CALIPSO-MODIS Observations of Increases in Aerosol Optical Depths near Marine Stratocumulus

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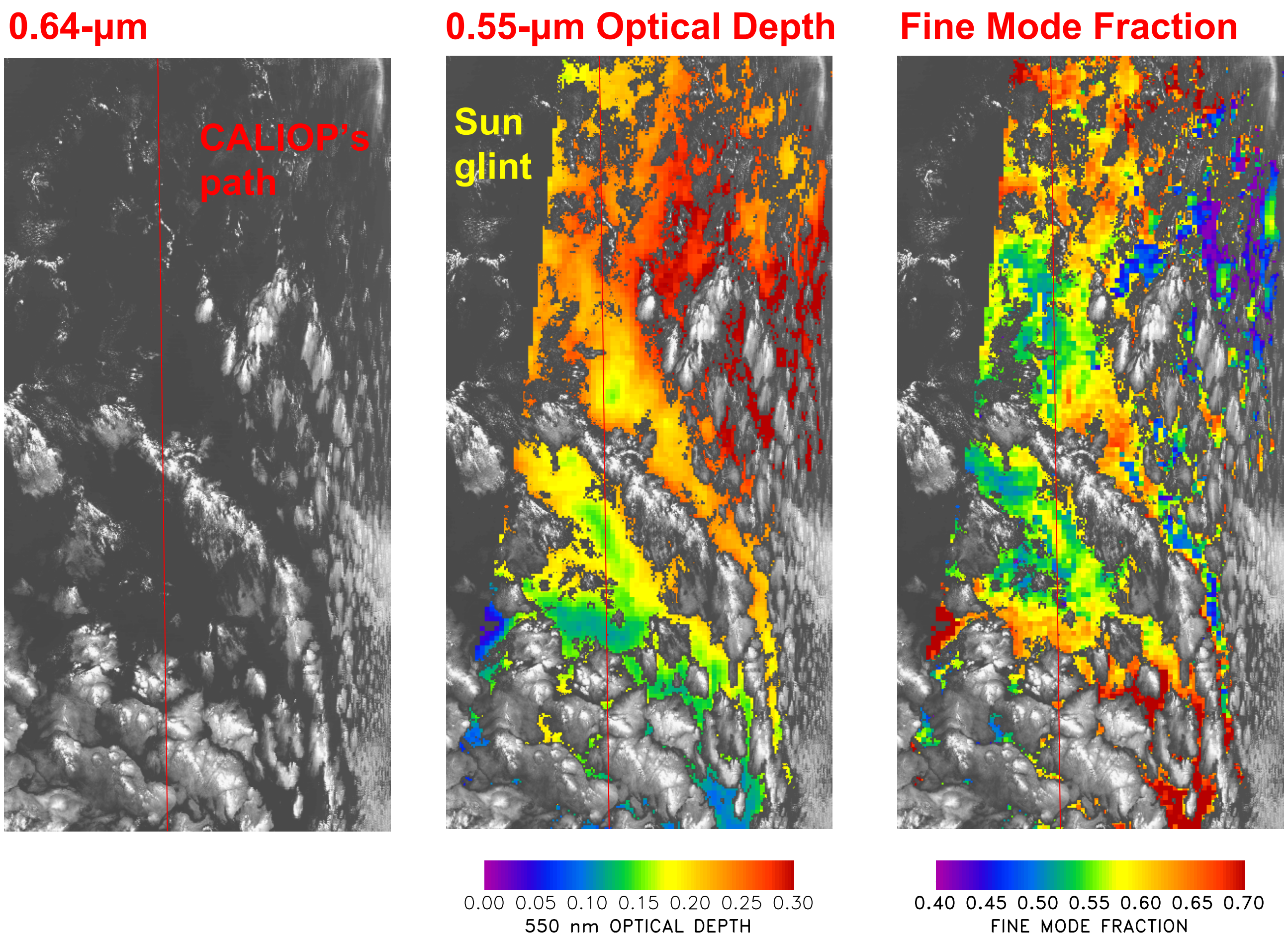
GOAL: **Characterize the changes in aerosol properties in cloud-free ocean regions as the edges of extensive layers of marine stratocumulus are approached.**

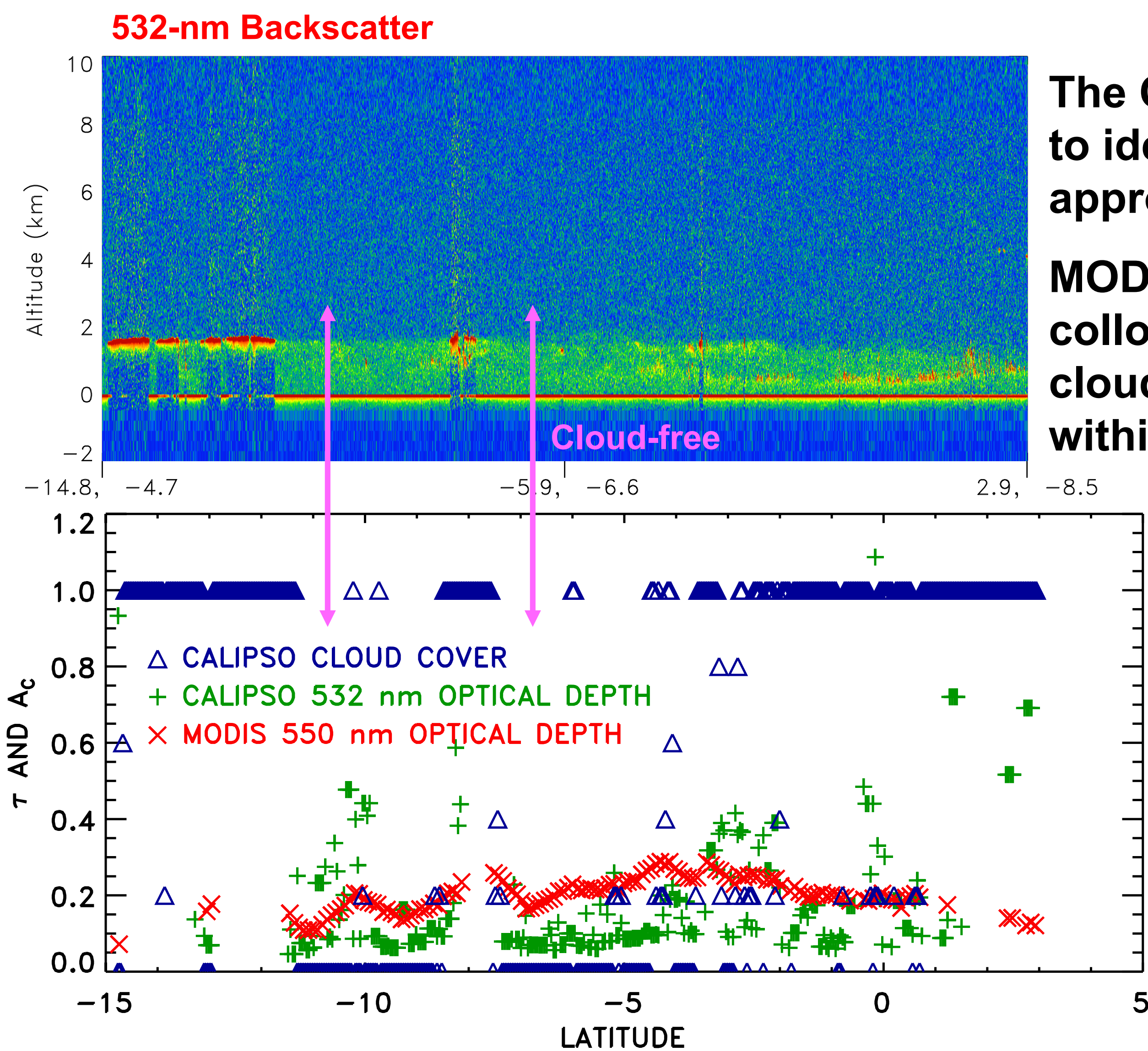
Photo by Tony Clarke

MODIS aerosol optical depths and fine mode fractions generally increase in the vicinity of marine stratocumulus.



Low-level marine stratocumulus in the Southern Atlantic off the coast of Africa, 1410Z 2 July 2007.

CALIPSO and MODIS observations of aerosol optical depths studied for large cloud-free ocean regions embedded within marine stratocumulus systems.



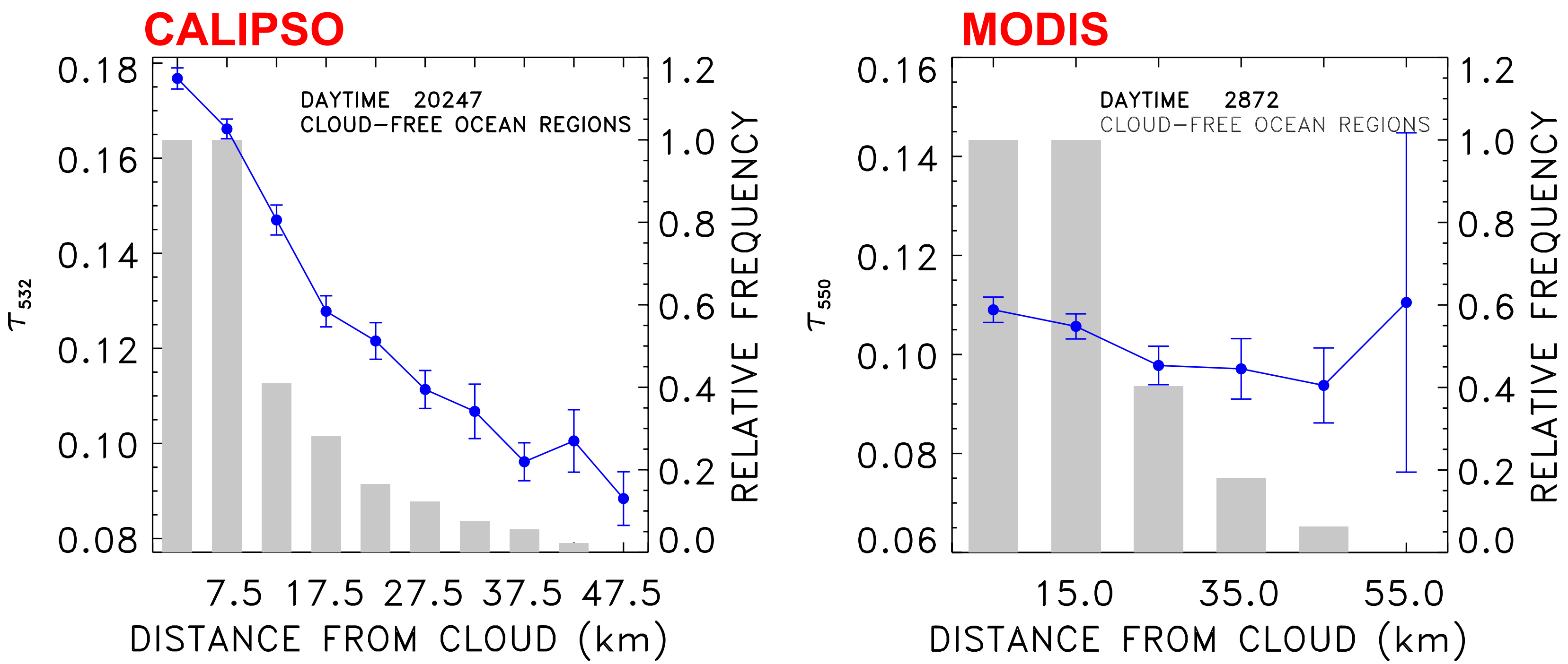
The CALIPSO VFM was used to identify cloud-free regions appropriate for analysis.

MODIS observations were collocated with the CALIOP cloud-free backscatter returns within the regions.

CALIPSO optical depths are noisy.

Is the noise in the CALIPSO optical depths too great to observe the changes in the aerosols as clouds are approached?

MODIS and CALIPSO aerosol optical depths increase as clouds are approached.

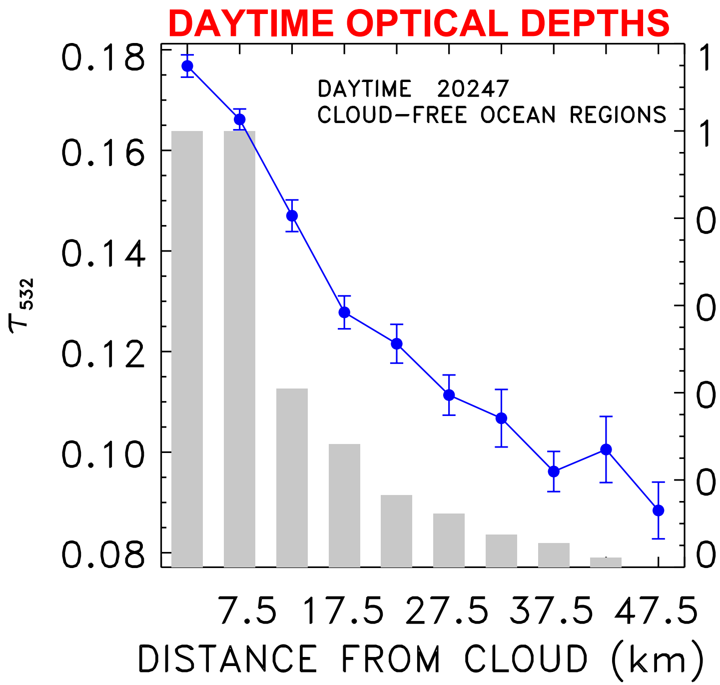


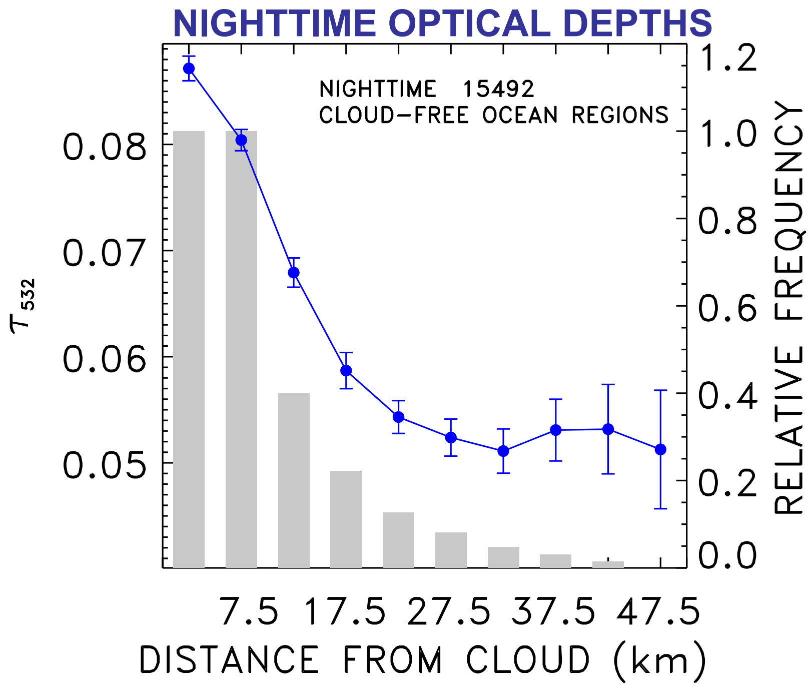
10-km MODIS and 5-km CALIPSO aerosol optical depths have been composited for 15 months of cloud-free ocean regions between 60°S and 60°N. The cloud-free regions were embedded in marine stratocumulus systems with a 25-km extent of marine stratocumulus at one end.

The minimum size of the cloud-free regions were 15 km for CALIPSO and 30 km for MODIS (*twice the distance to cloud indicated on the abscissa*).

Gray bars give the relative frequency for the cloud-free regions; error bars give the 95% confidence interval for the mean optical depths, and the total number of cloud-free regions studied is indicated.

Cloud-free regions among marine stratocumulus are more common during the day than at night.



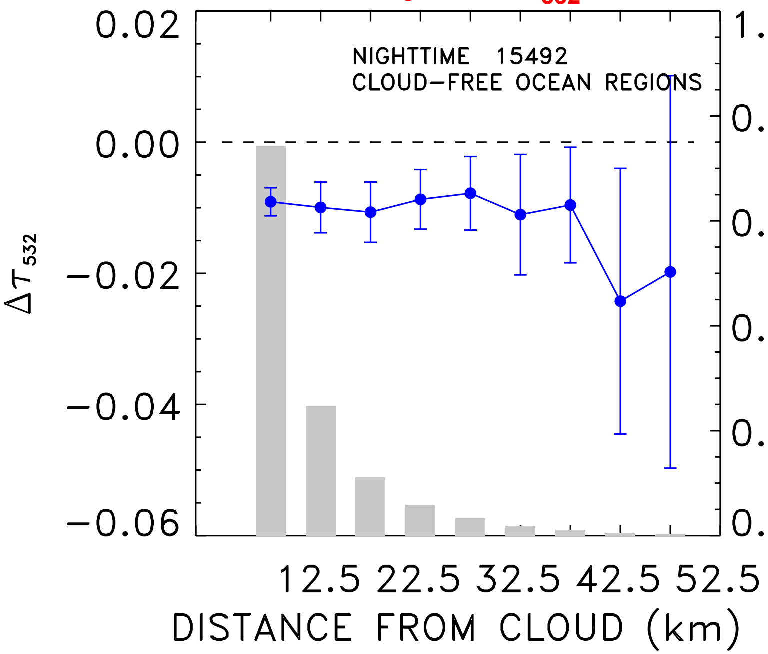


Nighttime observations are less noisy than daytime observations and are thus more sensitive to small aerosol loadings that go undetected during the day.

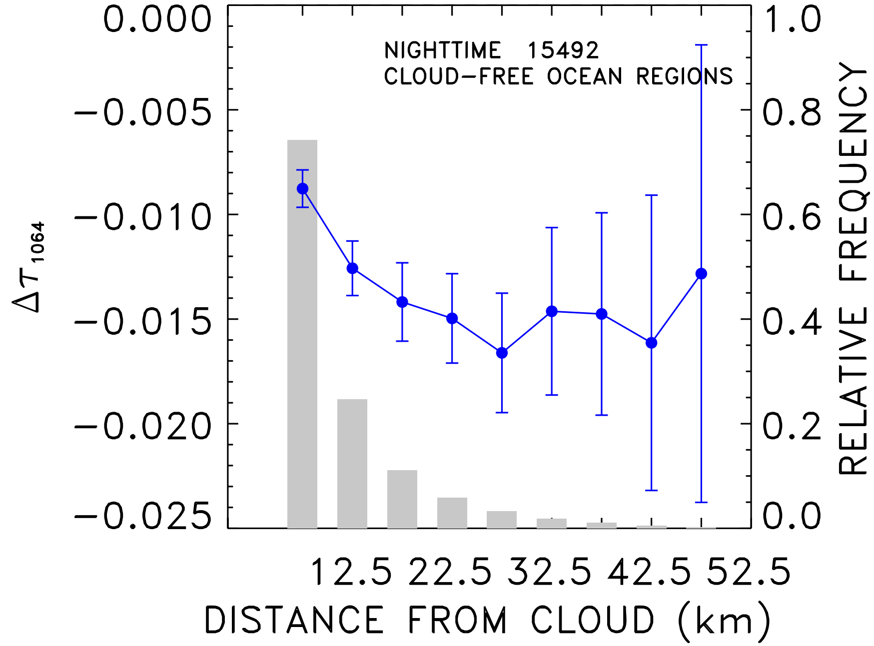
The 532 and 1064-nm optical depths both decrease as the area of the cloud-free region expands up to regions that are about 50-km in extent (*25 km from clouds*).

532 and 1064-nm aerosol optical depths adjacent clouds are significantly larger than those 5 km further from the clouds.

7.5-km – Adjacent τ_{532}



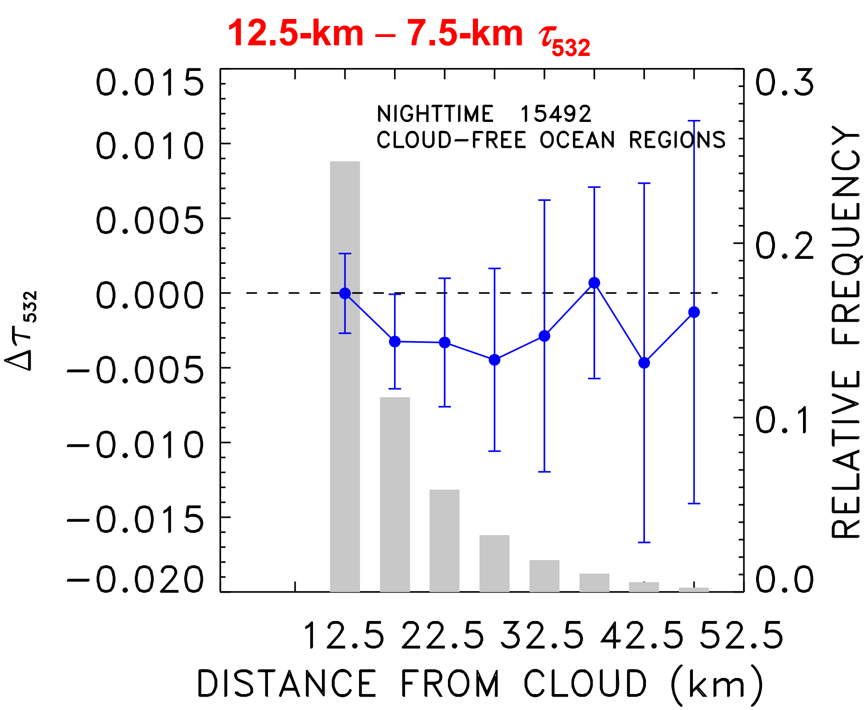
7.5-km – Adjacent τ_{1064}

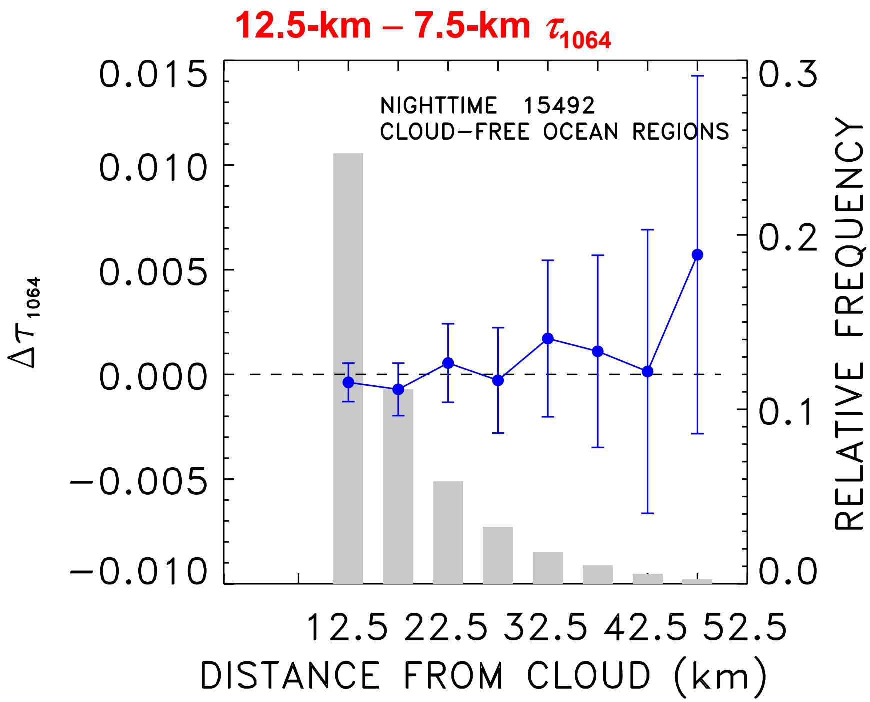


Effects due to the averaging of profiles for 20 and 80 km have been removed by *NOT* considering cloud-free regions in which any two 5-km aerosol optical depths are identical.

532-nm optical depths appear to have flattened by 7.5-km from the cloud while 1064-nm optical depths appear to continue to decrease for another 5 km.

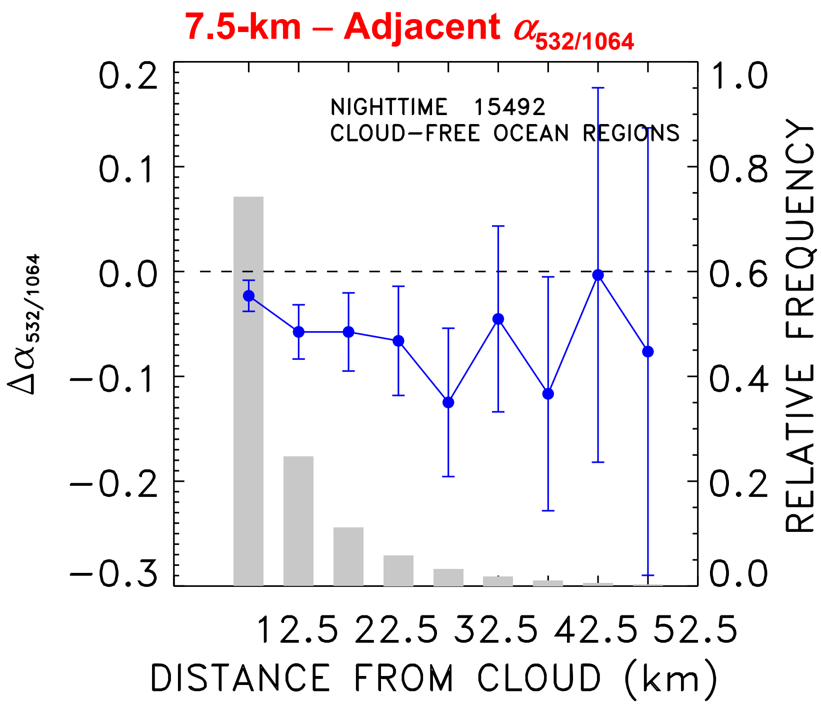
532 and 1064-nm aerosol optical depths have both flattened out within 7.5 – 12.5 km of the cloud.

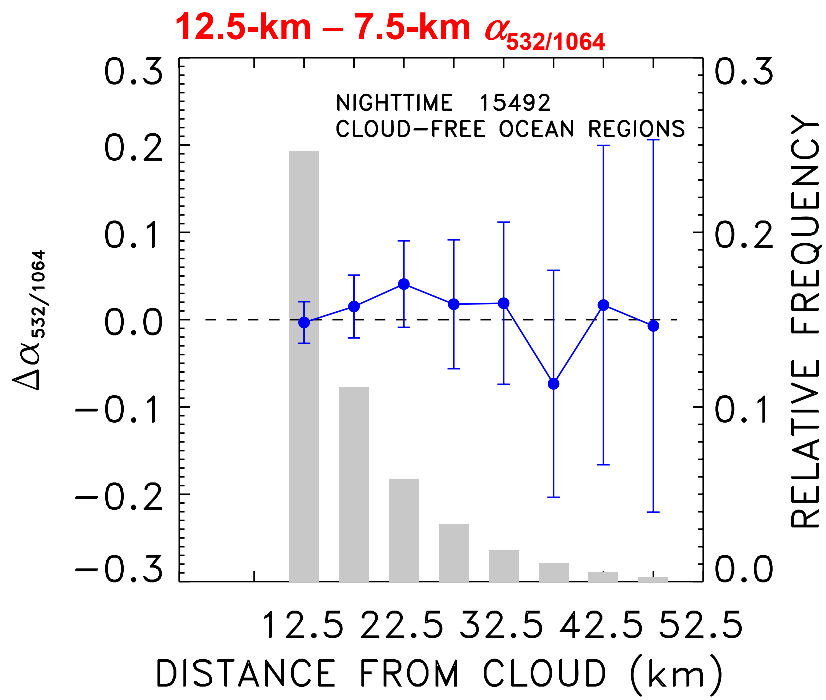




The results suggest that any changes to aerosol physical properties arising from the near cloud environment have died away in cloud-free ocean regions larger than ~25 km, the size of a CERES field of view.

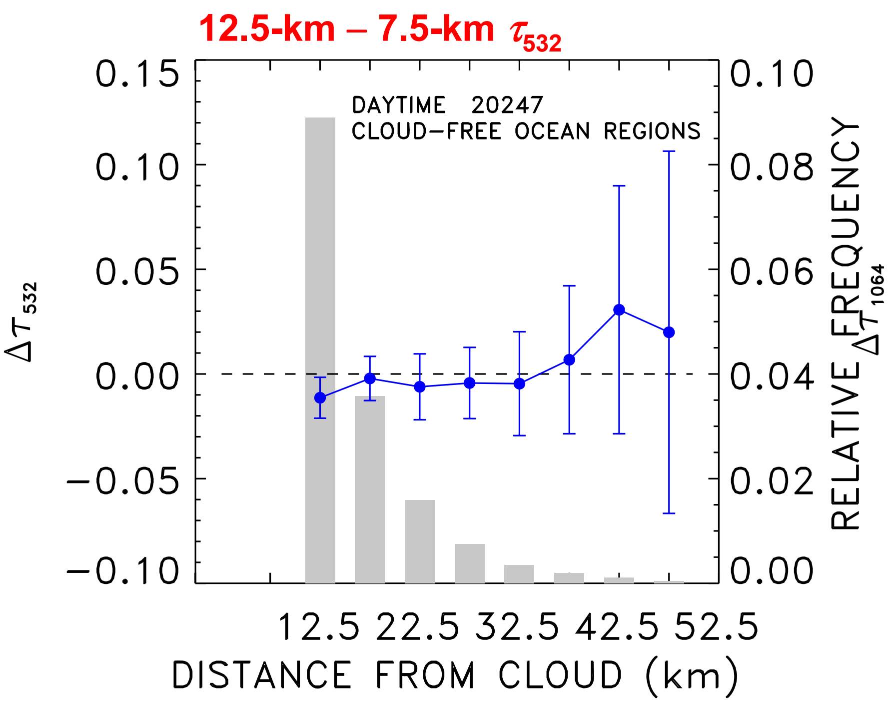
532/1064 Ångström Exponent adjacent the clouds is significantly larger than that 5 km further away, but *NO* additional changes occur within the next 5 km.

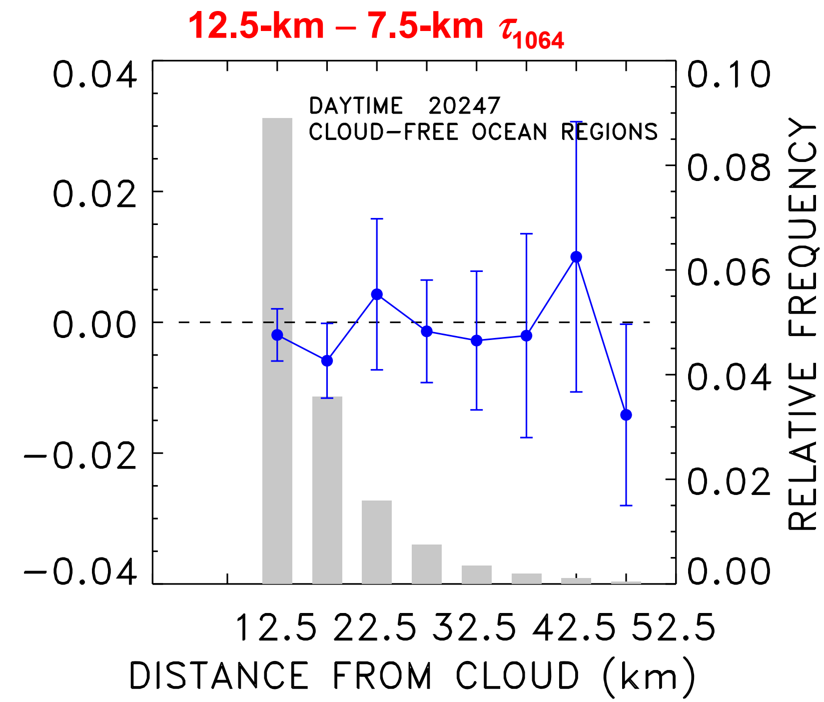




The results suggest that the particles are growing as clouds are approached, ***but since the changes die out within 12.5 km (cloud-free regions > 25 km), could the changes be evidence of cloud contamination in the CALIPSO aerosol optical depths?***

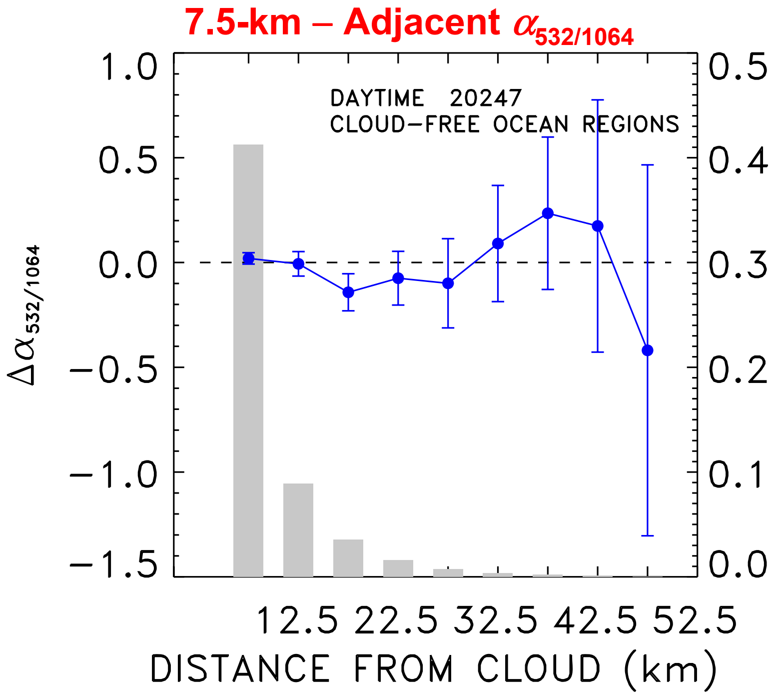
The 532-nm aerosol optical depth is significantly (*just*) smaller at 7.5 km from cloud than at 12.5 km but the 1064-nm optical depths remain unchanged.

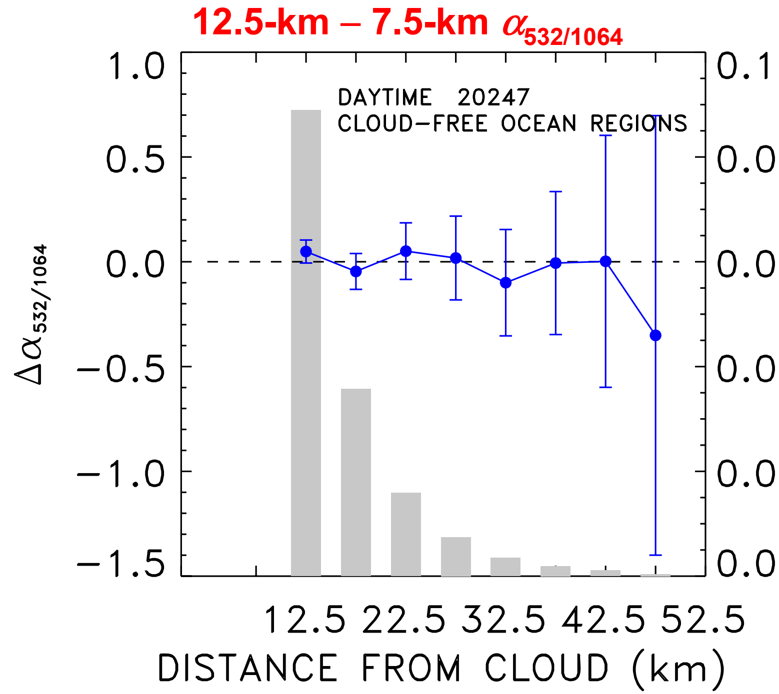




The fall of the 532-nm optical depth from 7.5 − 12.5 km is unlikely to be the result of cloud contamination.

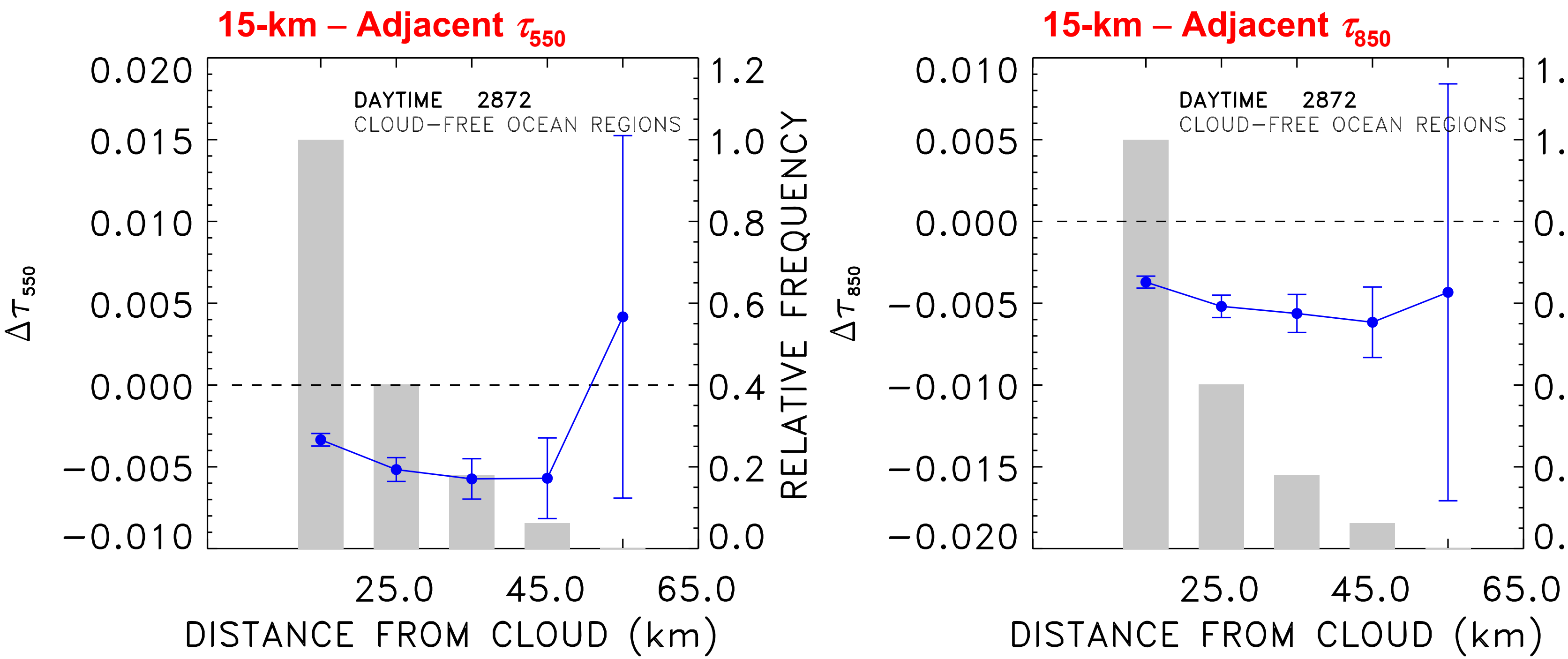
Daytime 532/1064 Ångström Exponents show no change with distance from cloud.





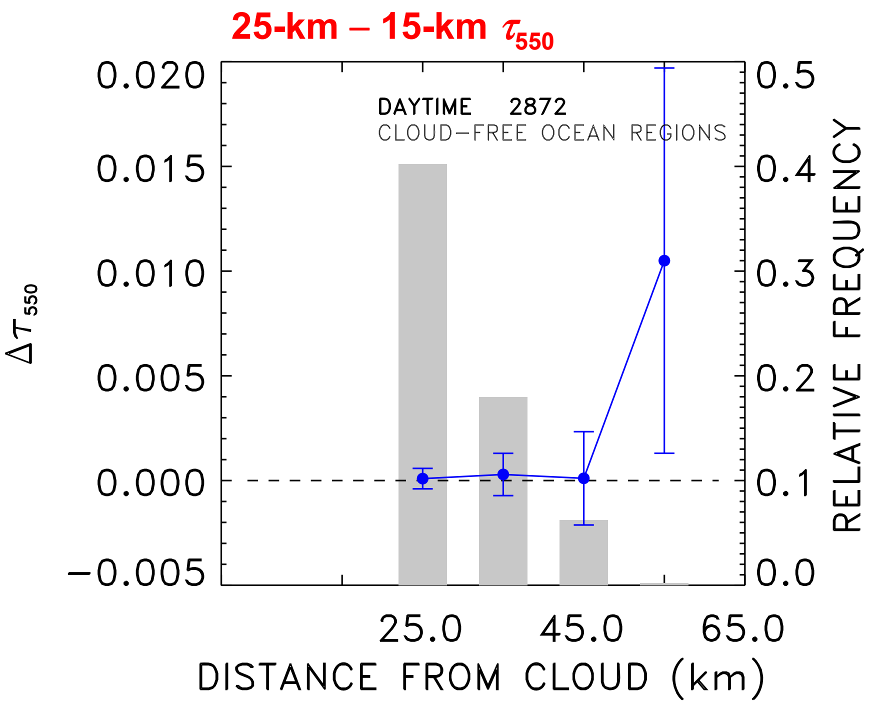
Noise in the daytime aerosol optical depths too great to allow detection of a change in the color of the scattered light, ***although the change from 7.5 to 12.5 km from clouds (cloud-free regions > 25 km) is consistent with the fall in the 532-nm aerosol optical depth from 7.5 to 12.5 km*****.**

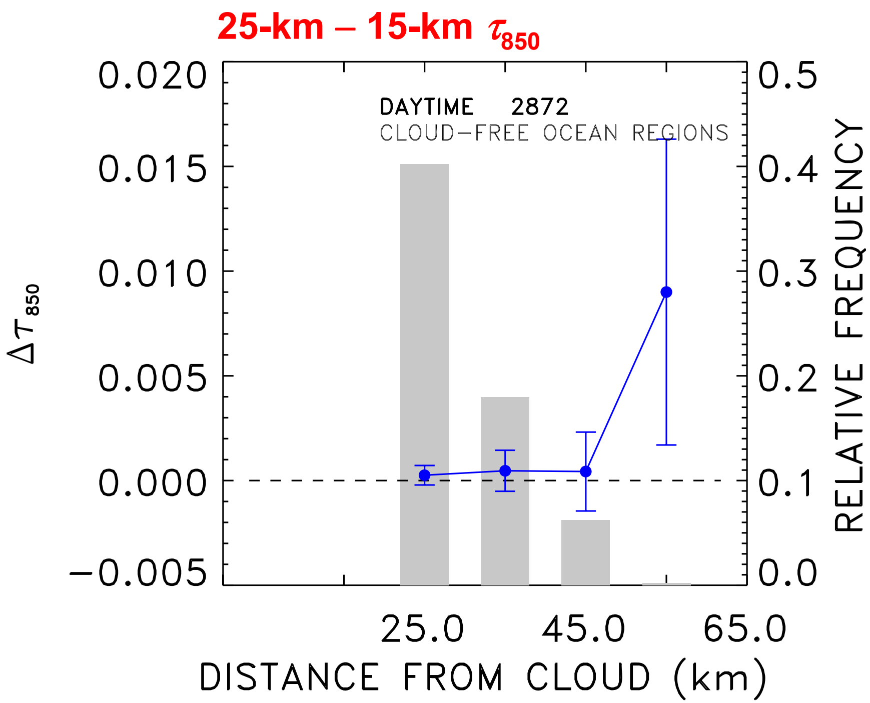
The 550 and 850-nm MODIS aerosol optical depths are both significantly larger adjacent to clouds than at 15 km from clouds.



MODIS aerosol optical depths for cloud-free regions embedded in marine stratocumulus systems with a 25-km extent of marine stratocumulus at one end as identified from the CALIPSO VFM.

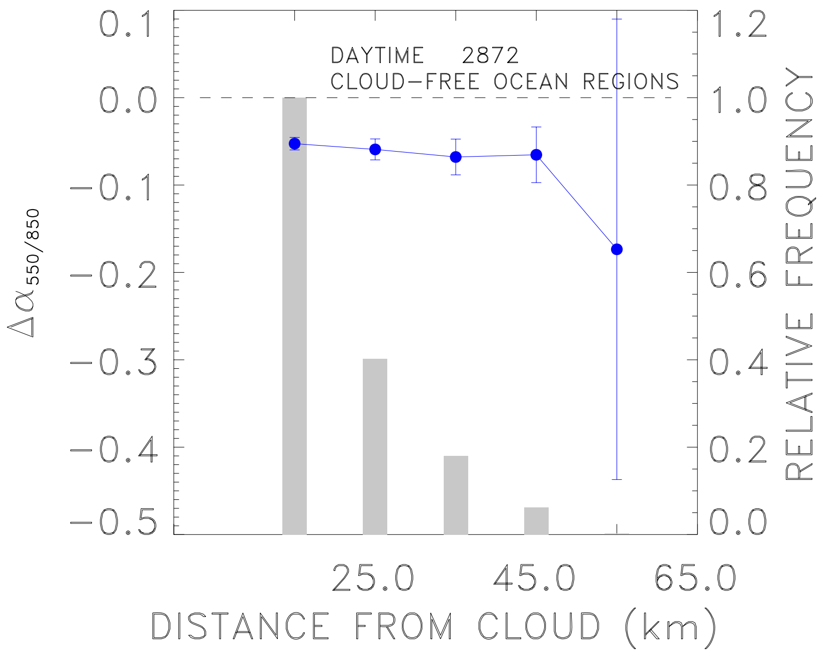
The 550 and 850-nm MODIS aerosol optical depths remain unchanged between 15 and 25 km from clouds.



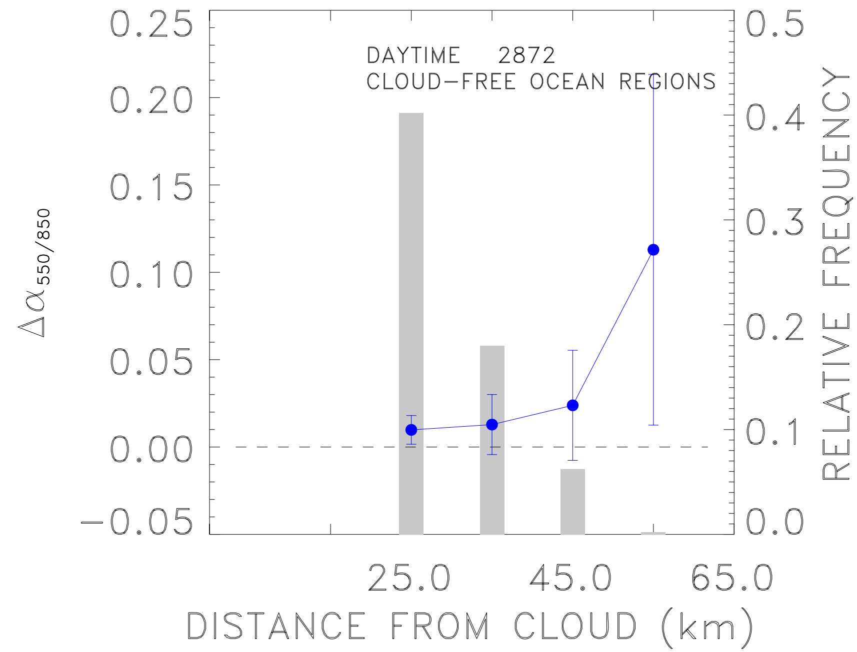


The 550/850 MODIS Ångström Exponent adjacent the clouds is significantly larger than that 10 km further away, but *NO* additional changes occur within the next 10 km.

15-km – Adjacent $\alpha_{550/850}$



25-km – 15-km $\alpha_{550/850}$



The MODIS fine mode fraction decreases as marine stratocumulus are approached, consistent with the increase in the 550/850 Ångström Exponent.

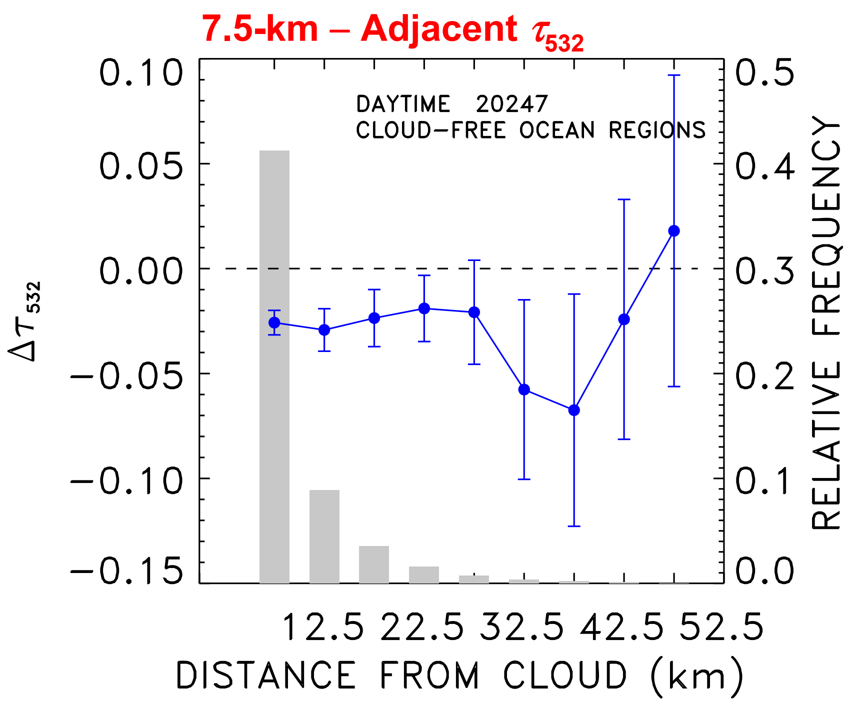
For large cloud-free ocean regions (25 km − 50 km) CALIPSO and MODIS aerosol optical depths suggest that particles grow within 10 km − 20 km from cloud.

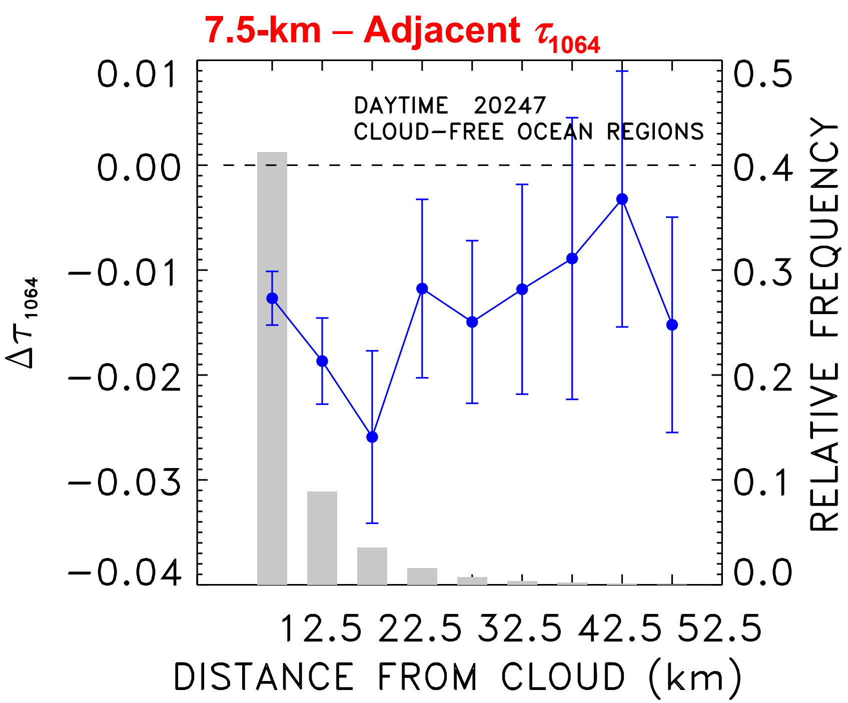
For cloud-free ocean regions, aerosol particles appear to grow when the particles are within 10 – 20 km *(and probably the range is shorter)* from marine stratocumulus.

Is the particle growth indicative of cloud contamination in the MODIS and CALIPSO aerosol optical depths?

What happened to the increase in fine mode fractions found by Kaufman et al. (2005) and Loeb and Schuster (2008)? ***Perhaps these effects are found closer to the clouds.***

532 and 1064-nm aerosol optical depths adjacent clouds are significantly larger than those 5 km further from the clouds.





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532-nm and 1064-nm optical depths appear to have flattened by 7.5-km from the cloud.