PACE SAT polarimetry sub-group meeting notes February 22nd, 2021

Presentations and these notes can be found here:
https://pacesat.marinesciences.uconn.edu/polarimetry/

We had two speakers today addressing the issue of Maritime aerosol optical properties that may, in some cases, not have the optical properties we expect. Specifically, they may be non-spherical. Would this impact the atmospheric correction and/or aerosol retrieval algorithms that we would use for PACE?

- This is motivated by an analysis of airborne HSRL-2 lidar observations by **Rich Ferrare** (NASA LaRC) from the ACTIVATE field campaign (Sorooshian et al, 2019, https://doi.org/10.1175/BAMS-D-18-0100.1). Rich found evidence of aerosols with higher than expected depolarization (indicating non-sphericity) for cases where the lidar ratio, back trajectory analysis, and GEOS-Chem indicate maritime aerosols (only) should be present. This corresponds with low relative humidity, and there is literature showing that sea salt transitions from 'spherical' to non spherical as relative humidity decreases below roughly 70%. Several of us became aware of Rich's work from a poster at AGU. He gave an expanded version of the talk, slides for which are posted at the location above.

- Additionally, **Jacek Chowdhary** (NASA GISS/Columbia) gave a related presentation on airborne RSP polarimeter observations from a few years back. He examined coastal measurements as part of the CLAMS field campaign in 2001 (?). He found that wet sea salt aerosols (from MODIS models) match the radiometric observations, but not the polarized reflectance. He then investigated different types of aerosols that do match, but do not have homogenous, spherical properties. His presentation is also included at the above link.

- Following these talks there was a lively discussion, all of which I was not able to capture. Chat window comments, are below, however. **Andy Sayer**'s comment is particularly relevant as to how we would proceed from here: "*Thinking about implementing things in retrieval algorithms which are built on varying size, refractive index, and proportion of uncoated spheres and spheroids. For large-scale data processing.*"

- **Brian Cairns** later sent a message to the group with these potentially useful papers: "*In addition to Michael Mishchenko's papers the following papers have relevant information:*"
    - Bi, L., W. S. Lin, D. Liu, and K. J. Zhang (2018), Assessing the depolarization capabilities of nonspherical particles in a super-ellipsoidal shape space, Opt Express, 26(2), 1726-1742, doi: 10.1364/Oe.26.001726.

- Bi, L., W. S. Lin, Z. Wang, X. Y. Tang, X. Y. Zhang, and B. Q. Yi (2018), Optical Modeling of Sea Salt Aerosols: The Effects of Nonsphericity and Inhomogeneity, J Geophys Res-Atmos, 123(1), 543-558, doi: 10.1002/2017jd027869.
- Haarig, M., Ansmann, A., Gasteiger, J., Kandler, K., Althausen, D., Baars, H., Radenz, M., and Farrell, D. A.: Dry versus wet marine particle optical properties: RH dependence of depolarization ratio, backscatter, and extinction from multiwavelength lidar measurements during SALTRACE, Atmos. Chem. Phys., 17, 14199–14217, https://doi.org/10.5194/acp-17-14199-2017, 2017.
- Murayama, T., H. Okamoto, N. Kaneyasu, H. Kamataki, and K. Miura (1999), Application of lidar depolarization measurement in the atmospheric boundary layer: Effects of dust and sea-salt particles, J Geophys Res-Atmos, 104(D24), 31781-31792, doi: Doi 10.1029/1999jd900503.
- Sakai, T., T. Shibata, S. A. Kwon, Y. S. Kim, K. Tamura, and Y. Iwasaka (2000), Free tropospheric aerosol backscatter, depolarization ratio, and relative humidity measured with the Raman lidar at Nagoya in 1994-1997: contributions of aerosols from the Asian Continent and the Pacific Ocean, Atmos Environ, 34(3), 431-442, doi: Doi 10.1016/S1352-2310(99)00328-3.
- Zieger, P., Väisänen, O., Corbin, J. et al. Revising the hygroscopicity of inorganic sea salt particles. Nat Commun 8, 15883 (2017). https://doi.org/10.1038/ncomms15883

- **Jacek Chowdhary** sent this message after the meeting:
  - *Furthermore: yesterday, there was a good discussion on the impact on ocean color remote sensing of differences between the MODIS and RSP salt models. I mentioned that both models provided a good fit to the RSP total reflectance data. What I forgot to mention is that I obtained a good fit for these RSP data at 2250, 1590, and 865 nm, but not at 550 nm because I assumed a black water body in my simulations. So the total reflectance differences seen between simulation and observation at 550 nm correspond to the ocean color contribution at 550 nm. In fact, on slides 2 & 3 you can see that write this explicitly. Of importance to this discussion is that this inferred ocean color contribution changes with coarse-mode aerosol model. To show this in more detail, I added a figure on slide 4 that compares these differences. You can see there that, for this particular example, the choice of salt model has an impact on the inferred ocean color contribution at 550 nm (it's about 5%-10% of the RSP total reflectance).*
  - *So I anticipate that worst case scenarios (i.e. PACE observations that contain sideward-scattering geometries where the sun glint contamination is absent and where the scattering differences between spherical and spheroid coarse-mode particles can be even more pronounced) will show a measurable impact on OCI retrievals of IOPs for different salt particle shape choices. The good news, of course, is that the PACE polarimeters will very likely help us decide which shape to choose.*

- Finally, **Jacek Chowdhary, Pengwang Zhai, Snorre Stamnes** (and to a lesser extent, myself) agreed to look into a small 'project' to examine the importance that these may have on retrievals. Here is a proposed plan:
  1) identify a few scattering geometries that PACE will encounter
  2) choose a spherical model and refractive index for completely hydrated salt particles
  3) choose a non-spherical model and refractive index for partially hydrated salt particles
  4) choose one or more optical depth for these salt particles
  5) choose one or more optical depths for a standard fine-mode aerosol model
  6) choose a reference case for ocean IOPs (e.g., Case 1 with Chl = 0.05-0.1 mg/m3)
  7) do forward computations to get TOA results for select observations by OCI, SPEXone, HARP2
  8) do an inversion for those TOA results
  9) compare IOP retrievals for those cases

Thanks for logging in everybody! Next meeting will be March 15th at 1pm EST. **Vanderlei Martins** will discuss HARP L1 and L2 data processing advancements.

-Kirk Knobelspiesse, Feb. 24, 2021

Meeting chats:

[Monday 1:17 PM] Xiaodong Zhang (Guest)

how was the depo-ratio measured?

[Monday 1:19 PM] Xiaodong Zhang (Guest)

So it is for ~180 degree scattering.

[Monday 1:21 PM] Knobelspiesse, Kirk D. (GSFC-6160)

yes

[Monday 1:28 PM] Xiaodong Zhang (Guest)

The light source is vertically polarized?

[Monday 1:30 PM] Stamnes, Snorre A. (LARC-E304)
Correct, it's linearly polarized (i.e. parallel) and they measure parallel and perpendicular. Or total and perpendicular.

[Monday 1:38 PM] Zhibo Zhang (Guest)

Yes, I have a quick question

[Monday 1:40 PM] Dierssen, Heidi (Guest)

Couldn't the spectral information differentiate between sea salt and minerogenic dust

[Monday 1:41 PM] Zhibo Zhang (Guest)

Thanks

[Monday 1:43 PM] Schuster, Gregory L. (LARC-E302)
Rich showed a slide that indicates this occurs when coarse mode dominates => probably low AE like dust

[Monday 1:43 PM] Zhibo Zhang (Guest)

If we know the shape and composition of the nonspherical sea salt, there are multiple tools to model the scattering properties, such as DDA and FDTD

(1 liked)

[Monday 1:43 PM] Sayer, Andrew (GSFC-616.0)[UNIVERSITIES SPACE RESEARCH ASSOCIATION]
Thanks Rich, Brian, and Zhibo!
Edited

[Monday 1:44 PM] Schuster, Gregory L. (LARC-E302)
Texas A&M has new hexahedral shapes
(2 liked)

[Monday 1:44 PM] Sayer, Andrew (GSFC-616.0)[UNIVERSITIES SPACE RESEARCH ASSOCIATION]
Thinking about implementing things in retrieval algorithms which are built on varying size, refractive index, and proportion of uncoated spheres and spheroids. For large-scale data processing.
(2 liked)

[Monday 1:45 PM] Van Diedenhoven, Bastiaan (GISS-611.0)[TRUSTEES OF COLUMBIA UNIVERSITY]

https://pubs.giss.nasa.gov/docs/1995/1995_Mishchenko_mi04000r.pdf

(1 liked)

[Monday 1:46 PM] Knobelspiesse, Kirk D. (GSFC-6160)

Sayer, Andrew (GSFC-616.0)[UNIVERSITIES SPACE RESEARCH ASSOCIATION] that is my interest as well, and partly motivating why I wanted to talk about this today

(1 liked)

[Monday 1:46 PM] Zhibo Zhang (Guest)

Sea salt is unlikely hexagonal

[Monday 1:46 PM] Schuster, Gregory L. (LARC-E302)
agreed

[Monday 1:48 PM] Zhibo Zhang (Guest)

very interesting talk. Thanks Rich.

[Monday 1:48 PM] Sayer, Andrew (GSFC-616.0)[UNIVERSITIES SPACE RESEARCH ASSOCIATION]
It was one of my favourite presentations from AGU this year.

[Monday 1:48 PM] Pahlevan, Nima (GSFC-619.0)[SCIENCE SYSTEMS AND APPLICATIONS INC]
Great talk!

[Monday 2:04 PM] Cairns, Brian (GISS-6110)

I think that the scattering angles in Jacek's figure that are not impacted by glint do not include those where sphere/spheroid P11 phase matrix elements are most different.

[Monday 2:07 PM] Cairns, Brian (GISS-6110)

CLAMS was July over the Chesapeake lighthouse and was generally quite humid. It is also possible to get far traveled dust wrapping around the Bermuda high at that time of year.

[Monday 2:09 PM] Pengwang Zhai (Guest)
Thanks. That makes sense. @ Cairns

[Monday 2:10 PM] Gao, Meng (GSFC-616.0)[SCIENCE SYSTEMS AND APPLICATIONS INC]

maybe this article is relevant to the coated sea salt particle:
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017JD027869

(1 liked)

[Monday 2:16 PM] Ibrahim, Amir (GSFC-6160)

Sounds great Jacek and Pengwang. Thanks all!

[Monday 2:16 PM] Pahlevan, Nima (GSFC-619.0)[SCIENCE SYSTEMS AND APPLICATIONS INC]

Agreed, Kirk! Thanks, Jacek!

[Monday 2:17 PM] Sayer, Andrew (GSFC-616.0)[UNIVERSITIES SPACE RESEARCH ASSOCIATION]
Thanks all!