1 WATFLOOD/KENUE Workshop (2 days) May, 2009

The watershed name (BSNM) is DEMO, the DEM was named **Sapochi_DEM.asc** and the land cover map was named **Sapochi_Landcover.tif**

You can substitute these names with your own.

1.1 Installing Watflood & KENUE

1. Copying stuff (you may use a different drive for executables & data)
   a. **Make folder:**
      c:\spl   (all executables go here – see c. below)
   b. **Copy files**:   *cd = the CD drive*
      cd:\spl\simout   → c:\spl\simout
      cd:\spl\demo   → c:\spl\demo
      cd:\spl\spch   → c:\spl\spch
   c. Change read only to read
      i. In My Computer go to Properties of each sub directory simout, demo & spch   (right click on each name)
      ii. Get rid of check mark in read only and apply to sub folders

   d. **Files needed in the c:\spl\demo\basin folder:**
      sapochi_dem.asc
      sapochi_landcover.tif
      power_line.i2s
      hwy_391.i2s
      flow_stations.xyz
      met_stations.xyz
      demo.par
      demo.sdc
      class_combine.txt

   e. **Files (on the CD) needed in the c:\spl folder:**
      bsn.exe
      make_evt.exe
      moist.exe
      ragmet.exe
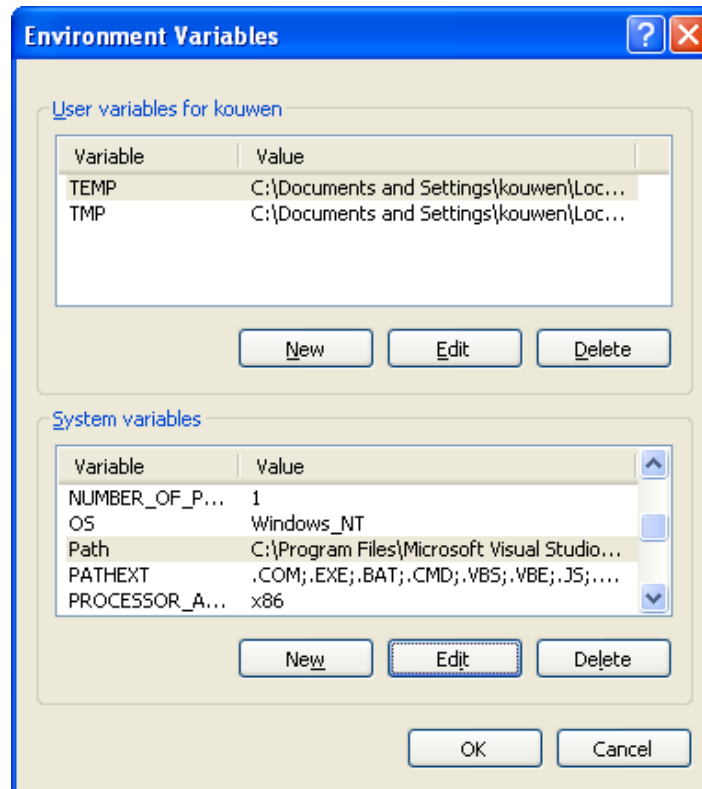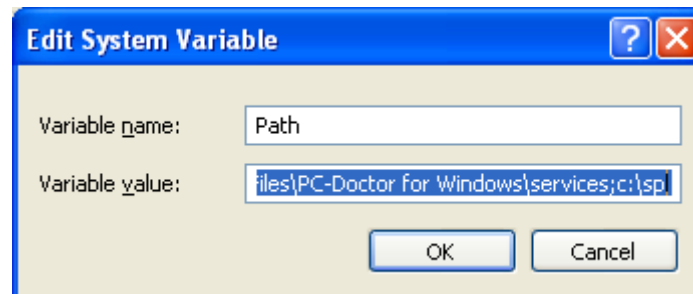   snw.exe
      spld.exe
      splx.exe
      tmp.exe

   f. **Set the path (only if you have administrator priveleges):** Right click on **My Computer** and go to **Properties.** Click on **Advanced** and go to **Environment Variables** and select Path under System variables:

Click on **EDIT** and add ;c:\spl to the end of the Path line and click OK:

1.2 Working with KENUE

1.2.1 Creating the watershed file for WATFLOOD

2. Open KENUE & make it full screen.
   a. Import the Goetiff file spl\basin\Sapochi_Landcover.tif and drag into 2D view (open view if not already there)
   b. double click on the landcover icon
   c. change from default colour to 40 nice colours & make water blue
   d. Import the DEM Sapochi_DEM.asc [ArcINFO GRID (ASCII)] and drag into 2D view (ignore warning)
   e. change the display from wireframe to surface & make it transparent & apply. (This is just to learn about views & importing data)

    f.   Save your workspace in \spl\demo\demo.ews (KENUEWorkSpace)

3. Creating a New Watershed Object. **P. 118 KENUE manual**.

    a.   Remove the land cover map from the 2D view (just right click and make it invisible)

    b.   Set the colour scale for the DEM: double click on the file name & click on ColorScale

         i.   Set min = 230 (lowest elevation on the DEM)

        ii.   Interval = 2

       iii.   Levels = 40 (the max allowed)

       iv.   Adjust the colour scale

        v.   Also just look at what the other buttons show: data, spatial & meta data

       vi.   Apply

      vii.   Save your workspace in \spl\demo\demo.ews

    c.   Create a new watershed object:

         i.   File → New → watershed ↵

        ii.   Drag the Sapochi_DEM into the DEM under New Watershed

       iii.   A object appears: Properties of new watershed and click on generate. The channels & the largest watershed in the view have now been delineated.

       iv.   Drag the channels * basin 1 into the 2D view (shows stream order)

        v.   We don't care about stream order so click on the channels icon & in the display tab make the colours monochrome (I like dark blue or white – depending on the back ground colour. Also make the point size 1. Apply & OK if you like it.

       vi.   Bring in some features: Import the dra_UTM18.shp and pva_UTM18.shp file and drag into the view. These are the Water Survey drainage layers – to check the generated channels.

      vii.   File → open & pick files of type .xyz in the spl\demo\basin folder, cntrl click on xyz files in the basin folder & open

     viii.   Drag the flow_station_location icon into the 2D view & make the points triangles, white, monocrome with line width 3 & point size 10 - apply & ok if happy. ☺

       ix.   Bring in some more features: File → open & pick flies of type .i2s in the spl\demo\basin folder, cntrl click on both i2s files in the basin folder & open. Drag into 2D view

        x.   Zoom in or out to get the whole picture.

       xi.   Save your workspace in \spl\demo\demo.ews (**EnsimW**ork**S**pace)

    d.   Delineate watersheds for the WATFLOOD model – one for each streamflow gauge

         i.   Zoom in on the middle gauge = No. 1 (To check attributes, click on the flow_station_location icon under views & then on a triangle. This will show gauge number)

        ii.   Now click on the channel icon under 2D view & double click on the channel where it crosses hwy 391. the channel is highlighted.

       iii.   Right click on the channel there & add basin

       iv. Do the same at the other 2 flow stations

       v. Remove basin 1 under Data Items (the one automatically generated)

       vi. Change the colour if the basin to black to make them more visible

       vii. Save your workspace in \spl\demo\demo.ews   Answer yes to saving the new watershed object.

       viii. Delete the demo watershed from the workspace by clicking on Load Workspace

       ix. Reload it   (possible bug in ensim – this gets rid of the original basin outline which although hidden, seems to be there still.)

       x. Save your workspace in \spl\demo\demo.ews   Answer yes to saving the new watershed object.

4. Creating a new WATFLOOD map file **P. 155 KENUE Manual**

   a. Generate map file spatial attributes

       i. File → New → Watflood Map & hit OK

       ii. Drag the demo watershed object into the new Watflood map

       iii. Double click on new Watflood map, click on Calculate Frac & hit collect.

       iv. Save the new_watflood file demo.map: File → Save copy as *demo* → save in basin folder

       v. Drag demo into the 2D view & drag basins & channels & reservoir_location over top.

       vi. Click on the demo watflood map file & make it transparent & show drainage directions.

       vii. Click on the colour scale & make it the same as for the DEM: min-230; Intvl=2; levels-40 and adjust the colour scale. Reset the colourscheme & put a check mark in show legend. In options you can insert a title for the legend = m asl

       viii. Click on Demo & make directions visible

       ix. Check that the arrows follow the channels & do not cross basin boundaries. (Here & there the generated flow directions take a few detours or shortcuts. We will fix these later.)At this point you can bring in other shape files for stream channels & watershed boundaries (if you have them) to check on what was automatically generated.

       x. Have a look at the data in the map file: Double click on demo & click on the data tab – e.g countour density. (Contour density is also known as the *internal slope.* It refers to the overland slope in a grid. (Channel slope is not in the file – it is computed later with the program bsn.exe) Note that grids with the higher contour density occur on higher ground – a good sign!) **P. 162 KENUE manual**.

   b. Adding land cover information to the map file.

       i. **Follow the directions in the KENUE manual on p. 166.** The Sapochi land cover map is already in your workspace.

       ii. Right click on the demo map file and select **Map Land Use Data from GeoTIFF in the shortcut menu –** use Sapochi_Landcover

       iii. Look at Data in the Demo map file & note landcovers are listed

       iv. Click on the demo map file and Save copy as demo.map

> v. Save your workspace in \spl\demo\demo.ews

c. Create the shd file for WATFLOOD demo_shd.r2c We want the classes to be in this oder to match the existing par file:

> 1. Deciduous
> 2. Coniferous
> 3. Mixed
> 4. Regen (open forest)
> 5. Taiga
> 6. **Wetland**
> 7. **Water**
> 8. **impervious** (rock and roads)

Note that there are 18 classes in the Sapochi_lland cover.tif file but we want fewer for the WATFLOOD model. A file called class_combine.txt in the basin directory has the information to rearrange & combine the land cover classes:

```
 4     1      wet_conif
 3     2      dry_conif
 5     3      mixed
14     4      decid
10     5      regener
11     5      regener
 5     6      burn
 9     7      wetland
 6     8      water
 7     9      impervious
```

This file will cause class 4 in the land cover map to be mapped to class 1 in the watflood shd file. Note that classes 10 & 11 in the land cover map will be combined in watflood class 5. We ignore the Class 0's

> ii. Open a DOS window   Run cmd
> iii. Go to whatever drive spl\demo is on   dr:↵
> iv. Cd \spl\demo\basin
> v. Run the program bsn.exe: bsn ↵ **(there will likely be an error to fix!)**

Please note that when BSN.exe is run for the first time, the responses are written to a file called "bsn_responses.txt". When you run BSN.exe again, you will be asked if you want to use the same responses as before and you can answer 'y' to avoid entering the data again.

```
C:\workshop_mh_cd\demo\basin>bsn
 ********************************************************
 *                                                      *
 *                    WATFLOOD (TM)                     *
 *                                                      *
 *      Program BSN Version 10        Apr 24, 2009      *
 *                                                      *
```

```
*               (c) N. Kouwen, 1972-2009                        *
*                                                               *
****************************************************************

 Please see file bsn_info.txt for information re: this run

 VERY IMPORTANT CHANGE:

 In the bsnm.map file
 the impervious area is now the LAST class - not the first
 The no of classes is now the TOTAL number - including the
 impervious class

 Please change the .map file accordingly if you have not
 yet done so.  Sorry for the inconvenience  NK

Hit enter to continue - Ctrl C to abort


 Enter the basin (map) file name:
```
demo.map
```
 Enter the parameter (par) file name
 if you want a bsnm_par.r2c file for watroute
 other wise, hit return

 bsnm_par.r2c not wanted for watroute

 Enter your name or initials
```
nk
```

  Enter the grid you would like included
  in the simulation

  This should NOT be the receiving grid!!!!

  There can only be one (1) outlet with this option

  example:  6639   Hit Return to use whole dataset



 Ensim compatible free format map file expected

:CoordSys           CARTESIAN

 :CoordSys           CARTESIAN
 #
 :xOrigin            515000.0
 :yOrigin            6170000.
 :xCount              17
 :yCount              17
 :xDelta            2000.000
 :yDelta            2000.000
 :contourInterval   1.000000
 :imperviousArea          0
```

```
:classCount                         18
:elevConversion               1.000000
#-------------------
:endHeader
  Computed nominal grid size=     2000.000
please check above numbers & hit enter to continue
```

Enter the split: % of wetland coupled to channel
only if you have two identical sets of wetland
land cover gridsas the 2 classes before the
water class in the land use section of the map file
Enter 0 if you have just 1 block of wetland cover

Split =

25

```
 Number of classes now includes the impervious class
 Number of classes stipulated =            18

 Is this correct?  y or n
```
y
```
 before allocating area17
 area17 allocated

  Often DEM have flat spots filled and you end up with
  unwanted flat spots in your river profile
  It causes severe flattening of the hydrographs
  Enter the minimum allowable river slope
  that you have in your sustem - e.g. 0.0001
  Min accepted value = 0.0000001
  Max value accepted is 1.0 (45 degrees!)

.001
 No of river classes found in the map file =        1
 This should match the number specified in the par file

 class
 class
 dri
 wet
 mixed
 water
 impervious
 Class
 wetland
 regen
 regen
 class
 class
 decid
 class
 class
 class
 class
          1
          2
```

```
          3
          4
          5
          6
          7
          8
          9
         10
classes found =          10 new_class_count=           9
 end of map file reached
Note:    impervious area > 0 in the header
         0 % of the impervious class (urban)
has been subtracted from class          9
and added to class 1
Class 1 should be a land cover compatible with
the pervious areas in urban areas (eg. grass)


The value entered for "split" =          25
Another land cover class was be added to the
new_shd.r2c file
Please ensure that the par & sdc files are modified
to accomodate the extra wetland class

 frame=              1  written
 frame=              2  written
 frame=              3  written
 frame=              4  written
 frame=              5  written
 frame=              6  written
 frame=              7  written
 frame=              8  written
 frame=              9  written
 frame=             10  written
 ios=           -1

 No bankfull values found
 Default assumed
```

frac_2d(13   4)=   0.000 - please check

**   next grid = 0 @ grid #   168 @ 16   13 elv=234.964**
Possible cause: wrong drainage direction
Errors OK if last receiving grid
!!!!!!!!!!!!!

```
Please see new_format.shd file for -ve slope location
 receiving grid higher in grid   16   13  168 elv=    234.964

 frac_2d(   17   13)=     0.000 - please check
   Basin # not coded @ grid #   169 @      17     13 elv=234.552
# contours not coded @ grid #   169 @      17     13 elv=234.552
# channels not coded @ grid #   169 @      17     13 elv=234.552
      next grid = 0 @ grid #   169 @      17     13 elv=234.552
```

```
Possible cause: wrong drainage direction
Errors OK if last receiving grid !!!!!!!!!!!!!

Please see new_format.shd file for -ve slope location
 receiving grid higher in grid   17   13  169 elv=   234.552
 na,naa/          169          167
  frame=            1  written
  frame=            2  written
  frame=            3  written
  frame=            4  written
  frame=            5  written
  frame=            6  written
  frame=            7  written
  frame=            8  written
  frame=            9  written
  frame=           10  written
  frame=           11  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
  frame=           12  written
 new_shd.r2c written
 wfo_spec.new  written
 new.pdl  written


 The value entered for "split" =           25
 Another land cover class was be added to the
 new_shd.r2c file
 Please ensure that the par & sdc files are modified
 to accomodate the extra wetland class

 finished writing c:\spl\simout\profil01.dat
 finished writing river01.xyz
 There seems to be a problem in
 grid no          55  row            13  column            16
 Check for -ve slope or missing data
 in this grid
 OR
 More than one grid drains into the very last grid
 Which means there is more than one outlet.
 This can be a problem. Edit the map file so only
 one grid drains into each receiving outlet grid.
 OR
 Did you leave blank columns & rows around the
 edges of the data? Maybe not

 River profile data not printed
 Please check new_format.shd for problems
```

```
new_shd.r2c and new_format.shd have been written

Program ended in bsn @ 2953

C:\workshop_mh_cd\demo\basin>
```

     i. Load the file New_shd.r2c into KENUE & have a look (note r2c file type)

    ii. Save your workspace

Fix Errors:
Note area in gray above. Edit the file basin\new_format.shd and look at grid 18 to see what is wrong. Note frac = 0.0 so it needs to be fixed in the map file. In KENUE, make the map file the top layer and look at row 13 col 4 – note frac = 0. Just change it to 1 and save the file**. Repeat the last step – run bsn.exe** (sometimes you may not notice the error until you run the model splx.exe) Select "y" for same values.

    iii. In DOS, in the dr:\spl\demo\basin directory, rename new.pdl to demo.pdl

    iv. Copy new_shd.r2c demo_shd.r2c (in the basin folder)

d. Setup event for WATFLOOD

    i. Copy & rename spl\demo\basin**wfo_spec.new** to spl\demo**wfo_spec.txt**

    ii. In a dos window in folder dr:\spl\demo, change the event: copy event\19950801.evt event\event.evt

    iii. Distribute data from point form to gridded form:

       1. distribute snow   **snw** ↵

       2. distribute moisture   moist ↵

       3. distribute rainfall   ragmet ↵

       4. distribute temperature   tmp ↵

e. **Initial run**

    i. Edit the **event\event.evt** file to pick the flags you want (See Sec. 1.3.9 in the WATFLOOD manual)

```
:snwflg                      y
:sedflg                      n
:vapflg                      y
:smrflg                      n
:resinflg                    n
:tbcflg                      n
:resumflg                    n
:contflg                     n
:routeflg                    n
:crseflg                     n
:ensimflg                    a
:picflg                      n
:wetflg                      y
:modelflg                    n
:shdflg                      n
:trcflg                      n
```

```
:frcflg                              n
```

    ii. Edit the **wfo_spec.txt** file & select the state variables you would like to view in KENUE. Probably you would like:

```
3.0 Version Number
132 AttributeCount
  6 ReportingTimeStep Hours
  0 Start Reporting Time for KENUE (hr)
  0 End Reporting Time for KENUE (hr)
1   1 Temperature
1   2 Precipitation
1   3 Cumulative Precipitation
1   4 Lower Zone Storage Class
1   5 Ground Water Discharge m^3/s
1   6 Grid Runoff
1   7 Grid Outflow
1   8 Weighted SWE
0   9 Wetland Depth
0  10 Channel Depth
0  11 Wetland Storage in m^3
0  12 Wetland Outflow in m^3/s
```

    iii. Edit the outfiles.new file & change the path of the output files - use replace:

            ../   to   c:\spl/

    iv. Save as outfiles.txt in the demo directory (folder)

5. While in the working directory c:\spl\demo run the model: **splx ↵ (or if you did not set your path: c:\spl\splx ↵**

1.3   Post processing with KENUE

  6. New files today

     a. Snow course data – time series ts3 files in snow1 folder

     b. str.tb0 files

     c. splx.exe

     d. demo.par file

     e. met.r2c files

  7. **Run 1 month of data for DEMO (above)**

     a. Follow the instructor to look at stuff.

         i. In ENSIN load the file **c:\spl\simout\watflood.wfo**

        ii. Follow the instructor to look at stuff: make the `Grid Outflow` the top layer

        iii. Right click on Grid Outflow in the 2D view & activate "animate"

        iv. Double Click on Grid Outflow -> colour scale and set NLOG & 40 levels & Apply

        v. Fix the colour scale and make it transparent

        vi. Drag the demo map file into the 2D view and make it a wireframe with directions visible.

        vii. Extract some time series for points along the river going upstream

     viii. Open a 1D view and drag each grid outflow time series into the 1D view

     ix. Fix the scale: hold left click & drag graph; use thumb wheel to zoom in and out

     x. Synchronize animation: Cliclick on **View** and then **Select Sync View** and select view & hit **OK**

     xi. Try the play, pause, rewind buttons in the animation toolbar

     xii. Animate to the peak flow time

     xiii. Note the discontinuity in the flow near the small off-line lake (probably caused by a flat spot in the river – see grapher plot)

b. Sensitivity

     i. Edit the basin\demo.par file and double the R2n value

     ii. Run the model: **splx** ↵

     iii. In KENUE, leave the previous watflood.wfo file and load the new c:\spl\simout\watflood.wfo file (note: same name)

     iv. Follow the instructor to look at stuff: make the new `Grid Outflow` the top layer and extract time series for the same points along the river going upstream

     v. Note that you can see a bit of damping

     vi. Delete the first watflood.wfo file from the data items

c. Editing the map file: add lakes

     i. delete the watflood map from **Data Items**

     ii. open **demo.wsd**

     iii. open **demo.map** (if not present) in the basin folder and drag into 2D view

     iv. In 2D view, raise landcover map and demo.map

     v. change the colours in the land cover map to grey except the water class – so it stands out.

     vi. In the properties of demo.map activate the reach Number

     vii. Set the colour scale to 3 items & fix the colour scale

     viii. Edit the lakes: 1, 2 & 3 as we go upstream. Mark all grids that are part of a lake – it doesn't depend on how much of the grid is in the lake.

     ix. Check drainage directions & falling channel elevation in the outlet area (follow arrows)

     x. Save the demo map file

     xi. In the demo\basin folder, run bsn.exe as before & if ok, change the name of the file new_shd.r2c demo_shd.r2c

     xii. Rename of the **res_rl** folder to **resrl**

     xiii. Run splx & look at results. Compare with previous run without lakes by leaving the previous wfo file in ensim and loading the new one after running splx with lakes. Extract hydrographs upstream and downstream from a lake & compare.

d. Multiple events

     i. In a dos window in folder dr:\spl\demo, change the event: copy event\19950701.evt event\event.evt

     ii. Again, distribute data from point form to gridded form:

       1. distribute snow   **snw** ↵

       2. distribute moisture   moist ↵

       3. distribute rainfall   ragmet ↵

       4. distribute temperature   tmp ↵

  iii. Edit the event\event.evt file and make it look like this (actually done already)

```
:noeventstofollow               01
#
event\19950801.evt
eof
```

  iv. Now run splx (in the demo directory)

8. Looking at hydrographs

  a. In Ensim

    i. Just extract grid outflow time series after loading in a spl\simout\watflood.wfo file. (These cannot yet be compared with observed flows in the tbo files as there is still some coding to do in watflood & ensim to make them compatible)

  b. In EXCEL

    i. Load spl\simout\spl.csv into EXCEL

    ii. Make line plots of cols b&c (watershed #1) d&e (#2) f&g (#3)

    iii. Grapher is easier as you can make templates and just reload every time you re-run splx

9. Optimization (The wrong way?) Pattern search optimization coded by Monro NWS

  a. Edit up basin\demo.par file

    i. In line 6 set numa = 1

    ii. Make delta for fpet 1,2,5 & 7 +ve

    iii. Check limits

    iv. Save par file & run splx

    v. Monitor the c:\spl\simout\opt.txt file (possible with ultra edit)

    vi. When the error no longer reduces, kill the run

    vii. Edit the event\event.evt file replace demo.par by new.par

    viii. Run splx

    ix. Compare with previous watflood.wfo file

10. Do a 3 year run on the spch

  a. Look at flows

    i. Make the spl\spch the working directory

    ii. Run splx

    iii. Look at the hydrographs as before

    iv. Load the wfo file (spl\simout\watflood.wfo)

    v. Drag grid outflow into 2D view

    vi. Set the colour scale change linear to NLog and set 40 levels. Fix the colours.

    vii. Animate

    viii. Extract hydrograph at the outlet.

        ix. Syncronize views: clicl on 1D view to highlight bar. Then View -> Select Sync View and pick the 2D view you are animating. You should see a red line in the 1D view.

        x. Hit the play button and be amazed!

   b. Look at SWE

        i. Drag Weighted SWE into a 2D view

        ii. Extract time series, open a new 1D window & drag time series into it

        iii. Make the flow & swe window the same size and compare.

        iv. Set colour scale black= 0% and high = 100%

        v. Set sync view and animate

   c. Look at any other variable

        i. Edit the wfo_spec.txt file and pick what you want to see $ set timestep

11. **Question period**