P1.2 Assessment of radar-based precipitation products in the CONUS for advances in multi-sensor precipitation reanalysis

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1. INTRODUCTION

The National Climatic Data Center (NCDC) and the National Weather Service (NWS) Office of Hydrologic Development (OHD) have worked together on the multi-sensor precipitation reanalysis (MPR) proof of concept. The proof of concept has shown the benefits of performing a reanalysis of radar-based precipitation products, mainly the products that come from the NEXRAD Level III archive (Nelson et al. 2009). In particular the collaboration used the NEXRAD digital precipitation array (DPA) as well as the Hydrometeorological Automated Data System (HADS) rain gauge data and the NWS Cooperative observers network rain gauge data in a reanalysis. The objectives of the proof of concept were to: implement the real-time multi-sensor precipitation estimation algorithm in order to make improvements to this system and then leverage these for improvments in quantitative precipitation estimation (QPE); use additional data inputs that are not available in real-time; perform optimization for parameter estimation that is also not possible in the real-time setting; and to take advantage of the lessons learned from 15-years of operational experince and put them to use in the reanlysis effort.

As an extension of the reanalysis effort we provide an assessment of the radar-based precipitation products available for the CONUS. Some of the radar-based QPE available are the National Centers for Environmental Prediction (NCEP) Stage IV, the developmental National Severe Storms Laboratory (NSSL) Q2, the NWS Stage III, and the NCDC-OHD MPR products. In the framework of reanalysis, our assessment looks at the large-scale precipitation products in a climatological sense as well as at finer scales (i.e. daily, monthly). We provide looks at temporal accumulations for CONUS-wide scales. The challenges we found in this assessment include finding a suitable overlap period for all products, finding a suitable spatial overlap, determining the input data sets for the multi-sensor products, and deciphering the key points in the data set development that might make one product different from another. We focus on the NCEP Stage IV product in order to learn lessons that we can apply to a reanalysis product.

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2. STAGE IV ASSESSMENT

Many radar-based and gauge-based precipitation products are available for the CONUS. They are developed at many different agencies and institutions. Currently the Stage IV national mosaic is the only CONUS-wide radar-based precipitation product generated operationally. We present an analysis of the Stage IV product for the available years (2002-2007).

2.1 *Seasonal Stage IV*

The NCEP Stage IV product is generated in near real-time by mosaicking the multi-sensor precipitation estimates from the NWS River Forecast Centers (RFC). NCEP processes the data each hour and then generates 6-hrly products. There is post-processing to fill in temporal gaps that are then used to generate a daily CONUS product. We use the NCEP Stage IV product to learn lessons when scaling the MPR proof of concept to the large CONUS area.

Figure 1 shows the seasonal mean precipitation for the years 2002-2007. There are several precipitation related and non-precipitation related issues to identify. Precipitation related issues are: (seasons are defined as June, July, August (JJA), September, October, November (SON), December, January, February (DFJ), and March, April, May (MAM))

1. The largest regional seasonal means occur in the Gulf Coast for JJA, the Texas-Louisiana Coast for SON, the Pacific Northwest for DJF and SON.
2. Hurricane activity can clearly dominate the seasonal means for the Gulf Coast.
3. The smallest regional seasonal means occur in the mountain west and southwest. However this should be taken as cautionary as the

NEXRAD coverage in these regions is lacking as compared to other regions.

4. The Midwest and Central Plains largest seasonal means occur in JJA and MAM.
5. The wintertime (DJF) largest seasonal mean in the Pacific Northwest and Northern Californian are due to climatology.
6. Florida's largest seasonal mean occurs in JJA.
7. The largest seasonal mean for New England and Atlantic states occurs in SON.

Non-precipitation related issues are:

1. Radar coverage contributes to larger seasonal means in certain regions as compared to others.
2. Lack of coverage in the mountains makes it difficult to make conclusions for seasonal means in this region.
3. The effective coverage of the radar in the cool season (DJF) causes reduced spatial representation of precipitation. The effective coverage of the radar is determined from a long term assessment of radar-only estimates at a specific radar site over a specified season (e.g. warm or cool). The result shows areas in the radar domain that provide reliable reflectivity returns and other areas that are not reliable – mostly due to beam blockage.
4. There is a lack of coverage over California for the JJA season.
5. There is a lack of coverage in the southern portion of the pan-handle of Texas.
6. Radar artifacts are present in each seasonal mean. Artifacts are caused by radar beam blockage, anomalous propagation, bright band, range effects, effective coverage of the radar, radar-rainfall estimation, and radar overlap issues.

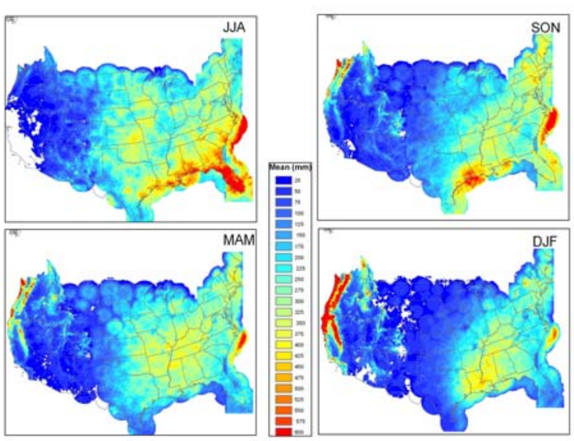

Figure 1: Seasonal mean (2002-2007) precipitation based on Stage IV product. (JJA – June, July, Aug; SON – Sept, Oct, Nov; MAM – March, Apr, May; DJF - Dec, Jan, Feb)

Figures 2 (JJA), 3 (SON), 4 (DJF), 5 (MAM) show the seasonal total for each of the four seasons. Again each figure shows issues that are both precipitation and non-precipitation related issues which are different from season to season. A few notable points are:

1. Hurricanes dominant in some years for both the JJA and SON seasons.
2. Rainfall dominates specific seasons for specific regions in all of the years. Pacific Northwest – DJF, Gulf Coast – JJA, Florida – JJA, New England – SON.
3. Periods of drought are identifiable based on yearly patterns of seasonal precipitation.
4. Certain events can dominate a year's seasonal accumulation.

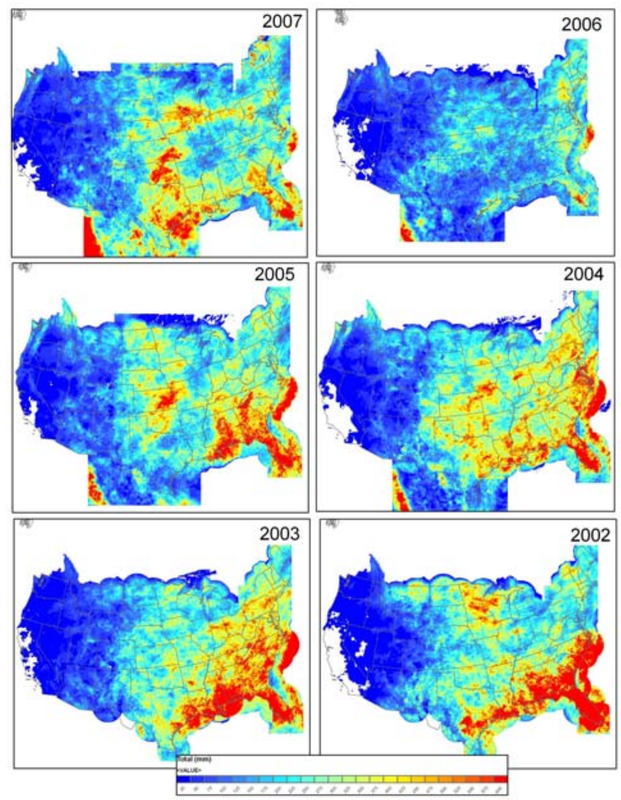

Figure 2: Seasonal mean for each year 2002-2007 for **JJA** season.

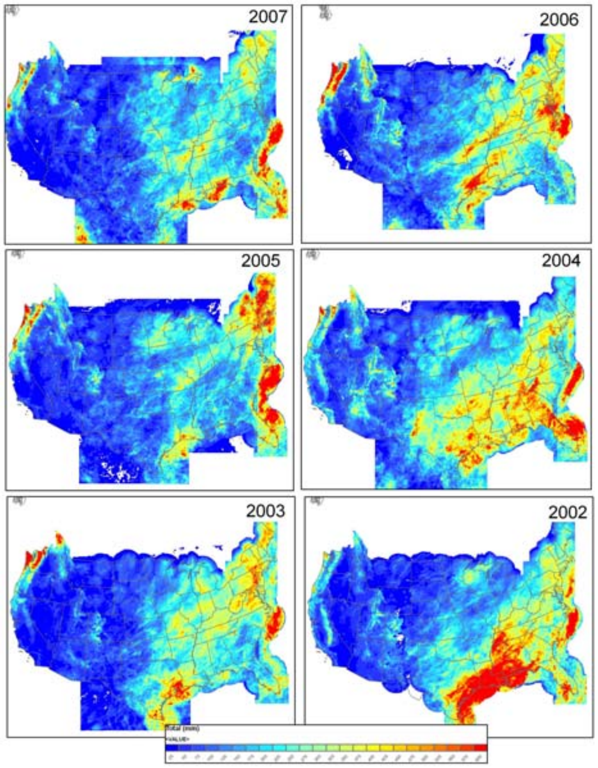

Figure 3: Seasonal mean for each year 2002-2007 for **SON** season.

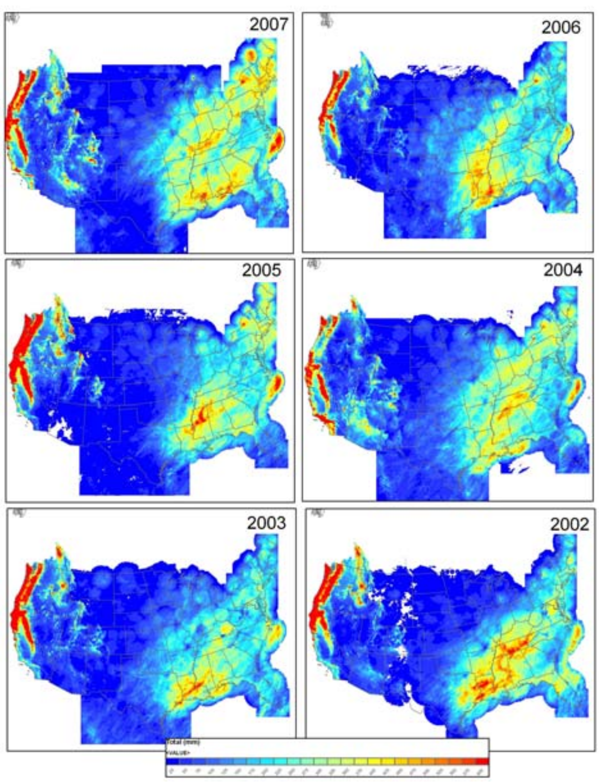

Figure 4: Seasonal mean for each year 2002-2007 for **DJF** season.

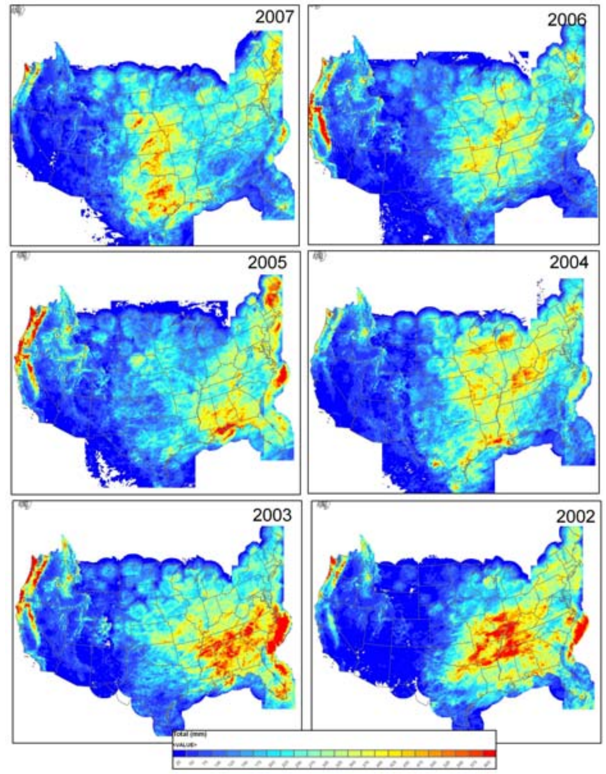

Figure 5: Seasonal mean for each year 2002-2007 for **MAM** season.

2.2 *Daily Stage IV*

We look at daily estimates of precipitation in addition to the seasonal analysis. Figure 6 shows the daily mean precipitation conditioned on greater than zero precipitation and Figure 7 shows the standard deviation of the daily precipitation.

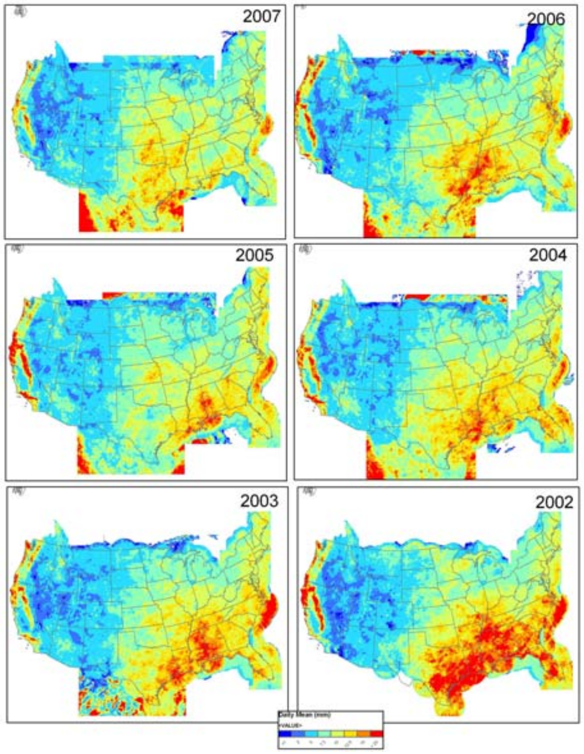

Figure 6: Daily mean precipitation conditioned on greater than zero precipitation.

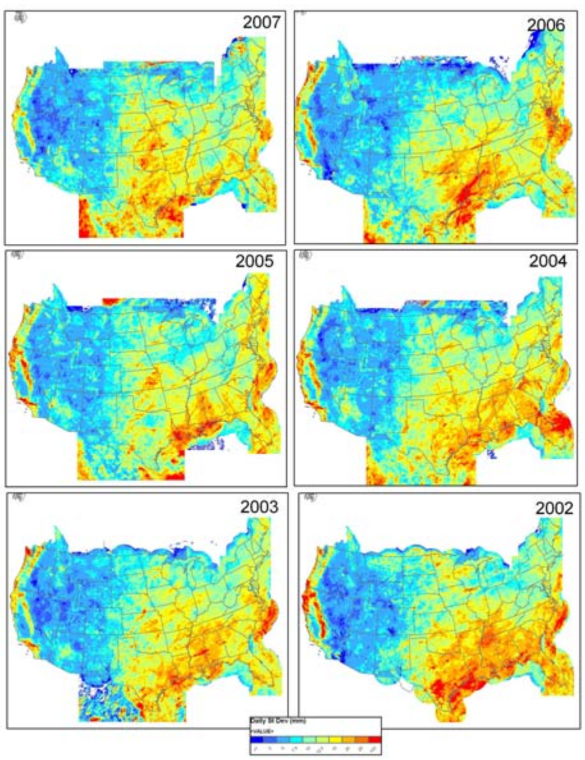

Figure 7: Standard deviation of daily precipitation conditioned on greater than zero precipitation.

Several points can be made by looking at these representations of daily precipitation:

1. Radar artifacts can also dominate the daily mean precipitation. This is as we would expect because artifacts such as anomalous propagation and bright band can dominate a certain radar or region for the particular day.
2. Regional representations of precipitation in the most general and wide scale are mostly represented by the radar-based product.
3. Regional representations of precipitation at the daily scale are mostly similar to the results from the seasonal scale.

3. SUMMARY

NCDC and OHD have shown a proof of concept for the MPR algorithm. The next step in the process is to scale the MPR from the proof of concept domain to the CONUS domain. To do this, it is important to learn about and to detect issues that may arise during the process of scaling MPR to the CONUS domain. One way to try and identify these issues is to assess the existing product. We have provided an assessment of the existing NCEP Stage IV product at the seasonal scale and at the daily scale. Some of the following points will need to be addressed during the development of CONUS wide MPR.

1. There is a need to identify and correct radar artifacts throughout the CONUS. Anomalous propagation and bright band enhancement (Smith et al, 1997) can dominate much of the estimates east of the Rocky Mountains.
2. Lack of radar coverage in the Mountain West causes problems with underestimation of precipitation. Further enhancement of radar artifacts can be caused because of only single radar coverage, i.e. there is not accompanying information from adjacent radars to filter artifacts.
3. The effective coverage of the radar in the wintertime reduces the spatial representation of precipitation.
4. The variability of precipitation in both space and time will cause a particular challenge for any implementation of a CONUS-wide reanalysis effort. Certain results from this spatio-temporal assessment may be used as a priori information in the CONUS-wide reanalysis effort.
5. As certain seasons in certain regions are dominated by hurricanes or other synoptic scale events, the reanalysis effort will need to account for synoptic-scale statistical properties

of precipitation fields (e.g. anisotropy) to be able to match the regional climatology.

6. Similarly reanalysis will need to account for statistical properties of meso-scale events where they can dominate the precipitation climatology like in the Midwest, Southern Plains, and Florida.
7. Both radar site specific biases (Seo et al 1999) and regional biases (Seo and Breidenbach 2002, Steiner et al 1999) need to be addressed before implementation of a CONUS-wide reanalysis effort.

4. REFERENCES

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