Breakout #3: Cloud Properties and Data Products (Agenda)

- **Update on LLNL data products (Xie)**
- **CLWG VAPs (Jensen)**
- **An outline of the conventional and Bayesian approaches to uncertainty quantification and an application example on cloud fraction data (Shen et al.)**
- **A 10-year climatology of cloud fraction and vertical distribution derived from both surface and GOES observations of the DOE SGP site (Xi)**
- ***Retrievals and consistency checks of cloud variables from the AMF-China campaign (Zhao/Li) Withdrawn!***
- **Advective tendencies and Q1, Q2 in the new NCEP CFSR product at the ARM sites and their comparison with ARM IOP analyses (Zhang)**
- **The Meteorological Similarity Comparison Method (MSCM): A new tool for satellite model testing and development (Long)**
- **Discussion**

Development of Integrated ARM Datasets in Support of ASR Cloud Modeling Studies

Shaocheng Xie, Renata McCoy, Yunyan Zhang, and Chuanfeng Zhao

Lawrence Livermore National Laboratory

Acknowledgments:

Steve Klein (LLNL)

Minghua Zhang (Stony Brook University)

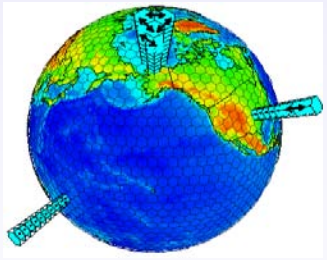
ARM Infrastructure Teams at DOE Labs (PNNL, BNL, ORNL …)

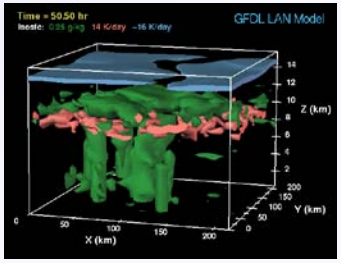
PIs who contribute to their products to our integrated datasets

Outline

- **Integrated Data Products Developed at LLNL**
  - **Forcing data for SCMs/CRMs**
  - **Climate Modeling Best Estimate (CMBE) data for climate modeling studies**
  - **Cloud Retrieval Ensemble Dataset (CRED)**
- **Future Plan**

Task #1: Create Large-Scale Forcing Data for SCM/CRM Studies





Most Used Modeling Testbeds in ASR: SCM + CRM

Forcing: Omega and advective tendencies of T and q

Large-Scale Forcing for SCM/CRM

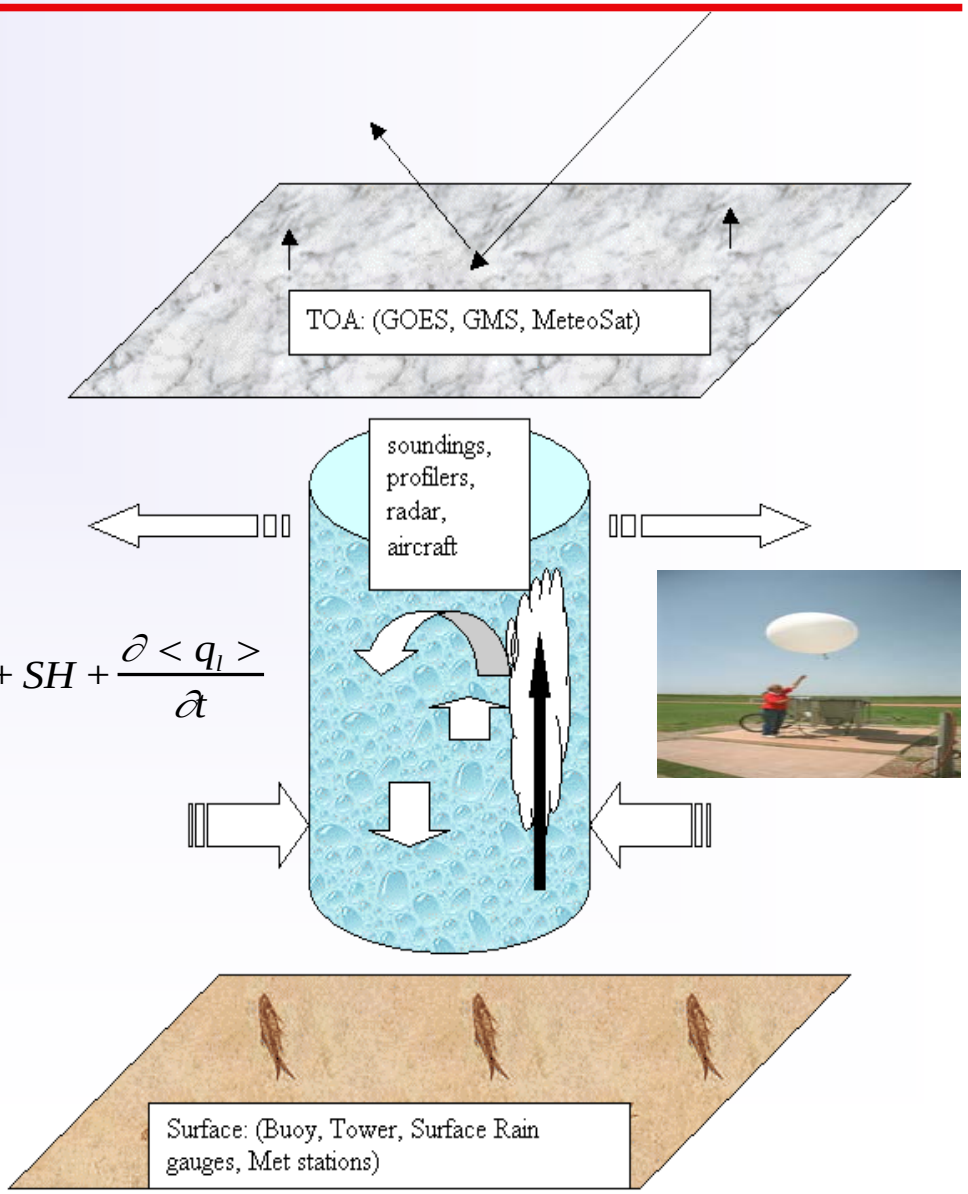
Variational Analysis (Zhang and Lin 1997)

$$< \nabla \cdot \vec{V} >= -\frac{1}{gp_s}\frac{dp_s}{dt}$$

$$\frac{\partial < q >}{\partial t} + < \nabla \cdot \vec{V}q >= E_s - Prec - \frac{\partial < q_l >}{\partial t}$$

$$\frac{\partial < s >}{\partial t} + < \nabla \cdot \vec{V}s >= R_{TOA} - R_{SRF} + LPrec + SH + \frac{\partial < q_l >}{\partial t}$$

$$\frac{\partial < \vec{V} >}{\partial t} + < \nabla \cdot \vec{V}\vec{V} > - f\vec{k} \times < \vec{V} > - \nabla < \phi >= \vec{\tau}_s$$

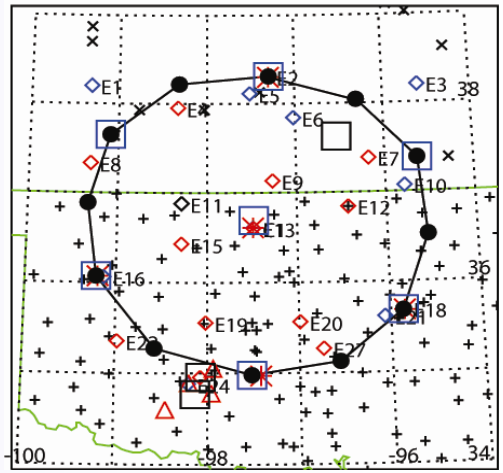


Courtesy of Dr. Minghua Zhang)

Forcing Data Products

Domain-averaged

Variational Analysis Domain



Forcing

- Large-scale vertical velocity
- Large-scale advective tendencies of T and q

Surface and TOA Fluxes

- TOA satellite measured radiative fluxes
- Satellite retrieved cloud fraction and cloud properties
- Surface radiative fluxes
- Surface turbulent fluxes
- LWP and PW
- Surface precipitation and other meteorological fields

Two Types of Forcing Datasets

- **IOP Forcing – Sounding Based**
  SGP (14), NSA (MPACE), and TWP-Darwin (TWP-ICE)

- **Continuous Forcing – NWP Analysis Based constrained by Surface and TOA Observations**

CF has better quality than NWP forcing

Continuous Forcing

- 11 yrs (1999-2009) for SGP **– RUC analysis constrained by ARM observations**
  - ***Released three year data 1999 – 2001 a few years ago***
  - ***Released the first 6 months in 2009 for RACORO***
  - ***Created another 7-year forcing (2002-2008) (under review)***

- 3 wet seasons (2004-2007) for TWP-Darwin **– ECMWF analysis constrained by C-POL radar precipitation (*Christian Jakob, Laura Davies*). *Released!***

11/03/04 - 04/06/05; 11/10/05 – 04/30/06; 10/12/06 – 04/19/07

ensemble forcing with 100 members!

Future Plan on Forcing Data

- **Release continuous forcing data for 2002-2008**

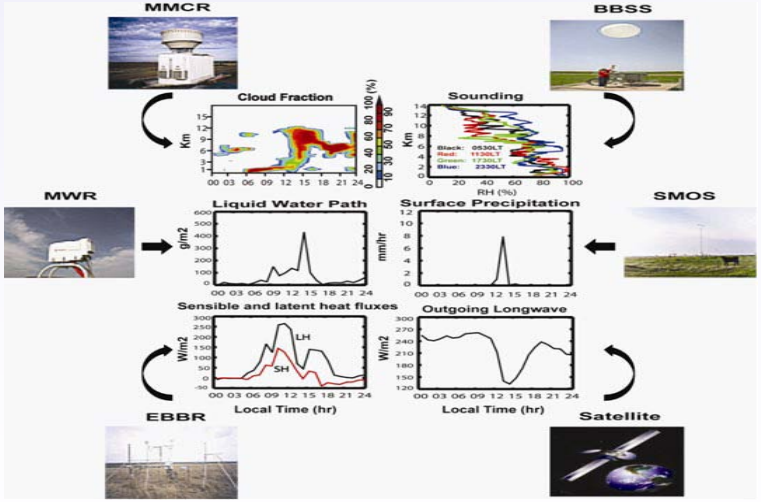
- **Develop forcing for selected AMF deployments (*Needs to be prioritized by the CLWG*)**

  Initial list:

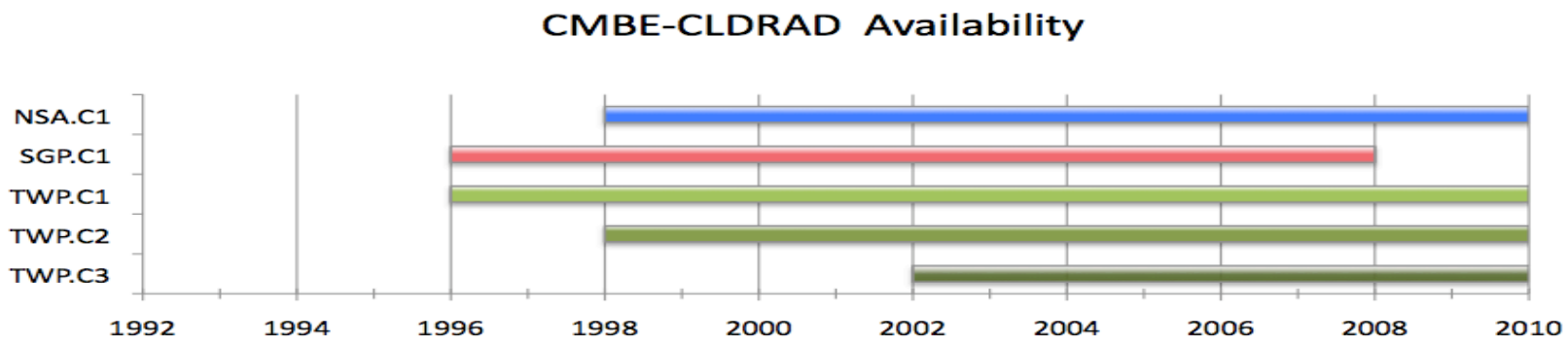
  - **AMF China (2008) (*Aerosol-cloud interaction, YOTC??)***
  - **AMF Azores (2009-2010) (*Clouds, Aerosol, and Precipitation in the Marine Boundary Layer*)**

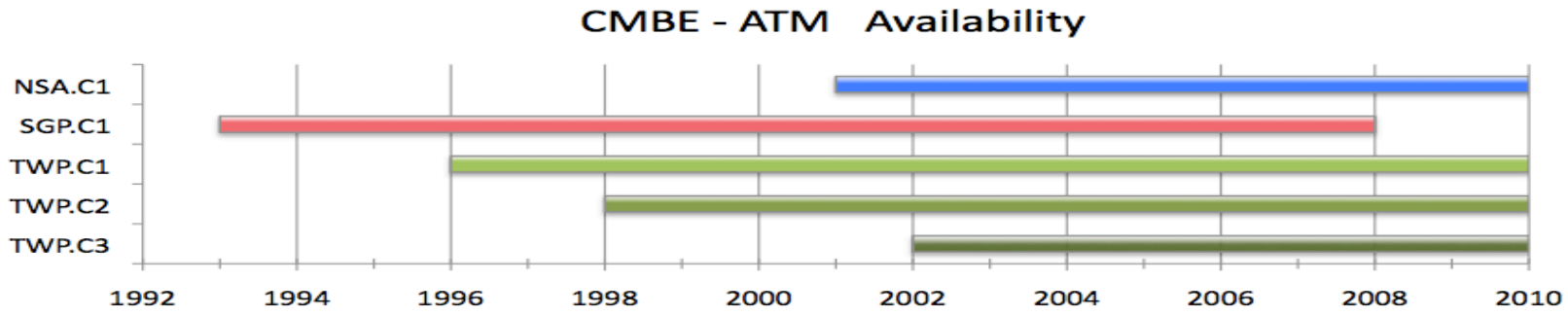
Comments needed!!!!!!!!

Task #2: Climate Modeling Best Estimate (CMBE) for Climate Modeling Studies



CMBE Data Availability



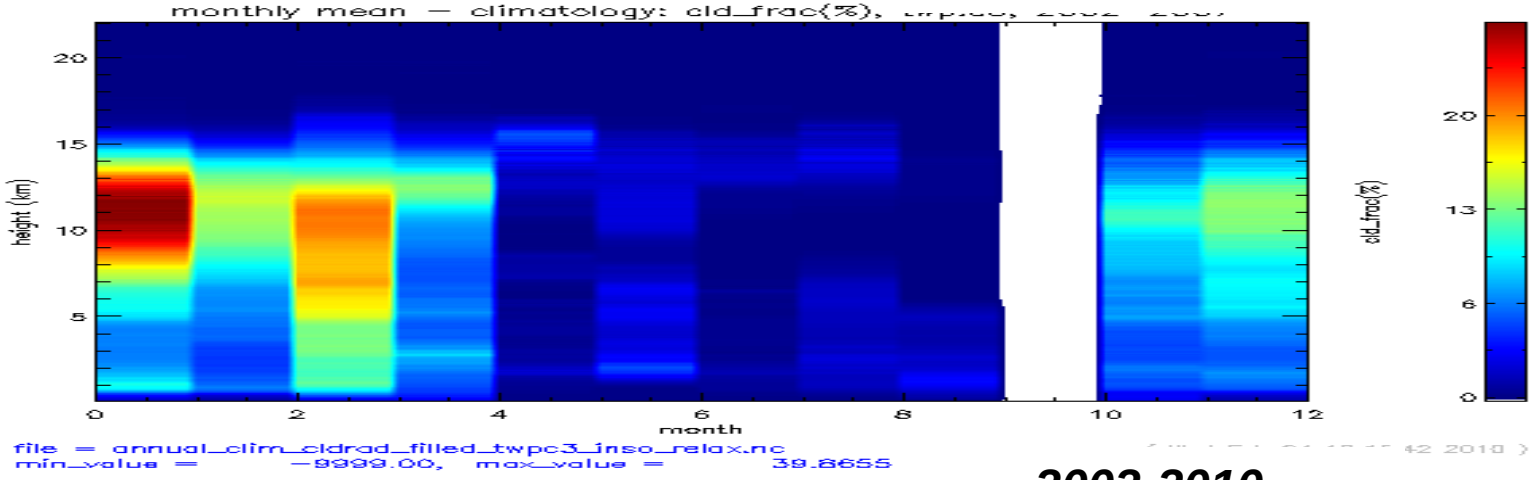


- **Sounding and surface meteorological quantities added to NSA and TWP sites (*new*)**
- **Data are available to most current years except for SGP (*new*)**
- **Statistical summary files are provided**

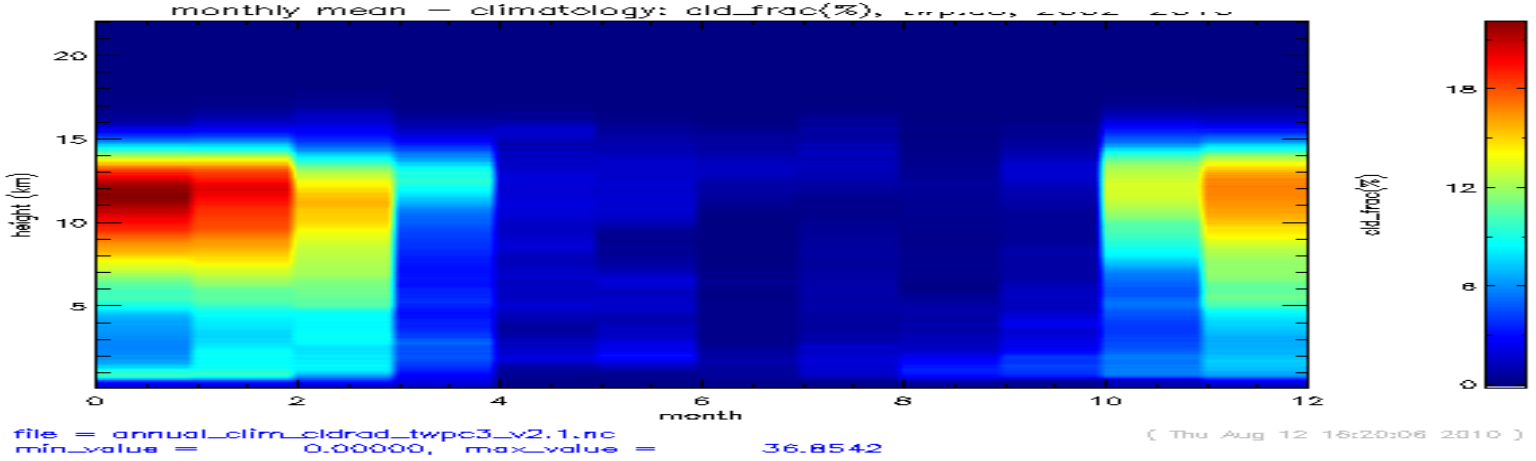
Longer Data Record Improves Climatology

Seasonal Cycle of Cloud over Darwin

2002-2007



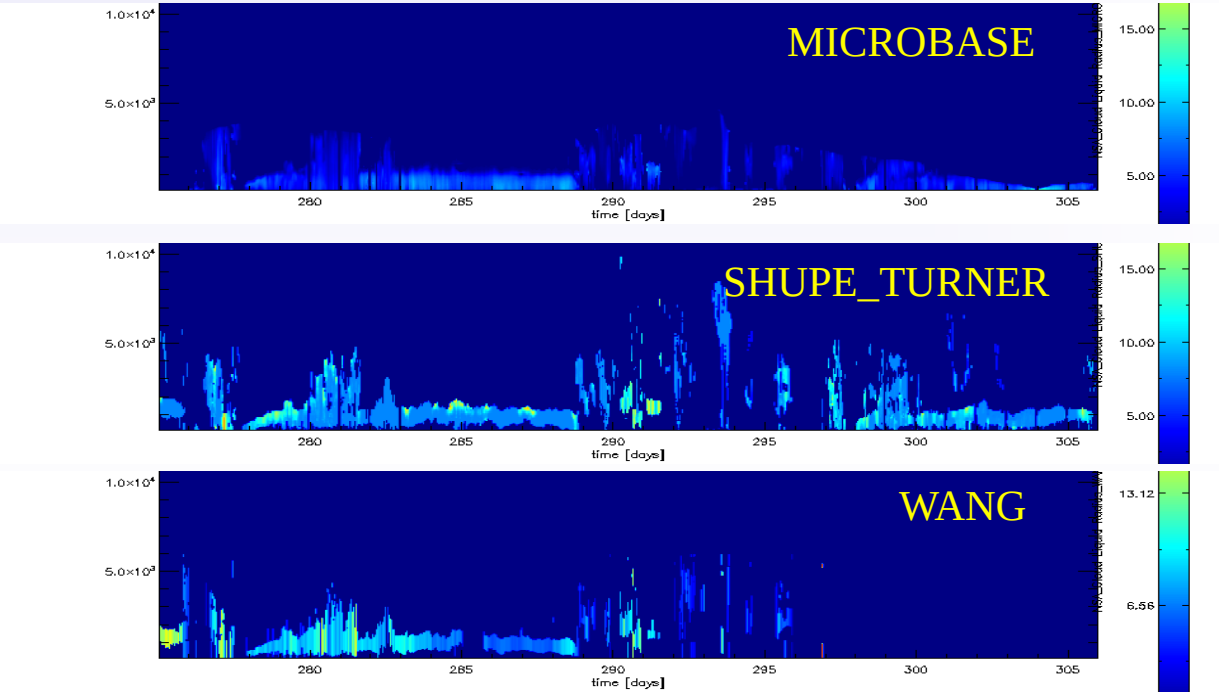
2002-2010



Future Plan on CMBE Data

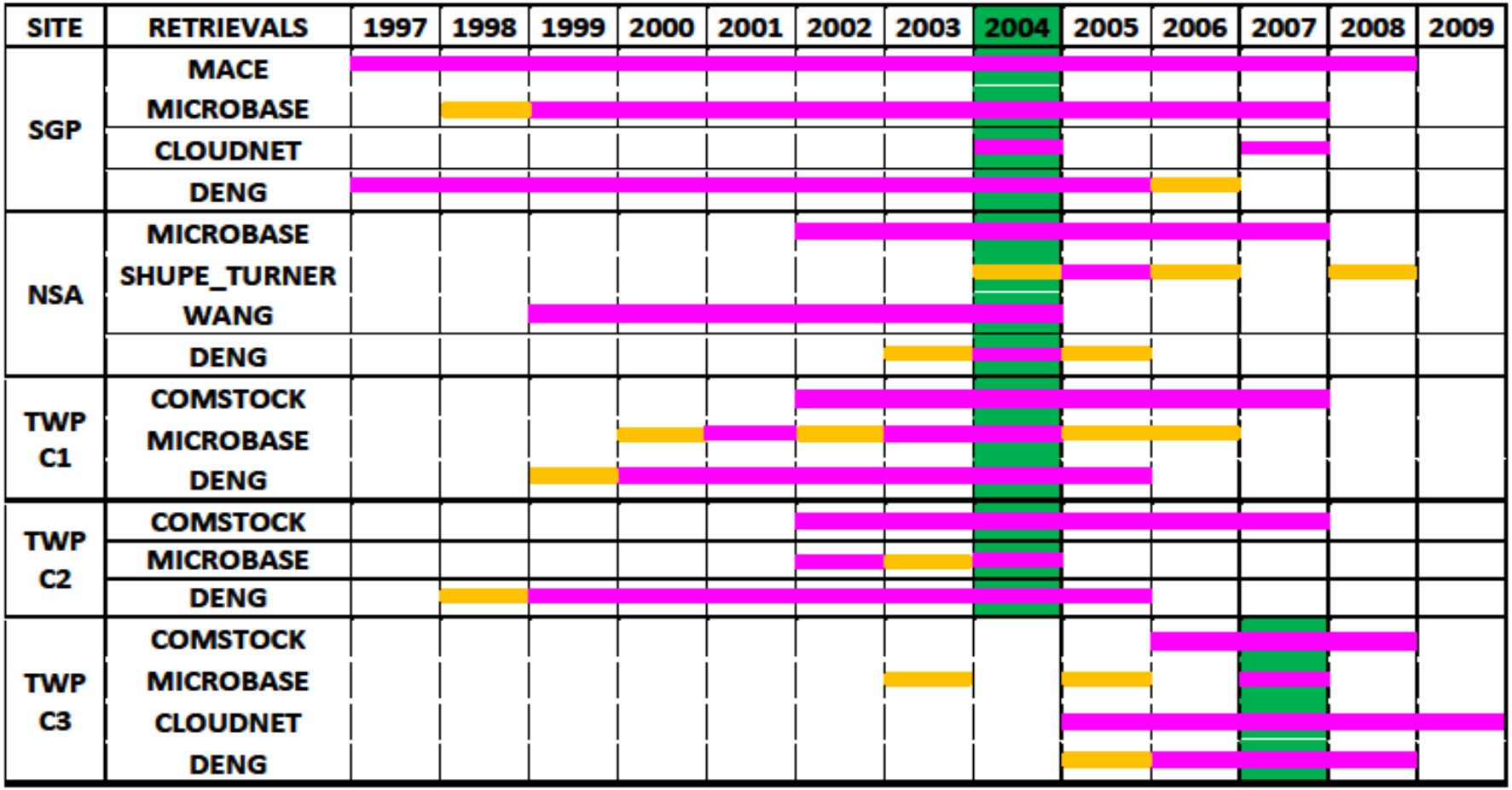
- **CMBE-enhancement**
  - **Add surface clear-sky SW for calculating effective cloud albedo for SGP**
  - **Add satellite data for NSA and TWP sites**
  - **Create CMBE – area-mean data (SGP)**
    - ***from long-term continuous forcing data***
  - **Provide satellite retrieved surface precipitation for TWP sites**
- **CMBE for AMF sites**
- **CMBE-RIPBE *(Sally McFarlane)***
  - **Cloud microphysical properties**
  - **Aerosol properties**
  - **Surface albedo**

A Multi-Year Cloud Retrieval Ensemble Dataset (CRED)



A Little Background ……

ARM has various cloud microphysical retrievals for LWC/IWC available for different periods and sites

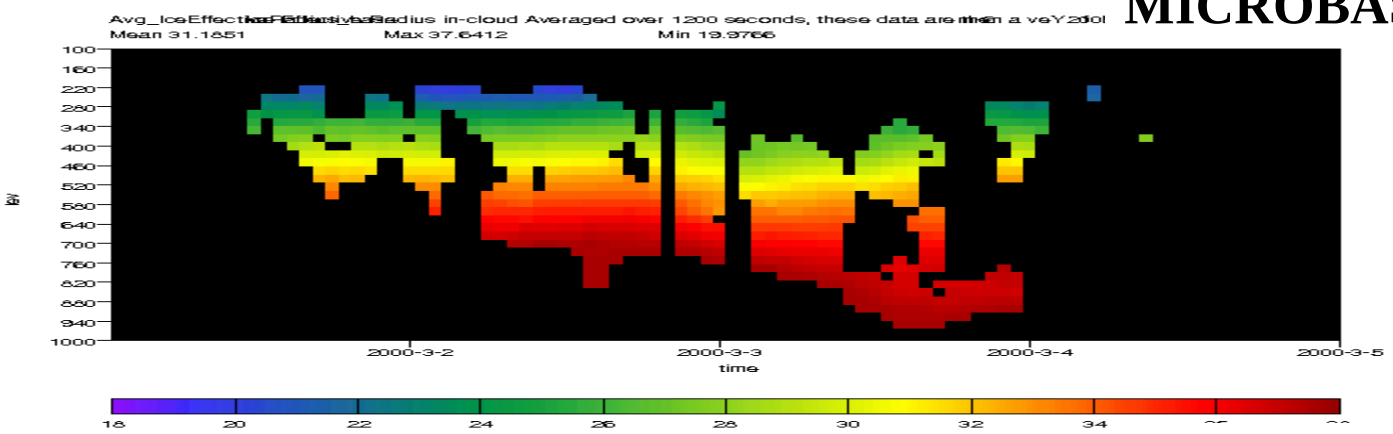


Note that Purple bar means whole year, yellow bar means partial year.

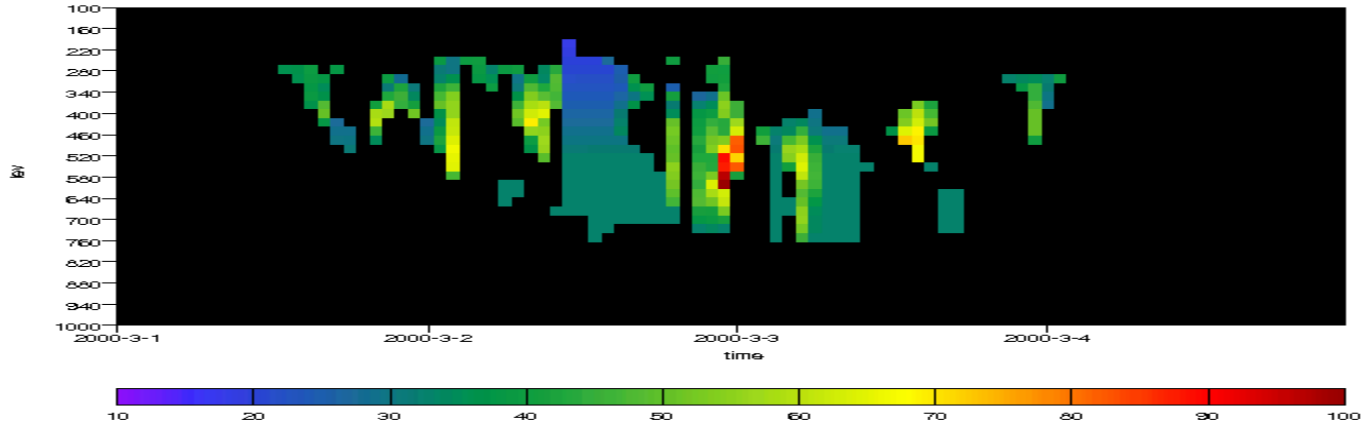
They usually do not agree with each other …

Cloud Ice Particle Radii

MICROBASE



MACE



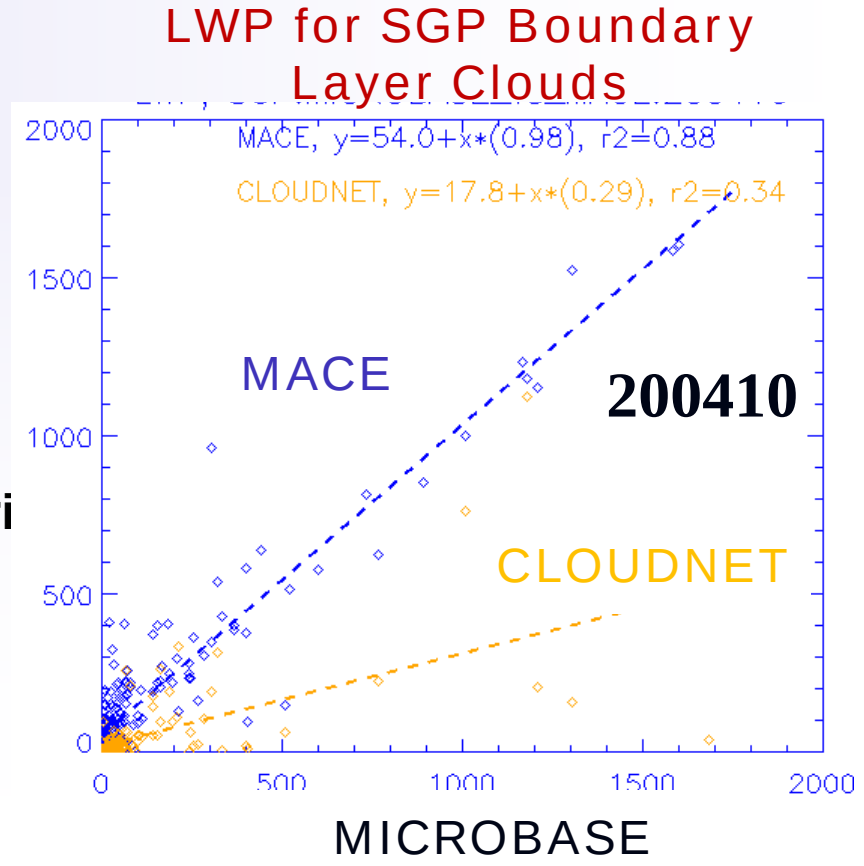
March 1 – 4, 2000, SGP

Possible Reasons

- ✓ **Retrieval algorithms developed for different types of clouds and situations and work for different instruments → partly results in different assumptions used in these retrieval algorithms**
  - **Particle Habit Particle**
  - **Size Distribution (PSD)**
  - **Vertical/Horizontal Distribution**

- ✓ **Input Data**
  - **Cloud Boundaries/detection**
  - **Cloud Classifications/Categori**

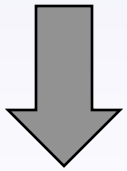
- ✓ **Constraints**
  - **Liquid Water Path from MWR**



How to address this issue?

A Best Estimate of Cloud Properties – very difficult to achieve!

- Complexity of clouds
- limitations of instruments
- our insufficient knowledge



Alternative approach is to develop a Cloud Retrieval Ensemble Dataset(CRED) using those existing cloud retrieval algorithms

Plan

- First assemble current available cloud property products into one single dataset with uniform temporal and vertical levels for all ARM sites
- Understand these data from their algorithms, assumptions, and input files
- Make suggestions on how to reduce differences between different cloud retrievals

Plan

- **Further evaluate these retrievals with aircraft data and radiative closure experiments using the BBHRP testbed with the hope to develop a best estimate of cloud properties by combining all available cloud retrievals.**

- **Provide feedback to cloud retrieval experts and work with them to improve their retrieval products**

The first CRED data will be available by next ASR science meeting in 2011

Comments are welcome!!!!!!

THE END