BBHRP Breakout Session

ARM Atmospheric Radiation Measurement Program

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Flux Analysis Code: Basic Cloud Properties and Cloud Effects Derived from Surface Radiation Measurements

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ARM Atmospheric Radiation Measurement

SW Flux Analysis

- Long and Ackerman (JGR, 2000)
- Detection of clear (i.e. cloudless) sky periods
- Empirically fit functions to clear-sky data, interpolate for cloudy periods
- Produce continuous estimates of clear-sky global, direct, and diffuse SW
- Infer fractional sky cover for solar elevations of 10° and greater (Long et al., 1999)
- <u>Current ARM VAP, 15-min. Sky Cover</u>

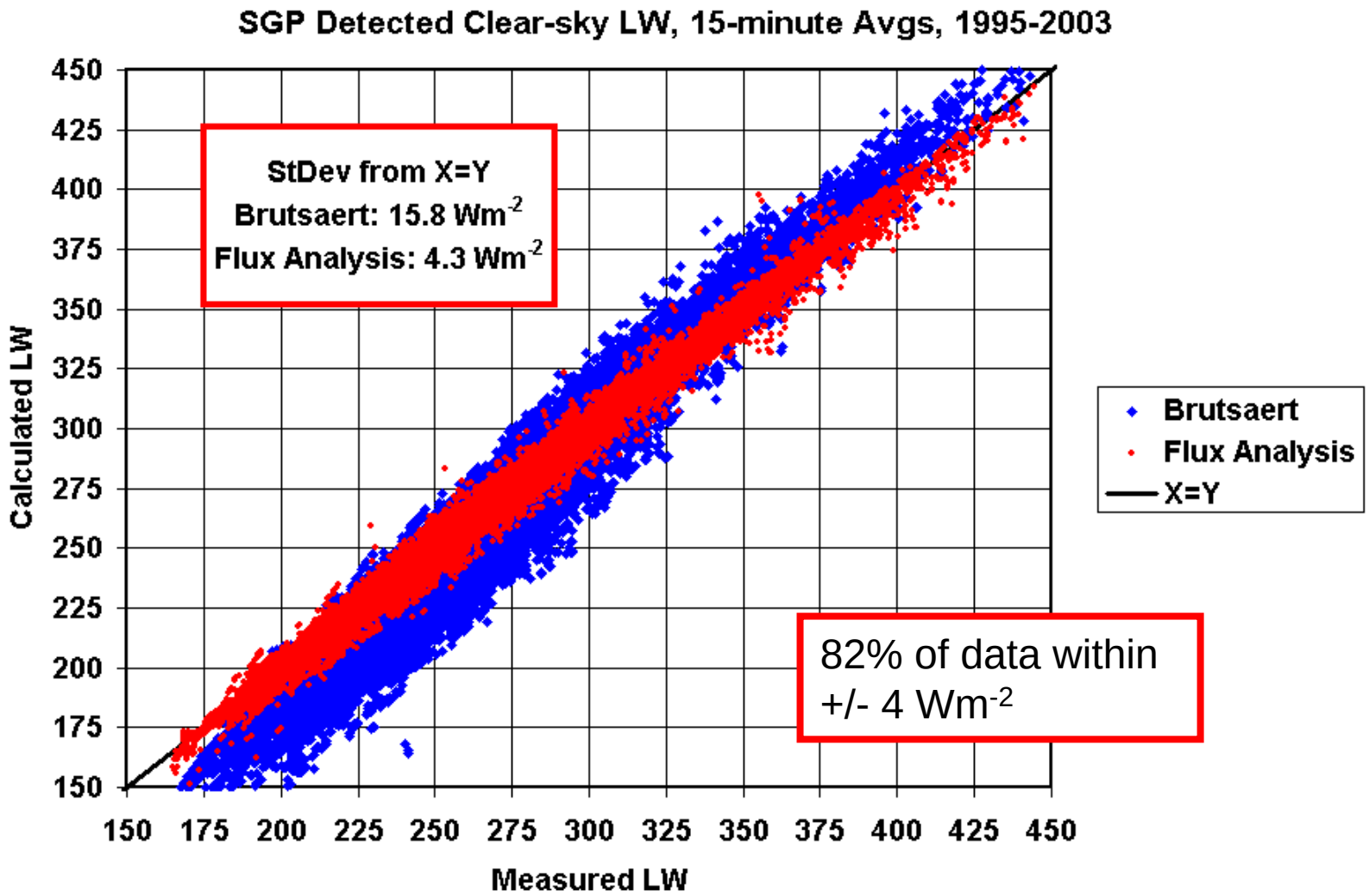
Cloud Visible Optical Depth

- Effective plane-parallel cloud visible optical depth for overcast skies
  - Based on Min and Harrison, 1996, GRL.
  - Barnard and Long, 2004, JAM, empirical formulation
    - Agreement within 10%
  - New formulation including surface albedo and asymmetry parameter
  - Latest improvements:
    - Better low optical depths
    - Discrimination for g_{liq}/g_{ice}

Clear-Sky Downwelling LW

- Related work by Marty and Philopona (2000), Duerr and Philipona (2004), Sutter at al. (2004)
- Use SWFA detected clear-sky periods,
- Additionally detect “LW effective clear-sky” periods
  - Variability of LW time series
  - Use $T_a - T_e$ difference
- Use clear-sky measurements to calculate Brutsaert lapse rate coefficients
  - include adjustment for RH>75%
- Interpolate coefficients for cloudy periods similar to SWFA

Estimated Clear-Sky LW



82% of data within +/- 4 Wm^{-2}

LW Effective Sky Cover and Radiating Temperature

- LW effective sky cover
  - Durr and Philipona (2004, JGR)
  - Low and middle clouds
  - Technique adapted for Flux Analysis
- Cloud effective radiating temperature
  - use independent pixel approximation arguments, the LW effective cloud amount, and the clear-sky and measured LW
  - “effective” - assumes single uniform layer
  - Results for low and middle clouds, when LW Scv > 50%

Clear-Sky Upwelling SW

- Use daily sampling of near-noon albedo and running analysis of solar zenith angle dependence of “direct” albedo
  - Needed for significant albedo changes under cloudy skies: <u>SNOW</u>
  - Recall that high sun albedos nearly same
- $Alb_{clr} = Alb_{noon} + [a + b*Cos(SZA)]$
- Interpolate for days not fitted

Clear-Sky Upwelling LW

- Upwelling LW
  - Product of total surface energy exchange
    - Including latent and sensible heat
  - Sequential fitting and interpolation
    - Using LWdn, SWnet, RH, Wspd
    - Primary driver is <u>LWdn</u>
    - Some <u>SWnet</u> for vegetated surface converted to plant energy, not heat; not so for bare soil or snow
    - <u>RH & Wspd</u> surrogates for relative changes in surface latent and sensible exchange

Flux Analysis Summary

- More than just surface radiation measurements
  - Detected clear-sky periods
  - Clear-sky upwelling and downwelling SW and LW
    - for cloud effect/forcing
  - SW total and LW effective fractional sky cover
  - Clear-sky effective LW emissivity
  - Effective cloud transmissivity
  - Cloud visible optical depths (OVC)
  - Cloud effective radiating temperature
    - (LW Scv > 50%)
  - Crude effective cloud height

VAP Question:

- Is it time to upgrade from the SW Flux Analysis to the full Flux Analysis as a VAP?
- Alternately, just upgrade current SW Flux Analysis to 1-minute sky cover and add visible optical depths?
  - No separation between water/ice clouds

The Broadband Radiative Heating Rate Profile (BBHRP) Project: Status and Developments

The ARM BBHRP Focus Group

General BBHRP Outline

Atmospheric State
Surface Albedo

Aerosol Best-Estimate Profiles

Cloud Property Profiles

Radiative Transfer Model (RRTM)

Vertical Profile
Fluxes/Heating Rates

Two resolutions:
"soda straw"
grid-cell

TOA Validation
Satellite LW/SW Fluxes

Surface Validation
ARM LW/SW Fluxes

Recent Developments on BBHRP

- Focus on improving BBHRP 'infrastructure'
  - goal: make BBHRP more useful to ARM community

    - BBHRP: 'Research Spotlight' on ARM home page

    - release of latest versions as PI product

    - direct input to BBHRP of cloud property retrievals by ARM PIs

    - tool to compute average heating rates for cases satisfying various criteria

- Plan in place to improve NSA results, especially clouds properties
  - improved thermodynamic profiles from Mergedsounding VAP

- Generation of many new versions of BBHRP at SGP

BBHRP Featured on ARM Home Page

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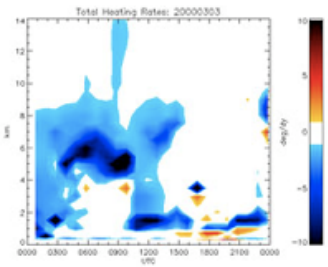
SEARCH

ABOUT ARM | ABOUT ACRF | SCIENCE | SITES | INSTRUMENTS | MEASUREMENTS | DATA | PUBLICATIONS | EDUCATION | FORMS

A Science Research Program for Global Climate Change

RESEARCH SPOTLIGHT 1 2 3



Heating Rate Profiles Available for ACRF SGP Site

Vertical heating rates, which are governed by the presence and structure of the clouds, have been generated for a 1-year period (2000/03 - 2001/02) for the ARM Climate Research Facility (ACRF) Southern Great Plains (SGP) locale. The dataset is referred to as the "instantaneous" product and focuses on a narrow column centered at the Central Facility. Further goals of this effort include the production of multi-year datasets of validated heating rate profiles for all ACRF locales. For more information:

- Read documentation
- To place a custom order, login to the Archive. Please contact the Archive if you have questions regarding logging in.
- See development website

Atmospheric Radiation Measurement Program

The Atmospheric Radiation Measurement (ARM) Program is the largest global change research program supported by the U.S. Department of Energy (DOE). It was created to help resolve scientific uncertainties related to global climate change, with a specific focus on the crucial role of clouds and their influence on radiative feedback processes in the atmosphere. The primary goal of the ARM Program is to improve the treatment of cloud and radiation physics in global climate models in order to improve the climate simulation capabilities of these models. ARM's scientists research a broad range of issues that span remote sensing, physical process investigation and modeling on all scales. ARM's site operators focus on obtaining continuous field measurements and providing data products to promote the advancement of climate models.

ARM Climate Research Facility

Atmospheric Radiation Measurement Climate Research Facility

A National User Facility for the Scientific Community

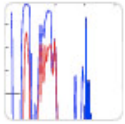
ARM's climate research sites serve as a national scientific user facility for collaborative research primarily with university, government agency, and national laboratory researchers. These sites provide significant research capability for the global scientific community. The resulting new ARM Climate Research Facility (ACRF) has been designated a national user facility for the purpose of providing this unique asset for the study of global change to a broader national and international research community. Proposed projects at the ACRF are reviewed by the ACRF Science Board, a highly respected group of scientists who assist with reviewing proposals for use of the facility.

Field Campaigns

Learn all about our research in the field!

News

DOE awards Aerial Vehicles Program to PNNL



Results

"Roobik" is part of the answer, not a puzzle

Jobs

Stony Brook University seeks six faculty members

Events

Deadlines approaching for WGNE/PCMDI workshop

Direct Input of Cloud Property Retrievals into BBHRP

- All BBHRP trials of alternate cloud property retrievals have been coded by BNL
  - Microbase w/o MWR, Dong-Mace, Frisch, Matrosov
- More such trials desired ⇒ direct path into BBHRP has been designed:

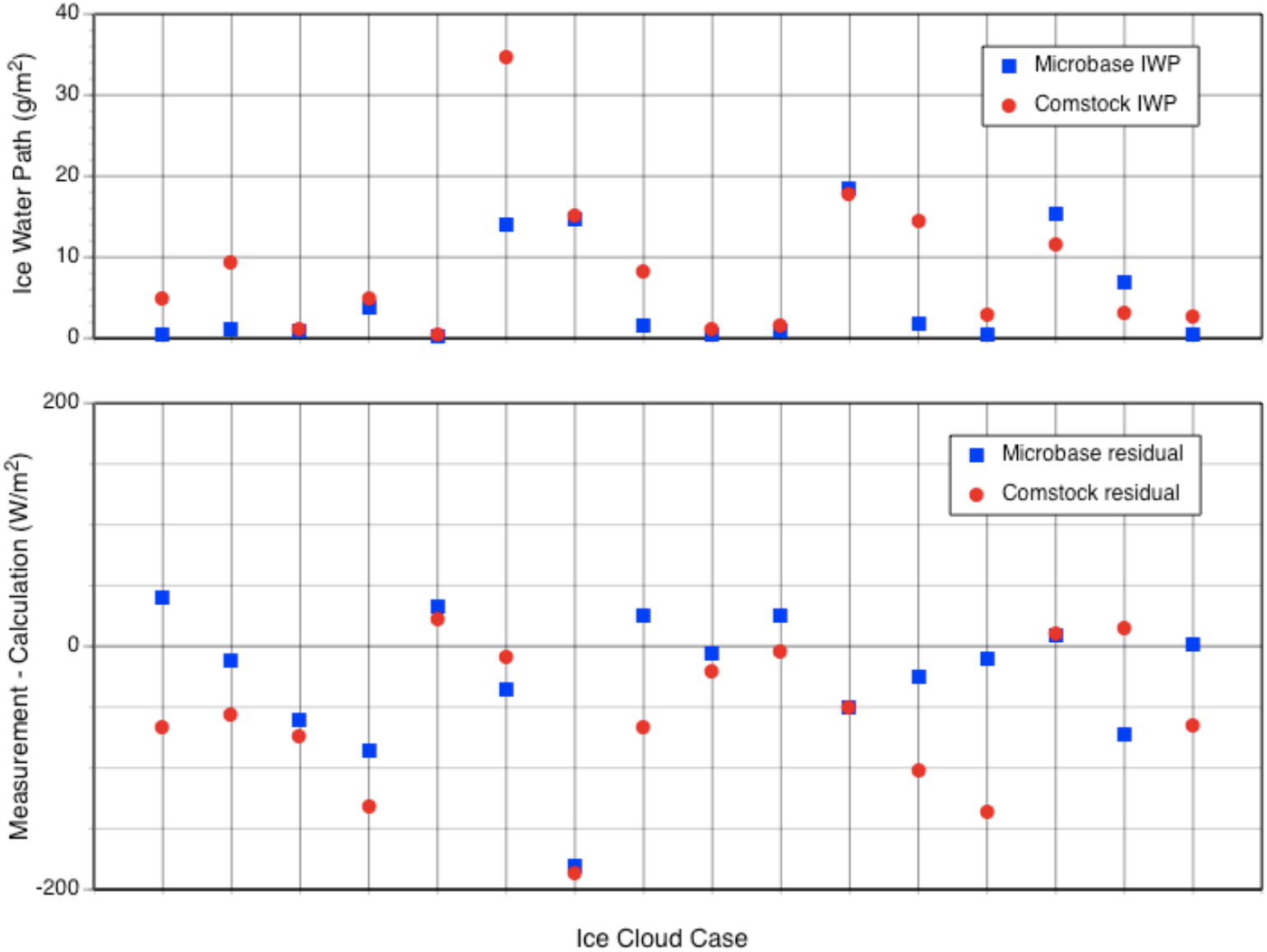
```
float Heights(nheights) ;                                   Heights:long_name = "Height of Computed
Value (in the                                               center of the layer)" ;
                                                                    Heights:units = "m ASL" ;
float Avg_Retrieved_LWC(time, nheights) ;          Avg_Retrieved_LWC:long_name = "Retrieved, MWR-
                                                            Scaled, Liquid Water Concentration in-cloud
Averaged                                                    over 120 seconds" ;
                                                            Avg_Retrieved_LWC:units = "g m-3" ;

float Avg_Retrieved_IWC(time, nheights) ;          Avg_Retrieved_IWC:long_name = "Retrieved Ice Water
                                                            Concentration in-cloud Averaged over 1200
seconds" ;
                                                            Avg_Retrieved_IWC:units = "mg m-3" ;
float Avg_LiqEffectiveRadius(time, nheights) ;     ……….
```

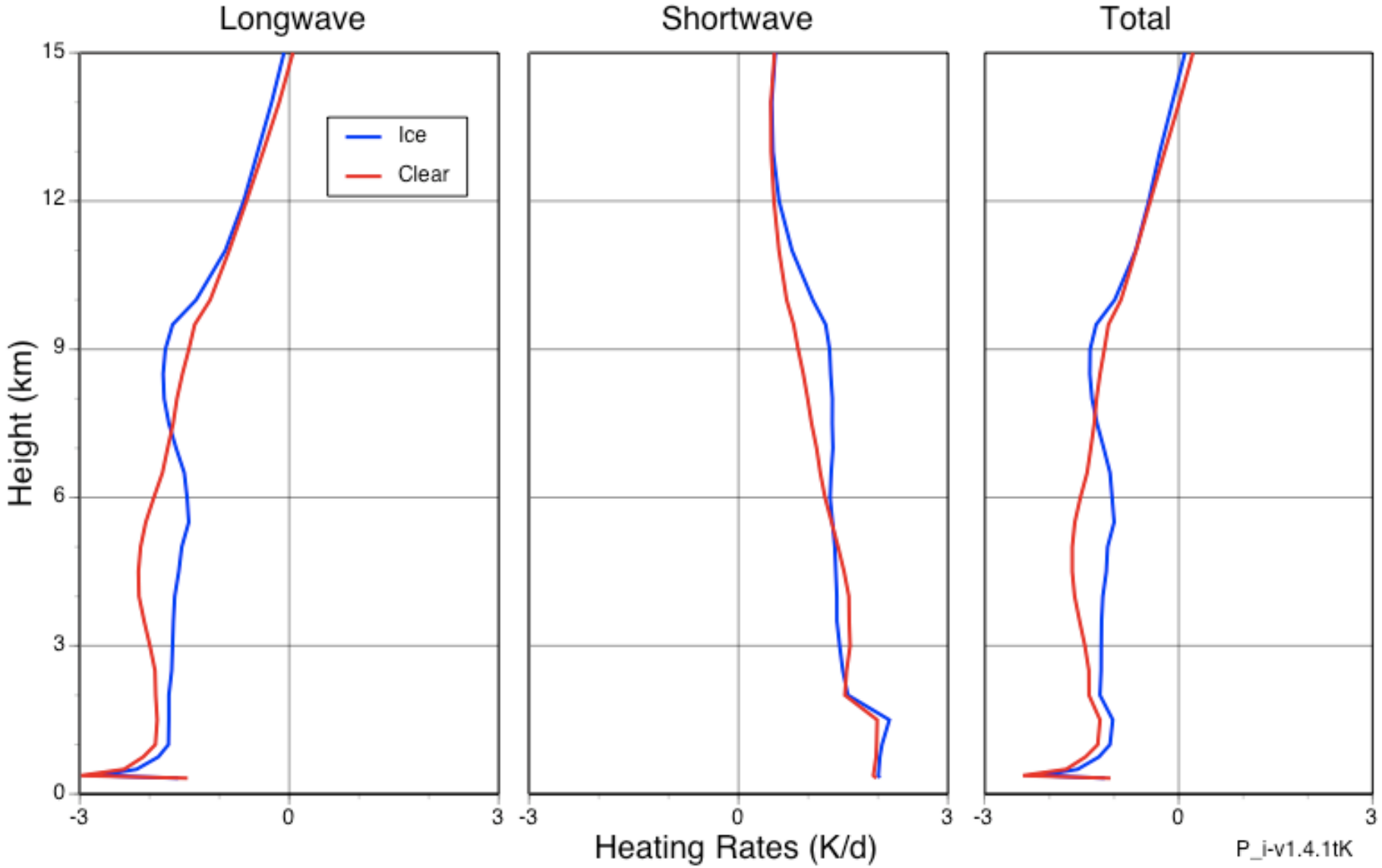
- First ARM PI to use this: Jennifer Comstock (trial run)

next: B. d'Entremont/D. Mitchell

SW Diffuse - Comparing Microbase and Comstock Ice Cloud Retrievals



Heating Rates of Ice and Clear Cases: SGP 2000



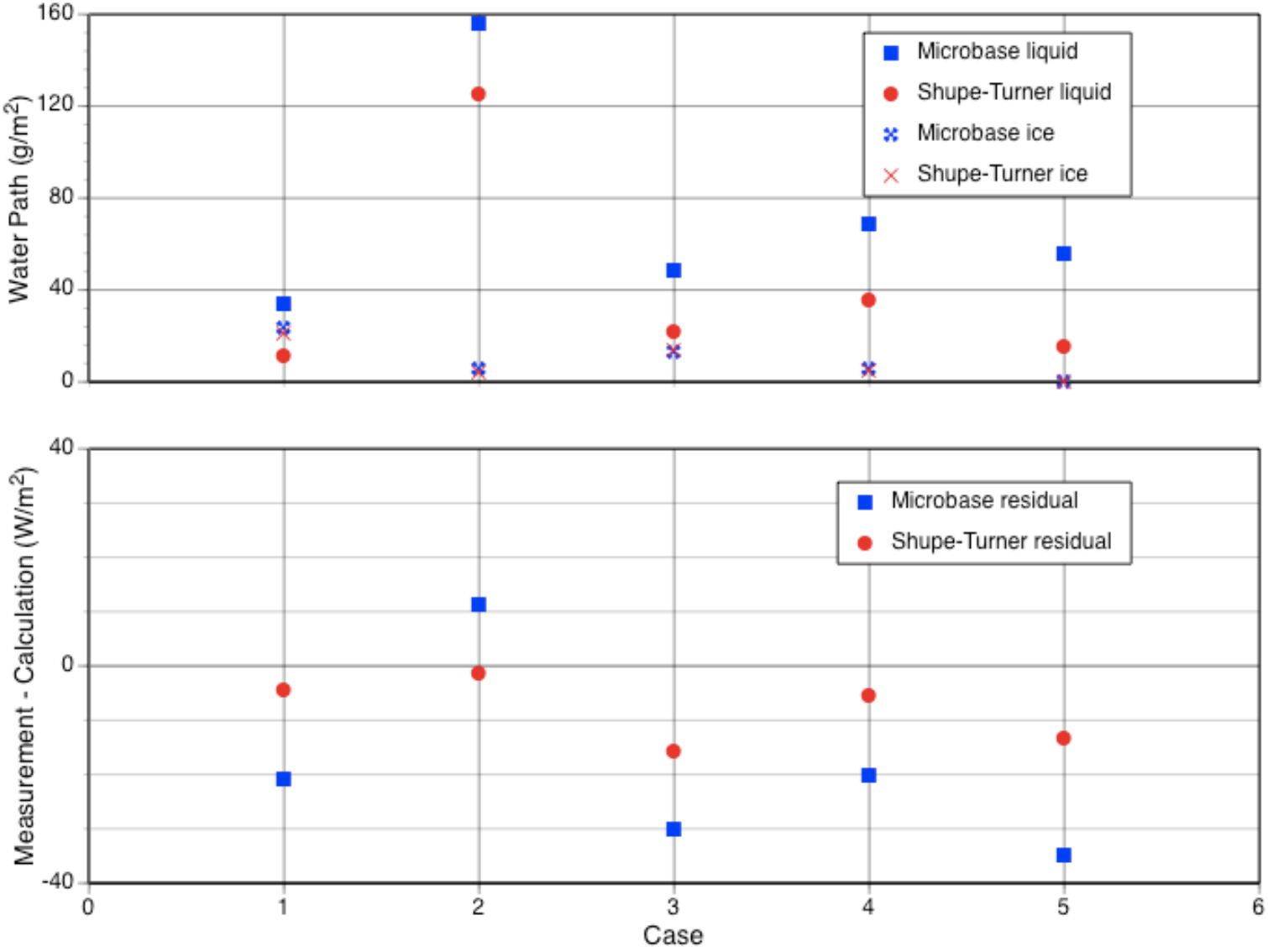
Improving BBHRP Results at NSA

- Committee formed to design plan:

  Delamere, Dunn, Jensen, Johnson, Miller, Mlawer, Shupe, Troyan, Turner

- Approach
  - Improve Mergedsounding
  - Remove ‘clutter’ from ARSCL
  - Redo Microbase with new Mergedsounding and clutter removed
  - New Shupe-Turner cloud property retrieval

NSA: Evaluation of Shupe-Turner Cloud Retrieval - March 13-14, 2004



BBHRP Trials Based on Current Version (1.4.1)

Trial	Description
A	Removal of unscaled sondes
B	Miloshevich (partial correction)
C	Miloshevich (full correction)
D	Matrosov ice properties
E	Frisch liquid properties
F	Dong-Mace properties
H	Time-averaging analysis (ICA using 10s data)
J	CERES overpasses using Mergedsounding
K	Every hour (GOES overpass at HH:48) using Mergedsounding
L	Improved aerosol extinction in RRTM_SW
M	Evaluation of beta-test version of newly-calibrated MFRSR data
N	Evaluation of old PIR calibration
O	Evaluation of new PIR calibration
P	Test run of direct input of cloud properties (Comstock)
Q	RRTM_SW with Monte Carlo Independent Column Approximation (ref)
R	RRTM_SW with Monte Carlo Independent Column Approximation (actual)
S	Evaluation of ECMWF Cloud Overlap Method

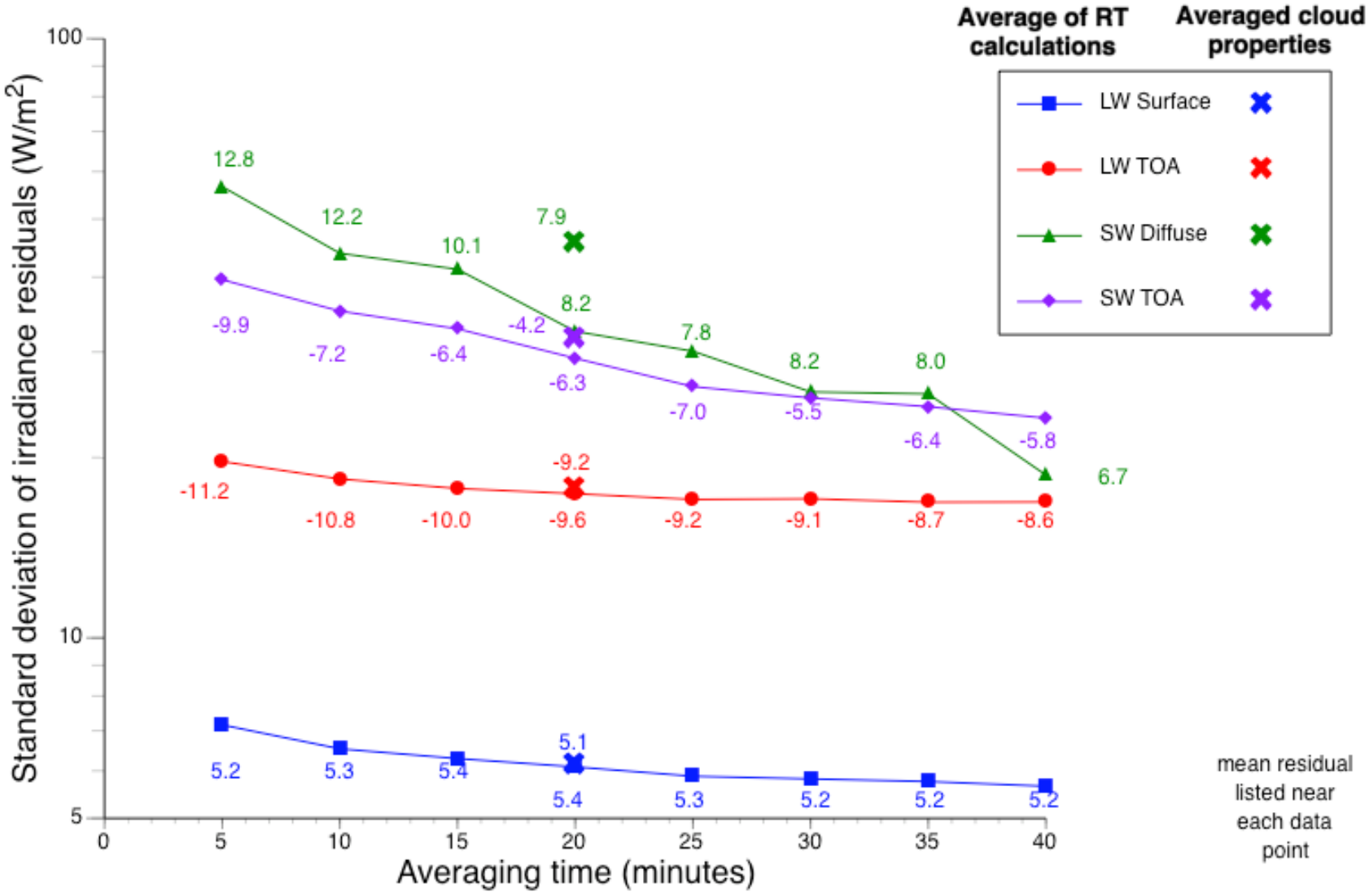
More than 60 BBHRP versions have been created since the inception of the project.

Evaluating MC-ICA

SW Diffuse Residuals, Overcast Cases, 3/00 - 2/01

Method	Cloud type	N	Mean residuals ($W\ m^{-2}$)	Stdev of residuals ($W\ m^{-2}$)
Reference (non-GCM)	Mixed	72	22.2	46.1
v1.4.1tL	Ice	53	-19.3	49.9
ECMWF (GCM)	Mixed	65	13.9	101.3
v1.4.1tR	Ice	55	72.3	84.9
MC-ICA (GCM)	Mixed	72	19.1	47.2
v1.4.1tS	Ice	53	-26.8	51.2

Effect of time-averaging on residuals: ice clouds



Summary

- BBHRP a key tool for ARM community

  Welcome input about:

  - Cloud retrievals (directly from PIs)
  - New trials
  - Analyzing heating rates

- SGP: Mature, but still improving

  Return to grid cell

  NSA: Improvement plan being implemented

  PRY: Next (or maybe TWP)

- Journal articles in works

Web sites: //engineering.arm.gov/~shippert/BBHRP

//iop.archive.arm.gov/arm-iop/0pi-data/mlawer/