Rapid Post-Fire Watershed Assessment using the AGWA (Automated Geospatial Watershed Assessment) Tool

USDA ARS

Southwest Watershed Research Center
Tucson, Arizona

NATIONAL INTERAGENCY TEAM
BAER
Burned Area Emergency Response

Primary Contributors

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OVERVIEW

- AGWA Background
- Modeling Post-Fire Response
- Effects of rainfall representation model results
- Summary & Lessons Learned

AGWA – Background - Basics

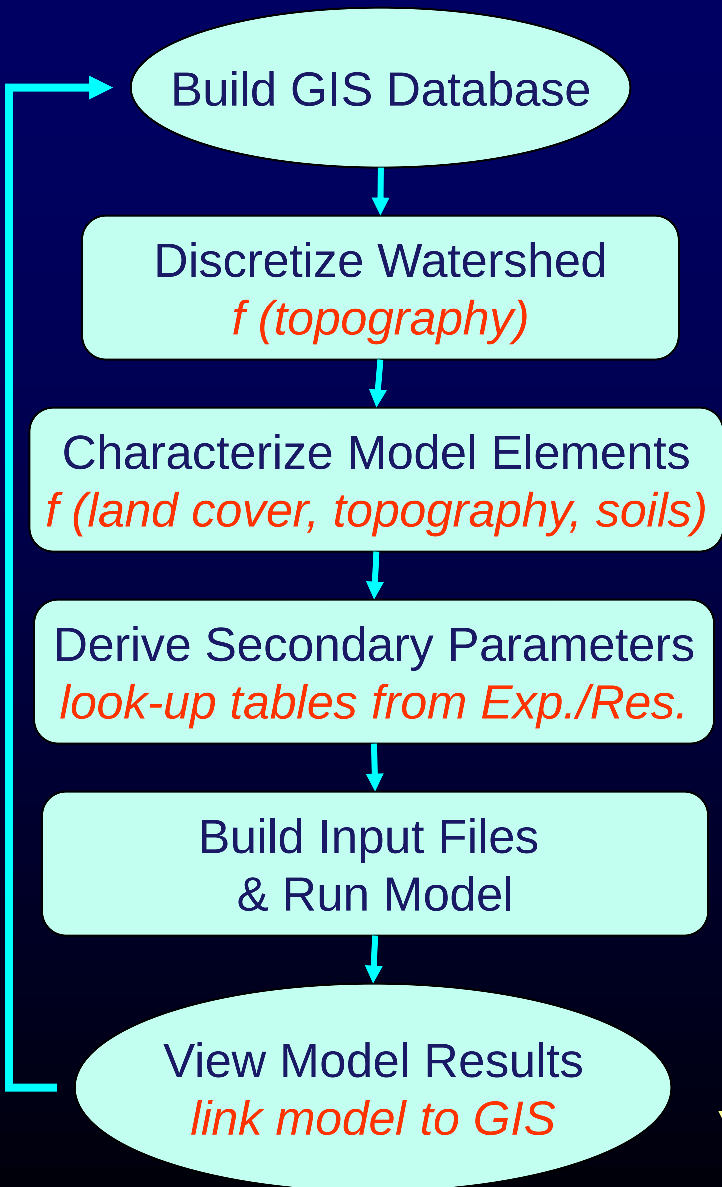
- **An <u>automated GIS interface</u> for watershed modeling (hydrology, erosion, WQ) designed for resource managers**
- **Applicable to ungauged / gauged watersheds**
- **Operates with nationally available data (DEM, Soils, Land Cover)**
- **Investigate the impacts of land cover change**
  - **Historical and future**
  - **Identify sensitive, "at-risk" areas**
  - **Assess impacts of management (e.g. growth, fire, mulch)**
- **Provide repeatable results for relative change assessments**
- **Three established watershed/hillslope models for multiple scales**
  - **SWAT for large basins, daily time steps**
  - **KINEROS2 for small-medium basins, sub-hour time steps**
  - **WEPP and RHEM for hillslope runoff and erosion**

SWAT Soil & Water Assessment Tool

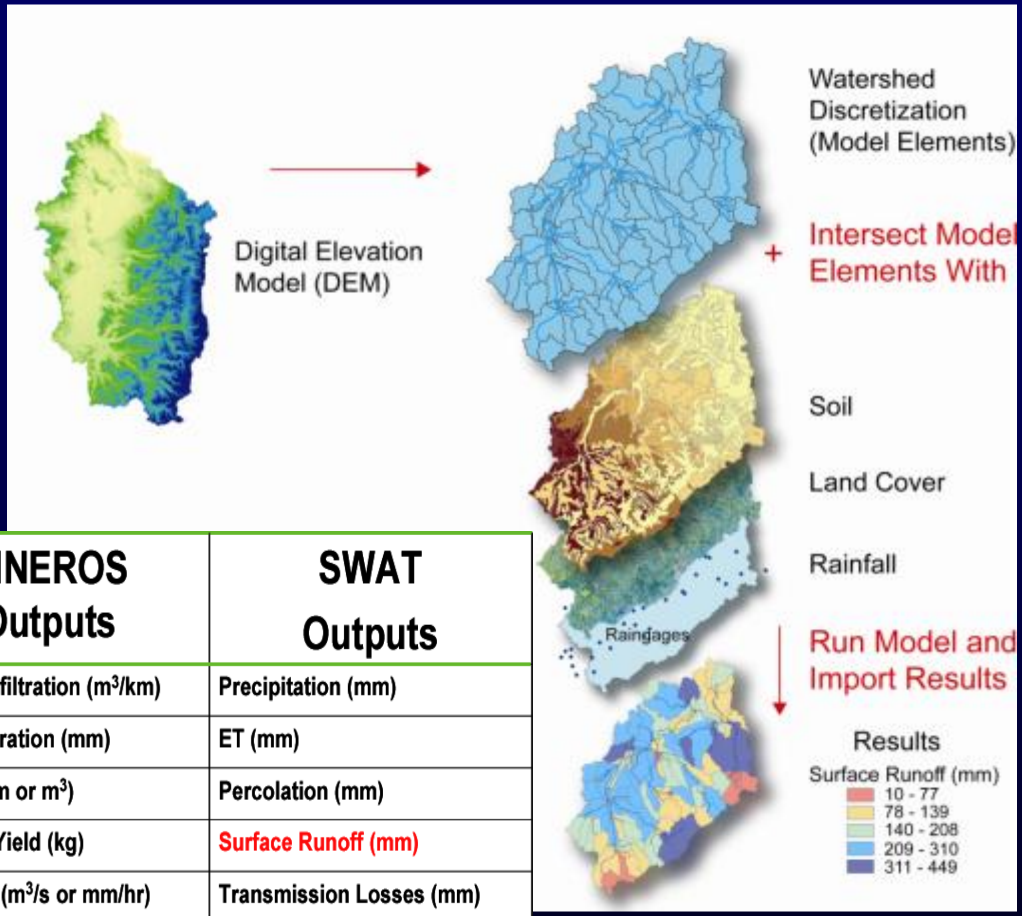
KINEROS2 A KINEMATIC RUNOFF AND EROSION MODEL

Conceptual Design of AGWA

PROCESS

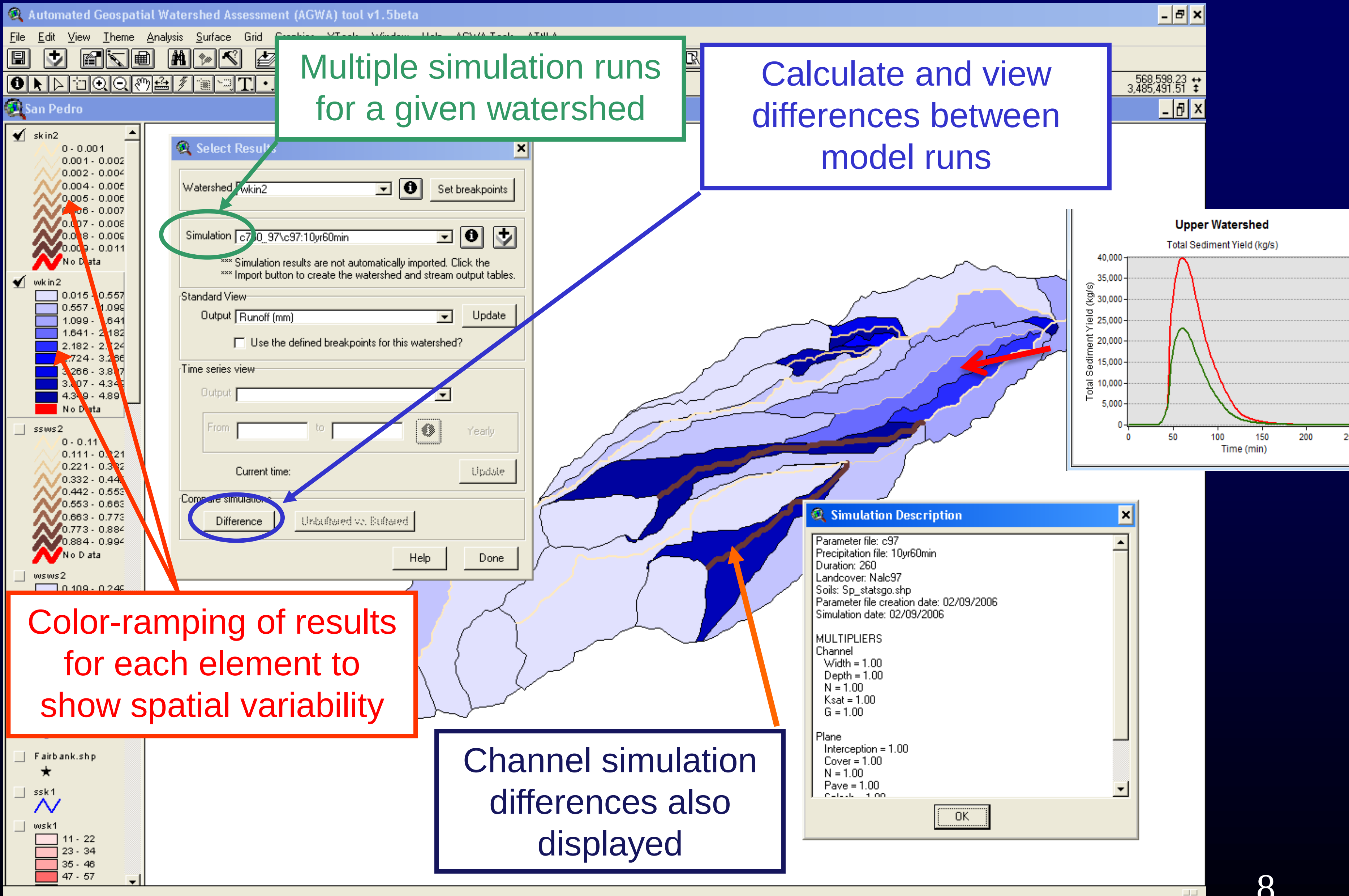


INPUTS & OUTPUTS



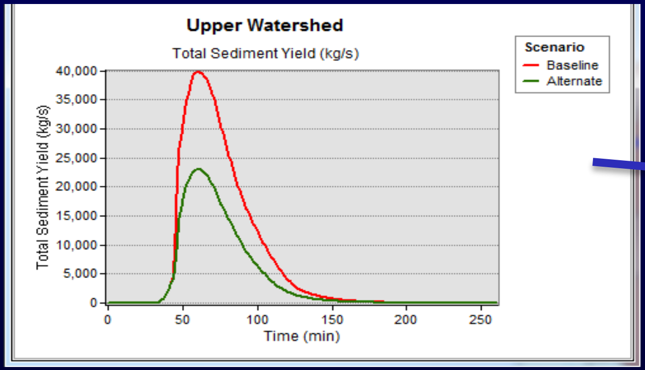
KINEROS Outputs	SWAT Outputs
Channel Infiltration (m^3/km)	Precipitation (mm)
Plane Infiltration (mm)	ET (mm)
Runoff (mm or m^3)	Percolation (mm)
Sediment Yield (kg)	Surface Runoff (mm)
Peak Flow (m^3/s or mm/hr)	Transmission Losses (mm)
Channel Scour (mm)	Water Yield (mm)
Sediment Discharge (kg/s)	Sediment Yield (t/ha)
	Nitrate in Surface Runoff (kg N/ha)
	Phosphorous in Surface Runoff (kg P/ha)

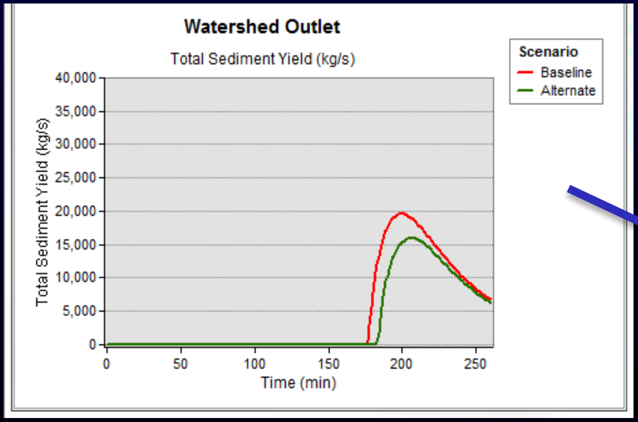
Visualization of Results

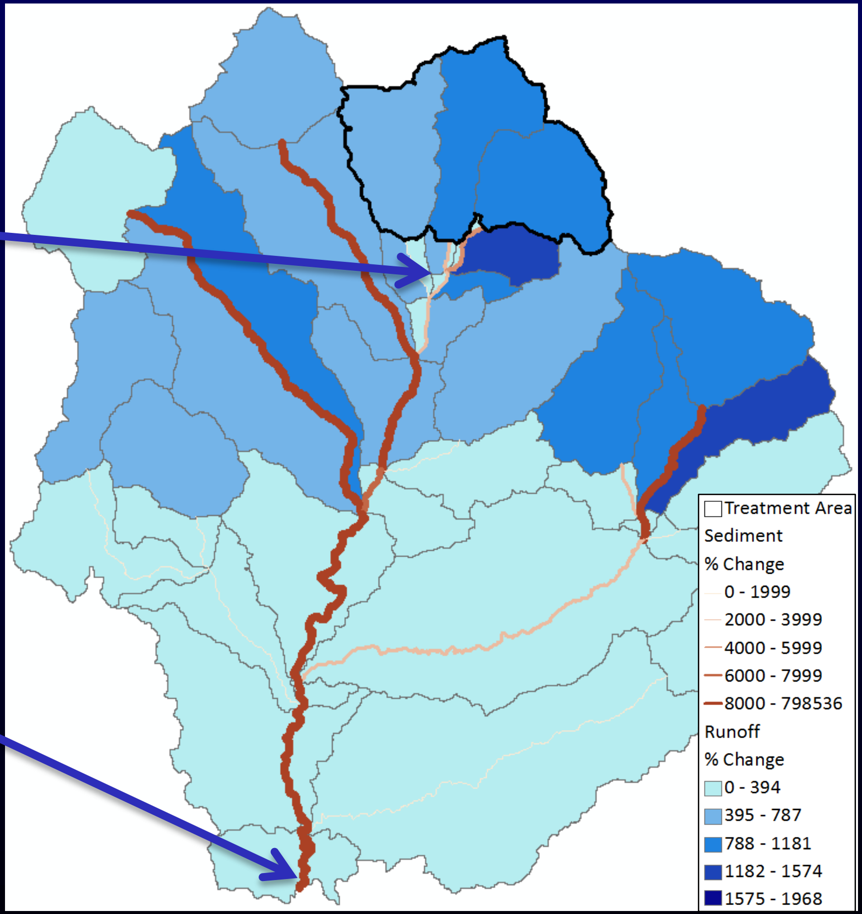


Visualization of Results

- Results are written for all hillslope and channel model elements
- The last channel segment in a watershed represents the response for the entire watershed.
- Graphs (discharge, sediment yield can be created for different sections of the watershed and compared.



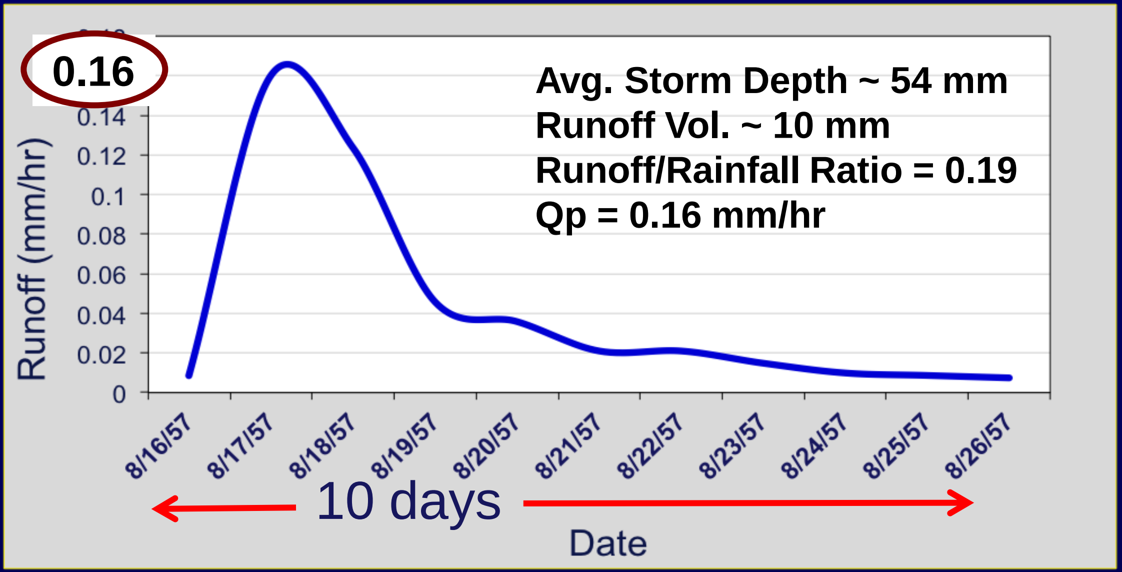




Marshall Gulch

Pre - Fire Hydrograph

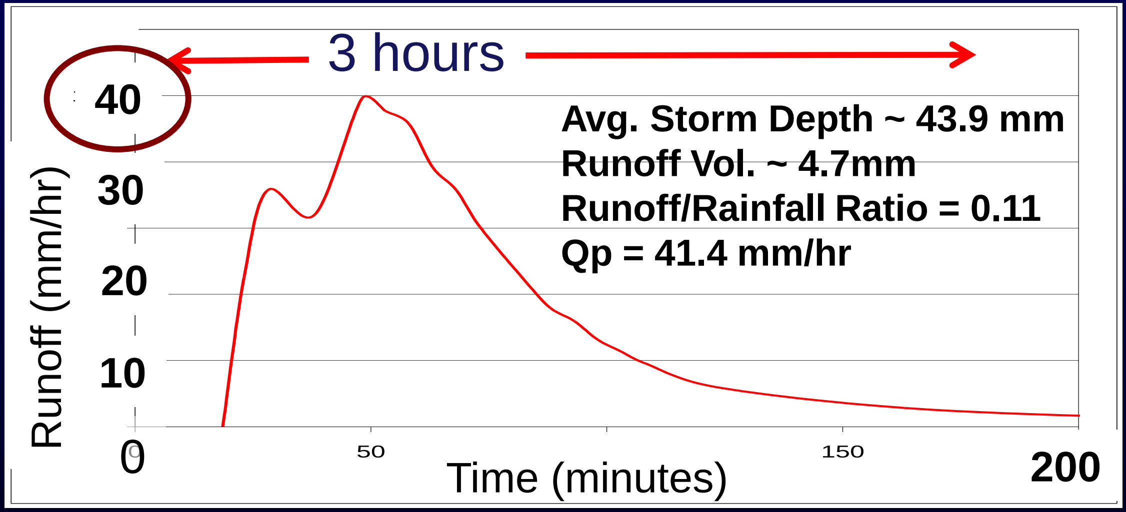
8/16/57 – 8/26/57



Post - Fire Hydrograph

7/24/03

(Aspen Fire – 6/17/03 ~ 7/10/03)



Runoff / rainfall ratio similar; time & peak runoff rate are profoundly different (also noted by Springer & Hawkins 2005; McLin et al. 2001).

Post-Fire Assessments

- Define look-up table for pre- and post-fire model parameters as a f (land cover & burn severity) from well gaged basins
  - SWAT (CN, roughness)
  - KINEROS2 (roughness, Interc., cover, Sat. Hydraulic Cond.)

- Pre-fire data and simulations can be done for any given watershed at any time or in run up to BAER deployment

- Directly import post-fire burn severity map as a shape file

- Run model with same rainfall input as pre-fire simulation

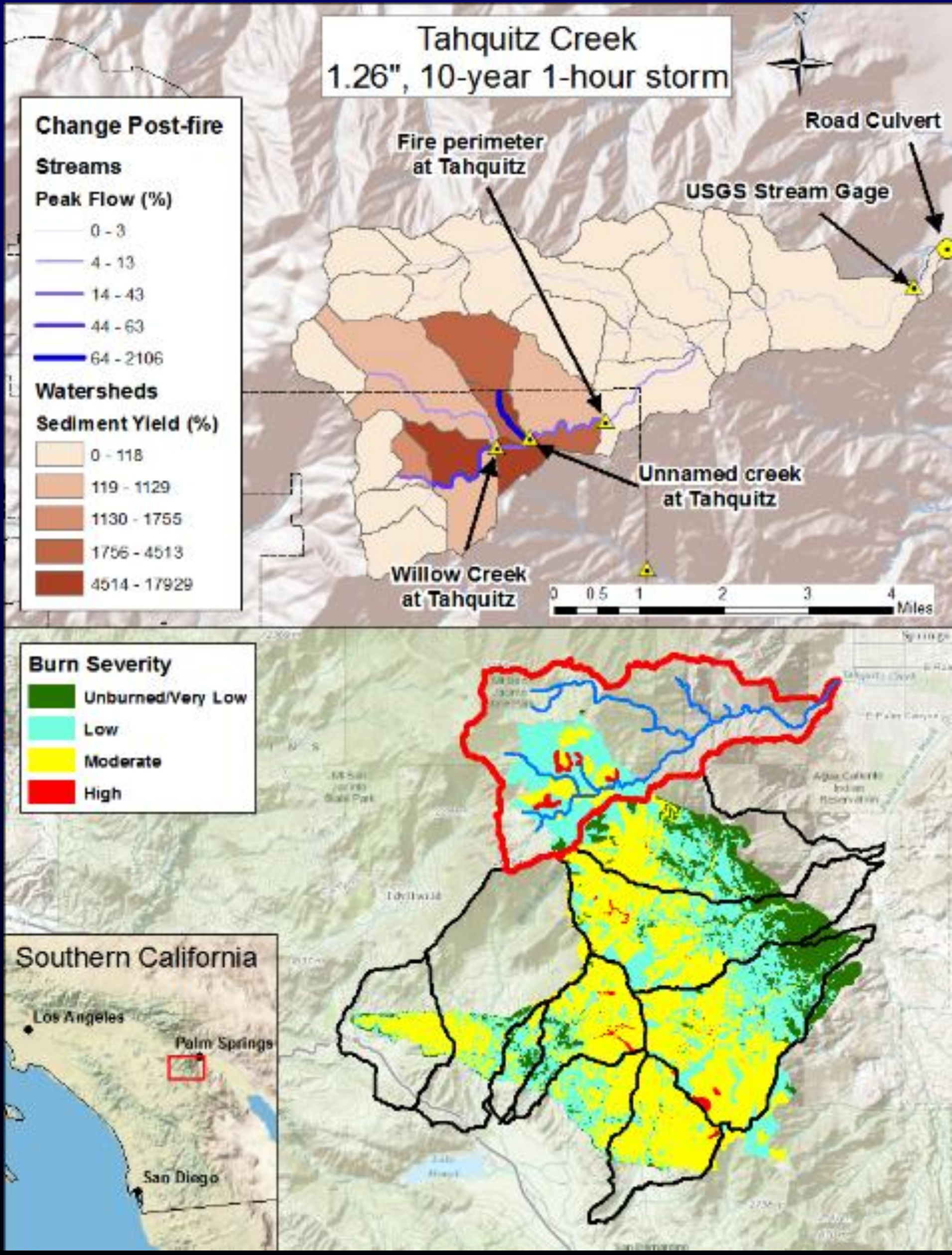
- Difference post- and pre-fire simulations and spatially display results

- Allows rapid visual recognition of watershed areas most prone to post-fire impacts so mitigation and remediation can be targeted

Mountain Fire nr Palm Springs – AGWA/K2 Results

Aug. 12, 2013

- I.D. points of interest (POI)
- Discretize watersheds to these points
- Simulate pre-fire conditions with SCS Type II spatially uniform storm
- Import burn severity map
- Simulate post-fire (same storm)
- Difference pre- and post-fire simulations
- Results served BAER purposes (Becky Bigelow)



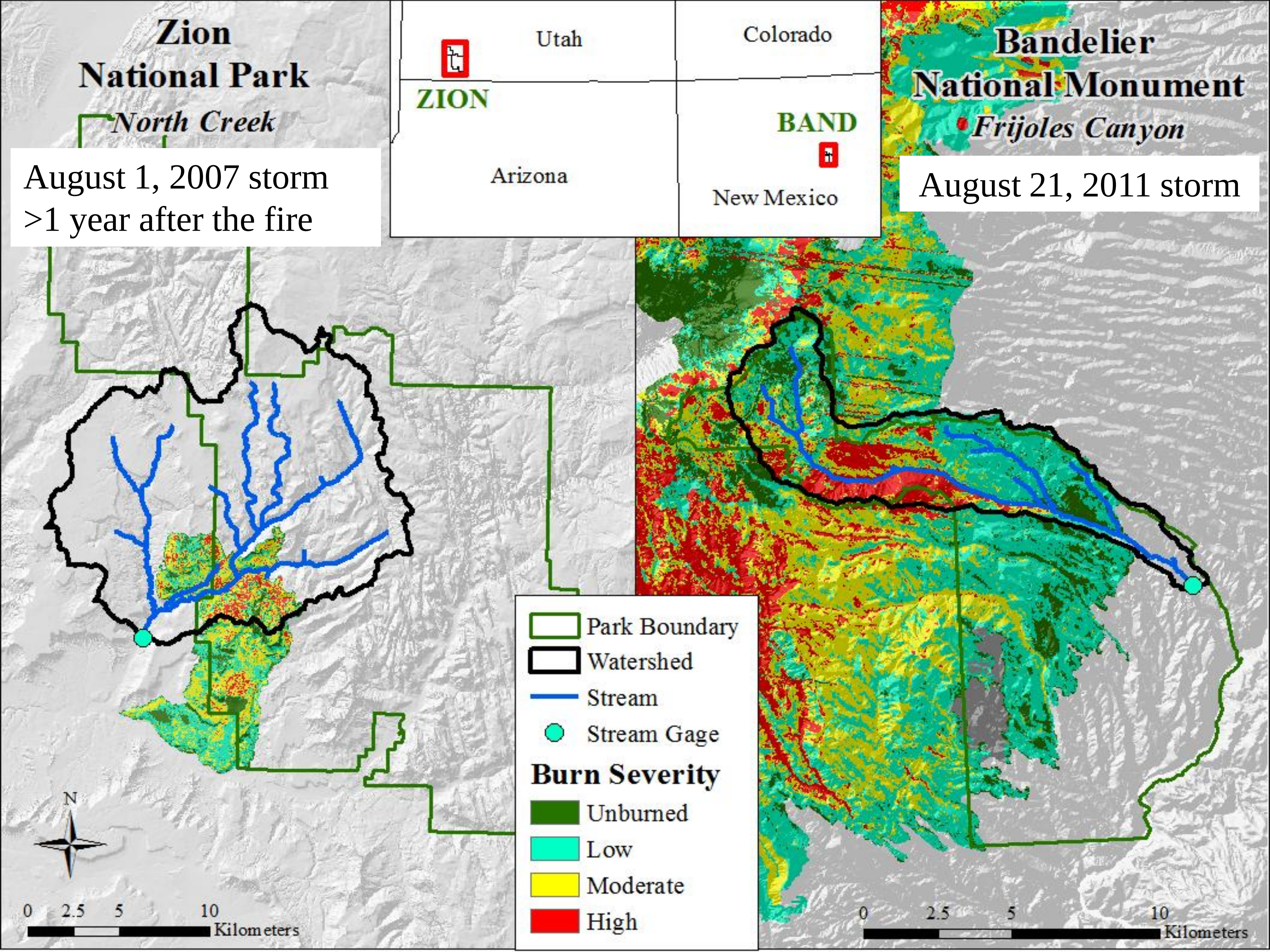
How should rainfall be input into the model?

Typical goals when modeling post-fire runoff

1) Accurately predict or reproduce magnitude of an event

2) Predict which stream reaches and hillslopes are at risk (values at-risk)

How does rainfall representation affect our ability to meet these goals?

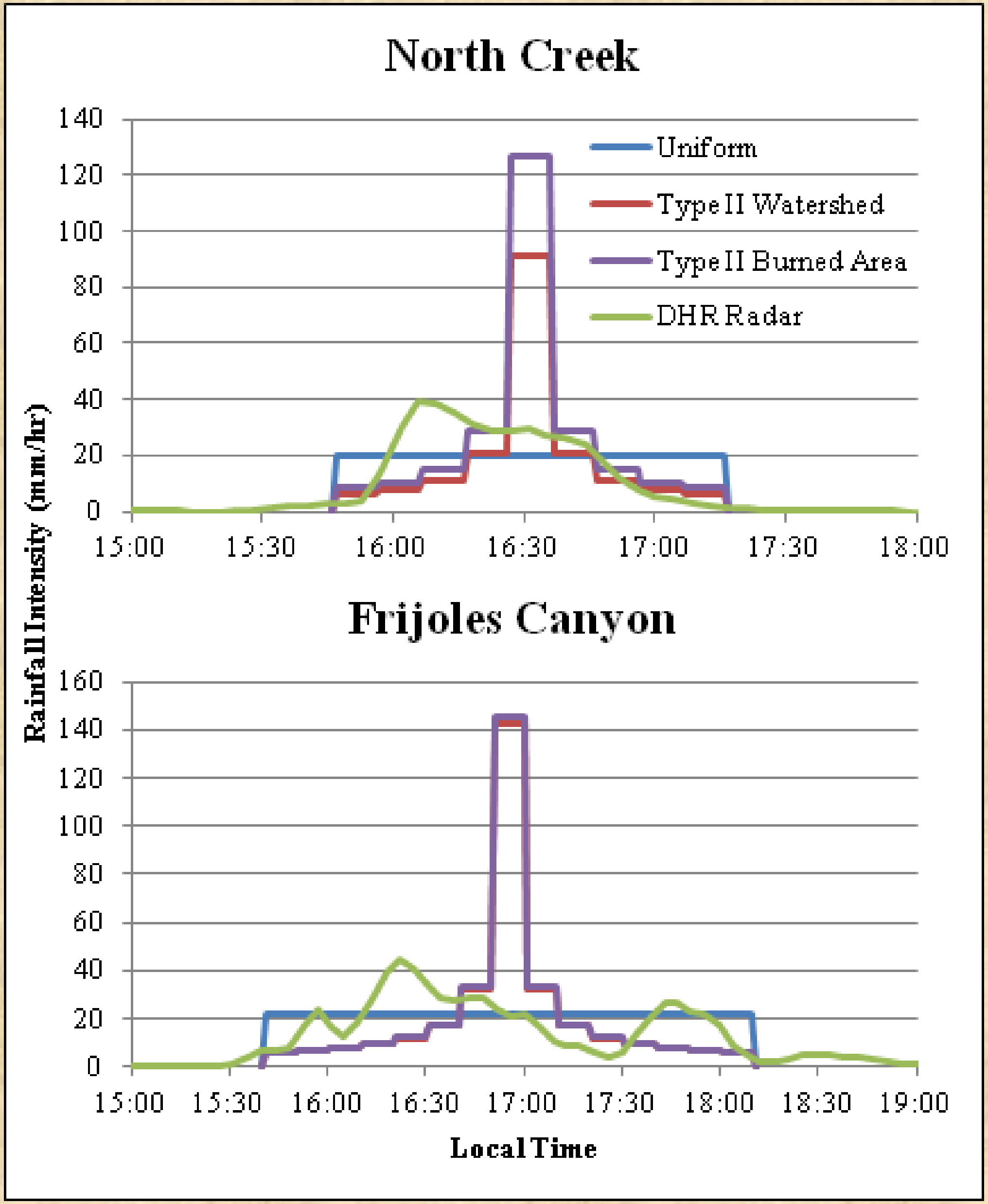

Zion
National Park
North Creek
August 1, 2007 storm
>1 year after the fire
Utah
Colorado
ZION
BAND
Arizona
New Mexico
Bandelier
National Monument
Frijoles Canyon
August 21, 2011 storm
Park Boundary
Watershed
Stream
Stream Gage
Burn Severity
Unburned
Low
Moderate
High
N
0 2.5 5 10
Kilometers
0 2.5 5 10
Kilometers

Reproducing Post-fire Flood Magnitude

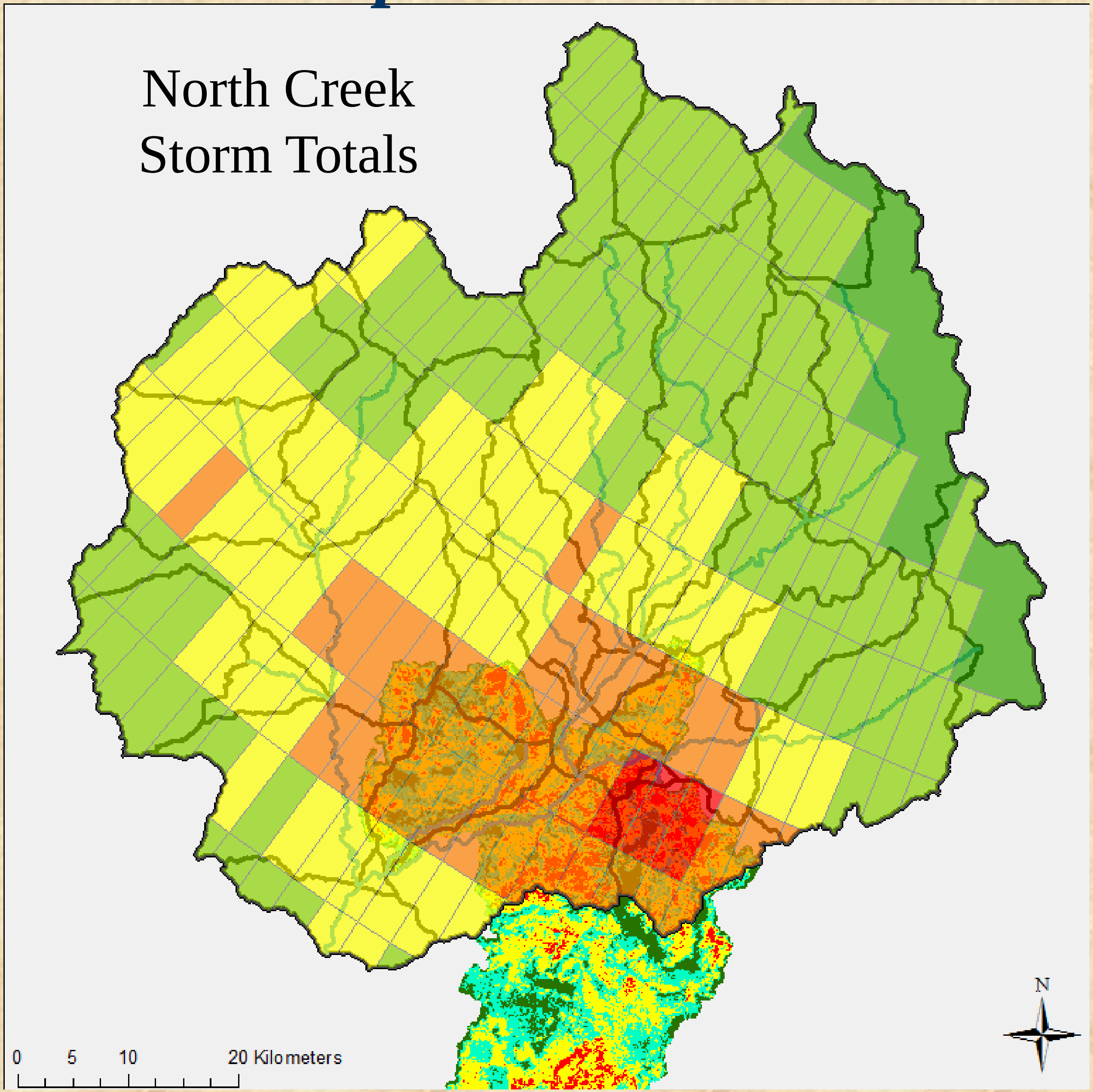
What rainfall representation gives us the best estimate of peak discharge?

Rainfall Representations modeled:

1. Uniform rainfall intensity over the entire watershed
2. SCS Type II storm over the entire watershed
3. SCS Type II storm centered over the burned area
4. Digital hybrid reflectivity (DHR) radar data



Radar Representation in KINEROS2



- Average rainfall depth over watershed: 30.22mm (1.19”)
- Approximate duration of event: 1.5 hours
- Correlates to ~10-year rainfall event

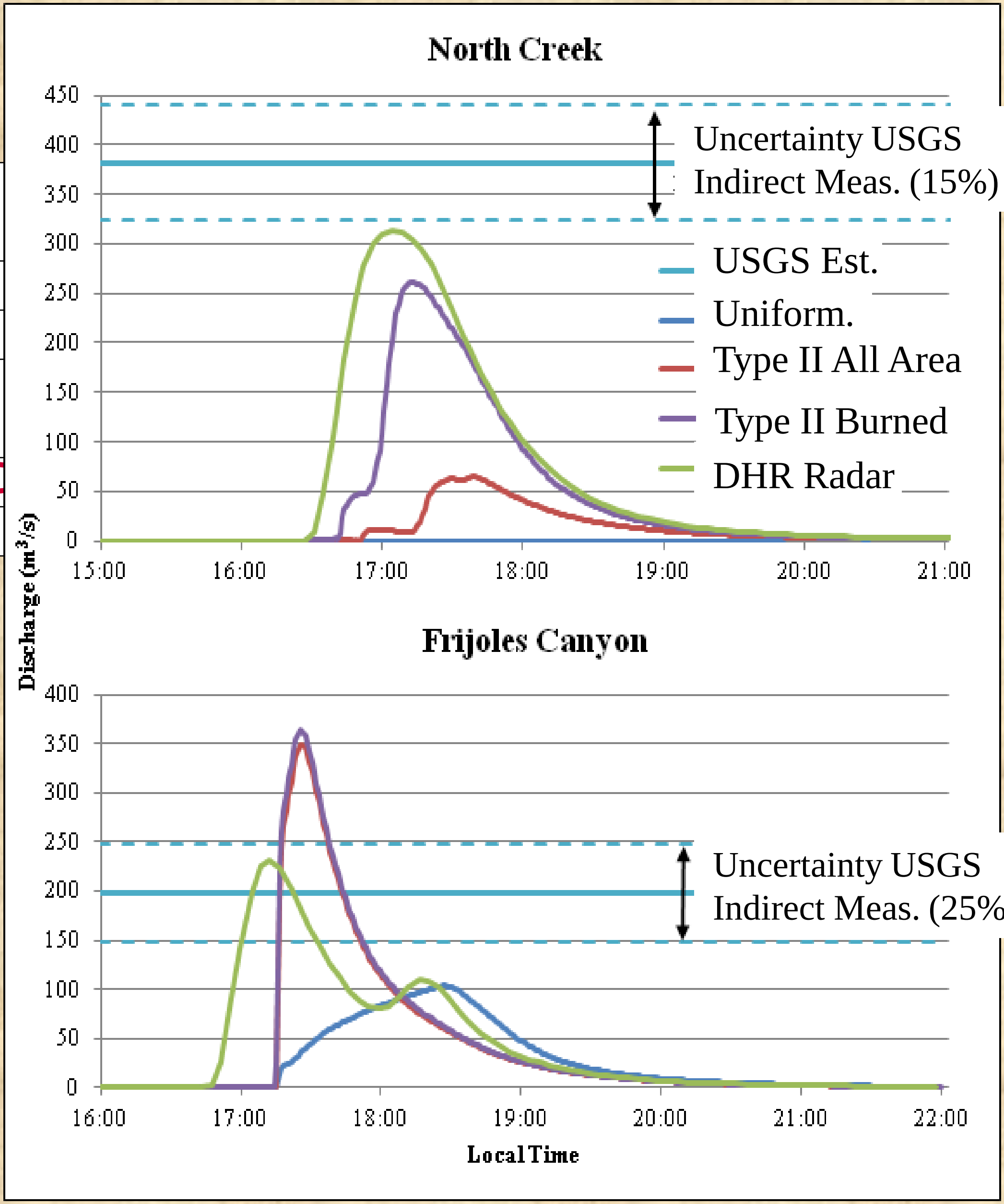
Storm Totals

Rainfall Depth (mm)

- 0.000000
- 0.01 - 25.4
- 25.41 - 50.8
- 50.81 - 76.2
- 76.21 - 82.3

Post-fire Magnitude: Results

Rainfall Representation	Peak Discharge (m3/s)	Time to Peak (min)
Uniform	2.53	355
Type II	64.69	215
Type II Burned Area	261.23	189
DHR Radar	312.91	184
USGS Estimate	382.33	~180-240



Predicting At-Risk Areas

Does rainfall representation change the model's prediction of high-risk areas?

For rapid assessment of post-fire risk, a design storm is used:

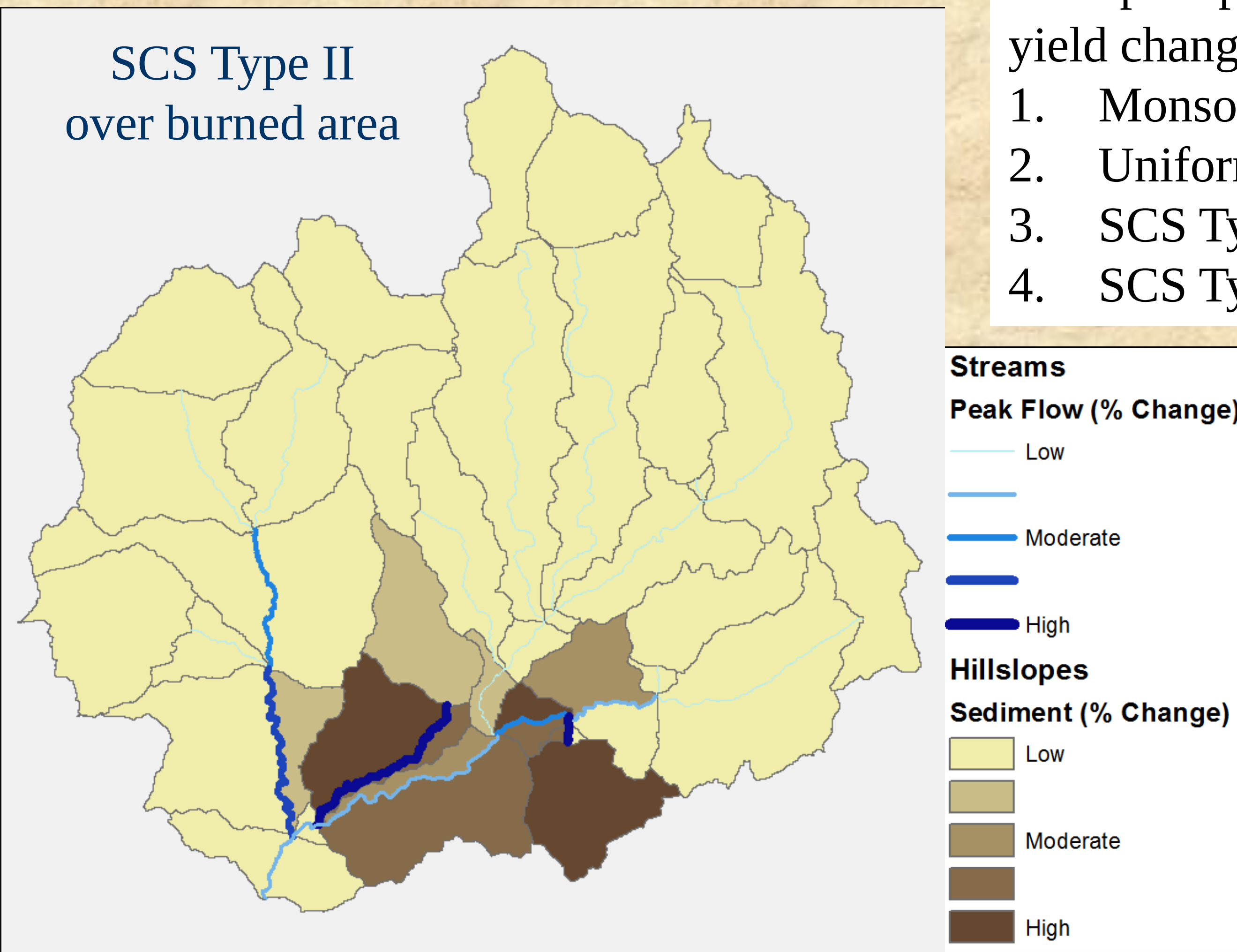
- Monsoon Storm: 2-year 30-minute, 13.18mm (0.52")

Predicting At-Risk Areas

Which stream reaches and hillslopes change the most pre- to post-fire?

Compare peak flow and sediment yield change from 4 storms:

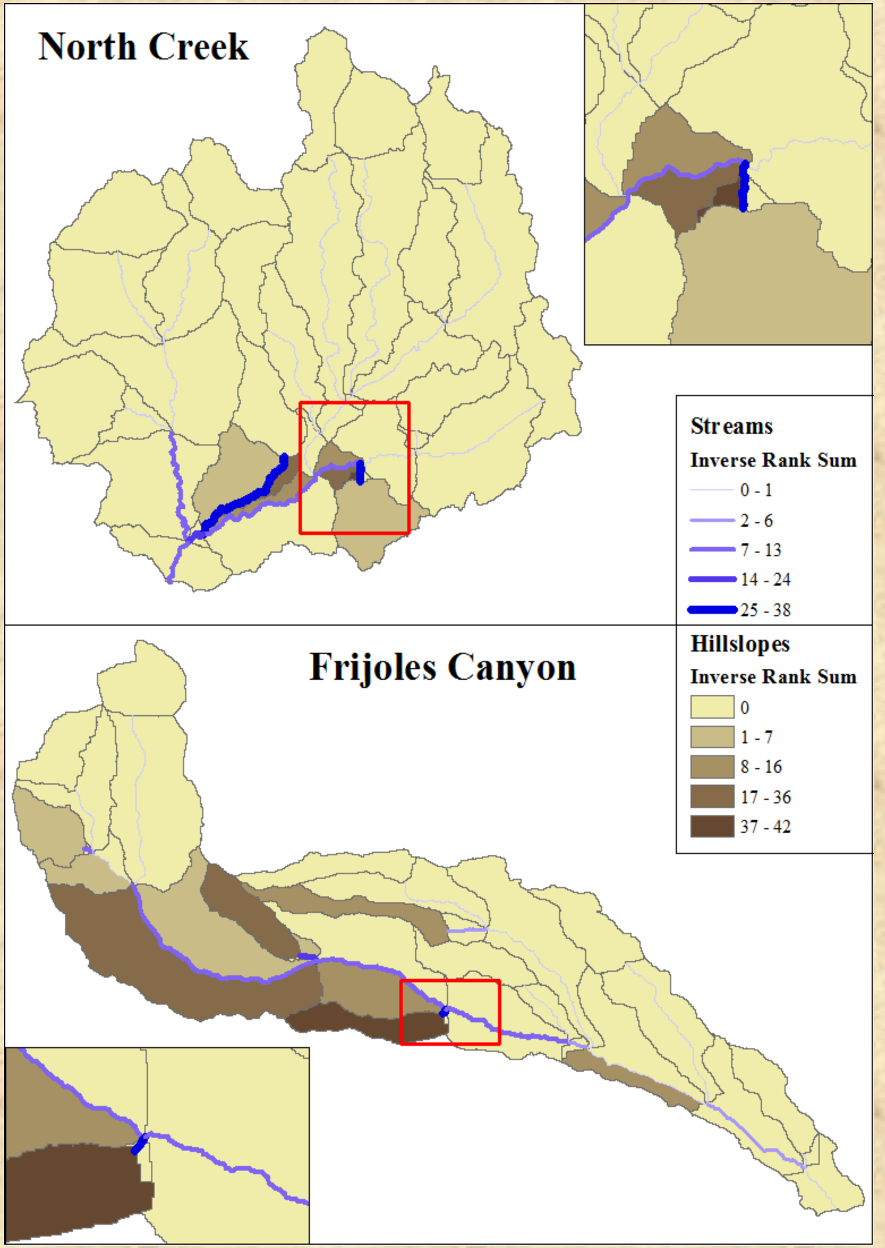
1. Monsoon Storm
2. Uniform Intensity
3. SCS Type II over watershed
4. SCS Type II over burned area



High-Risk Stream Reaches

Map of high risk areas.

To determine if rainfall representation changed the model's predicted areas of high risk, peak runoff rate of stream reaches and sediment yield of hillslopes were ranked from highest to lowest percent change from pre- to post-fire for each rainfall representation.



Comparing Ranking of Risk Areas

North Creek (ZION)			
Peak Flow for Stream Reaches			
Type II Burned Area	0.76	0.66	0.46
0.90	**Type II Watershed**	0.84	0.73
0.89	0.98	**Uniform**	0.88
0.89	0.97	0.99	**Monsoon**
Sediment Yield for Hillslopes			
Frijoles Canyon (BAND)			
Peak Flow for Stream Reaches			
Type II Burned Area	1.00	0.83	0.83
1.00	**Type II Watershed**	0.82	0.85
0.80	0.81	**Uniform**	0.62
0.67	0.68	0.70	**Monsoon**
Sediment Yield for Hillslopes			

Spearman's Coefficients (SC) are generally high (SC = 1 implies a perfect agreement in ranking, SC = -1 corresponds to an inverse in ranking order)

Rainfall-Representation Conclusions

- Rainfall representation drastically changes our ability to accurately model post-fire storm magnitude
- Radar is the best method for modeling magnitude

- High-risk areas do not vary drastically between different rainfall representations

- AGWA/KINEROS2 can reliably be used to predict relative pre- to post fire change to identify these areas

Models are more reliable at predicting relative change than absolute change

Summary

- **AGWA provides framework to quickly parameterize hydrologic / erosion models and visualize the results.**
- **AGWA provides watershed scale assessments for both runoff and erosion / sediment transport at multiple points of potential risk and for all model elements.**
- **Identifying areas at risk is not sensitive to how rainfall is represented.**

Information

AGWA Web Pages:

http://www.tucson.ars.ag.gov/agwa/

http://www.epa.gov/nerlesd1/land-sci/agwa/

Includes:

- Documentation
- Software
- Tutorials
- Pubs / Presentations