Summertime Aerosols over the South Eastern United States from CALIPSO and other A-Train Measurements

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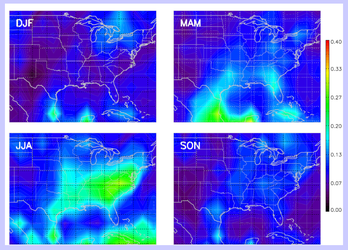
INTRODUCTION

Satellite data show a strong summertime maximum in aerosol optical depth (AOD) over the Southeastern (SE) USA that can not be explained by anthropogenic sulfate or organic aerosols at the surface (Goldstein et al., 2009). The biogenic volatile organic compound (BVOC) emissions peak over the same region and models indicate a large source of secondary organic aerosols (SOA) here (van Donkelaar et al., 2007, Zhang et al., 2007, Liao et al., 2007). Aircraft measurements indicate dominance of organic aerosols over sulfates with altitude and models suggest most SOA production from isoprene oxidation takes place above the surface layers. Goldstein et al. (2009) hypothesized that these SOA drive the AOD maximum in summer with an altitude dependence. We examine the distributions of AOD and other optical properties over SE USA using height resolved aerosol data from CALIPSO. We also use AOD data from MODIS and OMI and UV aerosol index from OMI to characterize the aerosols over SE USA.

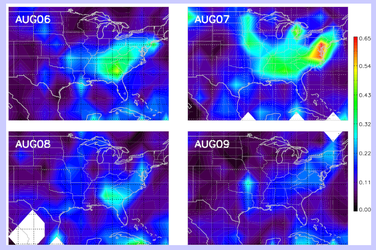
DATA

- Version 3 CALIPSO aerosol layer and profile products
  - → significant improvements because of new cloud-aerosol discrimination, extension of profiles below optically thick layers
  - → Column integrated aerosol optical depth directly available.
  - → Winker et al. (2009) for details of CALIPSO data analysis.
- MODIS AOD and OMI AOD and UV aerosol index data from the NASA Giovanni system.
- Version 4 MOPITT CO data (level 3 gridded monthly mean profiles from 900 hPa to 100 hPa) (Deeter et al. 2009)
- Winds from the NCEP/NCAR reanalyses.

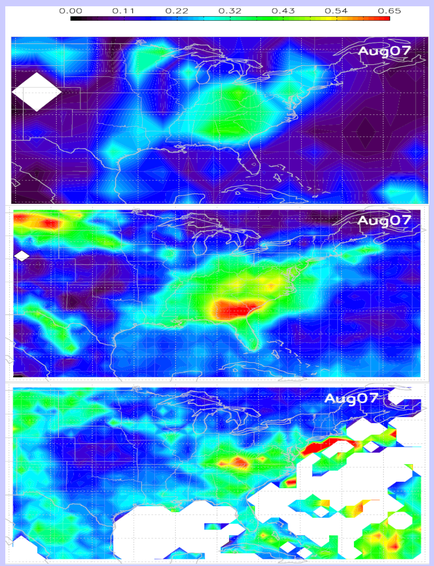
AEROSOL OPTICAL DEPTH OVER SOUTH EAST USA



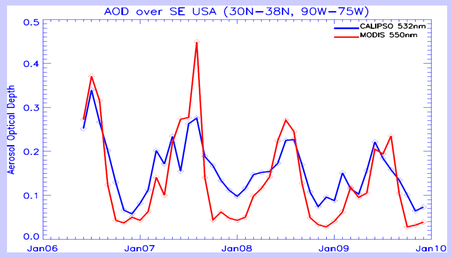
Seasonal climatology (2006-2010) of AOD at 532 nm from CALIPSO (nighttime, cloud free data with extQC= 0 or 1 for each layer comprising the column).→ **distinct maximum over the SE USA in summer.**



Significant inter annual variation can be seen (AOD at 532 nm, night) for the summer maximum.

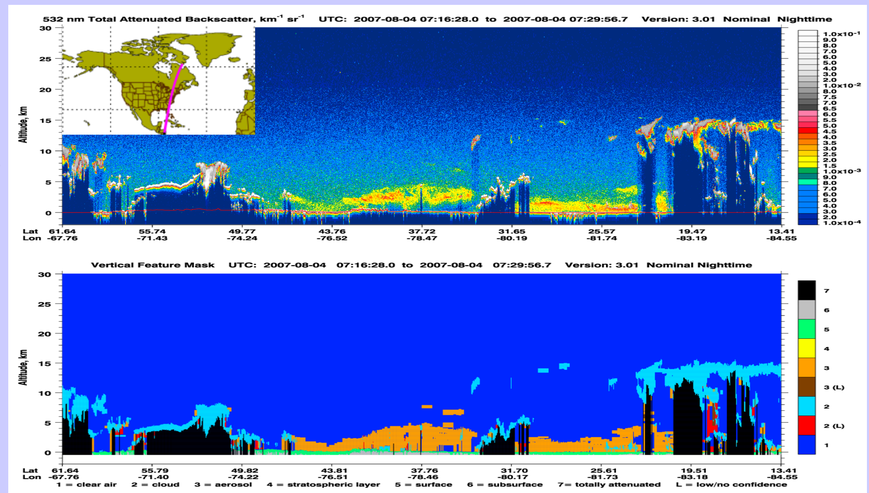


Comparison of daytime CALIPSO AOD at 532 nm with MODIS AOD at 550 nm and OMI extinction AOD at 500 nm show generally similar spatial patterns. Sampling differences might explain some of the anomalies. Subpixel cloud contamination for OMI AOD retrievals may also be significant

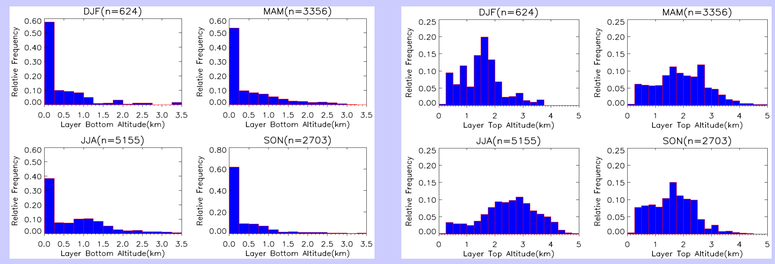


Time series of AOD (Daytime 532 nm for CALIPSO and 550 nm for MODIS) over SE USA show similar seasonal variations

HEIGHT RESOLVED AEROSOL INFORMATION FROM CALIPSO



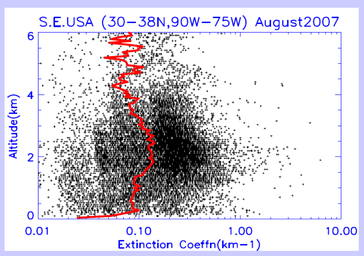
CALIPSO browse image of total attenuated backscatter at 532 nm and the vertical feature mask show the aerosol layers above SE USA on August 4, 2007.



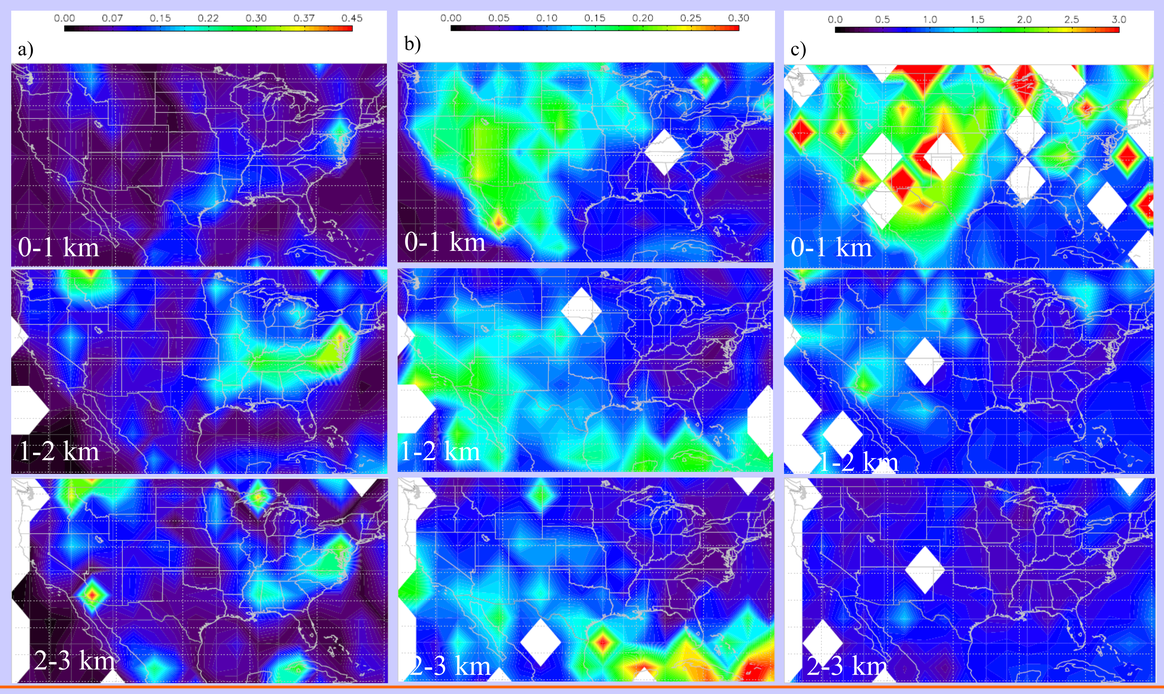
Seasonal histograms of layer bottom altitudes (2007, night data, 532 nm, CAD = -100)
→Maximum no. of layers in summer
→Significant no of layers with bottoms above 1 km

More layers with higher top altitudes in summer.

OPTICAL PROPERTIES OF AEROSOLS OVER SOUTHEAST USA

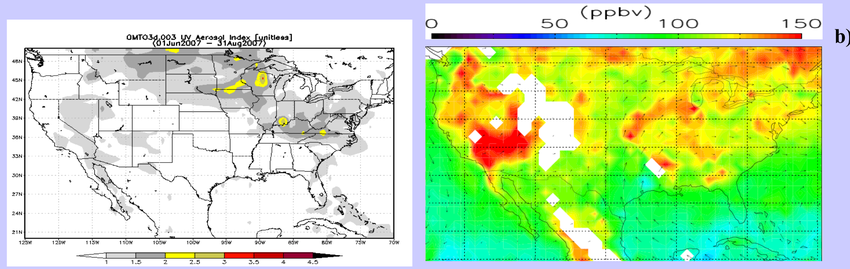


Example of extinction coefficient profiles over SE USA in August 2007 shows significant contribution from aerosols above the surface. Red line is the median.



Spatial distribution of the optical properties using the layer product: a) layer AOD, b) layer particulate depolarization ratio, c) layer particulate color ratio
- Nighttime data (JJA 2007), 532 nm
- altitudes are referred to the mid point of the layers

→ Indicates significant contribution to AOD from layers above the surface over SE USA
→ Distinct and localized minimum depolarization ratio in these layers indicate spherical particles
→ Color ratio also indicates somewhat lower values over SE USA implying smaller particles



a) UV aerosol index from OMI and b) MOPITT (version 4) CO mixing ratio at 800 hPa for JJA 2007 (winds shown are at 850 hPa) show some transport of smoke and CO from fires in the North West, but that is not likely to significantly impact the localized features over SE USA as seen in the layer AOD, depolarization and color ratios→ the distributions do not match and the depolarization ratios are very different between the west and east.

→Significant AOD, low depolarization and color ratio in layers above the surface over SE USA are consistent with the hypothesis of SOA in these layers dominating the seasonal high in AOD (Goldstein et al., 2009).

→**Signature of biogenic aerosols in CALIPSO data?! Lidar ratio ~ 70 for biogenic aerosols, similar to that of smoke and polluted continental, two major subtypes in JJA over SE USA.**

References

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Conclusions:

- CALIPSO AOD retrievals (532 nm) consistently reproduce the aerosol maximum over the SE USA in summer.
- Height resolved CALIPSO (version 3) aerosol data shows significant contribution to AOD from layers above the surface over SE USA.
- The particulate depolarization ratios show a distinct minimum over SE USA for these layers above the surface.
- The particulate color ratios also tend to show a similar minimum over SE USA albeit not as clearly as the depolarization ratios.

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