



LIDAR SCIENCE WORKING GROUP

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Enhancements to the CALIOP aerosol subtyping and lidar ratio selection algorithms for Level II version 4.



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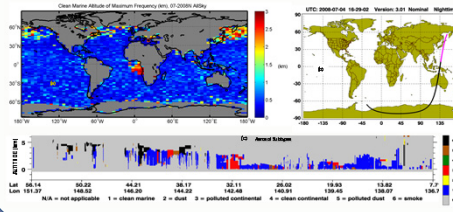
Proposed Changes in Subtyping Algorithms for Version 4

Several changes are underway for the version 4 subtyping algorithms. These include:

- The addition of a new aerosol type – ‘dusty marine’.
- Definitions of elevated layers
- Bug corrections in assignments of layer top and base heights
- Changes to lidar ratios based on the most recent measurements
- Revision of the depolarization ratio thresholds

Threshold Adjustments and Bug Fixes

Smoke and polluted continental aerosol layers are routinely misclassified as marine layers near continental outflows. The map (Figure 1a) shows the altitude at which clean marine aerosols are most frequently found. There is a high frequency of elevated marine layers on the south west coast of Africa and the region stretching from the Kamchatka peninsula to the Sea of Japan. Figures 1 (b) and (c) are a case study of this misclassification arising from a number of bugs and incorrect elevated layer flag thresholds. Note the large number of elevated marine layers and attached polluted continental layers.



Addition of a Dusty Marine Type

Several comparisons of CALIOP's lidar ratios with HSRL over the ocean show that while the S_a estimates for dust and marine are reasonable, the S_a estimates of the two instruments when CALIOP detects polluted dust, are significantly different. Since S_a is a good proxy for aerosol type, this can only mean that CALIOP's aerosol model is wrong for moderately depolarizing cases near the ocean surface and points to a need to define a more representative aerosol type. The version 4 aerosol subtyping algorithms will use a dusty marine (dust + marine) aerosol type for moderately depolarizing aerosols near the ocean surface.

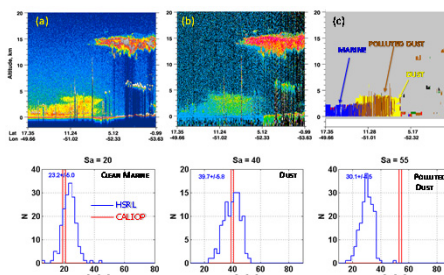


Figure 2. (a) 532 nm Attenuated Backscatter, (b) Volume Depolarization Ratio, and (c) Aerosol Subtypes measured over the ocean by CALIOP and the HSRL distributions of the corresponding lidar ratios (HSRL data courtesy of Rogers). The blue lines are HSRL distributions for the CALIOP type and the red line is CALIOP's fixed lidar ratio.

Dusty Marine Model: The dusty marine model will be built from the clean marine and dust models of the current CALIPSO models and will have a lidar ratio between 20 and 40 sr. The final model will be consistent (in S_a) with the HSRL measurements of similar aerosols (in the above example ~ 30 sr)

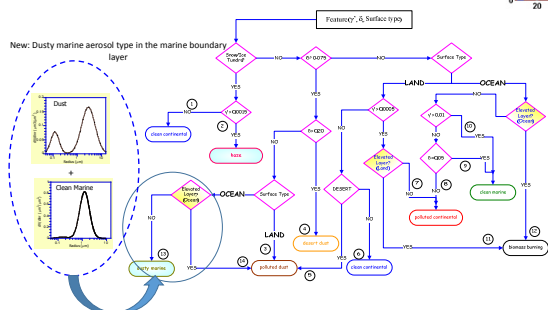


Figure 3. Flowchart of the CALIPSO S_a selection scheme for tropospheric aerosols showing the addition of the dusty marine aerosol type in the marine boundary layer

Dust Lidar Ratio Adjustments

Hu et al. (2007) developed a technique that takes advantage of the relatively small variability of the lidar ratio for water clouds and uses opaque water clouds as a reference to determine the optical depth of overlying transparent aerosol or cirrus layers. Liu et al. (2014) applied this technique to CALIOP L1 measurements in dust region off the coast of W. Africa to retrieve, unambiguously, distributions of dust lidar ratios shown below. These are used to inform the adjustment of the S_a (44-46 sr range) for version 4 products.

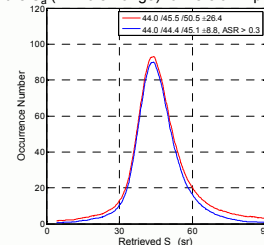


Figure 4. Distributions of extinction-to-backscatter ratios of dust retrieved from CALIOP Level 1 measurements of dust layers above opaque water clouds (Liu et al. 2014)

Hu et al. (2007) Retrieving optical depths and lidar ratios for transparent layers above opaque water clouds from CALIPSO lidar measurements, IEEE Trans. Geosci. Remote Sens. Lett., 4, 523-526, 2007

Liu et al. (2014) "Evaluation of CALIOP 532 nm AOD over opaque water clouds", ACPD, 14, 23583-23637.

Nighttime Seasonal Frequency Distributions of Marine, Polluted Continental, and Smoke Layers in 2009-10 and 2010-11

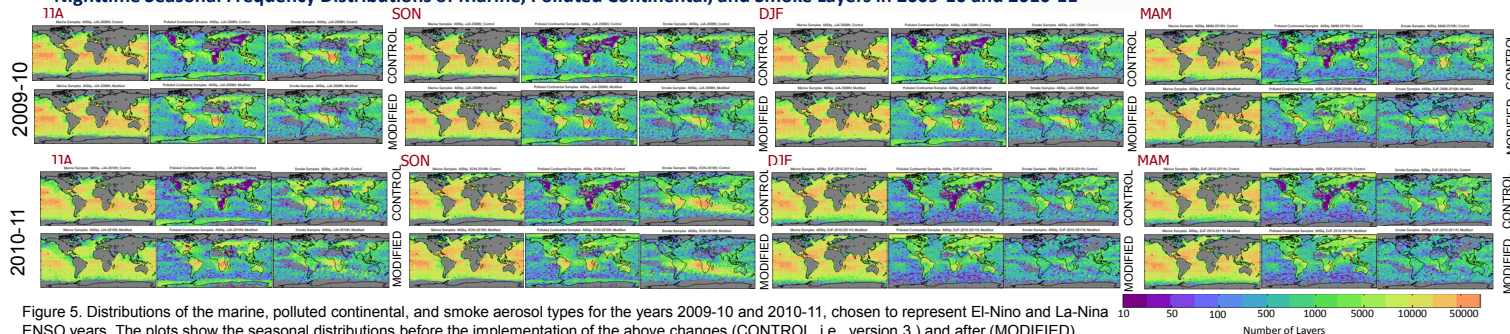


Figure 5. Distributions of the marine, polluted continental, and smoke aerosol types for the years 2009-10 and 2010-11, chosen to represent El-Nino and La-Nina ENSO years. The plots show the seasonal distributions before the implementation of the above changes (CONTROL, i.e., version 3) and after (MODIFIED).

Summary

- The distributions show a marked increase in the polluted continental aerosol types over land in populated regions
- The clean marine distributions are relatively unchanged
- The polluted continental increases are at the expense of smoke in biomass burning regions
- Off shore smoke distributions in the biomass burning region of West Africa increases
- The aerosol distributions in El-Nino and La-Nina Years are similar.

Future activities for v4 and beyond

- Update models, 1064 lidar ratios and phase functions for all aerosol types
- Determine independent daytime and nighttime depolarization ratio thresholds
- Determine feasibility of variable dust, dusty marine, polluted dust lidar ratios
- Improve the location of layer bases of absorbing aerosol (smoke)