

# Overestimation of Cloud Cover in the MODIS Cloud Product

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**Goal:** *Use MODIS 250-m imagery to assess accuracy of cloud properties derived using partly cloudy pixel retrievals applied to 1-km imagery.*

# Retrieval Method

*Retrieval scheme follows Arking and Childs (1985) and is described in Coakley et al. (2005).*

- For single-layered cloud systems, identify overcast pixels and determine altitude of cloud layer.
- For each pixel, radiances are given by

$$I = (1 - A_C)I_S + A_C I_C(z_C, \tau, R_e)$$

$A_C$  = Fractional cloud cover within a pixel

$I_S$  = Average cloud-free radiance within a pixel

$I_C(z_C, \tau, R_e)$  = Average overcast radiance within a pixel

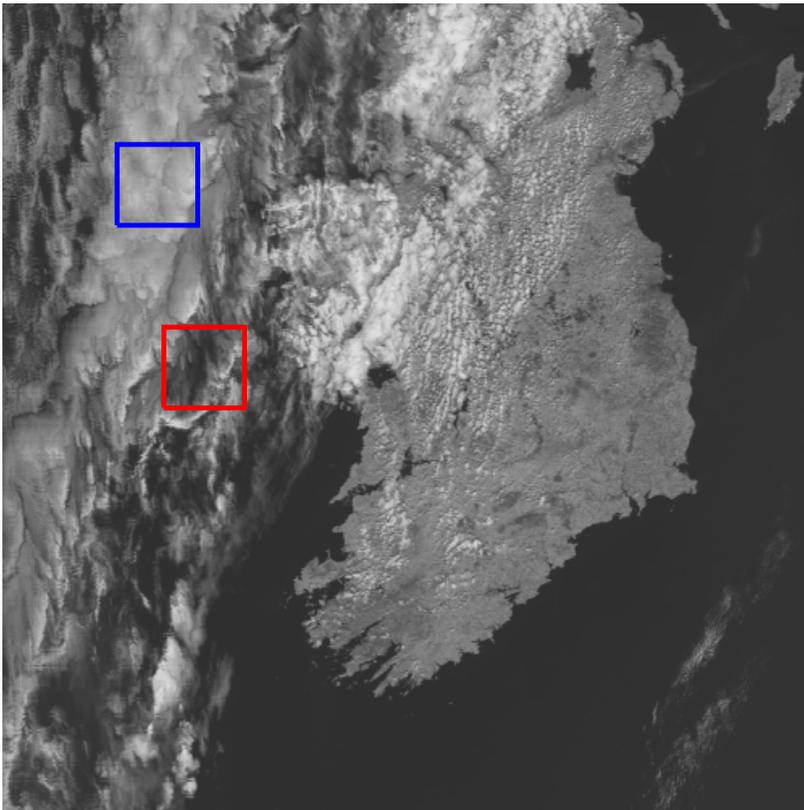
$z_C$  = Average cloud altitude obtained from nearby overcast pixels

- For each pixel, adjust  $A_C$ ,  $\tau$ ,  $R_e$  so that calculated radiances at 0.64, 1.6, 2.1, 3.7, and 11  $\mu\text{m}$  match those observed.

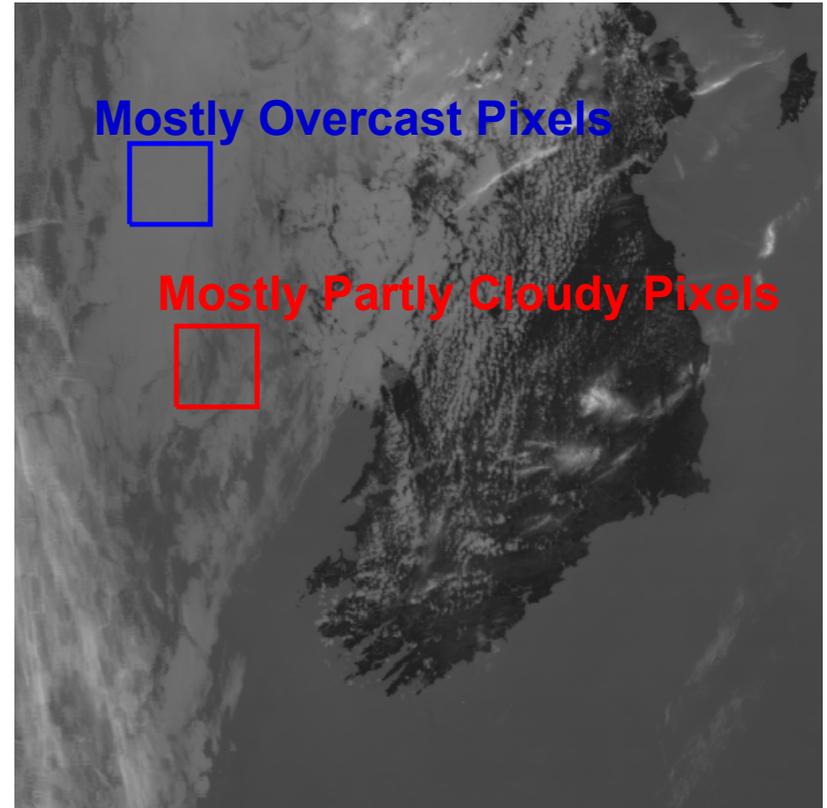
# 1-km MODIS Imagery

Terra 1 May 2001 1140 Z North Atlantic

0.84  $\mu\text{m}$

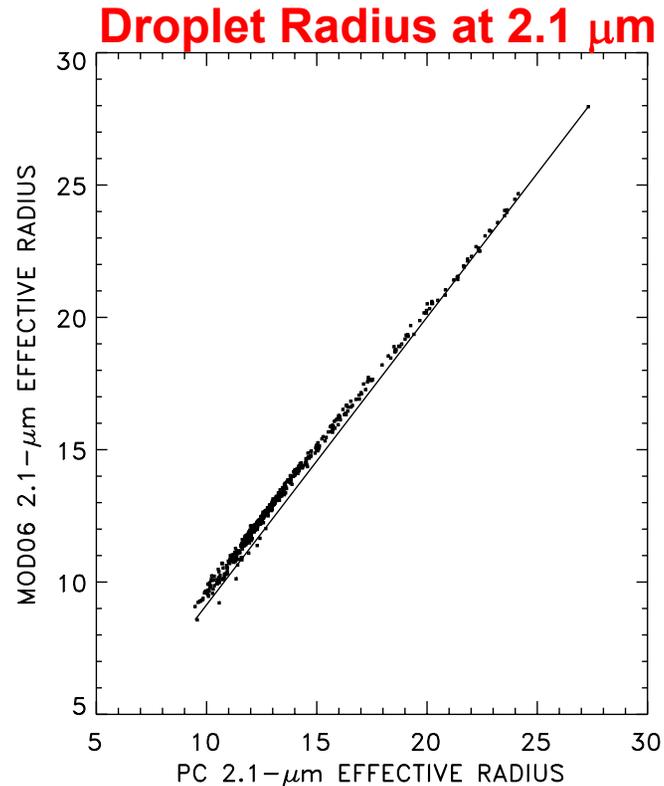
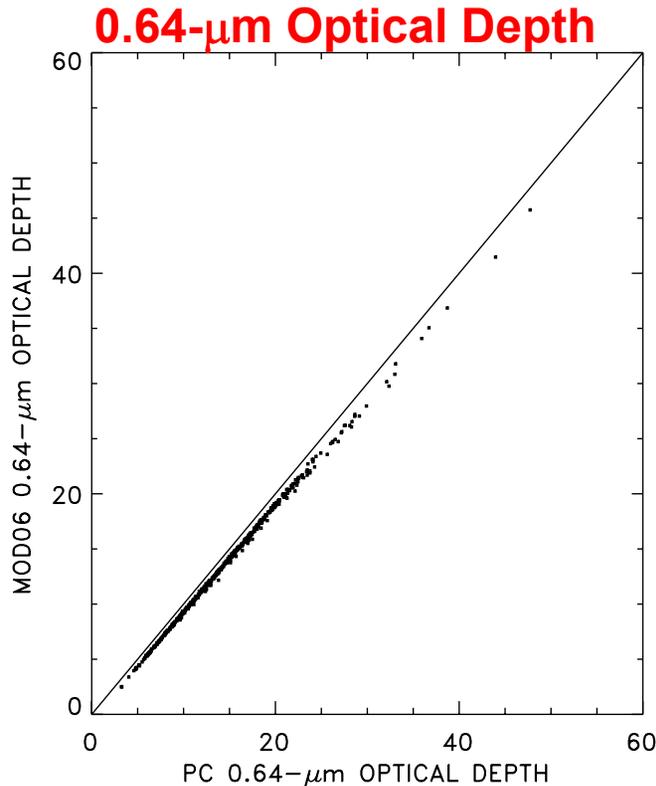


11  $\mu\text{m}$



*50-km scale regions selected that contain only single-layered, low-level marine stratocumulus.*

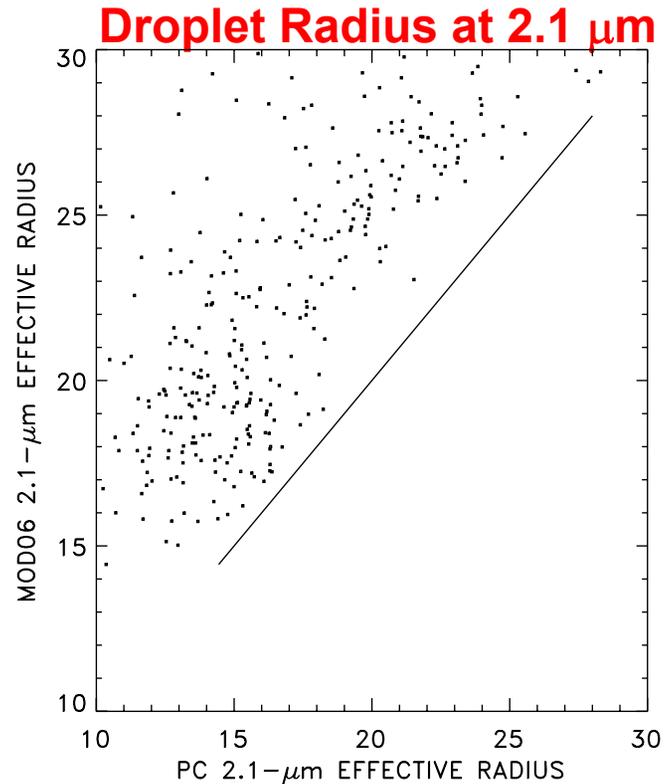
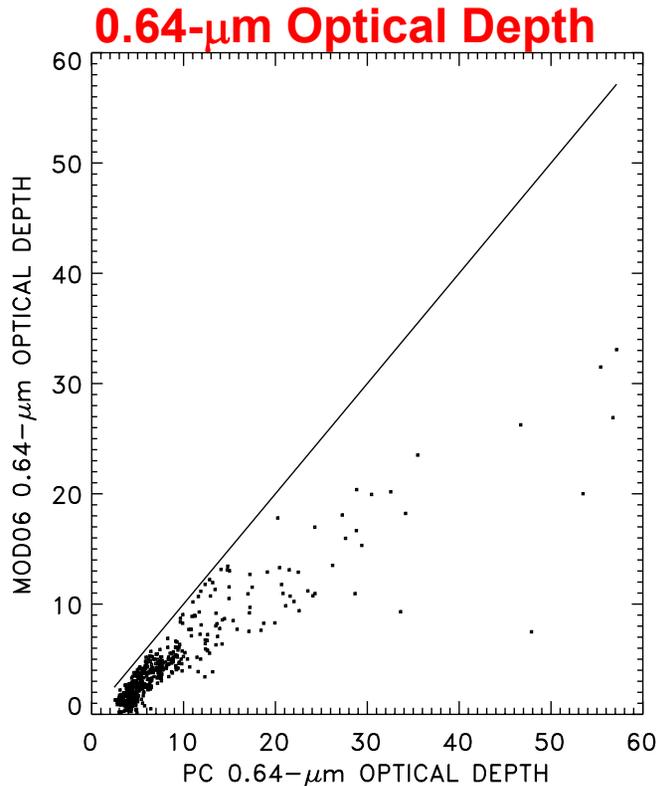
# Optical Depth and Droplet Effective Radius for *Overcast Pixels*



*1-km overcast pixels drawn from 50-km scale region containing mostly overcast pixels.*

*MOD06 cloud products and partly cloudy pixel retrievals agree when 1-km pixels are overcast.*

# Optical Depth and Droplet Effective Radius for *Partly Cloudy Pixels*



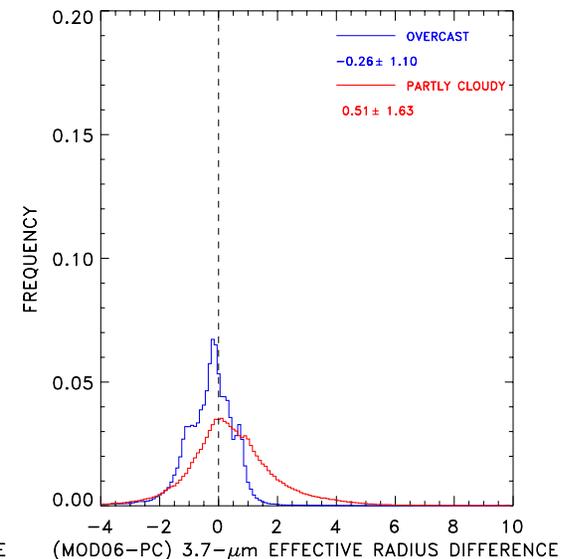
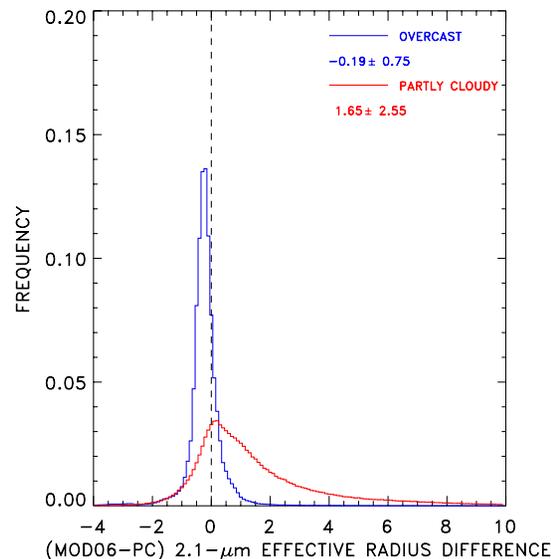
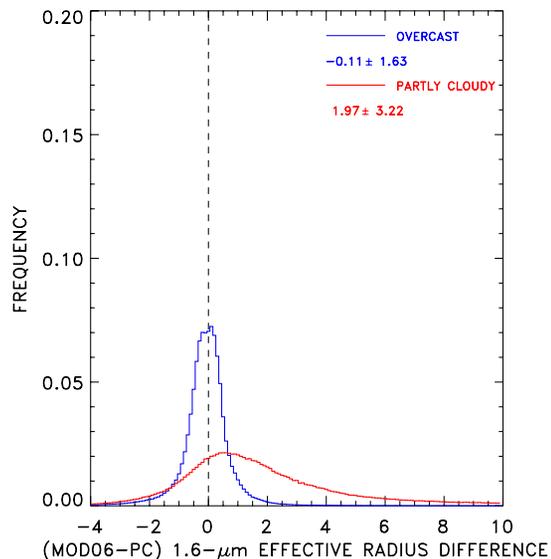
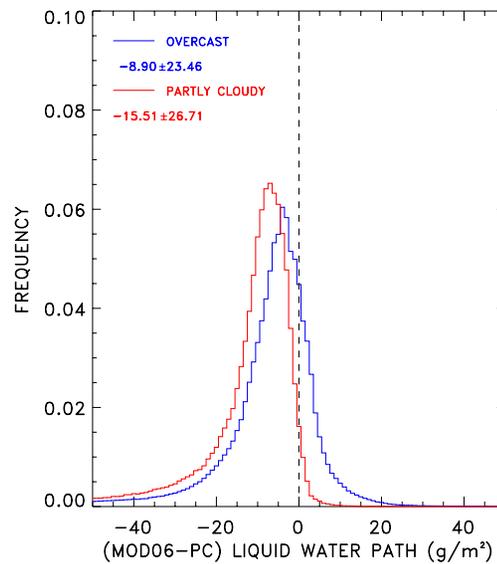
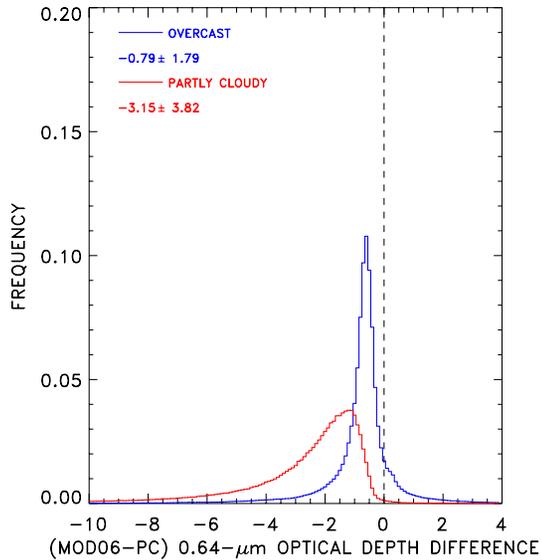
*1-km partly cloudy pixels drawn from 50-km scale region containing mostly partly cloudy pixels.*

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

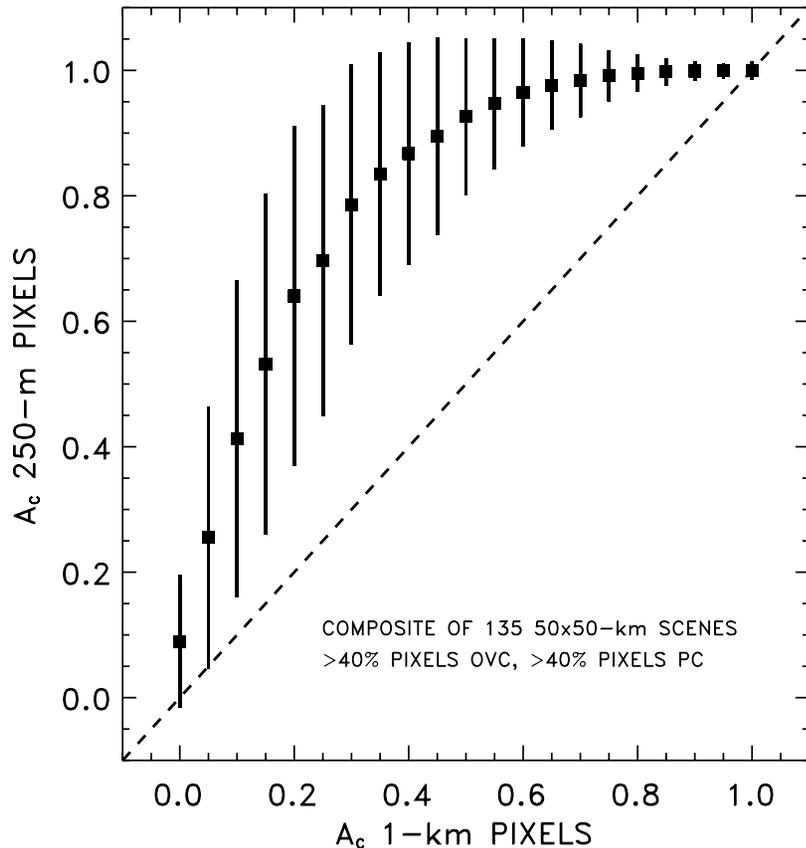
# OVERCAST PIXELS IN BLUE PARTLY CLOUDY PIXELS IN RED

## 1-km Pixel Scale Differences, MOD06 – *Partly Cloudy Pixel* Retrieved Optical Depths and Droplet Radii

Results derived from Terra,  
Collection 5, for several  
hundred 50-km scale regions  
of the North Atlantic, May-  
August 2001.



# 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.

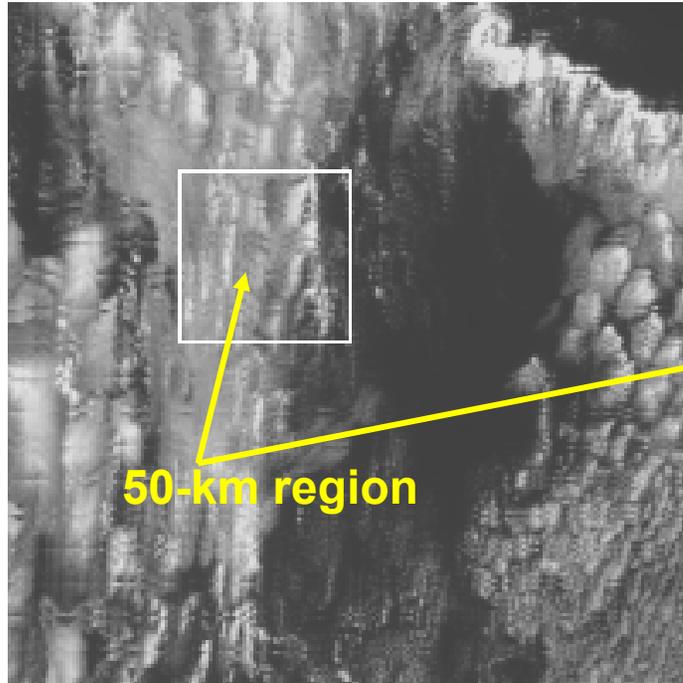
Cloud cover fractions binned according to pixel-scale fractional cloud cover.

***MODIS 250-km cloud mask severely overestimates the fractional cover.***

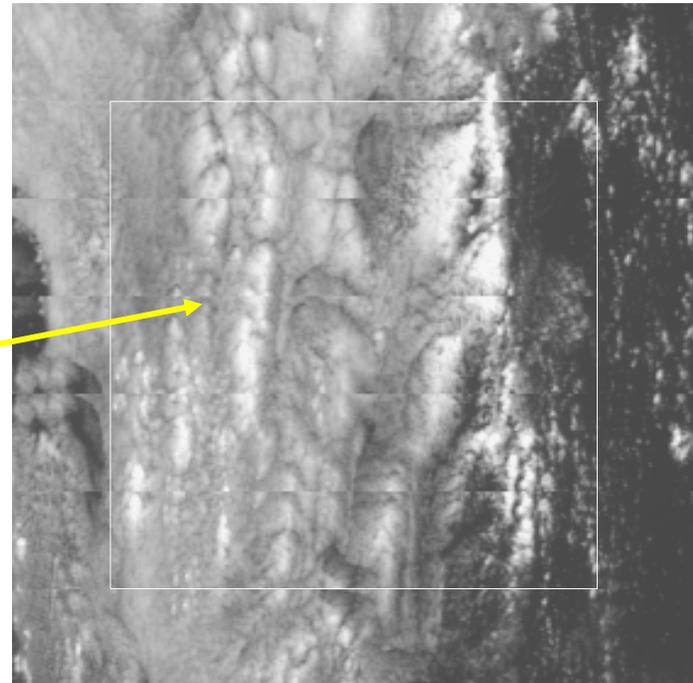
# Partly Cloudy Marine Stratocumulus

0.64- $\mu\text{m}$  Reflectances Terra 13 May 2004 1110 UTC

1-km

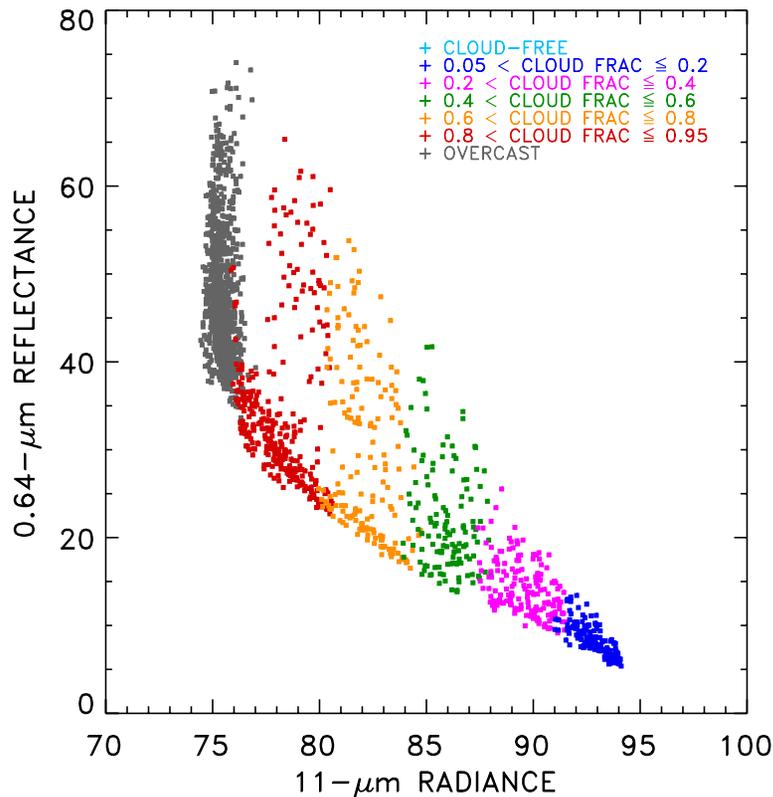


250-m

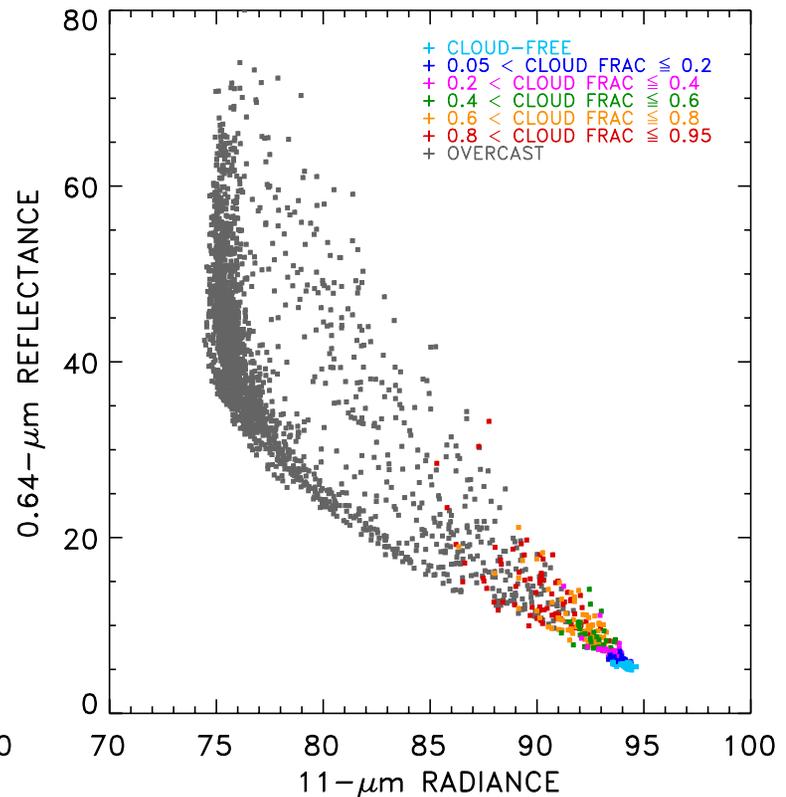


# Visible-IR Interpretation

## Partly Cloudy Pixel Retrievals



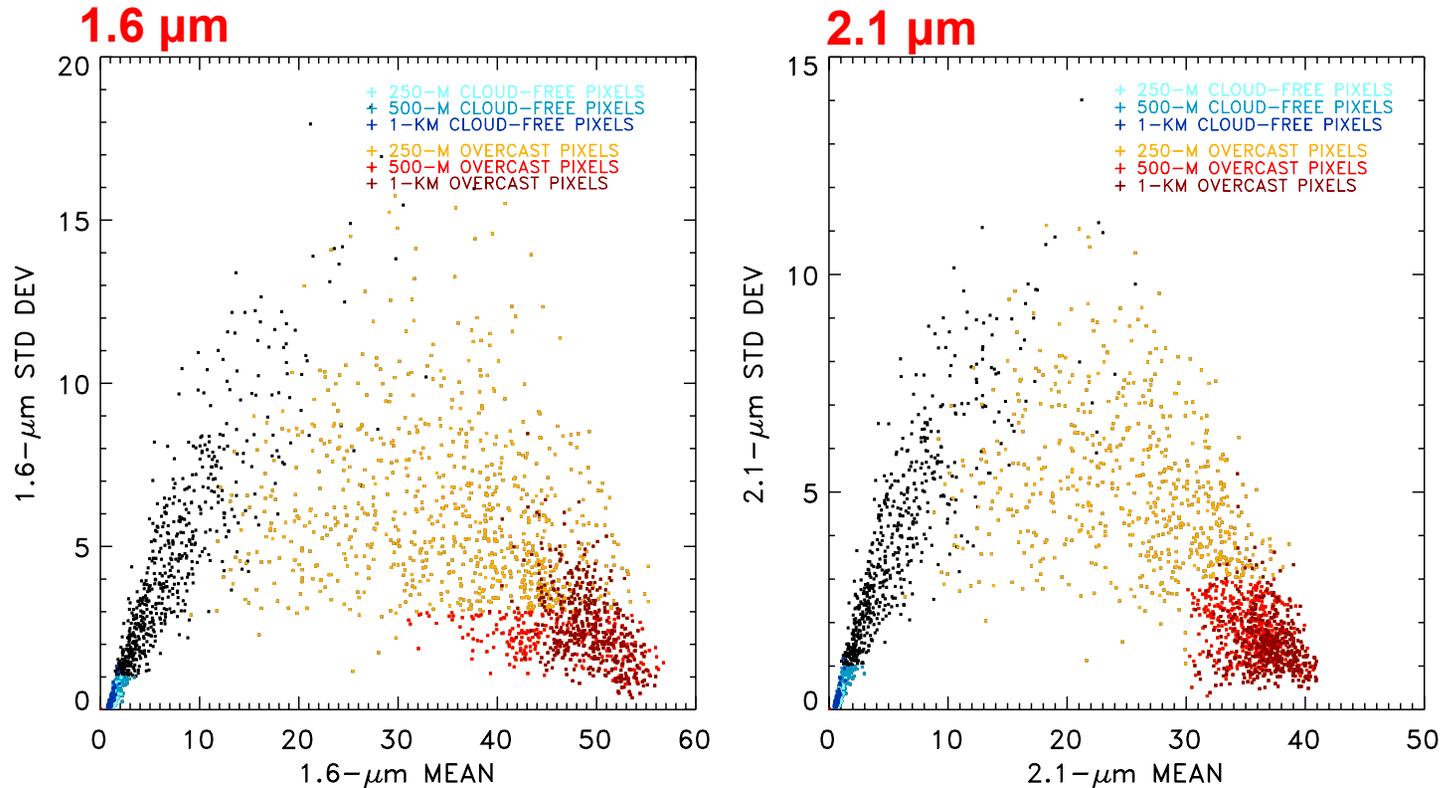
## 250-m Cloud Mask



**250-m cloud mask aggregated and used to determine fractional cloud cover for 1-km pixels.**

**For this system, 250-m cloud mask appears to identify as overcast pixels with cloud fraction  $> 0.5$ .**

# Spatial Uniformity at 1.6 and 2.1 $\mu\text{m}$



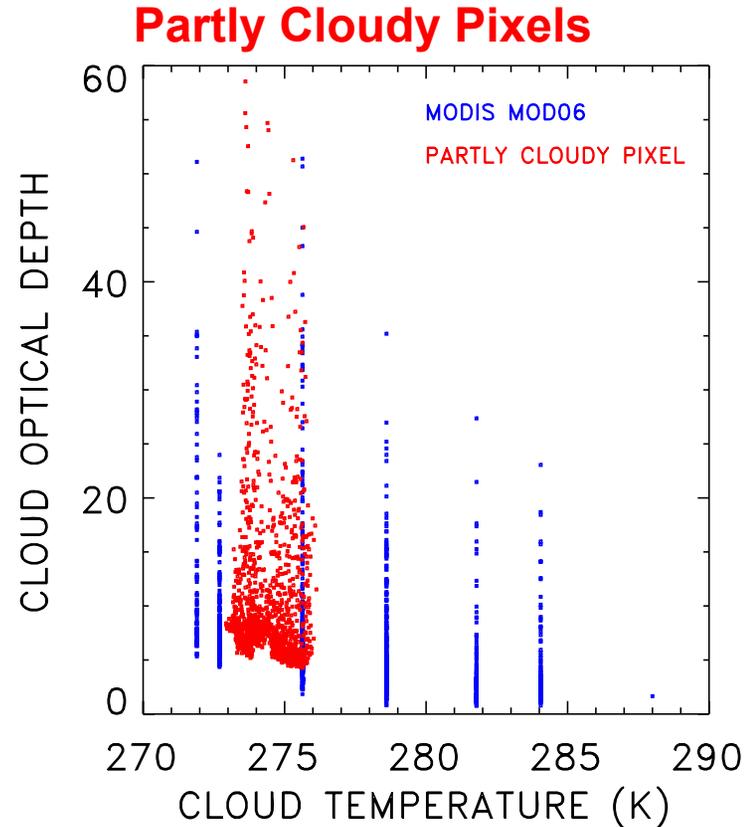
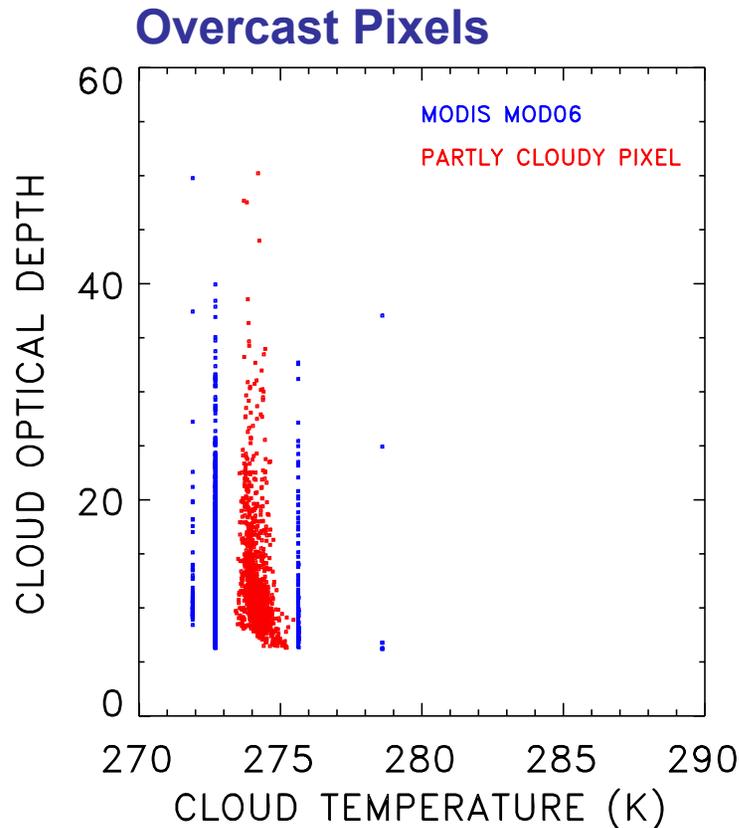
Mean reflectances and standard deviations obtained for  $4 \times 4$  arrays of 500-m observations for 100-km system of marine stratocumulus.

250-m cloud flags aggregated to 2-km arrays.

250-m cloud flags identify partly cloudy pixels as overcast compared with both the 500-m spatial uniformity analysis and the 1-km partly cloudy pixel retrievals.

# Consequences of Biased Cloud Products

## *50-km Scale Region of Marine Stratocumulus*



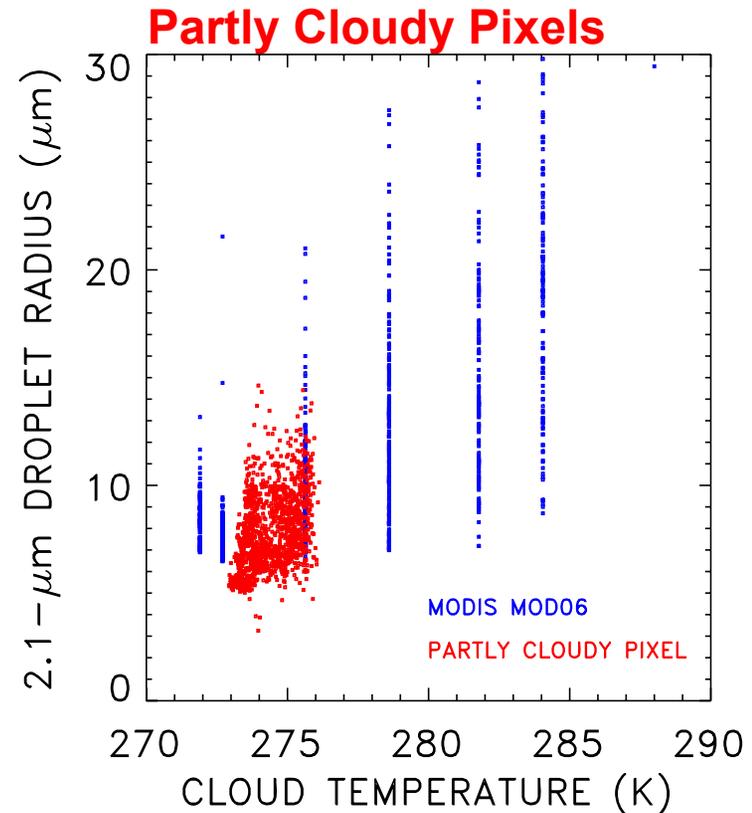
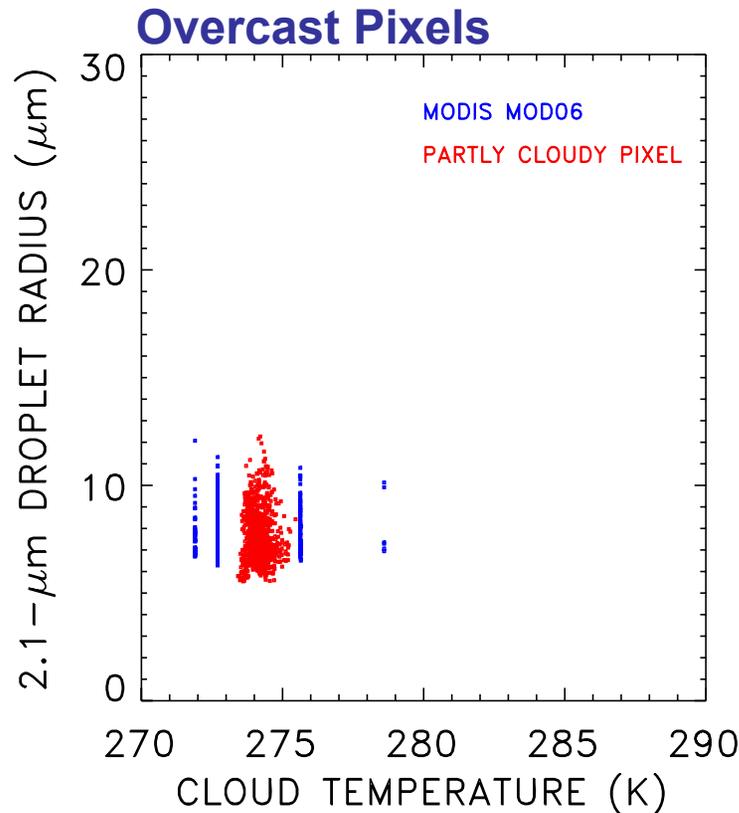
**Optical depth increases with cloud altitude, as it does for cloud parcel models.**

**Growth with altitude is amplified in the MOD06 retrievals for the partly cloudy pixels.**

**The altitude variations indicated for the partly cloudy pixels in the MOD06 product are inconsistent with those derived from CALIPSO (Hayes et al. 2006).**

# Droplet Radius and Temperature

## *50-km Scale Region of Marine Stratocumulus*

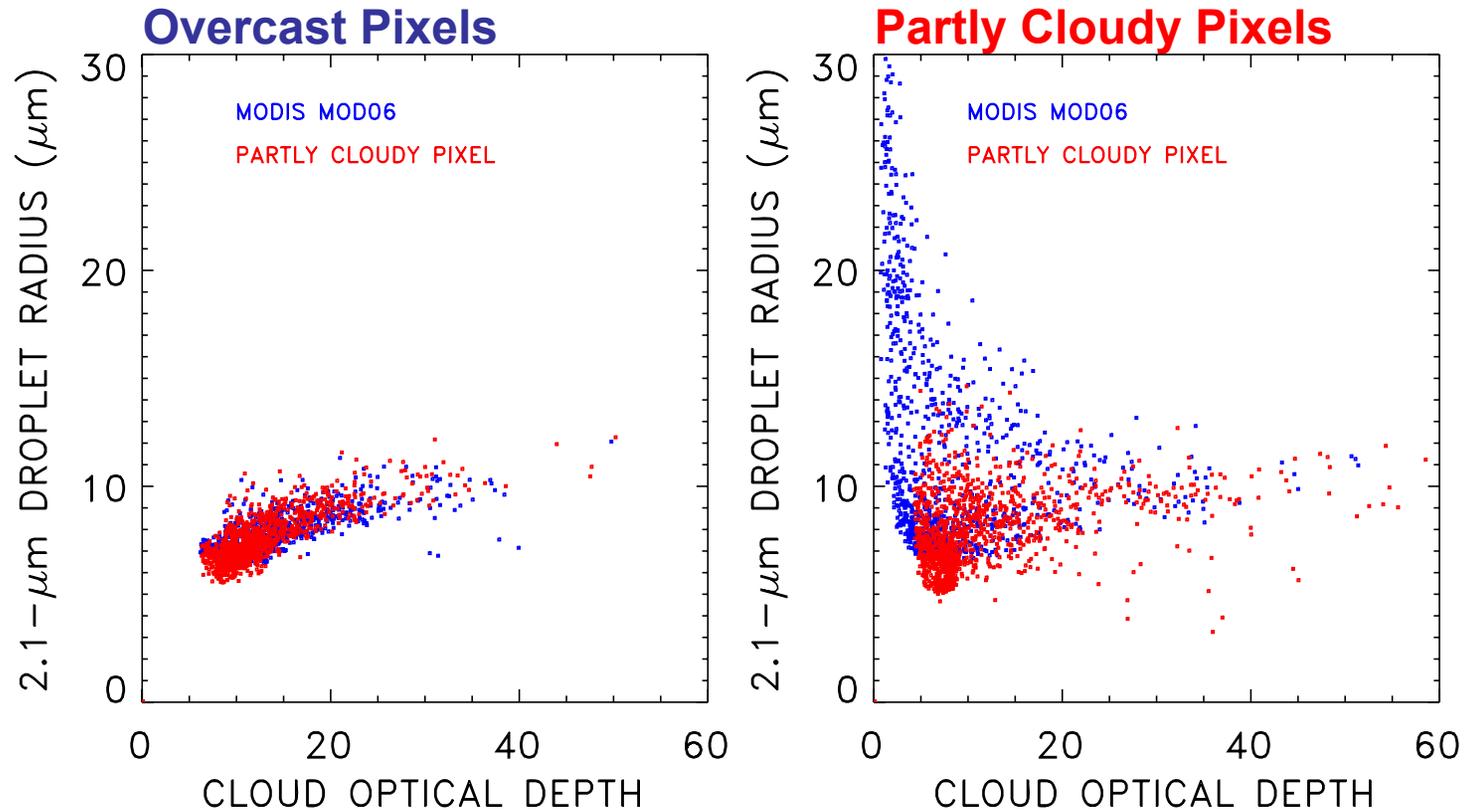


For overcast pixels, droplet radius increases with cloud altitude, as it does for cloud parcel models.

For partly cloudy pixels, droplet radius increases with decreasing altitude in the MOD06 cloud product. Coupled with the decrease in optical depths, the results imply very small droplet concentrations in thin clouds,

# Droplet Radius and Optical Depth

*50-km Scale Region of Marine Stratocumulus*



The growth of droplet radius and optical depth for overcast pixels reflect the growths with altitude expected in cloud parcel models.

For partly cloudy pixels, the droplet radii and optical depths obtained with the partly cloudy pixel retrievals generally slightly smaller than those obtained for overcast pixels. The droplet radii in the MOD06 product are much larger and the optical depths much smaller than those obtained for the overcast pixels.

# *To be done...*

- **Apply retrievals to the 500-m 0.64, 1.6, and 2.1- $\mu\text{m}$  reflectances to characterize behavior of retrieved optical depths and droplet radii in 500-m pixels suspected of being partly cloudy.**
- **Obtain ultra-high spatial resolution ASTER data to assess the merits of the partly cloudy pixel retrievals.**