# Cloud Property Comparisons Among CERES, CALIPSO Version 3 and CALIPSO Version 2

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# Outline

- References for CERES cloud retrievals
- Data used for the cloud property comparisons
- Cloud top height comparisons
- Cloud column optical depth comparisons
- Summary

# References for CERES Cloud Retrievals

*Minnis et al.*

*CERES Edition-2 Cloud Property Retrievals Using TRMM VIRS, Terra and Aqua MODIS data.*

*Part I: Algorithms. Submitted to TGRS Dec 2009, currently in review.*

*Part II: Examples of Average Results and Comparison with other. Submitted to TGRS Feb 2010, currently in review.*

# DATA

## C3M (CALIPSO, CloudSat, CERES, MODIS)

**Collocate:**

**Aqua - MODIS:**

**L1B --- MAC02 ( radiance )**
**L1B --- MAC03 ( geolocation )**
**L2 --- MAC04 ( aerosol )**

**CALIPSO:**

**L2 --- Vertical Feature Mask ( VFM )**
**L2 --- 5 km Cloud Profile ( 05kmCPro )**
**L2 --- 5 km Aerosol Layer ( 05kmALay )**
**L2 --- 5 km Cloud Layer ( 05kmALay )**

**CloudSat:**

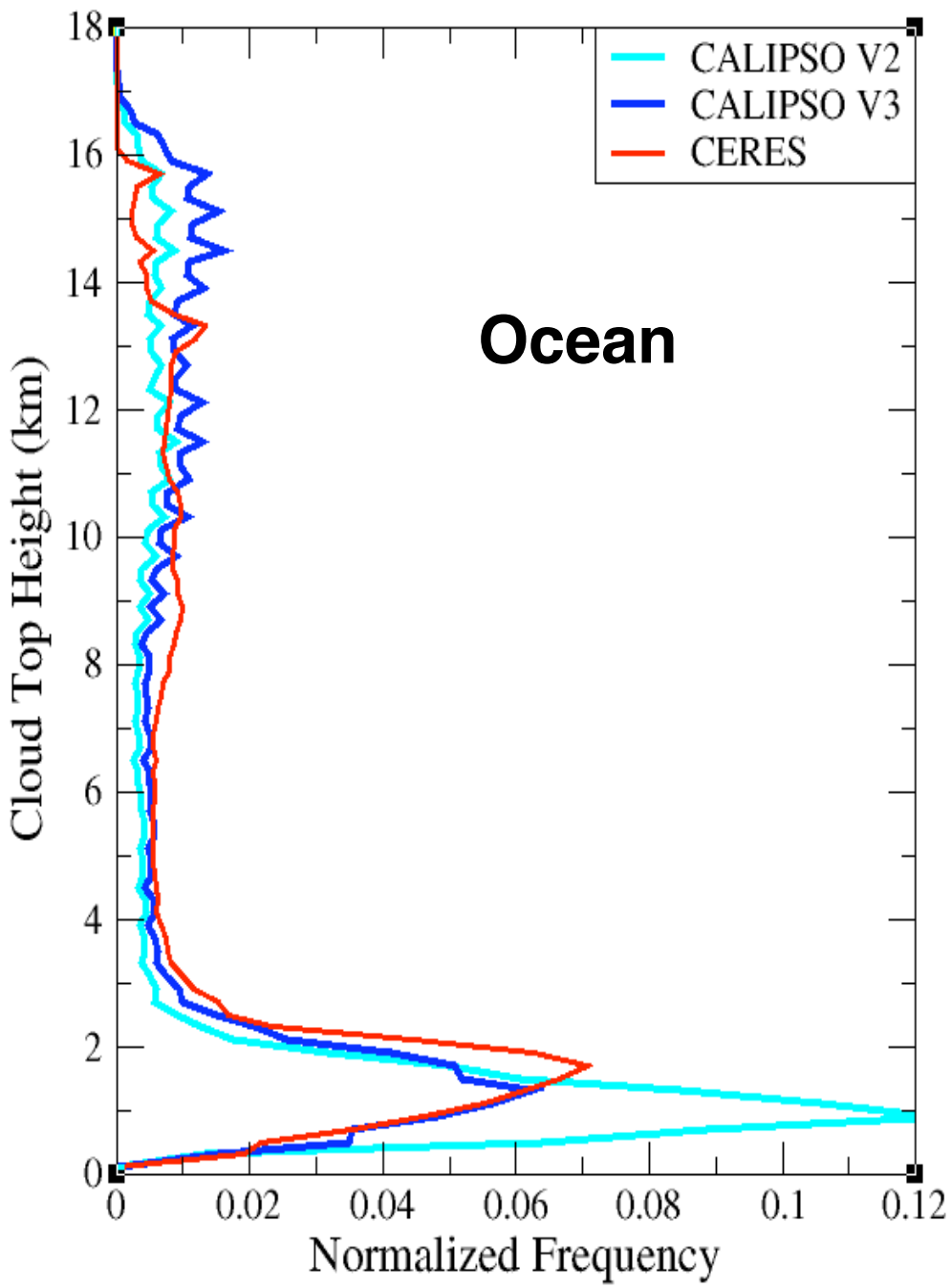
**L2 --- Cloud Scenario Classifi. ( CLDCLASS )**
**L2 --- Cloud Water Content ( 2B-CWC-RO )**

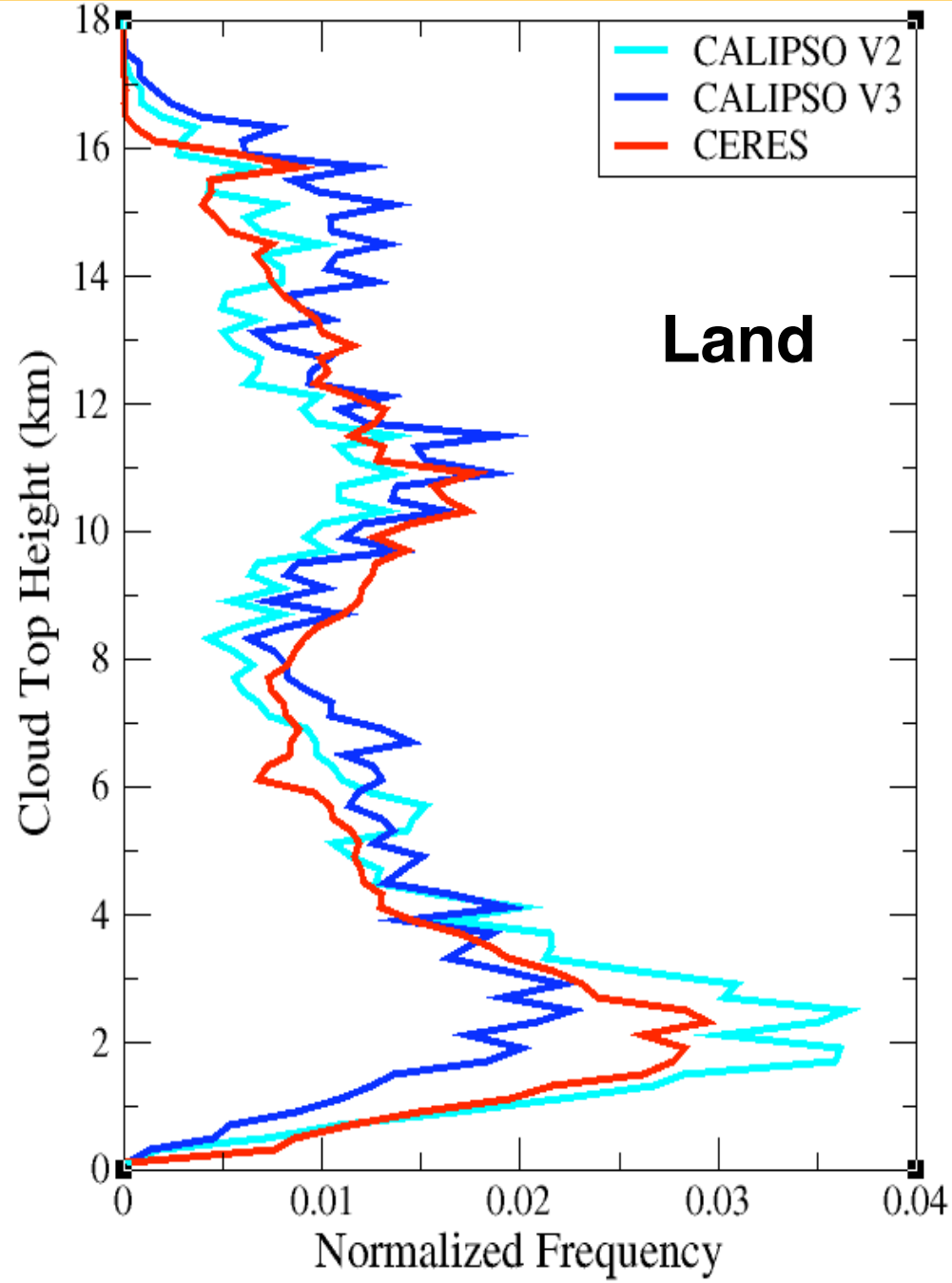
**Contain:**

1. CERES derived cloud properties with MODIS data
2. CERES TOA radiative flux (SW, LW, and WN)
3. Vertical radiative flux profiles
4. Heating rate vertical profiles

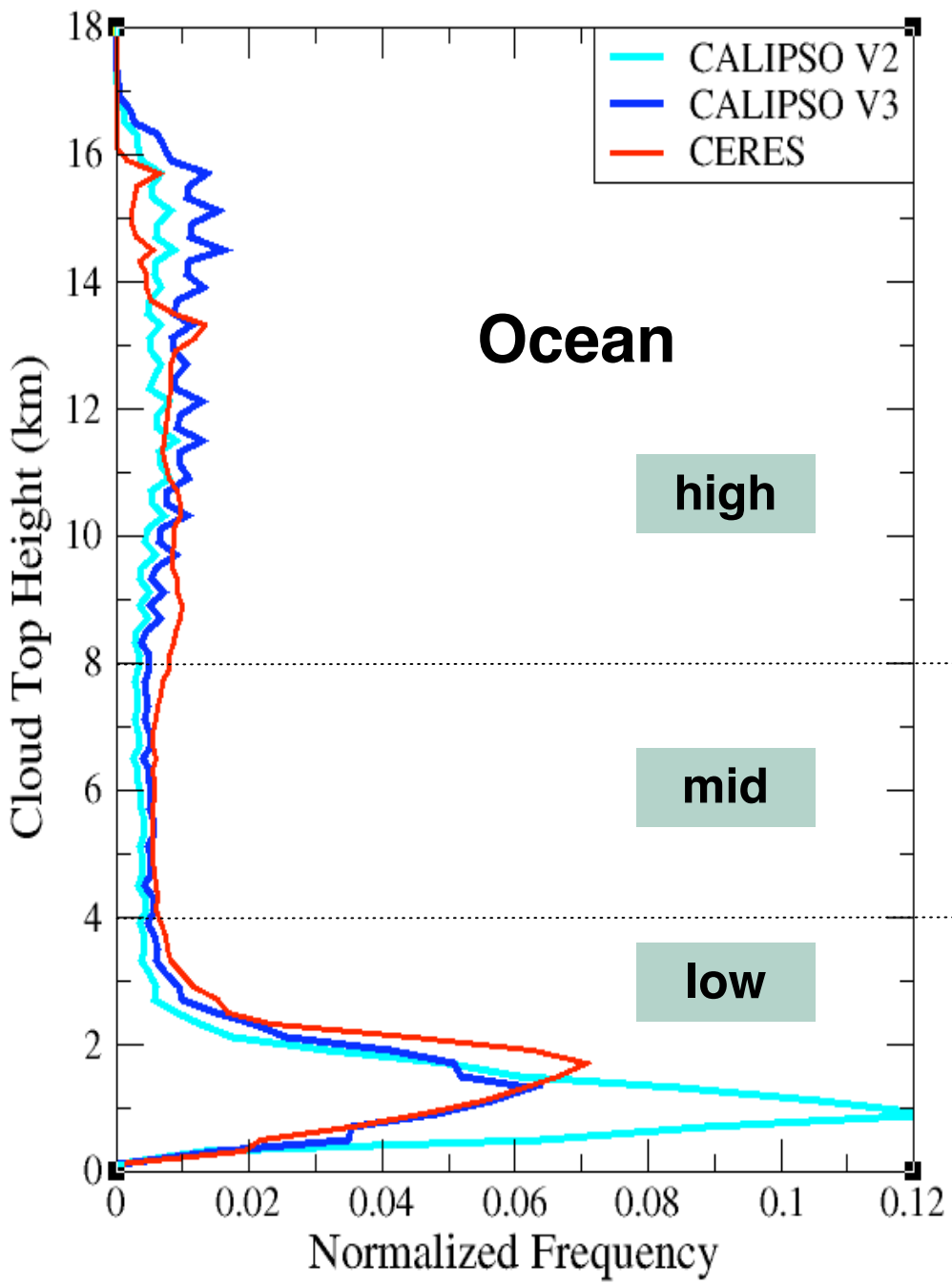
# Cloud Top Height Comparisons

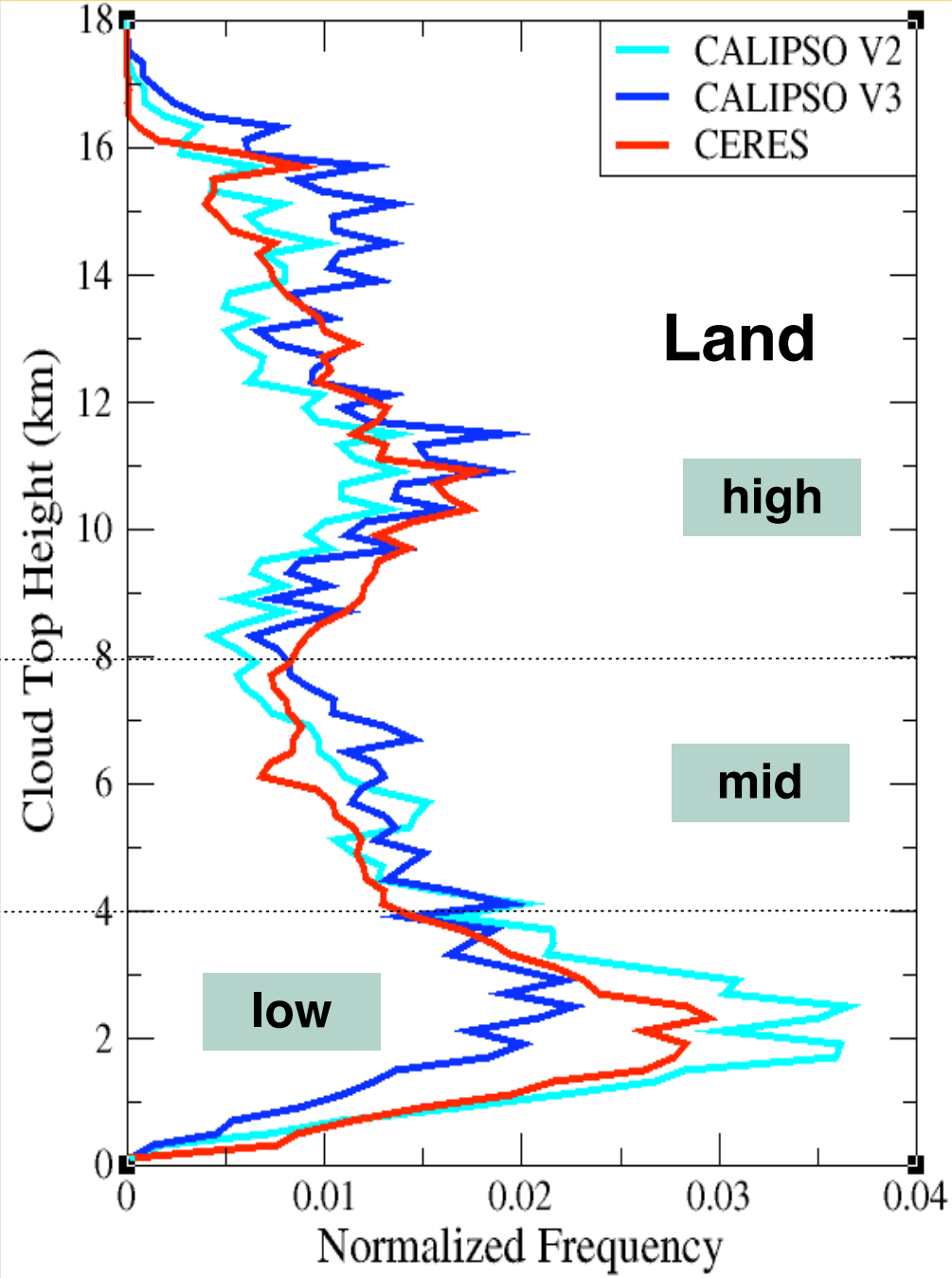
# Cloud Top Height Histogram
# ATrain C3M, July 2008, Single Layer, Non-Polar, Day Time



# Cloud Top Height Histogram
## ATrain C3M, July 2008, Single Layer, Non-Polar, Day Time



## Agreement and Disagreement in Cloud Top Heights (%) between CALIPSO V3 and CERES

| CERES \ CALIPSO | **Low** (0-4 km) (%) | **Mid** (4-8 km) (%) | **High** (8-18km) (%) |
|---|---|---|---|
| **Low** (0-4 km) | 83 | 24 | 23 |
| **Mid** (4-8 km) | 4 | 44 | 9 |
| **High** (8-18km) | 1 | 14 | 60 |
| **No Retrieval** | 2 | 5 | 6 |
| **Clear** | 10 | 13 | 14 |

**Non-polar**

**ATrain C3M**

**July 2008**

**Single Layer**

**Day Time**

| CERES \ CALIPSO | **Low** (0-4 km) (%) | **Mid** (4-8 km) (%) | **High** (8-18km) (%) |
|---|---|---|---|
| **Low** (0-4 km) | 80 | 16 | 8 |
| **Mid** (4-8 km) | 6 | 51 | 6 |
| **High** (8-18km) | 1 | 20 | 63 |
| **No Retrieval** | 0 | 0 | 0 |
| **Clear** | 13 | 13 | 23 |

**Night Time**

## Agreement and Disagreement in Cloud Top Heights (%) between CALIPSO V3 and CERES

| CALIPSO / CERES | Low (0-4 km) (%) | Mid (4-8 km) (%) | High (8-18km) (%) |
|---|---|---|---|
| Low (0-4 km) | 84 | 36 | 17 |
| Mid (4-8 km) | 5 | 33 | 13 |
| High (8-18km) | 1 | 11 | 22 |
| No Retrieval | 2 | 7 | 15 |
| Clear | 8 | 13 | 33 |

**Polar**

**ATrain C3M**
**July 2008**
**Single Layer**

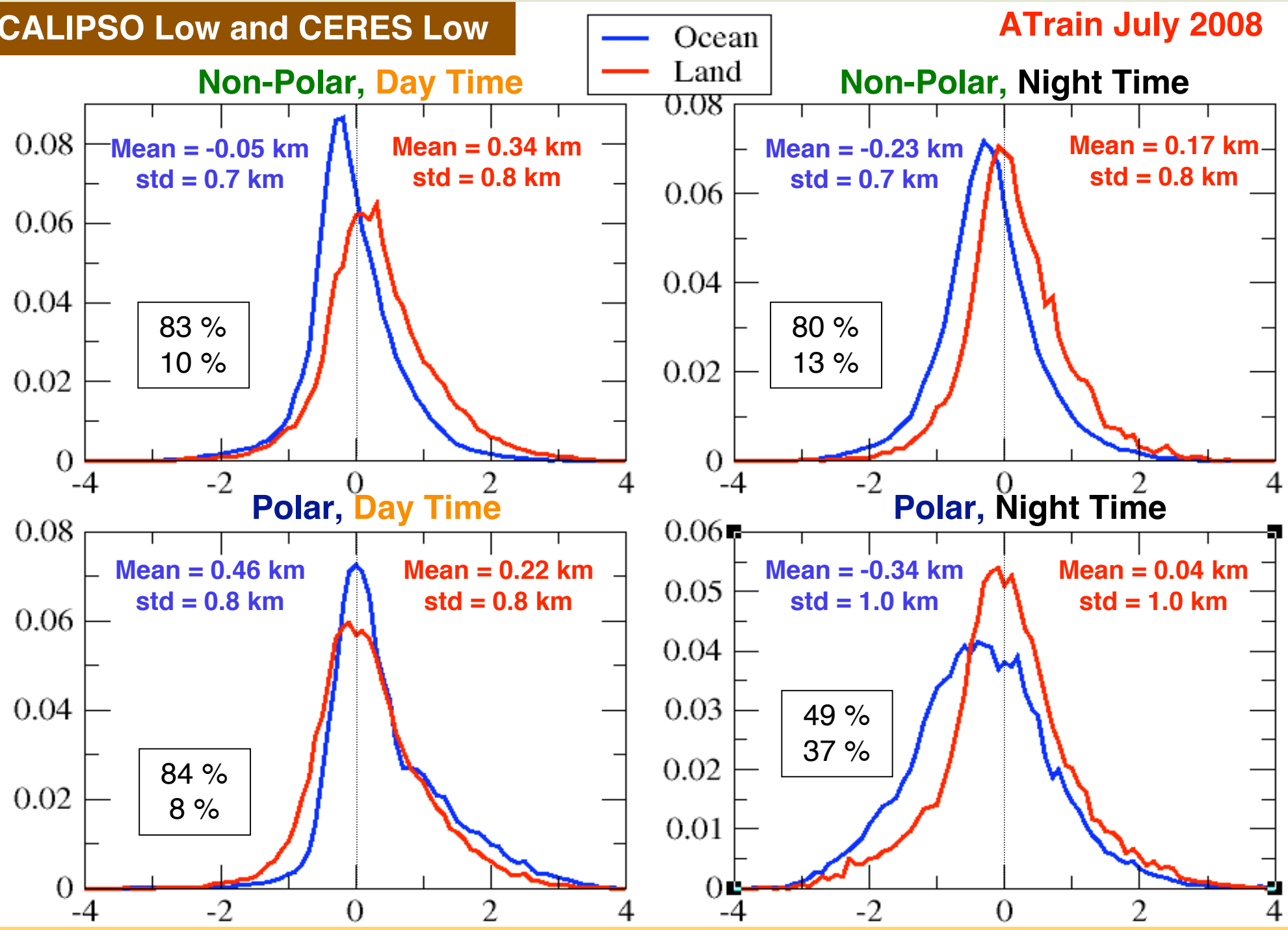
**Day Time**

| CALIPSO / CERES | Low (0-4 km) (%) | Mid (4-8 km) (%) | High (8-18km) (%) |
|---|---|---|---|
| Low (0-4 km) | 49 | 15 | 12 |
| Mid (4-8 km) | 12 | 44 | 26 |
| High (8-18km) | 2 | 10 | 37 |
| No Retrieval | 0 | 0 | 0 |
| Clear | 37 | 31 | 25 |

**Night Time**

# CALIPSO Low and CERES Low

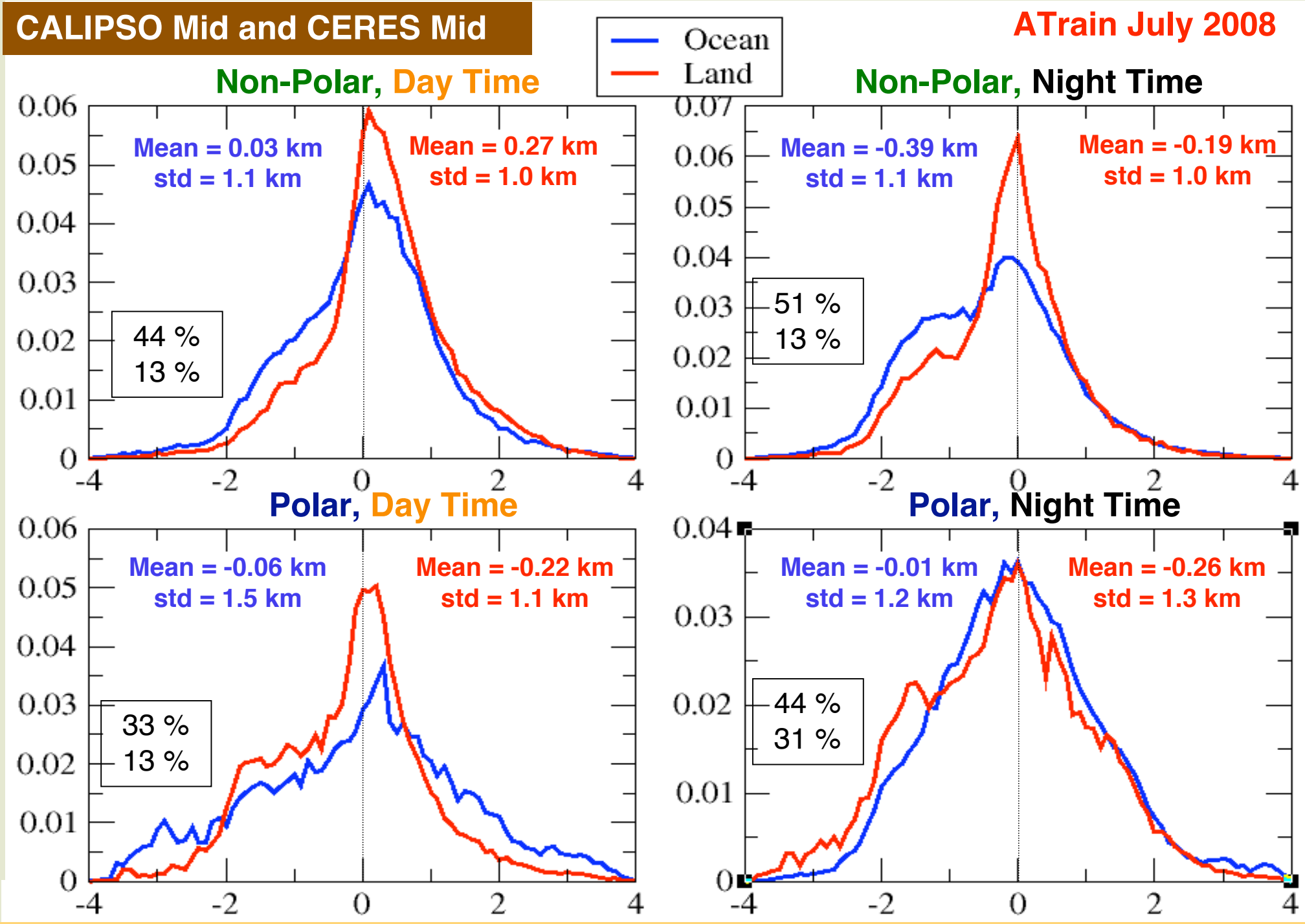
ATrain July 2008




**Cloud Top Height Difference (CALIPOS - CERES) (km) for Both Low clouds**

# CALIPSO Mid and CERES Mid

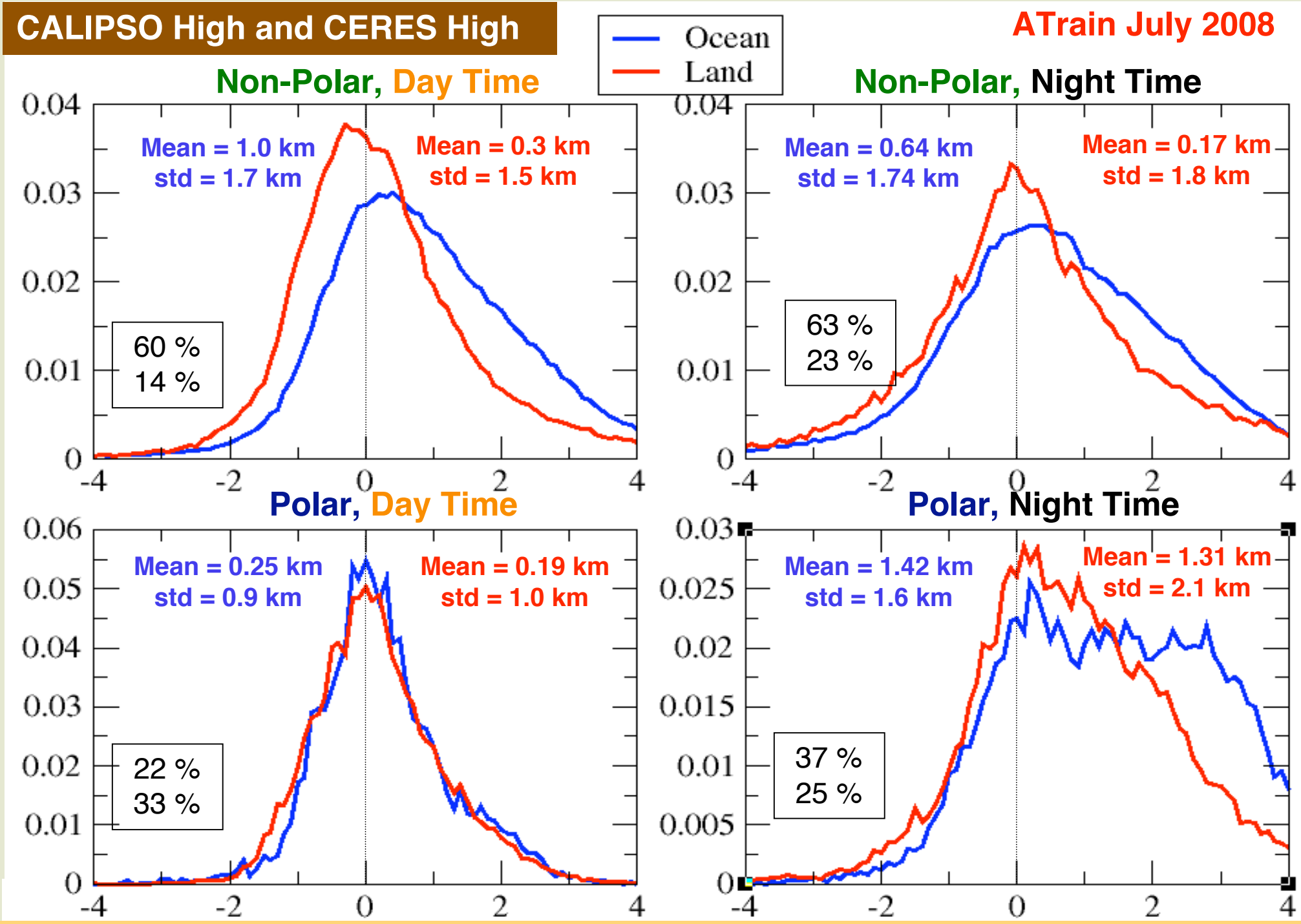
ATrain July 2008



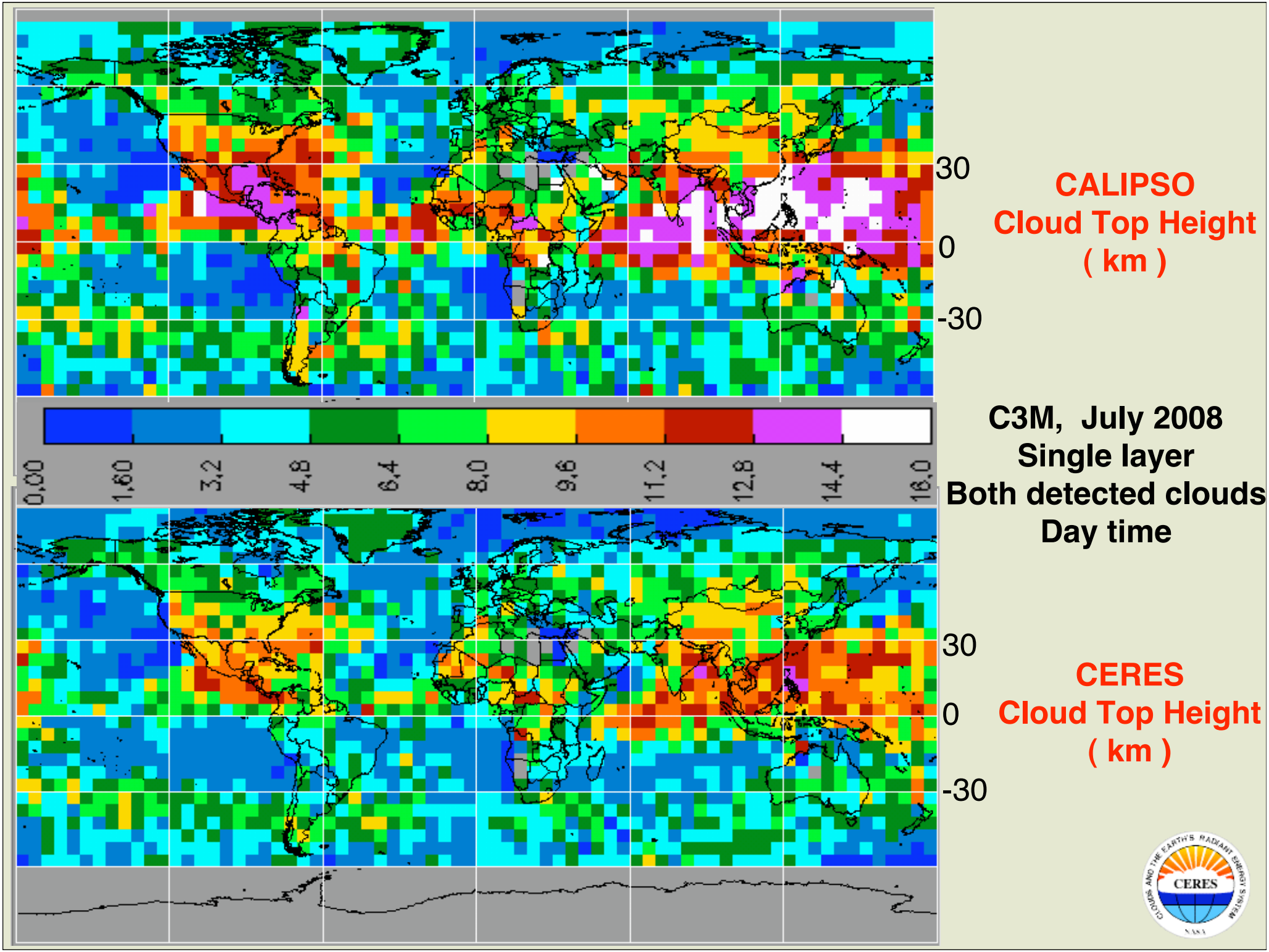

**Cloud Top Height Difference (CALIPOS - CERES) (km) for Both Mid Level clouds**

# CALIPSO High and CERES High

ATrain July 2008




**Cloud Top Height Difference (CALIPOS - CERES) (km) for Both High clouds**




**CALIPSO**
**Cloud Top Height**
**( km )**

**C3M, July 2008**
**Single layer**
**Both detected clouds**
**Day time**

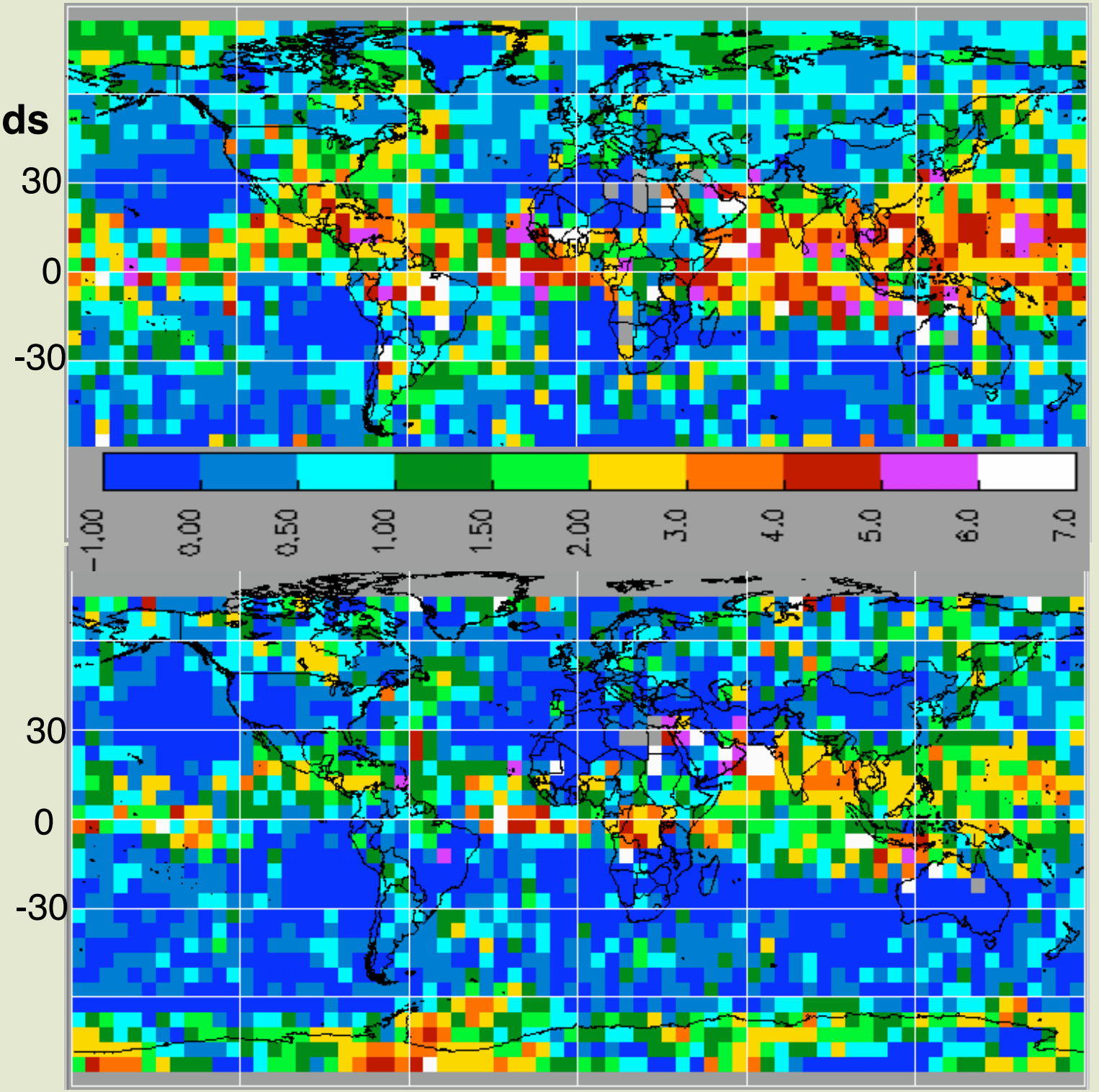
**CERES**
**Cloud Top Height**
**( km )**

# C3M, July 2008
# Single layer
# Both detected clouds

## Day time

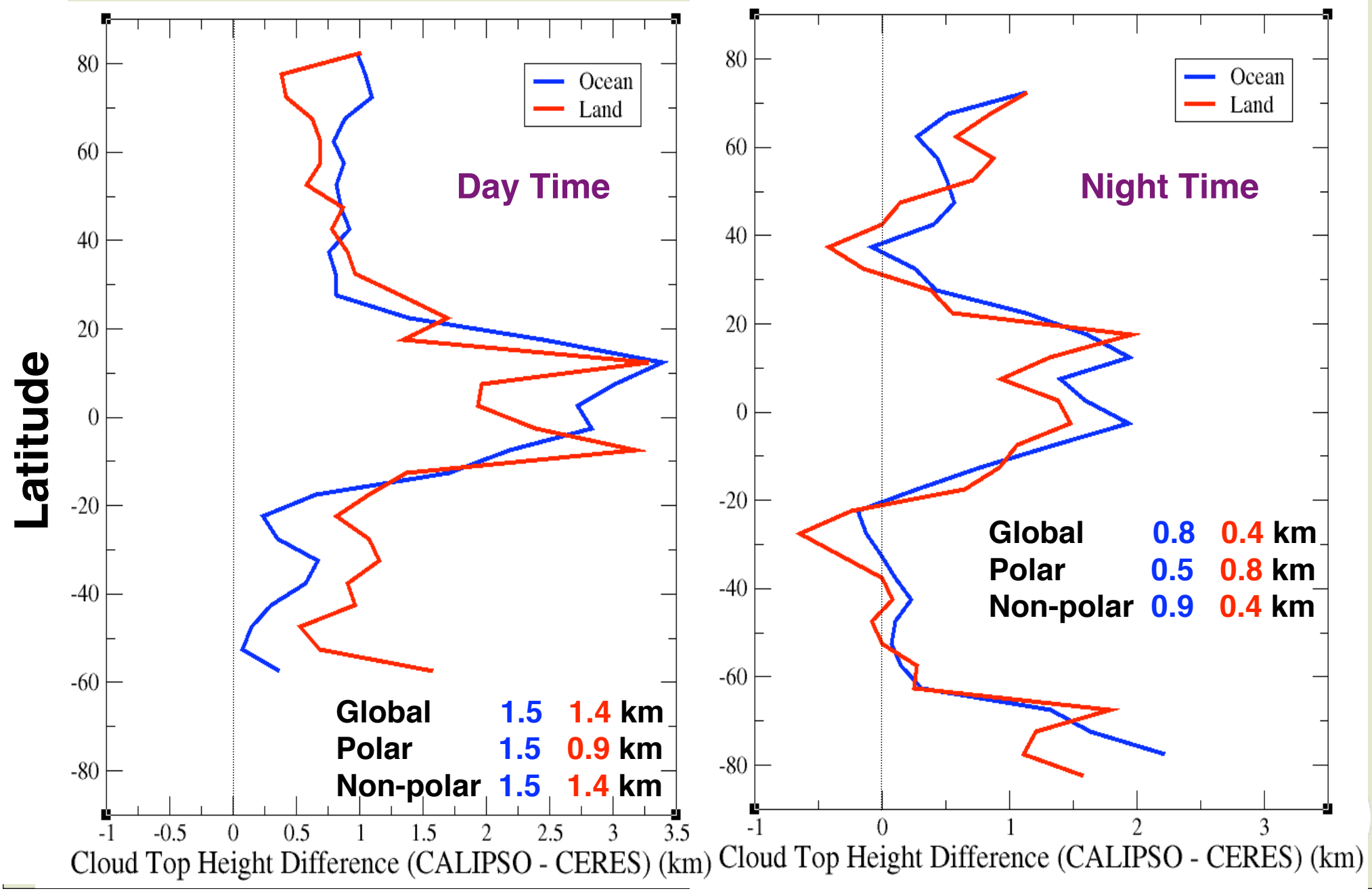
## Cloud Top Height Difference (CALIPSO – CERES) ( km )

## Night time



# C3M, July 2008, Single layer, Both detected clouds

## Zonal Cloud Top Height Difference (CALIPSO – CERES) ( km )



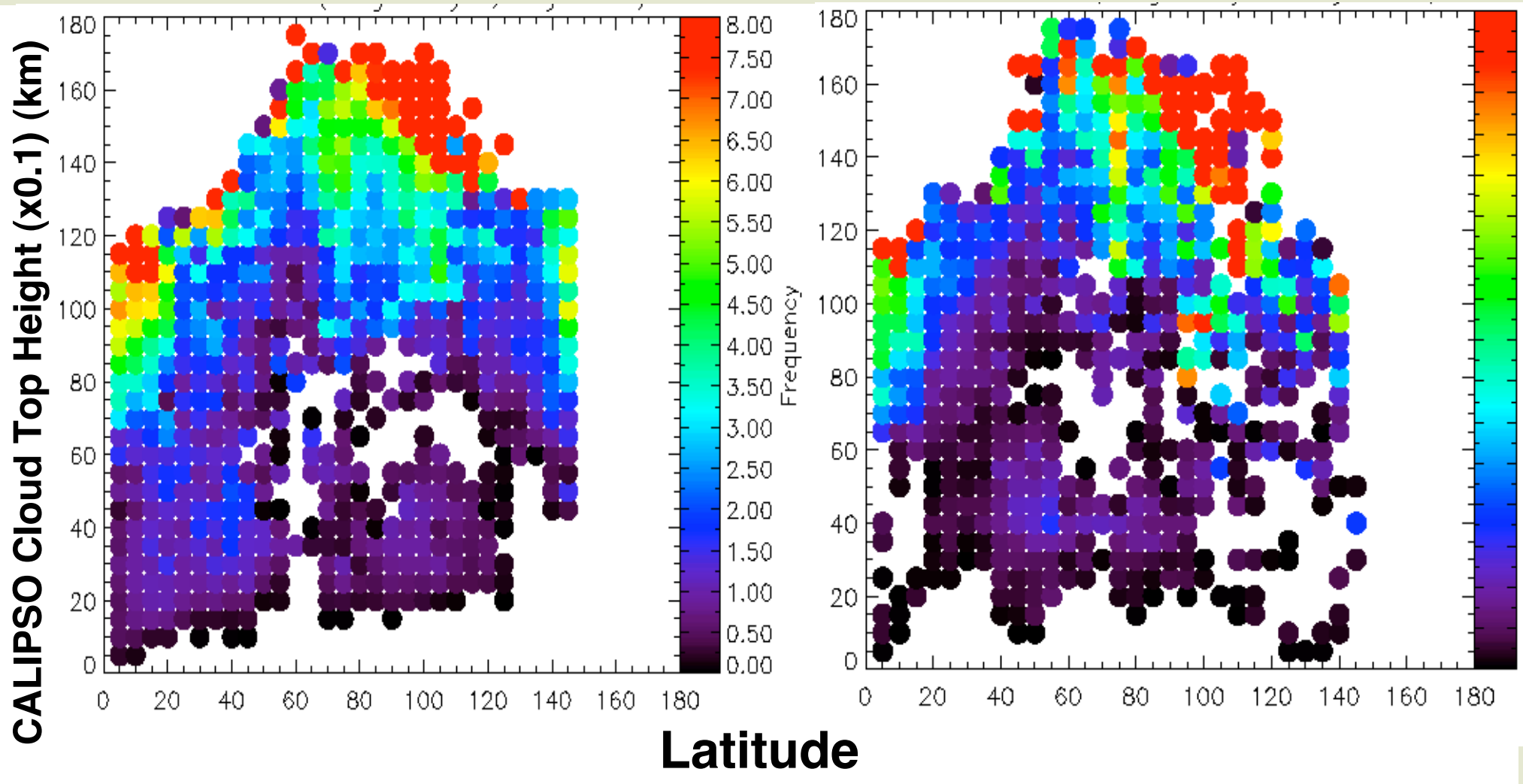
# Cloud Top Height Difference (CALIPSO – CERES) (km)

## C3M, July 2008, Single Layer

## Day Time

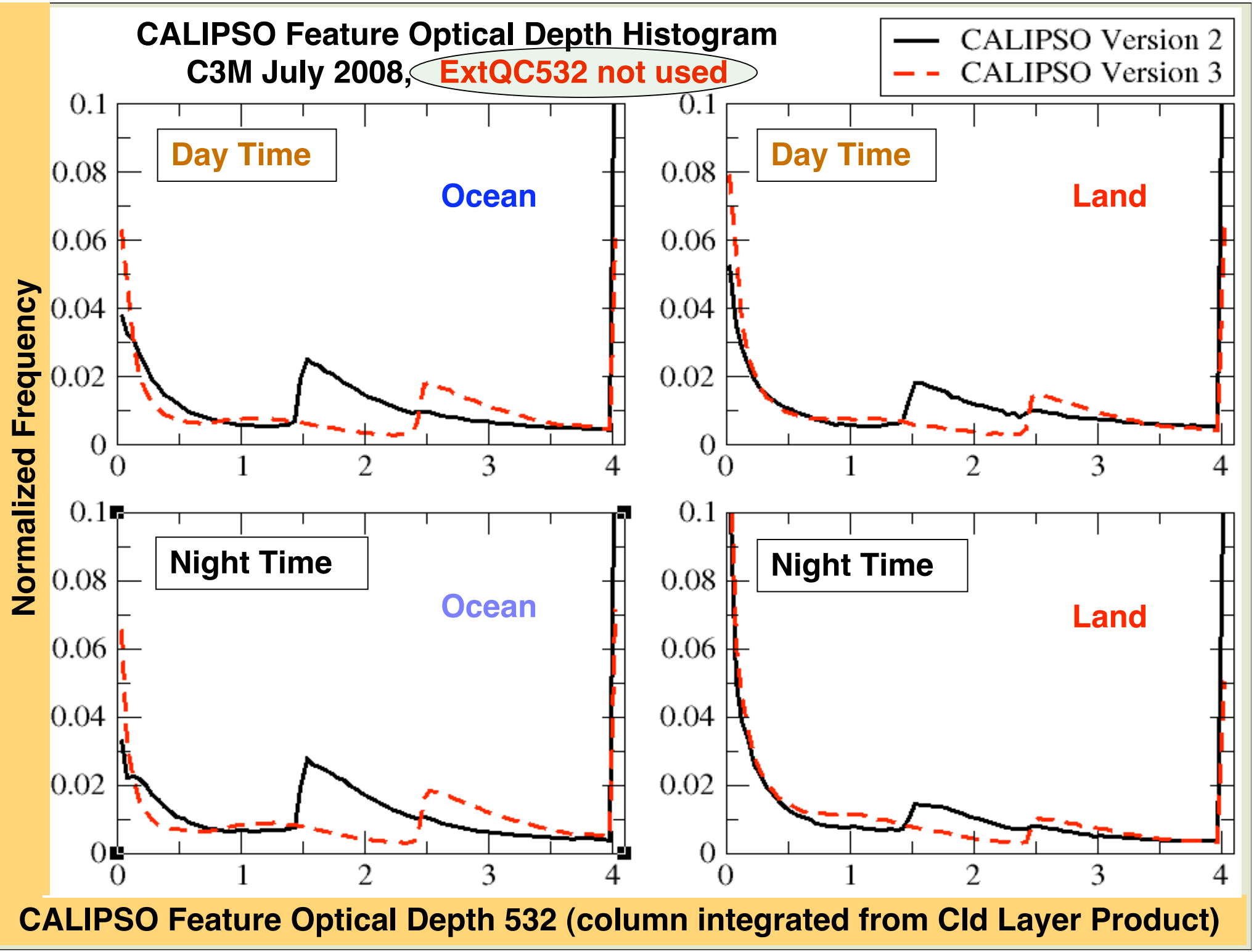
ocean

land



# Column Cloud Optical Depth Comparisons

- **CALIPSO Version 3 vs Version 2**

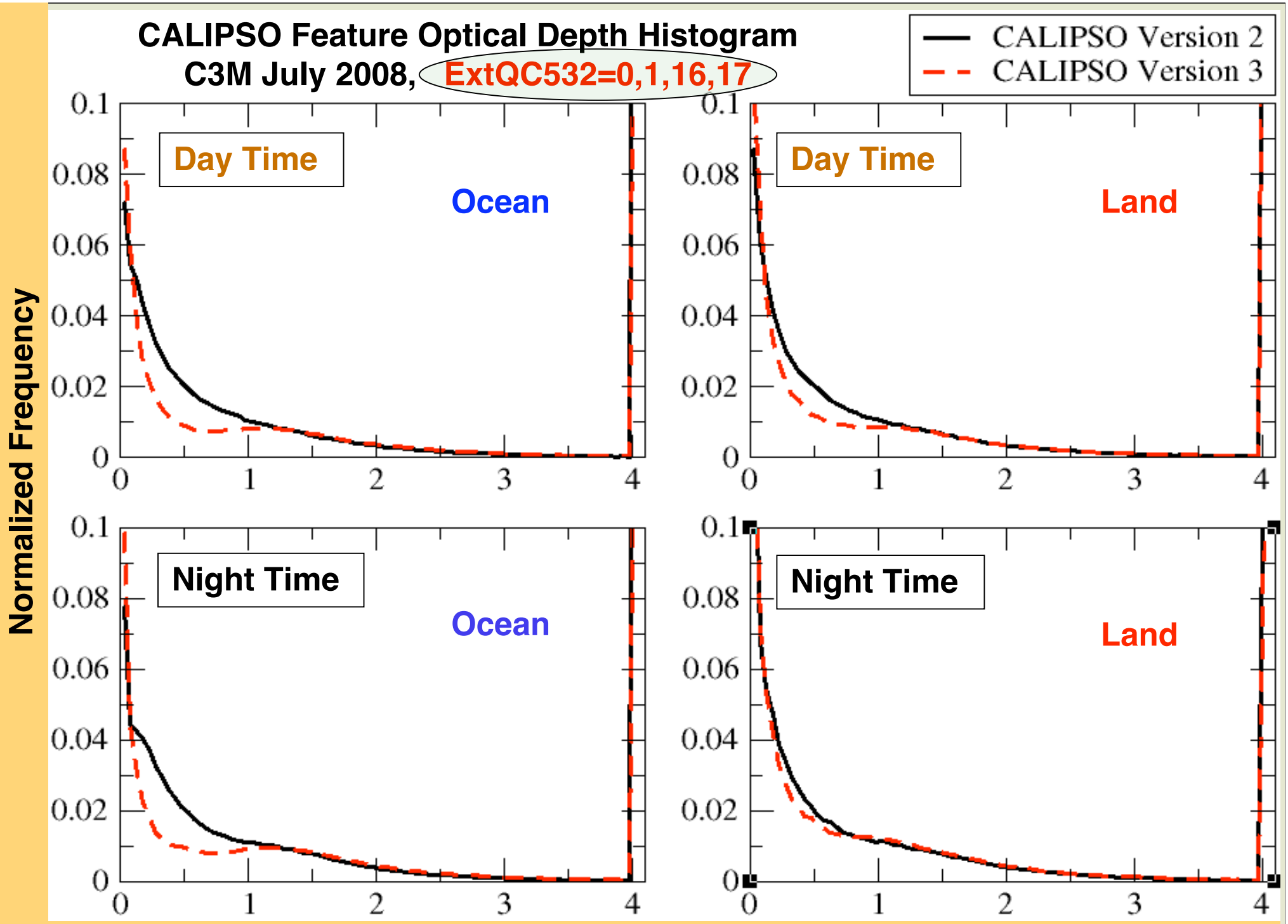

CALIPSO Feature Optical Depth Histogram
C3M July 2008, ExtQC532 not used
CALIPSO Version 2
CALIPSO Version 3
Day Time
Ocean
Day Time
Land
Night Time
Ocean
Night Time
Land
Normalized Frequency
0.1
0.08
0.06
0.04
0.02
0
0
1
2
3
4
CALIPSO Feature Optical Depth 532 (column integrated from Cld Layer Product)

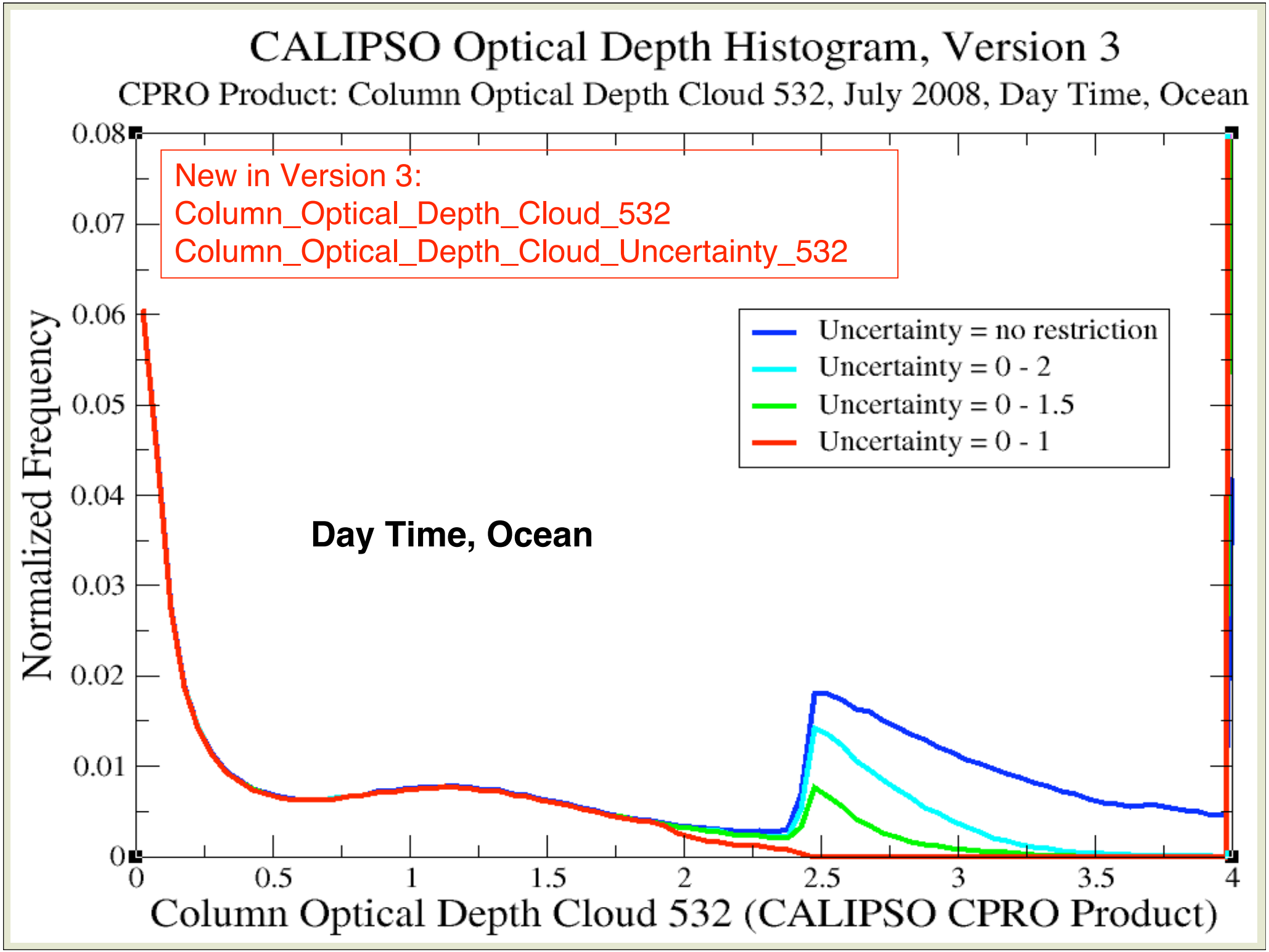
# CALIPSO Version 3 Quality Statement

## Extinction QC Flag 532

| Bit | Value | Interpretation |
|---|---|---|
| 1 | 0 | unconstrained retrieval; initial lidar ratio unchanged during solution process |
| 1 | 1 | constrained retrieval |
| 2 | 2 | Initial lidar ratio reduced to prevent divergence of extinction solution |
| 3 | 4 | Initial lidar ratio increased to reduce the number of negative extinction coefficients in the derived solution |
| 4 | 8 | Calculated backscatter coefficient exceeds the maximum allowable value |
| 5 | 16 | Layer being analyzed has been identified by the feature finder as being totally attenuating (i.e., opaque) |
| 6 | 32 | Estimated optical depth error exceeds the maximum allowable value |
| 7 | 64 | Solution converges, but with an unacceptably large number of negative values |
| 8 | 128 | Retrieval terminated at maximum iterations |
| 9 | 256 | No solution possible within allowable lidar ratio bounds |
| 16 | 32768 | Fill value or no solution attempted |

**The bits assignments are additive.**


CALIPSO Feature Optical Depth Histogram
C3M July 2008, ExtQC532=0,1,16,17
CALIPSO Version 2
CALIPSO Version 3
Day Time
Ocean
Day Time
Land
Night Time
Ocean
Night Time
Land
Normalized Frequency
0.1
0.08
0.06
0.04
0.02
0
0
1
2
3
4
CALIPSO Feature Optical Depth 532 (column integrated from Cld Layer Product)


CALIPSO Optical Depth Histogram, Version 3
CPRO Product: Column Optical Depth Cloud 532, July 2008, Day Time, Ocean
New in Version 3:
Column_Optical_Depth_Cloud_532
Column_Optical_Depth_Cloud_Uncertainty_532
Uncertainty = no restriction
Uncertainty = 0 - 2
Uncertainty = 0 - 1.5
Uncertainty = 0 - 1
Day Time, Ocean
Normalized Frequency
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Column Optical Depth Cloud 532 (CALIPSO CPRO Product)

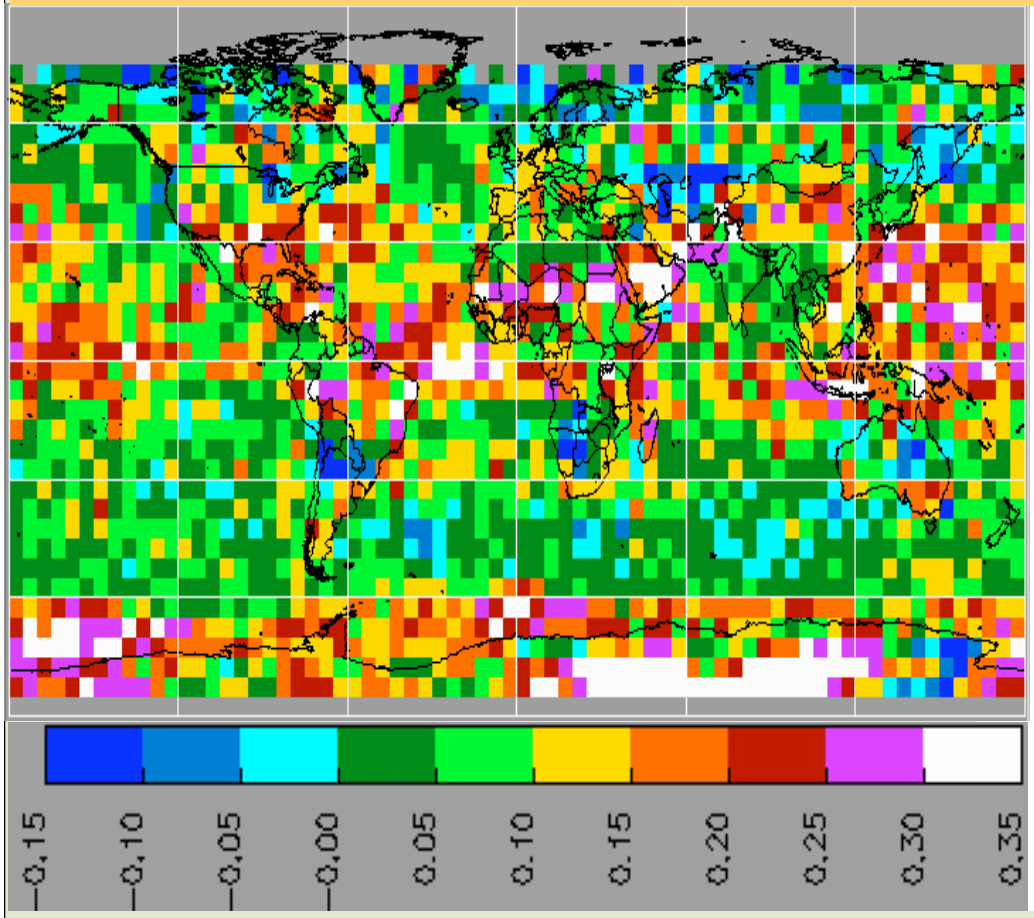
# Optical Depth Distributions for all CALIPSO Detected Cloud

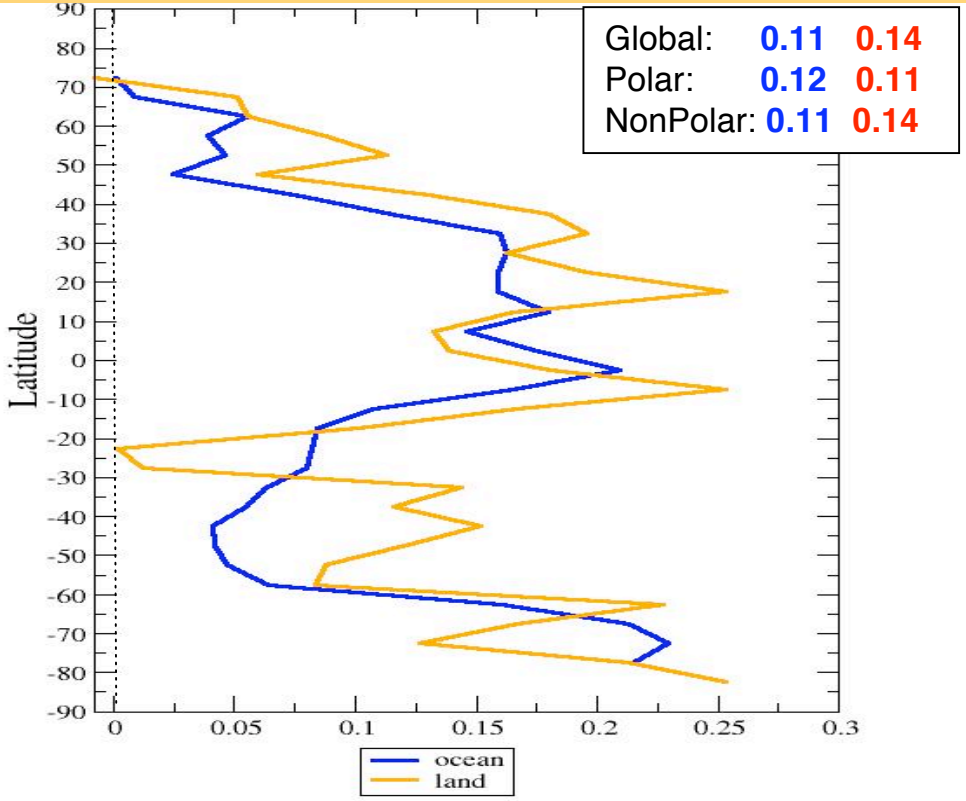
## C3M, July 2008

| Ocean | Day | Day | Night | Night |
|---|---|---|---|---|
| | Version 2 | Version 3 | Version 2 | Version 3 |
| Optical Depth | 4,089,483 | 3,313,896 (81%) | 4,528,947 | 3,744,702 (83 %) |
| Tau < 1.5 | 61 % | 55 % | 61 % | 54 % |
| 1.5 < Tau < 4 | 9 % | 13 % | 10 % | 15 % |
| Tau > 4 | 30 % | 32 % | 29 % | 31 % |

| Land | Day | Day | Night | Night |
|---|---|---|---|---|
| | Version 2 | Version 3 | Version 2 | Version 3 |
| Optical Depth | 1,639,370 | 1,376,061 (84%) | 2,255,267 | 2,150,331 (83 %) |
| Tau < 1.5 | 62 % | 65 % | 74 % | 74 % |
| 1.5 < Tau < 4 | 10 % | 12 % | 11 % | 13 % |
| Tau > 4 | 28 % | 23 % | 15 % | 13 % |

# Cloud Fraction Difference (CALIPSO V3 - CERES)
# July 2008, Night Time



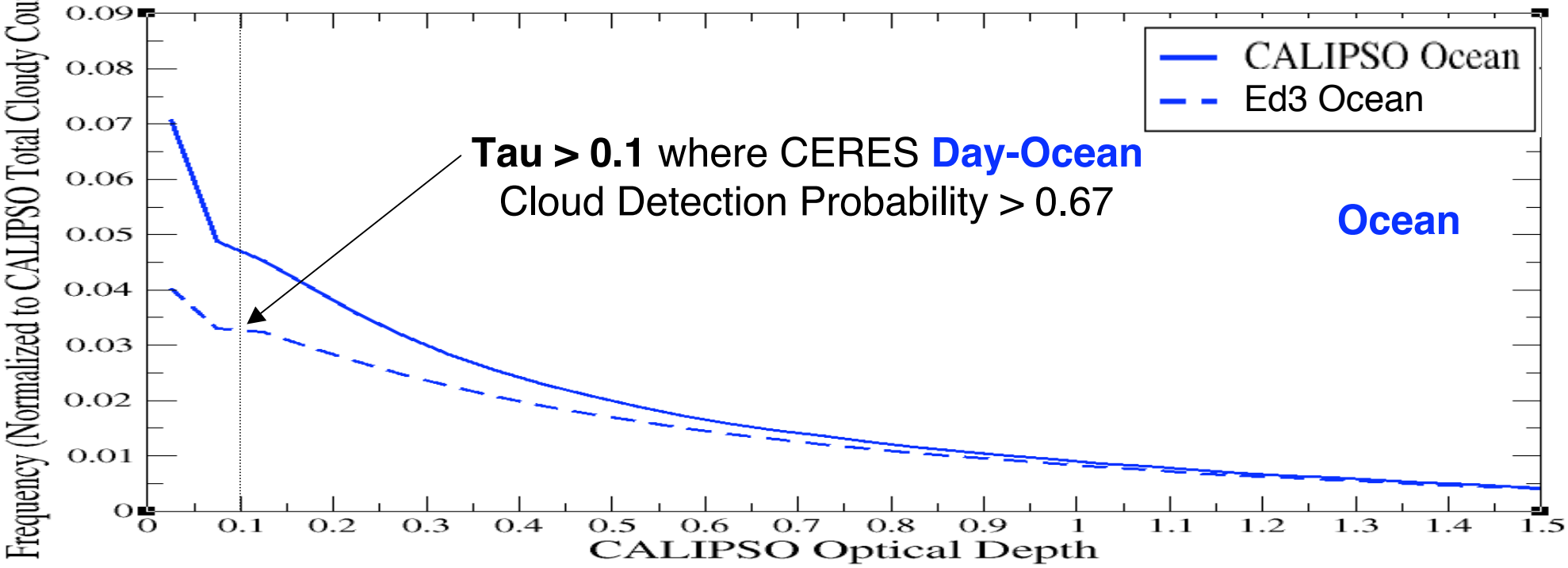



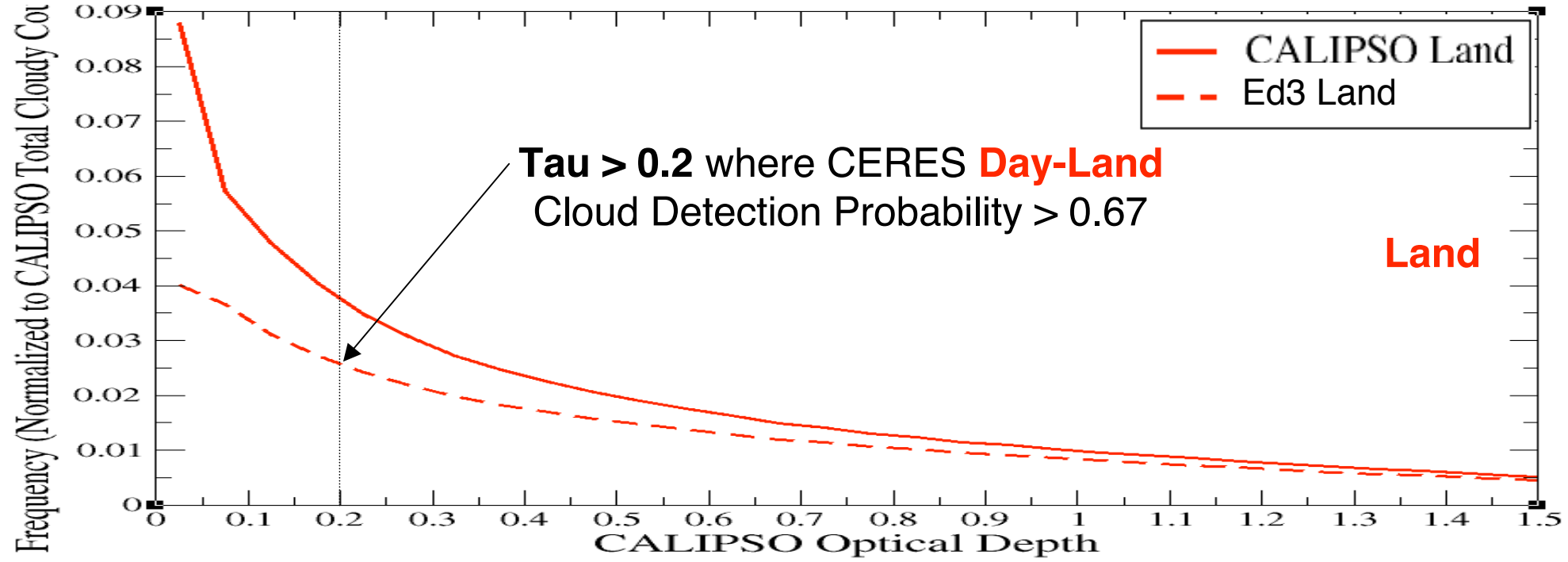

**Cloud Fraction Difference (CALIPSO V3 – CERES)**

**Day Time**

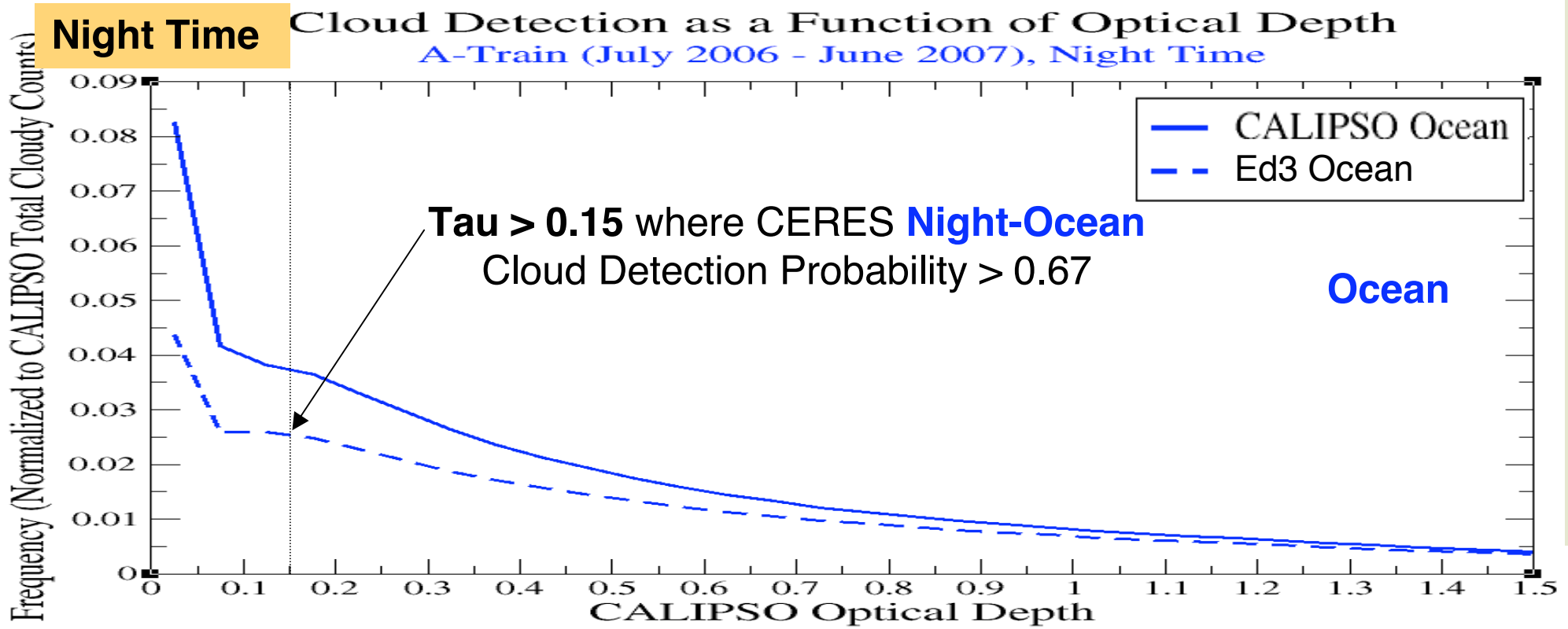
# Cloud Detection as a Function of Optical Depth

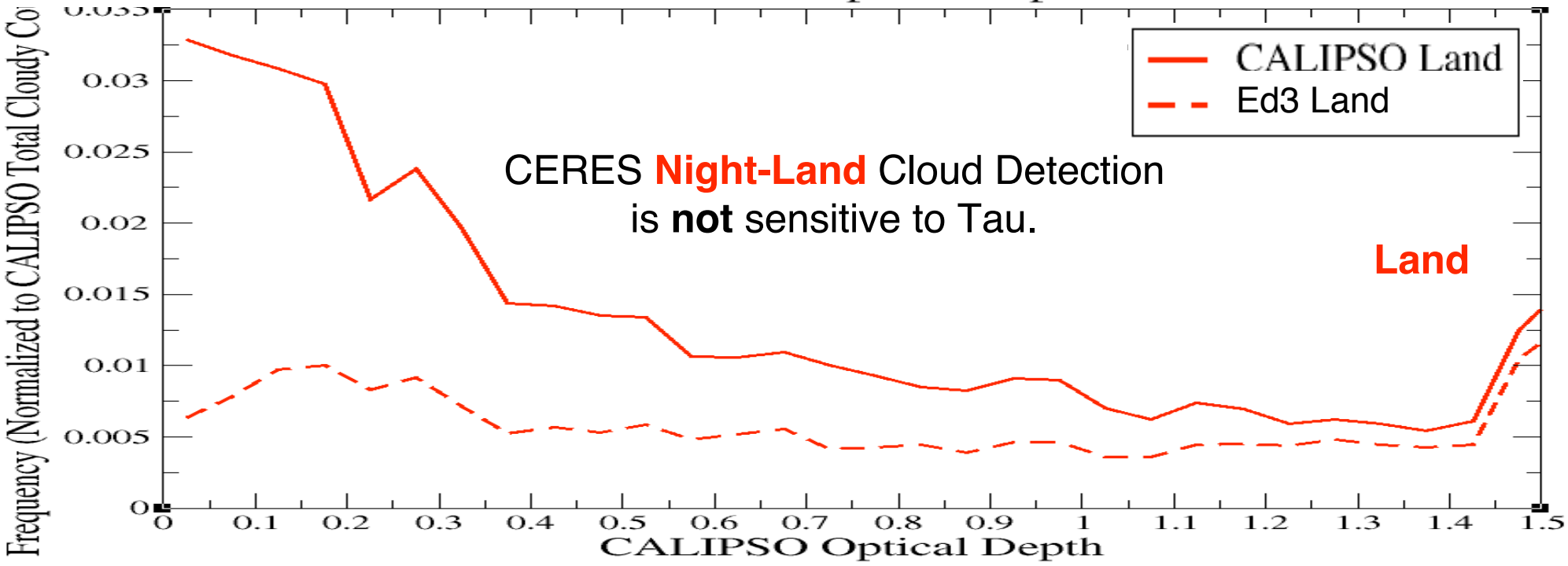
A-Train (July 2006 - June 2007), Day Time



**Night Time**


Cloud Detection as a Function of Optical Depth
A-Train (July 2006 - June 2007), Night Time
Frequency (Normalized to CALIPSO Total Cloudy Counts)
CALIPSO Optical Depth
CALIPSO Ocean
Ed3 Ocean
Tau > 0.15 where CERES Night-Ocean
Cloud Detection Probability > 0.67
Ocean


Frequency (Normalized to CALIPSO Total Cloudy Co
CALIPSO Optical Depth
CALIPSO Land
Ed3 Land
CERES Night-Land Cloud Detection
is not sensitive to Tau.
Land

# Summary

- **CERES Cloud-top height distributions for single layer clouds quite good**
  - Best height matching for low clouds (81%) and high clouds (61%)
  - CERES tops too low (~1.4 km) for high clouds, small tau?

- **CALIPSO V3 vs V2**
  - V3 has fewer clouds
  - V3 has more very thin clouds
  - When using V3 new parameter: Column_Optical_Depth_Cloud_532" in V3, make sure to use "Column_Optical_Depth_Cloud_Uncertainty_532" to remove false Tau.