The Broadband Heating Rate Profile (BBHRP) Project

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Objectives of the Broadband Heating Rate Profile VAP

- ❖ Extend ARM measurement-model **closure studies** to:
  - shortwave
  - cloudy skies
    - issues: retrieval method, inhomogeneities, sampling, …
  - grid-cell-sized domain
  - TOA
  - All ARM Climate Research Facilities
- ❖ For use by SCMs, compute **heating rate profiles** based on in-situ measurements and using validated radiative transfer model
- ❖ Generate **dataset** of measured and modeled radiation for both Central and Extended Facilities at SGP
- ❖ Provide **'test suite'** for researchers evaluating parameterizations and data sources

"So the first question that we need to answer is: Given a specified three-dimensional field of cloud properties, can we compute with sufficient accuracy the solar and terrestrial radiative flux transfer and associated atmospheric heating rates through the clouds?"

Ackerman and Stokes, *Physics Today*

☆ Obtain BBHRP results, documentation, etc. at **http://engineering.arm.gov/~shippert/BBHRP** ☆

☆ Obtain BBHRP PI product at ARM IOP archive: http://iop.archive.arm.gov/arm-iop/0pi-data/mlawer ☆

Analysis of Temporal Averaging of Retrieved Cloud Properties in BBHRP

Background: The cloud properties used in BBHRP are a 20-minute average of the cloud properties retrieved by Microbase (every 10 s).

Questions: Is 20 minutes a reasonable time period over which to average?

Should averaging be done at all or does it introduce large errors that prevent retrieval quality from being assessed?

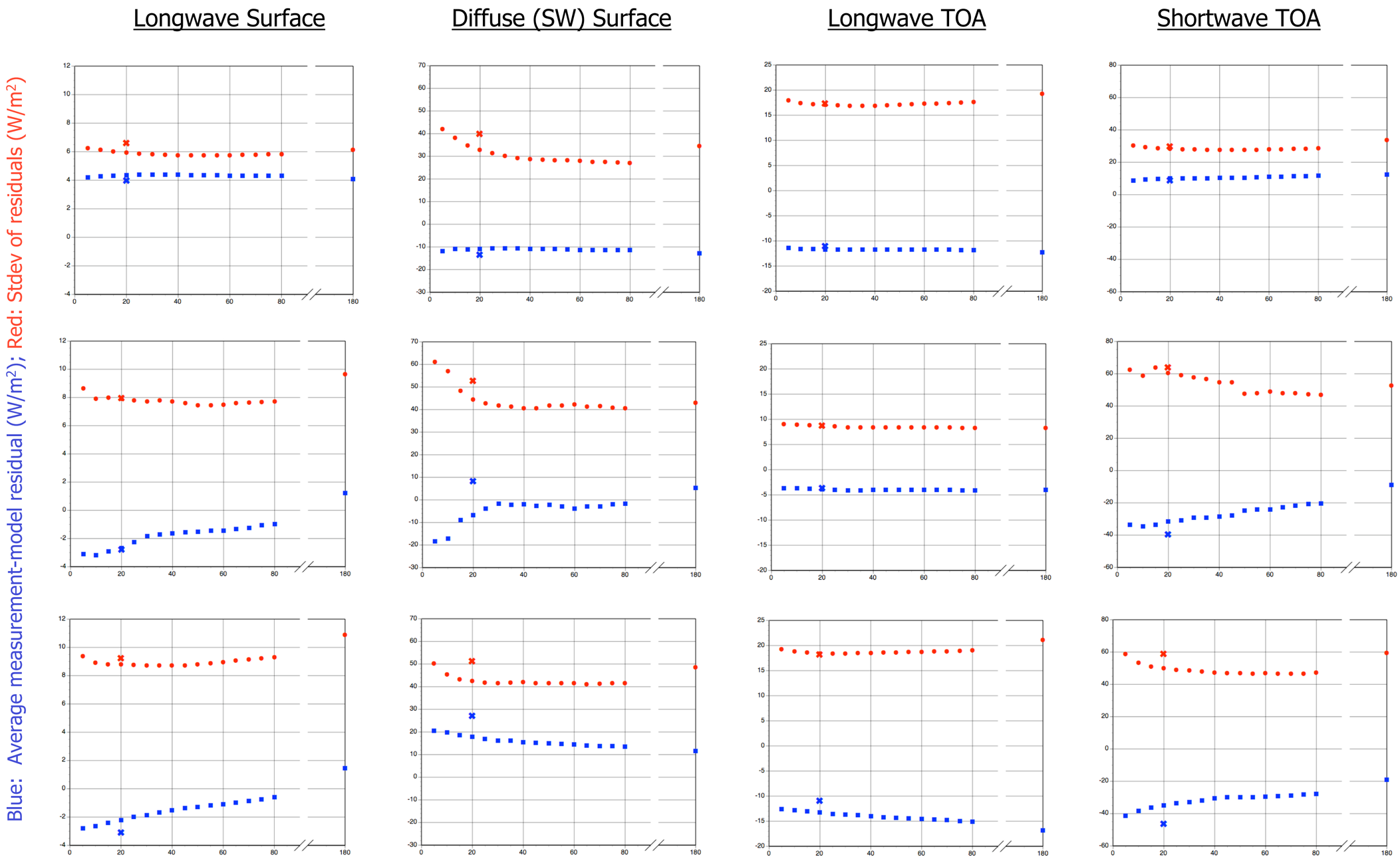
Approach:

1) Run separate calculations for each 10 s retrieval (i.e. Independent Column Approximation) for year at SGP (3/00-2/01).

2) Average surface and TOA ICA LW and SW fluxes every hour (hh:50) for different averaging periods: 5,10,…,80, 180 mins.

3) Compute residuals for each averaged flux vs. the usual BBHRP measurements: (at hh:50) 5-min avg. of surface fluxes, 10 km GOES.

4) For each cloud type, compare statistics of residuals for each averaging period and for standard BBHRP calculation (symbol **X** on plots).



Results:

1) Almost all boundary conditions have a temporal averaging period for which the stdev is minimized (i.e. no asymptotic behavior).

2) Standard deviation minimum varies depending on field -- in general, 30-60 minute averaging works well -- 20 minutes is not optimal.

3) The average residual can be a deceiving measure of quality of the calculation.

4) Using the average retrieved cloud properties can introduce large errors, especially for surface diffuse flux.

Plan: **Evaluate using shorter (5-min.) average of cloud properties for calculation, then averaging calculated fluxes over longer time period than 20 min. (30 min.) for comparison with measurements.**

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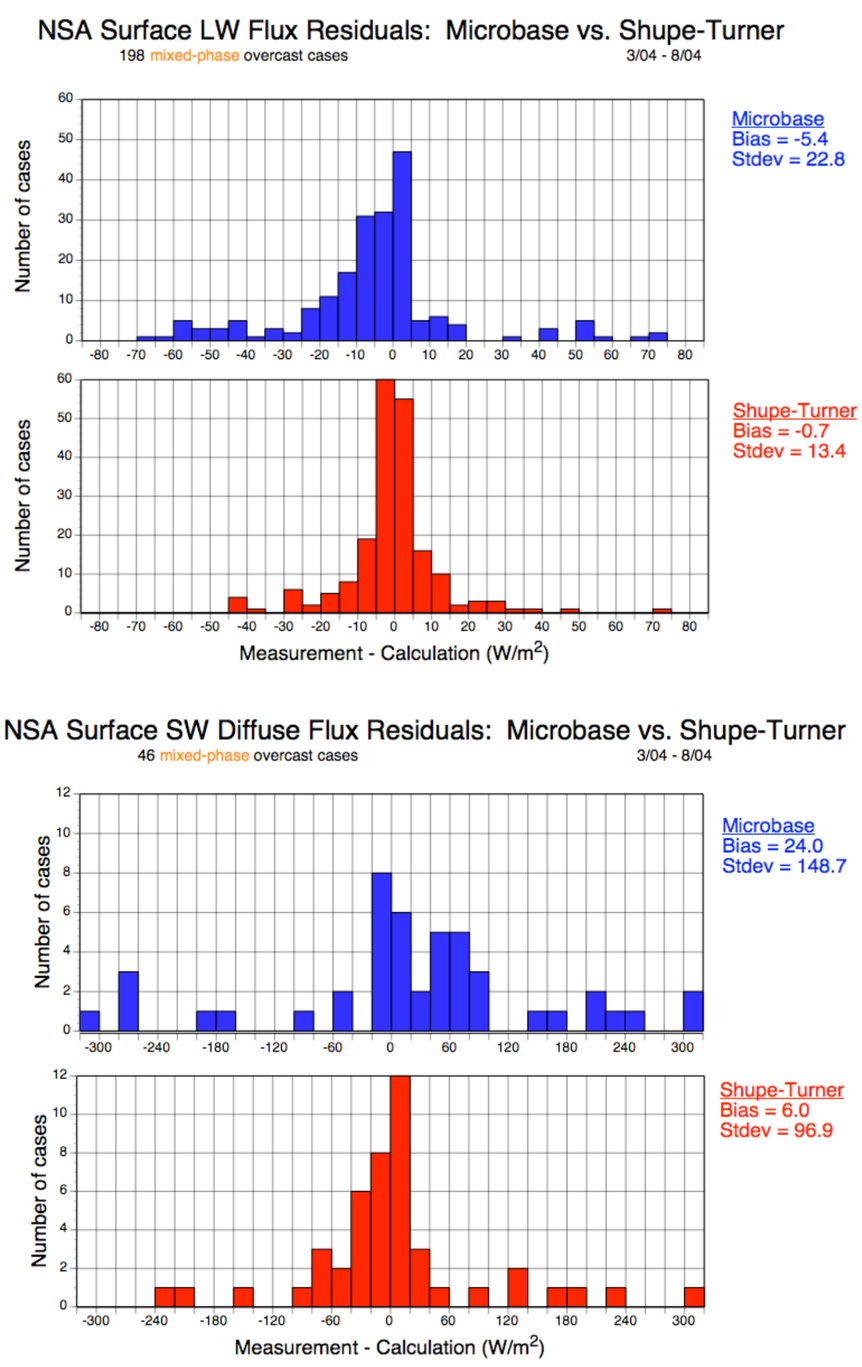
Evaluating Shupe-Turner Mixed-Phase Retrieval at NSA

Background: Mixed-phase cloud are prevalent at NSA, but their microphysical properties are challenging to retrieve. The measurement-model statistics using the Microbase retrieval show there is room for improvement.

Question: Can the multi-sensor retrieval approach of Shupe-Turner improve the measurement-model agreement for mixed-phase clouds at NSA?

Approach: Run BBHRP trials for 6-month period at NSA using Microbase and Shupe-Turner retrievals.

Results:



- The BBHRP results using Shupe-Turner show significant improvement at the surface relative to those from Microbase. The TOA agreement (not shown) is basically unchanged.

Evaluating McICA Cloud Overlap with BBHRP

Background: The Monte Carlo Independent Column Approximation (developed by Barker, Pincus, and collaborators) employs a stochastic approach for handling the vertical overlap of clouds, obtaining the correct solution on average.

Questions: How does the variability introduced by McICA affect the statistics of measurement-model agreement in BBHRP? How do the BBHRP/McICA statistics compare with those obtained with an existing GCM cloud overlap code?

Approach: Run year-long BBHRP trials with shortwave radiation codes RRTM (v1.4.1tL), RRTMG/ECMWF (v1.4.1tS), and RRTMG/McICA (v1.4.1tR), all using MR overlap.

Results:

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

- RRTMG/McICA, as expected, provides effectively the same mean residual as RRTM (but is a much faster code). The variability introduced by the statistical approach of McICA does not appreciably degrade the statistics of measurement-model agreement relative to RRTM.
- The MR solution of the radiation code RRTMG/ECMWF does not agree well with measurements compared to the other MR approaches.

As of today, RRTMG/McICA is the new operational shortwave radiation code at ECMWF.

Other BBHRP Developments

♦ Top priorities for this coming year:
- Evaluation of additional cloud retrievals
- Tropical Western Pacific
- SGP GCM-grid (P_a) product

♦ BBHRP cases chosen for Phase 1 of Continuous Intercomparison of Radiation Codes (CIRC) project - See Oreopoulos et al. poster

♦ Longwave clear-sky comparisons at Niamey AMF deployment show residuals between measurements and model larger than at other sites - See Bharmal et al. poster

♦ North Slope of Alaska ACRF - One-year run complete
- Shupe-Turner mixed-phase retrieval compared to Microbase (see above)
- Recent trials:

2.3tF	Revised Microbase and Aerosol Best Estimate
2.3tG	Radar 'clutter' removed for Microbase
2.3tH	Small change to Microbase
2.3tJ	Limited trial of Shupe-Turner retrieval
2.3tN	Microbase with improved Mergedsounding
2.3tO	Shupe-Turner with improved Mergedsounding

♦ Southern Great Plains ACRF - Year 2000 analyzed thoroughly
More years to be processed
- Easy input capability for alternate cloud retrievals has been developed
  - o Comstock lidar-based algorithm in process
  - o Mitchell/d'Entremont on deck
  - o all retrievals welcome
- Current version of 'instantaneous' VAP: P_i version 1.4.1
- Recent trials:

1.4.1tH	Temporal averaging analysis (see poster)
1.4.1tL	Revised RRTM_SW
1.4.1tM	Revised MFRSR data
1.4.1tN,O	Analyze revised pyranometer calibration
1.4.1tP	Comstock lidar-based retrieval
1.4.1tQ,R	RRTMG_SW with McICA cloud overlap
1.4.1tS	RRTMG_SW with ECMWF cloud overlap
1.4.1tT	Improved Mergedsounding
1.4.1tU	9-pixel GOES instead of 10 km