

# Update on LLNL ARM Value-Added Products and Tools for Cloud/Climate Modeling Studies

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## Introduction

The goal of the ARM Infrastructure project at LLNL is to develop necessary Value-Added Products (VAPs) and tools from ARM observations to support cloud/climate modeling studies. This poster presents new additions, updates, and future plans on the VAPs and tools being developed by the LLNL ARM Infrastructure team.

## Data/Tool Availability

Data Products	Period and Site
Sounding Based forcing	All the ARM major IOPs (~20) at SGP, NSA, Darwin, and the DYNAMO site
Continuous Forcing	SGP: 1999 – 2014, summer 2015/2016 Darwin: wet seasons 2004-2006 AMIE-GAN: Oct 2011 – March 2012 GOAmazon: 2014 – 2015 AMF-HEF: Nov 2008
ARMBECLDRAD, ARMBEATM	SGP: 1993 – 2016 TWP: 1996 – 2011 NSA: 1998 – 2011
ARMBELAND	SGP: 1993 – 2016
ARMBE2DGRID, ARMBESTNS	SGP: 2011-2015
ACRED (cloud retrievals)	Multiple years at SGP, NSA, and TWP
ARM - CFAD	Multiple years at SGP, NSA, and TWP
QCECOR (ECOR fluxes)	SGP: 2003 – 2016, all AMF sites

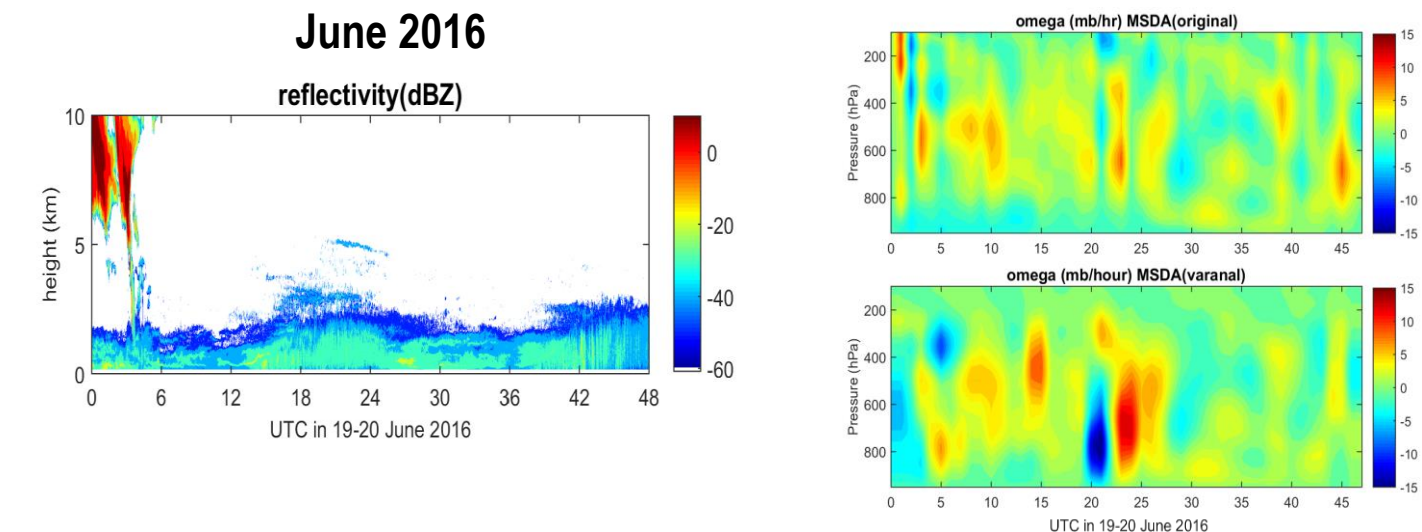
### Diagnostic tools:

- ARM diagnostics package: v0 available based on request
- ARM radar simulator: v0 available based on request (contact Shaocheng Xie [xie2@llnl.gov](mailto:xie2@llnl.gov))

## Ongoing Activities

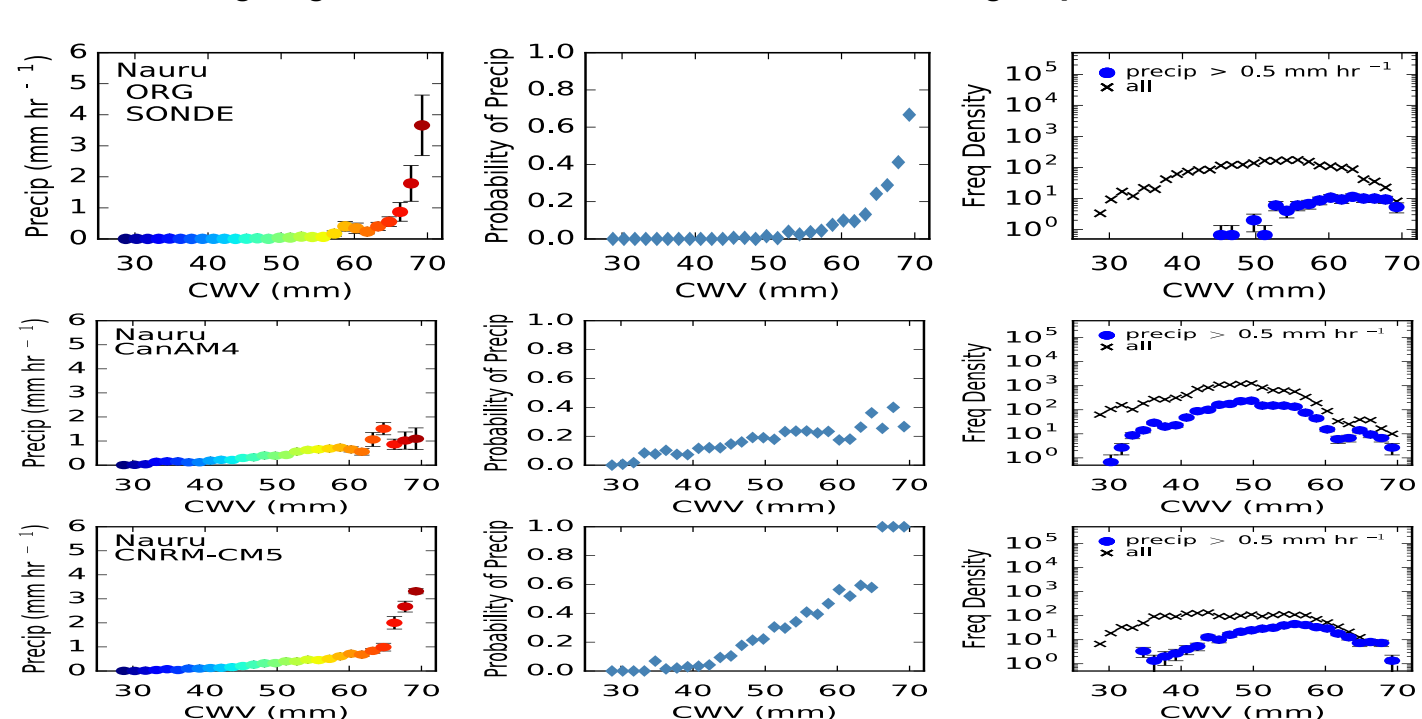
### Exploring Forcing Strategy for LASSO

LASSO Shallow Cloud Cases in June 2016 Forcing of MSDA with/without constraints



### Diagnosis of Convective Onset in Tropics

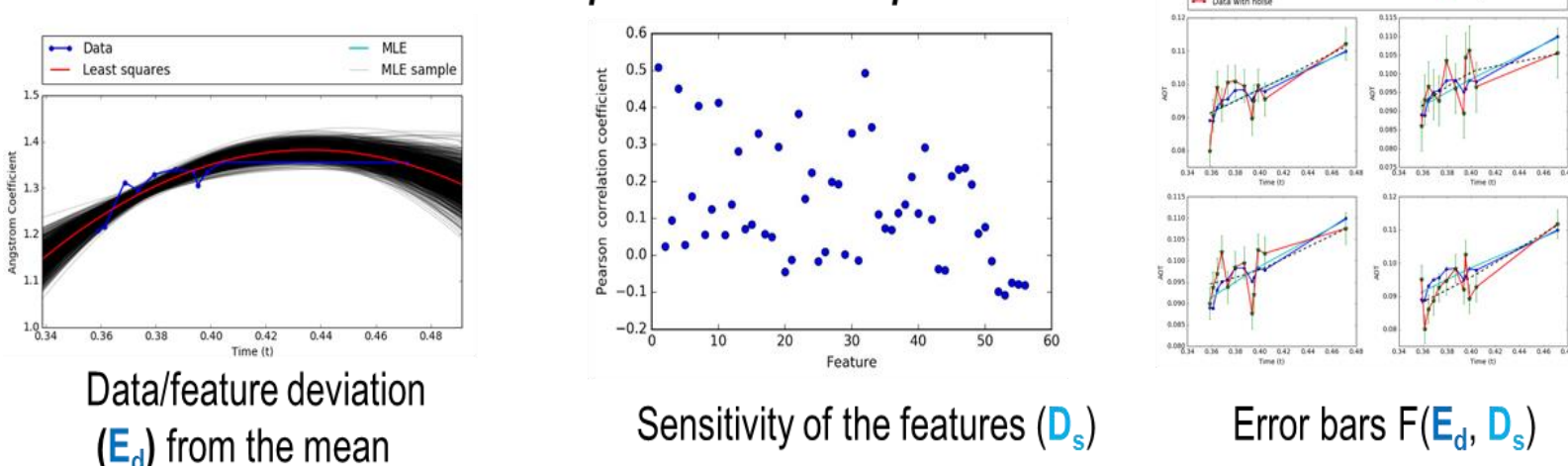
Ongoing collaboration work with David Neelin's group of UCLA



### Estimating Data Uncertainty via Machine Learning

Machine learning and UQ are used to predict the error bars on ARM data and anomaly source identification.

Example: Error bar computation

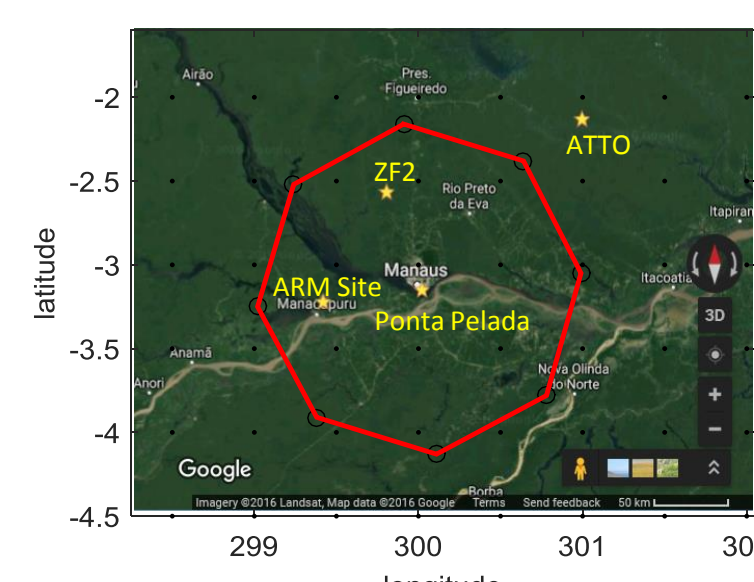


## Data Product Highlight

### Continuous Forcing for GoAmazon 2014/15

The large-scale forcing data for the entire GoAmazon 2014/5 experiment are derived using the ECMWF analysis that were subsequently constrained with the surface rainfall rate derived from the System for the Protection of Amazonia (SIPAM) S-band radar operated at the Ponta Pelada airport using the variational analysis method of Zhang and Lin [1997] (Tang et al. 2016).

### GoAmazon Domain

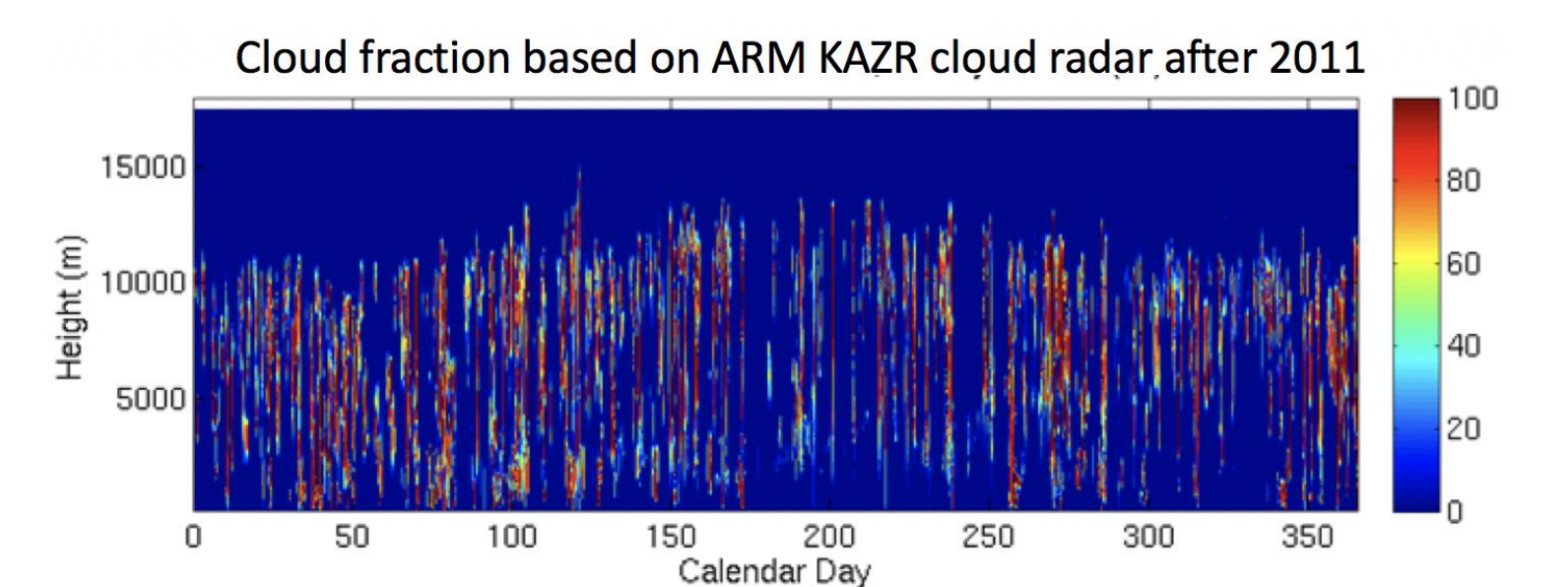


- Precipitation from SIPAM radar at Ponta Pelada
- Other required fluxes are from the ECMWF analysis
- Analysis domain is in 110km radius centered at Ponta Pelada airport (location of SIPAM radar).

### ARM Best Estimate Data Products

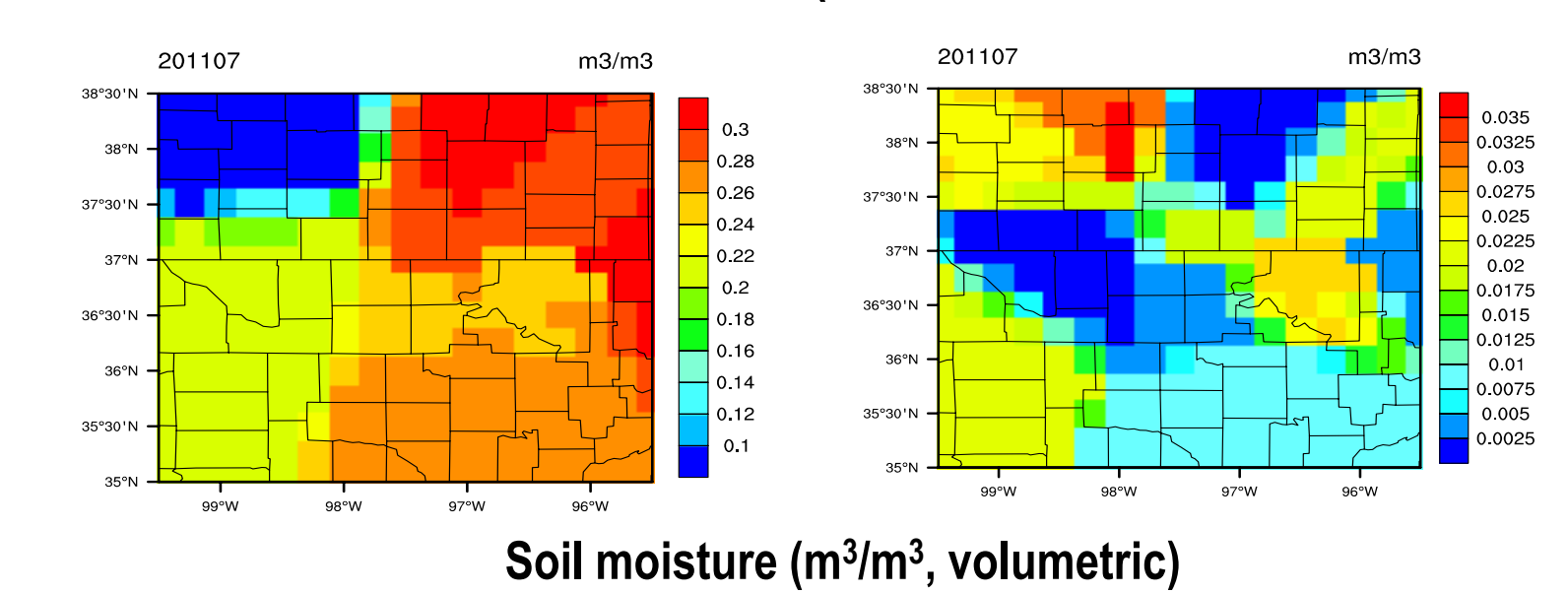
The ARM Best Estimate (ARMBE) data are created specifically tailored to climate modelers for use in the evaluation of global climate models and are formerly known as the Climate Modeling Best Estimate (CMBE) data.

### ARMBE-CLDRAD, -ATM, and -LAND at Central Facility



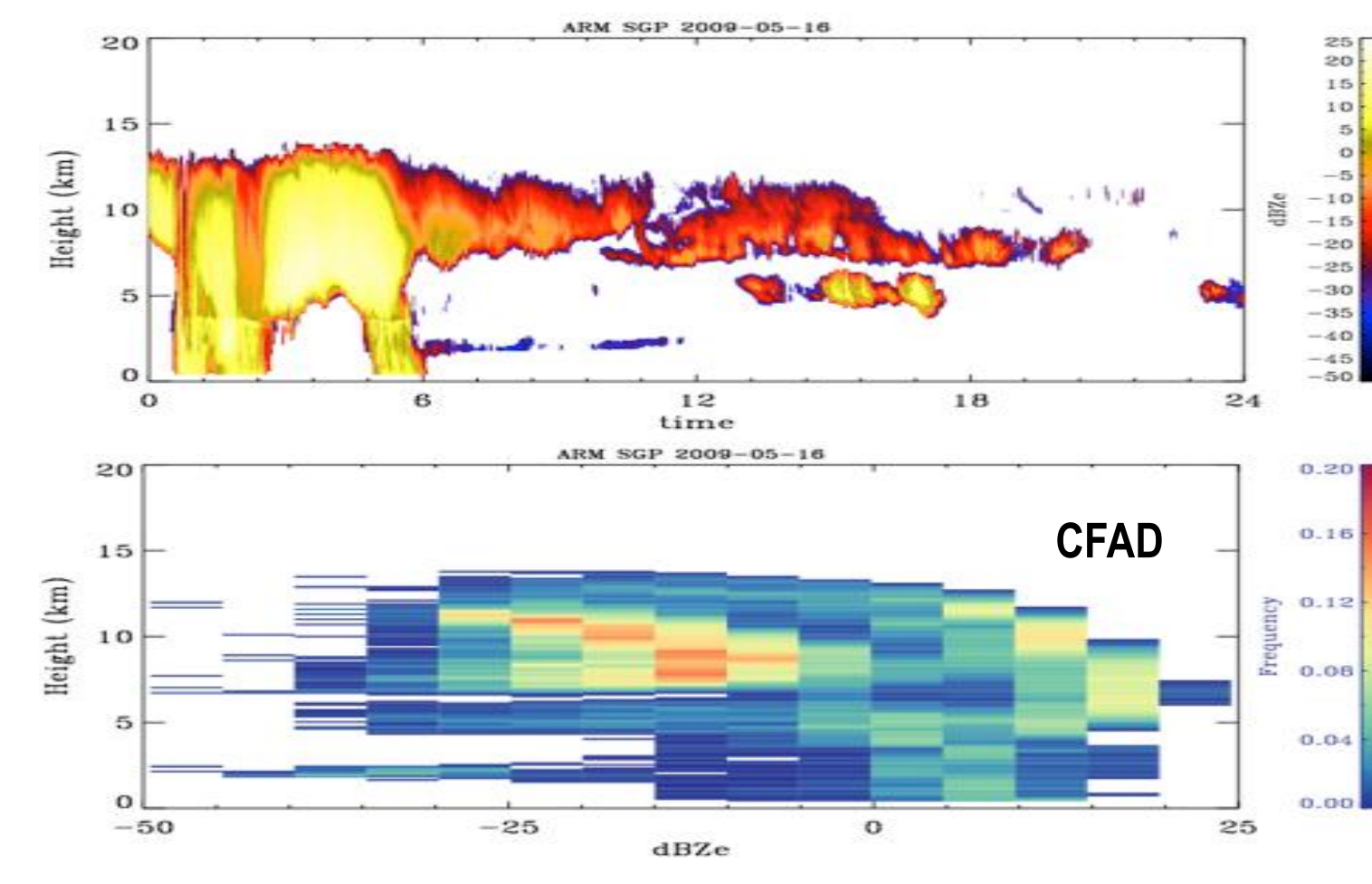
The ARMBE data products are extended to 2016 including the new ARM KAZR cloud radar after 2011.

### ARMBE Over the SGP Domain (ARMBE2DGRID, ARMBESTNS)



### ARM Radar Reflectivity-Height Joint Histograms

The climate model oriented ARM cloud radar data product, the reflectivity-height joint histograms, i.e., the Contoured Frequency by Altitude Diagram (CFAD), is produced to compare with the ARM radar simulator output.



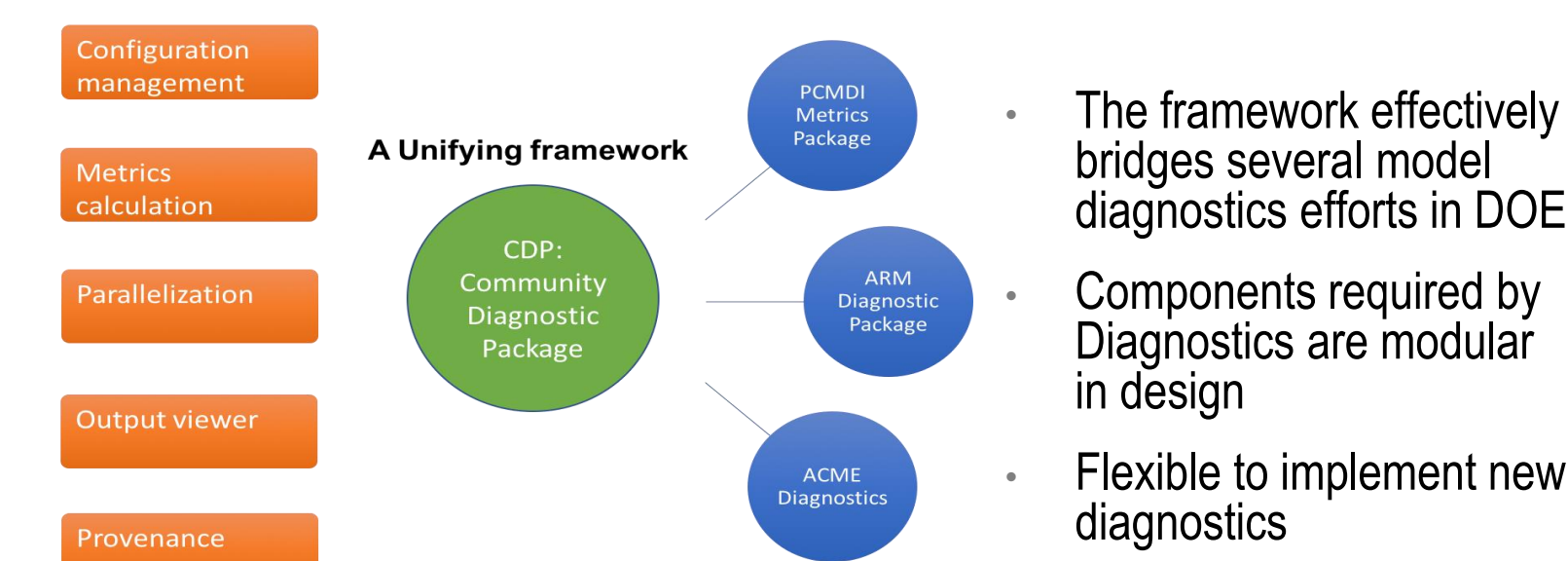
Measured radar reflectivity (top) and the calculated radar CFAD (bottom) are displayed for May 16, 2009.

## ARM Diagnostics/Tools

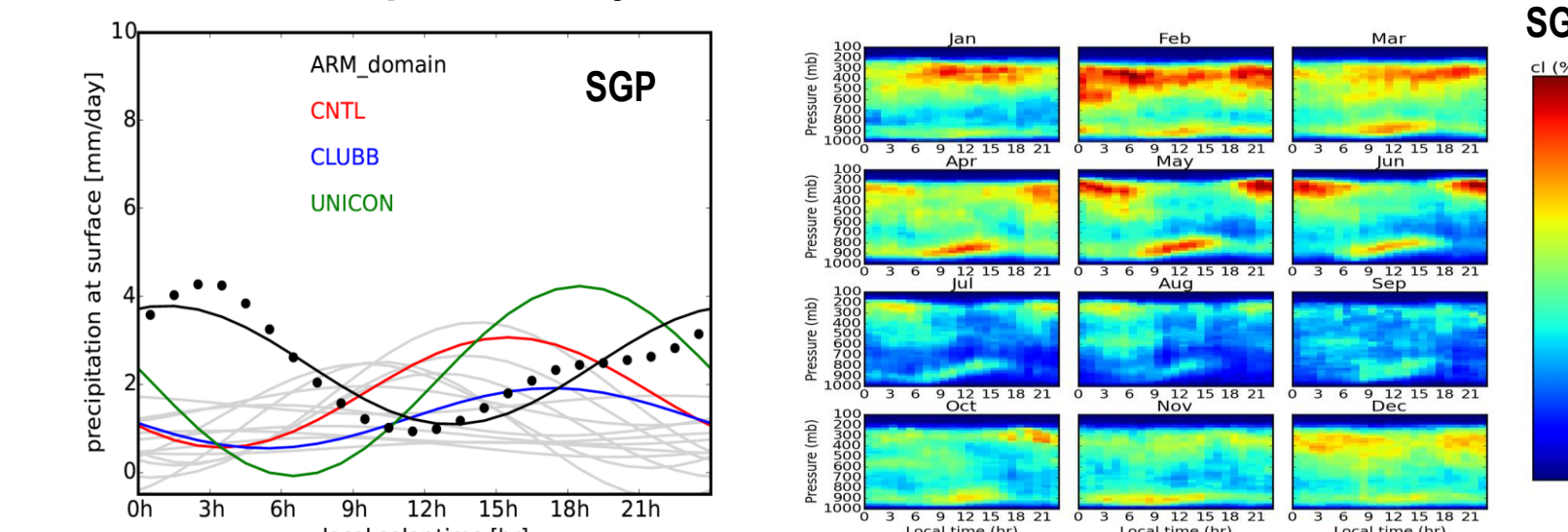
### ARM Metrics and Diagnostics Package

The goal is to make ARM data more accessible and useful for model developers and the community

- Provide process-oriented diagnostics to help understand model errors and improve physical parameterizations
- Integrated into the Community Diagnostic Package platform to effectively interact with the PCMDI and ACME Diagnostics Packages.



### Summer Precip Diurnal Cycle Monthly Climatology of Clouds



### New Diagnostic for L-A coupling strength

The goal is to Provide a robust observation-based estimation of LA coupling strength at the SGP for model evaluation

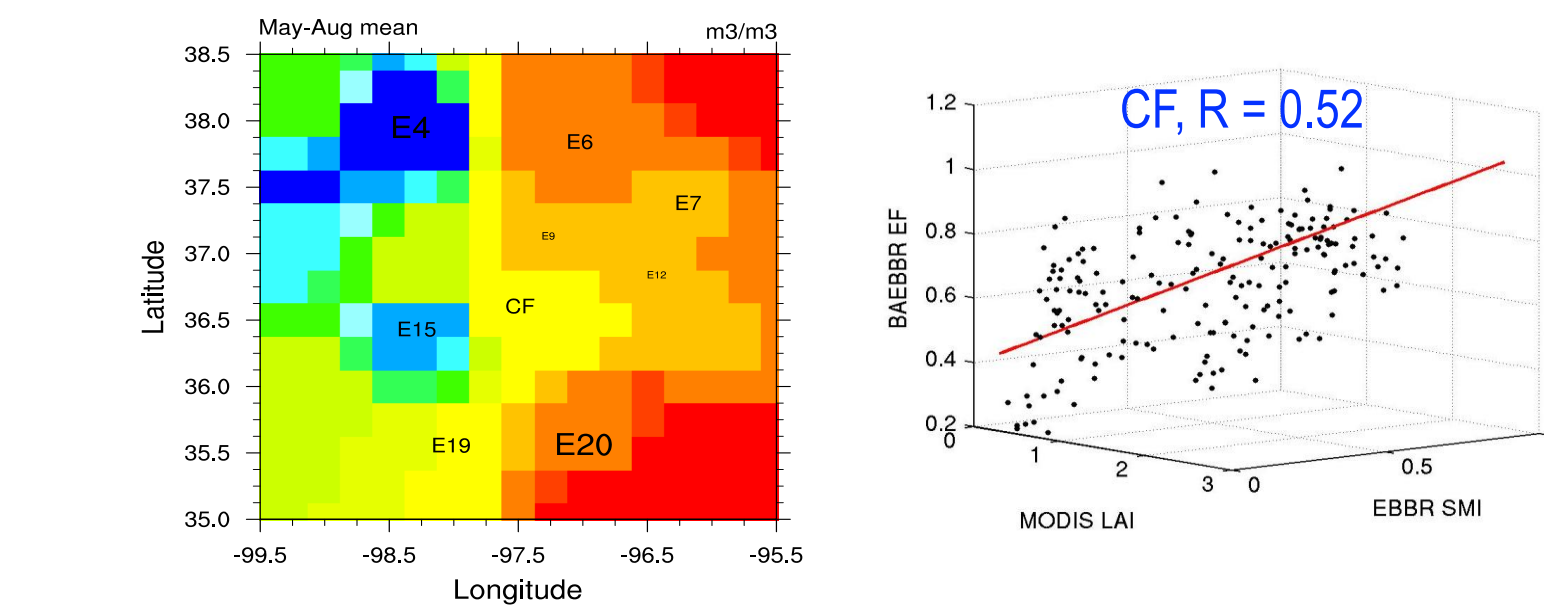
- Considers impacts from both land surface and soil moisture
- Quantifies relative contributions from land surface and soil moisture

### New Diagnostic Method:

Multiple linear regression is performed for EF with respect to SMI and LAI

$$EF = b(0) + b(1)*SMI + b(2)*LAI$$

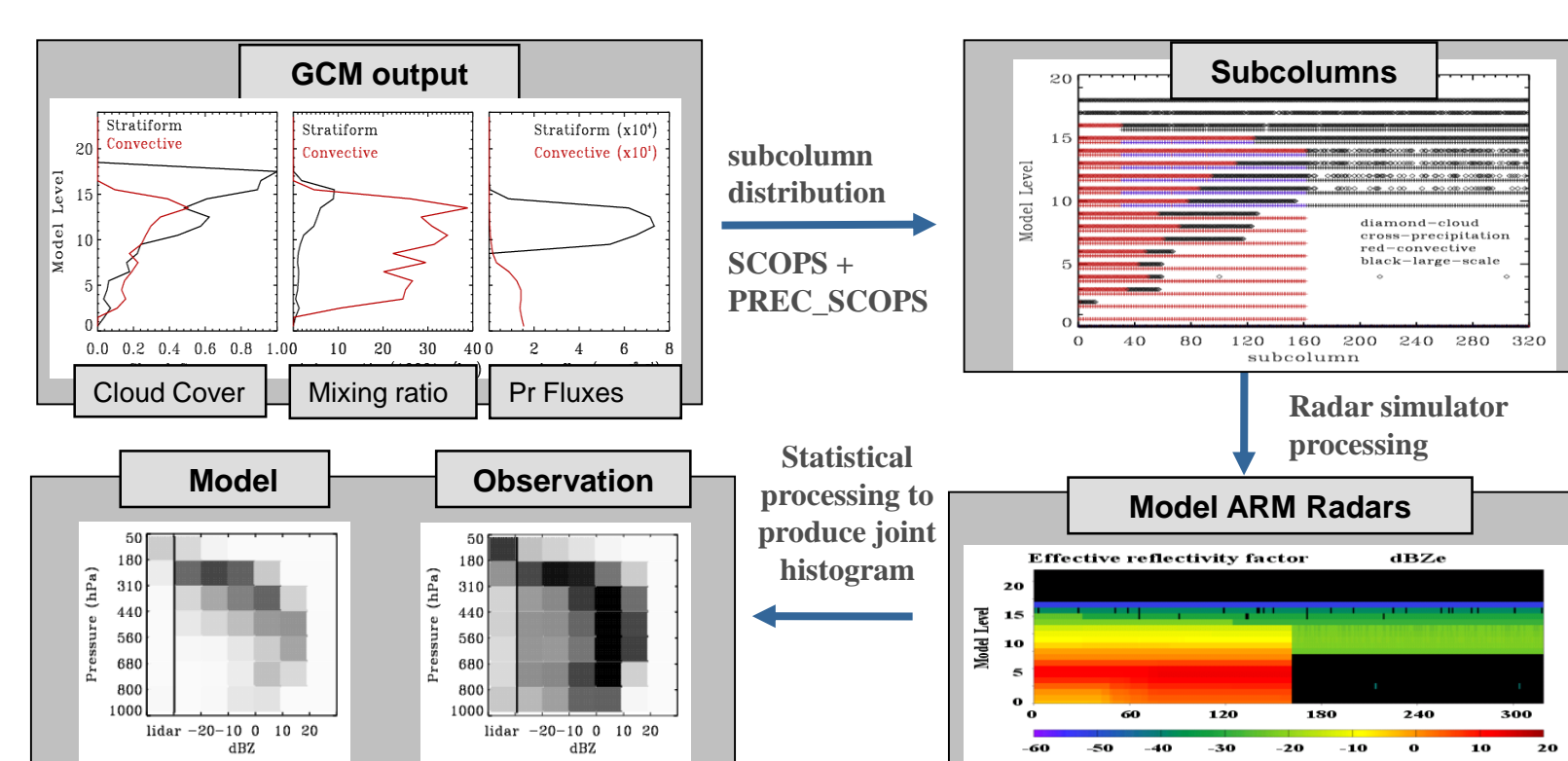
### SWATS 5cm Soil Moisture font size: LA coupling strength



Tang, Q., S. Xie, Y. Zhang, et al. (2017), Land-atmosphere coupling strength at the ARM SGP: A new Diagnostic. In Preparation.

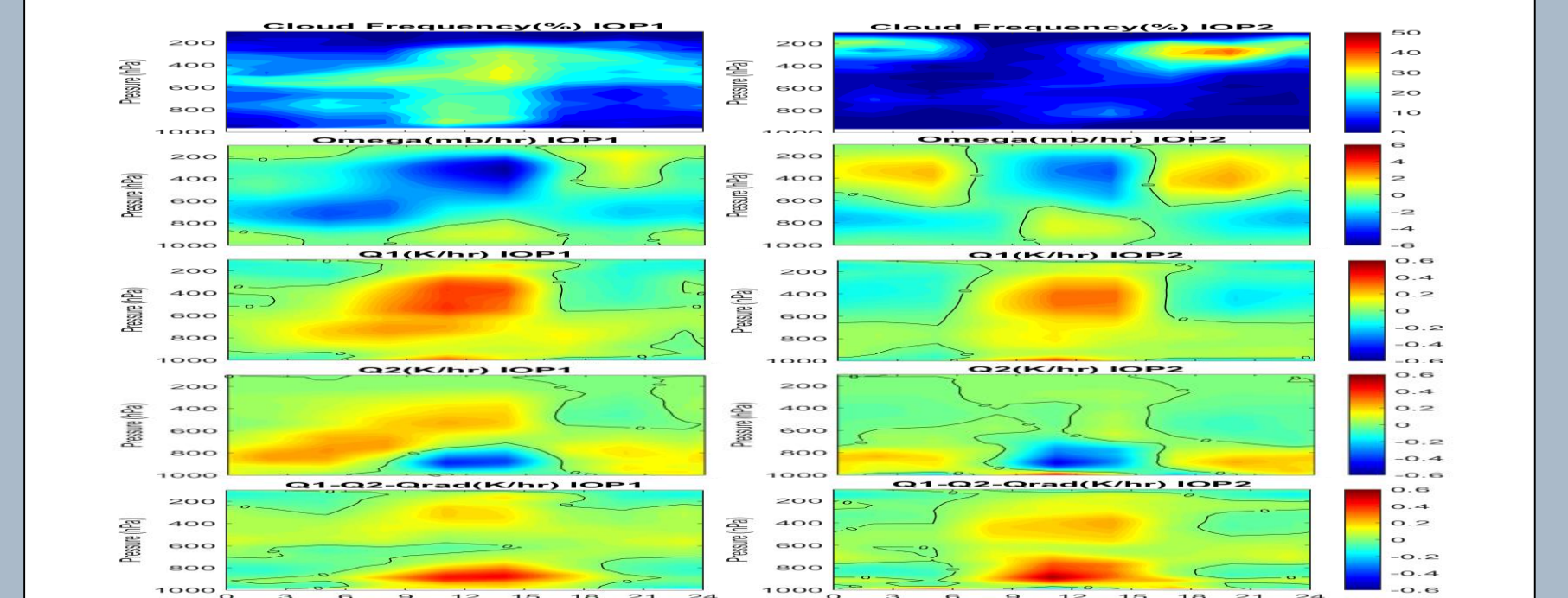
### ARM Radar Simulator for GCMs

- Bridge the gap between detailed ARM cloud observations and GCM clouds
- Modify the COSP radar simulator to mimic the way how cloud mask was generated from ARM cloud radar observations
- Merge ARM cloud radar simulator into COSP for climate model applications



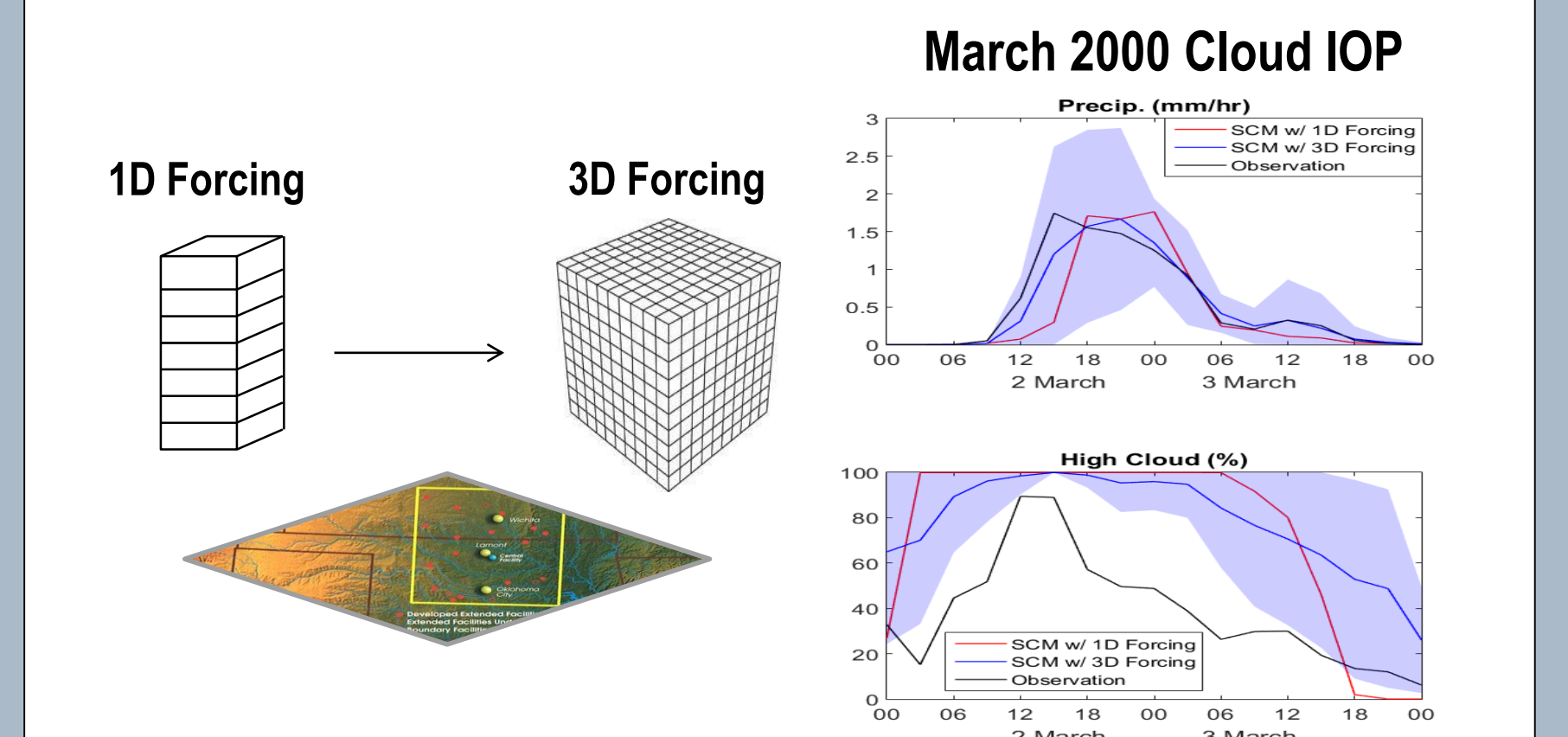
## Applications

### Observed Clouds and Their Associated Structures During the GOAmazon 2014/5 Experiment



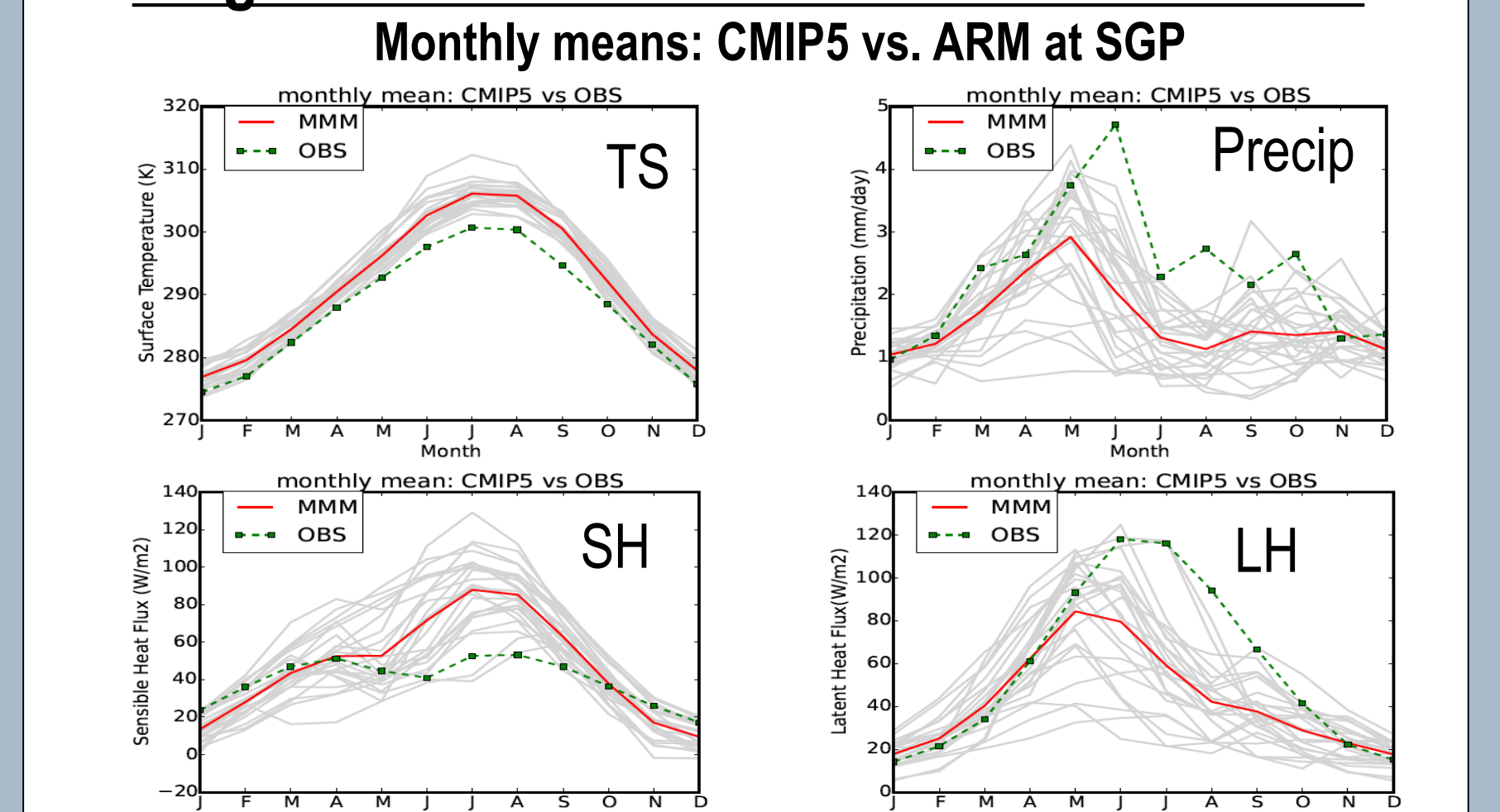
Tang, S., S. Xie, Y. Zhang et al. (2016), Large-scale vertical velocity, diabatic heating and drying profiles associated with seasonal and diurnal variations of convective systems observed in the GoAmazon2014/5 experiment, ACP, 16(22), 14249-14264, doi: 10.5194/acp-16-14249-2016.

### Impact of 3D forcing in SCM Simulated Clouds



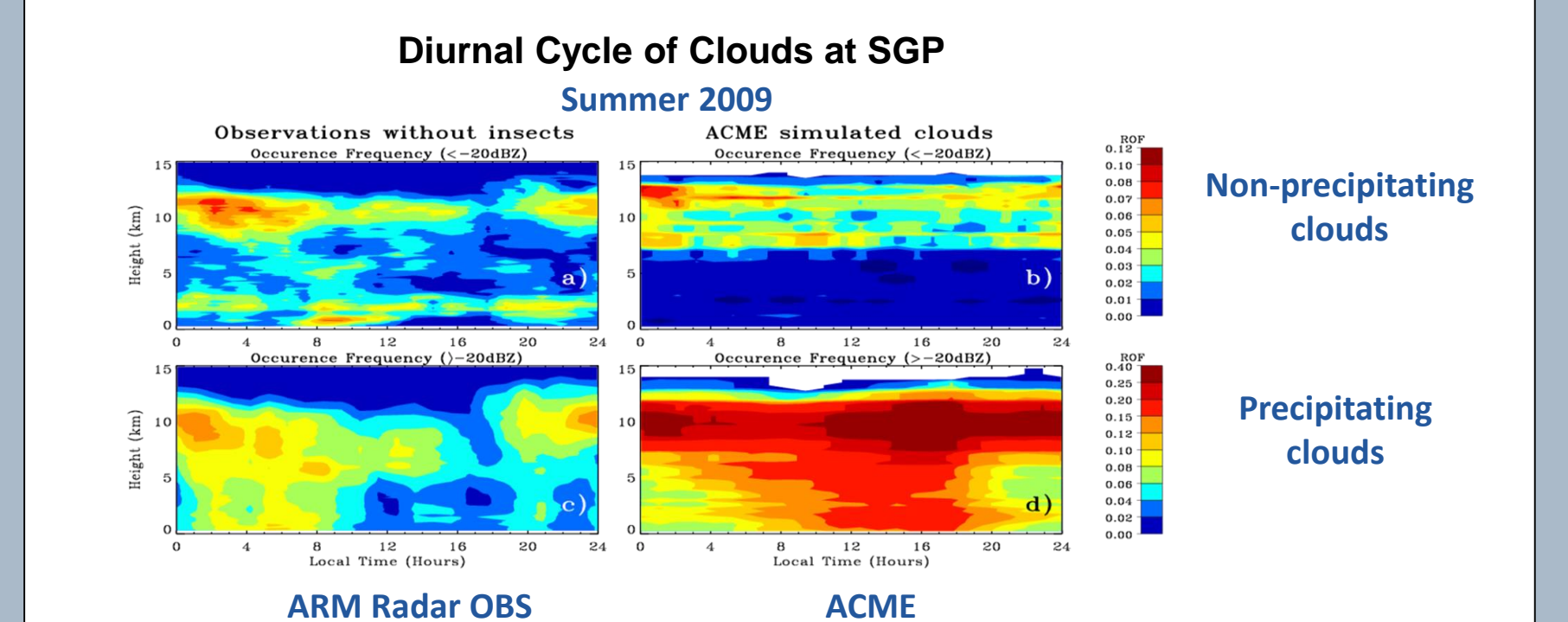
Tang, S., M. Zhang, and S. Xie (2017), Investigating the Scale Dependence of SCM Simulated Precipitation and Clouds by Using Gridded Forcing Data at SGP. JGR, Submitted.

### Diagnosis of Summertime Warm Bias at SGP



Zhang C., S. Xie, S. Klein, H. Ma, et al. (2017), Diagnosis of the Summertime Warm Bias in Climate Models at the ARM Southern Great Plains Site. In Preparation.

### Validating ACME Clouds with the ARM Simulator



Zhang, Y., S. Xie, S. Klein, et al., 2017: ARM Cloud Radar Simulator for Global Climate Models – A New Tool for Bridging Field Data and Climate Models. BAMS, submitted.

## Acknowledgements

The work presented here is supported by the DOE ARM program. We thank all the ARM/ASR scientists and infrastructure staff who have provided both scientific input and data support to the project. David Neelin's group at UCLA is acknowledged for providing the convection onset diagnostic set to the ARM diagnostics package.