Characterization of Precipitation Features in the Southeastern United States Using a Multi-sensor Approach: Quantitative Precipitation Estimates

Task Leader Olivier P. Prat (NOAA Collaborator Brian R. Nelson)
Task Code
Date Awarded 08/16/2010
Contribution to CICS Themes Theme 1: 20%; Theme 2: 75%; Theme 3: 5%
Contribution to NOAA Goals Goal 1: 20%; Goal 2: 80%

EXECUTIVE SUMMARY

We use a multi-sensor approach to characterize precipitation features at high spatial and temporal resolution. Focused over the Southeastern United States, this work aims at representing a proof of concept and a first step toward the development of rainfall climatologies at high spatial and temporal resolution. More broadly, this work is part of an on-going effort at NCDC to provide high-resolution precipitation estimates for hydrological applications and to derive trends in the evolution of precipitation patterns over time.

BACKGROUND

The primary goal of this project is to investigate long-term precipitation characteristics in the Southeastern United States at fine spatial and temporal resolution using a multi-sensor approach. The frequency and spatial distribution of precipitation extremes are evaluated using an ensemble of satellite and radar rainfall estimates. We use the precipitation reanalysis from the National Mosaic and Multi-Sensor Quantitative precipitation Estimates (NMQ/Q2), in order to derive yearly, seasonal, and sub-daily precipitation trends at high resolution (1-KM/5-minute) for the period 1998-2010 with an attention to intense precipitation events.

This particular task is focused on the inter-comparison of satellite observations from the Tropical Rainfall Measurement Mission (TRMM) and ground based (Q2) precipitation estimates in terms of precipitation intensity, accumulation, diurnal cycle, event duration, precipitation type (stratiform/convective), and precipitation systems (localized thunderstorms, mesoscale convective systems, tropical storms). In addition we investigate the impact of the spatial and temporal resolutions on each of these quantities, as well as the ability of satellite products to capture extreme precipitation events.

ACCOMPLISHMENTS

- Developed precipitation climatology at fine scale using satellite datasets TRMM Precipitation Radar (TPR 2A25: 5km/daily) and TRMM Multisatellite Precipitation Analysis (TMPA 3B42: 25KM/3HR) for the period 1998-2010. Subtasks included: (A) The derivation of yearly, seasonal, and diurnal precipitation trends from both datasets (TPR 2A25 and TMPA 3B42) (Prat and Nelson 2012); and (B) the quantification of the rainfall contribution originating from tropical cyclones (Prat and Nelson 2011).
- Initiated the inter-comparison TRMM satellite data versus NMQ/Q2 (National Mosaic and Multi-Sensor QPE) data (1km/5min) for the Carolinas. Current work consists intending the domain of study to the Southeastern United States (Prat et al. 2012).

Figure 1 displays a comparison of the instantaneous rain-rate and the 3-hourly rain accumulation derived from the different sensors (Q2, TMPA, TPR) in the case of the tropical cyclone Frances (2004). We note comparable patterns between satellite (TMPA, TPR) and ground based Q2 estimates for the rainfall distribution and the rain bands. As expected we have a much higher resolution with estimates derived from Q2. We also note important local differences due to beam blocking effect (Q2) and to different rain rates estimation algorithms, sensor sensitivity, characteristics and technical limitation, or the number of NEXRAD sites processed (9 in the figure).

Figure 2a displays the average daily precipitation for summertime at 1km resolution derived from NMQ/Q2 from 1998 to 2010. We note higher rainfall along the coast (sea breeze effects) and over ocean (Gulf Stream). We also note over the mountains the beam blocking effect with those characteristics lines starting from the radar site location. In western North Carolina, we observe a very low daily accumulation because neither of the two radars located in TN and SC is able to fully capture rainfall events. Figure 2b presents the differences between the satellite estimates TMPA 3B42 and Q2 re-gridded at 25-km. Larger differences are observed in Western North-Carolina and upstate South Carolina with a lower daily rain rate on the order of 75% for the radar based product Q2 as the result of the beam blocking effect. Over the coastal Carolinas, we note a higher daily accumulation on the order of 75% observed by Q2 that corresponds to sea breeze effects captured by Q2 due to a higher spatial resolution than TMPA 3B42 for which those localized events are harder to capture.
!

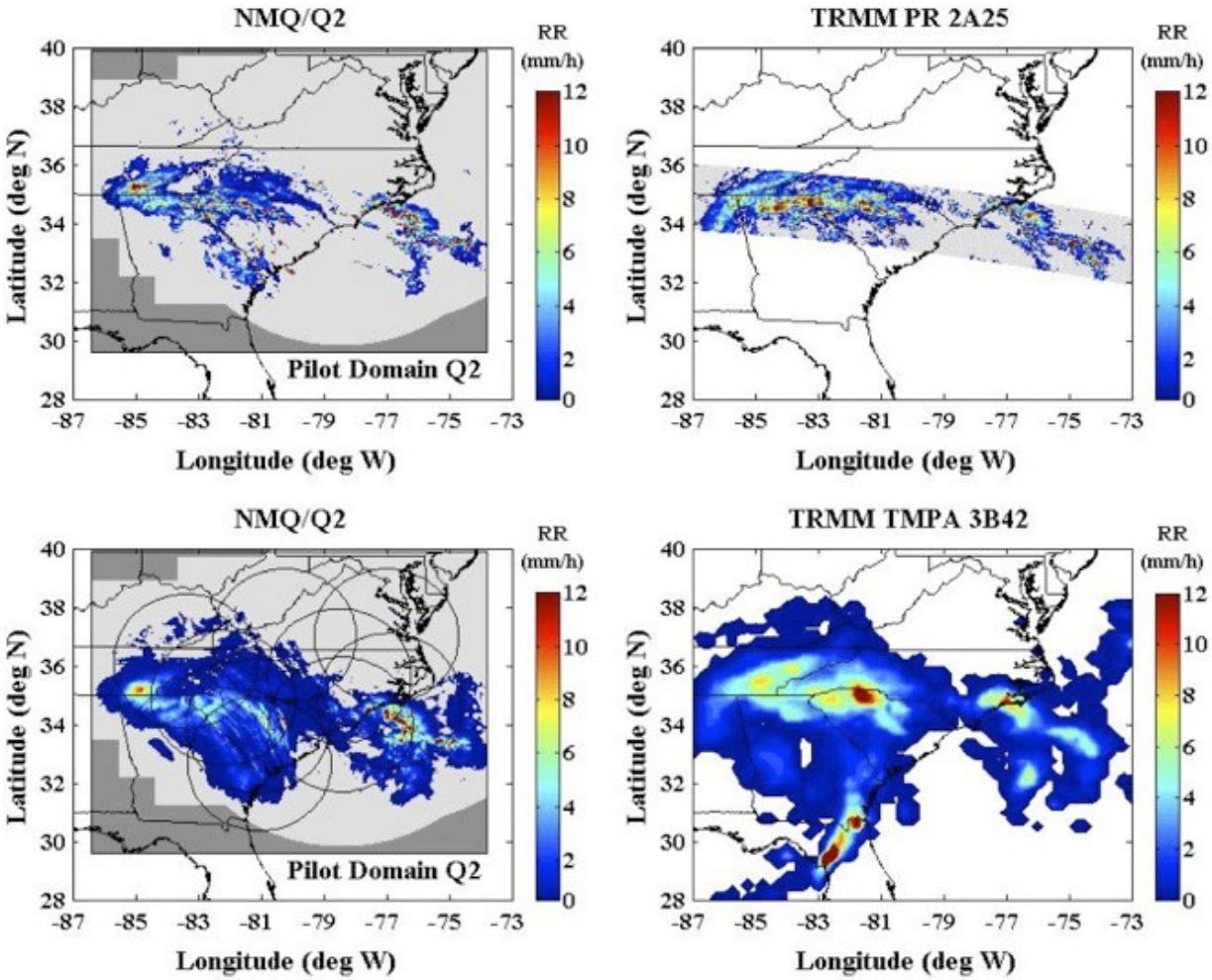

Figure 1: Hurricane Frances on 09/07/2004. Instantaneous rain-rate at 1235UTC for: a) NMQ/Q2 (1km), and b) TPR 2A25 (5km). Three-hourly averaged rain-rate c) NMQ/Q2(1km) and d)TMPA 3B42 (25km)

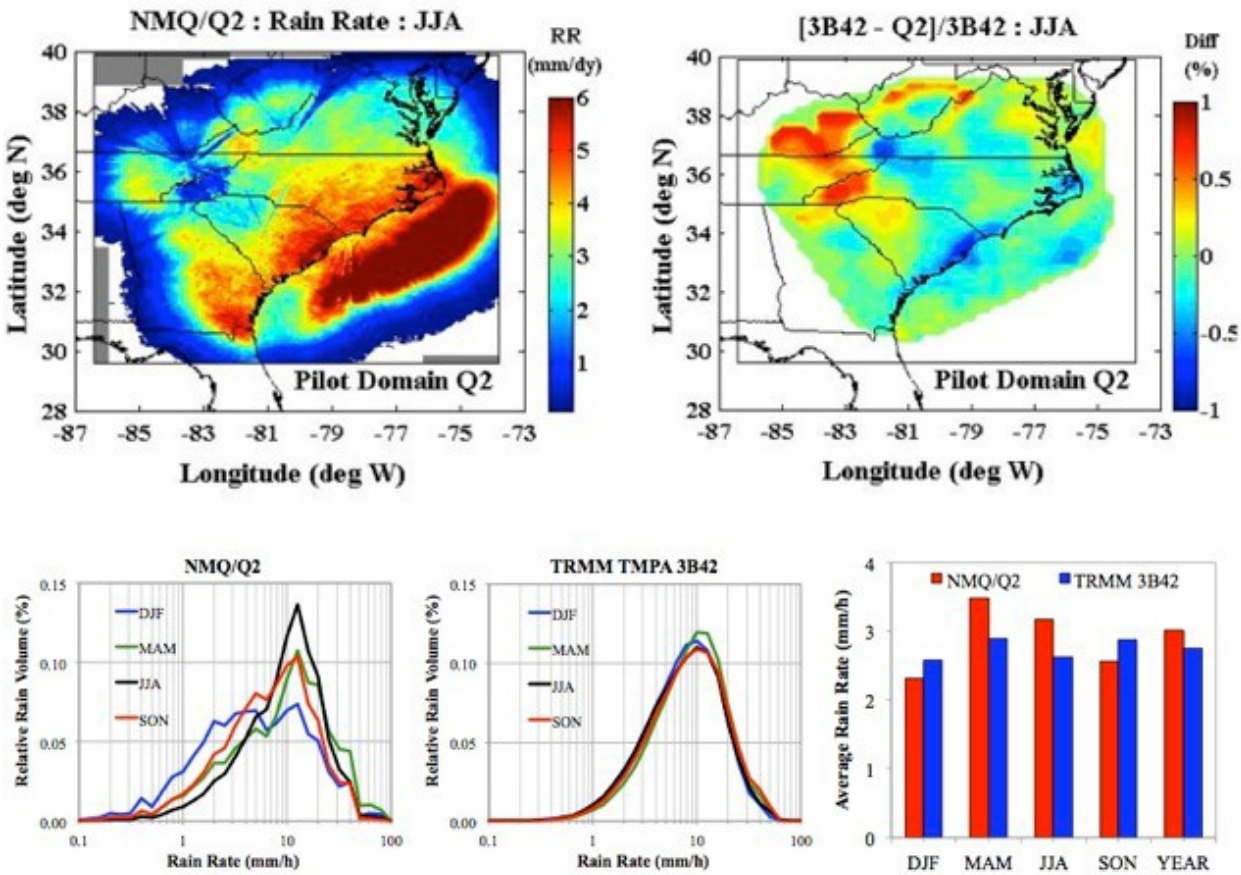

Figure 2: a) Mean precipitation derived from NMQ/Q2 (1km), and b) differences between NMQ/Q2 and TMPA 3B42 (25km) for summer (JJA). Seasonal PDFs derived from: c) NMQ/Q2, and d) TMPA 3B42. e) Seasonal and annual average rain-rate for NMQ/Q2 and TMPA 3B42.

Figures 2c and 2d display the seasonal PDFs for the relative rain volume derived from Q2 (Fig. 2c) and TMPA 3B42 (Fig. 2d) respectively over the same area corresponding to the actual footprint of the nine radars. In both cases we note that a rain rate around 10mm/h hour contributes the most to the rain volume. We observe a higher seasonal variability for Q2 than for TMPA 3B42, which displays very similar PDFs throughout the year regardless of the seasonal characteristic of precipitation. Furthermore, the PDF for summer derived from Q2 is shifted towards higher rain intensity, mainly due to the presence of summertime convection activity over the area. In addition, we note that winter PDF derived from Q2, indicates a more widespread rain rate contribution from 2mm/h to 10mm/h, when compared to 3B42, and that is due to cold precipitation such as snow or mixed phase.

Finally, Figure 2e displays the seasonal average rain rate (i.e. integration of the area under the curves). We observe a lower rain intensity of about 11% between Q2 and TMPA 3B42 during the cold season (winter and fall), and a higher rain intensity of about 17% between Q2 and TMPA 3B42 during the warm season (summer and spring) with globally a higher annual rain rate of about 8% for Q2 (radar only) when compared to satellite estimates TMPA 3B42.

!

PLANNED WORK

- Continue work on the characterization of precipitation features for the period 1998-present. Extend the current domain of study to 36 radars to cover the domain [86°W-74°W, 24°N-40°N].
- Examine differences in precipitation estimates between satellites (TMPA 3B42, TPR 2A25, and others) and Q2. Differences observed will be discussed as a func- tion of the geographical location, precipitation type (stratiform, convective), and events characteristics (MCS, Tropical Cyclones). Local characteristics of the di- urnal cycle of precipitation will be investigated.
- Assess the effects of local artifacts including beam blocking effects on precipita- tion estimates over mountainous areas. Focus will be on areas where precipitation estimates are the less reliable (for example coasts and mountains).

PUBLICATIONS

Prat, O.P., and B.R. Nelson, 2011: Precipitation contribution of tropical cyclones in the Southeastern United States from 1998 to 2009 using TRMM satellite data. *J. Climate*. Submitted.

Prat, O.P., and B.R. Nelson, 2012: Yearly, seasonal, and diurnal precipitation trends in the Southeastern United States derived from long-term remotely sensed data. *Atm. Res*. Submitted.

Prat, O.P., B.R. Nelson, and S.E. Stevens, 2012: Characterization of precipitation features in the Southeastern United States using high spatial and temporal resolution quantitative precipitation estimates derived from the National Mosaic and Multi-sensor QPE (NMQ/Q2). *J. Hydrometeorol*. In preparation.

PRESENTATIONS

Prat, O.P., and B.R. Nelson, 2011. Characterization of precipitation extremes at high spatial and temporal resolution in the Southeastern United States derived from long-term satellite and radar rainfall estimates. 2011 AGU fall meeting, December 5-9 2011, San Francisco, CA, USA.

Nelson, B.R., O.P. Prat, and E.H. Habib, 2011. Diurnal cycle of precipitation in the Southeast U.S. using high spatial and temporal resolution quantitative precipitation estimates and radar-reflectivity products derived from National Mosaic and Multi-sensor QPE (NMQ/Q2). 2011 AGU fall meeting, December 5-9 2011, San Francisco, CA, USA.

Wilson, A., J. Tao, K. Olson, A.P. Barros, O.P. Prat, and D. Miller, 2011. From fog to tropical cyclones: Challenges to comprehensive ground validation in the Southern Appalachians. 2011 NASA Precipitation Measurement Missions (PMM) science team meeting, November 7-10 2011, Denver, CO, USA.