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Quality Assurance Framework for Forest Monitoring Programmes

Alexandra Barker
Niall Origo
Joanne Nightingale

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Alexandra Barker, Niall Origo and Joanne Nightingale
Optical Measurement Group
Engineering Measurement, National Physical Laboratory

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National Physical Laboratory
Hampton Road, Teddington, Middlesex, TW11 0LW

Approved on behalf of NPLML by David Gibbs, Group Leader

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GLOSSARY

DQO	Data Quality Objective
FAO	Food and Agriculture Organisation
FRA	Forest Resource Assessment
IP	Intellectual Property
ISO	International Organization for Standardization
MRV	Monitoring, Reporting and Verification
NMI	National Measurement Institute
NMO	National Measurement Office (UK)
QA	Quality Assurance
QC	Quality Control
RADAR	RAdio Detection And Ranging
REDD+	Reducing Emissions from Deforestation and forest Degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks, in developing countries.
SAR	Synthetic Aperture RADAR
SI	International System of Units
SOP	Standard Operating Procedure
TOA	Top-Of-Atmosphere
UAV	Unmanned Aerial Vehicle

1 INTRODUCTION

1.1 Overview of Forest Mapping

Forest monitoring programmes are designed to collate information on forest resources concerning their condition, development and significance for ecosystem services. Knowledge of forests is essential to help understand and mitigate climate change. Assessment of forests through the implementation of forest monitoring programmes is therefore of high importance to decision-makers such as governments and international organisations. However, the value of forest monitoring is underpinned by the data quality, traceability and fitness-for-purpose of the products or services it produces.

Forests cover about 30% of the global land area and play a significant role in the delivery of ecosystem services including climate regulation, carbon storage, biodiversity, prevention of soil erosion and flood mitigation. Climate change has driven the need for globally applicable techniques to reliably monitor afforestation, natural expansion, deforestation and natural disasters, which in turn control the net change in forest area.

It is estimated that there has been a net loss of approximately 5.2 million hectares of forest per year from 2000 to 2010. In total over this period, this equates to the loss of 0.13% per year of the 3.9 billion hectares of global forest area; an area approximately the size of Costa Rica (FAO, 2010). Forest (or forest quality) loss from clearing, overusing and degrading is estimated to contribute to roughly one-sixth of global carbon emissions.

Guidance for the methodologies implemented within forest MRV programmes was provided at COP 15, Copenhagen (2009) - it outlined three main components:

1. **M**onitoring – Combine activity data collected from sources such as models, remote sensing and ground-based approaches with emissions factors to independently map forests. This data is analysed and ground-based measurement used for validation;
2. **R**eporting – Compilation and harmonization of all information to provide consistent, transparent estimates with minimum uncertainty; and
3. **V**erification – External party independently reviews all variables that contribute to the development of the product or service to ensure its accuracy and reliability, and that it meets the requirements of the end user. These results are to be made available.

This will lead to the establishment of *'robust and transparent national forest monitoring systems'* (Decision 4, COP 15).

Anthropogenically-induced climate change mitigation and adaptation is of importance to governments and international organisations since the ramifications (drought, flooding, food/water scarcity, etc.) are severe. Forest mapping is essential in order to assess the contribution attributed to deforestation and forest degradation. Assessment of the carbon content of forests has been attempted using a number of techniques; ground-, airborne- and satellite-based. Satellites can collect information over vast areas of the earth's surface at regular intervals (e.g. from 15 minutes to monthly). By contrast, ground survey work can take a significant amount of time and expense to cover small areas and is quickly outdated. In essence, the exploitation of satellite-derived data provides an efficient method to monitor and quantify biophysical parameters such as coverage and abundance.

A recent comparison of forest maps based on satellite datasets calibrated using ground-based measurements (e.g. Mitchard et al, 2013), has demonstrated the need for verification of forest mapping capabilities. Remote sensing based measurements (i.e. of reflectance or backscatter) rely on the accuracy of in situ measurement techniques in order to quantify the relationship between these parameters and land cover / biomass / etc. Reflectance, as mapped by optical sensors, represents the wavelength sensitivity to biochemical properties of vegetation (e.g. chlorophyll, carotenoids, etc.), whilst backscatter data recorded by RADAR sensors is sensitive to surface roughness and can determine the structural attributes of the vegetation. Using different datasets and/or techniques in forest monitoring can produce maps of biomass, forest cover, land cover change and degradation at different levels of accuracy or precision. For example, CLASlite uses satellite data to map tropical forest degradation and deforestation, and when combined with airborne LiDAR can produce a map of carbon stock estimates (Asner, 2009). Products derived from different data sources and using independent methods need to be traceable and provided with quantifiable uncertainties for comparability (achieved through transparent quality assurance procedures).

A whole suite of potential satellite-derived biophysical products exist. However, to date, none have managed to employ full traceability[1]. As a result significant and in some cases unexplained differences are present between similar products. The practical reasons for these may include: parameter definitions; definitions of retrieval algorithms; indirect (inferred) measurement of the target quantity for in situ validation; and the unknown effect of measurement instruments, sampling methods and up-scaling on different surface types. Quality assurance of satellite-derived data is required since these datasets can be adversely affected by revisit schedules, radiometric and geometric differences and atmospheric contamination (e.g. clouds and aerosols). The different stages of processing these datasets also introduce uncertainty as pre-flight calibration of sensors cannot be maintained in space. Consequently top of atmosphere (TOA) measurements by different sensors vary significantly, leading to differences in derived products. Post-launch calibration and product validation are essential. However, field calibration and validation exercises are often limited in their spatial scale, global extent and temporal frequency due to time and resources. Forest mapping and carbon modelling services should be calibrated and validated in a number of forest field sites in order to maintain representivity. Whilst advancements in biomass mapping have been widely reported, large uncertainties remain where little field data is available (Mitchard et al, 2013).

1.2 Carbon Market

The carbon market (or emission trading) is the trade of carbon emission permits, allowances and certificates representing mitigation or sequestration (also known as carbon credits or offsets) to enable countries and companies to limit their greenhouse gas emissions (expressed in units of tons of carbon dioxide equivalent, or CO_2e). Regulation affecting country and private sector organisations drive the need for forest monitoring to put a value on the sequestered/stored carbon.

Carbon is an important asset for many public and private sector stakeholders. Carbon pricing mechanisms are incentives for regulated entities such as countries or companies to reduce their greenhouse gas emissions in order to meet obligations such as those agreed within the Kyoto Protocol (Bellassen and Stephan, 2015). Market-based measures catalyse private sector involvement, resulting in the development and implementation of least-cost solutions for climate mitigation and adaptation (Carbon Finance, 2012). Two major market-based options exist to regulate greenhouse gas emissions: (1) carbon trading and (2) carbon tax. The former is the most commonly implemented economic solution to climate change. The key difference between the two is that with carbon trade a level of emissions is guaranteed but there is less control over the price (a function of supply and demand), whereas with a tax, the price is defined but the emission level is not guaranteed.

The size and shape of the forest carbon market is still not widely known and consequently developers remain cautious amid significant market uncertainties (Diaz et al, 2011). Growth within the forest carbon market relies on the creation of new demand for forest carbon credits i.e. new policies which require emission reductions and allow emissions trading that includes certificates for carbon sequestered in forests (Diaz et al, 2011). In 2010, the global market for forest carbon projects hosted the largest volume and value of credits contracted in history, with an estimated value of transactions of US$ 178 million. Forest carbon markets reached 75MtCO2e (estimated at US$ 432 million) with projects impacting more than 7.9million hectares in 49 countries. The average price for offsets across the primary forest carbon markets (transactions of credits directly from a project) reached US$ 5.5/tCO_2e in 2010 – though prices vary across regulated and voluntary markets (Diaz et al,

[1] Traceability as implemented by National Metrology Institutes (NMIs) is defined within the JCGM 200 (2012) International vocabulary of metrology as being the *"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"*.

2011). The shift towards third party verification of forestry-based climate change mitigation in 2010 increased buyer's confidence in methodologies and consequently increased investment in new projects (Diaz et al, 2011). Many countries have already implemented forest monitoring programmes. Forest monitoring programmes can determine forests' potential as a carbon sink and assess their carbon stocks for greenhouse gas reporting / carbon accounting. A market analysis has been produced by CDC Climate (see Market Analysis Dossier, 2014) that discusses a number of these programmes. The usefulness of these programmes is reliant on their ability to capture and monitor important attributes such as carbon stocks over large temporal and spatial scales. While the numerical values are important, the provision of knowledge concerning the likely spread of these values is equally important in equipping decision makers, since informed decisions on forest (and carbon) management need to be based on well-quantified data to assure a certain level of quality of baseline and change analyses data (Ferretti et al, 2010). Climate finance therefore relies on reliable, fully integrated and cost-effective Monitoring, Reporting and Verification (MRV) of greenhouse gas emissions. Improved monitoring methodologies and forest carbon accounting can reduce uncertainties in the global carbon cycle (Mitchard et al, 2013).

Estimating carbon stock is useful for a number of reasons: the measurement and crediting of carbon sequestration and conservation projects; to prepare for Reducing Emissions from Deforestation and Forest Degradation (REDD+) (to track deforestation); and for climate modellers to test the vegetation aspects of their models (Mitchard, 2014). Forest carbon market players and stakeholders such as national governments, forestry services, project developers, carbon standards and research institutes rely on forest monitoring data. Quality assured data will enable efficient management of forest carbon projects from development to credit issuance, including risk management and decision making support. MRV can enable forest carbon projects and initiatives to achieve carbon goals, i.e. emission reduction and/or stock enhancement, as well as providing guidance on appropriate pricing of stocks (based on uncertainty).

1.3 Quality Assurance

Quality Assurance (QA) is defined by ISO (8402: 1994) as 'the assembly of all planned and systematic actions necessary to provide adequate confidence that a product, process, or service will satisfy given quality requirement.' QA and verification activities should be an integral part of forest assessment within monitoring programmes. The concept of QA (with regards to climate-related activities) was established in the IPCC Guidelines for National Greenhouse Gas Inventories (2006). The outcomes of implementing QA procedures may result in reassessment of procedures and improvements in methodologies, datasets and reduce error in carbon estimates.

The purpose of developing a QA system is: (1) to provide a framework for the development of products or services with associated QA information; and (2) to provide end users with QA information to assess the products in relation to their intended application. All measurements should satisfy specified levels of reliability through the provision of traceability information on the methods and procedures as identified in Section 2: Quality Assurance Process. QA procedures enable fair comparability and assessment of the datasets produced. Evaluation of the quality of a monitoring system requires knowledge of two factors: (1) the level of precision (expressed in terms of confidence) and (2) the comparability of measurements through time and space (Ferretti et al, 2009). Therefore data of a known quality and consistency is required (Allegrini et al, 2009).

The objective of this document is to identify the procedures necessary to implement a robust and traceable QA framework for forest monitoring services that are based on data from ground survey, airborne or satellite remote sensing techniques. A framework for implementing QA procedures is necessary to ensure good practice. Once identified, QA procedures can be employed within forest monitoring programmes to understand the quality of different forest datasets and applications.

1.4 Implementation of QA in Industry

The importance of quality assurance is recognised across industries all around the world. Having a well implemented and robust quality assurance system can provide multiple benefits to any organisation including improving profits, company reputation and the safety of employees and members of the public. The European

Standard EN ISO 9001 approved by CEN is an international QA system standard, outlining the means for obtaining assurance of quality. The importance of quality assurance can be demonstrated by incidents caused by the failures in quality systems. For example, the 2010 explosion of the Deepwater Horizon oil rig was the result of poor quality assurance management – cement around the oil well was not suitably tested and a fluid pressure test was incorrectly interpreted. If proper QA procedures had been followed, the oil spill disaster could have been prevented at a cost of only US$ 128,000. However, the consequence of the attempt to save time and money cost more than US$ 10 billion, the loss of 11 lives and tremendous environmental damage (BP, 2014).

1.5 Development of a QA System

Successful implementation of a QA system relies on the development of a QA plan; the QA plan is intended to be a reference through which QA procedures for forest mapping can be organised (Emmanuel et al, 2000). Descriptions of each task to be undertaken should be given, in addition to a timeline for their delivery (commonly in the form of a Gantt chart). This document scopes the requirements for the development and implementation of a QA programme, intended for use by any organisation undertaking a forest assessment[2].

The benefits of QA information embedded within products or services include but are not limited to:

- the ability to assess products or services for fitness-for-purpose;
- traceability of products or services;
- comparison of products developed using different datasets and procedures;
- and, confidence in products or services.

The need for quality assured data is evident from the disparity in the measurement of carbon stocks and fluxes from terrestrially vegetated surfaces (Mitchard et al, 2013). In order to determine the reason for these differences it is important to quantify the uncertainties associated with different measurement techniques and data sources. Uncertainties should be traceable to a stated metrological reference (i.e. free community reference standard) or if possible, International System of Units (SI) via one of the National Measurement Institutes (NMIs). An important component of developing traceable uncertainty on data products is the ability to prove that traceability exists. This is provided through documented procedures and calibration certificates as well as the use of community-accepted best practices for measurement and modelling. The QA plan enables the organisation of this documentation (IPCC, 2006).

2 QUALITY ASSURANCE PROCESS

This document scopes a generic system for the implementation of QA procedures for any forest data product or service. This QA framework will help to provide transparent and well documented procedures that support the use of products and services.

The QA system can be implemented to assess in situ, airborne or spaceborne datasets and methods to derive reliable information related to forest resources. All QA processes leading to the production of data should be documented as these will be used to assess whether data meet the standard of reliability and level of quality specified / required by the end user (e.g. scientists, policy-makers, public). It is important to assign the roles and responsibilities of each party contributing to the science output i.e. those responsible for the overall service output should be explicitly stated prior to implementation of a QA framework.

[2] It does not contain full specifications as this will vary with each monitoring programme.

2.1 QA Process

Forest assessment within a monitoring programme should be traceable such that the quality of the input data, processes/algorithms and output datasets can be assessed. The QA framework should provide templates for data producers or service providers to document evidence of traceability (see Appendix: Example RADAR Product Template); part of this should include a diagram of the MRV system architecture with each component designed by the relevant partner. The organisation of the QA framework is split into six steps; these steps identify the manner in which data producers or service providers should integrate QA within a monitoring programme:

STEP 1. Document
STEP 2. Self-assessment
STEP 3. External Audit
STEP 4. Implement recommendations
STEP 5. Final Check
STEP 6. Publish

The first step within a QA framework is to identify the data quality objectives (DQOs) of the forest monitoring programme – the level of precision and accuracy of the outputs required must be defined (Ferretti et al, 2009). These will be based on explicit and reasonable data quality indicators to avoid subjectivity. Monitoring programmes should also prepare actions to be undertaken when data quality is not acceptable.

The following description of each of the six steps has been provided to identify the level of detail required at each stage of the QA framework implementation.

STEP 1. Document

Using the templates provided, each product developer is responsible for producing evidence which clearly and concisely outlines their activities to an accepted level of detail (inputs, processing steps and outputs); this includes the following:

a. Report standard operating procedures (SOP) in monitoring[3], including a description of the inputs (e.g. field data, satellite-derived estimates, elevation data) and outputs at each stage in the processing chain (i.e. in the field, laboratory, and data management). The Technical Manuals and national QA/QC programmes should be taken into account as well as the definition of the variable, measurement units, uncertainty (e.g. units, coverage factor, probability distribution, how it was produced), calibration certificates for measurement instruments, evidence of validation activities, links to ISO, etc. Having SOPs in place ensures that all personnel perform the same procedures, consequently avoiding variance of data quality between personnel, and ensuring work is carried out with a good understanding of QA.
    - Input data – identify source, active/passive, size, spectral band, amount data is pre-processed, etc. – see 6.1 for example.
    - Calibration of measurements – number of ground-based sites (ground control points)
    - Pre-processing techniques – method for atmospheric, radiometric and geometric correction, error removal, filtering.
    - Display of data – software used to map datasets (was the data format converted?), projection, etc.
b. Each processing step will include: a description of the procedures to be carried out and an explanation of the role of each input variable; an explanation of how uncertainty is handled including the list of sources considered and omitted with appropriate reasons; identification of assumptions including those applied when deriving uncertainties - where applicable, traceable uncertainties will be assigned to parameters.

[3] SOPs should be regularly reviewed and updated

c. A summary of all processing steps employed to derive a forest parameter in the form of a flow diagram. This should contain all inputs and outputs and include the product developer's assessment of the quality of the uncertainty procedure employed.
d. Any information that is dependent on another input source should be noted
e. Intellectual Property (IP) issues should be identified and the processes covered by IP should be described in as much detail as can be allowed.

STEP 2. Self-assessment

Product developers are required to report / provide evidence[4] of: QA; accuracy assessment; uncertainty analyses; validation in their processing steps (including input data, methods, outputs, validation of outputs, and Monte Carlo analysis); and linkages to ISO, SI and other international best practice guidance where possible. Internal assessment demonstrates that data producers are taking responsibility for QA of their product.

STEP 3. External audit

An external and independent (third) party (i.e. NMI) should examine the monitoring operations and assess the evidence provided by each producer to ensure it is accurate and properly documented. Evaluation by an external party demonstrates that the QA information provided is reasonable, relevant and clear. At a first level of implementation a simple traffic light system should be employed to designate red, amber or green status to each component of a forest monitoring service. As the concepts within the QA framework are advanced, this will lead the way to the development of methodological tools that allow propagation of uncertainties and quantitative assessment.

Suggestions for improvements to procedures will be submitted to project producers (i.e. improved methods, follow existing best practices, conduct uncertainty analyses, validation etc.). The implementation of recommendations and reporting on changes carried out in processes/methodologies need to be reported in a timely manner so that producers can consider these changes within the QA service.
QA evaluation may involve officials with knowledge of different areas e.g. RADAR and optical processing and field measurements. The audit will address:

a. Has the product producer addressed all the QA information requirements?
b. How complete is the information provided?
c. Identification of any missing information and justification
d. Summary of the state of uncertainty procedures including identification of possible improvements
e. Where IP information is disclosed to QA evaluators, comments and suggestions will be sent privately and not published for community access.

STEP 4. Implement Recommendations

Product developers have a period to implement recommendations applied to QA procedures and evidence.
a. Time to make changes should be allowed.
b. Changes will be included in the original QA framework for the service where most relevant, including a time stamp for when the change was made; a summary of all the changes will be provided in the change log.
c. Where changes are recommended but not implemented, evidence-based justifications should be documented in the external QA evaluation report and returned to the evaluating body.

STEP 5. Final Check

[4] Where a product is developed from combining datasets, the party responsible must be identified and accept the responsibility of undertaking an assessment.

Checking the QA system is an iterative process that facilitates improvement in QA information. A final check allows the external party to ensure recommendations have been implemented or where this is not the case, a credible reason has been provided.

STEP 6. Publish

Information should be accessible for the international community. This will include links to: QA documentation; reference standards; best practice guidance; validation datasets; and instrumentation manuals. Publishing this QA framework for forest monitoring will provide clarification on how products are developed (i.e. how, what, where, when), as well as making information relating to QA procedures, uncertainty, validation and accuracy assessment and improvements to existing implementations, more easily accessible. This framework will highlight areas that require further attention and more robust QA. The potential to recognise the associated uncertainty with final products is possible where all aspects of the service have been documented and analysed.

2.2 Time-Frame For Implementation

A timeframe for implementation of a QA framework should be agreed at the onset of a forest monitoring programme and documented in the form of a Gantt chart. The order of activities to be carried out is as follows:

- overview of general procedures within each component of the forest MRV system;
- review of tools, methods, data, procedures and status of existing QA verification and uncertainty estimation activities;
- development of traceability and uncertainty analyses for specific components where there is ability to do so;
- reporting, documentation and archiving;
- and, recommendations for improvement in various MRV system components (possible improvements to existing, or development of new, best practice documentation).

3 EXAMPLE: IMPLEMENTATION OF QA SYSTEM

FOREST: Fully Optimised and Reliable EmissionS Tool is a project funded by Climate-KIC (www.climate-kic.org) which aims to respond to the growing demand of forest carbon stakeholders for trusted, fully integrated and cost effective Monitoring Reporting Verification (MRV) service components. The service provided will enable forest carbon projects and initiatives to achieve carbon goals, i.e. emission reduction and/or stock enhancement. Within this project a range of services will be developed based on reliable quality assured data for forest carbon market players and stakeholders (e.g. national governments, forestry services, forest carbon project developers, carbon standards, and research institutes). This data will enable efficient management of forest carbon projects from origination to carbon credits issuance, including risk management and decision making support.

The FOREST MRV System is based on satellite images, and supported by ground based in-situ parameterization and validation. MRV services to be produced from the different input datasets include ‘forest mapping’ and ‘carbon modelling’ products (see Figure 1: Outputs). The comparison of these products is achieved through the traceability and assessment of the quality of data and processing techniques in the development of these services as identified in Figure 1.

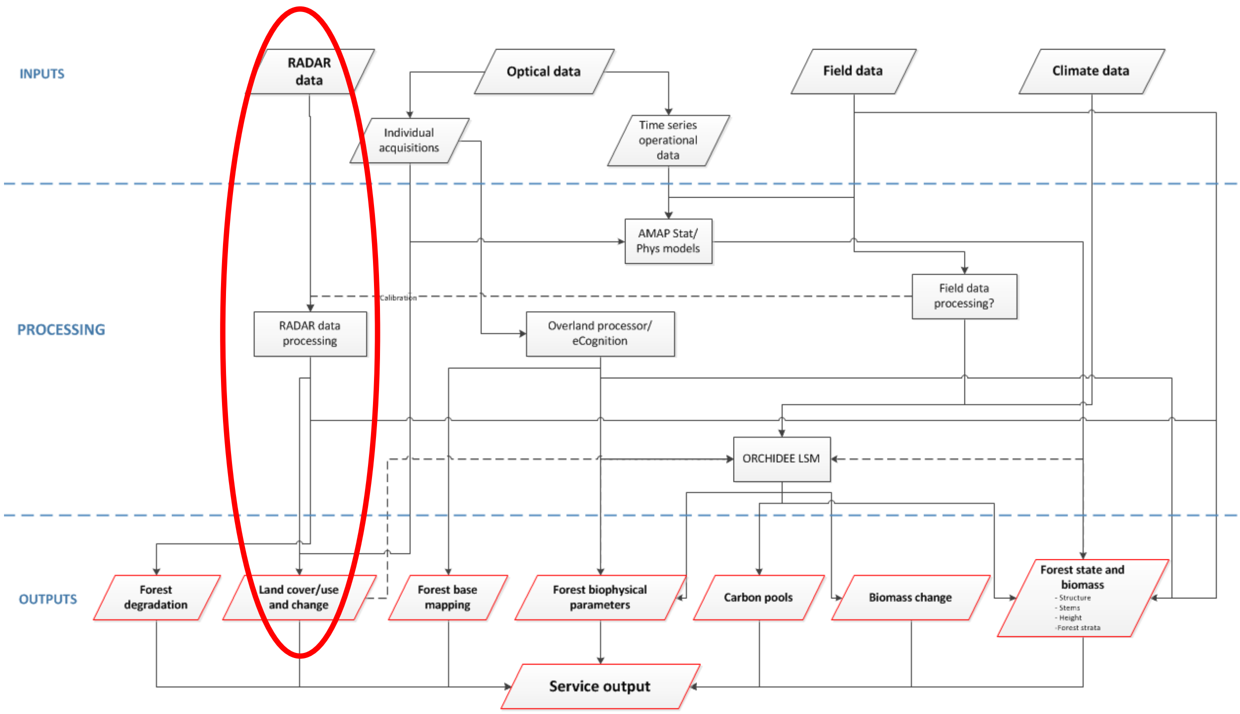

Figure 1 Example of the FOREST MRV system structure; the circle highlights the processing chain relating to RADAR data (presented in more detail in Figure 2)

3.1 QA of 'Forest Degradation' Product

In order to assess the quality of the 'forest degradation' product derived from the TanDEM-X RADAR data (highlighted in Figure 1), its input data and processing techniques need to be clearly identified. A graphical display of processing steps, e.g. as in Figure 2, provides an easy summary of the procedures leading up to the generation of the service output, which, in this instance is a forest degradation map. By documenting a QA system in this way it is easy to add information on the QA status at each step, and documenting evidence of QA within processing steps allows easy identification of the crucial steps (from a QA perspective) that need addressing in order to improve the service.

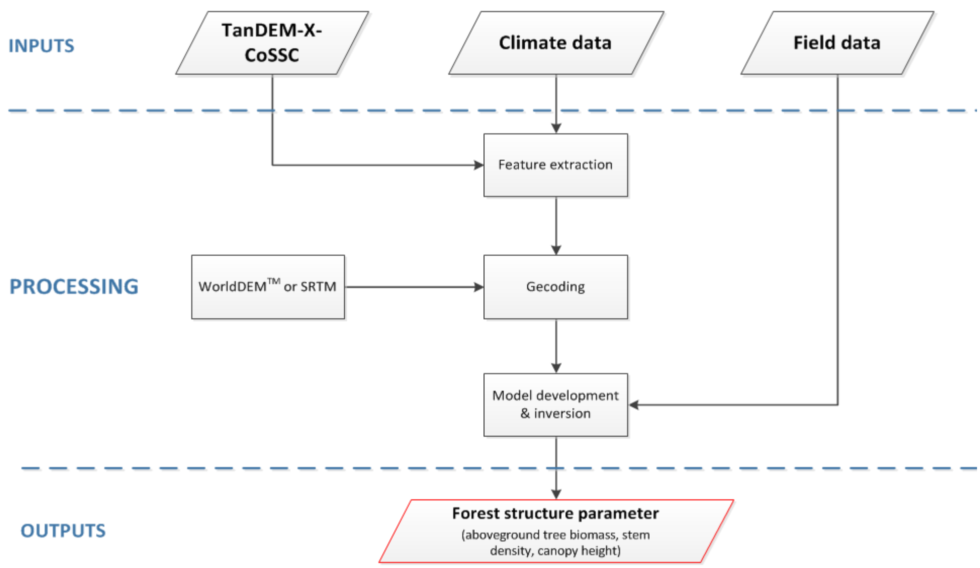

Figure 2 Example of processing chain for TanDEM-X RADAR data

Traceability of the MRV system was recorded by documenting information on templates developed within the FOREST project. The templates provide a consistent approach for data producers or service providers (see Appendix: Example RADAR Product Template). They were designed to capture all information throughout the processing chain required to assess data quality. The information is separated into three categories: input datasets, processes and output datasets. As a result, each dataset or process within the RADAR data processing chain includes:

- detailed information regarding the data e.g. resolution, date, number of bands;
- indication of where quality is/is not considered;
- documentary evidence of the justification for a particular technique;
- uncertainty assessment;
- validation.

4 CONCLUSION

The implementation of this QA framework ensures the quality of datasets and processes is acknowledged within forest monitoring programmes. Such a framework can lead to and support the future development of a full uncertainty assessment on forest MRV products and services. This framework provides a consistent approach to follow in order to apply QA measures within forest MRV services which enables the comparison of different products. It provides confidence both internally and externally for customers and authorities, that quality requirements have been fulfilled. The QA process outlined also encourages recommendations and improvements to be considered and, where possible, implemented prior to the full development of a product or service on a large-scale. This will act as a tool to help service users decide which product is best suited for their requirements based on data quality.

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6 APPENDIX

6.1 Example RADAR Product Template

Information required to capture the processing chain when mapping forests using a spaceborne RADAR data approach have been identified below – the fields in this template can vary depending on the dataset and can be adapted for a forest product derived from optical data. The template tables have been devised with regards to three categories: inputs, outputs and processes. A QA system requires information such as that identified below to: discern the quality of documentation associated with the processing steps; the justification for using a particular input or processing procedure; and whether (and how) quality is considered (e.g. uncertainty propagation).

Table 1 Inputs

Input Dataset #1	
Satellite platform / Sensor #1	**e.g. TanDEM-X / SAR-X**
Space Agency	e.g. DLR
Orbit	e.g. sun synchronous
Satellite position	e.g. ascending or descending
Field site	
Image location accuracy	
Projection	e.g. WGS84
Global incidence	
Across / along the track incidence	
Solar azimuth	
Solar elevation	
Bands, wavelength range	e.g. X-band
Polarisation	
No. of looks	
Acquisition date(s) / range	
Spatial resolution / swath dimension	e.g. 16 m resolution, 10 km swath
Units	e.g. digital numbers (DN)
Data processing level (Pre/Post-launch processing – do you know what was done prior to you getting it)	e.g. speckle-reduced, corrected for antenna pattern or range-spreading loss, terrain correction, geocoded, radiometric correction
What processing steps (specific implementation) do you undertake prior to using the data and how (software/tools/methods)	
Existing quality control	e.g. visual inspections and at what stage
Other information (web link etc.)	e.g. www.dlr.de/hr/desktopdefault.aspx/tabid-2317/3669_read-5488/

Input Dataset #2	**Field Inventory**
Measurement device #1	**e.g. Trupulse 360 R**
Measurement taken	e.g. tree height
Location	
Collection date / time	
Number of measurements	
Sampling strategy	
Who collected it	
QA checking done? And how?	
Post-processing of data	
Accuracy	
Other information (web link etc.)	

Input Dataset #3	e.g. digital elevation model
Provider	
Resolution, extent, date	e.g. 2 m (relative) / 4 m (absolute) vertical accuracy in a 12 m x 12 m raster
Projection	
Parameter used (slope, aspect, height)	
Data processing level (Pre/Post-launch processing – do you know what was done prior to you getting it)	
What processing steps (specific implementation) do you undertake prior to using the data and how (software/tools/methods)	
Other information (weblink etc)	e.g. www.geo-airbusds.com/worlddem/

Table 2 Processing steps

Process #1	**e.g. Geocoding & Calibration**
Input(s)	
Brief description of process	
Algorithm (& paper if applicable)	
GCPs	e.g. number of GCPs, sampling approach
Output(s) – include spatial resolution, uncertainty information and units	
Is uncertainty propagated from input variables through this step? If so, how? If not, why not?	

Table 3 Outputs

Output #1	**e.g. Biomass (Above ground biomass density)**
Units	
Resolution, extent, etc.	
Conditions / assumptions of derivation	
Is there associated uncertainty?	
Is the uncertainty traceable to SI/community standards?	