CERES Multilayer Cloud Property Retrieval Validation Report

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Objective

- Evaluate the performance of the CERES Multilayer cloud properties using the CALIPSO and CloudSat data merged at 1-km MODIS pixel resolution.
- Understand the retrieval constraints of the CERES Multilayer cloud property retrieval algorithms.

CERES-CO_2 Multilayer Cloud Property Retrieval

What CERES ML Retrieves?

- Upper-layer (UL) cloud properties:

  Limited to the retrieval of UL Pc < 550 hPa.
- Overlapping lower-layer (LL) cloud properties:

  Limited to the retrieval of LL Pc > 600 hPa and the separation between UL Pc and LL Pc being greater than 100 hPa.

- UL Pc < 600hPa: retrieved by a modified CO_2 absorption technique;
- UL visible Tau: derived from the UL IR emissivity;
- LL Pc: retrieved and estimated from the nearby region;
- UL and LL, 2-layer cloud properties: retrieved by an iteration scheme.

Cirrus and Multilayer Cloud Fractions from CERES-CO_2 and CALIPSO/CloudSat (CLCS)

1) For all CALIOP cirrus Tau > 0

%	CLCS Multi	CLCS Single
CERES CO_2 Multi	6.4	3.9
CERES CO_2 Single	7.9	7.8
No CO_2	11.2	7.5
Total	25.5	19.2

2) For all CALIPO cirrus Tau > 0.1

%	CLCS Multi	CLCS Single
CERES CO_2 Multi	6.3	3.9
CERES CO_2 Single	7.2	7.5
No CO_2	4.2	2.5
Total	17.7	13.9

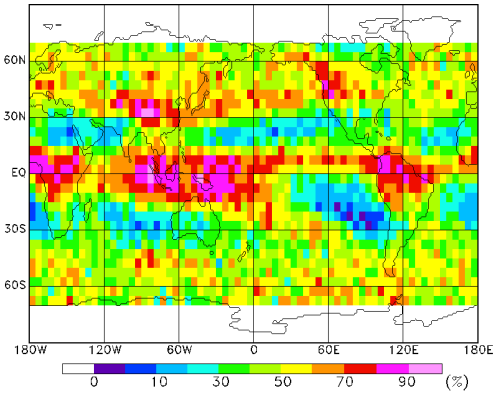
3) For all CALIOP cirrus Tau > 0.3

%	CLCS Multi	CLCS Single
CERES CO_2-Multi	6.1	3.8
CERES CO_2-Single	5.7	6.7
No CO_2	1.4	0.8
Total	13.2	11.3

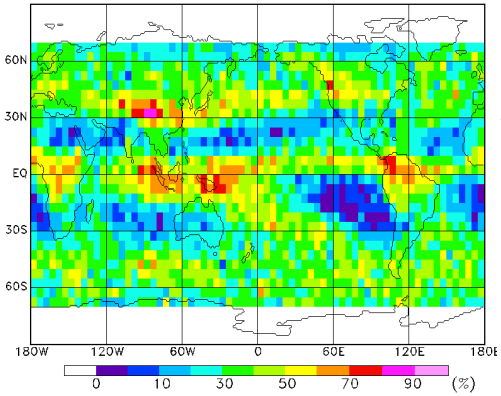
- CERES CO_2-multilayer fractions were ~10%.
- CLCS multilayer fractions were ~26%, ~18% and ~13% for cirrus Tau greater than 0.0, 0.1 and 0.3, respectively.
- CERES CO_2-multilayer and CLCS multilayer fractions matched at ~6%.

Cirrus and Multilayer Cloud Fractions from CALIPSO/CloudSat and CERES-CO_2

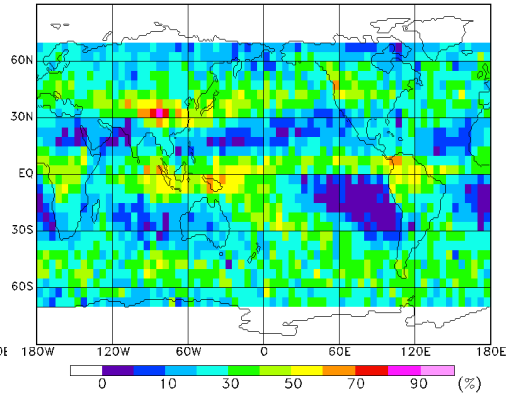
1) CALIOP Cirrus Tau > 0.
CLCS Cirrus Fraction ~47%



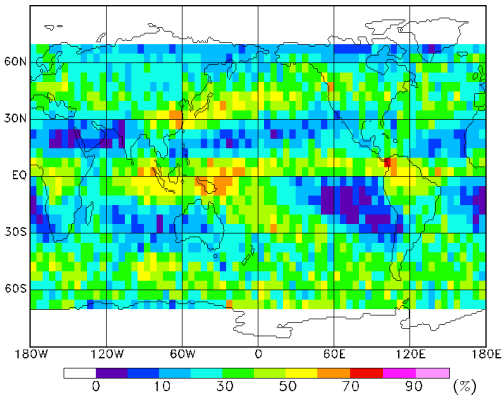
2) CALIOP Cirrus Tau > 0.1
CLCS Cirrus Fraction ~33%



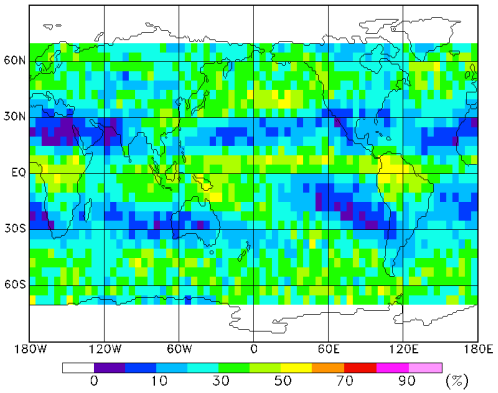
3) CALIOP cirrus Tau > 0.3
CLCS Cirrus Fraction ~26%



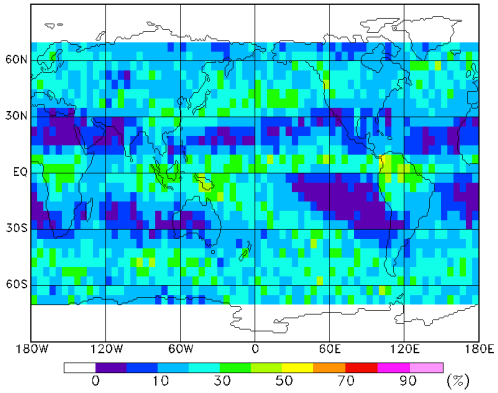
4) CERES-CO_2 retrieved
Cirrus Fraction ~29%



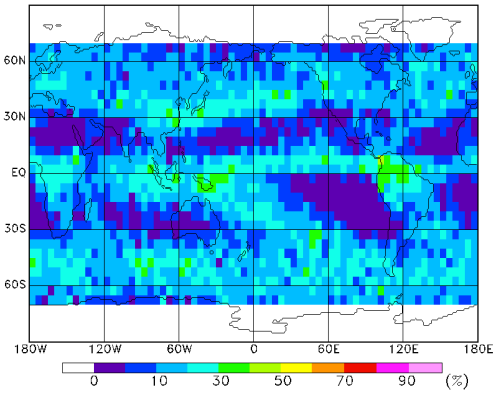
1) CALIOP Cirrus Tau > 0.
CLCS Multi Fraction ~26%



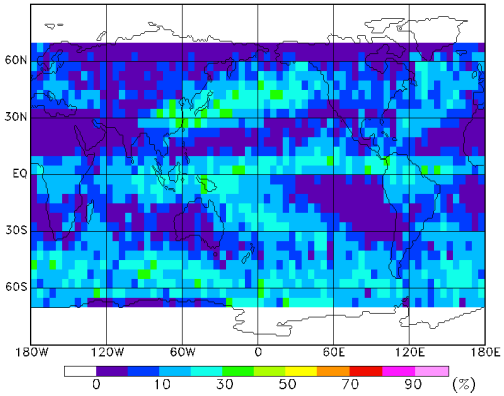
2) CALIOP Cirrus Tau > 0.1
CLCS Multi Fraction ~18%



3) CALIOP cirrus Tau > 0.3
CLCS Multi Fraction ~13%

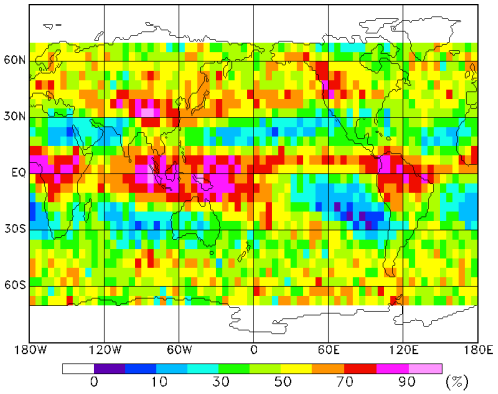


4) CERES-CO_2 retrieved
Multi Fraction ~10%

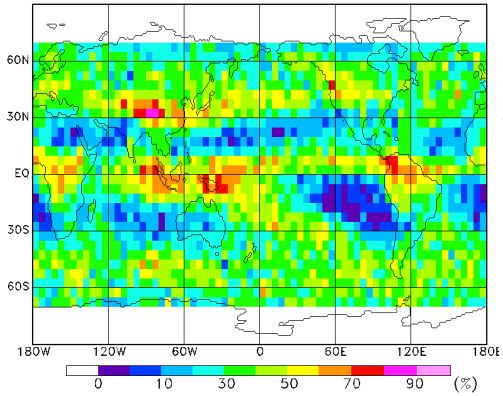


Cirrus and Multilayer Cloud Fractions from CALIPSO/CloudSat and CERES-CO_2

1) CALIOP Cirrus Tau > 0.
CLCS Cirrus Fraction ~47%



2) CALIOP Cirrus Tau > 0.1
CLCS Cirrus Fraction ~33%



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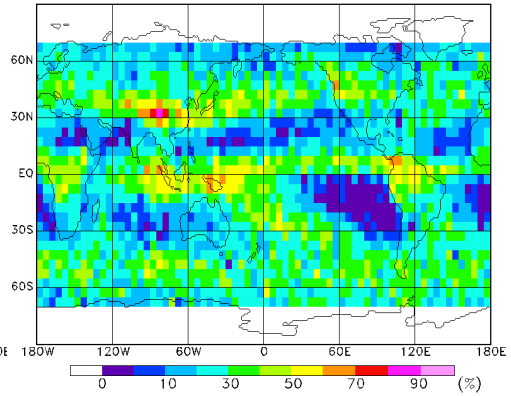
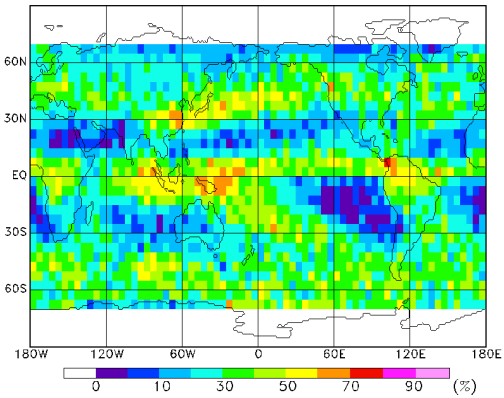
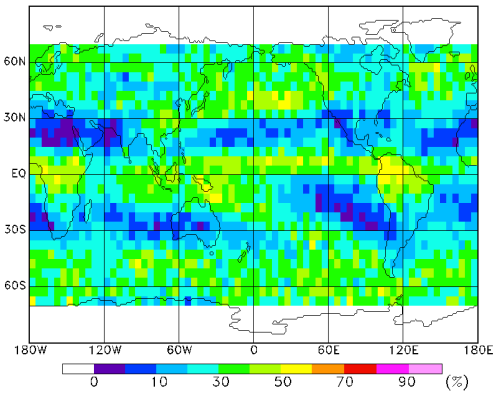


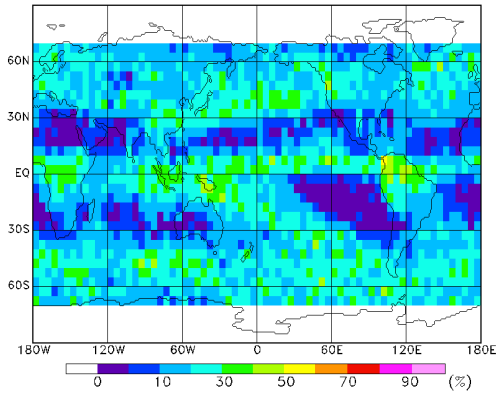
4) CERES-CO_2 retrieved
Cirrus Fraction ~29%



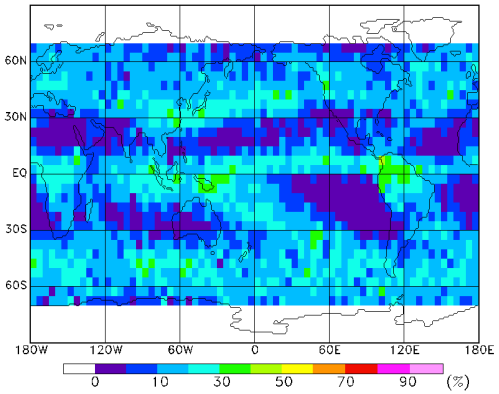
CLCS Multi Fraction ~26%



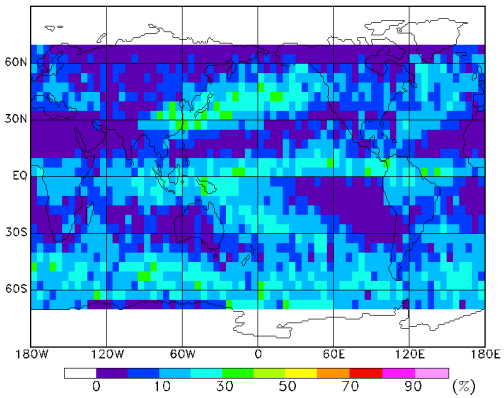
CLCS Multi Fraction ~18%



CLCS Multi Fraction ~13%



CERES Multi Fraction ~10%



Multi		No multi	
26%		20%	
Att	No	Att	No
6%	20%	9%	11%

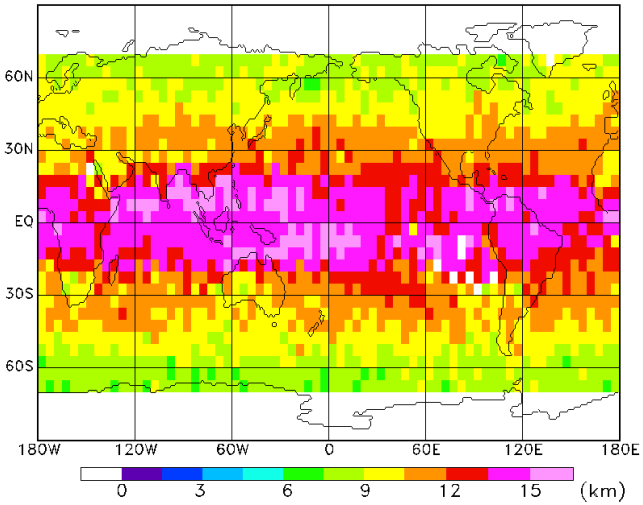
Multi		No multi	
18%		15%	
Att	No	Att	No
6%	12%	9%	6%

Multi		No multi	
13%		13%	
Att	No	Att	No
6%	7%	9%	4%

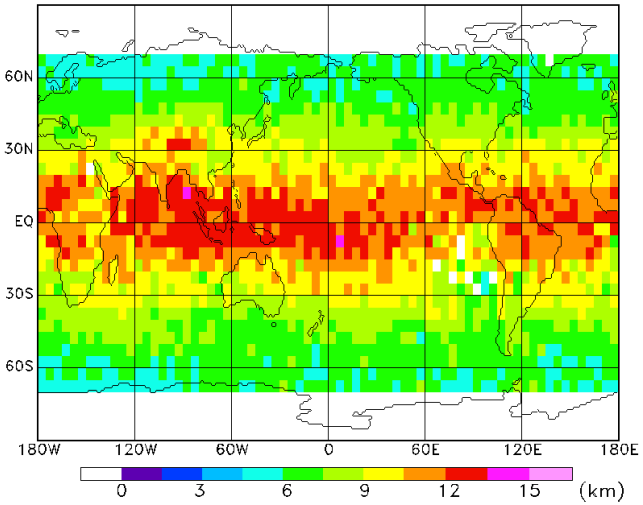
Multi		No multi	
10%		19%	
		Emiss	No
		6%	13%

Cirrus Cloud Top Heights from CALIPSO/CloudSat (CLCS) and CERES-CO_2

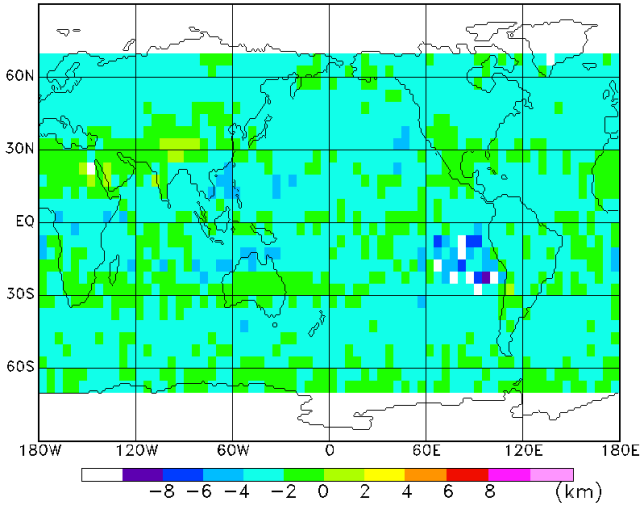
1) CLCS Cirrus Top Height
Mean = 11.1 km



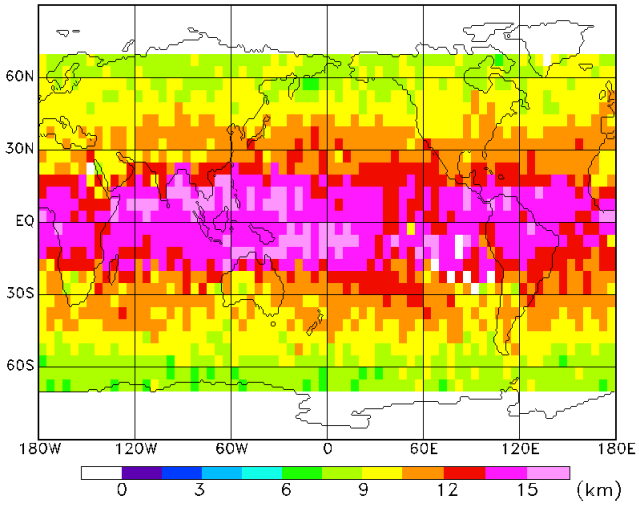
2) CERES-CO_2 Cirrus Top Height
Mean = 8.7 km



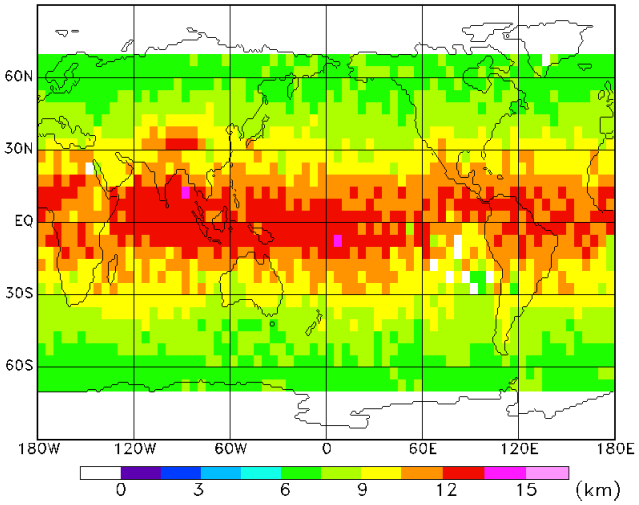
3) CERES-CO_2 minus CLCS
Mean difference = -2.4 km



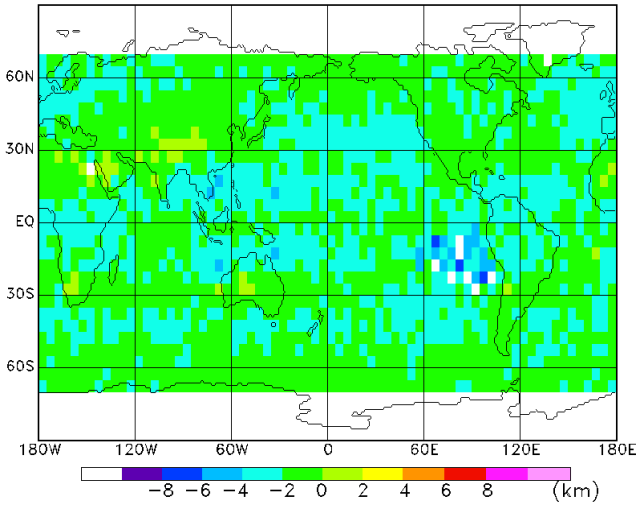
1) CLCS Cirrus Top Height
Mean = 11.1 km



2) CERES-CO_2 Cirrus Top Height
Mean = 9.3 km

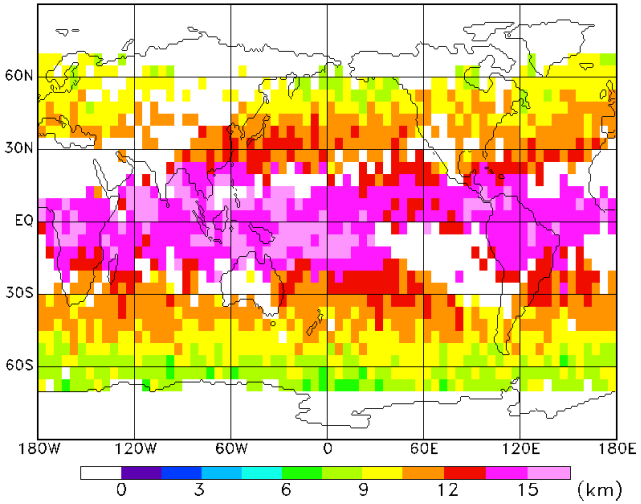


3) CERES-CO_2 minus CLCS
Mean difference = -1.8 km

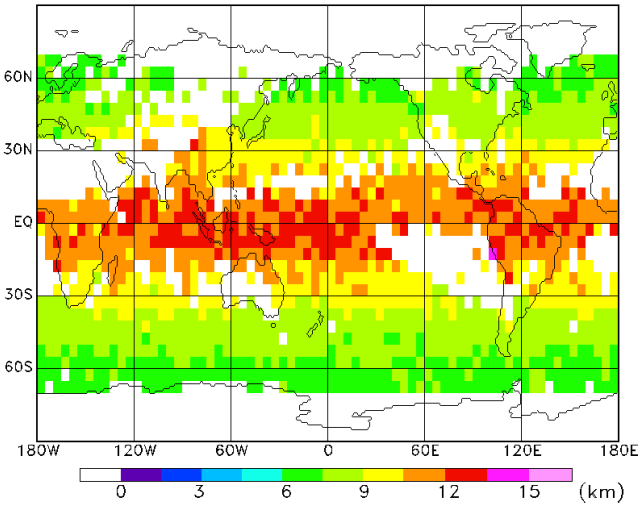


Multilayer Cloud Top Heights from CALIPSO/CloudSat (CLCS) and CERES-CO_2

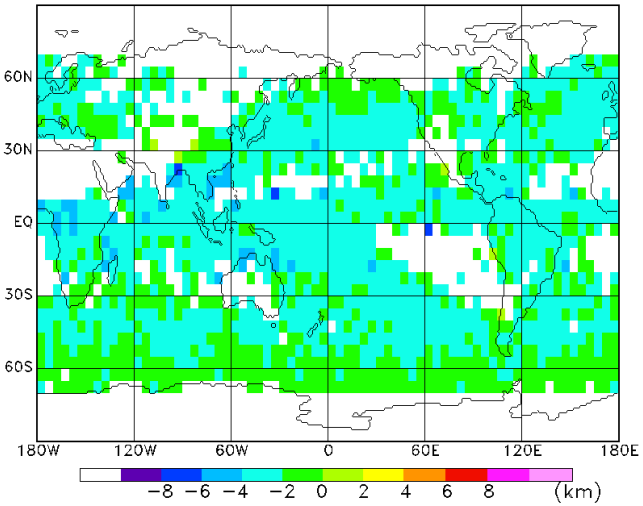
1) CLCS Multi Upper Top Height
Mean = 11.4 km



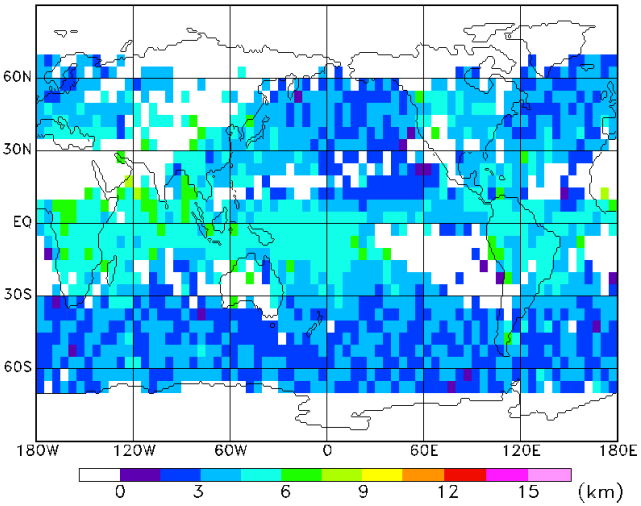
2) CERES Multi Upper Top Height
Mean = 9.2 km



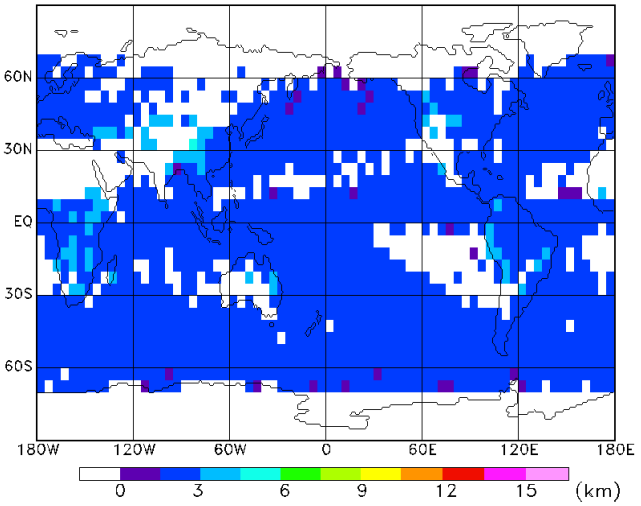
3) CERES Upper minus CLCS Upper
Mean difference = -2.2 km



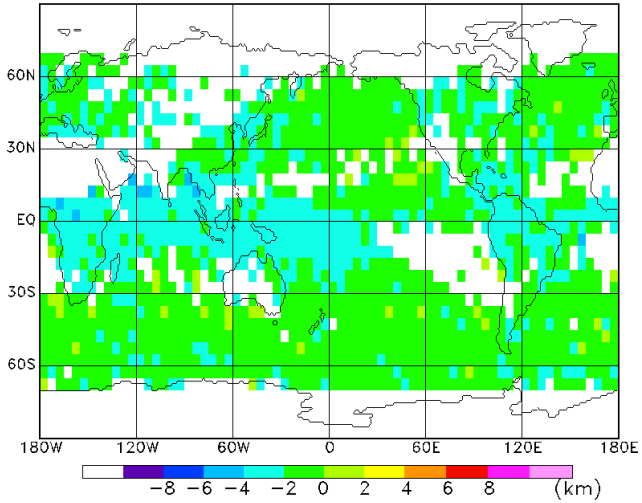
1) CLCS Multi Lower Top Height
Mean = 3.8 km



2) CERES Multi Lower Top Height
Mean = 2.2 km



3) CERES Lower minus CLCS Lower
Mean difference = -1.6 km



Validation of CERES Ed4 Multilayer Cloud Properties

Summary

- The near-global ML cloud overage was found to be ~0.10 for the CERES Ed4 data and ~0.26 for the merged CALIPSO/CloudSat (CLCS) data.
- ~30% (50%) of the CLCS ML clouds had thin upper-layer cirrus optical depth < 0.1 (0.3).
- ~15% of the CLCS ML clouds had near-opaque upper-layer emissivity > 0.8. For those, CERES ML was undecided.
- Another 20% of the CLCS ML clouds had small lower cloud optical depth. For those, CERES ML retrieved them as single-layer clouds.
- ~60% of the CERES ML clouds agreed well with CLCS ML clouds while ~20% were vertically continuous clouds.
- ~26% of the CERES ML clouds had CLCS-UL only clouds, where CALIPSO were attenuated by the UL clouds and no lower cloud was detected by CloudSat.
- On the average, CERES ML UL and LL cloud heights were both ~2km lower than CLCS.

Known Potential Errors

- The CERES-ML UL IR emissivity computations may contain errors due to a common block error in the data processing code.
- The CERES ML Lookup Table used for conversions from water-phase to ice-phase optical depths was not up-to-date.