Approaches for predicting flash flood potential using GIS assisted spatial-hydrologic modelling

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Flash Flooding

• Flash Floods are defined as rapid unexpected inundation, generally within six hours of an intense precipitation.

• Over past few years, we had several incidences of extreme events, for example, flash floods in Toowoomba and Sunshine Coast.
Spatial variables influencing flash flooding

- Rainfall
- Runoff
- Drainage network characteristics
- Catchment morphology
- Catchment response to runoff
- Channel size and geometry
- Catchment slope
- Stormwater management infrastructure
Derived variables for flash flood prediction

• Many catchment based characteristics can be derived from DEM
• Techniques such as LiDAR can provide a high resolution DEMs
• The drainage network as well as sub-catchment boundaries can be derived from such DEMs
• Other datasets such as slope, land use, etc. can be easily obtained
• These methods are often used to determine areas prone to flooding with ArcGIS or open source GIS such as GRASS.
Open source software to derive catchment characteristics: Basinsoft

This model is based on DEM and easy to run or the indices can be calculated with GIS software. This will provide various indices that can be related to stream flow and flood.
Hydrological Models for Flash Flooding

• Traditional method for flood analyses mainly include
  – Hydrologic modelling that simulates catchment runoff from rainfall and stream flow accumulation
  – Hydraulic modelling that computes water surface elevation from stream flow.

• Integration with GIS considers changes in terrain and land use thereby offering a better approach.
Open source hydrologic software: ANUGA

- Rainfall/flow hydrographs
- Bounding polygon
- Start time for simulation
- ASCII files
- 3D representation of the simulation
- Time series information
- Statistics

This model is powerful and flexible, however Python Scripting language is required. The variety of outputs data types can be used for further analysis.
Open source hydrologic software: IHACRES

This model is based on few parameters and easy to run. The output will be stream flow on the time scale. Key challenge will be to transform this data to flood depth. There will be a single output for each catchment.
Open source hydrologic software: WBNM

This model is a lumped model which can account for the non uniform distribution of rainfall over a watershed. It can model design storms from 5 minutes to 72 hours duration and ARI from 1 to 500 years. Inputs can easily be added or deleted. The output is easily overlaid on GIS maps.
Open source hydrologic software: HAZUS

Stream cross-section with elevation OR Base flood elevation

This model is based on two parameters and easy to run. The output will be the flood depth in the geographic space that can be easily integrated with GIS data. Key challenge will be to get the second parameter.
Integration of Data sets and Tools for Possible Products

Requires:

1. Pre-processing data into suitable format
2. Support for analysis calibration and prediction
3. Post processing to create final products

Meteorological or climatological data can also be integrated to analyse historic events or assess potential flash flooding from designed extreme events.
Steps to Create a Flash Flood Index

1. Collect data (Terrain, hydrology etc)
2. Research catchment characteristics which influence flash flooding
3. Derive spatial functions for determining flash flooding potential (ffp)
4. Develop ffp criteria (high -low) to define flash flooding potential index (ffpi)
5. Apply ffp functions to sample catchment
6. Setup hydrologic model for sample catchment. Test design and/or historical rainfall patterns.
7. Extract hydrographs and review for flash flooding potential characteristics relative to ffp index
8. Publish maps and discuss application of findings

Review results and adjust functions if required
Integrated Spatial Hydrologic Modelling Framework

Databases
- Gauging stations
- Hydrographs
- DEM
- Drainage map
- Landuse
- Images
- Impervious surface
- Vegetation
- Soil types
- Rainfall
- Temperature
- Evapotranspiration

Models
- Hydrologic models
  - Tools
    - ArcGIS
    - R-statistics
    - ANUGA
    - WBNM
    - HAZUS
    - IHACRES
    - RAFTS
- Spatial models

Intermediate products
- Discharge
- Hydrograph Run off
- Stream channel width and altitude
- Flood plains
  - Watershed boundaries, total drainage area, basin length, basin perimeter, effective basin width, shape factor, elongation ratio, rotundity of basin, compactness ratio, relative relief, channel length, channel slope, slope ratio, stream order, drainage frequency, relative stream density

Final product
- Flood depth in the geographic space under different scenarios
- Verification of the predicted model
Conclusion

Modelling extreme weather event variables at finer scales requires consideration of spatial and hydrological parameters that augment water flow leading to possible flash flood.

Integration of data can provide important insights into catchment response to indicate flash flood potential.

Creating a subsequent flash flood index will be a risk management and mitigation tool.