Hydrological Modeling of the Potential Impact of a Forest Fire on Runoff in a Mediterranean Catchment

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Background:www.go

Outline

- Mediterranean forest fires and impacts on hydrology
- HEC-HMS model description
- Modeling requirements
- Study site and data
- Calibration of parameters
- Results
- Conclusions
- Applications and significance
- My further steps

Mediterranean forest fires

- rom 2000 to 2005– 95,000 fires in uropean countries
- lmost 600,000 ha of forest burned every ear (Barbosa et al., 2009)
- wo-thirds of fires (65,000) in 5 Euro-Mediterranean countries (Portugal, Spain, rance, Italy, Greece)
- auses of fire – human (accidents or ntentional) and lightning (Konstantinos et l., 2010).

Photos: D.

orest fires and hydrology

mpacts of forest fire on hydrology:

- Combustion of soil organic matter and loss of soil structure
- Conversion of organic compounds into soluble ash
- Potential increase in hydrophobicity & water repellency
- Reduced infiltration
- Increased overland flow
- Greater flow velocities
- Decreased water holding capacity
- Risk of downstream flooding

Water repellent surface after burnin pine needles *(Photo: D. Fox)*

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ɔtruction of vegetation at
pe/landscape scales
ɔ: *D. Fox)*

2) Loss of litter layer decreases infiltration *(Photo: D. Fox)*

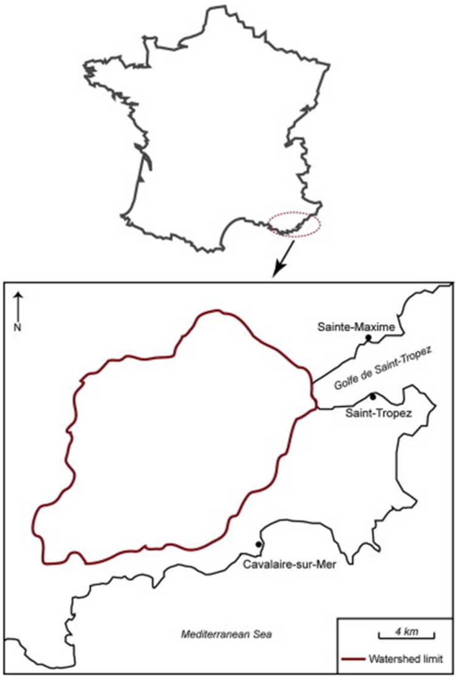
3) Increase in runoff afte
(Photo: D. Fox)

ermath of forest fire: risk of flooding vnstream with potential loss of life and property

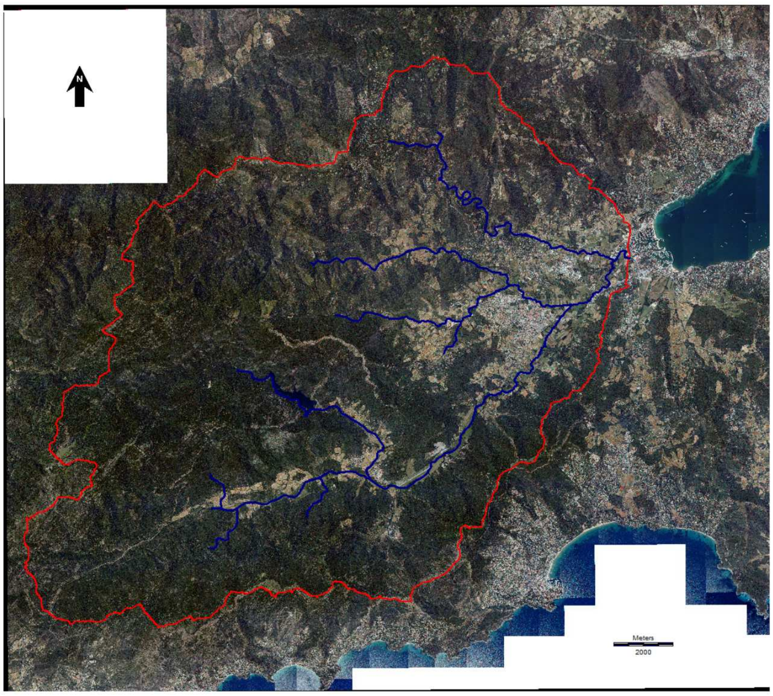
Study Area: Giscle watershed

- Mediterranean Watershed
- Area of 234 km^2
- 70% of watershed is forest
- *Quercus suber* (cork oak), *Pinus pinaster* (pine), *Quercus pubescens* are the dominant trees
- Urban area and vineyards in lowland area

Study Sight: Giscle watershed



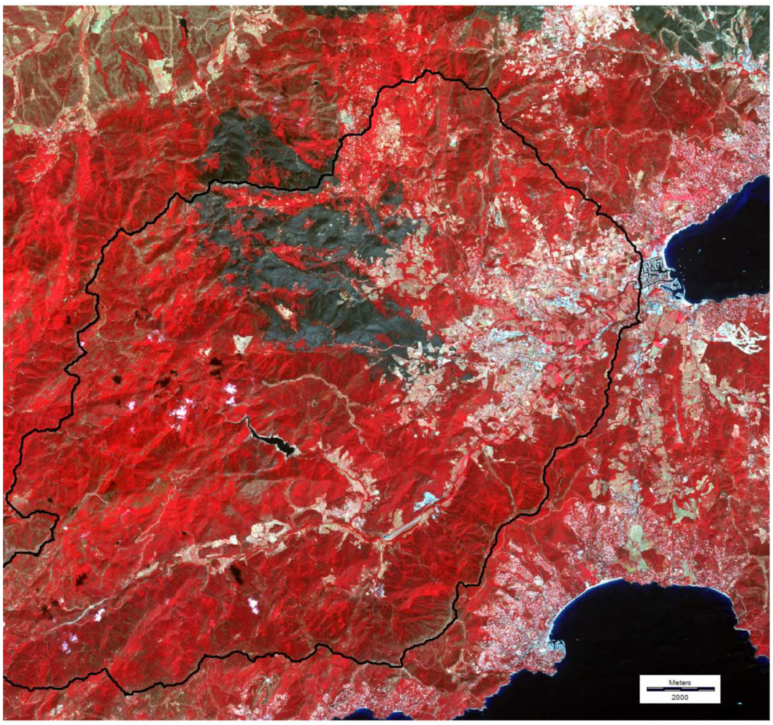
Giscle Watershed



Giscle Watersehd

ennis M., Emmanuelle Witz, Violaine Blanc, Cécile Soulié, Marc Penalver-Navarro, and Alain Dervieux. 2012. "A Case Study of Land Cover Change (1950–200 in a Mediterranean Catchment." Applied Geography 32 (2): 810–21. doi:10.1016/j.apgeog.2011.07.007.

Study Sight: Giscle watershed

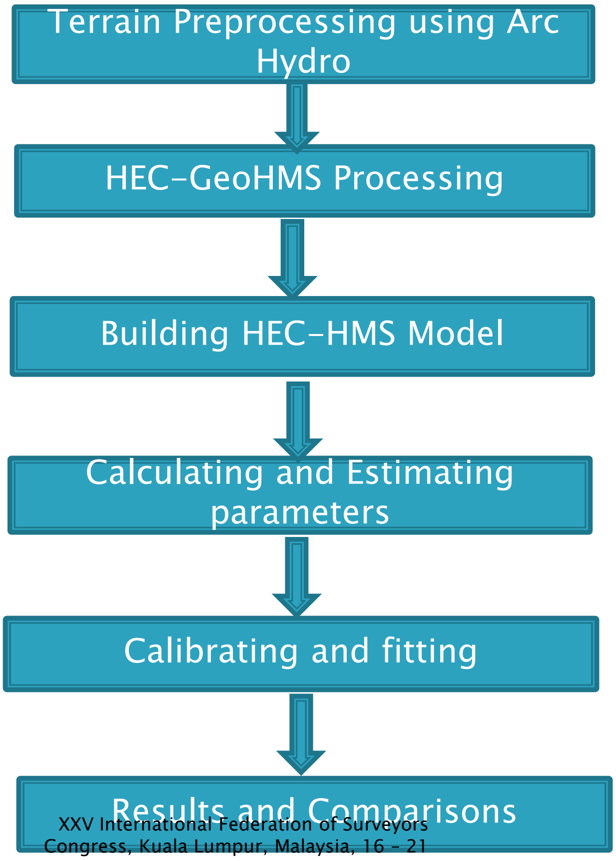


T 5 image of Fire : about 2,000 ha, August 2003

Upper part of catchment burned *(Photos: D.*

M., Maselli F., and Carrega P., 2008. Using SPOT images and field sampling for mapping burn severity and vegetation factors affecting post fire erosion risk. CA 5-335.

METHODOLOGY



HEC HMS

- Computer program developed by US Army Corps of Engineers HEC
- Simulates precipitation-runoff and routing process-natural and controlled
- Allows user to subdivide the watershed into smaller sub basins for analysis and route to corresponding outlet
- Uses separate sub models to represent each component of the runoff process like models that compute rainfall losses, runoff generation, base flow, and channel routing

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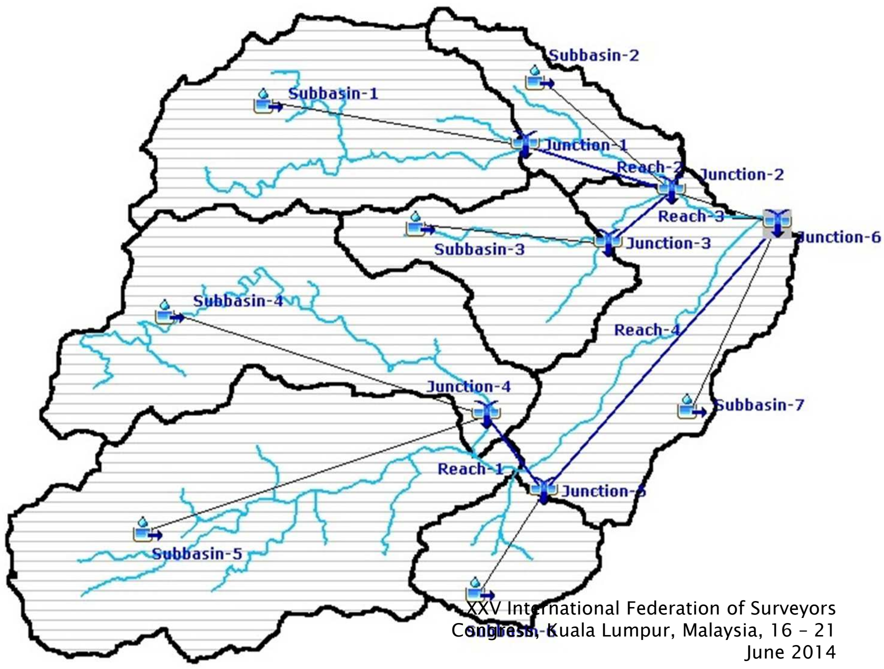
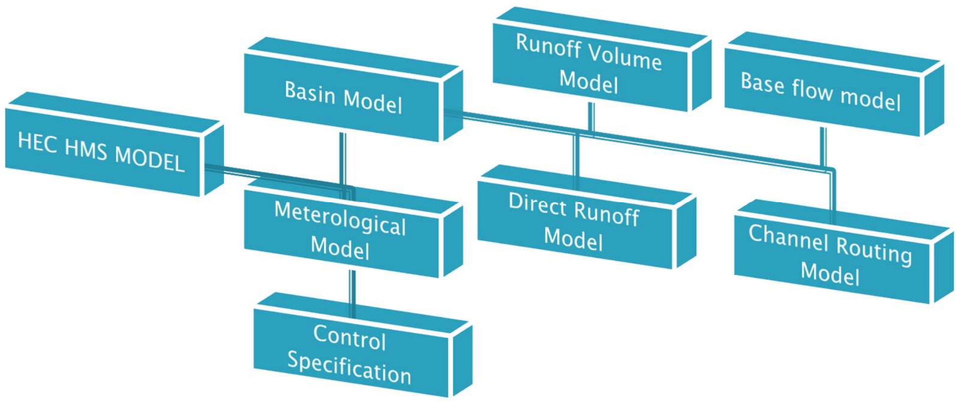
Model Development in HEC HMS



Sub Models used in HEC HMS



Adopted Model, methods and parameters

Model	Method	Estimated Parameters
Runoff Volume Model (Loss)	SCS Curve Number	Initial Abstraction, Curve Number, Impervious rate
Direct Runoff Model (Transform)	Clark Unit Hydrograph	Time of Concentration, Storage Coefficient
Base flow Model	Recession	Initial Discharge, Recession Constant, Threshold Flow
Channel Flow Model	Muskingum Routing	Muskingum K and X

Parameters

- Transform method: Clark Unit Hydrograph Model

Time of Concentration (min)

Kirpish's equation : $T_c = 0.0195L^{0.77}/S^{0.385}$

L = flow length (m)

S = average slope along the flow path

- Loss method: SCS Curve Number

Initial abstraction (mm)

$I_a = 0.2*S$

S = (25400 – 254*CN)/CN

Parameters

<u>Routing method: Muskingum</u>

Muskingum's parameters K

K= L/u

L = flow lenght

U= flow velocity

Muskingum's parameters X

$0 \leq X \leq 0.5$

CN LOSS	SB1	SB2	SB3	SB4	SB5	SB6	SB7
Initial Abstraction	58.5	48	51.5	58.5	57	57	45
SCS CN	40.7	40.3	36	40.7	37.6	33	36.3
Impervious	0	0	0	0	0	0	0
CLARK UNIT HYDROGRAPH							
Time of Concnt.(Hr)	46.77	37.9	33.21	66.19	52.51	21.33	50.94
Storage Coff (Hr)	4.6	3.7	3.3	6.6	5.2	2.1	5.0
RECESSION *							
Initial Discharge(m^3/s)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Recession Constant	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Threshold Ratio	0.1	0.1	0.1	0.1	0.1	0.1	0.1
MUSKINGUM	REACH1	REACH2	REACH3	REACH4			
K(hr)	1.05	4.22	2.23	8.83			
X(hr)	0.1	0.1	0.1	0.1			

Methods and their parameters involved for normal condition

Selection of storm

Storm I

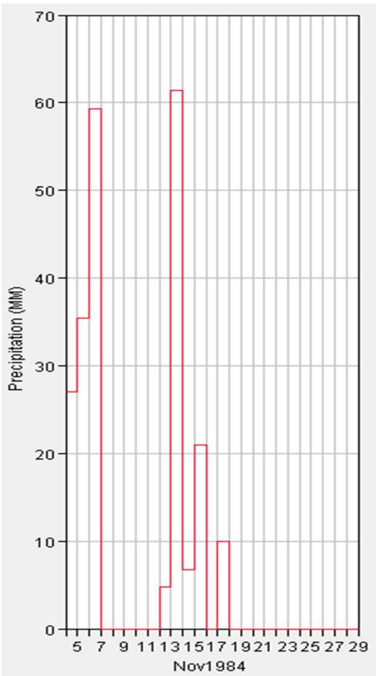
- 4^{th} Nov–29^{th} Nov 1984
- Two peak rainfall in 9^{th} and 15^{th} Nov.
- Two peak discharge
- Not wet environment
- Low initial soil moisture

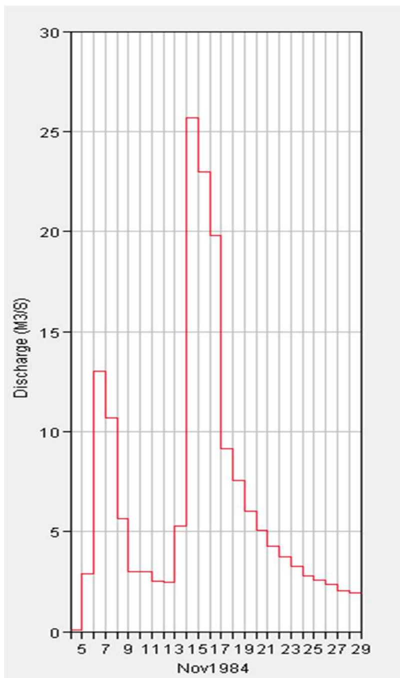
Storm II

- 13^{th} April 1976 to 22^{nd} April 1976
- Only one peak discharge
- Wet environment
  - –second rainiest time of year
  - –Observing rainfall data before two week
  - –Hence correction was applied in CN

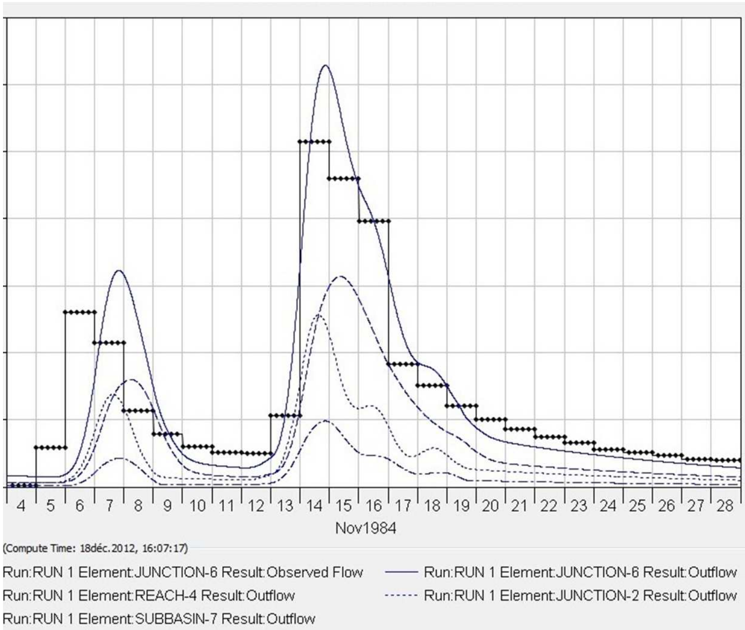
ɔrm I (before fire)

ecipitation and
scharge plotted
ainst time for Storm I





Storm I (before forest fire)

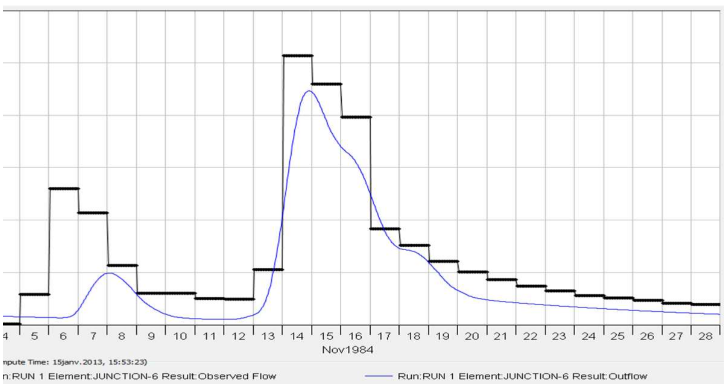


Result obtained without calibration

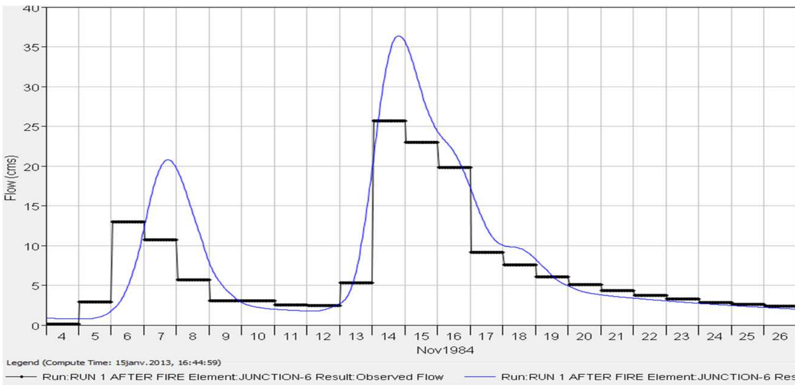
Sub Basins	Curve Number	Initial Abstraction
1	56.2	39.6
2	45.8	60.1
3	44.5	63.4
4	39.9	76.5
5	37.6	84.2
6	32.9	103.7
7	36.2	89.4

Changed parameters for normal condition a forest fire

Storm I



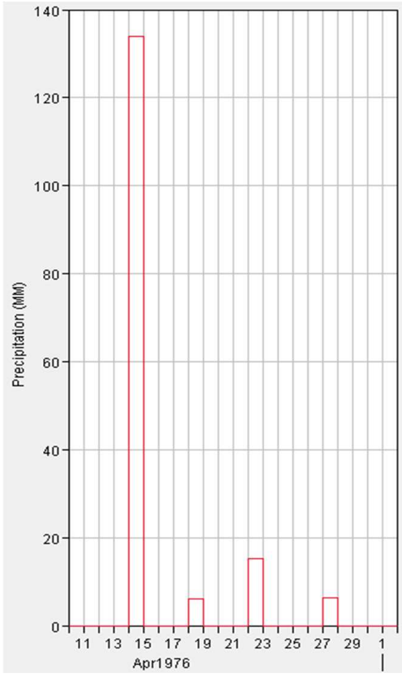
ılt obtained after calibration (before forest fire)

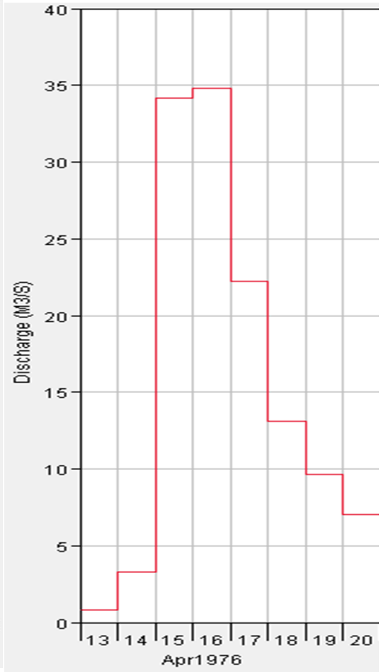


Storm after forest fire

Storm II

ecipitation and
scharge plotted against
ne for Storm II





Storm II

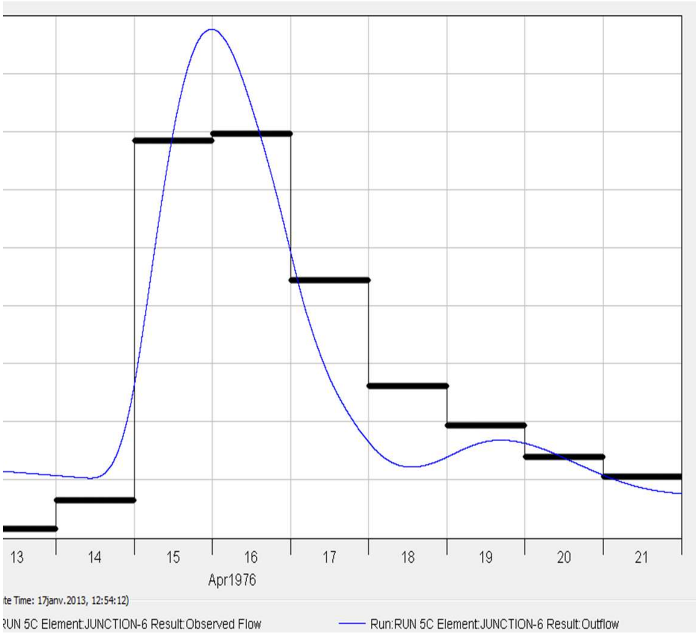
Sub Basins	Curve Number	Initial Abstraction
1	61.02	74.63
2	60.32	76.83
3	56.29	90.70
4	60.42	76.51
5	58.08	84.30
6	53.00	103.60
7	56.61	89.53

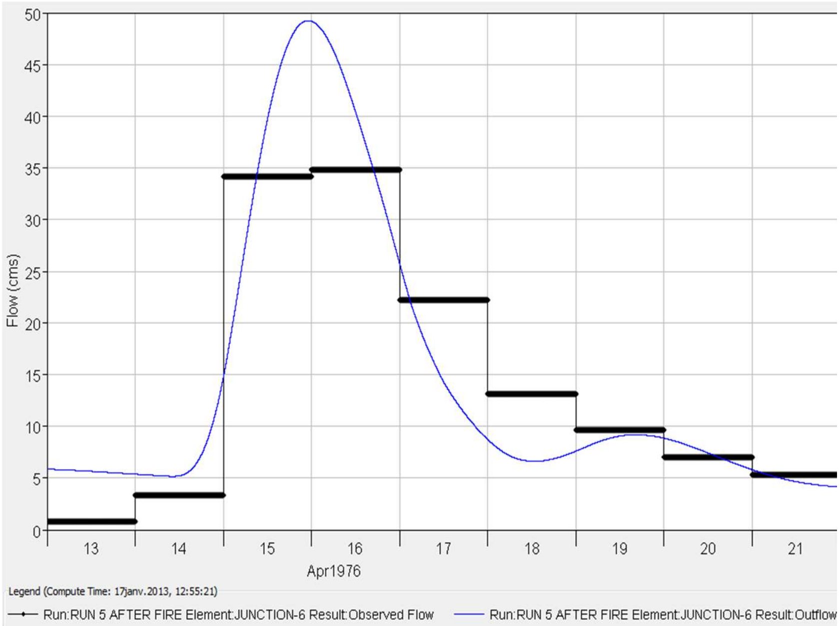
Changed parameters for wet condition before forest fire

Sub Basins	Curve Number
1	74.69
2	65.48
3	64.84
4	60.42
5	58.08
6	53.00
7	56.61

Changed Curve Number for wet condition a forest fire

Storm II





Second Storm before forest fire

Second Storm after forest fire

Conclusion

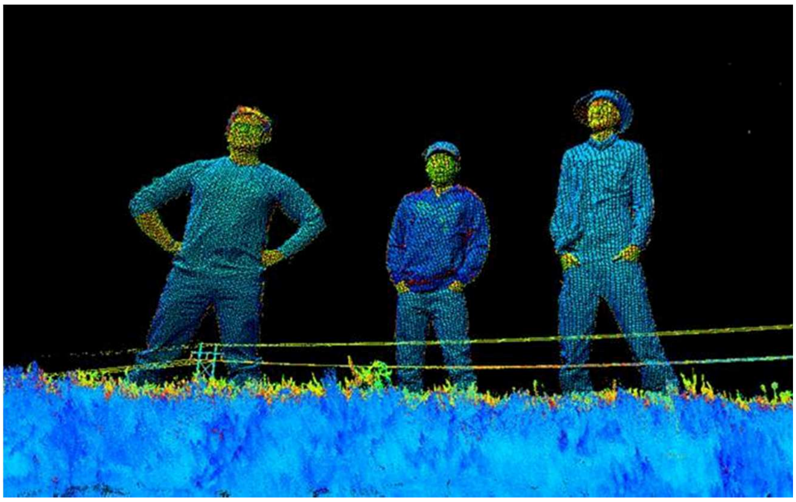
- After forest fire, peak discharge increased in the range 10%–50%
- In some instances, discharge rate was not in sync with precipitation
- Soil moisture amongst others was the possible cause
- Curve number varies from normal to wet condition
- Sensitivity analysis of the parameters is crucial for calibration
- Model can be improved by estimating the effect of soil moisture condition before the event and modeling for longer period

Application and Significance

- Early warning system
- Can be used to predict flood risk and possibly save loss of life and property
- Attempted in Mediterranean region but can be used elsewhere
- Helps in mitigating the loss or building the protection in low cost
- Prevents erroneous flood forecasting

My further study

- Research in remote sensing
- Boise Center Aerospace Laboratory
- Scaling up plot level data to Lidar (ALS) scale
- Using TLS and ALS
- Might use statistical approaches like Random Forest, Baysein Hierarchical or even simple regression



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