QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

QA4EO Workshop on Facilitating Implementation

Tuesday 29th September – Thursday 1st October 2009

Chaired by GEO
Hosted by TÜBİTAK UZAY
In Antalya, Turkey

Minutes

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Executive summary

A Workshop on Facilitating Implementation of the Quality Assurance Framework for Earth Observation (QA4EO), chaired by the Group on Earth Observations (GEO) and hosted by TÜBİTAK UZAY (TÜBİTAK Space Technologies Research Institute), was held from September 29th to October 1st, 2009 in Antalya, Turkey. Aslı Aytaç, Vice Director at TÜBİTAK UZAY welcomed the participants and thanked GEO for making the workshop possible. Presentations and discussions throughout the three-day workshop spanned a cross-section of EO disciplines as the participants considered how best to take QA4EO forwards and encourage its rapid uptake by the full GEOSS (Global Earth Observation System of Systems) community.

The GEOSS community represents a wide variety of disciplines, which utilise a multitude of monitoring methodologies and procedures that require an association of a quality metric to their outputs to enable them to be reliably integrated into the various systems and services, supporting the Earth Observation (EO) needs of Society. The fundamental principle of QA4EO - "that all EO data and derived products has associated with it a documented and fully traceable quality indicator (QI)", addresses this core requirement and is universally applicable to all disciplines. This principle is not in itself novel and is already being practised by many. QA4EO seeks to ensure it is implemented in a harmonious and consistent manner throughout all EO communities to the benefit of all stakeholders. The end-user, "customer" is the driver for any specific quality requirements and will assess if any supplied information, as characterised by its associated QI, are "fit for purpose".

The workshop participants agreed to a series of steps to facilitate implementation of QA4EO into the GEOSS community.

- The current QA4EO task team will be augmented to reflect the cross-cutting nature and importance of this task at the GEO level. In the longer-term this body should include representatives from other GEO tasks and all Societal Benefit Areas (SBAs). The augmented team will not regulate but will provide a coordination role, monitor progress and provide a guidance, harmonisation and capacity building function.
- A high-level implementation and action plan will be drafted to facilitate the expansion and where necessary the applicability of QA4EO to the wider EO community and to engage data providers and users. This will include the identification of key target communities and individuals together with the resources needed to support this process.
- A one-page summary describing the key principle of QA4EO will be drafted and become the primary reference. This document will contain all pre-requisite information against which compliance can be assessed and will constitute QA4EO. To aid its implementation across all GEO communities the framework document containing a set of guidelines based on best practises will be evolved to provide guidance through templates and where appropriate exemplars to facilitate the translation of the principle within the various GEO communities.

The GEO QA4EO process should initially be established as a self-declaring process.

- Where organisations already have well established and documented quality management systems and processes, e.g. WMO, this process will be relatively simple and transparent.
- In other cases a questionnaire/template will be drafted to enable data providers to make visible the evidence that supports any declared quality information for users to assess its adequacy. The questionnaire will make clear the requirements needed for QA4EO compliance and thus also be educational.
- The GEO dataset registration will be adapted to encourage the association of a Quality Indicator to each dataset, which will be linked to the "quality questionnaire" (previous bullet). When users access these datasets, the GEOSS infrastructure will allow access to this quality information and should preserve its association to each dataset.

It has also been decided to develop a 'communication toolbox' – presentations, posters, brochures, etc. – to summarise the scope and benefits of QA4EO and to provide material for use in outreach throughout the EO community via the QA4EO website (http://qa4eo.org/).

To review the status of the QA4EO implementation, measure its impact on the Earth Observation community and coordinate future activities, a new workshop is tentatively proposed in 9 to 12 months from now (summer 2010).

QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

Tuesday 29th September

QA4EO: Facilitating Implementation – The bigger picture
Chair: Rob Koopman (GEO)
Facilitator: Pascal Lecomte (ESA)

Welcome and introduction from TÜBİTAK UZAY (Aslı Aytaç, Vice Director, TÜBİTAK UZAY)

Aytaç welcomed the participants to the workshop and thanked the Group on Earth Observations (GEO) for making the workshop possible. Aytaç introduced the institute in Ankara, which employs 258 people in total with over 65% of these being researchers. TÜBİTAK UZAY (TÜBİTAK Space Technologies Research Institute) is a not-for-profit organisation covering work in space technologies, electronics, software, power electronics and power distribution systems. Example images from the satellites the institute operates were shown.

Mackin asked if the new Turkish satellite was to be integrated into the Disaster Monitoring Constellation (DMC). Aytaç explained that this had not been considered, but agreed that it could be an option.

Lecomte introduced Koopman and explained that Koopman has recently joined GEO on secondment from ESA.

GEO & QA4EO (Rob Koopman, GEO)

Koopman introduced and outlined GEO and the vision for a Global Earth Observation System of Systems (GEOSS). A GEOSS common infrastructure had been agreed by all members. All participating organisations would provide data and this would be accessed via a common source (portal). The international charter on space and major disasters now connected to GEO and now any GEO member now had an interface to this charter. The most important topic for the 2010 ministerial summit would be to focus on the data sharing principles. The virtual constellations and that the datasets from these would be the greatest contribution entering into GEOSS. Koopman talked about the GEO 10-year plan and the task sheets. He outlined the GEO organisation structure and talked about how to integrate QA4EO into GEO. There will be a task-level workshop in Spring 2010 and at that workshop there should be a concerted effort to explain QA4EO to the Societal Benefit Areas (SBAs) and to try to integrate it more into their processes.

Alber asked about connecting to the SBAs and asked Koopman to clarify a statement he had made that the QA4EO guidelines should be specific to an SBA in the framework of this workshop. Koopman explained that, if a framework was sent out, many people would likely not go deeper and cover all levels that would be needed to fully embrace QA4EO. The question was how to go from the current framework to the next level. More effort would be needed to engage other parties. Alber asked if any other groups were beginning to integrate QA4EO. Koopman responded that the interoperability group had set guidelines on what to use but they were in a difficult phase due to limited resources. Already when data is

registered questions are being asked to start the process, although this is only one element in the many steps needed.

Mackin suggested that GEOSS seemed to be targeted to government space organisations and their assets. He asked about any incentives that were being given to the private sector, who would be expected to be paid for their data. Koopman responded to say that this was very much an issue. People are interested in this and, because of GMES (Global Monitoring for Environment and Security), some data had been purchased and would be injected into the public system. This was one way but other methods were needed. High resolution data could be used to derive lower resolution data (with the original high resolution data not seen externally) and this may bring more data through. However, currently though there is no mechanism to actively bring commercial data into GEOSS. If commercial data did come through, the commercial sector would be expected to comply with the QA4EO guidelines.

Lafeuille asked if Koopman thought that there was an SBA that did not already have any low-level guidelines. Koopman responded to say that all QA4EO guidelines should be registered on the GEO best practises registry. This would help in identifying which ones were adaptable and applicable. If a perfectly compliant system exists it should be registered. Lafeuille asked how it was possible to discuss data sharing without interfering with the higher-level decisions. Koopman explained that there are a lot of low-level technical issues that could be addressed without disrupting higher-level decisions. By working together with the task force and task teams on data sharing, solutions to any technical problems could be sought. Thomas suggested that it would be important to keep track of the concept of data sharing and interoperability, although a 'guideline' could not actually be enforced. Koopman agreed that enforcement was the wrong term to use. It is all about increasing momentum and exemplifying the 'win-win' situation.

Ungar suggested that if the calibration and validation (Cal/Val) data sharing technical issues were resolved then it may open the door for others. Koopman affirmed that early release of data for Cal/Val was a continuing request. Ottavianelli asked how much of the data already included within GEOSS contained quality information. Koopman did not know the answer to this as the current registration process does not have anything implemented to declare quality information at the time of submission. A self-declaration questionnaire is currently being drafted for implementation during the registration process. Also, only a fraction of the datasets expected have so far been registered.

Chander asked for more information about the GEO clearing house. Koopman explained that this support function is the only central component in GEO. It consists of 3 layers: registries holding data sets and services that are available to the user, on top of this the clearing house layers (3) sit to allow interrogation, and finally on top of this are the data portals. The current idea is to have a single clearing house and maybe a single portal. This will be discussed at the next GEO plenary in Washington.

Iacovazzi suggested that it may be useful to know what the processes in the data chain would be from beginning to end and what the stop lights would be along the way. Koopman explained that the GEO common infrastructure does very little to the data; it provides the user with a direct path to the actual data. Fox clarified that the key principles of QA4EO were expected to be seen as good practise to be used as guidelines only. They are not intended to be compulsory entities in their own right. There may be many examples in existing communities / SBAs that already fully meet, and maybe go beyond, the requirements.

QA4EO is an umbrella and a means for the community to demonstrate how well they are doing, but it cannot be made compulsory. The only one who can make it compulsory would be the user, who could only make this decision if the information is available to them. Koopman agreed on the need to promote this 'win-win' approach.

Lecomte & Stensaas explained the facilitation methods to be employed during the workshop discussions. A *tour de table* was then undertaken.

QA4EO and the WIGOS (WMO Integrated Global Observing System) framework (Jerome Lafeuille, WMO)

Lafeuille explained that the World Meteorological Organisation (WMO) has a mandate from the United Nations for weather, water, climate and applications. One of the most important achievements of the WMO had been the establishment of operational networks. There is a great number and a large diversity of observing systems and a new challenge is to integrate this diversity of observing systems. A comprehensive and interdisciplinary view of the state of the planet has to be developed; there is a better awareness of this need and a better understanding of the complexity compared to only a few years ago. WIGOS has as its objective the "Integration of WMO observing systems and enhanced coordination with observing systems of partner organisations". Driving requirements for WIGOS are interoperability through data sharing, standardisation of observation and data management practices, and quality management, which is fully in line with the QA4EO principles. Lafeuille suggested that, if QA4EO becomes more than just a set of proposed guidelines, then a governance issue should be considered. As it currently stands, QA4EO is effectively approving itself.

Lecomte agreed that there was an issue relating to governance and by the end of the workshop he hoped that there would be some resolution. Alber: commented that the WMO was implementing a similar logic to that being done for QA4EO. He asked how the WMO defined standards and how they were related to ISO (International Organisation for Standardisation) standards. Lafeuille confirmed that WMO was a standardising body through agreement with ISO, but wished to defer any more detailed discussion until the following day's presentation from CIMO (Commission for Instruments and Methods of Observation) by John Nash. Thomas suggested the need to talk to people about what they use data for. Then when assimilation processes are undertaken and/or data joined together an error would not made through misunderstanding what that data actually represents.

The importance of traceability for climatology (Serhat Sensoy, DMI)

Sensoy outlined the systems used by the Turkish meteorological office and talked about paleoclimatology, historical data and data rescue. At least 30 years worth of data is necessary for climate monitoring processes. If it is available, this data is essential for statistical predictions.

Iacovazzi identified that it is sometimes hard to assign a data quality indicator to climate data and that, even a quality indicator itself may change over time. Alber asked about the intercalibration problems between different sensors that have acquired data over long periods of time. Sensoy explained that after 1980 when automatic weather stations were set up all

around the world, big increases in temperature were seen. This is a homogeneity problem. Meteorological data must all work together and some data must be adjusted. This statistical adjustment must also be put onto the metadata. Stensaas identified that it is a significant problem today that a lot of data is being acquired but that there are no standard laws to say how those data should be archived.

The QA4EO framework and guidelines (Nigel Fox, NPL / Pascal Lecomte, ESA / Greg Stensaas, USGS / Bob Iacovazzi, NOAA)

Lecomte explained that QA4EO is simple. QA4EO has at its heart the need for quality indicators and traceability. All the rest is detail on how the users are supported in defining their quality indicators (QIs) and in implementing traceability in their processes. QA4EO should be applicable to all. The difficulty is that space is a complex matter and when satellite exemplars are used they are by definition complex. However, QA4EO is not complex; it is the current examples used from within the space community that are complex.

Fox stressed the need for data quality and went through the guidelines and how they fit together.

Stensaas talked about data policy explaining that the two dedicated QA4EO documents were guidelines to provide people with information that already exists. There are links within these documents to GEO, ISO, etc and these will be expanded as QA4EO broadens outside of the space arena. Those present were asked to provide feedback and recommendations.

Lecomte outlined QA4EO's communication and education guidelines. He stressed the need for a clear understanding of the data and its 'fitness for purpose'. This is something that needed to be defined by the user not the data provider. Evidence should be accessible and traceable to its origin and it should also be easily understandable. Practically speaking, it is important to 'speak the same language' and so a dictionary of terms is a necessity. Dictionaries already exist and QA4EO should reference and highlight / fill any gaps.

Iacovazzi talked about the Global Space-Based Inter-Calibration System (GSICS) and the GSICS Procedure for Product Acceptance (GPPA). He explained that GPPA is already fundamentally in line with the QA4EO principles.

Stensaas discussed the issue of data release and associating quality flags to it. There are many data providers who have quality flags on their data and they all have a different idea of what they mean. Iacovazzi added that there is a large definition procedure behind the flags. Alber asked if GSICS only dealt with its own data or if the span of data was wider. Iacovazzi explained that GSICS is a mix of a number of international meteorological agencies. Data is compared to a recognised reference to assess its quality. The idea is that the actual acceptance / rejection is done through a panel comprising representatives from all GSICS members. Alber suggested that within QA4EO there was no need to do such a type of certification. Lafeuille added that acceptance by GSICS does not refer to the satellite dataset itself but to the process by which calibration information is associated with that data. This acceptance certifies that the calibration information delivered by the GSICS community is calculated in accordance with community rules. Fox suggested that there is no thought that GEO will be setting up a body to prove or disprove data for all of the SBAs at this time. However, each SBA may wish to set up its own body to approve or otherwise its own data. There are plans, for example, to set up a mechanism to give a stamp of approval for

comparisons undertaken within the Committee on Earth Observation Satellite (CEOS)'s Working Group on Calibration and Validation (WGCV) and he encouraged others to do the same. The aim is not, however, to seek to establish a body to do anything more official at the moment. Lecomte clarified that GSICS approves the processes and not the actual data. Ungar suggested that, by providing the ability in the guidelines to have confirmation of processes, this would allow other communities to understand that they can have something that flags the quality of their data.

Tarasova asked how QA4EO could be implemented for near real-time (NRT) data delivery. Fox explained that the desire was to approve procedures and processes and have standardised procedures and processes with QIs on the processes. Once the process and traceability chains had been endorsed, the QIs (uncertainties) would effectively be propagated through that process, and this could be done in real time. This should be clarified within the QA4EO documentation.

Thomas identified a contradiction between the guideline documents, particularly with reference to GEO. Because GEO provides a higher level focus there are some conflicts within the detail. Thomas also talked about metadata, the need to maintain all data and to have search interfaces to help users interrogate the data for GEOSS. The facility for search is important as the future user community is unknown and the important thing is that people can actually discover the data. Lecomte suggested that the existing QA4EO guidelines could be moved to address a different level, e.g. a CEOS only level. The role of this workshop was to review this and envisage the way forward.

Mackin explained that at DMC one of their issues was how traceability was presented to the end user. Their plan is to have a database of the uncertainties that detail all the processing steps and allow access at any step to assess the quality. This is a big overhead but it will guarantee the quality of the data to the end user. Lafeuille reported that a few years ago a database of observing requirements had been compiled as a joint initiative between CEOS and the WMO. Also, more recently the SEO had been working on an update of a definition of all parameters. These are one important contributions to the terminology issue. Lafeuille went on to recommended that the QA4EO framework document should be almost a self-supporting one. However, currently it is a summary of, or a forward to, the guidelines. It would probably benefit from re-drafting to bring it more in line with the objectives presented at this workshop. Lecomte agreed that the documents should be reviewed and placed at the right level once a governance process had been established.

Ottavianelli reported that GMES is trying to coordinate the access and distribution of different data. GMES has a big database that handles all the data and allows access to the quality information from the users. The idea is to harmonise the way the information is handled and so make it better for users to access the quality information. ESA's GECA project also tries to harmonise the way Cal/Val data is handled and distributed. Koopman explained that higher level documents would be distributed to the GEO ministerial. At the moment the QA4EO documentation was still be too low-level to do this, but after review it may be acceptable to put forward for distribution at a higher level for review / comment / acceptance.

Intercomparisons (Nigel Fox, NPL)

Fox recommended that each community set up key comparisons. As they are quite expensive in terms of time and money, the recommendation would be that only a few key comparisons should be undertaken within each community to scope key activities and generally an aggregate of processes. Fox reported on some intercomparisons that had been undertaken within the WGCV's Infrared and Visible Optical Sensors (IVOS) subgroup as community key intercomparisons:

- Using snow fields of Antarctica at DOME C in December 2008 – January 2009
- Using Landnet sites August 2009 and August 2010
- Comparing to ground based measurements August 2009 and August 2010

All results for the IVOS intercomparisons were run blind to avoid any potential biases or lack of independence. The direct involvement of national standards laboratories allowed the intercomparisons to automatically establish full traceablility. New comparisons should ideally be piloted first, but still with clear agreed protocols. Full community inclusion should be promoted with resource sharing where possible. The pilots should ideally be independent and the number of activities in each comparison exercise maximised.

Ungar agreed that intercomparisons are to be very much encouraged, although field measurement programmes cannot be used for proper instrument calibration. There should be a push to use the moon as a stable target and to try to convince as may satellite providers to look at the moon as a calibration (monitoring) target. Intercomparisons are very complex and there is a need to also encourage people to tie things in more directly as well. Stensaas clarified that, through IVOS, recommendations had been set down for all systems to have adequate pre-launch calibration. It has also been highly recommended that all systems use the moon as a stable target. Koopman added that for atmospheric chemistry the sun or moon is used, or else a portable reference. Ungar stressed that the moon serves as a (cheap) long term solar diffuser monitor. Fox emphasised that comparisons included the regular observation of IVOS reference standards such as the Moon. Such observations need to occur on a regular operational basis whereas others such as instrumentation and methods were less frequent.

Ottavianelli asked how the meteorological community handled all the thousands of instruments that were used within this large and diverse group and how all the instrument calibrations were maintained, particularly when the aim of the international community is to increase instrumented networks. Thomas explained that the most basic techniques used models to detect anomalies in the measurement systems. All instrumentation goes through a set of procedures to calibrate the instruments. This is very specific and is generally undertaken through field visits and operations, although there are many ways to calibrate the instruments. Fox exemplified traceability by intercomparisons that regularly occur at the world radiation centre in Davos. Every 5 years around 100 radiometers come to Davos where the reference instrumentation is housed and this comparison is fully traceable.

Alber asked if the IVOS intercomparisons that used a variety of different satellites would take into account the viewing geometries. Fox explained that, particularly in terms of DOME C, it was essential this is taken into account as the BRDF is quite significant. For the Tuz Gölü campaign actual measurements of the BRDF of the surface were taken and these can then be applied to each image. CHRIS on PROBA can also be used to assess the BRDF. The aim is

to try to normalise (and declare the uncertainties) of all the satellite measurements. In the future there will also be intercomparisons of the instrumentation used to measure BRDF.

Wednesday 30th September – Morning

QA4EO: Facilitating Implementation within satellite communities

Chair: Pascal Lecomte (ESA)
Facililitator: Nigel Fox (NPL) / Giuseppe Ottavianelli (ESA)

Test sites and post-launch cal/val activities: the ocean colour case (Giuseppe Zibordi, JRC)

Zibordi talked about water-leaving radiance and that this is translated into ocean colour from satellite sensors. Water-leaving radiance is at best 5-10% of the signal received at the sensor. Zibordi also talked about chlorophyll-a from space and the concept of ocean colour. Ocean colour requires consolidated field programmes capable of delivering traceable, globally distributed, cross-site, consistent, continuous and accessible field measurements such as AERONET-Ocean Colour (AERONET-OC).

Marine Optical Buoy (MOBY) (Carol Johnson, NIST) – presented by Giuseppe Zibordi

The top of atmosphere (TOA) signal has a quite minor contribution to the overall total signal measured at the satellite sensor. The uncertainty of the water-leaving radiance has to be a stringent +/- 0.2% and this drives the need for vicarious calibration. The TOA signal is derived from the normalised water-leaving radiance.

General discussion

Chander asked about the lessons learnt in setting up AERONET-OC in terms of funding and support. Zibordi explained that some of the Principal Investigators (PIs) in ocean colour are funded through their own activities. The Joint Research Council (JRC) is supported through its own internal funding, with some extra through the European Space Agency (ESA). For US sites, some is funded through the National Aeronautics and Space Administration (NASA), other money through specific organisations. Three new sites are planned in the US and these sites will be in place to support new sensors; one site in Australia and one in South Africa are funded through national ocean colour programmes. Ungar agreed that such calibration is an essential piece of the puzzle, but the sensor does need to be very well calibrated itself to enable vicarious calibration.

Ungar explained that NASA is involved in taking 60m resolution data and integrating it over 1km stretched of the ocean. However, there is a real issue of glint and he asked if there would be a way of having a QI to account for the presence of glint. Zibordi answered that glint affects both satellite and *in situ* information. The problem for *in situ* data is a completely different problem. Glint affects perturb the above water measurements and so do not affect such systems as MOBY, although they may affect AERONET-OC. The geometry

of measurements change over the day to minimise the glint affects, but there are still some perturbations and these have some affect on the quality of the data. For satellite data it is easy to figure out if there is glint. Above water measurements may be affected based on sea state and this has to be taken into account. Glint depends on sea state and will probably not be homogeneous across the image. Linking sea state to wind speed has in the past been used to try to minimise glint affects. Recent work by Roland Doerffer has tried to remove glint affects using AERONET. Mortimer added that, for SLSTR's fire channel calibration, sun glint was actually used as for calibration, thereby exemplifying that someone's problem is another's solution.

Iacovazzi wondered how one would achieve a supported measurement network, such as AERONET-OC, for other communities, such as those interested in land sites. Ottavianelli suggested that GEO could have a place to play in pushing for such programmes. Zibordi agreed that AERONET-OC is an effective solution and having GEO provide a clear recommendation to the user / scientific community would be a very good thing.

Alber asked about the kind of errors that were achievable for water-leaving radiances. Zibordi explained that to reach a 0.5% error one would need to remove the residual uncertainties in the satellite, the measuring systems and also in the codes that are used. In doing so, a specific radiative code for the system would have to be employed. The levels of uncertainties of *in situ* water-leaving radiances are generally within 0.5%. Fox clarified that the discussions had been about uncertainties and not error – errors can be considered as biases and can be corrected for where as uncertainties refer to "how well we believe we know the answer". Breaking down an uncertainty into a proper budget, can allow specific problem areas to be identified, which may also lead to a lower overall uncertainty for specific situations as some components may not be relevant.. Lecomte explained that, as WGCV chair, he was working with GEO on AERONET-OC. He also stressed that MOBY is clearly already QA4EO compliant.

Infrared sensors & SLSTR Sea and Land Surface Temperature Radiometer (Hugh Mortimer, RAL)

Mortimer explained that the Rutherford Appleton Laboratory (RAL) has been tasked with Sea and Land Surface Temperature Radiometer (SLSTR) calibration for Sentinel-3. This will be based on the heritage of the ATSR series and the community is trying to make this type of sensor the standard to ensure continuity into the future. Mortimer summarised the main requirements for the SLSTR. 0.2 K absolute calibrations are required for the IR channels. Mortimer identified the importance of making sure the instruments can actually be calibrated; in the same way that the requirements drive the instrument design, the need for good calibration drives the requirements. The calibration campaign should be planned well in advance of the instrument build. The procedures that are being implemented for SLSTR will be formed into QA4EO best practices.

Tuz Gölü test site (Selime Gürol, TÜBİTAK UZAY)

Gürol explained that TÜBİTAK UZAY is to launch its new satellite, RASAT, in 2010. The calibration activities for this new satellite are being planned and the Tuz Gölü reference test

site has been established to assist. Gürol outlined the requirements for the definition and establishment of a reference test site and outlined the characteristics of the Tuz Gölü site. The results from the setting up and maintenance of this test site will benefit from, and also feed into, QA4EO.

Calibration & Validation for KOMPSAT in KARI (Dong-Han Lee, KARI)

The Korean AeroSpace Research institute (KARI) is government funded. The Satellite Information Research Institute (SARI) in KARI is in charge of its Cal/Val activities. Lee presented, amongst other things, the well equipped sites developed for image quality and emphasised how KARI were keen to be involved and be compliant with QA4EO.

General discussion

Stensaas asked if the 1kg laser retro-reflector for Sentinel-3 was just to be used solely for geometric correction Mortimer explained that this was its primary purpose. He went on to say that the higher density thermal arrays that are now available mean that the spectral calibration and image quality now need to be looked at and this is a new challenge to the IR community. Fox added that the end user (customer) wants to know the actual image quality and quality matrices are being developed to provide this information. The next move should therefore be to try to qualify standards in matrices.

Gürol and Lee were asked if the data from their test sites would be freely available to the community. Lee explained that any information on KARI's sites could be given to those who asked. Gürol similarly identified that all data from the campaigns over the Turkish sites would be freely available to the community. Fox stressed that if test sites were being developed, it should be ensured that the data is available to the community, whilst recognising those who are contributing to the sites. Agencies also need to recognise this. He asked the same type of question to Mortimer in relation to the best practises being developed for the new SLSTR sensor. This would be quasi-commercial information and Fox asked if this would be made available to the community. Mortimer explained that RAL had no problem in making this type information and data freely available. In terms of the cost implications of doing big projects, making the data freely available may be an issue for some, but not in the case of RAL. Mackin added that there had been a problem with MERIS data in the past where the calibration data was not actually available aside from in published research papers. Mackin asked what mechanism RAL planned to put in place to make the actual data accessible. Mortimer explained that all options had been considered to make the data publically available. It would be available for research operators and it is fully available for the ATSR series. Mackin asked if RAL or ESA would actually be in charge of data access. Mortimer explained that Dave Smith at RAL was pushing for the procedures and to implement QA4EO, and also trying to outreach to those who do not currently have any knowledge of the systems. Fox clarified that there seemed to be the recognition that people wanted more information and that it should be made available. The next step would be to think about the infrastructure and how this type of information could be made available in a more "searchable" manner.

Lecomte made the point that data policy is also important. QA4EO is evolving and access to information is being improved, but currently there is no policy or agreement between

agencies to list the requirements; a code of good practices should be established. Stensaas informed the meeting that in 2003 there had been a joint CEOS/ISPRS workshop and a lot of effort on standards and guidelines was currently going on within ISPRS. These deal more with the high resolution commercial aspects and so it may be valuable to consider setting up another workshop jointly with ISPRS to address these issues. Stensaas also pointed out the strong need for high resolution MTF sites that are maintainable over time and this should be considered during the discussions. Currently a lot of focus is on radiometry, but sensor optics are also important.

Global Space-based Inter-Calibration System (GSICS) & the Product Acceptance Procedure (Bob Iacovazzi, NOAA)

Iacovazzi outlined the Global Space-based Inter-Calibration System (GSICS)'s Product Acceptance Procedure (GPPA). Iacovazzi explained the fundamental capabilities and elements of the GPPA and the GPAF (GSICS Product Application Form). netCDF file format is used throughout GSICS for data storage and exchange. GSICS uses as much information and as many procedures, models, etc., that are already available rather than create new. The objective is to run the GPPA from day one rather than wait for different parts of the chain to be developed. GSICS is keen to use already existing procedures but also to make sure that every step of the GPPA is done properly from the start. Iacovazzi suggested using a matrix to justify QA4EO compliance as an option and exemplified a matrix of GPPA documentation against QA4EO ones within his presentation.

General Discussion

Mackin asked if it would be possible within the Algorithm Theoretical Basis Document (ATBD) to swap the version numbers in and out so that when the product is released each version is attached for each section. Iacovazzi explained that this would be possible and the user would receive all the information about each version at each stage. Mackin asked how long the whole GPPA process took. Iacovazzi explained that the executive panel would give a recommendation and the actual decision could be quite quick.

Stensaas asked how the process worked with respect to changing the calibration of one of the systems. Iacovazzi explained that in terms of operational instruments, the GEO instruments are being benchmarked to IASI (Infrared Atmospheric Sounding Interferometer) and AIRS (Earth Observing System Atmospheric InfraRed Sounder). Options such as CLARREO (Climate Absolute Radiance and Refractivity Observatory) could be a good way of benchmarking in the future. It is an interesting and complex issue. Lecomte asked if there was any requirement for a calibration mission that is actually purposefully built as a reference. CLARREO, and in Europe TRUTHS (Traceable Radiometry Underpinning Terrestrial- and Helio- Studies), would address this with inward calibrators that are of very good quality. As there are more and more missions, the greater the need to align and inter-calibrate them and the more absolute calibration is needed. Lafeuille added that GSICS so far focuses on calibrating instruments, and not on validating products, so they are not dealing with the version change of product algorithms at all. When GSCIS speaks of products, these are GSICS deliverables, i.e. calibration coefficients, calibration formulae, etc.

Mora suggested that a good exercise would be for all present to undertake a matrix mapping exercise to see how they implement QA4EO and then what to focus on to improve their implementation. Fox agreed that his would be a valuable exercise and what Iacovazzi had presented was a good way to proceed. Ottavianelli asked how Mackin saw an acceptance procedure for higher level products that would strengthen the market for them. Mackin suggested that the whole QA4EO process needed to be expanded to cover the higher-level products. There is a clear movement within the community to have QIs within the higher-level products. The problem is that in some cases it is impossible to put a single number as a QI. QA4EO should be relevant all the way through to the data products.

DMC International Imaging Ltd (DMCii) & prototype demonstration (Steve Mackin, DMCii)

Mackin explained that DMCii wanted to produce QIs at a pixel level. DMCii deal with large images and the quality of one part of the image may be fit for purpose for the user but another part may not. The only way to assess this and to see if the user's area is of adequate quality would be to have per pixel QIs. Within his prototype Mackin had some remaining issues with versioning and with data volume and processing as it is not feasible to store all information at each stage of the processing. Break points had thus been chosen to reduce the amount of data / information that would be stored. The hope would be to go live by the end of 2009, with the first part of the data processing chain in continuous development during 2010.

General Discussion

Mortimer identified that Mackin's presentation had highlighted the added value that QA4EO can give to data processing. From a small commercial company's point of view, Mackin was asked how difficult it had been to persuade his boss to do this and then also to implement it. Mackin reported that it had taken a great deal of persuasion and in terms of implementation had been hard as DMCii is a small outfit. However, this is a first step and as the process started and things that had been ignored in the past had been addressed, the systems and the data had improved. Mackin suggested that it is important to take the first steps and not to be overwhelmed about how much there was to do, but to just make a start.

Stensaas asked whether the actual modules would be made available and how proprietary information was handled. Mackin informed the meeting that some of the modules would be made available but that there were currently around roughly 5% that we could not be released at the moment. This may change in the future but the remaining 95% presented no issue and they could be released.

Alber asked what kind of QIs would be released for each data product Mackin gave the example of a TOA radiance product that would have an associated image alongside it that detailed the uncertainty measure. This would be released with every data product as an option to all customers. Also, a set of flags would be released where uncertainties could be given. By the end of 2010 the hope was to have a complete set of uncertainty products. O'hara asked about the impact on processing time. Mackin explained that the QA/QC system would run alongside the already established processing chain. The processing overhead would not be affected, neither would it interfere with the operating systems. There would be

a dedicated server and the processing would be limited to defined breakpoints as the impact on data volume could be very substantial otherwise. Ungar suggested that there should be a way of building an ensemble dataset that exploited the spectral response functions from the datasets. Fox suggested that when there was a process in place to break down to the pixel / band level, the information would be there to do this type analysis. This process would allow one to get back to the basic measurands and, if there is confidence in the basic parameters, these could become linked product datasets.

Mackin exemplified the cross-calibration exercise over DOME C in 2008/9. The results from that campaign showed mean variability between 19 image pairs over a one-month period. This itself exemplified that it is not enough to cross-calibrate sensors once; even within the same sensor, over many images there is variability. Lecomte added that this was another pointer to the fact that calibration and cross-calibration were ongoing processes. Ungar explained that all NASA systems under development were driven by the science requirements and this drives the uncertainties. It is thus possible to create an uncertainty budget for each functional capability of the system. Sometimes it is not possible to meet the science requirement. In this case the next step would be to take a different approach and decide what the minimal approach would be. This includes the design of the instrument and also the design of field campaigns. Stensaas asked if there was a philosophy at space agency level to venture into the realm of creating uncertainty modules in the future. Fox suggested that this was in principle what was being been done for SLSTR in that a modular structure was being developed to enable the propagation of errors throughout the process.

Wednesday 30th September – Afternoon

QA4EO: Facilitating Implementation within wider communities

Chair: Greg Stensaas (USGS)
Facilitator: Jerome Lafeuille (WMO) / Bob Iacovazzi (NOAA)

Commission for Instruments and Methods of Observation (CIMO) best practices and standards in the context of QA4EO (John Nash, UK Met Office, President of CIMO)

Nash introduced CIMO, set up in the 1950s to support initiatives to seek collaborative efforts. The principles that CIMO adheres to are set out in the WMO guide to instruments and methods of observation. Nash outlined the current key challenges. The issue of interoperability is a big one as measurements from one instrument to the next are not the same in most conventional systems and systems change and improve constantly. Sustainability is often an issue where people, for example, buy an automatic weather station and then do not maintain it. Systems may also degrade. The CIMO guide is in 3 parts – 1: measurement of meteorological variables, 2: observing systems, 3: quality assurance and management of observing systems – and can be found on the WMO website at http://www.wmo.ch/pages/www/IMOP/publications/CIMO-Guide/CIMO_Guide-7th_Edition-2008.html. There are some areas where it would not be practical to standardise measurements and it would be better to simply continue what is being done. Nash showed an example of the upper wind network where three systems are needed and one system alone is not enough. Along with errors in the measurement system, errors related to the atmosphere at the time of data acquisition may be seen and estimates of these errors should also be considered. CIMO and WMO's work on quality should be linked in to fit with the general principles of QA4EO, but the framework must recognise where the complexity of *in situ* measurements requires different approaches. For example with radiosondes there is an absolute need to take multiple measurements and flying just once is not sufficient. Whatever data policy QA4EO adheres to, it should identify the need for international exchange.

General Discussion

Nash explained that the UK Meteorological Office's current observing philosophy for long term forecasts was to primarily use satellite observations. Conventional observations are only used where satellite observations cannot. Lafeuille asked how the useful links between CIMO and QA4EO could be elaborated upon and how CIMO and QA4EO could help each other. Ottavianelli went on to ask if any of CIMO's principles did not fit into QA4EO. Nash clarified that there was no problem with the general principles, just the examples used within the documentation. He suggested that the exemplars should be made more applicable to other communities and the satellite bias removed. Iacovazzi asked about CIMO's training in implementation. Nash explained that within the satellite community a lot of training on how to use the products is undertaken. However, here and elsewhere it is not just training, it is

exchange of information that is key. Within a region it would be valuable for people to get together to do something they could not do on their own.

Quality Assurance in the Global Atmospheric Watch (Oksana Tarasova, WMO)

Tarasova explained that the Global Atmospheric Watch (GAW) was a WMO programme based on the need for well developed quality assurance systems to provide reliable data. GAW focuses on global networks for atmospheric parameters and uses only one reference standard or scale across the entire network. Full traceability to the primary standard is sought for all measurements made by the GAW stations. There are established guidelines to meet the quality objectives and GAW has six scientific advisory groups to represent six areas of interest. GAW has a suite of world calibration facilities and data is asked to be submitted to the World Data Centres (WDCs) no later than one year after it was acquired. Training centres – GAWTEC (GAW training and education centre) – are hosted twice a year.

General Discussion

Fox suggested that Tarasova's presentation illustrated that what GAW is doing is QA4EO compliant and that QA4EO is following the same best practice pattern. Tarasova had illustrated that one of the requirements for GAW was consistency and not accuracy, and that consistency had been a driver. A single primary standard reference had been selected and had been consistently linked to, thereby providing traceability. This may or may not be the best approach, but it had come through as a requirement from the community. This was an illustration that it is the community who should define the requirements. Tarasova explained that the idea is that the primary standard should be reliable and maintained and this had been the focus. Lafeuille agreed that the community should decide and not just the provider. He asked about the exact nature of the GAW community. Tarasova explained that the GAW community is that which uses the data for climate prediction, analysis, etc. , with the aim to provide data products that are easy for policy makers to use for, e.g., carbon tracking. It is a real end-to-end approach. Iacovazzi asked about any next developments in the process. Tarasova reported that the integration of other measurements in the process, such as integrating aircraft data, would be a further step to try to achieve a 3D picture of the atmosphere. Fox asked about the costs involved in defining the traceability chain and cross linking. Tarasova reported that most of the sites had to buy this service. NOAA maintains the standard and cylinders used to calibrate the instruments had to be purchased. Fox suggested that there may be problems with developing nations finding the money. Tarasova responded that twinning is being developed to try to overcome this and to enlist others in helping to provide reliable measurements.

WMO Information System (WIS) data management best practices & standards (David Thomas, WMO)

Thomas identified that the goals of the WMO's Information System (WIS) included getting the Global Telecommunication System (GTS) open to all WMO activities in order to provide operational critical and time critical information exchange. The Internet is part of WIS to

allow support of less critical or high volume requirements. WIS should be open to others than just the WMO and should continue to improve and adapt new technologies in the GTS. An interoperable system is the desired goal, similar to the approach aspired to by GEOSS. In order to keep data moving quickly through the system and not slow it down, the actual filename is important as an identifier of what that file contains, thereby negating the need to open every file to find out what it contains. Data quality information is a product in its own right and it would be a good idea to follow a path towards producing a separate product to describe quality.

General Discussion

Mackin suggested that one of the big issues is data volume. In terms of metadata standards and given the expertise that already exists within WIS, Mackin asked if members of WIS would be able to work with QA4EO to improve and set standards. Thomas explained that this was a service already provided to help WIS members. Commercial members are already supported as well as WMO members. Stensaas added that, within CEOS, WGISS was doing an assessment to help define better systems and processes that should be used for GEO. With the help of WIS, WGISS may be able to better define this. Thomas agreed that participation between these groups would be a very good thing.

Data Quality management in Numerical Weather Prediction (Niels Bormann, ECMWF) remote presentation via Skype

Bormann detailed the data assimilation process at the European Centre for Medium-Range Weather Forecasts (ECMWF) and outlined the importance of operational data monitoring to identify any significant degradation in quality or availability of observations that may affect the quality of the forecast. ECMWF, because of the large volume of data handled, employs automated warnings to alert when the data quality broaches fixed limits. An email alert is sent to those looking after the instruments and corrective action can then be taken by the data providers. Monitoring of observing quality in numerical prediction is essential and continuous and quality information provided with data can be useful. Modern data assimilation systems provide a framework for the overall assessment of consistency and quality of observations.

General Discussion

Alber asked how valuable specific instruments were in terms of the numerical weather prediction (NWP) process and which one(s) carried the most weight from a satellite perspective. Bormann reported that observation experiments are regularly performed to check what impact they have on the forecast. All instruments contribute positively in some way to the forecast. Generally speaking there are a few that are used as they are generally reliable, but others are never discounted. The time taken to inject data into the NWPs varies from centre to centre, but for ECMWF it is probably 2 or 3 hours for a short cut off analysis (time is more critical here as this is used for operational forecasting); for the long cut off analysis the ingestion time may be longer. The aim is always to have as short a cut off as

possible, although that requires continuous monitoring as things can always go wrong. Lafeuille added that 30 minutes for some WMO initiatives had been put forward as the ideal.

Koopman reported that ECMWF's outputs were planned to be ingested into GEO. Koopman asked about quality indicators on that data. Bormann responded to say that there are a large number of products generated, so this would be hard to address. Quality estimates are provided as an *a priori* diagnostic, but it would be very difficult to derive a quality indicator for all the products from all the inputs. Internal indicators are constantly derived and this may help. Stensaas asked how useful having uncertainties on a pixel by pixel basis would be in the thinning process for ECMWF. Bormann suggested that there would be a number of aspects where that could be useful. There would be an advantage in monitoring the instrument noise to more readily see where the instrument has gone out of spec. It is unclear if having per pixel QIs would be useful to cross-check the data, but it would be useful to go inside the data to see any unexpected anomalies. Whether this level of quality information would need to be routinely provided or just be made available is a question to be considered. Lafeuille explained that having a QI associated to the data is one of the QA4EO's key principles. This approach should be applicable to non-space as well as space-based data and it will be important to check how it will be practically possible. Bormann agreed that it would be useful as some of these data have problems under certain conditions. Bormann was not sure to what extent this kind of information is already available, but the general principle would apply. ECMWF would also probably perform its own analysis of the quality of the data. Regarding radiance data, there is a need to provide QIs and this can be done in practise. For derived data there is probably more of a need to provide QIs, but this will be much harder. Fox explained that the intent was that any QI is not just a QI because a supplier says so, it has to be based on demonstrated traceability. There should also be evidence of the traceability and have community backup that the QI follows agreed procedures. Bormann identified some problems of traceability and that one would have to be pragmatic on what was accepted. However, having traceability would be much better and desirable. Fox suggested that this would be an improved starting point and may give ECMWF a better way of accepting or rejecting data early on.

Thursday 1st October – Morning

QA4EO: Facilitating Implementation within the Societal Benefit Areas

Chair: Nigel Fox (NPL)
Facilitator: Rob Koopman (GEO)

Quality Indicators for Societal Benefit (Irwin Alber, IEEE)

Alber presented QI4SB – Quality Indicators for Societal Benefit – with the plan to develop a set of QIs linking initial scientific instrument measurements to the products delivered to societal benefit end users. QIs should be based on the uncertainties of the key processing steps, including the uncertainties associated with the product modelling. Alber offered to take on the task of coming up with a set of QIs, based on an uncertainty budget, for one or more of the SBAs. Level 3 and 4 data products are important for the SBAs and QIs related to these products would be equally important. Alber wished to take real data and track it through from beginning to end whilst tracing all the pieces along the way. Alber suggested that this community should do this at least once for a direct SBA and bring in an SBA expert as part of the team. Alber proposed a QI4SB task be undertaken by the IEEE/GRSS community to establish methods for constructing budget-based QIs for GEOSS end users.

General Discussion

Fox agreed that part of the vision of this workshop was to see how the SBAs could be engaged. However, Fox stressed the need to use only the one "QA4EO" acronym to avoid confusion. A pilot study would obviously be the way to go and this would be discussed later in the workshop when discussing the way forward. Ungar suggested that MODIS would be a useful addition in this type of pilot and Ungar volunteered to help set up some meetings with relevant NASA staff. Lafeuille added that the data providers are linked with the data users and it is very difficult to merge the requirements from different communities. Alber suggested that the concern was that mainly scientist to scientist discussions took place, but that this should be expanded to involve the whole SBA and to include those operating at the "grass roots" as well. Lafeuille suggested that this would be outside the remit of QA4EO. Alber agreed that it would stretch the boundaries to take into account the broader end user. However, it would be important to get them onboard so that there is an understanding and a feel for how much they influence the discussion and how the QIs can come alive. Fox agreed that it is the interaction with the real end users that is the driver and it was very much the scope and intent of QA4EO to bring those in. QA4EO began in the satellite domain and has since moved forward. Even within the satellite domain there are product validation groups and these groups are interfaces to specific user communities who are working on projects to achieve specific tasks. These should be focused on and examples drawn from them. Alber added that the concept and architecture permits and encourages outreach to the real users.

What is needed are real worked examples. Fox agreed that one of the best ways for implementation would be to show case studies on how QA4EO would be taken through.

The role of QA4EO within NASA's SBA-oriented joint projects (Steve Ungar, NASA)

Ungar explained that NASA was working on an interoperable sensor architecture to facilitate Sensor Webs in pursuit of GEOSS. Even if everyone started out with the same calibrated image, there would be a variety of different products generated as people process the data in a myriad of ways. Some standardisation is required.

General Discussion

Stensaas reported that one of the things QA4EO was putting together was pre- and post-launch documentation showing all necessary components. Stensaas asked if NASA would continue to follow this strategy and generate uncertainty values throughout the process. Ungar explained that at NASA there was a team who wanted QA4EO and they were being pushed by the climate community. Ungar suggested that most of the SBAs wanted something quick and were not necessarily concerned about the data quality. It would thus be important to ensure all data is provided in a standardised way.

Lim asked if the calibration of Hyperion was still ongoing and if NASA had plans to launch a hyperspectral imager. Ungar reported that NASA does have a hyperspectral instrument concept that goes further into the blue and has a strong signal up to 2.5 microns. This is very close to being ready for full development although it does not have a high priority so will not be launched for a number of years. Ottavianelli pointed attention to the planetary skin initiative by NASA and CISCO systems to develop an online collaborative global monitoring platform to address environmental schemes around the world. This exemplified that the technologies were already available and that it is often a matter of enhancing collaboration and getting the users and producers of data together. The exemplification of end to end quality information is very important and Ottavienelli suggested that GEO should support this effort. Koopman informed the meeting that CISCO was already breaching the divide between the data users and the providers. Ungar added that there are those who collect data from observing platforms to feed information into a planetary skin and this could also be an input into the GEO portal which is compliant and consistent.

Stensaas reported on LGCM's uncertainties and that there was still some work to do to place it within a QA4EO process. With respect to the SBAs there are numerous quality requirements (special, radiometric, etc.) and Stensaas asked if any work was being undertaken at NASA to quantify the needs in terms of ocean colour, biomass, etc., and their actual geospatial and radiometric requirements. Ungar was not aware of any centralised body to address this at NASA but agreed that this was an important point. Koopman reported that surveys of user requirements were underway within GEO and should be published soon.

Calibration / Validation issues in Forest Carbon Tracking (Rob Koopman, GEO)

Koopman presented a set of forest tracking sites, with optical and SAR data acquisition participation, that had been defined for a 2009 demonstration. Integrating the data had been a challenge, as well as using the carbon models alongside. A network of processing facilities had been established to handle all the data processing for the pilot and the WGCV had been asked to support this initiative.

General Discussion

Lecomte reported that at the SIT meeting some 3 weeks prior to the workshop, the request for WGCV involvement had come. Lecomte suggested that Koopman's presentation had been useful in that it provided the requirements from the SBA to the space community, in this case for data and therefore for QIs and traceability. It was a good example of where QA4EO could be implemented and tested and there had been a formal request from this group to the WGCV to validate the products.

Alber asked about any consistent parameters that were adopted throughout the world to identify forest cover. Ottavianelli suggested that one way of doing this would be through the GNLC (Global Network for Land Cover), which is the group that defines the different land classes. Their approach is from the quantitative characteristics of what the vegetation looks like – density, etc. There are scientific measures and algorithms to define the different classes, but the definition of what is a forest or not is done on the ground. Stensaas asked about data release and policy relating to forest carbon tracking as there are currently a lot of data restrictions. Koopman explained that restricted and even commercial data were available within the task team. There would be some way to go to achieve expanded release and not all commercial data would be made available, but the hope is that such datasets would become more and more available. Chander showed the USGS dataset Earth Explorer search engine that is used to access Landsat and other land surface imaging constellations. CBERS and Landsat data can be freely downloaded through this and scenes of interest interrogated. This had all been done as a contribution to GEO from the United States Geological Survey (USGS) and would be freely available to the community. Stensaas explained that there would be similar implementation on Earth Explorer for the Landnet sites, including DOME C.

Stensaas recommended the development of a one-page summary to explain the essence of QA4EO. The framework and guideline documents should be re-written to improve then and make them clearer and more digestible. Lecomte explained that QA4EO was started with the guidelines and these had later been complemented by a summary framework document and also subsequently by the "guide". However, there is a clear need to go further and write a short one-page document to provide the substance of QA4EO and this would become the QA4EO reference. This is where QIs and traceability would be introduced and it would then become a tool to implement the substance of QA4EO within the various communities.

Chander suggested that the best way of communicating QA4EO would be to promote and present QA4EO at as many community meetings as possible. Tools – presentations, posters, brochures, etc. – should be prepared and put on the QA4EO website so that they are readily accessible for anyone to use on a daily basis whenever they are in meetings, etc. Iacovazzi asked Koopman if that would be considered acceptable from a GEO perspective as GEO had

not officially accepted or endorsed QA4EO yet. Koopman explained that it was almost a mandatory requirement that some outreach is undertaken. Lafeuille agreed that a one-page summary would be very good, but it would be prudent to avoid adding too many additional documentary layers. The existing documents like the framework should be redrafted or removed to avoid redundancy. Lecomte agreed that the one-pager should be both self-standing and completely self-describing. This should eventually become the unique reference replacing any others. Fox clarified that subsequent documents would have some adaptation or evolution, but they would always provide guidance and not be compulsory. The broad principle was that QA4EO is a set of principles and objectives and the documents are guidance to allow its implementation without being compulsory.

Nash suggested that people would be worried about where the authority comes from and recommended that this should possibly be GEO. It would be important to define the scope and then it would be clear what the onwards path would be. Alber agreed that a clear definition of the scope was need, as was defining QA4EO in a broader sense than Cal/Val. Alber agreed in the advantage of boiling down the essential truth to a single page but, when reaching the details, examples and lots of graphics should be included to make the principles easier to digest. Lecomte agreed with Alber. Cal/Val had been taken as a starting point and this just reflected the history of QA4EO. Taking things forwards, there should be a way found to pass the message efficiently, such as via clear diagrams, etc. The essence of QA4EO itself can be summarised in a few key words and this is one way forward. Mackin agreed that examples really do help, although these do not necessarily have to be physical examples, worked flow charts could be just as effective. The more broadly scoping the examples the better.

Lafeuille suggested the inclusion of a list of the processes involved, e.g. user requirements, etc. This may make life easier for organisations that already have a QA system in place. Koopman added that, in support of this, a QA4EO questionnaire will be drafted to optionally use for data submission to GEO. QA4EO is already registered on the GEO registry. Chander asked how GEO could help in the promotion of QA4EO. Koopman suggested that it was important to develop an implementation plan to effect outreach to other communities. It would be better to use more targeted routes to achieve this outreach. An action plan should also be formulated to identify who should do what to move forward. Lafeuille suggested that there needed to be a clear idea of the messages that should be put forward and also who should be targeted.

Alber suggested that one of the community outreaches could be to show that QA4EO interfaces with GEO. QA4EO should not be divorced from the rest of the community and there should be a two-way flow of information. The Architecture Data Committee (ADC) task connects to hundreds outside of the tasks and this is a good way to go. Stensaas agreed that a ‘communication toolkit’ should be made available to those going to conferences, etc. It would also be important to define organisations and task leads as contact points and have an outreach plan. Koopman suggested that it may be easier to assign the setting up of workshops to the GEO capacity building team. Facilities and teams within GEO should be accessed and utilised to assist the process. Iacovazzi suggested the need to ‘wow’ the audiences and so to have some really good end-to-end examples in the outreach presentations that detail the success stories.

Ottavianelli identified the fact that uncertainties are sensor and user specific. Traceability is not only to standards and to SI but also a matter of algorithms and documentation. It is

evolving knowledge that is based on evolving technologies and the value of QA4EO is being able to address every level.

Lecomte exemplified the French weather forecasters who associate a percentage flag to their rain predictions to estimate the probably of the chance of rain. This is a QI and so it should be possible to convince others that they should be able to do similar things. Lichtenberg identified that the end user should not provide the error, the data provider should. However, the user should provide feedback to the data provider as the latter cannot always provide everything. This feedback mechanism would also identity any problems. Fox added that, to some extent, ECMWF are feeding back issues to their users. They are also probably not being asked for QIs by the user and, if there is no requirement, then it is fit for purpose. It is the fitness for purpose that is the driver. Whilst it is the provider who is responsible to provide the uncertainties, if they cannot provide them, then it is up to the next stage along the processing chain to place something upon it, even if it is a 100% uncertainty. A QI needs to be assigned, whatever that may be, and reasons for the value of that QI given. This then starts to force the issue. Nash suggested that, as ECMWF shares its forecasts with many others, and where the forecast can be related to severe weather events, care should be taken in quantifying QIs in real time. Lecomte reported that ESA uses ECMWF products for processing Radar Altimeter data and in general the quality information does exist, although it is not necessarily related to the product. Mackin added that there is always the ability to estimate the uncertainty. If it is not possible to achieve an uncertainty for a series of small steps, it may be easier to take it over a bigger step.

Chander suggested that the QA4EO data principles should just refer to the GEO data sharing principles. Thomas added that the single QA4EO covering document could state the GEO data sharing principles but also make it clear that this is not compulsory. Stensaas informed the meeting that the original intent was to allow free and open information and data for GEO. However, one of the issues that regularly comes up for the Cal/Val community is the discomfort in releasing data too early. There has to be some process in which Cal/Val data is restricted for a period of time to stop people making false assumptions about the data for SBA issues. This is a specific issue and this and others should be addressed as and when they occur, but they need to somehow be integrated into the documentation. Nash agreed that there should be some words that recognise different ways of working. There has to be some agreement between users on how things will be organised and the requirement of each user community should be defined. Iacovazzi asked about the data policy at GEO level. Koopman explained that there is a dedicated page on the GEO portal where a white paper, based on most of the policies around, was available to all. Essentially it recommends that data be provided at the lowest cost possible and be totally free for science. For national interest there would always be a clause to adapt to national requirements as data access is never totally easy and / or provided completely free. The ministerial summit in 2010 will try to alleviate some or all of those national limitation barriers. QA4EO should refer to the GEO principles, with additionally having a clause inserted for Cal/Val that stops the release of data too early. Lichtenberg pointed out a certain risk for traceability of ground calibration data in that if just the GEO data sharing principles are pointed to calibration data may well not be given up.

Chander questioned the structure of the QA4EO documents and suggested that the guidelines themselves be condensed. Fox reported that the way the documents had been structured were as standalone documents that link into a framework. Maybe now they should not be

standalone, the common information going into the framework and the guidelines addressing the specifics only. Lecomte added that this was a reflection of the original bottom-up approach that now needed to be top-down. Iacovazzi agreed and identified that the current version of QA4EO was an example of how to actually write a procedure. A condensed version should now be drafted.

Thursday 1st October – Afternoon

QA4EO: Facilitating Implementation – The way forward
Chair: Jerome Lafeuille (WMO)
Facilitators: Greg Stensaas (USGS) / Gyanesh Chander (USGS) / Bob Iacovazzi (NOAA)

General discussion on adaptation of the QA4EO to wider EO communities

Chander suggested removing all words related to the satellite community from the QA4EO documentation in order to engage other communities. Stensaas saw the need to develop an engagement plan to engage data providers and users into the process. This plan would identify the major groups and players within GEO who should be engaged in this process. Lafeuille wondered if QA4EO would be ready to incorporate substantial changes if it appeared that other communities already did the job differently. Stensaas reported that the QA4EO document train and processes were living documents and if there was the need for revision this could be undertaken. Also, one of the main strategy points for the QA4EO process had always been to document best practises, whatever they may be. Fox added that in the detail and in the translation of QA4EO into specific sector domains and sector interests there would inevitably need to be differences in interpretation. Different examples and additions would also feed in to illustrate the principles in the same way to different domains. It is fundamental to QA4EO that the key principles are consistent and that the core content of the key guidelines, in particular the data quality guidelines, should be there. These are guidelines only but they still contain the basic principles. Chander added that the guidelines are the same but the procedures may change from group to group. People are looking for a type of 'cookbook' of procedures to pick up and easily use. Other than the key guidelines, the remaining procedures would likely be different from community to community. Lecomte suggested focusing on the main principles only, i.e. the necessity for a QI and for traceability, and to promote that.

Fox clarified that the definition of a reference standard is that it must seek to be a reference standard suitable for the activity it is being used for. Where a reference standard is an SI reference standard then this will be common and this will be the baseline. Elsewhere the reference standard is one that is fit for purpose and is the ownership of the community. The key guideline itself specifies that the characteristics of a reference standard should be known, it does not provide a list of reference standards. The guideline provides guidance on how to go about selecting and characterising a reference standard and how one goes about peer review in that community.

Nash tabled the issue that some do not see themselves as a community. There may be large groups or large numbers of people that do many and varied things and it is important to recognise that people operate in a variety of ways. The meteorological community, for example, references to SI standards and the customer asks for that. QA4EO should be general enough to be all-encompassing. Stensaas suggested that the hope would be to address this type of issue by restructuring the framework and guideline documents to make sure they are applicable to the GEO community as a whole.

General discussion on requirements for QA4EO infrastructure support

Lecomte suggested that the infrastructure support for QA4EO would involve specific communities being responsible for their own speciality – the WGCV would be the point of contact for CEOS Cal/Val purposes, GSICS for operational meteorological satellite calibration purposes, etc. In addition, a higher-level "QA4EO coordination body" would be needed to oversee the process. A peer-to-peer approval system should be promoted for procedures, documents and best practises for the broader community, although it would be perfectly acceptable for a person to undertake a specific task for a specific customer. Only where there is a generic procedure or generic best practise would proper peer-to-peer approval be required. GEO would not need to provide any specific approval mechanism. QIs should be fully traceable and it is the user who would determine if the QI and its characteristics are "fit for purpose".

Lafeuille asked what kind of coordination would be performed by the "QA4EO coordination body" and what would they approve. Lecomte suggested the "QA4EO coordination body" would approve the peer-to-peer approved procedures that would be developed within the community. Alber agreed that the end user should drive the requirement and this would be the desired outcome, but there was a need to be slightly realistic. It is incumbent upon the QA4EO "team" to promote the idea that it is the user groups that need to promote the QA4EO principles and implement them. It would be important to convene as many discussions with users from third world communities to find out their needs; this dialogue needs to start now. Lafeuille agreed and stressed the importance of dialogue.

Lecomte affirmed the need for QA4EO and the need to agree that for EO there should be a certain level of quality; this is the main purpose of QA4EO. If QA4EO is to be agreed by everybody in the EO community (including those interested in satellites, butterflies, etc.) there is a need at GEO level to have recognition that QA4EO exists. It has therefore to be represented by a high-level committee as an expression of that recognition. Stensaas agreed and suggested that, in order for the process to go forward and continue to evolve, there had to be some kind of a group to maintain any issues that come up. This group or committee would not have to get involved in any particular processes that were going on within the specific groups, but they would need to be there to maintain QA4EO's evolution. At community level education and training would take place. Koopman suggested that this group could also get involved in having an oversight and in monitoring the implementation of QA4EO. Fox recommended eventually having links from the QA4EO web to other communities.

Alber suggested that it would be sufficient that a body declares itself QA4EO complaint as people will eventually start to recognise if an organisation is QA4EO complaint or not, even if they say they are. Stensaas added that if someone declares themselves better than they are, you buy their data and you do not like their data, they would fall off the list of data that you would buy again. Over time it would be a self-declaring process. Fox suggested that self-declaration is fine, but you are declaring yourself to your customer and it will be up to those declaring their compliance to back-up their claim. The only way that QA4EO becomes anything more would be if it were to become regulatory with checks of compliance. This is not the current plan but it may be something to consider in the future. Nash suggested that this would be easy if there were limited products, but it would not be so simple where there are many customers. The philosophy works, but effort needs to be placed on making it fit to all circumstances.

Thomas reported that all the WMO processes had been registered into GEOSS registry, although it had been hard to put all the services in. It would be good to use the QA4EO documentation to help to describe the processes. Iacovazzi suggested that the QA4EO website could have a complaint section to register problems or good experiences. This would help people make a judgement and help the self-regulatory process. Mora added that it should not just be left to the users, the user had to be guided. Lecomte agreed, but said that it would be up to the user to express what he/she wanted, although they could be helped to express that requirement.

Fox clarified that QA4EO compliance means that there is a QI and it has full traceability. The user has to decide whether it would be suitable for his/ her application. Whether the QI is fit for purpose or not does not affect compliance. As long as there is a QI and there is traceability you are compliant. The level of QI determines the fitness for purpose of the data for a particular application, not compliance. Mackin exemplified DMC, which is not a high quality instrument and so would not be used for, e.g., water-leaving radiance determination. DMC would still be providing QIs and would still be QA4EO compliant, but it would never be fit for purpose for water-leaving radiance derivation.

Action item review

Stensaas presented a list of actions:

1. Acceptance of QA4EO as a deliverable to GEO

Alber asked what a deliverable to GEO actually was. Lecomte explained that QA4EO was an answer to GEO task DA-09-01a that requested the development a quality strategy for EO. The remit of the task can be considered covered by developing a strategy within the context of WGCV. When it was presented it to CEOS last year there had been a request to expand it to involve the GSICS and WMO world, and that has been done. However, there is a limit to how far the WGCV can take it. Expanding QA4EO goes beyond the capacity of the WGCV. Therefore, if GEO wants QA4EO to continue there should be a new task defined and new people should be asked to take it on. The WGCV would be happy to continue participating, but others would also be needed with a different type of mandate to take things further. Alber suggested that, even though QA4EO does not just have a Cal/Val perspective, it would seem that it still lies within the body of the existing GEO task for QA4EO to evolve into another organisation. Koopman added that this would be a normal route for the task. The task is cross-cutting and is a continuous process. It may need new involvement from others, but the process is normal and there should be no need to introduce discontinuity.

Lafeuille suggested that it would be useful to have some recognition from GEO to help take QA4EO forward. At what stage this should happen would be open for debate. Stensaas clarified that the group was simply saying to GEO that it would take additional resources and involvement from other groups. Assurance from GEO that there is the desire and request to move forwards with other resources and other groups would be greatly advantageous at this juncture. Koopman clarified that there is recognition from GEO that there is a mandate to progress and there would be no need to stop. All the interfaces, etc., within GEO are available to assist this. There is a need to demonstrate that QA4EO is truly cross-cutting before any true endorsement from GEO can be sought. Iacavozzi asked for clarification as to the exact point at which QA4EO would be on the agenda for GEO, i.e. when would there be

enough material to seek endorsement. Koopman reiterated that there already was a mandate and it is expected that QA4EO would be taken forwards. If GEO endorsement is to be sought it should stand separately, although this type of statement could be practically achieved through the committees. Chander asked if there could be some way of having two stages of endorsement, i.e. could QA4EO be endorsed first by GEO for the WGCV community and then for the wider communities. Lafeuille suggested that there was not a strong feeling that formal endorsement was needed, it was more a matter of communication of the good work. Koopman reiterated that having this exact mandate is already endorsement itself. Ottavianelli summarised that once we have QA4EO and the implementation strategy then that would conclude the GEO subtask DA-09-01a. At that point a specific new subcommittee could take over. Stensaas agreed on the need to formulate an implementation strategy on how QA4EO evolution could continue.

2. QA4EO Governance – Governance board or committee and charter

It was agreed that the workshop leads should propose a QA4EO committee, with review by the workshop participants. This implementation / governance committee would be led by GEO and would be subject to revision as QA4EO needs become addressed. Lecomte suggested that if the credibility of QA4EO is to be enlarged then the board should be enlarged. Alber informed the meeting that the leads for all the SBAs are available on the GEO website. Koopman added that GEO could send out a call for participation.

3. Implementation plan for QA4EO

Stensaas suggested that a QA4EO implementation plan would give a broad view of QA4EO and not just provide the current WGCV focus. Iacovazzi recommended that it was not the WGCV's responsibility to take this on and that it would need others to take it forward. What needed to be refined could be placed upon other groups who could better help to define the broader picture. Alber added that there should be a push for pilot projects to exemplify QA4EO. Lecomte reminded the meeting that there are already some QA4EO examples – DMC and the Miami, Tuz Gölu and DOME C intercomparisons. However, these cover the same type of a vision (WGCV-focused) and if this kind of example is only available QA4EO's position would be weakened. Alber proposed a broader context to bring together a pilot project within the SBAs. The committee would have to work this out as there would be many sub-elements. Ungar suggested that some of these components had already begun through the ADC. Fox added that it would probably not be necessary to actually talk to lots of other people in order to write an implementation plan. The idea would be to write the implementation plan and then take it to them, with the plan actually saying that there is a need to engage other communities. Thomas agreed that in order to implement anything one would need to come along with an implementation plan in the first place. Stensaas considered the first step to be the definition of an implementation strategy. On acceptance of that strategy the implementation plan could be written. Iacovazzi reiterated the need to get the one-page descriptor of the essence of QA4EO out into the EO community to get the tools to the people who would be implementing QA4EO.

4. GEO to adapt data entry form to allow and encourage a statement of quality with the data

This is an action for GEO.

5. Develop a QA4EO self evaluation questionnaire

Stensaas explained that this had already started. The participants to the workshop should be engaged in this to move forward with the process. Alber asked if this would be part of an implementation plan, a questionnaire being an element of implementation. Stensaas responded that this could well be one of the first things that the new committee could address.

6. Engagement plan

This would be an action for the committee. Stensaas took the action to start this plan and to pass it round the group. An engagement plan would need to define what organisations should be engaged and all the groups that could contribute.

7. Funding and resources support can be targeted via a developed engagement matrix

This is an action for the new committee.

8. Revise data sharing guidelines

Stensaas suggested that there were a few things to do from a Cal/Val perspective. Lafeuille reported that he would not encourage the WMO to have an action to discuss data sharing principles at this level, since the GEO Plenary has established a dedicated Task Force. Care should be taken not to create conflict between these two levels. Lecomte clarified that in the QA4EO principles there should be no mention of data sharing details, those details should de defined elsewhere. Lafeuille suggested that QA4EO could provide input to the Data Sharing Task Force for its particular area of expertise, but not duplicate these higher-level discussions.

9. One page document describing QA4EO

Stensaas suggested that this could be an action for the current workshop group. Lecomte clarified that this would be a single page description of what QA4EO is, the rest being supporting documentation.

General discussion wrap-up

Lecomte wrapped the workshop up by summarising the main action points:

- A one-page description of the essence of QA4EO would be drafted, along with a clear diagrammatic representation of the process and requirements.
- A high-level implementation plan that indicates how to proceed to enlarge the scope for QA4EO would also be drafted. This may include some orders or priorities within.

- A new QA4EO committee will be proposed to take QA4EO forwards and out of the WGCV arena. The new committee would define a lower-level implementation plan and address the SBAs. Lecomte suggested that it would be useful to have a list of entities that should be included in the new committee to take QA4EO forwards. Stensaas agreed to take an action to develop the GEO-related components that would be needed in such a committee and he asked for support from Lafeuille to identify any additional WMO components. Lafeuille agreed.
- The QA4EO framework and guidelines will be reviewed and version 4.0 produced.
- Concerning outreach and communication, the one-page descriptor would be the best communication tool. At next ESA conference in June-July 2010 a QA4EO session is planned and Lecomte would co-chair that session. At that point the idea would be to already have enlarged the scope of QA4EO to a wider community. There are probably other conferences too where QA4EO could be promoted. Stensaas proposed an action item for anyone in the workshop who had recommendations of venues where QA4EO should be presented as an outreach component to provide an email back to the QA4EO secretariat.

Planning for future QA4EO workshops

Lecomte suggested the need to plan for another workshop as part of the implementation plan that would be handed over to the new committee. This workshop should be open to all SBAs and be held within 9-12 months. Koopman suggested two possible workshops in 2010 to propose jointing working with – the ADC (Turkey) in June and the task-level workshop (Geneva) in September. Ungar suggested that QA4EO should show a presence at the ADC meeting in Buenos Aires at least. Lecomte agreed. Lafeuille offered to investigate hosting the next workshop at the WMO. Greening took an action to send an email to the group to ask for suggestions on where to hold the next workshop.

Annex A: Workshop Participants

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Annex B: Agenda

Tuesday 29th September

QA4EO: Facilitating Implementation – The bigger picture
Chair: Rob Koopman (GEO)
Facilitator: Pascal Lecomte (ESA)

09:30 Registration & coffee

10:00 Welcome and introduction from TÜBİTAK UZAY (Aslı Aytaç, Vice Director, TÜBİTAK UZAY)

10:30 GEO & QA4EO (Rob Koopman, GEO)

12:00 Lunch

13:30 QA4EO and the WIGOS (WMO Integrated Global Observing System) framework (Jerome Lafeuille, WMO)

14:00 The importance of traceability for climatology (Serhat Sensoy, DMI)

14:30 Coffee

15:00 The QA4EO framework and guidelines (Nigel Fox, NPL / Pascal Lecomte, ESA / Greg Stensaas, USGS / Bob Iacovazzi, NOAA)

16:00 Intercomparisons (Nigel Fox, NPL).

17:00 Close

Wednesday 30th September – Morning

QA4EO: Facilitating Implementation within satellite communities

Chair: Pascal Lecomte (ESA)
Facililitator: Nigel Fox (NPL) / Giuseppe Ottavianelli (ESA)

08:30 Test sites and post-launch calibration (Giuseppe Zibordi, JRC)

08:50 Marine Optical Buoy (MOBY) (Carol Johnson, NIST)

09:10 General discussion

09:30 Infrared sensors & SLSTR Sea and Land Surface Temperature Radiometer (Hugh Mortimer, RAL)

09:50 Tuz Gulu test site (Selime Gürol, TUBITAK UZAY)

10:10 Calibration & Validation for KOMPSAT in KARI (Dong-Han Lee, KARI)

10:30 General discussion

10:50 Coffee

11:10 Global Space-based Inter-Calibration System (GSICS) & the Product Acceptance Procedure (Bob Iacovazzi, NOAA)

11:40 General Discussion

11:50 DMC International Imaging Ltd (DMCii) & prototype demonstration (Steve Mackin, DMCii)

12:20 General Discussion

12:30 Lunch

QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

Wednesday 30th September – Afternoon

QA4EO: Facilitating Implementation within wider communities

Chair: Greg Stensaas (USGS)
Facilitator: Jerome Lafeuille (WMO) / Bob Iacovazzi (NOAA)

14:00 Commission for Instruments and Methods of Observation (CIMO) best practices and standards in the context of QA4EO (John Nash, UK Met Office, President of CIMO)

14:30 General Discussion

15:00 Quality Assurance in the Global Atmospheric Watch (Oksana Tarasova, WMO)

15:30 General Discussion

16:00 Coffee

16:30 WMO Information System (WIS) data management best practices & standards (David Thomas, WMO)

17:00 General Discussion

17:30 Data Quality management in Numerical Weather Prediction (Niels Bormann, ECMWF)

18:00 General Discussion

18:30 Close

Thursday 1st October – Morning

QA4EO: Facilitating Implementation within the Societal Benefit Areas

Chair: Nigel Fox (NPL)
Facilitator: Rob Koopman (GEO)

08:30 Quality Indicators for Societal Benefit (Irwin Alber, IEEE)

09:00 General Discussion

09:15 The role of QA4EO within NASA's SBA-oriented joint projects (Steve Ungar, NASA)

09:45 General Discussion

10:00 Calibration / Validation issues in Forest Carbon Tracking (Rob Koopman, GEO)

10:15 General Discussion

10:30 Coffee

11:00 General discussion on:

- Cross-cutting issues
- Communication / Education / Outreach
- Governance

12:30 Lunch

Thursday 1st October – Afternoon

QA4EO: Facilitating Implementation – The way forward
Chair: Jerome Lafeuille (WMO)
Facilitators: Greg Stensaas (USGS) / Gyanesh Chander (USGS) / Bob Iacovazzi (NOAA)

14:00 General discussion on:

- Previous sessions' information and issues
- Adaptation of the QA4EO to wider EO communities
- Defining any additional contributions to the GEO tasks
- Governance issues and the link between QA4EO and the GEO Architecture and Data Committee (ADC)
- Information access
- Training – web-based tools, courses, sponsorship of training aspects / components, web-based help desk, conference outreach.
- Requirements for QA4EO infrastructure support
- Implementation Strategy and next steps

15:30 Coffee

16:00 General discussion wrap-up

16:30 Action item review

16:50 Planning for future QA4EO workshops

17:00 Close