2017 Montana Floodplain Resource Seminar: Lecture 7 Model Calibration and Sensitivity

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Identify Hazards, Interpret Risks, Integrate Mitigation

Lecture 7 Overview

- Validation and Calibration
- Data Sources
- Calibration Process
- Sensitivity Analysis

Evaluating Model Results

"All models are wrong, but some are useful."

-Dr. George Box

- How well is our model representing the physical system?
  - Have you visited the area you are modeling??
- Calibrate parameters and validate results
- How sensitive are the results to parameters with uncertainty?

Calibration

- The **adjustment of a model's parameters**, such as roughness and hydraulic structure coefficients, so that it reproduces **observed prototype data** to an **acceptable accuracy**
- Model parameters
  - Adjust parameters with greatest uncertainty
- Available data
  - Most often the limiting factor
- Acceptable accuracy
  - Dependent on the application

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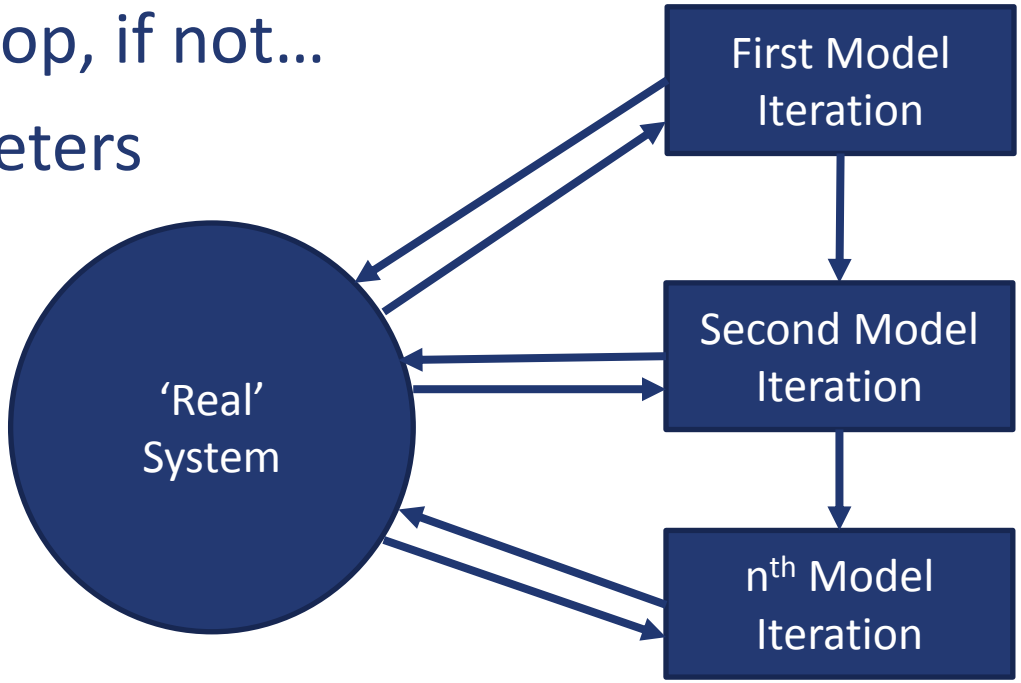
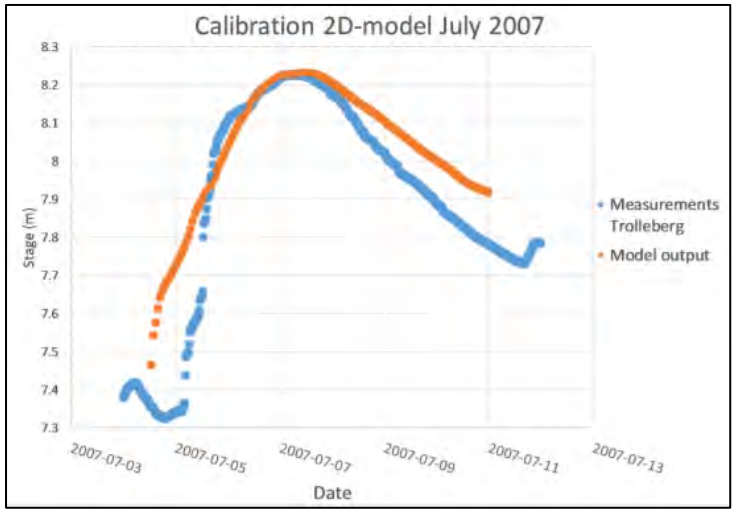
Calibration Process

- Iterative process
  - Run model
  - Compare model results to known data
  - If within tolerance stop, if not…
  - Refine model parameters
  - Run the new model



Calibration Data Sources

- Gage rating curves
  - Provides a range of discharge-stage points
- Surveyed or observed high water marks
  - Need a corresponding flow rate
- Observations
  - Flood photos/aerial imagery
  - Local knowledge
  - Historical floods



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Calibration Parameters

- Manning's n
- Structure coefficients
- Lateral weir coefficients
  - 1D/2D coupled models
- Hydrologic inputs
  - Hydrograph inputs calibrated in hydrologic model
  - Rain-on-grid
    - Hydrologic parameters
    - Curve Number

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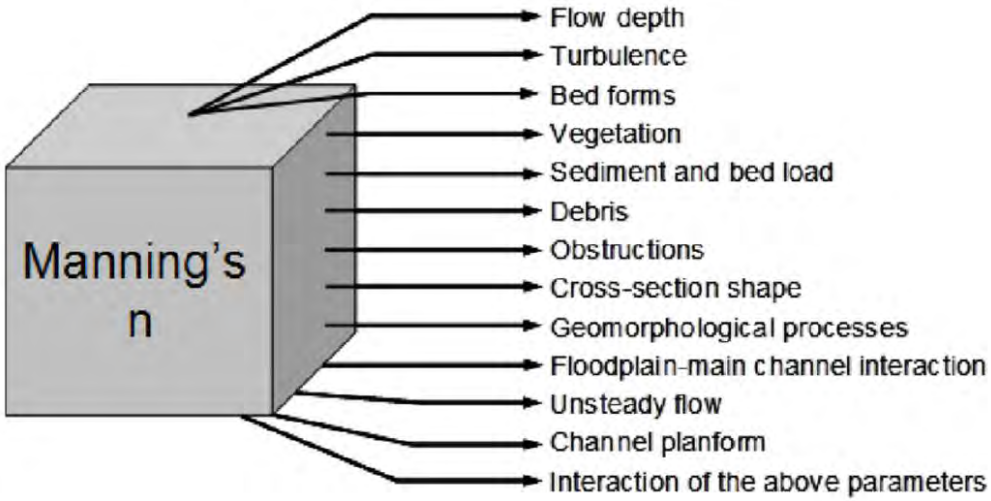
Manning's n

- Most common calibration parameter for hydraulic models
  - Delineating appropriate regions
  - Selecting appropriate values
  - Significant number of considerations….



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Estimating Manning's n

- Field observation
- Photos of calibrated streams
- Published documents
- Formulas
- Use combination of above methods
- In the end, no substitute for experience

$n = 0.032$

$n = 0.055$

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Calibration Adjustments

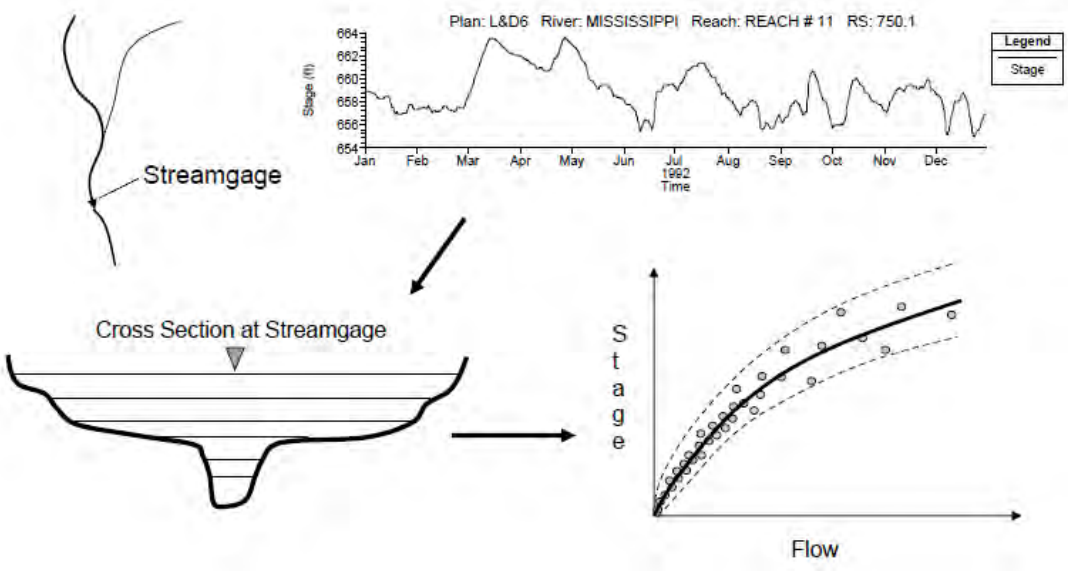
- Adjust Manning's n (or other calibration parameters) by incremental amounts (up or down depending on initial results)
- Find set of parameters that provides best agreement with calibration data
- Evaluate all model outputs for reasonableness
  - Make sure that the results make sense

Data Uncertainty

- All input data has an associated uncertainty
  - Hydrology
    - Gage data has uncertainty in measurements
    - Rainfall-runoff models – their own set of uncertain parameters
  - Terrain
    - Error in measurement and processing
  - Manning's roughness
    - User defined, very subjective
  - Structures
    - Loss coefficients

Flow Data Uncertainty Example

- Flow records computed from observed stages using single valued curves
- USGS classifies +/- 5 percent as a very good flow measurement from a price current meter
  - Translates to +/- 1 foot
- Discharge records for slope/area stations are +/- 10-percent



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Important Considerations

- Are the parameter adjustments within a reasonable range?
- Are there multiple parameters with significant uncertainty?
- Do all calibration data points provide consistent information?
- Do the adjustments need to be spatially varied or global?
- How good is the data we are calibrating to?

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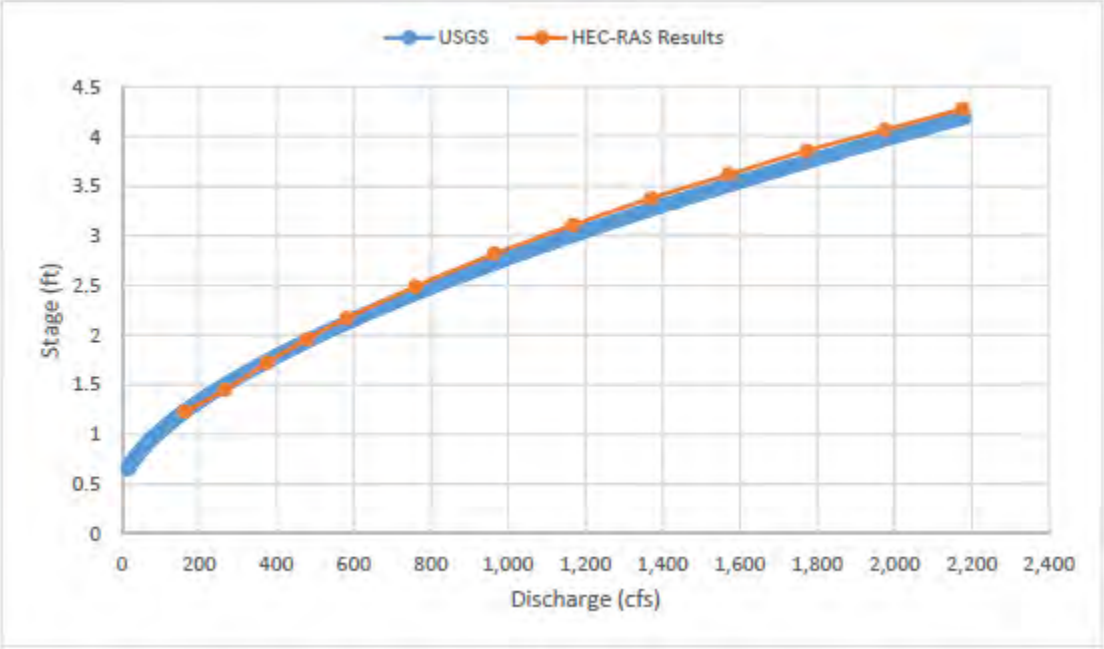
Validation

- If possible, calibrated model should be validated using a real event, separate from the calibration data
- This will ensure that the model is not biased based on the calibration performed
- Available data is often a limiting factor



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Sensitivity Analysis

- Adjust model parameters with uncertainty by some amount, up and down, to determine how sensitive the model results are to adjustment of different parameters
  - Manning's n, grid cell size, equation type, time step, dam breach parameters, structure coefficients, etc.
- Provides a reasonable range (or bracket) for the results in a spatial sense
- Never believe a single reported answer (remember George Box)

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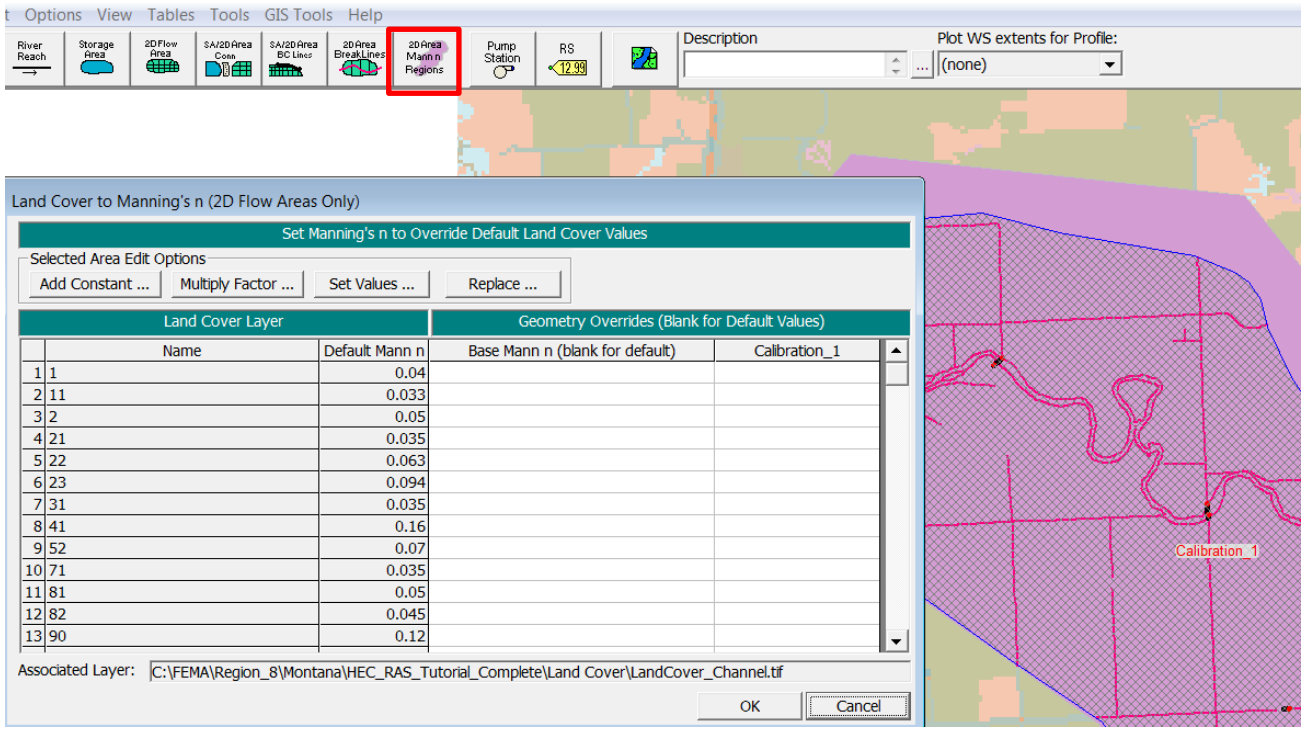
HEC-RAS 5.0 Tools

- Manning's n Regions
- Define any spatial region to adjust tManning's n values for sensitivity or calibration



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Documentation

- It is critical to document and report the calibration, validation, and sensitivity methods and results
- Data users need to be in tune with uncertainty in model results
- Never trust a value reported without an acknowledgement of uncertainty

"There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know." -***Donald Rumsfeld***

Questions

Photo from FEMA

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