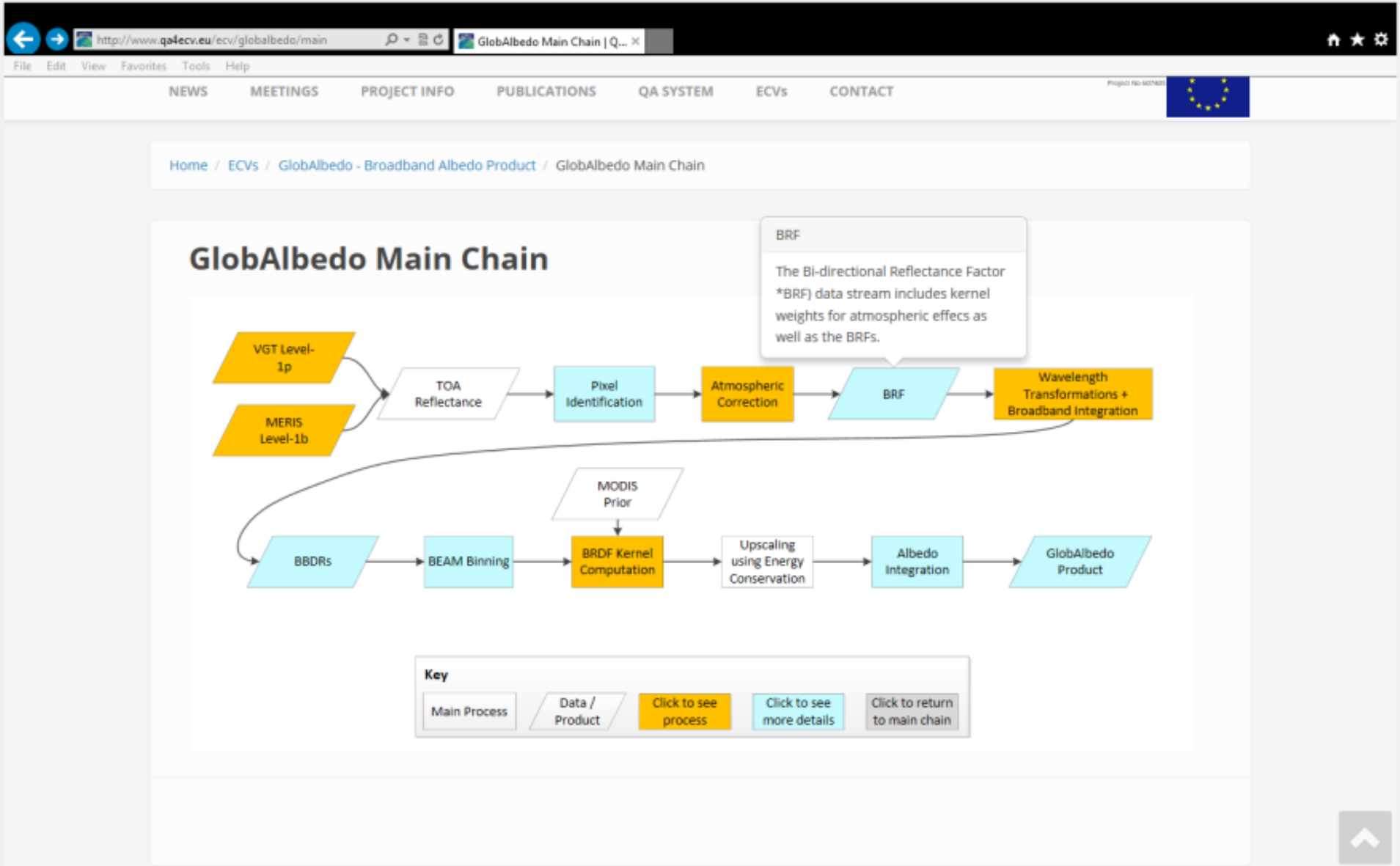
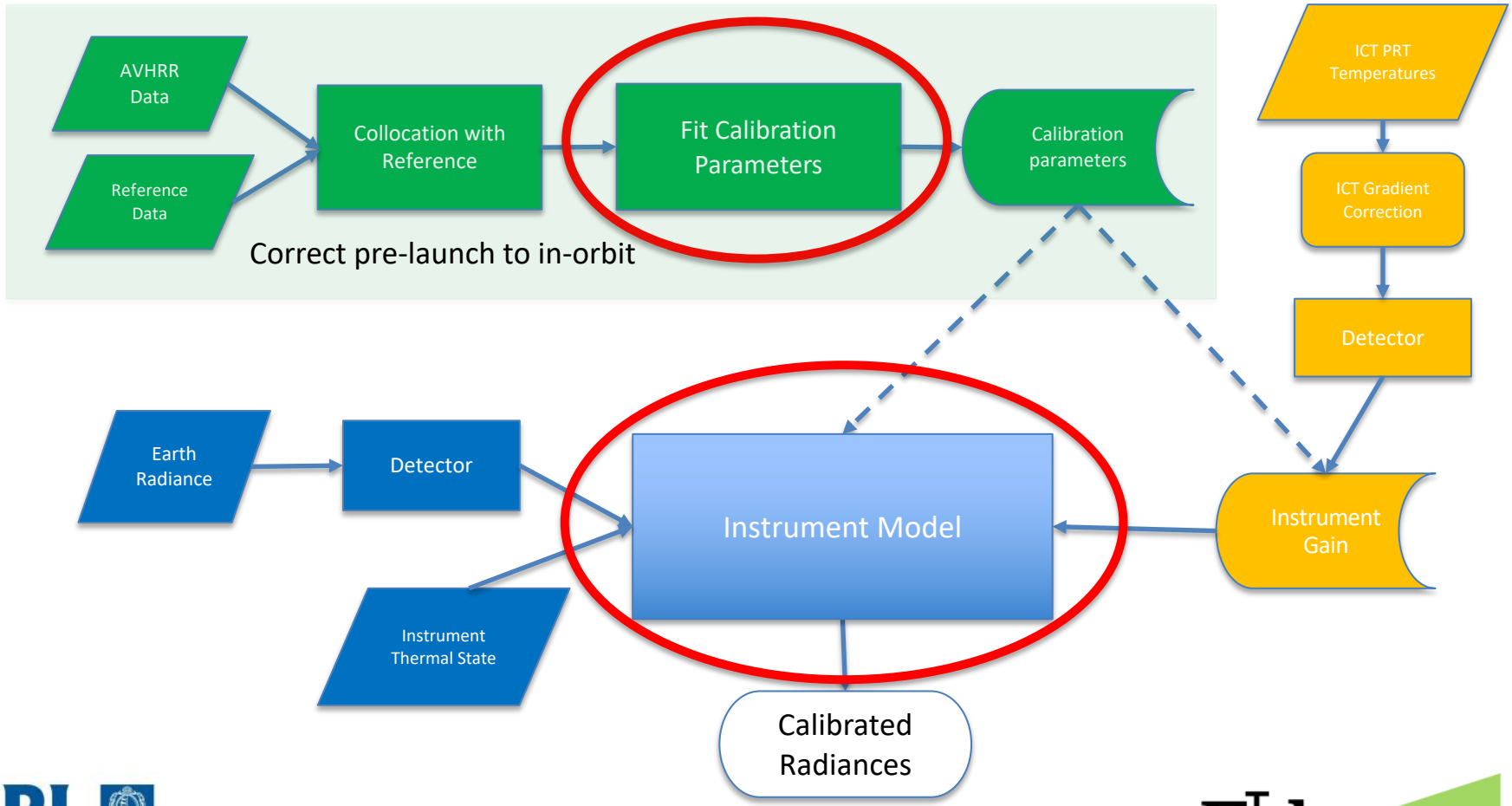
www.qa4ecv.eu/ecvs



AVHRR Calibration Traceability



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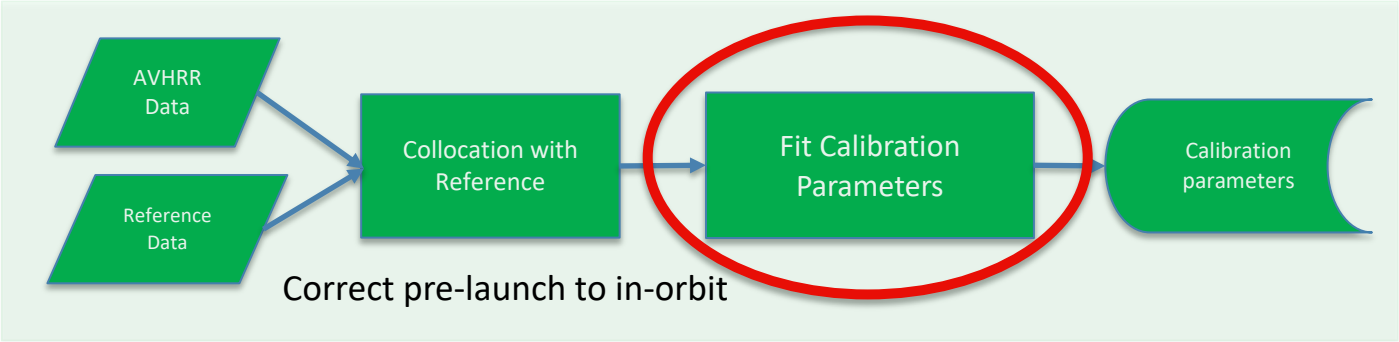
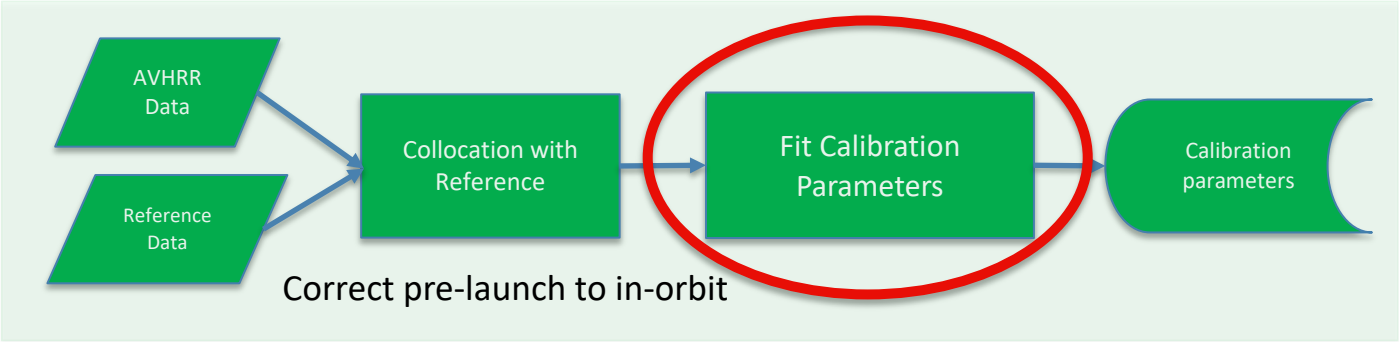
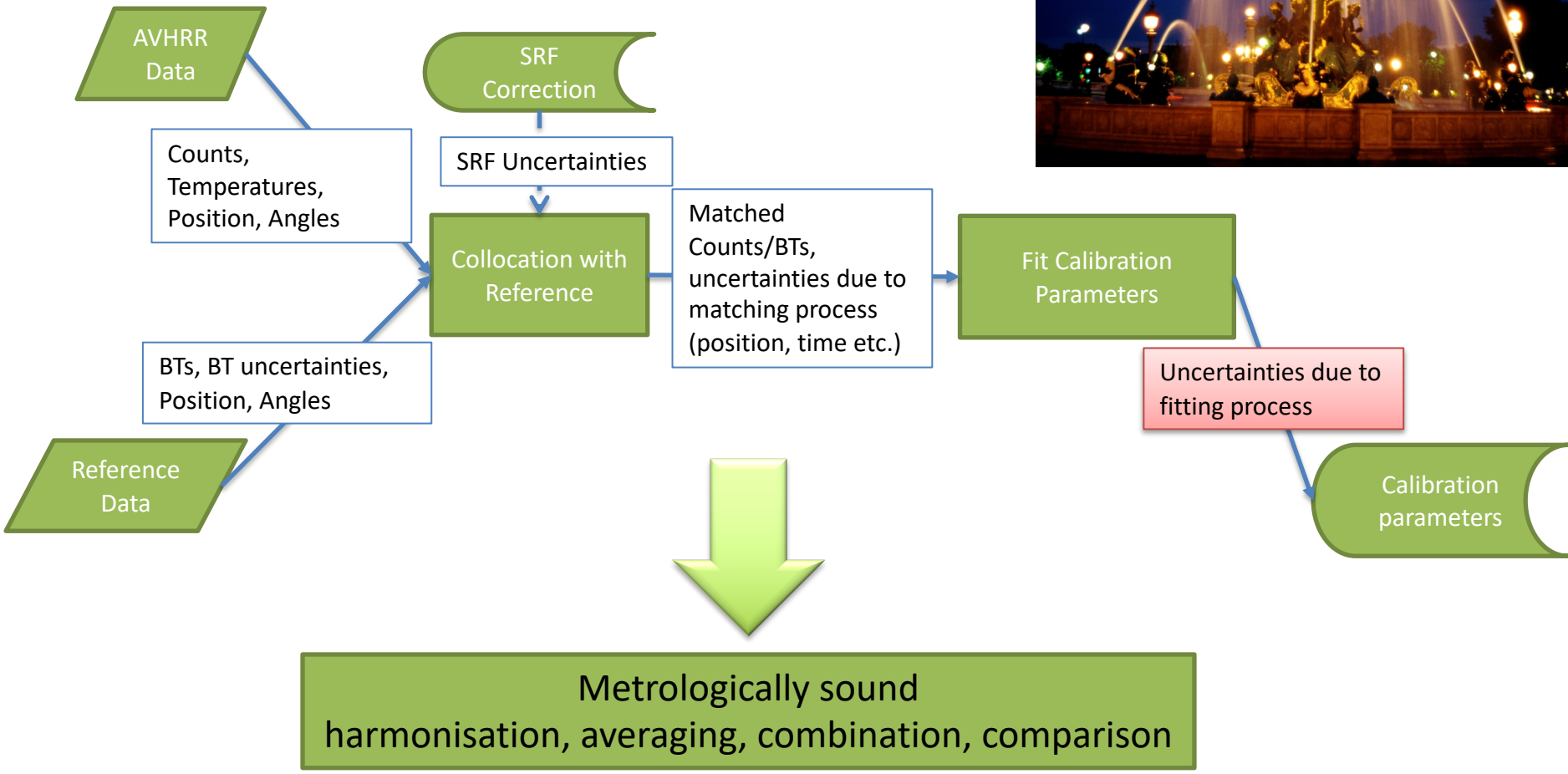


- Shares the process with others
  - Interactive record (clickable for different levels of detail)
  - Record of documentation, references, ATBDs etc
  - Simplifies the dialogue – shared language



- Shares the process with others
  - Interactive record (clickable for different levels of detail)
  - Record of documentation, references, ATBDs etc
  - Simplifies the dialogue – shared language
- Starts a process to understand system from end-to-end
  - Development of a physical model
  - Understanding of propagation (cascade) of uncertainties
  - Starts to show up assumptions

Uncertainty propag



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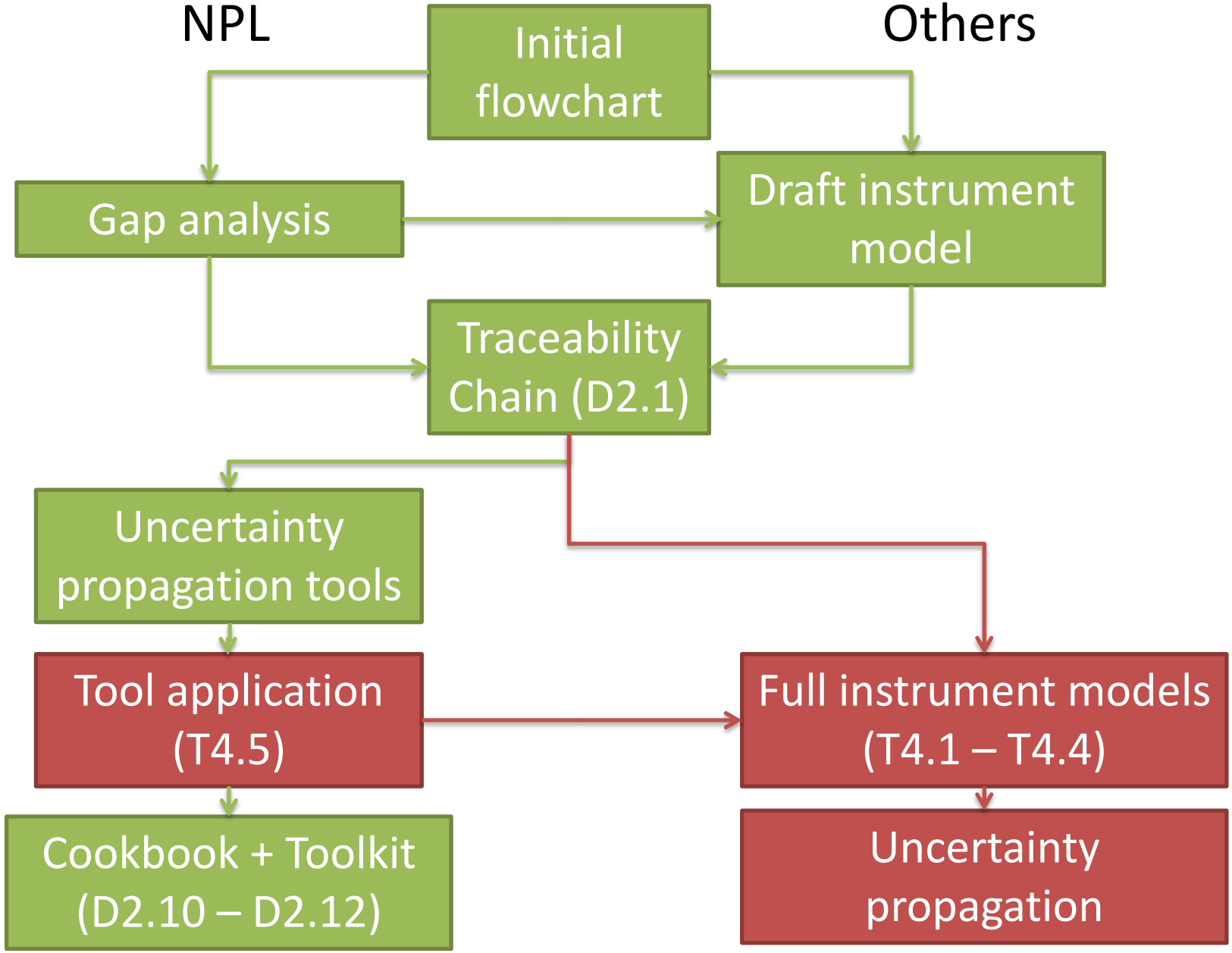

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FCDR Development Framework

- Common philosophy and approach
- Physics-based harmonisation
- Physics-based uncertainty analysis

NPL's role in WP2

- Metrology Perspective
- Asking those "hard" questions
- Seeing patterns and commonalities
- Developing metrological tools for common gaps
- Mathematical support for uncertainty analysis
- Developing training materials, case studies, examples, best practice
- Linkage to laboratory based traceability

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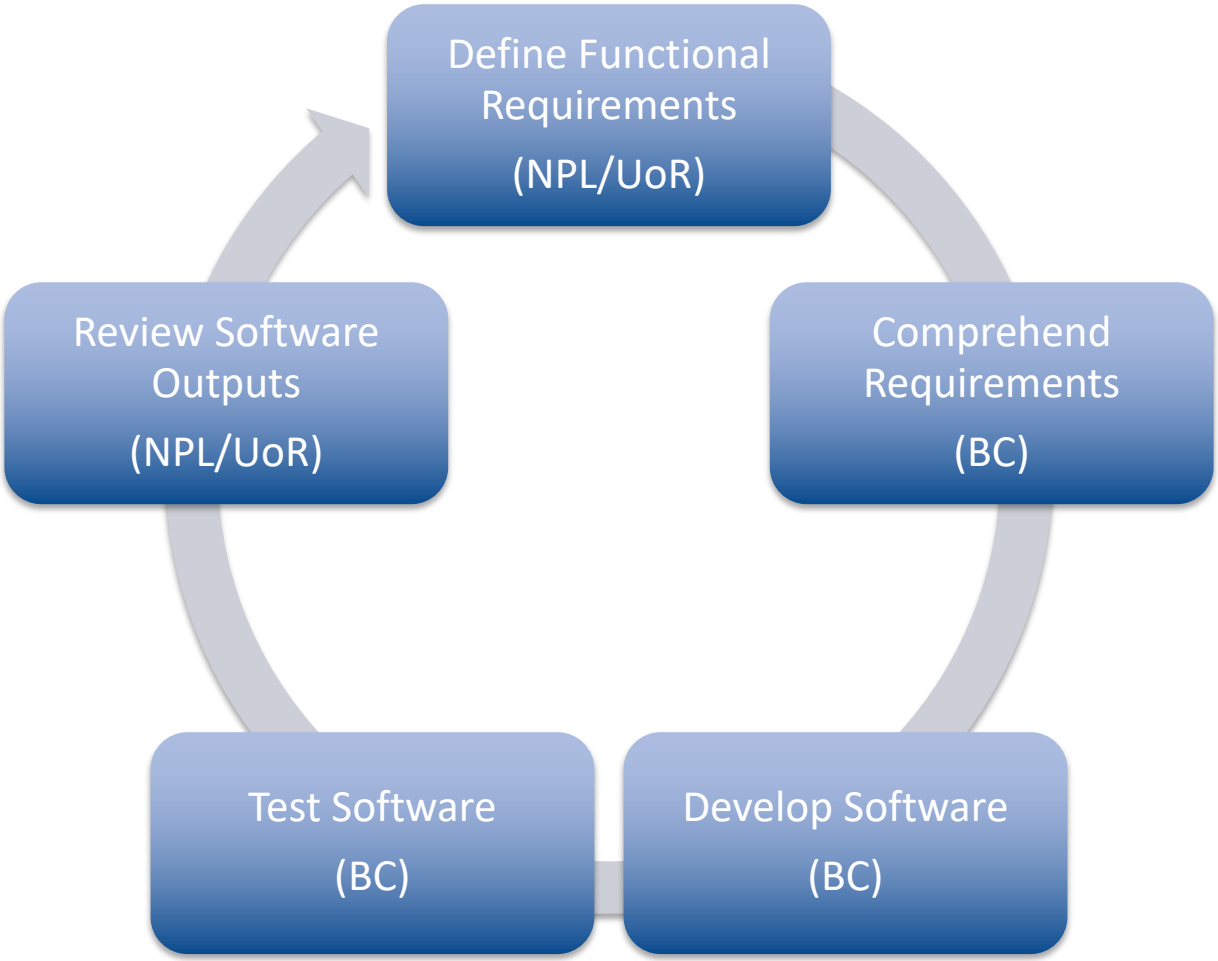
Reading's role in WP2

- Overview – 'holding the vision'
- Lead writing the development framework – report describing the common best practice approach
- Developing (in dialogue with NPL) traceability chains (including instrument models) for FCDRs: HIRS and AVHRR, and CDRs: SST, LSWT. Support NPL in writing tool specifications
- Support NPL and Eumetsat in metrological cookbook and toolkit preparation

University of Reading

Fiduceo

Brockmann Consult's role in WP2



Brockmann Consult GmbH

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Rayference's role in WP2

- Help with writing the development framework – giving own perspective
- Developing (in dialogue with NPL) traceability chains (including instrument models) for FCDR – MVIRI
- Developing (with NPL) traceability chains for CDRs – Surface Albedo and aerosol

rayference

Fiduceo

EUMETSAT's role in WP2

- Help with writing the development framework – giving own perspective
- Developing (in dialogue with NPL) traceability chains (including instrument models) for FCDR – MVIRI, HIRS
- Developing (with NPL) traceability chains for CDR – aerosol
- Support NPL and Reading in metrological cookbook and toolkit preparation

EUMETSAT

Fiduceo

DLR interest in WP2: metrological foundations

- Our CDR: AOD from AVHRR over land (2002-2012, Europe/Northern Africa)

- Algorithm + input data are characterized by
  - ill-posed / under-determined retrieval problem
  - weak calibration (use improved FCDR)
  - low information content (few channels)
    - need of auxiliary aerosol type climatology + 3.7 micron surface brightness
    - related uncertainty needs to be quantified for a meaningful ECV record

- We aim to benefit from best practice error propagation in FIDUCEO
  - stringent error propagation (orbit level2 and gridded level3 products)
  - pragmatic approach
    - focus on dominant uncertainties
    - treat uncertainties of assumptions / auxiliary datasets

  - validation of pixel level uncertainties vs. AERONET ground-based measurements

- We want to contribute with our requirements + test implementation of tools

DLR

Hamburg's role in WP2

- Help with writing the development framework – giving own perspective
- Developing (in dialogue with NPL) traceability chains (including instrument models) for FCDR – microwave sounders, HIRS
- Dialogue with NPL on traceability chains for CDR – upper tropospheric humidity
- Support NPL and Reading in metrological cookbook and toolkit preparation

WP2 In detail

#	Description	Who is involved?	Y1	Y2	Y3	Y4
T2.1	Develop traceability chains for the FCDRs and CDRs	**NPL** UoR UoH EUM DLR Ray	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.1a Report on full traceability chains for FCDRs		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.1b Report on full traceability chains for FCDRs		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

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#	Description	Who is involved?	Y1	Y2	Y3	Y4
T2.2	FCDR development framework	**UoR** UoH EUM Ray NPL	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.2 Report: FIDUCEO Framework for FCDR development v1		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.3 Report: FIDUCEO Framework for FCDR development v2		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

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WP2 In detail (jump to 2.4)

#	Description	Who is involved?	Y1	Y2	Y3	Y4
T2.4	Develop FCDR harmonisation and uncertainty propagation modules	**NPL** UoR BC	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.6 Functional requirement specification for FCDR modules		1 2 **3** 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.7 Software to implement FCDR functional requirement specification		1 2 3 **4**	1 2 3 4	1 2 3 4	1 2 3 4

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WP2 In detail

#	Description	Who is involved?	Y1	Y2	Y3	Y4
T2.5	Develop CDR harmonisation and uncertainty propagation modules	**NPL** UoR BC	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.8 Functional requirement specification for CDR modules		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.9 Software to implement CDR functional requirement specification		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

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WP2 In detail (back to 2.3)

#	Description	Who is involved?	Y1	Y2	Y3	Y4
T2.3	Tools to analyse stability of FCDRs and CDRs	**NPL** BC	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.4 Functional requirement specification for stability analysis tools		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.5 Stability analysis tool implementing		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

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Tipping point toolbox (being developed since 2007)

- Anticipating: early warning of climate tipping points
- Detecting: potential analysis
- Forecasting: PDF & potential analysis, recently added bayesian techniques

Potential analysis model

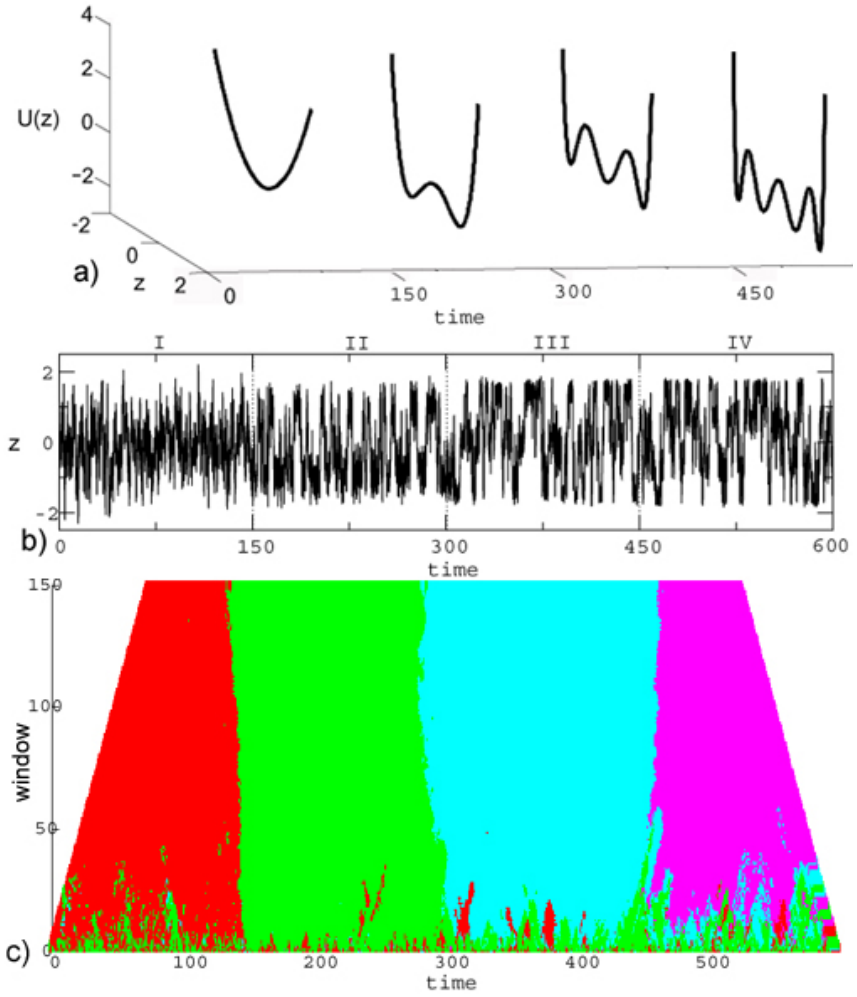
$$\dot{z}(t) = -U'(z) + \sigma\eta$$

$$U(z) = a_4 z^4 + a_3 z^3 + a_2 z^2 + a_1 z$$

double-well potential

Kwasniok & Lohmann, Phys Rev E, 2009
Livina et al, Climate of the Past 2010

AD with four potentials



Potential contour plot at different time scales

We generate artificial data using Euler scheme

$$x_{t+\Delta t} \approx x_t - \left.\frac{dU}{dx}\right|_t \cdot \Delta t + (W_{t+\Delta t} - W_t)$$

W is a Wiener process

Potentials:

$$U(z) = z^2$$

$$U(z) = z^4 - 2z^2$$

$$U(z) = z^6 - 4.5z^4 + 5z^2$$

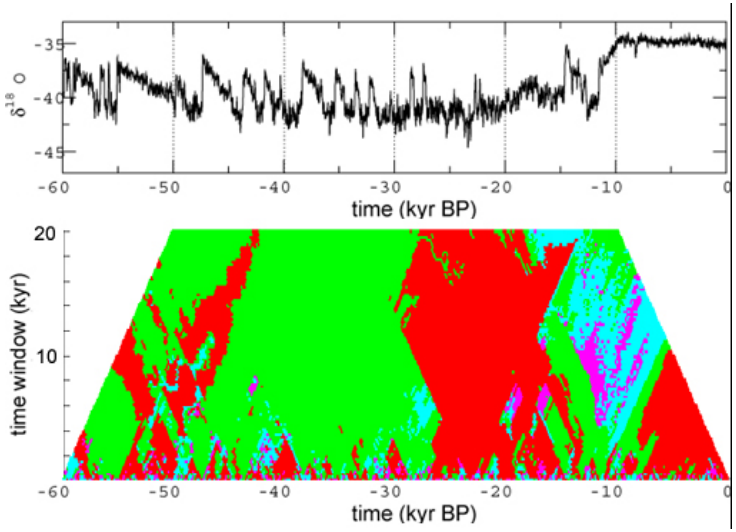
$$U(z) = z^8 - 6.5z^6 + 13z^4 - 8z^2$$

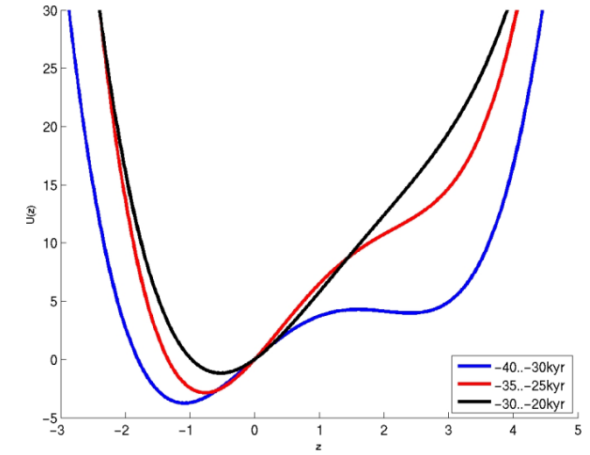
GRIP & NGRIP temperature proxies (Greenland Ice Core)

$\delta^{18}O$ data: bifurcation at 25-28 kyr BP

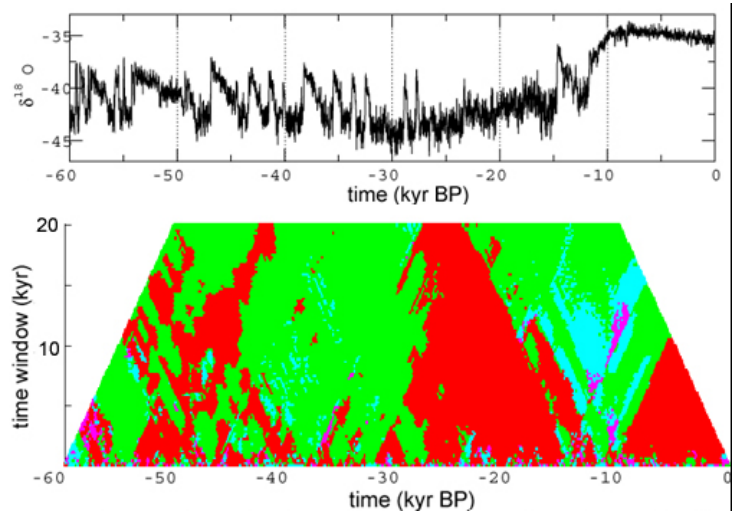
(Livina et al, Climate of the past, 2010)

GRIP



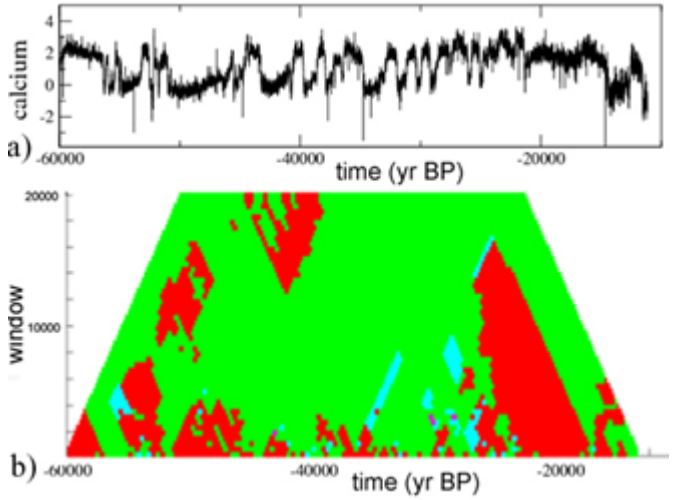


NGRIP



Calcium data: bifurcation at 27-28 kyr BP

GRIP



GICC05 time scale, resolution 20yr

Annual resolution

#	Description	Who is involved?	Y1	Y2	Y3	Y4
T2.6	Metrological cook-book and toolkit bundle	**NPL** UoR EUM BC	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.10 Metrological Cookbooks		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.11 Workshop sessions on uncertainty propagation and related metrological concepts		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
	D2.12 eLearning modules prepared and given		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

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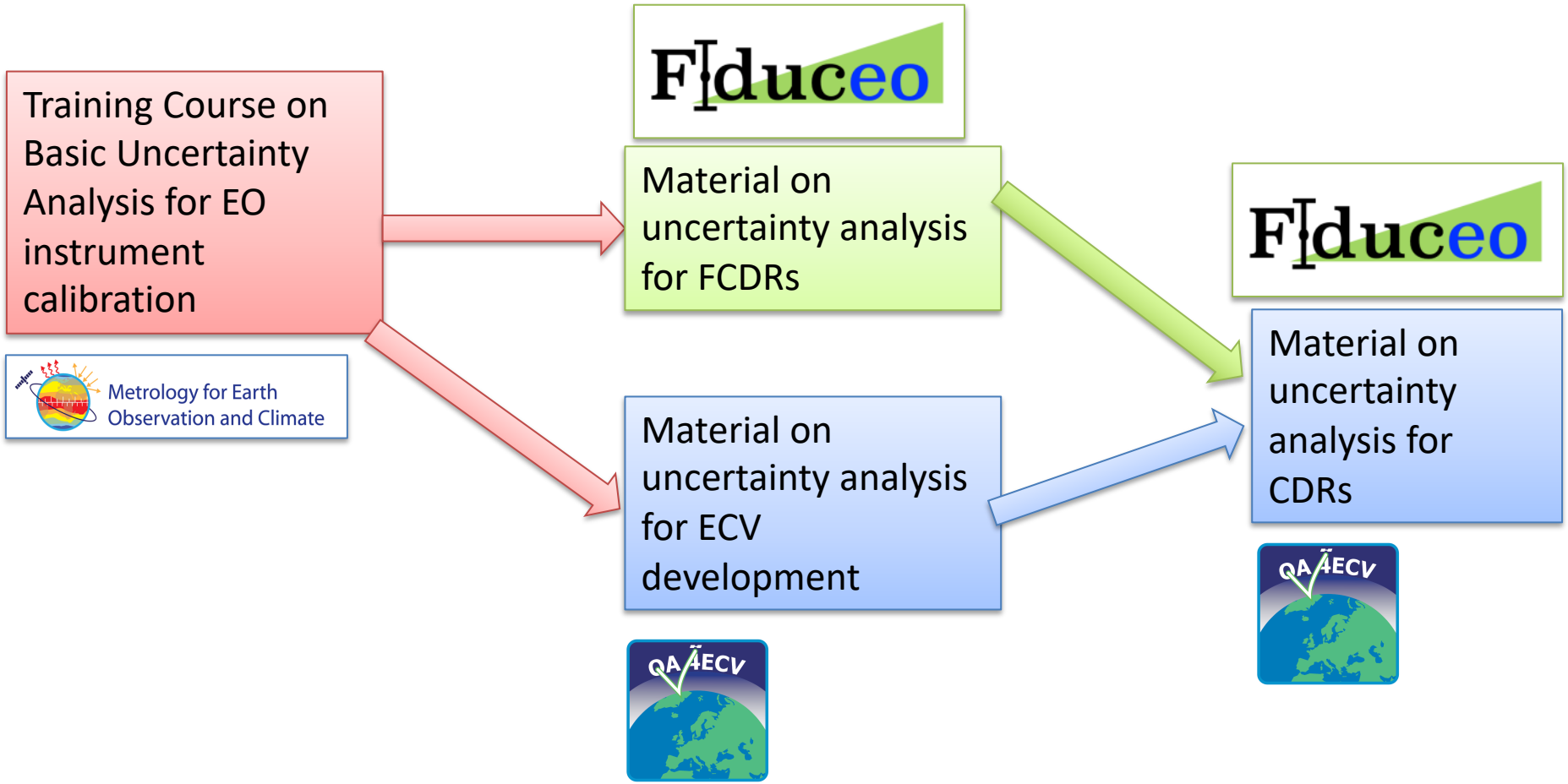
Learning Materials



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First 6 months

March	April	May	June	July	August
First draft framework (UoR)	Discussions of framework and deliver D2.2 (UoR, UoH, EUM, Ray, NPL)				
First draft FCDR traceability chains collated in discussion (NPL + others)		Gap analysis of traceability chains (NPL)		Improved traceability chains and start of system model (D2.1 for FCDRs)	
Reading and NPL (with everyone else!) to agree what building blocks are (start discussion today)					Start work on first building blocks
	Collate first data for trend analysis (NPL + …)		NPL to carry out initial statistical analysis of time-series information		

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What I want to talk to partners about today …

- How do we build on the traceability chains started in yesterday's break out sessions?
- What concerns do you have?
- How soon could we get some data for stability analysis – is there anything already available? (CCI Phase 1 data for SST? More?)
- With Brockmann Consult – how will we work together on functional requirements?
- What ideas do we now have for tools required?

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Tool ideas: FCDR

- Instrument model interfaces
  - ICT homogeneity, noise characteristics …
- Spectral Response Function issues
- Uncertainty propagation
- Monte Carlo Interfaces
  - Linkages between different traceability chain modules
  - Full MC estimates of uncertainty PDFs
- Recalibration modules
  - Related to MMD for the uncertainty estimates for a recalibration based on colocations with reference
- Harmonisation parameters for a sensor series (including covariance)
- SI traceability – what options are there? What about when it's not possible?
- Sensitivity analysis

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Tool ideas: CDR

- Stability / trend analysis
- Break points
- Averaging tools (spatial, temporal – with proper covariance)
- Uncertainty propagation from FCDR to CDR
  - At different time/spatial scales
- Using validation data (with its own uncertainties) – uncertainty based comparison

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