

Properties of Marine Stratocumulus Derived from MODIS, CERES-SSF, and CALIPSO for Overcast and Partly Cloudy MODIS Pixels

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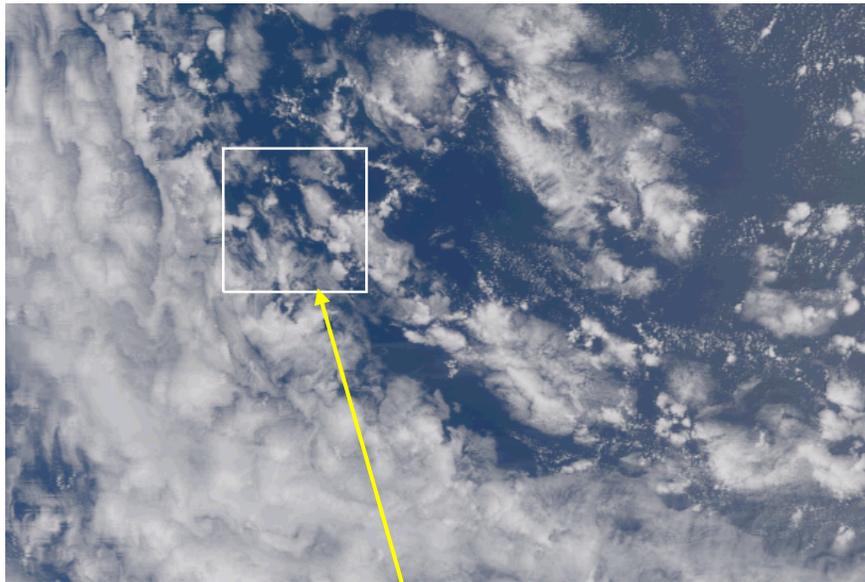
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NASA Goddard Space Flight Center

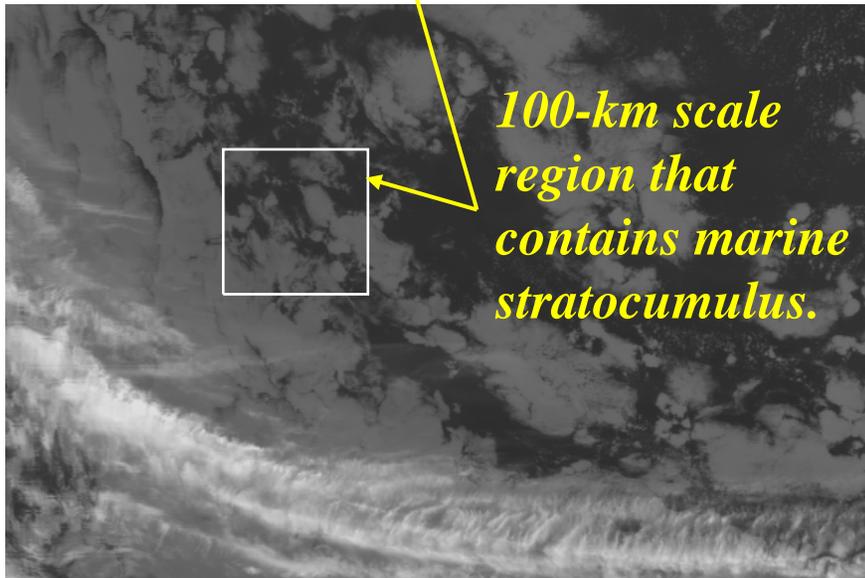
Goal: *Determine potential biases in cloud properties arising from the overcast pixel assumption applied to MODIS 1-km pixels.*

1-km MODIS Imagery

**Terra 6 May 2001 1205 Z
North Atlantic**



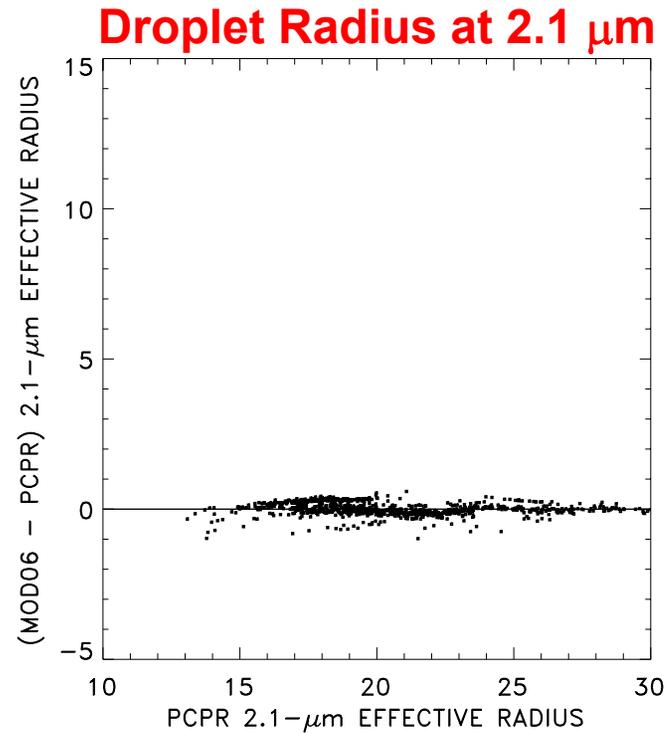
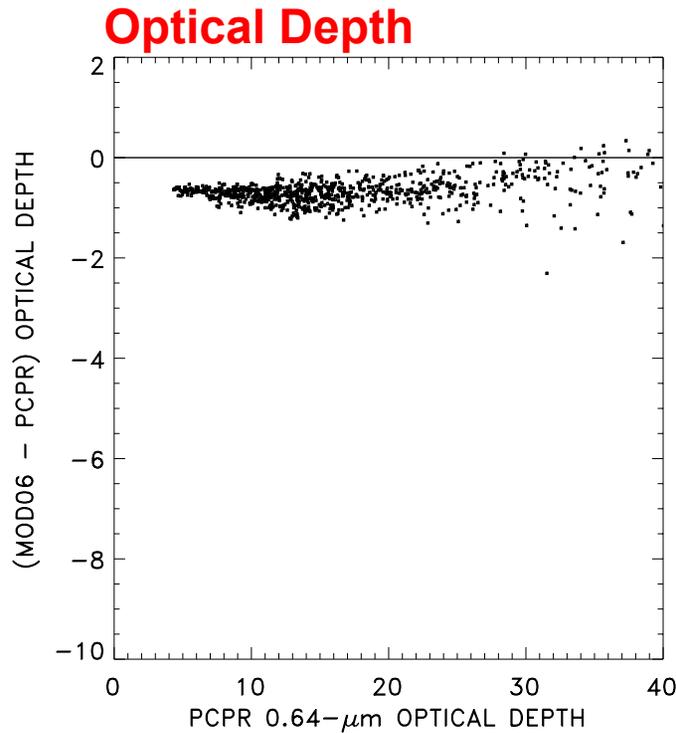
11 μm



*100-km scale
region that
contains marine
stratocumulus.*

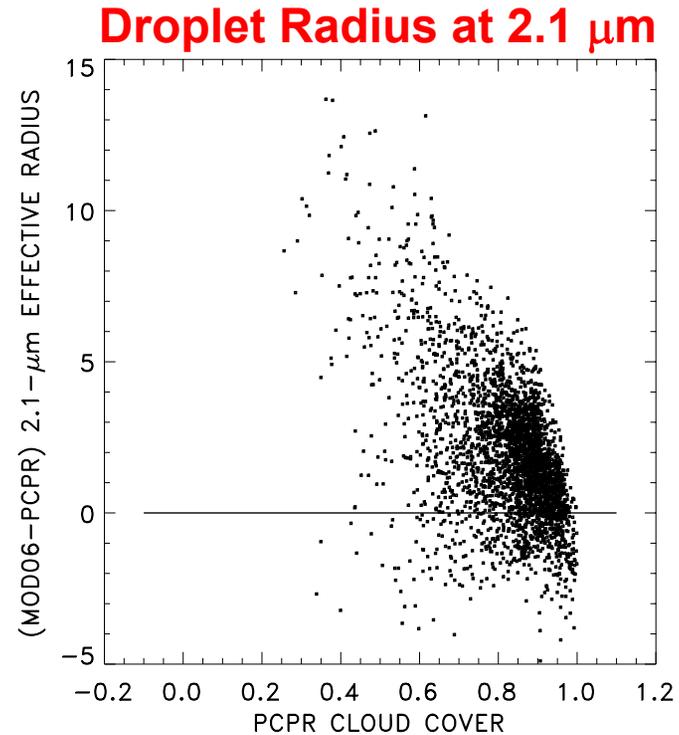
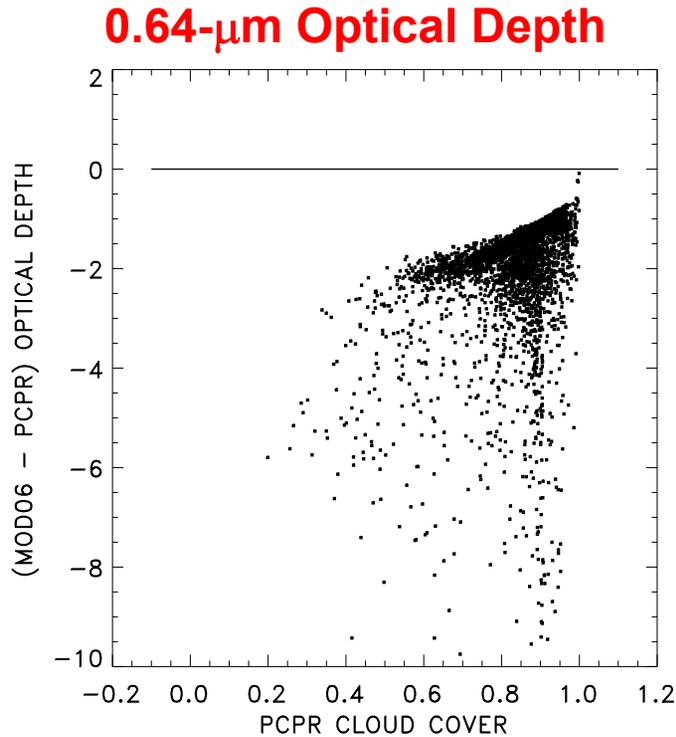
- **Study confined to marine stratocumulus in the North Atlantic.**
- **50-km scale regions selected in which the only cloud present is marine stratocumulus.**
- **Pixel-scale cloud properties obtained from the partly cloudy pixel retrievals and the MODIS cloud product are compared separately for overcast and partly cloudy pixels.**

Optical Depth and Droplet Effective Radius Differences (MOD06 – PCPR) for *Overcast Pixels*



MOD06 cloud products and partly cloudy pixel retrievals agree when pixels are overcast.

Optical Depth and Droplet Effective Radius Differences and Pixel Scale Cloud Fraction for *Partly Cloudy Pixels*



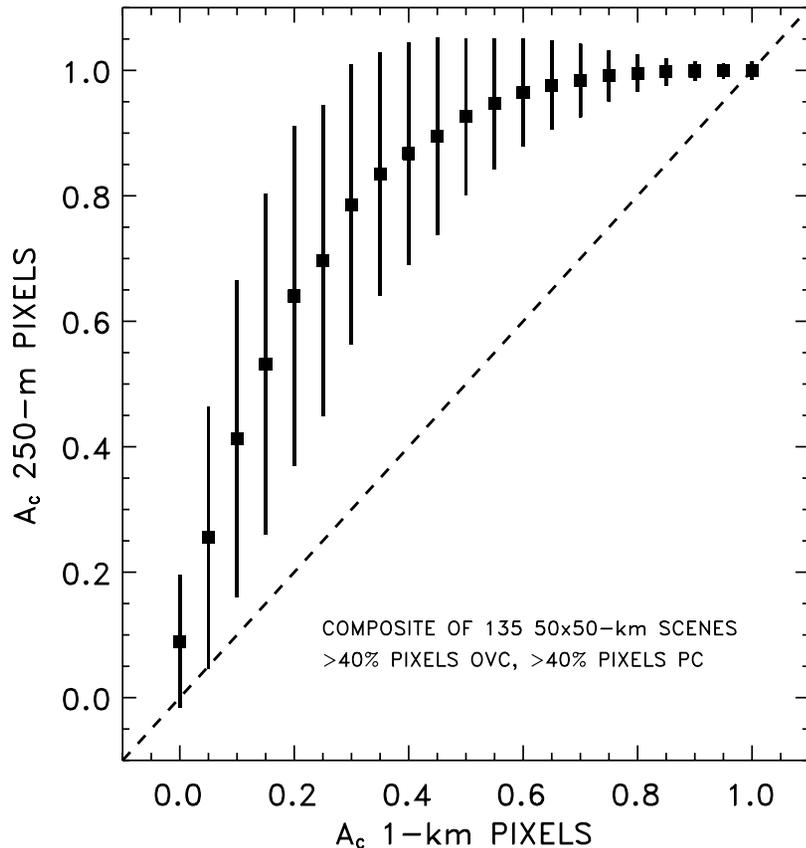
MOD06 optical depths too small and droplet radii often too large when 1-km pixels are partly cloud covered.

MOD06 and PCPR Properties for Marine Stratocumulus

Cloud Property	Overcast Pixels		Partly Cloudy Pixels	
	Mean	(MOD06–PCPR)	Mean	(MOD06–PCPR)
Cloud Cover	1.0	0	0.71±0.26	0.29±0.26
Temperature (K)	267.9±5.5	–0.4±1.1	268.3±5.7	2.6±2.9
Optical Depth	15.6±9.9	–0.7±1.8	10.2±8.4	–3.1±4.1
1.6- μm R_e (μm)	12.4±4.3	–0.2±0.8	11.4±4.7	1.6±2.5
2.1- μm R_e (μm)	12.7±4.2	–0.1±1.7	11.7±4.7	1.8±3.2
3.7- μm R_e (μm)	12.7±3.6	–0.4±1.2	11.2±4.1	0.5±1.7
3.7- μm LWP (gm^{-2})	131±96	–8.5±23.6	80±81	–14.6±26.8

- Results of pixel-scale comparisons based on a survey of marine stratocumulus for May 2001 in the North Atlantic.
- MODIS and partly cloudy pixel retrievals agree for overcast pixels.
- MODIS retrievals **underestimate cloud optical depth and liquid water path** but **overestimate cloud fraction, cloud layer temperature, and droplet radius** for partly cloudy pixels, consistent with the biases expected for the overcast pixel assumption.

Cloud Cover



Cloud cover derived for partly cloudy pixel retrievals at 1 km and MOD06 cloud flag at 250 m and then aggregated to 1 km.

Results are for 50-km scale regions that contained only single-layered, marine stratocumulus in the North Atlantic.

Based on the partly cloudy pixel retrievals, the 50-km regions selected had more than 40% of the 1-km pixels overcast and more than 40% of the pixels partly cloudy.

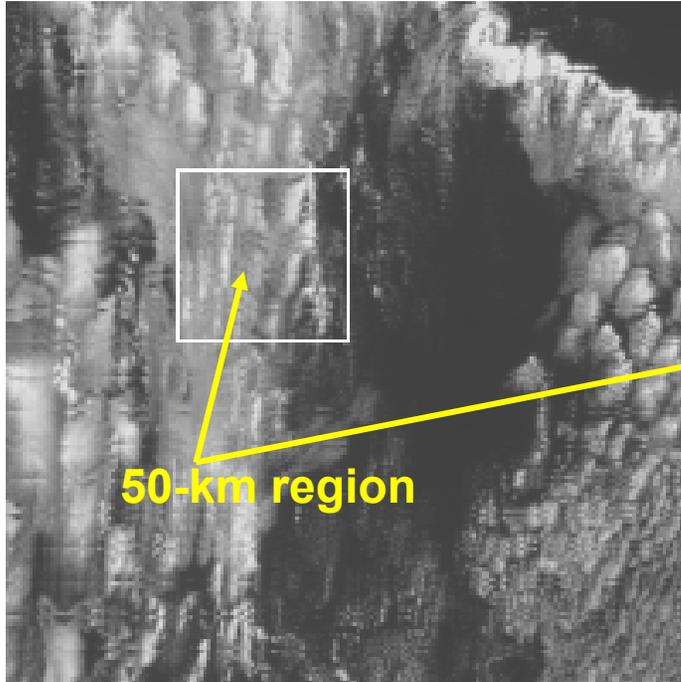
Cloud cover fractions binned according to pixel-scale fractional cloud cover.

MODIS 250-m cloud mask severely overestimates the fractional cover.

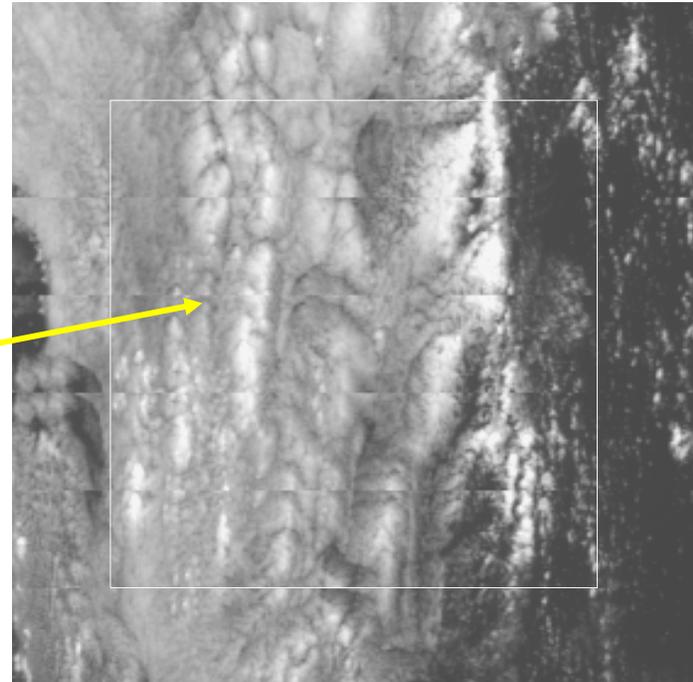
Partly Cloudy Marine Stratocumulus

0.64- μm Reflectances Terra 13 May 2004 1110 UTC

1-km

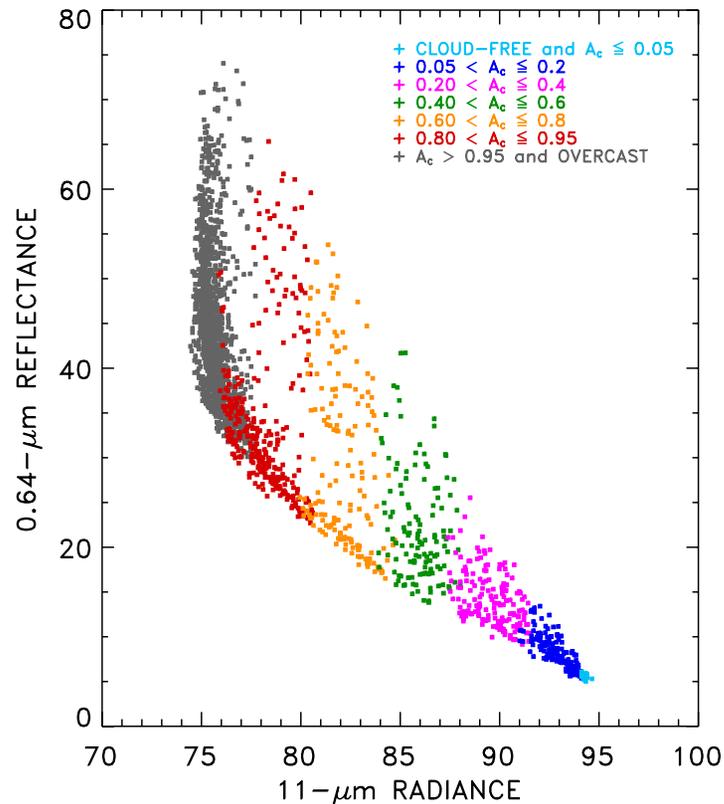


250-m

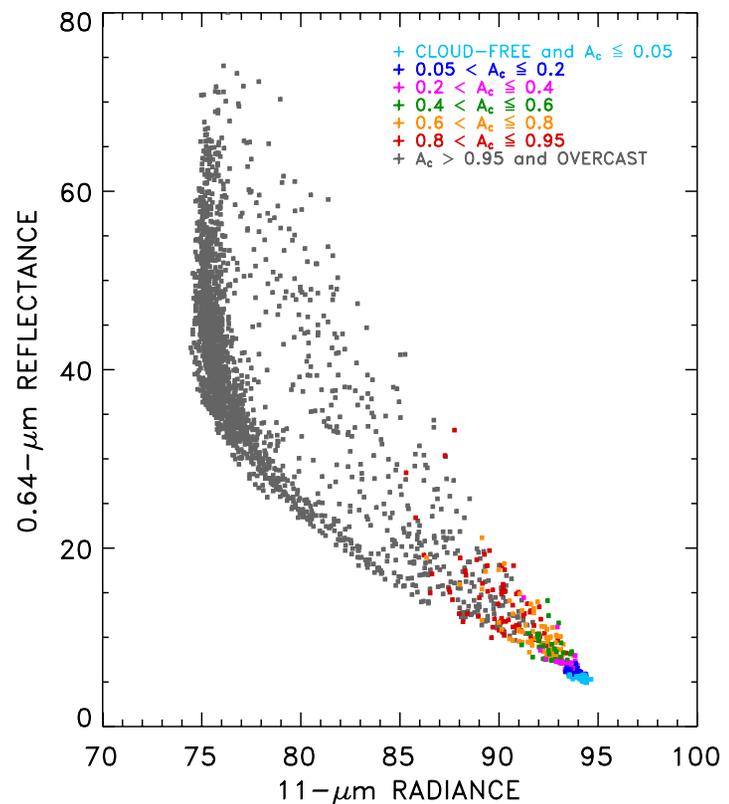


Visible-IR Interpretation

PCPR 1-km Retrievals



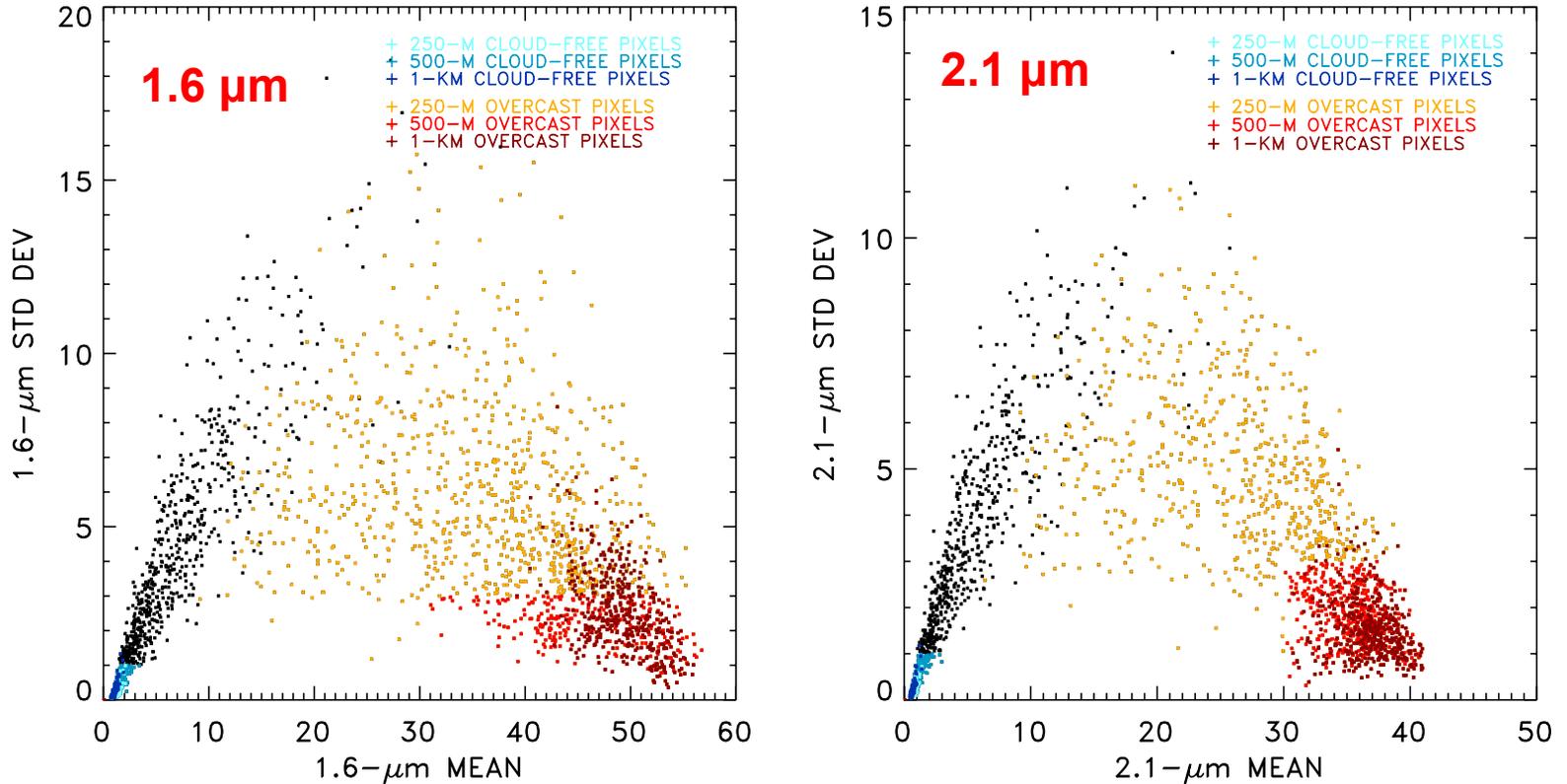
MOD06 250-m Cloud Mask



MODIS 250-m cloud mask identifies pixels with greater than 50% cloud cover as being overcast.

Spatial Uniformity at 1.6 and 2.1 μm

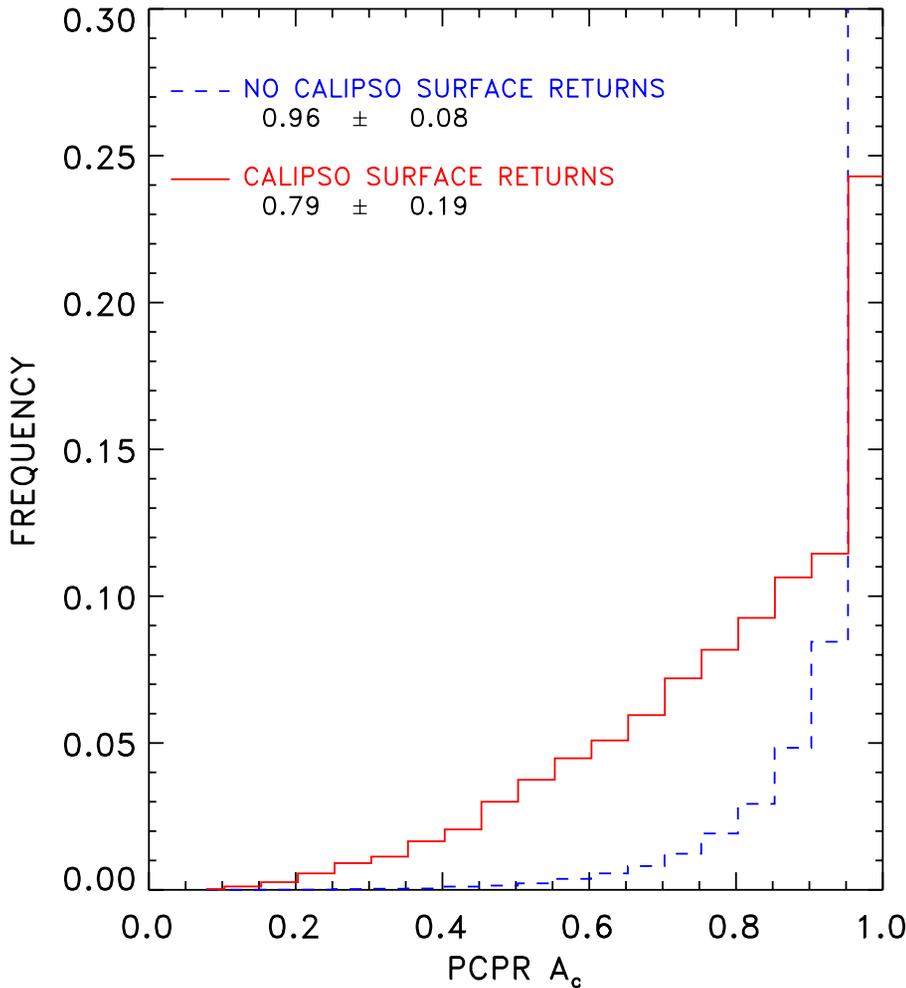
100-km scale region of marine stratocumulus



Droplet sizes in overcast pixels sufficiently uniform that reflectances at 2.1 μm and even at 1.6 μm exhibit spatial uniformity for 4×4 arrays of the 500-m pixels.

MODIS 250-m cloud mask overestimates cloud cover.

CALIPSO Identification of Overcast 1-km MODIS Pixels



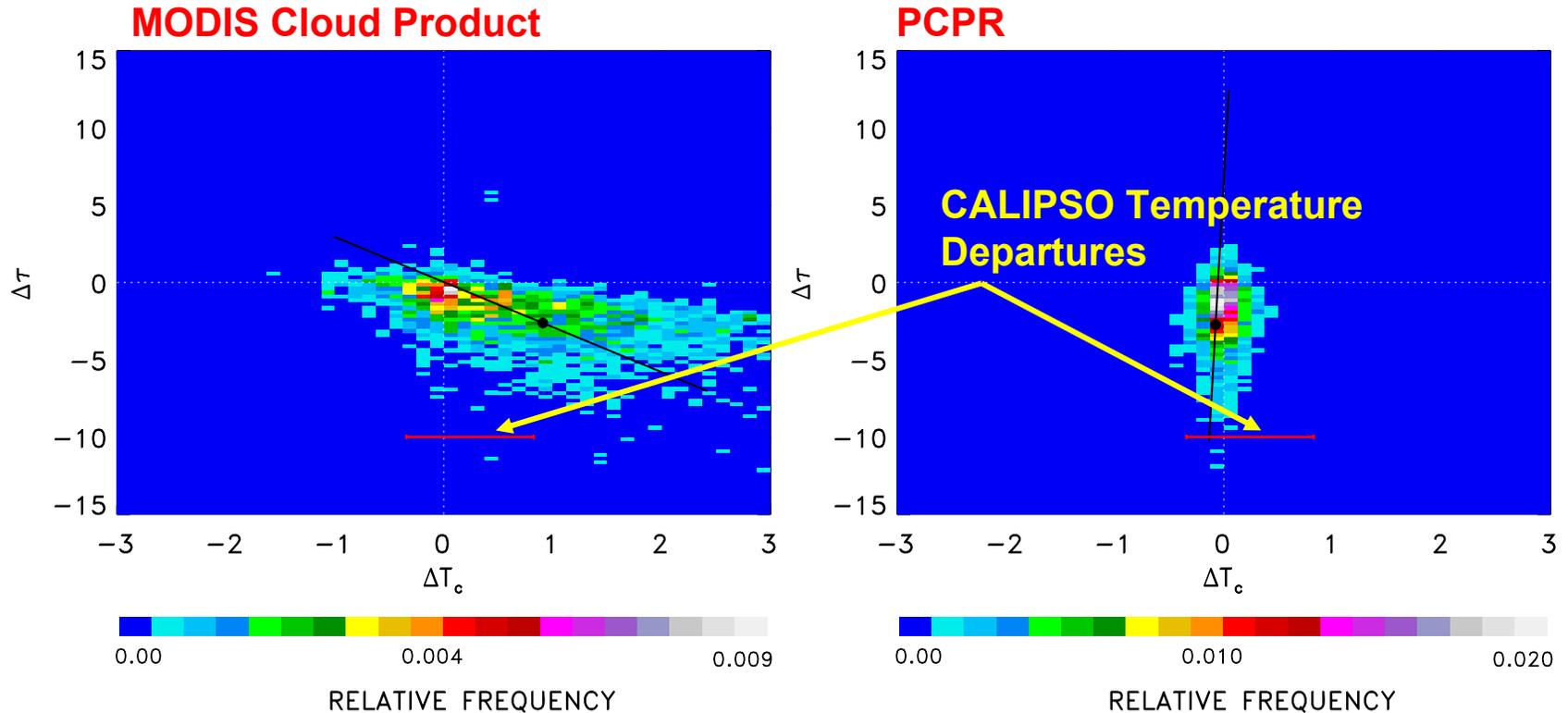
50-km regions which contain only marine stratocumulus, as determined using a combination of MODIS partly cloudy pixel retrievals and CALIPSO lidar attenuated backscatter returns.

Lidar returns (70-m scale) with no ocean surface detected are almost always associated with overcast 1-km MODIS pixels (80% occurrence).

Returns in which surface is detected almost always associated with partly cloudy pixels (>75% occurrence).

Departures from Overcast Means of Cloud Temperatures and Optical Depths in Partly Cloudy MODIS Pixels

Pixel-scale cloud temperatures and optical depths for partly cloudy pixels drawn from 50-km regions containing marine stratocumulus.

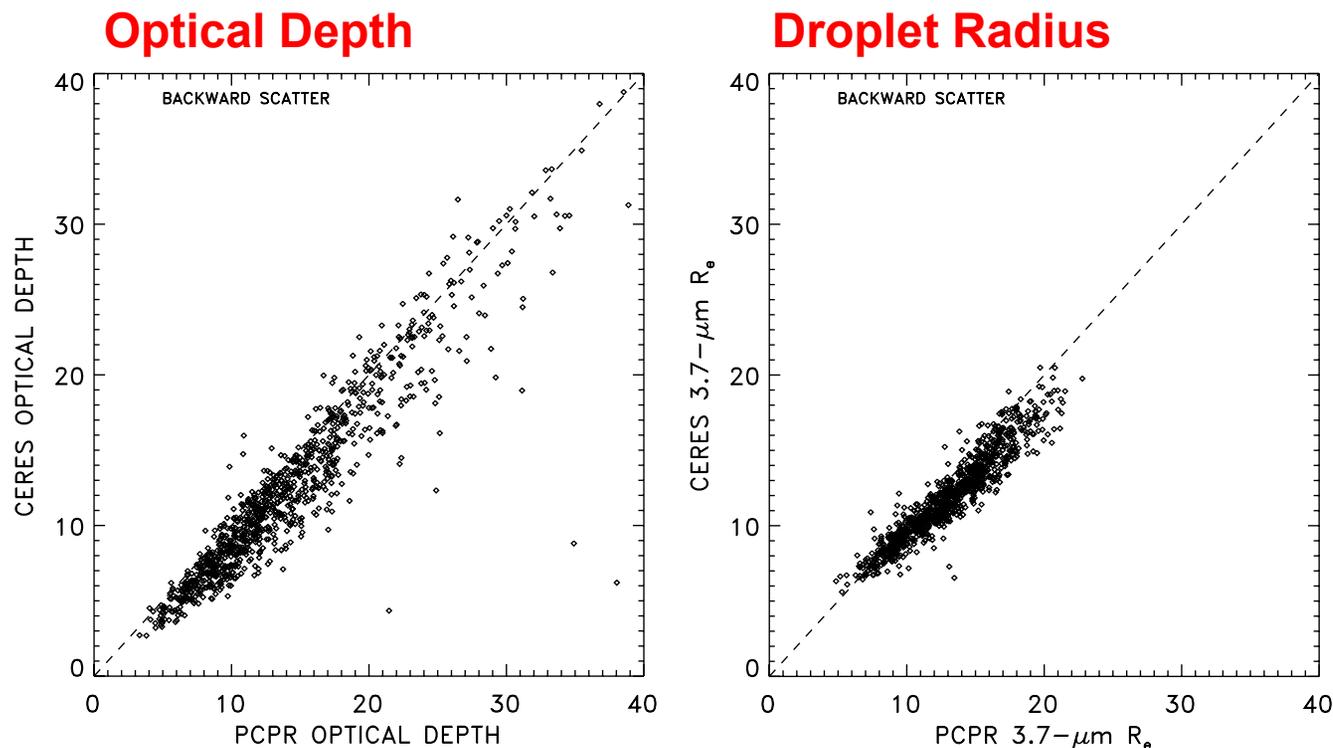


MODIS cloud temperature departures for partly cloudy pixels much larger than those deduced from CALIPSO lidar returns.

Cloud temperature departures for partly cloudy pixel retrievals consistent with CALIPSO lidar returns.

Cloud Properties from CERES-SSF and Partly Cloudy Pixel Retrievals

Nearly Overcast Regions ($A_c > 0.8$)



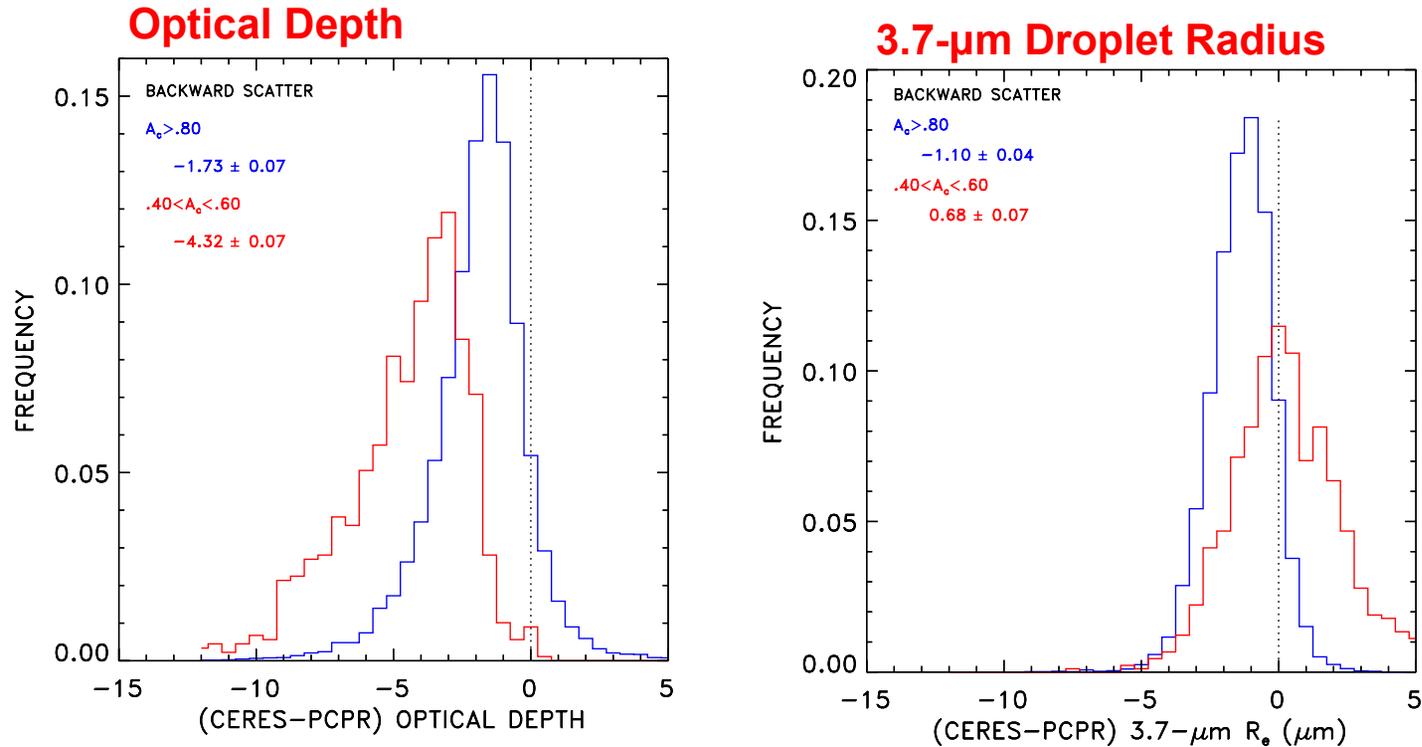
50-km scale regions with collocated MODIS and CERES fields of view.

Observations from Terra for four summer months from three years over the North Atlantic.

Study limited to regions which contain only marine stratocumulus.

Cloud Optical Depth and Droplet Radii Differences (CERES – PCPR)

Regions with $A_c > 0.8$ in blue and with $0.4 < A_c < 0.6$ in red

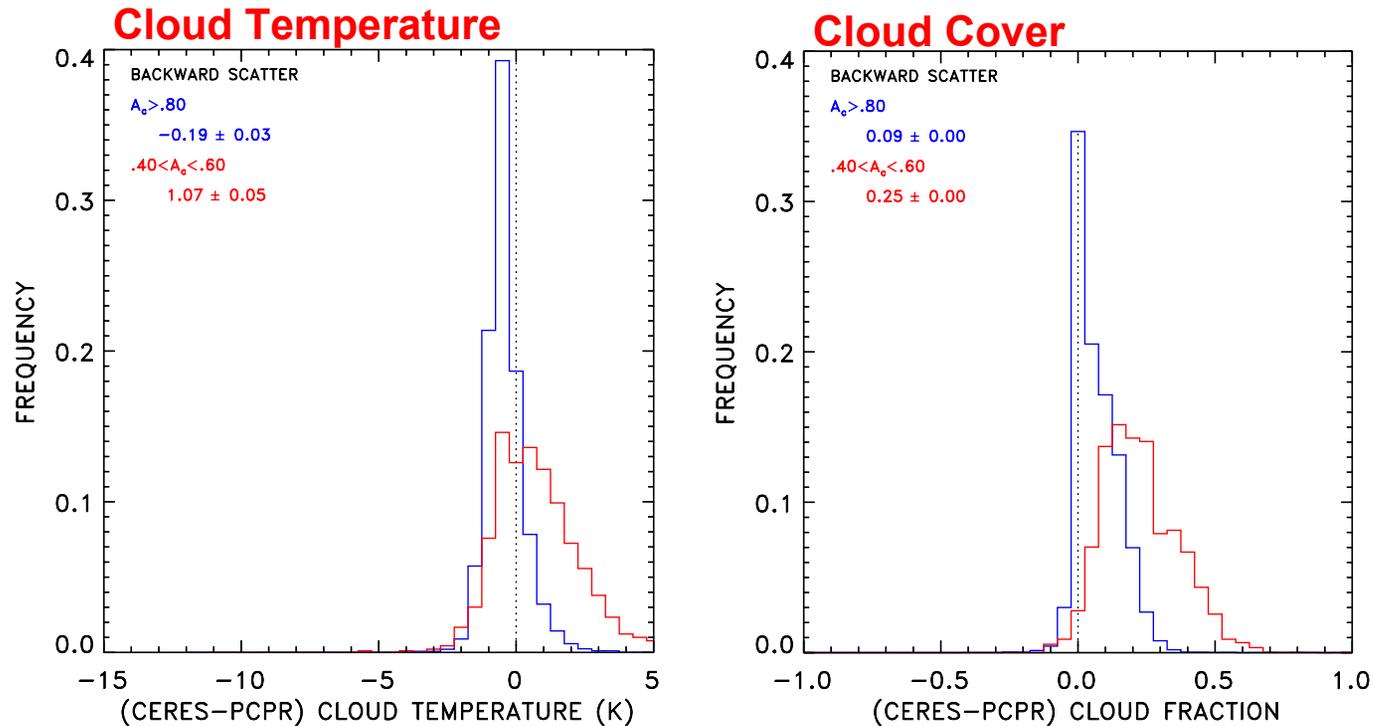


In nearly overcast regions, CERES optical depths are smaller than PCPR values, consistent with the trends for the MODIS cloud products for overcast pixels. Droplet radii are also smaller, but as much as 0.7 μ m smaller than in the MODIS cloud products.

In regions containing broken clouds, CERES optical depths are significantly smaller and droplet radii significantly larger than PCPR values, also consistent with the trends for the MODIS cloud products for partly cloudy pixels.

Cloud Temperature and Cloud Cover Differences (CERES – PCPR)

Regions with $A_c > 0.8$ in blue and with $0.4 < A_c < 0.6$ in red



In nearly overcast regions, CERES cloud temperatures agree with PCPR values. CERES cloud cover is almost always overcast while PCPR cloud cover is noticeably less.

In regions containing broken clouds, CERES cloud temperature and cloud cover are significantly higher consistent with the trends in the MODIS cloud products.

Conclusions

- Evidence of partly cloudy pixels at the 250-m and 1-km scale ***ABOUNDS*** for marine stratocumulus systems.
- MODIS observations suggest that for single-layered, low-level, marine cloud systems at least 30% of the 1-km MODIS pixels are partly cloudy.
- *These results affect only interpretations of the effects of clouds on radiative fluxes, not the values of the fluxes themselves.*