Precipitation, Infiltration, Evapotranspiration, and Wind

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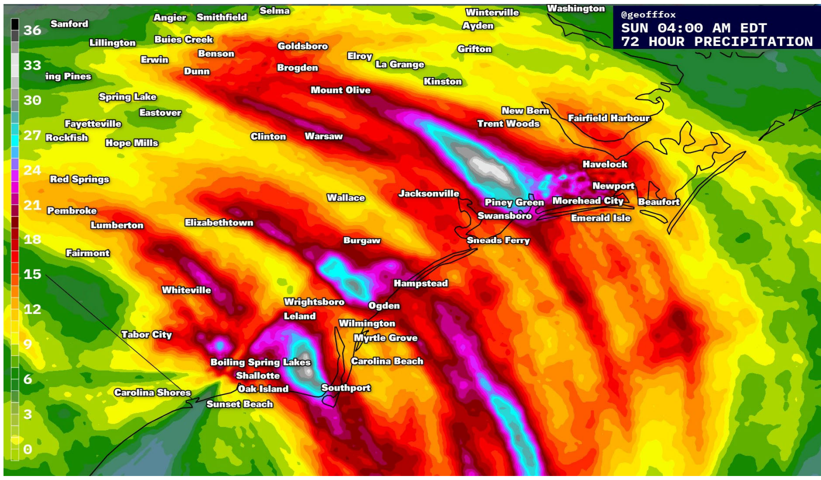
Overview

- Precipitation
  - Input Data Types
- Infiltration
  - Methods
  - Input Data
- Evapotranspiration
  - Methods
- Percent Impervious
- Wind
  - Formulation and Options
  - Input Data

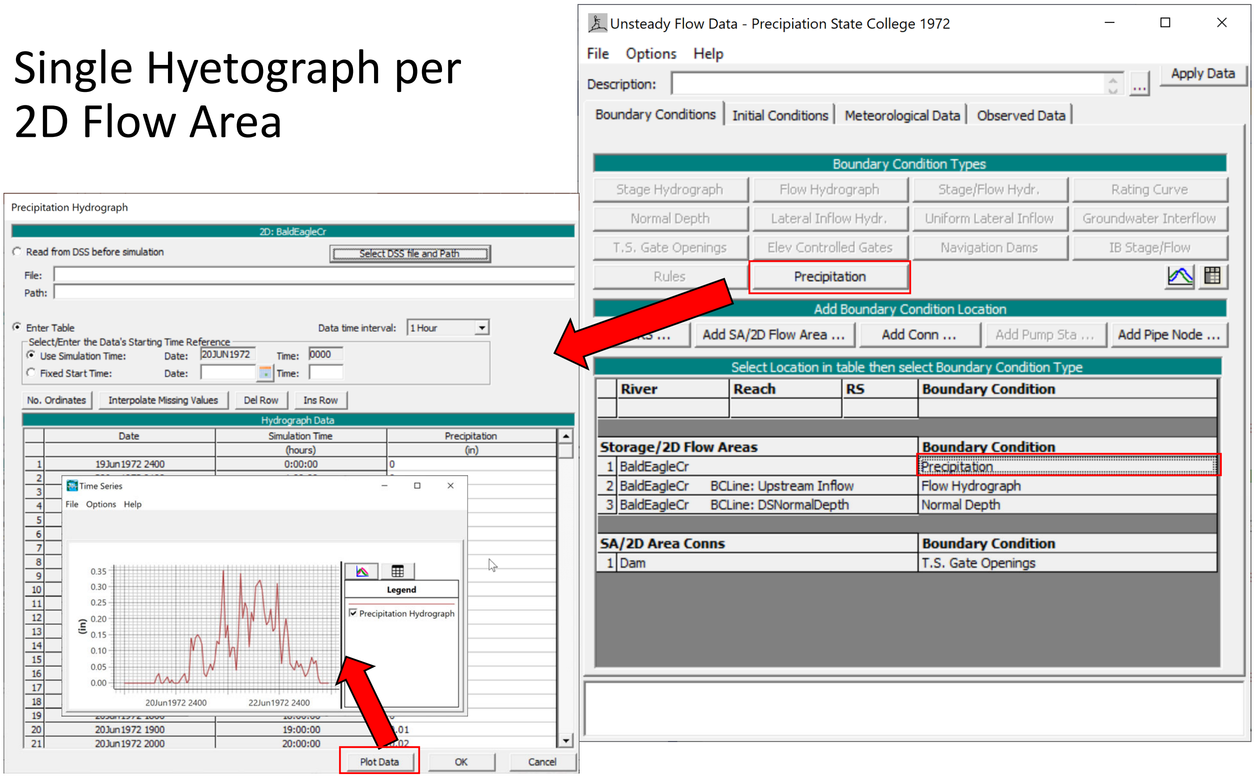
Precipitation

- Per 2D Flow Area
- Global
    - Constant Rate
    - Gridded Data
        - HEC-DSS file format (from HEC-MetView)
        - National Weather Service
            - GRIB
            - NetCDF
        - National Centers for Environmental Information
            - NetCDF
    - Point Gage Data
        - HEC-DSS time series
            - Regular Interval
            - Irregular Interval
        - User-specified time-series



Boundary Conditions

- Single Hyetograph per 2D Flow Area



Unsteady Flow Data - Precipitation State College 1972

Description:

Boundary Condition Types: Precipitation

Select Location in table then select Boundary Condition Type

River	Reach	RS	Boundary Condition

	Storage/2D Flow Areas		Boundary Condition
1	BaldEagleCr		Precipitation
2	BaldEagleCr	BCLine: Upstream Inflow	Flow Hydrograph
3	BaldEagleCr	BCLine: DSNormalDepth	Normal Depth

	SA/2D Area Conns	Boundary Condition
1	Dam	T.S. Gate Openings

Precipitation Hydrograph

2D: BaldEagleCr

○ Read from DSS before simulation

File:

Path:

● Enter Table

Data time interval: 1 Hour

Select/Enter the Data's Starting Time Reference

● Use Simulation Time: Date: 20JUN1972 Time: 0000

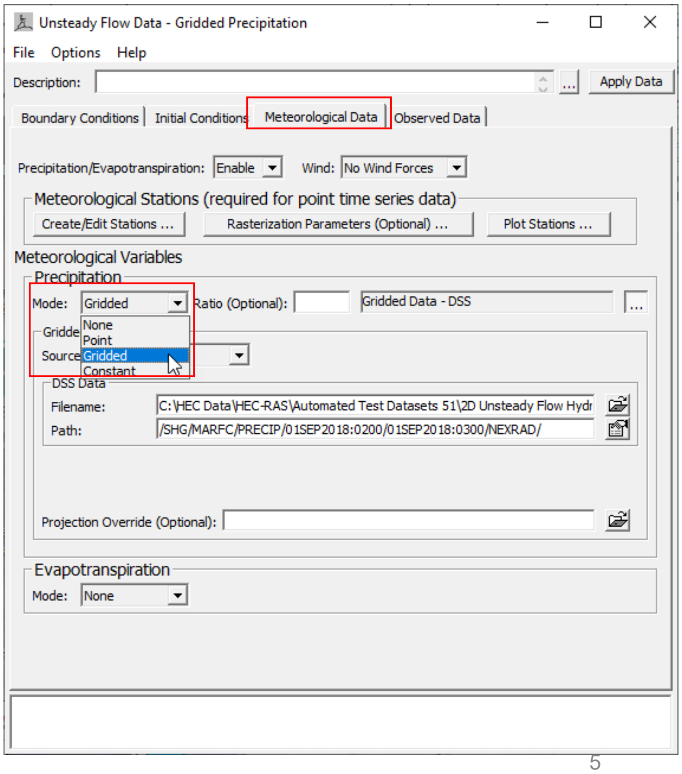
○ Fixed Start Time: Date: Time:

Hydrograph Data

	Date	Simulation Time (hours)	Precipitation (in)
1	19Jun1972 2400	0:00:00	0
20	20Jun1972 1900	19:00:00	.01
21	20Jun1972 2000	20:00:00	.02

Meteorological Data - Precipitation

- Gridded Data
  - HEC-DSS file format (from HEC-MetView)
  - National Weather Service
    - GRIB
    - NetCDF
  - National Centers for Environmental Information
    - NetCDF
- Meteorological Station Data
  - HEC-DSS time series
    - Regular Interval
    - Irregular Interval
  - User Entered into a Table
- Constant Rate



Description:

Precipitation/Evapotranspiration: Enable

Wind: No Wind Forces

Mode: Gridded

Ratio (Optional):

Gridded Data - DSS

Filename: C:\HEC Data\HEC-RAS\Automated Test Datasets 51\2D Unsteady Flow Hydr

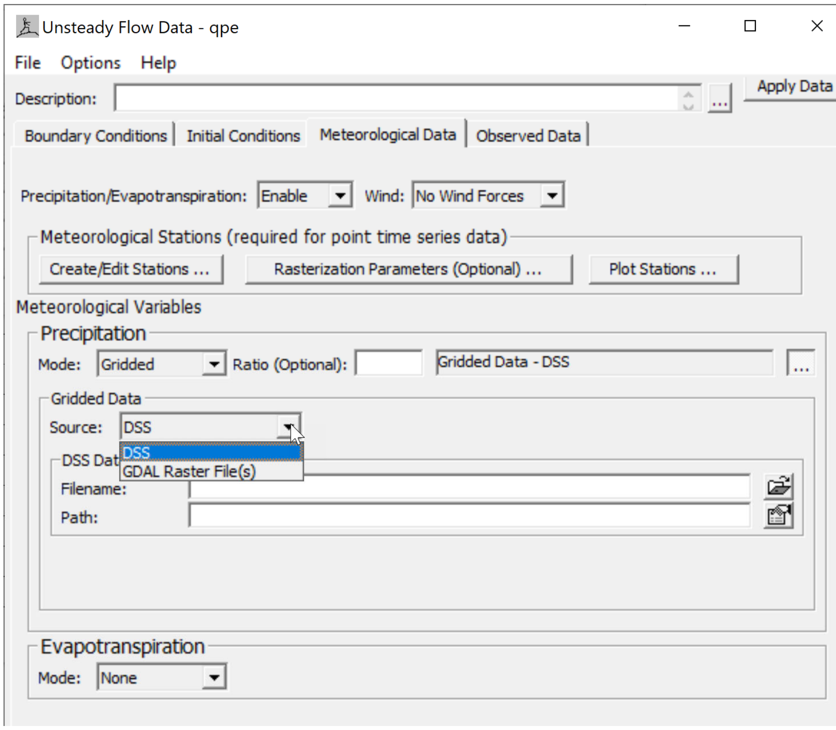
Path: /SHG/MARFC/PRECIP/01SEP2018:0200/01SEP2018:0300/NEXRAD/

Projection Override (Optional):

Mode: None

Gridded Precipitation

- Input Formats
  - DSS Grids
  - GDAL Raster File(s)
    - NetNCDF
    - GRIB
    - etc.
- Ratio (Optional)
  - Used to scale precipitation



Unsteady Flow Data - qpe

Precipitation/Evapotranspiration: Enable

Wind: No Wind Forces

Precipitation Mode: Gridded

Ratio (Optional):

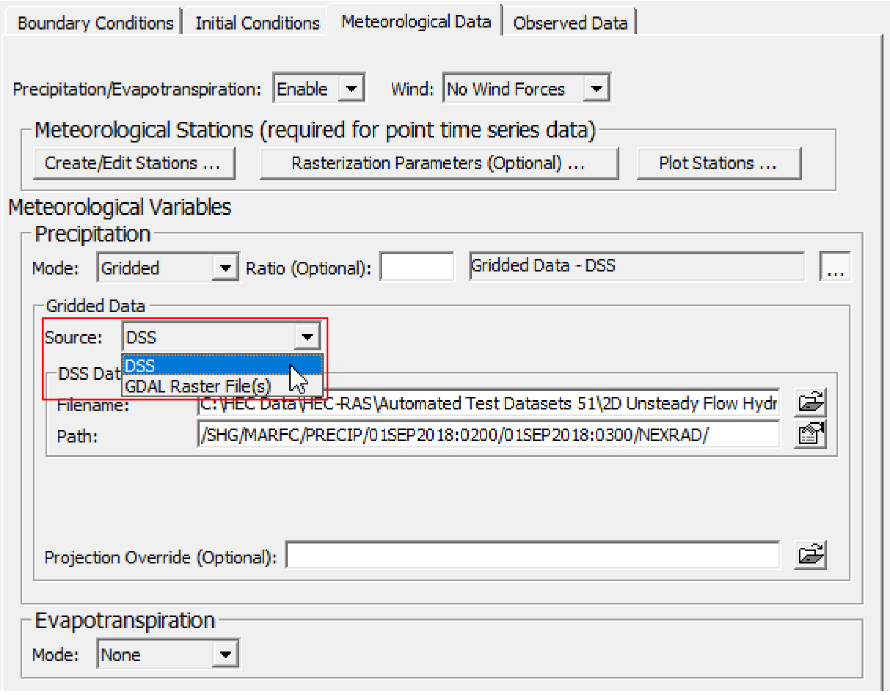
Gridded Data - DSS

Gridded Data Source: DSS

Evapotranspiration Mode: None

Gridded Precipitation

- Projection Override
  - If data has a different projection from RAS project



Precipitation/Evapotranspiration: Enable

Wind: No Wind Forces

Mode: Gridded

Ratio (Optional):

Gridded Data - DSS

Source: DSS

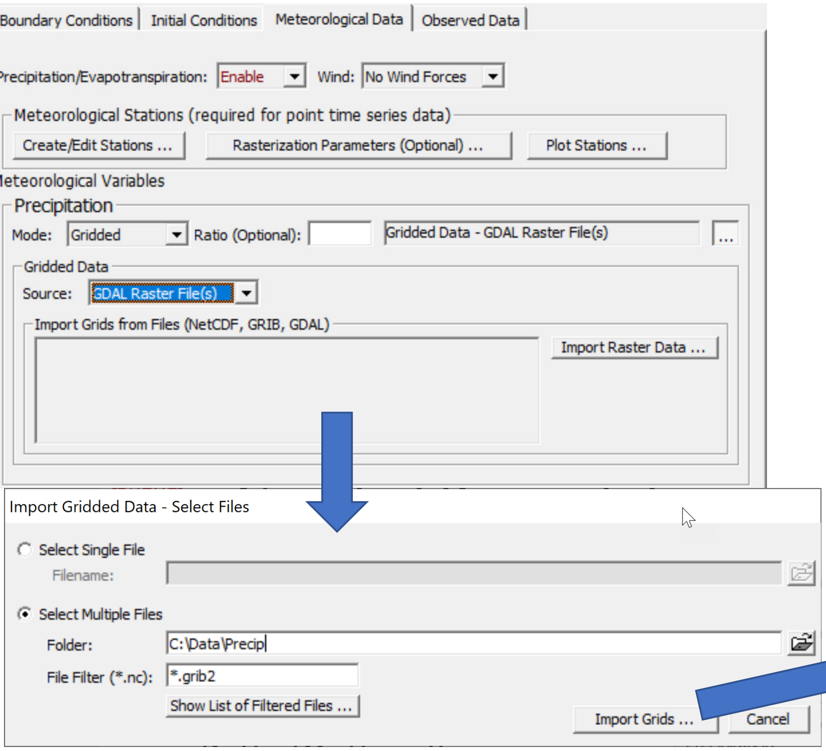
Filename: C:\HEC Data\HEC-RAS\Automated Test Datasets 51\2D Unsteady Flow Hydr

Path: /SHG/MARFC/PRECIP/01SEP2018:0200/01SEP2018:0300/NEXRAD/

Projection Override (Optional):

Mode: None

Gridded Precipitation - GRIB



recipitation/Evapotranspiration: Enable

Wind: No Wind Forces

Meteorological Stations (required for point time series data)

leteorological Variables

Precipitation

Mode: Gridded

Ratio (Optional):

Gridded Data - GDAL Raster File(s)

Gridded Data

Source: GDAL Raster File(s)

Import Grids from Files (NetCDF, GRIB, GDAL)

Import Gridded Data - Select Files

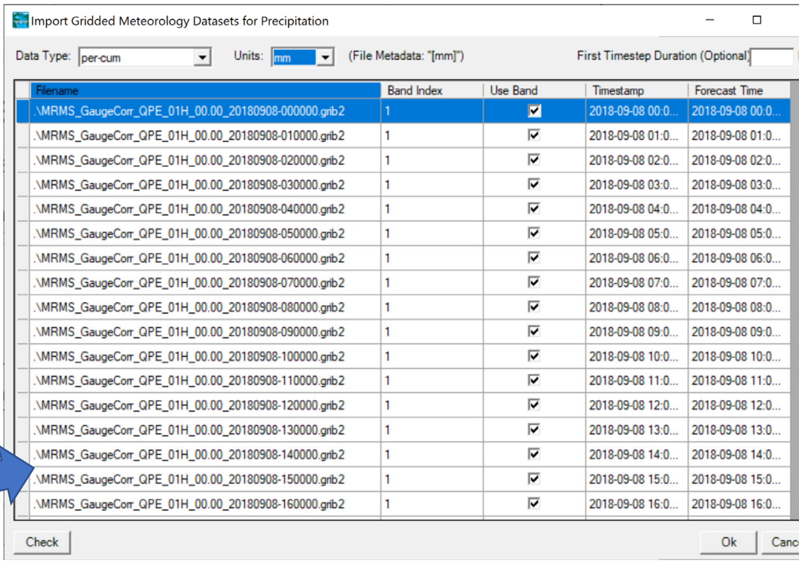
○ Select Single File

Filename:

● Select Multiple Files

Folder: C:\Data\Precip

File Filter (*.nc): *.grib2



Import Gridded Meteorology Datasets for Precipitation

Data Type: per-cum

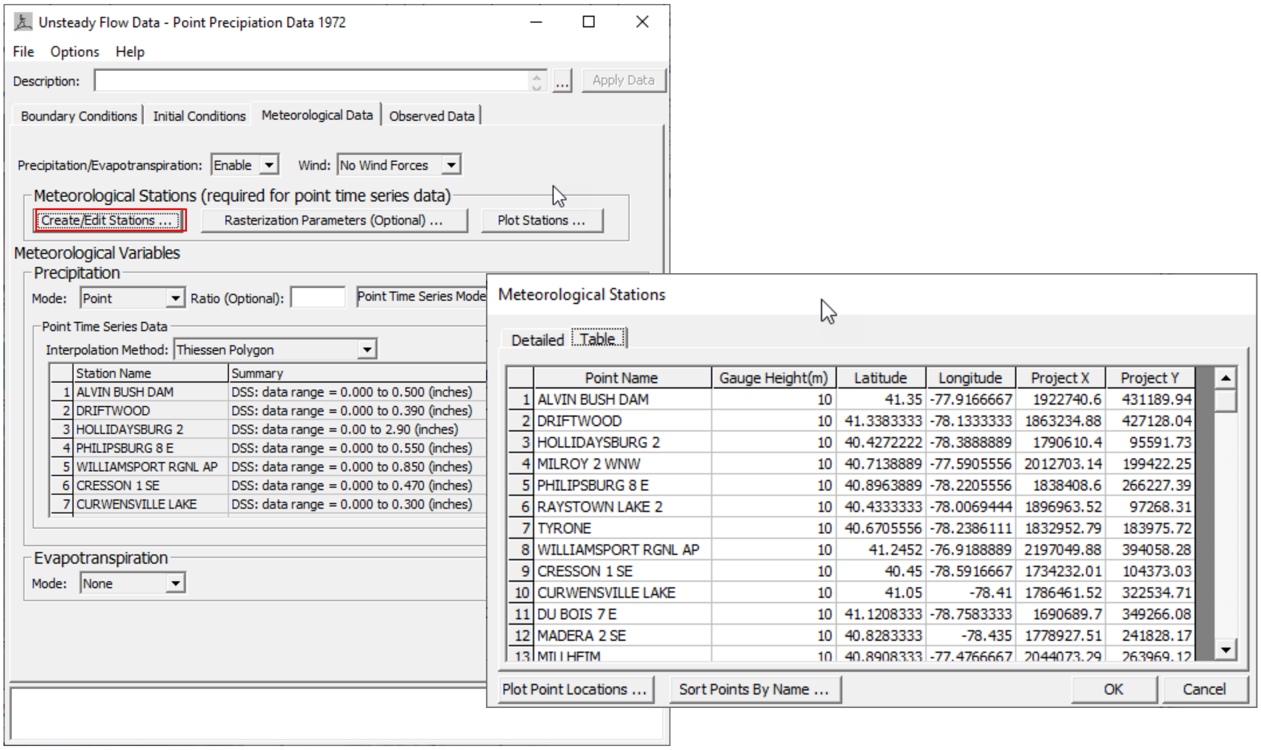
Units: mm

(File Metadata: "[mm]")

First Timestep Duration (Optional)

Filename	Band Index	Use Band	Timestamp	Forecast Time
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-000000.grib2	1	☑	2018-09-08 00:0...	2018-09-08 00:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-010000.grib2	1	☑	2018-09-08 01:0...	2018-09-08 01:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-020000.grib2	1	☑	2018-09-08 02:0...	2018-09-08 02:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-030000.grib2	1	☑	2018-09-08 03:0...	2018-09-08 03:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-040000.grib2	1	☑	2018-09-08 04:0...	2018-09-08 04:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-050000.grib2	1	☑	2018-09-08 05:0...	2018-09-08 05:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-060000.grib2	1	☑	2018-09-08 06:0...	2018-09-08 06:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-070000.grib2	1	☑	2018-09-08 07:0...	2018-09-08 07:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-080000.grib2	1	☑	2018-09-08 08:0...	2018-09-08 08:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-090000.grib2	1	☑	2018-09-08 09:0...	2018-09-08 09:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-100000.grib2	1	☑	2018-09-08 10:0...	2018-09-08 10:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-110000.grib2	1	☑	2018-09-08 11:0...	2018-09-08 11:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-120000.grib2	1	☑	2018-09-08 12:0...	2018-09-08 12:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-130000.grib2	1	☑	2018-09-08 13:0...	2018-09-08 13:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-140000.grib2	1	☑	2018-09-08 14:0...	2018-09-08 14:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-150000.grib2	1	☑	2018-09-08 15:0...	2018-09-08 15:0...
.\MRMS_GaugeCorr_QPE_01H_00.00_20180908-160000.grib2	1	☑	2018-09-08 16:0...	2018-09-08 16:0...

Point Gage Precipitation



Description:

Precipitation/Evapotranspiration: Enable

Wind: No Wind Forces

Meteorological Stations (required for point time series data)

Meteorological Variables

Precipitation

Mode: Point

Ratio (Optional):

Point Time Series Data

Interpolation Method: Thiessen Polygon

	Station Name	Summary
1	ALVIN BUSH DAM	DSS: data range = 0.000 to 0.500 (inches)
2	DRIFTWOOD	DSS: data range = 0.000 to 0.390 (inches)
3	HOLLIDAYSBURG 2	DSS: data range = 0.00 to 2.90 (inches)
4	PHILIPSBURG 8 E	DSS: data range = 0.000 to 0.550 (inches)
5	WILLIAMSPORT RGNL AP	DSS: data range = 0.000 to 0.850 (inches)
6	CRESSON 1 SE	DSS: data range = 0.000 to 0.470 (inches)
7	CURWENSVILLE LAKE	DSS: data range = 0.000 to 0.300 (inches)

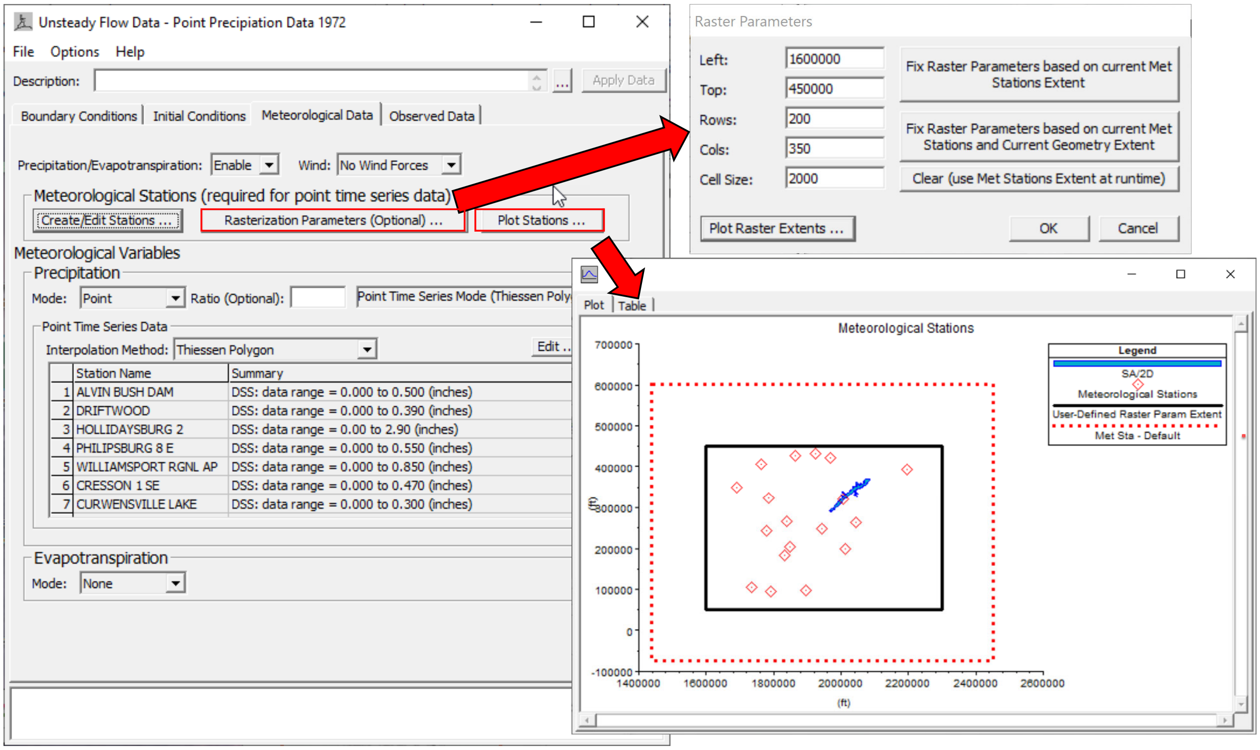
Evapotranspiration

Mode: None

Meteorological Stations

	Point Name	Gauge Height(m)	Latitude	Longitude	Project X	Project Y
1	ALVIN BUSH DAM	10	41.35	-77.9166667	1922740.6	431189.94
2	DRIFTWOOD	10	41.3383333	-78.1333333	1863234.88	427128.04
3	HOLLIDAYSBURG 2	10	40.4272222	-78.3888889	1790610.4	95591.73
4	MILROY 2 WNW	10	40.7138889	-77.5905556	2012703.14	199422.25
5	PHILIPSBURG 8 E	10	40.8963889	-78.2205556	1838408.6	266227.39
6	RAYSTOWN LAKE 2	10	40.4333333	-78.0069444	1896963.52	97268.31
7	TYRONE	10	40.6705556	-78.2386111	1832952.79	183975.72
8	WILLIAMSPORT RGNL AP	10	41.2452	-76.9188889	2197049.88	394058.28
9	CRESSON 1 SE	10	40.45	-78.5916667	1734232.01	104373.03
10	CURWENSVILLE LAKE	10	41.05	-78.41	1786461.52	322534.71
11	DU BOIS 7 E	10	41.1208333	-78.7583333	1690689.7	349266.08
12	MADERA 2 SE	10	40.8283333	-78.435	1778927.51	241828.17
13	MILLHEIM	10	40.8908333	-77.4766667	2044073.29	263969.12

Point Gage Precipitation



Unsteady Flow Data - Point Precipiation Data 1972

Description:

Precipitation/Evapotranspiration: Enable
Wind: No Wind Forces

Meteorological Stations (required for point time series data)

Meteorological Variables

Precipitation

Mode: Point
Ratio (Optional):
Point Time Series Mode (Thiessen Poly

Point Time Series Data

Interpolation Method: Thiessen Polygon

	Station Name	Summary
1	ALVIN BUSH DAM	DSS: data range = 0.000 to 0.500 (inches)
2	DRIFTWOOD	DSS: data range = 0.000 to 0.390 (inches)
3	HOLLIDAYSBURG 2	DSS: data range = 0.00 to 2.90 (inches)
4	PHILIPSBURG 8 E	DSS: data range = 0.000 to 0.550 (inches)
5	WILLIAMSPORT RGNL AP	DSS: data range = 0.000 to 0.850 (inches)
6	CRESSON 1 SE	DSS: data range = 0.000 to 0.470 (inches)
7	CURWENSVILLE LAKE	DSS: data range = 0.000 to 0.300 (inches)

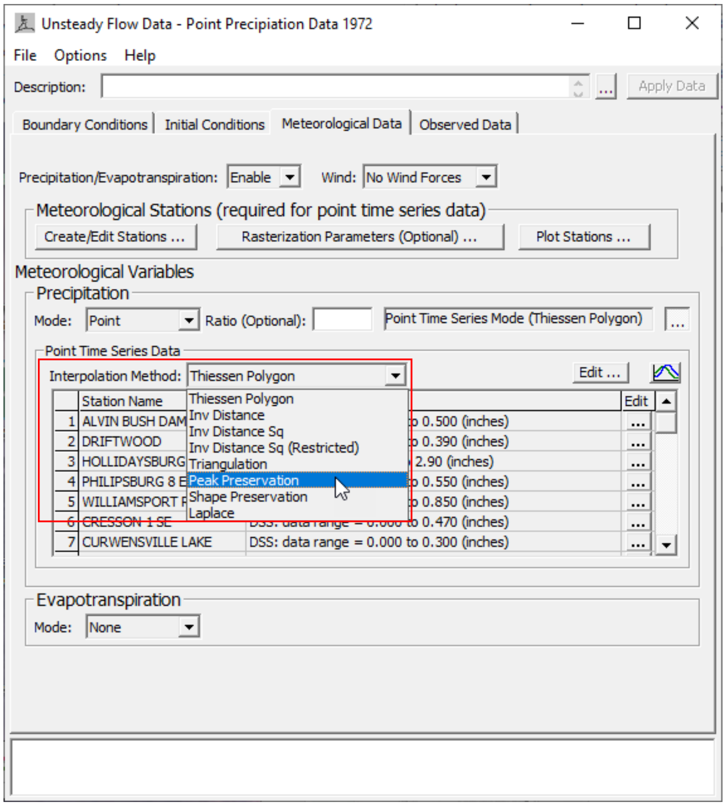
Evapotranspiration

Mode: None

Raster Parameters

Left: 1600000
Top: 450000
Rows: 200
Cols: 350
Cell Size: 2000

Point Gage Interpolation Methods



Description:

Precipitation/Evapotranspiration: Enable
Wind: No Wind Forces

Meteorological Stations (required for point time series data)

Meteorological Variables

Precipitation

Mode: Point
Ratio (Optional):
Point Time Series Mode (Thiessen Polygon)

Point Time Series Data

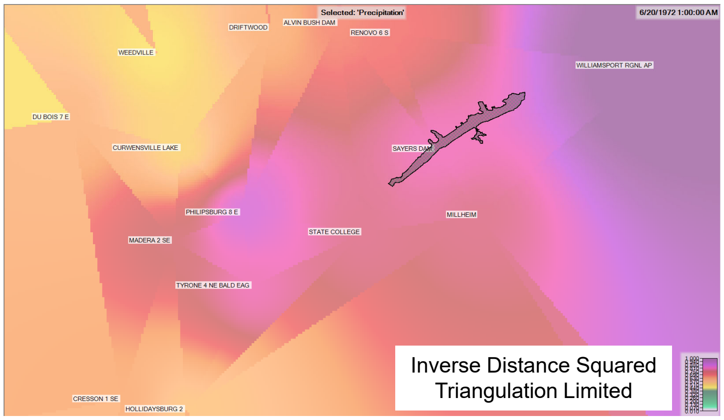
Interpolation Method: Thiessen Polygon

	Station Name		Edit
1	ALVIN BUSH DAM	o 0.500 (inches)	...
2	DRIFTWOOD	o 0.390 (inches)	...
3	HOLLIDAYSBURG	2.90 (inches)	...
4	PHILIPSBURG 8 E	o 0.550 (inches)	...
5	WILLIAMSPORT F	o 0.850 (inches)	...
6	CRESSON 1 SE	DSS: data range = 0.000 to 0.470 (inches)	...
7	CURWENSVILLE LAKE	DSS: data range = 0.000 to 0.300 (inches)	...

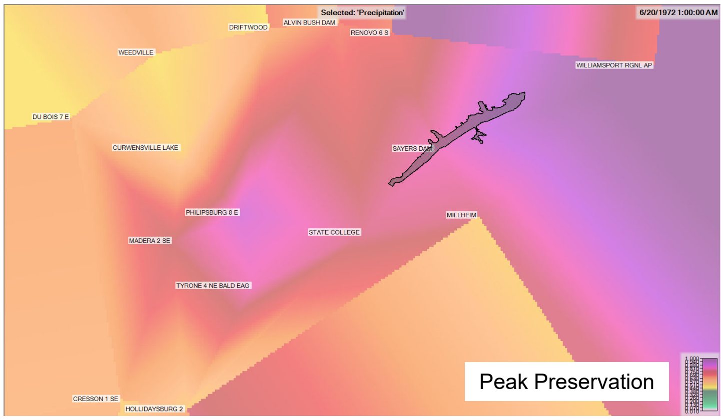
Evapotranspiration

Mode: None

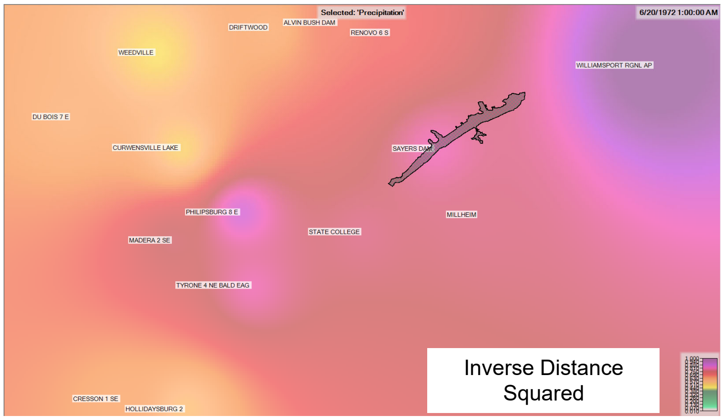
Cumulative Rainfall



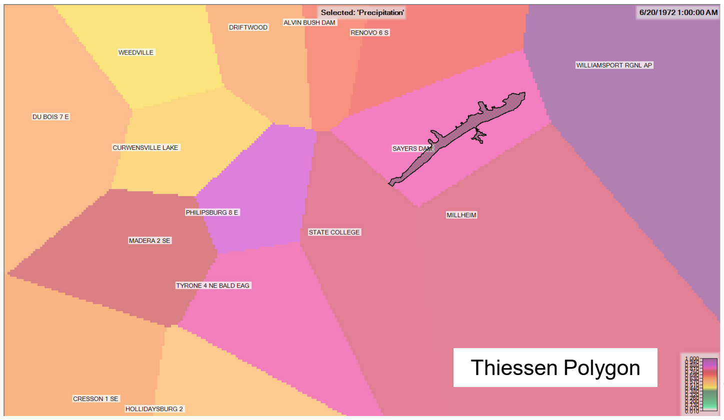
Inverse Distance Squared Triangulation Limited



Peak Preservation

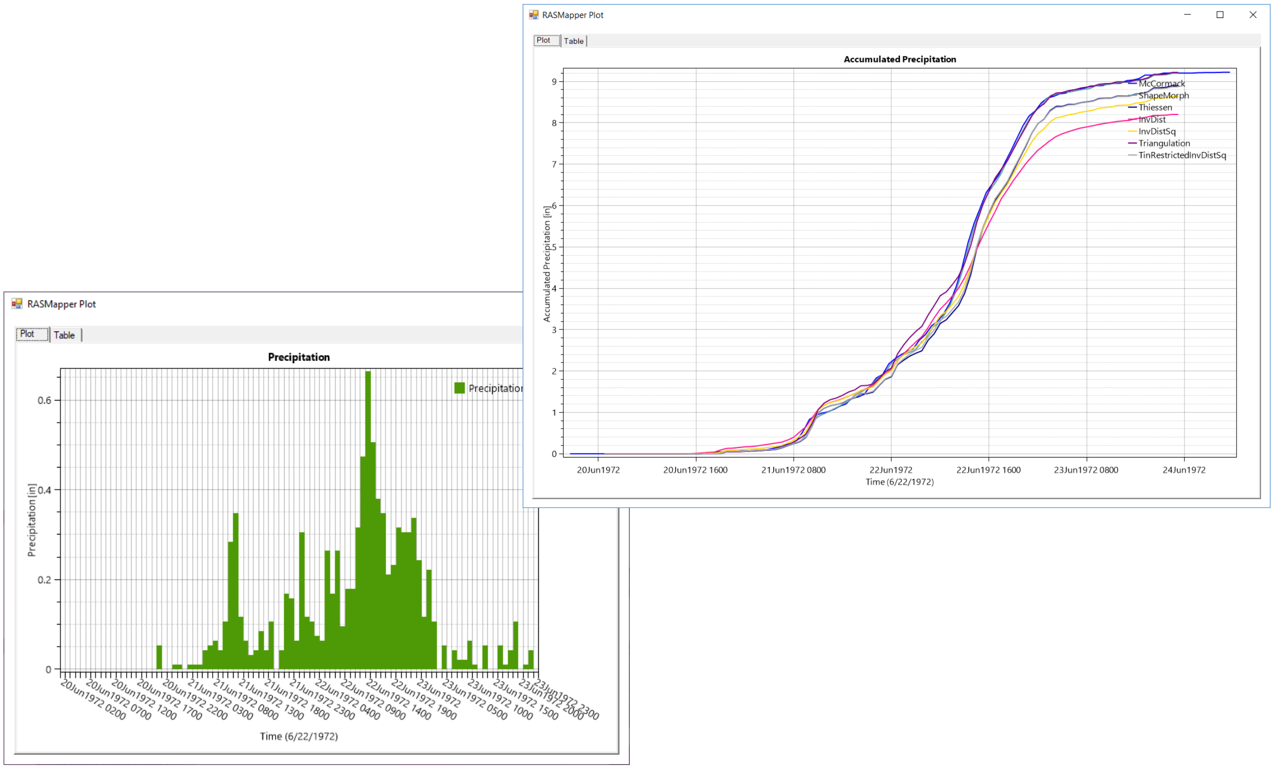


Inverse Distance Squared



Thiessen Polygon

Rainfall Time Series Plots



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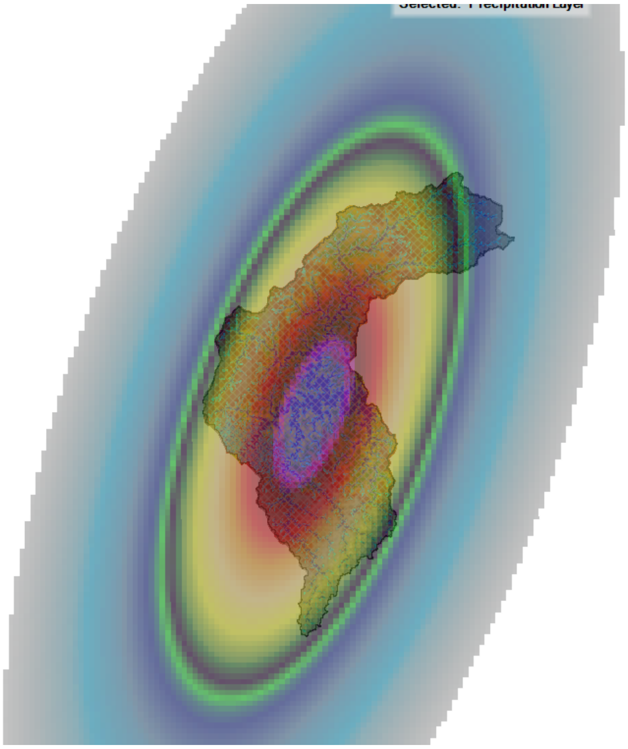
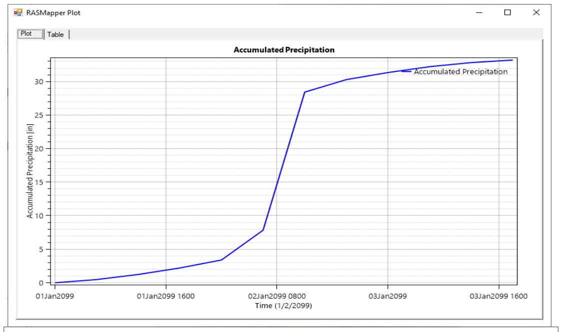
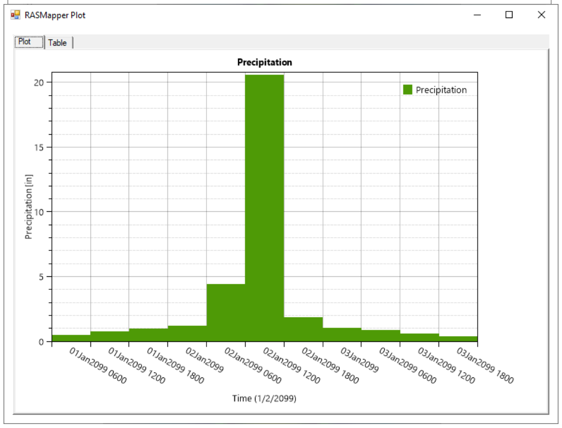
Probable Max Precipitation Example







Infiltration

- Computed at 1D XS's, Storage Areas, and 2D Cells
- Supported in all Equation Sets
- Methods
  - Deficit-Constant (DC)
  - SCS Curve Number (CN)
  - Green and Ampt without (GA) and with Redistribution (GAR)
- Parameterization based on
  - Soils
  - Land cover
- Other Optional Data
  - Percent Impervious

Deficit-Constant Method

- Governing Equation

$$\frac{dD}{dt} = E_v - f + p$$

where

D: Soil moisture deficit [L]

E_v: Soil evaporatranspiration [L/T]

f: Infiltration [L/T]

p: Percolation [L/T]

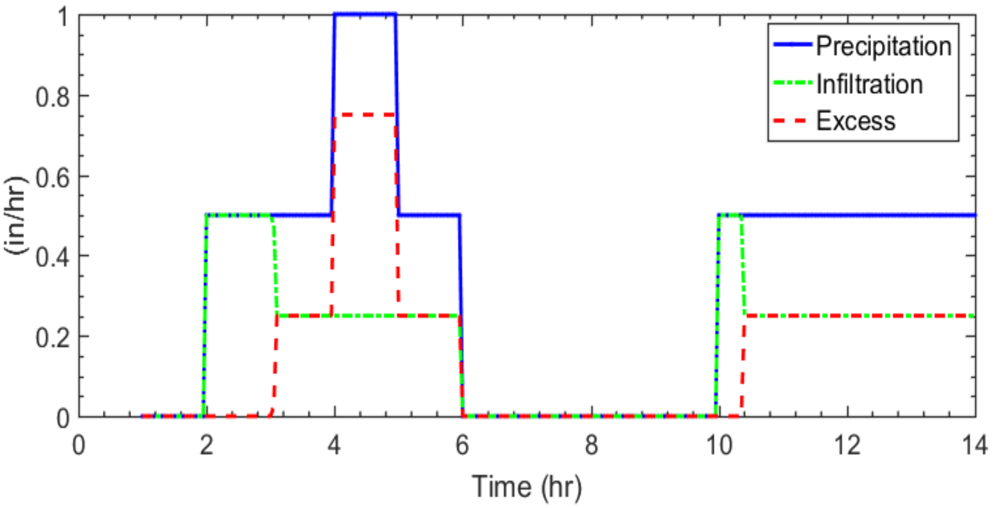
SCS Soil Group	Description	Loss Rates (in/hr)
A	Deep sand, deep loess, aggregated silts	0.3 - 0.45
B	Shallow loess, sandy lam	0.15 - 0.30
C	Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay	0.05 - 0.15
D	Soils that swell significantly when wet, heavy plastic clays, and certain saline soils	0.00 – 0.05

- Input
  - ▶ Initial deficit [L]
  - ▶ Maximum deficit [L]
  - ▶ Potential percolation rate (loss rate) [L/T]

Deficit-Constant Verification

- Comparison with HEC-HMS dataset from PROSPECT Class

Time (hrs)	Precipitation (in)	Deficit (in)	Loss (in)	Excess (in)
1	0.0	0.5	0.0	0.0
2	0.5	0.0	0.5	0.0
3	0.5	0.0	0.25	0.25
4	1.0	0.0	0.25	0.75
5	0.5	0.0	0.25	025
6	0.0	0.05	0.0	0.0
7	0.0	0.1	0.0	0.0
8	0.0	0.15	0.0	0.0
9	0.0	0.2	0.0	0.0
10	0.5	0	0.35	0.15
11	0.5	0	0.25	0.25
12	0.5	0	0.25	0.25
13	0.5	0	0.25	0.25
14	0.5	0	0.25	0.25



SCS Curve Number Method

- Equations

$$P_e = \frac{(P - I_a)^2}{P - I_a + S} \qquad S = \frac{1000}{CN} - 10 \qquad I_a = r_a S$$

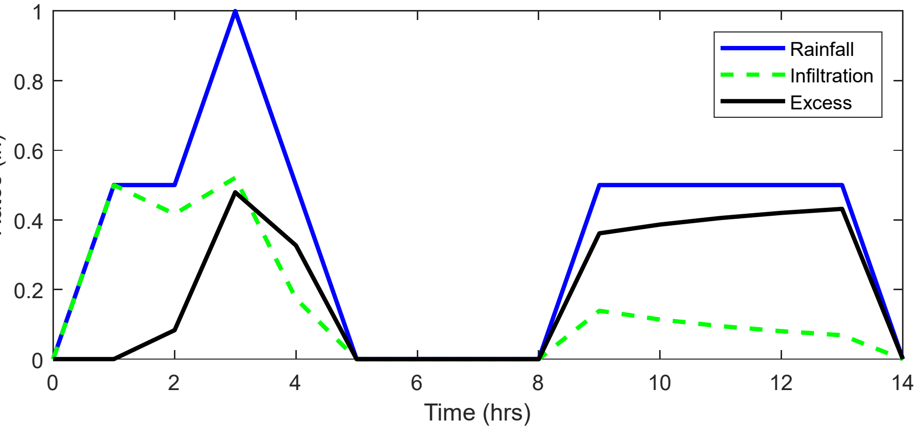
where

P_e : Accumulated excess depth [L]
P : Accumulated rainfall depth [L]
CN: Curve number [-]
I_a: Initial abstraction [L]
r_a : Abstraction ratio [-]
S : Potential maximum retention [L]

- Input
  - Curve Number
  - Abstraction ratio
  - Minimum infiltration rate (optional)
  - Dry period used to reset method (optional)

Cover			Hydrologic Soil Group			
Land Use	Treatment or Practice	Hydrologic Condition	A	B	C	D
Fallows	Straight row		77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
		Good	67	78	85	89
	Contoured	Poor	70	79	84	88
		Good	65	75	82	86
	Contoured and terraced	Poor	66	74	80	82
		Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	Contoured and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes or rotation meadow	Straight row	Poor	66	77	85	89
		Good	58	72	81	85
	Contoured	Poor	64	75	83	85
		Good	55	69	78	83
	Contoured and terraced	Poor	63	73	80	83
		Good	51	67	76	80
Pasture or range	Contoured	Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
		Poor	47	67	81	88
		Fair	25	59	75	83
		Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads			59	74	82	86
Roads (dirt)			72	82	87	89
(hard surface)			74	84	90	92

SCS CN Verification



		HEC-HMS	Computed	HEC-HMS	Computed
Time	Precip (in)	Loss (in)	Loss (in)	Excess (in)	Excess (in)
1:00	0	0	0	0	
2:00	0.5	0.5	0.5	0	
3:00	0.5	0.417	0.4167	0.083	0.083
4:00	1	0.521	0.5208	0.479	0.479
5:00	0.5	0.174	0.1736	0.326	0.326
6:00	0	0	0	0	
7:00	0	0	0	0	
8:00	0	0	0	0	
9:00	0	0	0	0	
10:00	0.5	0.139	0.1389	0.361	0.361
11:00	0.5	0.114	0.1136	0.386	0.386
12:00	0.5	0.095	0.0947	0.405	0.405
13:00	0.5	0.08	0.0801	0.42	0.419
14:00	0.5	0.069	0.0687	0.431	0.431

Green-Ampt Method

- Equations

$$\frac{dF}{dt} = f \qquad f = \min(f_*, R) \qquad f_* = K_s\left(1 + \frac{\psi\theta_d}{F}\right)$$

where

f : Infiltration potential [L/T]

f_* : Infiltation potential (infiltration rate given unlimited [L/T]

R : Rainfall [L/T]

ψ : Wetting front suction [L]

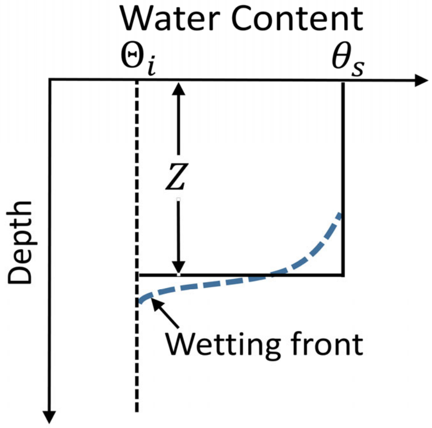
K_s : Saturated hydraulic conductivity [L/T]

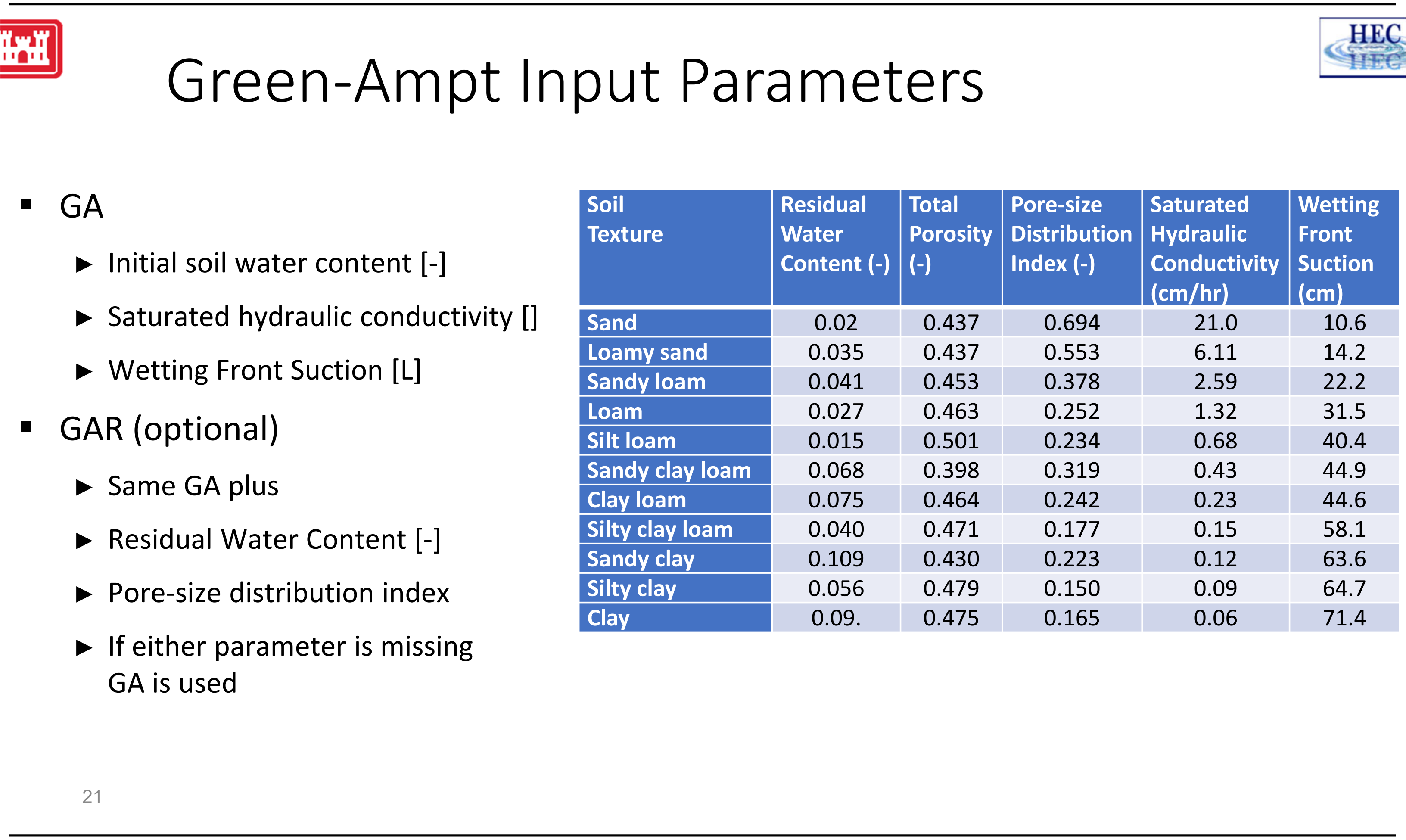
F : Cumulative infiltration depth [L]

$\theta_d = \theta_s - \theta_i$: Moisture deficit [-]

θ_s : Saturated moisture content [-]

θ_i : Initialmoisture content [-]





Green-Ampt Input Parameters

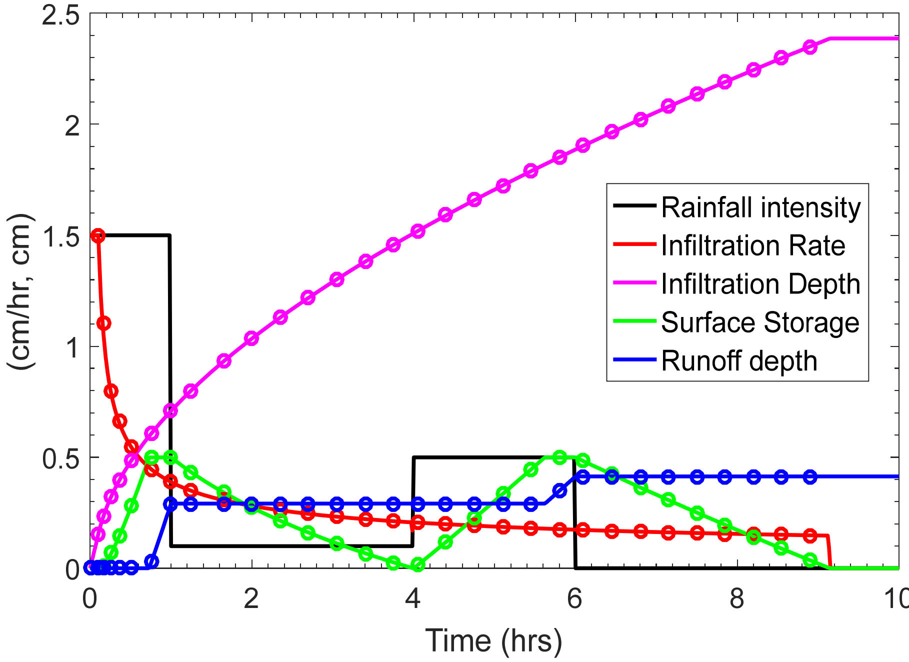
- GA
  - Initial soil water content [-]
  - Saturated hydraulic conductivity []
  - Wetting Front Suction [L]
- GAR (optional)
  - Same GA plus
  - Residual Water Content [-]
  - Pore-size distribution index
  - If either parameter is missing GA is used

Soil Texture	Residual Water Content (-)	Total Porosity (-)	Pore-size Distribution Index (-)	Saturated Hydraulic Conductivity (cm/hr)	Wetting Front Suction (cm)
Sand	0.02	0.437	0.694	21.0	10.6
Loamy sand	0.035	0.437	0.553	6.11	14.2
Sandy loam	0.041	0.453	0.378	2.59	22.2
Loam	0.027	0.463	0.252	1.32	31.5
Silt loam	0.015	0.501	0.234	0.68	40.4
Sandy clay loam	0.068	0.398	0.319	0.43	44.9
Clay loam	0.075	0.464	0.242	0.23	44.6
Silty clay loam	0.040	0.471	0.177	0.15	58.1
Sandy clay	0.109	0.430	0.223	0.12	63.6
Silty clay	0.056	0.479	0.150	0.09	64.7
Clay	0.09.	0.475	0.165	0.06	71.4

Green-Ampt Verification

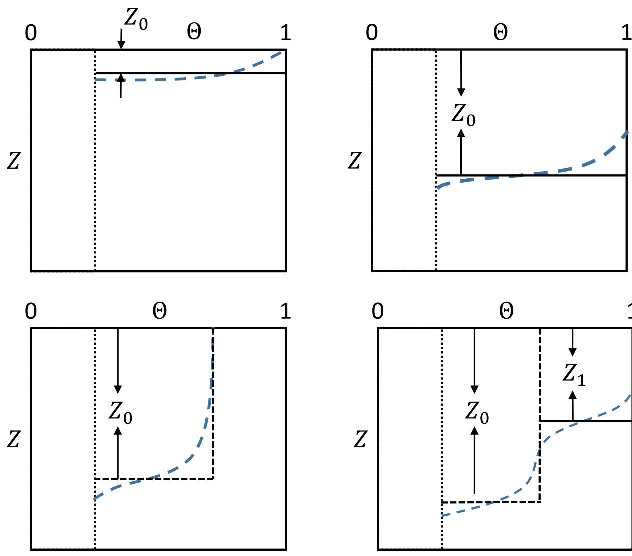
- Comparison with code by Daliakopoulos (2015)
  - Computed – solid lines
  - Daliakopoulos (2015) - Circles

Parameter	**Value**
Saturated hydraulic conductivity (cm/hr)	0.044
Wetting front suction (cm)	22.4
Saturated water content (-)	0.499
Residual water content (-)	0.03
Initial water content (-)	0.25



Redistribution Method (GAR)

- Governing Equation (Ogden and Saghafian 1997)



$$\frac{d\theta_0}{dt} = \frac{1}{Z_0}\left\{ f - E_v - K_i - \left[K_0 + \frac{K_s G(\theta_i,\theta_o)}{Z_0} \right] \right\}$$

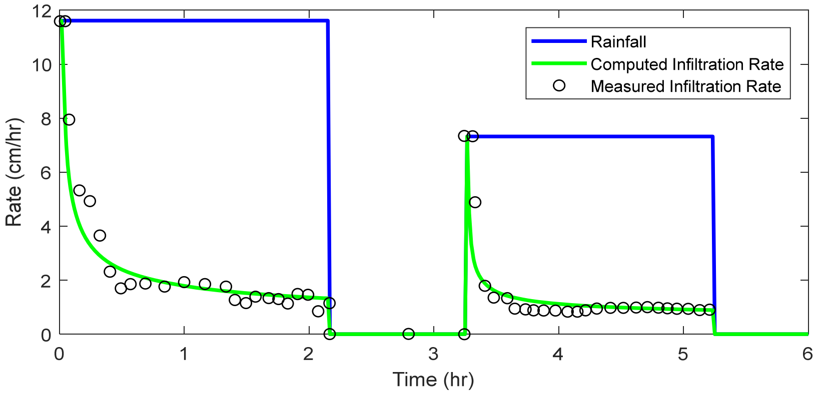
where

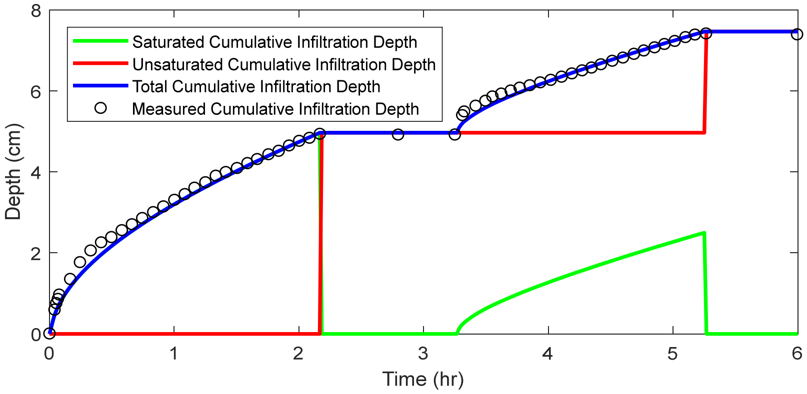
$G(\theta_i,\theta_o)$: Integral of the capillary drive through the saturated front [L]
$Z_0 = F_0 / (\theta_0 - \theta_i)$: Depth of wetting front [L]
F_0: Cumulative infiltration [L]
θ_0: Soil moisture content corresponding to unsaturated front [L]
$K_0 = K(\theta_0)$: Unsaturated hydraulic conductivity corresponding to θ_0 [L/T]
$K_i = K(\theta_i)$: Unsaturated hydraulic conductivity corresponding to θ_i [L/T]

GAR Validation

- Comparison with Alapaha Sand Tests (Rawls et al. 1976)

Parameter	Value
Saturated hydraulic conductivity (cm/hr)	0.47
Suction at the wetting front (cm)	45
Saturated water content (-)	0.38
Residual water content (-)	0.06
Initial water content (-)	0.19
Pore distribution index	0.45





Percent Impervious and Surface Excess

- Percent Impervious
  - ▶ Associated with **Land Cover** classification layer
  - ▶ Between 0 and 100
  - ▶ Usually set to 100 for open water
- Surface Excess Rate

$$v = R - \left(1 - \frac{P_{imp}}{100}\right) f$$

v : Excess [L/T]

R : Rainfall [L/T]

f : Infiltration [L/T]

P_{imp} : Percent impervious [%]

Evapotranspiration

- Evapotranspiration Potential ET_0
- Actual Evapotranspiration

$$ET = E_h + E_v$$

where

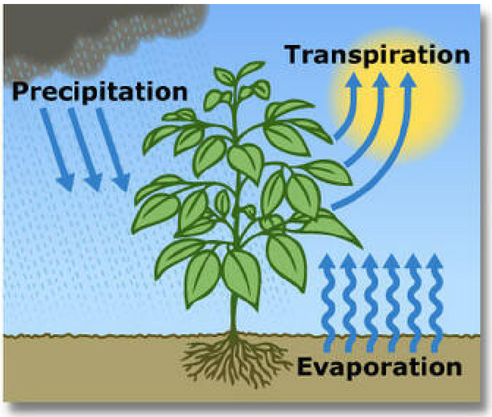
$E_h = \min\left(ET_0, h/\Delta t\right)$: Surface water evaporation [L/T]

$E_v = \min\left(ET_0 - E_h, S_w/\Delta t\right)$: Evapotranspiration [L/T]

h: Water depth [L]

S_w: Soil water [L]

Δt: Time step [T]



- Input Data Modes
  - Constant, Point Gage, or Gridded

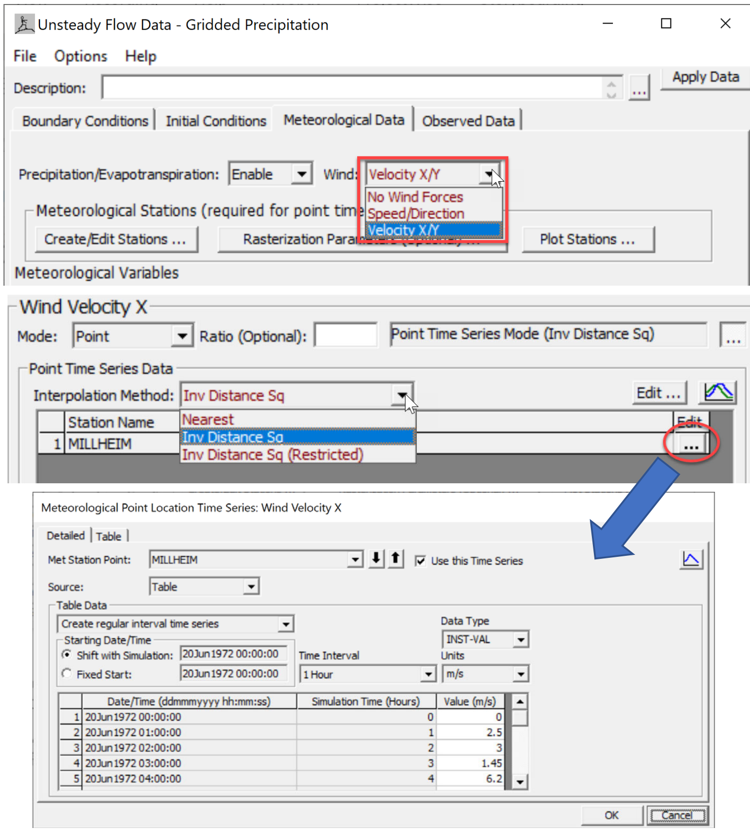
Limitations

- No Spatial Compositing of Infiltration Parameters
  - Parameters extracted from land classification layer based on location of Computation Points
- Surface water cannot infiltrate
- Does not include
  - Inter-flow
  - Base-flow
  - Ground water flow
  - Canopy storage and dynamics
  - Depression storage

$$X_c = \frac{\sum_i A_i X_i}{\sum_i A_i}$$

Meteorological Data - Wind

- Enabled in **Meteorological Data** tab of **Unsteady Flow Data** editor
- Velocities defined at 10-m height
- Input Data Modes
  - Gridded
    - HEC-DSS file format (from HEC-MetView)
    - GDAL Formats
  - Meteorological Station Data
    - HEC-DSS time series
    - User Entered into a Table
  - Constant Rate
- Interpolation Methods
  - Nearest
  - Inverse Distance
  - Inverse Distance Squared
- Ratio (optional)
  - Used to scale the wind velocities or convert height to 10-m



Unsteady Flow Data - Gridded Precipitation

Description:

Precipitation/Evapotranspiration: Enable

Wind: Velocity X/Y

Meteorological Stations (required for point time series)

Wind Velocity X

Mode: Point

Ratio (Optional):

Point Time Series Mode (Inv Distance Sq)

Point Time Series Data

Interpolation Method: Inv Distance Sq

	Station Name
1	MILLHEIM

Meteorological Point Location Time Series: Wind Velocity X

Met Station Point: MILLHEIM

☑ Use this Time Series

Source: Table

Table Data

Create regular interval time series

Starting Date/Time

● Shift with Simulation: 20Jun1972 00:00:00

○ Fixed Start: 20Jun1972 00:00:00

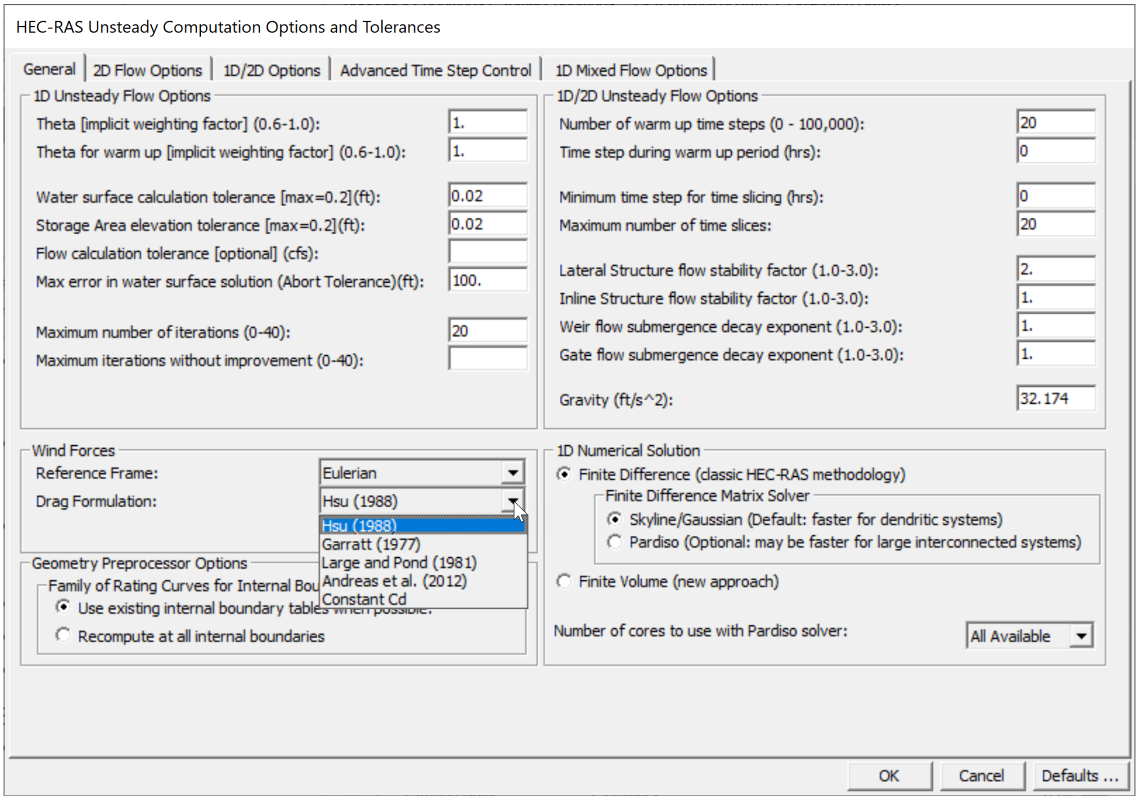
Time Interval: 1 Hour

Data Type: INST-VAL

Units: m/s

	Date/Time (ddmmmyyyy hh:mm:ss)	Simulation Time (Hours)	Value (m/s)
1	20Jun1972 00:00:00	0	0
2	20Jun1972 01:00:00	1	2.5
3	20Jun1972 02:00:00	2	3
4	20Jun1972 03:00:00	3	1.45
5	20Jun1972 04:00:00	4	6.2

Wind Options



1D Unsteady Flow Options

Theta [implicit weighting factor] (0.6-1.0): 1.
Theta for warm up [implicit weighting factor] (0.6-1.0): 1.
Water surface calculation tolerance [max=0.2](ft): 0.02
Storage Area elevation tolerance [max=0.2](ft): 0.02
Flow calculation tolerance [optional] (cfs):
Max error in water surface solution (Abort Tolerance)(ft): 100.
Maximum number of iterations (0-40): 20
Maximum iterations without improvement (0-40):

1D/2D Unsteady Flow Options

Number of warm up time steps (0 - 100,000): 20
Time step during warm up period (hrs): 0
Minimum time step for time slicing (hrs): 0
Maximum number of time slices: 20
Lateral Structure flow stability factor (1.0-3.0): 2.
Inline Structure flow stability factor (1.0-3.0): 1.
Weir flow submergence decay exponent (1.0-3.0): 1.
Gate flow submergence decay exponent (1.0-3.0): 1.
Gravity (ft/s^2): 32.174

Wind Forces

Reference Frame: Eulerian
Drag Formulation: Hsu (1988)

- Hsu (1988)
- Garratt (1977)
- Large and Pond (1981)
- Andreas et al. (2012)
- Constant Cd

Geometry Preprocessor Options

Family of Rating Curves for Internal Bou
● Use existing internal boundary tables when possible.
○ Recompute at all internal boundaries

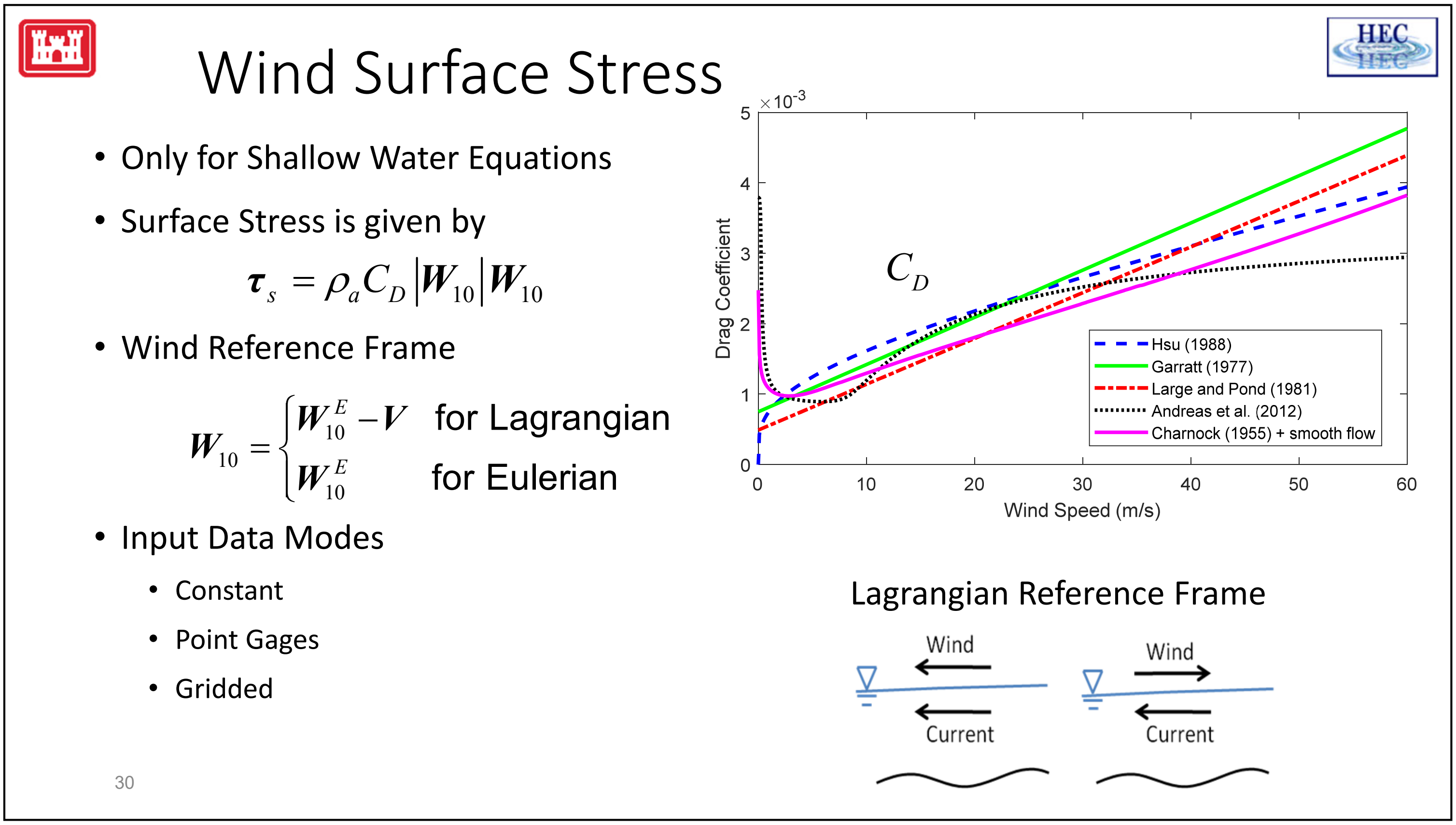
1D Numerical Solution

● Finite Difference (classic HEC-RAS methodology)

Finite Difference Matrix Solver
● Skyline/Gaussian (Default: faster for dendritic systems)
○ Pardiso (Optional: may be faster for large interconnected systems)

○ Finite Volume (new approach)

Number of cores to use with Pardiso solver: All Available



Wind Surface Stress

- Only for Shallow Water Equations
- Surface Stress is given by

$$\boldsymbol{\tau}_s = \rho_a C_D \left|\boldsymbol{W}_{10}\right| \boldsymbol{W}_{10}$$

- Wind Reference Frame

$$\boldsymbol{W}_{10} = \begin{cases} \boldsymbol{W}_{10}^E - \boldsymbol{V} & \text{for Lagrangian} \\ \boldsymbol{W}_{10}^E & \text{for Eulerian} \end{cases}$$

- Input Data Modes
  - Constant
  - Point Gages
  - Gridded

Lagrangian Reference Frame

- Wind forcing is new feature 6.0.
- The wind surface stress is computed as a function of the atmospheric density, a drag coefficient, and the 10-m wind velocity.
- Several options are available to compute the wind drag coefficient.
- There is also an option to choose between Eulerian and Lagrangian reference frames.
- The Lagrangian reference frame takes into account the relative motion between the air and water whereas the Eulerian reference frame ignores the water velocity.
- In general, it always recommended to use the Lagrangian reference frame because it’s more physically accurate and stable.

Thank You!

HEC-RAS Website:
https://www.hec.usace.army.mil/software/hec-ras/

Online Documentation:
https://www.hec.usace.army.mil/confluence/rasdocs

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