On the Spatial Structure of Hydrometeors over the Maritime Continent

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Introduction

A primary objective of the CloudSat mission is to provide observations of cloud and precipitation vertical structure. To that end, CloudSat observations are being used to construct joint histograms of radar reflectivity with height and a variety of two-point spatial statistics, including vertical and horizontal correlations in hydrometeor (cloud and precipitation) occurrence, reflectivity, and rain rate [Marchand 2012]. This poster examines the structure of hydrometeor fields over the Maritime Continent. Particular attention is paid to differences between hydrometeor fields over land and ocean and between CloudSat daytime and nighttime overpasses with respect to the phase of the Madden-Julian Oscillation (MJO).

Marchand, R. (2012), Spatial correlation of hydrometeor occurrence, reflectivity, and rain rate from CloudSat, *J. Geophys. Res.*, 117, D06202, doi:10.1029/2011JD016678.

Summary of Observations

CloudSat reflectivity-height histograms show a peak in hydrometeor occurrence along a characteristic curve with a peak reflectivity near 0 dBZ at the surface, increasing reflectivity with altitude moving toward the freezing level, and then decreasing reflectivity with altitude ending in a cirrus peak. Over the Maritime region, the cirrus cloud peak occurs near 13 km at a reflectivity near -25 dBZe. This peak is near the CloudSat sensitivity limit; a more sensitive radar might well show a cirrus peak at a somewhat higher altitude and at a lower reflectivity.

Active vs. Suppressed

There is an increase in hydrometeor amount at almost all reflectivities and altitudes during the active phase of the MJO. Of particular interest is an increase in the amount of mid-level cloud, which is larger at night than during the day.

Day-Night and Land-Ocean differences are similar between the active and suppressed phases. There are, however, some differences including:
- Active: a larger increase in daytime, oceanic cirrus above the characteristic curve.
- Suppressed: more non-precipitating low-level clouds over land.

The phase of the MJO has only a small impact on the hydrometeor occurrence correlation structure. There is slightly stronger horizontal correlation during active phase, primarily below 5 km.
- Consistent with an increase in stratiform precipitation (day and night).
- Suggests cloud systems are slightly larger on average during active phase.

Vertical correlation between mid-level and high-level hydrometeors is weaker over land at night during the active phase of the MJO, perhaps due to compensating subsidence.

Over Ocean

Nighttime overpasses show more low and mid-level cloud, lower anvil bottoms, and more high-level hydrometeors with very large radar reflectivities than daytime overpasses, all consistent with an early morning peak in MCS activity.

Daytime overpasses show more hydrometeors just above the characteristic curve and more cirrus above 13 km. This may be due to :
- Remnants from the previous night's MCSs [Chen and Houze 1997] ?
- And/Or daytime convection producing higher anvils ?

Horizontal correlation at night is stronger above 11 km during the active phase, implying larger anvils.

Over Land

There are more non-precipitating low-level clouds over land than over ocean (except perhaps below 1.2 km) and more during the daytime overpasses than nighttime overpasses.

There is much less convection over land during the daytime overpasses including less area with surface rains. The CloudSat daytime overpasses occur near 13:30 local time, well before the late afternoon to evening peak in land convection.

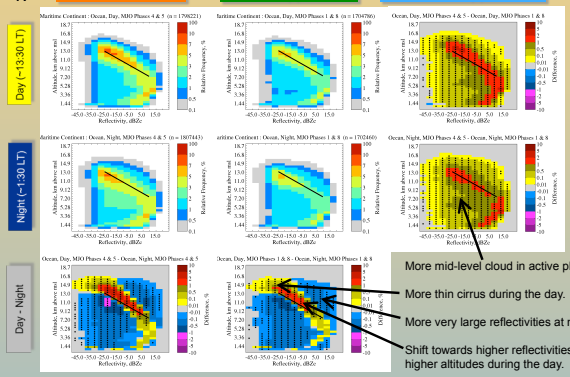
In sharp contrast to ocean areas, the correlation of hydrometeor occurrence in the horizontal and the vertical is much stronger at night than during the day at all altitudes, especially near 5 km. This result indicates that cloud systems are much larger over land during the nighttime overpasses.

Ocean

Land

Reflectivity-Height Histograms

1. MJO Active | MJO Suppressed | Active - Suppressed



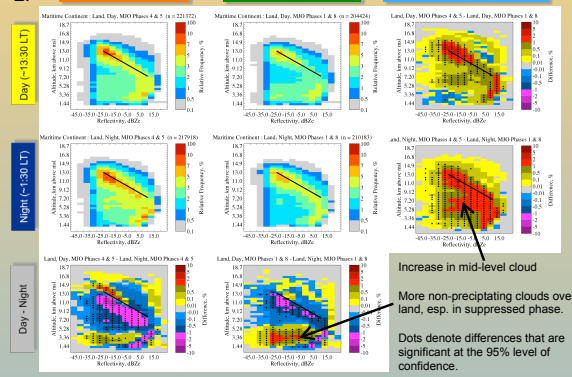
More mid-level cloud in active phase.

More thin cirrus during the day.

More very large reflectivities at night.

Shift towards higher reflectivities and higher altitudes during the day.

2. MJO Active | MJO Suppressed | Active - Suppressed



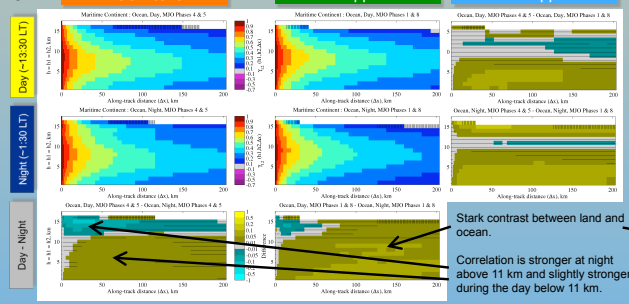
Increase in mid-level cloud

More non-precipitating clouds over land, esp. in suppressed phase.

Dots denote differences that are significant at the 95% level of confidence.

Occurrence Horizontal Correlation

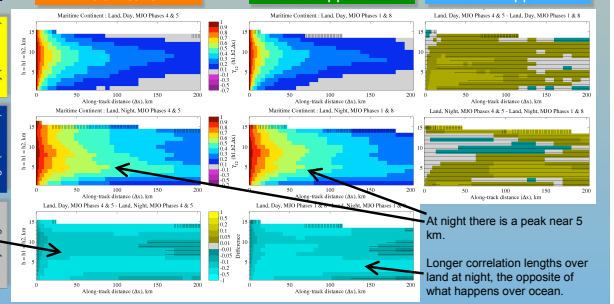
3. MJO Active | MJO Suppressed | Active - Suppressed



Stark contrast between land and ocean.

Correlation is stronger at night above 11 km and slightly stronger during the day below 11 km.

4. MJO Active | MJO Suppressed | Active - Suppressed

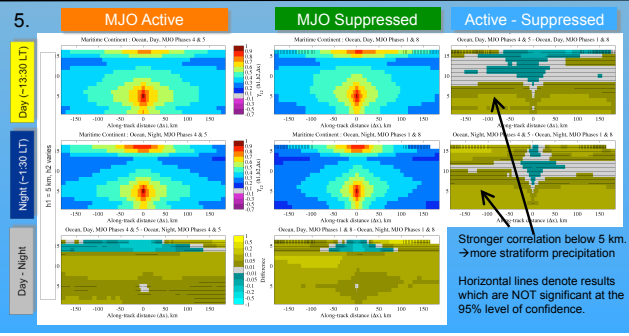


At night there is a peak near 5 km.

Longer correlation lengths over land at night, the opposite of what happens over ocean.

Occurrence Correlation at 5 km

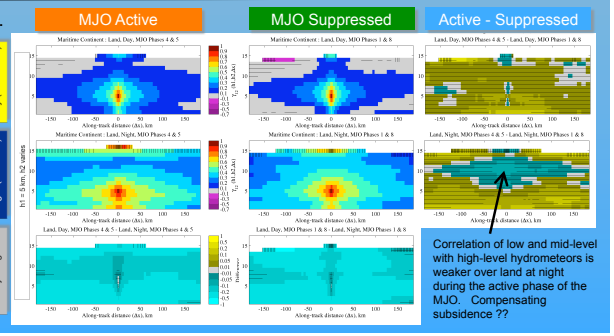
5. MJO Active | MJO Suppressed | Active - Suppressed



Stronger correlation below 5 km. →more stratiform precipitation

Horizontal lines denote results which are NOT significant at the 95% level of confidence.

6. MJO Active | MJO Suppressed | Active - Suppressed



Correlation of low and mid-level with high-level hydrometeors is weaker over land at night during the active phase of the MJO. Compensating subsidence ??