Water quality modeling and hydrological analysis

Miguel Oliveras-Berrocales

Mentor: Dr. John J. Ramirez-Avila

About myself…

- University :
  - University of Puerto Rico-Mayaguez Campus
  - Department of Crops and Agroenviromental Sciences.
- Level of Education
  - Graduate student
  - Major: Soil Science
- Hometown: Guanica, P.R.

About my Mentor…

- John J. Ramirez-Avila, Ph D.
- Postdoctoral Associate at the Geosystems Research Institute.
- Adjunct Faculty at the CEE Department, MSU.
- Area of Study: Soil and Water Conservation, Nutrient Management, Hydrology, Modeling.

Background Information

Part I

- Application of Simulation Models to Predict Nutrient Loads from Agricultural Fields
  - Nutrient Tracking Tool (NTT)
  - Annual Phosphorous Loss Estimator (APLE)
  - Water Quality Index (WQI)
  - Nitrogen Index (N-Index)

Part II

- Curve Number Determination for a specific soil with different Land uses
  - Asymptote Definition

Part III

- Hydrologic Analysis.
  - Regional Frequency Analysis Pearl River Basin, MS.
    - Data collection and screening
    - ICI-RAFT model application

Part I - Nutrient Loads prediction

Study Area

- Deep Hollow Lake watershed
- Leflore County, Mississippi
- Entire extension: 82 ha
- Models Evaluation: 11.3 ha
- Land use: Row crops

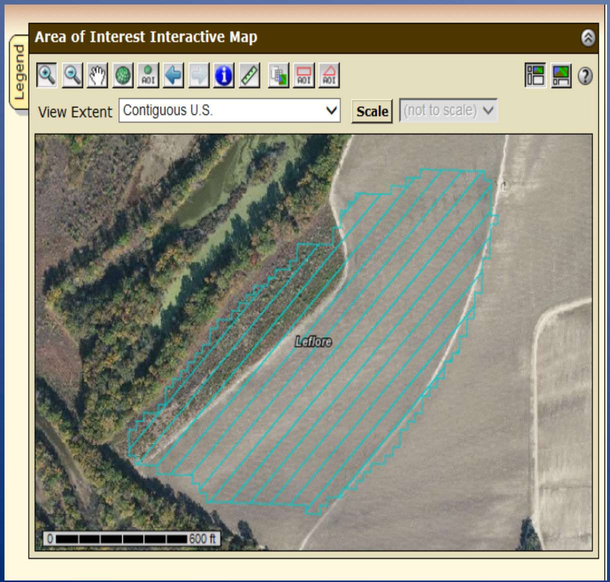
The evaluation and selection of appropriate applicable analytical tools has been identified as one of the strategies needed for designing, sitting and assessing the potential reductions from multiple management practices implemented within the Mississippi Delta region.

Models Evaluation: NTT (Web tool)

- The NTT tool compares agricultural management systems to calculate a change in nitrogen, phosphorous, sediment loss potential and crop yield.

- Analysis of scenarios were conducted for the 4-year simulation period, to estimate the effects of land use and management practices changes on each parameters.

- Selecting an area of interest using the web soil survey mapping system.
    - Soil information



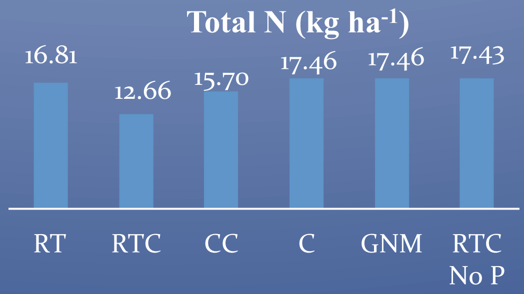
- Statistical comparisons between observed and predicted results

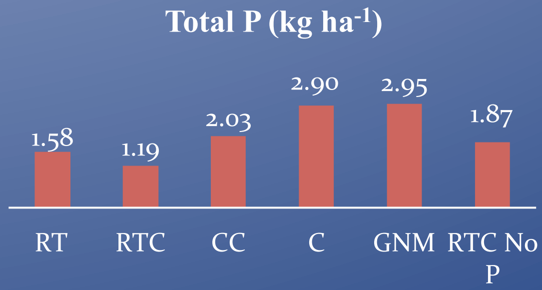
Table. Limits of confidence for the predicted means.

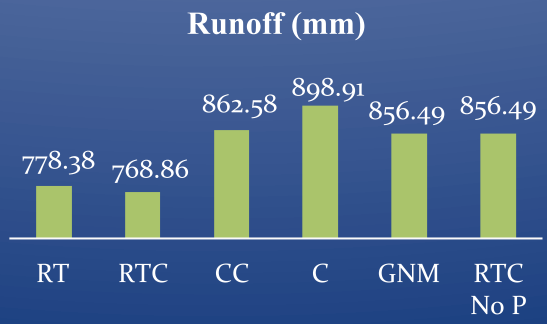
Parameter	IL (95%)	SL (95%)	Observed	Predicted
Total N	3.82	13.77	8.79a	12.66a
Total P	0.41	4.05	2.23a	1.19a
Runoff	248.11	746.28	497.2a	768.86b*
Sediments	1199.93	4532.14	2866.03a	5143.75b*
Cotton yield	0.46	1.31	0.89a	1.80b*
Soybean yield	1.37	1.83	1.6a	3.06b*

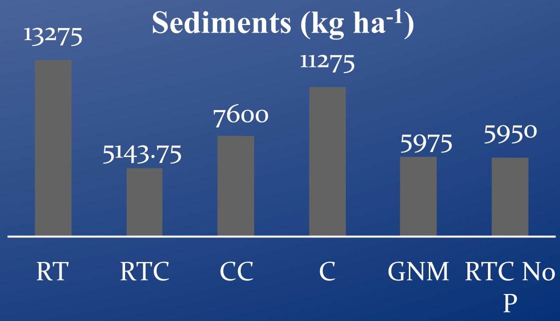
Limits of Confidence

*Outside of the limits of confidence. (α = 0.05







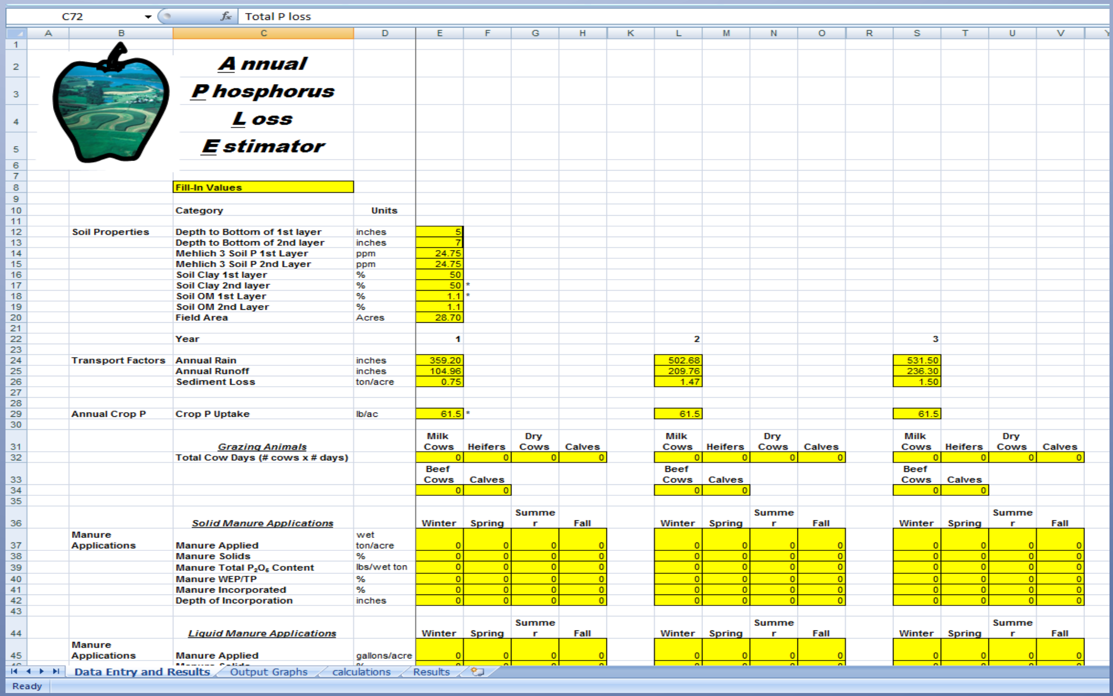


Models Evaluation: APLE

○ APLE is a Microsoft Excel spreadsheet model that runs on an annual time step.

○ The model simulates dissolved and sediment bound Phosphorous (P) loss in surface runoff.

○Statistical comparisons between observed and predicted results for DP and TP



Statistical Test for Differences in Model Prediction: ANOVA

Ho: μ observed=μ predicted

P-value: 0.2998

Acceptance range (α=0.05)

Decision: Accept Ho

Statistical Test for Differences in Model Prediction: ANOVA

Ho: μ observed=μ predicted

P-value: 0.1706

Acceptance range (α=0.05)

Decision: Accept Ho

Assessments of Risk for the 4-year period simulated

N-Index

- The N-Index is an example of several models that can be used to assess the effects of management on nitrogen losses to the environment.
- This model ranks management practices in levels of nitrogen risk loss to the environment.

Water Quality Index (Web tool)

- The WQI is driven by a need to evaluate existing conservation practices.
- This model calculate a value of runoff water quality ranked from 1 to 10 depending on the site factors and management practices.
- This index assigned a value of 10 to the runoff water of highest quality and a value of 1 to the lowest water quality.

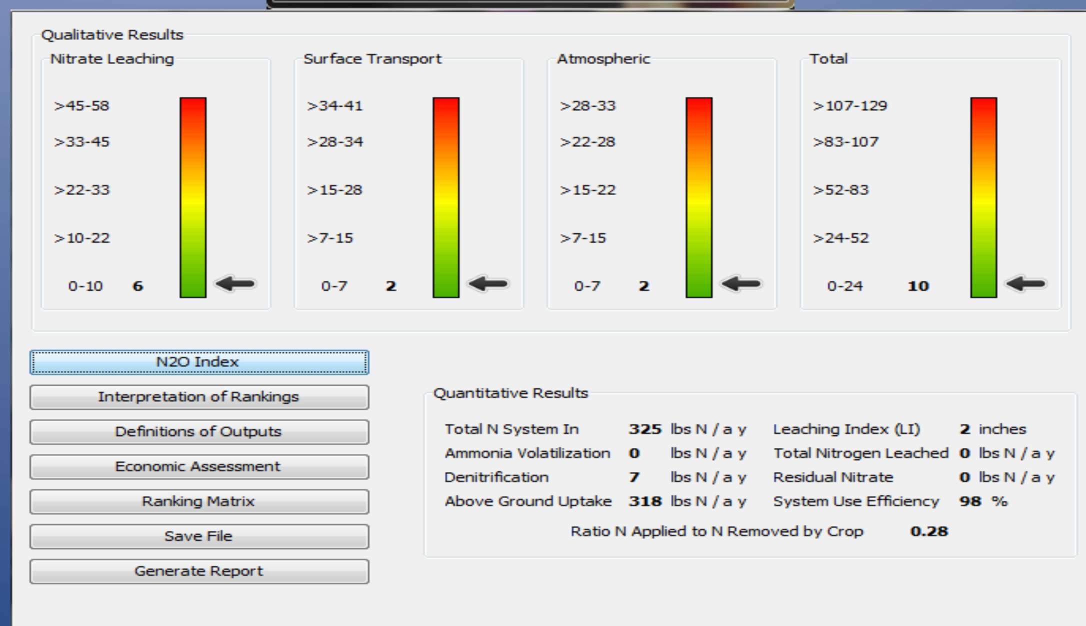
Assessments of Risk for the 4-year period simulated: N-Index

Rankings year 1996	Very Low	Low	Medium	High	Very High
Nitrate Leaching	6				
Surface Transport	4				
Atmospheric Quality	2				
Total	12				

Rankings year 1997	Very Low	Low	Medium	High	Very High
Nitrate Leaching	6				
Surface Transport	4				
Atmospheric Quality	2				
Total	12				

Rankings year 1998	Very Low	Low	Medium	High	Very High
Nitrate Leaching		14			
Surface Transport	2				
Atmospheric Quality	2				
Total	18				

Rankings year 1999	Very Low	Low	Medium	High	Very High
Nitrate Leaching		14			
Surface Transport	2				
Atmospheric Quality	2				
Total	18				



Assessments of Risk for the 4-year period simulated: WQI

Scenario	Year 96 Station	W.CP	Custom	W.CP
Cotton+soy-CC	6.05	8.20	6.08	8.22
Cotton+Soy No CC	5.89	8.13	5.92	8.14

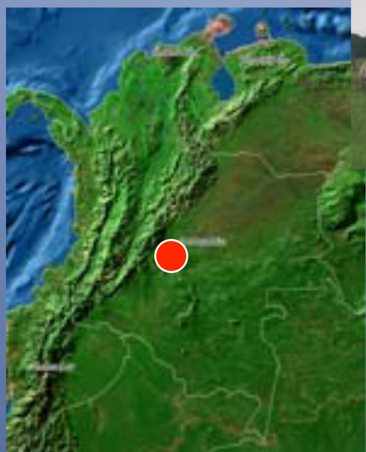
Scenario	Year 97 Station	W.CP	Custom	W.CP
Cotton+soy-CC	6.05	8.20	6.06	8.21
Cotton+Soy No CC	5.89	8.13	5.90	8.13

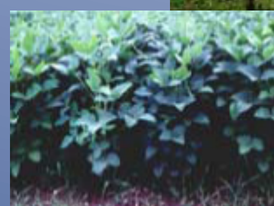
Scenario	Year 98 Station	W.CP	Custom	W.CP
Cotton+soy-CC	4.60	7.35	4.61	7.36
Cotton+Soy No CC	4.47	7.22	4.48	7.23

Scenario	Year 99 Station	W.CP	Custom	W.CP
Cotton+soy-CC	4.84	7.57	4.86	7.60
Cotton+Soy No CC	4.70	7.44	2.35	7.45

Part II: Curve Number Determination

- Study area



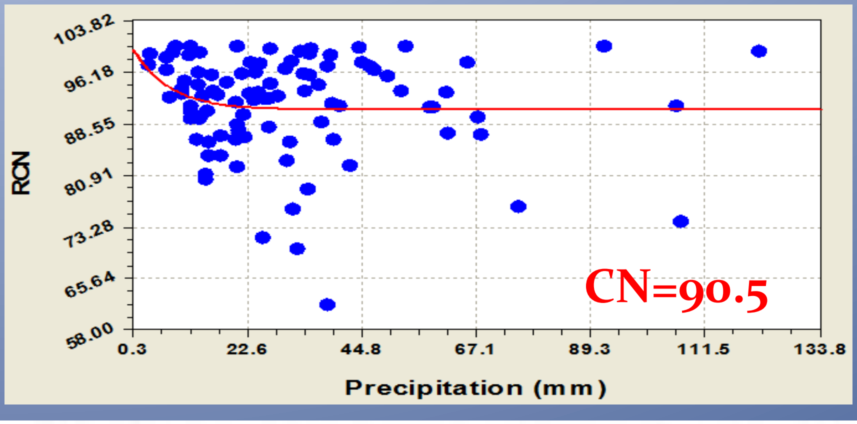
- The Eastern Savannas of Colombia (15% of the entire Colombian extension).
- Currently underused on extensive livestock production on low quality native savanna pastures.
- Predominant conditions of strong rainfall seasonality and high soil susceptibility and vulnerability to erosion and fertility losses.
- Hydrological and physical processes need to be understood to identify the potential effect caused by water erosion on the productivity of its soils.

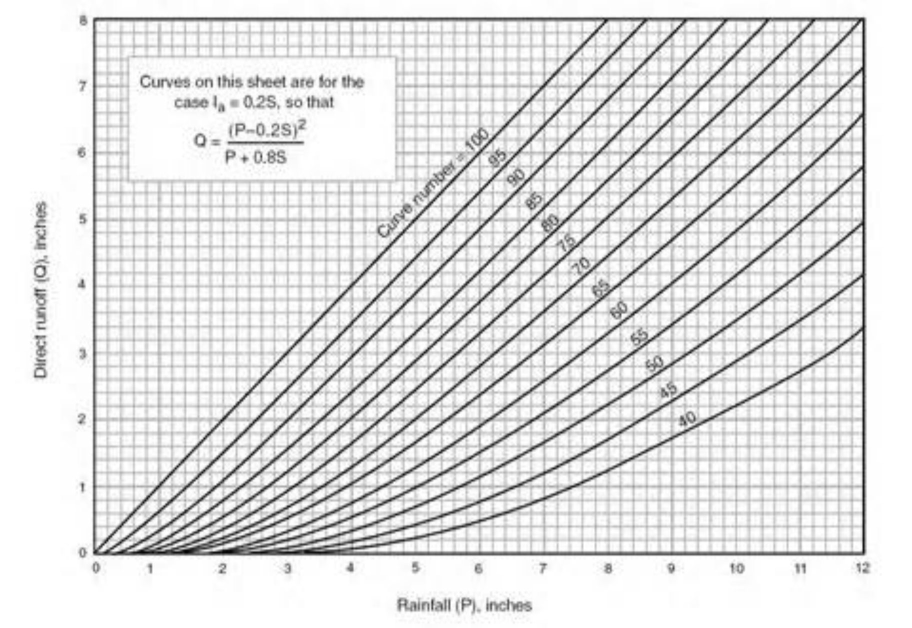
- A major activity in applied hydrology is the estimation of storm event runoff.
- Such estimations are needed in the engineering design and in environmental impact work.
- The most popular technique for meeting this need is the curve number method, developed by the USDA-SCS.
- Methods:
  - Curve Number Determination for a specific soil with different Land uses using the Asymptotic Determination Method.

Asymptotic Determination Method

- Procedure
- Analyze the rainfall-runoff data
- Order the rainfall-runoff data.
- Determine CN's for the matched pairs.
  - CN= 25,400/(254+S)

  S= 5[P+2Q-(4Q^2+5PQ)^1/2]
- Asymptote Definition, in which a classification must be made.
- Hawkins, R.H. (1993) describes the method in detail.



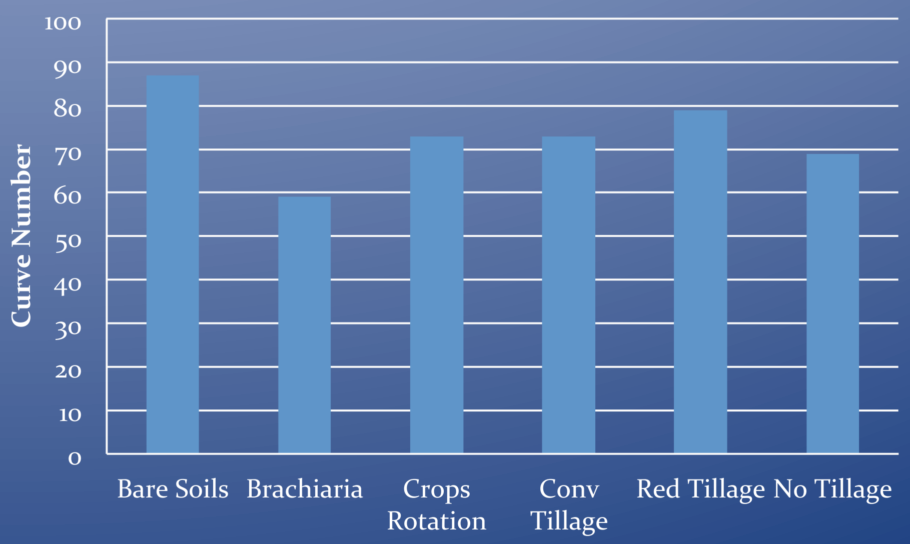


Results

- CN values for different land use types and crop management conditions were estimated for soils of the Eastern Savannas of Colombia.
- Higher and lower curve number values were observed for bare soil (more runoff events) and pastures (less runoff events), respectively.

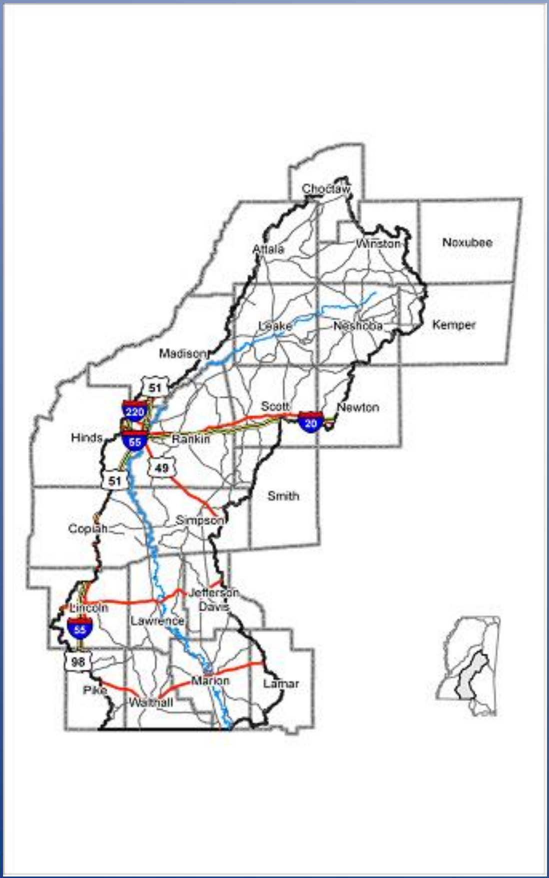
Scenario	CN
Bare Soils	87
Brachiaria	59
Crops Rotation	73
Conv Tillage	73
Red Tillage	79
No Tillage	69

(Events P/S>0.46)



Part III – Hydrologic Analysis

- Regional frequency Analysis for Pearl River Basin (MS)



•Climate information from NCDC-NOAA website (Precipitation and Temperature 1981-2010)

•Organize and clean dataset

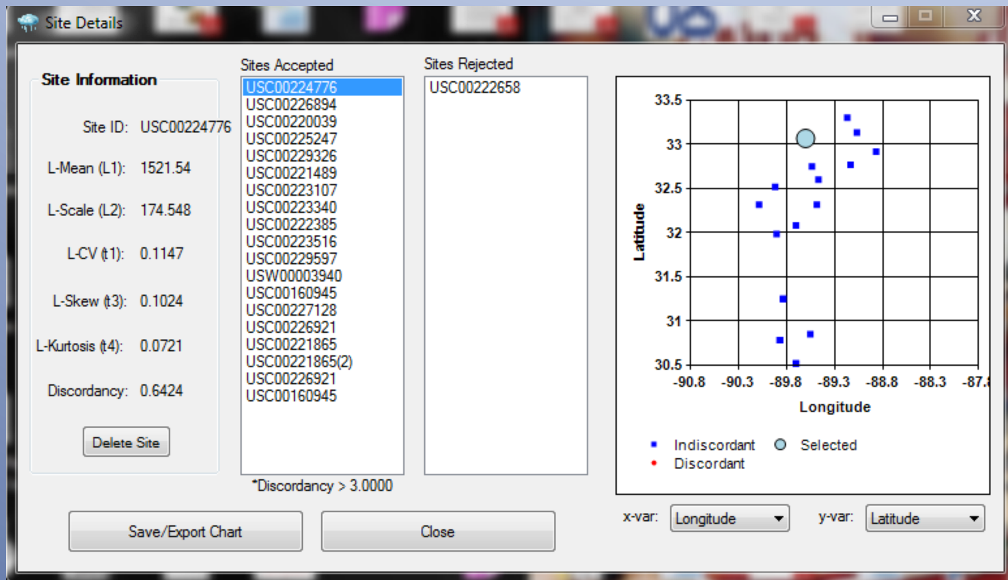
•Prepare Database Template

•ICI-RAFT tool application

  •Rainfall Frequency Regionalization

  •Frequency Distribution Selection

Future application to determine probability of a drought to be reduced


Site Details
Site Information
Site ID: USC00224776
L-Mean (L1): 1521.54
L-Scale (L2): 174.548
L-CV (t1): 0.1147
L-Skew (t3): 0.1024
L-Kurtosis (t4): 0.0721
Discordancy: 0.6424
Delete Site
Sites Accepted
USC00224776
USC00226894
USC00220039
USC00225247
USC00229326
USC00221489
USC00223107
USC00223340
USC00222385
USC00223516
USC00229597
USW00003940
USC00160945
USC00227128
USC00226921
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Sites Rejected
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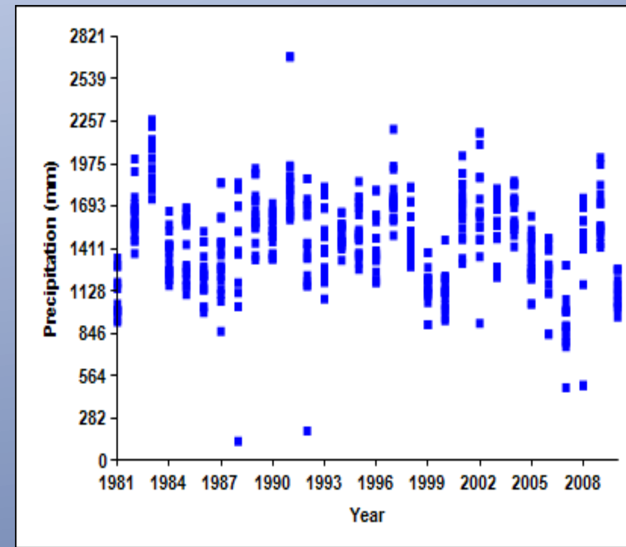
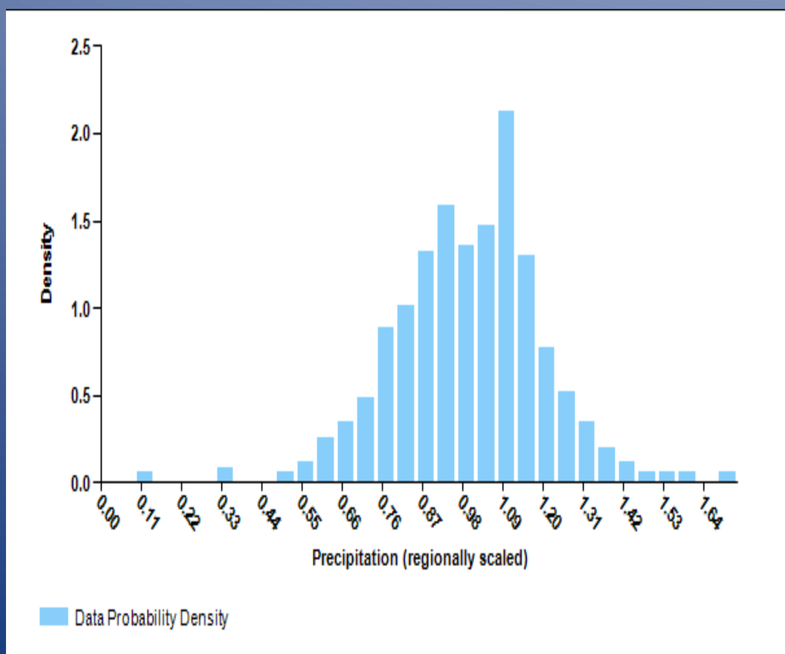
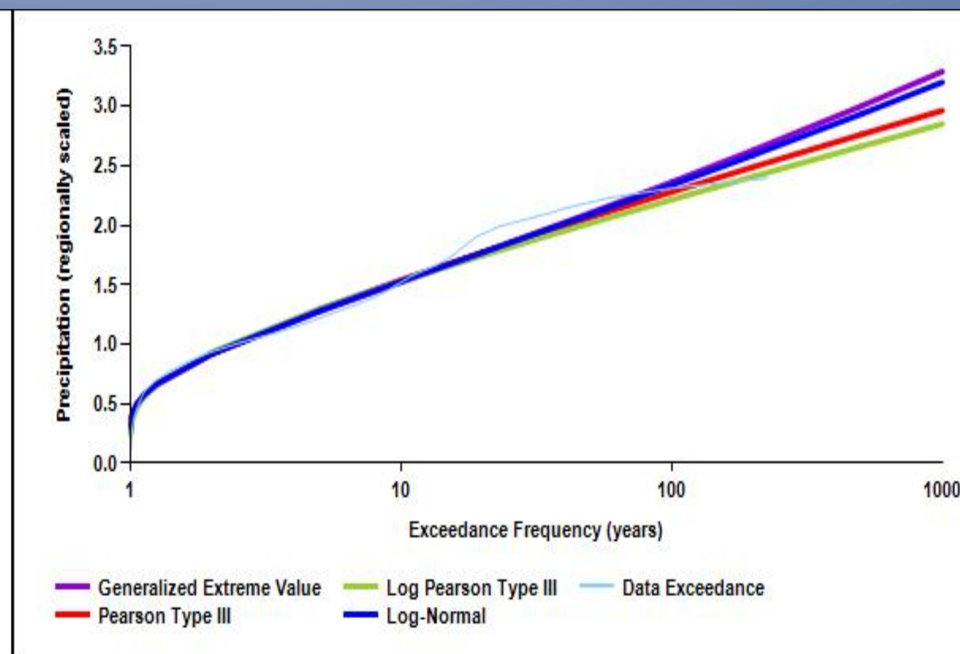
Latitude
Longitude
Indiscordant
Selected
Discordant
Save/Export Chart
Close
x-var: Longitude
y-var: Latitude

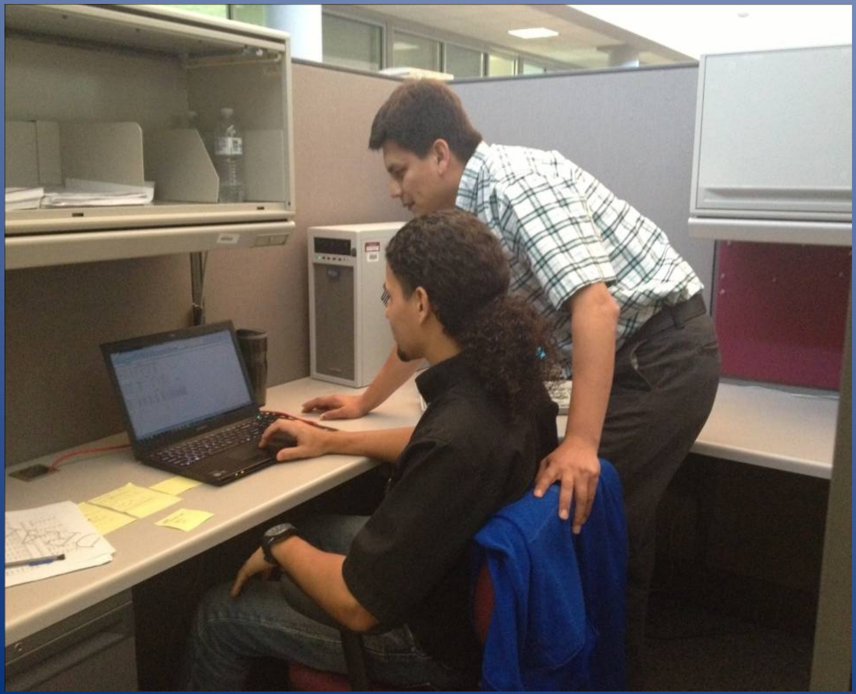

Precipitation (mm)
Year


Density
Precipitation (regionally scaled)
Data Probability Density


Precipitation (regionally scaled)
Exceedance Frequency (years)
Generalized Extreme Value
Log Pearson Type III
Data Exceedance
Pearson Type III
Log-Normal

Content & Skills I learned

- Modeling
- Simulation Models Application & Validation
- Scenario Analysis
- Hydrology Concepts



Internship Experience

- The Internship prepared me professionally.
- I developed new connections with professors in my field of study.
- I made new connections and opportunities with researchers to continue in collaboration.

Acknowledgments

- NOAA-NGI Internship Program
- Dauphin Island Sea Lab
- Dr. Robert Moorhead; GRI-NGI Director at MSU
- Dr. Dennis Truax; Head Department at CEE-MSU.
- Dr. John J. Ramirez-Avila; Mentor