

PennState Integrated Hydrologic Model (PIHM)

Version: 2.0

Input File Formats



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PIHM is an integrated finite volume hydrologic model. It simulates channel routing, overland flow and groundwater flow in fully coupled scheme. It uses semi-discrete Finite Volume approach to discretize PDE (equations governing physical processes) into ODE to form a system of ODEs and solved with SUNDIALS¹.

PIHM incorporates an object-oriented model data structure which provides extensibility and efficient storage of data at the same time. PIHM v2.0 requires a total of eight [8] input files:

File	Purpose
1 .mesh File	: Spatial information of Nodes and Irregular Meshes (TINs)
2 .att File	: Attribute defining different classes an element belongs to
3 .soil File	: Soil parameters for the soil types
4 .lc file	: Vegetation parameters of different land cover types
5 .riv file	: Spatial, geometry and material information of river segments
6 .forc file	: All the forcing variables (forcing time-series)
7 .ibc file	: Boundary condition information for elements
8 .para file	: Control parameters (solver options; model modes; error control)

This document describes the function of all the data files and the structure in which data is stored in details.

¹ SUIte of Nonlinear and Differential/ALgebraic equation Solvers
[<http://www.llnl.gov/casc/sundials/>]

1. .mesh File

Mesh file has all the irregular mesh (TIN) geometry information in it. It contains all the nodes and elements. For nodes, it records its location in space and for elements, it saves index of nodes of which elements comprise of and some topological relations in the form of its neighbor elements.

File Structure:

NumEle	NumNode					
Index	Node[0]	Node[1]	Node[2]	Nabr[0]	Nabr[1]	Nabr[2]
Index	Node[0]	Node[1]	Node[2]	Nabr[0]	Nabr[1]	Nabr[2]
.						
.	Repeat NumEle times...					
.						
Index	Node[0]	Node[1]	Node[2]	Nabr[0]	Nabr[1]	Nabr[2]
Index	X	Y	Zmin	Zmax		
Index	X	Y	Zmin	Zmax		
.						
.	Repeat NumNode times...					
.						
Index	X	Y	Zmin	Zmax		

Description:

Variable Name	Variable Type	Variable Description	Remarks
NumEle	Integer	Total Number of Elements	
NumNode	Integer	Total Number of Nodes	
Index	Integer	Element Index	
Node[0]	Integer	1 st Node of Element	
Node[1]	Integer	2 nd Node of Element	
Node[2]	Integer	3 rd Node of Element	
Nabr[0]	Integer	1 st Neighbor of Element	0: boundary
Nabr[1]	Integer	2 nd Neighbor of Element	0: boundary
Nabr[2]	Integer	3 rd Neighbor of Element	0: boundary
Index	Integer	Node Index	
X	double	x co-ordinate of node	meters
Y	double	y co-ordinate of node	meters
Zmin	double	bed elevation of node	meters
Zmax	double	surface elevation of node	meters

2. .att File

An att (attribute) file is a record which stores all the physical parameters class of each mesh elements such as soil type, land cover type, several forcing types. It allows efficient data storage.

File Structure:

Index	Soil	LC	IS_IC	Snow_IC	Surf_IC	Usat_IC	Sat_IC	BC	Ppt	Temp	RH	Wind	Rn	G	VP	src
Index	Soil	LC	IS_IC	Snow_IC	Surf_IC	Usat_IC	Sat_IC	BC	Ppt	Temp	RH	Wind	Rn	G	VP	src
.																
.				Repeat NumEle times...												
.																
Index	Soil	LC	IS_IC	Snow_IC	Surf_IC	Usat_IC	Sat_IC	BC	Ppt	Temp	RH	Wind	Rn	G	VP	src

Description:

Variable Name	Variable Type	Variable Description	Remarks
Index	Integer	Element Index	
Soil	Integer	Soil Class	
LC	Integer	Land Cover Class	
IS_IC	Integer	Interception Storage	Initial Condition
Snow_IC	double	Snow Accumulation	Initial Condition
Surf_IC	double	Surfaceflow State	Initial Condition
Usat_IC	double	Usaturated State	Initial Condition
Sat_IC	double	Saturated State	Initial Condition
BC	Integer	Boundary Condition	
Ppt	Integer	Precipitation Series	
Temp	Integer	Temperature Series	
RH	Integer	Rel. Humidity Series	
Wind	Integer	Wind Velocity Series	
Rn	Integer	Solar Radiation Series	
G	Integer	Dummy	
VP	Integer	Vapor Pressure	
src	Integer	Source/Sink	

3. .soil File

All the hydrologic and hydraulic parameters related to different soil classes for surface and subsurface flow are stored in this file.

File Structure:

NumSoil											
Index	Ksat	SitaS	SitaR	Alpha	Beta	MP	Base	gamma	Sf	Rzd	Inc
Index	Ksat	SitaS	SitaR	Alpha	Beta	MP	Base	gamma	Sf	Rzd	Inc
.											
.			Repeat NumSoil times...								
.											
Index	Ksat	SitaS	SitaR	Alpha	Beta	MP	Base	gamma	Sf	Rzd	Inc

Description:

Variable Name	Variable Type	Variable Description	Remarks
NumSoil	Integer	Number of Soil Classes	
Index	Integer	Soil Class Number	Beginning with 1
Ksat	Double	Saturated Hydraulic Conductivity	
SitaS	Double	Porosity	
SitaR	Double	Residual Porosity	
Alpha	Double	Soil Parameter	
Beta	Double	Soil Parameter	
MP	Integer	Macropore? Yes:No	1 : 0
Base	Double	Dummy Variable	
gamma	Double	Soil Parameter	
Sf	Double	Soil Friction Slope	
Rzd	Double	Root Zone Depth	meters
Inc	Integer	Dummy Variable	

* ROSETTA: United States Salinity Laboratory (USDA-ARS), Riverside, California can be a useful tool for getting these parameters.

4. .lc File

Lc file contains several vegetation parameters corresponding to different land cover classes present in the modeling domain.

File Structure:

NumLC						
Index	LAI _{max}	R _{min}	R _{s_ref}	Albedo	VegFrac	n
Index	LAI _{max}	R _{min}	R _{s_ref}	Albedo	VegFrac	n
.						
.		Repeat NumLC times...				
.						
Index	LAI _{max}	R _{min}	R _{s_ref}	Albedo	VegFrac	n

Description:

Variable Name	Variable Type	Variable Description	Remarks
NumLC	Integer	Number of Land Cover Classes	
Index	Integer	Land Cover Class Number	
LAI _{max}	Double	Maximum LAI	
R _{min}	Double	Minimum Stomatal Resistance	
R _{s_ref}	Double	Stomatal Resistance Reference	
Albedo	Double	Albedo	
VegFrac	Double	Vegetation Fraction	
n	Double	Manning's Roughness Coefficient	day/m ^{1/3}

Description:

Variable Name	Variable Type	Variable Description	Remarks
NumRiv	Integer	Number of River Segments	
Index	Integer	River Segment ID	Beginning with 1
FromNode	Integer	From Node ID	
ToNode	Integer	To Node ID	
Down	Integer	Downstream Segment ID	
LeftEle	Integer	Left Element ID	
RightEle	Integer	Right Element ID	
Shape	Integer	Shape ID	
Material	Integer	Material ID	
IC	Integer	Initial Condition ID	
BC	Integer	Boundary Condition ID	
Res	Integer	Reservoir ID	
NumShape	Integer	Number of Shape Types	
Index	Integer	Shape ID	Beginning with 1
Dummy	-	-	
Depth	Double	Depth of the River Segment	
Dummy	-	-	
InterpOrder	Integer	Interpolation Order *	1 if a rectangular
InterpCoeff	Double	Interpolation Coefficient *	width if a rectangular
NumMat	Integer	Number of Material Types	
Index	Integer	Material ID	Beginning with 1
n	Double	Manning's Roughness Coefficient	
Cwr	Double	Discharge Coefficient	
Sf	Double	Soil Friction Slope	
NumIC	Integer	Number of Initial Condition Types	
Index	Integer	Initial Condition ID	Beginning with 1
Value	Double	Initial Condition Water Table	
NumBC	Integer	Number of Boundary Conditions	
Type	Integer	Boundary Condition Type	
Index	Integer	Boundary Condition ID	
Length	Integer	Length of BC TimeSeries	
Time	Double	Time	(days)
Value	Double	BC Value	(m or m/day)
NumRes	Integer	Number of Reservoirs	

* Interpolation Order (b) and Interpolation Coefficient (a) are parameters defining relation between Width and Depth of a river segment as: $[W = a \times D^b]$.

6. .forc File

Forc file contains all the forcing variable information (time series).

File Structure:

NumPrep	NumTemp	NumRH	NumWind	NumRn	NumG	NumVP	NumLAI	NumMF
"Prep"	Index	Length						
Time	Value							
Repeat Length times...								
Time	Value							
"Prep"	Index	Length						
Repeat NumPrep times...								
"Temp" *	Index	Length						
"RH" *	Index	Length						
"Wind" *	Index	Length	Height					
"Rn" *	Index	Length						
"VP" *	Index	Length						
"LAI" *	Index	Length	SIFactor					
"DH" *	Index	Length						
"MF" *	Index	Length						

* Same as "Prep" time-series

Description:

Variable Name	Variable Type	Variable Description	Remarks
NumPrep	Integer	Number of precipitation time-series	
NumTemp	Integer	Number of temperature time-series	
NumRH	Integer	Number of relative humidity time-series	
NumWind	Integer	Number of wind velocity time-series	
NumRn	Integer	Number of solar radiation time-series	
NumG	-	Dummy	
NumVP	Integer	Number of vapor pressure time-series	
NumLAI	Integer	Number of LAI time-series	
NumMF	Integer	Number of melt factor time-series	
Index	Integer	Time-series ID	
Length	Integer	Number of time steps	
Time	Double	Time	
Value	Double	Data value	
Height	Double	Height of wind velocity observation	
SIFactor	Double	Interception Storage Factor	

7. .ibc File

IBC file contains all the information related to boundary conditions corresponding to elements.

File Structure:

NumBC1	NumBC2	
"BC1"	Index	Length
Time	Value	
Repeat Length times...		
Time	Value	
"BC1"	Index	Length
Repeat NumBC1 times...		
"BC1"	Index	Length
"BC2"	Index	Length
Time	Value	
Repeat Length times...		
Time	Value	
"BC2"	Index	Length
Repeat NumBC2 times...		
"BC2"	Index	Length

Description:

Variable Name	Variable Type	Variable Description	Remarks
NumBC1	Integer	Number of Dirichlet BC	
NumBC2	Integer	Number of Neumann BC	
Index	Integer	Boundary Condition ID	
Length	Integer	Number of time steps	
Time	Double	Time	
Value	Double	Value	(m or m/day)

8. .para File

Para file provides all the control data to the model. It contains solver options; model modes; also parameters that govern model error.

File Structure:

Verbose	Debug	Init_type		
UsatMode	SatMode	RivMode		
Solver	GSType	MaxK	Delta	
AbsTol	RelTol	InitStep	MaxStep	ETstep
StartTime	EndTime	Output		
a	b			

Description:

Variable Name	Variable Type	Variable Description	Remarks
Verbose	Integer	Verbose mode?	Yes/No :: 1/0
Debug	Integer	Debug mode?	Yes/No :: 1/0
Init_type	Integer	State initialization type	Relax(0); AttFile(1); InitFile(3)
UsatMode	Integer	Unsaturation formulation	Shallow(1); Full(2)
SatMode	Integer	Saturation formulation	Kinematic(1); Diffusion(2)
RivMode	Integer	River formulation	Kinematic(1); Diffusion(2)
Solver	Integer	Cvode Solver Type	DirectDense(1); Iterative(2)
GSType	Integer	GS Solver Type	Modified(1); Classical(2)
MaxK	Integer	Max Krylov dimension	
Delta	Double	GMRES convergence criterion	
AbsTol	Double	Absolute Tolerance	
RelTol	Double	Relative Tolerance	
InitStep	Double	Initial time-step	[see SUNDIALS manual]
MaxStep	Double	Maximum time-step	[see SUNDIALS manual]
Etstep	Double	ET time-step	
StartTime	Double	Simulation start time	
EndTime	Double	Simulation end time	
Output	Double	Output step-size	
a *	Double	Step-size factor	
b *	Double	Base step-size	

* $\text{stepsize} = b \times a^i$