PCM Manual

Version 1.0

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Introduction

The Pothole Cascade Model is a conceptual model of the storage of water in ponds in Prairie landscapes. It adds and subtracts water, and calculates the transfer of water from pond to pond by "fill and spill" (Spence and Woo, 2003).

Licence

Referencing

Please acknowledge the use of this program in any research papers.

Compiling

The source code for PCM is available from Kevin Shook. PCM is written in Fortran 95 and must be compiled before it can be executed. The FOSS Fortran compiler (gfortran) is available from https://gcc.gnu.org/wiki/GFortranBinaries.

Building the program takes 2 steps, compilation and building as shown below. When compiling for Linux or OSX, the extension "`.exe`" is not required in the second line.

```
gfortran -c PCM.f95
gfortran -o PCM.exe PCM.o
```

The program has 2 empirical parameter values p1, and p2, which are hard-coded in the program. These are value of the parameter *p*, which sets the relationships between the water depth, area and volume in each of the ponds, as described in (Hayashi et al., 2000). The value p1 is used for ponds with maximum areas smaller than 10,000 m^2, p2 is used for larger ponds. Changing the values of p1 and p2 from their defaults will require editing the source code before compilation.

Running the program

PCM is run from the command line or from a command file. The program has 5 parameters, which are specified on the command line. The parameters are:

Pond maximum areas
Pond maximum volumes
Pond connectivity
Pond initial state
Water addition/removal
Runoff fraction
Output state file name

The files can be created using a spreadsheet, but be certain to save to values as a text file.

Pond maximum areas

This is a text file containing the maximum areas of each pond (in m^2), one per line. These values were taken from the LiDAR DEM of Sub-Basin 5 at Smith Creek, SK.

```
600
200
4400
100
1500
200
600
39800
...
```

There can be more values in this file than are required by the program.

Pond maximum volumes

This is a text file containing the maximum volumes of each pond (in m^3), one per line. These values were taken from Smith Creek, SK. Note that the first pond has its volume set artificially low, to prevent the whole set of wetlands from being affected by gatekeeping.

```
1
37.10
1567.4
16.02
425.77
37.10
140.36
22567.36
60.63
16.02
...
```

As with the pond maximum areas, the number of maximum volumes may be greater than are used.

Pond connectivity

The pond connectivity file defines which pond a given pond drains to. This file defines the number of ponds that will be used in a given model run. Each pond is numbered from 1 to the maximum number of ponds in use. The file consists of a text file of the pond numbers, one per line. The first line should always be zero, which is the number of the stream channel, as shown in the example (the comments are NOT included in the actual file). Note that any number of ponds may drain to a given pond.

```
0     - pond 1 drains to stream
1     - pond 2 drains to pond 1
1     - pond 3 drains to pond 1
1     - pond 4 drains to pond 1
2     - pond 5 drains to pond 2
2     - pond 6 drains to pond 2
3     - pond 7 drains to pond 3
3     - pond 8 drains to pond 3
4     - pond 9 drains to pond 4
4     - pond 10 drains to pond 4
...
```

Pond initial state

The initial state is the areas of water initially stored in each of the ponds, i.e. before the changes being applied by the program. The initial state may be specified by the words ‘empty’ or ‘full’ or by a file name. The inital state file contains the areas of water in each of the files, one value per line.

Runoff fraction

Water addition consists of direct precipitation and runoff. Direct precipitation is added to the area of water in each pond. Runoff is calculated from the upland area for each pond, multiplied by the runoff fraction (0-1). The upland area is calculated from the scaling relationship described in (Shook et al., 2013).

Water addition/removal

The depth of water added or removed is specified as a positive or negative value.

Output state file name

The output state file contains the pond water areas calculated at the end of the model run. These values can be used as inputs for another model run.

Model output

Model output is written to the screen, and consists of the following variables:

Variable	Meaning
num_sloughs	Number of ponds in simulation
total_basin_area	Total area of all ponds and uplands
max_slough_area	Sum of all pond maximum areas (m^2)
max_slough_volume	Sum of all pond maximum volumes (m^3)
initial_state	Empty, full or filename
precip	Added/removed water depth (mm)
final_vol	Total water volume at end of run (m^3)
final_area	Total water volume at end of run (m^2)
delta_vol	Change in total water volume over run (m^3)
outflow_volume	Water volume output during run (m^3)
volfrac	final_vol / max_slough_volume
areafrac	final_area / max_slough_area
runofffrac	Fraction of applied depth of water that ran off

The values are space-delimited.

Examples

This model run adds 1 mm of water, with a runoff factor of 1, to empty sloughs:

```
PCM PondAreas.txt PondVolumes.txt  PondConnectivity.txt  empty 1.0
1.0 1mmAreas.txt
```

This run adds 100 mm of water. The output is redirected to the file PCM_summary.txt.

```
PCM PondAreas.txt PondVolumes.txt  PondConnectivity.txt  empty 100.0
1.0 100_areas.txt > PCM_summary.txt
```

This run subtracts 50 mm from the previous run, and adds a line to the summary file. Note that the >> operator appends output to an existing file, both under Windows and under real operating systems.

```
PCM PondAreas.txt PondVolumes.txt  PondConnectivity.txt
100_areas.txt -50.0 1.0 100minus50_areas.txt >> PCM_summary.txt
```

References

Hayashi, M., G. van der Kamp, and G. Van Der Kamp (2000), Simple equations to represent the volume-area-depth relations of shallow wetlands in small topographic depressions, *J. Hydrol.*, *237*, 74–85.

Shook, K., J. W. Pomeroy, C. Spence, and L. Boychuk (2013), Storage dynamics simulations in prairie wetland hydrology models: evaluation and parameterization, *Hydrol. Process.*, *27*(13), 1875–1889, doi:10.1002/hyp.9867. [online] Available from: http://doi.wiley.com/10.1002/hyp.9867 (Accessed 7 July 2014).

Spence, C., and M. Woo (2003), Hydrology of subarctic Canadian shield: soil-filled valleys, *J. Hydrol.*, *279*(1-4), 151–166, doi:10.1016/S0022-1694(03)00175-6. [online] Available from: http://linkinghub.elsevier.com/retrieve/pii/S0022169403001756 (Accessed 30 May 2014)