Model Status and Calibration

Stephen Hundt
Context
The modeling process

- **Define problem**
  - Literature review
  - Preliminary analyses
  - Data collection

- **Develop conceptual model**
  - Processes/budget
  - Boundary conditions
  - Hydrogeologic framework
  - Data collection

- **Develop mathematical model**
  - Choose model code
  - Choose how to represent processes and boundary conditions
  - Construct the model

- **Calibration**
  - History matching
  - Sensitivity analysis
  - Data collection

- **Assessment of problem using model**

- **Project completion**
  - Results based on simulation results

After Reilly (2001) TWRI 3,B8
Work since last meeting
Reminder: Diagnostic (Monte Carlo) Plots

Parameter value

![Diagram showing parameter value with lower and upper bounds and a 'best guess'.]
Reminder:
Diagnostic (Monte Carlo) Plots
Troubleshooting: Model Structure

- 7.5
- 1989
- 2004
- 2009
- 2014

- From Lake Lowell
- To Lake Lowell
- From River
- To Lower Ny Carlin
- From other zones
- To other zones
Troubleshooting:
Model Structure
Troubleshooting: PEST ‘mechanics’

- **MODEL**: MODFLOW (solving flow equations)
  - **INPUT**: (adjustable and non-adjustable properties and boundaries)
  - **OUTPUT**: (heads and flows at grid cells)

- **PEST**: Write input files with calculated parameters
  - Calculate new parameter values
  - Objective function too high
  - Objective function good

- **DATA**: Observation Data

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**PEST**
Model Independent Parameter Estimation
(Version: 9.43, 2014-09-21)

**Troubleshooting**: PEST ‘mechanics’

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Troubleshooting: PEST ‘mechanics’

Writing MODFLOW input files

MODFLOW

- HK, VK, SS value grids
- Pilot point parameter files
- Interpolation routines
- Template Files
- Parameter replacement routine
- Irrigation Parameter Files
- Irrigation Supply and Demand Data
- Irrigation Demand Supply Routine
- Boundary Stress Time Series Files
- Parameter replacement routine
- Template Files
- Modflow Package Files
- PEST Algorithm: Parameter Adjustment
**Troubleshooting: PEST ‘mechanics’**

**PEST**

Model Independent Parameter Estimation

For Manual Part 3:
PEST, SENSI, and Global Optimization

Import for documentation of USGS programs and manuals

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**MODEL**

MODFLOW
(solving flow equations)

**INPUT**
(adjustable and non-adjustable properties and boundaries)

**OUTPUT**
(heads and flows at grid cells)

**PEST**

Write input files with calculated parameters

Calculate new parameter values

Calculate Objective Function

objective function too high

Objective function good

**DATA**

Observation Data

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**Troubleshooting: PEST ‘mechanics’**

Write input files with calculated parameters

Calculate new parameter values

Calculate Objective Function

Objective function too high

Objective function good
Troubleshooting: PEST ‘mechanics’

Reading MODFLOW Output Files

- MODFLOW
- Drain boundary fluxes
- Lowell boundary fluxes
- River boundary fluxes
- Setting files
- Cell-by-cell head files
- Head processing routine
- Setting files
- Processed heads
- Vertical and temporal difference calculation
- Processed Head Difference Files
- Output extraction routine
- Instruction file

Output extraction routine

Output extraction routine

Instruction Files

PEST Algorithm: Calculate Objective Function
Manual Adjustments

East - West

North - South
Manual Adjustments
<table>
<thead>
<tr>
<th>Observation Type</th>
<th>Approximate Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Levels</td>
<td>10,000 's</td>
</tr>
<tr>
<td>Drain Flows</td>
<td>100's</td>
</tr>
<tr>
<td>Lower Seepage</td>
<td>100's</td>
</tr>
<tr>
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<td>100's</td>
</tr>
<tr>
<td>Temporal Differences</td>
<td>10,000</td>
</tr>
<tr>
<td>Vertical Water Level Differences</td>
<td></td>
</tr>
<tr>
<td>Net Water Budget Values*</td>
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- Number of measurements at location
- Spatial density
- Temporality
- “Events”
- Structural error
- Overall budget
- Others???
### Observation Type vs. Approximate Number

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Current calibration status*

*ugly, but preliminary
Residual Summary

-1.6 -1.4 -1.2 -1.0 -0.8 -0.6 -0.4 -0.2 0.0

measured

-1.6 -1.4 -1.2 -1.0 -0.8 -0.6 -0.4 -0.2 0.0

residual, in cubic feet per month

1e7 1e6

drn drn

~ 1 cfs

modelled, in cubic feet per month
Residual Maps

Drain flux residuals

USGS
science for a changing world
Residual Maps

hd residuals in layer 4
Residual Maps

hd residuals in layer 5
Phi Proportion Maps

$r_i = \text{observed}_i - \text{simulated}_i$

$w_i = \text{weight}$

objective function: $\Phi = \sum w_i r_i^2$
Phi Proportion Maps

hd phi in layer 1

Proportion of group phi

USGS science for a changing world
Phi Proportion Maps

hd phi in layer 3

proportion of group phi
Phi Proportion Maps

hd phi in layer 4

hd in layer 4 proportion of group phi
Phi Proportion Maps

hd phi in layer 5

proportion of group phi

USGS
Phi Proportion Maps

hd phi in layer 6

hd in layer 6 proportion of group phi

USGS science for a changing world
Causes?
Causes?
Causes?

Layer 1
wel-infil_irr
Causes?

Layer 1
wel-ny_canal

USGS
science for a changing world
Causes?
Causes?
Causes?
Upcoming efforts
Troubleshoot Model Structure
Layer 3
wel-pump_1rr
Troubleshoot Model Structure

Layer 4
wel-pump_irr
Adjust Weighting

hd phi in layer 4

hd in layer 4
proportion of group phi
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Thanks for listening!