AeroSAT 2015

8 / 9 October, Frascati, ESA-ESRIN

Agenda

Day 1

chair: ***R. Kahn***

9:00 – 10:30	**SESSION 12**	**new examples of satellite retrievals (15 min each)**
	T. Popp	*Brief introduction to AEROSAT and meeting goals (5 min)*
	A. Lyapustin	*Joint AOT-Single Scattering Albedo Retrieval in Algorithm MAIAC*
	L. Klüser	*IASI Dust algorithm inter-comparison in ESA Climate Change Initiative*
	G. Curci	Satellite *Aerosol Composition Retrieval using Neural Networks*
	discussions (25 min)	
10:30 – 11:00	coffee-break	

chair: ***R. Kahn***

rapporteur: ***M. Chin***

11:00 – 13.15 **SESSION 13** **satellite – model interaction** *(needs and supply)*

	seed questions by the chair	**(5 min)**
A.Gettelman, P.Stier, S.Ghan	*modeling needs*	**(20 min)**
	discussions	**(110 min)**

13:15 lunch

Day 2

chair: ***T. Popp***

rapporteur: ***M. Garay***

9:00 – 10:30 **SESSION 14** **aerosol type from satellite (15 min each)**

seed questions by the chair **(5 min)**

R. Kahn *Progress toward a global aerosol type climatology*

L. Mona *Aerosol typing – a key information*

discussions (55 min)

10:30 – 11:00 coffee-break

chair: ***T. Popp***

11:00 – 11.50 **SESSION 15** **combined use of satellite data (15 min each)**

C. Ichoku *Level-2 AOD median from multiple satellite sensor retrievals*

M.Christensen *New Assessment of Aerosol-Cloud Interactions with ORAC (A)ATSR*

discussions (20 min)

chair: ***G. de Leeuw***

rapporteur: ***L. Sogachewa***

11:50 – 13:15 **SESSION 16** **pixel-level uncertainties (15 min each)**

seed questions by the chair **(5 min)**

A. Povey *Ensemble techniques to satellite remote sensing uncertainty estimation*

F. Patadia *Pixel Level Uncertainty in MODIS AOD Dark Target Algorithm*

discussions (50 min)

13:15 – 14:30 lunch

chair: ***S. Pinnock***

rapporteur: ***A. Sayer***

14:30 – 16.00 **SESSION 17** **Long-term satellite-based time series (15 min each)**

seed questions by the chair **(5 min)**

R. Levy *Aerosol retrieval for MODIS, VIIRS and beyond*

Y. Govaerts *MPF/MVIRI potential for aerosol retrieval*

P. Lynch *Towards An 11-year global gridded AOT reanalysis*

discussions **(55 min)**

16:00 – 16:30 **SESSION 18** **wrap up**

Kahn/Popp AEROSAT *action items & conclusions*

Session 12: New examples of satellite retrievals

Introduction (T. Popp): Goals of the AEROSAT meeting and issues from discussions at AEROCOM 2015

The goal of the meeting is to have much discussion time for interaction between satellite retrieval and modeling experts. Focus topics of last year (uncertainties, aerosol type) shall be continued.

Discussion points relevant for AEROSAT from AEROCOM2015 during the 3 days before included: role of satellite datasets in Model Intercomparison Projects (MIPs), optimized trade-off between simplicity and accuracy / detail in retrieval output and its communication, satellite simulators for column products, new multi-model / multi-satellite AOD comparison in AEROCOM led by Nick Schutgens (needs to be global and regional; link to planned GEWEX aerosol satellite lv2 assessment should be made), use of uncertainties in satellite retrievals, linking aerosol types from model and satellite.

➔ Teams who want to participate in the multi-model/-satellite AOD comparison with their satellite dataset should contact Nick Schutgens

Examples of new satellite retrievals were presented (MAIAC AOD and SSA from MODIS, IASI aerosol retrievals at 10 micron, Neural network for retrieval trained with model simulations).

Discussion

- Compare dust source detection from different retrievals vs. Chiwawa database (
- Retrievals need to take into account information content
- Combine complementary retrieval information UV – VIS – TIR
- 10 micron provides different information (hyperspectral: dust optical depth, height <-> radiometer channels: dust detection)
- Model Dust AOD output at 10 micron and 550 nm + effective radius could be compared to satellite retrievals (AOD depends much on size distribution)

Session 13: satellite – model interaction

Goal: to identify information content of observed properties and suggest approaches to address aerosol-cloud interactions.

Steve Ghan lists observation quantities needed to address aerosol-cloud interactions in warm and ice clouds.

Philip Stier shows (1) the appropriateness of using AOD as a proxy for CCN. With self-consistent model simulations, it shows that the CCN is better correlated with surface aerosol extinction than with the column AOD, mainly due to the vertical distribution of aerosols. (2) the AOD-precipitation relationship from MODIS-TRMM is quite different from HadGEM model simulations, and the sampling bias plays an important role in creating the difference. Suggested discussion on:

- Need to understand errors of retrievals
- Need to understand what has not been retrieved and why. This is key to avoid sampling biases
- Satellite simulators can help

Andy Gettelman emphasizes the importance of simulators for appropriate comparisons between observations and models. He also points out that the MODIS retrieval of cloud top, LWP, and droplet number are not independent quantities.

Discussion

1. Model-data comparisons:

i) Simulator:
It provides a tool to more properly compare/evaluate the model results with satellite observations. The first step is to sample the model output at the satellite overpass time and location, then re-compute the model results for "mimicking" satellite radiances or algorithms. The CALIOP simulator was given as an example. There were a lot of questions about the definition of "simulator", the approach, and the value, including:

(a) It could mean simulating radiances as would be observed by the satellite instrument, or simulating the aerosol product(s) when and where the instrument samples. Radiance comparisons are more fundamental, whereas aerosol product comparisons directly address the geophysical products of interest. If a simulator does not compute radiance, should the simulator be called "emulator" or just a "sampler"?
(b) It is required to build different simulators for different satellite products. For example, comparison with MISR or MODIS AOD would require much more complicated levels of "mimicking" than CALIOP. Is it practical?
(c) Is a simulator so important that all the comparisons we have done so far are wrong?

ii) Nick Schutgens' tool to compare observations and models:
The Community Inter-comparison Suite (CIS) that can simplify the tasks to handle the spatio-temporal sampling for different datasets and offer the colocation and visualization for comparisons.

2. Product uncertainty:

AERONET: Satellites and models use AERONET data to validate/evaluate their products. However it should be understood that the AERONET SSA and aerosol size are not direct measurements, but retrieved products that can have large uncertainties and also need validation. AERONET data has two parts: direct measurements (AOD, spectral-dependent AOD or Angstrom Exponent, very high accuracy) and retrieval (SSA, size distribution, indices of refraction).

➔ We should invite AERONET group to come to the meeting next time (based on the expected new AERONET dataset version in 2016).

Satellite data: We need to better document the uncertainties, and multi-retrieval diversity and openly document + communicate them. It should clarify the random vs. systematic error, and the use of diversity as (a lower bound on) uncertainty. There are "bias corrected" MODIS AOD products, but the data points are much reduced compared to the standard MODIS AOD product. Some satellite-derived products, such as "anthropogenic fraction of AOD", are based on arbitrary assumptions and can have very large uncertainties and systematic errors, even though that is what modelers want, and some data producers generate such quantities. However, there are also two levels of reporting satellite data: one is the quantity actually retrieved, which provides a true representation of the information content of the measurement, including the uncertainty, and the other is derived or interpreted from the retrieved product, by adding assumptions and/or ancillary data, to provide a certain result, such as anthropogenic AOD fraction.

3. Observable quantity and information that models need/can use:

i) For aerosol-cloud interactions:
we need constraints on CCN. From Philip Stier's work on the AOD-CCN relationship from a fully self-consistent model calculation, it was demonstrated that surface extinction and CCN are much better correlated than column AOD and CCN. Based on this work, it is desirable to have vertically resolved extinction aerosol index (rather than extinction or sub-column AOD multiplied by Angstrom exponent) as a proxy of CCN. In that regard, CALIOP and HSRL may be able to provide that quantity for models to test.

➔ Clear nomenclature: aerosol index **AI** = AOD*Angström (or "fine mode / scattering aerosol index"), aerosol absorption index AAI

Other quantities (e.g., cloud droplet size, liquid water path) are available from observations.

ii) Optical/microphysical properties:
Models simulate the aerosol mass and then convert it to aerosol extinction and absorption using the mass extinction efficiency (MEE) and mass absorption efficiency (MAE), computed with the refractive indices and size distributions of aerosol species and their hygroscopic growth. These terms are poorly constrained due to lack of data. A lot of models still use the OPAC optical properties, which are outdated and have a lot of errors. We need observations of MEE/MAE, spectral-dependence of refractive indices of different aerosol species, f(RH), and size distributions. Some of these properties are available from aircraft measurements (e.g., DC3 and SEAC4RS), but need more systematic approach.

➔ AEROCOM WIKI description of what models do to produce optical properties needs updating

iii) There were discussions on Infrared algorithms dust products at 10 microns regarding the presentation by L. Klüser (IASI dust retrievals). The aerosol optical properties at 10 micron from the model simulations have never been examined; previous studies had mostly focused on mid-visible wavelength. It is probably a good idea that the models should compare the long-wave properties with satellite data.

Session 14: Aerosol Type from Satellite

R. Kahn showed several examples of satellite definitions of aerosol types. L. Mona presented an inventory of aerosol type characterization schemes and analysed common structures.

Discussion

- The goal should be to link to the models
- There could be more than the 6 aerosol components listed (e.g., agricultural dust, industrial dust, etc.)
- Not every group has the same objective for its classification
- Hierarchical classification (like land surface community), distinguishable by retrievals
- What about organic vs. non-organic? From the retrieval perspective the difference is non-retrievable…
- What do aerosol classes "mean" in terms of components? Modelers would like an algorithm to take a composition and size distribution and map to aerosol classes – this would have to take account of differences based on location and season
- Nomenclature – one name for what is a "pure" component (lowest level of hierarchy)
- List shown by L. Mona is really a list of aerosol "sources" as opposed to aerosol "types"
- Modeling community can help guide development
- What about hydration?
- Lots of criticisms of particular aerosol components listed by L. Mona (sulfate, volcanic ash)
- Don't see how modelers can quantitatively use aerosol types to evaluate models, except to compare the spatial extent of aerosol air mass types with satellite retrieval results
- Modelers also want to have uncertainty in the aerosol type
- Common denominator is the source type
- Would it be better to directly compare observed parameters and uncertainties (e.g., lidar ratio) with modeled parameters? This is similar to what one type of satellite simulator does
- Physical properties would define the "basic" aerosol component
- We need to be really clear about what we want to do with this classification
- Focus on the role of AEROSAT in terms of model validation
- Can't do temporal/spatial averaging of categories (need numbers)
- Would like to understand why models went wrong (need more information than just AOD and SSA)
- There are different regions where satellite information is useful to the models
- It might be useful to use multi-instrument observations to get better information about aerosol characteristics at particular location
- Table with 3 columns: (Left) What modelers need, (Right) what satellites can provide, (Middle) find linkages
- Can we benefit from the way that the data assimilation community uses satellite data?
- Use model information to guide the retrieval process (e.g., as initial guess)
- Names are preferred for the end user community (non-experts)
- Are there specific cases (experiments) that could be used to compare models to satellite retrievals? Either where there is agreement or disagreement

➔ Consensus that the inventory analysis should be completed using a hierarchical structure (but not going into every possible detail)

➔ Consensus that aerosol typing involves steps, which can both be useful: (1) retrieval of optical properties (for quantitative comparison to models, data assimilation), (2) their interpretation to link to source-related /

chemical aerosol types (usage: model validation for specific conditions / case studies, policy support / public communication using easily understandable names)

Session 15: Combined Use of Satellite Data

Presentations discussed the provision of mean / median satellite product (of several retrievals) in MAPPS, satellite simulator / emulator definition in AEROCOM and data assimilation as one method to combine different retrievals.

Discussion

- Is there a way to provide a "merged" aerosol product? (e.g., TRMM and ground-based) Yes, GRASP can use multiple sensors. Here differences in sampling and aerosol type information content would still need to be accurately represented in the final product.

Session 16: pixel-level uncertainties

Presentations described concepts / limitations of error propagation and practical examples of error propagation.

Discussion

- Further discussion on how systematic errors are treated is needed
- Satellite people need to know how the quantitative information can be used by modelers
- relative error for low AOD is of little meaning (there is an absolute uncertainty at the low-signal end of the measurement range)
- Issues in uncertainty calculations
    - uncertainty is calculated for each variable separately, but not for ensemble
    - is seasonality well covered in calculated uncertainties?
    - Cloud contamination can be estimated by determining the fraction of pixels close to clouds to the total number of pixels in the super-pixel
    - Aerosol model uncertainty can be estimated by determining an AOD pdf with all aerosol models, provided the algorithm's aerosol mixture set is adequate
- Uncertainty validation is topic in evolution and is needed to achieve confidence. Question is how to estimate the true error
- Relative uncertainty between pixels have value of information
- Error = measure – truth; uncertainty is a distribution of a systematic error?
- Problem for modelers is how to move from pixel uncertainties to aggregated area estimates (L2->L3->…)
- Question: Under what conditions are monthly mean uncertainties meaningful?
- Use the satellite simulator for uncertainty validation
- Data assimilation needs pixel level uncertainties
- Modelers often use monthly averages and thus need their uncertainties
- Modelers should do averaging of satellite data
- Most satellite data products do not contain information on spatial correlation, day to day, daily variation

- AOD PDFs should be provided
- Validation and uncertainty propagation are different, complementary tasks
- Satellite-model comparison is a different task from using any monthly means for science

➔ Now is an opportunity for twinning satellite / model to develop estimation and use of uncertainties in both communities

Session 17: Long-term satellite-based aerosol time series session discussion

Summary slides and overview of goals (Simon Pinnock):

- GCOS have defined various requirements for a CDR in general, as well as specific requirements for aerosols.
- Illustrated examples of progress and challenges to data with aerosol and cloud CCI data.
- What are the technical activities needed to increase the uptake of satellite aerosol CDRs in climate research?

MODIS and VIIRS Dark Target (Rob Levy)

- Separate land and ocean algorithms, applied to the two MODIS sensors, plus VIIRS.
- Illustrated that calibration can lead to offset/trends, even with identical sensors and algorithm.
- Some reasons for offsets are not understood – can models help resolve e.g. expected cloud cover/AOD differences between orbital times?
- Small differences between sensors (e.g. MODIS/VIIRS) also lead to differences in retrieval products that are not trivial to resolve, even when the algorithm is as close as practical.
- Inter-algorithm retrieval solution differences (e.g. Dark Target vs. NOAA VIIRS) also not trivial to resolve, even though validation statistics may be similar. There are also differences in data coverage.
- Questions/comments:
    - Can Dark Target be applied to Himawari, GOES-R? Yes in principle, not being pursued at moment.
    - Resolving MODIS Terra/Aqua differences? Extra calibration activities ongoing.
    - Does MODIS/VIIRS swath width difference affect gridded statistics? Does not greatly appear to.

Meteosat (Yves Govaerts)

- Meteosat gives continuous time series since 1982: first generation (MFG) had one broad solar band, digitization (6, 8 bit) and pixel size (2.5 km at sub-satellite point) limitations. Also spectral response function not well characterised pre-launch, and degradation post-launch. Big advantage is time series of one image every 30 minutes.
- Use time series of images for combined surface/atmosphere inversion (already applied to Meteosat Second Generation, MSG); resolution of MFG calibration issues is currently a work in progress. More recent (e.g. MSG) and future (e.g. MTG) are more capable.
- Use of multiple geostationary satellites with similar capabilities can make a contribution towards an aerosol CDR.
- Questions/comments:
    - Will MFG calibration activity extend to geostationary sensors from other agencies? Not planned at present.
    - Geostationary has great opportunities for examining aerosol diurnal cycle, and cloud cover changes (complementary to polar-orbiters).

- Poor digitization (6/8 bit) may be a very strong limitation to data quality of the older geostationary data; should be clear about this. Although if we can quantify uncertainties it may be useful.

NRL NAAPS aerosol reanalysis (Peng Lynch)

- Global 1x1 degree, 6-hourly, 200301-201309 550 nm AOD product generated. Output total, fine-mode, and coarse-mode AOD.
- Satellite aerosol, fire, precipitation products assimilated in NAAPS model. Validated against AERONET; better in transport regions than source regions, agrees well and stable quality overall.
- Applies additional data filtering, corrections, and regional tuning to ingested data.
- Trend analysis (consistent with prior trend studies) and attribution.
- Questions/comments:
  - Is AERONET data incorporated? It was used for tuning, but was not assimilated directly.
  - How does assimilation affect surface concentrations? Not included in the product; from the model there is some change but not validated so not provided.
  - Can you examine effect of assimilation on the model, for those areas/times where no satellite data was available to assimilate? Yes, it changes things.
  - Meteorology reanalysis system changes over time, so this makes attribution of aerosol trends harder, as they could be influenced in changes in the meteorology reanalysis.

AOD from AVHRR over land (Yong Xue)

- Over 35 years of data from 16 satellites carrying AVHRR.
- Two methods developed:
  - LABITS (time series analysis) for simultaneous surface/aerosol retrieval with 0.63 micron band.
  - Dark Target-like algorithm using 3.75 micron band and NDVI to estimate surface reflectance at 0.63 microns.
- Difficult to validate early part of the time series due to lack of AERONET data.
- Also, calibration issues with some of the AVHRR sensors.

General discussion

- What can we do to validate before the AERONET era? Some possible options:
  - Solar dimming/brightening data (pyranometers are being looked into by group in Finland).
  - MFRSR.
  - Infer from solar irradiance measurements taken at observatories.
- TOMS onwards also provides a 35-year record of e.g. UV AAI.
- → Should we organise a working group/workshop with a focus on what is being done and can be done from the older sensors (in terms of aerosol algorithm and validation)? Some think yes.
- Is it better to spend time improving current products or creating new ones from older sensors? Answer: do both, not a clear view that one or the other is more useful right now.

Session 18: Wrap-up, conclusions

AEROSAT 2015 had 70 – 45 participants

“Monthly mean datasets” are typically used in modelling, but need to be used carefully in comparing to satellite datasets (different sampling)

Comparing AEROSAT2014 and AEROSAT2015, an evolution of thinking, examples of tests, demonstrations based on last year’s discussions can be observed.

Suggestions for AEROSAT 2016 (to be supported or rejected)

“new OPAC”

PM2.5, PM10

Next AEROSAT meeting will be held in Bejing, 22+23 (+24?) September 2016