

# Validation of NWS Stage IV Multi-Sensor Precipitation Estimates (MPE) in Mid-Atlantic Region

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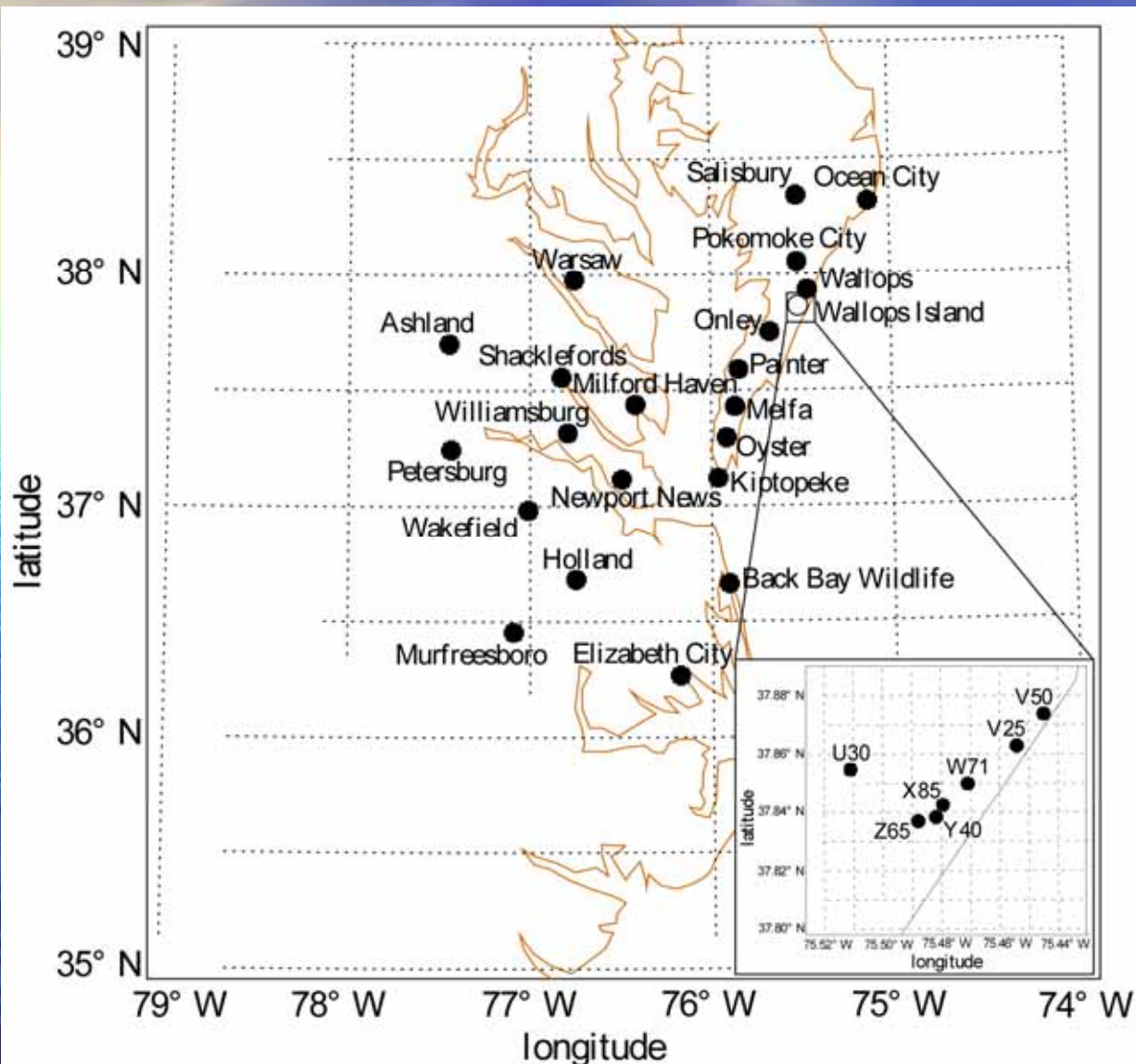
# Objectives

- Validation of MPE with independent rain gauge observations. Three-fourths of the gauges are at the coast.
- Pave the way for further studies regarding comparison of NEXRAD MPE with satellite rainfall products including NASA's Tropical Rainfall Measuring Mission (TRMM) Multi-sensor Precipitation Analysis (TMPA)

# Study Site and Data

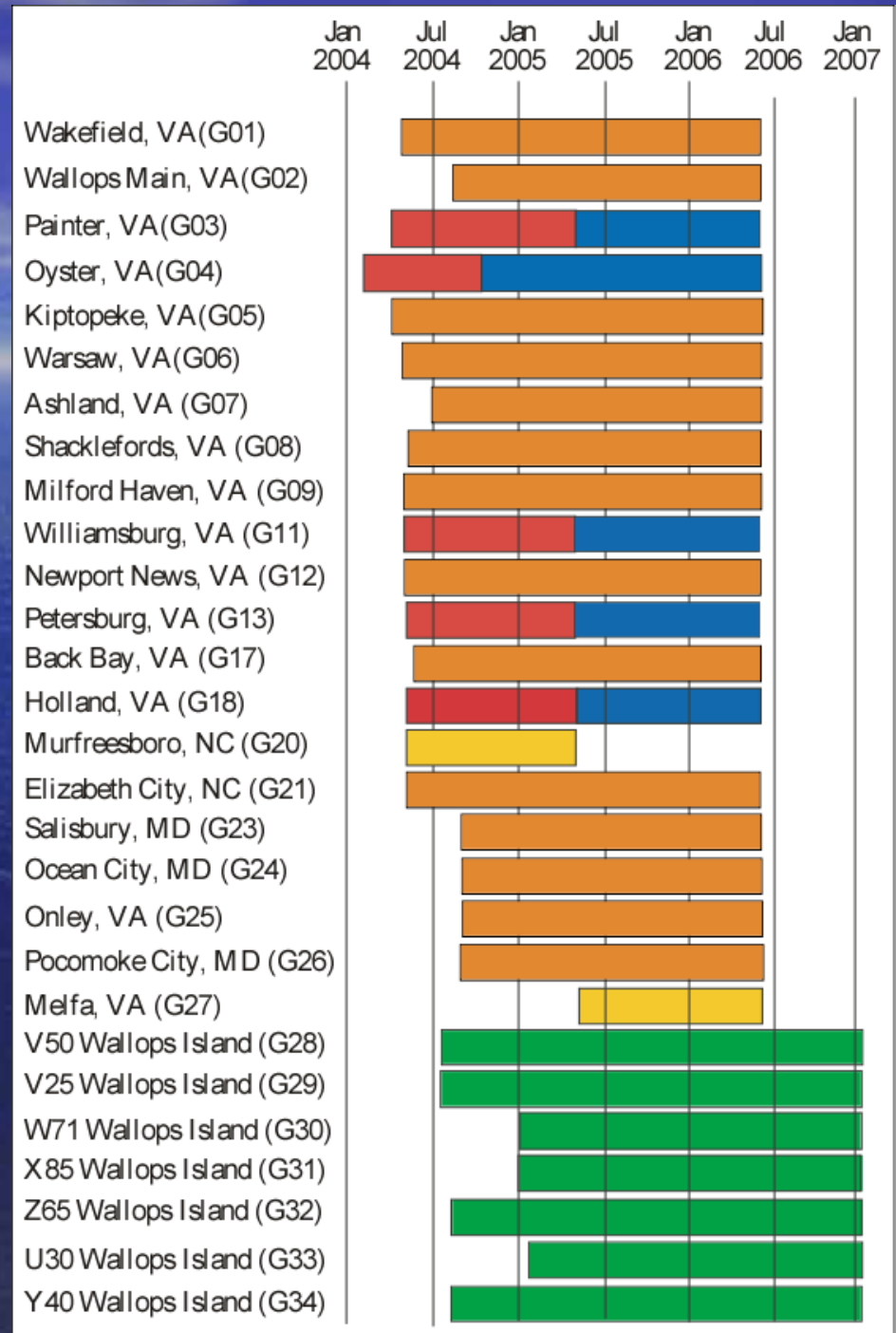
- Study site: Eastern Virginia, Delmarva, and northeast North Carolina.
- Gauge Network consists of 28 gauge sites maintained by TRMM satellite validation office.
- Each site contains dual or triple gauges.
- Each gauge site contained approximately 1-2 years of data. All gauge data spans from mid '04 - early '07
- Precipitation occurs mostly by tropical cyclones, convective thunderstorms, and frontal systems

# Rain Gauge Network Map



Each gauge site is within its own MPE pixel with exception of Wallops Island. At the island, 2 MPE pixels each contain 3 gauges while another MPE pixel contains 1 gauge.

# Rain Gauge Data Periods



# Rain Gauges



Petersburg, VA

- Met One tipping bucket
- Resolution = 0.01 inches
- Maintenance- once a month
- Shortcomings:
  - Snow melt tips
  - Pivotal point failure
  - Battery failure



# Multi-sensor Precipitation Estimates (MPE)

- MPE ~ merging operational radar, automated gauge, as well as geo-stationary satellite rainfall following manual quality control and bias adjustment.
- Stage IV ~ Mosaicking of MPE products on over a 4km resolution grid (HRAP) over the ConUS.
- Hourly MPE obtained through NWS National Center for Environmental Prediction (NCEP) Stage IV archives.
- MPE products are used by River Forecast Centers (RFC) in hydrologic model prediction.

# Methodology (Rainfall Statistics)

Pearson Correlation Coefficient

$$r = \frac{Cov(l_G, l_{MPE})}{\sqrt{Var(l_G) \times Var(l_{MPE})}}$$

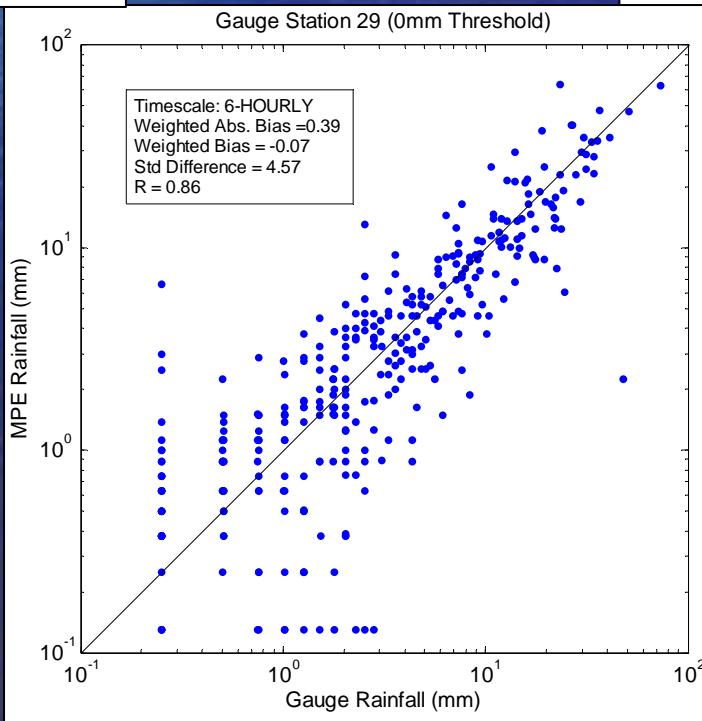
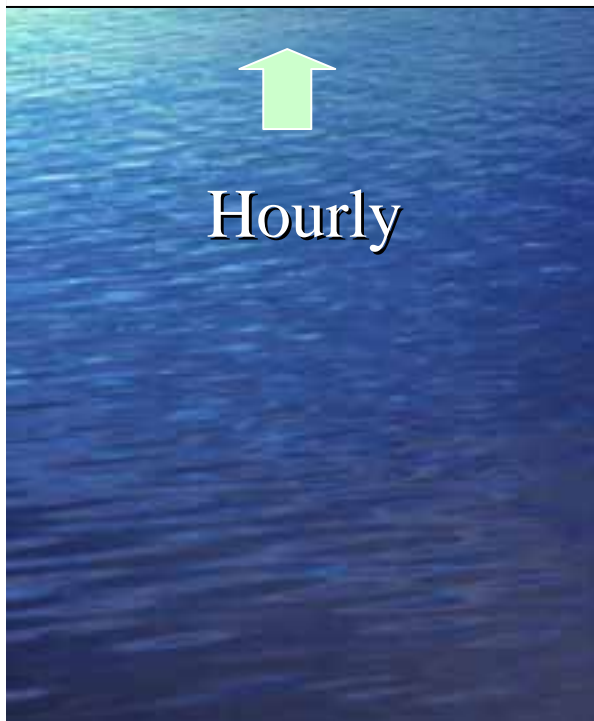
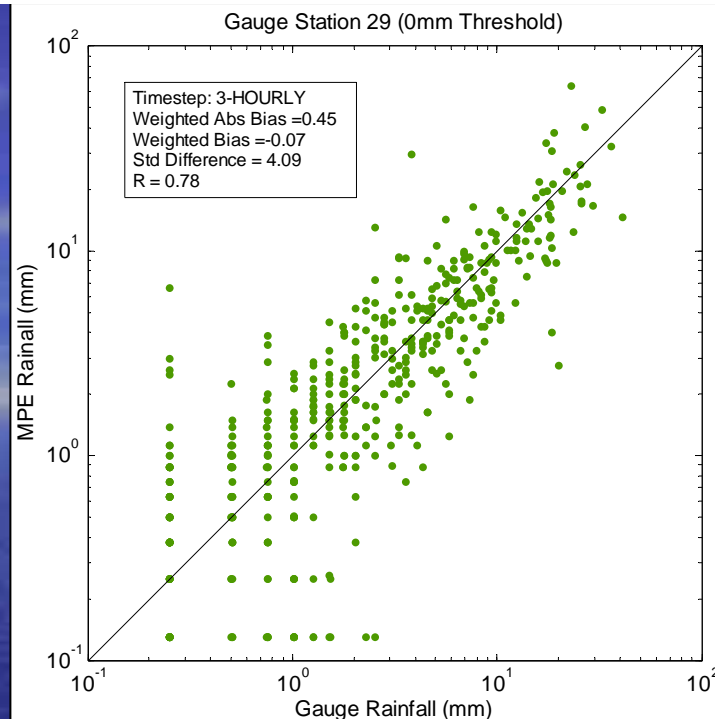
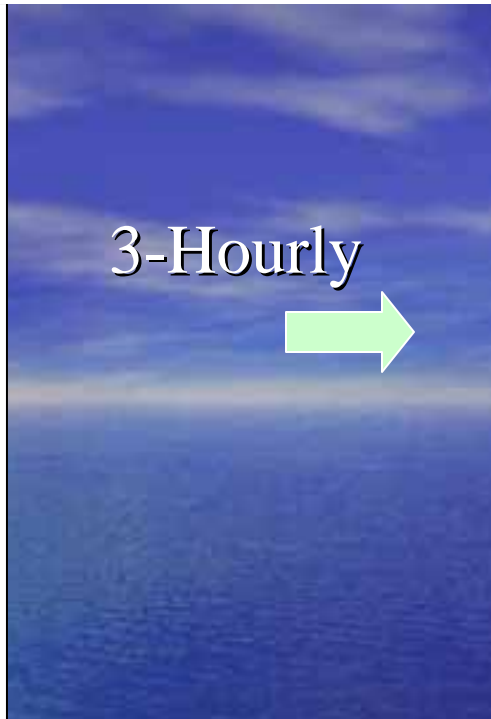
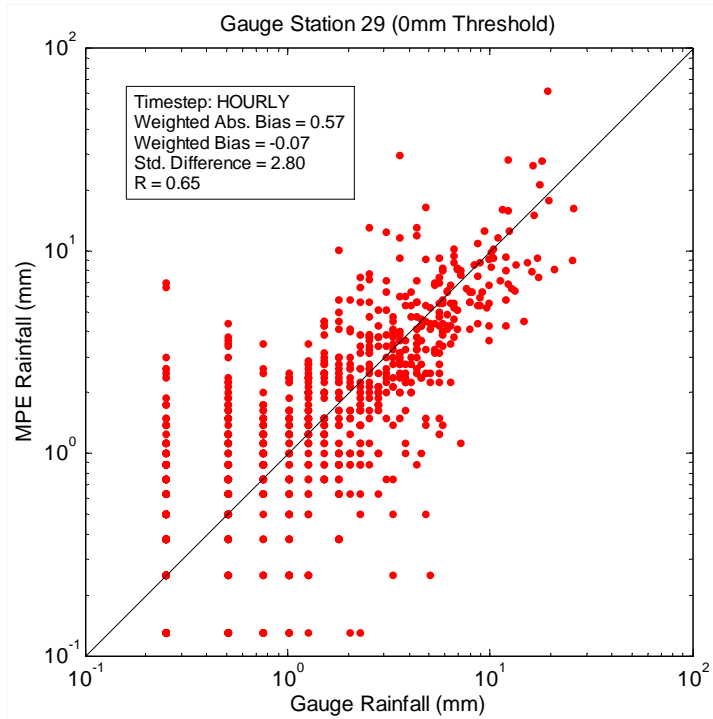
Weighted Absolute Bias

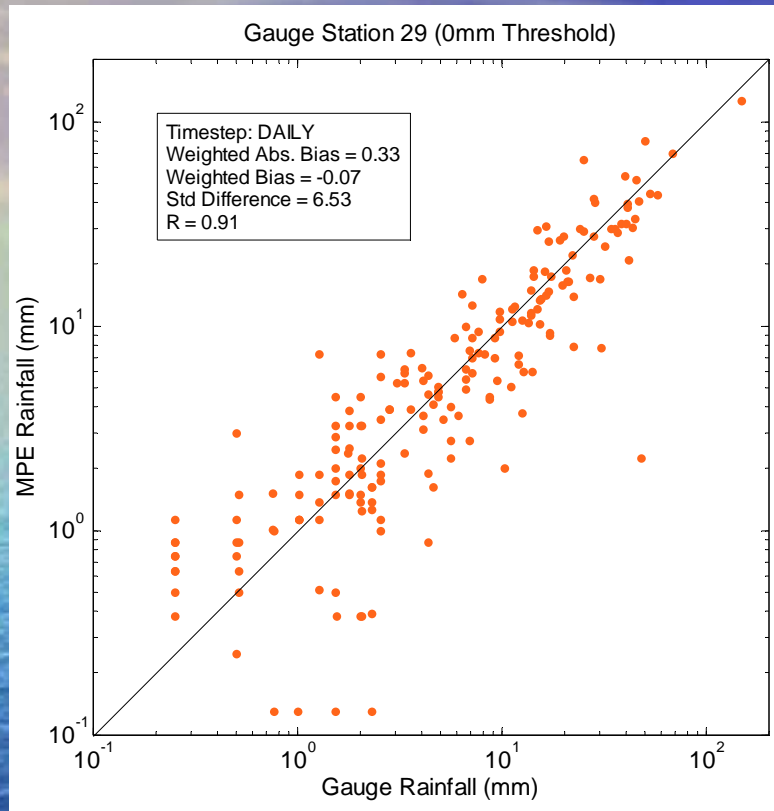
$$weighted\_bias = \sum_{i=1}^N \frac{\omega_i |l_{MPE_i} - l_{G_i}|}{l_{G_i}}, \text{ where the weighting function is:}$$

$$\omega_i = \frac{(l_{G_i})}{\langle l_G \rangle \times N}$$

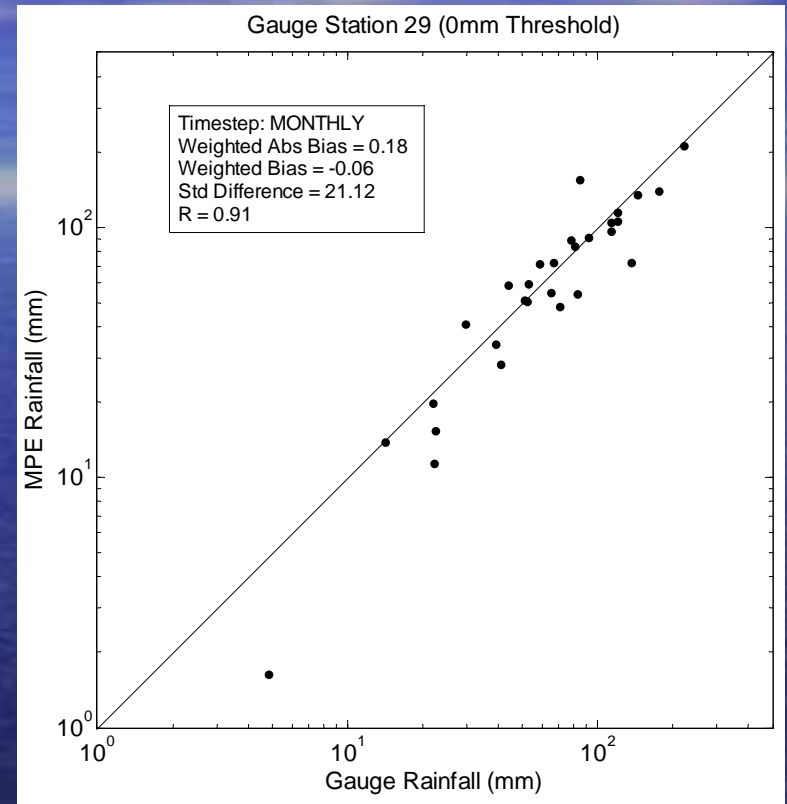
Standard Deviation of the Difference

$$Std_{Diff} = (Var(l_G) + Var(l_{MPE}) - 2 \times Cov(l_G, l_{MPE}))^{1/2}$$





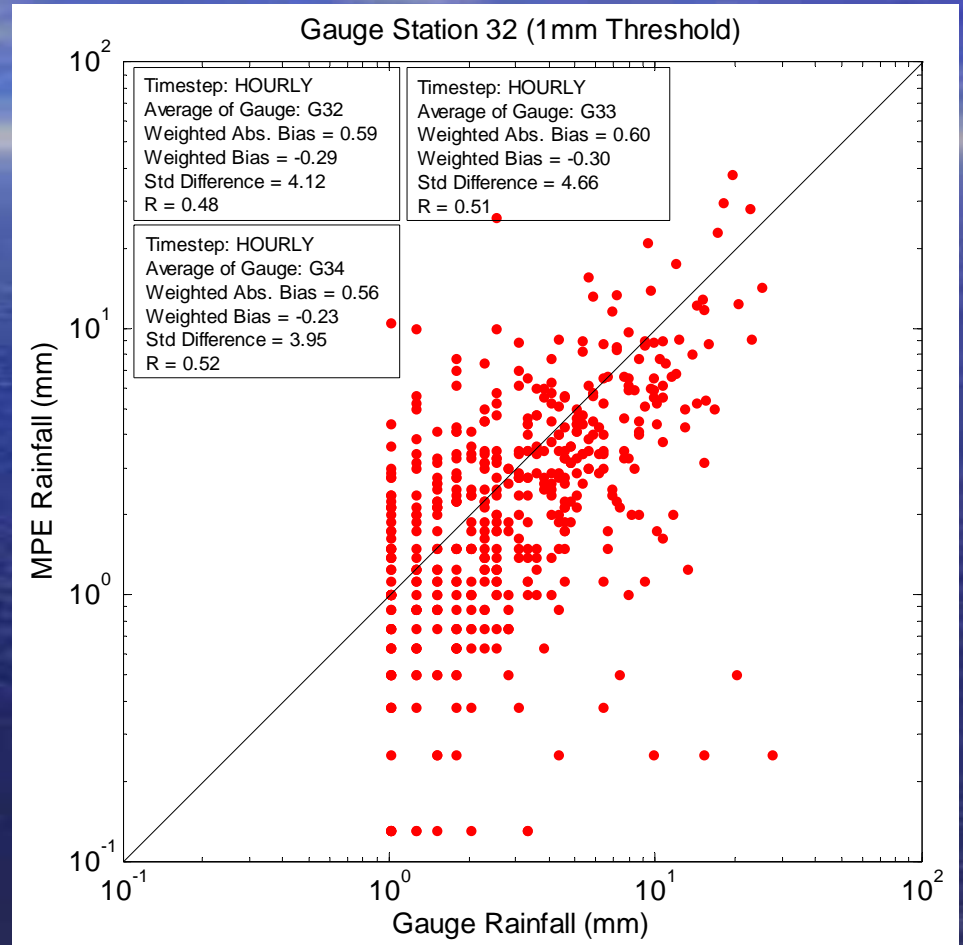
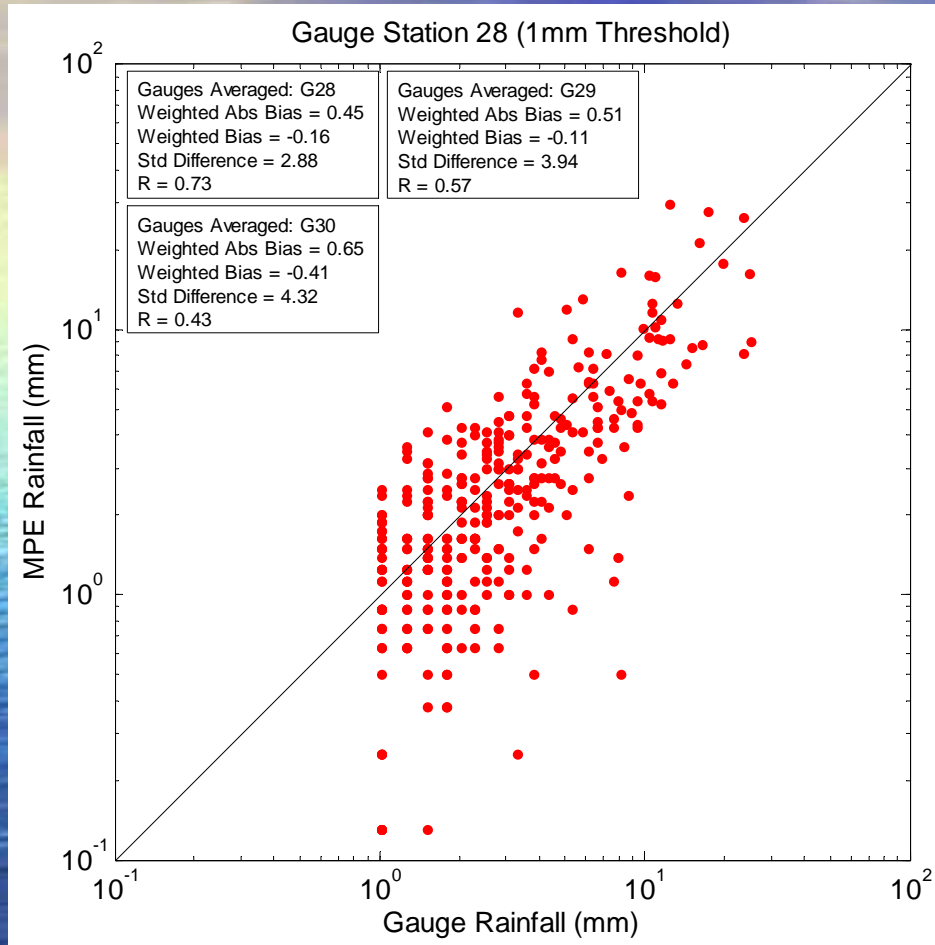
Daily



Monthly

Hourly Statistics of all 28 Gauges	2005		
	Hourly	Daily	Monthly
Mean (MPE) (mm)	1.58	7.71	68.82
Mean (gauge) (mm)	1.90	7.80	69.57
Standard Deviation (MPE) (mm)	2.66	12.66	36.67
Standard Deviation (gauge) (mm)	3.27	12.54	36.96
Normalized Bias w.r.t gauge average	-0.17	-0.01	-0.01
Normalized RMSE w.r.t gauge average	1.34	0.38	0.13
Correlation Coefficient (All MPE vs. gauge)	0.65	0.97	0.97
Correlation Coefficient (non-zeros)	0.65	0.97	0.97
	2006		
	Hourly	Daily	Monthly
Mean (MPE) (mm)	1.67	7.23	62.66
Mean (gauge) (mm)	2.01	7.16	62.01
Standard Deviation (MPE) (mm)	3.08	13.94	57.99
Standard Deviation (gauge) (mm)	3.37	13.37	53.91
Normalized Bias w.r.t gauge average	-0.17	0.01	0.01
Normalized RMSE w.r.t gauge average	1.31	0.44	0.19
Correlation Coefficient (All MPE vs. gauge)	0.67	0.97	0.98
Correlation Coefficient (non-zeros)	0.67	0.97	0.98

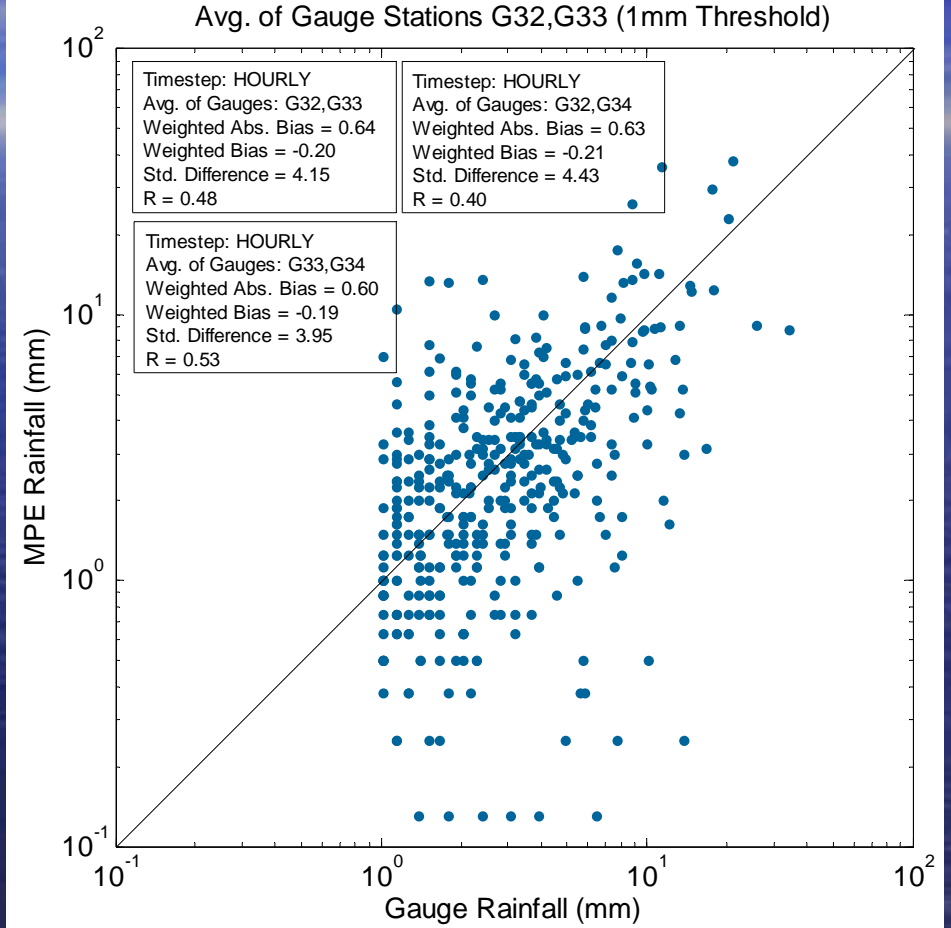
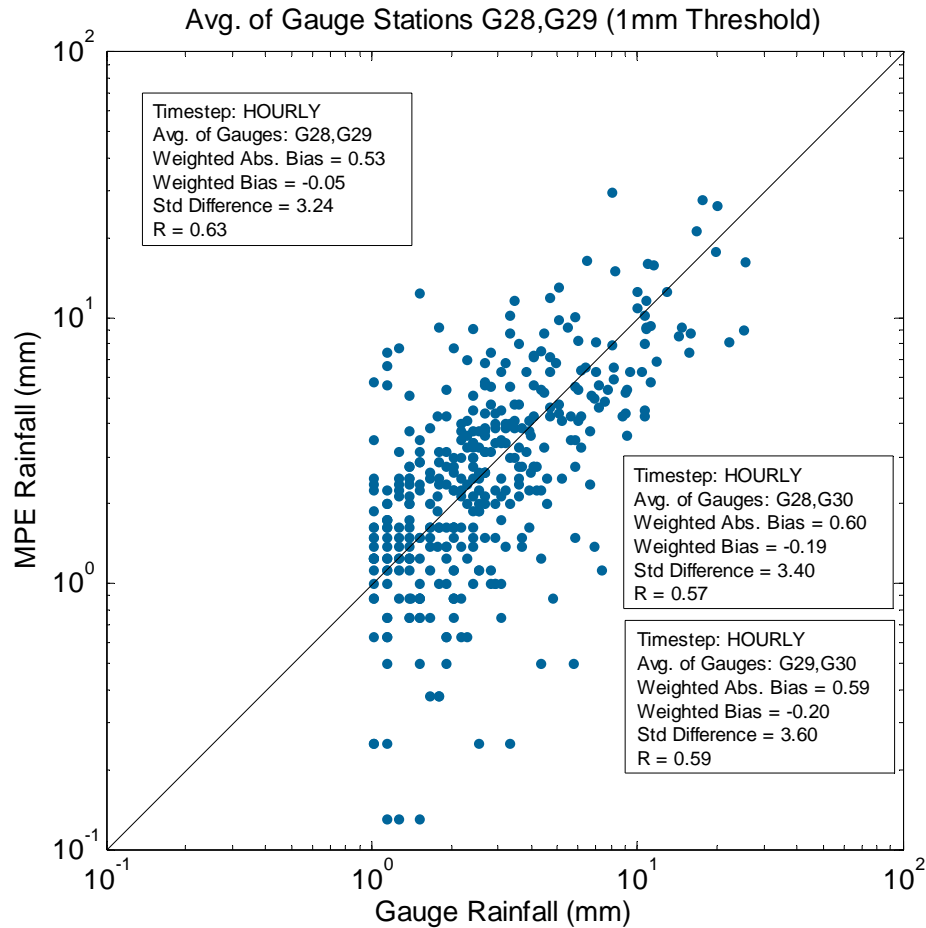
# Wallops Island Hourly Gauge Analysis



Pixel One: Single Gauge  
(G28, G29, G30)

Pixel Two: Single Gauge  
(G32, G33, G34)

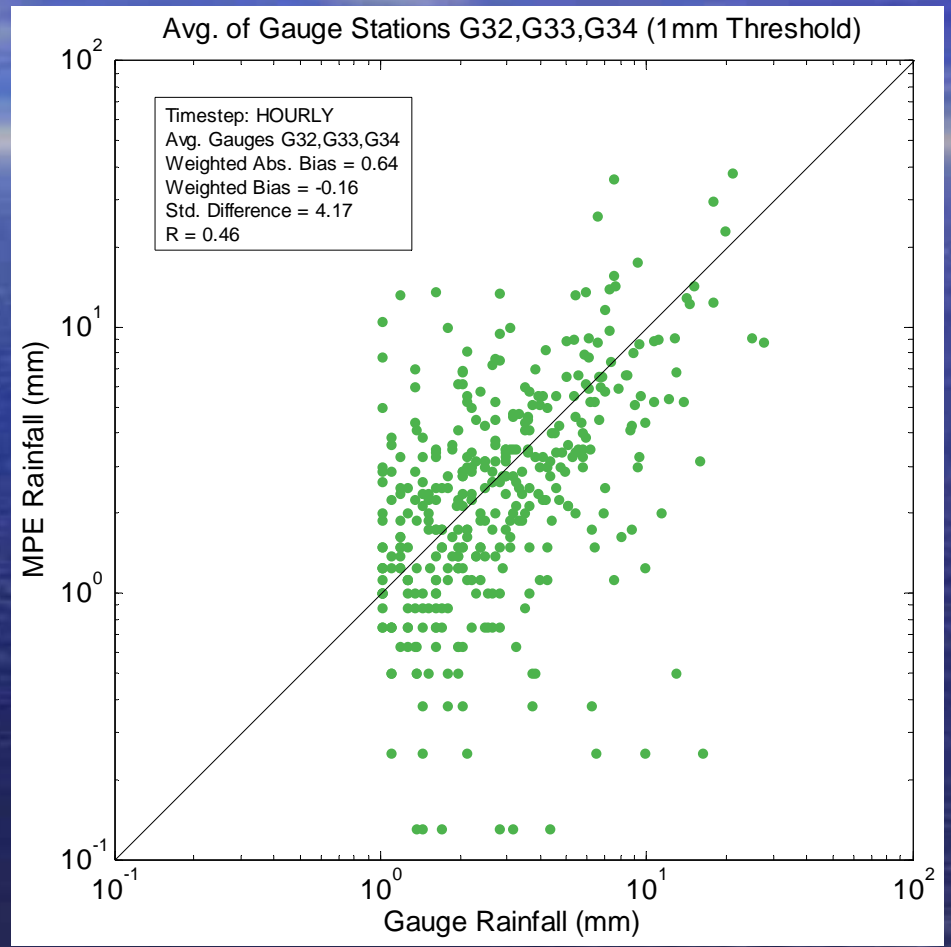
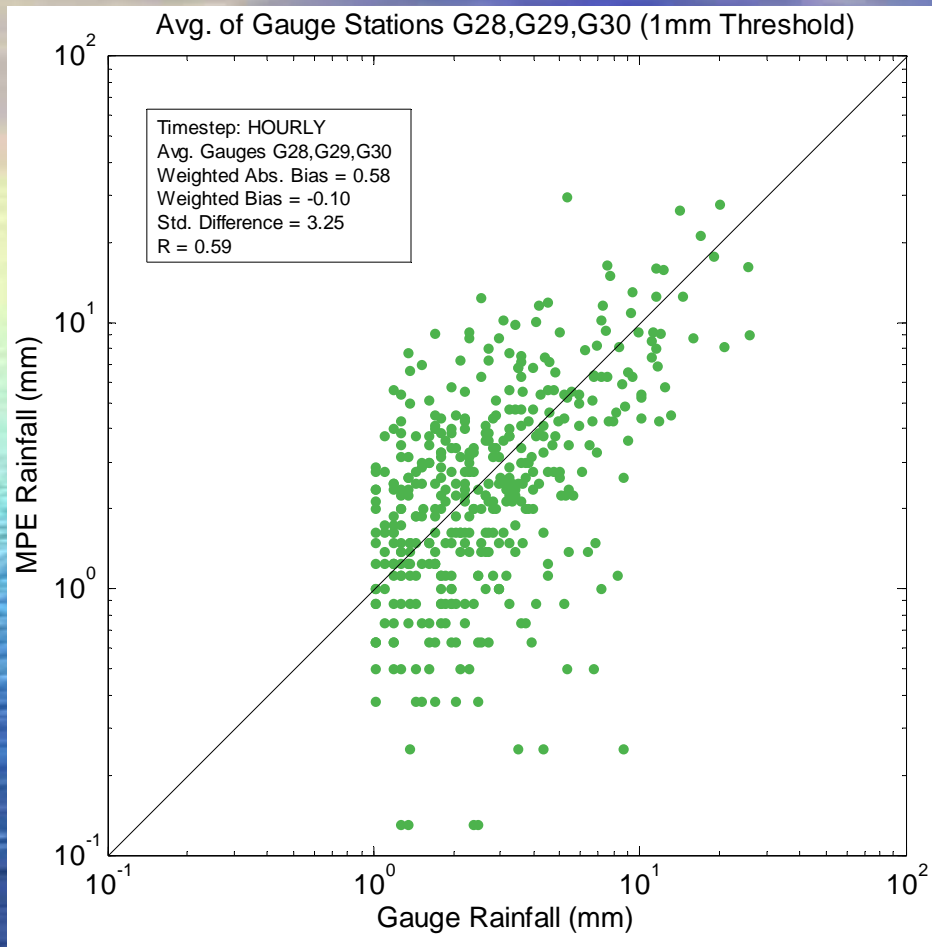
# Hourly Gauge Analysis



Pixel One: 2-Gauge Average  
(G28-G29, G28-G30, G29-G30)

Pixel Two: 2-Gauge Average  
(G32-G33, G32-G34, G33-G34)

# Hourly Gauge Analysis



Pixel One: 3-Gauge Average  
(G28-G29-G30)

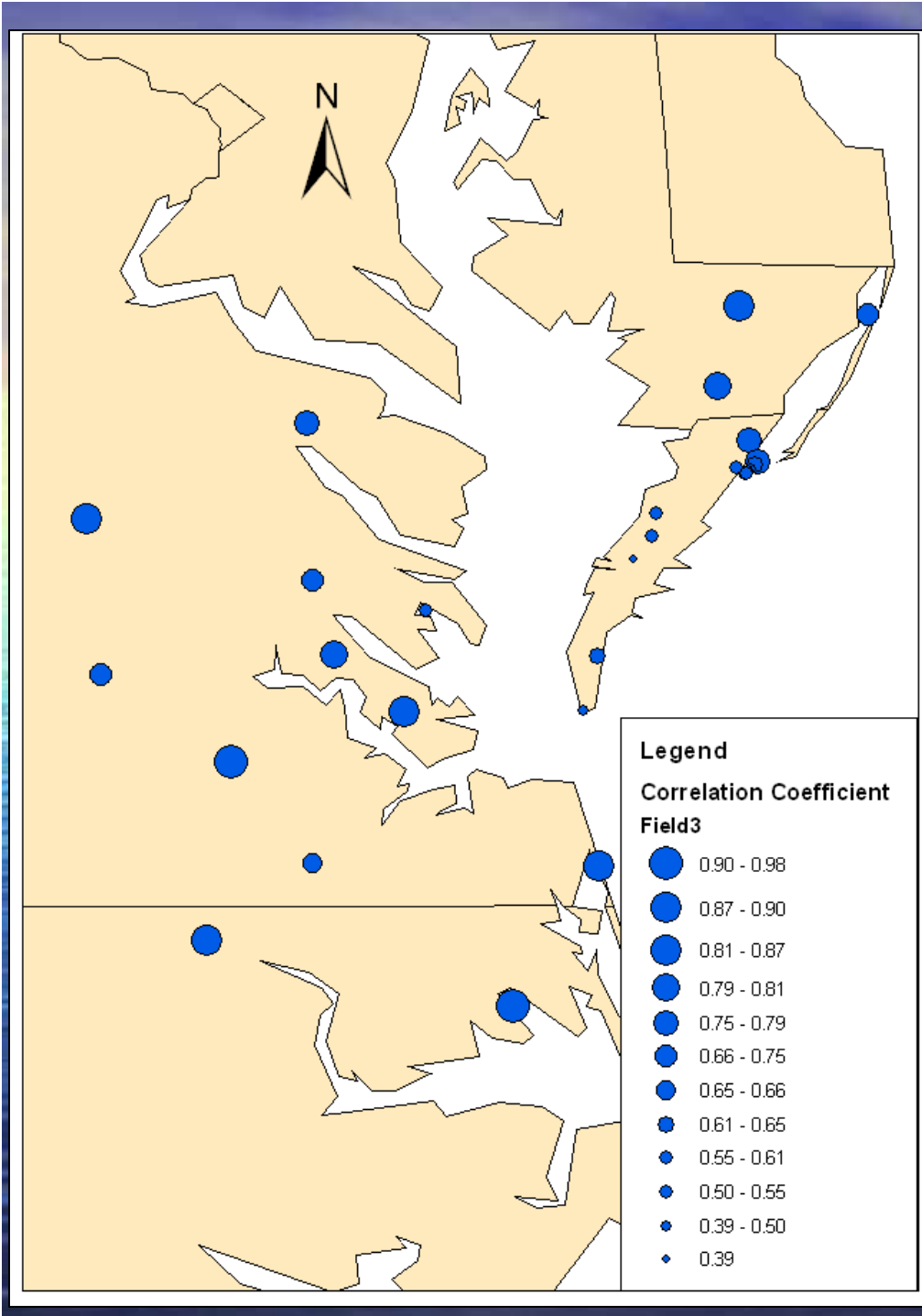
Pixel Two: 3-Gauge Average  
(G32-G33-G34)

# Internal MPE Analysis

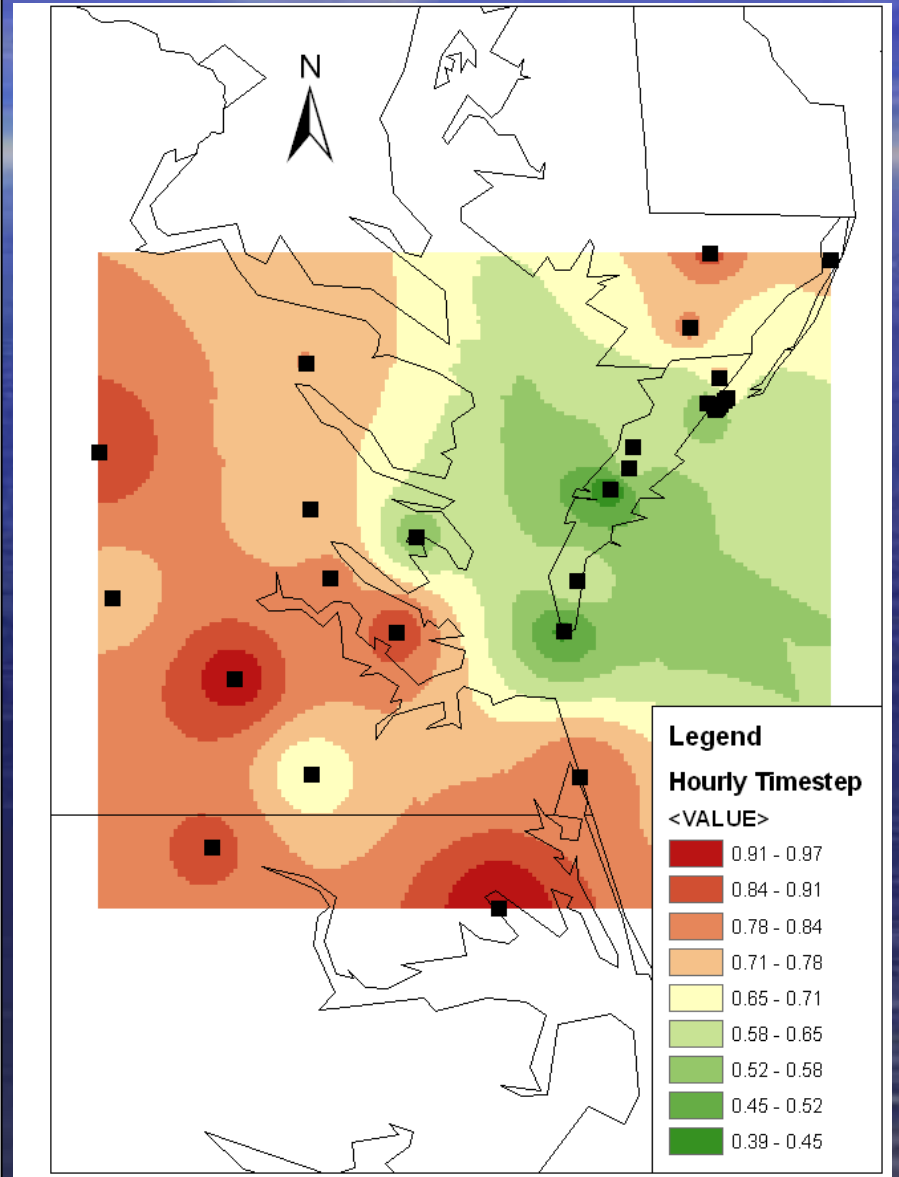
Gauge 29	Gauge Threshold: 0 mm		Gauge Threshold: 1 mm	
Pixels Compared	Correlation	Wt. Abs. Bias	Correlation	Wt. Abs. Bias
M.C. / M.L.	0.83	3.06	0.79	3.49
M.C. / M.R.	0.89	2.47	0.87	2.81
M.C. / T.C.	0.95	1.66	0.95	1.86
M.C. / T.L.	0.77	3.61	0.73	4.08
M.C. / T.R.	0.93	2.06	0.93	2.31
M.C. / B.C.	0.97	1.34	0.96	1.49
M.C. / B.L.	0.89	2.55	0.87	2.89
M.C. / B.R.	0.78	3.49	0.73	3.95
	Gauge Threshold: 5 mm		Gauge Threshold: 10 mm	
Pixels Compared	Correlation	Wt. Abs. Bias	Correlation	Wt. Abs. Bias
M.C. / M.L.	0.66	6.14	0.53	11.18
M.C. / M.R.	0.83	4.45	0.79	7.75
M.C. / T.C.	0.94	2.95	0.94	4.75
M.C. / T.L.	0.57	7.14	0.42	12.86
M.C. / T.R.	0.94	3.16	0.95	5.00
M.C. / B.C.	0.95	2.27	0.95	3.49
M.C. / B.L.	0.83	4.60	0.78	8.08
M.C. / B.R.	0.59	6.65	0.46	11.60

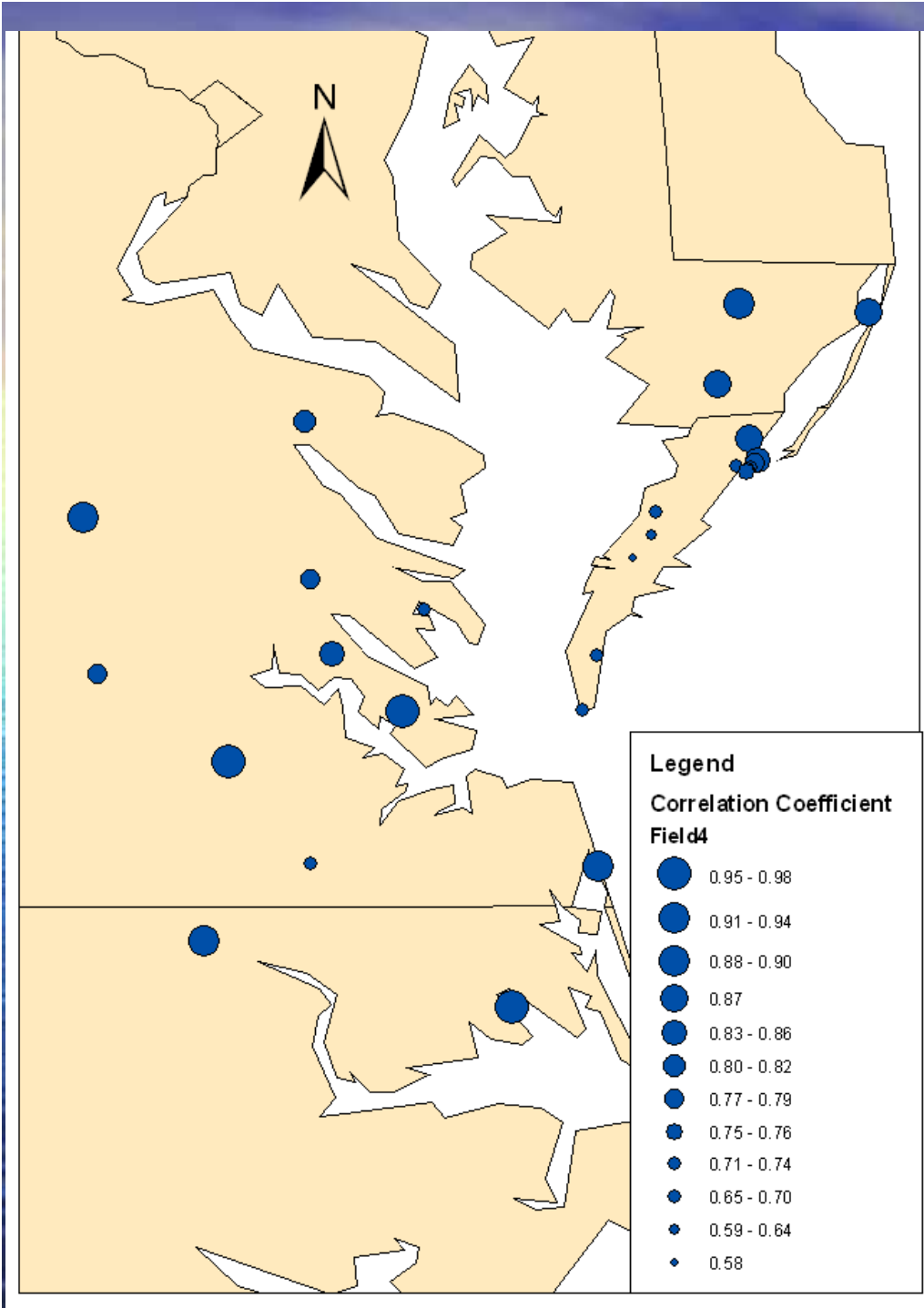


# Correlation Maps

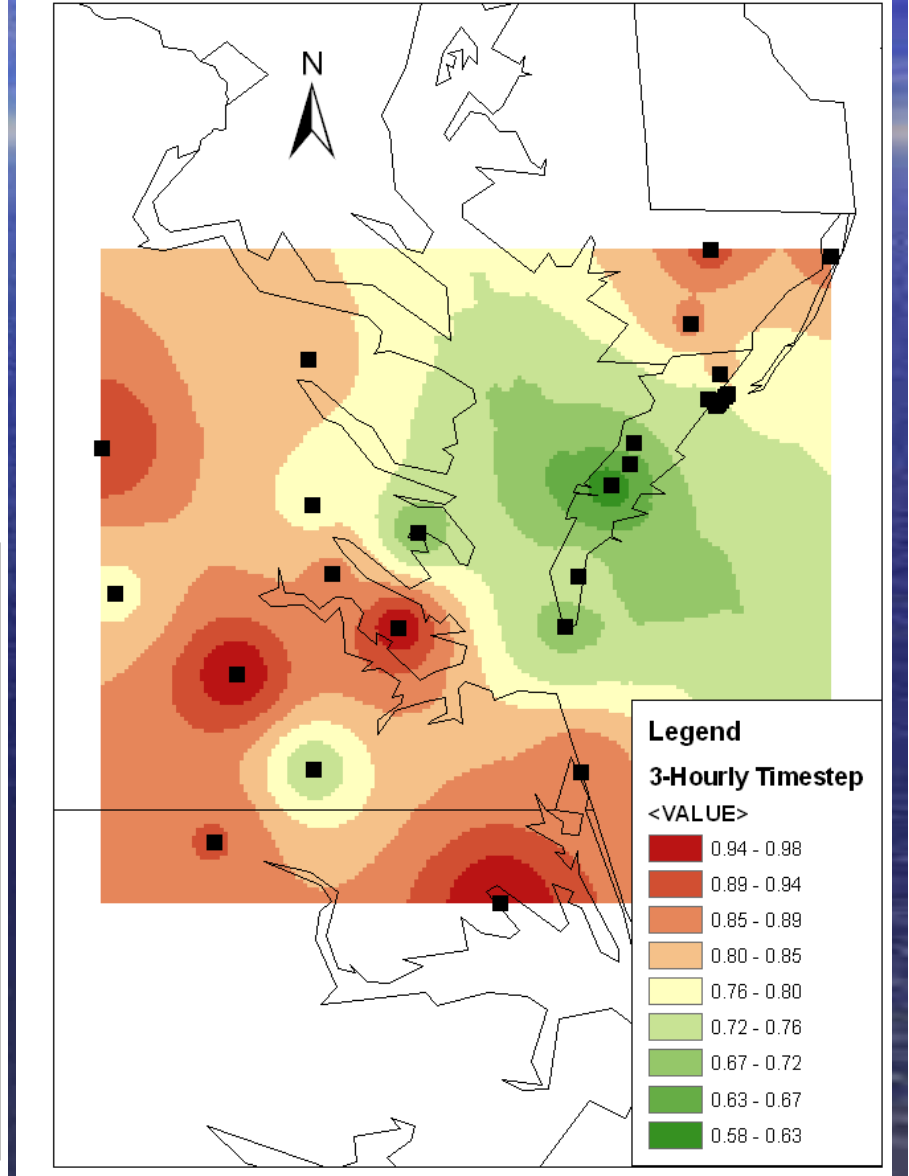


# Hourly

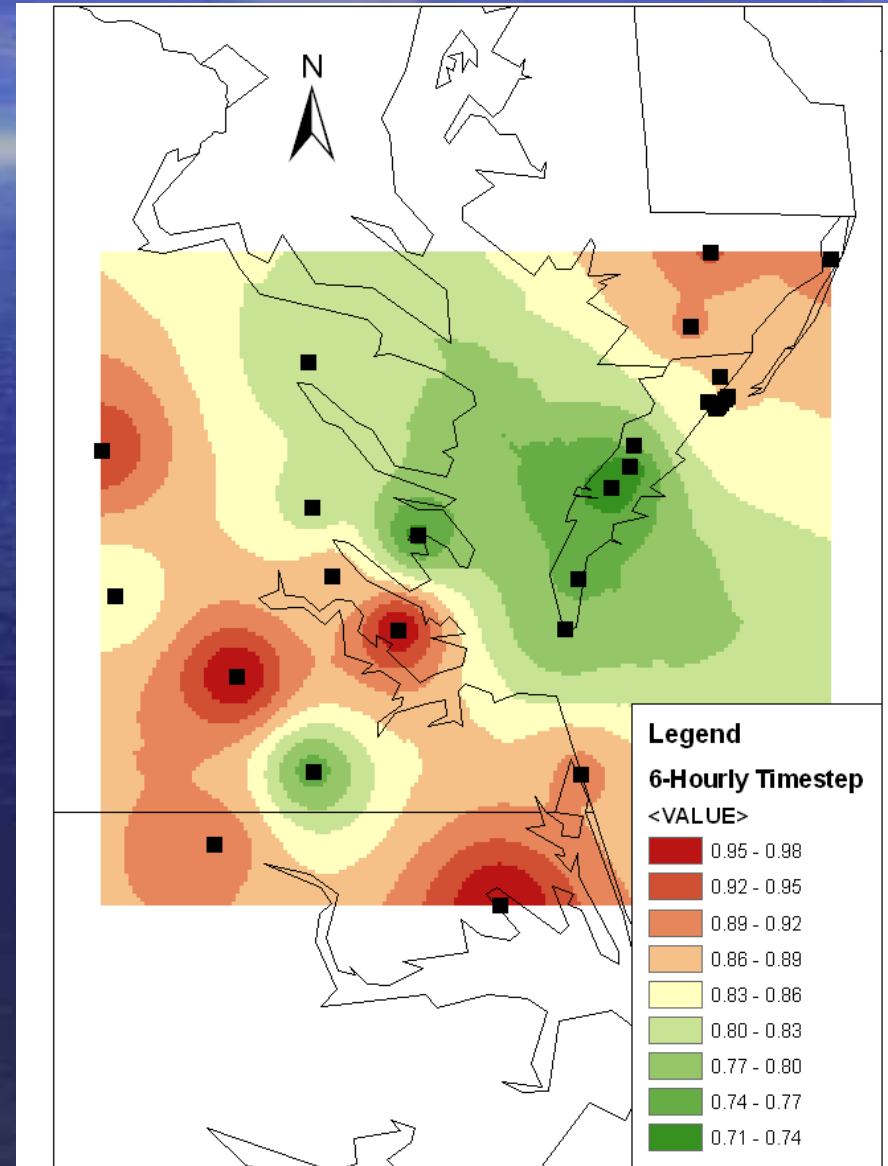
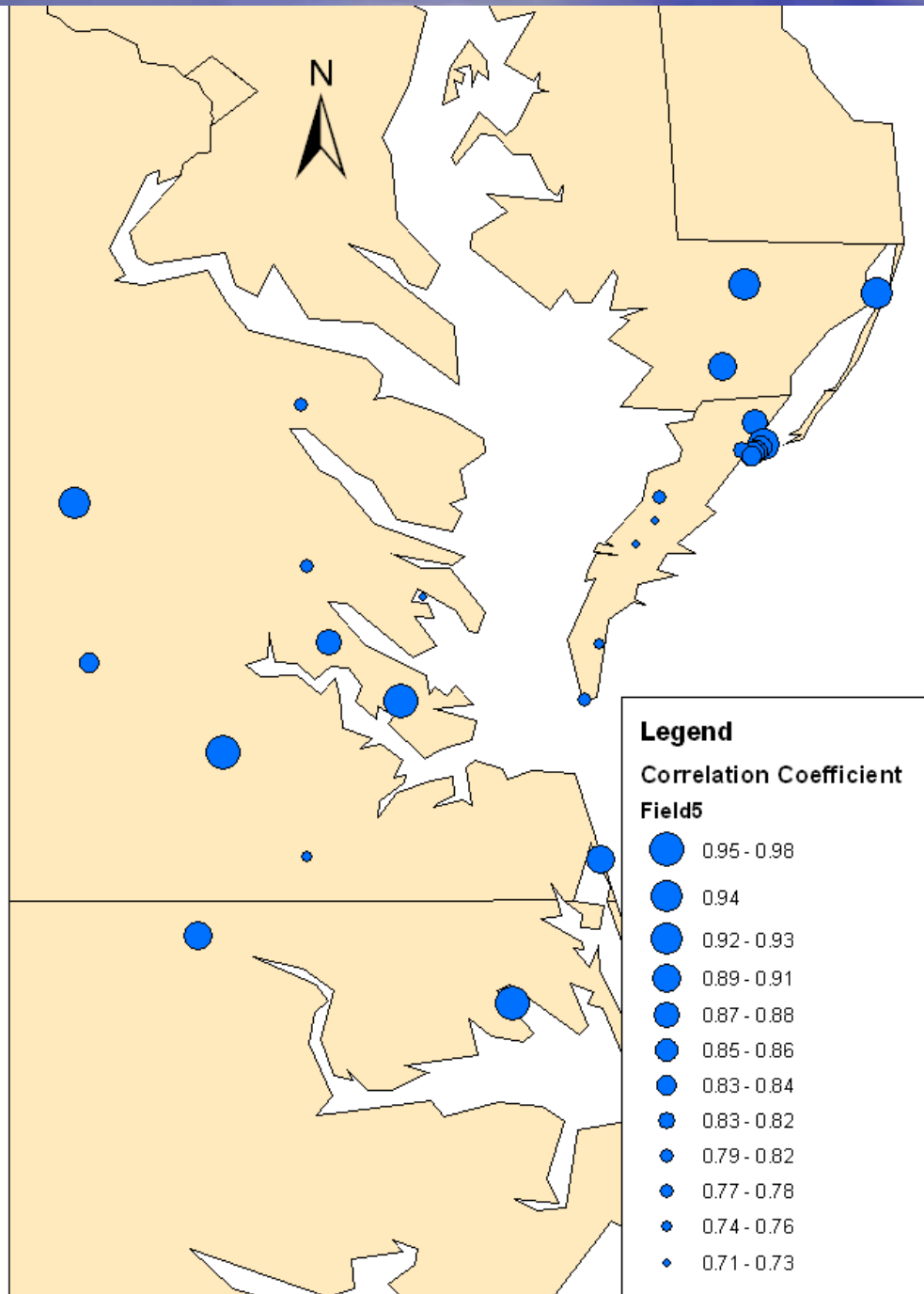




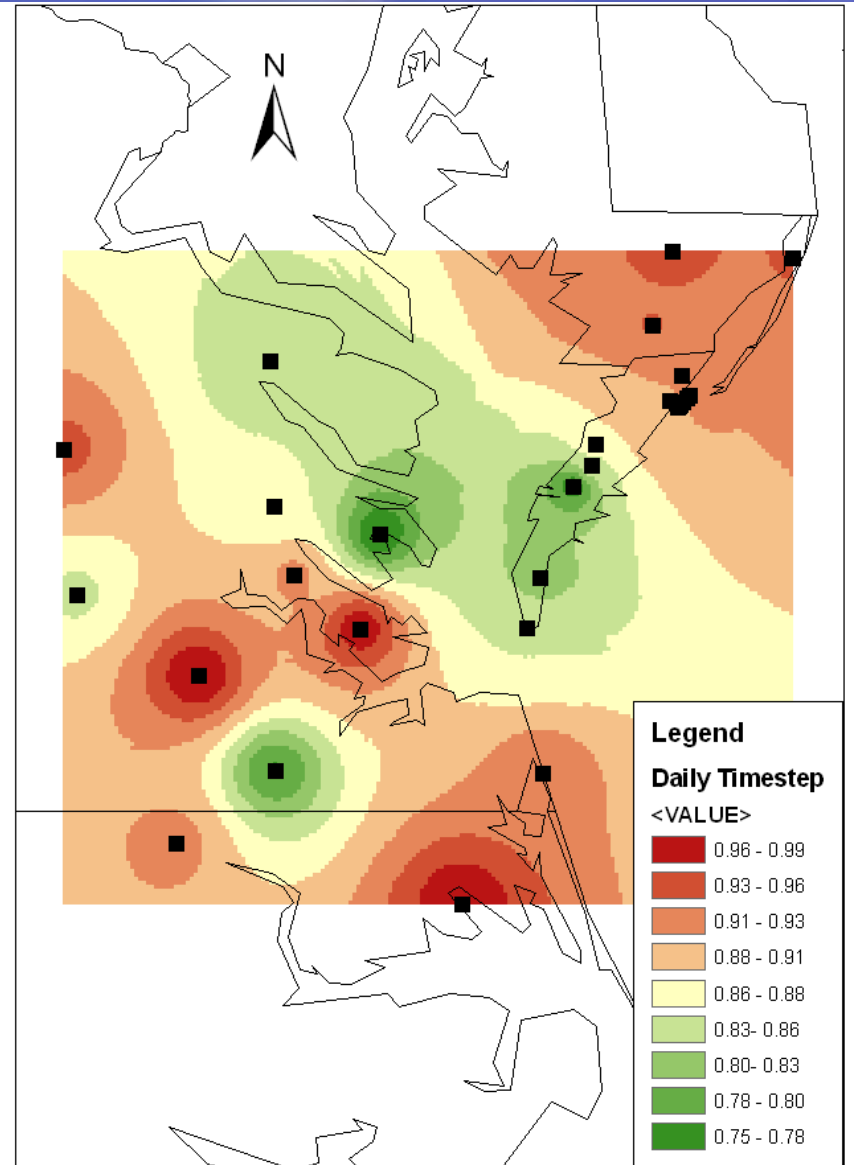
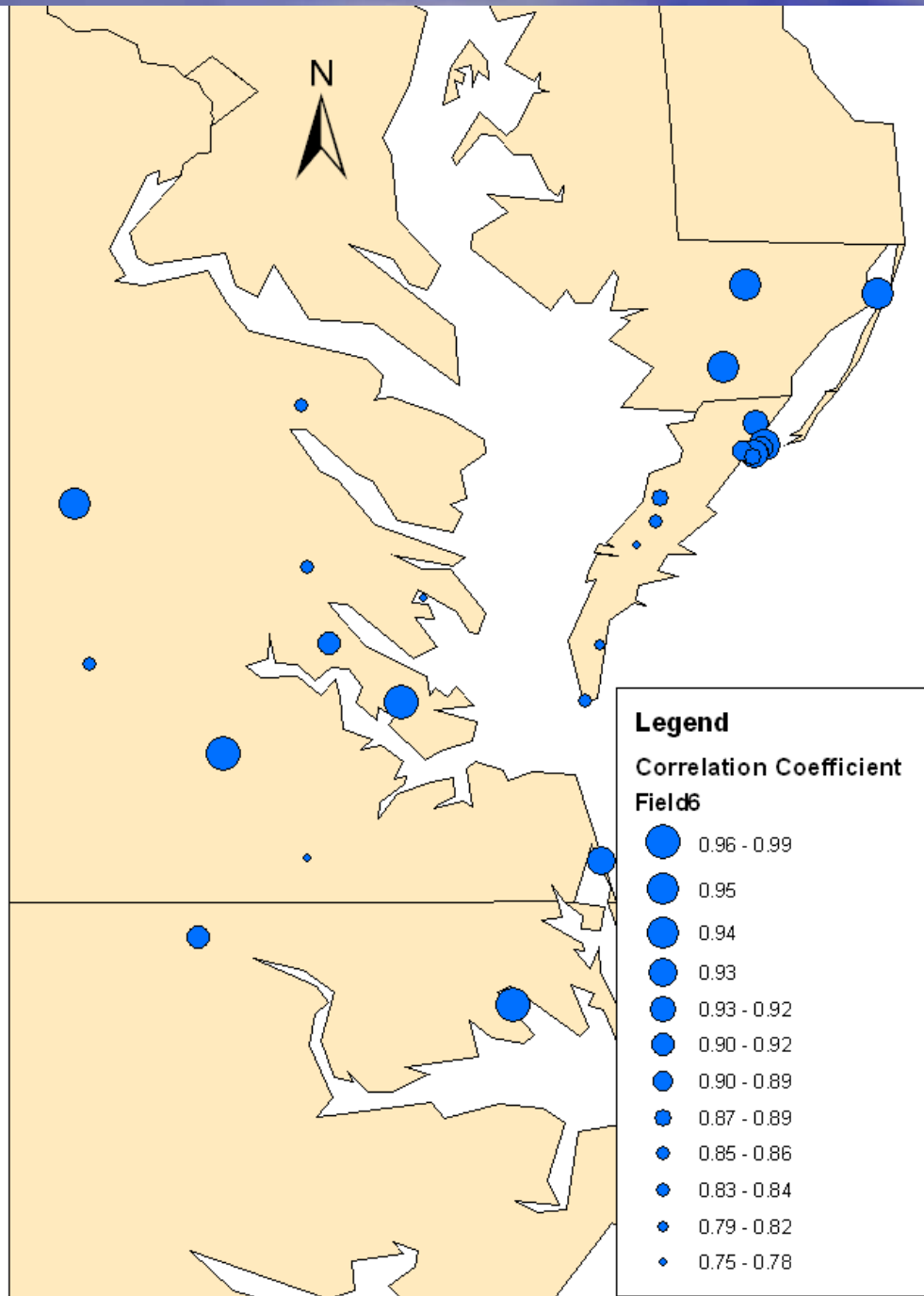
# 3-Hourly



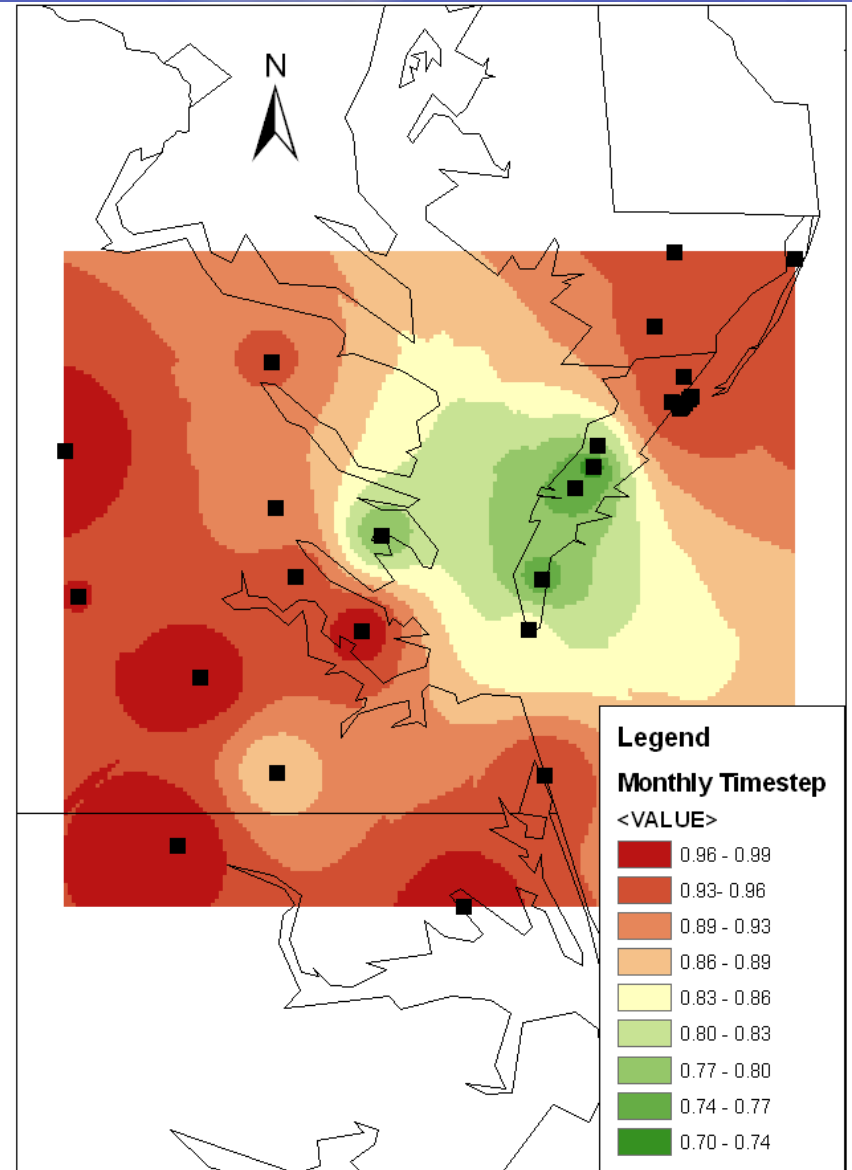
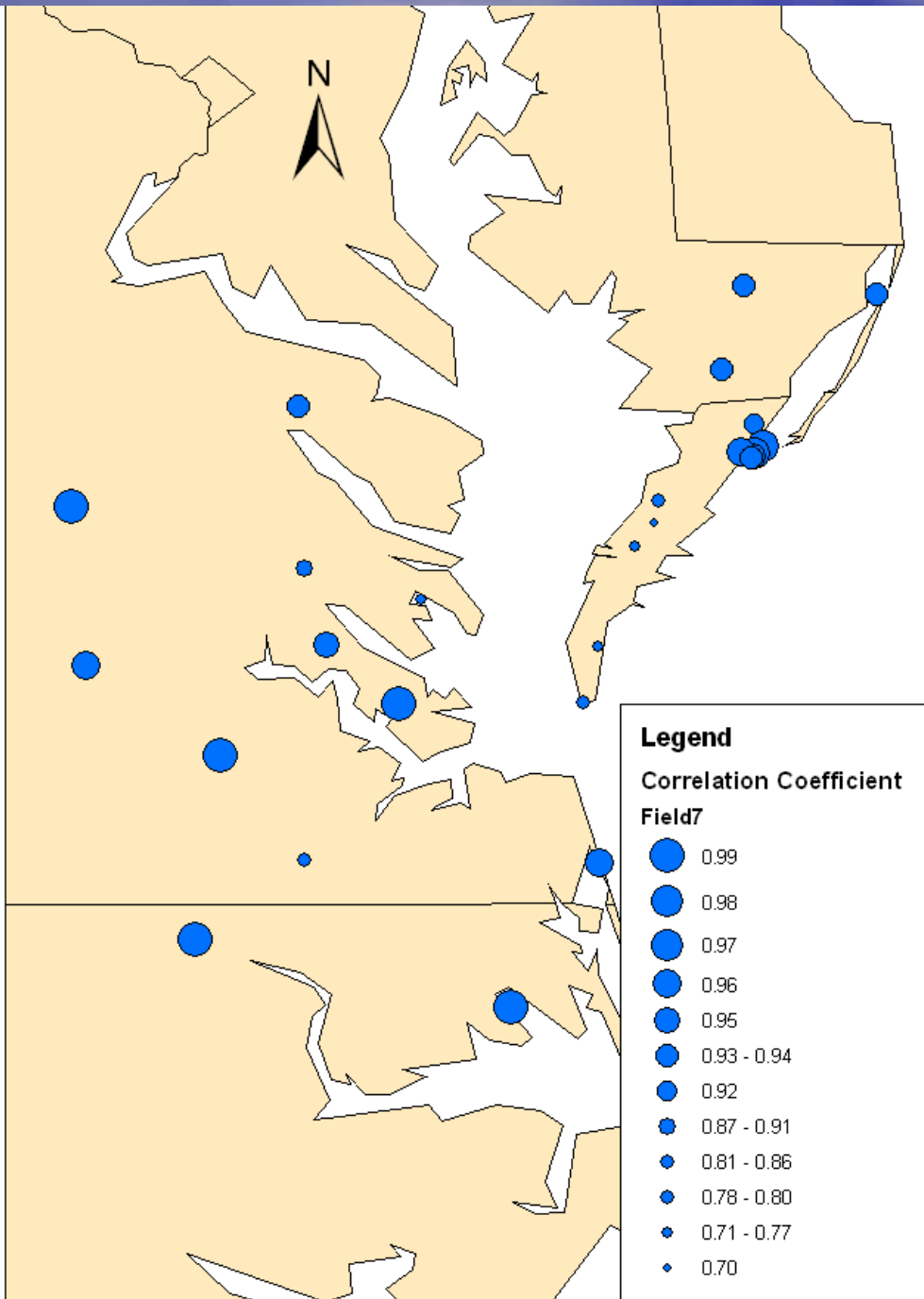
# 6-Hourly



# Daily



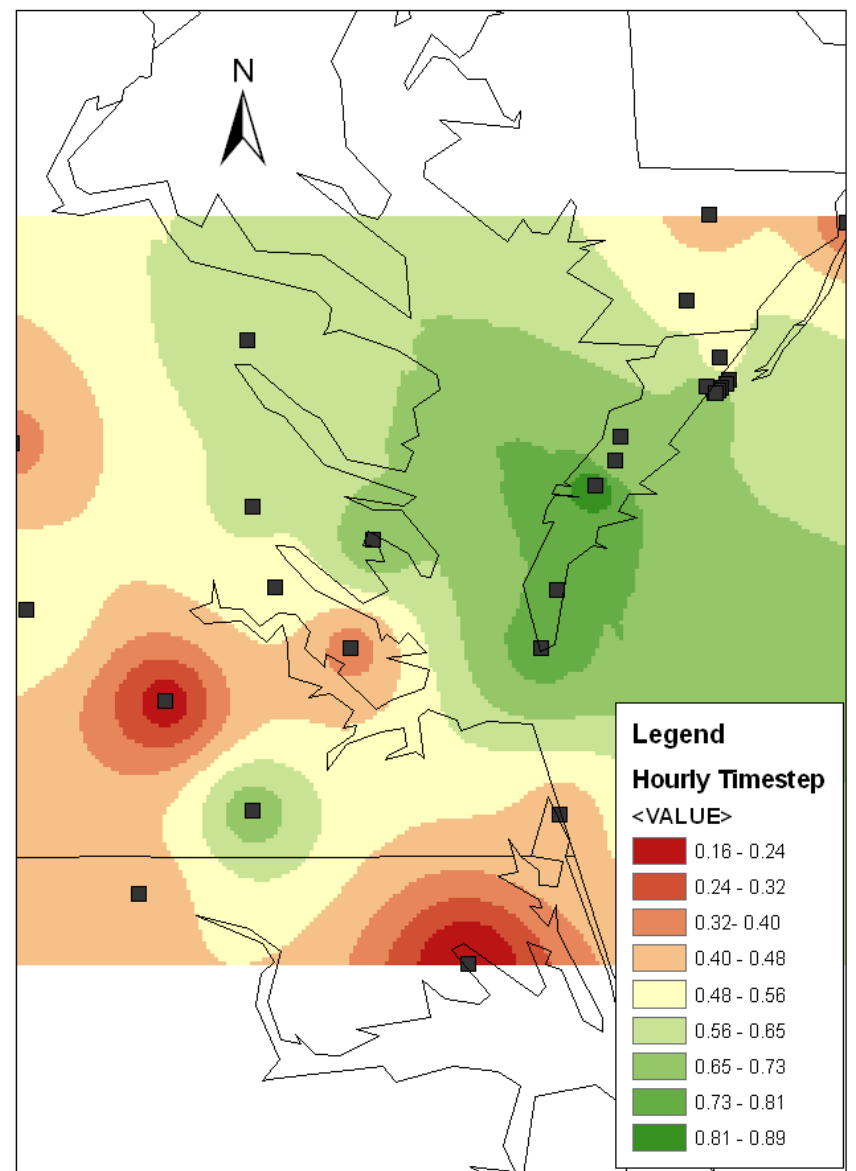
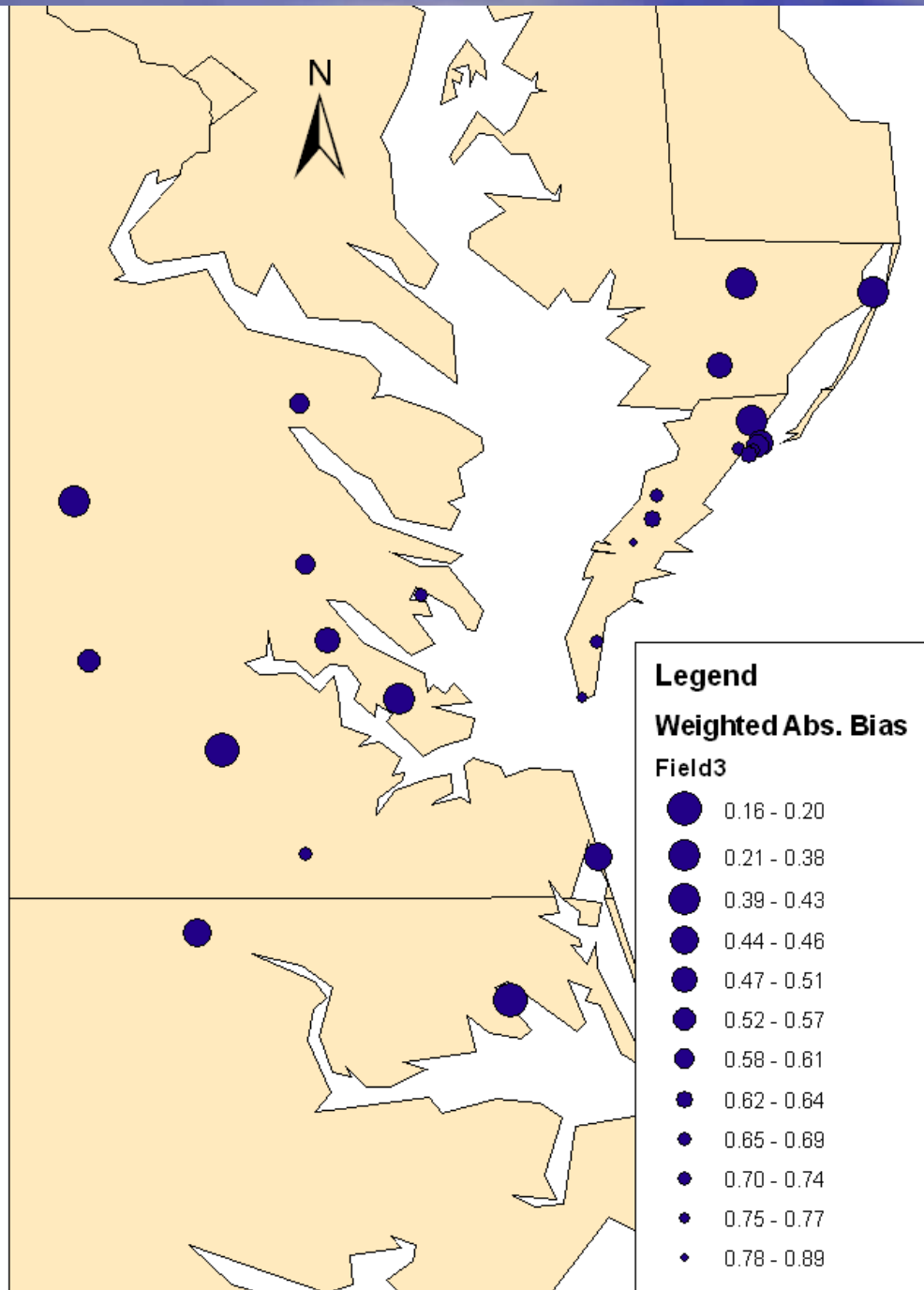
# Monthly



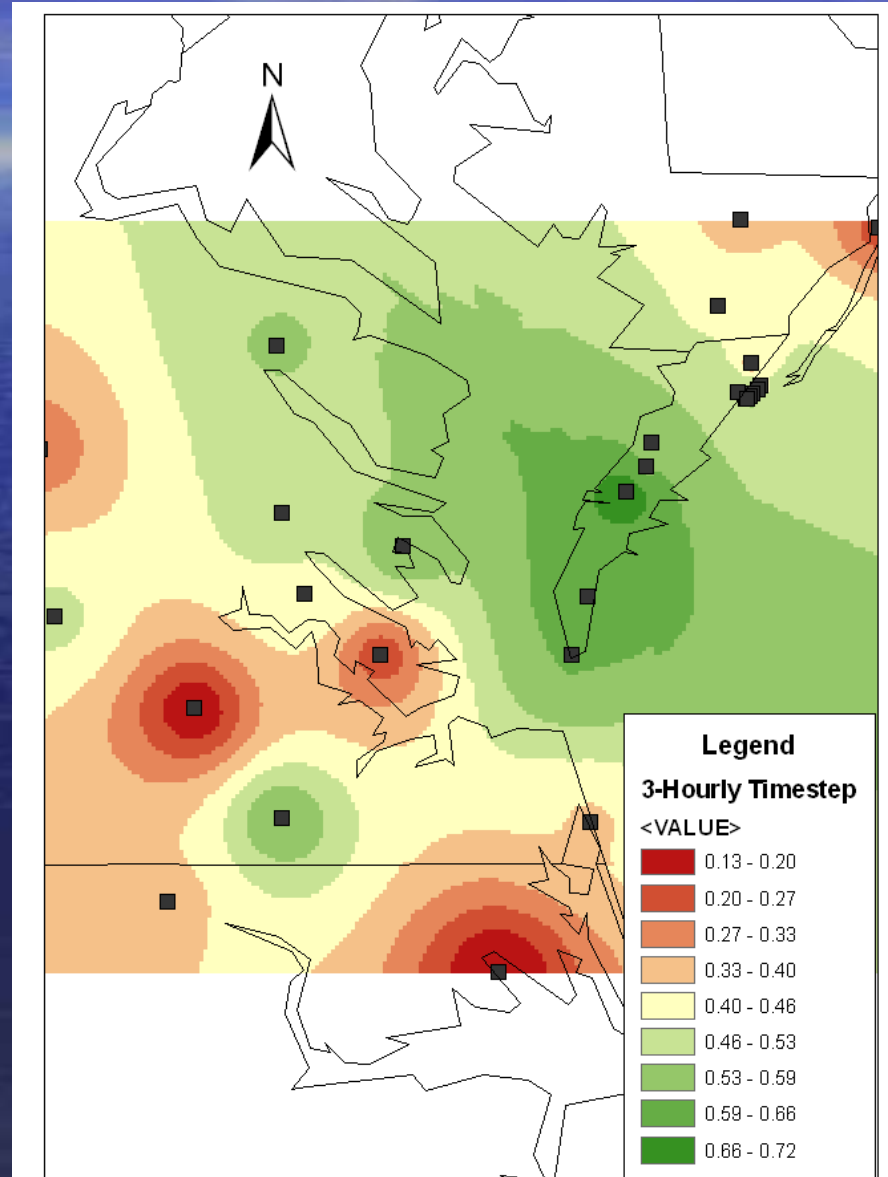
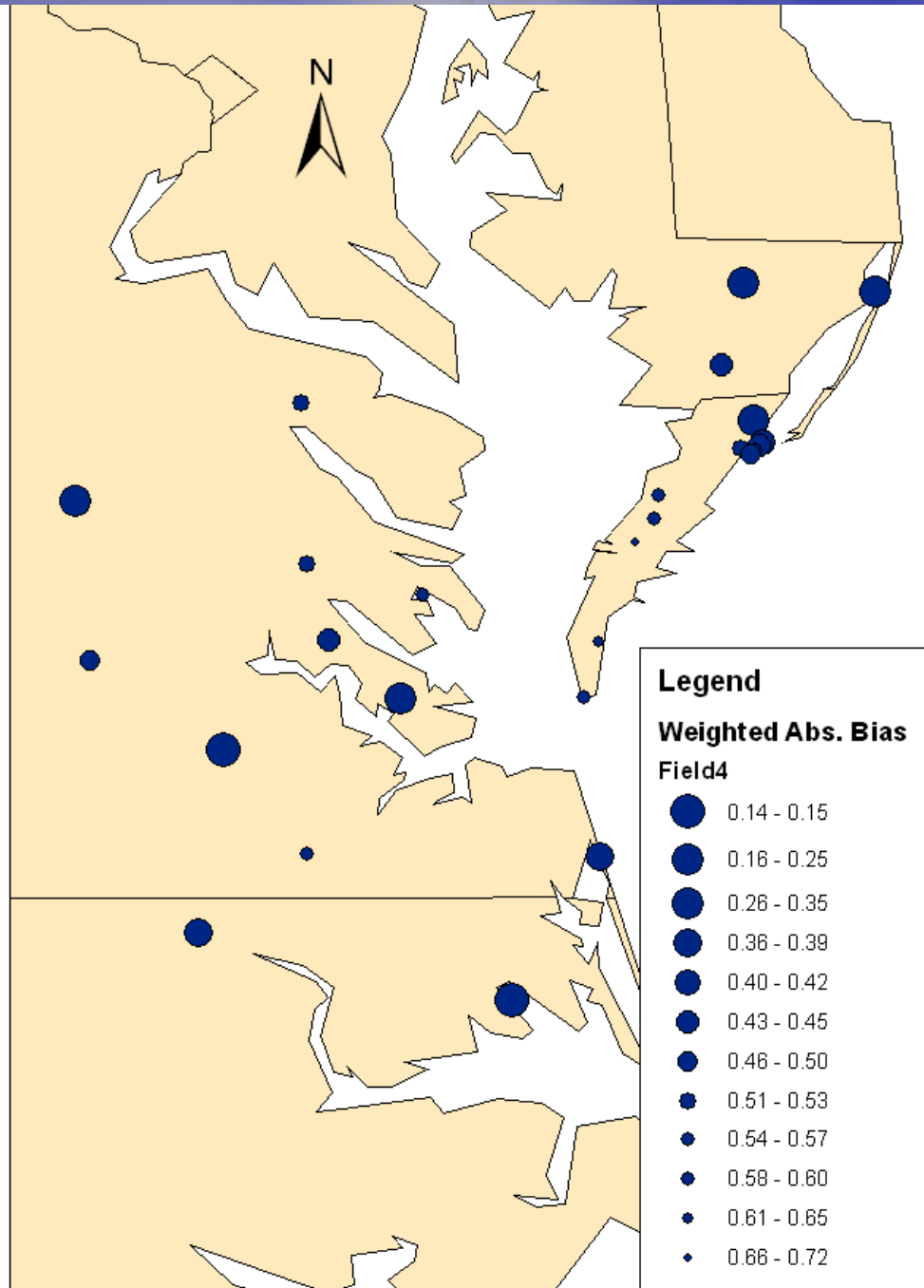
The background of the slide is a photograph of a sunset or sunrise over a large body of water. The sky is a deep blue with wispy white clouds. The sun is low on the horizon, creating a bright glow and a rainbow on the left side of the image. The water is dark blue with gentle ripples.

# Weighted Absolute Bias Maps

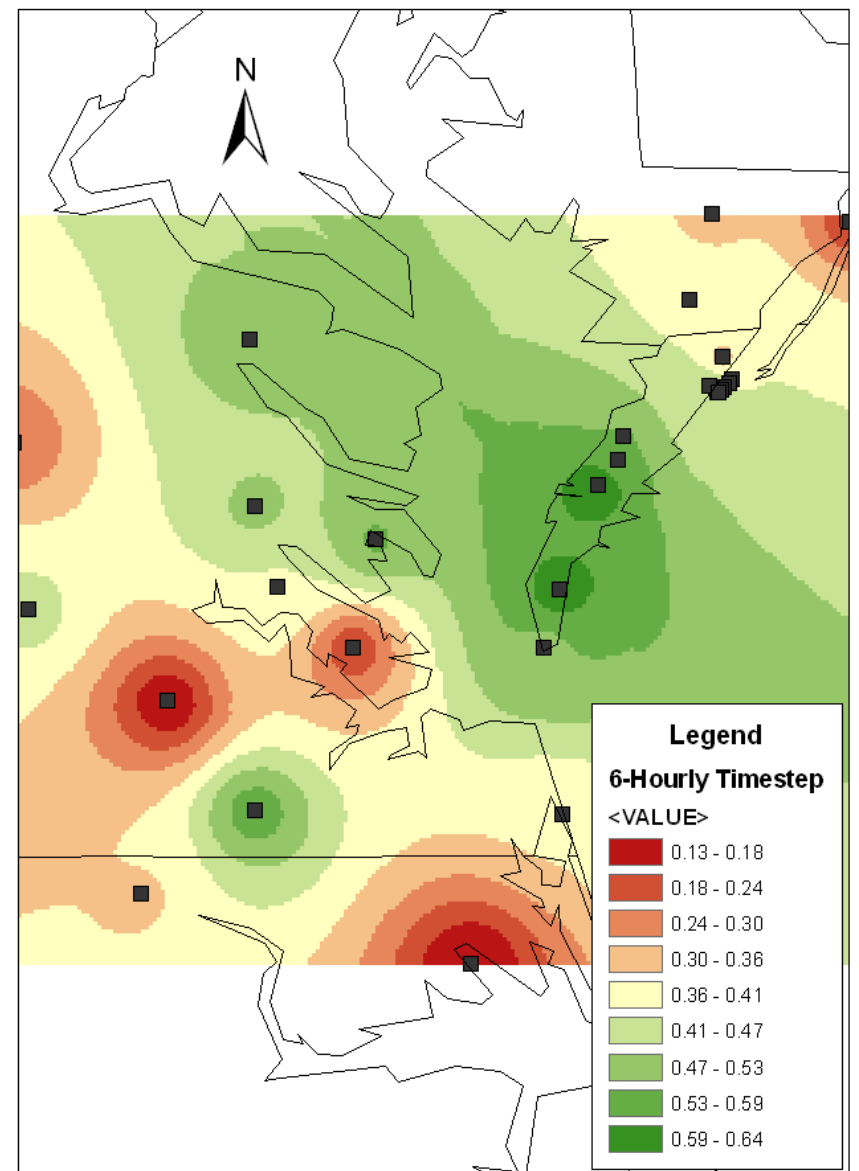
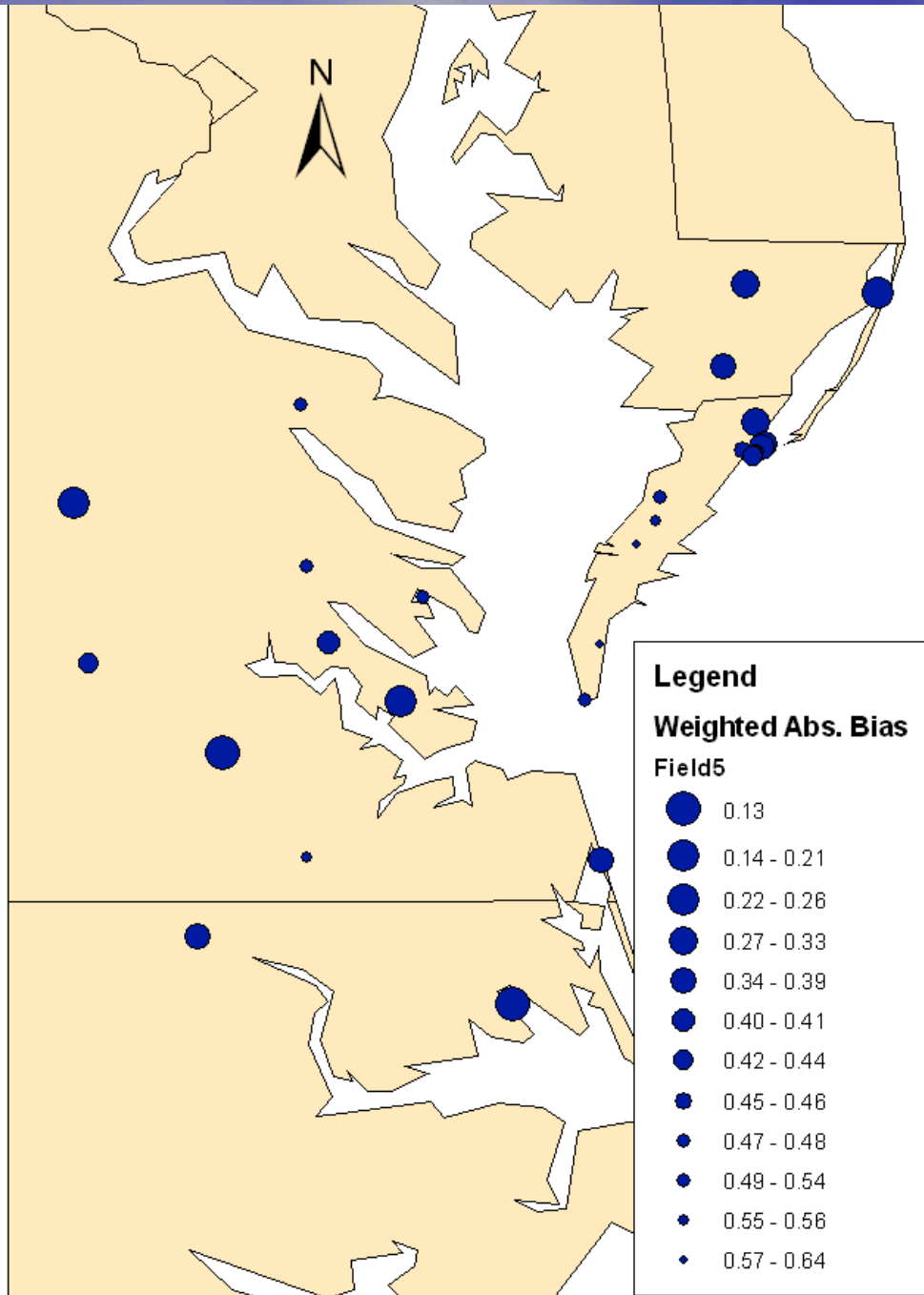
# Hourly



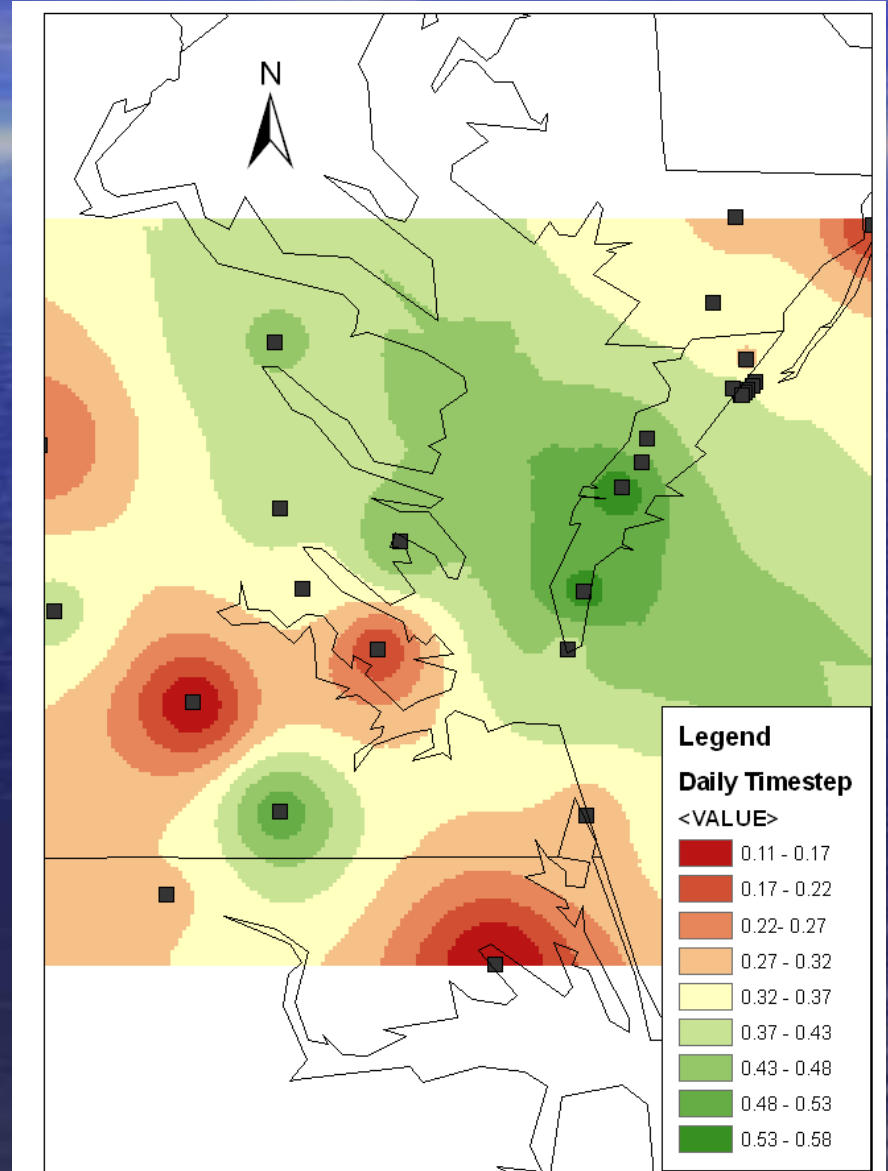
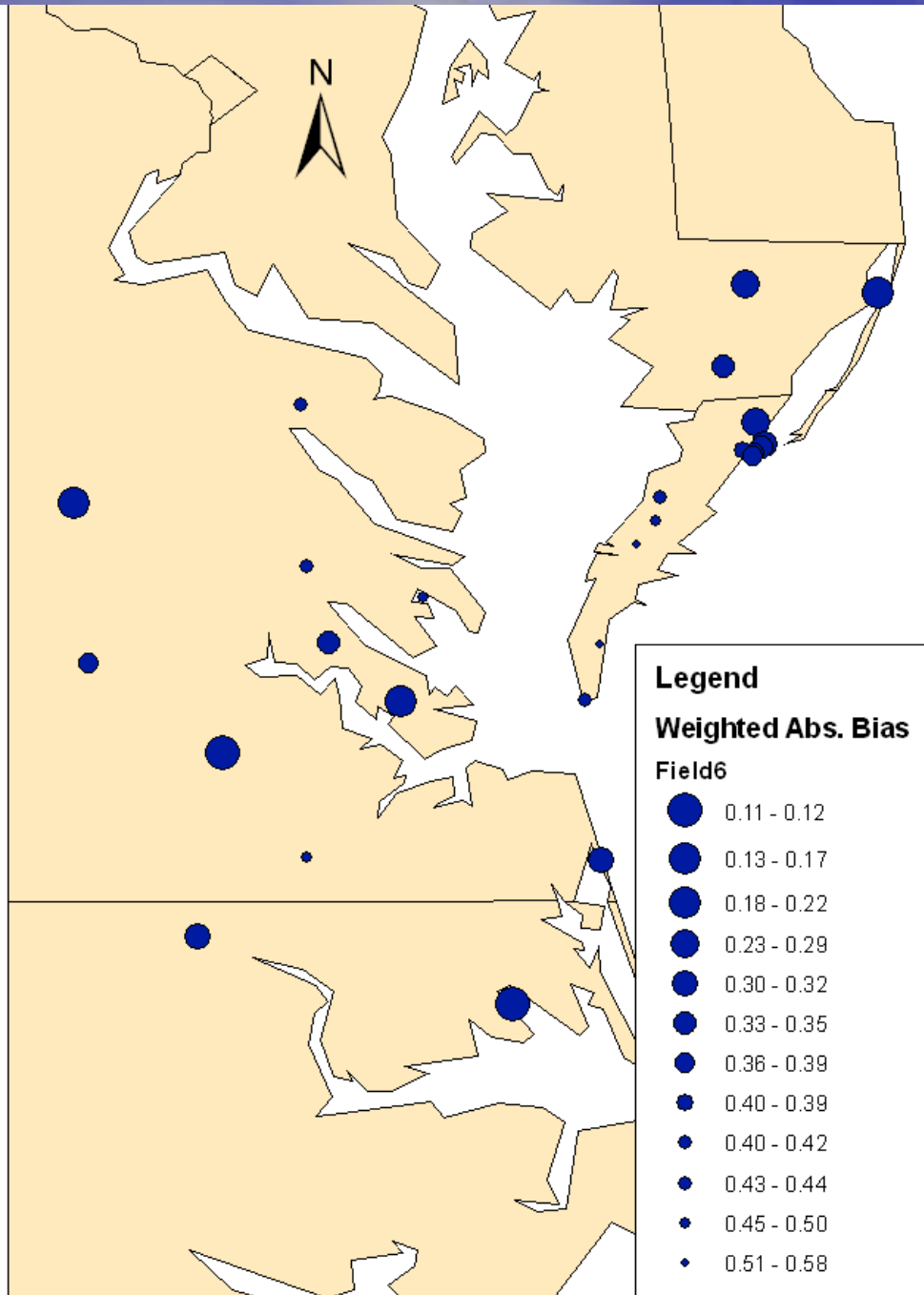
# 3-Hourly



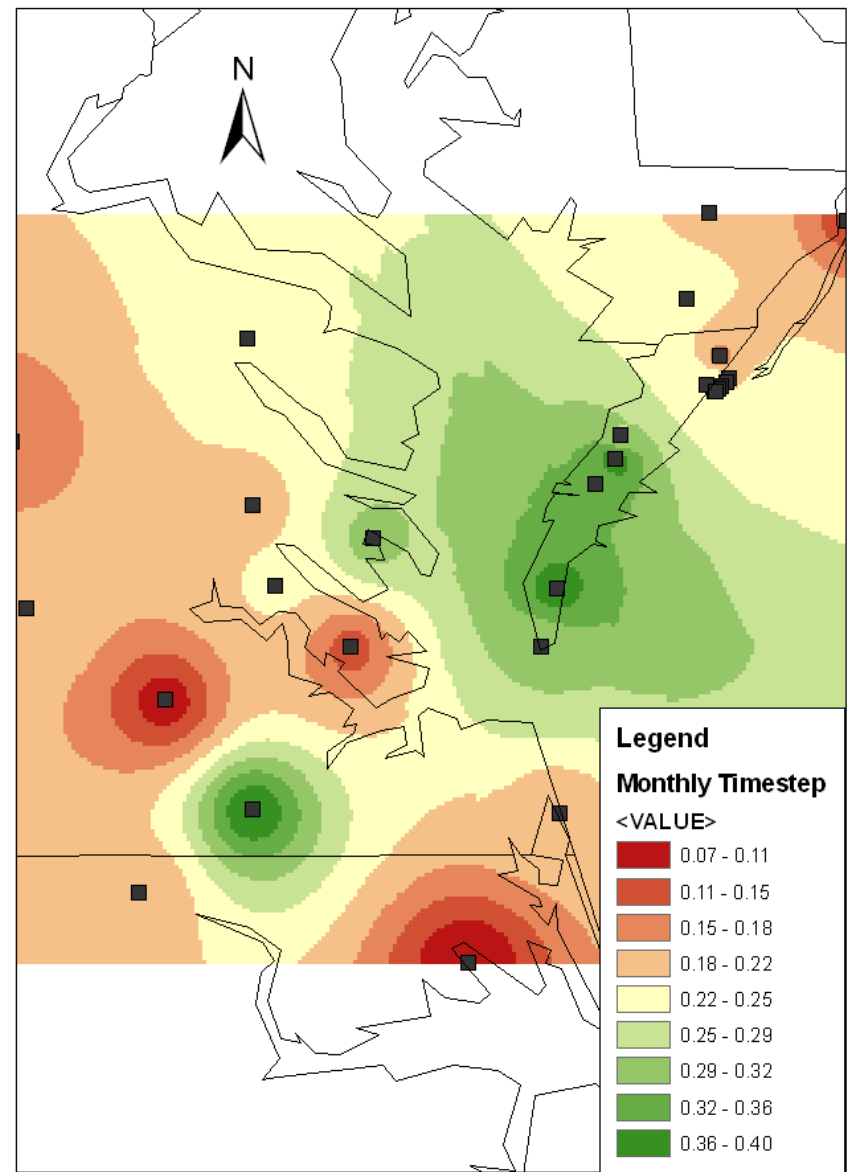
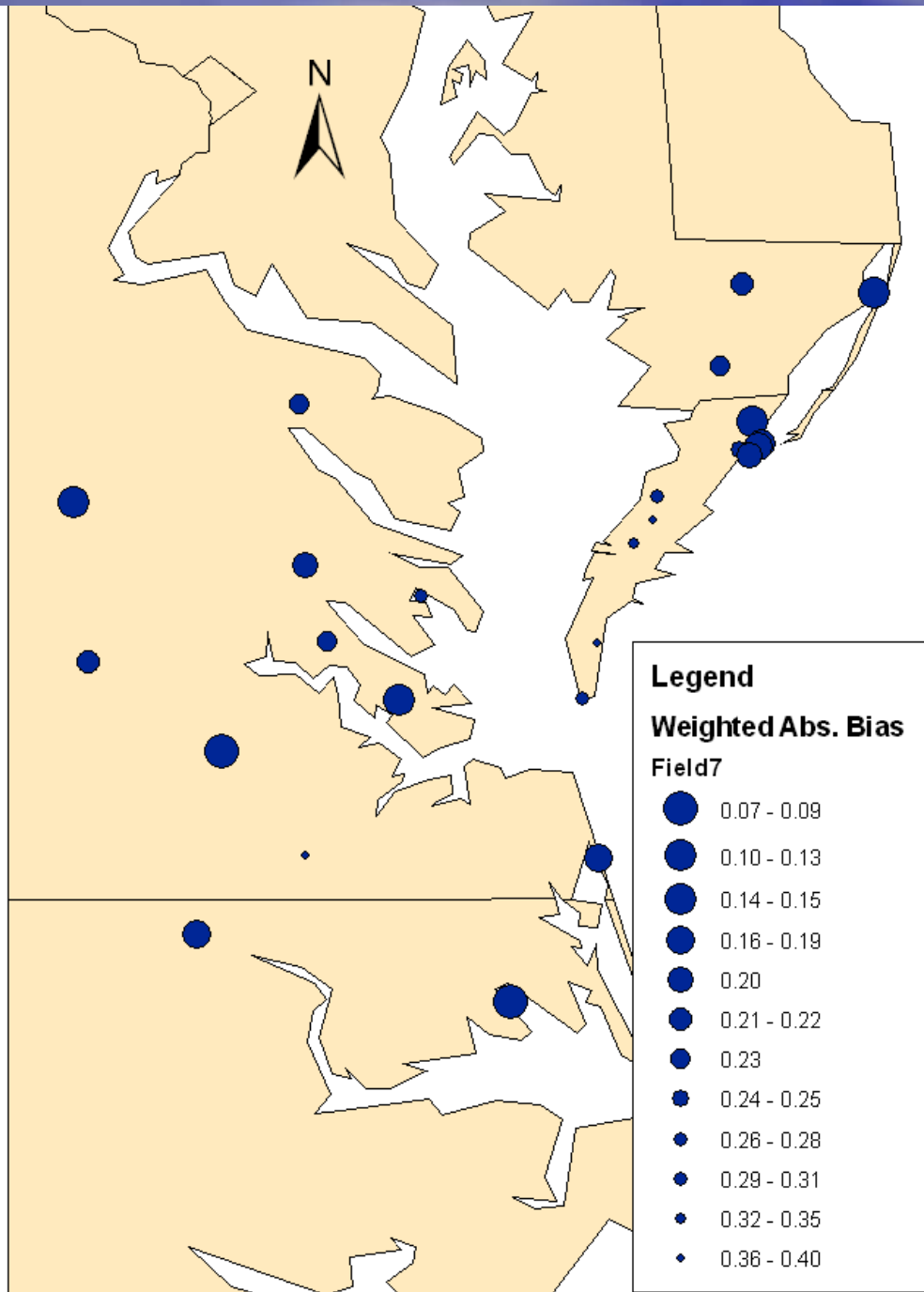
# 6-Hourly



# Daily



# Monthly



# Conclusions

- Overall, MPE showed promising results within this region when using gauge as a reference.
- Averaging gauges within an MPE pixel at Wallops Island did not seem to improve the statistics.
- The internal MPE analysis reveal similar statistics between center pixel and surrounding pixels while the largest differences occurred mostly within the corner pixels. Also, decreases in correlation (increases in bias) were evident as the threshold was raised.
- Spatially representing correlation and weighted bias showed areas of consistent high correlation and low bias. However, low correlation and high bias were observed in the southern Delmarva region.

# Acknowledgements

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