Python - Raster Analysis

Kevin M. Johnston
Nawajish Noman
The problem that is being addressed

- You have a complex modeling problem
- You are mainly working with rasters
- Some of the spatial manipulations that you trying to implement are difficult or not possible using standard ArcGIS tools
- Due to the complexity of the modeling problem, processing speed is a concern
Outline

• Managing rasters with management tools and performing analysis with Map Algebra

• How to access the analysis capability - Demonstration

• Complex expressions and optimization - Demonstration

• Additional modeling capability: classes - Demonstration

• Full modeling control: NumPy arrays - Demonstration

• Pre-10 Map Algebra
Emerald Ash Borer

Originated in Michigan
Infest ash trees
100% kill
Coming to Vermont
The ash borer model

• Movement by flight
  - 20 km per year
  - Vegetation type and ash density (suitability surface)

• Movement by hitchhiking
  - Roads
  - Camp sites
  - Mills
  - Population
  - Current location of the borer (suitability surface)

• Random movement
Raster analysis

• To prepare and manage raster data
  - Displaying
  - Adding, copying, deleting, etc.
  - Mosaic, Clip, etc.
  - Raster object
  - NumPy, ApplyEnvironment, etc.

• To perform the analysis use raster analysis/modeling
  - Spatial Analyst
  - Map Algebra
What is Map Algebra

• Simple and powerful algebra to execute Spatial Analyst tools, operators, and functions to perform geographic analysis

• The strength is in creating complex expressions

• Available through Spatial Analyst module

• Integrated in Python (all modules available)
Importing Spatial Analyst

- Module of ArcPy site package
- Like all modules must be imported
- To access the operators and tools in an algebraic format the imports are important

```python
import arcpy
from arcpy import env  # Analysis environment
from arcpy.sa import *
```
General syntax

- Map Algebra available through an **algebraic format**

- Simplest form: output raster is specified to the left of an equal sign and the tool and its parameters on the right

```
from arcpy.sa import *
outRas = Slope("indem")
```

- Comprised of:
  - Input data
  - Operators
  - Tools
  - Parameters
  - Output
Input data

• Input elements
  - Rasters
  - Features
  - Numbers
  - Constants
  - Objects
  - Variables

```
outRas = Slope("inraster")
```

Tip: Names are quoted – if in workspace no path is necessary (or if using Python window and the layer is in the TOC)
Map Algebra operators

- Symbols for mathematical operations
- Many operators in both Python and Spatial Analyst
- Cast the raster (Raster class constructor) indicates operator should be applied to rasters

```python
outRas = Raster("inraster1") + Raster("inraster2")
outRas2 = Raster("inraster") + 8
```
Map Algebra tools

- All the tools that output a raster are available (e.g., Sin, Slope, Reclassify, etc.)

  \[ \text{outRas} = \text{Aspect}(\text{“inraster”}) \]

- Can use any Geoprocessing tools

**Tip:** Tool names are case sensitive
Tool parameters

• Defines how the tool is to be executed

• Each tool has its own unique set of parameters

• Some are **required**, others are **optional**

• Numbers, strings, and objects (classes)

```python
outRas = Slope("inraster", "PERCENT_RISE")
```

**Tip:** Keywords are in quotes and it is recommended they are capitalized
Map Algebra output

- Stores the results as a **Raster object**
- Object with methods and properties
- Generally, in Python window and scripting the output is **temporary**

```python
outRas = Hillshade("inraster")
```
Access to Map Algebra

• Raster Calculator
  - Spatial Analyst tool
  - Easy to use calculator interface
  - Stand alone or in ModelBuilder

• Python window
  - Single expression or simple exploratory models

• Scripting
  - Complex models
  - Line completion and colors
Demo 1: Data management

- Raster management tools
- Raster Calculator
- Python window
- ModelBuilder
- Simple expressions
Outline

• Managing rasters with management tools and performing analysis with Map Algebra

• How to access the analysis capability - Demonstration

• **Complex expressions and optimization** - Demonstration

• Additional modeling capability: classes - Demonstration

• **Full modeling control: NumPy arrays** - Demonstration

• Pre-10 Map Algebra
Complex expressions

- Multiple operators and tools can be implemented in a single expression

- Output from one expression can be the input to a subsequent expression

Tip: It is a good practice to set the input to a variable and use the variable in the expression
More on the raster object

- A **variable** with a pointer to a dataset

- Output from a Map Algebra expression or from an existing dataset

- The associated dataset is **temporary** (when created from Map Algebra) but has a save method

- A series of properties describing the associated dataset
  - Description of raster (e.g., number of rows)
  - Description of the values (e.g., mean)
Optimization

- A series of local tools (Abs, Sin, Cell Statistics, etc.) and operators can be optimized

- Work on a per-cell basis

- When entered into a single expression each tool and operator is processed on a per cell basis
The iterative aspects of the ash borer model

• Movement by flight
  - Depends on the year how far it can move in a time step
  - “Is there a borer in my neighborhood”
  - “Will I accept it” – suitability surface

• Movement by hitchhiking
  - Based on highly susceptible areas
  - Nonlinear decay
  - Random points and check susceptibility

• Random movement
  - Nonlinear decay from known locations (NumPy array)
Demo 2: Movement by hitchhiking

Roads, Campsites, Mills, Population, and current location (suitability)

Complex expressions
Raster object
Optimization
Outline

• Managing rasters with management tools and performing analysis with Map Algebra

• How to access the analysis capability - Demonstration

• Complex expressions and optimizations - Demonstration

• Additional modeling capability: classes - Demonstration

• Full modeling control: NumPy arrays - Demonstration

• Pre-10 Map Algebra
Classes

- Objects that are used as parameters to tools
  - Varying number of arguments depending on the selected parameter choice (neighborhood type)
  - The number of entries into the parameters can vary depending on the specific situation (a remap table)

- More flexible

- Query the individual arguments
Classes - Categories

• General
  - Fuzzy classes
  - Hf classes
  - KrigingModel classes
  - Nbr classes
  - Time classes
  - VF classes
  - Radius classes

• Composed of lists
  - Topo classes

• Composed of lists within lists
  - Reclass
  - Weighted reclass tables
  - Topo classes (a subset)
Classes - Categories

- Creating
  
  `neigh = NbrCircle(4, “MAP”)`

- Querying
  
  `radius = neigh.radius`

- Changing arguments
  
  `neigh.radius = 6`
Vector integration

• Feature data is required for some Spatial Analyst Map Algebra
  - IDW, Kriging, etc.

• Geoprocessing tools that operate on feature data can be used in an expression
  - Buffer, Select, etc.
The iterative aspects of the ash borer model

• **Movement by flight**
  - Depends on the year how far it can move in a time step
  - “Is there a borer in my neighborhood”
  - “Will I accept it” – suitability surface

• **Movement by hitchhiking**
  - Based on highly susceptible areas
  - Nonlinear decay
  - Random points and check susceptibility

• **Random movement**
  - Nonlinear decay from known locations (NumPy array)
Demo 3: Movement by flight

- 20 km per year
- Vegetation type/ash density (suitability)
  - Classes
  - Using variables
- Vector integration
Outline

- Managing rasters with management tools and performing analysis with Map Algebra

- How to access the analysis capability - Demonstration

- Complex expressions and optimization - Demonstration

- Additional modeling capability: classes - Demonstration

- **Full modeling control: NumPy arrays** - Demonstration

- Pre-10 Map Algebra
NumPy Arrays

• A generic Python storage mechanism

• Create custom tool

• Access the wealth of free tools built by the scientific community
  - Clustering
  - Filtering
  - Linear algebra
  - Optimization
  - Fourier transformation
  - Morphology
NumPy Arrays

- Two tools
  - RasterToNumPyArray
  - NumPyArrayToRaster
The iterative aspects of the ash borer model

• Movement by flight
  - Depends on the year how far it can move in a time step
  - “Is there a borer in my neighborhood”
  - “Will I accept it” – suitability surface

• Movement by hitchhiking
  - Based on highly susceptible areas
  - Nonlinear decay
  - Random points and check susceptibility

• Random movement
  - Nonlinear decay from known locations (NumPy array)
Demo 4: The random movement

Random movement based on nonlinear decay from existing locations

Custom function

NumPy array
Outline

• Managing rasters with management tools and performing analysis with Map Algebra

• How to access the analysis capability - Demonstration

• Complex expressions and optimization - Demonstration

• Additional modeling capability: classes - Demonstration

• Full modeling control: NumPy arrays - Demonstration

• Pre-10 Map Algebra
Pre-10.0 Map Algebra

- Similar to Map Algebra 10.0
- Faster, more powerful, and easy to use (line completion, colors)
- Any changes are to take advantage of the Python integration
- Raster Calculator at 10.0 replaces the Raster Calculator from the tool bar, SOMA, and MOMA
- SOMA in existing models will still work
Summary

• When the problem become more complex you may need additional capability provided by Map Algebra

• **Map Algebra** powerful, flexible, easy to use, and integrated into Python

• Accessed through: Raster Calculator, Python window, ModelBuilder (through Raster Calculator), and scripting

• Raster object and classes

• Create models that can better **capture interaction** of phenomena
ArcGIS Spatial Analyst Technical Sessions

- An Introduction - Rm 1 A/B
  Tuesday, July 12, 8:30AM – 9:45AM
  Thursday, July 14, 10:15AM – 11:30AM

- Suitability Modeling - Rm 1 A/B
  Tuesday, July 12, 1:30PM – 2:45PM
  Thursday, July 14, 8:30AM – 9:45AM

- Dynamic Simulation Modeling – Rm 5 A/B
  Wednesday, July 13, 8:30AM – 9:45AM

- Raster Analysis with Python – Rm 6C
  Tuesday, July 12, 3:15PM – 4:30PM
  Wednesday, July 13, 3:15PM – 4:30PM

- Creating Surfaces – Rm 5 A/B
  Wednesday, July 13, 1:30PM – 2:45PM
ArcGIS Spatial Analyst Short Technical Sessions

• Creating Watersheds and Stream Networks – Rm 6A  
  Tuesday, July 12, 10:40AM – 11:00AM

• Performing Image Classification – Rm 6B  
  Tuesday, July 12, 8:30AM – 8:50AM

• Performing Regression Analysis Using Raster Data – 6B  
  Tuesday, July 12, 8:55AM – 9:15AM
Demo Theater Presentations – Exhibit Hall C

• Modeling Rooftop Solar Energy Potential
  Tuesday, July 12, 3:30PM – 4:00PM

• Surface Interpolation in ArcGIS
  Wednesday, July 13, 9:00AM – 10:00AM

• Getting Started with Map Algebra
  Wednesday, July 13, 10:00AM – 11:00AM

• Agent-Based Modeling
  Wednesday, July 13, 5:30PM – 6:00PM
Open to Questions
...Thank You!

Please fill the evaluation form.

www.esri.com/sessionevals