Using MODIS and MISR Observations to Retrieve Cloud Phase and Ice Cloud Habit

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

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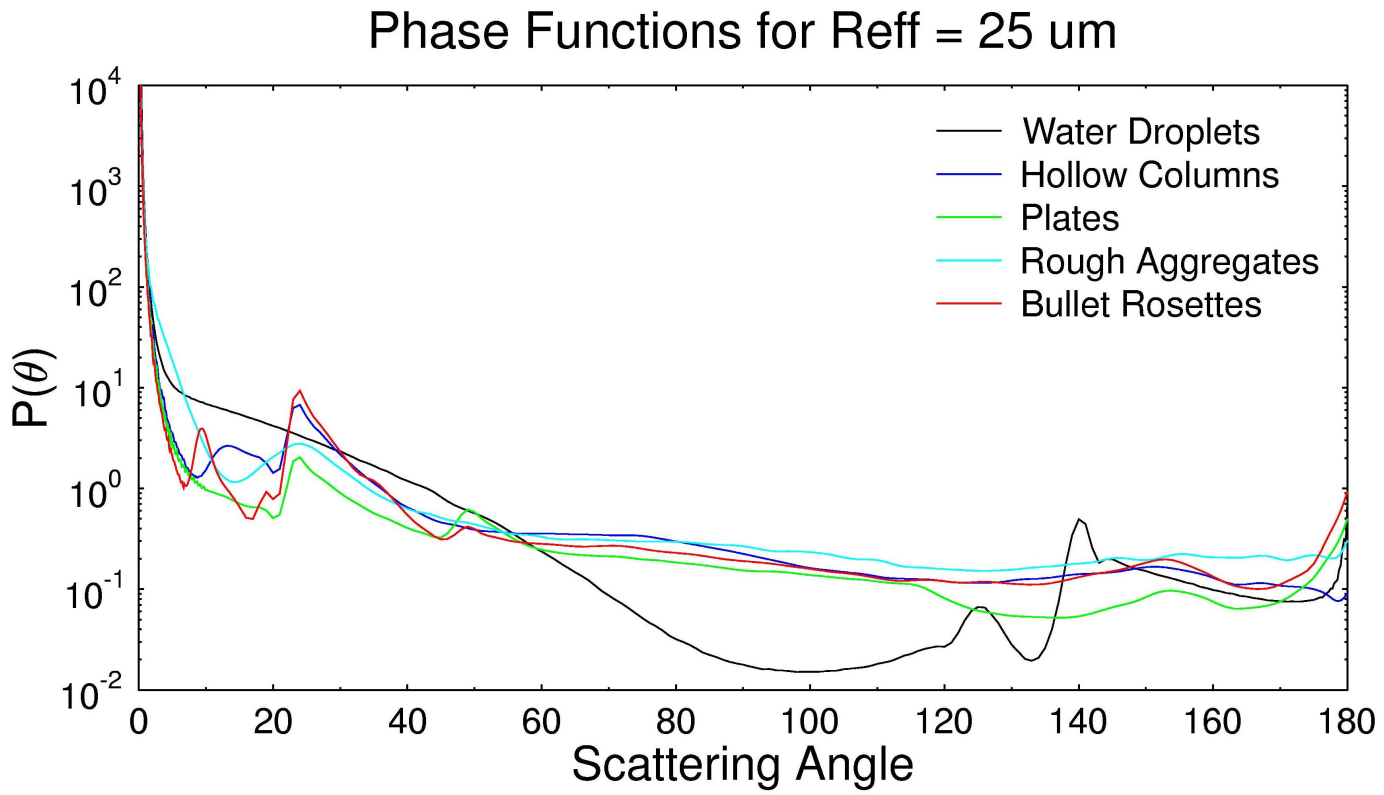
Introduction

- e and habit are fundamentally
  remote sensing and climate

- GCM studies have shown that treatment of habit is significant, especially in tropics (Kristjansson et al., 2000)
- Satellite and ground based retrievals of cloud properties depend strongly on habit assumptions

Put MISR Multiple Angles to Work

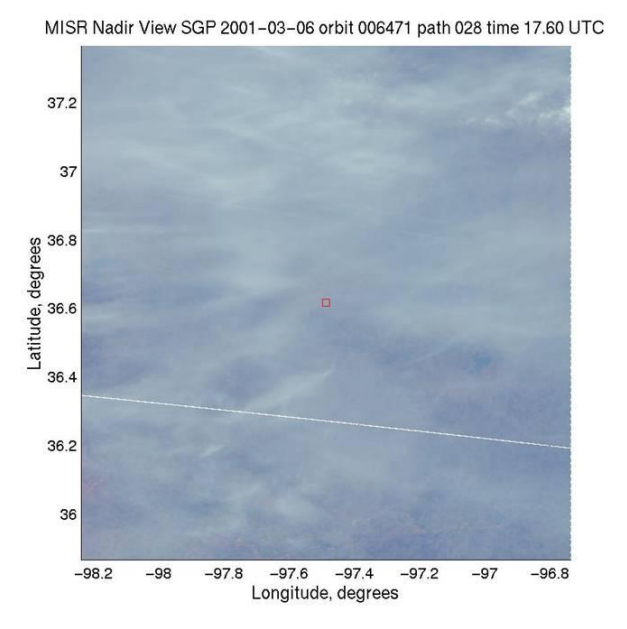


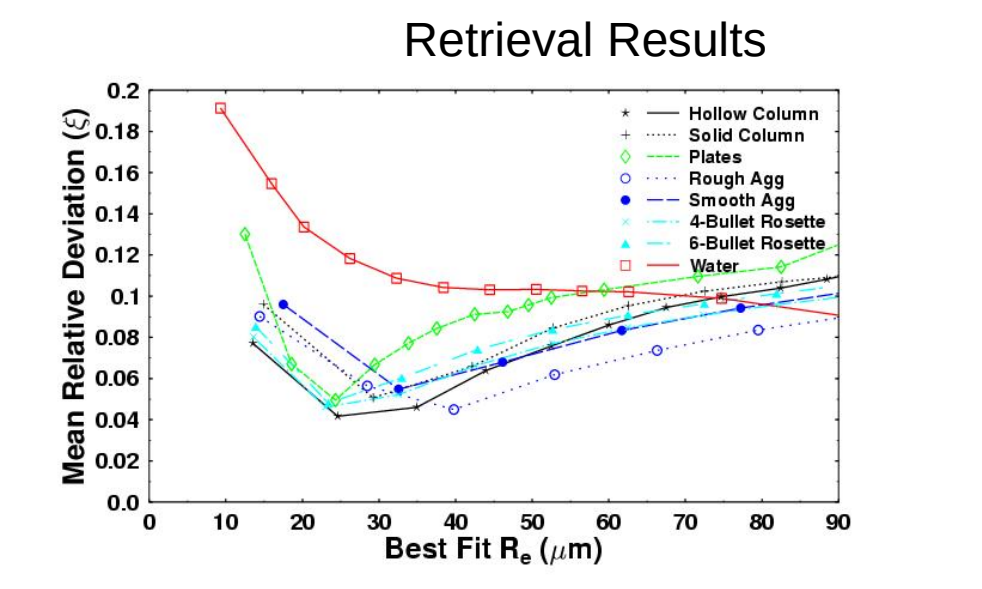
Procedure

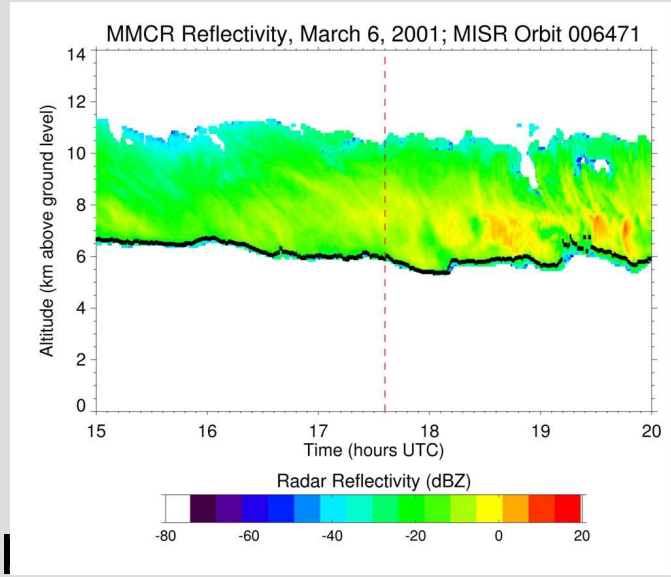
- ines multi-angle information from MISR blue
  with MODIS 2.1 um band for sensitivity to
- Retrieve best fit r_e, IWP, and crystal habit by minimizing deviation between modeled and measured reflectance over all cameras
- Ice cloud scattering properties from Yang et al. (2000) assuming gamma distribution with fixed effective variance and given r_e

$$\xi(\mathrm{Re}, \mathrm{IWP}, \mathrm{H}) = \frac{1}{\mathrm{N}} \sum_{\mathrm{i}} \left[\frac{|\mathrm{Sat_i} - \mathrm{Model_i}(\mathrm{Re}, \mathrm{IWP}, \mathrm{H})|}{\mathrm{Sat_i}} \right]$$

Case Study 1: Cirrus at SGP

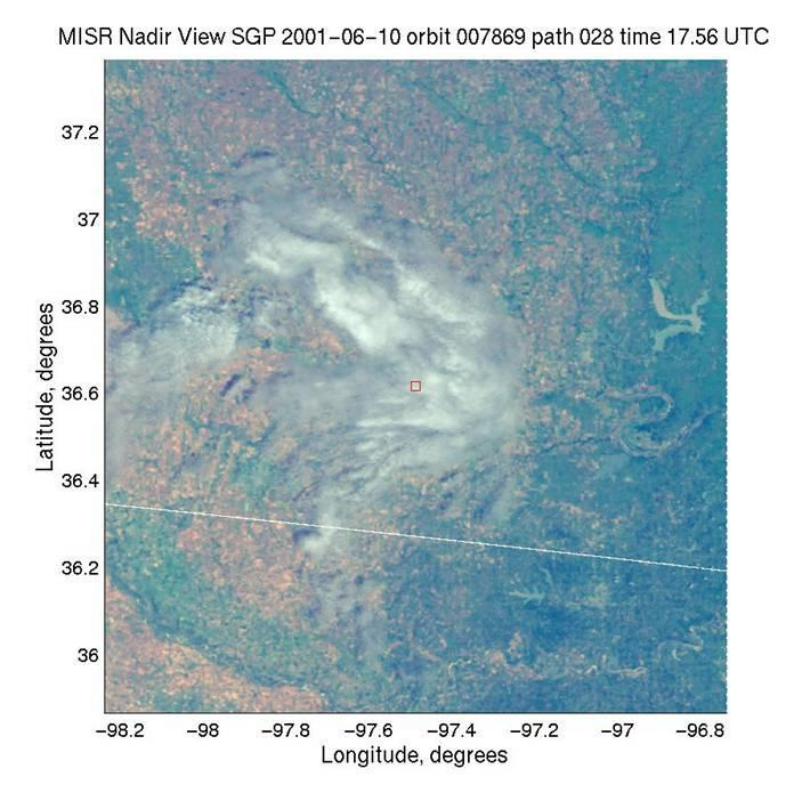


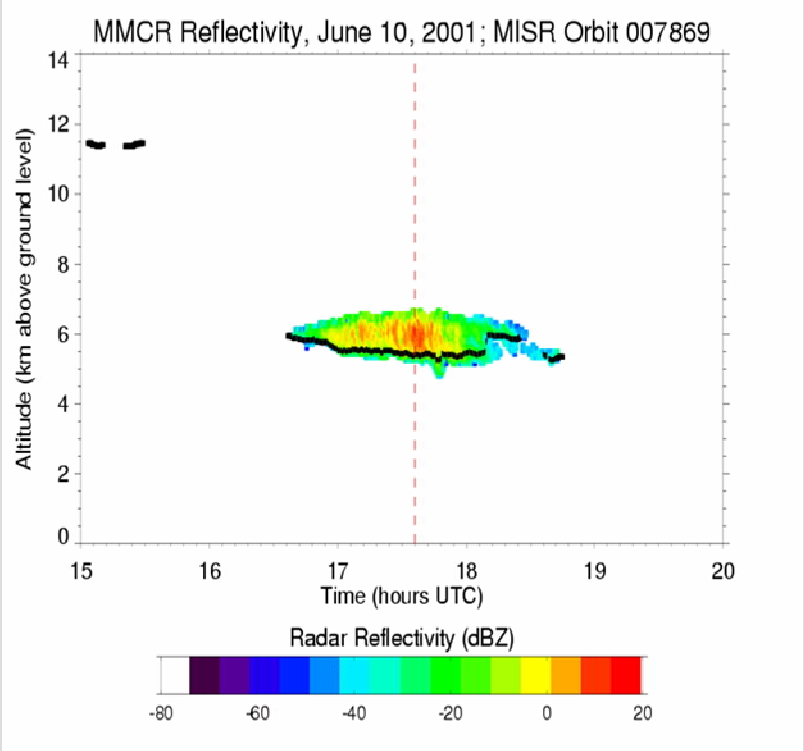


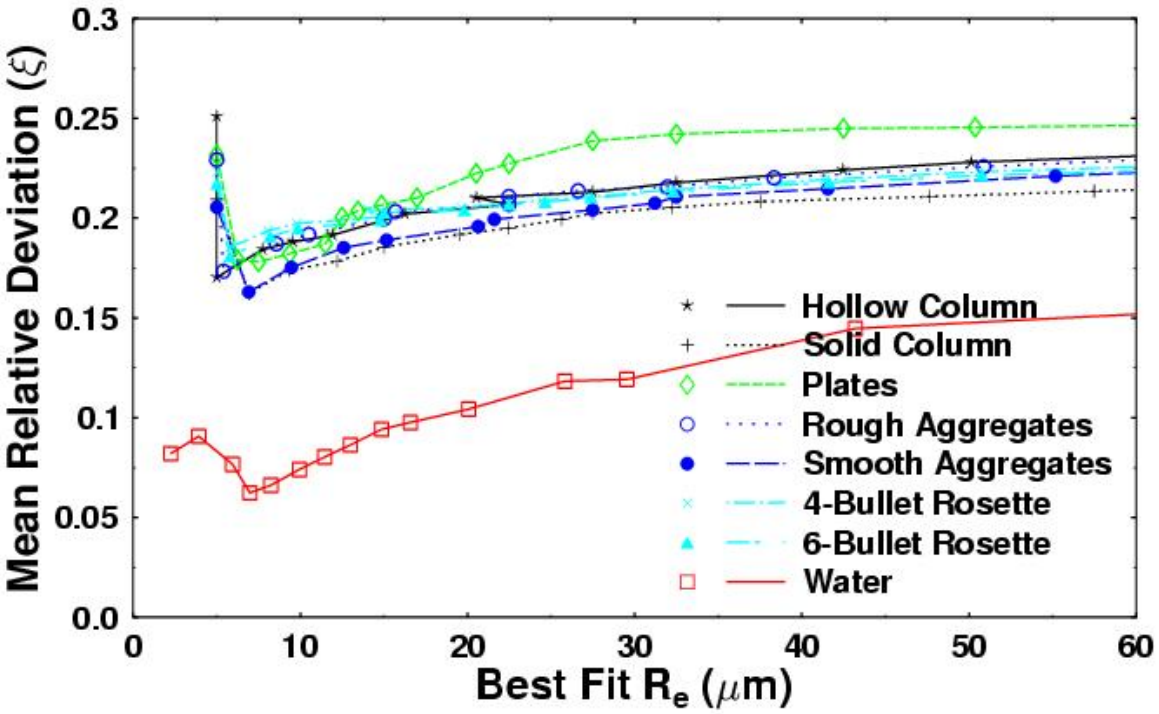


Habit	Metric	Reff	IWP	
Hollow Columns	0.032	27.6	51.3	3.3
4-Bullet Rosettes	0.039	27.4 μm	54.5	3.5
Rough Aggregates	0.041	37.5	63.5	2.9
Plates	0.046	22.5	62.1	4.8
Water	0.085	100 μm	364	5.7
MODIS		**29.7 μm**	**77.0 g/m²**	**3.5**

Case Study 2: Altocumulus at SGP





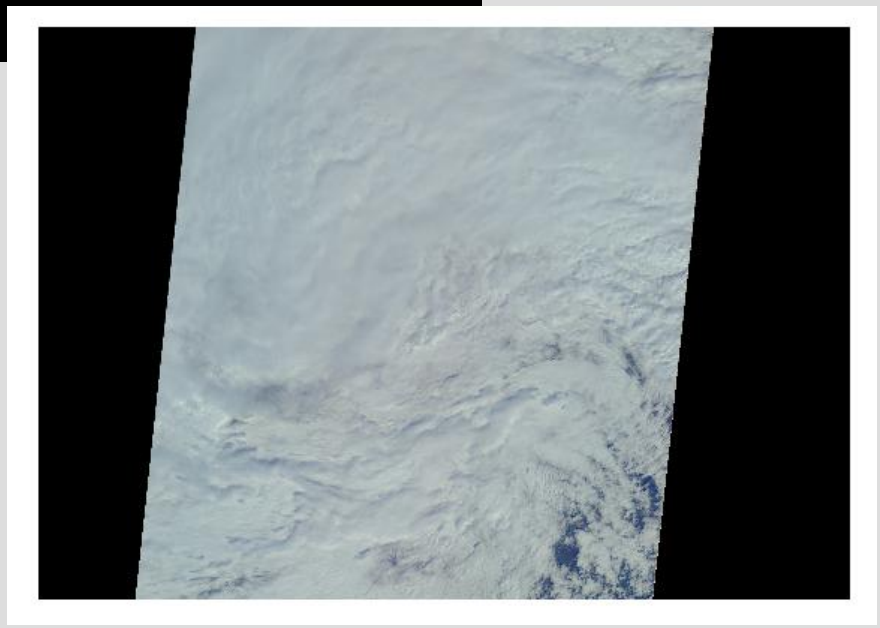


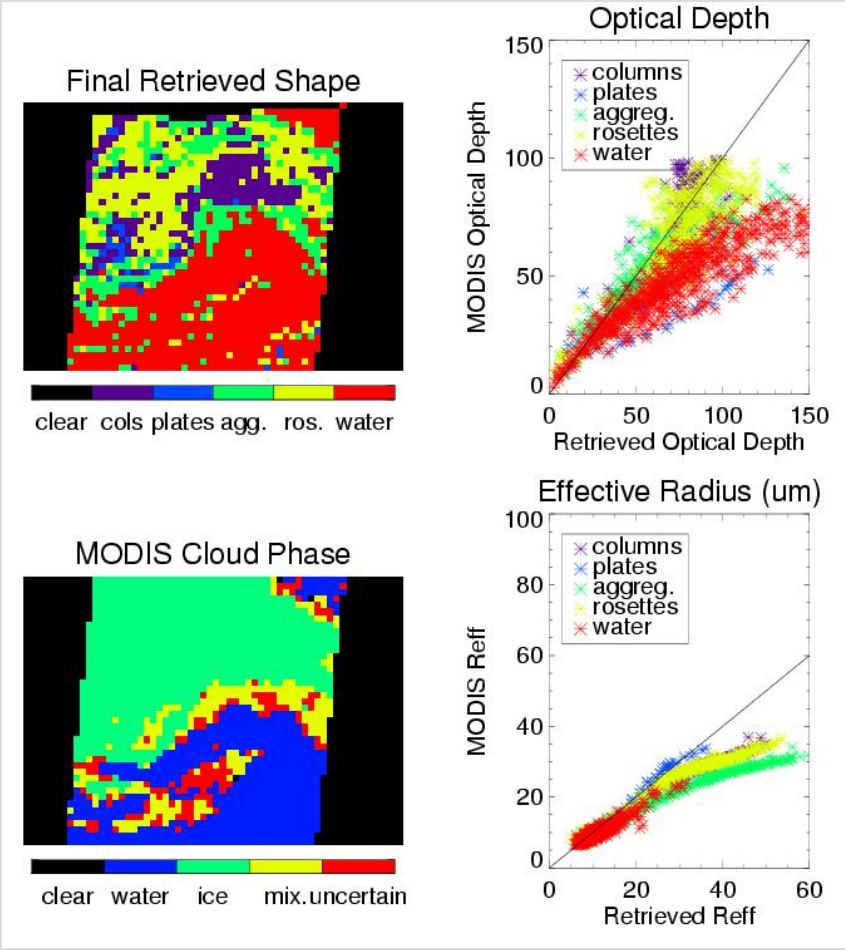
- Water is best fit; MODIS retrievals indicate mixed phase cloud; ARM microwave radiometer shows LWP of 40-80 g/m^2
- Altocumulus actively growing as it moved over the ARM site; likely to have water at top of cloud
- Need sensitivity studies to determine depth in cloud to which retrieval is sensitive

Current Work

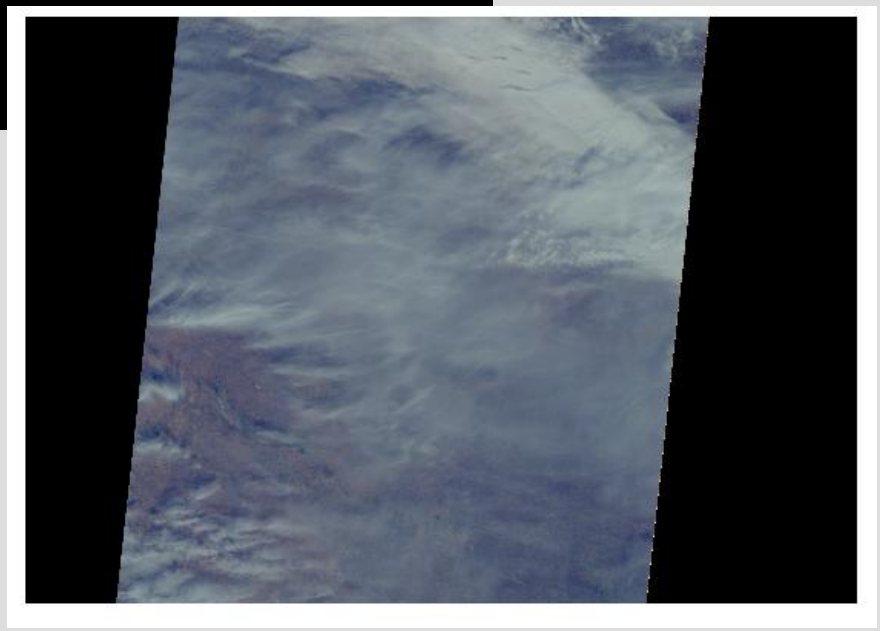
- un operationally, rather than in case study
- up table of MISR/MODIS reflectances as a
  it, water path, effective radius, cloud height, solar and viewing geometry
- For each retrieval, correct reflectances for atmospheric transmittance and surface albedo
- Run retrievals on $(10km)^2$ boxes; average MISR/MODIS reflectances and MODIS cloud properties over box
- Preliminary results for all MISR overpasses of SGP in 2001; 32 cases with clouds and available MISR + MODIS data
- Beginning comparisons with MOD06 retrievals; trying to understand differences

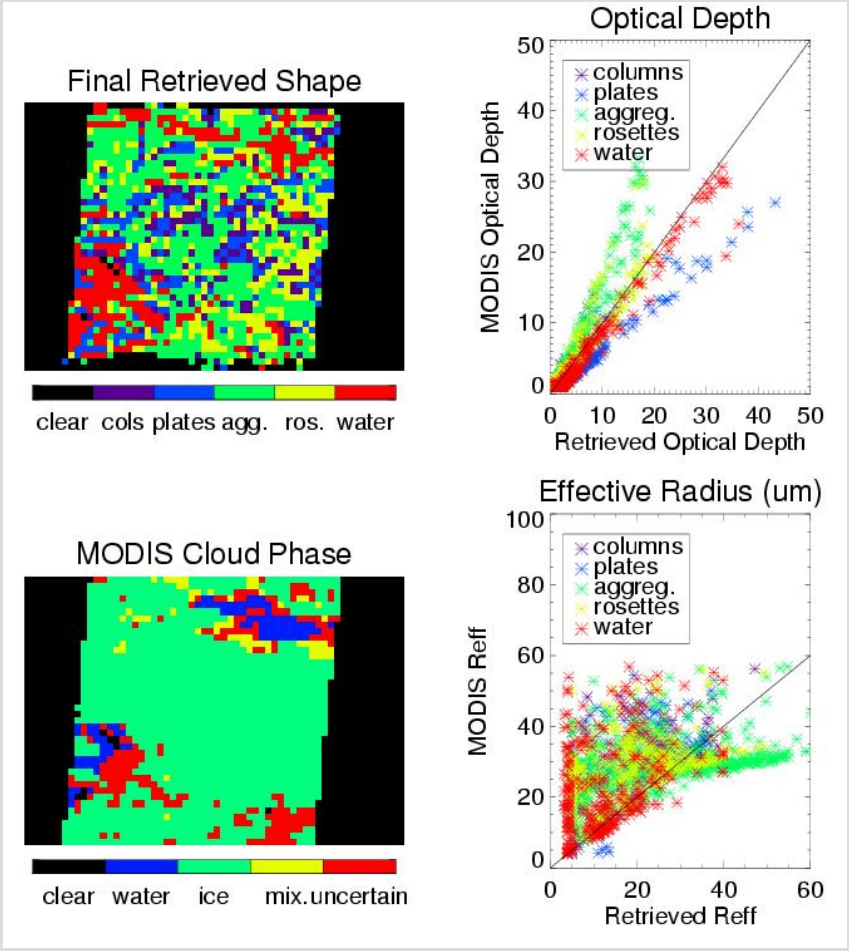
Thick Cloud Retrieval Example



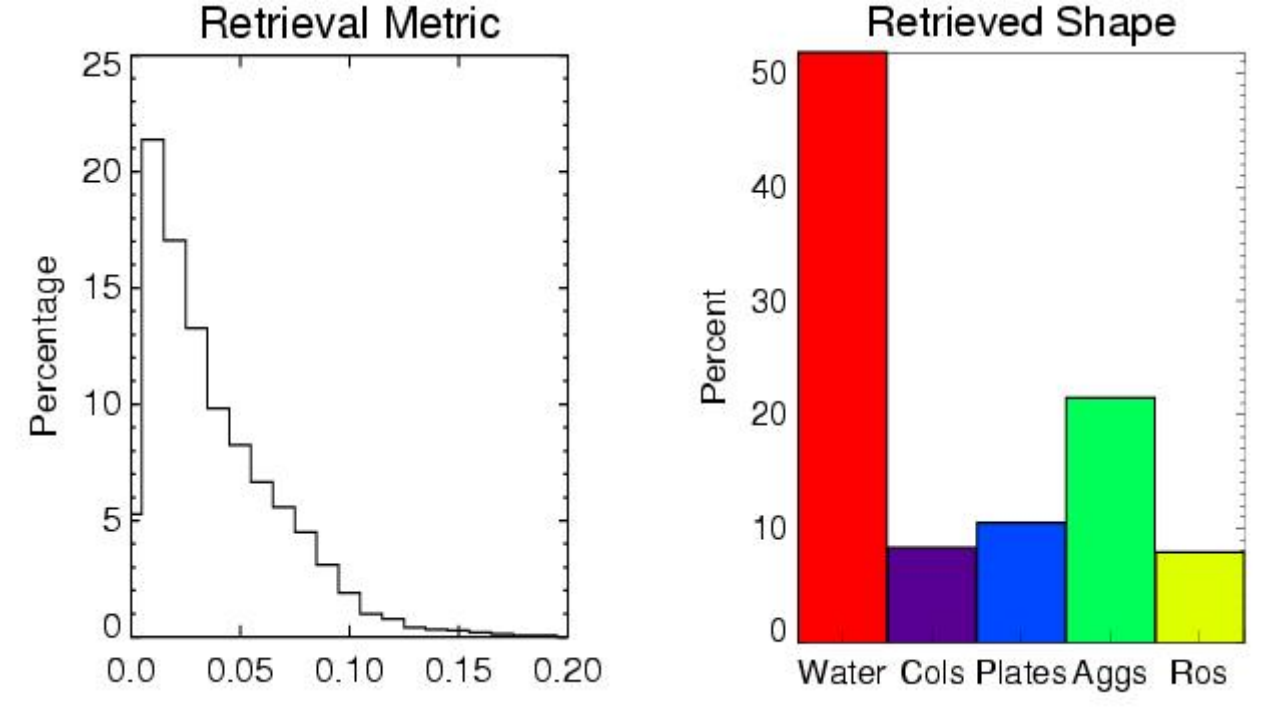


Thin cloud retrieval example





Summary of Retrieval Statistics



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  orms well?
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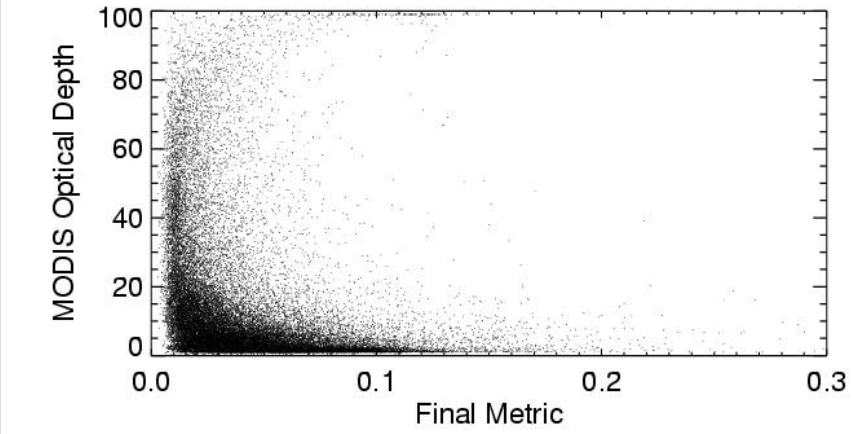
  - Variability in reflectances



- Metric is measure of relative deviation from observed reflectance; metric = .05 implies matching reflectance within 5% on average
- Metric increases with decreasing optical depth due to:
  - Averaging of reflectances
  - MISR parallax issues
  - Effect of surface albedo

Future Work

- es with MOD06
  als
- tatistics to determine
  forming well
- tical structure; habit
  mixtures
- Compare retrieved IWP/effective radius to radar retrievals at ARM site
  - New radar retrievals which use reflectivity and Doppler velocity can retrieve vertical profiles of R_e and IWC (Mace et al., 2002)
  - Retrievals are sensitive to crystal habit because particle fall speed and effective density depend on habit
  - Constraining the particle habit reduces the uncertainty in the radar retrievals
- Look at retrievals over ocean to extend to lower optical depths
- Include realistic surface albedo from MOD43 product