Variations of Tropical Cloud Regime Occurrence During the MJO Using ARSCL and ISCCP Data

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Summary

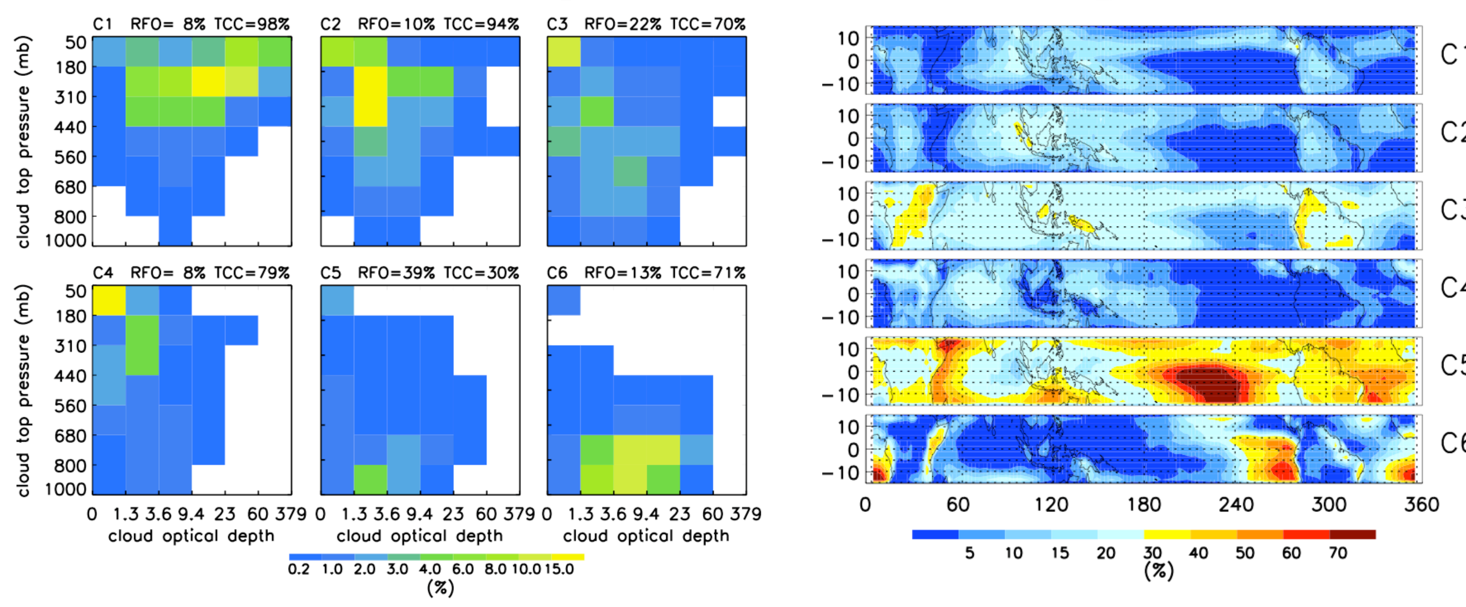
❖ ARSCL highest cloud-top height profiles indicate that differences among some cloud regimes defined by cluster analysis of ISCCP optical thickness – cloud top pressure histograms may not be as prominent as suggested by ISCCP. Subtle regime differences in optical thickness may be manifested primarily by their effect on the ISCCP retrieval of cloud-top pressure.

❖ Clustering ARSCL highest cloud-top profiles alone we can identify 4 regimes at Manus, including a middle-level regimes and 3 at Nauru.

❖ Hovmöller diagrams and MJO composites based on the ISCCP regimes show systematic and dynamically repeatable cluster variations consistent with proposed MJO mechanisms (e.g., recharge-discharge). MJO composites of ARSCL cloud profiles, precipitation and relative humidity at Manus show similar transitions between MJO phases.

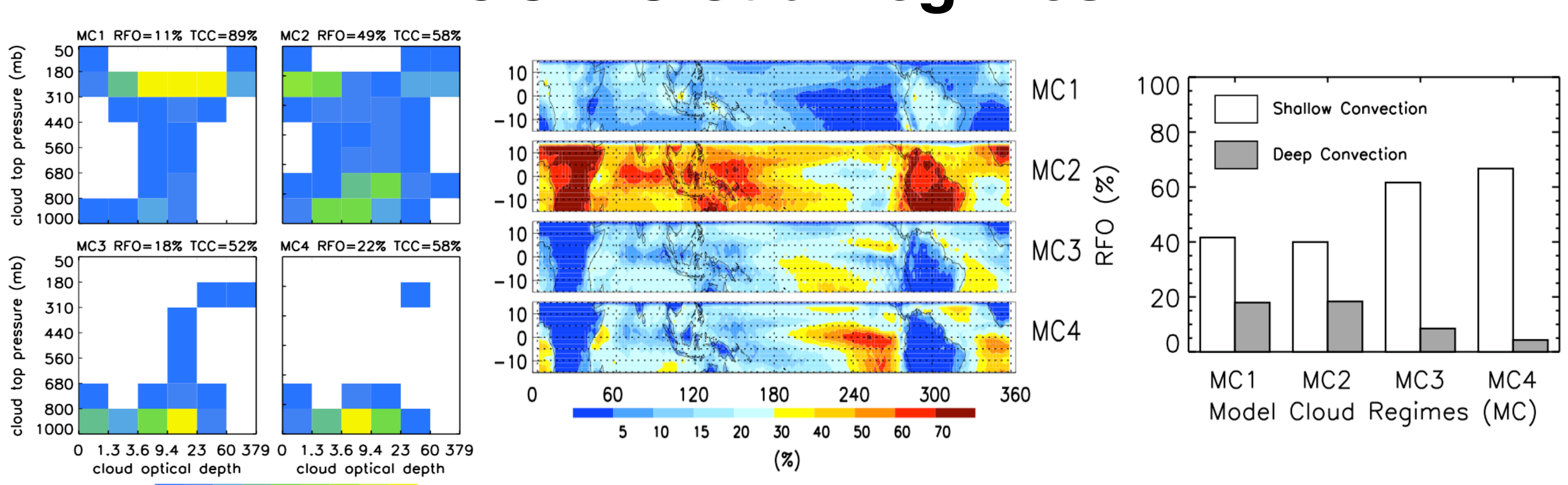
❖ The GISS GCM separates two disturbed and two suppressed regimes with some similarity to those from ISCCP. There is, however, no real distinction between regimes in the physical processes behind them.

ISCCP Tropical Cloud Regimes



The figures above show 6 cloud regimes (left) and their geographic occurrence frequency (right) based on the cluster analysis. Clusters C1-C4 correspond to regimes dominated by deep convective clouds, cirrostratus anvils, midlevel cumulus congestus, and isolated cirrus respectively, which all have a preference to occur in the ITCZ and SPCZ. The other 2 clusters (C5-C6) represent suppressed cloud regimes: shallow trade cumulus over the central/east Pacific, and marine stratocumulus off the west coast of South America.

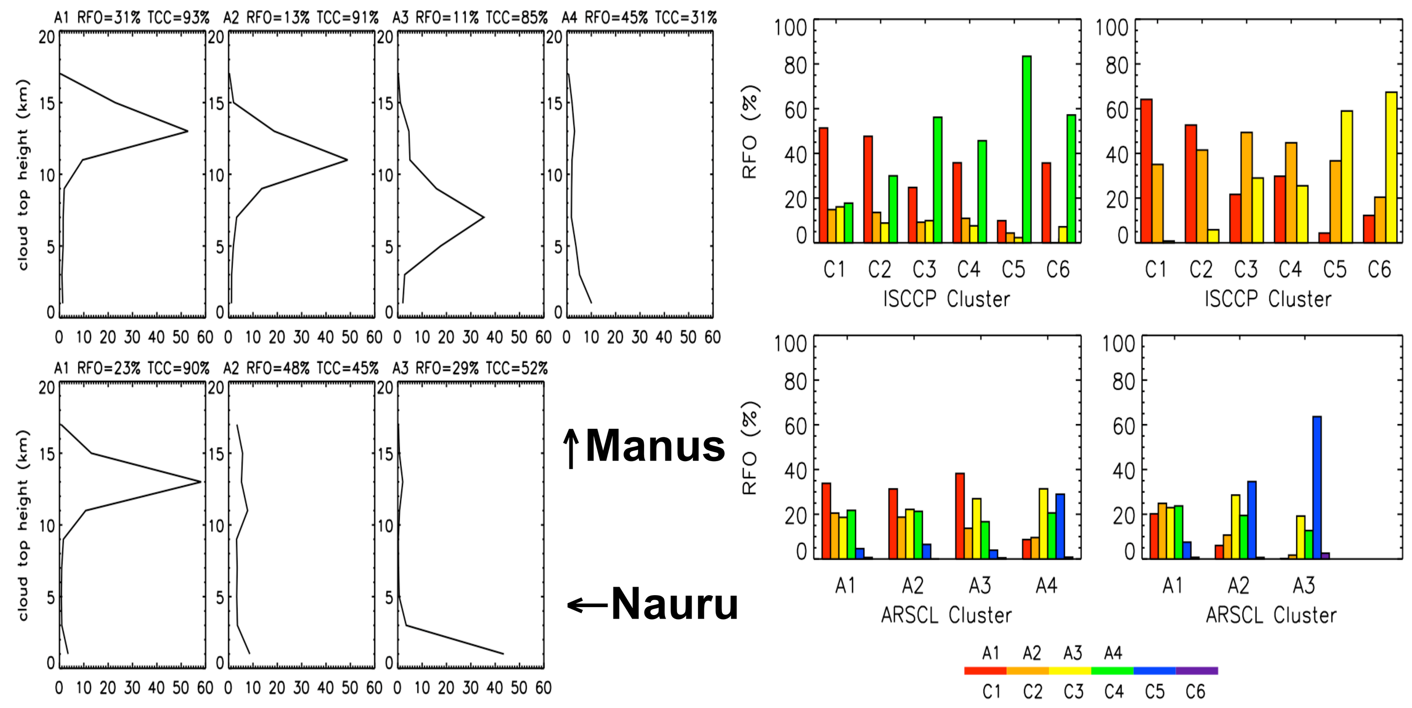
GCM Cloud Regimes



Left and Middle: MC1 mostly resembles the ISCCP deep convection regime which occurs frequently in the ITCZ and SPCZ. The two model suppressed regimes (MC3 and MC4) have some similarity to ISCCP shallow cumulus and marine stratocumulus regimes (C5 and C6). The dominant regime MC2 is a mixture of 3 types of clouds.

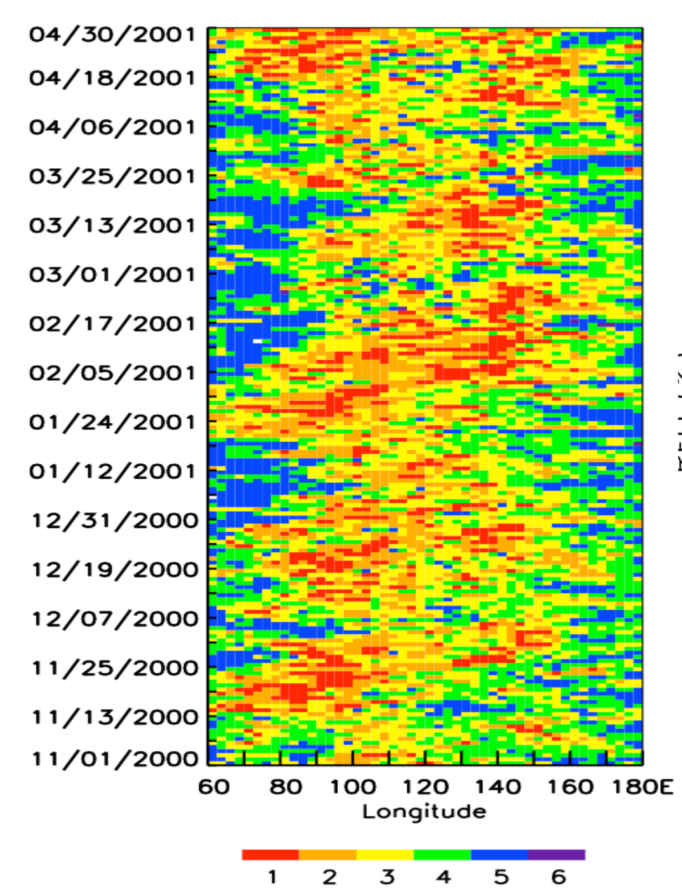
Right: Association of clusters with specific physical mechanisms is not reliable except for the clear distinction between deep and shallow processes.

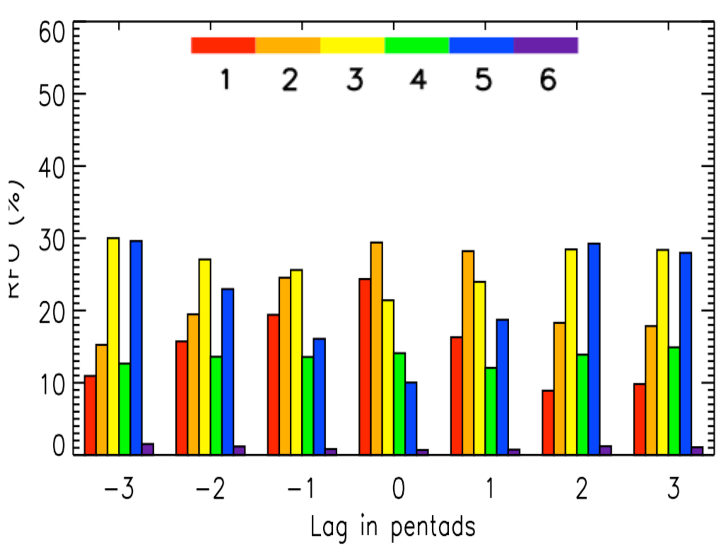
ARSCL Cloud Regimes

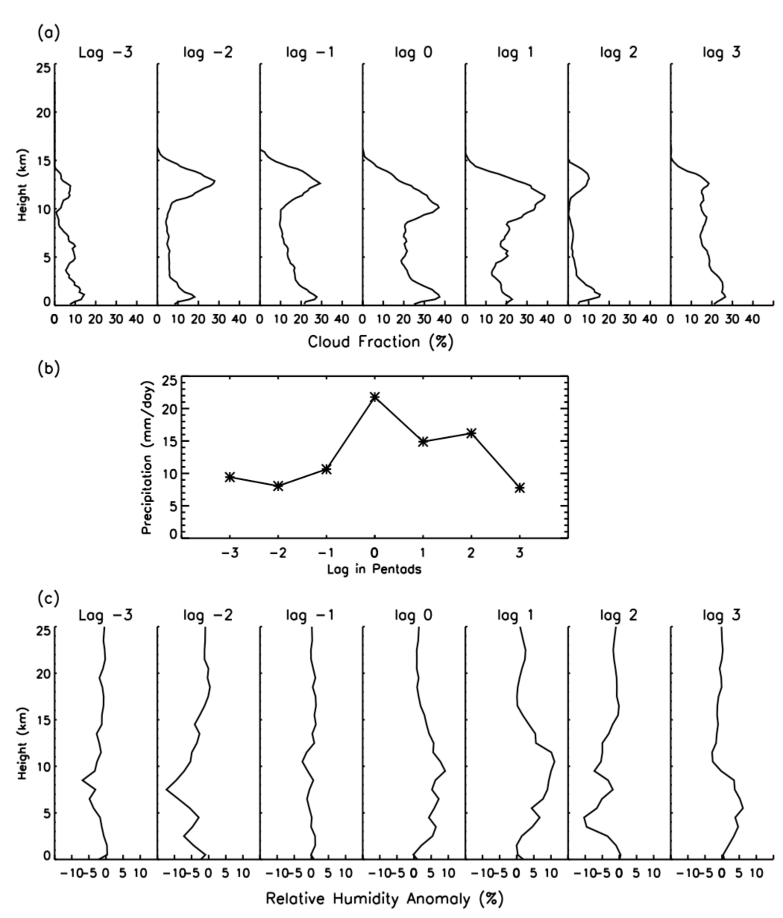


A trimodal distribution of tropical convective cloud tops is seen in the ARSCL clusters at Manus. At Nauru the 3 ARSCL clusters occur about as often as ISCCP C1 and C2, C3 and C4, C5 and C6 combined respectively. At both sites, the most highly correlated ISCCP C3 and C4 have similar relative occurrences of ARSCL clusters.

Regime Shifts in the Context of MJO





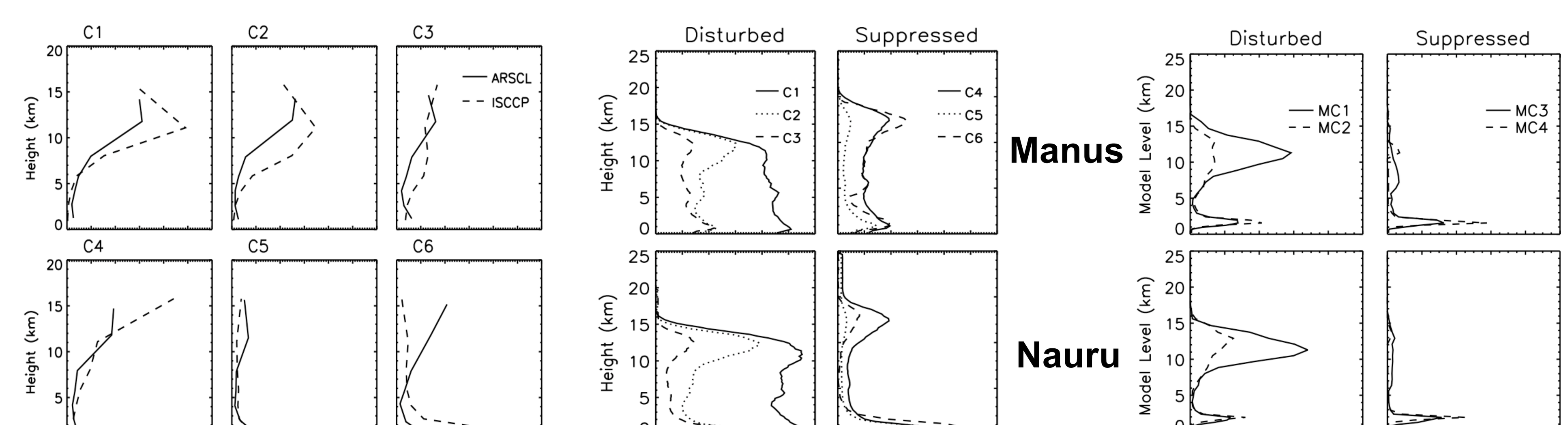


Left: A Hovmöller diagram using color-coded ISCCP cloud regimes clearly shows eastward propagation of the deep convective regime (red) with a period ~ 30 days.

Middle: Deep convective (red) and anvil (orange) regimes increase approaching the peak of MJO and decrease afterwards, while mid-level congestus (yellow) and shallow cumulus (blue) reach a minimum at the peak phase and dominate several weeks before/after. The thin cirrus regime is uncorrelated with MJO phase, suggesting a non-convective origin.

Right: Cloud profile, precipitation and relative humidity changes at Manus during MJO support the impression of regime shifts in the middle figure.

ISCCP and GCM Cloud Profiles vs. ARSCL



Left: ISCCP cloud-top profiles differ more between regimes than do those from ARSCL. In general, more mid-level cloud-tops are detected in less disturbed and more suppressed conditions and low cloud occurrence is underestimated.

Middle (ARSCL) and Right (GCM): ARSCL profiles of all cloud levels show that all ISCCP regimes except C5 contain significant mid-level cloud, while there is little mid-level cloud in the GCM, whose distribution is distinctly bimodal. C3 and C4 have similar profiles.