The Consistency of Satellite and Model-resolved Aerosol Speciation during the Southeastern U.S. Summer from CALIOP and NAAPS

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SUMMARY

The predominance of summertime organic aerosol (OA) production in the southeastern U.S. (SEUS) presents a unique challenge for Level 2 Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) typing algorithms. CALIOP algorithms account for six distinct aerosol particle clusters, based on backscatter and depolarization signal properties. To date, it is unclear how organic aerosol particles, alone and in mixtures, are distinguished using the CALIOP typing scheme, and thus what potential biases exist from their presence in long-term aerosol optical depth and extinction coefficient profile trends resolved within these products. We have previously applied the U.S. Navy Aerosol Analysis and Prediction System (NAAPS) global aerosol transport model as context for evaluating the depth of regional speciation-related biases in CALIOP Level 2 datasets (Campbell et al., 2013). A research-grade version of NAAPS resolves organic aerosol presence through an empirical source function. Airborne High Spectral Resolution Lidar (HSRL) measurements collected from the summer 2013 SEAC4RS experiment are also available to constrain aerosol typing in greater detail relative to CALIOP, and serve as general constraint relative to the model.

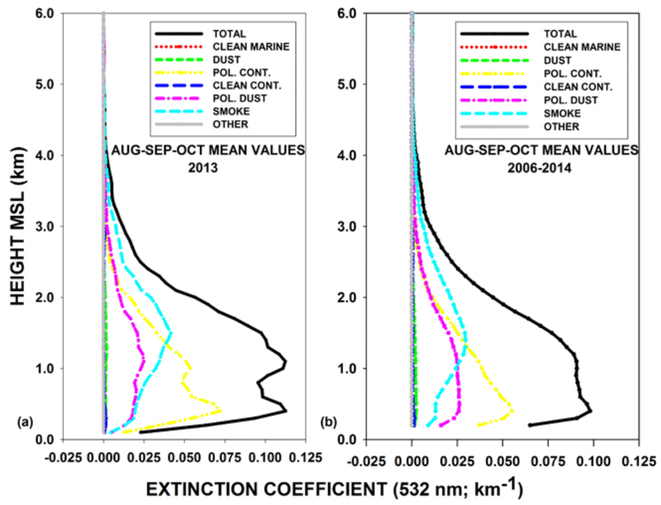

FIGURE 1 - *Mean vertical profiles of speciated CALIOP 532 nm extinction coefficient shown for 30 - 35 N/95-80 W over land from Aug-Sep-Oct 2013 (during SEAC4RS) relative to a nine-year seasonal mean (2006-2014).*

The SEAC4RS season was relatively typical compared with mean conditions. Polluted Continental aerosols contribute most to the mean sample, followed by Smoke and Polluted Dust. Secondary species contribute little to the overall sample.

We generally anticipate that OA would be masked within the bounds of current of the two "Polluted" CALIOP groupings, though much more likely "Continental" given relatively small spherical particles and relatively low absorption.

AUG/SEP/OCT	TOTAL (CALIOP = 0.222)					DUST (CALIOP = 0.007)					POLLUTED CONTINENTAL (CALIOP = 0.080)				
	TOTAL	SULFATE	DUST	SMOKE	SEA SALT	TOTAL	SULFATE	DUST	SMOKE	SEA SALT	TOTAL	SULFATE	DUST	SMOKE	SEA SALT
NAAPS	0.187	0.079	0.053	0.051	0.033	0.019	0.008	0.007	0.004	0.000	0.078	0.035	0.021	0.021	0.002
	CLEAN CONTINENTAL (CALIOP = 0.002)					POLLUTED DUST (CALIOP = 0.058)					SMOKE (CALIOP = 0.073)				
	TOTAL	SULFATE	DUST	SMOKE	SEA SALT	TOTAL	SULFATE	DUST	SMOKE	SEA SALT	TOTAL	SULFATE	DUST	SMOKE	SEA SALT
NAAPS	0.028	0.012	0.008	0.007	0.001	0.097	0.041	0.028	0.027	0.002	0.084	0.037	0.023	0.023	0.001

TABLE 1 - *For Aug-Sep-Oct 2006-14, NAAPS speciated 550 nm AOD corresponding with when CALIOP identifies either of Dust, Pol. Cont., Clean Cont., Pol. Dust, Smoke and Total. Corresponding CALIOP 532 nm AODs are noted.*

Focusing on the three major species referenced above, the NAAPS model is generally consistent with depiciting a coarse mixture of sulfate, dust and smoke with the Pol. Cont. model is chosen by CALIOP. Pol. Dust is less consistent, but we are wary of this result given known issues with the Pol. Dust model (see Burton et al., 2013). Smoke looks very similar to Pol. Cont., according to NAAPS. Interestingly, NAAPS sulfate AOD is roughly the same across each of these three aerosol models.

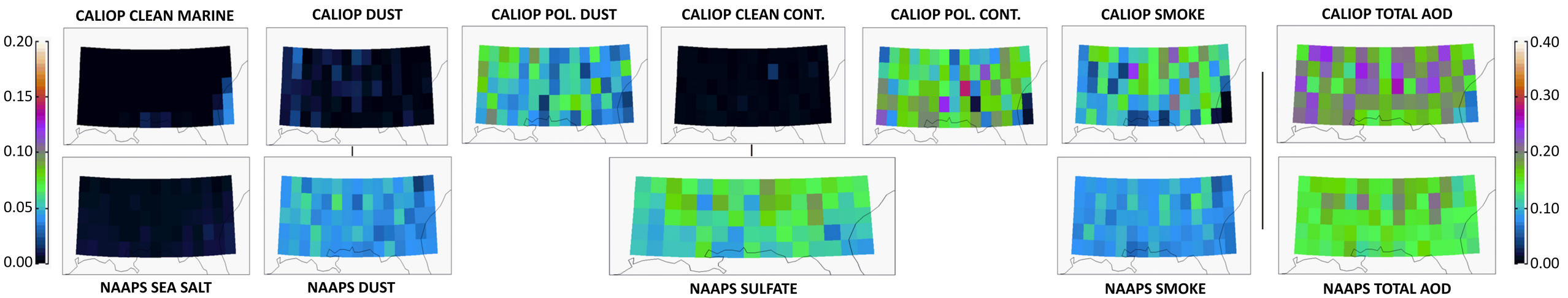

FIGURE 2 - *For Aug-Sep-Oct 2006-14, CALIOP 532 nm and NAAPS 550 nm mean 1x1 AOD for each of their corresponding species resolved (right to left) and the total sample (far left). The color bar on the right represents each of the individual species. That on the left represents the mean composites.*

A standing question right now is to what degree the lidars can represent an adqequate number of particle species relative to the needs of the modeling/transport community. At present, as such, its not straight-forward relating CALIOP to NAAPS. We pair the composites above, drawing leads between likely mixtures, to help.

NAAPS sulfate, which includes OA, is not well represented spatially by either of the CALIOP "polluted" models. The ambiguity of the Pol. Dust model, however, is likely contributing significantly to this inconsistency. A refinement of the Pol. Dust (pending V4 CALIOP Level 2 release) will very likely have a great impact on better understanding the relationship between pollution and CALIOP typing, and is thus a likely predicate to investigating the potential for OA typing. Though offsets between the CALIOP and NAAPS with resepect to smoke are considered less significant, spatial inconsistencies and concerns raised above from how CALIOP smoke corr sponds with similar NAAPS mixtures to Pol. Cont., suggest that some polluted cases are falsely labeled smoke.

Speciated DIAL HSRL data collected during 2013 for SEAC4RS and DISCOVER-AQ will prove an important constraint on these analyses. These data are presently being paired with NAAPS.

CONCLUSIONS

The research goals of missions like SEAC4RS raise awareness for the lidar community that aerosol typing and the distinguishing of specific species are high-value products. The CALIOP Level 2 algorithm is one of the first, and certainty the most broadly scrutinized, typing schemes available. Here, we investigate Level 2 product response over the southeastern U.S. relative to a transport model, with the goal of searching for evidence of organic aerosol (OA) presence.

Though we find general consistency between the two datasets, the ambiguity presently in the CALIOP Polluted Dust model limits our understanding of how the pollution based models compare with NAAPS, and OA presence within its Sulfate AOD. Attempts to decouple the CALIOP pollution models will be aided by integration of airborne DIAL HSRL measurements available for SEAC4RS and DISCOVER-AQ, which includes an advanced aerosol typing scheme. Pending Version 4 CALIOP datasets will also reduce the ambiguity of the Polluted Dust model. Some concern is raised for ambiguities in the CALIOP smoke model, as well, which will requires further investigation.

REFERENCES

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