US National Oceanic and Atmospheric Administration
Climate Test Bed Joint Seminar Series
ESSIC/UMD, College Park, Maryland, 9 March 2009

Validation of Reanalysis Daily Precipitation over the Americas

V. B. S. Silva, V. E. Kousky, R. W. Higgins and Emily Becker
Climate Prediction Center, NOAA/NWS/NCEP
Camp Springs, MD, 20746

1. Introduction

An intercomparison of the statistics of daily precipitation over the Americas is carried out using gridded station data and the current generation of reanalysis products in use at the National Centers for Environmental Prediction (NCEP). Several simple measures are used to characterize relationships between the observations and reanalyses for the period of record, including difference in the means, ratio of variances, and correlation. Seasonality is accounted for by examining these measures on a monthly basis, using daily data in each case.

The intercomparison is motivated by Climate Prediction Center (CPC) plans to replace the current generation of reanalysis products in use for operational monitoring and prediction activities with a new generation of reanalysis products currently under development at the National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC) as part of the Coupled Forecast System Reanalysis and Reforecast (CFSRR) Project. A careful validation of the current generation of reanalysis products will provide a benchmark that can be used to confirm that the new generation of reanalysis products is an improvement.

2. Background

Since the mid-1990's the Climate Prediction Center (CPC) has used the National Centers for Environmental Prediction (NCEP) / National Center for Atmospheric Research (NCAR) reanalysis products (Kalnay et al. 1996; referred to as R1) and their real-time extension forward in time via the Climate Data Assimilation System (CDAS) for operational climate monitoring and prediction activities. The current generation of reanalysis products is among the most popular and widely used climate data sets currently in existence. The NCEP/DOE Reanalysis (R2), obtained using an updated forecast model and data assimilation system (Kanamitsu et al. 2002), is also used at CPC.

The NCEP is currently developing the next generation of reanalysis products as part of the Climate Forecast System (Saha et al. 2006) Reanalysis and Reforecast (CFSRR) project – a project that is driven by NCEP's intraseasonal-to-interannual prediction needs. The Environmental Modeling Center (EMC) plans call for the CFSRR to extend over the period 1981-present. CPC plans to extend the CFS reanalysis backward in time to 1948 and forward in real-time in order to satisfy operational climate monitoring and prediction needs. One of the advantages of the extension backward in time is that it will increase the number of cases of the low frequency modes of climate variability, such as ENSO, for a proper comparison of the CFSR to the current generation of reanalysis (R1 and R2). The CFS reanalysis products are expected to be a major improvement over the current global reanalysis, as they will be the result of a coupled Ocean-Atmosphere-Land system at higher spatial resolution.

3. Preliminary results for United States

Daily precipitation statistics were computed for the reanalyses (R1 and R2) and the observations (CPC gridded precipitation analysis). R1, R2 and OBS time series were constructed for the domain 20°N-60°N, 60°W-140°W, at a horizontal resolution of (lat/lon)=(2.5°x2.5°). Here we will show some results of three basic statistics: a) differences in probability of occurrence, b) ratio of variances, and c) correlation.

The probability of daily precipitation greater than 1 mm (Fig. 1) is less than observed in R1 and R2 over the Southeast during November to March (with slightly greater biases in R2) and less than observed over the Southwest during June to September (with greater biases in R1). Both R1 and R2 have greater than observed probabilities over the Southeast during June to September (with greater biases in R1).

Correspondence to: V. B. S. Silva, Climate Prediction Center, NOAA/NWS/NCEP, Camp Springs, MD, 20746;
E-mail: Viviane.Silva@noaa.gov

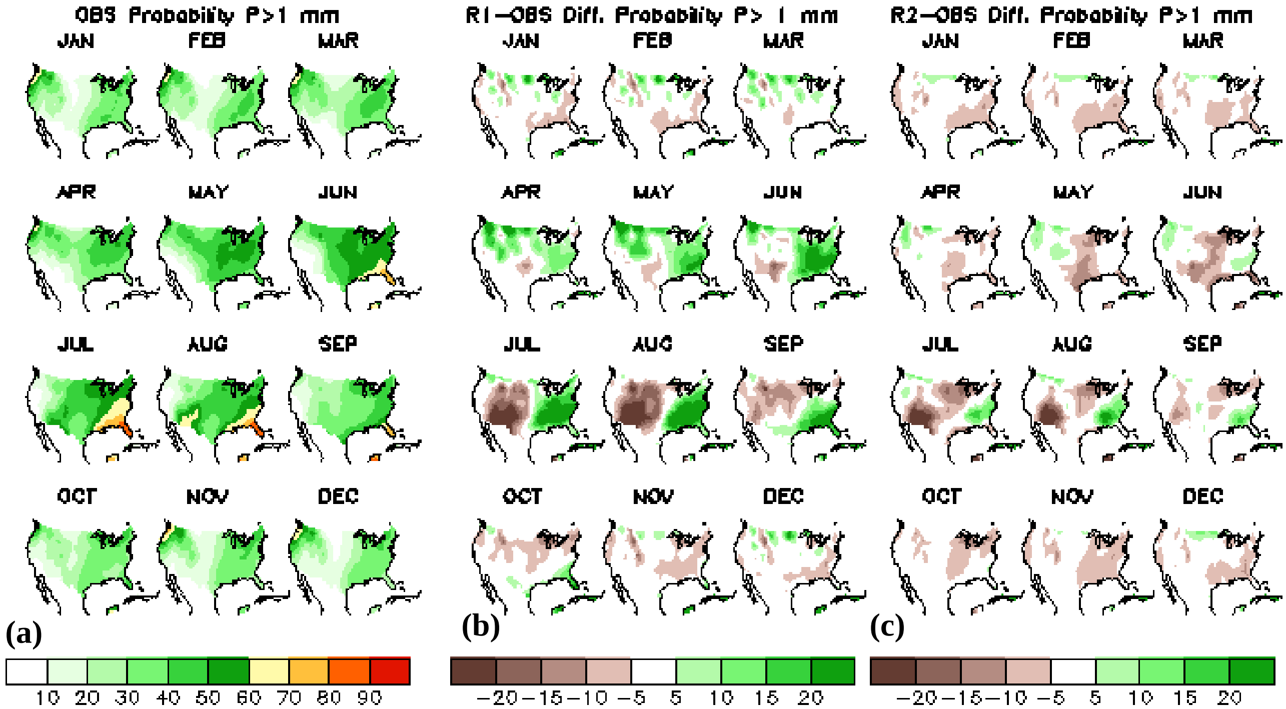

Fig. 1. Probability of daily precipitation greater than 1 mm in (a) OBS, and expressed as the difference between (b) R1 and OBS, and (c) R2 and OBS. Results are shown for each month of the year and are based on daily data for the period 1979-2006.

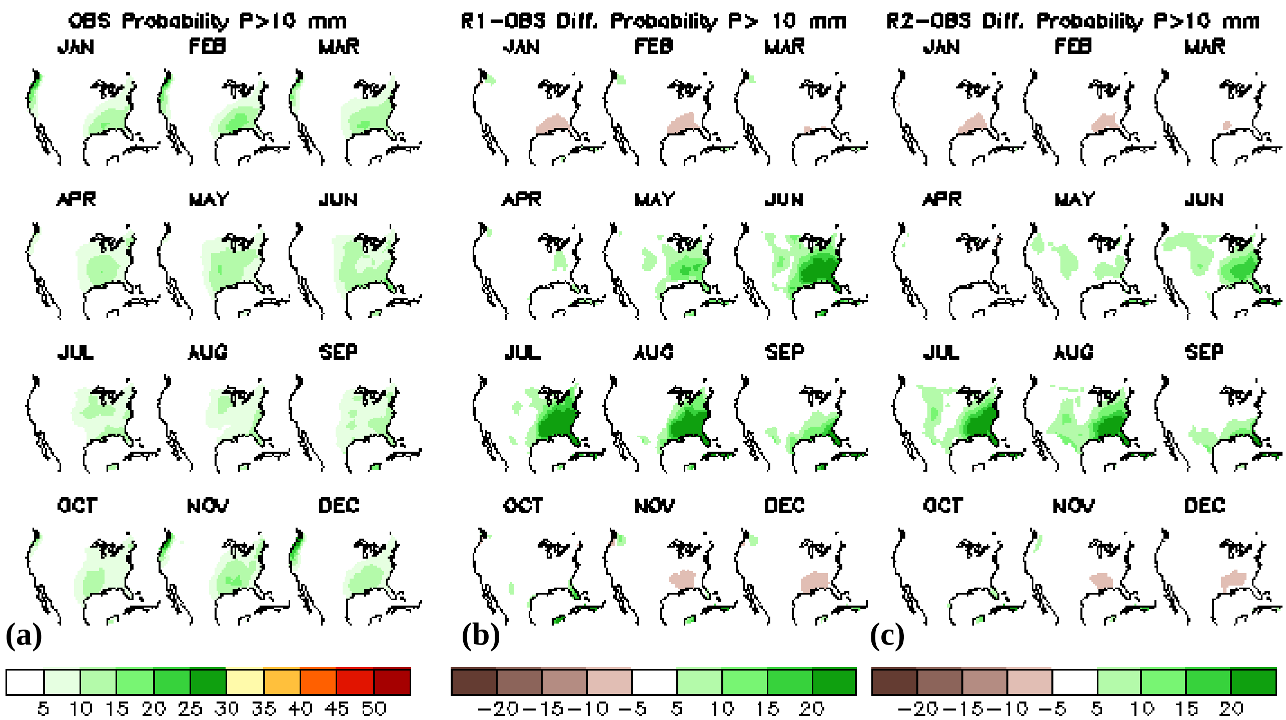

Fig. 2. Probability of daily precipitation greater than 10 mm in (a) OBS, and expressed as the difference between (b) R1 and OBS, and (c) R2 and OBS. Results are shown for each month of the year and are based on daily data for the period 1979-2006.

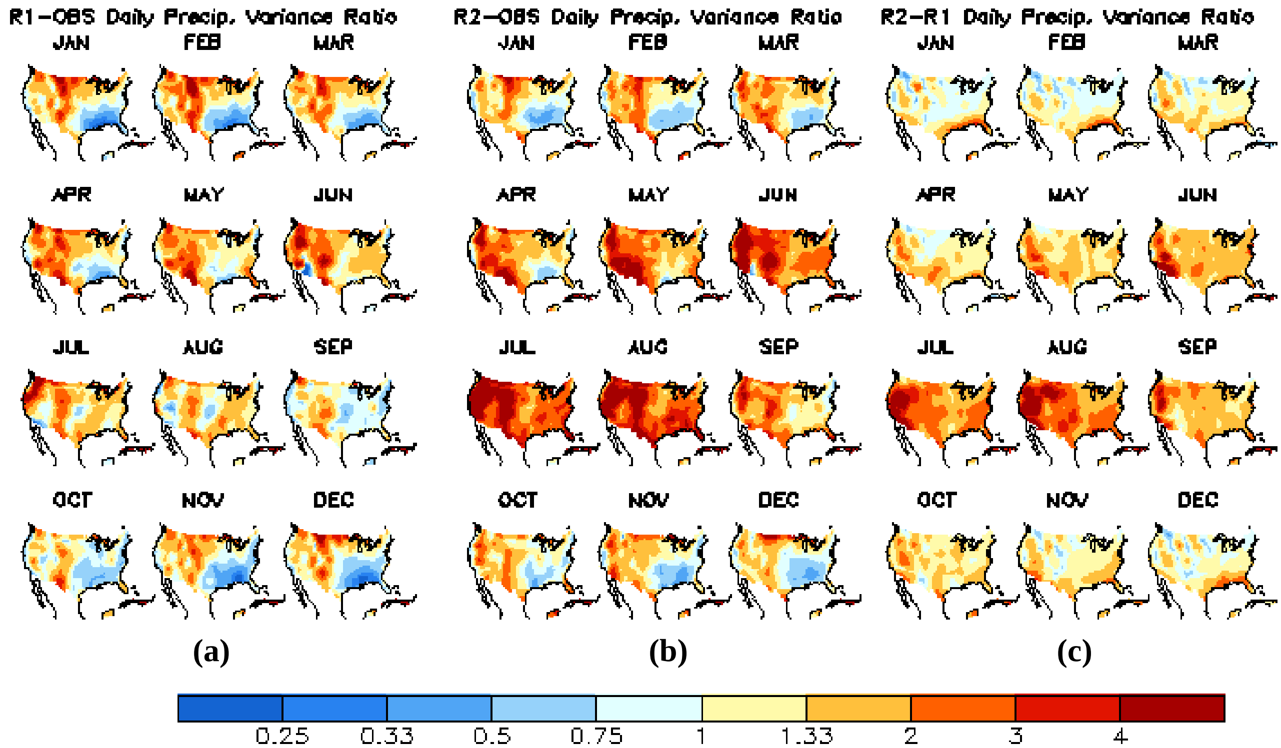

Fig. 3. Ratio of variance of daily precipitation: (a) R1 / OBS, (b) R2 / OBS and (c) R1 / R2. Results are shown for each month of the year and are based on daily data for the period 1979-2006.

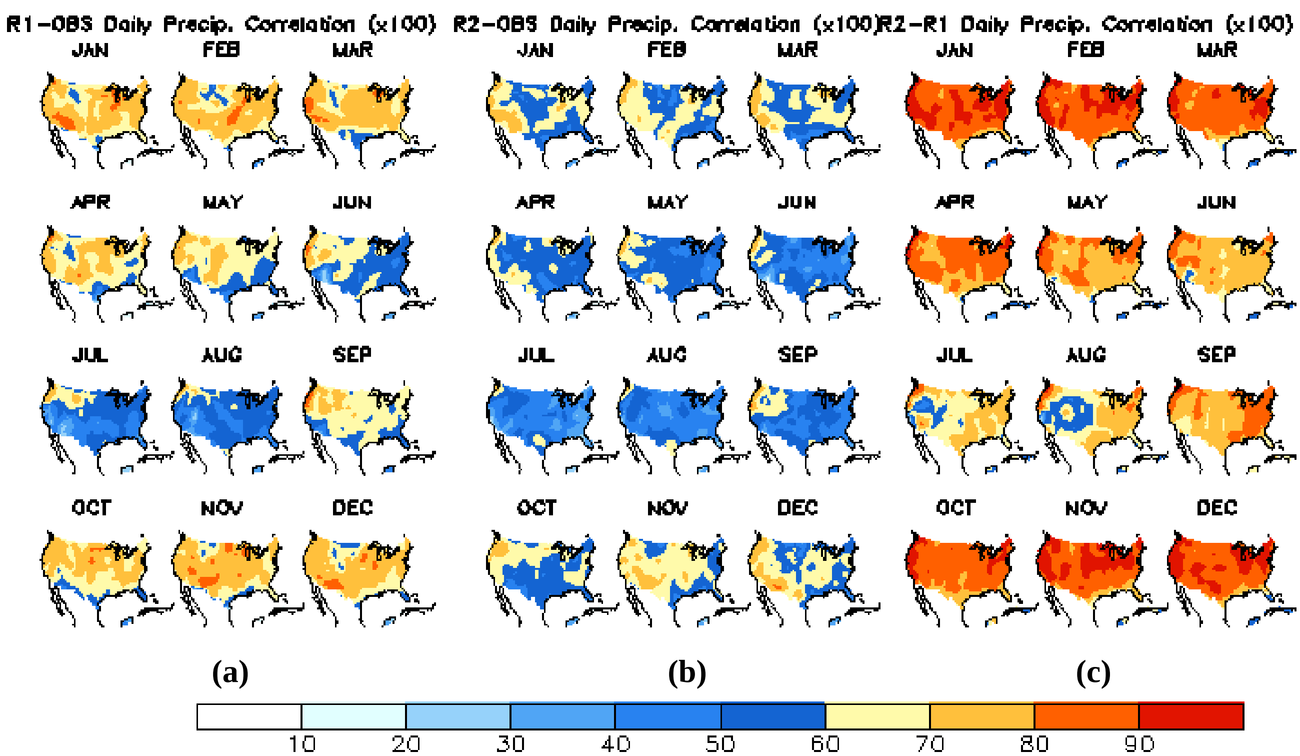

Fig. 4. Spatial maps of the temporal correlation between (a) R1 and OBS, (b) R2 and OBS and (c) R1 and R2. Results are shown for each month of the year and are based on daily data for the period 1979-2006.

The probability of daily precipitation greater than 10 mm (Fig. 2) is less than observed in R1 and R2 over the Southeast during November to February. Both R1 and R2 have greater than observed probabilities over the Southeast during May to September (with greater biases in R1). We note that the differences in the Southeast during May to September are nearly as large as they are in Fig. 1, indicating that the overestimates in R1 and R2 are probably for the relatively heavy (convective) precipitation events.

An examination of the ratio of variance (Fig. 3) of daily precipitation between a) R1 and OBS and b) R2 and OBS by month shows that both R1 and R2 exhibit less variability than observations on daily timescales over eastern TX, the Gulf Coast states and Tennessee Valley during October-April (ratios are less than 1), while the reanalyses display more variability than observed over the West throughout the year (ratios are greater than 1). A notable exception is along the immediate West Coast where R1 and R2 are less variable than observations on daily time scales during much of the year (Figs 3a and 3b). Figure 3c shows that R2 variance is greater than R1 variance across the entire CONUS during May-October (greatest differences during July-September). In addition, R2 variance exceeds R1 variance along the Gulf Coast region during November-April. Since the R2 and R1 variances are less than OBS during November-April (see figures 3a and 3b) over the Gulf region, the R2/R1 ratio greater than 1 shown in figure 3c indicates that R2 is closer to OBS in this region.

Spatial maps of the temporal correlation between daily precipitation in R1 and OBS (R2 and OBS) (Fig. 4a and b) show generally high correlations in winter and low correlations in summer when convection is present. Throughout the year, the correlations between R2 and OBS are lower than those for R1 and OBS. So, in spite of improvements in the mean bias of daily precipitation in R2 (figure not shown), the correlation with observations is not as good.

4. Summary

Before CPC can confidently base its operational climate monitoring and prediction activities on a new generation of reanalysis and reforecast products, a comprehensive intercomparison of the old and new products is required. Although the next generation of reanalysis products is not available yet, a careful validation of the current generation of reanalysis products will serve as a benchmark from which an objective evaluation of improvements in the new generation of reanalysis products can be made. An important long term goal is to identify and correct biases in the statistics of daily precipitation within a season to improve CPC’s current operational monitoring and outlook products and to develop new outlook products on intraseasonal and seasonal timescales.

References

Kalnay E., and co-authors, 1996: The NCEP/NCAR 40-year reanalysis project. *Bull. Amer. Met Soc.*, **77**, 437-471.

Kanamitsu, M., W. Ebisuzaki, J. Woollen, S-K. Yang, J. J. Slingo, M. Fiorino and G. L. Potter, 2002: NCEP–DOE AMIP-II Reanalysis (R-2), *Bull. Amer. Meteor. Soc.*, **83**, 1631-1643.

Saha, S., S. Nadiga, C. Thiaw, J. Wang, W. Wang, Q. Zhang, H. M. van den Dool, H.-L. Pan, S. Moorthi, D. Behringer, D. Stokes, M. Peña, S. Lord, G. White, W. Ebisuzaki, P. Peng, P. Xie, 2006: The NCEP Climate Forecast System. *J. Climate*, **19**, 3483-3517.