

Arc Hydro in ArcGIS Pro: The Next Generation of Tools for Water Resources

Dean Djokic

2020 ESRI FEDERALGIS CONFERENCE | WASHINGTON, D.C.

Topics

- Definitions
- Review of core hydro tools
 - Difference between "hydro" and "Arc Hydro"
- What is Arc Hydro?
- Arc Hydro Pro development plan and status
- What's new with Arc Hydro
- Getting involved
- Questions



Defitions: Hydro Analysis in ArcGIS

- Hydro Analysis in ArcGIS is used to model the flow of water across a surface.
- What are the primary objectives of hydrologic analysis in a GIS?
 - Extract hydro information and drainage system characteristics from a digital elevation model.
 - To know where the water comes from, and where it is flowing to.



GIS for Hydro Modeling "Cycle"

- **GIS** is used for landscape characterization and model parametrization.
- Hydrology and Hydraulics (H&H) is used for determination of flows, depths and velocities.
- GIS is used for result postprocessing and visualization.
- GIS and H&H modeling are closely connected as one impacts the other



Review of Core Hydro Tools



Hydrology Tools

ArcMap / ArcGIS Pro



ArcGIS Pro



ArcGIS Image Server



de la compacta de la comp

Fill

Fills sinks in a surface raster to remove small imperfections in the data.

- Remove smaller imperfections and noise in surface raster.
- Remove larger sinks and pits in the terrain.
- Provide depth filter using Z-Limit.





Geoproces	ssing	→ □ ×
۲	Fill	\oplus
Parameters	Environments	?
* Input surfac	ce raster	•
* Output sur	face raster	~
Z limit		
		Run 🕟



Flow Direction: D8

Create a raster of flow direction from each cell to its steepest downslope neighbor using D8 method.



Elevation



Flow Direction

D8 Method



PPF enabled

d.



D-Infinity best for modeling distributed hydrologic processes, such as runoff generation or erosion.

j-1

Column indices

Proportion of flow to pixel.

(i-1, j) is $\alpha_{\alpha}/(\alpha_{\alpha}+\alpha_{\alpha})$.

i+1

Proportion of flow to pixel

(i-1, j+1) is $\alpha /(\alpha + \alpha)$.

Flow direction

measured as counter-clockwise angle from east.

D-Infinity Method

Tarboton, D. G., (1997), "A New Method for the Determination of Flow Directions and Contributing Areas in Grid Digital Elevation Models," Water Resources Research, 33(2): 309-319.

Divergent flow: flow proportioned up to two downstream neighbors





Flow Direction: D-Infinity

Creates flow direction as the steepest downward slope on eight triangular facets formed in a 3x3 cell window centered on the cell of interest.

Ξ

Row indices

Flow Direction: Multiple Flow Direction (MFD)



- Better flow accumulation maps in low-relief areas
- Flow partitioning is adaptive to local terrain conditions.





D8 Flow Accumulations MFD Flow Accumulations



Flow proportioned to all downstream neighbor(s)

Qin, C., Zhu, A. X., Pei, T., Li, B., Zhou, C., & Yang, L. 2007. "An adaptive approach to selecting a flow partition exponent for a multiple flow direction algorithm." International Journal of Geographical Information Science 21(4): 443-458.

Flow Accumulation

Creates a raster of accumulated flow into each cell. A weight factor can optionally be applied. Select from D8, D-Infinity or MFD flow methods.



Flow Direction



Flow Accumulation





Run 🕟

Flow Distance



- Compute vertical/horizontal downslope distance to streams over single or multiple flow paths.
- Supports D8, D-Infinity and MFD algorithms for computing flow distance.
- In case of multiple flow paths, minimum, weighted mean, or maximum flow distance can be computed.
- Used in computation of Height Above Nearest Drainage (HAND). Flooding occurs when water depth is greater than HAND.





Geoproc	essing	≁ □ ×
€	Flow Distance	\oplus
Paramete	Environments	0
* Input stre	eam raster	• 🚘
* Input sur	face raster	
* Output r	aster	
Input flo	w direction raster	
Distance	type	• 🚞
Vertical		-
Input flo	w direction type	
D8		•
Statistics	type	
Minimu	m	•
	1	Run 🕟

Watershed

Determines the contributing area above a set of cells in a raster.



d.









Entern | Areas Markeleice | Felp | Terrarel Dia | Trivery | Cented

Ready-to-use services on ArcGIS Online: Create Watershed & Trace Downstream

How to Use the Analysis Services In ArcGIS Online

🔚 Save 🗸 📟 Share 🚔 Print 🗸 | 🚸 Directions 📳 Details 🛛 📩 Add 🚽 🛛 🚼 Basemap 🔝 Analysis North Sea Perform Analysis LATVIA +DENMARK Summarize Data 0 LITHUANIA UNITED 4 oM ▼ Find Locations 0 Amsterdam BELAR IRELAND Berlin _ POLAND X oLondon Find Existing Locations 0 GERMANY 0 CZECH REPUBLIC Vienna Budapest **Derive New Locations** 0 Paris Find Centroids FRANCE 0 Milan ROMANIA Bucha Find Similar Locations 0 ITALY BULGARIA Barcelona oMadrid Ì Choose Best Facilities 0 o Lisbon SPAIN GREECE oAlgiers Create Viewshed 0 Tunis Mountain Create Watersheds 0 TUNISIA Medite Tripoli Trace Downstream 0 ALGERIA 300 600mi 0 Data Enrichment a LIBYA Libyan

de.

de la compacta de la comp

National Water Model

Flows and anomalies

- Mid-range (10 days ahead)
- Short-range (18 hours ahead)
- Velocity estimate added
- New, more scalable architecture





What is Arc Hydro?





"Provide practical GIS framework for development of integrated analytical systems for water resources market."



Brief History

1999 – 2002

- Project to demonstrate geodatabase capabilities in water resources.
- Worked with Dr. David Maidment at the University of Texas.
- Focused on the Arc Hydro Data Model.
- Released in 2002 as a data model, a toolset, and an Esri Press book (Arc Hydro).
 - Initial set of ~ 30 tools (8.3) developed by Esri (PS) as a complement to the data model.





Brief History

Since 2003:

- Arc Hydro tool development through projects.
 - This added ~300+ tools over the years.
- Tool maintenance (version updates, move to Pro, etc.).
- User support (Web pages, GeoNet, response to emails, etc.).
 - https://community.esri.com/community/gis/solutions/arc-hydro
- Training classes (managed as standard Esri training and are delivered by PS).
- Arc Hydro Groundwater
 - Added in 2007.
 - Collaboration with Aquaveo and published Esri Press book (Arc Hydro Groundwater, 2011).
 - Aquaveo provides extensions (fee) and support





Arc Hydro Tools Summary Functionality Grouping

Foundation

Terrain preprocessing

- ID mgmt.

Administration

- QA

- Configuration

- Streams

- Sinks

- Flow patterns

General implementation domains

Watershed delineation

- Watershed

- Sub-watershed
- Batch processing

Floodplain delineation

- Streams
- Lakes

- Forecast

Watershed characterization

de la compacta de la comp

- Pollutant loads

- Impervious areas
- Runoff characteristics

Stormwater

- Built infrastructure
- Surface drainage
- Connectivity

Living Atlas

- Specific implementations
- Watershed delineation
- Downstream tracing
- Floodplain delineation

Customer Specific

- Nebraska DNR
- USFS GRAIP-Lite
- Illinois DNR
- - HEC-HMS - HEC-RAS - ICPR

Scientific model

integration

Arc Hydro Tools Key Concepts

Build foundation for analytical capabilities

- Start with landscape (e.g. terrain)
- Identify drainage patterns
- Define necessary characteristics
- Define node-link representation
- Support scientific/engineering models (I/O)

- While maintaining spatial and referential integrity (collocation, IDs, vector/raster references, remove redundancy in processing, ...)



Product \ Capability Summary

- "No fee" downloadable offerings:
 - Data model
 - Tools
 - Workflows
 - Documentation
 - Available now :

Optional offerings:

Training (paid)

Consulting (paid)

- ArcMap tools all versions up to 10.7.1
- Pro tools all versions up to 2.4
- Web services in the Living Atlas



[To Parent Directory]		
7/21/2014 3:53 PM	<dir> 10.0</dir>	
8/31/2015 3:00 PM	<dir> <u>10.1</u></dir>	
4/13/2016 10:36 AM	<dir> <u>10.2.x</u></dir>	
3/15/2018 10:28 AM	<dir> <u>10.3</u></dir>	
5/13/2019 9:45 AM	<dir> <u>10.4</u></dir>	
5/13/2019 9:08 AM	<dir> 10.5</dir>	
5/10/2019 2:28 PM	<dir> <u>10.6</u></dir>	
5/10/2019 2:35 PM	<dir> 10.7</dir>	
7/21/2014 3:54 PM	<pre><dir> 9.3 9.3.1</dir></pre>	
1/31/2019 12:20 PM	<dir> Pro</dir>	

 Average of 1000 views per month of the download page

Arc Hydro Data Model and Tool Development General Approach



Water Resources



Arc Hydro Users

- Fed / State / Local Government
 - USGS, FEMA, NWS, EPA, ...
- Water Management Districts
- Defense / Intelligence
- Private consultants
 - Engineering companies
 - Hydro professionals
- Anyone involved in water resources / environmental activities



Arc Hydro Adoption Over the Past 15+ Years

- Arc Hydro: ~ 1,000 views/downloads per month
- Projects: ~ 100 projects for Arc Hydro-related work
- Training: over 1,600 customers reached through ~120 classes for Arc Hydro and H&H on 4 continents
- 2019 Projects (PS)
 - NWS/NWC NWM-based floodplain modeling
 - EPA/USFS GRAIP Lite (watershed scale erosion assessment)
 - Missouri DNR modernization of tracing and characterization services
 - Novel-T (Switzerland) custom training

Arc Hydro Pro Development Plan and Status



Key Driver

Enable our users to efficiently use Arc Hydro within their organization and workflows

- Simplify
- Streamline
- Advance
- Document
- Disseminate
- Engage





Arc Hydro Pro Transition Activities

Design

- GN replacement tools (Trace Network).
- Updated workflows.
- Tool categories
 - Terrain preprocessing.
 - Floodplain delineation.
 - Watershed delineation.
 - Watershed characterization.
 - Modeling / model integration.
- Documentation
 - Tools.

Processes.

- Programming
 - Python first
 - Open source
 - Systematic programming framework
- Testing
 - Tools.
 - Processes.
 - Release.
- Release

Arc Hydro Pro Release Plan Overview

Baseline Critical Functionality – 244 tools



- Activities synchronized with core development teams.
 - Trace Network, Spatial Analyst
- Beta release February 2020 (FedUC)
- Full release July 2020 (UC)

Continuing maintenance and transition of other Arc Hydro tools not in the Baseline

Critical Functionality release – continuous past July 2020

Arc Hydro Applicability Matrix

Industry \ AH	Watershed delineation	Stormwater	Wetlands	Hydrology	Hydraulics	Flood
	and character.					
Transportation			Х	Х	Х	Х
Insurance						Х
AEC	Х	Х	Х	Х	Х	Х
Facilities		Y				Y
management		Λ				~
Local/state	X	X	X	X	X	X
government	Λ	Λ	Λ	Λ	Λ	Λ
Mining		Х		Х		Х
Defense		Х		Х	Х	Х
Environmental	Х	Х	Х	Х	Х	Х
Emergency						
response / public				Х		Х
safety						
Agriculture	Х		Х			



Arc Hydro Demo

Presenter(s)

What's New with Arc Hydro



What's New With Arc Hydro

- Stormwater (not so new already in Pro)
- Wetlands identification model (already in Pro)
- Floodplain analysis and tie into forecasting (NWM) and impact analysis



Stormwater Concepts

- Two "systems" in play:
 - Collection system takes overland flow and places it into the conveyance system.
 - Conveyance system takes the collected water and moves it through
- These systems interact through open channels and inlets.
 Overland flow does NOT interact with pipes directly



Stormwater delineation - pipe

Global (in the pipe)

Local (same as land)



Stormwater delineation - stream

Global







Wetlands Identification Model

Machine leaning approach to wetlands identification using geomorphological characteristics based on Lidar-derived DEM



🔺 🛃 We	etland Identification
E	Assess Accuracy
E	Calculate Curvature
l II	Calculate Depth to Water Index (DTW)
l I	Calculate Topographic Wetness Index (TWI)
l II	Hydrocondition High Resolution DEM
l I	Run Random Trees
l I	Smooth High Resolution DEM
l I	Train Random Trees
E	Train Test Split
200	Wetland ID Workflow

Wetlands Identification Model



Flood Impact Forecasting

WHEN:

National Water Model

Arc Hydro Tools 🗞 Arc Hydro Setup + Search Attribute Tools + Solution Contraction Contractic Contract + 🖃 🗞 H & H Modeling Section Characterization + 🗞 Floodplain Delineation + SeolCPR + 🗞 Green and Ampt + 🗞 Map to Map + 🗞 Streamstats + 🗞 Time of Concentration +

WHERE:

Arc Hydro Tools

🗄 🚳 Utility

WHO: Local County GIS Data



Dave Sekkes, Chester County EOC

WHO: Flood Impact Short Range Forecast Ops Dashboard



Dave Sekkes, Chester County EOC

Getting Involved



Getting involved

- Arc Hydro GeoNet:
 - https://community.esri.com/community/gis/solutions/arc-hydro
- archydro@esri.com
- <u>ddjokic@esri.com</u>
- Soon to be released industry pages for Arc Hydro and water resources



Work in Progress

Goal for Pro 2.6 (summer 2020)

- Completion of code transfer for baseline capability
- Model integration (HEC-RAS, HEC-HMS, ICPR4)
- Floodplain and impact assessment tools and workflows
- Documentation, documentation, documentation
 - Getting started with Arc Hydro
 - Domain specific workflows, docs
- Prioritization of further updates
 - Talk to us!!!



Questions?



Print Your Certificate of Attendance

Print Stations Located in 150 Concourse Lobby

Tuesday

12:30 pm – 6:30 pm Expo Hall B

5:15 pm – 6:30 pm Expo Social Hall B

Wednesday

10:45 am – 5:15 pm Expo Hall B

6:30 pm – 9:30 pm Networking Reception Smithsonian National Museum of Natural History

Please Share Your Feedback in the App

