The Climate Rainfall Data Center

An Online Data Service Center

BY WESLEY BERG AND CHRISTIAN KUMMEROW

Most datasets are well described by the individuals generating or distributing them, but no data sites exist that summarize the strengths and weaknesses of all the diverse options. As such, it is not surprising that many users are confused about what product to use and where to go to get the data. In addition, errors associated with time-dependent regional biases can limit the usefulness of these data for certain climate applications. Even within the realm of climate rainfall products (i.e., products averaged over significant time and space scales such as 2.5° monthly averages), the choice of the best product or products can be very much dependent on the application. For example, some passive microwave-based retrievals, such as the Microwave Sounding Unit (MSU) precipitation dataset or the Tropical Rainfall Measuring Mission (TRMM) 3A11 dataset, only provide estimates over ocean areas, while others, such as the TRMM 2A12 dataset, utilize different techniques over land and ocean. In addition, due to the tropical orbit of the TRMM satellite, products from the TRMM sensors are limited to between approximately 40°S and 40°N. Products from geostationary satellites are also limited to maximum latitudes of around 40° to 50°, while products from polar-orbiting satellites such as the Special Sensor Microwave Imager (SSM/I) often suffer from relatively poor temporal sampling. These are but a few examples of many of the relevant factors that must be considered when selecting a dataset. The result is that researchers may use the available datasets in an inappropriate manner, which may lead to erroneous conclusions.

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To assist users in the selection of the appropriate dataset(s) for a given application, NASA has funded the development of a Climate Rainfall Data Center (CRDC) (**http://rain.atmos.colostate.edu/CRDC**). The CRDC is an experimental data service center designed to assess if overall data access and usage from NASA data centers can be improved by adding a layer of service that is discipline specific, while leaving the data distribution task to existing data centers. The CRDC Web site is designed to provide users with information on available climate rainfall datasets, provide online tools for users to compare most publicly available climate rainfall products, and, perhaps most importantly, give users access to scientists with expertise on the available products. Some examples using the online plotting capabilities of the CRDC Web site are explored in the section titled "ENSO variability in tropical mean rainfall."

CLIMATE RAINFALL DATA. The longest time series of rainfall observations are available from rain gauges dating back over 100 years. In contrast, the global coverage needed for many applications is only available from satellites since 1979. Unfortunately, these early estimates do not come from satellites designed for precipitation monitoring. Instead, these rainfall estimates are based upon proxy data collected from infrared (IR) imagers and microwave sounders on board NOAA's operational geostationary and polar-orbiter programs. As such, these products have significant limitations that have become apparent through comparisons with higher quality data from in-situ observations as well as more recent satellite sensors designed to detect and retrieve rainfall. A major technological advance in satellite rainfall observations occurred with the launch of the SSM/I on board the Defense Meteorological Satellite Program (DMSP) spacecraft in 1987. While the SSM/I provided a more physically direct, and thus more accurate, method for estimating rainfall from space, poor temporal sampling (i.e., ≤ once daily) limited its use for many applications. This led investigators (Xie and

Arkin 1997; Huffman et al. 1997) to merge these data with rain-gauge records and 3-hourly infrared imagery from geostationary satellites. In 1997, there was another significant technological advance in satellite precipitation monitoring when a complement of sensors, including the first spaceborne precipitation radar (PR), was launched onboard TRMM. The TRMM precipitation radar provided high-resolution (~4 km) vertical rain profile information of storm systems across the global Tropics. Outside the Tropics, observations from the Advanced Microwave Scanning Radiometer (AMSR-E) instrument onboard the Earth Observing System (EOS) *Aqua* satellite, launched in March 2002, promise to provide improved near-global rainfall observations. Following the success of TRMM, plans for the Global Precipitation Mission (GPM), currently scheduled for launch in 2010, promises to offer an even more accurate description of rainfall processes in the future by combining near-global coverage of a dual-frequency precipitation radar system with a constellation of radiometers.

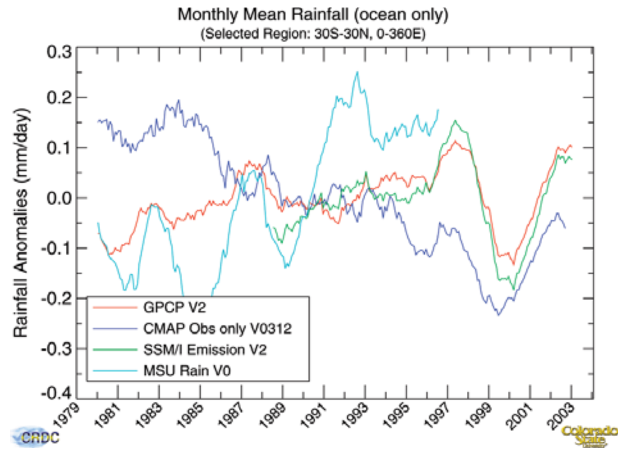

Fig. 1. Time series of tropical mean oceanic rainfall (30°S–30°N) from GPCP version 2 and CMAP version 0312. Rainfall estimates based on passive microwave observations from MSU (through July 1997) and SSM/I (from July 1987 forward) are also shown. The time series have been smoothed using a 25-month running mean filter to remove seasonal variability, resulting in a truncation at the ends of the time series.

ENSO VARIABILITY IN TROPICAL MEAN RAINFALL. Given that existing climate rainfall products either do not contain estimates of the uncertainties or contain uncertainty estimates that do not include the impact of regional biases, one of the best strategies for a user to determine whether or not a given dataset is appropriate for a particular application is to compare results between existing products. As an example, a comparison of tropical mean rainfall anomalies generated using the online interactive plotting capabilities of the CRDC Web site is shown in Fig. 1. This comparison includes data from two long-term merged rainfall products, the Climate Prediction Center's (CPC) Merged Analysis of Precipitation (CMAP) and the Global Precipitation Climatology Project (GPCP) dataset, as well as single-sensor passive microwave rainfall estimates from MSU and SSM/I. The most obvious difference between the two merged products is that of a significant decreasing trend in the CMAP dataset, but no discernible trend in the GPCP dataset. Both datasets exhibit an increase in rainfall associated with the strong 1997/98 El Niño; however, the impact of the 1982/83 El Niño on the CMAP dataset is much less clear. Surprisingly, although the CMAP product incorporates the MSU estimates while the GPCP product does not, the increase in MSU rainfall associated with the 1982/83 El Niño is larger than that shown by either of the merged products.

Understanding why there are such large differences in ENSO-related climate variability between these datasets requires intimate knowledge of the data products, including limitations of the sensors and the associated retrieval methods and/or merging approaches. In the example shown in Fig. 1, the interannual variability of the GPCP dataset tracks the SSM/I estimates much more closely than does the CMAP dataset. This is likely due to the fact that while both these merged datasets rely heavily on the SSM/I data for oceanic rain estimates, they use distinct approaches to combining the various satellite/gauge component datasets. Specifically, the GPCP dataset uses the SSM/I emission estimates over the ocean to adjust the IR-based rainfall estimates, while CMAP relies on data from the Pacific atoll gauge network to remove tropical rainfall biases from each of the component satellite datasets. For this reason, it is not surprising that although there are differences, variability in tropical mean rainfall from GPCP is relatively similar to that exhibited by the SSM/I emission estimates.

A subsequent comparison of ENSO-related variability in tropical mean rainfall using state-of-the-art estimates from TRMM is shown in Fig. 2. Although the time series shown in Fig. 2 is limited to the period from December 1997 through mid-2004, rainfall estimates from the TRMM microwave

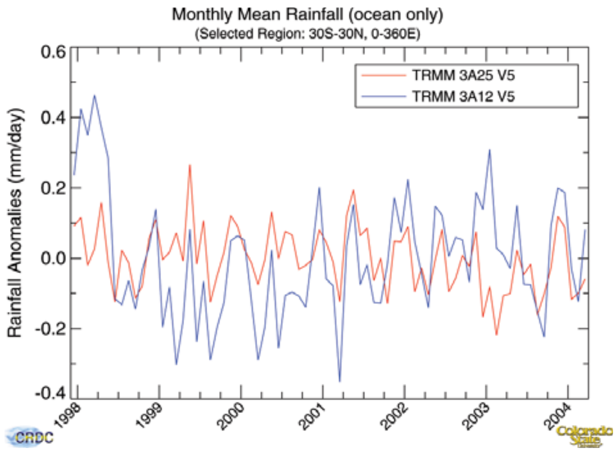

FIG. 2. Time series of tropical mean oceanic rainfall (30°S–30°N) from the TRMM PR (2A25) and TMI (2A12) retrieval algorithms.

imager (TMI) 2A12 algorithm and the PR 2A25 algorithm display significantly different responses to the 1997/98 El Niño. It should be noted that the 3A12 and 3A25 products shown in Fig. 2 are simply gridded monthly accumulations of the pixel-level 2A12 and 2A25 estimates, which are computed from the satellite overpass data. The TMI 3A12 dataset indicates a significant increase in tropical mean rainfall associated with El Niño, but there is little or no response in the PR 3A25 data. Results from two different TMI retrieval algorithms (3A12 and 3A11) are shown along with estimates from SSM/I in Fig. 3 for the same period. As indicated in the figure, the three retrieval techniques on the two different platforms exhibit remarkably good agreement over the nearly 7-yr period. In addition, the PR and TMI estimates show good agreement over land regions (not shown), suggesting that the PR/TMI differences are significant and not simply a manifestation of random sampling and/or algorithm details. It should not be assumed, however, that either the TMI or PR results are correct, as both retrieval algorithms employ assumptions that can exhibit significant regional variations. These results led Berg et al. to conclude in the *Journal of Climate* in 2002 that changes in the structure and microphysical properties of oceanic clouds result in time-dependent regional biases in even the latest TRMM satellite estimates. The only conclusion that can currently be drawn from these results is that regional biases have a significant impact on estimates of tropical mean rainfall variability from even the most advanced satellite rainfall sensors and associated retrieval algorithms, and that the "true" response of tropical rainfall to ENSO is uncertain.

Results such as those shown in Figs. 1 and 2 do not mean that currently available climate rainfall datasets are unsuitable for any climate applications. In the case of tropical mean rainfall variability, increases in rainfall over the central/east Pacific associated with ENSO are countered by decreased rainfall over the warm pool region. As a result, errors associated with regional biases in the rainfall estimates are as large as or larger than the changes in tropical mean rainfall. In contrast, Fig. 4 compares monthly mean

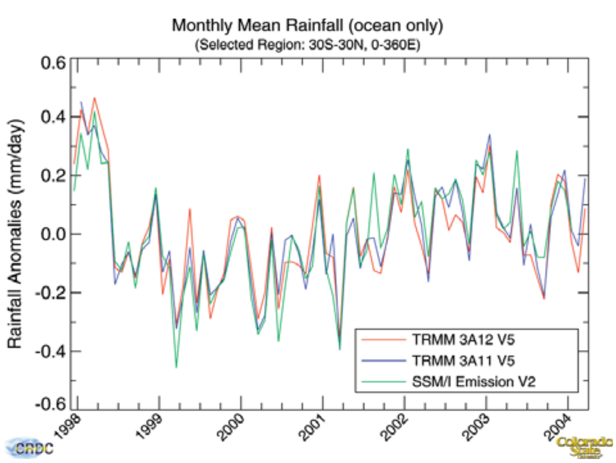

FIG. 3. Time series of tropical mean oceanic rainfall (30°S–30°N) from three different passive microwave retrieval algorithms, including TRMM 2A12 and 3A11 and an SSM/I emission-based algorithm.

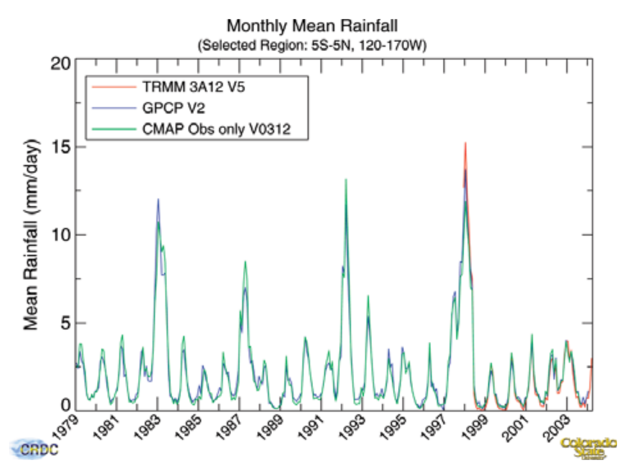

FIG. 4. Time series of monthly mean rainfall over the Niño 3.4 region from GPCP Version 2, CMAP version 0312, and TRMM 3A12 version 5.

rainfall time series over the Niño-3.4 region (5°S–5°N, 120°–170°W). Trenberth and Stepaniak used SST anomalies exceeding 0.4°C in this region to identify the occurrence of El Niño. In this case, the latest TMI (2A12) estimates agree very well with the long-term merged rainfall products. Both GPCP and CMAP show significant increases in rainfall associated with the major 1982/83 and 1997/98 events as well as the weaker 1987/88 and 1991/92 events. This is due to the fact that the climate signal in this case is significantly larger than the errors associated with time-dependent biases over this region.

All of the figures shown in this paper were generated online using the interactive product intercomparison feature on the CRDC Web site (**http://rain.atmos.colostate.edu/CRDC**). This interactive plotting capability gives climate rainfall data users the opportunity to quickly compare most publicly available datasets over their specified region and period of interest. As shown in Figs. 1 and 2, this may indicate significant discrepancies between available datasets suggesting caution in their use, or, as in Figs. 3 and 4, such a comparison may indicate that the products of interest are in good agreement. Of course, while such comparisons provide a useful indication of the strength of the climate signal relative to errors in the retrieval, a more detailed understanding of the limitations of the various datasets is often needed. For this reason, users who have questions that are not answered via the online CRDC resources are encouraged to contact the authors via the CRDC Web site.

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FOR FURTHER READING

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