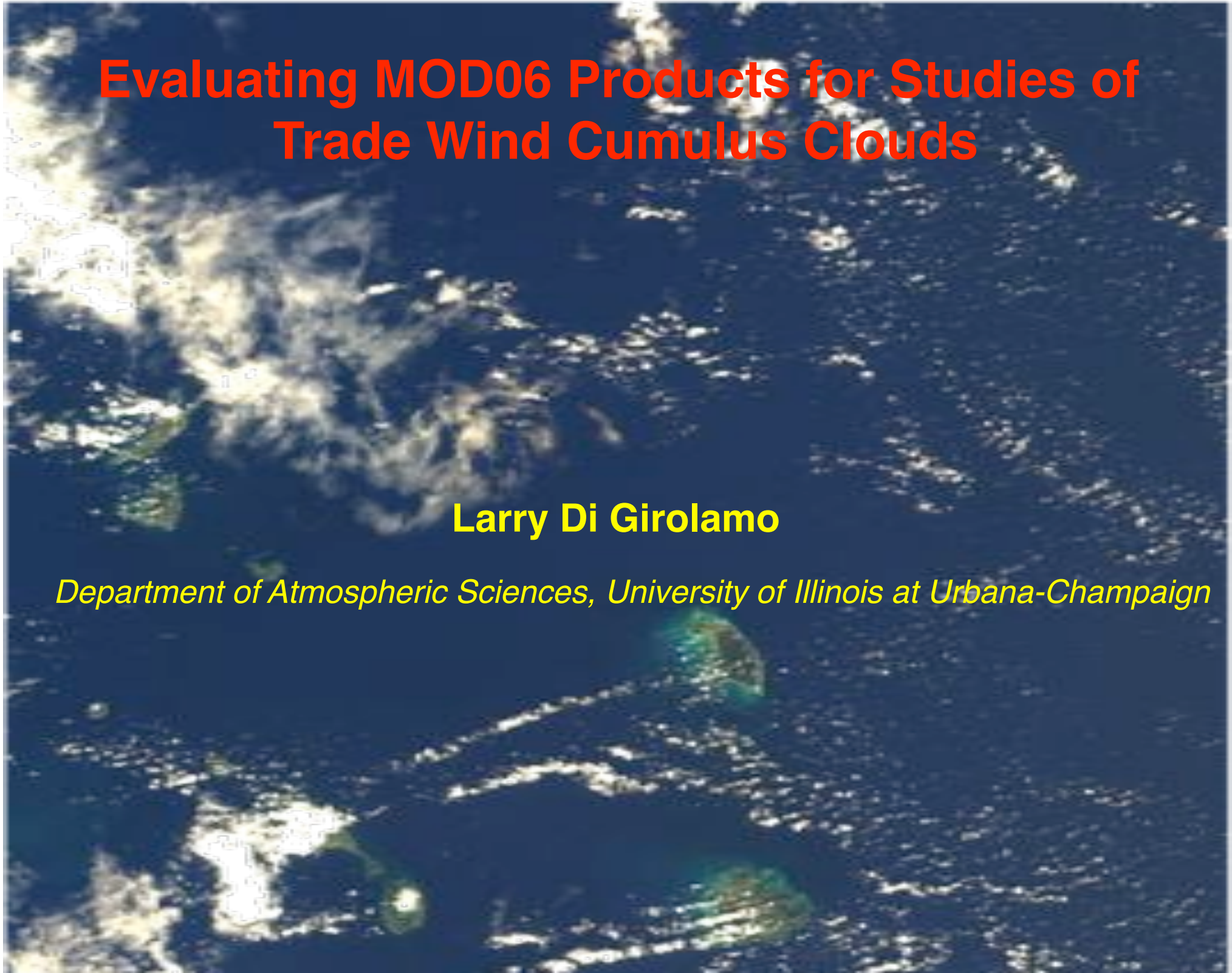

Evaluating MOD06 Products for Studies of Trade Wind Cumulus Clouds

Larry Di Girolamo

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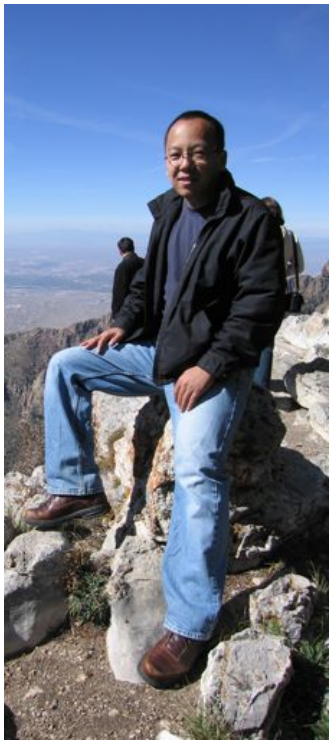
Acknowledgements

Steve Platnick

Hal Maring

Acknowledgements

Bob Rauber



Guangyu Zhao

Lusheng Liang

Conor Haney

Rain In Cumulus over the Ocean (RICO)

NSF sponsored intensive field campaign

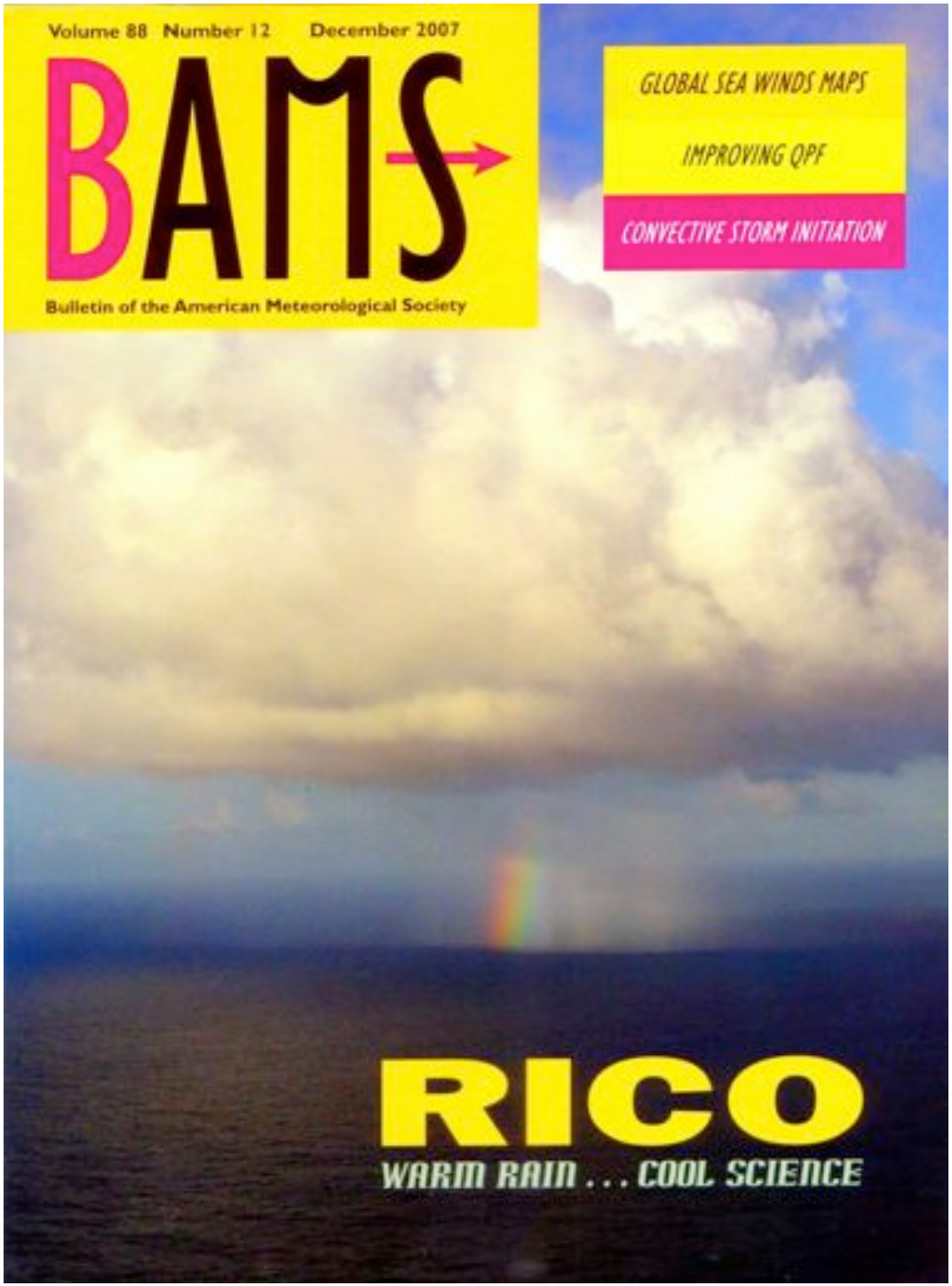
Antigua and Barbuda

11/24/04 - 01/24/05

CORE OBJECTIVE:

Study precipitation formation in shallow cumuli, and how it modifies the structure and ensemble statistics of trade wind clouds.

http://www.eol.ucar.edu/projects/rico/



Central America and the Caribbean

A few broad questions going into RICO…

What mechanisms are responsible for the rapid onset and subsequent evolution of precipitation in trade wind cumuli?

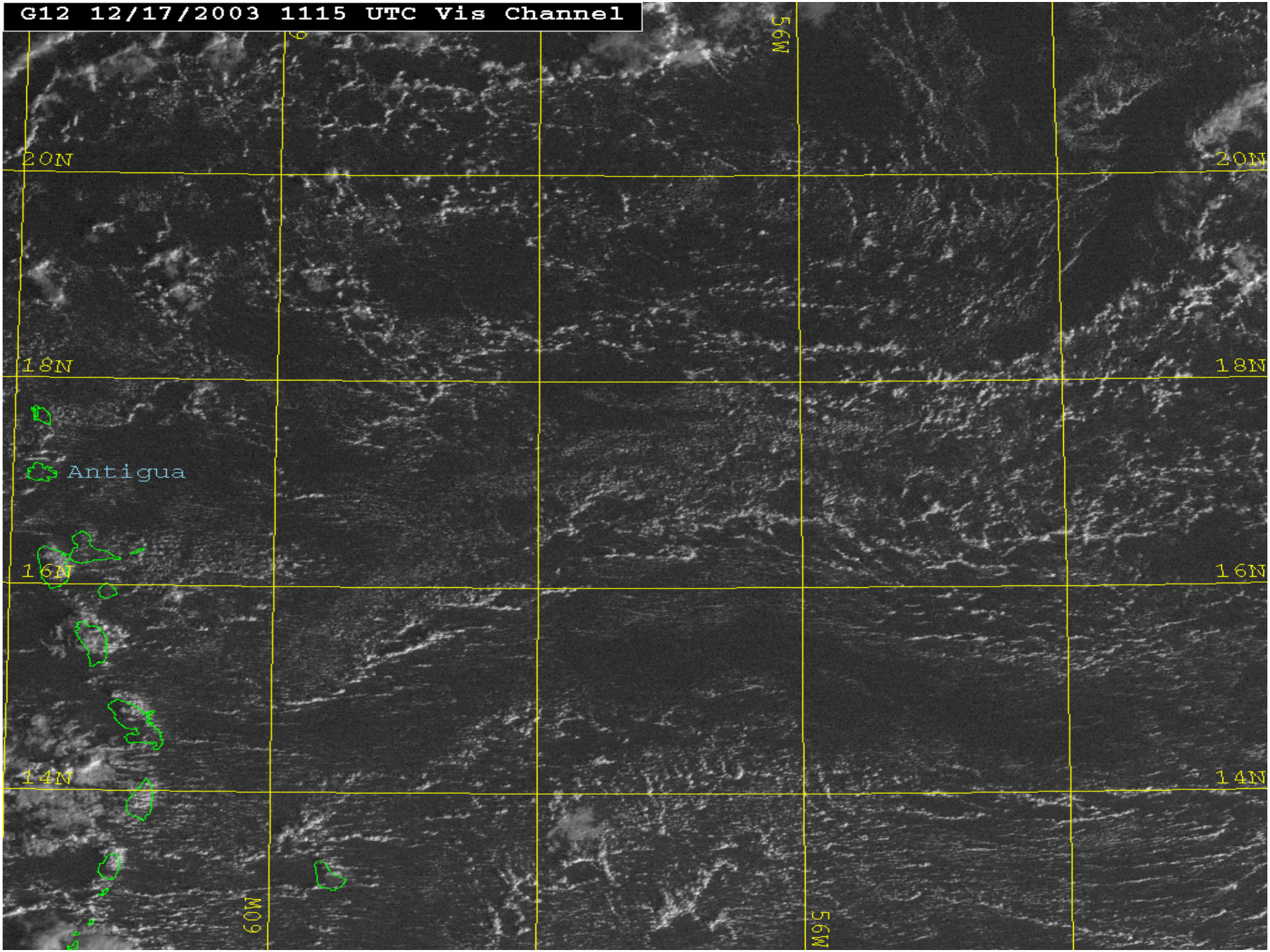
What are the mechanisms by which trade wind clouds organize and how does this organization impact the development of precipitation?

What are the impact of trade wind clouds on the moisture, turbulence, and aerosol content of the trade wind layer?

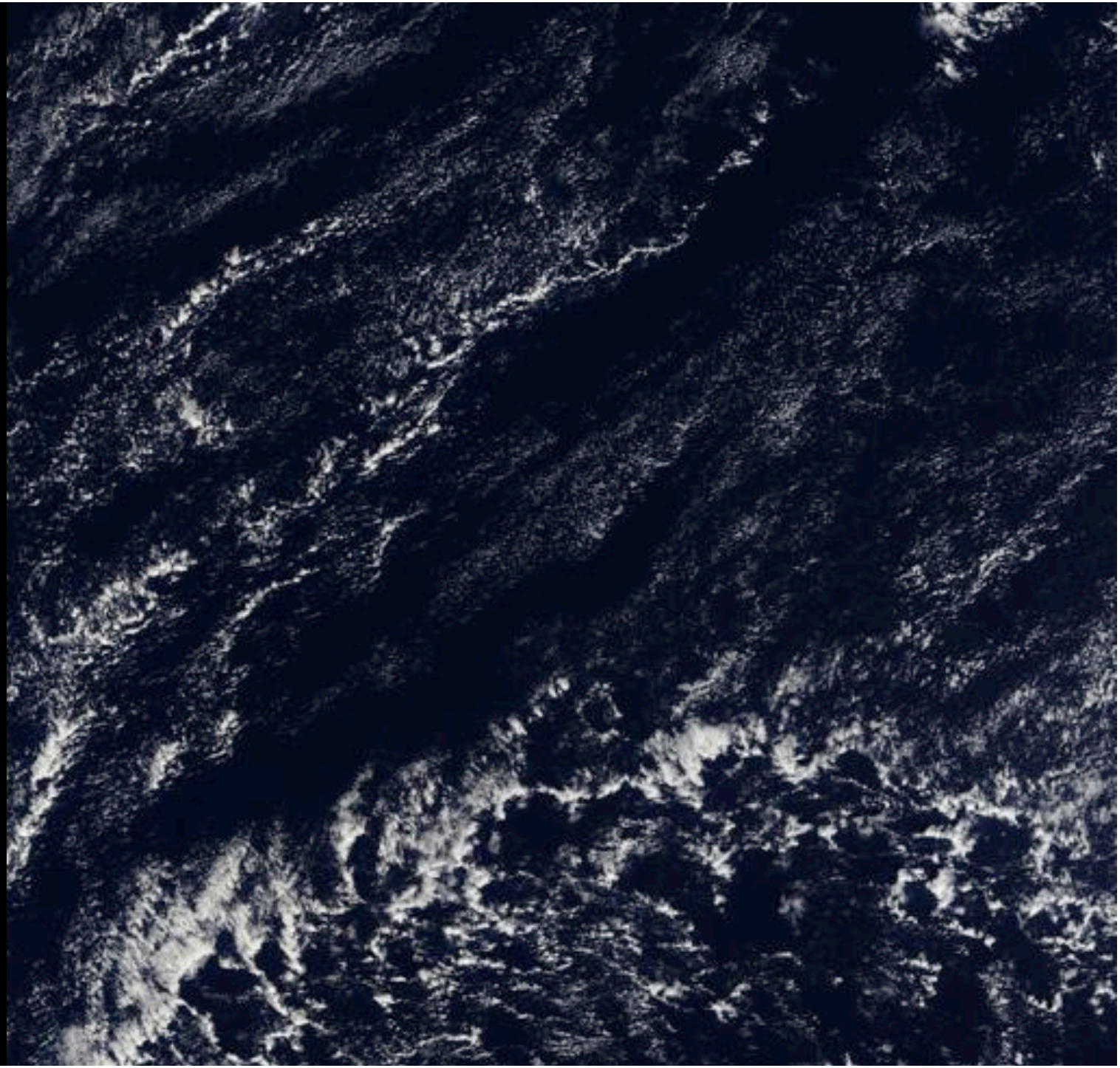
What is the contribution of precipitation from trade wind clouds to the energy budget in the trade wind regime?

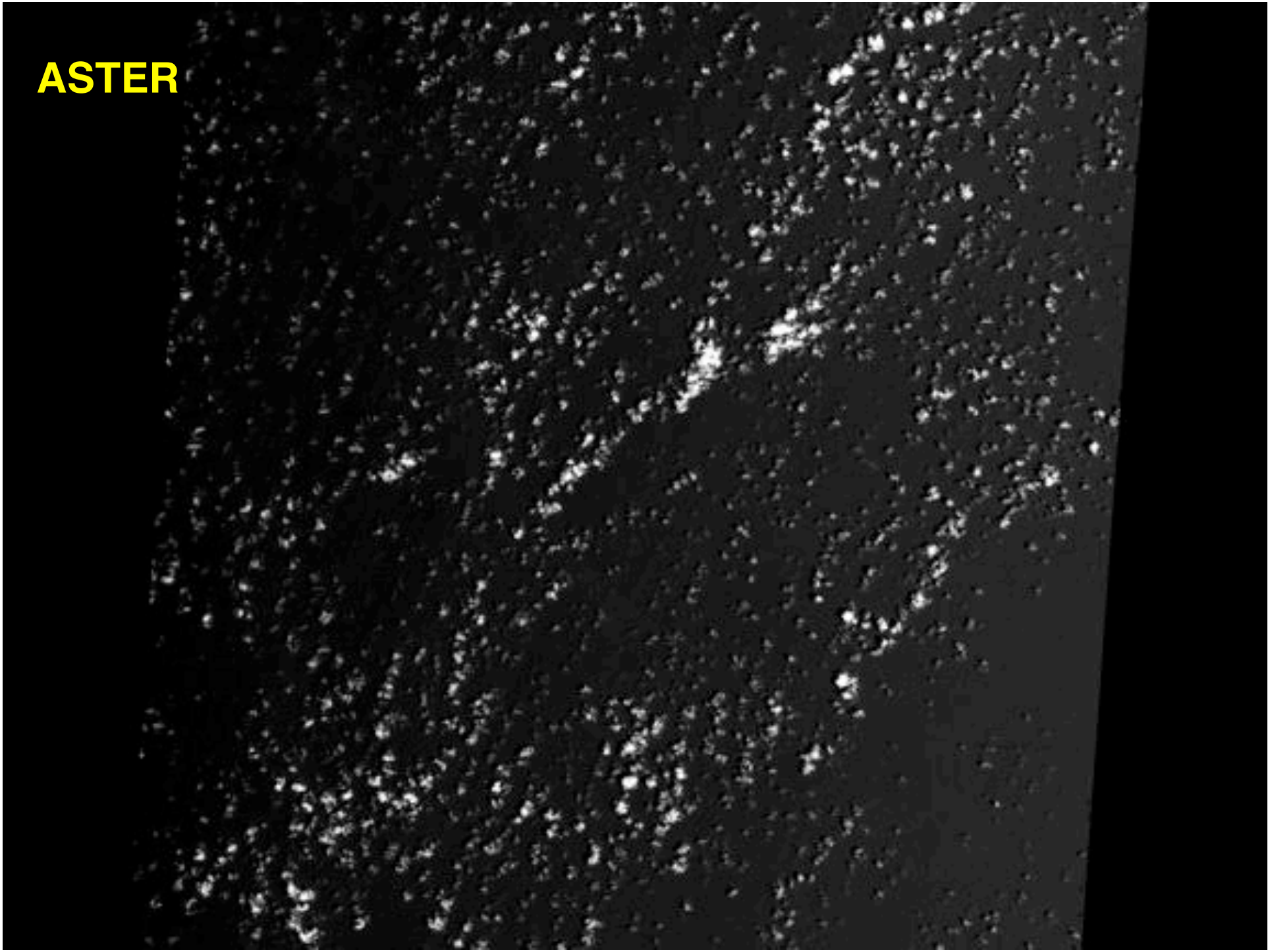
What contribution do trade wind clouds have to the global water and energy cycles?

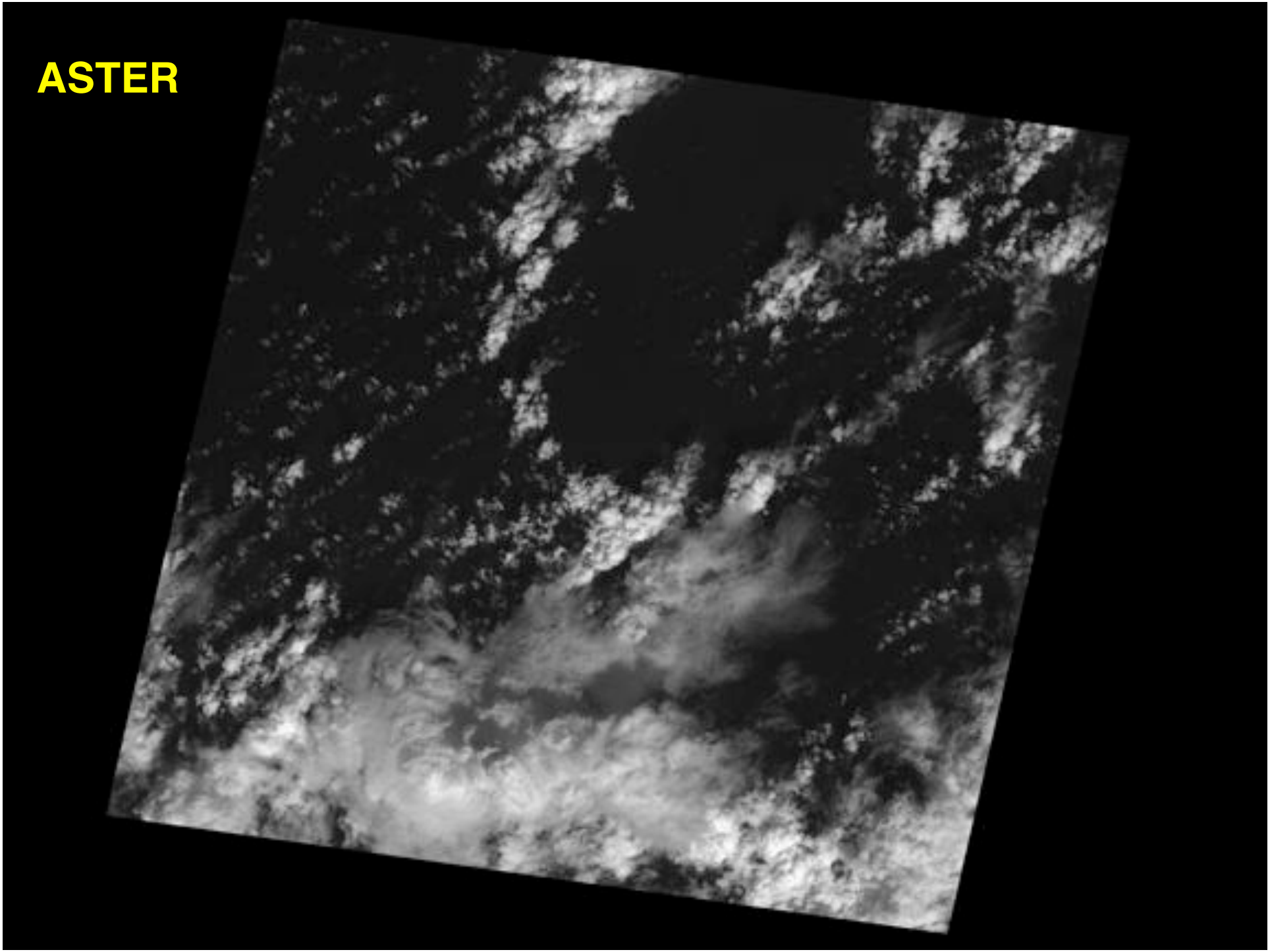
…Strong GCSS connection


G12 12/17/2003 1115 UTC Vis Channel
20N
18N
16N
14N
60W
56W
Antigua

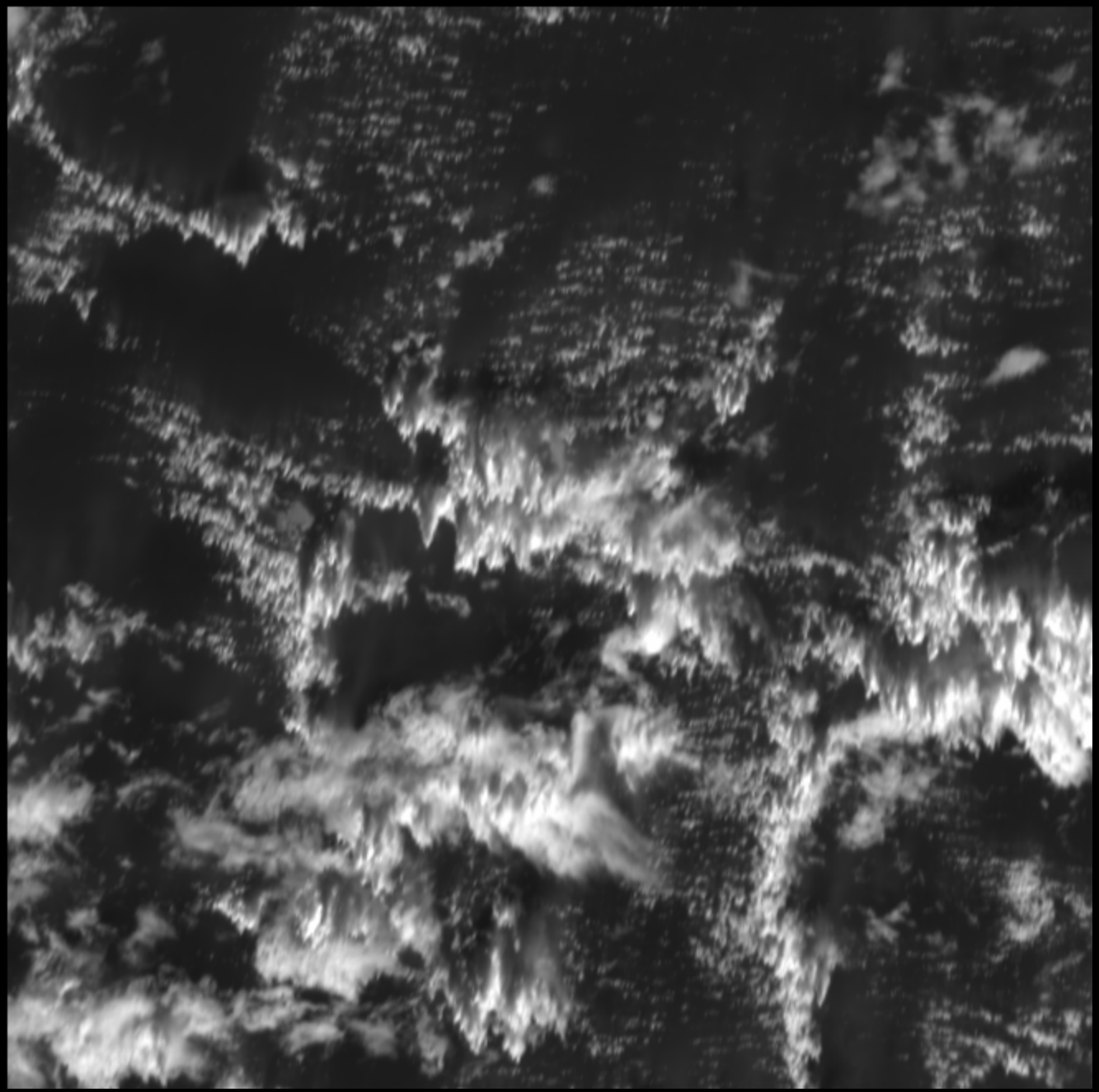
MODIS




ASTER


ASTER

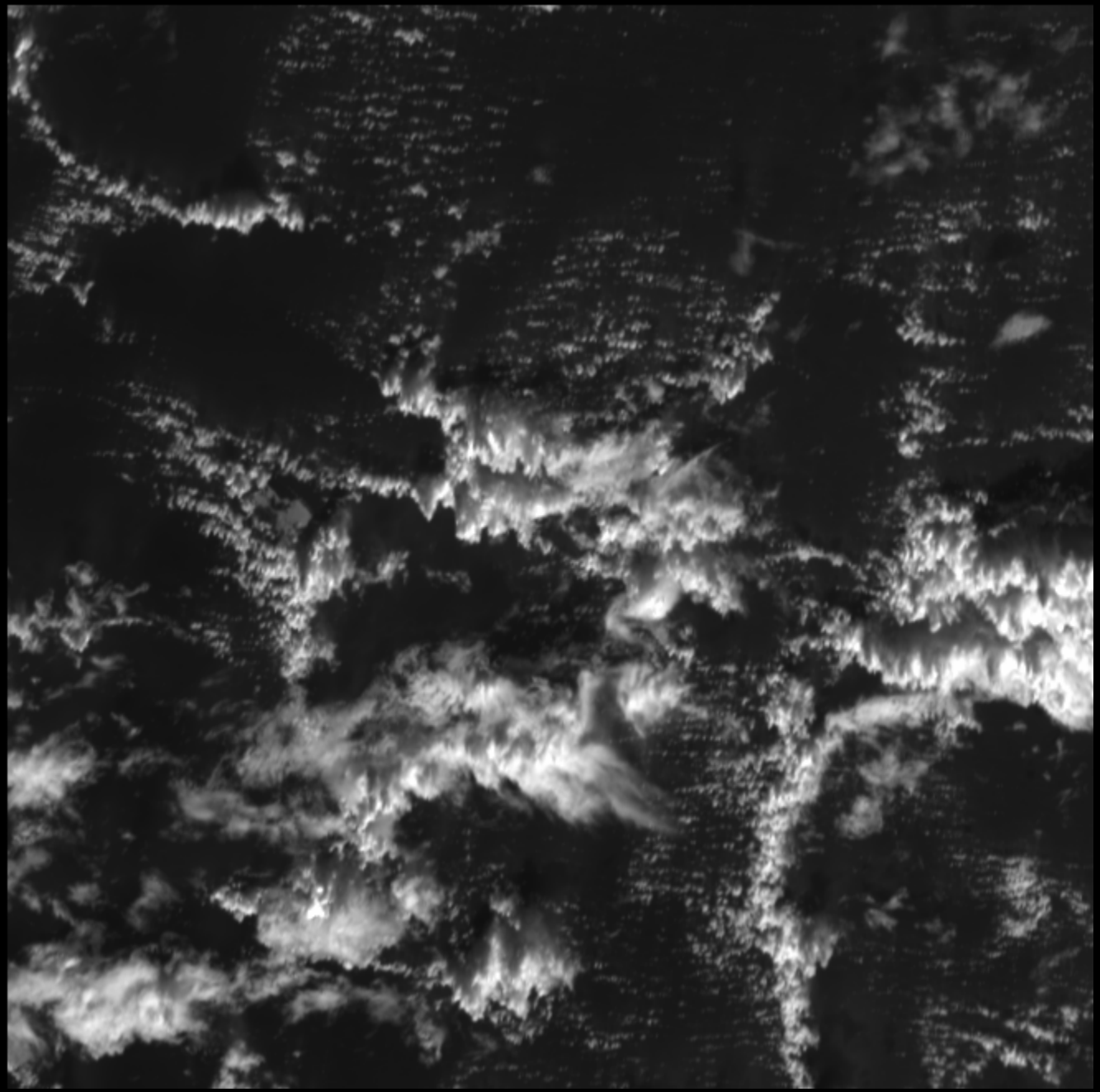
+70°



MISR

December 14, 2006

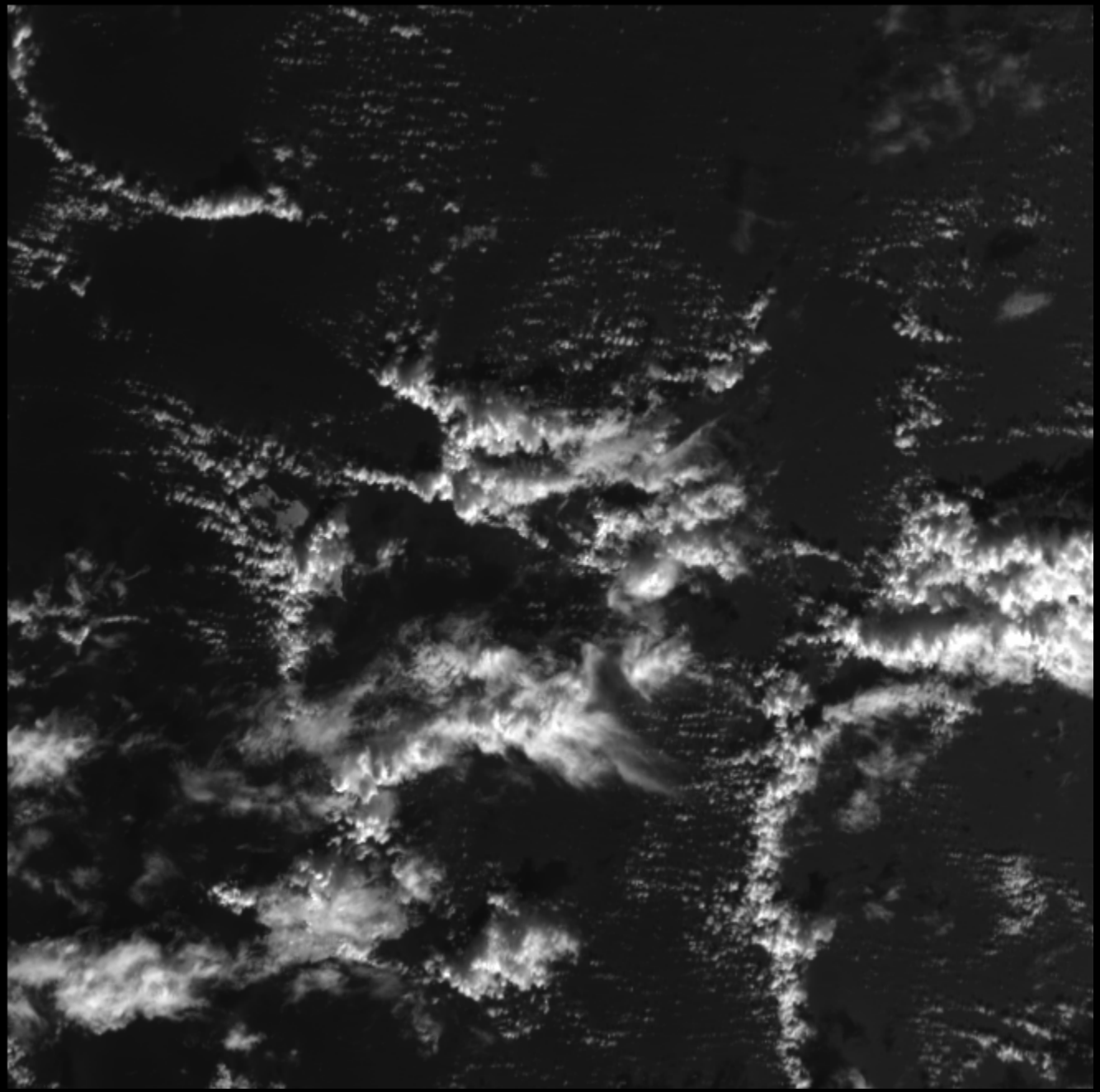
+60°



MISR

December 14, 2006

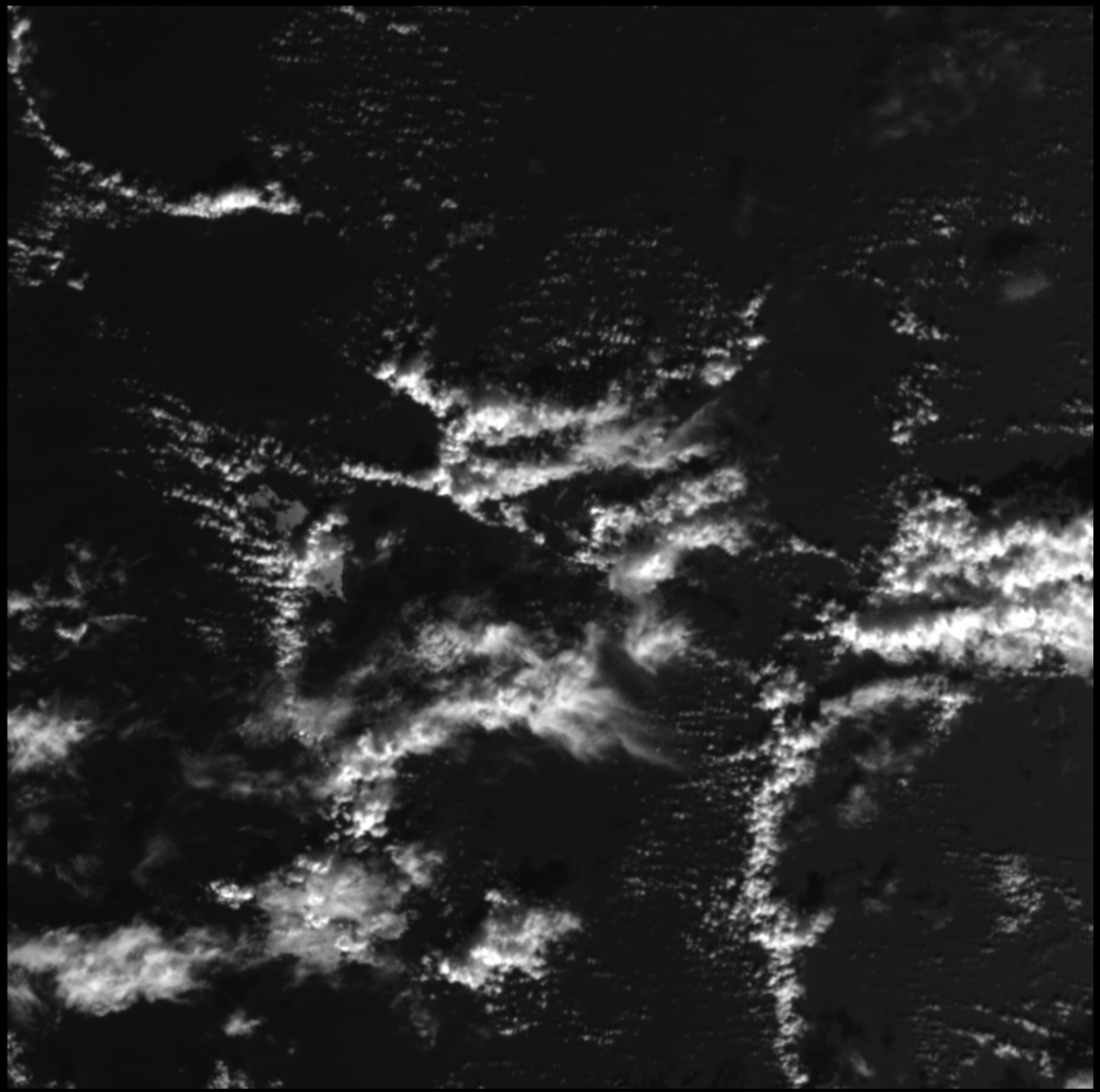
+45°



MISR

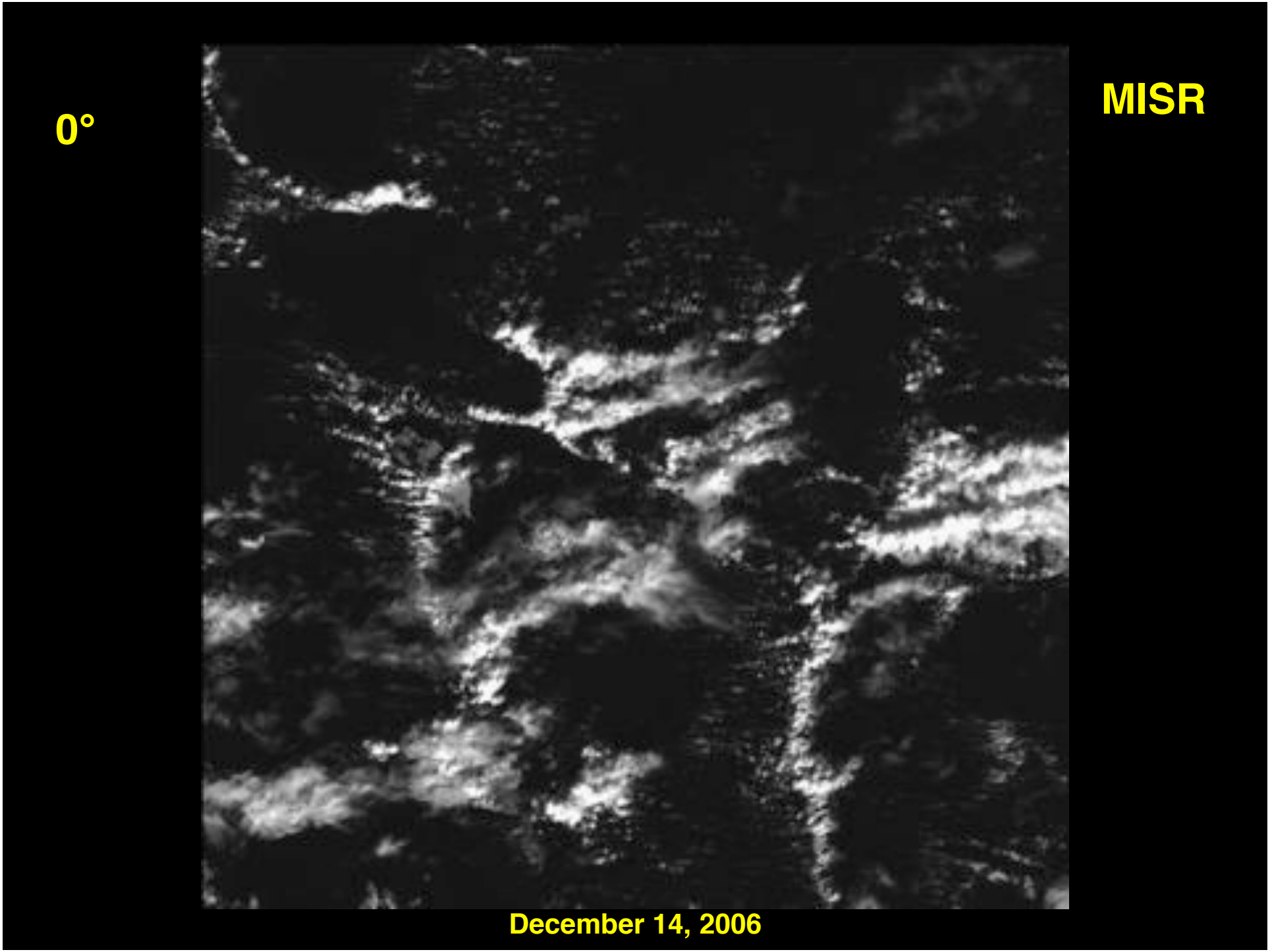
December 14, 2006

+26°

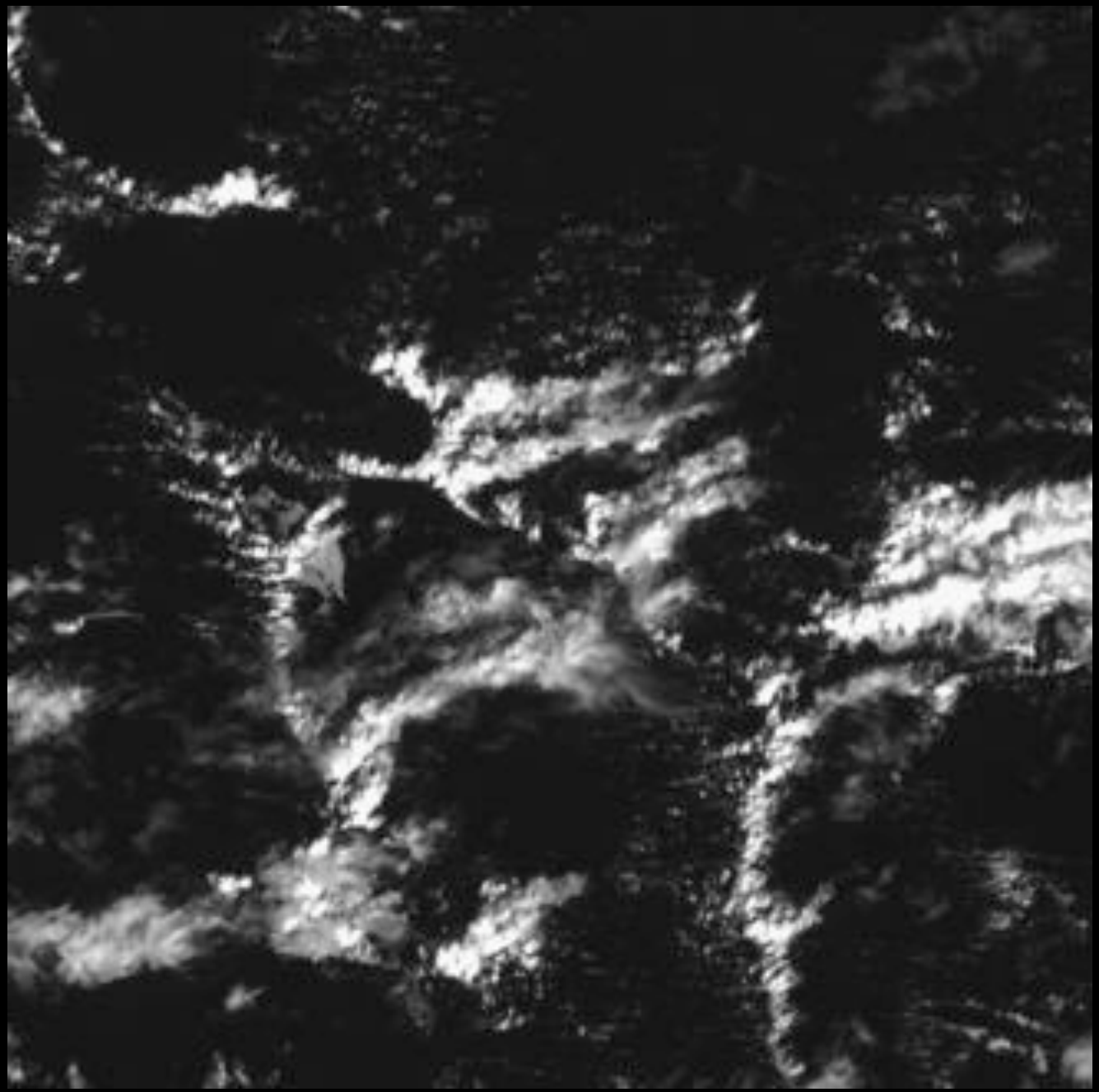


MISR

December 14, 2006

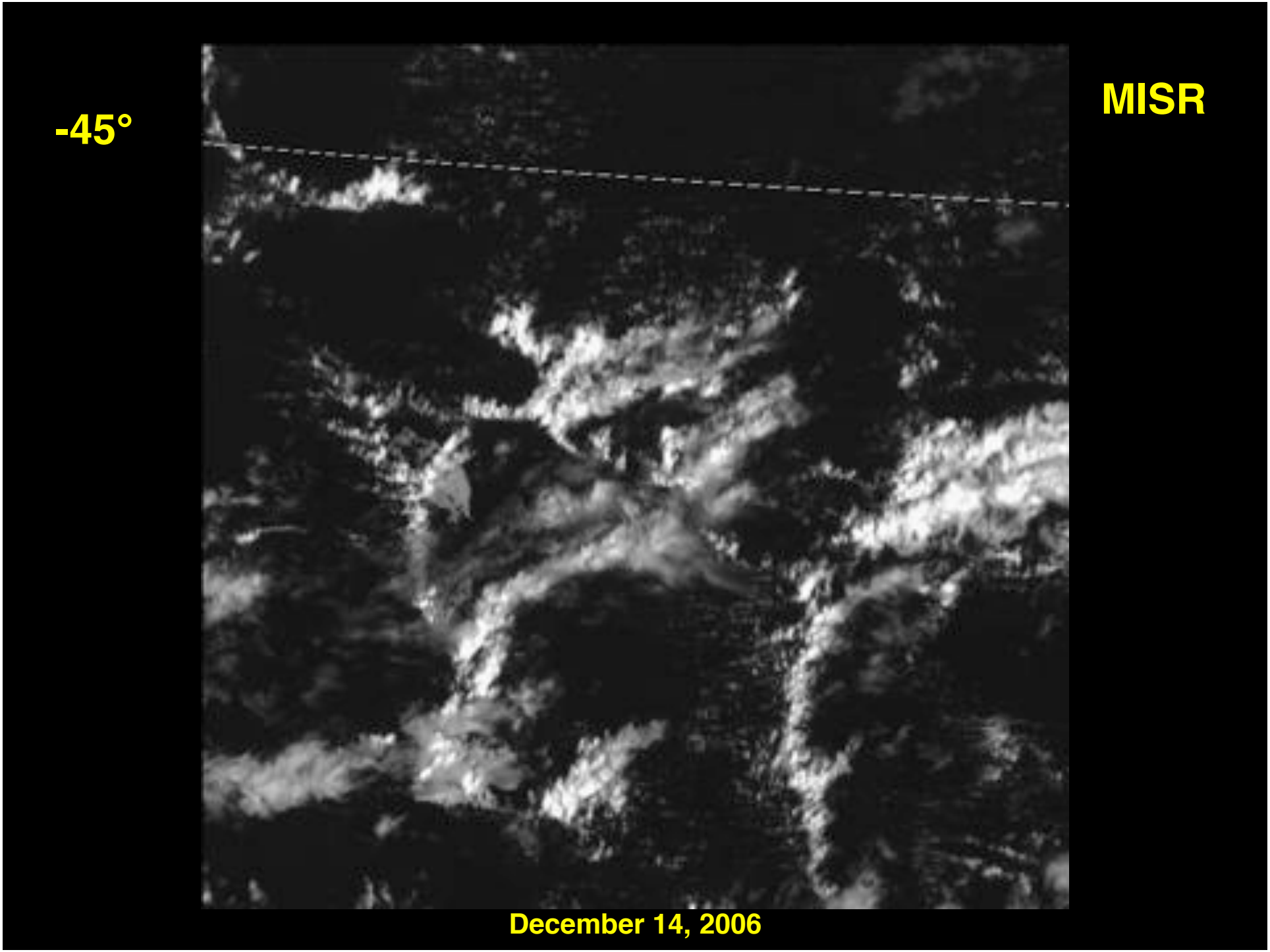

0°
MISR
December 14, 2006

-26°

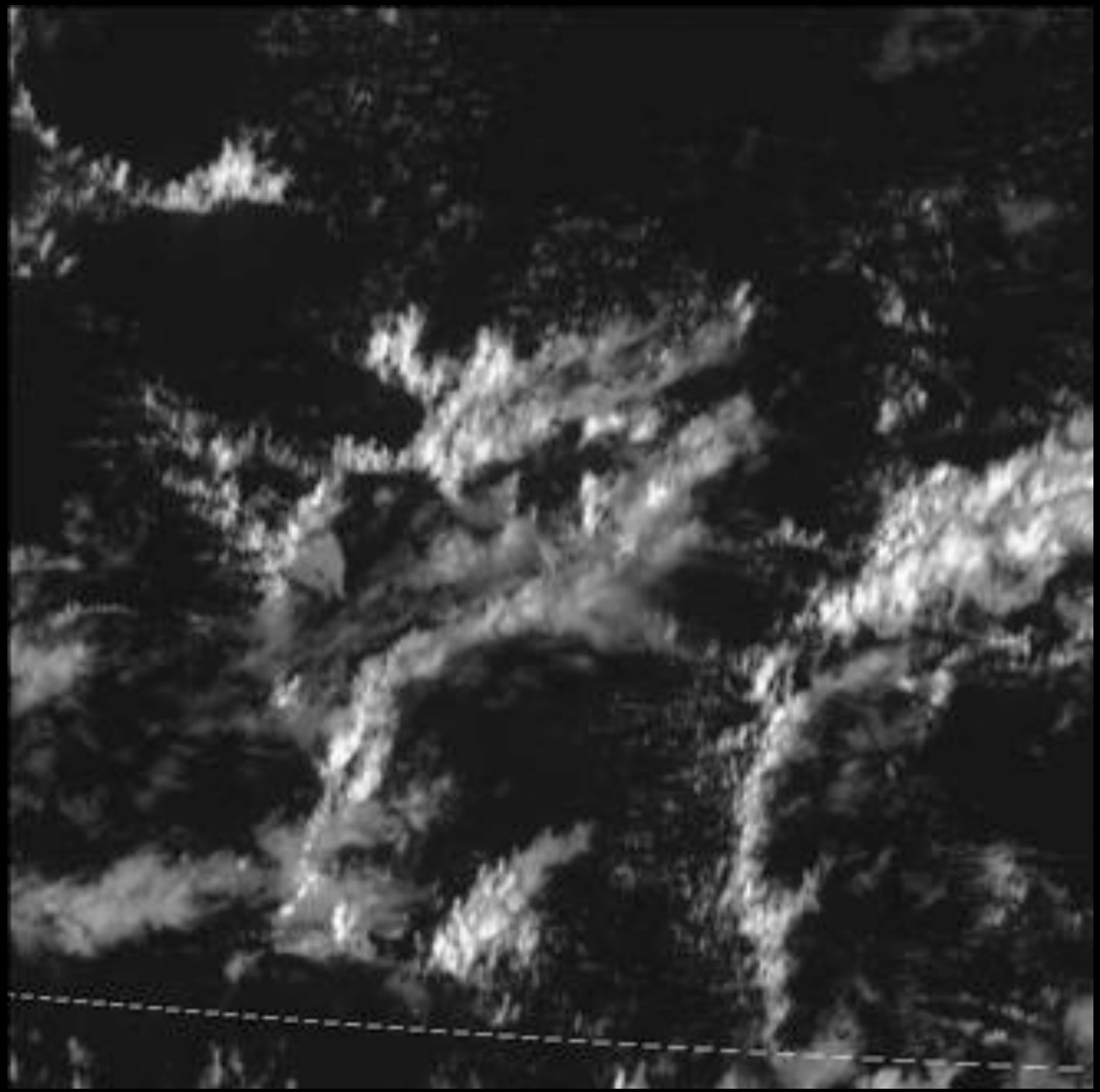


MISR

December 14, 2006


-45°
MISR
December 14, 2006

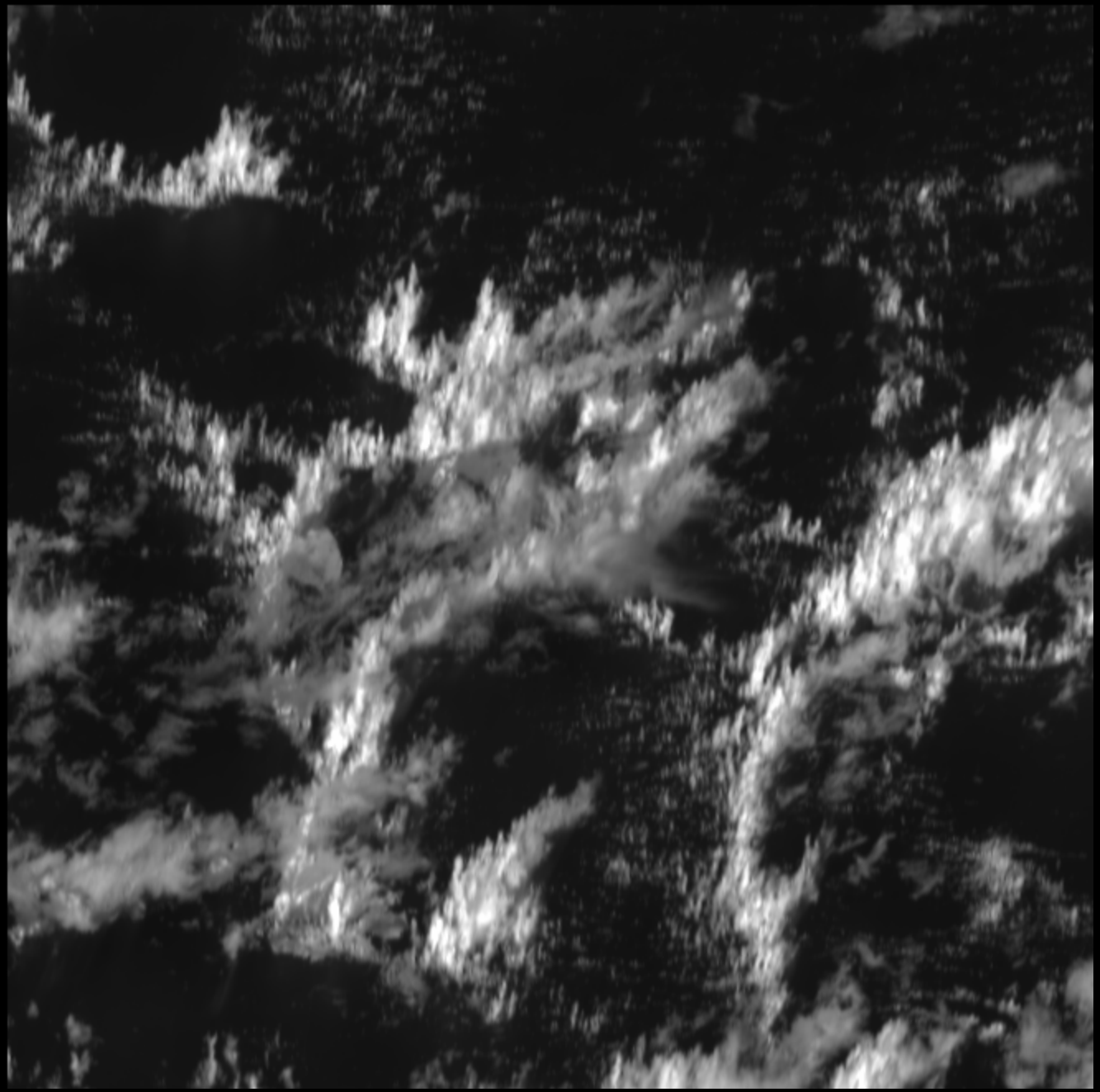
-60°



MISR

December 14, 2006

-70°



MISR

December 14, 2006

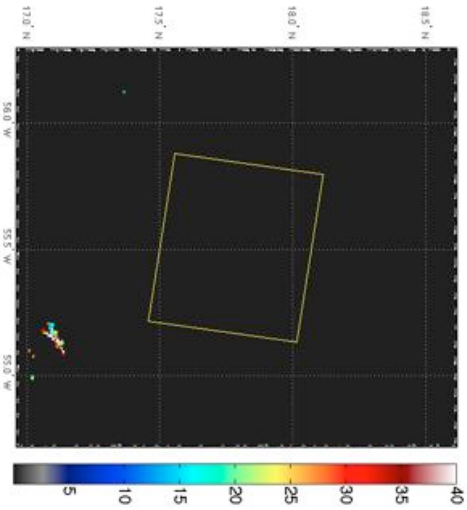
From these satellite datasets, we were able to quantify the macrophysical properties of trade wind cumuli, the uncertainties in these properties, and their relationship to precipitation and aerosol properties.

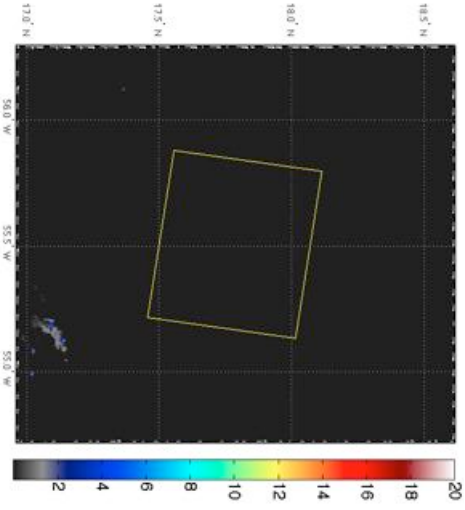
But what about the microphysical/optical properties?

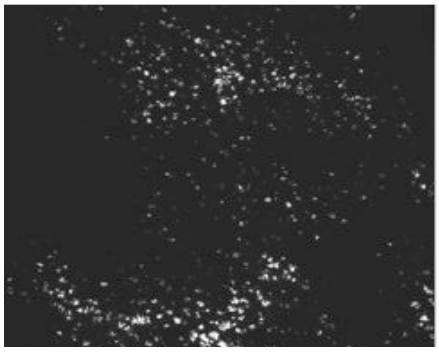
MODIS
Effective Radii

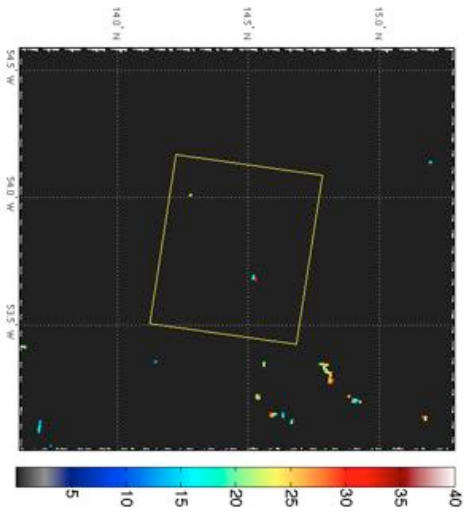
MODIS
Optical Depth

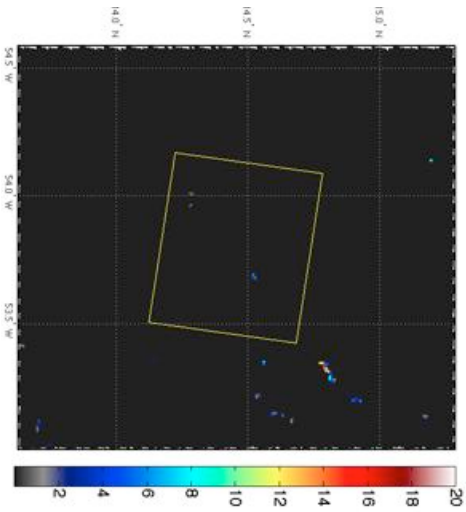
ASTER
Cloud
Mask

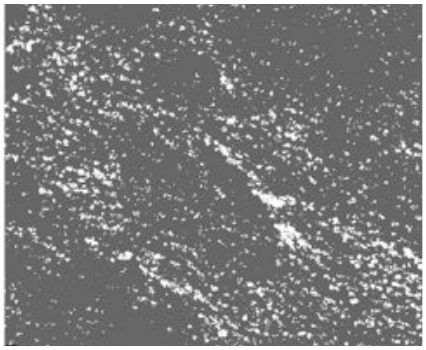


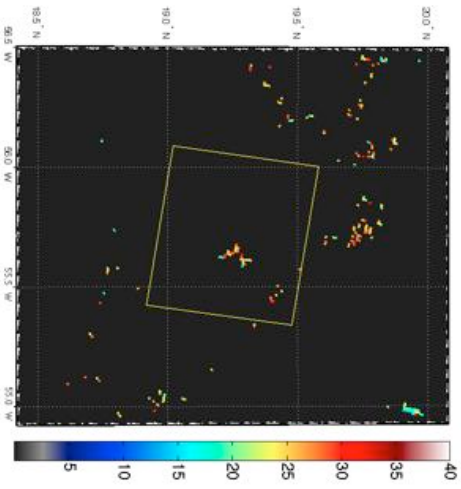


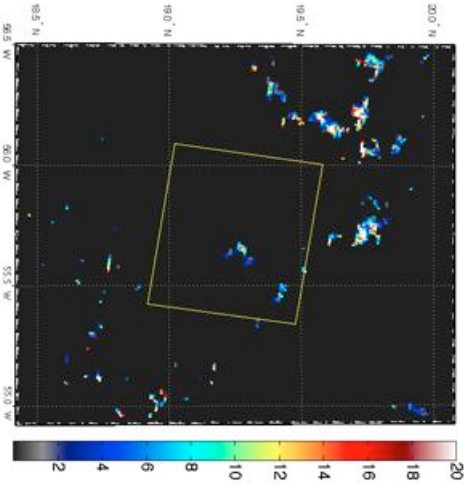


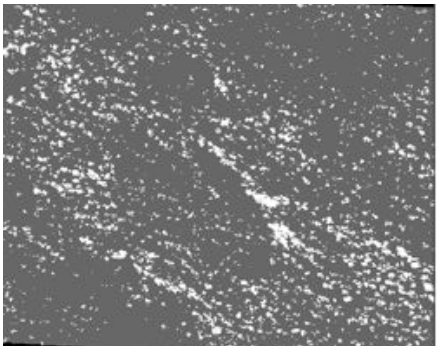








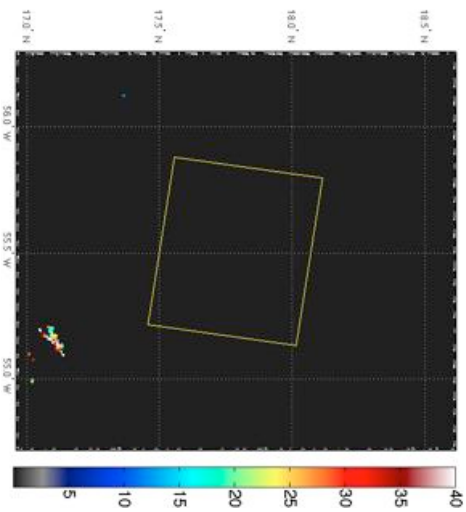


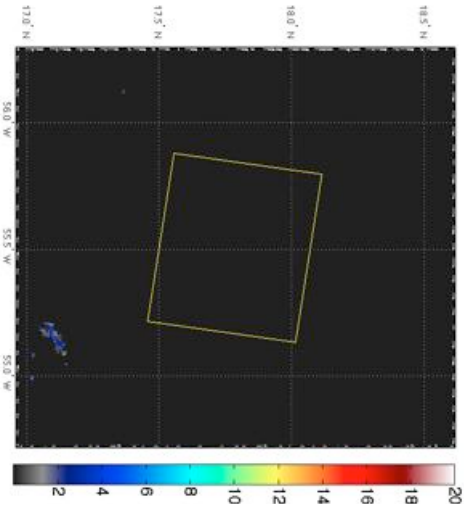


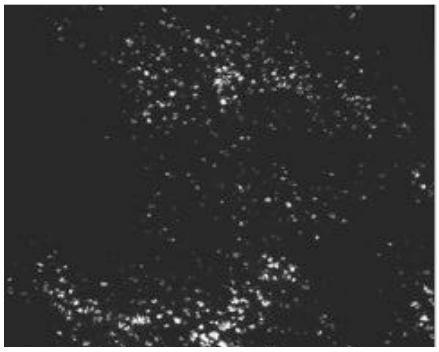
MODIS
Effective Radii
Bands 7 and 6

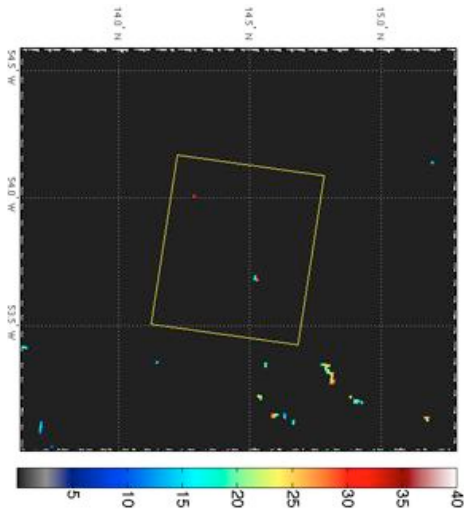
MODIS
Optical Depth
Bands 7 and 6

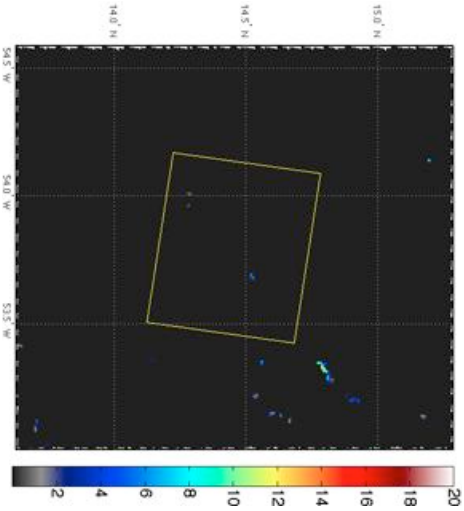
ASTER
Cloud
Mask

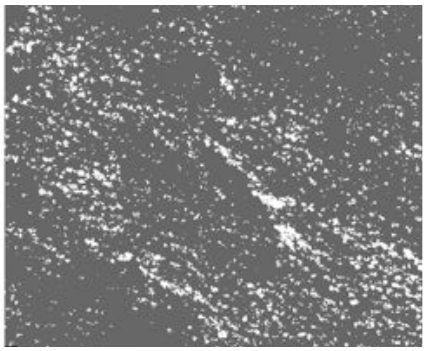


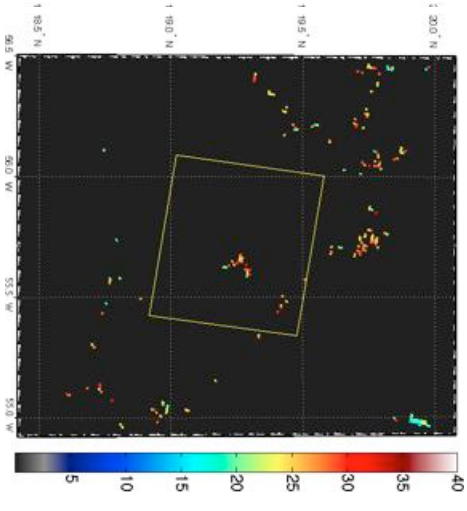


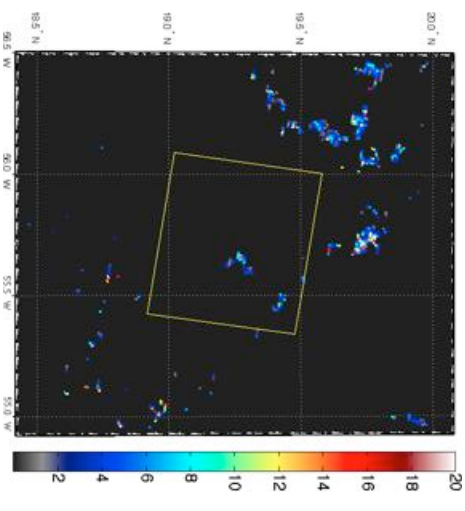


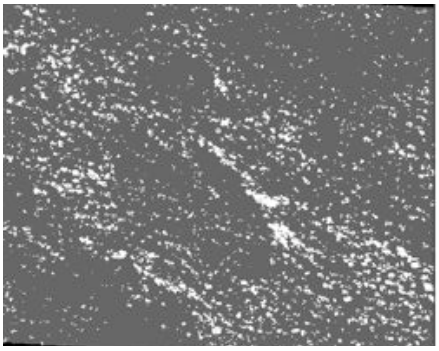












Marshak et al. 2006:

"Ignoring shadowing in 1-D retrievals results in substantial overestimation of r_e that often goes in pair with underestimation of τ."

Many such 3D radiative transfer studies have provided an incredible amount of physical insight…

… but they were produced from only a few simulated cloud fields. Are they representative of the breadth of cloud heterogeneity found in nature?

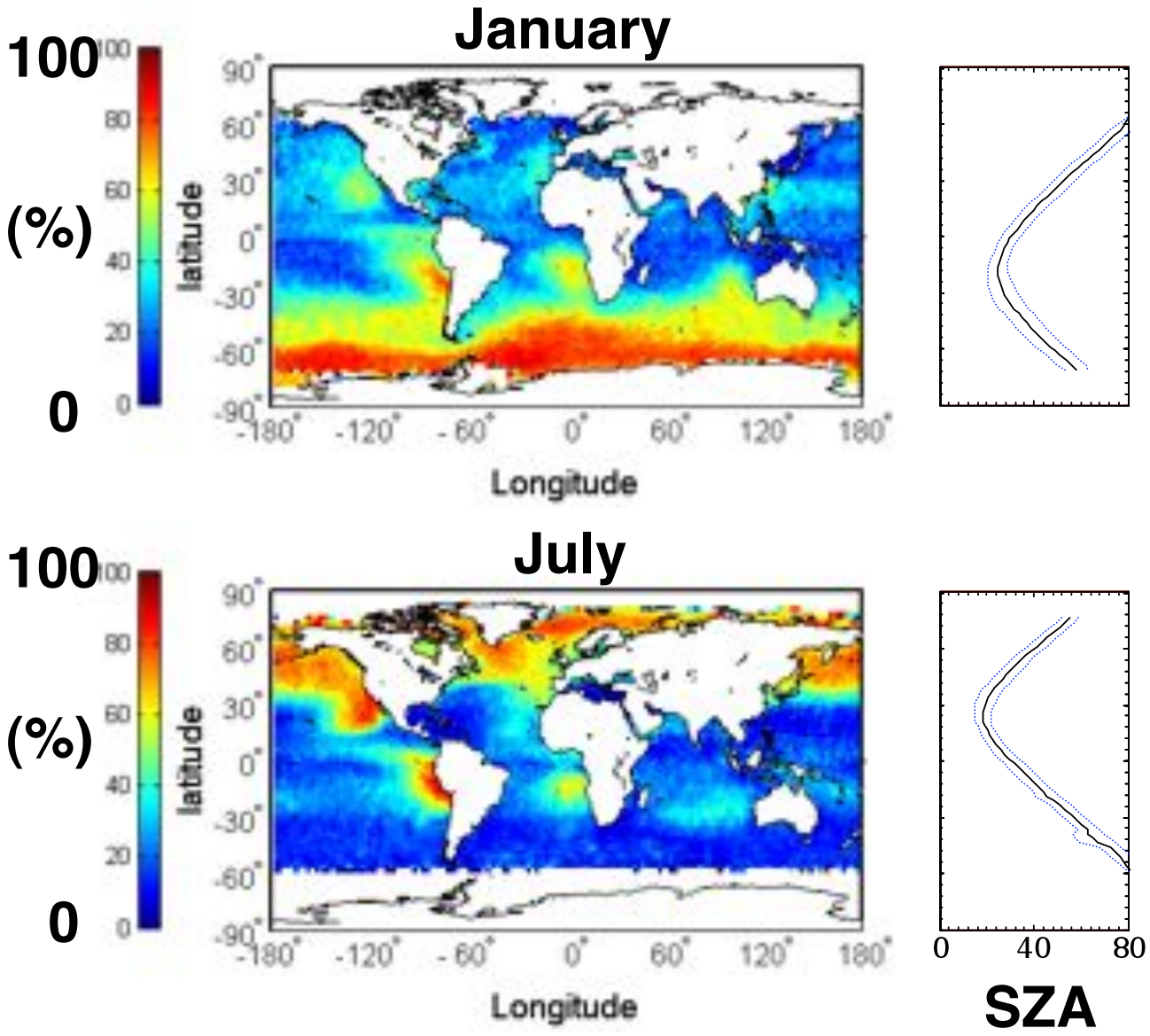
… and they do not connect the errors introduced by the plane-parallel assumption to some measure of cloud heterogeneity that we can go out and measure in nature.

We would like a global perspective from satellite observations to tell us about the plane-parallel nature of clouds.

Di Girolamo, Liang, Platnick (GRL 2010)

$m_{BRF} < 5\%$

Fully cloudy over 3 x3 km domains



Highest frequency of occurrence in regions dominated by stratiform clouds under SZA < 60°

Spatial heterogeneity

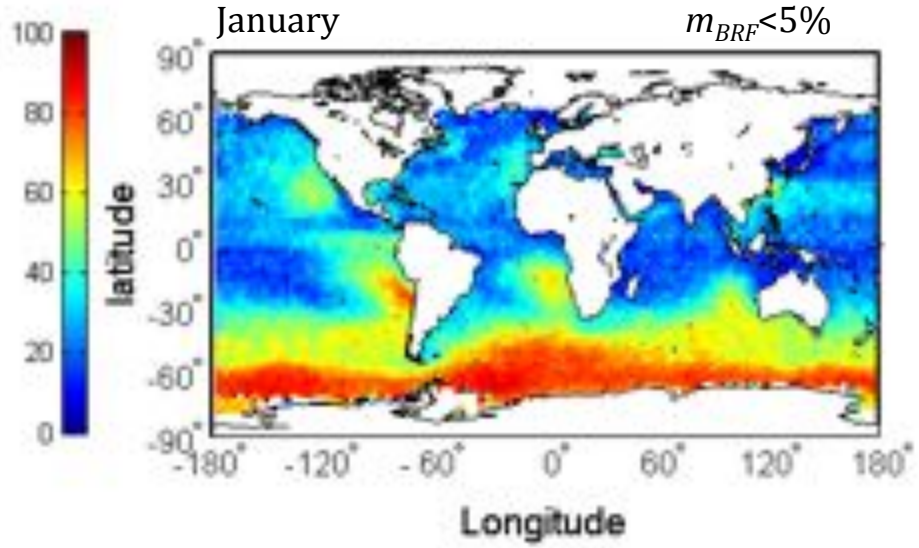
$m_{BRF} < 5\%$

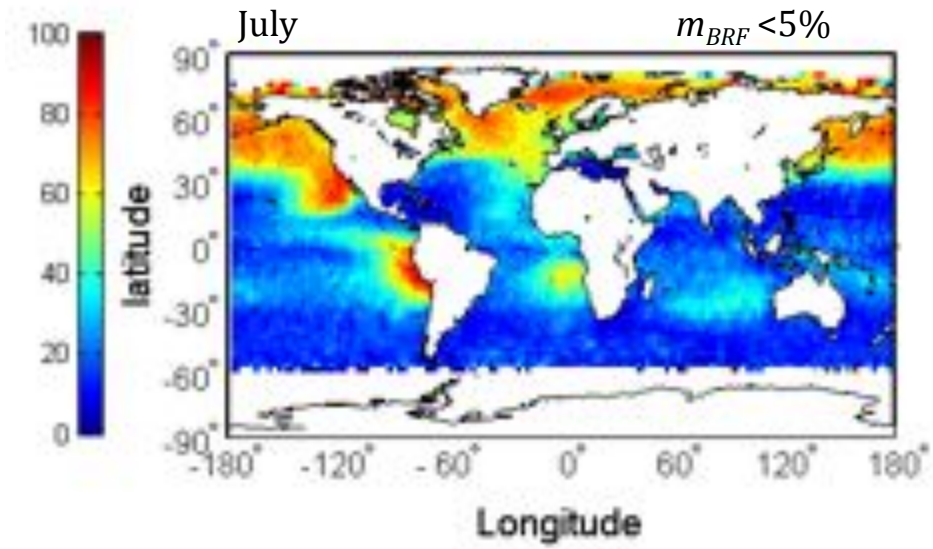
$$H_\sigma = \frac{\sigma}{\overline{R}}$$

R **= 250-m nadir red-channel BRF**

$\overline{R}$ **= mean R over 3 x 3 km²**

σ **= standard deviation of *R***





The mean uncertainty in τ reported in MOD06 = 7.5% as calculated from p-p theory

As the measured H_σ goes to 0, the mean value of measured m_τ(68%) = 7.9%

Stage 3 Cross-Validation!

Implications

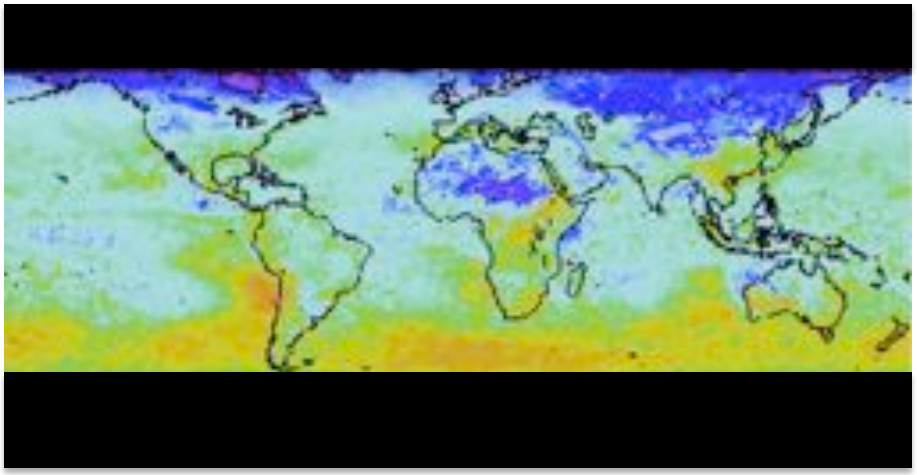
- **Need a more concentrated effort to handle 3D radiative transfer in passive remote sensing.**
- **Future 3D radiative transfer simulations need to quantify τ and r_e biases in terms of H_σ so as to provide a way to correct the biases.**
- **Add H_σ (perhaps other texture measures) in MODIS Collection 6 as a push toward studying potential bias correction methods, and as a means of placing greater confidence in the microphysical retrievals and their estimated pp-uncertainties reported in MOD06.**
- **Until bias correction is initiated, users need to be very careful in using the data for scientific analysis and interpretation.**
- **Our results provide a basis for interpreting space-time variability in satellite derived cloud properties.**

Oreopoulos and Platnick (2008)

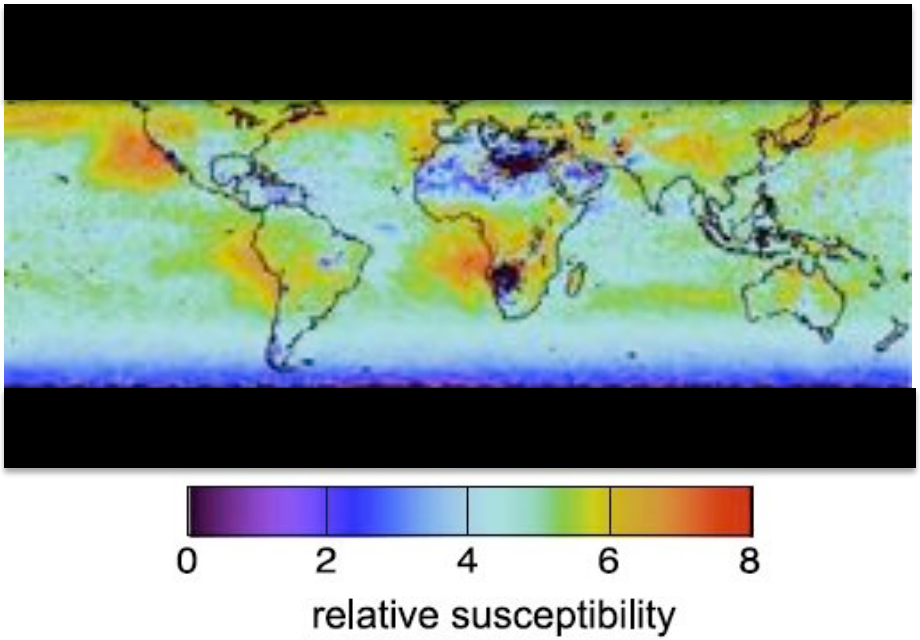
Relative cloud albedo susceptibility:

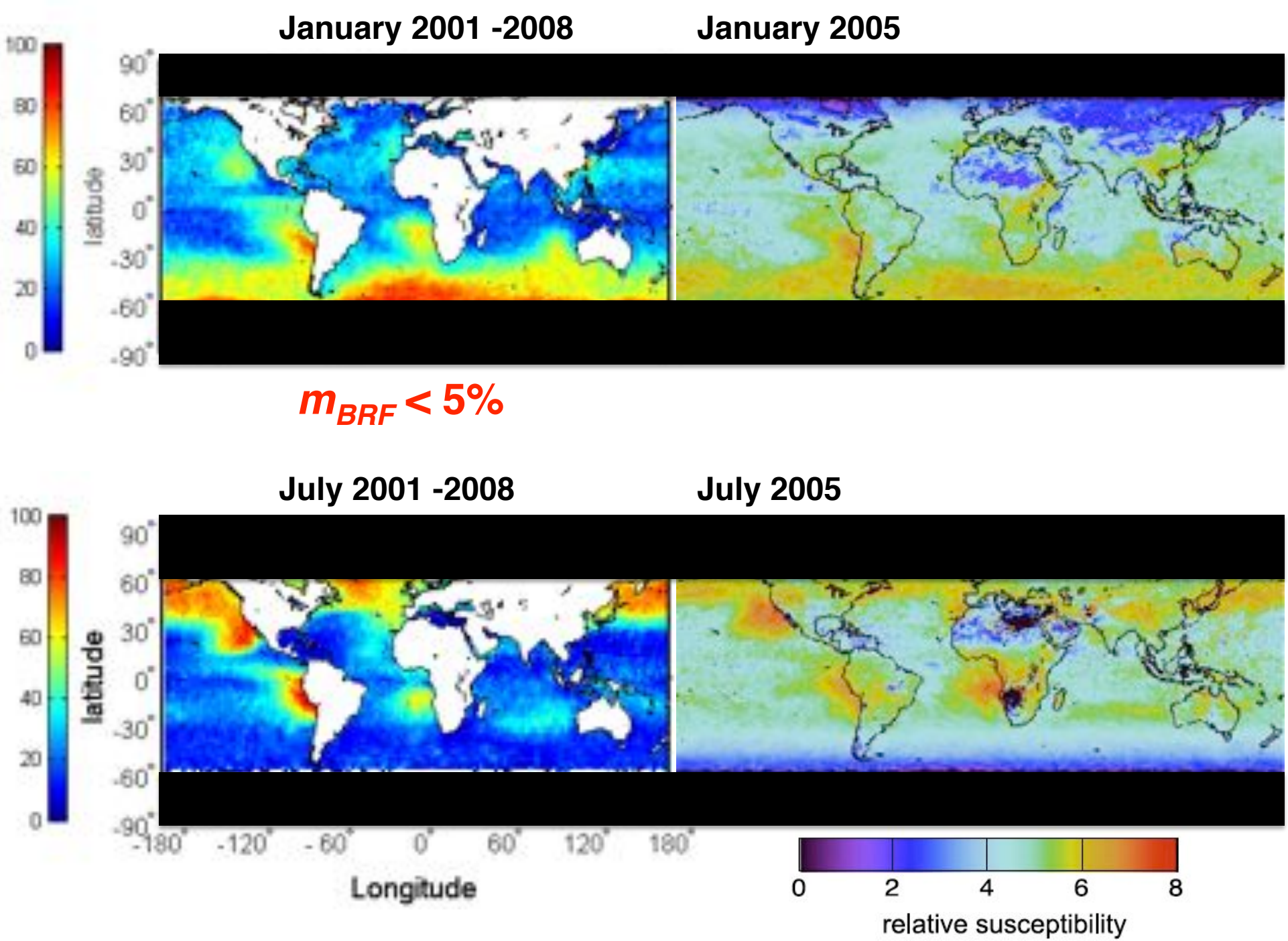
$$S = \frac{dA}{dN/N} = N\frac{dA}{dN}$$

January 2005



July 2005




January 2001 -2008
January 2005
$m_{BRF} < 5\%$
July 2001 -2008
July 2005
latitude
Longitude
relative susceptibility
0
2
4
6
8
-180
-120
-60
0
60
120
180
90
60
30
0
-30
-60
-90
100
80
60
40
20
0

Field campaigns used in evaluating VIS/NIR cloud optical depths and effective radii for warm marine clouds…

APEX, ASTEX, COSAT, FIRE, SOCEX II, VOCALS, WENPEX

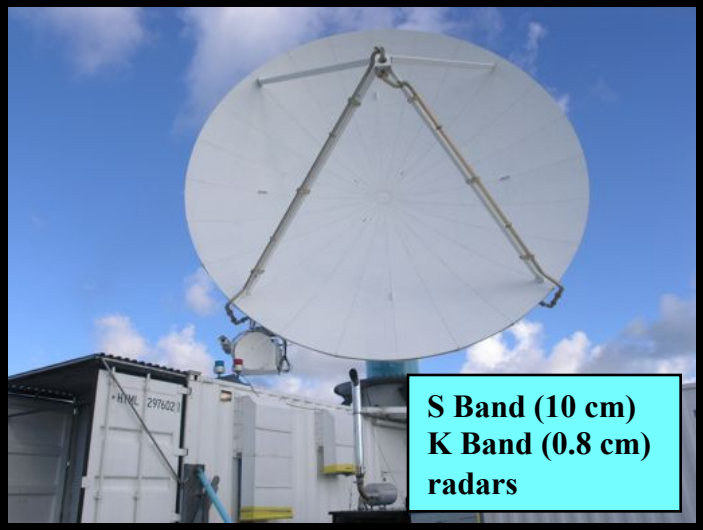
… all for marine stratiform clouds under high sun conditions

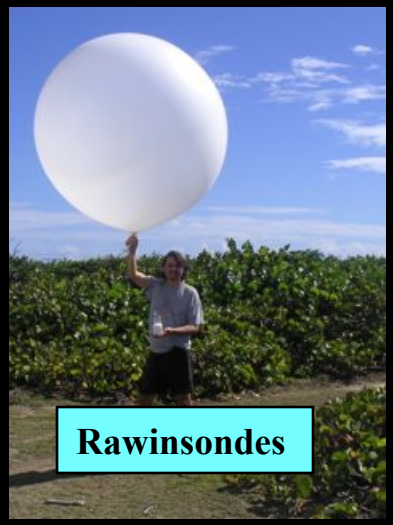
Evaluating MOD06 Products for Studies of Trade Wind Cumulus Clouds

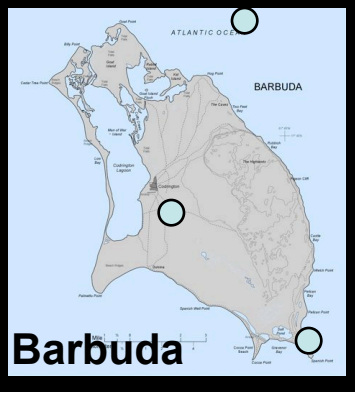
RICO, ASTER, MISR

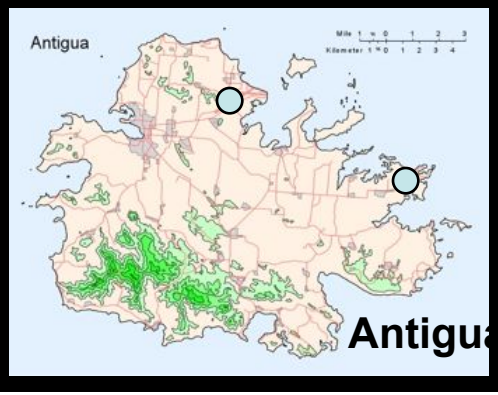
MOD06 retrieval and sampling biases

RICO Instrumentation Platforms

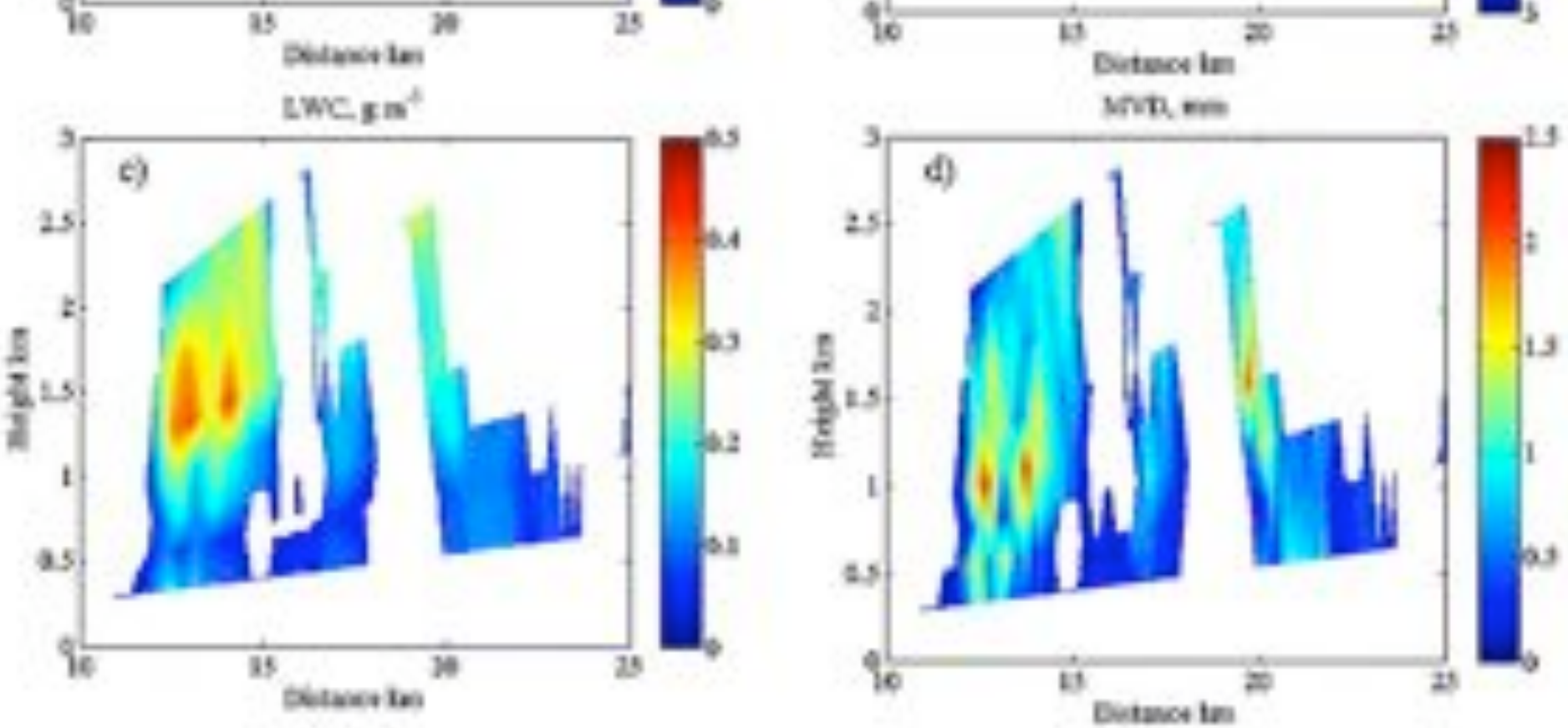








17 “Golden days” of flight data and 62 days of continuous coverage from S and K band radars



… from RICO S and Ka band radars

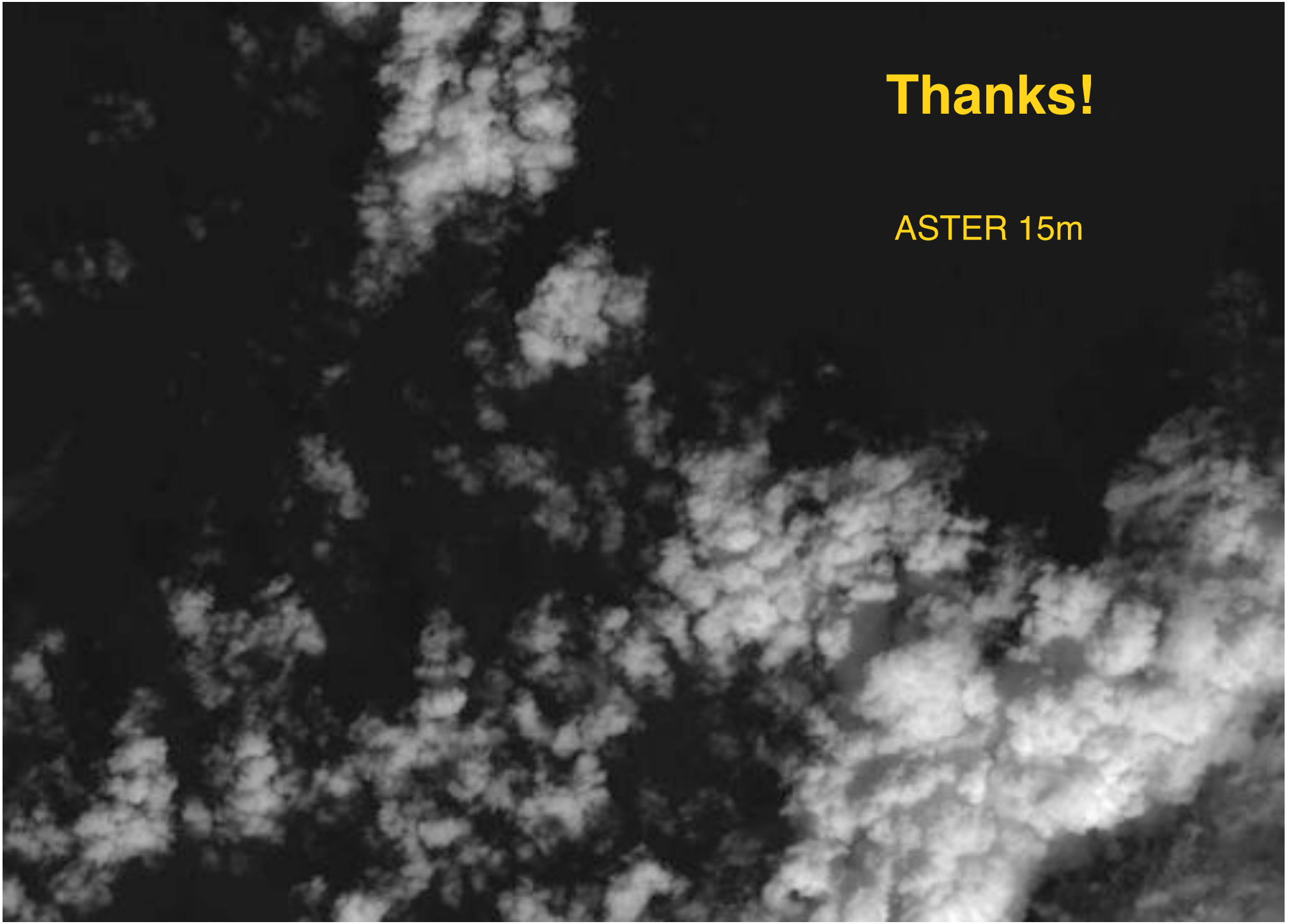
Ellis and Vivekanandan (Radio Science 2011)

RICO-II

Return to Antigua and Barbuda

Science Overview Document: October 2011

Target field deployment 12/12 – 1/13 or 12/13 – 1/14


Thanks!
ASTER 15m

MISR 60° view