National Aeronautics and Space Administration

The CloudSat-centric A-Train and ECMWF Analysis Data Set:

Applications for Characterizing the Cloud, Convection, and Radiation Associated with Different MJO Phases During the Year of Tropical Convection (YOTC)

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Motivation

- The representation of **deep convective clouds and the associated precipitation** in global climate models remains a major source of uncertainty in climate projections and weather forecasts.
- Recent advances in satellite retrievals offer a new opportunity to evaluate and improve the key processes in atmospheric models.
- The synergistic use of the **multi-sensor** measurements from the A-Train satellite constellation can offer more comprehensive and valuable information of the Earth's weather and climate systems.
- To characterize the dynamic, radiative and micro-physical processes associated with clouds and convection, a **CloudSat-centric**, multi-parameter A-Train and high-resolution ECMWF analysis data set is being developed, as a contribution to the WMO Year of Tropical Convection (**YOTC**) research activity (May, 2008 to Apr, 2010).

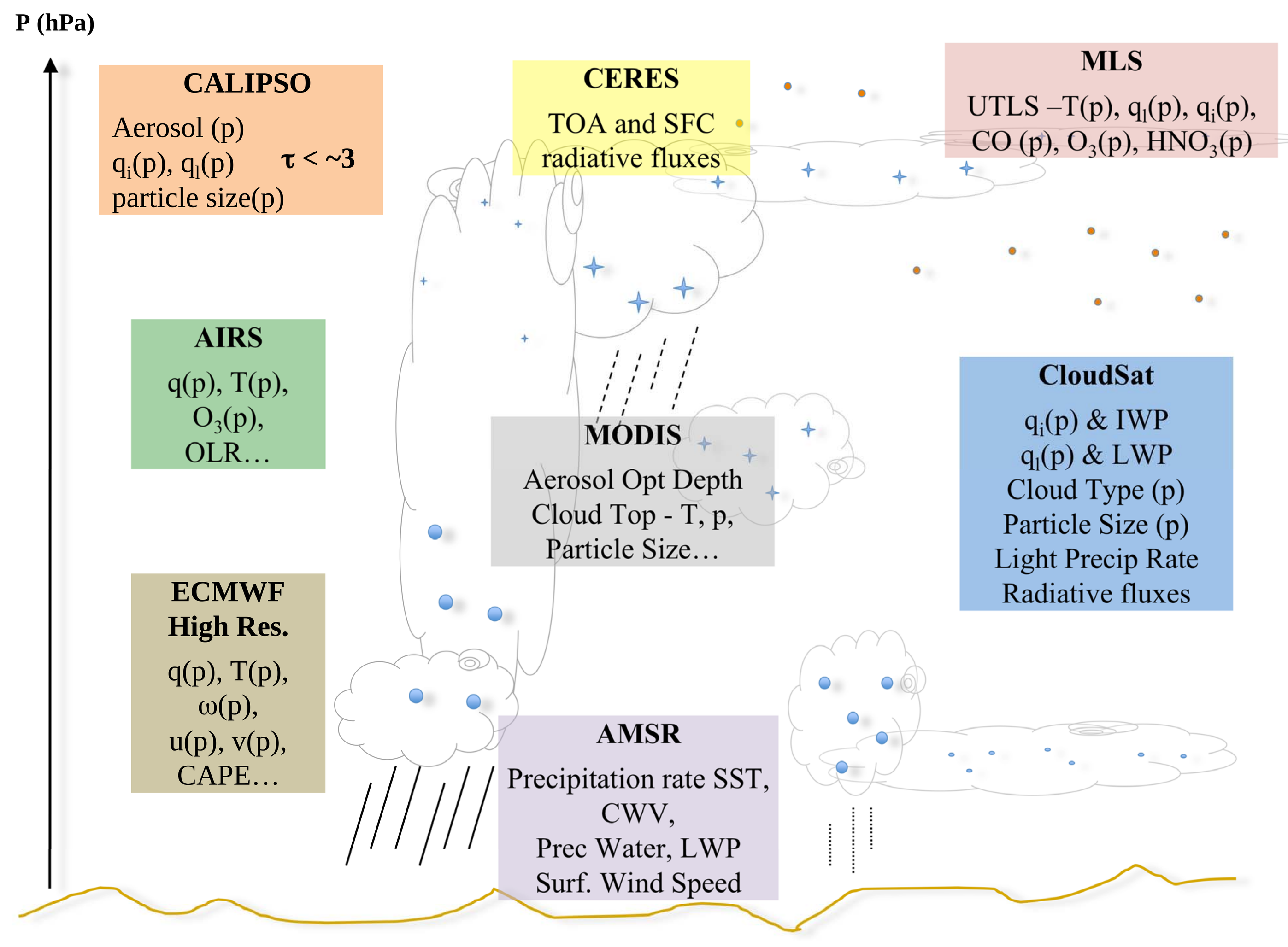

Fig. 1 The Co-located A-Train and ECMWF Analysis Data Set

Co-location Algorithm

- An efficient **nearest-neighbor** finding algorithm has been developed with a **flexible** software architecture that is not limited to a particular pair of the target and source data.

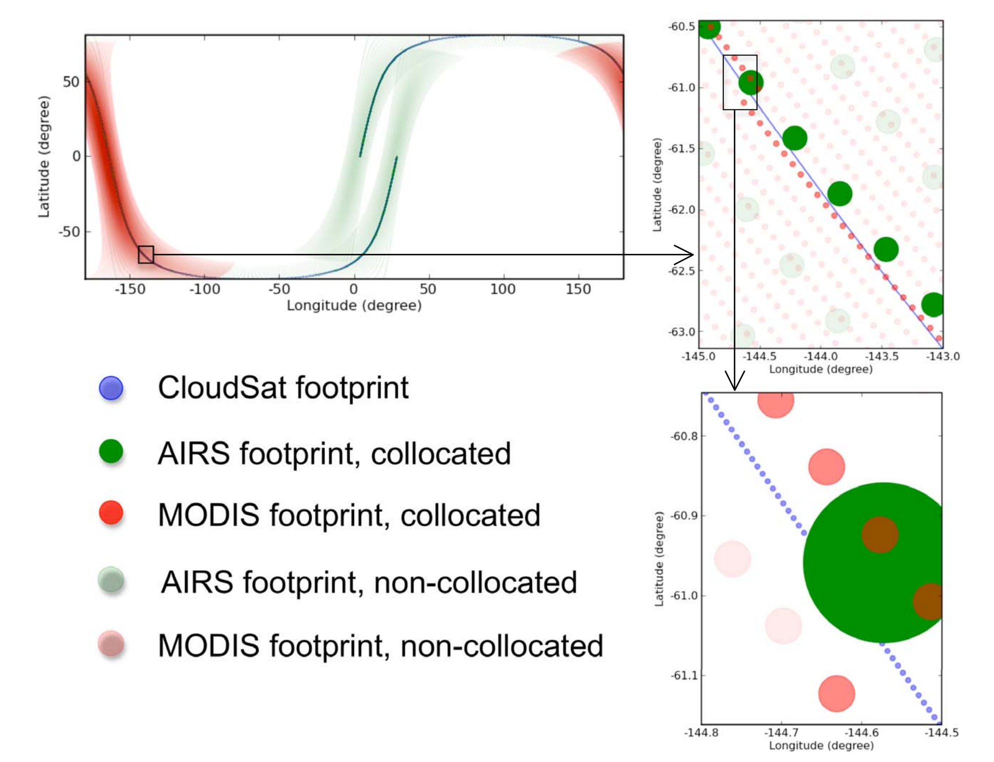

Fig. 2 Example of Co-locating MODIS and AIRS Data to CloudSat Footprints

Preliminary Scientific Analyses: Cloud, Convection, and Radiation in different MJO Phases over the Tropical Indian Ocean

Region and Time Period Analyzed

- Analyze the co-located dataset over the selected region in the **tropical Indian Ocean** (Fig. 3), during the season when the Madden-Julian Oscillation (MJO) events frequently occur (Nov-Apr, 2008-2010).

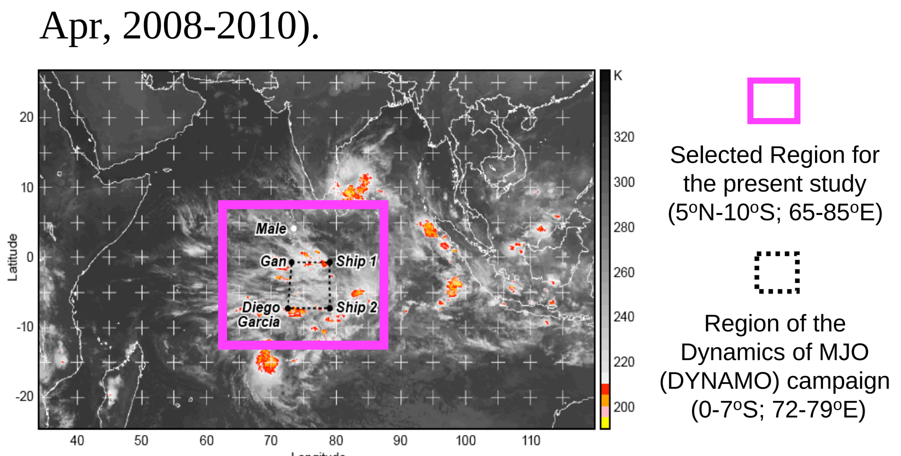

Fig. 3 The region selected for statistical analyses in the present study (pink).

Methodology

- Collect composite for the eight MJO phases (Fig. 4), based on the MJO index (Wheeler and Hendon, 2004)..
- Over the selected region:
  Phases before active convection -- Phases 1 and 8
  Phases with active convection -- Phases 2 and 3
  Phases after active convection -- Phases 4 and 5
  Phases with suppressed convection -- Phases 6 and 7
- Use "non-MJO" days (days with the amplitude of the MJO index <1) as the mean state; derive deviations of the mean vertical profile (Fig. 5) and the Probability Distribution Function (PDF, Fig. 6) for each phase.

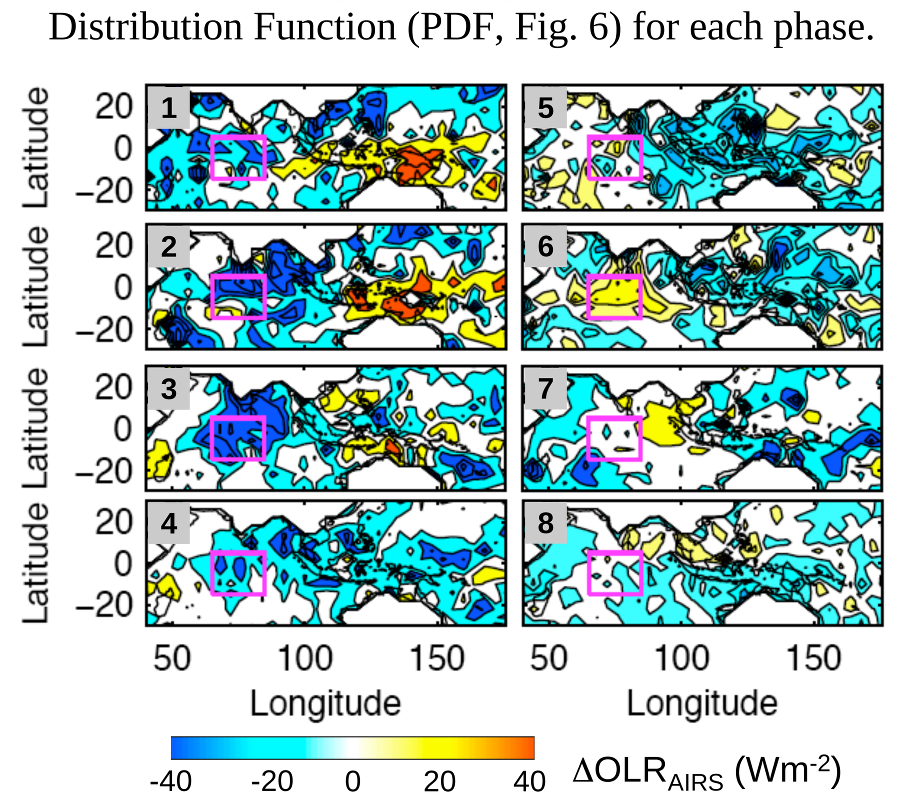

Fig. 4 Composite of OLR anomaly over ocean for each MJO phase during Nov-Apr, 2008-2010, from AIRS retrievals in the co-located data set.

Preliminary Results and Future Work

- Active phases are associated more frequently with:
  - Low OLR, high outgoing SW at TOA
  - High RH and high column vapor
  - High precipitation rate and liquid water path
  - High wind speed and high cloud top
  - Updrafts, high IWC, and high mid-level LWC
- Transitions of MJO phases are generally consistent among different variable/sensor/products
- Carry out EOF Analysis and significance test.
- Difference between retrieval and analysis data in CWV, RH, and in-cloud IWC requires careful investigation (resolution? sampling issue?).

Mean Profiles for Different MJO Phases

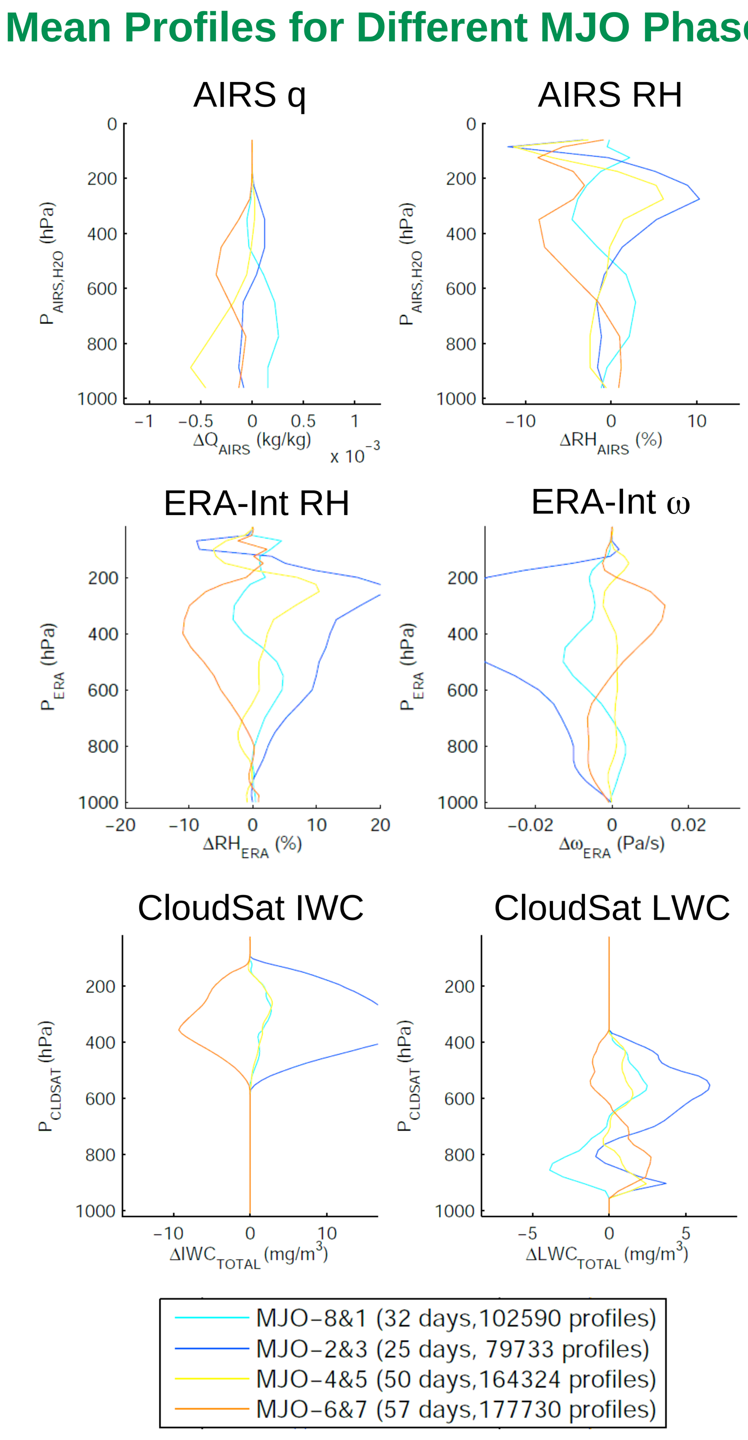

Fig. 5 Deviations of the mean vertical profiles in different MJO phases from the "non-MJO" mean, for selected variables in the co-located data set over the region of interest.

Probability Distribution Functions for Different MJO Phases

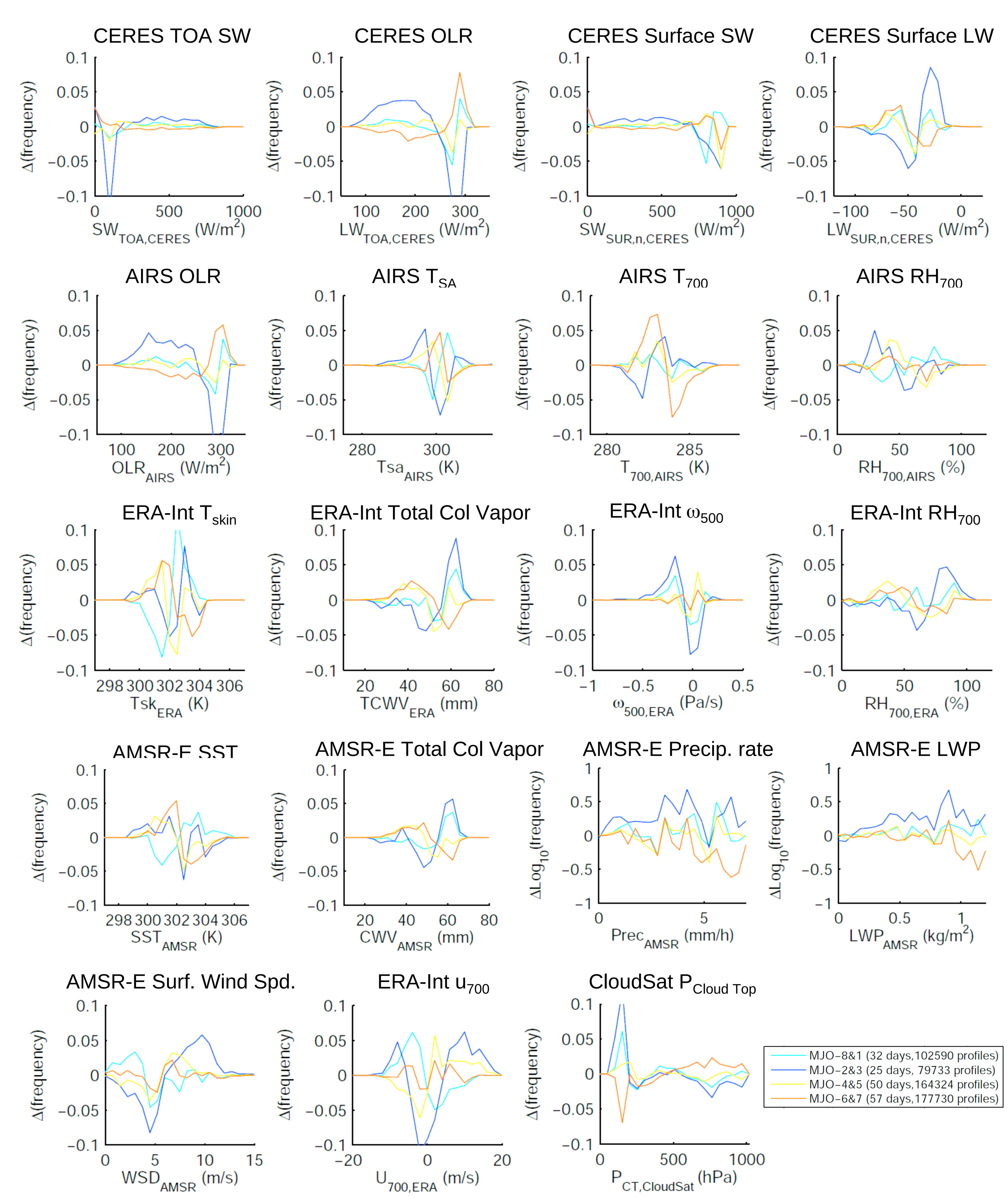

Fig. 6 Deviations of the probability distribution function (PDF) in different MJO phases from the "non-MJO" PDF, for selected variables in the co-located data set over the region of interest.

Summary

- As a contribution to the YOTC activity, a comprehensive CloudSat-centric, multi-parameter A-Train-ECMWF collocated data set is produced for characterizing the structures and properties of the deep convection and the environmental context. An efficient, flexible co-location algorithm is developed to temporally and spatially co-locate the nearest A-train data and ECMWF analysis outputs to each of the CloudSat footprint.
- The data set provides new opportunities in developing, constraining and validating representations of moist convection, connections between convection and associated cloudiness, and cloud-to-precipitation processes.
- Preliminary analysis on the composite statistics based on the MJO indices show transition from suppressed to active convection MJO phases consistent among different instruments and retrievals.
- The co-located data set **will be released publicly through CloudSat data portal in November, 2011**.

Reference: Wheeler, M. C., and H. H. Hendon (2004), An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, Mon. Wea. Rev., 132, 1917-1932.