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SWAT Calibration Techniques

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

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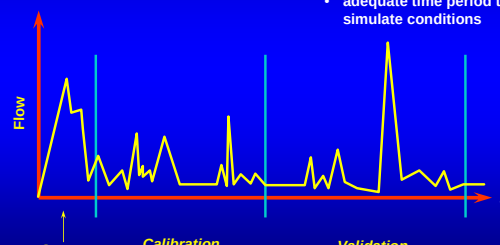
Calibration/Validation Periods

- distinct time period
- similar range of conditions
- adequate time period to simulate conditions



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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

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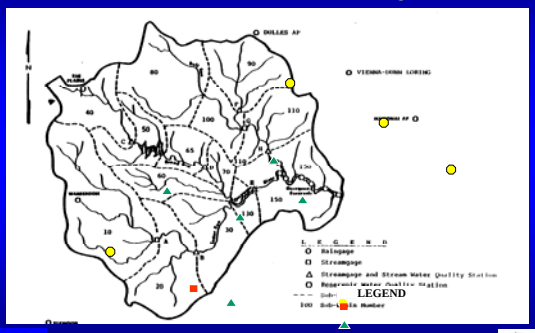
Model Configuration
Calibration Points Example



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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

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Calibration Time Step

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

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Calibration/Validation Statistics

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

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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

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Calibration/Validation Suggested References

- Neitsch, S. L., J. G. Arnold, J. R. Kiniry and J. R. Willams. 2001. Soil and Water Assessment Tool – Manual, USDA-ARS Publications. pp: 341-354. http://www.brc.tamus.edu/swat/manual.
- Santhi, C., J. G. Arnold, J. R. Williams, W. A. Dugas, R. Srinivasan and L. M. Hauck. 2001. Validation of the SWAT Model on a Large River Basin with Point and Nonpoint Sources. J. American Water Resources Association 37(5): 1169-1188.
- Srinivasan, R., T. S. Ramanarayanan, J. G. Arnold and S. T. Bednarz. 1997. Large area hydrologic modeling and assessment: Part II - Model application. J. American Water Resources Association 34(1): 91-102.
- Arnold, J.G., R. S. Muttiah, R. Srinivasan and P. M. Allen. 2000. Regional estimation of baseflow and groundwater recharge in the upper Mississippi basin. J. Hydrology 227(2000): 21-40.

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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

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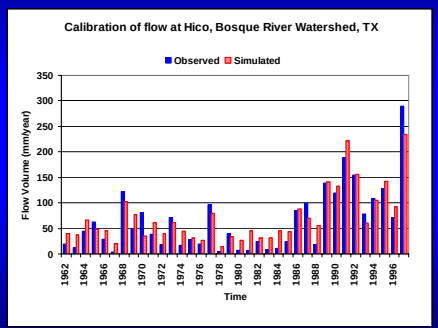
Example Calibration Plot



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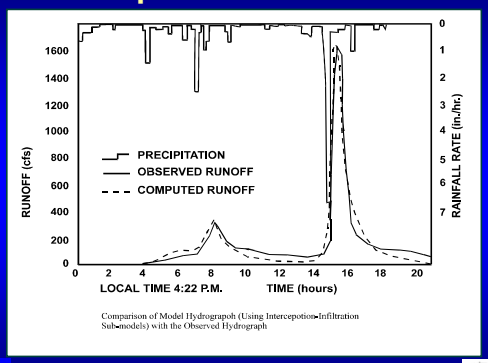
Example Calibration Plot



Comparison of Model Hydrograpoh (Using Intercepotion-Infiltration Sub-models) with the Observed Hydrograph

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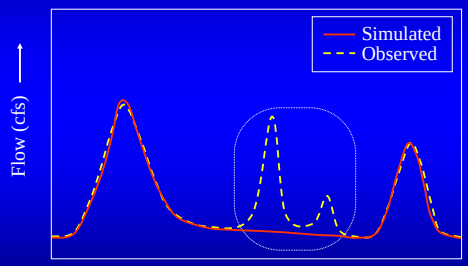
Hydrologic Calibration Scenario 1



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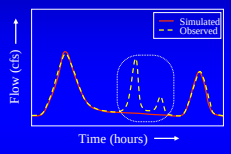
Hydrologic Calibration

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

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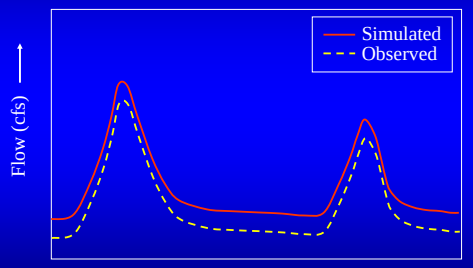
Hydrologic Calibration Scenario 2



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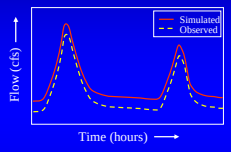
Hydrologic Calibration

Model consistently over predicts the flow

- **High Surface flow**



Solutions

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

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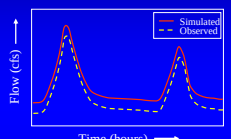
Hydrologic Calibration

Model consistently over predicts the flow

- **High base flow**
- **Too little evapotranspiration**



Solutions

- 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 theshold depth of water in shallow aquifer for revap to occur (REVAPMN in .gw)

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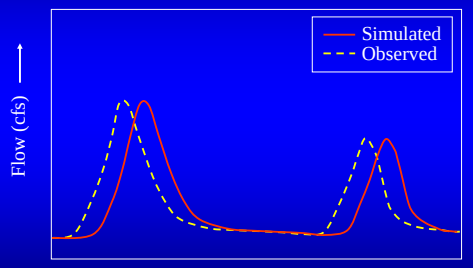
Hydrologic Calibration Scenario 3



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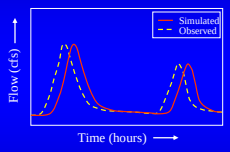
Hydrologic Calibration

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

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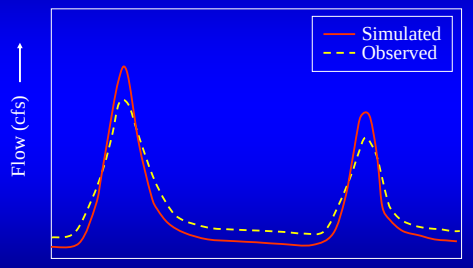
Hydrologic Calibration Scenario 4



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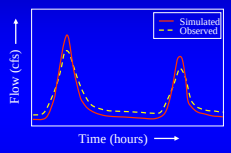
Hydrologic Calibration

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

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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

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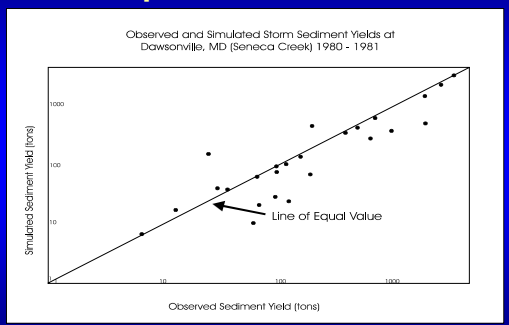
Example Calibration Plot



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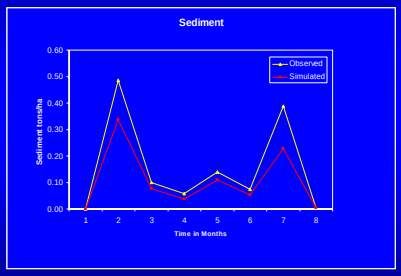
Sediment Calibration Scenario 1



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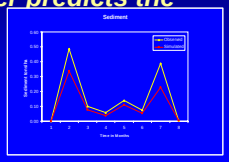
Sediment Calibration

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 .bsn)
  - Channel erodibility facor (CH_EROD in .rte)
  - Channel cover factor (CH_COV in .rte)

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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

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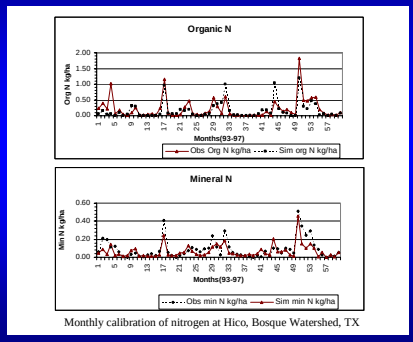
Example Calibration Plot



Monthly calibration of nitrogen at Hico, Bosque Watershed, TX

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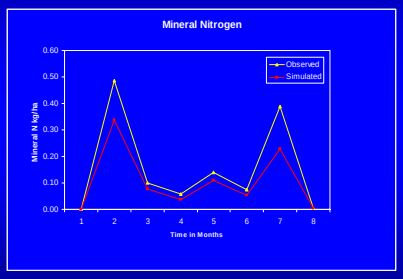
Mineral Nitrogen Calibration Scenario 1



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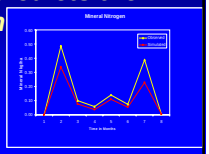
Mineral Nitrogen Calibration

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)

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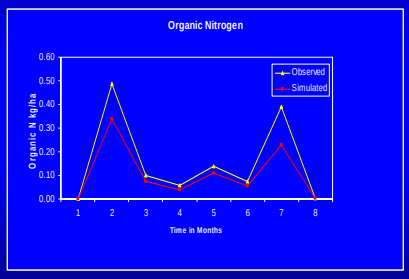
Organic Nitrogen Calibration Scenario 1



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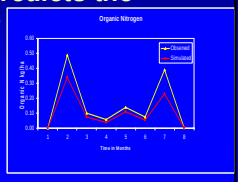
Organic Nitrogen Calibration

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_LY1 in .mgt)
- Calibrate in-stream organic nitrogen processes
  - Adjust fraction of algal biomass that is as nitrogen for water quality (AI1 in.wwq)

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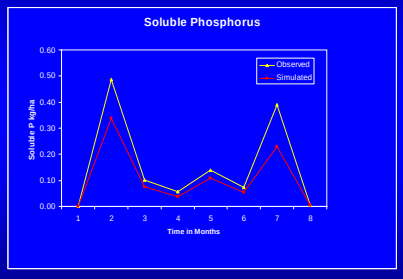
Soluble Phosphorus Calibration Scenario 1



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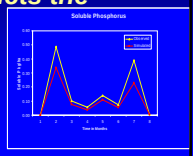
Soluble Phosphorus Calibration

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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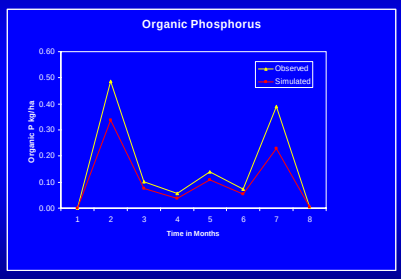
Organic Phosphorus Calibration Scenario 1



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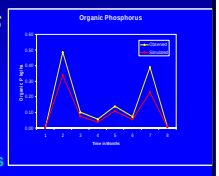
Organic Phosphorus Calibration

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)

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