Cluster analysis of low level thermodynamics profiles to characterize cloud regimes on tropical and subtropical oceans

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Objetive

In the context of tropical and subtropical ocean-atmosphere interaction, cloud-topped boundary layer (CTBL) constitutes an important contributor to radiative forcing and climate cloud feedbacks. Identifying the primarily thermodynamic structure that corresponds to low cloud regimes can serve a multitude of purposes. In this study, we report preliminar results of a technique that aims to identify boundary layer (BL) cloud regimes based on clustering thermodynamics profiles from National Centers for Environmental Prediction (NCEP) operational analysis and the cluster correspondence to satellite cloud property from International Satellite Cloud Climatology Project (ISCCP).

Dada and Analysis Procedure

Seven days of June 2006 six-hourly NCEP analysis with ~0,39° horizontal resolution and the latitude range 40°S to 40°N were used for this study. The clustering variables were profiles of static stability ($d\theta/dp$) and relative humidity (*RH*) at 19 levels below 700 hPa pressure level.

Satellite observations from ISCCP-D1 data set with 2.5° horizontal resolution contain cloud-top frequency in seven pressure level intervals. This statistical grid data were averaged within each group for those grid observation that the allocate classified fields present a single group frequency greater than 70%.

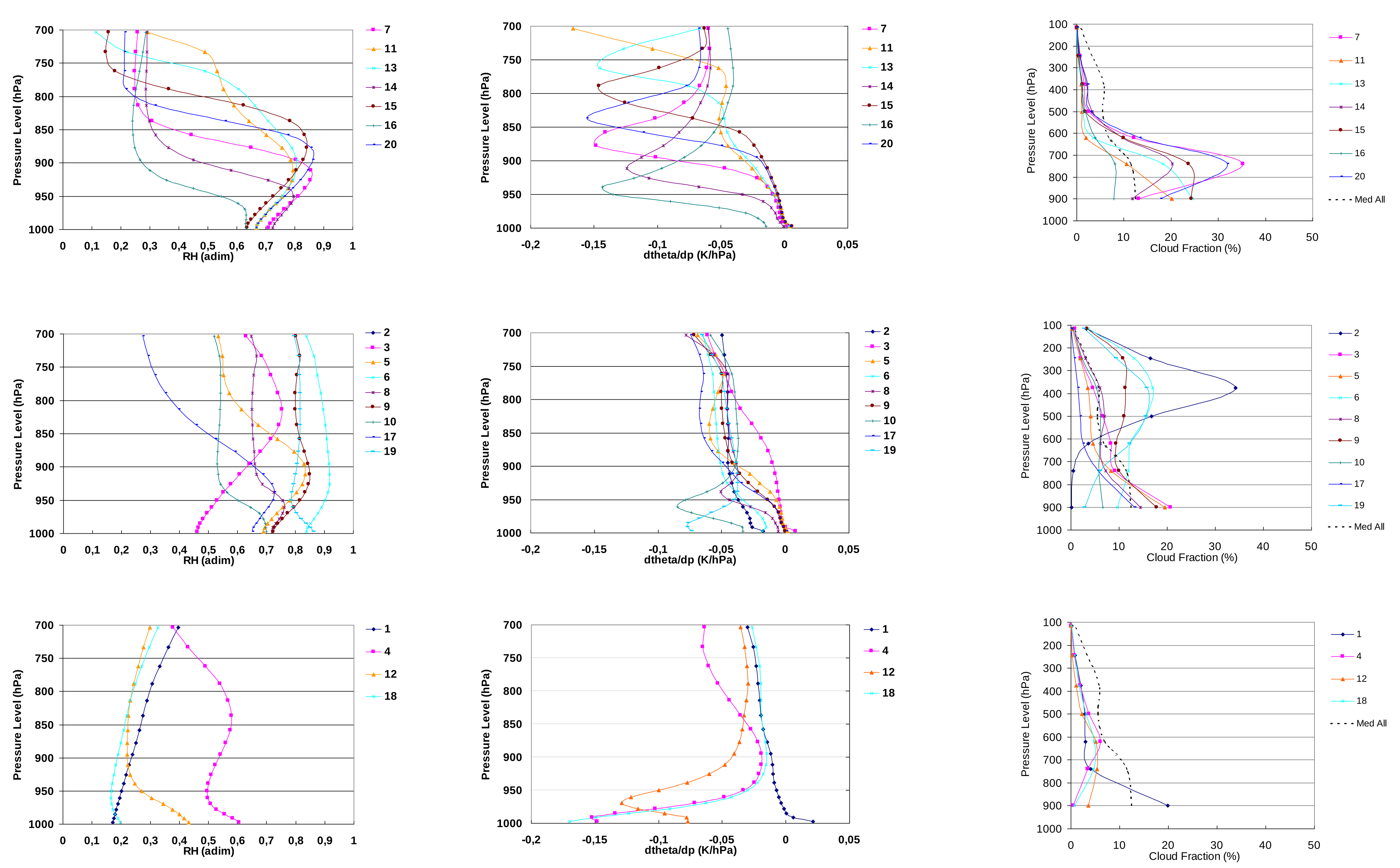
Clustering method

The multivariate iterative cluster method algorithm "dynamic cluster" (Desbois et al. 1982) performs classification of the thermodynamic profiles using the minimum Euclidian distance as similarity measure and an iterative procedure of dynamical centroids in order to minimize the variance of groups. To deciding on appropriated number of groups we have adopted a criteria of clusters union (Ward 1963), and a stopping rule based on the plot of the total within cluster sum of squared deviations against the number of groups.

Strong static stability subset

Conditionally unstable or weak stability subset

Low relative humidity subset



Relative humidity (adim) | Static stability $d\theta/dp$ (K/hPa) | Observed Cloud-top frequency (%)

Results

The clustering algorithm applied to $d\theta/dp$ and *RH* profiles from NCEP analysis resulted nearly 20 primarily groups.

The 20 centroids, corresponding to mean profiles of *RH* and $d\theta/dp$ (plotted on left and center columns in figure), were selected in subsets (rows in figure) with the following characteristic regimes:

1) strong static stability [min($d\theta/dp$)< -0.1 K/hPa], ;

2) conditionally unstable/weak stability [min($d\theta/dp$)> -0.1 K/hPa];

3) dry with low relative humidity layer [max(*RH*)< 60%].

The observed mean cloud-top frequency bellow and above the 680 hPa pressure level for each regime.

Level/Regime	Stable	Cond. Inst.	Dry
Low	38	19	11
Mid/high	12	36	10

Groups with strong static stability occur almost exclusively over the ocean and show a vertical distribution of base inversion layer from 960 to 730 hPa pressure level. The layer with maximum *RH* is just bellow the base of inversion for shallow coupled BL and at the subcloud level, around 900 hPa pressure level, for the decoupled BL (Albrecht et al. 1995). As air moves equatorward around sub-tropical highs SST increase, large-scale subsidence weakens, the BL deepens, and the inversion strength weakens. A solid stratocumulus deck becomes cumulus-under-stratocumulus and then tradewind cumulus. This behavior is according to the observed mean cloud-top frequency in 900 and 740 hPa nominal pressure level (Wood and Bretherton 2004).

Conclusion

The cluster analysis of low troposphere $d\theta/dp$ and *RH* profiles seem able to capture the primarily thermodynamic structure, which correspond to the observed cloud regimes. The methodology can serve to obtain mean BL and cloud properties to improve model parameterizations.

Reference

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