Global Cloud Type Distributions: From ISCCP Cloud Type to CloudSat Type

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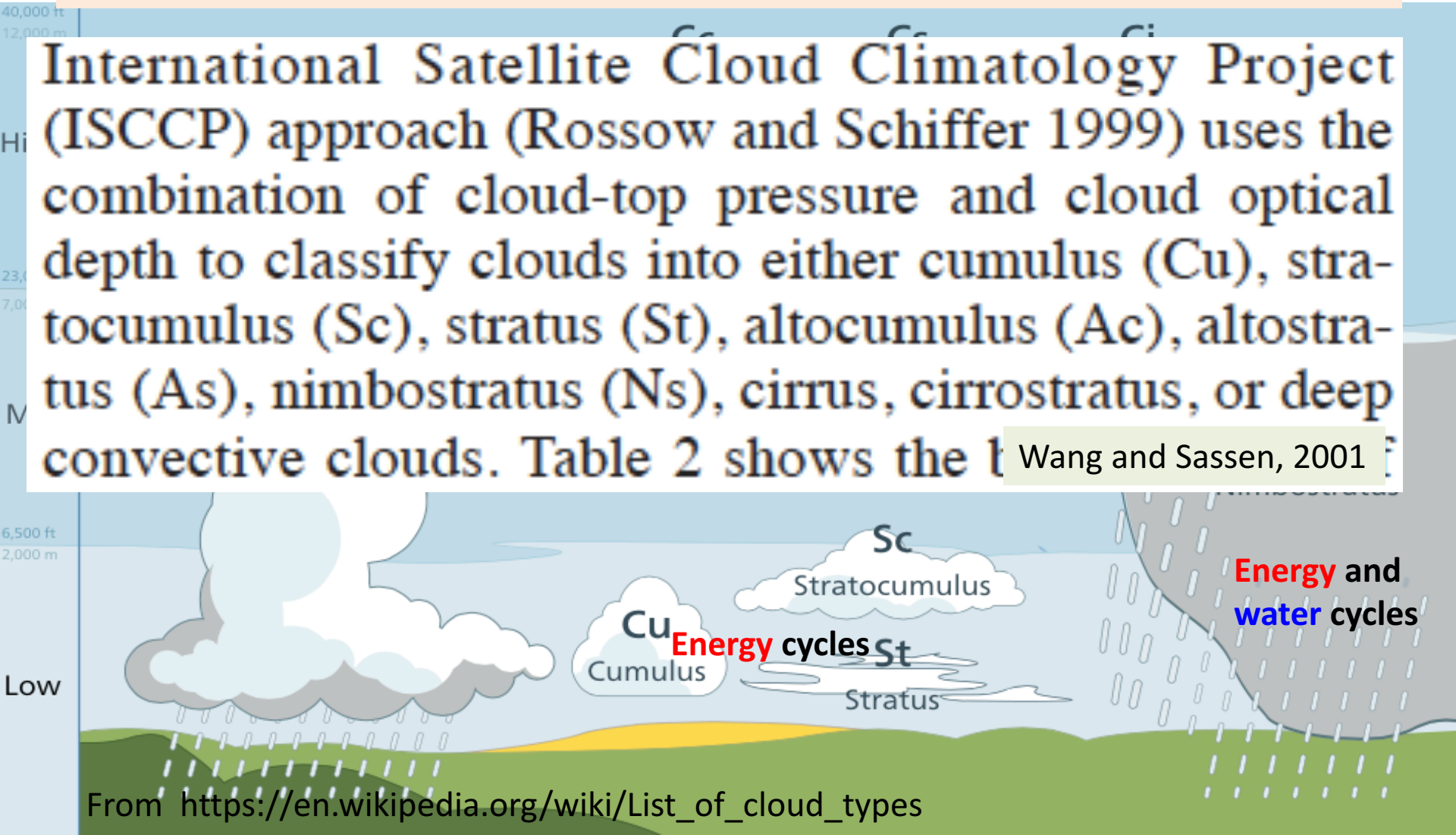
Cloud Types and Their Roles

Cloud types are controlled by different dynamics, thermodynamics, and microphysics.

International Satellite Cloud Climatology Project (ISCCP) approach (Rossow and Schiffer 1999) uses the combination of cloud-top pressure and cloud optical depth to classify clouds into either cumulus (Cu), stratocumulus (Sc), stratus (St), altocumulus (Ac), altostratus (As), nimbostratus (Ns), cirrus, cirrostratus, or deep convective clouds. Table 2 shows the t

Wang and Sassen, 2001



From https://en.wikipedia.org/wiki/List_of_cloud_types

Cloud Type as an Important Part of ISCCP

TABLE 1. Data specification for the International Satellite Cloud Climatology Project.

Parameters—Spatial and temporal averages and variances (or another statistical measure of the shape of the temporal distribution) are required for each of the following parameters.

	Precision (30-day averages)
Amounts	
Total cloud amount (fraction)*	±0.03
Cirrus cloud amount (fraction)*	±0.05
Middle cloud amount (fraction)	±0.05
Low cloud amount (fraction)*	±0.05
Deep convective cloud amount (fraction)	±0.05
Height	
Cirrus cloud-top height (km)*	±1.00
Middle level cloud-top height (km)	±1.00
Low-level cloud-top height (km)	±0.50
Deep convective cloud-top height (km)	±1.00
Cloud Top Temperature (K) for each cloud category*	±1.00
Cloud Optical Depth	
Cloud Size Distribution	
Average Narrow Band Radiances (VIS and IR)*	
Spatial Averaging—The information is to be averaged over approximately 250-km by 250-km boxes	
Time Sampling—Every 3 hours, i.e., 8 times a day, centered around the synoptic observation times	
Time Averaging—The global cloud climatology will consist of 30-day averages for each of the 8 observing times per day	
Length of Time Series—5 years	

* Highest priority

ISCCP Cloud Type Classifications

C2

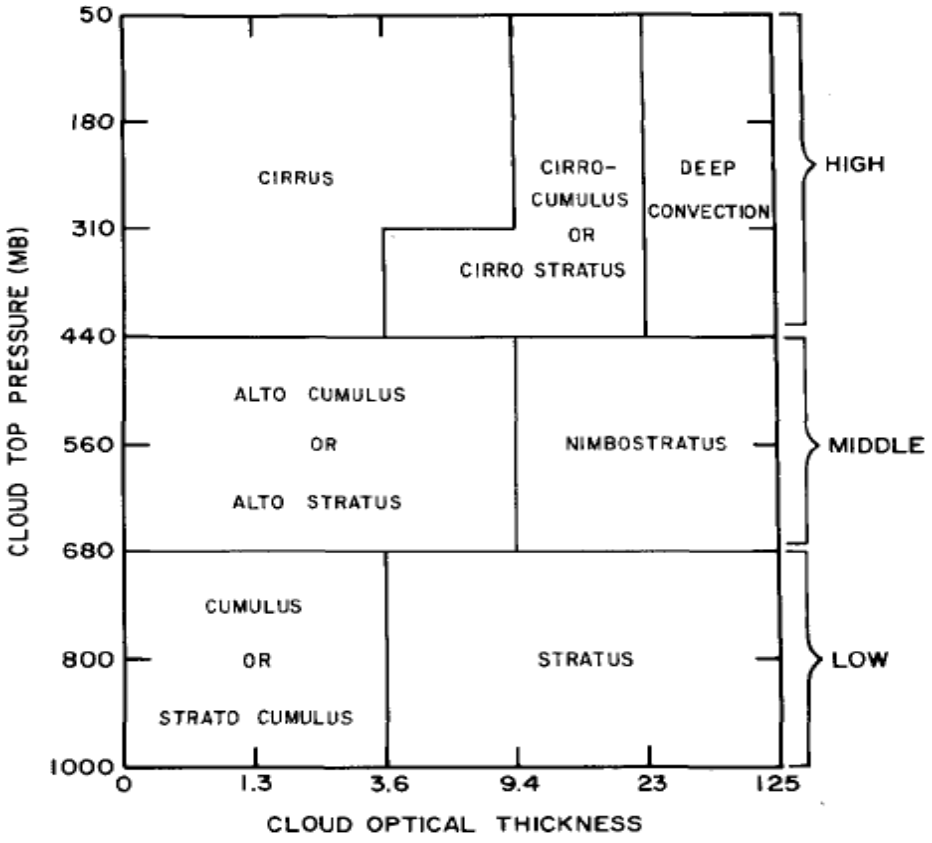


FIG. 4. Radiometric classification of cloudy pixels by the measured values of optical thickness and cloud top pressure (at night only cloud top pressures are determined so that only the low, middle, and high cloud types are counted). The frequency of cloudy pixels is reported in Stage C1 data for all 35 combinations of optical thickness and cloud top pressure intervals, indicated by the values on the axes. The association of classical morphological cloud type names with these ranges of cloud top pressure and optical thickness is only qualitative, but indicates the cloud types summarized in Stage C2

D-series

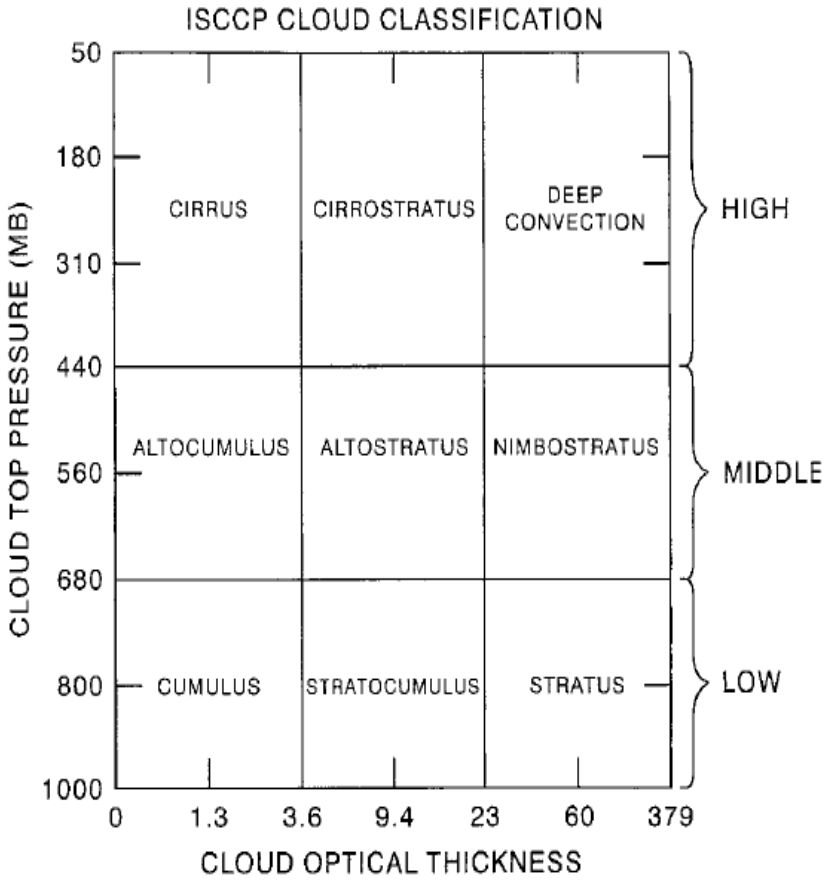
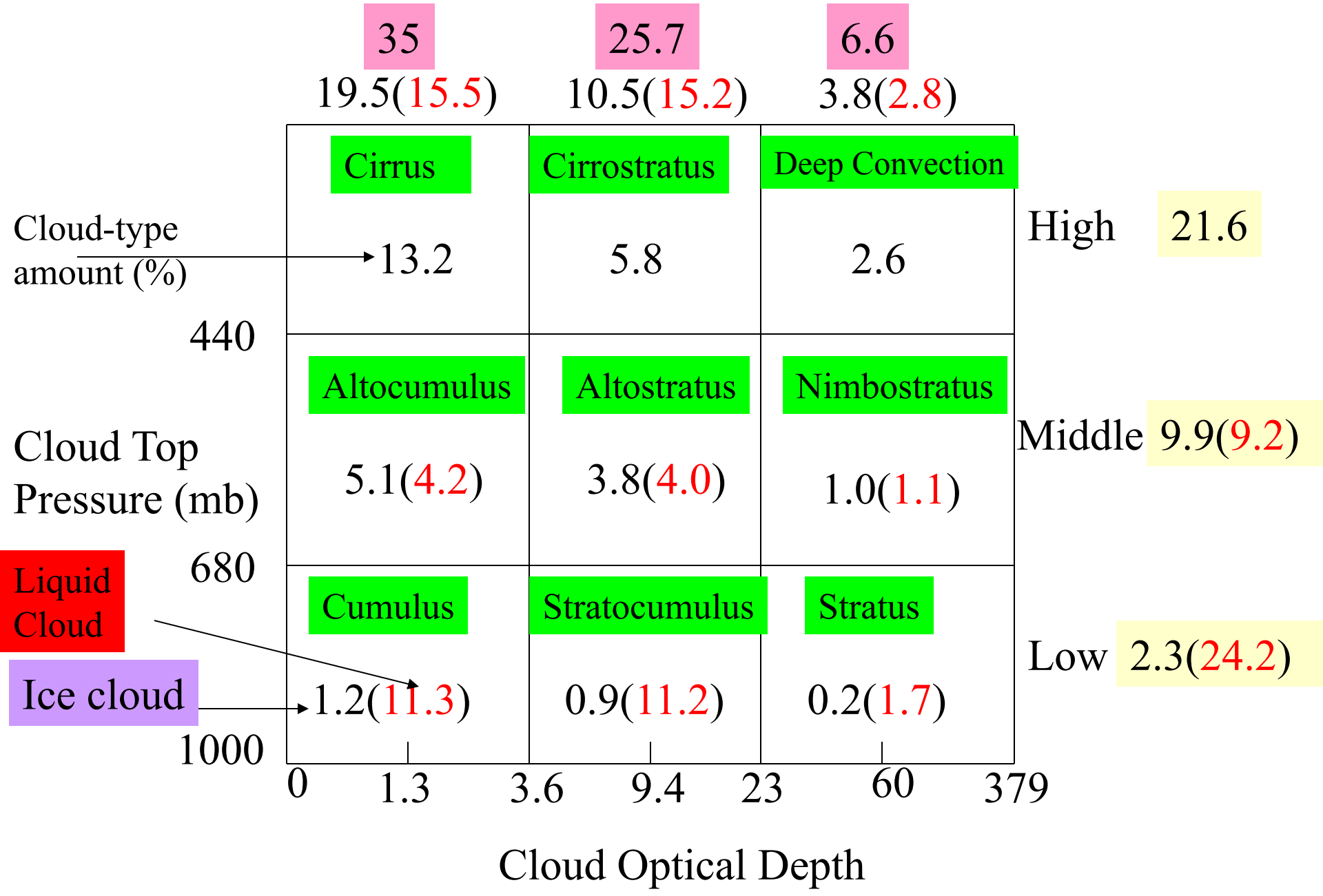
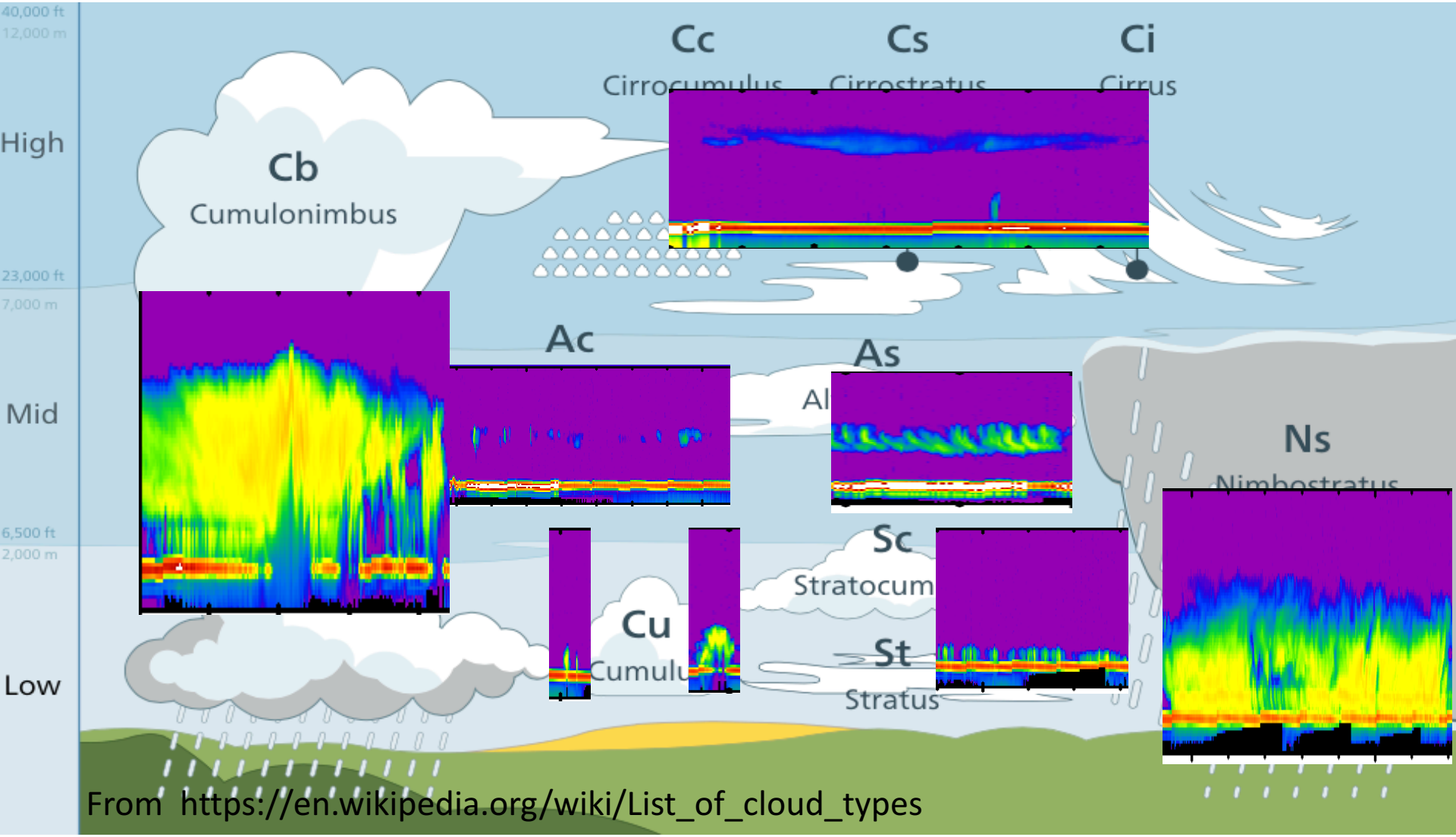


FIG. 2. New cloud-type definitions used in the ISCCP D-series datasets for daytime. All low and middle cloud types are separated into liquid and ice types; all high clouds are ice. Nighttime cloud types are low, middle, and high, as indicated on the right.

Cloud Climatology from the ISCCP



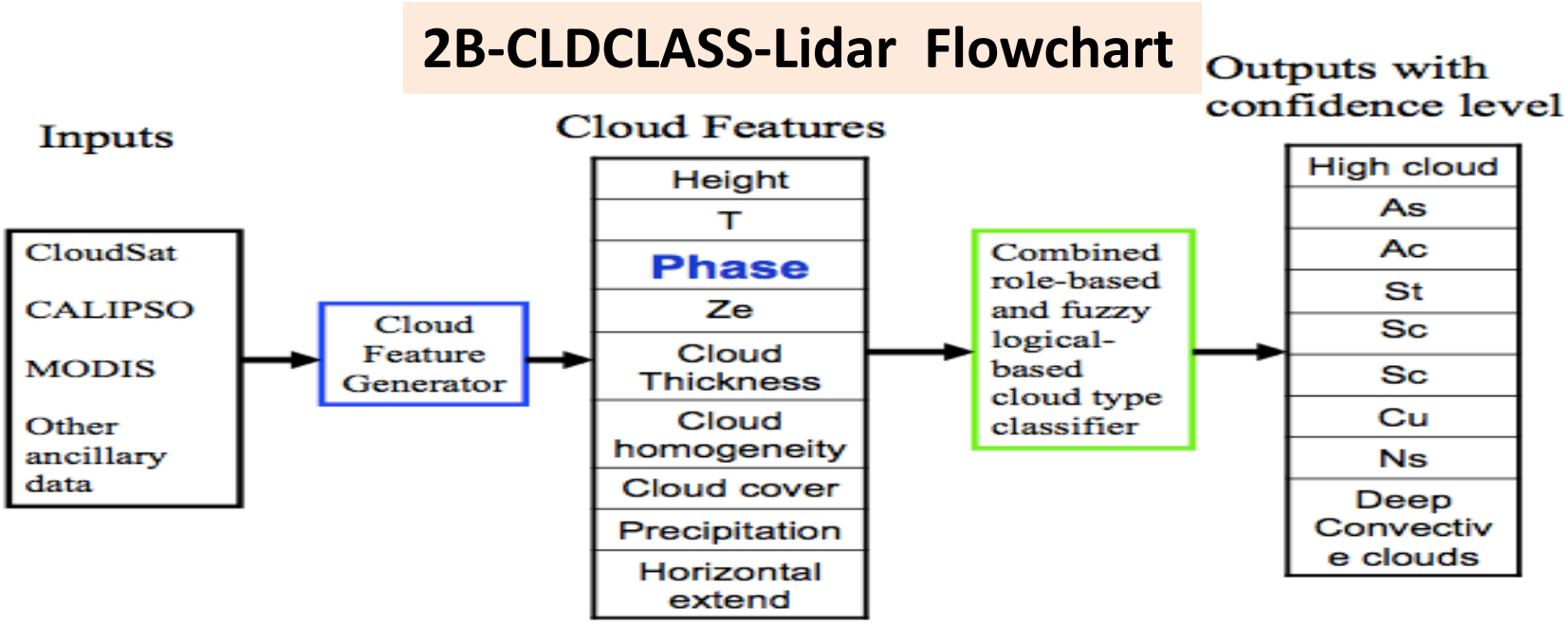
Active Measurements for Effective Cloud Type Identifications



From https://en.wikipedia.org/wiki/List_of_cloud_types

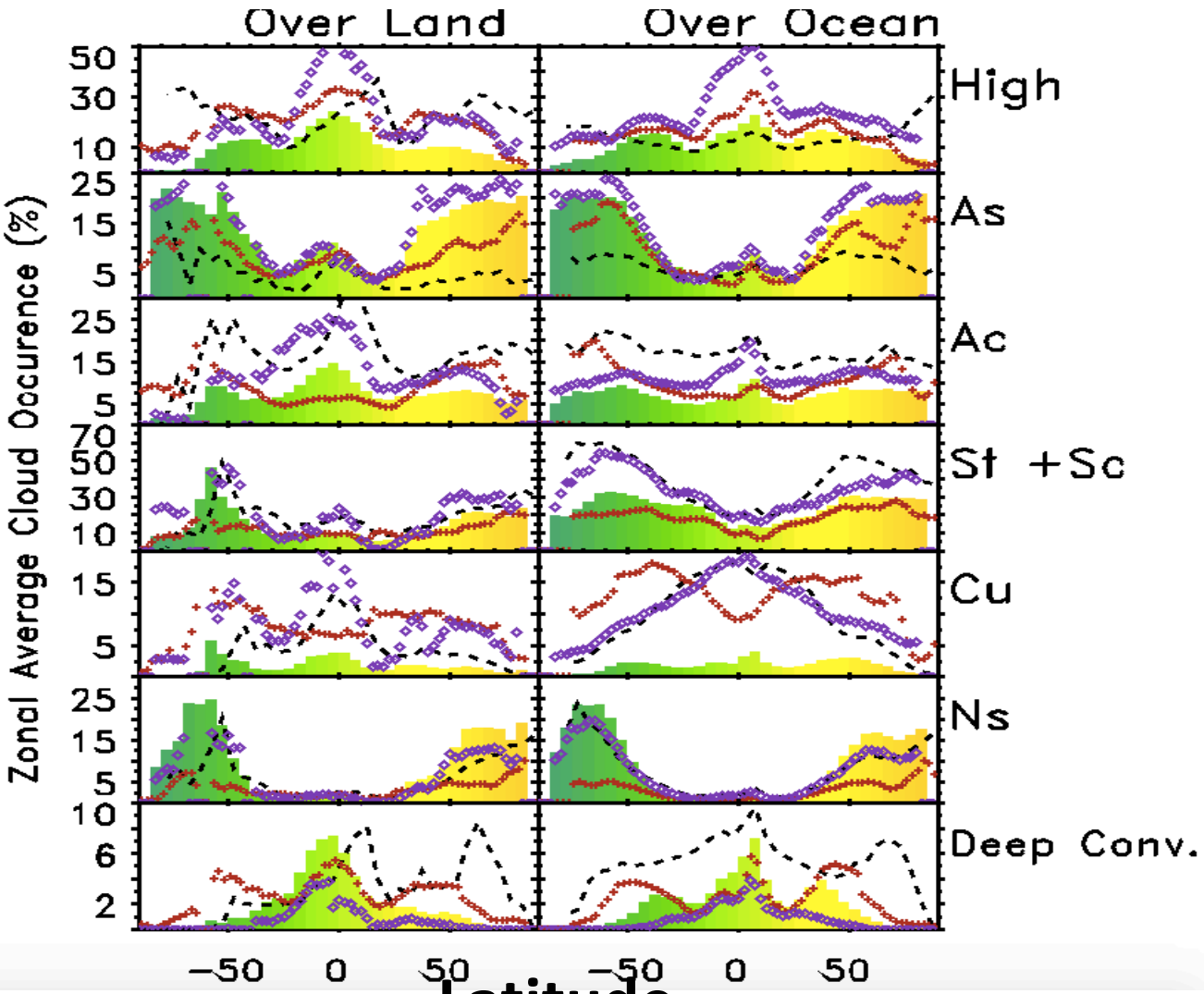
CloudSat Cloud Classification Products

- Radar-only (2B-CLDCLASS)
- Radar-lidar combined (2B-CLDCLASS-Lidar)

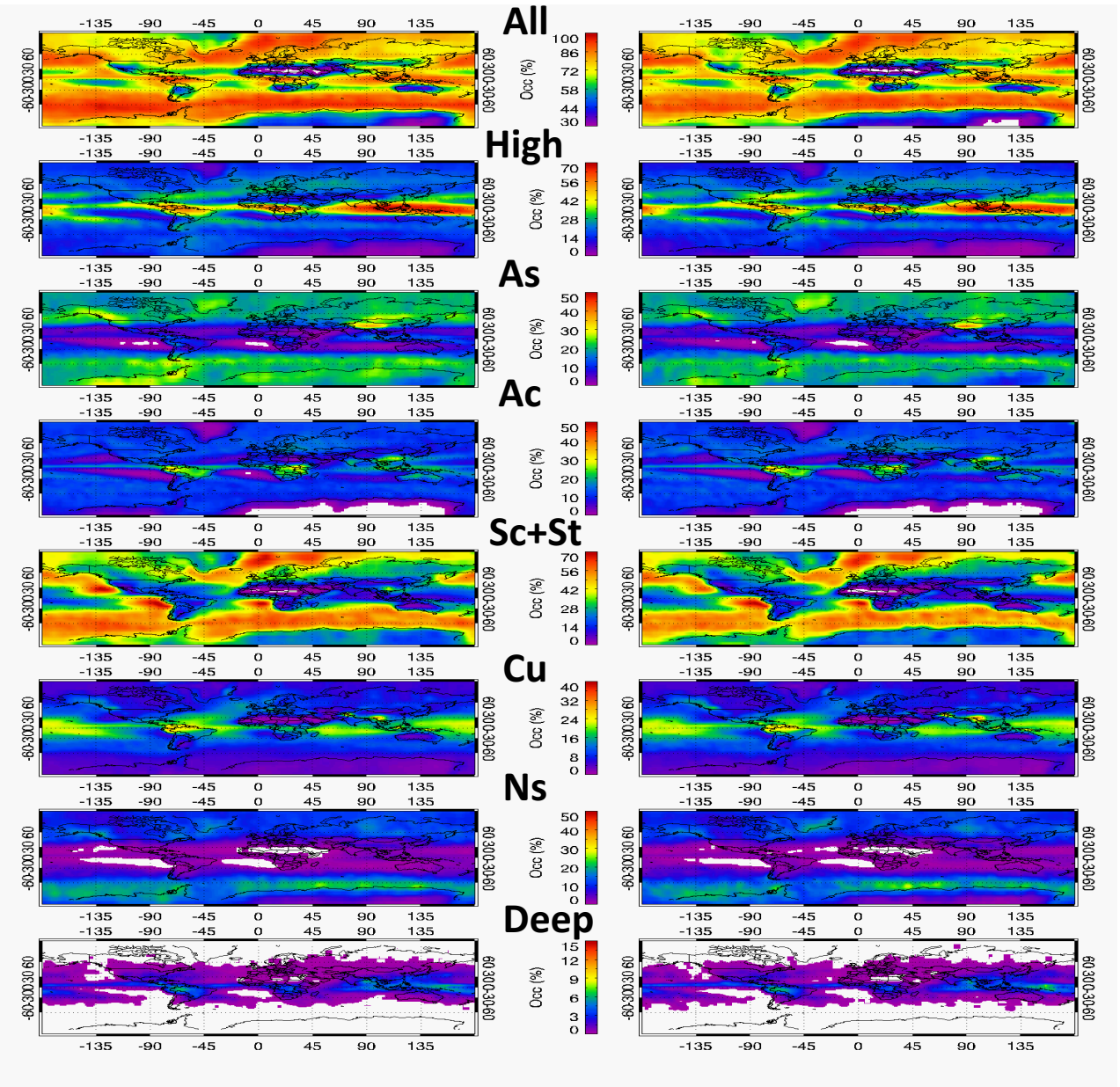


Comparison of Different Cloud Type Climatology

- Surface Based
- ISCCP
- CloudSat Radar-Lidar



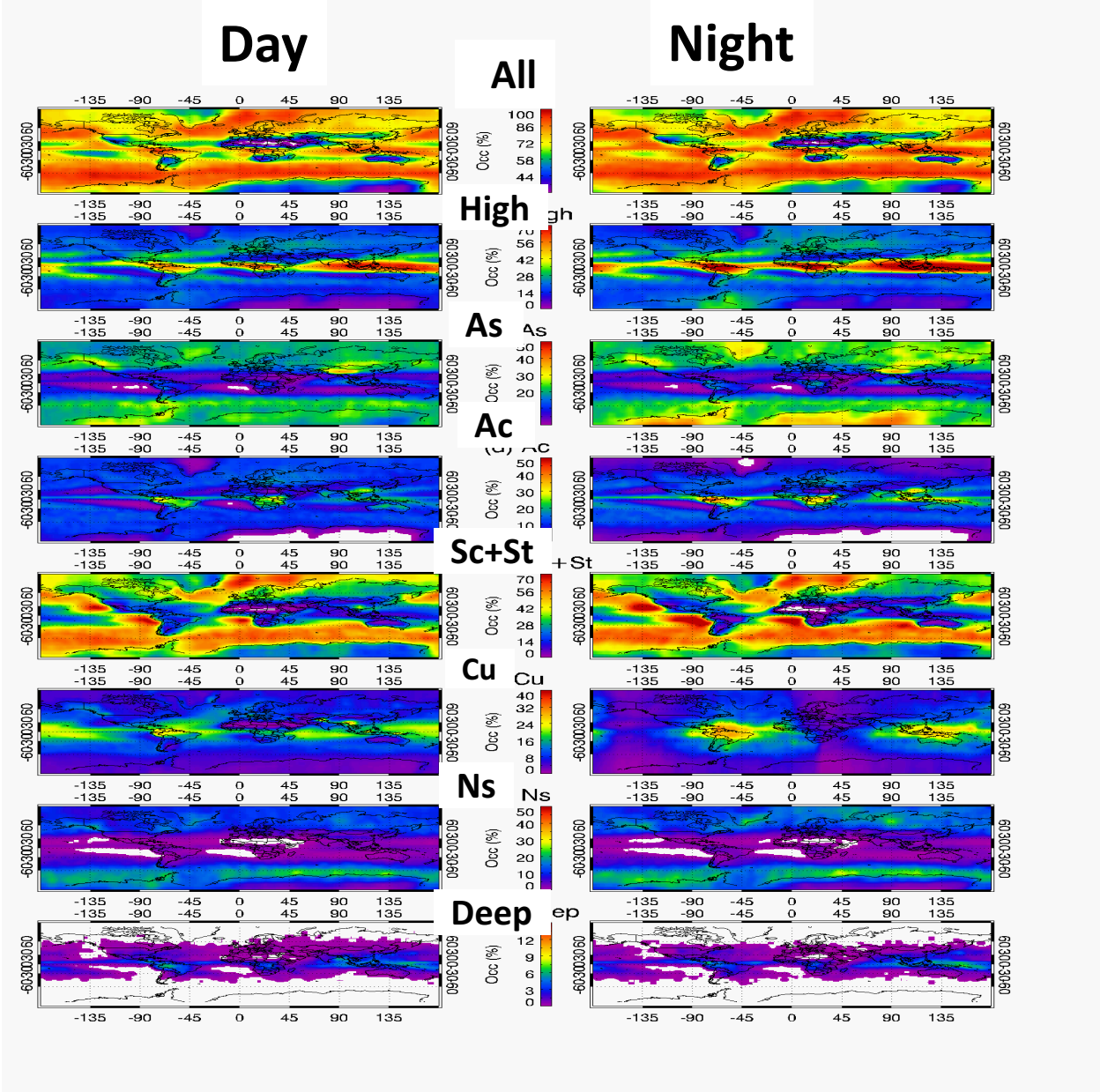
Normal with DOOP Periods



- The two periods offer a consistent annual mean daytime cloud type distributions.
- Each type cloud has their preferred regions associated with dynamics, thermodynamics, and water vapor supply.

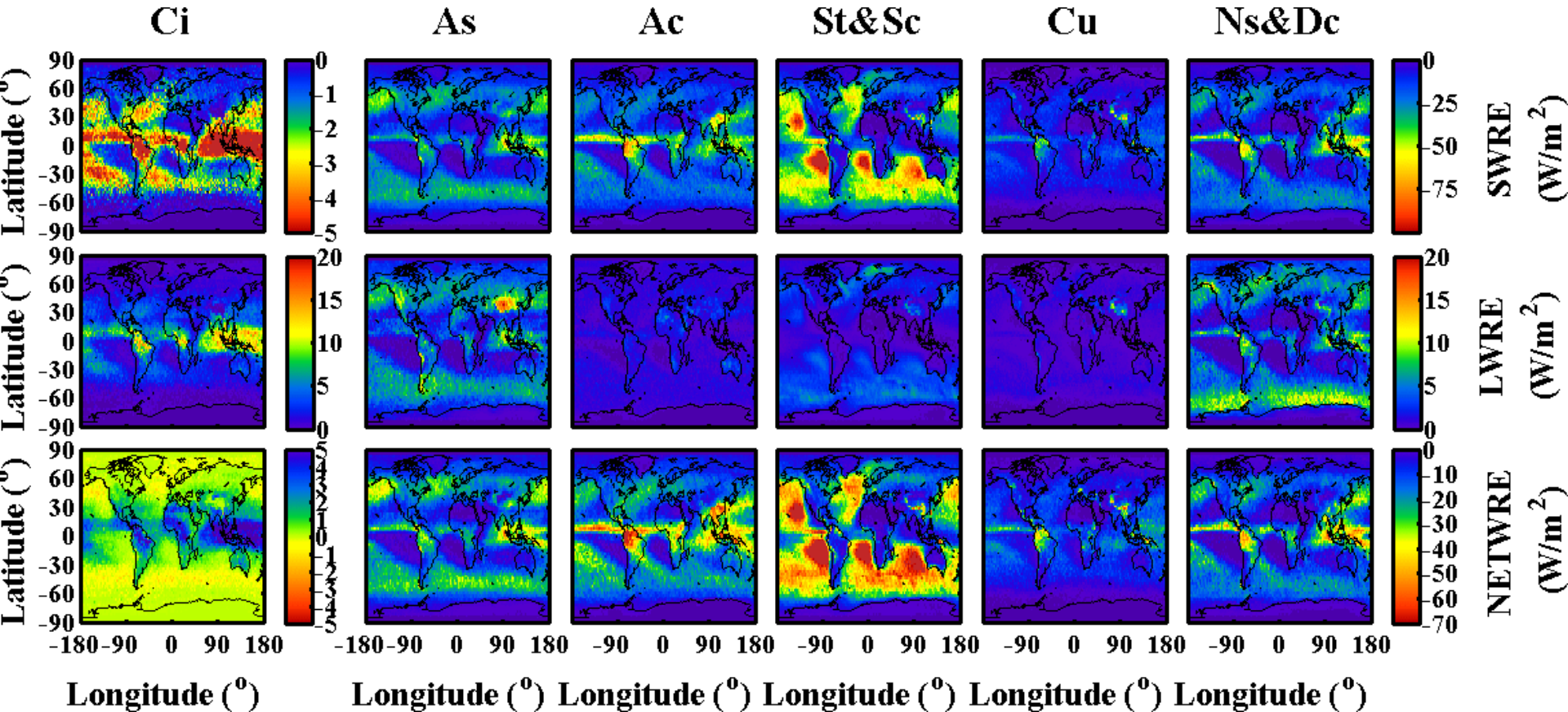
Day/Night Cloud Type Variations

- For weaker surface driving clouds, Cirrus, Sc +St and Ac, LW cooling increase their amount during night.
- Less convective clouds (Cu +Deep) over middle-latitude land during night.
- For Cu over oceans, changes depend on regions.



Cloud Type Dependent TOA Cloud Radiative Forcings

- 2B-CLDCLASS-lidar data (2006-2015) were collocated with CERES TOA cloud radiative forcings (FlashFlux, 25x25 km).
- Single type dominated CERES data were used.



Dynamics

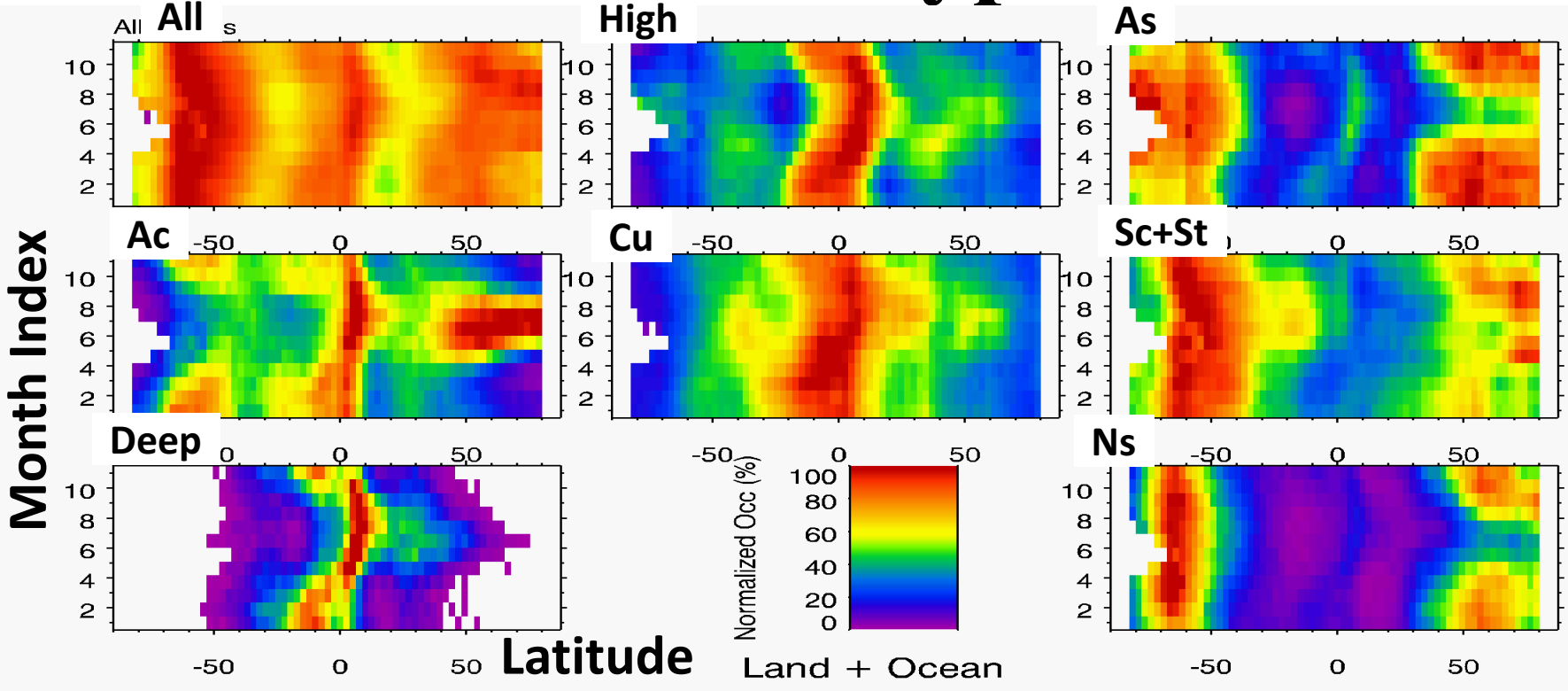
Thermodynamics

Microphysics

Cloud

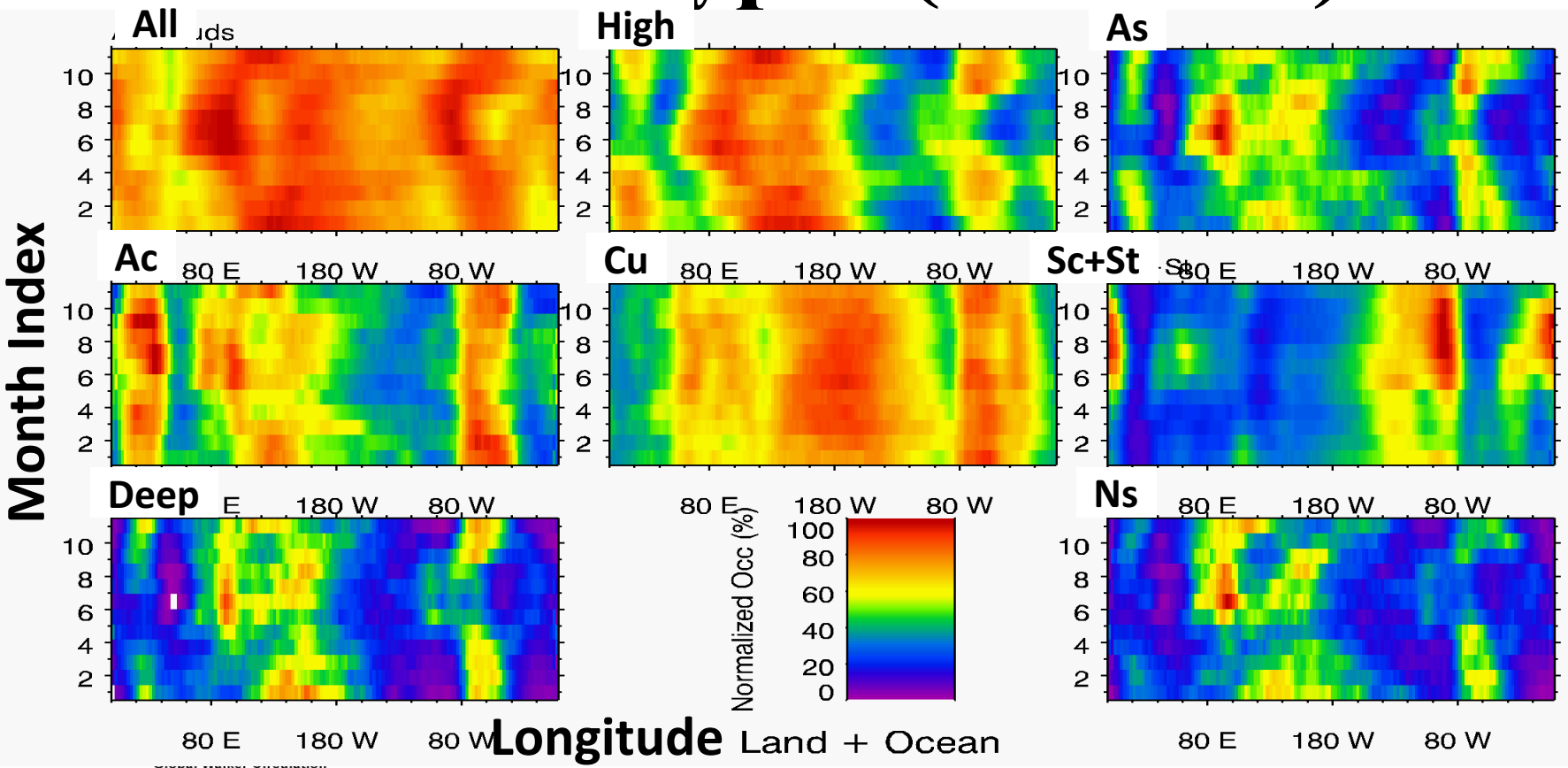
Types

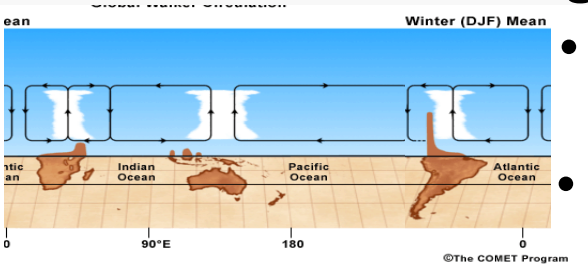
Annual Cycles of Zonal Mean Cloud Types



- Clear signatures of solar radiation driven annual cycle.
- In tropics, high, Ac, Cu, and deep convective clouds share similar features.
- As, Sc + St, and Ns clouds are also driven by large-scale dynamics and thermodynamics.

Annual Cycles of Meridional Mean Cloud Types (20S-20N)



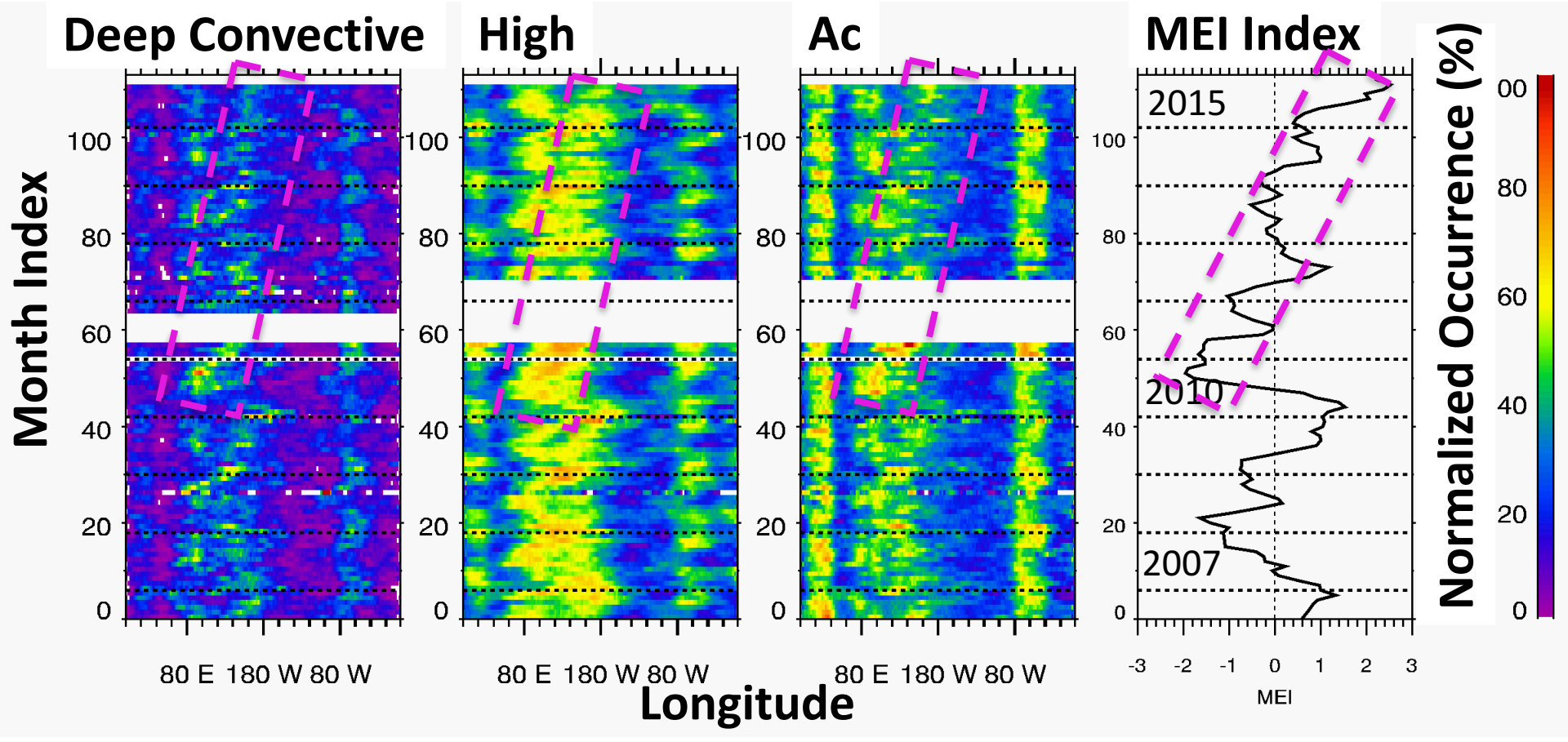


- The locations of tropical deep convective clouds indicate the Walker circulations.
- High cloud production or maintenance rate is higher over the warm pool region.

Interannual Cloud Type Variations

20S-20N

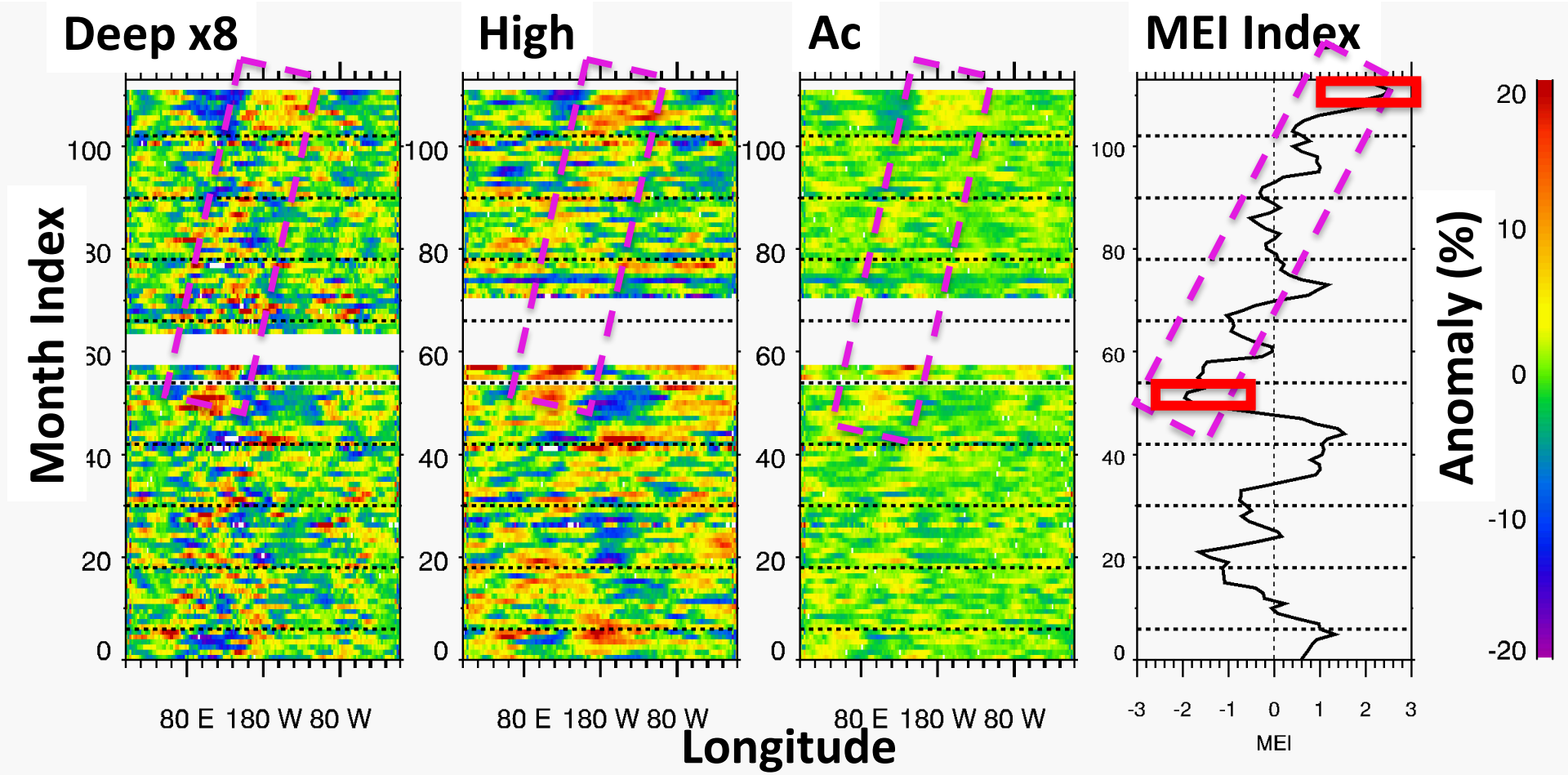
- From 2006-2015, there are a few significant ENSO events, which drive interannual tropical cloud type variations.
- During 2010-2015, from the negative to positive phase, clouds shift accordingly.



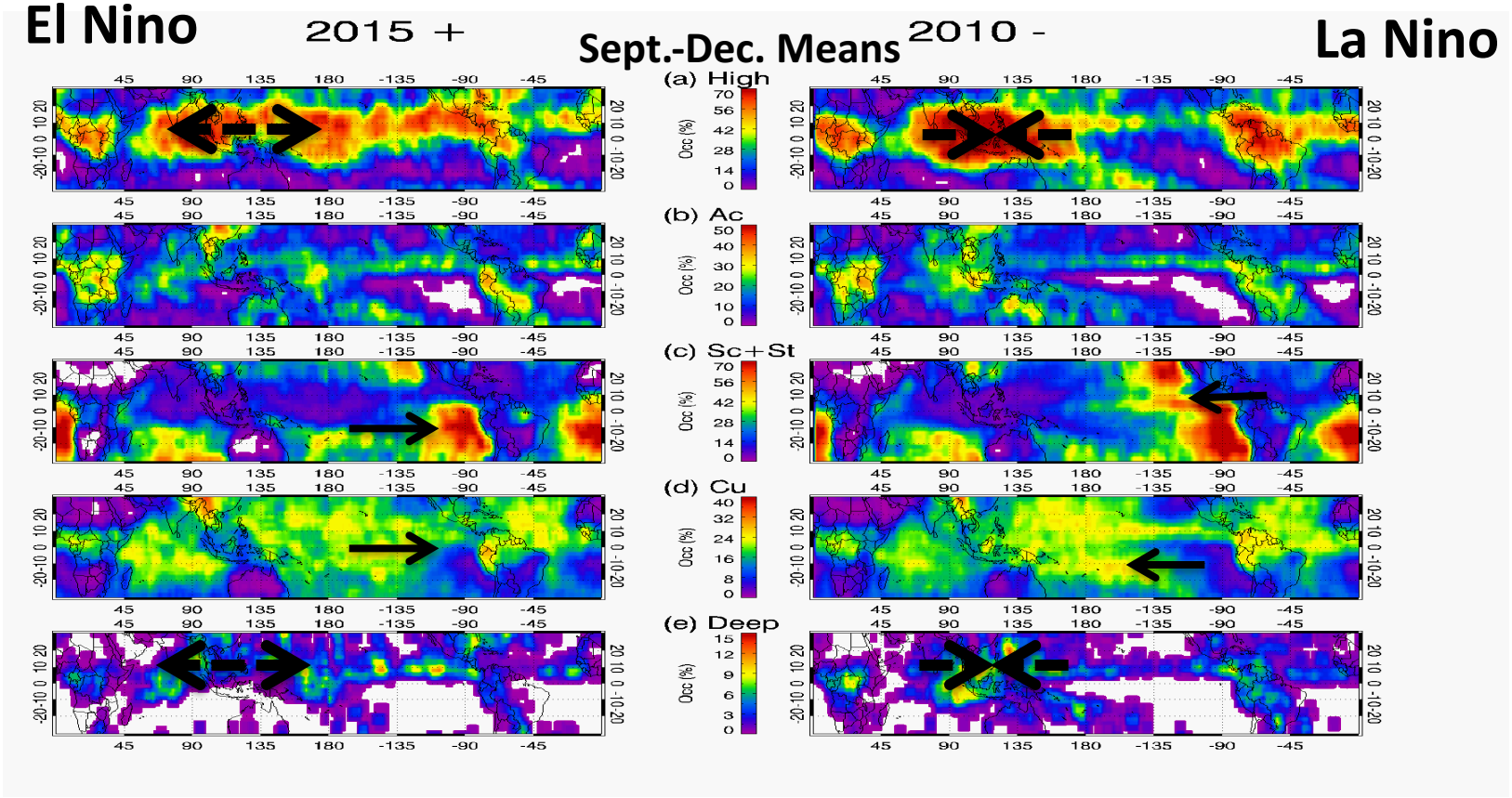
Interannual Cloud Type Variations

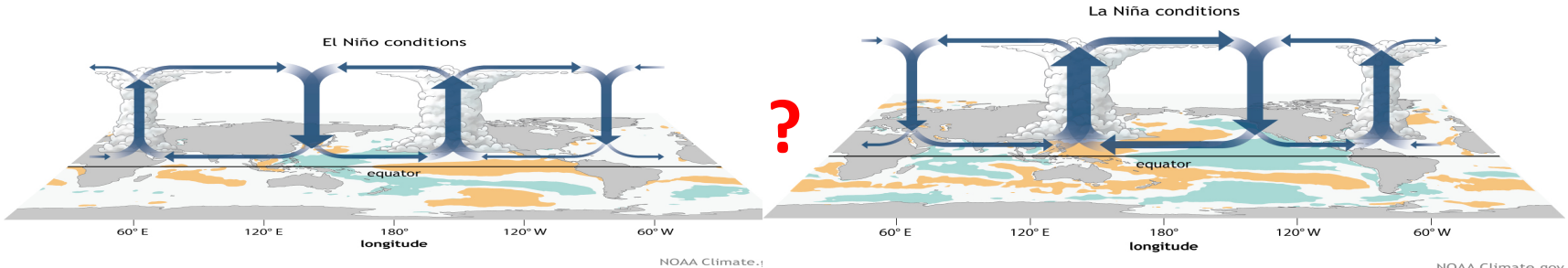
Anomaly

Deep convective clouds and associated high and Ac clouds move systematically as ENSO evolving!



Tropical Cloud Type Distributions during Positive and Negative Phases



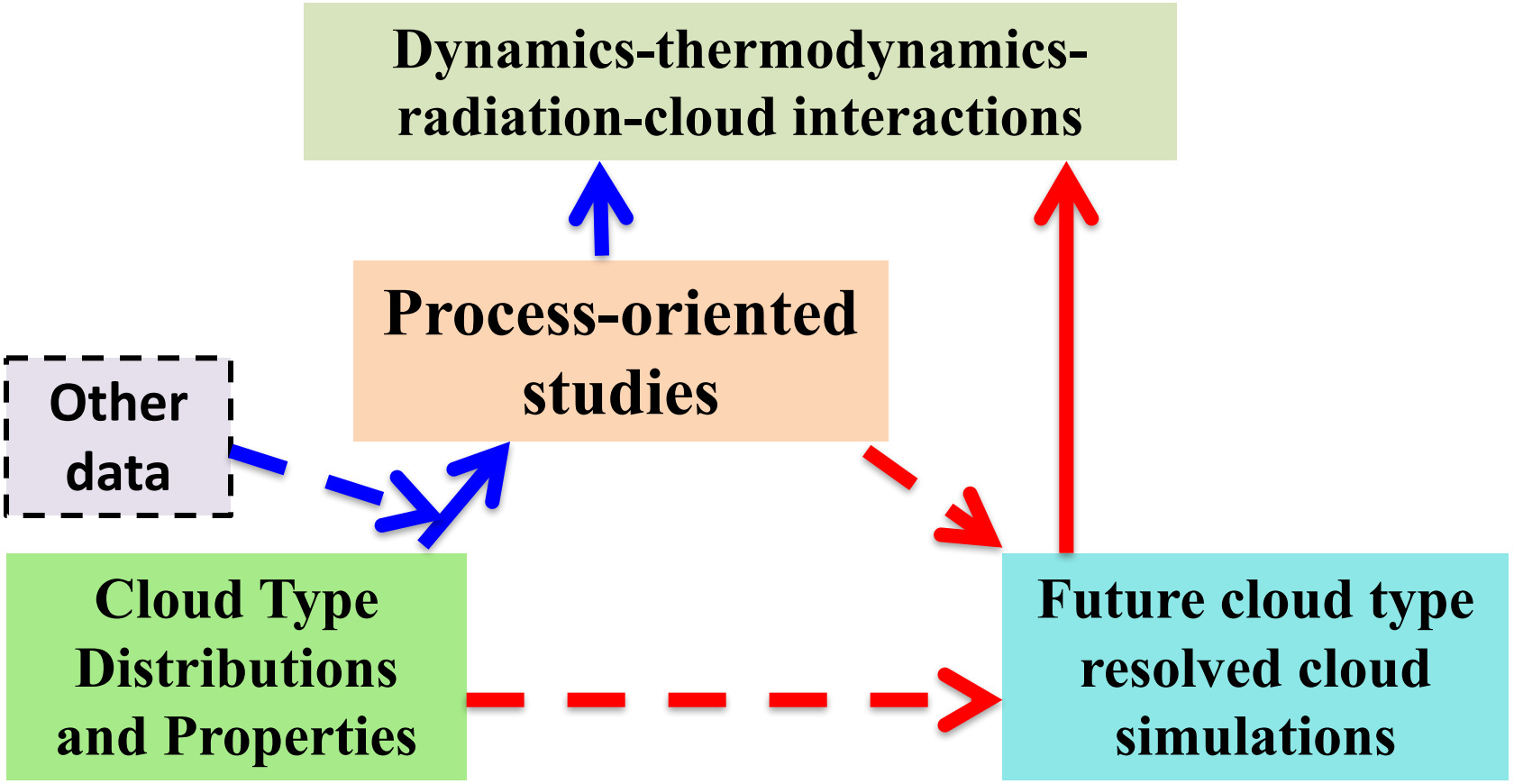


Summary and Thoughts

- Difference types of clouds working together regulate global water and energy cycles.

- Cloud-radiation feedbacks as a result of changing frequency of cloud types and changing properties of a cloud type.

- ISCCP and CloudSat cloud type products offer an important data source to study cloud type dependent feedbacks.



Following Natural Clouds.

Bill,
Congratulation!
Thank You!