Python: Working with Raster Data

Nawajish Noman

Elizabeth Graham

Outline

- Managing rasters with tools and performing analysis with Map Algebra
- How to access the analysis capability
  - Demonstration
- Complex expressions and optimization
  - Demonstration
- Additional modeling capability using classes
  - Demonstration
- Extending modeling capability using NumPy arrays
  - Demonstration
- Raster Analysis using Multiprocessing

The problem that is being addressed

- You have a complex modeling problem
- You are working with rasters, features and tables
- You want to write a script that is
  - Reusable - repeat the workflow with the same or different set of data
  - Dynamic – repeat analysis by using different parameter values
  - Extends capabilities - by taking advantage of 3rd party python packages
  - Performs well – optimized to improve execution speed

The ash borer model

- Movement by flight
  - Fly up to a half mile under its own power
  - 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

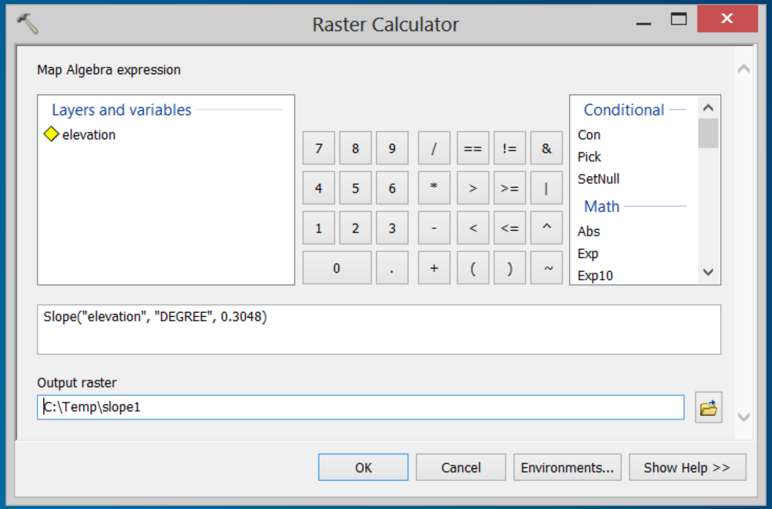
- To prepare and manage raster data
  - Displaying
  - Adding, copying, deleting, etc.
  - Mosaic, Clip, etc.
  - Raster object
  - NumPy, ApplyEnvironment, etc.
- To perform the analysis use raster analysis/modeling
  - Spatial Analyst
  - Map Algebra

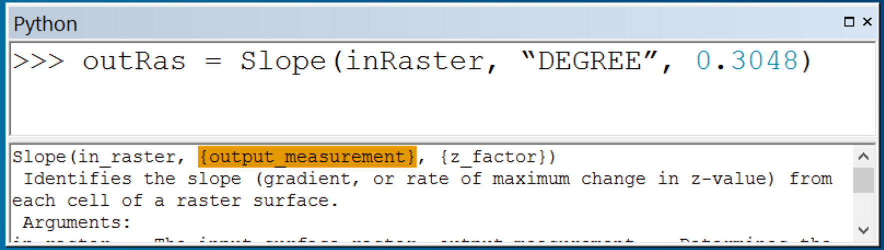
What is Map Algebra

- 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)

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





Importing Spatial Analyst Module

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

```
import arcpy
from arcpy import env  # Analysis environment
from arcpy.sa import * # BEST Practice for Map Algebra

import arcpy.sa # NOT Recommended for Map Algebra
```

General syntax

- Write algebraic expression to perform Map Algebra
- 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 and Parameters
  - Output

Inputs for analysis

- Rasters
- Features
- Numbers
- Text

- Objects
- Constants
- Variables

```
outRas = Slope(inRaster, “DEGREE”, 0.3048)
```

Map Algebra operators

- Symbols for mathematical operations
- Many operators in both Python and Spatial Analyst

```
outRas1 = inRaster1 + inRaster2
```

- Cast the raster (Raster class constructor) to indicate operator should be applied to rasters

```
outRas1 = Raster("rastername1") + Raster("rastername2")
outRas2 = Raster("rastername1") + 8
outRas3 = outRas2 + Raster("rastername2") * 8
```

Map Algebra tools

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

```
outRas = Slope(inRaster, “DEGREE”, 0.3048)
outRas = Aspect(“rastername”)
```

- 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)

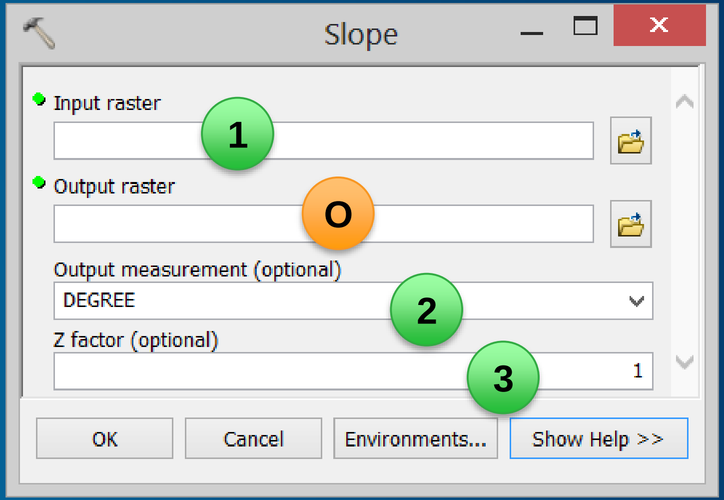
1 2 3

Slope(in_raster, {output_measurement}, {z_factor})

O outRas = Slope(inRaster, "DEGREE", 0.3048)

outRas = Slope(inRaster, "", 0.3048)

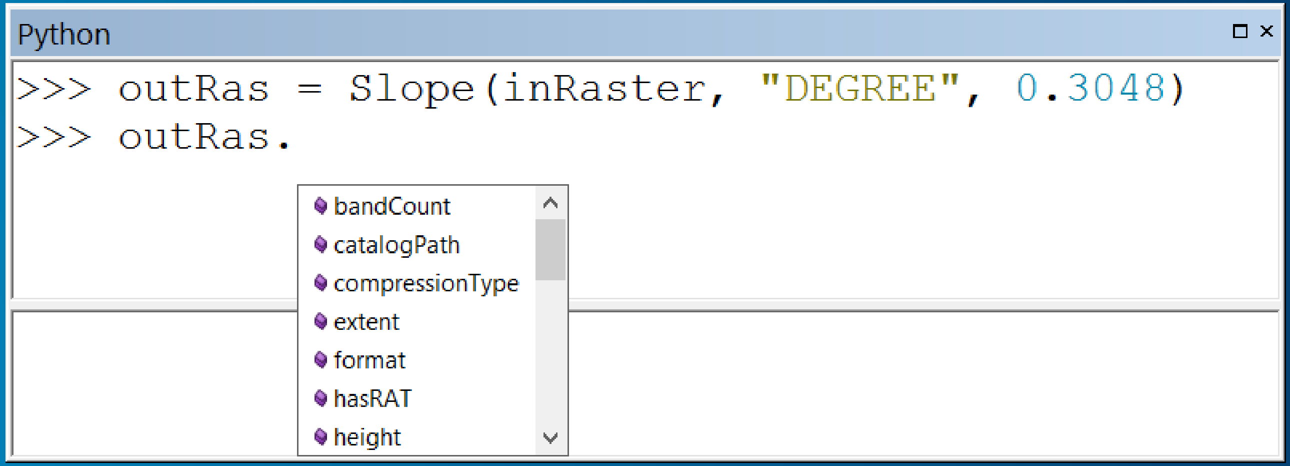
outRas = Slope(inRaster)



Tip: Keywords are in quotes and it is recommended they are capitalized

Map Algebra output

- Returns the results as a Raster object
- Object with methods and properties
- The output is temporary



Demo 1
Data management

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

Complex expressions

- Multiple operators and tools can be executed 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 pointing to a dataset
- Output from a Map Algebra expression or pointing to 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

- Operators and local tools work on a per-cell basis
- A series of local tools (Abs, Sin, Cell Statistics, etc.) and operators can be optimized
- When entered into a single expression all local tools and operators are processed together on a per cell basis

The iterative aspects of the ash borer model

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

- 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

- 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

Classes

- Objects that are used as inputs 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
- You can query and modify the individual arguments

Classes (contd.)

- Creating

```
nbr01 = NbrCircle(4, “MAP”)
```

- Querying

```
radius01 = nbr01.radius
```

- Changing arguments

```
nbr01.radius = radius01 + 2
```

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

- 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

- Random movement
  - Nonlinear decay from known locations (NumPy array)

Demo 3
Movement by flight

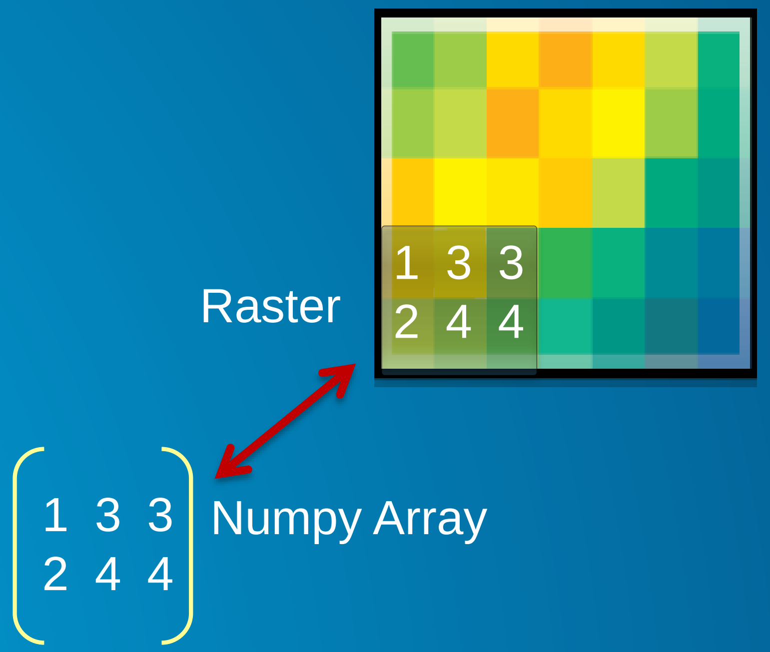
- 20 km per year
- Vegetation type/ash density (suitability)
- Classes
- Using variables
- Vector integration

NumPy

- An extension package to Python
  - Adds support for large, multi-dimensional arrays
  - Provides a large library of high-level mathematical functions
- Can be used to extend raster analysis capabilities by creating
  - custom functions
  - custom tools
- Access the wealth of free functions built by the scientific community
  - Clustering
  - Filtering
  - Linear algebra
  - Optimization
  - Fourier transformation
  - Morphology

NumPy Arrays

- Two functions to work with raster
  - RasterToNumPyArray(in_raster, {lower_left_corner}, {ncols}, {nrows}, {nodata_to_value})
  - NumPyArrayToRaster (in_array, {lower_left_corner}, {x_cell_size}, {y_cell_size}, {value_to_nodata})



The iterative aspects of the ash borer model

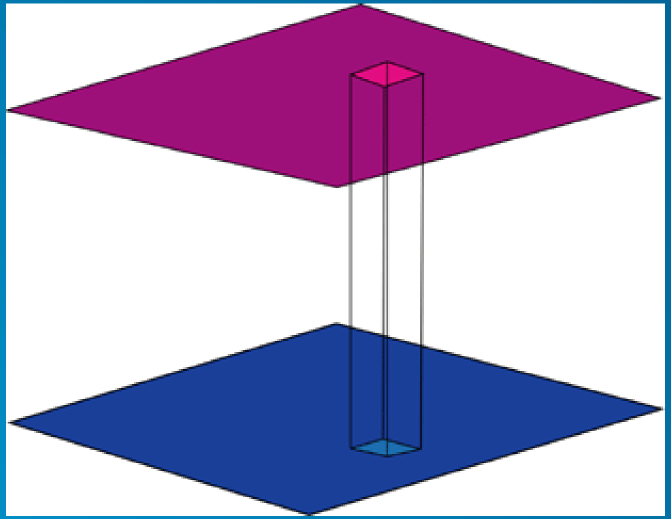
- Movement by flight
  - Depends on the year how far it can move in a time step
  - “Is there a borer in my neighborhood”
  - “Will I accept it” – suitability surface
- Movement by hitchhiking
  - Based on highly susceptible areas
  - Nonlinear decay
  - Random points and check susceptibility
- Random movement
  - Nonlinear decay from known locations (NumPy array)

Demo 4
The random movement

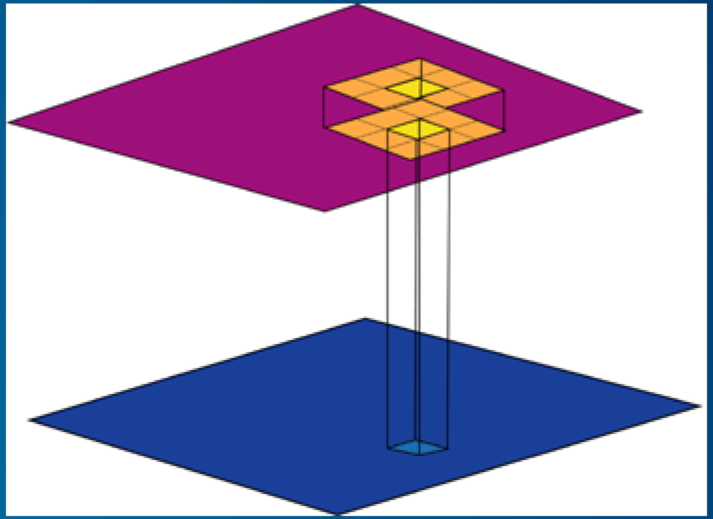
- Random movement based on nonlinear
- decay from existing locations
- Custom function
- NumPy array

Raster analysis using multiprocessing

- Types of raster operations:
  - **Local**
  - **Focal**
  - **Zonal**
  - **Global**

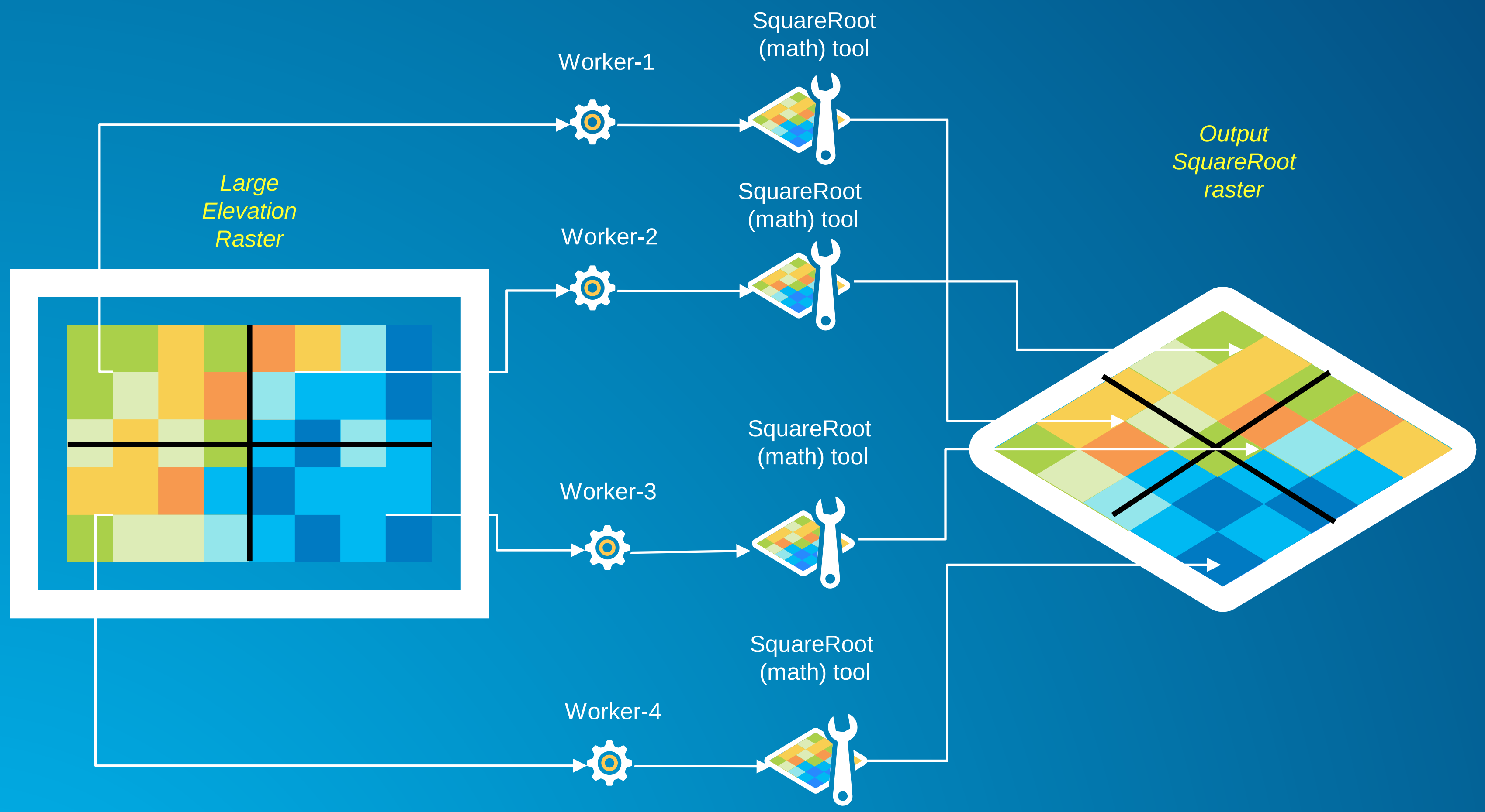


Local raster operation



Focal raster operation

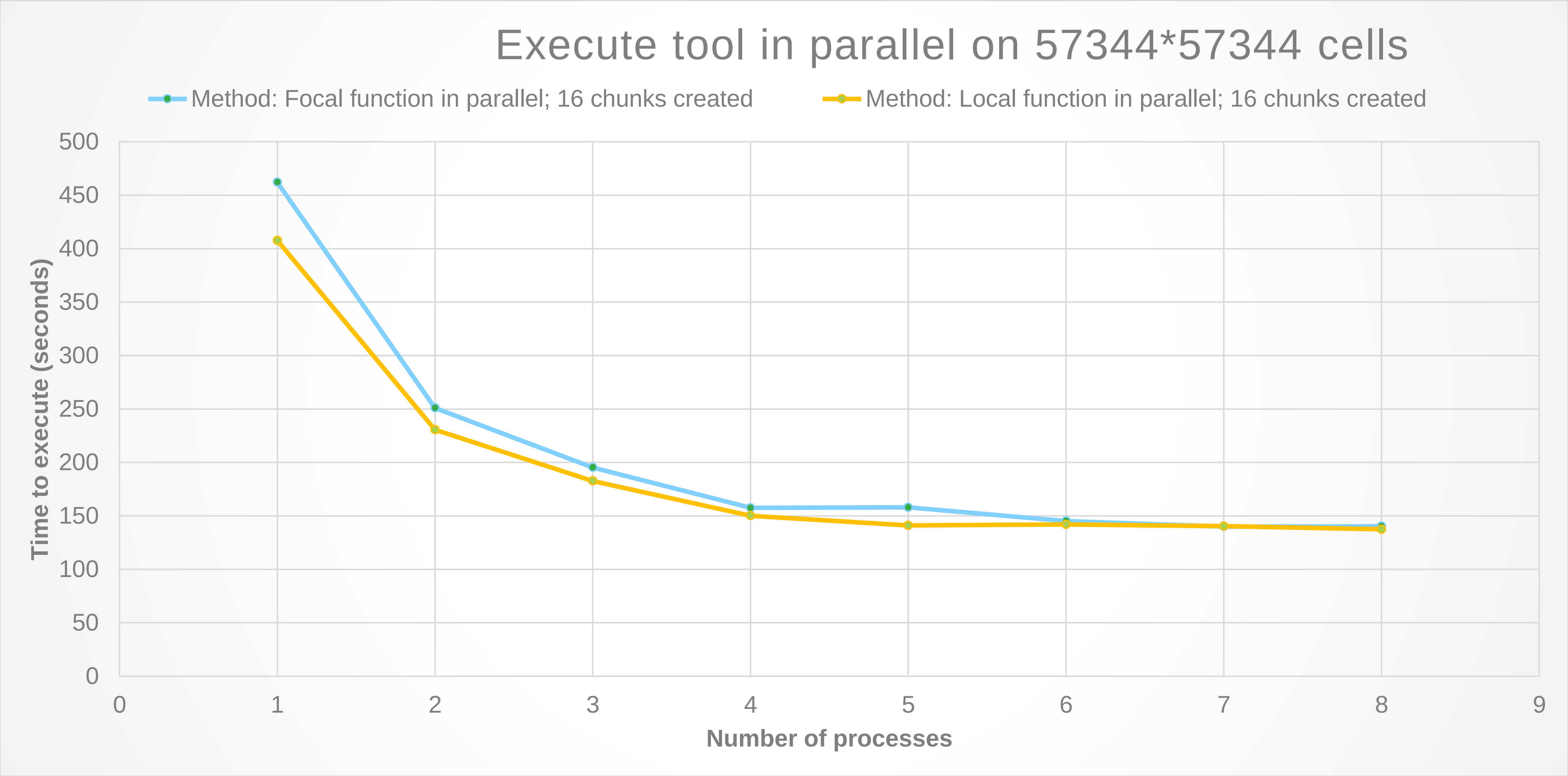
Pleasingly parallel problems



Tool executed parallelly on a large input dataset

Why is multiprocessing relevant to Geoprocessing workflows?

Performance improvement using multiprocessing



Run a local raster operation parallelly on a large raster dataset

Use of multiprocessing for raster analysis

```
if __name__ == '__main__':
    #start the clock
    time_start = time.clock()
    # call create fishnet functionlarge6insectlkuk
    logger.info("Creating fishnet features..")
    create_fishnet(in_raster_path,out_fishnet_path)
    #get extents of individual features, add it to a dictonary
    extDict = {}
    count = 1
    for row in arcpy.da.SearchCursor(out_fishnet_path, ["SHAPE@"]):
        extent_curr = row[0].extent
        ls = []
        ls.append(extent_curr.XMin)
        ls.append(extent_curr.YMin)
        ls.append(extent_curr.XMax)
        ls.append(extent_curr.YMax)
        extDict[count] = ls
        count+=1
    # create a process pool and pass dictonary of extent to execute task
    pool = Pool(processes=cpu_count())
    pool.map(execute_task, extDict.items())
    pool.close()
    pool.join()
    #add results to mosaic dataset
    arcpy.env.workspace = os.getcwd()
    in_path = os.path.join(os.getcwd(), r"local_rast_wspace")
    arcpy.AddRastersToMosaicDataset_management("mosaic_out.gdb\localFn_Mosaic", "Raster Dataset", in_path)
    #end the clock
    time_end = time.clock()
    logger.info("Time taken in main in seconds(s) is : {}".format(str(time_end-time_start)))
```

Run a local raster operation parallelly on a large raster dataset

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
- Use multiprocessing to improve performance where applicable
- Demos are available online at http://www.arcgis.com/home/item.html?id=5a42c7c368e444818615c584fdddb13a

esri

THE SCIENCE OF WHERE