**8th AeroSAT workshop**

October 14 – 16, 2020, Online

co-hosted by Kostas Tsigaridis, NASA GISS - New York / Lamont

**Minutes**

**Agenda**

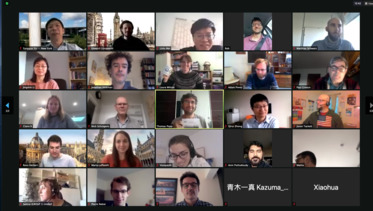
All presentation slides will become available at <https://aero-sat.org/meetings>

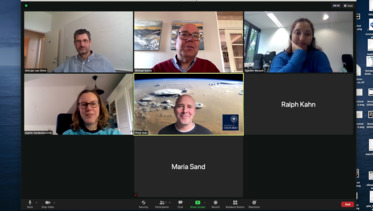
AEROSAT2020 was part of a joint week with AEROCOM2020 comprising of AEROCOM plenary sessions 1-5 and breakout sessions A on Monday and Tuesday, joint AEROCOM / AEROSAT plenary sessions 6-9 and breakout sessions B and C on Wednesday and Thursday, and AEROSAT sessions 10-14 on Friday. This document summarizes the discussions of all AEROSAT-related parts (i.e. Wednesday – Friday).

These minutes comprise of following elements:

* Online discussions recorded at board.net (saved on 10 November 2020)
* Rapporteur summaries for the breakout sessions
* Overall AEROSAT SSC summary in the closing session

AEROCOM / AEROSAT 2020





**AEROSAT minutes**

**Plenary sessions**

**Plenary Session 6  -  Covid impact on aerosol loads, air quality and forcing [90 min]**

Moderator: Kostas Tsigaridis  
Rapporteur: Hickman  
  
Johannes Quaas: Assessing aviation-induced cirrus from satellite during COVID-19 (5 min)  
MichaelS: very nice... Emissivity... what exactly is that? Is that measured by MODIS? – [it is (sort of) like optical depth, but measuring the cloud effect in the thermal]  
Ralph: I'm wondering how much the loss of cirrus was offset by the reduction in aircraft fuel burned.

Johannes - do you mean what is the microphysical effect? Don't know, we hope to dig into this once Calipso/Cloudsat (the Sourdeval et al. ACP 2018 ice crystal number retrieval on the basis of DARDAR) data are processed  
Andrew: I wonder if the sensitivity would be the same in each quintile? The quintiles are by absolute, not relative change, correct? Does that matter?  
Ralph: I was thinking of the greenhouse gas emission reduction (both short and long-term), but the presumably reduced microphysical effect is certainly another factor, working in the opposite direction.  
Nicolas: Very nice study Johannes. Do you have plans to work with DLR on comparing to their models? That could be a nice constraint.  
Andrew: We are doing contrail studies with the NCAR contrail model as well. The radiative effect seems broadly linear with the reduction in aviation traffic.  
  
Nicolas Bellouin: Impact of Chinese Covid-19 lockdown on aerosol and radiative fluxes over East Asia Seas (5 min)   
Michael D: What are the AOD anomalies defined in relation to?

Nicolas: They are defined with respect to the long-term average 2003-2019.

Thanks! Is the analysis sensitive to trends? There are big increases from 2003-2011 and decreases from 2013-2019 over that region.

Nicolas: There is probably sensitivity to the period used to calculate trends, given the large changes in AOD observed over China over the past 20 years. Something to look at but the lockdown signal should stay, I think. Other signals (like Beijing Olympics) are weaker.

Andy Sayer: I would also be curious what the uncertainty in the AOD baseline is, due to the long-term trend. The uncertainties on trends from satellite (and also AERONET) can be quite large because the distribution is skewed and sampling is limited. I have seen various studies into trends in China, often putting in a breakpoint around 2010, but many of the analyses have problems (e.g. the trend line is discontinuous or breakpoint is hand-waved). My guess is that subtracting the trend from the natural variation might make a precise quantification different. Having said that, the drops Shobha showed in China from VIIRS were pretty large so maybe it is significant enough that it will stick out. :)

Nicolas: I agree Andy, we have to remain cautious. But according to MODIS the AOD anomaly over the Northern Yellow Sea is -0.15 -- largest monthly anomaly for March since MODIS was launched. So, from the point of view of signal-to-noise ratio, this is a good opportunity.

Michael D: Wow, that does seem quite large. It would be good to get to the bottom of the differences in results, as my paper with Rob in GRL (<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020GL088913)> and a nice new work out of NASA GISS (<https://acp.copernicus.org/preprints/acp-2020-567/)> are not able to distinguish an AOD difference from the long-term trends whereas the results shown today are more striking and clear.

Nicolas: We focus on the month of March, where anomalies are largest. February was anomalously hot and humid in China, and that affected hygroscopic growth in a direction opposite to the emission perturbation. So perhaps the choice of time period affects the results? We also focus on the Marginal Seas -- anomalies over land may be less statistically significant because of larger variability. (Not sure.)

I took a quick look at our results for March 2020 in more detail. We do see a coherent AOD decrease (albeit not stat. sig.) over the East China Sea in March 2020. I'll send a follow-up email in case you're interested. The points are: meteorology and higher variability over land are well-taken

Zak: is this all-sky AOD compared to clear-sky DRE, or are both clear-sky? I'm guessing the latter since all-sky AOD is easy to model but hard to observe!

Nicolas: Yes, all is clear-sky. I have never been really sure of what an all-sky AOD would mean.

Gerrit de Leeuw: you reduced aerosol emissions in your model simulations, did you also reduce trace gas emissions? in particular NO2? there are several publications on enhanced AOD due to secondary formation

Nicolas: We reduced primary emissions of BC and OC, and precursor emissions of SO2 and NH3. But not other emissions, which may feedback on the aerosol. It is possible that anomalies are smaller than they could have been because of secondary formation, but on the regional scale the signal seems dominated by industrial aerosols.

Toshi: How long did you assume emissions would have decreased in the simulation (a few months or through the year 2020)?

Nicolas: We perturbed emissions from February to April 2020 -- we ran the simulations in June, so were limited by the nudging data available then!

Michael: Can the slope in TOA flux vs AOD over land and ocean be used as a constraint for AeroCom models?

Nicolas: I think it can. I tried in fact, using the "old" AeroCom Hindcast experiments but not many models participated then, and the data is of poor quality. If you have suggestion for a nice pair of control/perturbation experiments, that would be great! Probably no need to run simulations just for that.

Michael: let’s try indeed - your values looked very reasonable!

Philip: Nicolas, Norman – positive RFari off the cost of China seem reasonable, however, I was surprised to also see relatively large positive RFari off the east coast of the USA. This seems a bit puzzling. Any thoughts?

Nicolas: That feature was also found by Fabien Paulot in his 2018 paper: <https://acp.copernicus.org/articles/18/13265/2018/> According to their model, that is explained by the decrease in SO2 emissions in the US. (Their section 3.2.1.)

Shobha Kondragunta: China and Taiwan: A Tale of Two COVID-19 Lockdown Measures and Air Quality (5 min)  
Michael D: AOD has been decreasing over China since 2011-2013... I think we should expect AOD in China in 2020 to be below climatology without accounting for trends even for no COVID-19 impacts.

Andy Sayer: similar comment from me about Nicholas' talk. Though the VIIRS pdf shift here was pretty convincing so it seems likely we can say there was some drop!

Shobha: Michael, true.  same with NOx emissions too.  But these reductions are huge (about 0.5).  So that is not trend.  It is due to shutdown  
Mian Chin: AOD over Taiwan is higher than that in China?  
Shobha: Mian, don't think so.  For China the domain is bigger so average may look like similar to Taiwan.  But China has higher AODs  
Michael: Probably NO2 is correlated with other pollution. But maybe still be a good proxy. Although BC and SO4 are more long lived then NO2....  
Shobha: Michael, that is the whole point.  NO2 short lived and aerosols long-lived.  So, we can isolate near source aerosols using NO2 as a filter  
Toshi: Good talk. Do you have any information on a change in tropospheric O3 concentration before and after the pandemic in Taiwan?  
Mian @Toshi: Shobha uses VIIRS AOD and also showed NO2 from TROPOMI. For tropospheric O3 amount that needs some work to separate stratosphere from troposphere. I think there are products available or in progress.  
Mian, thanks for responding.  Maybe Toshi is thinking of surface ozone values.  Toshi, no we did not look at ozone from ground monitors either in Taiwan or in China  
Toshi @ Mian and Kondragunta: Thank you for your response. A change in O3 concentration is interesting as shown in Xiaohong's presentation in which O3 concentration may increases due to NOx emission reduction because of the titration effect (e.g., <https://doi.org/10.1016/j.scitotenv.2020.139542)>.  
Lucia: Do you plan looking at AOD correlation with SO2/SO4 as well?  
Lucia, we plan to.  But can be challenging  
Gerrit: AOD over China decreased 2011-2017, but we are not sure what happened thereafter. For NO2 we see the decreased halted in recent years, we are checking that for AOD too  
Gerrit, thanks.  Will look forward to seeing your results  
The 2011 -2017 AOD trends over China were published in Sogacheva et al. ACP, 2018  
Larisa Sogacheva: satellite AOD in 2018-2019 has been continuing to decrease (not published)  
Larisa, is the trend bigger than the signal we are seeing in China, especially?  
Larisa : may be figure 8 in ACP 2018, Part 2 is an answer to your question?  
  
Xiaohong Liu: Impacts of COVID-19 on Aerosol Direct and Indirect Radiative Forcing (5 min)  
Mian@Xiaohong: I may have missed it - where did you get the emission datasets for COVID period? Forster et al 2020  
Mian: Do you have data to support the precip and temperature increase/decrease simulated by model?  
Andrew: are these changes significant given the variability?  
  
Ragnhild Skeie: Changes in aerosol composition and radiative forcing due to COVID-19 in OsloCTM3 (5 min)  
Thomas: why was there a sulfate burden reduction at the Andes?

Andy Sayer: I think there is a lot of mining activity there. Perhaps that shut down too? I don't recall hearing about it in the news, though I don't know whether I would have. <https://en.wikipedia.org/wiki/Andes#Mining>

Christoph: might be also due to volcanoes in the Andes

Ragnhild: Natural emissions are kept constant. I haven't dug deep into the anthropogenic emissions. Emission per country and sector are available here if interested: <https://github.com/Priestley-Centre/COVID19_emissions>

Augustin Mortier: COVID-19: Impact on AOD and European Air Quality (5 min)  
Mian Chin: Dust was only seen in March over S Europe? Not in April?  
Augustin Mortier: I guess it was mostly in March, this year. But I will check day by day what's happening in this region!  
Mian Chin: Large fires in N America   
Yves; Could we use your technique to point to regions that are rather pristine (i.e. regions that do not see any deviations from their climatology?)  
Augustin: Yes, I guess we could filter the regions associated to a low/not significant deviation!  
Andy Sayer: I wonder if we could use bootstrapping or something to estimate uncertainties on these drops. It is interesting to me that a lot of sites were at the low end of the box whiskers plots but not super below. It is true that most of the maps looked blue, but spatial covariation could mean that things like weather systems affect many sites at once (i.e. these sites are not independent, especially in dense areas). The -10% for the whole world was quite interesting. I guess the upper limit for a drop we might expect to see would be the overall anthropogenic fraction (I don't know what the rough % is for different parts of the world) - so seeing the regional variation on your last time series plot might also reflect regional differences in anthropogenic vs natural aerosols.  
Augustin: The bootstraping is a good idea. We could probably use model data and subsets of the data to investigate the effect of the spatial and time gaps in the observations. I agree that the drops are expected in the different regions depending on the relative contributions of anthropogenic and natural particles. We will definitely dig a little bit more into that!  
Betsy: nice - we tried looking for a signal in our (very sparse) surface in situ measurements but didn't see anything striking relative to the previous 3 years.  our sites are mostly pretty remote so less immediate impact from anthropogenic sources.  we also didn't control for weather but anecdotally were hearing from site techs that there were some anomalies.  
Augustin: thanks :) It's funny, I would have expected a more clear signal at the ground level… I don't know if the Aeronet stations are more remote…?  
Tom Eck: These are AERONET total aerosol optical depth comparisons (correct?), of 2020 versus 'climatology'. However, there are long term trends in AOD at several of the sites shown, including MD\_Science\_Center and sites in China. Due to decreasing AOD in time over the last 10-15 years the reductions in 2020 are not all due to COVID lockdown emission reductions We looked at AERONET data in the group at Goddard comparing to the previous 5 year means and did not see the dramatic decreases in AOD that were shown in your presentation today. Also, the reductions shown in May through August are not likely due to COVID, as restrictions in economic activity had been greatly reduced by then. The meteorology has been very unusual in some of the sites you analyzed such as in Maryland, USA there was much greater frequency and amount of precipitation thereby washing out aerosol and resulting in lower AOD. +1  
I agree with your comments. Our AOD deviation might be affected by potential trends. In the second part of my results (not the ones available on the web interface), I limited the years for constructing the climatology to the years after 2010 in order to reduce the potential bias induced by a trend.   
Regarding the meteorology, I also agree that using only AOD measurements, we cannot distinguish a reduction of anthropogenic emissions from unusual meteorological contributions.  
Tom Eck: There is still a significant trend in AOD from 2010 to 2019, so that does not fully reduce the effect of downward AOD trends at several sites.  
True… which means Paul G's idea (next comment) of detrending could be nice!  
Paul G: Isn't it important to first detrend before looking at 2020 anomaly?  
yes, that is our plan to de-seasonalize the data but we don't have AOD data for the whole time period processed with the same algorithm.  So, we are reprocessing right now to create the 10-year VIIRS consistent record

Paul G: I can share with you the daily value MODIS Deep Blue (0.1x0.1) Terra & Aqua AOD with derived fAOD and cAOD at the AERONET sites

Tom Eck: Paul, we at AERONET have been analyzing the fine and coarse AOD from SDA for hundreds of sites in the context of COVID lockdowns in addition to MODIS data retrievals of AOD (Jianglong Zhang) for the globe plus data assimilation analyses by Xian Peng at NRL.

Paul G: Are these the O'Neil values (that I always used to validate the fAOD nd cAOD from MODIS DB)? Are these results published?

Tom Eck: Yes, these are SDA fine and coarse AOD from O'Neill's algorithm, they are a product on the AERONET web page. SDA retrievals have been published many times; what are you asking regarding publication? Our COVID analysis is still in progress, so not published.

Paul G @TOM: When detrending the long-time series of MODIS/AERONET AOD would you include 2020 or not?

Paul G.: Augustin very nice work  
Thanks a lot :) The detrending strategy is a good idea!

Svetlana Tsyro: Impacts of COVID-19 lockdown on European air quality (5 min  
Mian Chin: Why observations showed PM10 increases but model shows decreases? Dust?  
Different reasons in different cities: anthropogenic and natural (dust, fires) from long-range transport, and local road dust (but also increased biomass burning in Paris, N. Italy etc. - not shown here).  Some of those sources are not reproduced in the model (road dust, increase in wood burning).  
What are "indigenous sources"?  
Svetlana: in those slides they are city-regions plus national ("Local" on the graphs)  
Pierre Nabat: in the decrease in PM10, could you identify which aerosol species explain most of the decrease? (using notably EMEP model) sulfates, nitrates, BC?  
Svetlana: we have not looked at this as we focused on explaining why we could NOT see Covid effect in most cases. But of course, it's possible - and interesting, thanks!   
Roxana: a small comment in you talk about lockdown, but there were no lockdowns in Germany or Sweden, only restrictions. I guess your dates refer to travel restrictions. but also, these mean something different from country to country, maybe another term would be better for clarification.  
Svetlana: You are right. We just started using this 'lockdown' term loosely while working on this study, including in it all types of restrictions/measures, and stuck to it. We should have found a more generic word (or clarify what we meant). Do you have any good suggestions? Regarding the 'lockdown' dates, the BCS has not provided any. So, we adopted "non-essential movement banned" from Politico (which by this says for Germany: Partial lockdown).  
  
Discussion 60 (min): What have we learnt so far from the Covid-19 natural experiment?  
Best practices to analyze the various data of such an exceptional situation against the long-term background  
Andrew: One major issue is sampling uncertainty in emissions.  
Mian .... did anyone separate sector contributions to AOD reductions?  
Mian, yes Kazu and Kevin.  In China (their model runs) transportation sector was dominant.  They saw in the model reductions of up to 12 ug/m3 when they included NOx reductions.  So, it is nitrate and secondary organic aerosols that decreased due to decreased emissions compared to Business as Usual  
Mian: Also separate fine with coarse mode AOD from AERONET  
Paul G@Mian: I did separate fine and coarse AOD over land using MODIS DB & VIIRS. Detrend then look at the 2020 anomaly. Will compare with AERONET from Augustin.  
Michael D: One point are: emissions: My impression is that the industrial sector emissions changes in particular may be overestimated in the Le Quere et al analysis and thus subsequent analyses. They estimated ~40% decreases based on preliminary coal data which is not really consistent with the relatively muted change in thermal power generation in China (based on nationwide government data). Because the China lockdowns occurred earliest, I think they might have an over-sized impact on the initial estimates that has been carried through.  
Gunnar: This paper includes GHGs <https://www.nature.com/articles/s41558-020-0883-0>  
Greg: NASA quit flying field missions during the early lockdown, so that is a problem too.  
Andrew: But NASA and NOAA did do some flights I think at the end of lockdown and during this summer.   
Yes. Missed the early transition but they are flying now.  
Andrew: Let's hope they don't catch another lockdown... but we'll see what winter brings!  
Mian Chin: Most models presented here use Forster et al 2020 emissions, which is based on mobile data from Apple and Google. But how reliable are they? Any other emission datasets in preparation?  
The Forster et al emissions are mobile data that is baselined against earlier emissions from Le Quere et al 2020, which is sector by sector, but preliminary. So definitely more work could be done on emissions. But it's a thankless task, and not many groups do it. One other option is to try to get uncertainty estimates and vary emissions. It does seem as if some of the aerosols were baselined to mobility data and that’s not really correct.   
Gerrit: for NO2 over China: Ding et al, GRL, just published (top-down using TROPOMI  
Mian @Gerrit: Thanks - I know there are a couple of efforts on NO2 emission based on satellite data, which is probably the most straightforward dataset to use. But other species are more challenging.  
Mian, Kazu and Kevin (JPL) already published in ACP.  Used TROPOMI NO2 and SO2 data to modify model emissions for COVID scenario  
Zhining Tao: To Xiaohong, your simulation reveals the increase in surface ozone during Feb-Apr. due to COVID-19 (mostly through emissions change). How about stratospheric ozone intrusion? Is 2020 special in this regard?   
Flo Malavelle: Rebounding on Yves argument. With the Icelandic volcano eruption in 2014-15 we roughly estimated that it released 10 times the amount of annual SO2 emissions released by the combined 28 (back then) European countries. That was the order of magnitude required to get a clear signal on cloud effective radius at a regional scale. One could work out natural variability in specific regions to get a feeling of how much reduction in emissions due to covid would be required to have a detectable effect on ACI.  
That being said, it might be hard to untangle an effect on ACI due to covid at the regional scale. At the city scale however, there is potentially something to tease out. In Air Quality modelling we've seen clear reduction in some pollutants (e.g., NOx) that ties well with traffic but the picture on PM25 was much more complicated. This indicates that the main source of aerosol emissions maybe not the one affected by restrictions (in UK at least). Big cities with large population but limited surrounding industries might be interesting candidates for looking at things like city tracks.

**Plenary Session 7 - indirect effects and observational constrains [90min]**

Moderator: Johannes Quaas

Rapporteur: Edward Gryspeerdt  
  
Paquita Zuidema: Oracles overview [10min]  
Why is the impact of humidification on SSA small?  
Greg: Smoke is generally less hygroscopic than pollution, so maybe that has something to do with it. Also, in situ folks generally assume that absorption does not change wrt RH.  
Paquita: yes, we could not evaluate absorption changes with RH. We did have two nephelometers, one providing a scattering measurement at the ambient RH, and the other at a dry (~20%) RH. Their ratio was less than 1.2 for 90% of the time in the free troposphere. This translates into a change in the SSA of less than 0.01 - so not zero, but nevertheless small. That's what the original statement is based on.  
Michael: What are the plans for further comparison to other (AeroCom) models?  
Paquita: Sarah Doherty is finishing her manuscript examining the vertical structure from basically the same models and comparing them to the obs. Her study extends to more years and includes a comparison of the clouds - everything that is needed for a DARE calculation. This is still not an aerocom-type assessment. We don't have any other further plans at the moment unfortunately.  
  
Edward Gryspeerdt: Indirect effect - Identifying observational constraints (10min]  
Michael:  CAM5-3-CLUBB also has a bent relationship? a bit opposed to CAM5-3

Ed: Yes - I am not sure it is really clear yet what causes this relationship. There are a variety of possibilities, entrainment, precipitation feedbacks etc.

Michael: It was a major shift in the convection parameterizations, so it’s an interesting change.

Ed: Agreed - it is a useful datapoint in identifying what is going on. The 'unpredictable' models are potentially the most interesting

We could explore if Andrew and colleagues could rerun this - otherwise I think we can also run the NorESM-CAM6 w and wo CLUBB, need to check.

Ed: More models are always interesting, so would be nice if possible

Mian Chin: SPRINTARS shows very different Nd LWP relationship compared to other models?

Ed: Yes - one possibility is that diagnostic Nd models are better able to re-produce the negative relationship at high Nd (if the wet-scavenging effect drives it), as they would be more sensitive to reductions in aerosol from wet-scavenging

Michael: Could you formulate an (updated) experiment proposal, and we add to the wiki?

Duncan: These are indeed very valuable, but I think we should add the diagnostics to the core set instead, it's not really an 'experiment'...

Ed: I agree - it wouldn't have to be something run separately. It would be great to add into other simulations/experiments where possible. Given that there is not much output required, it would be great to make it a more common set of output (or something like the control, where it is updated semi-regularly)

Dan: We tried to include a lot of the key diagnostics from the indirect experiment in our current trajectory experiment. Worth checking if we cover your needs there.

Ed; Do you have matching PD-PI simulations? That is mostly where we end up with things that are missing

Dan: No PI I'm afraid (except for UKESM1 which we plan to extend to PI)

Ed: UKESM is about the only more up-to-date one I already have (thanks to you and Flo :-) )

No problem Ed!

Duncan: What was the ECHAM-HAM AAC model out of interest?

Ed: I am not 100% sure, I think it was Johannes Mülmenstädt's 'best estimate' model

Cool, thanks

Kai: nice talk. For "ice-free boxes", do you mean sea-ice free, or cloud-ice free?

Ed: Cloud-ice free, in an attempt to do something similar to a satellite observation. This reduces the statistics quite a lot though, so the 'all-data' results are \*probably\* more useful

Nicolas: Very interesting talk, Ed, thank you. But given the challenges of modelling clouds (and that's before even mentioning aerosol-cloud interactions!) in GCMs, should you not look at other models? Large domain LES simulations are appearing, and applying your methods on them could be most insightful.

Ed: Absolutely, although I think the GCM results are still useful. The question is not so much 'are the models correct?', but 'could we ever measure this?' (given meteorological covariations, feedbacks etc.) For this, I think GCMs are really useful

Bastiaan van Diedenhoven: Since precip can be assumed to scale with LWP and inversely with Nd, does the LWP-Nd variation in models correlate with precipitation variations in the models?

Ed: From what I have seen, it doesn't seem like there is a huge variation between precipitating and non-precipitating locations within the GCM. There might be some ways to better identify potential wet-scavenging driven cases though.

Lazaros: Can/should you separate in the GCMs the liquid clouds coming from the large-scale (stratiform scheme) and from shallow convection scheme?

Ed: That would be interesting - I am not sure how we could do that with the current output we have though. Perhaps something similar to your regimes would be a way forward (assuming we could show it works in one model at least!). Currently there is output for cf-cod-ctp type regimes from most of the models, but only at a grid-mean level, rather than the full histograms.

* Johannes: most GCMs do not diagnose convective clouds, only stratiform/large-scale ones (in terms of optical properties)

Ed: Would it matter for the detrained cloud? Perhaps that is not a real distinction for the model though

Velle Toll: constraint on cloud water response to aerosols (10min]  
Michael D: For the On-Off behavior, I wonder how much of the differences are due to limited detectability of small perturbations versus there actually being no perturbations under some conditions

Velle: Good point Michael. I agree that other cases are most likely perturbed as well. However, these strongest perturbations could matter the most in terms of radiative forcing in many regions, depending on how often they occur.

Nick Schutgens: why is the importance of open to close change not well known?

Velle: Closing of open cells has been observed in ship tracks and is documented in multiple studies. There we can compare the track and less polluted area about 10-20 km further away. But it is much more challenging to estimate how large-scale industrial emissions affect this as we do not know the unperturbed case.

Rob Wood: what criterion are you using to detect the tracks? Are you using r\_eff, some combination of near-IR and visible channels, or some other method? Does this choice matter? The reason I ask is that 2.1 micron is also sensitive to LWP, so selecting based on this may be also selecting for LWP

Velle: Good point. We have used NIR. In principle the Segrin et al method. I have tested reff and Nd, results remain similar.

Ed: Is there a selection effect, in that you identify them in NIR images? I don't have a good idea on how much that matters, but you could get a good idea with the industrial/fixed location sources

Velle: I first use MODIS RGB 3-6-7 available from NASA GIBS to select the cases. And then use 2.1 micron reflectance to classify pixels as polluted and unpolluted. As these perturbations we are looking at are very strong, the automated method does not throw away too many cases below defined perturbation threshold (2sigma).

Otto Hasekamp: Retrieval of Cloud Condensation Nuclei to Quantify Radiative Forcing due to ACI (10 min)   
Sophie Vandenbussche: [maybe a bit out of scope] what do you mean precisely with hydrophobic mineral dust not suited as CCN? I mean is this a common "type" of dust or pretty rare? Is there any way to distinguish it from measurements?

Our explanation is that particle sphericity is a good indication for the capability of an aerosol to take up water (and hence act as CCN).

Thank you. Must the particles be spherical or not to be good CCN?

Yes, that is what we find  
  
Dan: r\_lim will vary significantly with environmental conditions (e.g., number/updraft limited regimes), as will the associated susceptibility. How do you account for this? (e.g., under certain conditions particles smaller than the Dusek limit you referred to can act as CCN). See recent paper for sensitivity of smallest activated dry aerosol radius on environmental parameters using a cloud parcel model: <https://www.nature.com/articles/s41467-019-12982-0>

By choosing a rather large value for r\_lim we expect that we only include CCN particles which gives the 'correct' relation with Nd. The assumption is that it is better to exclude non-CCN (and missing some CCN) that the other way around.

Dan: I think that assumption will be quite dependent on the shape of the aerosol size distribution, and under certain environments might not hold - i.e., you miss a lot of CCN. You might be able to use the results in the above paper I cited to identify which regions the assumption is valid. I agree, that for most regions it is a better trade off to select a higher r\_lim value, but for certain regions it might not be optimum.

Betsy: has this technique been applied to the size distributions retrieved from aeronet? could then get values over land. (assuming the aeronet size distributions are comparable to the satellite size distributions you are using.)

We compared our Nccn to AERONET, see backup slides. Yes, AERONET can do this over land.

Hamish Gordon: is the aerosol forcing over land from models surprisingly strong? Naively I would have expected the effect of the higher land albedo to outweigh aerosol changes.  
There is really large variation among the models for the ratio RF\_global / RF\_ocean, from ~1.1 to >2

Thanks...I think maybe I misinterpreted the ratio - does 1.1 mean 10% of the RF is from the land, or does 1.1 mean the RF over land is 10% stronger than the RF over ocean?

1.1 means 10% comes from land

makes sense now, thanks!   
  
Marta Luffarelli: Aerosol retrieval in presence of clouds (10 min)  
Sophie Vandenbussche: I'm interested in the full reference for Larisa's work on Cloud Post Processing Scheme :)

<https://amt.copernicus.org/articles/10/491/2017/amt-10-491-2017.html> -- we use it in product generation

-> thanks!! I'll read that. Do you think it would be applicable also in infrared (IASI)?

It is based on 10 km retrieved AOD grid with spatial constraints.Yes, but the thresholds may depend on your resolution

Thanks again. I am printing the paper and will read ;) You'll know if I manage to make it work for me!

Andy Sayer: how does the CISAR joint (aerosol plus cloud) approach work - does the algorithm try both aerosol and cloud models and see what fits best (e.g. Optimal Estimation cost function)? or is it some sort of adaptive mask? What fraction of pixels are ambiguous?+1

Pekka: If I remember correctly, way over 10% (LS:21%) were in the twilight zone in our cloud/aerosol cci experiment (not retrieved either aerosols or clouds) (Andy: thanks Pekka!)

Marta Luffarelli: CISAR defines a solution space through the selection of 6 classes, 3 for aerosols and 3 for clouds. All classes are used in the same run (all 6 at once) and the through the Optimal Estimation method we find the "best" OT associated to each class.

Adam: I'd be curious to dig around the information content on that. (Would never have the time, but a man can dream.)

I'll be happy to notify you as soon as we publish a paper on this :)

Maybe you have a reference to provide? ;)

Marta Luffarelli: <https://doi.org/10.5194/amt-11-6589-201> here are the basic concepts of the CISAR algorithms are described, but without including clouds. A new paper should hopefully be published in the next few months :)

Bastiaan van DIedenhoven: What are the inputs to CISAR (e.g., wavelength bands needed)? +1

Marta Luffarelli: CISAR is applicable to any sensors, it is not based on any particular bands, However it does exploit the spectral response to build the prior information and clearly some bands are more "interesting" than others for building a good prior information on clouds. At the moment CISAR needs the acquisition time and geometry, the spectral response function, and model parameters, i.e. TCWV, TCO3, surface pressure.

Sophie: would your approach (joint retrieval) be applicable to other instruments? (In my case IASI)

Marta Luffarelli: CISAR is theoretically applicable to any instrument operating in the visible/ nir spectrum. so far it has been applied to SEVIRI, MVIRI, SLSTR, PROBA-V.

Sophie: OK, so not for IASI then unfortunately. Thanks

Anin: Is the CISAR applicable only to MODIS observations? Is it possible to port it to multi-angle polarimeters?

Andy Sayer: Anin - these data shown were I think SLSTR, which is a dual-view instrument. I know CISAR has been applied to SEVIRI (geostationary) too.

Anin: @Andy Thanks for the clarification. This technique seems very interesting considering the fact normal MAP aerosol retrieval algorithms take a lot of time to run retrievals for a whole scene.

Anin: @Marta What is the processing time for a single-pixel retrievals using the CISAR?

Marta Luffarelli: It is about 2s per pixel per accumulation period (16 days).

Duncan: Perhaps it's a silly idea, but is there any way of comparing optical depth (at a narrow wavelength) regardless of whether it was a cloud or aerosol (or something in between...!) between the satellite and models?

Adam Povey: Yes, but not many algorithms produce aerosol and cloud in a manner that's radiatively consistent at TOA, so it can be difficult to tell the modelers what they should be outputting+1

Duncan: OK, thanks.

Marta Luffarelli: @Duncan, indeed, one of the main goals of CISAR is consistency, as surface reflectance, cloud and aerosol single scattering properties are retrieved with the same radiative assumptions.

Lazaros Oreopoulos: How can one distinguish between 3D artifacts in aerosol retrievals near clouds from genuine differences in the properties of aerosols near and far away from clouds?

Marta Luffarelli: @Lazaros, very interesting question. I have to admit I need to investigate more on this.

Anin: A collocated observation of HSRL2 plus a multiangle polarimeters will be useful to study these 3D effects. ACEPOL 2017 campaign had 4 polarimeters + 2 Lidars onboard an ER-2 aircraft and I am sure that you can find some cases where this 3D effect is evident.

Lazaros: For example, aerosols near clouds may be subject to more swelling because of increased humidity. This can be investigated if some info on aerosol size (e.g., AE) is available (devoid of 3D effects!). See here: <https://modis.gsfc.nasa.gov/sci_team/meetings/201810/presentations/plenary/varnai.pdf>

Discussion (40 min): Ways forward to better constrain aerosol-cloud effects with observations  
Andrew: Yes, there are several things underway. Like with volcanoes as Michael mentioned. We intend to develop a database that could be used for GCMs.

Philip: @Ben: nice stuff on self-raising aerosol. Effectively this is the same as the well documented thermally direct circulation induced by absorbing aerosols? This is likely to only work in the tropics... c.f. <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL083479>   
Michael @Ben: What is the mechanism? are air parcels lifted on average?   
Philip: @Michael: I assume it is a large scale thermally direct circulation induced by the absorption... 

**Plenary Session 8 - compare model and satellite data: treating clouds, derived trends [90min]**

Moderator: Andrew Sayer

Rapporteur: Larisa Sogacheva  
  
Gunnar Myhre: model simulated historical (HIST) forcing and trends [7min]  
Rapporteur (R): main problem raised in presentation: Most CMIP6 models have too rapid global mean temperature increase over last decades compared to observations. How important contributor are aerosols to the differences between observations and CMIP6? Any change in the aerosol forcing over the last decades? Model diversity has been discussed; importance of measurements; multi-model perspective  
Yves: trend of natural vs anthropogenic aerosols. How to identify natural aerosols in the last decade?  
Mian Chin@Gunnar: Do you have gridded dimming/brightening data up to 201x to share? Do you have clear/all sky and direct/diffuse data?  
R: Michael promised to share data

We should contact Kine Moseid, who is doing this dimming/brightening comparison work (Martin Wild is involved and should know more).

Michael: Maybe worth to distill what we believe and what not from all trend papers, an overview paper would be nice indeed.  
Tero Mielonen: Which natural aerosols have a trend in recent years? Dust, sea salt or organics? And is it global or regional?  
Hongbin: MODIS observations show significant decline trend of dust in Gobi deserts from 2000 onward.

Hongbin: also, in NW Pacific. The trend is consistent with CALIOP observation and ADNet in Japan.

Tero: Thanks, Hongbin!

Wenying Su: comparing historical (HIST) trends with (CERES) observations [7min]  
R: summary: Consistency in observed clear-sky flux/DARE and AOD trends is very encouraging; Model simulation captured many notable aerosol changes derived from satellite observations, though at smaller magnitudes. Problem: emission dataset issues  
discussions: Michael - on surface albedo trend   
Kostas: can't you use CMIP6 data for this study? Do we need long AeroCom simulations?  
Jane Mulcahy: for sure there should be annual and even monthly data from the cmip6 models available.  
Pete Colarco: Do the CMIP6 models attempt to cope with the trend in surface albedo she is talking about?

Twan van Noije: to some extent: for instance, land use change is included, but vegetation is not interactive in all models; snow cover responds to climate changes

Michael: Can you be sure that the surface albedo trend observation is not impacted by aerosol trends?  
Wenying: @Michael, the consistency btw surface albedo trend and the TOA clear-sky SW flux trend also adds confidence to the robustness of the surface albedo trend   
Michael: very nice, what is needed from the AeroCom / CMIP6 models to make it a multi-model comparison?   
Wenying: @Michael, my wish list is monthly output from July 2002 to now, preferably on 1 deg by 1 deg spatial resolution.   
Michael: "every 5-year AeroCom output"... I think the CMIP6 historical simulations could be used. Models having done CMIP6 hist could be possibly motivated to add missing diagnostics, if any....

Kostas: Certainly!

Mian@wenying: SO2 decrease over China does not mean all aerosols have the same trend. especially if the model does not include ammonium nitrate.  
Wenying: @Mian, I agree, SO2 is just one piece of the puzzle of AOD.  
Paul Ginoux: Any reason for surface albedo decreasing over pretty much all deserts?  
Wenying: @Paul, not quite sure, will look into that!  
Twan van Noije: which anthropogenic emissions were used in the model? CMIP6/CEDS?

Gunnar: Yes, the CMIP6/CEDS emissions.

Mian @Gunnar: CEDS just released an updated version of emission that covers the more recent years (to 2019).

Kostas: This is still beta, and they have not released gridded emissions yet (although they are available on request by Steve).

Steve Smith: Yes, we have a pre-release version out until 2019 for comment and testing.  We'd appreciate any comments so we can try to address any issues in the final release.

Susanne Bauer: Very nice talk, we compared also the trends in the GISS model to AOD and CERES you can find the results here: <http://dx.doi.org/10.1029/2019MS001978>  
Larisa Sogacheva: AOD monthly satellite merged 1-deg resolution product : <https://doi.org/10.5194/acp-20-2031-2020>, data access: <https://nsdc.fmi.fi/data/data_aod>  
@Larisa, the point of the study is not just look at AOD but also adding other constraints to the comparison (i.e., TOA flux and surface albedo).     
Susanne: Does anybody has an understanding of the reasons behind the trend we see over Pakistan? In AOD and radiation? Its opposite from India and I never found a good explanation in the literature. Irrigation was one thought, but no idea if that is the cause.

Yang Yang: modeled 1980-2018 trends over E.Asia [7min]  
R:Constructing long-term PM2.5 based on machine learning   
Visibiity data in ncdc archive <https://www.ncdc.noaa.gov/paleo-search/study/23410>  
Gerrit: before 2000, there is ATSR-2 (1995- 2002), AVHRR, and MERRA

Pete Colarco: MERRA-2 is a model reanalysis, assimilating AVHRR-derived AOD. Skeptical of its utility to understanding trends here.

Andy Sayer: also, SeaWiFS from late 1997-2010. Although the last update to the SeaWiFS Deep Blue product was 2012 and there's no funding to revisit it. I would like to if there were an opportunity. I do like SeaWiFS because it can help bridge some of these gaps and extends the early-afternoon record back a few years (as ERS-2, Envisat, Terra are all AM). AVHRR is early PM too but quite different bands.

Claire Ryder: Are the station data (specifically for visibility) publicly available?

Paul Ginoux: Check Mahowald et al. Global trends in visibility: implications for dust sources, 2007 in Atm. Chem Phys. This may be the most extensive use of visibility for dust research

Claire: Thanks Paul, will check that out. See also my point below with a publication linked.

Kostas: Yes, but the data are not as simple to interpret as other datasets.

Paul Ginoux: Indeed, you have to visually check any time series for all stations as jumps may appear when the person in charge of measuring visibility has changed.

Kostas: or the point of reference changes.

Rob Levy: I have had some experience with automated airport visibility data: doi:10.1016/j.atmosenv.2013.08.050..   But it was easy access for the U.S.  and would have to think about before that era.

Claire: Some similar (same?) station visibility data has previously been published wrt dust (<https://www.sciencedirect.com/science/article/pii/S0169809518308688)> - looks like it should be useful for longer term dust evaluation in China. But accessing the data appears tricky.

Mian Chin - 50% decrease of PM2.5 after 2014 from 1980 level does not seem realistic. Air at the surface now is much dirtier than that in the 1980s from my own eyes and nose...

Zhining Tao - PM2.5 before 2010s was constructed based on visibility data, just like linking AOD to PM2.5, I suspect that visibility ~ PM2.5 relationship is very complicated.

Svetlana: Looks like this 50% PM2.5 reduction is in summer, while the annual mean shows like 20-25% decrease

Sabine Undorf: Would the strong recent decrease, if real, indicate a large role for non-local emissions, a decrease of which would have mostly compensated for an earlier increase in local ones symmetric to the visible decrease?   
Larisa Sogacheva: satellite seasonal AOD trends in Fig. 7 <https://acp.copernicus.org/articles/18/16631/2018/>  
Yang, what are the uncertainties in estimated PM2.5 using machine learning algorithms from AOD?  especially on the higher end?  
  
Ryan Kramer: Observed aerosol forcing trends over the A-Train satellite era (7 min)  
R: conclusions :   
- Nearly all of the increase in CERES-observed TOA radiative imbalance is due to an increase in instantaneous radiative forcing of roughly 0.53+/-0.11 W/m2  
- Roughly 0.1+/-0.05 W/m2 of this increase comes from SW aerosol radiative forcing  
comments: increase in radiative forcing from GHG  
Mian: feedback maybe estimated wrong  
Mian Chin: There is a strong decrease of SW IRF over Sahara - dust has increased? This does not seem to be consistent with AOD trend there?  
Ed: Very nice Ryan - similar to Mian, what is going on over the Pacific in MERRA?

Ryan: As I said on the Webex, Sahara "may" be kernel/AIRS error in diagnosing the feedback. Not sure yet.  MERRA Pacific forcing is apparently sea salt. But the MERRA folks think it may be a misclassification by the reanalysis. Also looking into that.

Michael: nice indeed, can you point to the papers describing the methods?

Ryan: My specific work is not published yet but I'll try to get a preprint out soon.  General kernel method is in Soden et al. 2008 <https://doi.org/10.1175/2007JCLI2110.1>. We also used CloudSat-based kernels described here <https://doi.org/10.1029/2018JD029021>

Michael: Do you think the small positive aerosol trend is consistent with e.g., AOD trends?  
Ryan: Generally yes, but would be good to quantify this a bit more. Especially regionally to understand some of the discrepancies mentioned above..  
Ed: Can you link this trend to the overall magnitude of the RFari?  
Ryan: Bellouin et al. puts observed RFari between -0.37 and -0.12 W/m2, so my +0.1 W/m2 from 2003-2018 is a big (opposite) chunk of that, but seems consistent with CERES-Match trends e.g. <https://doi.org/10.1002/asl.975>  
Michael: Have you compared your analysis with Wenying Su's analysis (which uses the same data)?

Ryan: Same CERES fluxes, different way of getting the forcing, but yep they look consistent, including the albedo trends she saw

Nick Schutgens: An AEROCOM/AEROSAT study: evaluation of global models with satellite AAOD and SSA (7 min)   
R: summary:  
  - AERONET may not provide globally representative satellite eval.  
  - Significant biases in satellite products  
  - Model biases are often larger so satellite data are still useful  
  - Phase II low AAOD appears due to emissions (30%) and MACs (50%)  
  Nick's message - satellite diversity can be an estimate of the satellite uncertainty  
  Comments on spatial sampling of AERONET, availability of other SSA and AAOD  products (MISR, Sentinel/AATSR, MODIS over land)  
Mian: what is the detection limit for AAOD and SSA? Uncertainty levels?

Nick: Sinyuk recently published AERONET AAOD & SSA uncertainty levels at different AOD. However, they make no statement as to the nature of the errors: will they behave as biases or random errors. Our upcoming paper will show agreement between datasets as function of AOD and temporal averaging. Unfortunately, I have not found a single value that might serve as your detection limit.

Michael: repeating the question from Yves: How shall we use AAOD from Aeronet and satellites? Have we made progress here?

Nick: there is a lot I did not talk about, e.g. over source regions there is a clear correlation between model BC emissions and AAOD. We can use observed AAOD to infer BC emissions this way.

Greg: Oleg's group has done some work in this area. e.g. <https://doi.org/10.5194/acp-18-12551-2018> and <https://doi.org/10.5194/acp-19-14585-2019>

Nick: Thanks Greg, I'm familiar with that work. We're working on something very similar but using a different dataset, model and assimilation system: <https://acp.copernicus.org/preprints/acp-2020-468/>

Oleg -- yes, I had seen that. Looks very nice. One comment that I believe that I had mentioned before. If using V3 L1.5 AERONET, be sure to check that the flag if\_Lev2\_except\_AOD\_threshold = 1. Otherwise, the L1.5 retrievals will sometimes be based upon very few scattering angles.

Ralph: The MISR dataset (Version 23, which is current) is freely available from the NASA Langley ASDC

Felix: ASDC has changed their website links. If the above link doesn't work, try: <https://earthdata.nasa.gov/eosdis/daacs/asdc> or <https://asdc.larc.nasa.gov/>

Andy Sayer: Ralph, Felix - to decrease the download overhead, Nick had asked groups to provide data in a specific consistent format (basically a re-gridding to common resolution and variable naming conventions). Similar to his AOD comparison from a few years ago. It may be that the team just didn't have time to provide him the data.

Nick: actually, I have often spoken with Ralph and Mike about MISR, but I guess they were busy with other jobs and could not participate

Ross H: did you do the analysis on a regional basis too? do the conclusions still hold or are there compensating differences between regions? (or would you expect that to be the case…)

Nick: Yes, over individual regions, the differences between models and observations are usually larger than in a global sense. Uncertainty due to disagreement between datasets does not increase that much. So, this analysis is useful in a regional sense as well.

Yves: What was your point about the 2 products from Polder SSA, are they systematically off by 0.04 or 0.05 in SSA? You seem to say that if we explained why, this could be a giant step. Can you explain better? thanks

Nick: they have a mean difference of about 0.044 in SSA. Their differences consist of both random differences and a constant difference (bias). The latter is 0.044. Random differences can be averaged out so identifying (and hopefully resolving) the constant difference will improve agreement between the datasets. If this resolution is physical, I would bet it also improves the datasets vs the truth.

Sebastien Garrigues: AOD monitoring within the CAMS data assimilation (7 min)  
R: Needs for new observational data streams and use of data assimilation system to evaluate aerosol satellite products are discussed. Potential of DA system is in consistent comparison of multi-satellite and simulated AOD; identifying spatiotemporal deficiencies in satellite AOD products; evaluation of the observation error. Strategies for assimilating multiple satellite AOD are bias correction, adaptive thinning, etc. The impact of satellite observation diversity on the analysis has to be assessed. Further documentation is needed on uncertainty in each individual AOD product; multi-satellite product consistency/discrepancies; spatiotemporal structure of observation uncertainties (spatial and temporal length scales). Collaboration with AEROSAT is important in that activity. Need for more NRT products  
Mian @Sebastien: we have used CAMS forecast data and found AODs are normal, but the component concentrations are a bit strange, especially at higher altitudes. Have you looked aerosol components?

Zak: Yes, the operation of the data assimilation (which sees only column-integrated total AOD) tends to produce artefacts in the aerosol speciation and vertical distribution, even as it improves the total AOD. This is something we're considering how to address.

Sebastian, the VIIRS data we gave is 750m pixel level data.  You said 6 km.  Is this VIIRS data from somewhere else?

Andy Sayer: Shobha, I am guessing they used VIIRS Deep Blue as that is 6 km and also near real time. VIIRS Dark Target is 6 km but not sure if they have NRT yet. This ties to Bertrand's point that we should try to keep clear which exact products and versions we are using when we present.

Istvan Laszlo: Andy, the slide says NOAA-EPS VIIRS, and also lists the algorithm version number as v2r1, which is the NOAA enterprise VIIRS AOD algorithm at 750-m.

Andy: Thanks Istvan! I do not know why it would be 6 km then. Hadn't spotted that.

Paul Ginoux: Is your assimilation methodology (assimilate AOD and assume the model is right for aerosol composition and vertical profile) similar to what Phil Rash did 20 years ago for INDOEX? Rash et al. (JGR, 2001):  <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2000JD900508>

Zak: I'm not familiar with Phil Rash's work, but yes, the analysis increment preserves relative proportion of species (at the point of application, but of course increments to some species have a much longer lifetime than others, causing an imbalance). Vertical distribution of the increments is through the usual 4DVar cost function depending on the model-error covariance matrix e methodology is essentially still as described in Benedetti et al. (2009).

Hongbin: @Paul good point. Models need to be reasonable in characterizing species (or at least types). Then people can have confidence in components from the data assimilation.

Adam Povey: There's a surprising amount of structure in your zonal averages of the MODIS products, especially relative to the other sensors. I'm in the middle of making an equivalent plot and haven't seen such peaks. Any idea where they come from? +1  
Thanos Tsikerdekis: Great presentation! A question tied a bit with the previous presentation about absorption. Are you planning to assimilate into CAMS other kinds of observations (except AOD), like Angstrom Exponent or Single Scattering Albedo? (e.g. from AERONET). Although the evaluation of the effect of this would be impossible, it would certainly help with the speciation of aerosol particles.

Zak: AERONET is extremely sparse spatially to use for assimilation; in principle we'd like to get other types of observations into use, more likely from satellite, but Sebastien probably knows much more about the practicality.

Thanos: Indeed, AERONET is sparse and useful for independent evaluation of the system.

Zak: yes, independent validation is the other reason we've preferred to keep it out of the assimilation so far.

Thanos: If you are planning to go to historical periods, POLDER/PARASOL and OMI might be useful for SSA.

Zak: thanks - our focus is primarily on near-real-time work as a forecasting center, but better historical observations may certainly be useful when it comes to the next version of the CAMS reanalysis (or where similar operational instruments are expected to come online in coming years).

Thanos: Exactly what I had in mind the next CAMS reanalysis :)! Also, the PACE mission will carry similar multi-angle polarimetric instrument to POLDER that will provide absorption retrievals. Maybe they can be useful for near-real time assimilation.

Andy Sayer: I should caution that the latency of the PACE polarimeter data will depend on the computational overhead of the retrieval algorithms. There is no formal requirement for polarimeter level 2 data production. If there is a demonstrated use for it (globally and/or NRT), it could become a higher priority. There are prototype algorithms from the HARP2 and SPEXOne teams and we're working together to evaluate the computational burden. It is generally much higher than traditional algorithms due to the higher dimensionality and also online RT vs lookup tables. There are also various efforts in development from the funded Science Team.

Thanos: Thank you for the comment Andy. From the discussion of the last two sessions I am getting the feeling that complementary observations to AOD (e.g. AE/AOD other than 550nm and SSA/AAOD) would be needed. From retrievals point of view, I am not an expert, my colleagues (Otto Hasekamp and Guangliang Fu) work on SPEXone prototype retrieval algorithms and they may know more about retrieval algorithm burden. But from a data assimilation point of you I would certainly prioritize the development and use of these retrievals.

Zak: :-) We haven't really started planning for that yet, but (assuming there is a next phase to CAMS!) it's something that we expect to happen. I think there's a lot of potential to something like PACE, yes, although quite a lot of development work on observation operators etc. will probably be needed to make use of it.

Thanos: Indeed, that is true. Thank you for the discussion and the info!

Zak: Thanks too - you're welcome!

Istvan Laszlo: The NOAA/VIIRS AOD algorithm is almost identical to the MODIS algorithm over ocean in terms of aerosol models used. Solution of the radiative transfer and internal test used to select pixels for AOD retrieval are, however, different. These, and differences in cloud mask and input TOA reflectances, will inevitably lead to differences in the retrieved AOD. This is true even for instruments from the same family. For example, the NOAA-20 VIIRS TOA reflectances have been consistently lower than those from S-NPP, resulting in smaller NOAA-20 AOD over ocean. Interestingly, evaluation showed that NOAA-20 VIIRS AOD agreed better with AERONET AOD.

Andy: thanks for the note about SNPP vs. NOAA20!

Discussion (50 min): Best practices to integrate information from satellites and modeling  
What are conditions of high / low consistency within satellite data / modeling and between both?  
Development priorities to improve on some of them  
Best way to compare different products and resolve differences for data assimilation  
  
Sabine Undorf: I have a question/comment on the suggested focus on discrepancies: Do we understand enough as to why datasets agree where they do and don't? if not, would  someone who finds it more important not to underestimate uncertainty/erroneously identify something non-robust as robust, put as least as much effort in scrutinizing where datasets do agree?

Adam: I don't think there's much understanding of why datasets disagree in some areas. (I'm looking into it and was surprised that there was nowhere that all of the data I was looking agreed; I'm adding SeaWifs and MAIAC to see if that remains true.) The ORAC team typically blame disagreement on differences in cloud flagging.

Tero: I think typical situations for poor agreement are linked to bright surfaces, low aerosol loads, unexpected aerosol types (e.g. smoke plumes in locations where you don't usually have smoke), thick aerosol plumes masked as clouds, etc.

Andy: I think Sabine's point is to look at the flip side: if there is good agreement are they all right? And are they agreeing for everything or just mid-visible AOD?

Tero: OK, that makes sense. They could agree for the wrong reasons like models sometimes do :)

Rob Levy is running his DT algorithm on multiple sensors.  What is he seeing?  When you run same algorithm, you eliminate any algorithm dependent differences. Rob?

Adam: ORAC has also been run on several instruments (ATSR, SLSTR, SEVIRI, on a good day MODIS) but it doesn't make things much clearer. (Issues with calibration and gas lines remain.) The DT team might have had more time to pick the results apart.

Pekka: How is ORAC handling the SLSTR geometry? We have issues with NH geometries

Tero: Also, the FMI's ADV algorithm runs on ATSR-2, AATSR and SLSTR but I don't know if these instruments have any overlap in time series.

Pekka: there is overlap between ATSR2 - AATSR. Results with over land time series very good. Over ocean we had to make some adjustments due to calibration differences

Andy Sayer: Rob's team recently had a paper (led by Virginia Sawyer: <https://www.mdpi.com/2072-4292/12/2/308> ) comparing VIIRS and the two MODIS for DT. The short answer seemed to be some regional offsets linked to calibration and band differences (e.g. 488 vs 488 nm, 2.1 vs 2.2 micron) and sometimes spatial resolution. Even Terra/Aqua has a roughly 0.01 offset over open ocean. In general, though, the spatial and temporal patterns seem very close. I think things like larger offsets over Australia are primarily algorithmic than sensor-specific. I don't know how different the GEO data are but guess the different geometries could also led to larger differences.

Michael: it would be nice to concentrate a bit on (anthropogenic aerosol dominated) AOD trend consistency among satellite products... What is the assessment here?  
Wenying, @Michael, I think most of the data agree over US/China/India. I would emphasize using independent datasets and not only focusing on AOD.  
Michael @tall I would be interested to learn who is working on the "stability" of bias over time between different satellite products?

Andy Sayer: It seems to be up to individual teams. While on Deep Blue I included analysis of bias vs. time for MODIS Terra, Aqua, and VIIRS against AERONET. Results for "all sites" and "long term sites only" were fairly consistent. However, this is an assessment only at AERONET sites, not global. See section 3.7 here: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018JD029598>

R: discussion points

- Australia. does strong disagreement relate to certain conditions?

TP: for assimilation, bias correction is needed. How to simplify that process?

Sebastian: more documentation about the discrepancy between products is needed

TP: what do you need to qualify datasets? which kind of validation has to be done by data providers?

Adam: For trend evaluation, AERONET might be not representative; MODIS might be high

Bertrand: Combination of different satellites; Limit of validation data over the Southern Ocean; Different algorithms, performance: when we describe discrepancies, which also we should refer to?

Yves: Australia, high albedo region

Angela: expertise from retrieval community is critical; need to work with data providers; work on L2 reflectances/radiances assimilation is in progress, assumptions are all consistent in that case, first results are good

Michael: contribution of uncertainties in satellite retrievals to trends; if offset is systematic, bias is not important

Linlu: long-time trends seem to be reasonable also with less accurate (low quality) products

Others: usage of quality flags provided in the products; clear documentation is important

**Plenary Session 9 - Spectral dependence of AOD / constraining aerosol type [90 min]**

Moderator: Thomas Popp

Rapporteur: Marta Luffarelli  
  
Kostas Tsigaridis / Lucia Mona: Simulating instrumentally defined aerosol type(10min)  
Ed: Is the clear-sky AOD the AOD calculated without aerosol humidification/cloud effects or is it also sampled in low cloud fraction grid boxes? Those definitions may also differ if large scale airmass properties cause aerosol and cloud to be correlated

Kostas: This depends on the models, but my understanding is that they report ambient AOD (so humidified) at clear-sky conditions, based on whatever definition they have.

Hongbin: how to calculate clear-sky AOD in models?

Toshi @ Hongbin: It is not clearly defined. We should define it at least in the multimodal comparison.

Toshi: MIROC-SPRINATRS makes the clear-sky AOD by picking up all-sky AOD from grids where the 2-D cloud cover is less than 0.2 every time step.

Kostas: I hope to attack this question in the near future.

Michael: @Kostas- I don’t think you know well all models that provide clear-sky AOD / if models provide "just" AOD it may be Clear-Sky or All-Sky AOD!!! I agree asking models to provide clear sky AND all sky AOD might resolve some questions here. (see also Gliss et al. 2020 ACPD revised manuscript on that)

Kostas: When there is od550aer and od550csaer, I would expect that people report all-sky in od550aer, no?

Mian: But the time/location of clear sky would very likely be different from the real world. Also, satellite is a snapshot while model has certain time window.  
Mian: Also, models have different spatial resolutions and different definition of clear sky (e.g., cloud fraction threshold)

Kostas: Absolutely. In long-term means (e.g. monthly or longer) this should diminish, but it is a real issue. Colocation is important.

Michael: Also: humidity used in the clear and all sky should be documented.

Kostas: Agreed. Also, what the decisions are in partial-cloudiness cases.

Peter Colarco: We have been working on observation simulation like this for quite some time. A similar example relevant to this group is Ed Nowottnick's paper on the CALIOP type definition, as reconstructed from MERRA-2 model output. <https://amt.copernicus.org/articles/8/3647/2015/> This is useful for interrogating the satellite retrieval algorithm assumptions too.

Kostas: Thanks! I'll take a look. I want to repeat these plots following several different definitions.

Mian: Also, what is the "type" are we after? Composition? Size? Source origin (anthro vs natural)? Scattering vs absorption? Fine vs coarse mode? Or whatever?

Kostas: we can't ask the satellites to give us the type we want, so the models need to adopt to whatever types each instrument is able to identify.

Ralph: Mian -- We retrieve what we can.  These are optical constraints on particle spectral AOD (interpreted to first order as size), shape, and SSA in most cases.  The rest is interpretation, sometimes informed by relationships to sources (e.g., wildfires, deserts, etc.). We make some simple associations, e.g., non-spherical might be dust, especially if associated with a desert source, but the rest needs to come from models or other assumptions.

Ralph: One question about whether there should be a focus regarding aerosol type on severe events, such as major wildfires or volcanic eruptions.  Those are places where the "usual" type can be overwhelmed. Those are also places where AOD can be large and regionally or globally impactful (also easier to retrieve "type" in higher AOD plumes). +1+1

Andy Sayer: Ralph, I agree with you. This partly motivates my presentation (breakout 8, plenary 13) as well as some other stuff I am independently working on.

Kostas: Agreed. We are only starting, so much to do!

Zak: I think it's to be expected that resolution differences show up less in column quantities (which are mostly what we can observe from satellite) than perhaps for in-situ quantities in source regions or strong plumes. But it's certainly a good question what resolution gives us, since it always has to be traded off against other things (like a more detailed size distribution).  
Shobha: GISS model missing dust outside of Sahara (China, middle east) surprising.  Capturing synoptic scale features by all models not surprising.  Especially if source terms are the same or similar.  It is really specific events when you zoom in you will begin to see differences, no?

Kostas: Note that these plots are not where the dust is, but where the AOD and AAOD of dust is. If the selection criteria say something about absorption, the model might miss it if the model assumes less absorbing dust.

Santiago: when you talk about fine mode fraction are you talking about columnar FMF as in satellite retrievals or in the microphysical sense like FMF per unit volume?

Kostas: Column FMF as retrieved by the satellite. Same calculation as total AOD, but only taking into account the fine mode aerosols, as if coarse does not exist.

Greg: The Lee types here are pretty basic, and based mainly upon FMF. So, although the results are encouraging, I would hope that the models can do this. Nice talk. +1

Kostas: Thanks! I was more pessimistic when I started this, and got pretty excited to see that (if anything) the models capture the structure.

Tero Mielonen: Comparing aerosol types in climate models and satellite retrievals (5 min)  
Alcide Zhao: is it possible to extract a dust AOD from the FMI AOD?

Pekka: It is possible but we would have to extract it from our raw data.

Alcide Zhao: @Pekka, I will contact you after this. We (me, Claire Ryder, Laura Wilcox and our colleagues at Reading are very interested in using it for model evaluation work.)

Pekka: There was an action for us to provide dust AOD but now I cannot remember if it is already in the product. I will check

Mian Chin: this is CALIOP-like definition of aerosol type. But nothing here is 100% and how models deal with this is an art or philosophical work. For example, "mostly dust" - is it 99% or 51%? optical based or mass based?

Tero: I totally agree on philosophical side. As the examples show, the models disagree quite a lot regarding the types but the actual differences in optical properties can be quite small. For example, one model might have a SSA value of 0.94 and the other 0.95 but otherwise the properties are the same. This would mean that the aerosol types are different but in reality, the models agree really well. So, as a first step I would be happy if the models and satellite data would agree on the most common aerosol type regardless of the percentage of the type. And yes, these are optical based. When I used only 4 aerosol types in the analysis, the agreement improved but there are still interesting differences. So, we are now looking into the SSA, AE and AOD histograms in different regions to understand the reasons for the differences better.

Michael: slide 5: are the type cases really so cleanly separated on the scales used?

Pekka: No and here more robust classification is needed

Michael: Are there any cases which are just not classified?

Pekka: Yes, and this is partly why we also did an exercise with the limits Kostas was showing

Greg: Russel JGR 2014 did this as well. There are multi-dimensional spaces that need to be considered, not just SSA and EAE. I am not sure if the Hamill paper did this or not. If you apply the full Mahalanobis classification scheme to the models, you might get a different result. See Russell, P. B., et al. (2014), A multiparameter aerosol classification method and its application to retrievals from spaceborne polarimetry, J. Geophys. Res. Atmos., 119, doi:10.1002/2013JD021411. Really enjoyed the talk, Tero. I like the idea of applying the retrieval typing schemes to models.

Tero: Thanks, Greg! Yes, I'm familiar with Russel's paper and I agree that "proper" typing cannot be done with SSA and EAE solely. This was just the first step and we are now thinking how to improve from here. And this is something that I've been discussing with Antti Arola for years :D

Yves: Where did you infer that SSA is less than 0.94 for 550nm for dust. Is it cause by the optical properties you chose in the model or are you using measurements  from campaigns? If campaigns can you say from which datasets you are starting? thanks

Pekka: it is coming from some conference presentation for AERONET classification. I don't recall which, sorry

Gerrit@Pekka: Is Dust still prescribed by the Kinne climatology?

Pekka: yes, it is, as pointed in the slide, but the mixture with fine particles is retrieved

Gerrit@Pekka: Sorry, I missed that. L

Pekka: No worries. Speed is quite high :)

Larisa Sogacheva: Comparisons of satellite AOD at multiple wavelengths (5 min)  
Michael: Can you remind me: Why is the spectral AOD "better" than the AE for comparison to models?

Andy Sayer: AE is often a gradient of small numbers, so uncertainties propagate differently. When AOD is low, spectral AOD is probably more useful (as we care most about absolute AOD). Also, AE is an approximate metric for spectral curvature while spectral AOD is more direct.

In analogy we are discussing AAOD AND SSA as well... so I am just thinking we should still evaluate also AE.

Andy: good to evaluate as many parameters as practical :) Likewise FMF and fine/coarse AOD.

Hongbin: MODIS FMF is not a standard product over land.

Andy: agreed - it is in the files though (for VIIRS Dark Target at least, not sure about latest MODIS Dark Target). Also, important to note for MODIS over land it is a fine MODEL fraction and not a fine MODE fraction. Also, over water it is fine mode fraction under the single scattering assumption, so breaks down when AOD is high.

Yingxi: We are talking about putting the FMF back into MODIS over land product, so people know how to use them can have access. However, we want to have a good way to prevent users to use them incorrectly.

Kostas: If users don't read documentation, there is not much you can do about it.

Shobha: Just a FYI that NOAA VIIRS does not report FMF over land.  Andy, presuming you are referring to NASA VIIRS product

Andy: yep, Dark Target. (and I should note too that VIIRS Deep Blue has no fine mode fraction over land, but does over water).

Ralph: It is useful to distinguish between retrieval algorithms that report generic properties (size, shape, SSA, SSA spectral slope; e.g., MISR) and interpretive algorithms, that jump directly to a compositional constraint (pollution, dust, etc., e.g., CALIPSO), which requires additional assumptions.  
Mian Chin: I think "aerosol type" is a descriptive quantity and cannot be quantified. Maybe this should be treated as some kind of "index" rather than quantitative comparisons between model and satellite.  
Ralph: This might be worth pursuing. Also, as some models are attempting to assimilate radiances, perhaps a middle ground can be found to interpret the information content from the satellite in terms of the generic properties first (maybe within the model itself, to benefit from consistency, as Angela mentioned today), and then use the model to make further interpretation based on source-receptor relationships, etc., in a self-consistent way.  
Rob Levy: I can't figure out what to write here, but I will discuss with a group at later date.  Dark Target provides some information about the models chosen, and probably the information you need can be back-calculated, but it's not easy.

Andy: it's missing in the VIIRS Dark Target now. I know there is a balance between completeness, data volume, and user misuse. So not sure what the best solution is. Maybe we need two output file sets: one that is comprehensive, one that is only QA-filtered AOD, latitude, longitude?

Yingxi: two output files might be too complicated and doubles the processing time. I don't know if writing a note in the parameter description will work? I don't know how many "new" users actually read these before use the data.

Andy: yeah, I know. Shouldn't double processing time though, you could just write two files from the same processing chain? The MISR product file contains a second group called "auxiliary" where they put all this extra data sets. That is nice as it requires the user to dig a bit, but a lot of info is there.

Rob Levy:  I am willing to discuss. It keeps me up at night trying to decide what diagnostics should be reported, and the balance of providing information to be misused.   (all keeping file size in control).

Gerrit @Yves about 1 size distribution that is observed: even ground-based instruments have discrepancies, even when using the same type of instrument (optical or other physical principle)

Claire: Regarding dust - there has been a shift towards understanding the prevalence of coarser particles in recent years - due to better/improved processing of optical measurements, and use of measurements not based on scattering, and avoidance & better understanding of the biases of observations made behind inlets.

Discussion (70 min): How can we progress on constraining aerosol type with satellite observations?  
Peter Colarco: To the general discussion, our group has done some work to try to bridge the gap of the models. Here are the two papers I mentioned: Ed's on the CALIPSO typing algorithm: <https://amt.copernicus.org/articles/8/3647/2015/> . And my own modest contribution to understanding the OMI AI algorithm: <https://amt.copernicus.org/articles/10/4121/2017/>. And various papers by Gala Wind, Patricia Castellanos, Virginie Buchard... +1  
Rob Levy: Yay for OSSEs!  Also, assimilation: One thing we provide within our product are the "radiances" used for the coarse-resolution dark-target retrieval. If they have been cloud-cleared correctly (and that is a big "if"), and sufficiently corrected for trace-gas absorption, and they are sufficiently representative of coarse resolution scene (also "ifs"), then models can use these radiances and fit their own aerosol optical properties and assumptions.     
  
Greg: Just wanted to say that the satellite types are empirical, and often based upon location (or altitude, as with CALIPSO). Thus, it should be easy for models to get the type correct in regions where the types are defined. Dust in Africa, urban at AERONET sites located in cities, Biomass burning in S. Amer and Africa. Marine over ocean, unless it is elevated. The trick is getting it away from these areas with clear types. So, I would like to echo Mian's point that we need to quantify the "mixed" types to make some progress.

Andy Sayer: Greg, I agree with you. Speaking for myself, part of this is coding logistics. Constraints on RAM, CPU, and dimensionality from lookup tables. Some can be overcome with clever coding... but some of us (me) are not proficient enough to implement more comprehensive approaches without unfeasible overhead. Need to find time to learn some better coding skills. Training a neural network to replace a lookup table is a good option, I think. I guess what I am getting at is that algorithmic assumptions are motivated not only by satellite information content but also programming concerns.

Greg: Right, but aren't we always stuck with assuming certain optical properties represent our "pure" species, and that 1) how often are we truly observing "pure", and 2) how to handle different species with overlapping optical properties. AAE is my favorite parameter to be up on, for instance. And then how to quantify the mix when we get away from pure regions.

Andy: yep, you are right. But I think we can relax some of the assumptions about mixtures of these pure components with clever coding. Which will help in the mixed case. E.g. take model components and retrieve weights of those, rather than the current optical models.

Ralph: Andy -- This is what we do with the MISR Research Algorithm, as I think you know.  The \*aggregate\* of retrieved components we interpret as the "Retrieved Effective Particle Size" (REPS) and "Retrieved Effective Particle Absorption" (REPA).   The amount of particle-type information in the radiances varies with observing conditions, much more than for AOD. We report what we can – sometimes just a constraint of non-spherical AOD and none for SSA, for example.

Andy: yes, exactly. :) But other retrieval products don't do that level of detail. I think this is partially a coding issue. Can be overcome but needs big rewrite of retrieval codes.

Greg: I wonder what would happen if we created the Hamill/Russel diagrams (SSA vs EAE, etc.) with the models. Would we get similar separations?

Ralph: to Greg -- with MISR we do NOT make any geographical assumptions in our aerosol-type retrievals.  The whole point is not to "report" what we think we already know without any measurement constraints, but to report whatever new we can offer from observations. Also, aerosol type can be retrieved most reliably near-source, where the AOD is high enough. For MISR, AOD >~ 0.15 or 0.2 is needed under typical observing conditions to obtain good constraints on aerosol type.   
Greg: Ralph -- I was referring to the Hamil plot that Tero showed which was not based upon MISR. Also, the CALIOP discussion, which uses location and altitude for almost everything except dust (where they use linear depolarization ratio).  
Ralph: Ok, Greg. I agree.  I just noticed there was some confusion between MISR and other aerosol-type products in several talks and comments, so I wanted to clarify.  We've put a lot of work into offering what we can with MISR in terms of aerosol type with a minimum of assumptions, and with a clear understanding of what these assumptions are.  
Greg: The problem still remains, though. We know there is dust over Africa, etc., so we don't need to know the type there. We need to be able to quantify the amount of smoke vs dust over the Atlantic, for instance.   
Ralph: Agreed.  We actually did this very thing, distinguishing smoke from dust, with MISR, for example, in the following paper: Guo et al. (2013; JGR., doi:10.1002/jgrd.50409).   
Greg: Thanks Ralph. Cut and paste of the link did not work. :(  I'll send you the paper...  
Greg: Nice -- thanks! So that is dust and smoke, so now all we need is marine and urban. Would be nice to have smoldering/flaming or dark/light smoke, too. Or smoke with high/low BrC/BC ratios. Great that you quantified those two types, though.  
Ralph: Greg -- With the MISR Research algorithm, we distinguish in wildfire plumes small, spherical, strongly light-absorbing, and spectrally flat absorbing particles from small-medium, spherical, moderately absorbing and spectrally steep particles as Black Carbon and Brown Carbon, respectively.  An example of this work, with coincident aircraft validation during the BBOP campaign, is in this paper (Junghenn et al., Remt. Sens. 2020 doi:10.3390/rs12050769).  Similarly, in volcanic plumes we distinguish ash from sulfate, and can see changes in REPS and REPA that we then interpret in terms of particle evolution (size-selective and size-independent deposition, particle hydration or coating, secondary aerosol formation, etc.).  An example is Flower & Kahn (JGR 2020, doi:10.1029/2019JD031625). Plumes have high enough AOD so we have confidence in the particle microphysical property retrievals; the interpretations in terms of particle composition or evolution are a second step, with lower confidence, but we have validated where possible.  
  
Dave W: a late follow-up on the CALIPSO typing algorithm - in Version 4, the only location information we use is land/ocean.  If we're over land we assume there is no marine aerosol (which is not always correct), and over ocean we assume marine unless it appears to be another type.  In Version 4 we've added a 'dusty marine' type to flag dust-marine mixtures.  With more effort, we could quantify the dust fraction.  The original purpose of our typing algorithm was to estimate an aerosol lidar ratio.  It turns out CALIOP can't really distinguish between fine mode pollution and smoke, but they tend to have similar lidar ratios so that is not a big problem for our aerosol extinction retrievals. The actual type information in CALIOP signals is quite limited.  For ACCP we hope to have joint HSRL-polarimeter observations which will have substantially more information on type.  
Ralph: So, Dave, clearly the Omar et al. (JAOT 2009) paper giving the CALIPSO typing scheme is outdated.  Is there a new reference?  
Greg: There is a V4 special issue at <https://amt.copernicus.org/articles/special_issue903.html> . The paper you want is <https://doi.org/10.5194/amt-11-6107-2018> , Fig 1. No Snow/Ice decision box anymore, but there is still an altitude decision box at Z=2.5 km in a few places.   
  
Michael: following Yves idea: Any volunteers for a Commission on Constraining Aerosol Properties? (setting up bounds on any useful global aerosol property, revised annually… what should models respect "at least"?)  
Please put your name here or write email to me:   
Yves/ Michael you should also announce it, not everyone will read your post. Y+1

Volunteers: Kostas. Rob Levy, Tero Mielonen, Don Grainger/Adam Povey, Yves Balkanski, Pekka Kolmonen, Ralph Kahn, Claire Ryder, Thomas Popp, Nick Schutgens, Peter Colarco, Dave Winker, Hongbin Yu, Gerrit de Leeuw/Ying Zhang, Andy Sayer, Greg Schuster, Claudia Di Biagio, Larisa Sogacheva

How can satellite AOD at multiple wavelengths be used in modeling?  
Christoph: Models can output at different wavelengths  
Shobha: I actually like this. approach  
Adam: And can be interesting! I've found Angstrom < -1 in model output that was otherwise sensible.  
  
How far can satellite interpretation schemes for aerosol type be applied to models?  
Mian Chin: We need to define a commonly agreed upon approach+1  
Christoph: We should have a common database for refractive indices between satellites and models+1

**Plenary Session 10 - breakout-group summaries days 2-4 [45 min]**(see at the end of each breakout session)

**Plenary Session 11 – requirements “new OPAC” (‘a-prioiri choices’) in-situ / lab meas. [40min]**

**Moderator: Ralph Kahn**

**Rapporteur:  Lucia Mona**

**Claudia Di Biagio (ACTRIS representative):** Update on lab experiments, how to define new experiments (5 min)  
Rich Ferrare: aerosol hygroscopicity can be obtained via remote sensing. See Dawson et al. 2020 <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019JD031708>  
Mian Chin @Rich: I wonder if you have cases with dominant aerosol type, such as dust or smoke, that can be linked to RH?  
I don't think either dust or smoke were dominant in the cases presented in the paper. κext = 0.27 (κext = 0.31) at 532 (355) nm  
There are new Raman lidars developed in Europe (Volher Wulfmeyer's company) that measure water vapor, temperature, aerosol backscatter and extinction at high temporal and vertical resolution that can do this even better than demonstrated in this paper.   
Greg: Good point, Rich. See also my 2009 GRL paper doi:10.1029/2008GL036576.   
I think that it is also worth pointing out that there are plenty of problems with in situ measurements. Hygroscopicity is not an easy measurement, as one can deduce by the many papers that are not able to produce column AOD with in situ profiles in moist atmospheres. Mass extinction efficiencies require the aerosol density, which is not routinely measured (and if I remember correctly, cannot be done in real time. Requires laboratory samples). Many size distribution techniques require assumptions about refractive index and spherical shapes. Finally, in situ refractive indices are very similar to remote sensing. People measure size, extinction, and absorption, and then iterate refractive index in a Mie code to obtain refractive index. I agree that we need in situ, but they are not the "truth" that some people believe them to be. They are difficult measurements that require people with special skills.

Ralph: For in situ measurements, especially from aircraft, it is critical to sample each aerosol air mass type adequately to capture the PDF of the particle properties.  This in part addresses the uncertainties in individual measurements.  Another part is making complementary measurements to capture uncertainty.  For example, if you measure hygroscopicity inside the aircraft from a tandem DMA, you also measure the ambient particles with an open-I nephelometer and the ambient RH. This makes it possible to compare the internally derived hygroscopicity with the ambient measurements.  Similarly, if you have an open instrument coarse-aerosol /cloud probe, you can test the size-dependent efficiency of the inlets and compare them to the standard estimates of inlet efficiency.

Greg: You echo my point that it is not easy. Moving HTDMAs are relatively new. When I wrote my 2009 paper, there were none and I could only find one long-term HTDMA measurement site (at ARM-SGP). I recall the LARGE group testing a moving HTDMA in a large van during the SeaC3RS in Texas, and that is the first one that I know of. It is flying now, I believe, but it is probably not at "turn-key" instrument. Likewise, the open-I nephelometer is very new and requires special training. It captures both fine and coarse modes, so it would provide an apples/oranges comparison to the HTDMA. The particle sizes provided by the open-I neph require conversion of a scattering phase function into size (just like satellite retrievals). The information content of the open-I neph is much higher b/c there are more angles and less issues like surface albedo, but it still relies upon a single-scatter model that iterates particle size and complex refractive index. It also requires a particles shape assumption.

Ralph: There are \*always\* uncertainties in measurements.  But systematic in situ measurements, if the payload is well constructed, would make a substantial contribution beyond just what we have now.

Greg: Agreed. But systemic measurements with prototype instruments will have some hurdles to overcome. I agree that we need a program for systemic measurements, but well, we haven't demonstrated that it can indeed be done in the way that you describe. We still need to determine the robustness of some of these measurements before making them routine.

Andy Sayer: many (most?) satellite retrievals, and AERONET inversion, treat dust as a mixture of oblate and prolate spheroids. Most use the Dubovik JGR (2006) shape distribution (Figure 13 of <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019JD031708> ). This was constrained with lab measurements of Feldspar at 440 and 630 nm. Unfortunately, there were not many measurements to use to constrain. It works well but there is a danger that this might not be the case at wavelengths far from the visible, e.g. retrievals in the UV and swIR. (1) Are there/can we find newer measurements covering a broader spectral range to check/update? (2) Or is there some other way we can tell whether this is sufficient? (3) It is not clear that this is a problem, but it is also clear that it is not. ;) Might also be more acute for polarized measurements than intensity. (4) Perhaps this is a topic for a future AeroSat experiment. (Many groups are interested in this and/or have been taking steps in this direction recently.)

Oleg: I agree with you (AS) that our spheroid model as most of models are based on very limited measurements data base (mostly 2 wavelengths). There is no doubt that it’ highly desirable to extend that measurements data base. I would like to note that there are numerous efforts to improve the non-spherical model and to establish the model, based on the more adequate/sophisticated shape. For example, one of promising approach is based on super-spheroid model by Lei Bi team. This model has additional degree of freedom (roundness) compare to spheroids. One of most promising features is the possibility to get quite adequate phase matrices for small axis ratios (even 1) that are comparable with spheroid mixture (mixing spect ratio from ~1.4 to 3). At the same time, there is no to evident sharp differences with spheroid mixture. Lin et al JGR 2018: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018JD029464>

Ralph: some algorithms (e.g. MISR) have not had success with spheroids.

Oleg: Recently we have applied our GRASP approach to MISR data and didn’t see any specific issue in fitting.

Bastiaan: We were interested in the super-spheroids, but it has the inconvenient issue that it is a Chinese model and it's difficult for us NASA to collaborate with the team because of restrictions....+1

Peter Colarco: For the modeling...shape can enter in several ways. One is impacts on settling velocities, which in GEOS we haven't fussed much with but I know others have (Ginoux 2003). Probably there are relevant shape things with respect to the dust indirect effect. And of course for the optical properties...this we have played with. In lieu of doing our own calculations we started from the tri-axial database of Meng et al. (2010). The database was based on various theoretical techniques and spanned a range of size parameter, refractive index, and shape/aspect ratio combinations. As a practical matter had to sample from the database for our choices of refractive index and shape distributions. We tried a couple of distributions, one was Oleg's spheroidal model, which is what we use at present. In practice this helps us to more realistically calculate the scattering from our dust aerosols for the observation simulation/emulation stuff discussed earlier (it does not, however, solve this perfectly...we do not get realistic depolarization ratios, though they are better than for spheres). Additionally, significantly, we got about a 25% enhancement in the mass scattering/extinction efficiency in the SW from using non-spherical optics. This has real consequences to the simulation of the AOD and the aerosol direct effect. Since we generally tune to AOD it has a practical consequence of tuning down emissions. On the other hand, as was raised many times here, we need better accounting for the coarse dust particle mode. There are limitations in the Meng database, too coarse in the spectral resolution and size parameter resolution, limits on the refractive index range considered.  
I would think from a modeling point of view we could work together to develop consistent lookup tables and maybe even consistent recommendations for bin number and spacing (for sectional models, which most are for dust...sorry modal folks).

Andy: thanks Pete. The comment about depol ratios not being realistic suggests that it might indeed present more of an issue for future polarimetry.

Discussion (35 min): concrete requirements for “new OPAC”  
Philip: I might have missed something (sorry) but it is not clear to me why we need a new OPAC... What concerns me is that direct measurement of radiative properties without relating this back to material constants will make it impossible to ensure consistency between direct and indirect effects in models. There still exist models that have different assumptions for water uptake (direct effect) and activation (indirect effects) – which we should really avoid...

Adam: IIRC, some of the basic details haven't been updated for the last decade of observations, particularly vertical distribution. Your actual point about consistency is an important concern, though.

Greg: Yes, needs updating. For example, Bond and Bergstrom 2006 recommended that the OPAC BC be retired, as they could not find measurements to back it up. The sulfate in OPAC can be traced to sulfuric acid. The dust is too absorbing in the SW.

@Adam and Greg: totally agree that we need updated measurements and a database for all of this (as started by the Oxford EODG group) - but don't think that compilation into something like OPAC will deliver consistent models. Models need representative spectrally resolved refractive indices, and representative measurements of hygroscopicity, ideally something on the mixing state – and maybe something on morphology (but that normally goes too far).

Yes, but I believe that some people are still using some of the OPAC species. To the extent that we "replace" OPAC, that might induce them to stop using it.

Claudia Di Biagio: Yes, I agree that the definition "a new OPAC" is misleading. OPAC is oversimplified as it is basically 10 components with lognormal size and refractive index, components that can be mixed as the user wishes. We need to go towards spectrally-resolved data for natural mixtures; then there is also the question of "natural variability" and aging effects, that mean there does not exist an "aerosol type" in nature even if we look at a single specie (dust, BC, ...). Optical properties can change with the source and further modify during aging. The extent of this variability should be understood if you want to have a reliable representation in models (see dust vs mineralogy for example).

OPAC assumptions about hygroscopicity can be off

Mian Chin: Wavelength range? Any measurements of inorganic aerosols (sulfate, nitrate) and OA (other than brown carbon)? Also, BC? Sea salt?  
Claudia Di Biagio: <https://acp.copernicus.org/articles/15/3339/2015/> here some work on the optical properties and hygroscopicity of SOA from the ozonolysis of alfa-pinene, a biogenic VOC  
@Mian: mostly focusing on dust, BC, BrC, ashes now, but we can talk about the possibility to work on inorganic salts  
Svetlana to @Claudia: you mean it would be wrong to use SO4 ext. efficiencies for polluted regions... should one then use "soluble" ones for also SO4?  
Claudia Di Biagio: what I have understood from the OPAC publications is that the sulfate is thought to represent stratospheric and Antarctic aerosols, but I am not really sure of what this means and what is the applicability; the WASO is probably more appropriated?  
Svetlana: Thanks! I should probably perform some model tests....  
Paul Zieger: What is the idea behind the "new OPAC"? Should it be a similar, simplified model as the old OPAC? Do you plan to exploit existing (in-situ) data sets? Concerning the aerosol hygroscopicity and particle size, there is already a large amount of data available.  
Concerning the hygroscopic growth in the original OPAC: The original OPAC growth factor values are too high especially in the intermediate RH range. In our 2013 paper, we provided updated hygroscopic growth factors as a quick fix for OPAC (<https://acp.copernicus.org/articles/13/10609/2013/)>   
@Paul: thanks! yes, we consider to combine with the literature in situ data as a general approach. I was just focusing on our activity in the presentation, but much work is available from other groups, even if approaches are somehow different and should be considered. For OPAC, see my previous answer to Philip  
Paul: In Maria Burgos's paper, we have also compiled particle light scattering (full and backscattering) at 3 wavelengths (450, 550 and 700nm) global dataset that is covers various defined RH range (and also for PM1 and PM10): <https://www.nature.com/articles/s41597-019-0158-7> (data set is available on EBAS and ACTRIS database)  
Claudia: yes, a very nice paper  
  
Paul @Claudia: What are your plans concerning sea salt? We are operating a sea spray simulation chamber at Stockholm, which also provides water-temperature dependent properties of sea salt. There is a lot of data concerning size, chemical composition, hygroscopicity around (and published). Let me know if you need input here.  
@Paul: thanks! We still do not have plans on sea salts at CESAM, but expertise on sea spray lab experimentation would be welcome  
  
Greg: Very nice talk, Claudia. Are there any plans to determine refractive indices for Goethite? There are many people looking for this, and it would be very helpful for understanding the SW spectral absorption of dust. The hematite/goethite ratio varies regionally, and so does the spectral absorption of dust (e.g., red vs yellow dust).  
  
Claudia: there is some literature on the refractive index of goethite and hematite, some old work; we see the different SW signature of dust with different origin and iron content and speciation <https://acp.copernicus.org/articles/17/7175/2017/>  and  <https://acp.copernicus.org/articles/19/15503/2019/>  
  
Christoph: I'm very interested to get updated refractive indices for different types of mineral dust and volcanic ash for use in modelling (from UV to IR). Are you also able to analyze meteoric dust that is seen in the stratosphere (metals)?  
@Christoph: yes, many published data on mineral dust, and to come for volcanic ashes; meteoritic dust is possibly assimilable to dust in some way, what is the mineralogy?

Adam: A range of ash refractive indices can be found in <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017JD027362> and  <http://eodg.atm.ox.ac.uk/ARIA/data>

Mian @Claudia: Will you be able to measure the refractive indices beyond 16 microns? In the modeling work we uses wavelengths from 0.25 to 40 micron

Claudia Di Biagio: yes, models go towards 40 µm, but it is relevant what you use beyond the 8-12 µm? I mean, there is relevant signal at 20-40 µm wavelength?

Claire: There seems to be significant extinction beyond 12 microns - e.g. see figure 6 <https://acp.copernicus.org/articles/19/15353/2019/> here

Claudia Di Biagio: yes, I see but I wonder how much this counts when considering the intensity of outgoing LW radiation, that for 300 K blackbody peaks at 10 µm wavelength and it is reduced to 1/3 at >20µm, anyhow

Claire: Yes, fair point. I could probably quantify it by digging out some old calculations...

Zhibo Zhang @Claudia: but no other aerosols can have extinction at 40 um. So, this might be useful from the perspective of remote sensing. If we can find a clean window band in this region, then we might be able to use it to detect dust.... just a thought

@Zhibo: to test, but not sure the signal intensity could be high enough

Zhibo Zhang @Claire: very interesting! I just realized that the size parameter of dust change from ~3 um to 12 um is about a factor of 4 and similarly from ~12 um to 40 um, also a factor of 4. So, in terms of size parameter 40 um is not that large.

Zhibo Zhang @Claudia: How well can we predict the LW dust refractive index if we know, say, the refractive index at the SW and some hints about dust composition? Or the other way, how well can we predict the RI of SW if we know LW RI and some information of composition? Theoretically we should do this, I'm just wondering how well can theory predicts the experiment results.   
 @Zhibo: for the SW we found linear relationship between the amount of iron oxides and the imaginary refractive index, meaning that you can predict SW absorption if you can predict dust iron oxide content, see <https://acp.copernicus.org/articles/19/15503/2019/>  
Greg: Claudia and Chrisoph -- you are probably already away of the many dusts that Hans Moosmuller group has in stock. doi:10.5194/acp-16-10809-2016. No refractive indices, but many, many samples. Hans would probably be willing to share for a collaborative effort. Let me know if you need his contact info.   
Claudia Di Biagio: yes, there is also this nice work of the Moosmuller group as well <https://acp.copernicus.org/articles/16/10809/2016/> thanks!  
Greg --> Andy: Oleg's code has the flexibility to accommodate different aspect ratio distributions, but nobody plays with it. Need more measurements

Andy: thanks Greg, agreed!  
Claire Ryder: In response to Ralph's question about other field observations/lab measurements being done, there is a very interesting campaign led by Vassilis Amiridis (ASKOS) planned. They will look at dust orientation, shape, charging and size. Originally it was planned for Cape Verde July 2020, but postponed due to Covid. May be worth catching up with results as and when the field campaign has taken place. Thanks for a nice summary of CESAM capabilities and new results available, Claudia.   
  
Zhibo Zhang @ Claudia: Your retrieval of RI is partially based on the Kramers–Kronig (K–K) relationship. I'm wondering how well can this relation quantitatively predict the mixture of aerosols at different wavelengths? For example, if half of a dust particle is quartz and half is calcite, does the refractive index of the particle follow the simple mixing model, e.g., K-K relation or even simple mass mixing?  
Claudia: mixing models are not always so good/easy to apply, but to test

**Plenary Session 12 - new retrievals: strengths, limitations, new developments [90min]**

**Moderator: Adam Povey**

**Rapporteur:  -**

**Robert Levy**: GEO-LEO synergy of different groups (5 min)  
Tero: Really nice talk, Rob! I'm sure there a lot of obstacles but GEO-LEO synergy seems like the best way forward. We really need a better temporal resolution of observations.

Andy Sayer: there is a recent initiative called GeoNEX to put GEO data on a common grid and format, including overlap where applicable. I don't know too much about it. <https://www.nasa.gov/geonex/dataproducts> I only heard about it third party, not through any official NASA distribution. Also not clear to me if it would make it easier to combine with LEO data. I know Alexei has used both in MAIAC so possibly some code he has could be adapted. Also, Wisconsin here have a lot of experience matching and sticking things together.

Shobha: Andy, yes.  But so far, they only have 6 months or so MAIAC algorithm run on AHI.  Moving data through cloud seem to be the only option going forward.  But is very expensive and may prove cost prohibitive.  This is a challenge we all have to think about on how to solve.

Andy: good point, Shobha - I know you have a lot more experience with the GEO stuff at NOAA too. Agree it is a challenge, especially for this new generation of instruments with more channels and timesteps.

Shobha: Right.  Cloud providers are trying to make money.  Future missions should negotiate with providers and make it cheap.

    Robert Levy:  Yes, Andy, thanks.  we are aware of GeoNEX.  It is not the direction we decided to go with our project, (we previously had invested in other systems, before GeoNEX was in place).  Yes, we invested in Wisconsin infrastructure.  Crazy, the biggest obstacle is moving data around. 'The Cloud' is in our future, but we are already heavily invested in "DAACs" and other archive systems.

Yingxi: I always wondering what is the pros and cons of using normal gridded format as what we usually do in atmospheric community vs. what land community use for the sinusoidal grid.  I found sinusoidal format is hard to chase back to the exact MODIS granule, which might be a problem if one wants to know details of data quality. Because within one grid, the data is uniformly changed due to observing angles.

**Felix Seidel**: “Beyond AOD”, quantify vertically resolved aerosol absorption (5 min)  
Mian Chin: absorption aerosol concentrations are much lower at higher altitudes and I would think it will be much harder to retrieve. What is the anticipated retrieval sensitivity?

Andy: We are starting to try and figure out what would be needed and what capabilities that would require, how it links to what capabilities are achievable with current and future hardware. I think a nice minimum would be to be able to separate boundary layer from lofted aerosols. This would be the first increment above column average SSA. Also relevant is a size split (fine/coarse AAOD), which I know e.g. Stefan is interested in too.

Kirk: sounds like the beginnings of a review paper? +   :-) 🙂  
Yves: How do you tie the aircraft measurements of aerosol absorption acquired during campaigns to your initiative?

Andy: they can be a test-bed for developing/evaluating potential future retrievals. And identifying gaps which will need to be addressed in the future.

Kirk: I agree with Andy, and to some extent this has happened in the ACE era at NASA and with OSIRIS

Kostas: I wonder if one way to move beyond AOD is an engineering task to reduce the detection limit for absorption?

Nick: I doubt if detection limit is a useful concept. What matters is the error, and this will not suddenly become small above a certain AOD threshold. On the other hand, random errors can be averaged out. +1

Kostas: I was thinking of the AOD high threshold that is required to get a meaningful SSA. Is this an error problem, not a detection limit one?

Nick: both Sinyuk's paper and my own show there is a grey scale. There is not a meaningful AOD threshold above (below) which you can trust (distrust) SSA

Adam: Practically, I think this is a function of using passive imagery. Differentiating absorption from scattering requires a lot of light.

Kostas: So, the 0.4 AERONET threshold for SSA is what?

Tom Eck: The SSA uncertainty for AOD(440)=0.4 is 0.03, and decreasing uncertainty as AOD increases. There were several studies over a decade or 2 ago that suggested the SSA uncertainty of 0.03 or less was needed for aerosol radiative forcing estimates. The Sinyuk et al. (2020; AMT) paper shows SSA uncertainty as a function of AOD and clearly the uncertainty increases rapidly as AOD decreases for AOD(440)<0.4.

Nick: a communication tool, but not a scientifically meaningful value. +1

Kirk: SSA capability is a fuzzy boundary, I think the AERONET group just had to pick a threshold somewhere.

Tom Eck: Not so Kirk, it was not picked casually. From my comment above: There were several studies over a decade or 2 ago that suggested the SSA uncertainty of 0.03 or less was needed for aerosol radiative forcing estimates. The SSA uncertainty for AOD(440)=0.4 is 0.03, and decreasing uncertainty as AOD increases (see Sinyuk et al.2020).

Andy: AERONET version 3 also has a more detailed uncertainty model (parameterization of ensembles of perturbed retrievals). Isn't clear to me how much uncertainty is random vs. systematic but it provides more nuance than a single threshold/uncertainty. See Sinyuk AMT 2020: <https://amt.copernicus.org/articles/13/3375/2020/>

Greg: We need to remember that there are many restrictions for L2 retrievals in AERONET, not just AOD(440) > 0.4. There are scattering angle requirements, number of good angles, etc. V3 has a new parameter called if\_Lev2\_except\_AOD\_threshold. WE need to use that. +1+2

Kostas: I was not aware of that parameter!

Nick: Greg, you are right and my own experience is that some of these restrictions are too strict. E.g. Inversion L2 differs from L1.5 mostly by AOD threshold and better cloud screening. Together this leads to tremendous data loss (30x if I remember correctly) but L1.5 and L2 give other similar results when evaluating models :)

Greg: Well, L1.5 allows virtually any SZA. So, some of the retrievals can be based upon a very small scattering angle range. Also, the residual requirements are much more lax in Lev 1.5 (I am not even sure if they have a restriction for L1.5). You can create your own restrictions, but taking Lev 1.5 w/o any restrictions is very unreliable. +1

Nick: yet when I use L1.5 with only AOD440>0.4 as an additional constraint, I get very similar model evaluation results as when using L2. However, I have many more L1.5 (AOD440>0.4) observations than L2

Tom Eck: Nick you have to consider that L2 is a subset of L1.5 retrievals, so to make a valid comparison the L1.5 retrievals that do not get raised to L2 should be compared to L2. +1

Nick: maybe, but I guess it depends on what you call "valid" in this context. I never did such subsampling and am only making a statement about multi-year/regional averages of data.

Greg: But why would you want quantity over quality?

Nick: My point is that you get better quantity over similar quality :)

Greg: I don't think that you are getting similar quality. Try parsing with respect to SZA. Also, if your residuals are 20+%, do you really have a constrained retrieval? +1

Nick: I'm not talking about individual measurements but about data averaged over regions and several years (hence suitable to model evaluation). This will average out random errors which may be larger in L1.5 than L2.0

Tero: Models are also evaluated with case studies, episodes, flight campaigns and "natural laboratories", so in some cases the quality of relatively small number of observations are important even for model evaluation.

NIck: agreed. And then there is data assimilation where one purposefully works with daily data.

Greg: Well, I have to disagree. We already know absorption is non-gaussian. Errors result in many low SSA but the high end is capped as SSA=1. Take the average that includes the extra low SSA data (some values as low as 0.4), and you'll be biasing yourself low.

Nick: I'm not disputing your findings but why would you dispute mine? :) When I do the numbers, I get very similar model evaluation results.

Rob: Median!

Greg: Yes, more medians Rob. Maybe we can talk offline, Nick. We are probably at the point to send each other slides.

Nick: Greg, I'll share some of my results with you after AEROCOM. Look forward to your view on them.

Greg: Sounds good, Nick -- looking forward to it! and I enjoyed the chat.

**Oleg Dubovik**: Assessment of multi-angular polarimetry potential (5 min)  
Paul Ginoux: I missed the differences between GRASP-HP and GRASP-MODELS. What are they? Thanks.  
Oleg: I simply didn't have time to describe them. In summary, the simplest "Models" shows better performance for AOD. The more complex approaches have notably bigger biases for AOD, but they provide some advantages for AE, AODF, AODC, SSA and AAOD. At the same time, there is no significant inconsistencies between GRASP-HP and GRASP-MODELS. The reference for now:

Chen, C., **O. Dubovik**, D. Fuertes, P. Litvinov, T. Lapyonok, A. Lopatin, F. Ducos, Y. Derimian, M. Herman, D. Tanré, L. A Remer, A. Lyapustin, A. M. Sayer, R. C. Levy, C. Hsu, J.  Descloitres, L. Li, B. Torres, Y. Karol, M. Herrera, M. Herreras, M. Aspetsberger, M. Wanzenboeck, L. Bindreiter, D. Marth, A. Hangler, and C. Federspiel, Validation of GRASP algorithm product from POLDER/PARASOL data and assessment of multi-angular polarimetry potential for aerosol monitoring, Earth Syst. Sci. Data Discuss., <https://doi.org/10.5194/essd-2020-224>, in review, 2020.

Thanos Tsikerdekis: Very interesting presentation, thank you! A naive question, why POLDER is able to get better performance in comparison to MODIS over AERONET site for AE? Does it have to do with the nature of the multi-angle polarimeter measurements that can constrain the retrieval better for multiple wavelength AODs?

Andy: yep, some of the assumptions which can lead to large AE errors can be relaxed/overcome by the polarimetric and multiangle measurements. For example, assumptions about the spectral behavior of surface reflectance, which is one of the larger uncertainty sources in a passive single-view imager retrieval.

Oleg: Yes, I agree with explanation by Andy.

Thanos: Great, thank you both!

**Bertrand Fougnie**: How consider the geometry of acquisition on the aerosol retrieval performance (5 min)  
Nice to see similar, yet independently determined conclusions from our work  
Andy: Bertrand, I read your paper and like it a lot. It is nice and laid out clearly, and I liked that you were able to get quantitative in it. I agree that we should do our best to consider practical scattering angle constraints when doing retrieval simulations and related analyses. Agreed!  
Thanks. Was nice to see this considered yesterday on the talk about geometry of polarimeters by Sabrina.  
Also, not unrelated to the geometry is the interaction of shadows in your observation.   High SZA --> more shadows.  In DT retrievals I hope I have statistically removed those shadows, but you have preferential 3D scattering in those shadows. (whether they are from big clouds or tiny buildings)

Andy: good point. I know this is an issue for cloud retrievals as well (see e.g., Zhibo Zhang's work).

**Kirk** **Knobelspiesse**: Analysis of simultaneous aerosol / ocean glint retrieval using multiangle observations (5 min)  
  
Discussion (65 min) Most promising breakthrough potentials to improve aerosol retrieval information?  
Antti L.: About deriving covariance matrices: We have used AERONET and simulations to derive the (full) covariance matrix in BAR. More info here in the paper (Sect 3.3, Approximation Errors): <https://amt.copernicus.org/articles/11/1529/2018/> The idea is to take accurate aerosol information (such as AOD) from AERONET and simulate the TOA reflectance with the LUT used in the retrievals using AERONET values. Then we compare the measured TOA reflectances and simulated and derive the covariance as sample covariance. This will take into account both the observation uncertainties and model approximation errors

Nick: do you have any idea how important this was in getting a good retrieval? As you know, BAR was performing very well among 9 different satellite products (our joint ACP paper). Is the full covariant the main reason for this, or something else?

Antti L.: "The results show that the approximation error model plays the most significant role in improving the retrieval accuracy." Tables 2 and 3 show comparison with and without approximation errors (full covariance) so it is important to take these into account, I think that taking all the model (e.g. radiative transfer, aerosol) related uncertainties into account plays a big role here. I would guess the model related uncertainties result into larger uncertainties in TOA reflectances than the observation noise. +1

Nick: Thanks, Antti.

Kirk: here's a nice book about the 300-year history of the discussion we're having now about the use of priors or not: <https://yalebooks.yale.edu/book/9780300188226/theory-would-not-die>

Tero: Thanks!: D +!

Andy: thanks Kirk - just checked and it is $1.99 on Kindle now, for those in the USA. Purchased as I am using your comment as my prior about its interest to me. ;)

We have not yet utilized our existing datasets yet - like we can use high temporal resolution of GEO - mesoscale views.  For example, GOES and Himawari observe at 1 minute or even 30 second intervals at small scenes, or 5 minutes on a sub-continental scale.  Way beyond my ability to handle, but there is information there to tackle 'processes'.   
  
Filling gaps in aerosol retrievals

Mian: what about aerosol retrievals around clouds? Or integrating above, below, and in between clouds to assemble a "quasi all sky AOD"? Or combining UV and IR information of aerosols within clouds?

Andy/Oleg/Ralph: there are some retrievals below thin cirrus (in principle, e.g. Lee JGR 2013, <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/jgrd.50806>, not yet applied widely), some above liquid clouds (polarimeter as well as imager). Broken cloud is challenging, 3D effects etc., probably not much can be done there right now. Of course, lidar (CATS, CALIOP) can function in these conditions too.

Also thin cirrus retrieval: Pierce et al., 2010, JGR, doi:10.1029/2009JD013019. The main issue with thin cirrus retrieval for MISR is if it is not uniform, the imagery must be co-registered at cirrus elevation.

Larisa, Linlu: there are still gaps in retrievals above snow/ice in many aerosol retrieval algorithms. Recent work filling these gaps e.g. Mei 2020 <https://www.sciencedirect.com/science/article/pii/S0034425720301012> . But it has been neglected for a long time.

Kirk: I'm interested in retrieval algorithms that incorporate cloud screening/flagging as part of the retrieval process. Otto Hasekamp and his group has written on this (www.atmos-meas-tech.net/3/839/2010/ doi:10.5194/amt-3-839-2010). Snorre Stamnes has a project for PACE that intends to retrieve aerosol properties and a measure of cirrus clouds (essentially treated as another 'aerosol' mode) Snorre's project: <https://pace.oceansciences.org/people.htm?id=47>.

Andy: Marta Luffarelli's presentation was on this topic (retrieve every pixel trying as an aerosol and a cloud). Pekka Kolmomen made some comments about an effort in the ESA aerosol CCI earlier this week. These were binary "cloud/not cloud" decisions rather than "aerosol plus cirrus" though.

Rich F: About half the time CALIOP measures aerosols, there are thin clouds above. Tyler Thorsen has done some nice work with CALIOP data to show such statistics.   
  
When we can all travel again, next AeroSat on a cruise ship!  (and we can measure stuff). +1

**Plenary Session 13 - recent extreme events [40min]**

**Moderator: Larisa Sogacheva**

**Rapporteur:  Adam Povey**  
  
AP(rapporteur): Larisa Sogacheva - Introduction  
- Extreme meteorological/aerosol events can be a personal tragedy for individuals, communities, and nations but are often neglected from climatologies and models, which consider "average" circumstances. Extremes also provide unique opportunities to test scientific theories. Retrievals are a vital bridge between the two, helping the community to improve the representation of extreme events in models and improve our ability to forecast them and avert suffering.  
- Presented FMI products of central Russian fires and the 2010 Ejya eruption as examples.  
  
**Andrew Sayer**: How consistent are satellite retrievals of smoke from the 2019-2020 Australian fires? (5 min)

Adam P (rapporteur):

- Satellite products must make some set of assumptions about in order to provide AOD on a global basis, but extreme events break those assumptions. The importance of extreme events forces us to re-examine our methods.

- He has collected an ensemble of observations of this year's Australian wildfire season to inter-compare in order to ask what practical steps can be taken to improve our representation of such events.

- Australia has always been a problem for global AOD datasets, exemplified by the significant differences in spatial structure and magnitude of the AOD fields for four datasets. This is not helped by the sparse distribution of AERONET sites on the continent.

- Even once collocated, the retrievals show significant disagreements in the retrieval of smoke properties. Different processing techniques may be necessary in such circumstances.

Ralph: Andy -- Good points about standard products.  I'm thinking these extremes events are situations where aerosol property retrievals \*could\* be done to advantage, due to high AOD.  With the MISR research algorithm, we get really quite good property retrievals over the Australia, California, and Siberia fires, and we account for aerosol elevation in the retrievals as well, using the MISR/MINX stereo height (also a "research" product), again due to high AOD.

Andy: 100% agree, research algorithms are ideal for this. So, the questions would be (1) how do we encourage generation and use of these research products within our existing work mechanisms (as well as/instead of people going to standard products which may not be optimal here) and (2) what if anything can we tweak in operational algorithms to improve the situation? (For #2 I would say better population of files and clearer statements of assumptions is a first step. OMI and MISR were good here.)

Ralph: Regarding Point 1, we have papers, and we continue to generate them for severe volcano and wildfire events. (I'm working on one for Australia just now).  Fortunately, journals now allow us (sometimes demand) that we archive our data, so this is becoming available, if others want to use them. Point 2 becomes a bit political, depending on what the standard algorithm team feels is most important.

Andy: agree! Rob put #2 nicely as "how to leave the dock without rocking the boat". But I would hope that adding more diagnostic info (in files or in ATBDs/ancillary data bases online) would be an easy step.

Istvan: Ralph and Andy, I agree that research algorithms would likely be more suitable for better capturing the real characteristics of aerosols from extreme events. Air quality applications (forecast) need this type of information in near-real time. Are the research algorithms capable of handling this requirement?

Ralph: For MISR, not real-time, though our plume heights have been used for air quality forecasting in extreme CA fires. Fortunately, these are still relatively rare events.

Andy: Istvan, I agree with you about the need for NRT. So, if there is something we can improve in the operational processing too, I think that would be important (for that reason and others)

Anin: The tail you have mentioned in comparison plot in the slide #7 could be coming from the spatial resolution mismatch of the two instruments. What is the spatial resolution the AOD products you are using from AHI?

Andy: I collocated all the data at 0.5-degree, 30-minute resolution (cf. Nick Schutgens' work) and imposed constraints on number of retrievals. Took medians to reduce outliers and effects of skew. I think pixel size differences can contribute to scatter here but not the large systematic differences in distribution shapes. VIIRS is 6 km, at nadir AHI is 5 km, MISR 4.4 km, OMI 12x24 km at nadir

Yingxi: One thing that I am facing when doing research algorithm on those events is that we don't have a truth to validate that this part of the plume is actually smoke or there is cloud start forming underneath. Also, at what point do we give up on retrieving at 550 and either switch to longer wavelength or simply just give a flag and not retrieve.

Andy: yes, exactly - this is a discussion we need to have. I think the standard products are not optimal for extreme events for that reason. A lot of people use level 3 data for comparisons and model evaluation and these will be quite sensitive to the extreme events, as your work has nicely shown for MODIS DT also. We have spent a lot of time focusing on evaluation of retrievals, but not as much on evaluation of where we do/do not do retrievals, and I would like to look at that.

Wenying Su: Andy, I might miss your description of the comparison. Did you also compare the AOD retrievals over ocean, were the agreement better? How much the disagreement can be attributed to cloud detection?

Andy: the scatter plots in the main presentation were over ocean with collocated data. I have some for land in the backup slides too, but the picture was not too different. Felt best to focus on the ocean as most of the smoke is there, and also the retrievals should be less difficult. And yes, some differences here could well be cloud/aerosol discrimination issues (both over and underscreening).

Shobha: Andy, for Australian fires when fire emissions were generated and provided to NWS global model, model generated very high visible AODs (> 10).  No way we can evaluate the model AOD at that point because no imager provides AOD > 5 or cloud mask screens those out.  And if models assimilate MODIS or VIIRS AOD they get it wrong because model will be nudging the AODs towards observations.  And observations are not realistic.  Even AERONET...either smoke did not go over or even if it did once sun is not visible they won't make measurements.

Andy: yes, I agree with you! We know if there is no consistency, though, that something is wrong. So, it's worthwhile I think to try and evaluate as far as we can and make adjustments where we can. Even though we know AOD > 5 will disagree or be missing, hopefully for AOD up to 1 or so (i.e. above baseline but within theoretical capabilities) we can get better agreement. And if we don't we can point to something concrete to work on (e.g. cloud masking or whatever it might be).

Caroline: Agree with you Andy Australia is a 'perfect storm' of aerosol retrieval problems, not just surface, but low baseline AOD and different optical properties.  
Caroline: We collected smoke particles from the latest Australian fires so we can develop Australia specific optical models... Will let you know when we have some data

Andy: thanks Caroline! That would be great. I would like to tie in AERONET inversions with retrieval assumptions and any other optical properties. Even if we can't fill the gaps we can find where they are.

Caroline: Dan Robbins my PhD student will be looking at sensitivity to optical property assumptions during the fire period.

Andy: nice! His talk on AHI cloud masking in smoke is of course very relevant here too.

Nick Schutgens suggested also doing an evaluation in Australia during "non-extreme" times, in order to provide a comparative baseline of consistency. This is a good idea, though the 6-month period looked at (Sep 2019-Feb 2020) does contain a lot of "normal" conditions over much of the continent, it is perhaps not enough. Also, practically, downloading (and storing) the level 2 data is problematic. Could start with this and see how it goes.  
Caroline: I would be very interested in being involved with that, I think 6 months would be enough to give a good story. Thanks! :)  
Xiaohua: Andy, you mentioned about the difficulty to download MODIS data. You may try to send your feedback to LAADS, MODAPS User Support at MODAPSUSO@lists.nasa.gov. According to my working experience in GES-DISC so far, DAAC takes user's feedback seriously.

Andy: I have sent feedback to DAAC people on various issues, numerous times. Generally, ASDC (MISR, CALIOP) and GES DISC (OMI) seem to be smoother than LAADS (MODIS, OMI). Those are the principal servers for the NASA products I've been using. LAADS is a lot slower than the others and has more frequent corrupt downloads and timeouts. This could be because they have a very wide distribution of data (as MODIS is used heavily). (The AHI download was pretty fast too from JAXA; I don't have any European data sets in this ensemble yet.)

**Hongbin Yu**: Gigantic African Dust Intrusion into the Caribbean Basin and southern U.S. in June 2020 (5 min)  
Adam P (rapporteur):   
- According to MODIS observations, a dust plume at the end of June 2020 was the largest AOD observed over the Caribbean in the last twenty years. Though not such an outlier over the Gulf of Mexico, it is unusual  
to see such elevated AOD during summer rather than spring.  
- The plume may be connected to the northward drift of the Bermuda-Azores high.  
- The GEOS model captured these plumes, but underestimated their magnitude in simulated imager and lidar observations. Increases in surface PM were also recorded.  
  
Ron Miller: Doesn't GEOS assimilate AOD?  Is there a large assimilation error?  Alternatively, is the AOD being attributed to another aerosol species?

Qian: This is a GEOS run Huisheng made without MODIS AOD assimilation, driven by MERRA-2 wind

Ron: thanks for the explanation, Qian.

Hongbin: for the event like this one with AOD of 1-3, I think dust is a major contributor to the MODIS-GEOS discrepancy.

Paul Ginoux: Do you think haboobs played a significant role along the sub-Sahara-Sahel regions? I think the period was particularly wet.

Claire: Also, haboobs and mesoscale convective systems were very active in uplifting many of the dust events which contributed to this event. I wonder if this contributed to MODIS missing much of the high AOD events over land due to cloud presence?

Paul G @Claire: You are exactly right!!

Ron: Good points Claire and Paul.  Similarly, if haboobs were responsible then GEOS wouldn't have the resolution to simulate them.

Qian: <https://worldview.earthdata.nasa.gov/?v=-62.05687554638127,-10.116749755257304,32.656402813668,39.664500244742676&t=2020-06-17-T16%3A00%3A35Z&l=Reference_Labels(hidden),Reference_Features(hidden),Coastlines,VIIRS_NOAA20_CorrectedReflectance_TrueColor(hidden),VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor,MODIS_Terra_CorrectedReflectance_TrueColor(hidden)>

Qian: for June 14-18, over land it is relatively cloud free. Off the coast, on June 16, cloud might block aerosol retrievals. On other days, it is relative cloud-free.

Claire: Looking at SEVIRI imagery, you can see that uplift actually began as early as 4-13 June, via a series of haboobs with associated cloud.

Qian: @Claire, thanks. By 4-13, you mean 4am on June 13, right? Does SEVIRI image available online some where?

No, I mean from 4th June till 13th June. I will email you.

Qian: Cool, thanks! qian.tan@nasa.gov

Hongbin: thanks, Claire.

Hongbin: all good points. I know that Bing Pu just finished a paper that discusses the atmospheric conditions favoring this event. It is possible that cloud presence may have led to lower AOD in MODIS (Deep blue).

Claire Ryder: Interesting analysis, thanks. I agree with your point about the surface pressure high/low positions - you can also see this in the 700mb winds anomalies, and how this is very weak while the dust is 'accumulating' over the Tropical east Atlantic, before the winds pick up again and the dust gets transported westwards.

Hongbin: I did look into winds at other altitudes. They are quite consistent.  Surface pressure pattern in June 2020 was an anomaly over the last 20+ years based on my analysis of MERRA2 meteorology.

Discussion (30 min): How improve representation of extreme events with limited sampling in extreme events?  
  
Michael: Can we better understand the similarities between these large wildfires by increasing our sampling?  
Ralph: The events remain rare and so may be better suited to case-by-case study.  
Mian: Curious about the similarity between the results shown and a previous presentation of model-assimilated retrievals.  
Pete: Models that assimilated observations showed similar signals he the results shown here, including the higher magnitude.  
Larisa: Can synergistic products identify events? Do we need less strict cloud flagging?  
Et al: Probably.  
Wenying: Much of the inconsistency between AOD products can be attributed to differences in cloud flagging and calibration. How do we homogenize current records once we move to VIIRS?  
Adam: It's difficult as there is no absolute calibration from space.  
Nick: Has Andy evaluated AOD over Australia in normal times to see how the differences between algorithms changes between typical conditions and the fire season?  
Andy: He hopes to make that comparison clear in the paper that will follow.  
Both: More work is needed.  
Tom: Asks Andy how the implementations of Dark Target to MODIS and VIIRS compare?  
Andy: To be done.  
  
Adam : The Met Office does assimilate MODIS AOD into something, to improve their dust

Claire: Into their NWP global forecast model

**Plenary Session 14 - closing remarks [20min]**

**Thomas Popp**: **AeroSAT closing remarks**  
(feel free to comment)  
  
1)      Online meeting

* Overall went well
* Also, lively discussions, very good discipline, maybe some people were shied away by the “attendee” status and need to get unmuted
* Board.net helped collect rich set of comments from many participants – however, too many anonymous contributions
* Wonder.me allowed even some socializing, but we were missing the shared glass of wine / beer and the traditional Wednesday afternoon local activity
* IF POSSIBLE, next year should be a physical meeting – if not possible, an online meeting makes also sense

Paul Ginoux: I would keep board.net for any type of meetings (physical or virtual). It is so great. It provides many dynamic exchanges without interrupting anybody. Can go back. +1+1+1+1+1+1+1+1+1+1

Kostas: Completely agree. Whoever found it, thousand thanks, great tool.

Mian: board.net was recommended by Bjorn Samset

Tero: It also enables everyone to ask questions which is not possible with only "live" questions.

Steve: I agree, boarrd.net worked very well. Would be useful to keep around.

Xiaohua: and capture and preserve the ideas which otherwise will fly back and forth in the air and are forgotten later. [Editors’ note: this is indeed the main contribution to these minutes]

Kostas: The other thing I liked was that we had several time zones on the program, so I did not have to make conversions. +1+1

Mian: But we will exclude people and potential participants from Asia, which is not optimal

Michael D: Some other meetings, such as ACPC, have done three daily sessions separated by more time (several hours), so one was optimized for US, one for Europe, one for Asia, e.g. Could be worth exploring a schedule more like that, with short summaries of previous sessions for those in an inconvenient time zone.

2)      More integration if AEROCOM and AEROSAT sessions on Wed + Thu

* Went very well, but more effort to agree in larger SSC

Indeed, sessions discussing shared scientific topics were rewarding.

3)      Breakouts

* Went very well and allowed to give more attention to posters
* In future we should avoid 1-slide presentations of plenary talks (which pushed the number of 1-slides too high) +1+1

Breakout summaries of posters sounds much better than the long blocks of 1-slide intros+1

Perhaps enforce a strict slide format (e.g. 5 PDFs without animation that automatically progress every 60s)

4)      Some science outcomes

* Covid-19: complex challenge to disentangle the signal from meteorology, regional trends, natural / transported aerosol due to the lifetime longer than NO2
* Comparisons / trends
  + i.      Unlike for models, satellite product AOD diversity can be used as proxy for their uncertainties ii.      Comparisons should focus on regions with high discrepancy to better understand the reasons (Australia, over deserts, Southern ocean)
  + iii.      Consistency of trends between different datasets should be a focus
* c.       Optical properties: create AEROCOM / AEROSAT commission of optical properties for annual review; Larisa will analyze definitions in retrievals
* d.       Aerosol type
  + only few multi-spectral AOD operational products (look for other, experimental)
  + promising initial application of an interpretation scheme to models
  + Emulators could be a middle ground between radiance assimilation and constraining model w/satellite-retrieved optical properties
  + (breakout 7) future work should focus on specific types, feasible for satellite retrievals + needed for model improvements (dust AOD, fine mode AOD, absorbing AOD)
* e.       Machine learning techniques: Few examples of their use, at some point need to do a critical review of strengths and limitations
  + including laboratory groups / perspective of more lab measurements towards “new OPAC”
* f.        Extreme events
  + maybe we need multi-sensor (at level 1) retrievals or special processing with different assumptions for these events
  + Cloud screening is critical - to allow relaxing it, use a simple fire detection module (for fires), a BT test (for dust episodes), SO2 auxiliary data or MISR plume height (for volcanic eruptions)
* g.       New retrievals: information content / constraints; uncertainties of gridded / averaged products; synergy; systematic in-situ / laboratory measurements
  + Satellites provide the global picture, not details – synergy model + satellite + sub-orbital

**Michael Schulz: AeroCom closing remarks**  
(feel free to comment)  
  
**AeroCom/Aerosat workshop 2020**  
Thanks all for the very nice presentations  
Excellent idea to preassemble presentations, thanks Stefan+  
Thanks for the engagement on board.net - minutes are ready:)  
Thanks Tom and Mian for coordinating and mastering the webex challenge  
   
**Primary near term goal**  
AeroCom and AeroSat are the best communities to summaries our knowledge on aerosol trends and aerosol forcing over the 2-3 last decades. We have an indication that the clear sky direct aerosol effect has weakened, but the trend in aerosol-cloud interaction is highly uncertain. To summarize findings and data on trends will require some work, but should be a primary goal for near term activities.  
  
**Commission on Constraining Aerosol Properties?**  
Purpose:   
Setting up bounds on any useful global aerosol property, which is revised annually… what should models respect "at least" when simulating global aerosol loads, optical properties and forcing?   
Formulate it as Recommendation for Modellers  
Revise bounds every year at AeroCom (Bounds: maybe be global averages, or vertical distribution, regional averages, to be discussed)  
Create a maintenance framework, With a table that will be updated every year.   
Are there maybe measurements missing?  
  
Possibly write an initial paper for announcing the concept+1  
Mixed compositon : observational and modelling experts  
Volunteers: Kostas Tsigaridis. Rob Levy, Tero Mielonen, Don Grainger/Adam Povey, Yves Balkanski, Pekka Kolmonen, Ralph Kahn, Claire Ryder, Thomas Popp, Nick Schutgens, Peter Colarco, Dave Winker, Hongbin Yu, Gerrit de Leeuw, Ying Zhang, Claudia Di Biagio, Michael Schulz, Mian Chin, Betsy, Andy Sayer, Larisa Greg Schuster  
 Nicolas?  
  
**What is needed to pursue the AeroCom experiments?**  
Revision of wiki and documentation is partly needed.  
Coordination of requests - AeroCom SSC will invite for an “AeroCom experiment” telecon not too late, best well before end of year   
Model experiment genealogy (versions, participation, overview, commitment) how to document that better?  
New questionaries? nitrate ? absorption optics? size? Coupling between various processes?  
  
How to make progress on the "remaining issues" discussed on day1?  
Make a list of remaining issues - attach action points

* Aerosol life cycle
* Dust lifetime and size
* sea salt size?
* BC and absorption
* Nitrate
* Organics
* Vertical profiles
* Biomass burning aging and height (injection height and self-rising)
* MEC/AE/FMF/CMF
* Hygroscopicity
* Clear/all sky AOD and rad flux calculations <- on my list, volunteers for help welcome (Kostas)

Yves: There is work in the group of Jasper Kok on the constraints of dust regional budgets: the work is quite important so it was split between 2 papers: 1) is entitled:  **“Improved representation of the global dust cycle from integration of constraints on dust properties and abundance”** so quite topical.  
  
Vertical profile comparison with new aircraft measurements  
Transport tracers  
  
**Biomass Burning Emissions**  
  
Shobha: product developers are somewhat handicapped with insufficient information on emissions factors.  Especially, for different vegetation type and the vegetation moisture content.  
If any of the experiments being proposed take into consideration for these sorts of measurements, it will be very helpful to improve fire emissions.  
  
**New AeroCom experiments?**  
board.net contains some nice ideas… need to be extracted and formulated  
EG: repeat PI+PD indirect experiments, or include respective diagnostics in CTRL 2020?  
Sea salt experiment+2

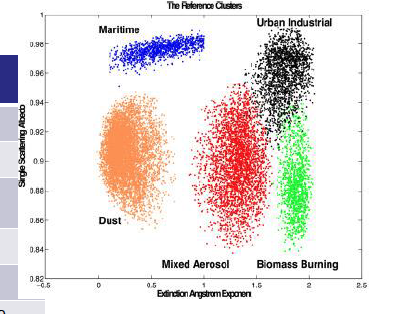
Paul Z: Would be interested as well (also hygroscopicity and coarse mode)

Please send propositions to AeroCom SSC  
betsy: full size distribution experiment (include AODf/AODc and FMF)?  model RH intercomparison?  
yves: could modellers produce routinely this diagram (from Tero Mielonen) but for their models. The types could be (SO4, dust, BC, OA, SOA etc...). It gives a kind of ID card of what the model is doing. Inputs from others welcome!

Tero: We are actually just preparing plots where we compare the SSA and EAE distributions of the 5 models with the AATSR data in different regions to see how well they compare and if we are able to separate any aerosol types from there

betsy: the AAE vs EAE relationship might also be interesting to look at (but requires spectral absorption) (see, e.g., cazorla et al ACP, 2013 and cappa et al ACP 2016) +1

greg: See also doi:10.5194/acp-16-1587-2016. Many of the AAE approaches are unable to account for low EAE simultaneous with low AAE. +1

Mian: That would be comparing apples with oranges, i.e., comparing composition with mixtures of origins  
Greg: Phil Russel et al (2014) doi:10.5194/acp-16-1587-2016 was the first to apply this technique to AERONET. That paper leveraged Burton et al (2014) doi:10.5194/amt-7-419-2014.   
I wonder if it would make sense just to make sure that the emissions fall in these places. That is, what are the optical properties of the MEE and MAE lookup tables that modelers use for the different species? Would smoke land in the green region, for instance?   
These classifications basically come from AERONET climatology. Basically, BB sites during BB season are used for green, urban sites are used for the black, etc.   
  
**AeroCom box model and multi-hypothesis framework? +1**  
Some interest and new initiatives on the horizon  
Telecon on this ?  
Assemble open source code and code bits on aerosol life cycle aspects (emissions, sources, removal)  
  
**AeroCom website**  
MetNo is preparing a relaunch of the website, open to be shared in maintenance by others (Augustin)  
Volunteers???  
betsy: i could help update text but not any fancy web coding stuff!  
Anin: I am happy to help with the front and back end of the website.  
  
**Distribute AeroCom products**  
AeroCom median, mean, std, 25% and 75% percentile fields as reference (Jonas, documentation in Gliss et al 2020)  
Model data associated to reference AeroCom papers. (frozen versions)  
  
**ACP special issue**  
Maria Kanakidou agreed in principle to coordinate editing, needs to be followed up  
  
**AeroCom 2021, where will it be?**  
Virtual again? .... NY, Stockholm, Nanjing  
AeroCom/Aerosat SSCs shall decide in winter/spring  
  
Susanne Bauer: I just want to give a big thank you to the organizing team. This was extremely well planned and executed! Well done!!! Best online conference so far in 2020!!! +1+1+1+1+1  
2021 - if we believe the COVID forecasters, they assume that the world will not be normal until the end of 2021. So, my bet is another online conference in 2021. +1+2+1+1+1+1+1  
  
Greg: I was muted and unable speak, but I wonder if having shorter days over a longer period of time would help our Asian friends (or whoever gets stuck with the worst time zone). Say 3 hours a day for two weeks? Perhaps I have not thought that through, though.  
Tero: One option could also be that we would have meetings on two days per week for a couple of weeks. Then you would have some time to rest between the meeting days  
Christoph: maybe include Saturday, to cut the meeting into parts would distract too much. The SPARC/SSIRC community on stratospheric aerosol still plans an in-person meeting in April.

**Breakout sessions**

**Breakout session 4: Suborbital observations & biomass burning & COVID remainder of discussion**

Moderator Kostas Tsigaridis

Rapporteur Jonathan Hickman   
  
Link to Kristina Pistone paper regarding in situ and remote sensing retrievals of smoke properties during ORACLES is <https://acp.copernicus.org/articles/19/9181/2019/>  
Note (Sampa Das): Just to add, based on Paquita's talk this morning and based on Yohei's ORACLES 2016 paper (<https://acp.copernicus.org/articles/20/11491/2020/acp-20-11491-2020.pdf)>, " The FT SSA ranges widely across the models, with mean model values ranging between 0.80 and 0.92; in situ values are approximately 0.86."  
  
Tom Eck  
betsy: can that weird BB size distribution be tracked across the US with other aeronet sites?  
Tom Eck: Yes, we have seen this anomalous AOD spectra in Colorado and UP Michigan AERONET sites.

does it shift at all - like i guess I'm wondering if you can say something about aging by looking at changes across the country

Yes it does shift slightly with the most extreme case being at GSFC. Much aging occurred over the Pacific so there are even some extreme SD to the east of Los Angeles after aging for 3 days or so in an elevated layer (~5km) over the Pacific Ocean

Tom, UMD did a flight to measure absorption of this aged smoke plume on September 16th if you want to follow up with Russ Dickerson and Xinrong Ren  
Tom Eck: Hi Shobha, Brent talked to Russ Dickerson and found out that they could not fly up to the 5 km altitude where the smoke was located on Sep 15.  
Tom, yes.  They flew on the 16th and sampled smoke between 2 km and 4 km.  
Tom Eck: On the Sep 16 the smoke type was somewhat different, not as large particle size as on the 15th, and we are beginning to investigate that.  
Rich F: The NASA ACTIVATE project has both airborne remote sensing and in situ measurements of smoke observed this past September off the east coast.   
Tom Eck: Thanks Rich. I heard from Brent that found out that the aircraft sampling was not high enough to get to the 5 km layer from this CA smoke event.   
Rich F: that's true on one day. However, there was another day when the smoke was lower (just above teh marine BL), when teh Falcon flew within the smoke with the in situ sensors.   
I can send you some preliminary images showing this.   
Tom Eck: OK great, thanks again.  
We are also planning to do combined (lidar+polarimeter) retrievals of the smoke from teh HSRL2+RSP measurements.  
Did you have HSRL measurements on Sep 15?  
Yes. I just sent you some preliminary images.    
Anin: Hi Tom, I have a question regarding the HYSPLIT back trajectory you have shown in your slides. Looking at the worldview and MODIS data, we can trace that, a quiet a lot smoke coming from the fires near to Denver, CO. However, HYSPLIT is not showing that in the back trajectory towards the GSFC station.   
Tom Eck: Hi Anin, we have looked at GOES time loops in addition to the HYSPLIT back trajectories, and for the Sep 15 date at GSFC it seems that the smoke is coming from the west coast fires. The West coast plume also passed over Colorado on Sep 14 and we see the extreme size distributions at AERONET sites near to Boulder, CO as well.

Anin: Yes, looking at the ABI images will give a clear picture on the trajectory of the plume. I wish we had some HARP observations during the same time. But the orbit was bad for that day, that it was capturing data close to terminator for the North American region.

In case it's of interest, here's the last 30 days of continuous surface spectral scattering and absorption measurements just north of boulder CO.  <https://www.esrl.noaa.gov/gmd/aero/net/getplot.php?key=overview&sta=bos&type=avg>  you can see the broad multi-day peak which was more long range/aged smoke in mid-September and the sharp peaks more recently which were from more local (CO-based) fires.

Rich Ferrare  
Lucia Deaconu: It's great to see a validation of the SODA product with HSRL observations. I was wondering how were you retrieving the lidar ratio? It is for the operational product? I think I missed the explanation.

We used the constrained retrieval using the opaque water cloud to derive the AOD then use this to derive the lidar ratio.  It is actually the output of the SODA retrievals.  Damien Josset has been working with us on this.

Nice. Is there a paper on this yet?

No, unfortunately not yet. Hopefully soon.

Qian Tan, is CALIPSO Cloud product you showed available to the public?  
  
Ben Johnson  
Claire: Really interesting results Ben. Did you use a realistic SSA for BC? I also wonder if your results could extend to similar problems/effects we see in the Saharan dust plume? Also, can you rule out circulation changes due to BC absorption radiative effects, which might impact the plume transport and height?  
Hi Claire, thanks for your comments.   
  
1) The SSA for the absorbing aerosol layers varies interactively as I'm using the GLOMAP-mode scheme. In HadGEM3-GA7.1 the BC absorption is quite strong, maybe 30% too strong compared to AAOD observations from AERONET. This happened after we upgraded to CMIP6 which puts out a lot more BC emissions. Nevertheless, I think the conclusions would be the same if we tone down our BC RI slightly, just slightly smaller magnitude.   
  
2) Yes, I'm sure that the absorption in dust could have the same physical effect, although CLASSIC dust isn't that absorbing so I think it'd only make a difference in thick plumes with plenty of coarse (absorbing) particles.   
  
3) The lofting in the model occurs through the impact of the absorption on the large-scale vertical velocity, rather than on local effects. Sorry I was rushing and probably didn't make that clear.

Thanks Ben!

Yves: Ben, is it important in your study to have the correct SSA for BC (same question than Claire) and also how much care do you have to put in having the correct particle size distribution? Have you done sensitivity runs on these two?  
Ben: See comment above on the SSA. The size distributions in HadGEM3 (GLOMAP-mode) have been validated with aircraft observations and come out pretty good for biomass burning haze (CLARIFY, AMMA, etc).   
Lucia: Nice study! I was wondering if you plan looking at humidity advected as well..that might not be an actual thing but in a study I made before we were unable to separate the humidity from the biomass burning aerosols so one explanation we had was that they were advected and transported together...You think that could be the case?

Ben:Yes, that it an interesting point. I have thought about the BC absorption helping to lift up CO and other trace gases, but you are right it will likely aid the vertical transport of water vapor too. Typically, the large-scale ascent that is enhanced by BC heating drives increases in deep convection in those regions that are convectively unstable already. Monsoon precip is increased for example due to the elevated heat pump.

Interesting! Thanks! It would be nice to be able to separate meteorology from aerosols - or humidity from BC

Ben:Yep, it’s very hard to disentangle the BC direct impact on ascent from the meteorology because as soon as deep convection is present, the BC heating can lead to strong feedbacks (more BC heating, more precip, more latent heat release, more circulation change...) I've noticed that such latent heat releases can be 5 times more than the original BC radiative heating input.

That's why doing simplified model simulations could help understand the processes there.

Ben:Hmm, yes that's something to think about. Even a back of the envelope calculation is enough to show what vertical velocity change you expect from a certain heating rate. That calculation only works in the tropics mind, where you can assume a balance between radiative cooling / heating and adiabatic heating / cooling from subsidence / ascent.

Sampa Das: Hi Ben, Nice talk! So, just to confirm you did a free-running simulation or a nudged meteorology run?   
Yes, it was free-running.  
  
Ron, what sort of simple model simulations did you have in mind?  
  
Anin Puthukkudy  
Yves: Hi Anin, in your retrieval, you have to assume a PSD. For GRASP, do you have the same PSD for all the geographical locations or do you vary the PSD with the distance to the source regions?  
Anin: Hi Yves, In GRASP there are multiple options for retrieving the PSD. For the smoke case, we are assuming that the PSD is represented using 5 log-normal modes. However, the concentration of each mode is a free parameter in the retrieval. Basically, it means that we are retrieving the PSD with some a priori constraints. For the case of AERONET comparison we have tried a more simplified approach where, PSD, complex refractive index (RI), and shape distribution are fixed for the five aerosol components and we are retrieving only the weight for the aerosol components. This simplified approach reduces the number of retrieved parameters from 15 to 6 for the case of AirHARP. All the retrievals I have shown are single pixel retrievals so there is no constrain on the aerosol properties over the spatial dimension. For the case of size of the particles, both the HSRL2 AE and AirHARP AE shows that the AE is increasing when we move away from the smoke source.  
Reed: In the five-mode configuration are the 15 parameters 1 concentration, 1 RRI and 1 IRI times 5 modes? If so, is the RI spectrally flat? Do you think that impacts retrieval performance?

Anin: 15 parameters include: 5 for the PSD, 4 for the RRI, 4 for IRI (since we are using 4 bands, spectrally smooth), 1 for SF and 1 for the aerosol layer height.  So, RI is not spectrally flat. I didn't mention the surface parameters since it stays same for both cases. I'm not retrieving RI for each size modes.

Reed: Okay, I see now. RI is constant across size bins but not wavelength.

Anin: Yes, exactly. I will try to do a multimode retrieval for RI in the future for high AOD cases.

Rapporteur summary

**Presentations  
Tom Eck** described Aeronet detection of brown carbon in biomass burning; anomalous observations over Maryland on September 15, 2020 at 500nm, suggestive of growth of biomass burning-derived aerosols following long-range transport from the west coast. Detection and time series of both brown carbon and desert dust iron oxides were presented.  
**Rich Ferrare** introduced an alternative method for deriving above cloud AOD and aerosol extinction profiles from CALIOP observations. The method provided improved observations of the altitude of enhanced AOD relative to cloud top, with application over the Atlantic and western coast of central Africa.  
**Ben Johnson** examined the magnitude of self-raising in aerosols as a result of radiative heating. Statistically significant elevation of aerosols was observed over the tropical Atlantic, with the strongest heating at 700 mb, and ~1km elevation of black carbon over the Atlantic during the central/southern African biomass burning season. Of potential interest is how black carbon deposition in the Arctic might be affected by self-raising.  
**Anin Puthukkudy** conducted and evaluated aerosol retrievals from AirHARP observations during ACEPOL 2017 using the Generalized Retrieval of Aerosol and Surface Properties (GRASP) approach. Demonstrated the ability to retrieve low, medium, and high AOD from a HARP instrument. There is some sensitivity for polarization and potential insight into spherical fraction, but this product does not yet have high confidence.

**Discussion  
Aeronet retrieval of SSA**: Some discussion about the degree to which SSA is accurately retrieved in AERONET given possible bias in size distribution—i.e., if giant particles are present, but are not accounted for in the retrievals. It was argued that SSA should still be robust because SSA is calculated using both the size distribution and retrieved refractive index, and bias in the size distribution is offset by the second parameter. Aeronet matches angular scattered radiation within 5% or better of L2 retrievals.  
**Modeling self-lofting of aerosols**, and the balance between retaining real meteorology as well as interactive processes needed to simulate self-lofting. In some 10X black carbon experiments using both nudged and free-running simulations, self-lofting still emerges in the nudged experiments so long as the nudging isn’t too tight. However, nudging suppresses broader teleconnections that emerge in the free-running simulations.  
**The potential for the ORACLES campaign to be leveraged for model improvement.** One challenge is that currently most/all models have difficulty capturing the cloud deck in the ORACLES region. More regional analyses may be required. On a practical level, there is a need for biomass burning emissions, which are only available in beta from GFED for 2017-present (GFED is used in CEDS, which most models rely on). It may be desirable to have ATOM- or ORACLES-specific biomass burning emission runs using a non-GFED database.  
**Some initial discussion** about species retrievals and size distributions using Aeronet. Also, some brief discussion about the potential insights from EMIT.

**Breakout session 5: Aerosol and clouds, indirect effect**

Moderator Johannes Quaas

Rapporteur Ed Gryspeerdt

Natalia Chubarova, Possible mechanism of the increase in solar irradiance cloud transmittance and decrease in cloud cover over Europe due to negative trends in sulphate aerosols: a study with the INMCM5 climate model  
Suvarna Fadnavis, Elevated aerosol layer over South Asia worsens the Indian droughts  
Haruka Hotta, valuation of Cloud-Aerosol Interactions Using the Cloud System Resolving Model NICAM-SPRINTARS and Satellite Observations.  
Mattia Righi, Coupling aerosols to (cirrus) clouds in a global aerosol-climate mode

Rapporteur summary

Improving the ACI diagnostics in AeroCom experiments  
- Aim for simple properties (LWP, CF, cloud top Nd), rather than derived ones. Restrict to 2D.  
- Consider integrating into CTRL simulation  
- Collect a list of useful diagnostics that could be added to experiments that make them useful for ACI analyses (please send your favourite variables to Ed Gryspeerdt, [*e.gryspeerdt@imperial.ac.uk*](mailto:e.gryspeerdt@imperial.ac.uk)*)*

Closer link with higher resolution studies  
- Follows a move to more high resolution modelling generally  
- Could link with ACPC, particularly with natural laboratories  
- Perhaps through groups that contribute to both initiatives  
Natural experiments work beyond Holuhraun  
- SE Atlantic ship corridor (if appropriate scale)  
- Perhaps implemented as emissions perturbation for CTRL (PI, PD, PD+)  
- *Velle Toll* had some ideas for how this could be implemented (also *Michael Diamond?, Rob Wood?*)

**Breakout session 6: Aerosol trends**

Moderator: Andrew Sayer

Rapporteur: Thanos Tsikerdekis

Douglas Alyson: Understanding changes in warm cloudiness since pre-industrial times using machine learning of satellite observations

Adam Povey: <drags out hobby horse> To what extent is the poor performance of linear trends due to AOD being log-normally distributed? Or the trends having a change in behavior in the middle of the timeseries?  
Alyson Douglas: I believe it is hard to say overall. In order to quantify how a linear approximation artificially introduces error because ACI are not linear means you would have to also exactly quantify how the environment modulates every interaction. And then you would also have to take into account how high aerosol concentrations regions are more likely to experience changes in the local environment due to direct aerosol effects as well. So, there are many reasons why linear regressions may have poor performances, one of which is the log-normal distribution.  
Duncan: Nice talk! Why does the error increase when using the higher resolution CF?  
Also: How did you do your train/val/test split?  
Alyson Douglas: At a 12 km cloud fraction, you really only have 12 possible states of cloud fraction (1-12 pixels being cloudy) so exactly predicting between 1 or 2 pixels being cloudy leads to a higher error at a 12 km scale than a 96 km scale. We did 80-20 test, within the 80 is a validation split of 20%.  
But was that randomly, across different grid-cells, or did you split it across time (e.g. different years?)  
  
Tsikerdekis Athanasios: Aerosol emission estimation using future satellite observation capabilities under the framework of Observing System Simulation Experiments (OSSEs)  
Tero Mielonen: What are the spatial and temporal resolutions of the simulations?

Thanos: Hi Tero, as I mentioned is 1.8degrees (T63) and every 3hours.

Tero: Thanks! By the way, I also did some simulations with different meteorology (ERA-Interim and CERA-20C) and noticed big differences in AOD levels. I think the main reason was dust and sea salt emissions which depend on wind speed so small changes near the wind speed emissions affected the emissions quite a lot.

Thanos: That is very interesting! Sea salt and dust emissions under difference meteorology of course will be different. The differences in my case at least were far away from the source regions and can be attributed to the different transport path for ERA-5 and ERA-interim.

Tero: Yes, the transport routes can also change. I was surprised on the size of the effect. I had assumed that the different ERA data sets wouldn't have big differences. Apparently, I was wrong :) If you are interested, I can share some results .

Thanos: Definitely interested! Indeed I thought that ERA-5 and ERA-interim would be similar. But for an averaged period July-September the transport path over the gulf of Guinea is quite different, hence the different AOD.

Tero: Great! I'll put some figures together and I'll send them to you in a couple of days. I'm using ECHAM-SALSA so our models are quite similar.

Thanos: Thank you!

Wandji William: How close to sunshine-duration based AOD retrievals is the ECHAM aerosol load over Europe?  
Thomas: SD-AOD is a relevant dataset for early period satellite and model evaluation, but needs a comparison to AERONET  
Gunnar: A link to the validation of the SD-AOD would be useful.

William: Please, find here the link for the paper <https://amt.copernicus.org/articles/13/3061/2020/amt-13-3061-2020.html>

Thomas Popp also made the suggestion to try using SD-AOD as a way to evaluate satellite obs before AERONET was widespread (e.g. AVHRR, ATSR2, early GEO)  
  
Xie Bing: The contributions of short-lived climate pollutants to global climate change since the pre-industrial era  
Interesting to see more work on aerosols and the Asian monsoon  
  
Yang Yang: Impacts of domestic emissions and regional transport on aerosol concentration, radiative forcing and climate during 1980–2018  
Tero: Why there's no change in European BC in the Arctic (slide 6).  
Andy wondered if we could use model "tagging" capabilities to trace aerosol types from different source regions (cf. African smoke separately from South American smoke) in order to draw better "boxes" for regional assumptions in satellite retrieval optical models.  
Nick noted it is difficult to evaluate tagging, though radioactive tracers are one option.  
  
Plenary presentations of this break-out session are planned for tomorrow (Thursday Session 8). The link for these presentations: <ftp://ftp-projects.zmaw.de/aerocom/meetings/ny2020/pdf_summaries/AC_session08_talk.pdf>  
- Garrigues, Sebastien - AOD monitoring within the CAMS data assimilation  
- Kramer Ryan: Observed aerosol forcing trends over the A-Train satellite era  
- Myhre Gunnar: Update on AeroCom Historical experiment  
- Schutgens Nick: An AEROCOM/AEROSAT study: evaluation of global models with satellite AAOD and SSA  
- Wenying Su: Regional trend comparison between satellite observations and model simulations: 200207-201712  
- Yang Yang: Modeled 1980-2018 trends over E.Asia  
  
General discussion focused on AOD, AAOD, forcing, and uncertainty confronting models with obs (some topics for tomorrow's plenary)

Other suggested topics for discussion in breakout 6 (and plenary 8):

Best practices to integrate information from satellites and modeling

What are conditions of high / low consistency within satellite data / modeling and between both?

What should be development priorities to improve on the above over the next year or so?

Best way to compare different products and resolve differences for data assimilation

**Nick Schutgens -** Schutgens et al., ACP in press, https://acp.copernicus.org/preprints/acp-2019-1193/  
A lot of uncertainty sources don't occur in isolation but are structured and link with each other.  
We don't have sufficient satellite AAOD retrievals to get a meaningful satellite diversity, as we do for total AOD.  
Diversity is a fair proxy for uncertainty in satellite AOD. The paper also notes a few AERONET sites where all retrievals seem to do poorly. Pick one of these  
regions and figure out why diversity is high there! Potential topic for a future AeroSat experiment??

**William Wandji -** Wandji Nyamsi et al., 2020, AMT, https://amt.copernicus.org/articles/13/3061/2020/amt-13-3061-2020.html  
Based on William’s work **Tomas Popp** suggested to use Sunshine Duration AOD as a way to evaluate satellite observations, before AERONET stations were  
widespread (e.g. AVHRR, ATSR2, early GEO)

**Wenying Su:**With CERES we can combine AOD and flux to estimate forcing efficiency, which is not AAOD, but is something related for model evaluation.

**Larisa Sogacheva -** Sogacheva et al., 2020, ACP, https://acp.copernicus.org/articles/20/2031/2020/  
Inter-comparison of satellite monthly AOD over different regions.

**Breakout session 7: Aerosol type from satellite**

Moderator: Thomas Popp

Rapporteur: Hongbin Yu

Jafariserajehlou, Soheila, PMAp: synergistic global Aerosol product from Metop satellites

Kauppi, Anu , Studying aerosol type selection and retrieved AOD estimates when applied to TROPOMI measurements

Lipponen, Antti, Model Enforced Post-Process Correction of Satellite Aerosol Retrievals  
Song, Quianqian, Comparison Study of Global Dust Climatology derived from CALIOP and MODIS Aerosol retrievals

Mian Chin: I think this "conditional DAOD" is problematic in a way that excluding "zero" values will definitely overestimate DAOD, because the zero is not really zero but close or below the CALIOP detection limit. In reality, some of the zeros should be included in the average but others should be excluded, which is not possible to do until we have a better sensitivity instrument...  
Qianqian: yes, I agree, thanks so much for your comment.  
Jason Tackett: Great work! I was curious in the CALIOP dust AOD averages, how are aerosol layers not classified as dust treated? Are they excluded in the average?  
Qianqian: Thanks for the question, in the CALIOP-based dust AOD retrieval, we derived the backscattering fraction of dust aerosol in each CALIOP-detected aerosol layers. Then by multiplying lidar ratio of dust aerosols to get dust extinction vertical profile. In this way, we could further get dust column AOD. Therefore, this study is not based on the standard CALIOP aerosol classification in which each layer of aerosol is classified as one type. In other words, we derived dust extinction for each layer and then calculate column AOD.   
In the climatological data product, we include those cases that the derived CALIOP-based AOD is equal to 0 in our average.

Jason: Thanks! Yes that answers my question.

Tackett, Jason, CALIOP Aerosol Typing Performance of Smoke from the 2019-2020 Australian Bushfire Event  
  
Zhang, Ying, Improved inversion of aerosol components in the atmospheric column from remote sensing data  
see : Zhang, Y., Li, Z., Chen, Y., de Leeuw, G., Zhang, C., Xie, Y., and Li, K.: Improved inversion of aerosol components in the atmospheric column from remote sensing data, Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2019-1062>, in press, 2020.

Rapporteur summary

*Q1: How far can we progress on constraining aerosol type with satellite observations?***Presentations**Applying/modifying heritage aerosol type (OMI) for new sensor (TROPOMI) PMAp – synergistic aerosol retrieval from GOME-2 (e.g., identifying ash from AVHRR+IASI, as well as dust from IASI)  
Improving CALIOP stratospheric aerosol typing (pyroCb smoke vs. ash/sulfate)  
Using ML technique to post process MODIS DT retrievals over land *(bias correction)***Discussion/Recommendations**Focus on some major events (e.g., wildfires, dust storms, volcanic eruptions)  
Need to update aerosol models on a regular basis based on emerging data (e.g., dust size and shape)  
To form a commission on “constraining aerosol properties” – many volunteers!

*Q2: How can satellite AOD at multiple wavelengths be used in modeling?*Multi-spectral AOD AEROSAT exercise (*recommended at last year’s meeting)*go beyond AOD at 550 nm  
data collected: MODIS, VIIRS, MISR, SLSTR, POLDER  
so far not too many datasets have AOD at other wavelengths  
also aerosol type (or aerosol model for satellite retrieval) *– differing among sensors***Discussion/Recommendations**Evaluating multi-wavelength AOD will provide additional insights into deficiencies in aerosol modeling. We should do it.  
Asking modelers to calculate TIR AOD *(needed for comparing with IASI retrievals)*

*Q3: How far can satellite interpretation schemes for aerosol type be applied to models?***Presentations**Comparing satellite-model aerosol typing *(qualitative)*Applying an AERONET-based aerosol classification algorithm (FMF, SSA) to 2 models *(similar patterns)*AATSR vs models - 8 components based on AE & SSA - *large discrepancies between satellite and models*Deriving aerosol components from remote sensing observations *(quantitative)*Global dust climatology from CALIOP and MODIS (dust vs non-dust)  
Aerosol components (8) from China’s SONET  
**Discussion/Recommendations**“satellite aerosol type” is “descriptive” & “empirical”, and depends on sensor, which makes it hard to be used by models in a quantitative way. For example, for a dust-smoke mixture, we don’t know the amount of dust vs. smoke.  
“We need to define a commonly agreed upon approach” – size, source, composition, etc?  
It should be *“purpose driven”* (e.g., what science questions to address?) and *“feasible”.*To form a commission on developing satellite-based aerosol components that modelers can use quantitatively, including:  
- Dust optical depth climatology (several size-based and shape-based methods)  
- Fine AOD vs coarse AOD

**Breakout session 8: Aerosol Representation Beyond AOD**

Moderator: Ralph Kahn

Rapporteur: Andrew Sayer   
  
Reed Espinosa – Surface/Aerosol RT simulation + GRASP retrieval testbed  
Monte Carlo simulator to draw various realistic real-world state vector of atmospheric properties. Forward-simulate satellite signals, add noise, and do retrievals with GRASP. Purpose is to test capabilities of potential future sensors. Focus on multiangle polarimeters, and polarimeter/lidar combinations.  
Fine mode particle shape is important for polarimeters to get right, but not so much for intensity-only measurements. So, more information can mean more challenges too!  
Mode-resolved simple vertical profiles can be achieved using a polarimeter and backscatter lidar.  
Anin: Hi Reed, when you are using the monte-carlo method finding the uncertainty in retrieved parameters, are you using a normal distribution around initial guess of each retrieved parameter? or using a uniform distribution around the bounds of retrieved parameters?

Reed: Hi Anin, the simulated state variables are chosen from a relatively wide uniform distribution.  The retrieval initial guess is also selected randomly, but from a second uniform distribution that is slightly narrow than the one used to derive the simulated state variables.

Anin: I am just curious to know if using a normal vs uniform distribution will give us different uncertainties. Which one represents the realistic retrievals uncertainties?

Reed: I haven't tried using a normal distribution, but I would expect the results to be a little different. I think the standard deviation (or bounds of uniform distribution) would likely play a larger role though.

Athanasios Tsikerdekis – Aerosol size and absorption from POLDER/PARASOL  
Assimilate AOD, AE, and SSA rather than only AOD. Allows adjustment of model component mixing ratios.  
Find this does better than assimilating AOD alone, in comparison to reference satellite data and also AERONET. Using the trio helps as assimilating only AOD can sometimes make e.g. AAOD worse.  
Paper in discussion in ACPD now: <https://acp.copernicus.org/preprints/acp-2020-468/>  
  
Bastiaan van Diedenhoven – RSP retrievals from CAMP2Ex, results & issues

CAMP2Ex data available here: <https://www-air.larc.nasa.gov/cgi-bin/ArcView/camp2ex>

Simultaneous retrieval of aerosol and surface (over water) properties from MAPP algorithm (Stamnes). Notes instrument flown in other campaigns too.  
CAMP2EX data (including level 1 and retrievals) available at link above. Sampled a variety of aerosol (and cloud) conditions. Good comparison of AOD with HSRL over largeish range; layer height uncertainty around 1 km (depends on HSRL definition)  
Anin: Hi Bastiaan, Are you using all the spectral bands from RSP in MAPP algorithm? Have you explored if you filter out the retrievals which has AOD < 0.4 at 410 nm

Bastiaan: All bands except the 960 and 1880 nm bands that are at water vapor absorption regions are used. These plots showed results for all data points. I'll have a look at AOD\_440<0.4 only.

Anin: For the case of AirHARP I was using the pixels with AOD\_440 > 0.4 for the RRI, IRI and SSA. However, for the case of RSP, this might be an overkill since you have longer wavelengths.

The extra wavelengths add some information but mainly for coarse mode. I think others often use a AOD at 550 of 0.2 as a cut off. When I do that, the histograms do not change much. It should also be reflected in the error covariance matrix if the info content for size, refractive index become small. What I showed was an overview and preliminary comparison to HSRL, but we need to take a better look at information content and estimated errors.

Pete Colarco – June 2020 Saharan Dust Event – Testing ICAP models w/data  
Looking at the Saharan dust event from a forecast model (NRT, assimilation) rather than climate perspective. 3 AERONET sites at various points downwind for evaluation. With assimilation, transport path of ICAP models is pretty consistent. However, there remain larger differences near the sources, and magnitudes of AOD in the Caribbean (~factor 2). Models with assimilation have lower diversity than those without.  
Thanos: Thank you for the presentation! Very interesting how the assimilation of AOD can ensure such consistency in the long-range transport of dust over Caribbean! Is aerosol mixing ratio or aerosol emissions the state vector in these assimilation experiments? Also, I may have missed that information, are these assimilation experiments using the same meteorology (or nudged to the same meteorology)?  
AOD is what is assimilated in the models that do it, I think 550 nm MODIS-based AOD in all cases. They translate back to their mixing ratios with whatever assumptions they make about the aerosol composition. In the NASA model for example it practically amounts to a rescaling of the prior concentration distributions. There is little information about speciation or altitude in the assimilation in our model except that we look locally around the target assimilation point.  
The models are all using their own meteorology. This is something I hope to work on deconvolving in a proposal we wrote to NASA with the ICAP colleagues to run the various meteorologies through a single CTM framework. We've worked out the approach, but have not yet been funded to do the work. It would be interesting!  
Thanos: I would be very interested to see the results of the different meteorology experiment, I hope it gets funded. We have done some similar work under an OSSE framework (my yesterday poster), and show that ERA-5 and ERA-interim meteorology may lead to quite different transport paths of aerosols and can impact emission estimation. Although they are both reanalysis products and ERA5 just an upgrade of ERAinterim. Also I am suspecting that if you were scaling emissions in your data assimilation experiments you might not get the same level of consistency in this long-range transport.  
  
Daniel Robbins – AI to separate Himawari smoke/cloud for the 2020 Australia fires  
Trained a neural network on CALIOP-Himawari cloud mask to separate smoke and cloud. Tends to perform better than operational (JMA) cloud mask.  
Neural network seems better at dust/smoke vs cloud identification, but misses some edges and thin clouds.  
Caroline: AI techniques rely on accurate training data, we have found that CALIOP type is not very accurate at least in the Himawari region.  
  
Marta Luffarelli –  Consistent retrieval of cloud, aerosol, and surface properties  
Optimal Estimation retrieval where optical properties of cloud/aerosol are parameterised in SSA and g space (different classes which are linearly mixed).  
Attempting retrieval of all pixels as clouds and aerosols bypasses the need for a preprocessing cloud mask. Presented application to SLSTR.  
Caroline @Marta what uncertainty do you use in your retrievals?  
  
**General discussion**  
Yves: assimilating AOD and absorption is a good idea. There are many instruments/algorithms coming up. How important do you think the absorption is as the quantity to go after?

Andy: I think absorption and height (at least boundary layer vs. free troposphere) are most important as they feed directly to both climate and air quality goals.

Thanos: In terms of retrievals it is important to narrow the uncertainty of absorption aerosol properties (SSA, AAOD) and the upcoming instruments (e.g. SPEXone and HARP-2) can certainly help with that. Although from what I am seeing from my experiment, there is already valuable information in SSA and AAOD despite their big errors, since models have way higher errors in absorption. To answer more specifically Yves question, if we don’t get absorption correct we certainly misrepresent the radiative effect of models and hence their effect on climate. So I think it is quite important to get it right (to the extent that we can, considering the errors of absorption retrievals).

Ralph: Angela's discussion of radiance (rather than AOD) assimilation earlier points to a way to bypass some assumptions that might differ between satellite-world and model-world.

Pete: have also been able to develop emulators (e.g. CALIOP aerosol type, OMI UV) to facilitate the "translation" between satellite and model contents. Helps iterate improvements in models and retrievals.

Greg Schuster: isn't the computational burden of large-scale radiance assimilation too high?

Pete: not sure but it is done routinely in the NWP community. They may have simplified radiative transfer.

Angela: there is a whole group of people who work to make RT codes that are fast and accurate enough for assimilation. These are e.g. regression approaches. Fairly mature for the IR. For aerosols, they have adapted the ORAC lookup table approach.

Ralph: we also need lab/suborbital constraints on the fundamental particle properties like mass extinction efficiency and hygroscopic growth. Needed to reduce the uncertainties in those assumptions. See Claudia presentation tomorrow.

Pete: this also applies to satellite emulators - an additional source of uncertainty we need to be mindful of when developing these and doing the comparisons. Modeled state (including optical properties) needs to be realistic.

Yves: as Christoph Bruehl pointed out earlier, the model really starts at spectral refractive index, so we should come to consistency on that and provide recommendations. (And we don't have enough measurements now.)

Ralph: Here is a reference giving an approach to obtaining systematic in situ measurements of aerosol microphysical properties that are either unobtainable from remote-sensing, or cannot be obtained with adequate accuracy for climate and/or air quality applications: Kahn et al., BAMS 2017, doi:10.1175/BAMS-D-16-0003.1.

Related presentations from plenaries tomorrow (not discussed in this breakout):  
Claudia di Bagio – Lab measurements of aerosol microphysical properties  
Andrew Sayer – 2020 Australia fires AOD and AAOD retrieval results & prospects  
Larisa Sogacheva– Comparisons of multi-spectral satellite AOD

Rapporteur summary

Two presentations (**Espinosa, van Diedenhoven**) focused on capabilities of next generation: retrieval simulations and airborne prototype, respectively  
These link to presentation by **Tsikerdekis** on the utility of aerosol size and absorption (in addition to AOD) for aerosol data assimilation

Two presentations (**Robbins, Luffarelli**) dealt with better strategies to distinguish clouds from heavy aerosols, especially important for extreme events.

Presentation by **Colarco** tied some of these threads together showing utility of AOD assimilation at constraining spatial patterns of transport (though not magnitude or source strength) for an extreme Saharan dust storm

Bigger-picture thoughts and next steps:  
Challenges include translation between satellite and model optical properties; lack of sufficient ***lab/airborne measurements*** (see also plenary 11)  
Emulators (e.g. GEOS5 work with CALIOP, OMI) can be a ***“middle ground”*** between (a) constraining model with satellite-retrieved optical properties and (b) radiance assimilation; could help both sides retrievals refine assumptions.  
-- Could apply ***properties satellites can retrieve*** in emulation, e.g., FMF, non-spherical AOD fraction, light-absorbing AOD fraction (maybe also absorption AOD spectral slope)  
-- Some consensus to focus on ***light-absorption*** as the next key retrieved property  
Possible future AeroCom - AeroSat joint experiment?  
Open questions include: (1) When to use empirical ***neural networks*** (including suitable training data) vs. physical retrievals, (2) How to determine ***error covariance matrices*** for optimal estimation retrievals

**Breakout session 9: New retrievals**

Moderator: Adam Povey

Rapporteur: Pekka Kolmonen  
  
**Chimot, Julien**) Copernicus Sentinel-3 near-real-time aerosol optical depth baseline Collection 1 product by EUMETSAT  
Adam Povey: What techniques did you use to evaluate the information content? I'm familiar with these being used in spectrometer retrievals but they're rarer with imagers.  
The geometrical part was an important part of it (see our other contribution on it) in the case of SLSTR. It rapidly informed us on why the retrieval was failing.  
  
**Litvinov, Pavel**) Surface and aerosol retrieval from S5P using GRASP: baseline requirements and expected performance  
  
**Marbach, Thierry**) EUMETSAT aerosol missions and products: focus on 3MI, the multi-view polarimeter flying on Metop-SGA  
Istvan Laszlo: Is the input to GRASP the L1B or the L1C 3MI data? What is the data granule size for the aerosol product?   
Today the input is L1C because in line to what was done on POLDER. Later we can image starting from L1B and use the fact that the pixels have not been co-registered (which can induce loss of information).  
concerning the data granule size, do you mean time or MB?  
Istvan Laszlo: I mean time, this of course translates to number of scan lines by number of pixels per scan line.  
3MI does not scan, all pixels are acquired (e.g. 512\*512 for VNIR). The preliminary results for the NRT GRASP is about 0.2-0.4 second (core average time)   
Istvan Laszlo: Yes, I am aware of 3MI is not scanning; I meant the number of pixels in one granule when I said scan lines. Apologies for the unclear question, and thanks for the answer.  
  
**Piontek, Dennis**) Recent advances in satellite retrieval of volcanic ash properties  
Adam: Any idea why the errors in top height are a function of latitude rather than zenith angle?  
Dennis: I assume this might be connected to a lowering of the tropopause at higher latitudes. As we still have ash plumes at heights up to 18km those samples are probably harder to retrieve. Also it is possible that the neural network learns mainly the temperature profile at low latitudes, leading to wrong estimates towards the poles.

**Thompson, Sabrina**) Analysis of scattering angle sampling by multi-angle imaging polarimeters for different orbit geometries  
   
**Zheng, Jianyu**) Research-level retrieval algorithm of dust thermal infrared optical depth properties using collocated IIR/CALIOP observations   
I am sorry for not presenting the poster online due to the time conflict. Mainly the poster shows the advantage of combining active lifts CALIOP and passive infrared radiometer IIR with 1-km resolution to actively identify cloud-fee dust layers with accuracy dust vertical distributions. The retrieved dust AOD at 10.6 um can be retrieved by assuming dust particle size distribution and refractive index along with atmospheric states. We have tested that the uncertainty of assumed particle size distribution is not obvious compared with that of the assumed atmospheric states (atmospheric profiles and surface properties).   
  
**Povey, Adam**) Making the old new again: Overhauling ORAC  
Pekka: the azimuth is a headache here. Our best estimate is that mirroring is needed with respect to LUT

That was sort of where we started. DISORT et al use a different definition to the surface reflectance people

I've run into the Azimuth angle while working with OMI and MODIS Level 1b data, very simple yet very easy to get confused definition

Rapporteur summary

The new advances in the aerosol retrieval are here collected from the breakout session divided into three categories:  
Enhancement or re-use of existing methods (ORAC ATSR/SLSTR, GRASP S5P & 3MI)  
New methods (NN approach to ash retrieval MSG-SEVIRI). New methods with instrument synergy (Dust retrieval IIR/CALIOP)  
Geometry effects on retrieval (Scattering angle sampling for Multi-Angle Polarimeters, dual-view SLSTR)

Remarks

Quite some development is currently concentrated on studying the retrieval geometry  
Detecting deficiencies in aerosol retrieval performance and determining the information content as a function of the geometry  
Studying the scattering angle for future mission recommendations  
Neural networks as a retrieval method is pursued.  
Combining data from two instruments is seen beneficial in special circumstances. In this session no general aerosol retrieval with synergy approach was presented. (See plenary Friday 16th for a GEO/LEO use.)

**AGENDA**

**AeroCom / AeroSAT**

**Day 3 Wednesday, October 14, 2020**

EU:2:00–3:30pm/NY:8:00–9:30am/CA:5:00–6:30am/JP:9:00pm–10:30pm/CN:8:00– 9:30pm

**Plenary Session 6  -  Covid impact on aerosol loads, air quality and forcing [90 min]**

one slide by moderator with main issues + key questions / 5 min presentations of recent work

Moderator: Kostas Tsigaridis

Rapporteur:  Jonathan Hickman

- Johannes Quaas: Assessing aviation-induced cirrus from satellite during COVID-19 (5 min)

- Nicolas Bellouin: Impact of Chinese Covid-19 lockdown on aerosol and radiative fluxes over East Asia Seas (5 min)

- Shobha Kondragunta: China and Taiwan: A Tale of Two COVID-19 Lockdown Measures and Air Quality (5 min)

- Xiaohong Liu: Impacts of COVID-19 on Aerosol Direct and Indirect Radiative Forcing (5 min)

- Ragnhild Skeie: Changes in aerosol composition and radiative forcing due to COVID-19 in OsloCTM3 (5 min)

- Augustin Mortier: COVID-19: Impact on AOD and European Air Quality (5 min)

- Svetlana Tsyro: Impacts of COVID-19 lockdown on European air quality (5 min)

Discussion 60 (min): What have we learnt so far from the Covid-19 natural experiment?

Best practices to analyze the various data of such an exceptional situation against the long-term background

**15 minutes break**

EU:3:45–5:15pm/NY:9:45–11:15am/CA:6:45–8:15am/JP:10:45pm–0:15am/CN:9:45–11:15pm

**Plenary Session 7 - indirect effects and observational constrains [90min]**

one slide by moderator with main issues + key questions / five 10 min presentations

Moderator: Johannes Quaas

Rapporteur: Edward Gryspeerdt

1 slide by moderator with main issues + key questions

- Paquita Zuidema:  Oracles overview [10min]

- Edward Gryspeerdt: Indirect effect - Identifying observational constraints (10min]

- Velle Toll: constraint on cloud water response to aerosols (10min]

- Otto Hasekamp: Retrieval of Cloud Condensation Nuclei to Quantify Radiative Forcing due to ACI (10 min)

- Marta Lufarelli: Aerosol retrieval in presence of clouds (10 min)

Discussion (40 min): Ways forward to better constrain aerosol-cloud effects with observations

**5 minutes break**

EU:5:20–7pm/NY:11:20am–1pm/CA:8:20–10am/JP:00:20am–02am/CN:11:20pm–1am

**Introduction and Breakout Discussion Session B [100 min]**

- 1. Plenary-Introduction: 1 slide introductions from breakouts 4-6 of non plenary talks (ca 15 minutes altogether)

**10 minutes break**

- 2. Breakouts 4-6: discussions in 3 parallel sessions by topic - extra attention to non-plenary talks   
Moderators: Kostas Tsigaridis, Johannes Quaas, Andrew Sayer (plus rapporteurs – see break.pdf)

Icebreaker mingling probably on yotribe.com / Details will be sent around before meeting

**AeroCom / AeroSAT**

**Day 4 Thursday, October 15, 2020**

EU:2:00–3:30pm/NY:8:00–9:30am/CA:5:00–6:30am/JP:9:00pm–10:30pm/CN:8:00– 9:30pm

**Plenary Session 8 - compare model and satellite data: treating clouds, derived trends [90min]**

one slide by moderator with main issues + key questions / 4 presentations

Moderator: Andrew Sayer

Rapporteur: Larisa Sogacheva

- Gunnar Myhre: model simulated historical (HIST) forcing and trends [7min]

- Wenying Su: comparing historical (HIST) trends with (CERES) observations [7min]

- Yang Yang: modeled 1980-2018 trends over E.Asia [7min]

- Ryan Kramer: Observed aerosol forcing trends over the A-Train satellite era (7 min)

- Nick Schutgens: An AEROCOM/AEROSAT study: evaluation of global models with satellite AAOD and SSA (7 min)

- Sebastien Garrigues: AOD monitoring within the CAMS data assimilation (7 min)

Discussion (50 min): Best practices to integrate information from satellites and modeling

What are conditions of high / low consistency within satellite data / modeling and between both?

Development priorities to improve on some of them

Best way to compare different products and resolve differences for data assimilation

**15 minutes break**

EU:3:45–5:15pm/NY:9:45–11:15am/CA:6:45–8:15am/JP:10:45pm–0:15am/CN:9:45–11:15pm

**Plenary Session 9 - Spectral dependence of AOD / constraining aerosol type [90 min]**

one slide by moderator with main issues + key questions / 3 presentations

Moderator: Thomas Popp

Rapporteur:  Marta Luffarelli

- Kostas Tsigaridis / Lucia Mona: Simulating instrumentally-defined aerosol type(10min)

- Tero Mielonen: Comparing aerosol types in climate models and satellite retrievals (5 min)  
- Larisa Sogacheva: Comparisons of satellite AOD at multiple wavelengths (5 min)

Discussion (70 min): How can we progress on constraining aerosol type with satellite observations?

How can satellite AOD at multiple wavelengths be used in modeling?

How far can satellite interpretation schemes for aerosol type be applied to models?

**5 minutes break**

EU:5:20–7pm/NY:11:20am–1pm/CA:8:20–10am/JP:00:20am–02am/CN:11:20pm–1am

**Introduction and Breakout Discussion Session C [100 min]**

- 1. Plenary-Introduction: 1 slide introductions from breakouts 7-9 of non plenary talks (ca 15 minutes altogether)

**10 minutes break**

- 2. Breakouts 7-9: discussions in 3 parallel sessions by topic - extra attention to non-plenary talks   
Moderators: Thomas Popp, Ralph Kahn, Adam Povey (plus rapporteurs – see break.pdf)

**AeroSAT**

**Day5  Friday, October 16, 2020**

EU:2:00–3:30pm/NY:8:00–9:30am/CA:5:00–6:30am/JP:9:00pm–10:30pm/CN:8:00– 9:30pm

**Plenary Session 10 - breakout-group summaries days 2-4 [45 min]**Rapporteurs  [9\*5min]

**5 minutes break**

**Plenary Session 11 – requirements “new OPAC” (‘a-prioiri choices’) in-situ / lab meas. [40min]**

one slide by moderator with main issues + key questions

Moderator: Ralph Kahn

Rapporteur:  Lucia Mona

- Claudia Di Biagio (ACTRIS representative): Update on lab experiments, how to define new experiments (5 min)

Discussion (35 min): concrete requirements for “new OPAC”

**15 minutes break**

EU:3:45–5:15pm/NY:9:45–11:15am/CA:6:45–8:15am/JP:10:45pm–0:15am/CN:9:45–11:15pm

**Plenary Session 12 - new retrievals: strengths, limitations, new developments [90min]**

one slide by moderator with main issues + key questions

Moderator: Adam Povey

Rapporteur:  TBA by moderator

- Robert Levy: GEO-LEO synergy of different groups (5 min)

- Felix Seidel: “Beyond AOD”, quantify vertically resolved aerosol absorption (5 min)

- Oleg Dubovik: Assessment of multi-angular polarimetry potential (5 min)

- Bertrand Fougnie: How consider the geometry of acquisition on the aerosol retrieval performance (5 min)

- Kirk Knobelspiesse: Analysis of simultaneous aerosol / ocean glint retrieval using multiangle observations (5 min)

Discussion (65 min) Most promising breakthrough potentials to improve aerosol retrieval information?

**15 minutes break**

EU:5:30–7pm/NY:11:30am–1pm/CA:8:30–10am/JP:00:30am–02am/CN:11:30pm–1am

**Plenary Session 13 - recent extreme events [40min]**

One slide by moderator with main issues + key questions

Moderator: Larisa Sogacheva

Rapporteur:  TBA by moderator

- Andrew Sayer: How consistent are satellite retrievals of smoke from the 2019-2020 Australian fires? (5 min)

- Hongbin Yu: Gigantic African Dust Intrusion into the Caribbean Basin and southern U.S. in June 2020 (5 min)

Discussion (30 min): How improve representation of extreme events with limited sampling in extreme events?

**Plenary Session 14 - closing remarks [20min]**

- Thomas Popp AeroSAT

- Michael Schulz  AeroCom

Perosn acronyms used in the minutes

|  |  |
| --- | --- |
| Adam | Adam Powey |
| Andrew, Andy | Andy Sayer |
| Anin | Anin Puthukkudy |
| Angela | Angela Benedetti |
| Antti L | Antti Lipponen |
| Augustin | Augustin Mortier |
| Bastiaan | Bastiaan van Diedenhoven |
| Ben | Ben Johnson |
| Bertrand | **Bertrand Fougnie** |
| Betsy | Betsy Andrews |
| Caroline | Caroline Poulsen |
| Christoph | Christoph Bruehl |
| Claire | Claire Ryder |
| Claudia | Claudia di Bagio |
| Dan | Daniel Robbins |
| Dave W | David Winker |
| **Dennis** | **Dennis Piontek** |
| Duncan | Duncan Watson-Parris |
| Ed | Edward Gryspeerdt |
| Felix | **Felix Seidel** |
| Gerrit | Gerrit de Leeuw |
| Greg | Greg Schuster |
| Gunnar | Gunnar Myhre |
| Istvan | Istvan Laszlo |
| Johannes | Johannes Quaas |
| Hongbin | Hongbin Yu |
| Kai | Kai Zhang |
| Kirk | **Kirk** **Knobelspiesse** |
| Larisa | Larisa Sogacheva |
| Lazaros | Lazaros Oreopoulos |
| Linlu | Linlu Mei |
| Lucia | Lucia Mona |
| Mian | Mian Chin |
| Michael D | Michael Diamond |
| MichaelS, Michael | Michael Schulz |
| Nicolas | Nicolas Bellouin |
| Oleg | Oleg Dubovik |
| Paquita | Paquita Zuidema |
| Paul G | Paul Ginoux |
| Pekka | Pekka Kolmonen |
| Pete | Pete Colarco |
| Philip | Philip Stier |
| Qianqian | Qianqian Song |
| Ragnhild | Ragnhild Skeie |
| Ralph | Ralph Kahn |
| Rich F | Richard Ferrare |
| Ron | Ron Miller |
| Ross H | Ross H |
| Roxana | Roxana Cremer |
| Shobha | Shobha Kondragunta |
| Sebastien | Sebastien Garrigues |
| Steve | Steven Smith |
| Svetlana | Svetlana Tsyro |
| Tero | Tero Mielonen |
| Thanos | Athanasios Tsikerdekis |
| Thomas | Thomas Popp |
| Toshi | Toshi Takemura |
| Velle | Velle Toll |
| Wenying | Wenying Su |
| William | William Wandji |
| Xiaohong | Xiaohong Liu |
| Yingxi | Zhang Ying |
| Yves | Yves Govaerts |
| Zak | Zak Kipling |