Coastal Modeling System: Advanced Topics using CMS 5.1 and SMS 13.0

Day 4: Salinity/Temperature Calculations

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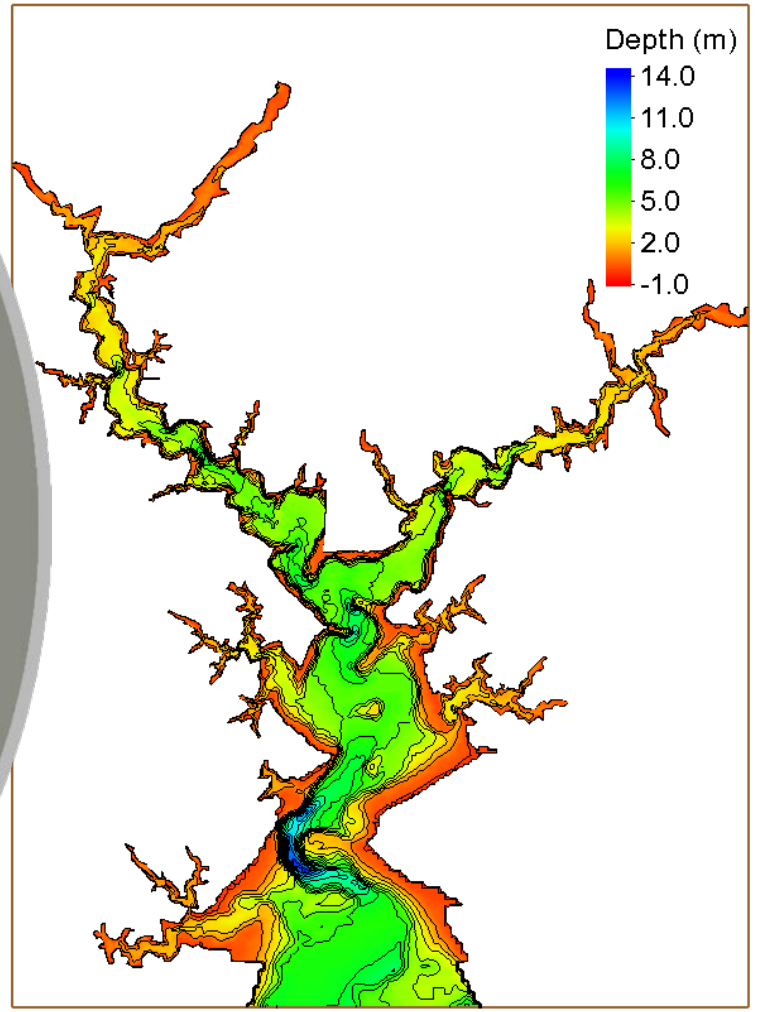
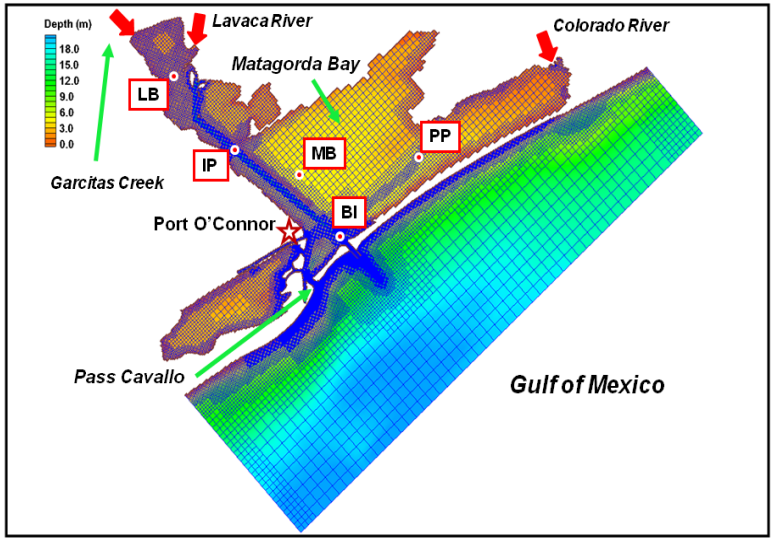


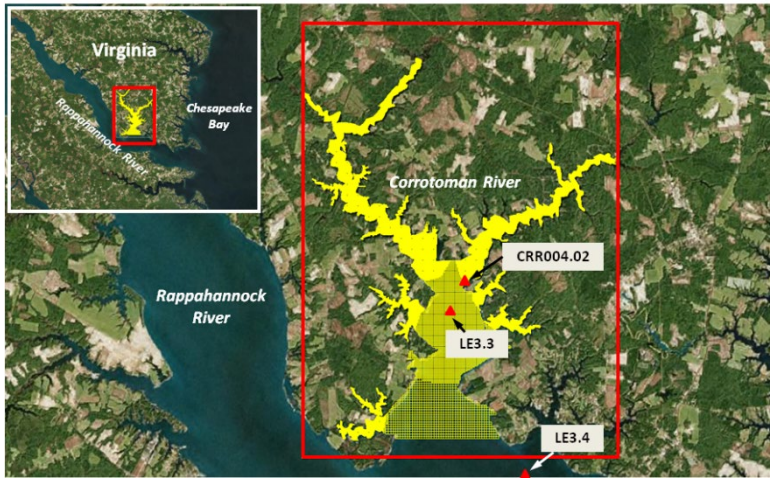
Outline

- Background
- Salinity/temperature calculations in CMS-Flow
- Setup of salinity/temperature calculations
  - Initial condition
  - Boundary condition
- Export CMS-Flow files

Background

- Water salinity and temperature influence environmental conditions in aquatic systems
- Changes in salinity can change the aggregation and consolidation of cohesive sediment
- Salinity and temperature can alter the water physical environment that impacts marine organisms with the change of water turbidity in coastal and estuarine systems
- Water quality and ecological models often require input of water temperature and salinity information from a hydrodynamic model
- Modifications of coastal inlets, such as channel deepening and widening and rehabilitation or extension of jetties, may alter the salinity/temperature distributions within the estuary
- Salinity/temperature calculations do not affect hydrodynamics in CMS





Salinity/Temperature Calculations in CMS-Flow

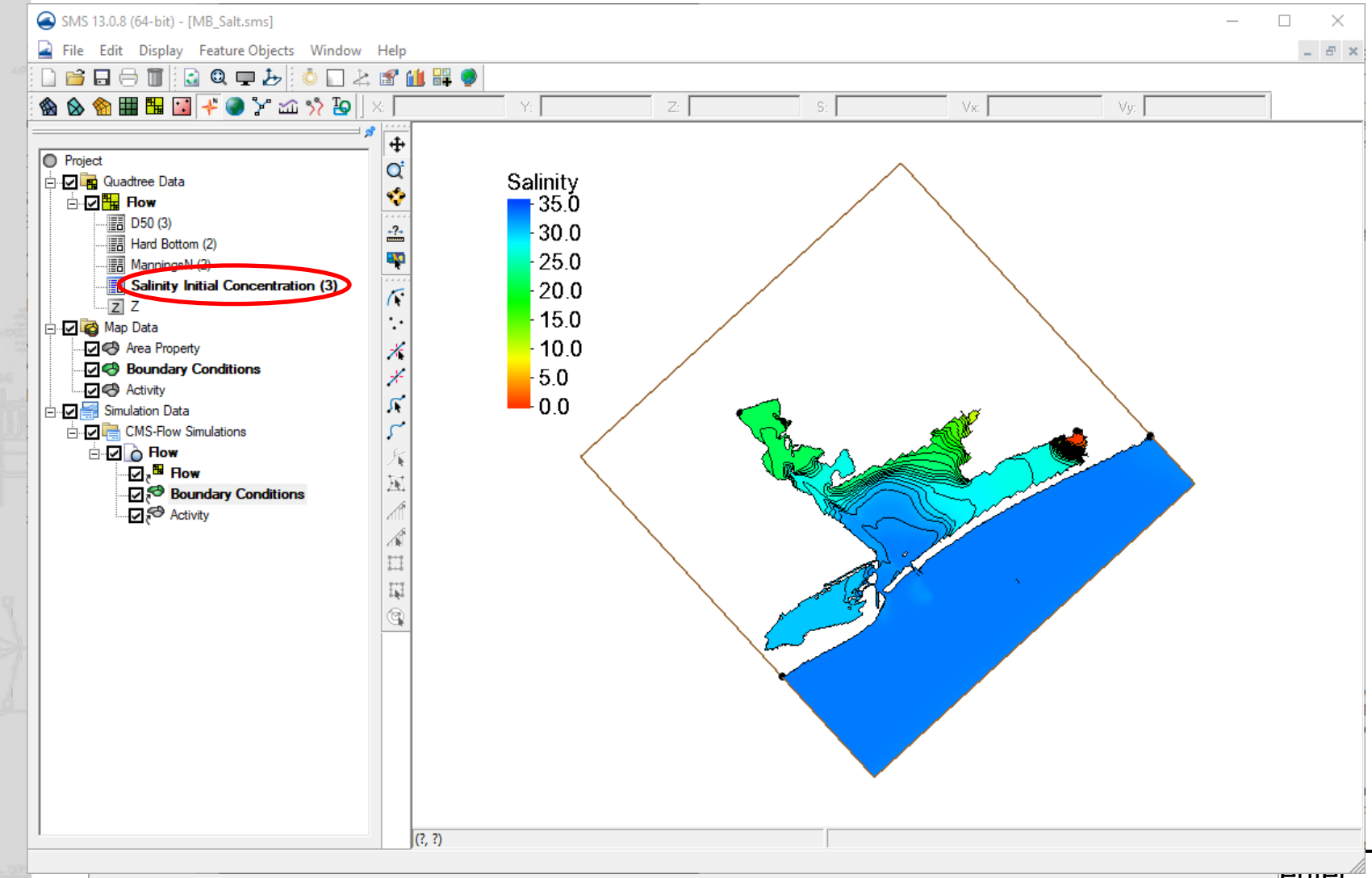
$$\frac{\partial(Sd)}{\partial t}+\frac{\partial(Sq_x)}{\partial x}+\frac{\partial(Sq_y)}{\partial y}=\frac{\partial}{\partial x}\left[K_x d\frac{\partial S}{\partial x}\right]+\frac{\partial}{\partial y}\left[K_y d\frac{\partial S}{\partial y}\right]+(P-E)S$$

$$\frac{\partial(Td)}{\partial t}+\frac{\partial(Tq_x)}{\partial x}+\frac{\partial(Tq_y)}{\partial y}=\frac{\partial}{\partial x}\left[K_x d\frac{\partial T}{\partial x}\right]+\frac{\partial}{\partial y}\left[K_y d\frac{\partial T}{\partial y}\right]+\frac{J_T}{\rho c_P}$$

S: **depth-averaged salinity**
T: **depth-averaged temperature**
d: **total water depth**
q_x, q_y: **flow per unit width**
K_x, K_y: **diffusion or mixing coefficients of salt and heat**
P: **Precipitation**
E: **Evaporation**
ρ: **water density**
c_P: **specific heat**
J_T: **net heat flux across water surface**

- **CMS-Flow lateral open and flux boundaries allow water exchanges with specifications of input salinity and temperature**
- **Surface boundary requires specifications of precipitation and evaporation for salinity and air-water heat exchange for temperature**
- **Initial condition files need to be prepared based on measured data**

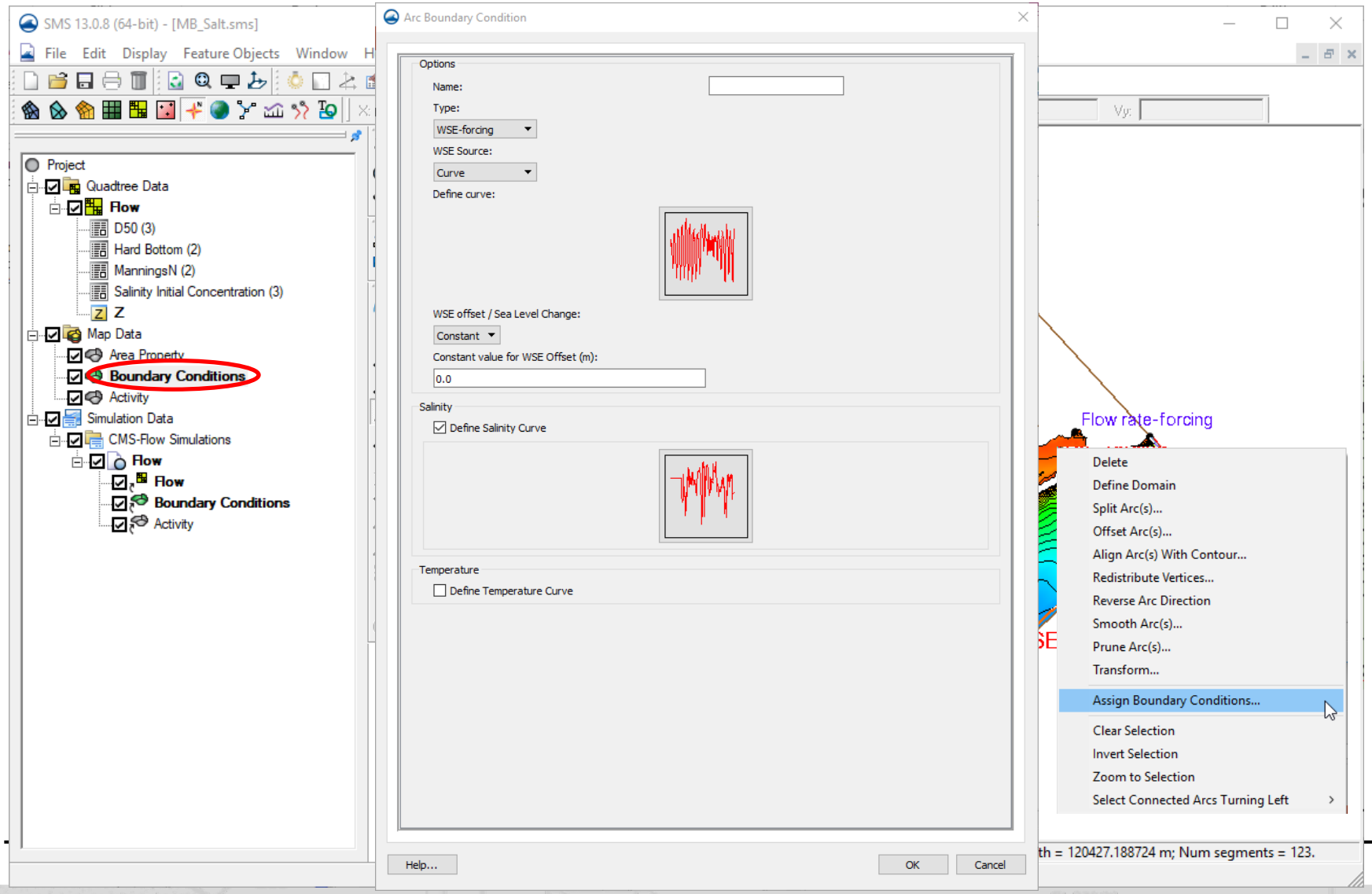
Setup of Salinity/Temperature Calculations
(Initial Condition)



Specify a constant initial value for the entire model domain or generate a spatially varying initial salinity field

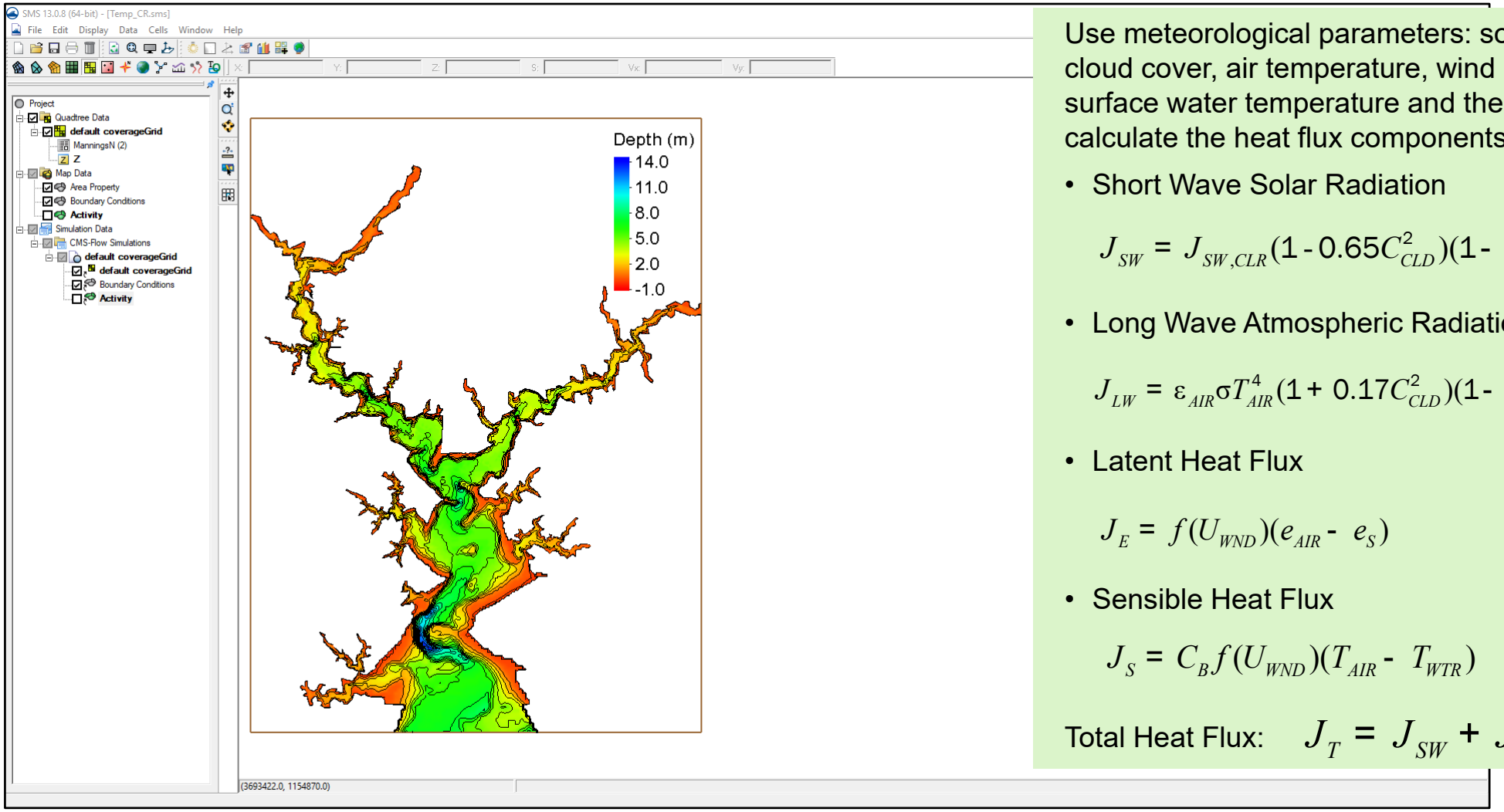
- Go to *CMS-Flow Simulations* –> *Model Control*
- Check *Calculate salinity* and choose the *Spatially varied* toggle under the *Initial condition*
- Click *Select* –> *Create* toggle and *Data Set Toolbox* pops up
- Assign a value and name the initial condition dataset in the pop-up window
- "*Salinity Initial Concentration*" appears in the *Flow* data tree
- Highlight the dataset to specify different salinity values in the CMS domain

Setup of Salinity/Temperature Calculations
(Lateral Boundary Condition)



- Specify time series of salinity values along lateral boundaries
  - Go to *CMS-Flow Simulations –> Boundary Conditions*
  - Right-click boundary arc. Select *Assign Boundary Conditions* and check *Define Salinity Curve* under *Salinity*
  - Click small icon and import salinity values (manually key in the values or read from a *xys data file)

Setup of Salinity/Temperature Calculations
(Air-water Heat Exchange)



Use meteorological parameters: solar radiation, cloud cover, air temperature, wind speed, and surface water temperature and the bulk formulas to calculate the heat flux components

- Short Wave Solar Radiation

$$J_{SW} = J_{SW,CLR}(1 - 0.65C_{CLD}^2)(1 - R_{SW})(1 - f_{SHD})$$

- Long Wave Atmospheric Radiation

$$J_{LW} = \varepsilon_{AIR}\sigma T_{AIR}^4(1 + 0.17C_{CLD}^2)(1 - R_{LW}) - \varepsilon_{WTR}\sigma T_{WTR}^4$$

- Latent Heat Flux

$$J_E = f(U_{WND})(e_{AIR} - e_S)$$

- Sensible Heat Flux

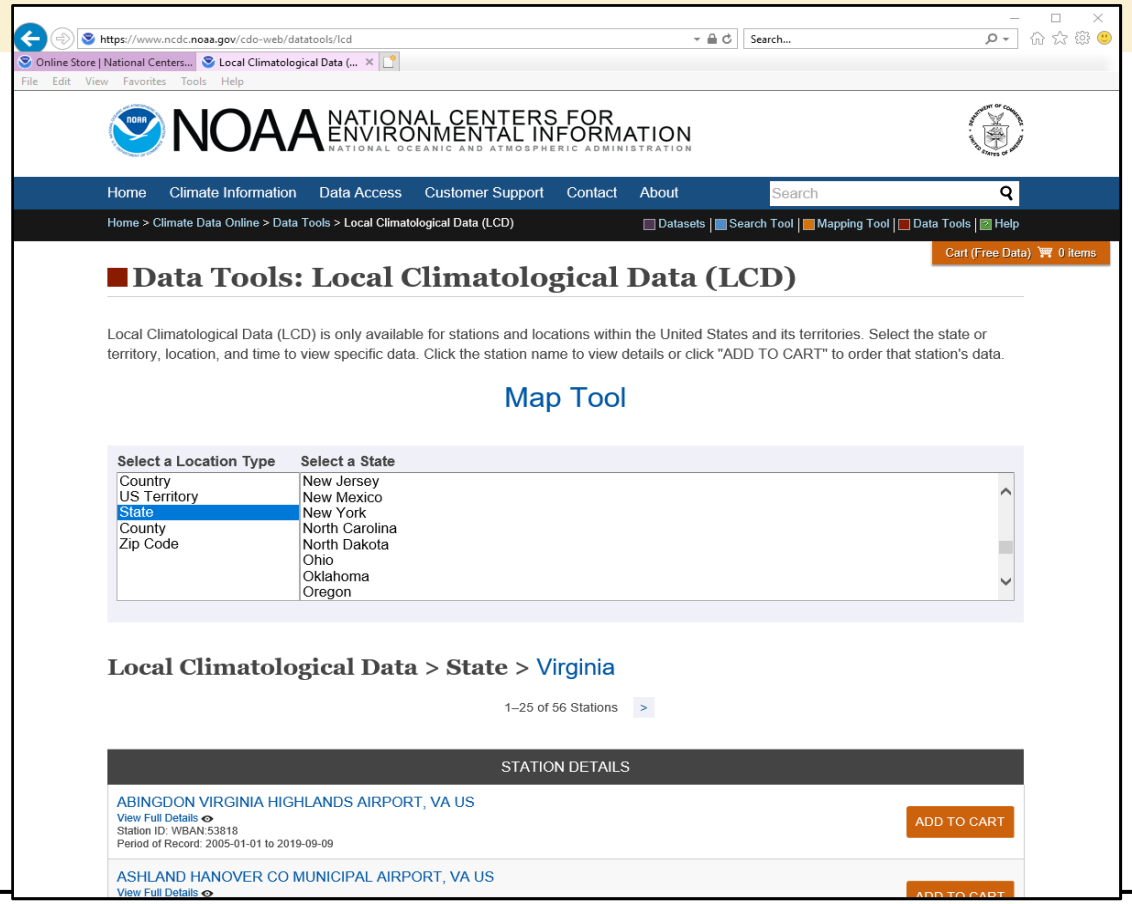
$$J_S = C_B f(U_{WND})(T_{AIR} - T_{WTR})$$

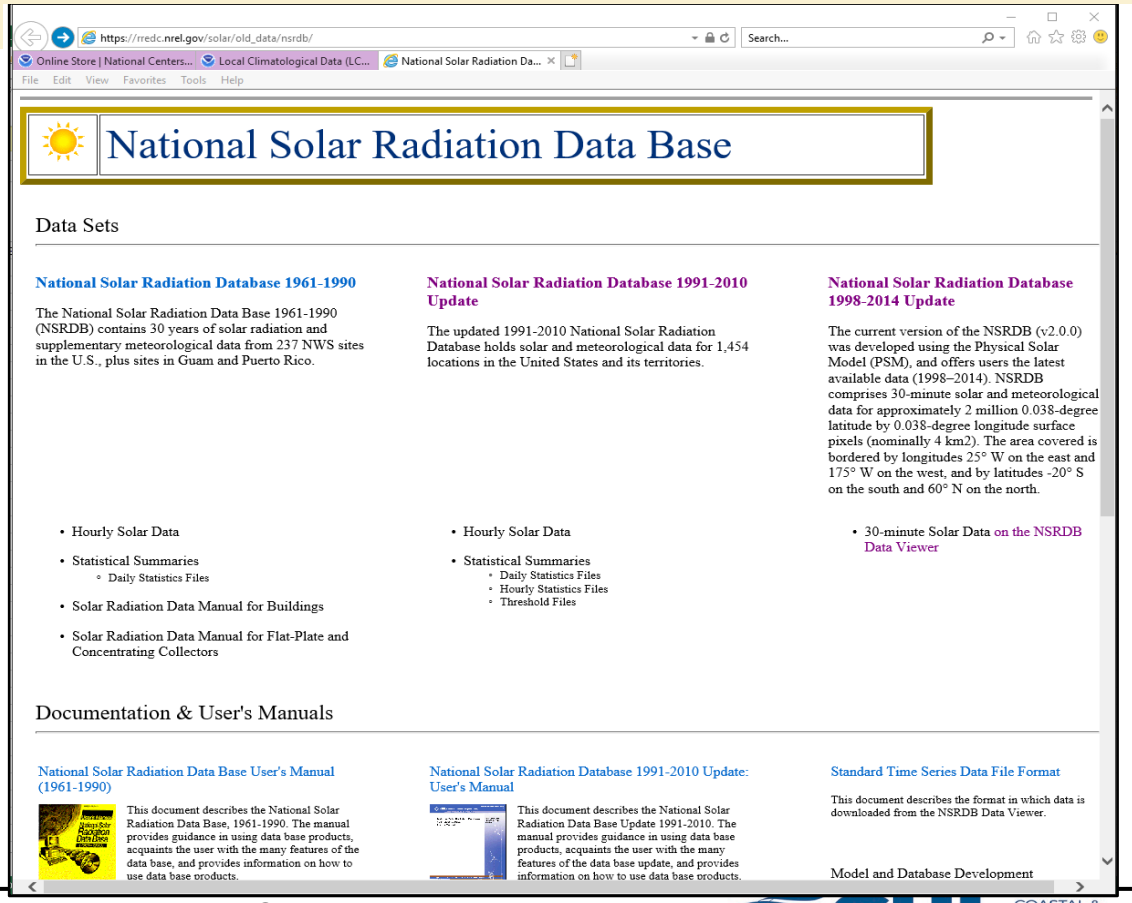
Total Heat Flux: $J_T = J_{SW} + J_{LW} + J_E + J_S$

Setup of Salinity/Temperature Calculations
(Air-water Heat Exchange)

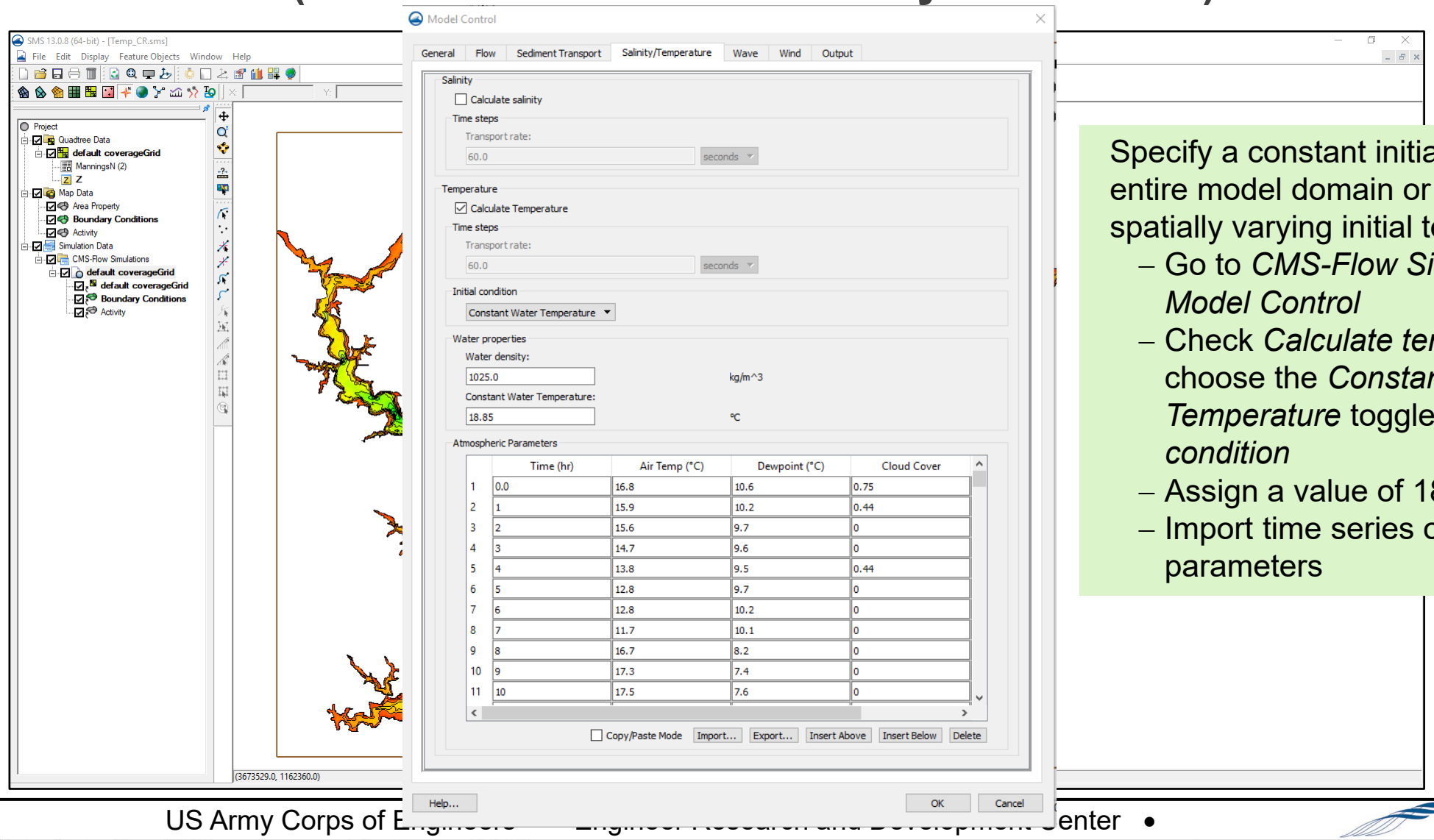
Wind, air temperature, and cloud cover were obtained from National Centers for Environmental Information:
https://www.ncdc.noaa.gov/cdo-web/datatools/lcd

Solar radiation data from National Solar Radiation Data Base:
http://rredc.nrel.gov/solar/old_data/nsrdb/





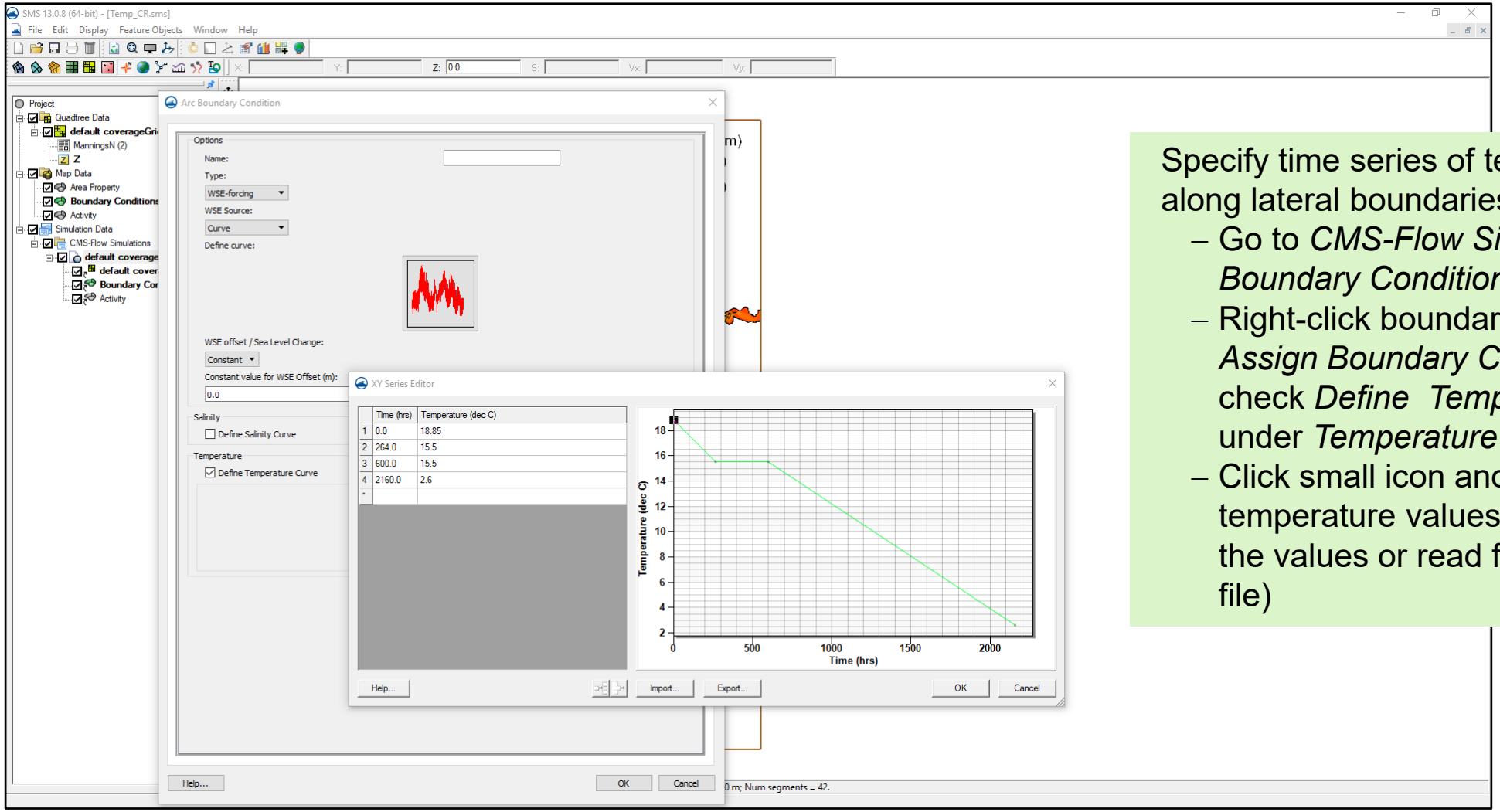
Setup of Salinity/Temperature Calculations
(Initial and Surface Boundary Conditions)



Specify a constant initial value for the entire model domain or generate a spatially varying initial temperature field

- Go to *CMS-Flow Simulations* –> *Model Control*
- Check *Calculate temperature* and choose the *Constant Water Temperature* toggle under the *Initial condition*
- Assign a value of 18.85 ° C
- Import time series of meteorological parameters

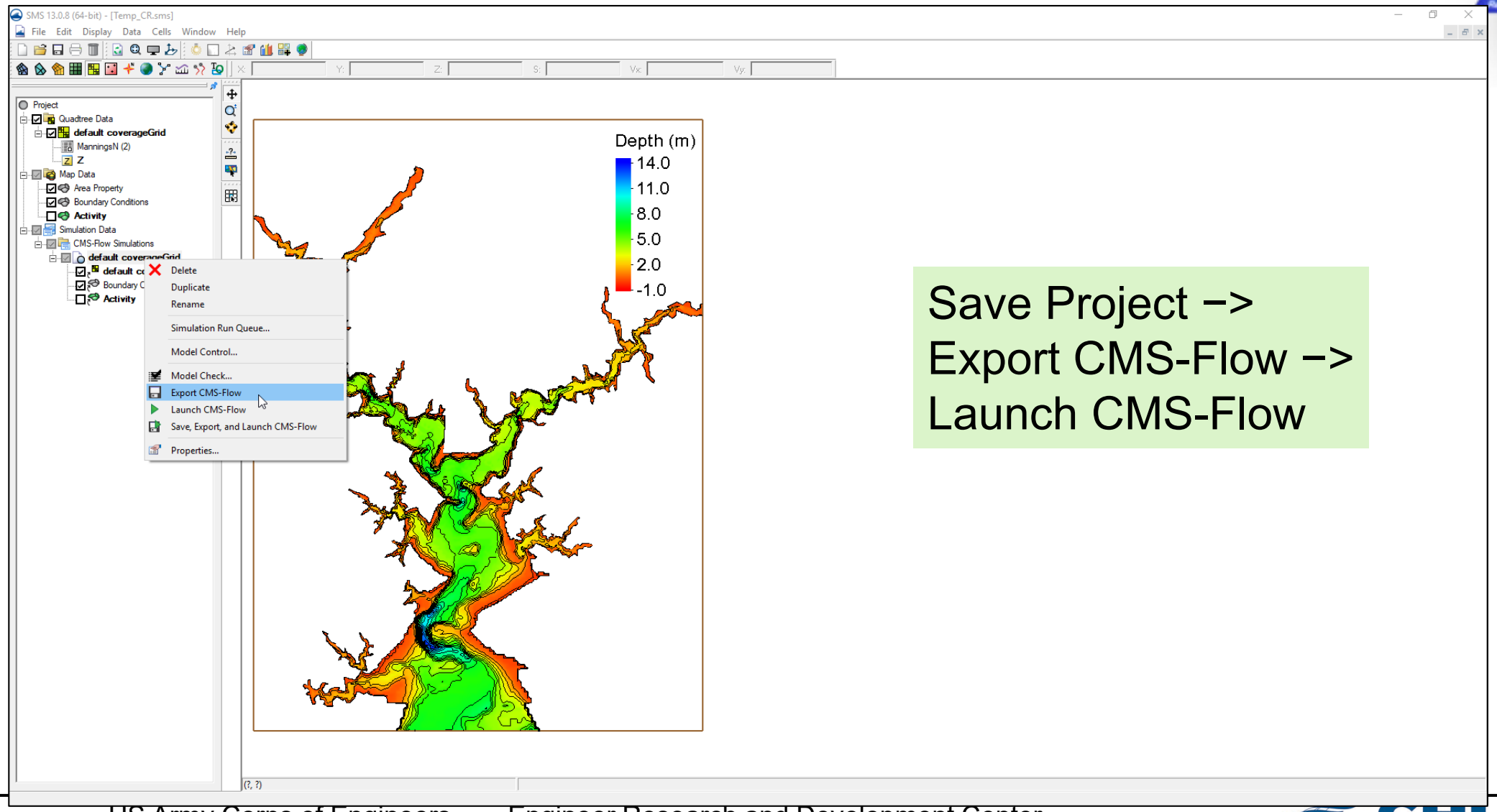
Setup of Salinity/Temperature Calculations
(Lateral Boundary Condition)



Specify time series of temperature values along lateral boundaries

- Go to *CMS-Flow Simulations –> Boundary Conditions*
- Right-click boundary arc. Select *Assign Boundary Conditions* and check *Define Temperature Curve* under *Temperature*
- Click small icon and import temperature values (manually key in the values or read from a *xys data file)

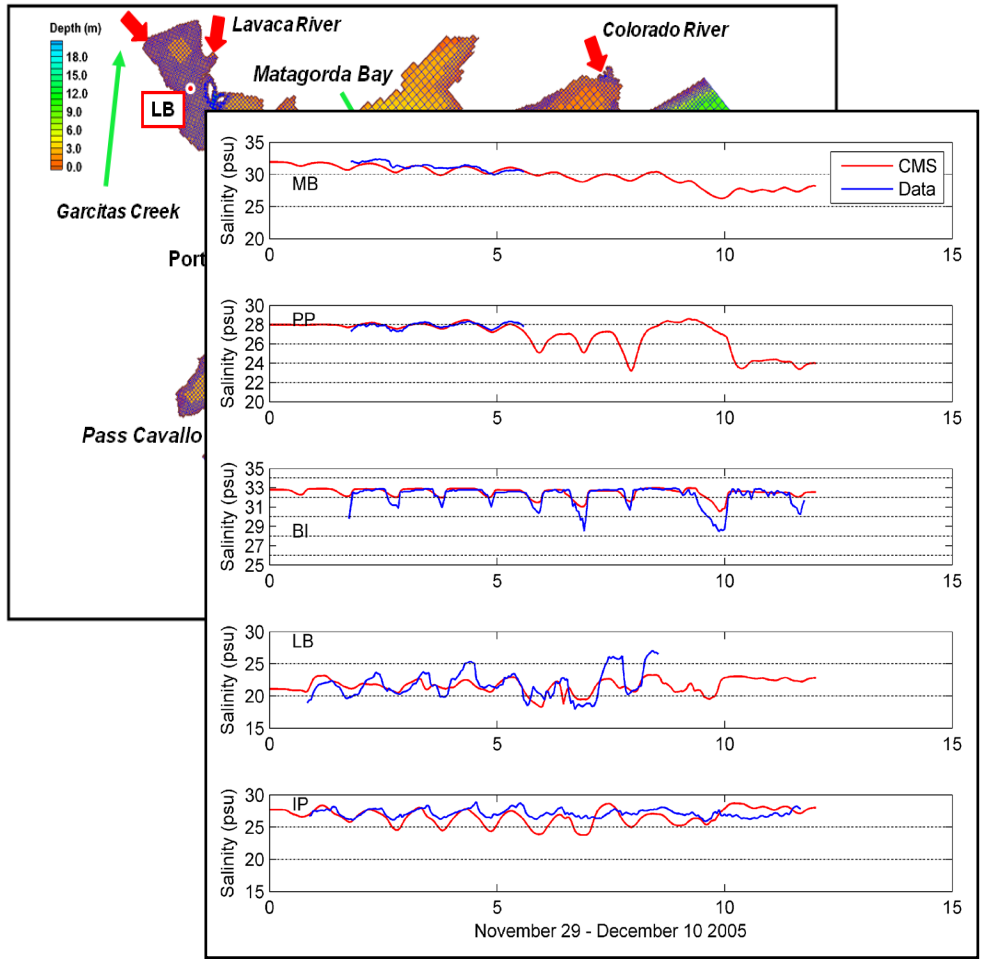
Export CMS-Flow Files



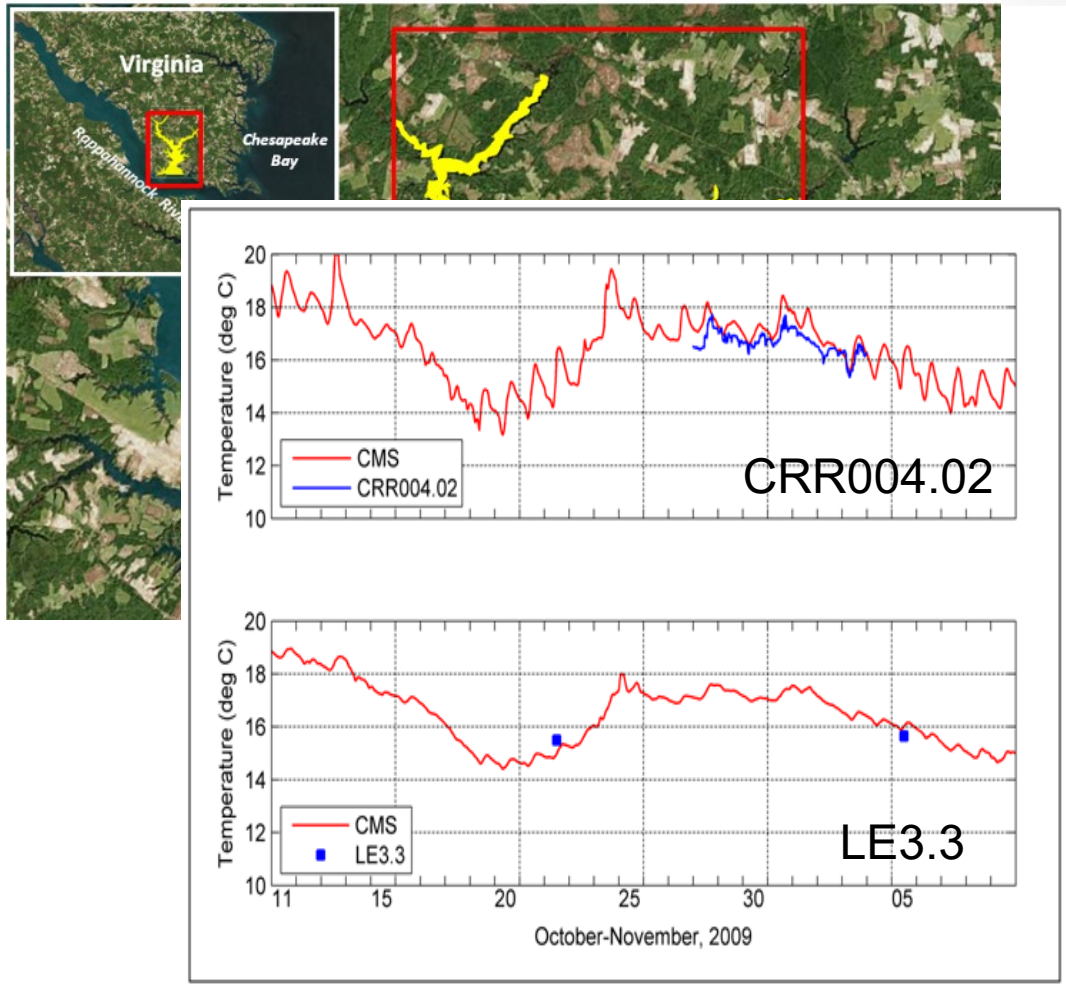
Save Project –>
Export CMS-Flow –>
Launch CMS-Flow

Simulation Results

Salinity – Matagorda Bay



Temperature – Corrotoman River



References

Salinity Calculations in the Coastal Modeling System
Li, H., Reed, C., and Brown, M. (2012)
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Temperature Calculations in the Coastal Modeling System
Li, H. and Brown, M. (2017)
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