

Further Reading and Materials in Support of *SpatialSTEM*

...map analysis and modeling fundamentals within a mathematical context that resonates with science, technology, engineering and math/stat communities

Three-Part Series for the *Beyond Mapping* column in *GeoWorld*, January-March, 2012

by Joseph K. Berry

January	2012	SpatialSTEM Has Deep Mathematical Roots (Part 1) — provides a <u>conceptual framework</u> for a map-ematical treatment of mapped data http://www.innovativegis.com/basis/MapAnalysis/MA_Intro/MA_Intro.htm#sSTEM1
February	2012	Map-ematically Messing with Mapped Data (Part 2) — discusses the nature of grid-based mapped data and <u>Spatial Analysis</u> operations http://www.innovativegis.com/basis/MapAnalysis/MA_Intro/MA_Intro.htm#sSTEM2
March	2012	Paint by Numbers Outside the Traditional Statistics Box (Part 3) — discusses the nature of <u>Spatial Statistics</u> operations http://www.innovativegis.com/basis/MapAnalysis/MA_Intro/MA_Intro.htm#sSTEM3

An extended treatise is available in the online book **Map Analysis III**, [Topic 30](#), "A Math/Stat Framework for Grid-based Map Analysis and Modeling"

Notes: When viewing this listing in HTML and .pdf formats, each reference contains an embedded URL as blue underlined text. When viewing as hardcopy, the following direct links to the general online document containing the references are—

- Online book **Beyond Mapping III** is posted at <http://www.innovativegis.com/basis/MapAnalysis/Default.htm>
- **White papers** are posted at http://www.innovativegis.com/basis/Papers/Online_Papers.htm
- General **BASIS website** containing books, additional papers, presentation decks and teaching materials is posted at <http://www.innovativegis.com/basis/>

Links to [Royalty-free Workshop and Course Materials](#) are posted at the end of this listing

General Overview

- [A Brief History and Probable Future of Geotechnology](#) — white paper overview on the evolution and future directions of GIS technology

- [An Analytical Framework for GIS Modeling](#) — white paper detailing a conceptual framework for map analysis and GIS Modeling

Part 1 – *SpatialSTEM* Has Deep Mathematical Roots

sSTEM Topic	Link and Description
Defining Geotechnology	<ul style="list-style-type: none"> • Beyond Mapping III, Introduction, Is it Soup Yet? — describes the evolution in definitions and terminology; What's in a Name — suggests and defines the new term Geotechnology • Beyond Mapping III, Epilog, Lumpers and Splitters Propel GIS — describes the two camps of GIS (<i>GeoExploration</i> and <i>GeoScience</i>); The Softer Side of GIS — describes a Manual GIS (circa 1950) and the relationship between social science conceptual frameworks for understanding/judgment in GIS modeling; Melding the Minds of the "-ists" and "-ologists" — elaborates on the two basic mindsets driving the geotechnology community; Is GIS Technology Ahead of Science? — discusses several issues surrounding the differences in the treatment of non-spatial and spatial data
Beyond Traditional GIS Education	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 4, Where Is GIS Education, Where Is GIS Education — describes the broadening appeal of GIS and its impact on academic organization and infrastructure; Varied Applications Drive GIS Perspectives — discusses how map analysis is enlarging the traditional view of mapping; Diverse Student Needs Must Drive GIS Education — identifies new demands and students that are molding the future of GIS education; Turning GIS Education on Its Head — describes the numerous GIS career pathways and the need to engage prospective students from a variety of fields; A Quick Peek Outside GIS's Disciplinary Cave — discusses future directions of geotechnology with particular emphasis

	<p>on career outlook and GIS education; GIS Education's Need for "Hitchhikers" — establishes the need for engaging "domain experts" in moving geotechnology to the next level; Fitting Square Pegs into Round GIS Educational Holes — discusses the need to engage non-GIS students in developing spatially distributed solutions; Which Direction Are You Headed? — describes four perspectives on the trailing "S" in the GIS acronym</p> <ul style="list-style-type: none"> • Infusing Grid-Based Map Analysis into Introductory Courses, conference paper on teaching map analysis and modeling • Education, Vocation and GIS Enlightenment, plenary presentation on GIS education
A Mathematical Structure for Map Analysis/Modeling	<ul style="list-style-type: none"> • Map-matical Models: Doing the Math, short paper with links on mathematical modeling with GIS • A Mathematical Structure for Analyzing Maps— a 1986 <i>Journal of Environmental Management</i> article establishing a framework for map analysis/modeling • Beyond Mapping III, Topic 22 – Reclassifying and Overlaying Maps, Use a Map-matical Framework for GIS Modeling — describes a conceptual structure for map analysis operations and GIS modeling • Beyond Mapping III, Topic 24 – Overview of Spatial Analysis and Statistics, Moving Mapping to Analysis of Mapped Data — describes <i>Spatial Analysis and Spatial Statistics</i> as extensions to traditional mapping and statistics; Bending Our Understanding of Distance — uses effective distance in establishing erosion setback to demonstrate spatial analysis • Beyond Mapping III, Topic 29 – Spatial Modeling in Natural Resources, Putting GIS Modeling Concepts in Their Place — develops a typology of GIS modeling types and characteristics; A Suitable Framework for GIS Modeling — describes a framework for suitability modeling based on a flowchart of model logic; GIS's Supporting Role in the Future of Natural Resources — discusses the influence of human dimensions in natural resources and GIS technology's role
Types of Digital Maps	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 18 – Understanding Grid-based Data, Multiple Methods Help Organize Raster Data — discusses different approaches to storing raster data; Grids and Lattices Build Visualizations — describes Lattice and Grid forms of map surface display; Contour Lines versus Color Gradients for Displaying Spatial Information — discusses the similarities and differences between discrete contour line and continuous gradient procedures for visualizing map surfaces
Grid Data Structure	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 18 – Understanding Grid-based Data, VtoR and Back! — describes various techniques for converting between vector and raster data types; Multiple Methods Help Organize Raster Data — discusses different approaches to storing raster data; Use Mapping "Art" to Visualize Values — describes procedures for generating contour maps; What's Missing in Mapping? — discusses the need for identifying data dispersion as well as average in Thematic Mapping

Part 2 – **Map-matically Messing with Mapped Data**

sSTEM Topic	Link and Description
Spatial Data Perspectives— Where is What	<ul style="list-style-type: none"> • Beyond Mapping III, Introduction, Finding Common Ground in Paper and Digital Worlds — describes the similarities and differences in information and organization between traditional paper and digital maps • Beyond Mapping III, Topic 18, Understanding Grid-based Data, Maps Are Numbers First, Pictures Later — discusses the numeric and geographic characteristics of map values
Basic Grid Math and Algebra (Precision Farming Example)	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 16, Characterizing Patterns and Relationships, Spatial Data Mining "Down on the Farm" — discusses process for moving from Whole-Field to Site-Specific management • Who's Minding the Farm — feature article in <i>GeoWorld</i> on applying map analysis in precision agriculture
Advanced Grid Math— Trig (Cosine)	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 11 – Characterizing Micro-Terrain Features, Use Surface Area for Realistic Calculations — describes a technique for adjusting planimetric area to surface area considering terrain slope; Ironing Out Colorado— extended discussion comparing planimetric and surface area results for Colorado
Map Calculus— Derivative (Slope) and Integral (Zonal)	<p><i>Derivative (Slope):</i></p> <ul style="list-style-type: none"> • Beyond Mapping III, Topic 11 – Characterizing Micro-Terrain Features, Characterizing Terrain Slope and Roughness — discusses techniques for determining terrain inclination and coarseness; Beware of Slope's Slippery Slope — describes various slope calculations and compares results • Beyond Mapping III, Topic 26 – Assessing Spatially-Defined Neighborhoods, Computer Processing Aids

	<p>Spatial Neighborhood Analysis — discusses approaches for calculating slope and profile <i>Integral (Zonal)</i>:</p> <ul style="list-style-type: none"> • Beyond Mapping III, Topic 22 – Reclassifying and Overlaying Maps, Overlay Operations Feature a Variety of Options — discusses the basic overlaying map operations
Map Geometry— Distance, Simple and Effective Proximity	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 25 – Effective Distance and Connectivity, Measuring Distance Is Neither Here nor There — discusses the basic concepts of distance and proximity; Use Cells and Rings to Calculate Simple Proximity — describes how simple proximity is calculated; Extend Simple Proximity to Effective Movement — discusses the concept of effective distance responding to relative and absolute barriers • Beyond Mapping III, Topic 13 – Creating Variable-Width Buffers, Extending GIS Procedures with Variable-Width Buffers — discusses the basic considerations in establishing variable-width buffers that respond to both intervening conditions and the type of connectivity; Create Effective Distance Buffers to Improve Map Accuracy — develops procedures for creating buffers that respond to the relative ease of movement • Beyond Mapping III, Topic 29 – Spatial Modeling in Natural Resources, Harvesting an Understanding of GIS Modeling — describes a prototype model for assessing off-road access to forest areas; Extending Forest Harvesting’s Reach — discusses a multiplicative weighting method for model extension; A Twelve-step Program for Recovery from Flaky Forest Formulations — describes a spatial model for identifying Landings and Timbersheds; E911 for the Backcountry — describes development of an on- and off-road travel-time surface for emergency response; Extending Emergency Response Beyond the Lines — discusses basic model processing and modifications for additional considerations; Comparing Emergency Response Alternatives — describes comparison procedures and route evaluation techniques; Assessing Wildfire Response (Part 1): Oneth by Land, Twoeth by Air — discusses a spatial model for determining effective helicopter landing zones; Assessing Wildfire Response (Part 2): Jumping Right into It — describes map analysis procedures for determining initial response time for alternative attack modes
Plane Geometry Connectivity— Optimal Path	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 19 – Routing and Optimal Paths, A Three-Step Process Identifies Preferred Routes — describes the basic steps in Least Cost Path analysis; Consider Multi-Criteria When Routing — discusses the construction of a discrete “cost/avoidance” map and optimal path corridors; A Recipe for Calibrating and Weighting GIS Model Criteria — identifies procedures for calibrating and weighting map layers in GIS models; Think with Maps to Evaluate Alternative Routes — describes procedures for comparing routes
Solid Geometry Connectivity— Visual Exposure	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 13 – Creating Variable-Width Buffers, Line-of-Sight Buffers Add Intelligent to Maps — describes procedures for creating buffers that track relative visual exposure and noise levels; • Beyond Mapping III, Topic 15 – Deriving and Using Visual Exposure Maps, Identify and Use Visual Exposure to Create Viewshed Maps — discusses basic considerations and procedures for establishing visual connectivity; Visual Exposure is in the Eye of the Beholder — describes procedures for assessing visual impact and creating simple models; Use Exposure Maps and Fat Buttons to Assess Visual Impact — investigates procedures for assessing visual exposure; Use Maps to Assess Visual Vulnerability — discusses a procedure for identifying visually vulnerable areas; Try Vulnerability Maps to Visualize Aesthetics — describes a procedure for deriving an aesthetics map based on visual exposure to pretty and ugly places
Unique Map Analytics	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 22 – Reclassifying and Overlaying Maps, Options Seem Endless When Reclassifying Maps — discusses the basic reclassifying map operations; Contiguity Ties Things Together — describes an analytical approach for determining effective contiguity (clumped features)

<i>Part 3</i> – Paint by Numbers Outside the Traditional Statistics Box	
sSTEM Topic	Link and Description
Overview of Spatial Statistics	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 24 – Overview of Spatial Analysis and Statistics, Use Spatial Statistics to Map Abnormal Averages — discusses surface modeling to characterize the spatial distribution inherent in a data set; Making Space for Mapped Data — investigates the link between geographic space and data space for mapping data patterns
Linking data Space and Geographic Space	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 28 – Spatial Data Mining in Geo-Business, Twisting the Perspective of Map Surfaces — describes the character of spatial distributions through the generation of a customer density surface; Linking Numeric and Geographic Distributions — investigates the link between numeric and geographic distributions of mapped data • Beyond Mapping III, Topic 24 – Overview of Spatial Analysis and Statistics, Making Space for Mapped

	<p>Data — investigates the link between geographic space and data space for mapping data patterns</p> <ul style="list-style-type: none"> • Beyond Mapping III, Topic 16 – Characterizing Patterns and Relationships, GIS Represents Spatial Patterns and Relationships — discusses the important differences among discrete mapping, continuous map surfaces and map analysis • Beyond Mapping III, Topic 7 – Linking Data Space and Geographic Space, Beware the Slippery Surfaces of GIS Modeling — discusses the relationships among maps, map surfaces and data distributions; Link Data and Geographic Distributions — describes the direct link between numeric and geographic distributions; Normally Things Aren't Normal — discusses the appropriateness of using traditional “normal” and percentile statistics; Explore Mapped Data — describes creation of a Standardized Map Variable surface using Median and Quartile Range; Babies and Bath Water — discusses the information lost in aggregating field data and assigning typical values to polygons (desktop mapping); Explore Data Space — establishes the concept of “data space” and how mapped data conforms to this fundamental view
<p>Basic Descriptive Statistics and Classification</p>	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 16 – Characterizing Patterns and Relationships, Use Mapping “Art” to Visualize Values — describes procedures for generating contour maps; What’s Missing in Mapping? — discusses the need for identifying data dispersion as well as average in Thematic Mapping • Beyond Mapping III, Topic 18, Understanding Grid-based Data, Maps Are Numbers First, Pictures Later — discusses the numeric and geographic characteristics of map values; Grids and Lattices Build Visualizations — describes Lattice and Grid forms of map surface display; Contour Lines versus Color Gradients for Displaying Spatial Information — discusses the similarities and differences between discrete contour line and continuous gradient procedures for visualizing map surfaces
<p>Unique Map Descriptive Statistics</p>	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 18, Understanding Grid-based Data, Correlating Maps and a Numerical Mindset — describes a Spatially Localized Correlation procedure for mapping the mutual relationship between two map variables
<p>Map Comparison</p>	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 10 – Analyzing Map Similarity and Zoning, Compare Maps by the Numbers — describes several techniques for comparing discrete maps; Use Statistics to Compare Map Surfaces — describes several techniques for comparing map surfaces • Beyond Mapping III, Topic 16 – Characterizing Patterns and Relationships, Statistically Compare Discrete Maps — discusses procedures for comparing discrete maps; Statistically Compare Continuous Map Surfaces — discusses procedures for comparing continuous map surfaces • Beyond Mapping III, Topic 18, Understanding Grid-based Data, Normalizing Maps for Data Analysis — describes map normalization and data exchange with other software packages; Comparing Apples and Oranges — describes a Standard Normal Variable (SNV) procedure for normalizing maps
<p>Spatial Autocorrelation and Surface Modeling</p>	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 2 – Spatial Interpolation Procedures and Assessment, The Average Is Hardly Anywhere — discusses the difference between spatial and non-spatial data distributions; Under the Hood of Spatial Interpolation — investigates the basic concepts in IDW and Krig interpolation procedures; Justifiable Interpolation — describes the “Residual Analysis” procedure for assessing interpolation performance; Move Beyond a Map Full of Errors — discusses a technique for generating a “shadow map” of error; Comparing Map Errors — describes how normalized maps of error can be used to visualize the differences in error surfaces • Beyond Mapping III, Topic 8 – Investigating Spatial Dependency, Unlocking the Keystone Concept of Spatial Dependency — discusses spatial dependency and illustrates the effects of different spatial arrangements of the same set of data; Measuring Spatial Dependency — describes the basic measures of autocorrelation; Extending Spatial Dependency to Maps — describes a technique for generating a map of spatial autocorrelation; Use Polar Variograms to Assess Distance and Direction Dependencies — discusses a procedure to incorporate direction as well as distance for assessing spatial dependency • Beyond Mapping III, Topic 26 – Assessing Spatially-Defined Neighborhoods, Milking Spatial Context Information — describes a procedure for deriving a customer density surface • Beyond Mapping III, Topic 28 – Spatial Data Mining in Geo-Business, Myriad Techniques Help to Interpolate Spatial Distributions — discusses the basic concepts underlying spatial interpolation; Interpreting Interpolation Results (and why it is important) — describes the use of “residual analysis” for evaluating spatial interpolation performance
<p>Advanced Classification</p>	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 7 – Linking Data Space and Geographic Space, Identify Data Patterns — discusses data clustering and its application in identifying spatial patterns • Beyond Mapping III, Topic 16 – Characterizing Patterns and Relationships, Use Similarity to Identify Data Zones — describes level-slicing for classifying areas into zones containing a specified data pattern; Use Statistics to Map Data Clusters — discusses clustering for partitioning an are into separate data groups; Correlating Maps and a Numerical Mindset — describes a Spatially Localized Correlation procedure for mapping the mutual relationship between two map variables

	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 28 – Spatial Data Mining in Geo-Business, Use Map Analysis to Characterize Data Groups — discusses the use of “data distance” to derive similarity among the data patterns in a set of map layers; Get “Map-ematical” to Identify Data Zones — describes the use of “level-slicing” for classifying locations with a specified data pattern (data zones); Discover the “Miracle” in Mapping Data Clusters — describes the use of “clustering” to identify inherent groupings of similar data patterns
Spatial Correlation and Predictive Statistics	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 28 – Spatial Data Mining in Geo-Business, Can We Really Map the Future? — describes the use of “linear regression” to develop prediction equations relating dependent and independent map variables; Follow These Steps to Map Potential Sales — describes an extensive geo-business application that combines retail competition analysis and product sales prediction • Beyond Mapping III, Topic 16 – Characterizing Patterns and Relationships, Spatial Data Mining Allows Users to Predict Maps — describes the basic concepts and procedures for deriving equations that can be used to derive prediction maps; Stratify Maps to Make Better Predictions — illustrates a procedure for subdividing an area into smaller more homogenous groups prior to generating prediction equations • Beyond Mapping III, Topic 10 – Analyzing Map Similarity and Zoning, Use Scatterplots to Understand Map Correlation — discusses the underlying concepts in assessing correlation among maps; Can Predictable Maps Work for You? — describes a procedure for deriving a spatial prediction model
Geographic Space as Universal database Key	<ul style="list-style-type: none"> • Beyond Mapping III, Topic 28 – Spatial Data Mining in Geo-Business, The Universal Key for Unlocking GIS’s Full Potential — outlines a global referencing system approach compatible with standard DBMS systems • Beyond Mapping III, Topic 16 – Characterizing Patterns and Relationships, Multiple Methods Help Organize Raster Data — discusses different approaches to storing raster data; VtoR and Back! — describes various techniques for converting between vector and raster data types

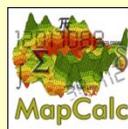
Links to Royalty-free Workshop and Course Materials

[Map Analysis Workshop Materials](#) by Joseph K. Berry

...all of the materials (PowerPoint, Software, Exercises) needed for a 4 hour (real-time demos) session or an 8 hour (hands-on lab) session (2010)

[GIS Modeling Course Materials](#) by Joseph K. Berry

...all of the supporting materials (PowerPoint, Software, Exercises, Exams, Projects) needed for an Upper Division/Graduate college course (2011)



[MapCalc Description & Example Applications](#)

describes Map Analysis capabilities using several GIS modeling examples

[GeoWorld Quick-Take Review](#) of *MapCalc Learner*

[Online Paper](#) describing *MapCalc Academic* for instructors

[Cross-reference](#) to ESRI Grid/SpatialAnalyst and ERDAS

[MapCalc Legacy](#) describing the history of the software

[MapCalc](#) is a comprehensive set of grid-based tools for advanced analysis and display of spatial information (downloads)

MapCalc [Learner](#) and [Academic](#) Versions

[MapCalc Tutorials](#) and [MapCalc Data Sets](#)

[MapCalc User’s Manual](#)