VI.3.6D FLASH FLOOD GUIDANCE (FFG) GRIDDED THRESHOLD RUNOFF

This section contains general information about threshR programs used to derive gridded threshold runoff. Specific details on executing the threshR software are documented in the threshR User's Manual.

Types and Sources of Data Required

Obtain state index maps from USGS (1:500,000) to determine cataloging units (CU) desired.

Land Use Land Cover (LULC):

The contents include data on (1) borders and (2) lakes and reservoirs. Each file covers a 2 degree wide by 1 degree high area and requires about 40 Mb for storage.

USGS LULC data is available on CD-ROM from private vendors.

The data is also available on 9-track magnetic tape from the USGS. Specify CTG (composite thematic grid) 1:250,000 on 9 track tape in ASCII format. The areas are ordered as follows:

LAND USE, LAND COVER AND ASSOCIATED MAPS: SMALL SCALE (1:250,000), one 1x2 degree unit for each map number/map name to include Composite Grid Cell data category:

Map #	Map Name	States	SE Corner
201500	Tulsa	OK,MO,AR	36, -94
36500	Washington	VA,DC,MD	38, -76

Digital Elevation Model (DEM) Data:

DEM data contains elevation data at a 90 meter horizontal resolution and 1 meter vertical resolution (30 meter accuracy) and on a scale of 1:250,000. Each file contains data for a one degree by one degree area and requires about 10 Mb for storage.

DEM data is available on CD-ROMs from private vendors.

The Defense Mapping Agency (DMA) Digital Elevation Model Data is available from the USGS. Areas are ordered from the USGS as follows:

DIGITAL ELEVATION MODEL: SMALL SCALE (1:250,000), two 1-degree square units (unless indicated otherwise) for each 1x2 degree map number/name listed below:

Map #	Map Area Name		Southeast Corner	
36094-A1	Tulsa	West Half	36.000	-95.000
38076-A1	Washington	West Half	38.000	-77.000
41094-A1	Omaha		41.000	-94.000

River Reach Files:

The River Reach files contain latitude and longitude points that define stream locations. The vector data uses the 1927 datum and is on a scale of 1:100,000 but were derived from 1:24,000 scale maps. Data is available by USGS cataloging units (CU). Each CU includes two ASCII files which require a combined maximum of three Mb for storage.

River Reach data is available from the Environmental Protection Agency (EPA) over INTERNET or by a modem and terminal that emulates 3270. An account is needed with the EPA in North Carolina to access their database. Data is requested by specifying the USGS eight digit cataloging unit number. Two files are provided for each cataloging unit. Data is available by states, too.

Two-Year Return Period Flows:

The 2-year return period flows that approximate bankfull flows are available in the US Geological Survey (USGS) Water-Resources Investigations Report, January 1992. Regression equations are provided for each state.

Data Storage Requirements

Raw data will probably reside in a packed format on CD-ROMs and tape. Therefore, only a small portion of the raw data and intermediate files needs to be available for processing at any one time. To allow for adjacent cataloging units across files, provide the following storage:

File Type	Description	Number Files	Size (MB)	Total (MB)
CTG	LULC	4	40	160
DMA	Elevation	4	10	40
RF3	River Reach	10	2	20
CTG cell	LULC GRASS cell	4	2.5	10
DMA cell	Elevation GRASS cell	4	2	8
Output	10 sets of output	--	16	160
				398

A total of 400 MB of storage should be available for ingesting raw data and generating intermediate and output files. The GRASS cell files and output files should definitely be archived for future use. The cell files will not change unless the LULC, DEM data, or River Reach data changes. Generating cell files is the most time-intensive function.

Disk space for running the programs is listed below:

Description	Size (MB)
GRASS	55
CR (working directory for each user)	10
Virtural memory (RAM and swap space)	450
	515

If a machine has 64 MB of RAM, the system's swap space should be about 390 MB.

Considerable storage is required for all input and intermediate data. One LULC file covering a two degree wide by one degree high area uses about 40 MB of storage. One digital elevation model file covering a one degree by one degree area uses about 10 MB of storage. An EPA river reach file for a USGS cataloging unit uses about 3 MB of storage for a pair of files.

Raw data for LULC, DEM, and river reach requires about 35 MB of storage per square degree. An additional 16 MB of storage per square degree is required for intermediate files (GRASS cell files) and output files. A total of 51 MB of storage is needed for every square degree of area being analyzed.

The 35 MB of raw data storage per square degree of area can be archived after the raw data has been processed to reuse the space for the next area of interest.

Processing of Raw Data

A window defined by latitude and longitude specifies the area of analysis. Within the window, drainage basins are designated as hydrologic units or cataloging units (USGS terminology). The program can process a group of up to 40 hydrologic units in a batch. Some computers may be limited to only 10 hydrologic units depending on hardware.

The first menu provides the following:

(a) Select rectangular window containing at least one cataloging unit. Several CUs can be processed as a group.
(b) List cataloging units currently selected for processing
(c) Select cataloging units to process from above list

Watershed Program

The GRASS program r.watershed locates the stream junctions and determines the sub-basin boundaries. The only interactive input is to select the CUs to process from the Preprocessing step above.

R-Value Program

The program rvalue computes the gridded threshold runoff values. The threshold runoff values are determined at the stream junctions whose areas are between 5 and 12 square miles. These values are then interpolated to the HRAP grid.

Graphical Displays

This step provides various map displays of raw, intermediate and output data.

Outline of threshR Procedure

INPUT

OUTPUT

Regional Window
(ascii) LULC CTG files
(ascii)'hufiles'

Select Options & CU

init_opts. huscan, huselect

Analysis Window
(ascii) option. hucs_cells
(ascii) CU#.water
(cell) Hu_solid*, hu_border*
(cell) lakes*, reservoirs*

Convert RFC Stream Files

rf3_cvt

(ascii)
CU#.rf3
(ascii) CU#.trc (cell)
reaches*
(ascii) CU#.str

Prepare CU Elevation File With Carving

(ascii)'dmafiles' (cell)
composite
(ascii)DMA elevation
(cell) reaches, lakes, reservoirs

r.watershed

(ascii) water.in (ascii)
water,outl, water,out2
(cell) composite (ascii)
lakes,stats

(cell) lakes

(cell) water.ba*. water.ac
(cell) water.streams*

Prepare R-Value Code Input

primer,connect,lakes

(ascii)water,out1 (ascii)
water,out
(ascii)water,out2 (ascii)
nstreams, res.areas
(ascii)lakes,stats (ascii)
connect.out

Compute R-Values

rglobal,getpcip,scaler

(ascii) options, (ascii)
rvals, newrval
res,areas (ascii)
scaler.
(ascii) watershed.out (cell)
rval.ba*

(ascii) precip.dat

Grid Generation & Gridded R-Values

nodes

Analysis Window (ascii)
nodes.out
(ascii) scaler (ascii)
noder.out

Grid Interpolation

interpol2

(ascii) noder,out (ascii)
rvalgrid
(cell)

rgrid*

Underlined items are used in subsequent steps
Asterisked items are used in displaying results
Italisized items refer to specific codes developed

The threshR Method

The r.watershed program in GRASS determines the geographical boundaries for drainage areas or subbasins. The program works with a hydrologic unit (HU) as defined by the USGS. Starting at the outlet of the HU (lowest elevation cell), the basin delineation algorithm looks up-slope (higher elevation cells) for ridges that define drainage areas at the stream junctions. The size of the smallest drainage area is specified by the user and can be as small as 2 sq mi (5 sq km).

While determining the drainage areas, four files are created that are used in the calculation of threshold runoff. Two ascii files contain subbasin connectivity and geometric parameters, including basin drainage area, stream length and channel slope. The geometric parameters are given for individual subbasins and stream segments as aggregate areas, lengths and slopes accumulated along the stream path. Each subcatchment and stream segment is assigned a basin identification number, and the parameters are written according to this basin identification number. The basin identification numbers, areas, lengths, slopes and connectivity are used in the computation of threshold runoff values. Runoff values of zero are assigned to subbasins when (a) the accumulated area is greater than approximately 770 sq mi (2000 sq km), (b) the computed runoff is considered an outlier greater than 3 inches, or (c) the area is covered by or drains directly to a lake. The subbasins and stream segments can be displayed using the other two files created by r.watershed.

Steps in Executing threshR

FOR EACH REGION OF INTEREST:

DEFINE WINDOW ENCOMPASSING USGS CATALOGING UNITS (CU) OF INTEREST (called the REGIONAL WINDOW, RW):

program init_opts

SCAN USGS COMPOSITE FILE AND CREATE MOSAIC CELL FILE OF CU's, RESERVOIRS, and LAKES WITHIN RW:

-- uses "Hydrologic" & "Land Use" layers of USGS LAND-USE-LAND-COVER (LULC) 200m composite Thematic Grid files
program huscan & GRASS

IMPORT AND DISPLAY MOSAIC OF CU's AND LAKES WITHIN RW:
   GRASS

SPECIFY ONE OR MORE CU's TO PROCESS, IN PARALLEL:
   program huselect

FOR EACH CU SELECTED:

IMPORT 200M-RESOLUTION CELL FILES OF:
   -- CU
   -- USGS lakes within CU (interpolated to a 90m lake "depression" map)
   -- USGS reservoirs within CU
   program huselect & GRASS

DEFINE TWO GRASS WINDOWS USING CU BOUNDARY:
   -- Display Window (DW) just encompassing bounds of CU
   -- Analysis Window (AW) 20% larger on each side
   GRASS

CONVERT EPA STREAM (RF3) FILE WITHIN CU TO GRASS FORMAT:
   -- export from EPA mainframe
   -- transfer to workstation with ftp
   -- run rf3_cvt to convert to GRASS ASCII vector import format
   -- import into GRASS vector format
   -- convert to 90m GRASS cell file
   program rf3_cvt & GRASS

MOSAIC DMA ELEVATION FILES TO MAKE AN ELEVATION CELL FILE:
   -- program dmascan identifies DMA 90m elevation data files in AW
   -- convert each DMA file to an elevation cell file
   -- composite elevation cell files
   program dmascan & GRASS

LOWER ELEVATION OF WATER CELLS BY 100M:
   -- subtract 100m from each cell in elevation cell file which is a
      stream, lake, reservoir, wide river shoreline, lake shoreline, or
      reservoir shoreline stored in either the EPA stream cell file or
      in an USGS lakes and reservoirs cell file
   GRASS

RUN R.WATERSHED USING LAKES CELL FILE AS A "DEPRESSION" MAP TO PRODUCE:
   -- sub-basin cell file
   -- drainage relationship ASCII file (water.out1)
   -- sub-basin cumulative & non-cumulative parameters ASCII file
      (water.out2)

IDENTIFY SUB-BASINS THAT ARE IN RESERVOIRS:
   -- set cells in USGS reservoir cell file to -1=water, 1=no water
      creating a binary map
   -- multiply binary map by sub-basin map from watershed
   -- produce an ASCII file of sub-basin areas with negative areas
      representing fraction of sub-basin that is covered by a reservoir
   GRASS

CREATE INPUT FILES NEEDED FOR R-VALUE COMPUTATION:
   -- separate out the cumulative portion of water.out2

-- using water.out1, determine branches of stream network ordered
from source to outlet
-- determine residual areas for the sub-basins downstream of
a reservoir
-- create ASCII file containing residual areas (res.areas)
program primer & subroutines connect and lakes

COMPUTE R-VALUES:
program rvalue

CREATE AND DISPLAY R-VALUE COLORED SUB-BASIN MAP:
GRASS

GRIDDING OF R-VALUES:
-- create ASCII file of HRAP grid coordinates within AW
-- create ASCII file of gridded r-values
program nodes & GRASS

INTERPOLATE FOR ANY MISSING R-VALUES:
program interpol2

CREATE GRIDDED R-VALUE CELL FILE AND DISPLAY:
GRASS