Trade-wind cloud amount and its controls

An observational and model perspective

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Nuijens, Medeiros, Sandu and Ahlgrimm (in preparation for JAMES): The behavior of trade-wind cloudiness in observations and models. I: The major cloud components and their variability & II The dependence on humidity and the large scale flow.

In this talk

Questions:

- a) How do different components of cloud vertical structure contribute to total cloud amount?
- a) How do these components vary with time, on time scales shorter than a month?
- a) Do large-scale models represent the cloud profile and its variability?

In this talk

Data:

- 1. BCO: 4 years of cloud, humidity and temperature profiling at Barbados Cloud Observatory
- 2. ECMWF IFS at the BCO location:

short integrations (24 hrs) : $\Delta t = 3$ hrs, T1297, 91lev long integrations (4 x 1yr) : $\Delta t = 30$ min, T255, 91lev

3. cfSites output: AMIP runs at the BCO or BOMEX location:

30yrs ∆t = 30 min MPI-M BCC CCCma IPSL CNRM MOHC MRI

Bottom- as well as top-heavy distributions



Nuijens et al. (2014) QJRMS

The "bottom" contribution relatively invariant on longer time scales



Nuijens et al. (2014) QJRMS

Large skewness in cloud fraction distributions



Large skewness in cloud fraction distributions



In terms of Florent's gamma



 $\gamma^* = \mathsf{CF}_{925} \, / \, [\, \mathsf{CF}_{925} + \mathsf{CF}_{825} \,]$

Is monthly mean output sufficient to address modeled cloud deficiencies?



Is relative humidity an issue?



Conclusions

Observational perspective:

- a) Cloud near cloud base is a relatively robust component of trade-wind cloudiness, and varies little with variations in the large-scale flow
- b) Long-term variations in trade-wind cloudiness are carried by stratiform cloud near the detrainment level of cumulus tops
- c) More stratiform cloud is present when clouds occur in somewhat deeper and larger clusters that rain. Note the importance of cloud organization and detrainment

Model perspective:

- a) Models unrealistically vary cloud near cloud base
- b) Near cloud base, the relationship between cloud and the large-scale environment (e.g. relative humidity) is different from observed relationships
- c) The (shape of the) monthly mean profile may not be representative of model's instantaneous behavior

Photograph by Kerry Emanuel

Back up

Relationship between cloud fraction and humidity on time scales less than a month



Relationships between cloud fraction near cloud base and the large-scale environment



See also: Brueck et al (2014) JAS

Back-up



Back-up



Top-heavy distributions favored during the dry season



What makes a bottom-heavy distribution or clear sky?



What makes a bottom-heavy or top-heavy distribution?

