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DOCUMENT

Sentinel-3 OLCI/SLSTR and MERIS/(A)ATSR Workshop: **Session Summaries**

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Rescaling of fig 1		7	2
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1 INTRODUCTION

This document gathers the session summaries with seed questions, conclusions and recommendations of the Sentinel-3 OLCI/SLSTR & MERIS/(A)ATSR workshop, hosted by the European Space Agency at ESRIN, Frascati, Italy, on 15-19 October 2012

The main objectives of the workshop were:

- to gather the future Sentienl-3 R&D user community
- to report on progress/status of recommendations of the 2008 MERIS/(A)ATSR workshop
- to provide a forum for ESA PIs and scientists to present new results from MERIS and (A)ATSR application development projects
- to review lessons learned from the ENVISAT MERIS/(A)ATSR era
- to discuss the transition from MERIS/AATR to Sentinel-3 OLCI/SLSTR in terms of scientific exploitation
- to present the status of the Sentinel-3 mission, its operations concept, the data products, and the Ground Segment
- to learn about the future Sentinel-3 R&D user community activities to use OLCI/SLSTR data
- to discuss what new research and tools are needed to best exploit the improved capabilities of the new OLCI/SLSTR instruments.

The workshop focussed on the following themes:

- Lessons learnt from the Envisat era
- Sentinel-3
- GMES Services
- Third Party Missions
- Calibration/Validation
- Global Land Monitoring
- Lakes
- Ocean and Coastal Zones
- Atmosphere

The web site of the workshop is available at
http://congrexprojects.com/sen3symposium/background

2 WORKSHOP PROGRAMME

The workshop has been organised along the following oral sessions:

Date	Sessions Title
Monday 15 October	Opening
	Lessons learned from the Envisat era
	GMES Services
	Third Party Missions
Tuesday 16 October	Global Land Monitoring
	Land
	Land and Lakes
Wednesday 17 October	Cal/Val I & II
	Ocean and Coastal Zones I & II
Thursday 18 October	Ocean and Coastal Zones III, IV, V
Friday 19 October	Atmosphere
	Session Summaries
	Conclusion

The program was complemented by two poster sessions:

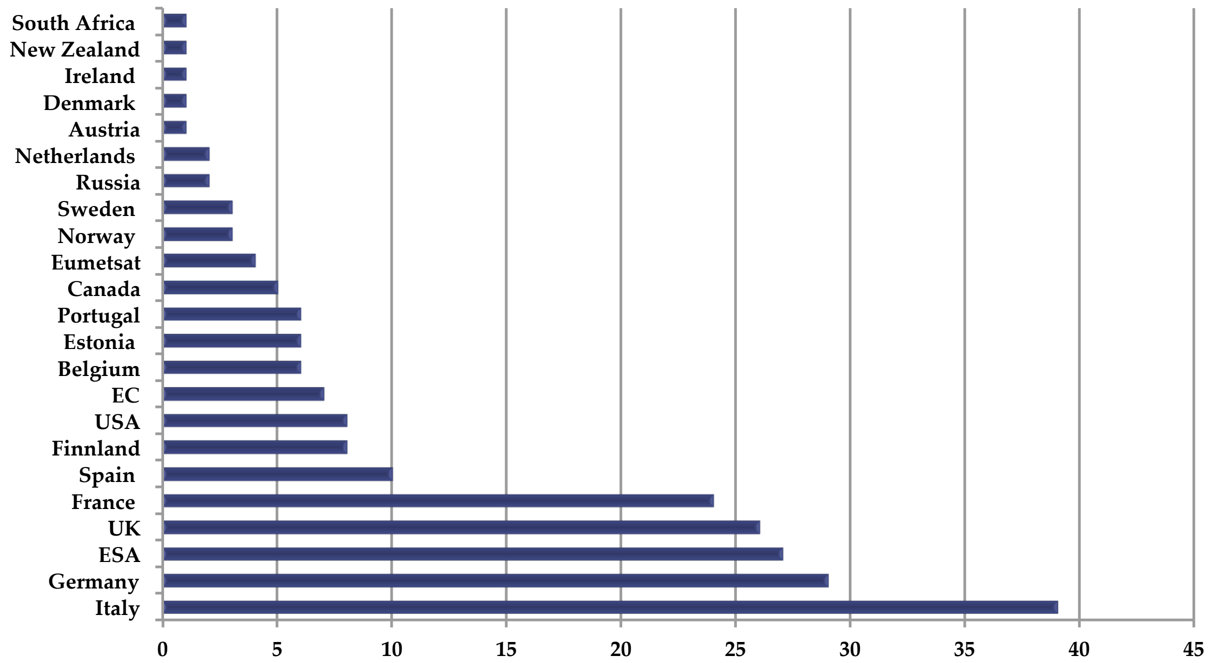
- Tuesday 16 October: Cal/Val, Land & Lakes, Sentinel-3, Tools
- Thursday 18 October: Ocean and Coastal Zones, Atmosphere

The workshop has been attended by a total of 220 participants originating from 20 countries (see figure 1 for national distribution of the participants). The participants were well representing the scientific as well as the GMES operational EO community (the participant list is available on the workshop website). The European Commission participated to the workshop with keynote talks by the acting head of the GMES Unit (DG ENTR), as well as by a JRC scientist from the Institute for Environment and Sustainability (IES).

67 oral presentations (18 keynote addresses and 49 thematic speeches) were given and 130 posters were presented.

The Workshop website http://congrexprojects.com/sen3symposium/ contains all oral presentations and most of the posters presented at the workshop.

Fig. 1: Participants per country



3 SEED QUESTIONS

Nine seed questions were addressed to all presenters and to the participants during the round table discussions concluding each thematic session:

#	Seed Question
1	What should the priorities be on how to best exploit the 20 years of (A)ATSR and 10 years of MERIS data archives (e.g. improved calibration, new products, additional climate data set generation)?
2	How can the 20 years of (A)ATSR and/or 10 years of MERIS data archives be used best for the preparation of the future Sentinel-3 mission?
3	Are MERIS/(A)ATSR products in their current versions accurate and reliable enough for your applications or do they need improvements/enhancements? Which ones? What is required?
4	Are data from Missions such as MODIS Terra/Aqua, NPP VIIRS, Spot Vegetation, Proba-V, OceanSat-2 OCM, AVHRR, and GCOM-W1 appropriate for filling the

	MERIS/(A)ATSR data gap w.r.t. information content and data quality? What is your experience?
5	Any recommendation for the preparation of Sentinel-3, e.g. a) exploitation of MERIS/AATSR synergy in preparation for the exploitation of the S3-SYN product suite b) exploitation of MERIS spectral campaign or MODIS data to test improved turbid water atmospheric correction or cirrus cloud detection algorithms using new OLCI/SLSTR bands c) dedicated tools.
6	Based on the ENVISAT/MERIS experience, what improvements are required for optimal exploitation of Sentinel3/OLCI as regards: a) data distribution, b) software tools for processing and visualisation, c) validation?
7	What do you require for the synergistic use of data from the Sentinels or with other missions?
8	Do you expect any difficulties related to the large volume of Sentinel data?
9	Any recommendations for specialized geophysical products that could be developed nationally as part of the collaborative ground segment initiatives, not covered by the presently agreed Sentinel-3 product suite?

4 WORKSHOP CONCLUSIONS

4.1 Lessons learnt from the Envisat era

This session provided an overview of the key achievements and improvements that the MERIS and (A)ATSR instruments onboard Envisat have brought to the ocean, land and atmosphere communities.

MERIS was a global mission that has provided climate-quality data records. The excellent performance and stability of the MERIS instrument with a maximum degradation of only ≈ 5 % after more than 10 years in space was highlighted. The 10 years of data records are maintained to high-level quality standards through regular reprocessing campaigns taking into account calibration updates, improvements in instrument knowledge and algorithm evolution. Limitations of current algorithms and perspectives for future evolutions and reprocessing were given.

The relevance of MERIS data and products for a wide range of land applications was recognized. Beyond the use of data/products to monitor the state and evolution of terrestrial surfaces, MERIS offers a unique opportunity to promote research and development, including the implementation of novel techniques to assess plant phenology, to exploit data assimilation techniques in biosphere modelling, and to improve semi-automatic land cover classifications. However further work on some land surfaces, such as desert, ice or snow is still needed.

It was noted that in the early phase of the Envisat mission access to data was not straightforward for users. In particular MERIS full resolution data were initially not broadly available and thus the high value of the 300 m resolution data, in particular for land and coastal zone applications could not be fully exploited by the community. It took time before MERIS reached (nearly) the same ease of use and efficiency than other missions. It was noted that for MERIS there are less publications in the peer reviewed literature, and less citations per paper than for other missions, such as MODIS and SeaWifs.

The unique N1 data format required some adaption time by the scientific community and exploitation of the data happened only with some delay. The availability of the BEAM software in free source code was recognized as very helpful and facilitated this adaption process.

It was noted that a validation plan for land level 2 products was not foreseen at the beginning of the mission and Level 3 products have been available only as demonstration products.

The session stressed that there is a clear need for an integrated approach for the design and implementation of a satellite mission, i.e. an end-to-end concept. A "satellite mission" should be more than just the hardware and software required to make a measurement from space.

A few important lessons learnt from the MERIS were highlighted and recommendations for the future OLCI were formulated by the speakers and by the participants:

Id	Recommendations
1	Building an organised and funded science team working permanently on algorithm testing/improvements is important.
2	Establish a sound plan for pre-launch, post-launch and across mission cal/val activities, to ensure continuity and traceability, including vicarious calibration, regular match-ups and field data for model development; also ensure the appropriate funding from agencies and nationally
3	Involvement of instrument experts across space agencies in cal/val activities.
4	Regular, efficient, fast and flexible reprocessing.
5	The Sentinel-3 data policy must be a real "free and open" data policy and the access to the Sentinel-3 data must be "seamless and effortless" through

	appropriate systems for data distribution ("3-click access").
6	Rapid release of data in order to get feedback from the user community (both scientific and operational users) is essential. Don't wait for the data to be "perfect" before starting to release it (in particular to the Collaborative Ground Segments that are being developed across Europe).
7	To exploit the MERIS/OLCI data/time series to the full, both data sets should be available and distributed in similar manner (i.e. one archive/one format).
8	Bridging versus filling the minimum 2-year data-gap between ENVISAT and S-3: significant work will need to go into making existing data sets consistent. This shall include an agreement of the favoured approach and the development of methods how to use existing data sets for gap filling/bridging.
9	The MERIS Full Resolution (FR) dataset shall be systematically processed, both for Level 1 and for Level 2.
10	The AMORGOS tool (i.e. geolocation improvement) shall be embedded in the FR systematic processing.
11	The systematic processing of MERIS FR dataset shall use the feedback of the CCI Land Cover project.
12	Full access to the MERIS FR data archive shall enable the re-analysis of this unique data set and the development of enhanced cloud masks over land and atmospheric correction algorithms ahead of the launch of Sentinel-3
13	The atmospheric corrections applied to the MERIS and MODIS datasets shall be harmonised.

In the session it was stressed that AATSR "was undoubtedly one of Envisat's many great success stories". Not only did AATSR demonstrate the ability to measure Global SST to higher levels of accuracy than otherwise achievable, it gained also full acceptance of the Climate Research Community. It also pioneered the largely uncharted path from experimental innovation to operational applications. It was also highly productive scientifically, as indicated by the Special Issue of the scientific journal, RSE, devoted to major results from AATSR and published in 2011.(doi:10.1016/j.rse.2011.06.002)

The most important of the many lessons from the (A)ATSR ear are summarised in the table below:

Id	Topic	Recommendations
1	Data-product & development	• Need to form a consortium comprising relevant expertise AND user/customers representation. • Generate the data sets and archive them for general access.

	refinement	• This activity requires a proper funding framework.
2	Validation programme	• The Validation Plan needs to define, in addition to activities during the main mission period, early mission phase activities and objectives, which are necessarily limited, but they must be feasible within the time-scale. • Also, the Validation Plan must assign and define the overall responsibility for timely and effective validation programme. • Validation teams must make clear decisions and agree on: o Data-collection programmes o Timescales for data-processing and reporting o Data-formats o Provision of uncertainty information (both bias and random components).
3	Development of user community	• Must consult users and understand their constraints – What is preventing them using your excellent data? • It is important, especially in the case of 'power users', to adapt where necessary products, formats and delivery methods to meet the needs and constraints of the users. This is often a major undertaking requiring rescores and extensive international coordination. ESA's DUE Programme is an excellent and proven vehicle for achieving this.
4	Ground-based reference data	• The availability of and access to ground-based reference data is vital to ensure the high quality of measurements from space. Concern was raised wrt the future (continuous) availability and provision of ground-based reference data for validating space data; the institutional split of responsibility/ administration between space (ESA, EC) and ground-based reference data (EEA, national) introduces a disjoint between the two data sources and thus a high risk, strong need for coordination!
5	General	• It is essential to listen and repeat the constraints and limitations of the users – and then to act in response.

The data gap between AATSR and SLSTR poses a greater challenge to SST data continuity than anticipated. For climate users, gap bridging is more important; for operational users gap filling is now an urgent need.

The objective of bridging the gap is to ensure that the data collected just before the data-gap and the data collected immediately upon resumption of the data-collection service are, in each case compared to traceable reference standards, preferably using the same reference data system.

To achieve this, there is a requirement for an SI-standard traceable reference to calibrate AATSR data products at end of life and SLSTR at the beginning of the Sentinel-3 mission. Experience with AATSR has demonstrated that ship-borne radiometers can do this. However, the measurement systems need to be made available, with the appropriate calibration procedures applied. It is suggested that the AATSR sampling strategy, which has been in place for the last two years of the Envisat mission, is replicated for SLSTR reference measurements to be carried out for at least the first two years of the S-3 Mission.

To summarise:

Id	Recommendations for gap-bridging
6	There is a need for an SI-standard traceable reference to calibrate AATSR data products at end of life and SLSTR at beginning of life. Ship-borne radiometers can do this.
7	Proven AATSR sampling strategy to be replicated for SLSTR reference measurements.

It should be recognised that in situ measurements are also required to supplement the ship-borne radiometers. Drifting buoys are needed to evaluate spatial biases (ideally 2 years of AATSR and SLSTR data tested). The Argo data needs to be tested for stability, ideally within the ATSR period.

Whereas gap-bridging only requires consistent and traceable calibration of the data-products at the beginning and end of the interruption to data service, gap-filling seeks to monitor the geophysical parameter with alternative data-sources, in order to monitor details of geophysical behaviour during the interruption. Is it feasible to use an alternate satellite system for this purpose? The following points need to be observed:

Id	Recommendations for gap-filling
8	There is a need to match the calibration and sampling performance of AATSR.
9	Of the currently available SST sensors, MetOp/AVHRR and MODIS have similar sampling characteristics.
10	Calibration of the SST data products can be monitored with in situ reference data (radiometers) and, where necessary, empirical bias corrections can be applied.
11	In this way, it should be possible to develop a non-AATSR satellite data stream to fill the gap, utilising METOP AVHRR, IASI or MODIS. It is important to verify the alternative SST against SLSTR data for at least 2 years.

Taking these points into account, it should be feasible to use a non-AATSR satellite climate SST analysis to develop SST-reference data stream for operational uses during the gap period.

The availability of and access to ground-based reference data in support of cal/val activities was discussed in some detail. The GMES Space Component should be given a pro-active role in supporting the collection of ground-based reference geophysical data relevant for Cal/Val activities. This is because it is increasingly being recognised that ground-based reference data and satellite data both have fundamental roles in the creation of global geophysical data-sets that meet the criteria for accuracy, stability and traceability that are essential if the data are to be used for climate applications.

A particularly clear example is provided by Sea-Surface Temperature (SST) where satellites provide the required coverage and accuracy, but traceability can only be achieved by using *in situ* sensors, which have been regularly calibrated to traceable, internationally recognised, standards. Thus certain *in situ* measurements need to receive stable support.

Moreover, such support is vital in the case of any interruption in the satellite service, so that traceable reference observations can be used to bridge the resultant data-gaps. It is considered important that the GMES Programme recognises this fact and efforts are made to enable the GMES *in situ* element to provide support to in situ measurements when they comprise a fundamental element of a climate-standard geophysical data-set.

To summarise:

Id	Recommendations
12	The GMES Space Component should be given a pro-active role in supporting the collection of ground-based reference geophysical data relevant for Cal/Val activities. The latter will ensure long term consistency of the geophysical records as desired for climate related studies.

4.2 Sentinel-3

The session provided an overview on the
- GMES Space Component
- Sentinel-3 mission, including instrumentation and specification
- Preparations for the operations
- Sentinel-3 (core) data products

The discussion focussed on:
- Availability of EU funding for Sentinel operations phase
- Gap bridging versus gap filling

- Availability and access to ground-based reference data
- Users' data access needs
- Masking for data products over land and ocean
- Availability of fire product through core data products

The following recommendations were formulated:

Id	Recommendations
1	The availability of and access to ground-based reference data is vital to ensure the high quality of measurements from space.
2	Sentinel data access needs to be as easy and open as possible; this includes easy extraction tools that can be configured by the users (in addition to pre-defined target validation areas, tiles etc.) and easy access (via ftp for example) of large volume data sets (one click for bulk download or one ftp command).
3	The fire radiative power and fire detection products shall be made available to users as soon as possible from the core ground segment (= formal change of baseline by EC). Further possibility could be to provide this product via collaborative ground segment. The fire detection product is needed for operational applications and should be provided in near-real time. NB: The algorithm exists (developed by KCL) and it has been prototyped, but it is not in the current list of core products.
4	Bridge the gap between MERIS and OLCI → use other satellite instruments including MODIS and OCM (India). It was recommended that ESA takes the lead in: (1) assessing the data quality of these instruments with respect to MERIS and OLCI for the respective applications, (2) developing tools for exploiting the data (3) standardizing the data from the overlapping period with MERIS. Results of the analysis should be well documented and easily accessible to users.
5	OLCI data shall be made available in full resolution also for the open ocean (detect features such as small scale eddies and associated plankton booms, not possible to observe up to now; detection of clouds is much easier with high resolution data, sub-pixel clouds reduce significantly data quality).

4.3 GMES Services

This session introduced the GMES services for ocean (MyOean), atmosphere (MACC-II) and land monitoring (Geoland-2). It was stressed that GMES serves operational services, but is available also to science users. Science will be crucial to advance services and provide critical input to the definition of new observation systems.

It was recognised that the Sentinel data policy envisages full and open access, with free of charge licenses, subject to restrictions only if security or other European interests need to be preserved.

The session underlined that easy access to Sentinel data via (on-line) interfaces is key to ensure rapid take-up by services, science and new users. Long-term continuity of Sentinel observations, through recurrent satellites and new generations, is crucial for private industry to invest in developing GMES services for the market.

The recommendation for the availability of ground-based reference data was repeated.

4.4 Third Party Missions

ESA's Third party and GMES Contributing Missions (NOAA AVHRR, Terra/Aqua MODIS, SeaWifs, Spot VGT, and future Proba-V) supply data since 35 years for science use and application development, and since 2008 for GMES use.

NPP, VIIRs: NASA is currently working with the NOAA JPSS Program to transition responsibility for certain science-quality time series products, with Suomi NPP playing a critical role.

VIIRS products will not achieve validated status for a while yet. VIIRS data are available now through NOAA CLASS, but are only at Beta maturity; also, NOAA has no plans for re-processing to produce a consistent time series.

The Suomi NPP Science Team's research/experimental VIIRS products can be obtained, but NASA cannot guarantee their quality or long-term availability at this point in time.

Id	Recommendations
1	Recommendation by NASA to use MODIS Vis/nIR data to fill the gap for ocean colour since data need is immediate.

EPS/Metop: provides continuous operational service from low mid-morning Earth orbit for operational meteorology, climate monitoring. Continuity is assured through the recent launch of Metop-B, with opportunities for the use of data from two satellites in the same orbit, looking at min. 15 years of operations through 3 Metop satellites.

Proba-V: Launch scheduled in March 2013. The mission will provide continuity to SPOT-V while S-3 is being deployed, mapping systematically all land -56 to +75 degree.

1 km products will be available under a 'free and open' ESA data policy.

Id	Recommendations
2	Provide also 300m products following the same approach as for 1km products.

Oceansat-2: A permanent Cal/Val site for OceanSat-2 data is available. GAC data products incl. some L2 geophysical products are disseminated by www.nrsc.gov.in; LAC data and geophysical products are available from NRSC Data Centre, NRSC, Hyderbad.

Id	Recommendations
3	Seek to establish Oceansat as an ESA TPM with direct acquisition.

4.5 Land

Land issues were addressed in several sessions, including “Global Land Monitoring”, “Land”, and “Land & Lakes”. Results from the ESA Fire-CCI and Land Cover-CCI were presented as well as latest results form the DUE GlobAlbedo, GlobSnow and GlobTemperature projects. The importance of a timely launch of Sentinel-3 with the OLCI and SLSTR instruments for the continuity of land products at global scale and in an operational manner was stressed.

The synergistic use of the future S-2 MSI instrument in combination with the S-3 OLCI/ SLSTR instruments for improved multi-sensor LST products was explored. Other talks discussed the prospects for future developments making use of the full spectral capabilities of the OLCI/SLSTR sensors for enhanced snow maps and cloud masks or the improved spatial resolution of OLCI and Proba-V for the generation of global maps of LAI and FAPAR in support to the modelling of canopy functioning.

It was recognized that the available EO data sets coming from SPOT4/5-VEGETATION, NOAA/Metop-AVHRR and Terra/Aqua-MODIS do not satisfy key requirements for in-season crop yield monitoring and forecasting, such as (1) having an adequate spatial resolution to have a crop specific signal; (2) a high revisit frequency to follow the rapid growth of crops despite cloud cover; (3) a long term warranty of data continuity; and (4) the capacity to have interoperable remote sensing products, partly to construct a valid long term archive of the past, but also to assure the possibility to use different present and future sensors. It was recognised that the advent of the S-3 OLCI instrument provides the opportunity to have a data source that could potentially satisfy these requirements.

Strategies for bridging and filling the prospective minimum 2-year data gap were discussed. The importance of having consistent ground-based reference measurements for calibration of the data products just before the data gap and collected immediately upon resumption of the data collection with Sentinel-3 was underlined. Methodologies need to be developed to fill the data gap with currently available alternate sensors of the same class as MERIS and AATSR taking into account the major issue of consistency when combining sensors with different sampling characteristics.

Speakers raised several times concerns about the complementarity between S-3 products - how ready-to-use is the SYN product between OLCI and SLSTR? Similarly, to what extent will S-3 products be compatible with S-2 products?

The following recommendations were formulated:

Id	Recommendations
1	Maintain ground-based reference data needed for consistent calibration of the satellite data products just before and after the data-gap.
2	Explore methods to fill the gap with sensors of the same class as MERIS and AATSR taking into account major issues of consistency that need to be solved.
3	Ensure that within the next 12-15 months a re-processing of AATSR takes place, which will provide sub-pixel co-registration information with the corresponding pixels from MERIS to allow sensible data fusion for land applications. The current situation continues to be unacceptable. This will also provide for the more precise geo-referencing information already available for MERIS to be applied to AATSR.
4	ESA should develop a separate G-POD2 enabled system to allow multiple (fast) re-processing of the entire MERIS & AATSR archive for continued development of better cloud masks, improvements in radiometric calibration and geometric correction.
5	Next ESA reprocessing should provide Sentinel-3-like products from AATSR and MERIS.
6	Ensure that GMTED2010 becomes the global topographic dataset of first choice. This has already been accepted by NASA EOS. GMTED2010 is QA4EO compliant given that the sources are traceable and extensive validation has been performed of its Quality Indicators provided with each pixel. It is also available at 250m, 500m and 1000m.
7	ESA should consider the application of stereo-matched cloud-top heights to create a better cloud mask as well as the ALANIS smoke plume masking results for better detection of smoke, desert dust, volcanic ash.
8	ESA should include probability in cloud masks and test -by using MODIS- the improvement feasible with the additional OCLI and SLSTR bands
9	ESA should take care or make sure that global ready-to-use daily (single acquisition) MERIS and S-3 products are made available: typically for land, a level-2 surface reflectance product already projected and including different cloud flags to define a more or less restrictive cloud screening according to applications. This would allow the research community to focus on the methodological development

	for level 3 and level 4 products, instead of investing lot of their energy and resources in pre-processing steps.
10	Access to data Sentinel-3 should be via programmable web interfaces that would allow you to "rip-out" large quantities of data. (CEOS-WGISS has defined how this can be done).
10	Merged & co-located OLCI-SLSTR Level-1B product at original resolution ("Synergy Product") should be available to users to stimulate synergy product development.
11	Need full, detailed and up-to-date documentation of instrument characteristics, e.g. footprint.
12	Need for a financial support mechanism to allow ESA to manage/run reprocessing satellite archive like MERIS and S-3 according to state of the art in order to keep the archives useable and attractive for scientific research and future mission preparation.
12	With increasingly large size of satellite datasets, such as for S-3, it will be necessary to provide more processing next to satellite data archives to give improved ability to utilise these significant data sets.

4.6 Lakes

Lakes were addressed in 3 presentations and 5 posters. They covered methodical developments for chl-a retrieval in alkaline-saline waters, MERIS/AATSR synergy in African lakes, retrieval of lake surface water temperature, and validation issues.

It was noted that optical remote sensing of lake water quantities (IOPs, constituents, temperature, indicators) is an evolving discipline. There is an increasing demand for water quality information by the EU Water Framework Directive or World Bank initiatives supporting water resource management. Satellite sensors used to provide this information include Landsat TM, MERIS, AATSR, and in the future the S-2 MSI and S-3 OLCI/SLSTR.

The following recommendations were formulated:

Id	Recommendations
1	Existing methods for atmospheric correction, IOP retrieval, and surface water temperature retrieval are based on methods developed for coastal waters and need adaption to the specific physical and bio-optical properties of lake waters.
2	Lake remote sensing requires more attention. Inland water quality and quantity are major issues of concern, however the planned Sentinel 3 product suite does not (yet) include a lake product (except a few very large lakes).
3	Lake products shall be developed for Sentinel-3 including both, lake water quality and water surface temperature, thus exploiting the synergy of OLCI and SLSTR.

	NRT is not a key requirement; synergistic use of OLCI and SLSTR for better retrieval quality is of higher priority.
4	Validation of lake water products requires more ground-based reference data including radiometric measurements and measurements of IOPs and concentrations.
5	The preparation for the exploitation of Sentinel 3 and Sentinel 2 data for lake remote sensing needs to be intensified in the frame of ESA's STSE and DUE programmes.
6	Gap filling requires data from various sensors including MODIS and VIIRS, as well as OCM-2, WorldView2, HICO. For the latter ESA's TPM portfolio should be extended to these missions.

4.7 Cal/Val

This session addressed the methods used for the calibration of the MERIS and ATSR instruments to provide consistent Level 1b radiometric data sets. Perspectives for continuity into the Sentinel-3 OLCI/SLTSR era were discussed and three top-level requirements were identified:

- Continuity from one mission to the next, i.e. existing cal/val assests need to be maintained;
- Consistency among field data used for cal/val;
- Traceability of instruments/protocols etc.

The high quality of the (A)ATSR global SST data with an accuracy and stability suitable for climate change detection was highlighted. It was shown that for at least the period from 1993 to date the uncertainty of the dataset is < 0.1 K (90% confidence) and the stability in the tropics is of order 0.03 K/decade.

Another presentation assessed the MERIS calibration after the 3rd reprocessing through various in-flight calibration techniques using natural targets including desert sites, Rayleigh scattering, sunglint, Antarctica, and clouds. It was concluded that in general there is very good consistency between all results for all methods. Cross-calibration between MERIS and MODIS over desert sites reveals very good consistency between the two instuments within 1-2%. It was recommended that all calibration methods should be applied to OLCI.

The session formulated the following recommendations:

Id	Recommendations
1	Need for stable land calibration sites (upper part of the dynamic range).

	Vicarious calibration / validation methods of NIR bands over dark targets exist for dark ocean waters.
2	Satellite instruments do not necessarily behave as anticipated → frequent monitoring is necessary.
3	Data and code inter-comparisons using standard data sets (diagnostic sites) is key to understanding the measurement errors
4	Reprocessing may require many trials before reaching a satisfactory result → must be fast & flexible.
5	Distribute the data ! Don't be afraid because they are not perfect; they will never be if you keep them hidden. Openness is the only way to get feedback in a timely manner. Behave as a data provider, not a data owner.
6	Need for radiometers for skin temperature validation measurements (at least 10 different transit lines (e.g. ferry routes) spread around the ocean); cf GCOS-154, satellite suppl. Update 2011).
7	Need for high-accuracy VIS & NIR radiometry for the ocean (specific instrument developments in addition to commercial instrumentation are strongly recommended).
8	Quantify uncertainty budgets for field data acquisition, and also for validation/ calibration methods.
9	Need for different validation tools.
10	Do not separate calibration from users.
11	Cal/val information should be provided with the products (e.g., xml metadata).
12	Maintain "independent" satellite sensors (don't try to align them "artificially"; provide the relevant information to users enabling them to do this by themselves).
13	Establishing a cal/val office per instrument, which includes skilled people (i.e. engineers + scientists), in charge of overseeing the entire chain of activities from the cal/val team.
14	Set up well-funded cal/val sites. Consolidate / improve the existing ones. Seek co-funding with national institutions that can finance field sites (e.g., CNRS/INSU in France, CNR in Italy, etc.).
15	Provide cal/val budget lines independent from missions (for continuity).
16	Set up some centralized facilities for instrument radiometric characterization and calibration, in order to reduce spread in the data used for cal/val (this is not exclusive).
17	Provide efficient tools to evaluate calibration/algorithms changes (e.g., ODESA, MERMAID, BEAM, SEADAS…); please ensure further evolution and adaption to Sentinel-3 data products.
18	Provide L3 products, which are an important means for product validation.

19	Develop web-based applications (like NASA Giovanni) that provide a simple and intuitive way to visualize, analyse, and access vast amounts of Earth science remote sensing data without having to download the data.

4.8 Ocean & Coastal Zones

One of the focal points of the workshop was the subject of "Oceans and Coastal Zones". A broad range of topics was covered in the presentations ranging from validation of ocean colour and SST products, the use of SST and radiance measurements for climate research, operational ocean analysis and forecasting, developments of enhanced ocean colour algorithms and products including turbid case 2 waters, to the use of these products in operational applications.

The Ocean colour and SST community emphasised the need for MERIS and AATSR class of sensors because of their unique capabilities. The gap in data from ENVISAT to Sentinel-3 is regrettable and should be kept to minimum and ways should be pursued to bridge the gap by linking to existing third party missions.

The sessions formulated the following recommendations:

Id	Recommendations (Envisat and Sentinel-3)
1	Need for strategy that utilizes operational sensors (e.g. AVHRR for coverage and IASI for calibration) and in situ networks of buoys and radiometers.
2	Provide opportunity to users to familiarize themselves with Sentinel-3 data prior to launch.
3	Provide example data products to allow tools and algorithm development to be ready for S3 launch.
4	Allow users to provide feedback to improve product content.
5	Maximize synergy between SLSTR and OLCI (e.g. level 1c synergy product).
6	Prepare to take advantage of novel aspects of Sentinel-3 sensors (e.g., need to look at the band settings on OLCI for PFT decomposition in support of GMES EcoSystem Modelling).
7	In the frame of GMES the monitoring of coastal waters is a key objective. Improved algorithms for atmospheric correction and water constituents retrieval in complex case 2 waters need to be developed taking into the account the strong adjacency effects along the coastline and utilizing the improved observation capabilities of the OLCI and SLSTR instruments.

Id	Recommendations (Integrated System)
8	It takes more than an excellent sensor to make an excellent system.
9	In situ calibration and validation exercises are key: continued support of sustained, high-quality observation programs, for example MOBY, BOUSSOLE, Aeronet-OC, reference ocean skin temperature measurements.
10	Important that these activities continue during the data gap, to facilitate incorporation of third-party missions to bridge the gap, ensure continuity and hence enhance the value of Sentinel-3.
11	Continuity and stability is important for climate products; need to validate merged products, not just products from individual sensors.
12	Need comprehensive match-up database, stewardship of existing and historical data, new data to support new missions, open and free access to the database.
13	Request ESA to take responsibility for the whole mission, including the in situ operations in support of the satellite segment.
14	Coordinate ocean-colour and SST validation exercises to minimize costs and effort, exploit synergy.
15	Quality control: Put in place a meticulous process for testing products.

Id	Recommendations (International Project)
16	Sentinel-3 will be a global mission, of global interest. Foster the interest and commitment from outside Europe for mutual benefit.
17	Need for full-resolution data across the globe, even in the open ocean (detection of small-scale features, improved cloud detection). Agreements should be in place prior to launch.
18	Reliance on third-party missions to bridge gaps, to exploit complementarity (e.g., AVHRR spatial coverage and AATSR quality, IASI, MODIS, VIIRS and OCM-2), to retain users.
19	Important to participate in, and foster, international community efforts, e.g., through GHRSST, IOCCG, CEOS virtual constellation.
20	International validation team is important.

Id	Recommendations (Science and Operations)
21	Science and operations form a continuum, not a dichotomy: need for reprocessing; need for updates to serve the operational community in the best way possible.
22	Multiple applications, growing family of algorithms (important to explore novel and complementary algorithms), many coastal, regional and global applications.

23	Engage users: community consultation, encourage application projects, ESA to continue data exploitation programs.
24	Need to encourage synergy science applications of multiple sensors (e.g. SST and ocean colour).

4.9 Atmosphere

The 5 presentations in the session on "Atmosphere" demonstrated the gain of utilising the synergistic capabilities of past, present and upcoming earth observation missions for the generation of coherent long-term atmospheric datasets.

New developments in the frame of ESA's Climate Change Initiative for the generation of reliable long-term cloud and aerosol properties exploiting the synergy of multiple earth observation missions were presented and the adaption of these methods to the upcoming OLCI and SLSTR instruments was discussed.

Another example of sensor synergy was the exploitation of temporally and spatially co-incident wind (RA-2), SST (AATSR) and biology (MERIS) retrievals for Sulfphur flux estimates in the Arctic Seas.

The session expressed some concerns on the strong focus on heritage from historically developed algorithms and products for the MERIS and (A)ATSR instruments. It was stressed that OLCI and SLSTR are new instruments with measurement characteristics different from MERIS and AATSR providing new spectral bands and requiring the adaption of existing algorithms and/or the development of new algorithms. The need for frequent algorithm updates in the initial phase of the Sentinel-3 missions was stressed, as well as the required flexibility to develop new and advanced atmospheric products such as e.g. multi-layer cloud retrievals exploiting the new S-3 bands. In particular the new channels 1.37 and 2.25 micron channels are considered very exciting for cloud and aerosol retrievals.

The issue of gap filling for aerosol retrievals was discussed and the use of PARASOL data was recommended as they provide excellent aerosol retrievals over ocean (and possibly also over land). Other options which are currently being explored are the use of METOP AVHRR/GOME-2 instead of ENVISAT AATSR / SCIAMACHY, as well as MODIS & MISR.

The session formulated the following recommendations:

Id	Recommendations
1	ESA to plan for frequent algorithm updates in the early phase of the S-3 mission.

2	ESA to support the development of new algorithms exploiting the enhanced capabilities of the OLCI and SLSTR instruments (e.g. 1.37 and 2.25 micron channels for improved cloud and aerosol retrievals).
3	ESA to provide OLCI and SLSTR test data sets to the research community.
4	Use PARASOL, AVHRR/GOME-2, MODIS and MISR as Envisat gap fillers for long-term aerosol retrievals.

5 CONCLUSIONS AND PERSPECTIVE

The workshop has been well attended by 220 participants demonstrating that although Envisat no longer delivers new data the research community is still very active in exploiting the 10 years of MERIS and 20 years of (A)ATSR archived data that are freely available and provide a wealth of information for a broad range of applications.

An overview of the ERS/Envisat era including key achievements and lessons learnt from the MERIS and (A)ATSR instruments were presented. Suggestions for further improvements in the next reprocessing of the data were made by the ocean, land and atmosphere communities.

The need to fill the Envisat gap is immediate and many groups are tackling this problem. Strategies for bridging and filling the data gap with alternate satellite missions were discussed and the need for the availability of and access to ground-based reference data for calibrating and validating space data was repeatedly stressed by the participants. The need and the manifold opportunities for collaboration were highlighted.

The community is waiting for the Sentinel-3 mission with great expectations and is actively preparing for it. The improved radiometric, spectral and spatial characteristics of the OLCI and SLSTR instruments and the enhanced revisit capacity and coverage of the mission enabling the development of new applications on regional and global scales was very well appreciated.

Suggestions were made to develop and test -by using MODIS- improved algorithms for cloud screening, aerosol retrieval and atmospheric correction over ocean and land surfaces making full use of the OLCI and SLSTR performance and sampling characteristics.

It was recommended to perform a reprocessing of the MERIS/AATSR archives into Sentinel-3 compliant data formats and to provide the provision of OLCI and SLSTR test data sets to the community at an early stage enabling them to familiarize them with the new formats.

Concern was expressed on issues related to the “heritage” algorithms from MERIS and AATSR which on one side need to be carefully adapted to the enhanced OLCI/SLSTR sampling characteristics, and on the other side should not prevent the development of new algorithms utilizing the full capacity of these new instruments.

The toolbox training sessions that have been organized as accompanying side events to the workshop were considered very useful and were much appreciated. The community repeatedly expressed the strong need to maintain these tools and adapt them to the OLCI and SLSTR data.

The recommendations made during the workshop should be addressed in the exploitation programs of the European Space Agency, European Commission as well as national and international institutions. The achieved progress on the recommendations should be reported on the next Sentinel-3 workshop after the launch of the Sentinel-3 mission.