Role of Climate Variability in Modulating Surface water and Groundwater Interaction over the Southeast US

Sankar Arumugam, Naser Almanaseer

Department of Civil, Construction and Environmental Engineering

North Carolina State University

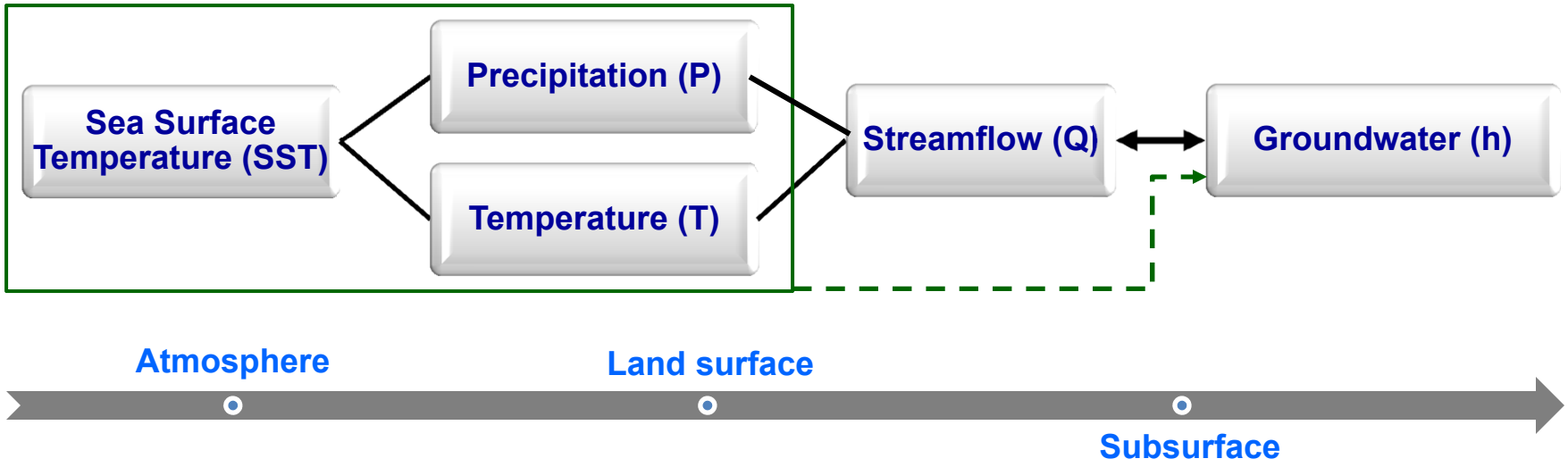
and

Jerad Bales

United States Geologic Survey, Reston

NOAA in the Carolinas, March 15, 2012, Charleston, SC

Introduction: Motivation

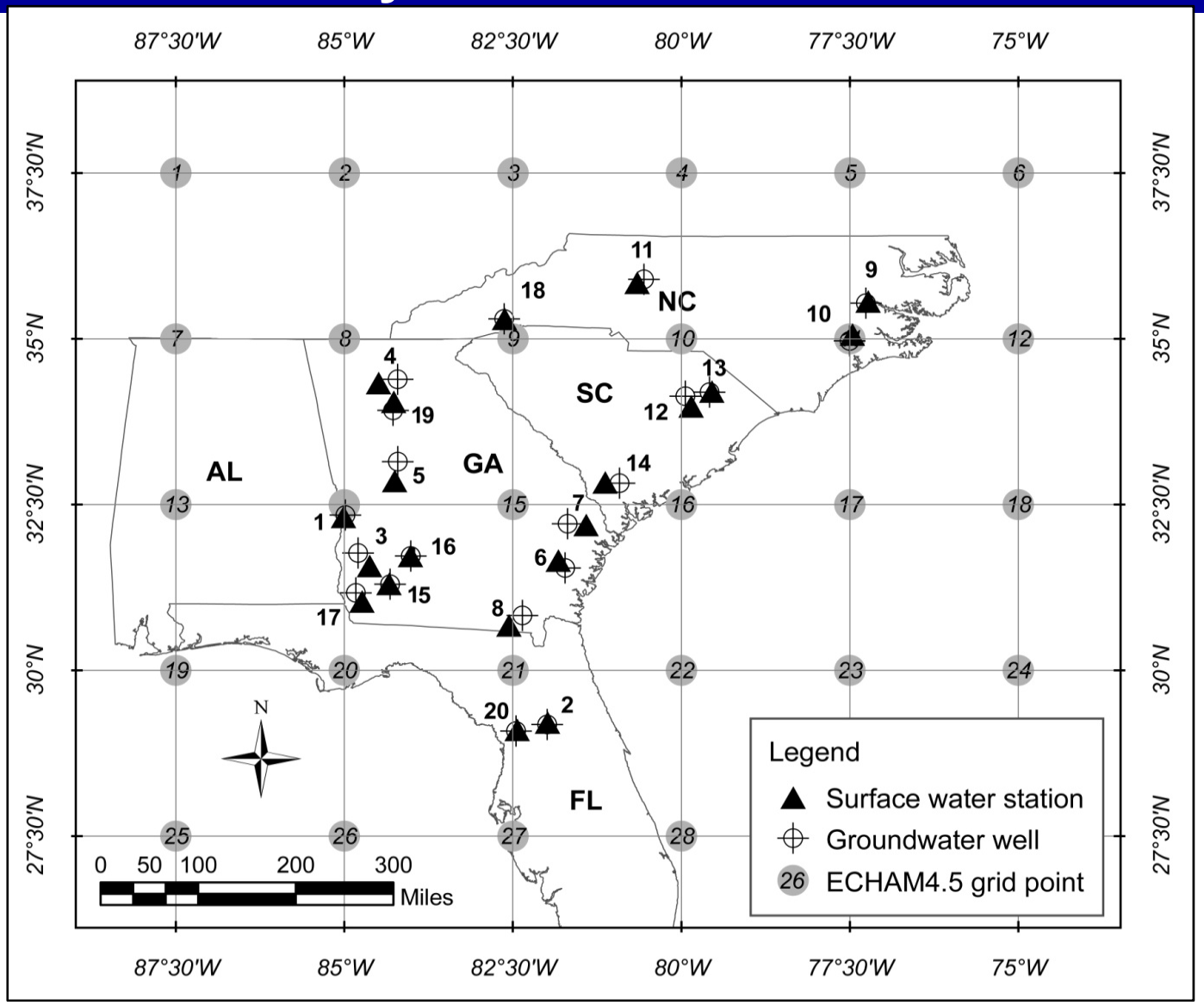


❑ Motivation:

1) Climate variability influences precipitation, temperature and streamflow

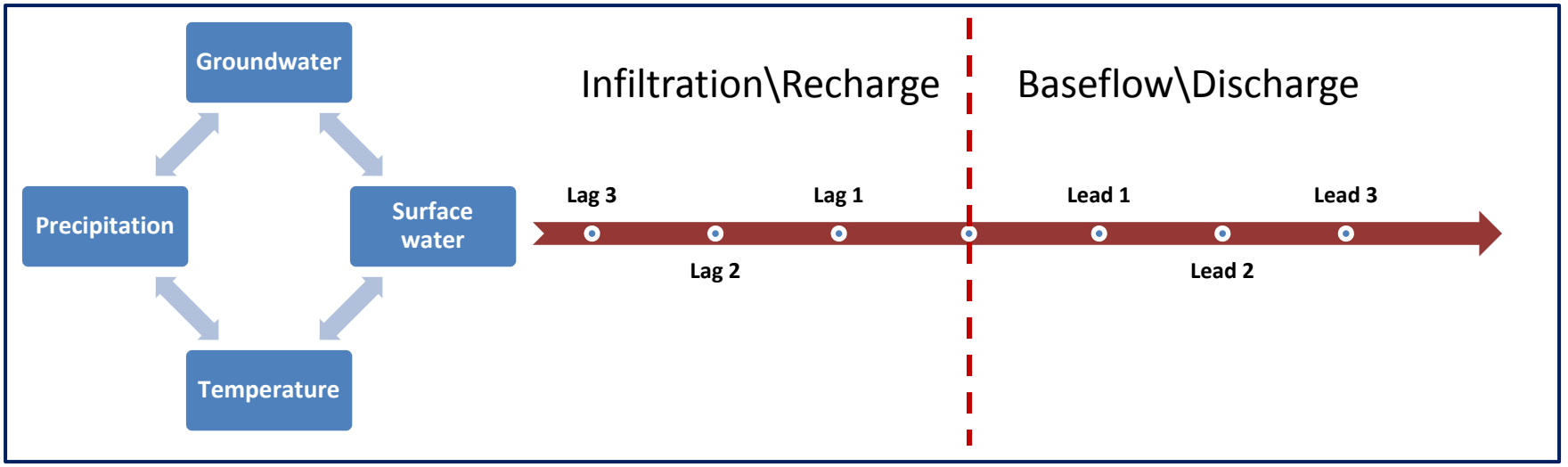
2) Goal is to understand how climate influences basin hydroclimatology including groundwater availability.

Study Area and Database



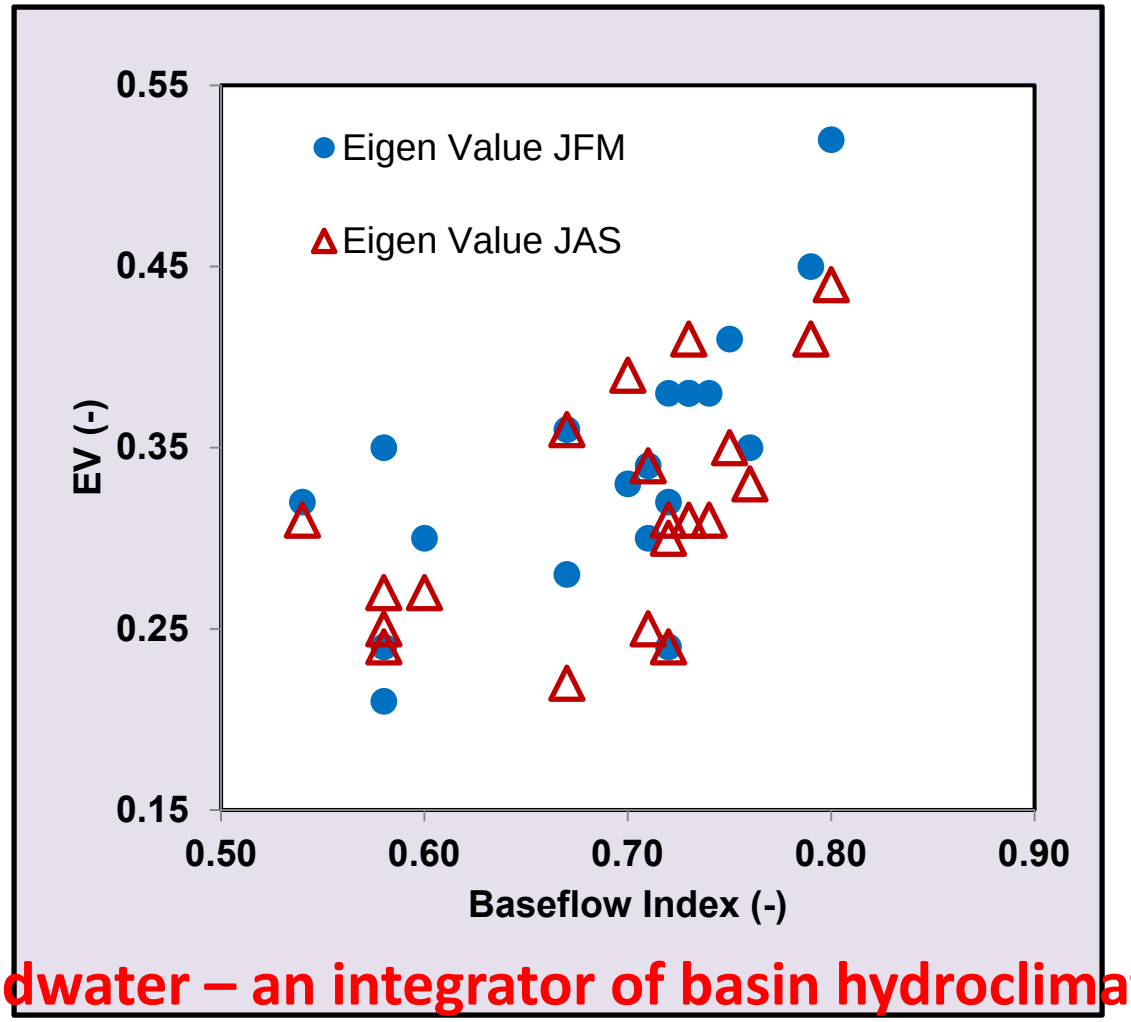
Basins: HCDN (Streamflow); Groundwater (Climate and Groundwater response network - USGS)

Dependency Analysis: Recharge and Discharge Months



18 variables:	• Q, h, P and T at various months
2 Seasons	• JFM, and JAS
Eigen Values	• Variance Proportion
Eigen Vectors	• Source of variability

Principal Component Analysis - Eigen Values



Groundwater – an integrator of basin hydroclimatology

Rank Correlation:

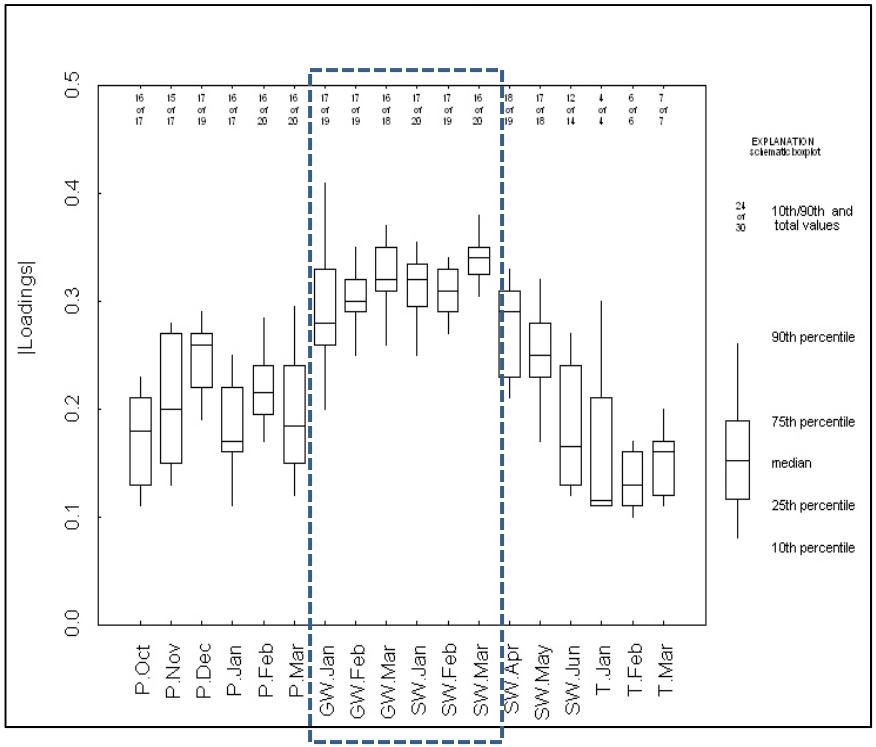
$\rho\ (EV_{JFM}, BFI_{JFM}) = 0.72$

$\rho\ (EV_{JAS}, BFI_{JAS}) = 0.66$

Principal Component Analysis - Eigen Vectors

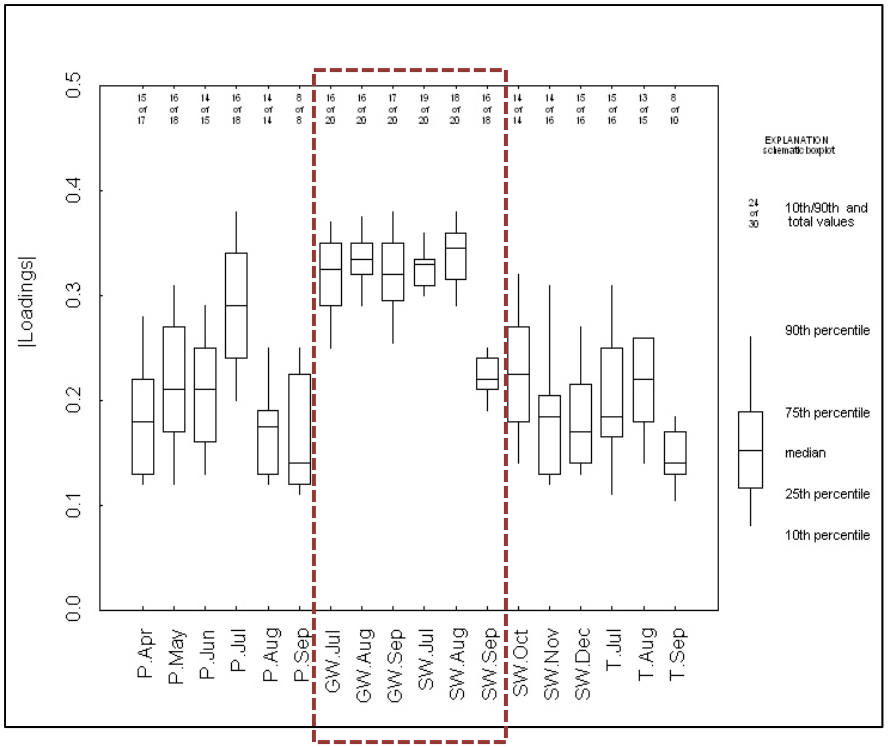
Primary Source of Variability – Surface water and Groundwater

JFM Loadings



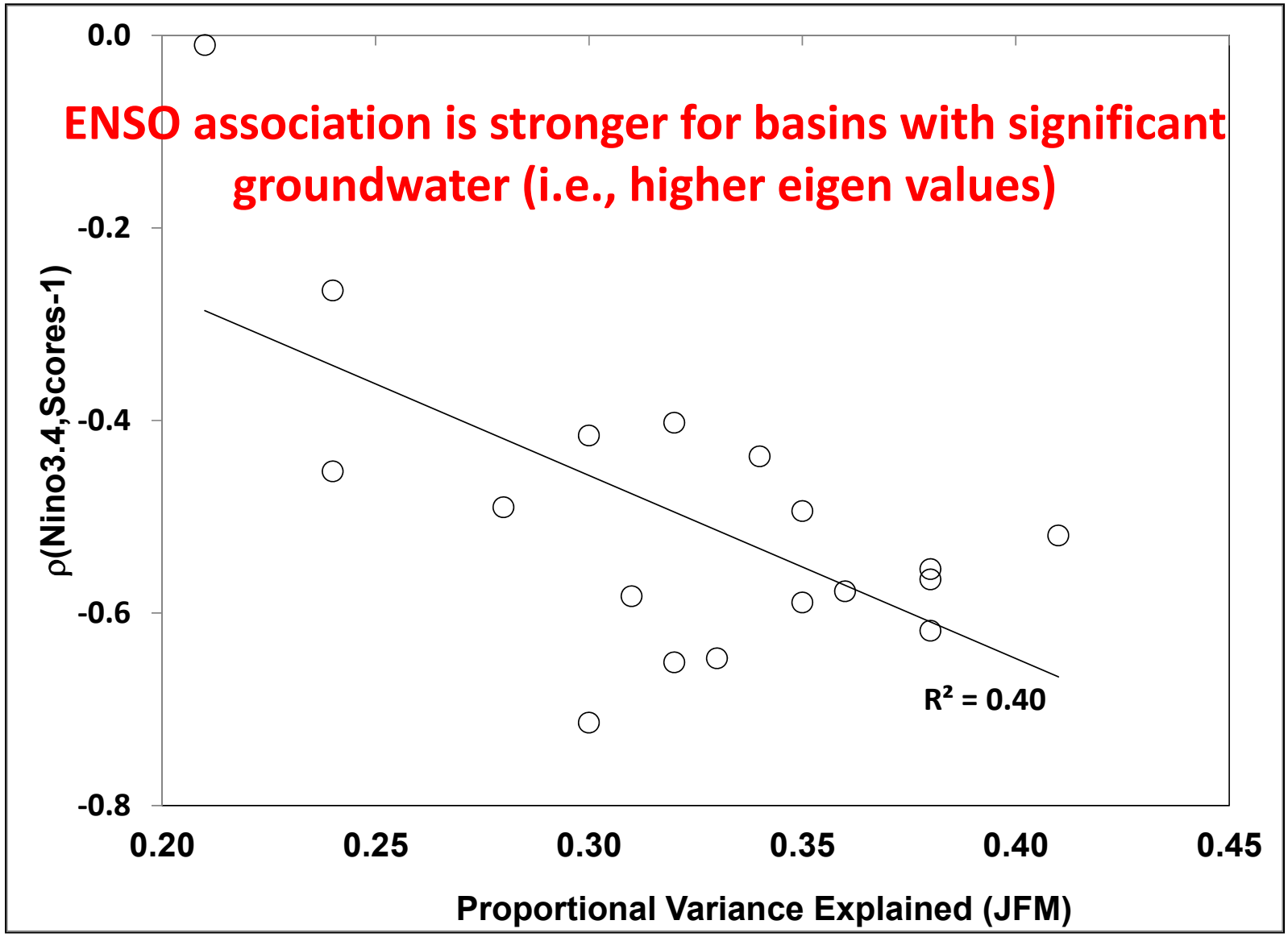
P	6	O	N	D	J	F	M			
T	3				J	F	M			
Q	6				J	F	M	A	M	J
h	3				J	F	M			

JAS Loadings



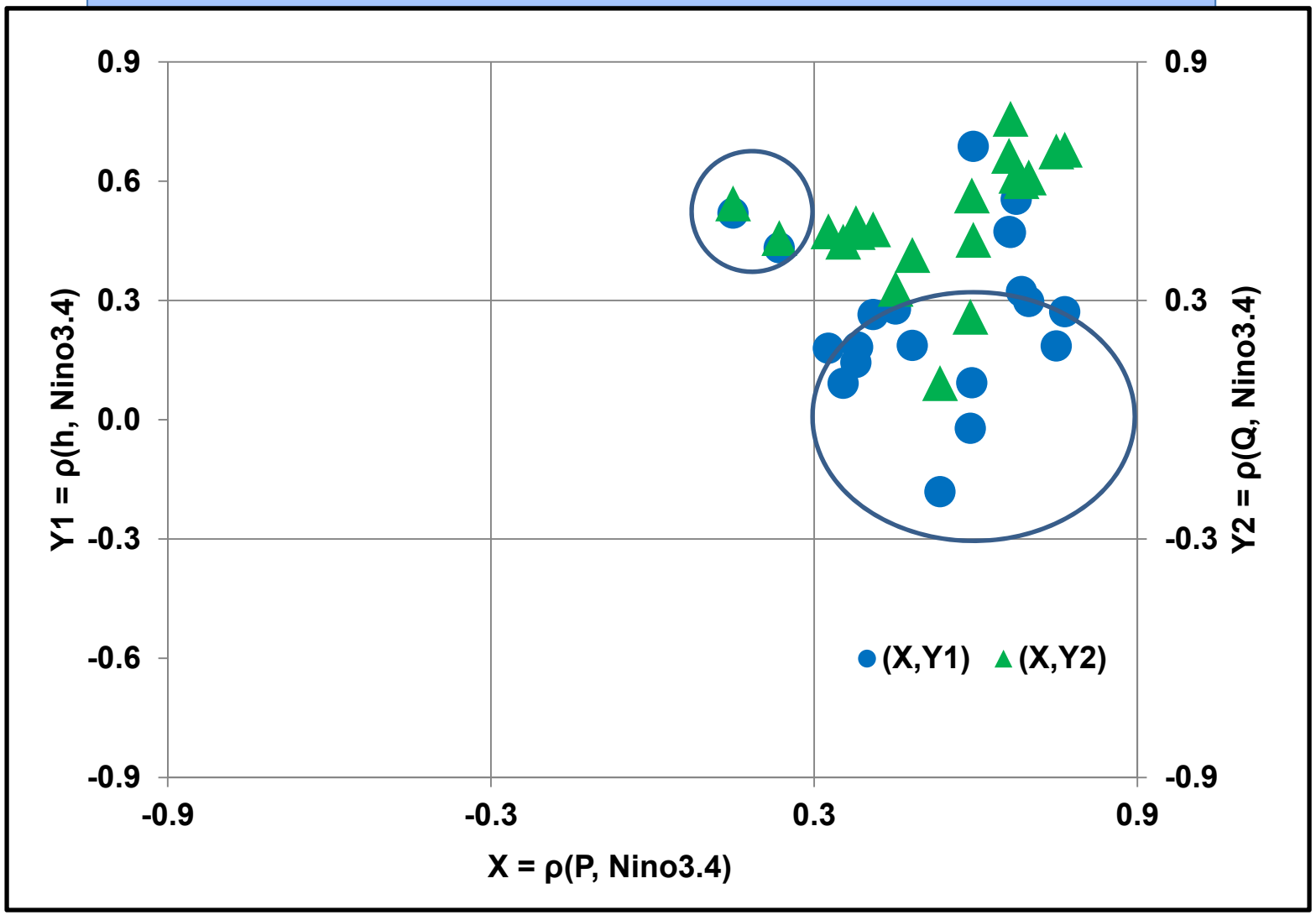
P	6	A	M	J	J	A	S			
T	3				J	A	S			
Q	6				J	A	S	O	N	D
h	3				J	A	S			

PCA – Eigen values vs Nino3.4 (ENSO)

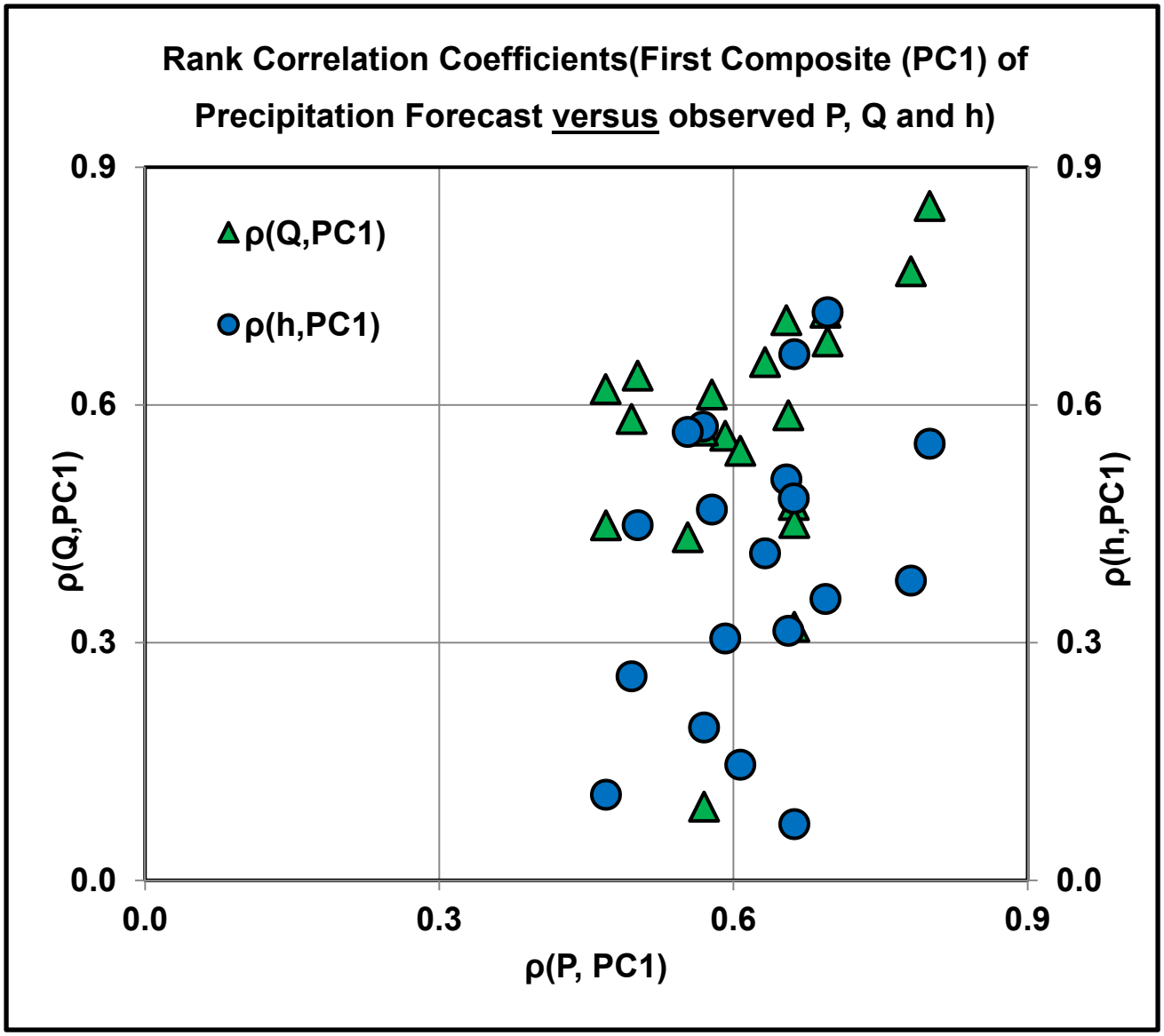


Role of ENSO Winter (JFM)

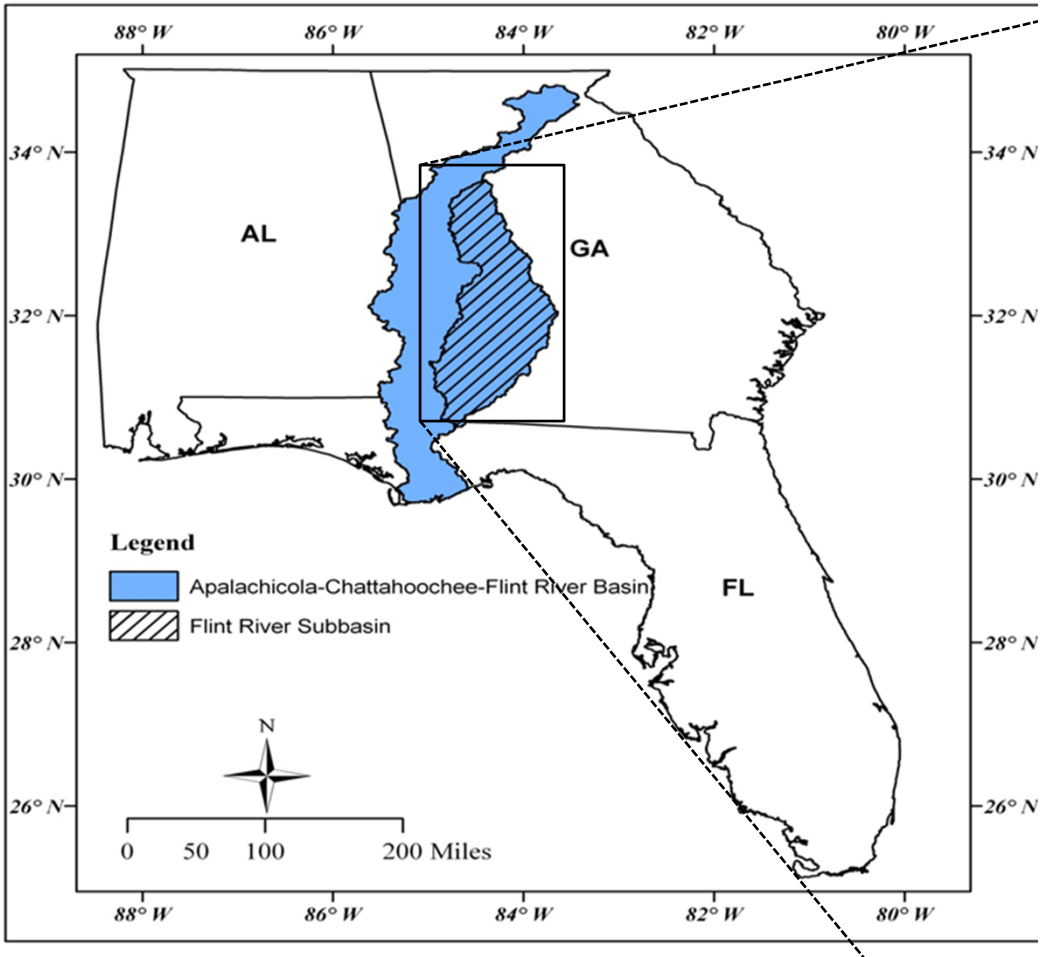
Rank correlation: JFM Nino3.4 versus JFM P, Q and h

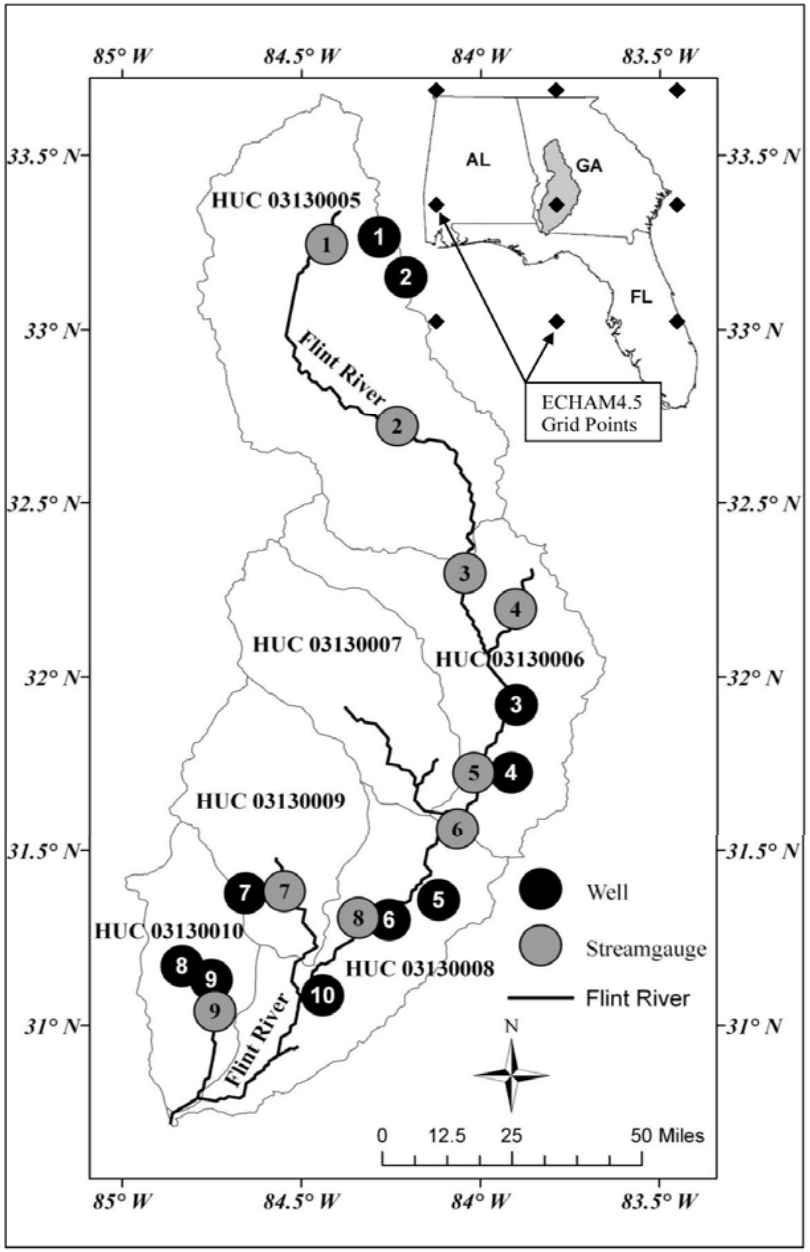


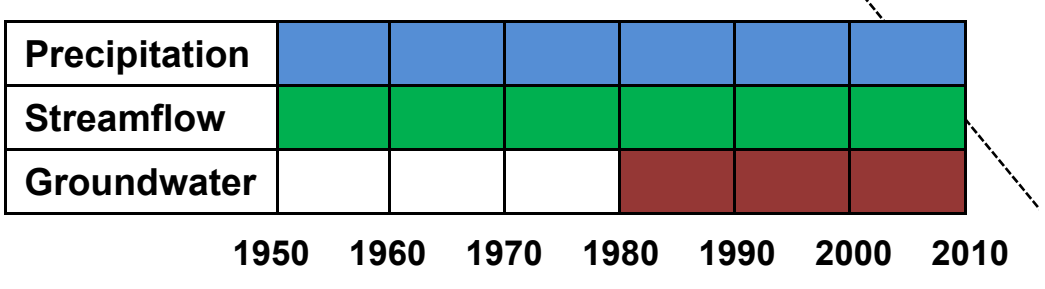
Precipitation Forecasts versus observed P, Q and h



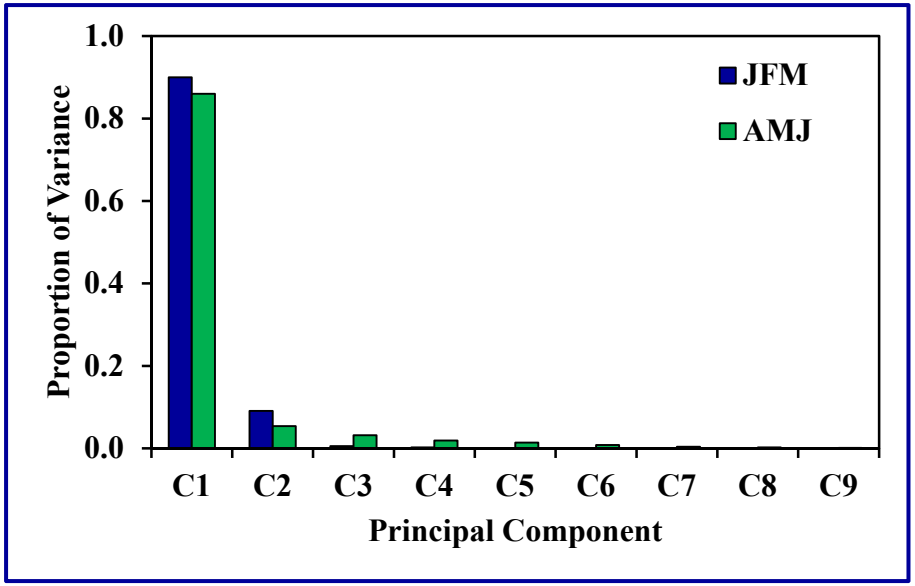
Study Area and Data Description

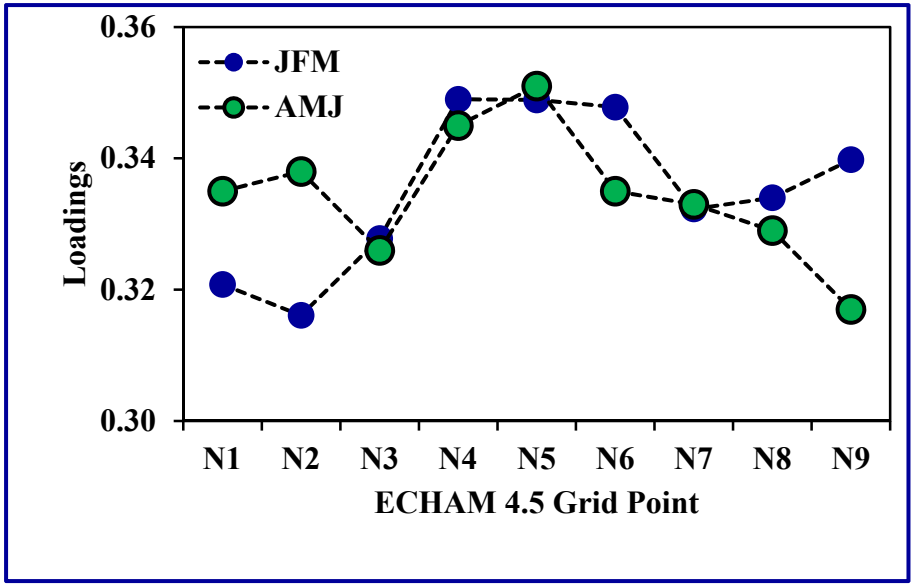


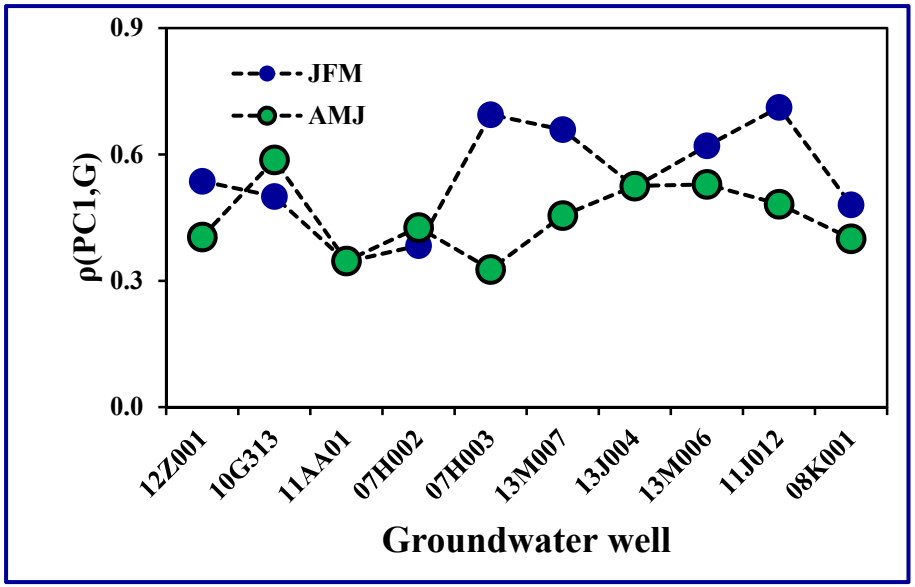


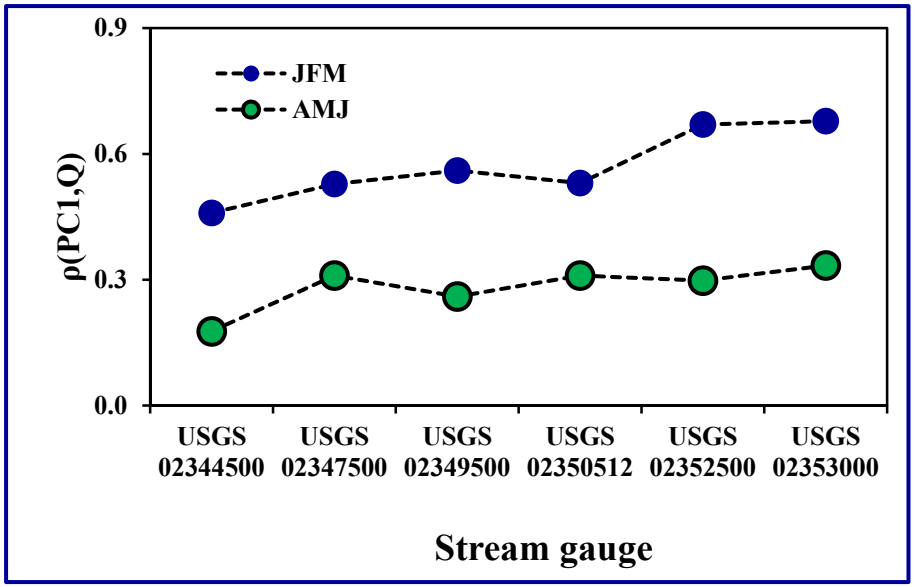


Correlation between Precipitation Forecasts and Q, P and h







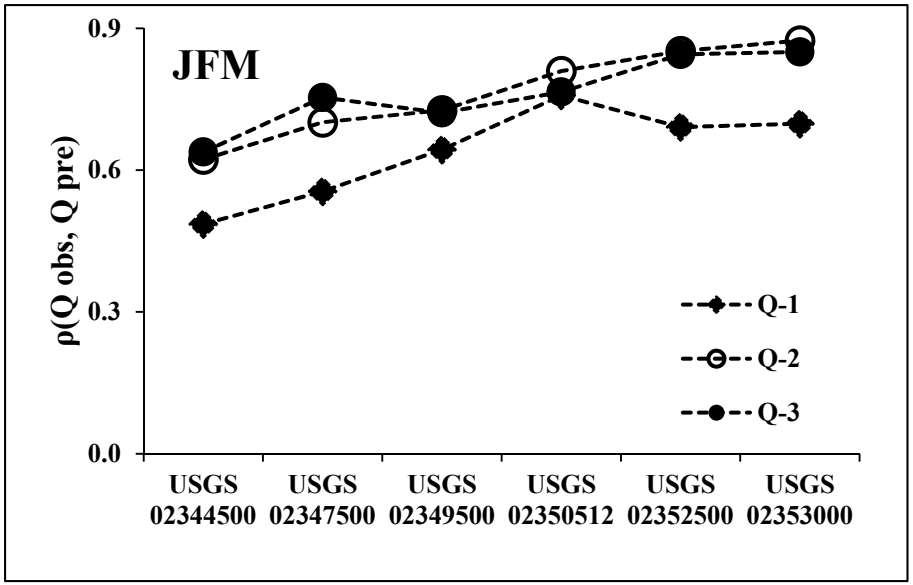


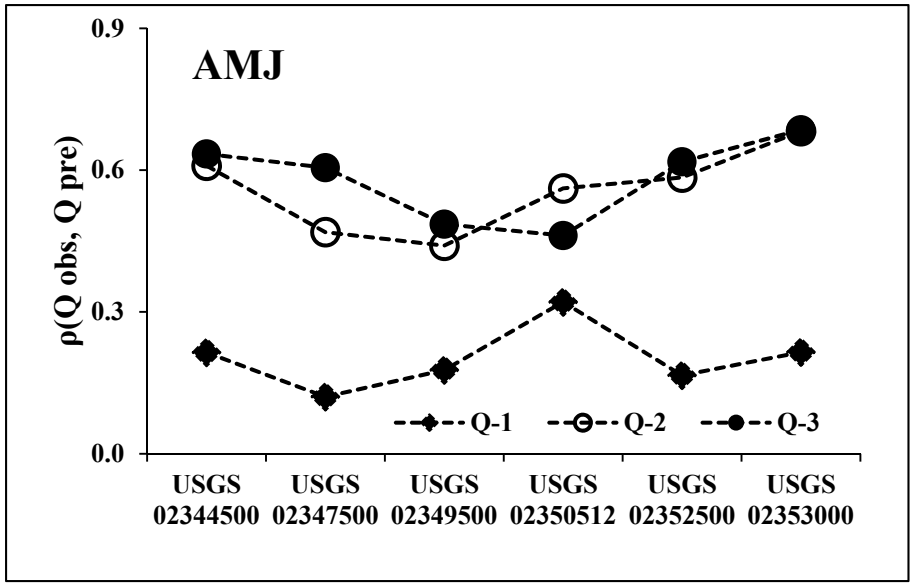
Statistical Models: Predictors and Predictands

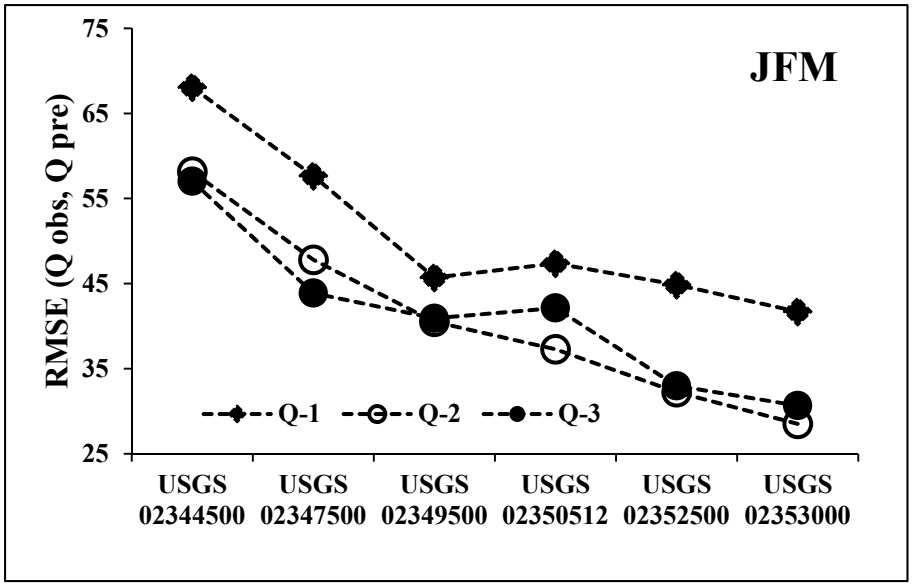
- **Principal Component regression (PCR)**
- **Canonical Correlation Analysis (CCA)**
- **Leave-5 Out Cross-Validation 1980 – 2010**

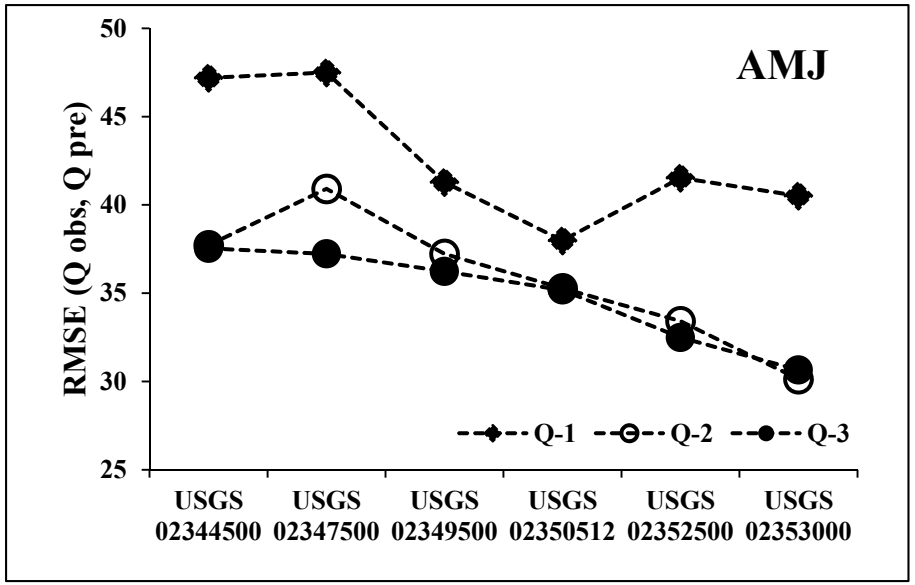
Variable	Model	Data Period	Method	Predictors			Predictand	
				G	Q	P forecasts	G	Q
G	G-1	1980 - 2010	PCA	OND	-	-	JFM AMJ Jan - Jun	-
	G-2			OND	-	JFM AMJ		
	G-3		CCA	OND	-			
Q	Q-1	1980 - 2010	PCA	-	OND	-	-	JFM AMJ Jan - Jun
	Q-2			-	OND	JFM AMJ		
	Q-3		CCA	-	OND			

Statistical Models for Seasonal Streamflow

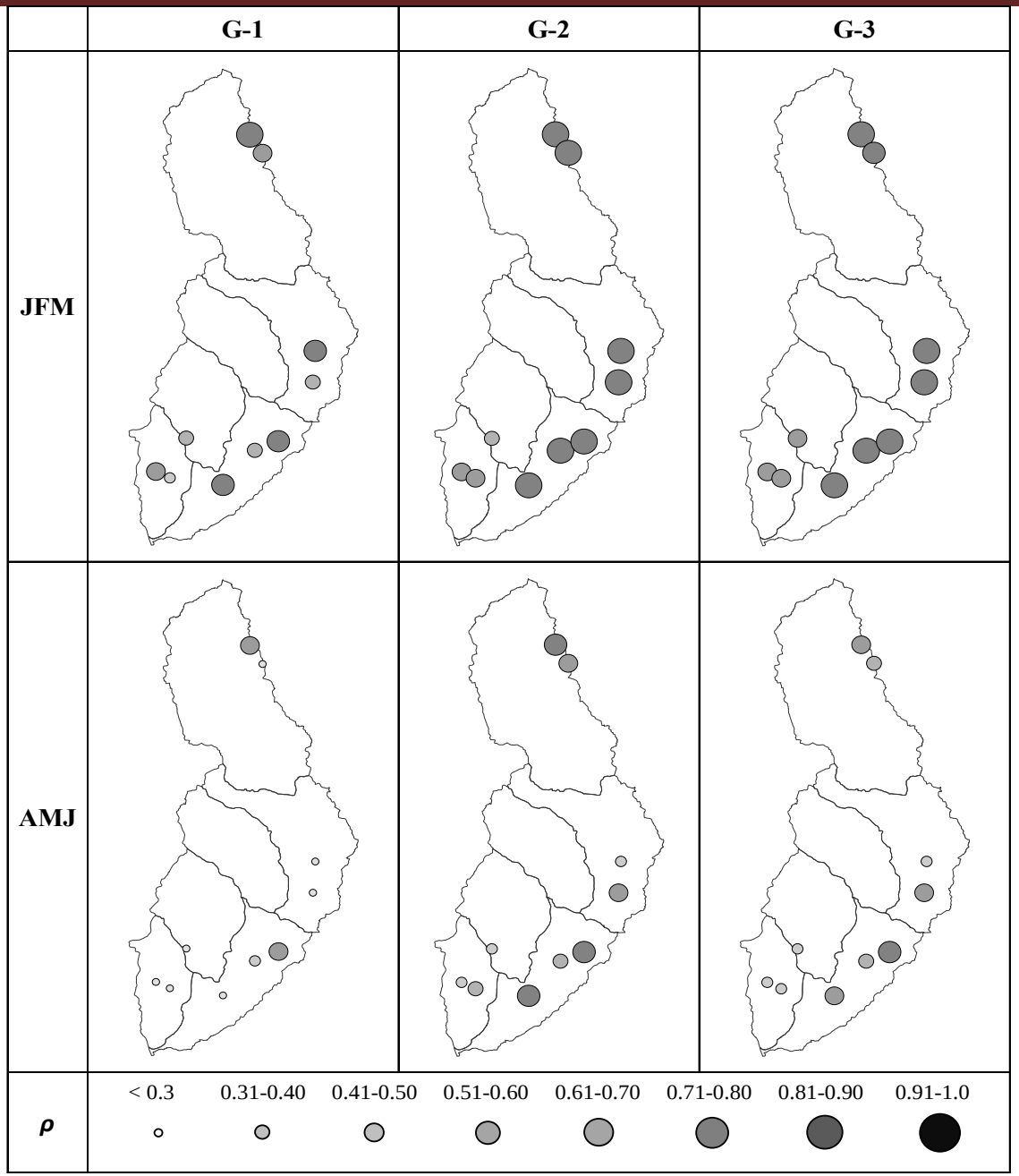




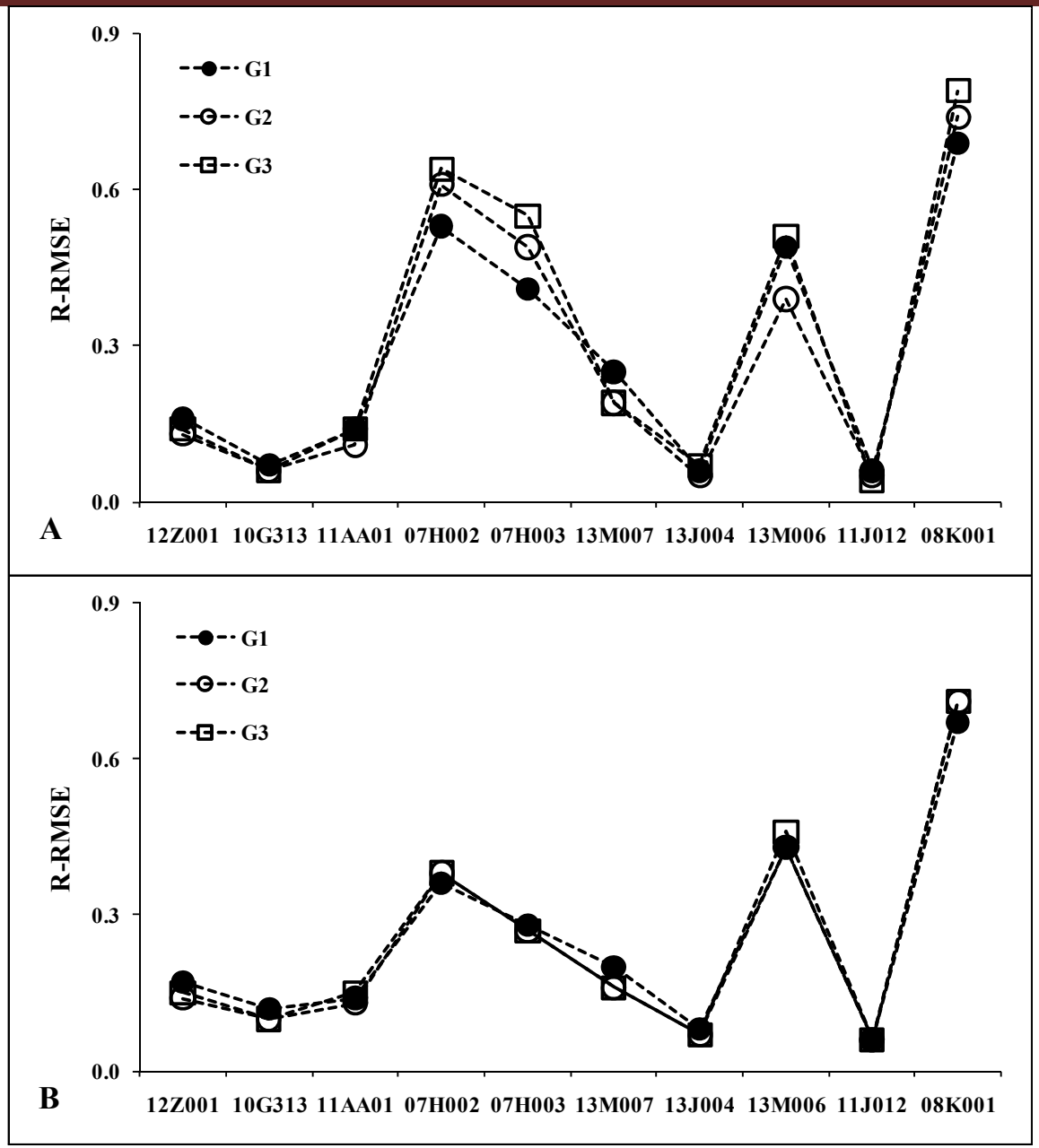




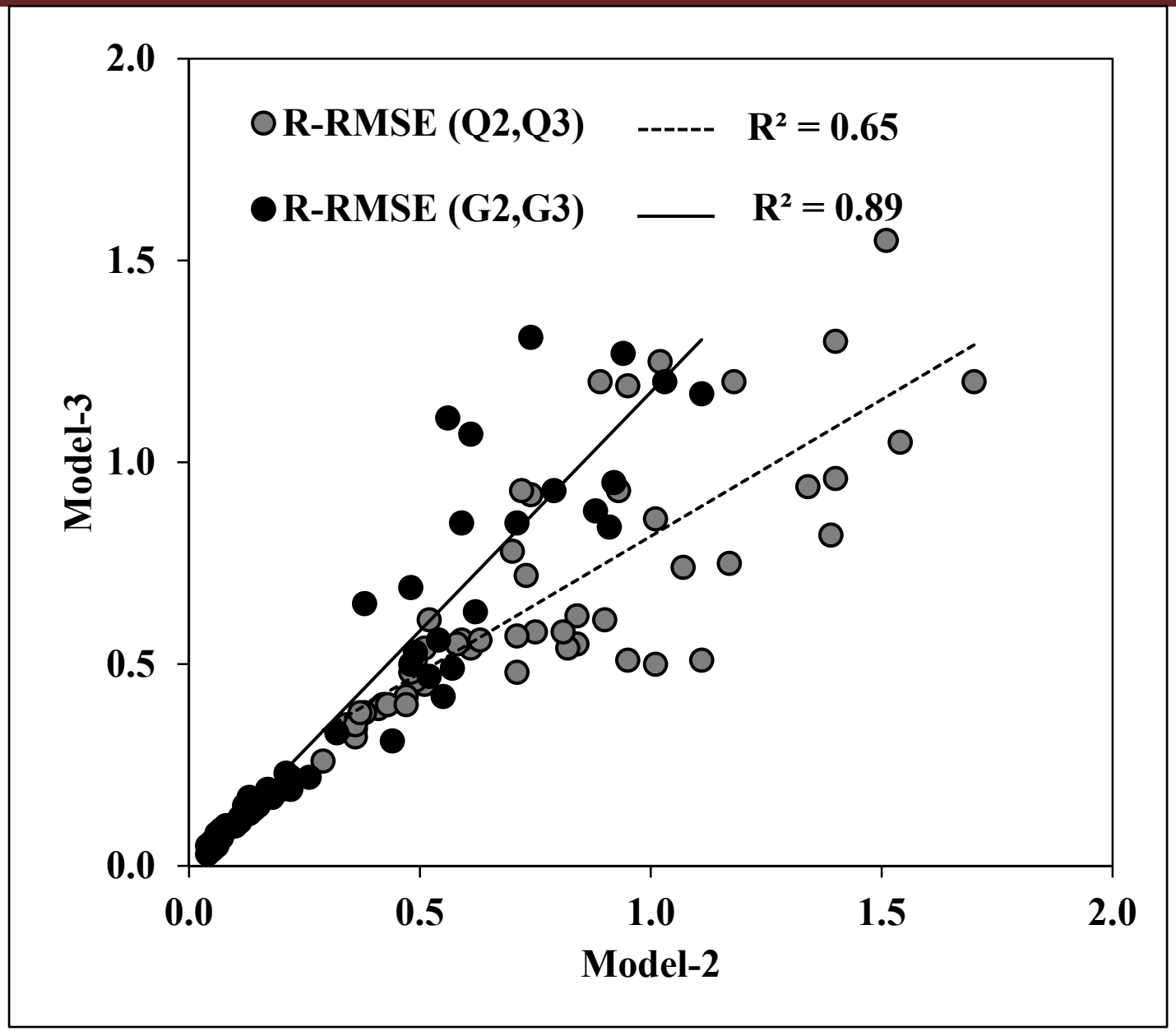
Statistical Model: Seasonal Groundwater



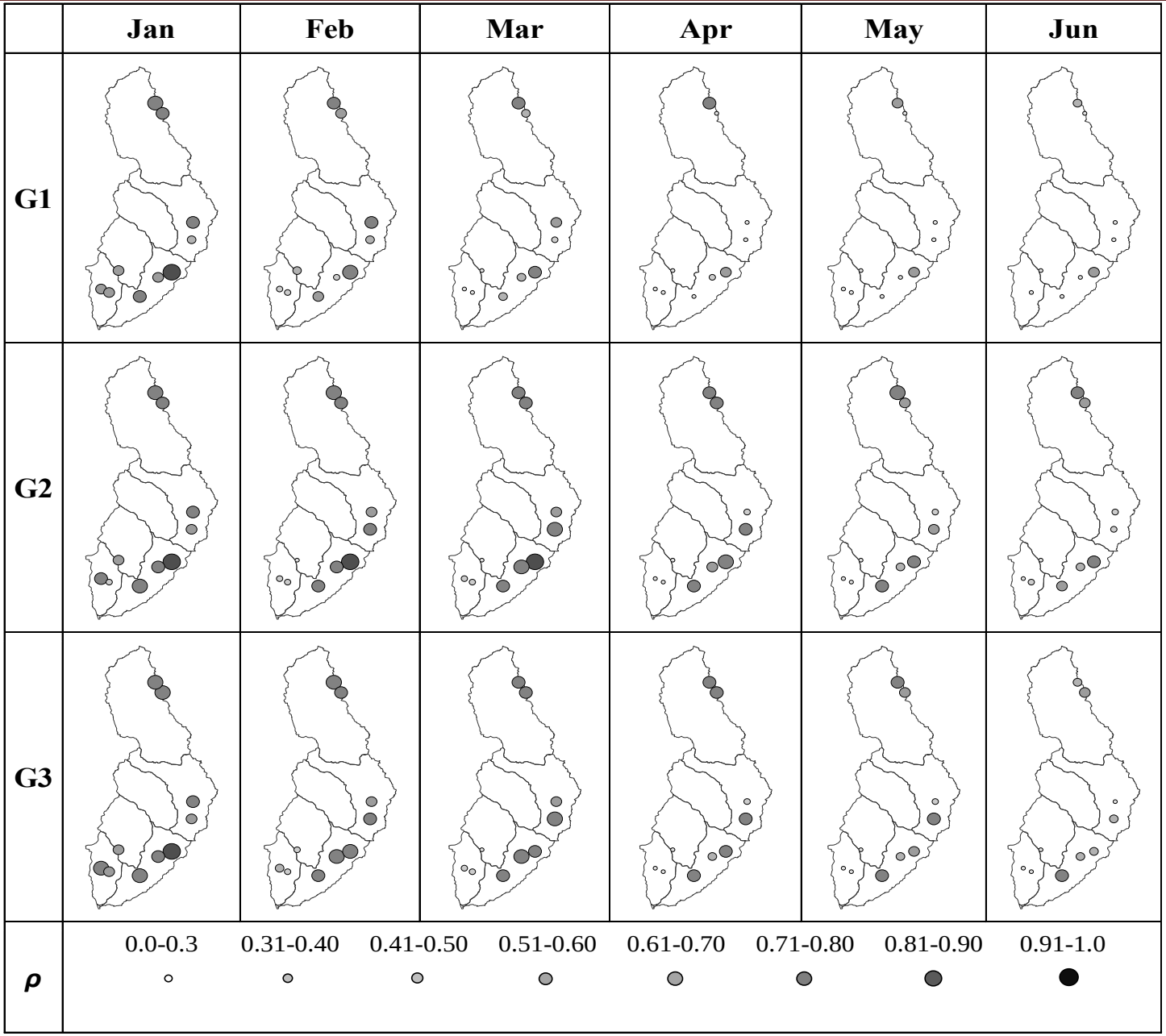
Statistical Model: Seasonal Groundwater



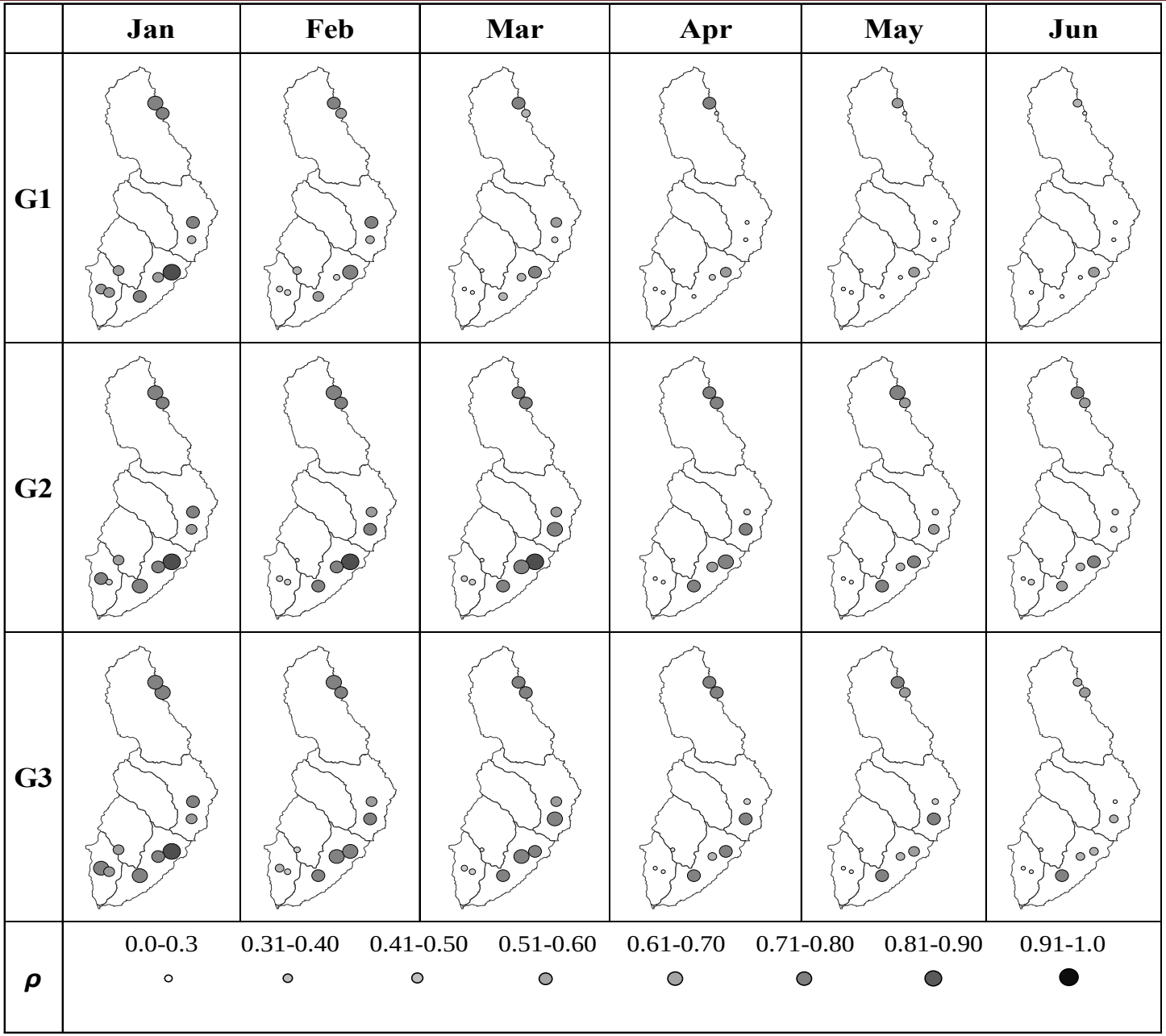
RMSE: Seasonal Streamflow and Groundwater Forecasts



Statistical Model: Monthly Groundwater Forecasts



Statistical Model: Monthly Groundwater Forecasts



Summary and Conclusions

1) Climate variability signature is prevalent over the entire basin

2) Groundwater integrates basin hydroclimatology

3) Initial results show potential in predicting surface water up to three months and groundwater up to a lead time of six months

4) Skill in predicting both surface water and groundwater improves as we approach downstream

5) Canonical Correlation Analyses, in general, performs better than Principal Component Regression since it uses the spatial correlation in both predictors and predictand

Acknowledgements

- NC Sea Grant and NC WRRI
  - Early Career grant supported Naser Almanaseer's PhD dissertation
- NSF - CAREER grant
  - Partially supported Naser's PhD.