Comparison of the Sensitivity of Marine Boundary-layer Clouds to SST Variations between the Cloud Deck Regions and the Rest of the Subtropics and Tropics

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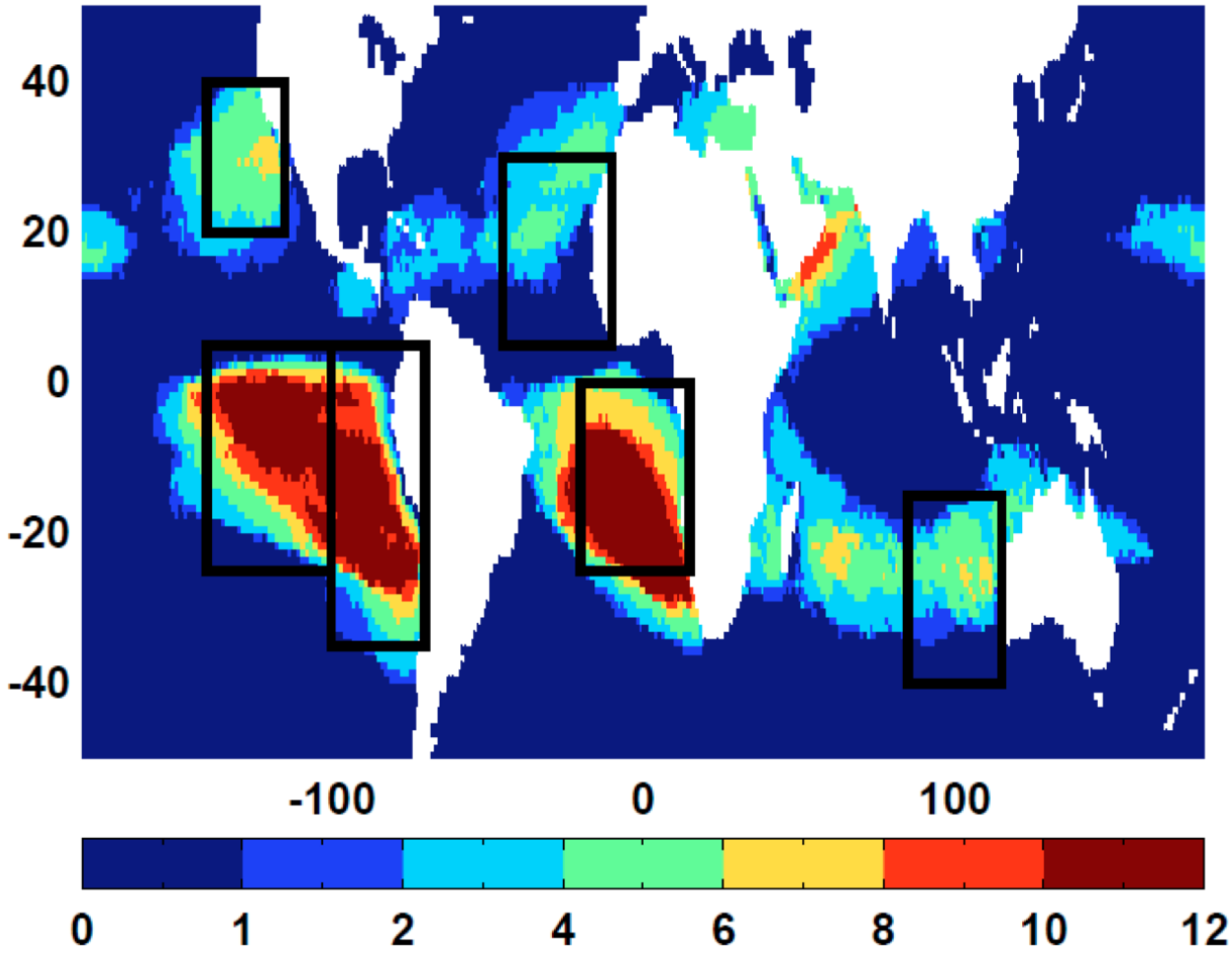
Motivation

- Uncertainties in boundary-layer cloud (BLC) feedbacks in climate models
- Most field experiments related to BLC were carried out in the cloud deck regions where the stratus/ stratocumulus populations dominate
- Different cloud types (cumulus, stratocumulus and stratus) have very different cloud physical and radiative properties (Xu et al. 2005; 2008)
- How much changes in these properties are due to changes in the proportion of cloud types and how much due to changes in the properties within each cloud type as the SST increases?

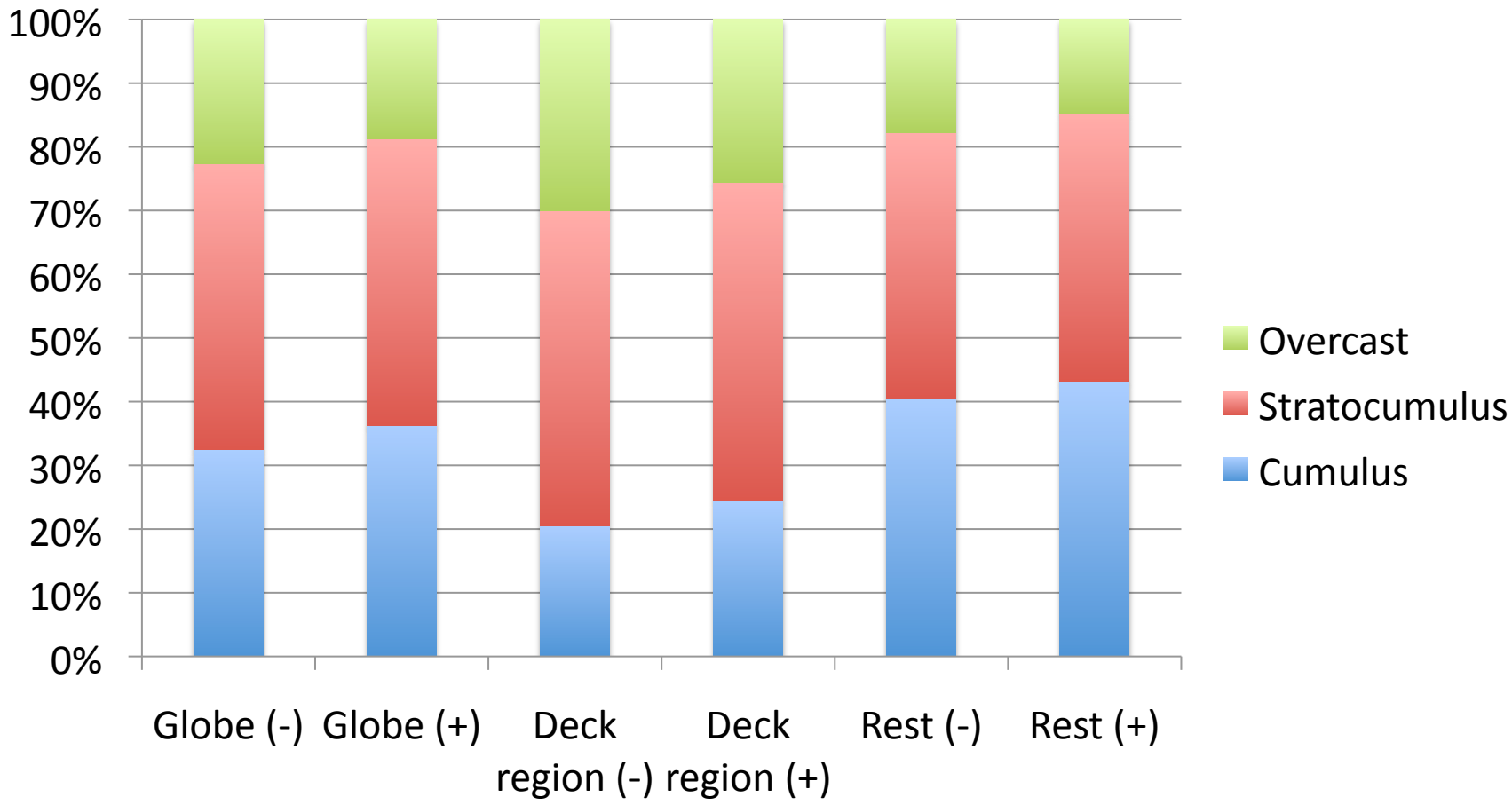
Cloud deck regions



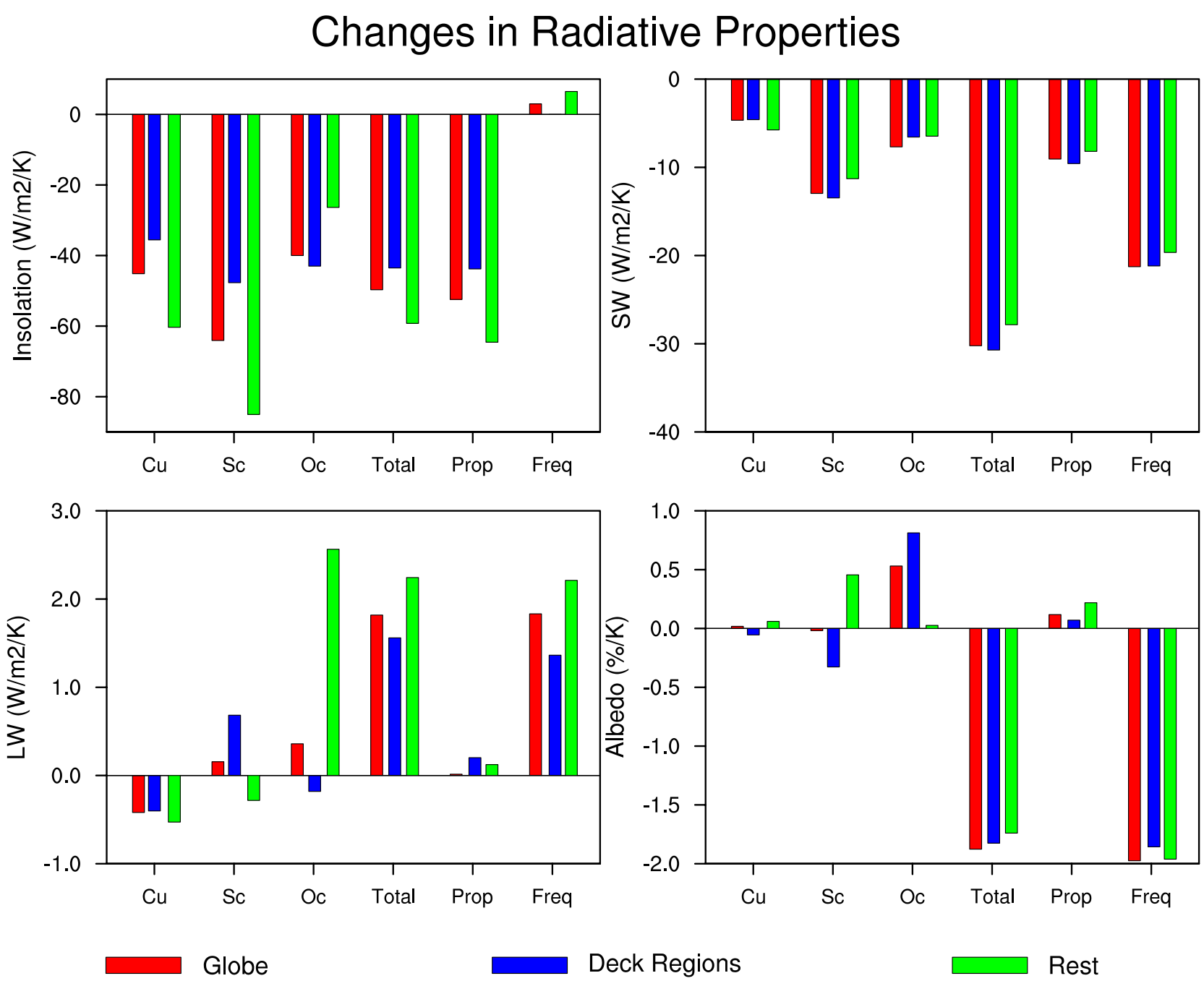
Approach

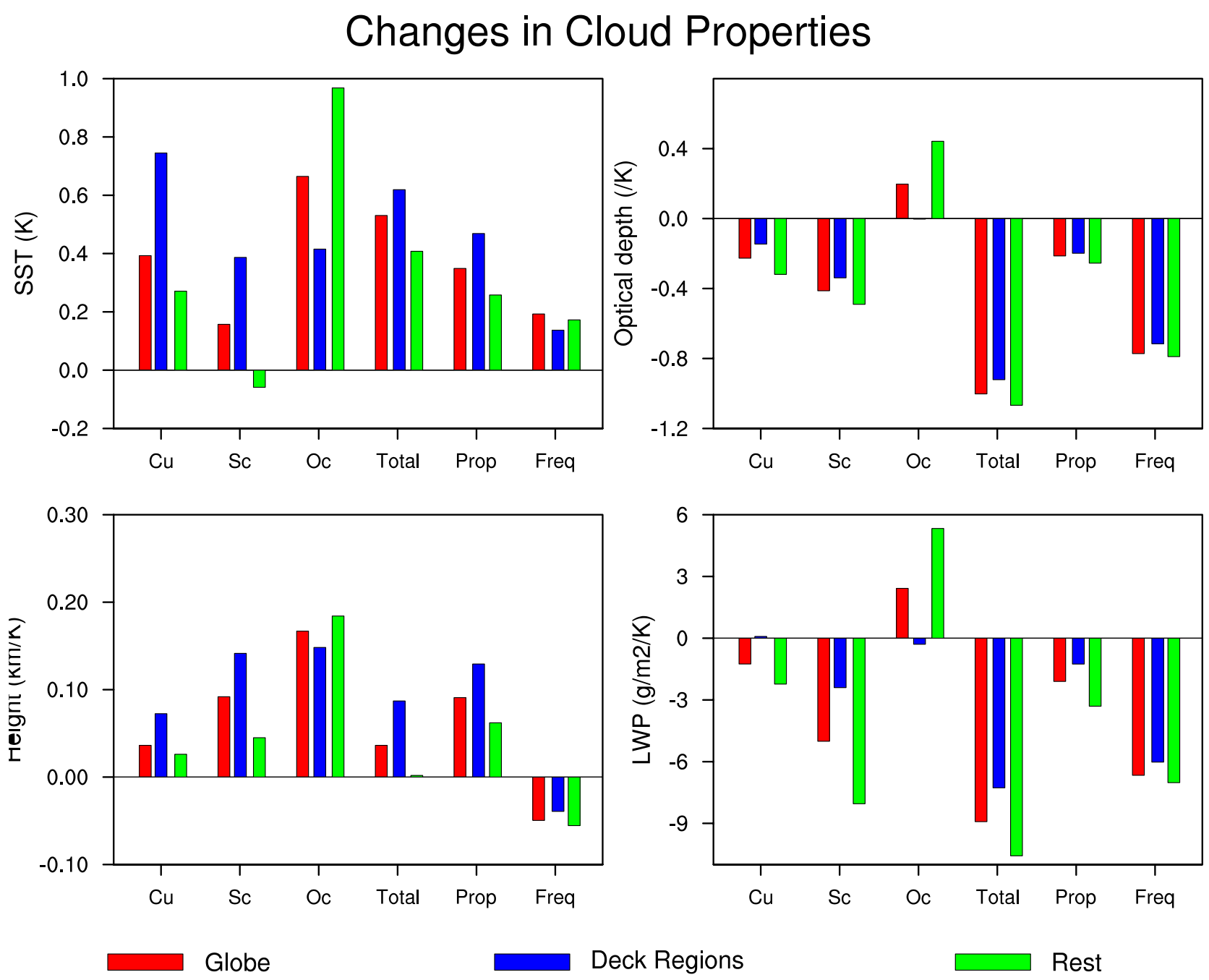
- Identifying contiguous boundary-layer cloud systems by types (Xu et al. 2005)
- *Cumulus* (satellite footprint cloud fraction 0.1 – 0.4), *stratocumulus* (0.4 – 0.99) and *overcas*t (0.99-1.00); also with cloud top height < 3 km
- Deseasonized SST anomalies corresponding to each cloud system are used to subdivide the total cloud population into positive and negative anomaly subsets
- The mean property is the sum of the property of each cloud type weighted by its proportion: $A = \alpha_{cu} A_{cu} + \alpha_{sc} A_{sc} + \alpha_{oc} A_{oc}$
- The difference in A between the two subsets will be normalized by the SST difference between the two subsets and decomposed into that due to changes in α and that in *A*

Proportion of Cloud Types by Regions



Total footprints: Rest ~ 2 x BCL regions


Changes in Radiative Properties
Insolation (W/m2/K)
0
-20
-40
-60
-80
SW (W/m2/K)
-10
-30
LW (W/m2/K)
3.0
2.0
1.0
0.0
-1.0
Albedo (%/K)
0.5
-0.5
-1.5
-2.0
Cu
Sc
Oc
Total
Prop
Freq
Globe
Deck Regions
Rest


Changes in Cloud Properties
SST (K)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Optical depth (/K)
0.4
0.0
-0.4
-0.8
-1.2
Height (km/K)
0.30
0.20
0.10
0.00
-0.10
LWP (g/m2/K)
6
3
0
-3
-6
-9
Cu
Sc
Oc
Total
Prop
Freq
Globe
Deck Regions
Rest

Summary

- The proportion of cumulus cloud type in the rest regions is much higher than the deck regions; those of stratocumulus and overcast cloud types are smaller.
- As SST increases, however, the proportion of cumulus increases while that of overcast decreases in all regions. The change in the proportion of stratocumulus type is relatively small.
- As SST increases,
  - total decreases in LWP, cloud optical depth and SW are > 2/3 due to changes in the proportion and < 1/3 due to changes in the properties,
  - total increase (decrease) in OLR (albedo) is due solely to changes in the proportion with rather small offsets due to changes in the properties,
  - total increase in cloud top height is the residual of the increase due to change in the properties and the decrease due to change in the proportion
- The total change rates in the aforementioned properties with SST are rather similar between the deck and the rest regions, except for LWP and cloud top height.
- The change rates with SST for individual cloud types are much different between the two regions, especially for LWP, albedo, cloud top height and OLR and the overcast cloud type.

CALIPSO-CloudSat-CERES-MODIS (C3M) Merged Product

- Funded by the NASA Energy Water Cycle Study (NEWS) project.

Expected contribution of the product

To provide a global data set along the lidar/radar ground track with the most accurate and comprehensive aerosol properties, cloud properties, and vertical radiative flux profiles.

Area of studies that are greatly improved by our data set includes:

1. Assimilation and prediction by global aerosol models through better understanding of aerosol layer location.
2. Better understanding of multi-layered and polar cloud systems and their radiative impacts.
3. Better understanding of frequency of occurrence of thin cirrus and boundary layer clouds and their radiative impacts

C3M (CCCM) product

- Contains:

1. Merged CALIPSO, CloudSat derived clouds, CERES TOA radiative flux (SW, LW, and WN), MODIS (CERES_ST) derived cloud properties both along CALIPSO-CloudSat ground-track and over the whole CERES footprint,
2. MODIS derived cloud properties by an enhanced cloud algorithm,
3. CALIPSO and MODIS derived aerosol properties
4. Vertical radiative flux profiles computed with CALIPSO (version 3), CloudSat, and MODIS derived cloud properties.

- Data are available from http://eosweb.larc.nasa.gov/PRODOCS/ceres-news/table_ceres-news.html