On Factors Controlling Marine Boundary Layer Aerosol Optical Depth

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Abstract: Marine aerosol is one of the largest natural contributors to the global aerosol loading and thus plays an important role in the global radiative budget. However, there are large differences in sea salt source and atmospheric loading among different aerosol transportation models. Many studies have provided different relationships of marine aerosol optical depth (AOD) as a function of near surface wind speed, but with large differences among them.

Our goal is to improve the estimation of marine aerosol optical depth over global ocean by considering factors beyond near surface wind speed with satellite measurements and ACRF observations at Azores.

1. Single Factor Dependency

AOD and aerosol layer structure were retrieved from CALIPSO, and only cloudy free single aerosol layers were considered. Daily surface wind speed data and sea surface temperature were obtained from the AMSR-E. Meteorological environment was obtained from ECMWF. All the data were collocated to AMSR-E footprint.

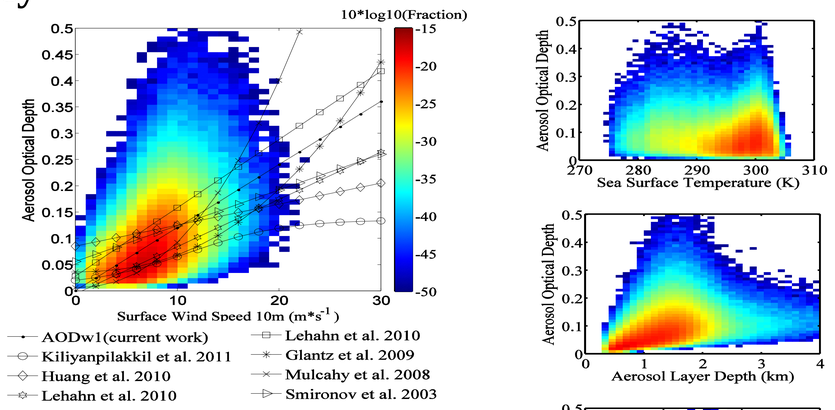
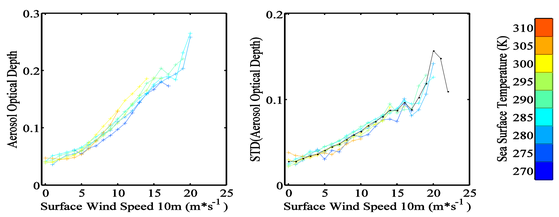


Figure 1 AOD as a function of surface wind speed at 10m (left), sea surface temperature (right top), aerosol layer depth (right middle) and lower troposphere stability (right bottom). The other relationships of AOD and surface wind speed are listed in Kiliyanpilakkil et al. 2011.

2. Two Factors Dependency



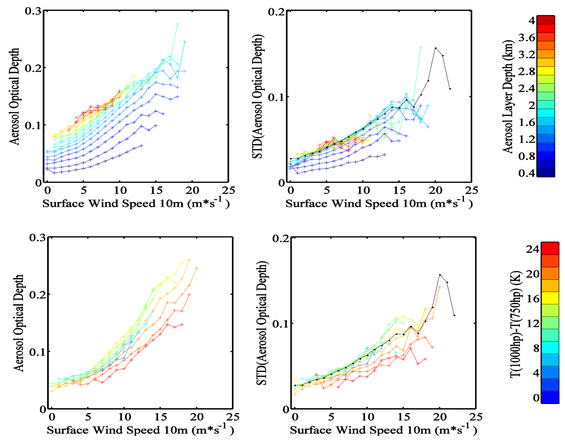
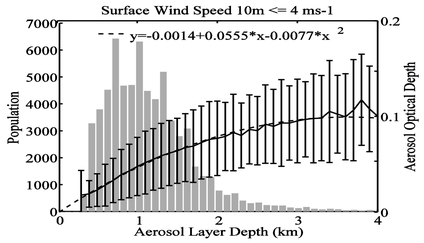
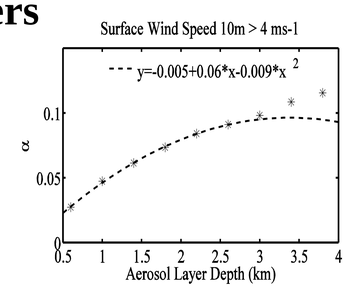


Figure 2 AOD as a function of surface wind speed at 10m under different sea surface temperature (left top), aerosol layer depth (right top) and lower troposphere stability (right bottom) ranges. It is clear that AOD strongly depends on aerosol layer depth.

3. New Relationship with two parameters



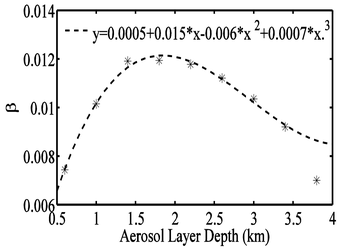


- **Left: when sws10 ≤ 4 ms^{-1}**

$$AODwh = -0.0014 + 0.056 \times \Delta H - 0.0077 \times \Delta H^2$$

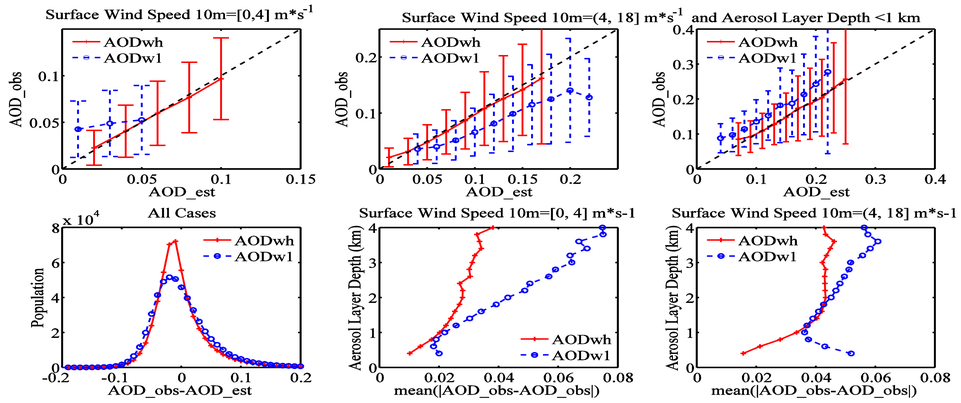
- **Right: when sws10 > 4 ms^{-1}**

$$AODwh = \alpha + \beta \times (sws10 - 4)$$



ΔH is the aerosol layer depth, and sws10 is the surface wind speed at 10 m. α and β are functions of ΔH as in the right figures.

4. Comparison with single-parameter relationship



The new two-parameter relationship (red) is better than single-parameter relationships (others).

Marine aerosol optical depth is controlled by both mechanical production of sea-spray particles driven by wind processes, and vertical re-distribution driven by turbulent mixing in boundary layer.

The aerosol measurements at Azores will be used to better understand the roles of different factors.