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Long-term Regional Cloud Vertical Distributions over the ARM Sites

S.A. McFarlane

We are in the first year of our NEWS project and are still in a spin-up phase. Our project involves developing a long time-series of cloud vertical distribution products plus associated radiative heating profiles over the ARM tropical and Southern Great Plains (SGP) sites and exploring the variability of the retrieved profiles to environmental conditions and cloud regime. The ARM measurements are very detailed, with high spatial and temporal resolution, but only exist at fixed sites. They cannot be used directly to create the type of monthly, global mean datasets that are being developed for the integration projects. However the utility of the ARM datasets is that through comparisons with the satellite products being produced by other investigators, the strengths and limitations of these satellite products can be better delineated. Thus the satellite datasets become more useful for model evaluation.

We have produced a year of cloud properties and heating rates at two of the tropical sites and are working on expanding that dataset to a longer time period. We have begun comparisons of reflectivity, retrieved cloud properties, and calculated heating rates to similar profiles from the CloudSat instrument (Figure 1). This is the first set of comparisons of cloud properties and radiative heating rates from ground-based and satellite cloud radars. Differences may be due to detection sensitivities of the radars; differences in observing from space versus ground; and differences in retrieval algorithms. Our project also involves improving the cloud property retrievals by implementing an optimal estimation retrieval algorithm, which will provide error estimates on the retrieved properties, unlike most current methods. We are in the process of hiring a postdoctoral researcher to implement the optimal estimation algorithm, and plan for this work to start within the next few months.

At this early point in our project, our primary collaboration with the NEWS team is with Tristan L'Ecuyer. We plan to compare the statistics of the heating rate profiles derived from the ARM observations with those he has derived from the TRMM satellite. An initial comparison was made for the 2007 NEWS meeting, and a more detailed and extended comparison is planned, once some improvements to the TRMM algorithms are fully implemented. Additional comparisons will also be performed using the new ARM retrieval algorithm, when available. These comparisons will help identify cloud types/conditions where the assumptions used in the TRMM retrievals are performing well and where they are not. Since direct measurements of the vertical radiative heating profile are very difficult, these types of comparisons are the best way to evaluate these products. This comparison benefits the NEWS team by improving the understanding of the uncertainties in the global TRMM products being provided. Additionally, we plan to expand this to a larger project that will combine information from ARM, TRMM, CloudSat, and AIRS (Eric Fetzer's group) to evaluate integrated global datasets.

We have also had exploratory discussions about a possible integrative project with Tristan L'Ecuyer and Bill Olsen to explore the relationship of the full diabatic heating

(latent plus radiative) in the tropics to the phase of the MJO. Additionally, as our ARM products become more mature, we plan to develop collaborations with the CERES group (Weilicki and Kato) and do comparisons between the ARM and SARB atmospheric and surface radiation products.

At this point, we have not made specific contributions to the defined integration products. When our full time series of cloud properties and heating rates have been produced, we will provide information on these vertical distributions at SGP to Project 2, which is studying the two extreme years (2006-2007) at the SGP site. There is some overlap in this effort with Xiquan Dong's work, which also involves cloud and radiation analysis at the SGP site, so at this point we have primarily been focusing on the ARM tropical sites rather than SGP to reduce overlap. We also anticipate future participation in Integration Project 1, which is constructing a long-term climatology of the global energy and water cycles. Our role in this project, which is similar to our overall role in NEWS, will be to compare our ARM products to selected satellite products to improve understanding of the uncertainties in the satellite atmospheric and surface energy components.

We have not experienced any issues with our project that our NEWS point of contact would be able to address. Our main issue has been with staffing. Due to the delay in receiving funding, some of our staff became involved in other projects and were not able to devote much time to the NEWS project initially. Re-alignment of projects and the hiring of a postdoctoral researcher within the next couple of months should alleviate this issue.

We anticipate providing the NEWS data center with vertical profiles of retrieved cloud properties (including uncertainty estimates) and corresponding heating rates for several years at the ARM tropical and SGP sites using the updated retrieval algorithm. Some limited datasets at the tropical sites using our current algorithm are available and we will post these on the NDIC. We are examining the time series of datasets from the ARM sites, identifying issues, and determining additional periods for which retrievals and radiative heating can be calculated. We expect to have an expanded dataset ready for the NEWS data center by the fall meeting.

Although the surface and top-of-atmosphere energy budget are more easily measured, the vertical distribution of radiative heating in the atmosphere is an important aspect of the Earth's energy balance and has implications for local and large-scale dynamics. At this point, only limited information is available about the detailed vertical distribution of radiative heating. Our research project thus directly meets the NEWS goal of making significant advances in *"Assessing the global energy and water cycle through an observational record of all associated geophysical parameters"*. In addition, the long time series of observations from the multiple ARM sites allows us to address the seasonal and regional aspects of the cloud properties and radiative heating, which addresses the NEWS goal of "*Assessing the variability of the global energy and water cycle on time scales ranging from seasonal to decadal, and space scales ranging from regional to continental to global."* Comparisons between ARM and satellite products are useful to establish the accuracy and consistency of the satellite products, which can then be used to assess climate model results.

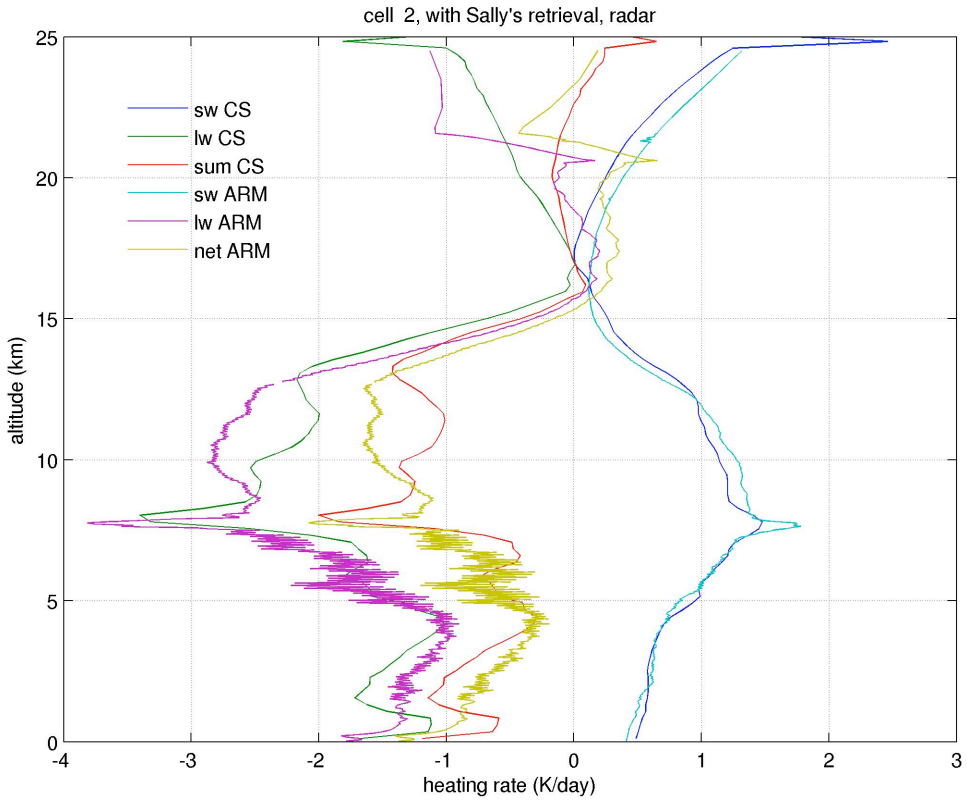

Figure 1. Preliminary comparison of CloudSat (CS) and ARM derived heating rates at Manus Island, in the tropical western Pacific.