Aerosol typing from HSRL-1 and CALIOP

CALIOP uses a combination of extensive parameterizations, estimated extinction, and HSRL information, to infer the lidar ratio and aerosol type. Aerosol classification results from HSRL-1 are used here to validate the CALIOP aerosol type inference.

### Measurement Curtains

- CALIOP aerosol typing depends on a pre-retrieval estimate of particulate depolarization, which depends on the measured attenuated backscatter + 2 backscatter wavelengths. Attenuated backscatter is expected to have greater retrieval accuracy in CALIOP marine layers with at least 2 HSRL types, because the CALIOP layer detection algorithm does not attempt to detect aerosol type variations. Boundaries between types are defined solely by changes in backscatter intensity.

### Case Studies

#### CALIOP

- **CALIOP**: 17 June 2006, off the coast of Virginia and Carolina (nighttime).
- **CALIOP Aerosol Type**: Marine Type

#### HSRL

- **HSRL**: 25 June 2006, off the coast of Virginia and Carolina (nighttime).
- **HSRL Aerosol Type**: Marine Type (93% marine + 7% smoke)

#### Hybrid HSRL+CALIOP

In this experiment, HSRL-1 attenuated backscatter data is used as input to the CALIOP processing algorithms, ignoring the higher information content of the HSRL direct extinction measurements. Aerosol classifications using the CALIOP algorithms on the higher SNR HSRL “Level 1” is no better. Therefore, the higher information content (direct measurements of aerosol intrinsic properties) matters more than the lower SNR of the airborne HSRL. Intrinsically, the higher SNR allows CALIOP to detect at the most all the aerosol in a single pass through the multi-attenuating atmosphere. This is in almost all internal layer boundaries and a single type throughout the boundary layer.

### Overall Comparisons from 109 flights

#### CALIOP Versus HSRL Type Classification

<table>
<thead>
<tr>
<th>CALIOP Type</th>
<th>HSRL Type</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine</td>
<td>Marine</td>
<td>&gt;90%</td>
</tr>
<tr>
<td>Smoke</td>
<td>Marine</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Dust</td>
<td>Marine</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Mixed</td>
<td>Marine</td>
<td>&lt;5%</td>
</tr>
</tbody>
</table>

### Aerosol Types

- **CALIOP Marine**: 62% of layers are dominated by HSRL marine type.
- **CALIOP Desert Dust**: 36% of layers are dominated by HSRL dust type.
- **CALIOP Desert Dust**: 34% of layers are dominated by HSRL dust type.
- **CALIOP Desert Dust**: 30% of layers are dominated by HSRL dust type.
- **CALIOP Desert Dust**: 26% of layers are dominated by HSRL dust type.

### Conclusion

The aerosol layer detection does not consider aerosol type. Internal boundaries between contiguous aerosol layers often do not accurately reflect transitions between types.

- In the coincident HSRL-1 and CALIOP layer observations, 50% of CALIOP types are requested to account for 90% of the AOT in 74% of the CALIOP-defined layers.
- There is agreement in aerosol type between CALIOP and HSRL in 62% of CALIOP marine layers, 54% of CALIOP marine layers, and 33% of CALIOP desert dust layers.
- There is poor agreement in CALIOP smoke layers, but this will not lead to bias in CALIOP retrieval of aerosol backscatter and extinction.
- There is poor agreement in polluted dust layers.
- Specifically, CALIOP version 3 includes a bias towards polluted dust and dust in attenuated layers.
- CALIOP Level 2 Version 3 includes a correction for attenuation from absorbing layers.
- Polluted dust is frequently a mixture of dust + marine rather than dust + pollution, leading to overestimated lidar ratios and AOT.

### Depolarization bias

CALIOP aerosol typing depends on a pre-retrieval estimate of particulate depolarization, which depends on the measured attenuated backscatter at 322 nm and 1064 nm for detection layers. CALIOP aerosol typing depends on a pre-retrieval estimate of particulate depolarization for these cases was much larger than the true aerosol depolarization, for a month of CALIOP data over CONUS, according to the CALIOP thresholds of 7.5% and 10%.

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NASA Langley Research Center, Hampton VA

Science and Systems Applications, Inc.