Summary and Conclusions

AATSR Validation
Summary and Conclusions

D. Llewellyn-Jones

G. Corlett

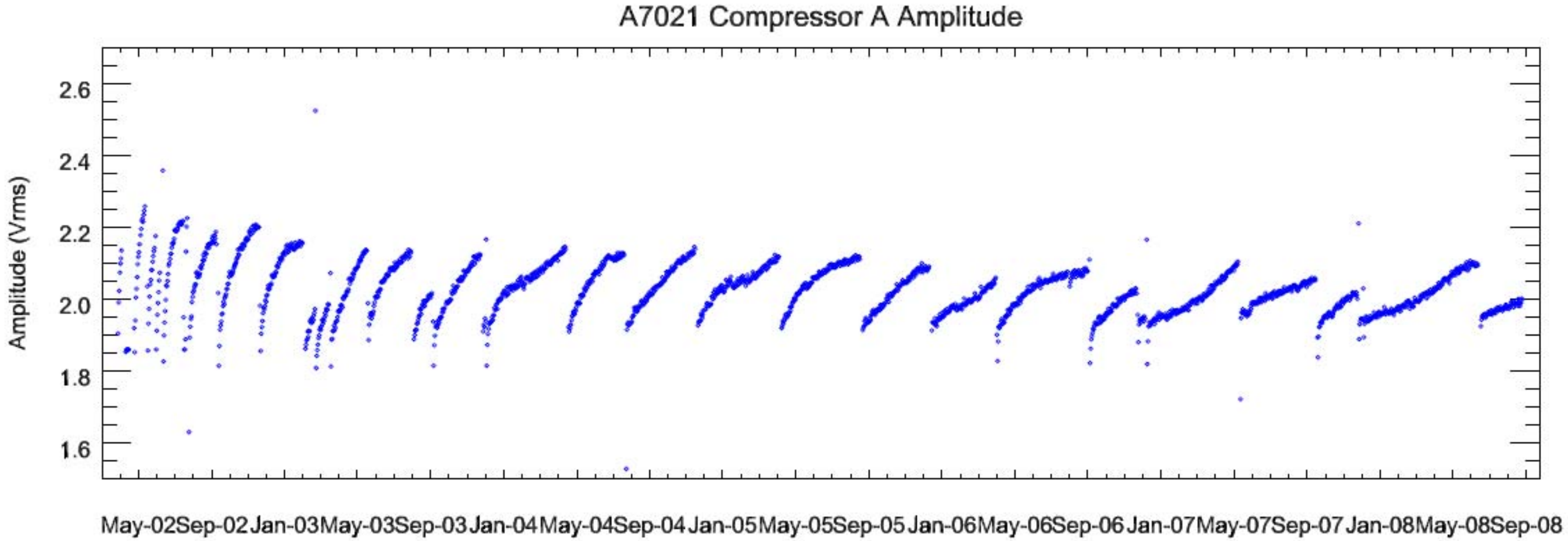
AATSR Validation – Key Points

- Instrument performing very well
  - Small increase in scan mirror jitter (expected)
  - Improved VISCAL calibration to correct for degradation in optical performance
  - Suspected calibration offset of 0.2 K at 12 μm
  - Misalignment of forward and nadir views

- SST product within specification
  - Small residual retrieval errors being addressed
  - Users should use the L2P product

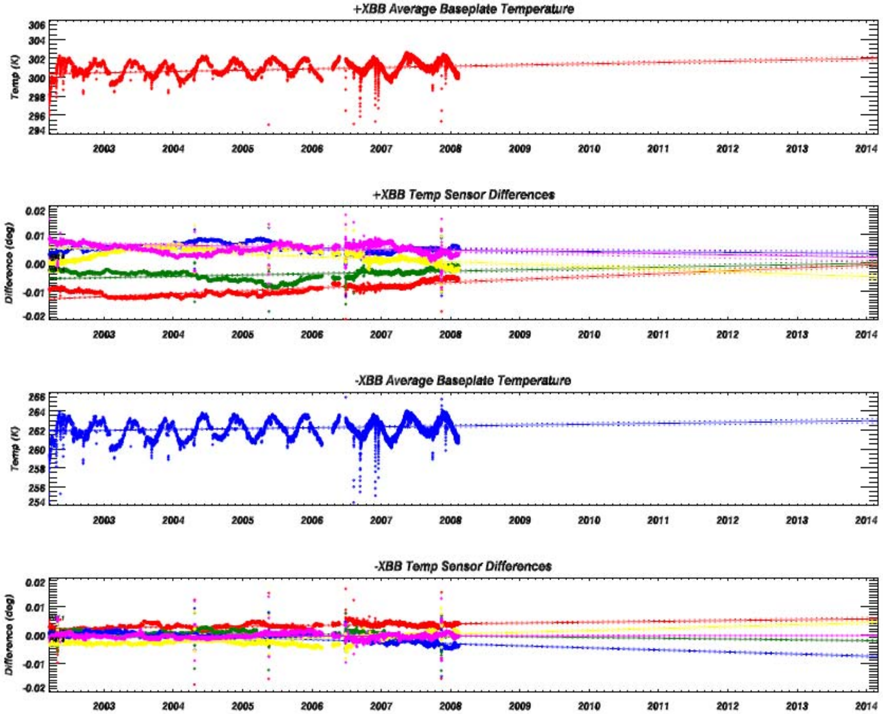
AATSR IR Radiometer - Stability

Cooler – how hard does it have to work?

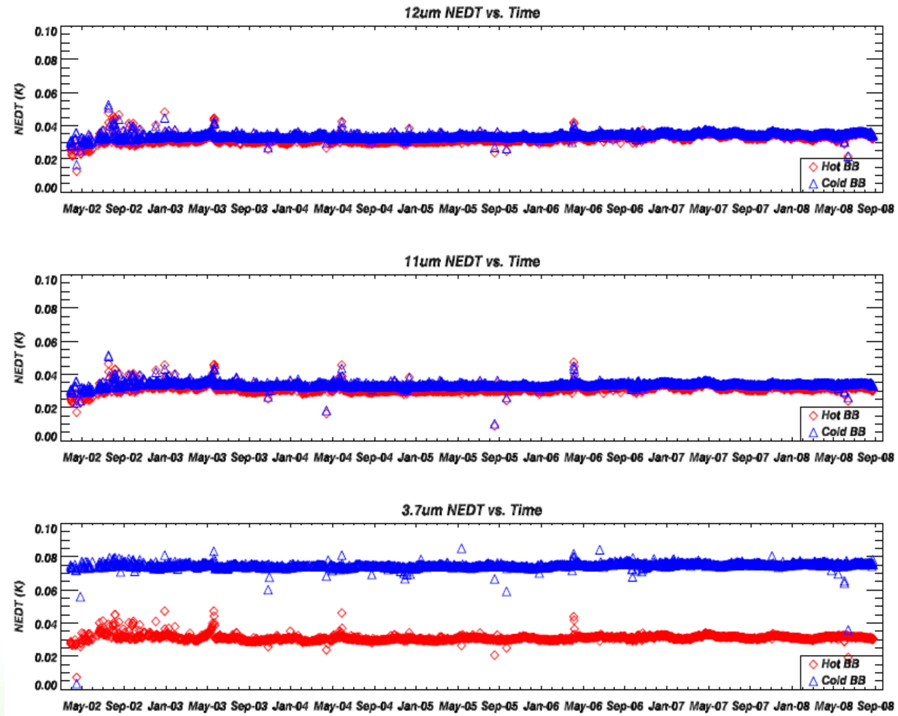


AATSR IR Radiometer - Stability

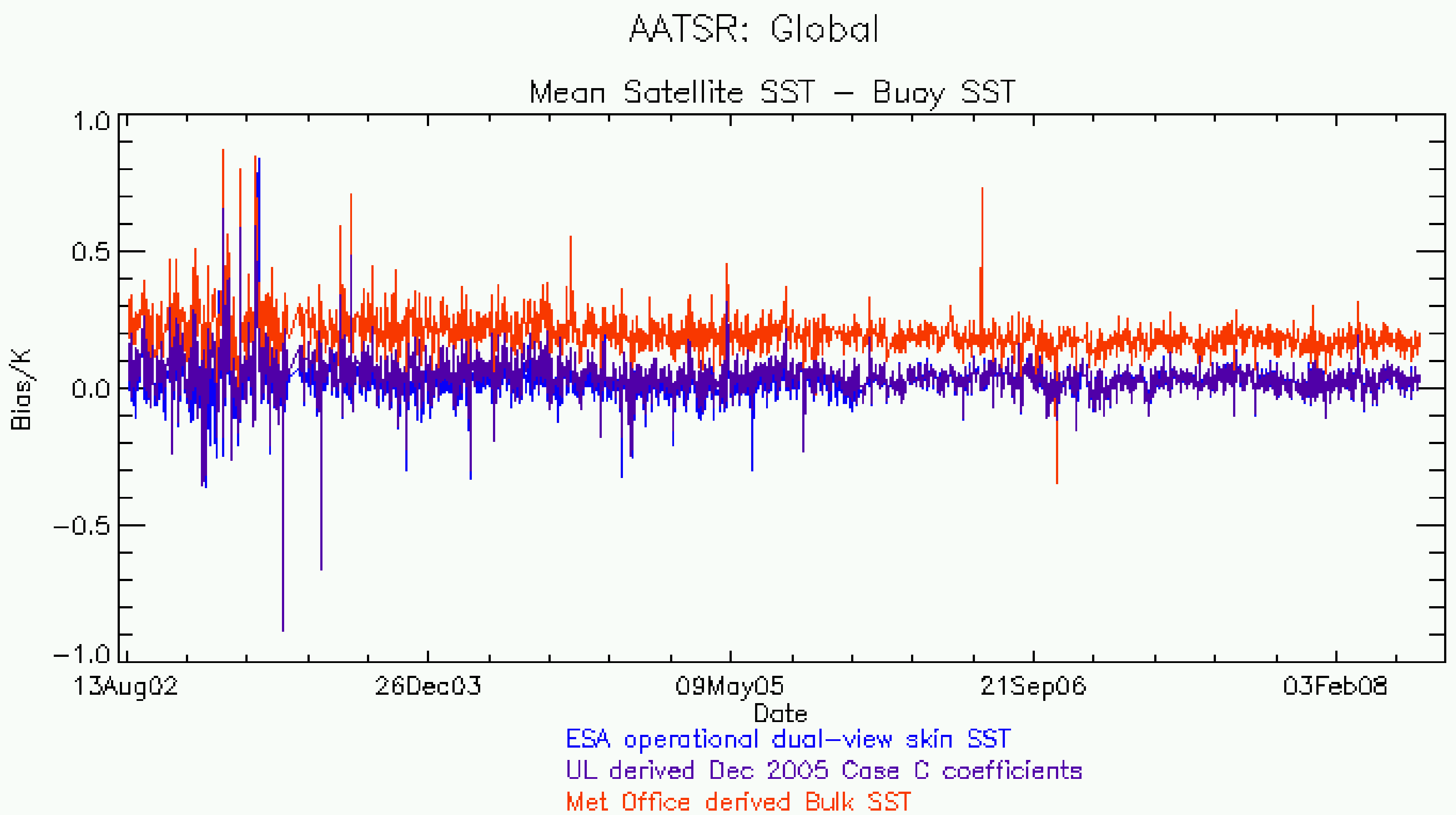
Black body Temperatures



Radiometric Noise



Buoy match-ups



Match-up data from Anne O'Carroll (Met Office)

Proposed Recommendations to ESA

Recommendation 1

ESA should seek to promote AATSR SST validation activities in high latitudes, including Polar Regions, probably using autonomous ship-mounted radiometers.

Recommendation 2

ESA should ensure sufficient metadata are provided in operational products to provide information about the calibration corrections which have been applied to the data.

Recommendation 3

ESA, in collaboration with other agencies, should consider ways of promoting generic, product-orientated validation activities, perhaps targeting a set of ECVs, including SST.

Proposed Recommendations to ESA

Recommendation 4

ESA should develop a strategy for establishing traceable data continuity over the likely data-gap between AATSR and SLSTR.

Such a strategy must:

a) involve continuous high-quality radiometric SST data;

b) be established during the Envisat Mission, extending into the S3 Mission; and:

c) be combined with the availability of historical (A)ATSR data in Sentinel-3 format.

Questions and Discussion (1)

1. From the validation results now available from AATSR, what are the priority areas and conditions which need additional *in situ* observations in the future ?
   High latitudes & Polar region

2. Does the workshop think that current methods for in-flight calibration of visible spectral channels are satisfactory ?
   Vis-cal correction procedures not transparent (information not in product)

Questions and Discussion (2)

3. There is a need for agencies to collaborate and validate products (such as SST) and not individual missions (such as Envisat).
   Does the workshop support this statement?
   Yes, this is very important for possible gap period before Sentinel

4. How do we ensure continuity with Envisat and Sentinel 3 Cal/Val given the likely data gap?
   Continuity of high-quality validation data
   Targeting existing sensors (e.g. AVHRR, VIRS, MW etc.)

Acknowledgements

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- Funding Agencies and Institutes who supported AATSR Validation (Defra, Met Office, NOCS, RAL, ESA, RSMAS, NASA, CSIRO)
- Peter Regner & Supporting Cast from ESA – for organising another highly successful MERIS-AATSR Workshop

MERIS Cal/Val
Summary and Conclusions

Ph. Goryl

J-P. Huot

On board Calibration monitoring shows good results:

• MERIS instrument has degraded less than 3.5 %
The frequently used diffuser has aged less than 1.4 %

• The good on-board calibration is confirmed by the vicarious techniques:
Rayleigh + glint + deserts
Measurements agree with MERIS Level 1 calibration within 2 %

Recommendation MERIS VAL 1
Good diffuser characterisation and modelisation is crucial → lesson for S3

Water Products (1):

It has been confirmed that today the MERIS products don't meet the requirements in terms of atmospheric correction. The water-leaving radiances provided at 412 nm have an overestimated bias of about 20% for oligotrophic waters.
But this uncertainty does not significantly influence the "blue-to-green" reflectance ratio.

Recommendation MERIS VAL 2:
Vicarious adjustment at Level 2 in the marine processing branch should (and will) be included in the MERIS L2 processing.

The algorithm for vicarious adjustment is being defined. MERIS Match-Up Database (MERMAID) has been put in place. Vicarious adjustment will be the major change for the next reprocessing. Adjustment in the NIR is still under debate.

Recommendation MERIS VAL 3 :
BPAC should be consistent with vicarious calibration.

Water Products (2):

In coastal areas the current algorithm gives sometimes good results. There is not a complete awareness of the necessity to correct for environment effect in the users community.

Recommendation MERIS VAL 4 :
Adjacency effect correction should be validated using BEAM before future integration into the operational products.

It is a urgent need to give an error estimate for the coastal products to be able to comply with the Water Directive. Satellite data is generally used in combination with models and *in situ* data Validation and product confidence remains a user concern.

Recommendation MERIS VAL 5 :
Product confidence or error bar or uncertainties should be provided. Format is still to be defined.

Water products – discussion

Product definitions

There are different user communities:

"User products" still need to be provided together with error estimates – Chlorophyll, TSM, YS…

There is also the need to provide IOPs (IOCCG recommendation).

PS: Water IOPs are already an implicit part of the current MERIS processor for Case II waters, and their relationships with the geophysical products are fully described.

Ground truth instrument inter-calibration

This is a well-recognized necessity. Workshops will be organised (MAVT workshop to come).

International effort is also needed: CEOS coordination for instance.

Sea-truthing measurements (Buoys, campaigns) should continue.

Validation through atmosphere parameters should be reinforced: the OC-Aeronet initiative goes in this direction.

Land products – discussion (1)

MGVI

MGVI is used in operation/application (e.g.: diagnostic assessment of European gross primary production).

Good performance of MERIS operational FAPAR values:

- Validation against ground-based measurements shows MERIS FAPAR products agree within ±0.1.
- Preliminary validation with higher resolution products is encouraging but requires additional data.
- A method for validating FAPAR from albedo products demonstrates the high quality of the MERIS FAPAR.

Land products – discussion (2)

MTCI

More than 17 institutions using the MTCI global data set.
Many independent studies suggesting MTCI has the strongest relationship with chlorophyll content.
MTCI has been used to estimate the length of the growing season, productivity, map land cover, and monitor tree mortality rate.

Recommendation MERIS VAL 6:
MGVI and MTCI should be part of Sentinel-3 products (and Sentinel-2 tbc)

Recommendation MERIS VAL 7:
Validation activities should continue addressing more vegetation types, in particular in full resolution.

Land products – discussion (3)

Aerosol

AOT(443), a primary L2 product, is validated. Comparison with others sensors and Aeronet shows good results.
The main issue remains cloud contamination (also for L3 products). Needs filtering.
Use of the MERIS Albedo map seems to improve the quality of the retrieval.
Angström exponent sensitive to instrument and algorithm noise.

Recommendation MERIS VAL 8:
Improve the filtering of clouds both at Level 2 and Level 3. Angström exponent should be retrieved on a macro pixel basis only.

Land products – discussion (4)

Water Vapour

GPS and MERIS IWV fusion is very interesting over remote areas where GPS network is not very dense. GPS IWV can be used to fill cloud gaps in MERIS IWV.

Glint

It is recognised that the glint is a major issue for MERIS products. Methods have been developed to address this issue. The Polymer algorithm appears robust to the sun glint and semi-transparent clouds. Other methods have been presented in other sessions. Quantitative validation is still needed. This is an ongoing effort (MERMAID, etc..).

Conclusion

Cal/Val activities are indispensable for any EO program and should continue during mission lifetime.

It is important to have continuous validation reference measurements, especially to avoid potential gap between similar sensors (Envisat-Sentinel-3).

On ground instruments inter-calibration exercises (e.g.: Miami-3) should be encouraged. Traceability of the calibration of radiometers to a reference standard is a requirement and will be critically followed.

Overestimation of MERIS water leaving radiance in the blue will be addressed in the next reprocessing by the introduction of a vicarious adjustment at Level 2 in the marine processing branch.

The BEAM Toolbox and G-POD offer good opportunities to test alternative and complementary processing algorithms.

MERIS Ocean & Coastal Zones
Summary and Conclusions

R. Doerffer
J. Fischer
J. Gower
E. Kwiatkowska

Summary – session highlights

- 13 presentations, 16 posters; focus on coastal/case 2 waters
- Validation of products, intervalidation using different sensors
- Improved alternative methods regarding atmospheric & sun glint, adjacency effects correction
- Unique features of MERIS: bands at 620, 681, 709 nm, FR with 300 m
- Combination of sensors (MERIS: other ocean colour sensors MODIS SeaWiFS, AATSR, RA-2, Sciamachy, Laser)
- New validation and combination using FerryBox systems
- Cloud filling technique
- Data assimilation
- Classification using spectra and fuzzy logic
- Operational applications: monitoring in coastal zones, e.g. exceptional blooms, water quality, water quality framework in EU, US waters
- New global maps of using sun glint and smile corrections, combination with altimeter derived currents

Recommendations I

- Users anticipate that the new reprocessing will significantly improve MERIS standard products, want more and understandable infos and road map (more transparency)
- Most important is a clear and reliable separation of atmosphere (incl. surface effects) from water, because some applications in research and monitoring require only a relative distribution
- Uncertainty estimates should be provided beside flags; user can better decide if data are acceptable than with a predefined threshold
- Recommendation to eliminate camera-to-camera discontinuities and increasing noise (e.g. in algal_2 products)
- Recommendation to provide standard processing L1->L2 in BEAM
- Recommendation to establish a user on-line forum with MERIS-specific announcements and communication, e.g. about reprocessing, failures
- Recommendation to make global FLH / MCI products available to public

Recommendations II

- Interest in the new algorithms which are recommended to be either incorporated in BEAM or as MERIS evaluation products. The evaluation products need to be mature enough not to exhibit implausible behavior.
  - glint correction: Polymer, NN based on Monte-Carlo photon tracing
  - case 2 water algorithms
  - cloud screening
- Recommendation to offer service of historical data orders and future data subscriptions for customized data extracts, level 1 and level 2, for user-defined geographical locations
- Recommendation to inter-calibrate in situ instruments and calibrate them with high accuracy traceable to a common world standard (NIST) organized by ESA
- Recommendation to judiciously implement new in situ campaigns to make sure that under-sampled geographical regions and types of waters/atmospheres are covered

MERIS Land
Summary and Conclusions

J. Moreno

F. Baret

Data access / data processing issues:

Easy access to data and visualization tools, plus easy-to-use data analysis tools is essential to increase the community of users and for optimal exploitation of available data sets.

In 2005: *We should do something to improve the availability and accessibility of the data*.

In 2008: Data availability has significantly improved. We should do something to improve the created image that ESA data is difficult to access.

Calibration issues, aerosols retrievals for atmospheric corrections, compensation for topographic effects, etc. pre-processing issues is still limiting applications development, but we start seeing science outcomes and high-level products emerging for land applications.

Data products:

(a) Special interest in time series (general trend in the research community)

(b) Intercomparison of products becoming a relevant topic:
from direct radiance measurements up to high-level products,
not yet clear plans to use products together (even MGVI+MTCI)

(c) Usage in combination with high spatial resolution data
(i.e. Landsat, SPOT) or detailed thematic maps as ancillary data

(d) Validation with field measurements: accuracy of field data,
adequacy and representativity of test sites for validation

Final users:

Primarily research institutions, climate modellers, administrative users (i.e. update of "official" thematic map)

Key applications:

(a) Classification and thematic mapping:

Mostly based on MERIS-only data, exploiting temporal and spectral characteristics, but synergy with AATSR identified.

Use of high resolution data for down-scaling / validation of classification products

(b) Inputs to regional / global carbon models (i.e. fAPAR, but also LAI, fCover, albedo, chlorophyll, land classes, etc.)

Most applications deal with carbon cycle studies and global modelling

(c) Time series of products used for multiple applications (i.e. GlobCover)

Records of climatic interest for the future (lessons learned for Sentinel-3)

MERIS Lakes
Summary and Conclusions

T. Pyhalahti

K. Sørensen

- Significant progress since 1st MERIS AATSR workshop
  - BEAM processors for lake water quality (WQ) estimation from MERIS
  - Tools for adjacency effect correction (ICOL, SCAPE-M, WOMBAT-c) are clearly required for lake water quality earth observation
  - Datasets and classifications of water optical properties
  - EO method demonstrations for different lake cases
  - Significant differences in water optical properties of lake waters

- Clearly still a field of on-going research & development
  - Adjacency effect correction and water quality processor results are still somewhat preliminary for routine applications
  - Further algorithm development is required to improve current results: experiences of practical application and validation in optically different lakes

- User applications still evolving
  - Cyanobacteria detection has been demonstrated
  - Users request parameters which require advanced and especially for lake waters difficult interpretation techniques from EO data: quantitative measures of CHL are particularly problematic
  - Water optical property based indicators not (yet?) recognized by the user community
  - EO is used for research purposes and for assisting monitoring / water classification activities
  - Currently still limited experience in fulfilling actual WFD monitoring obligations

Conclusions (1)

- Lake EO clearly has potential for operational use
  - Improvements are needed for methods of WQ parameter estimation
  - Mapping and classification EO products are potentially emerging due to activities in in-situ optical spectral data measurement devices
  - Low spatial resolution of satellite instruments is a problem:
    - Instruments capable of observing WQ are not capable of observing small lakes or lakes close to the shore in case of complex shorelines
    - Increasing resolution increases challenges for adjacency effect correction
  - Application to remote areas and developing countries (e.g. Africa) has demonstrated significant potential
  - Practical application strategies are emerging, but not established
  - Position of lake EO in GMES/Copernicus future framework?

Conclusions (2)

- **'GLOBLAKES'** project is recommended in order to focus the parallel development efforts and requirements
  - Harmonisation of protocols, methods and products
  - Validation and demonstration activities
  - Connections to user community, GEO/GEOSS, Kopernicus etc.

(A)ATSR Applications 1
Summary and Conclusions

C. Donlon

P. Minnett

Session Summary

In the AATSR Applications 1 session there were 40+ people in attendance

Future MERIS/AATSR meetings should **not** split AATSR and MERIS sessions – particularly with a need to encourage synergy and community integration in preparations for S3 where OLCI and SLSTR will be used together.

Recommendations (1)

- Cloud clearing techniques need to be improved in High SST gradient areas – for Ops., Science and ECV applications.
  - MERIS and AATSR data could be used in synergy to look at this in preparation for Sentinel-3. Further work to solve this issue should be encouraged.
- Issues (cloud contamination) with METEO products need to be corrected although it is likely that Met Office are not likely require METEO in ~2 years.
- Synergy with Third Party Missions and (A)ATSR is proving useful and should be extended (e.g., TOMS)
- There is now a large user base for AATSR data (both NRT and from the archive)

Recommendations (2)

- ESA should ensure continuity and access to AATSR data particularly during the transition from Medspiration prototype service to full ESA Operational service later this year.
  - AATSR accepted as a reference sensor but more work is required to improve algorithm differences at the 0.1K level.

1. The AATSR Single Sensor Error Statistics (SSES) derived for AATSR should be reviewed on a regular basis and new innovative methods
   - the infrastructure to support this activity is critical (in situ data).
   - L2P archived product will contain SSES that will provide a correction for the 12um leak problem – need to inform users of this.

- It will be beneficial ahead of SLSTR launch to reformat/reprocess the (A)ATSR archive into a SLSTR-format archive which can be used seamlessly with SLSTR data when they arrive.

Recommendations (3)

- There is the opportunity (almost a need) for the new format to include operational meteorological data (e.g. at tie points) if these are to be used in L1 to L2 processing. If this were done for the (A)ATSR archive prior to launch it would support several objectives:
  - It would facilitate the adoption of (A)RC methods into the ESA product
  - The science code for (A)RC could readily be turned into a prototype SLSTR L1b -> L2 processor for SST if NWP is embedded in L1b.
  - It would allow characterization of (a) the biases of other sensors against SLSTR-like SSTs ahead of any data gap that may arise if Sentinel 3 slips and of (b) SLSTR-like SSTs against in situ radiometry. As discussed, these are important elements in carrying a satellite-based climate data record across any AATSR-SLSTR gap.
  - It would support rapid applications of SLSTR data, since REAL data in the same format would be worked on by users prior to launch.

Recommendations (4)

- L3 and dynamic gridding: Is it worth considering **not** having an archive dedicated to L3 products on fixed and limited grids, but instead dynamically generating gridded data for users on request according to their grid requirements from L2?

- There is an essential need to have constant vigilance on the AATSR instrument drifts using in situ radiometers that are traceable to international standards (good start but need an initiative)
  1. There is a need for **more in situ radiometers** to underpin the **credibility of all AATSR and SLSTR** records and to ensure proper characterization as required for ECV production
  2. Pre launch characterization must be done well for SLSTR.
     i. SLSTR flight calibration blackbody sources need to be calibrated with standards based reference blackbodies before integration.
     ii. The in situ radiometers used to validate AATSR SST products must also be calibrated and validated in a manner that provides traceability to the same accepted reference blackbody used by the satellite.

Recommendations (5)

3. The CEOS WGCV IVOS activity that plans to establish core sites that will be used by agencies for calibration and validation is currently dominated by land sites and there is a need to ensure the inclusion of Ocean sites (OceanSites?) ACTION SST IVOS members to write to IVOS to get this set up.
4. Need to prepare and continue this validation approach for S-3 SLSTR and other sensors
5. Strongly request that the Agency help coordinate the international community to ensure the future of essential in-situ SST (and Ocean Colour) radiometer activities that underpin the credibility of the AATSR (GHRSST can help)
6. Need to be sure that there are insurance policies for AATSR sensor failure in the form of in situ radiometers that can act as transfer radiometers between AATSR and SLSTR. We need to ensure that this approach is planned properly and funded appropriately as a matter of urgency

(A)ATSR Applications 2
Summary and Conclusions

M. Caetano

J. Moreno

Summary

World Fire Atlas – the longest fire distribution series

AATSR as a radiance calibration reference for AVHRR

A comparative study of AATSR, SEVIRI, MODIS and AVHRR

The use of (A)ATSR images for deriving a 12 year global dataset of surface reflectance and aerosol optical depth

A new analysis tool: SOILMAPPER

Conclusions and recommendations (1)

(A)ATSR as a calibration reference sensor for other flying instruments, particularly in the thermal infrared.

We recommend large efforts in sensor calibration and characterization before launch (particularly for Sentinel-3).

Current identified time-series products relevant for land applications are:
• surface temperature
• aerosol AOT
• surface reflectance (possible after aerosol product is available)
• fire statistics
• cloud statistics

•Some time series already used in actual applications (i.e. fire product)

Conclusions and recommendations (2)

(A)ATSR sensors are providing already key information for 10 climate variables. (A)ATSR already contributes to GCOS, GEO.

We have realised that longer time series than initially expected are really needed to identify trends, but current time series from (A)ATSR data are of high relevance. Results should be published in open literature to get impact (i.e. for IPCC reports).

Different needs for real-time users and climate records in such time series of products.

GMES/Sentinel-3 needs to be specifically oriented to provide consistent long-time series of products.

Efforts need to be put to make sure that such time series have enough accuracy and consistency.

Conclusions and recommendations (3)

Georegistration is the key issue for land applications.

Given the experience gained with ENVISAT in automatic geolocation procedures, such accuracy should be guaranteed for Sentinel-3 satellite.

New land applications envisaged, but pre-processing is still an issue.

Ordering and analysis tools for AATSR should be improved (i.e. new products available in BEAM).

Users should make their algorithms available to the broader EO community.

Sea community is more advanced in operational uses; the land community is more spread.

We need to promote effective links with user communities to identify and develop new applications of (A)ATSR imagery.

Clouds & Atmosphere
Summary and Conclusions

R. Preusker,

J. Fischer,

G. De Leeuw

Take home messages from the talks

1. Cloud detection for MERIS is an issue! SWIR/TIR/AATSR is crucial for reliable cloud detection of MERIS

2. The (A)ATSR series is very valuable for cloud climatologies !

3. AATSR + MERIS aerosol RS is under successful development !

4. MERIS AOD → PM10 fusion looks promising but is difficult (spatial resolution)

5. Sentinel-3 coverage will greatly gain from tilted view

6. Users shall be informed about any BEAM algorithm update

Questions and Discussion

1. Lessons learned for OLCI ? Are the additional channels and spectral selection sufficient ?

   Depending on the physical parameter, YES and NO. For cloud/snow detection and aerosol RS O2A is important but SWIR and TIR channels are indispensable.

2. Should we combine MERIS and AATSR (in future: OLCI and SLSTR) in the standard ground-segment ? (Higher quality vs. more complex algorithms)

   YES !

MERIS/(A)ATSR Synergy
Summary and Conclusions

C. Mutlow

P. North

I. Barton

"MERIS/AATSR Synergy - 1”

The work presented in the session demonstrated that there is significant synergistic use covering a range of science areas: ocean, land and atmosphere.

1. What are the key research questions to be addressed for future ENVISAT & Sentinel-3 synergy?

   - Atmosphere (cloud and aerosol) and atmospheric corrections
   - How to exploit synergy for land products / processes?

2. Does lack of collocation affect your ability to process data synergistically?

   - Key issue for users was having the sensors on the same platform; no particular concerns over co-location of channels between MERIS & AATSR for ocean; For land, co-location is critical - Sentinel-3 will be major improvement.

3. How has inter-calibration of the two instruments limited synergy use?

   - No particular concerns over cross-calibration for existing applications. Needed for full use of synergy over land.

"MERIS/AATSR Synergy - 2"

4. Has your work demonstrated an advantage in the synergistic use of data from the two sensors?

   - The derivation of cloud top pressure was identified as one highlight
   - Aerosols over deserts and land another
   - Yes the work presented showed there were significant synergies and more to come in the future.

5. What are the main successes and problems with existing synergy experiences?

   - We still have two teams – need to encourage cross-working (this meeting is a good first step)
   - Need tools to present users with MERIS and AATSR pixels at the same time making it easy to undertake synergistic studies!

6. What tools would be useful to improve synergy research / operation?

   - Tools to facilitate joint use of data - perhaps an extension to BEAM to drag in MERIS or AATSR data automatically as needed, provide co-location etc.

"MERIS/AATSR Synergy - 3"

7. What joint AATSR/MERIS products would you like to see produce operationally?

   - Products that contain both AATSR and MERIS data pixels
   - Ocean temperature and colour on the same grid
   - Cloud and cloud properties – mask, fractional cover, particle size, optical depth, height and phase – over all surface types
   - Aerosol – type and optical depth over all surface type
   - Atmospheric corrections
   - Snow products

8. ERS-2 & Envisat observe(d) the same ground targets with a time difference of 28 minutes. Based on this constellation, can specific geophysical phenomena be observed?

   For clouds and aerosol we need to consider how to operate S3 in conjunction with Earthcare

Tools & Services
Summary and Conclusions

J-P. Muller

G. Corlett

Talks (1)

1. New developments in BEAM
   - Optical sensor toolbox
     - Many formats/constantly evolving (NEW-GeoTIFF)
   - “Power users” to be supported using Javascript & Python scripting
   - Many users developing plug-in modules
   - Facilitates development of new algorithms

2. SEBS Module for BEAM
   - Surface Energy Balance System (AATSR)

3. Mosaics - Level 3 products
   - MIRAVI migrates to MOSRI
   - Runtime/realtime environment for reprojection

Talks (2)

4. Information based services for exploitation of MERIS data
   - Interactive Information Discovery, Direct access to information contained within images and collections, Service Support Environment, GPOD,
   - Knowledge based information mining (KIM), Knowledge centered Earth Observation (KEO)
   - Can be used to automatically inform users when new cloud free products are available
   - Can be embedded in new WPS applications
5. General satellite service provision
   - Tools for mapping snow cover for Scandinavia, oil response unit (BORIS)
6. Medspiration HR-DDS
   - Online real time analysis tool for data mining multiple data sets (mainly SST) for 250 sites worldwide - very powerful

Talks (3)

7. New products with (A)ATSR
   - Consistently processed (A)ATSR archive in ENVISAT N1 format and L2P for 17 years
   - Access by FTP and AATSR-MERCI, or on 100 LT0-4 tapes
   - Available early 2009
8. Leicester (A)ATSR Global Analyzer
   - Simple IDL based tool to display (A)ATSR 0.5° x 0.5° data focused on teaching & learning
   - Can see real environmental behavior
   - Can be adapted to other sensors and products
9. Prediction model for Jellyfish blooms
   - Use of Scalar Vector Machine (SVM) to ingest MERIS and AATSR to predict jellyfish blooms

Recommendations (1)

1. On Data Availability

- The current data policy is perceived to be restrictive and thus a limitation on the number of users and range of applications
  - Europe needs an open data policy
- In general, data availability has improved
  - ESA needs to promote recent changes to win back “lost” users

2. On Data delivery

- Okay, but final decision pending new developments
- ESA needs to ensure there is a seamless transition from Medspiration L2P to ESA L2P
  - ESA needs to warn current L2P users of changes to data provision well before they are implemented

Recommendations (2)

3. On Documentation

- In general, the level of information is good
- ESA needs to review the structure of its website and update its ATBDs for products
  - AATSR handbook very difficult to follow; current search capability is poor

4. On Data Tools

- ESA needs to continue to support and develop BEAM
  - Improve command line capability
- ESA needs to provide better support for users to include heritage code
  - Re-implement the BEAM IDL API plus other packages/languages (C & Fortran were mentioned)
- Is Google Earth a serious scientific tool?
- Or do we require a web environment for online data visualization/analysis such as GIOVANNI
- ESA should support a coordinated effort to provide an improved land/sea mask that has better specification of surface types

Recommendations (3)

5. On Data formats
   - Do we need better harmonization of product formats?
   - ESA and other agencies need to work on this, especially product inter-operability
   - ESA should provide seamless interoperability of grid formats and file formats for Level 3 products to support better synergy

6. On User Support
   - ESA needs to improve its communication channels with end users, especially the turnaround time for technical questions