New Tools for Spatial Data Analysis in the Social Sciences

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Outline

- Background
- Visualizing Spatial and Space-Time Association
- DynESDA2
- What's Next - Future Directions

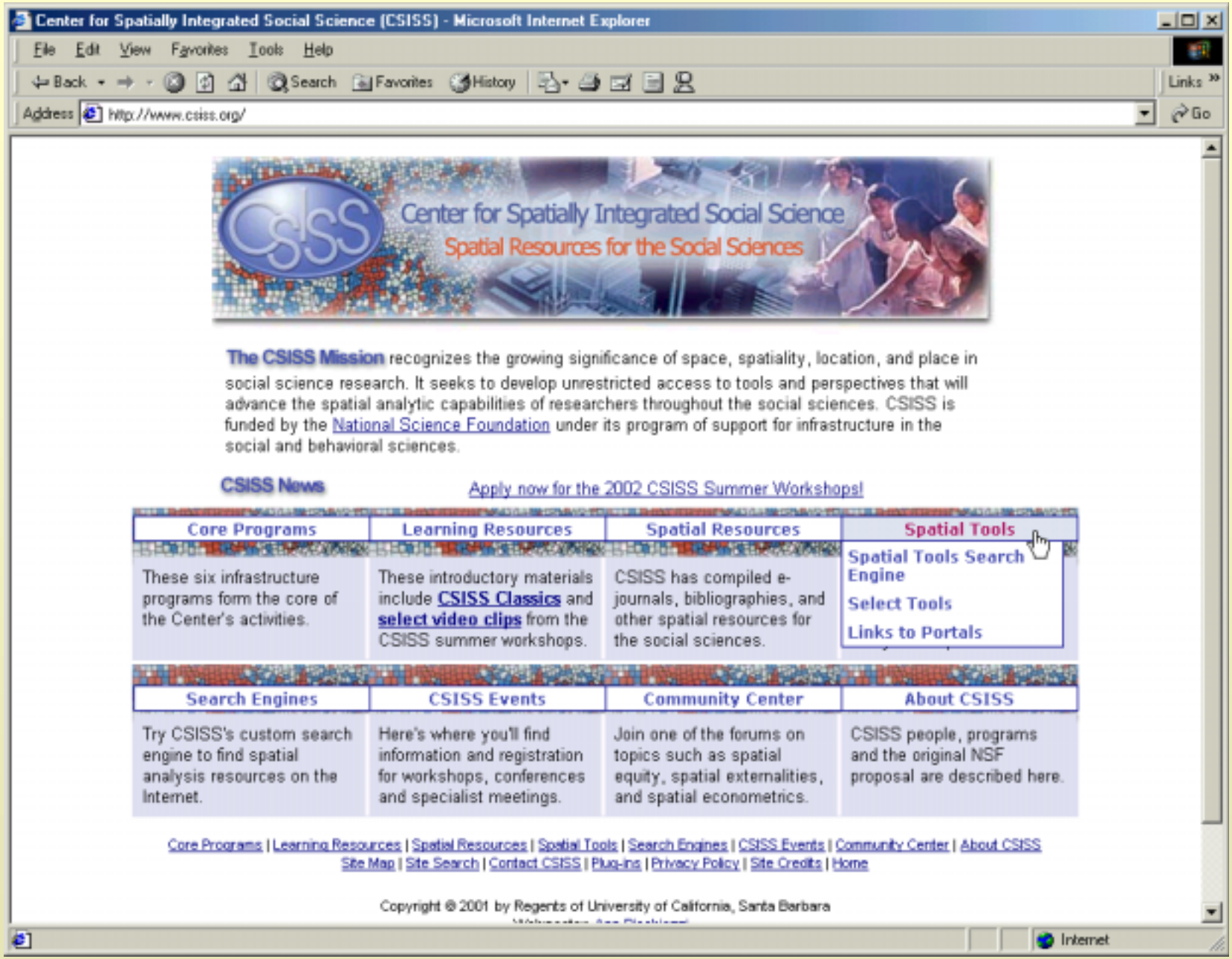
Background

CSISS Tools Program

- Software Tools Clearing House
- The OpenSpace Project
- Dynamic ESDA with GIS

Software Tools Clearing House

- **Search Engine**
  - specialized searches focused on spatial data analysis methods and software
- **Links to Portals**
  - portals with links to spatial data analysis sites
- **Links to Tools**
  - selected software sites, academic, commercial, public sector, individuals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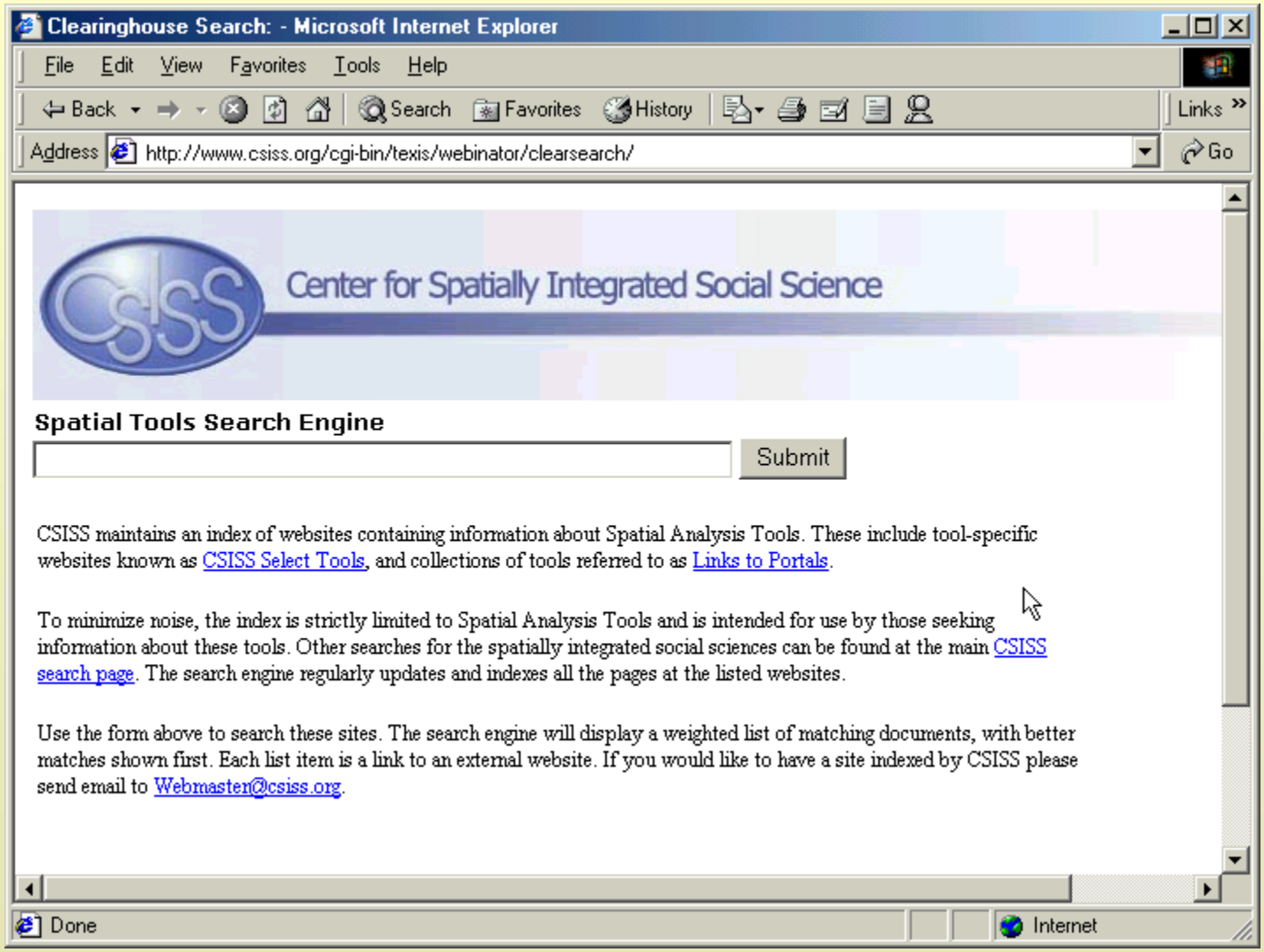
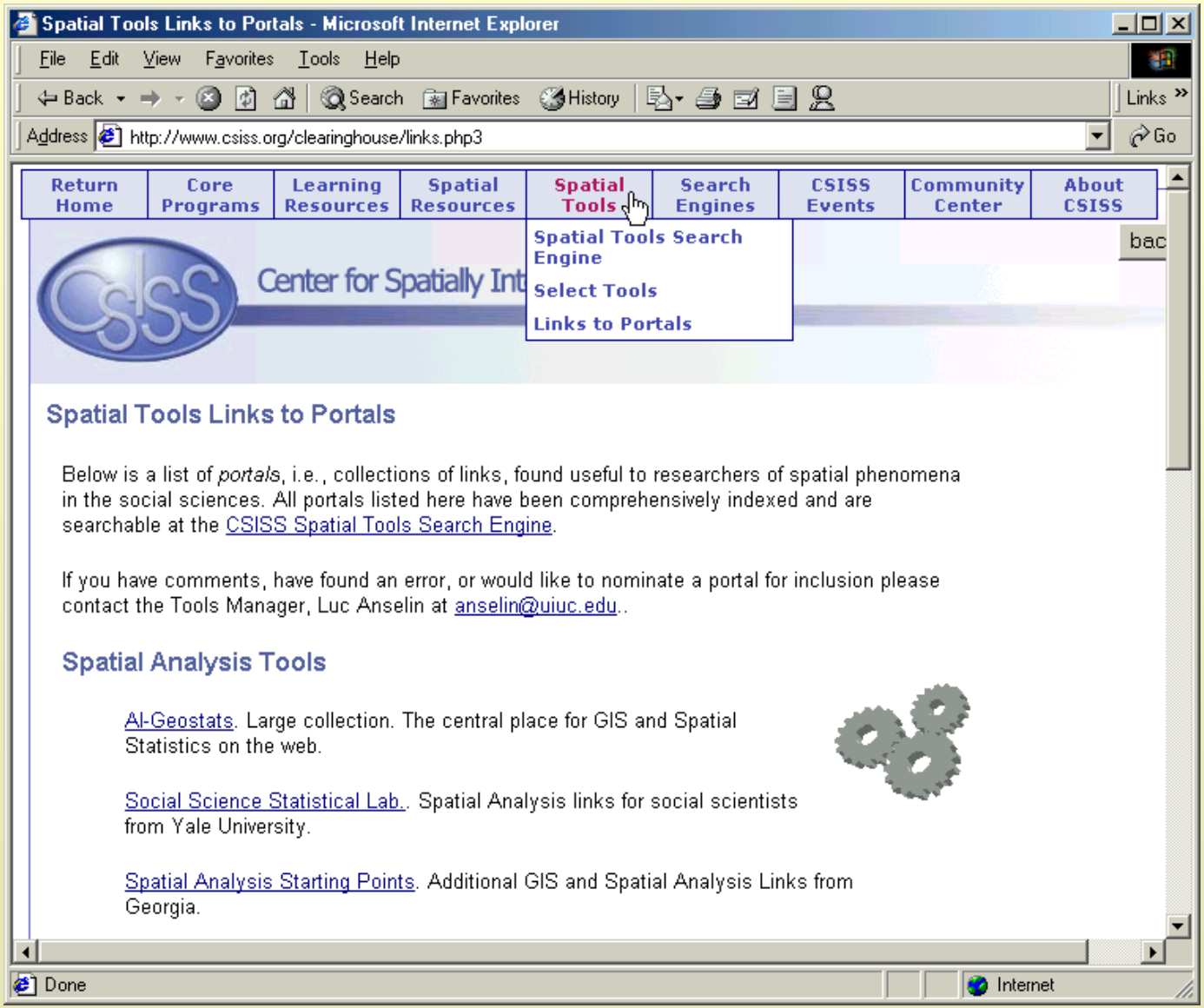
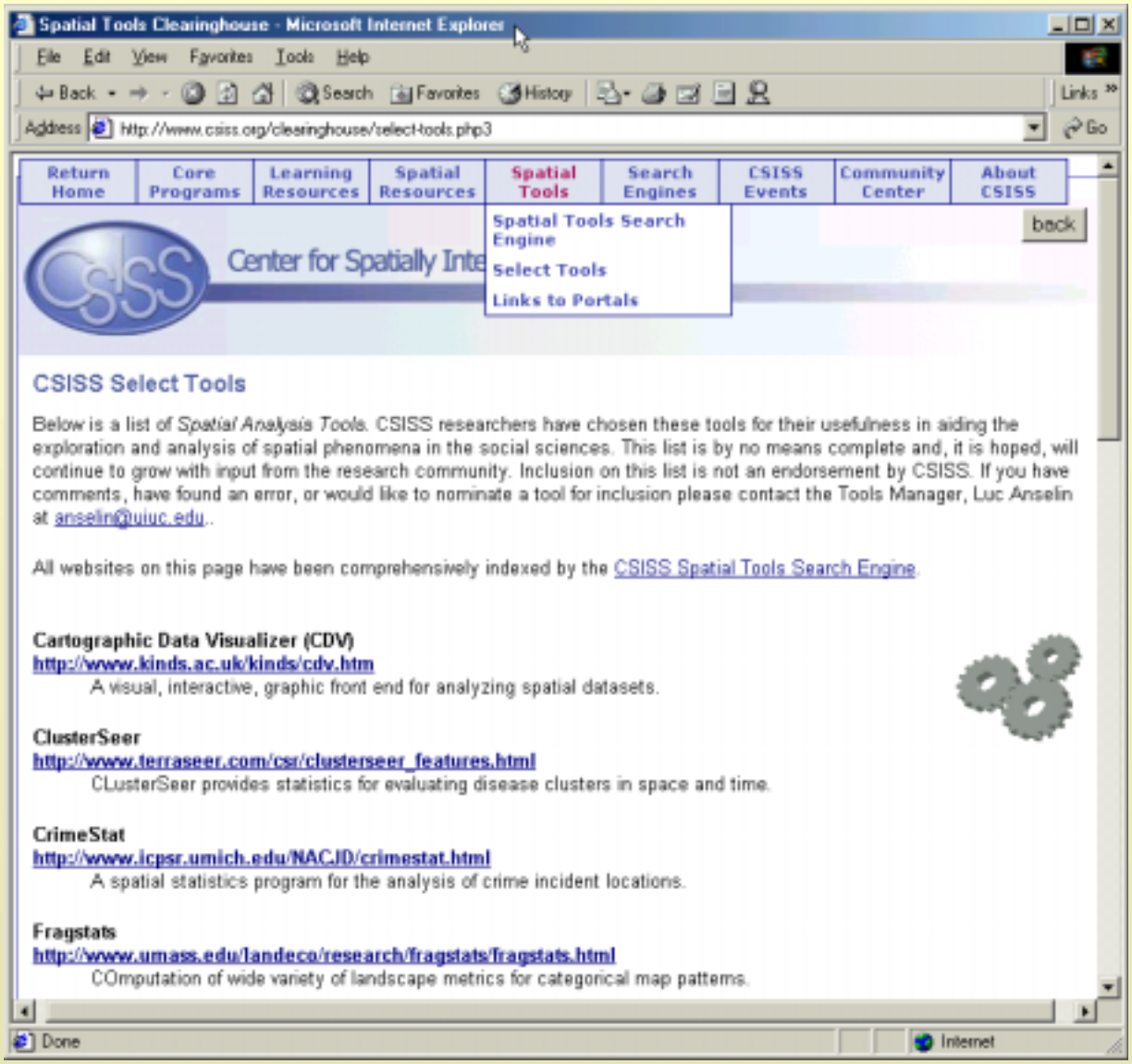
Spatial Tools Search Engine



Links to Spatial Tools Portals



Select Tools



OpenSpace Project

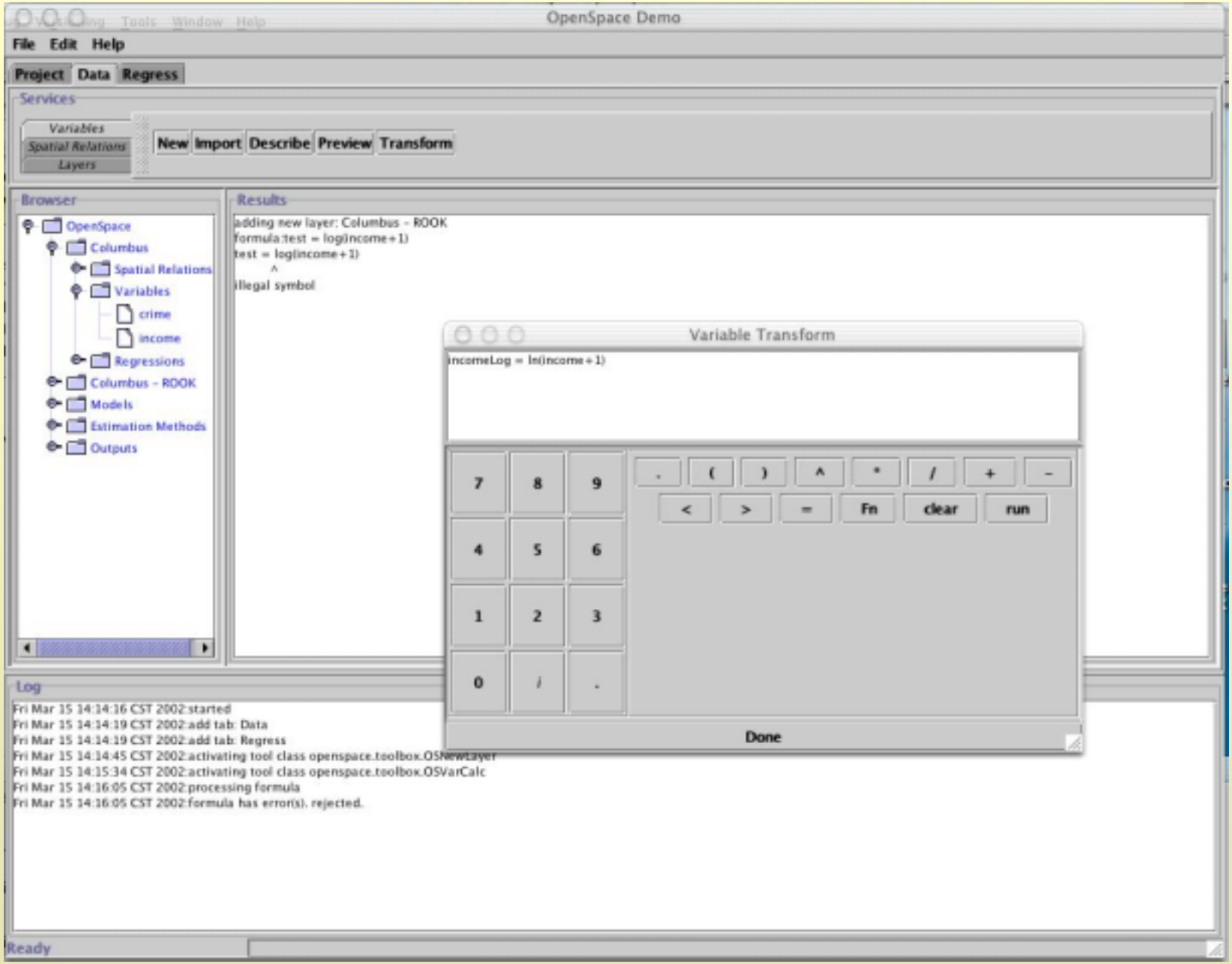
- **Goal**
  - develop collection of open source spatial data analysis modules that incorporate state of the art methods
    - » moving target requires open environment
- **Organization**
  - core development team at UIUC
  - facilitating a community of collaborators

OpenSpace Development

- **Cross Platform Tools**
  - open source software development
    - » Python + Numpy, Jython, Java
    - » to run on linux, windows, mac
  - open source toolboxes
    - » Xlispstat, R, …

OpenSpace Functionality

- **Modular**
  - common kernel of basic classes
  - develop collection of modular components
    - » library, modules, packages
    - » all the basic techniques (estimation, diagnostics)
    - » open design allows for high end users/programmers


OpenSpace Demo
File Edit Help
Project Data Regress
Services
Variables
Spatial Relations
Layers
New Import Describe Preview Transform
Browser
OpenSpace
Columbus
Spatial Relations
Variables
crime
income
Regressions
Columbus - ROOK
Models
Estimation Methods
Outputs
Results
adding new layer: Columbus - ROOK
formula:test = log(income+1)
test = log(income+1)
^
illegal symbol
Variable Transform
incomeLog = ln(income+1)
7 8 9
4 5 6
1 2 3
0 / .
. ( ) ^ * / + -
< > = Fn clear run
Done
Log
Fri Mar 15 14:14:16 CST 2002:started
Fri Mar 15 14:14:19 CST 2002:add tab: Data
Fri Mar 15 14:14:19 CST 2002:add tab: Regress
Fri Mar 15 14:14:45 CST 2002:activating tool class openspace.toolbox.OSNewLayer
Fri Mar 15 14:15:34 CST 2002:activating tool class openspace.toolbox.OSVarCalc
Fri Mar 15 14:16:05 CST 2002:processing formula
Fri Mar 15 14:16:05 CST 2002:formula has error(s). rejected.
Ready

Visualizing Spatial and Space-Time Association

Space-Time ESDA

- **Extensions**
  - Space-time linking and brushing
  - Space-time Moran Scatterplot
  - Space-time LISA

Combining Space and Time

- **Perspectives**
  - "Lattice data" = discrete objects (not surface)
  - Pooled analysis = combining all time periods
  - Comparative statics = cross-sectional slices at different points in time
  - True Space-Time dynamics = dependence of x at i and t on "neighbors" at t-h
- **Metric**
  - What are neighbors in space-time
  - Importance of dynamics of the processes studied = scale

Moran Scatterplot Extensions

- **Generalized Moran Scatterplot**
  - Regression slope of Wz_2 on z_1
    - » Both variables standardized
    - » = visualization of Wartenberg multivariate Moran statistic
  - Significance testing
    - » Permutation
    - » Permutation envelope (2.5% and 97.5% from permutation reference distribution)
- **Four Types of Association**
  - High-high, Low-low; High-low, Low-high

LISA Extensions

- **Generalization of Local Moran**
  - $z_{1i} \times \sum_j w_{ij} z_{2j}$
    - » z_1 and z_2 different variables, or same variable at different times
- **Inference**
  - Null hypothesis
    - » random assignment between value of z_1 at i, t and "neighboring" values of z_2

LISA Extensions (2)

- **Space-Time Cluster = Diffusion/Contagion**
  - High (above avg) values at a location surrounded by High values at different time
    - » Compare to high-high same time
  - Similar for Low-Low
- **Space-Time Outlier = Change**
  - High (above avg) surrounded by Low (below avg) at different time
  - Similar for Low-High
- **Significance based on permutation**

DynESDA2

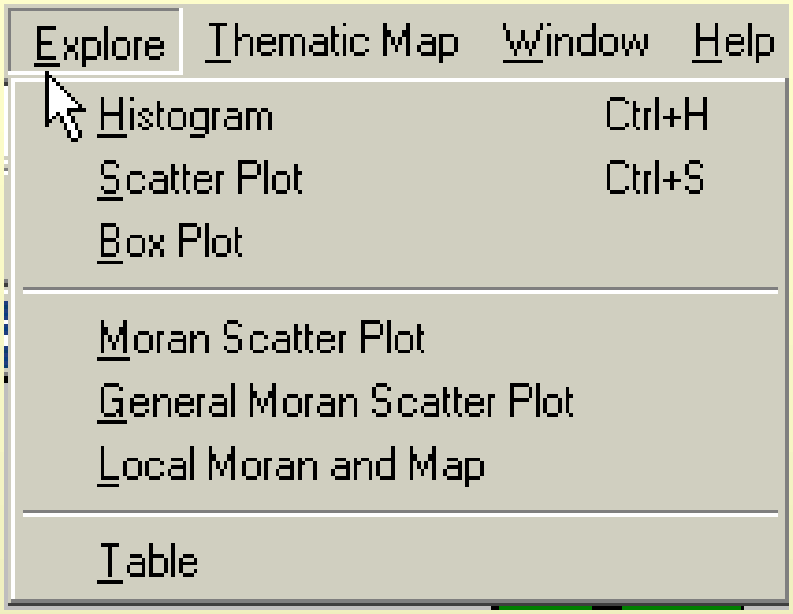
Antecedents

- **Link ArcInfo-SpaceStat**
- **Link ArcView-SpaceStat**
  - SpaceStat Extension for ArcView
    - » visualize ESDA results from SpaceStat
    - » construct spatial weights
  - DynESDA Extension for ArcView
    - » dynamic linking of View and statistical graphs
    - » link map, histogram, box plot, scatterplot
    - » Moran Scatterplot

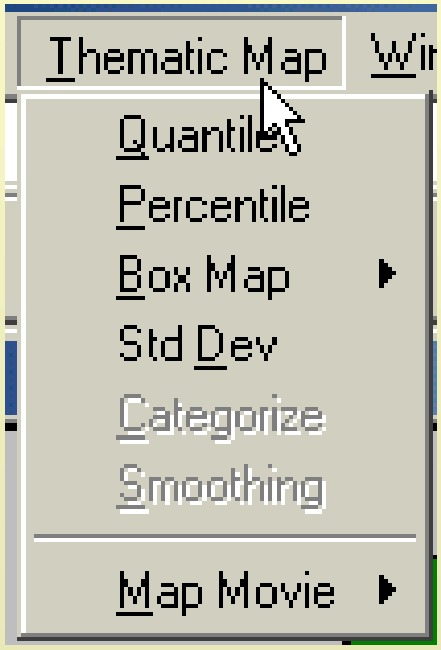
DynESDA2 Design

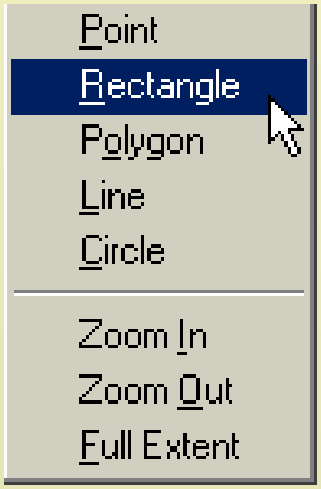
- **Map as One of the Views**
  - no longer ArcView driven
  - MapObjects Lite for mapping functionality
  - multiple maps linked
  - transparent selection identifier
- **Modular Design**
  - modules for statistical graphics
  - modules for mapping function
  - linked through common bitmap

User Interfaces



< Explore Menu





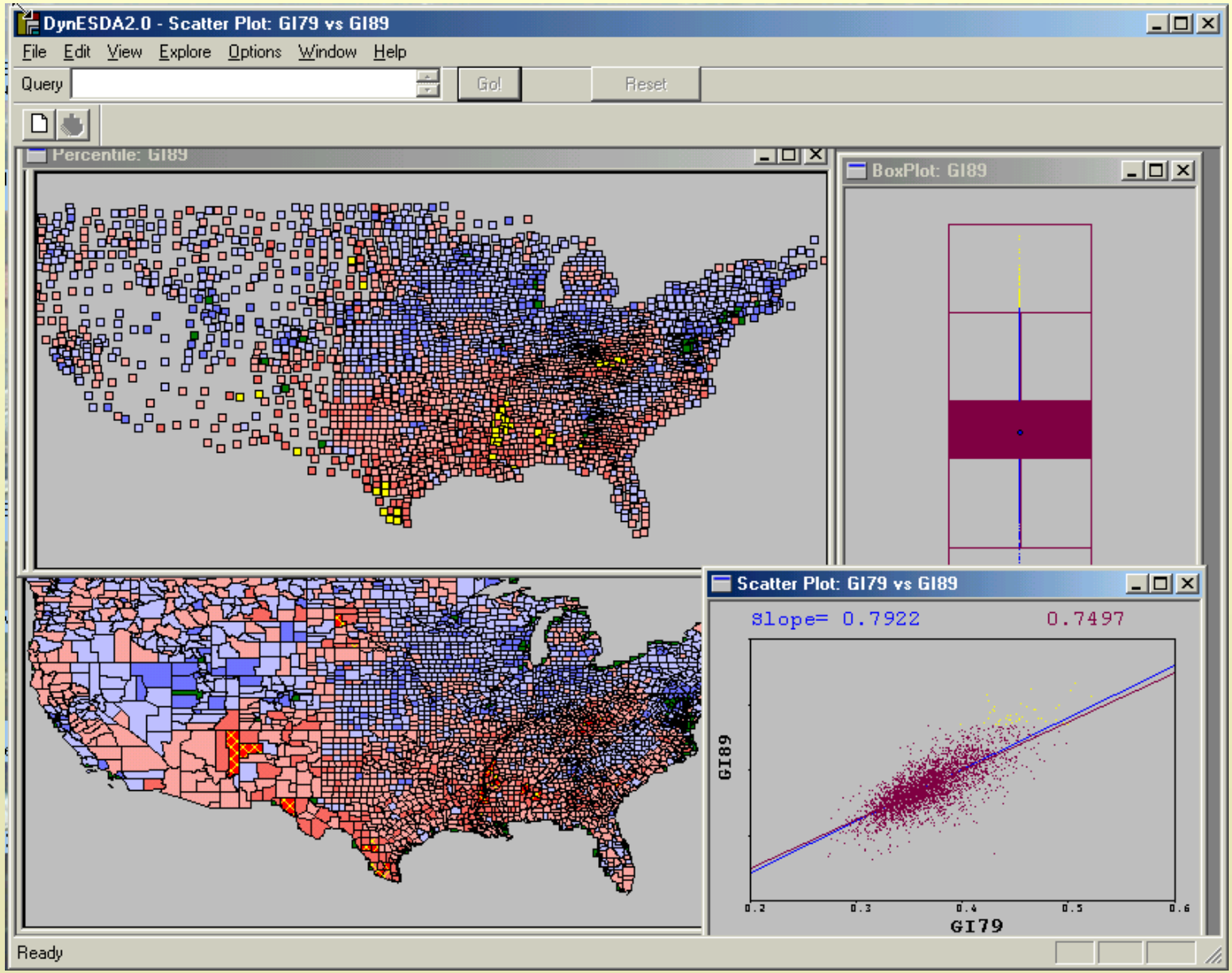
< Selection Tools

Mapping Menu

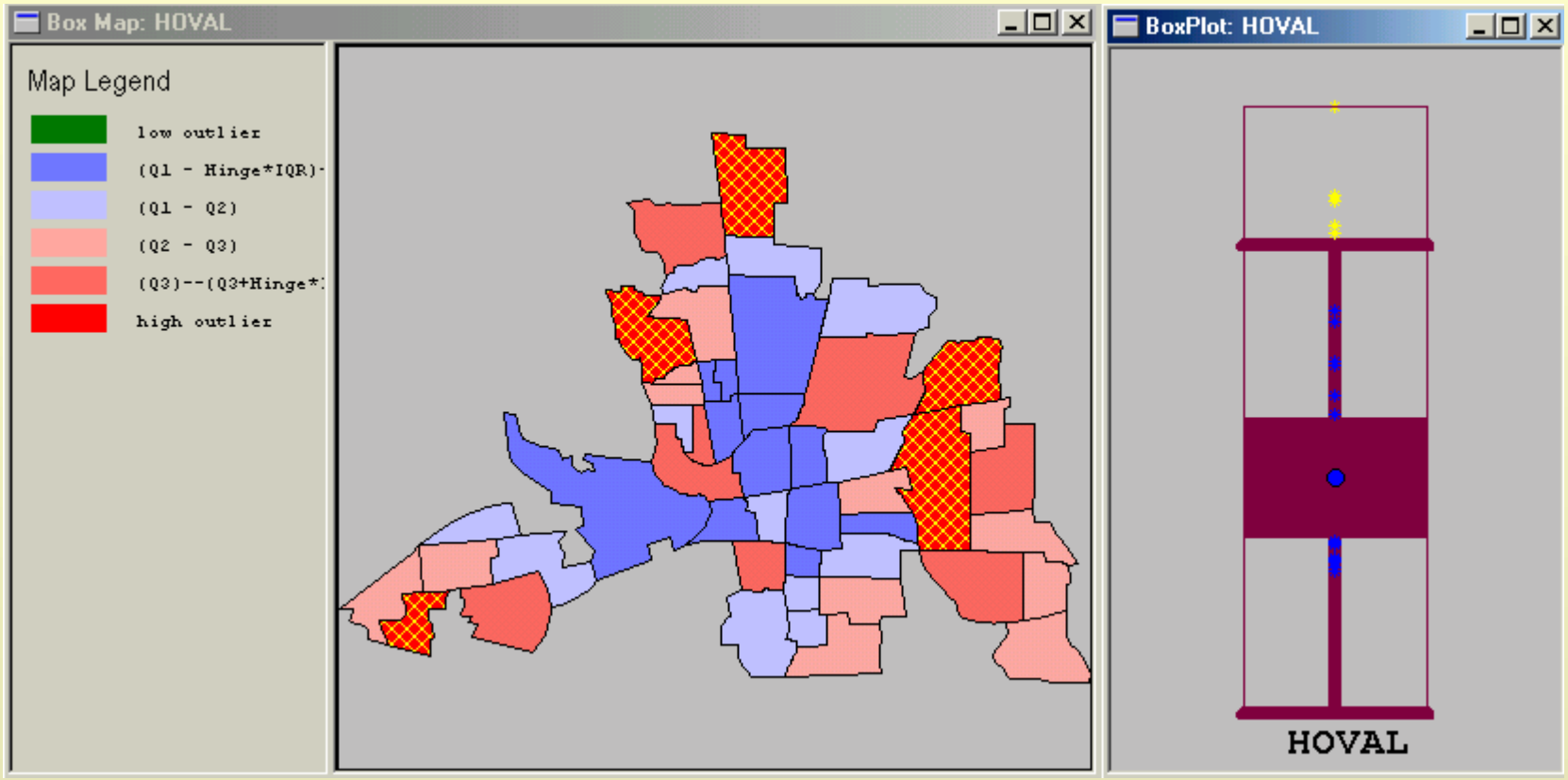
New Features

- **Data Structure**
  - both polygon and point shape files
  - Thiessen polygons – centroids
- **Brushing**
  - brushing of multiple maps
  - linking to table
- **Visualizing Spatial Autocorrelation**
  - generalized Moran scatterplot
  - linking and brushing LISA maps

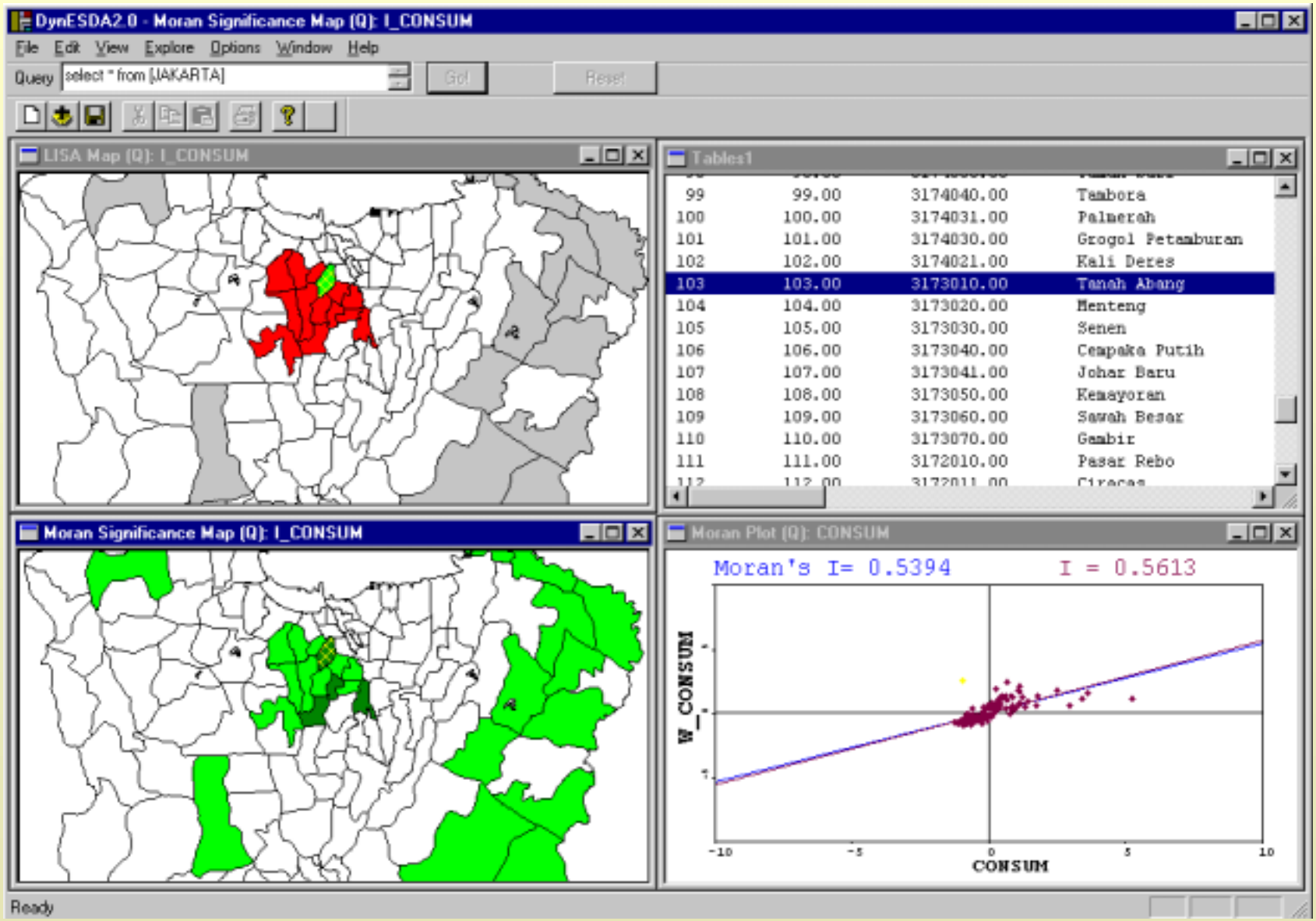
Linking Point and Polygon Maps



Box Map and Box Plot

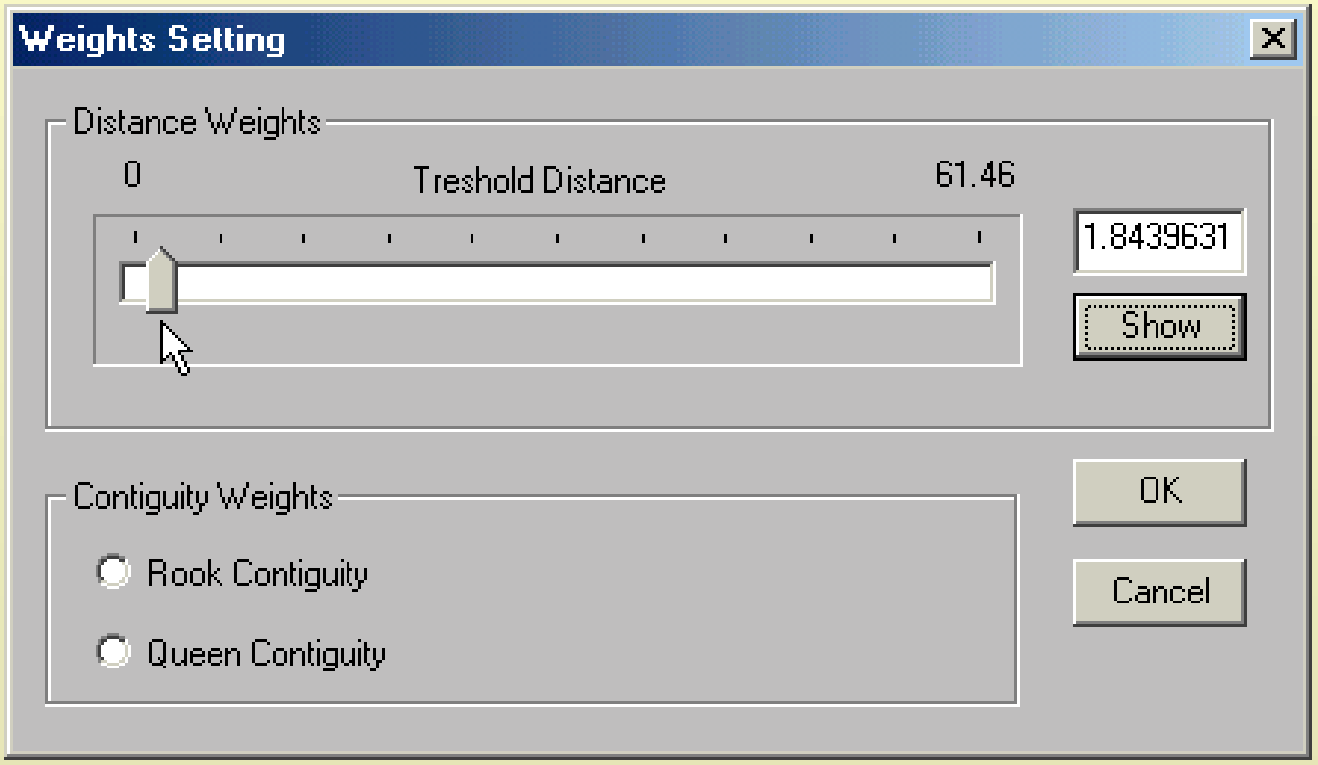


LISA Maps Linked to Table and Moran Scatterplot

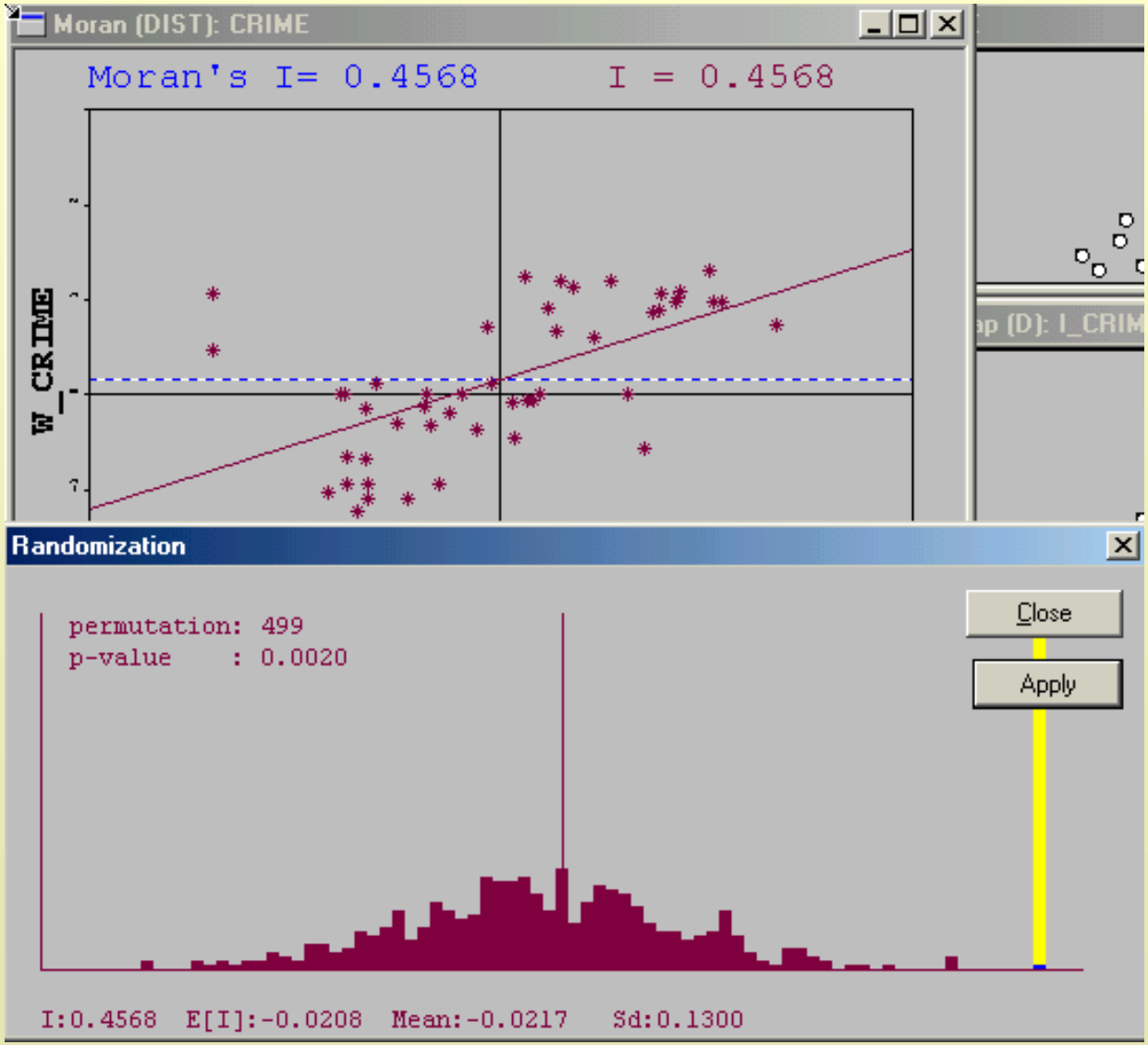


Weights Construction

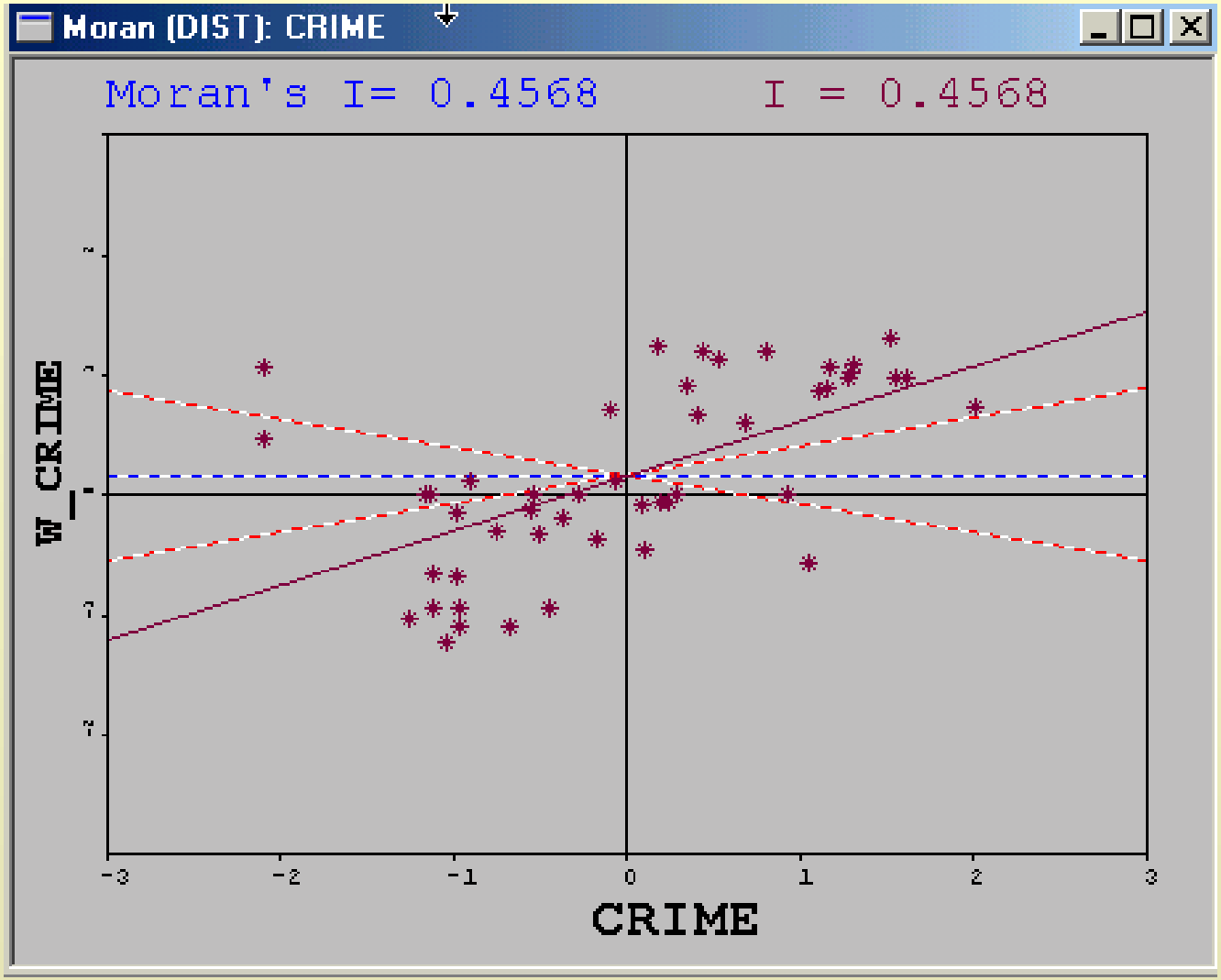
Distance Weights
Contiguity Weights



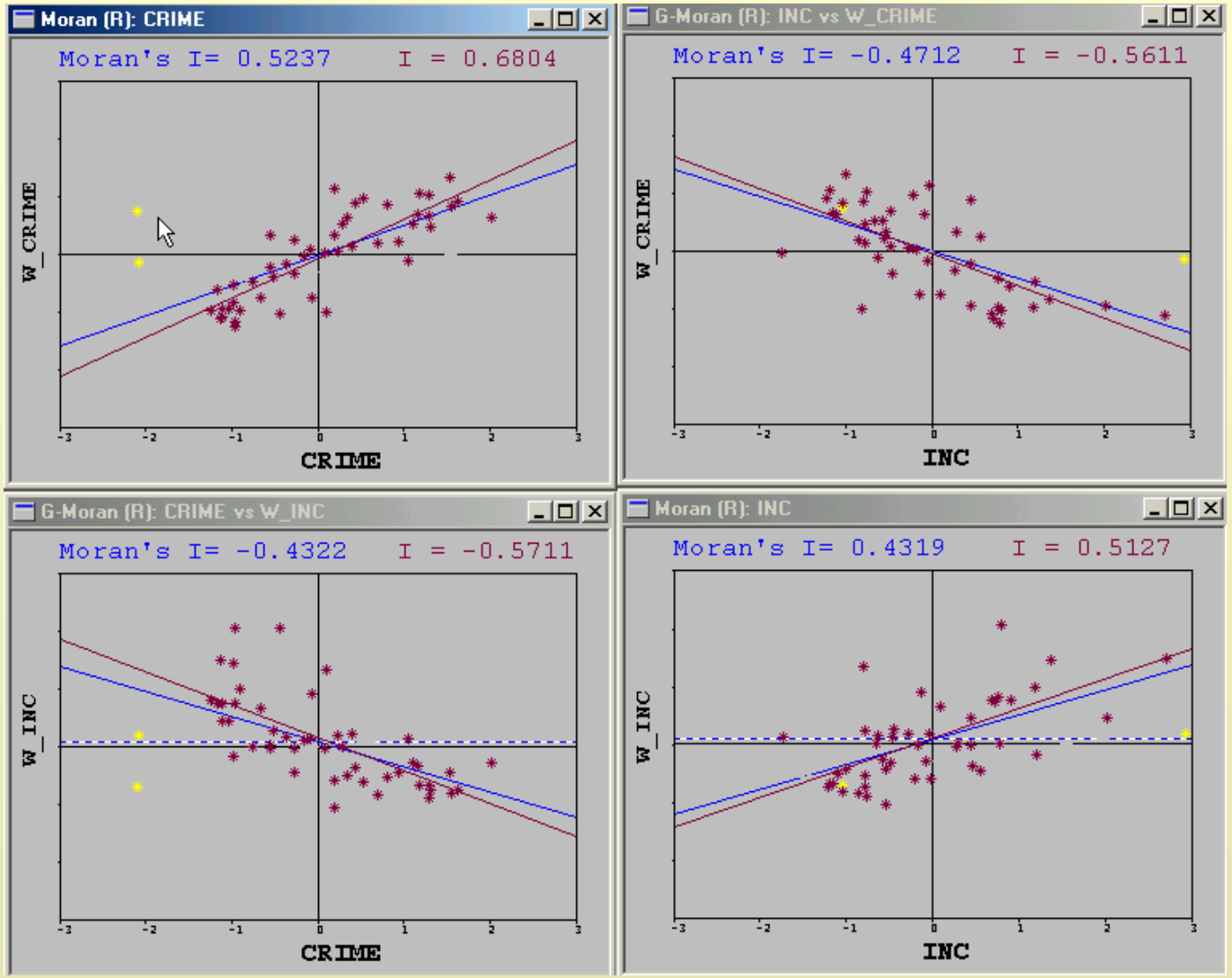
Randomization in Moran Scatterplot



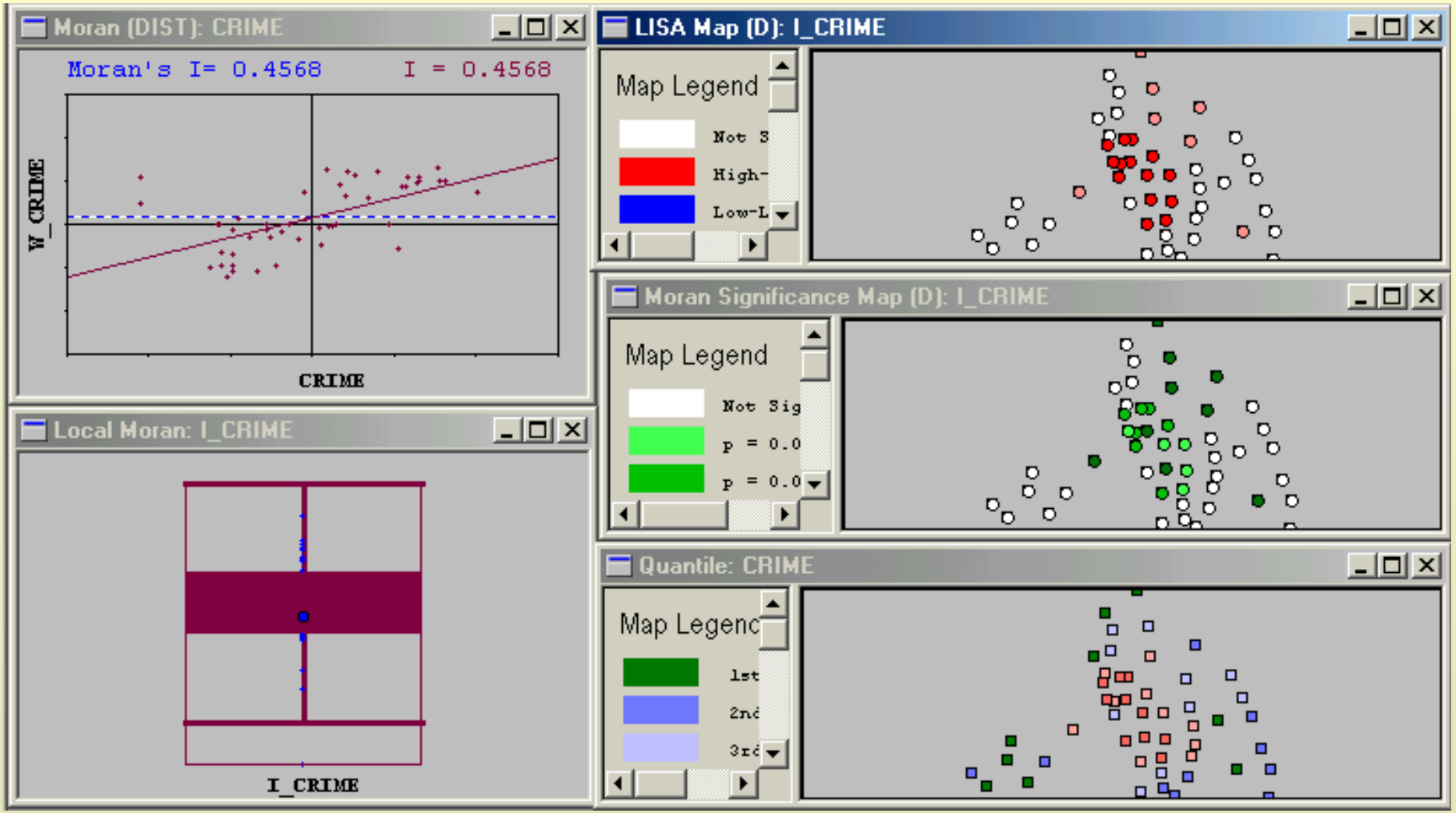
Significance Envelope



Generalized Moran Scatterplot Matrix



Linked LISA Map Suite



Future

What's Next

- **Tool Developers Specialist Meeting**
  - compendium/showcase of tools
  - white paper on standards, interoperability
- **DynESDA2 Beta Release**
  - late spring
- **Template for Linear Regression**
  - libraries in Xlispstat, Python, Java
  - links to related work (R project)
    - » diagnostics for spatial effects
    - » ML estimation of spatial regression
    - » IV/GMM estimation of spatial regression

Future Directions

- **Performance Issues**
  - extend DynESDA functionality to large data sets
- **New Methods**
  - space-time regression models
  - spatial probit
- **New Platforms**
  - web-based spatial data analysis