Cloud Properties from MODIS, CERES-MODIS and CAM3 Simulation

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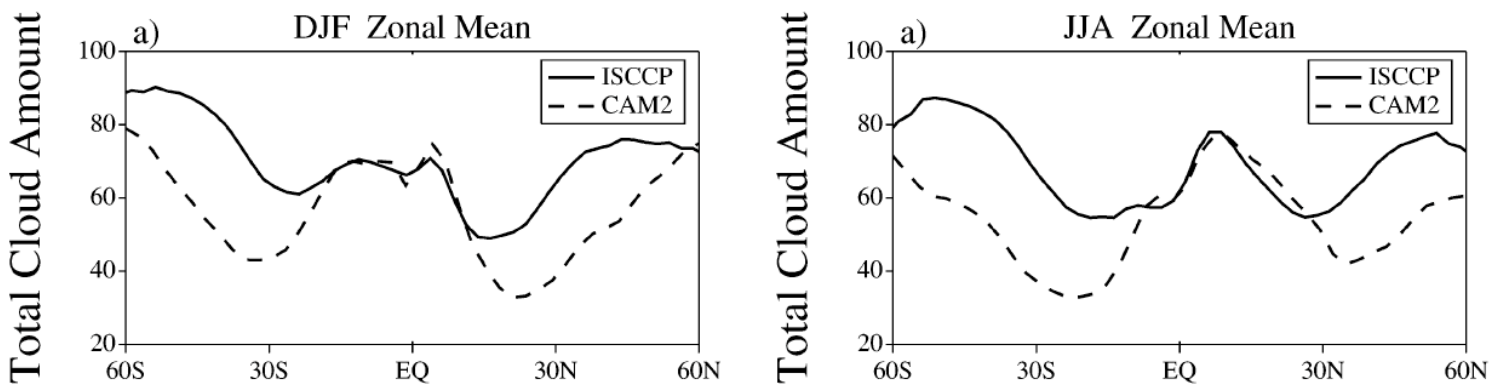
Motivation

TABLE 1. Summary of the properties retrieved from data collected on 6 Mar 2001. Shown are the mean and std dev of the properties observed in the rectangular region depicted in Fig. 1 for the MOD06 and MODIS-CERES retrievals and in the time series of properties from the ground-based Z-velocity algorithm shown in Fig. 4.

Property	Z velocity	MOD06	MODIS-CERES
r_e (μm)	30.3/1.7	29.9/2.2	31.2/3.1
IWP (g m^{-2})	54.0/12.7	61.8/16.2	59.1/18.0
Optical depth	2.02/0.34	2.78/0.68	3.08/0.83
Cloud-top temperature (K)	216.2/2.2	237.6/3.6	
Cloud-top pressure (hPa)	236.7/8.8	359.3/28.2	307.7/24.5

Mace et al. (2005)



Lin and Zhang (2004)

Questions

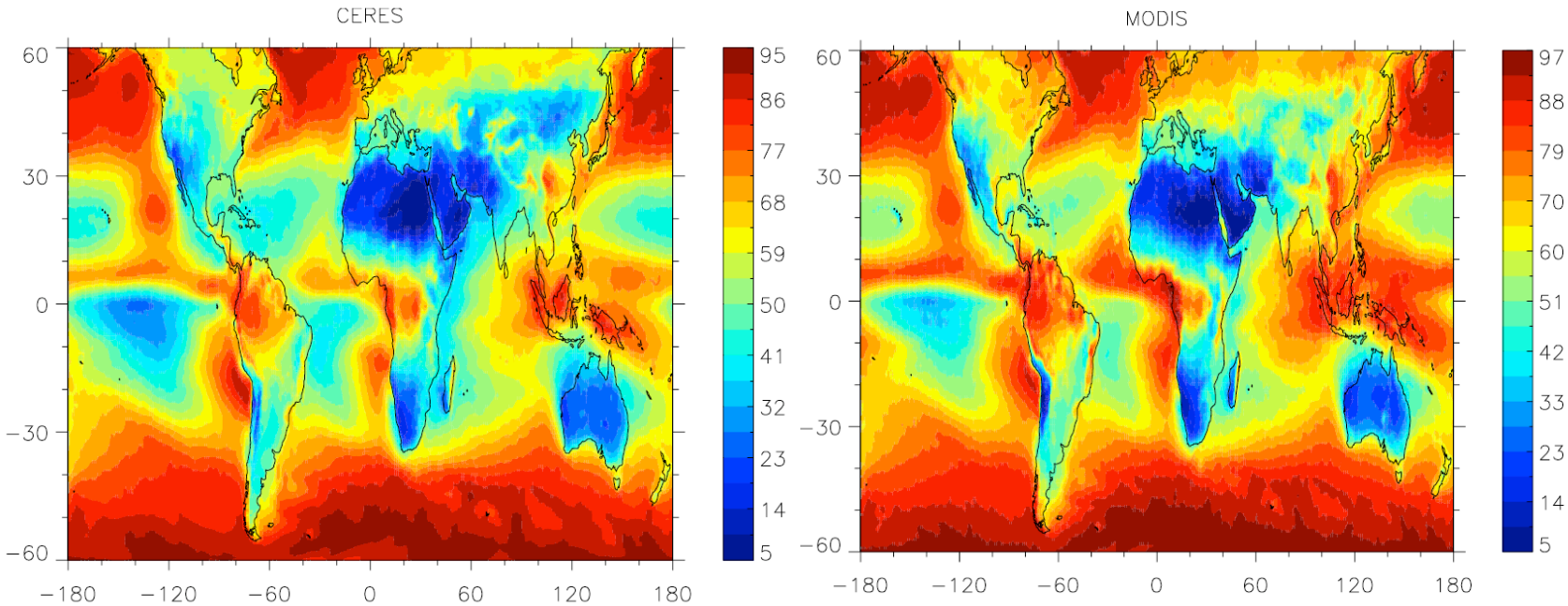
- How large are the differences between the MODIS and CERES-MODIS cloud properties from a global perspective?

- How well can a climate model simulate cloud properties observed by MODIS?

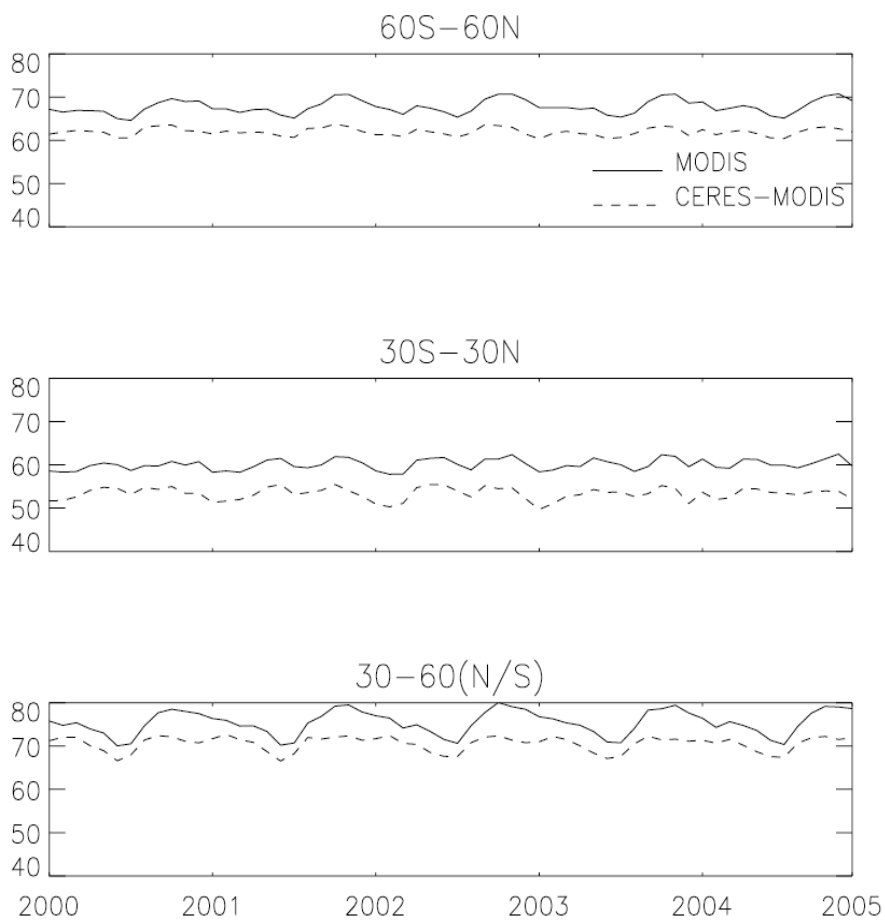
CERES-MODIS (Minnis et al., 1995, 1998) and MODIS (King et al., 1992, 2004) Comparison

Data: 5 year monthly mean cloud data (March 2000 to Feb 2005) from Terra MODIS

NOTE: The comparison is based on MODIS daytime only and CERES-MODIS day and night cloud products.



Total cloud fraction (%)



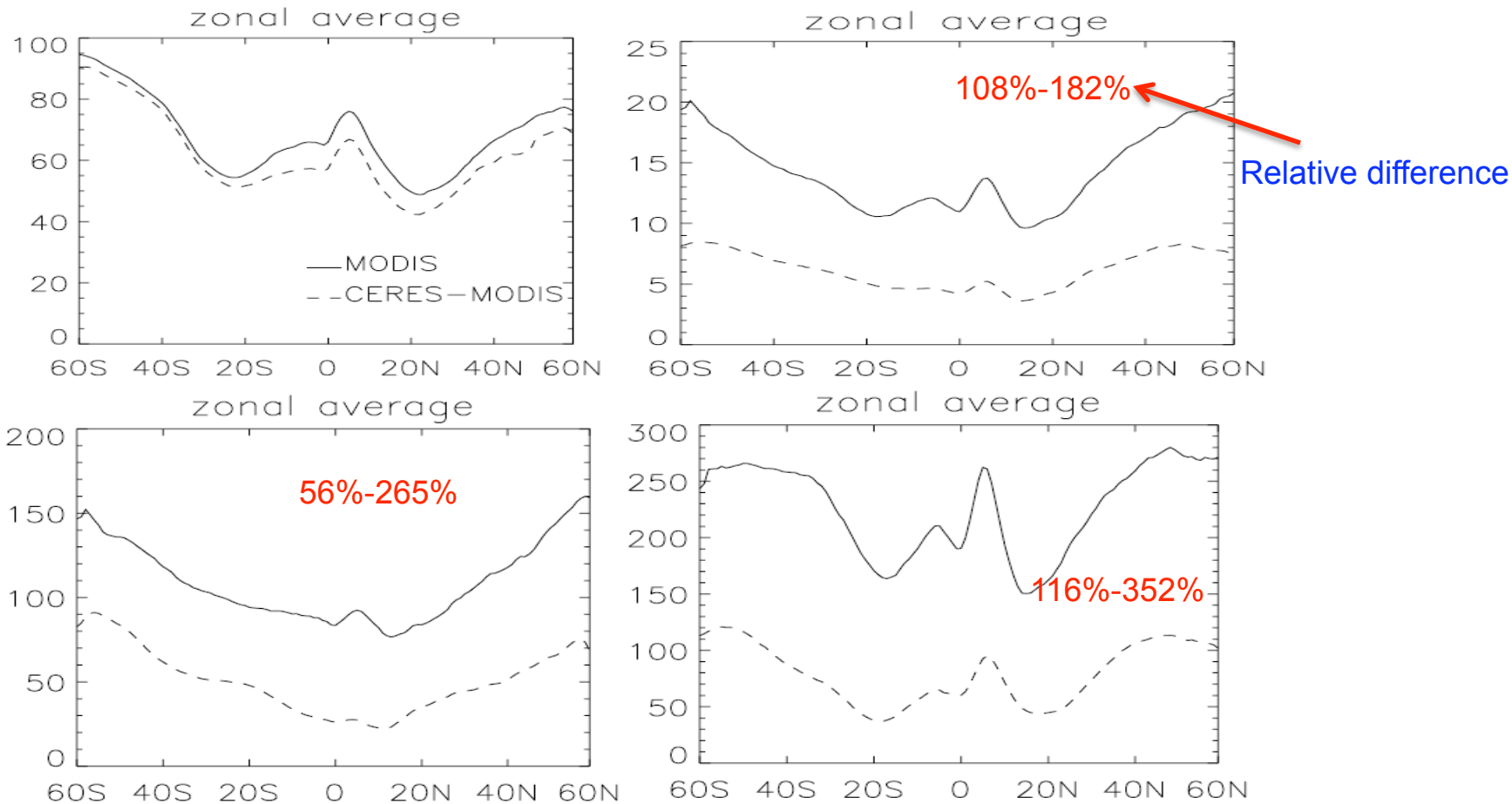
MODIS estimates a higher amount of cloud fraction than CERES-MODIS with a similar time pattern.

The difference is larger for the tropics:

- Entire region: 4.9% to 7.4%
- Tropics: 6.2% to 8.4%
- Midlatitudes: 2.7% to 7.1%

Time series of cloud fraction (%) from March 2000 to February 2005.
The years labeled correspond to the months of March

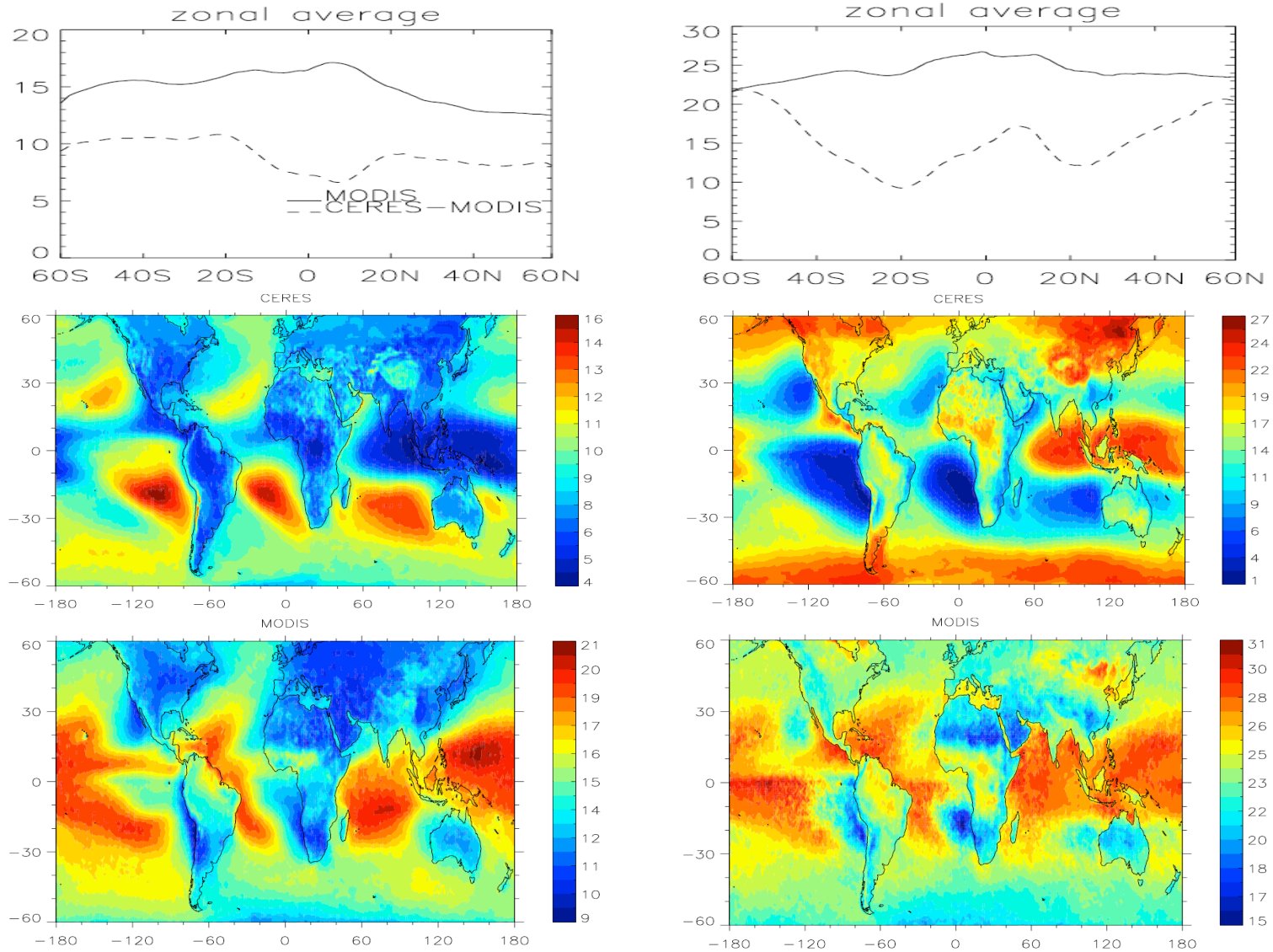
Comparison of Zonal Distribution



Upper Left: Cloud Fraction (%); Upper Right: Cloud Optical Depth;

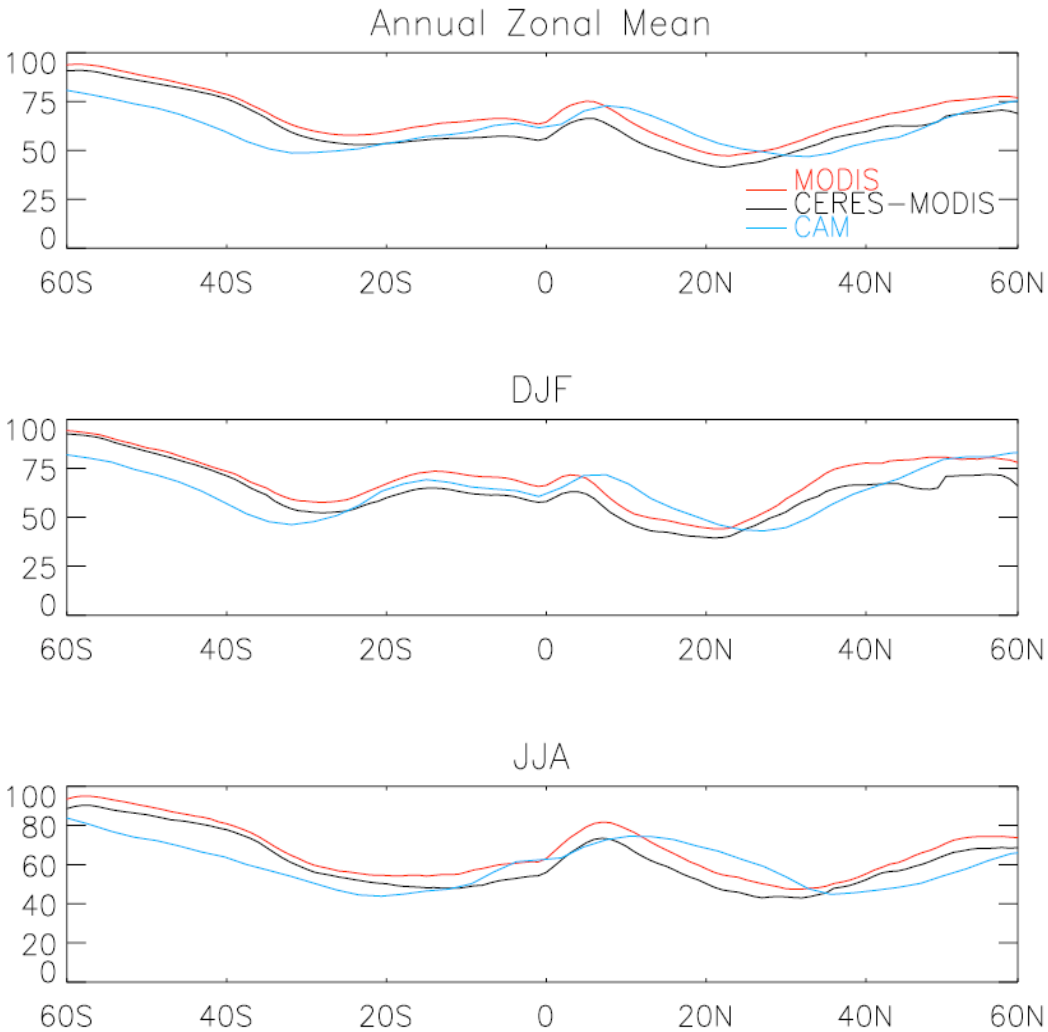
Bottom Left: Liquid Water Path (g/m^{-2}); Bottom Right: Ice Water Path (g/m^{-2})

Particle Effective Radius



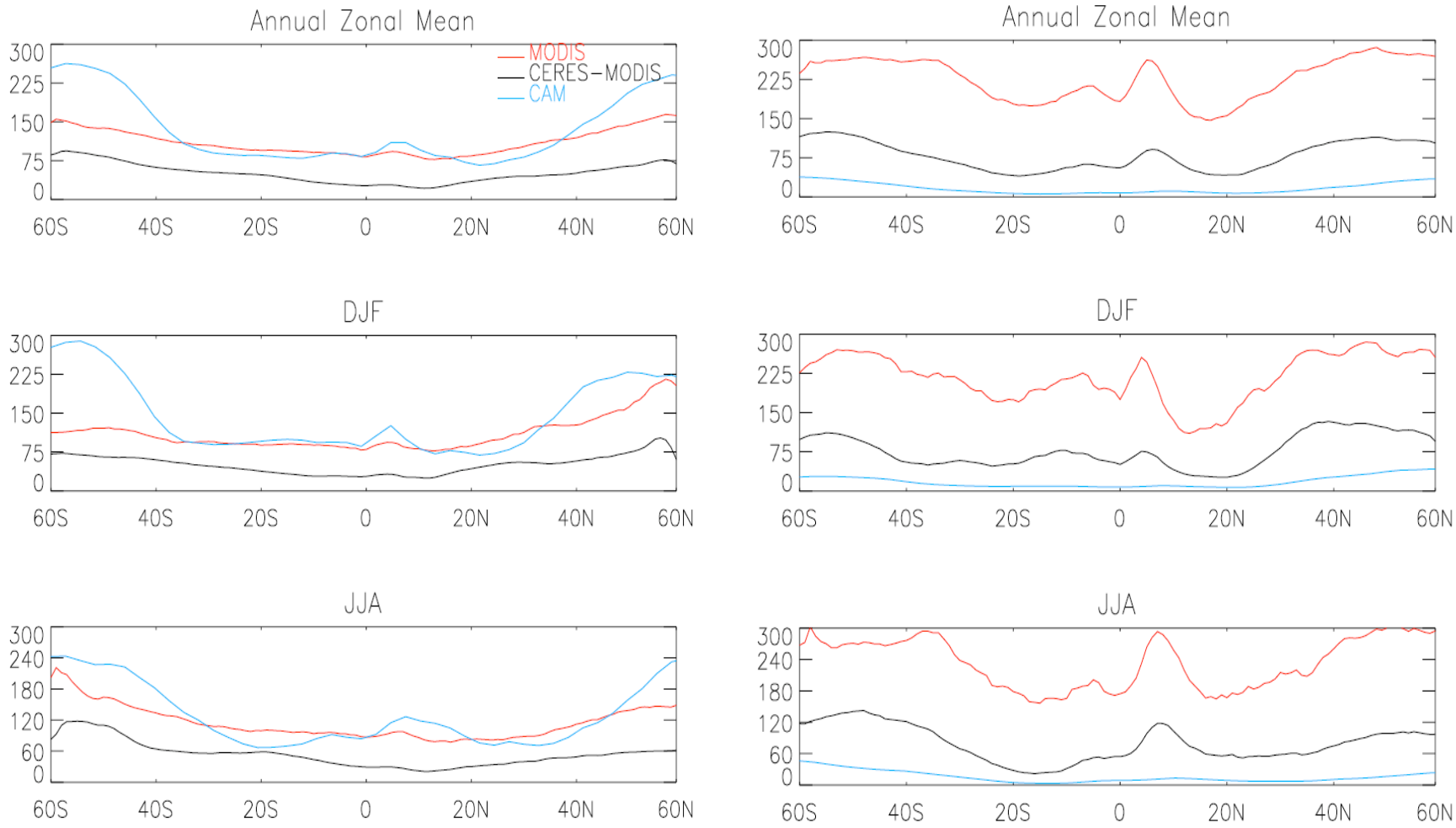
Left: Water particle effective radius (μm); Right: Ice particle effective radius (μm)

Total Cloud Fraction (%)

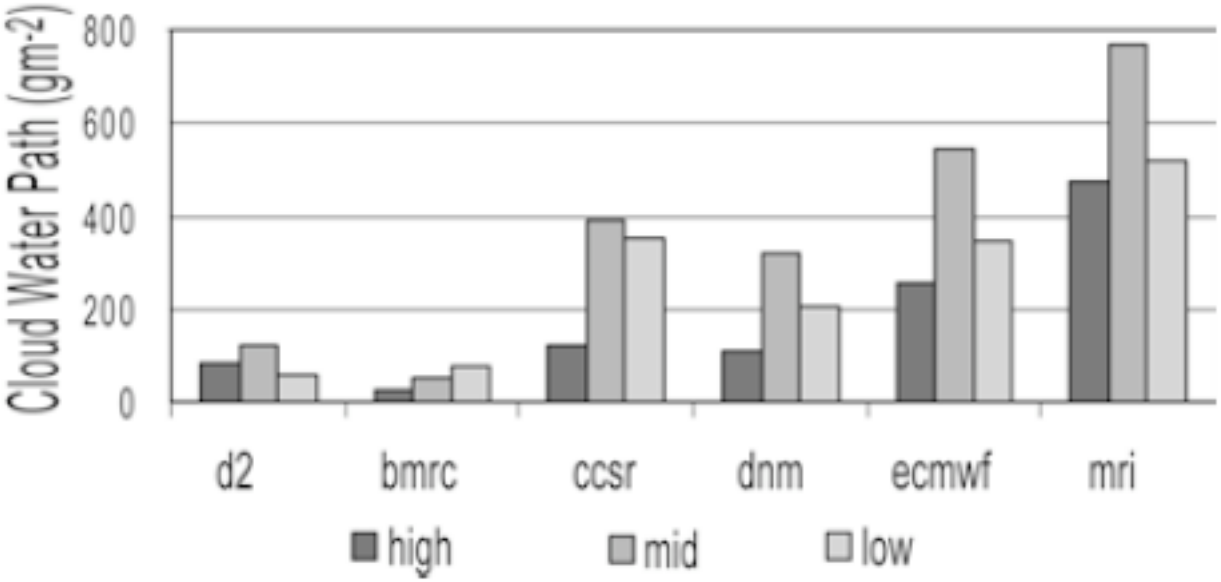


The Community Atmosphere Model (CAM), forced with monthly SST, run for one year from March 2000 to Feb 2001 to compare with MODIS and CERES-MODIS for the same period

Cloud Water Path

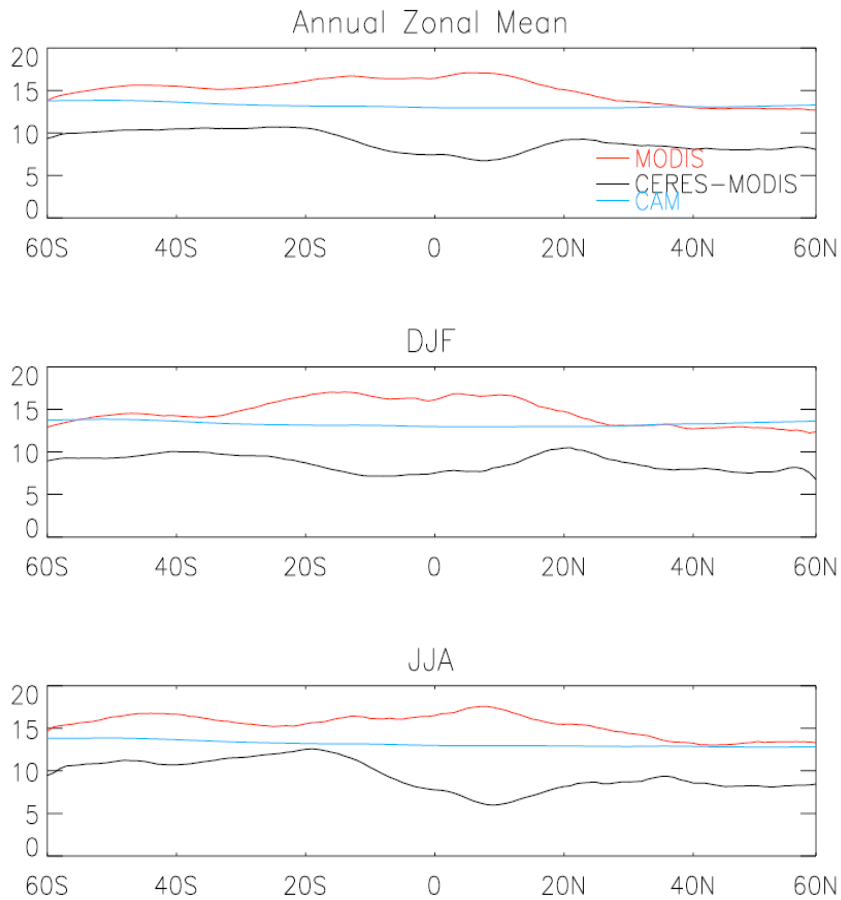


Left: Liquid water path (g/m^{-2}); Right: Ice water path (g/m^{-2})

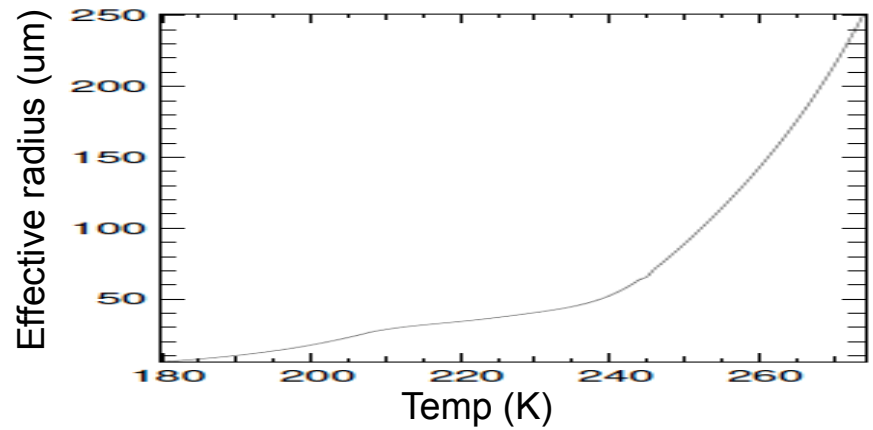

Cloud Water Path (gm-2)
800
600
400
200
0
d2
bmrc
ccsr
dnm
ecmwf
mri
high
mid
low

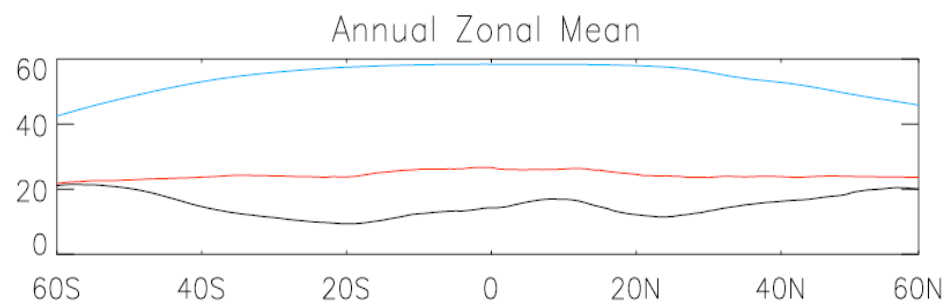
Weare (2004)

Particle Effective Radius



(CAM science document)



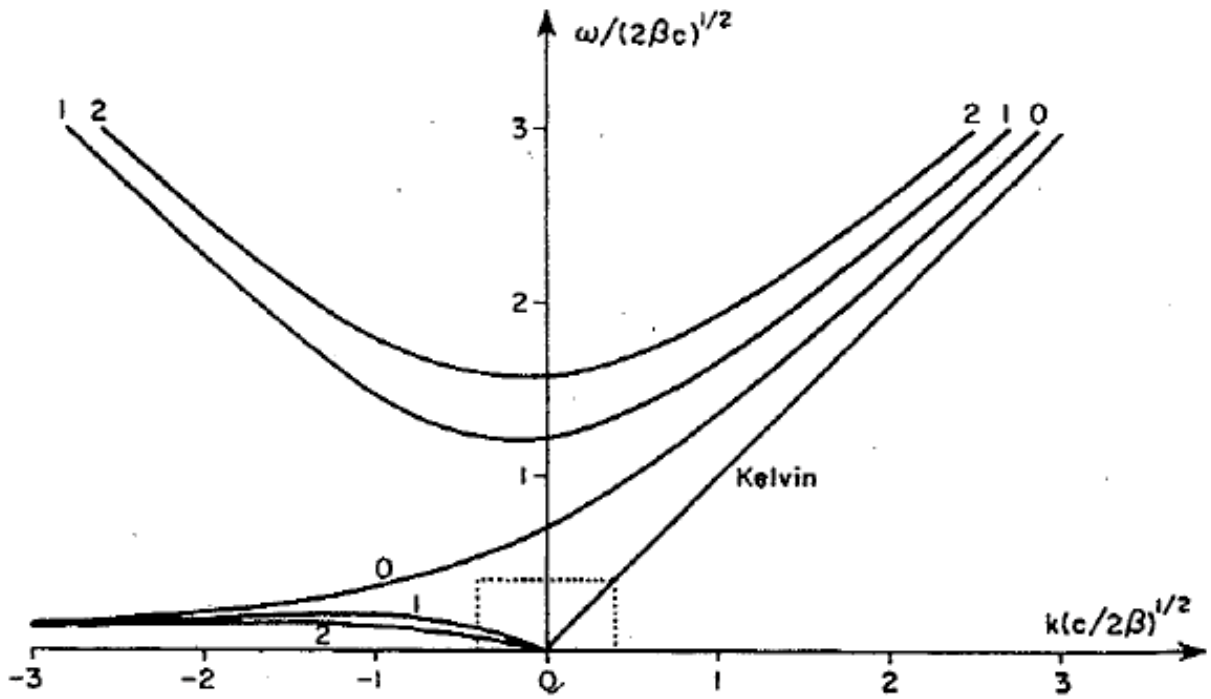


Left: Water particle effective radius (μm); Right: Ice particle effective radius (μm)

Equatorial Waves

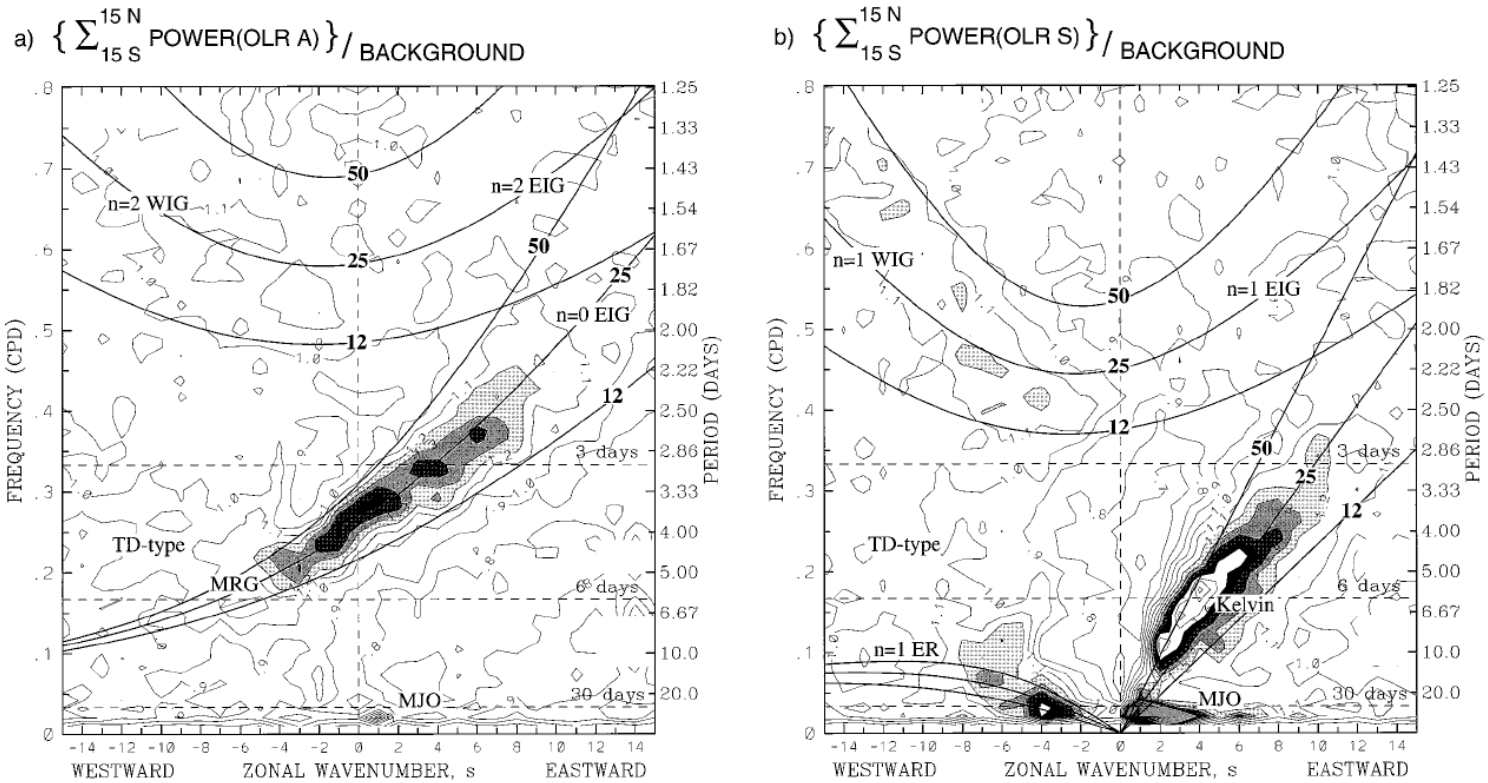
Why study equatorial waves?

Data: Aqua daily cloud top temperature between 15N and 15S from 2003 to 2007



Gill, 1982

Equatorial Waves



Wheeler and Kiladis (1999)

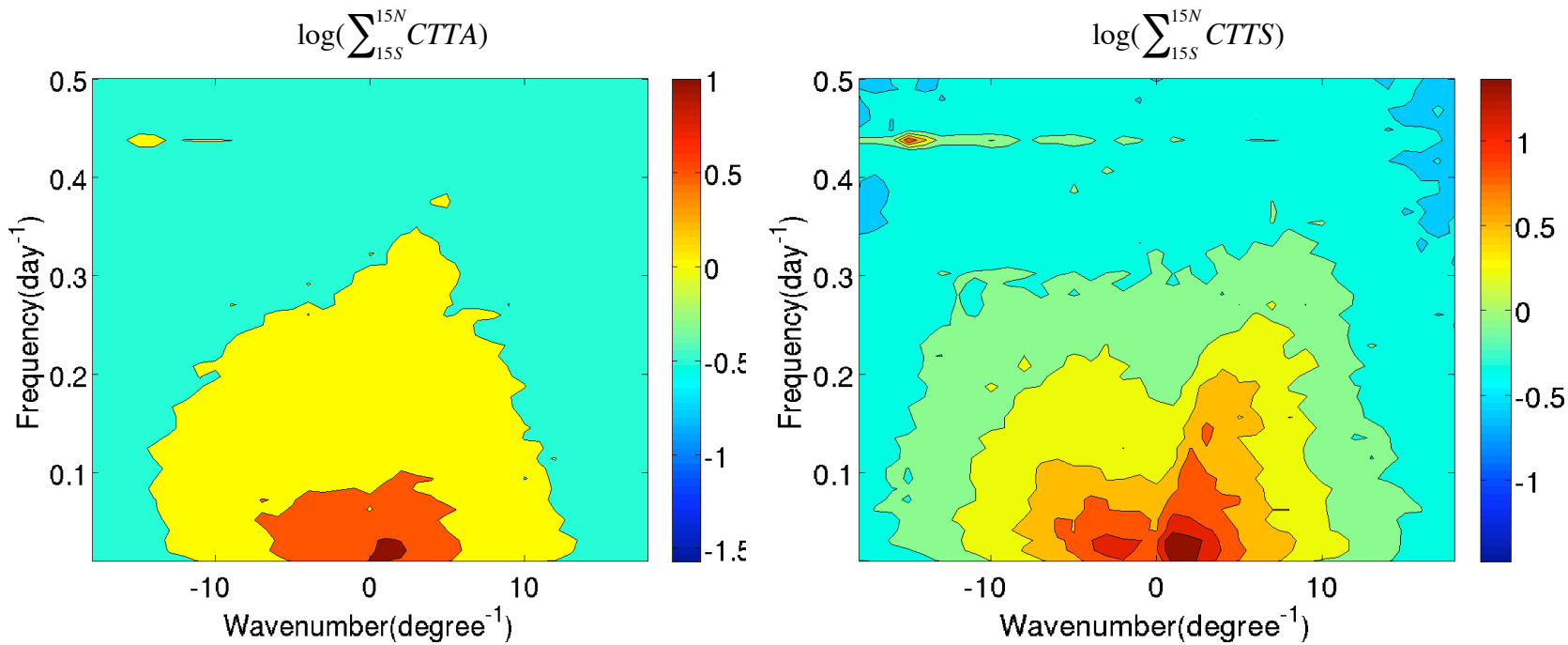
Can we detect equatorial waves from MODIS data?

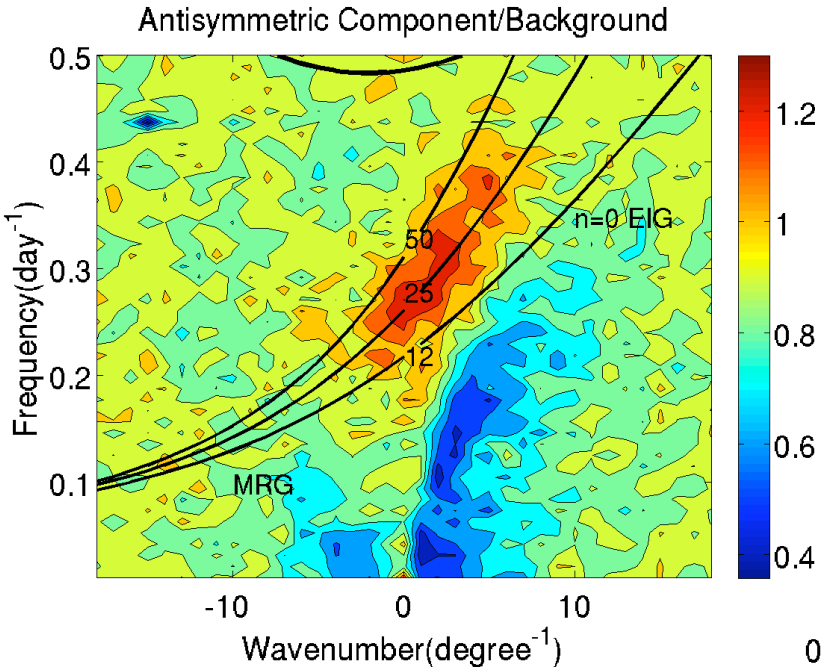
To get the wavenumber-frequency spectrum, we applied **Fourier transform** twice in both time and space.

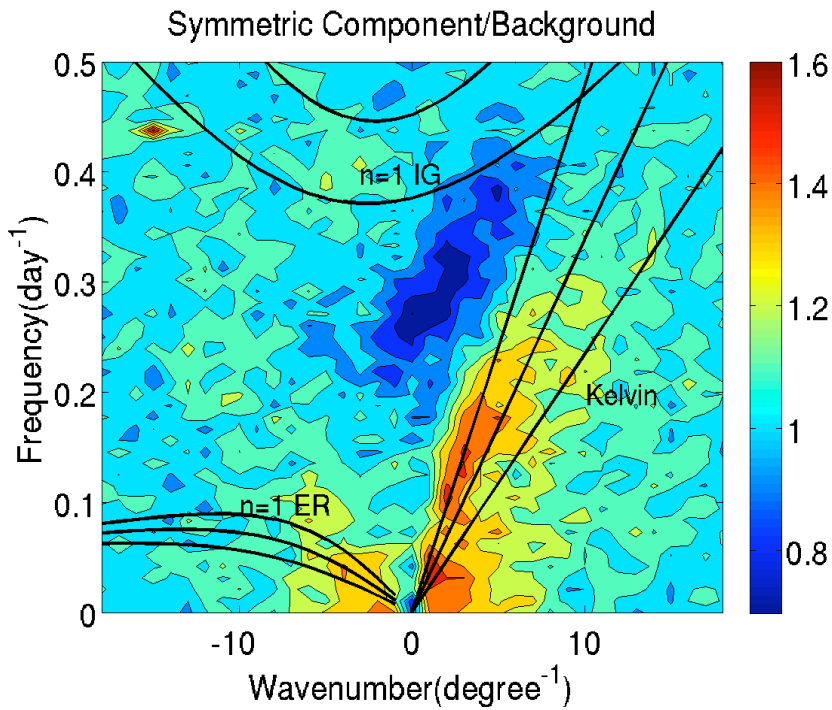
For each grid, we make use of the antisymmetric-symmetric characteristics of the equatorial waves.
Define antisymmetric-symmetric components:

$$CTTA(\Phi) = (CTT(\Phi) - CTT(-\Phi))/2$$

$$CTTS(\Phi) = (CTT(\Phi) + CTT(-\Phi))/2$$




Antisymmetric Component/Background
Frequency(day^{-1})
Wavenumber(degree^{-1})
n=0 EIG
MRG
50
25
12
0.5
0.4
0.3
0.2
0.1
-10
0
10
1.2
1
0.8
0.6
0.4


Symmetric Component/Background
Frequency(day^{-1})
Wavenumber(degree^{-1})
n=1 IG
Kelvin
n=1 ER
0.5
0.4
0.3
0.2
0.1
0
-10
0
10
1.6
1.4
1.2
1
0.8

Summary

- The MODIS estimates higher values than CERES-MODIS, based on the monthly means of MODIS daytime only and CERES-MODIS day and night cloud products
- Zonal distributions of cloud fraction, ice water path, liquid water path and cloud optical depth are consistent between the MODIS and CERES-MODIS
- Ice and water particle effective radii show inconsistent patterns, particularly in the tropics
- The CAM simulations agree reasonably well with the observed zonal distributions of cloud fraction and tropical liquid water path
- Ice particle effective radii are significantly overestimated in model simulation
- MODIS data is capable of detecting equatorial waves