Python Scripting for ArcGIS

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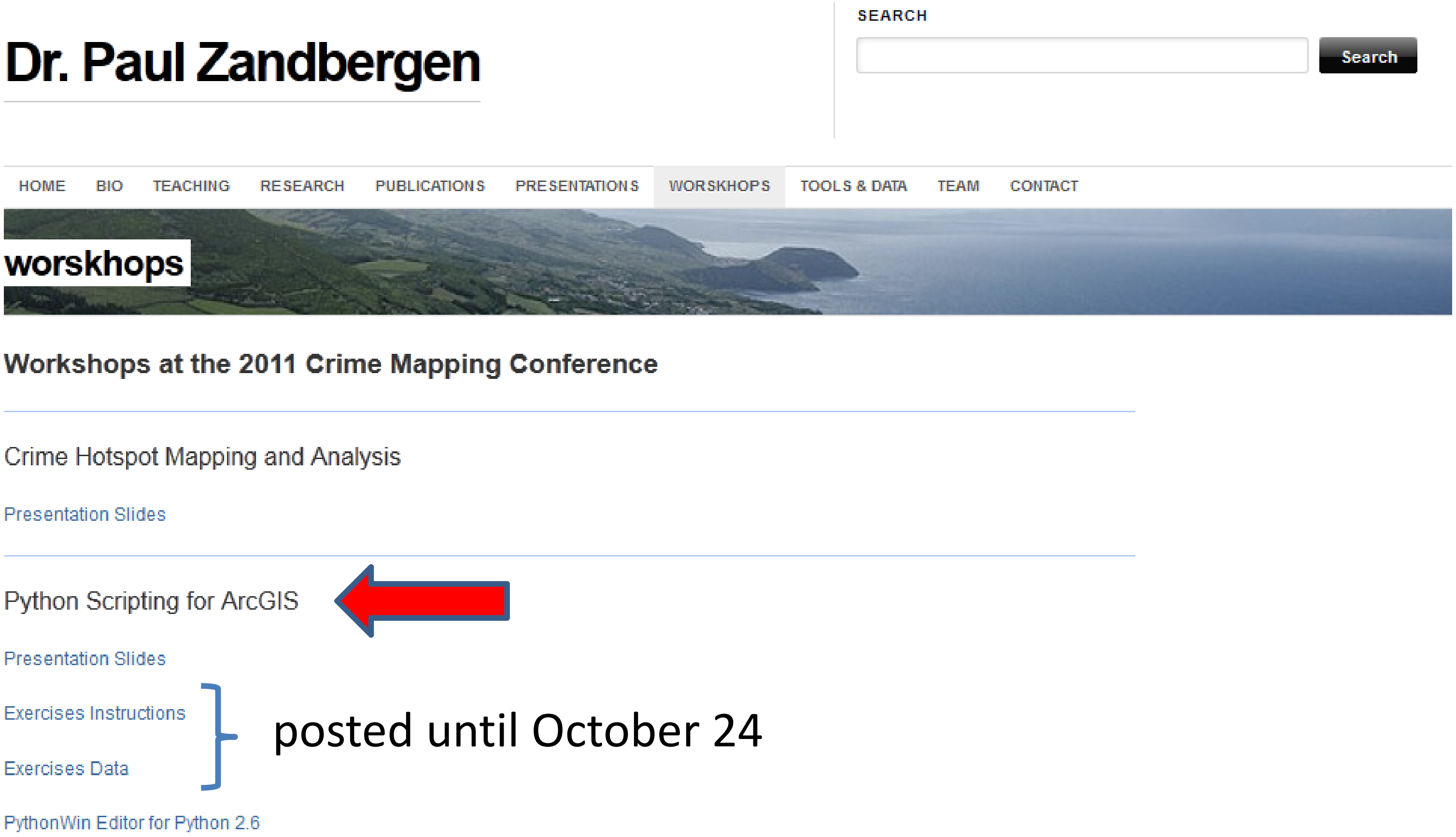
Outline of Topics

- Introduction
  - Examples, Python and ArcGIS, Python versions
- Fundamentals of geoprocessing in ArcGIS
- Python language fundamentals
  - Where to run Python code
  - Data types: numbers, strings, lists
  - Functions and modules
  - Controlling workflow
- ArcPy: Geoprocessing using Python
  - Using tools, functions, classes
  - Describing data, listing data, working with lists
- Creating custom tools
  - Script tools, tool parameters
- Resources

Workshop Materials Posted



Dr. Paul Zandbergen

worskhops

Workshops at the 2011 Crime Mapping Conference

Crime Hotspot Mapping and Analysis

Presentation Slides

Python Scripting for ArcGIS

Presentation Slides

Exercises Instructions

Exercises Data

PythonWin Editor for Python 2.6

posted until October 24

http://www.paulzandbergen.com/workshops

Forthcoming Book

- Python Scripting for ArcGIS
- Esri Press
- Sometime in 2012
- Updated for ArcGIS 10.1

- Sample exercises posted (for 10.0)

Introduction

Prior Knowledge and Experience

- Using ArcGIS 9.3 or 10.0?
  - Workshop is for 10.0

- Prior Python experience?
  - I’m not assuming any

- Other programming experience?
  - I’m not assuming any

Example 1

- Script to copy all shapefiles in a folder into a geodatabase

```
import arcpy
from arcpy import env
env.overwriteOutput = True
env.workspace = "c:/workshop/ex01"
fclist = arcpy.ListFeatureClasses()
for fc in fclist:
    fcdesc = arcpy.Describe(fc)
    arcpy.CopyFeatures_management(fc, "c:/workshop/ex01/study.mdb/"
                                  + fcdesc.basename)
```

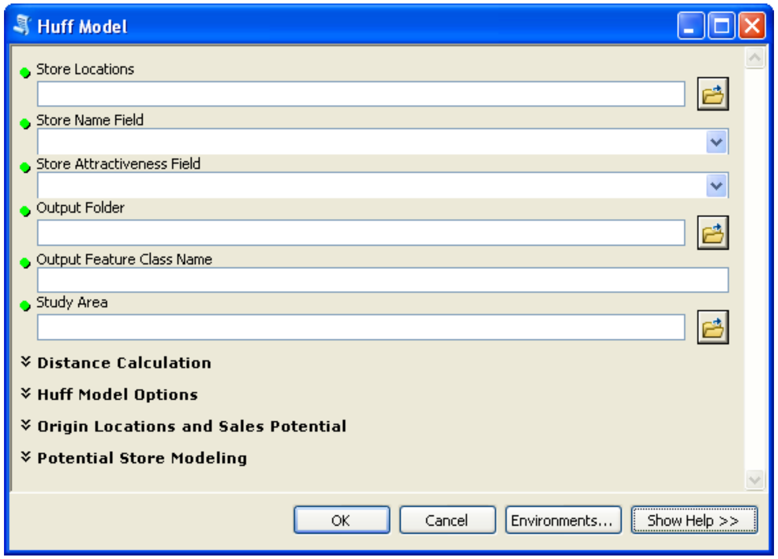
Example 2

- Script tool to generate a k-nearest neighbor table
- Runs an existing ArcGIS tool multiple times, writes the result

```
import arcpy
from arcpy import env
env.overwriteoutput = True
infc = arcpy.GetParameterAsText(0)
output = arcpy.GetParameterAsText(1)
k = arcpy.GetParameter(2)
n = 1
f = open(output, "w")
while n <= k:
   result = arcpy.CalculateDistanceBand_stats(infc, n)
   f.write(str(n) + " " + str(result[1])+ "\n")
   n = n + 1
f.close()
```

Example 3

- Script tool to run Huff model
- Sophisticated analysis not available in ArcGIS



Huff Model

Store Locations

Store Name Field

Store Attractiveness Field

Output Folder

Output Feature Class Name

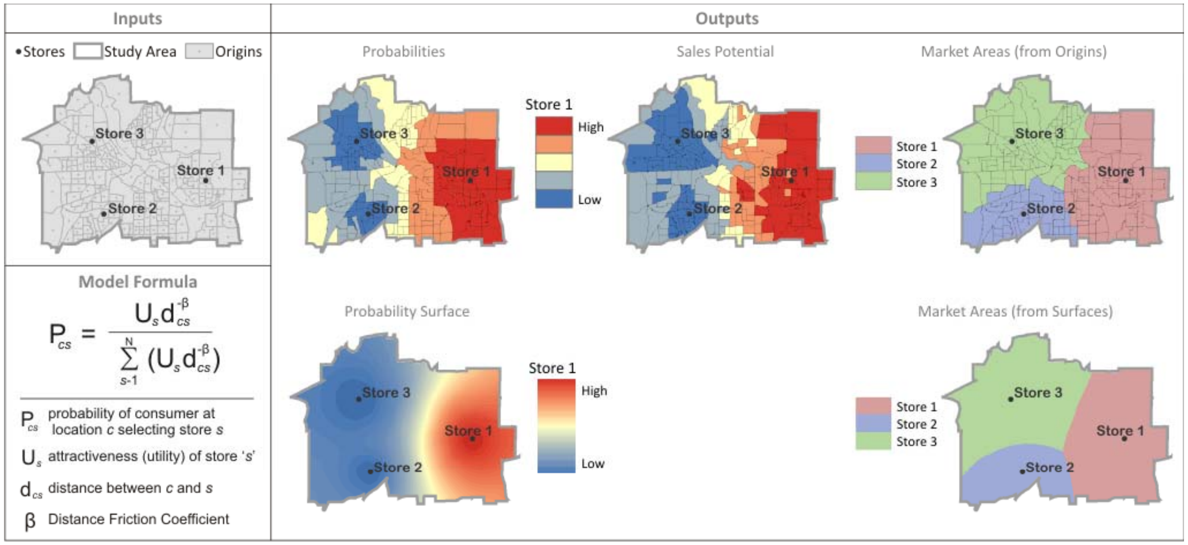
Study Area

Distance Calculation

Huff Model Options

Origin Locations and Sales Potential

Potential Store Modeling



$$P_{cs} = \frac{U_s d_{cs}^{-\beta}}{\sum_{s-1}^{N} (U_s d_{cs}^{-\beta})}$$

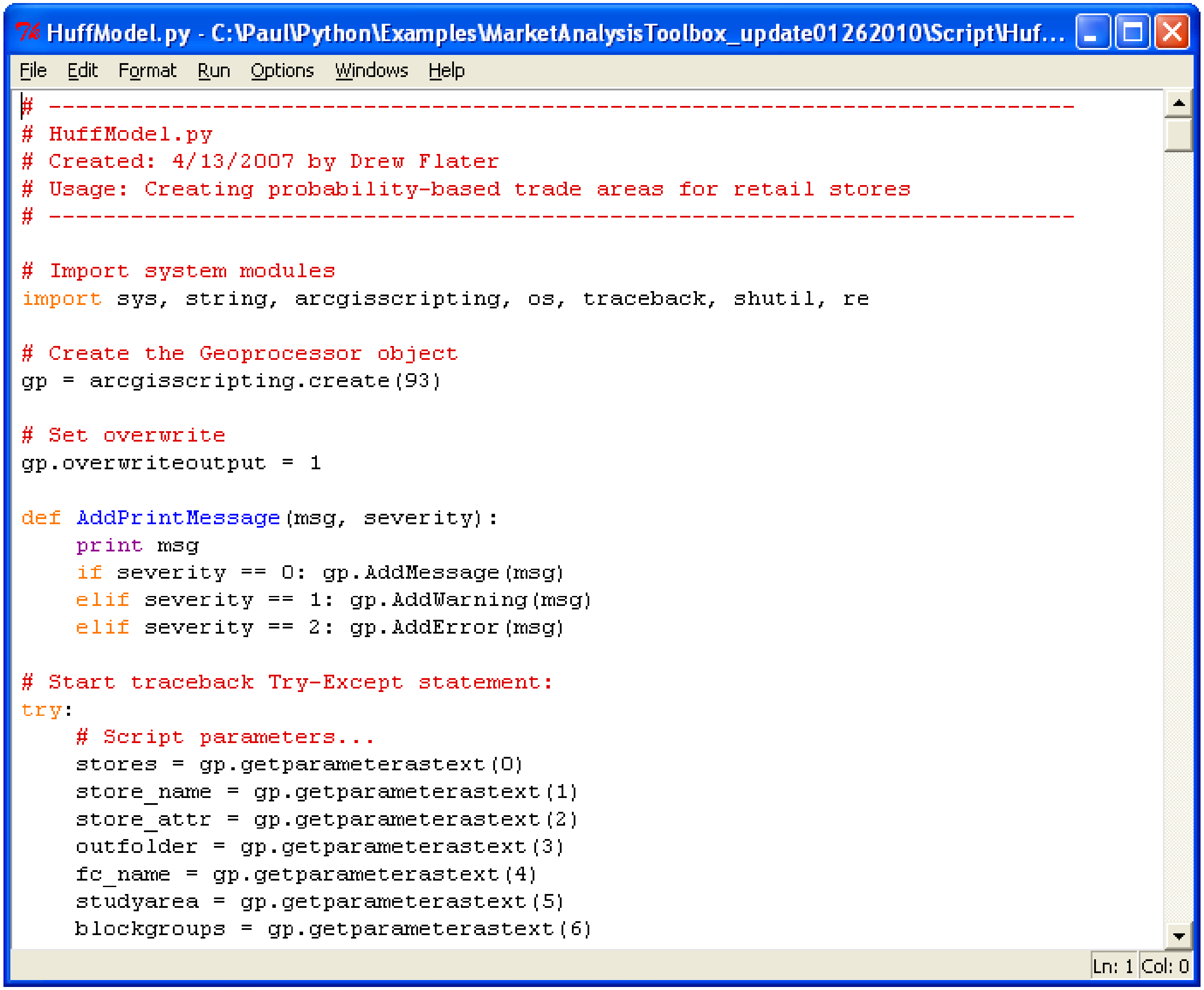
P_{cs} probability of consumer at location *c* selecting store *s*

U_s attractiveness (utility) of store '*s*'

d_{cs} distance between *c* and *s*

β Distance Friction Coefficient

Example 3


HuffModel.py - C:\Paul\Python\Examples\MarketAnalysisToolbox_update01262010\Script\Huf...
File Edit Format Run Options Windows Help
Ln: 1 Col: 0

```
# ---------------------------------------------------------------------------
# HuffModel.py
# Created: 4/13/2007 by Drew Flater
# Usage: Creating probability-based trade areas for retail stores
# ---------------------------------------------------------------------------

# Import system modules
import sys, string, arcgisscripting, os, traceback, shutil, re

# Create the Geoprocessor object
gp = arcgisscripting.create(93)

# Set overwrite
gp.overwriteoutput = 1

def AddPrintMessage(msg, severity):
    print msg
    if severity == 0: gp.AddMessage(msg)
    elif severity == 1: gp.AddWarning(msg)
    elif severity == 2: gp.AddError(msg)

# Start traceback Try-Except statement:
try:
    # Script parameters...
    stores = gp.getparameterastext(0)
    store_name = gp.getparameterastext(1)
    store_attr = gp.getparameterastext(2)
    outfolder = gp.getparameterastext(3)
    fc_name = gp.getparameterastext(4)
    studyarea = gp.getparameterastext(5)
    blockgroups = gp.getparameterastext(6)
```

What is Python Scripting?

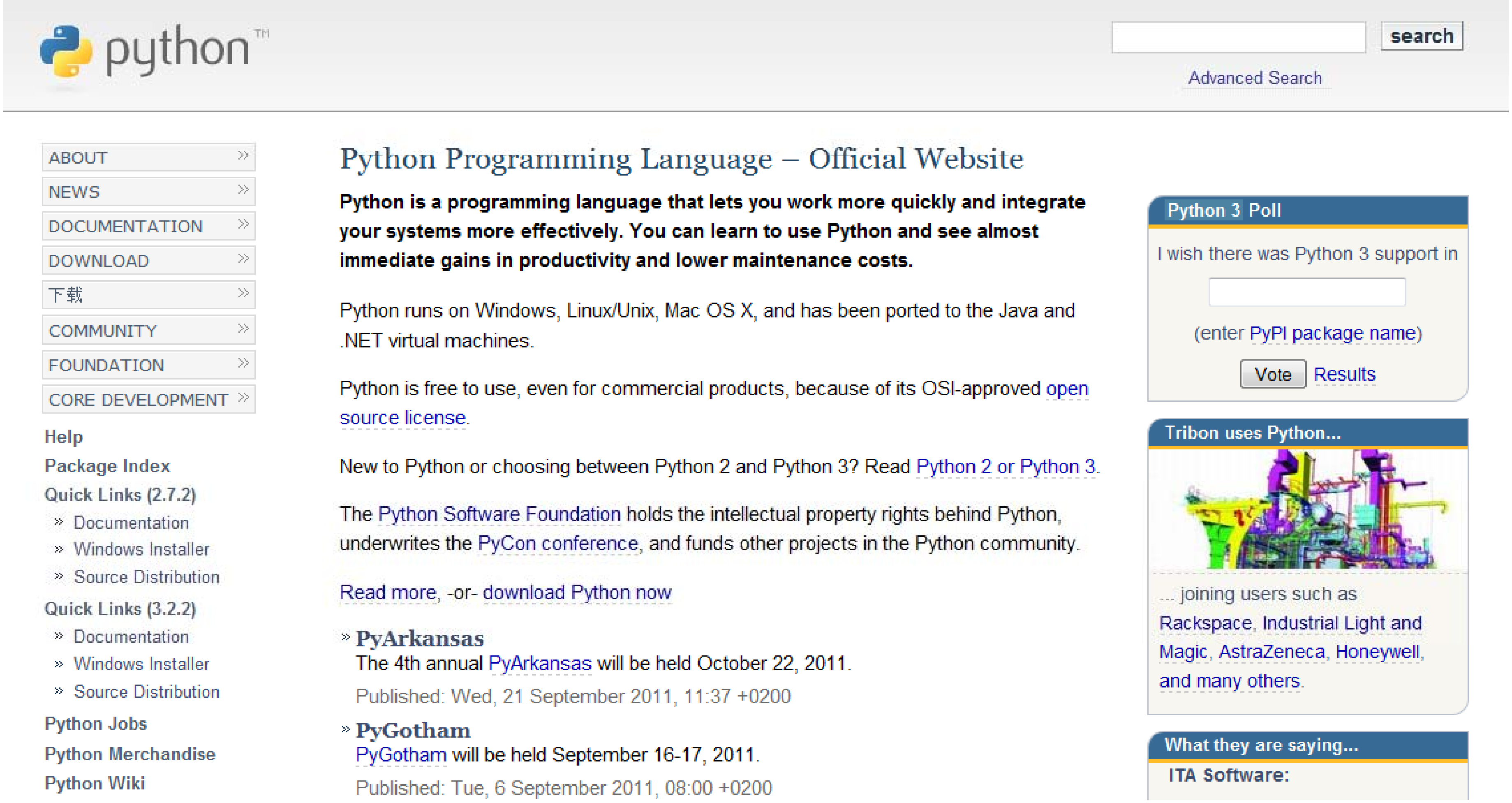
- Add functionality to ArcGIS
  - Integrated into ArcGIS interface
  - Builds upon existing functionality
  - Automates repetitive tasks
  - Expands analysis options

- Share new functionality
  - Script tools work just like regular tools
  - Can be integrated into models, tools
  - Easy to share with others (free)

Why Python?

- Free, open source
- Object oriented
- Basic scripting AND complex object-oriented programming
- “Batteries included”
- Embraced by geospatial community, including ESRI
- Many libraries

Python Community



Python Programming Language – Official Website

Python is a programming language that lets you work more quickly and integrate your systems more effectively. You can learn to use Python and see almost immediate gains in productivity and lower maintenance costs.

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Python is free to use, even for commercial products, because of its OSI-approved open source license.

New to Python or choosing between Python 2 and Python 3? Read Python 2 or Python 3.

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Read more, -or- download Python now

» **PyArkansas**
The 4th annual PyArkansas will be held October 22, 2011.
Published: Wed, 21 September 2011, 11:37 +0200

» **PyGotham**
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Published: Tue, 6 September 2011, 08:00 +0200

Python 3 Poll

I wish there was Python 3 support in

(enter PyPI package name)

Vote Results

Tribon uses Python...

... joining users such as Rackspace, Industrial Light and Magic, AstraZeneca, Honeywell, and many others.

What they are saying...

ITA Software:

http://www.python.org

Python and ArcGIS

- Python is the preferred scripting language for ArcGIS

1. You can run Python from within ArcGIS
   – Python Window works like an interactive interpreter
2. All tools in ArcToolbox can be accessed from Python
   – Import ArcPy to get full library of tools
3. Python scripts can be made into tools
   – Extend functionality of ArcGIS
4. Support for other scripting languages will go away
   – VBScript and JScript being replaced by Python

Python Versions and ArcGIS

- Versions:
  - Current version of Python is 3.2.2
  - Python that works with ArcGIS 10.0 is 2.6.x
  - Python that works with ArcGIS 10.1 is 2.7.x
  - Move to Python 3.x likely only with ArcGIS 11

- ArcGIS only works with a specific version of Python:
  - Use the one that comes installed with ArcGIS
  - Don’t install your own version of Python

Installing Python

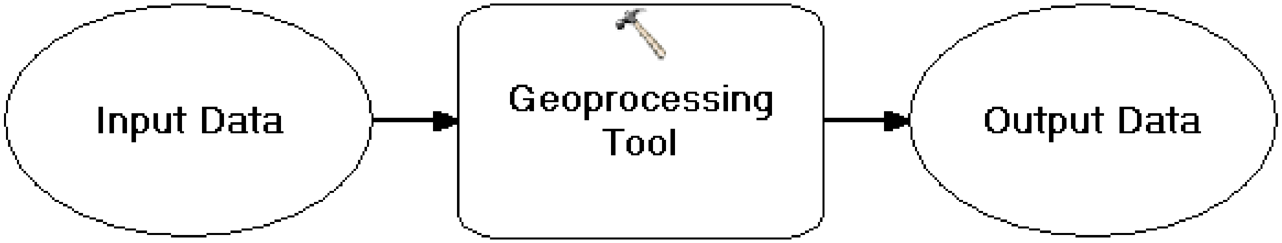
- Remove any existing installations of Python
- Install ArcGIS 10.0
  - Python 2.6.5 will be installed by default
- Install a Python editor
- Configure the editor to work with ArcGIS

- *Note: You can run different versions of Python on one machine – however, a clean install of Python2.6.5 with ArcGIS 10.0 is recommended*

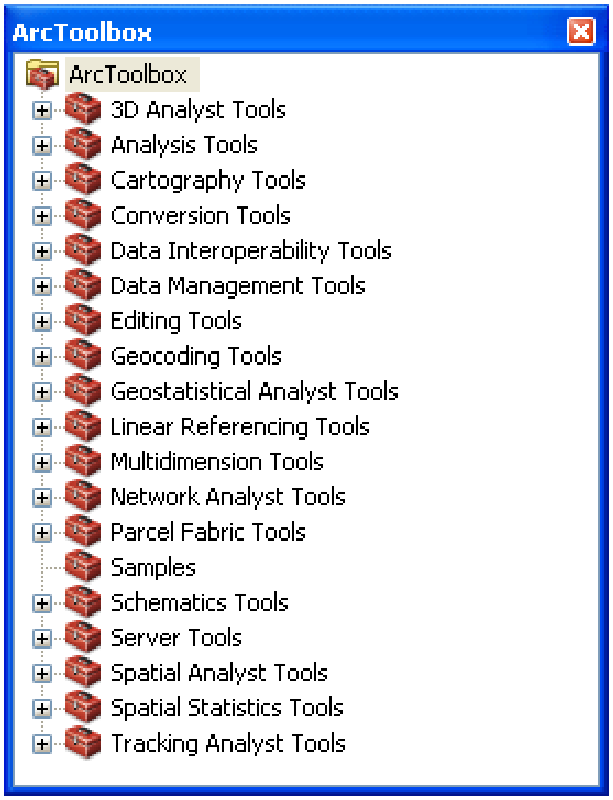
Demo: Check ArcGIS and Python installation

Fundamentals of Geoprocessing in ArcGIS

Geoprocessing Tools

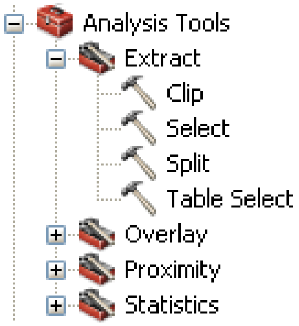


Tool Organization



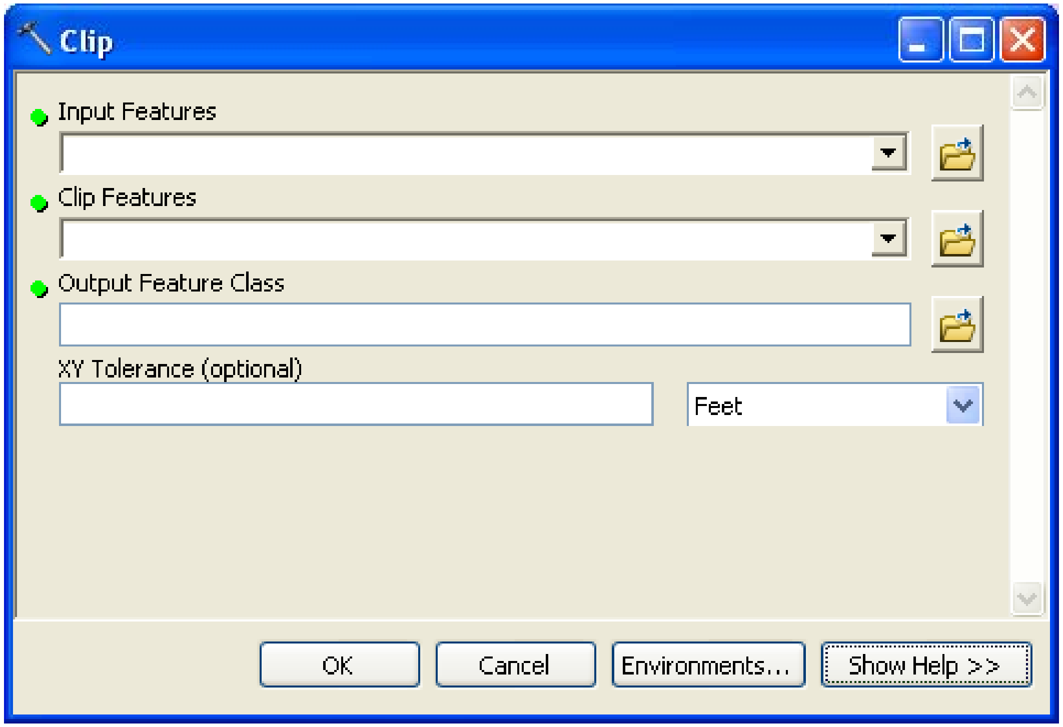
ArcToolbox

- ArcToolbox
  - 3D Analyst Tools
  - Analysis Tools
  - Cartography Tools
  - Conversion Tools
  - Data Interoperability Tools
  - Data Management Tools
  - Editing Tools
  - Geocoding Tools
  - Geostatistical Analyst Tools
  - Linear Referencing Tools
  - Multidimension Tools
  - Network Analyst Tools
  - Parcel Fabric Tools
  - Samples
  - Schematics Tools
  - Server Tools
  - Spatial Analyst Tools
  - Spatial Statistics Tools
  - Tracking Analyst Tools



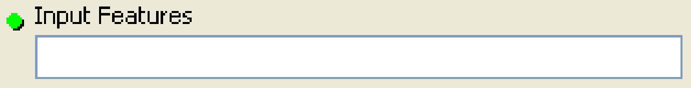
- Analysis Tools
  - Extract
    - Clip
    - Select
    - Split
    - Table Select
  - Overlay
  - Proximity
  - Statistics

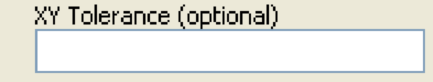
Tool Dialogs



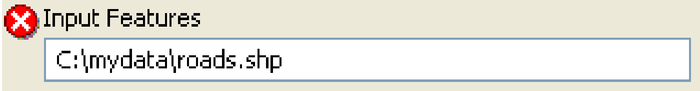
Tool Parameters

- Parameters
  - Required
  - Optional

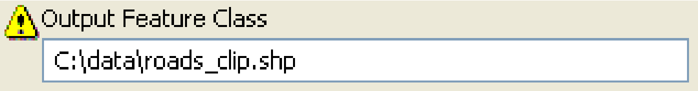

Input Features


XY Tolerance (optional)

- Errors
- Warning

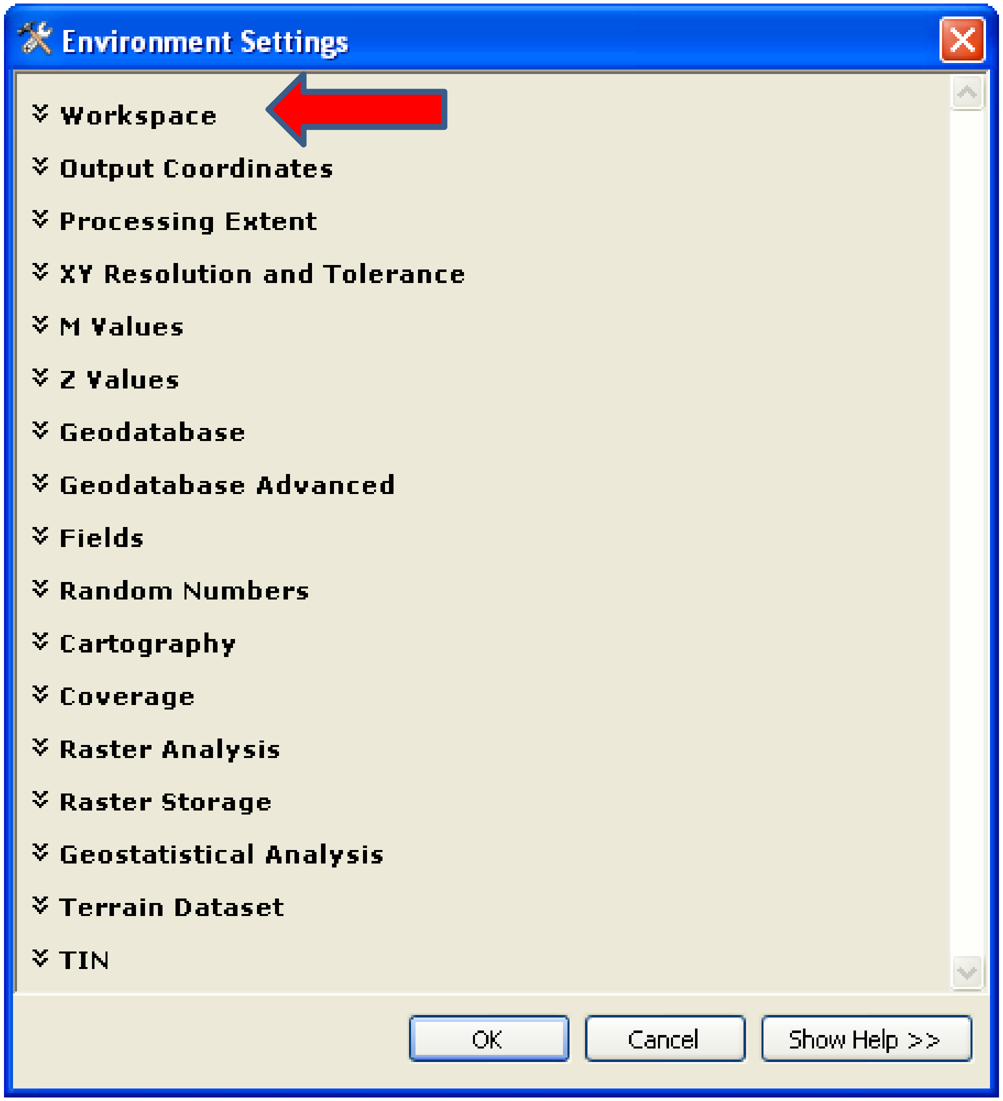

Input Features

C:\mydata\roads.shp


Output Feature Class

C:\data\roads_clip.shp

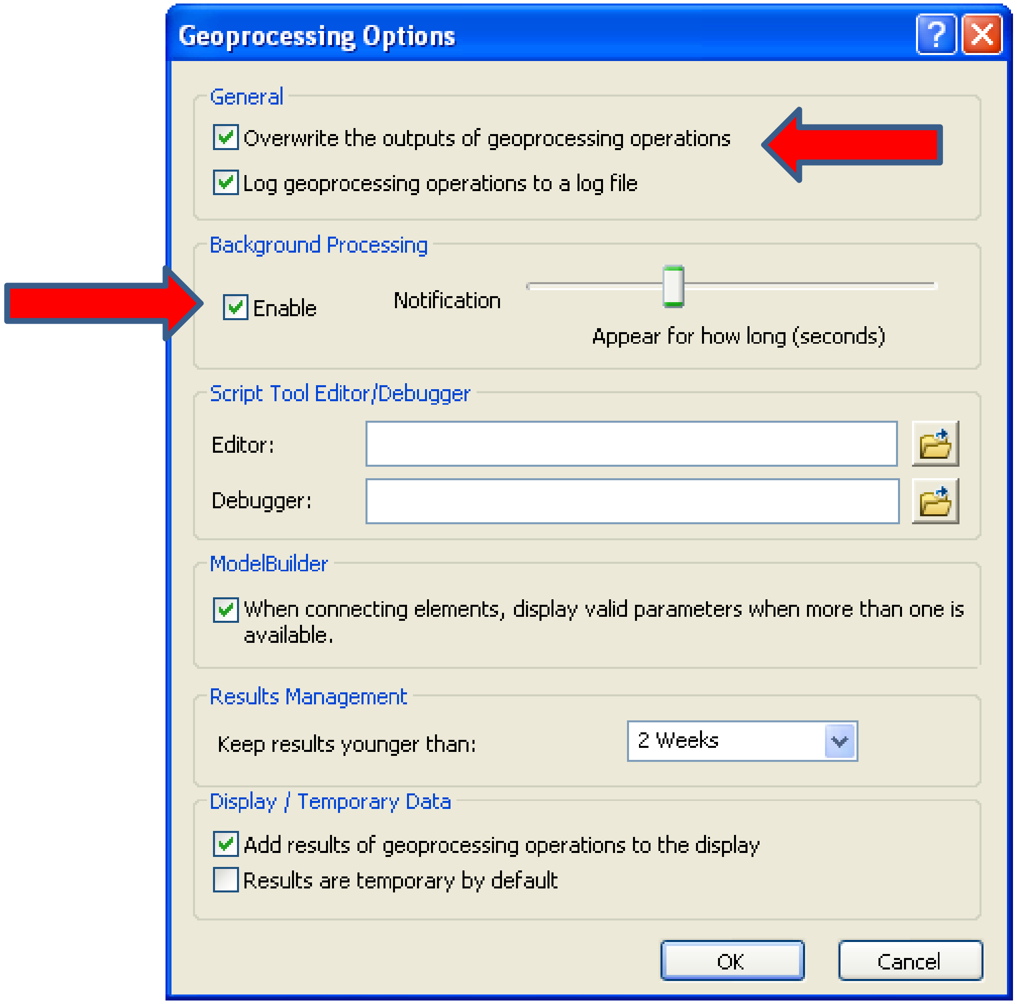
Environment Settings



Environment Settings

- Workspace
- Output Coordinates
- Processing Extent
- XY Resolution and Tolerance
- M Values
- Z Values
- Geodatabase
- Geodatabase Advanced
- Fields
- Random Numbers
- Cartography
- Coverage
- Raster Analysis
- Raster Storage
- Geostatistical Analysis
- Terrain Dataset
- TIN

Geoprocessing Options



Geoprocessing Options

General

☑ Overwrite the outputs of geoprocessing operations

☑ Log geoprocessing operations to a log file

Background Processing

☑ Enable

Notification

Appear for how long (seconds)

Script Tool Editor/Debugger

Editor:

Debugger:

ModelBuilder

☑ When connecting elements, display valid parameters when more than one is available.

Results Management

Keep results younger than: 2 Weeks

Display / Temporary Data

☑ Add results of geoprocessing operations to the display

☐ Results are temporary by default

Demo: Geoprocessing Fundamentals

Running Python Code

Two ways to run Python Code

1. Using an Interactive Interpreter
   - Code is executed directly line-by-line

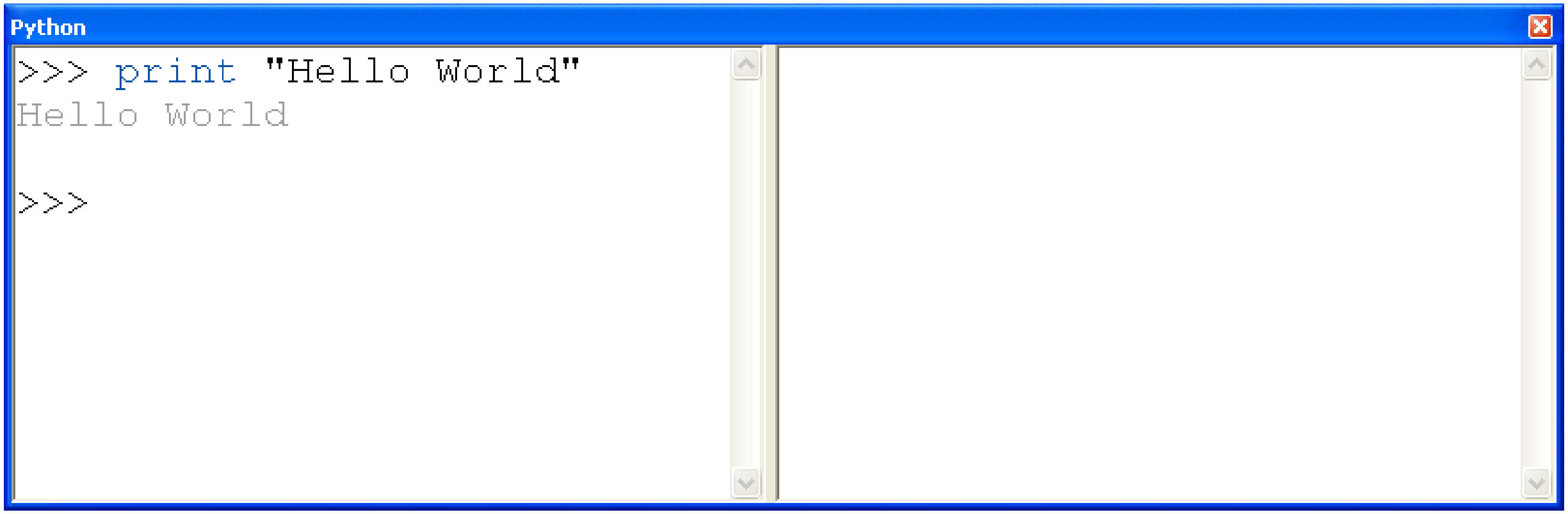
2. By running a script
   - Code saved in a .py file
   - Run from within a Python editor or directly from operating system

Where to type and run Python code?

1. Python window in ArcGIS
   - Built into any ArcGIS Desktop application
   - Good for testing code, very short scripts

2. Python editor
   - IDLE installed by default
   - Many others, PythonWin is a good one to start
   - Good for more complex code, saving scripts

Python Window in ArcGIS



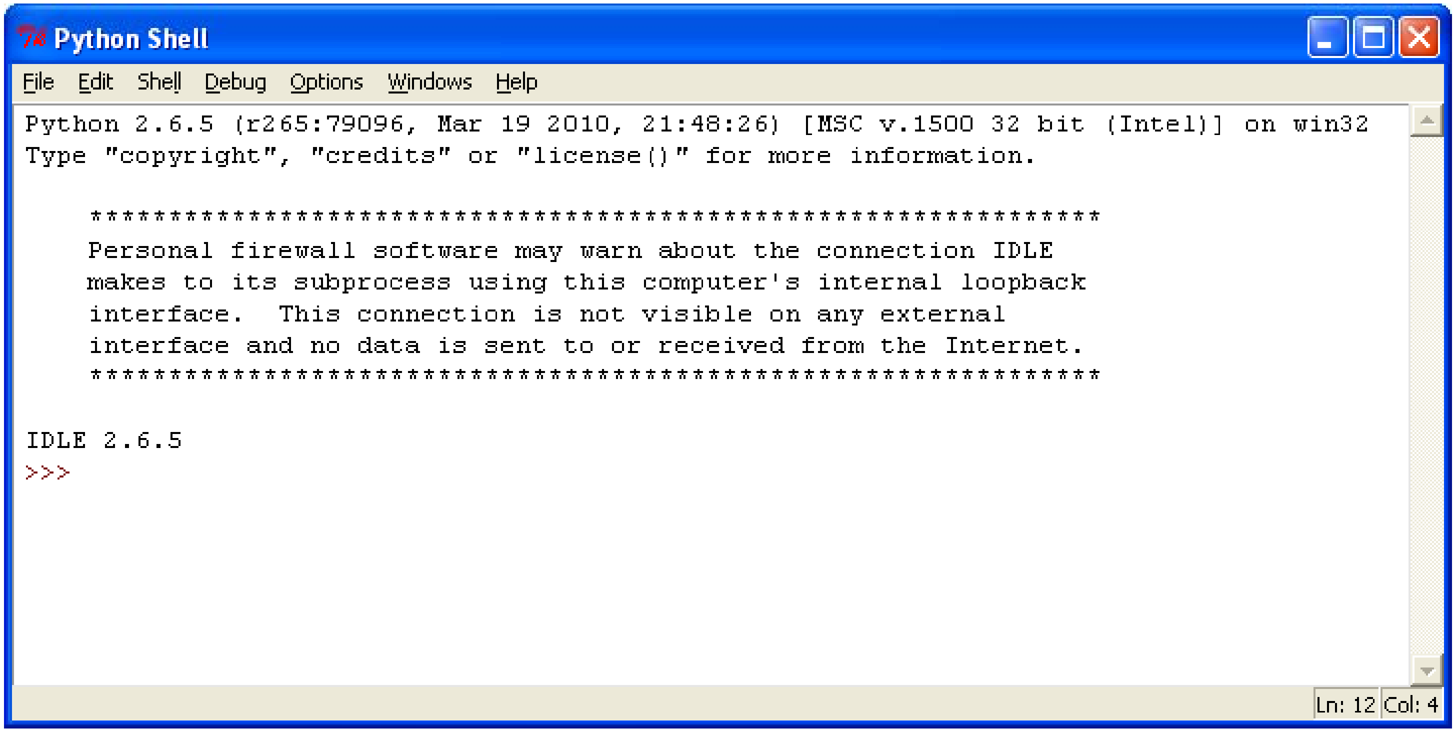
```
>>> print "Hello World"
Hello World

>>>
```

Python Window in ArcGIS

- Works with current map document
- Interactive interpreter:
  - Executes code directly line-by-line
- Good for testing short code
- Code can be saved
- No error checking / debugging

Python Editor - IDLE

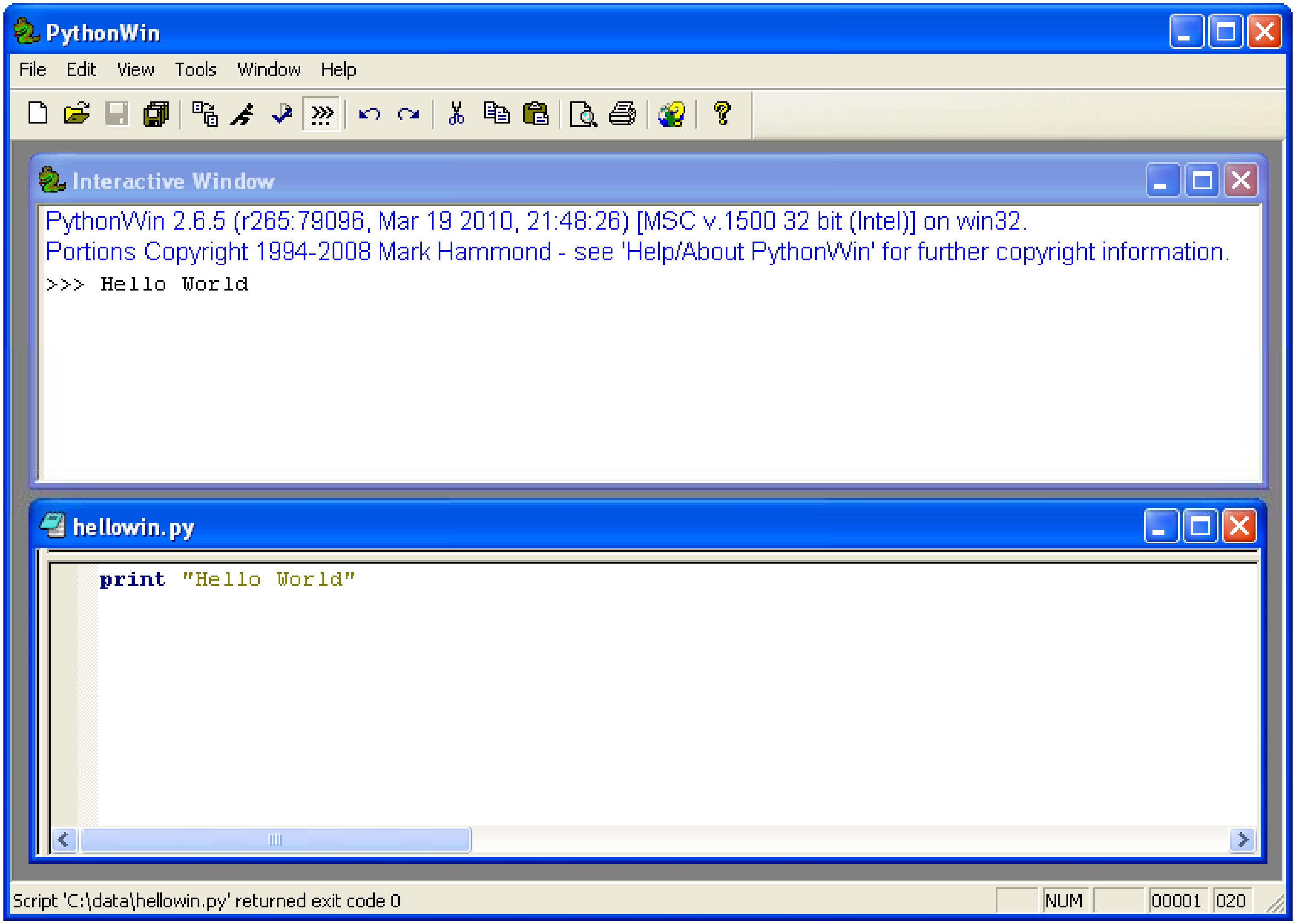


```
Python 2.6.5 (r265:79096, Mar 19 2010, 21:48:26) [MSC v.1500 32 bit (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.

    ****************************************************************
    Personal firewall software may warn about the connection IDLE
    makes to its subprocess using this computer's internal loopback
    interface.  This connection is not visible on any external
    interface and no data is sent to or received from the Internet.
    ****************************************************************

IDLE 2.6.5
>>>
```

Python Editor - PythonWin



```
PythonWin 2.6.5 (r265:79096, Mar 19 2010, 21:48:26) [MSC v.1500 32 bit (Intel)] on win32.
Portions Copyright 1994-2008 Mark Hammond - see 'Help/About PythonWin' for further copyright information.
>>> Hello World
```

```
print "Hello World"
```

Script 'C:\data\hellowin.py' returned exit code 0

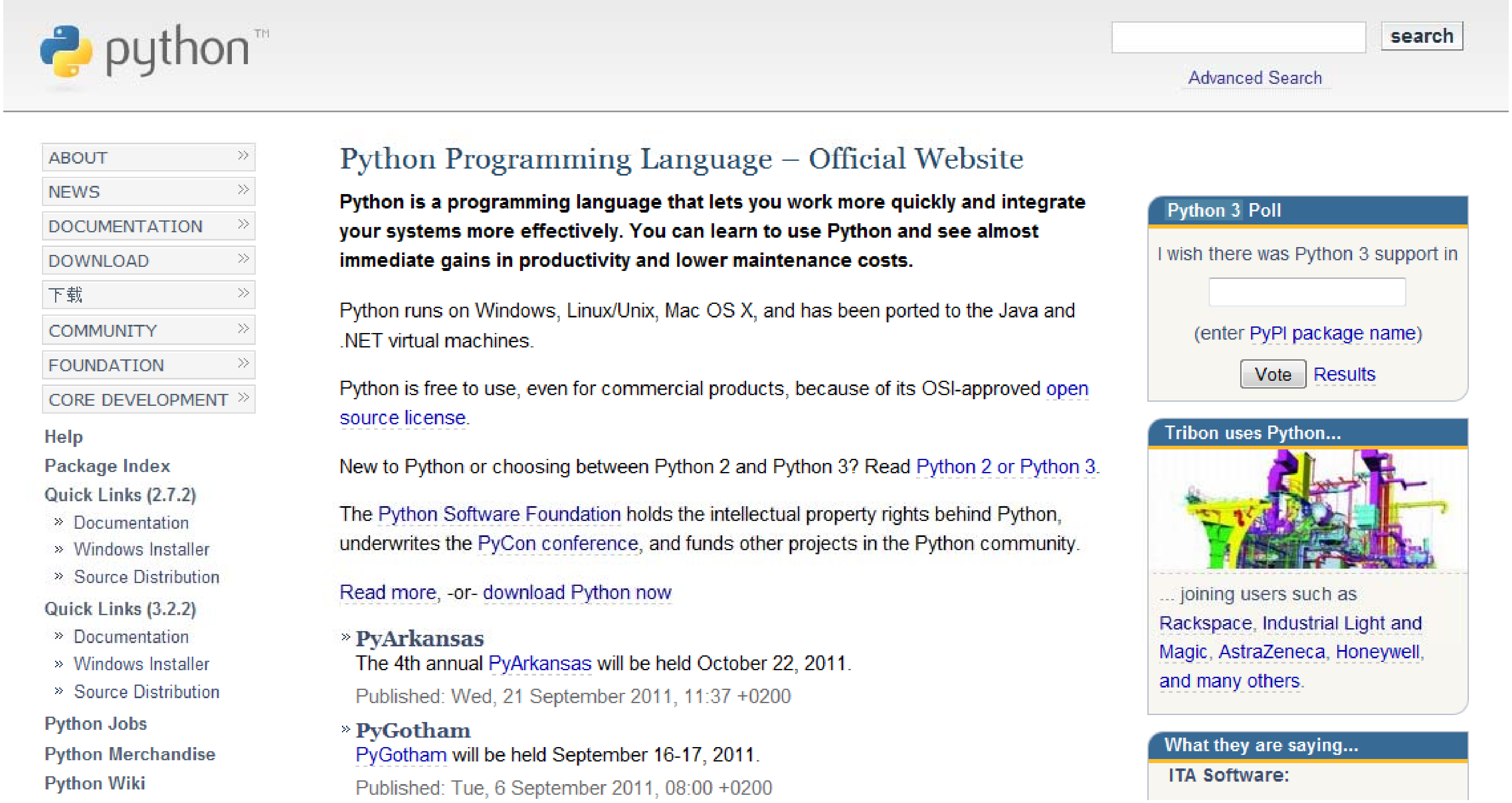
Python Editor

- Stand-alone – outside of ArcGIS
- Interactive interpreter:
  - Executes code directly line-by-line
- Save code as script files (.py)
- Good for organizing more complex code

Demo: Running simple Python code

Python Documentation

Python Documentation



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(enter PyPI package name)

Tribon uses Python...

... joining users such as Rackspace, Industrial Light and Magic, AstraZeneca, Honeywell, and many others.

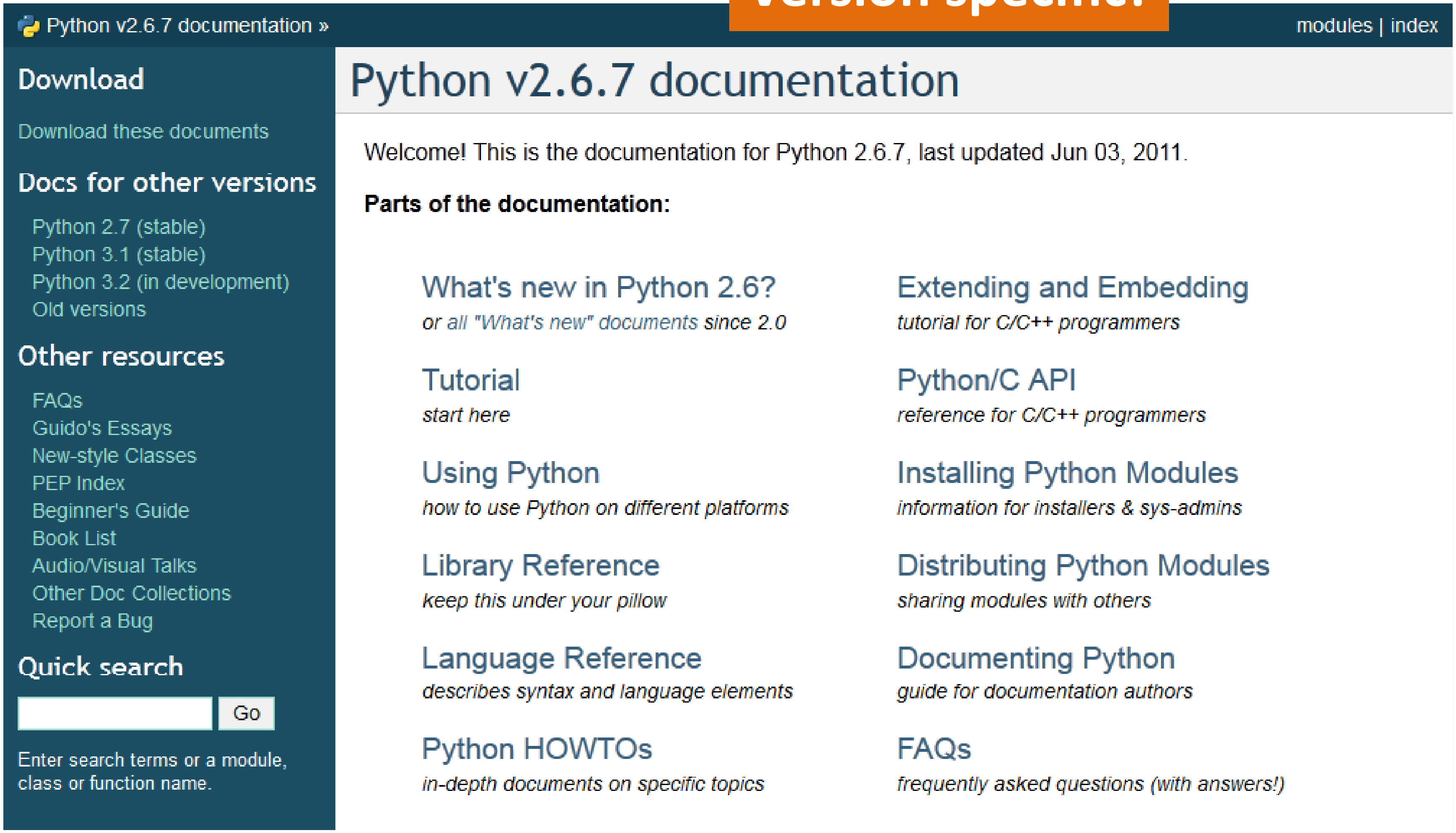
What they are saying...

ITA Software:

http://www.python.org

Python Documentation

Version specific!



Python v2.6.7 documentation »

modules | index

Download

Download these documents

Docs for other versions

- Python 2.7 (stable)
- Python 3.1 (stable)
- Python 3.2 (in development)
- Old versions

Other resources

- FAQs
- Guido's Essays
- New-style Classes
- PEP Index
- Beginner's Guide
- Book List
- Audio/Visual Talks
- Other Doc Collections
- Report a Bug

Quick search

Enter search terms or a module, class or function name.

Python v2.6.7 documentation

Welcome! This is the documentation for Python 2.6.7, last updated Jun 03, 2011.

Parts of the documentation:

What's new in Python 2.6?
or all "What's new" documents since 2.0

Tutorial
start here

Using Python
how to use Python on different platforms

Library Reference
keep this under your pillow

Language Reference
describes syntax and language elements

Python HOWTOs
in-depth documents on specific topics

Extending and Embedding
tutorial for C/C++ programmers

Python/C API
reference for C/C++ programmers

Installing Python Modules
information for installers & sys-admins

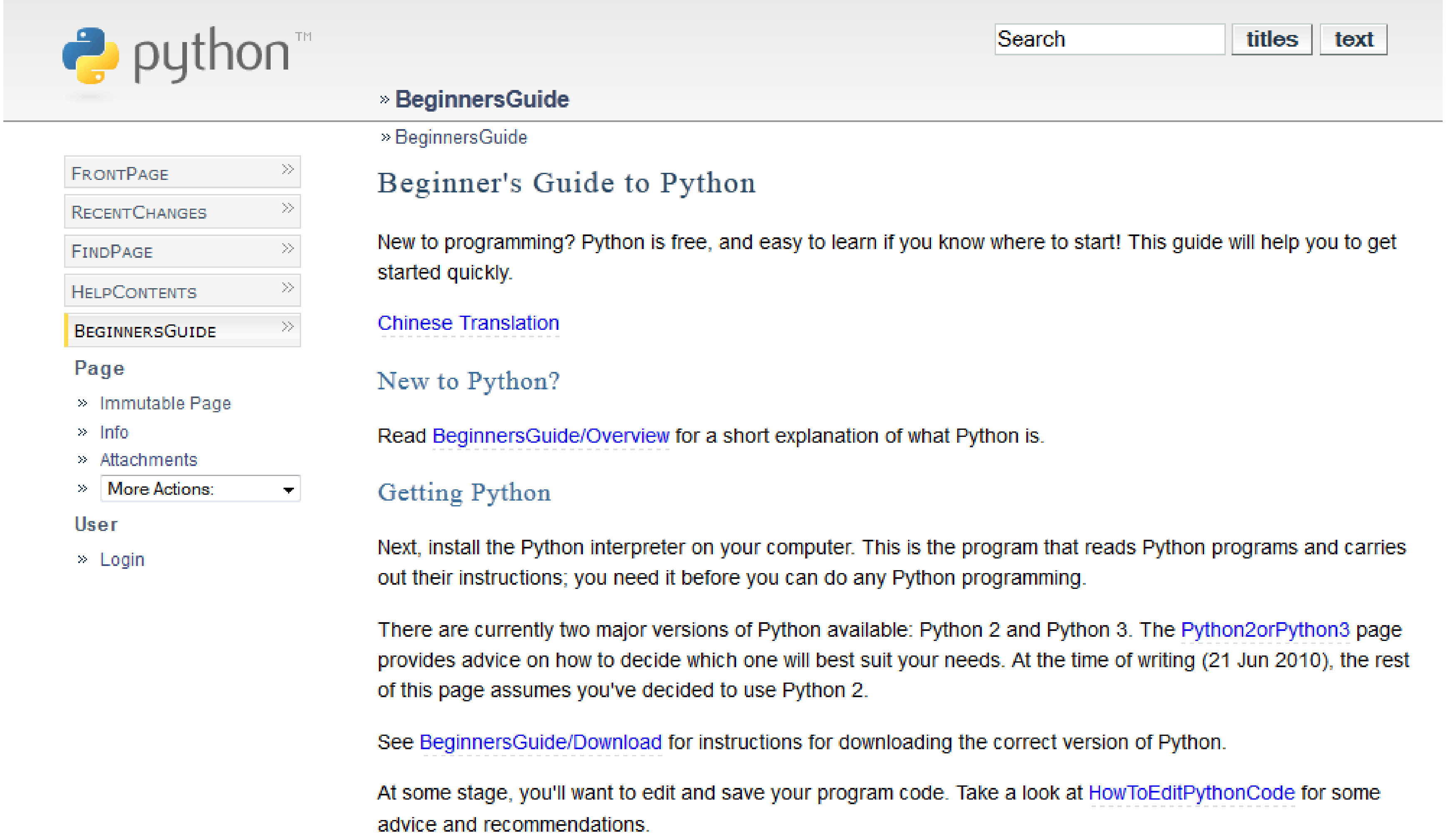
Distributing Python Modules
sharing modules with others

Documenting Python
guide for documentation authors

FAQs
frequently asked questions (with answers!)

http://docs.python.org

Python Beginners Guide



Beginner's Guide to Python

New to programming? Python is free, and easy to learn if you know where to start! This guide will help you to get started quickly.

Chinese Translation

New to Python?

Read BeginnersGuide/Overview for a short explanation of what Python is.

Getting Python

Next, install the Python interpreter on your computer. This is the program that reads Python programs and carries out their instructions; you need it before you can do any Python programming.

There are currently two major versions of Python available: Python 2 and Python 3. The Python2orPython3 page provides advice on how to decide which one will best suit your needs. At the time of writing (21 Jun 2010), the rest of this page assumes you've decided to use Python 2.

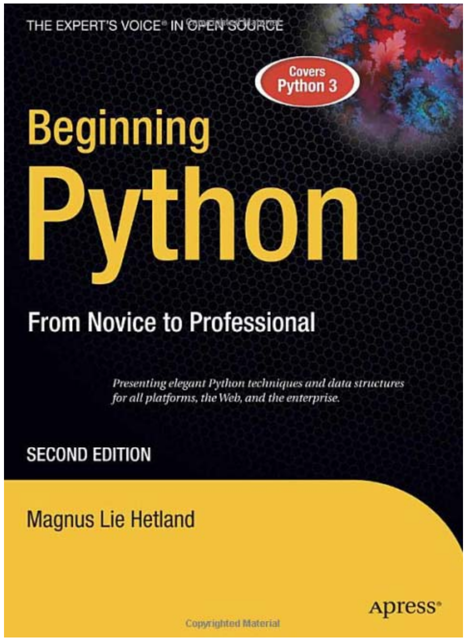
See BeginnersGuide/Download for instructions for downloading the correct version of Python.

At some stage, you'll want to edit and save your program code. Take a look at HowToEditPythonCode for some advice and recommendations.

http://wiki.python.org/moin/BeginnersGuide

Python Books

Version specific!


THE EXPERT'S VOICE® IN OPEN SOURCE
Covers Python 3
Beginning
Python
From Novice to Professional
Presenting elegant Python techniques and data structures for all platforms, the Web, and the enterprise.
SECOND EDITION
Magnus Lie Hetland
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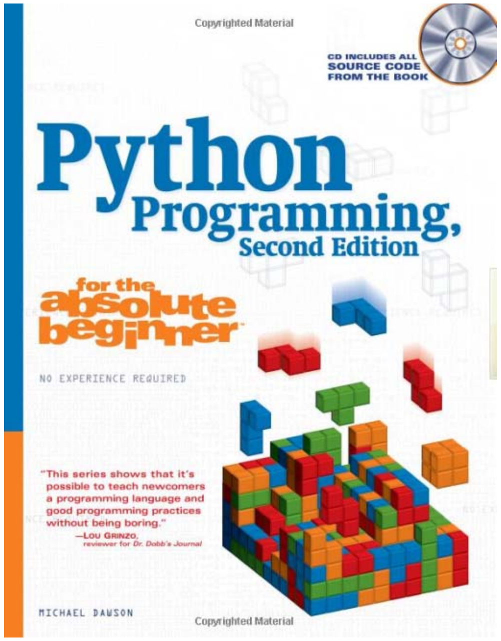
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Python Programming, Second Edition
for the absolute beginner
NO EXPERIENCE REQUIRED
"This series shows that it's possible to teach newcomers a programming language and good programming practices without being boring."
—LOU GRINZO, reviewer for Dr. Dobb's Journal
MICHAEL DAWSON
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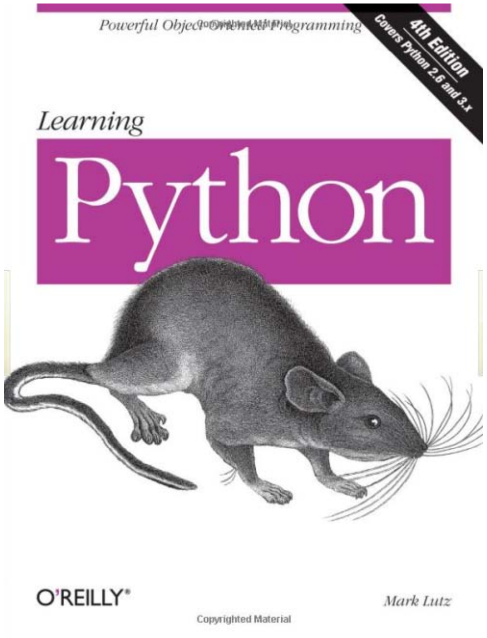


None of these books including anything on ArcGIS or geoprocessing!

Python Language Fundamentals

Python Data Types

- Number (integer and float)
- String
- List
- Tuple
- Dictionary

- Strings, lists and tuples are *sequences*
- Strings, numbers and tuples are *immutable*
- List and dictionaries are *mutable*

Numbers

- Integers
  - Whole number, i.e. no decimals
  - e.g. -34
- Floats
  - Decimal point
  - e.g. -34.8307

Numerical Operators

Operator	Description	Integer		Floating-point	
		Example	Result	Example	Result
*	Multiplication	9 * 2	18	9 * 2.0	18.0
/	Division	9 / 2	4	9 / 2.0	4.5
%	Modulus	9 % 2	1	9 % 2.0	1.0
+	Addition	9 + 2	11	9 + 2.0	11.0
-	Subtraction	9 - 2	7	9 – 2.0	7.0

Demo: Numerical Operators

Strings

- A set of characters surrounded by quotes is called a *string literal*
- To create a *string variable*, assign a string literal to it

```
>>> mytext = "Crime hotspot maps are cool."
>>> print mytext
Crime hotspot maps are cool.
```

Quotes in Python

- In Python single and double quotes are the same
- `"NIJ"` is the same as `'NIJ'`

```
>>> print "I said: 'Let's go!'"
```

- Quotes in Python are straight-up
- `"text"` or `'text'`, not `“text”` or `‘text’`

- Be aware of copy/paste and auto-formatting

Variables

- Python scripts use *variables* to store information
- To work with variables use an *assignment* statement

```
>>> x = 17
>>> x * 2
34
```

Variables

- Python uses *dynamic* assignment

```
>>> x = 17
>>> type(x)
<type 'int'>
>>> x = "GIS"
>>> type(x)
<type 'str'>
```

- No need to declare variables
- Value defines the type

Variable Names

- Rules
  - Letters, digits and underscores
  - Cannot start with a digit
  - Don’t use keywords (`print`, `import`, etc.)

- Recommendations
  - Be descriptive (`count` instead of `c`)
  - Keep it short (`count` instead of `count_of_records`)
  - Follow convention: all lowercase, use underscores

Statement and Expressions

- A Python *expression* is a value

```
>>> 2 * 17
34
```

- A Python *statement* is an instruction to do something

```
>>> x = 2 * 17
```

Working with Strings

- Concatenate strings

```
>>> x = "G"
>>> y = "I"
>>> z = "S"
>>> print x + y + z
GIS
```

Converting to String

```
>>> temp = 100
>>> print "The temperature is " + temp + " degrees"
TypeError: cannot concatenate 'str' and 'int' objects
```

```
>>print "The temperature is " + str(temp) + " degrees"
```

- Converting the value of a variable from one type to another is known as *casting*

Lists

- A Python list is an ordered set of items
- The list of items is surrounded by square brackets [ ], and the items are separated by commas (,)
- Items can consist of numbers, strings and other data types

```
mylist = [1, 2, 4, 8, 16, 32]
mywords ["jpg", "bmp", "tif"]
```

- Lists are very widely used in geoprocessing:
  - e.g. list of feature classes, list of records, list of fields, etc.

Python Functions

- A *function* carries out a certain action
- Python has many built-in functions

```
<function>(<arguments>)
```

```
>> pow(2,3)
8
```

- Using a function is referred to as *calling* a function
- Additional functions can be accessed using *modules*

Python Methods

- A *method* is a function that is closely coupled to some object

```
<object>.<method>(<arguments>)
```

```
>>> topic = "Crime Mapping"
>>> topic.count("i")
2
```

- Many of Python’s data types have methods

String Indexing

- Python strings have an index positioning system

```
>>> mystring = "Crime Mapping"
>>> mystring[0]
'C'
>>> mystring[-1]
'g'
```

- Strings can be sliced into smaller strings using *slicing*

```
>>> mystring[0:5]
'Crime’
```

Working with List

- Python lists have an index positioning system

```
>>> crimes = ["arson", "burglary", "robbery"]
>>> cities[1]
'burglary'
```

- There are many list methods

```
>>> crimes.append("homicide")
>>> crimes.remove("arson")
>>> crimes
['burglary', 'robbery', 'homicide']
```

Working with Pathnames

- Pathnames are critical when writing scripts:
  - Example workspace: c:\data\results
  - Example shapefile: c:\data\results\streams.shp
- In Python a backslash (\) is an escape character
- Pathnames in Python should therefore look like one of the following

```
"c:/data"
"c:\\data"
r"c:\data" (raw string)
```

Python Modules

- *Modules* are like extensions that can be imported into Python to extend its capabilities

```
>>> import time
```

- A typical module contains a number of specialized functions which can be called once the module has been imported

```
<module>.<function>
```

```
>>> time.localtime()
```

Conditional Statements

- *Branching* can be used to control workflow

```
import random
x = random.randint(0,6)
print x
if x == 6:
    print = "You win!“
```

- Syntax: keyword `if`, followed by a condition, followed by (:)

Indentation in Python

- Indented code is referred to as a *block*
- Use tabs or spaces – be consistent
- Recommended: 4 spaces

- *Tip: be careful with copy/paste from other applications*

More Conditional Statements

- Use of `elif` and `else` is optional

```
import random
x = random.randint(0,6)
print x
if x == 6:
    print "You win!"
elif x == 5:
    print "Try again!"
else:
    print "You lose!"
```

Loop Structures: While

- *Loop* structures allow you to repeat a certain part of your code
- A `while` loop repeats until a particular condition is reached

```
i = 0
while i <= 10:
    print i
    i += 1
```

- The `while` statement uses a *sentry variable* in the exit condition

Loop Structures: For

- A `for` loop repeats a block of code for each element of a sequence

```
mylist = ["A", "B", "C", "D"]
for letter in mylist:
    print letter
```

- In the example, letter is the name of a variable and for each iteration of the loop this varaible is assigned a different value

ArcPy: Geoprocessing using Python

What is ArcPy?

- ArcPy was introduced with ArcGIS 10.0
- ArcPy is a collection of modules, classes and functions which give access to all the geoprocessing tools in ArcGIS from within Python
- Most geoprocessing scripts will start with:

```
import arcpy
```

- *Note: ArcPy replaces the older* `arcgisscripting` *module*

Setting Current Workspace

- After importing ArcPy, most scripts start with setting a workspace to retrieve and store files

```
import arcpy
arcpy.env.workspace = "c:/workshop"
```

- In the code above `env` is a class and `workspace` is a property of this class

```
arcpy.<class>.<property>
```

Using Tools

- ArcPy gives you access to all tools in ArcToolbox
- All tools are provided as functions

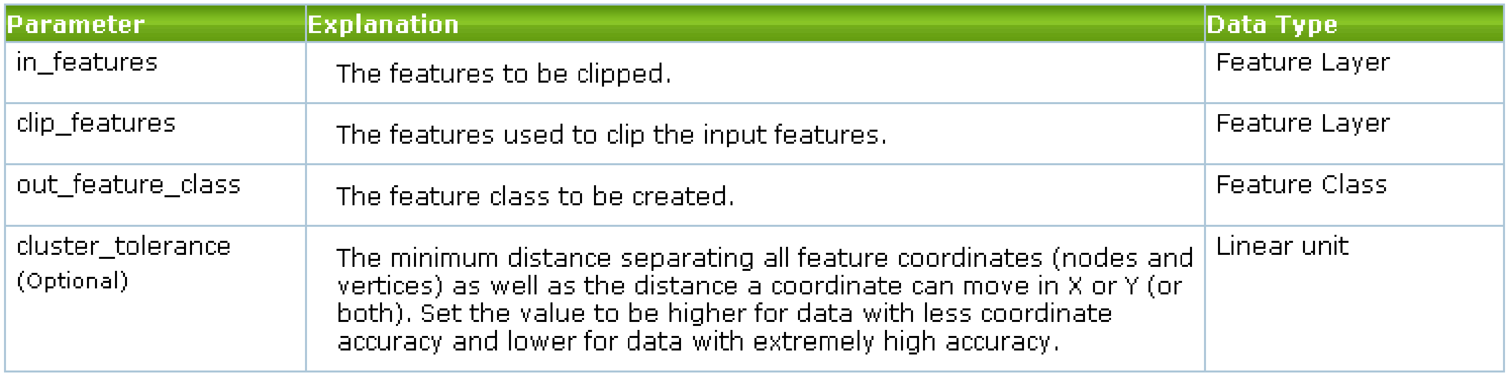
```
arcpy.<toolname_toolboxalias>(<parameters>)
```

- Example:

```
import arcpy
arcpy.env.workspace – "c:/data"
arcpy.Clip_analysis("streams.shp", "study.shp", "result.shp")
```

Tool Parameters

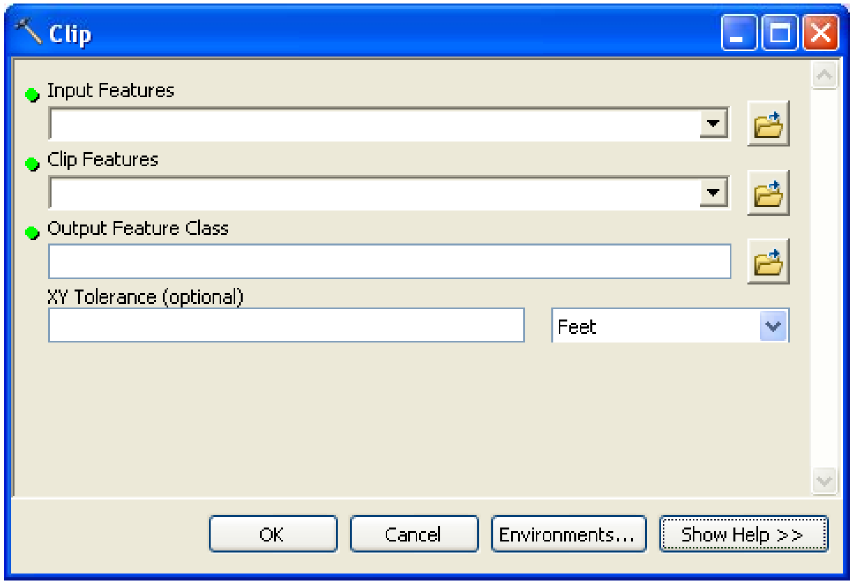
- A good understanding of tool parameters is essential
- Parameters have properties:
  - Name
  - Type (feature class, integer, etc.)
  - Direction (input or output)
  - Required or optional
- Example: Clip tool



Parameter	Explanation	Data Type
in_features	The features to be clipped.	Feature Layer
clip_features	The features used to clip the input features.	Feature Layer
out_feature_class	The feature class to be created.	Feature Class
cluster_tolerance (Optional)	The minimum distance separating all feature coordinates (nodes and vertices) as well as the distance a coordinate can move in X or Y (or both). Set the value to be higher for data with less coordinate accuracy and lower for data with extremely high accuracy.	Linear unit

Tool Syntax

Tool dialog:



Python syntax:

```
Clip_analysis(in_features, clip_features,
              out_feature_class,
              {cluster_tolerance})
```

Example:

```
Clip_analysis("streams.shp","study.shp",
              "result.shp")
```

Optional Parameters

- Required tool parameters are listed first
- Optional tool parameters can be left out
  - But what if some need to be set?

```
Buffer_analysis (in_features, out_feature_class
   buffer_distance_or_field, {line_side}, {line_end_type},
   {dissolve_option}, {dissolve_field})
```

```
arcpy.Buffer_analysis("roads", "buffer", "100 METERS", "",
   "", "LIST", "Code")
```

```
arcpy.Buffer_analysis("roads", "buffer", "100 METERS",
   dissolve_option=LIST, dissolve_field=Code)
```

Hard-coded Parameters

- Consider the example

```
import arcpy
arcpy.env.workspace = "c:/data"
arcpy.Clip_analysis("streams.shp", "study.shp", "result.shp")
```

- How can we make this code more usable?

Using Variables for Parameters

```
import arcpy
arcpy.env.workspace = "c:/data"
infc = "streams.shp"
clipfc = "study.shp"
outfc = "result.shp"
arcpy.Clip_analysis(infc, clipfc, outfc)
```

Variables Provided by a User

```
import arcpy
infc = arcpy.GetParameterAsText(0)
clipfc = arcpy.GetParameterAsText(1)
outfc = arcpy.GetParameterAsText(2)
arcpy.Clip_analysis(infc, clipfc, outfc)
```

Result Objects

- ArcPy returns the output of a tool as a Result object

```
import arcpy
arcpy.env.workspace = "c:/data"
myresult = arcpy.Clip_analysis("streams.shp“,"study.shp","result.shp")
print myresult
```

- This will print the path to the output dataset

```
c:/data/result.shp
```

Multiple Operations using Result Objects

- Result objects can be used as the input into another function

```
import arcpy
arcpy.env.workspace = "c:/data/study.gdb"
buffer = arcpy.Buffer_analysis("str","str_buf","100 METERS")
count = arcpy.GetCount_management(buffer)
print count
```

- This allows complex geoprocessing operations

ArcPy Classes

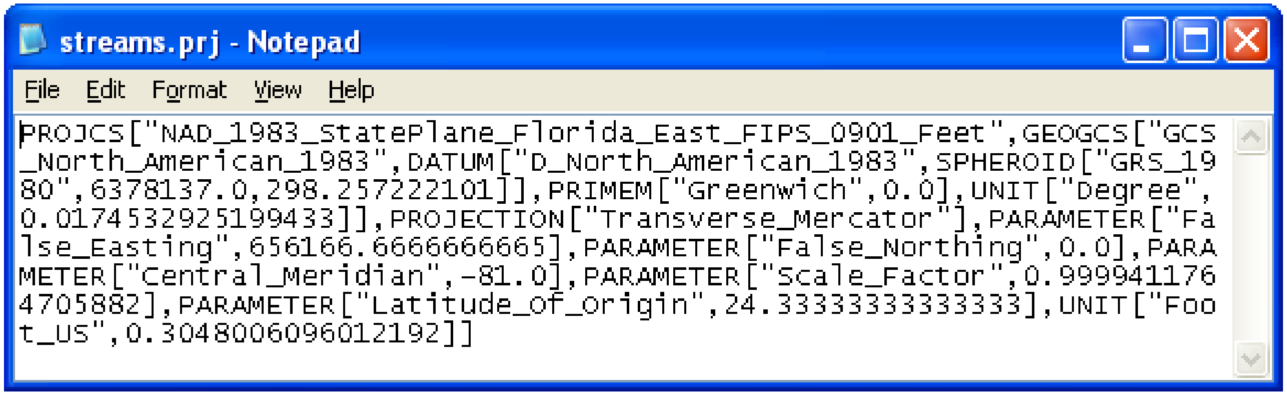
- Some tool parameters are complicated/detailed
  - e.g. coordinate system
- ArcPy classes are used to work with these parameters
  - Classes are used to create objects
  - Classes have properties and methods

- General syntax

```
arcpy.<classname>(<parameters>)
```

ArcPy Classes: Example

- The following is an example of the contents of a .prj file



```
PROJCS["NAD_1983_StatePlane_Florida_East_FIPS_0901_Feet",GEOGCS["GCS
_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_19
80",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",
0.0174532925199433]],PROJECTION["Transverse_Mercator"],PARAMETER["Fa
lse_Easting",656166.6666666665],PARAMETER["False_Northing",0.0],PARA
METER["Central_Meridian",-81.0],PARAMETER["Scale_Factor",0.999941176
4705882],PARAMETER["Latitude_Of_Origin",24.33333333333333],UNIT["Foo
t_US",0.3048006096012192]]
```

- To avoid having to work with this actual string, we can use a `SpatialReference` class

ArcPy Classes: Example

- The following example creates a spatial reference object based on an existing .prj file - properties of this object can then be used

```
import arcpy
prjfile = "c:/data/streams.prj"
spatialref = arcpy.SpatialReference(prjfile)
myref = spatialRef.name
print myRef
```

- This will print

```
NAD_1983_StatePlane_Florida_East_FIPS_0901_Feet
```

ArcPy Classes: Example

- The following example creates a spatial reference object and use this to define the coordinate system of a new feature class

```
import arcpy
out_path = "c:/data"
out_name = "lines.shp"
prjfile = "c:/data/streams.prj"
spatialref = arcpy.SpatialReference(prjfile)
arcpy.CreateFeatureclass_management(out_path, out_name,
                 "POLYLINE", "", "", "", spatialref)
```

ArcPy Functions

- All geoprocessing tools are ArcPy functions
- Additional ArcPy functions:
  - listing data
  - Retrieving and setting properties
  - Many more…
- General syntax

```
arcpy.<functionname>(<arguments>)
```

ArcPy Functions

- Cursors
- Describing data
- Environment and settings
- Fields
- General
- General data functions
- Getting and setting parameters
- Licensing and installation
- Listing data
- Messaging and error handling
- Progress dialog
- Tools and toolboxes

Describing and Listing Data

Describing Data

- The Describe function is used to determine properties of dataset
- General syntax

```
import arcpy
<variable> = arcpy.Describe(<input dataset>)
```

- Example:

```
import arcpy
desc = arcpy.Describe("c:/data/streams.shp")
print desc.shapeType
```

Describing Data: Example

```
import arcpy
arcpy.env.workspace = "c:/data"
infc = "streams.shp"
clipfc = "study.shp"
outfc = "streams_clip.shp"
desc = arcpy.Describe(clipfc)
type = desc.shapeType
if type == "Polygon":
    arcpy.Clip_analysis(infc, clipfc, outfc)
else:
    print "The clip features are not polygons."
```

Listing Data

- Listing data is very common
- Several different list functions in ArcPy
  - ListFields
  - ListIndexes
  - ListDataset
  - ListFeatureClasses
  - ListFiles
  - ListRasters
  - ListTables
  - ListWorkspaces
  - ListVersions
- Similar logic:
  - Create a list
  - Iterate over the list using a `for` loop

Listing Feature Classes

- The `ListFeatureClasses` function returns a list of feature classes in the current workspace
- General syntax:

```
ListFeatureClasses ({wild_card}, {feature_type},
                  {feature_dataset})
```

- Example:

```
import arcpy
from arcpy import env
env.workspace = "c:/data"
fclist = arcpy.ListFeatureClasses()
```

Listing Feature Classes

- No filtering:

```
fclist = arcpy.ListFeatureClasses()
```

- Filtering based on wild card

```
fclist = arcpy.ListFeatureClasses("w*")
```

- Filtering based on feature type

```
fclist = arcpy.ListFeatureClasses("", "point")
```

Listing Fields

- The `ListFields` function lists the fields in a feature class or table in a specified dataset.
- General syntax:

```
ListFields (dataset, {wild_card}, {field_type})
```

- Example

```
import arcpy
arcpy.env.workspace = "c:/data"
fieldlist = arcpy.ListFields("roads.shp")
```

Using Lists in `for` loops

- The following script creates a list of fields of type String and determines for each text field what the length of the field is

```
import arcpy
arcpy.env.workspace = "c:/data"
fieldlist = arcpy.ListFields("roads.shp", "",
                             "String")
for field in fieldlist:
    print field.name + " " + str(field.length)
```

Using Lists in `for` loops

- The following script creates a list of TIFF files and iterates through each file in the list to build pyramids

```
import arcpy
from arcpy import env
env.workspace = "c:/data"
tifflist = arcpy.ListRasters("","TIF")
for tiff in tifflist:
    arcpy.BuildParamids_management(tiff)
```

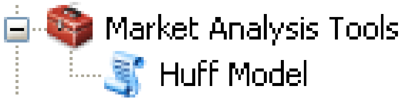
Creating Custom Tools

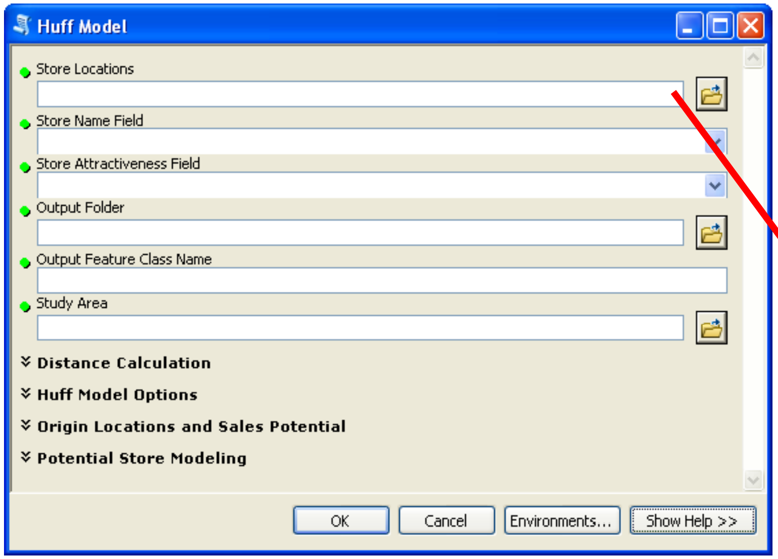
Ways to Execute a Script

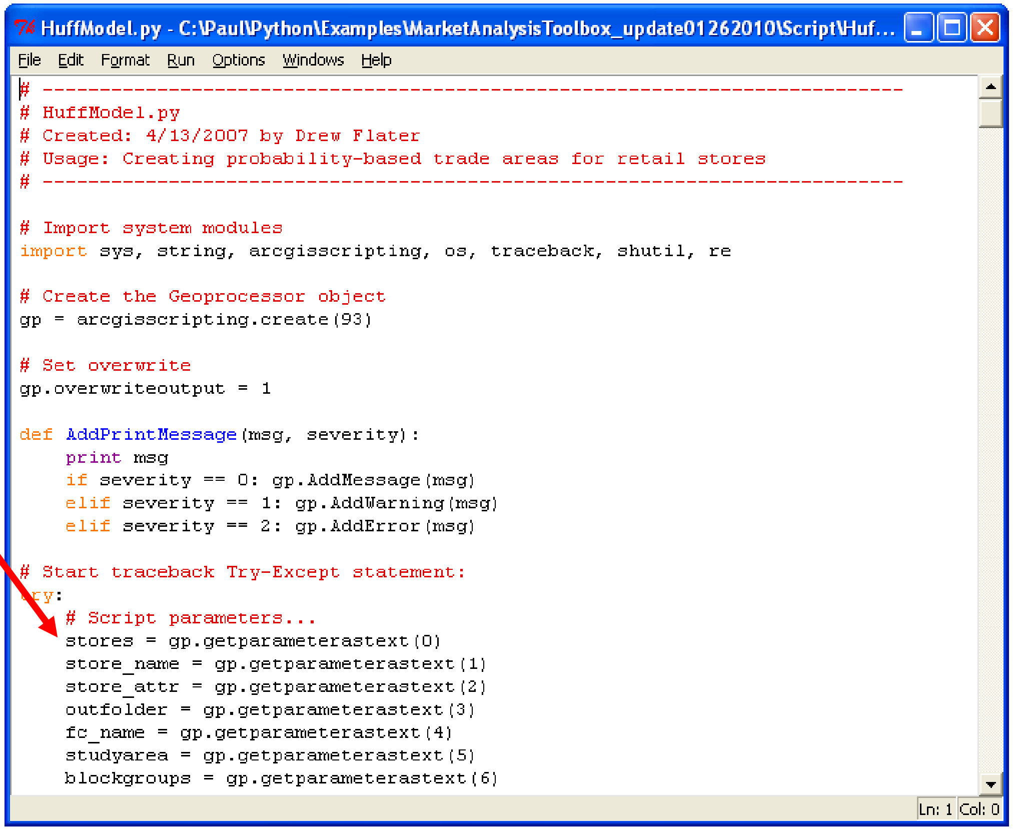
1. As a stand-alone script
   - The script is executed from the operating system or from within a Python editor such as PythonWin
   - When using ArcPy, ArcGIS needs to be installed and licensed
   - No ArcGIS Desktop application needs to be open

2. As a script tool within ArcGIS
   - A tool dialog is created to execute the script
   - Script tool looks like any other tool in ArcToolbox
   - Tool execution is controlled from ArcGIS Desktop

Python Scripts as Tools






HuffModel.py - C:\Paul\Python\Examples\MarketAnalysisToolbox_update01262010\Script\Huf...
File Edit Format Run Options Windows Help
Ln: 1 Col: 0

```
# ---------------------------------------------------------------------------
# HuffModel.py
# Created: 4/13/2007 by Drew Flater
# Usage: Creating probability-based trade areas for retail stores
# ---------------------------------------------------------------------------

# Import system modules
import sys, string, arcgisscripting, os, traceback, shutil, re

# Create the Geoprocessor object
gp = arcgisscripting.create(93)

# Set overwrite
gp.overwriteoutput = 1

def AddPrintMessage(msg, severity):
    print msg
    if severity == 0: gp.AddMessage(msg)
    elif severity == 1: gp.AddWarning(msg)
    elif severity == 2: gp.AddError(msg)

# Start traceback Try-Except statement:
try:
    # Script parameters...
    stores = gp.getparameterastext(0)
    store_name = gp.getparameterastext(1)
    store_attr = gp.getparameterastext(2)
    outfolder = gp.getparameterastext(3)
    fc_name = gp.getparameterastext(4)
    studyarea = gp.getparameterastext(5)
    blockgroups = gp.getparameterastext(6)
```

Why Create Script Tools?

- Tool dialog makes it easier to use
- Tool dialog validates user inputs
- Becomes part of all geoprocessing
- Environment settings are passed on
- Writes messages to the Results window
- Easier to share
- Does not require user to know Python

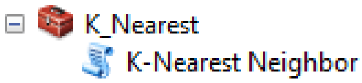
Steps to Create Script Tools

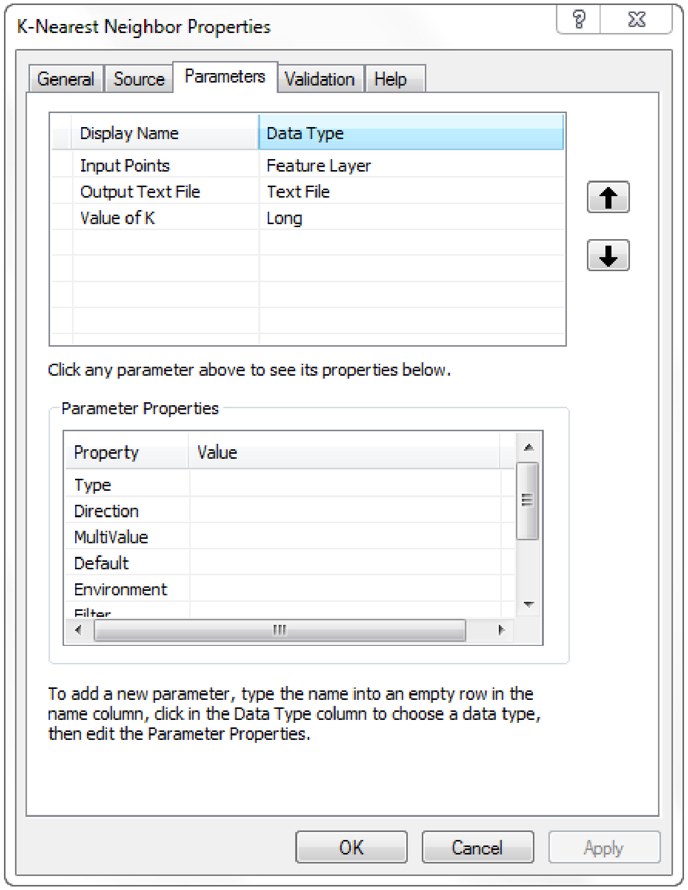
1. Create a Python script (.py)
2. Create a custom Toolbox (.tbx)
3. Add a tool to the Toolbox using Add Script
4. Modify the script with inputs and outputs

Example Script: Hardcoded Variables

```
import arcpy
from arcpy import env
env.overwriteoutput = True
infc = "c:/data/points.shp"
output = "c:/data/result.txt"
k = 10
n = 1
f = open(output, "w")
while n <= k:
   result = arcpy.CalculateDistanceBand_stats(infc, n)
   f.write(str(n) + " " + str(result[1])+ "\n")
   n = n + 1
f.close()
```

Tool Parameters and Dialog





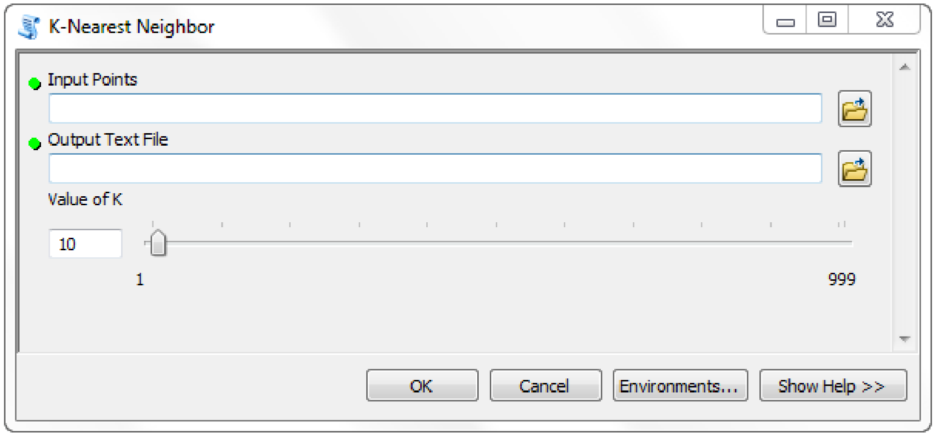
Display Name	Data Type
Input Points	Feature Layer
Output Text File	Text File
Value of K	Long

Click any parameter above to see its properties below.

Parameter Properties

Property	Value
Type	
Direction	
MultiValue	
Default	
Environment	
Filter	

To add a new parameter, type the name into an empty row in the name column, click in the Data Type column to choose a data type, then edit the Parameter Properties.



Input Points

Output Text File

Value of K

10

Example Script: User Provided Parameters

```
import arcpy
from arcpy import env
env.overwriteoutput = True
infc = arcpy.GetParameterAsText(0)
output = arcpy.GetParameterAsText(1)
k = arcpy.GetParameter(2)
n = 1
f = open(output, "w")
while n <= k:
   result = arcpy.CalculateDistanceBand_stats(infc, n)
   f.write(str(n) + " " + str(result[1])+ "\n")
   n = n + 1
f.close()
```

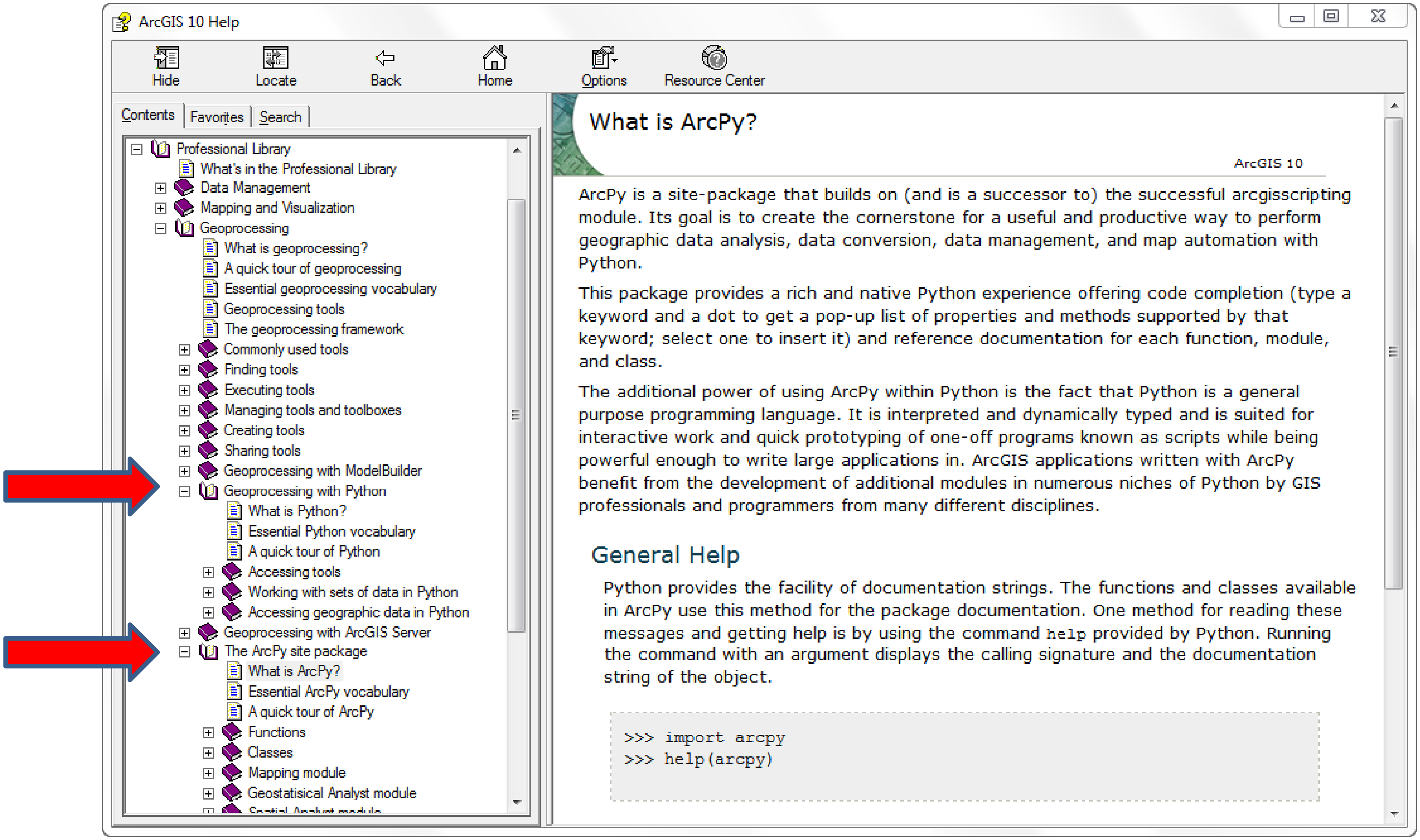
More ArcPy Functionality

More ArcPy Functionality

- Cursors to work with rows and geometry
  - Retrieve, edit, create
- `arcpy.sa` module to work with rasters
- `arcpy.mapping` module for map automation
- Creating custom functions and classes

Resources for Python Scripting in ArcGIS

ArcGIS Desktop Help


ArcGIS 10 Help
Hide
Locate
Back
Home
Options
Resource Center
Contents
Favorites
Search
Professional Library
What's in the Professional Library
Data Management
Mapping and Visualization
Geoprocessing
What is geoprocessing?
A quick tour of geoprocessing
Essential geoprocessing vocabulary
Geoprocessing tools
The geoprocessing framework
Commonly used tools
Finding tools
Executing tools
Managing tools and toolboxes
Creating tools
Sharing tools
Geoprocessing with ModelBuilder
Geoprocessing with Python
What is Python?
Essential Python vocabulary
A quick tour of Python
Accessing tools
Working with sets of data in Python
Accessing geographic data in Python
Geoprocessing with ArcGIS Server
The ArcPy site package
What is ArcPy?
Essential ArcPy vocabulary
A quick tour of ArcPy
Functions
Classes
Mapping module
Geostatisical Analyst module
Spatial Analyst module

What is ArcPy?

ArcGIS 10

ArcPy is a site-package that builds on (and is a successor to) the successful arcgisscripting module. Its goal is to create the cornerstone for a useful and productive way to perform geographic data analysis, data conversion, data management, and map automation with Python.

This package provides a rich and native Python experience offering code completion (type a keyword and a dot to get a pop-up list of properties and methods supported by that keyword; select one to insert it) and reference documentation for each function, module, and class.

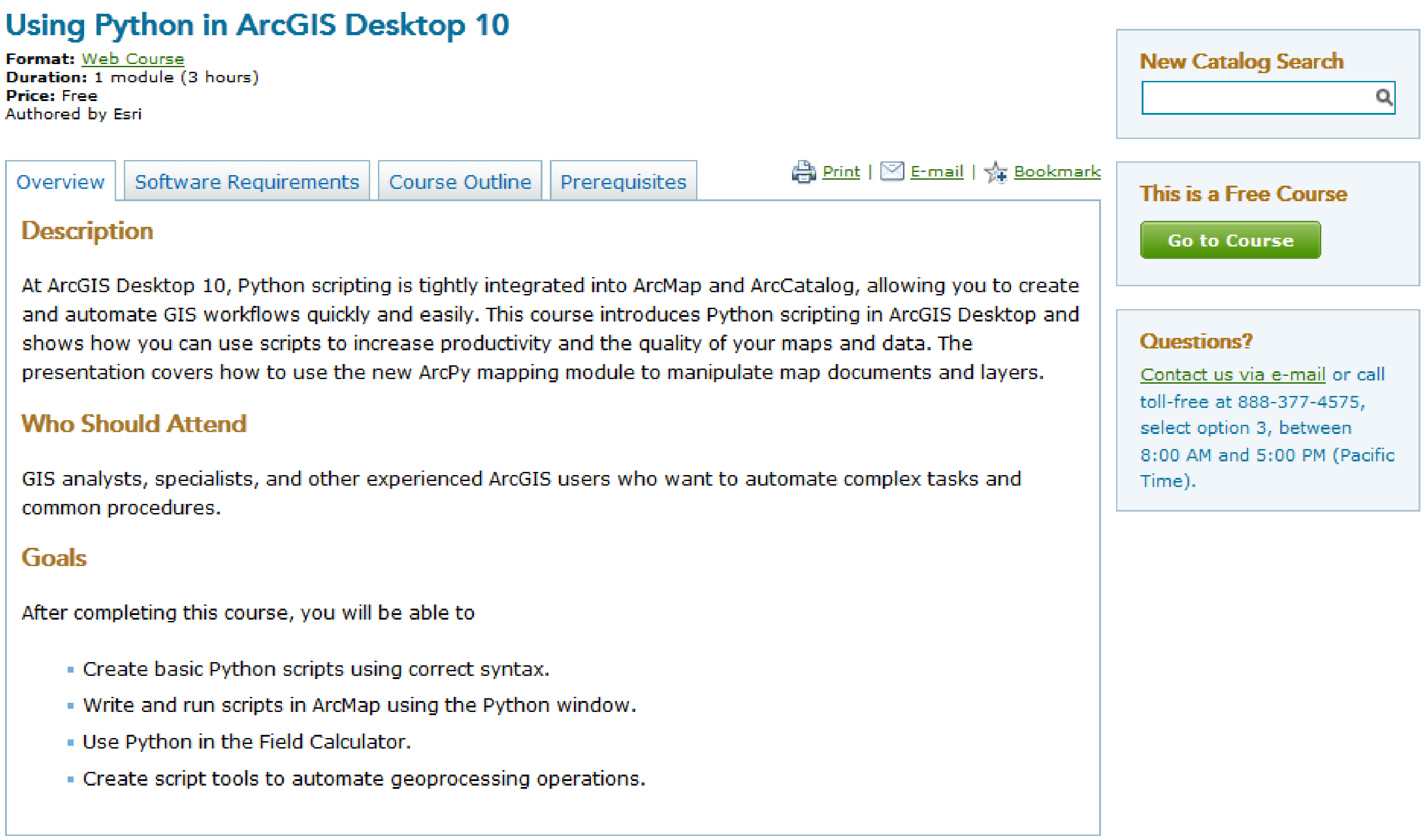
The additional power of using ArcPy within Python is the fact that Python is a general purpose programming language. It is interpreted and dynamically typed and is suited for interactive work and quick prototyping of one-off programs known as scripts while being powerful enough to write large applications in. ArcGIS applications written with ArcPy benefit from the development of additional modules in numerous niches of Python by GIS professionals and programmers from many different disciplines.

General Help

Python provides the facility of documentation strings. The functions and classes available in ArcPy use this method for the package documentation. One method for reading these messages and getting help is by using the command `help` provided by Python. Running the command with an argument displays the calling signature and the documentation string of the object.

```
>>> import arcpy
>>> help(arcpy)
```

Virtual Campus Courses



Using Python in ArcGIS Desktop 10

Format: Web Course
Duration: 1 module (3 hours)
Price: Free
Authored by Esri

Description

At ArcGIS Desktop 10, Python scripting is tightly integrated into ArcMap and ArcCatalog, allowing you to create and automate GIS workflows quickly and easily. This course introduces Python scripting in ArcGIS Desktop and shows how you can use scripts to increase productivity and the quality of your maps and data. The presentation covers how to use the new ArcPy mapping module to manipulate map documents and layers.

Who Should Attend

GIS analysts, specialists, and other experienced ArcGIS users who want to automate complex tasks and common procedures.

Goals

After completing this course, you will be able to

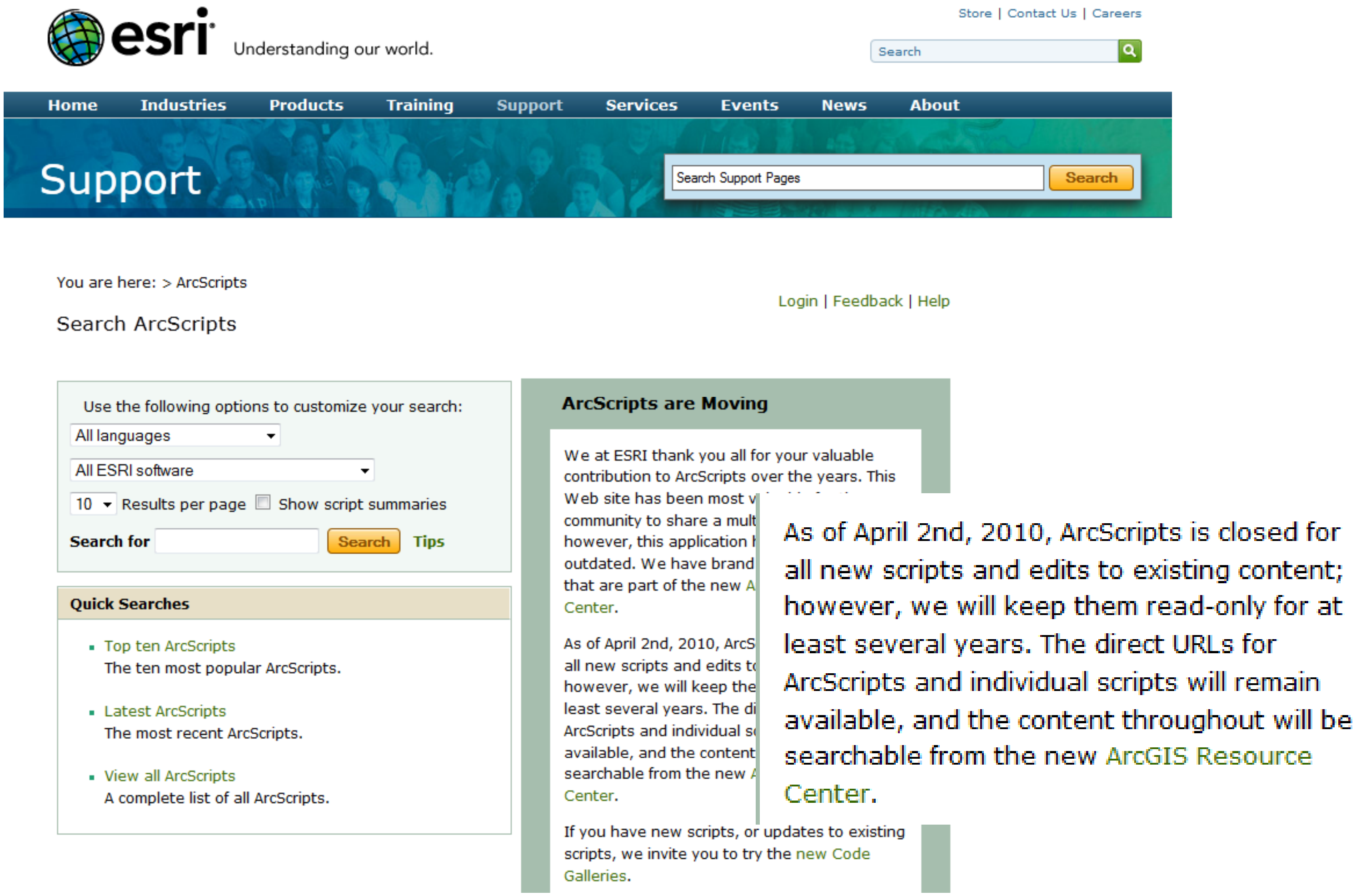
- Create basic Python scripts using correct syntax.
- Write and run scripts in ArcMap using the Python window.
- Use Python in the Field Calculator.
- Create script tools to automate geoprocessing operations.

Questions?

Contact us via e-mail or call toll-free at 888-377-4575, select option 3, between 8:00 AM and 5:00 PM (Pacific Time).

http://training.esri.com

ArcScripts



You are here: > ArcScripts

Search ArcScripts

Use the following options to customize your search:

10 Results per page ☐ Show script summaries

Search for

Quick Searches

- Top ten ArcScripts
  The ten most popular ArcScripts.
- Latest ArcScripts
  The most recent ArcScripts.
- View all ArcScripts
  A complete list of all ArcScripts.

ArcScripts are Moving

We at ESRI thank you all for your valuable contribution to ArcScripts over the years. This Web site has been most v community to share a mult however, this application h outdated. We have brand that are part of the new A Center.

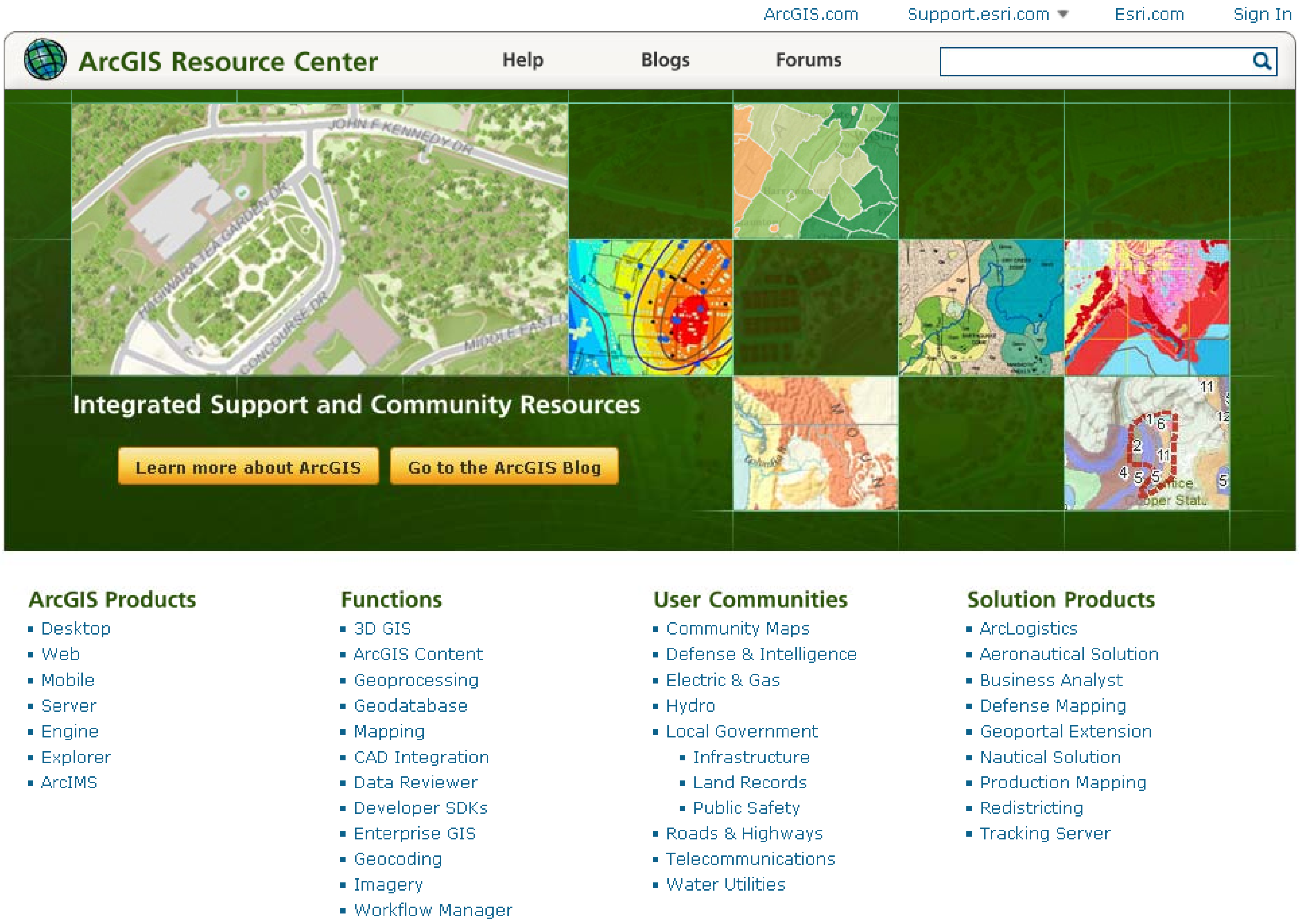
As of April 2nd, 2010, ArcS all new scripts and edits to however, we will keep the least several years. The di ArcScripts and individual s available, and the content searchable from the new A Center.

As of April 2nd, 2010, ArcScripts is closed for all new scripts and edits to existing content; however, we will keep them read-only for at least several years. The direct URLs for ArcScripts and individual scripts will remain available, and the content throughout will be searchable from the new ArcGIS Resource Center.

If you have new scripts, or updates to existing scripts, we invite you to try the new Code Galleries.

http://arcscripts.esri.com

ArcGIS Resource Center



ArcGIS Products

- Desktop
- Web
- Mobile
- Server
- Engine
- Explorer
- ArcIMS

Functions

- 3D GIS
- ArcGIS Content
- Geoprocessing
- Geodatabase
- Mapping
- CAD Integration
- Data Reviewer
- Developer SDKs
- Enterprise GIS
- Geocoding
- Imagery
- Workflow Manager

User Communities

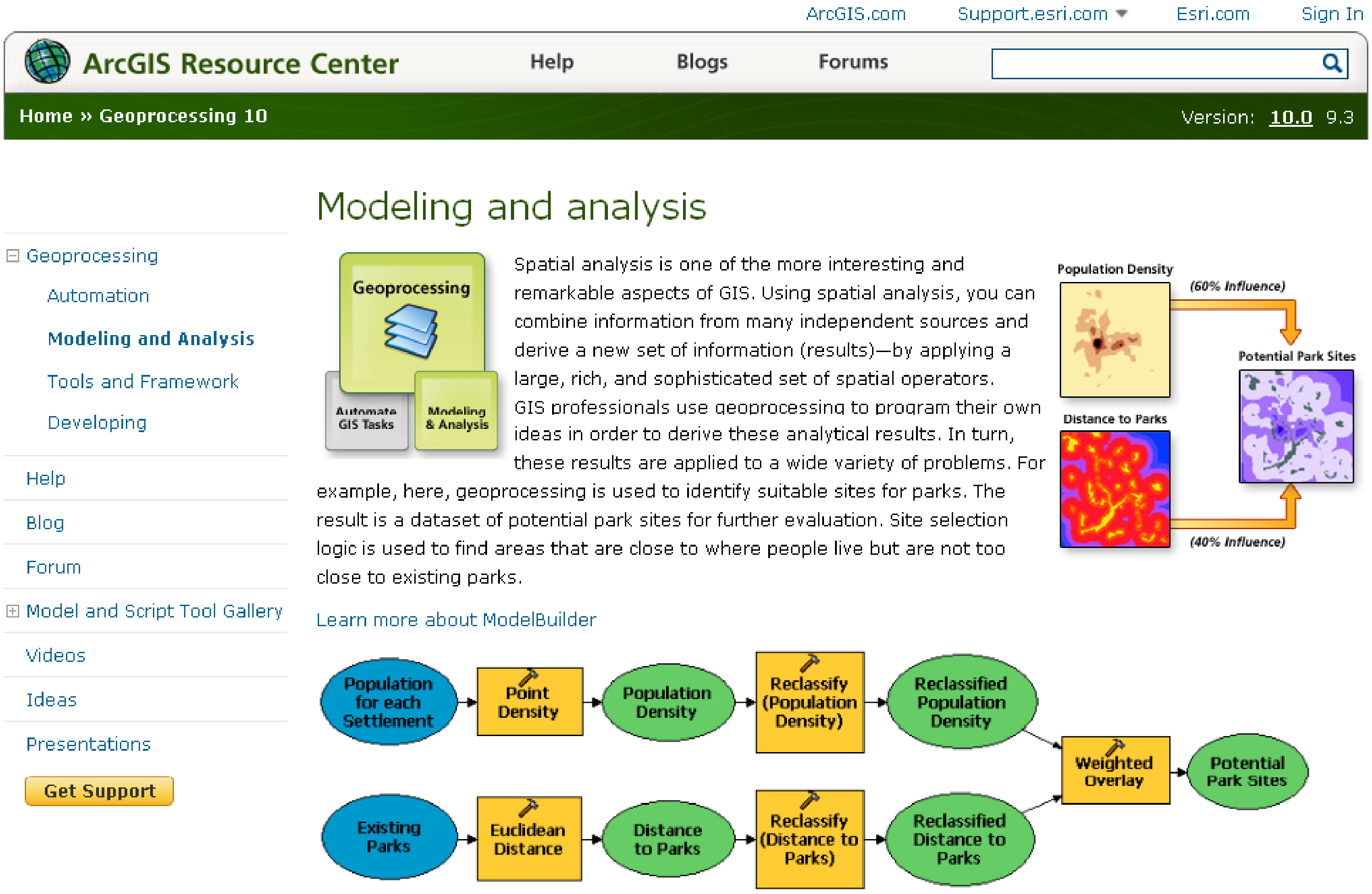
- Community Maps
- Defense & Intelligence
- Electric & Gas
- Hydro
- Local Government
  - Infrastructure
  - Land Records
  - Public Safety
- Roads & Highways
- Telecommunications
- Water Utilities

Solution Products

- ArcLogistics
- Aeronautical Solution
- Business Analyst
- Defense Mapping
- Geoportal Extension
- Nautical Solution
- Production Mapping
- Redistricting
- Tracking Server

http://resources.arcgis.com

ArcGIS Resource Center



Modeling and analysis

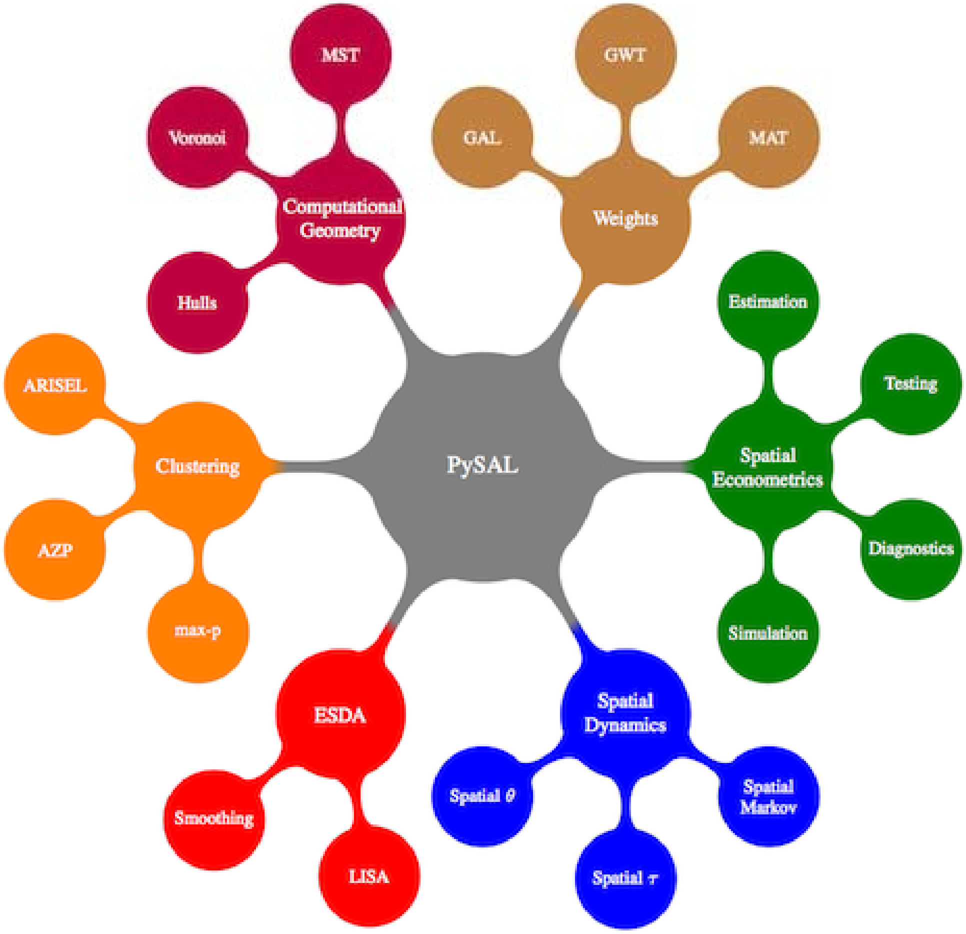
Spatial analysis is one of the more interesting and remarkable aspects of GIS. Using spatial analysis, you can combine information from many independent sources and derive a new set of information (results)—by applying a large, rich, and sophisticated set of spatial operators. GIS professionals use geoprocessing to program their own ideas in order to derive these analytical results. In turn, these results are applied to a wide variety of problems. For example, here, geoprocessing is used to identify suitable sites for parks. The result is a dataset of potential park sites for further evaluation. Site selection logic is used to find areas that are close to where people live but are not too close to existing parks.

Learn more about ModelBuilder

http://resources.arcgis.com/content/geoprocessing/10.0/about

Beyond ArcGIS

Using PySAL for Spatial Analysis



http://geodacenter.asu.edu/pysal

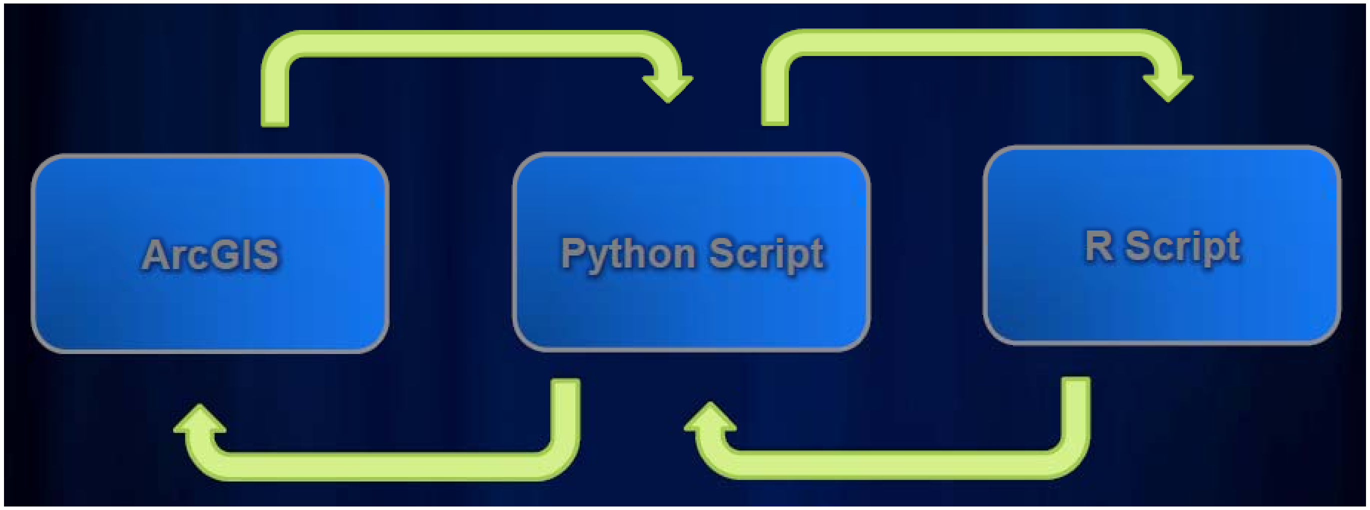
PySAL

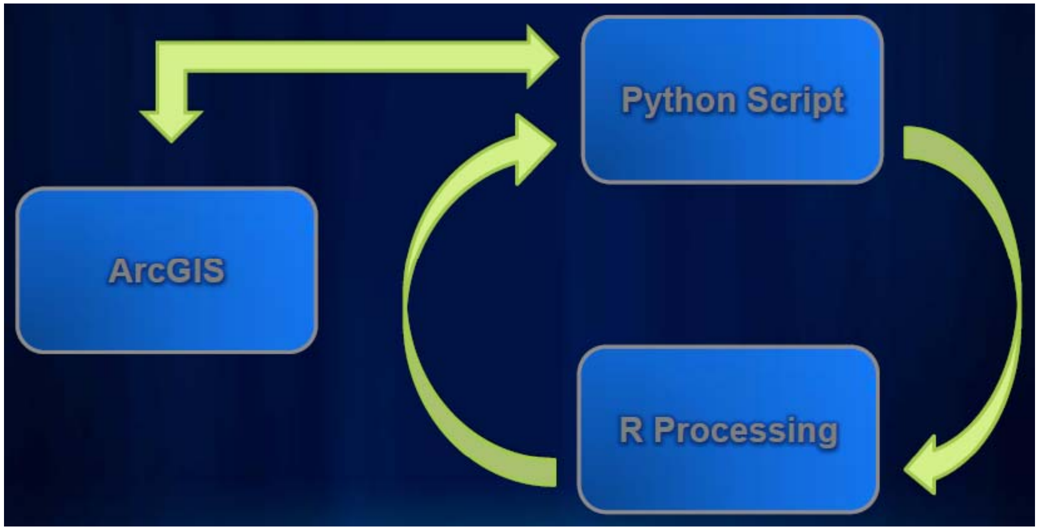
- Python library of spatial analysis methods
- ESDA, spatial statistics, geostatistics
- Growing and expandable

Using R for Spatial Analysis

- Open source language for data analysis
- Libraries have been developed for spatial methods
- Large and active user community
- Growing and expandable

ArcGIS and R



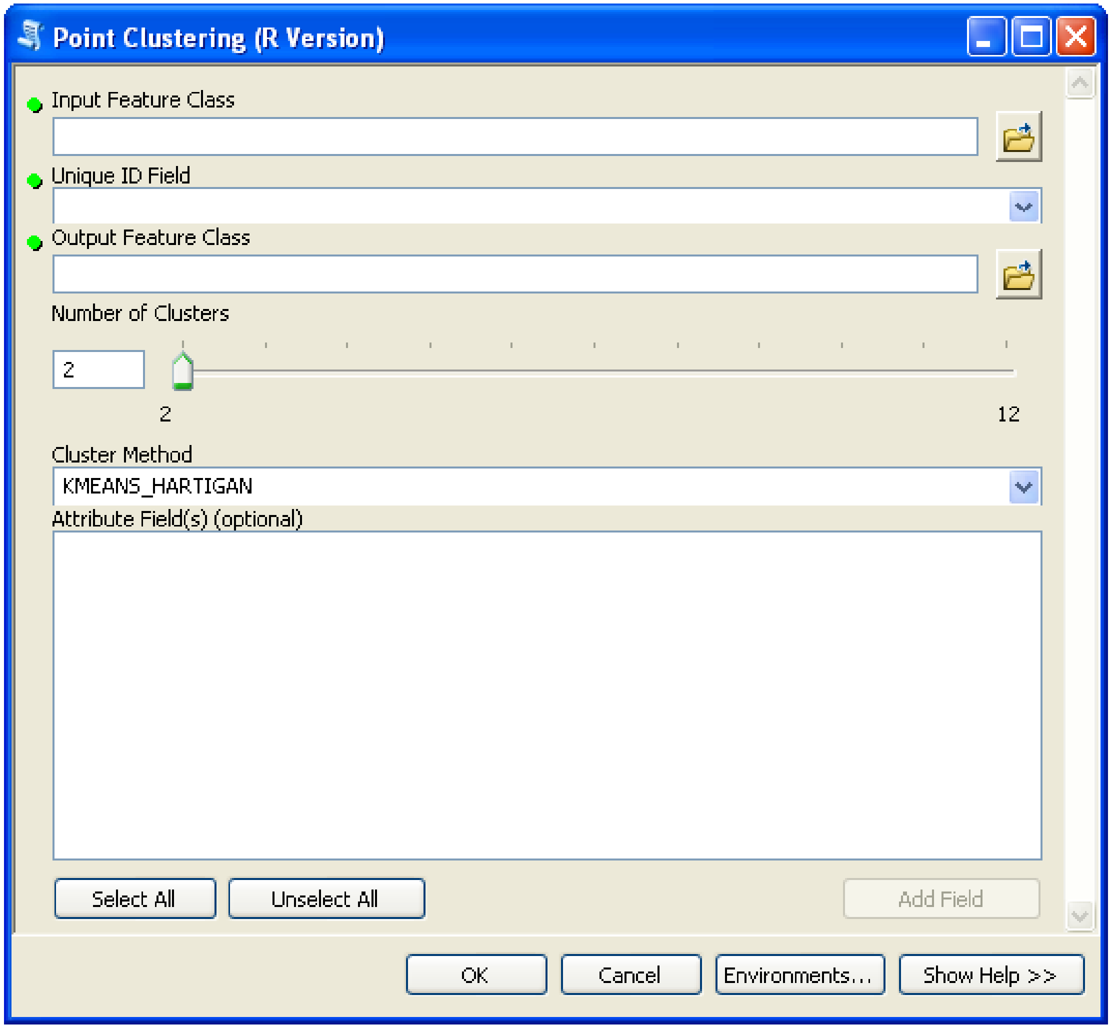


RPy

Script Tool

R Tools.tbx

Point Clustering (R Version)



Point Clustering (R Version)

Input Feature Class

Unique ID Field

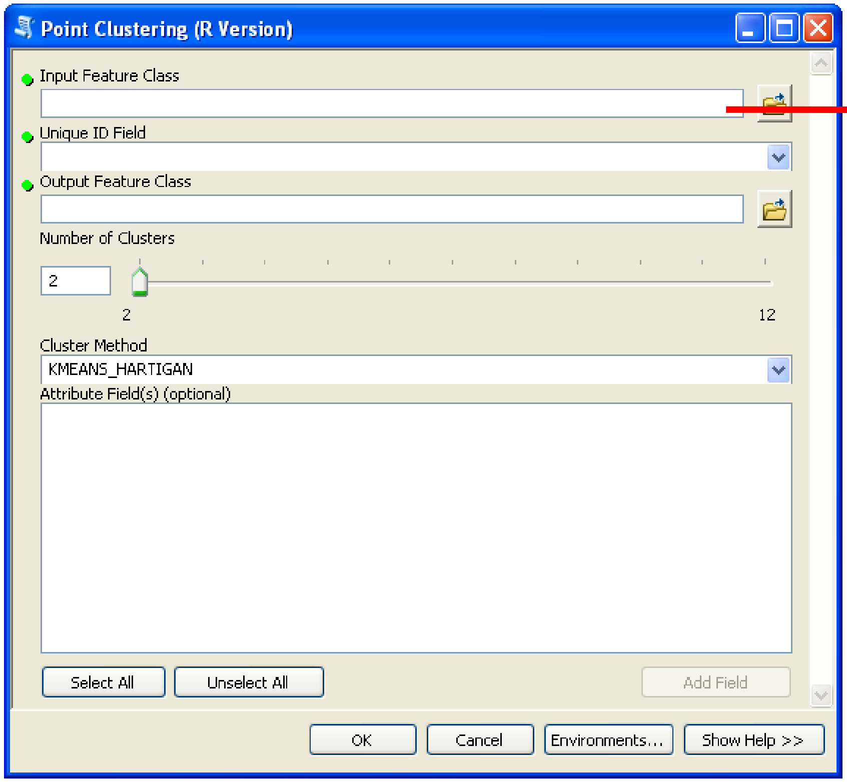
Output Feature Class

Number of Clusters: 2

Cluster Method: KMEANS_HARTIGAN

Attribute Field(s) (optional)

Python script that calls R



Point Clustering (R Version)

Input Feature Class

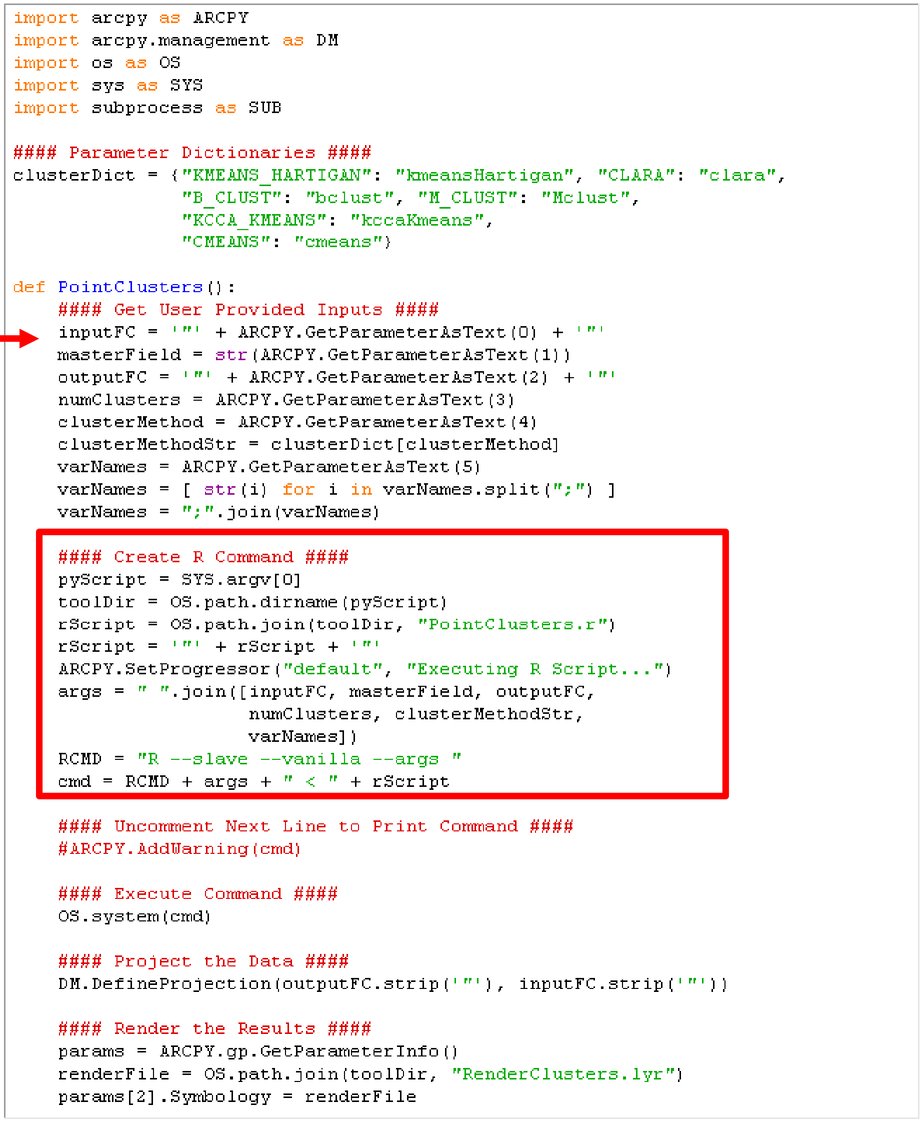
Unique ID Field

Output Feature Class

Number of Clusters: 2

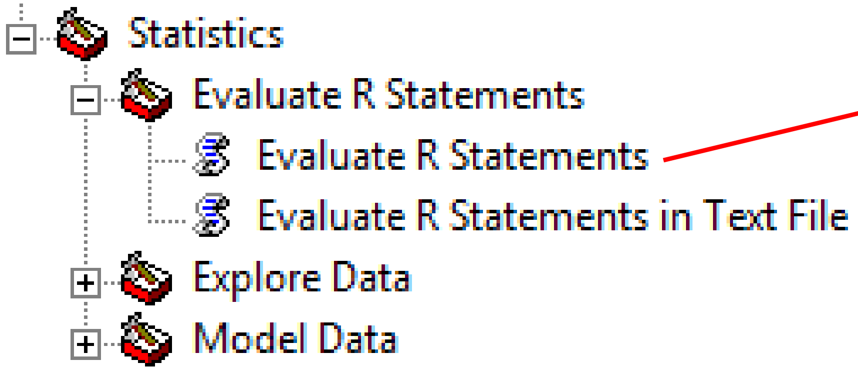
Cluster Method: KMEANS_HARTIGAN

Attribute Field(s) (optional)

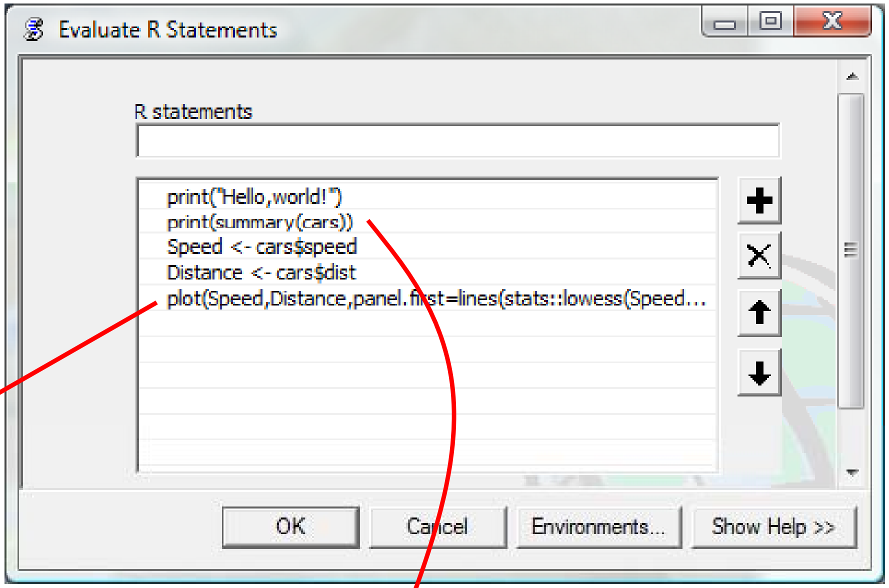


```
import arcpy as ARCPY
import arcpy.management as DM
import os as OS
import sys as SYS
import subprocess as SUB

#### Parameter Dictionaries ####
clusterDict = {"KMEANS_HARTIGAN": "kmeansHartigan", "CLARA": "clara",
               "B_CLUST": "bclust", "M_CLUST": "Mclust",
               "KCCA_KMEANS": "kccaKmeans",
               "CMEANS": "cmeans"}

def PointClusters():
    #### Get User Provided Inputs ####
    inputFC = '"' + ARCPY.GetParameterAsText(0) + '"'
    masterField = str(ARCPY.GetParameterAsText(1))
    outputFC = '"' + ARCPY.GetParameterAsText(2) + '"'
    numClusters = ARCPY.GetParameterAsText(3)
    clusterMethod = ARCPY.GetParameterAsText(4)
    clusterMethodStr = clusterDict[clusterMethod]
    varNames = ARCPY.GetParameterAsText(5)
    varNames = [ str(i) for i in varNames.split(";") ]
    varNames = ";".join(varNames)

    #### Create R Command ####
    pyScript = SYS.argv[0]
    toolDir = OS.path.dirname(pyScript)
    rScript = OS.path.join(toolDir, "PointClusters.r")
    rScript = '"' + rScript + '"'
    ARCPY.SetProgressor("default", "Executing R Script...")
    args = " ".join([inputFC, masterField, outputFC,
                     numClusters, clusterMethodStr,
                     varNames])
    RCMD = "R --slave --vanilla --args "
    cmd = RCMD + args + " < " + rScript

    #### Uncomment Next Line to Print Command ####
    #ARCPY.AddWarning(cmd)

    #### Execute Command ####
    OS.system(cmd)

    #### Project the Data ####
    DM.DefineProjection(outputFC.strip('"'), inputFC.strip('"'))

    #### Render the Results ####
    params = ARCPY.gp.GetParameterInfo()
    renderFile = OS.path.join(toolDir, "RenderClusters.lyr")
    params[2].Symbology = renderFile
```

Evaluating R Statements



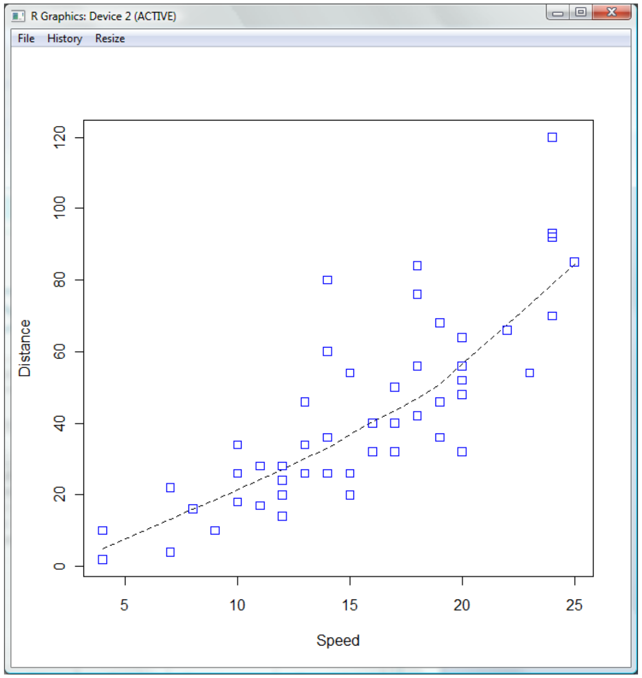
- Statistics
  - Evaluate R Statements
    - Evaluate R Statements
    - Evaluate R Statements in Text File
  - Explore Data
  - Model Data

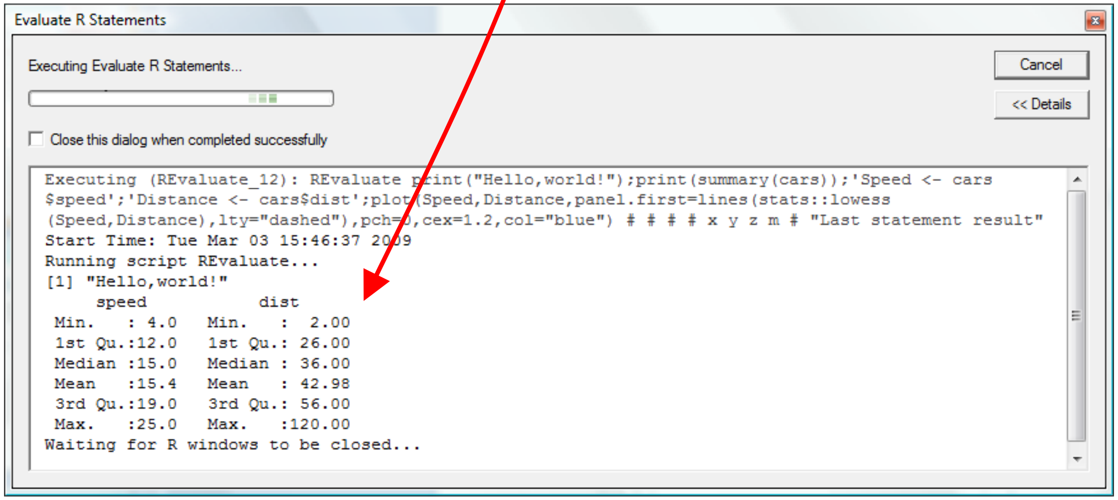


Evaluate R Statements

R statements

```
print("Hello,world!")
print(summary(cars))
Speed <- cars$speed
Distance <- cars$dist
plot(Speed,Distance,panel.first=lines(stats::lowess(Speed…
```





Evaluate R Statements

Executing Evaluate R Statements...

□ Close this dialog when completed successfully

```
Executing (REvaluate_12): REvaluate print("Hello,world!");print(summary(cars));'Speed <- cars
$speed';'Distance <- cars$dist';plot(Speed,Distance,panel.first=lines(stats::lowess
(Speed,Distance),lty="dashed"),pch=0,cex=1.2,col="blue") # # # # x y z m # "Last statement result"
Start Time: Tue Mar 03 15:46:37 2009
Running script REvaluate...
[1] "Hello,world!"
     speed           dist
 Min.   : 4.0   Min.   :  2.00
 1st Qu.:12.0   1st Qu.: 26.00
 Median :15.0   Median : 36.00
 Mean   :15.4   Mean   : 42.98
 3rd Qu.:19.0   3rd Qu.: 56.00
 Max.   :25.0   Max.   :120.00
Waiting for R windows to be closed...
```

Concluding Remarks

- Python is a relatively easy to learn language
- ArcGIS is becoming more “Pythonesque”
- Creating time-savings scripts for repetitive tasks does not take a lot of code
- Easy to share script tools

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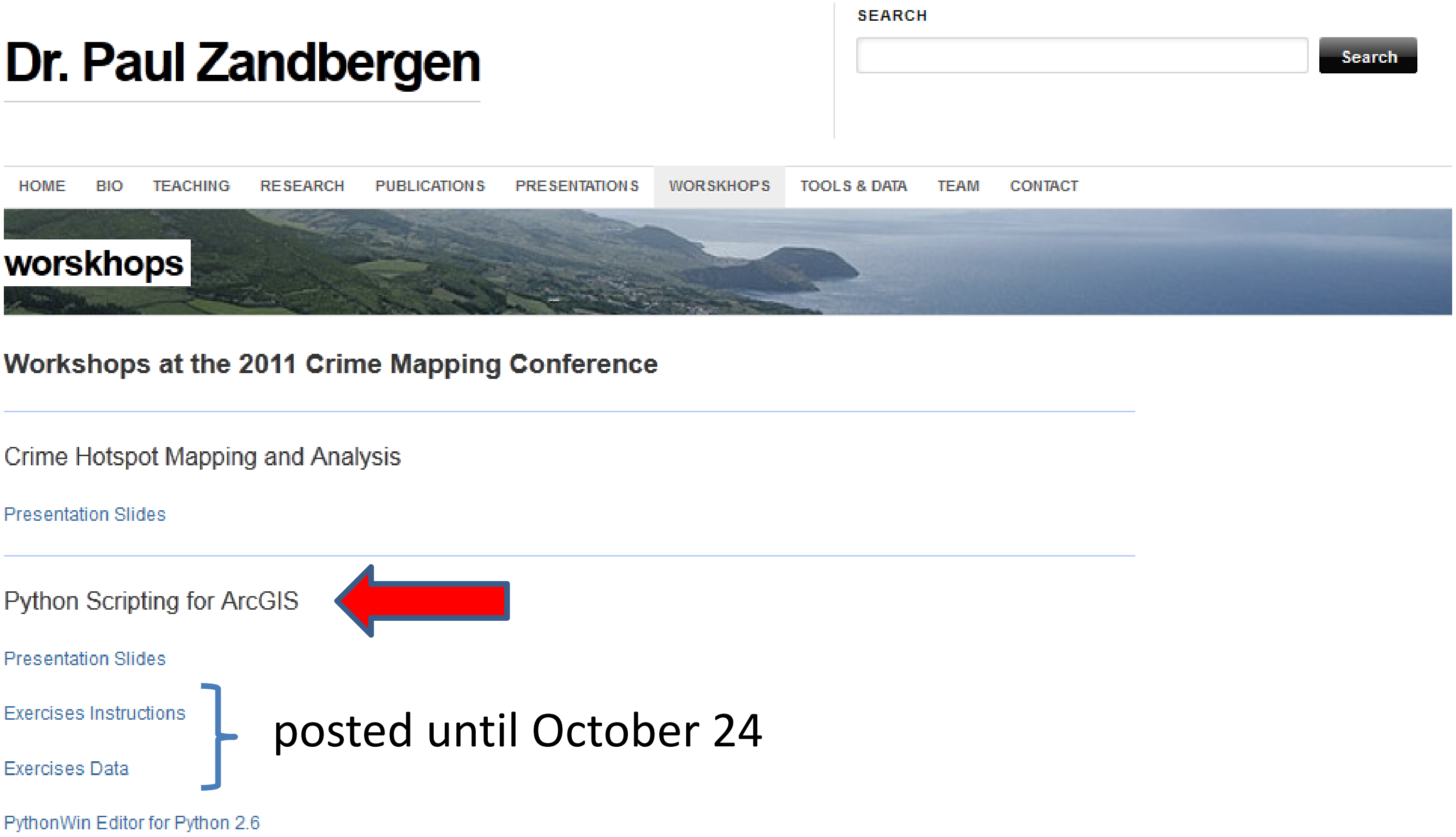
Workshop Materials Posted



Dr. Paul Zandbergen

worskhops

Workshops at the 2011 Crime Mapping Conference

Crime Hotspot Mapping and Analysis

Presentation Slides

Python Scripting for ArcGIS

Presentation Slides

Exercises Instructions

Exercises Data

PythonWin Editor for Python 2.6

posted until October 24

http://www.paulzandbergen.com/workshops