Modeling and Regulatory Support Workgroup Meeting August 4, 2020

Remote Access Only (see next slides)

Remote Access Options

Equipment Type	Access Information	Notes
Computers with microphones and speakers	Join Microsoft Teams Meeting **Please mute your microphone** unless you want to provide input.	Press control and click on this link to bring up Microsoft Teams through the internet. You can view the screen share and communicate through your computer's speakers and microphone
Computers without audio capabilities, or audio that is not working	Join Microsoft Teams Meeting (888) 404-2493 Passcode: 371 817 961# **Please mute your phone** unless you want to provide input.	Follow instructions above **Turn down your computer speakers, mute your computer microphone,** and dial the toll-free number through your phone and enter the passcode
Phone only	(888) 404-2493 Passcode: 371 817 961# **Please mute your phone** unless you want to provide input.	Dial the toll-free number and enter the passcode

Remote Access Guidelines

- This meeting will open 30 minutes prior to the official meeting start time to allow users to test equipment and ensure communication methods are working
- If you dial in through your phone, mute your microphone and turn down your speakers to avoid feedback
- Unless you are speaking, please mute your computer or device microphone and phone microphone to minimize background noise

Agenda

- Environmental Fluid Dynamics Code (EFDC) hydrodynamic model of Falls Lake
  - Study area and model development
    - Overview of the Environmental Fluid Dynamics Code (EFDC) Hydrodynamic Model
    - Simulation Period
    - Grid and Bathymetry
    - Inputs
    - Link between WARMF and EFDC
  - Calibration and validation stations and results
    - Performance statistics
    - Calibration and validation
    - Vertical temperature profiles
  - Summary
- Discuss potential training topics for MRSW
- Modeling and Regulatory Support status

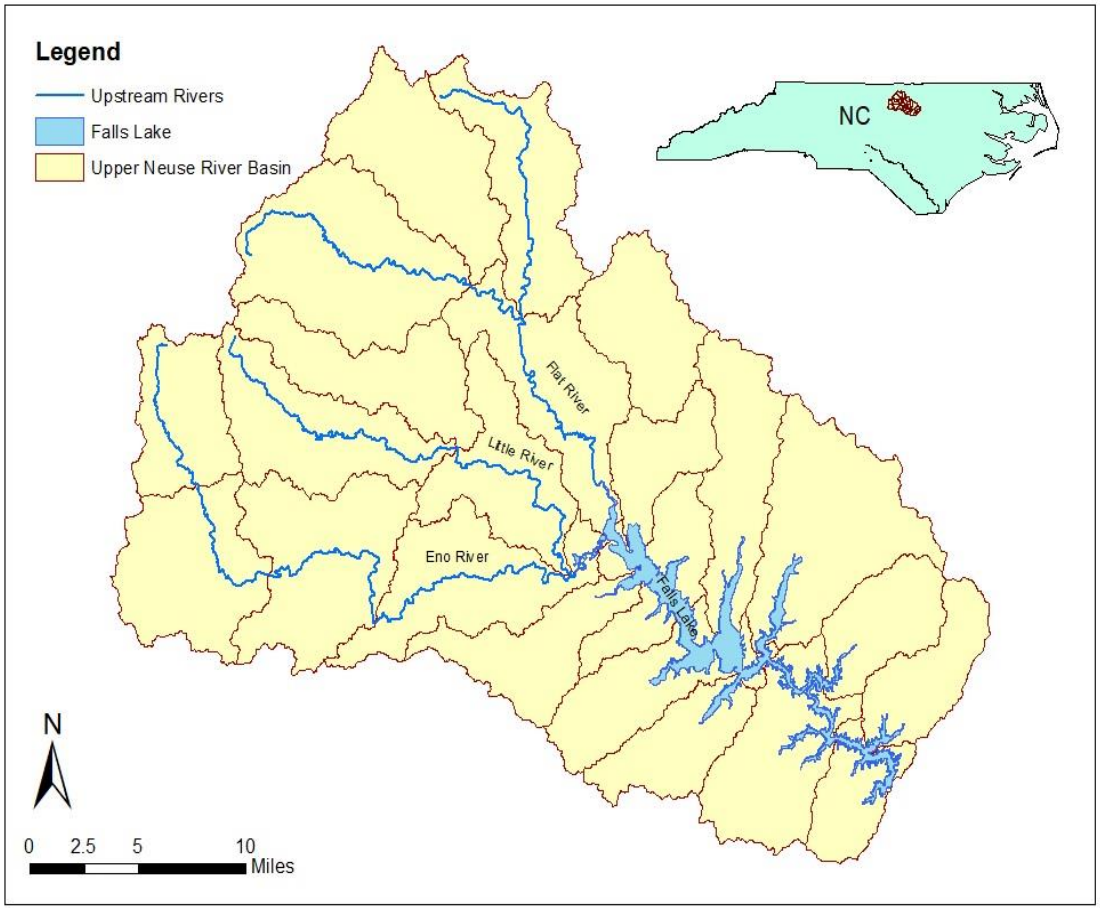
Preliminary Hydrodynamic Calibration of the Falls Lake EFDC Model

Dynamic Solutions LLC

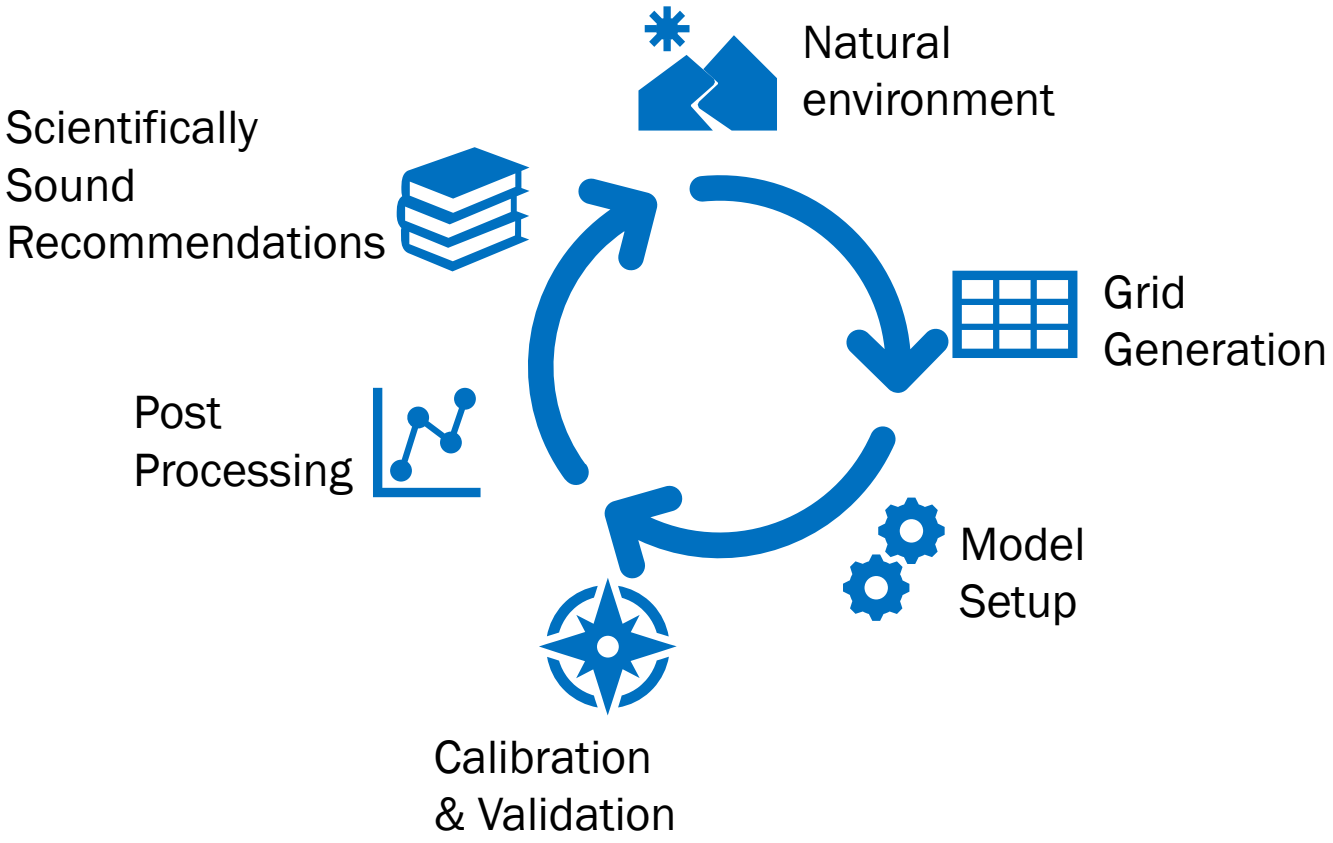
Study Area and Model Development

Study Area

- Upper Neuse River Basin and Falls Lake



Overview of the Environmental Fluid Dynamic Code (EFDC) Model



Simulation Period

Period	Start Date	End Date
Total Simulation Period	1/1/14	12/31/18
Spin-up Period	1/1/14	12/31/14
Calibration	1/1/15	12/31/16
Validation	1/1/17	12/31/18

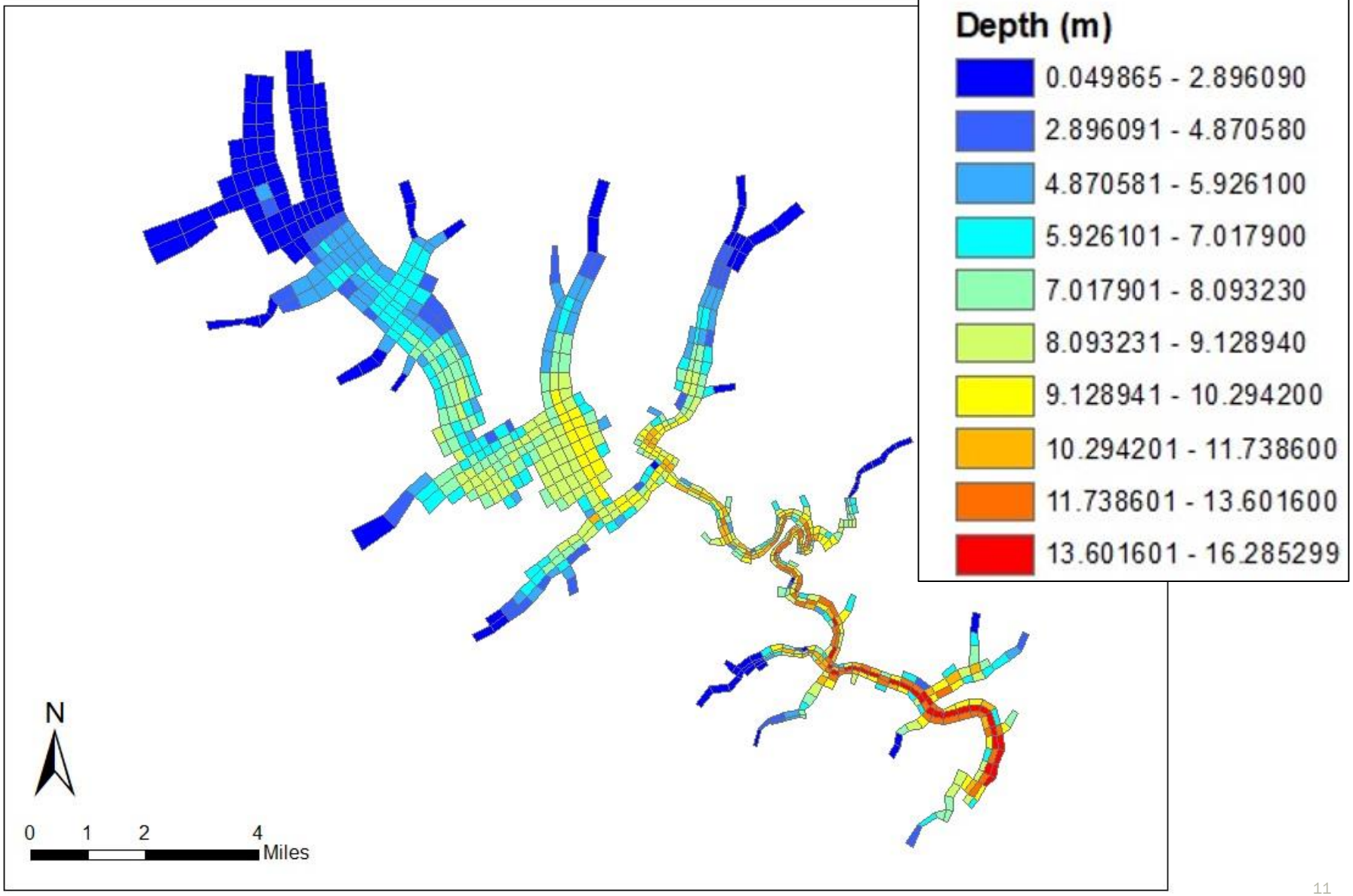
Grid Development and Bathymetry Data

UTM Zone	17
# of Cells	862
# of Layers	10
Vertical coordinates	Sigma Zed (Uniform Layers)

Bathymetry interpolation sources:

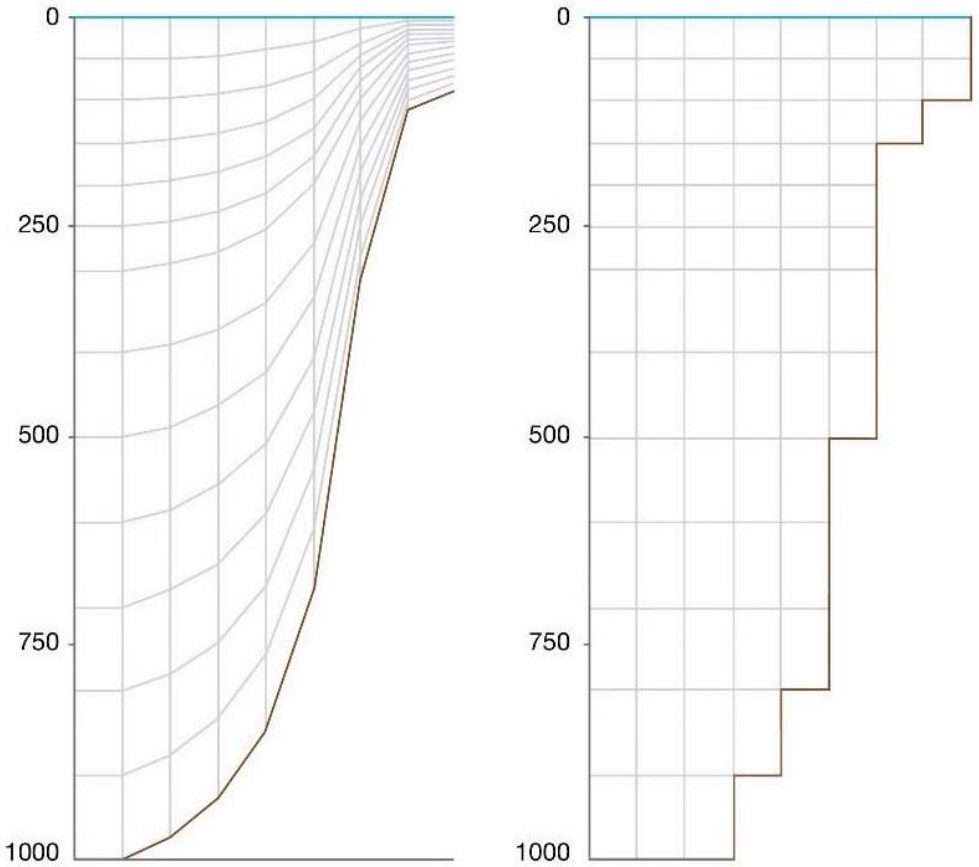
- Shoreline and road shape files including numerous bridges and causeways in the Falls Lake system downloaded from National Hydrography Dataset (NHD)
- UNRBA Bathymetry data (Falls_Lake_2017_ASCII_HF_DTM_10_ft_Grid.txt) obtained from BC.

Grid and Bathymetry



Sigma Zed Vertical Layering Advantages

1. Computationally efficient
2. Reducing pressure gradient errors



Vertical grids for Sigma stretch (left) and Sigma Z (right)

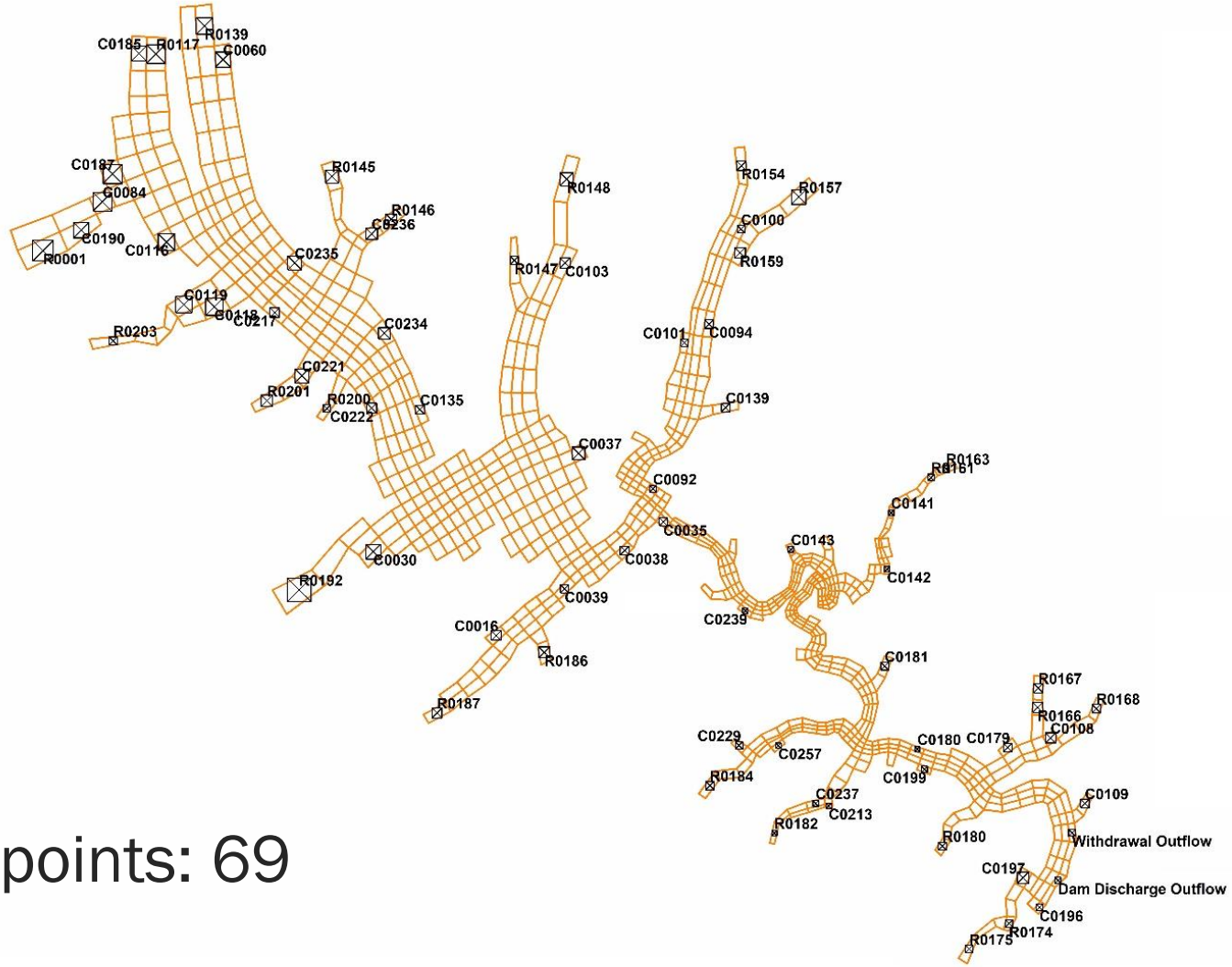
Model Inputs

- Watershed/Tributary Inflow
- Temperature

} Watershed model (WARMF)

- Dam Discharge Outflow
- Withdrawal Outflow
- Meteorological data (Air Pressure, Air Temperature, Relative Humidity, Wind, Rainfall, Solar Radiation, Cloud Cover)

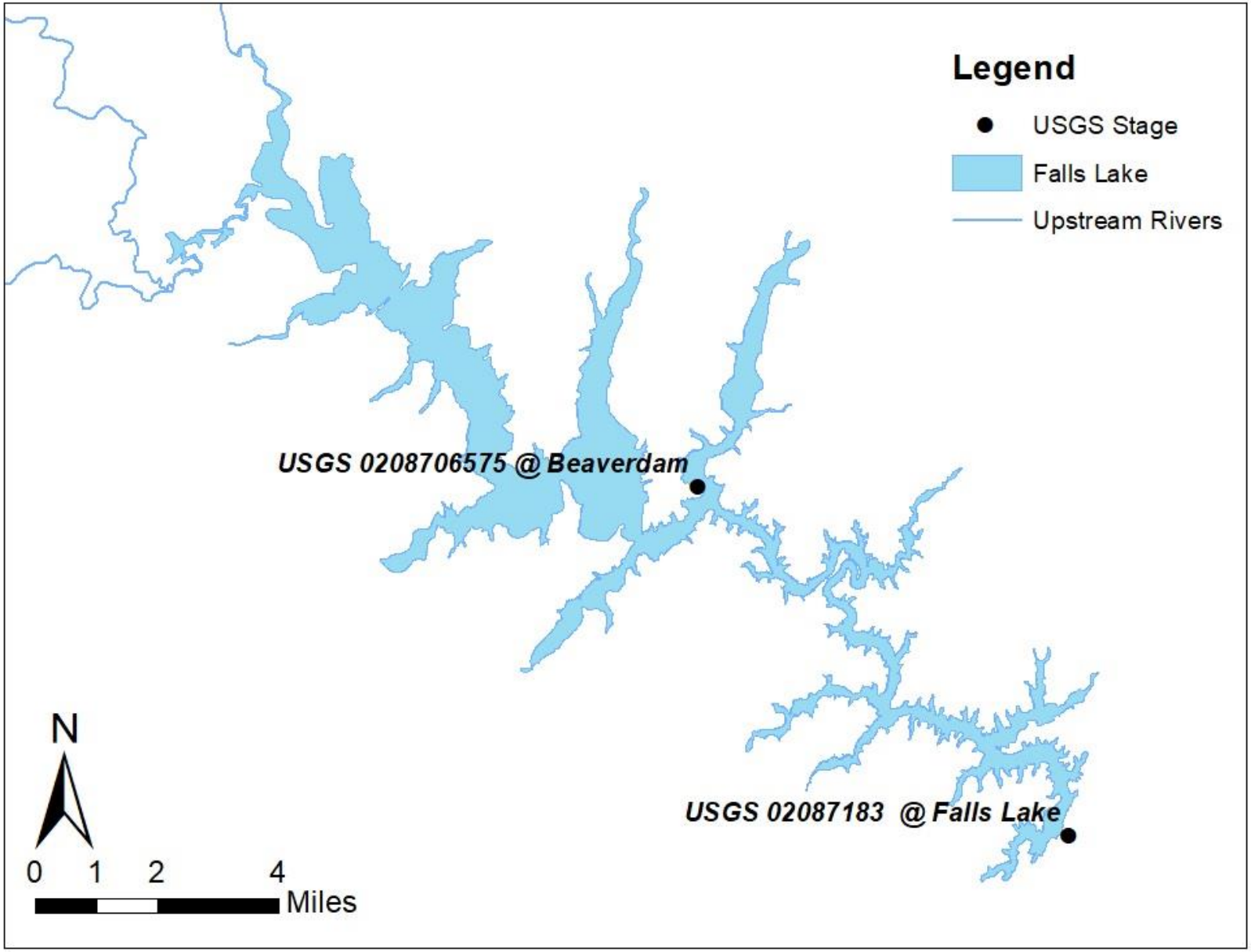
Link between WARMF and EFDC



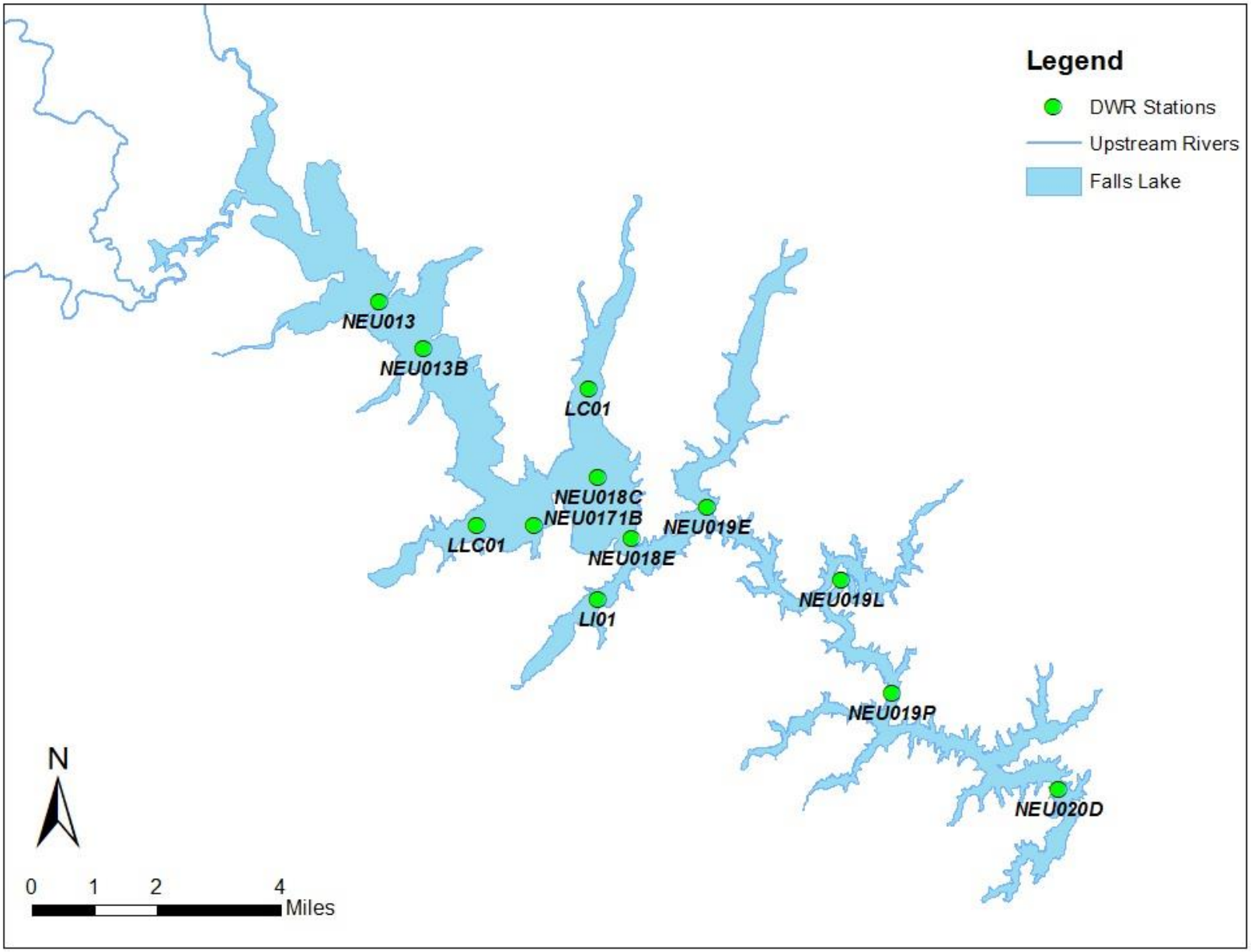
# of linkage points: 69

Model Performance

Calibration/Validation Stations: Stage



Calibration/Validation Stations: Temperature



Performance Statistics (Modeling QAPP)

- The primary statistical criterion for the EFDC lake model that will be adopted in this study is a normalized Root Mean Square Error (RMSE) performance measure (RSR).
- RSR (RMSE-$STDEV_{Obs}$ Ratio):

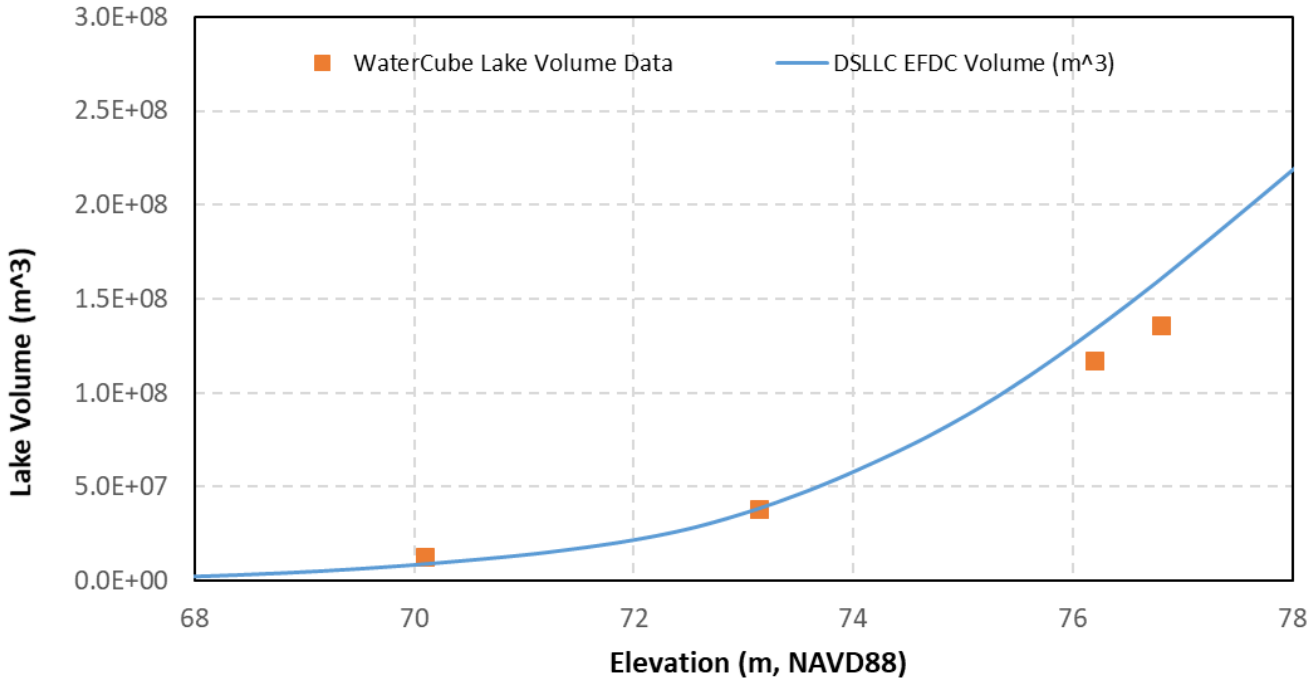
$$RSR = \frac{RMSE}{STDEV_{obs}} \times 100 = \frac{\sqrt{\sum (P-O)^2}}{\sqrt{\sum (O-\overline{O})^2}} \times 100$$

N: # of paired records of observed measurements and model results
O: observed measurement
P: predicted model result
$STDEV_{Obs}$: standard deviation of the observed data

- Calibration Target for hydrodynamic variables: RSR < 50%

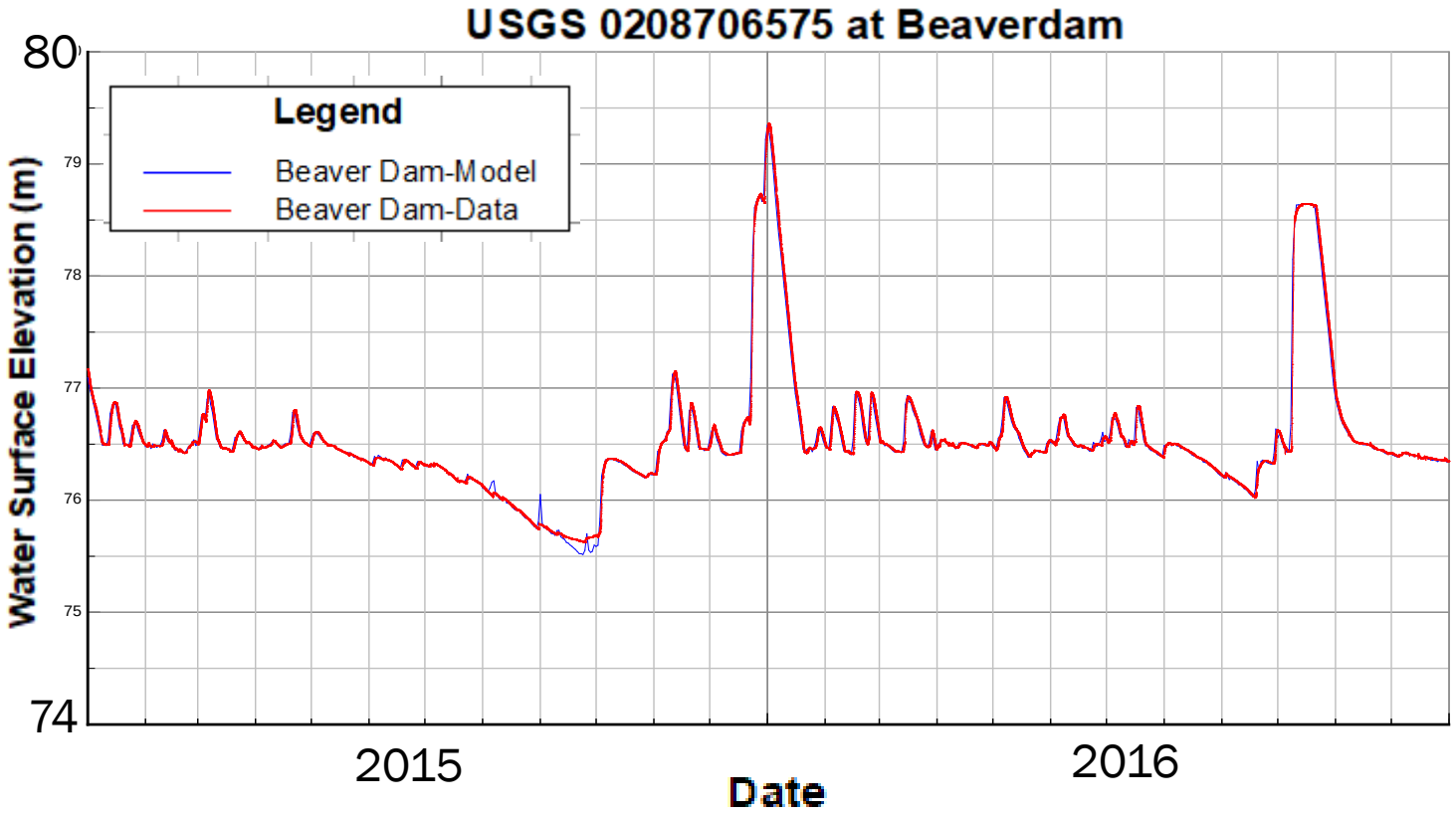
Lake Stage-Volume Relationship

- Because of inaccuracies in the lake inflows and outflows used in the model, additional balance flow is necessary to ensure the simulated lake stage matches the observed. EFDC model stage-volume relationship should be close to the data in order for the model to correctly reproduce lake residence time which is critical for simulation of lake water quality.



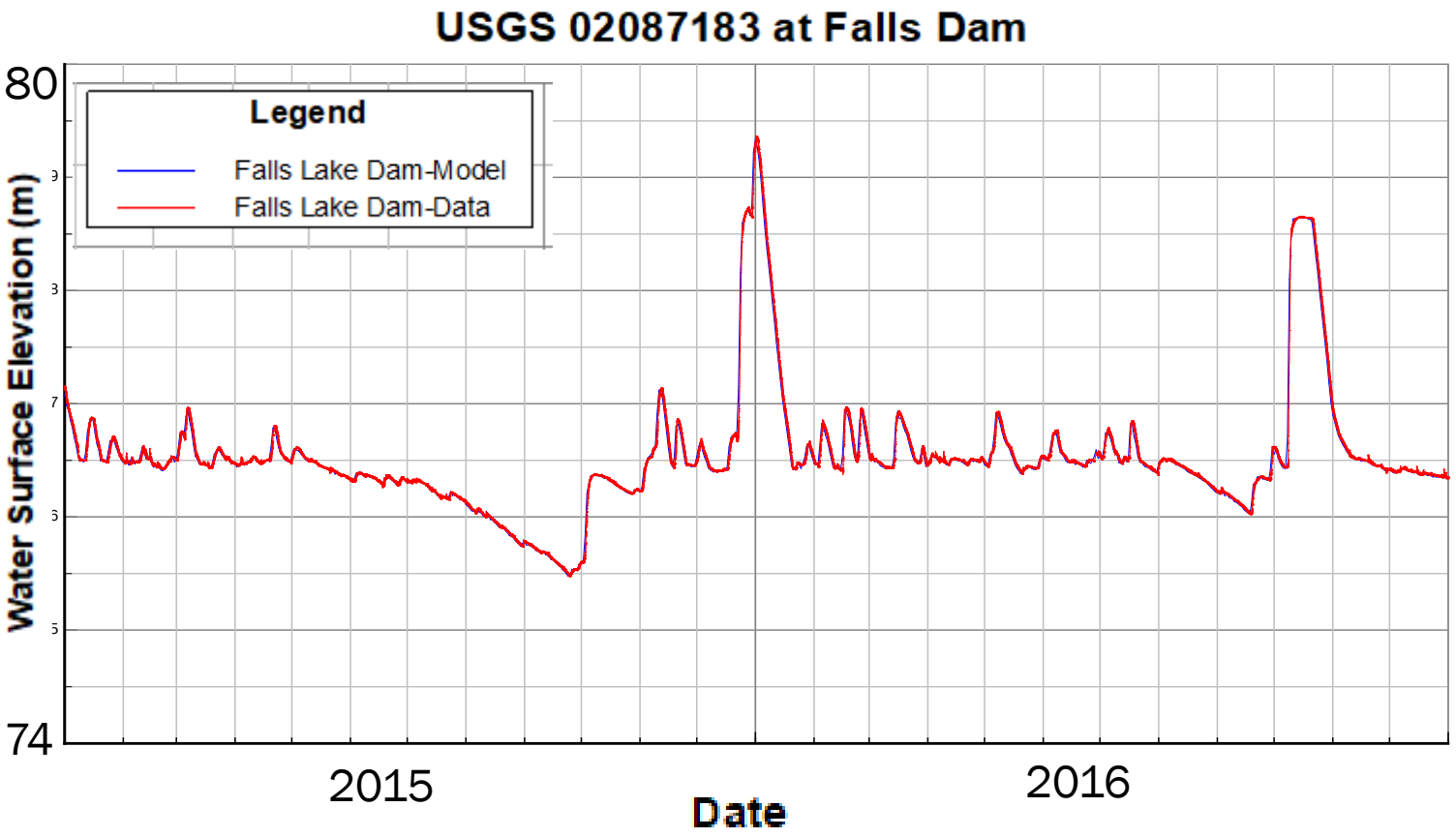
Lake Stage (m) Calibration - Beaverdam

Starting	Ending	# Pairs	RMS (m)	Rel RMS (%)	Data Average (m)	Model Average (m)
1/1/15	12/31/16	104577	0.057	1.524	76.542	76.539



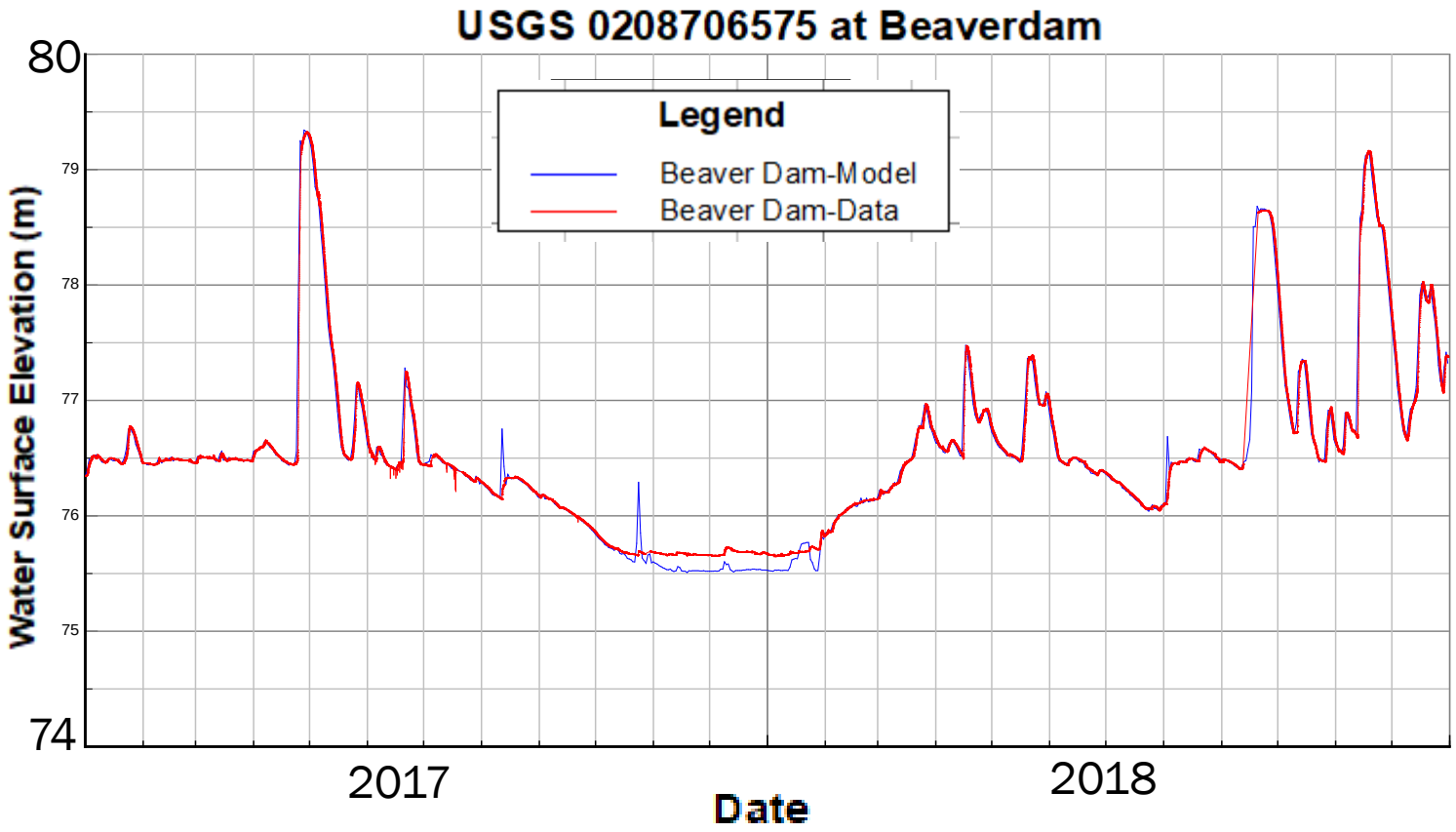
Lake Stage (m) Calibration –Falls Dam

Starting	Ending	# Pairs	RMS (m)	Rel RMS (%)	Data Average (m)	Model Average (m)
1/1/15	12/31/16	104855	0.051	1.319	76.541	76.535



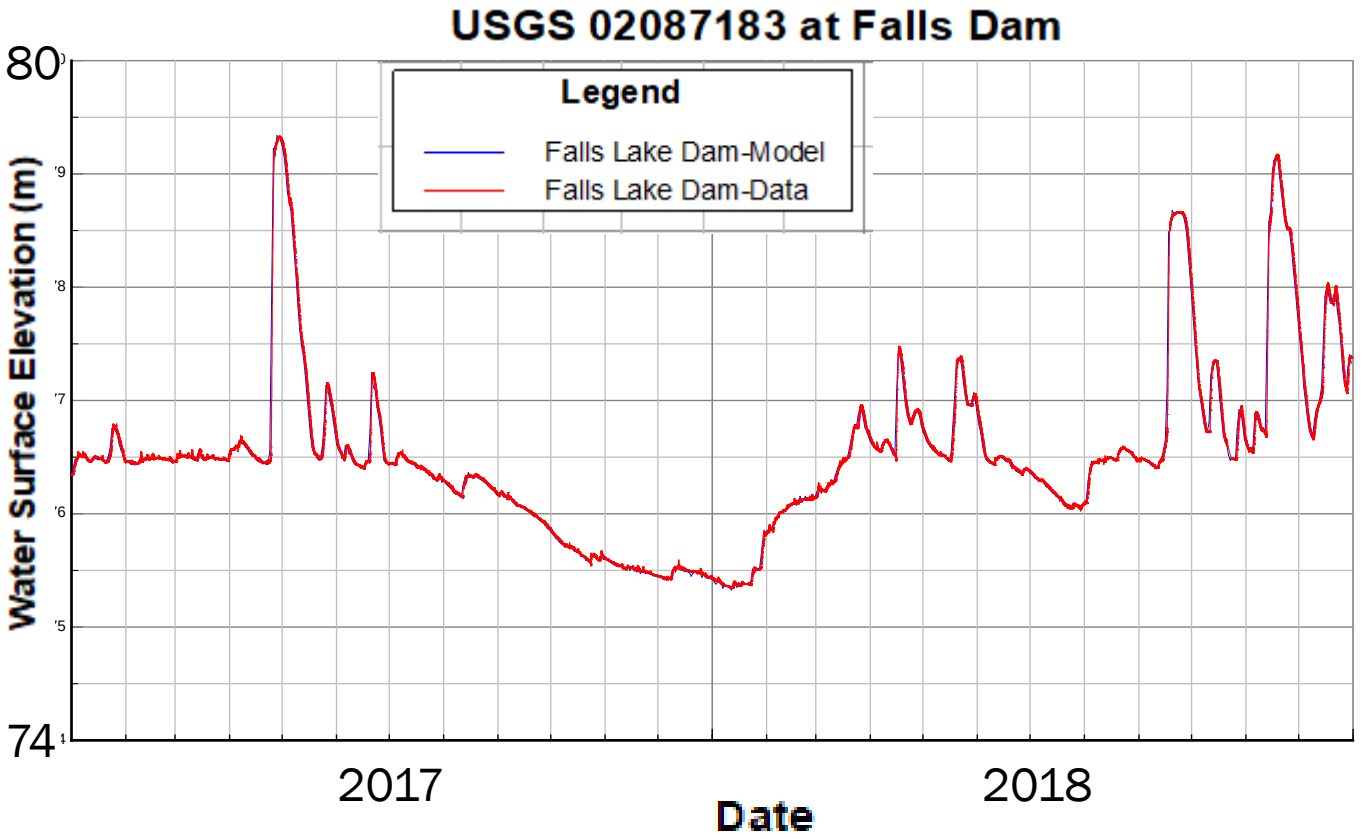
Lake Stage (m) Validation - Beaverdam

Starting	Ending	# Pairs	RMS (m)	Rel RMS (%)	Data Average (m)	Model Average (m)
1/1/17	12/31/18	68237	0.088	2.386	76.532	76.517



Lake Stage (m) Validation –Falls Dam

Starting	Ending	# Pairs	RMS (m)	Rel RMS (%)	Data Average (m)	Model Average (m)
1/1/17	12/31/18	69752	0.066	1.656	76.506	76.503



Water Temperature Calibration Procedures

1) Check the linkage between WARMF and EFDC

2) Check the meteorological data to make sure the solar radiation data are in the reasonable range

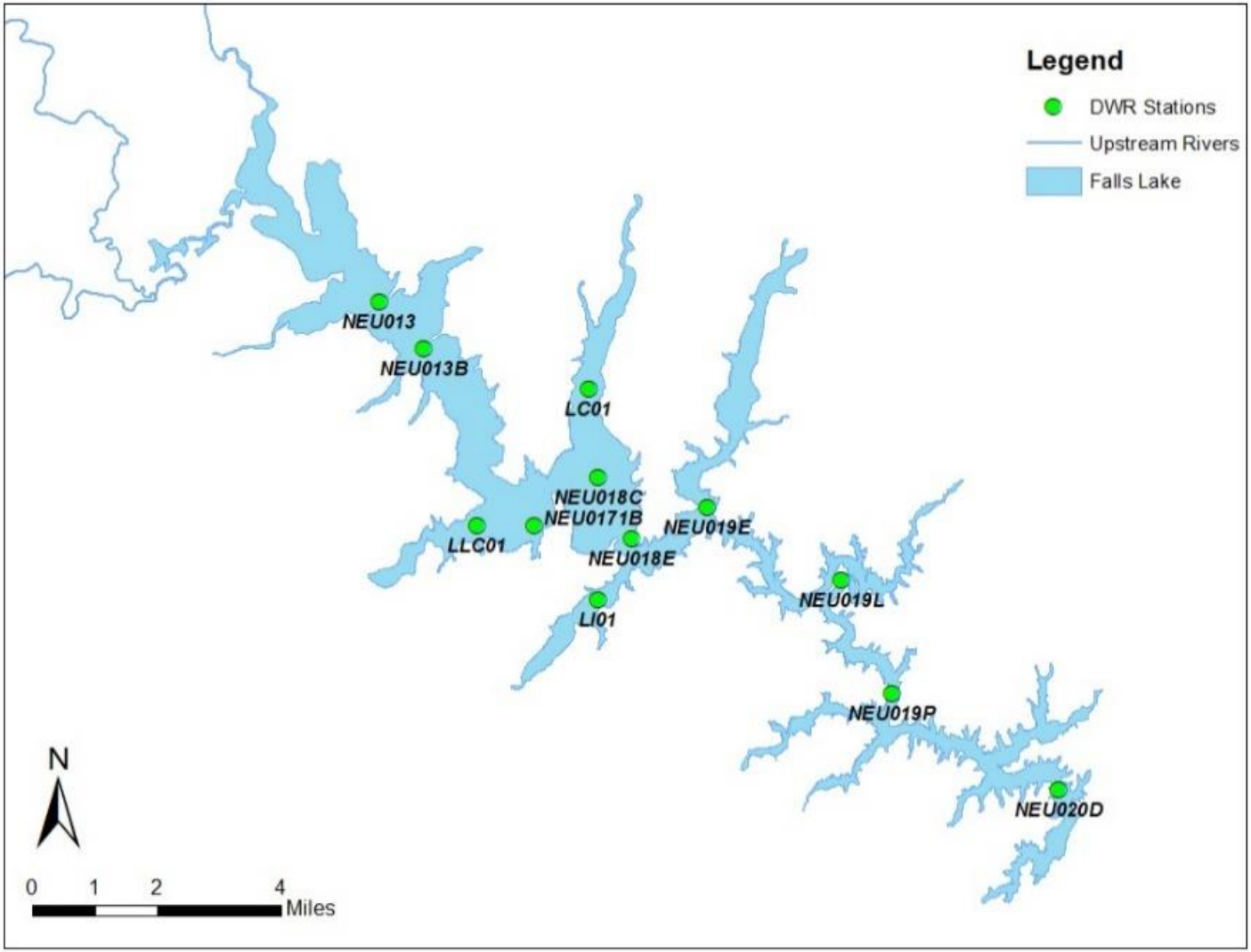
3) Adjust the key parameters within the reasonable ranges to best match the observed temperature data. Key parameters include:

- Light Extinction Coefficient
- Heat Transfer Coefficient
- Evaporative Heat Transfer
- Convective Heat Transfer
- Wind Shelter
- Shade factor
- Bed Temperature
- Vertical Eddy Viscosity
- Eddy Diffusivity
- Thermal Thickness

Simulation Layers Used for Calibration

- Observed data collected near the surface is compared to Layer 10
- Data collected near the bottom is compared to model results for the EFDC bottom layer
- For the stations located in the shallower parts of the lake, the Bottom Layer = 10 - # Layers
- At stations NEU019E, NEU018E, NEU018C, NEU0171B, and NEU013, the bottom layer evaluated for calibration was the lowest layer where there was the most data collected.

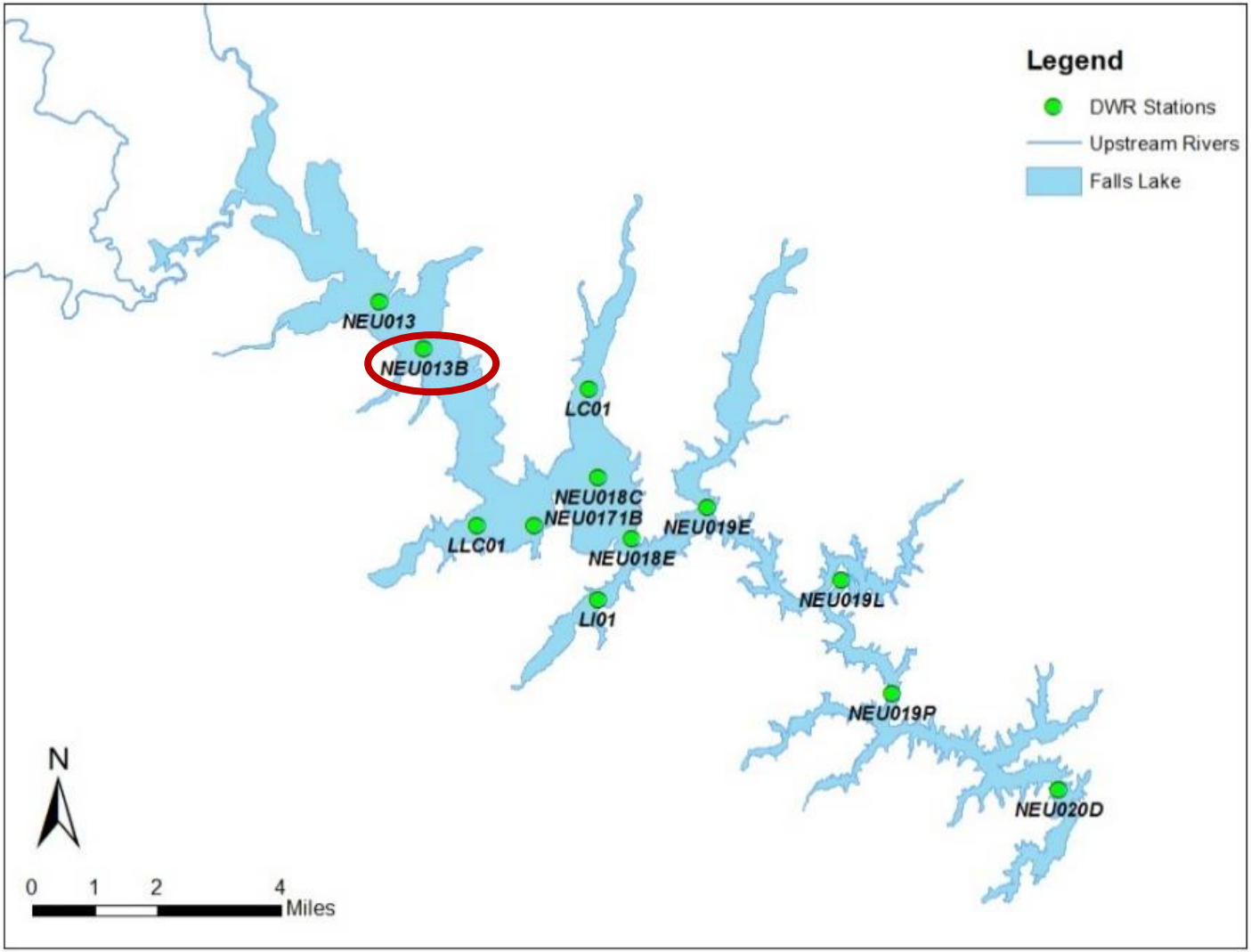
Water Temperature Calibration Stations



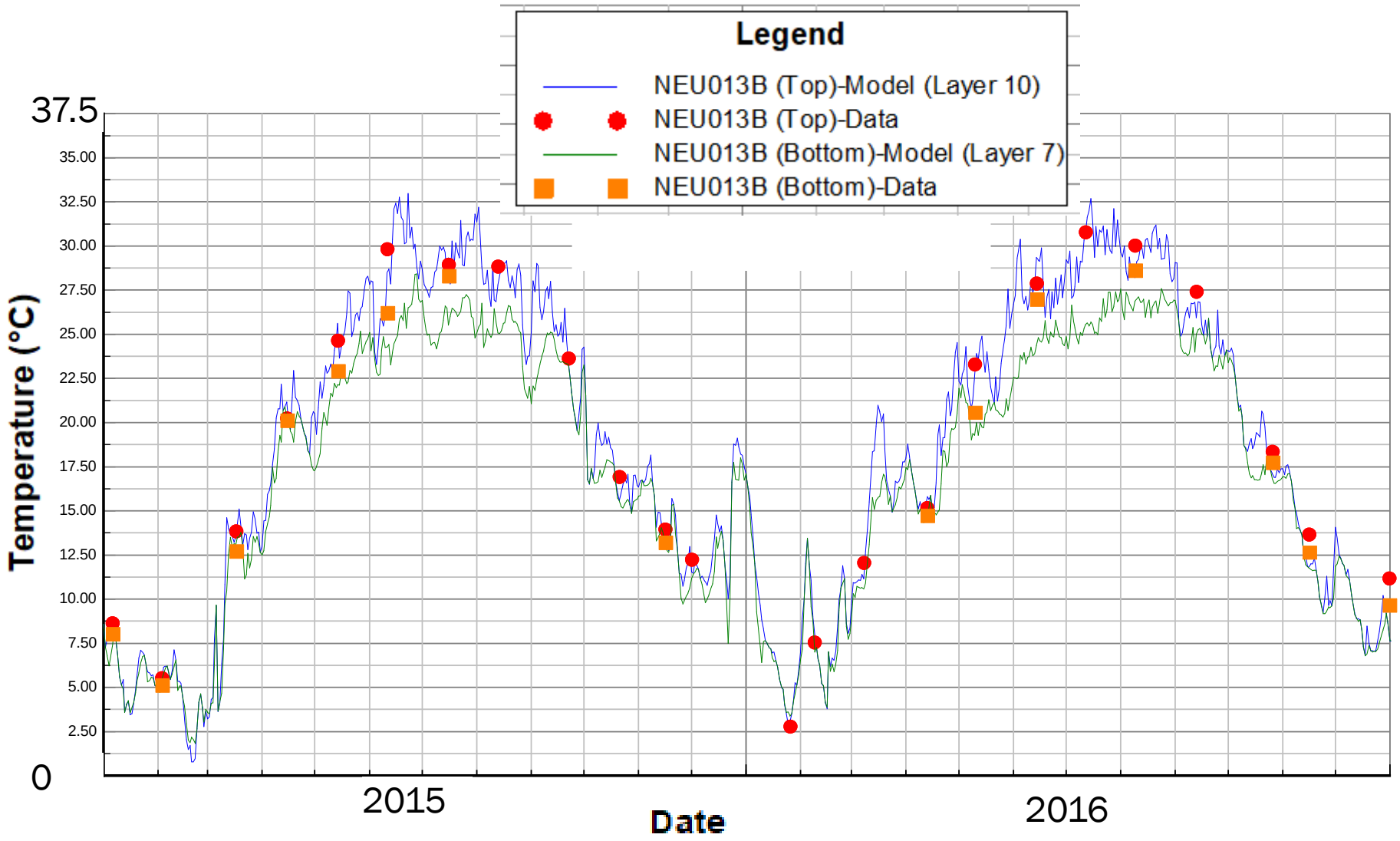
Water Temperature Calibration Layers

Station Code	Surface Layer #	Bottom Layer #
LC01	10	6
LI01	10	5
LLC01	10	6
NEU013	10	7
NEU013B	10	7
NEU0171B	10	7
NEU018C	10	7
NEU018E	10	5
NEU019E	10	5
NEU019L	10	2
NEU019P	10	1
NEU020D	10	1

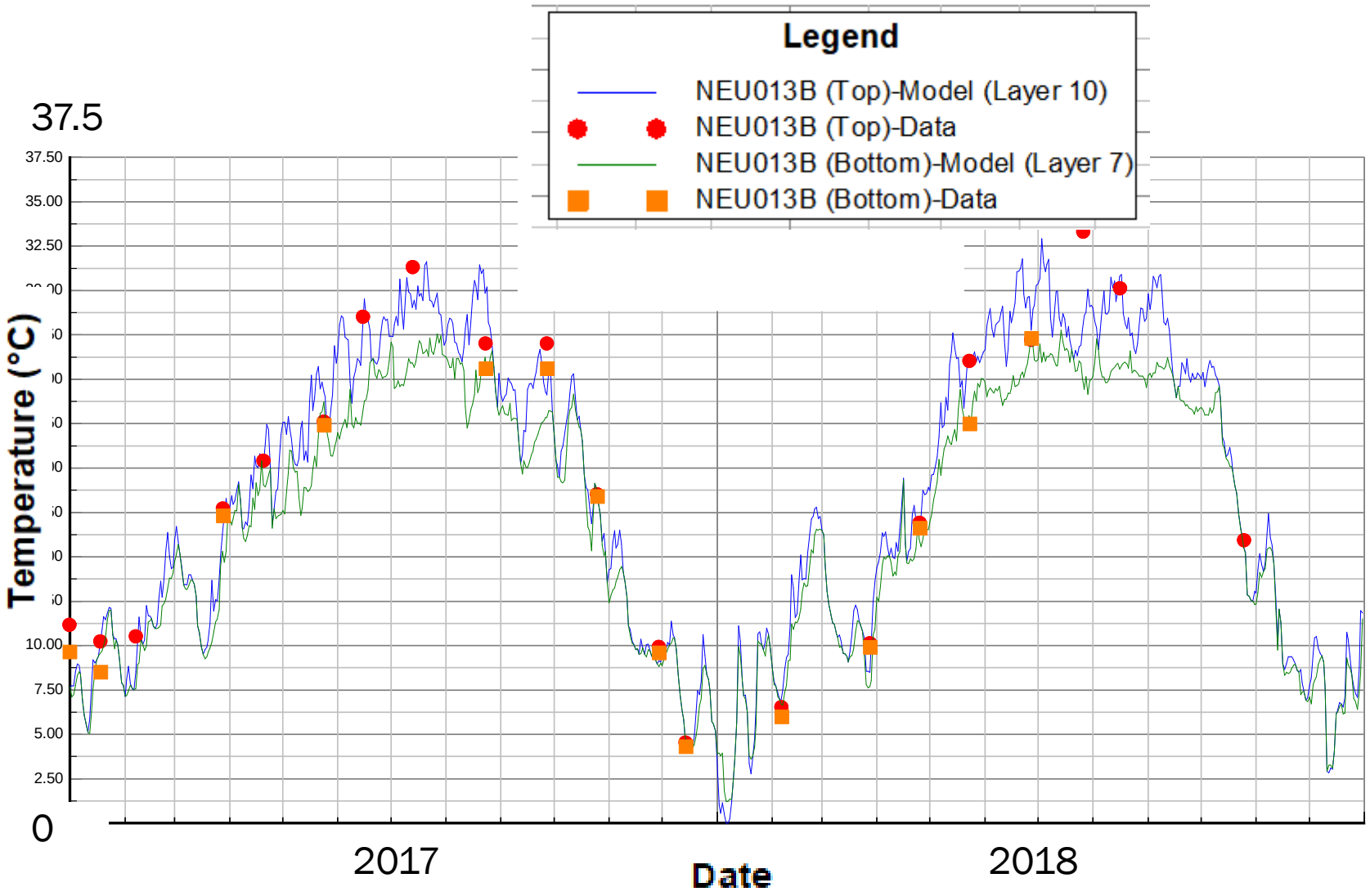
Results for Station NEU013B



NEU013B: Temperature Calibration Period

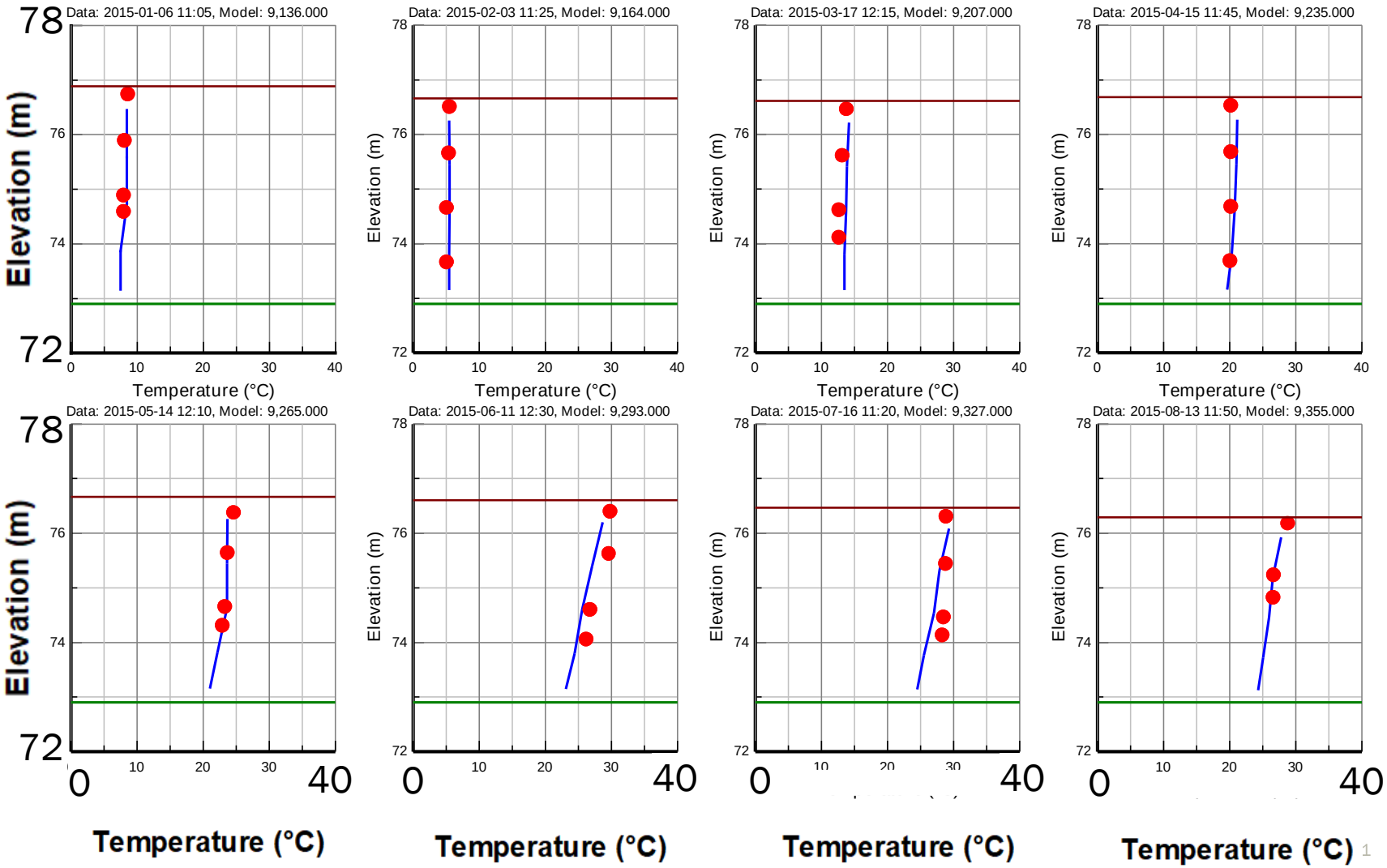


NEU013B: Temperature Validation Period



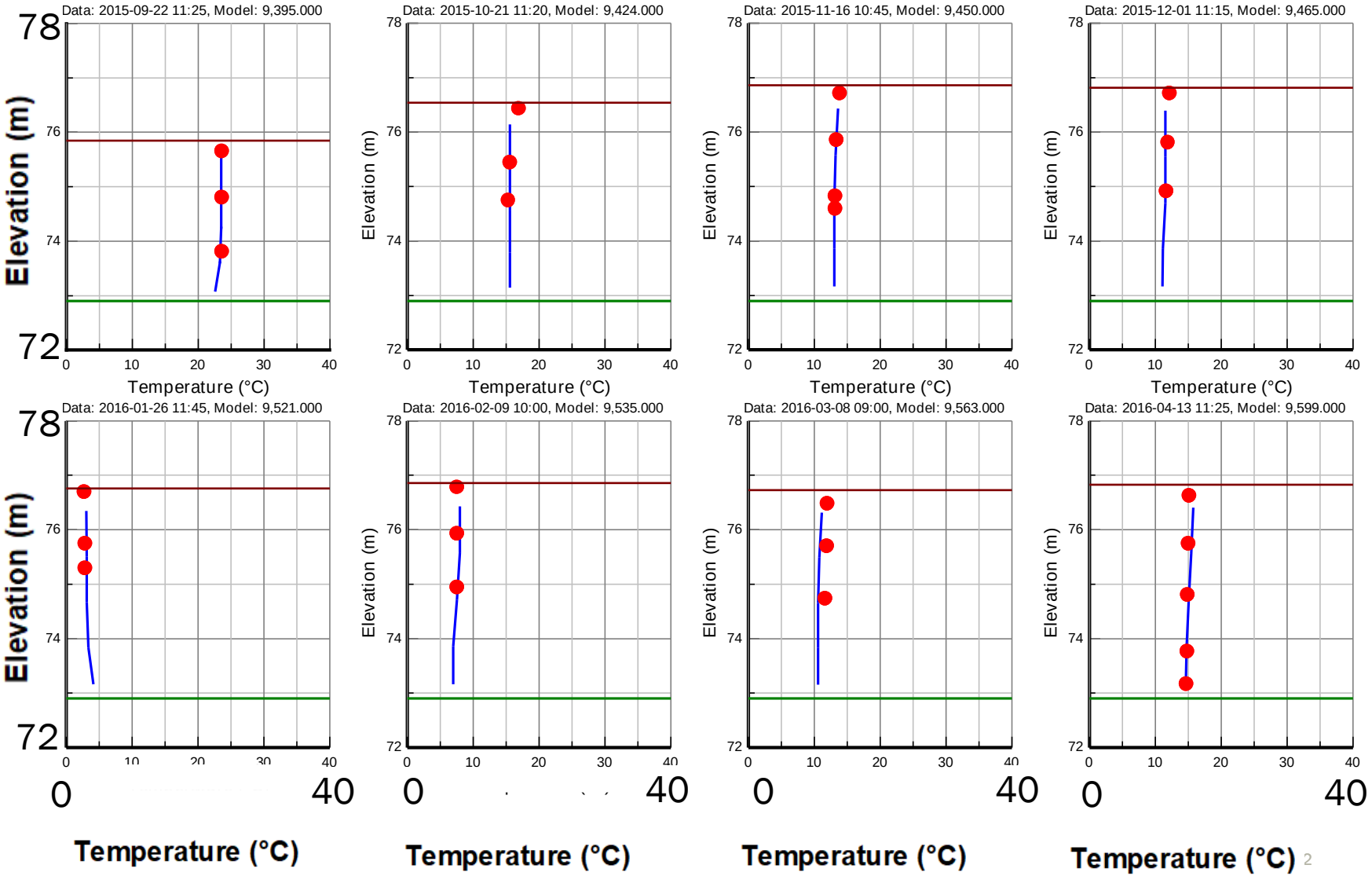
NEU013B: Vertical Temperature Profiles

January 2015 – August 2015 (1 of 6)



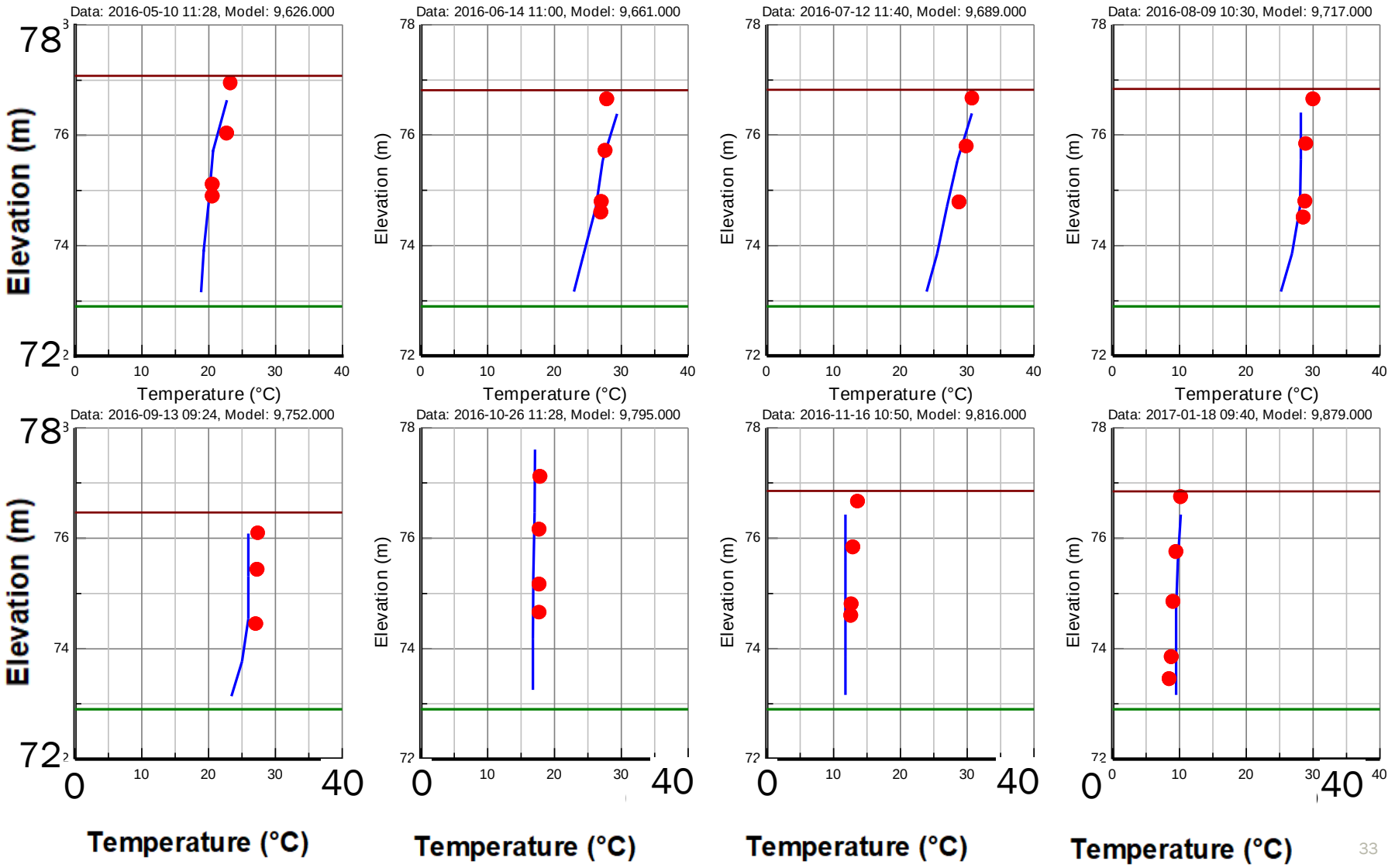
NEU013B: Vertical Temperature Profiles

September 2015 – April 2016 (2 of 6)



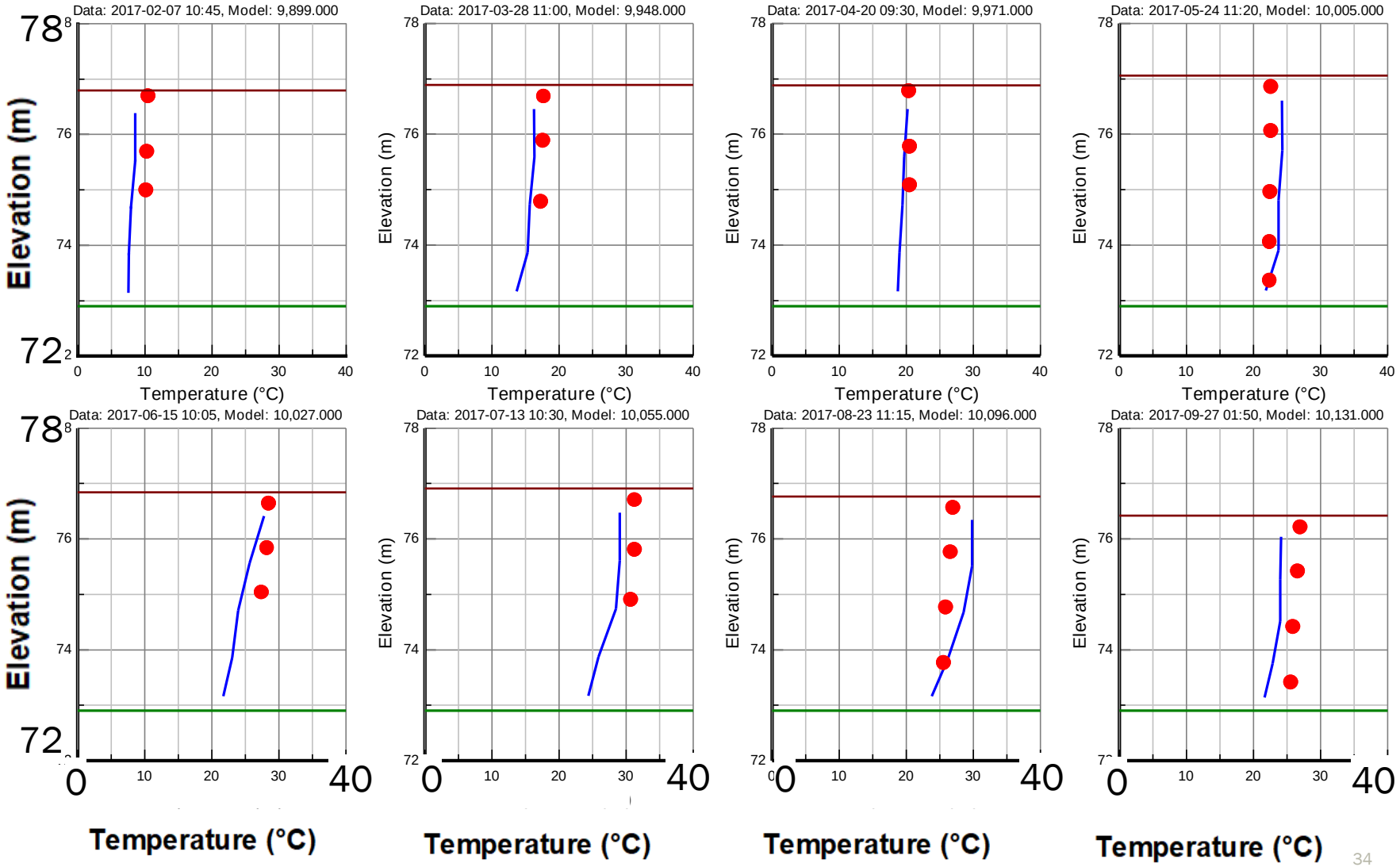
NEU013B: Vertical Temperature Profiles

May 2016 – January 2017 (3 of 6)



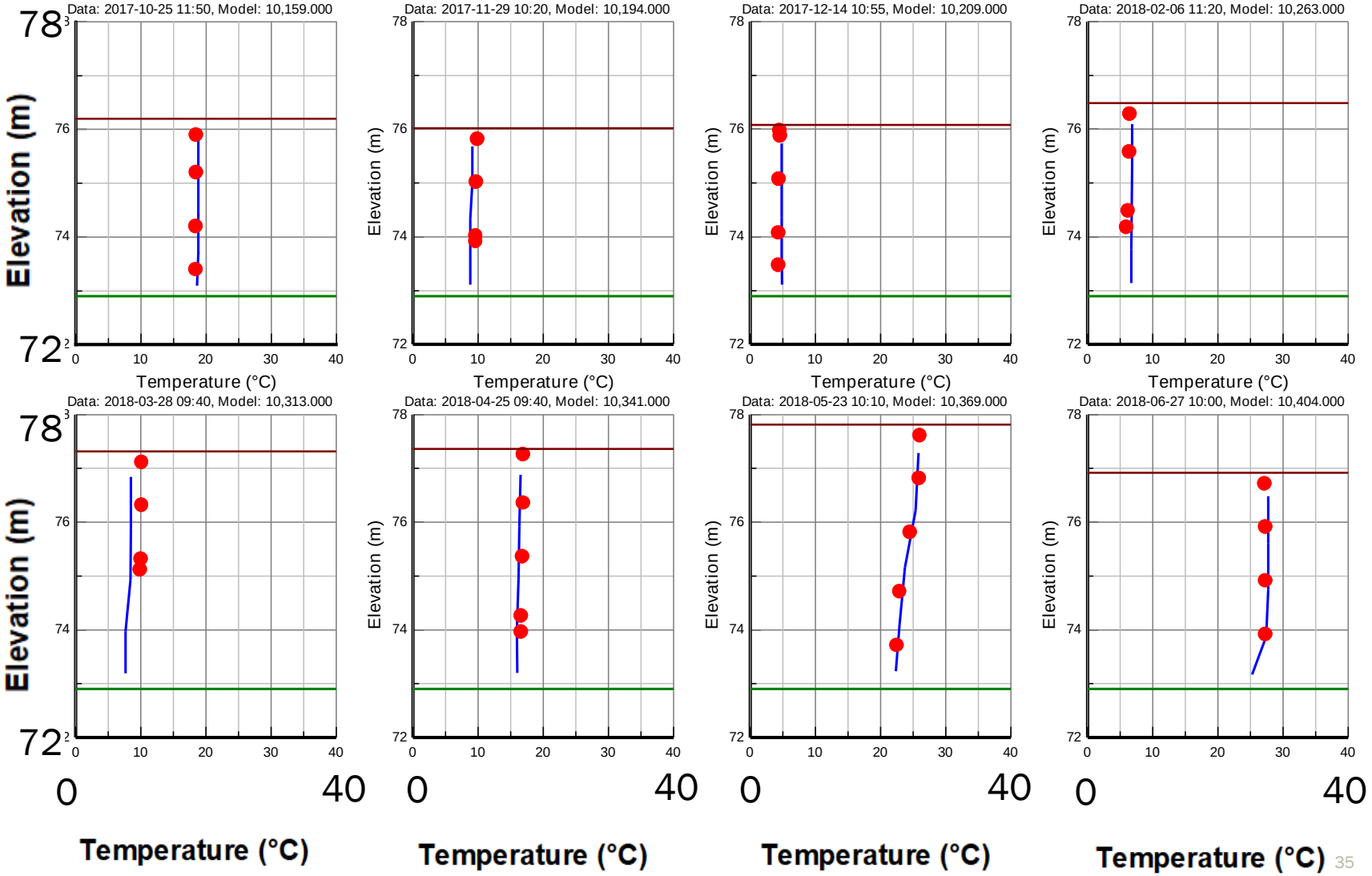
NEU013B: Vertical Temperature Profiles

February 2017 – September 2017 (4 of 6)



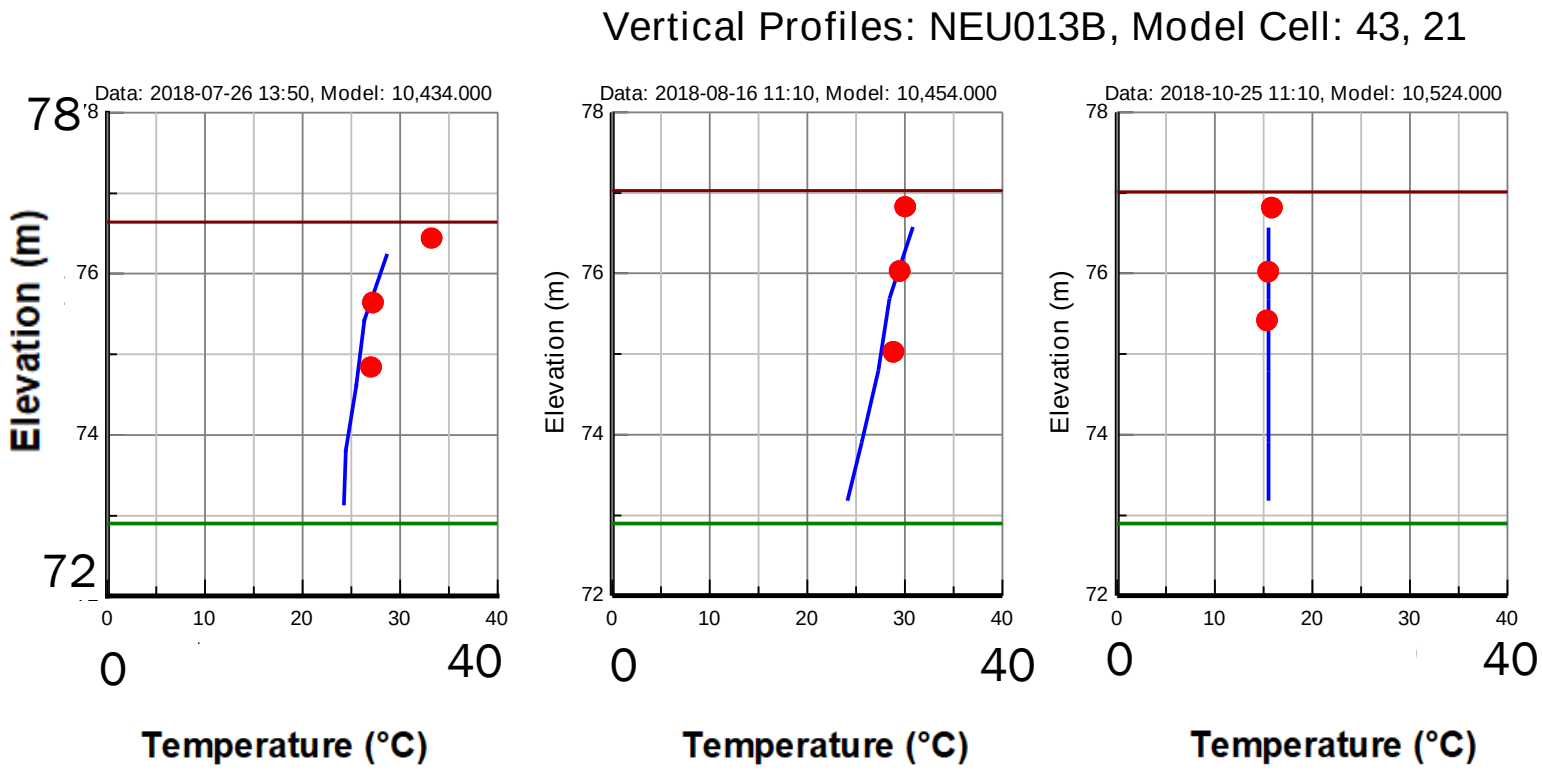
NEU013B: Vertical Temperature Profiles

October 2017 – June 2018 (5 of 6)

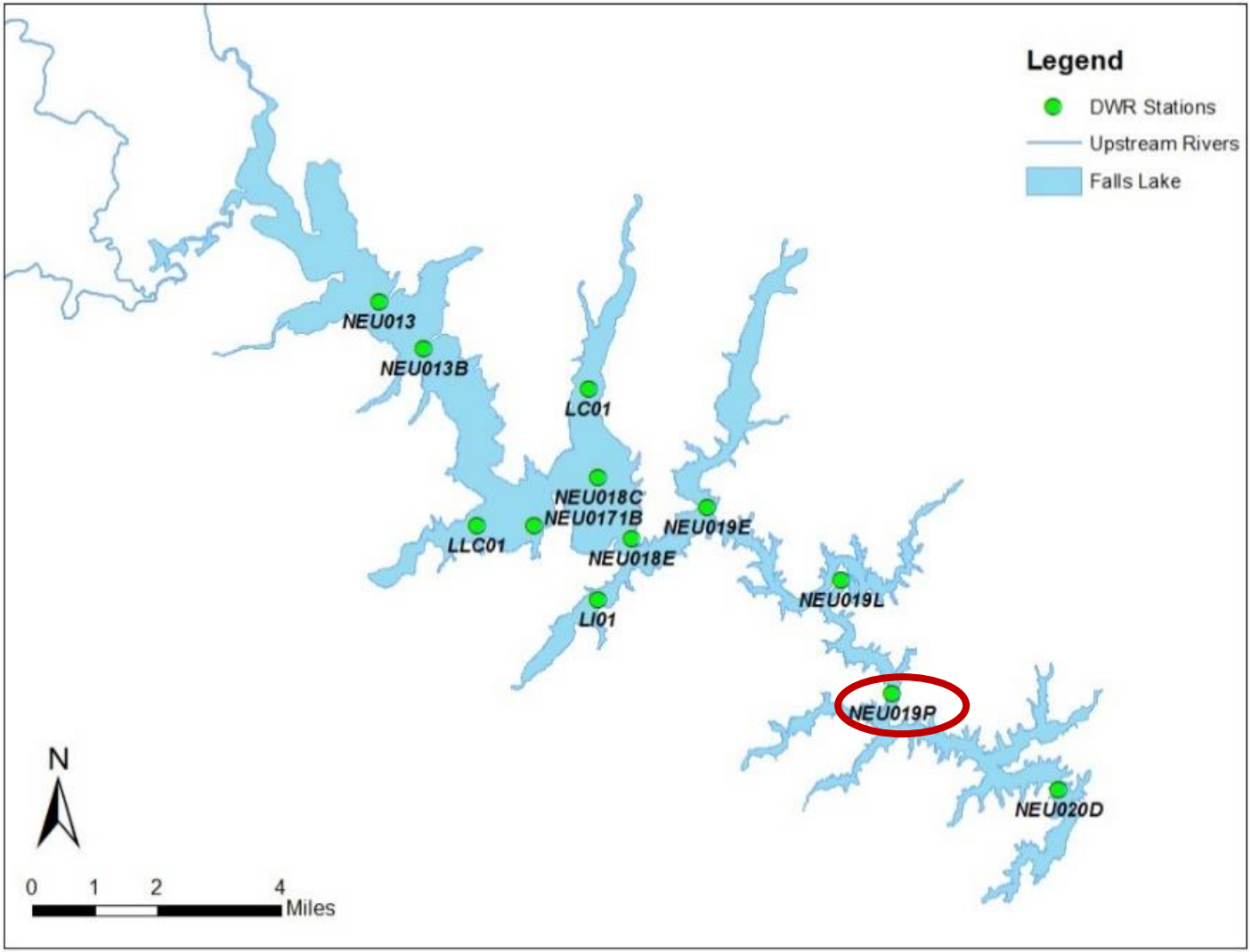


NEU013B: Vertical Temperature Profiles

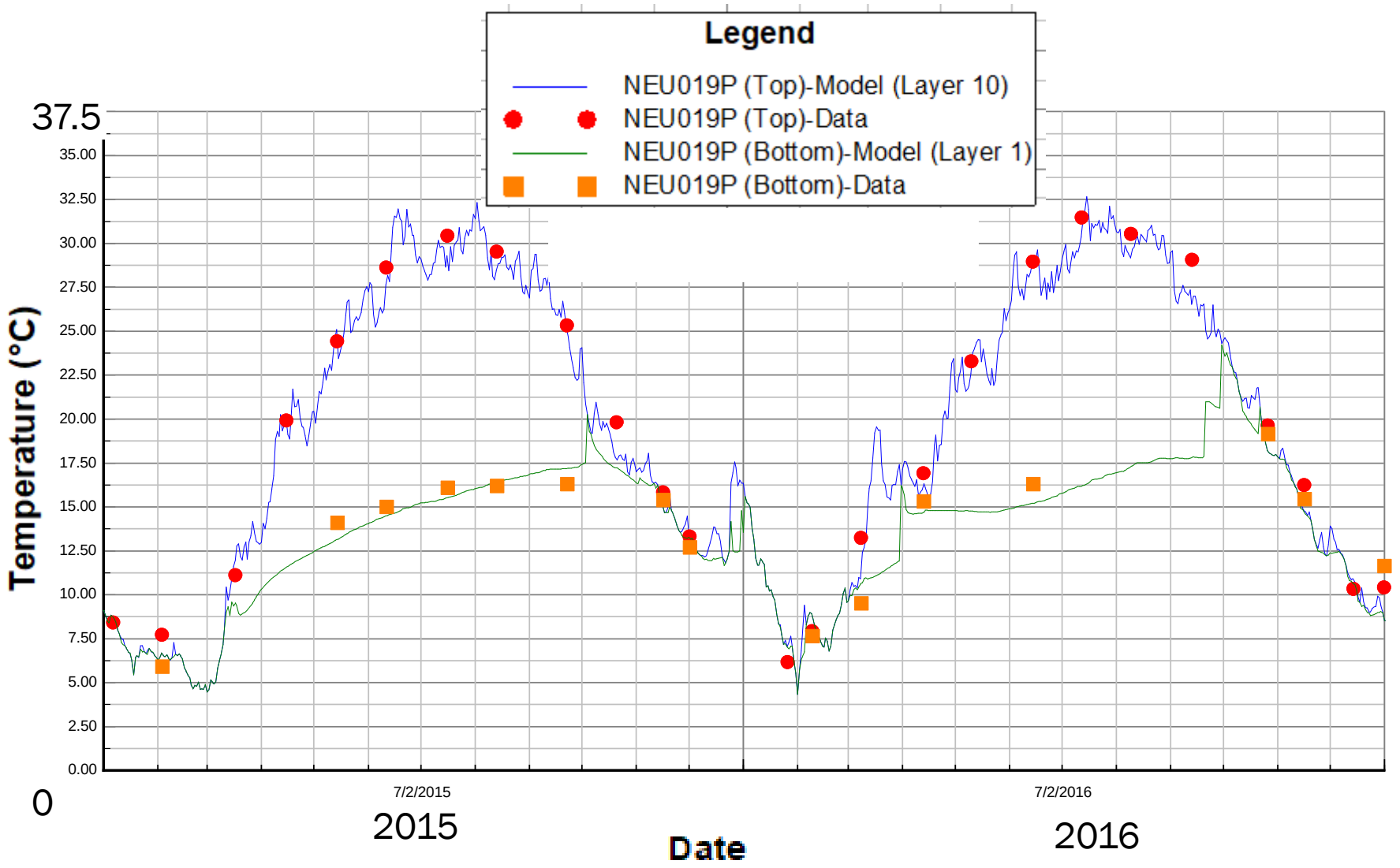
July 2018 – October 2018 (6 of 6)



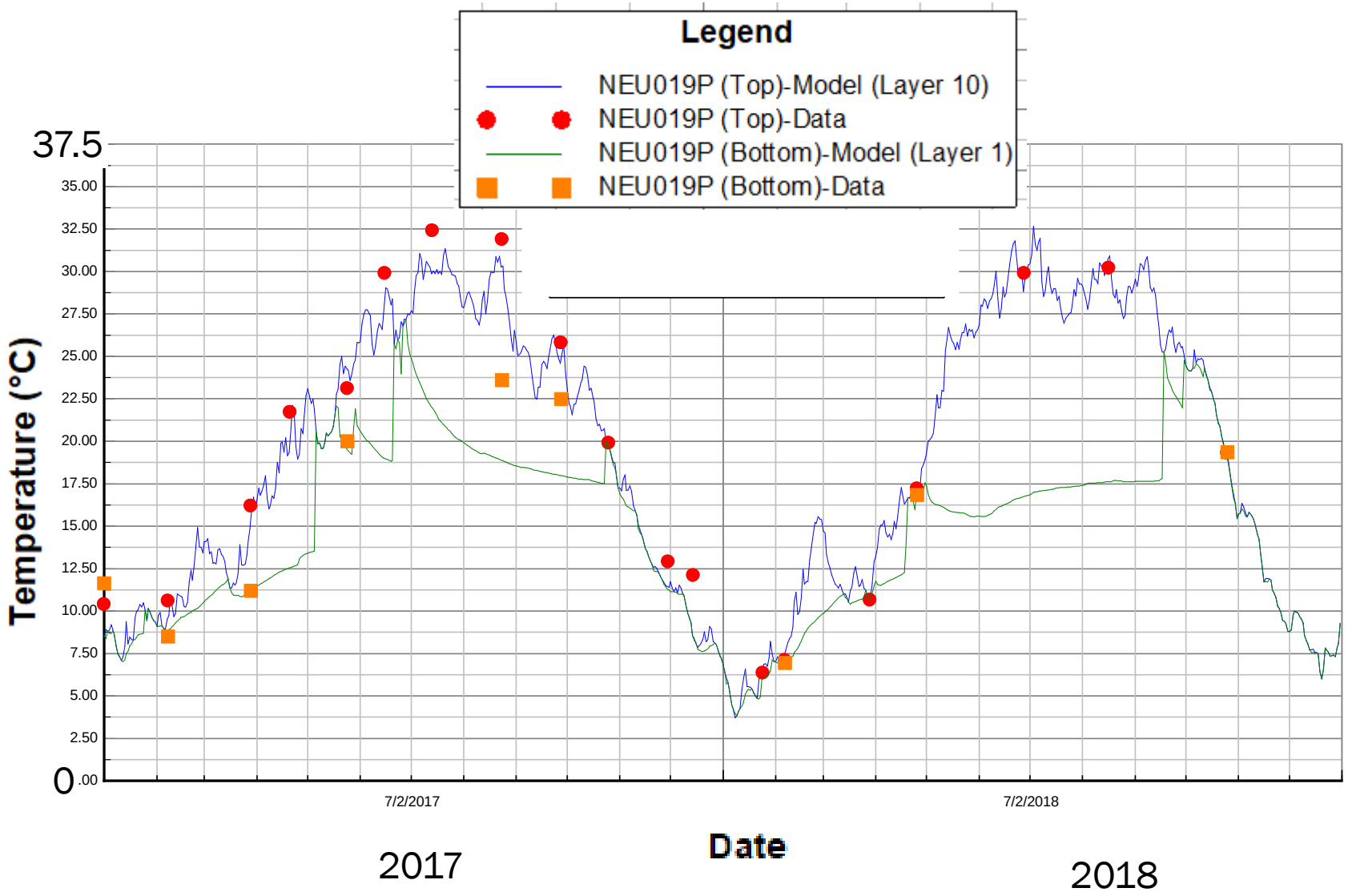
Results for Station NEU019P



NEU019P: Temperature Calibration Period



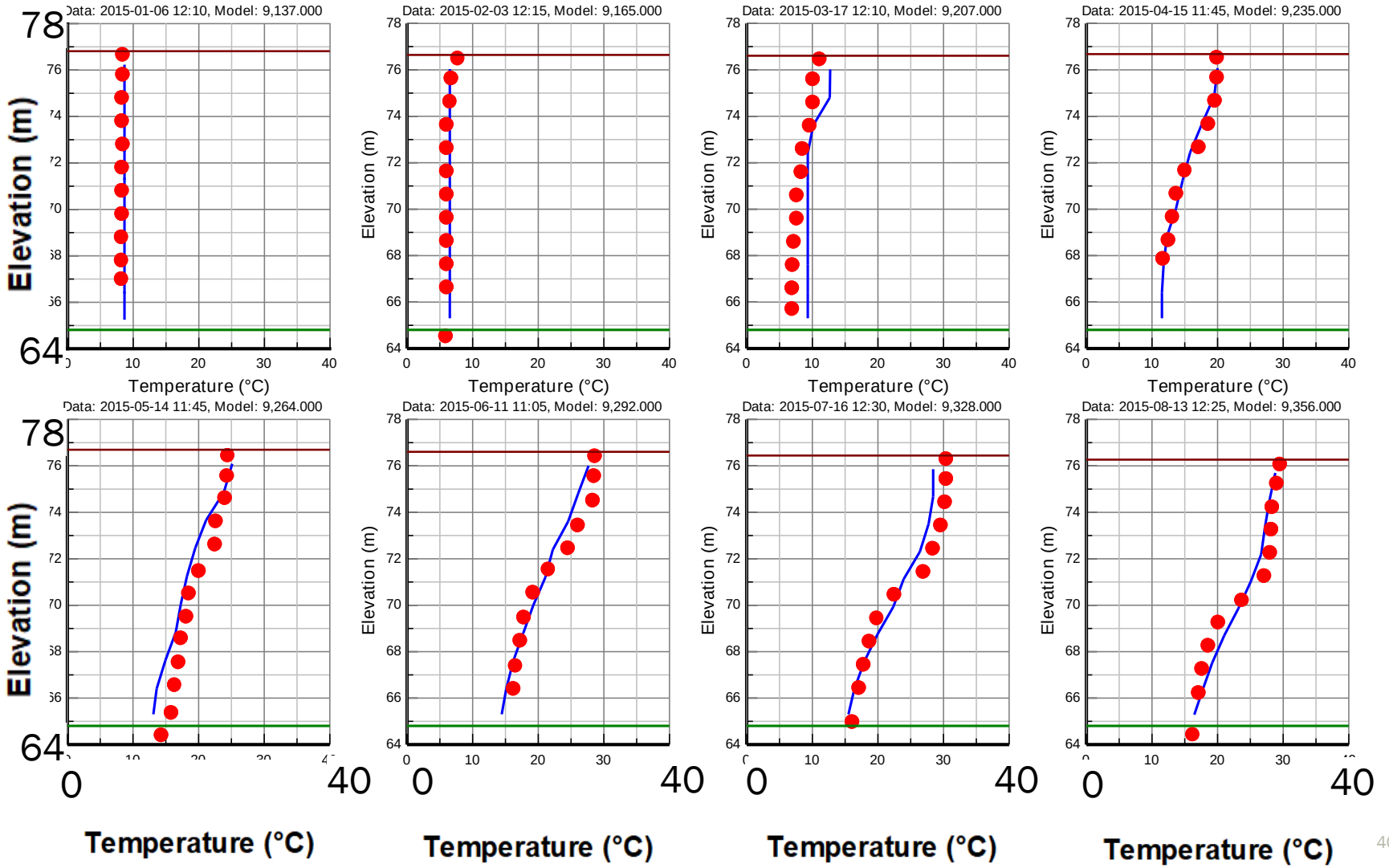
NEU019P: Temperature Validation Period



NEU019P: Vertical Temperature Profiles

January 2015 – August 2015 (1 of 6)

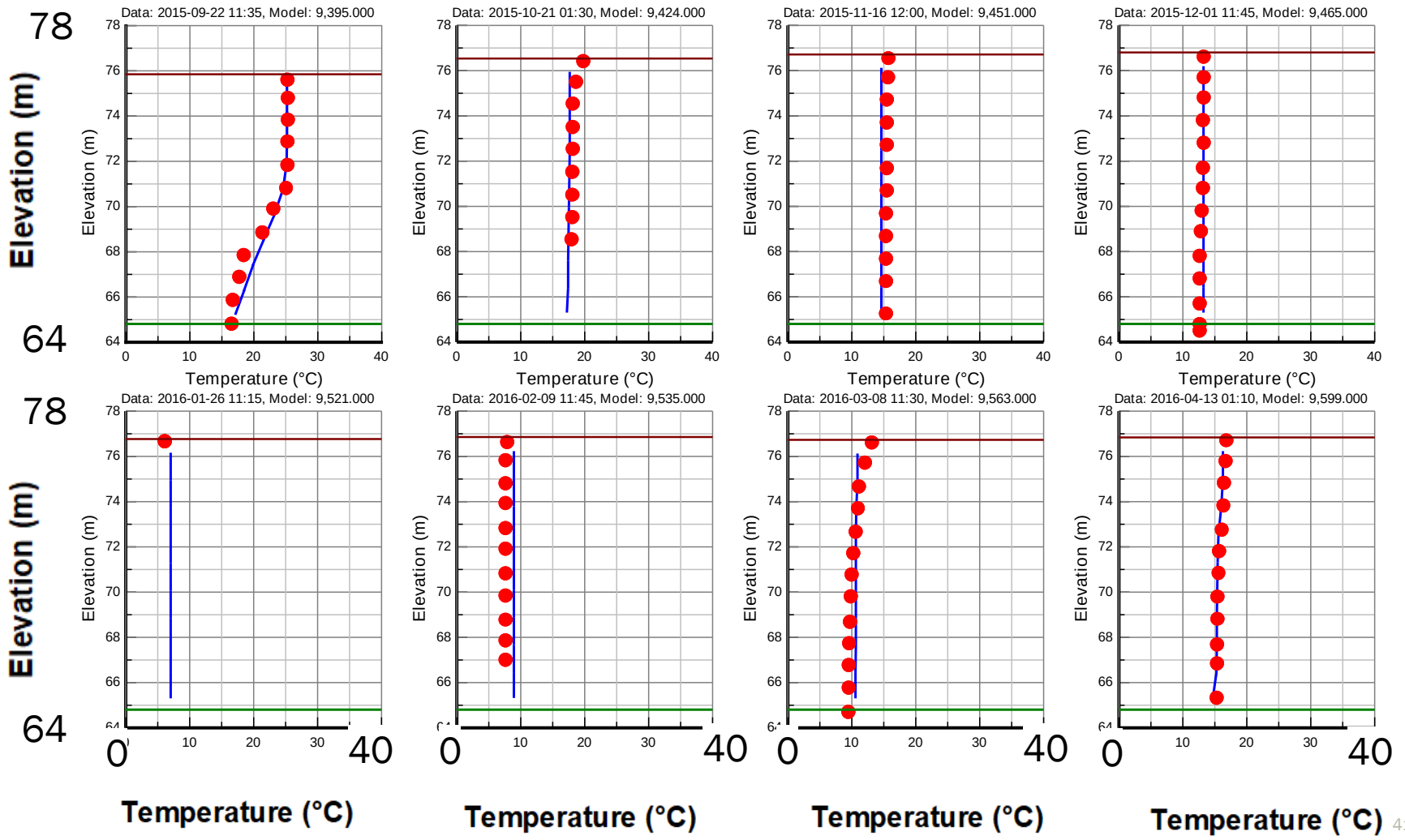
Vertical Profiles: NEU019P, Model Cell: 33, 95



NEU019P: Vertical Temperature Profiles

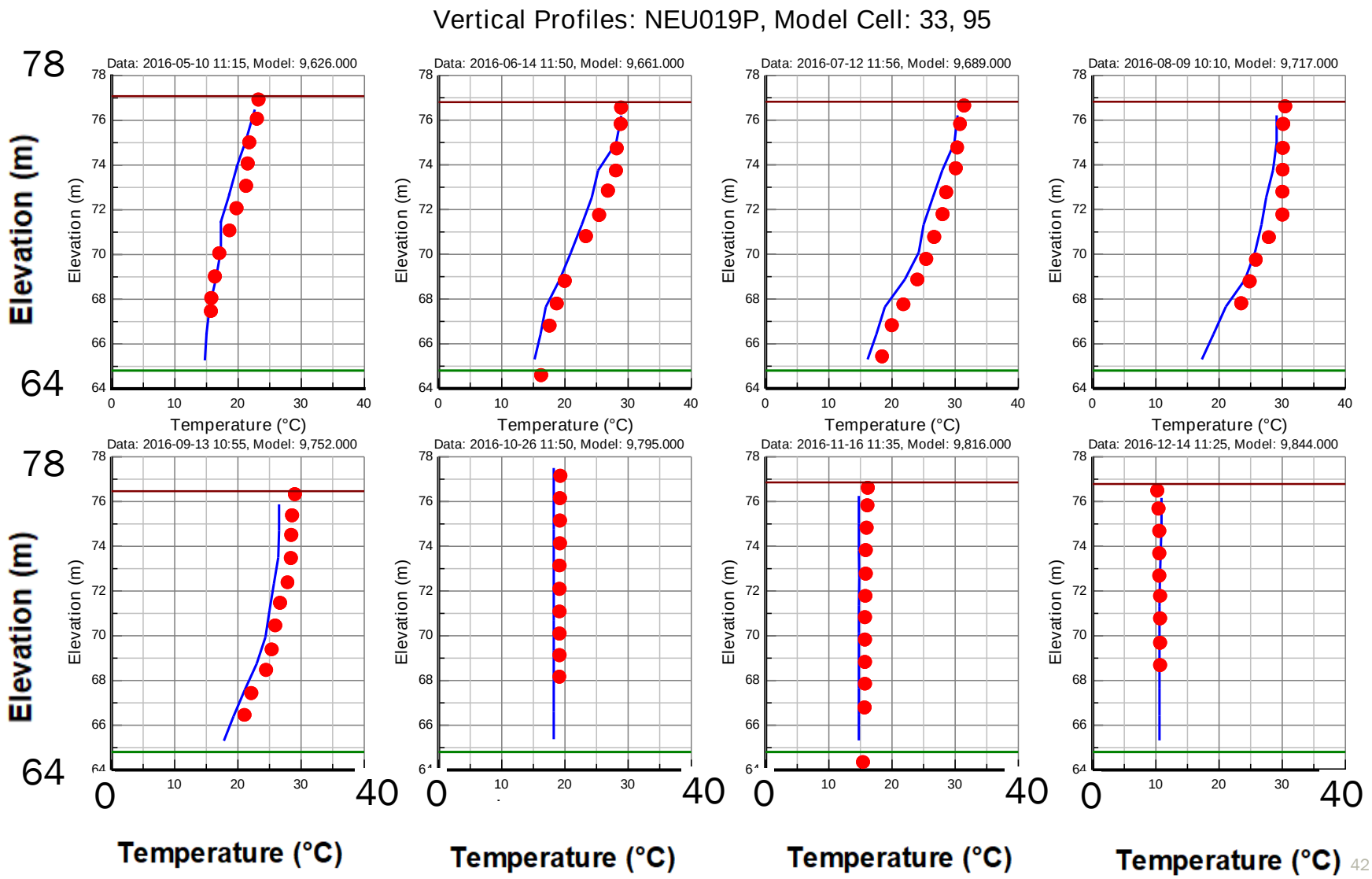
September 2015 – April 2016 (2 of 6)

Vertical Profiles: NEU019P, Model Cell: 33, 95



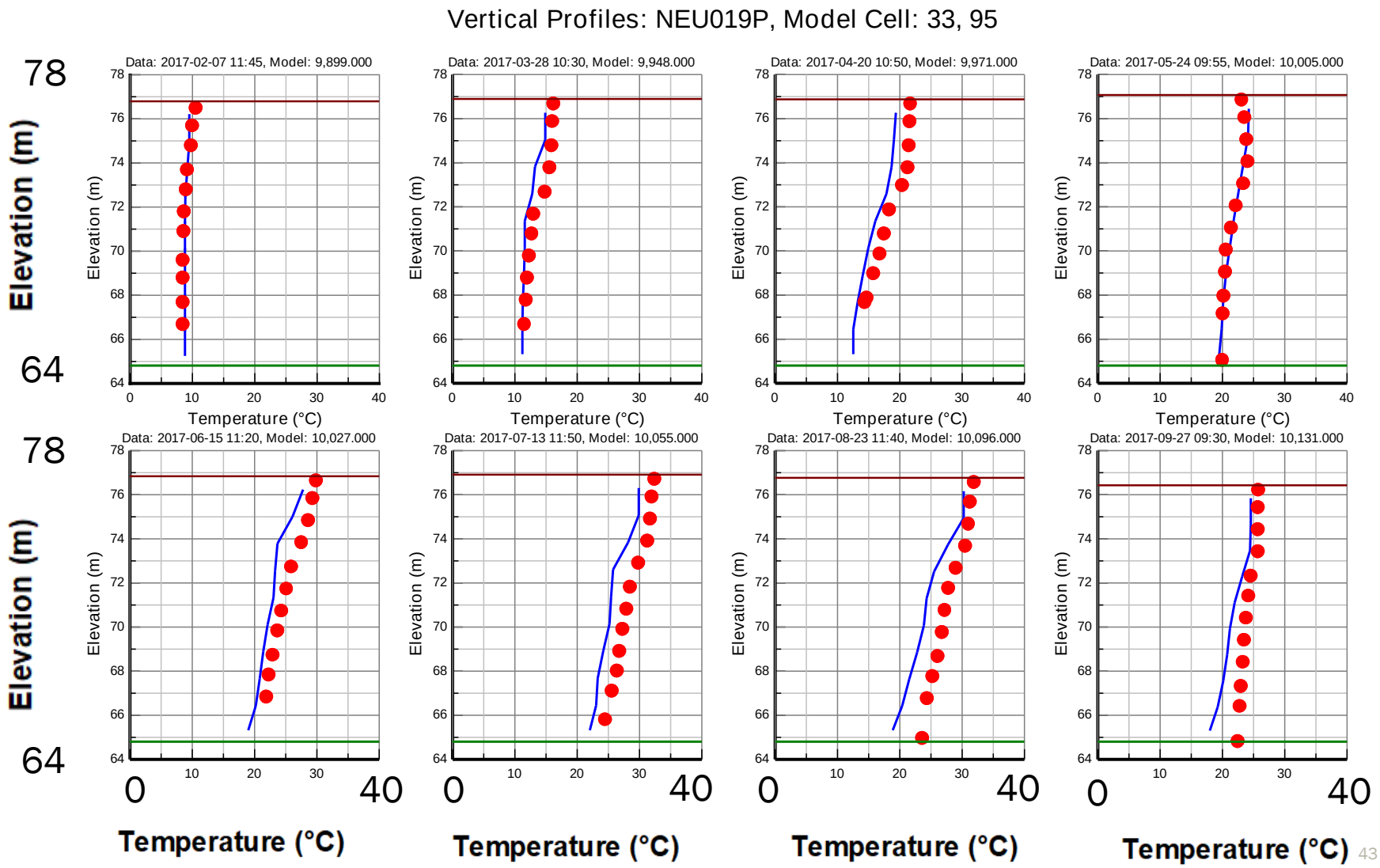
NEU019P: Vertical Temperature Profiles

May 2016 – December 2016 (3 of 6)



NEU019P: Vertical Temperature Profiles

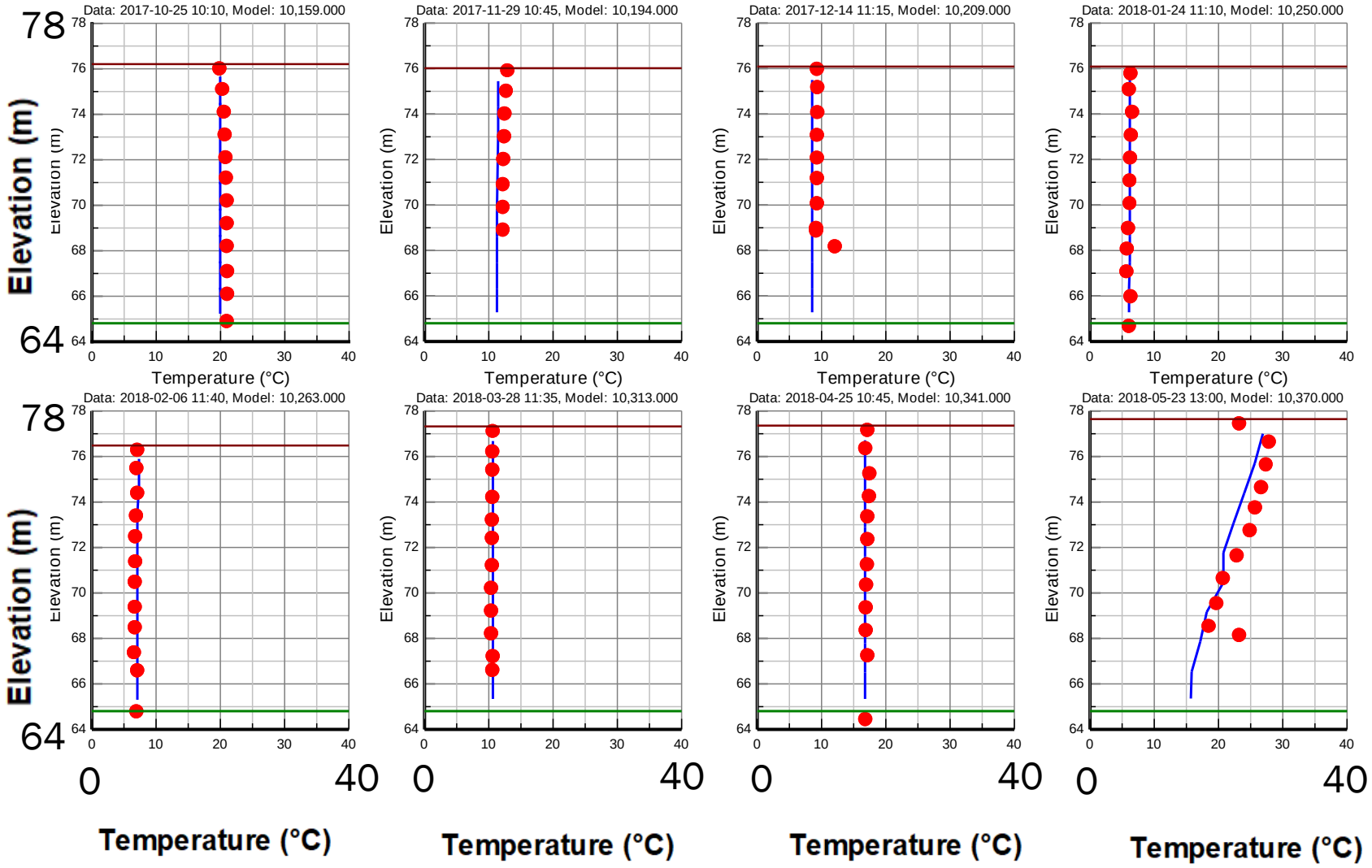
February 2017 – September 2017 (4 of 6)



NEU019P: Vertical Temperature Profiles

October 2017 – May 2018 (5 of 6)

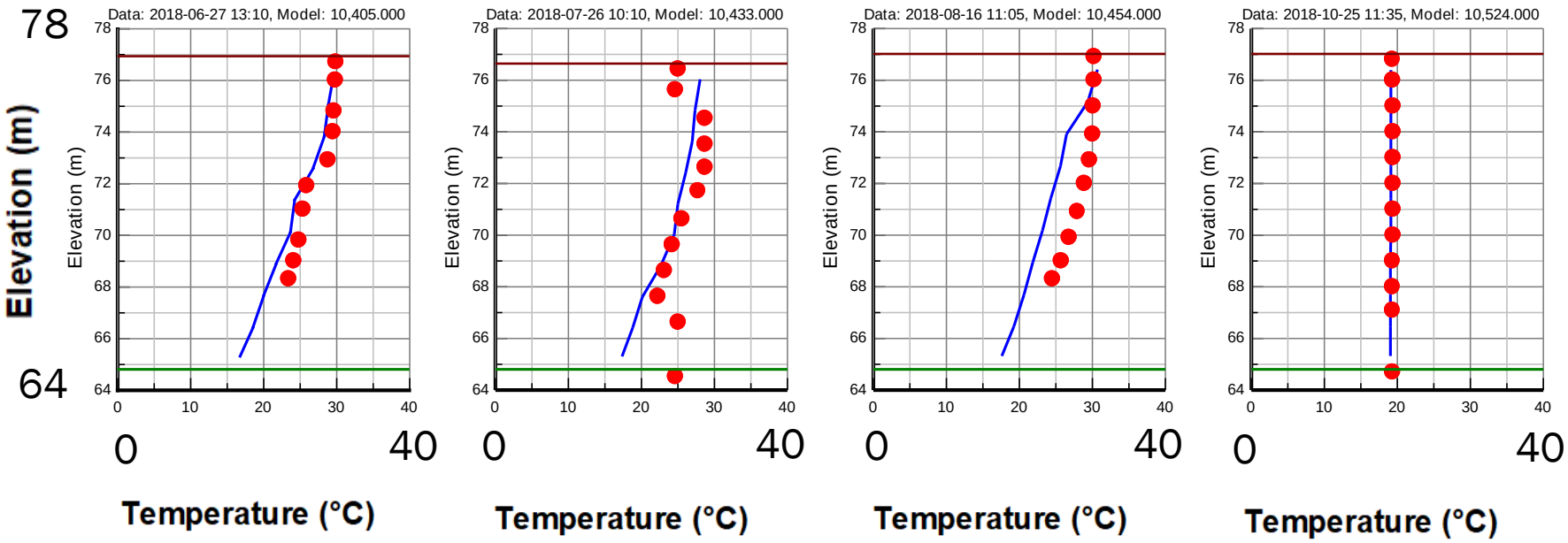
Vertical Profiles: NEU019P, Model Cell: 33, 95



NEU019P: Vertical Temperature Profiles

June 2018 – October 2018 (6 of 6)

Vertical Profiles: NEU019P, Model Cell: 33, 95



Additional Falls Lake Hydrodynamic Temperature Results:

Time series and temperature profiles for individual stations are included at the end of this presentation.

Summary of Hydrodynamic Model Results

Temperature Calibration Performance Criteria

Station	Layer: Top (T), Bottom (B)		# Pairs		Data Average		Model Average		RMSE		RSR (Target is <50)	
	T	B	T	B	T	B	T	B	T	B	T	B
LC01	10	6	23	23	18.66	17.79	18.78	17.10	0.904	1.575	10.70	19.49
LI01	10	5	23	20	19.32	16.65	18.85	14.74	1.160	2.723	13.89	37.65
LLC01	10	6	24	24	18.47	17.66	18.46	17.07	0.930	1.462	11.03	18.27
NEU013	10	7	24	12	18.39	17.29	18.13	16.36	0.958	1.218	10.77	15.72
NEU013B	10	7	23	14	18.93	18.41	18.57	17.85	0.825	1.005	9.67	13.68
NEU0171B	10	7	23	17	18.96	16.83	18.89	16.74	1.077	1.109	13.00	15.10
NEU018C	10	7	24	19	18.65	17.85	18.70	17.09	0.989	1.897	12.00	21.72
NEU018E	10	5	24	10	18.81	14.34	18.78	13.54	1.076	2.419	12.79	31.66
NEU019E	10	5	24	20	19.00	16.05	18.74	15.14	0.859	2.057	10.38	28.09
NEU019L	10	2	23	13	19.86	13.33	19.06	13.18	1.202	0.986	14.15	25.95
NEU019P	10	1	24	14	19.49	13.93	18.85	14.08	1.110	0.76	13.36	21.16
NEU020D	10	1	24	19	19.51	14.12	18.84	14.72	0.987	1.24	11.96	28.64

Temperature Validation Performance Criteria

Station	Layer: Top (T), Bottom (B)		# Pairs		Data Average		Model Average		RMSE		RSR (Target is <50)	
	T	B	T	B	T	B	T	B	T	B	T	B
LC01	10	6	21	20	18.66	17.79	19.15	17.01	1.667	1.763	19.97	21.45
LI01	10	5	21	15	19.32	16.65	18.67	15.64	1.551	3.305	18.35	41.08
LLC01	10	6	21	19	18.47	17.66	18.62	17.22	1.685	1.737	19.67	21.92
NEU013	10	7	19	14	18.39	17.29	18.72	17.89	1.954	1.765	23.46	22.50
NEU013B	10	7	20	13	18.93	18.41	19.32	16.19	1.656	1.223	19.04	15.87
NEU0171B	10	7	21	12	18.96	16.83	19.00	15.62	1.396	1.49	16.19	16.64
NEU018C	10	7	21	16	18.65	17.85	19.14	17.91	1.510	1.801	18.56	22.71
NEU018E	10	5	20	13	18.81	14.34	18.85	14.94	1.058	3.621	12.13	42.53
NEU019E	10	5	19	15	19.00	16.05	19.37	16.97	1.624	2.67	19.76	35.95
NEU019L	10	2	18	8	19.86	13.33	17.68	16.11	1.459	2.269	16.94	44.62
NEU019P	10	1	18	8	19.49	13.93	18.98	14.96	1.454	2.307	17.07	38.38
NEU020D	10	1	17	9	19.51	14.12	17.28	13.99	1.128	1.972	13.47	30.55

Summary

The calibration and validation results show that

- Simulated water level is in excellent agreement with the measured water level for the calibration and validation period.
- The model follows the trends of the bottom and surface water temperature very well.
- Calibration/Validation performance targets for stage and temperature have been met at all locations.

MRSW questions and discussion of EFDC Hydrodynamic Model for Falls Lake.

Discuss Potential Training Topics for MRSW

Potential Training Topics for MRSW

- Objectives
  - Increase understanding of model development and application
  - Answer questions and hear feedback
  - Increase comfort level for using the models to inform management decisions
  - Improve information sharing
  - Provide training on running the models for those interested
- Trainings can occur during model development and when models are being used to answer questions

MRSW discuss potential training topics and thoughts on timing.

Modeling and Regulatory Support Status

MRS Status

- Systech Water Resources is modifying the Watershed Analysis Risk Management Framework (WARMF) model code to simulate many types of onsite wastewater treatment systems (319 grant funded)
- Model development and reporting for WARMF watershed water quality modeling is underway
  - Air chemistry (wet and dry deposition)
  - Soil chemistry
  - Wastewater treatment plant effluent
  - Nutrient applicant rates
  - Onsite wastewater treatment systems
- Discussed WARMF Lake segmentation with Executive Director and subject matter experts
  - Present recommendation during the September 1, 2020 MRSW meeting

Closing Comments Additional Discussion

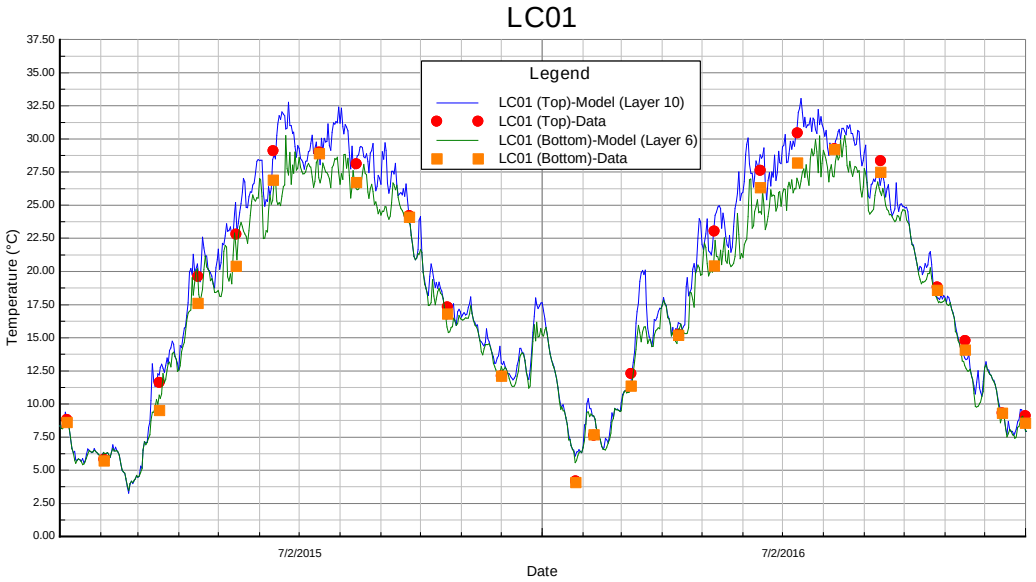
Additional EFDC temperature modeling results follow this slide.

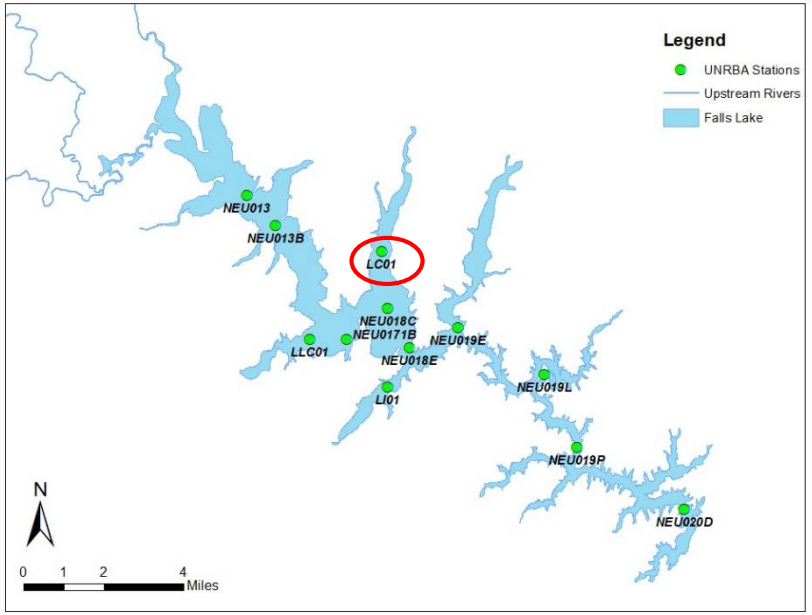
Additional Falls Lake Hydrodynamic Temperature Results

Temperature Time Series Calibration

Results

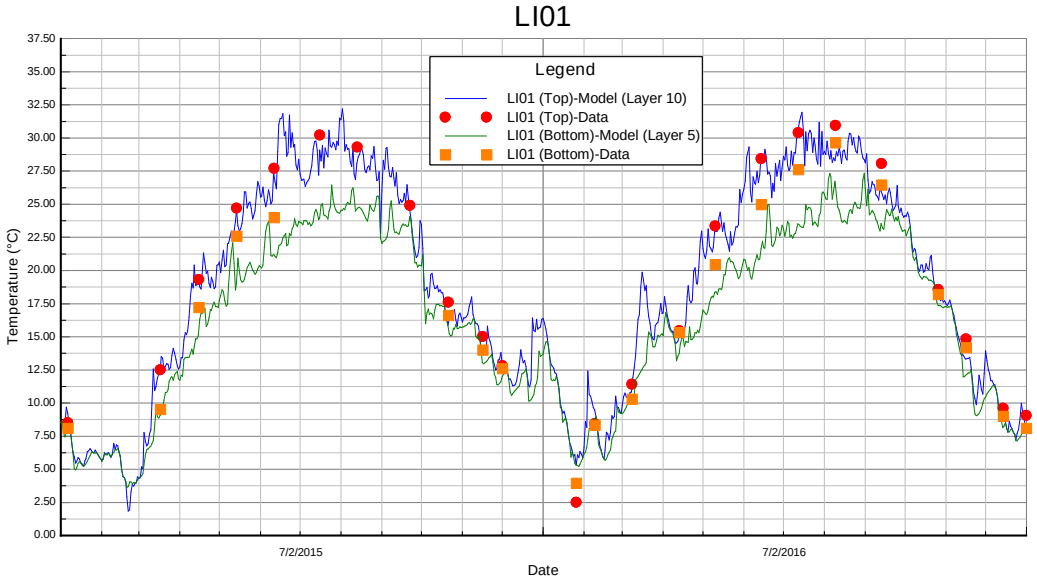
- Water Temperature Calibration:

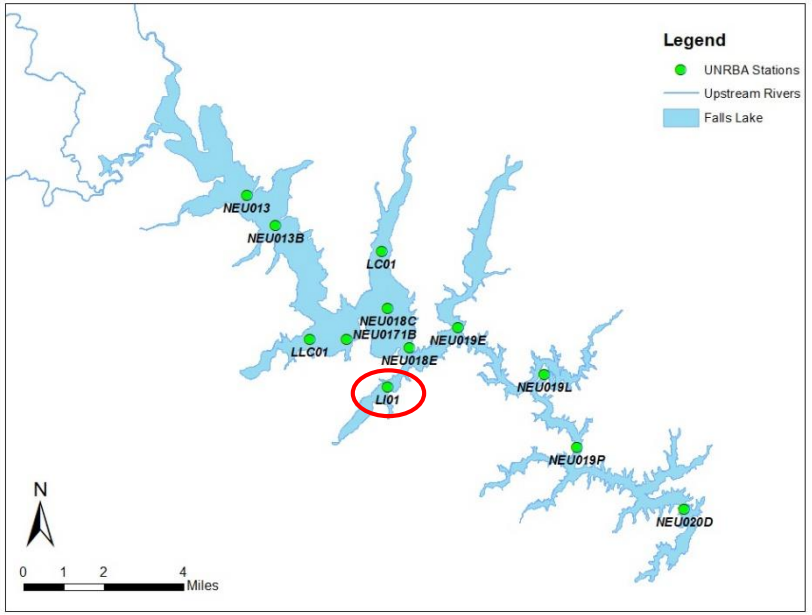




Results

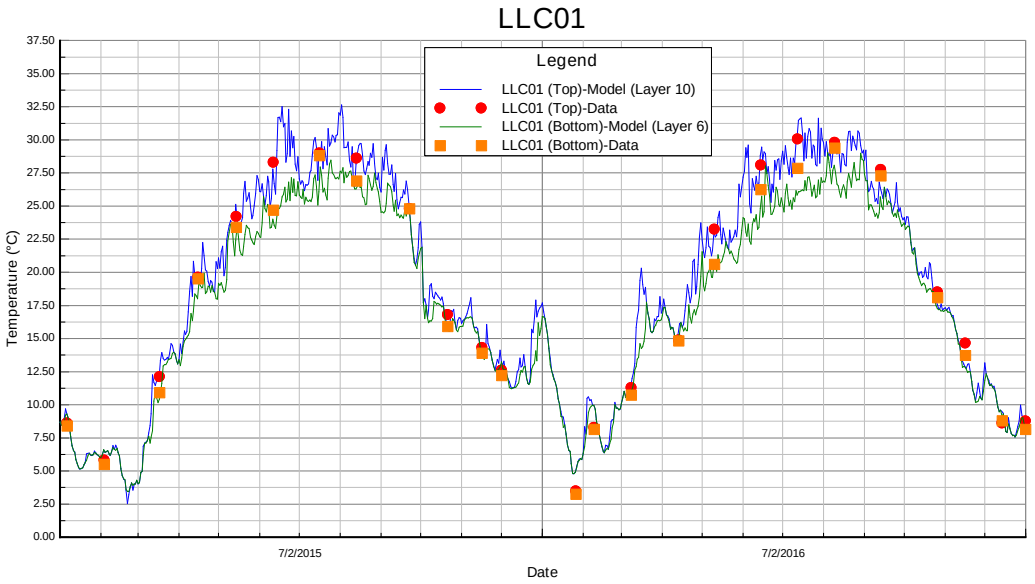
- Water Temperature Calibration:

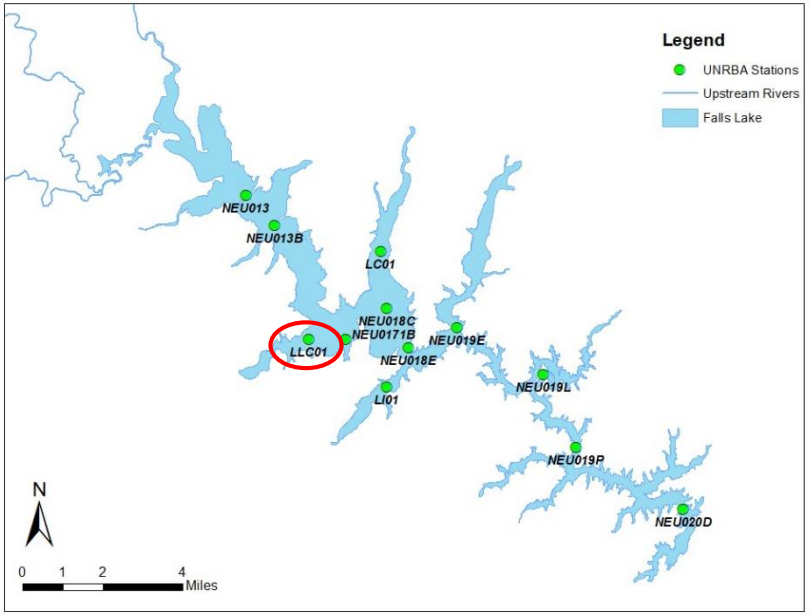




Results

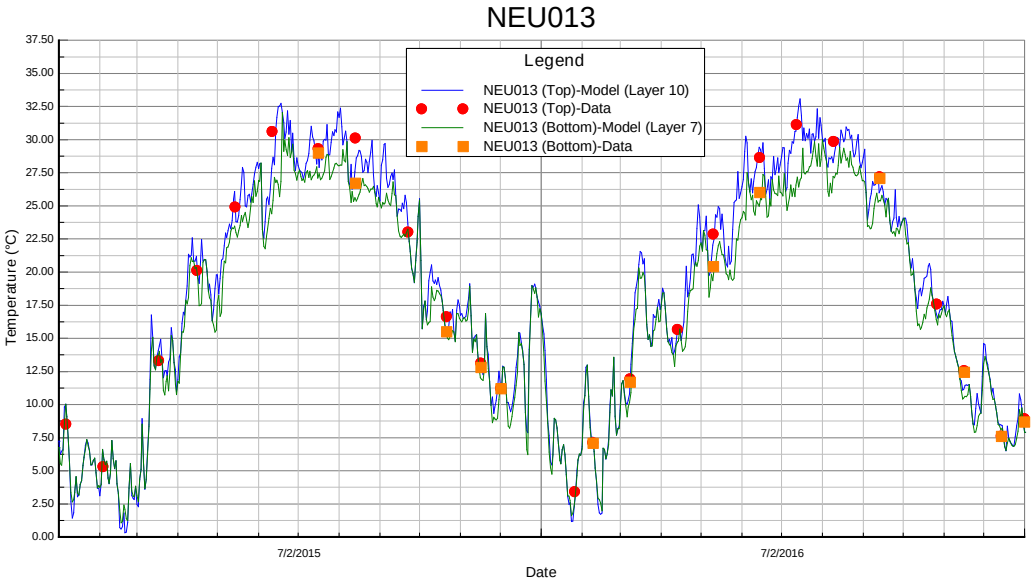
- Water Temperature Calibration:

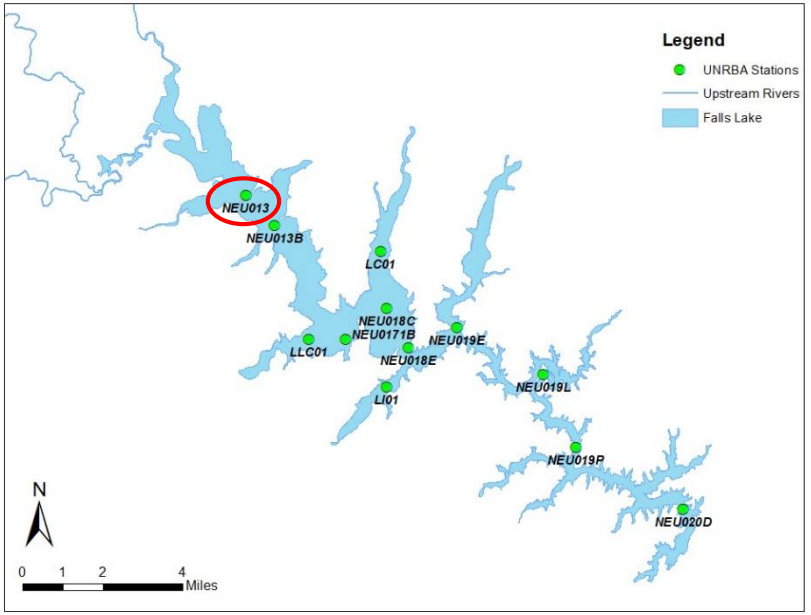




Results

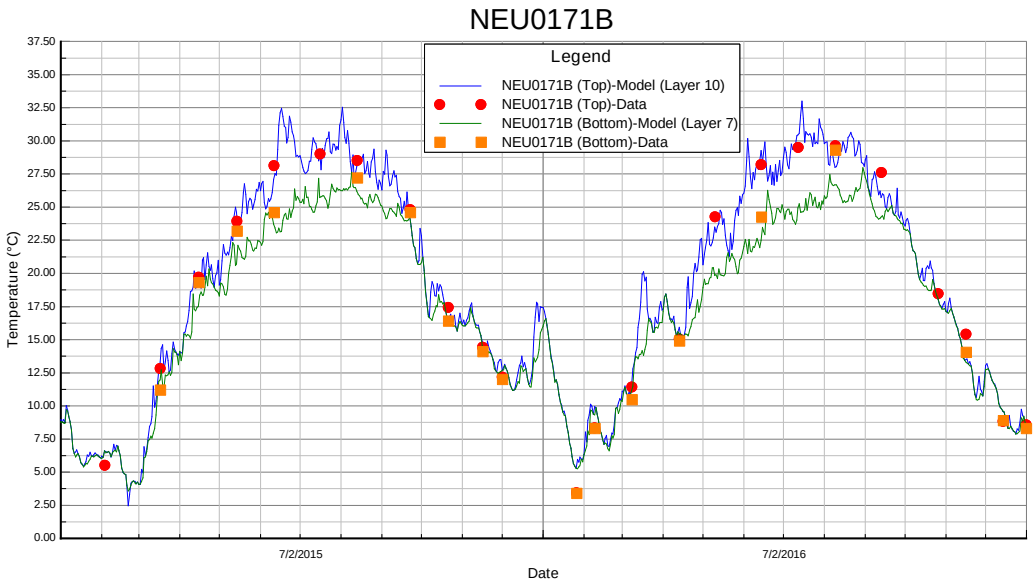
- Water Temperature Calibration:

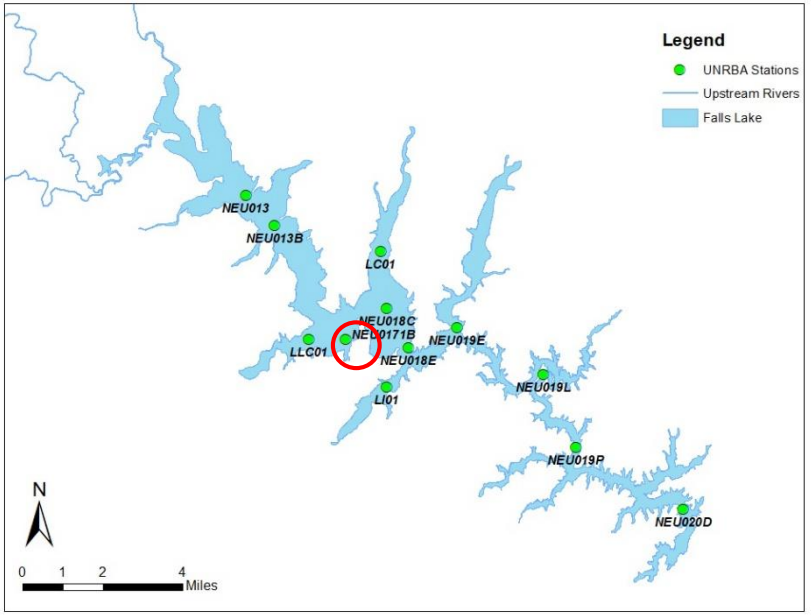




Results

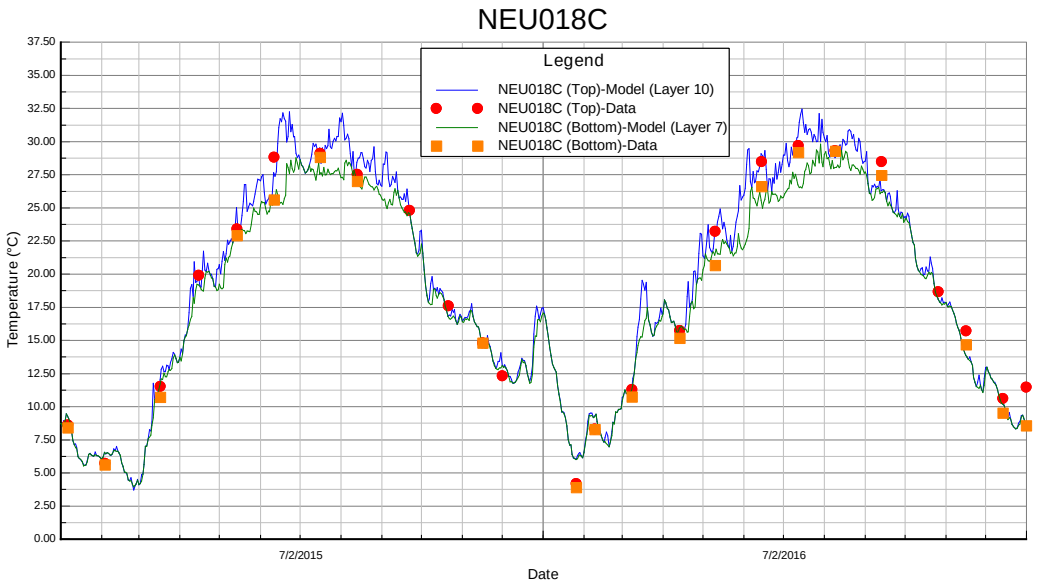
- Water Temperature Calibration:

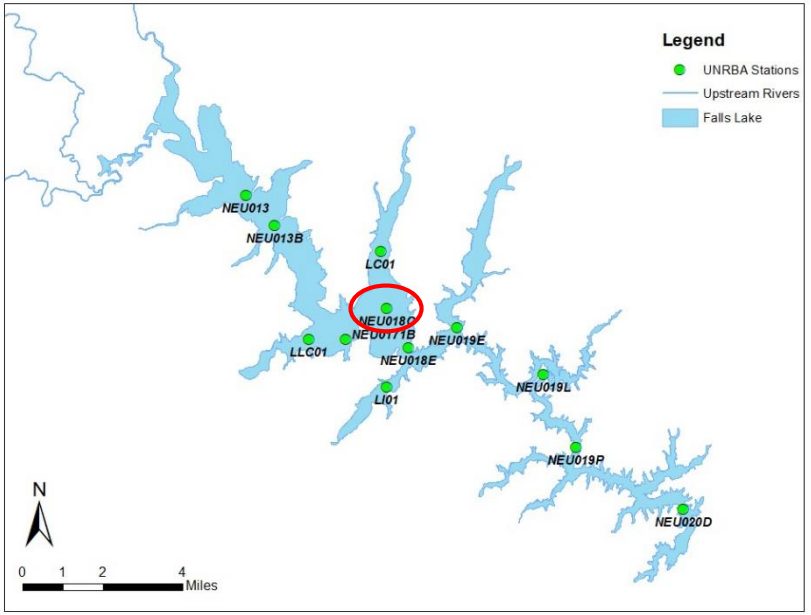




Results

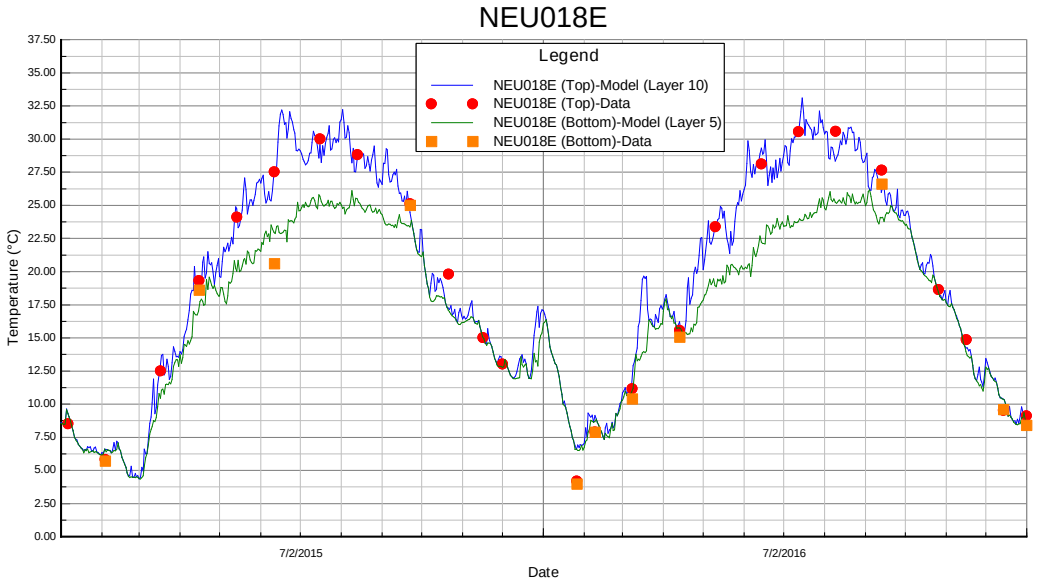
- Water Temperature Calibration:

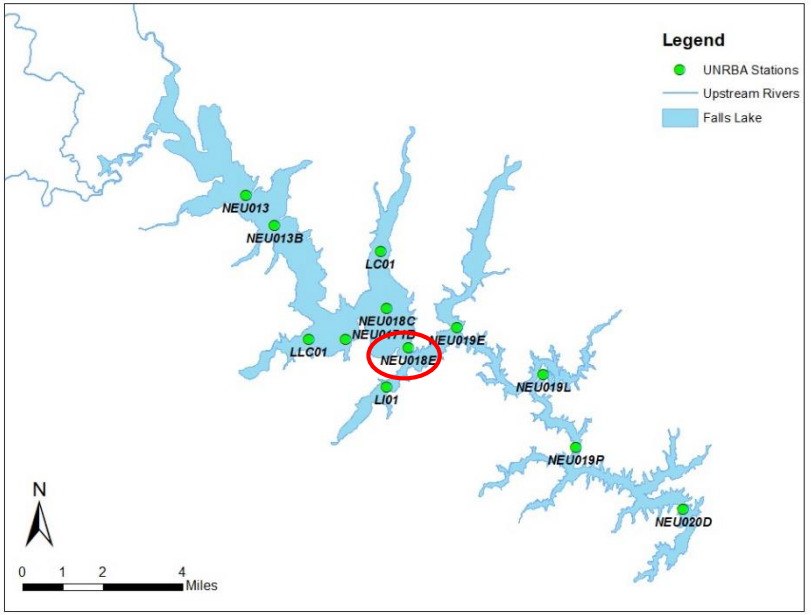




Results

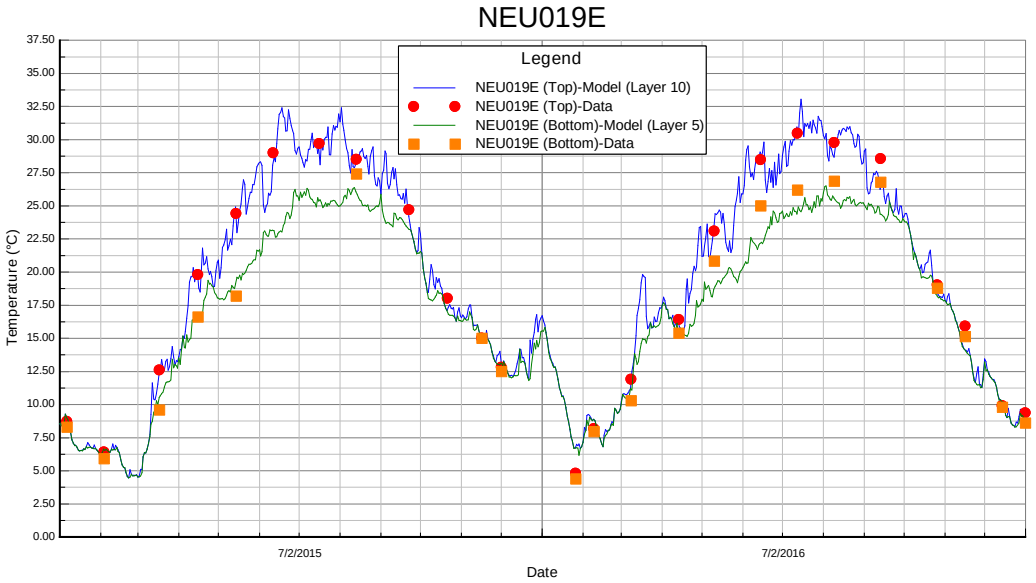
- Water Temperature Calibration:

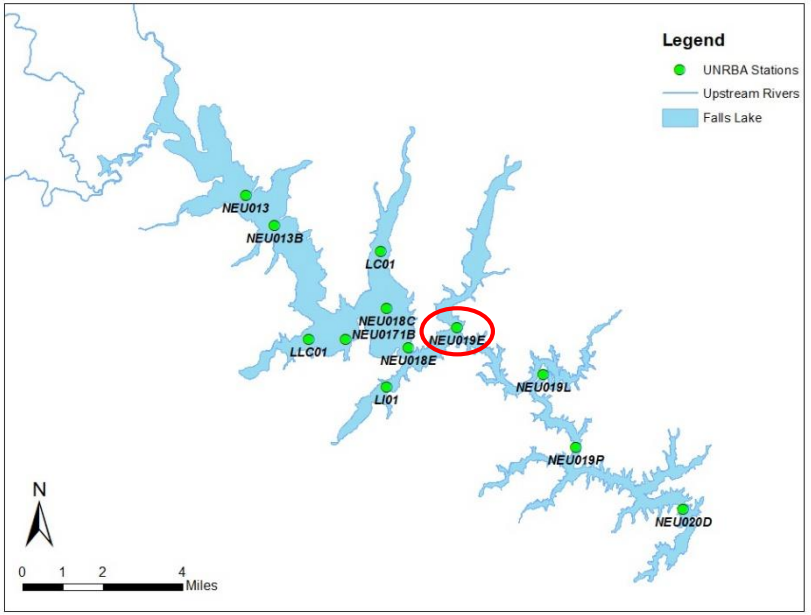




Results

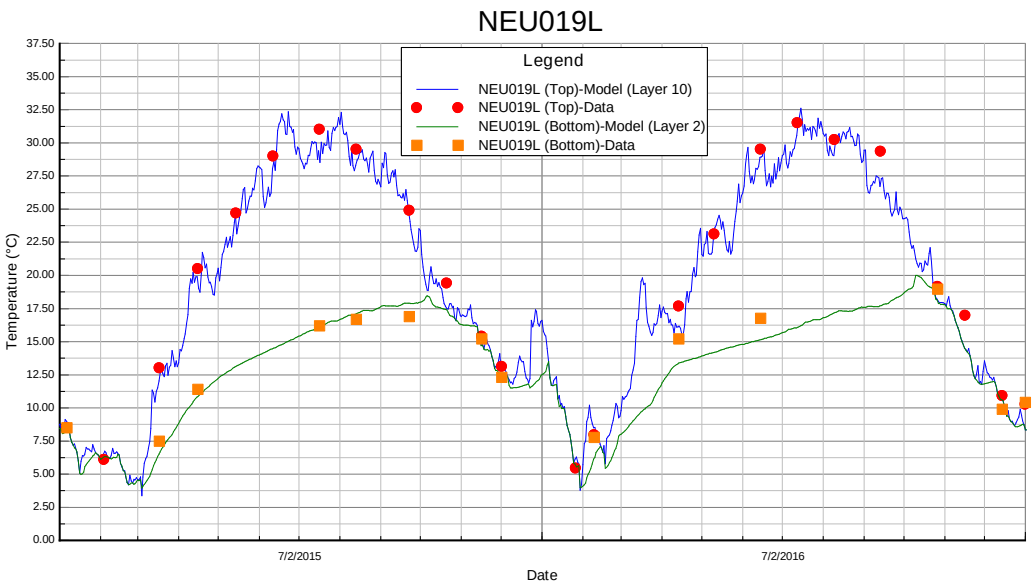
- Water Temperature Calibration:

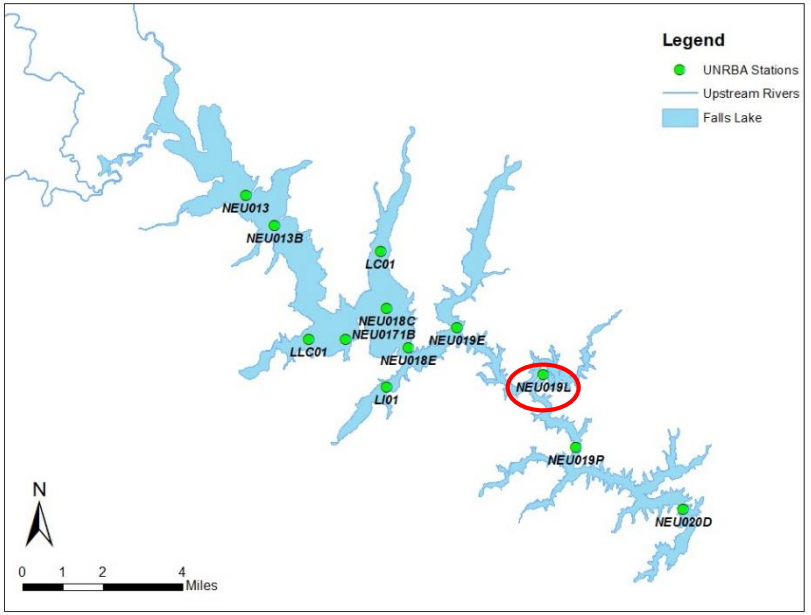




Results

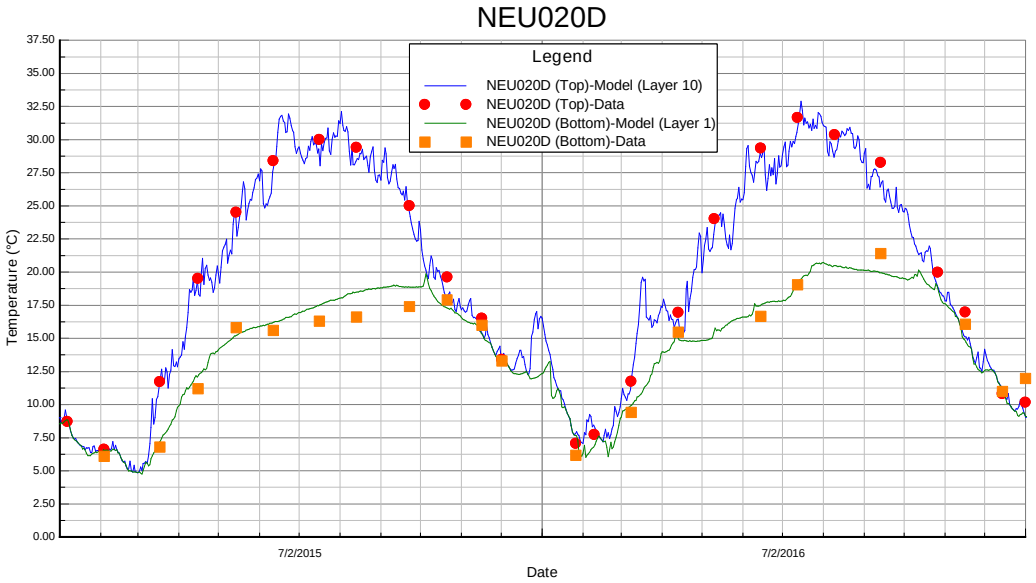
- Water Temperature Calibration:

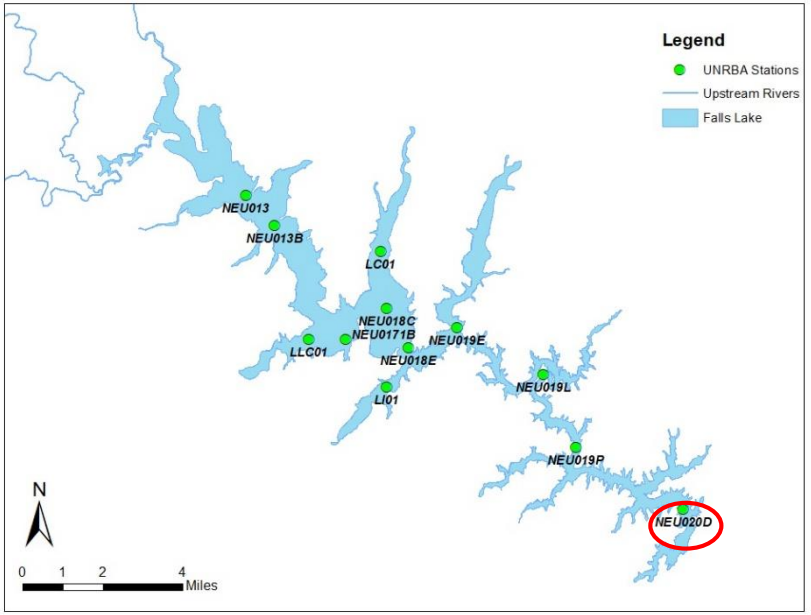




Results

- Water Temperature Calibration:



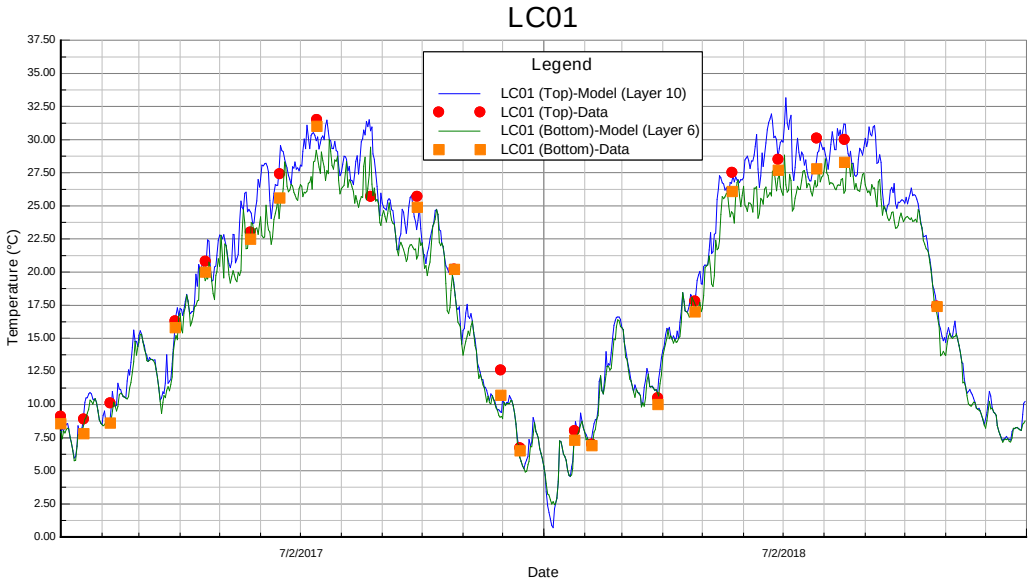


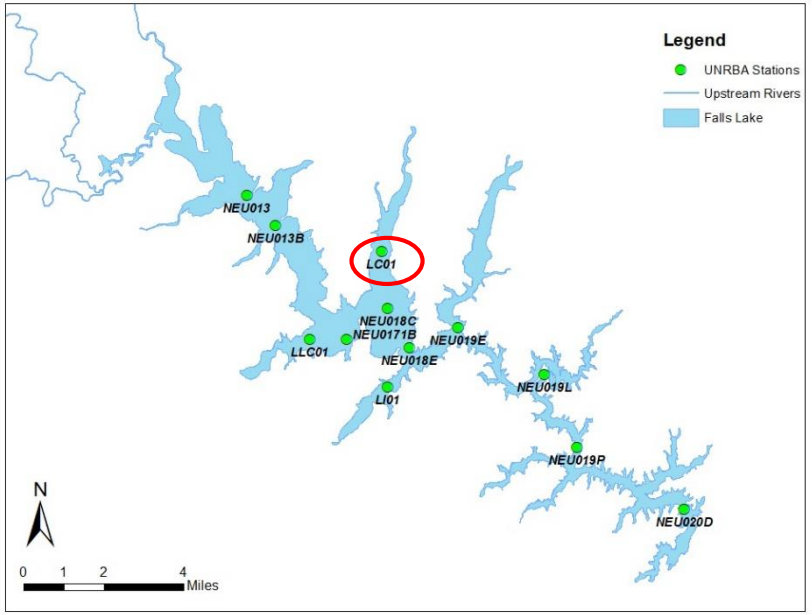
Temperature Time Series

Validation

Results

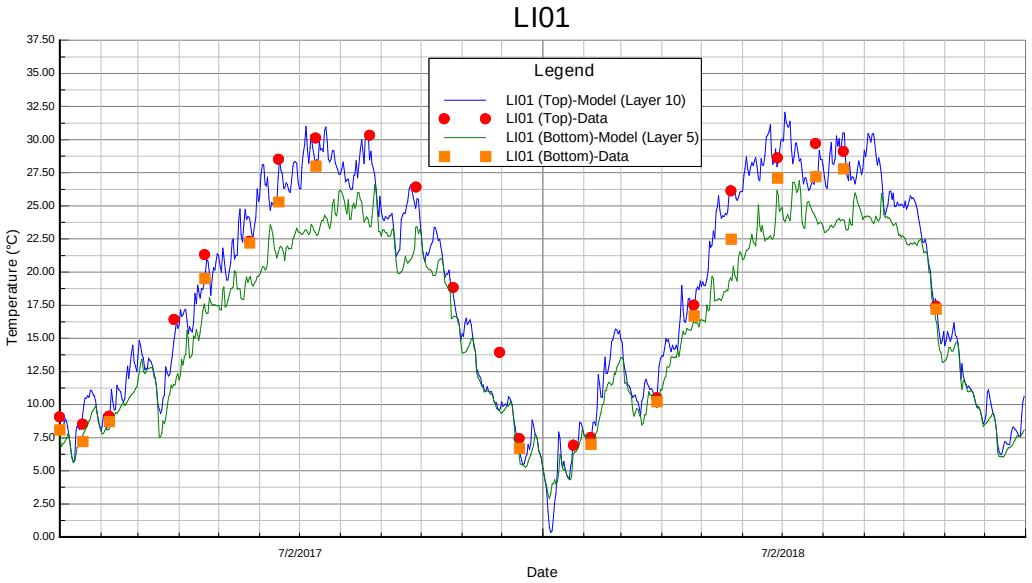
- Water Temperature Validation:

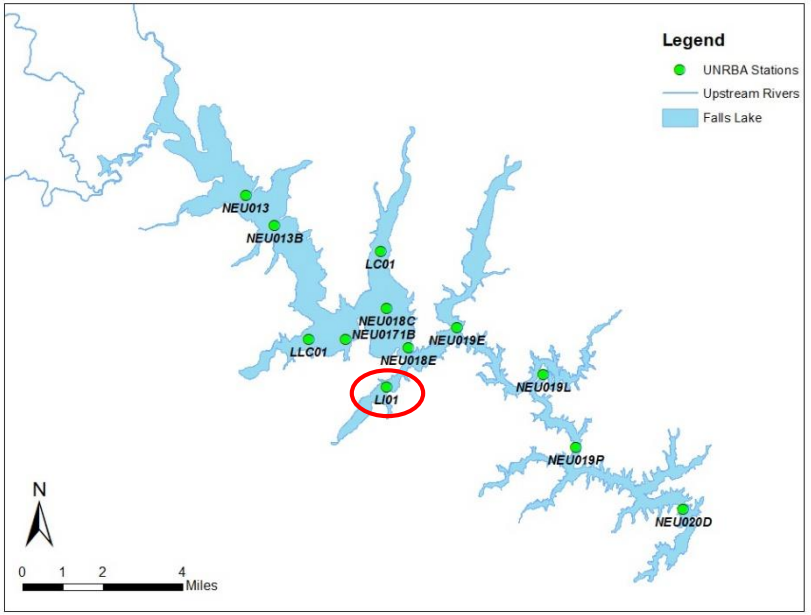




Results

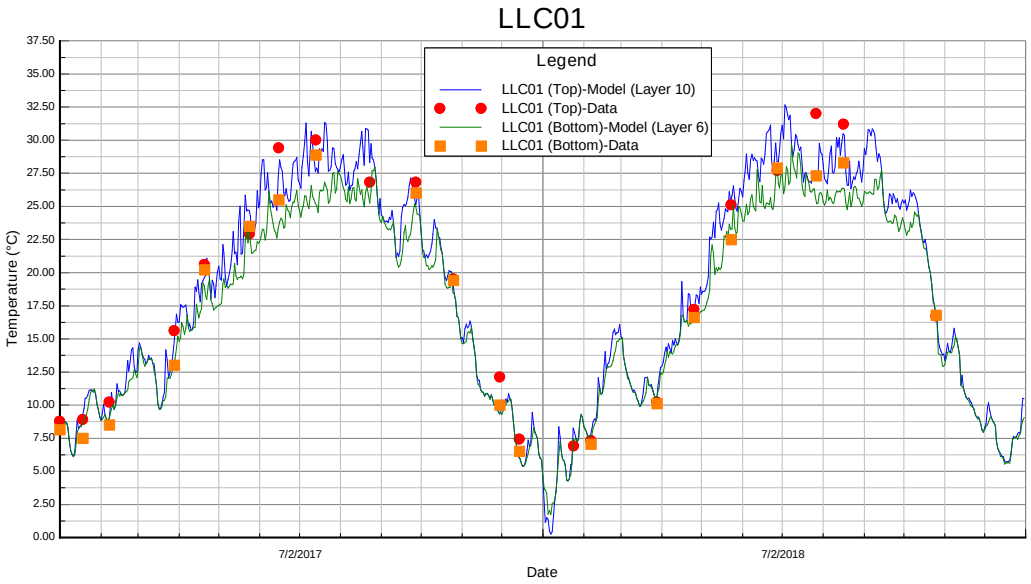
- Water Temperature Validation:

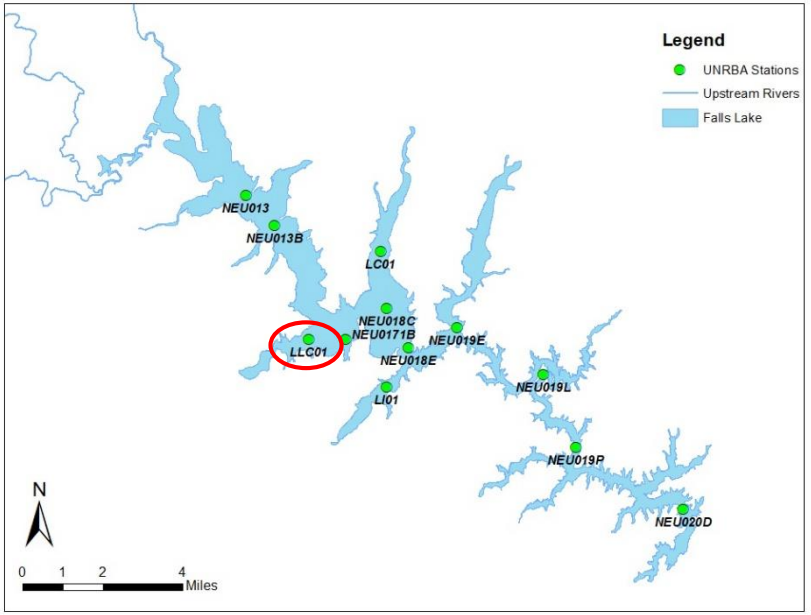




Results

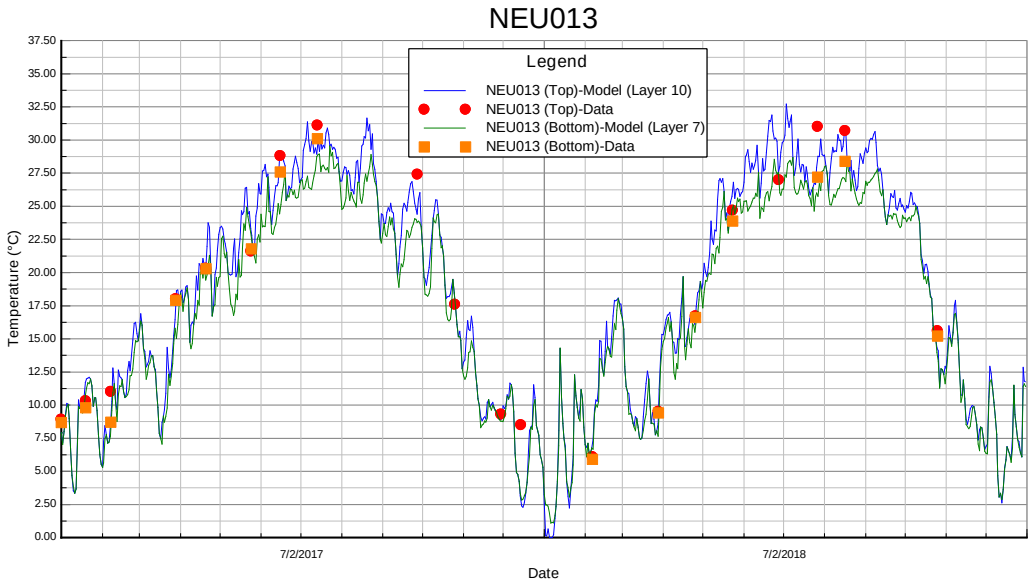
- Water Temperature Validation:

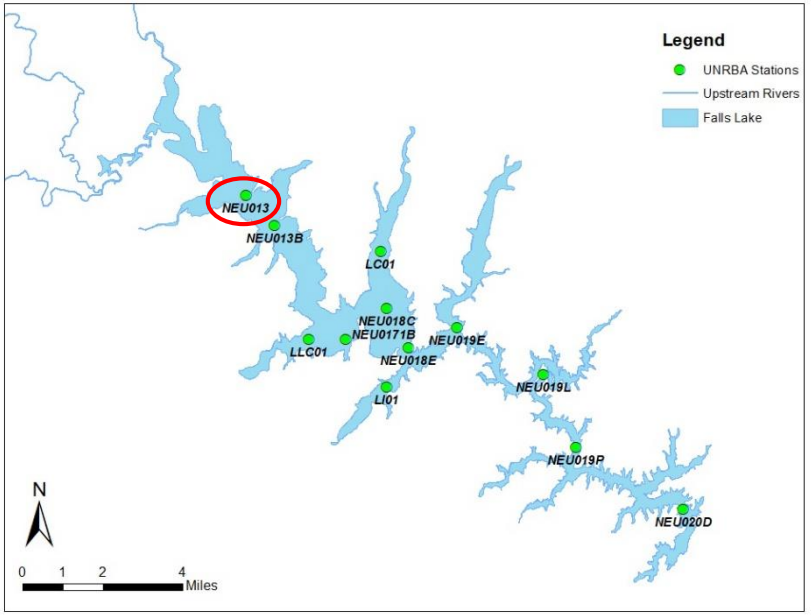




Results

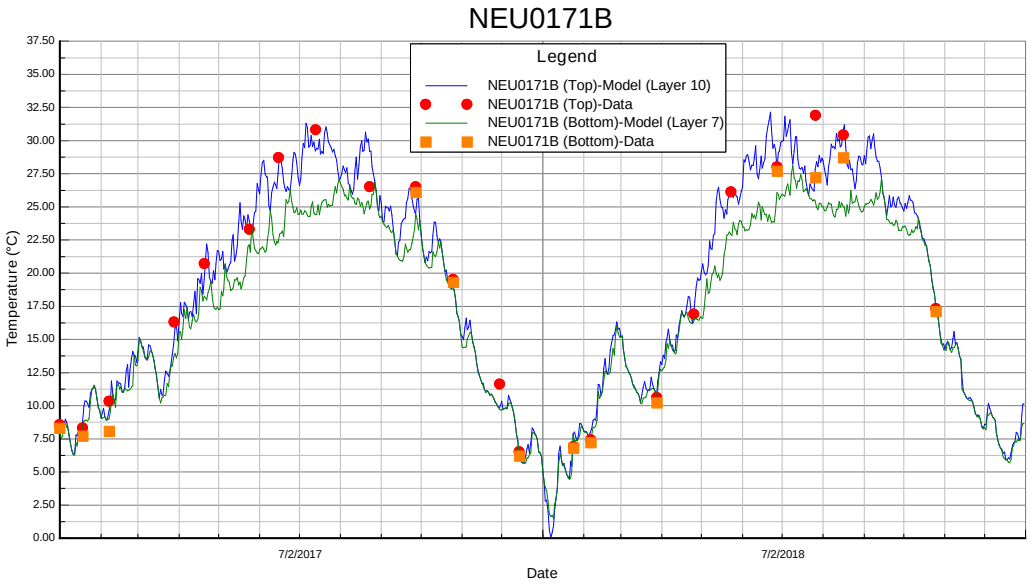
- Water Temperature Validation:

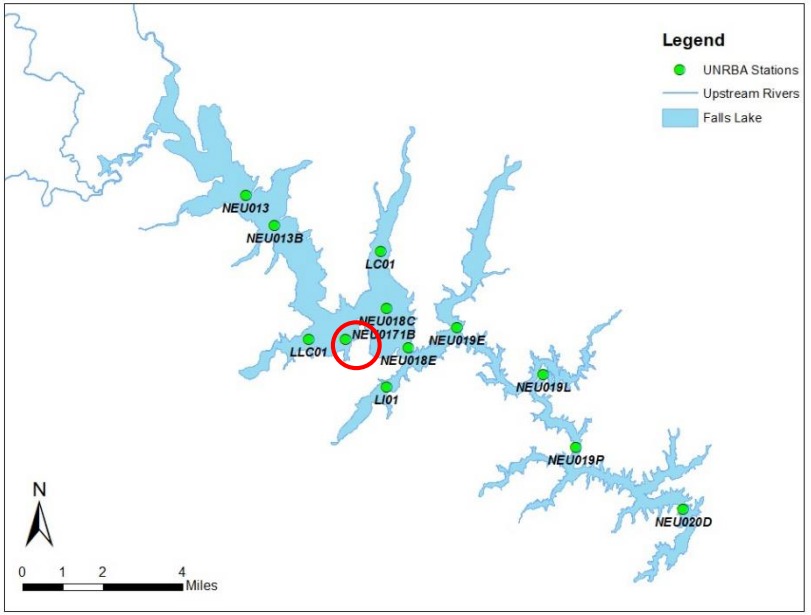




Results

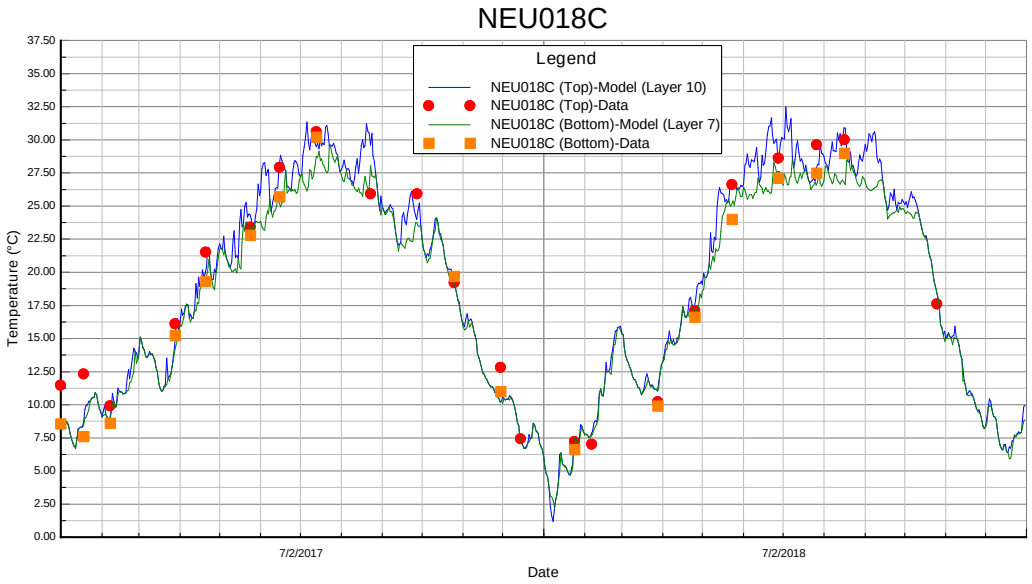
- Water Temperature Validation:

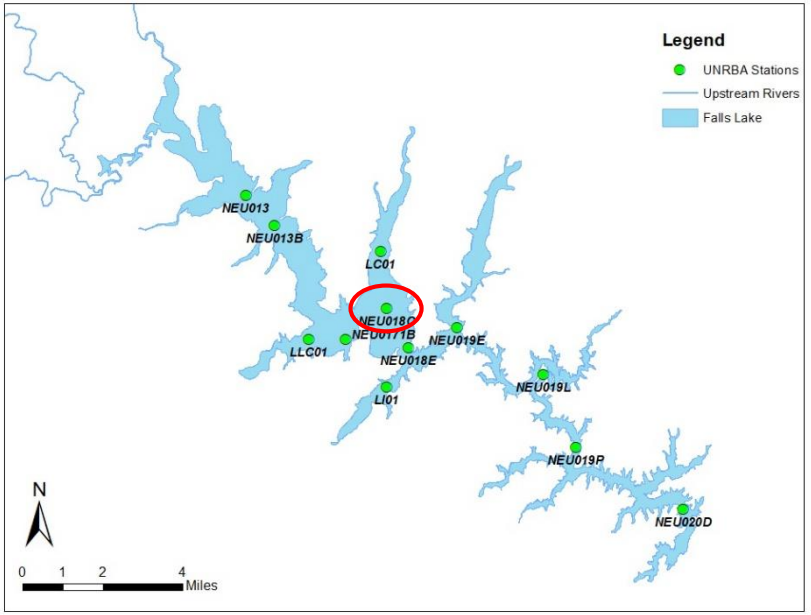




Results

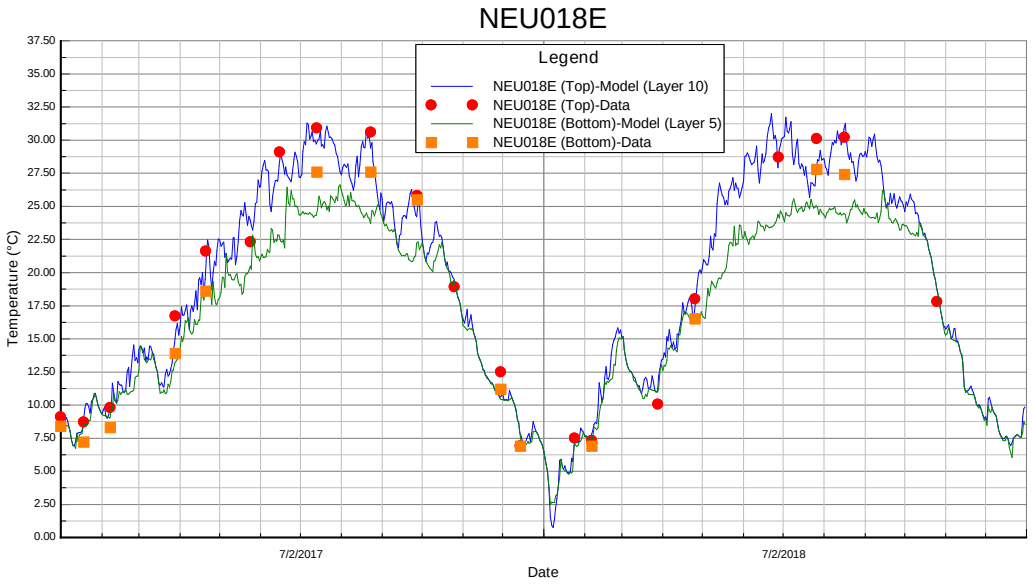
- Water Temperature Validation:

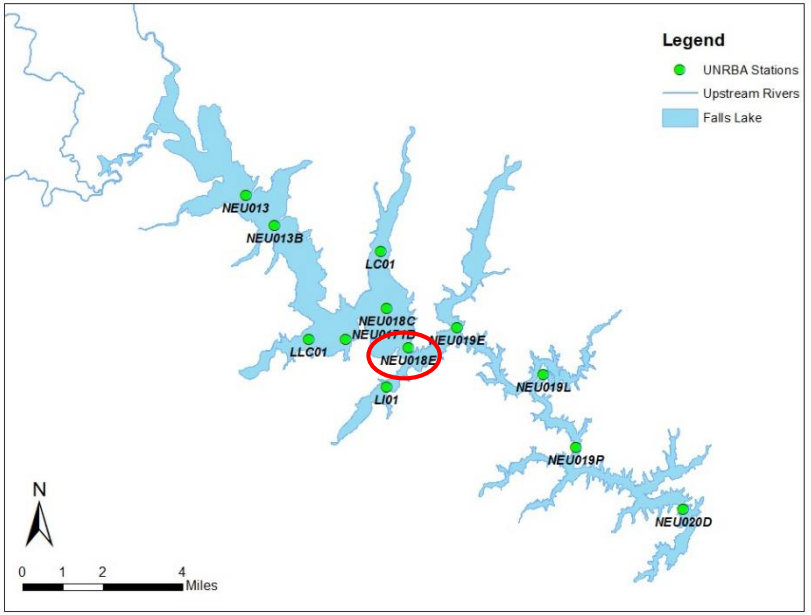




Results

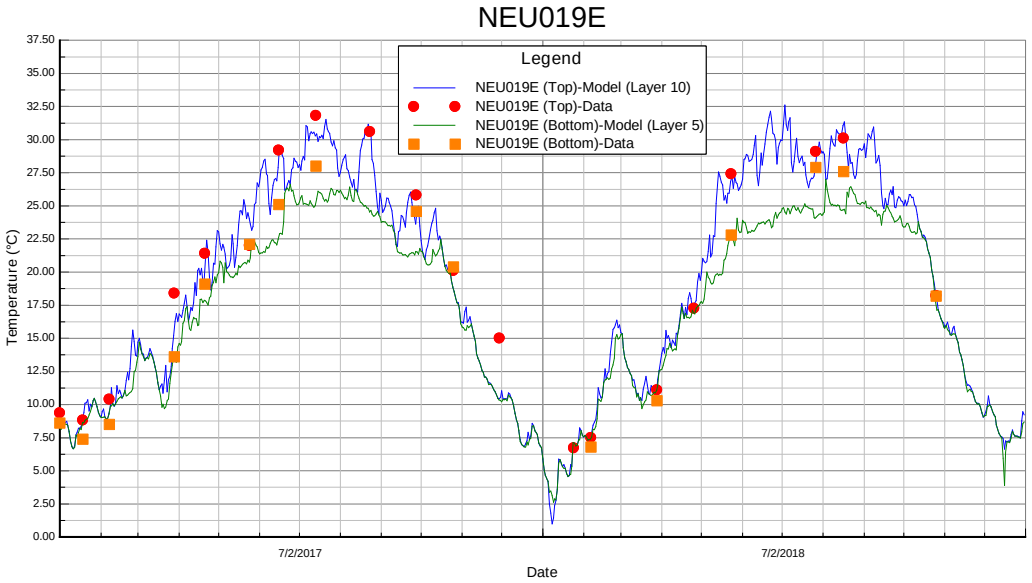
- Water Temperature Validation:

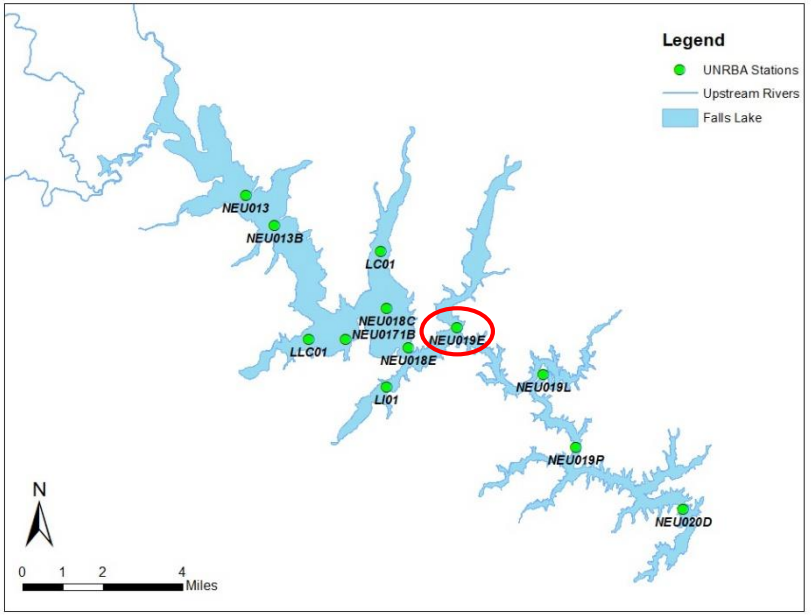




Results

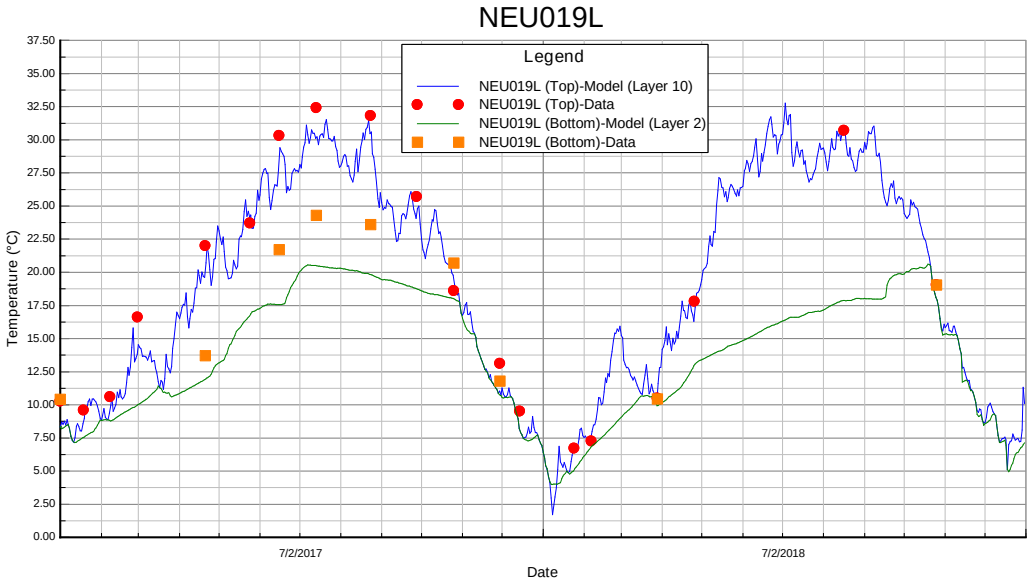
- Water Temperature Validation:

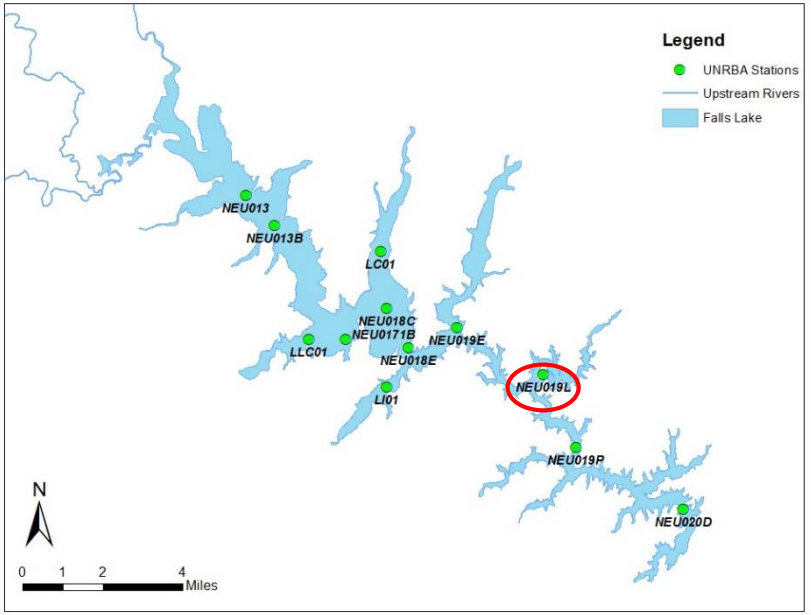




Results

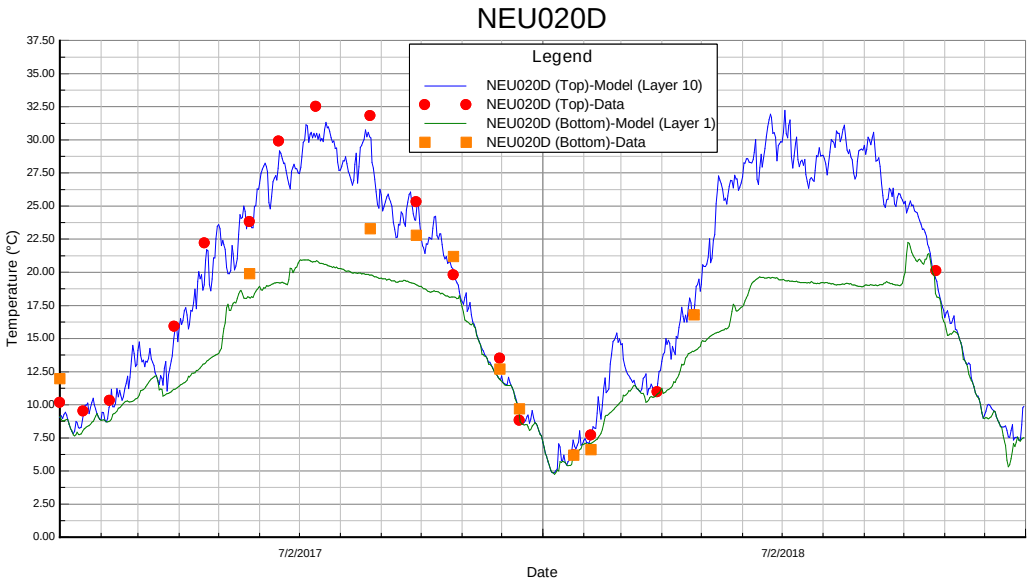
- Water Temperature Validation:

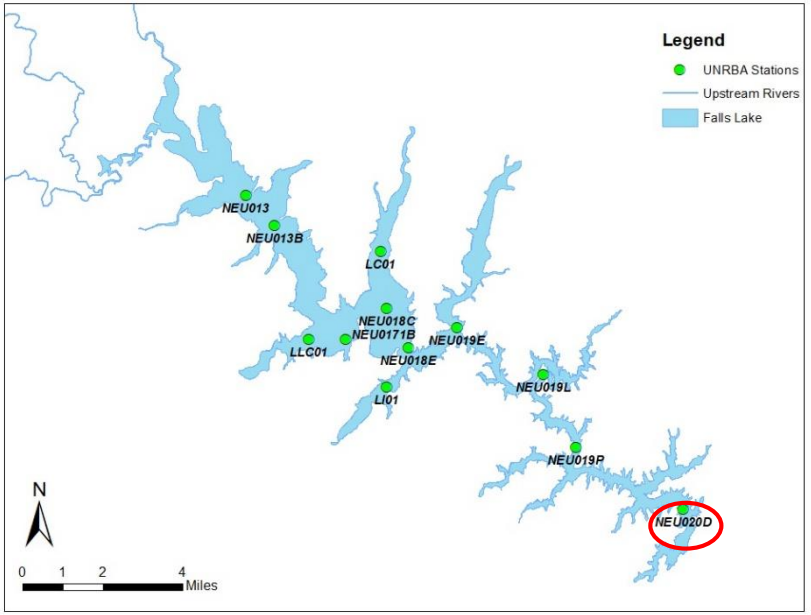




Results

- Water Temperature Validation:

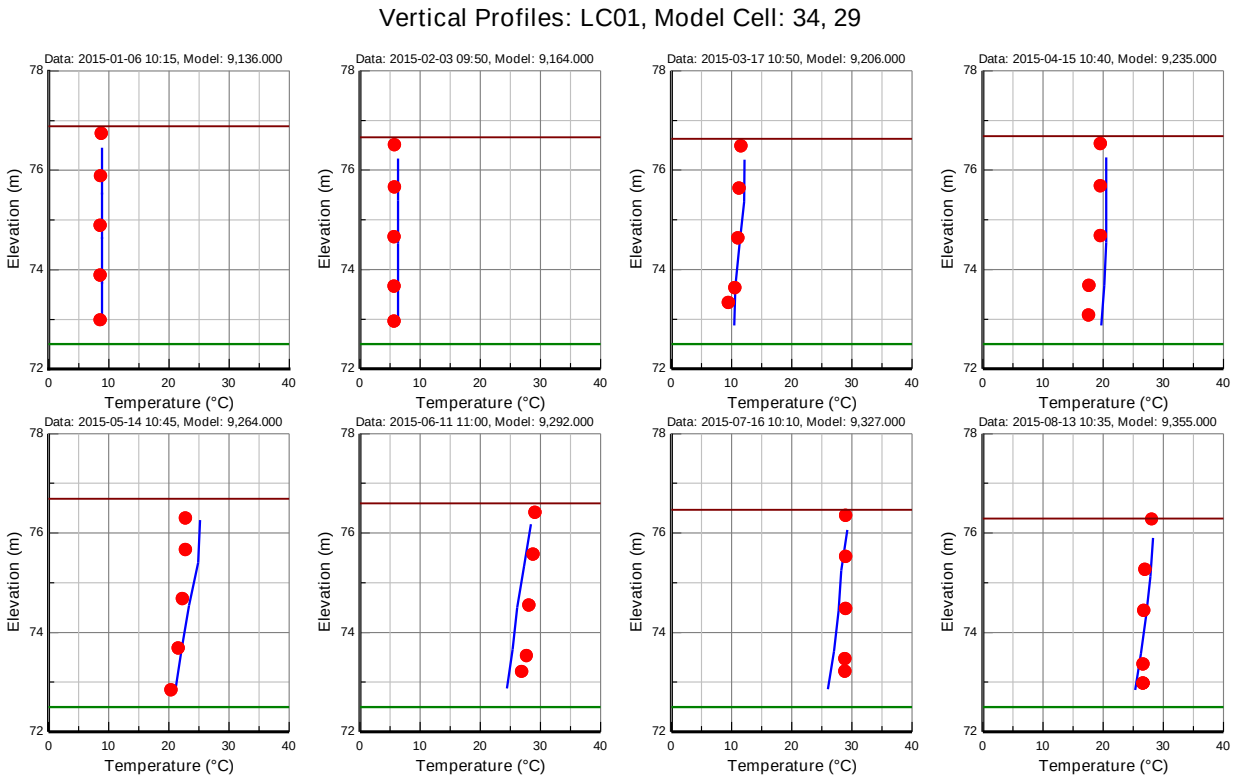




Vertical Temperature Profiles

Results

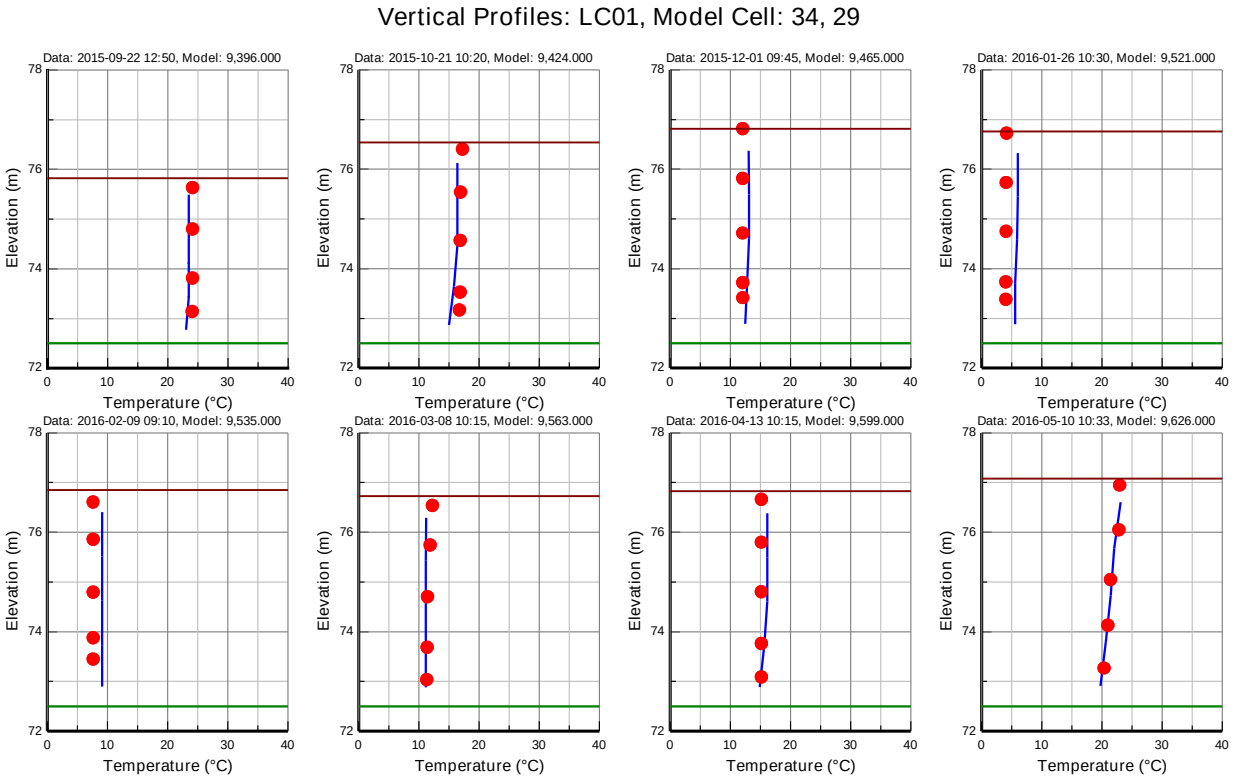
- Vertical Temperature Profiles:
  - LC01



January 2015 – August 2015 (1 of 6)

Results

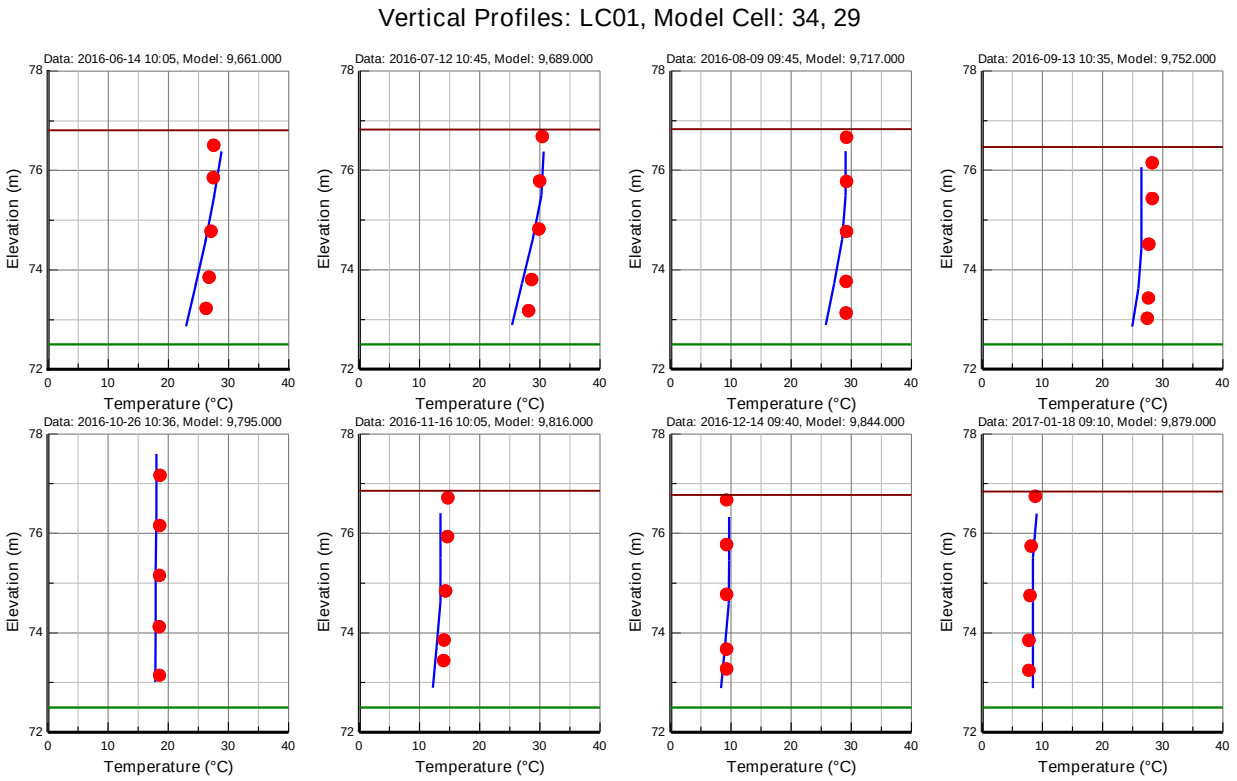
- Vertical Temperature Profiles:
  - LC01



September 2015 – May 2016 (2 of 6)

Results

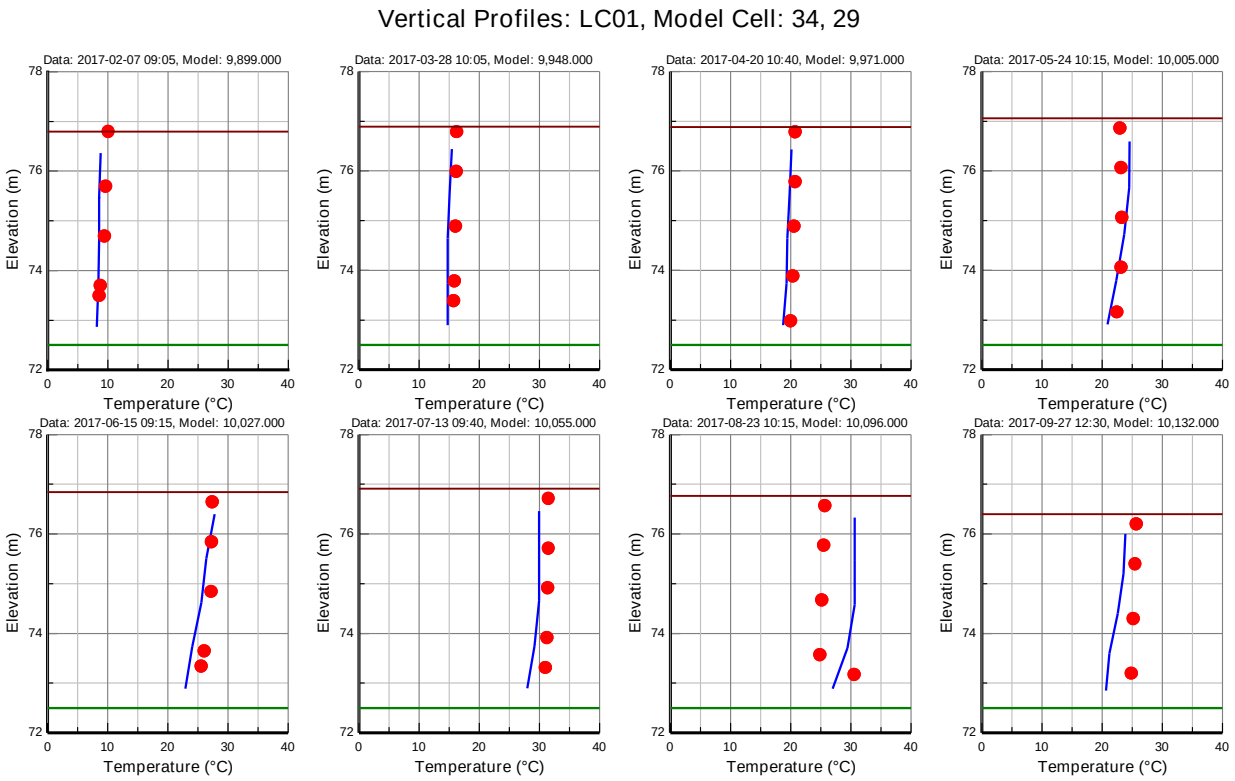
- Vertical Temperature Profiles:
  - LC01



June 2016 – January 2017 (3 of 6)

Results

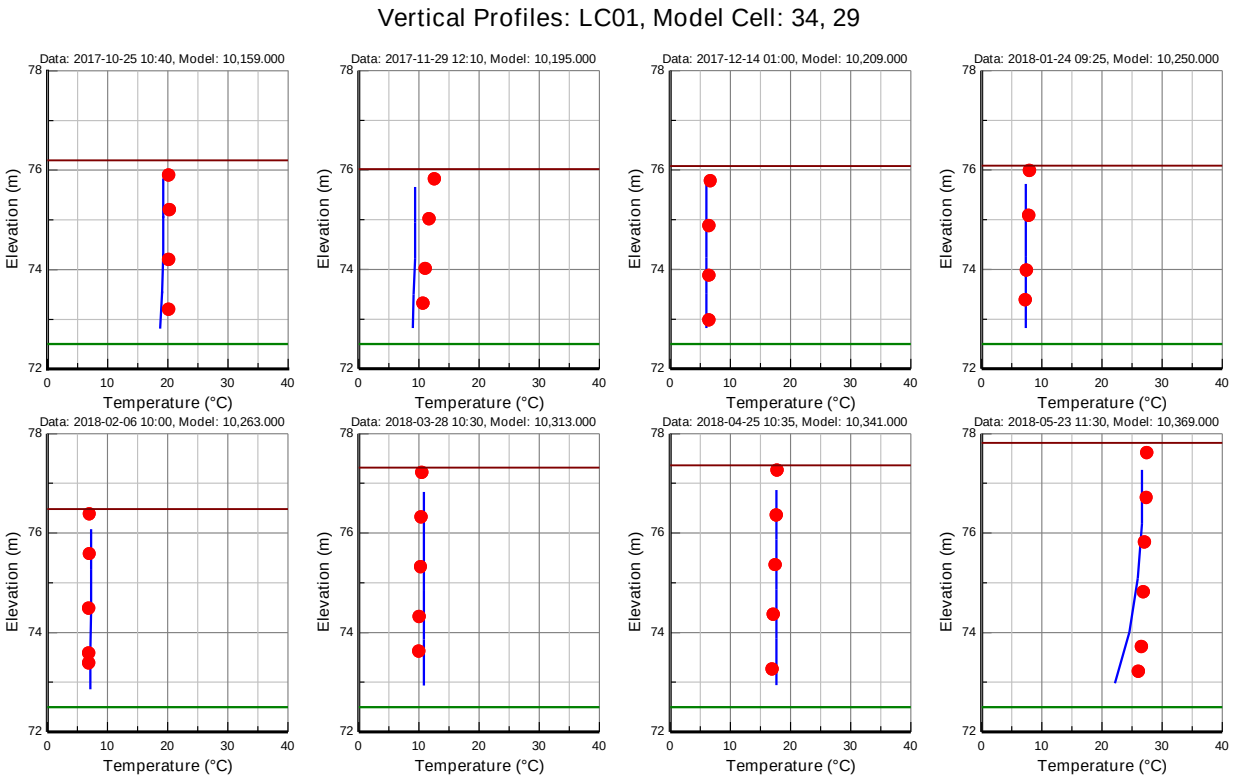
- Vertical Temperature Profiles:
  - LC01



February 2017 – September 2017 (4 of 6)

Results

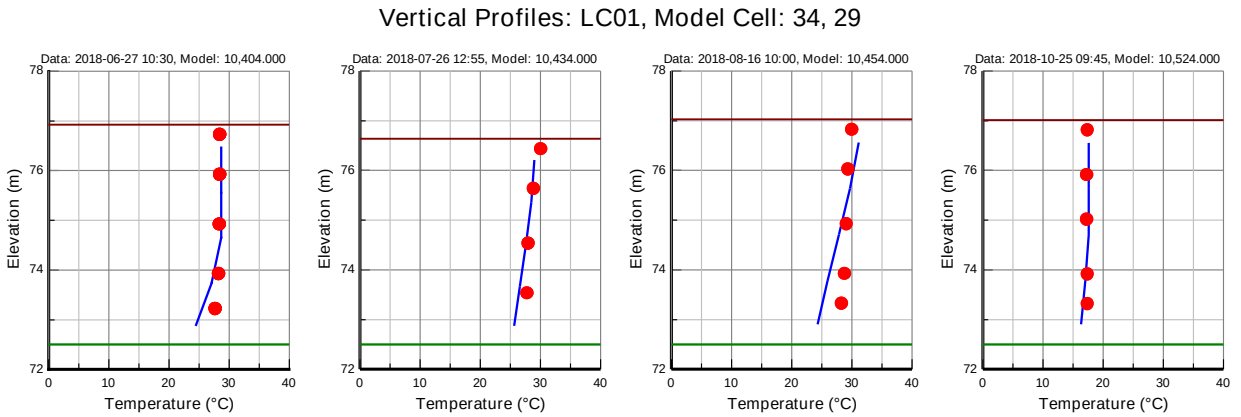
- Vertical Temperature Profiles:
  - LC01



October 2017 – May 2018 (5 of 6)

Results

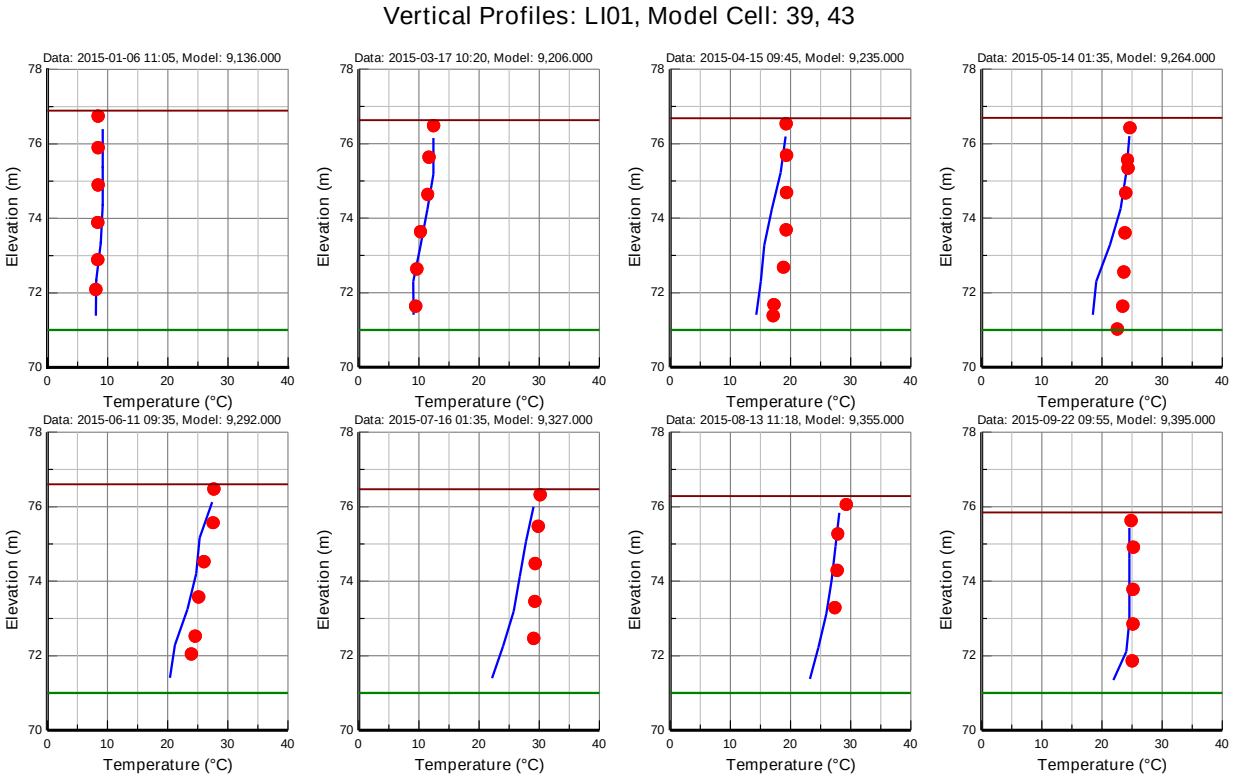
- Vertical Temperature Profiles:
  - LC01



June 2018 – October 2018 (6 of 6)

Results

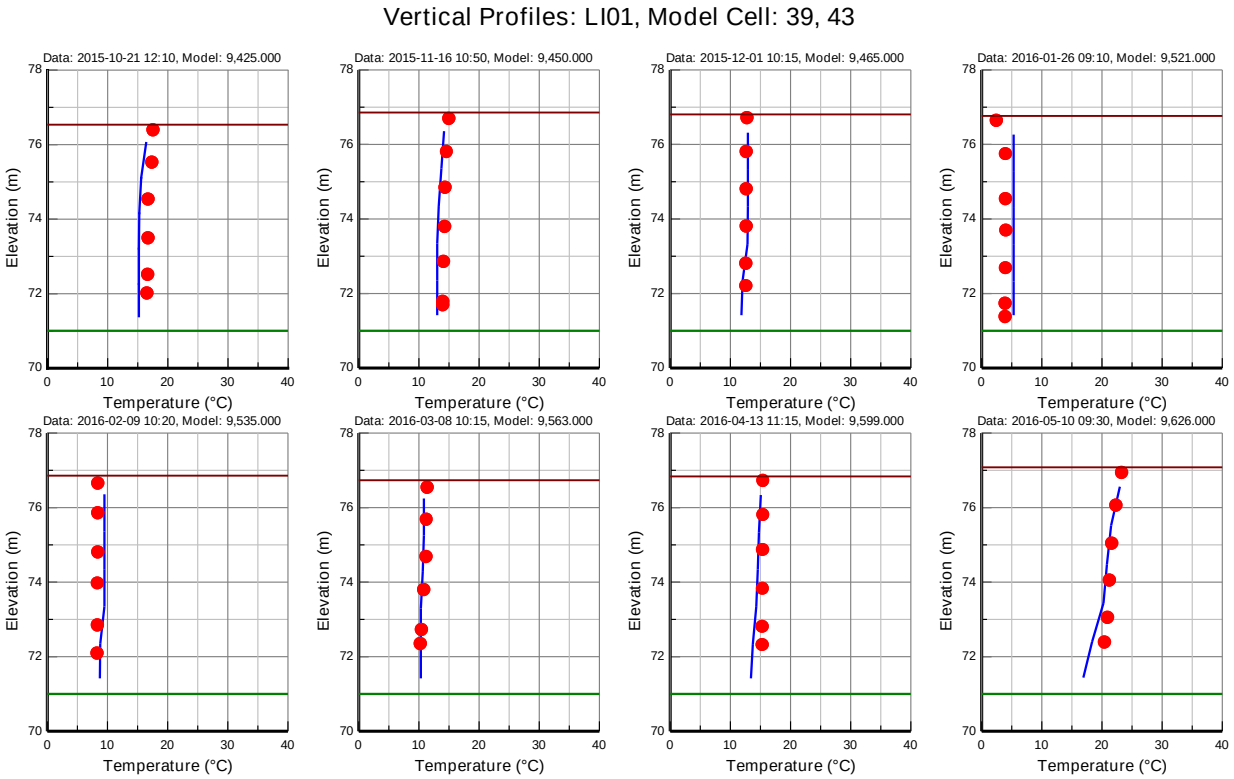
- Vertical Temperature Profiles:
  - LI01



January 2015 – September 2015 (1 of 6)

Results

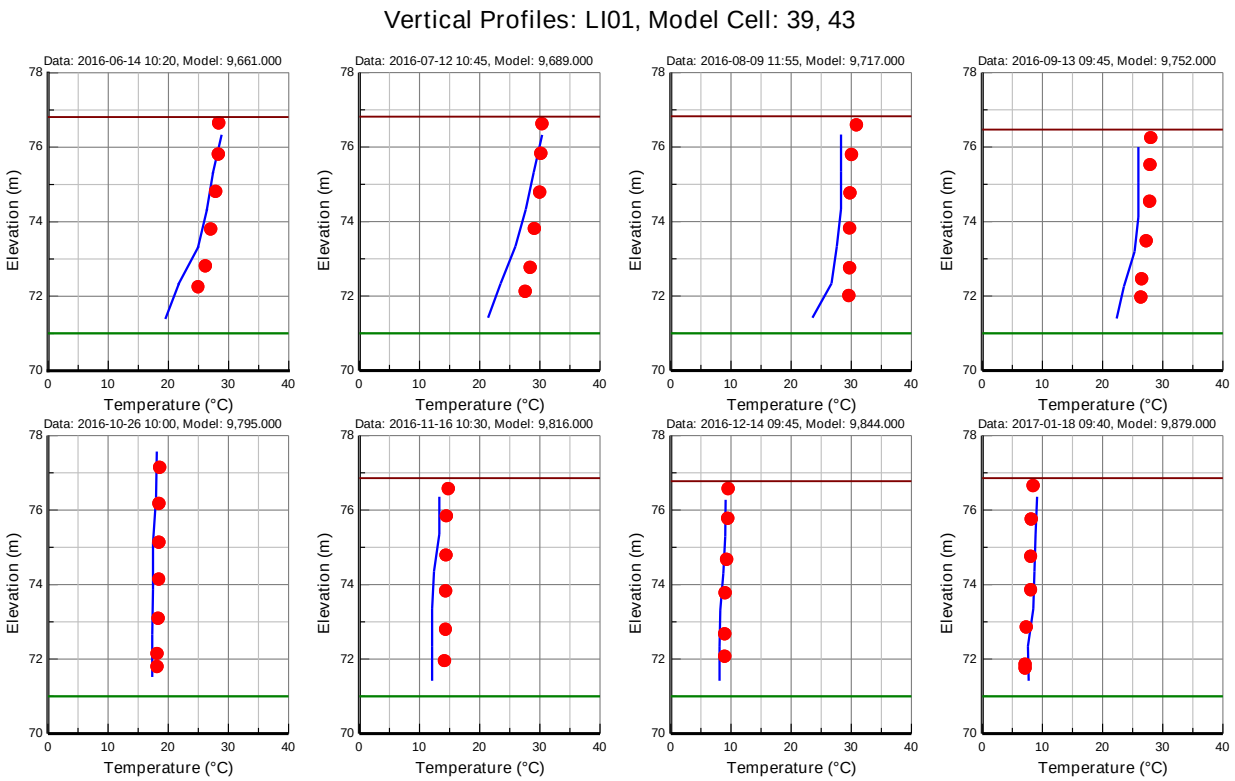
- Vertical Temperature Profiles:
  - LI01



October 2015 – May 2016 (2 of 6)

Results

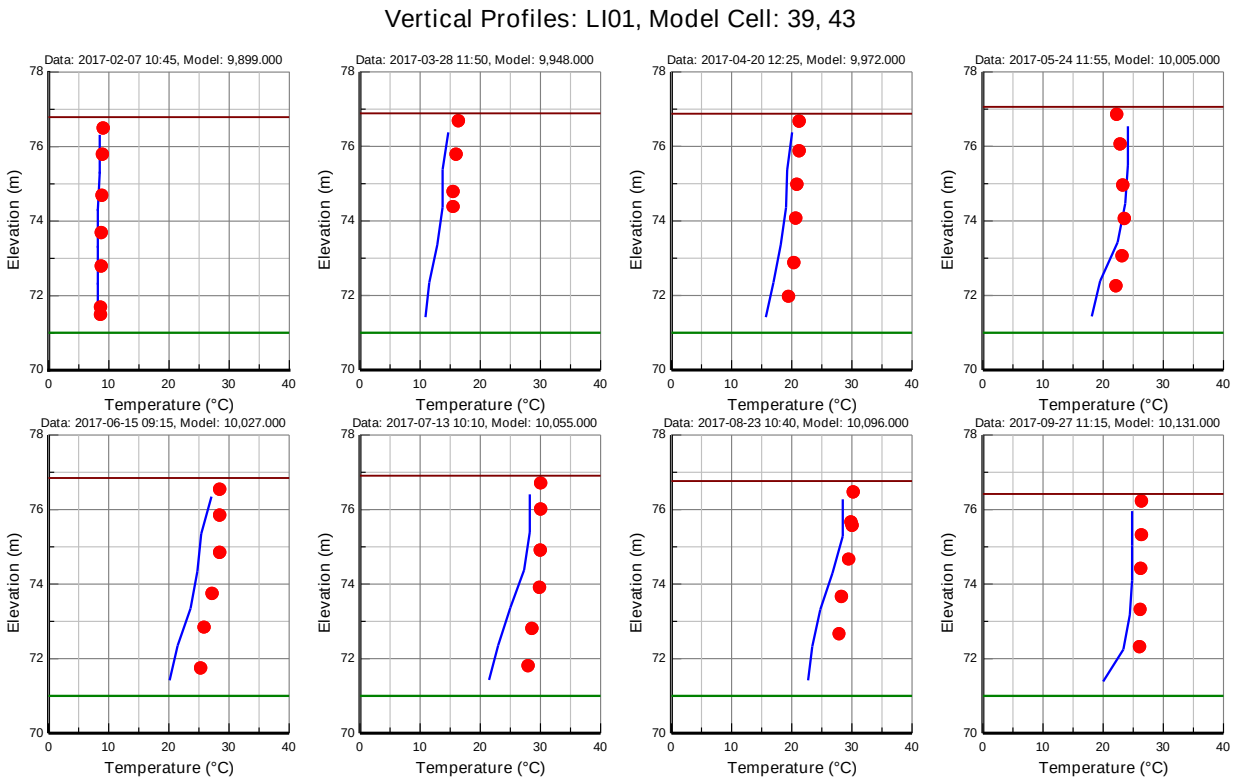
- Vertical Temperature Profiles:
  - LI01



June 2016 – January 2017 (3 of 6)

Results

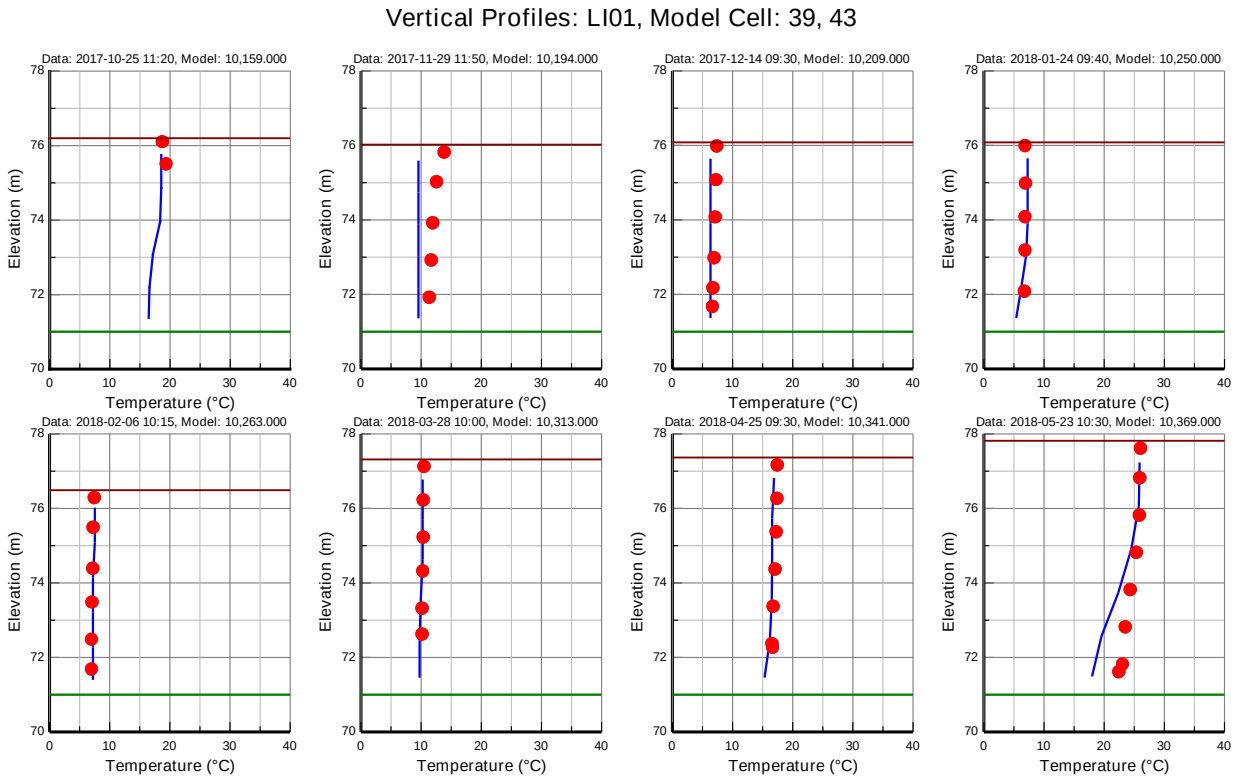
- Vertical Temperature Profiles:
  - LI01



February 2017 – September 2017 (4 of 6)

Results

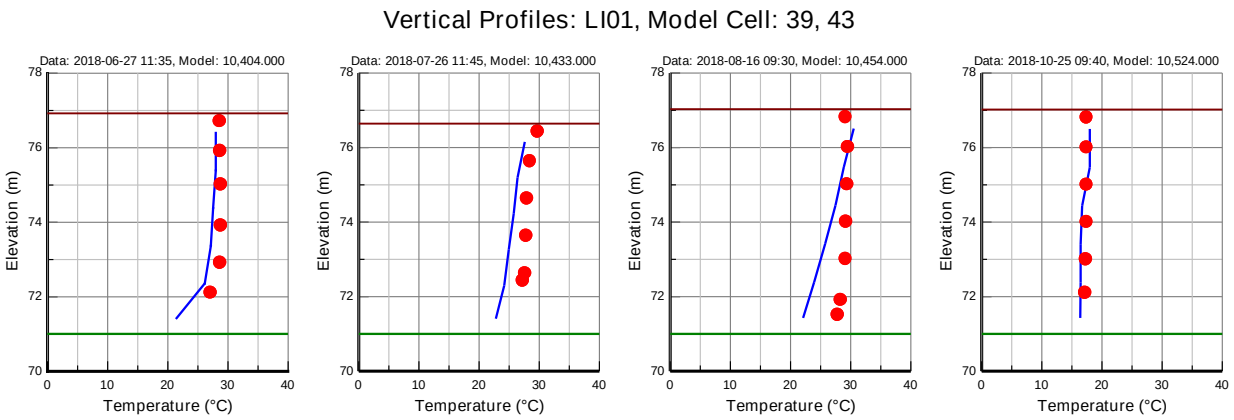
- Vertical Temperature Profiles:
  - LI01



October 2017 – May 2018 (5 of 6)

Results

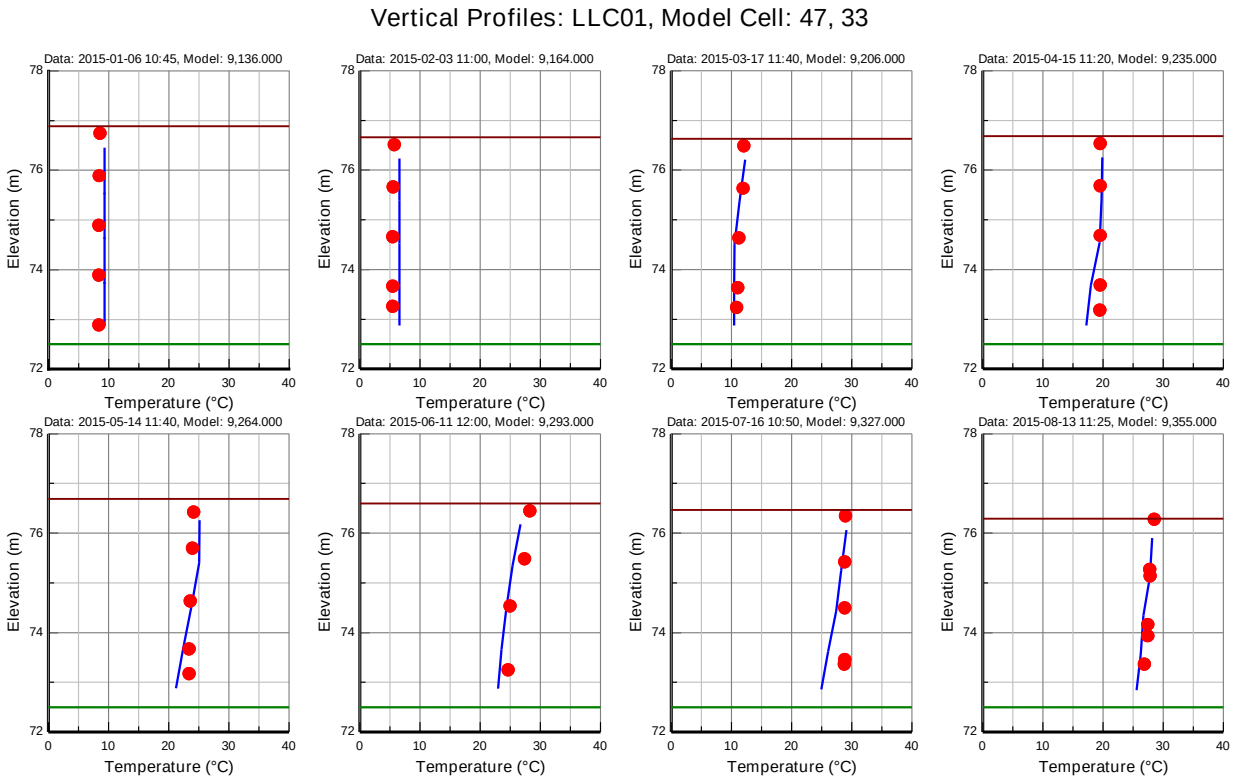
- Vertical Temperature Profiles:
  - LI01



June 2018 – October 2018 (6 of 6)

Results

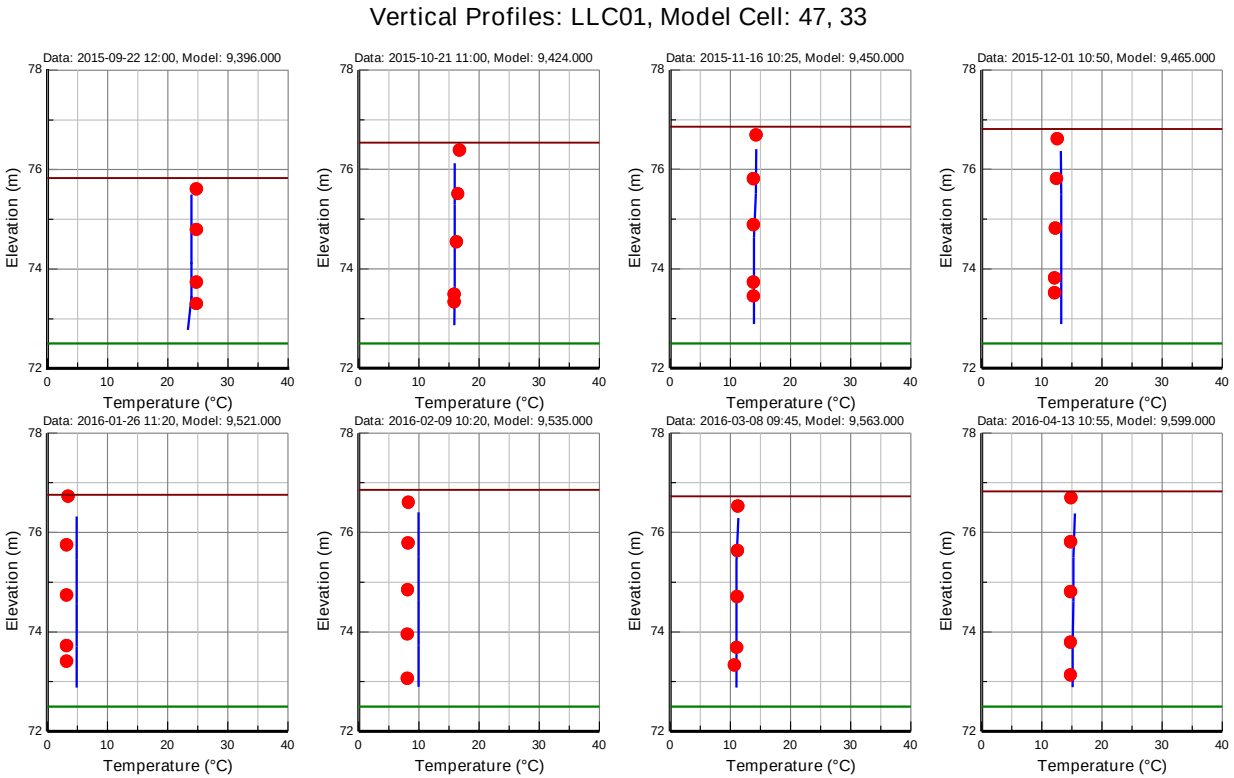
- Vertical Temperature Profiles:
  - LLC01



January 2015 – August 2015 (1 of 6)

Results

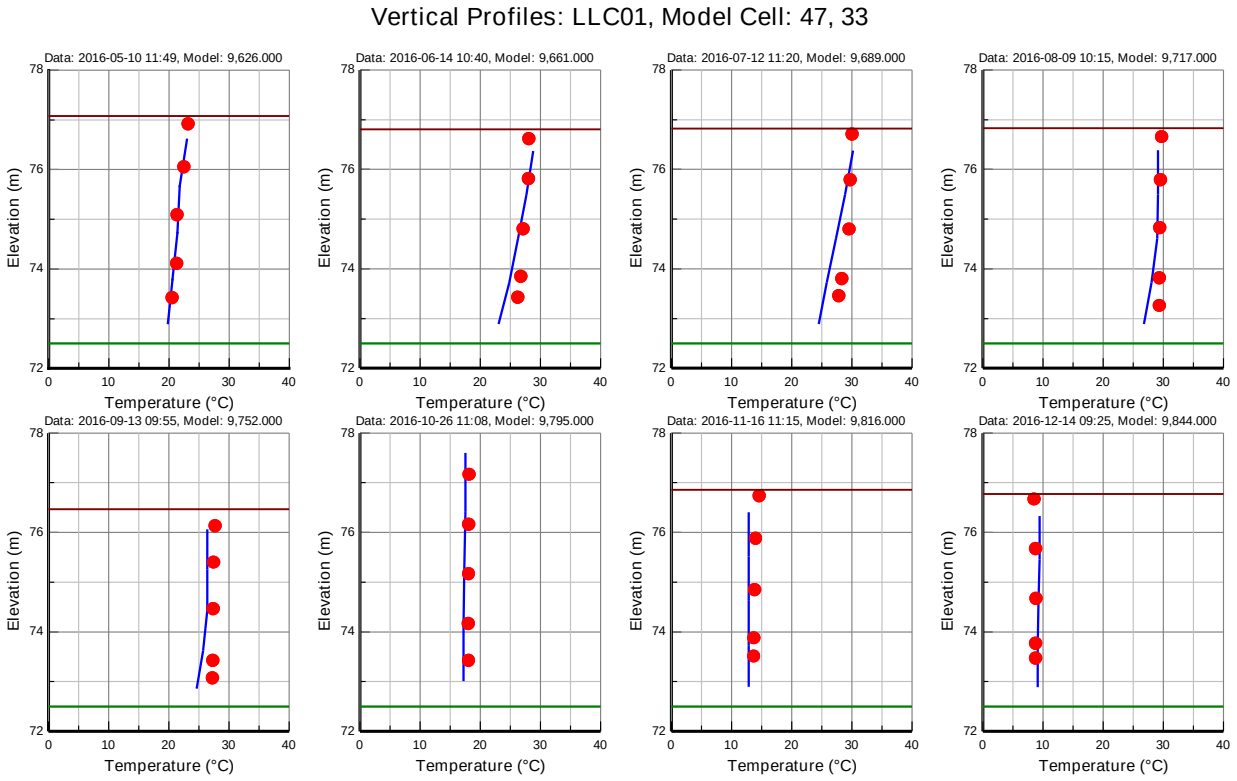
- Vertical Temperature Profiles:
  - LLC01



September 2015 – April 2016 (2 of 6)

Results

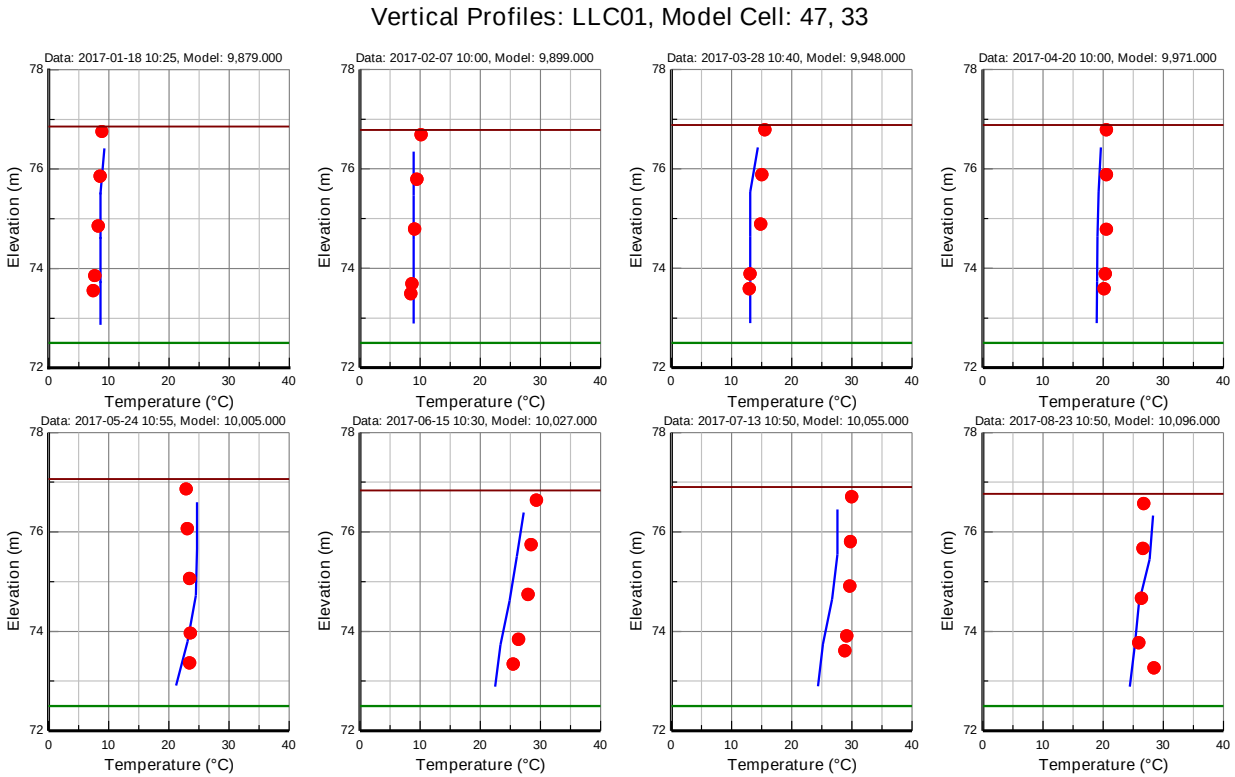
- Vertical Temperature Profiles:
  - LLC01



May 2016 – December 2016 (3 of 6)

Results

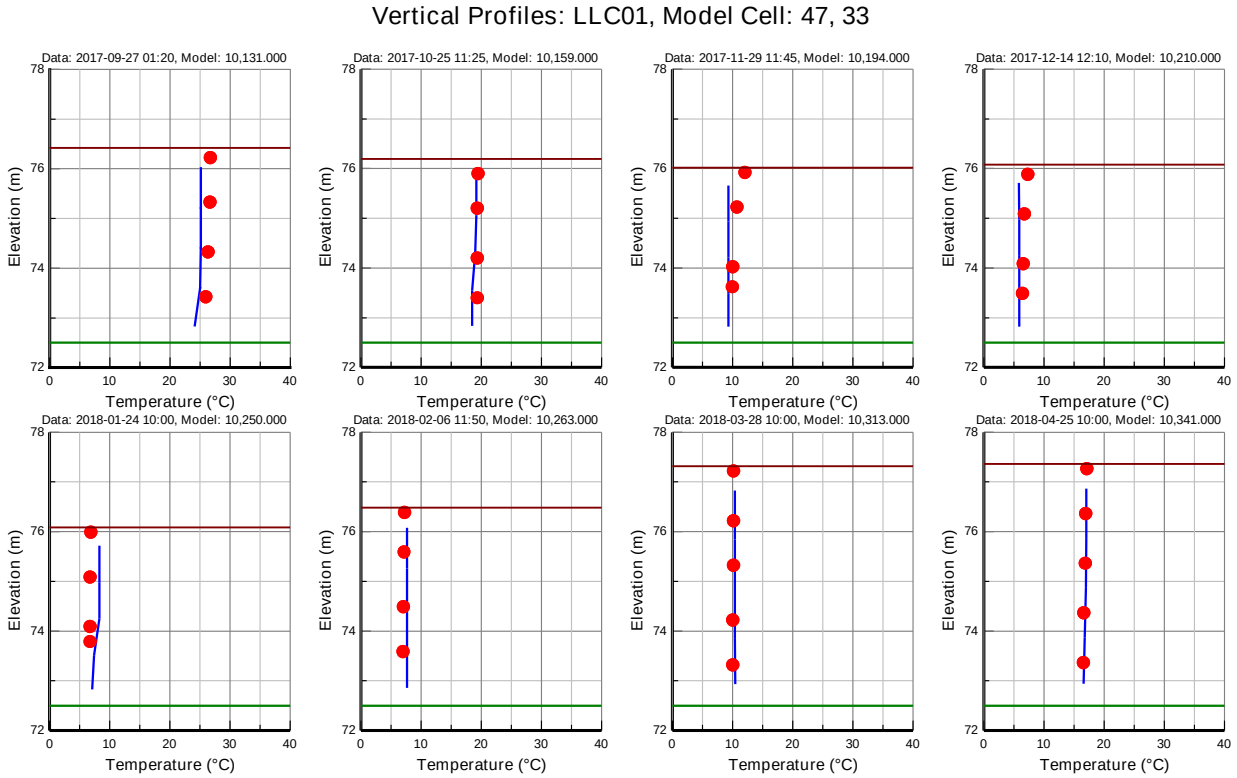
- Vertical Temperature Profiles:
  - LLC01



January 2017 – August 2017 (4 of 6)

Results

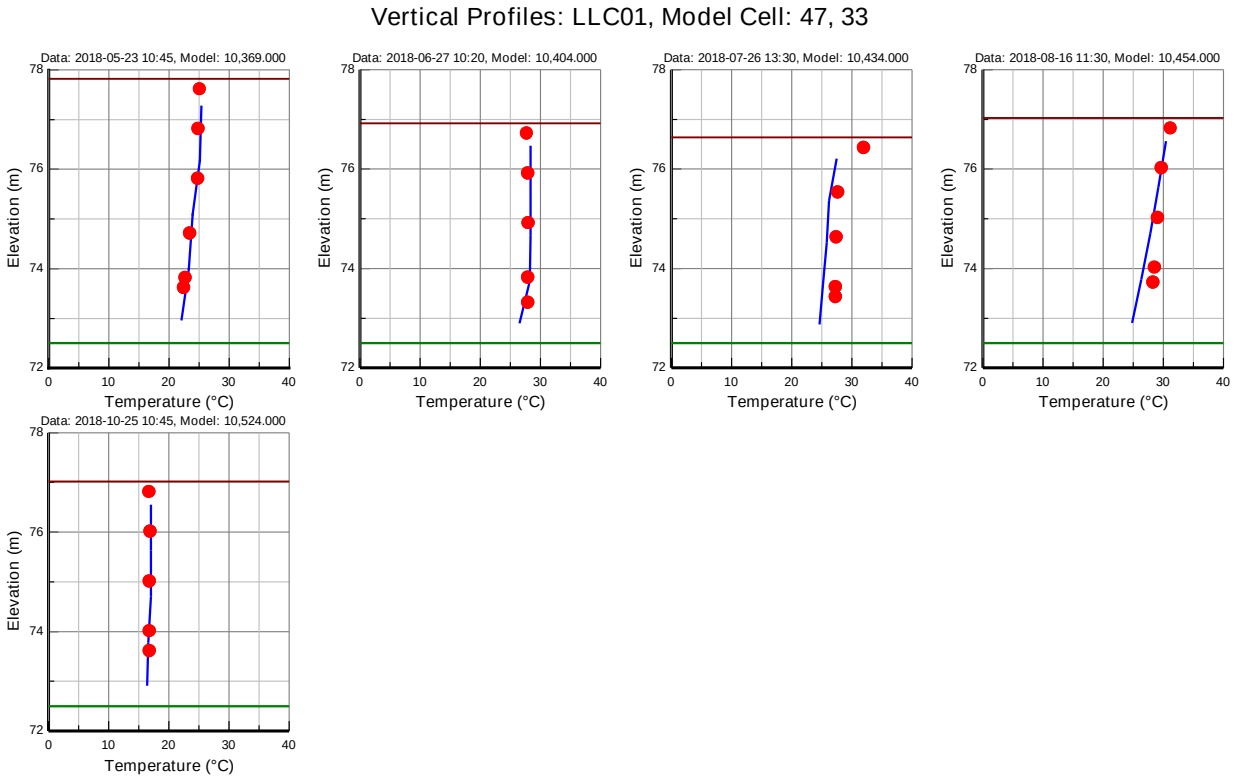
- Vertical Temperature Profiles:
  - LLC01



September 2017 – April 2018 (5 of 6)

Results

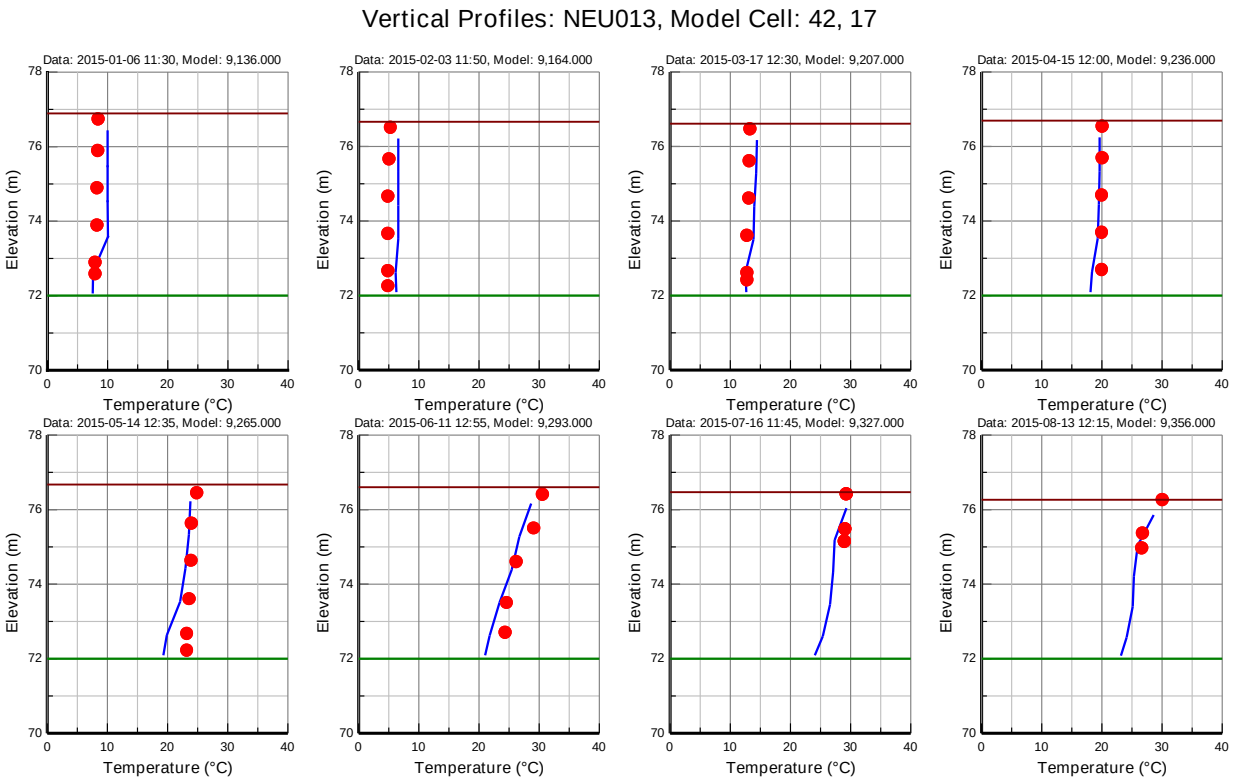
- Vertical Temperature Profiles:
  - LLC01



May 2018 – October 2018 (6 of 6)

Results

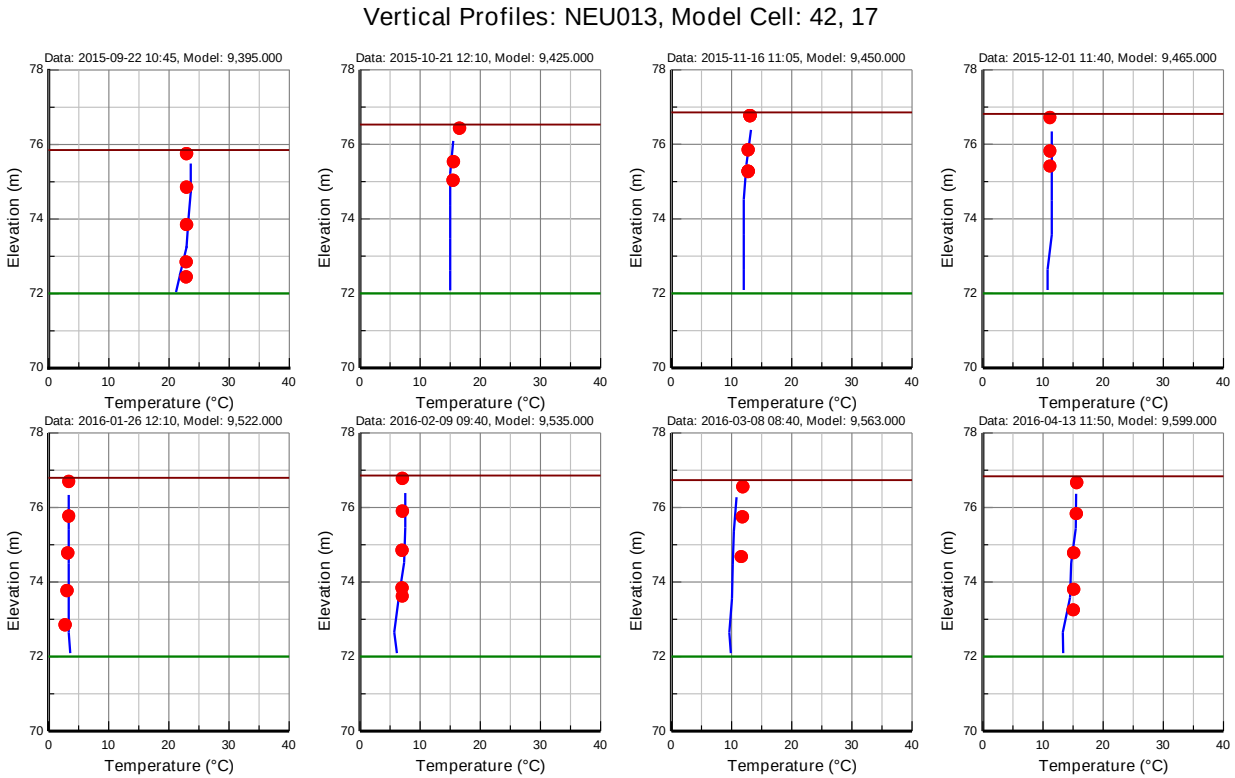
- Vertical Temperature Profiles:
  - NEU013



January 2015 – August 2015 (1 of 6)

Results

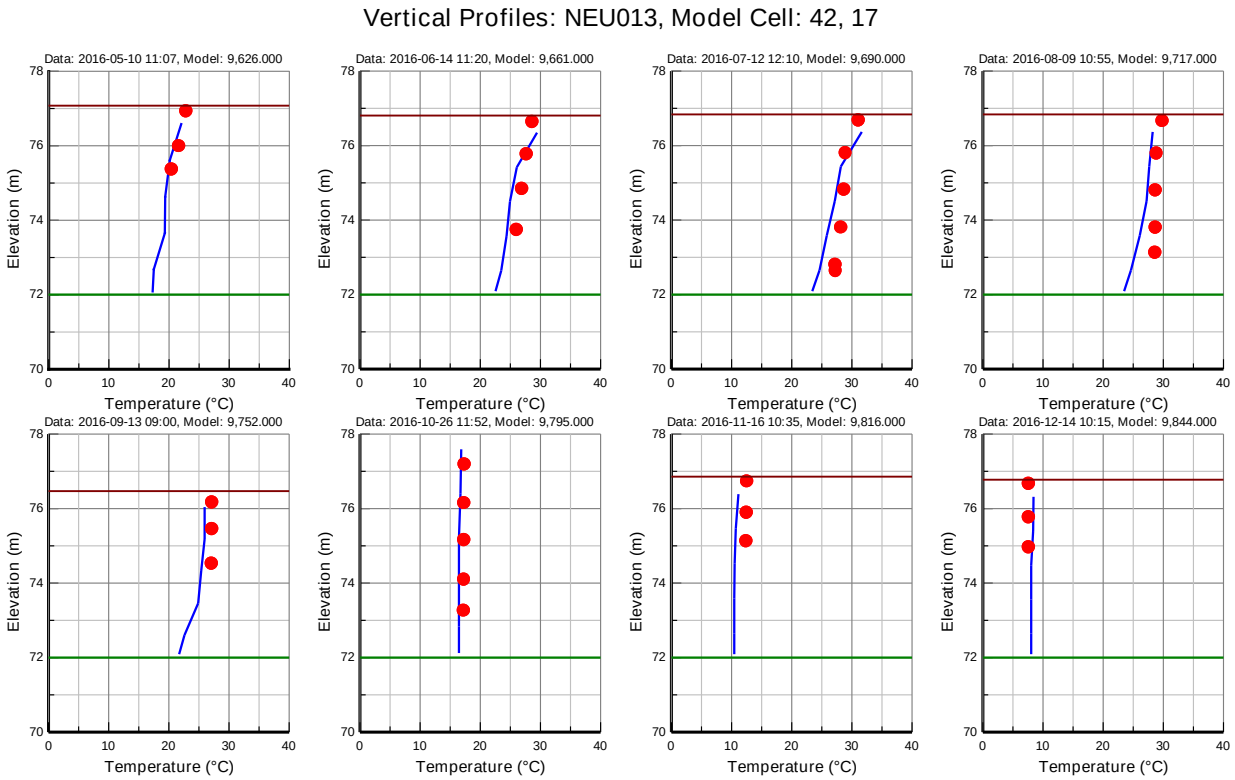
- Vertical Temperature Profiles:
  - NEU013



September 2015 – April 2016 (2 of 6)

Results

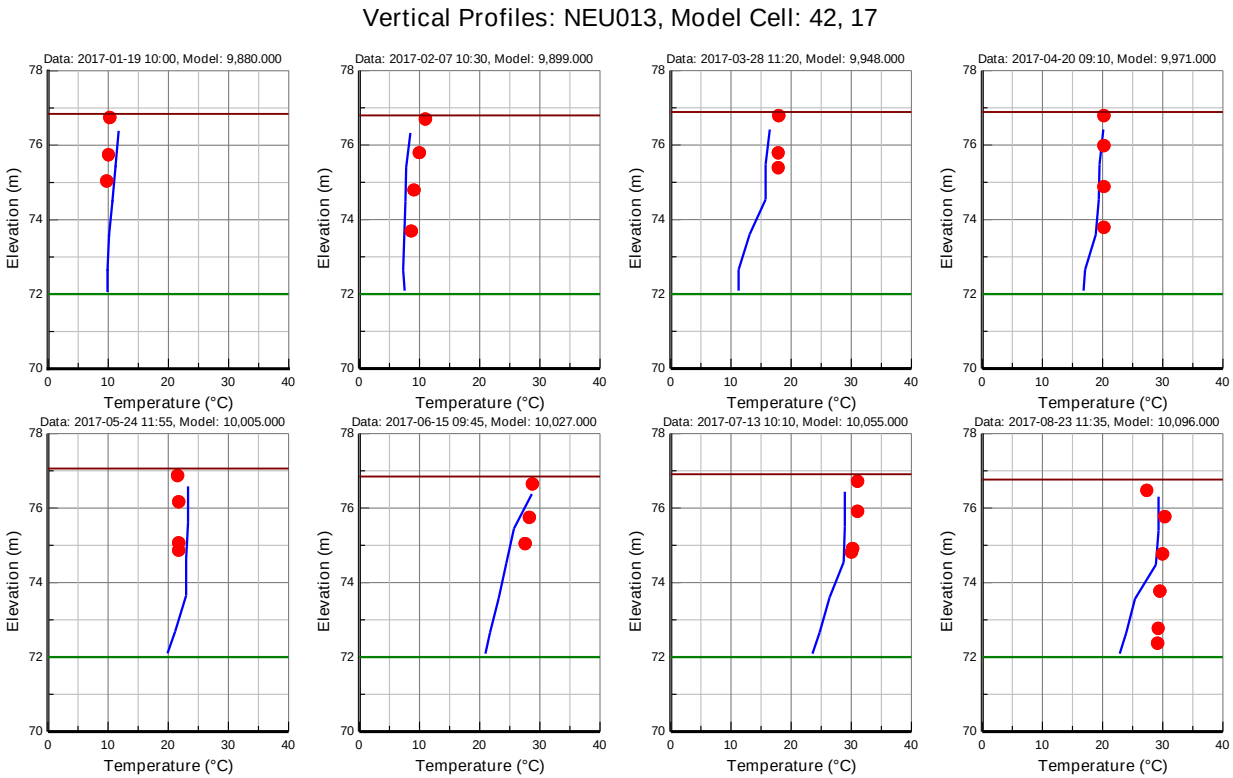
- Vertical Temperature Profiles:
  - NEU013



May 2016 – December 2016 (3 of 6)

Results

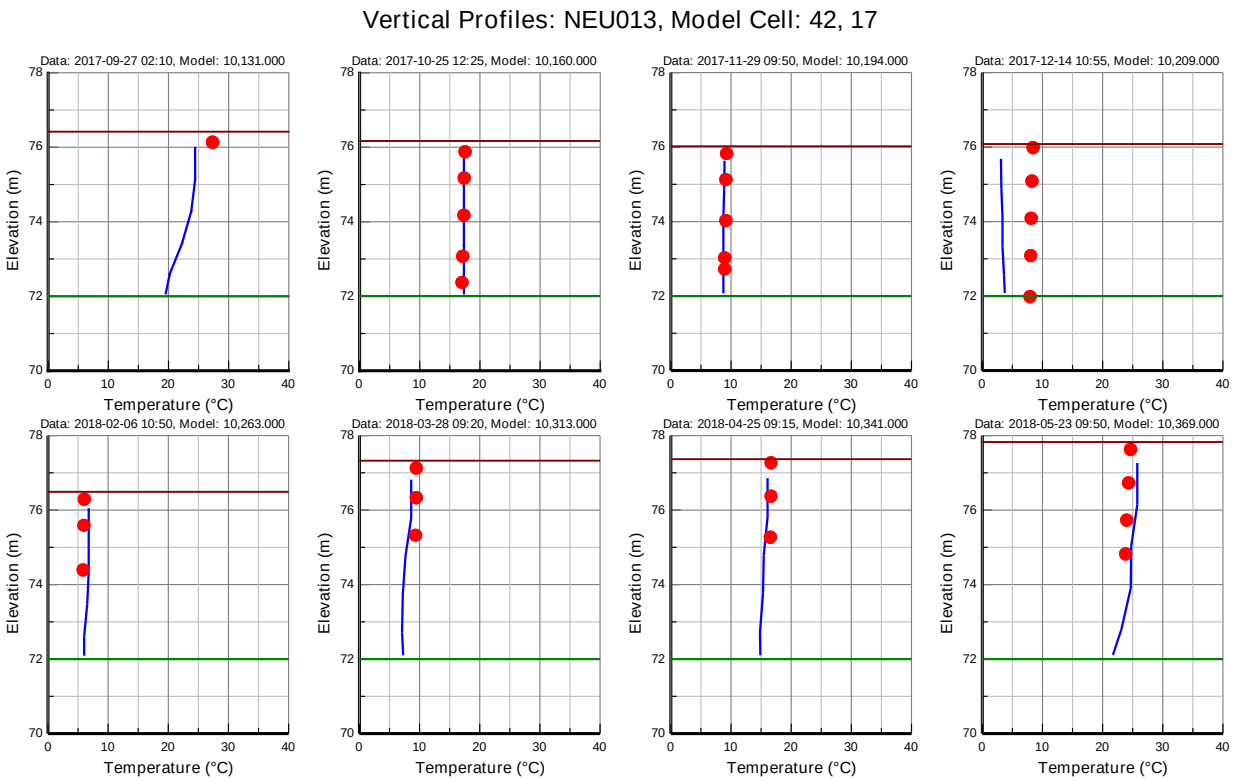
- Vertical Temperature Profiles:
  - NEU013



January 2017 – August 2017 (4 of 6)

Results

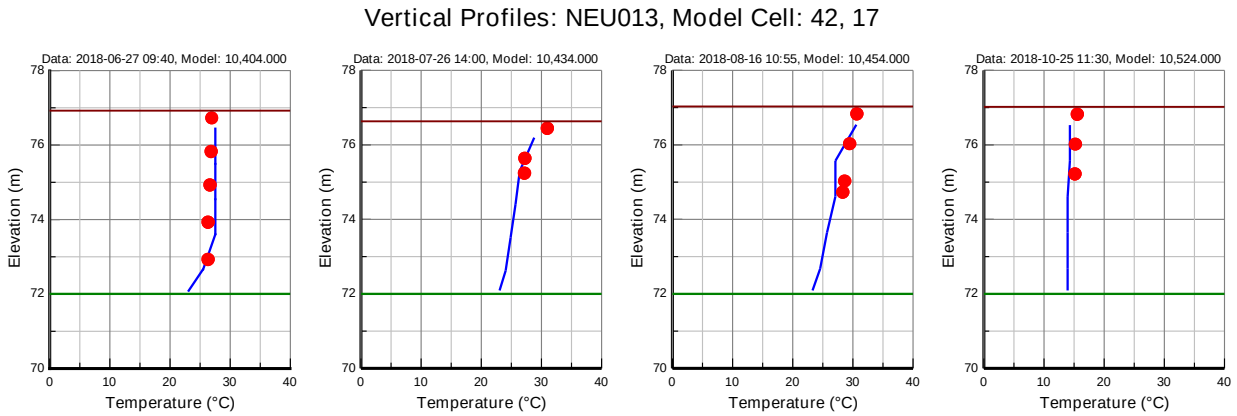
- Vertical Temperature Profiles:
  - NEU013



September 2017 – May 2018 (5 of 6)

Results

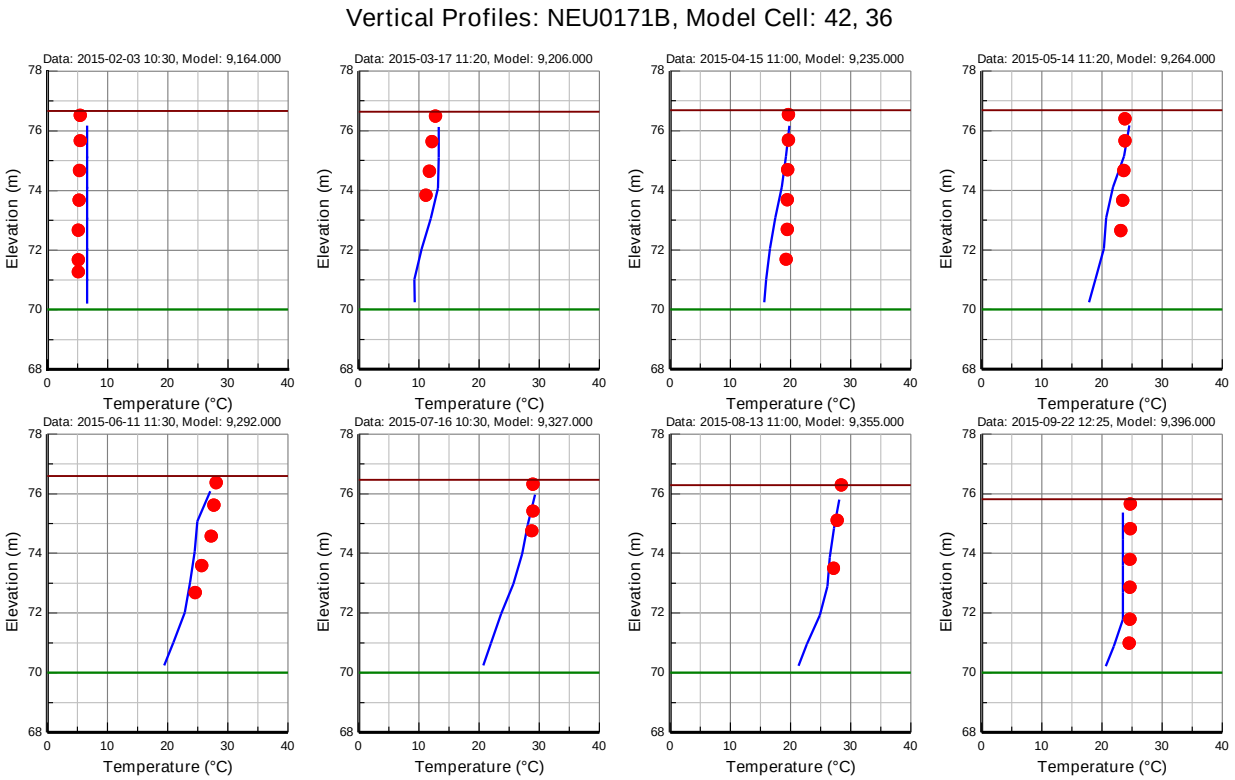
- Vertical Temperature Profiles:
  - NEU013



June 2018 – October 2018 (6 of 6)

Results

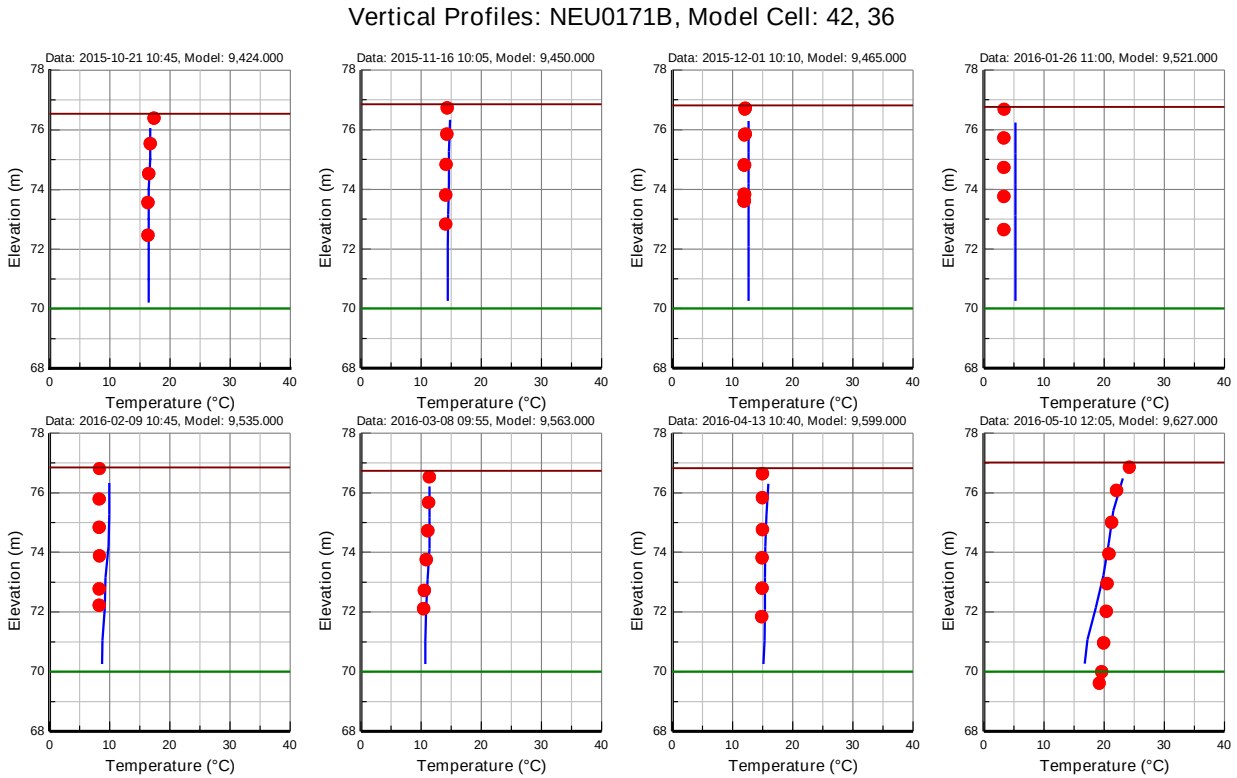
- Vertical Temperature Profiles:
  - NEU0171B



February 2015 – September 2015 (1 of 6)

Results

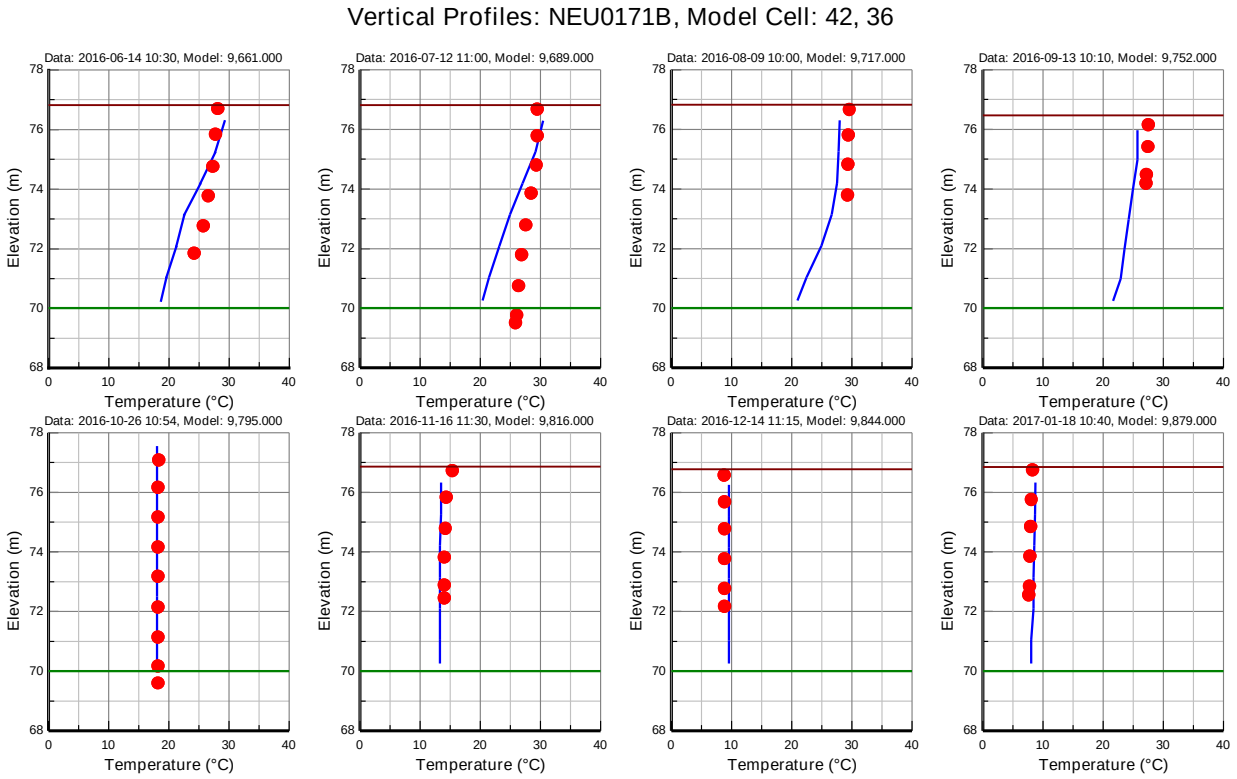
- Vertical Temperature Profiles:
  - NEU0171B



October 2015 – May 2016 (2 of 6)

Results

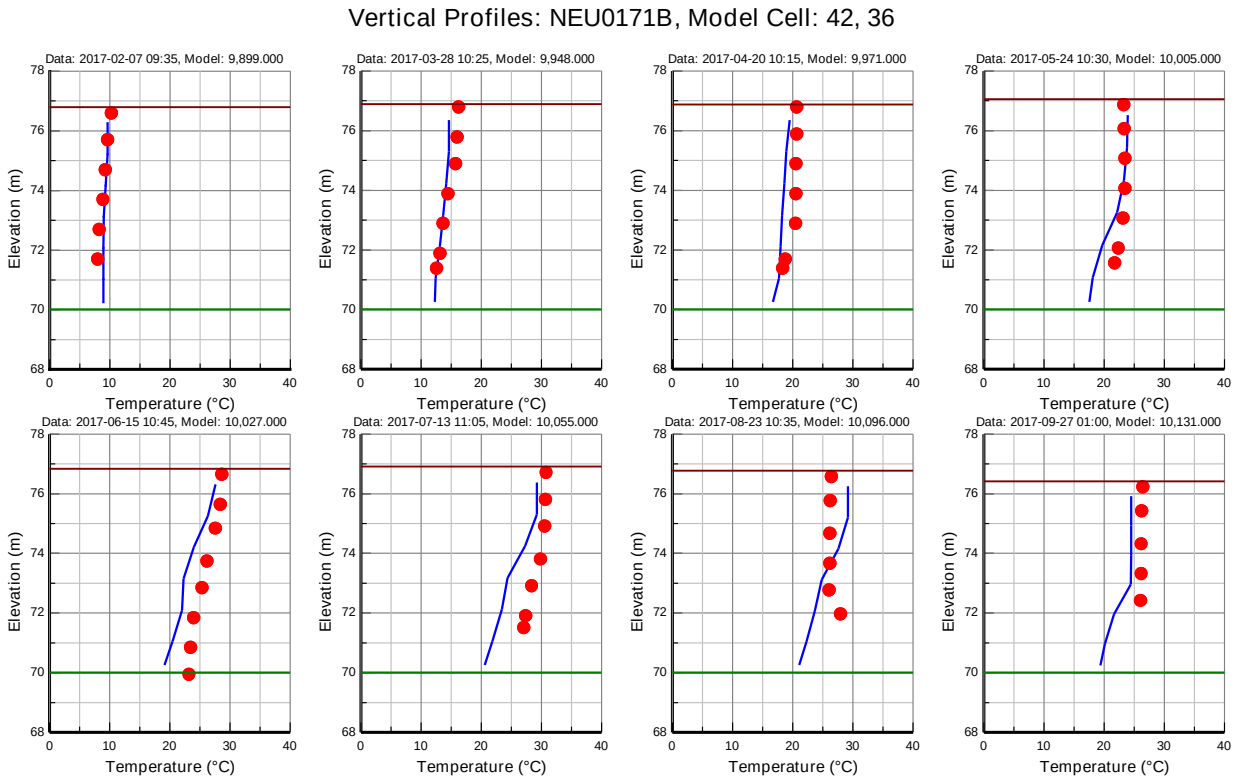
- Vertical Temperature Profiles:
  - NEU0171B



June 2016 – January 2017 (3 of 6)

Results

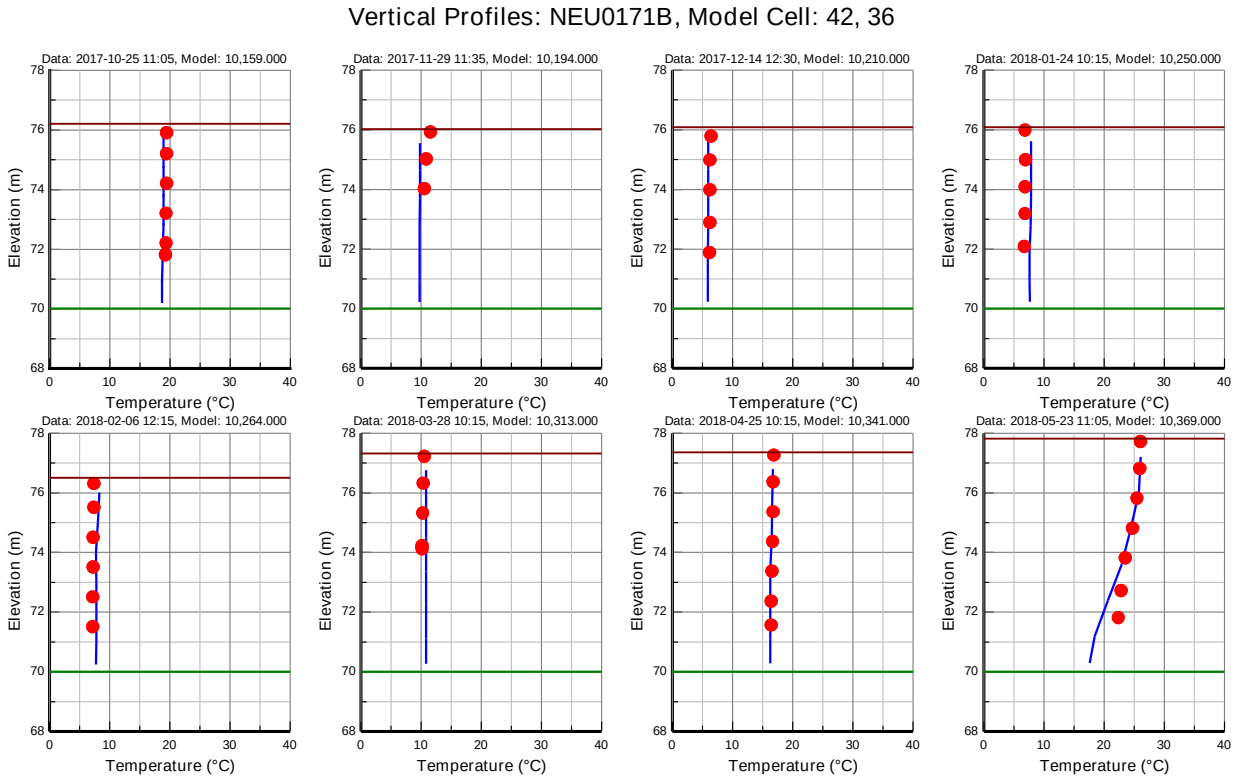
- Vertical Temperature Profiles:
  - NEU0171B



February 2017 – September 2017 (4 of 6)

Results

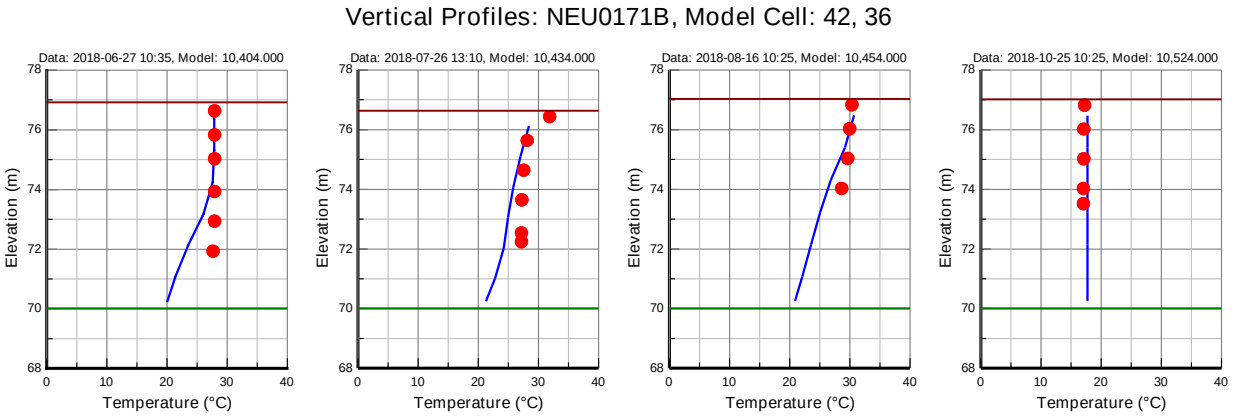
- Vertical Temperature Profiles:
  - NEU0171B



October 2017 – May 2018 (5 of 6)

Results

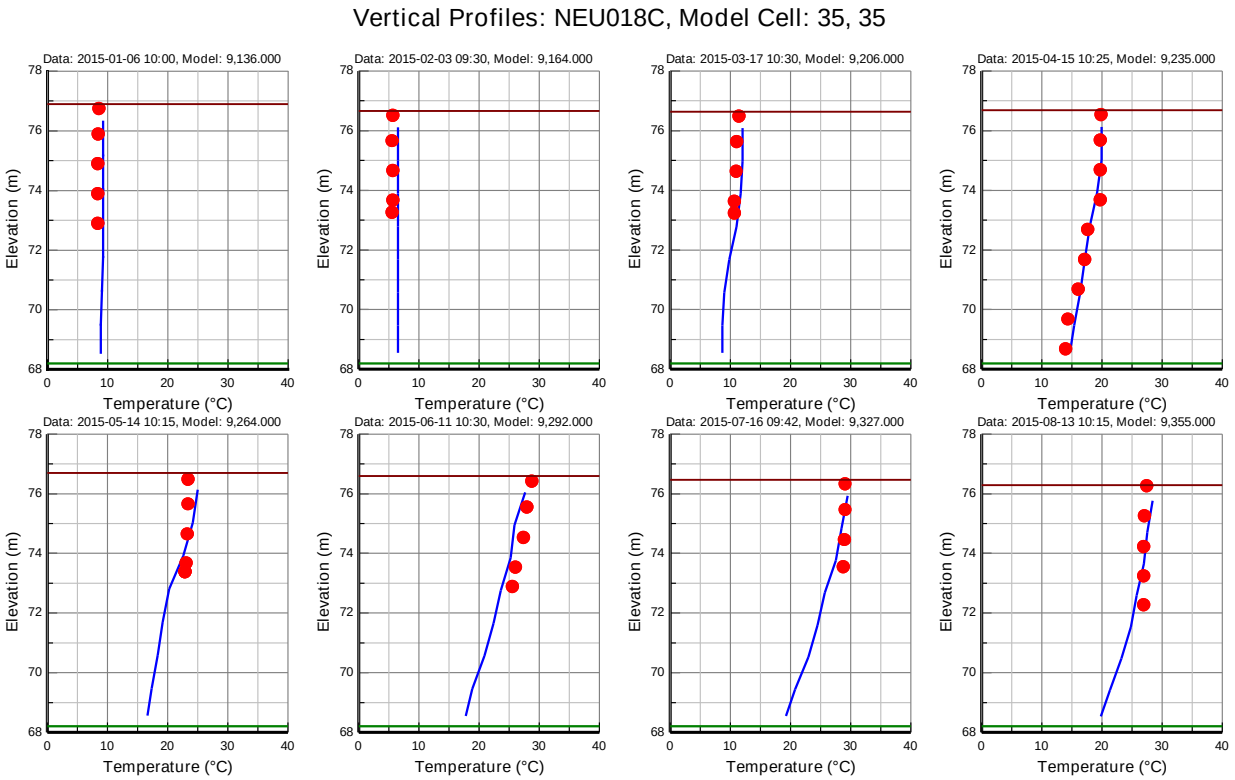
- Vertical Temperature Profiles:
  - NEU0171B



June 2018 – October 2018 (6 of 6)

Results

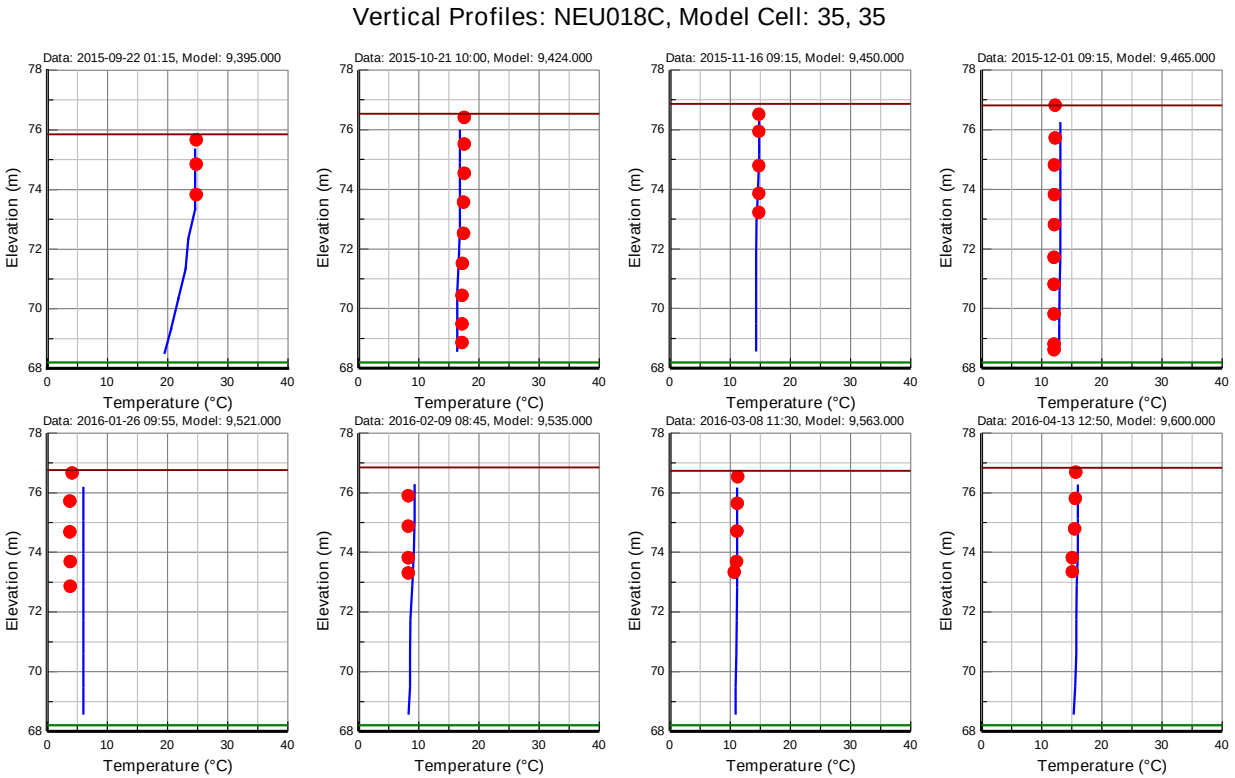
- Vertical Temperature Profiles:
  - NEU018C



January 2015 – August 2015 (1 of 6)

Results

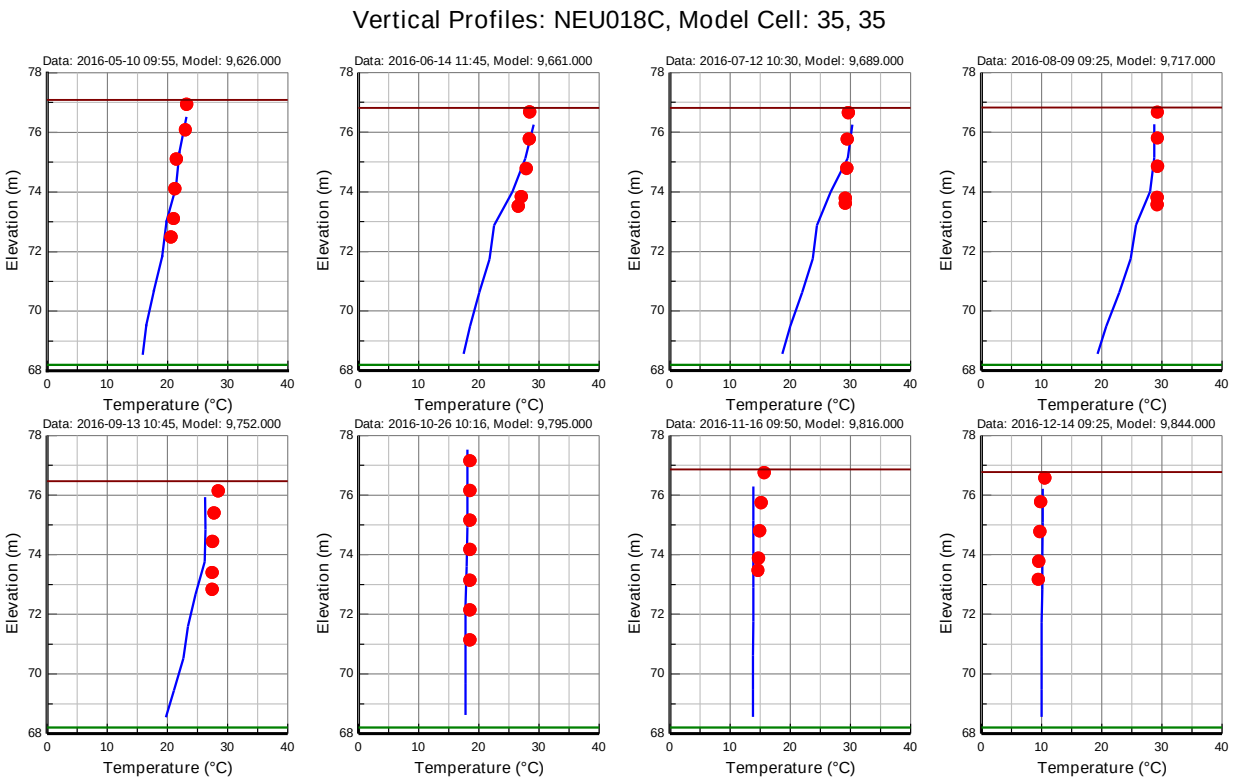
- Vertical Temperature Profiles:
  - NEU018C



September 2015 – April 2016 (2 of 6)

Results

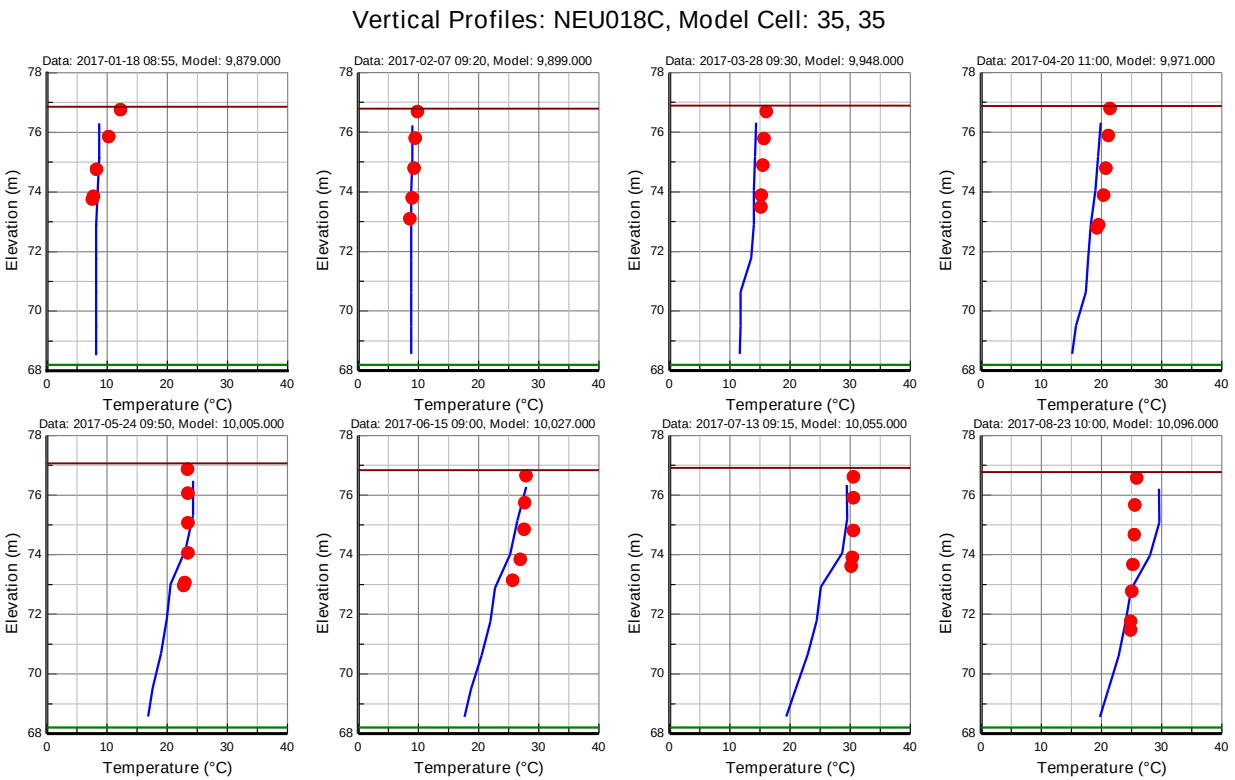
- Vertical Temperature Profiles:
  - NEU018C



May 2016 – December 2016 (3 of 6)

Results

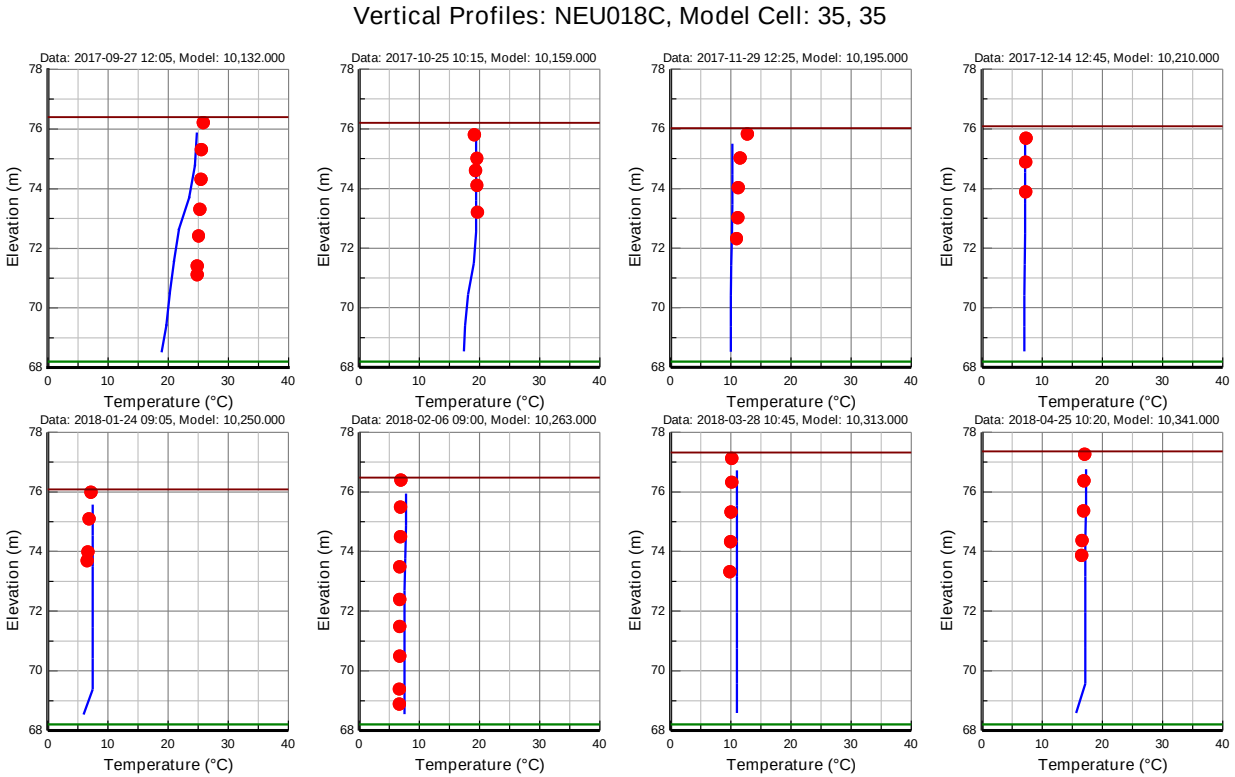
- Vertical Temperature Profiles:
  - NEU018C



January 2017 – August 2017 (4 of 6)

Results

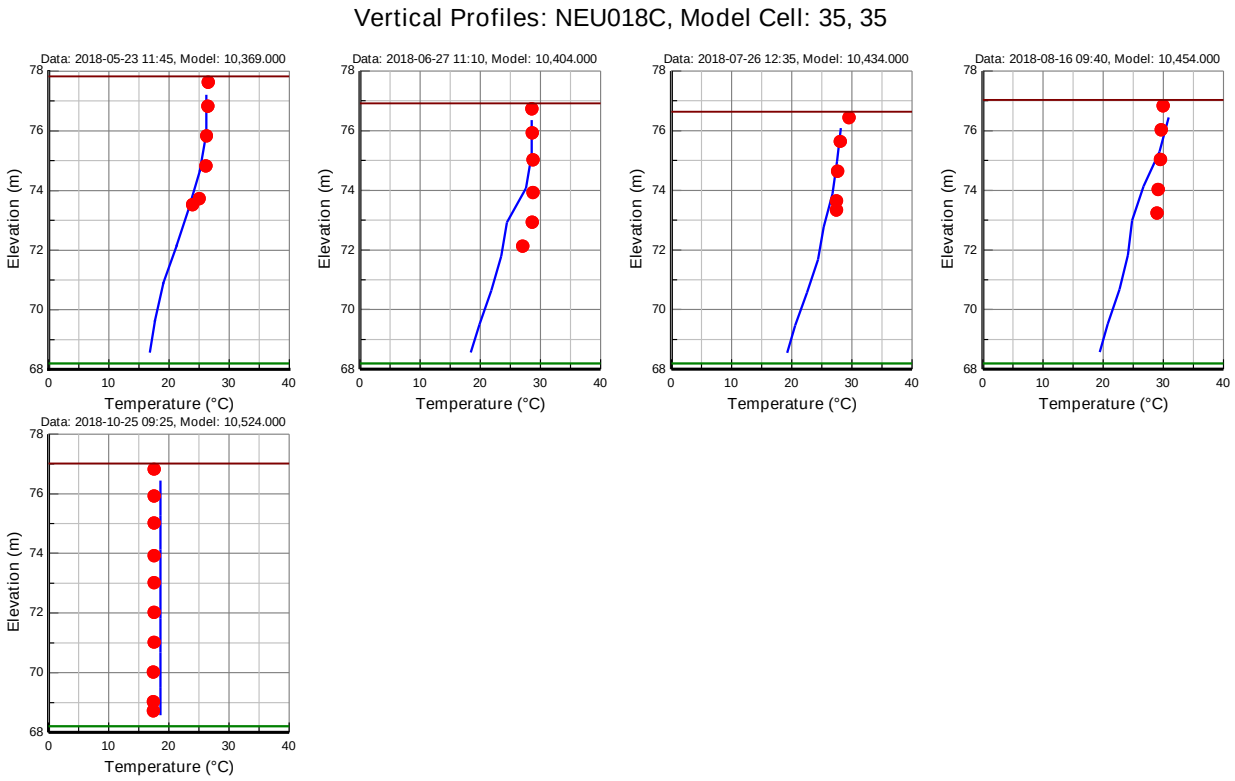
- Vertical Temperature Profiles:
  - NEU018C



September 2017 – April 2018 (5 of 6)

Results

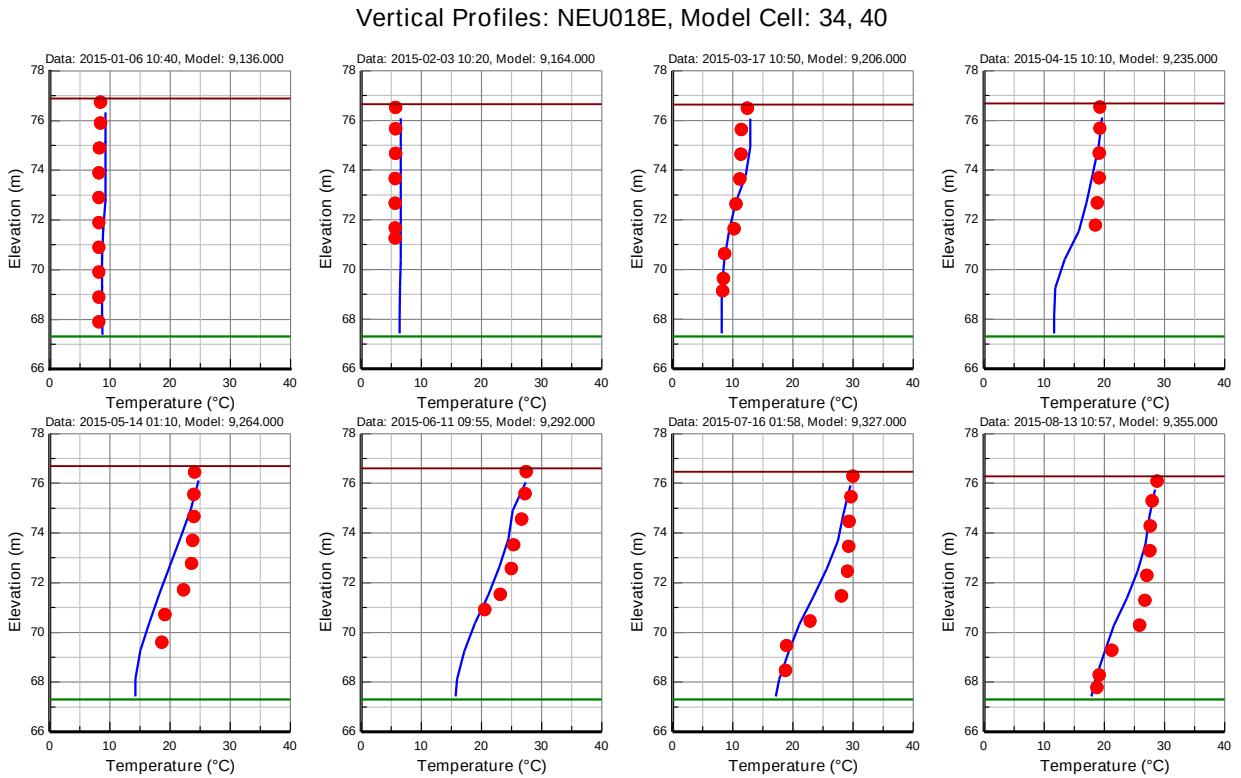
- Vertical Temperature Profiles:
  - NEU018C



May 2018 – October 2018 (6 of 6)

Results

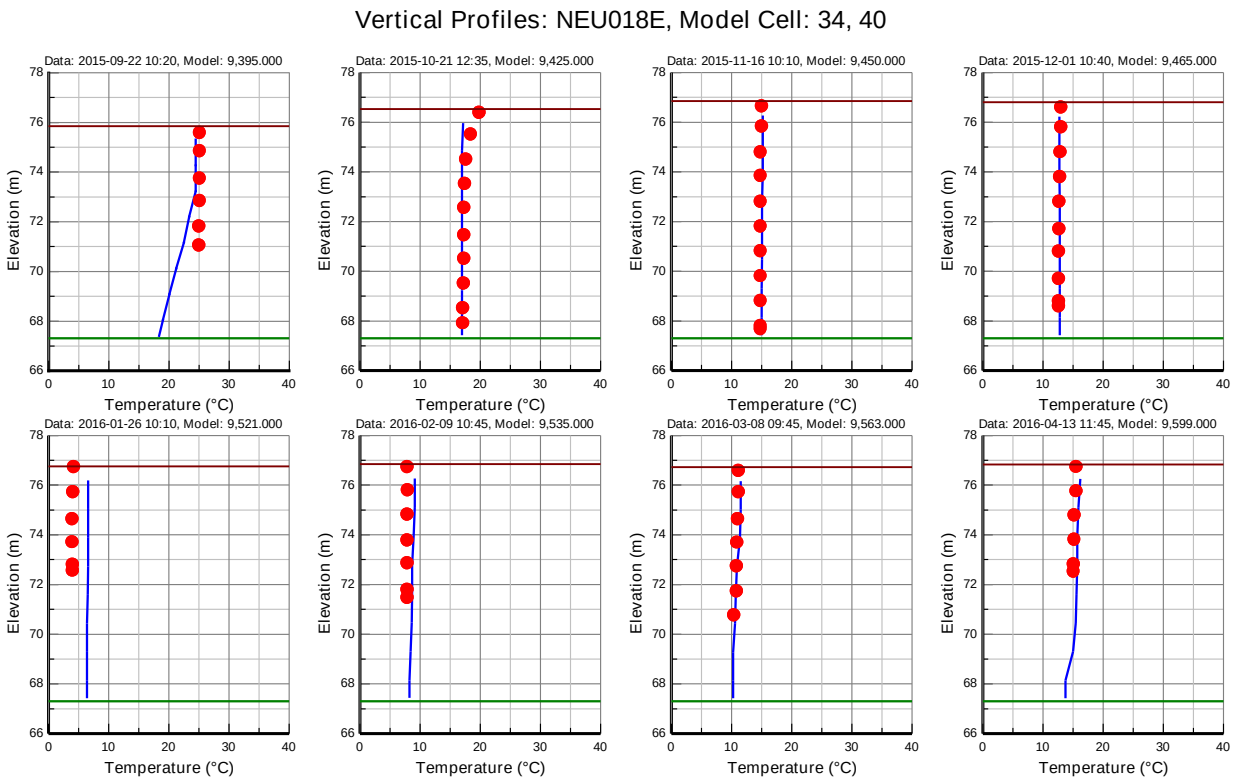
- Vertical Temperature Profiles:
  - NEU018E



January 2015 – August 2015 (1 of 6)

Results

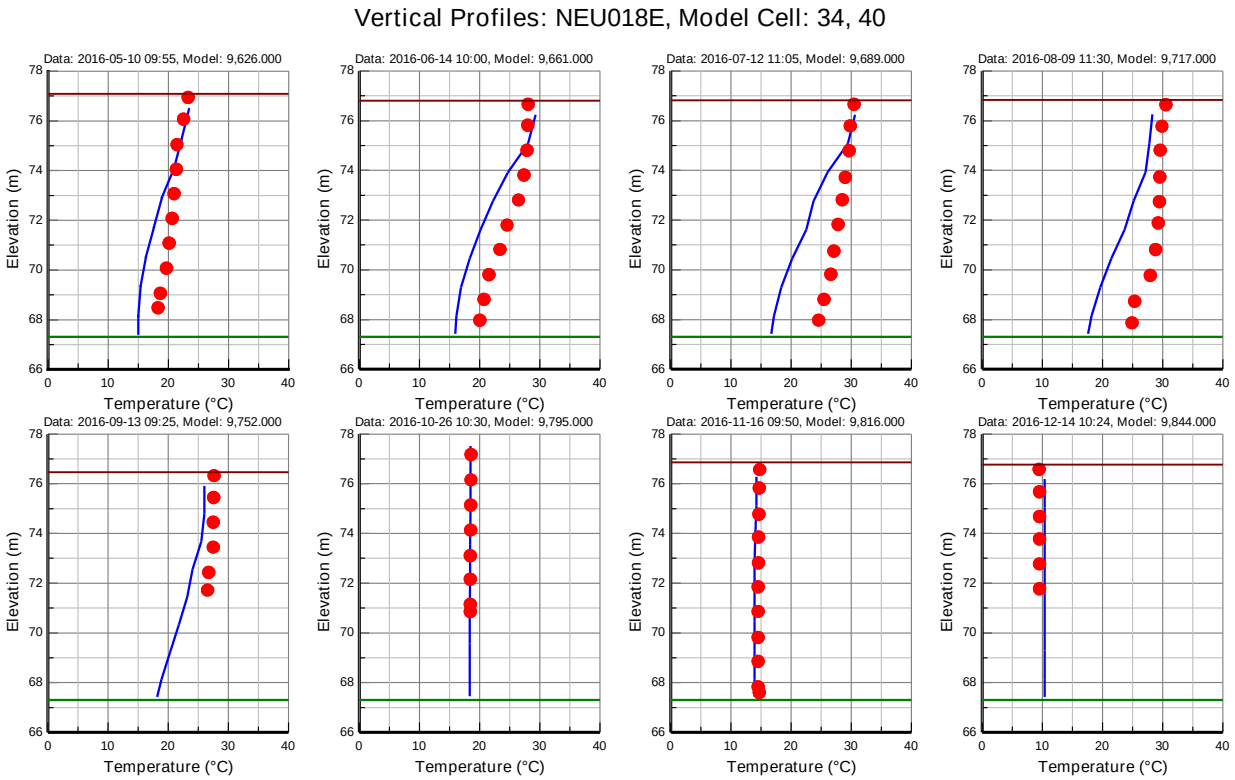
- Vertical Temperature Profiles:
  - NEU018E



September 2015 – April 2016 (2 of 6)

Results

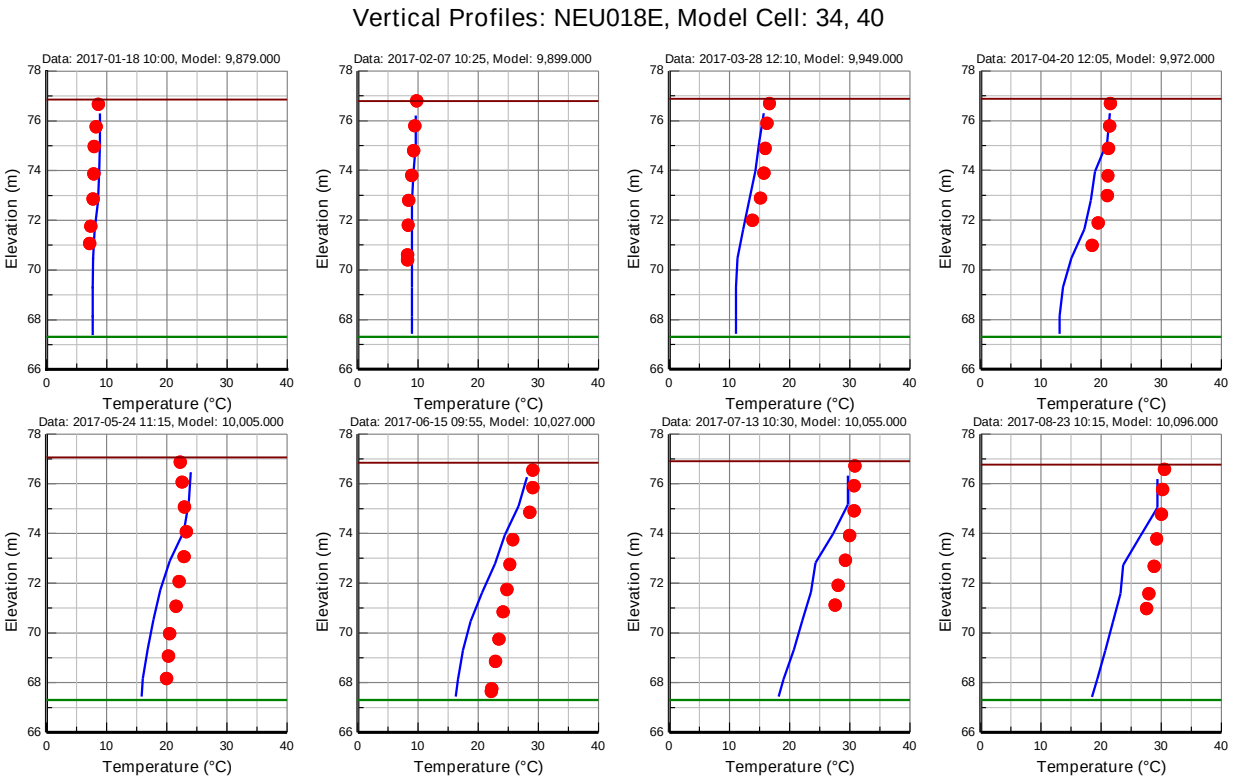
- Vertical Temperature Profiles:
  - NEU018E



May 2016 – December 2016 (3 of 6)

Results

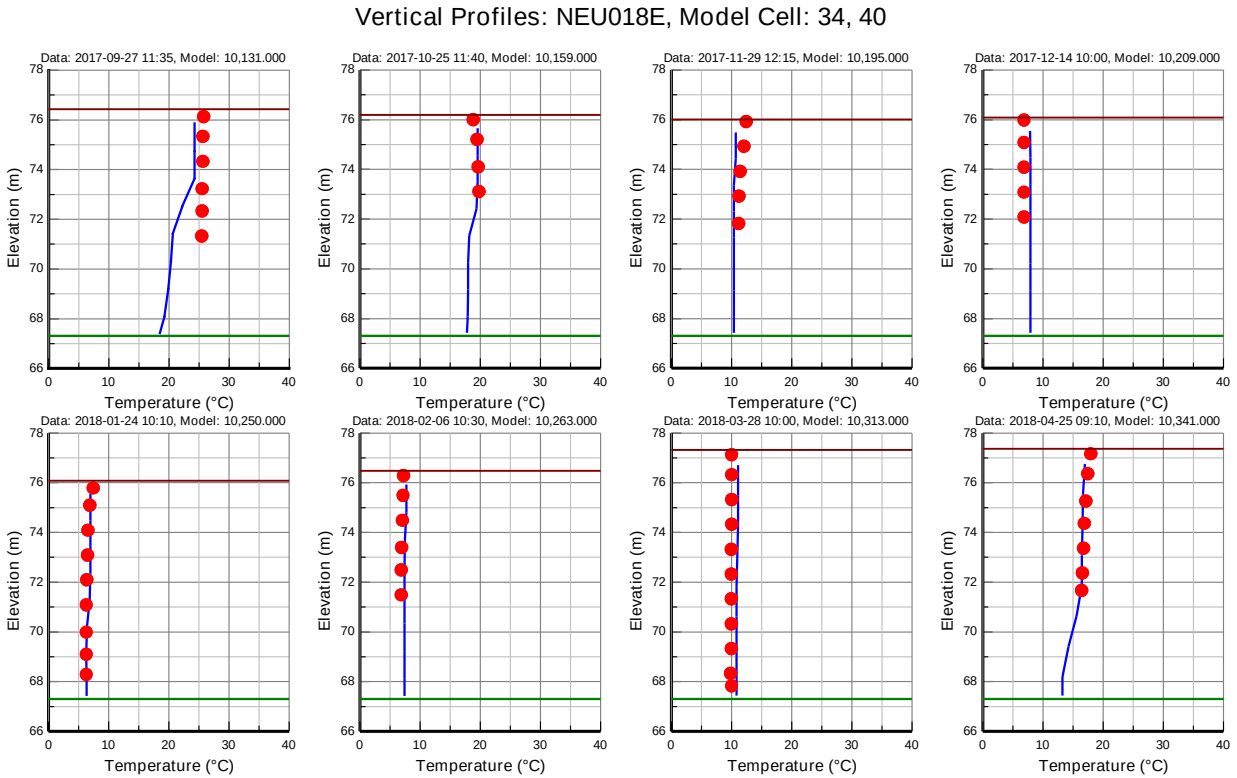
- Vertical Temperature Profiles:
  - NEU018E



January 2017 – August 2017 (4 of 6)

Results

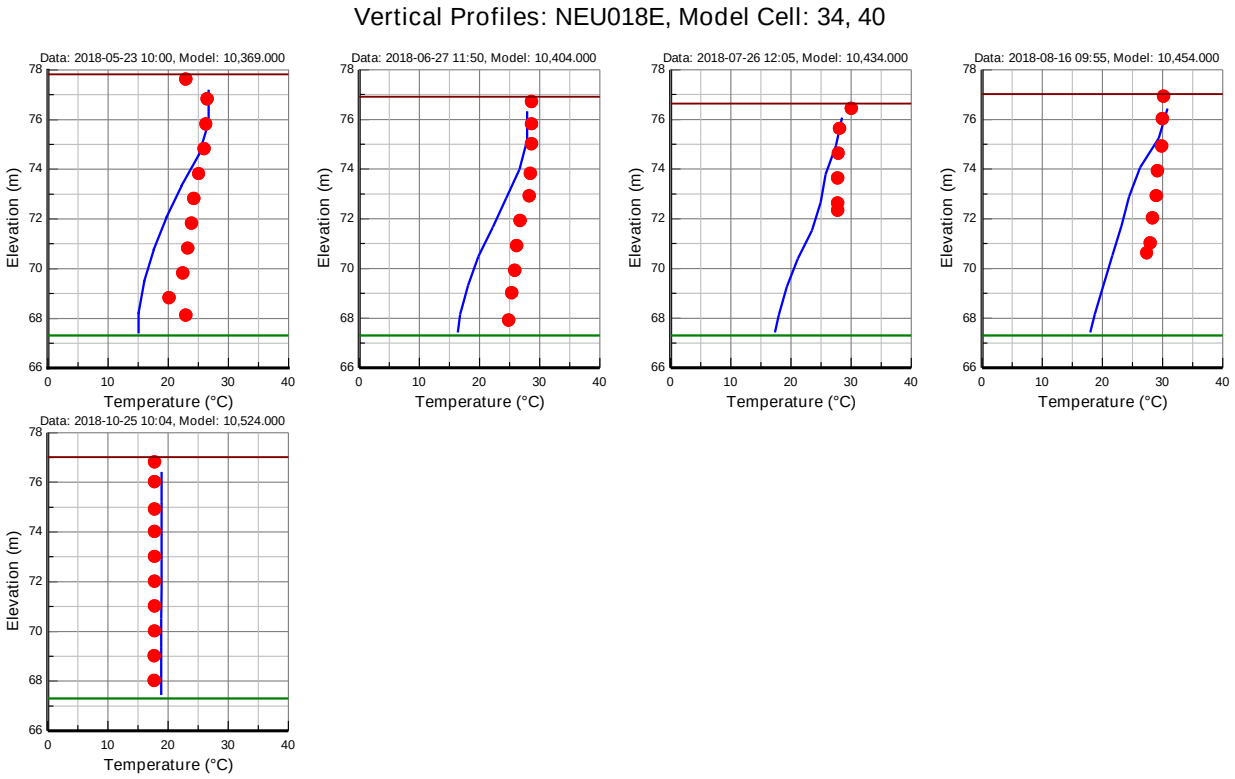
- Vertical Temperature Profiles:
  - NEU018E



September 2017 – April 2018 (5 of 6)

Results

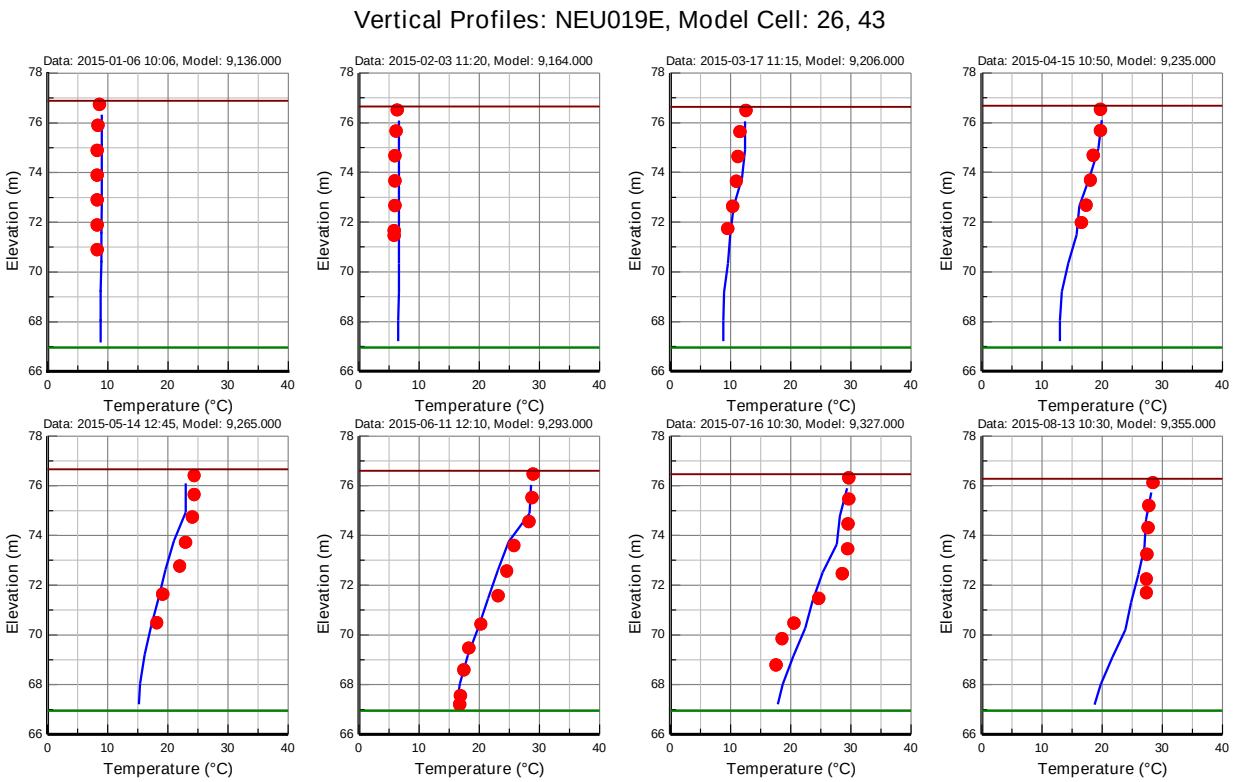
- Vertical Temperature Profiles:
  - NEU018E



May 2018 – October 2018 (6 of 6)

Results

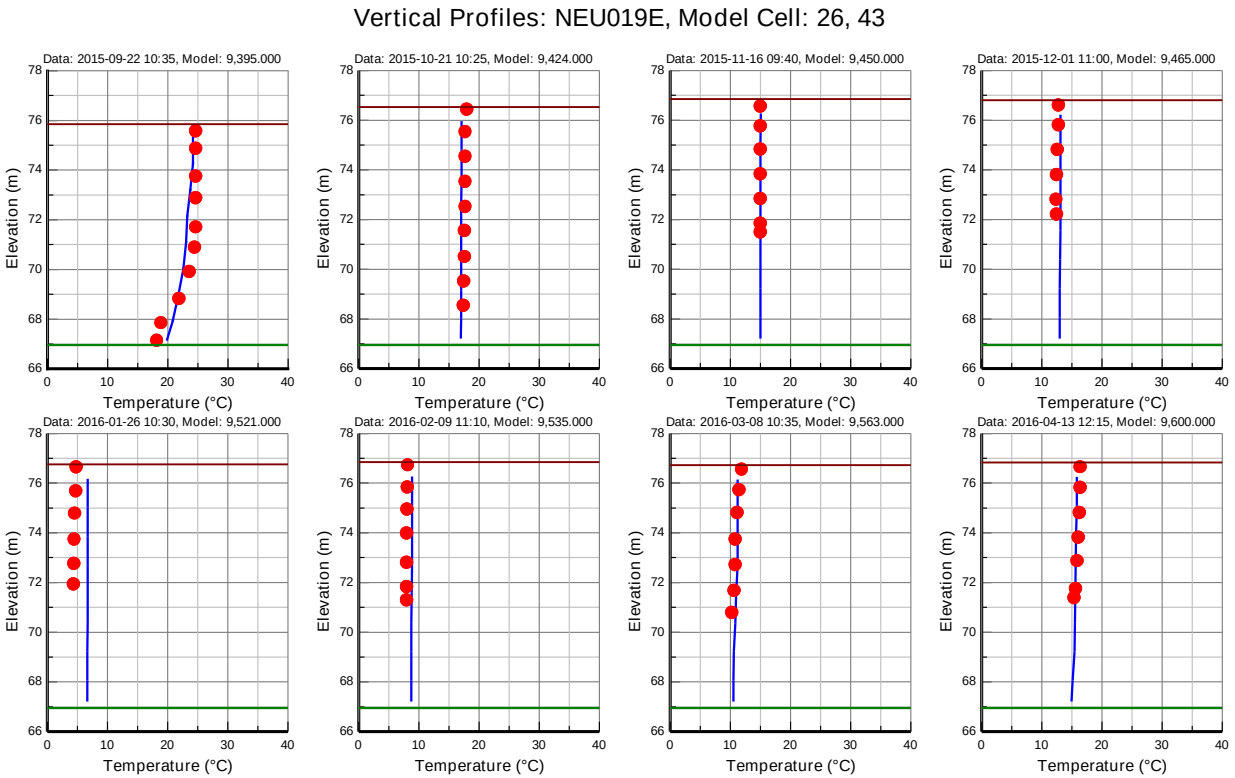
- Vertical Temperature Profiles:
  - NEU019E



January 2015 – August 2015 (1 of 6)

Results

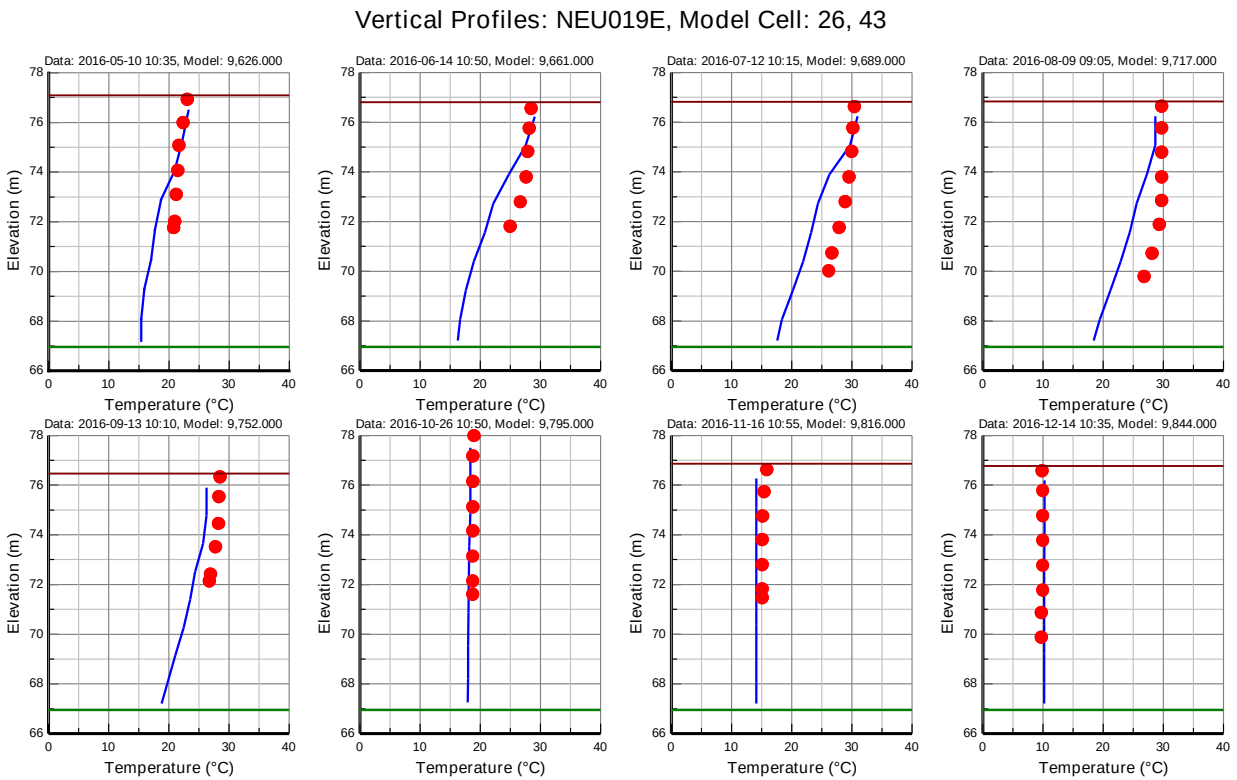
- Vertical Temperature Profiles:
  - NEU019E



September 2015 – April 2016 (2 of 6)

Results

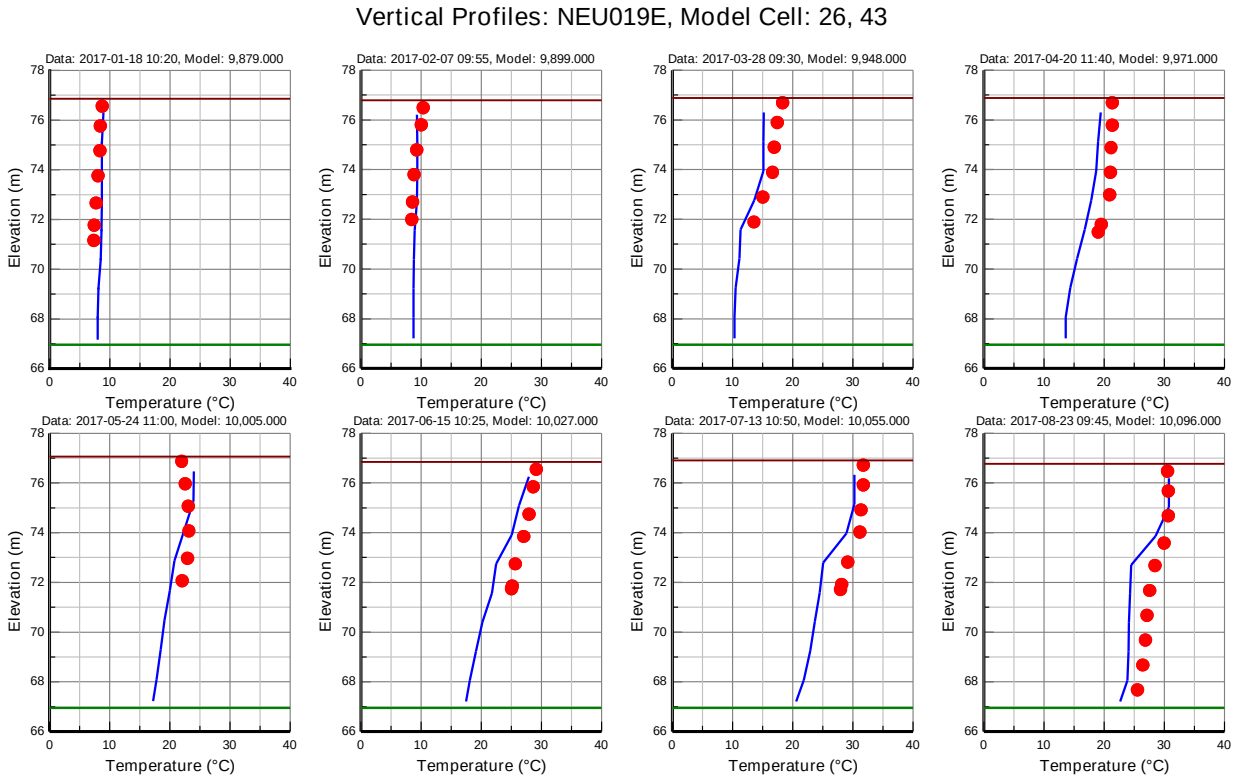
- Vertical Temperature Profiles:
  - NEU019E



May 2016 – December 2016 (3 of 6)

Results

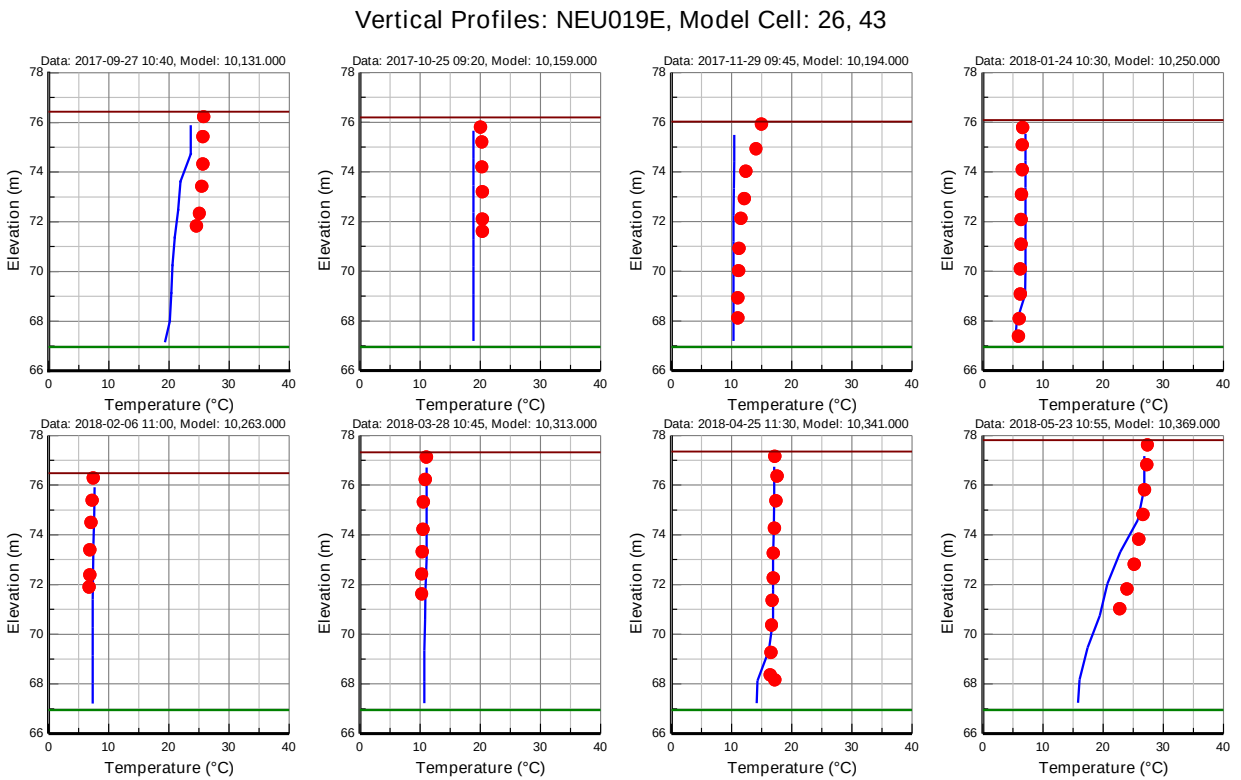
- Vertical Temperature Profiles:
  - NEU019E



January 2017 – August 2017 (4 of 6)

Results

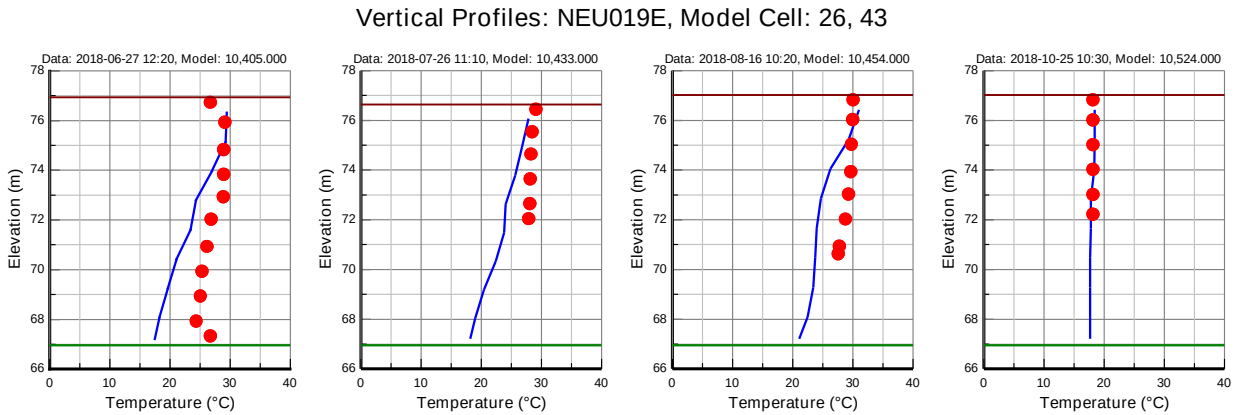
- Vertical Temperature Profiles:
  - NEU019E



September 2017 – May 2018 (5 of 6)

Results

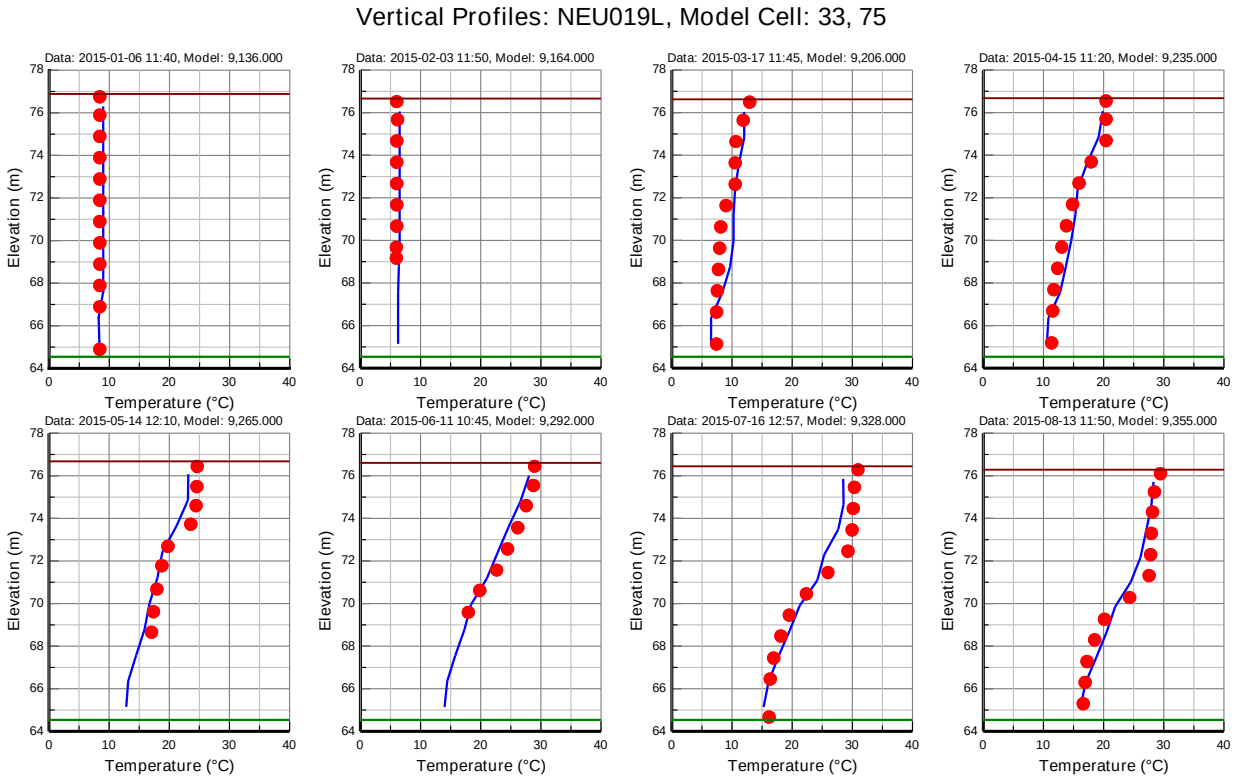
- Vertical Temperature Profiles:
  - NEU019E



May 2018 – October 2018 (6 of 6)

Results

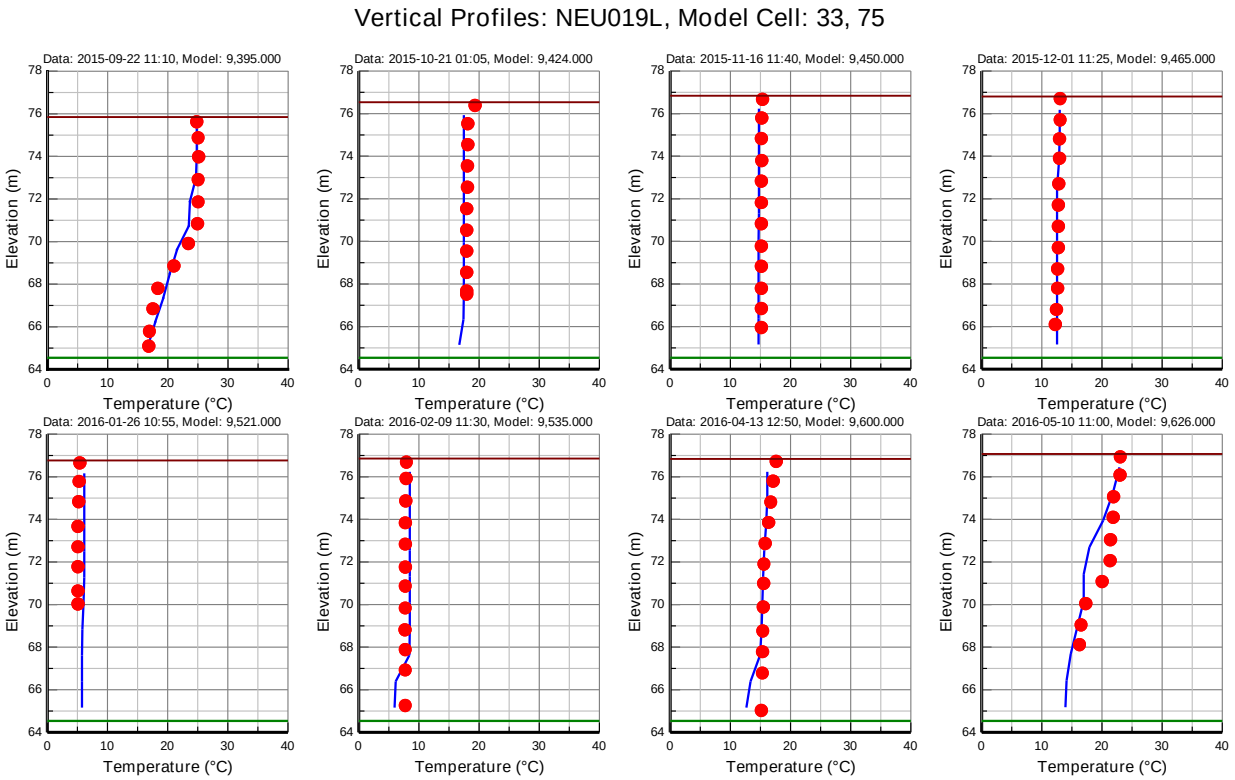
- Vertical Temperature Profiles:
  - NEU019L



January 2015 – August 2015 (1 of 6)

Results

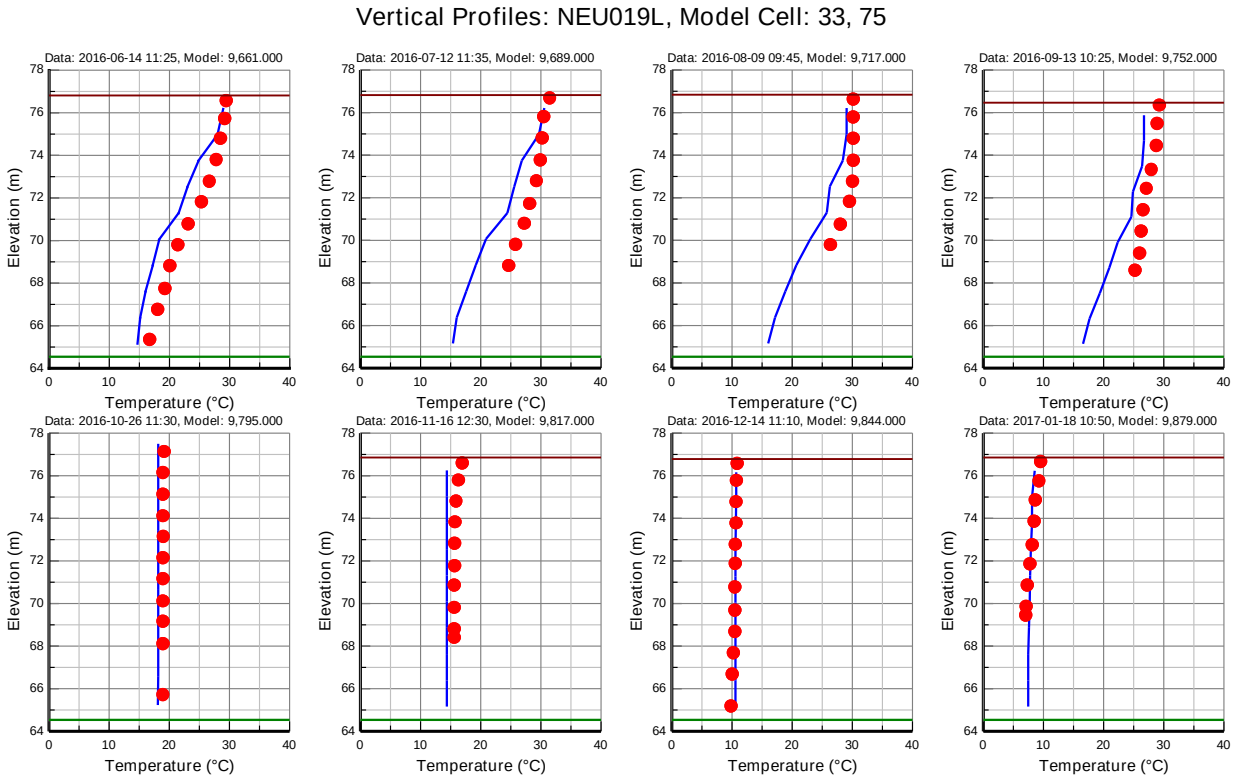
- Vertical Temperature Profiles:
  - NEU019L



September 2015 – May 2016 (2 of 6)

Results

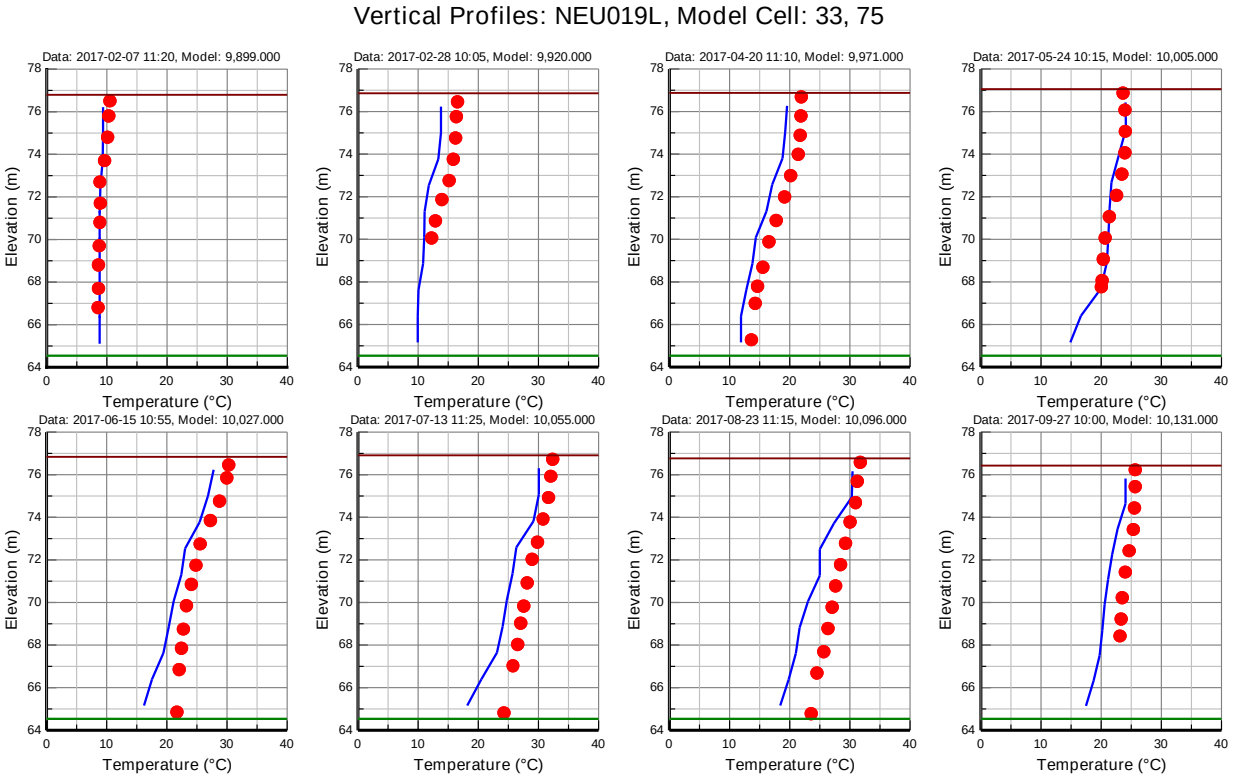
- Vertical Temperature Profiles:
  - NEU019L



June 2016 – January 2017 (3 of 6)

Results

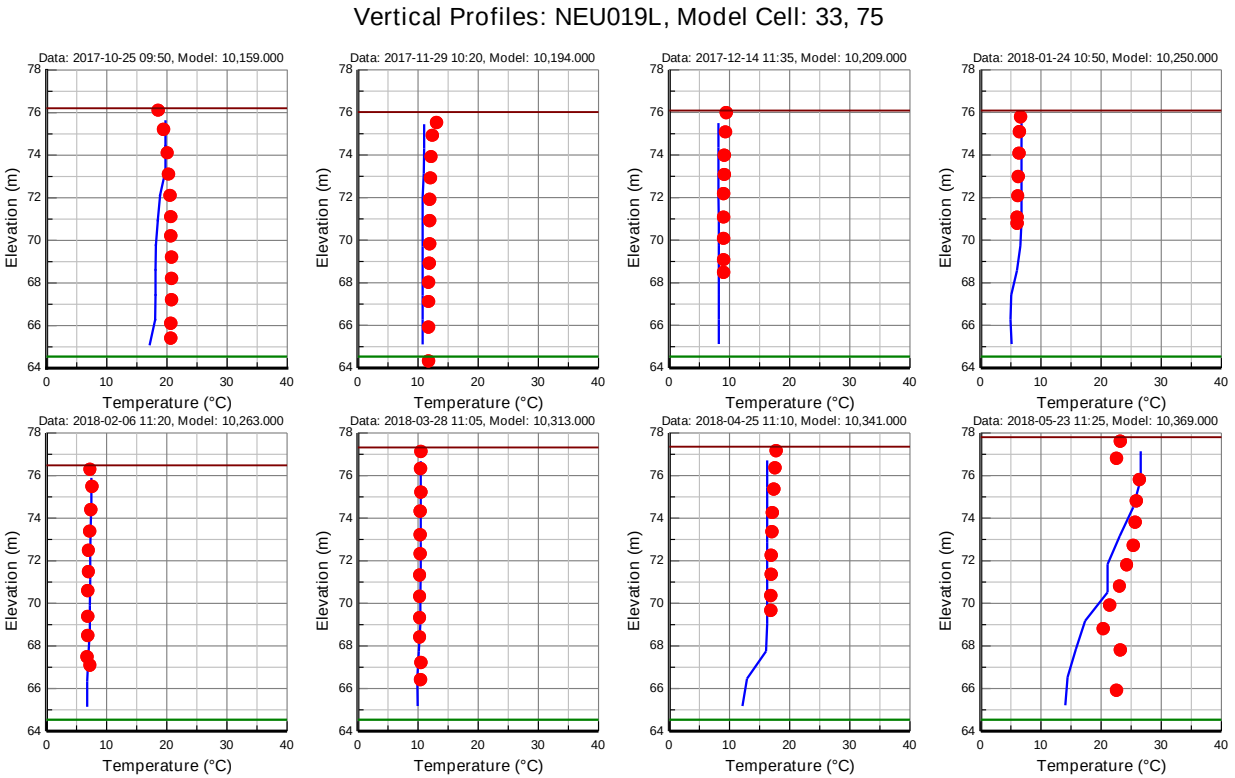
- Vertical Temperature Profiles:
  - NEU019L



February 2017 – September 2017 (4 of 6)

Results

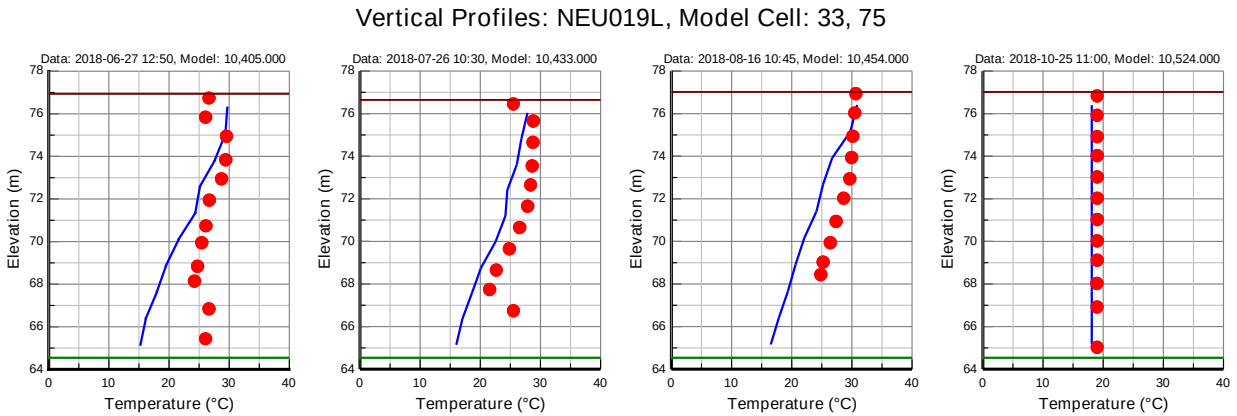
- Vertical Temperature Profiles:
  - NEU019L



October 2017 – May 2018 (5 of 6)

Results

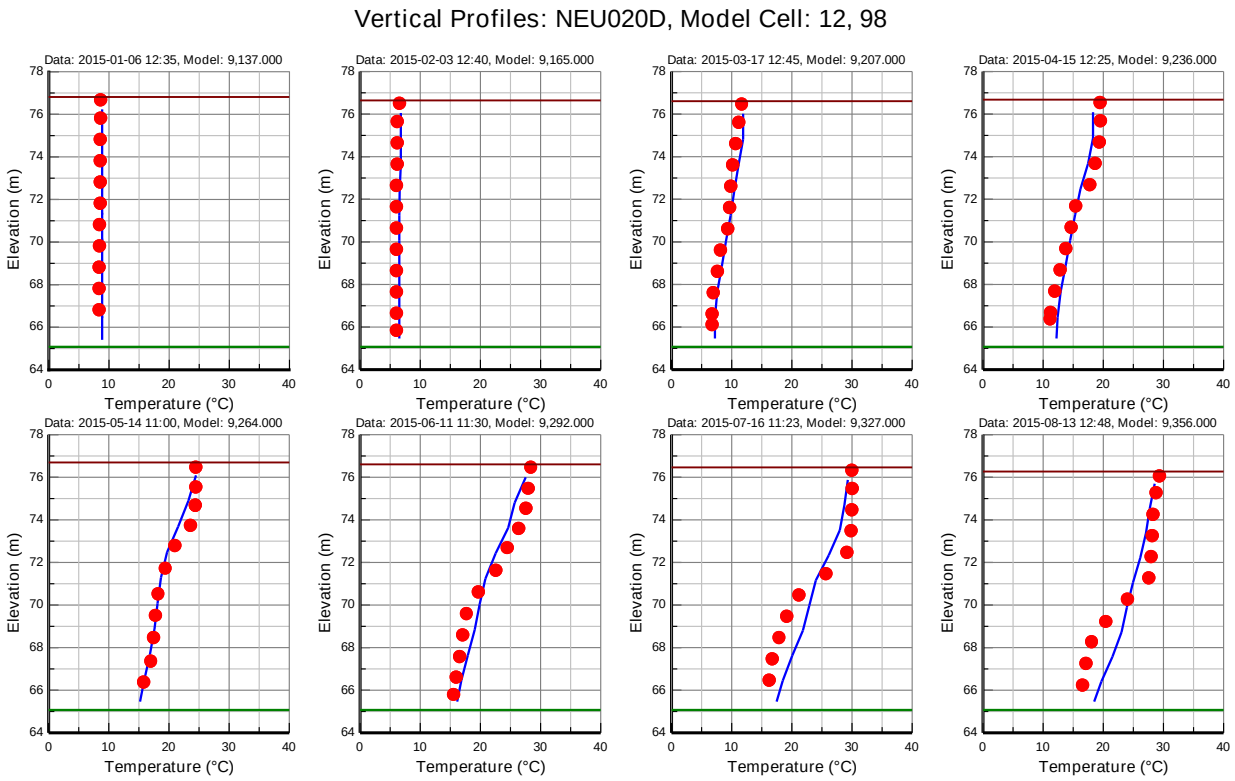
- Vertical Temperature Profiles:
  - NEU019L



June 2018 – October 2018 (6 of 6)

Results

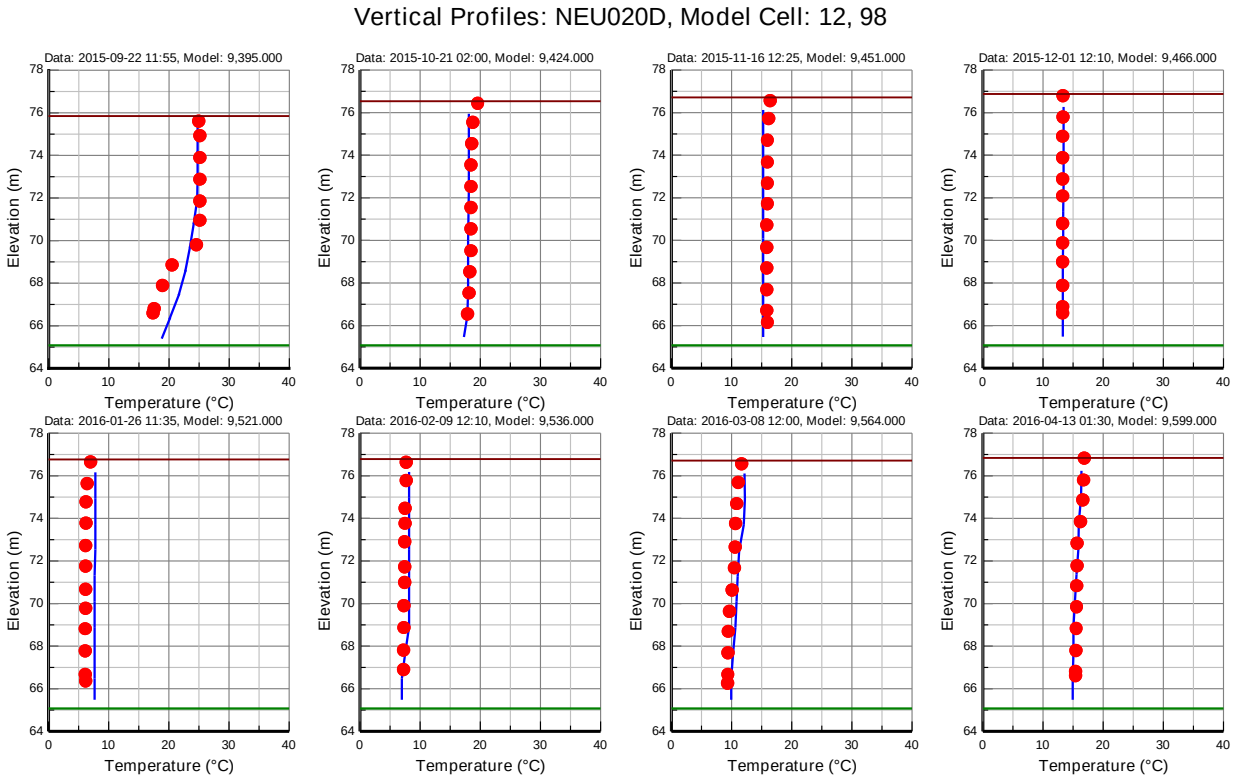
- Vertical Temperature Profiles:
  - NEU020D



January 2015 – August 2015 (1 of 6)

Results

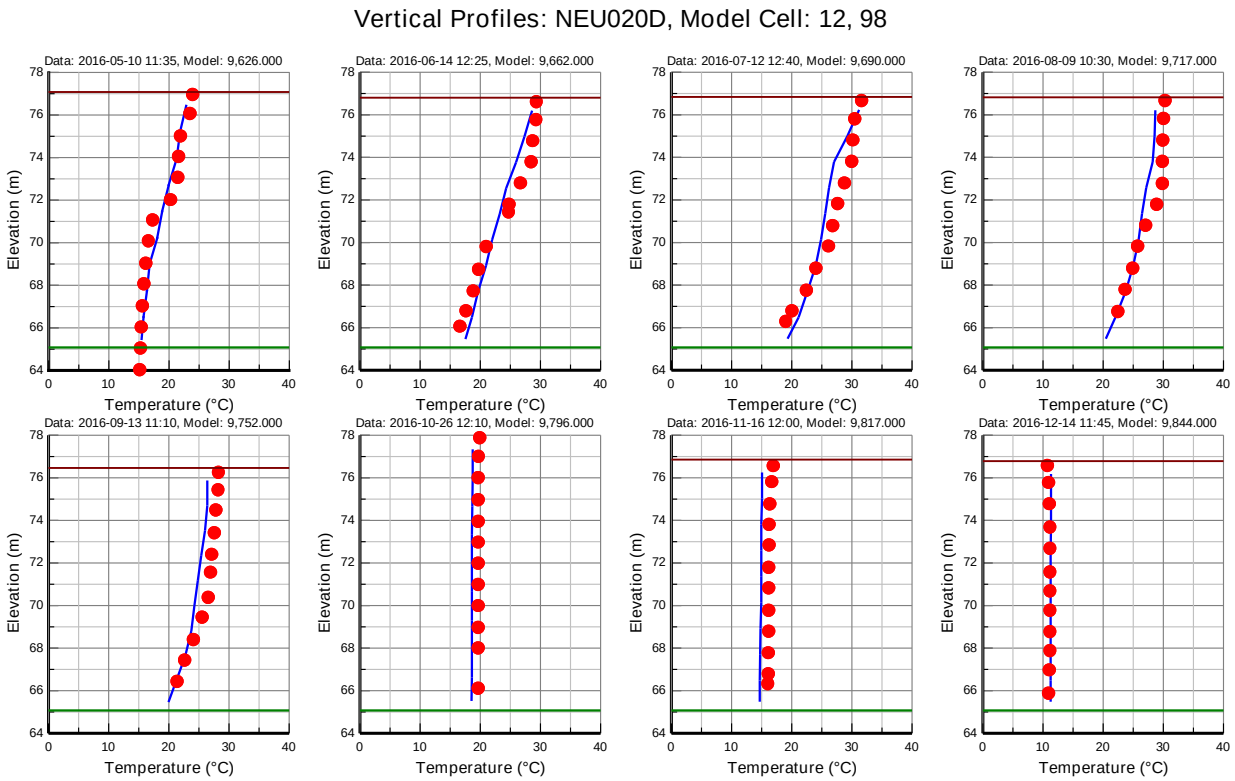
- Vertical Temperature Profiles:
  - NEU020D



September 2015 – April 2016 (2 of 6)

Results

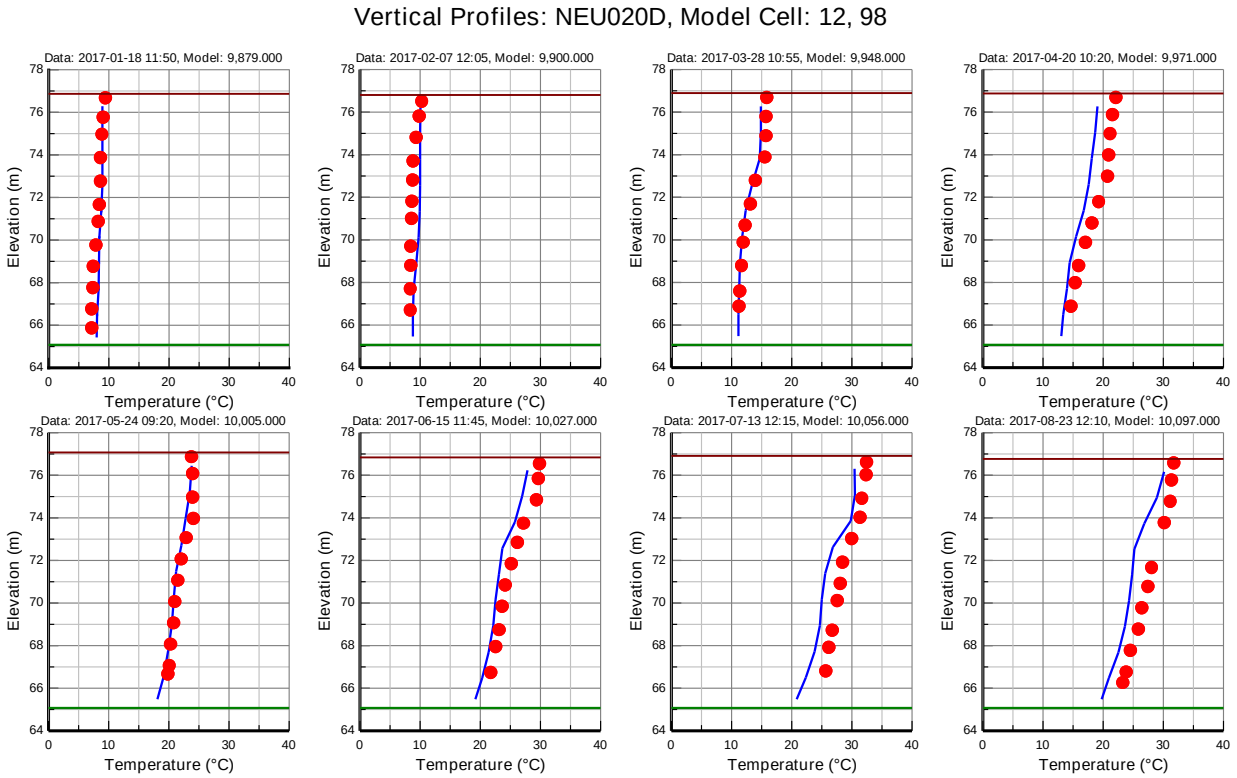
- Vertical Temperature Profiles:
  - NEU020D



May 2016 – December 2016 (3 of 6)

Results

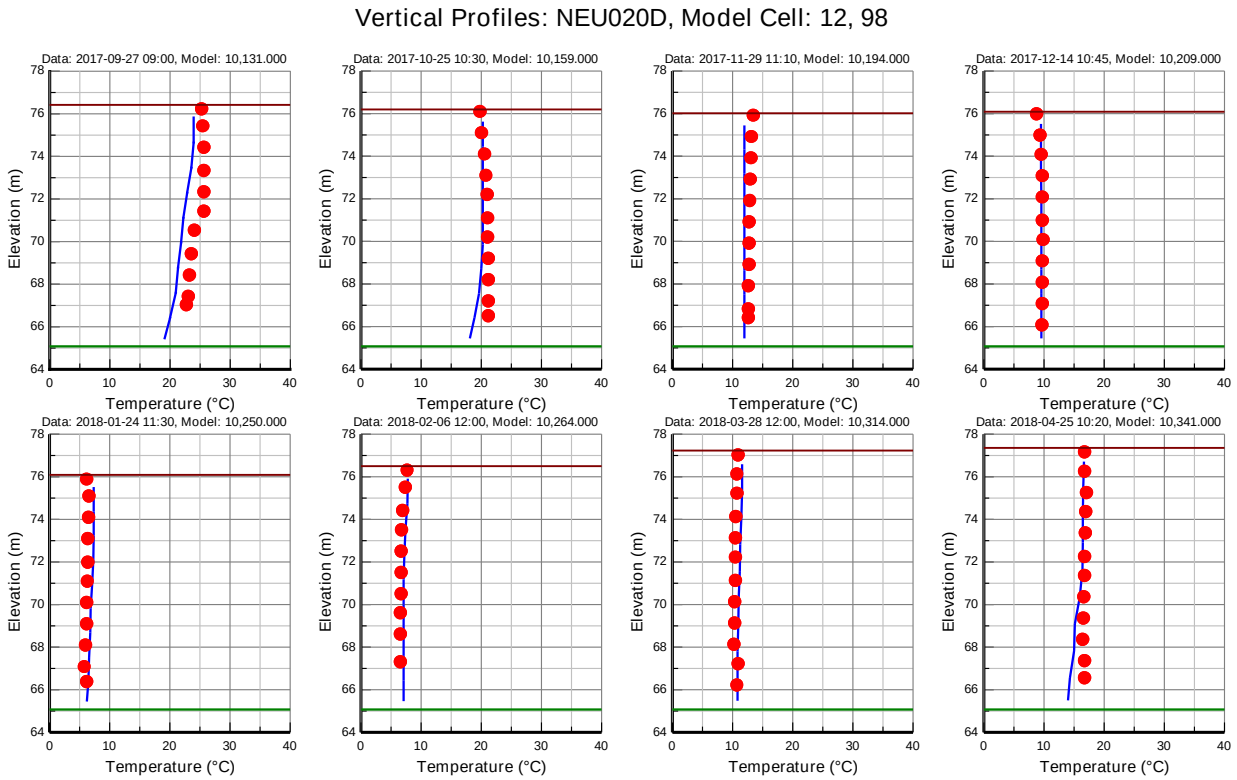
- Vertical Temperature Profiles:
  - NEU020D



January 2017 – August 2017 (4 of 6)

Results

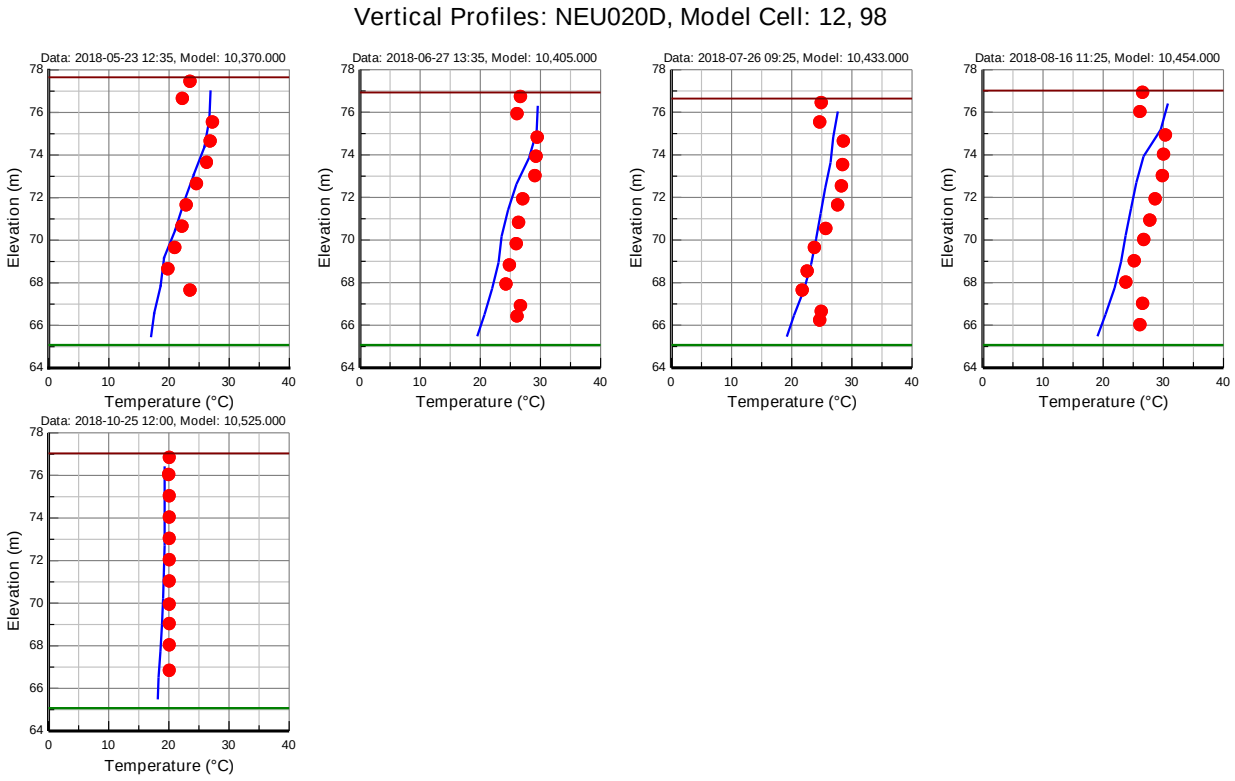
- Vertical Temperature Profiles:
  - NEU020D



September 2017 – April 2018 (5 of 6)

Results

- Vertical Temperature Profiles:
  - NEU020D



May 2018 – October 2018 (6 of 6)