Calibration, Validation & Verification

- **CALIBRATION**: model testing with known input and output used to adjust or estimate factors.
- **VALIDATION**: comparison of model results with an independent data set (without further adjustment).
- **VERIFICATION**: examination of the numerical technique in the computer code to ascertain that it truly represents the conceptual model and that there are no inherent numerical problems.

Calibration/Validation Periods

- distinct time period
- similar ranges of conditions
- adequate time period to simulate conditions
Model Configuration

- Land use categories
  - land use types in watershed, existing and future land uses, management techniques employed, management questions.
- Subwatersheds
  - location, physical characteristics/soils, gaging station locations, topographic features, management questions.
- Reaches
  - topographic features, stream morphology, cross-section data available

Calibration issues:
- individual land use parameter determination
- location of gaging station data
- location of water quality monitoring information
- available information on stream systems

Model Configuration
Calibration Points Example

Calibration/Validation Procedures

- Hydrology - first and foremost
- Sediment - next
- Water quality - last (nitrogen, phosphorus, pesticides, DO, bacteria)

- Check list for model testing
  - water balance - is it all accounted for?
  - time series
  - annual total - stream flow & base flow
  - monthly/seasonal total
  - frequency duration curve
  - sediment and nutrients balance
Calibration Time Step

- Calibration sequence
  - annual water balance
  - seasonal variability
  - storm variability
    - time series plot
    - frequency duration curve
  - baseflow
  - overall time series

Calibration/Validation Statistics

- Mean and standard deviation of the simulated and measured data
- Slope, intercept and regression coefficient/coefficient of determination
- Nash-Sutcliffe Efficiency

Calibration/Validation Common Problems

- too little data - too short a monitoring period
- small range of conditions
  - only small storms
  - only storms during the spring...
- prediction of future conditions which are outside the model conditions
- calibration/validation does not adequately test separate pieces of model
  - accuracy of each land use category prediction
- calibration adjustments destroy physical representation of system by model
  - adjustment of the wrong parameters
Calibration/Validation

Suggested References


Hydrology Calibration Summary

Key considerations

- Water balance
  - overall amount
  - distribution among hydrologic components
- Storm sequence
  - time lag or shifts
  - time of concentration, travel time
  - shape of hydrograph
    - peak
    - recession
    - consider antecedent conditions

Example Calibration Plot

Calibration of flow at Hico, Bosque River Watershed, TX

Observed Simulated
Hydrologic Calibration
Scenario 1

Model failed to simulate some peak flows
- Rainfall station is not representative
- Localized storm - no response
- Malfunctioning gages (precipitation or flow)

Solutions
- Use precipitation data from representative meteorological stations
- Carefully review precipitation and flow data for the particular duration
Hydrologic Calibration
Scenario 2

![Graph showing simulated and observed flow over time.]

Model consistently over predicts the flow

- High Surface flow
- Decrease curve number for different land uses (CN in .mgt)
- Soil available water (SOL_AWC in .sol)
- Soil evaporation compensation factor (ESCO in *.bsn)

Solutions

Hydrologic Calibration
Model consistently over predicts the flow

- High base flow
- Too little evapotranspiration
- Increase deep percolation loss (Adjust threshold depth of water in shallow aquifer required for the base flow to occur) (GWQMN in .gw)
- Increase groundwater revap coefficient (GW_REVAP in .gw)
- Decrease threshold depth of water in shallow aquifer for revap to occur (REVAPMN in .gw)

Solutions
Hydrologic Calibration
Scenario 3

- Simulated flow follows the observed pattern but lags the actual flow consistently
- Time of concentration is too long
- Less than actual slope for overland flow
- Over estimated surface roughness

Solutions
- Adjust slope for over land flow (SLOPE in .hru)
- Adjust Manning’s roughness coefficient (OV_N in .sub or .rte)
- Adjust the value of overland flow length (SLSUBBSN in .sub or .hru), if necessary

Hydrologic Calibration
Scenario 4

- Simulated flow follows the observed pattern but lags the actual flow consistently
- Time of concentration is too long
- Less than actual slope for overland flow
- Over estimated surface roughness

Solutions
- Adjust slope for over land flow (SLOPE in .hru)
- Adjust Manning’s roughness coefficient (OV_N in .sub or .rte)
- Adjust the value of overland flow length (SLSUBBSN in .sub or .hru), if necessary
Hydrologic Calibration

Simulated flow over predicts peak flows but under predicts all other times

- Too little base flow
- Too high surface runoff

Solutions
- Adjust infiltration
- Adjust interflow
- Adjust base flow recession parameter

Sediment Calibration Summary

- Key considerations
  - Sources of sediment loadings
    - Loadings from HRUs/Subbasins
    - Channel degradation/deposition
  - Sediment loading distribution
    - Overall amount
    - Seasonal loading
      - Distribution by storm sequence
      - Rising and falling limb of hydrograph
      - Peak concentration

Example Calibration Plot
Sediment Calibration

Scenario 1

Model consistently under predicts the sediment

- Low sediment yield

Solutions
- Calibrate HRU/Subbasin Loadings
  - Adjust USLE crop management factor (P) (USLE_P in .mgt)
  - Adjust USLE slope length factor (LS) (SLSUBBSN in .sub or .hru)
  - Adjust the slope of HRUs (SLOPE in .hru)
  - Adjust crop practice factor (C) for land use (USLE_C in crop.dat)
- Verify tillage operations in *.mgt files and adjust crop residue coefficient (RSDCO) and bio-mixing efficiency (BIOMIX) in .bsn
- Calibrate Channel degradation/deposition
  - Linear and exponential parameters used for channel sediment routing (SPCON and SPEXP in .bas)
  - Channel erodibility factor (CH_EROD in .rte)
  - Channel cover factor (CH_COV in .rte)

Nutrients Calibration Summary

- Key considerations
  - Sources of nutrients loadings
    - Loadings from HRUs/Subbasins
    - In-stream processes
  - Nutrient loading distribution
    - overall amount
    - Seasonal loading
      - distribution by storm sequence
        - rising and falling limb of hydrograph
        - peak concentration
Example Calibration Plot

Mineral Nitrogen Calibration

Mineral Nitrogen Calibration Scenario 1

Mineral Nitrogen Calibration

Model consistently under predicts the mineral nitrogen

- Low mineral nitrogen loading

Solutions

- Calibrate mineral nitrogen loadings
  - Adjust initial concentration of the nutrient in soils (SOL_NO3 in .chm)
  - Verify fertilizer application rates and adjust fertilizer application fraction to surface layer as 0.20 (FRT_LY1 in .mgt)
  - Verify tillage operations in .mgt files and adjust crop residue coefficient (RSDCO) and bio-mixing efficiency (BIOMIX) in .bsn
  - Adjust nitrogen percolation coefficient (NPERCO in .bsn)

- Calibrate in-stream mineral nitrogen processes
  - Adjust fraction of algal biomass that is as nitrogen for water quality (AI1 in .wwq)
Organic Nitrogen Calibration

Scenario 1

Model consistently under predicts the organic nitrogen

- Low Organic nitrogen loading

Solutions
- Calibrate organic nitrogen loadings
  - Adjust initial concentration of the nutrient in soils (SOL_ORGN in .chm)
  - Verify fertilizer application rates and adjust fertilizer application fraction to surface layer as 0.20 (FRT_L_Y1 in .mgt)
- Calibrate in-stream organic nitrogen processes
  - Adjust fraction of algal biomass that is as nitrogen for water quality (AI1 in .wwq)

Soluble Phosphorus Calibration

Scenario 1
**Soluble Phosphorus Calibration**

*Model consistently under predicts the soluble phosphorus*

- Low soluble phosphorus loading

**Solutions**

- Calibrate soluble phosphorus loadings
  - Adjust initial concentration of the nutrient in soils (SOL_MINP in .chm)
  - Verify fertilizer application rates and adjust fertilizer application fraction to surface layer as 0.20 (FRT_LY1 in .mgt)
  - Verify tillage operations in .mgt files and adjust crop residue coefficient (RSDCO) and bio-mixing efficiency (BIOMIX) in .bsn
  - Adjust phosphorus percolation coefficient (PPERCO in .bsn)
  - Adjust phosphorus soil partitioning coefficient (PHOSKD in .bsn)

- Calibrate in-stream soluble phosphorus processes
  - Adjust fraction of algal biomass that is as phosphorus for water quality (AI2 in .wwq)

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**Organic Phosphorus Calibration**

*Scenario 1*

**Organic Phosphorus**

<table>
<thead>
<tr>
<th>Soluble Phosphorus kg/ha</th>
<th>Observed</th>
<th>Simulated</th>
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**Organic Phosphorus Calibration**

*Model consistently under predicts the organic phosphorus*

- Low organic phosphorus loading

**Solutions**

- Calibrate organic phosphorus loadings
  - Adjust initial concentration of the nutrient in soils (SOL_ORGP in .chm)
  - Verify fertilizer application rates and adjust fertilizer application fraction to surface layer as 0.20 (FRT_LY1 in .mgt)

- Calibrate in-stream organic phosphorus processes
  - Adjust fraction of algal biomass that is as phosphorus for water quality (AI2 in .wwq)