FIDUCEO has received funding from the European Union's Horizon 2020 Programme for Research and Innovation, under Grant Agreement no. 638822

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Fidelity and uncertainty in climate data records from Earth Observations

Chris Merchant, University of Reading

Status of the FP7/H2020 Copernicus Climate Change projects, Brussels, 29th September 2016

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- **Ambition**: develop a widely applicable **metrology of Earth observation (EO)**

- **Motivation:** establish **traceable, uncertainty-quantified evidence** for climate and environmental change from space assets

- Project runs March 2015 to February 2019

www.fiduceo.eu

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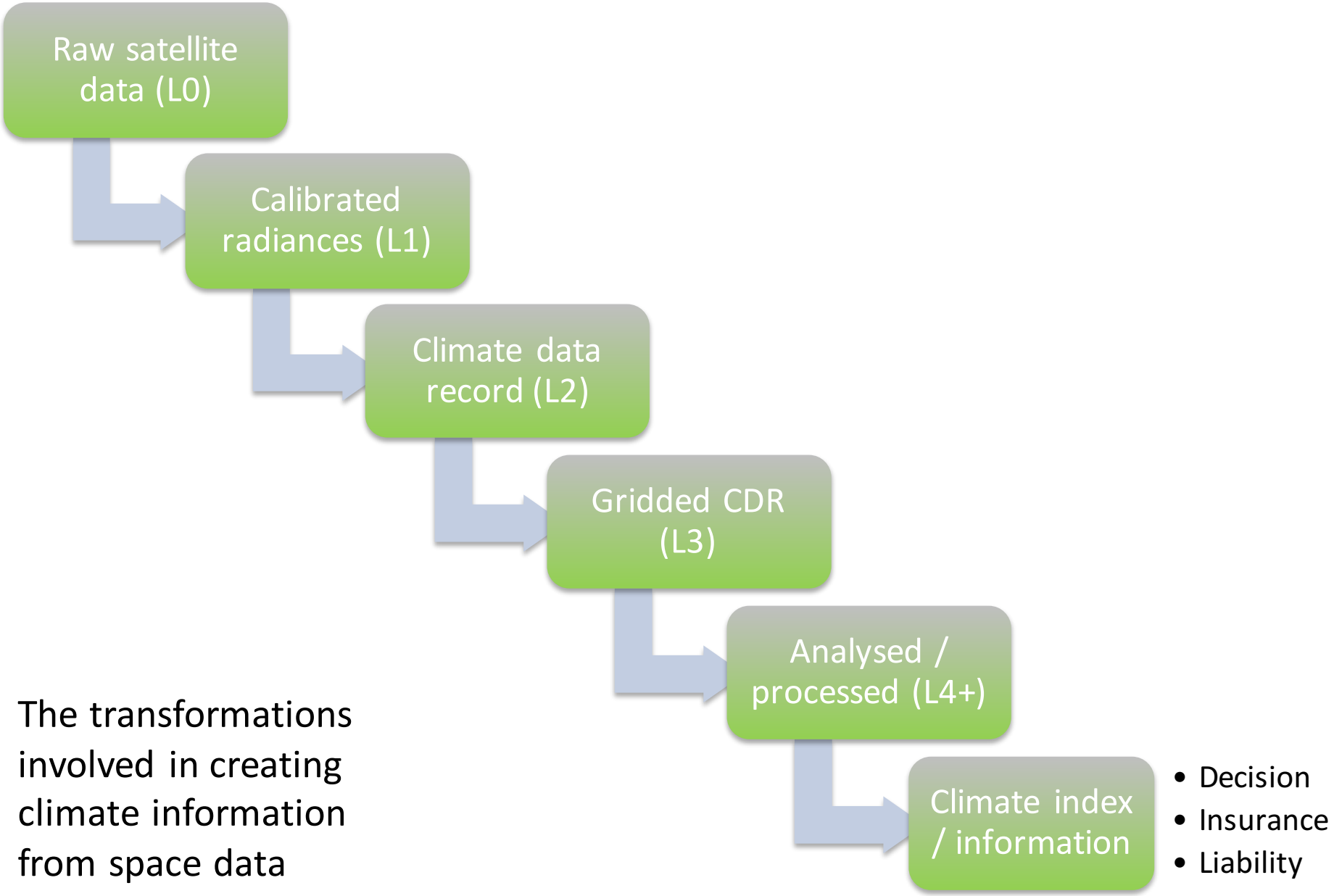

The transformations involved in creating climate information from space data

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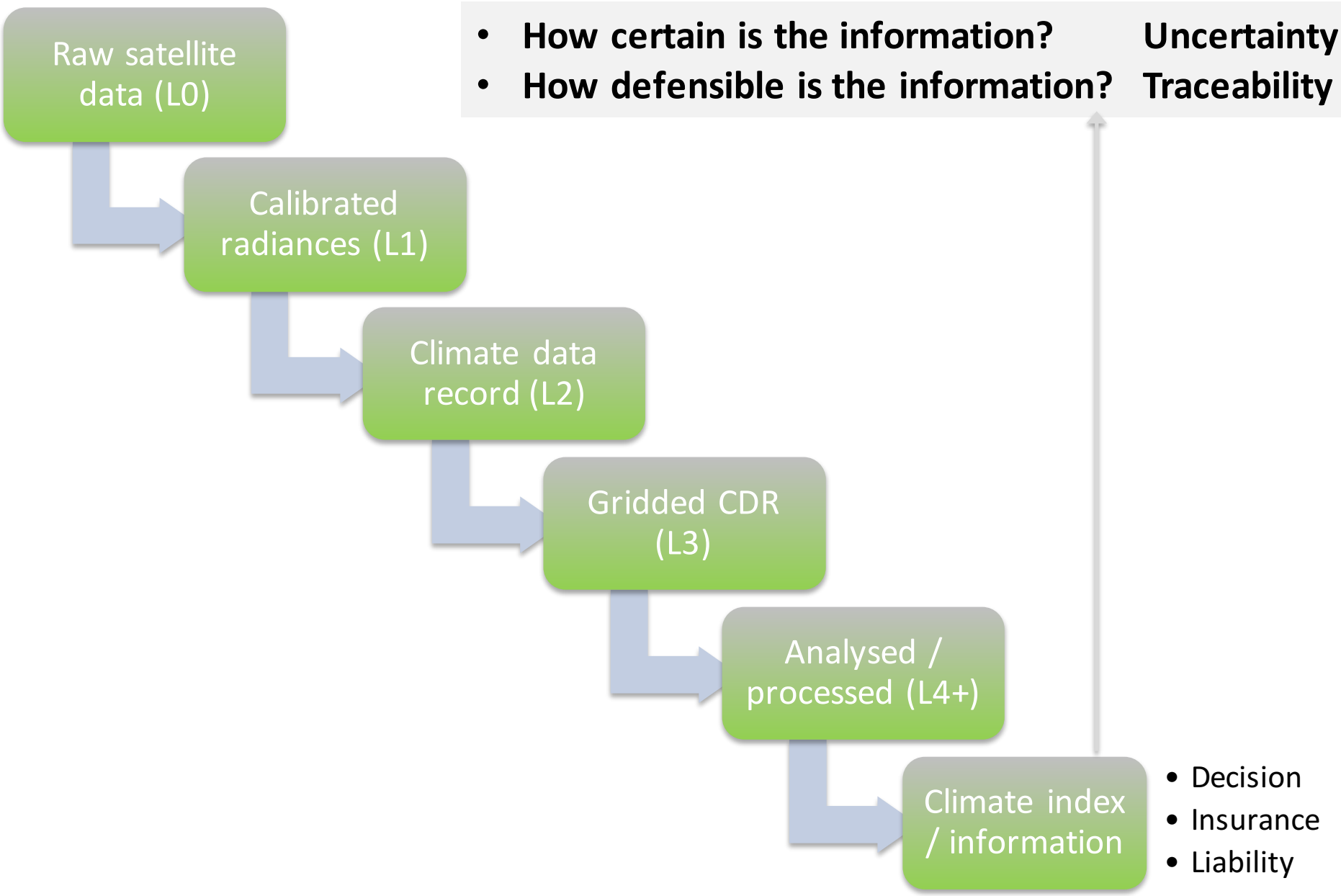

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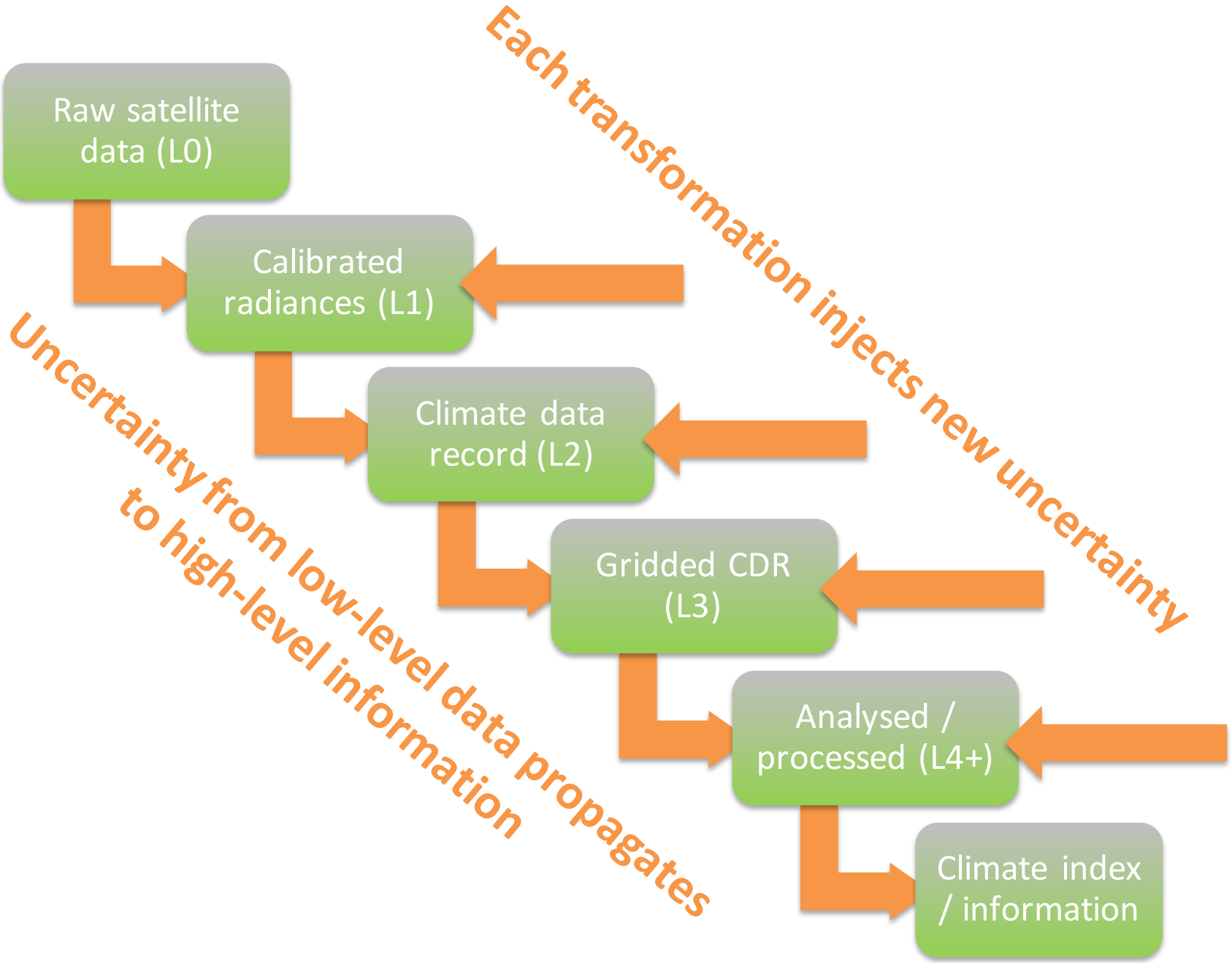

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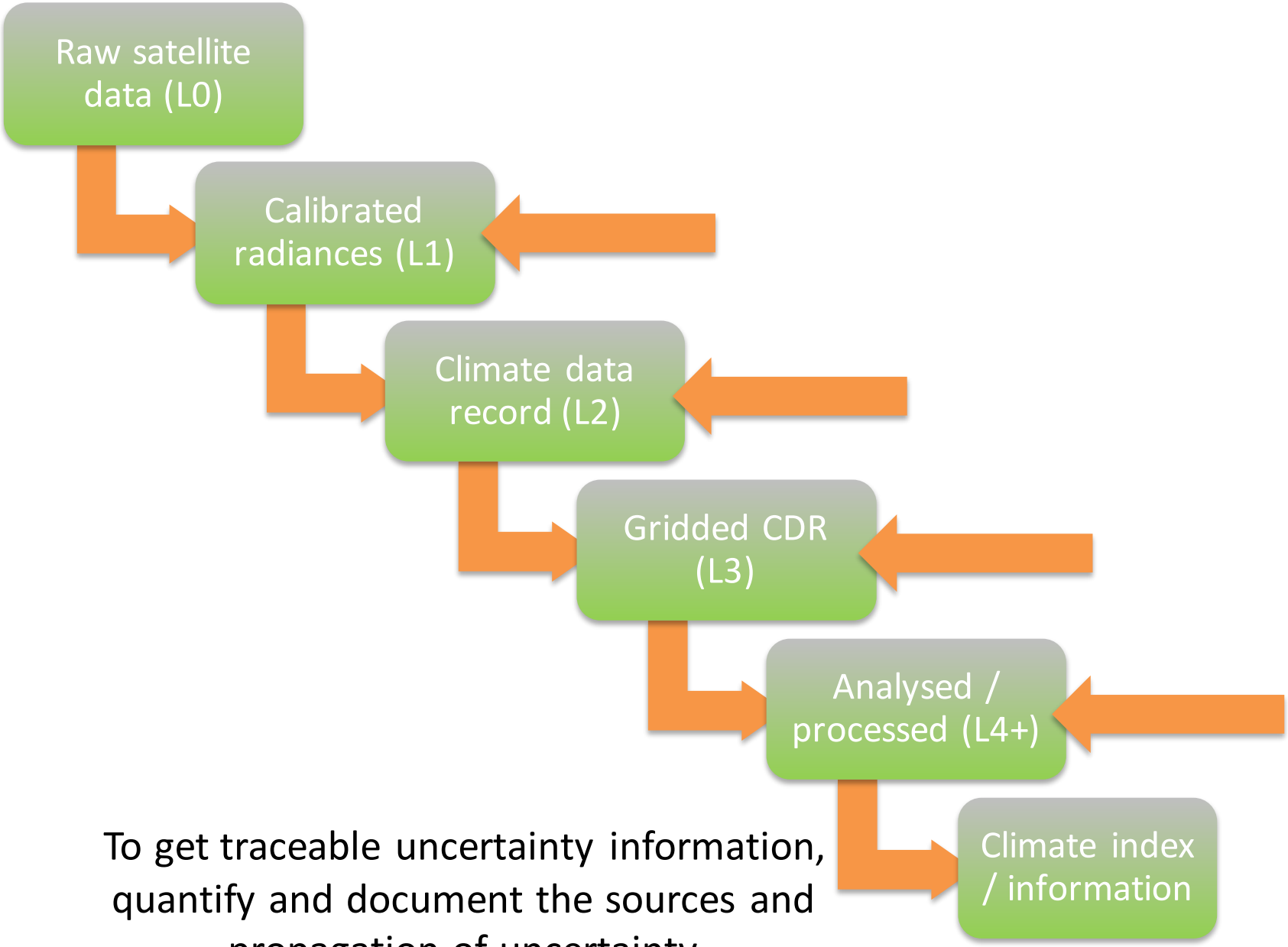
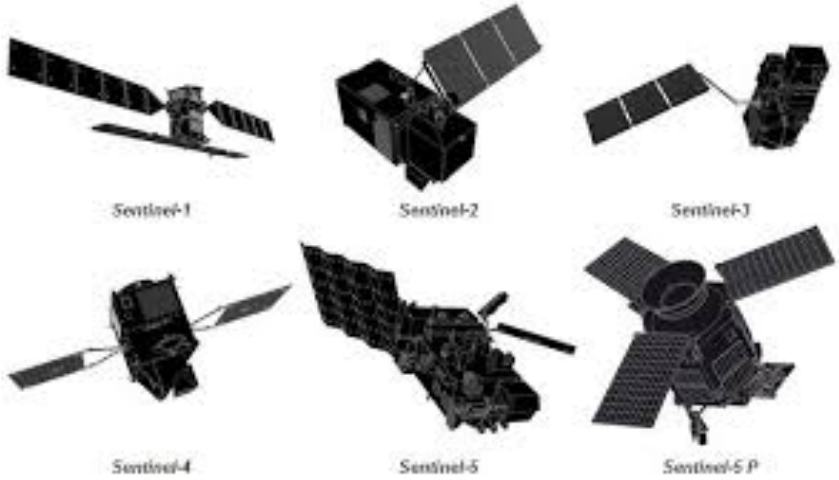


To get traceable uncertainty information, quantify and document the sources and propagation of uncertainty



Raw satellite data (L0)

Calibrated radiances (L1)

Climate data record (L2)

Gridded CDR (L3)

Analysed / processed (L4+)

Climate index / information

FIDUCEO addresses fundamental gaps in capability that prevent EO-based CDRs and climate information having traceable uncertainty

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FIDUCEO FCDRs (L1)

FCDR: fundamental climate data record (calibrated radiances)
from which climate data can be derived

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,…

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FIDUCEO CDRs (L2/L3)

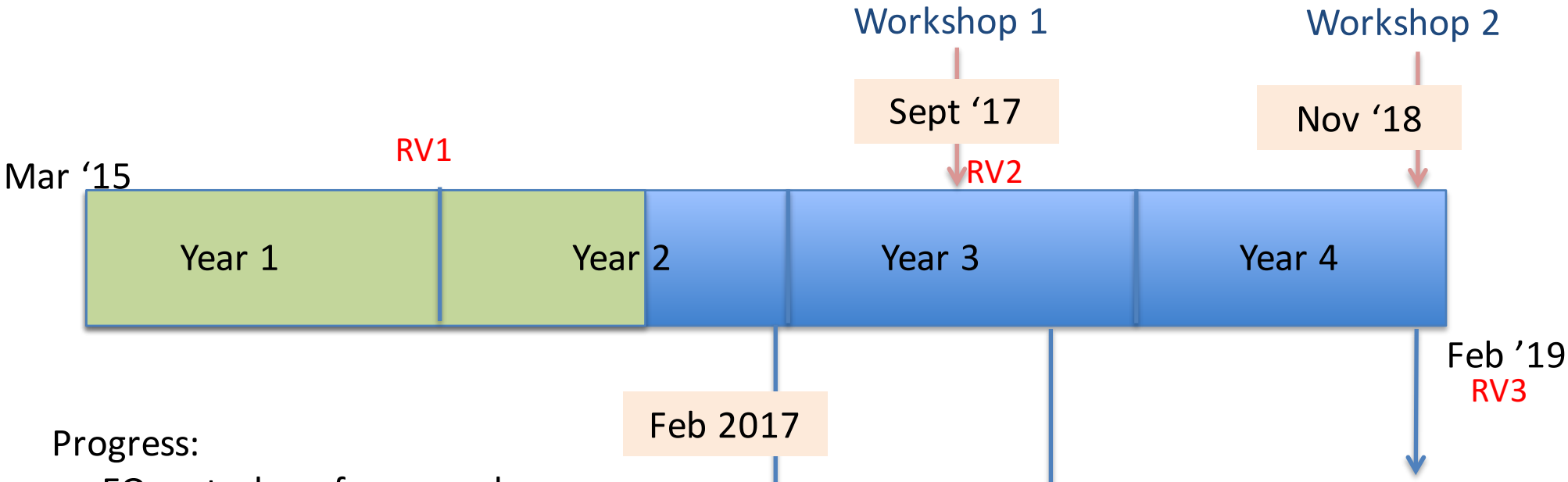
CDR: climate data record, the evidence base for high-level climate information and services

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 …

Why *metrology* of EO?

- Adopting language and tools of measurement science brings
  - conceptual clarity
  - rigorous practice
  - well-tested tools
  - better climate data records
- But the process is also *extending* the discipline of metrology in some ways
  - EO raises aspects not present in the laboratory

FIDUCEO project timelines



Progress:

- EO metrology framework
- Many methodologies
- Data acquisition / prep.
- User consultation
- Vocabulary

Beta version FCDRs - AVHRR, HIRS, MVIRI

Beta version MW FCDR

CDRs:

- *SST & LSW*
- *UTH*
- *Albedo and Aerosol*
- *Aerosol (from AVHRR)*

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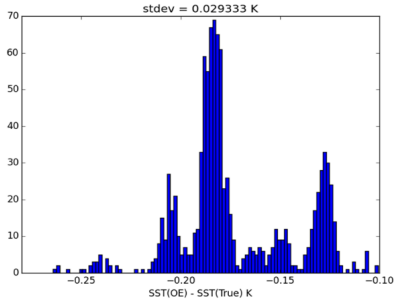
FIDUCEO and Copernicus

- Kick off *C3S Quality Assurance for ECV Products Derived from Observations* (planned October)
  - incorporating QA4ECV and FIDUCEO methods
- C3S contract (August) to EUMETSAT on reprocessed satellite observations
  - FIDUCEO methods on MW FCDRs propagated to CM-SAF sounder projects
  - FIDUCEO methods to be applied to Meteosat IR recalibration
  - FIDUCEO recalibration of AVHRR (global) to inform stewardship of AVHRR local (hi-res) FCDR



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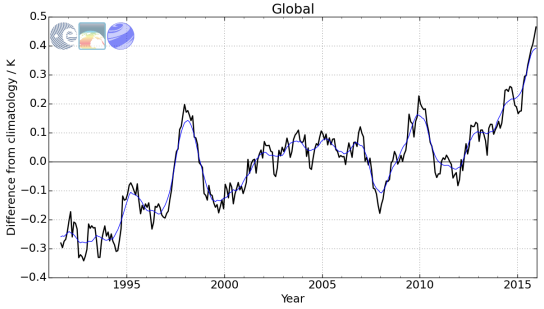
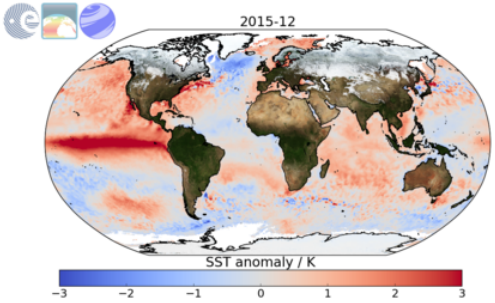
FIDUCEO and Copernicus

- Expect contract soon for provision of sea surface temperature (SST) climate data to C3S
  - Climate Change Initiative SST CDR v2 will be brokered through C3S, and operationally extended in time with an interim CDR (ICDR)
- The FIDUCEO ensemble SST CDR will be brokered through C3S once released
  - first ensemble CDR from EO (to our knowledge)
  - great interest in this approach from major users





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FIDUCEO and Copernicus

- FIDUCEO ensemble SST likely also to comprise a component of any CCI+ SST CDR v3
  - therefore in turn serving both C3S and the Copernicus Marine service, CMEMS
- FIDUCEO lake surface water temperature CDR
  - potential input to CCI+ Lake ECV
  - potential brokering through Copernicus Land Service (not yet discussed)
- FIDUCEO AVHRR FCDR may be used in C3S terrestrial ECVs
  - TBC, depends if timelines align

FIDUCEO and GAIA-CLIM

- Two highly complementary projects on metrology of climate observations
- Co-ordination through mutual representation on advisory boards
- Scientific opportunity to close the metrological uncertainty budget of a reference-network-to-satellite comparison for at least one FIDUCEO CDR
  - first fully rigorous validation of uncertainty

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Further research

1. FIDUCEO address the steps from L0 to L3 (i.e., gridded ECV products) : take forward
   - propagation and traceability to higher levels
   - including consistent uncertainty information across climate-relevant space-time scales
2. FIDUCEO addresses historic missions
   - translate methodologies to current missions, e.g., Copernicus S3 SLSTR etc
   - apply EO metrology to future mission development

Climate Change Service

Climate Change Service

Copernicus Europe's eyes on Earth

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Further research

3. FIDUCEO demonstrates traceable uncertainty for selected FCDRs/CDRs across VIS, IR and MW
   - broaden metrology of EO to include active sensors
   - spread metrology to more ECV groups, e.g., via CCI+
4. FIDUCEO pioneers ensemble CDR(s) for EO and will engage trail-blazer users; nonetheless
   - fully demonstrate exploitation of EO ensemble CDRs in
     - numerical weather prediction re-analysis
     - climate model evaluation
   - apply ensemble to operational ICDRs
     - e.g. for seamless prediction, event attribution service
5. For key CDRs, close metrological uncertainty budget between satellite and in situ references

Conclusions

- We need a metrology of EO in order to provide true traceability and uncertainty information for climate data / information
- FIDUCEO is addressing gaps at the lower-level products in this capability
- The metrological approach turns out to be greatly beneficial (trust, transparency, tools …)
- FIDUCEO in early, pre-product stage, but links and commitments to Copernicus services are emerging
- Need to see metrology of EO from FIDUCEO in due course
  - applied across a wider range of satellite missions and ECVs
  - propagated to higher-level products and climate information
  - exploited scientifically in re-analyses etc
  - applied prospectively during new mission development

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