Introduction

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(Brookhaven National Laboratory)

- **Welcome**
- **Major events since last ASR meeting**
- **Some operational and scientific highlights not presented here**
- **Breakout agenda**

Major Events since 2011 ASR meeting

- **DOE Modeling Meeting (19-22 Sep, 2011)**

-- Good FASTER presence (BNL, LBNL, CU/GISS, JPL, ANL)
-- Initiation of aerosol DA work/discussion (talk and poster by Z. Li et al)

- **FASTER-Co-lead AGU Fast Physics Section (Dec 2011)**

- **DOE Progress Presentation (9 March 2012)**

-- Valuable discussion with main DOE managers (D. Koch, A. Williamson, W. Ferrell, R. Petty, R. Joseph, G. Geernaert)

- **Team member news**

-- T. Del Genio selected as new AGU fellow, congrat!
-- S. Menon and G. de Boer left LBNL; welcome D. Romps and G. Ban-Weiss from LBNL on board

Overall Progress

- **Facility/Model Development (Long-Term Health)**

  -- Integration of SCM-testbed and NWP-Testbed
  -- Mulitiscale Data Integration and Visualization (poster by T. Toto)
  -- Multiscale Data Assimilation System (talk and poster Z. Li)
  -- WRF-FASTER as a typical CRM/LES and WRFing Suite (talk and posters by S. Endo, W. Lin, Z. Lin)

- **Publications**

  -- A total of 28 manuscripts: 5 published; 4 in press; 15 submitted; 4 to be submitted.
  -- Last ASR: 3 papers submitted and 6+ being drafted

FASTER progressing into publishing stage critical for renewal!

Additional Science Highlights

- Aerosol-cloud interaction (de Boer et al talk, 1:45 pm, Wed)
- CRM/LES-TWP-ICE (Fridlind talk, 9:15 am, Thursday)
- Entrainment-rate (Lu et al poster and talk this evening)
- Cloud top and cloud base evaluation (Wu et al. poster)
- Exploration of WRF setup influnces (posters by Lin et al, and Endo)
- Three moment-based parameterization (poster by Liu et al)
- Visualization and evaluation system (poster by Toto et al.)
- Microphysics sensitivity with WRF (papers by Van Weverberg et al)

Breakout Agenda

* SCM presentation plus open discussion

* HRMs

* Parameterization development

* Data integration and DA with focus on RACORO

* General open discussion

* Group dinner at 6 pm?

Highlights for Others and Discussion Items

- RACORO Issues

- How to use relationships to address coupling and tuning issues

- Entrainment rate as another potential evaluation variable

- How to capitalize on the new ARM measurements

- Generic issues: type partition; Point-to-domain upscaling; subgrid variability and scale-dependence

As always please contact me anytime you have ideas to share!

Evaluation of Aerosol Cloud Interactions

Overview:

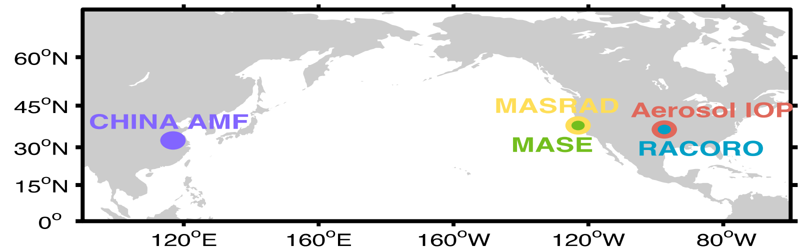
- Observations from ARM IOPs are being utilized to evaluate the interactions between clouds and aerosols in the NASA GISS ModelE.

- Parameterizations of droplet activation, droplet effective radius, and relationships between surface aerosol and cloud properties are tested.

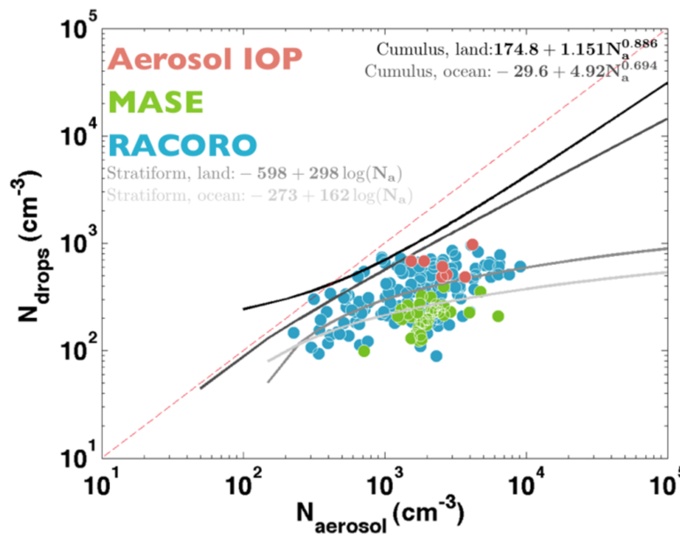
Highlights:

- Simulated droplet activation generally follows observations.

- Effective radius parameterizations result in significantly different values – the impact of these differences on climate are currently being evaluated.



Campaigns Utilized



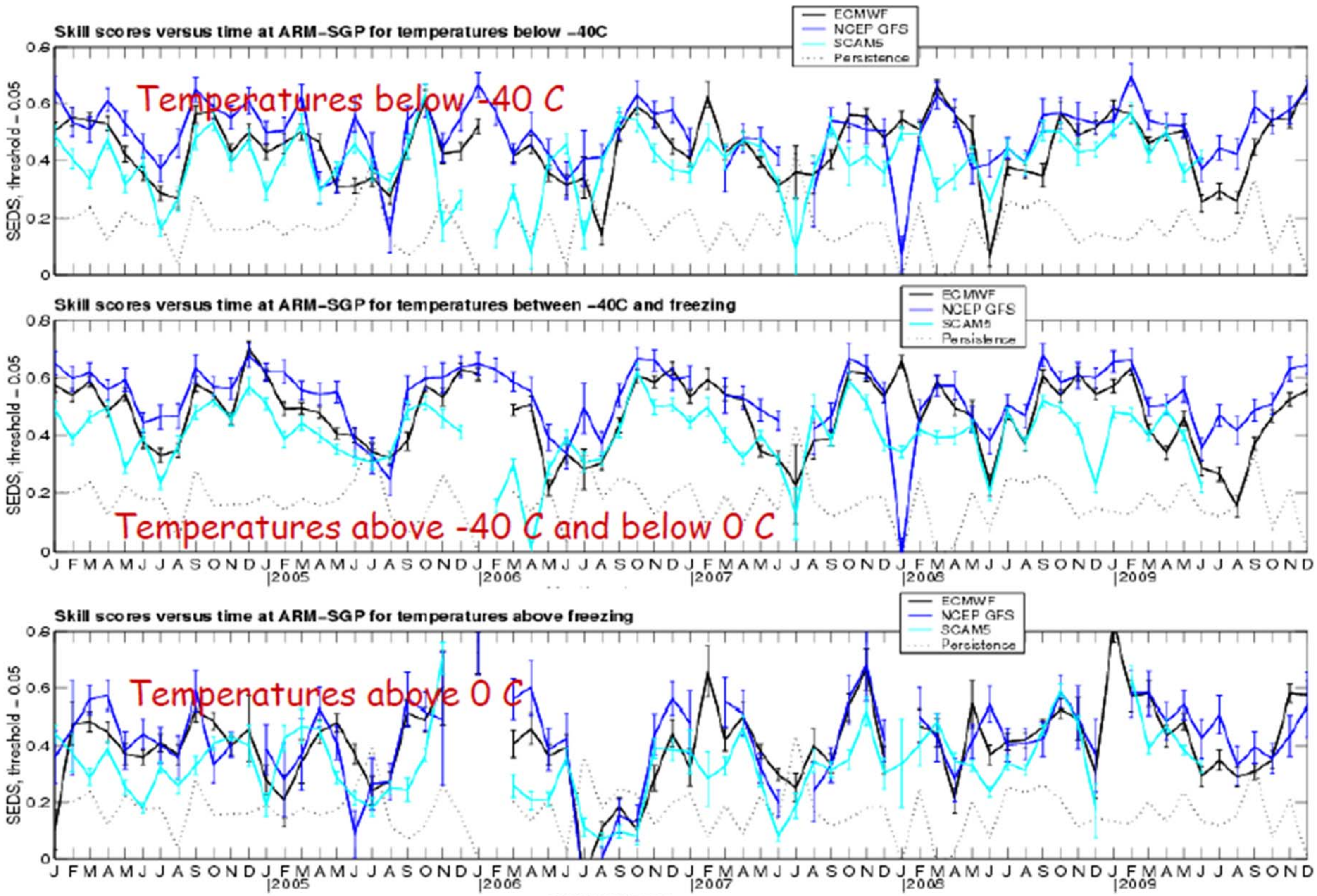
Droplet Activation

Reference:

de Boer, G., S. Menon, S.E. Bauer, T. Toto, A. Vogelmann and M. Cribb (2012): Evaluation of aerosol-cloud interactions in the GISS ModelE using ARM Observations, *Atmos. Phys. Chem.*, in preparation

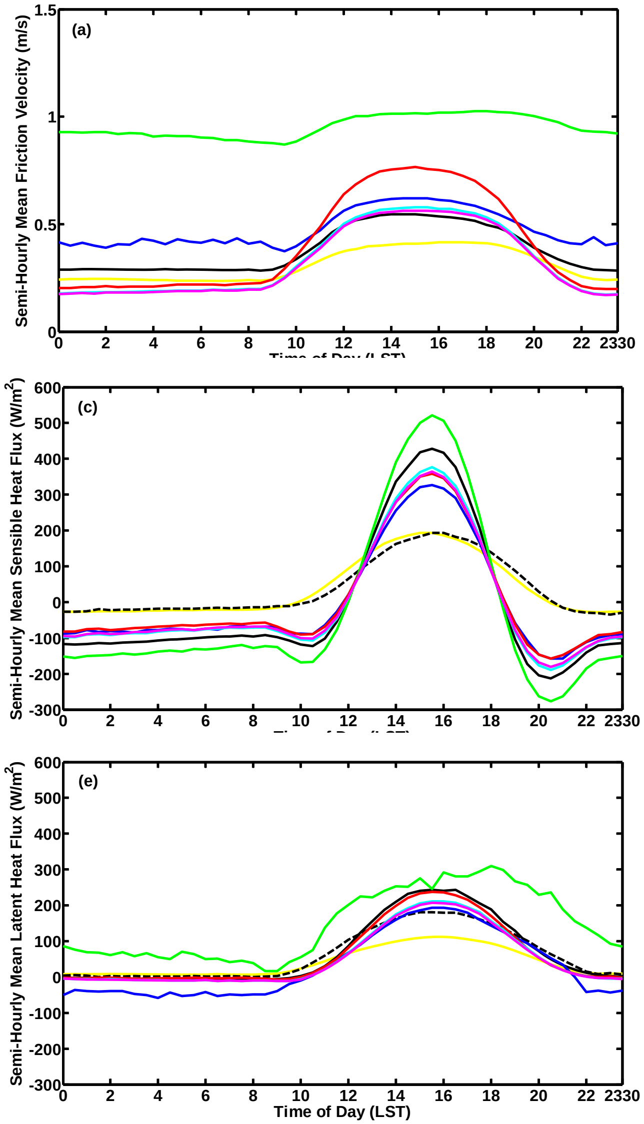
SCM-NWP Intergration

SCM forecast skill at SGP 2004-2009

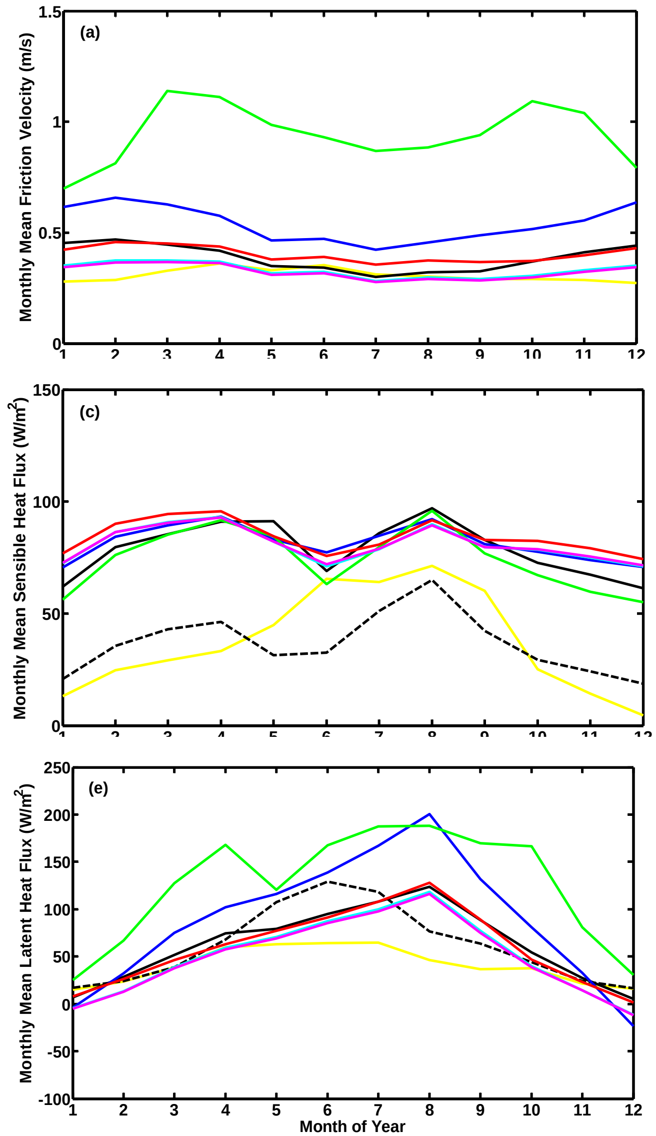


Evaluation of Surface Flux Variations

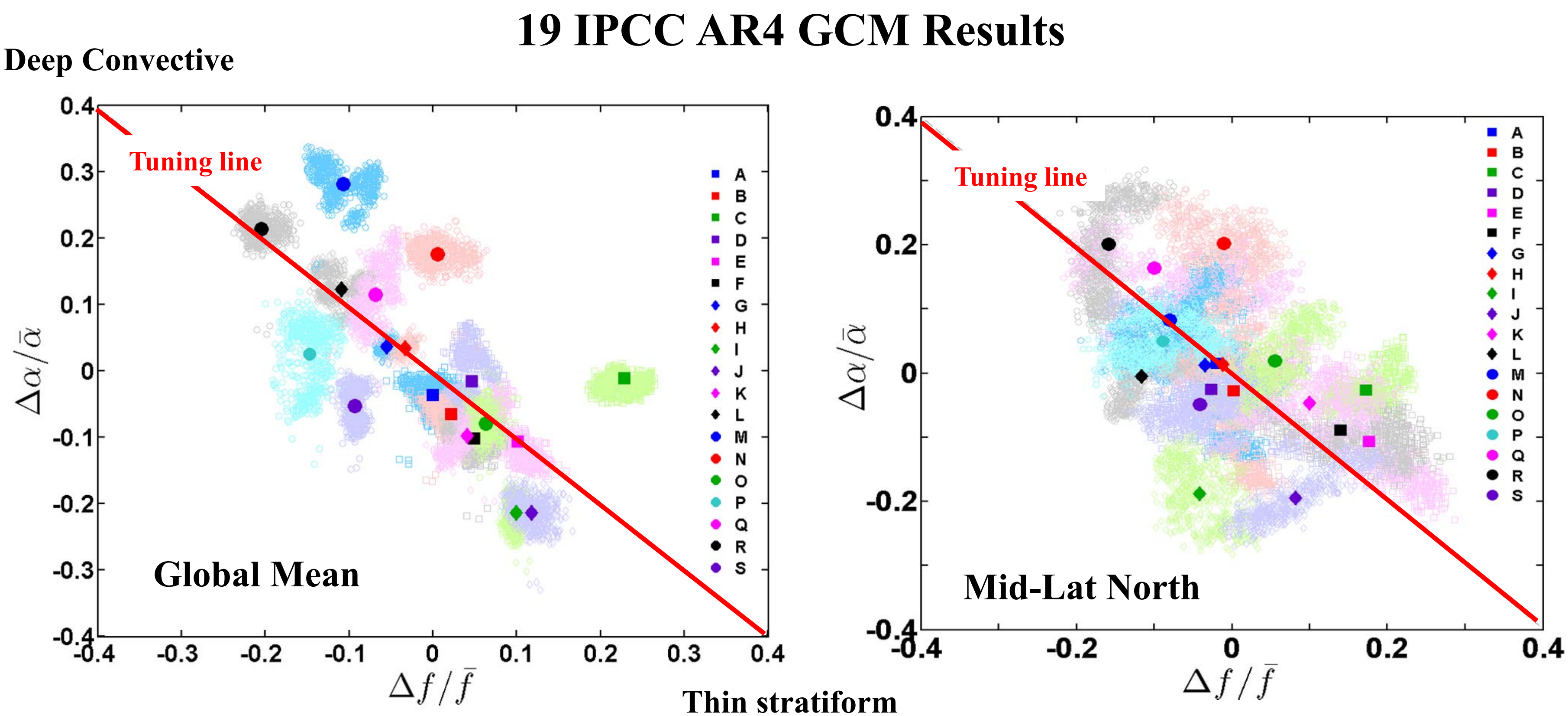
Diurnal Variation



Seasonal Variation



Tuning and Compensating Errors — Evidence



These results demonstrate that "tuning" parameterizations to observations lead to serious compensating errors, even distinct cloud regimes; we should derive parameterizations from first principles and reduce the number of tunable parameters as much as possible, and meantime look for smart objective "tuning" !!

Compensating Errors in Precipitation

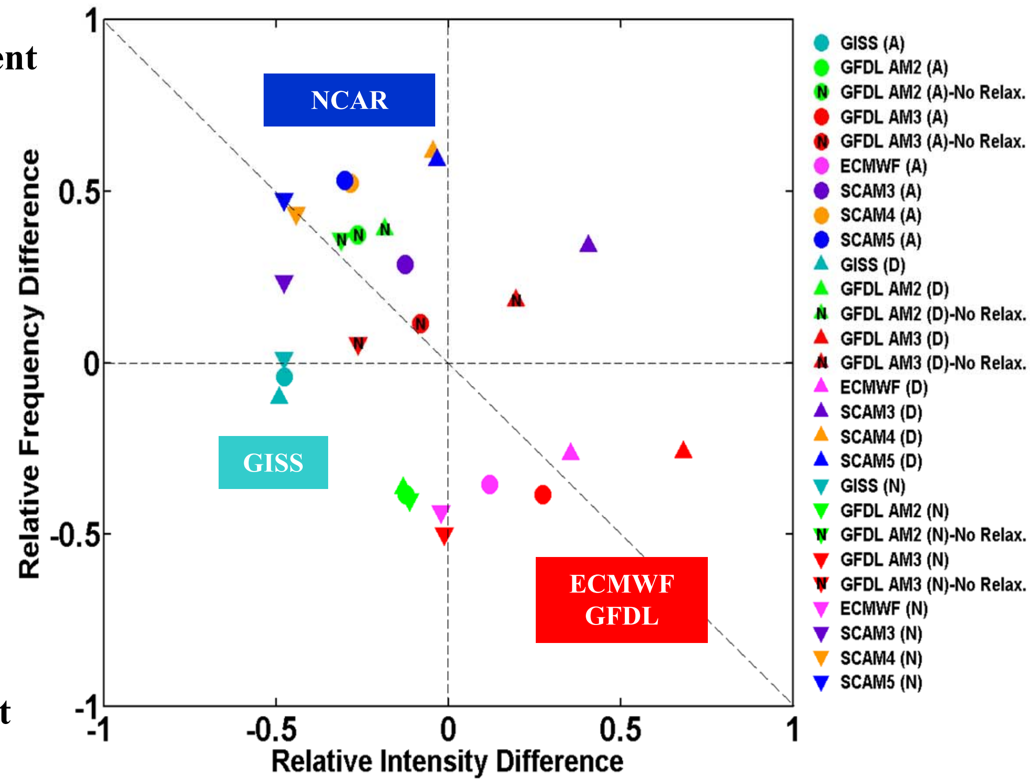
$$P = \overline{p}\,N$$

$$\frac{\Delta \overline{p}}{\overline{p}} = -\frac{\Delta N}{N}$$

P = Total precipitation
N = Number of event
$\overline{p}$ = Event mean

More Frequent

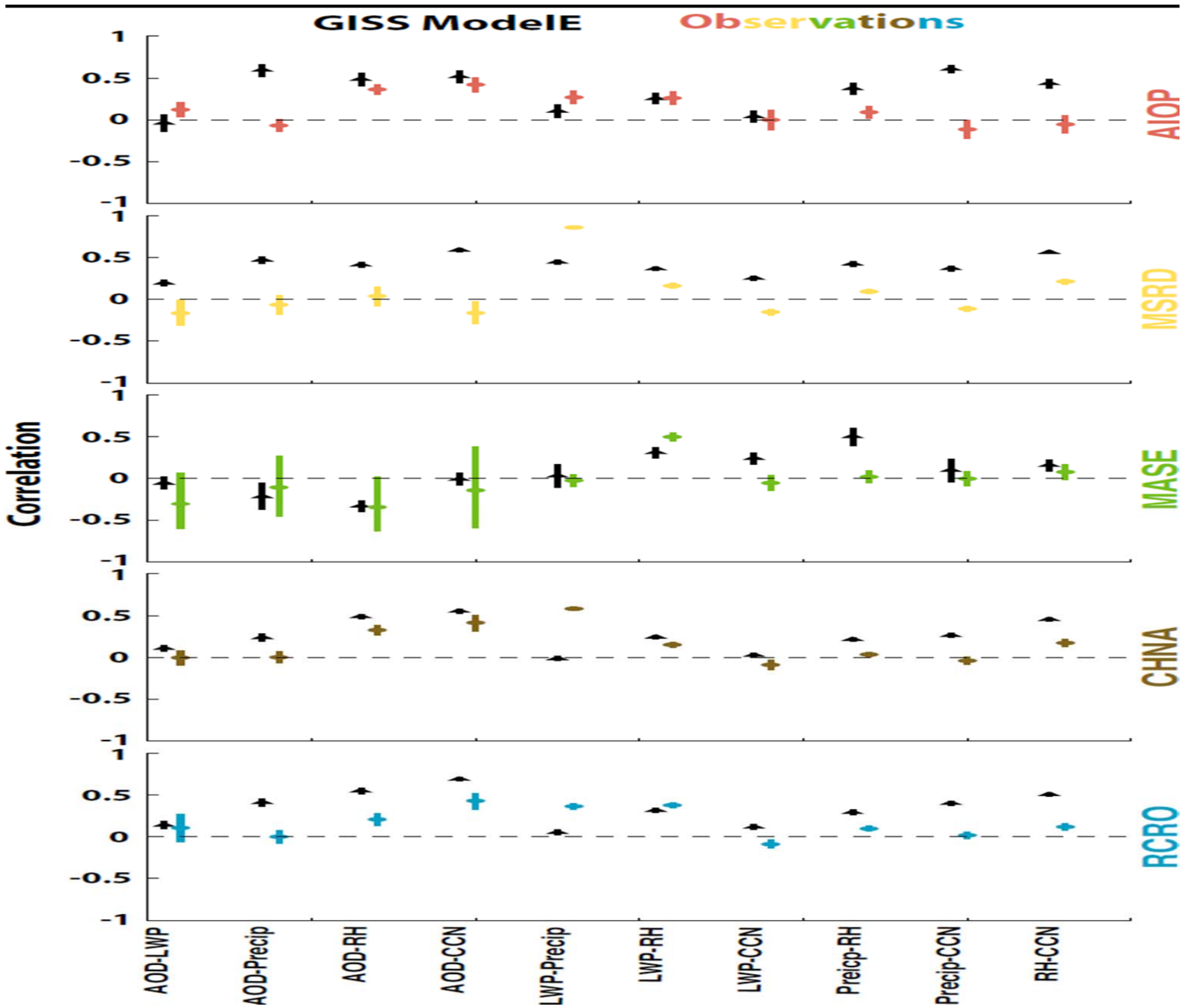
Less Frequent



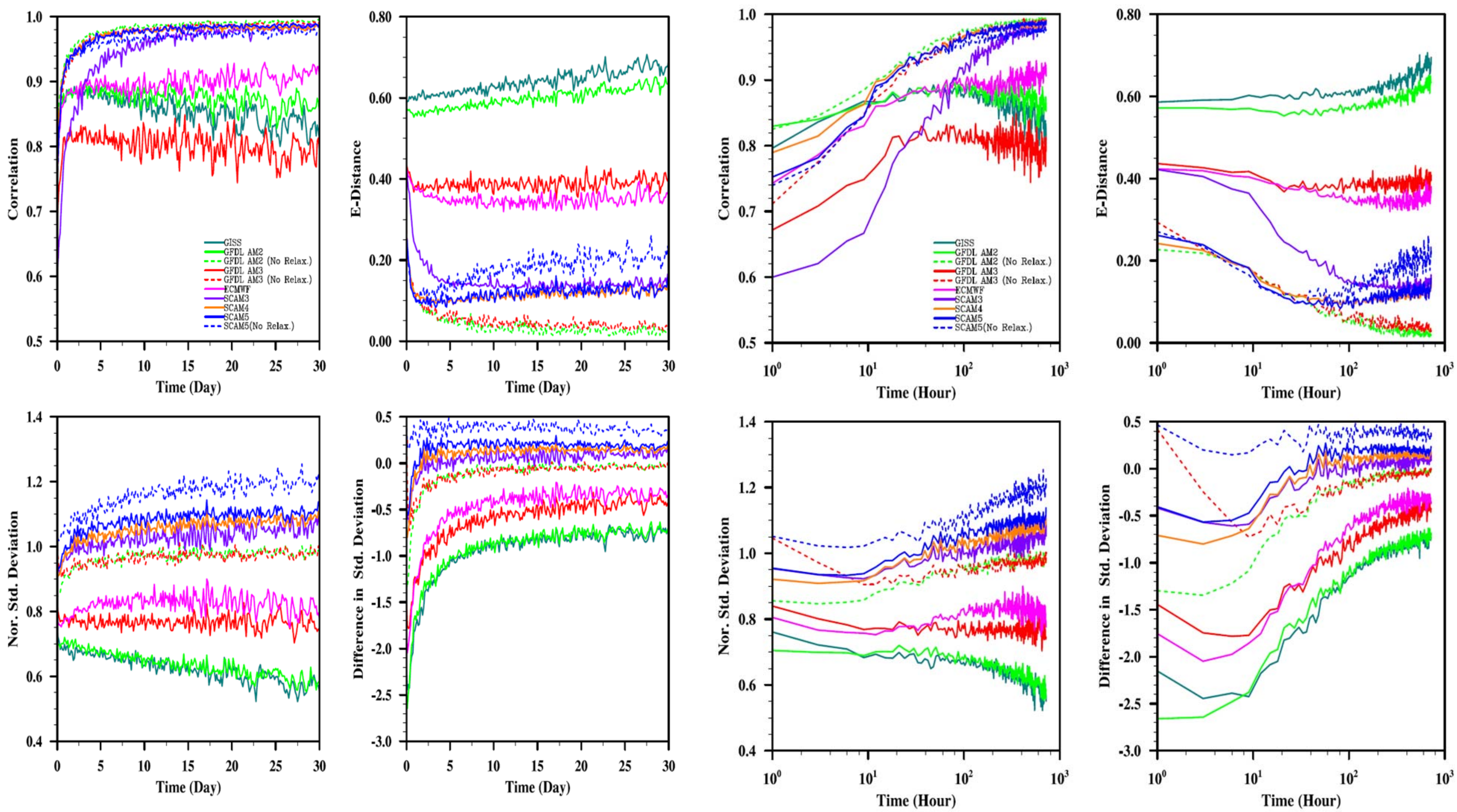
Weaker Precipitation → Stronger Precipitation

Crucial message: large scale forcing controls SCM total precipitation more, however, from different compensating errors in different GCMs >> convection trigger vs strength?

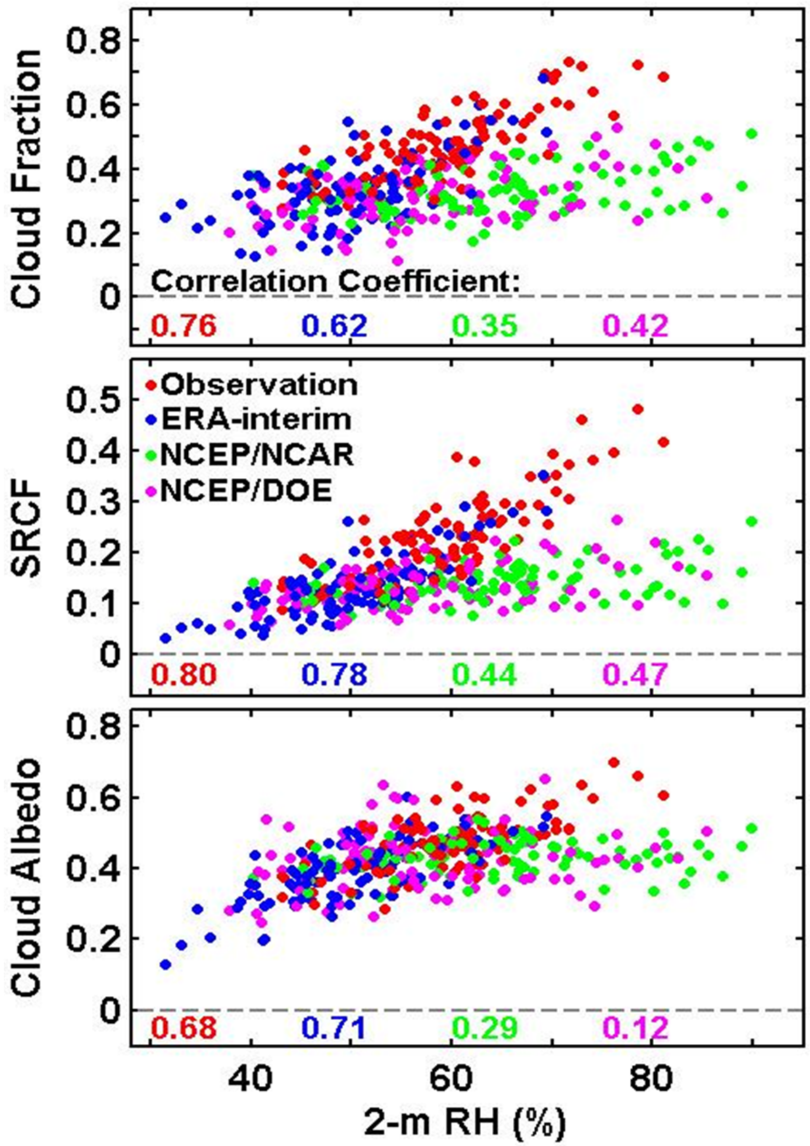
Multiple Correlation Evaluation ?



Dependence of Statistical Measures on Temporal Averaging Scales



(Near-) Surface Meteorology-PBL-Cloud Properties Coupling?



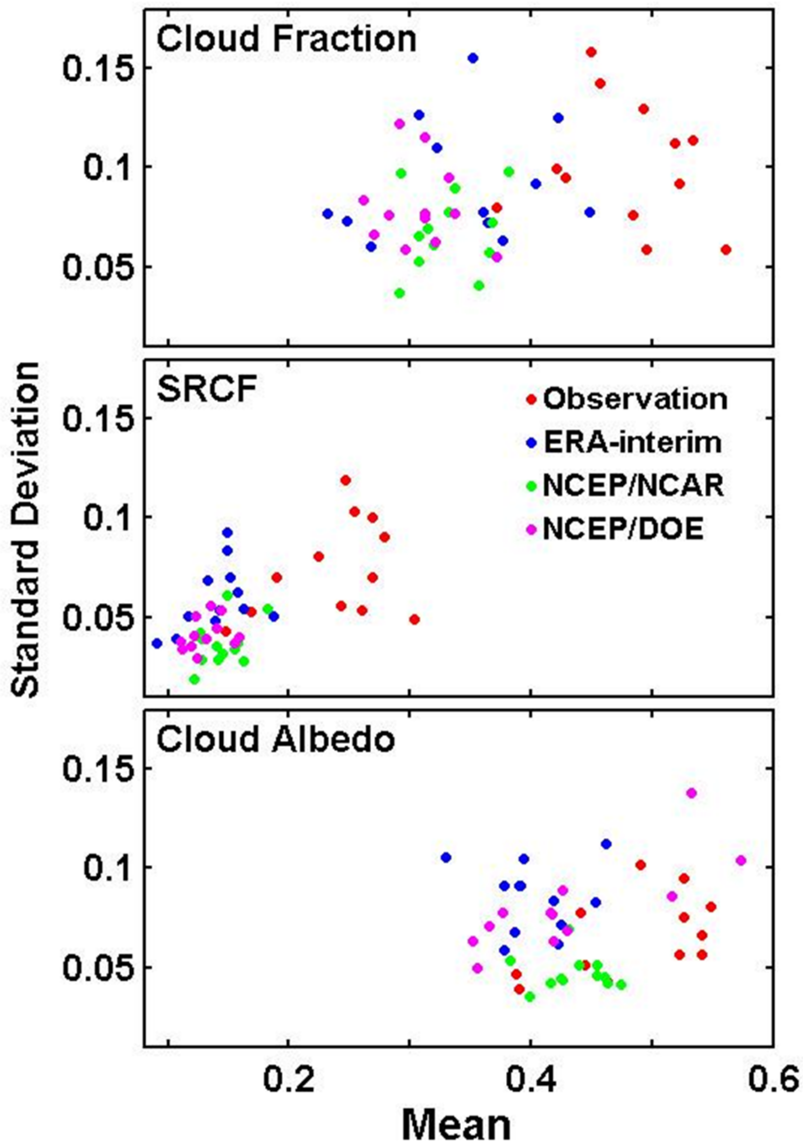
Obs
ERA-Interim
NCEP/NCAR
NCEP/DOE

The cloud properties strongly link to the relative humidity (RH):

- **Obs/ERA-Interim: strongest, with correlation [0.62, 0.80]**
- **R2: slightly stronger than R1 on the link between cloud fraction (or SRCF) and the RH**
- **R1/R2: relatively weak on the link between cloud albedo and the RH**

!!! Strong link between the cloud properties and RH !!!

Standard Deviation vs Mean (monthly)



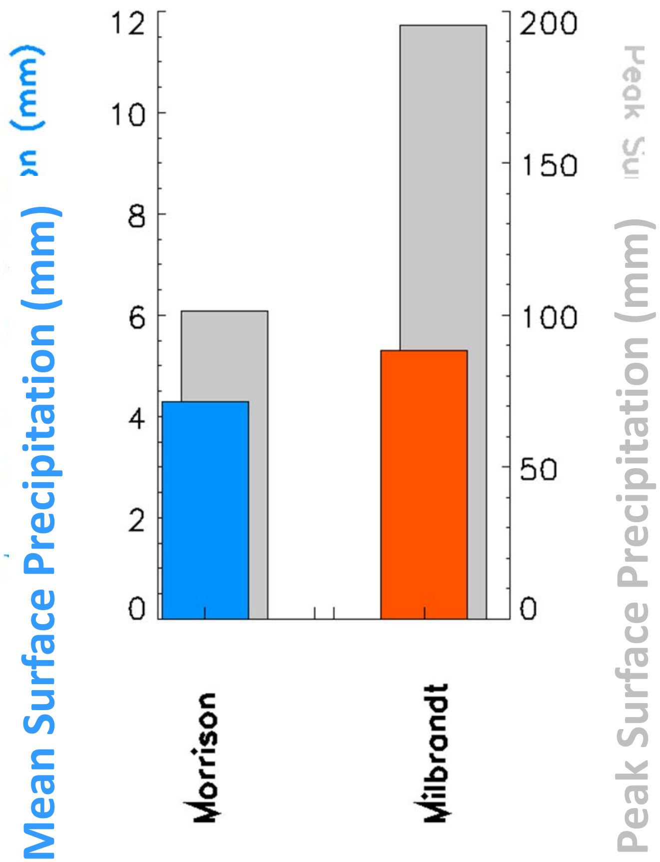
Obs
ERA-Interim
NCEP/NCAR
NCEP/DOE

The standard deviation and mean of the cloud properties :

- **Obs: overall largest mean/std for the cloud properties**
- **ERA-interim: overall second largest mean/std for cloud fraction, and second largest std for SRCF and cloud albedo**
- **R1/R2: overall similar mean/std, except R2 cloud fraction (albedo) std is slightly (significantly) larger than R1**

!!! Observations show the largest mean/std !!!

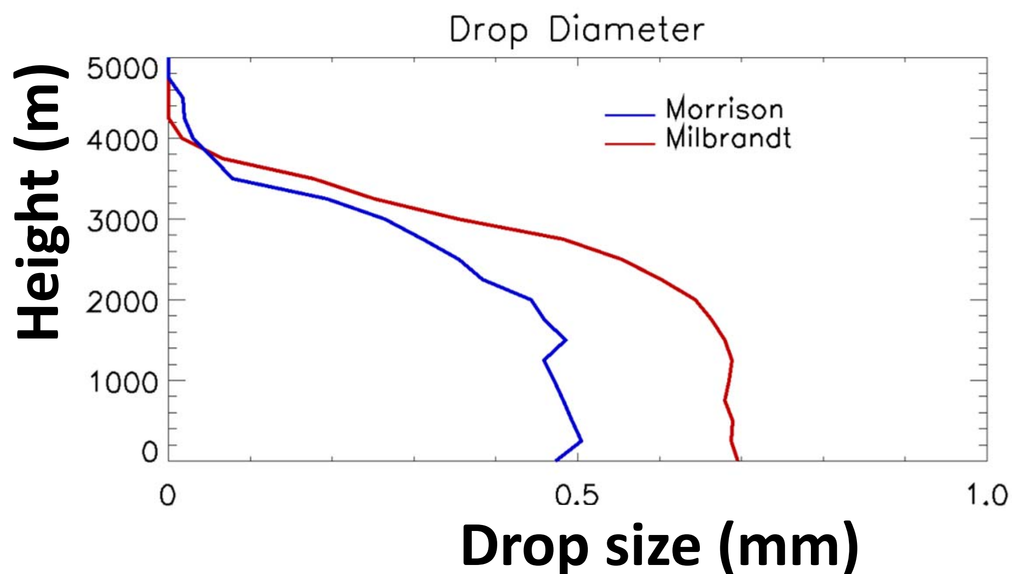
Morrison vs. Milbrandt Microphysics Schemes



Improving conversion parameterizations

(K. Van Weverberg)

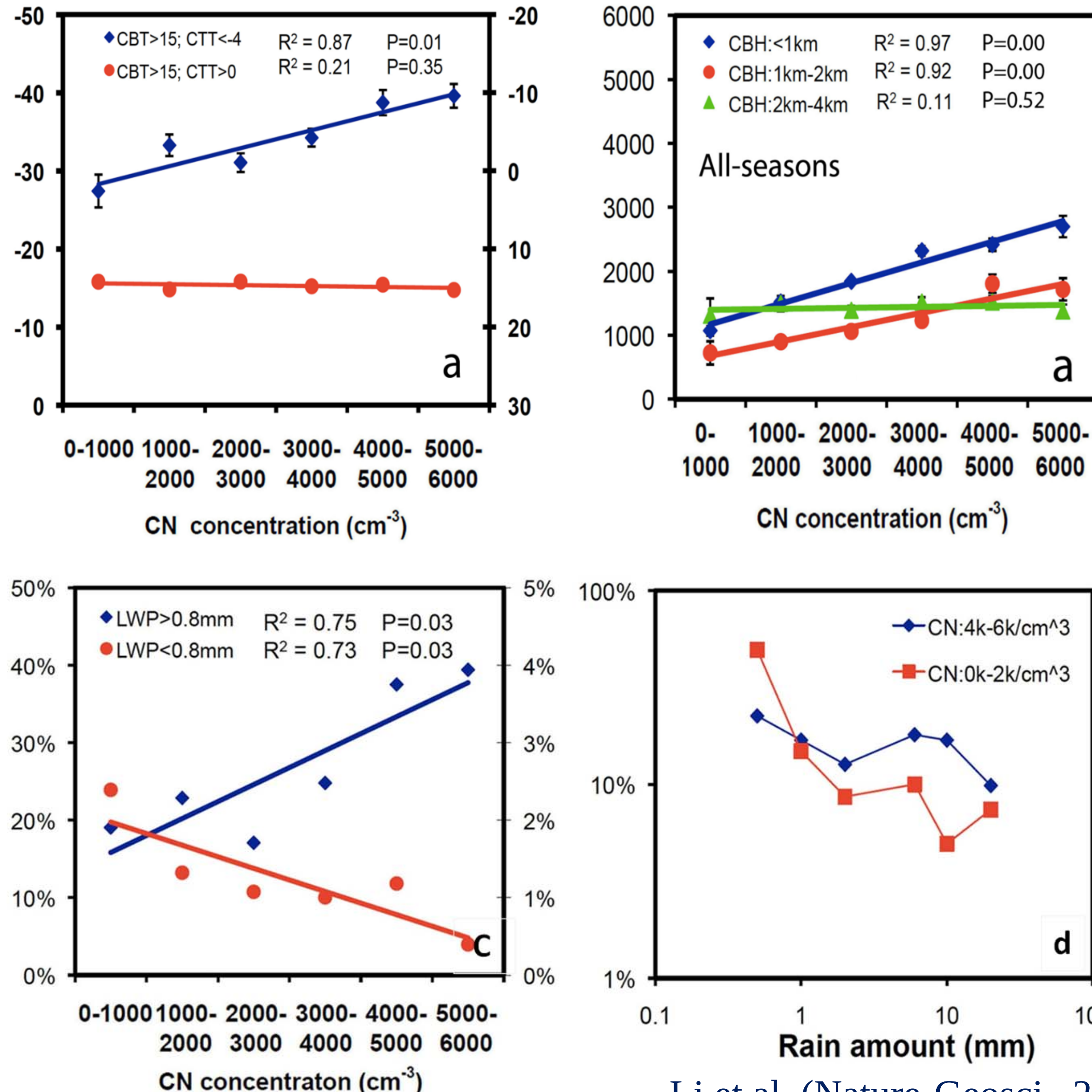
Peak precipitation: drop breakup



Mean precipitation: graupel sublimation

- **Morrison:** Large return of graupel to vapor
  → **Low Precipitation Efficiency**
- **Milbrandt:** No return of graupel to vapor
  → **High Precipitation Efficiency**

Long-term impact of aerosols on cloud top temperature
Cloud thickness and rainfall frequency



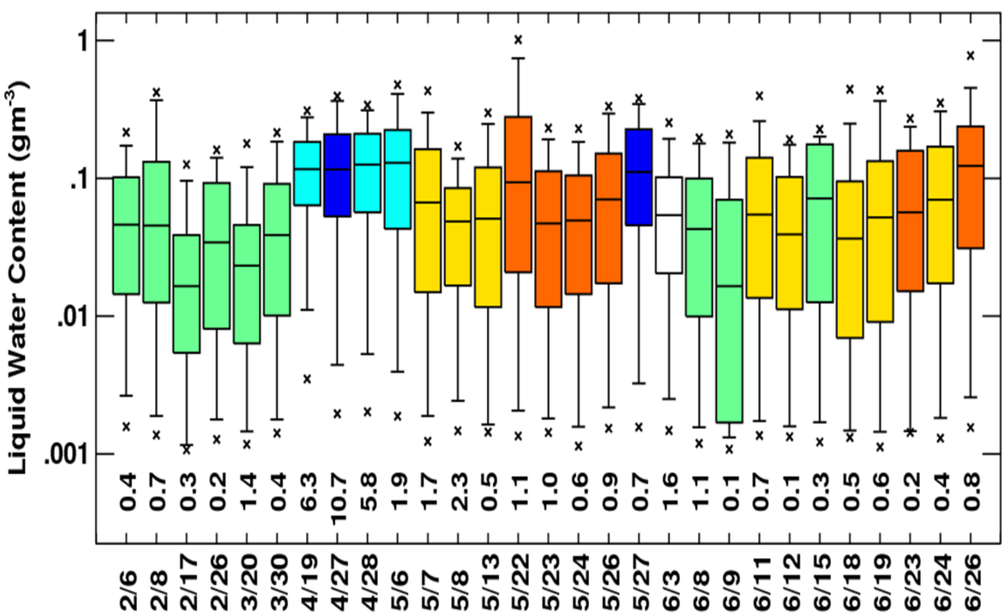
Li et al. (Nature-Geosci., 2011)

Next IOP to Focus: RACORO ?

Focus: Continental boundary layer liquid water clouds

RACORO

Routine
ARM Aerial Facility (AAF)
Clouds with Low Optical
Water Depths (CLOWD)
Optical
Radiative
Observations



Some Generic FASTER Issues

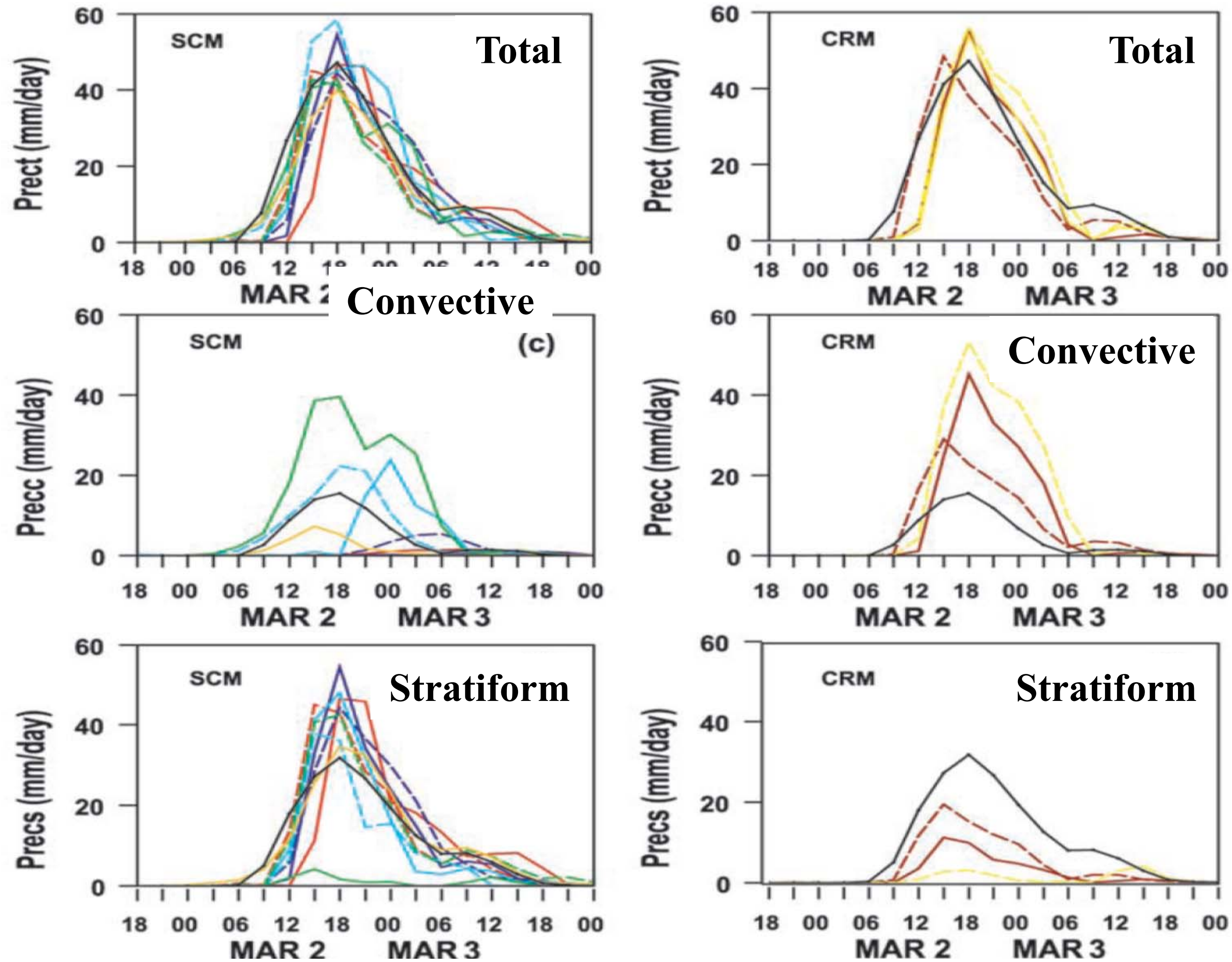
- Consistency of Partition between stratiform-convective clouds and precipitation between models and observations, and among different models of various scales (e.g., GCM vs. CRM)

- Consistency of cloud definition (e.g., including precipitation particles or not) between models and observations and among models of various scales (e.g., GCM vs. CRM)

- Scale mismatch in evaluation of model domain results against ARM pencil-like measurements

- Experiment design to identify model errors

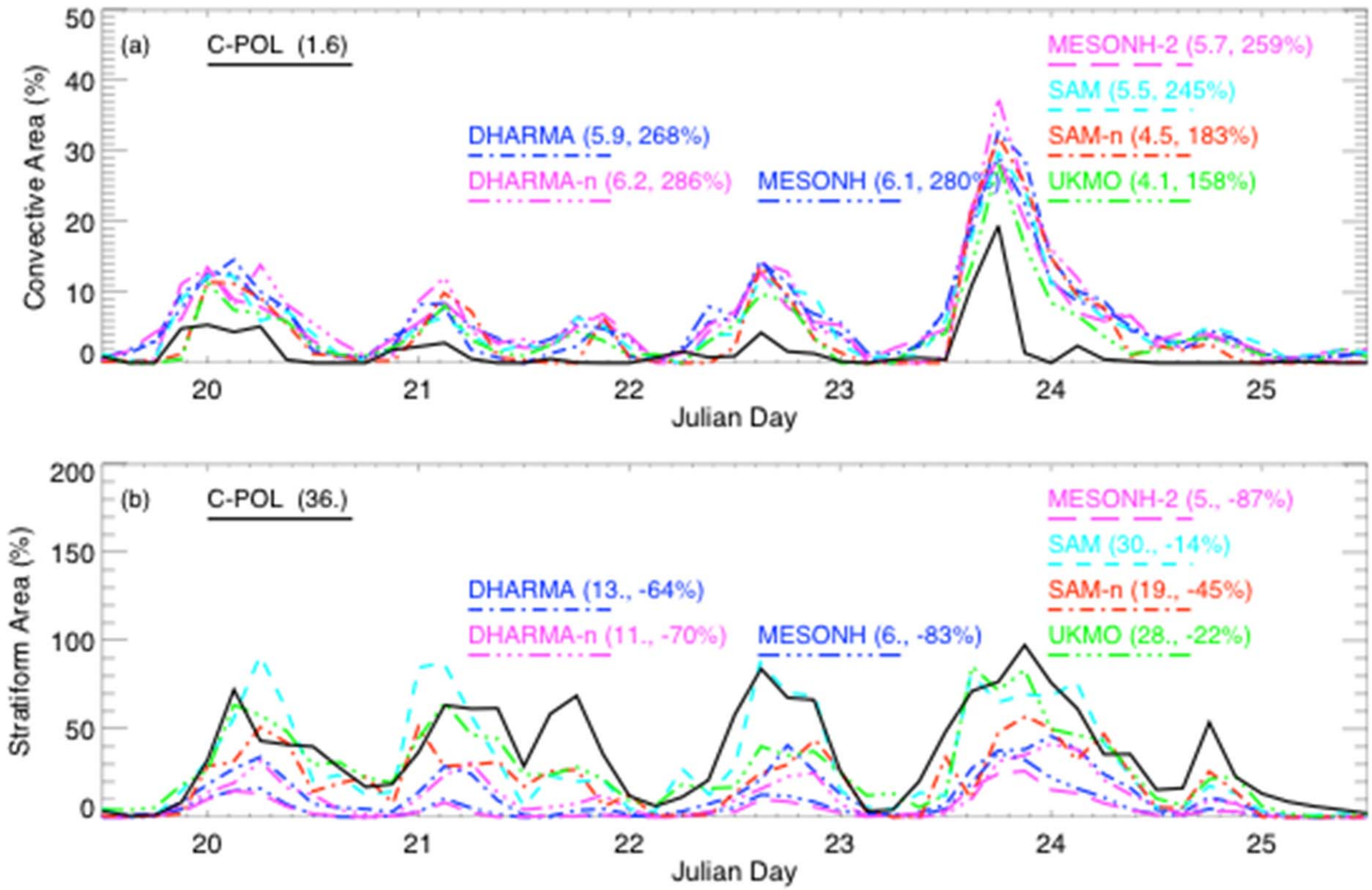
Cloud type partition is key to intermodel differences in both SCMs and CRMs



Precipitation rate vs. Time

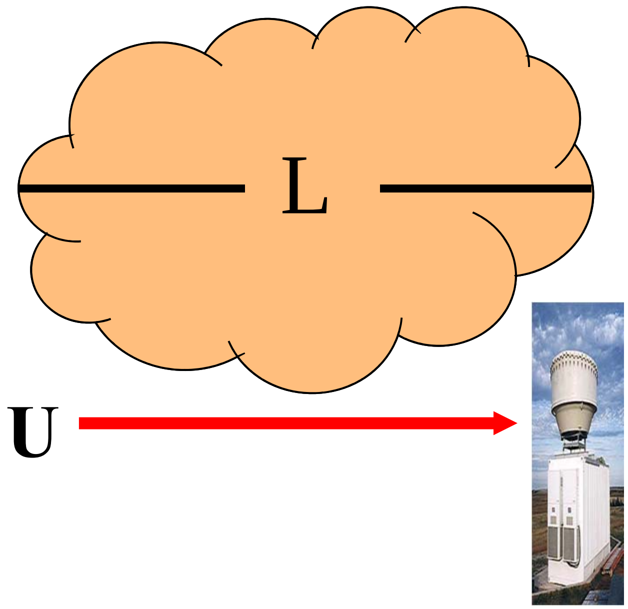
(Adapted from Xie et al., 2005, JGR, Special issue on March 2000 Cloud IOP)

Convective and stratiform areas



(from Fridland)

Comparison of Data at Different Scales



1. Taylor Hypothesis

$$T \sim \frac{L}{U}$$

Small Variation $\sigma < 0.5$ Mean

Temporal average = Spatial average

2. Ergodic hypothesis → **T***

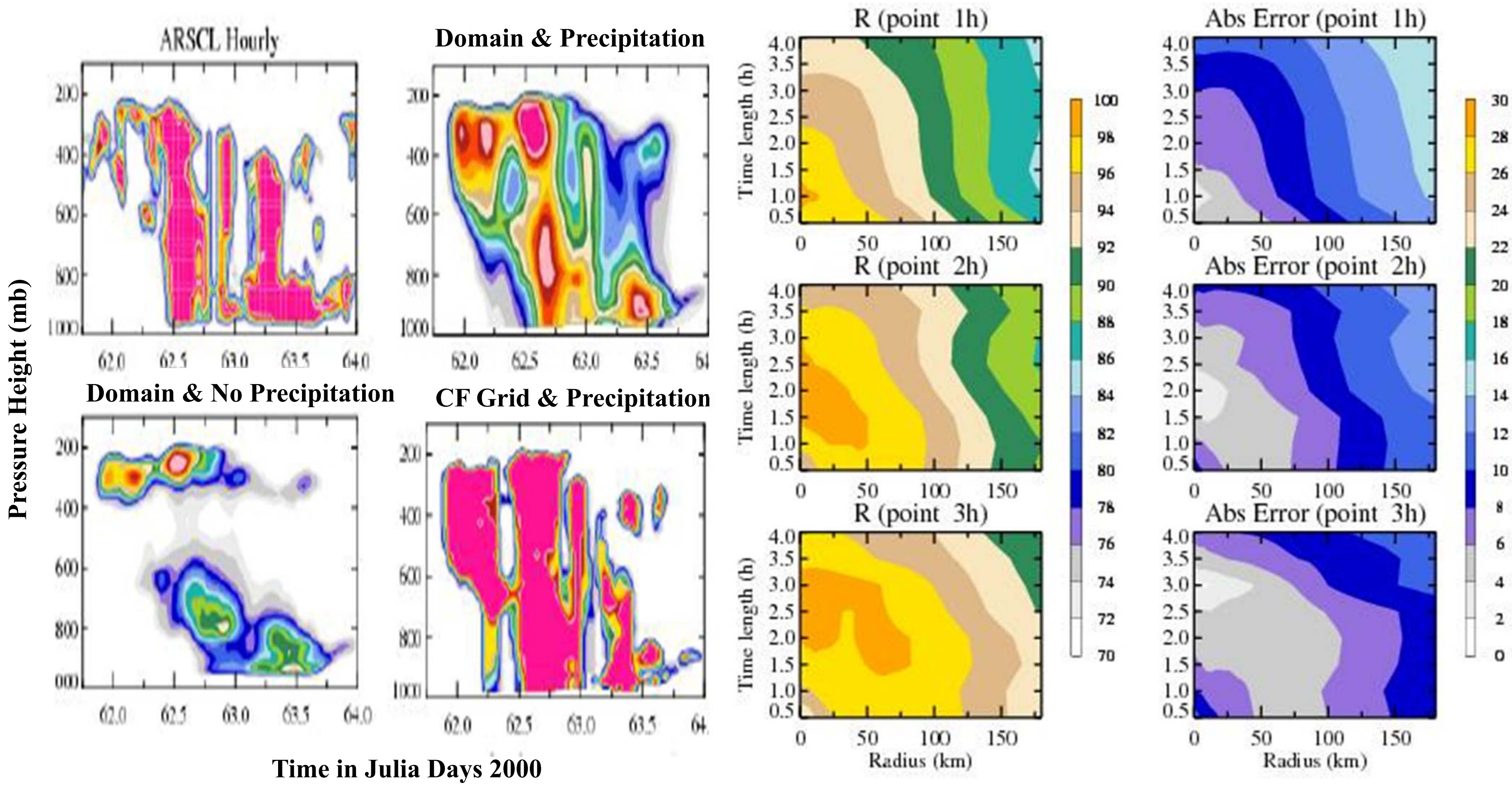
Explore detailed scale-dependence using CRMs:

Increasing averaging scale

CF grid, d = 0 **NWP grid** **GCM grid, d***

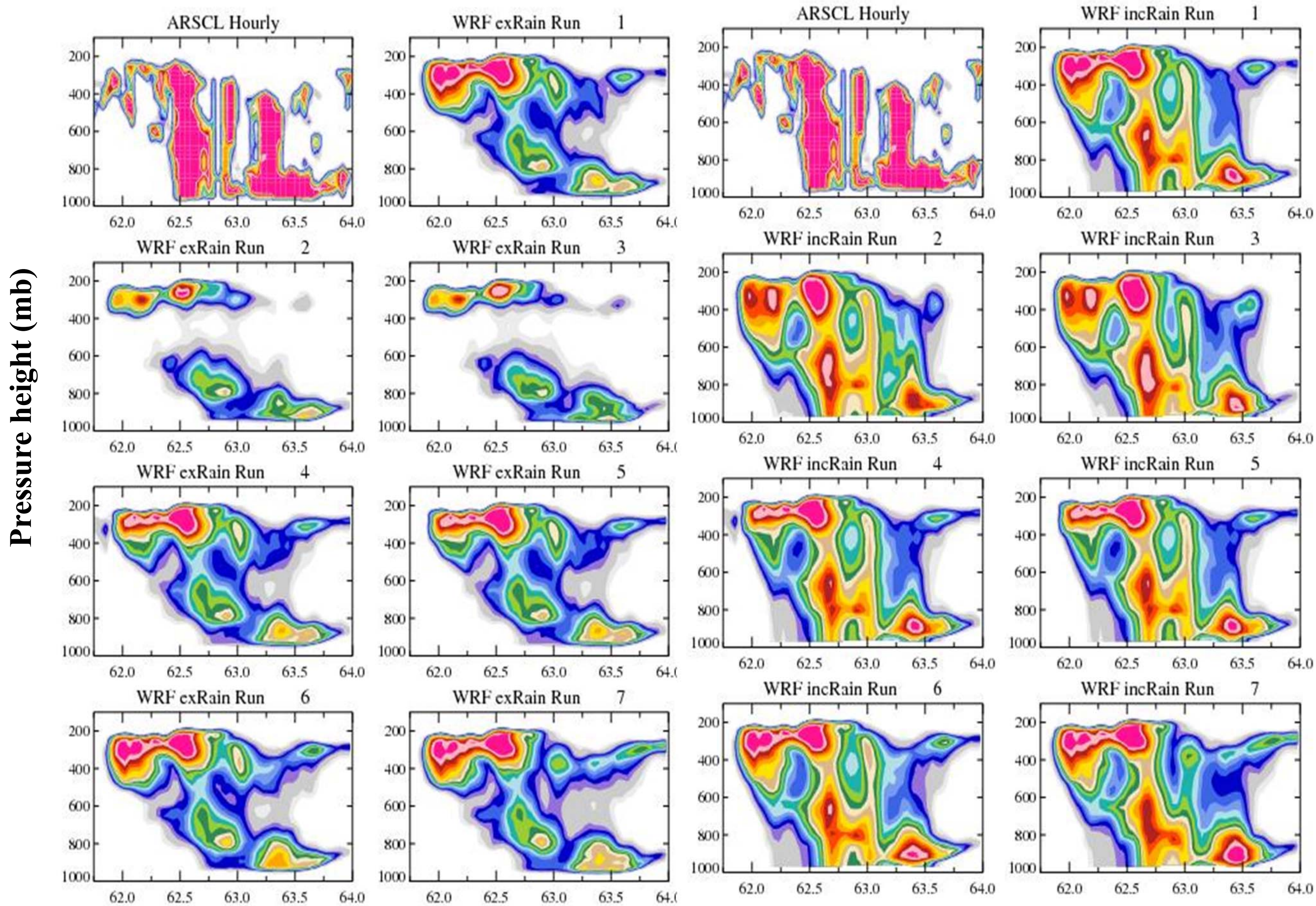
For a given averaging time

Observation-Model Comparison Issues



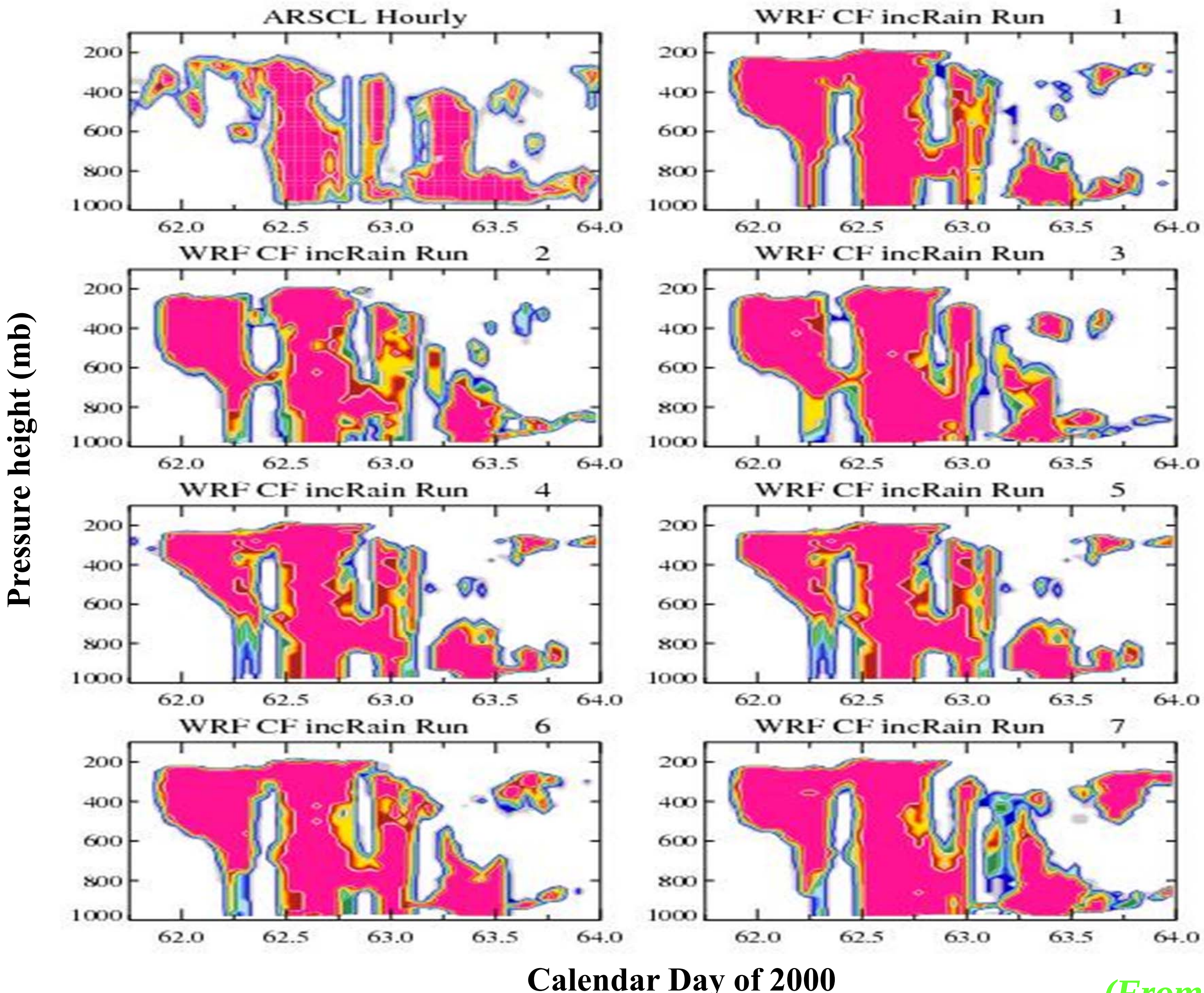
Two generic issues with evaluation of model results against ARM point-like measurements: Consistency of cloud definition in observation and models; scale-mismatch between point measurements and model domain >> a possible way to deal with these issues via CRMs.

Cloud Fraction: ARSCL vs WRF Domain



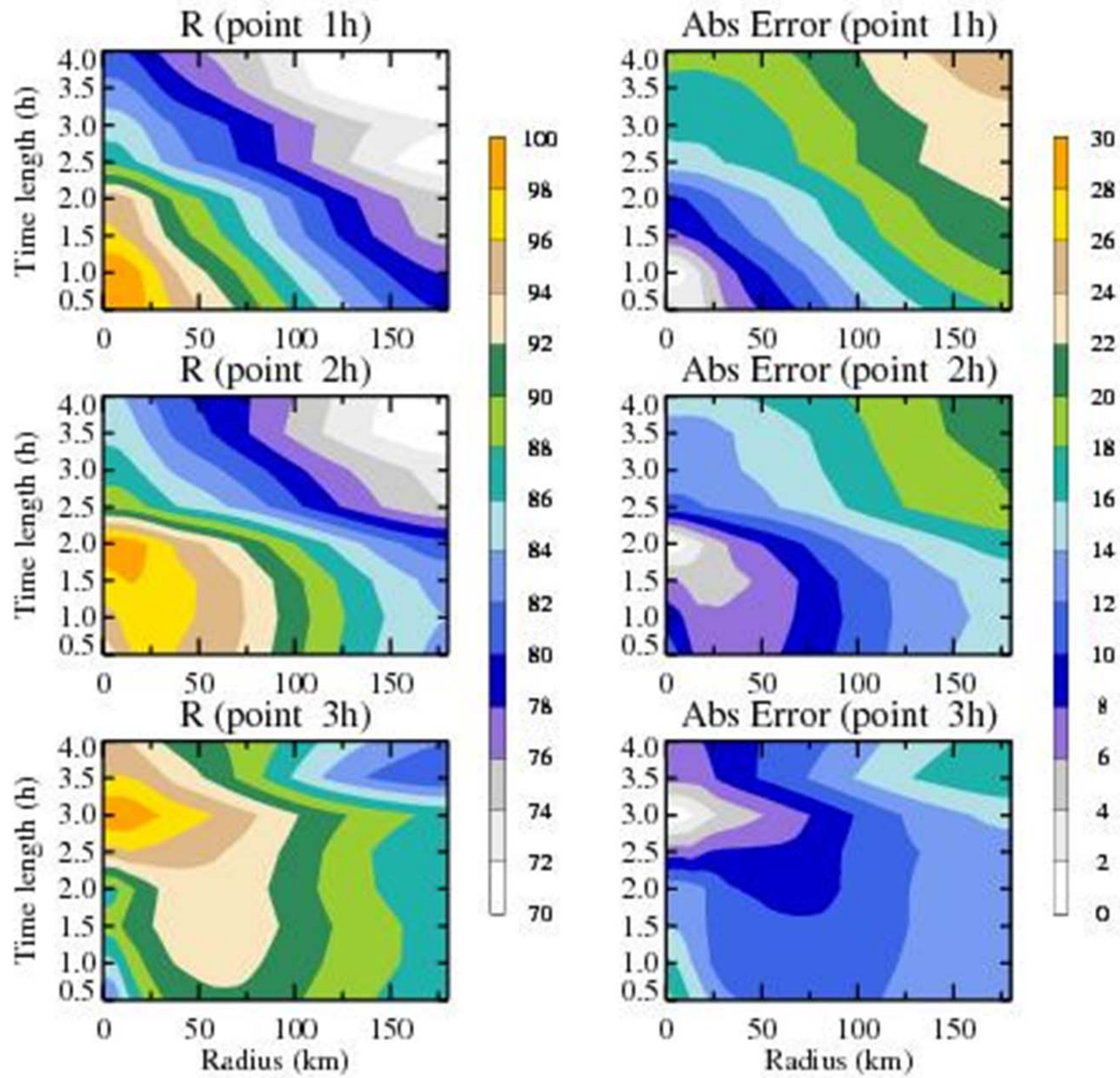
Precipitation particles excluded **Precipitation particles included**

ARSCL vs. CF Grid Cloud Fraction



(From W. Lin)

Example: WRF High Clouds



Increasing correlation with increasing averaging time

Decreasing error with increasing averaging time

Decreasing correlation with increasing R

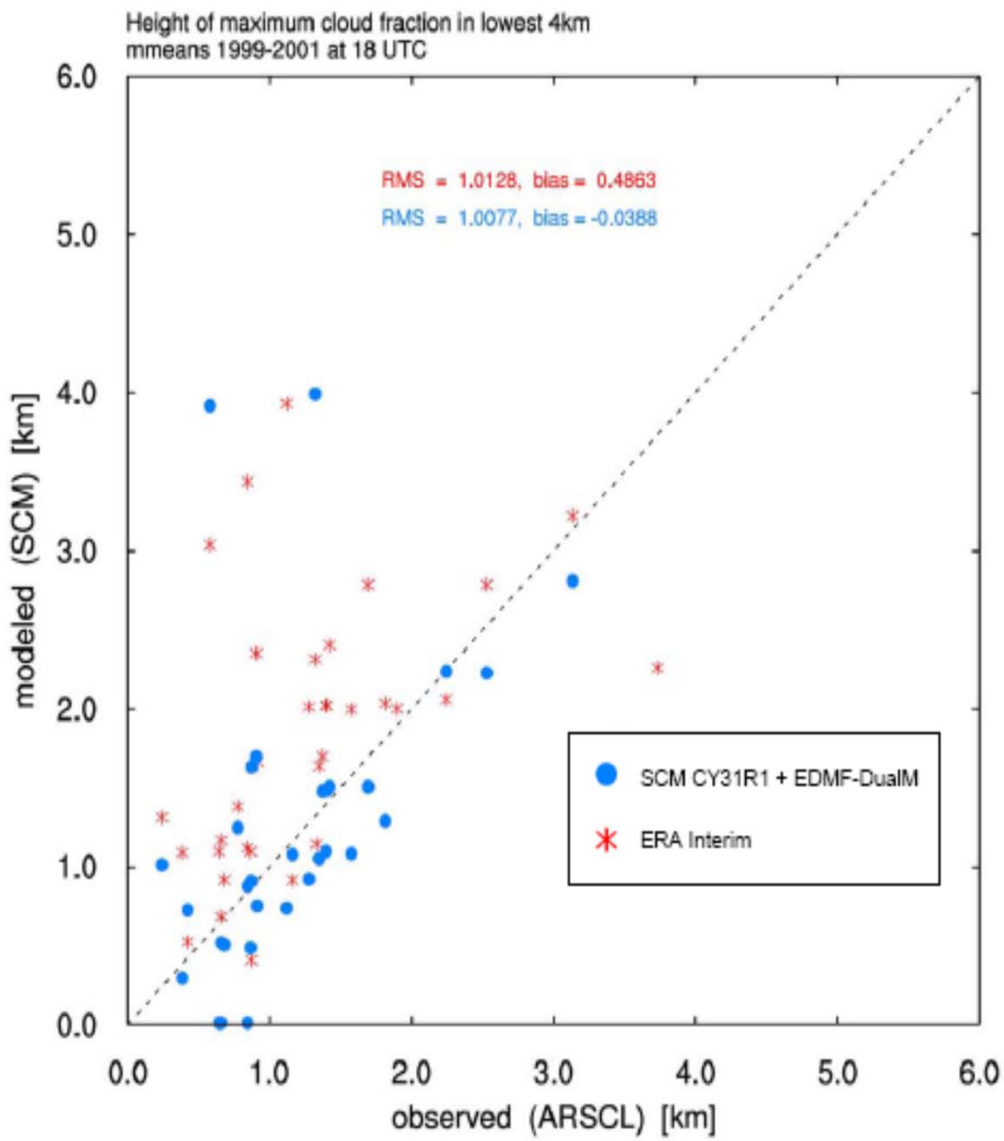
Increasing errors with increasing R

Better statistics:

Evaluation of the monthly mean height of the maximum cloud fraction in the lowest 4 km at 18 UTC against ARSCL for the period 1999-2001:

** CY31R1 overestimates this height, reflecting that it overestimates the occurrence of shallow cumulus outflow at the top of the PBL ("anvils")*

** EDMF-DualM agrees better with observations, reflecting that for fair-weather cumulus it typically puts the maximum cloud fraction at cloud base*



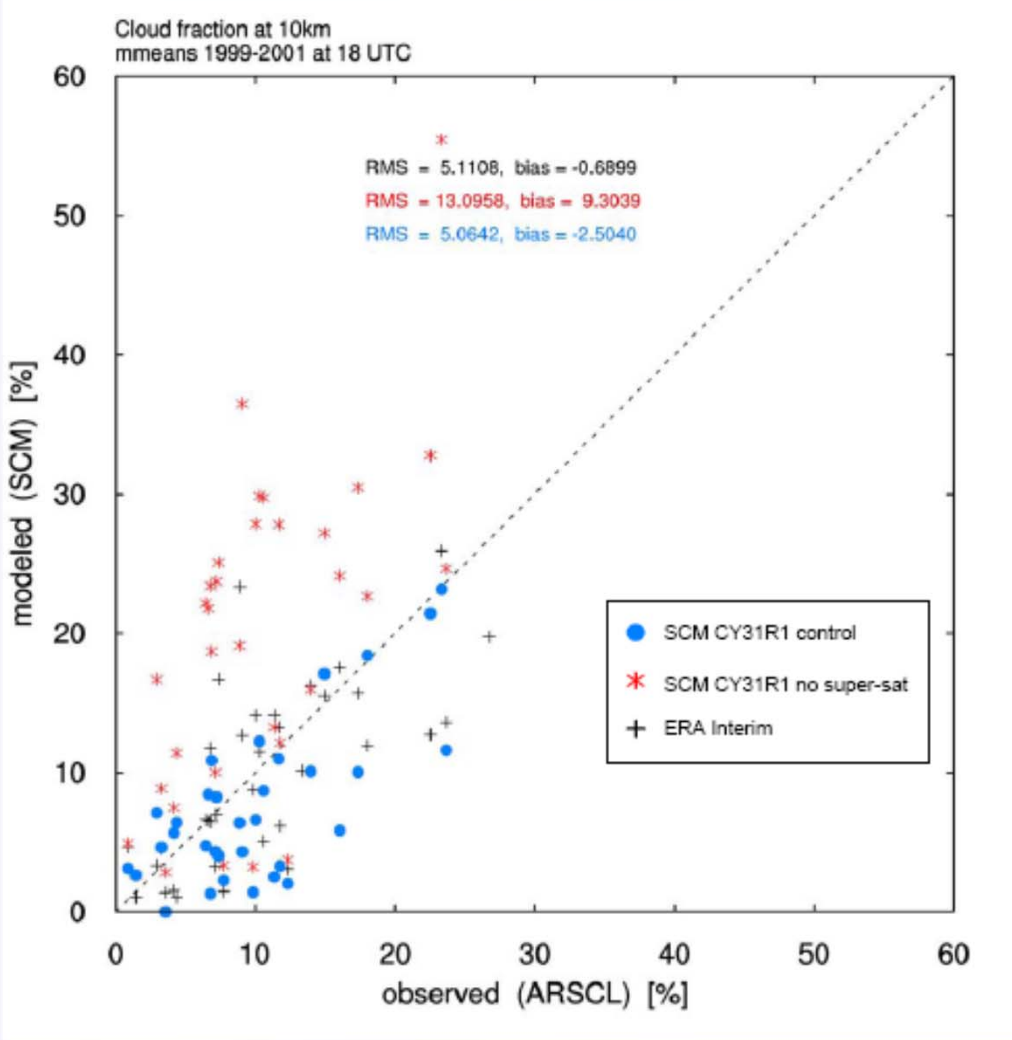
Better statistics:

Evaluation of the monthly mean cloud fraction at 10km height at 18 UTC against ARSCL for the period 1999-2001:

** The March 2000 result is representative of the longer-term*

** The supersaturation function brings a statistically significant improvement*

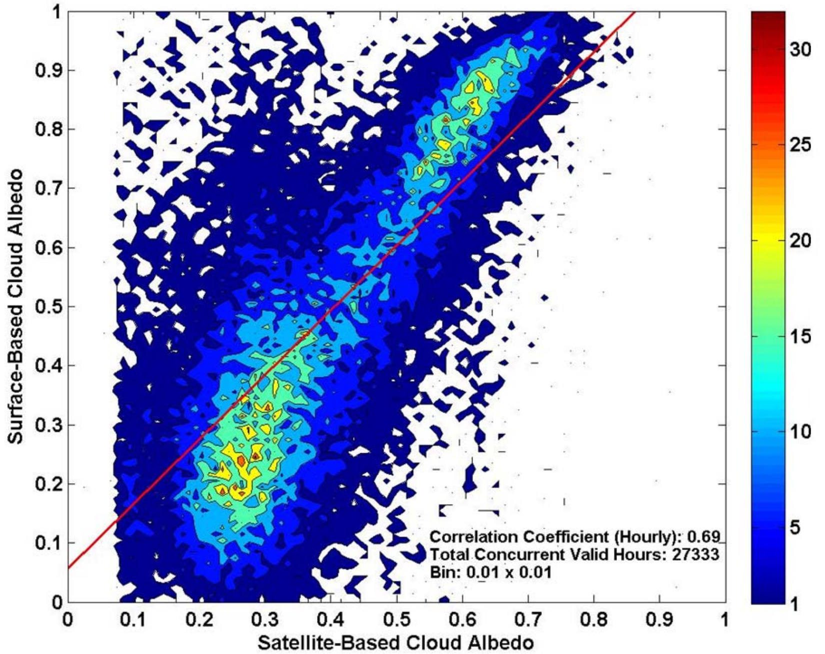
** Not accounting for super-saturation leads to too much high cloud occurrence*



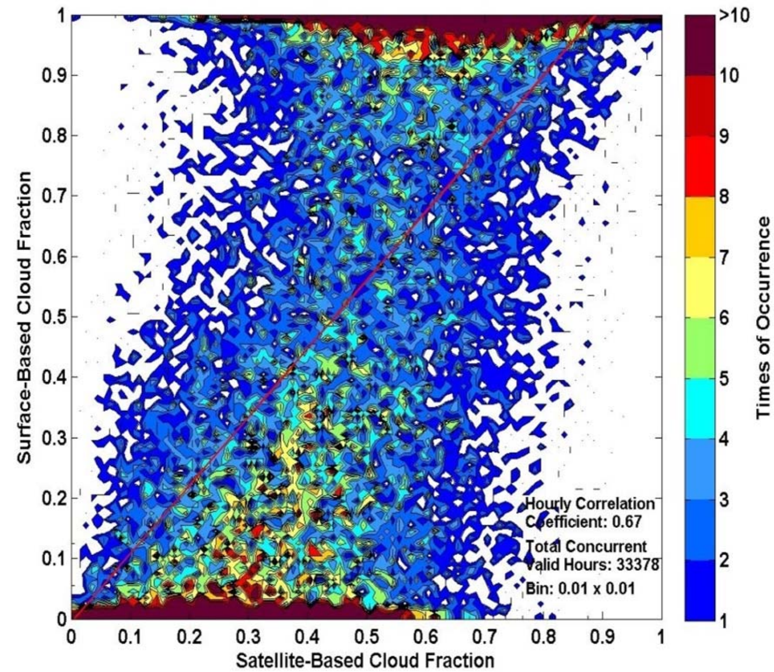
New Surface-Based Method for Measuring Cloud Albedo

Hourly data from 1997 to 2009 at SGP

Cloud Albedo



Cloud Fraction



The differences in cloud albedo and cloud fraction seem similar between GOES-based and surface-based Results, why?

Work Strategy and Plan

- Operation guided by ARM data quality/availability; research associated with operation

- Warm-up phase, streamlining coordination of different components and focusing on March 2000 Cloud IOP at SGP

- IOP phase, focusing on IOPs with high quality ARM data

- Continuous phase at SGP

- Continuous phase at the other ARM sites

• Research is organized around, and progress with operational phases. Better results or new findings are expected as project progresses and accumulates more cases, more cloud types, weather regimes, ever better statistics …. Exceptions?
• New strategy in the future: Science-drives operation and research or hybrid?

NWP-Testbed Results from Hogan/O'Conner

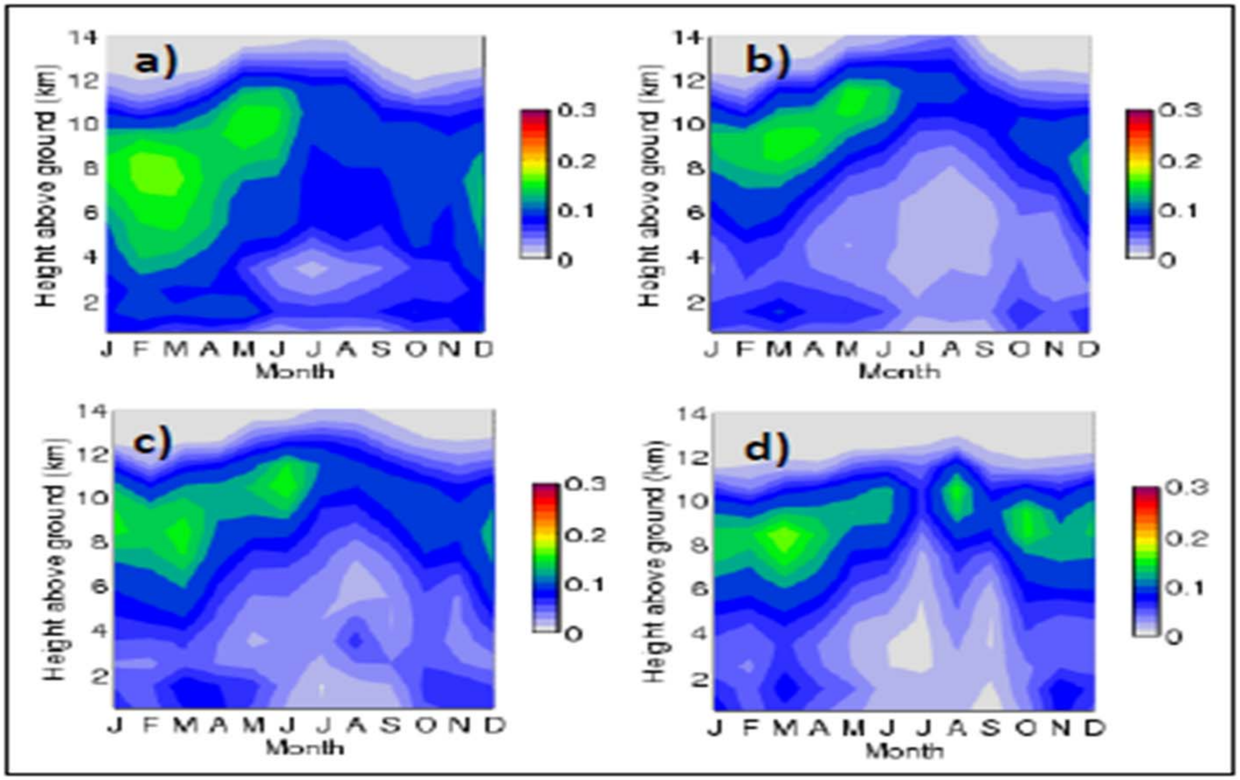
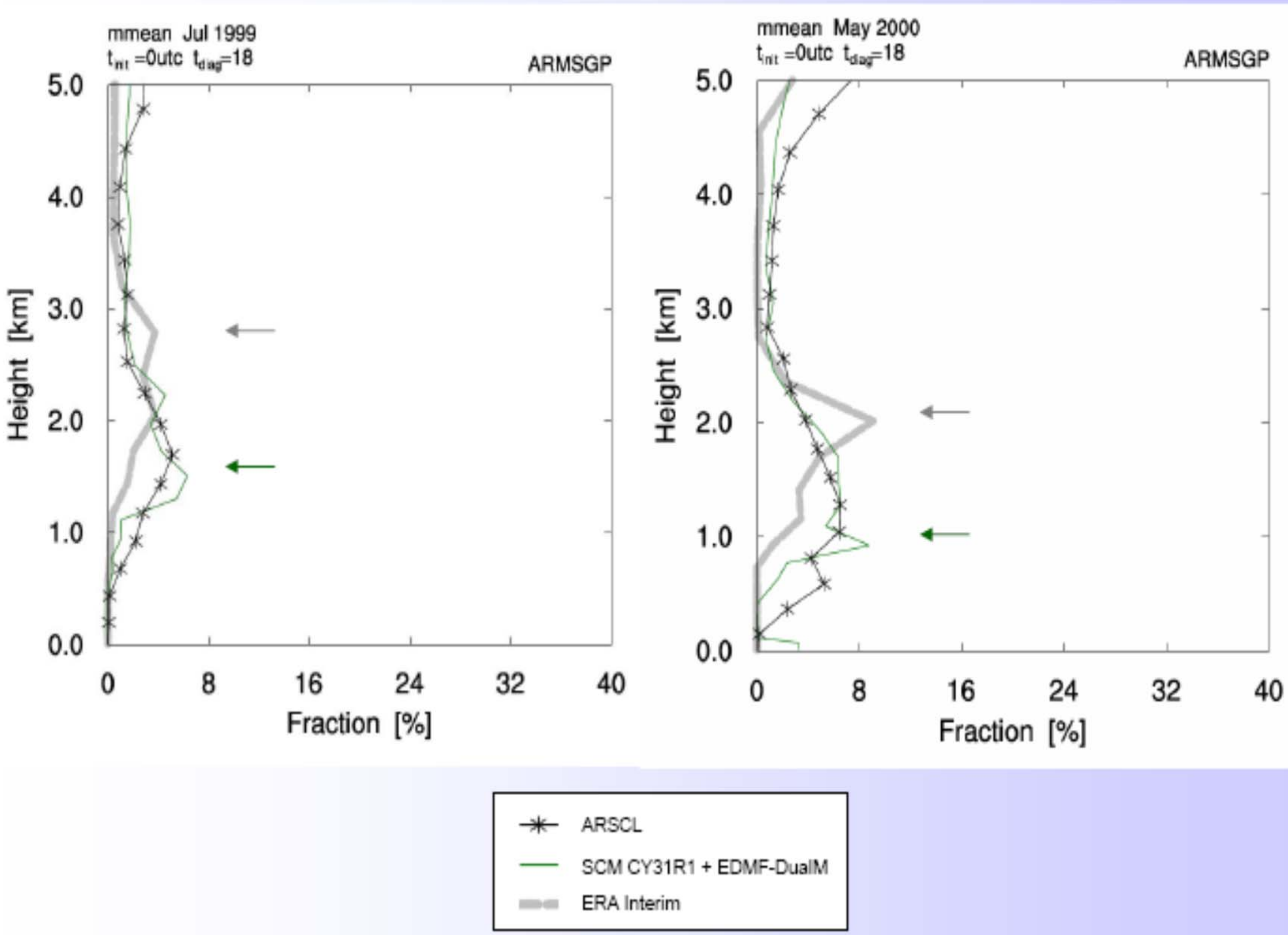


Figure 3. Comparison of the seasonal composites of cloud fraction (a) derived from observations at the ARM SGP site for the years 2004 to 2009 with the values held in (b) the ECMWF model, (c) the NCEP model and (d) the global version of the Met Office model.

Spring/summer cloud fraction at SGP:

EDMF-DualM has its low-level maximum at a lower height compared to ERA Interim (CY31R1)



March 2000

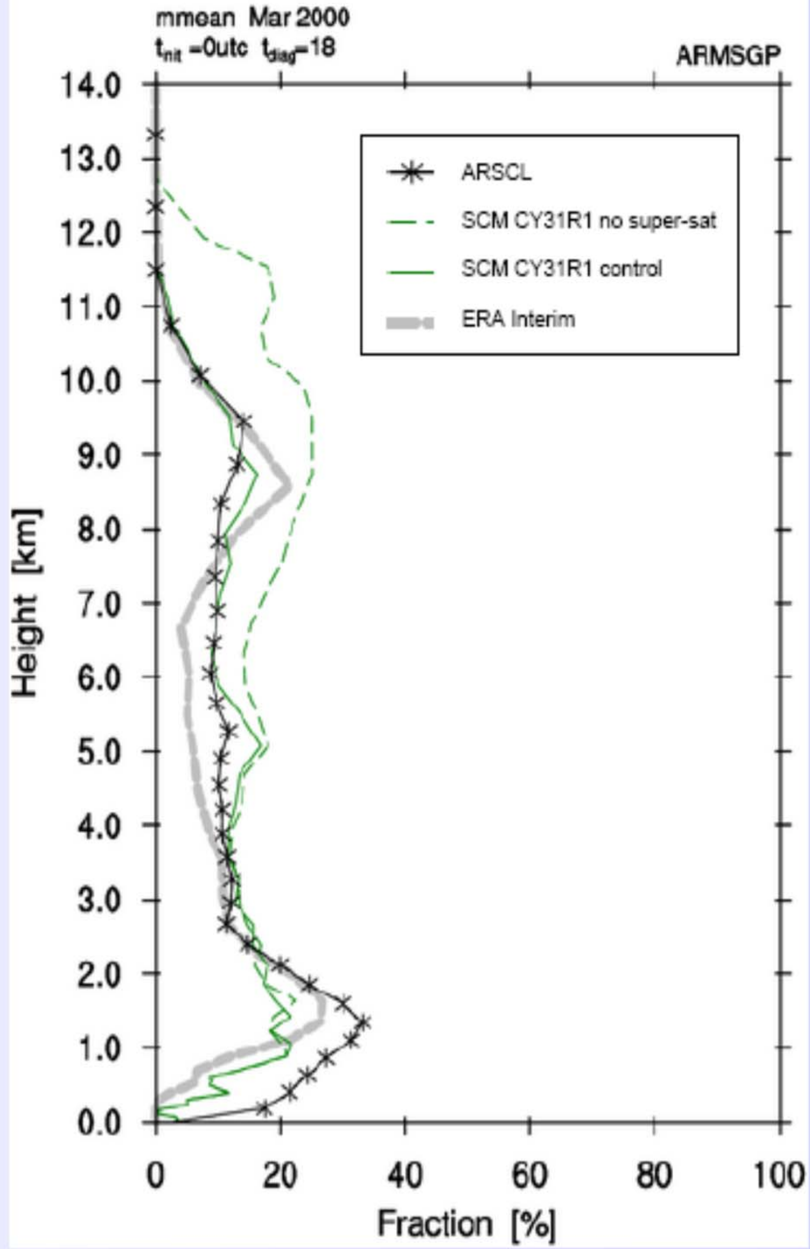
monthly mean at 18 UTC

Sensitivity test on ice super-saturation: it reduces the cloud fraction by about 10% at 10km height

This is in agreement with the GCM results

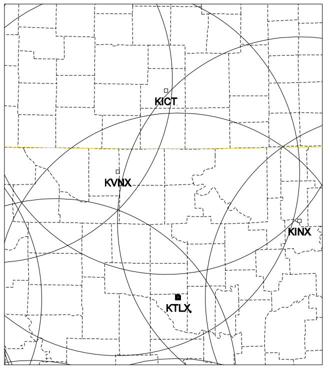
According to ARSCL this is an improvement (at least for this month)

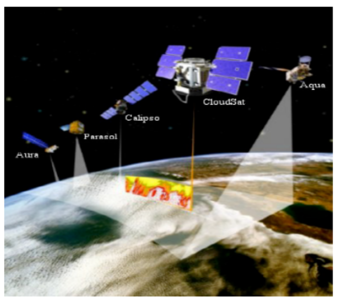
Also note: the CY31R1 SCM reproduces the cloud structure of ERA Interim (CY31R1 physics) reasonably well, even when driven by an independent forcings dataset

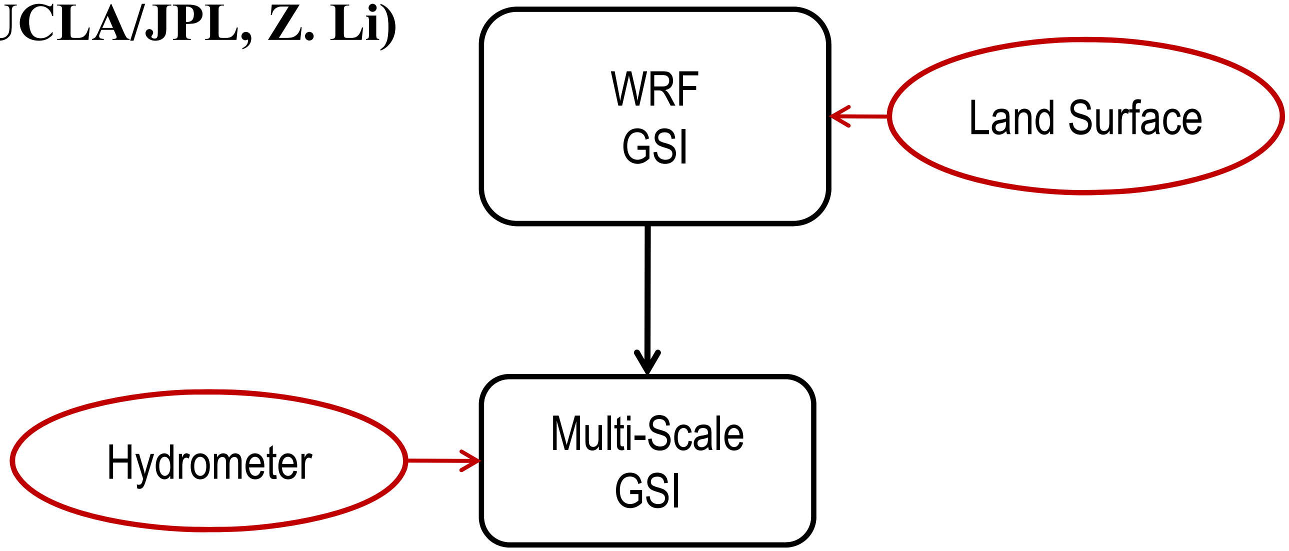


Multiscale Data Assimilation System

(Lead by UCLA/JPL, Z. Li)





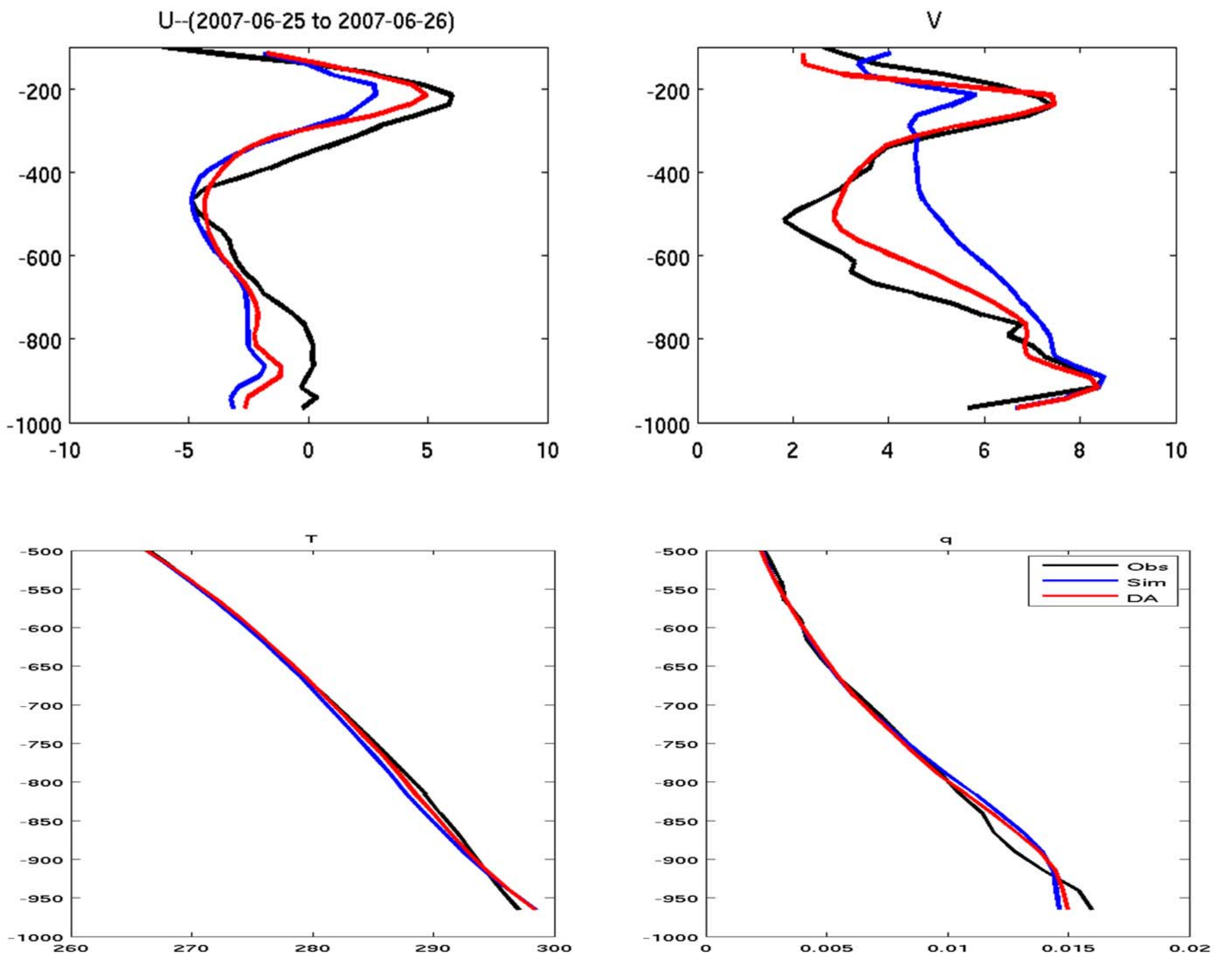


GSI = Grid Space Interpolation, NCEP-3DVAR scheme

Multi-Scale GSI = GSI + JPL Multiscale DA System

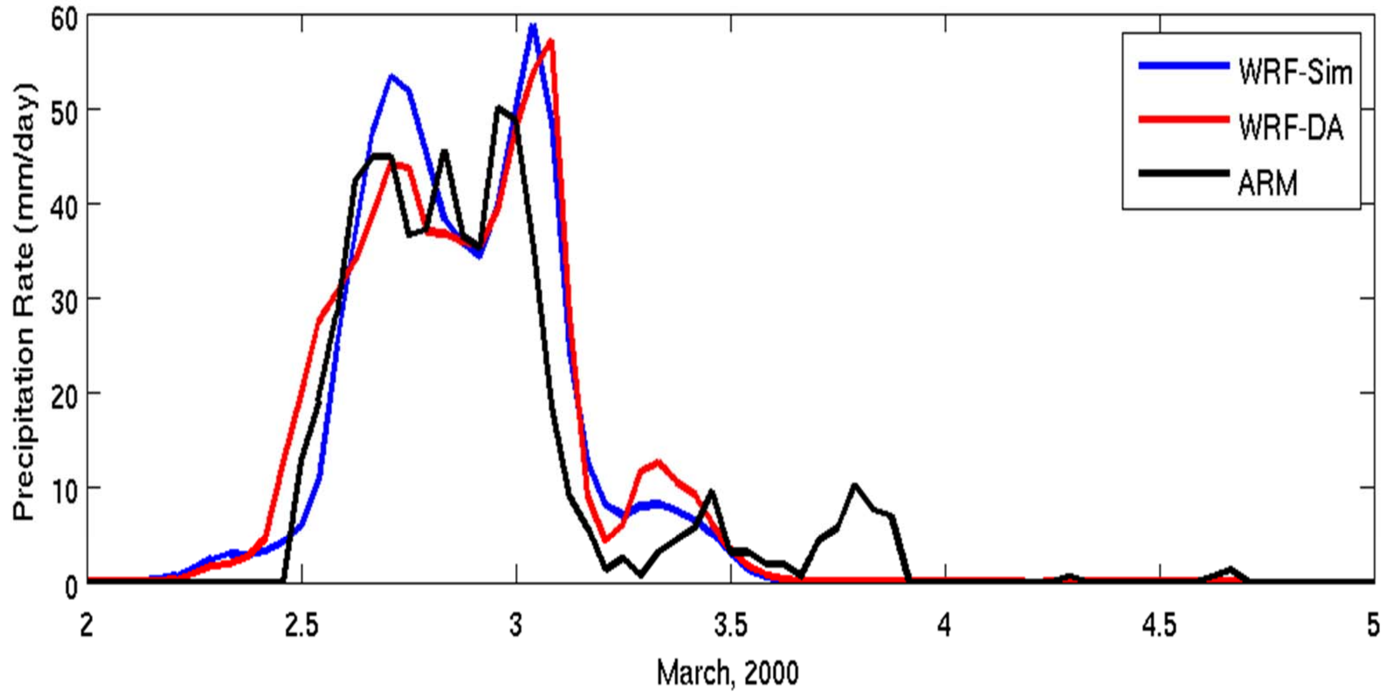
- WRF GSI has been implemented for a three-domain nesting configuration
- ARM Balloon-Borne Sounding (SONDE) profiles have been assimilated
- Conventional and satellite radiance data processed by NCEP have been assimilated
- Three cases investigated(2-5 March; 15-17 March 2000; 25-28 July2007)
- Temperature/moisture/wind profiles improved significantly;
- Cloud profiles and precipitation improved somewhat

Impacts of Data Assimilation on Meteorological Profiles



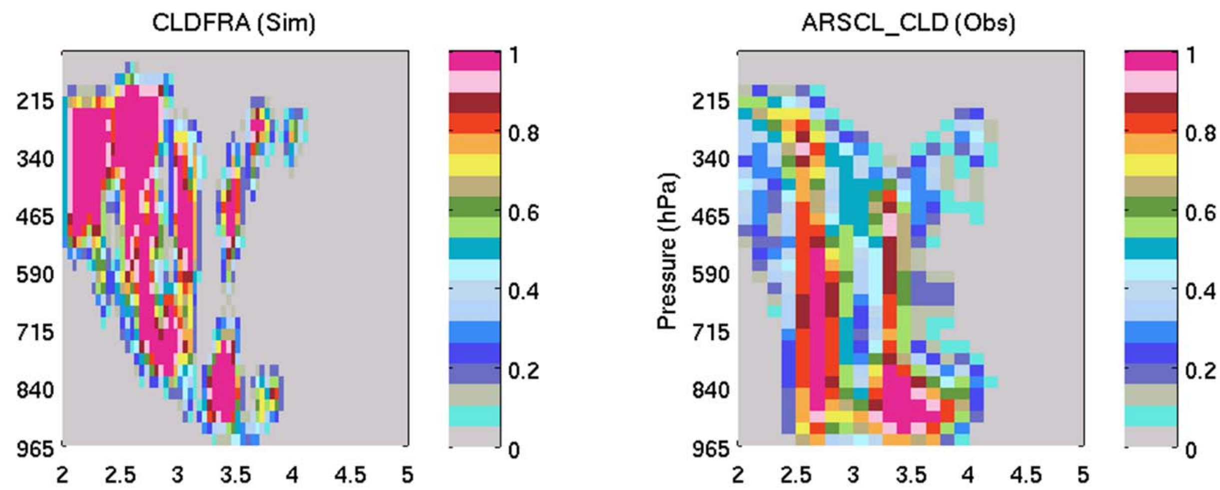
Data assimilation leads to significant improvement in profiles of the common meteorological variables at the SGP CF.

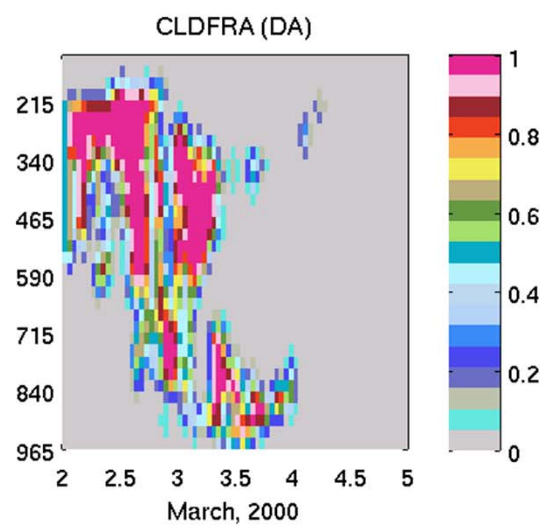
Impact of Data Assimilation on Domain-Precipitation



Data assimilation leads to significant improvement in domain-averaged precipitation. But, not in clouds (next)

Impact of Data Assimilation on Cloud Fraction





Under-simulated middle and low clouds but over-simulated upper clouds in both traditional WRF and DA-WRF? Why not much improvement in WRF simulated cloud fraction?

Emerging Patterns from SCMs and NWPs?

- Under-simulated middle and low clouds & over-simulated upper clouds?
  — Can we reduce this bias with improved fine scale vertical velocities?
  — Can we fix high-cloud issues by considering/improving ice supersaturation?

- The problems of sensible and latent heat fluxes
  — What causes the problem, temperature and water vapor mixing ratio?
  — What's the impact on model results?

More Discussions

-- Data integration
   * Aerosol data
   * Nexrad data

-- Ensemble of large scale forcing data from, e.g., reanalysis

-- Test development
   * SCM-and NWP-testbed integration
   * Web-based GDFL, GISS, ECMWF SCMs

-- Coordination and team-work !

ESM FASTER:
Improving the representation of cloud macrophysics in the RACMO and the IFS

A short description of the models

Preliminary SCM results for 1999-2001 at ARM SGP. Two research topics:

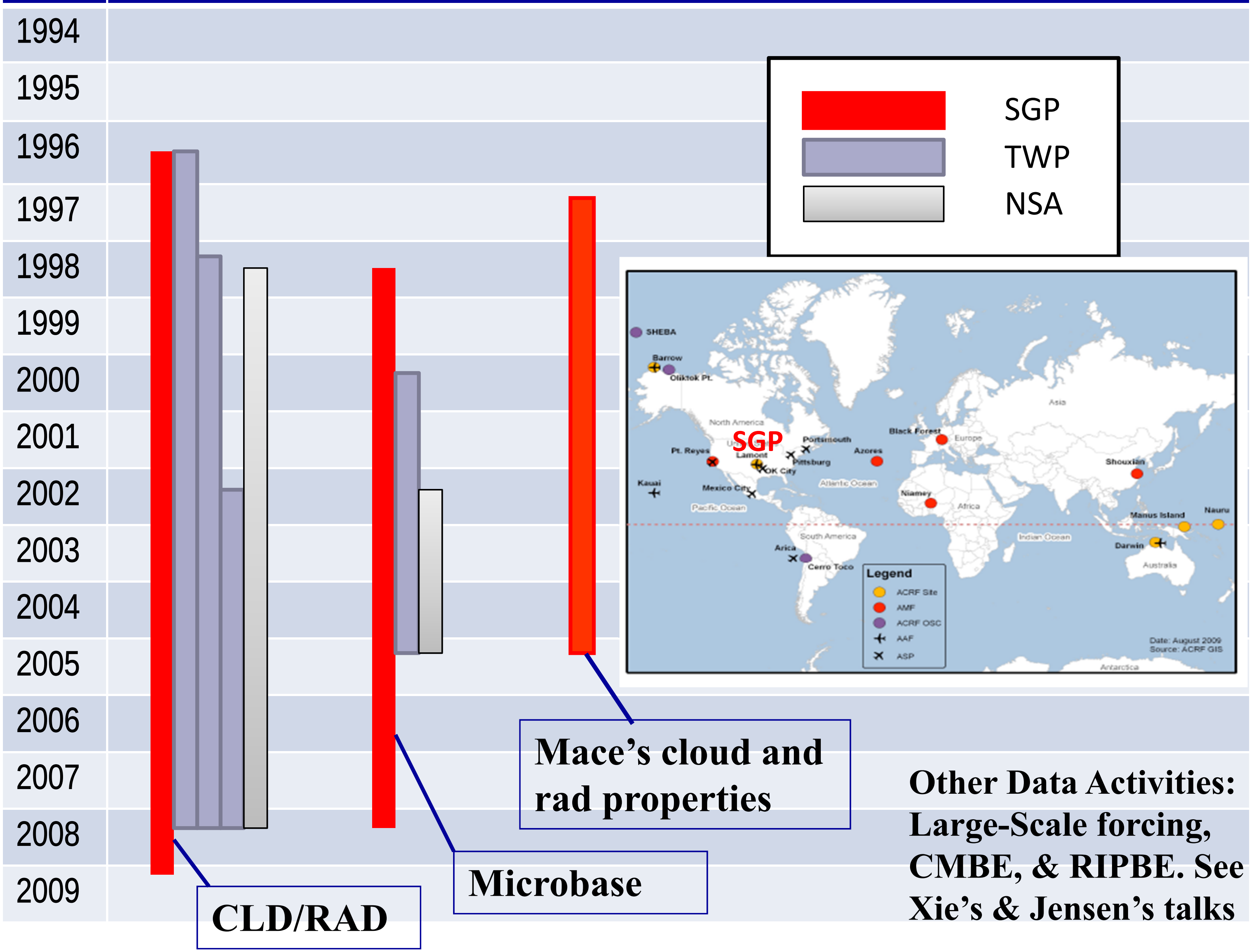
** Evaluation of the impacts of the ice super-saturation function on high cloud occurrence*

** Evaluation of the impact of the new EDMF-DualM boundary layer scheme on the vertical structure of low-level clouds*

Roel Neggers   Peter Baas

KNMI

Quick Summary of ACRF Data



Near-Future Work

- Continue examination and preparation of various measurements of cloud macrophysical properties and radiation at SGP site.

- Continue examination and comparison of various measurements of cloud microphysical properties at SGP site.

- Refine fast-physics testbed, website, and model issues

- Summarize “warmup” results and submit papers (~ 6 from BNL, other group? BAMS paper?)

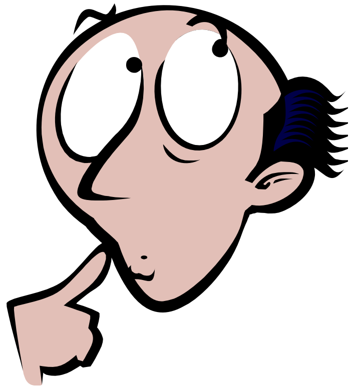
- Extend warmup to next IOPs (RACORO?) at SGP

- Extend SCM/NWP activities from 1999-2001 to 2009

Eight Tasks and Major Fast Processes

Eight Tasks

- Fast-physics testbed (NWP-testbed & SCM-testbed)
- A suite of high-resolution model simulations
- Model evaluation against measurements
  -- Model errors
  -- Error sources
- Evaluation metrics
  -- Statistical measures
  -- Forecast skill
- Theory and parameterization
- Data assimilation
- Full GCM assessment
- Data integration



Evaluation approach

Evaluation variables

Major Fast Processes

- Microphysics
  -- Warm clouds
  -- Ice clouds
  -- Mixed phase clouds
  -- Mono vs. multi-moment schemes
- Aerosol-cloud interactions
- Radiation
- Shallow convection
- Deep convection
- Entrainment/Detrainment
- Boundary processes
- Subgrid turbulence
- Cloud fraction
- Land-surface-atmosphere interaction

"ARM-Like Innovation" in Model Evaluation

Now is the time

- **ARM has made continuous, comprehensive, decade-long measurements, permitting better statistics, more cloud types, weather regimes ….**
- **SCM/CRM/LES approaches have been well developed and tested by ARM scientists and others.**
- **A smaller scale-SCM-testbed has been recently established by Dr. Neggers et al. at Netherlands**
- **Usefulness of NWP-testbed has been demonstrated by Cloudnet project.**

ARM-Like Innovation

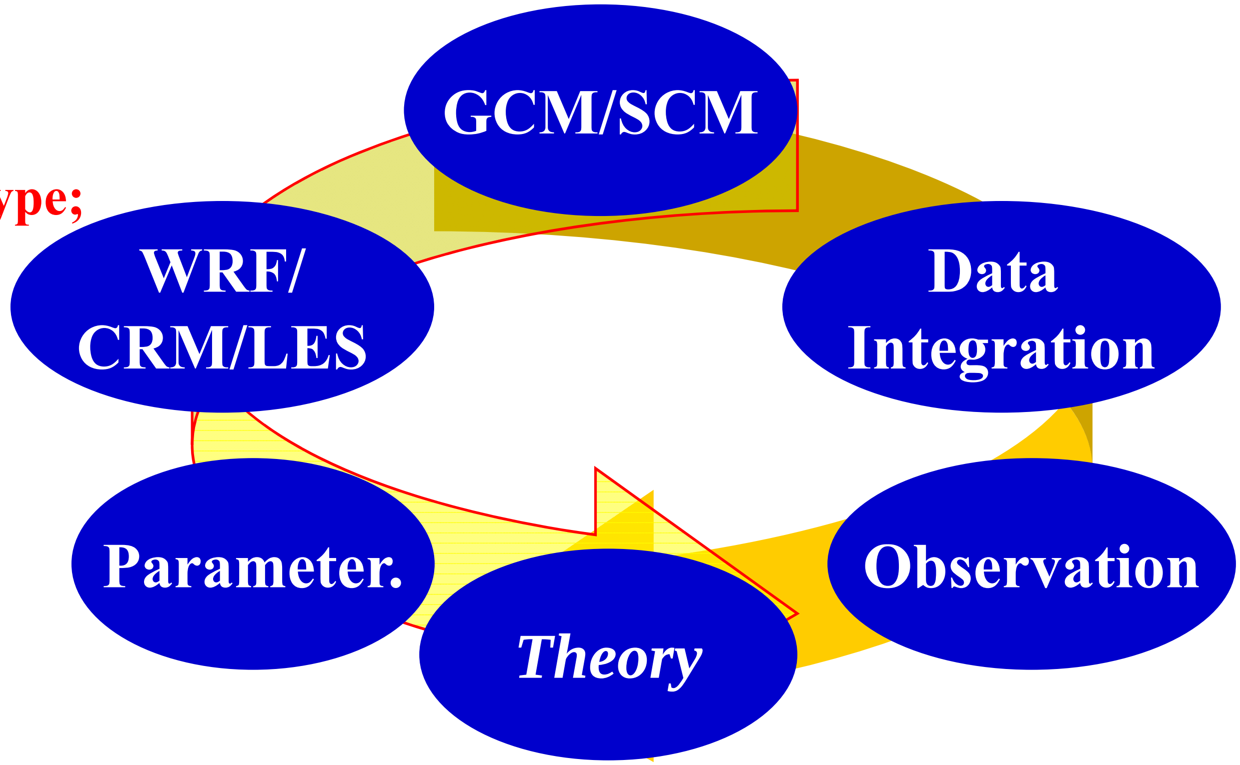
Ackerman and Stokes on ARM's Innovation (Physics Today, 2003): " …. Even before ARM, scientists had already made such efforts in field campaigns that lasted for a month or two. ARM's unique innovation was to perform the measurements continuously for a decade or more …."

To paraphrase: …. This project's unique innovation is to perform the evaluation continuously for a decade or more and in a more focused way …. better statistics, regime-based evaluation, system-based evaluation ….

The sheer complexity of the problem are certainly a reason for the slow progress.

Complexity:

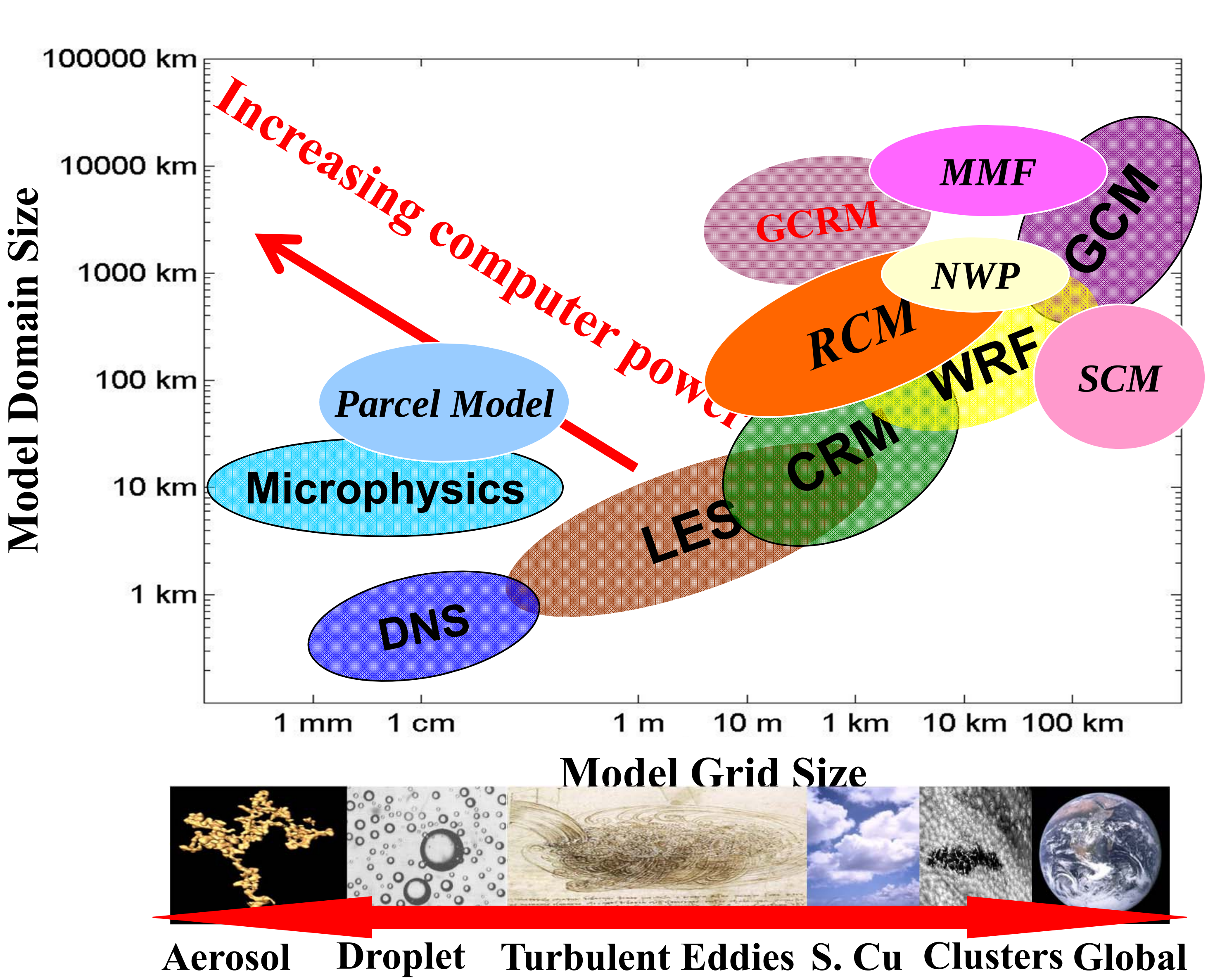
- **Scientific**
  - -- **4M (multibody; multitype; multiscale; multiD)**
  - -- **Conceptual**
  - -- **Numerical**
  - -- **Coupling**
- **Engineering**
  - -- **Inter-field interactions**
  - -- **Para. imple. in GCMs**
  - -- **…**



Randall et al. (BAMS, 2003): "A model-evaluation project is complicated in at least two distinctive ways. The technical complexities are obvious and daunting: Data must collected and analyzed, …. An additional and equally complex task is to foster communication and fruit interactions ….".

Some even considers the complexity as a *valley of death* for GCMs.

Complexity Seen in Model Hierarchy



Poorly understood 4M interactions/feedbacks

DNS = Direct Numerical Simulation

LES = Large Eddy Simulation

CRM = Cloud-Resolving Model

WRF = Weather Research and Forecast Model

GCM = Global Climate Model

RCM = Regional Climate Model

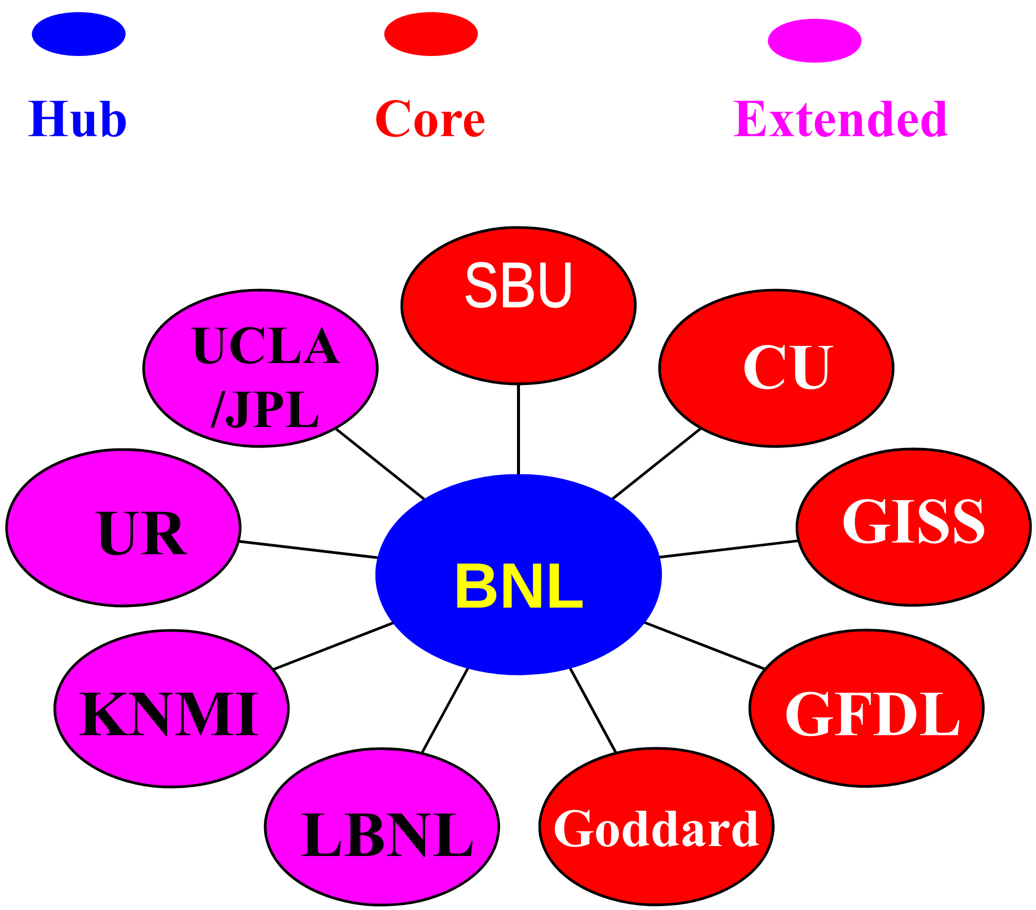
GCRM = Global CRM

NWP = Numerical Weather Forecasting

SCM = Single Column Model

FASTER Team

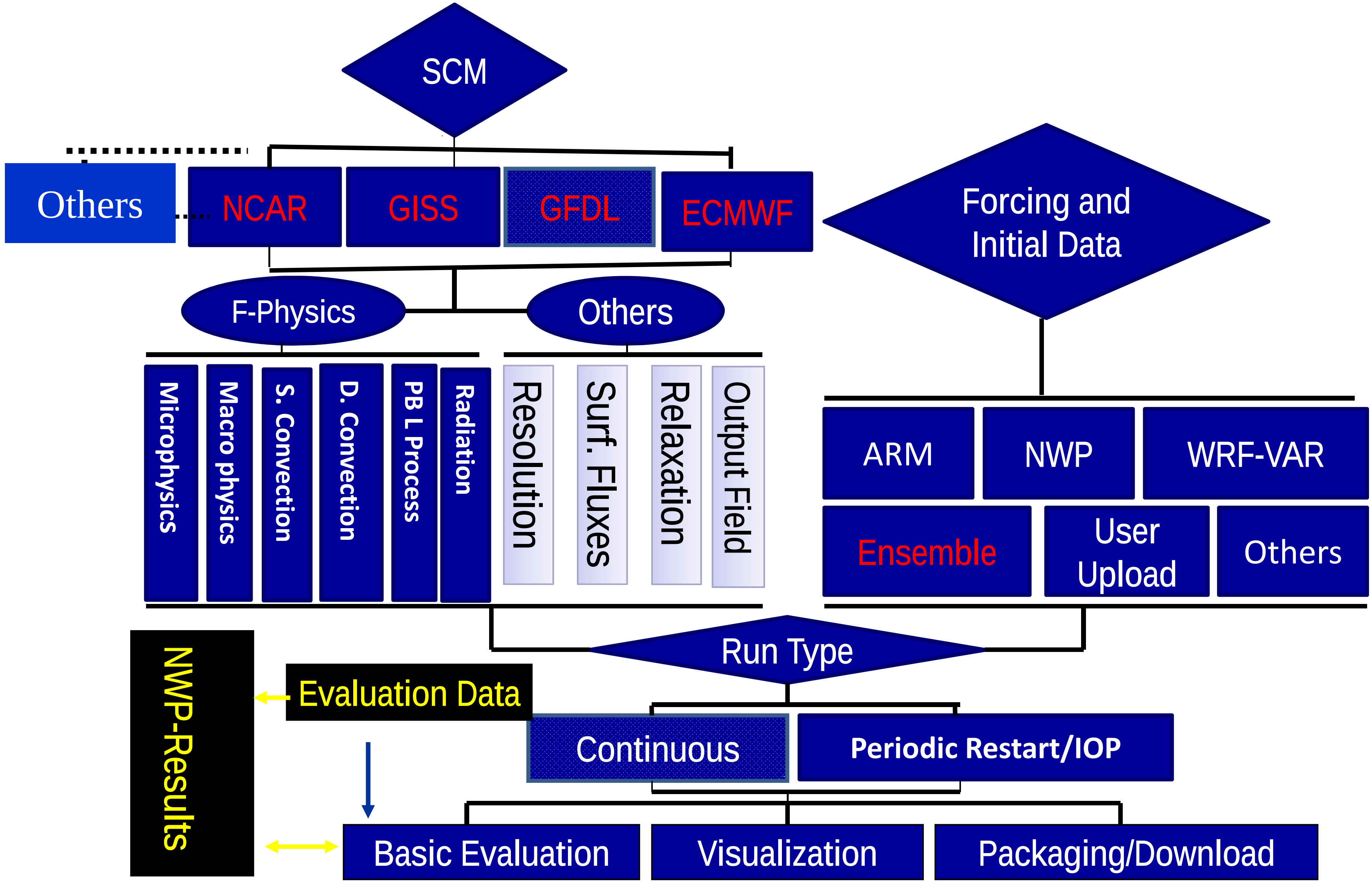
BCC (10 institutions and 21 scientists)



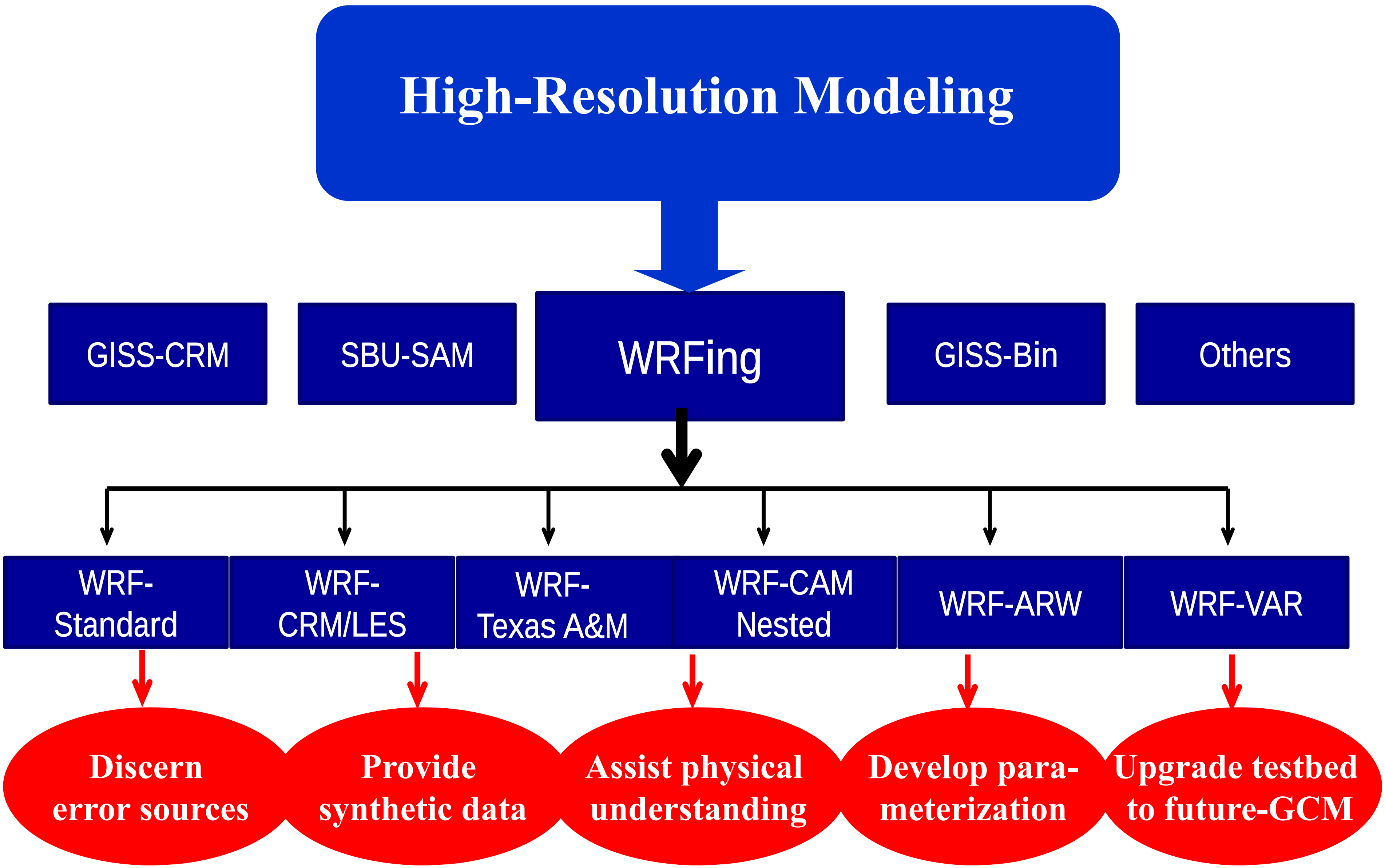
Investigator	Institution
Yangang Liu	BNL
Stephen Schwartz	BNL
Warren Wiscombe	BNL/Goddard
Robert McGraw	BNL
Wuyin Lin	BNL
Andrew Vogelmann	BNL
Michael Jensen	BNL
Richard Wagener	BNL
Dong Huang	BNL
Wei Wu	BNL
Surabi Menon	LBNL
Susanna Bauer	CU
Minghua Zhang	SBU
Marat Khairoutdinov	SBU
Anthony Del Genio	GISS
Ann Fridlind	GISS
Yonghua Chen	CU
Leo Donner	GFDL
Zhijin Li	UCLA/JPL
Robin Hogan	UR
Roel Neggers	KNMI

Core institutions are adjacent to BNL and operate three major US GCMs; many team members participate in ASR or related research, and has strong theoretical background on top of other areas of expertise essential for success

Concept of Fast-Physics Testbed



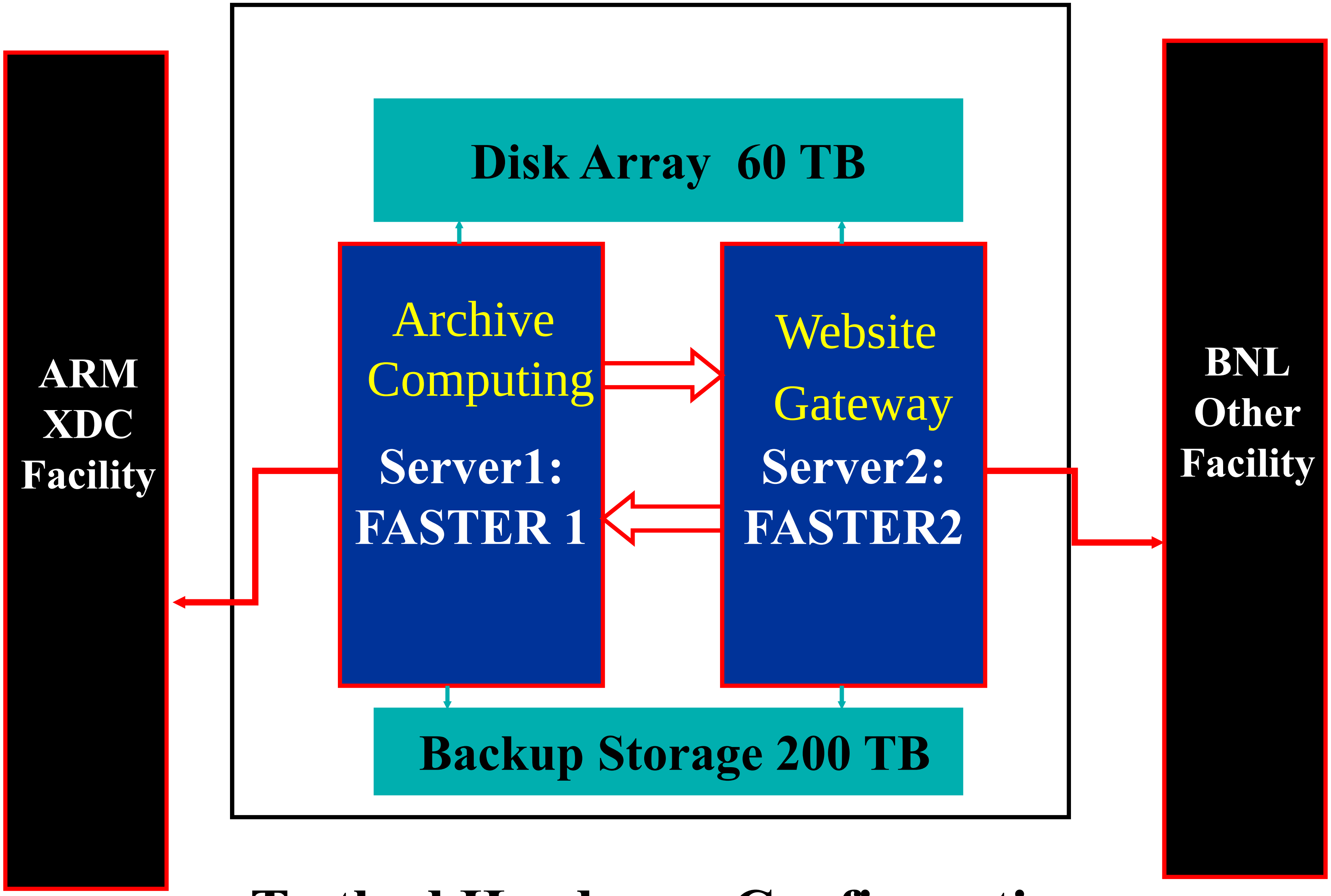
High-Resolution Modeling Activities



Near-Term Plan

- Digesting the results and writing papers
- Continue current activities
- Summarize warm-up and decide next focused SGP IOP (ROCORO)
- Integrate SCM-testbed and NWP-testbed
- Meeting at GISS next Wed, 10 Nov 2010.
- Fast-physics section at AGU (over 50 abstracts, growing and exciting)

Project Hardware



Testbed Hardware Configuration

Relationship between Cloud Albedo and Cloud Fraction in Observations and GCMs

• Three year (1999-2001) hourly data

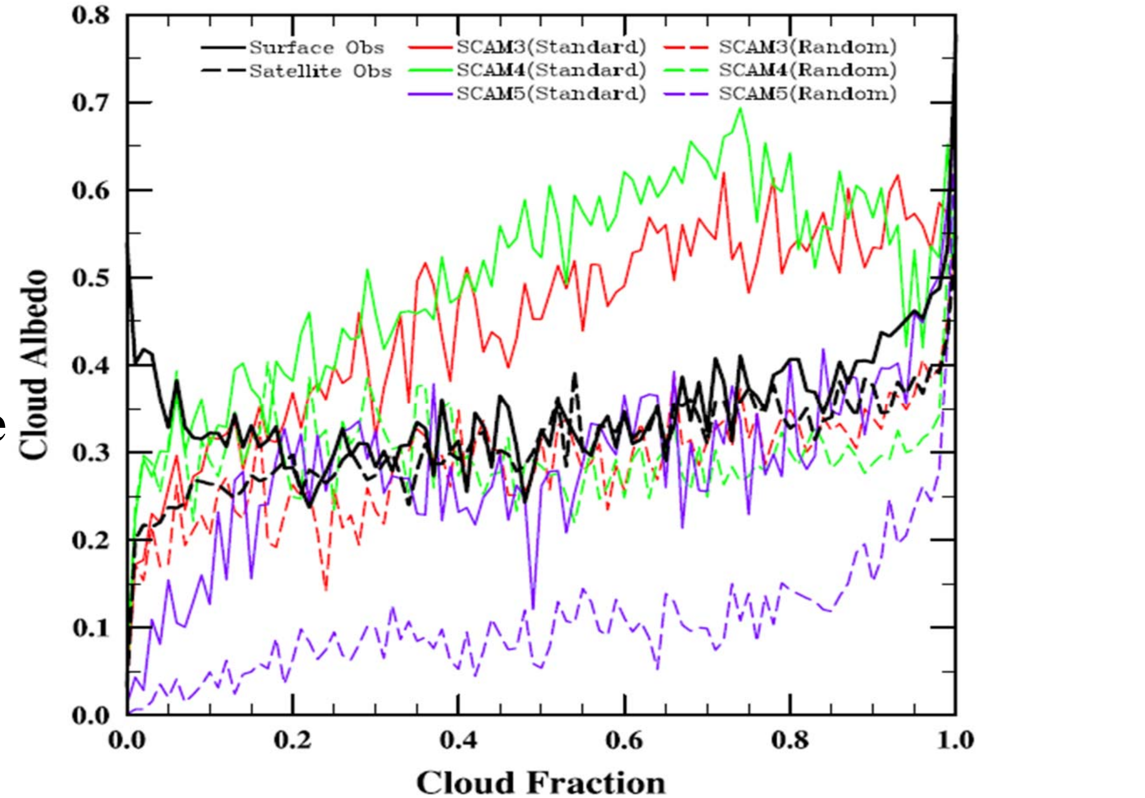
• Cloud albedo and cloud fraction are clearly related to each other

• Observational difference is much less than inter-model difference

• Model results can be improved by

-- changing parameterizations of specific fast processes (solid lines); or by

-- using different assumptions of vertical cloud overlap (dashed lines)



-- Underlying physics for albedo-fraction relation ?
-- Underlying parameterizations for model difference ?
-- Self-consistency of individual parameterizations and relationships to cloud overlap assumptions?

Four Levels of Model Evaluation

Subgrid Processes

Offline Evaluation

Direct no process interactions

SCM Evaluation

With process interactions but no column interactions

Full GCM Evaluation

Full interactions but propagation of parameterization errors

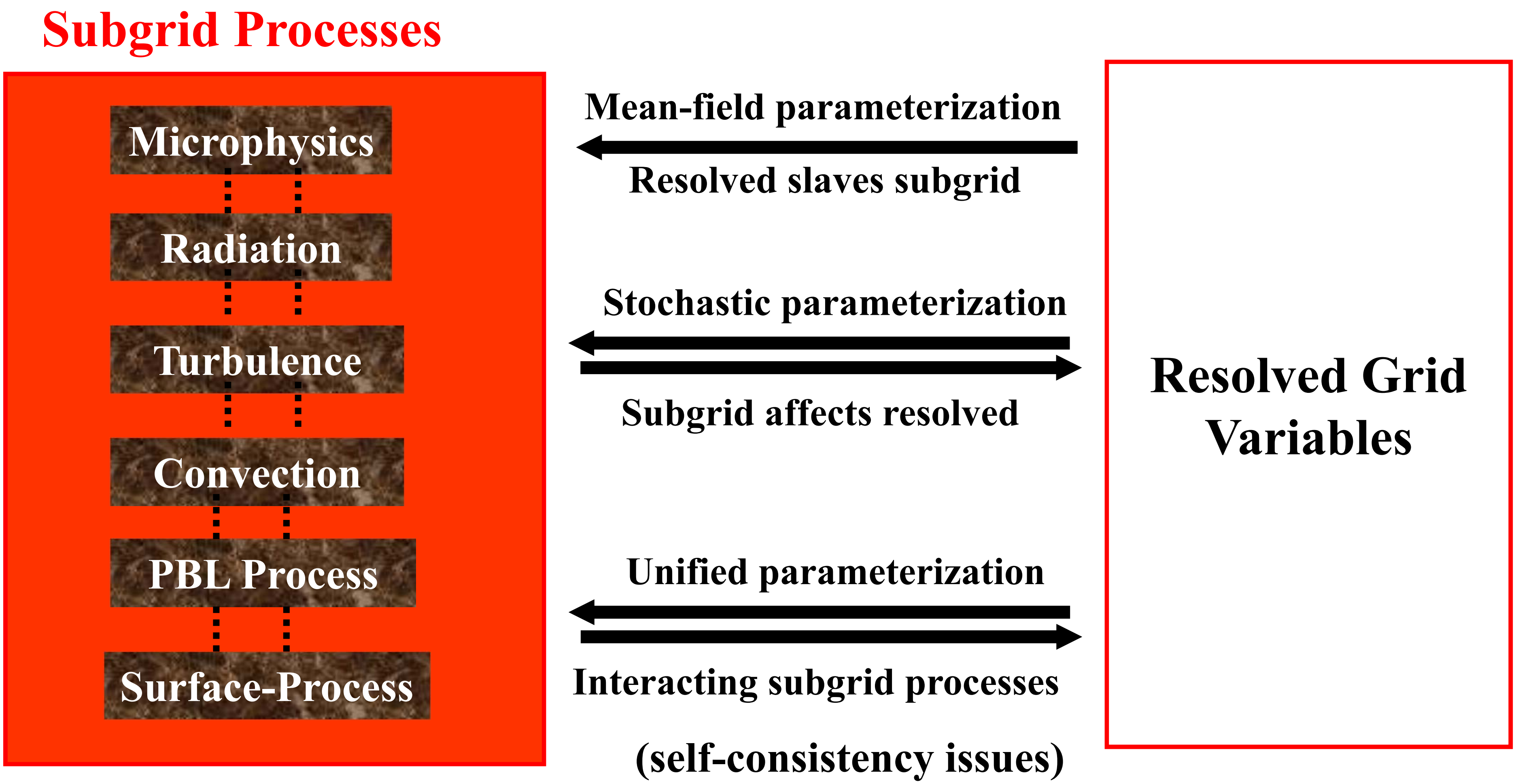
NWP Evaluation

Better Resolution

HRM Evaluation

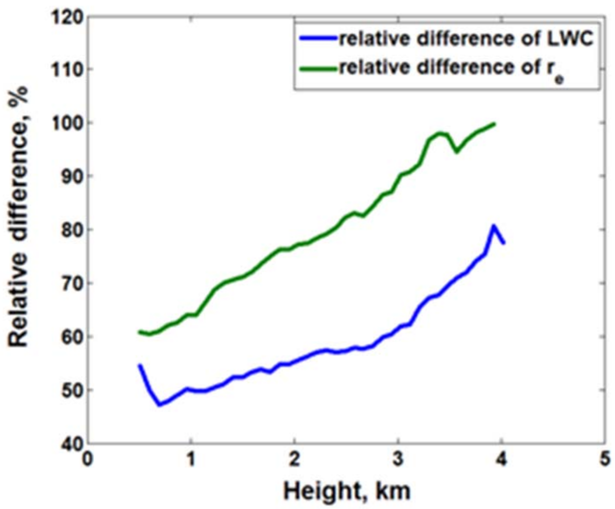
Best Resolution & Subgrid variability

Three Levels of Parameterizations



Parameterization is not just a practical necessity, but a deep theoretical underpinning of scale-interactions within the multiscale system in question.

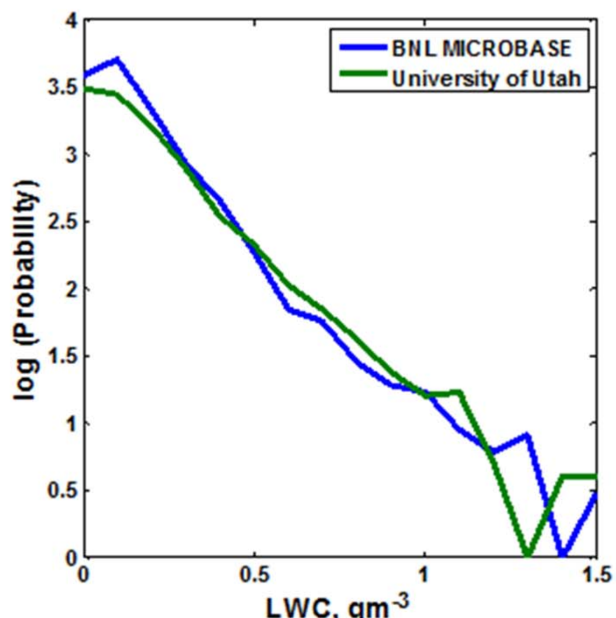
Large uncertainty in cloud microphysical retrievals

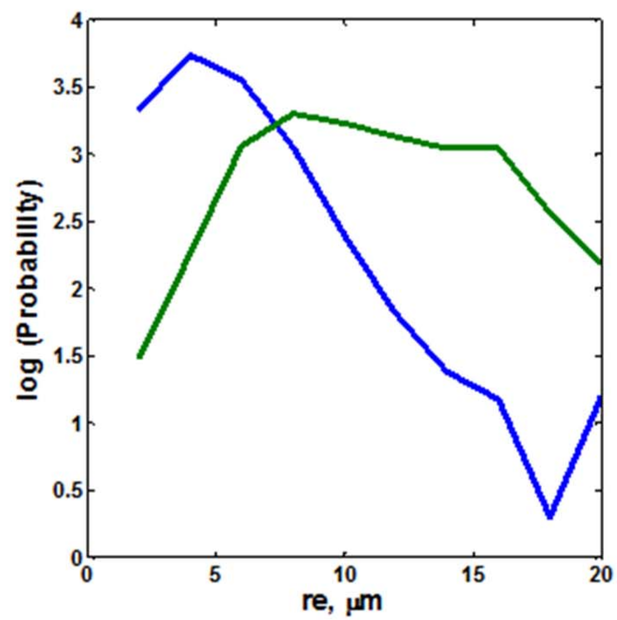


Large difference found between the seven year averages of the University of Utah and MICROBASE retrievals

PDFs of LWC look (both constrained by microwave radiometer)

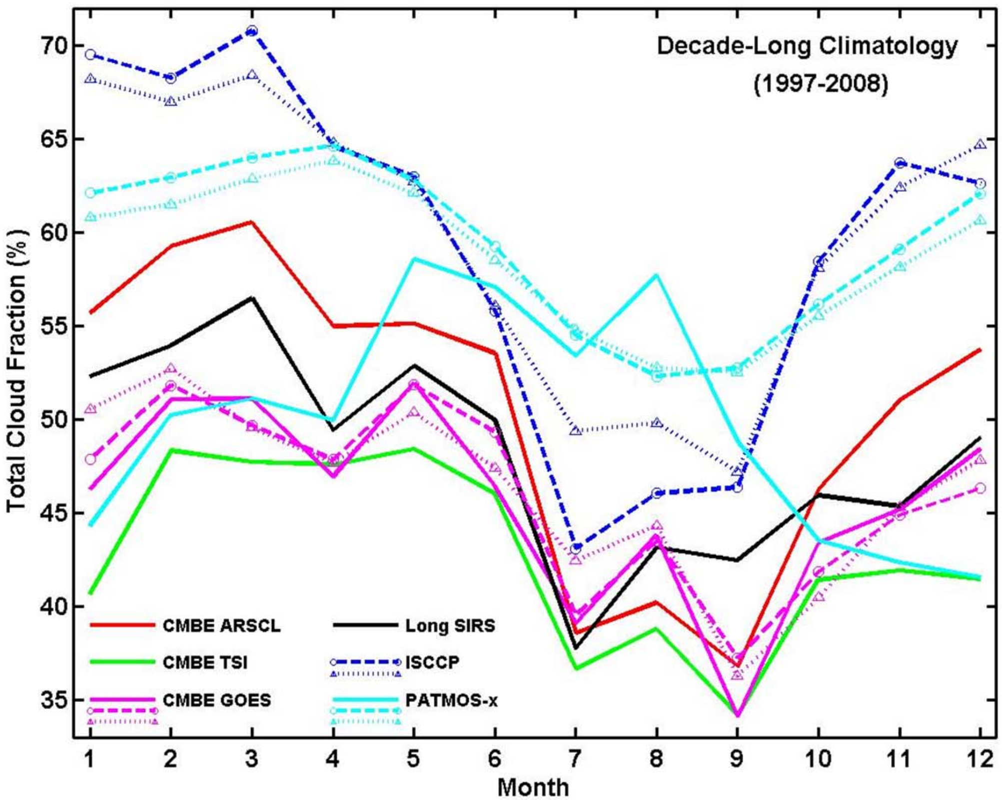
Very different PDFs of effective radius





(D. Huang)

Large Spread in Cloud Fraction Observations



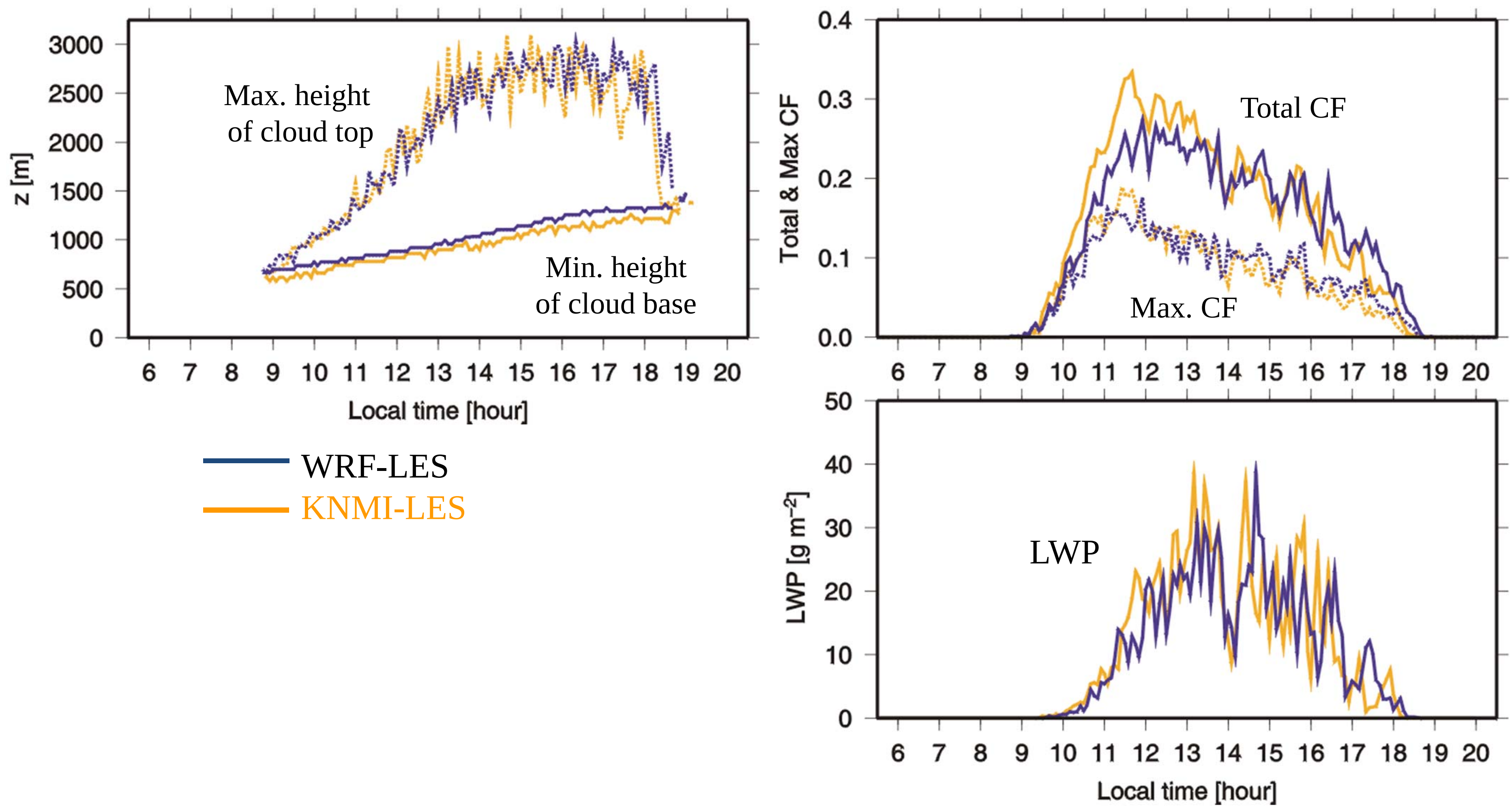
Lines: monthly climatology
solid: surface or 0.5° satellite
dashed: 2.5° satellite
dotted: the entire SGP domain

Characteristics:

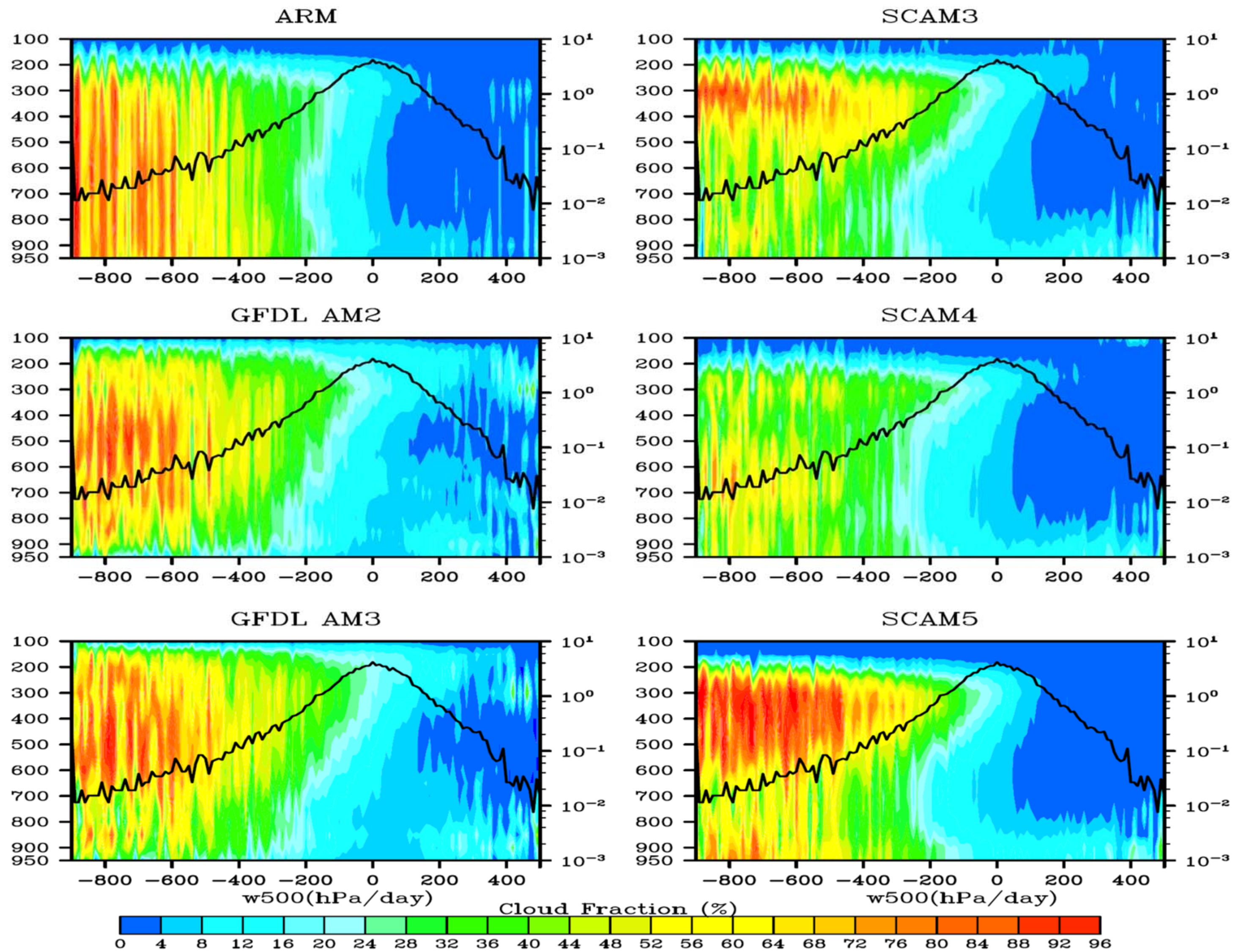
- **Difference: largest in Winter and Spring, smallest in Summer**
- **Surface measurements smaller than satellite measurements (except GOES)**
- **Not much sensitivity to spatial scale change (except 0.5° PATMOS-x with a phase problem)**

(W. Wu)

Comparison of Forcing-WRF with KNMI-LES

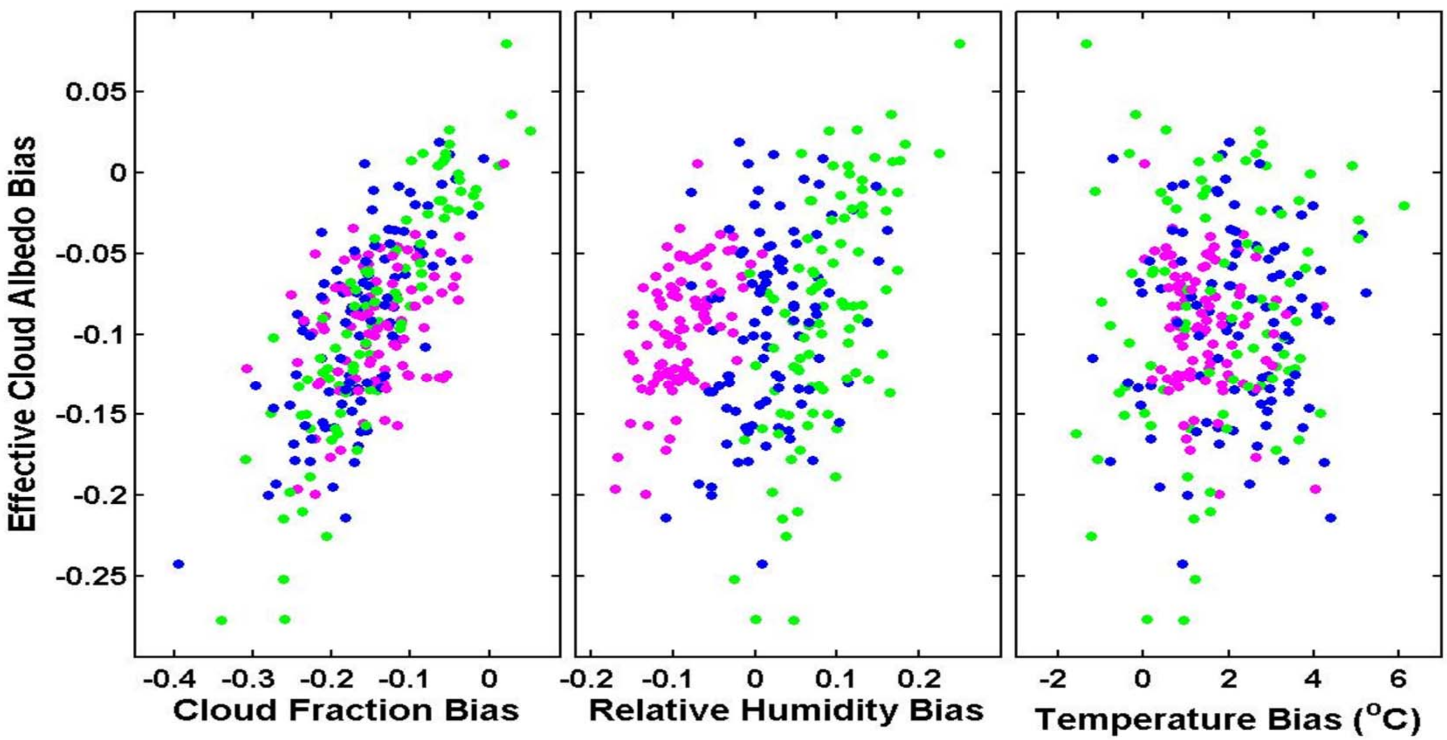


Three Years (1999-2001) SCM Runs at SGP



NWP Highlight: Relationship between Biases

Monthly Data

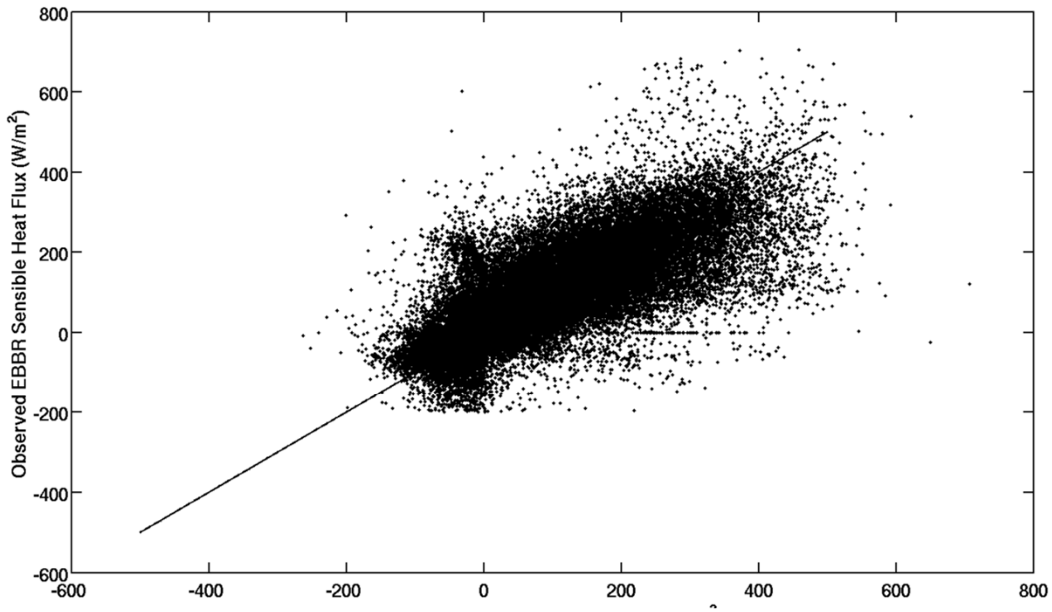


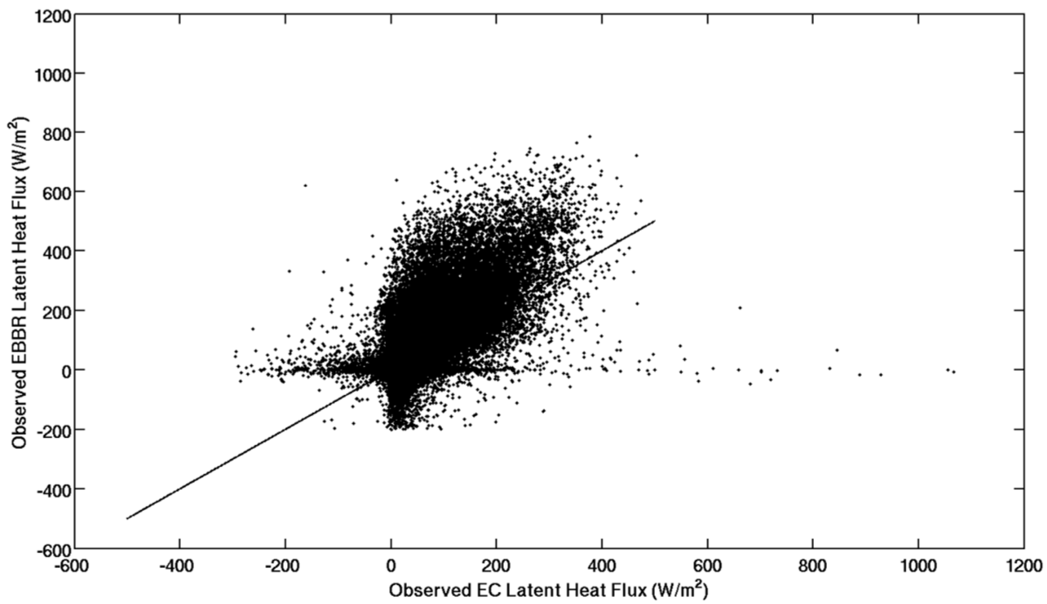
NCEP/NCAR Reanalysis, NCEP/DOE Reanalysis, ERA-Interim

Hypothesis: Error propagation from RH to cloud fraction to effective cloud albedo via parameterizations and couplings

(W. Wu)

Surface Fluxes



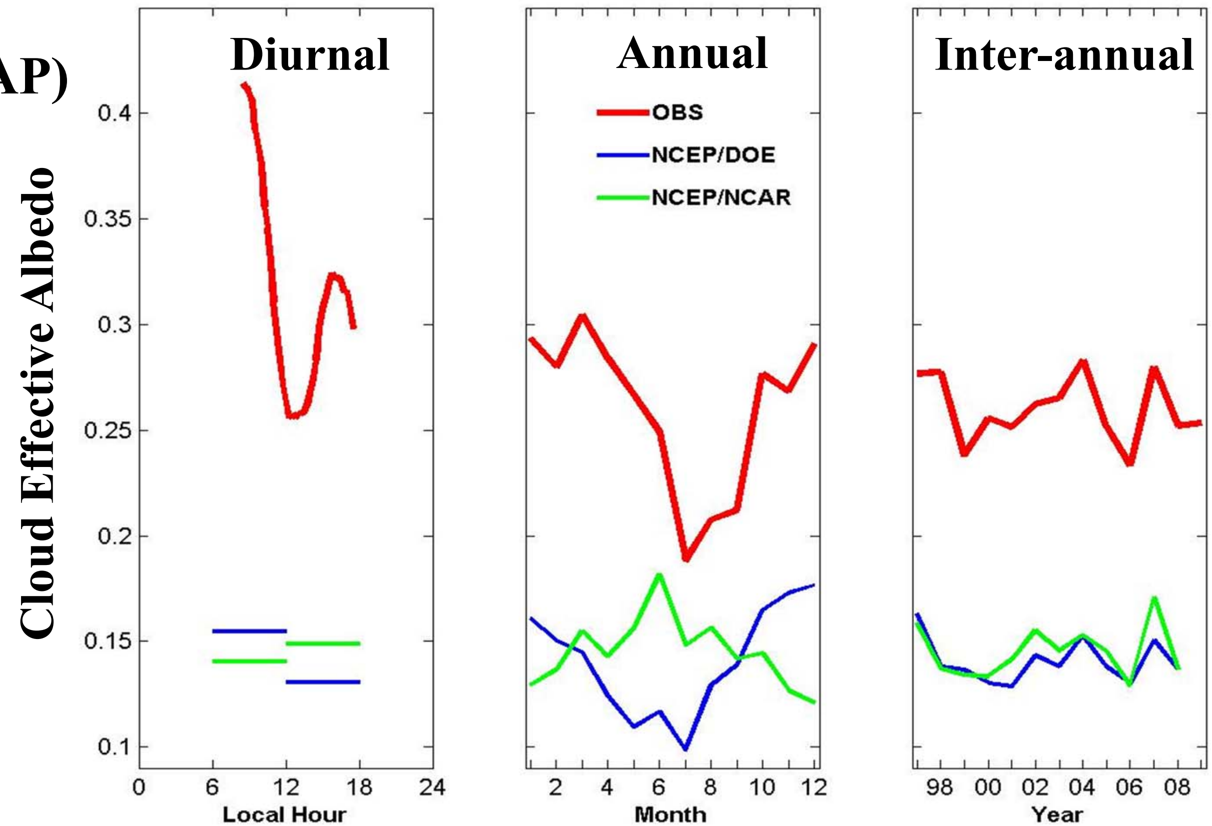


SGP Effective Cloud Albedo and Observation-Reanalysis Comparison

- **Long-term radiation measurement (Long's VAP)**
- **Minimizing non-cloud effects**
- **Effective cloud albedo (Betts, 2009):**

$$\alpha_e = \frac{F_{clear} - F_{all}}{F_{clear}}$$

- **Derived long-term cloud effective albedo data since 1997**



This diagram compares diurnal, annual, and inter-annual variations of effective albedo derived from radiation measurements (red), NCEP/DOE reanalysis (blue), and NCEP/NCAR reanalysis (green). Both reanalyses capture the inter-annual pattern well, but strongly underestimate. NCEP/DOE catches the annual variation better than NCEP/NCAR. → cloud fraction, albedo, and NWP usefulness

Version 1.0 Web-Based FASTER Testbed

http://www.bnl.gov/ems/

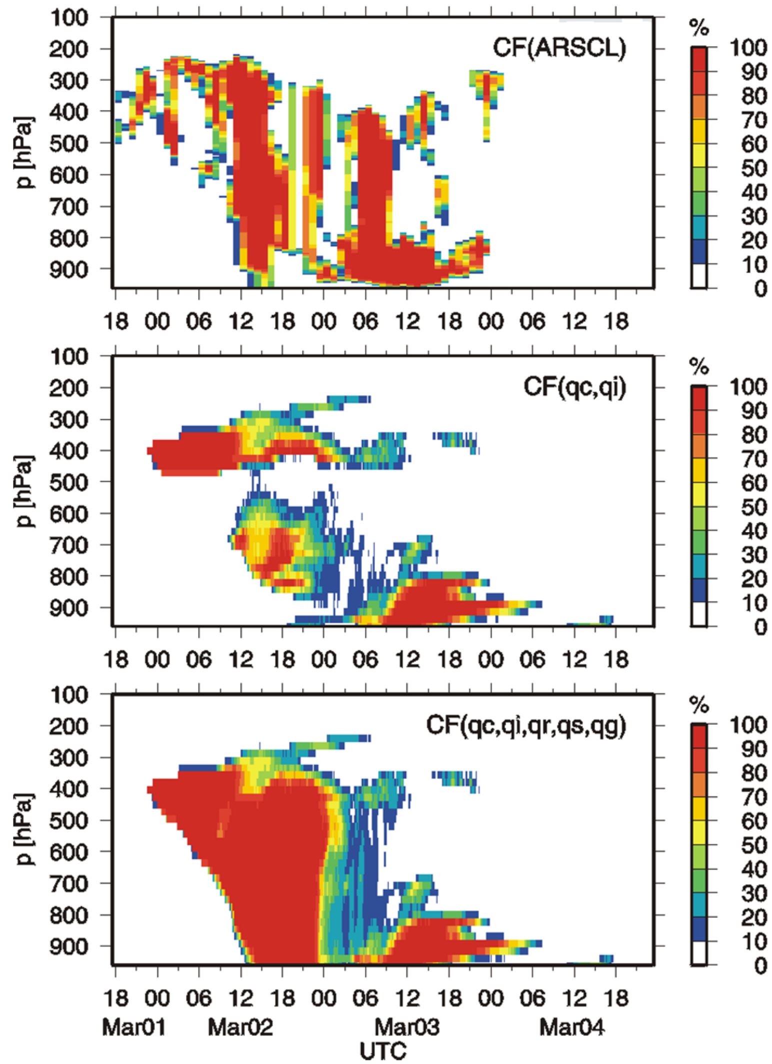
FASTER (FAST-PHYSICS SYSTEM TESTBED AND RESEARCH) Project

Brookhaven Climate Consortium

The FASTER project arises from the proposal "Continuous Evaluation of Fast Processes in Climate Models Using ARM Measurements" funded by the Department of Energy's Earth System Modeling (ESM) program. The overarching goal of this project is to narrow uncertainty and biases in GCMs by utilizing continuous ARM measurements to enhance and accelerate evaluation and improvement of parameterizations of fast processes in GCMs involving clouds, precipitation, and aerosols, with six primary objectives:

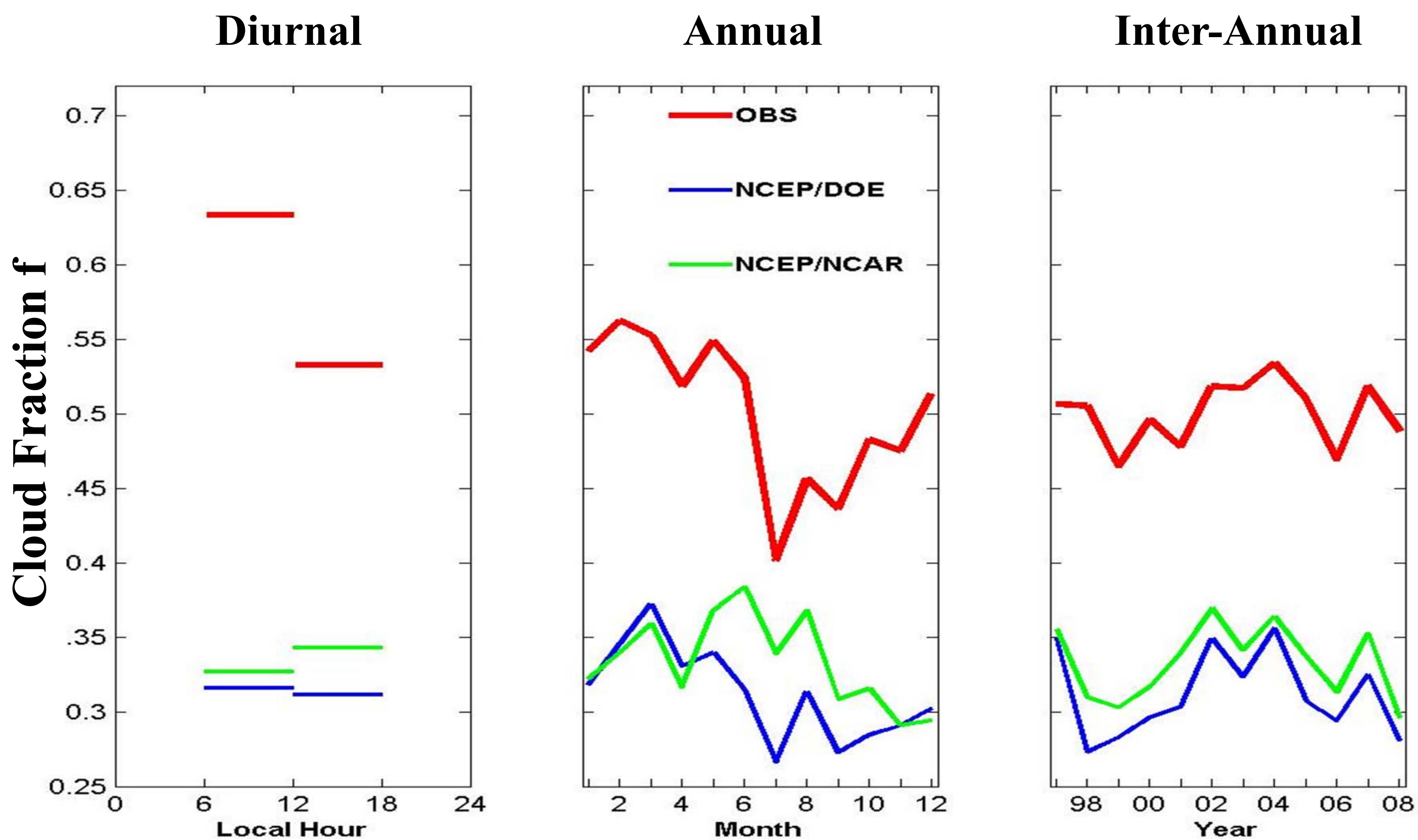
1. ***Construction of a Fast-Physics Testbed*** to rapidly evaluate fast physics in GCMs by comparing model results against continuous long-term cloud observations made by the ARM program.
2. ***Execution of a suite of CRM simulations*** for selected periods/cases to augment the Fast-Physics Testbed. We will run WRFs with different parameterizations as CRMs, CRMs with bin-microphysics, and multi-scale modeling framework.
3. ***Continuous evaluation of model performance*** to identify and determine model errors by comparing the NWP and SCM results against continuous ARM observations, and to each other. The long-time data record at the ARM sites (e.g., SGP) permits evaluation of various statistical properties (e.g., PDFs) and recurring cloud regimes.
4. ***Examination and improvement of parameterizations*** of key cloud processes/properties (e.g., convection, microphysics and aerosol-cloud interactions), thus narrowing the range of treatments of fast processes that exert strong influences on model sensitivity so as to better constrain climate sensitivity.
5. ***Assessment and development of metrics*** of model performance. Different metrics will be applied and tested in the evaluation, and new metrics will be explored. Special care will be taken to address the issue of scale-mismatch between observations and models.
6. ***Incorporation of newly acquired knowledge on parameterizations*** into the full participating GCMs to evaluate the impact of the refined parameterizations on GCM and ascertain the improvement in the representation of fast physics in the GCMs.

Configuration of WRF as a CRM



Cloud Fraction in Period A

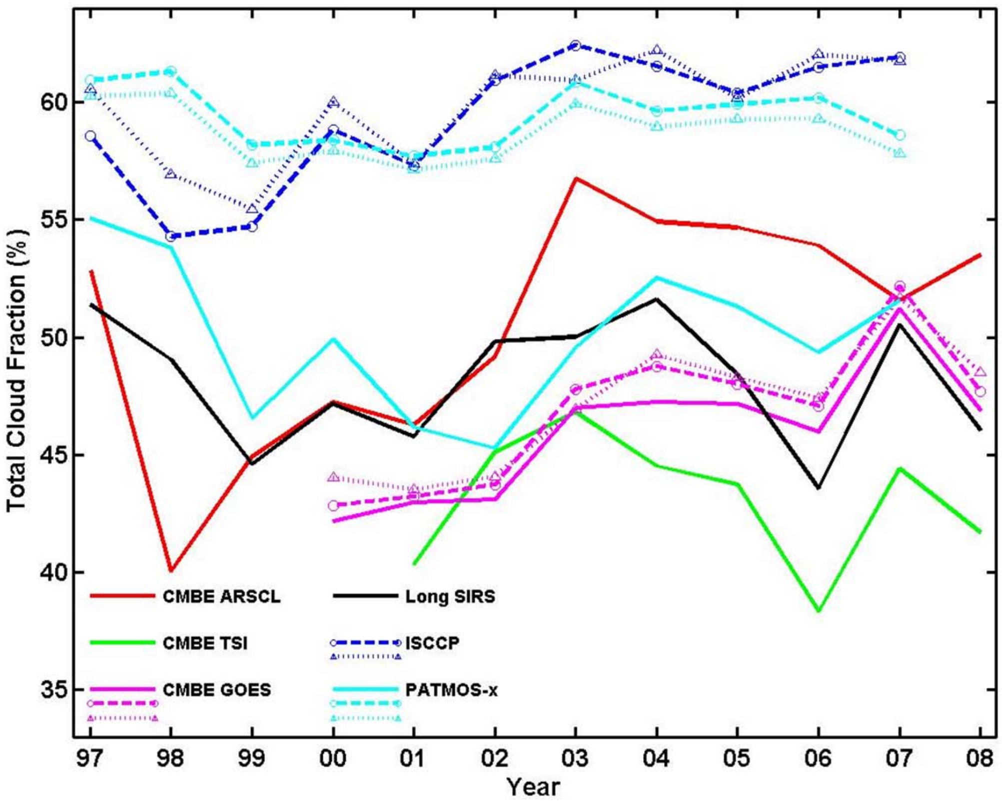
Cloud Fraction and Observation-Reanalysis Comparison at SGP



This diagram shows variations of cloud fraction are similar effective cloud albedo. Both reanalyses capture the inter-annual pattern well, but strongly underestimate. NCEP/DOE catches the annual variation better than NCEP/NCAR. >> cloud albedo

(Wei Wu)

Inter-Annual Variations of SGP Cloud Fraction Observations



Lines: inter-annual variations
solid: surface or 0.5^o satellite
dashed: 2.5^o satellite
dotted: the entire SGP domain

Characteristics:

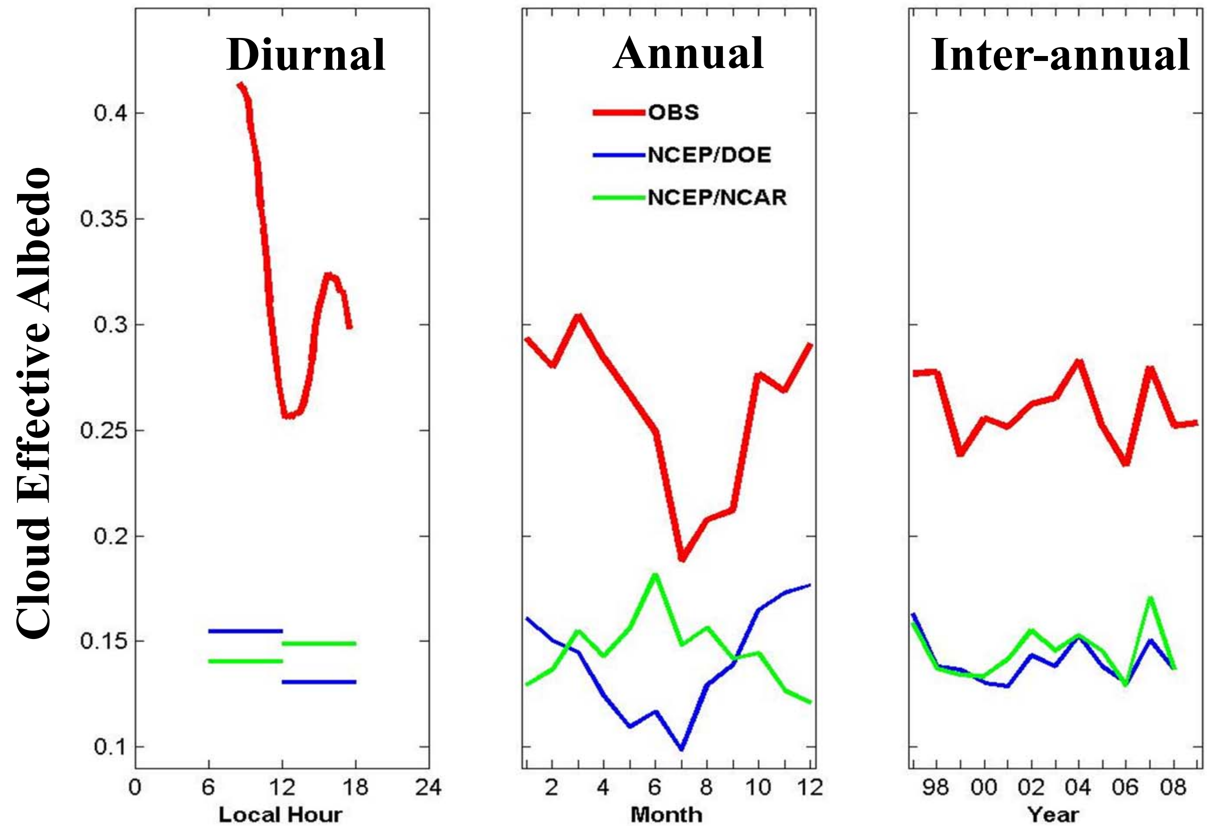
- **Magnitude: significant difference**
- **Phase: similar (including 0.5^o PATMOS-x with an annual-cycle phase problem)**

Effective Cloud Albedo and Observation-Reanalysis Comparison at SGP

- **Long-term radiation measurement**
- **Minimizing non-cloud effects**
- **Effective cloud albedo (Betts, 2009):**

$$\alpha_e = \frac{F_{clear} - F_{all}}{F_{clear}}$$

- **Long-term cloud effective albedo data since 1997 (Wei Wu)**



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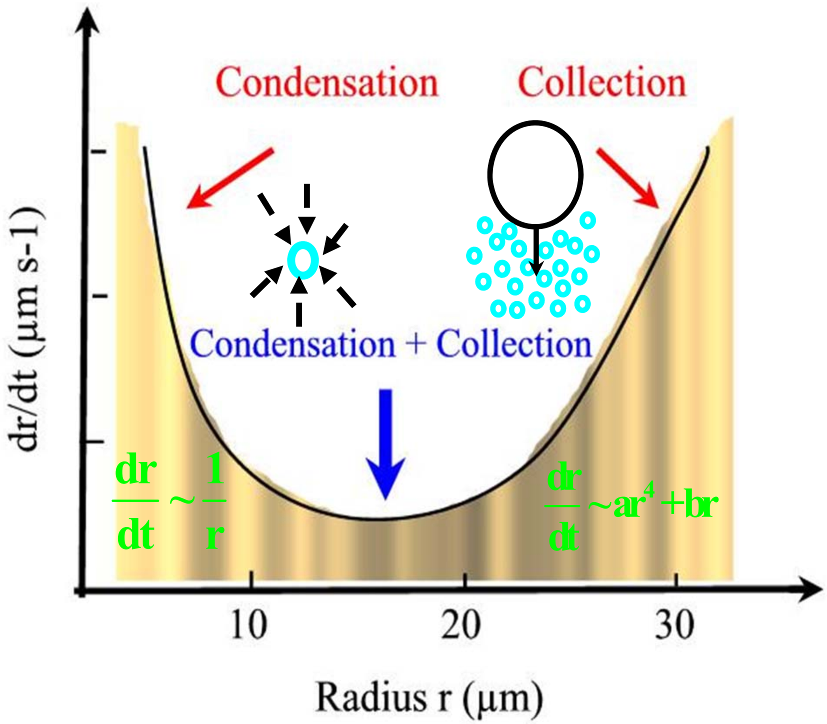
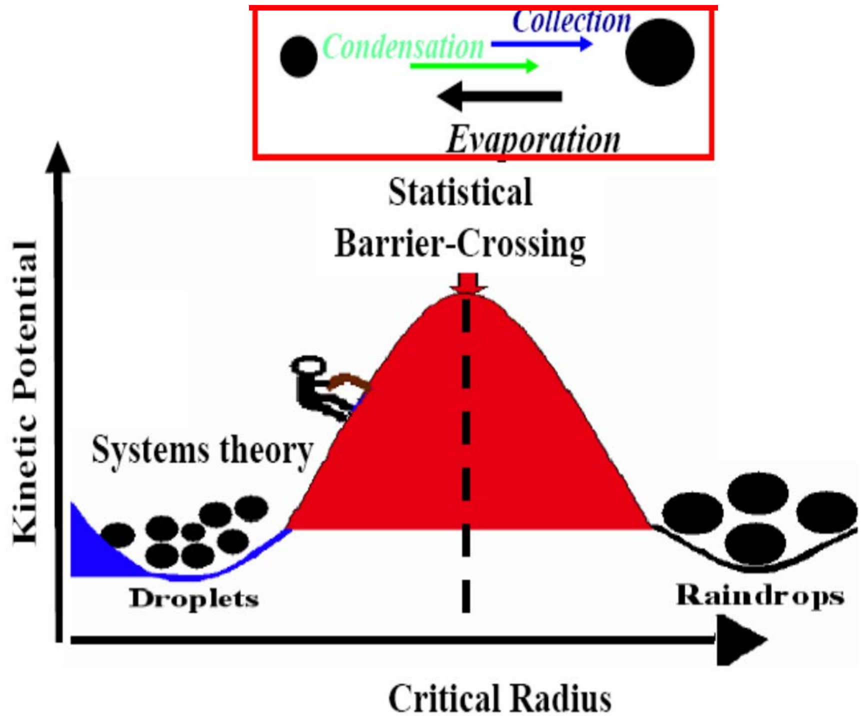
Valley of Death or Mountain of Life

Valley of Death



Rain initiation has been an outstanding puzzle with two fundamental problems of spectral broadening & formation of embryonic raindrop

Mountain of Life



The new theory considers rain initiation as a statistical barrier crossing process. Only those "RARE SEED" drops crossing over the barrier grow into raindrops.

Parameterization problem in GCMs is similar:
Issues well recognized, efforts made, & progress realized;
now is the time to for us to be a SEED that accelerate and crosses over the barrier !

Acceleration of progress and barrier-crossing demands more focused effort

History reveals to us a process of multiple evaluation approaches and increasingly focused efforts:

- **Brute force full-GCM (slow) -- Focused by IPCC**
- **GCM in forecast mode (faster than IPCC) -- Focused by CAPT**
- **SCM enhanced with CRM/LES modeling (fast and easily rerun) -- Used in ARM/GEWEX; Focused by KNMI SCM-testbed**
- **Available NWP forecast, analysis and reanalysis (NWP-testbed; fast but not easy to rerun) – Focused by European Cloudnet project**

There are less focused efforts in SCM-testbed and NWP-testbed in US, and FASTER is to fill this critical need to build a Fast-Physics Testbed by synthesizing SCM-testbed and NWP-testbed approaches and enhancing them via a suite of other activities, and perform continuous model evaluation against comprehensive, long-term ASR measurements.

Goal and Objectives

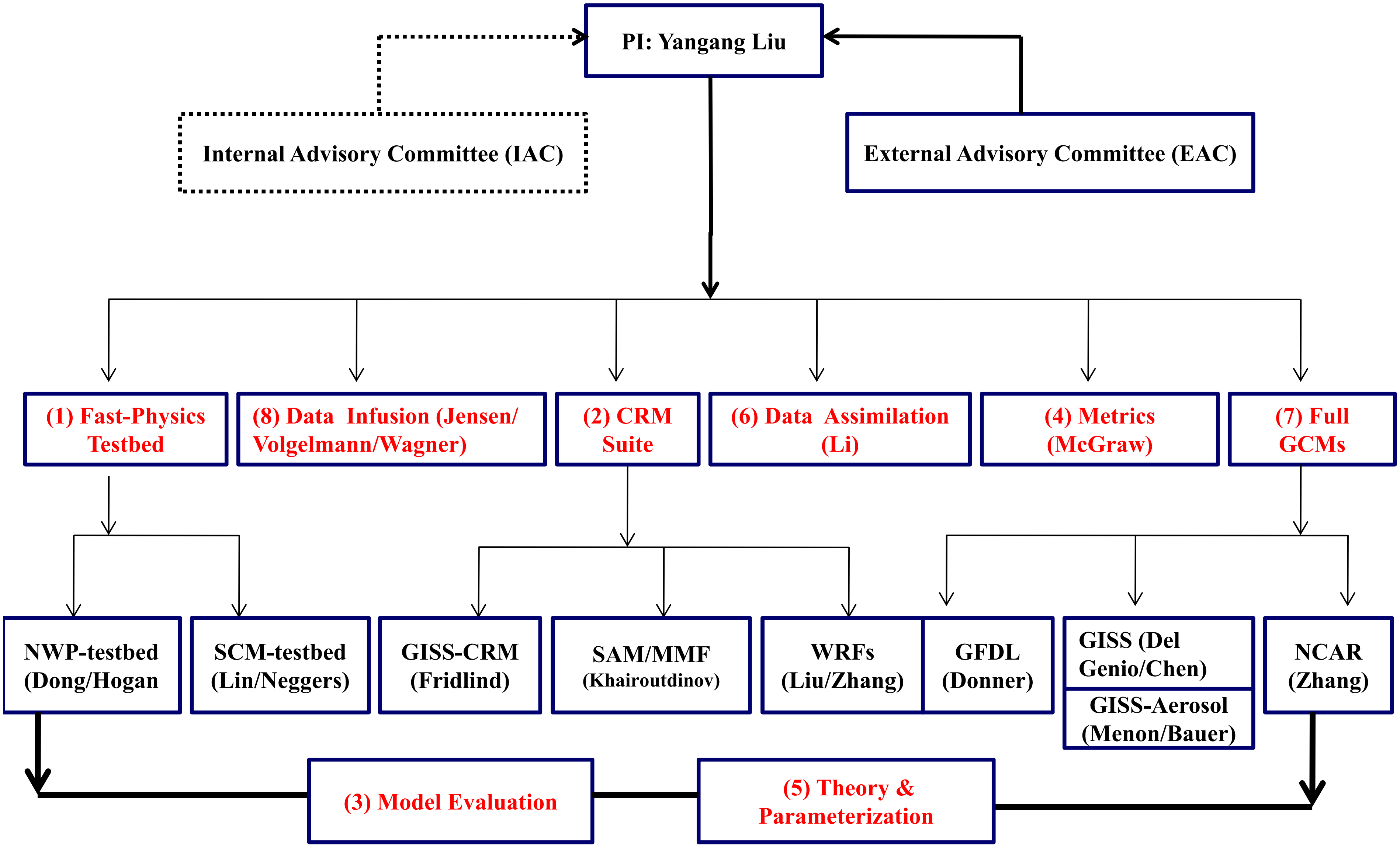
One Goal

Fully utilize continuous long-term ARM measurements to enhance/accelerate evaluation and improvement of parameterizations of cloud-related fast processes and narrow GCM uncertainties and biases.

Six Objectives

- **Construction of a fast-physics testbed**
- **Execution of a suite of CRM/LES simulations**
- **Evaluation of model performance**
- **Examination and improvement of parameterizations**
- **Assessment and development of evaluation metrics**
- **Incorporation of acquired knowledge into the full GCMs**

Scientific Management



Note that the flow chart is for illustrative purpose; all scientists work closely together, with focused areas identified. All scientists participate in (3) and (5), focusing on different processes/aspects.

Thanks again and Happy Thanksgiving!

FASTER has one overarching goal and eight major tasks.

Goal: Use continuous long-term ARM measurements to enhance/accelerate evaluation/improvement of parameterizations of cloud-related fast processes in GCMs. FASTER will be also valuable to NWP, WRF and CRM evaluation and development.

Testbed ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ Research

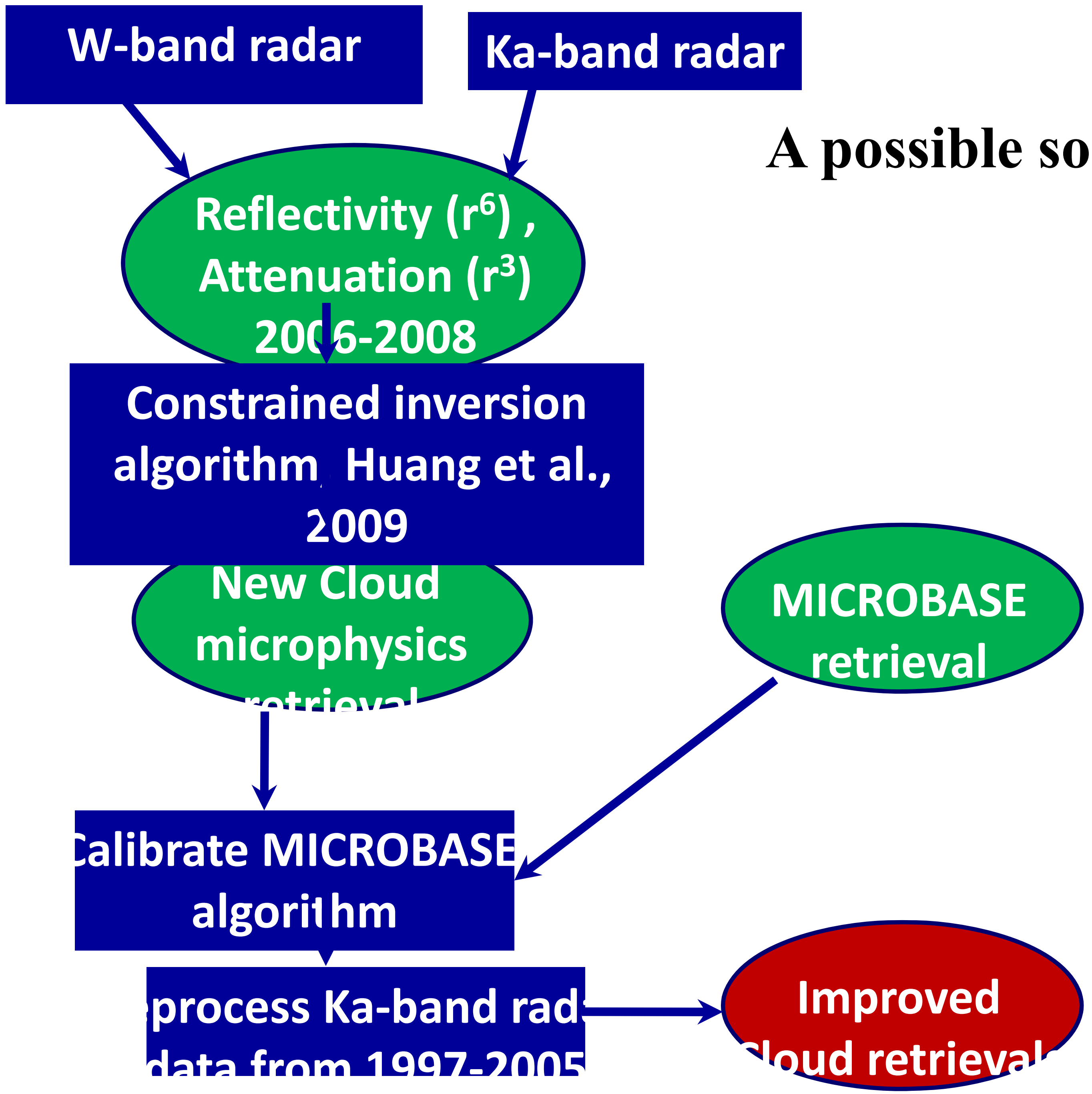
Eight Interconnected Major Tasks

- **Construction of fast-physics testbed by integrating SCM-testbed, NWP-testbed, and a WRF (see posters by Lin et al. and Wu et al.)**
- **Execution of a suite of WRF/CRM/LES simulations**
- **Integration of various data (see poster by Jensen et al)**
- **Construction of a multiscale data assimilation system**
- **Evaluation of model performance**
- **Examination and improvement of parameterizations**
- **Assessment and development of evaluation metrics**
- **Incorporation of acquired knowledge into the full GCMs**

Progress Report

- **Some timelines**
  - **-- 11/10/08, knew the proposal solicitation & charged to lead**
  - **-- 2/9/09, proposal submitted**
  - **-- 5/1/09, notified of the good news of proposal being funded**
  - **-- 6/09, DOE labs received $; able to use in July at BNL**
  - **-- 9/09, University received $**
- **New team members since proposal being funded**
  - **-- Wuyin Lin at BNL**
  - **-- Satoshi Endo at BNL**
  - **-- Tami Toto at BNL**
  - **-- Gijs de Boer at LBL**
  - **-- Catherine Rio at GISS-CU**
  - **-- Ewan O'Connor at UR-BNL**
- **Fast-physics testbed and web setup at BNL**
- **Examination of SGP radiation and cloud observations**
- **Model preparation and tune-up**
- **We are progressing from preparation stage to "warm-up" stage**

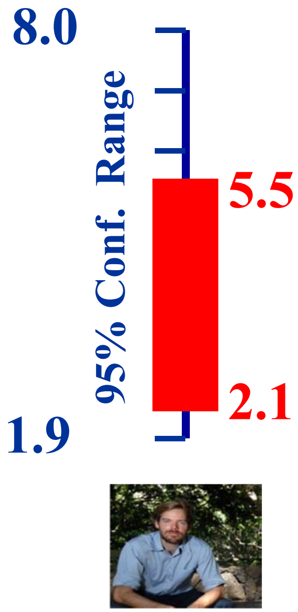
A possible solution



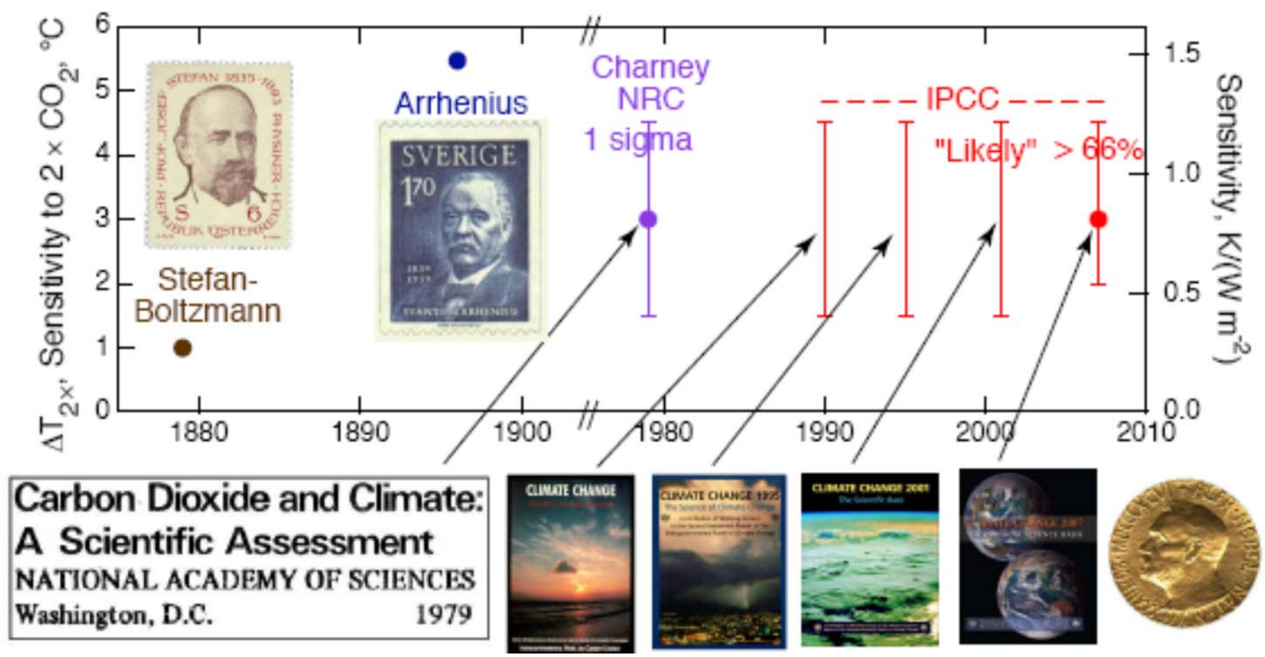
Research has progressed, but the pace has been frustratingly slow!

Virtually Unchanged Large Uncertainty of Model Climate Sensitivity through Ages

(Adapted from Schwartz 2009)



(Huybers, 2009)

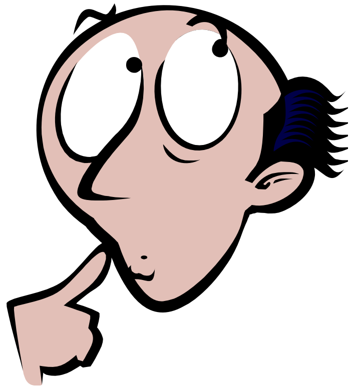


Wide spread are likely related to parameterizations of cloud-related fast (subgrid) processes.

Eight Tasks and Major Fast Processes

Eight Tasks

- Fast-physics testbed (NWP-testbed & SCM-testbed)
- A suite of high-resolution model simulations
- Model evaluation against measurements
  - -- Model errors
  - -- Error sources
- Evaluation metrics
  - -- Statistical measures
  - -- Forecast skill
- Theory and parameterization
- Data assimilation
- Full GCM assessment
- Data integration



Evaluation approach

Evaluation variables

Major Fast Processes

- Microphysics
  - -- Warm clouds
  - -- Ice clouds
  - -- Mixed phase clouds
  - -- Mono vs. multi-moment schemes
- Aerosol-cloud interactions
- Radiation
- Shallow convection
- Deep convection
- Entrainment/Detrainment
- Boundary processes
- Subgrid turbulence
- Cloud fraction
- Land-surface-atmosphere interaction

What is FASTER?

- FASTER = FAst-physics System TEstbed and Research
  -- testbed and research, system, evolving, faster work

- Result from CCPP (ESM) proposal "Continuous Evaluation of Fast Processes in Climate Models Using ARM Measurements"

- Collaborative effort: 21 investigators from 10 institutions

- Co-managed by ESM and ASR programs

FASTER is a multi-institutional ESM effort to bridge ESM and ASR sciences by fully utilizing ARM measurements to evaluate GCM parameterizations of cloud-related fast processes.

(Fast processes = GCM subgrid process)