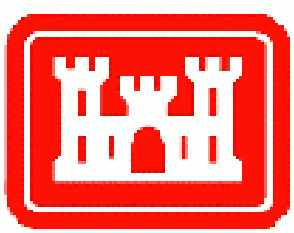

M2D Theory & Model Parameters

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Introduction

- Model Theory
  - Governing equations
  - Wind & friction coefficients
  - Grid definition
  - Courant stability condition
- Parameters & Boundary Conditions
  - Grid input information
  - Model control: settings & parameters
    - Run options
    - Output options
    - Parameter settings
  - Boundary condition input

Governing Equations

- Continuity

$$\frac{\partial \eta}{\partial t} = -\frac{\partial (h+\eta)u}{\partial x} - \frac{\partial (h+\eta)v}{\partial y}$$

- X momentum

$$\frac{\partial u}{\partial t} = -g\frac{\partial \eta}{\partial x} - u\frac{\partial u}{\partial x} - v\frac{\partial u}{\partial y} + 2a_h\frac{\partial^2 u}{\partial x^2} + fv - C_b\frac{u|U|}{(h+\eta)} + C_d\frac{\rho_a}{\rho_w}\frac{W^2\cos(\theta)}{(h+\eta)} - \frac{1}{\rho_w(h+\eta)}\left[\frac{\partial S_{xx}}{\partial x} + \frac{\partial S_{xy}}{\partial y}\right]$$

- Y momentum

$$\frac{\partial v}{\partial t} = -g\frac{\partial \eta}{\partial y} - u\frac{\partial v}{\partial x} - v\frac{\partial v}{\partial y} + 2a_h\frac{\partial^2 v}{\partial y^2} - fu - C_b\frac{v|U|}{(h+\eta)} + C_d\frac{\rho_a}{\rho_w}\frac{W^2\sin(\theta)}{(h+\eta)} - \frac{1}{\rho_w(h+\eta)}\left[\frac{\partial S_{xy}}{\partial x} + \frac{\partial S_{yy}}{\partial y}\right]$$

Wind Drag Coefficient

- Wind drag coefficient, Hsu 1988

$$C_{10} = \left(\frac{\kappa}{14.56 - 2 \ln W_{10}} \right)^2$$

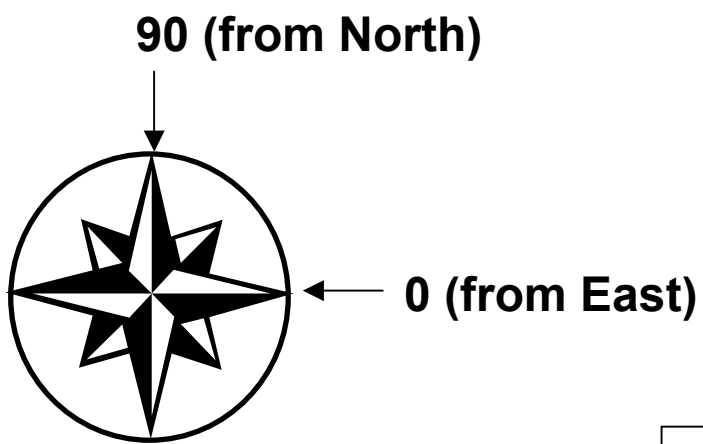
C_{10} = drag coefficient
W_{10} = 10 m wind speed
κ = von Karman's const

- Wind speed scaling

$$W_{10} = W_z \left(\frac{10}{Z} \right)^{1/7}$$

Z = height above surface
W_Z = Z m wind speed

- Wind direction convention



Bottom Friction Coefficient

- Bottom friction coefficient

$$C_b = \frac{g}{C^2}$$

C_b = bottom friction coefficient
g = acceleration due to gravity
C = Chezy roughness coefficient

- Chezy roughness coefficient

$$C = \frac{R^{1/6}}{n}$$

R = hydraulic radius
n = Manning roughness coefficient

Courant Stability Criterion

- Courant number

$$\xi \equiv u \frac{\Delta t}{\Delta s}$$

ξ= Courant number
u = shallow-water wave speed
Δt = time step
Δs = cell dimension

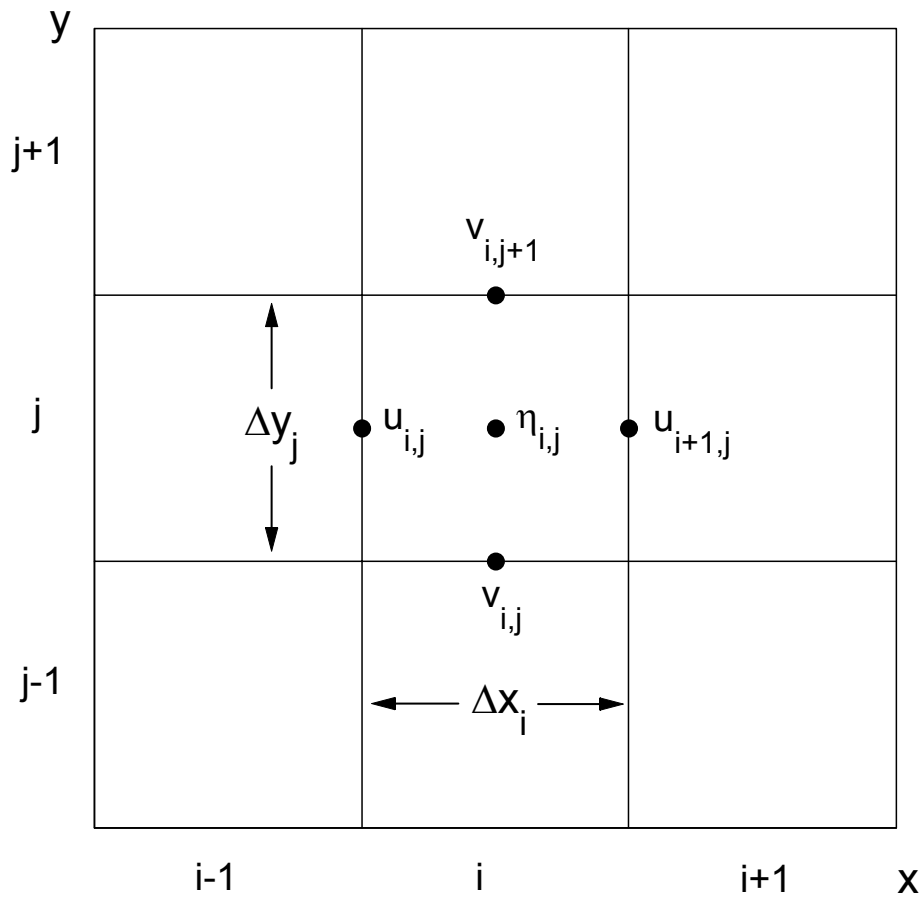
- Practical application of model

$$\Delta t < 0.7 \xi \frac{\Delta s}{u}$$

- Maximum time step dependent on hydraulic regime

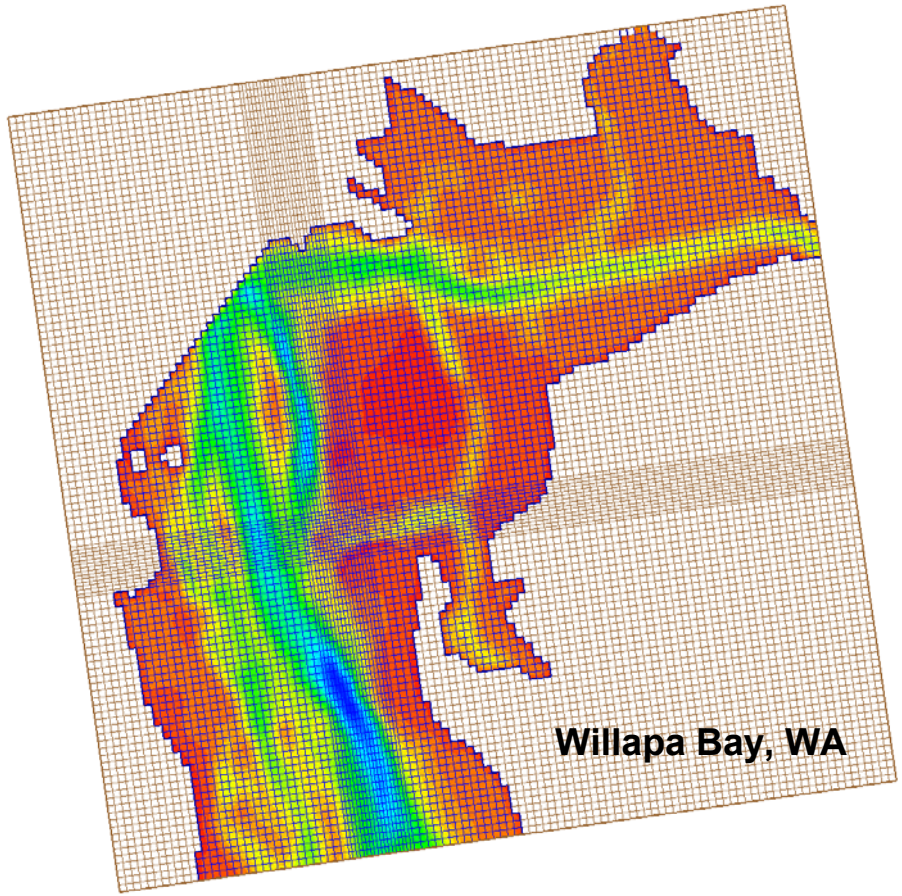
Grid Definition

- Staggered rectilinear grid
- Water level calculated at cell centers
- Velocities calculated at centers of cell faces
- Centered finite-difference algorithm (except for advection, which applies upwinding; higher-order scheme in progress)



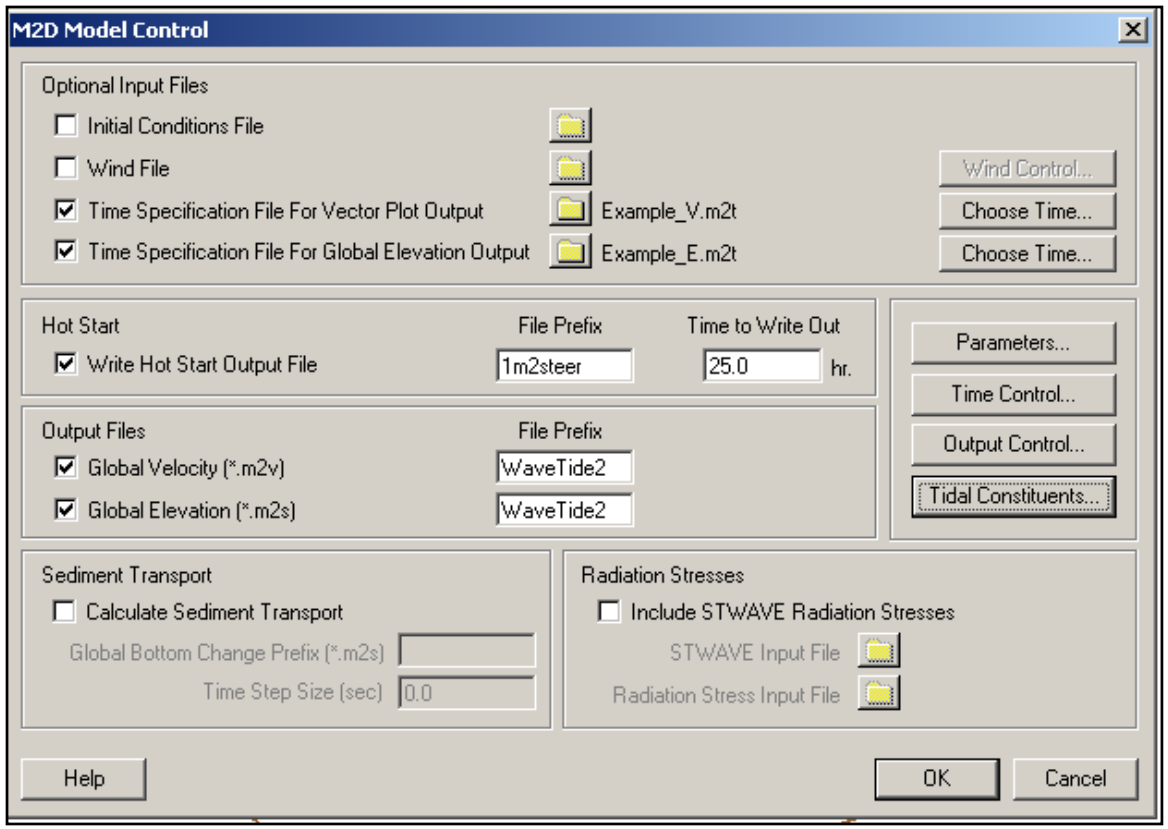
Grid Development

- Domain & discretization
- Bathymetric data
- Manning's *n*
  - Spatially variable
  - Dependent on properties of material
- Latitude
  - Coriolis calculation
  - Spatially variable or constant
  - For no Coriolis, set latitude to zero



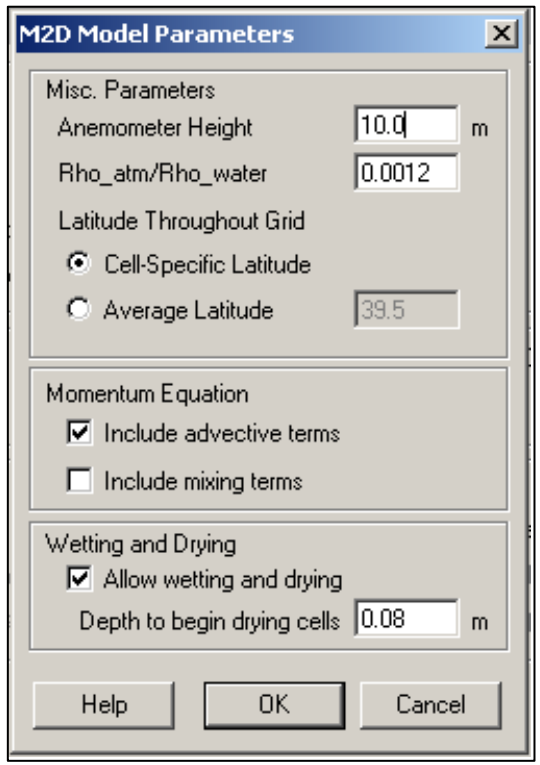
Model Control

- Parameter settings
- Run options
- Time control
- Station output specifications
- Global output specifications
- Hot start option
- Tide forcing option



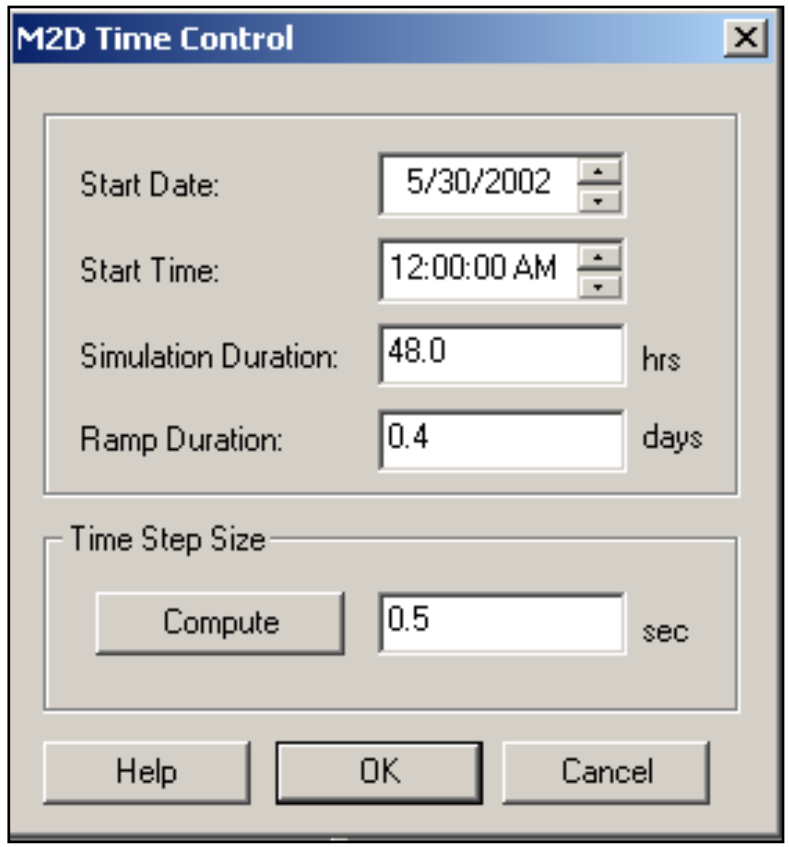
Parameter Settings & Run Options

- Atmospheric parameters
  - Anemometer height, typically 10 m
  - Density ratio, typically 0.0012
- Latitude
  - Constant or variable over grid
- Continuity equation
- Momentum equation
  - Advective terms
  - Mixing terms
- Wetting & Drying
  - Enable
  - Depth at which cells are treated as dry



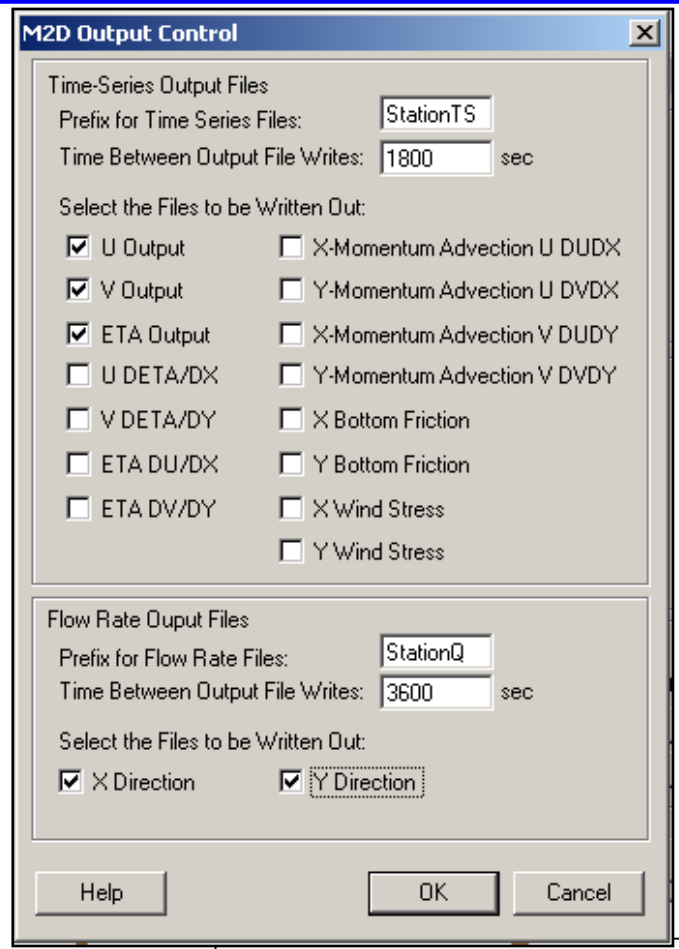
Time Control

- Start date & time
- Length of simulation (hr)
- Ramp duration (day)
- Time step (sec)
  - SMS has option to compute max time step based on Courant condition
  - M2D requires time step smaller than calculated max



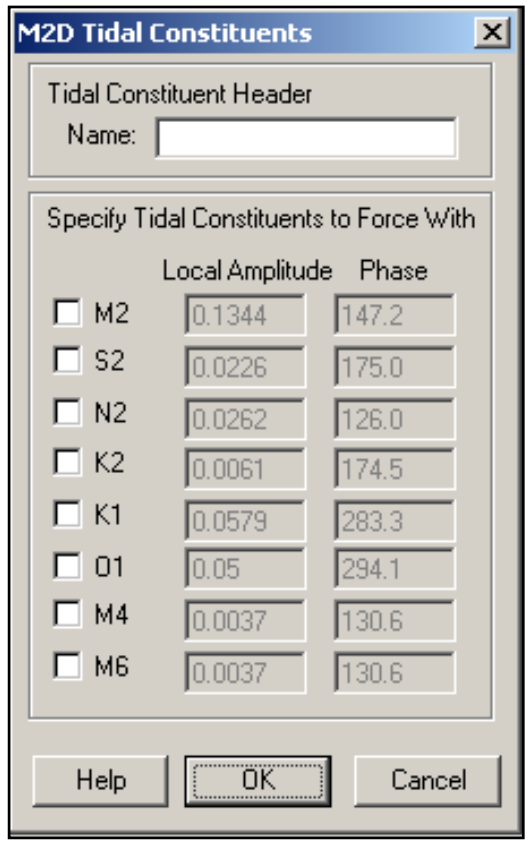
Station Output

- Variable or eqn term output
  - File name prefix
  - Time interval for output
  - Variables or terms to be written
- Flow rate output
  - File name prefix
  - Time interval for output
  - Q_x and/or Q_y output



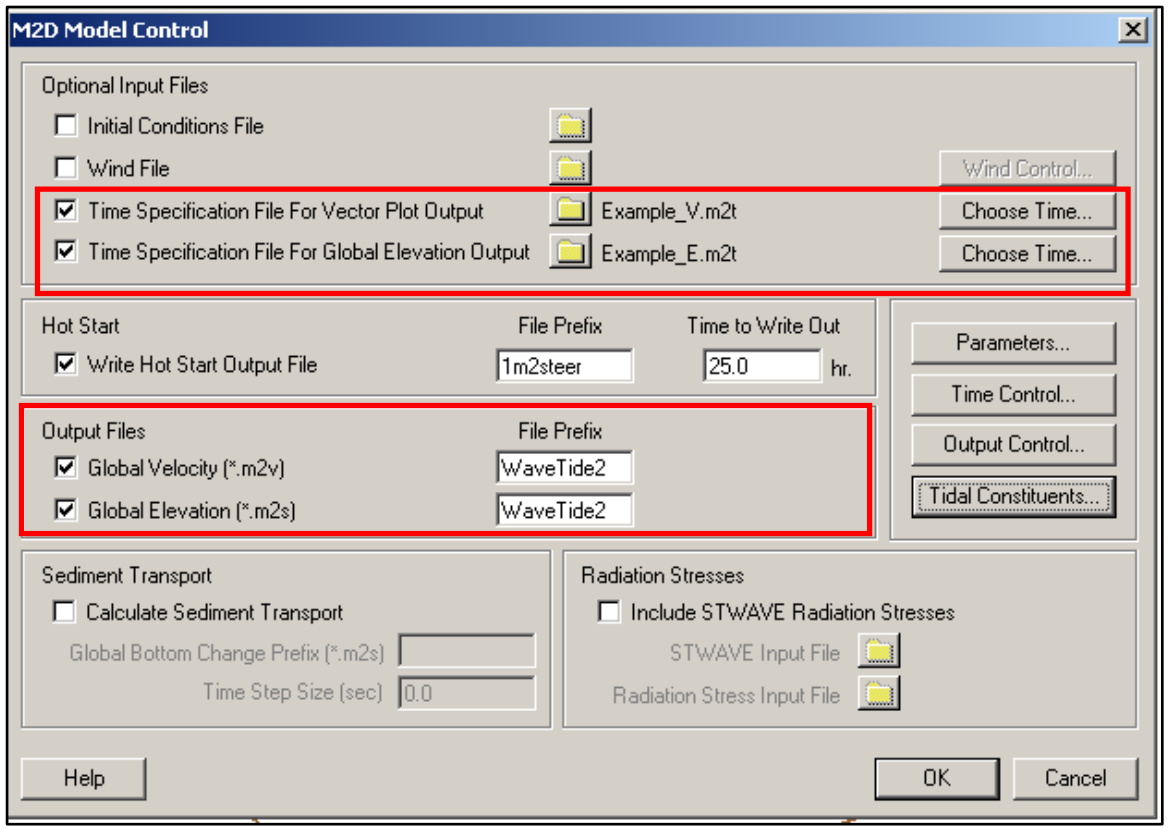
Tidal Constituent Forcing

- Header line
  - Text description, 1 line
- Select constituents for forcing
  - Constituent
  - Specify amplitude
  - Specify phase



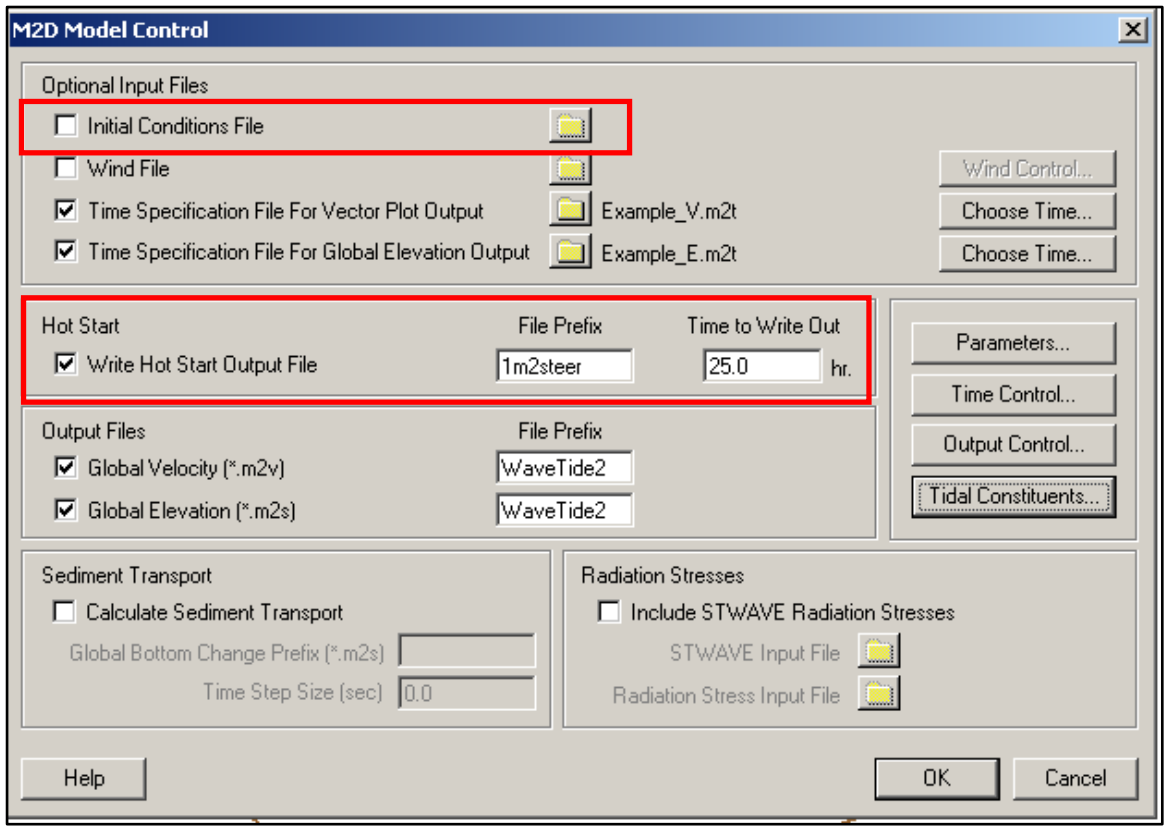
Global Output

- Water level, u, v
- Times for global output
  - Constant or variable time increments (hr)
  - Time increment generator in SMS
- Global output file prefix



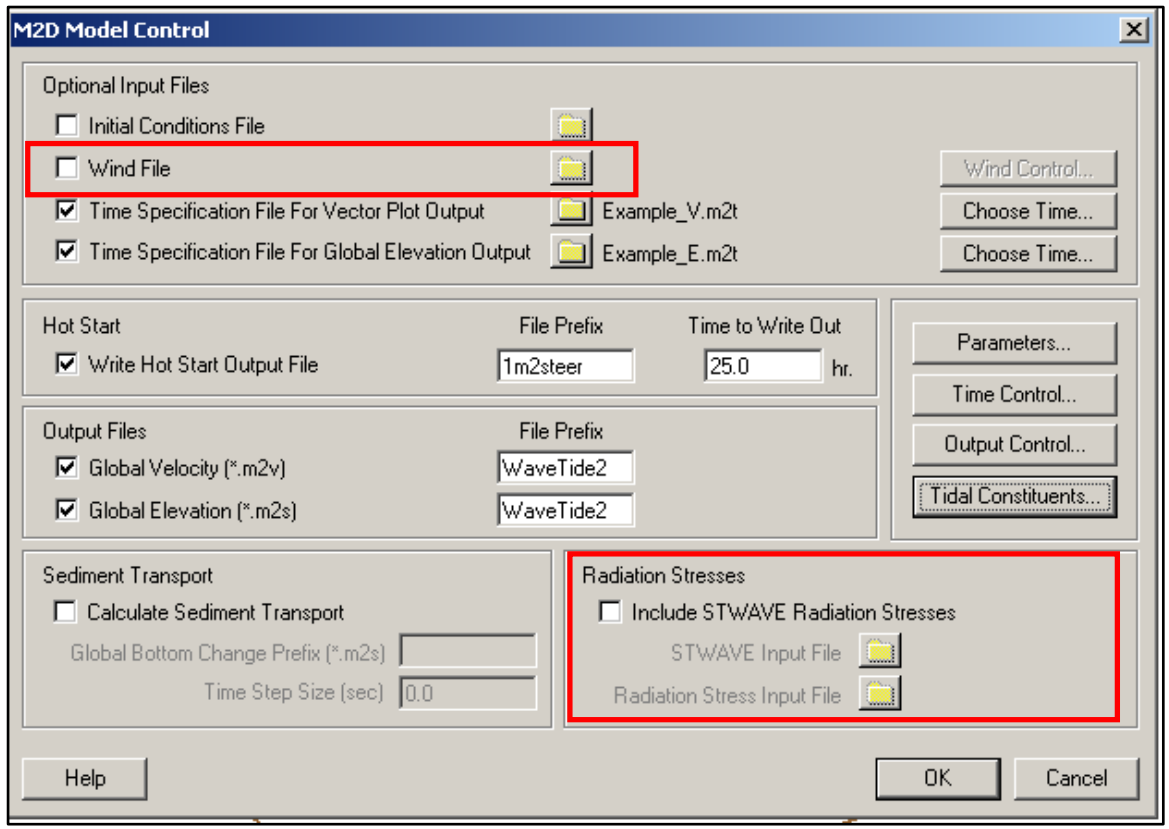
Hot Start & Initial Conditions

- Initial conditions file:
  - Hot starts
  - Numerical tests
- Save hot start file
  - Saves at 1 time
  - File name prefix



Wind & Wave Forcing

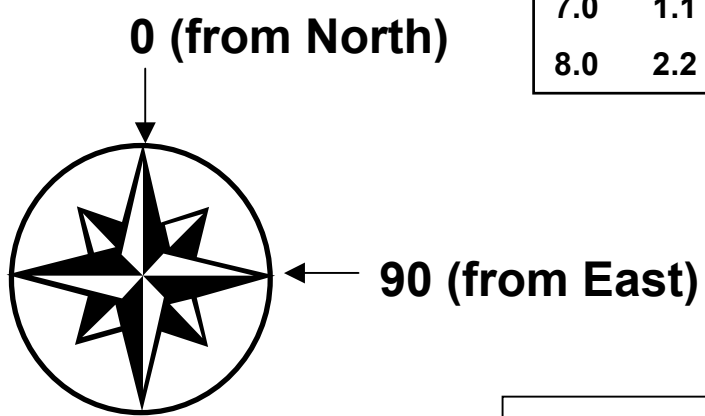
- Wind forcing
  - File containing times series of wind speed & direction
- Wave forcing
  - Use this dialog when not invoking Steering Module, wave stress file already present
  - Parameters automatically set when using Steering Module



Wind Forcing File

- Time series of wind speed & direction
  - Elapsed time (hr)
  - Speed (m/sec)
    - Positive value
  - Direction (deg)
  - Time increments can be variable
- Direction convention
  - 0 deg from North
  - 90 deg from East
  - M2D changes to model convention internally

Time	Spd	Dir
0.0	5.6	29.0
1.0	4.3	30.0
2.0	3.5	39.0
3.0	3.0	37.0
4.0	3.5	47.0
5.0	3.8	46.0
6.0	3.6	37.0
7.0	1.1	32.0
8.0	2.2	247.0

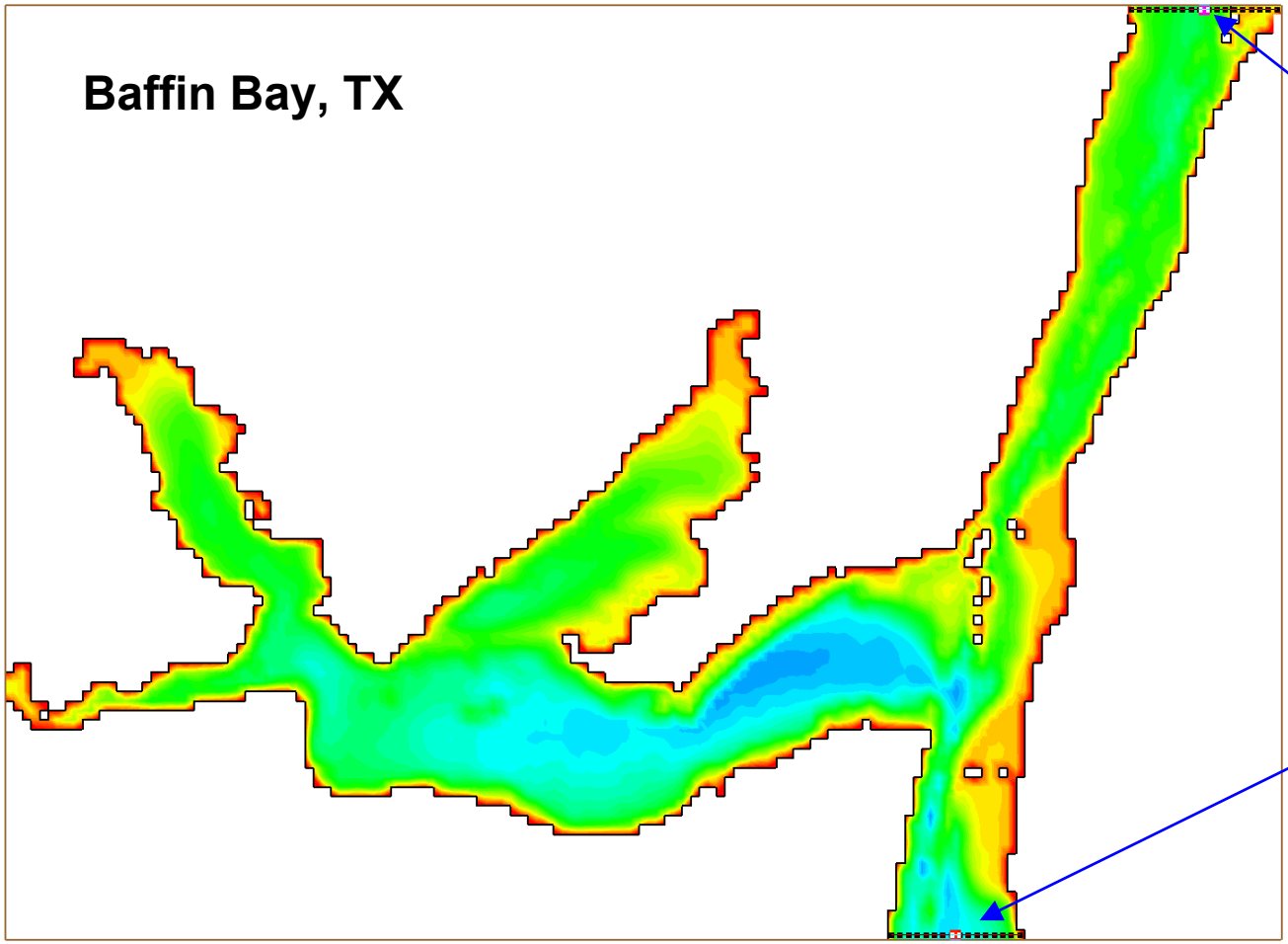


Water Level Forcing Files

- Single time series of water level
  - Specified for 1 or more boundary cells
  - Elapsed time (hr)
  - Water level (m)
  - Referenced to same datum as grid
  - Time increments can be variable

Time	WL
0.000	0.0481
0.096	0.0478
0.192	0.0491
0.288	0.0494
0.408	0.0502
0.504	0.0515
0.600	0.0527
0.696	0.0526
0.792	0.0507
0.888	0.0489
1.008	0.0470

Example



Forced w/ time series from Bird Island gauge

Forced w/ time series from Yarborough gauge

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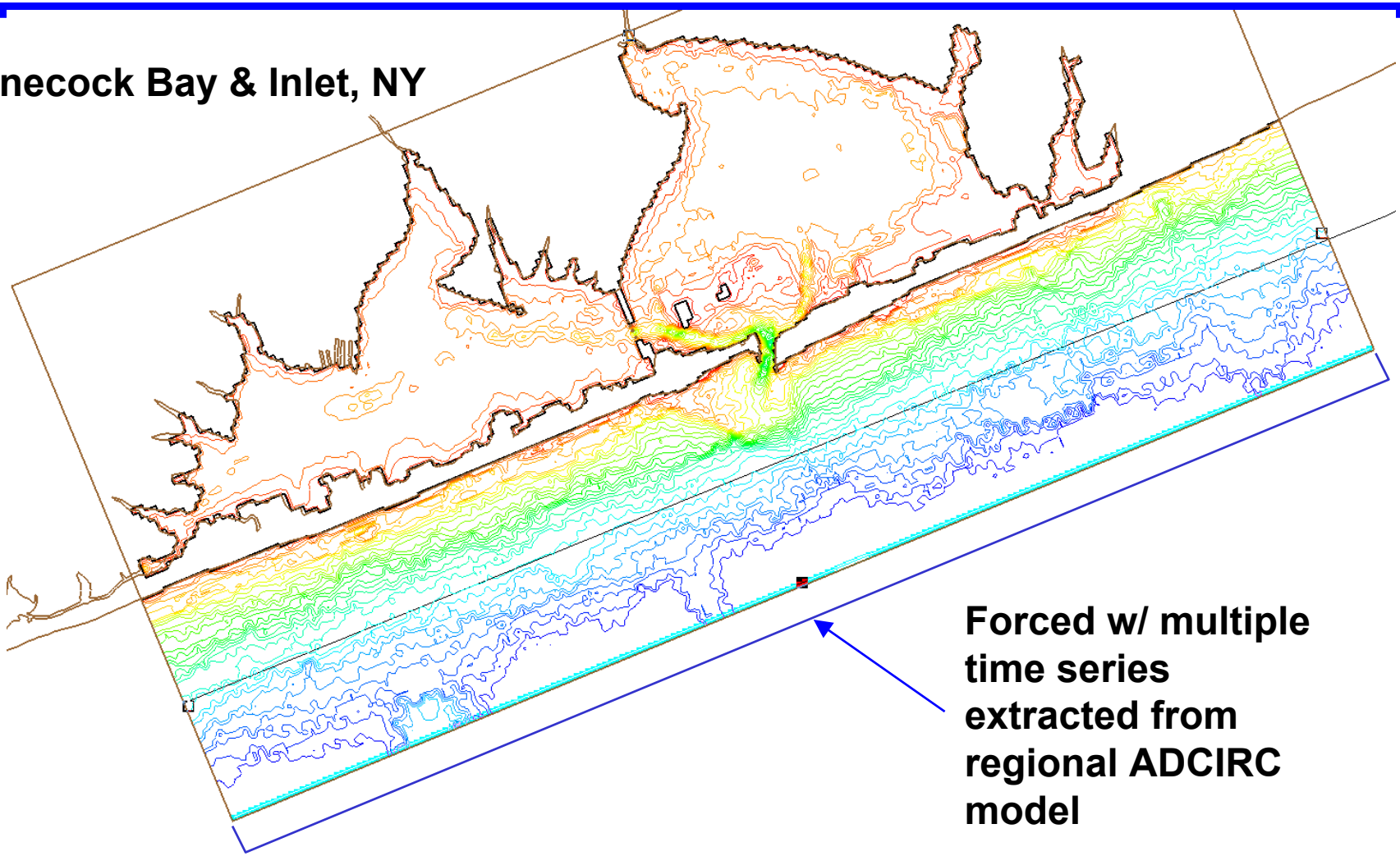
Water Level Forcing Files

- Multiple time series of water level
- Same format as single time series except >1 column of water-level values specified for each time stamp
- Elapsed time (hr)
- N columns of water level (m)
- Referenced to same datum as grid
- Time increment can vary
- Water-level boundary values extracted from larger model apply this format

Example

Shinnecock Bay & Inlet, NY



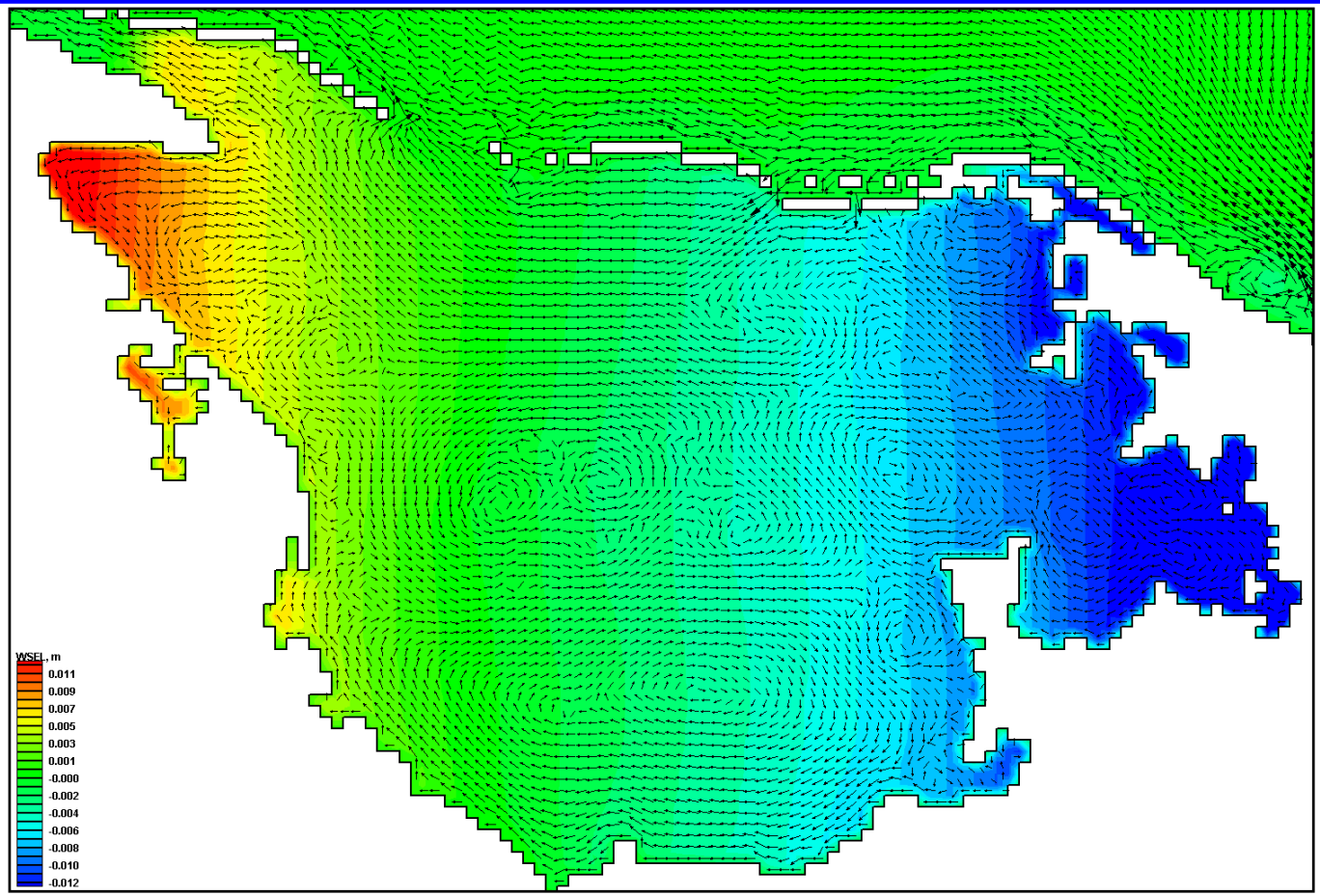
Forced w/ multiple time series extracted from regional ADCIRC model

Flow Rate Boundary File

- Time series of flow rate
  - Specified for 1 or more boundary cells
  - Elapsed time (hr)
  - Flow rate (m^3/sec)
  - Flow rate given is specified to each cell in the cell string
  - Time increments can be variable

Time	Q
0.0	0.0
5.0	5.0
10.0	5.0
15.0	0.0
20.0	-5.0
200.0	-5.0

Wind-Forced Water Level & Current
Grand Cayman Island



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