Water Temperature Modeling Update

Scott Wright, Craig Anderson, Nick Voichick

U.S. Department of the Interior
U.S. Geological Survey

Data Report

- Mainstem and tributary water temperature data collected by GCMRC since 1988

  "Water Temperature Data for the Colorado River and Tributaries between Glen Canyon Dam and Spencer Canyon, Northeastern Arizona, 1988 – 2005"

  By Nicholas Voichick and Scott Wright

- Summary of methods for data collection, QA/QC; provides basic statistics
- Currently in USGS review
- Data files and report to be served over the GCMRC website – data files updated annually

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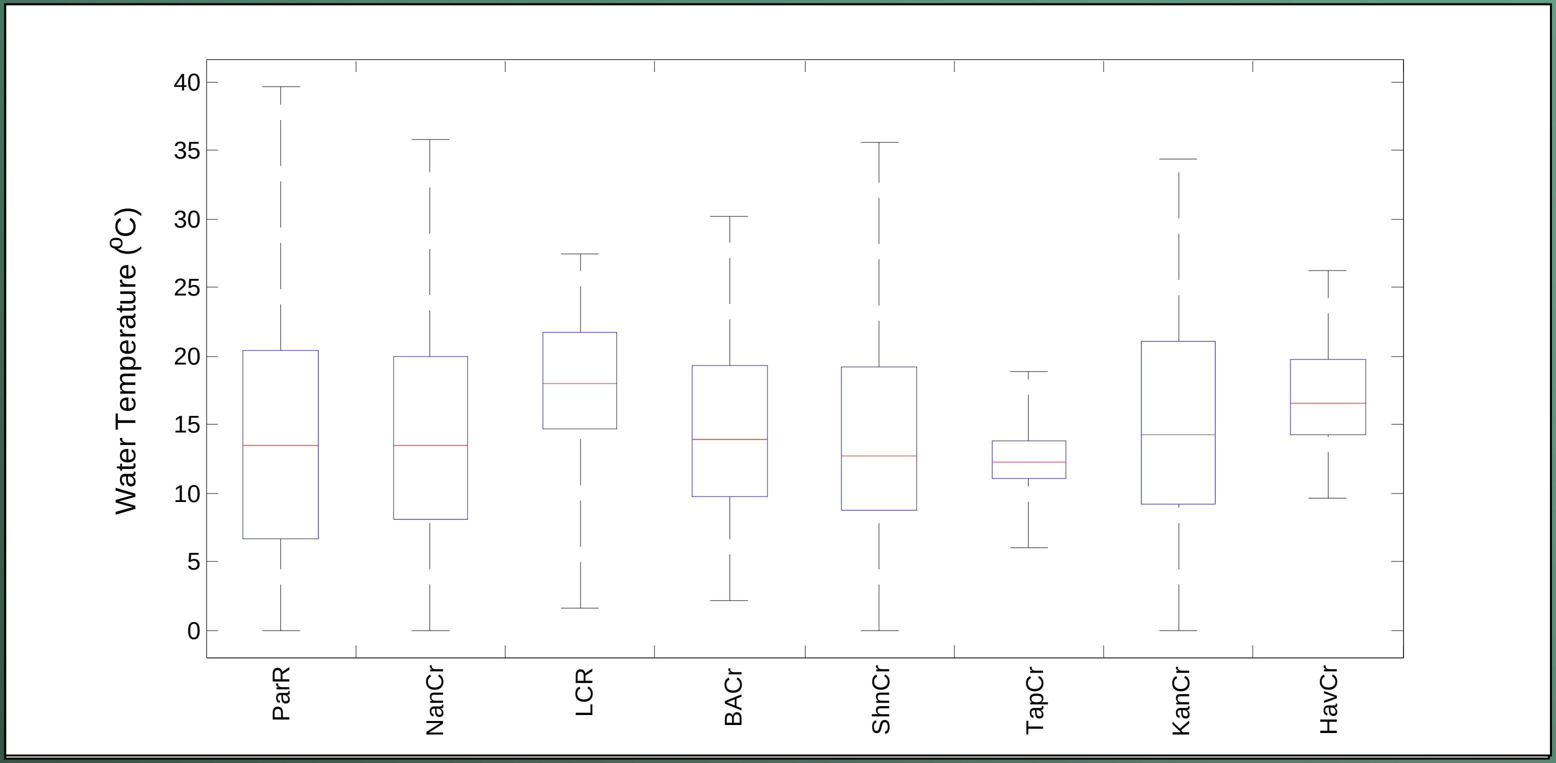
Data Report - Tables

Site name	Latitude	Longitude	Start of record	End of record
Colorado River below Glen Canyon Dam (CRBD)	-111.4826	36.9361	10-Aug-88	Continuing
Colorado River at Lees Ferry (CRLF)	-111.5846	36.8653	10-Oct-91	Continuing
Colorado River near river mile 30 (CR030)	-111.8457	36.5201	26-Oct-02	Continuing
Colorado River near river mile 33 (CR033)	-111.8434	36.4861	14-Apr-00	28-May-05
Colorado River near river mile 61 (CR061)	-111.8003	36.1964	11-Aug-90	Continuing

Site name	Percent good data	Mean (°C)	Median (°C)	Standard deviation (°C)	Minimum (°C)	Maximum (°C)
CRBD	80	9.4	9.2	1.3	6.8	15.7
CRLF	84	9.8	9.5	1.3	7.1	16.5
CR030	94	11.1	10.8	2.2	7.6	16.8
CR033	87	10.4	10.2	1.5	7.3	15.5
CR061	91	10.6	10.5	1.7	5.7	17.8

Data Report - Figures



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Modeling – Why?

- Predictions – Evaluation of Alternatives (e.g. LTEP)
- Isolate effects of interest (e.g. fluctuation versus volume) while holding other drivers contant
- Reduction in monitoring efforts
- Model development was a primary recommendation of the QW PEP

Modeling Approach

- Mainstem one-dimensional model
  - USGS Branched Lagrangian Transport Model
  - Linked to existing UNSTEADY flow model
  - Similar to Reclamation 1D GEMSS model
- Nearshore model
  - Simplified representation of backwaters
  - Complimentary to Reclamation 3D GEMSS model

BLTM (Branched Lagrangian Transport Model)

- Developed and widely used by USGS over past 15 years – open source code that can be modified
- Simulates fate of water quality constituents for open channels and unsteady flow – can incorporate hydrodynamic information from external models
- Can route up to 10 interactive constituents using known reaction kinetics and concentrations (EPA Qual-2E), or user defined equations
- Solves advective-dispersion equation using Lagrangian reference frame – numerically accurate and stable

Temperature Modeling 101

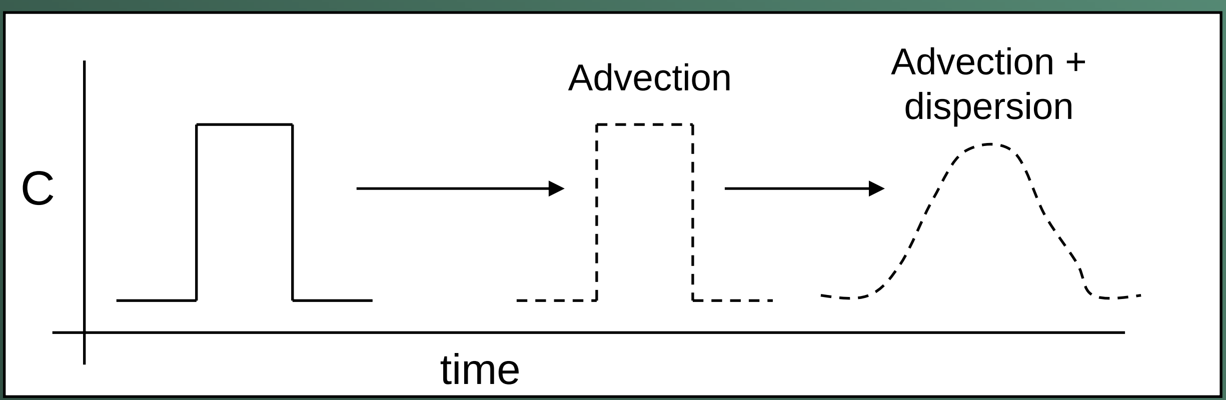
$$\frac{\partial T}{\partial t} = U\frac{\partial T}{\partial x} + \frac{\partial}{\partial x}\left(D\frac{\partial T}{\partial x}\right) + S_{HE}$$

Change in temperature

Advective transport

Dispersive transport

Surface heat exchange

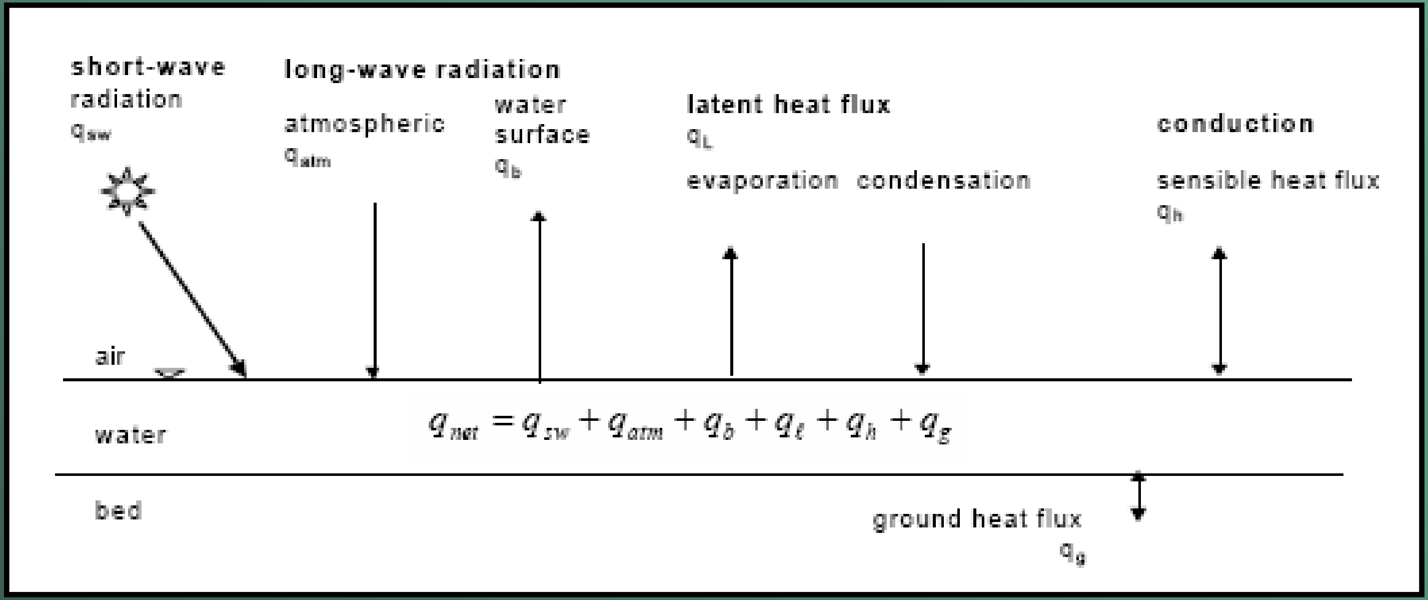


U – velocity (from UNSTEADY)

D – Dispersion coefficient (from Graf dye studies)

Boundary condition:
T at *x = 0*
(GCD release temperature)

Temperature Modeling 101



Calculation of q_{net} requires detailed meteorological information

BLTM uses simplified approach – Equilibrium temperature (q_{net} = 0)
Requires only max/min daily air temperature and wind speed

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Available Meteorological Data

Location	Period of Record	Frequency	Elevation (ft)	Parameters
Page	**1957 – present**	**Hourly**	**4,200**	**Air Temp, Dewpoint, Wind Speed and Direction, Cloud Cover, Bar Press, Precip**
Lees Ferry	1948 - present	Daily	3,200	Max Air Temp, Min Air Temp, Precip
Phantom Ranch	1948 - present	Daily	2,530	Max Air Temp, Min Air Temp, Precip
GCNP (South Rim)	1903 – present	Daily	6,800	Max Air Temp, Min Air Temp, Precip
Lake Mead	**2000 – present**	**Hourly**	**1,131**	**Air Temp, RH, Wind Spead and Direction, Atm Press, Solar Radiation**

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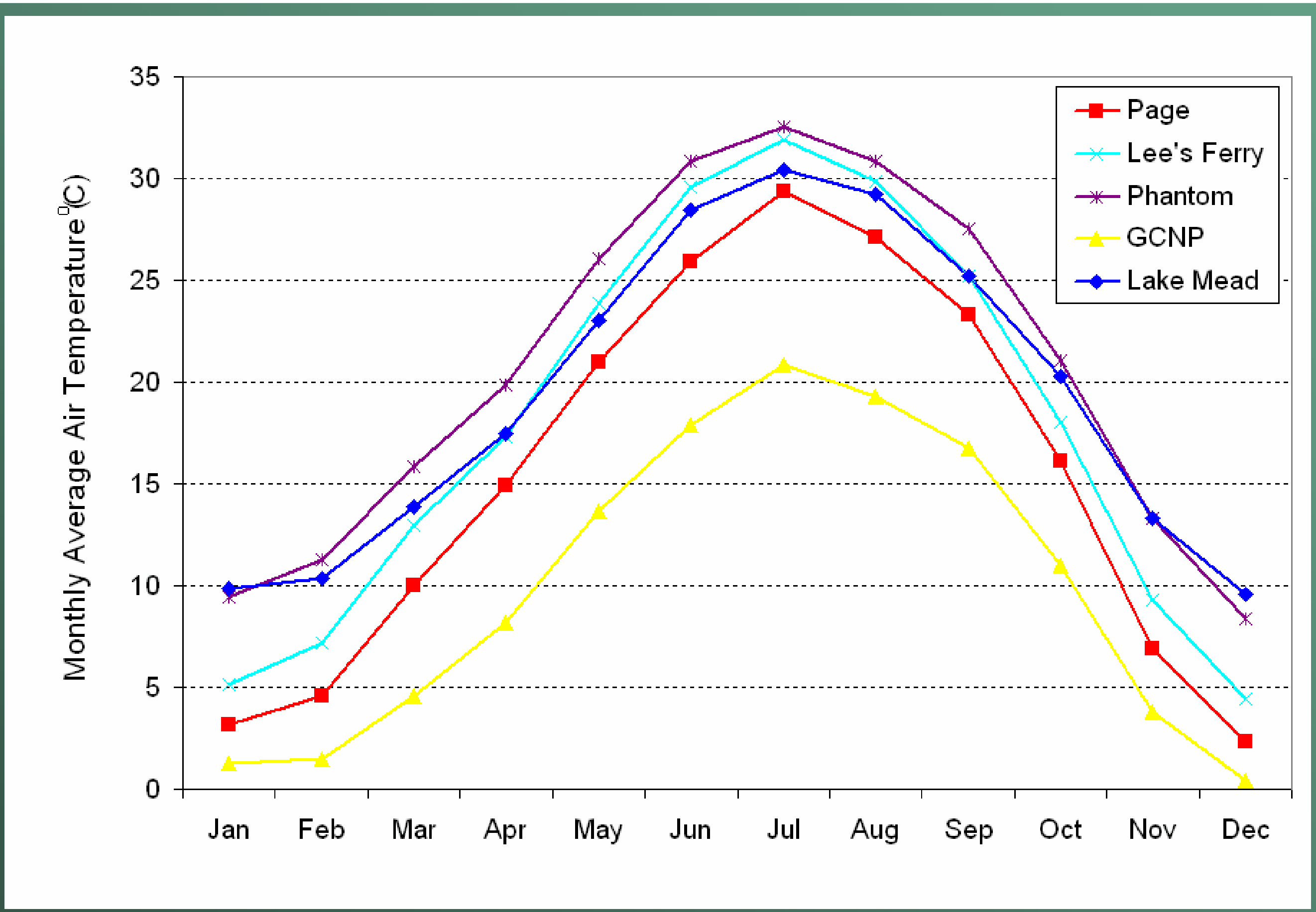
Available Meteorological Data



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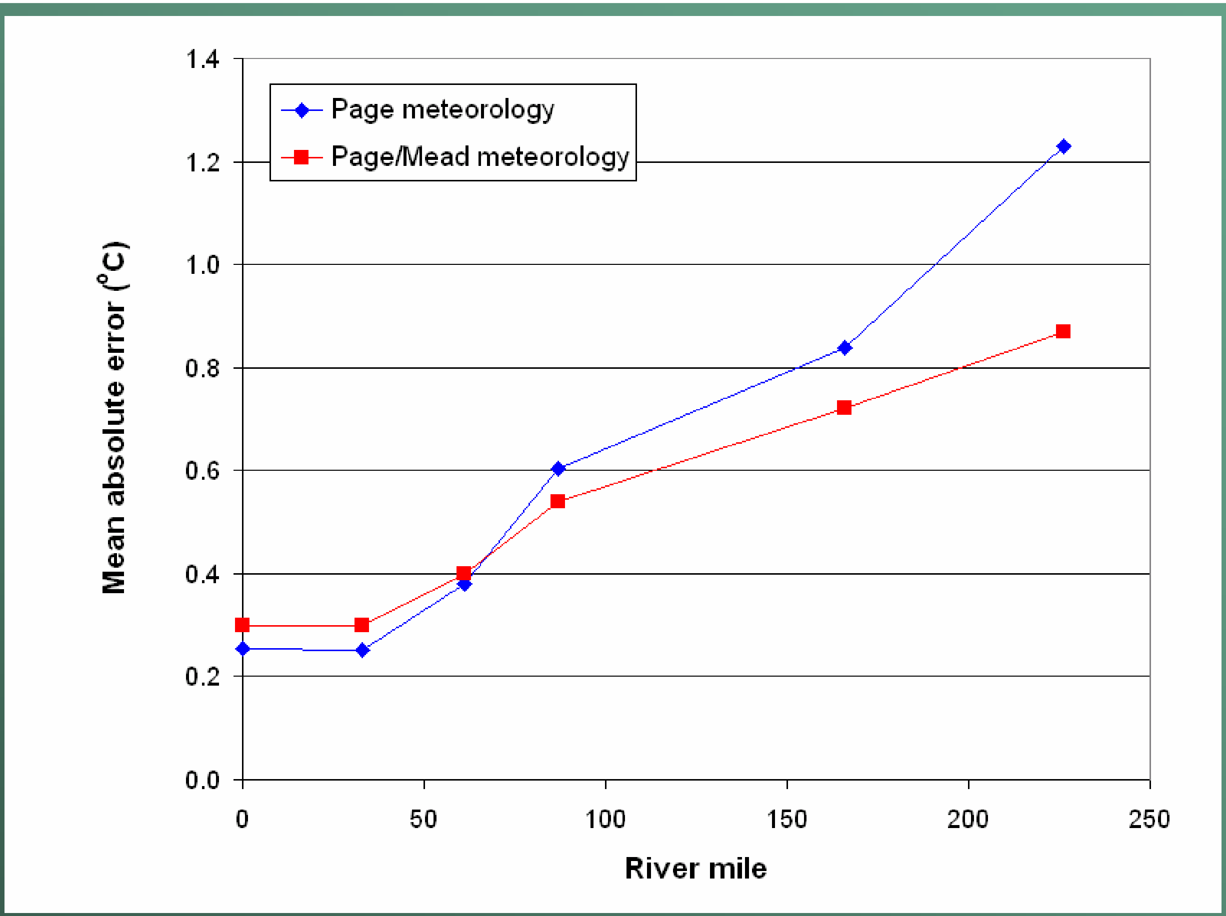
1D Model Calibration

- Year 2000 – Range in water temperature; steady and fluctuating flows, LSSF

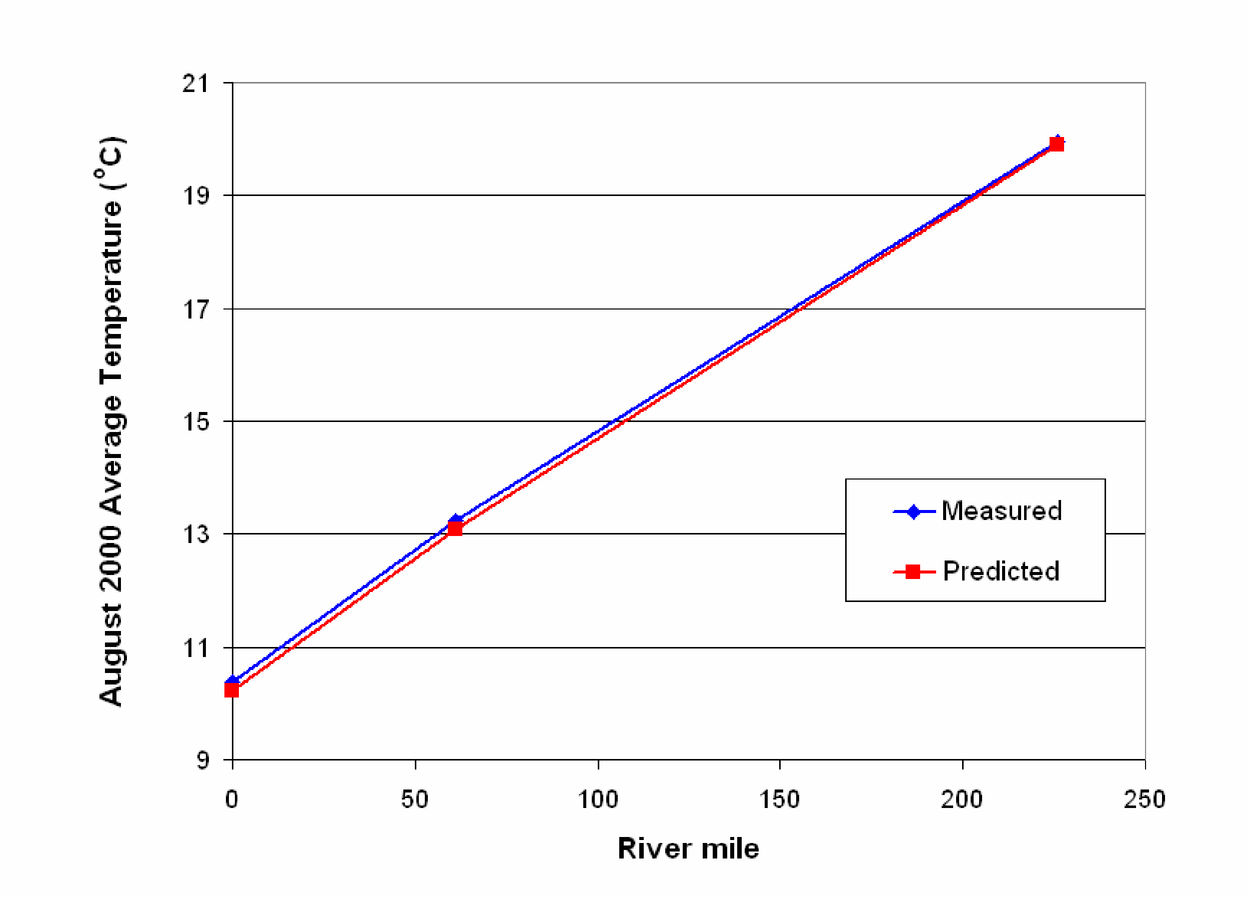
- Procedure
  - Adjust wind function parameters – evaporation
  - Adjust equilibrium temperatures – related to location of the meteorological data
  - Minimize differences between measured and predicted water temperature
  - Experiment with Page and Mead meteorology

Calibration Results (Year 2000)

Incorporating Lake Mead meteorology reduces errors in western Canyon



2000 LSSF Warming Prediction

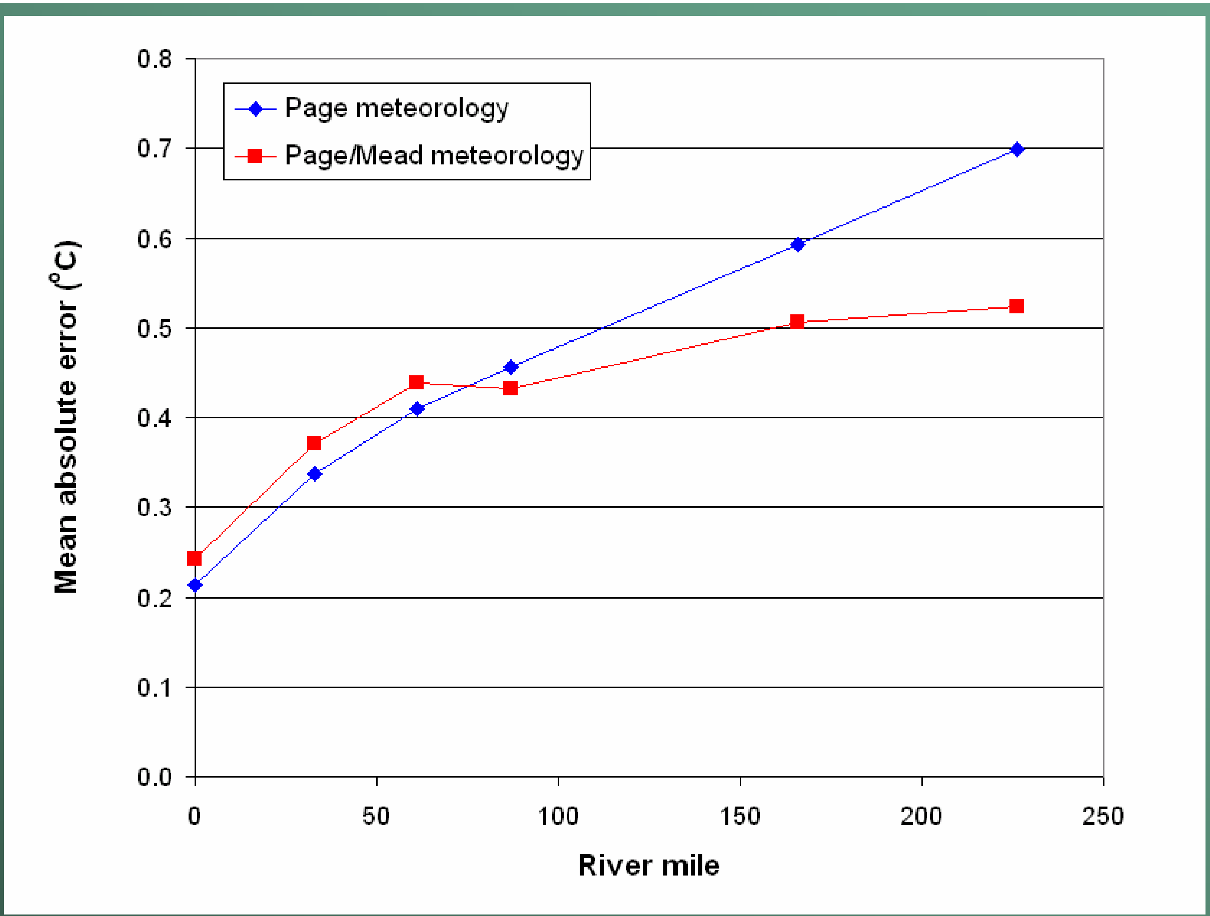


1D Model Validation

- Run model for different time period with no parameter adjustment
- Year 2005 – Variety of experimental flows; high release temperatures

Validation Results (Year 2005)

Errors less than calibration period



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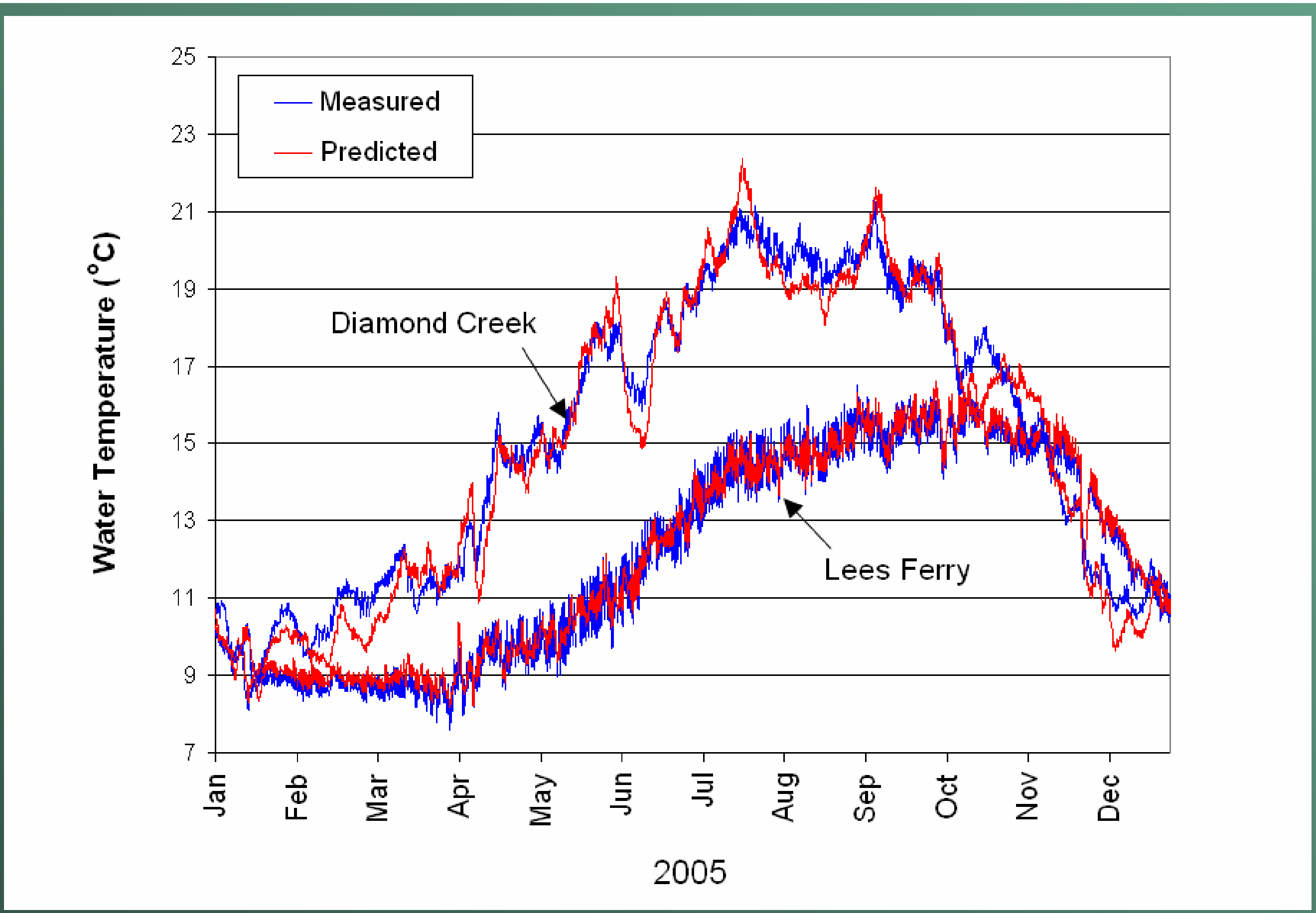
Validation - Hourly Time Series



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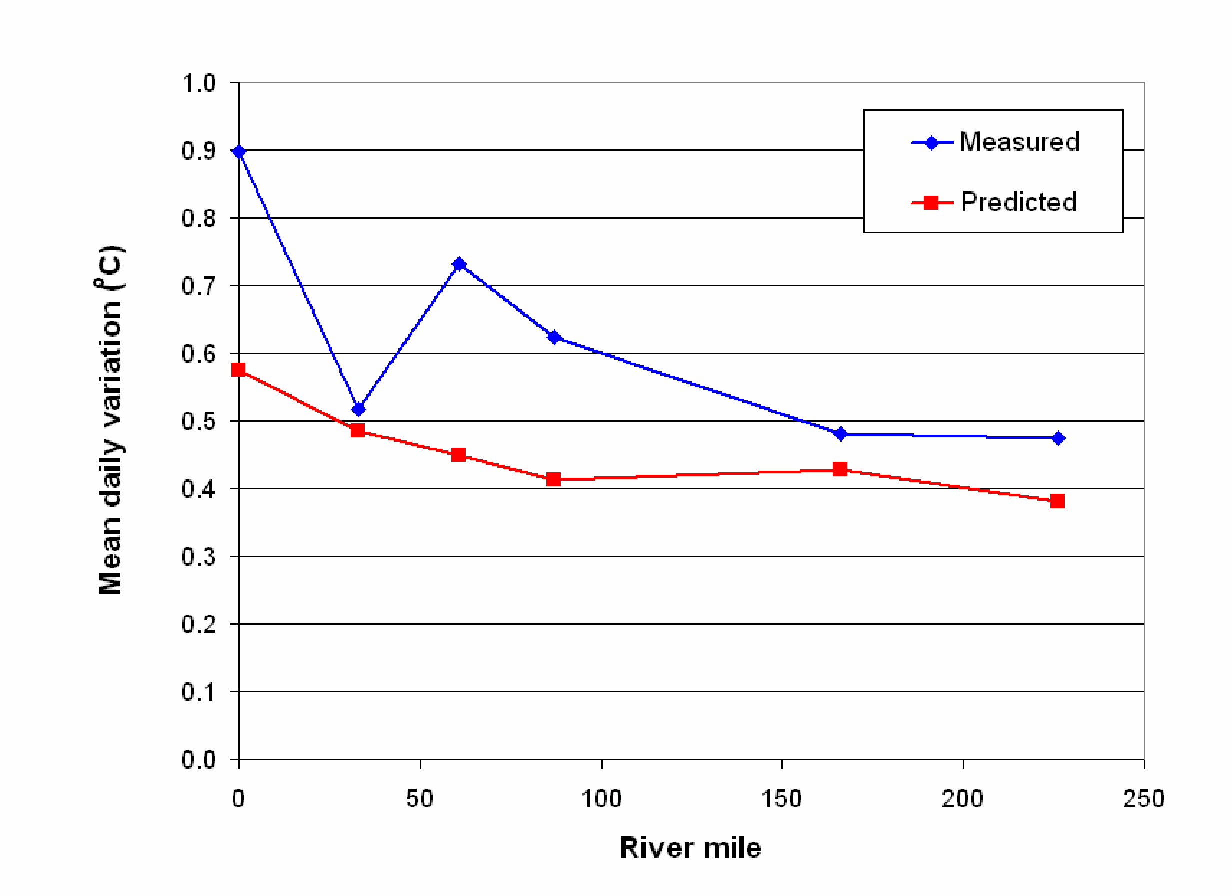
Validation - Daily Range

Model tends to *slightly* under-predict daily temperature range - probably due to local effects



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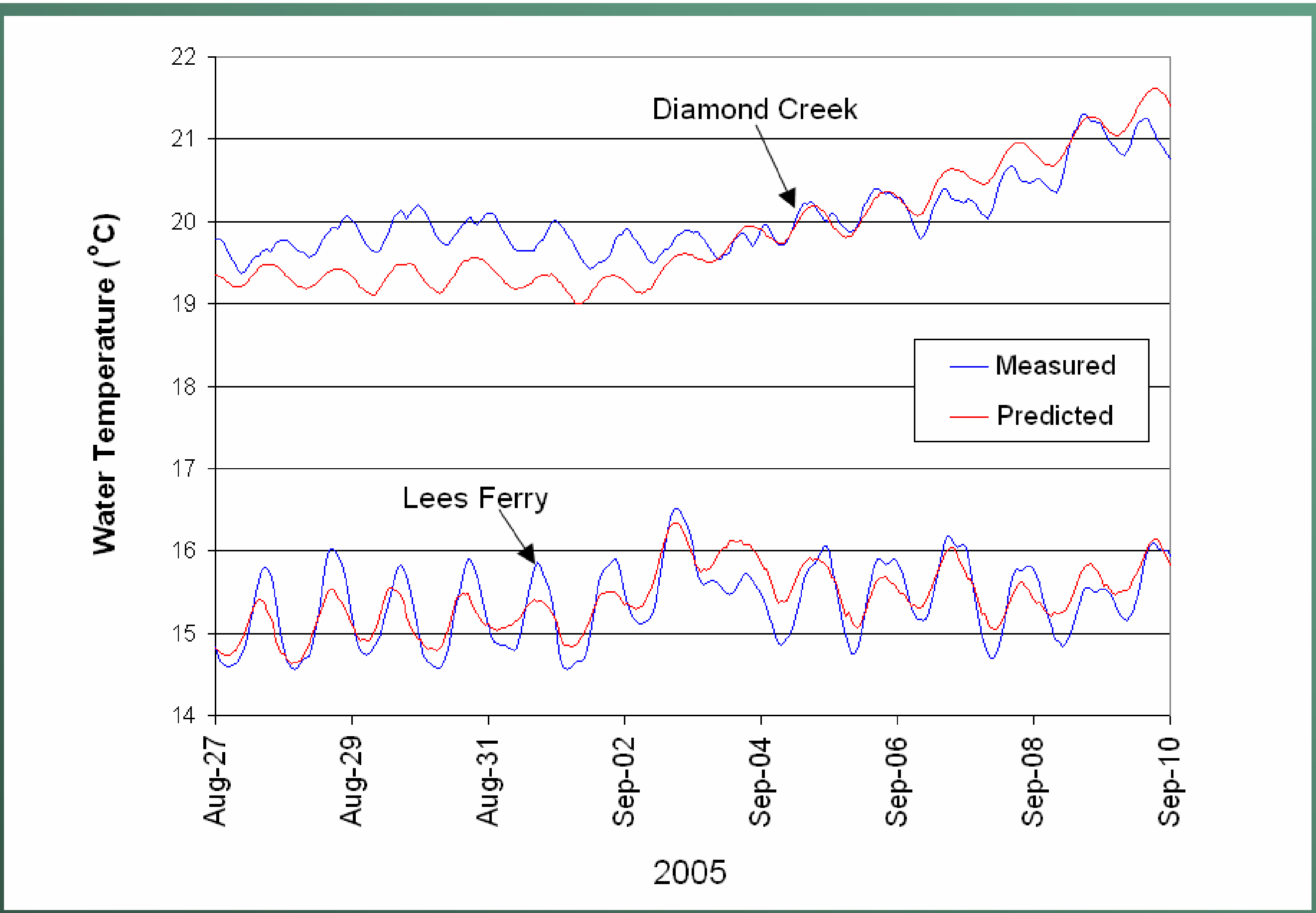
Validation – Daily Range



1D Model Conclusions

- Predictions agree with measurements to within 1°C, on average
- Incorporating Lake Mead meteorology improves predictions in western canyon
- Slight under-prediction of daily variation - could be improved but is it worth it?
- Next steps
  - Develop user-interface for 1D model
  - Write-up documentation for 1D model
  - Begin work on nearshore model

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Nearshore Model

- Reclamation has developed a 3D flow and temperature model for nearshore areas – limited to application in short reaches over short time periods
- Want to develop a nearshore model (particularly for backwaters) capable of simulating system-wide response – link dynamically with 1D model
- Need a simplified representation of nearshore environments – in the process of reviewing available data (Craig Anderson talk this afternoon)