Cloud detection challenges in LDCM

by Lazaros Oreopoulos (UMBC/NASA)

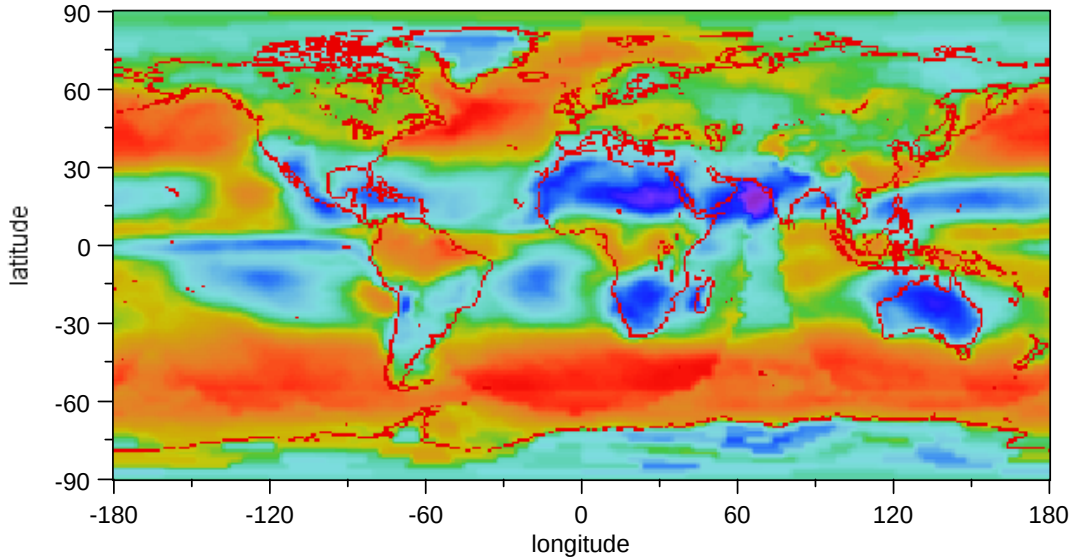
- ✓Cloud Climatologies (LTAP)
- ✓1.38 µm cloud detection (T. Várnai, K. Meyer, S. Platnick)
- ✓Small marine cloud properties (G. Feingold, I. Koren)

JCET The Joint Center for Earth Systems Technology

LANDSAT LDCM Data Continuity Mission

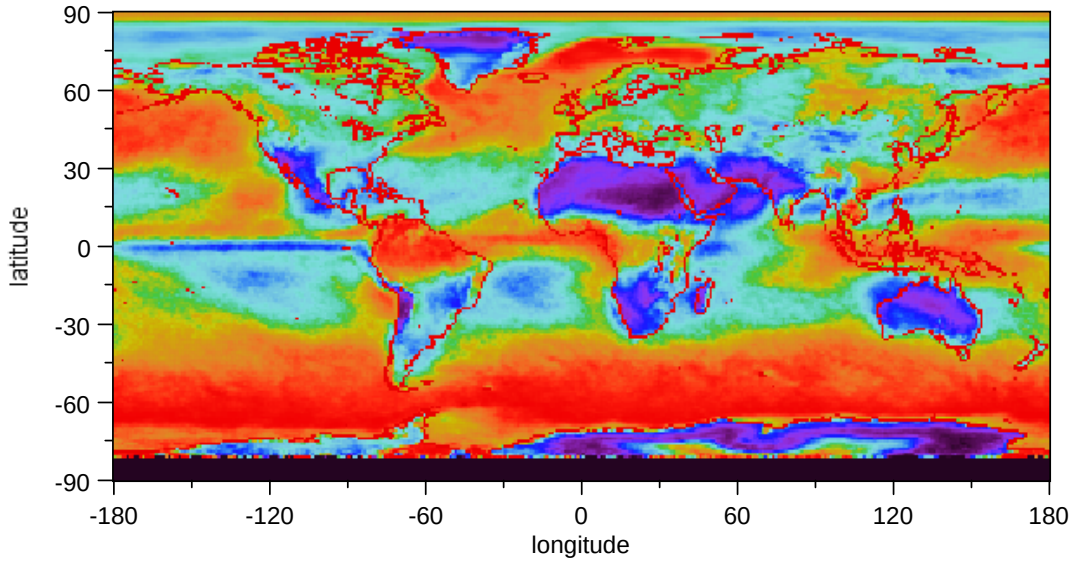
Cloud climatology comparisons

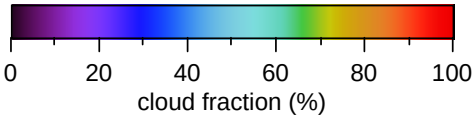
ISCCP
23-yr mean



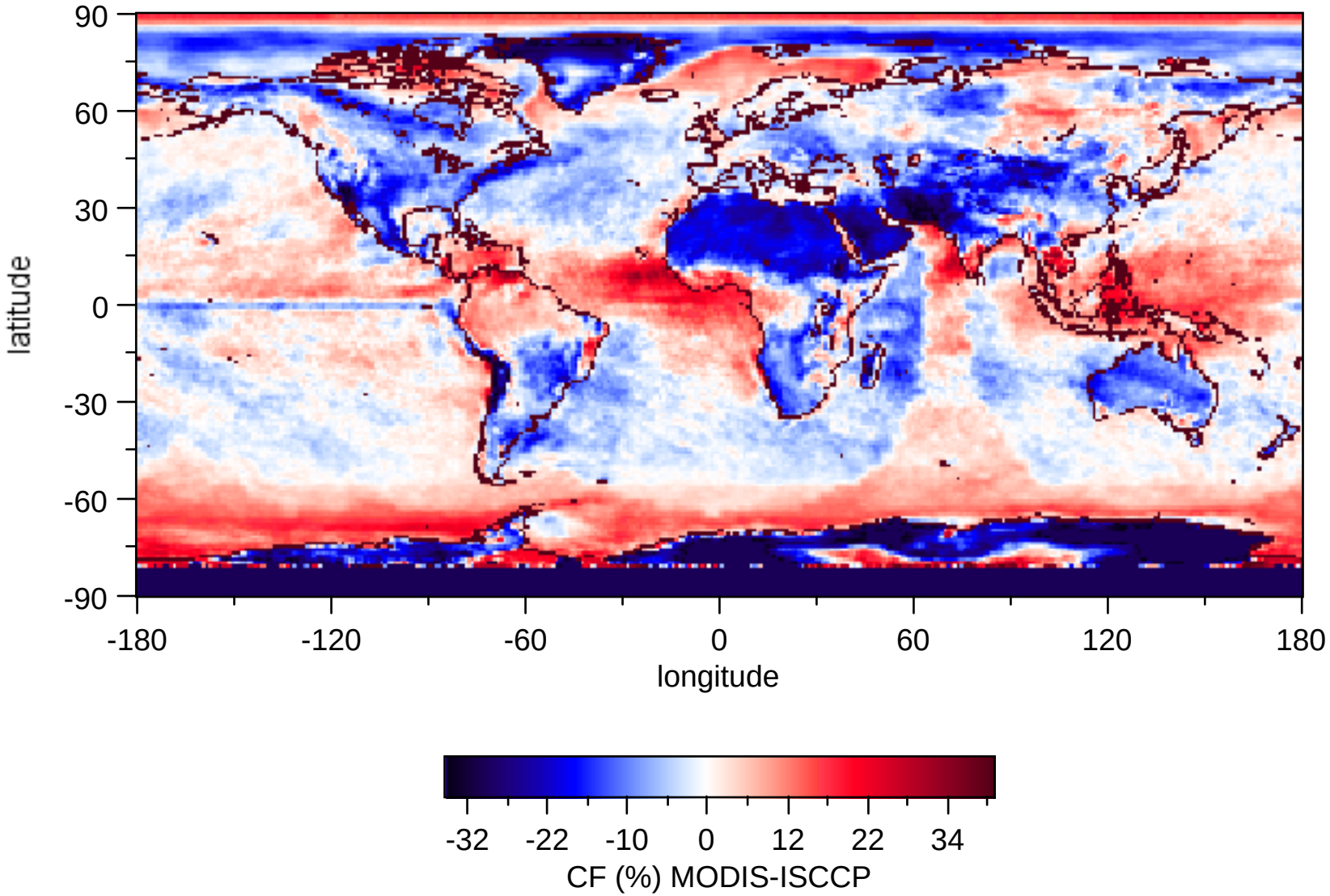
April

MODIS
7-yr mean



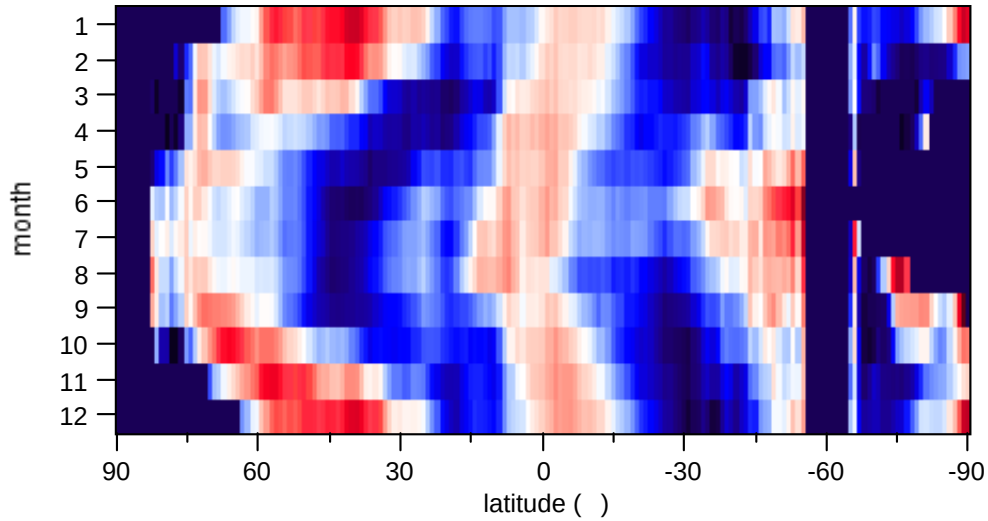


Cloud climatology comparison (MODIS-ISCCP)

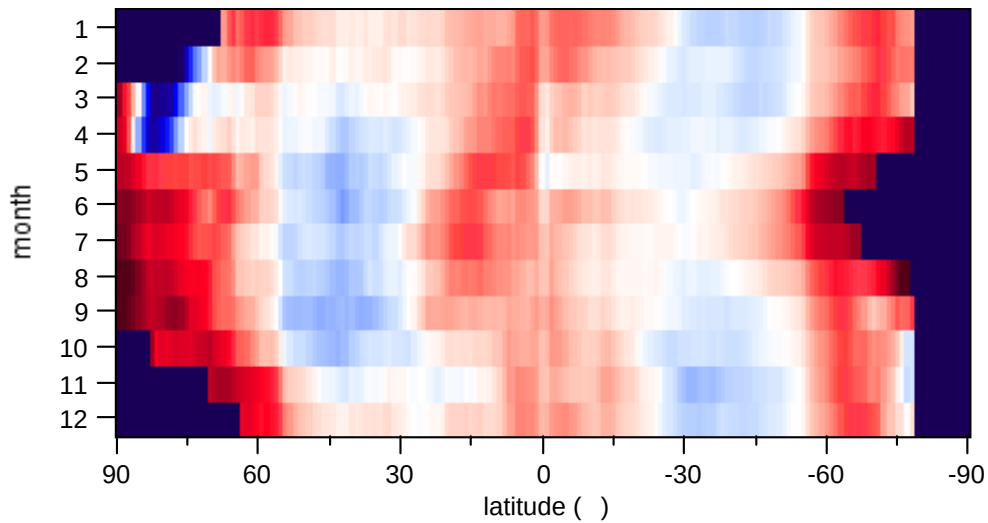


April

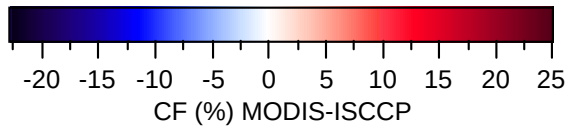
MODIS-ISCCP zonal differences



land

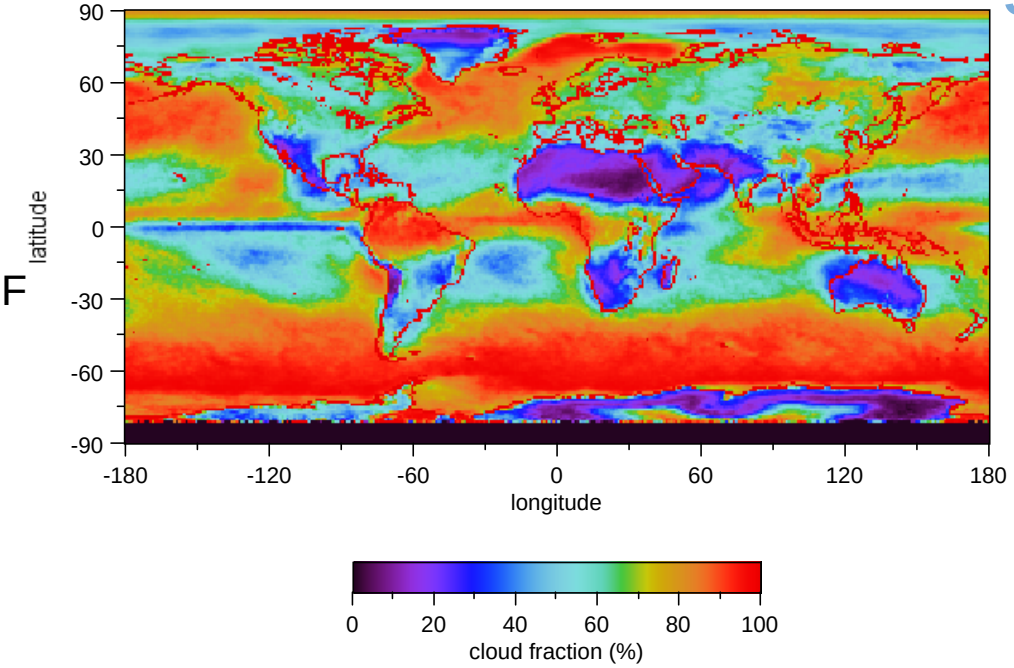


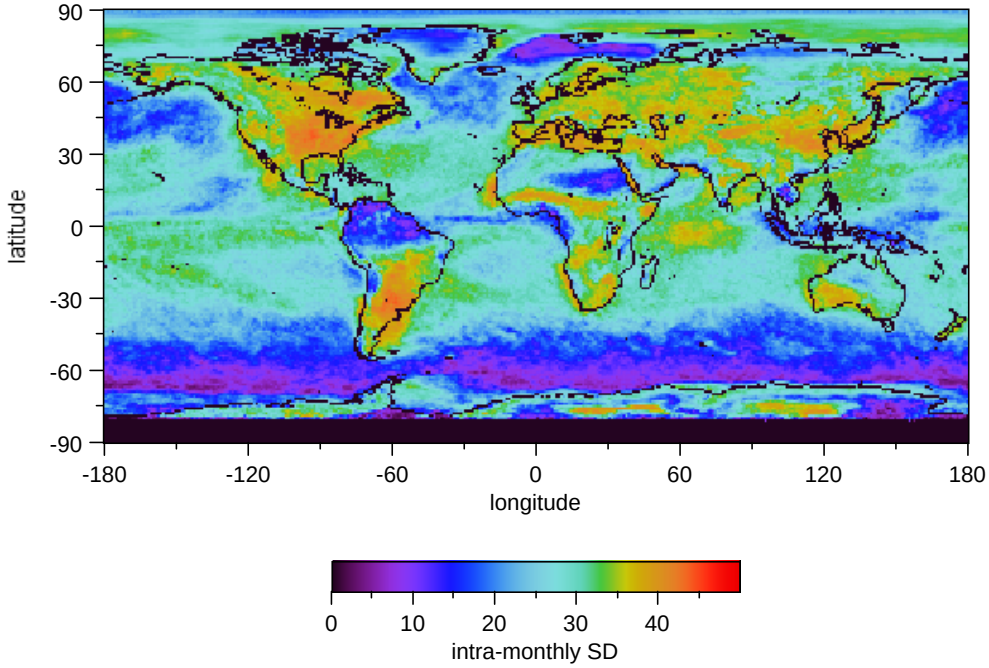
ocean



Another MODIS advantage

Mean monthly CF
April





Intra-monthly
variability (sdev)
April

MODIS 1.38 µm experiments (Várnai)

Data used:

- MODIS Terra
- Global daytime coverage on January 15, 2007
- 200 X 200 km areas at center of swath

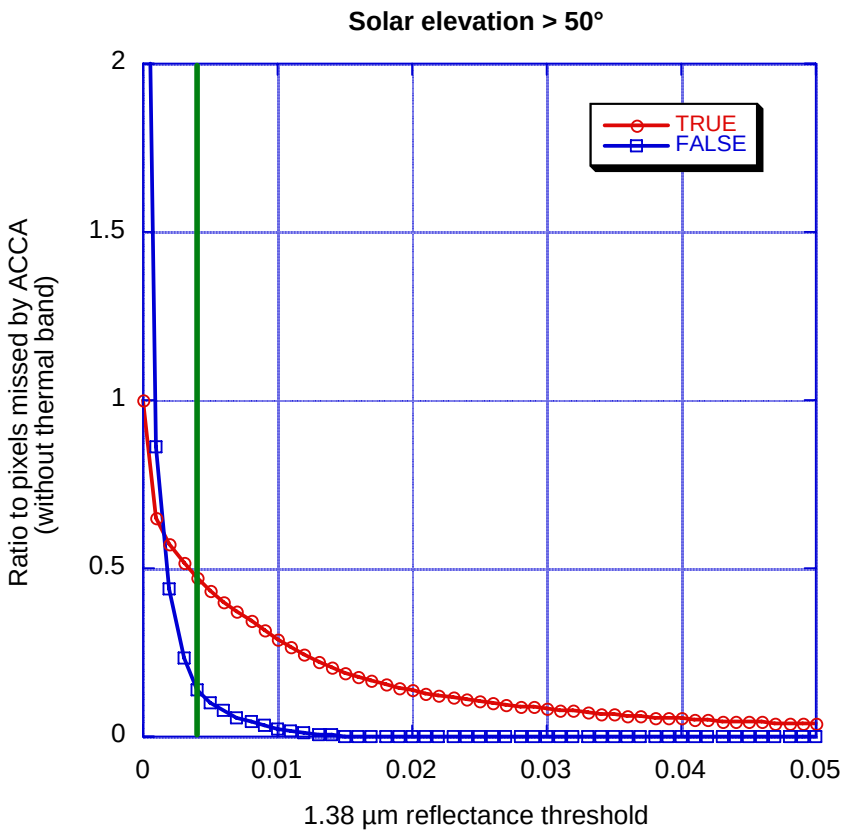
Apply ACCA without thermal to MODIS:

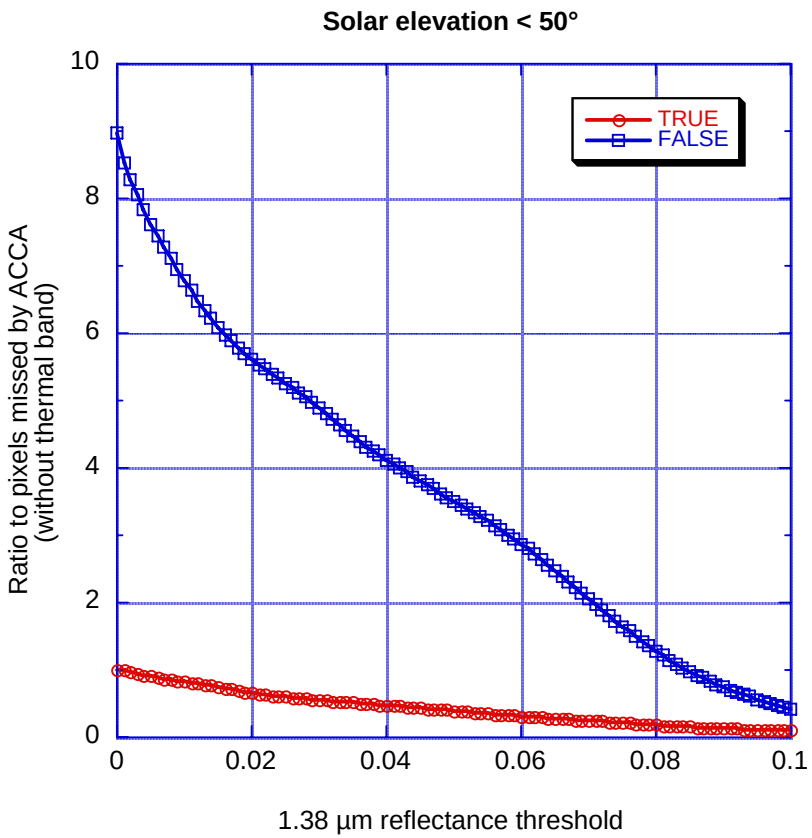
- No pass 2 (uncertain pixels set to clear)
- Band 5/6 test not performed (potential cold land not sent to pass 2)

Truth is provided by MODIS cloud mask (MOD35)

Problem with single threshold at 1.38 µm:

Variability in surface brightness (especially snow)



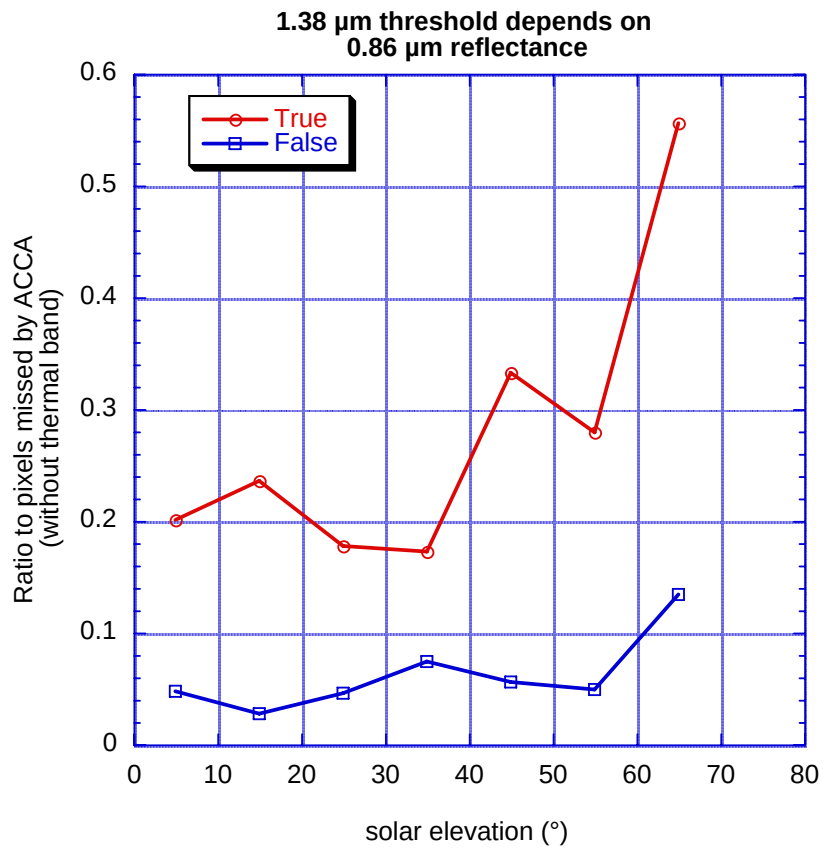


Possible solution:

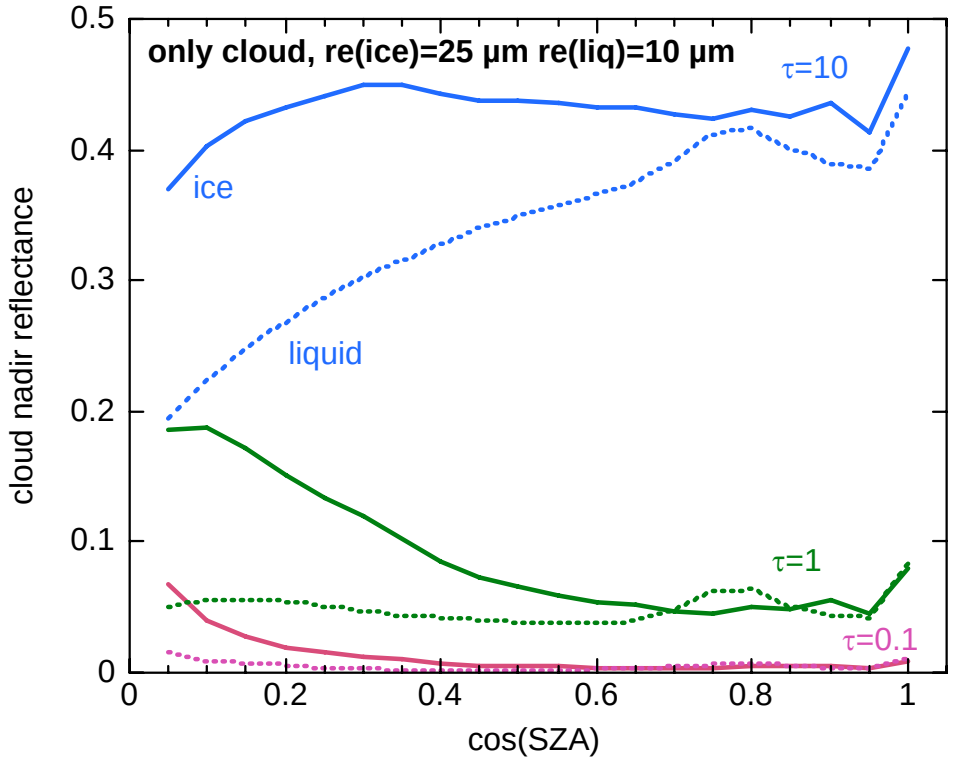
Make 1.38 µm threshold depend on 0.86 µm reflectance

Reclassify clear pixels as cloud if:
$R_{1.38} > R^*(R_{0.86})$

$R^*(R_{0.86})$ is set to ensure that:
$N_{true} / N_{false} \geq 1.2$ for $R_{1.38} = R^*(R_{0.86})$
$N_{true} / N_{false} \geq 1.2$ for $R_{1.38} > R^*(R_{0.86})$



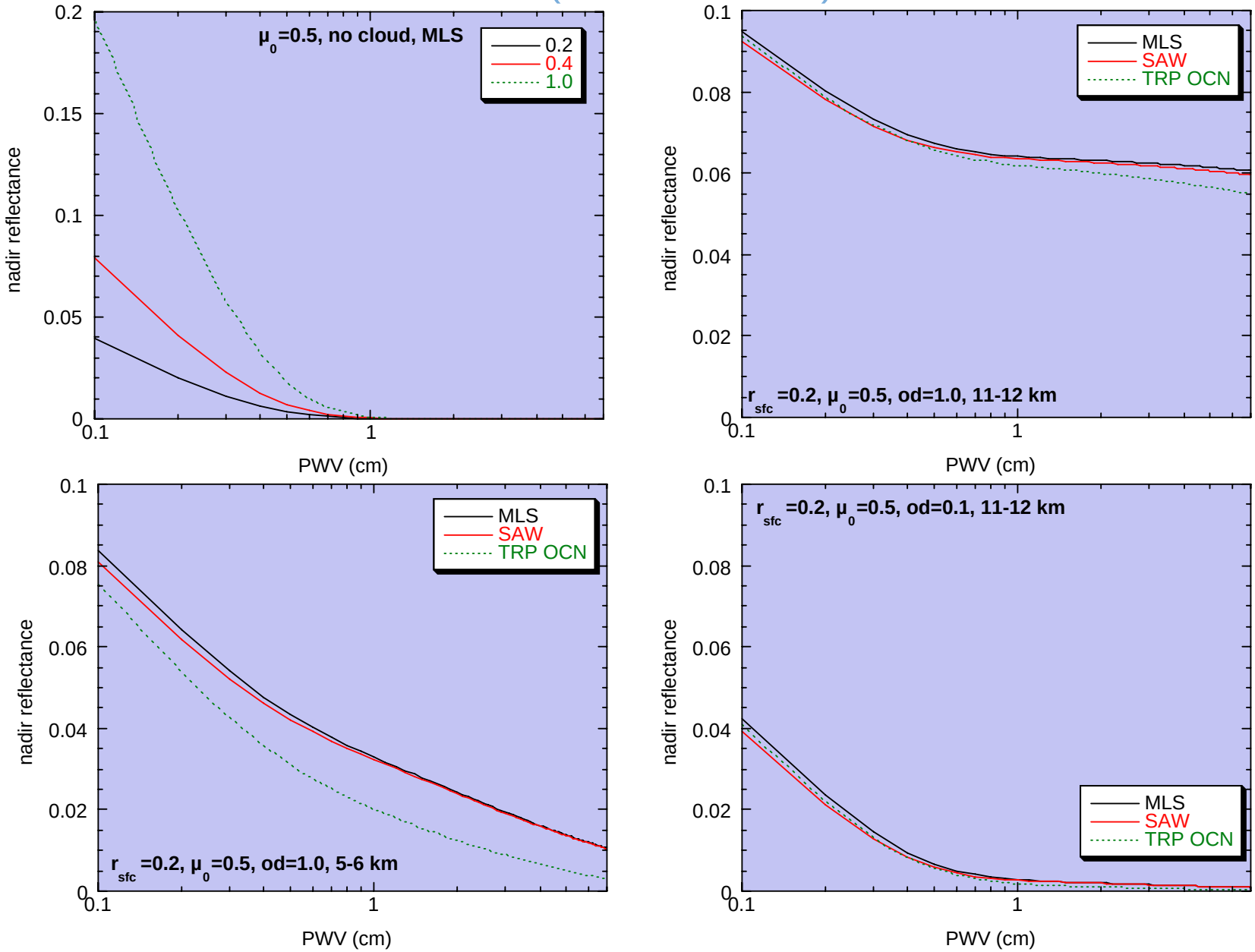
Theoretical 1.38 µm studies with a MODIS reflectance simulator (Meyer, Platnick)



<u>TOA 1.38 µm nadir reflectance depends on:</u>

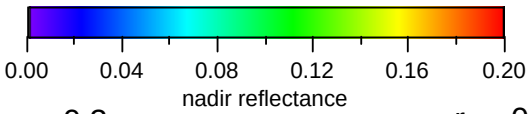
- Solar zenith angle
- Surface albedo (BDRF)
- Total column water vapor
- Profile of water vapor
- Cloud phase, vertical location, optical thickness, effective particle size

Theoretical 1.38 µm studies with a MODIS reflectance simulator (fixed SZA=60°)

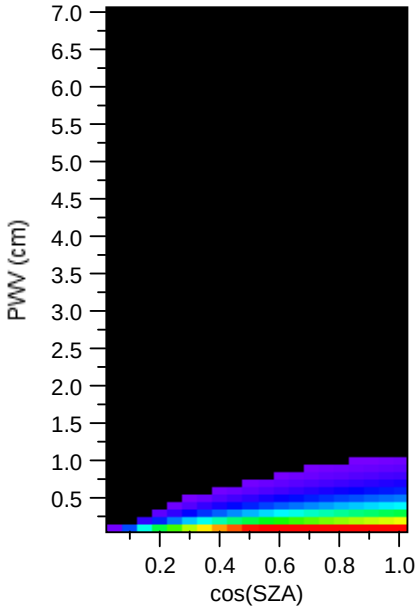


MLS WV profile

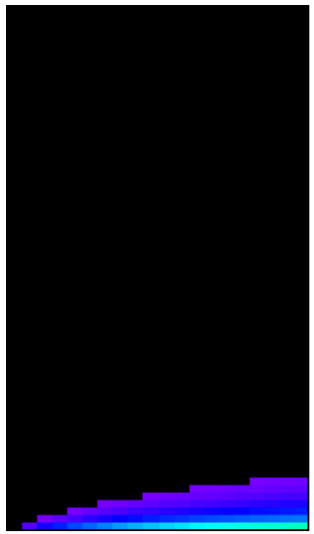
Ice clouds



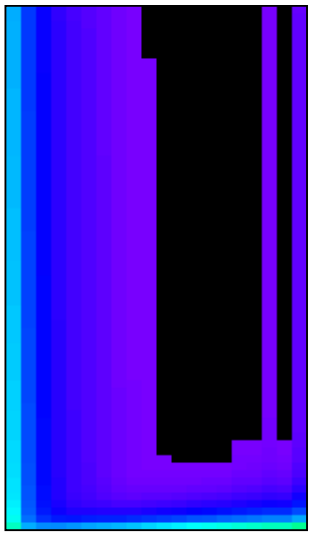
r_{sfc}=1.0



r_{sfc}=0.3

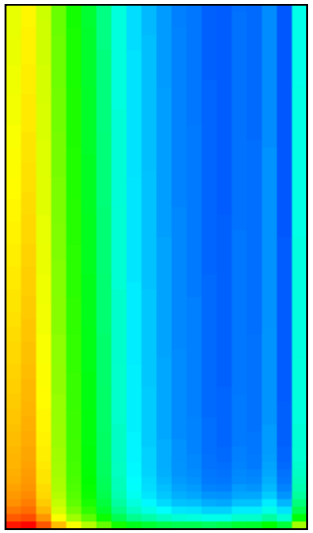


r_{sfc}=0.3, τ_{cld}=0.1, 11-12 km

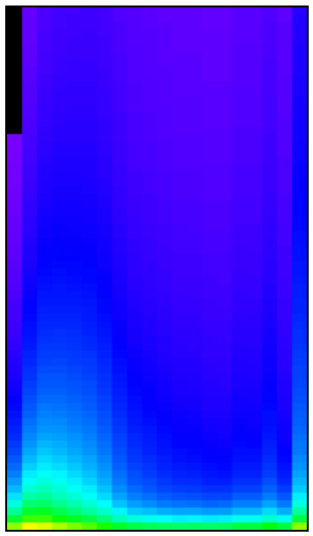


Black: < 0.004

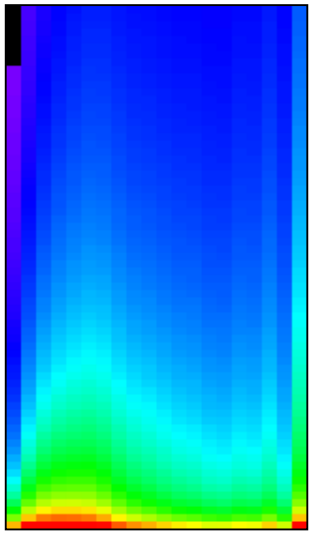
r_{sfc}=0.3, τ_{cld}=1.0, 11-12 km



r_{sfc}=0.3, τ_{cld}=1.0, 5-6 km

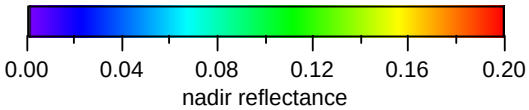


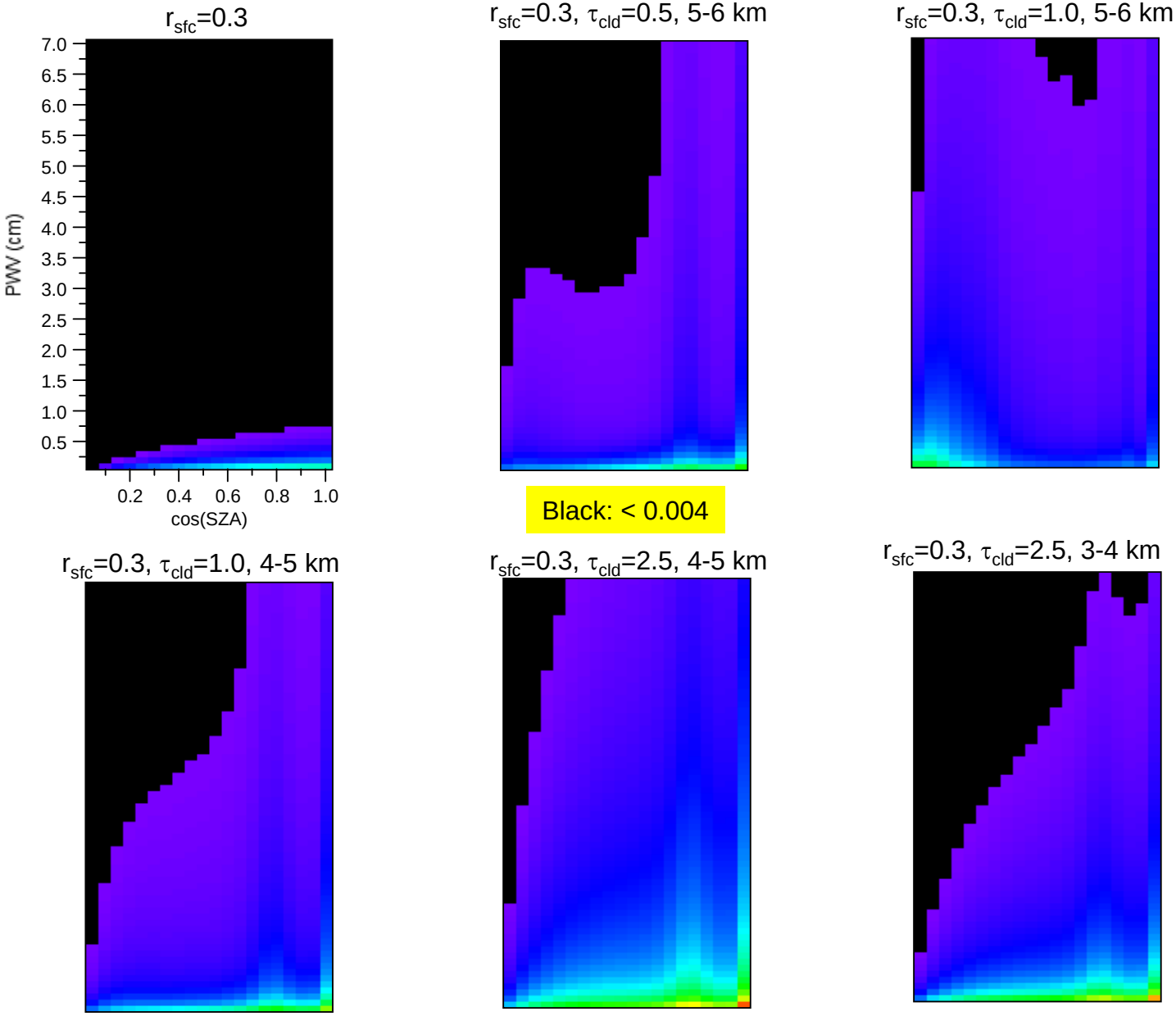
r_{sfc}=0.3, τ_{cld}=2.5, 5-6 km



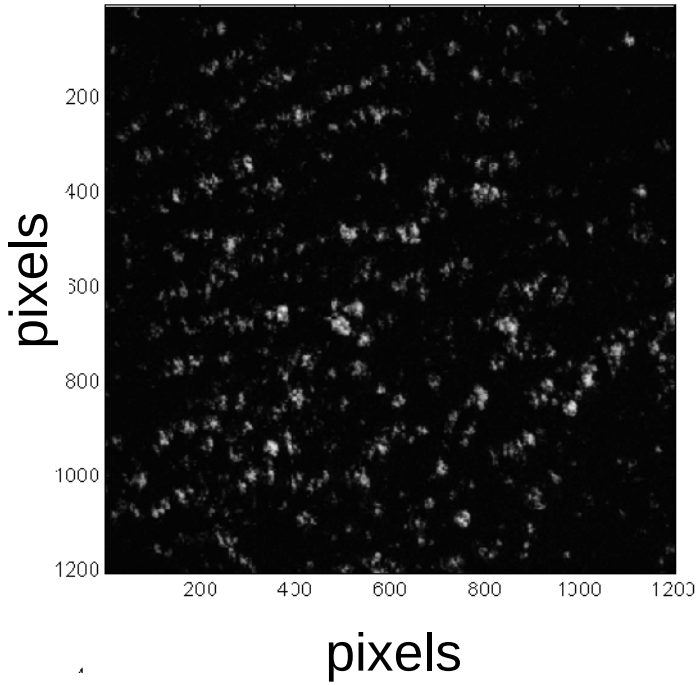
MLS WV profile

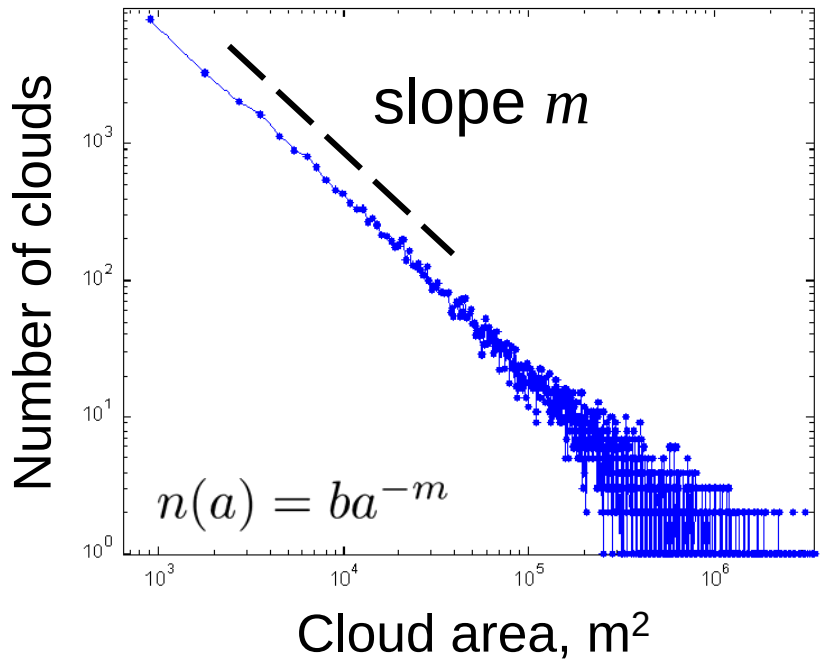
Liquid clouds





Sparse marine cumulus cloud from L-7 (Feingold, Koren)





Cloud fraction = $f(A)$

Reflectance = $f(A, \tau_c)$

$$A(a) = ba^{-m+1}$$

a = area of individual cloud

A = total area of clouds

τ_c = cloud optical depth

Koren, Oreopoulos, Feingold, Remer, Altaratz, ACP, 2008

What is the value of m and why does it matter so much?

$$n(a) = ba^{-m}$$
$$A(a) = ba^{-m+1}$$

A = total cloud area
a = area of individual cloud
m = slope on log-log plot

- 5 cloud scenes: Bahamas, Barbados, Hawaii, Polynesia, Ascension Island
- Various trade cumulus regimes
- 30 m resolution

m = 1.3 +/- 0.1

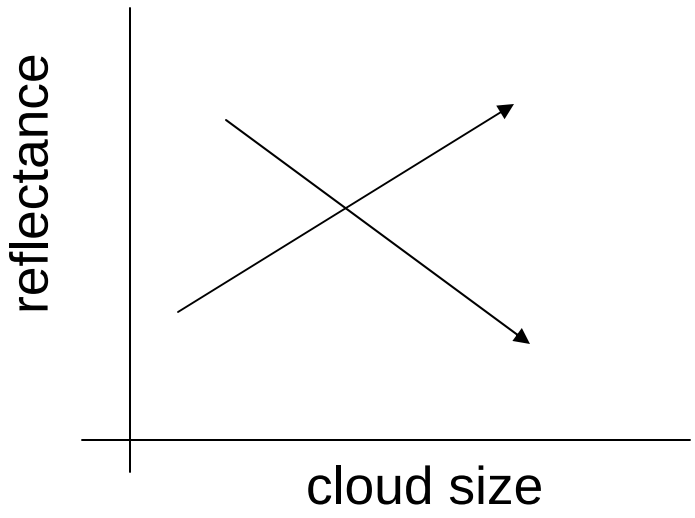
Because m > 1:
1) cloud number increases monotonically with decreasing size
2) cloud area increases monotonically with decreasing size

Small clouds contribute more to number and cloud fraction

What about Reflectance?

Two opposing forces:

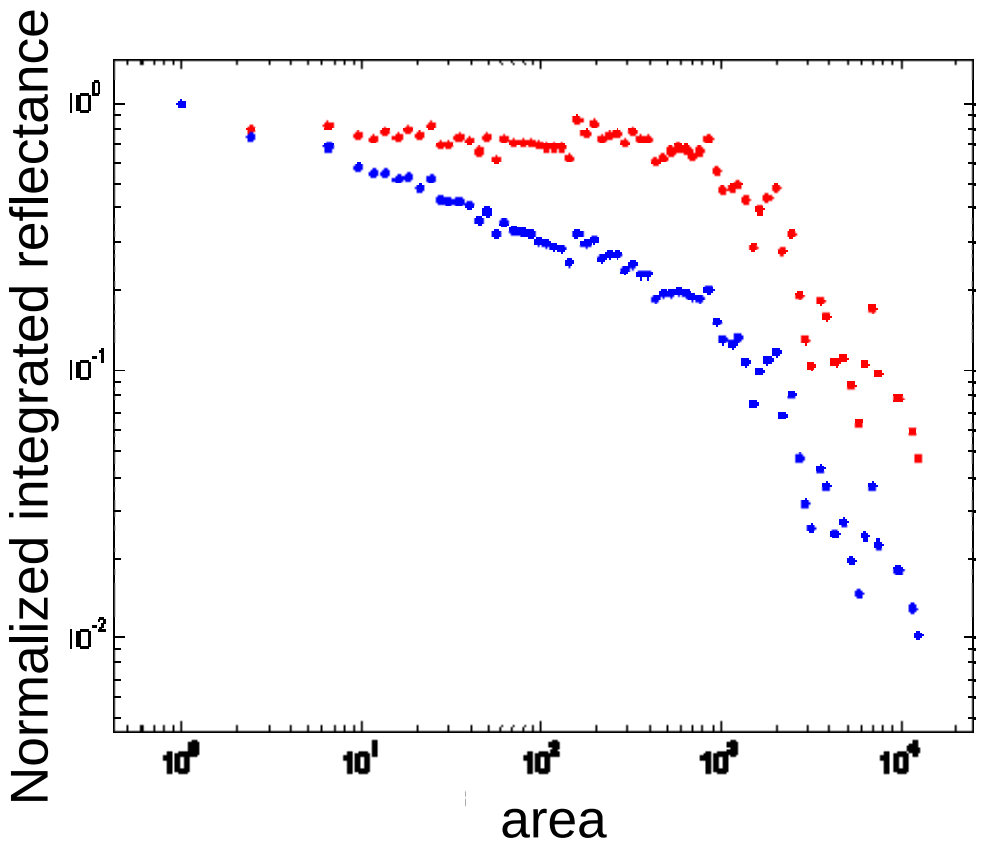
1) Large clouds are optically thicker and reflect more
2) Large clouds are less abundant

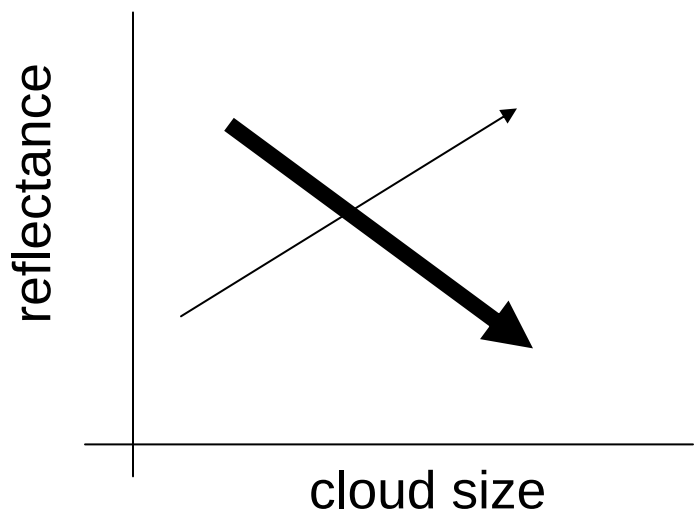


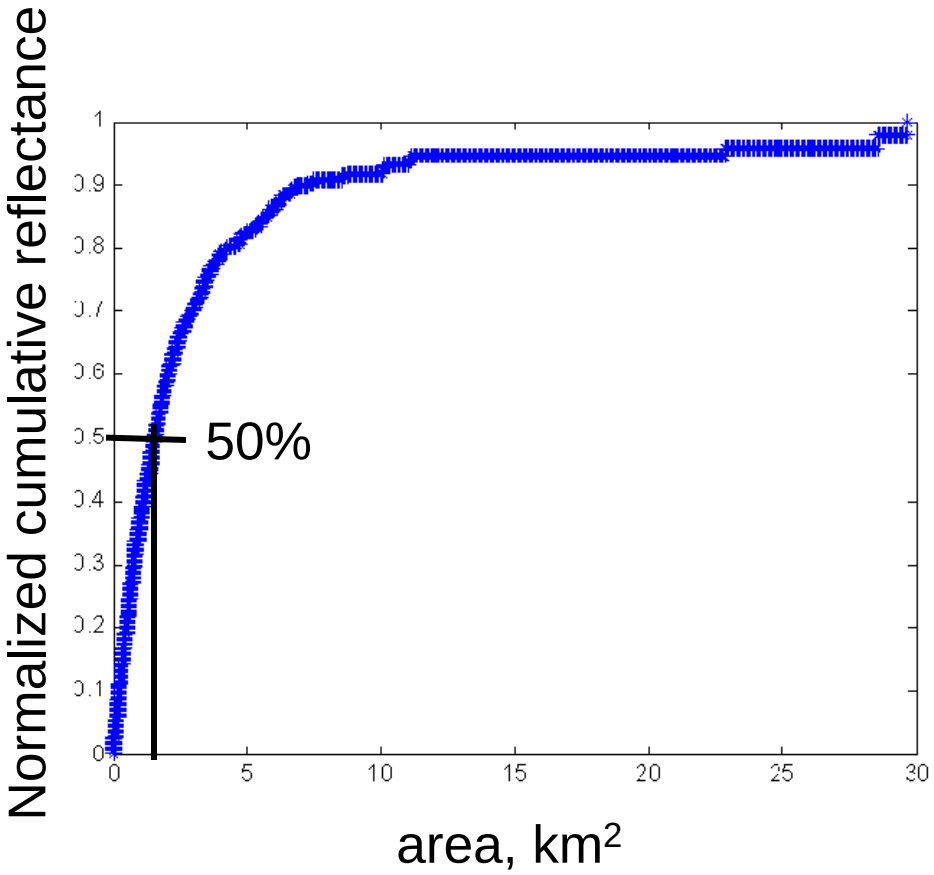
Reflectance decreases with increasing size provided

m>1.269 (1600 nm)

m>1.125 (470 nm)



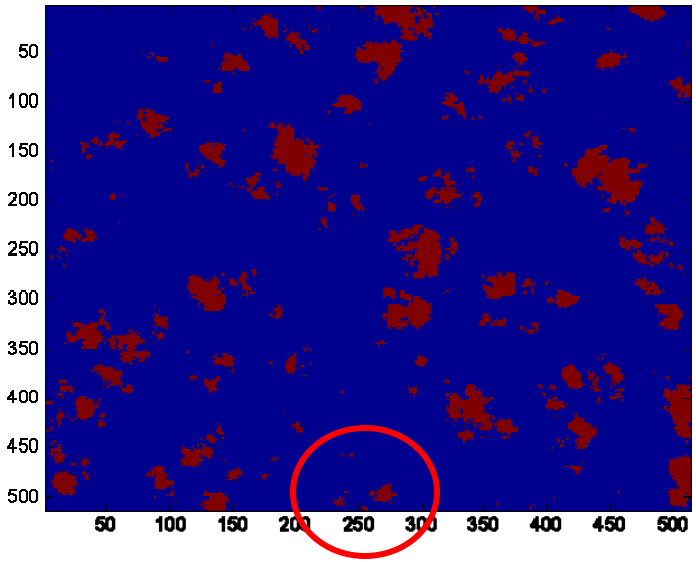




50% of the reflectance
derives from clouds with areas <1 km^2

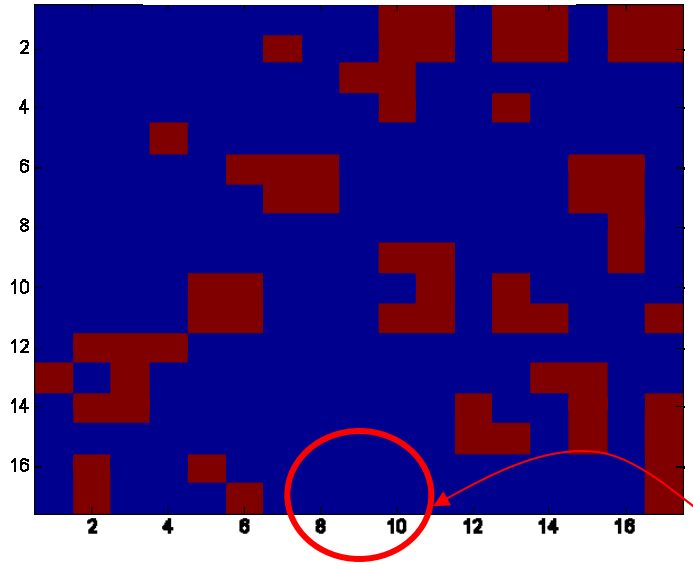
What about sensor resolution?

resolution: 30m



As resolution decreases:
Smaller clouds dissolve into background

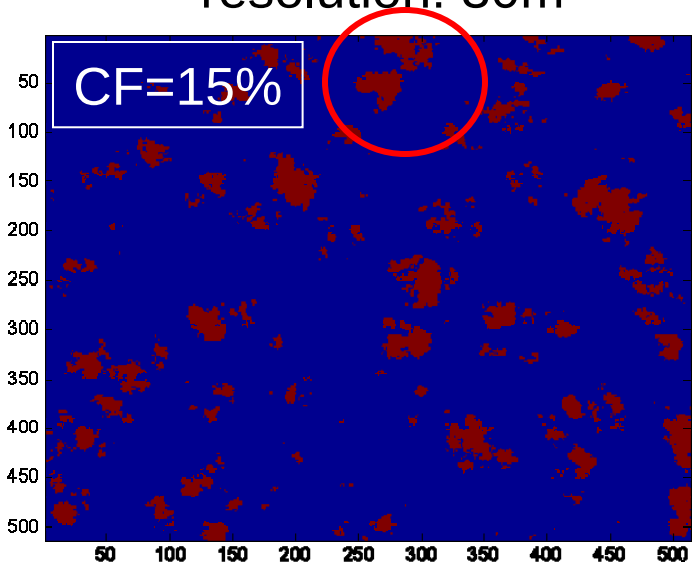
resolution: 960m



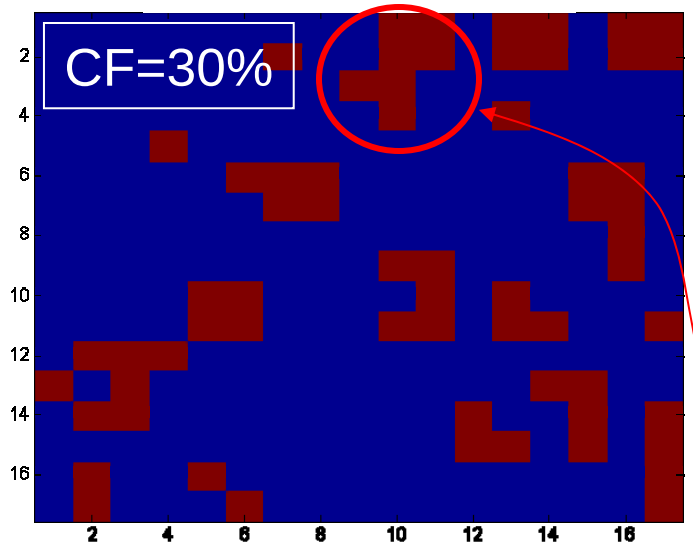
Small clouds dissolve into background

What about sensor resolution?

resolution: 30m



resolution: 960m



As resolution decreases:
Smaller clouds dissolve into background
Larger clouds accumulate those close by

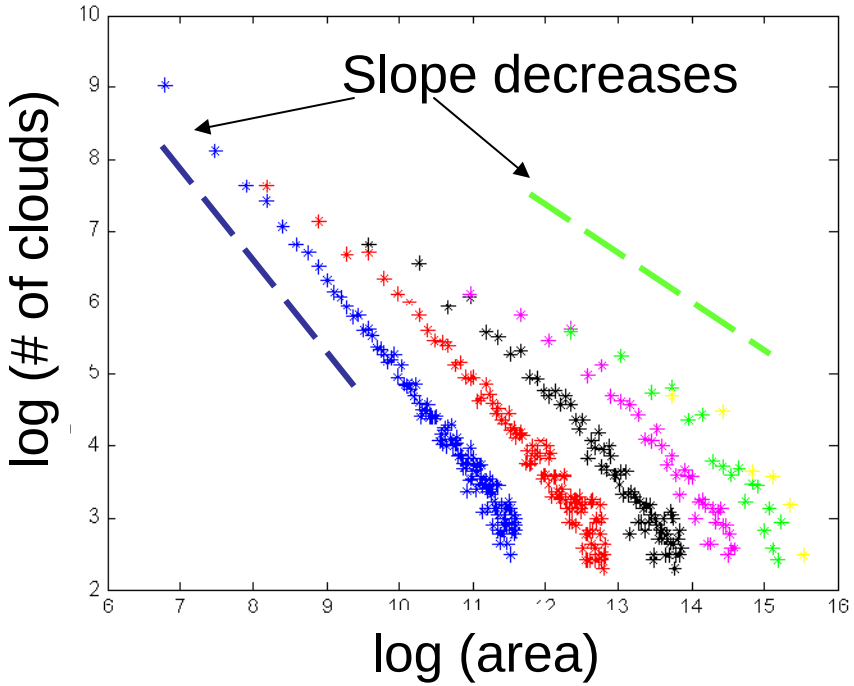
30 m → 960 m resolution:

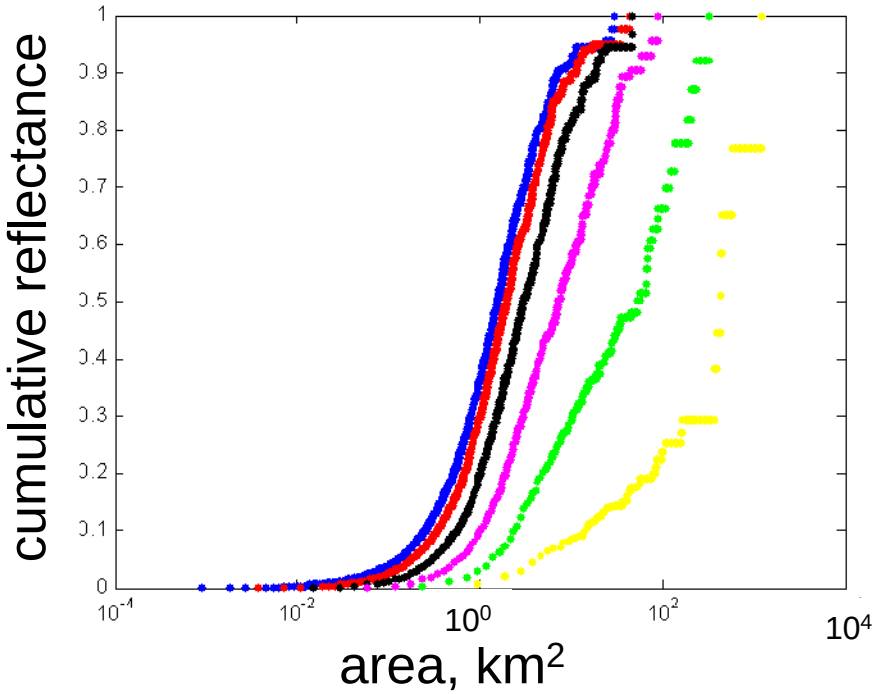
Doubling of cloud fraction

50% reduction in reflectance

Larger clouds collect others

Sensor resolution contd..





$$n(a) = ba^{-m}$$

$$A(a) = ba^{-m+1}$$

m = 1.3 +/- 0.1 (30 m)
m = 1.1 +/- 0.1 (1 km)

i.e., $m > 1$

- As resolution gets coarser, greater % of number, surface area and reflectance derives from larger clouds (m *decreases*)