# Aims and current status of GAIA-CLIM

February 8th 2017

Peter Thorne

With thanks to Richard Davy, Corinne Voces, Anna Mikalsen, Fabio Madonna, Karin Kreher, Jean-Christopher Lambert, Bill Bell, Joerg Schulz, Martine de Maziere


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# GAIA-CLIM in one slide

- Aim is to improve use of non-satellite measurements to characterise, calibrate and validate satellite measurements
- Ensure best metrological practices followed in comparisons
- Principal user outcomes a Virtual Observatory tool and documentation of gaps in capabilities and remedies w/prioritisation


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# Atmospheric focus

- Concentrate upon atmospheric domain as an exemplar
- Don’t duplicate other projects (e.g. QA4ECV)
- Look at a subset of ECVs in which consortium have expertise
  - Temperature
  - Humidity
  - Ozone
  - Aerosols
  - Carbon Dioxide
  - Methane


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# GAIA-CLIM scientific components

1. Mapping and assessing observational capabilities

2. Improving metrological characterisation of selected non-satellite measurements

3. Quantifying co-location mis-match effects

4. Using data assimilation as integrators of traceable measurements

5. Serving match-ups with uncertainties via a Virtual Observatory


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# Toy example of underlying concepts

A lidar – red points

A satellite – black line

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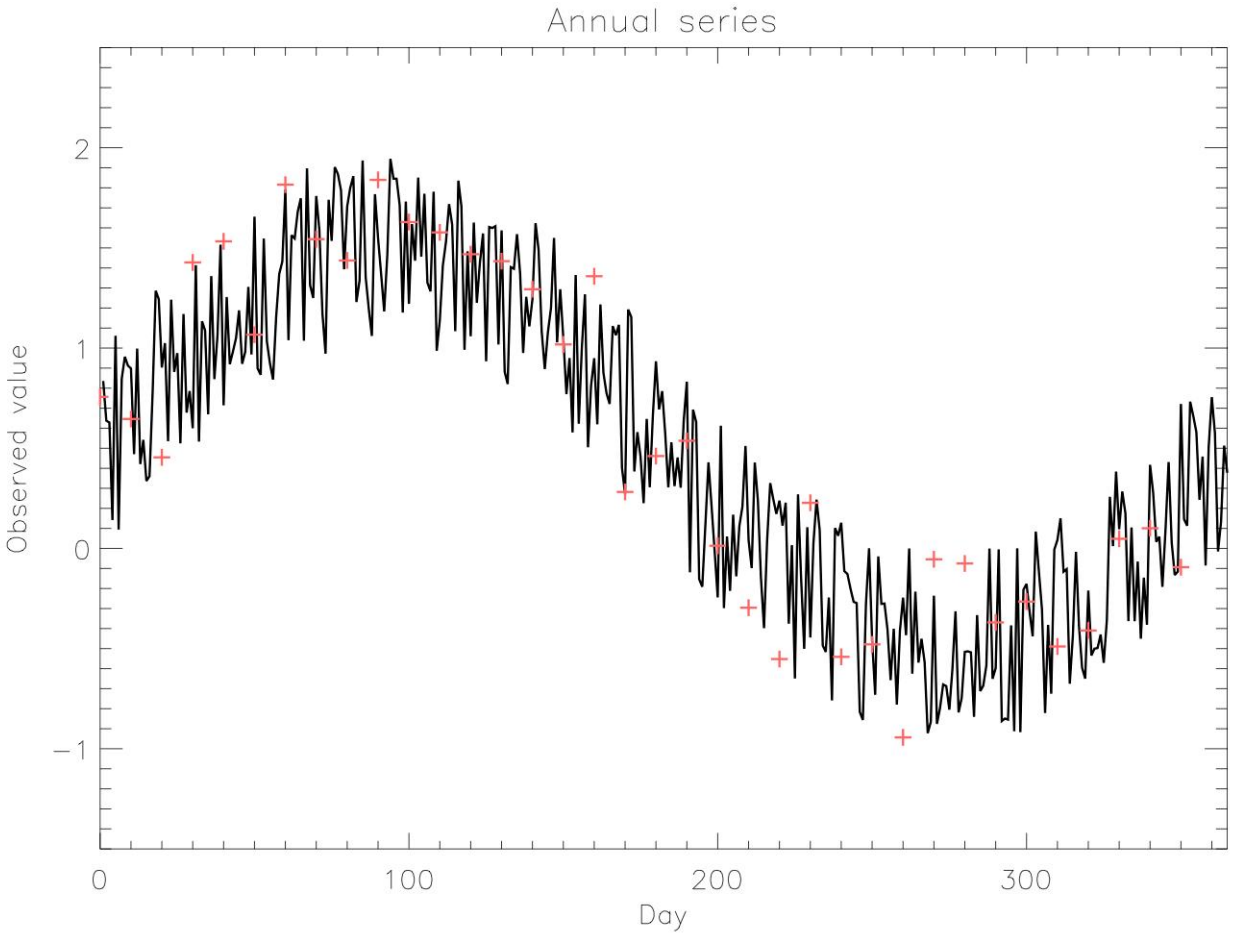
# Toy example series

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# Measurement A /= Measurement B


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# Focus on *reference* in-situ observations

A reference observation is defined as having the following characteristics:

- ✓ Is traceable to an SI unit or an accepted standard
- ✓ Provides a comprehensive uncertainty analysis
- ✓ Is documented in accessible literature
- ✓ Is validated (e.g. by inter-comparison or redundant observations)
- ✓ Includes complete meta data description

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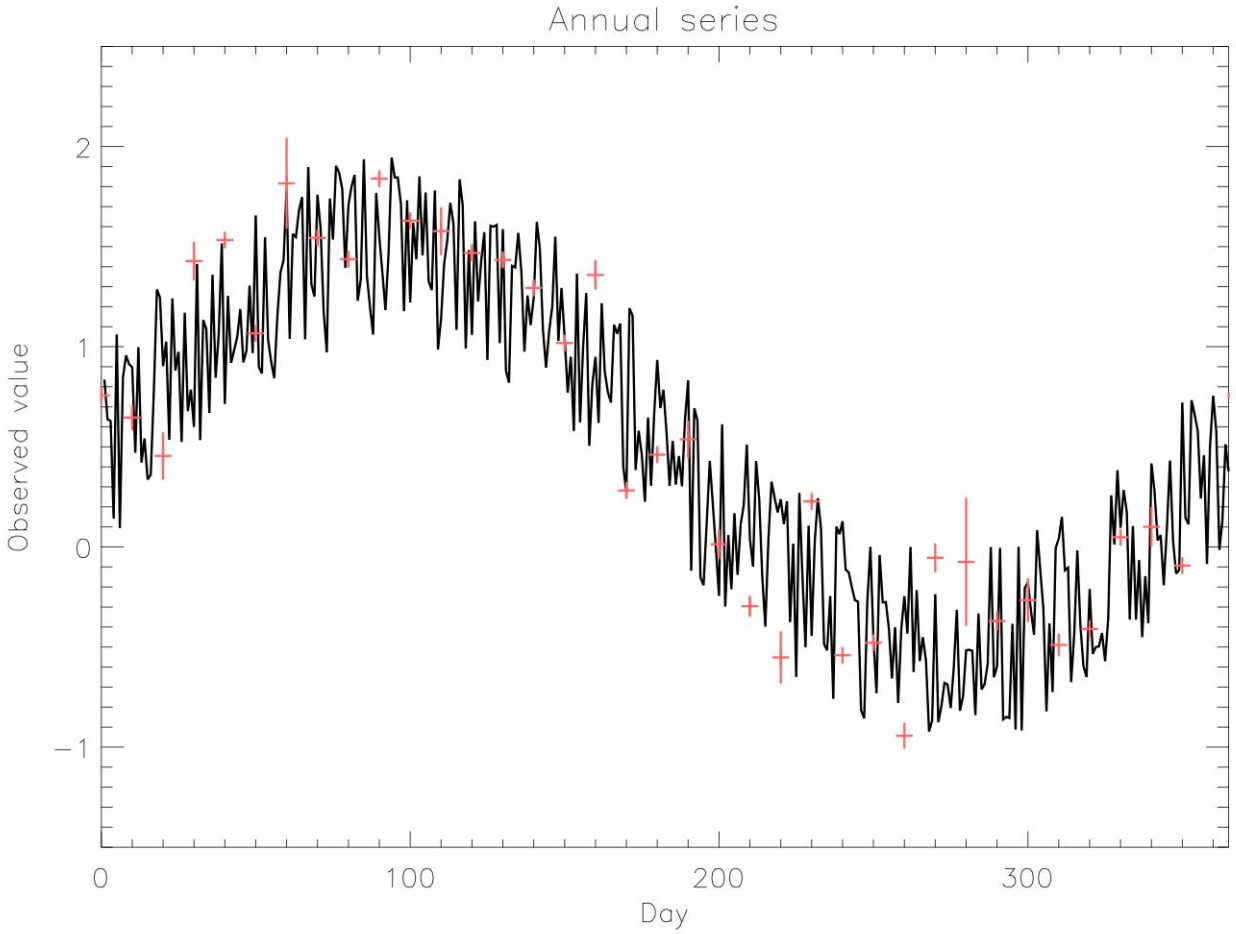
# Lidar measurements with uncertainties

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# But what about the satellite?

- In the absence of other information a useful test is whether the satellite is performing within design build specification …
- But I'd rather be using Fiduceo

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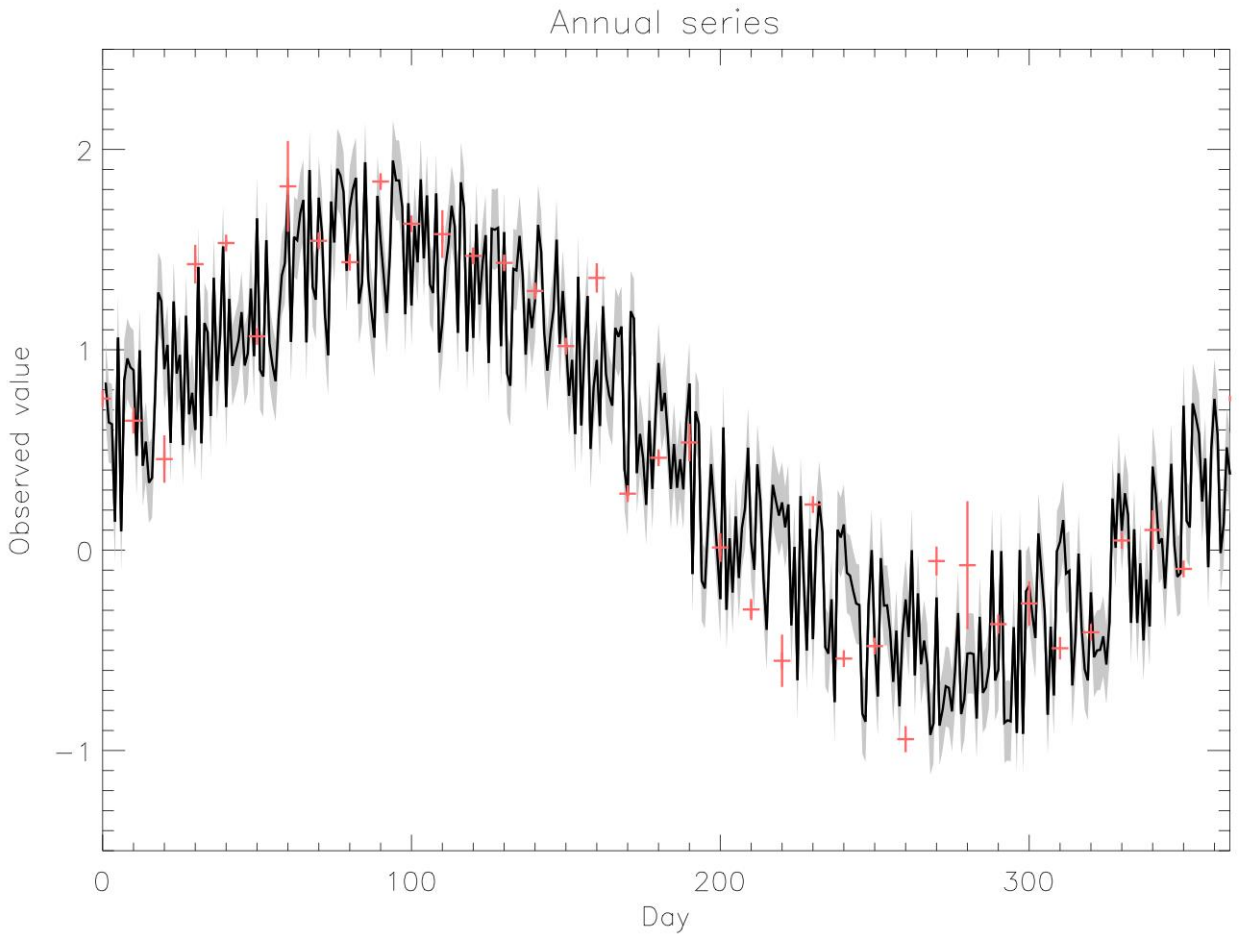
# Satellite measurements with design specification ranges

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# Consistency for perfectly co-located measures

- Reference quality in-situ (m1) and satellite measurements (m2) should be consistent:

$$|m_1 - m_2| < k\sqrt{u_1^2 + u_2^2}$$

  - ✓ No meaningful consistency analysis possible without uncertainties
  - ✓ if $m_2$ has no uncertainties use $u_2$ = satellite instrument specification

| $\lvert m_1 - m_2\rvert < k\sqrt{u_1^2 + u_2^2}$ | TRUE | FALSE | significance level |
|---|---|---|---|
| k=1 | consistent | suspicious | 32% |
| k=2 | in agreement | significantly different | 4.5% |
| k=3 | - | inconsistent | 0.27% |


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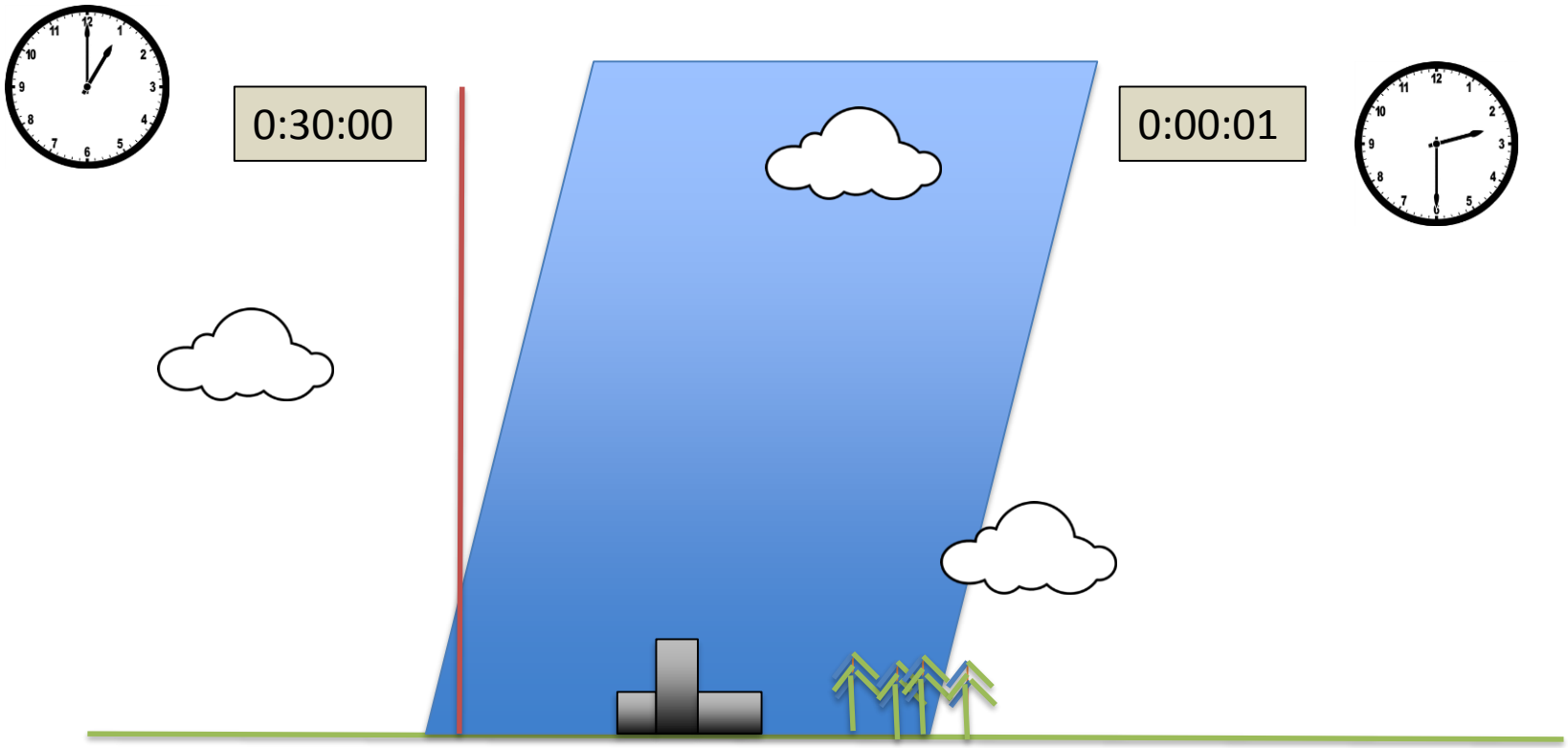
# Co-location uncertainties

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# Consistency in a finite atmospheric region

- Co-location / co-incidence matters and inflates the expected difference
- Determine the variability ($\sigma$) of a variable (m) in time and space from measurements or models
- Two observations on different platforms are consistent if

$$\left|m_1 - m_2\right| < k\sqrt{\sigma^2 + u_1^2 + u_2^2}$$

✓ We need to either minimize σ so that $\sigma << \sqrt{u_1^2 + u_2^2}$

or quantify σ so that it can be included in the above test.

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# Which products/services have become operational or nearly operational during the course of the project?

Editor's note: We are only half way through the project thus far and most products / services are envisaged for delivery in the second half …

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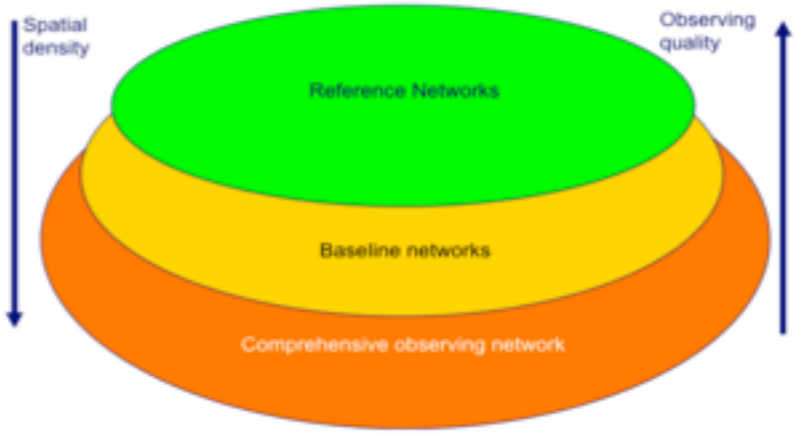
# 1. Sub-orbital measurement maturity assessment and metadata




Defined three fundamental measurement quality tiers

Extension of CORE-CLIMAX CDR maturity assessment to assess measurement maturity

Measurement maturity assessment completed for >40 candidate high-quality networks

Discovery (WIGOS/ISO19115) and measurement (ESA CCI -CF / WIGOS) metadata collected

| Metadata | Documentation | Uncertainty characterization | Public access, feedback and update | Usage | Sustainability | Software (optional) |
|---|---|---|---|---|---|---|
| Standards | Formal Description of Measurement Methodology | Traceability | Access | Research | Siting environment | Coding standards |
| Collection level | Formal validation report | Comparability | User feedback mechanism | Public and commercial exploitation | Scientific and expert support | Software documentation |
| File level | Formal measurement series user guidance | Uncertainty quantification | Updates to record | | Programmatic support | Portability and numerical reproducibility |
| | | Routine quality management | Version control | | | Security |
| | | | Long term data preservation | | | |

Legend

| 1 | 2 | 3 | 4 | 5 | 6 | Not applicable |
|---|---|---|---|---|---|---|

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# 1. Sub-orbital measurement maturity assessment and metadata

- Service available via CNR partner in restricted mode presently, shared with GAIA-CLIM partners and available for viewing in the breaks here
- Service to be integrated into the Virtual Observatory
- Paper to be submitted shortly on the system-of-systems, assessment approach and assessment results.


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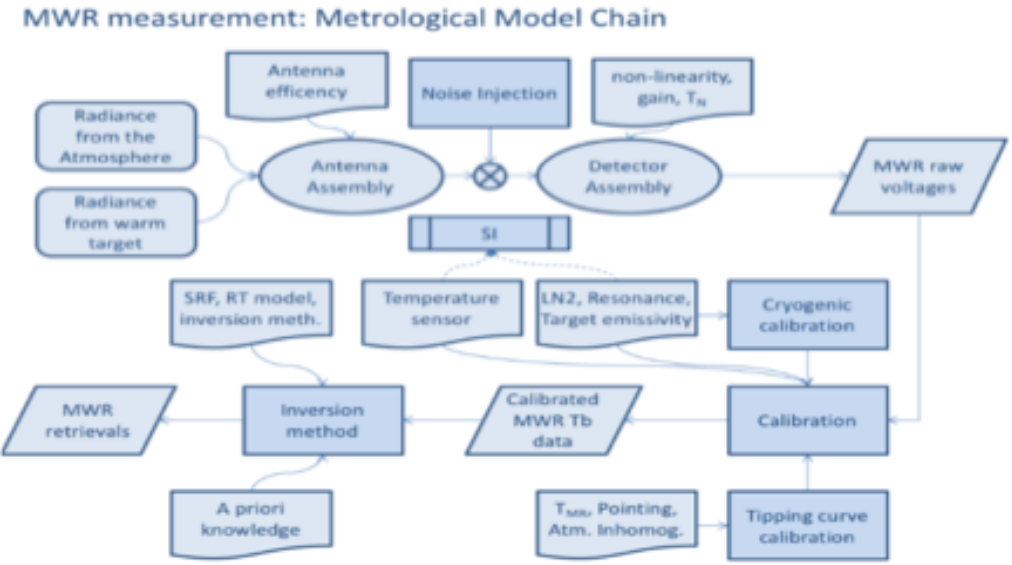
# 2. Traceability chains





As a first step to the production of metrologically traceable estimates traceability chains have been produced for: various lidars, MWR, FTS, UV/vis, MAX-DOAS / Pandora, and GNSS-PW

Working to make more interactive (would like to have some consistency w/QA4ECV and FIDUCEO in how presented and explorable – role for C3S to 'operationalise' provision?)

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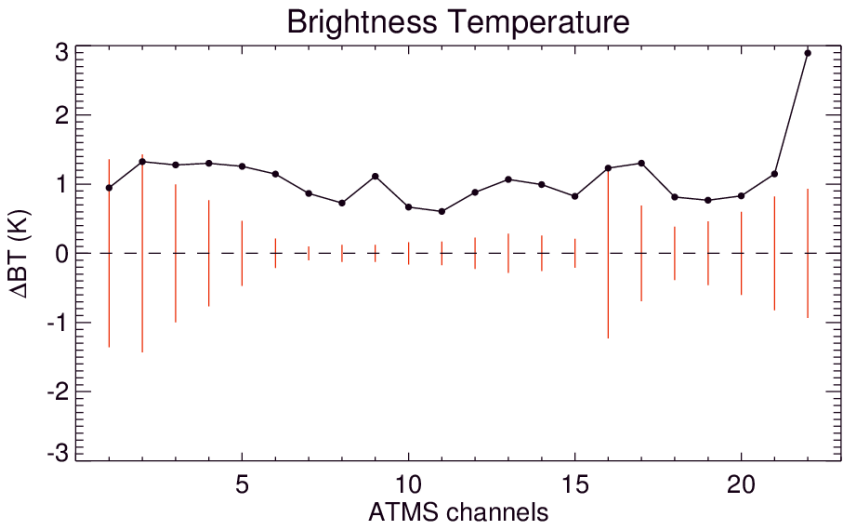
# 3. GRUAN data processor




Takes a GRUAN Vaisala RS92 radiosonde measured profile, which includes a metrologically traceable uncertainty estimate at every point in the profile.

Converts the profile and its uncertainty into an equivalent TOA radiative profile (level1b equivalent) and uncertainty (note assumptions about non-T,q,P components necessary).

Enables a comparison between the satellite and GRUAN measurement both at geophysical and radiance spaces.

Work with GRUAN ongoing to better account for systematic / random / structured random terms (c.f. FIDUCEO talk) in the GRUAN uncertainty.

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# 4. Gap Assessments and Impacts Document

Gap reference list

View | Edit

Content Access:
Public Content

Gap reference list

This is the full list of gaps identified in GAIA-CLIM to date, with a SMART analysis of each gap. Details of how and when such *SMART* remedies may be addressed for each gap are included in the full descriptions. The gaps each have unique gap identifier numbers of the form: X.XX, and full descriptions can be found at gaia-clim.eu/wiki/gX.XX; or by following the links below:

| Gap identifier | Gap name |
|---|---|
| G1.02 | Unknown suitability of measurement maturity assessment |
| G1.03 | Missing evaluation criteria for assessing existing observing capabilities |



G1.02

View | Edit | Revisions

SUBMITTED BY RICHARD DAVY ON 8 AUGUST, 2016 – 16:01

G1.02 Unknown suitability of measurement maturity assessment

**Gap detailed description**

Ensure that the measurement maturity assessment prepared by GAIA-CLIM is readily applicable to all reference, baseline and comprehensive networks, and is beneficial to identify shortcomings in the practices applied by network operators. The maturity assessment involves assessing against 7 major strands such as metadata, uncertainty quantification and sustainability, as outlined in D1.3. This assessment, in the context of Task 1.2, has now been carried out for a number of target GAIA-CLIM networks and ECVs , but it should be applied more broadly to other ECVs and measurement domains if it is to extend its utility. Testing needs to be performed and may result in a subsequent need for revision of D1.3 accordingly either within or after the project.

**Activities within GAIA-CLIM related to this gap**

Task 1.2 has undertaken an assessment of the measurement maturity matrix for in excess of 50 measurement networks of relevance to GAIA-CLIM. These analyses are in the process of being analysed by Task 1.2 participants and shall be the subject of a deliverable due in M18 of the project.

**Gap remedy(s)**

**Remedy**

Specific remedy proposed

Application of the measurement maturity matrix exercise to a number of networks and domains to assess suitability for purpose and gain broader buy-in to the concept and its scientific value.

Measurable outcome of success

Living 'document'

Identifies and assesses gaps in knowledge, capabilities, governance etc. for non-satellite measurements to be useful for satellite characterisation

3rd version -> web-based and interactive

http://www.gaia-clim.eu/page/gap-reference-list

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# Which products/services still require development work?

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# Things yet to come

- Virtual observatory allowing users to explore and download co-locations between satellite and non-satellite measurements (early version available today informally)
- Assessment of geographical gaps in the non-space observing system and their impacts
- Tools to quantify co-location mismatch effects for a range of ECVs and using a range of approaches to the problem
- Improved metrological characterisation of a range of instruments leading potentially to additional comparisons with satellite measurements


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# What are the further research needs?

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# Final deliverable: Prioritised recommendations

- Final output of the project shall be a prioritised set of recommendations as to future needs, including but not limited to, research needs.
- Will be driven off the version of the Gaps Assessment and Impacts Document as it stands at that time.
  - So, value in getting your input into the GAID document now!
- Drafting to start 3/17
- Shall benefit from input gained from planned ”road trip” to relevant stakeholders in 2017

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# Some needs already obvious

- Addressing issues around governance of non-satellite measurements
  - Includes instigating high-quality measures in the usual problematic areas and better schedule matching
- How to use metrologically traceable measurements in a smart way in data assimilation
- Expansion to remaining atmospheric ECVs and other domains
- Further work on metrological characterisation of several non-satellite techniques to attain traceable uncertainties
- Training the next generation of both measurement scientists and users of measurements


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# GAIA-CLIM and FIDUCEO


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# Possible interactions

- FIDUCEO are to provide the full characterisation of a set of satellite instruments.
- There is cross-over in terms of ECVs sensed by a subset of GAIA-CLIM and FIDUCEO
- Which should allow us to attempt a full metrological closure
  - Satellite measurement uncertainty (FIDUCEO)
  - Non-satellite measurement uncertainty (GAIA-CLIM)
  - Co-location mismatch uncertainty (GAIA-CLIM)

- Do we have full understanding? Do the measurements agree within the stated coverage factor at the frequency we respect them to?


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# Modifications to GAIA-CLIM foreseen / already undertaken to accomadate

- Extend the GRUAN processor to include the relevant FIDUCEO sensor channels
- Ensure AVHRR and AMSU-B are case studies in the virtual observatory
- New work on use of NWP to quantify co-location uncertainties for T and q
- Cross-representation on advisory panels (enacted)


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# Copernicus interactions

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# Copernicus contributions

- CNR led a proposal to recent C3S ITT under Lot 3 – provision of baseline and reference quality measurements to the CDS (under negotiation)
- Within EUMETSAT-ECMWF Copernicus contract there is an option that could be exercised to make the Virtual Observatory operational (dependent upon deemed success or otherwise which will only be able to be determined late 2017/early 2018)
- Further exploration of potential pull-through of project outcomes to Copernicus services expected in the breakouts after lunch


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# User input

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# User input

- User interactions are key if useful, useable outcomes to accrue
- Gaps assessment now online
  - New version to appear shortly. Feedbcak options implemented
- Virtual Observatory early version is available during breaks today for informal testing. Please provide feedback to help further development work.
- We shall be doing a series of visits to key stakeholders to discuss gaps, recommendations and beta version of VO

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# Thanks for your attention

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