BBHRP Radiative Flux Closure Under Cloudy Conditions from a “Shadow” Dataset

L. Oreopoulos[1], E. Mlawer[2], T. Shippert[3], and J. Delamere[2],

1. JCET– University of Maryland Baltimore County 2. Atmospheric and Environmental Research Inc. 3. Pacific Northwest National Laboratory

Our goal

To learn when and why we succeed or fail to achieve radiative flux closure (*RFC*) under cloudy conditions in BBHRP.

Our tools

The BBHRP dataset itself and radiative fluxes calculated as in BBHRP (aka our “shadow” dataset) with two pairs (SW and LW) of additional RT algorithms: from CAM3 and from GSFC’s fvGCM. BBHRP uses AER’s SW and LW RRTM codes.

How do we learn from such an approach?

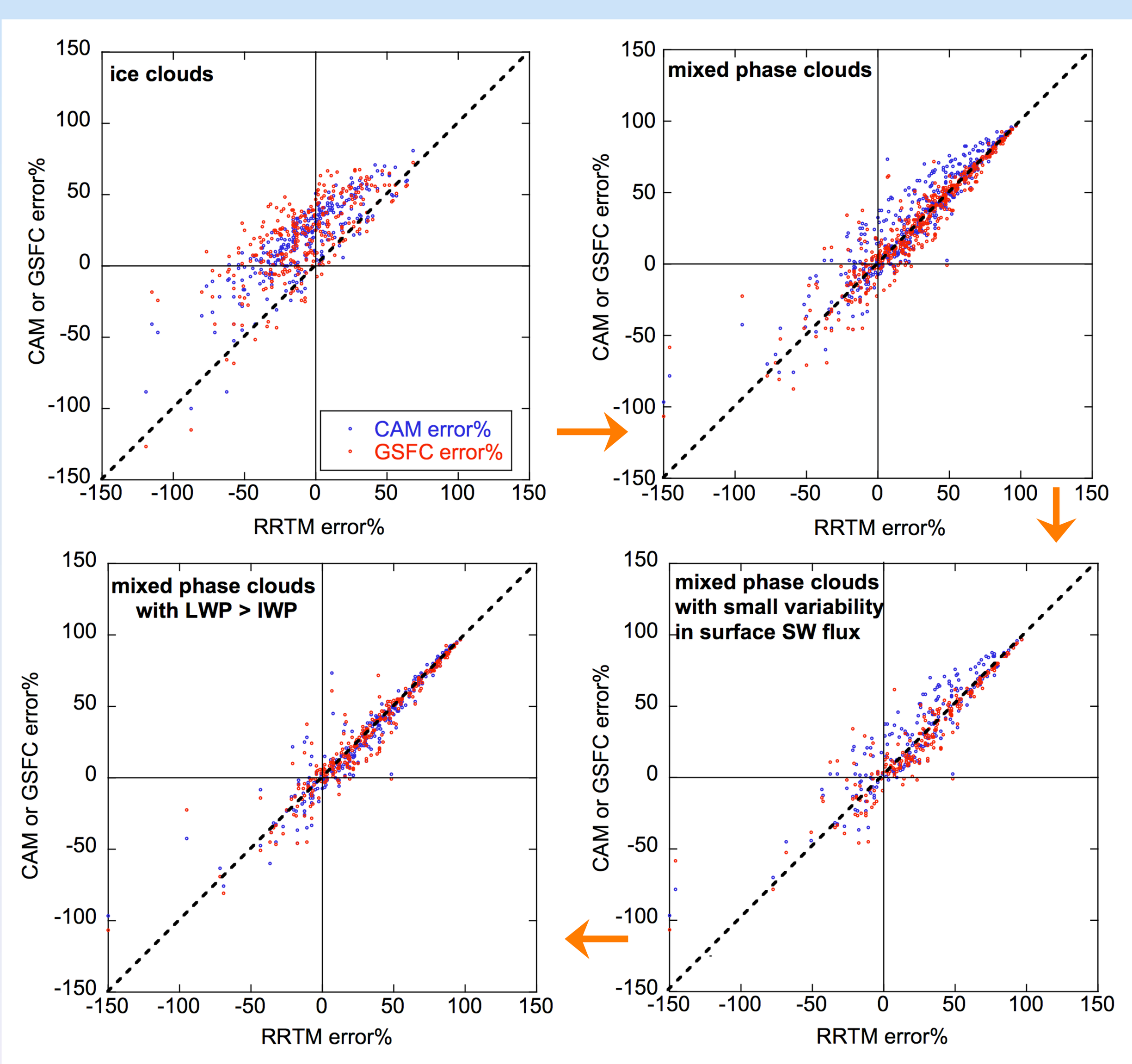
If the RT models generally agree, but disagree with the observations for particular types of conditions, there is greater likelihood that there are flaws in the input. If on the other hand, for the same conditions the models give a wide range of answers, with some being close and some being far from the observations, flaws in the failing models are likely.

Specific tests

We examine:

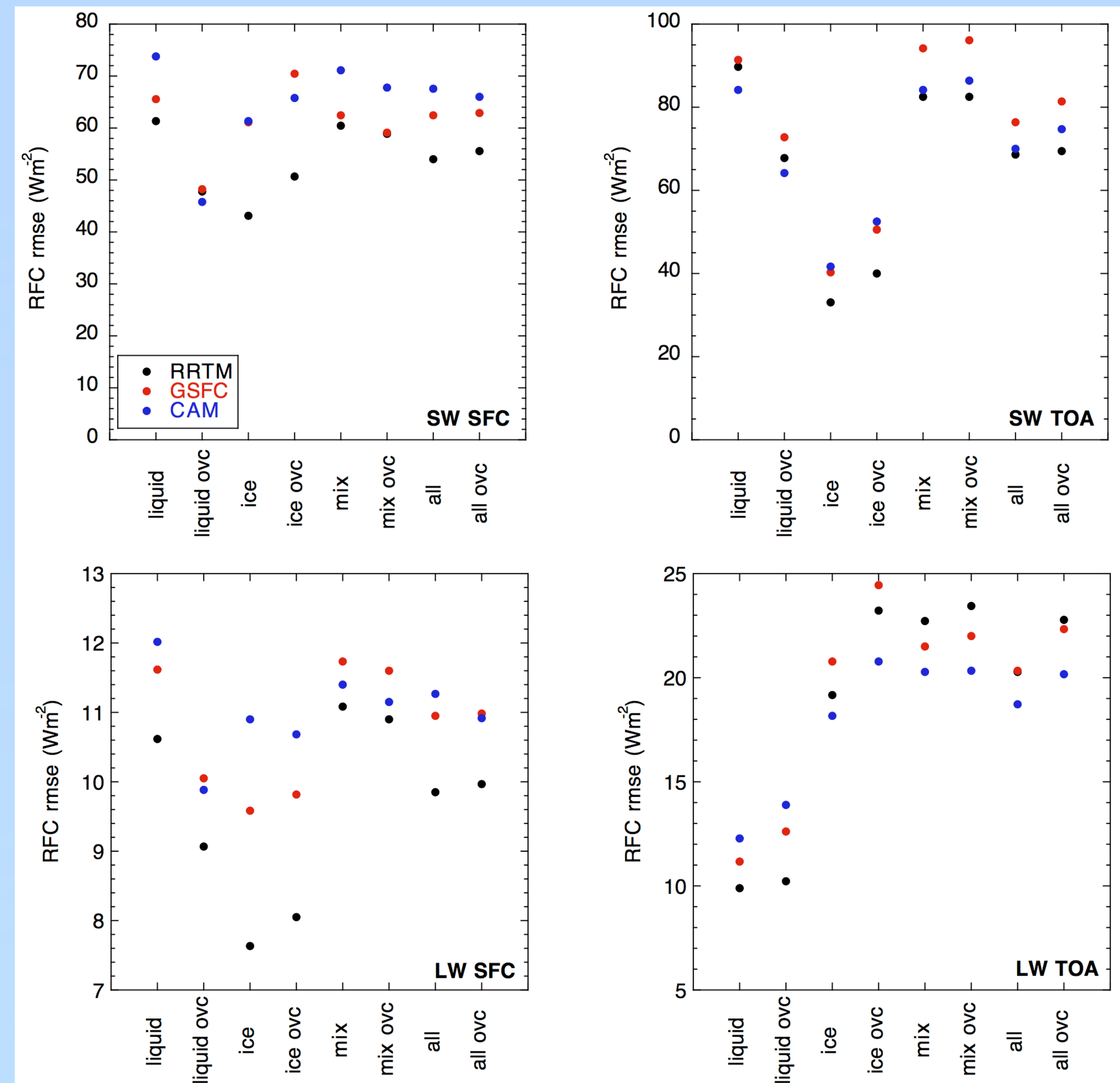
- The correlation of *RFC* errors between RRTM and the other models
- The *RFC* rmse’s for all models under different cloud conditions
- The *RFC* absolute mean deviation under different cloud conditions
- GSFC and CAM errors for small and large RRTM errors

Ice vs. mixed vs. liquid clouds

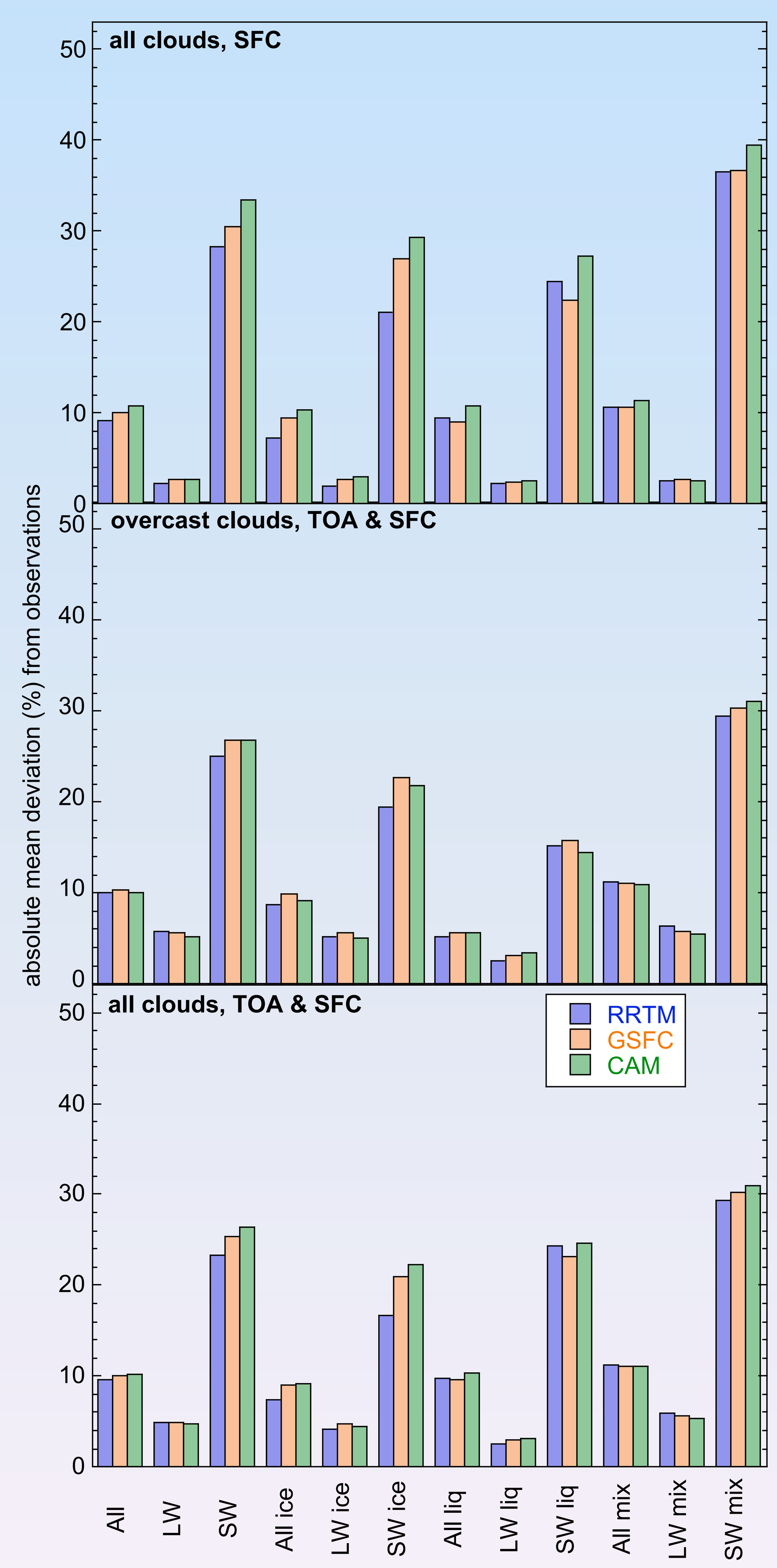


RFC errors (obs-calc) calculated for clouds containing ice crystals. Clockwise from top: Percent errors in downwelling SFC SW diffuse flux for the CAM and GSFC RT codes vs. those for RRTM for overcast clouds identified to consist exclusively of ice crystals; similar, but for overcast mixed-phase clouds; for overcast mixed-phase clouds that are relatively homogeneous; for overcast mixed-phase clouds with more liquid water than ice water. Note the greater scatter (but still correlated errors) for pure ice clouds and the significant tightening of the error dispersion only when significant water amounts coexist with ice. Based on BBHRP version 1.4.1tK data (like everything in this poster).

How close are the models?



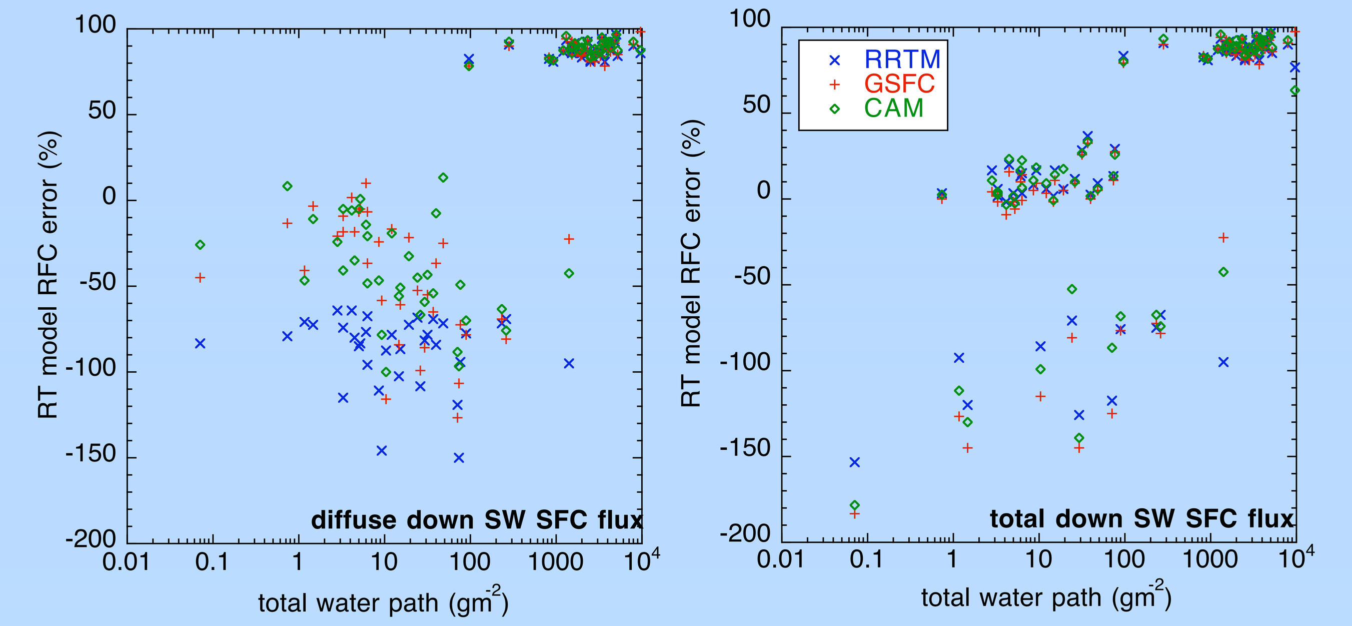
RFC rmse’s for different radiation budget components as function of cloud type (phase, cloud fraction). TOA rmse’s are worse than SFC, SW rmse’s are worse than LW, and overcast is not necessarily better than average cloud conditions. RRTM is almost always better (LW TOA has almost all exceptions). SW SFC is diffuse.



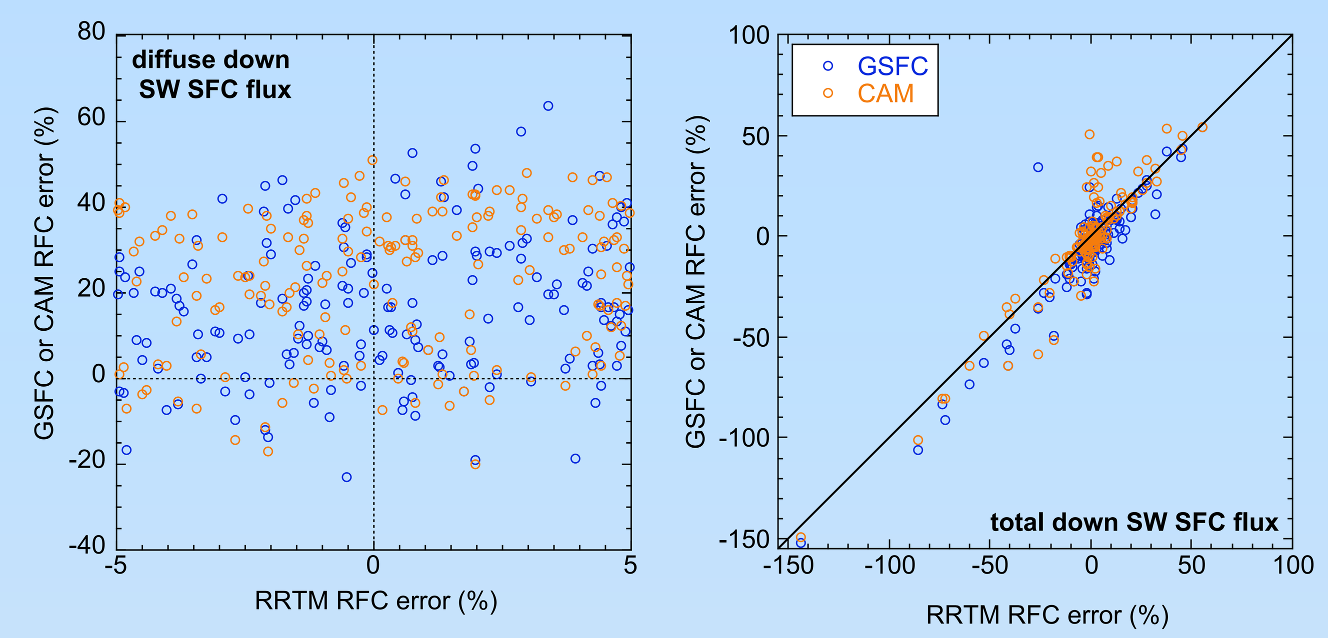
$$AMD(\%) = \frac{100}{N}\sum_{i=1}^{N}\frac{\left|F_i^{obs} - F_i^{calc}\right|}{F_i^{obs}}$$

RFC’s in terms of % absolute mean deviations (AMD, see above). “All” means both SW and LW, and N is the total number of measurements which depends on the type of AMD calculated. This metric expresses the overall performance of the models. Note that adding TOA in the AMD calculation actually improves the performance in the SW. Inter-model differences are much smaller than differences from observations. SW SFC is diffuse.

High and low RRTM errors



RFC % SW SFC errors (obs-calc) vs. TWP for cases with RRTM diff errors greater than mean ± 2sdev. For the thin and moderate TWP’s (~55% of cases) RRTM SW diff errors do not correlate with the errors from the other two models. However, for large TWPs, the errors collapse (left). Much better correlation is seen for total (diff+dir) flux (right), indicating differences in partitioning total flux into direct and diffuse.



RFC % SW SFC errors (obs-calc) of RRTM vs. those of GSFC and CAM for cases with RRTM diff errors within ± 5%. These are most often cases with very low TWP (~64% of cases with TWP < 30 gm^{-2}). SW diff errors seem to be totally uncorrelated (left), but SW total flux error correlate well. Again, we are dealing with discrepancies in the diffuse and direct partition.

Summary of findings

Our analysis shows that:

- There is broad consistency between the BBHRP (RRTM) closure errors and those of the “shadow” dataset, pointing to problems in the values or interpretations of the input.
- Inter-model inconsistencies are greater for ice and mixed-phase clouds.
- Many large SW SFC closure errors are associated with very thick clouds; for thin clouds the models differ in the partitioning of total flux into direct and diffuse.
- RRTM performs overall better than the other models.
- When all radiation budget components are accounted for (SW & LW, TOA & SFC) the overall flux closure error is ~10%. This is driven largely by the LW, but is still remarkable.

ARM

JCET The Joint Center for Earth Systems Technology