On the Evolution of Mesoscale Convective Systems during DYNAMO

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1. S-PolKa in DYNAMO

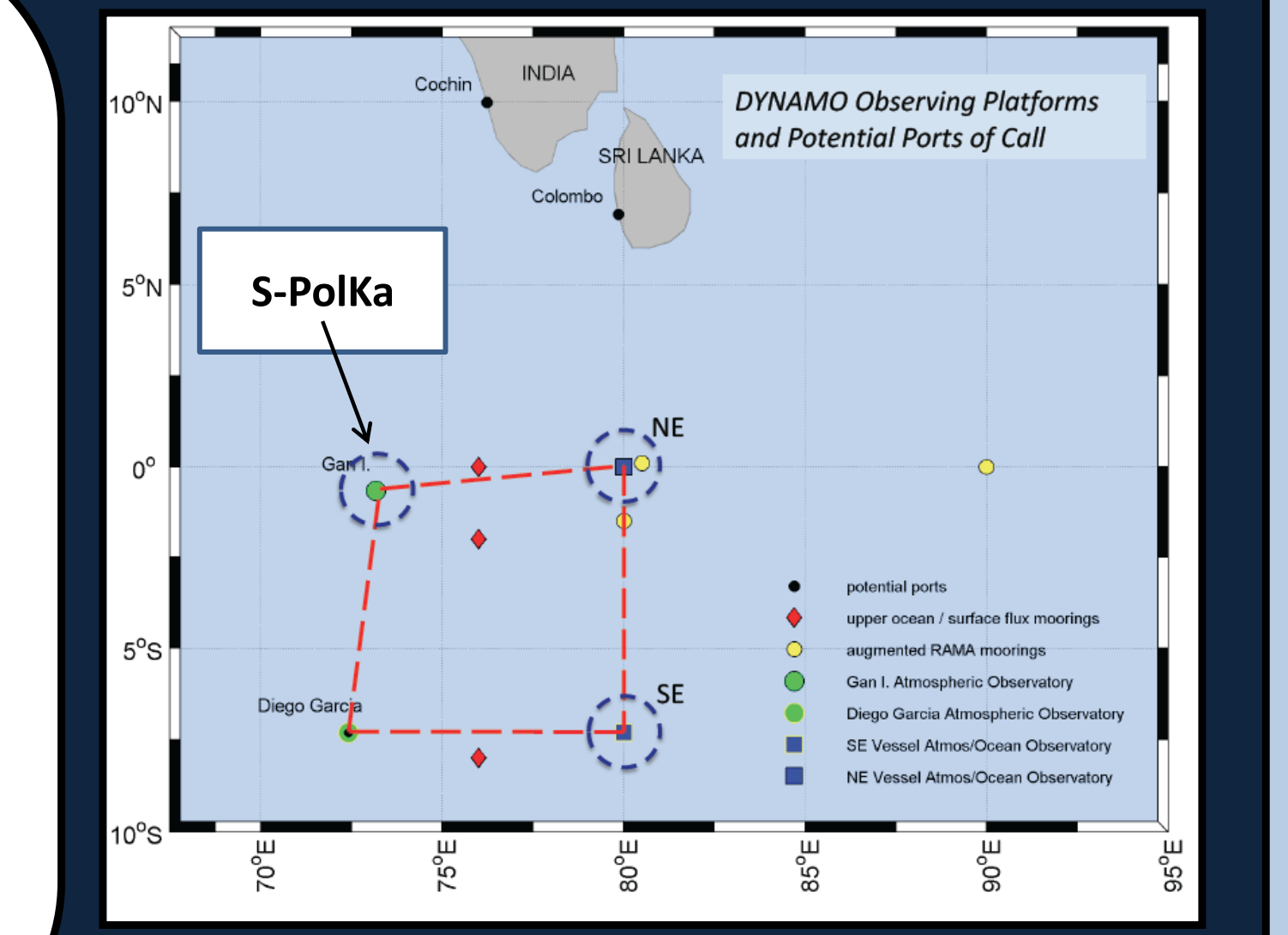
The goal of the Dynamics of the MJO (DYNAMO) experiment (Oct 2011 – March 2012) was to improve simulation and prediction of the Madden-Julian Oscillation (MJO) by understanding the coupling between convection and the large-scale environment over the Indian Ocean.

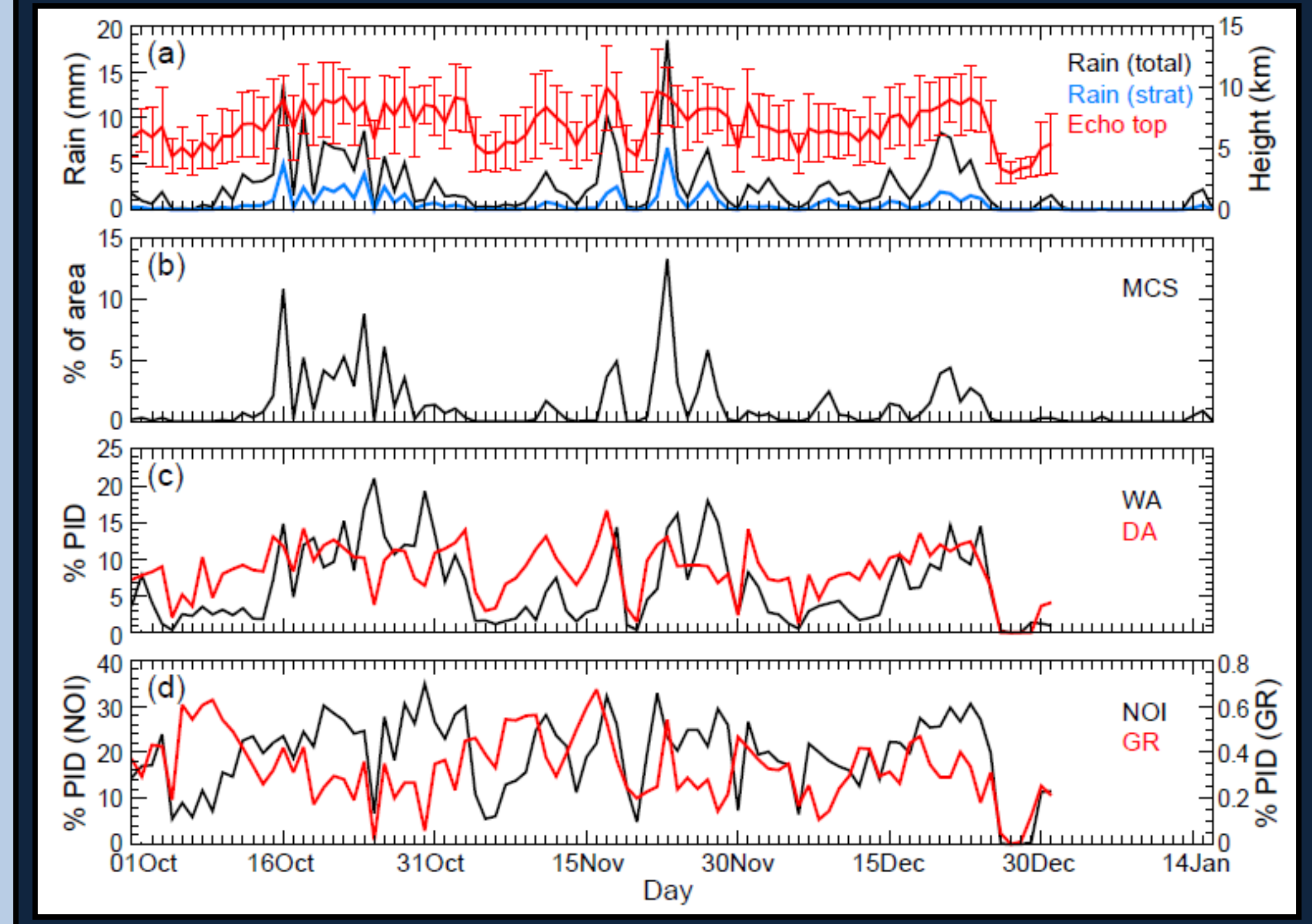
Goals of S-band:

-Observe the convective population and transition from shallow to deep (MCSs)

-Provide details on airflow within the storm

-Provide highly resolved hydrometeors information





-Increased rainfall, and MCS coverage during active MJO periods (late Oct., Nov., and Dec.) coinciding with periods of deep-layer moisture, deeper echo, and greater occurrence of wet, melting aggregates

-Dry aggregates peak just prior to wet, reflecting a transition from convective to stratiform

-Infrequent, relatively consistent presence of graupel

-Anomalous surface westerlies increase and deepen during December

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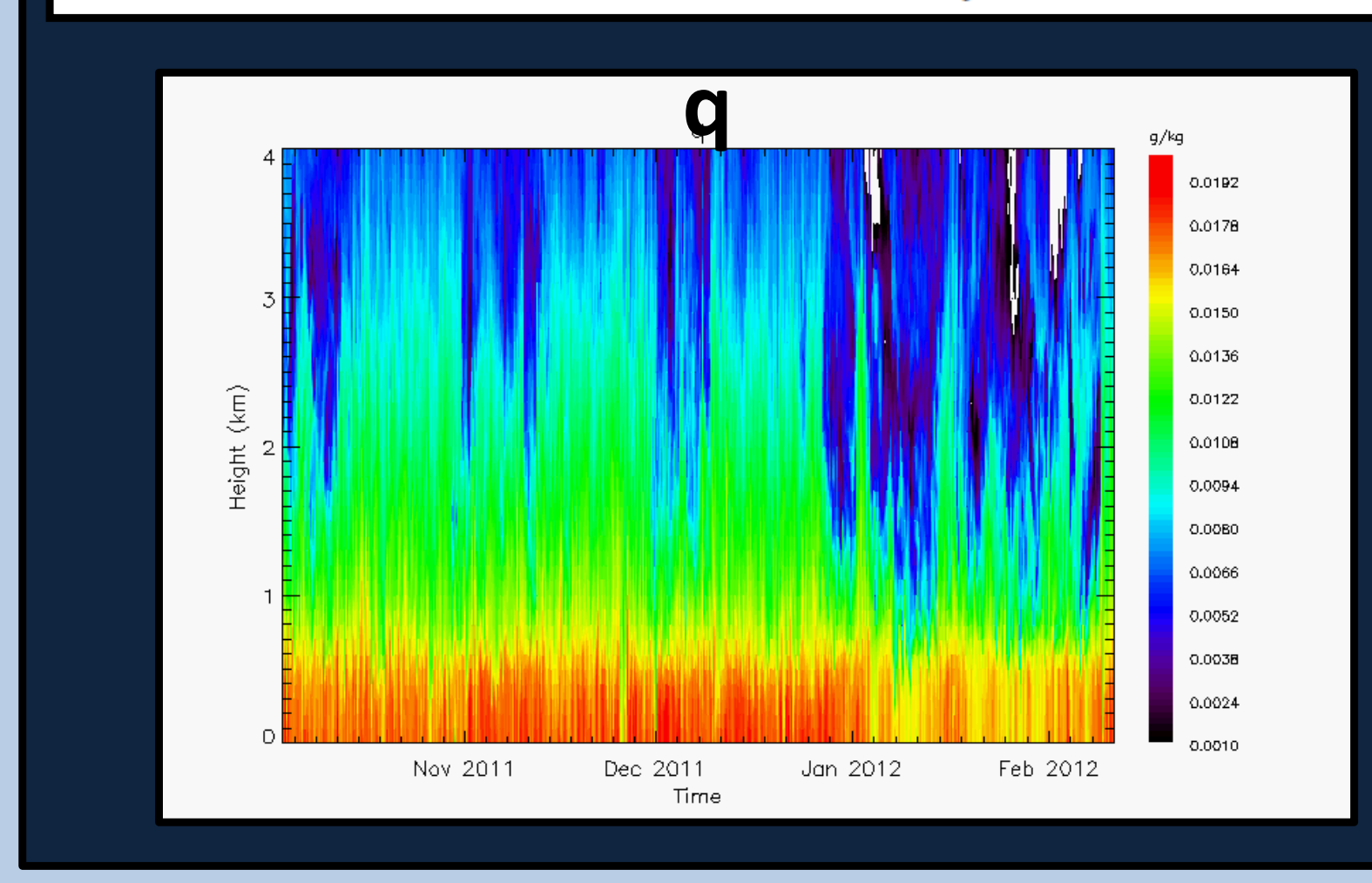

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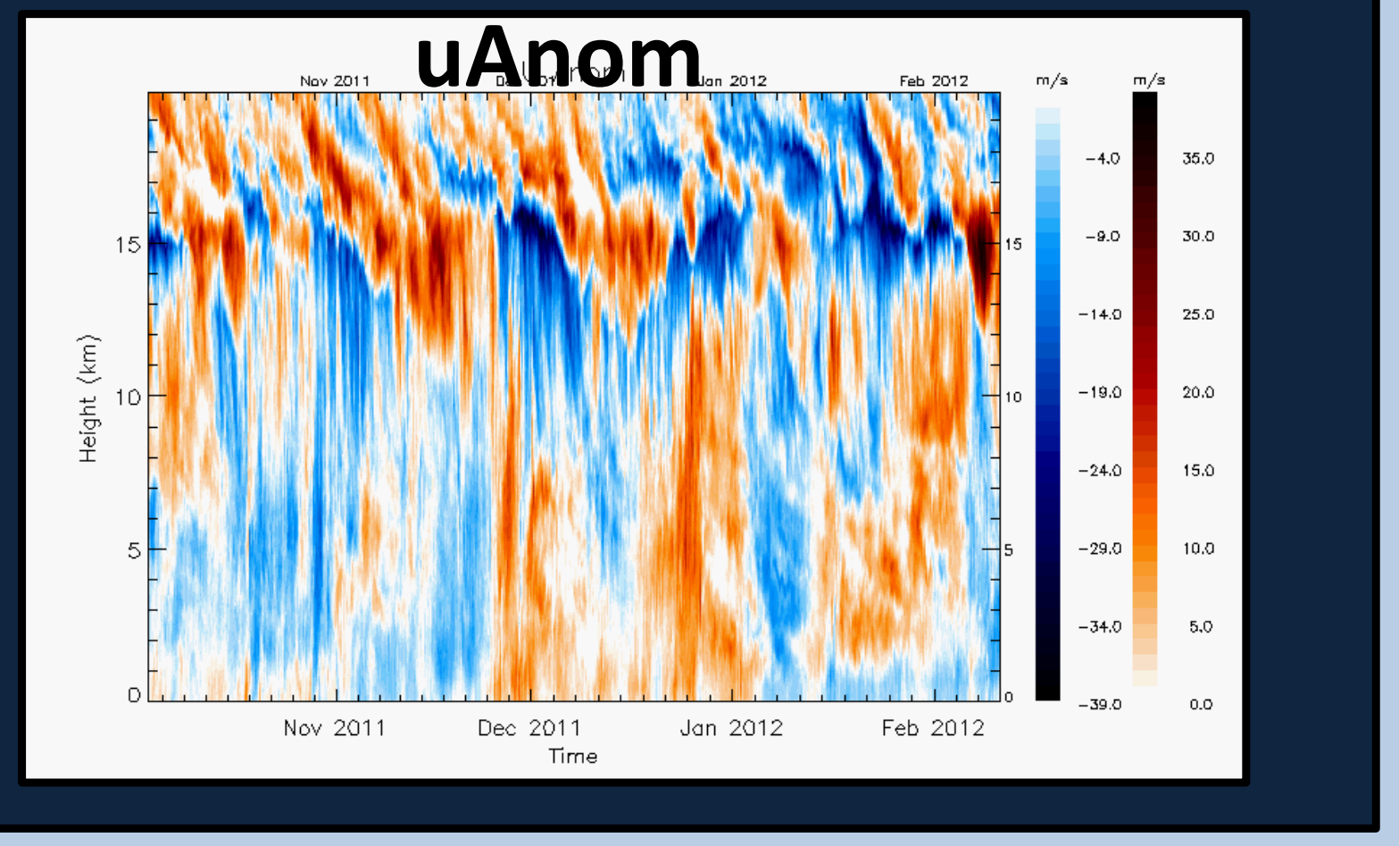
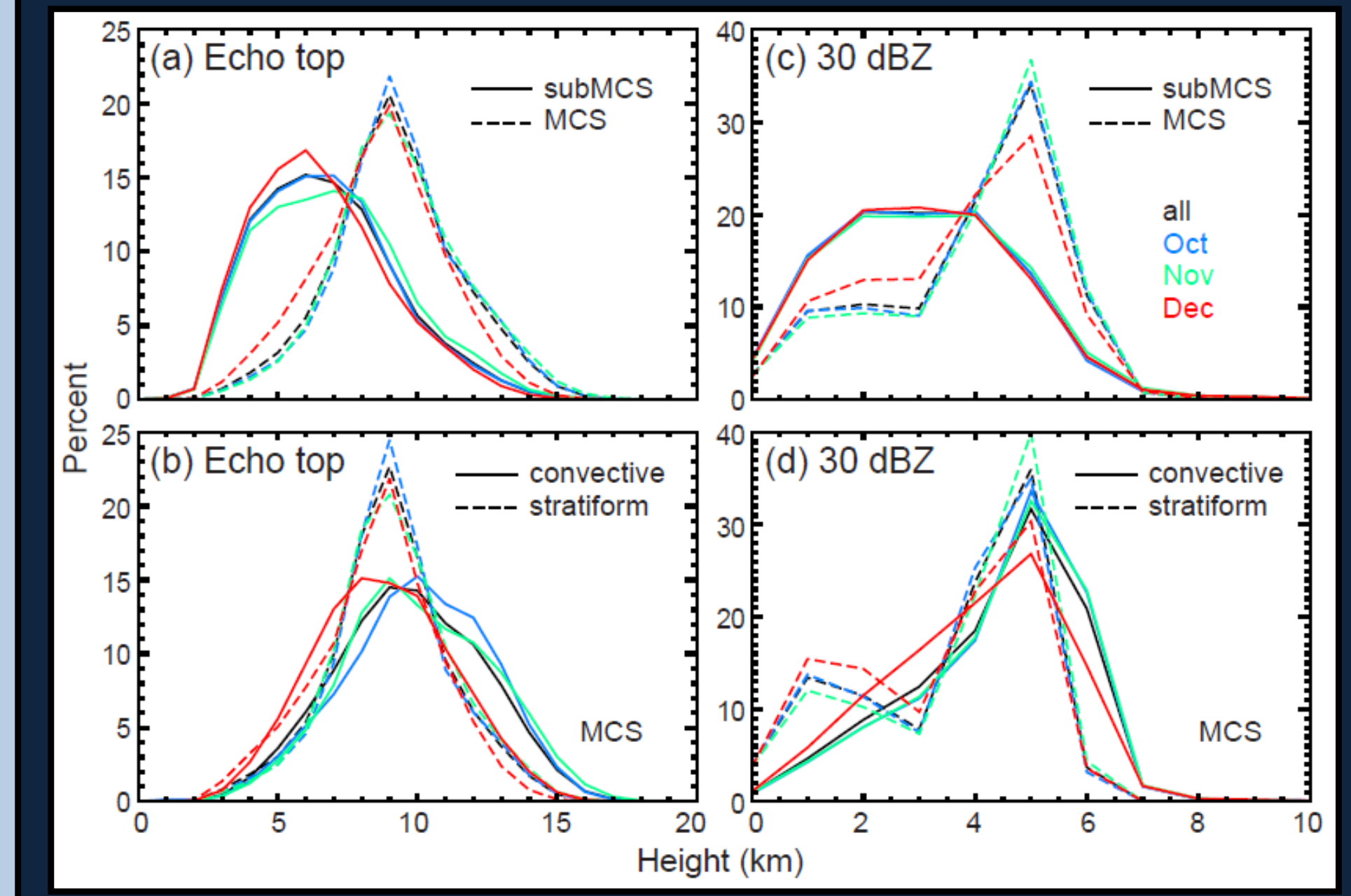


2. ECHO CHARACTERISTICS



-MCSs deeper for all months

-Max 30-dBZ height at or within a few km of melting level for MCSs (consistent with limited graupel above the melting level)

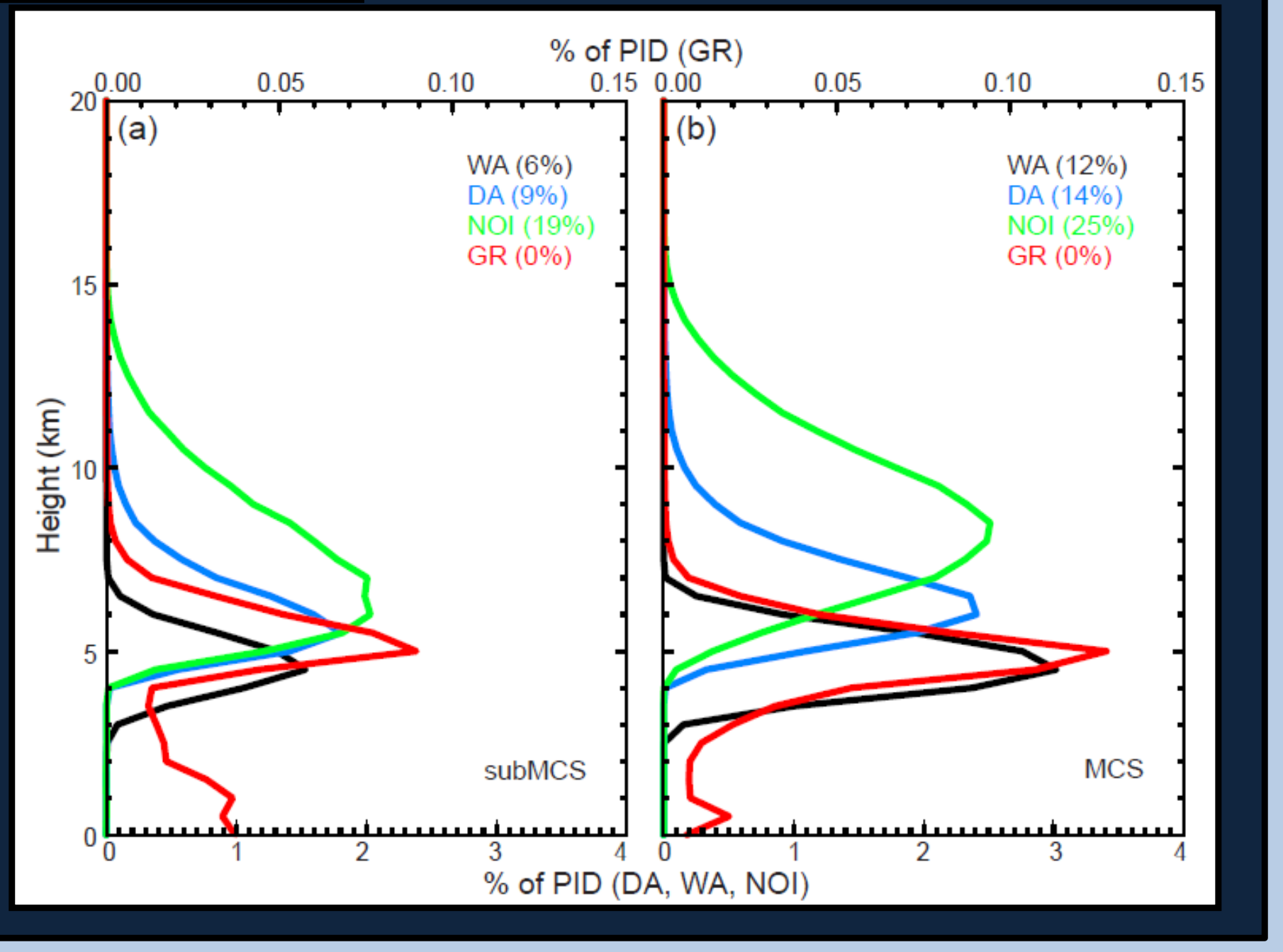
-Similar vertical distributions of hydrometeors with increased relative frequency of ice species in MCSs

-S-band data partitioned into convective/stratiform and MCS/sub-MCS (100 km threshold)

-Shallower echo in December (convection)

-Broader distribution (toward lower heights) for 30-dBZ echo

-Are the differences observed in December related to environmental conditions (i.e., stronger, deeper westerlies)?



3. MCS GROUPING

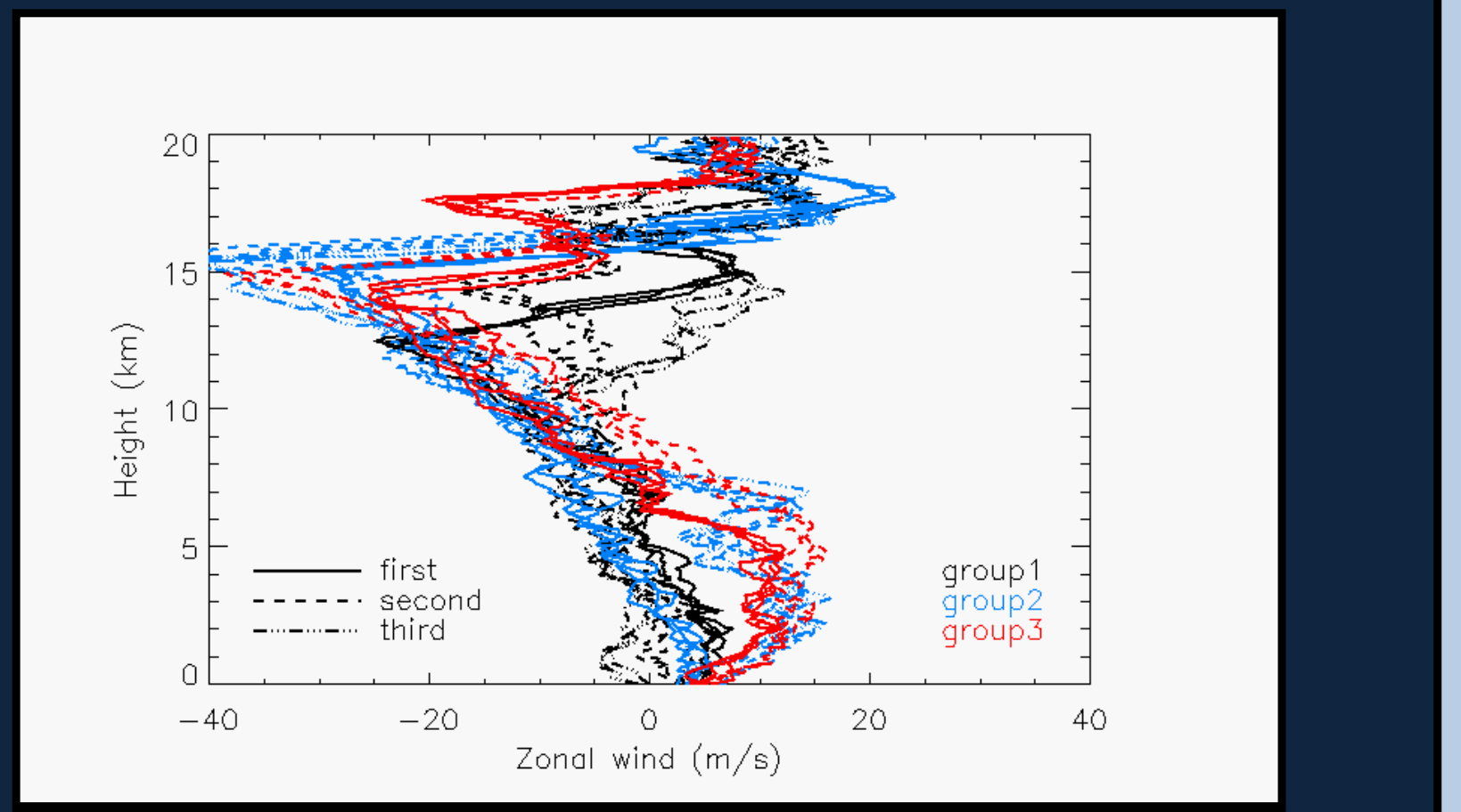
-Using a feature identification/tracking algorithm (e.g., Rowe et al. 2011), followed the evolution of individual MCSs occurring during DYNAMO

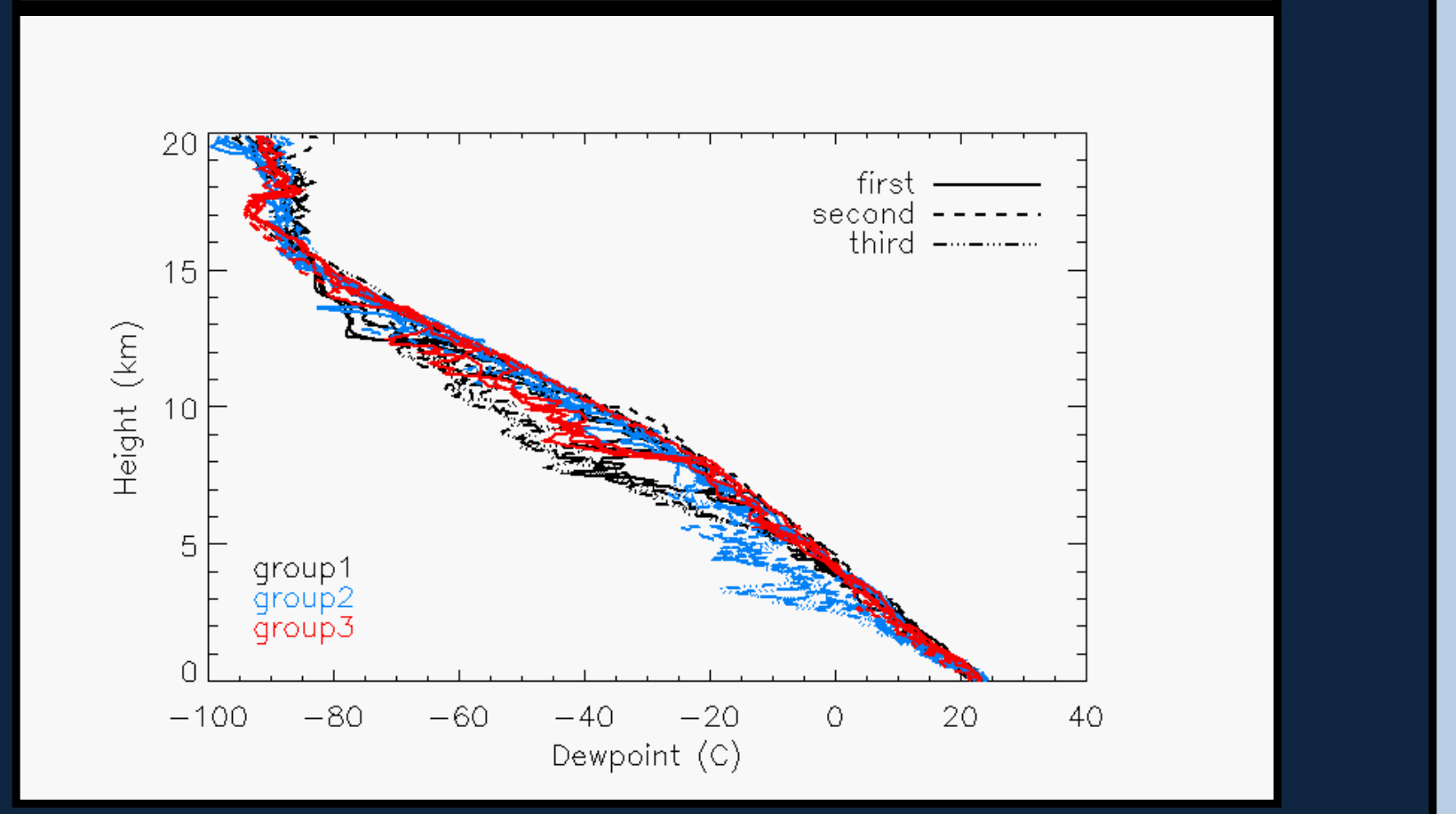
-Related environmental conditions and general characteristics of the MCSs to group cases

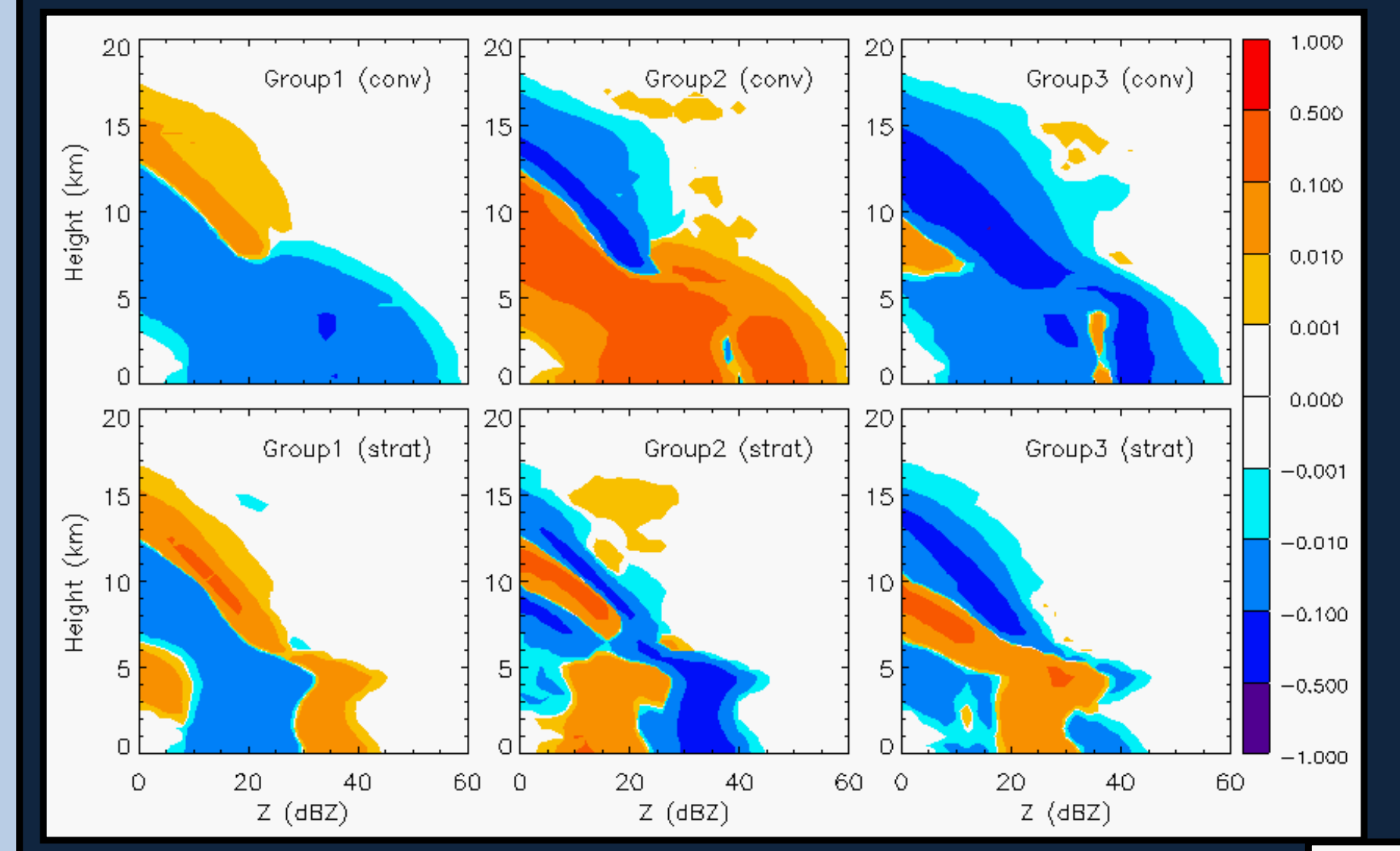
*Group1: embedded convection, easterlies over westerlies, conv/strat move in opposite directions (14-15 Oct, 24 Oct, 17 Nov)

*Group 2: Increased westerlies at end of active phase, drier mid-levels, weaker stratiform, conv/strat move same direction (31 Oct, 1 Dec, 2-3 Dec)

*Group 3: Deep, strong westerlies in Dec active phase, fast-moving squall lines, less widespread stratiform



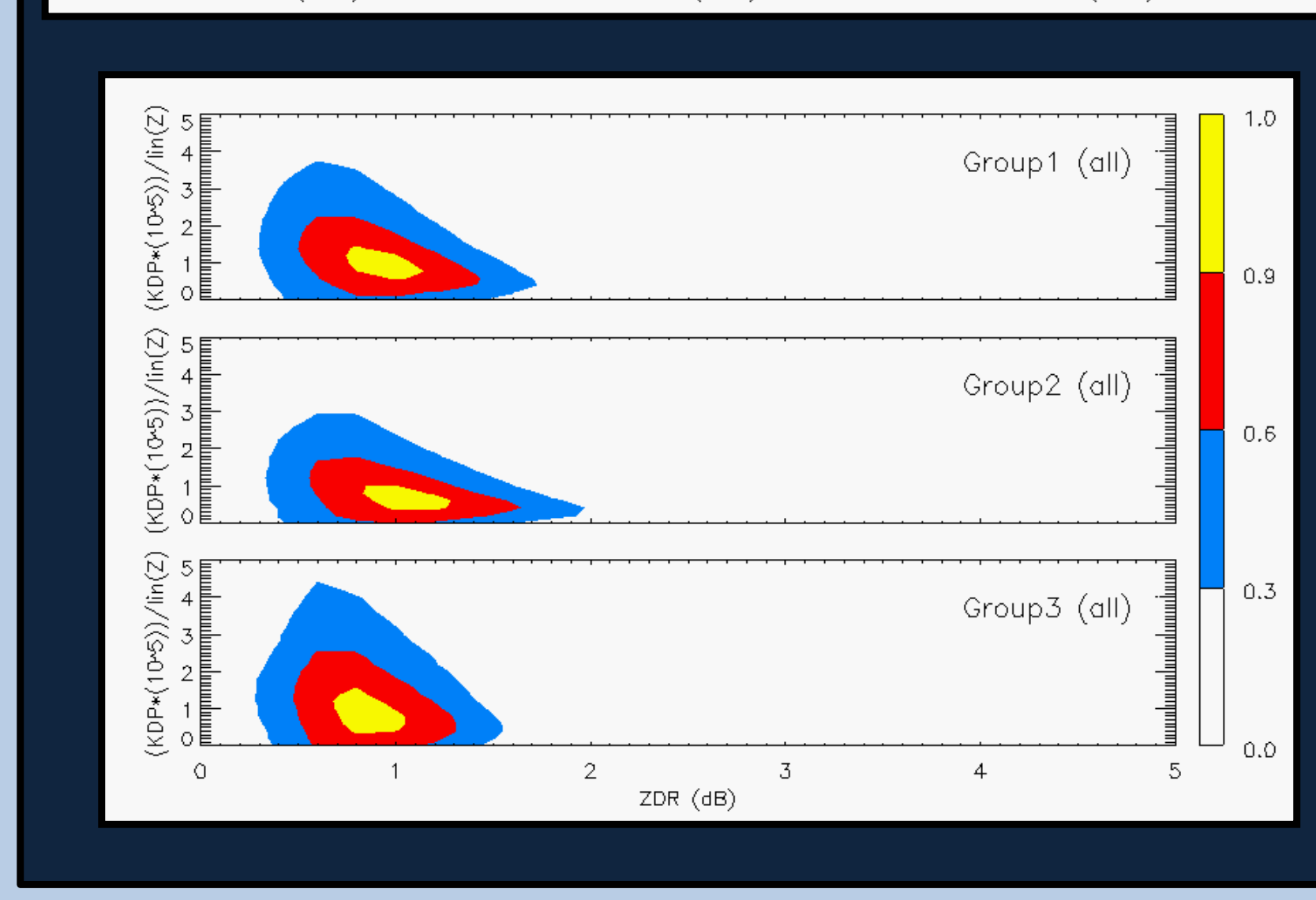


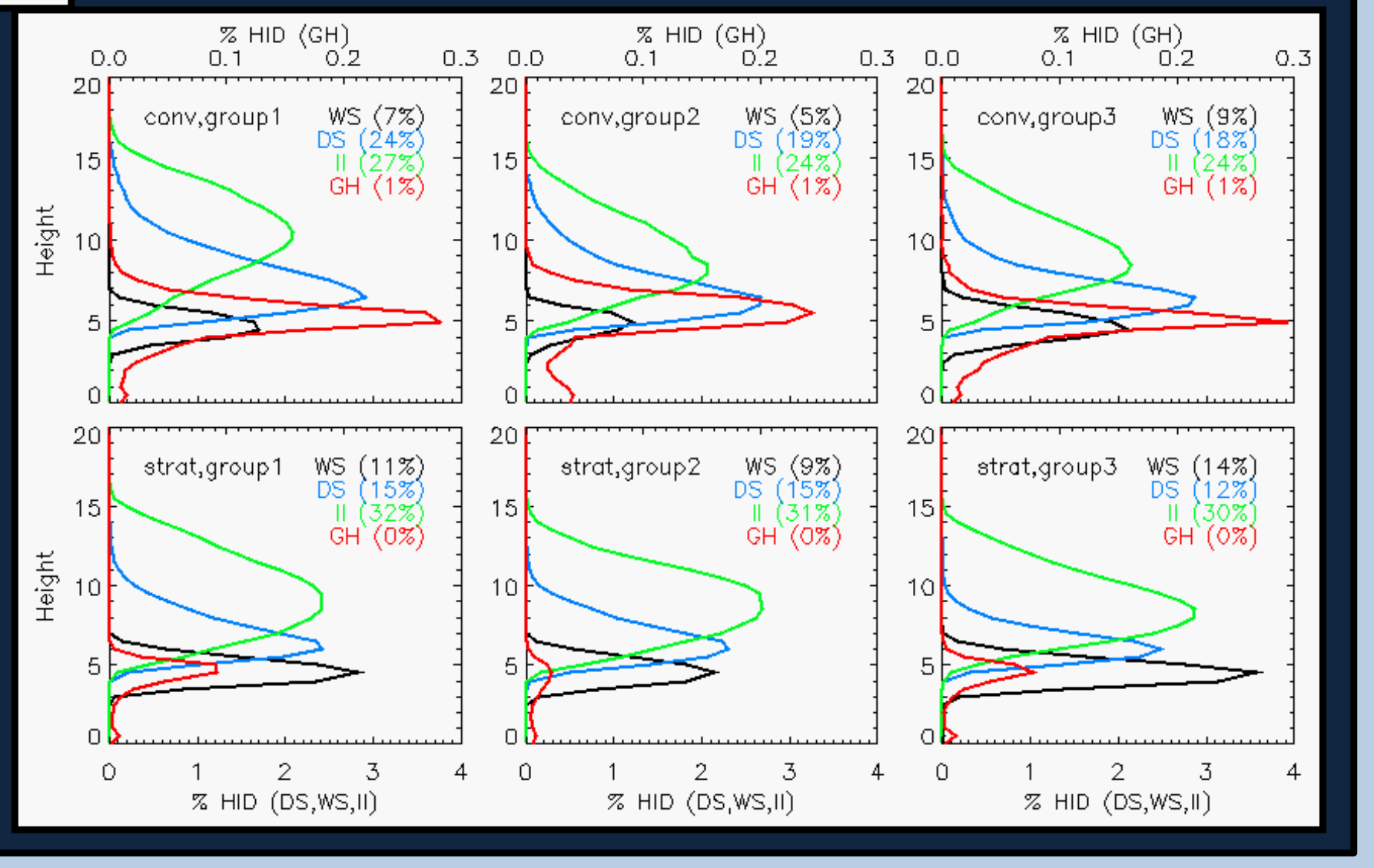


-Difference reflectivity CFADs show deepest convection and strongest brightband in Group 1, most bottom-heavy convection and weakest stratiform in Group 2

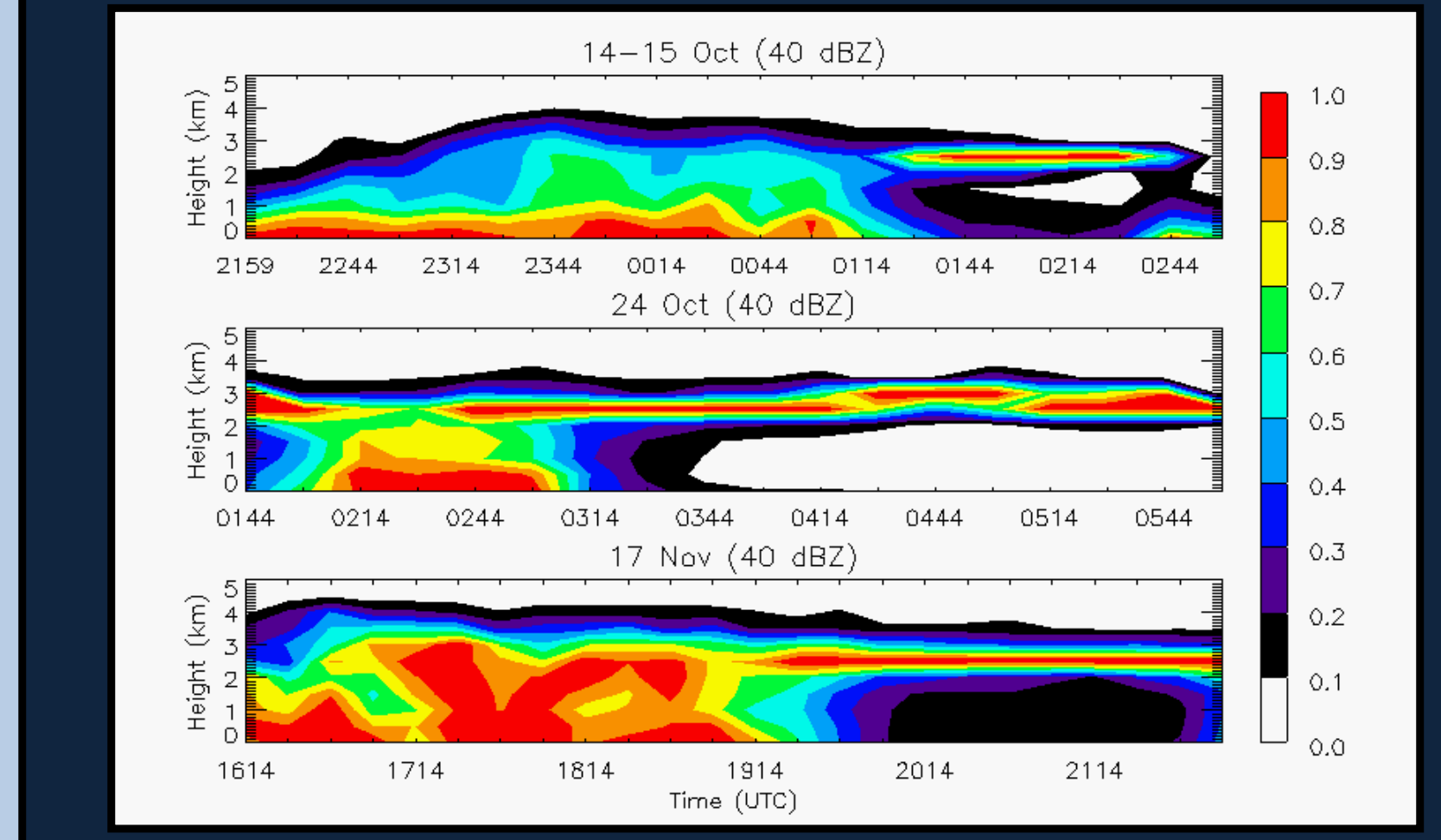
-Hydrometeor profiles show most wet aggregates in Group 3, little graupel in all, deepest ice in Group 1, but overall similar

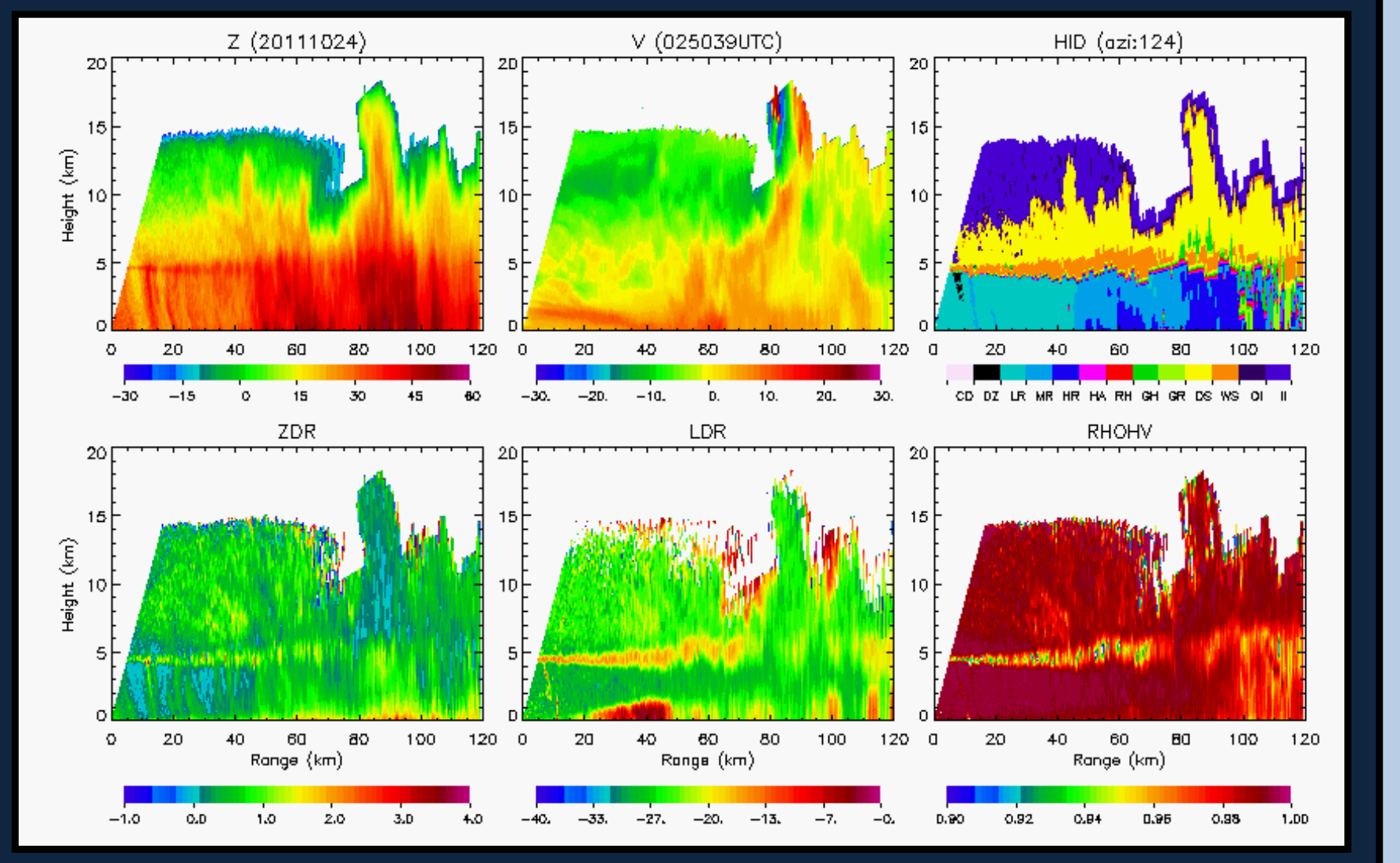
-Joint PDFs of normalized KDP vs. ZDR show a typical tropical population of small drops, with the largest contribution from ice-based processes in Group 2

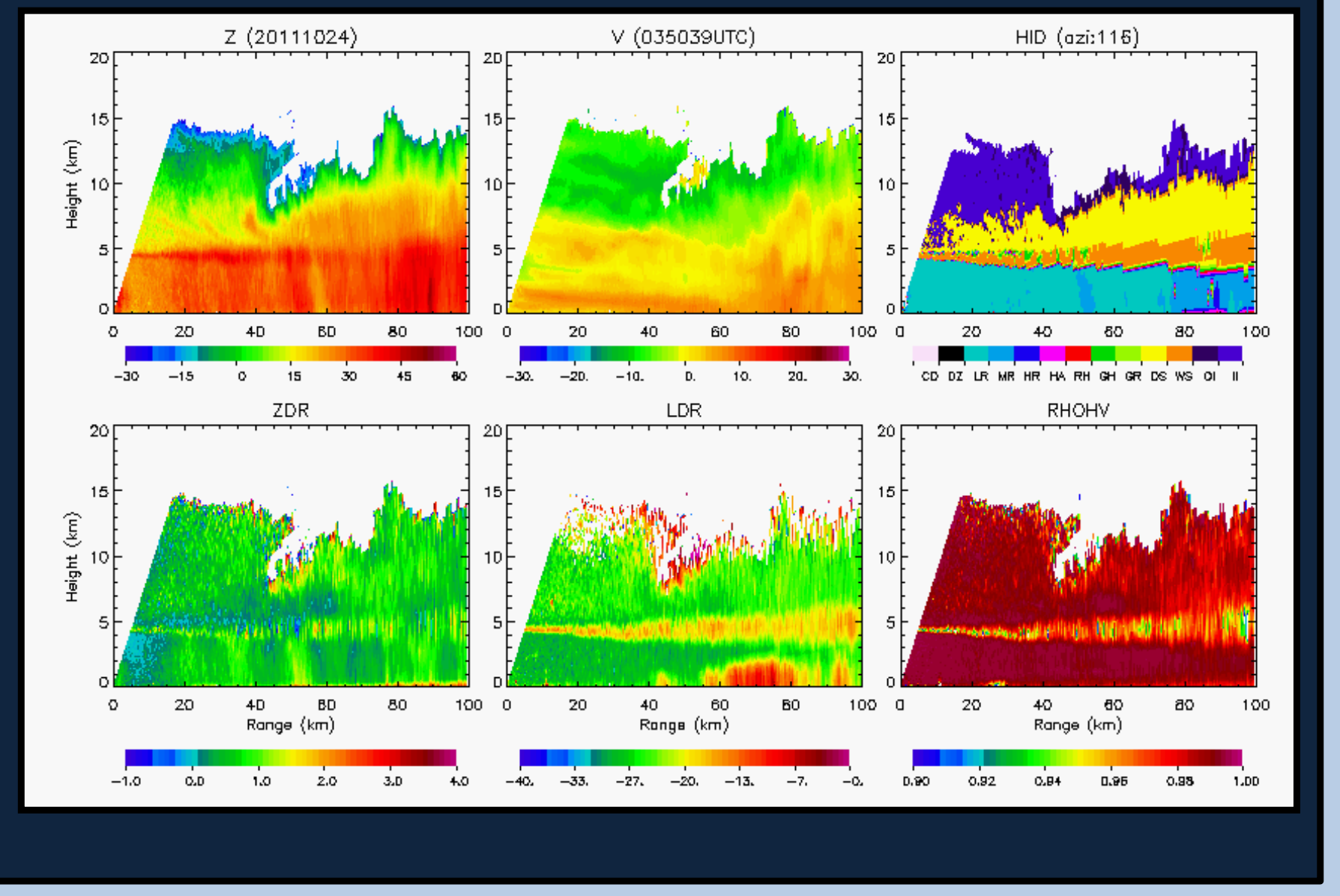




4. GROUP 1

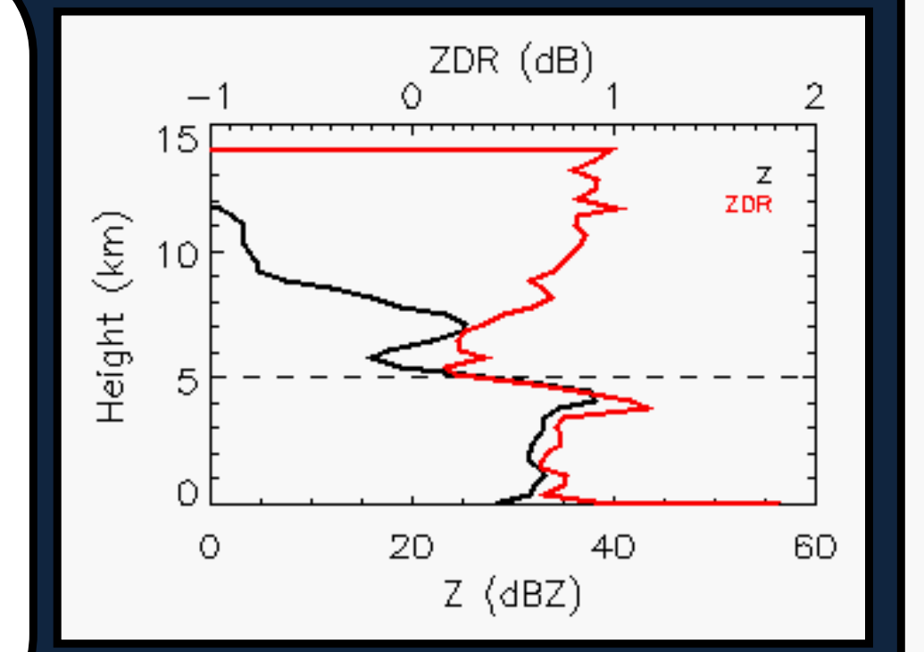






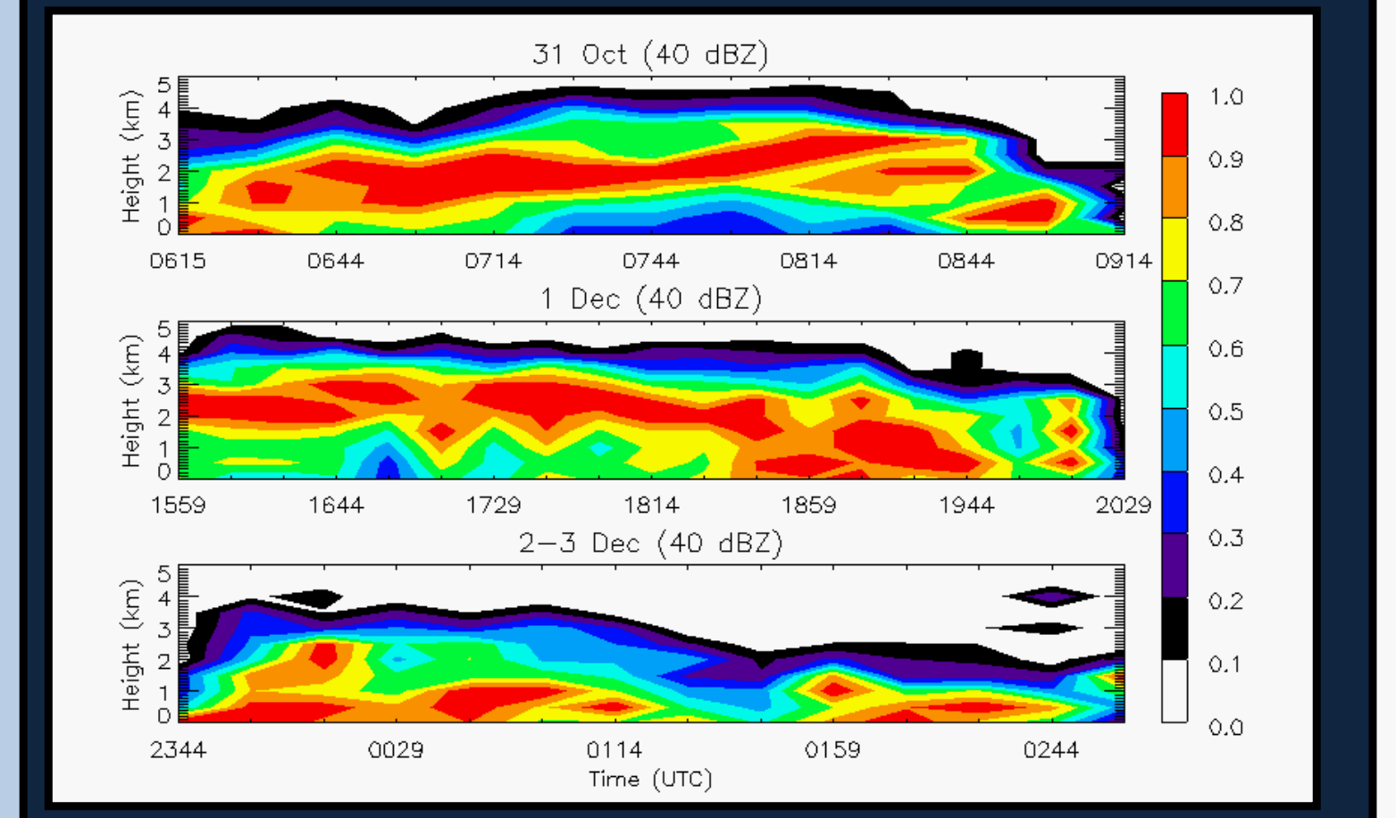
-During active phases in Oct and Nov, see transition from convective to stratiform with robust brightband signatures

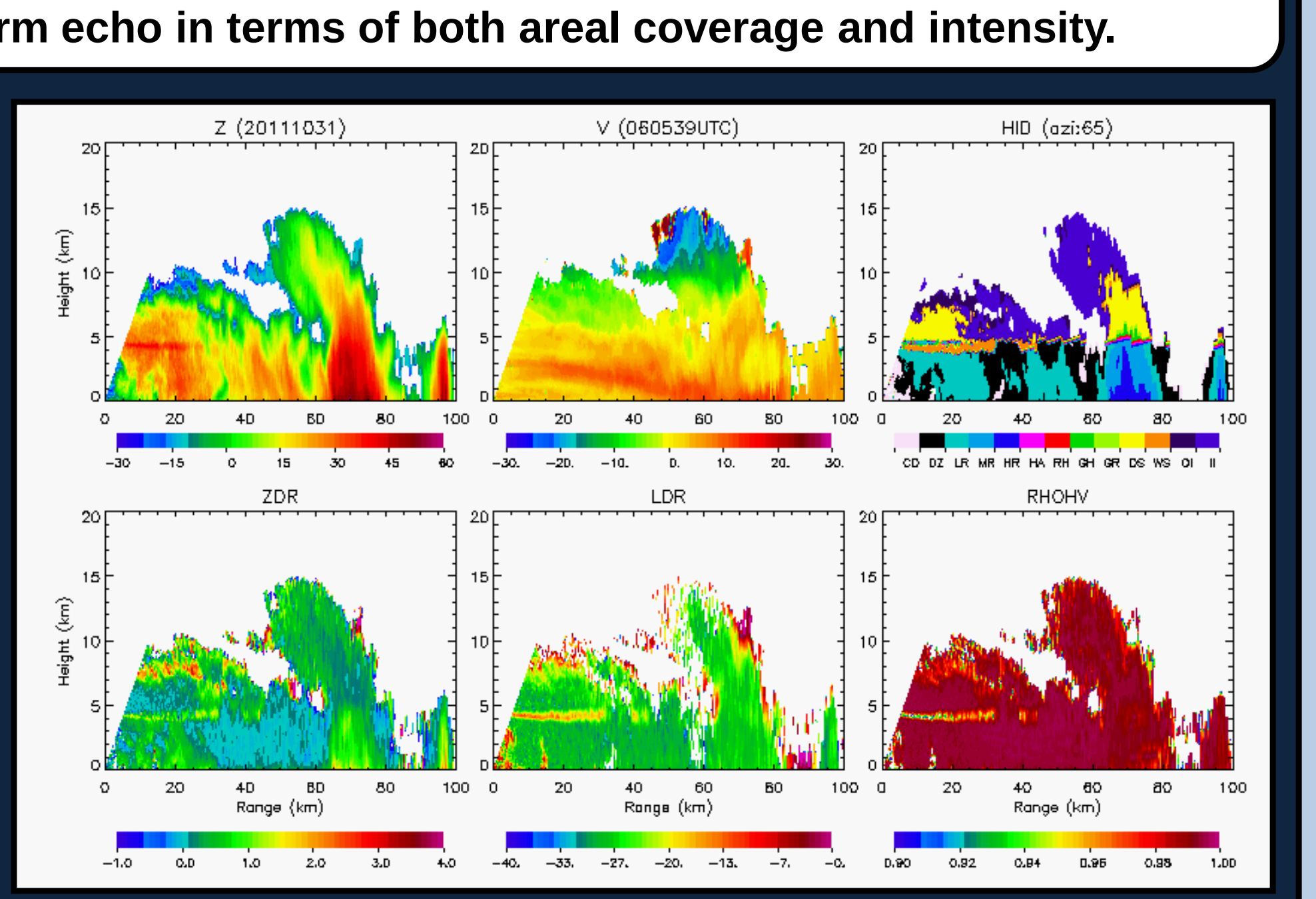
-Embedded, deep convection lofts ice which is advected toward the stratiform, then falling to create fallstreaks within transition between easterly and westerly flow



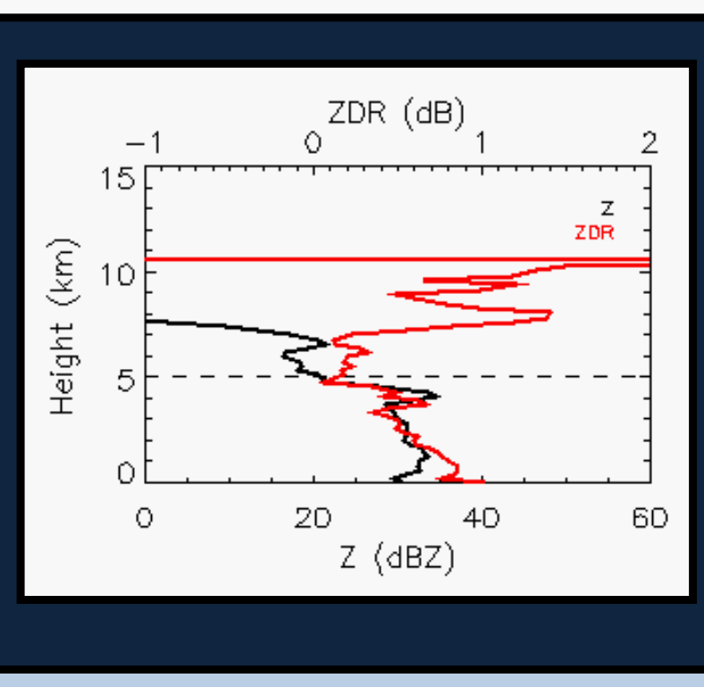
5. GROUP 2

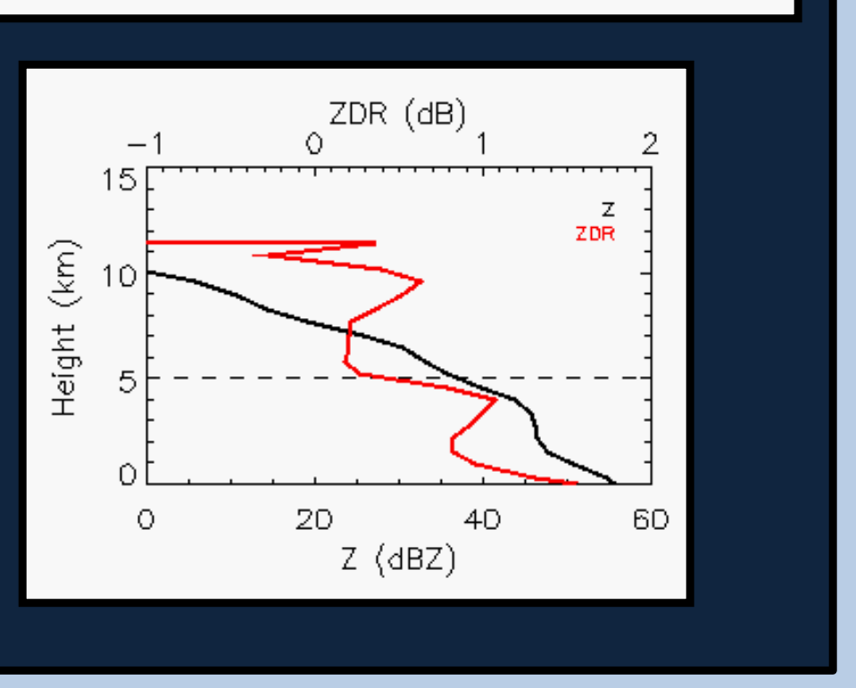
As the active phases transition back into more suppressed conditions, westerly winds near the surface increase and the mid-levels become drier. As a result, the MCSs that formed in these conditions featured shallower convection and less robust stratiform echo in terms of both areal coverage and intensity.





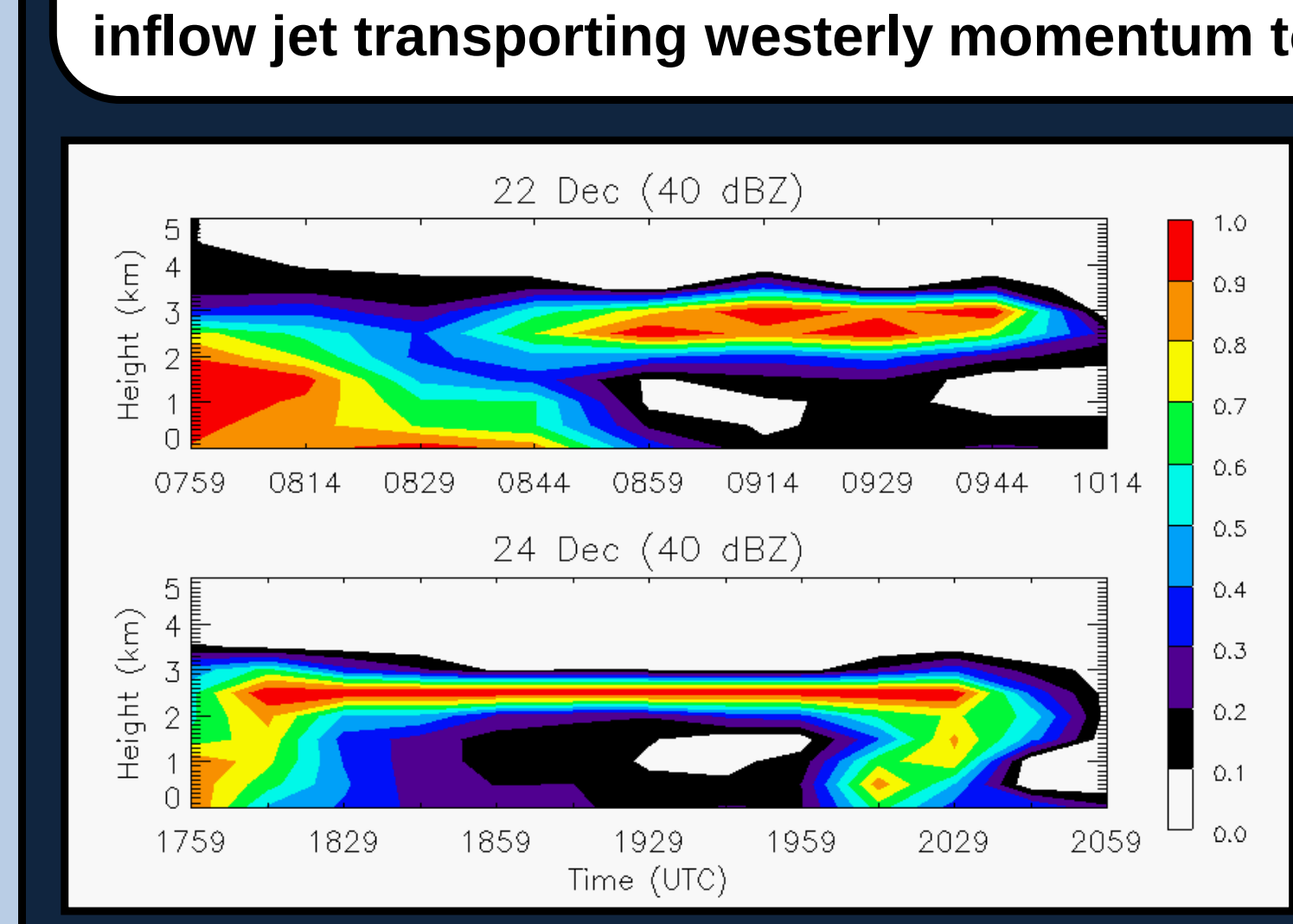
Vertical profiles of Z and ZDR through the stratiform region (left) show a weaker brightband compared to Group 1; profiles through the convective region (right) show reflectivity increasing toward the surface (typical of oceanic environments, Liu and Zipser 2012) and a localized increase in ZDR near the melting level where ice hydrometeors melt to contribute to large drops and a bottom-heavy profile characteristic of convection in this group.

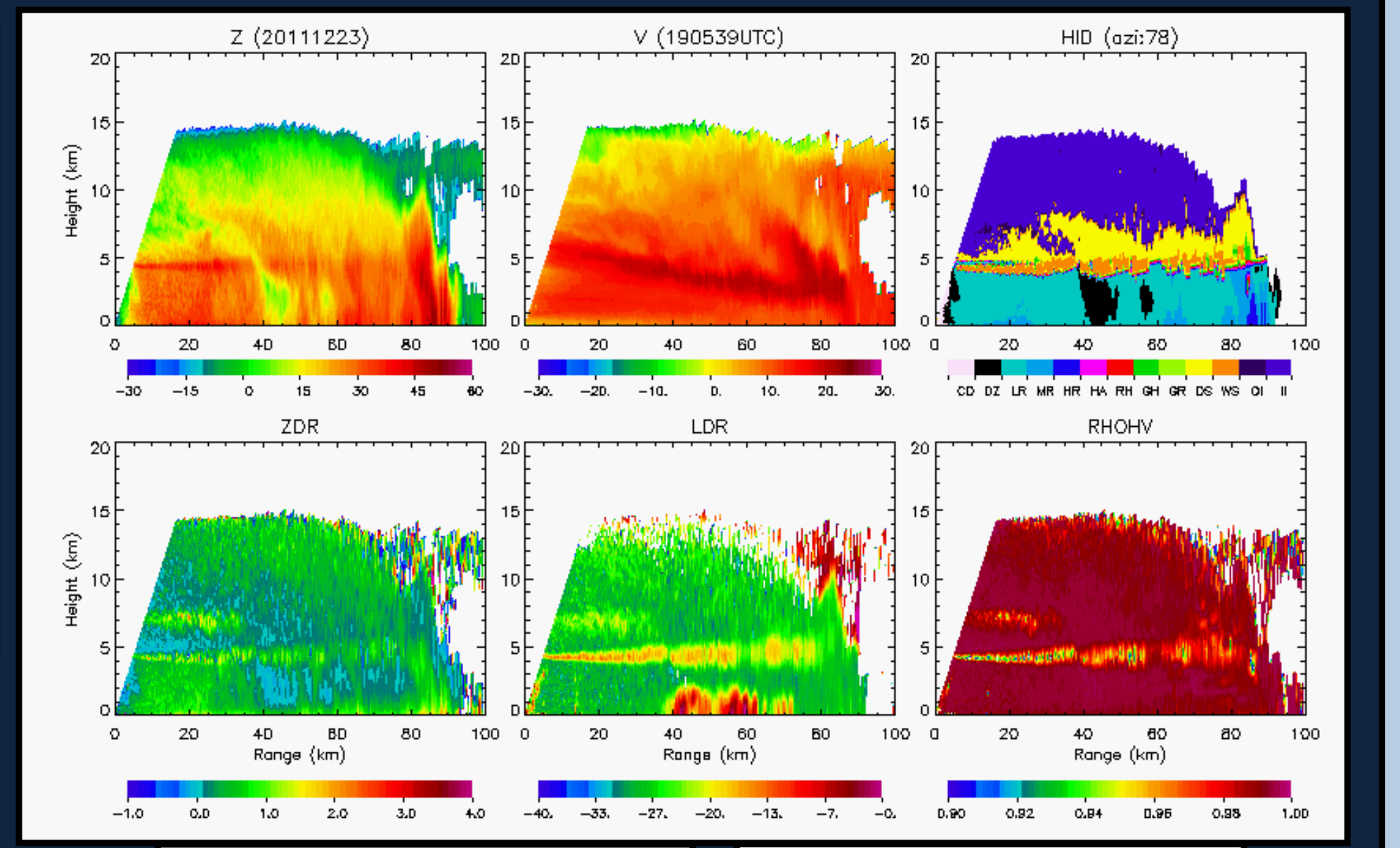




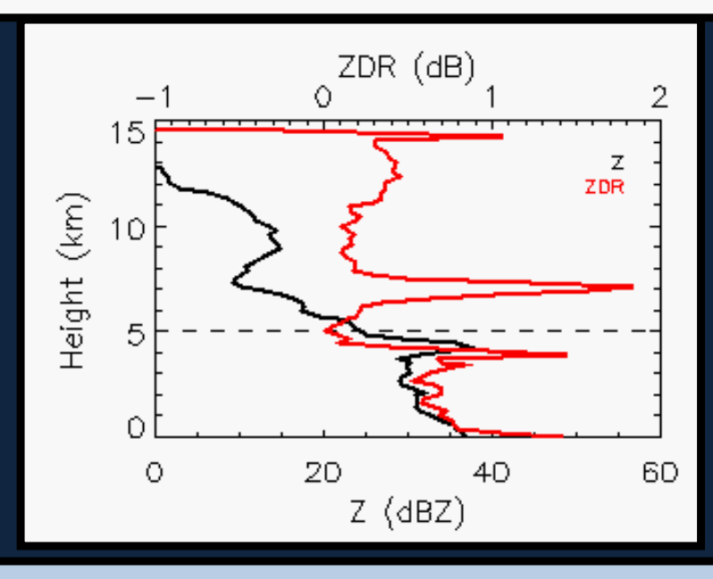
6. GROUP 3

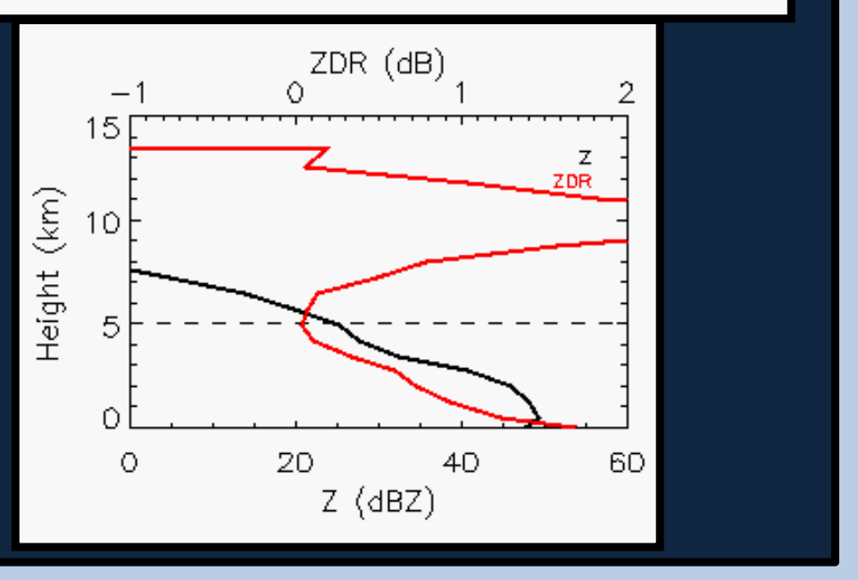
Group 3 are MCSs during the active phase in December, when deep, strong westerlies characterized the environmental wind profile. This environment resulted in fast-moving squall lines with shallower convection and less widespread stratiform echo. Brightband signatures were more pronounced than in Group 2, with signs of horizontally oriented ice crystals above the melting level and a descending rear inflow jet transporting westerly momentum to the surface (similar to TOGA COARE).





Vertical profiles of Z and ZDR through the stratiform region (left) show a brightband signature (Z peaking slightly above ZDR) and enhanced ZDR aloft where ice crystals become horizontally oriented; profiles through the shallow convection (right) again show increasing Z and ZDR toward the surface as drops grow by coalescence in this moist environment.





7. CONCLUSIONS

-Consistent hydrometeor profiles with low relative frequency graupel and enhanced wet aggregation during active periods as deep convection transitions to stratiform echo

-December active period characterized by shallower convection and less robust stratiform

-A closer look at individual MCSs shows different characteristics for three groupings based on the environmental wind profile, where increased westerlies generally resulted in shallower convection and less widespread stratiform as the active phases transitioned to more suppressed conditions

-Fast-moving squall lines in Dec featured shallow convection and descending rear-inflow/ momentum transport similar to TOGA COARE, while Oct/Nov active phase MCSs contained deep embedded convection in a weakly sheared environment with robust stratiform similar to results from MISMO

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