Gage Adjustment of Radar Rainfall Estimates Over Florida

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Motivation:

- Rain gages accurately measure rainfall at a given point but are blind to the spatial variability of rainfall
- Radar rainfall estimates accurately measure the spatial distribution of rainfall but are poor estimators of actual rainfall amounts
- By merging the complementary strengths of radar (spatial accuracy) and gages (point accuracy), we are able to obtain an accurate, seamless map of gage-adjusted radar rainfall over the state of Florida

Overview:

- One month of radar rainfall estimates over Florida are extracted from a national mosaic
- Pixel resolution is 2km x 2km, estimates are available every 15 minutes
- OneRain's GIS smoothing techniques are applied to the radar data to suppress ground clutter and smooth out discontinuities and other radar artifacts
- Gage data from the five water management districts in Florida are analyzed and quality-controlled
- Gage data are used to adjust the radar rainfall estimates, using a spatially variable adjustment (a technique similar to that proposed by Brandes, 1975)
- Final result is a seamless map of radar rainfall estimates over the entire state of Florida
- Volume estimates from the gage-adjusted radar rainfall dataset closely match the gage rainfall totals while still maintaining the spatial characteristics conveyed by the radar

OneRain's Gage Adjustment Technique:

- Loosely based on the technique pioneered by Brandes (1975)
- This is a spatial adjustment technique as well as a temporal one, in which each of the approximately 192,000 radar pixels receives it's own bias adjustment at each 15-minute time step
- A gage-radar ratio (GR ratio) is calculated at each valid gage location by dividing the gage rainfall in a given time window by the radar rainfall estimate over that pixel during that same time window
- The adjustment assigned to each radar pixel is a distance-weighted average of the calculated GR ratios at nearby gage locations
- The weights are assigned by distance via a Gaussian function rather than inverse-distance-squared function; in this way we are not force-fitting radar values to gage values and hence not creating unnatural concentric circles of rainfall around gages
- At a specified distance (100 km), the weights drop to 0: we do not want, for example, a radar pixel in South Florida to have it's adjusted rainfall value affected by a gage which is located in northern Florida
- Multiplication of the GR ratio field by the radar field produces a final gage-adjusted radar field
- OneRain has successfully utilized this spatial adjustment technique over a number of study locations (Hoblit et al. 2002 and Hoblit et al. 2003).

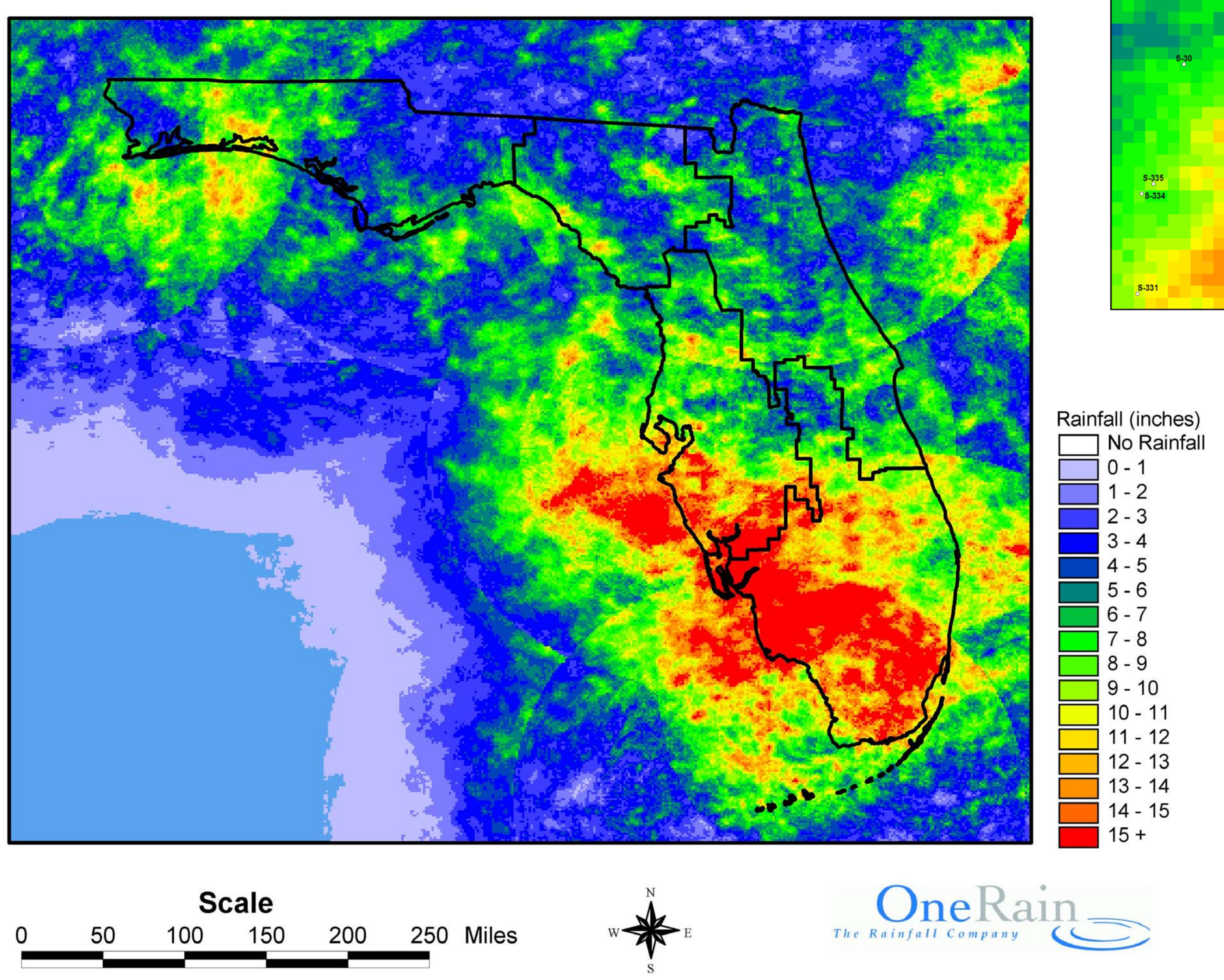
In Summary:

- GR ratios are calculated at each gage location at each time step centered on a three-hour window
- These ratios are interpolated onto the radar pixel field using a Gaussian function to determine the distance weighting
- The smoothed radar field is multiplied by the interpolated ratios to come up with a final gage-adjusted radar field

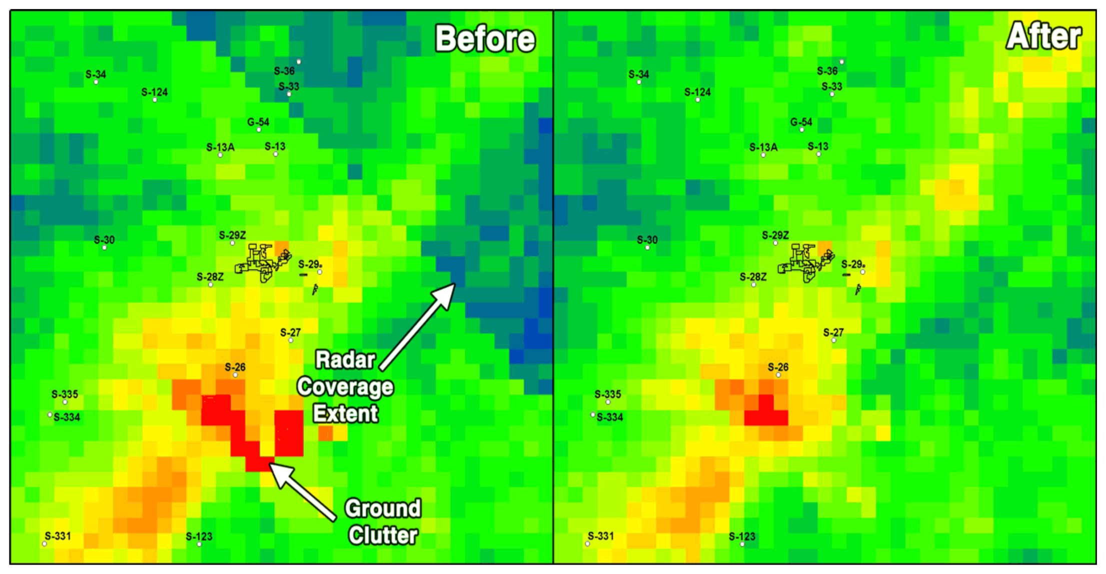
Step 1:

Extract raw 15 minute, 2 km data from OneRain's national archive of radar data, then integrate one month of data to highlight discontinuities—this example will use data from September 2003

Raw Radar Rainfall Estimates September 2003



In the example below, ground clutter and discontinuities are filtered out using OneRain's smoothing algorithm

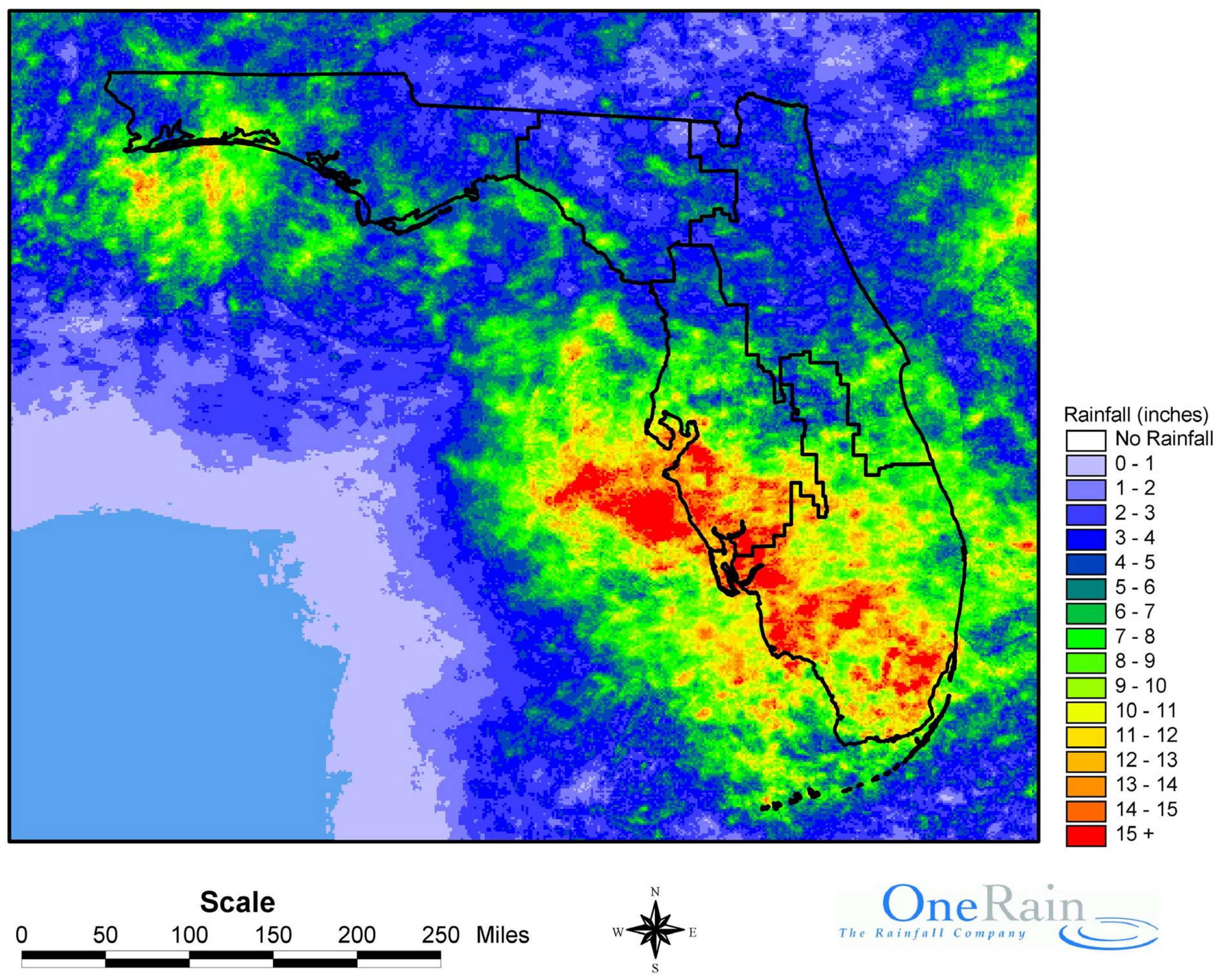


Filter

Step 2:

Filter the raw radar data into a smoothed radar dataset, removing discontinuities and ground clutter

Smoothed Radar Rainfall Estimates September 2003



Step 3:

Quality control the gage data supplied to OneRain by the five water management districts in Florida. 304 gages were deemed to be reporting accurately.

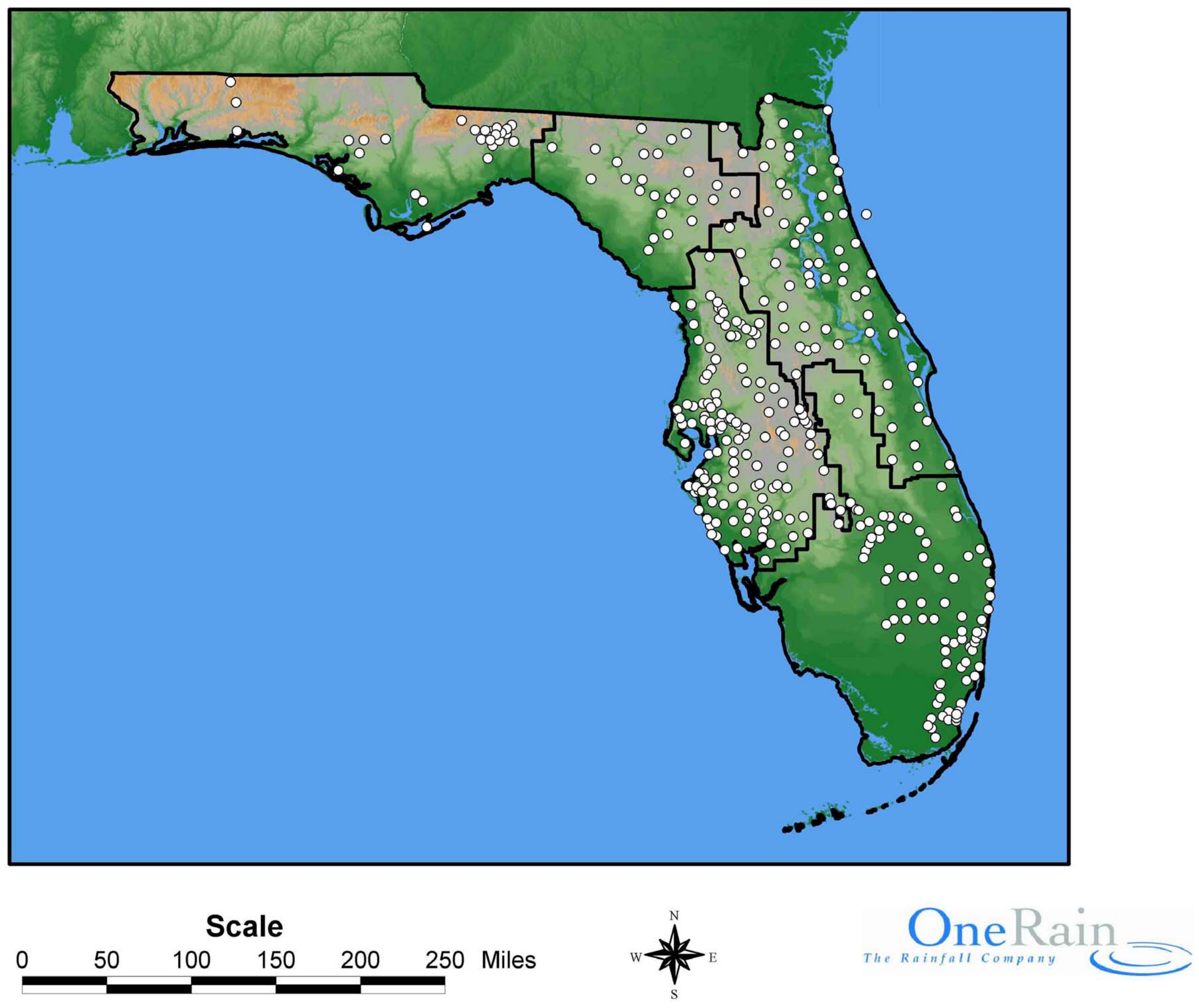
Step 4:

At each 15-minute time step, calculate GR Ratios at gage locations and interpolate those ratios onto the field of pixels

Step 5:

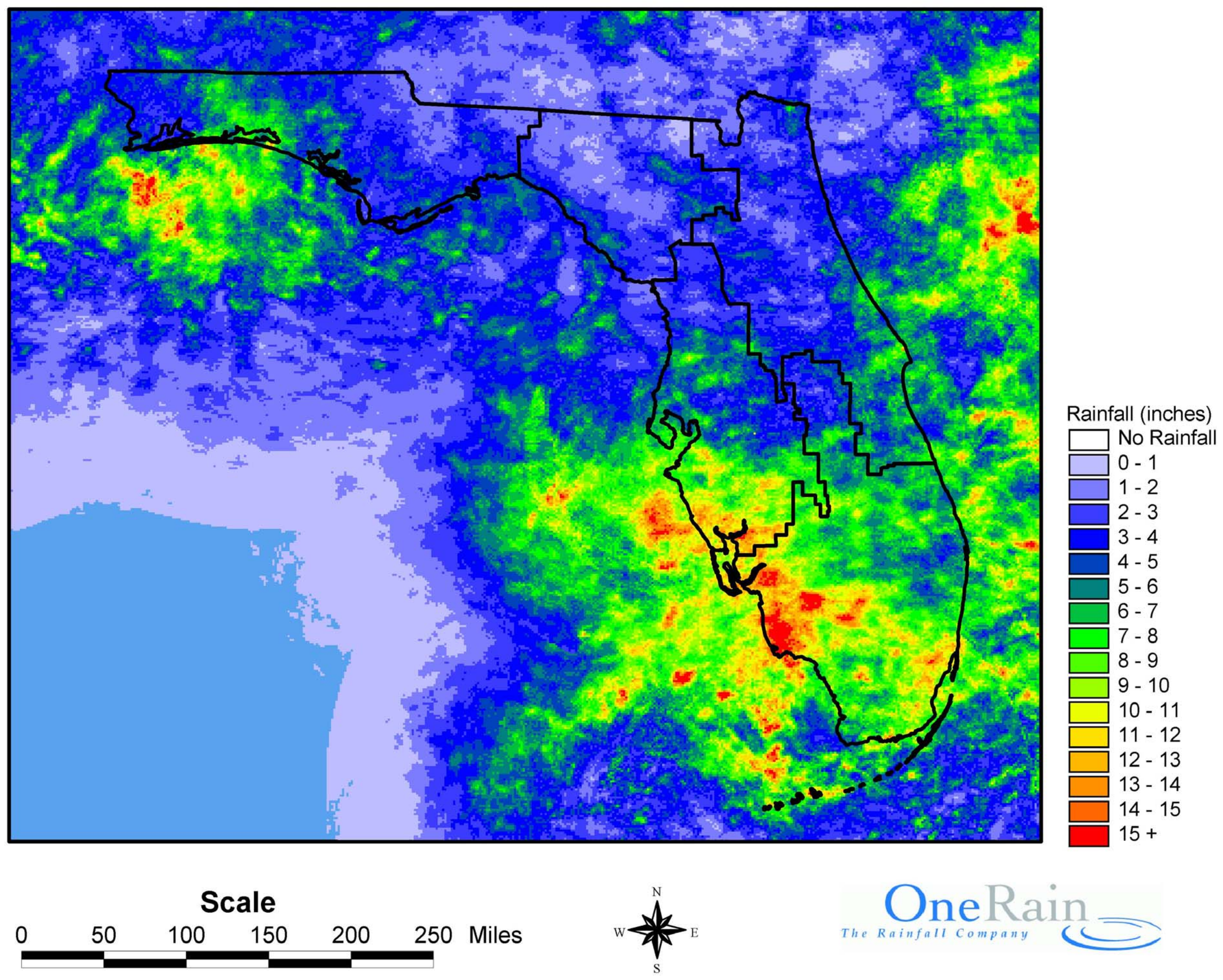
At each 15-minute time step, multiply field of interpolated GR ratios by smoothed radar field to obtain a final gage-adjusted radar field. The image below is a monthly total.

Florida
Water Management Boundaries and Gage Locations



OneRain's Spatial Adjustment

Gage-Adjusted Radar Rainfall Estimates
September 2003



Analysis of Results:

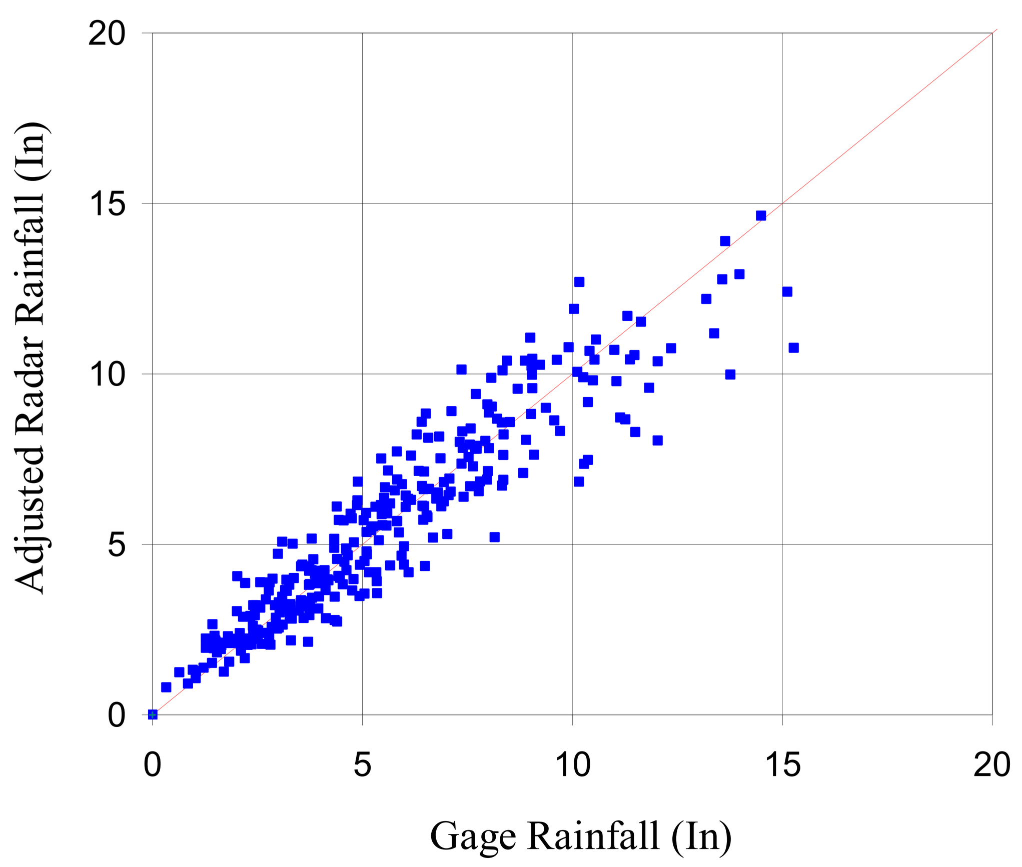
OneRain's spatial adjustment results in:

- An adjusted radar field that keeps the general spatial characteristics of the smoothed radar field (Step 2),
- An adjusted radar field that, in this particular analysis of September 2003, has lower rainfall totals than the smoothed radar field (Step 2) - this is due to the fact that, during this month, the gages recorded less rain than the original radar rainfall estimates, resulting in GR Ratios that tend to be less than 1

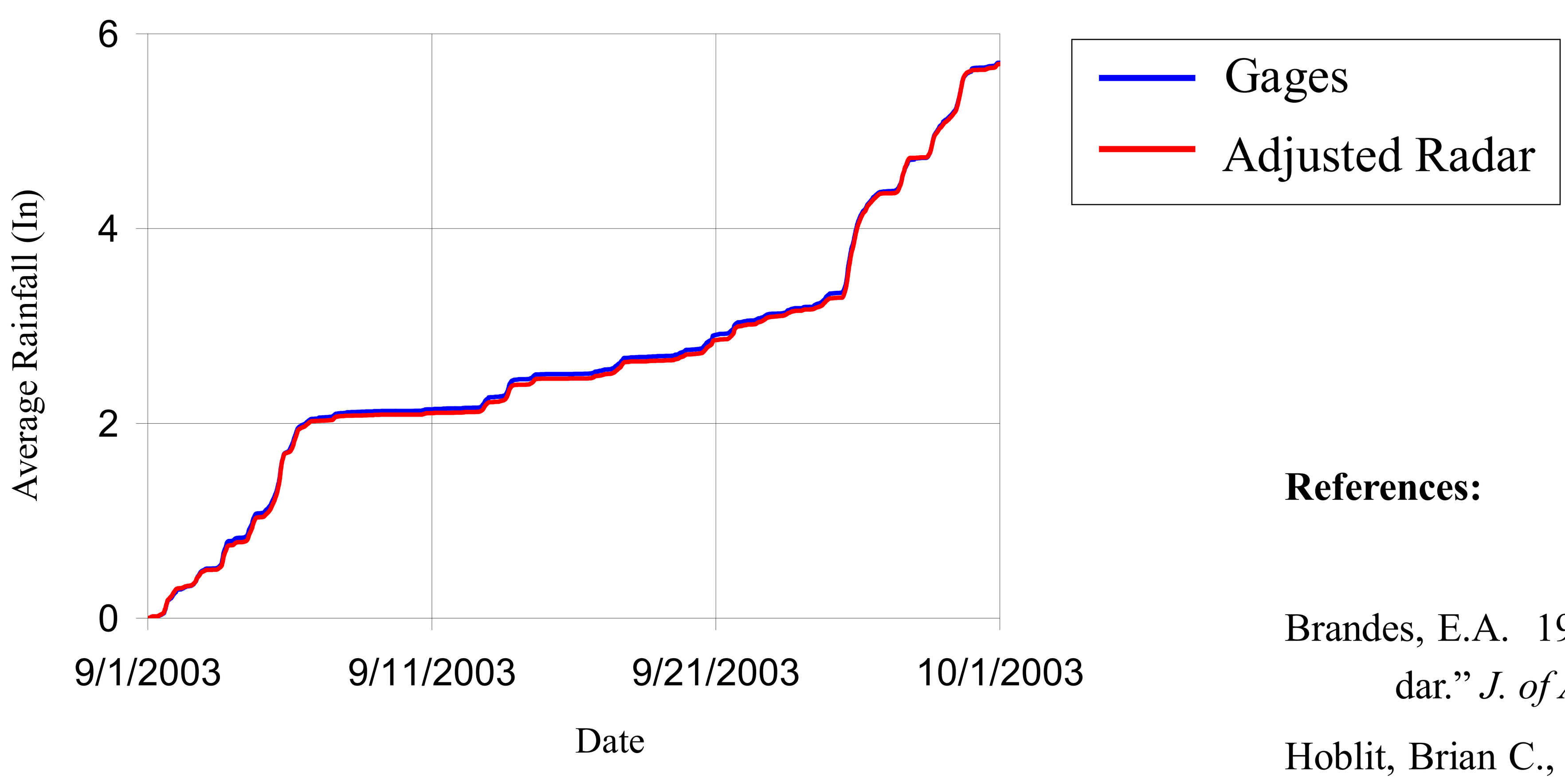
Comparing rainfall totals at the gages with adjusted radar rainfall totals at the radar pixels in which the gages are located (below) we find:

- Very good correlations between radar and gage totals at all valid gages
- A high degree of correlation between the radar and gage accumulations throughout the month
- Looking at each of the five water management districts separately (not shown) yields the same conclusions

Monthly Totals: Gages vs. Adjusted Radar



Average Accumulations



Possibilities for Future Enhancements:

- Use of Kriging for interpolation of GR Ratios instead of a function that solely depends on distance—this would improve the problem of data dependence (two gages located next to each other should not be treated as independent data sources when, in reality, they are not fully independent)
- Use of higher resolution rainfall data (1km, 5 minute)
- Use of emerging polarimetric radar technology to get better first estimates of rainfall as such enhancements become available in the NEXRAD network

References:

Brandes, E.A. 1975. "Optimizing Rainfall Estimates with the Aid of Radar." *J. of Applied Meteorology*, 14(7): 1339 – 1345.

Hoblit, Brian C., Leiji Liu and David C. Curtis. 2002. "Extreme Rainfall Estimation Using Radar for Tropical Storm Allison." *Proceedings of the EWRI 2002 Conference on Water Resources Planning and Management*, Roanoke, Virginia.

Hoblit, Brian C., Cris Castello, Leiji Liu, and David Curtis. 2003. "Creating a Seamless Map of Gage-Adjusted Radar Rainfall Estimates for the State of Florida." *Proceedings of the EWRI 2003 World Water and Environmental Resources Congress*, Philadelphia,