D2.6 Metrology Cookbooks and Workshop Session

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1 Introduction

1.1 Scope

This document is deliverable D2.6 “Metrology cookbooks and workshop session”. It discusses the work that was done to establish the cookbooks and eLearning materials to support eh FIDUCEO FCDRs.

1.2 Version Control

Version	Reason	Reviewer	Date of Issue
1.a	Submission	Rhona Phipps	25/05/2018
1.b			
1.c			

1.3 Glossary

CDR	Climate Data Record
FCDR	Fundamental Climate Data Record
FIDUCEO	This project
H2020 (EMPIR)	Horizon 2020 European Metrology Research Programme for Innovation and Research
MetEOC	Metrology for Earth Observation and Climate (H2020 EMPIR project series)

2 Supporting the application of metrological principles to the Fundamental Climate Data Records

In establishing metrologically-rigorous Fundamental Climate Data Records (FCDRs), the FIDUCEO project has had to develop new methods for thinking about the development of an FCDR. These methods are based on metrological principles, but are an extension of these principles to the specific challenges of Earth Observation data. As well as documenting the establishment of our own FCDRs, we have two other responsibilities related to the FCDR methodology, namely:

1) The provision of guidelines for CDR producers to understand what information is contained in the FCDRs and how to use it, and
2) The provision of guidelines for FCDR producers so that they can follow the FIDUCEO methodologies with other FCDRs.

The FIDUCEO methodology is novel and has great potential to change how the Earth Observation community considers the production and application of FCDRs to ensure long-term stability, interoperability and to provide rigorous uncertainty estimates for retrievals. It is also complex and builds on concepts that are not well understood in the relevant communities.

For these reasons, a core aspect of the FIDUCEO project has been the development of guidelines and "cookbooks", to teach the principles of FIDUCEO to others who may use them.

To provide someone with the right level of information to understand the FIDUCEO approach, we have developed different types of material at different levels.

Beginner level

At a beginner level, users need to understand the differences between errors and uncertainties, the basic concepts of error correlation and covariance, and the Law of Propagation of Uncertainties. While these ideas are fundamental to metrology, they are rarely taught well at universities in any of the disciplines that Earth Observation scientists study.

This material is already available, and FIDUCEO recommends (under tutorials on the website) the use of material available at http://www.npl.co.uk/e-learning/:

- Introduction to Measurement Uncertainty
- Earth Observation specific uncertainty analysis course

In addition a book "Uncertainty analysis for Earth Observation instrument calibration" prepared in the H2020(EMPIR) project MetEOC is available for download at: http://www.meteoc.org/wp-content/uploads/sites/35/2017/11/uaeo-int-trg-course-v2.pdf

FIDUCEO-specific, intermediate level

FIDUCEO-specific intermediate-level training material on the concepts of metrology applied to FCDRs has been developed. This material is/was provided:

- At the Lisbon Workshop on FCDRs (see Section 3)
- On the FIDUCEO website as tutorials (see Section 4)
- As the vocabulary on the website (see Section 0)
- Key concepts have been presented at scientific conferences (see Section 6)
- A paper is in preparation (see Section 6)
- A iPython notebook was prepared (see Section 7) to present a core concept of harmonisation

This intermediate-level material is designed to give people an overview of the core concepts of FIDUCEO. It is developed and presented in a teaching style with the focus on understanding.

FIDUCEO-specific, advanced level

Once people have understood the concepts of FIDUCEO, and are ready to apply them in practice, they need specific material that describes the FIDUCEO approach. This is provided in a set of documents that are available on the FIDUCEO website:

- The D2-2a deliverable, and the examples in the other D2-2 reports, provides a guidance to the development and recording on an FCDR
- FIDUCEO Notation Document, which describes the notation used in FIDUCEO documents
- The Easy FCDR Error Covariance formulae document, which describes how the Easy FCDR is calculated from the Full FCDR
- Full documentation has been prepared to explain the preparation of input files for the harmonisation process [Will be uploaded to: http://www.fiduceo.eu/documentation]
- The FCDR format specification document [Will be uploaded to: http://www.fiduceo.eu/documentation]

3 FCDR workshop

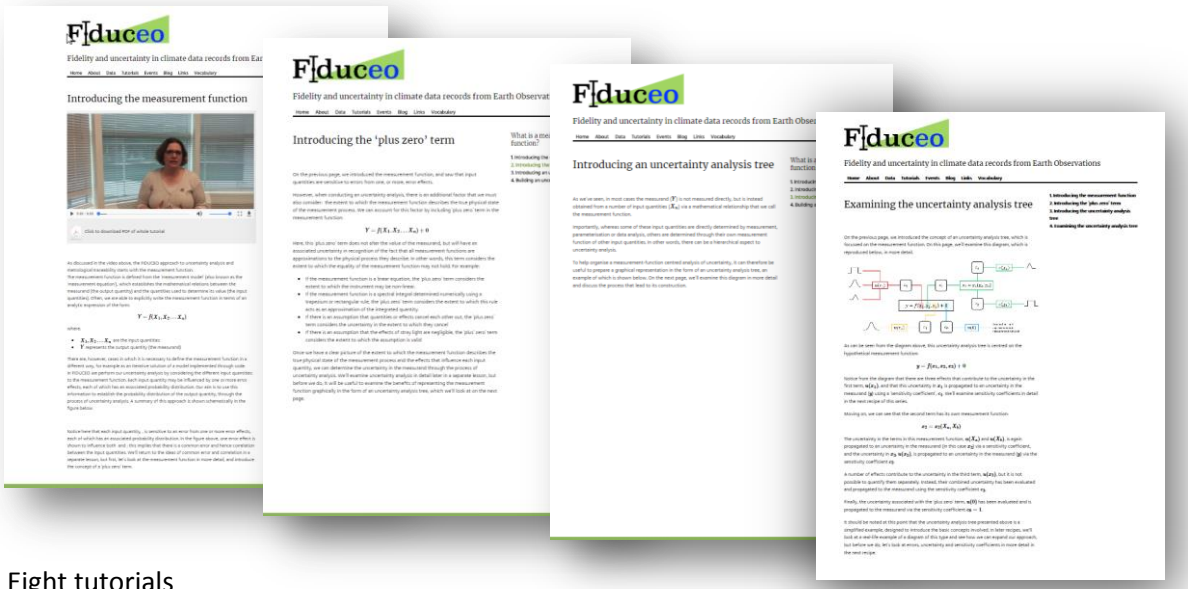
The first FIDUCEO workshop "Earth observation Radiances to Climate Data Records: Metrological Principles and their Application", was held on 17th to 19th April at IPMA premises in Lisbon, Portugal. A write up of the workshop was published on our online blog at: http://www.fiduceo.eu/content/fiduceo-first-workshop

The workshop was attended by 27 scientists who were not involved with the FIDUCEO project and 16 FIDUCEO project members. It involved a combination of tutorial lectures, group workshop exercises to ensure people engaged practically with the FIDUCEO project concepts, and discussion sessions. The presentations from the workshop have been made available online at: http://www.fiduceo.eu/publications

4 Online tutorial materials

The FIDUCEO project has considered it particularly important to develop online tutorial materials that can support people in understanding the FIDUCEO methodology. The tutorials are available on the webpage at: http://www.fiduceo.eu/tutorials-menu. Each tutorial consists of:

- A short introductory video to "set the scene" for the tutorial
- 4 webpages of text that explain the concepts
- Links to documents that provide more information



Eight tutorials are being developed. Four are already on the webpage and three are under review. The Easy FCDR one is still to come. These cover the following topics:

Tutorial title	Topics covered
What is a measurement function?	• Introducing the measurement function • Introducing the 'plus zero' term • Introducing the uncertainty analysis tree • Examining the uncertainty analysis tree
Sensitivity coefficients, errors and uncertainties	• Introduction • Error and uncertainty • Introduction to the sensitivity coefficients • Determining the sensitivity coefficients
Considering sources of uncertainty/effects	• What are effects? • Example uncertainty analysis tree • How do we think about effects? • What information do we need to combined effects?
The origin of error correlation	• Introduction to correlation • Introducing correlation structures via a rolling average • Correlation in different dimensions • Spectral correlation
Evaluating error correlation	• Introduction to evaluating error correlation • Type A methods for evaluating error correlation • Type B methods for evaluating error correlation • Spectral correlation due to common temperature
Introduction to the effects table	• Recap of what we need to know to combine effects • Introduction to the effects table • How FIDUCEO codes the effects table
Combining effects and the easy FCDR	• TBC
Harmonisation	• Introduction to harmonisation • The harmonisation problem • Optimisation methods • The FIDUCEO approach

5 Online vocabulary

A FIDUCEO vocabulary is available online in a searchable HTML format at: http://www.fiduceo.eu/vocabulary, and as a PDF document at: http://www.fiduceo.eu/content/fiduceo-vocabulary-0

The online vocabulary allows for interactive discussion about the terms used. An updated version of the vocabulary will be provided at the end of the project.

6 Scientific papers and conference participation

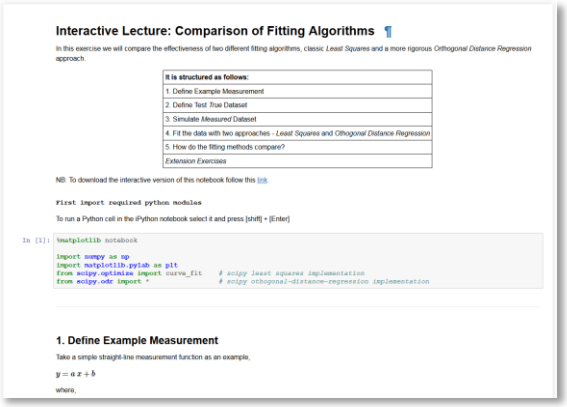
An important aspect to getting acceptance and understanding of the FIDUCEO principles is to publish our work in scientific conferences and in publications. A paper entitled "Applying Principles of Metrology to Historical Earth Observations from Satellites" is under preparation (we are waiting to confirm one aspect of the AVHRR FCDR that is used in an example, but otherwise the document is written). We intend to submit this to the journal *Metrologia* so that it can have (and be seen to have) a peer review by the metrological community.

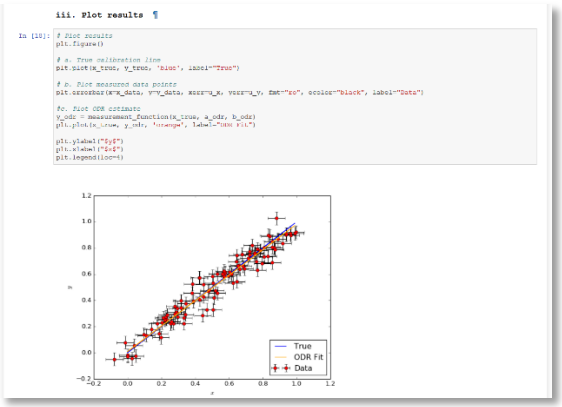
Other papers and conference presentations have been given. A full list is in the publication report.

7 iPython Notebook

An iPython notebook has been prepared to show one of the core principles of harmonisation: that we cannot use least squares analysis to fit a curve to data when there is uncertainty in both the input and output data. This iPython notebook uses an intuitively easy example – fitting a straight line – to demonstrate how an errors-in-variables approach is required for unbiased optimisation. This is followed by a set of extension exercises to allow users to investigate further aspects of the problem for themselves.

The iPython notebook is available in the project's harmonisation github repository, along with instructions on how to use it: https://github.com/FIDUCEO/Harmonisation/tree/master/src/main/workshop





8 Future plans for further training material

While the deliverable is completed with the material that has already been produced, and is described in here, we recognise the importance of developing this material further in order for it to have a full impact. During the remainder of the project we will add to the online tutorials and produce further user guides.

Work is also planned in WP7 to develop the second Lisbon workshop on CDRs and also to provide tutorials on CDRs.

NPL has also obtained funding in the H2020-EMPIR project MetEOC-3 to develop a further full e-Course on the principles behind the FIDUCEO FCDRs. This will expand and disseminate the FIDUCEO metrological concepts further to related projects and initiatives, e.g. the application to current sensors such as the Sentinels. The new funding reflects the community need and necessary investment in the area. The new eCourse will also help in the FIDUCEO legacy and in broadening the project impact.