**AEROSAT**

**27+28 / 9 / 2014**

**TOP1: Pixel level uncertainty discussion**

**Key discussions**

* What is uncertainty?
  + CCI program defines uncertainty as “a parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand”.
  + Random + systematic: random is easy to characterize but is rarely dominant; systematic will prove more difficult.
    - There are several processes that are known to introduce error into retrievals but it is not known how to quantify that.
* How to characterize pixel level uncertainty?
  + What is already being done:
    - Aerosol\_cci groups primarily using Jacobians.
      * Optimal estimation methods can propagate (known) uncertainties through the algorithm to estimate final value. Others perform calculations in postprocessing.
      * Swansea parametrised aerosol model uncertainty with Monte Carlo sampling of many different types and surfaces to estimate the observed spread.
    - MODIS Dark Target using Jacobians + AOD derived from standard deviation of aerosol model types [experimental].
      * Assessing uncertainty from an ensemble of aerosol models is imperfect as not all models will be sampled. Should be investigated if, regardless, it provides a useful result.
    - Other groups make extensive use of “expected error”(EE) envelopes:
      * Deep Blue has both EE envelopes and per-pixel uncertainty based on retrieved AOD and viewing geometry.
      * MISR provides a global EE, but also stratifies by aerosol type. It further considers situations with cloud, surface type, etc. and examines how that envelope changes.
      * OMI develops EE envelope based on sensitivity tests and comparing with AERONET.
      * The problem with EE envelopes is that there is a disconnect between local and global uncertainty. This complicates the integration of different products.
    - CALIOP has a mature uncertainty technique based on propagating errors through the lidar ratio. Detailed in publication. Every pixel, every layer, every product has an associated uncertainty.
  + Currently outstanding issues:
    - Pixel-level uncertainty sidesteps spatial/temporal correlations in error.
      * If you average data over large time or spatial areas, does that increase or decrease error?
    - Current methods only address the `known unknowns’. How can the `unknown unknowns’ be addressed?
      * By `unknown unknowns’, we mean sources of error for which we cannot produce a quantitative uncertainty estimate, such as cloud contamination.
    - Jacobian techniques assume errors are Gaussian; this is not true for some error terms.
      * Should the distributions of error should be investigated?
      * Is a single number meaningful for all uncertainties?
    - Need standardized ways of providing uncertainty so that satellites can be properly intercompared/integrated.
    - Though outside the current remit of the working group, we may wish to consider how best to characterize uncertainty at L3.
* Communicating uncertainty
  + Different users require different levels of information. Some users still want simple QA flags, some want qualitative percent uncertainty, some want quantitative absolute uncertainty.
    - Roughly, case studies desire quality flags to filter their data and the interest in information beyond a single number decreases as the volume of data considered increases.
    - Desire to report random and systemic uncertainties separately, but the latter is dominant and itself quite uncertain.
    - Data assimilators really want unbiased data rather than a bias with known uncertainty but are currently happy to apply the correction themselves. If an estimate of the bias is included, we should be aware of how it will be utilised.
    - The question of whether QA flags should be determined from uncertainty or from the algorithm remains open to each aerosol team.
    - We will need to iterate with users before producing a final uncertainty product.
  + Some users need information about spatial/temporal correlation of uncertainties; this has not currently been addressed.
  + There exist some parameters (i.e. subpixel cloud fraction) than can help guide users to potentially poor pixels, but this does not seem to be good enough to replace a quantitative per-pixel uncertainty.
  + Some products (MODIS, for one) provide pre-filtered datasets of only high quality data; these have been popular.
  + We need to be honest about the level of uncertainty in our uncertainties.
    - A warning – if some users are informed of a source of uncertainty but not given a quantitative estimate of it, at some point, the data assimilators will do it for you. You may not like what they come up with.
    - Need to ensure users do not take numbers too literally.
* Future steps
  + In the global mean, the pixel level uncertainties should agree well with the EE envelopes defined by validation. If they don’t, uncertainty has not been characterized correctly.
  + It is important to show improvement in aerosol algorithms over time. Uncertainty estimates can both show how we have improved and where we can improve in future.
  + Investigate what problems are caused by giving just a single, incomplete number to represent uncertainty?
  + Thomas stresses that we need to start simple [uncertainty for 550 nm AOD at each pixel] and iterate with users until we have usable uncertainty products.
    - Concentrate on how best to communicate where the algorithm is known to fail.
  + Must improve reputation of remote sensing data among users. Providing validated pixel-level uncertainties and continuing the conversation about how to improve them should help.

## TOP2: Satellite aerosol dataset intercomparison

Intercomparisons (THP)

* Mike (MISR) - Why are there not more intercomparisons? (perhaps because funding is often instrument specific)  
  - Mian published recently on trends
* KK: Information content analysis intercomparison could be useful - possibly list as a separate section  
  - AS: usually these studies investigate the potential capability of an instrument, but none of the retrievals make full use of all the potentially available info, whereas intercomparisons tells you about the actual products. Interesting to look at multiple algos applied to same instrument.  
  - Mike: we only retrieve a single AOD and a particle model, which is then reported as different parameters. Model selection of different retrievals is all diffrent, so all retrievals are really retrieving different things. Need to do a correct intercomparison in the first place.   
  - THP we did this in Aerosol\_CCI wheer we agreed on the same set of aerosol models to go into the intercomparison. But...  
  -GS: You have just proposed the first AeroSat experiemnt (c.f. AeroCom experiments)  
  - AS: On AeroSat experiments: some things you just can't do: e.g. MODIS dark target and deep blu use different wavelengths, so the assumed RI's would be different. Can never be consistent.  
  - RK: you can still do something that is more consistent, even if not fully consistent.
* OT: We have a paper on MISR-MODIS deep blue - OMI over arid areas. We could also offer climatology of SSA and AAOD.
* Yves: Need to identify the question you are trying to answer by each intercomparison
* CI: We have a system for intercomparison at L2: open and tied to GIOVANNI ("AeroStat") - no excuse for not doing more intercomparisons, because the system exists!
* Nick (Oxf): There are differences in how models calculate fine mode AOT - isn't ANG better?  
  GS: fine mode is dangerous because gives users the impression that measurement contains more info than it really does.

Stefan's Slides: GEWEX Aerosol Assessment

* Level-3: AVHRR (GACP & NOAA), MISR, MODIS (Dark T and deep blue), OMI , POLDER
* Phase 2 in the planning: look at Level-2.
* GEWEX report provides recommendations: algorithms need better documentation (e.g. obs4MIPs), but ATBDs need to be kept current. Should be a req. that science teams develop prognostic error models. Developers and outside users to work more together on evaluation studies.
* RK: Have defined a list of in-situ aircraft measurements required to address microphysical characterisation of air masses to improve retrieval algorithms, and to improve mass extinction values for major air mass types. Looking for funding.  
  - GdL: We did that (Zieger et al) but it didn't work.  
  - KK: there is an experiment A-JAX at Ames which is doing the same thing (for GOSAT). Could learn from their experience.  
  - Mike: NASA Managers don't understand the rationale for funding such experiments.
* THP: for Phase 2 of GEWEX, can we include CCI data sets? (answer = yes)
* SP: Why not integrate Aerosol\_CCI Phase 2 intercomparison exercise with GEWEX aerosol assessment Phase 2, instead of doing two separate exercises? (can also use Charles's intercomparison tools - GIOVANNI add-on)  
  - SK: AeroSat should take the lead in organising that (but must be led by users rather than algo developers)
* Yves: AAOD should be high priority on the list of gaps.

GAPS...

* AS: Plumes are often missed at granuale level - could look into frequencies of extreme events - get great agreement with Aeronet by looking at easy cases. Need to focus on better assessing the difficult cases, e.g. focus on a few plume events and compare how different algorithms deal with those cases (i.e. where there is no Aeronet).
* Mike: Spatial variability comparisons - how well do different retrievals capture spatial variability? Dragon networks....  
  - Lee: this is fantastic data for looking at spatial variability (wrote a paper on it).  
  - RK: Dragon networks (10) were all coordinated with "Discovery" air quality campaigns.
* Yves: What is the end goal, who is going to use the results of these studies?  
  - RK: for MISR, those intercomp papers were very important to identify the limitations of the MISR producst which leads to improvements of the algorithm. Need to do sufficient analysis to really see what is going on - not sufficient to simply intercompare.  
  - THP: extend var space, improve retrievals, and users do this anyway so we have to do it first.  
  - GT: from CCI point of view: need to compare the three different algorithms to advance the retrieval development. Its a tool for developing the algo and helps to identify wheer the algo needs improving.  
  - AS: we have no control over the MODIS reprocessing schedule.
* Mike: comparisosn are usually of mean AOD. Distributions of AOD over space and time are more important. Understanding the tails is important and their affect on the means.
* OK: MISR joint product includes dist of AOD by species in each 5x5 grid cell. Tails often correspond to dust events etc - so important to look at distribution of AOD rather than just the mean.
* KK: We should include not just American and European instruments, but also Japanese and Korean, etc.  
  - Mike: this becomes critical when we talk about GEO intercomparison
* Yves: modelling community is moving to much higher resolution (going towards 0.1 deg).
* Yves: could gain a lot by looking at intercomparison of specific cases - e.g. biomass burning over particular regions, to get better detail on what particular algos can or cannot do. Would be helpful if modellers had a point of contact (email list/discussion forum) for clarification of particular cases.  
  - RK: that was one of the motivations of AeroSat!  
  -THP: some info is there ( <http://wdc.dlr.de/data_products/AEROSOLS/index_oss.php> or <http://darktarget.gsfc.nasa.gov/>)
* Nick (Oxf): We are missing an absolute truth to compare - could use a high-res aerosol model as a proxy for this truth, forward model it, add clouds, then put these radiances into retrieval and see what you get out.  
  - RK: we've done it - it's a good exercise, but its a comparison.  
  - Nick: both Aeronet and satellite are cloud-cleared - this model approach might help disentangle the errors  
  - THP: we had Kokhanovsky approach in CCI Phase 1 - useful, but not a statistical sample to provide representative results. It's a tool, but it's not the "truth". It's also a large effort.  
  - GdL: do you have enough confidence in your aerosol models (transport models) - in practice you don't get closure.  
  - GS: The idea is to run this on multiple satellite retrievals. Philip Stier noted this is a ‘satellite simulator’ and is being done for clouds; Rob Levy noted a similar excercise made for a couple of synthetic MODIS granules.
* Xue: intercomparison with ground truth data: intercomparisons either of different algos on same instrument, or different algos on different instruments. Sometimes no satellite retrieval agrees with the ground measurement: all seem to have the same error. Can also get different results depending on different matchup criteria (1x1, 2x2, 3x3, etc).  
  - RK: spatial averaging study showed statistics for most aerosol types was best at 3x3; an exception was in urban areas where matchups were better with single pixels coincident with the AERONET station.  
  - CI: reason behind 50x50 for MODIS validation was to matchup AERONET temporal averaging with MODIS spatial averaging - i.e. 1hour (AERONET) ~ 55km (MODIS). Need to compare based on uniform sampling criteria.  
  - Mike: we tend to forget that Aeronet is a point measurement. Looking at a dust storm, we noticed that AERONET site was located 100km away from the lat-lon reported in the Aeronet data, which was why there was a mismatch with the satellite data. Is there temporal variability in the site. The temporal homogeneity of the Aeronet data must be checked, but you don't know anything about the spatial variability - e.g. when a plume is localised over the Aeronet site. No simple answer; it's challenging.   
  - SK: Aeronet is great, but ofetn sites disappear. Need a long term commitment to a few sites ideal for satellite intercomparisons - e.g. Ispra may be ill-posed for satellite remote sensing. Can we list the most important ones for satellite validation?  
  - Mike: There's a paper on this already (Shi et al., AMT, 2011  
  http://www.atmos-meas-tech.net/4/2823/2011/amt-4-2823-2011.html) - looking at where MISR and MODIS disagree with each other and highlighting these as priority locations for AERONET sites.
* THP: Part of the discussion today was on WHO do we want to do the intercomparison for? Is it to help the algorithm developers or to help the users? And sometimes different funding opportunities for different purposes.
* THP: Would like to look into intercomparison of regional trends, but perhaps this is too early.
* MvW (NL): there are fundamental gaps in modelling looking in particular regional AODs - aerosols over the northern Indian ocean. There could be specific questions from specific communities that could be used to focus intercomparison work.
* Yves: we have a simple system for user queries on coupled model simulations - a forum/mailing list.

## TOP3: Aerosol type

Aerosol type is a categorical/qualitative variable: tension between the categorical nature, and quantitative requirements (e.g. SSA) for various applications. Both an input and an output of retrievals. CTMs are composition/mass-driven, satellites are (essentially) optics-driven.

Lucia Mona has offered to do a review of aerosol typing methods used by different satellite groups.

What do we even mean by aerosol type: retrieval optical model, derived optical quantities, composition?

Thomas’ concept from ESA aerosol CCI:

* 4 components (weak abs fine, strong abs fine, spherical coarse, dust), external mixtures with 3 mixing fractions (based on theoretical information content, which is still under evaluation). Prescribed optical/microphysical properties.
* Output: fine AOD, dust AOD, AAOD
* Andy Sayer: this is tuned to AEROCOM, what about other applications?

Ralph’s MISR aerosol typing slides:

* Challenge: sensitivity to aerosol type is very condition-dependent; categorical in size, absorption, sphericity
* In low-AOD conditions many mixing groups are consistent with MISR measurements; at higher AOD fewer mixtures pass (i.e. better type sensitivity).
* Research algorithm useful for case studies but not practical for large scale processing
* Mentioned in previous discussion sessions: it is hard to evaluate things beyond AOD, ANG (AERONET has limitations; one option is to look at AOD-dependent regional/seasonal patterns).

Dave’s CALIOP aerosol typing slides:

* Typing done from level 1 profile data at present; interesting in own right and also provides lidar ratio constraint for the AOD/extinction retrievals.
* Based on location (land/ocean, vertical), backscatter, depolarisation. So some limitations, e.g. no dust in MBL; no smoke/dust in Arctic; no ‘organic aerosol’ type (but not clear whether these differ in terms of lidar ratio from e.g. pollution, smoke).
* Alexei: how much of an issue is low cirrus? Dave: probably not much.
* Some code bugs which are being worked on, which tend to overreport ‘polluted dust’ type.
* HSRL has a different scheme: lidar ratio, extinction, polarisation measured more directly, used afterwards to define an aerosol ‘type’.
* Ian, Rich, Ralph: difference in depolarisation, color ratio for different types of smoke and dust. Also wildfires can kick up smoke.

Nomenclature:

* Thomas: can we find a consensus that retrieval output be linked to the optical properties (like MISR), rather than a named specific type?
* Gerrit, Charles, Mike, Me: how far can we go with satellites? Given our limited information (some optical properties) does it make sense to talk about a type? We see optical, not physical/chemical, properties. Perhaps we should report similar to MISR (e.g. categorical size/absorption) and leave users to interpret? ISCCP use COD/height histograms to stratify clouds; each is associated with a cloud ‘type’. Can we do something like that? Multi-sensor data combination for a ‘level 4’ categorical ‘type’? ‘Unknown’ should be an acceptable answer.

Harmonisation of procedures (i.e. aerosol models)

* Ralph, Omar: Not realistic unless there is a good reason: lack of ‘truth’ data, large effort – what is the benefit? So internal to algorithms that it doesn’t make sense.
* Mike: thinks harmonisation would be a possible benefit to users to reduce confusion, can help guide use/convergence of datasets. Also can we try different models (e.g. MISR standard, MISR w/DT models, MISR w/DB models) to examine sensitivity. However notes benefit not clear.
* Olga: Typing should depend on application. Also note there are differences in aerosol components in global models, too: not ‘one size fits all’.
* Kirk: Are we talking about optical models used for a retrieval algorithm, or what we tell the community this is? These are often but not synonymous (e.g. POLDER), especially when we get better sensors in the future.
* Leigh: data producers need to make it clear to users which aspects of ‘type’ are prescribed and which are retrieved.
* Rich: Lidar have shown us that there can often be multiple ‘types’ present in a vertical column, which isn’t consistent with many current satellite algorithm formalism.
* Can we use relative humidity as a constraint on aerosol optical properties? Not really, met data are uncertain (vertical location of relevance, spatial/temporal resolution), as are growth factors from dry to wet and back. Olga has experimented with MSPI and WRF-Chem: did not really help. Gerrit has looked at dry/wet optical properties at Cabauw in combination with lidar, model etc and unable to achieve closure: no hope for satellites to make routine use of this type of information for this type of environment. Plus difficulty in making some measurements at wavelengths used by satellties (need to interpolate/extrapolate).

What do users actually want?

* Stefan: AEROCOM wants fine AOD, fine mode absorption AOD, and dust/non-dust coarse mode partition. Direct chemical composition less important.
* Charles: I want to identify smoke, dust, pollution. Quantiatively important, not just categorical. Acknowledges this may not be possible.
* Xue: Composition wanted.
* Yves: important to understand retrieval capability –so no point asking for chemical composition. But would like to know e.g. natural/anthropogenic contribution (Ralph comments like unlike IPCC assumptions, fine mode is not the same as anthropenic). Dust/sea salt distinguishing, submicron dust partition.
* Duncan: size, nonspherical or not, absorption characteristics. Reticent to go further (e.g. ‘consistent with dust/smoke’ but not saying ‘this is dust/smoke’. So this is the MISR approach.

Future directions:

* Yves, Ralph: can we use climate models as some benefit/bridge to help constrain aerosol models? MISR experimenting with this. Not necessarily possible for operational datasets.
* Mike: different models have different optical properties so still can’t entirely resolve the issue by using model to inform ‘type’, i.e. no settled chemistry/mass to optical transfer for each model ‘type’. However the models are continually improving so perhaps this will become better in coming years.

2013 IPCC report mainly relies on near-surface typing

## TOP4: Satellite-model-ground-based intercomparison

Key:

Presentation titles are in **bold**

Notes on the presentations themselves are in *italics*. This includes the four seed questions put forward by Ralph.

Notes on general discussion are in regular text.

Agreed actions are noted in red

I’ve attempted to note who made each individual point, mostly by name (except where I didn’t catch the name)

**Ralph - Introduction and seed questions**

*Goals*

* *identifying information content (limitations & strengths of both satellite and ground)*
* *Coming up with approaches to maximise the benefits of such comparisons*

*Each measurement/model approach provides different, complementary strengths*

*Discussion questions:*

1. *Are there additional aerosol data product validation steps or product modifications that would improve satellite-suborbital data (field campaigns, Dragon networks etc) integration (comparisons, constraints, assimilation & communication)?*

Stefan Kinne – we should distinguish between sub-orbital remote sensing and real in situ. The ground based in situ community which hasn’t really been engaged for satellite remote sensing.

Ralph agreed and said he would make this distinction clear in the summary document.

Mike (MISR) - It is, of course, much easier to make use of column integrated measurements than true in situ measurements. We also need to be aware of the spatial representativeness of point measurements and the spatial sc ale of satellite retrievals (there hasn’t been enough of this – Andersen 2003)

Leigh (MODIS) – HSRL should be a very powerful tool for linking surface and column properties.

1. *Are there additional aerosol data product modifications that would improve measurement-model integration?*

Mike – We need to revisit L3, because although retrieval people would like modellers to use L2, we have to provide L3 because that’s what people want. (Summary of what L1-3 are, with an emphasis on the arbitrary nature of the choices made in producing L3: sampling, QC, representativeness).

Andy Sayer – Agrees with Mike, especially with MODIS where we have overlapping swaths, with dependence on viewing angle. AOD is averaged (rather than log(AOD)). Even worse for things like Angstrom (averaging derivatives). Problem is that they are constrained by management and the slow process of updating official product specifications.

Rob Levy – Have put a lot of work into this, but there is still work to be done. Doesn’t stand by average Angstrom etc, but is more happy with averaged AOD.

Omar Torres – OMI has a L2g product which contains all the L2 data in a 1 degree box, so the user can use as they please.

Kirk Knobelspiesse – can we use pixel errors? THP – not simply. Error weighting creates biases.

Stefan – PDFs and joint histograms. Average by area and not number.

Charles – Users want to know the value at the location of their interest. L2g is good, and should be expanded to contain ALL instruments (including in situ, ground based data), because it provides the user with all the relative data.

Nick Schutgens – L3 monthly data causes big problems with model validation, daily seems better. Likes NRL L3 MODIS data, which is at 6 hourly resolution. Lack of global coverage in each file isn’t a problem.

Duncan – Would use L2 for quantitative comparisons, L3 for qualitative comparisons.

Yves – 6 hourly might be fine for now, but in a couple of years this won’t be sufficient for model comparisons. Putting effort into a NRL type product would probably be pointless – encourage L2 use.

Yong Xue – Can something be done with satellite SSA? Ralph/Omar: only OMI really; MISR in some circumstances.

– what spatial resolution for 3x3 km MODIS pixels for AERONET comparisons. Leigh – basically, 50 km box will be staying, but also smaller scales. Ralph suggests that it depends on where the AERONET site is (urban is probably better a smaller area). Some evidence that for global comparsions, 50 km is a sweet-spot. Mike pointed out that it all depends on aims of comparison.

Michel (KNMI) – Should be an action on modellers to actually sample their models according to the L2 measurements they’re interested in. Eg. have a specific MISR and MODIS output file from all models.

Andy – Question for modellers: HDF or NetCDF? (As a follow up to this, it appears that NetCDF4 and HDF5 can be read with exactly the same tools. So this may be another option to satisfy both communities. Note that this is not true for NetCDF3 or HDF4 or HDF-EOS.

)

Stefan – likes NetCDF. Easier, because of the breadth of tools available for it.

Yves – Thinks the division is between modellers and satellite people (not true in Europe). Modellers use NetCDF and won’t learn HDF.

Leigh – NASA won’t provide funding to convert formats, but what language would be best for a conversion tool? Stefan – Has used an IDL converter in the past.

Andy – is there any user preference for HDF. Answer = no. But – Mike – NASA does not provide an option. HDF is required for EOS.

There is a wide variety of opinions – some people aren’t worried about formats, as there are many tools to read and convert, others find different formats a real pain. There was a ground swell of opinions that some stability in format is desirable.

Ralph – perhaps AEROSAT can compile a list of conversion/reading tools with ratings of usability and functionality.

Ralph – NASA requires HDF, but AEROSAT has a way forward, which is to support conversion tools as above.

Michel – to encourage modellers not use L3, AEROSAT could provide satellite product operators. Stefan – L3 (monthly) is useful for quick comparison and reveals gross differences.

Dave Winker – perhaps we need better L3 products (eg. MISR L3 joint aerosol products). Mike – as far as he is concerned, all the effort in algorithm development is at L2. L3 is a poor cousin (compared to situation with cloud for example). Me- The problems with L3 are much worse for cloud than with aerosol.

1. *Are there specific additions to data product documentation that would improve their use in models?*

Mike – People DO NOT read the existing quality statements. If no one is reading the documentation, is it worth the effort? Also algorithms are fluid and documents (especially ATBDs) tend to get out of date. Producing a user guide, or something similar, would be a lot more effort.

Ralph – what else do the users want?

Yves – No more documents, just make it easier to find the existing documentation/papers. (His email address list, Q/A forum etc – Charles agrees)

THP – WMO GAW “one stop shop” is aiming to do just this.

Andy – How do we ensure people actually ask the right questions? Yves – it is not on the data producers. If people are sloppy they are sloppy.

Adam – Reiterates the idea of the central repository of general information on all aerosol products which links to detailed info. Could ensure this link is in the attributes of the files. Also, is currently hard to find up-to-date ATBDs etc.

Maksym – I can be very hard to find the relevant information at the moment. Ralph – back to the Q/A forum.

Clear action to include links to relevant information sources (quality statements, papers and ATBDs) for each algorithm and for specific questions in the AEROSAT Q/A forum or FAQ.

There is a SeaWiFs ocean colour Q/A forum which might be a good model.

1. *Are there new method or procedure ideas for measurement-model integration that should be explored?*

**Presentations**

**THP – Can we use in situ data for satellite validation**

*CCI attempted to use GAW in situ data (dry aerosol composition) for validation.*

* *Can tie to SI standards (escape AERONET inversion assumptions)*

*Failed, as even with super-sites can’t tie surface properties to column properties.*

*Possible solutions (both subject to representivity and correlation length questions):*

* *Extensive campaigns to really measure full column?*
* *High resolution chemical transport model?*

Mike – this failure is educational, but how badly did you fail?

* Badly. Humidity factors are needed and there was no correlation.

There was general agreement that there should be more effort put into making use of in situ measurement networks, but no clear approach to making this work in practice.

**Maksym – MAPSS: Multi-sensor aerosol products sampling system**

*Intro to the MAPSS suite (part of Giovani)*

* *Samples L2 aerosol products with 55 km of aeronet stations.*
* *Makes doing AERONET comparisons easy across different products*
* *Can also compare against MAN an AERONET retrieval products*
* *Can produce latitude plots, plots against AOD etc*

*Problem is that you end up with two many plots!*

* *Have produced an online tool (Giovanni MAPSS explorer) which can do all these plots online.*
* *Also recommends the AERONET synergy tool (which gives MODIS imagery etc for AEROENT sites)*

*Enables quick “what-if” analysis etc, but is enables poor analysis/abuse of the data. Really need a L2G file for all sensors, so that they can be included on the system.*

Gareth – there are a lot of similar efforts going on (CIS), shall we try and coordinate on this?

Ralph – that is a good idea, and a discussion on the approaches, tools and potential collaboration should be undertaken between the providers of these tools (Giovani/MAPSS, Community Intercomparison Suite (Ox-RAL), iCare tools, World Data Centre-RSAT,…)

**Olga – MISR L2 joint Aerosol product**

*Global statistics summaries of MISR L2 aerosol AOD by aerosol type, with multivariate histograms*

* *5x5 degrees, monthly files*
* *8 types (optical properties based – non/absorbing etc)*
* *Histograms of AOD and covariances between types*

*Have made an effort to link the MISR optical types to model (SPRINTARS) types:*

*Eg. strongly absorbing aerosols -> carbonaceous aerosol etc*

*Once these links are made, fractional AOD maps can be compared – seems to work, qualitatively. Note: not a quantitative comparison!*

Yves – This kind of work shows the possibilities of acting together between satellites and models and pushing both to their limits to answer specific scientific questions.

Note that these sort of products also show the strengths and weaknesses in satellite “type” selection.

THP – noted that the combinations of MISR types to look like the four SPRINTARS types actually look a bit like the four Aerosol CCI components. – encouraging.

**TOP5: Climate Data Records**

In his introduction, SP introduced the GCOS requirements for Aerosol CDRs as well as generic CDR requirements. He further addressed the operational production of satellite aerosol CDRs and how to guarantee scientific excellence. In the Aerosol-cci a science team is an integral component of the CDR production system to ensure scientific credibility. SP also introduced as an example the GHRRST data evaluation framework and asked the question whether such a framework is need for aerosol CDRs? Simon also started with the collection of a list of potential CDRs, for completion by the AERO-SAT community. SP finished with the objectives of the AERO-SAT Working Group on CDRs and some seed questions for discussion on this session.

**Objectives of the AERO-SAT CDR Working Group**:

* Improve the quality of aerosol CDRs by strengthening international collaboration
* Identify best-practice (e.g. minimum set of aerosol optical models, approach to uncertainty characterisation, ancillary data, ...?)
* Improve consistency by recommending standards for information content, formats, documentation and delivery mechanisms to facilitate uptake by users.
* Encourage intercomparison and consistent validation of aerosol CDRs for the benefit of users

**Seed questions:**

*Overall Objective:*

* To strengthen the uptake of satellite aerosol CDRs in climate research

*Question 1:*

* What can we do to provide technically better quality aerosol CDRs ?

***Question 2:***

* What can we do to provide CDRs that better meet climate users' needs in terms of:
  + format, specification, delivery
  + quality assurance
  + documentation, communication, training
  + other...?

The presentation was followed by a lively discussion which already started during the presentation.

Potential CDRs: overview of available data series

SP has started to collect information on potential aerosol CDR. Obviously the table is not nearly complete and both instruments, such as PMAP - EUMETSAT, GOME-2, VIIRS (not yet available), and entries for specific instruments are missing. The table will be posted on the website as a living document and the community is asked to provide missing elements. For each CDR a point of contact (POC) should be added.

In connection with this action, the need for an internal, password protected website was discussed.

Quality Assurance etc.

Quality of aerosol retrieval products has been discussed in several other WG sessions during this first AERO-SAT meeting. Quality statements have been given in publications and in brief (few pp) summaries on websites (in particular MISR and MODIS) with the advice that these summaries are read before they are used and before users ask questions to the providers. However, the providers encourage users to ask questions when, after reading the documentation, something is not clear, in particular through a Q/A form and accompanied by a list of FAQ. An easily accessible document should be provided in which quality statements are summarized (rather than scattered in publications) with reference for more elaborate explanation in peer-reviewed papers. What would be the format for a quality statements document? Something like the OBS4MIPS: a 5 pp technical note describing data sets etc. CALIPSO tries to do that.

Combined products

Inclusion of hybrid data (satellite + model)? Is that re-analysis ? Then it is not data! However, modelers call their results data. But retrievals may include information from a model.

Another consideration would be which products works best where? For instance, MISR works better over land, MODIS over ocean: may be merged product as proposed by CI would be the best solution? If they want only single products, how many of them wold they tolerate?

OBS4MIPS uses monthly L3 data on 1x1 degree, no albedo.

SP proposes to adopt the OBS4MIPS format and not invent something new.

YB proposes to include vertical profiles. DW comments that in aerosol re-analysis products MODIS data are assimilated and they want to include also CALIPSO; this is also done in MACC (EU Copernicus) for both forecasting and re-analysis. MISR provides injection heights for plumes which expands the vertical profile information data base: CALIOP could be used downwind. (Note that ECMWF has tested the assimilation of both MODIS and AATSR and this gave an improvement over MODIS only).

SK notes that it would be interesting to combine CALIOP with another satellite retrieval product. Or the combined satellite aerosol and cloud products. Users are interested in that.

Other interesting products are the long times series such as provided by the ATSR-2+AATSR+SLSTR aerosol products , or the MODIS+VIIRS products.

In this respect a workshop on merging was proposed to exchange experiences. This may be a topic for next year’s AERO-SAT meeting. Some issues were brought up, such as:

* sensor degradation effects and detrending,
* cross calibration for the two MODIS sensors
* removal of decadal residual trends (1% based on CEOS)
* spatial sampling, which is an issue when using AERONET with limited coverage
* there are only about 12 long-term AERONET sites, not all of them fully continuous and hence there is a question about consistency

GCOS requirements and CDR criteria

The GCOS requirements are stricter than what presently can be achieved. They were formulated for high-level planning purposes. The GCOS requirements have been relaxed in the latest version but it is not clear who contributes to their formulation and advice from the scientific community has not always been taken into account. The requirements do not match what we currently can provide, but on the other hand we do the best we can and have been improving our products substantially.

Discussion on the criteria for CDR: 30 years is the minimum considered by climatologists, but the satellite aerosol community is not yet ready for this. Is a CDR defined as instantaneous, L2, L3, or high level composite? THP explains that the WMO understanding is L2 (instantaneous). WMO has collected user requirements (UR) independent of the measuring device. This may lead to differences between methods (ground-based or aircraft in situ using specific and dedicated instruments for specific parameters, vs satellite remote sensing where only fee parameters can be measured by one optical instrument). So the question arises to what is needed? GCOS oversimplifies for our application. AERO-SAT feeds in to what is possible.

What is stability, what has been done? The GCOS requirements mention a stability of 0.02, can this requirement be made more realistic? The discussion in this respect, and in general, on the GCOS requirements could be seen in two ways: what are the wishes, or users’ needs, and what can we provide!

Data products: models vs satellite products:

Modellers think of uniform data sets: space, time, type and accuracy. Satellite data, on the other hand, are not at all uniform, so modellers need to find a way to use the satellite data sets. CI proposed that providers make a list of what satellite observations can provide, then refine this list and condense. Such a list is in the validation papers (RK), MISR has a 3 pp quality statement. Since this was discussed in the morning it will not be repeated here.

SK promotes the use of quality flags. AS proposes to condense the information, e.g by using SK’s scoring matrix. CI propses a table which tells the users how far they can go. AERONET has provided such a table (Dubovik 2000) informing the users about the limitations, but nowadays people try to extract more info. The focus should not be on the exact numbers but how to assess these.

MP suggested to put satellite and model people together to discuss the needed accuracies. (this happened to some extent during a lunch meeting on 29.9 during the AEROCOM conference). A question to modellers is whether they are happy with what we provide and what additional wishes do they have?

A recommendation from YB is to make the documents more accessible so that modellers are encouraged to come to the satellite providers. He also recommends that the response to wishes to produce certain products should not take too long.

What modellers want (SK):

* Big events (e.g. RK study on Eya volcano: did the best they could do with MISR, but this is not climate)
* Anomalies in biomass burning aerosol
* Consider aerosol together with related properties

SP: ESA’s CCI initiative has 13 teams for different ECVs. As an example, the consistency between aerosol and cloud cci products is not guaranteed. There is a contradiction for about 20% of the globe where neither aerosol not cloud is retrieved. The use of a cloud mask is not conclusive. Cloud cci does the masking after the retrieval. The CCI teams look at albedo/cloud/aerosol consistency. AL looks at consistent retrievals. In CALIPSO everything is classified as either aerosol or cloud.

The discussion continues on line and then again next years’ meeting

GHRSST approach and maturity matrix

A strong improvement has been made in the MODIS DT products between C4 to C6. AATSR has also been strongly approved as a result of cooperation in Aerosol-CCI, but is not yet of the same quality as MODIS and lacks coverage (due to swath width).

The maturity matrix is not on scientific quality but ensures long-term availability. This is relevant for services such as COPERNICUS and for funding applications. There also need to be regular updates.

Agenda

[**2nd AeroSAT workshop**](http://sprintars.net/aerocom2011/)

**September 27 – September 28, 2014**

Steamboat Springs, CO

Sheraton

**hosts**: **Gannet Hallar** / **Ian McCubbin** / **John Ogren**

co-organizers: Thomas Holzer-Popp and Ralph Kahn

**MAIN GOAL**

The main goal of the meeting is to substantiate and invigorate these five AEROSAT working groups:

* **pixel level uncertainties**
* **aerosol satellite product inter-comparisons**
* **aerosol typing**
* **intercomparisons**
* **aerosol Climate Data Records**

On each of those five topics, dedicated working groups have been established and members will report on initial activities followed by open discussions. Draft concepts and plans of the five working groups are summarized at the end of this agenda.

**Saturday, September 27, 20144** ***AeroSAT*** **Skyline Meeting Room**

8:00 – 9:00 Registration for AeroSat – Skyline Meeting Room

9:00 welcome, introduction to AeroSAT T. Holzer-Popp, (DLR) and R. Kahn (NASA-GSFC)

short round table introduction of participants

9:30 TOP 1**: pixel level uncertainties** chair: A. Povey (Uni. Oxford)

GOALS

* discuss different error propagation approaches and methods for validating pixel level uncertainties
* discuss best practices for including pixel level uncertainties in satellite products

introduction and seed questions by the chair (5 min)

summary on aerosol-CCI uncertainty discussions (5 min) A. Povey (Uni. Oxford)

uncertainty estimation for CALIOP (5 min) D. Winker (NASA-LaRC)

*10:30 coffee break*

11:00 discussions

*12:00 lunch*

13:30 TOP 2: **aerosol satellite product inter-comparisons** chair: T. Holzer-Popp (DLR)

GOALS

* identify gaps in existing inter-comparisons
* identify available / necessary reference data
* define meaningful additional exercises (to seek funding)

introduction and seed questions by the chair (5 min)

Aerosol\_cci: lessons and plans (5 min) T. Holzer-Popp (DLR)

GEWEX aerosol assessment (5 min) S. Kinne (MPI-M)

*14:30 coffee break*

15:00 discussions

**List of existing satellite aerosol dataset inter-comparisons** to be filled in prior to / at the meeting

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***publication*** | ***variables*** | ***method(s)*** | ***sensors*** | ***period*** | ***region(s)*** | ***reference(s)*** |
| G. de Leeuw et al., *Rem. Sens. Env.*, (2014) DOI: 10.1016/j.rse.2013.04.023 | AOD  Angstrom | Lv2 statistics  L3 statistics  L3 scoring | AATSR, MERIS, POLDER, SCIAMACHY/AATSR  (MODIS, MISR) | 4 months 2008 | global | AERONET |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

*15:45 short break*

16:00 TOP 3: **aerosol typing** chair: T. Holzer-Popp (DLR)

GOALS

* discuss different aerosol typing schemes in passive / active aerosol satellite measurements and ground-based remote sensing measurements
* discuss information content of satellite measurements for aerosol type and include new innovative approaches (e.g. polarization, spectral dependencies, data combination)
* based on this review start discussing new / common approaches

introduction and seed questions by the chair (5 min)

simple aerosol typing in aerosol-CCI (5 min) T. Holzer-Popp (DLR)

aerosol typing with MISR data (5 min) R. Kahn ( NASA-GSFC)

aerosol typing with CALIOP data (5 min) D. Winker (NASA-LaRC)

discussions

18:00 end of day

**Sunday, September 28, 20144** ***AeroSAT*** **Sunshine Peak Meeting Room**

8:30 review on actions/plans for **pixel level uncertainties** A. Povey (Uni. Oxford)

8:50 review on actions/plans for **product inter-comparisons** T. Holzer-Popp (DLR)

9:10 review on actions/plans for **aerosol typing** T. Holzer-Popp (DLR)

*9:30 coffee break*

10:00 TOP 4: **satellite-model-ground based intercomparison** chair: R. Kahn (NASA-GSFC)

GOALS

* suggest approaches to achieve widest benefit from comparing / integrating in situ data together with satellite data, ground-based remote sensing data and model results
* identify information content / thorough characterization and documentation of limitations for each (satellite and also ground-based) retrievals

introduction and seed questions by the chair (5 min)

lessons learned in Aerosol\_cci (5 min) T. Holzer-Popp (DLR)

experiences using Giovanni (5 min) C. Ichoku (NASA-GSFC)

discussions

*12:00 lunch*

13:30 TOP 5: **aerosol Climate Data Records** (CDR) chair: S. Pinnock (ESA)

GOALS

* define consensus requirements to qualify as an aerosol CDR
* compile inventory of satellite aerosol data sets that could qualify as aerosol CDRs

introduction and seed questions by the chair (5 min)

discussions

**list of available aerosol climate data records (CDRs)**  to be filled in prior to / at the meeting

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***satellite instrument*** | ***algorithm*** | ***main retrieved quanitiies*** | ***time span*** | ***provider*** | ***access*** | ***reference*** |
| ERS-2 ATSR-2, Envisat AATSR | SU v4.2 | AOD (550nm, 659nm, 865nm, 1610nm), mixing fractions, Angstrom | 1995-2012 | U.Swansea Aerosol\_CCI | www.esa-aerosol-cci.org | G. de Leeuw et al., *Rem. Sens. Env.*, (2014) DOI: 10.1016/j.rse.2013.04.023 |

*15:00 Coffee break*

15:30 summary, concluding remarks R. Kahn (NASA-GSFC) and T. Holzer-Popp (DLR)

*16:00 end of the meeting*

16:00 optional visit of the Storm Peak Aerosol Lab (register via web: <http://aerocom.zmaw.de>)

18:30 reception (together with AEROCOM – see AeroCom program)

**During AEROCOM:**

**September 29, 2014**

10:00-10:30 AEROSAT highlights T. Holzer-Popp & R.Kahn

13:00-14:00 open discussion with modellers

**Participants AEROSAT2**

|  |  |  |  |
| --- | --- | --- | --- |
| **name** | **org** | **nat** | **e-mail** |
| Arola, Antti | FMI | FI | antti.arola@fmi.fi |
| Balkanski, Yves | LSCE | FR | yves.balkanski@lsce.ipsl.fr |
| DeLeeuw, Gerrit | FMI | FI | gerrit.leeuw@fmi.fi |
| Fairlie, T. Duncan | LaRC | US | t.d.fairlie@nasa.gov |
| Ferrare, Rich | LaRC | US | richard.a.ferrare@nasa.gov |
| Garay, Michael | JPL | US | michael.j.garay@jpl.nasa.gov |
| Holzer-Popp, Th. | DLR | DE | thomas.holzer-popp@dlr.de |
| Ichoku, Charles | GSFC | US | Charles.Ichoku@nasa.gov |
| Jethva, Hiren | GSFC | US | hiren.t.jethva@nasa.gov |
| Kahn, Ralph | GSFC | US | ralph.kahn@nasa.gov |
| Kalashnikova, Olga | JPL | US | Olga.Kalashnikova@jpl.nasa.gov |
| Kim, Dongchul | GSFC | US | dongchul.kim@nasa.gov |
| Kinne, Stefan | MPI | DE | stefan.kinne@mpimet.mpg.de |
| Knobelspiesse, Kirk | Ames | US | kirk.knobelspiesse@nasa.gov |
| Kokkola, Harri | FMI | FI | harri.kokkola@fmi.fi |
| Kristiansen, Nina | NILU | NO | nik@nilu.no |
| Kuehn, Thomas | U.eFI | FI | thomas.h.kuhn@uef.fi |
| Levy, Rob | GSFC | US | robert.c.levy@nasa.gov |
| Lyapustin, Alexei | GSFC | US | Alexei.I.Lyapustin@nasa.gov |
| McCubbin,Ian | DRI | US | Ian.McCubbin@dri.edu |
| Mielonen,Tero | FMI | FI | tero.mielonen@fmi.fi |
| Munchak, Leigh | GSFC | US | leigh.a.munchak@nasa.gov |
| Petrenko, Maksym | GSFC | US | maksym.petrenko@nasa.gov |
| Pinnock, Simon | ESA | IT | simon.pinnock@esa.int |
| Pitkanen, Mikko | FMI | FI | mikko.pitkanen@fmi.fi |
| Povey, Adam | U.Oxf, | UK | povey@atm.ox.ac.uk |
| Robert, Charles | BIRA | BE | charles.robert@aeronomie.be |
| Sayer, Andrew | GSFC | US | andrew.sayer@nasa.gov |
| Schuster, Greg | LarC | US | gregory.l.schuster@nasa.gov |
| Schutgens, Nick | U.Oxf | UK | schutgens@physics.ox.ac.uk |
| Smirnow, Sascha | GSFC | US | Alexander.Smirnov-1@nasa.gov |
| Sundström, Anu-M. | U.Hel | FI | anu-maija.sundstrom@helsinki.fi |
| Thomas, Gareth | RAL | UK | gareth.thomas@stfc.ac.uk |
| Torres, Omar | GSFC | US | omar.o.torres@nasa.gov |
| Van Weele, Michiel | KNMI | NL | weelevm@knmi.nl |
| Winker, Dave | LARC | US | david.m.winker@nasa.gov |
| Xue, Yong | LonMU | UK | y.xue@londonmet.ac.uk |

**Participants Meeting with AEROCOM modellers (29/9/2014)**

