Hydrodynamic Modeling Report for the Big Bend Estuary Systems

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1.0 INTRODUCTION

Excess inputs of nitrogen and phosphorus (nitrogen/phosphorus pollution) in surface waters can be harmful in aquatic ecosystems by directly producing excess plant and algal growth, and indirectly leading to reduced clarity, reduced oxygen levels as the algae and plants decompose, and decreased biodiversity. Primary sources of nitrogen and phosphorus to aquatic ecosystems include waste water and sewage effluent, atmospheric deposition, landfill leachate, fossil fuel combustion, and runoff from commercial fertilizer and manure applications.

Nitrogen/phosphorus pollution contributes significant loadings of nitrogen and phosphorus to waters of the United States and is one of the leading causes of water quality degradation. Many of our nation's waters, including rivers, canals, lakes, estuaries, and coastal marine waters, are affected by nitrogen/phosphorus pollution. There is increasing evidence of nitrogen/phosphorus pollution in Florida's waters and clear, widespread indications of the resulting adverse effects on aquatic life in those waters.

The EPA is seeking to improve and enhance protection of aquatic life from the detrimental effects of nitrogen/phosphorus pollution through the implementation of Total Maximum Daily Loads (TMDLs). To aid in the development of TMDLs, estuary models throughout the state of Florida have been developed. The Big Bend estuarine system central region spans the central portion of the Gulf Coast side of Florida, and eventually drains into the Gulf of Mexico (Figure 1.0-1).

This report includes the hydrodynamic calibration and validation results for the Big Bend estuary system. The calibration and validation of the models were performed to data spanning the years 2002-2009. The goal of the hydrodynamic and water quality models was to produce a defensible and accurate model that EPA and the State of Florida could use to make management decisions in the estuaries.

2.0 MODEL SELECTION

2.1 EFDC Hydrodynamic Model

The Environmental Fluid Dyanamics Code (EFDC) model was selected to perform the hydrodynamic simulations because it was able to fulfill all of the requirements presented in the goals of the study. EFDC has been applied on many waterbodies within USEPA for TMDL and permitting modeling projects including complex systems similar to those in these study in the USEPA Region 4 area such as Mobile Bay, AL, Neuse River and Estuary, NC, Brunswick Harbor, GA, Indian River Lagoon, FL, Florida Bay, Lake Okeechobee, FL, and Cape Fear River, NC. EFDC has proven to capture the complex hydrodynamics in all these similar systems.

The EFDC model is a part of the USEPA TMDL Modeling Toolbox due to its application in many TMDL-type projects. As such, the code has been peer reviewed and tested and has been freely distributed and supported by Tetra Tech. EFDC was developed by Dr. John Hamrick and is currently supported by Tetra Tech for USEPA Office of Research and Development (ORD), USEPA Region 4, and USEPA Headquarters. The EFDC model is nonproprietary and publicly available through USEPA Region 4 and USEPA ORD from the Watershed and Water Quality Modeling Technical Support Center (http://www.epa.gov/athens/wwqtsc/index.html). The models, tools, and databases in the TMDL Modeling Toolbox are continually updated and upgraded through TMDL development in Region 4.

2.2 EFDC Model History

The EFDC model comprises an advanced three-dimensional surface water modeling system for hydrodynamic and reactive transport simulations of rivers, lakes, reservoirs, wetland systems, estuaries, and the coastal ocean. The modeling system was originally developed at the Virginia Institute of Marine Science as part of a long-term research program to develop operational models for resource management applications in Virginia's estuarine and coastal waters (Hamrick, 1992). The EFDC model is public domain, with current users including universities, governmental agencies and engineering consultants.

The EFDC model's hydrodynamic model component is based on the three-dimensional shallow water equations and includes dynamically coupled salinity and temperature transport. The basic physical process simulation capabilities of the EFDC hydrodynamic component are similar to those of the Blumberg-Mellor or POM model (Blumberg & Mellor, 1987), the U.S. Army Corps of Engineers' (USACOE) CH3D-WES model (Johnson, et al., 1993), and the TRIM model. Notable extensions to the EFDC hydrodynamic model include representation of hydraulic structures for controlled flow systems, vegetation resistance for wetland systems (Hamrick and Moustafa, 1996), and high frequency surface wave radiation stress forcing for near shore coastal simulations.

EFDC is a multifunctional, surface-water modeling system, which includes hydrodynamic, sediment-contaminant, and eutrophication components. The EFDC model is capable of 1, 2, and 3-dimensional spatial resolution. The model employs a curvilinear-orthogonal horizontal grid and a sigma or terrain following vertical grid. The EFDC model's hydrodynamic component employs a semi-implicit, conservative finite volume-finite difference solution scheme for the hydrostatic primitive equations with either two or three-level time stepping (Hamrick, 1992). The semi-implicit scheme is based on external mode splitting with the external mode being implicit with respect to the water surface elevation and the internal mode being implicit with respect to vertical turbulent momentum diffusion. Advective and Coriolis-curvature accelerations in both the external and internal modes are represented by explicit conservative formulations. Salinity and temperature transport are simultaneously solved with the hydrodynamics and dynamically coupled through an equation of state. The hydrodynamic component includes two additional scalar transported variables, a reactive variable which can be used to represent dye or pathogenic organisms, and a shell fish larvae variable which includes a number vertical swimming behavior options. Scalar transport options include a number of high accuracy advection schemes including flux corrected MPDATA and flux limited COSMIC. Additional hydrodynamic component features include, the Mellor-Yamada turbulence closure formulation, simulation of drying and wetting, representation of hydraulic control structures, vegetation resistance, wave-current boundary layers and wave induced currents, and dynamic time stepping. An embedded single and multi-port buoyant jet module is included for coupled near and far field mixing analysis.

The EFDC hydrodynamic model can run independently of a water quality model. The EFDC model simulates the hydrodynamic and constituent transport and then writes a hydrodynamic linkage file for a water quality model such as the Water Quality Analysis Simulation Program (WASP) model. This model linkage, from EFDC hydrodynamics to WASP water quality, has been applied on many USEPA Region 4 projects in support of TMDLs and has been well tested (Wool et al., 2003). EFDC is also directly linked to Waterways Experiment Station CE-QUAL-ICM (Cerco and Cole, 1993).

3.0 BIG BEND MODEL SET-UP AND CALIBRATION

3.1 Physical Characteristics of Model Study Area

Florida Big Bend model runs along the Gulf coast from Apalachicola Bay in the west to Clearwater Harbor in the east (Figure 3.1.1) The model covers seven major estuarine systems and six HUC8 Basins or Watersheds. The model extends in to the Gulf for greater than 20 miles with depths ranging from 30 meters at the ocean boundary to 1.5 meters in the embayments.

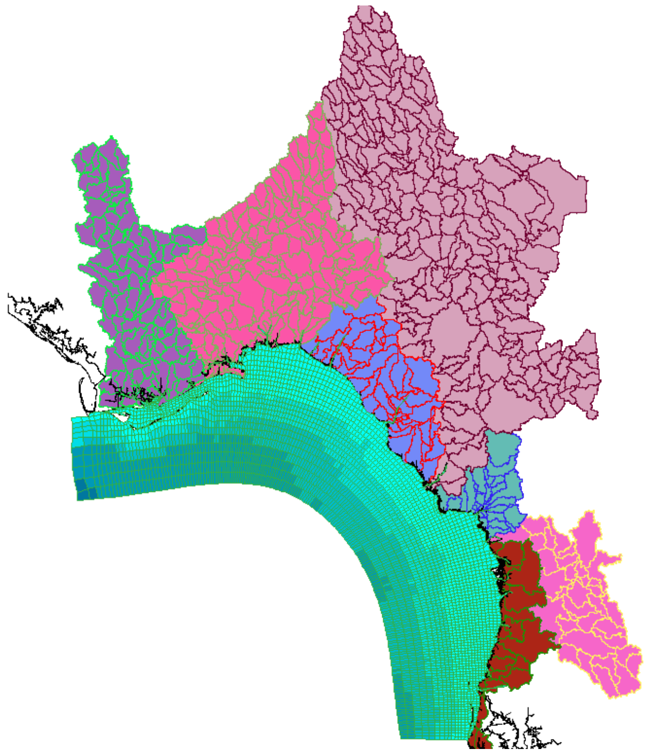

Figure 3.1.1 Location of the Big Bend estuarine system and its contributing watersheds.

The seven major estuarine systems are:

- Apalachicola Bay
- Alligator Harbor
- Ochlocknee Bay
- Apalachee Bay
- The Suwannee, Waccasassa, and Withlacoochee Estuaries
- Spring Coast Estuarine Area
- St. Joseph Sound and Clearwater Harbor

In this report, documentation will be provided for Springs Coast Estuarine Area and St. Joseph Sound and Clearwater Harbor. Dye tracer studies showed no mixing from the Suwannee, Waccasassa, and Withlacoochee Estuaries in this area, or any of the western Bays.

3.1.2 Spring Coast Estuarine Area

The Springs Coast of Florida is a low-energy coastline that functions like an estuary, despite the lack of physical barriers and enclosures (Figure 3.1.2). The region is characterized by extensive tidal marshes and swamps, with much of the coastline in conservation land, and a wide continuous seagrass bed that extends 15-30 miles offshore in some areas due to the very shallow and clear water of this coastline. The Springs Coast watershed includes coastal areas off Citrus, Hernando, and Pasco Counties, from Crystal River south to the Anclote River. The six major rivers in the watershed—Crystal, Homosassa, Chassahowitzka, Weeki Wachee, Anclote, and Pithlachascotee—their springs, and their associated coastal aquatic resources are dominant features. The coastline has very low relief, so the nearshore areas are very shallow with low wave energy. The coast contains numerous tidal creeks and salt marshes, as well as isolated islands fringed with mangroves. There are very few natural sandy beaches. Most of the region functions like an estuary, with its shallow waters, abundant freshwater flows, and low-energy shoreline. Seagrass beds cover almost the entire near shore area where depths are sufficient, and extensive oyster reefs are also present. Vast salt marshes up to ten miles wide provide a buffer between the upland land uses and the estuaries. (FDEP 2010)

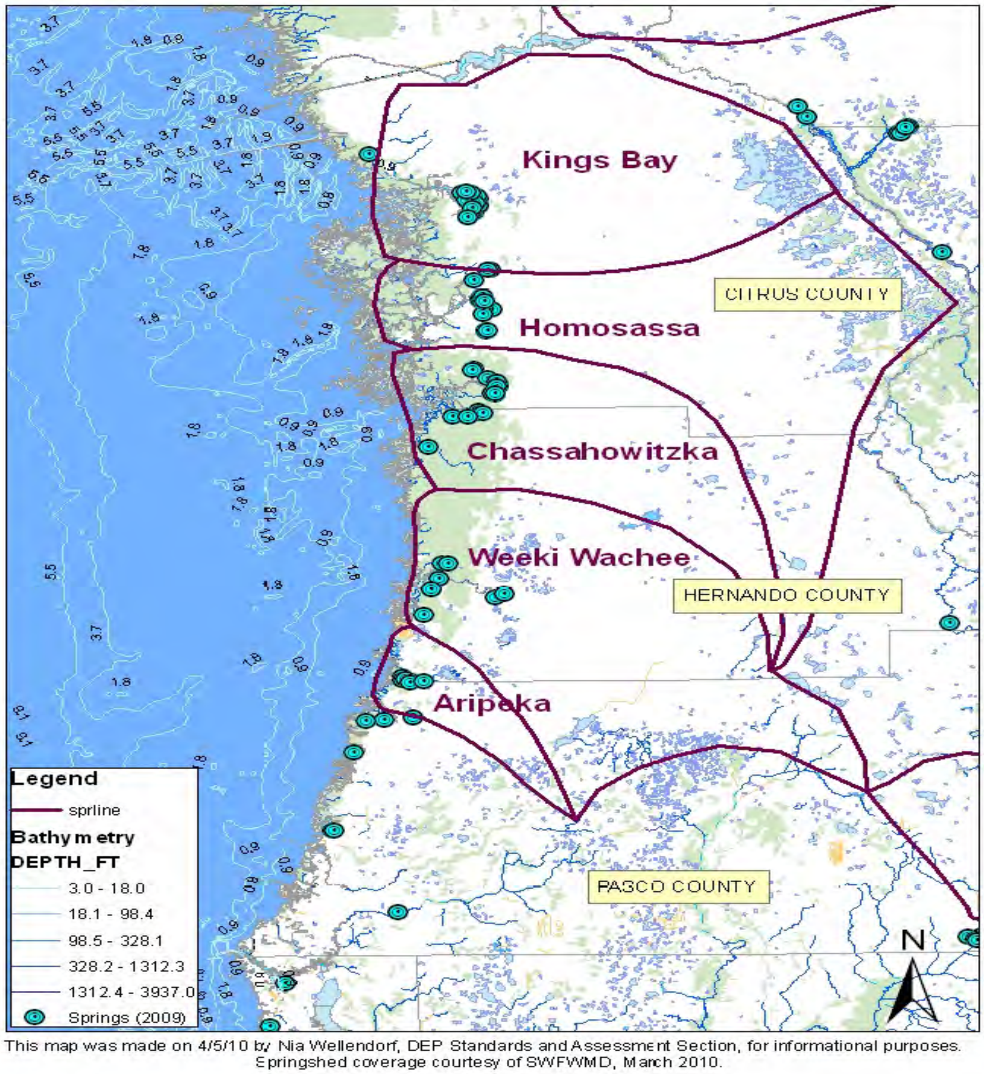

Figure 3.1.2 Spring Coast Estuarine areas

3.1.3 St. Joseph Sound and Clearwater Harbor

St. Joseph Sound, Clearwater Harbor, and Boca Ciega Bay are in western Pinellas County along the Gulf side of the cities of St. Petersburg, Largo, Clearwater, Dunedin, and Tarpon Springs. All three areas are constricted to varying degrees by barrier islands (Figure 3.1.3). St. Joseph Sound is well mixed with the Gulf of Mexico, Clearwater Harbor is fairly well flushed in the northern end, but less so in the southern portion, and Boca Ciega Bay has limited contact with the Gulf. In Clearwater Harbor, water exchanges with the Gulf of Mexico through Clearwater Pass (north end of Southern half) and Hurricane Pass (north end of

Northern half); Dunedin Pass (middle of Northern half) has been closed. (Site-Specific Information in Support of Establishing Numeric Nutrient Criteria in St. Joseph Sound and Clearwater Harbor, FlDEP August 2010)

Figure 3.1.3 St. Joseph Sound and Clearwater Harbor

3.2 Model Segmentation

An orthogonal, curvilinear grid system used in the hydrodynamic model of the Big Bend estuarine system is shown in Figure 3.2.1. The grid consists of 3995 horizontal cells and 4 equally spaced vertical σ-layers. There are 198 offshore boundary cells and 69 inland boundary cells.

Bathymetry data for the Gulf of Mexico adjacent area were obtained from the National Geophysical Data Center. This bathymetry data was interpolated into the grid resulting in the grid bathymetry shown in Figure 3.2.2.

The inland boundary cells receive LSPC simulated watershed discharges and point source discharges. The watershed boundary cells are marked in Figure 3.2.3and the point source locations are shown in Figure 3.2.4. The watershed discharges are described in the LSPC modeling report. In accordance to the report freshwater flows from watersheds are calculated on basis of geographical, hydrological and meteorological factors (land use/cover, landscape parameters, soils, air temperature, rainfall etc). The physical characteristics of the major watersheds and their rivers were discussed in the LSPC modeling report. The Crystal Watershed provides all flow and loadings to the Springs Coast Estuarine areas and St. Joseph Sound and Clearwater Harbor areas.

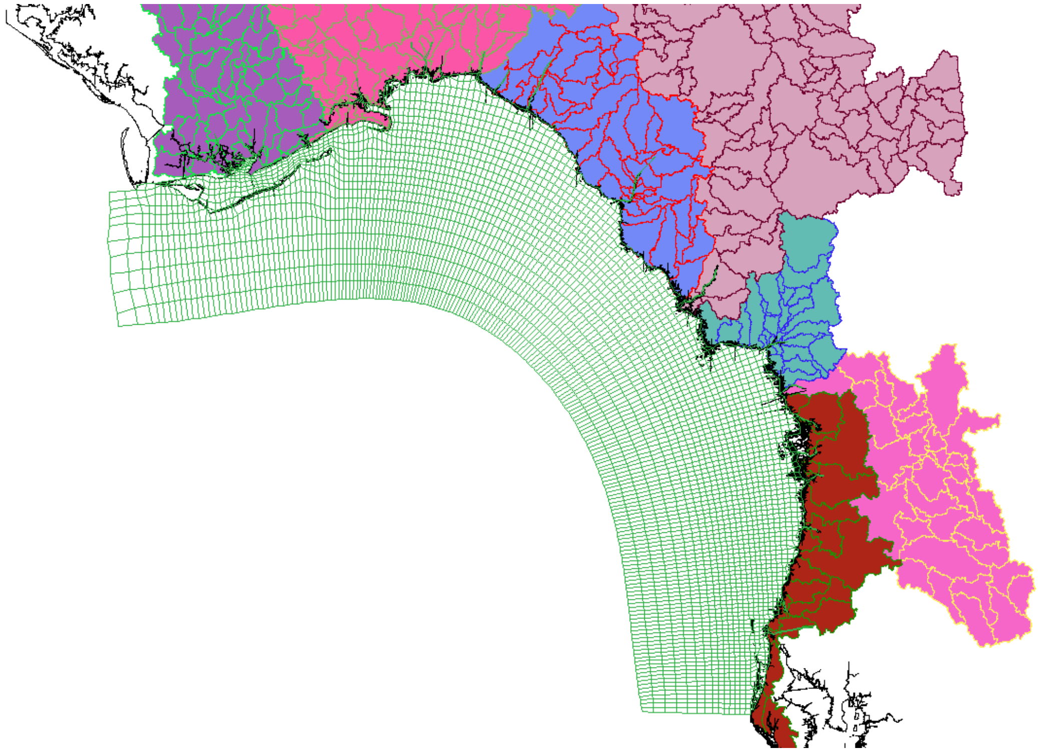

Figure 3.2.1 Grid for the Big Bend estuarine system

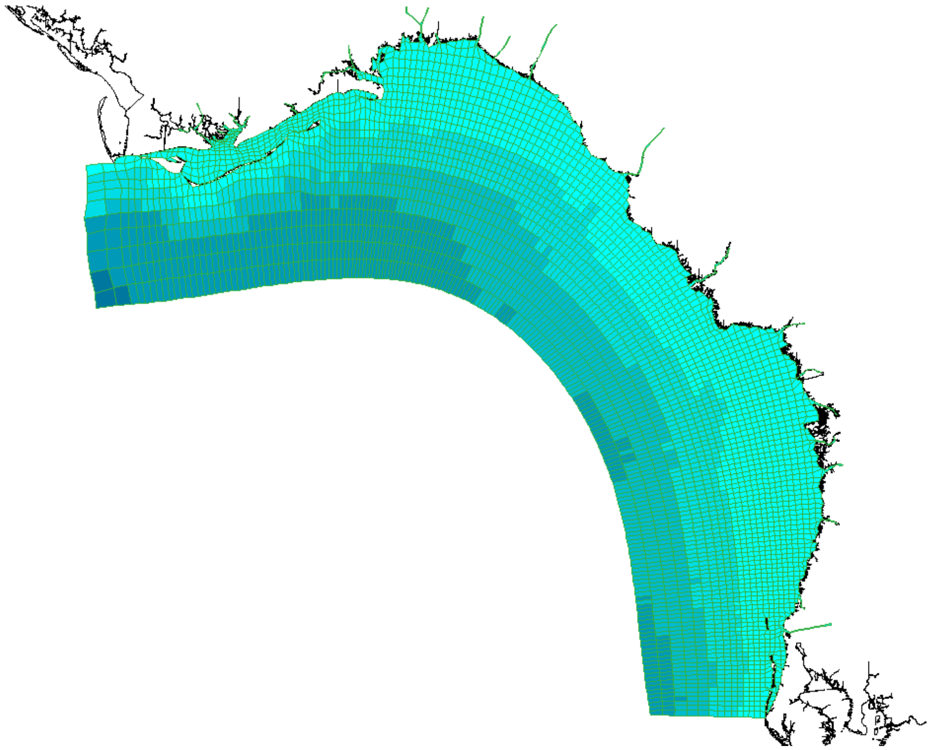

Figure 3.2.2 Grid Bathymetry for the Big Bend estuarine system

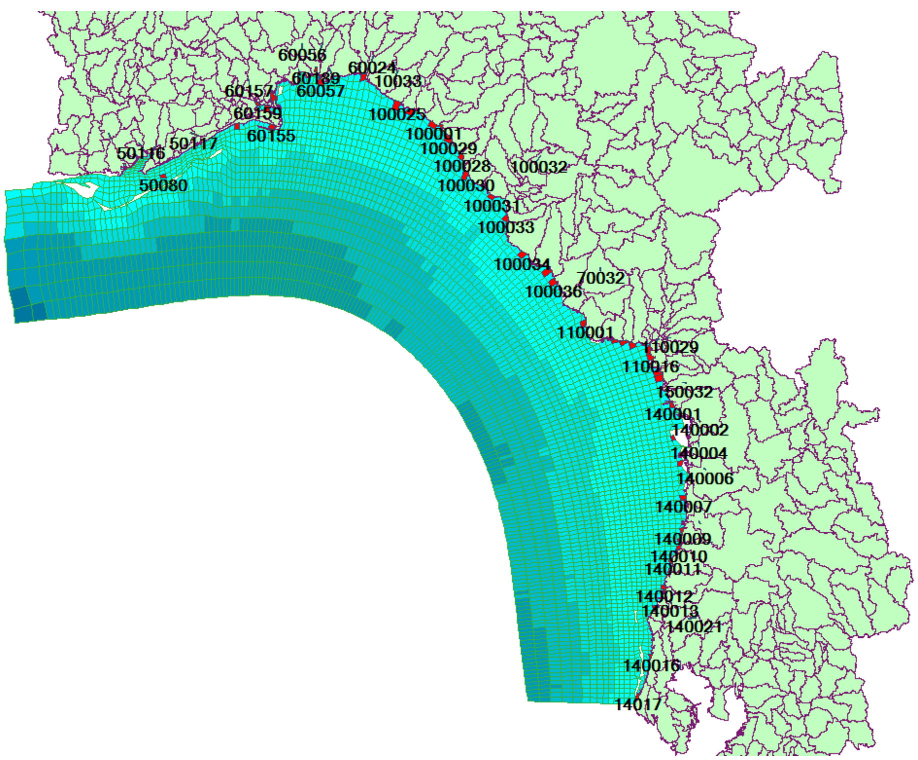

Figure 3.2.3 Watershed Input Locations for the Big Bend estuarine system

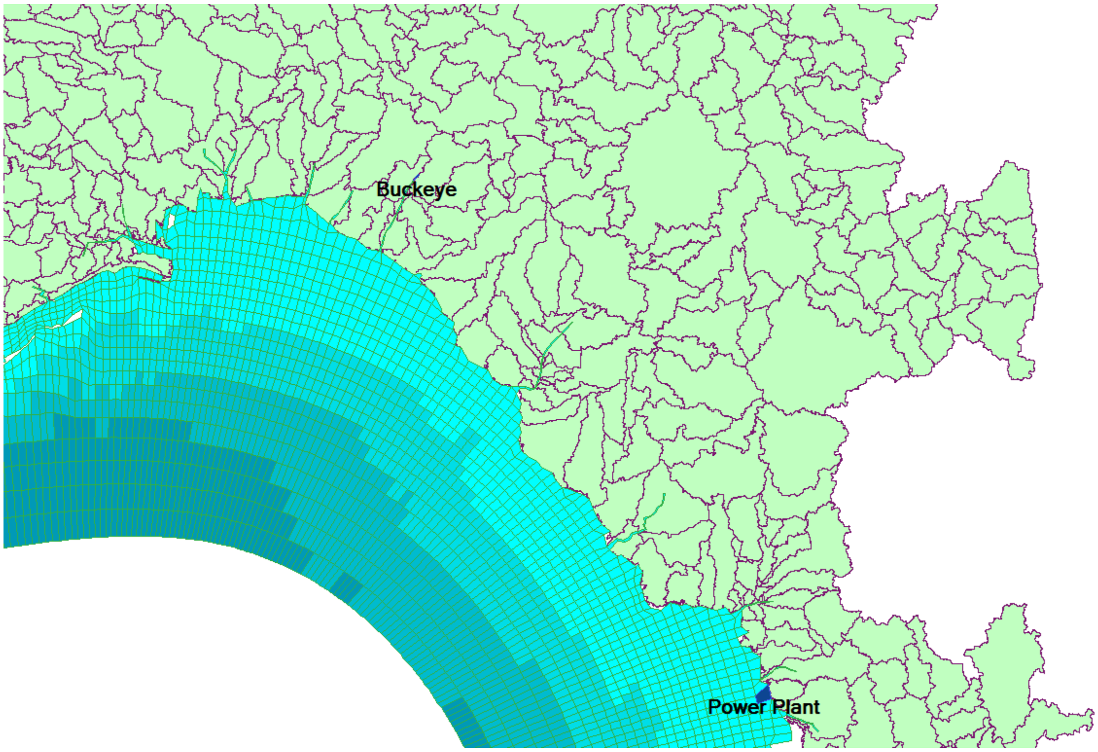

Figure 3.2.4 Point Source Locations for the Big Bend estuarine system

3.3 Big Bend Estuarine System Monitoring Stations

The calibration-validation process for the Big Bend estuarine system used data that was assembled by the Florida Department of Environmental Protection (FDEP) in their IWR database and collected by NOAA at their Apalachicola, Cedar Key and Clearwater Beach tidal stations (Table 3.3.1).

Table 3.3.1 NOAA Valparaiso tidal stations used in the Big Bend model

Permit Number	Name
8728690	Apalachicola, FL
8727520	Cedar Key, FL
8726724	Clearwater Beach, FL

The FDEP IWR database was also used to assemble data containing measurements of temperature and salinity at various monitoring stations in Big Bend estuarine (Figure 3.3.1). The samples were collected by various collection agencies that collected various types of data at various time periods and locations in the same general area. Data that were collected at various monitoring stations near a model grid cell were combined together as a single model cell station for model calibration. Because the data were combined from multiple stations and multiple locations and from all depths, the range of data for a given location and time is greater than would be expected from data collected at a single station. However this method of combining data provided a long-term period of record and the ability to assess the model performance over the period of record 1997-2009. This period of record contains a wide range of flow, tidal and meteorological conditions ranging from dry years to hurricane conditions and therefore provides a good predictive model for evaluating potential scenarios.

The EFDC hydrodynamic model was calibrated for salinity and temperature using data for the period of 2003-2009. For validation, data from the same stations were used, and validation took place from 1997-

2002. The model was later extended through 2011 using measured data to allow for TMDL development during years 2002 through 2011. The data used for calibration-validation of EFDC hydrodynamic are listed in Table 3.3.2, and the locations are shown in Figure 3.3.1 and Figure 3.3.2.

Table 3.3.2 Calibration and validation stations used in the Big Bend hydrodynamic model

Station ID	Station Name	Watershed	Parameter
I = 17 J = 4	21FLPDEMW3-A-04-08	Clearwater	Salinity, Temp
I = 18 J = 10	21FLPDEMW2-A-03-05	Clearwater	Salinity, Temp
I = 17 J = 18	21FLPDEMW1-C-07-03	Clearwater	Salinity, Temp
I = 20 J = 20	21FLPDEM01-01	Clearwater	Salinity, Temp
I = 20 J = 31	21FLPCSWST1148000428400	Spring Coast	Salinity, Temp
I = 22 J = 39	21FLPCSWST1150000430400	Spring Coast	Salinity, Temp
I = 25 J = 44	21FLPCSWST1143000425400	Spring Coast	Salinity, Temp
I = 30 J = 44	21FLGW 21836	Spring Coast	Salinity, Temp
I = 24 J = 47	21FLPCSWST1143000425900	Spring Coast	Salinity, Temp
I = 27 J = 53	112WRD 02310674	Spring Coast	Salinity
I = 24 J = 59	21FLPCSWST1145000427300	Spring Coast	Salinity, Temp
I = 31 J = 60	112WRD 02310747	Spring Coast	Salinity, Temp
I = 24 J = 62	21FLA 37720SEAS	Spring Coast	Salinity, Temp
I = 24 J = 68	21FLA 34076SEAS	Withlacoochee to Suwannee	Temp
I = 24 J = 68	21FLA 37660SEAS	Withlacoochee to Suwannee	Salinity, Temp
I = 24 J = 70	21FLA 34050SEAS	Withlacoochee to Suwannee	Salinity, Temp
I = 24 J = 73	21FLA 34220SEAS	Withlacoochee to Suwannee	Temp
I = 23 J = 78	21FLA 32092SEAS	Withlacoochee to Suwannee	Salinity, Temp
I = 25 J = 78	21FLA 32020SEAS	Withlacoochee to Suwannee	Salinity, Temp
I = 21 J = 79	21FLA 32120SEAS	Withlacoochee to Suwannee	Salinity, Temp
I = 17 J = 84	21FLA 30112SEAS	Withlacoochee to Suwannee	Temp
I = 14 J = 85	21FLA 30052SEAS	Withlacoochee to Suwannee	Salinity, Temp
I = 13 J = 89	21FLA 30448SEAS	Withlacoochee to Suwannee	Salinity, Temp
I = 16 J = 90	21FLA 28247SEAS	Withlacoochee to Suwannee	Temp
I = 14 J = 91	21FLA 28201SEAS	Withlacoochee to Suwannee	Temp
I = 17 J = 91	112WRD 291833083085100	Withlacoochee to Suwannee	Temp
I = 16 J = 92	21FLA 28223SEAS	Withlacoochee to Suwannee	Salinity, Temp
I = 16 J = 98	21FLA 25165SEAS	Apalachee Bay	Salinity, Temp
I = 16 J= 102	Combined	Apalachee Bay	Salinity, Temp
I = 18 J = 110	21FLSUW STN060C1	Apalachee Bay	Salinity, Temp
I = 18 J= 110	Combined	Apalachee Bay	Salinity, Temp
I = 22 J= 110	Combined	Apalachee Bay	Salinity, Temp

Station ID	Station Name	Watershed	Parameter
I = 24 J= 110	Combined	Apalachee Bay	Temp
I = 23 J= 128	Combined	Apalachee Bay	Temp
I = 25 J= 128	Combined	Apalachee Bay	Temp
I = 26 J = 128	21FLA 22050030	Apalachee Bay	Salinity
I = 31 J = 128	21FLSUW FEN030C1	Apalachee Bay	Salinity, Temp
I = 21 J= 129	Combined	Apalachee Bay	Salinity
I = 23 J= 133	Combined	Apalachee Bay	Salinity
I = 26 J= 133	Combined	Apalachee Bay	Salinity
I = 31 J= 133	Combined	Apalachee Bay	Salinity
I = 21 J= 134	Combined	Apalachee Bay	Salinity, Temp
I = 26 J = 145	21FLSEAS23SEAS030	Apalachee Bay	Salinity, Temp
I = 27 J= 145	Combined	Apalachee Bay	Salinity
I = 24 J = 146	21FLSEAS23SEAS007	Apalachee Bay	Temp
I = 24 J = 150	21FLA 22101SEAS	Ocklocknee	Salinity, Temp
I = 20 J = 152	21FLA 20020SEAS	Ocklocknee	Salinity, Temp
I = 22 J = 152	21FLA 20050SEAS	Ocklocknee	Temp
I = 24 J = 152	21FLA 20070SEAS	Ocklocknee	Salinity, Temp
I = 18 J = 154	21FLA 18006SEAS	Alligator Harbor	Salinity, Temp
I = 18 J = 156	21FLA 18001SEAS	Alligator Harbor	Salinity, Temp
I = 21 J= 156	Combined	Alligator Harbor	Salinity
I = 14 J= 169	Combined	Apalachicola Bay	Salinity, Temp
I = 14 J= 175	Combined	Apalachicola Bay	Temp
I = 19 J = 180	21FLA 16260SEAS	Apalachicola Bay	Salinity, Temp
I = 20 J = 180	21FLA 16255SEAS	Apalachicola Bay	Salinity, Temp
I = 10 J = 182	21FLA 16340SEAS	Apalachicola Bay	Salinity, Temp
I = 12 J = 182	21FLA 16323SEAS	Apalachicola Bay	Salinity, Temp
I = 14 J = 186	21FLA 16346SEAS	Apalachicola Bay	Salinity, Temp
I = 14 J = 188	21FLA 16341SEAS	Apalachicola Bay	Salinity, Temp
I = 14 J = 189	21FLA 16347SEAS	Apalachicola Bay	Salinity, Temp

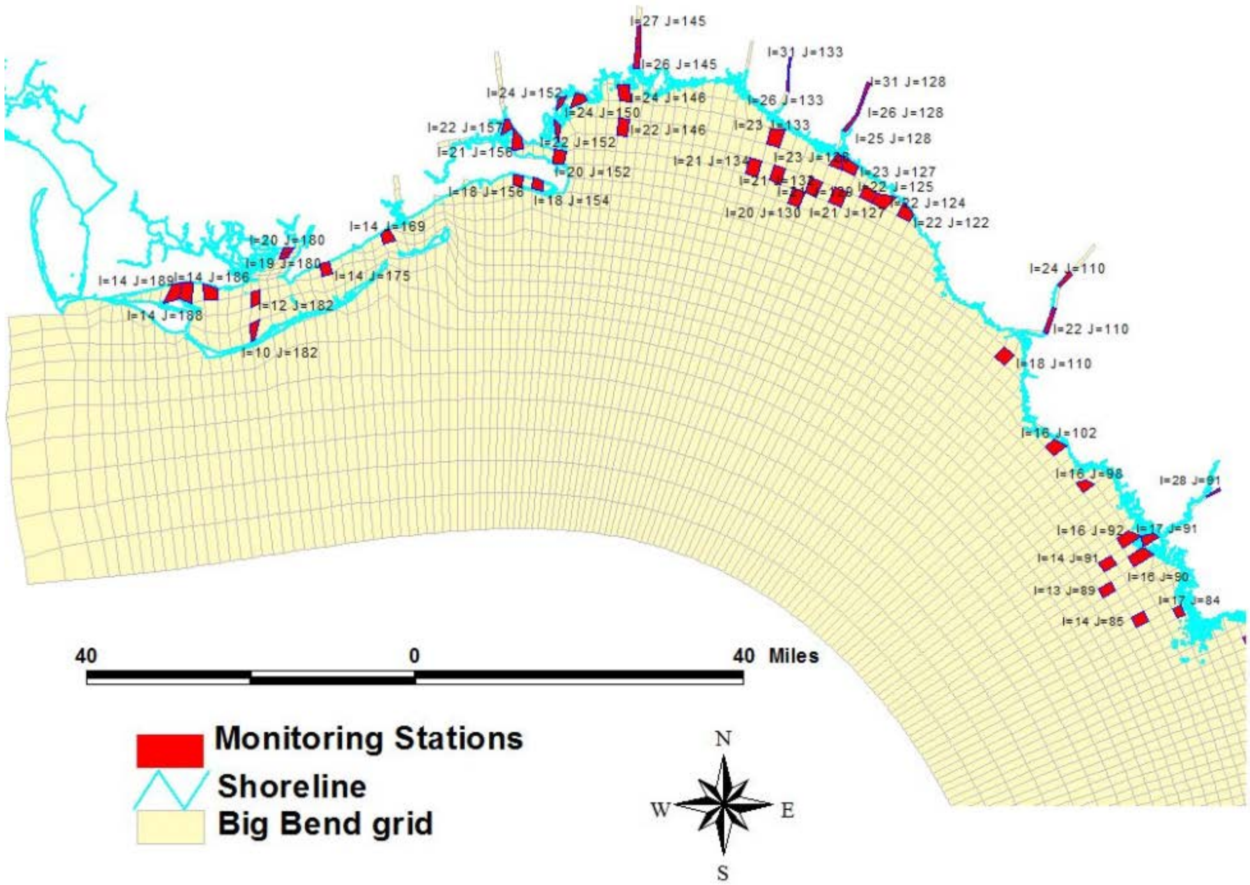

Figure 3.3.1 Monitoring station locations in the Big Bend estuarine system from Apalachicola to Florida Bend

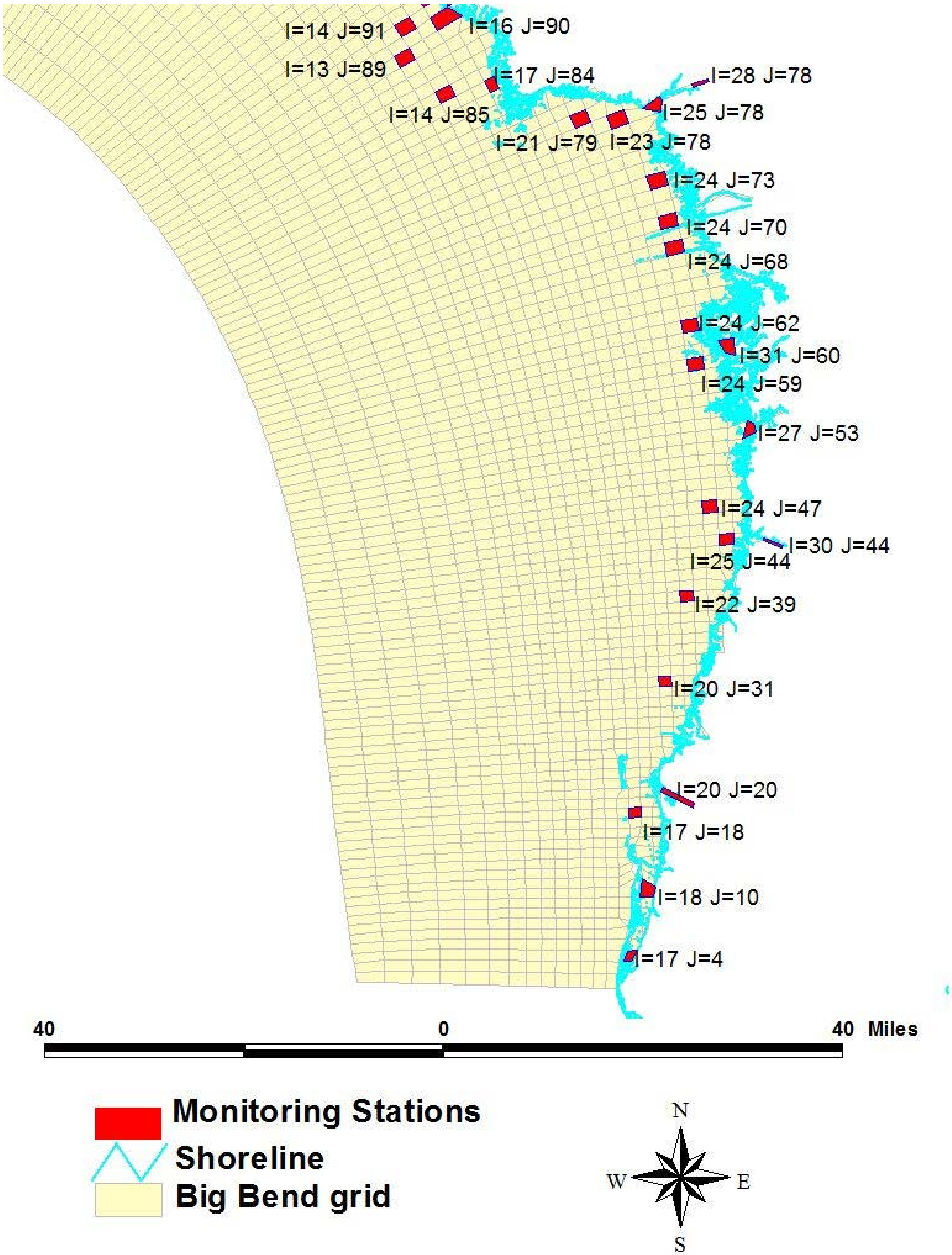

Figure 3.3.2 Monitoring station locations in the Big Bend estuarine system from Florida Bend to Clearwater

3.4 Hydrodynamic Model Forcing Conditions

The purpose of the EFDC based hydrodynamic modeling was to reproduce the three-dimensional circulation dynamics and salinity and temperature structure in the Big Bend estuarine system. The model predicts these parameters in response to a set of multiple factors: wind speed and direction, freshwater discharge, water level fluctuation, rainfall, surface heat flux, and temperature and salinity associated with boundary fluxes.

Meteorological Factors

Hourly measurements of atmospheric pressure, dry and wet bulb atmospheric temperatures, rainfall rate, wind speed and direction, and fractional cloud cover were obtained from data collected at two WBAN Stations, Apalachicola and Clearwater, for the period 1997-2011. Solar short wave radiation was calculated using the CE-Qual-W2 method. The meteorological factors for the EFDC hydrodynamic model are included in the file ASER.INP. WSER.INP file includes hourly measurements of wind speed and directions.

Freshwater flows and temperature

The watershed flows discharging into the Big Bend estuarine system and corresponding temperatures were calculated using the LSPC watershed models. The Crystal Watershed model provided flows and temperatures to the Springs Coast and Clearwater Harbor of the Big Bend model. The watershed input boundary cells for all watersheds are shown in Figure 3.2.3.

Point Sources

Although there were two major point sources are included in the hydrodynamic setup, neither of these were located in the Springs Coast area or Clearwater Harbor (Figure 3.2.4).

Offshore Boundary WSE and Water Temperature

Hourly time series of WSE Data from NOAA tidal stations previously mentioned were initially used as boundary conditions. These boundary conditions were adjusted during the WSE calibration by comparison of observed data with WSE simulations at the location of the tidal station. The datum used for WSE is mean sea level.

Observed temperature data at monitored near Apalachicola bay was used as boundary conditions at the open boundaries. WSE and Temperature at open boundary for the EFDC model are included in files PSER.INP and TSER.INP, respectively.

Offshore Boundary Salinity

There is a lack of salinity field measurements close to the open boundary. Because of this reason a constant value of salinity (37 ppt) was selected as the open boundary condition. This salinity values was approximate to the average salinity in this part of the Gulf of Mexico and similar to the maximum salinities measured in the Big Bend estuarine system. Salinity at open boundary for the EFDC model is included in the file SSER.INP.

All offshore and inland boundaries, as well as physical parameters of the hydrodynamic model are presented in the input file EFDC.INP.

3.5 Hydrodynamic Model Calibration and Validation Analysis

Results of calibration and validation of the hydrodynamic components of the Big Bend estuarine system model are presented in Section 4.0. Results are presented for stations throughout the entire Big Bend model.

Water Surface Elevation

Hourly data of WSE at NOAA tidal stations were selected as calibration data set. The period of calibration is years 2003-2009. Table 4.1.1 represents statistics of WSE calibration for the six year calibration period. The errors or simulation-observation differences in the table are presented in meters. The use of percent errors is not reasonable because of closeness of mean WSE values to zero. The table also presents 5th and 95th WSE percentiles that allow estimation of the WSE dynamical range.

The calibration results show the high accuracy of the modeling. The mean and percentiles difference between observed and simulated hourly WSE sets are in the range of 1-7 cm. The values of correlation coefficient R^2 show strong correlation between simulations and observations.

Table 4.1.2 shows the WSE validation results. The validation process uses observations at the same stations for the years 1997-2002. The values of coefficient R^2 show strong correlation between simulations and observations. Figures 4.1.1 through 4.1.6 demonstrate close correspondence of the calibrated model WSE output to NOAA observations for the calibration and validation periods.

Salinity

Salinity measurements at 37 Big Bend estuarine system monitoring stations for the period 2003-2009 were used as calibration data set and 1997-2002 for the validation data set. Tables 4.2.1 and 4.2.2 present the calibration and validation statistics of salinity, respectively. The tables present the mean, 5th and 95th water salinity percentiles that allow estimation of a range of seasonal dynamical changes.

The Big Bend estuarine system model cell middle layer salinity results were compared to all the measured data that was combined near the respective model cell sampling location. These samples were collected by various collection agencies that collected various types of data at various time periods and locations in the same general area. Data that were collected at various monitoring stations near a model grid cell were combined together as a single model cell station for model calibration. Because the data were combined from multiple stations and multiple locations and from all depths, the range of data for a given location and time is greater than would be expected from data collected at a single station.

This method of combining data provided a long-term period of record and the ability to assess the model performance over the period of record 1997-2009. The period of record contains a wide range of flow, tidal and meteorological conditions ranging from dry years to hurricane conditions and therefore provides a good predictive model for evaluating potential scenarios. Based on the range of data at the model cell stations, the mean percentage error is within the acceptable range for both calibration and validation time periods (Tables 4.2.1 and 4.2.2).. Calibration and validation figures 4.2.1 to 4.2.37 and 4.2.38 to 4.2.73 show good visual correspondence between the measured and simulated values of salinity. A visual examination illustrates that the model is predicting the seasonal salinity trends for the wide range of flow, tidal and meteorological conditions.

Temperature

Temperature measurements at 35 Big Bend estuarine system monitoring stations for the period 2003-2009 were used as calibration data set and 1997-2002 for the validation data set. Tables 4.3.1 and 4.3.2 present the calibration and validation statistics for temperature, respectively. The tables present the mean, 5th and 95th water temperature percentiles that allow estimation of a range of seasonal dynamical changes.

The Big Bend estuarine system model cell middle layer temperature results were compared to all the measured data that was combined near the respective model cell sampling location. These samples were collected by various collection agencies that collected various types of data at various time periods and locations in the same general area. Data that were collected at various monitoring stations near a model grid cell were combined together as a single model cell station for model calibration. Because the data were combined from multiple stations and multiple locations and from all depths, the range of data for a given location and time is greater than would be expected from data collected at a single station. However this method of combining data provided a long-term period of record and the ability to assess the model performance over the period of record 1997-2009. This period of record contains a wide range of flow, tidal and meteorological conditions ranging from dry years to hurricane conditions and therefore provides a good predictive model for evaluating potential scenarios. Based on the range of data at the model cell stations, the mean percentage error is within the acceptable range for both calibration and validation time periods (Tables 4.3.1 and 4.3.2). Calibration and validation figures (4.3.1 to 4.3.35 and 4.3.36 to 4.3.70, respectively) show good visual correspondence between the measured and simulated values of temperature. A visual examination illustrates that the model is predicting the seasonal temperature trends for the wide range of flow, tidal and meteorological conditions.

4.0 BIG BEND MODELING RESULTS

4.1 Water Surface Elevation Modeling Results

Table 4.1.1 Calibration Comparisons of Simulations and Measurements of WSE at NOAA Tidal Stations, 8728690, 8727520, 8726724: Years 2003-2009.

Station	Simulated Mean (m)	Simulated 5%ile (m)	Simulated 95%ile (m)	Measured Mean (m)	Measured 5%ile (m)	Measured 95%ile (m)	Error Mean (m)	Error 5%ile (m)	Error 95%ile (m)	R^2
8728690	0.08	-0.29	0.43	0.03	-0.37	0.36	0.05	0.08	0.07	0.91
8727520	0.05	-0.57	0.63	0.02	-0.65	0.61	0.02	0.09	0.02	0.95
8726724	0.09	-0.35	0.51	0.04	-0.48	0.49	0.05	0.13	0.02	0.88

Table 4.1.2 Validation Comparisons of Simulations and Measurements of WSE at NOAA Tidal Station, 8729501: Years 1997-2002.

Station	Simulated Mean (m)	Simulated 5%ile (m)	Simulated 95%ile (m)	Measured Mean (m)	Measured 5%ile (m)	Measured 95%ile (m)	Error Mean (m)	Error 5%ile (m)	Error 95%ile (m)	R^2
8728690	0.06	-0.31	0.40	0.00	-0.36	0.32	0.05	0.05	0.08	0.91
8727520	0.02	-0.57	0.60	0.01	-0.63	0.58	0.01	0.06	0.02	0.92
8726724	0.07	-0.36	0.47	0.01	-0.47	0.44	0.06	0.11	0.03	0.89

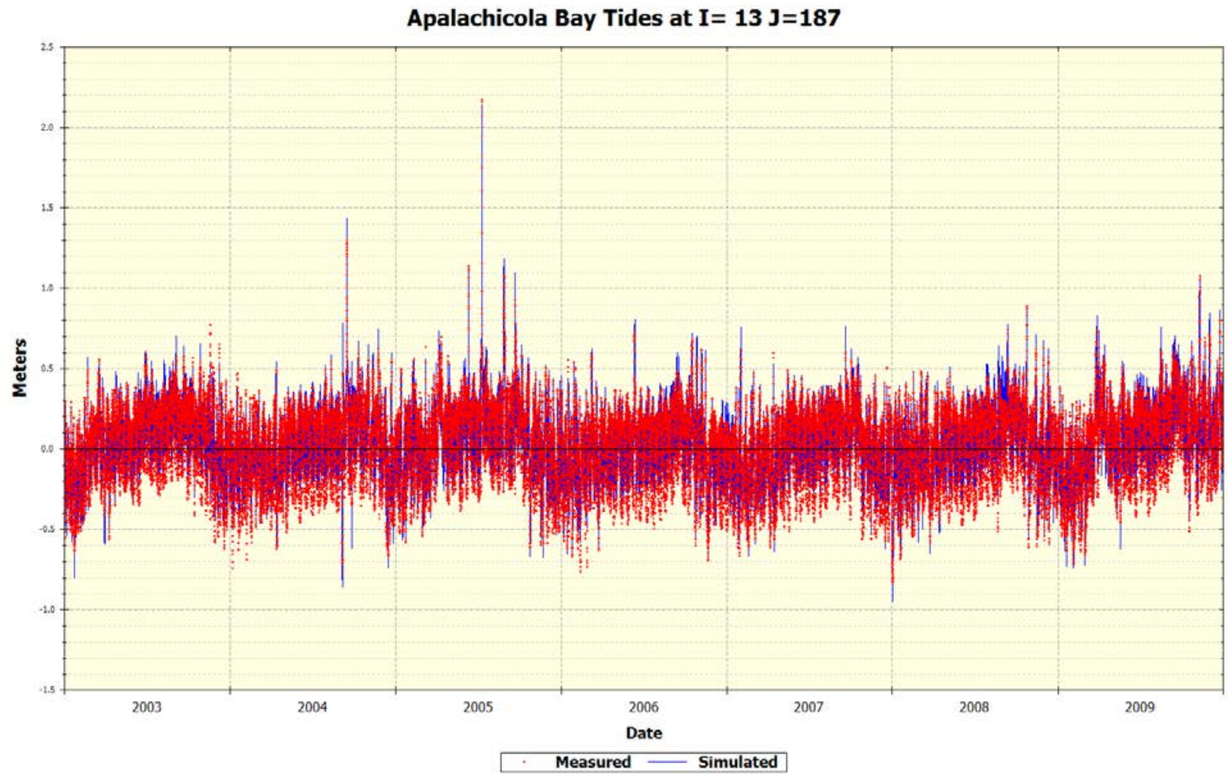

Figure 4.1.1 2003-2009 calibration measured versus simulated WSE at Apalachicola Bay

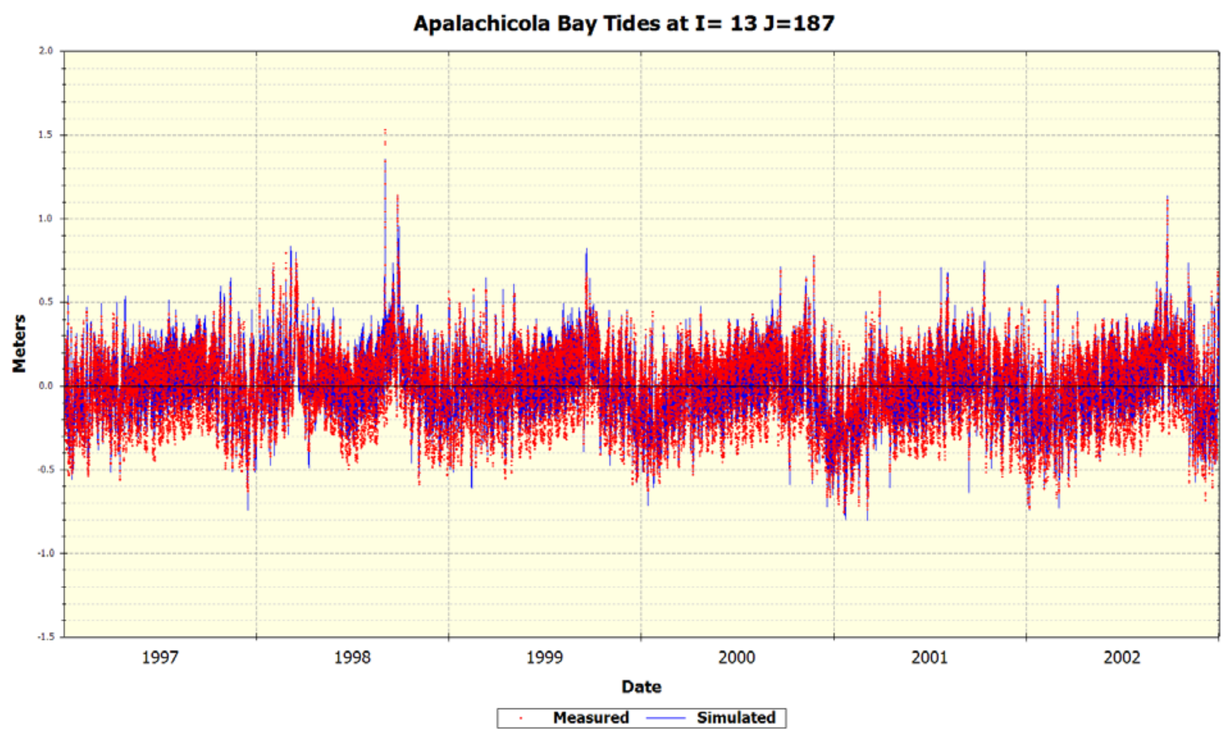

Figure 4.1.2 1997-2002 validation measured versus simulated WSE at Apalachicola Bay

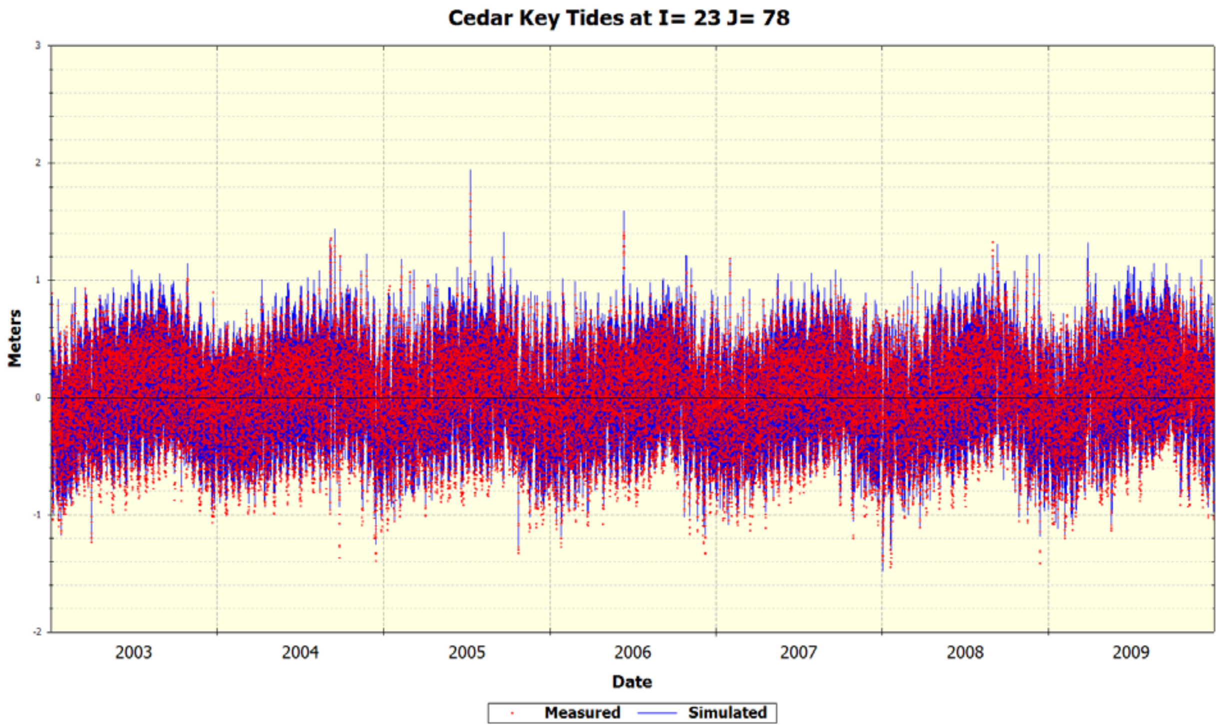

Figure 4.1.3 2003-2009 calibration measured versus simulated WSE at Cedar Key

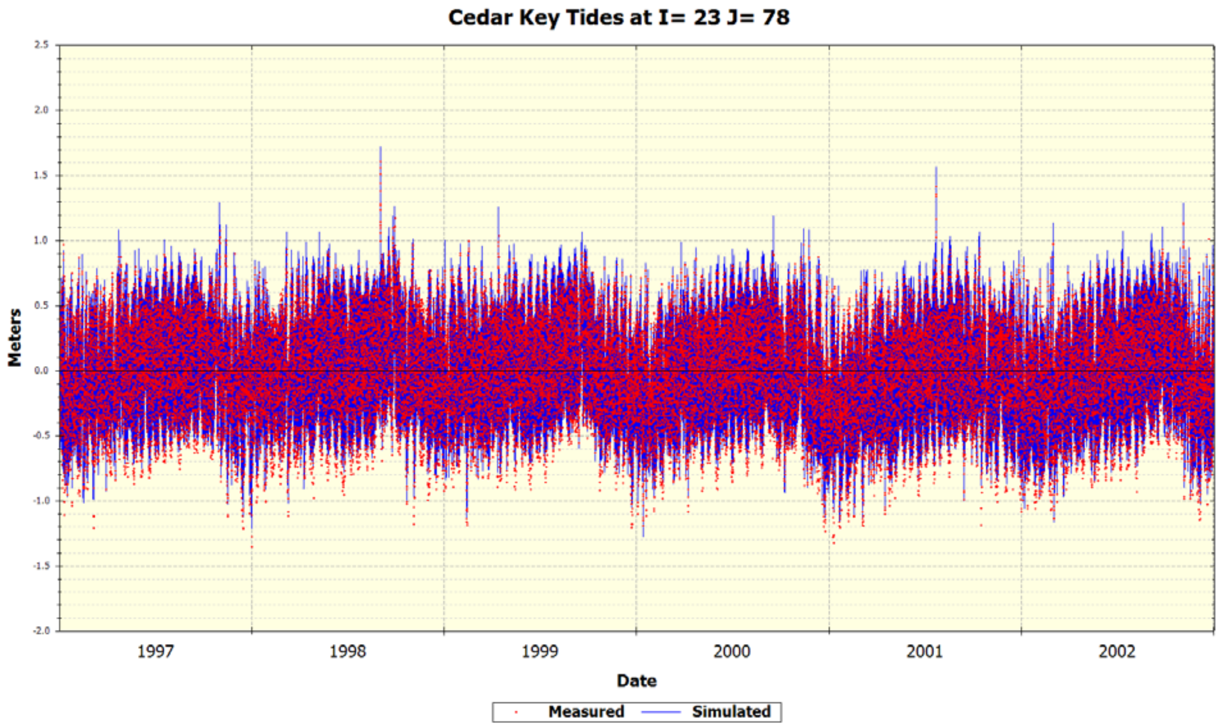

Figure 4.1.4 1997-2002 validation measured versus simulated WSE at Cedar Key

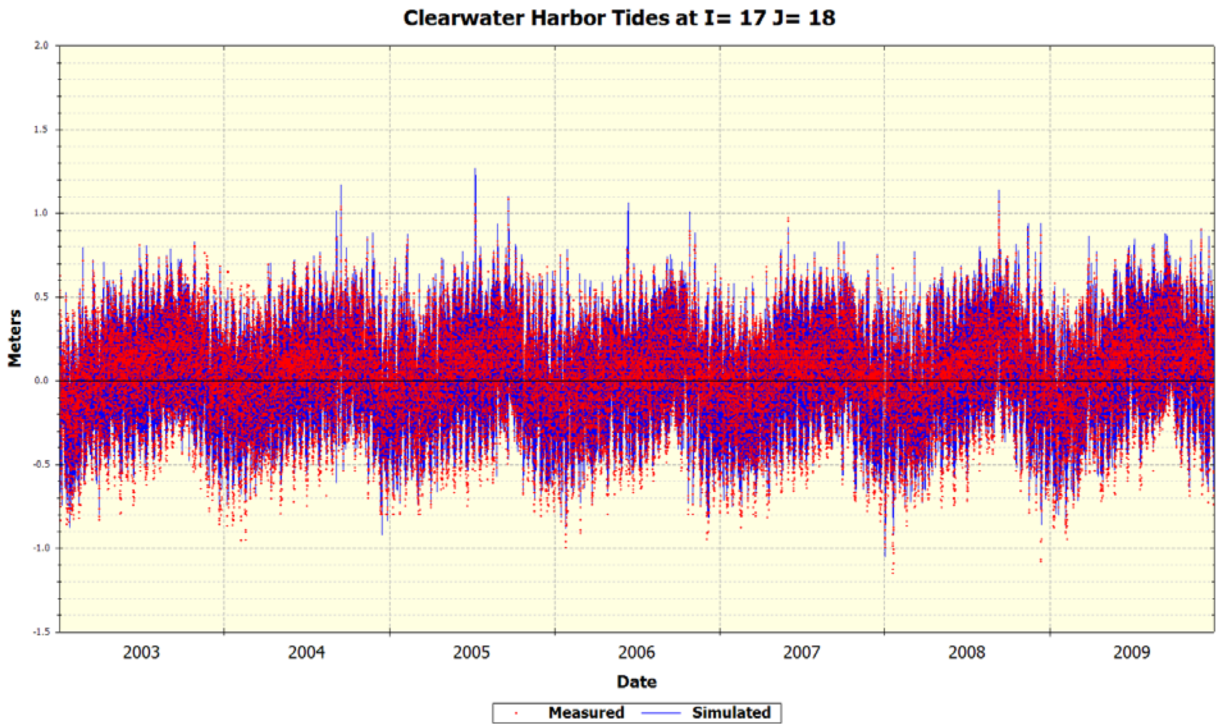

Figure 4.1.5 2003-2009 calibration measured versus simulated WSE at Clearwater Harbor

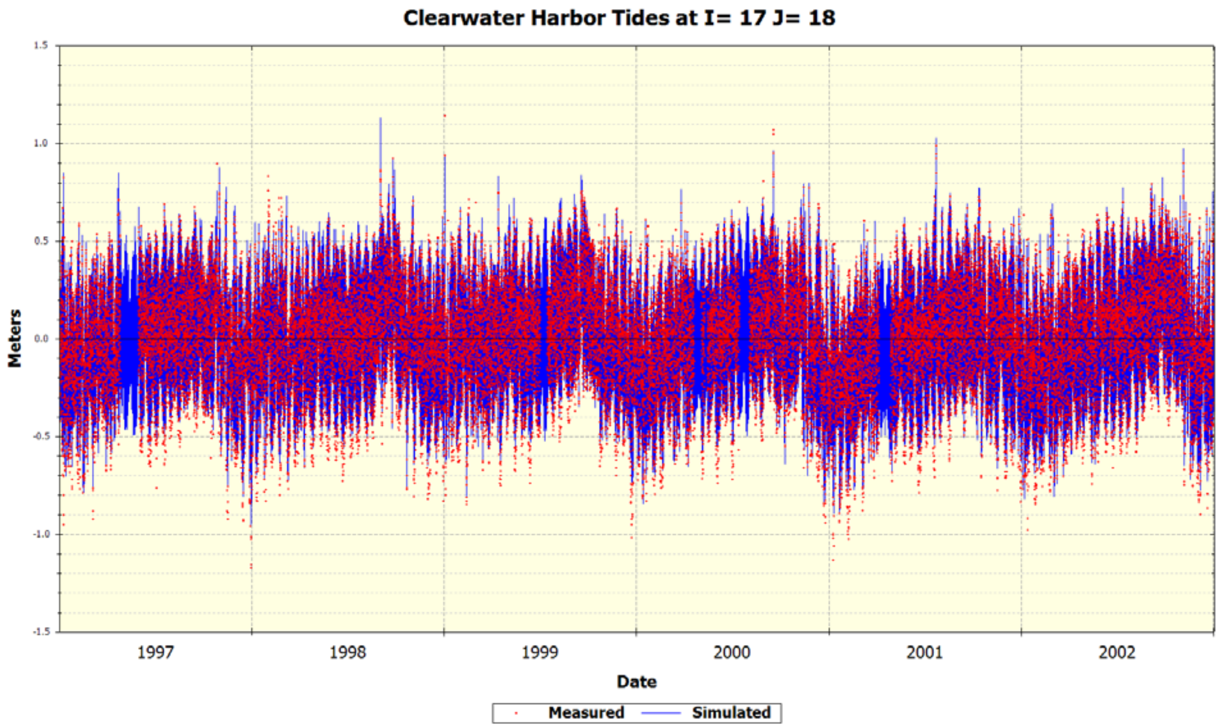

Figure 4.1.6. 1997-2002 validation measured versus simulated WSE at Clearwater Harbor

4.2 Salinity Modeling Results

4.2.1 Calibration

Table 4.2.1 Calibration Comparisons of Simulations and Measurements of Surface Salinity at Florida Big Bend monitoring stations for 2003-2009.

Station	Simulated Mean (PSU)	Simulated 5%ile (PSU)	Simulated 95%ile (PSU)	Measured Mean (PSU)	Measured 5%ile (PSU)	Measured 95%ile (PSU)	Error Mean (PSU)	Error 5%ile (PSU)
I= 18 J= 10	27.9	23.2	32.0	33.5	29.7	37.2	-5.6	-16.7
I= 17 J= 18	31.3	26.2	34.7	32.0	26.1	35.8	-0.7	-2.1
I= 20 J= 31	28.3	21.0	34.1	24.3	17.9	30.0	4.0	16.7
I= 22 J= 39	28.7	19.2	36.5	22.5	15.4	28.0	6.3	27.9
I= 30 J= 44	4.7	0.7	10.0	12.0	0.3	24.6	-7.3	-60.8
I= 24 J= 47	25.4	18.2	32.0	20.0	13.7	25.5	5.4	27.0
I= 27 J= 53	9.9	4.3	16.1	4.9	1.1	12.3	5.0	101.9
I= 24 J= 59	19.2	15.0	24.7	22.2	12.6	29.9	-3.0	-13.6
I= 24 J= 62	17.6	14.1	20.6	24.6	16.8	31.9	-7.0	-28.5
I= 24 J= 70	17.3	10.7	22.2	22.1	11.6	28.7	-4.8	-21.9
I= 23 J= 78	17.9	10.1	23.9	21.3	7.6	31.1	-3.4	-15.9
I= 25 J= 78	12.6	3.7	19.6	16.4	3.2	27.4	-3.8	-23.2
I= 21 J= 79	20.5	13.3	25.4	22.8	11.1	31.6	-2.4	-10.4
I= 14 J= 85	22.2	16.2	26.8	20.5	12.0	26.5	1.7	8.5
I= 13 J= 89	28.6	22.4	33.0	21.4	8.9	30.1	7.3	34.1
I= 16 J= 92	17.2	9.5	23.2	22.3	3.8	31.2	-5.1	-23.0
I= 16 J=102	26.2	19.8	31.5	25.5	15.3	34.8	0.7	2.7
I= 18 J=110	28.2	21.7	33.2	24.0	4.9	33.1	4.2	17.4
I= 22 J=110	12.6	1.1	23.6	4.3	0.1	20.8	8.2	189.9
I= 26 J=128	8.6	1.3	18.4	1.6	0.0	0.0	7.1	449.0
I= 31 J=128	1.7	0.0	5.3	0.5	0.1	0.9	1.2	242.9
I= 21 J=129	24.5	18.0	30.4	26.0	0.0	0.0	-1.4	-5.5
I= 23 J=133	21.0	12.1	30.0	19.1	8.3	27.2	1.9	9.8
I= 21 J=134	25.9	17.7	32.7	23.2	15.6	29.6	2.8	11.9
I= 26 J=145	12.9	2.7	22.0	13.4	2.1	28.6	-0.5	-4.0
I= 24 J=150	20.2	13.4	26.4	20.7	9.0	30.7	-0.5	-2.3
I= 20 J=152	18.2	7.2	26.4	20.5	5.1	32.7	-2.3	-11.2
I= 18 J=154	30.0	25.3	33.8	30.8	24.7	36.0	-0.9	-2.8
I= 18 J=156	30.1	25.3	33.9	30.9	24.6	35.9	-0.8	-2.5
I= 21 J=156	7.3	0.0	22.0	9.0	0.2	26.3	-1.7	-18.4
I= 14 J=169	26.3	13.5	34.3	24.3	6.8	34.8	1.9	8.0
I= 19 J=180	2.0	0.0	8.1	19.3	1.6	36.7	-17.3	-89.5
I= 20 J=180	1.4	0.0	6.4	3.2	0.0	14.5	-1.8	-55.4

Station	Simulated Mean (PSU)	Simulated 5%ile (PSU)	Simulated 95%ile (PSU)	Measured Mean (PSU)	Measured 5%ile (PSU)	Measured 95%ile (PSU)	Error Mean (PSU)	Error 5%ile (PSU)
I= 10 J=182	26.2	10.1	35.4	13.3	1.8	30.0	12.9	97.3
I= 14 J=186	9.9	2.1	19.6	15.3	2.2	34.6	-5.4	-35.2
I= 14 J=188	12.0	3.2	24.2	13.0	1.1	29.0	-1.1	-8.2
I= 14 J=189	12.8	3.4	25.9	13.4	2.2	28.6	-0.6	-4.3

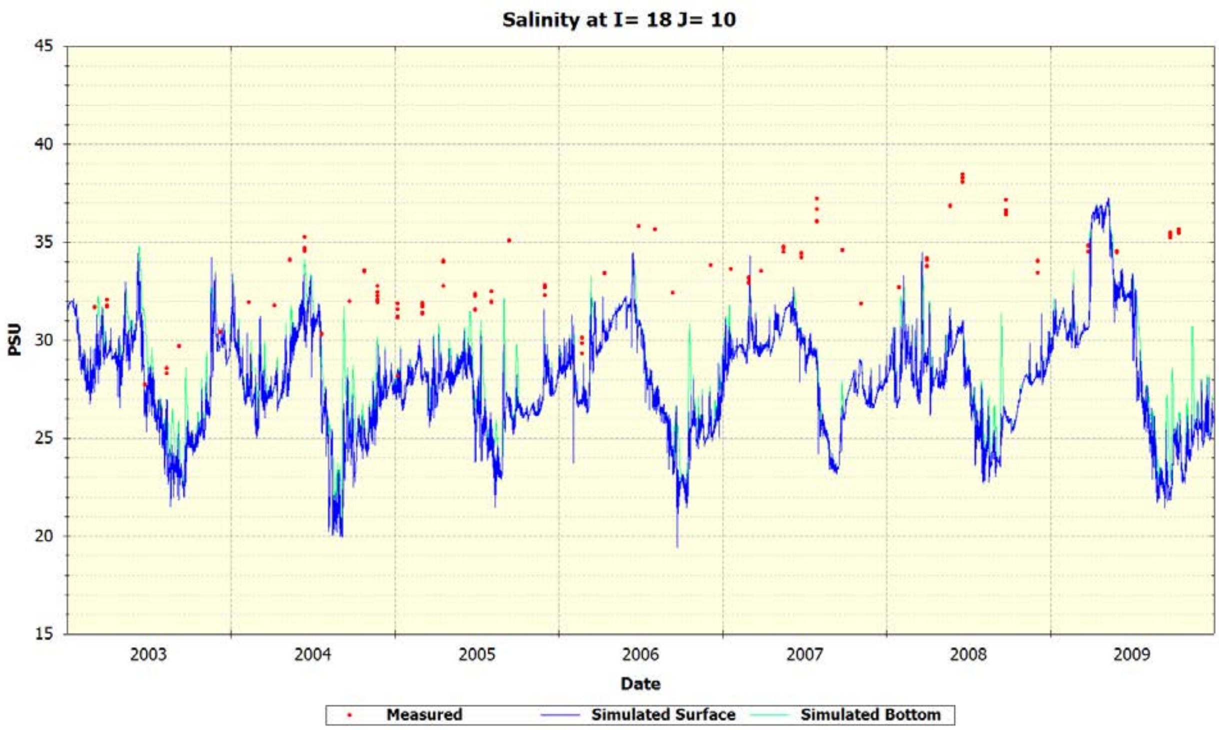

Figure 4.2.1 2003-2009 calibration measured versus simulated salinity at I=18 J=10

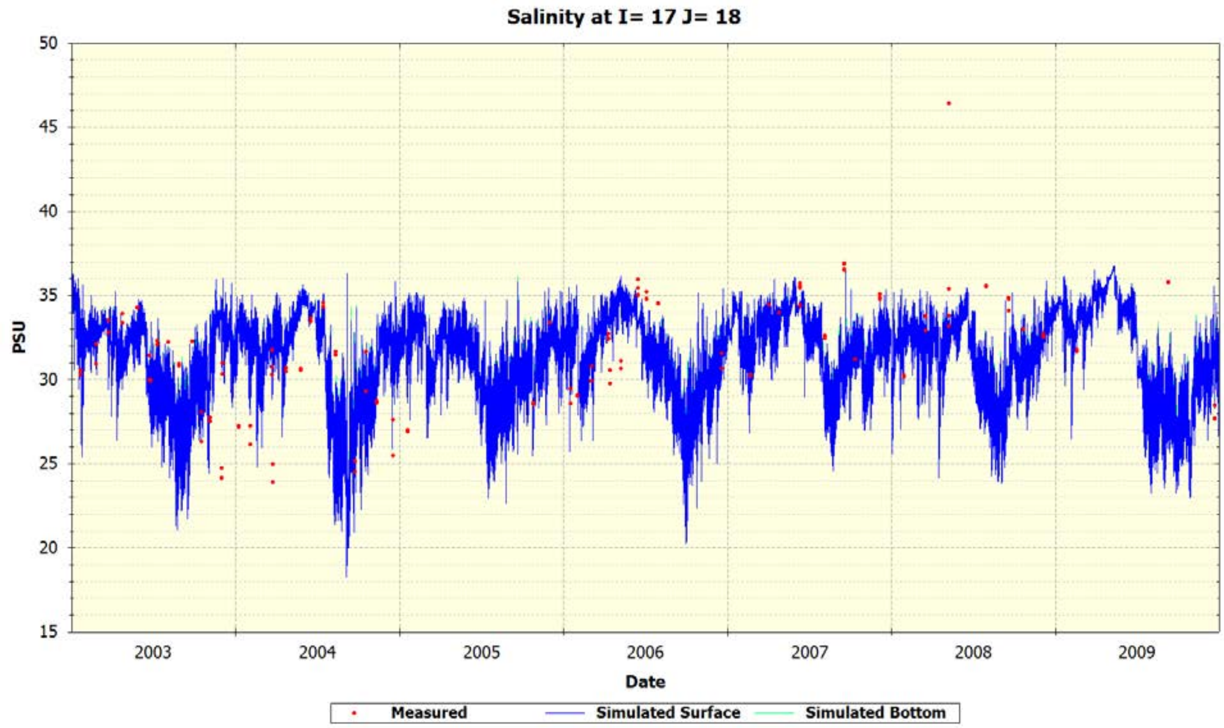

Figure 4.2.2 2003-2009 calibration measured versus simulated salinity at I=17 J=18

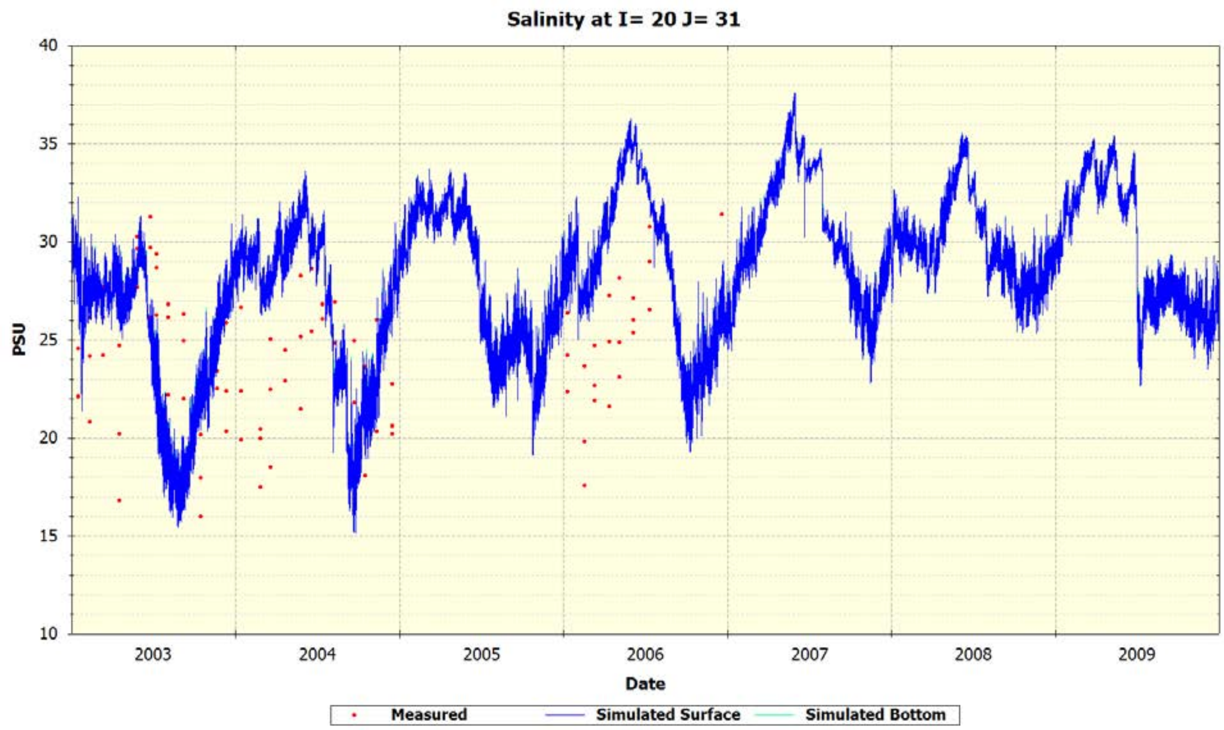

Figure 4.2.3 2003-2009 calibration measured versus simulated salinity at I=20 J=31

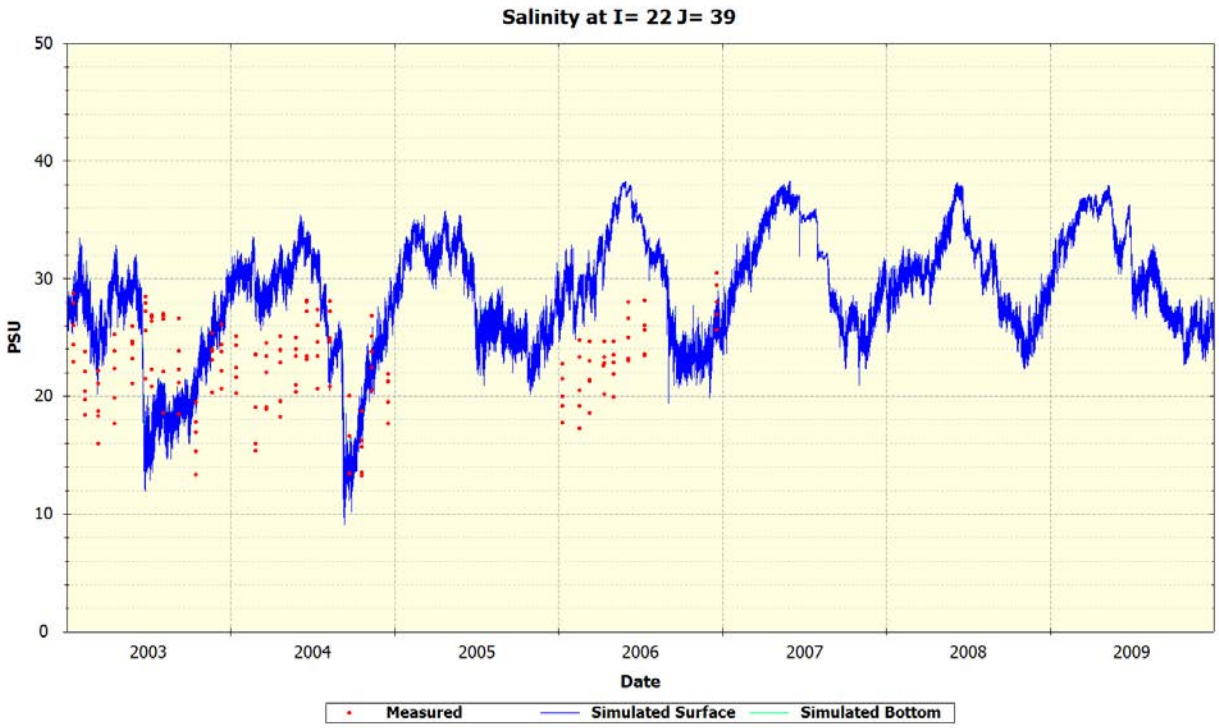

Figure 4.2.4 2003-2009 calibration measured versus simulated salinity at I=22 J=39

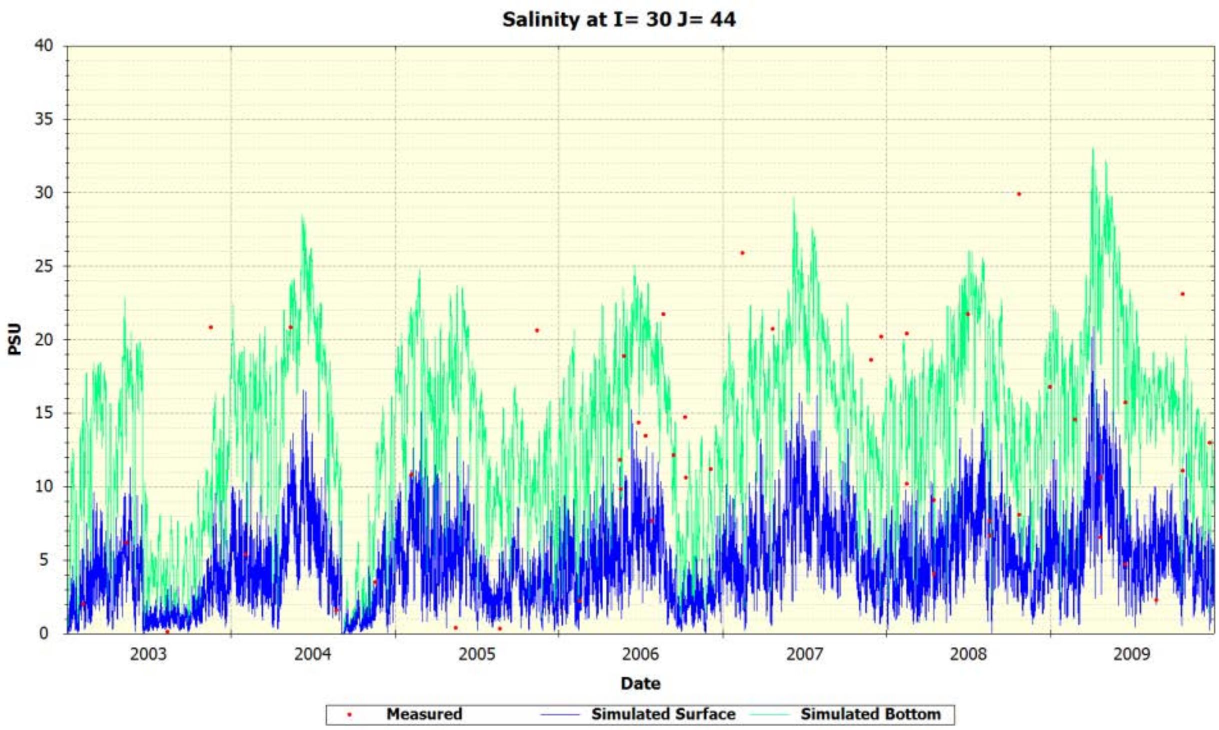

Figure 4.2.5 2003-2009 calibration measured versus simulated salinity at I=30 J=44

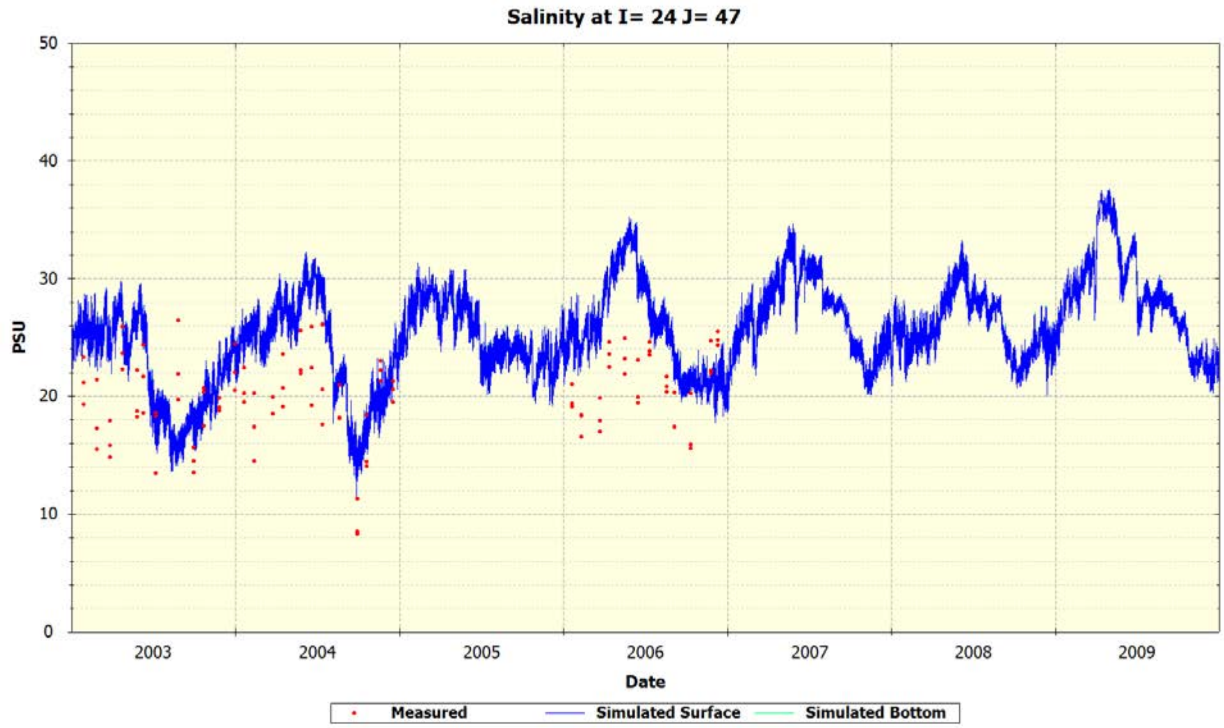

Figure 4.2.6 2003-2009 calibration measured versus simulated salinity at I=24 J=47

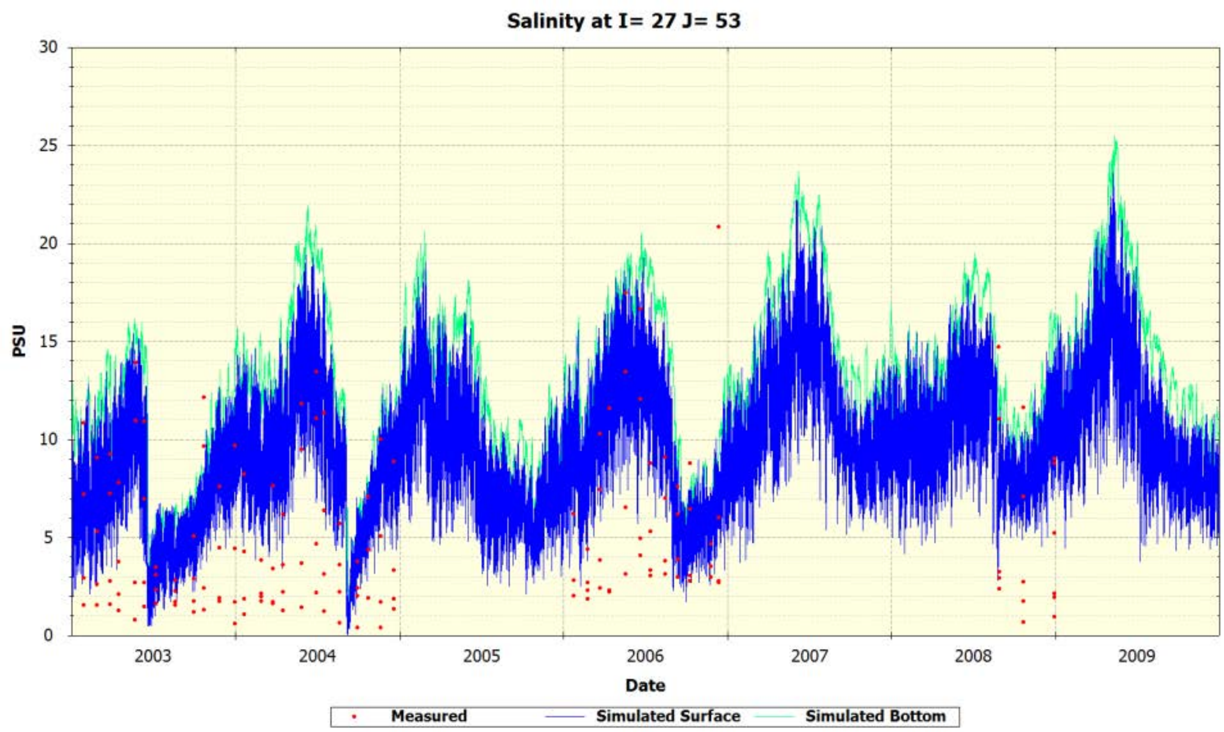

Figure 4.2.7 2003-2009 calibration measured versus simulated salinity at I=27 J=53

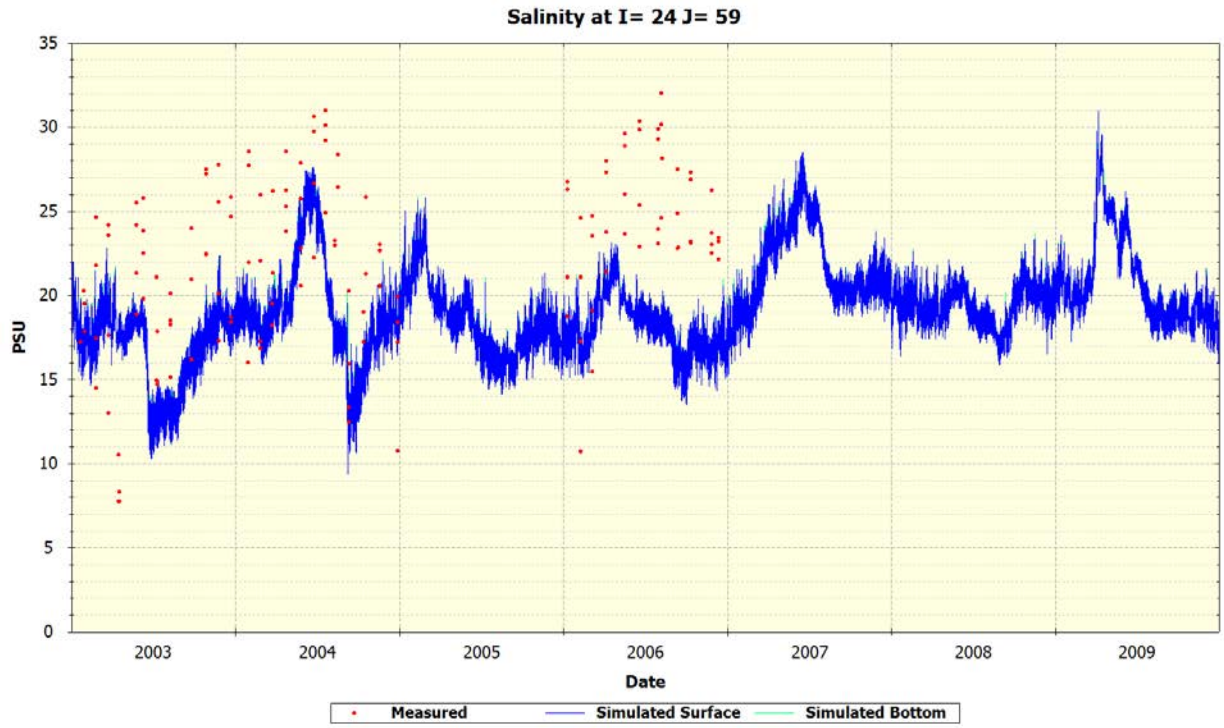

Figure 4.2.8 2003-2009 calibration measured versus simulated salinity at I=24 J=59

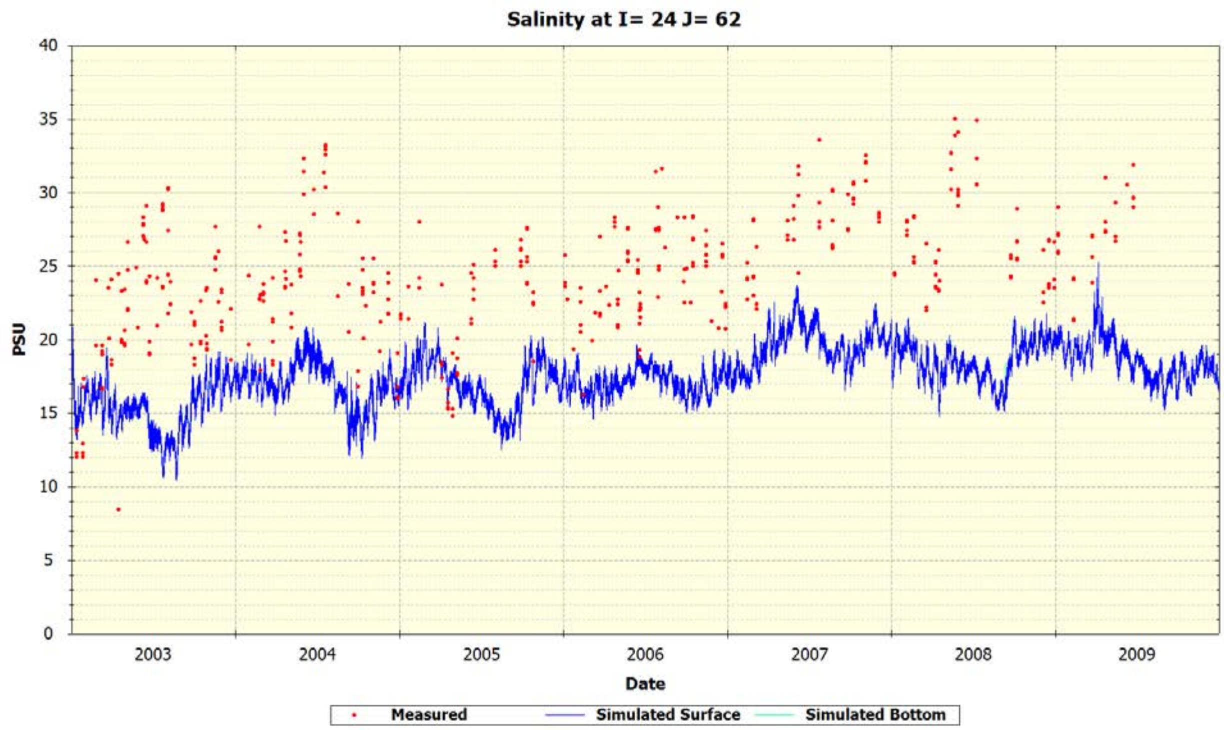

Figure 4.2.9 2003-2009 calibration measured versus simulated salinity at I=24 J=62

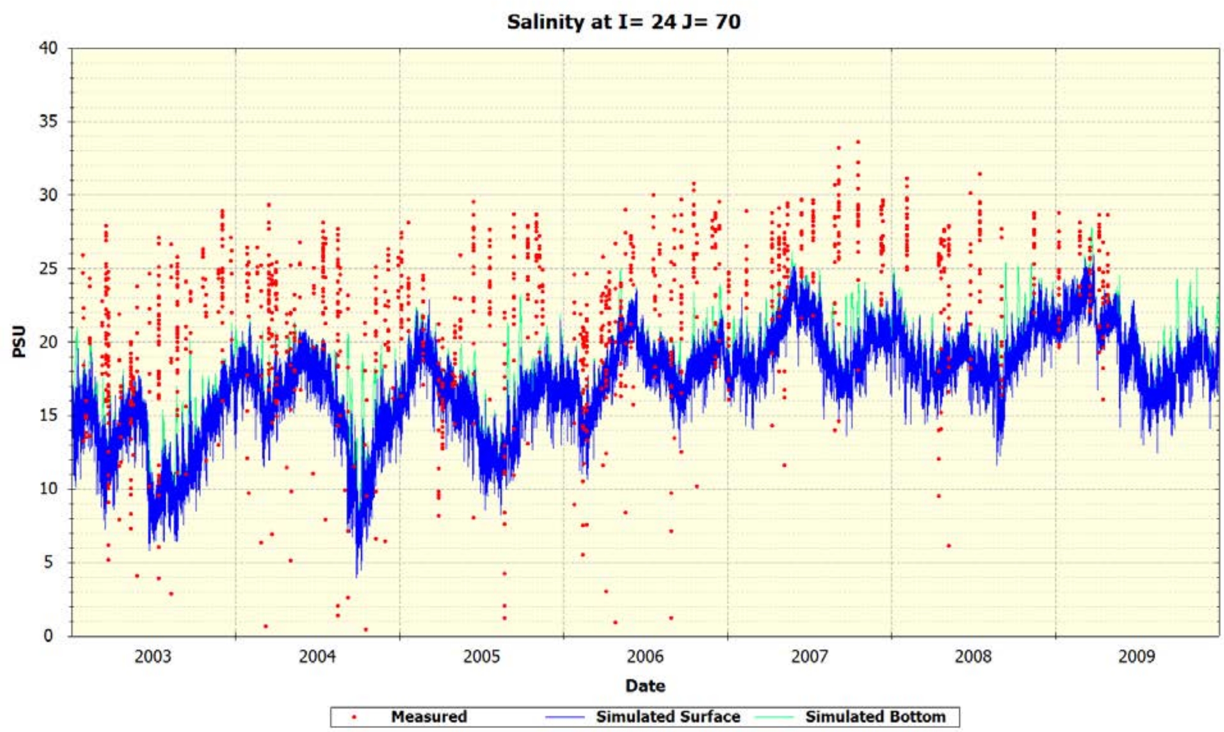

Figure 4.2.10 2003-2009 calibration measured versus simulated salinity at I=24 J=70

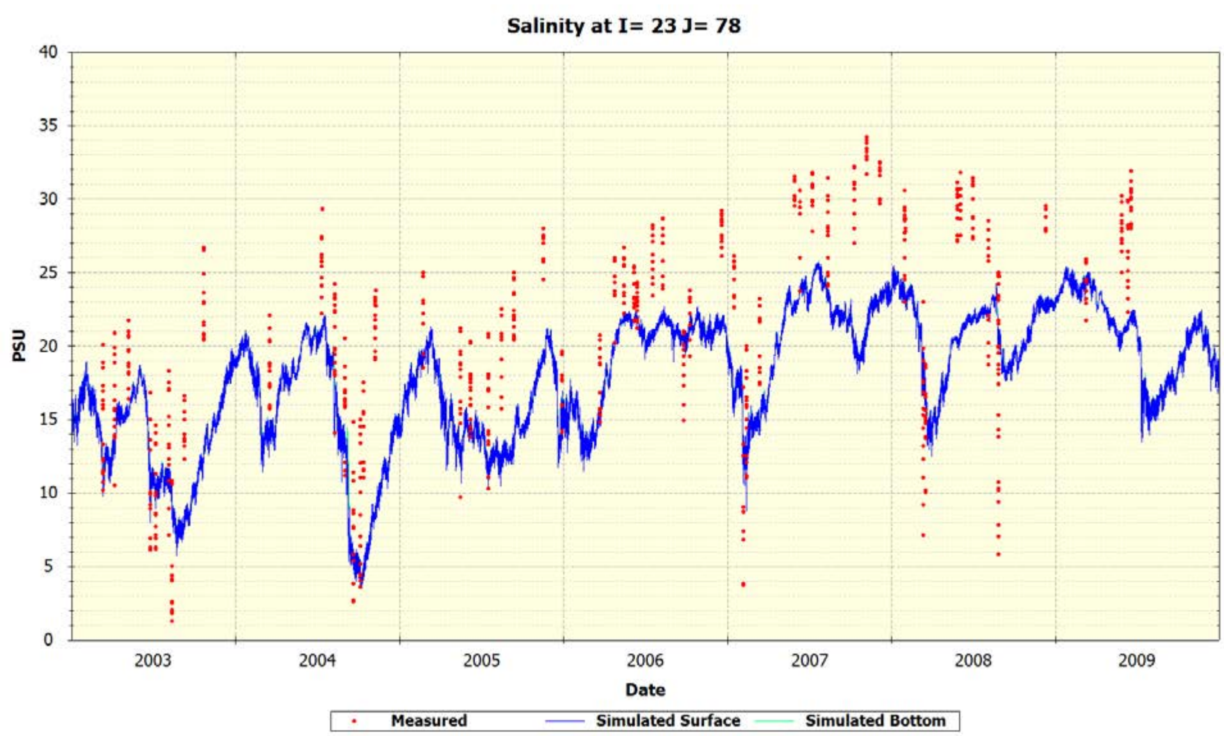

Figure 4.2.11 2003-2009 calibration measured versus simulated salinity at I=23 J=78

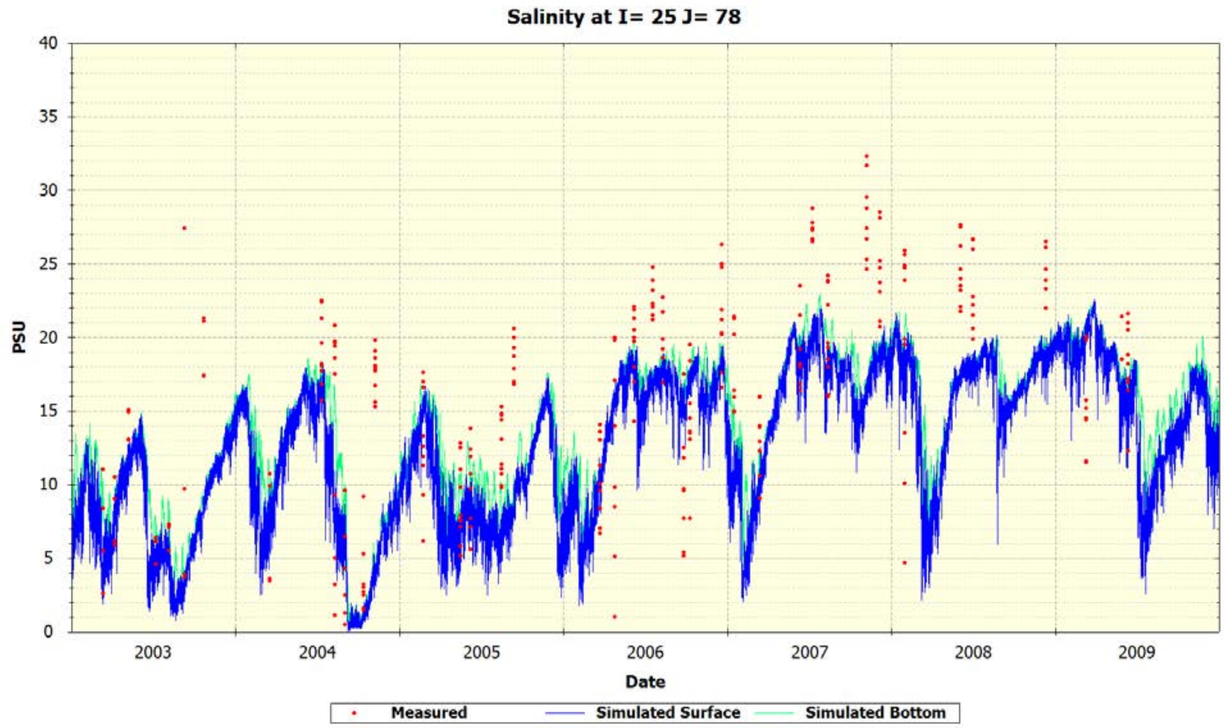

Figure 4.2.12 2003-2009 calibration measured versus simulated salinity at I=25 J=78

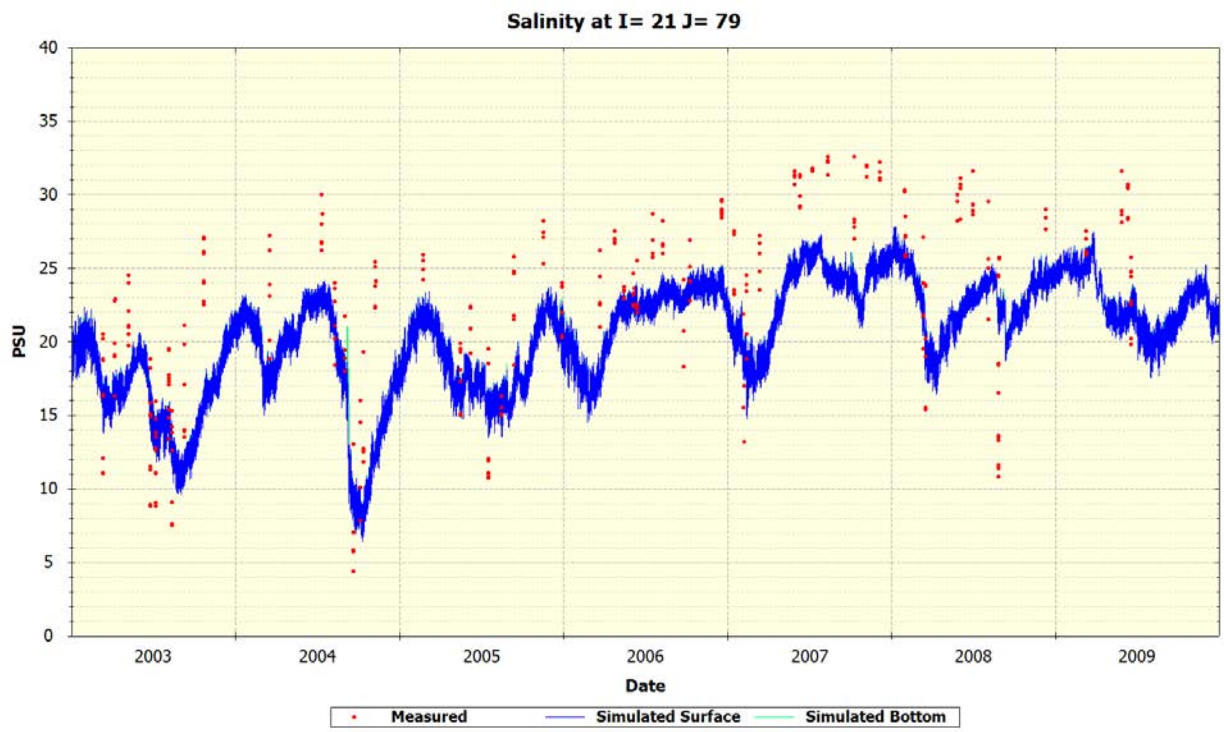

Figure 4.2.13 2003-2009 calibration measured versus simulated salinity at I=21 J=79

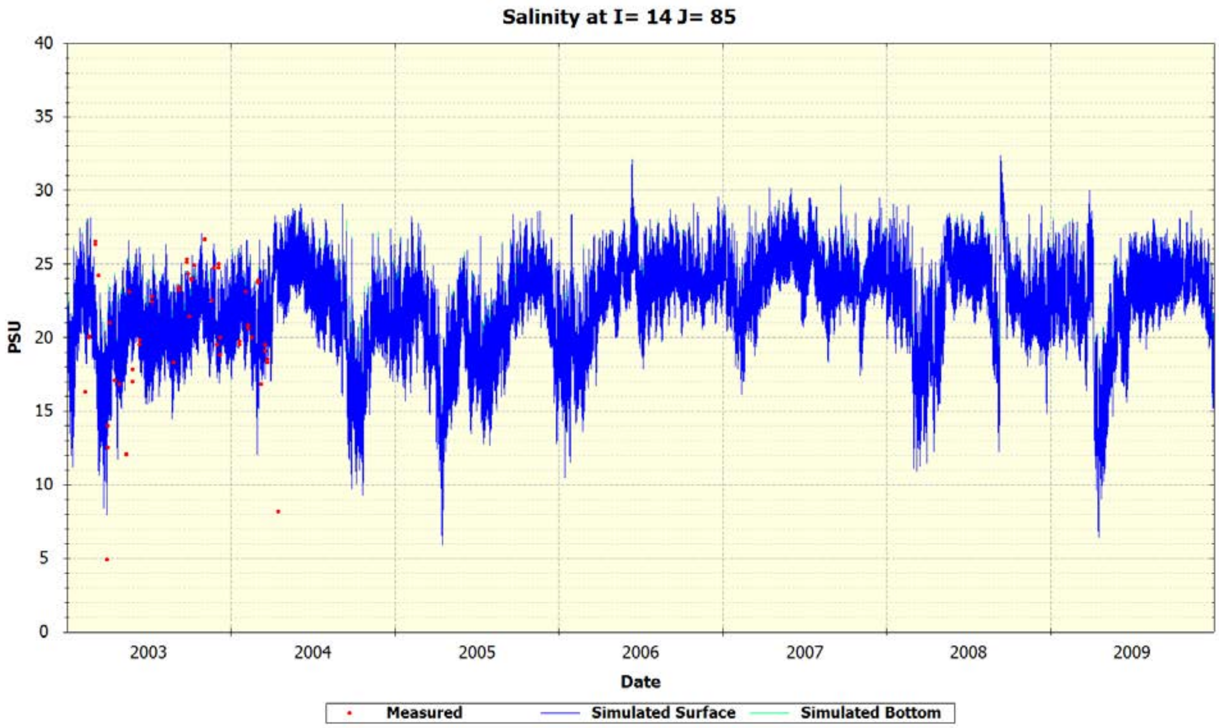

Figure 4.2.14 2003-2009 calibration measured versus simulated salinity at I=14 J=85

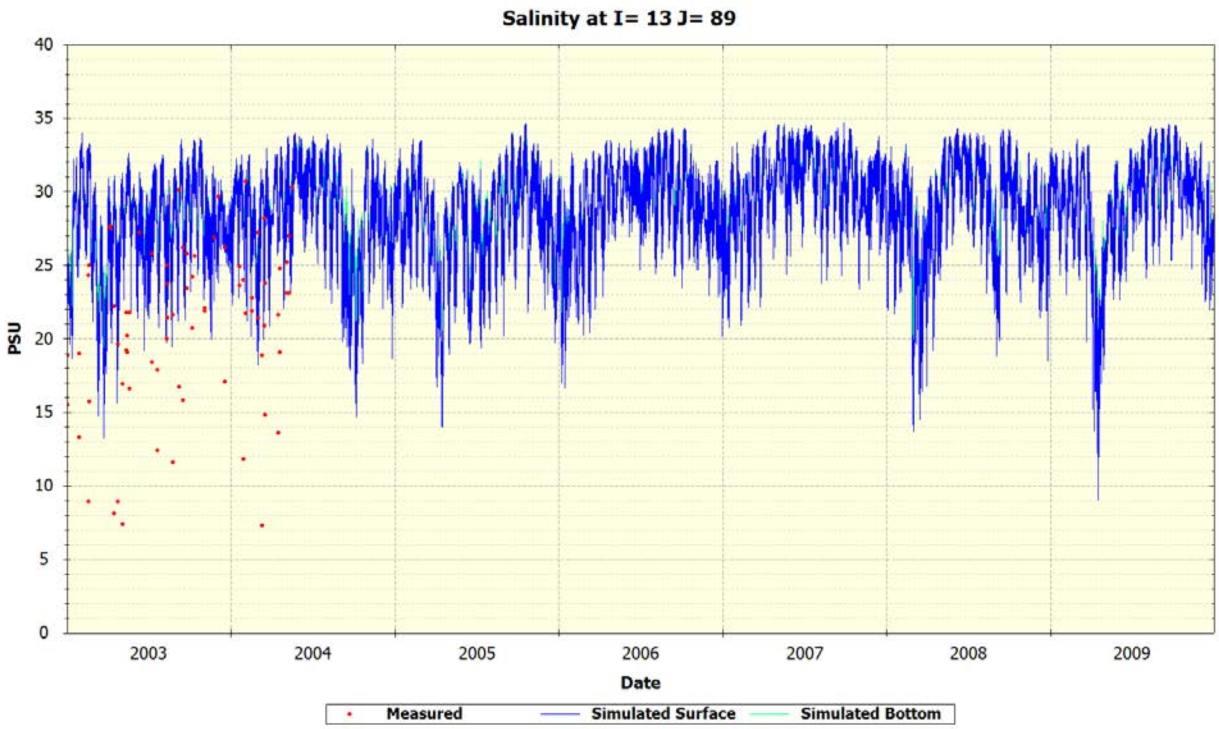

Figure 4.2.15 2003-2009 calibration measured versus simulated salinity at I=13 J=89

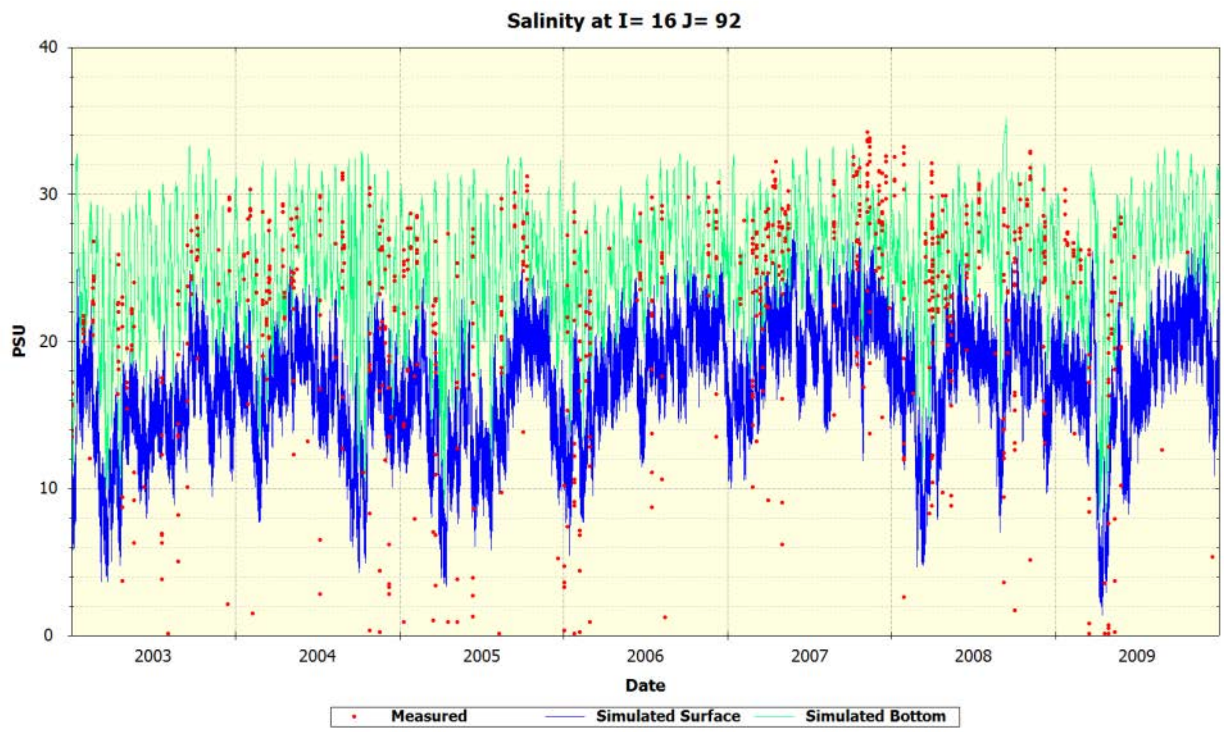

Figure 4.2.16 2003-2009 calibration measured versus simulated salinity at I=16 J=92

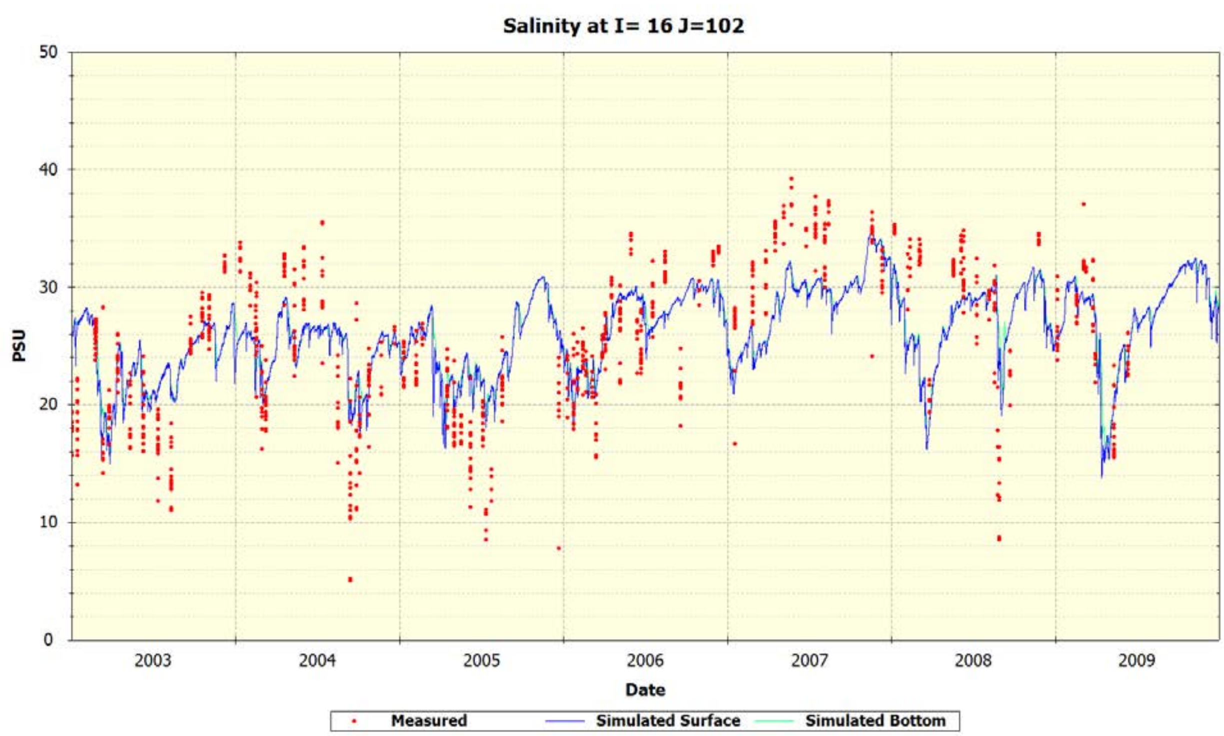

Figure 4.2.17 2003-2009 calibration measured versus simulated salinity at I=16 J=102

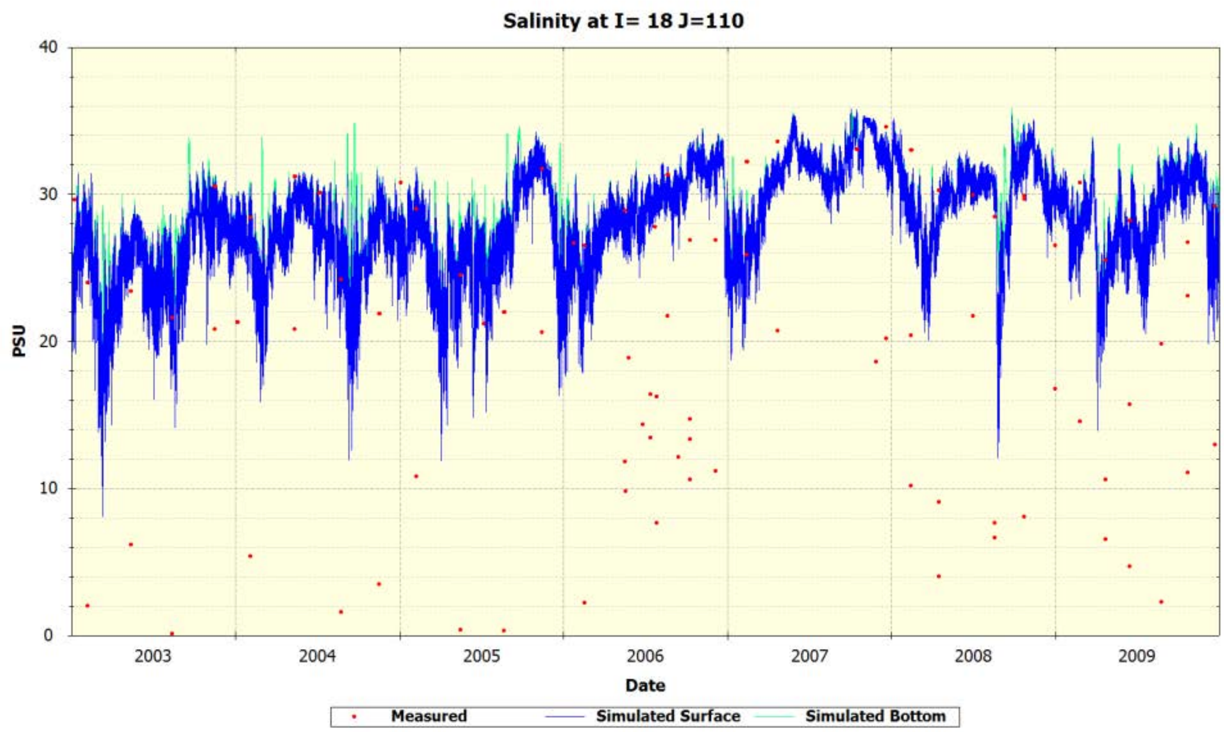

Figure 4.2.18 2003-2009 calibration measured versus simulated salinity at I=18 J=110

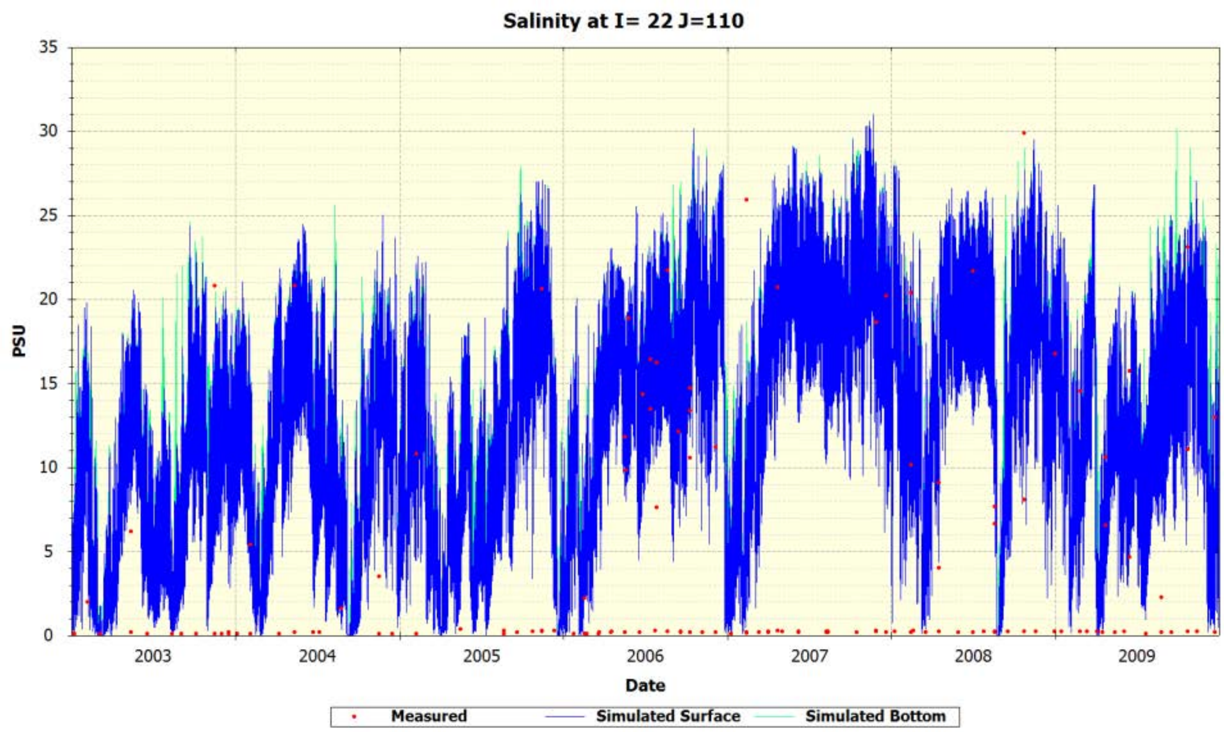

Figure 4.2.19 2003-2009 calibration measured versus simulated salinity at I=22 J=110

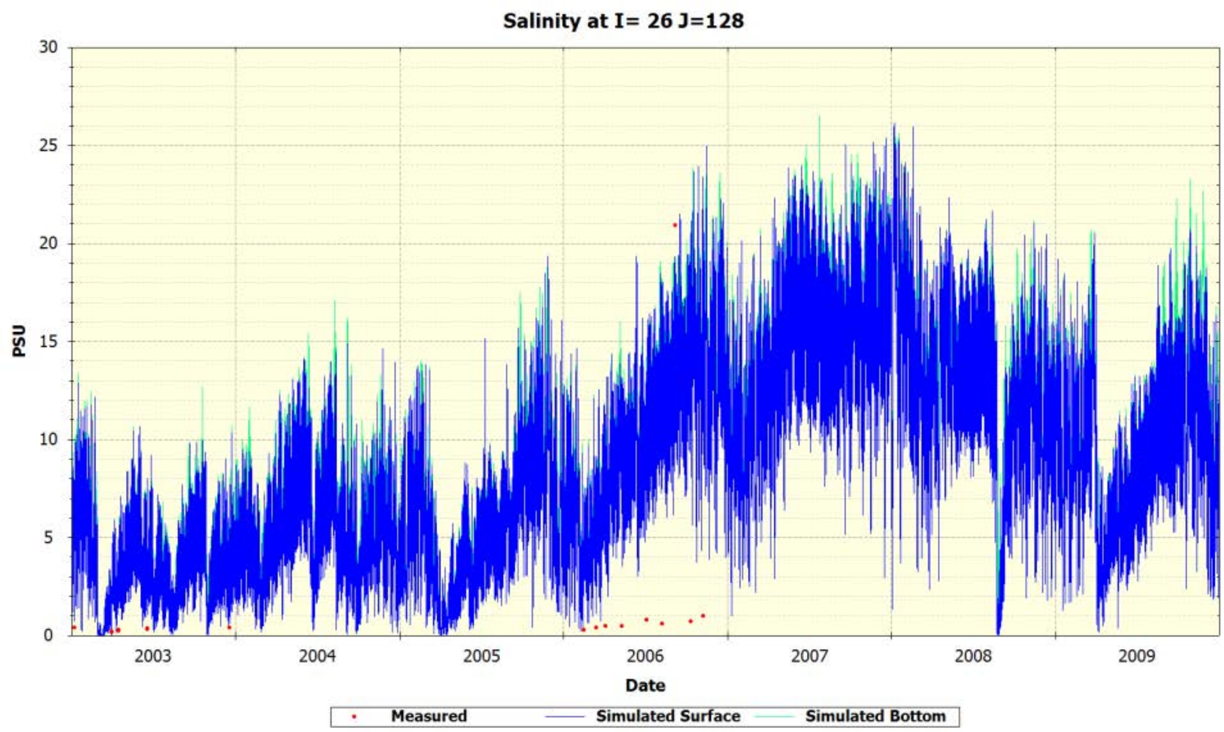

Figure 4.2.20 2003-2009 calibration measured versus simulated salinity at I=26 J=128

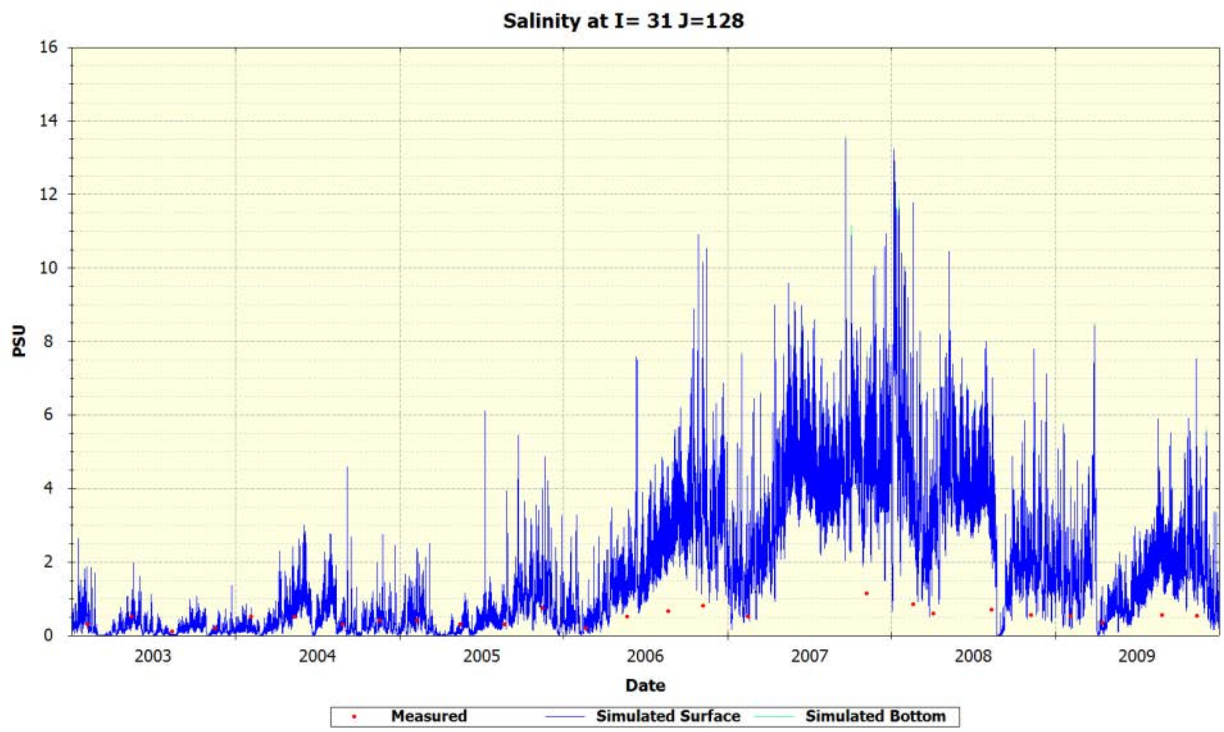

Figure 4.2.21 2003-2009 calibration measured versus simulated salinity at I=31 J=128

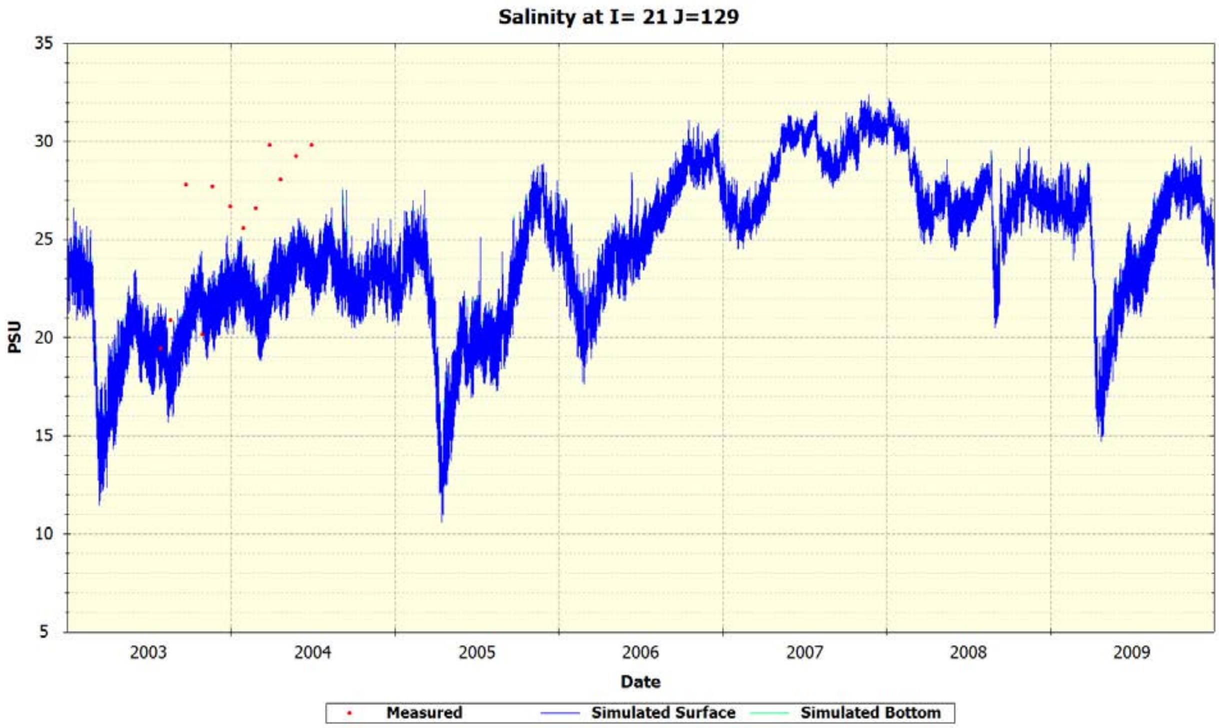

Figure 4.2.22 2003-2009 calibration measured versus simulated salinity at I=21 J=129

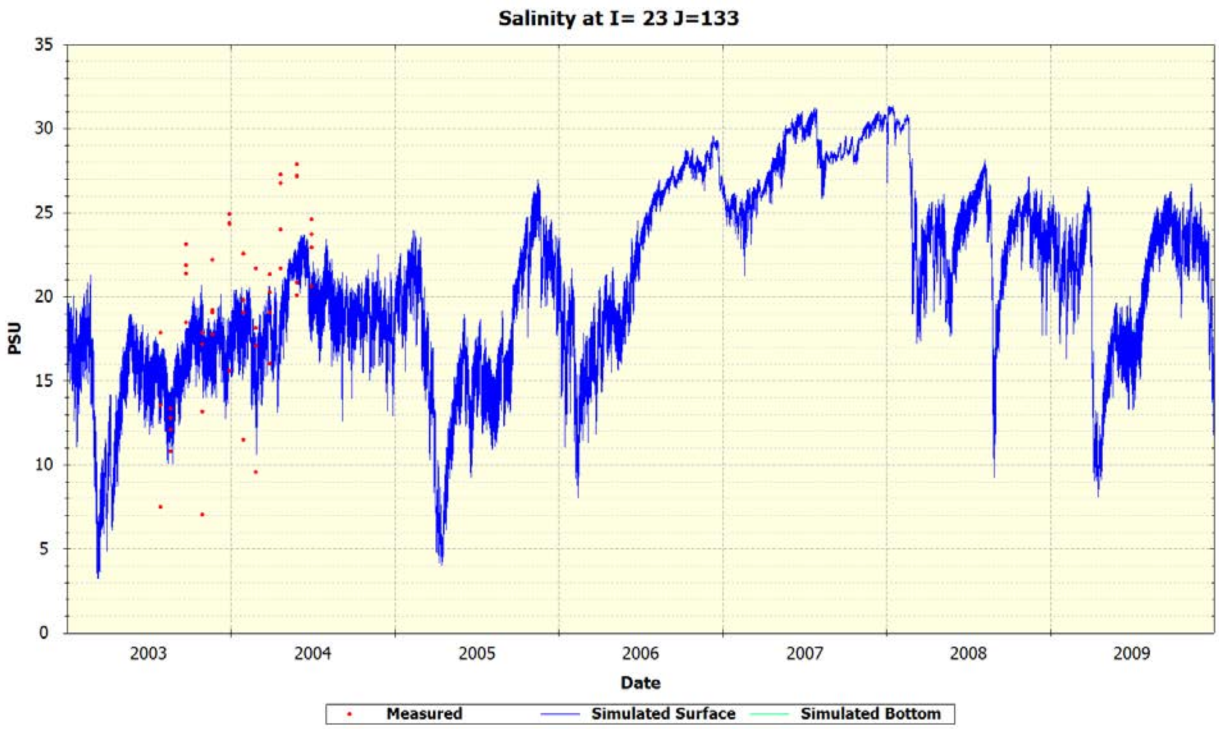

Figure 4.2.23 2003-2009 calibration measured versus simulated salinity at I=23 J=133

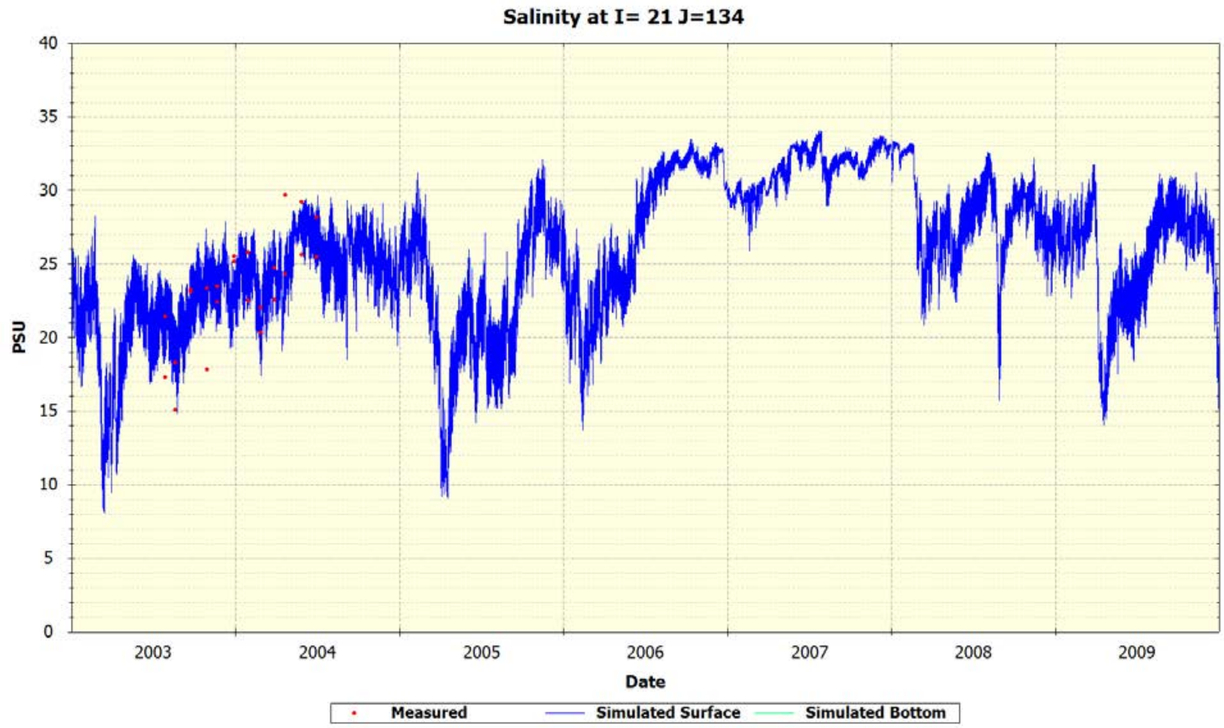

Figure 4.2.24 2003-2009 calibration measured versus simulated salinity at I=21 J=134

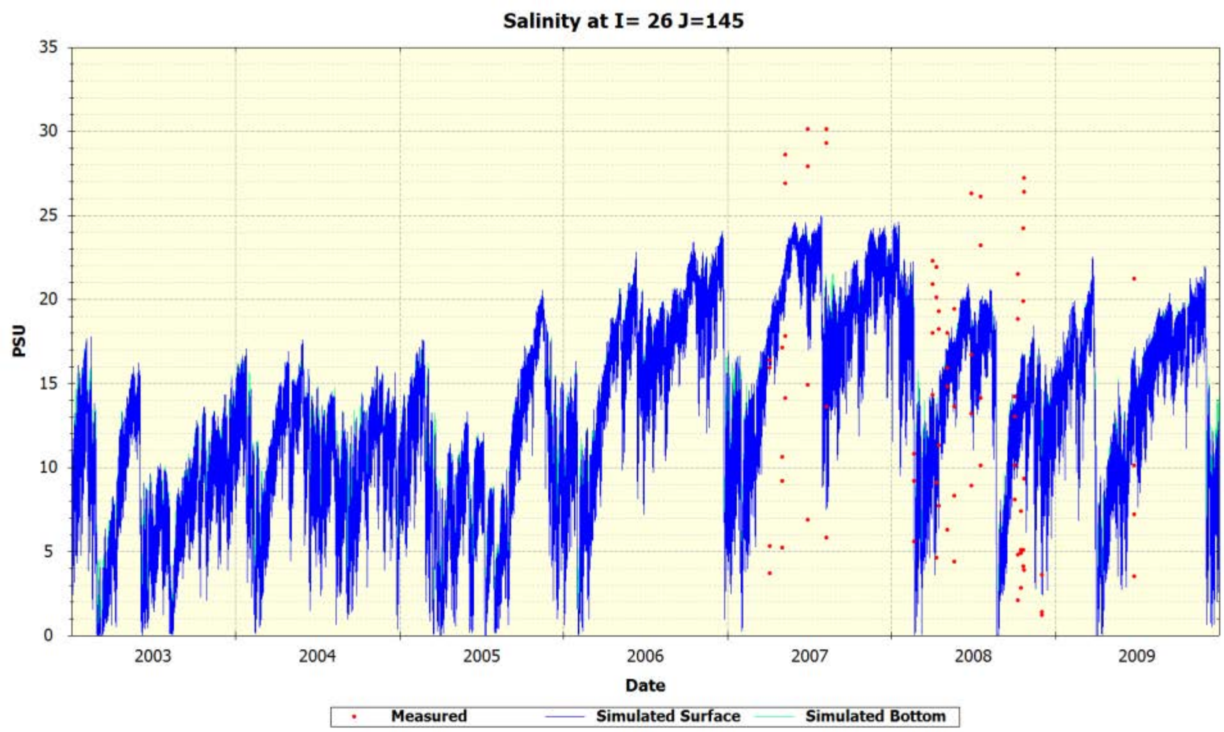

Figure 4.2.25 2003-2009 calibration measured versus simulated salinity at I=26 J=145

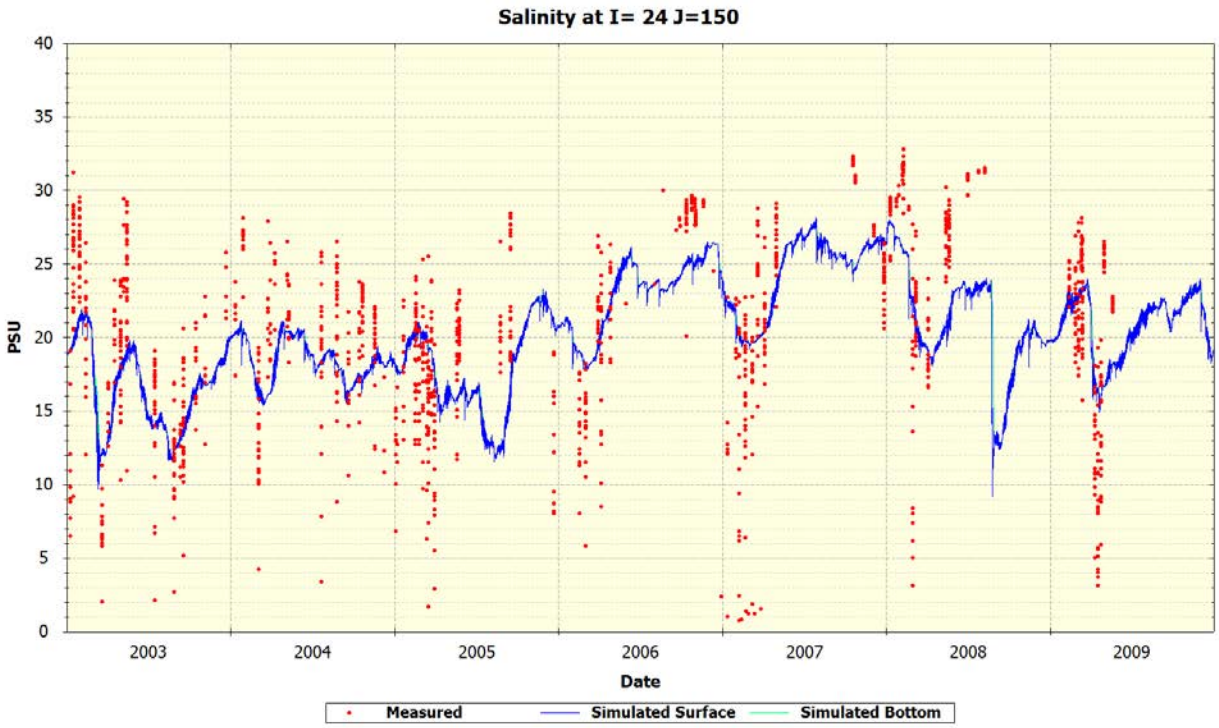

Figure 4.2.26 2003-2009 calibration measured versus simulated salinity at I=24 J=150

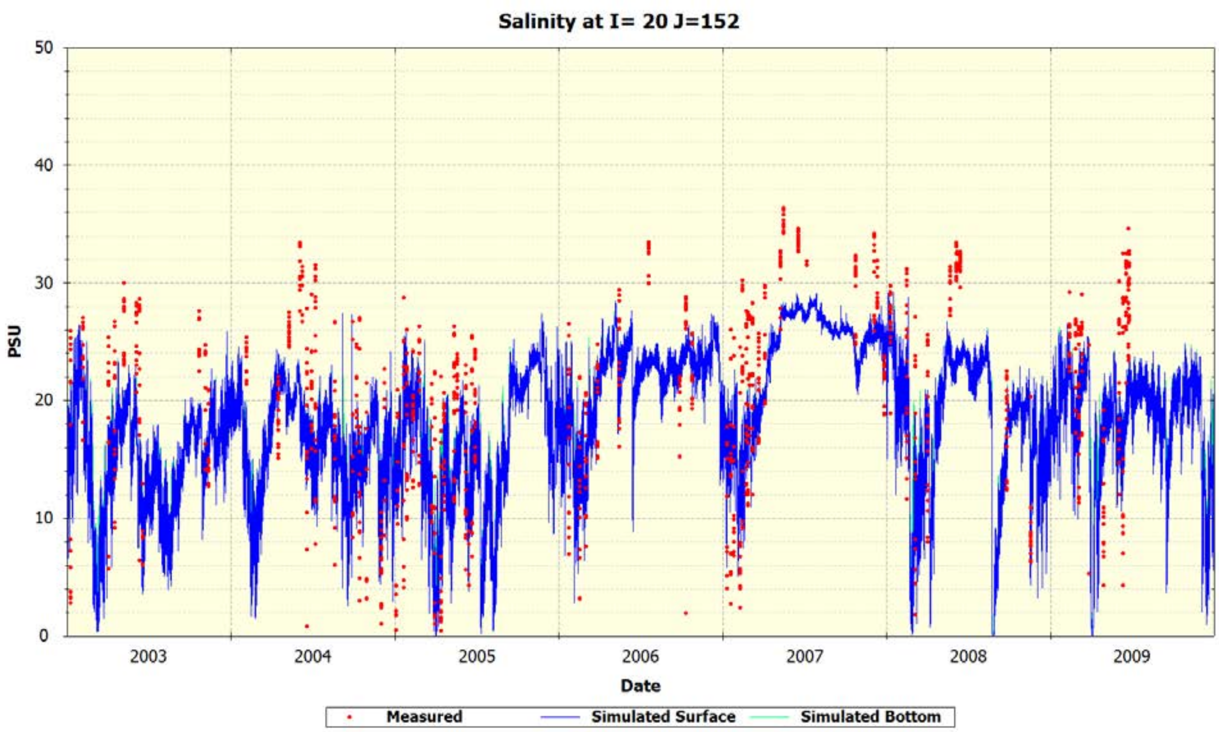

Figure 4.2.27 2003-2009 calibration measured versus simulated salinity at I=20 J=152

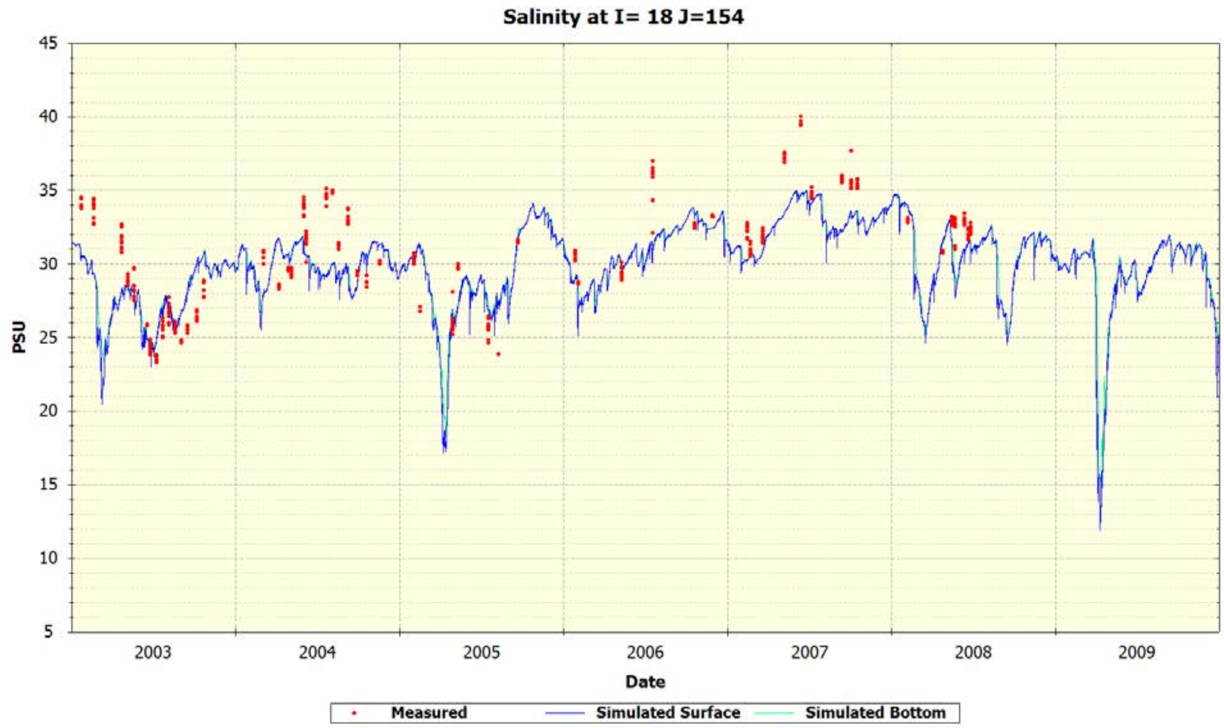

Figure 4.2.28 2003-2009 calibration measured versus simulated salinity at I=18 J=154

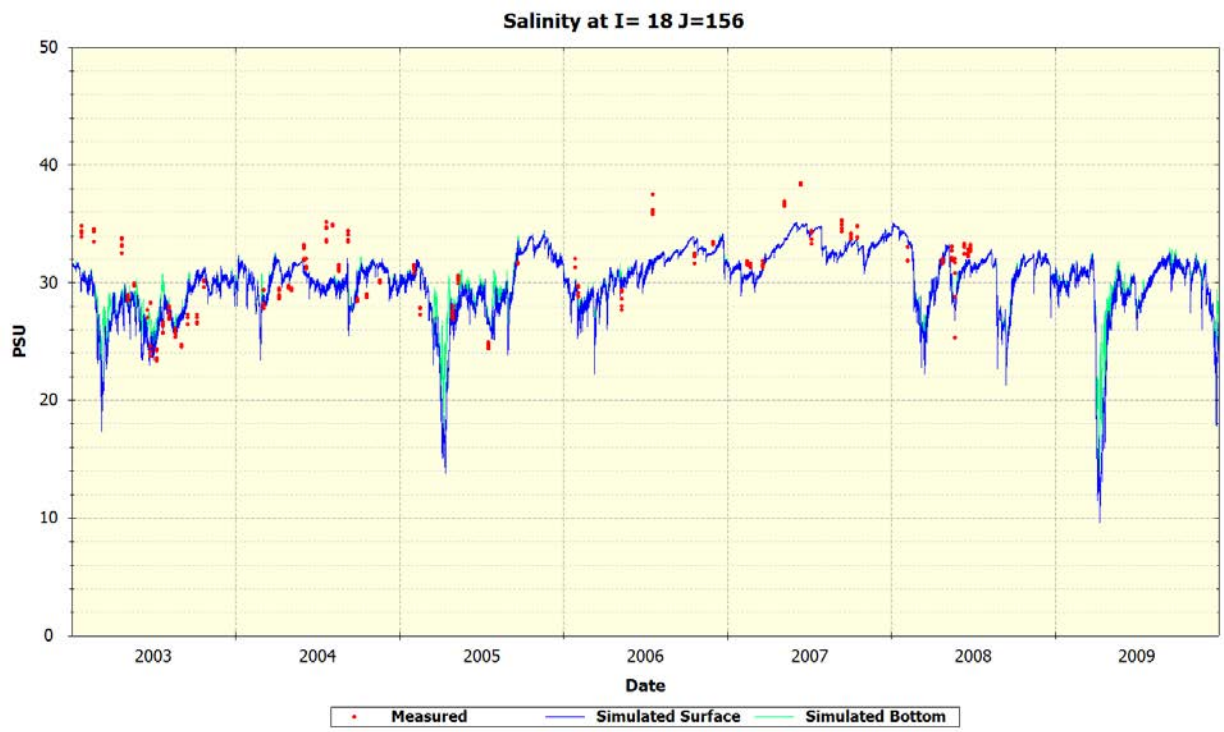

Figure 4.2.29 2003-2009 calibration measured versus simulated salinity at I=18 J=156

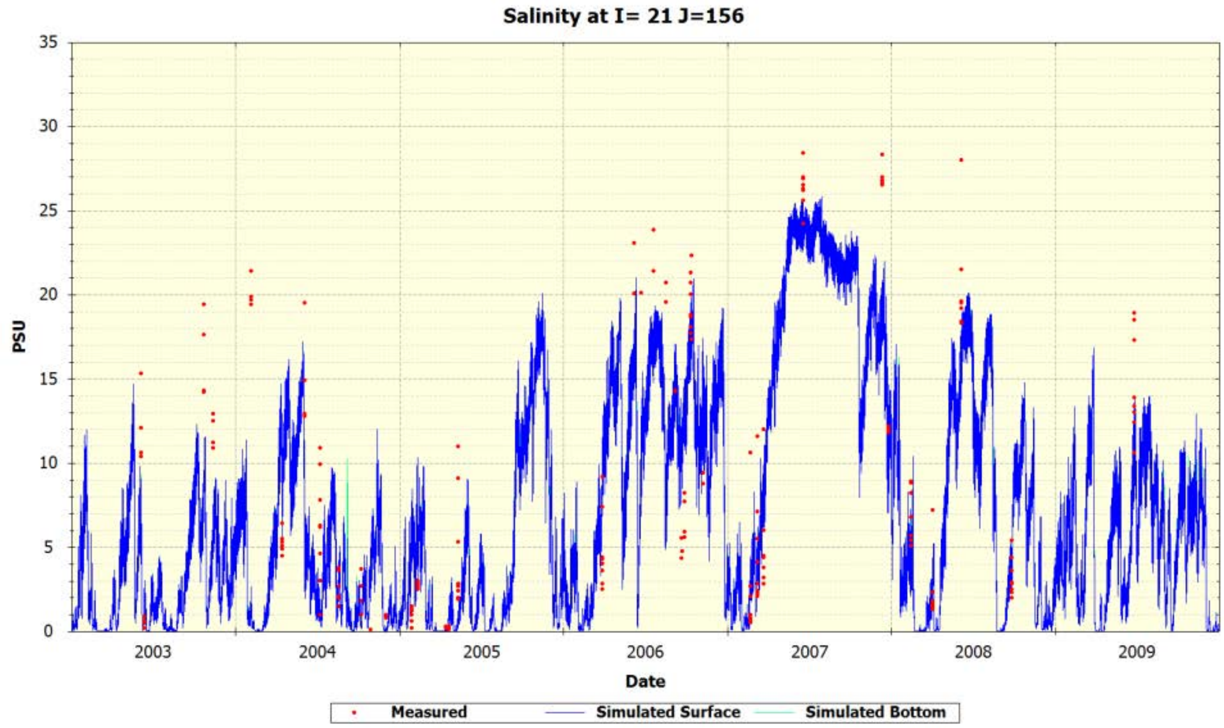

Figure 4.2.30 2003-2009 calibration measured versus simulated salinity at I=21 J=156

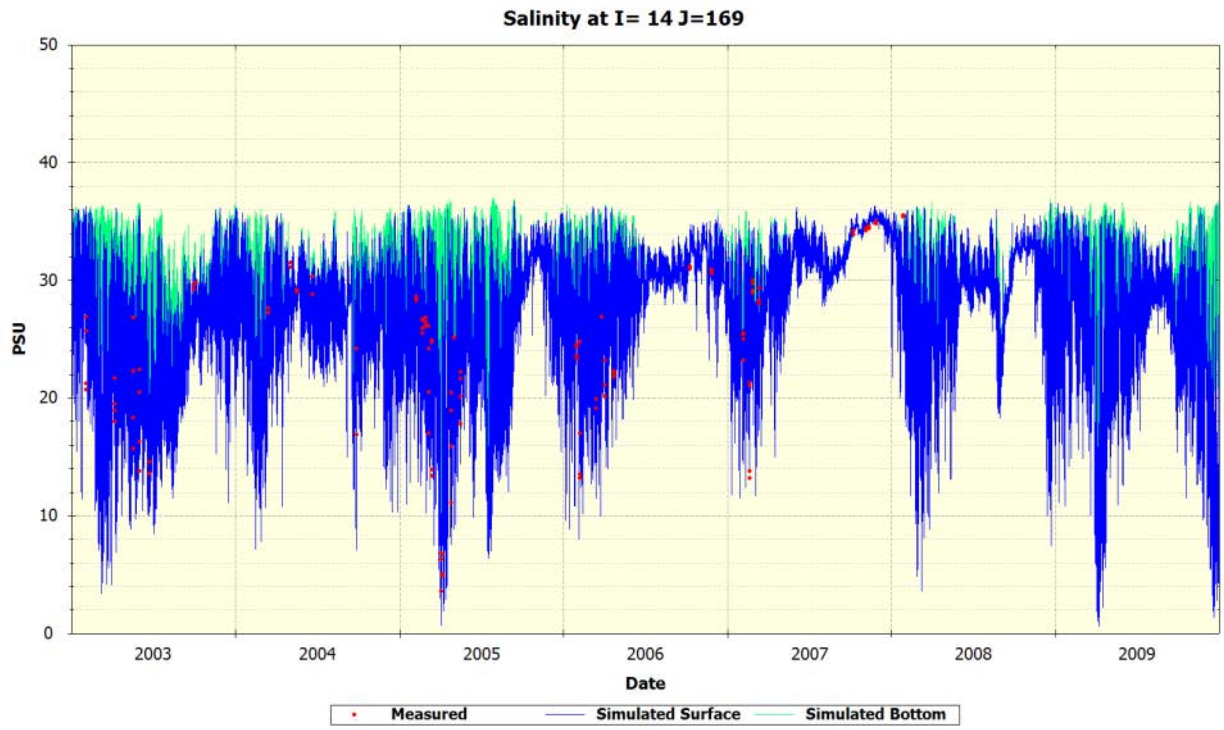

Figure 4.2.31 2003-2009 calibration measured versus simulated salinity at I=14 J=169

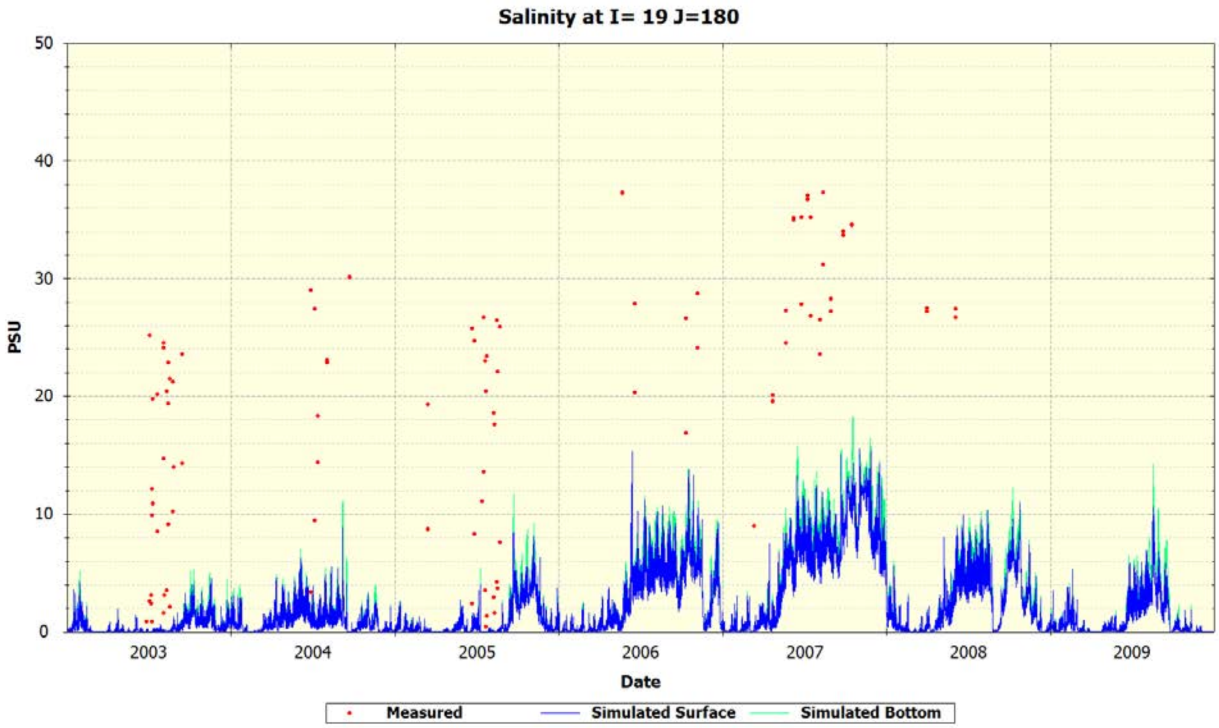

Figure 4.2.32 2003-2009 calibration measured versus simulated salinity at I=19 J=180

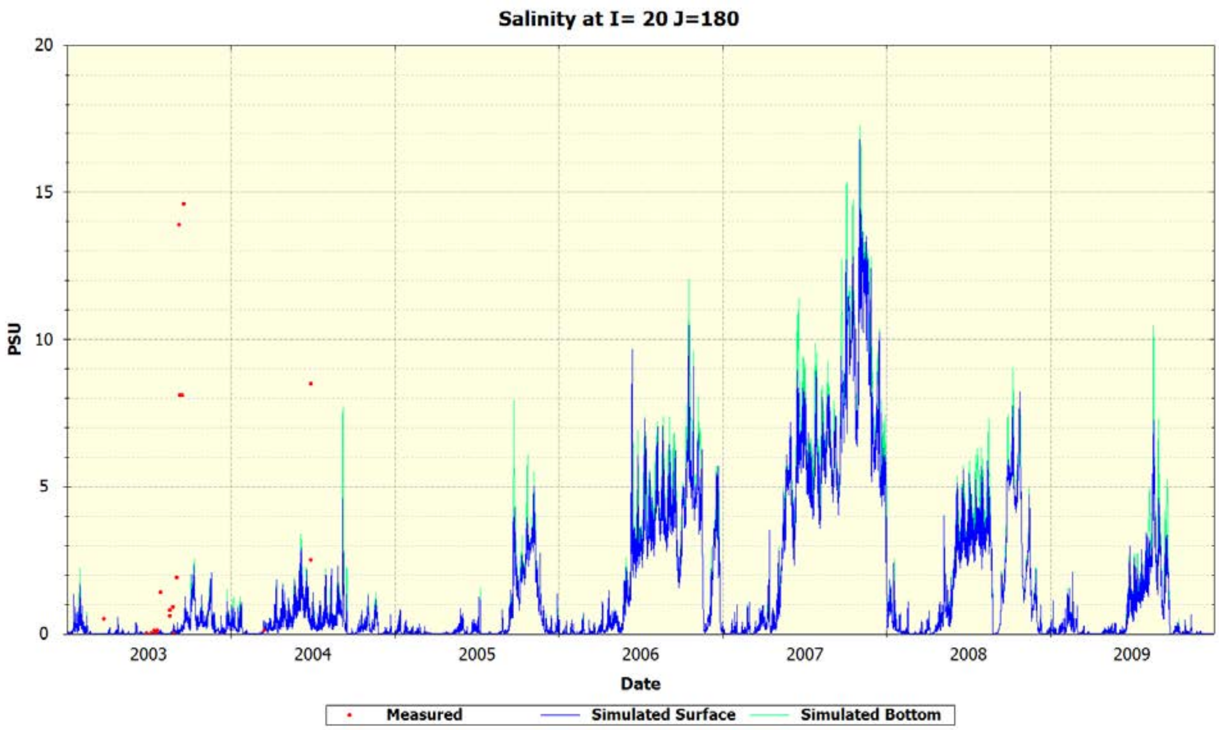

Figure 4.2.33 2003-2009 calibration measured versus simulated salinity at I=20 J=180

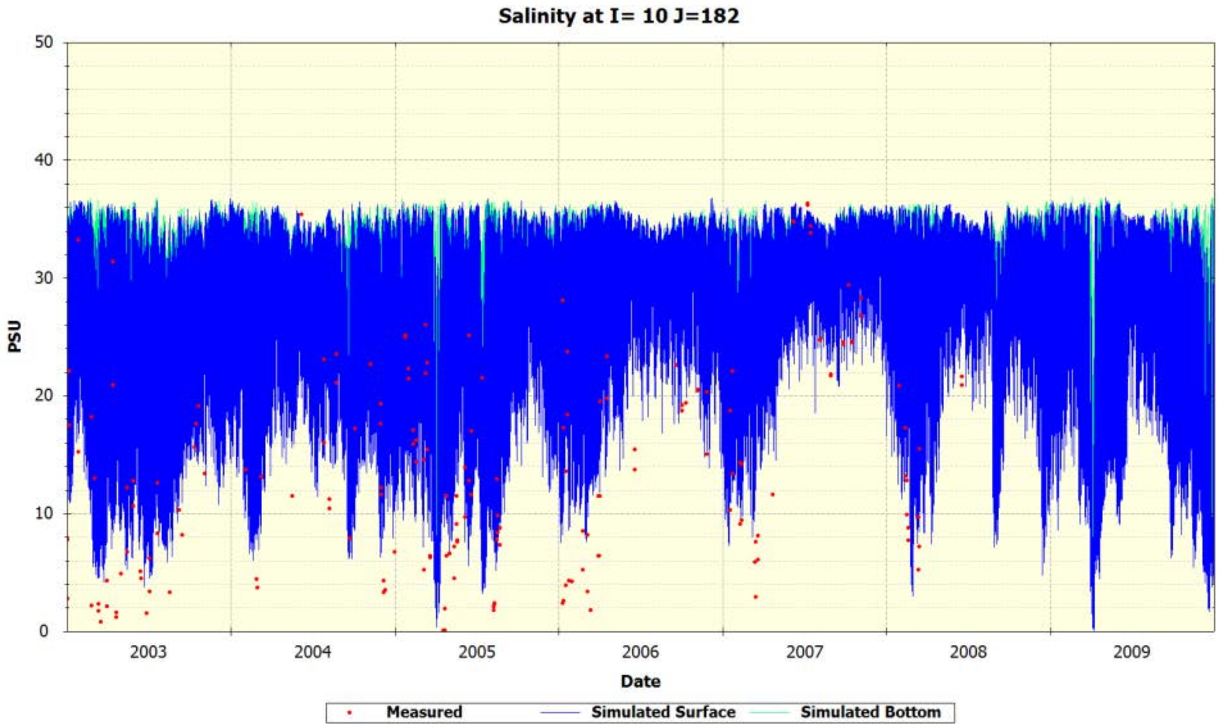

Figure 4.2.34 2003-2009 calibration measured versus simulated salinity at I=10 J=182

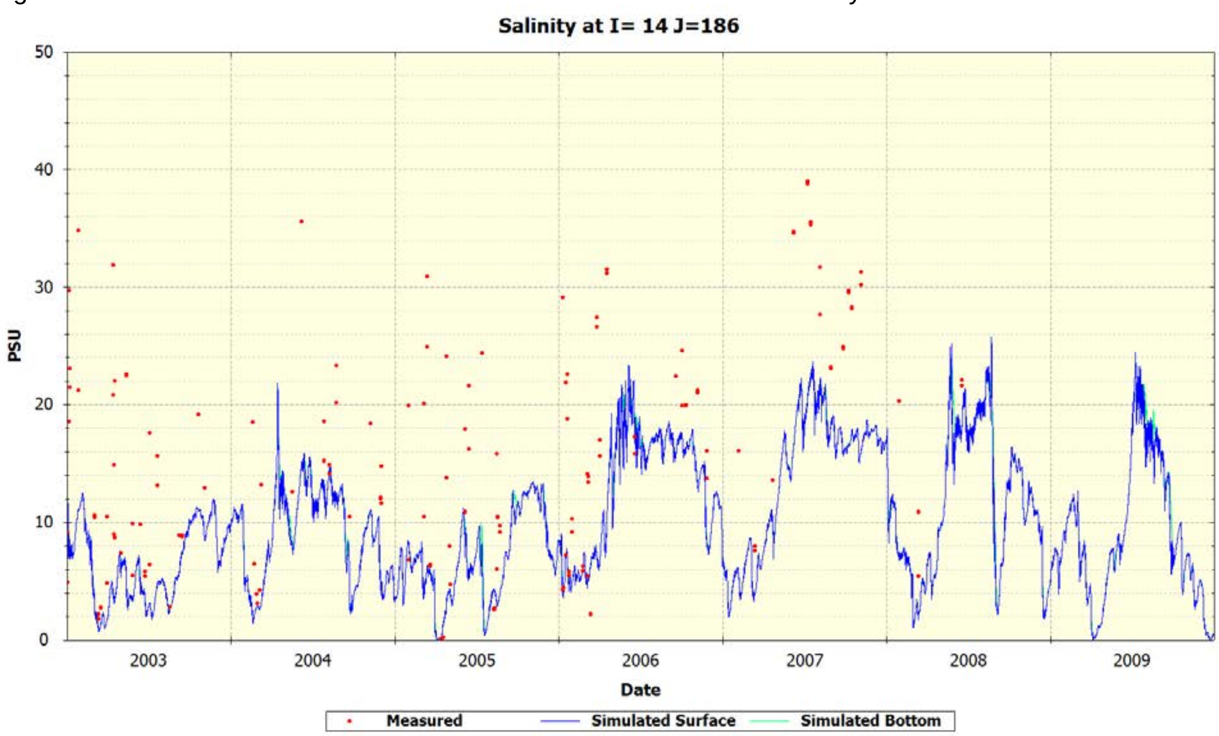

Figure 4.2.35 2003-2009 calibration measured versus simulated salinity at I=14 J=186

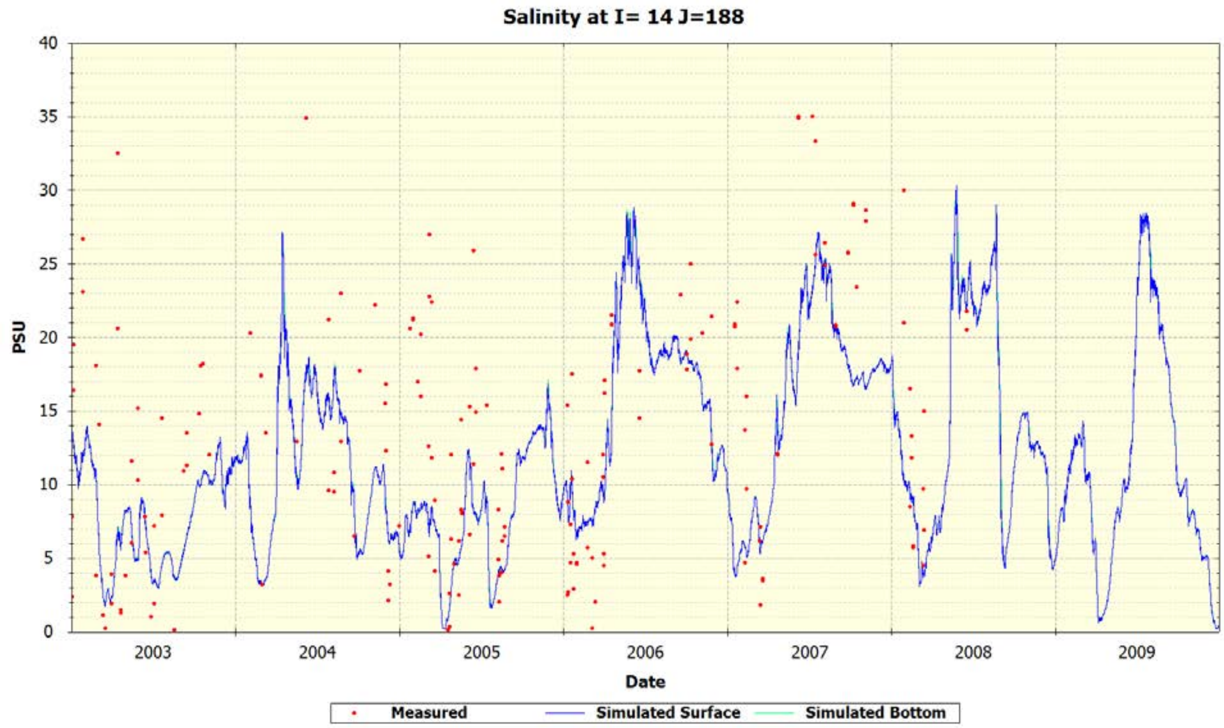

Figure 4.2.36 2003-2009 calibration measured versus simulated salinity at I=14 J=188

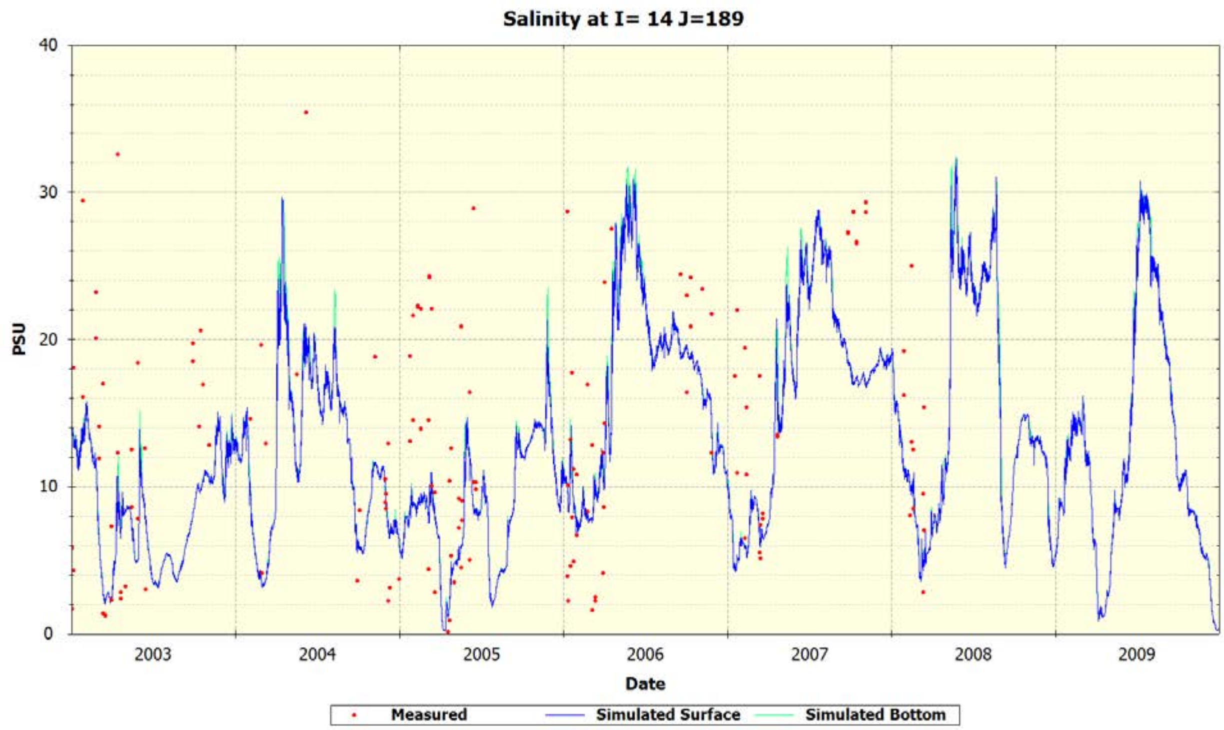

Figure 4.2.37 2003-2009 calibration measured versus simulated salinity at I=14 J=189

4.2.2 Validation

Table 4.2.2 Validation Comparisons of Simulations and Measurements of Surface Salinity at C at Florida Big Bend monitoring stations for 1997-2002.

Station	Simulated Mean (PSU)	Simulated 5%ile (PSU)	Simulated 95%ile (PSU)	Measured Mean (PSU)	Measured 5%ile (PSU)	Measured 95%ile (PSU)	Error Mean (PSU)	Error 5%ile (PSU)
I = 18 J = 10	27.7	21.3	33.5	31.7	28.2	35.5	-4.0	-12.8
I = 17 J = 18	31.1	24.7	35.8	33.2	28.8	36.9	-2.0	-6.1
I = 20 J = 31	28.0	17.6	35.5	29.8	24.0	34.1	-1.7	-5.9
I = 22 J = 39	28.4	15.0	37.9	28.6	22.7	33.6	-0.3	-1.0
I = 25 J = 44	20.0	8.9	29.6	23.7	15.7	32.1	-3.7	-15.7
I = 30 J = 44	4.6	0.1	10.8	16.8	0.0	0.0	-12.2	-72.7
I = 24 J = 59	19.7	12.0	26.4	26.2	18.9	33.4	-6.5	-24.7
I = 24 J = 70	18.0	9.4	23.4	23.9	14.9	30.8	-5.9	-24.8
I = 23 J = 78	18.4	8.2	24.9	23.9	12.7	32.8	-5.5	-23.0
I = 25 J = 78	13.1	2.5	21.4	14.1	0.5	27.4	-1.0	-7.0
I = 21 J = 79	21.0	12.1	26.1	26.2	15.1	33.7	-5.2	-19.8
I = 14 J = 85	23.1	17.2	27.3	23.2	15.1	30.2	-0.1	-0.3
I = 13 J = 89	29.6	23.6	33.6	23.9	15.7	33.9	5.6	23.6
I = 16 J = 92	18.1	10.3	23.3	23.0	4.6	31.6	-4.9	-21.4
I = 16 J = 98	25.3	18.0	29.8	27.6	17.6	36.7	-2.3	-8.4
I = 16 J = 102	26.9	20.5	31.0	29.1	17.9	38.2	-2.2	-7.6
I = 18 J = 110	28.6	22.6	32.5	29.4	17.2	33.5	-0.7	-2.5
I = 22 J = 110	13.3	1.6	23.4	3.8	0.1	24.3	9.5	250.9
I = 23 J = 128	21.6	14.7	27.0	22.8	0.8	32.2	-1.2	-5.0
I = 31 J = 128	1.7	0.1	4.6	0.6	0.1	0.9	1.1	182.0
I = 21 J = 129	25.2	19.7	29.4	29.2	22.5	34.3	-4.0	-13.6
I = 23 J = 133	21.8	13.1	27.9	24.8	16.4	31.4	-3.0	-12.1
I = 26 J = 133	13.3	3.7	22.2	15.1	0.3	26.7	-1.7	-11.4
I = 21 J = 134	26.6	18.5	32.3	27.7	20.7	32.9	-1.1	-3.8
I = 24 J = 150	20.6	15.3	26.6	21.3	11.8	28.5	-0.7	-3.2
I = 20 J = 152	19.3	9.2	26.8	23.7	10.4	32.1	-4.3	-18.3
I = 18 J = 154	30.2	24.9	33.5	31.5	28.0	34.7	-1.3	-4.2
I = 18 J = 156	30.3	24.8	33.6	31.5	28.3	35.0	-1.2	-3.8
I = 21 J = 156	9.2	0.0	21.6	11.3	1.0	25.4	-2.1	-18.4
I = 14 J = 169	25.9	12.6	33.5	27.3	18.2	33.0	-1.4	-5.2
I = 19 J = 180	1.9	0.0	6.9	21.1	1.7	33.5	-19.2	-91.0
I = 20 J = 180	1.2	0.0	5.4	7.8	0.1	23.0	-6.5	-84.1
I = 10 J = 182	26.3	10.3	35.5	15.1	0.9	29.9	11.2	74.5
I = 14 J = 186	10.3	0.9	18.9	17.6	2.4	32.8	-7.3	-41.4

Station	Simulated Mean (PSU)	Simulated 5%ile (PSU)	Simulated 95%ile (PSU)	Measured Mean (PSU)	Measured 5%ile (PSU)	Measured 95%ile (PSU)	Error Mean (PSU)	Error 5%ile (PSU)
I = 14 J = 188	12.5	1.5	24.4	14.5	0.8	28.2	-2.0	-14.1
I = 14 J = 189	13.3	1.7	26.2	14.2	0.9	29.3	-0.8	-6.0

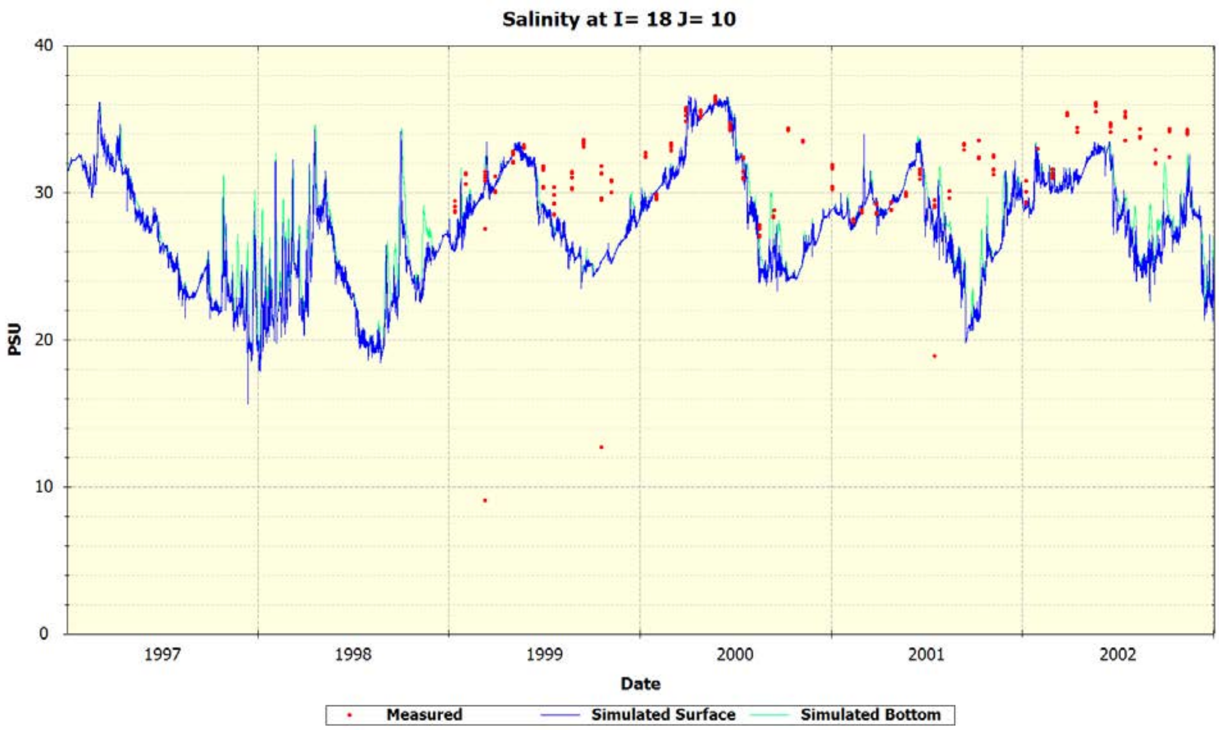

Figure 4.2.38 1997-2002 validation measured versus simulated salinity at I=18 J=10

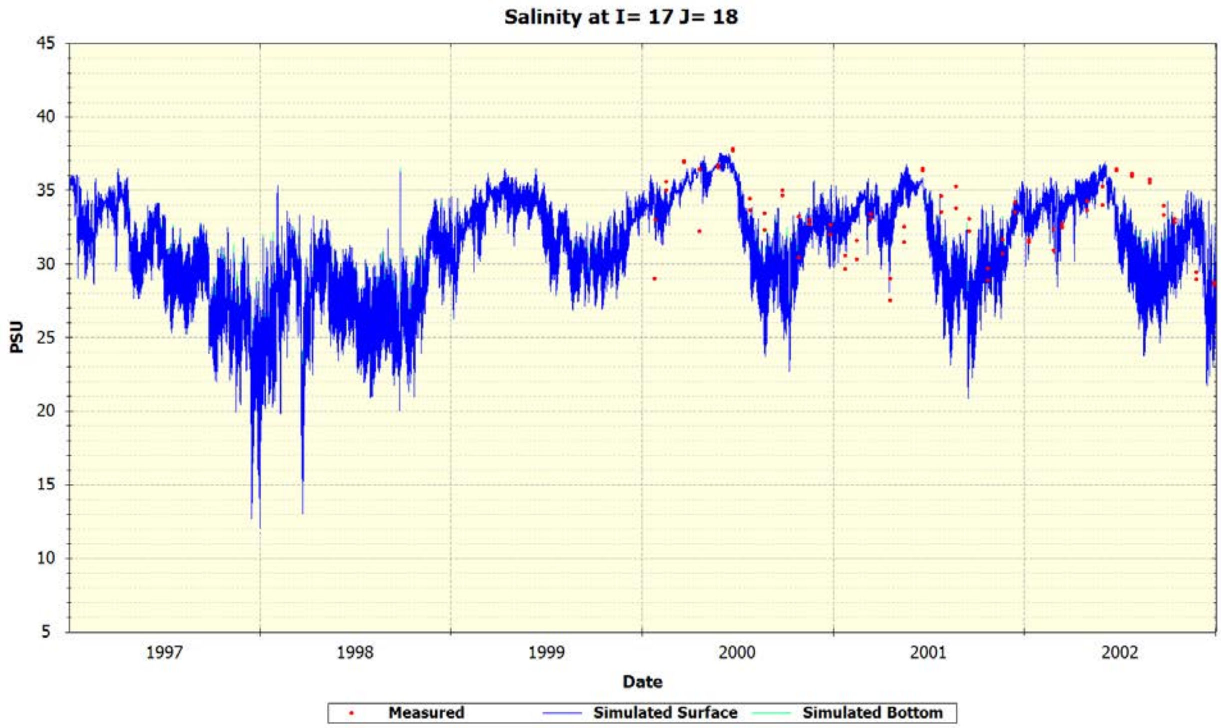

Figure 4.2.39 1997-2002 validation measured versus simulated salinity at I=17 J=18

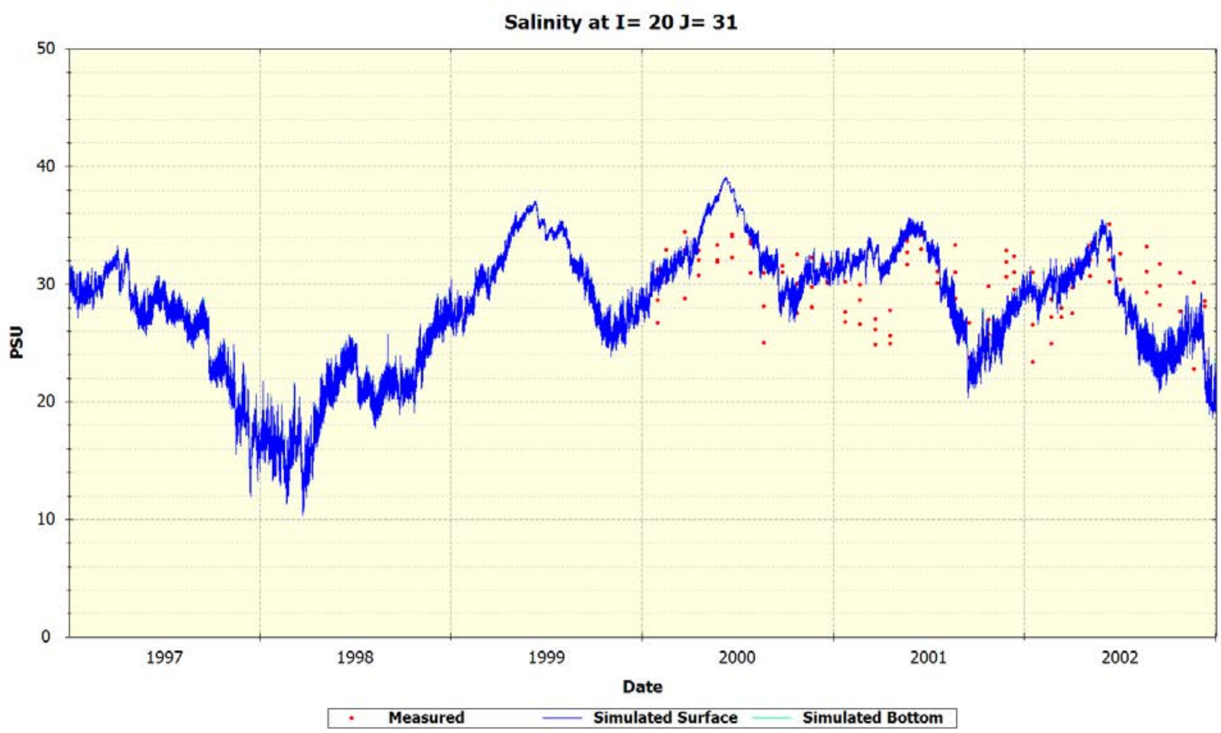

Figure 4.2.40 1997-2002 validation measured versus simulated salinity at I=20 J=31

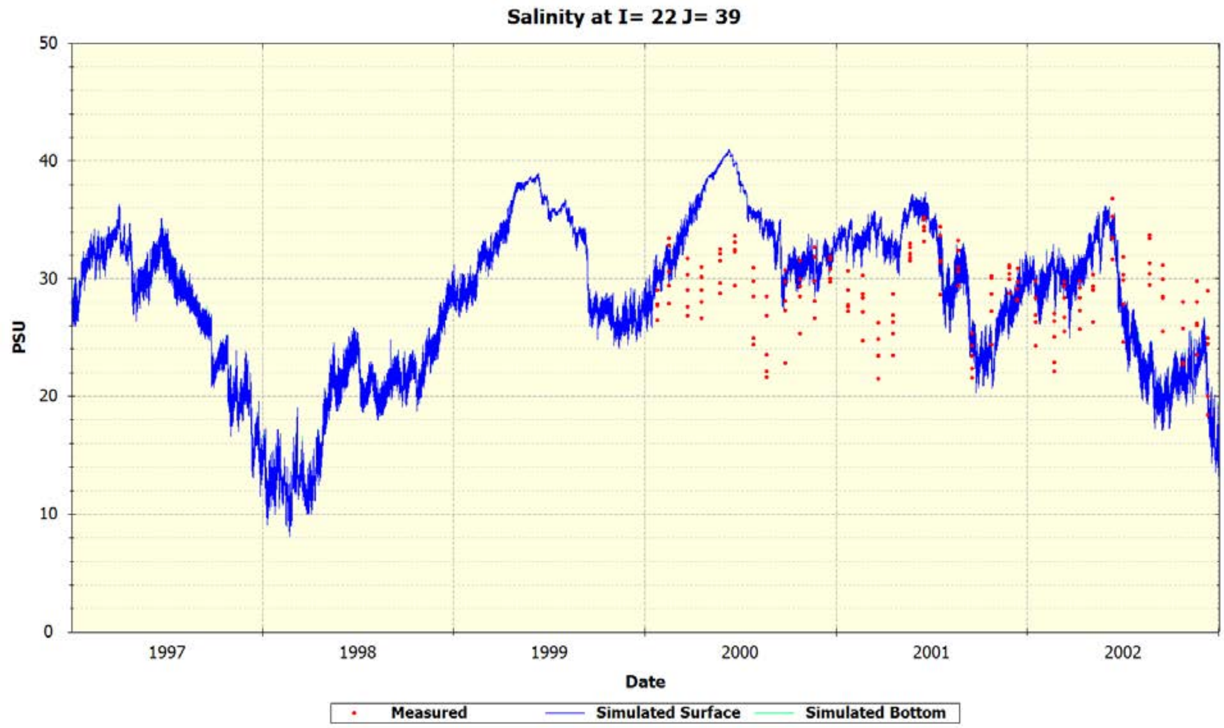

Figure 4.2.41 1997-2002 validation measured versus simulated salinity at I=22 J=39

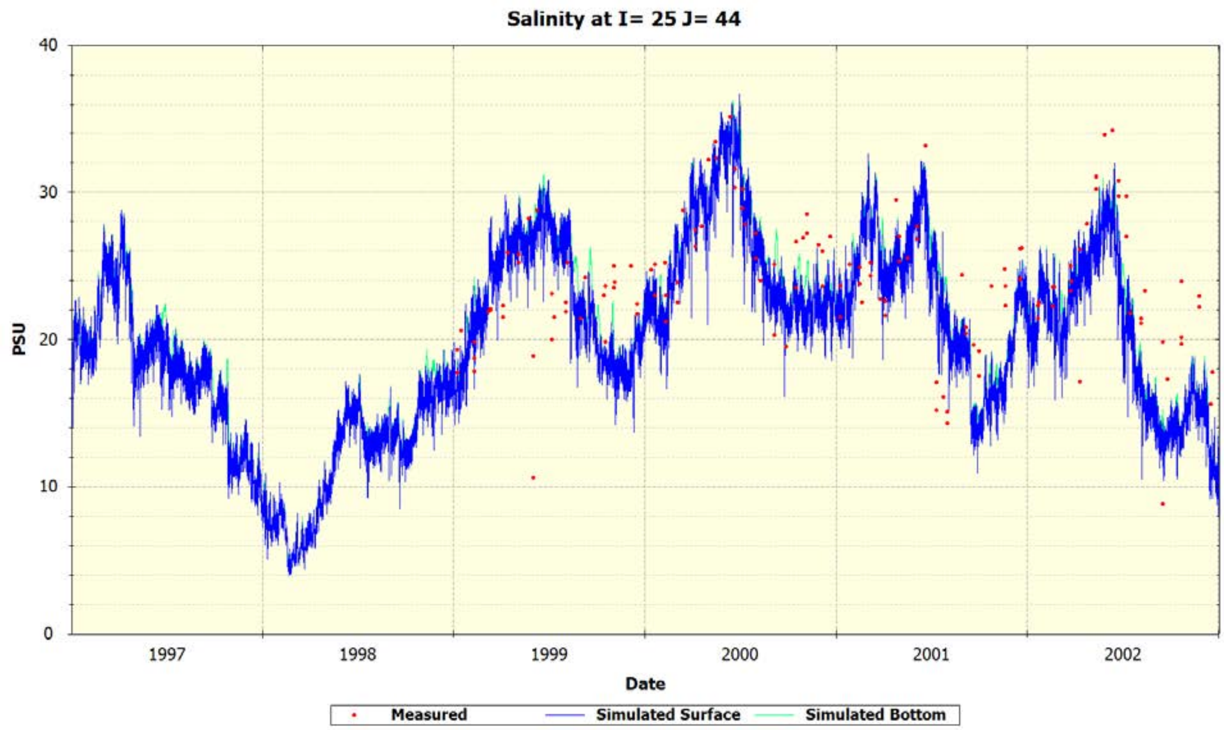

Figure 4.2.42 1997-2002 validation measured versus simulated salinity at I=25 J=44

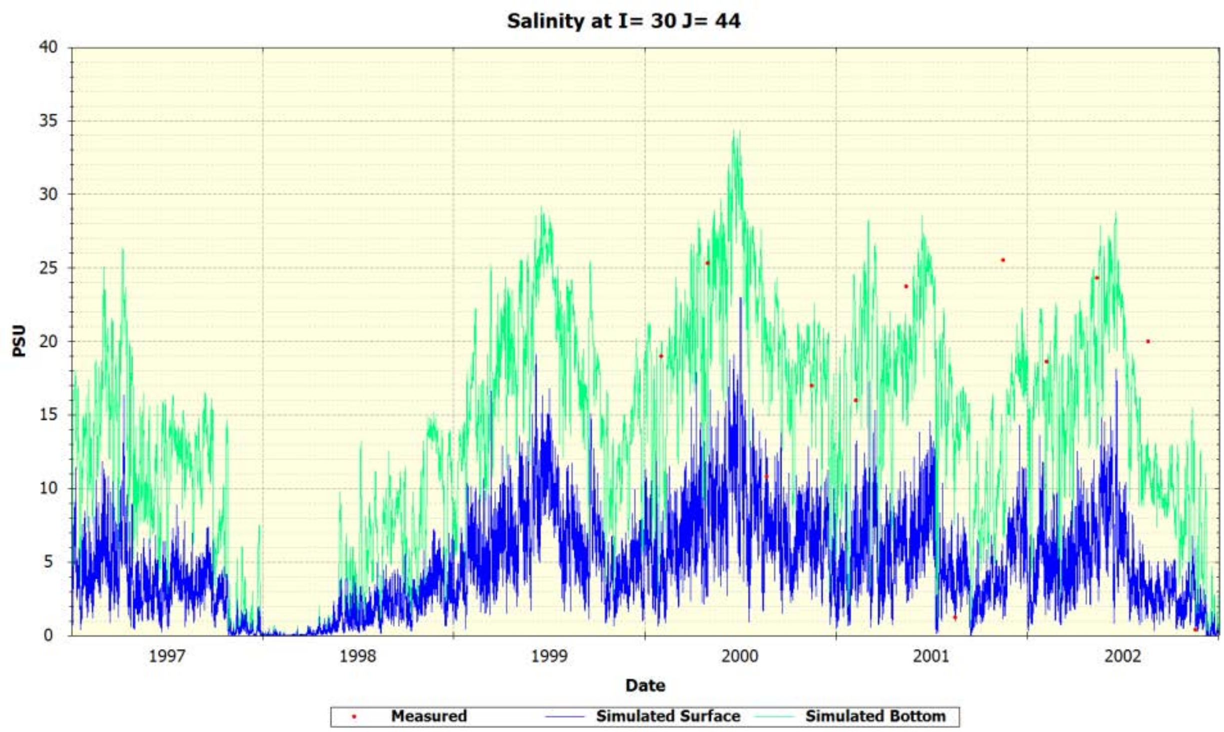

Figure 4.2.43 1997-2002 validation measured versus simulated salinity at I=30 J=44

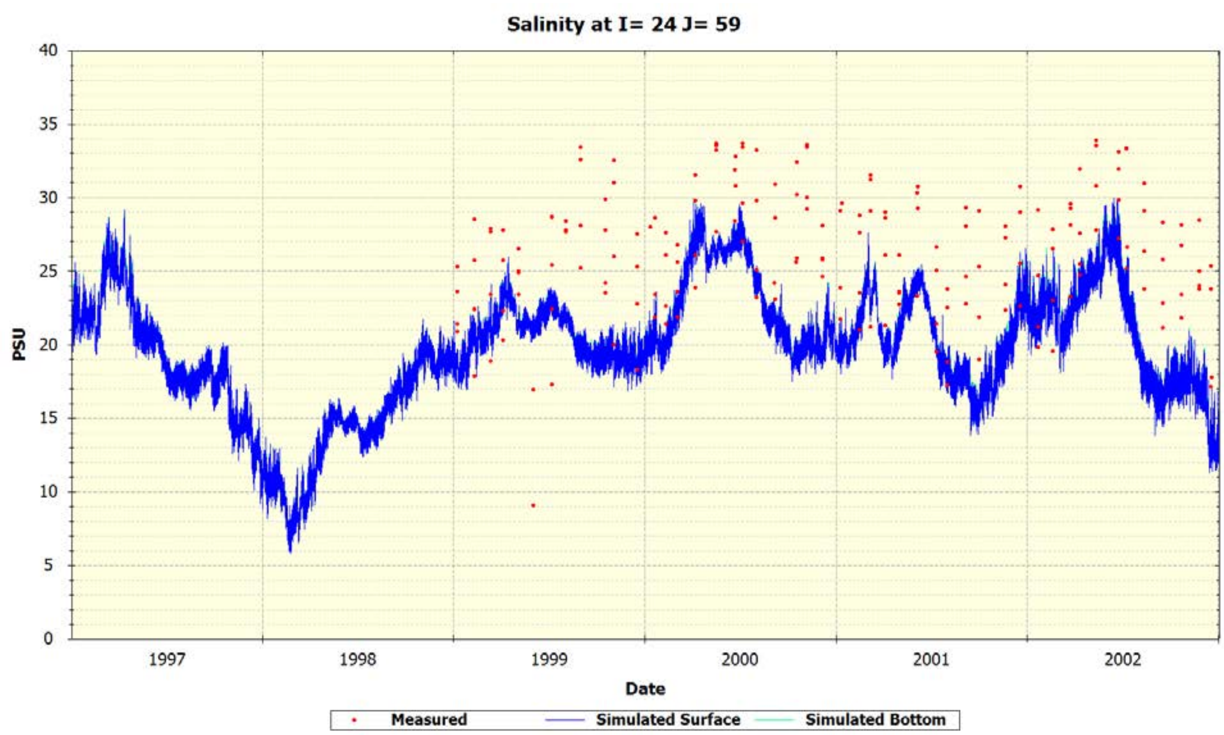

Figure 4.2.44 1997-2002 validation measured versus simulated salinity at I=24 J=59

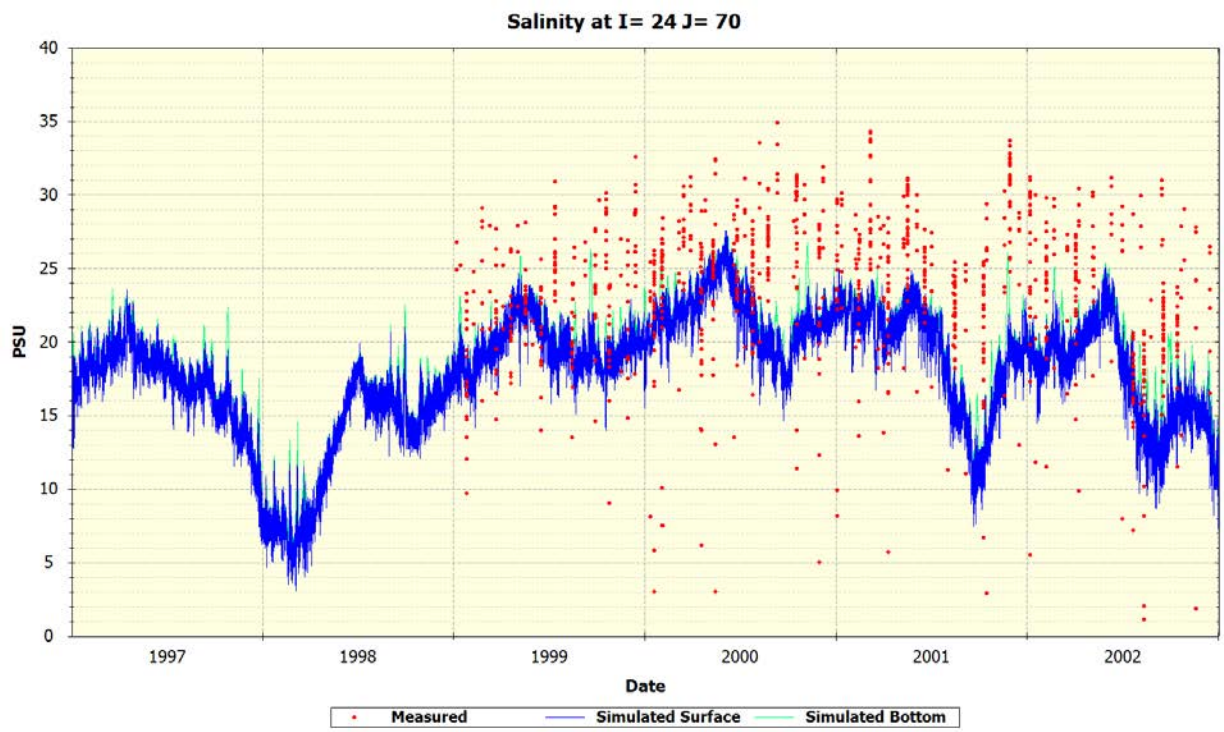

Figure 4.2.45 1997-2002 validation measured versus simulated salinity at I=24 J=70

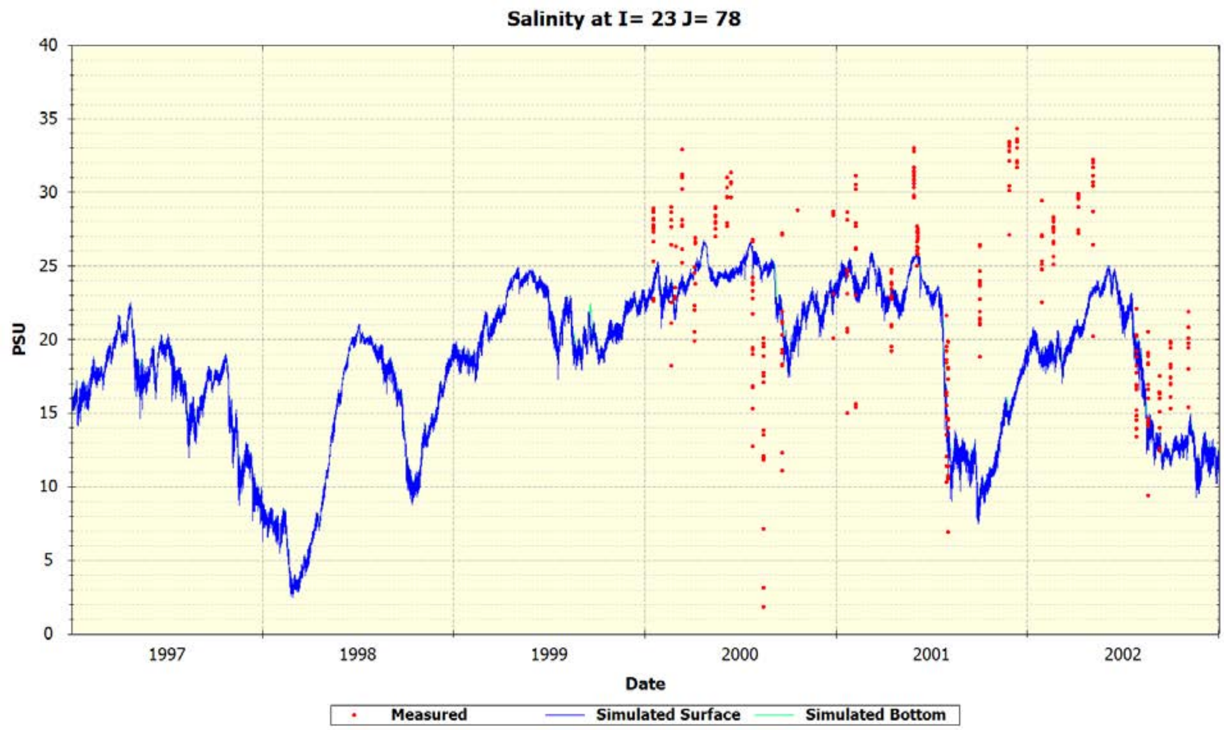

Figure 4.2.46 1997-2002 validation measured versus simulated salinity at I=23 J=78

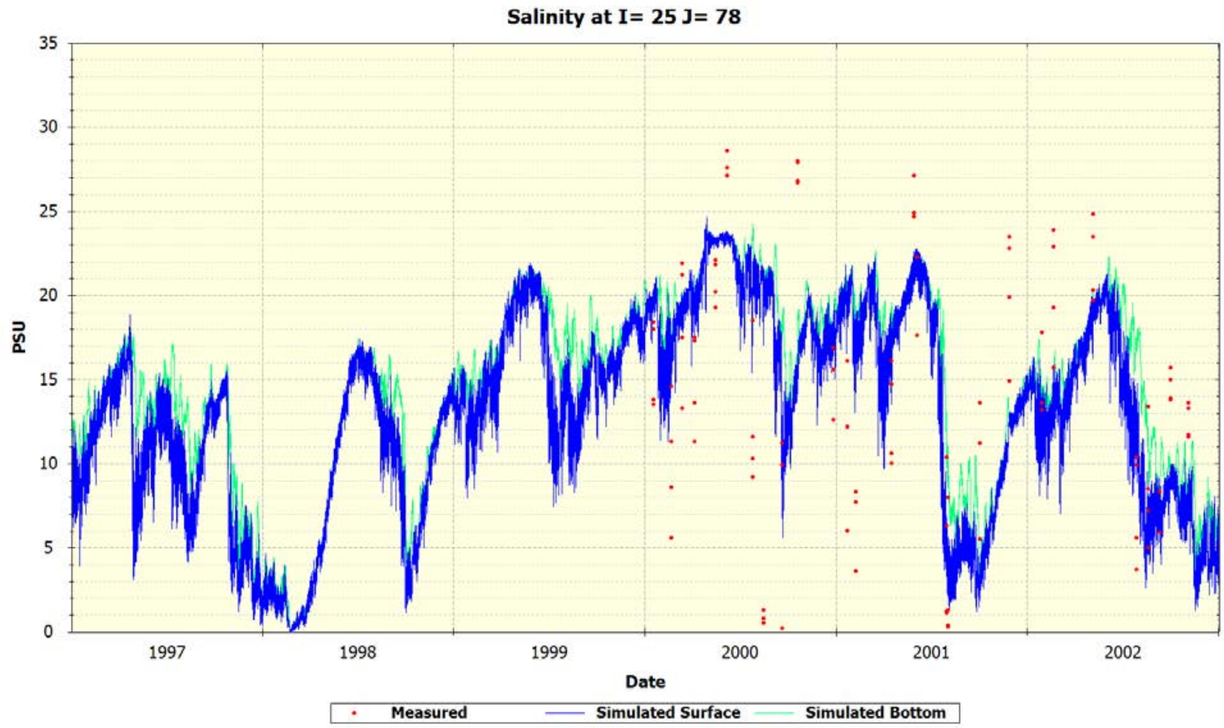

Figure 4.2.47 1997-2002 validation measured versus simulated salinity at I=25 J=78

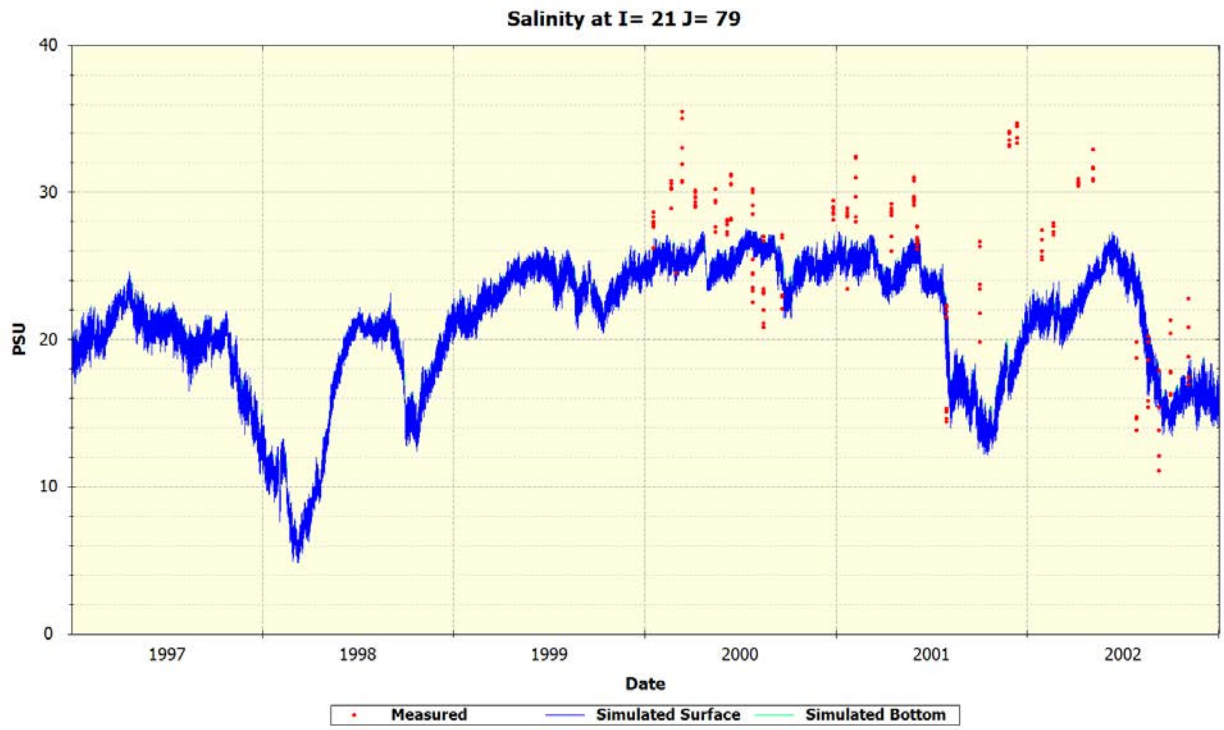

Figure 4.2.48 1997-2002 validation measured versus simulated salinity at I=21 J=79

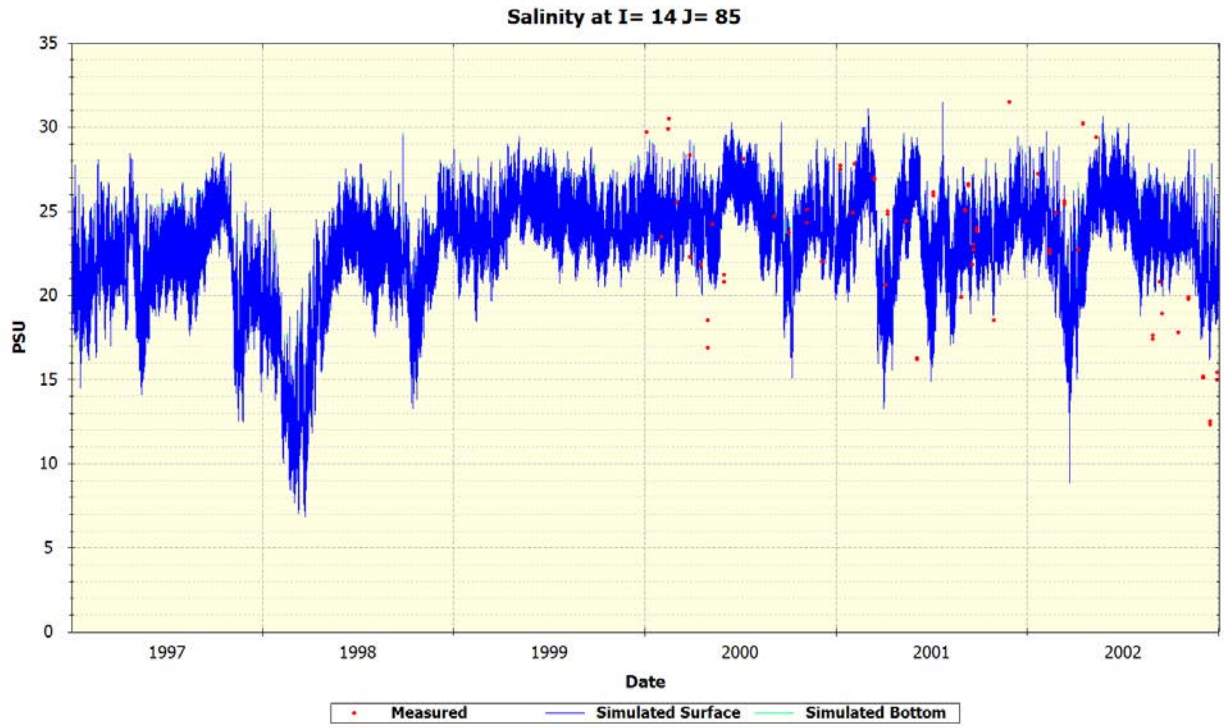

Figure 4.2.49 1997-2002 validation measured versus simulated salinity at I=14 J=85

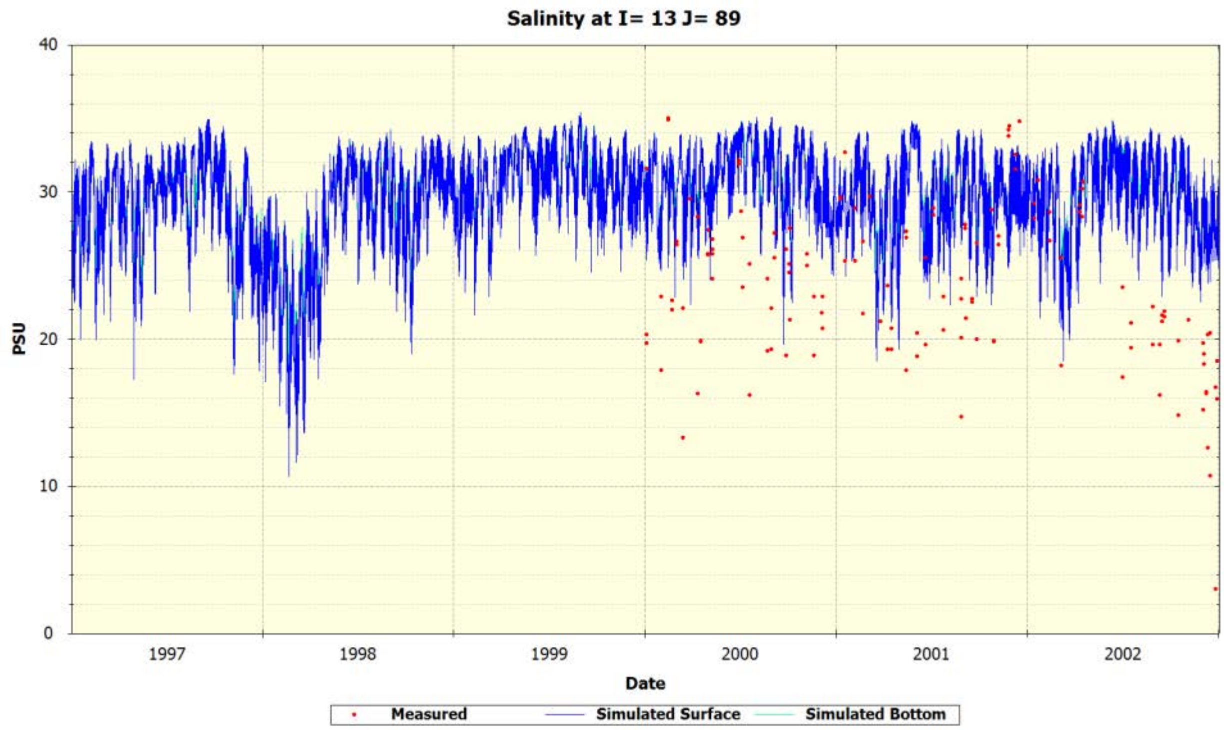

Figure 4.2.50 1997-2002 validation measured versus simulated salinity at I=13 J=89

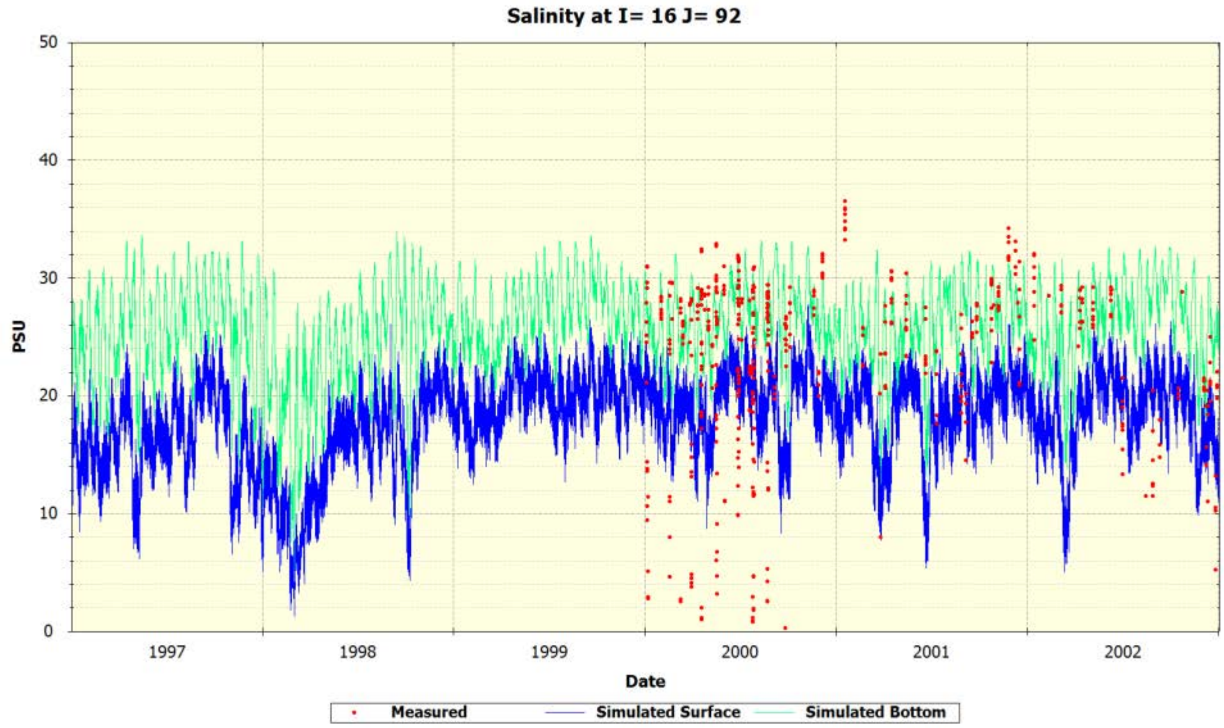

Figure 4.2.51 1997-2002 validation measured versus simulated salinity at I=16 J=92

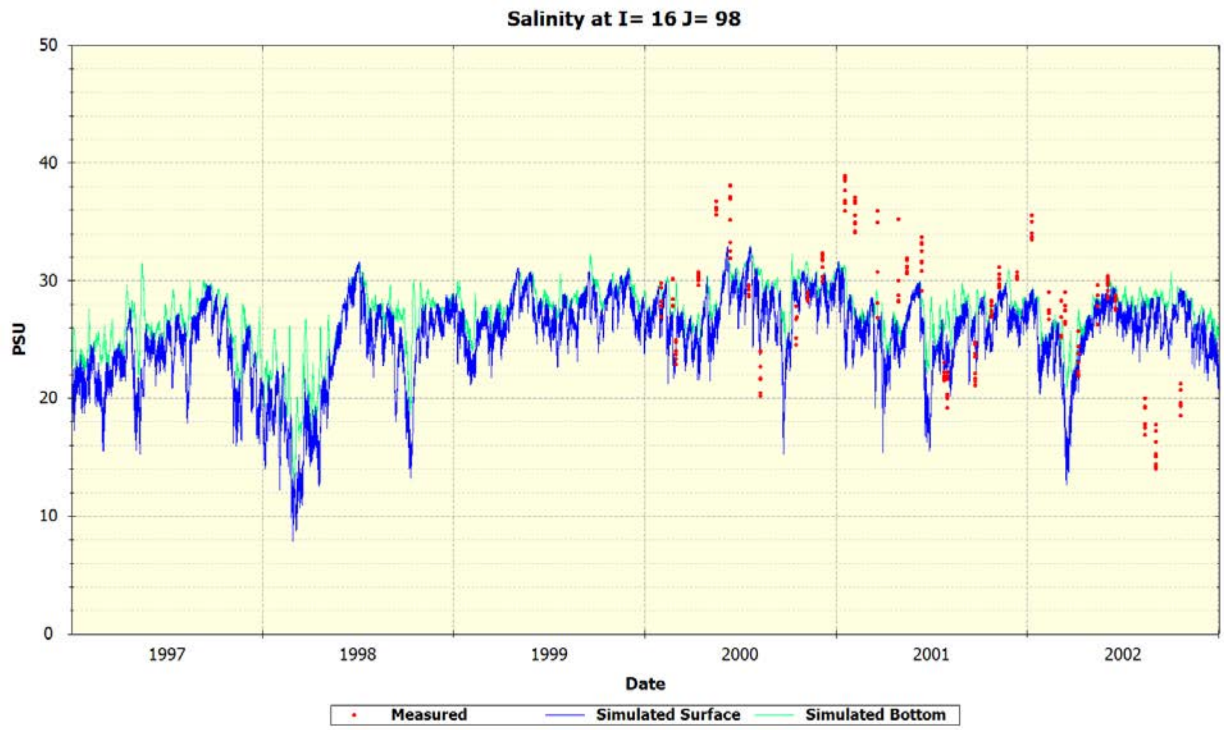

Figure 4.2.52 1997-2002 validation measured versus simulated salinity at I=16 J=98

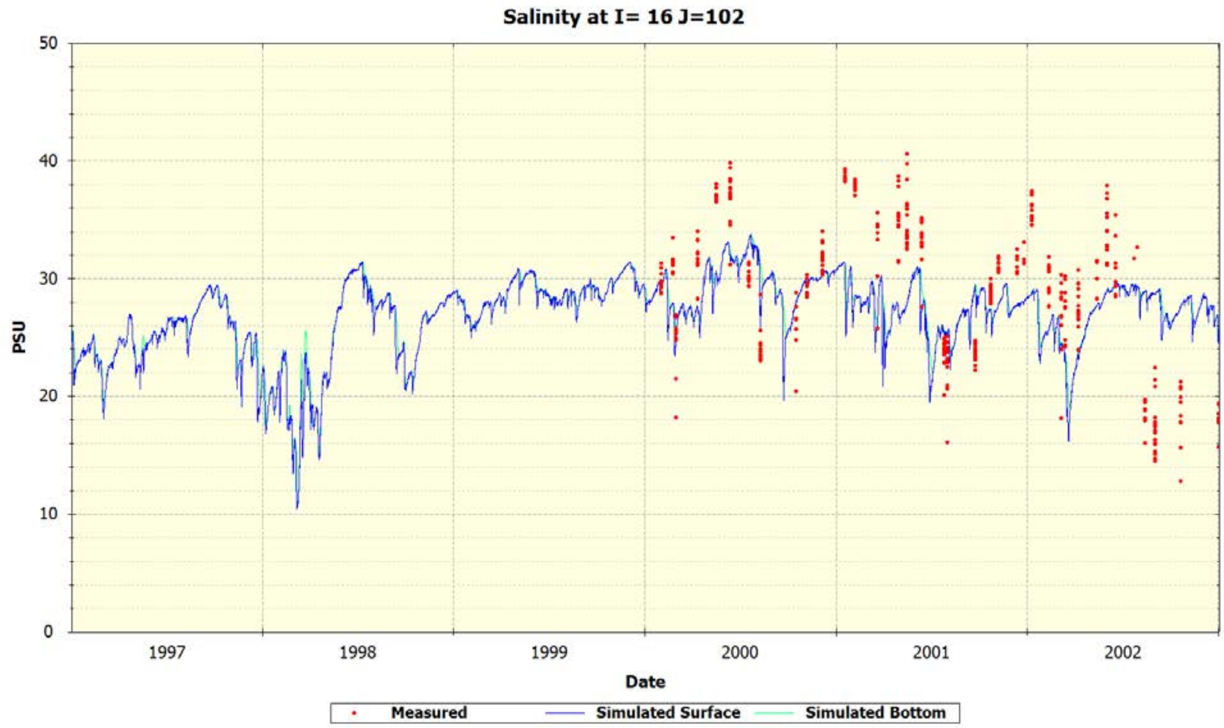

Figure 4.2.53 1997-2002 validation measured versus simulated salinity at I=16 J=102

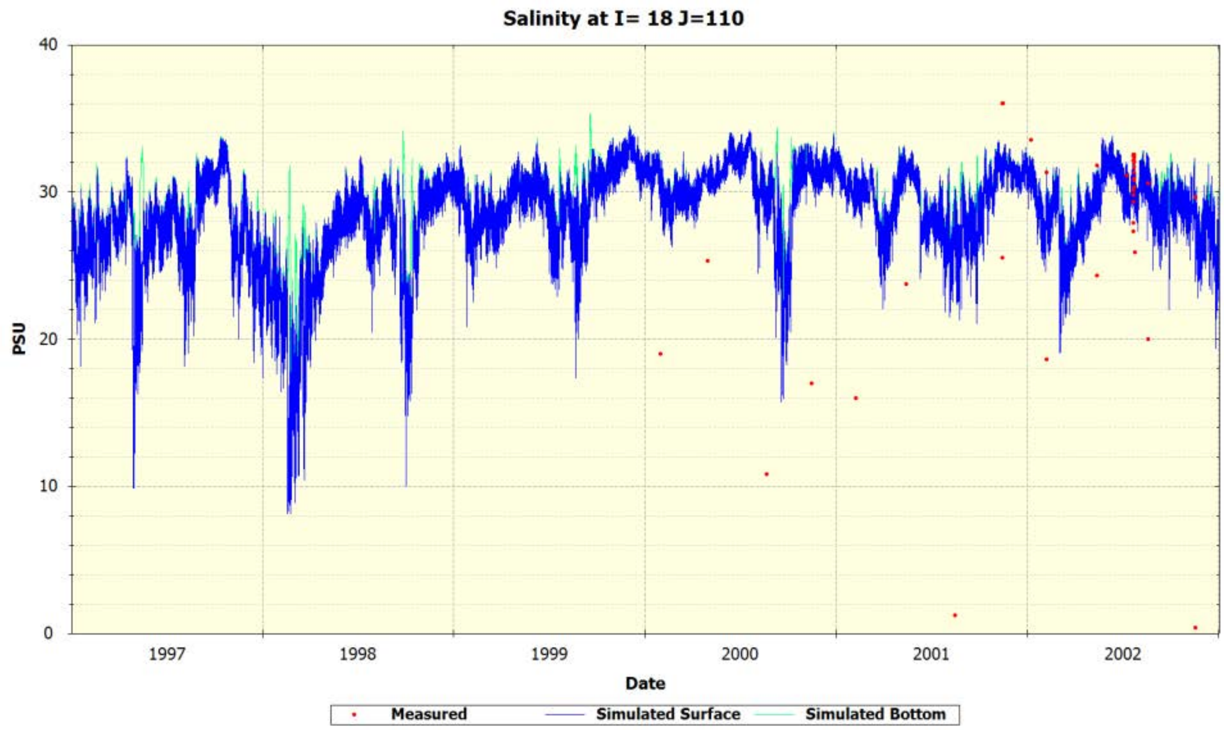

Figure 4.2.54 1997-2002 validation measured versus simulated salinity at I=18 J=110

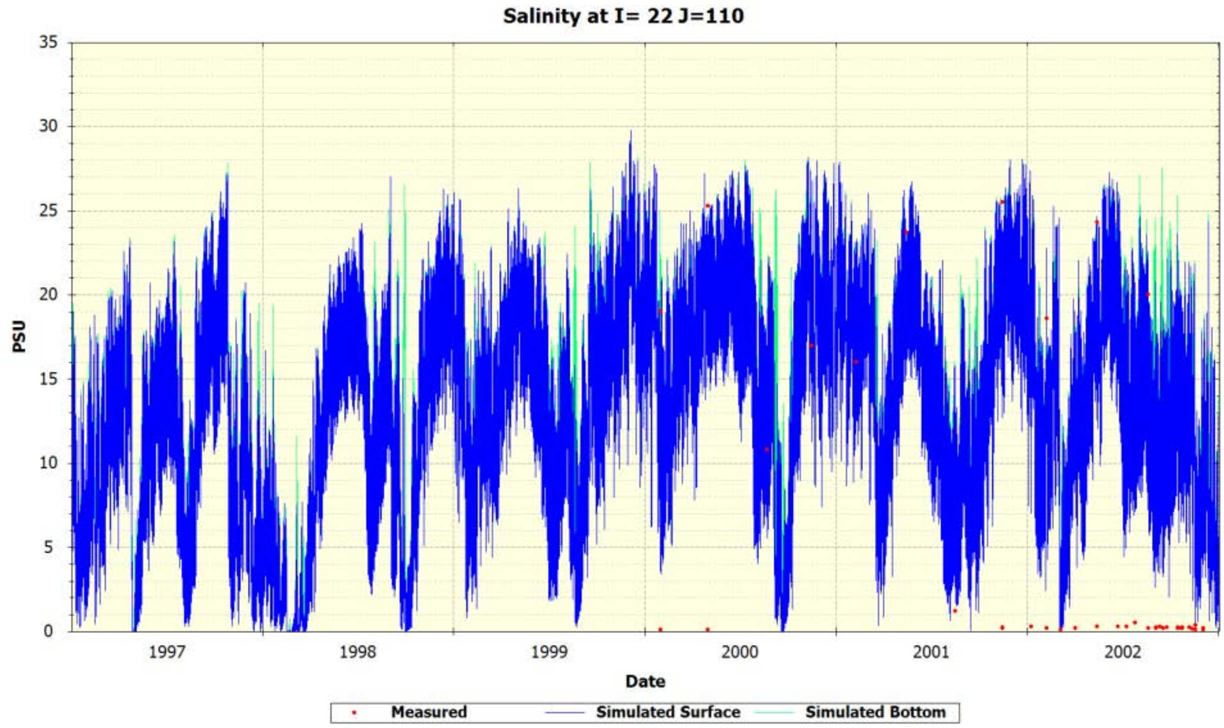

Figure 4.2.55 1997-2002 validation measured versus simulated salinity at I=22 J=110

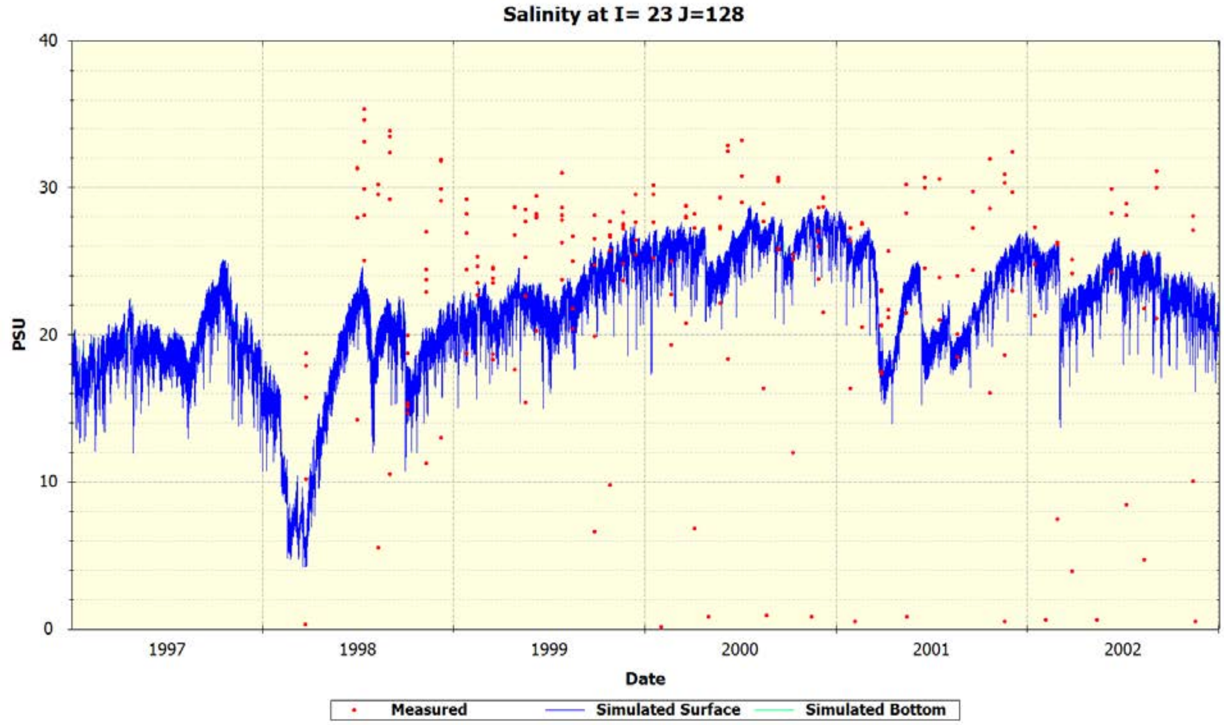

Figure 4.2.56 1997-2002 validation measured versus simulated salinity at I=23 J=128

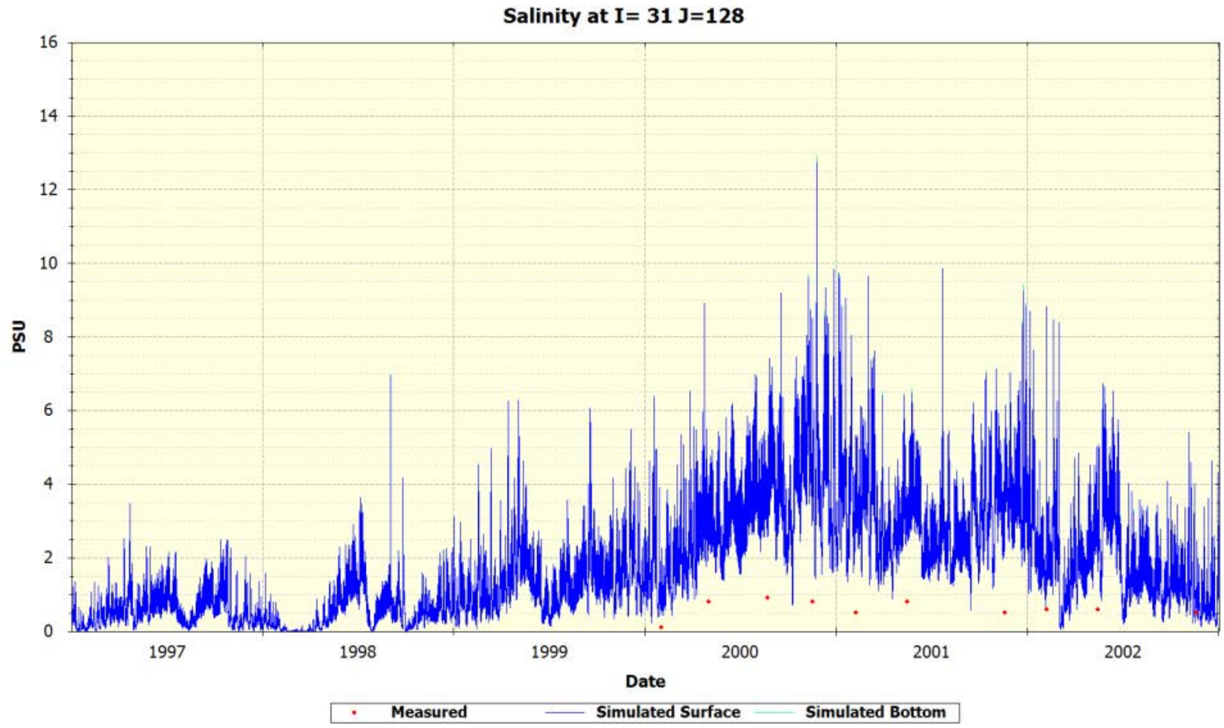

Figure 4.2.57 1997-2002 validation measured versus simulated salinity at I=31 J=128

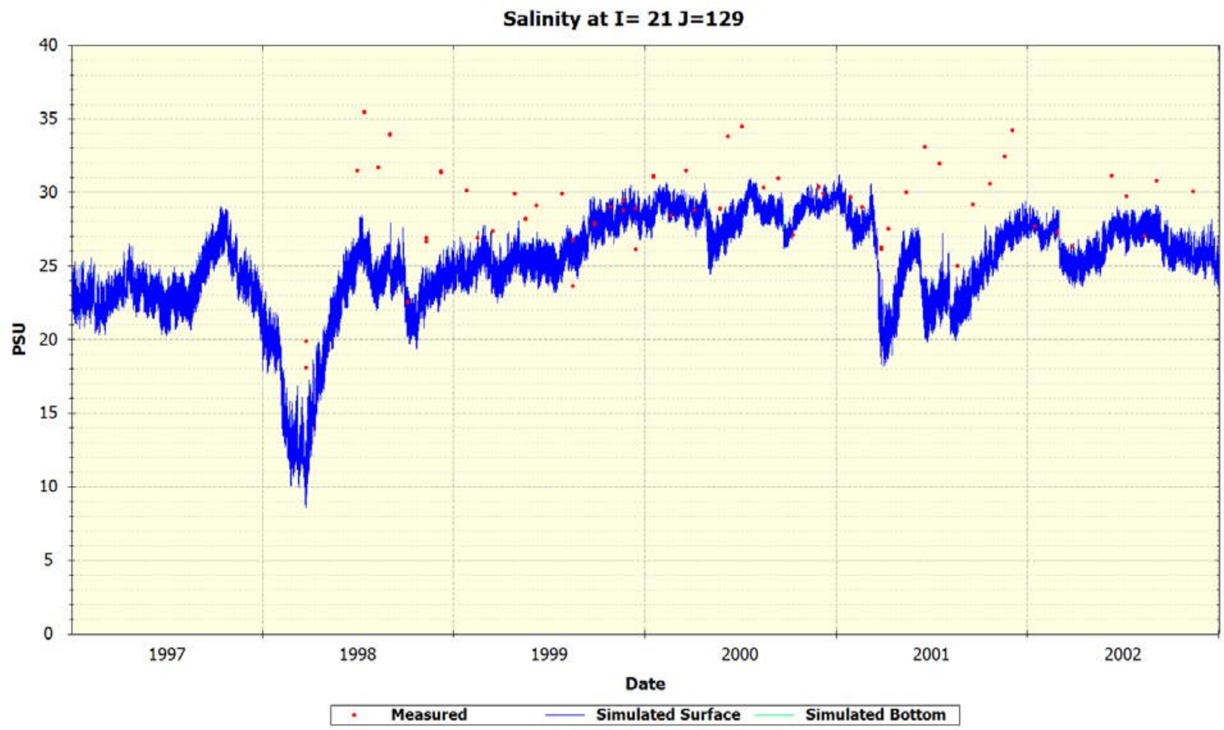

Figure 4.2.58 1997-2002 validation measured versus simulated salinity at I=21 J=129

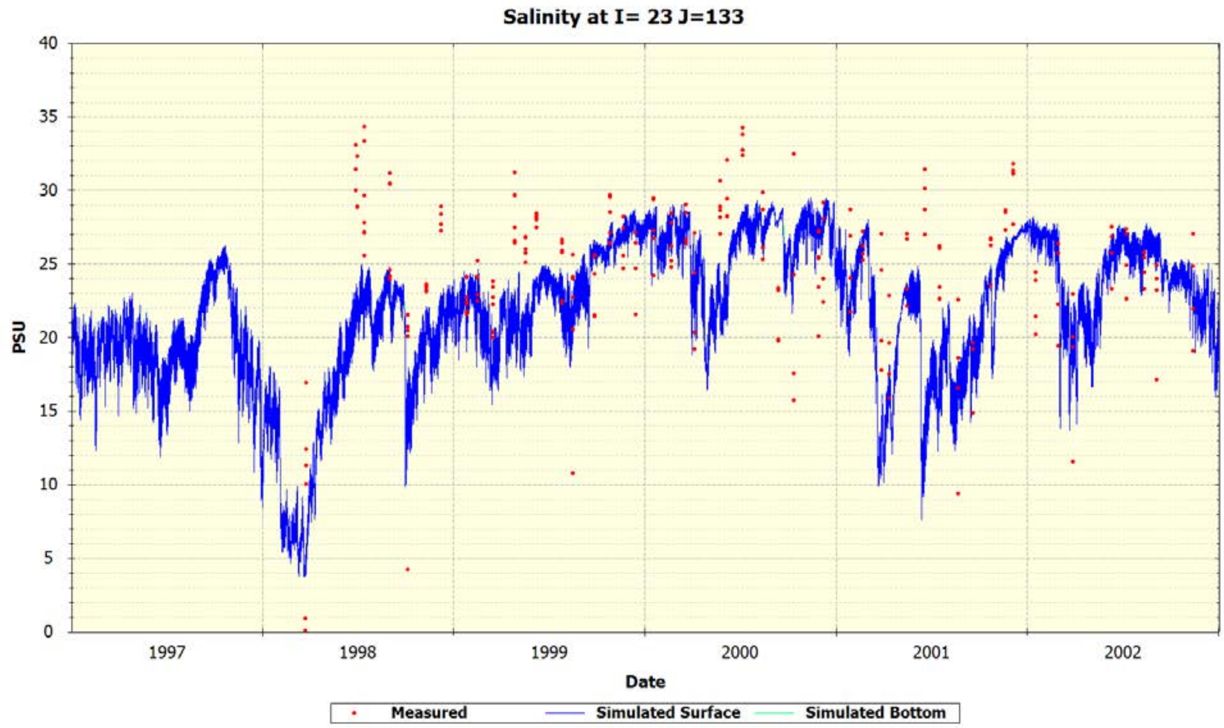

Figure 4.2.59 1997-2002 validation measured versus simulated salinity at I=23 J=133

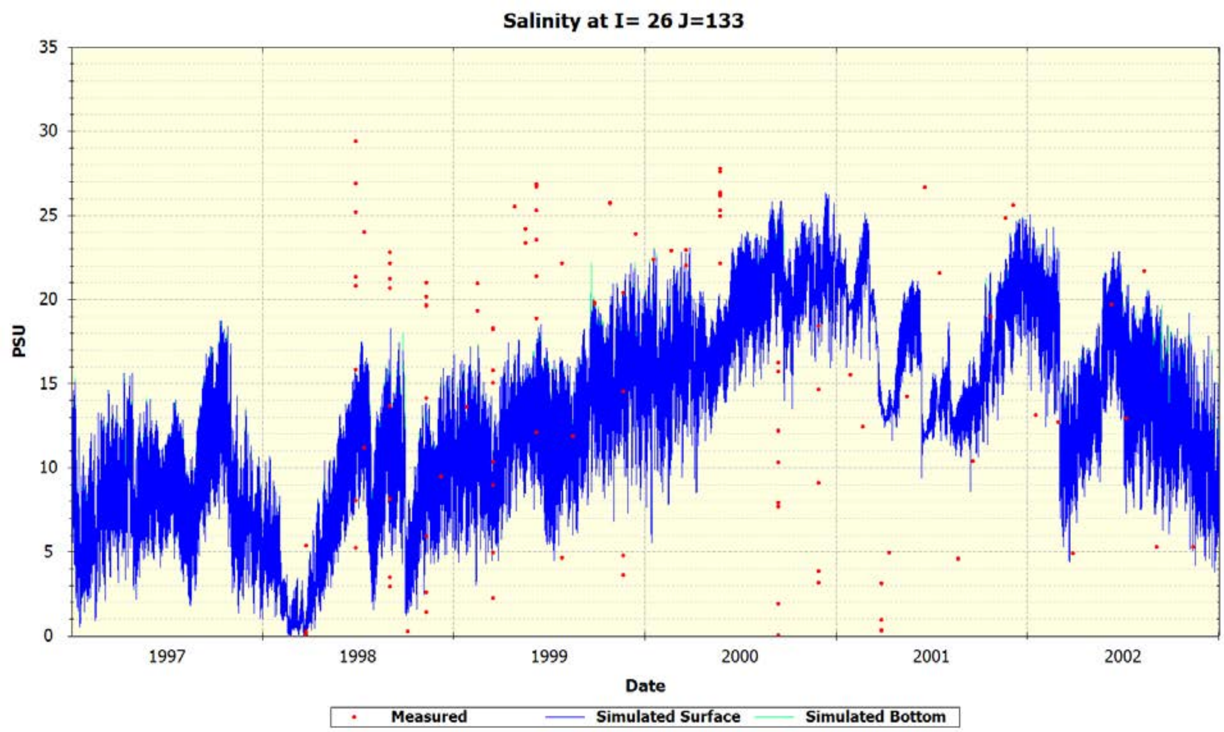

Figure 4.2.60 1997-2002 validation measured versus simulated salinity at I=26 J=133

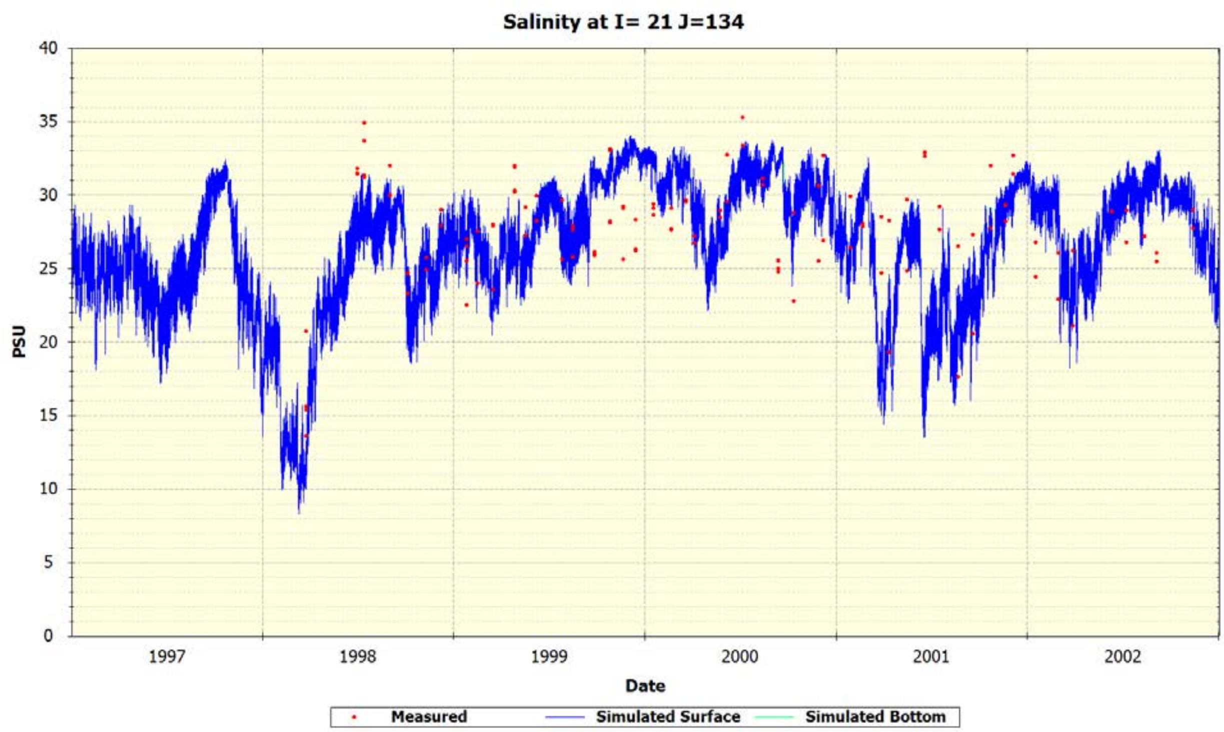

Figure 4.2.61 1997-2002 validation measured versus simulated salinity at I=21 J=134

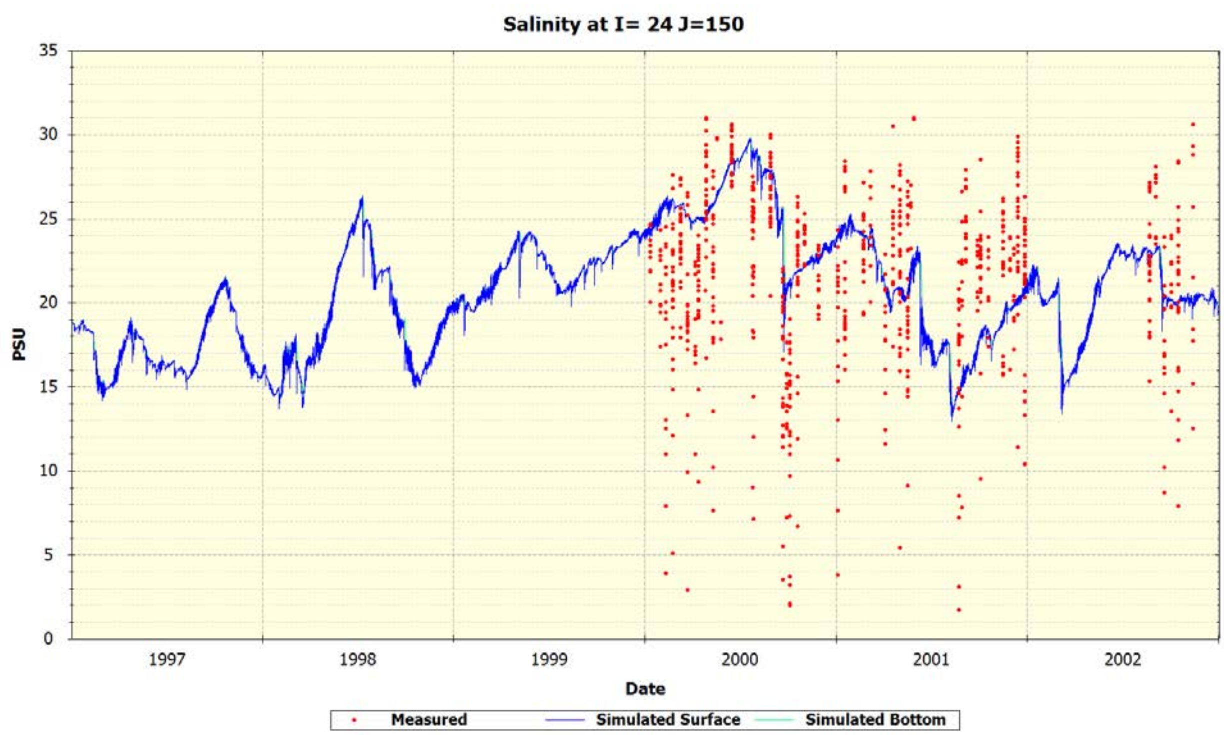

Figure 4.2.62 1997-2002 validation measured versus simulated salinity at I=24 J=150

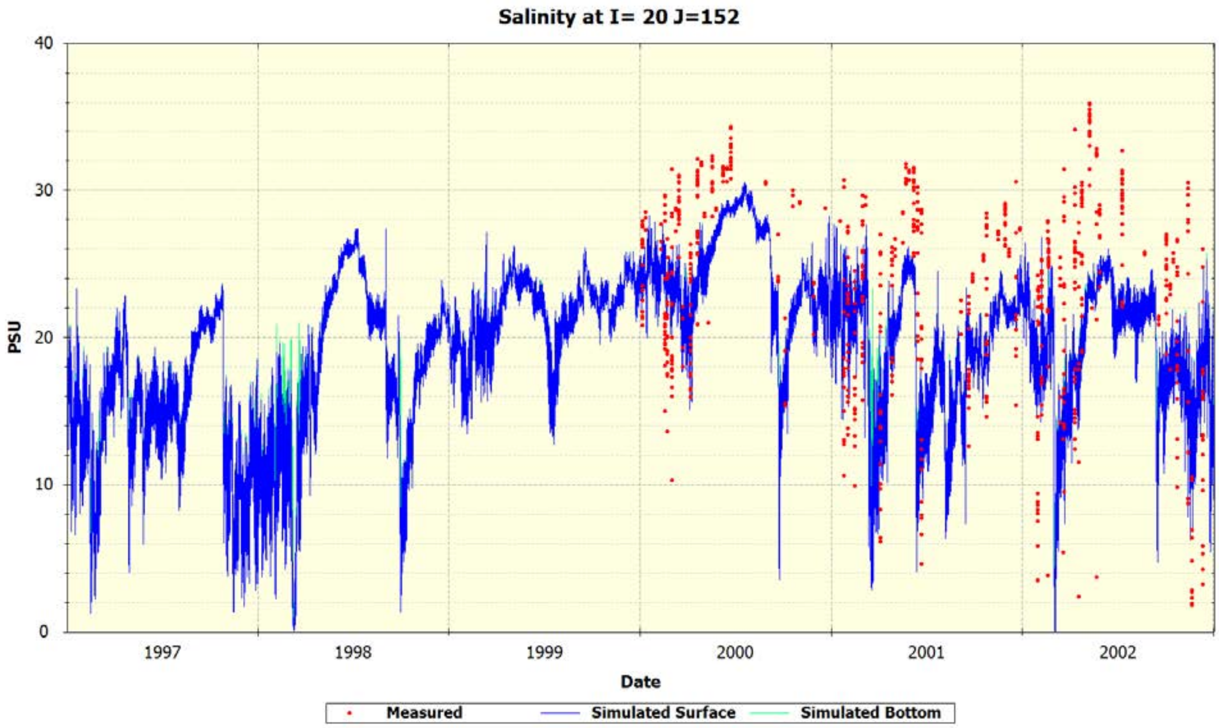

Figure 4.2.63 1997-2002 validation measured versus simulated salinity at I=20 J=152

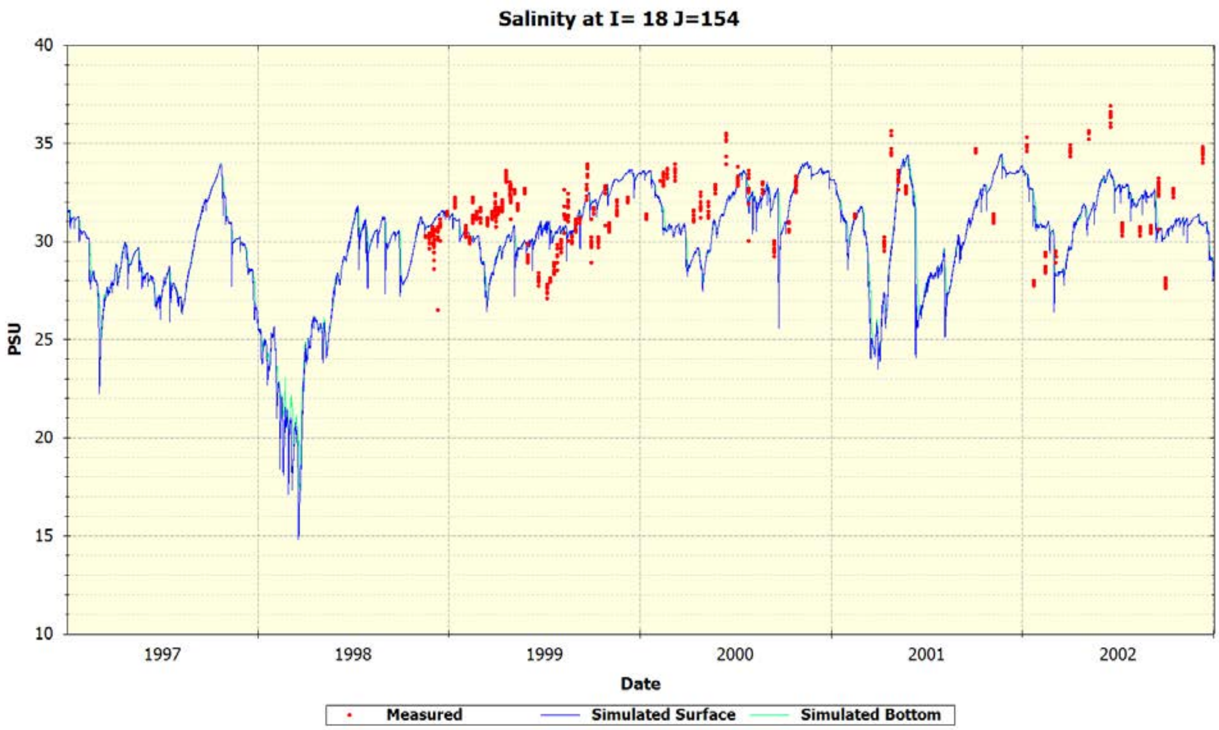

Figure 4.2.64 1997-2002 validation measured versus simulated salinity at I=18 J=154

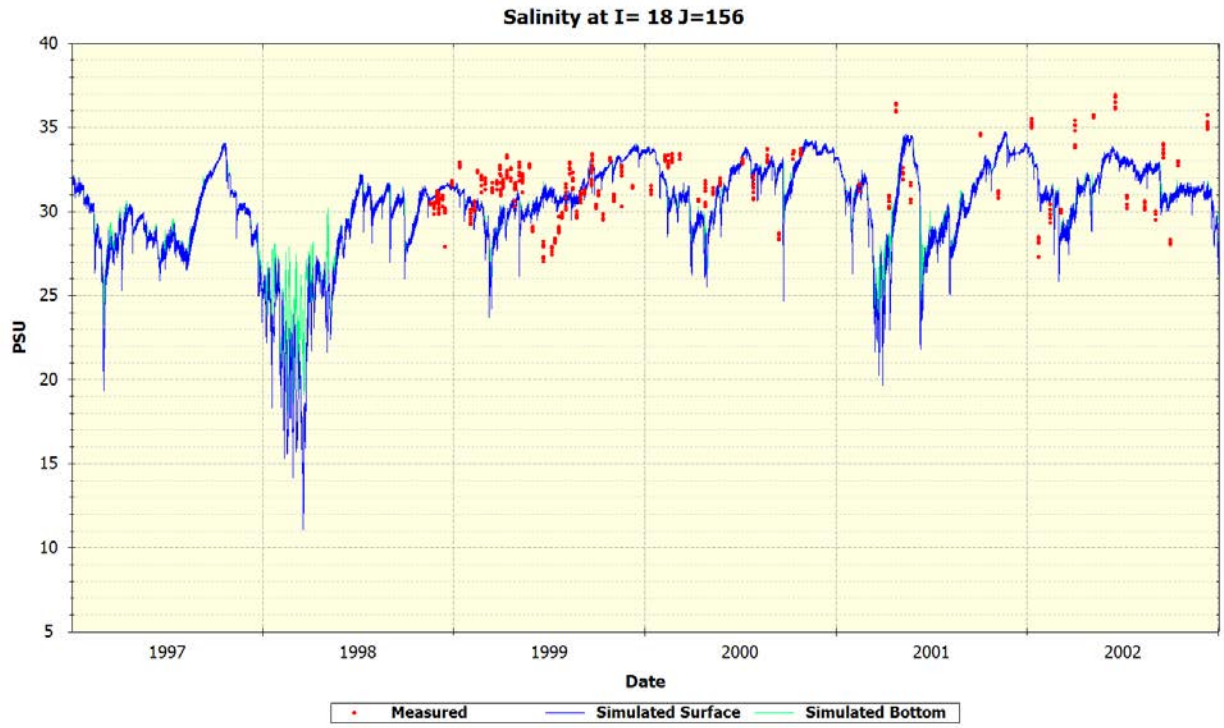

Figure 4.2.65 1997-2002 validation measured versus simulated salinity at I=18 J=156

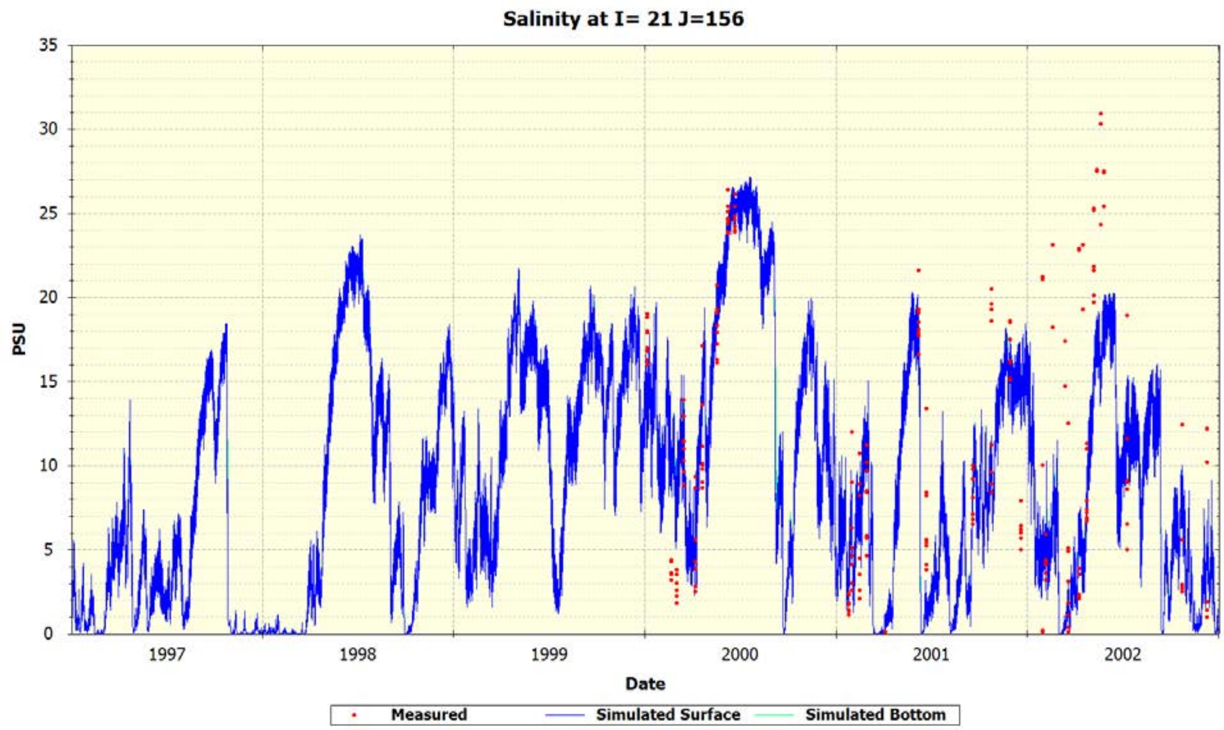

Figure 4.2.66 1997-2002 validation measured versus simulated salinity at I=21 J=156

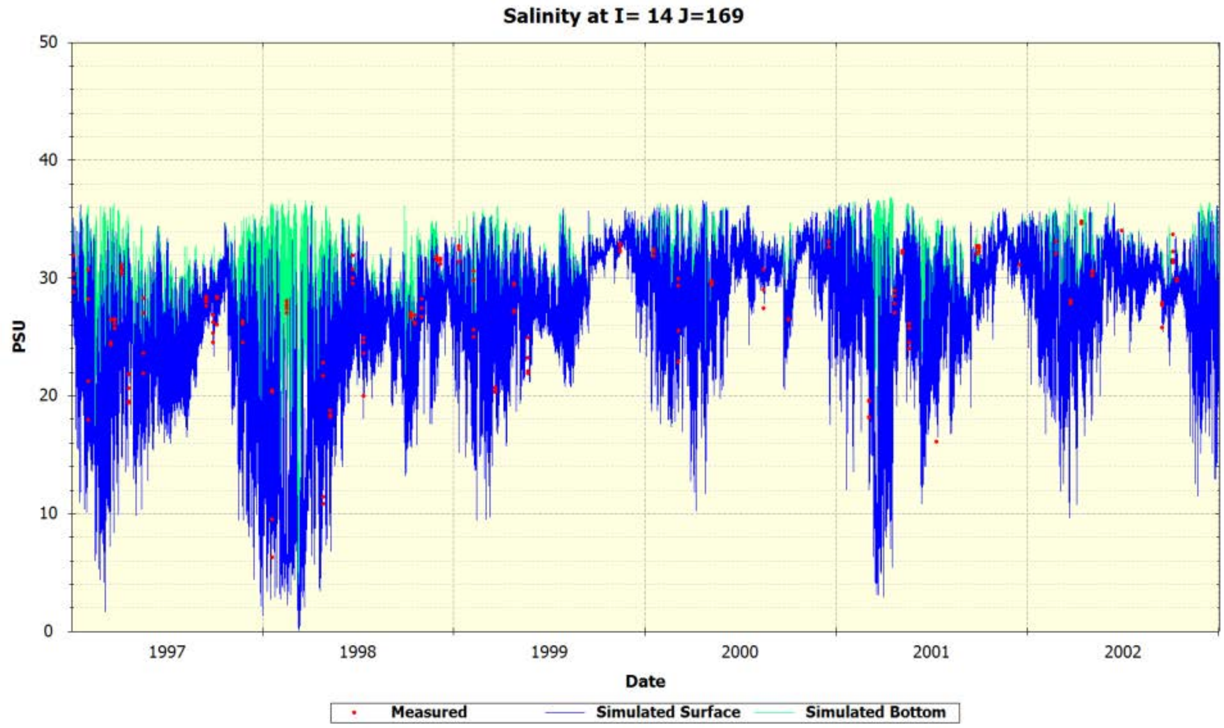

Figure 4.2.67 1997-2002 validation measured versus simulated salinity at I=14 J=169

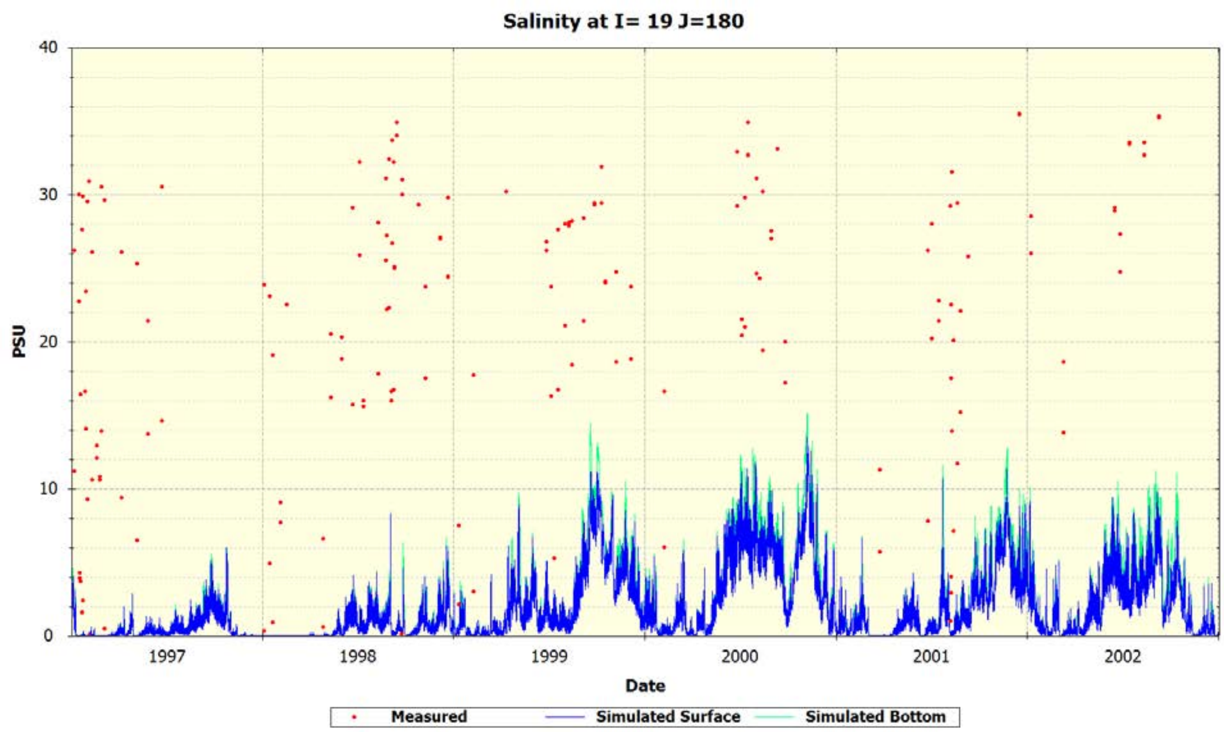

Figure 4.2.68 1997-2002 validation measured versus simulated salinity at I=19 J=180

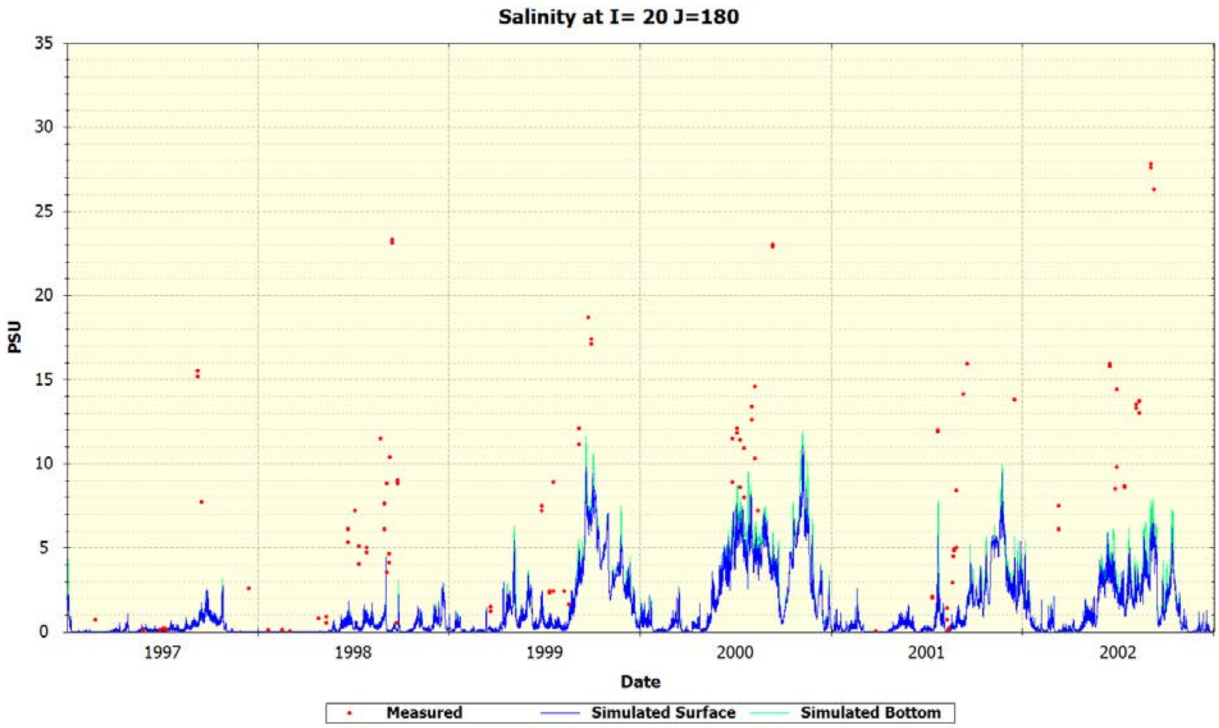

Figure 4.2.69 1997-2002 validation measured versus simulated salinity at I=20 J=180

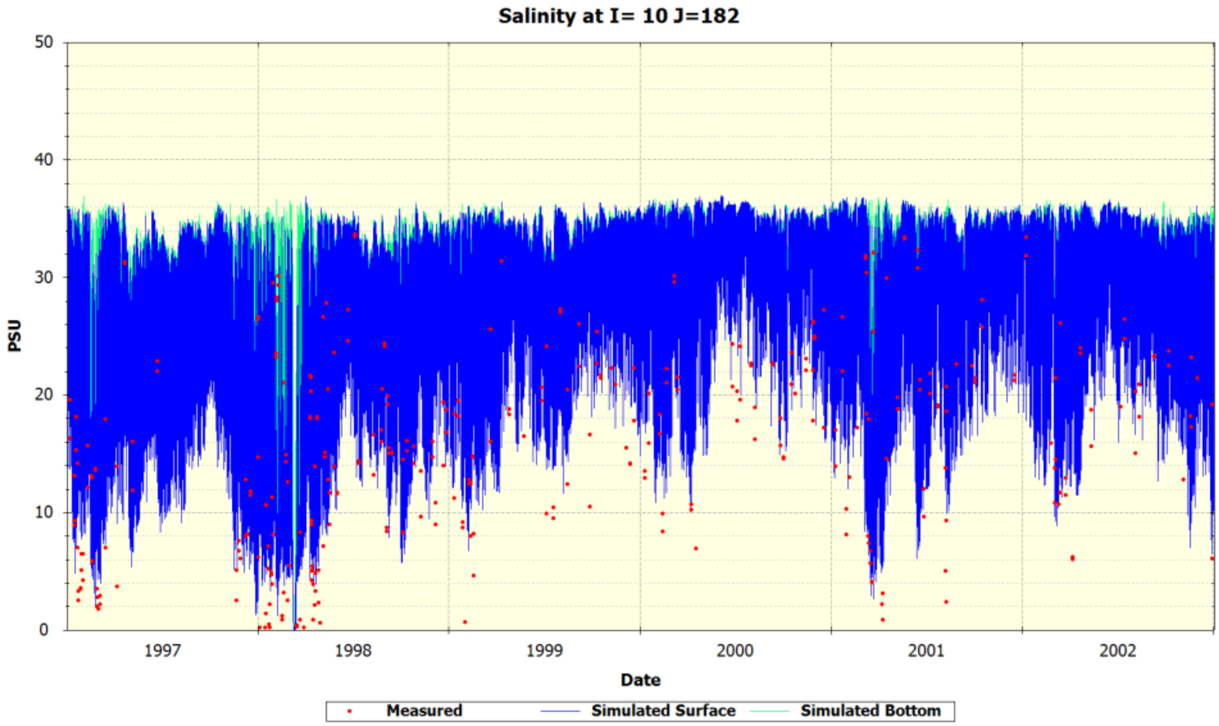

Figure 4.2.70 1997-2002 validation measured versus simulated salinity at I=10 J=182

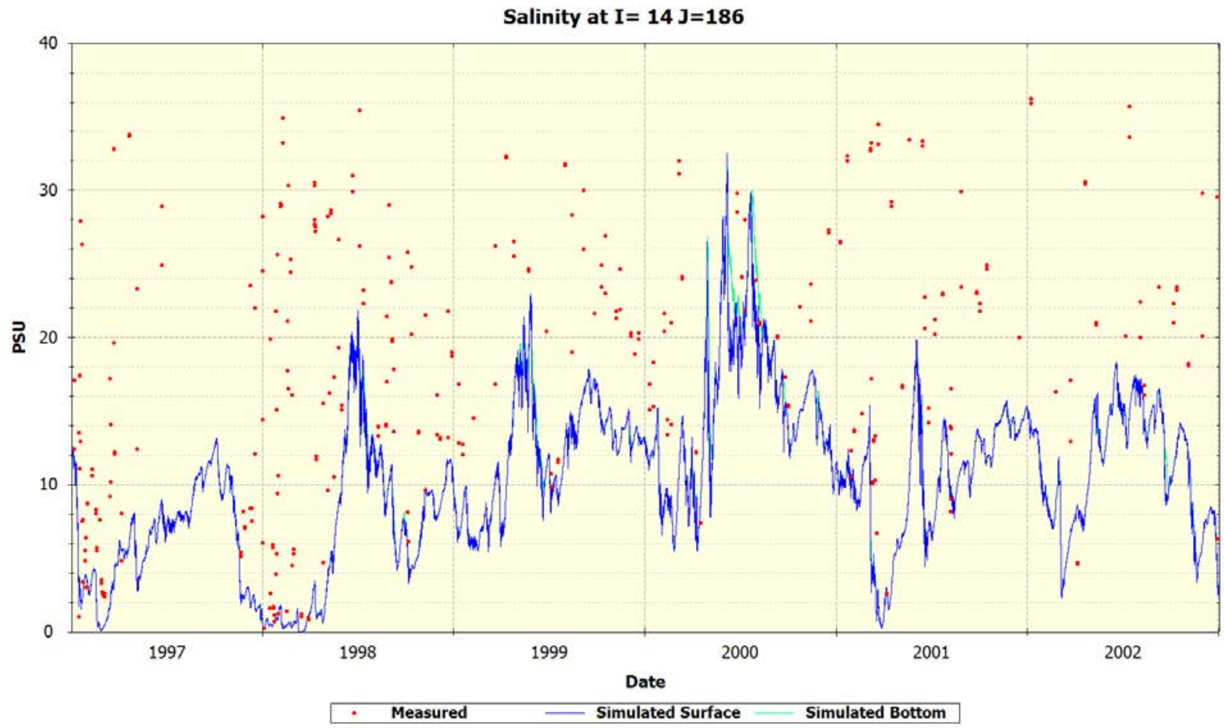

Figure 4.2.71 1997-2002 validation measured versus simulated salinity at I=14 J=186

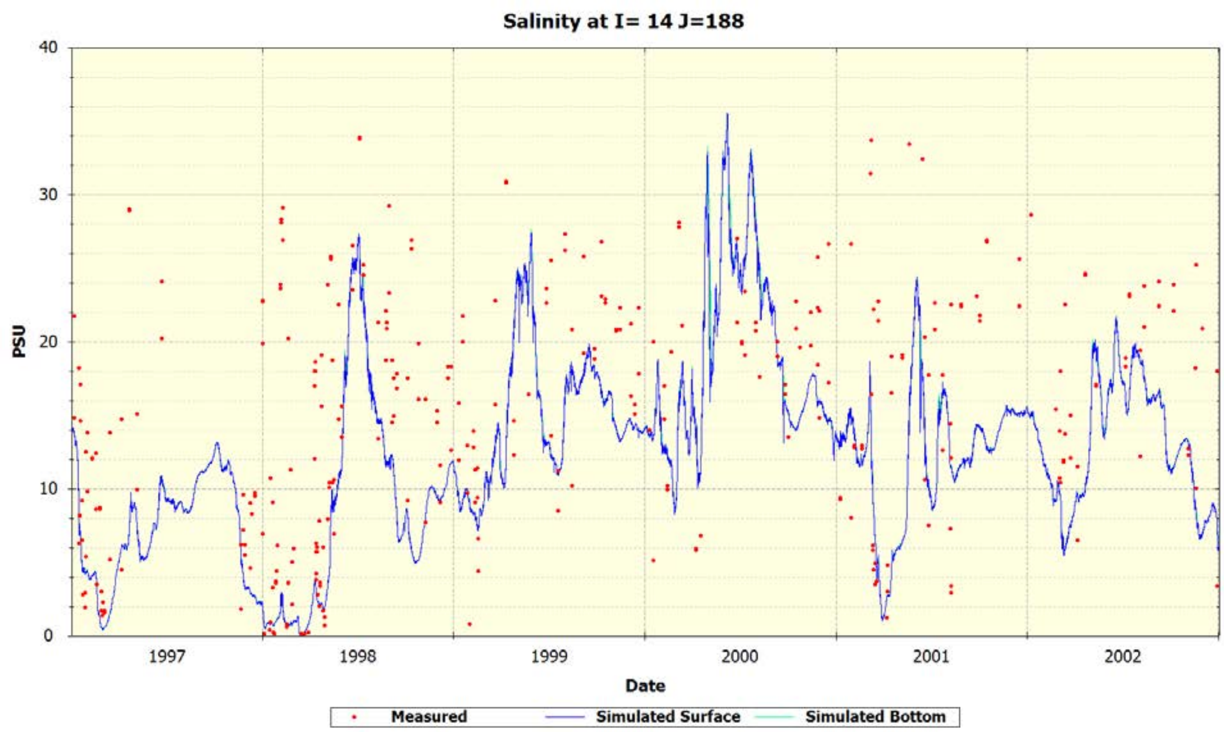

Figure 4.2.72 1997-2002 validation measured versus simulated salinity at I=14 J=188

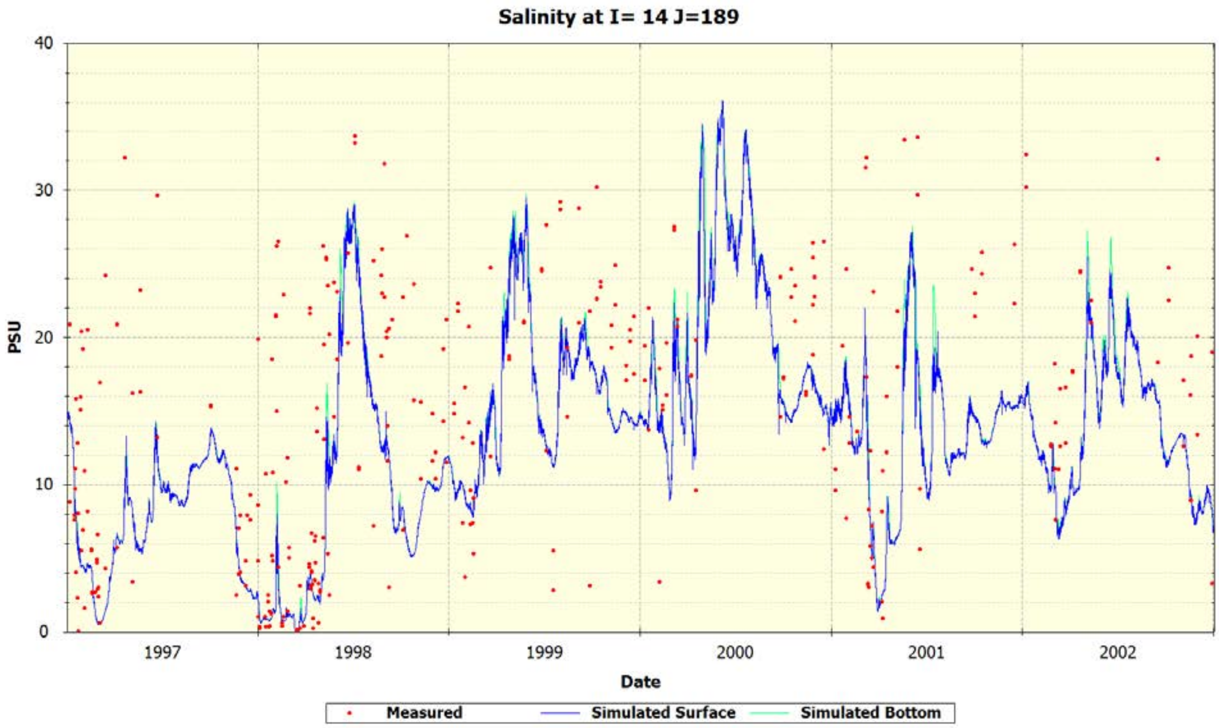

Figure 4.2.73 1997-2002 validation measured versus simulated salinity at I=14 J=189

4.3 Water Temperature Modeling Results

4.3.1 Calibration

Table 4.3.1 Calibration Comparisons of Simulations and Measurements of Surface Temperature for Florida Big Bend Stations for 2003-2009.

Station	Simulated Mean (˚C)	Simulated 5%ile (˚C)	Simulated 95%ile (˚C)	Measured Mean (˚C)	Measured 5%ile (˚C)	Measured 95%ile (˚C)	Error Mean (˚C)	Error 5%ile (˚C)
I = 17 J = 4	23.1	15.3	29.8	23.4	14.4	31.0	-0.4	-1.5
I = 17 J = 18	24.1	15.8	31.0	23.5	14.0	30.9	0.6	2.5
I = 20 J = 31	24.5	15.9	31.7	23.3	11.3	31.8	1.2	5.3
I = 22 J = 39	24.6	15.9	31.8	23.7	11.9	32.0	0.9	3.9
I = 25 J = 44	24.5	16.0	31.5	23.2	12.9	31.7	1.3	5.8
I = 24 J = 59	24.2	15.2	31.8	23.3	12.5	31.3	0.9	3.8
I = 24 J = 68	23.3	13.9	31.5	23.4	14.3	30.3	-0.1	-0.3
I = 24 J = 70	23.2	14.0	31.4	23.2	13.6	30.7	0.1	0.3
I = 25 J = 78	22.6	13.7	30.7	25.0	16.8	31.3	-2.4	-9.6
I = 21 J = 79	23.1	13.6	31.4	25.2	14.6	31.0	-2.1	-8.3
I = 17 J = 84	21.8	11.3	31.1	21.9	12.1	30.5	-0.1	-0.2
I = 13 J = 89	21.8	12.2	30.8	22.0	11.5	30.5	-0.2	-0.8
I = 16 J = 90	21.4	11.7	30.5	20.7	11.2	29.3	0.7	3.4
I = 17 J = 91	20.7	10.7	29.9	22.2	13.8	29.8	-1.5	-6.7
I = 28 J = 91	20.3	11.0	29.4	21.6	15.1	28.5	-1.3	-6.2
I = 16 J = 92	21.3	12.1	30.1	21.3	12.8	30.5	-0.1	-0.3
I = 16 J = 98	21.4	11.4	30.8	22.4	11.7	31.0	-1.0	-4.3
I = 18 J = 110	21.6	11.7	30.8	21.7	12.2	31.1	-0.1	-0.4
I = 21 J = 127	21.9	11.3	31.4	21.7	0.0	0.0	0.2	1.0
I = 23 J = 128	21.9	11.2	31.4	21.6	13.4	29.3	0.3	1.2
I = 20 J = 130	21.9	11.4	31.3	21.0	12.4	28.7	0.9	4.2
I = 21 J = 132	21.9	11.3	31.4	22.0	0.0	0.0	-0.1	-0.3
I = 23 J = 133	22.0	11.2	31.4	21.5	9.2	30.0	0.5	2.1
I = 26 J = 133	21.8	11.3	31.2	20.4	9.6	30.5	1.5	7.3
I = 24 J = 150	21.5	11.1	30.8	20.6	12.1	29.2	0.8	4.1
I = 22 J = 152	21.5	11.1	30.9	21.3	12.4	30.2	0.3	1.2
I = 18 J = 154	21.1	11.1	30.5	21.7	13.2	30.3	-0.6	-2.7
I = 18 J = 156	21.4	11.4	30.8	21.7	13.1	30.4	-0.3	-1.3
I = 21 J = 156	21.4	11.0	30.8	22.1	13.2	30.4	-0.7	-3.0
I = 14 J = 169	21.5	12.9	30.1	19.5	11.4	27.4	2.0	10.1
I = 14 J = 175	21.8	11.4	31.1	20.0	11.6	29.5	1.7	8.7
I = 12 J = 182	21.3	13.6	28.8	21.3	12.4	30.2	0.0	0.1
I = 14 J = 186	21.5	11.0	30.8	22.0	12.2	30.7	-0.5	-2.5

Station	Simulated Mean (˚C)	Simulated 5%ile (˚C)	Simulated 95%ile (˚C)	Measured Mean (˚C)	Measured 5%ile (˚C)	Measured 95%ile (˚C)	Error Mean (˚C)	Error 5%ile (˚C)
I = 14 J = 188	21.6	11.0	30.9	21.3	12.5	30.3	0.3	1.6
I = 14 J = 189	21.6	11.0	30.8	19.1	12.0	27.8	2.5	13.2

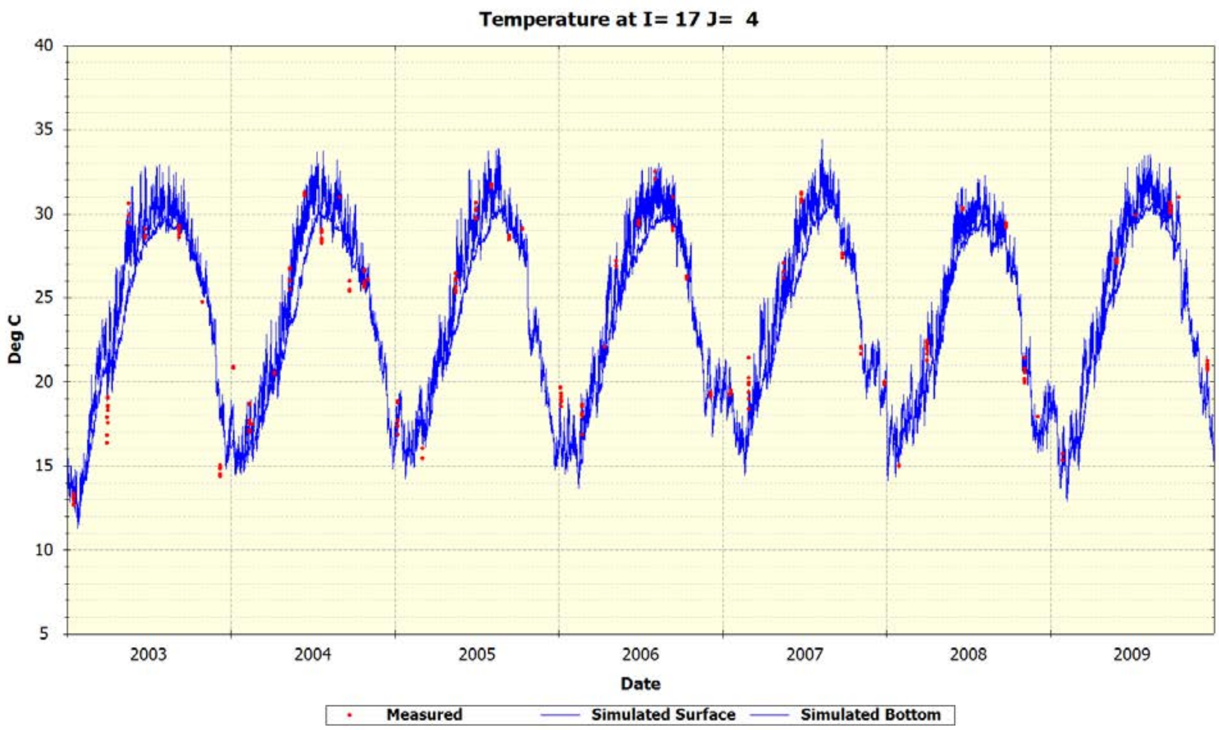

Figure 4.3.1 2003-2009 calibration measured versus simulated temperature at I=17 J=4

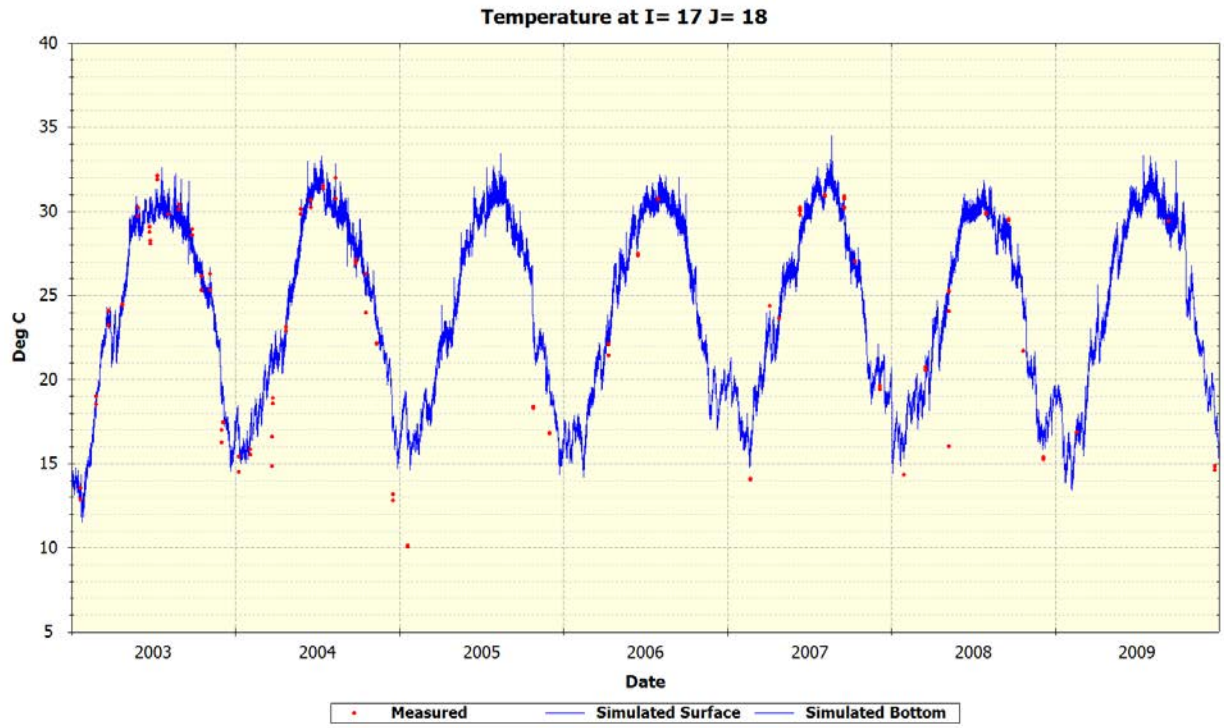

Figure 4.3.2 2003-2009 calibration measured versus simulated temperature at I=17 J=18

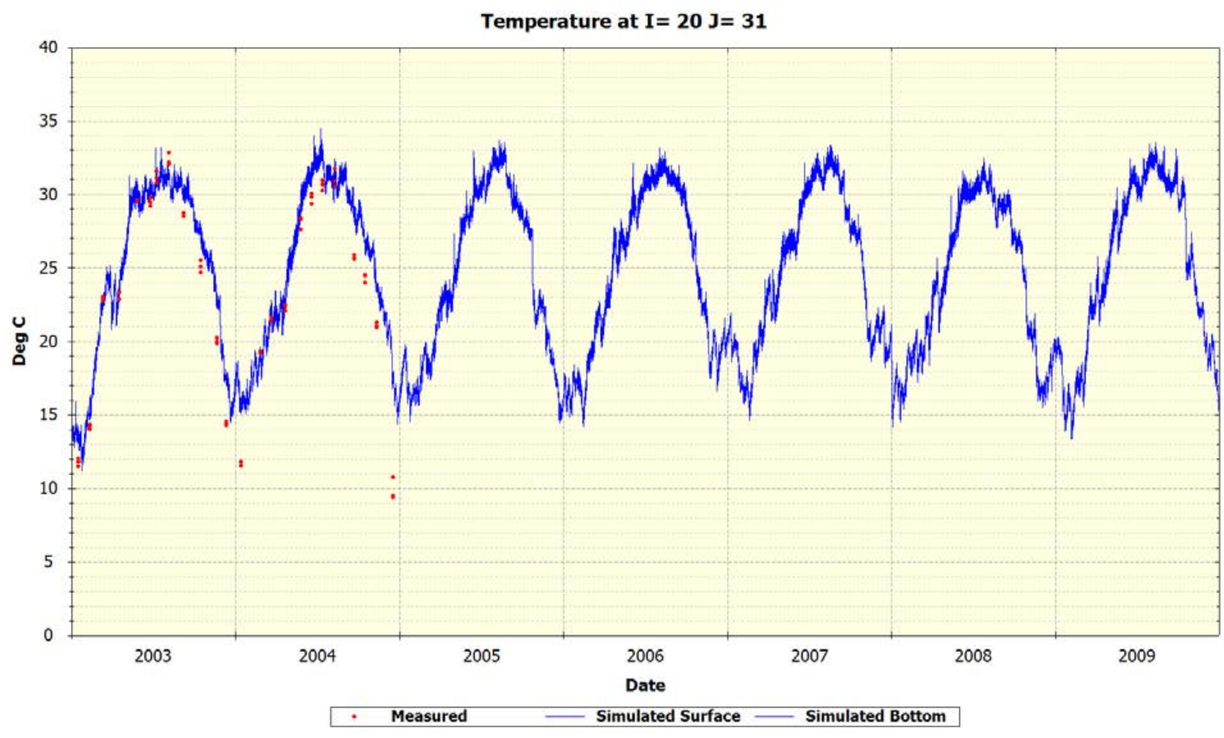

Figure 4.3.3 2003-2009 calibration measured versus simulated temperature at I=20 J=31

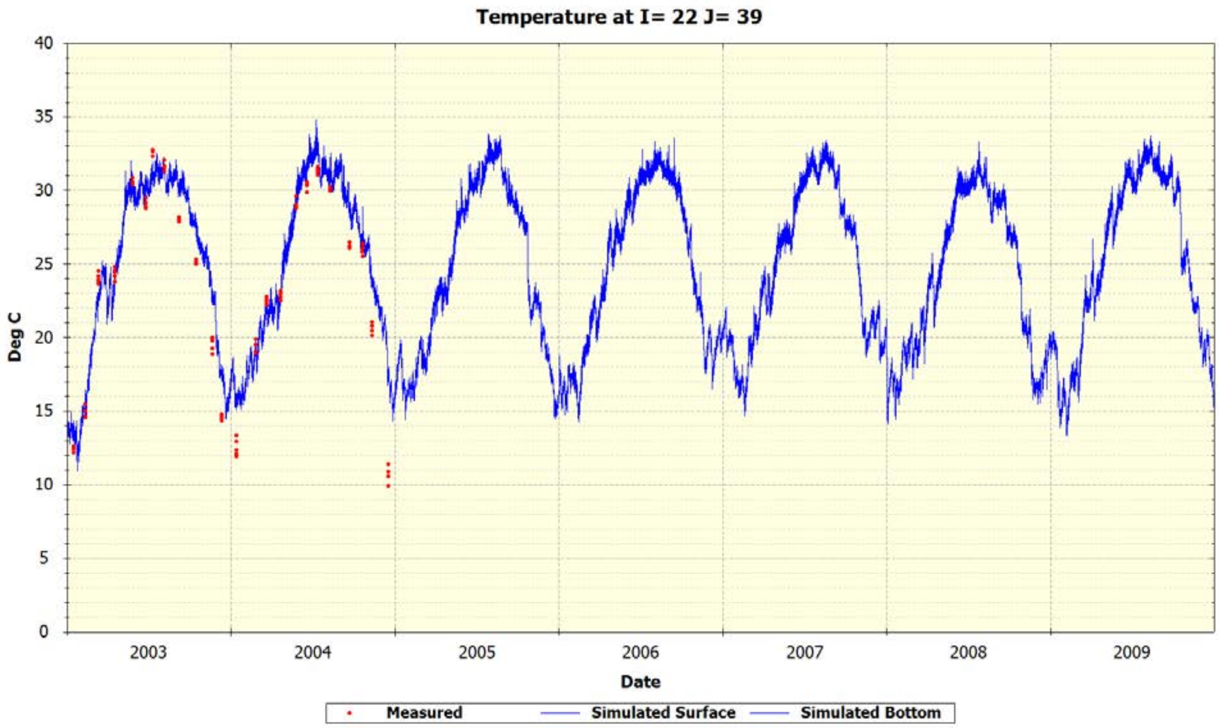

Figure 4.3.4 2003-2009 calibration measured versus simulated temperature at I=22 J=39

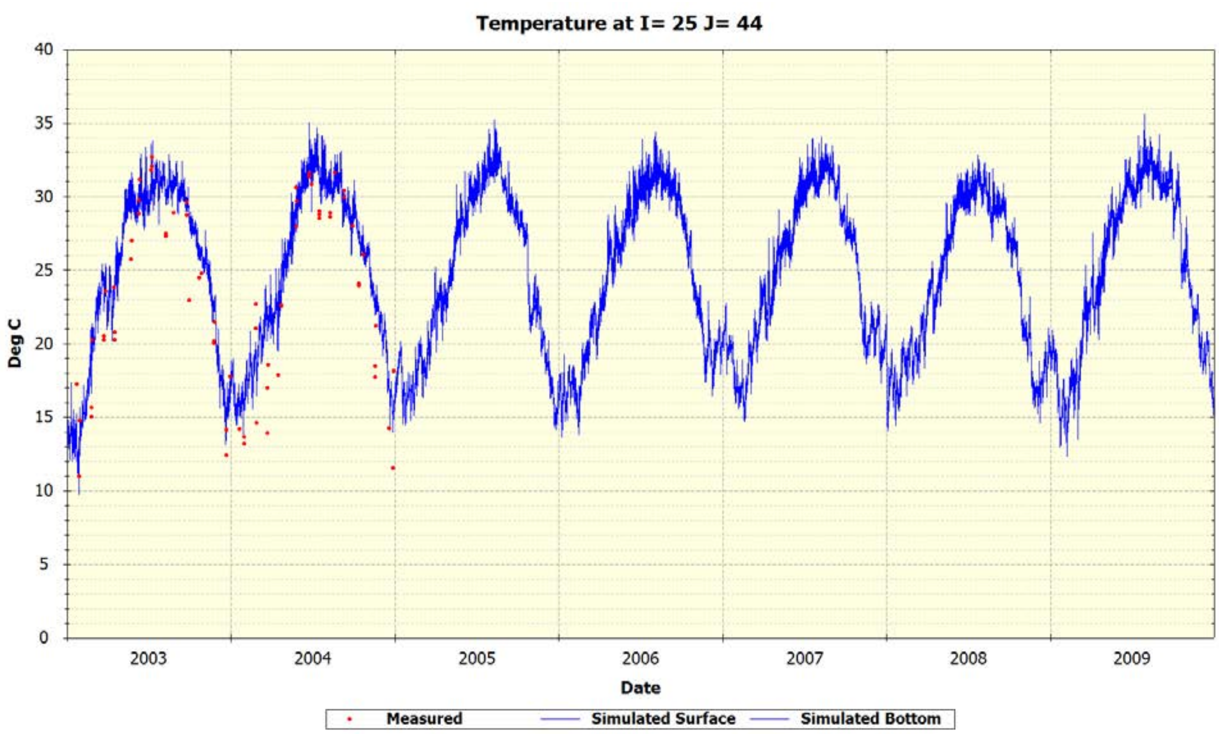

Figure 4.3.5 2003-2009 calibration measured versus simulated temperature at I=25 J=44

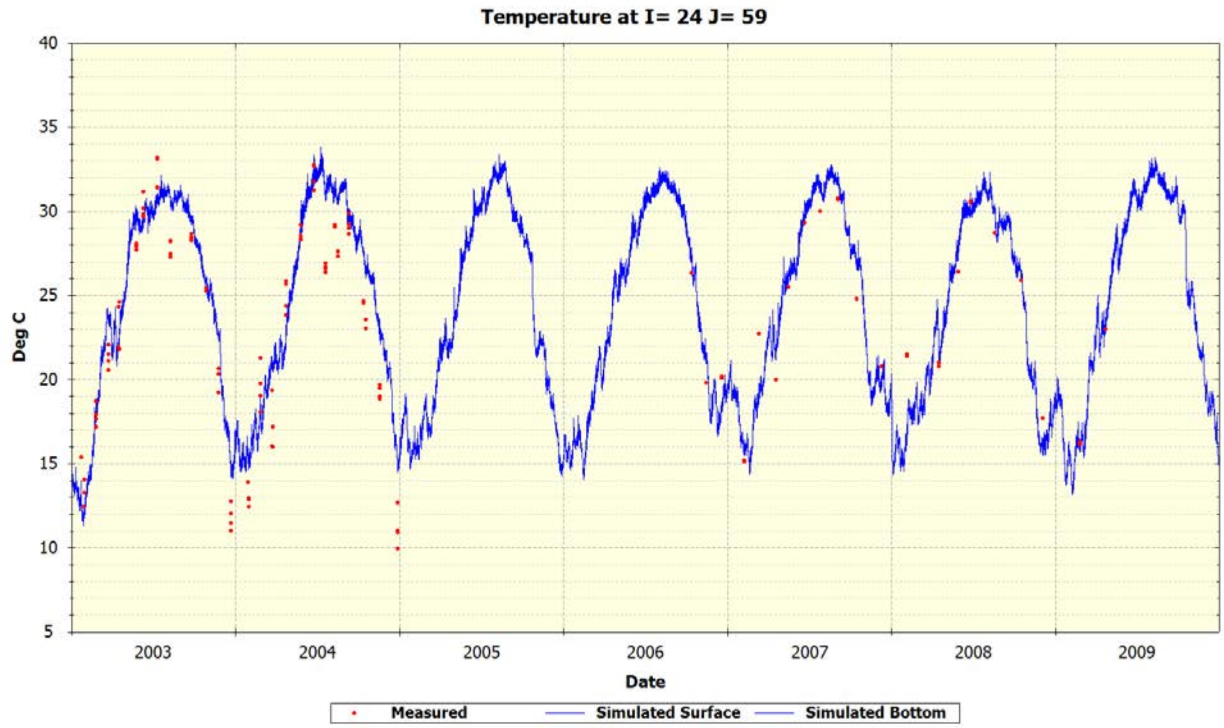

Figure 4.3.6 2003-2009 calibration measured versus simulated temperature at I=24 J=59

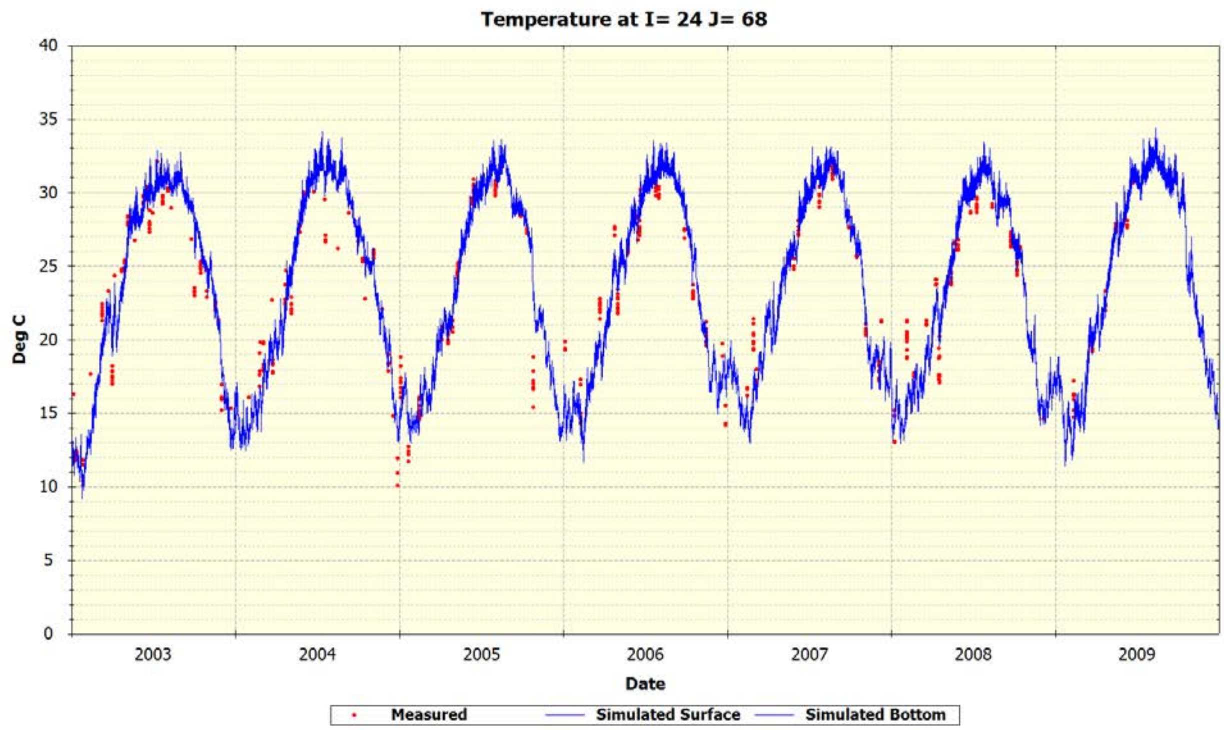

Figure 4.3.7 2003-2009 calibration measured versus simulated temperature at I=24 J=68

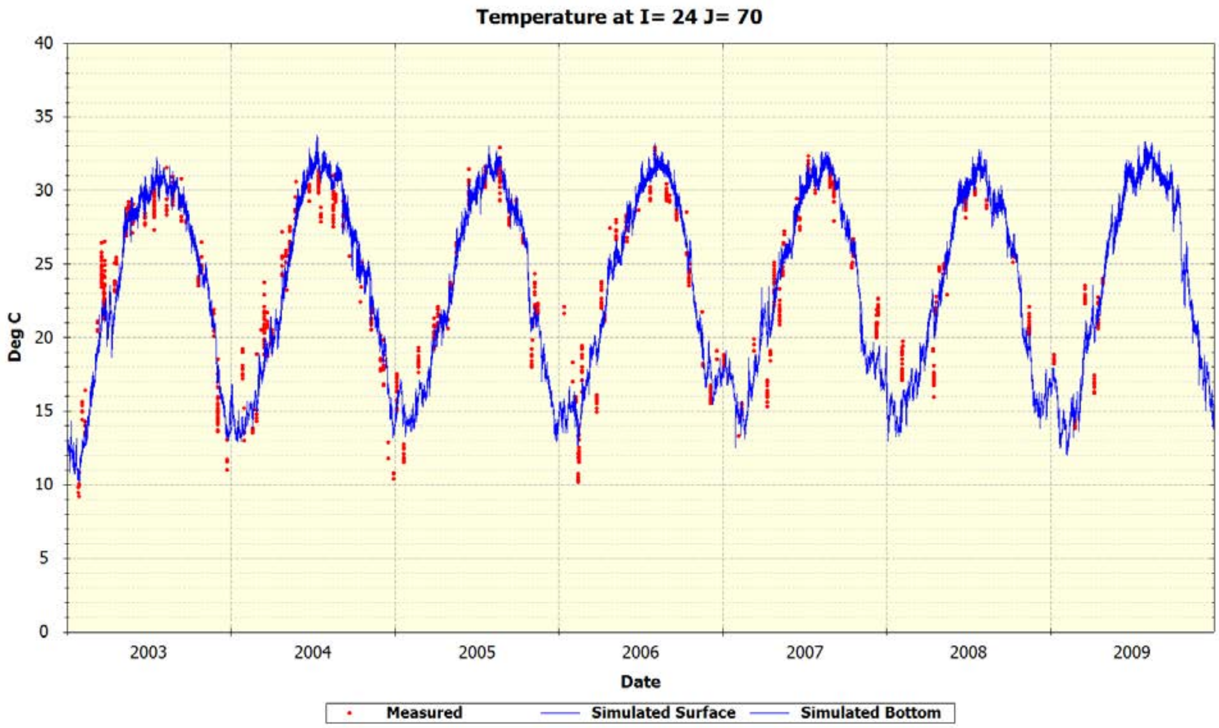

Figure 4.3.8 2003-2009 calibration measured versus simulated temperature at I=24 J=70

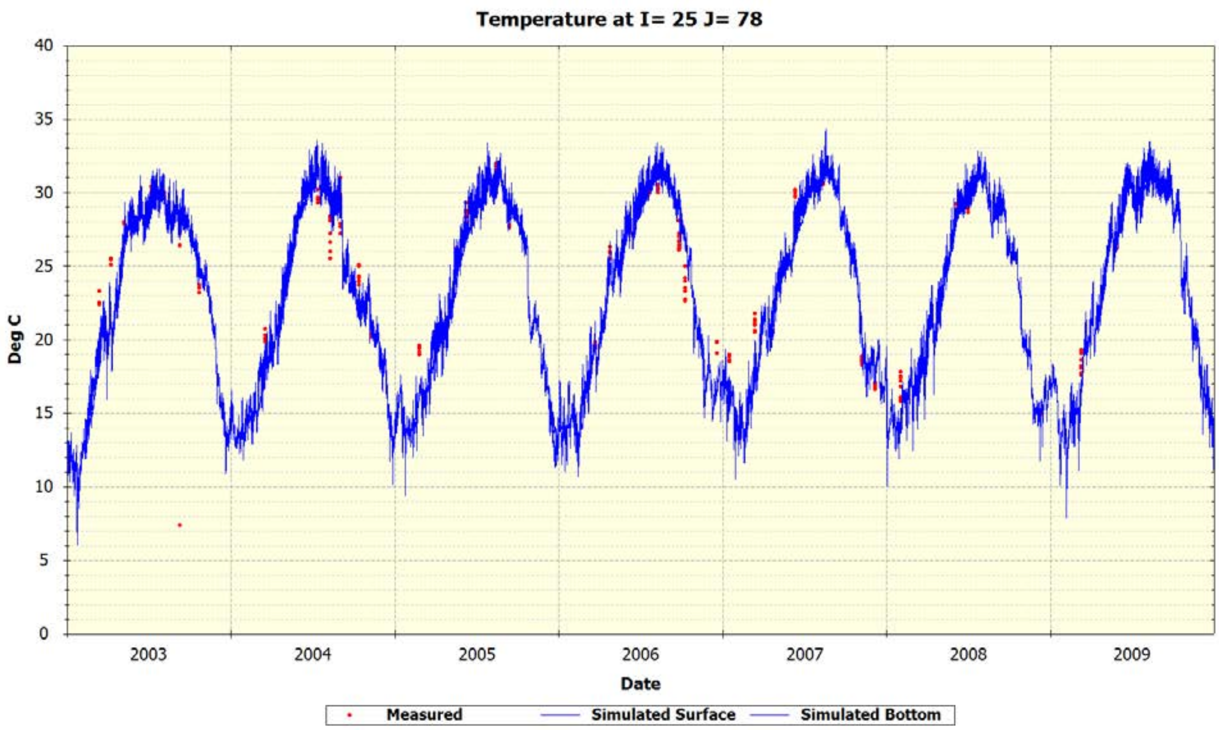

Figure 4.3.9 2003-2009 calibration measured versus simulated temperature at I=25 J=78

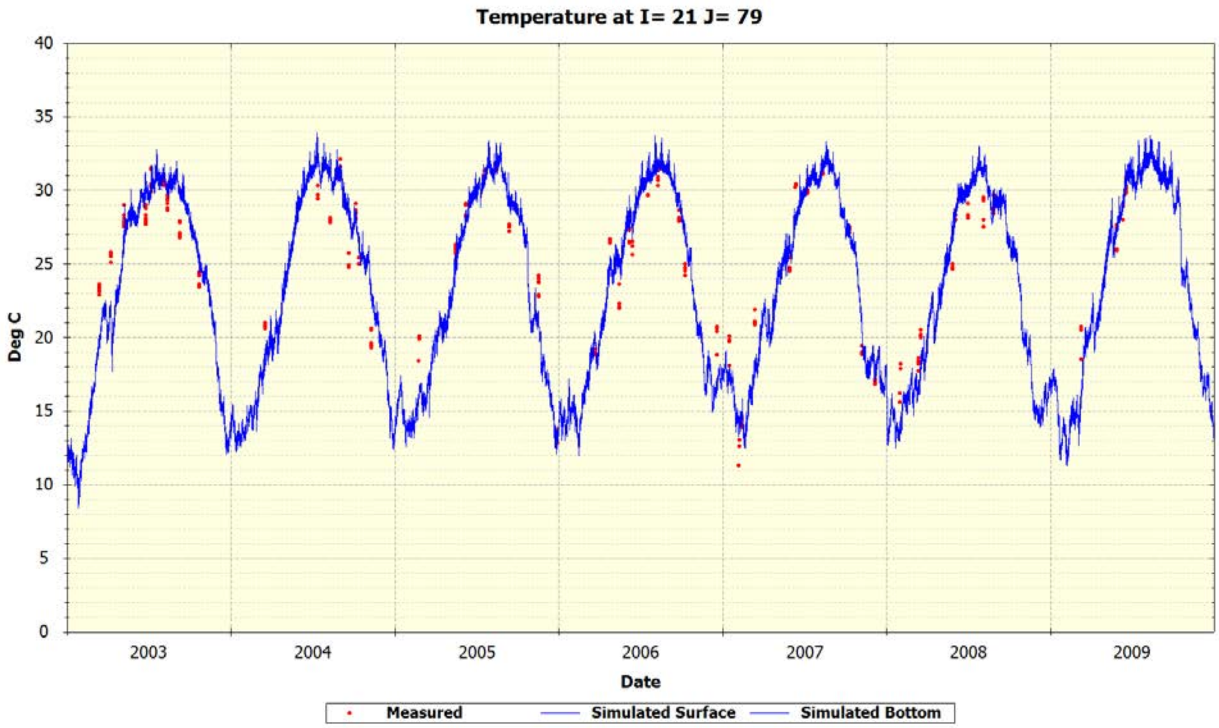

Figure 4.3.10 2003-2009 calibration measured versus simulated temperature at I=21 J=79

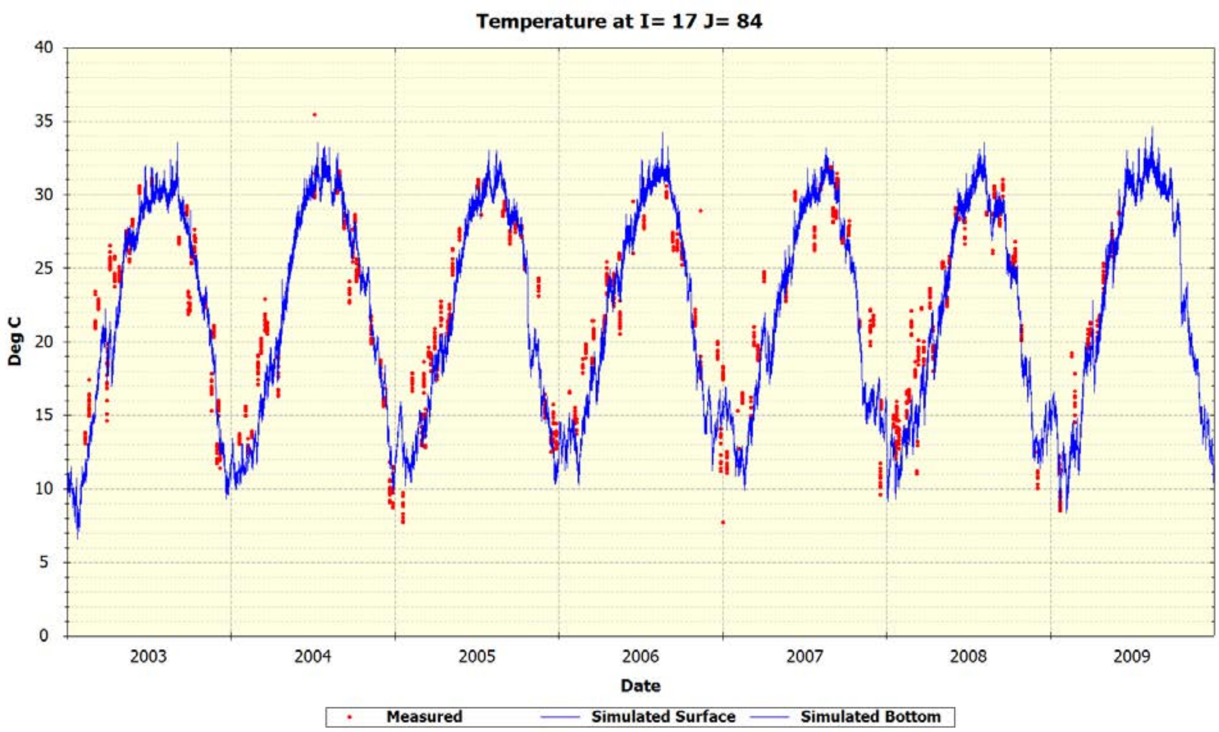

Figure 4.3.11 2003-2009 calibration measured versus simulated temperature at I=17 J=84

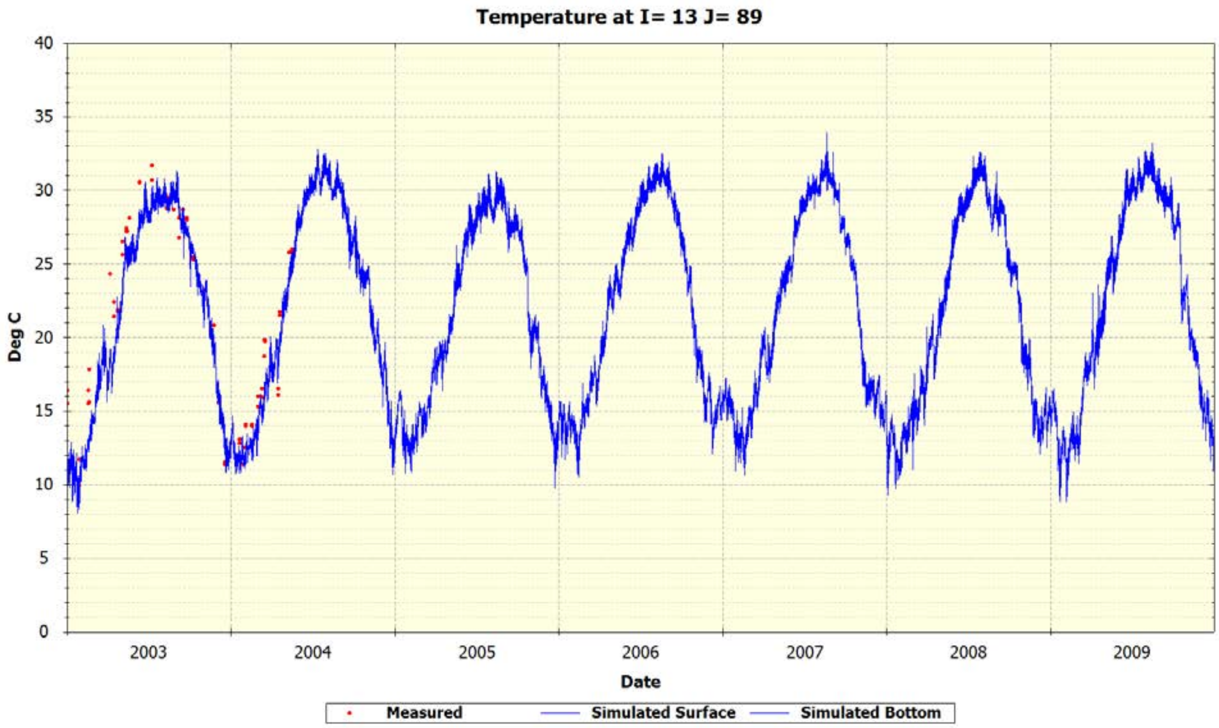

Figure 4.3.12 2003-2009 calibration measured versus simulated temperature at I=13 J=89

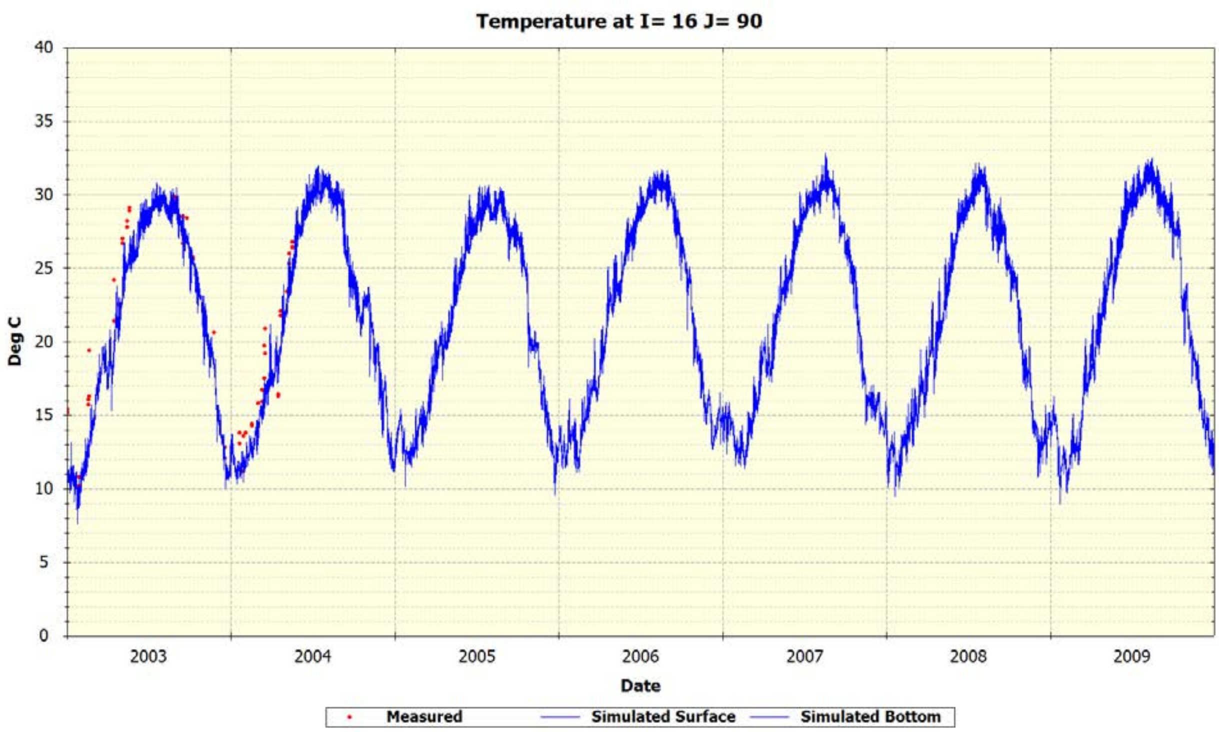

Figure 4.3.13 2003-2009 calibration measured versus simulated temperature at I=16 J=90

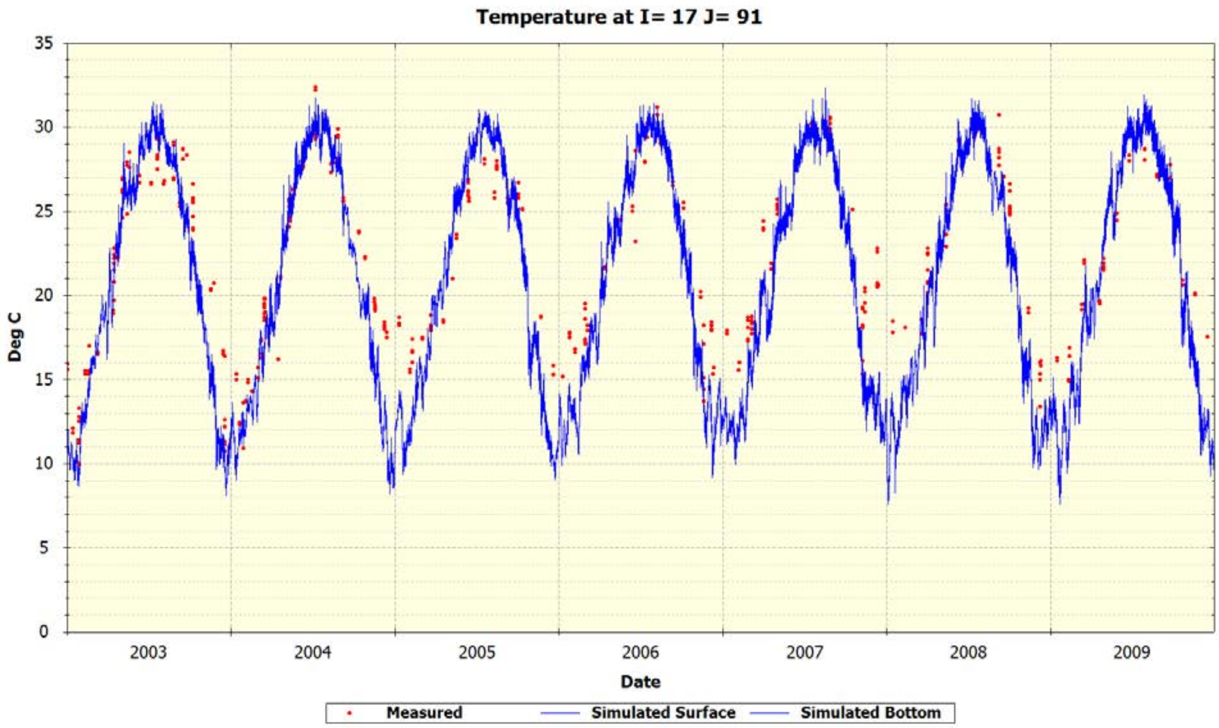

Figure 4.3.14 2003-2009 calibration measured versus simulated temperature at I=17 J=91

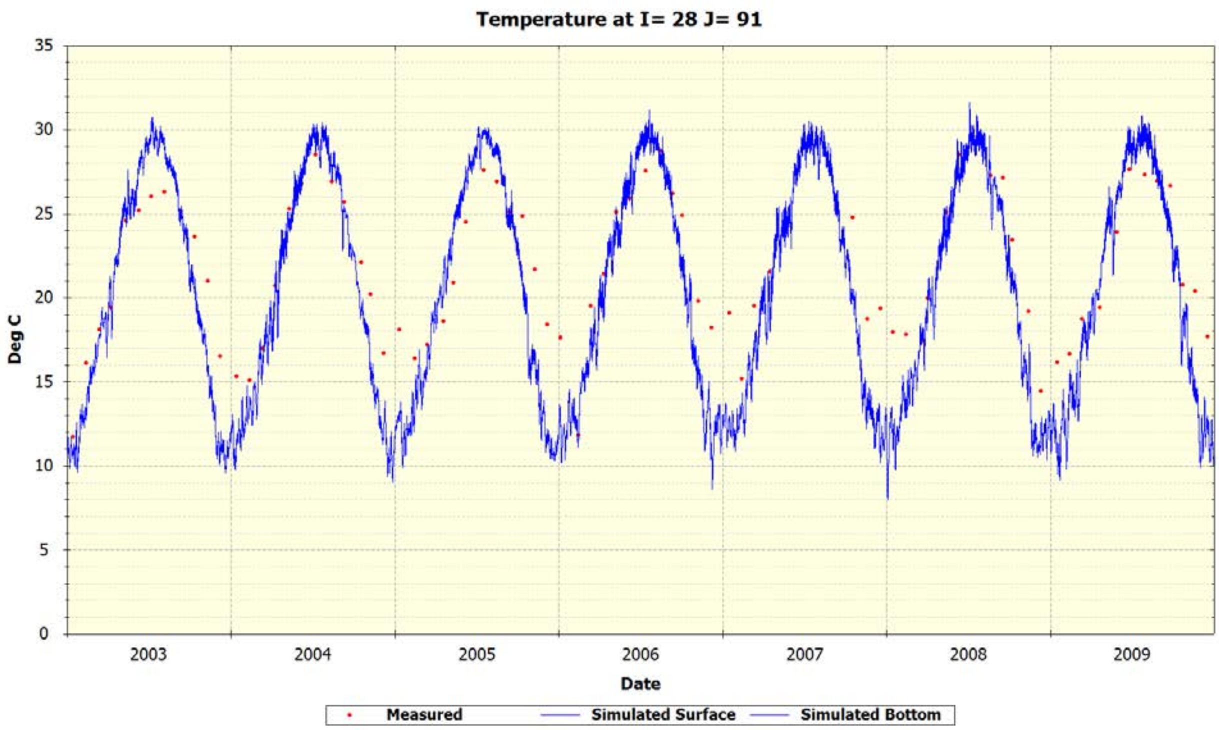

Figure 4.3.15 2003-2009 calibration measured versus simulated temperature at I=28 J=91

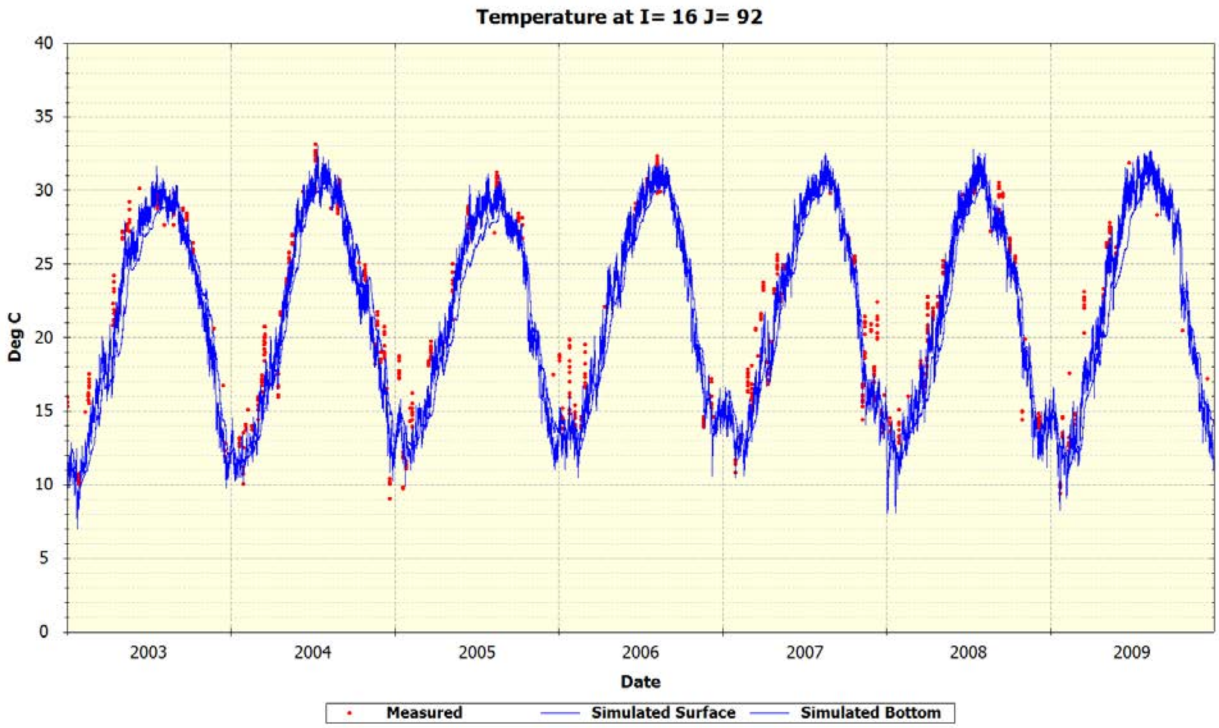

Figure 4.3.16 2003-2009 calibration measured versus simulated temperature at I=16 J=92

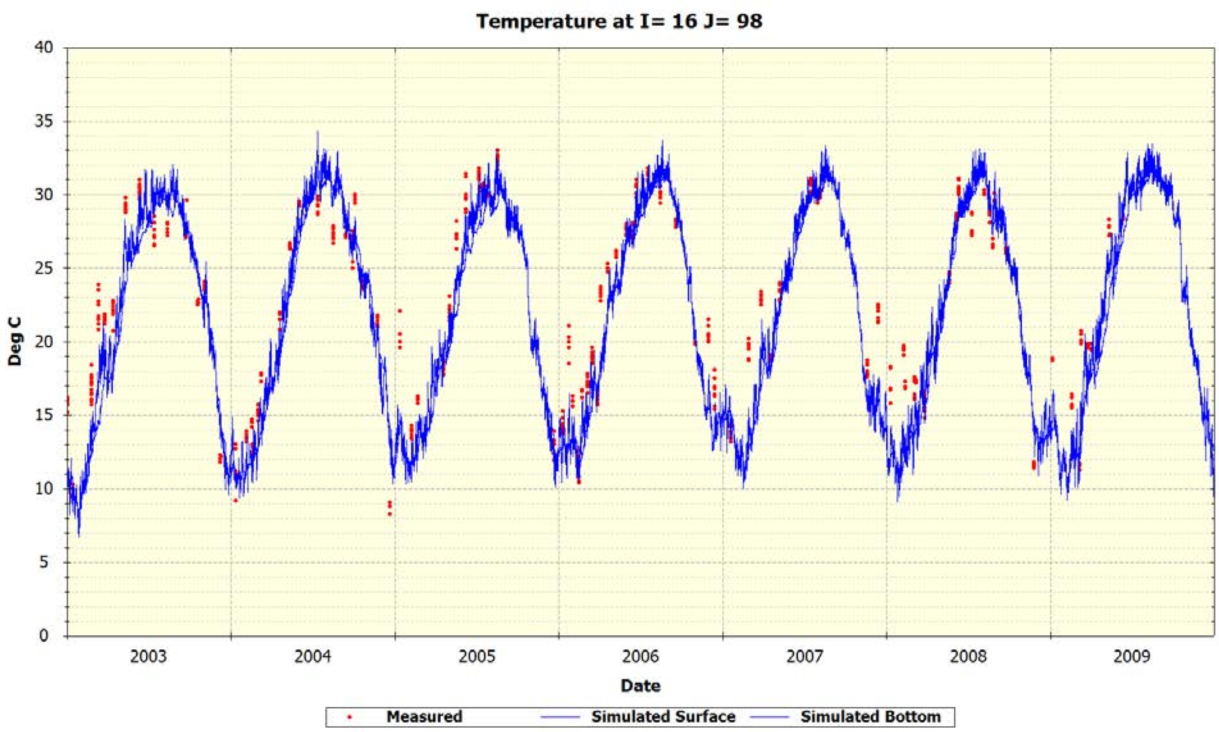

Figure 4.3.17 2003-2009 calibration measured versus simulated temperature at I=16 J=98

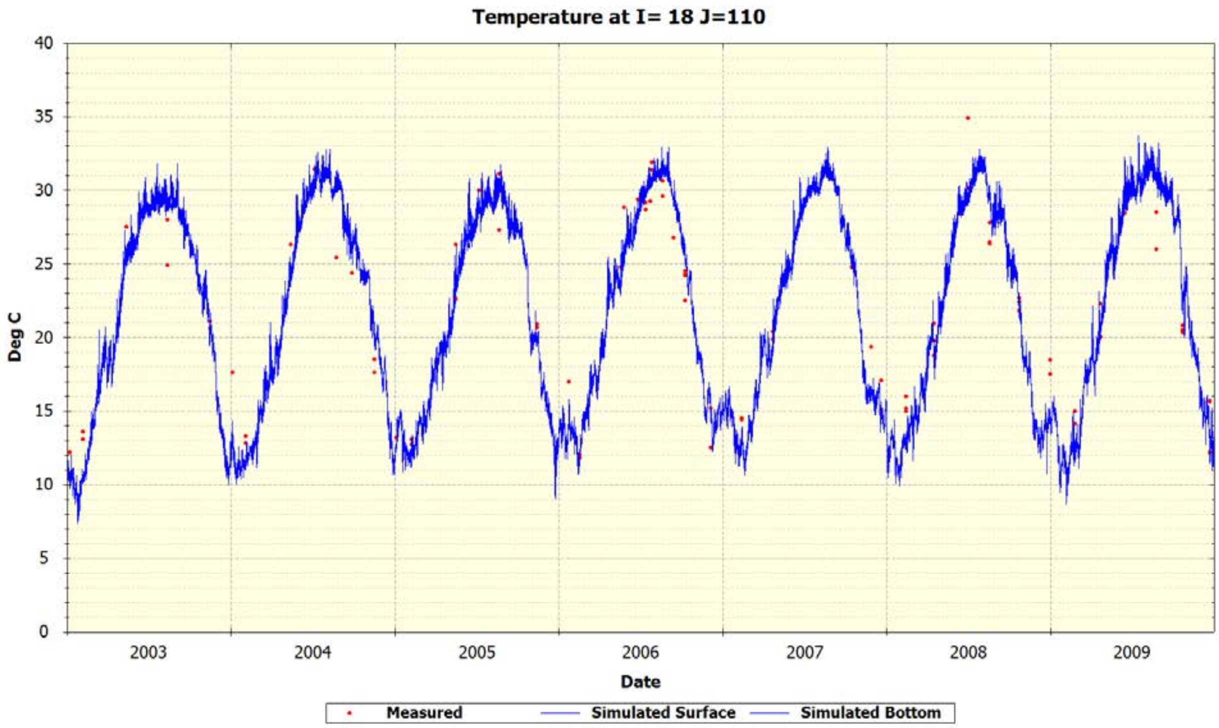

Figure 4.3.18 2003-2009 calibration measured versus simulated temperature at I=18 J=110

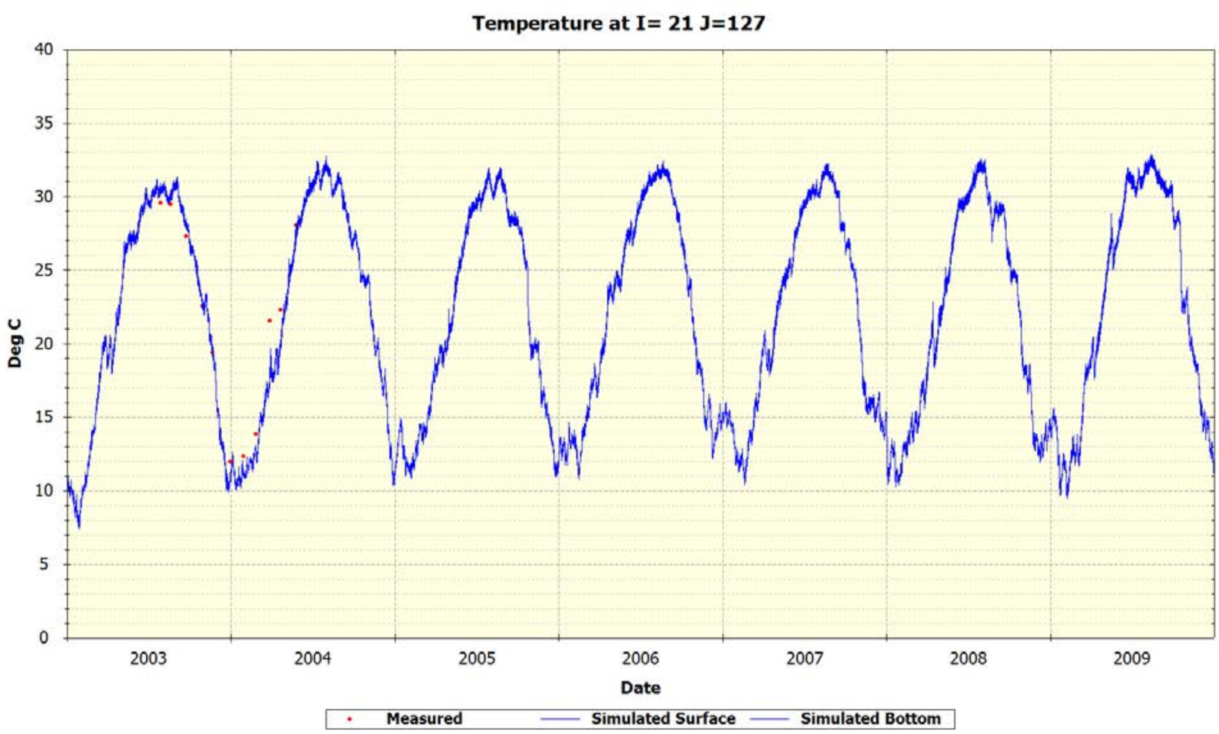

Figure 4.3.19 2003-2009 calibration measured versus simulated temperature at I=21 J=127

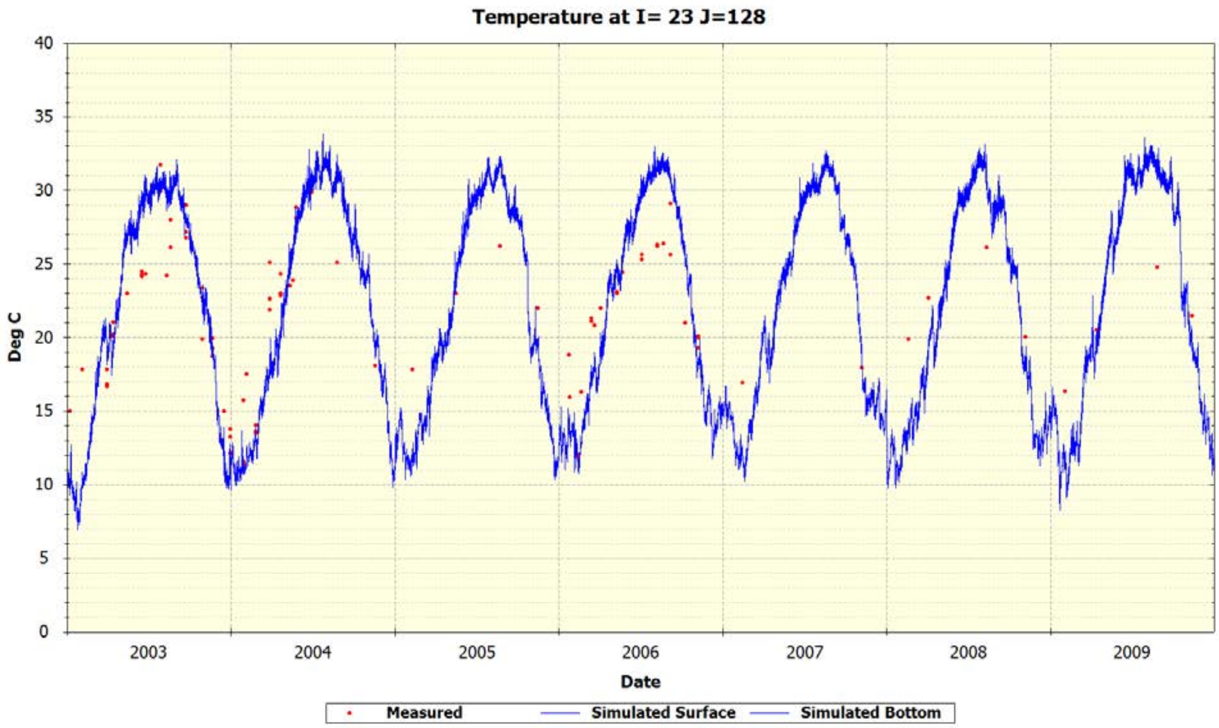

Figure 4.3.20 2003-2009 calibration measured versus simulated temperature at I=23 J=128

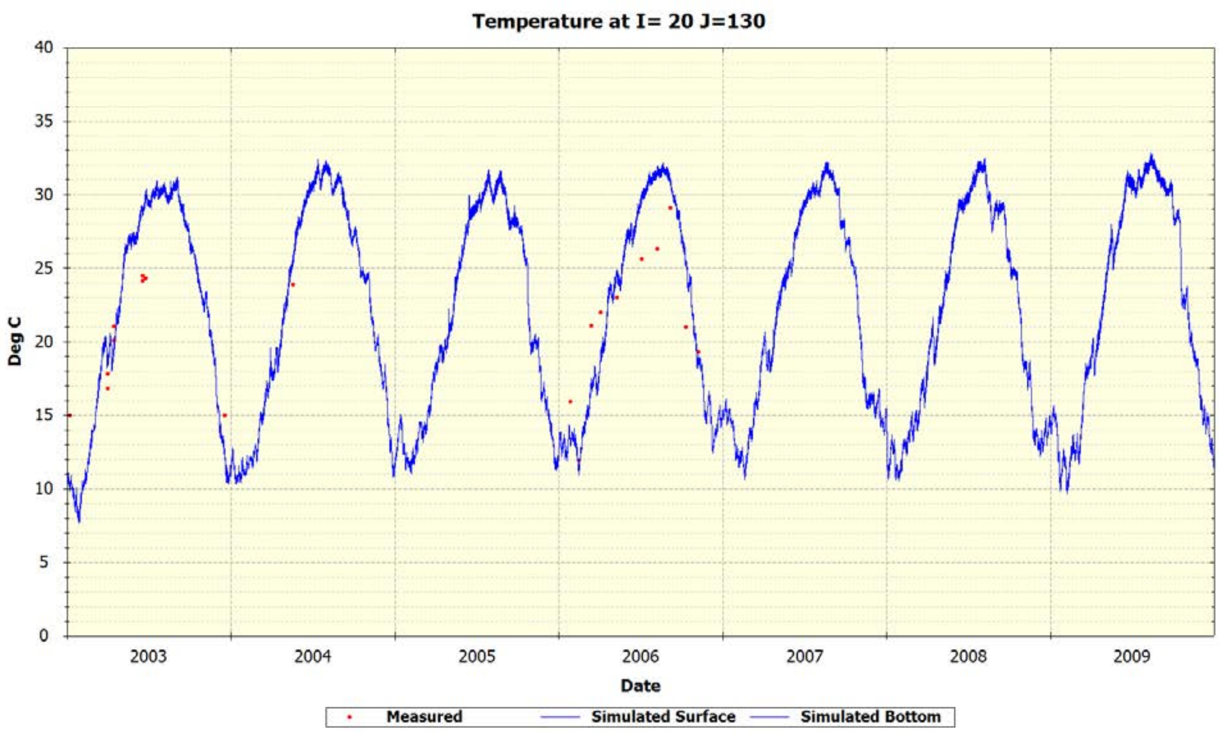

Figure 4.3.21 2003-2009 calibration measured versus simulated temperature at I=20 J=130

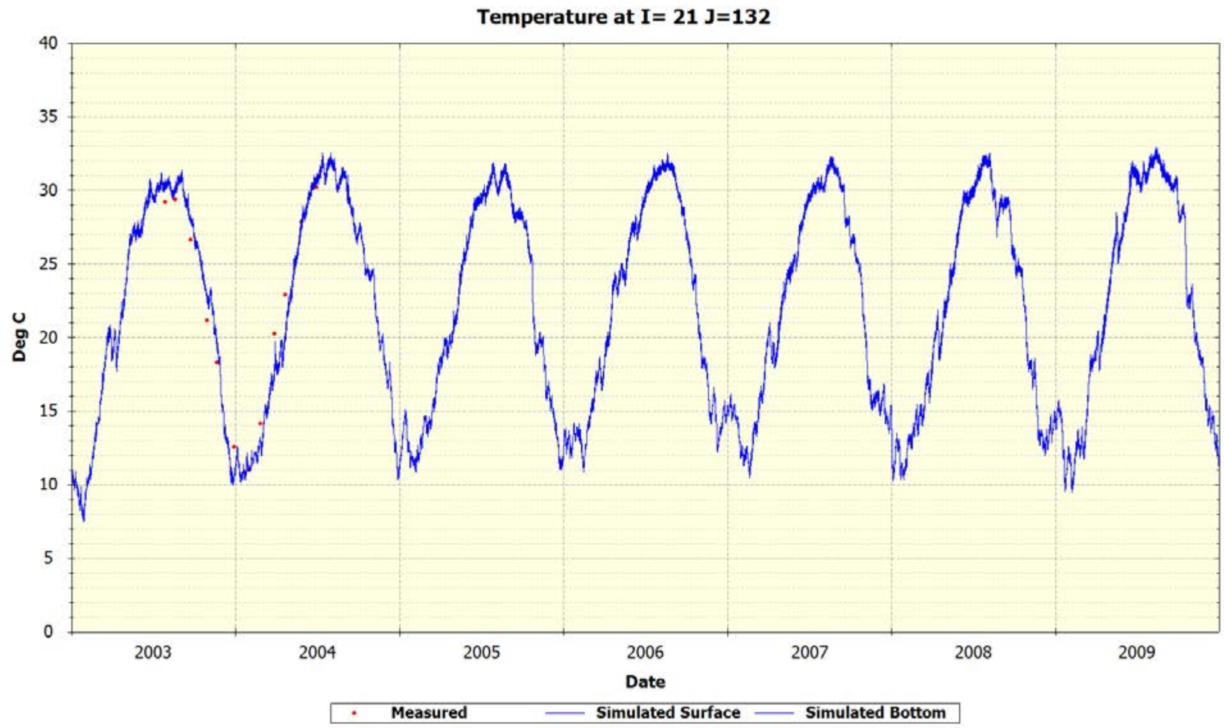

Figure 4.3.22 2003-2009 calibration measured versus simulated temperature at I=21 J=132

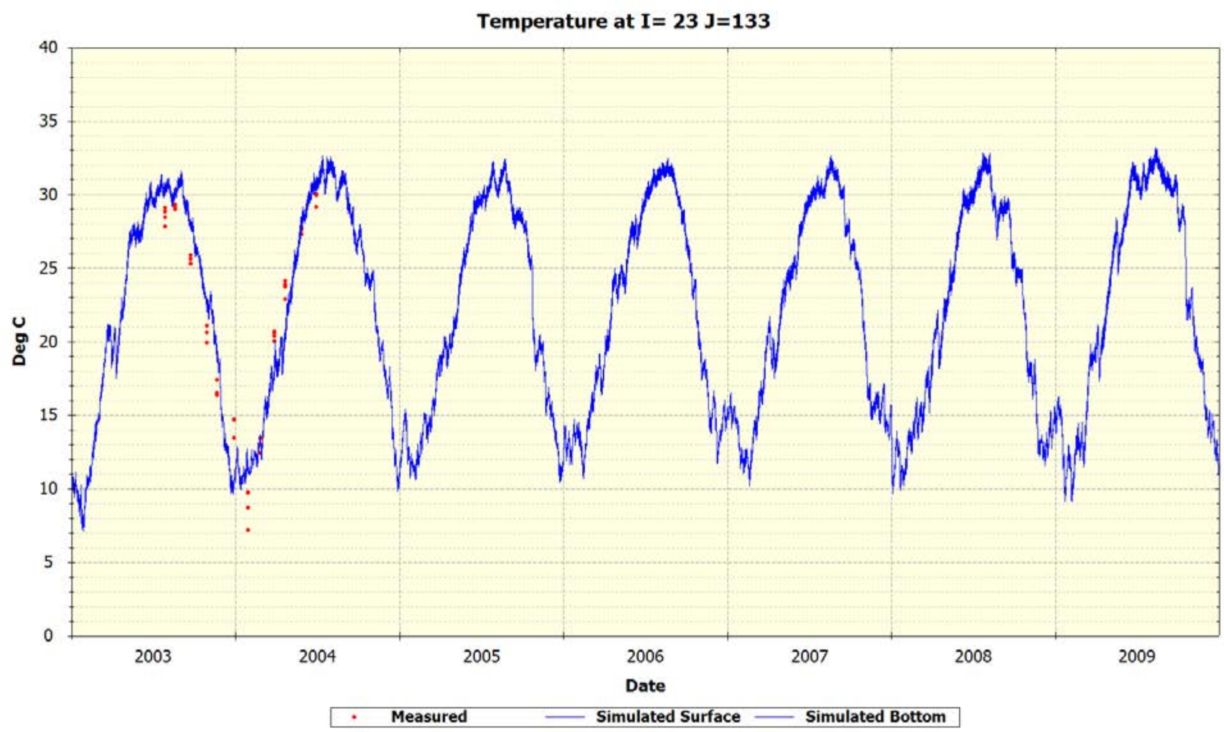

Figure 4.3.23 2003-2009 calibration measured versus simulated temperature at I=23 J=133

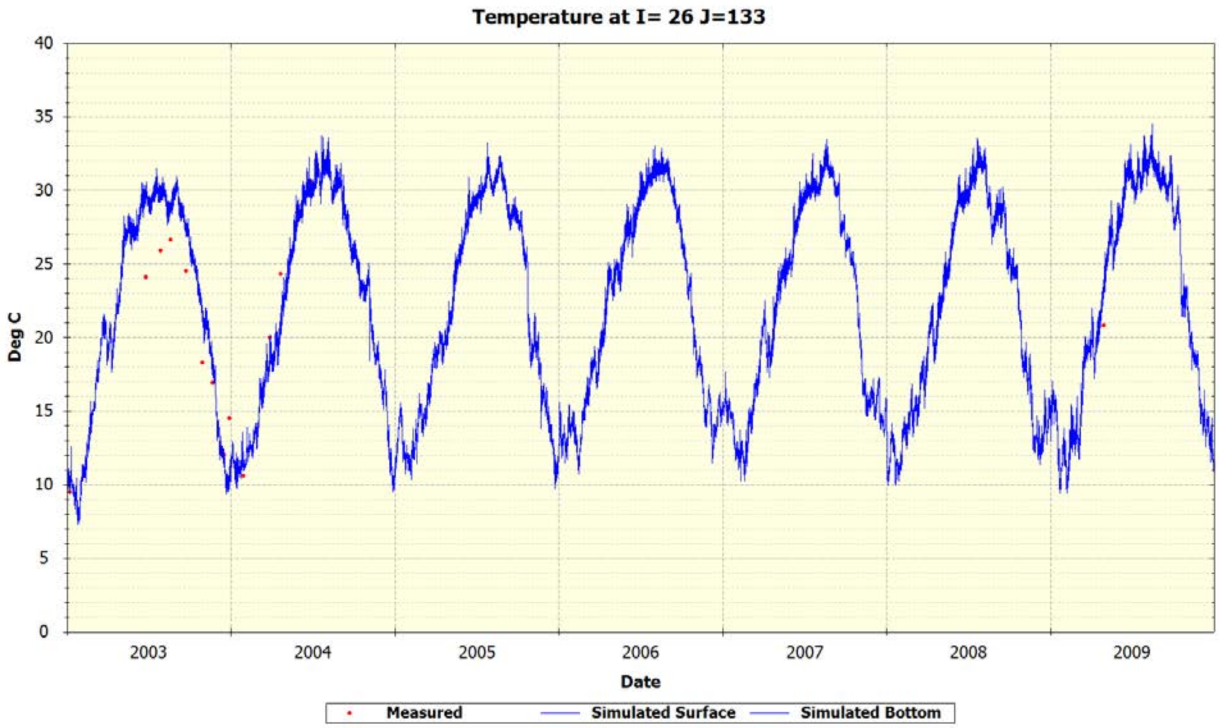

Figure 4.3.24 2003-2009 calibration measured versus simulated temperature at I=26 J=133

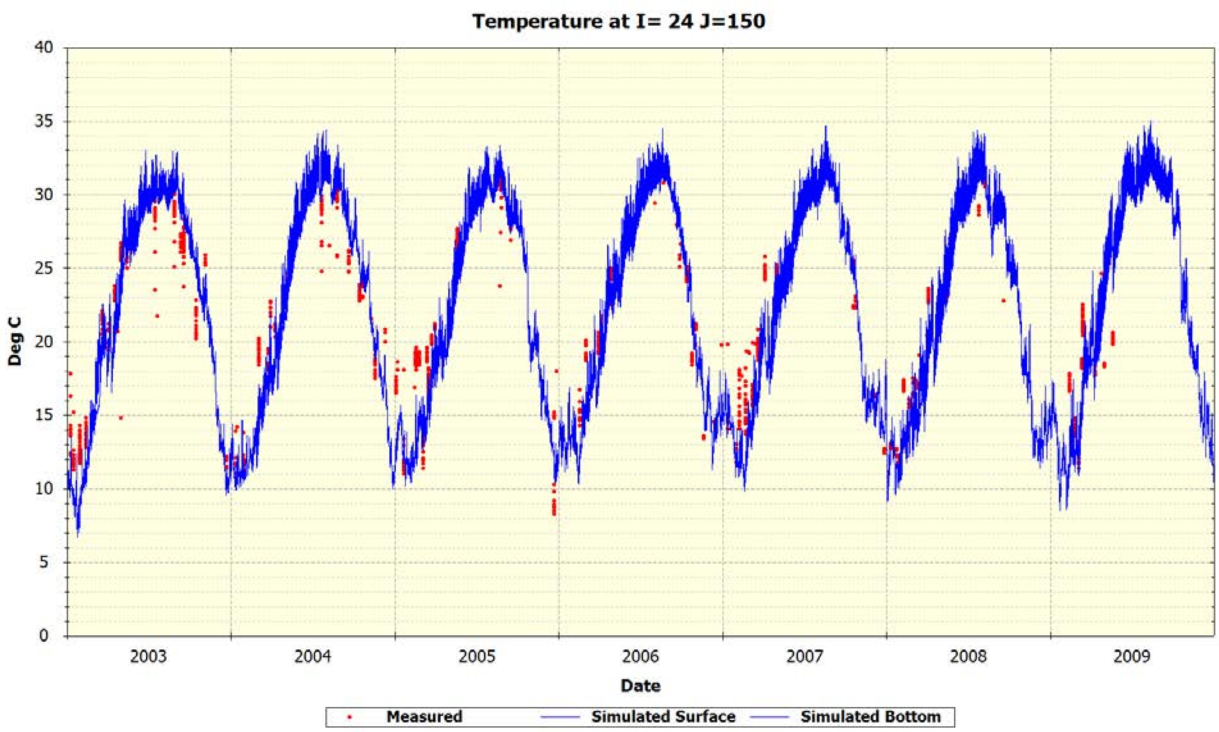

Figure 4.3.25 2003-2009 calibration measured versus simulated temperature at I=24 J=150

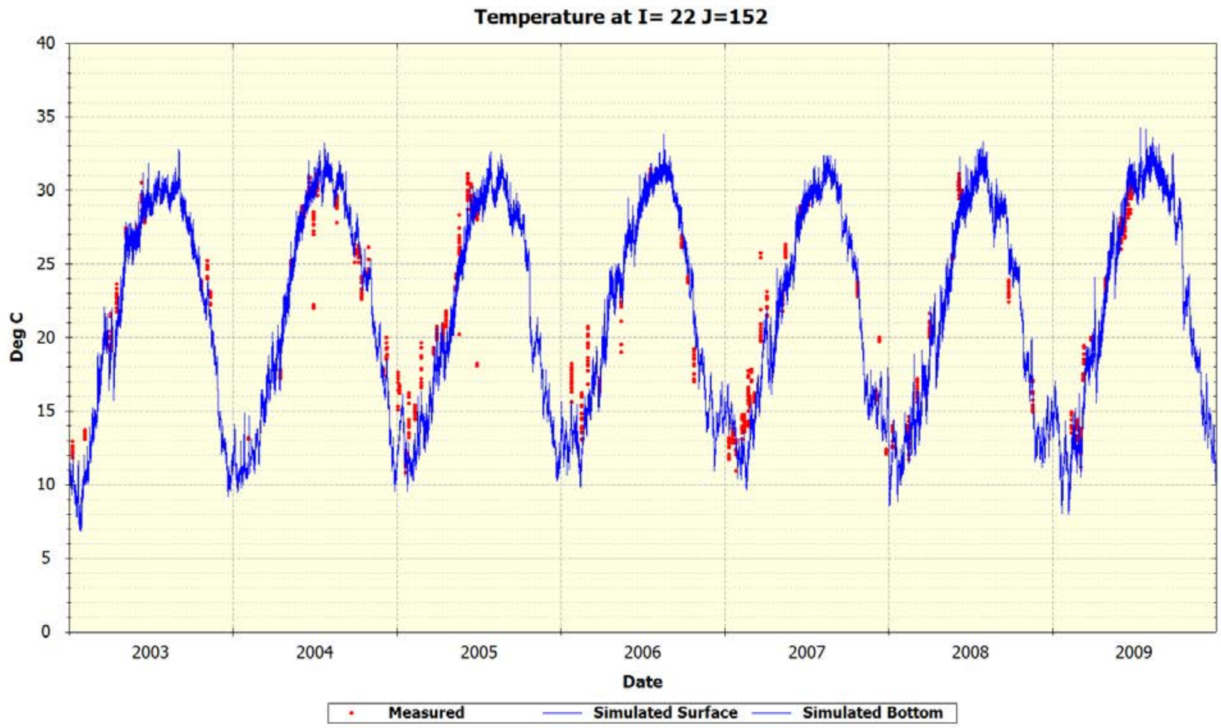

Figure 4.3.26 2003-2009 calibration measured versus simulated temperature at I=22 J=152

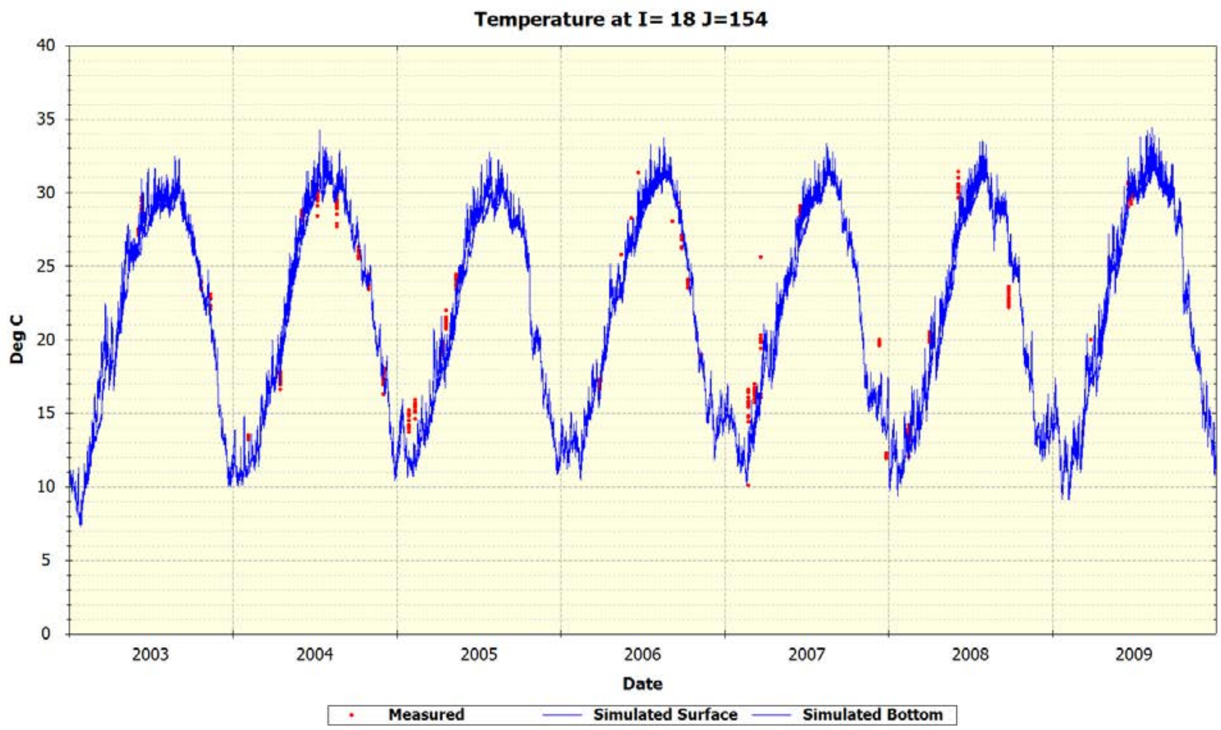

Figure 4.3.27 2003-2009 calibration measured versus simulated temperature at I=18 J=154

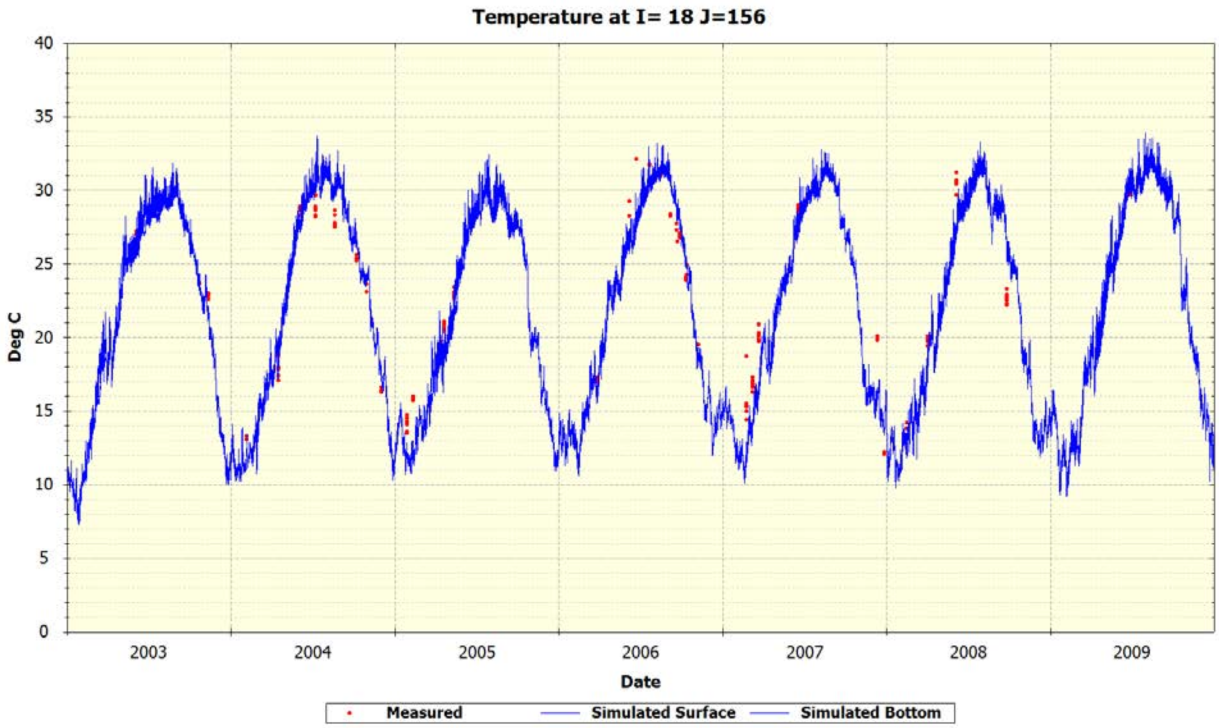

Figure 4.3.28 2003-2009 calibration measured versus simulated temperature at I=18 J=156

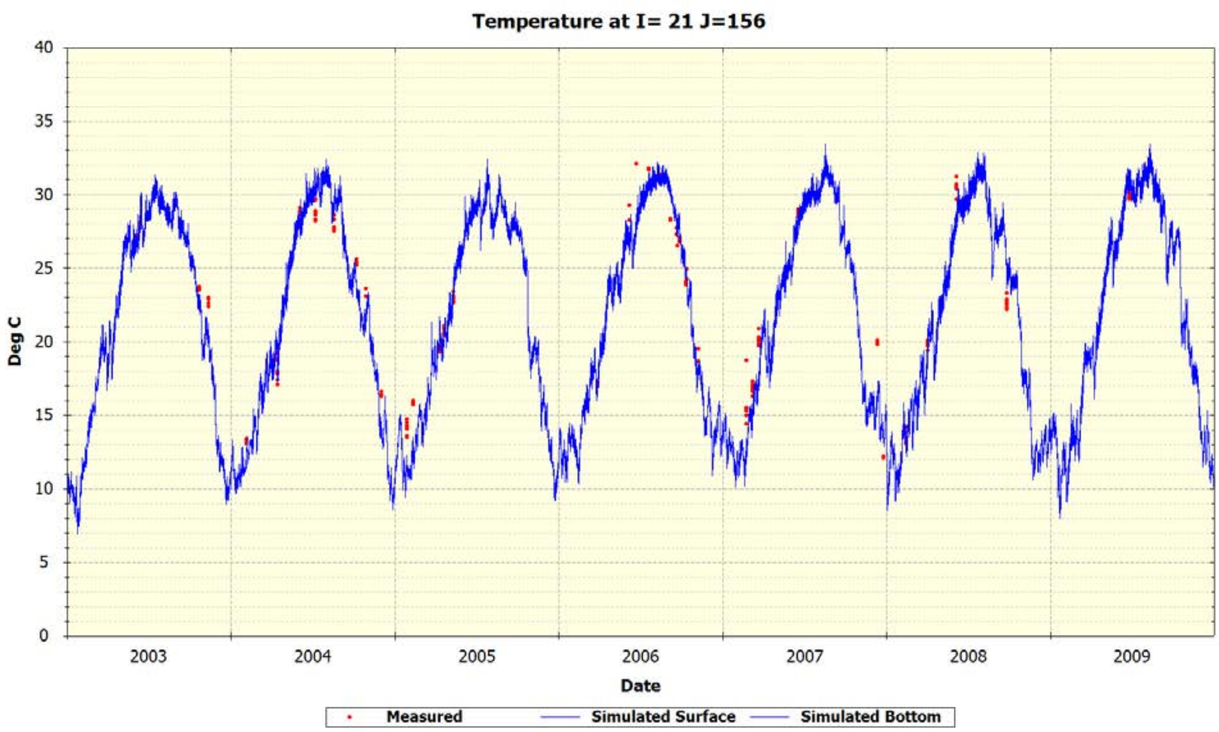

Figure 4.3.29 2003-2009 calibration measured versus simulated temperature at I=21 J=156

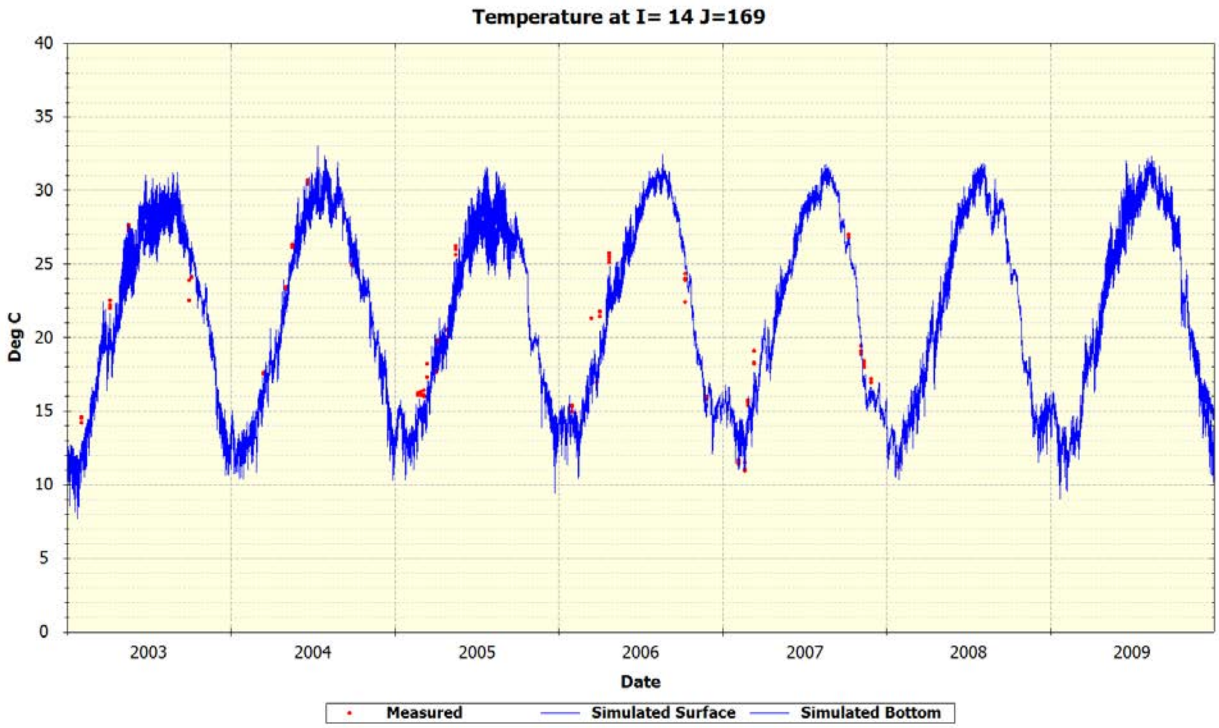

Figure 4.3.30 2003-2009 calibration measured versus simulated temperature at I=14 J=169

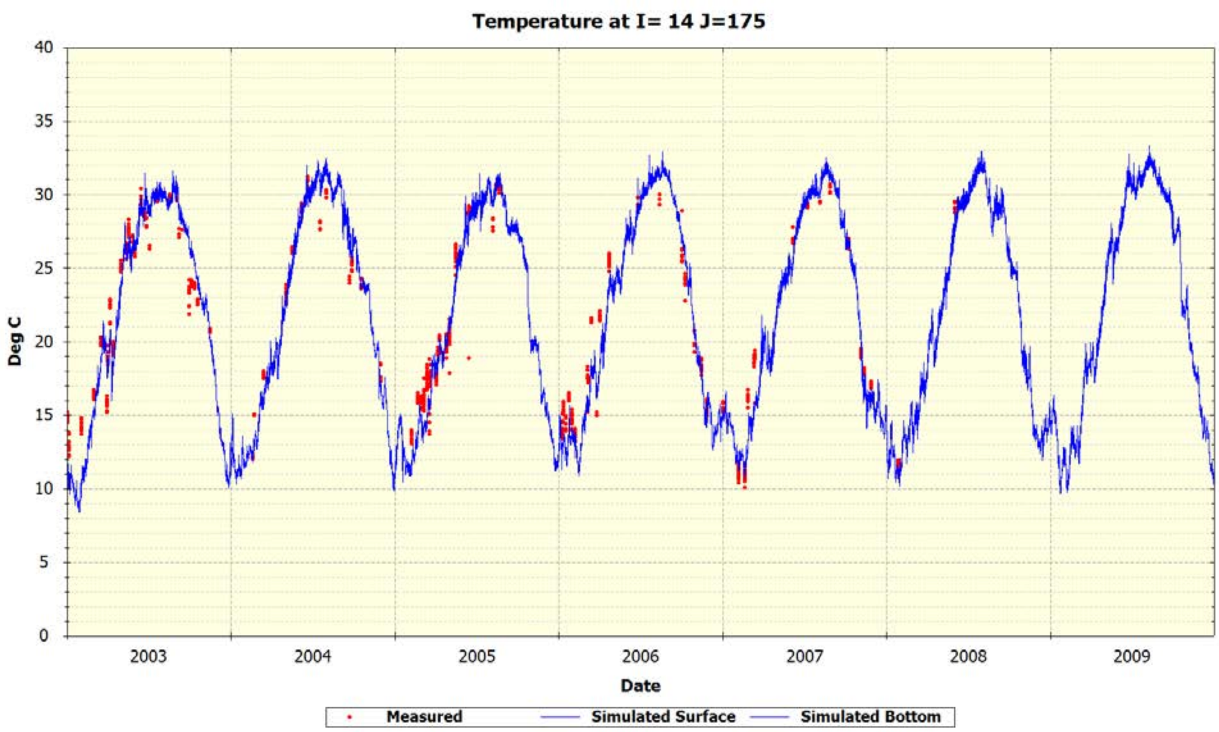

Figure 4.3.31 2003-2009 calibration measured versus simulated temperature at I=14 J=175

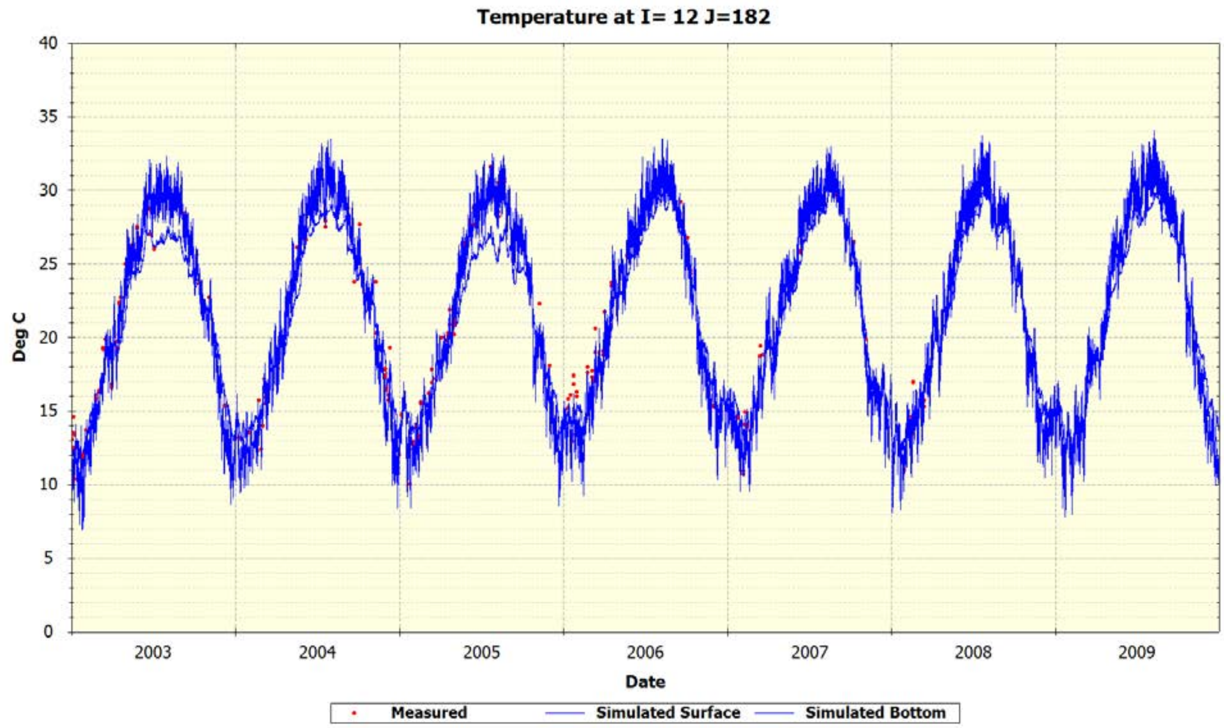

Figure 4.3.32 2003-2009 calibration measured versus simulated temperature at I=12 J=182

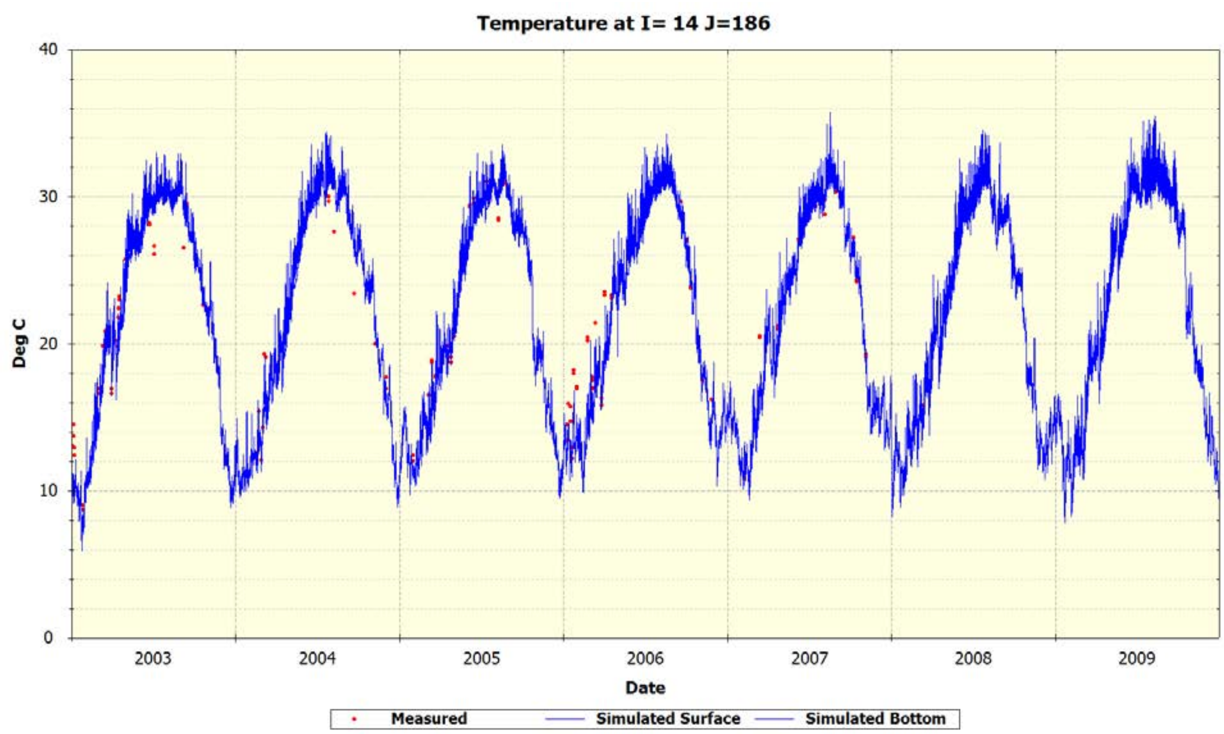

Figure 4.3.33 2003-2009 calibration measured versus simulated temperature at I=14 J=186

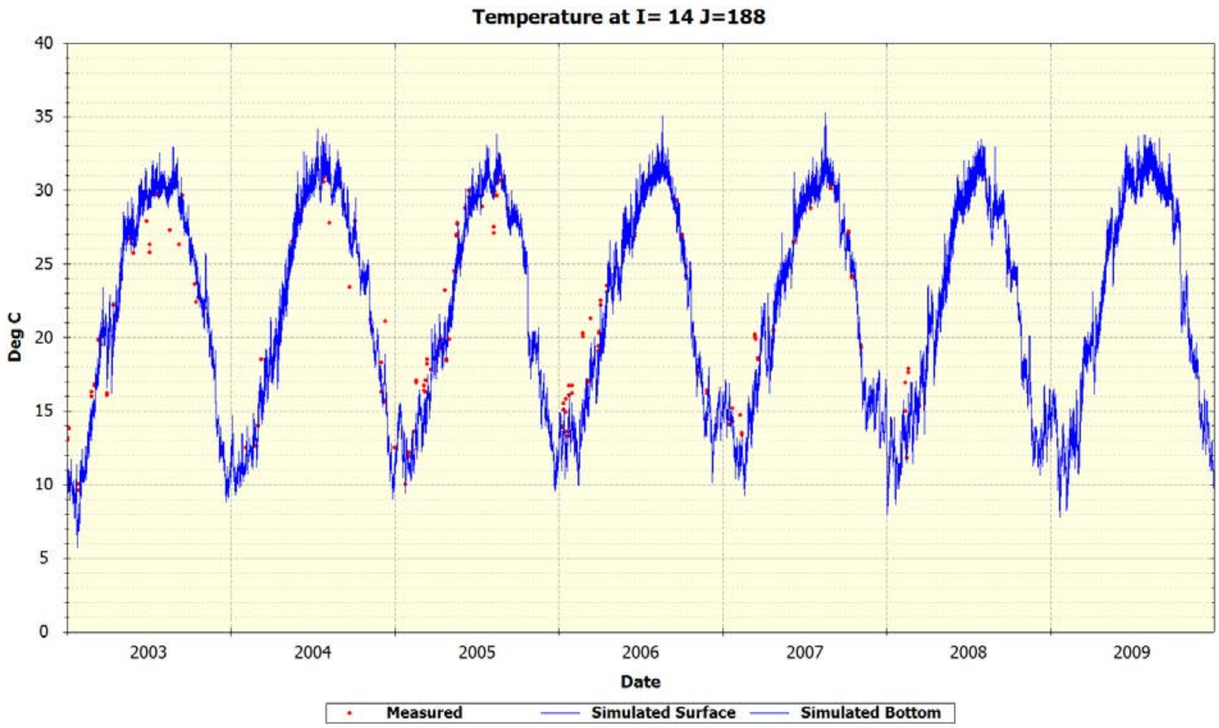

Figure 4.3.34 2003-2009 calibration measured versus simulated temperature at I=14 J=188

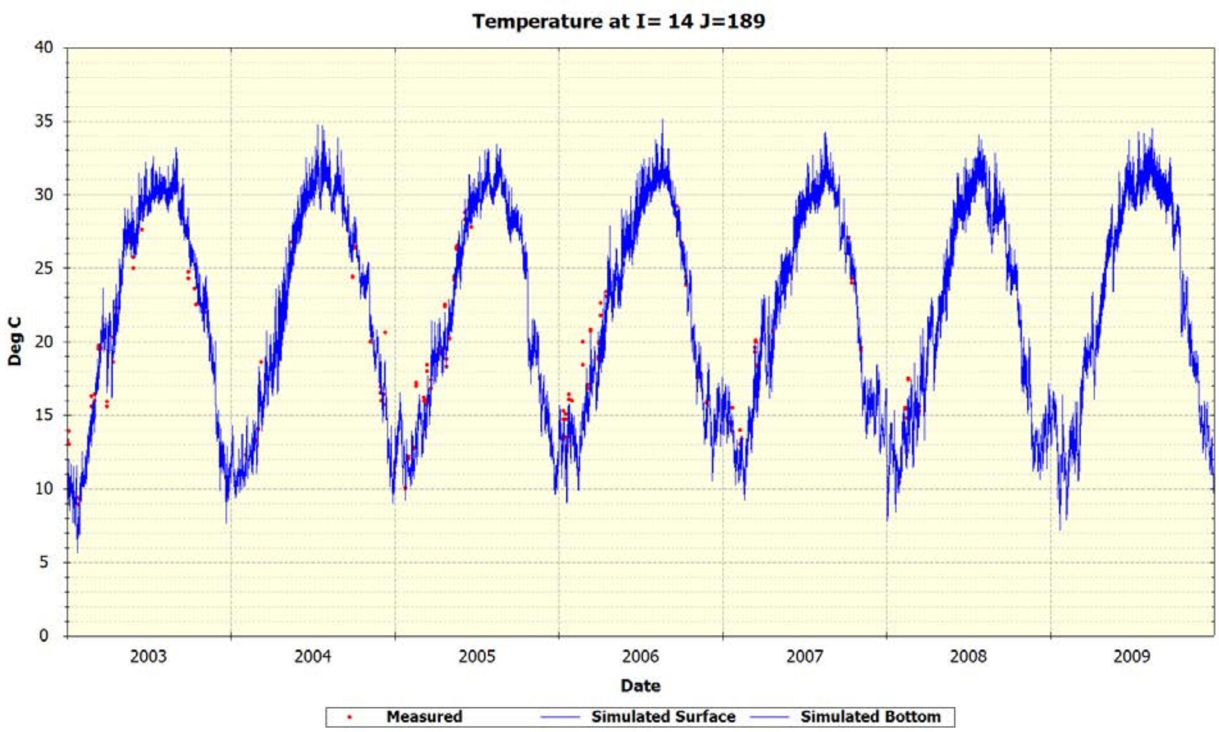

Figure 4.3.35 2003-2009 calibration measured versus simulated temperature at I=14 J=189

4.3.2 Validation

Table 4.3.2 Validation Comparisons of Simulations and Measurements of Surface Temperature for Florida Big Bend Stations for 1997-2002.

Station	Simulated Mean (˚C)	Simulated 5%ile (˚C)	Simulated 95%ile (˚C)	Measured Mean (˚C)	Measured 5%ile (˚C)	Measured 95%ile (˚C)	Error Mean (˚C)	Error 5%ile (˚C)
I= 17 J= 4	23.6	15.8	30.1	24.4	13.4	31.1	-0.7	-3.0
I= 17 J= 18	24.7	16.3	31.4	23.5	12.1	30.6	1.2	5.1
I= 20 J= 31	25.1	16.3	31.9	23.4	11.8	30.7	1.6	7.0
I= 22 J= 39	25.2	16.3	32.0	23.6	11.8	31.2	1.6	6.7
I= 25 J= 44	25.1	16.4	31.7	23.2	12.5	30.2	1.9	8.2
I= 24 J= 59	24.9	15.8	32.1	23.3	13.0	30.4	1.6	7.0
I= 24 J= 68	24.2	14.4	32.4	23.0	13.5	29.9	1.2	5.2
I= 24 J= 70	24.1	14.4	32.3	23.2	12.2	30.5	0.9	4.0
I= 25 J= 78	23.4	13.7	31.6	23.1	13.1	29.4	0.4	1.6
I= 21 J= 79	24.0	14.0	32.4	23.6	10.9	30.3	0.4	1.7
I= 17 J= 84	22.9	11.9	32.6	21.6	11.7	29.4	1.3	6.2
I= 13 J= 89	22.9	12.8	32.0	21.8	11.8	29.9	1.1	5.0
I= 16 J= 90	22.5	12.3	31.8	21.6	11.8	29.7	0.9	4.0
I= 17 J= 91	21.1	10.9	30.3	25.5	17.8	29.6	-4.4	-17.3
I= 28 J= 91	20.4	11.0	29.4	22.9	16.3	28.7	-2.6	-11.2
I= 16 J= 92	22.5	12.7	31.5	23.8	12.4	29.8	-1.3	-5.4
I= 16 J= 98	22.7	11.9	32.5	22.5	10.7	29.1	0.2	0.8
I= 18 J=110	22.8	12.3	32.3	26.1	11.8	31.1	-3.3	-12.6
I= 21 J=127	23.1	12.0	33.0	22.3	12.4	30.6	0.8	3.6
I= 23 J=128	23.0	11.8	32.9	22.6	13.8	30.8	0.4	1.8
I= 20 J=130	21.9	11.4	31.3	21.0	12.4	28.7	0.9	4.2
I= 21 J=132	23.1	12.0	33.0	22.4	12.2	30.9	0.6	2.8
I= 23 J=133	23.1	11.8	33.0	22.8	14.0	30.6	0.3	1.5
I= 26 J=133	23.0	11.8	32.7	23.4	15.5	30.2	-0.4	-1.6
I= 24 J=150	22.6	11.8	32.3	23.0	14.1	30.3	-0.4	-1.9
I= 22 J=152	22.7	11.7	32.4	22.0	13.0	30.0	0.6	2.8
I= 18 J=154	22.3	11.6	32.0	22.0	13.1	30.1	0.3	1.2
I= 18 J=156	22.6	12.1	32.3	22.2	13.4	30.0	0.4	1.9
I= 21 J=156	22.5	11.4	32.4	22.1	13.4	29.9	0.4	1.7
I= 14 J=169	22.5	13.5	31.4	22.3	14.6	29.4	0.2	0.7
I= 14 J=175	22.9	12.1	32.6	20.1	10.7	29.6	2.8	13.8
I= 12 J=182	22.1	13.9	29.8	20.5	12.3	29.7	1.6	7.6
I= 14 J=186	22.5	11.5	32.2	20.8	10.8	30.2	1.7	8.2
I= 14 J=188	22.7	11.6	32.4	20.3	11.2	30.1	2.4	11.8
I= 14 J=189	22.6	11.5	32.3	19.2	10.5	29.4	3.5	18.0

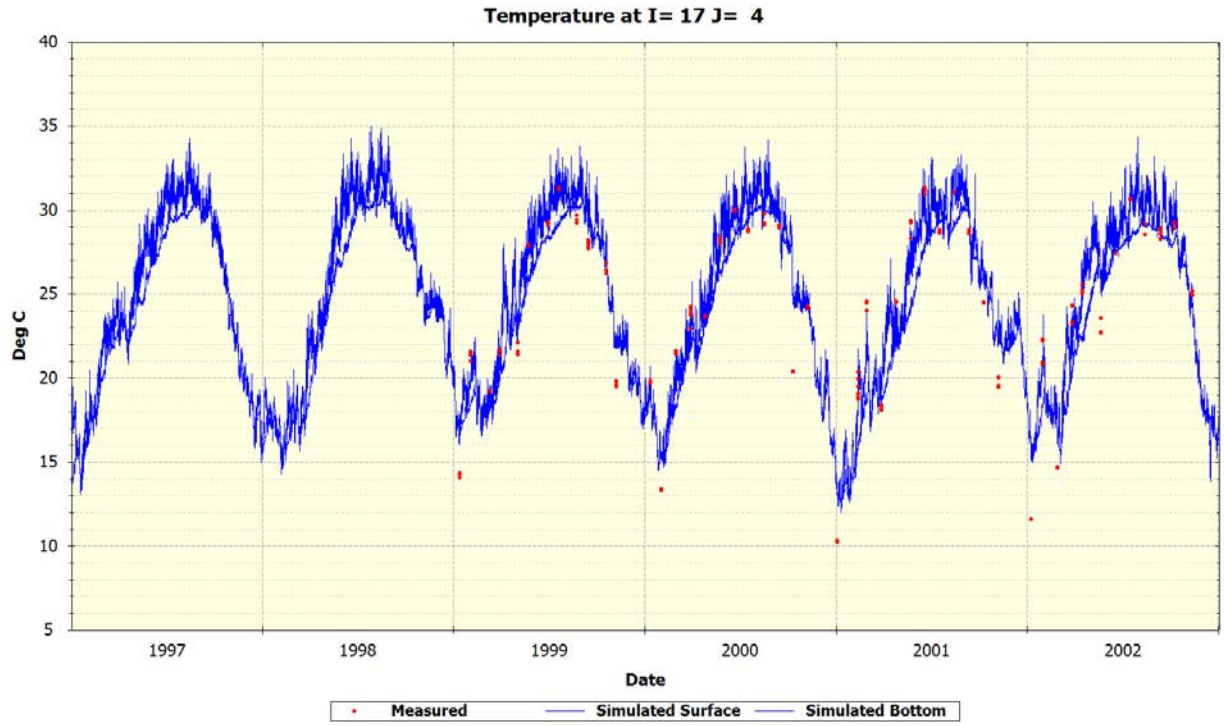

Figure 4.3.36 1997-2002 validation measured versus simulated temperature at I=17 J=4

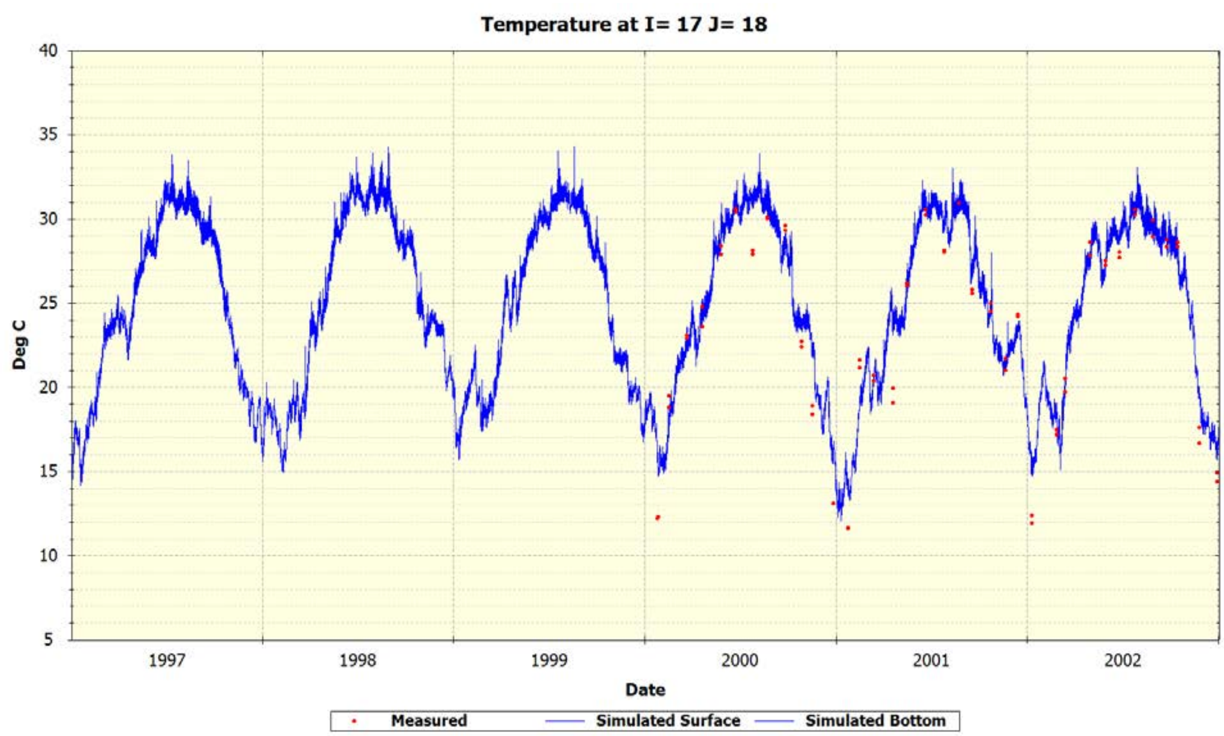

Figure 4.3.37 1997-2002 validation measured versus simulated temperature at I=17 J=18

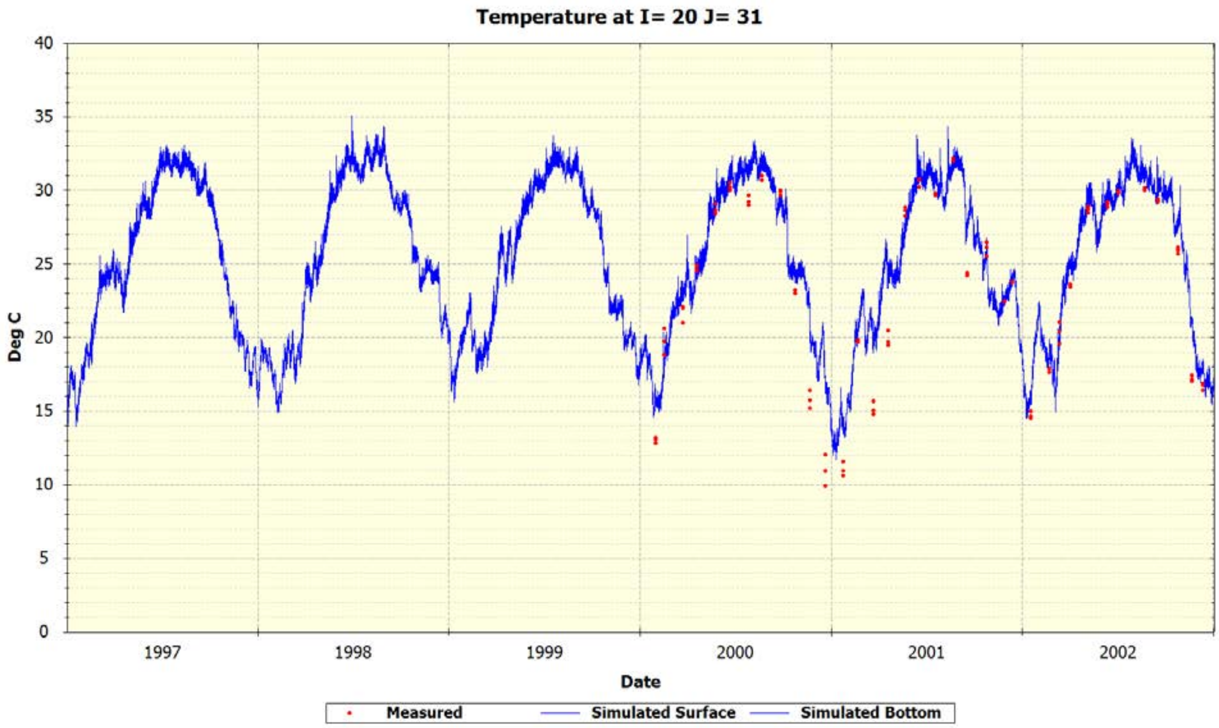

Figure 4.3.38 1997-2002 validation measured versus simulated temperature at I=20 J=31

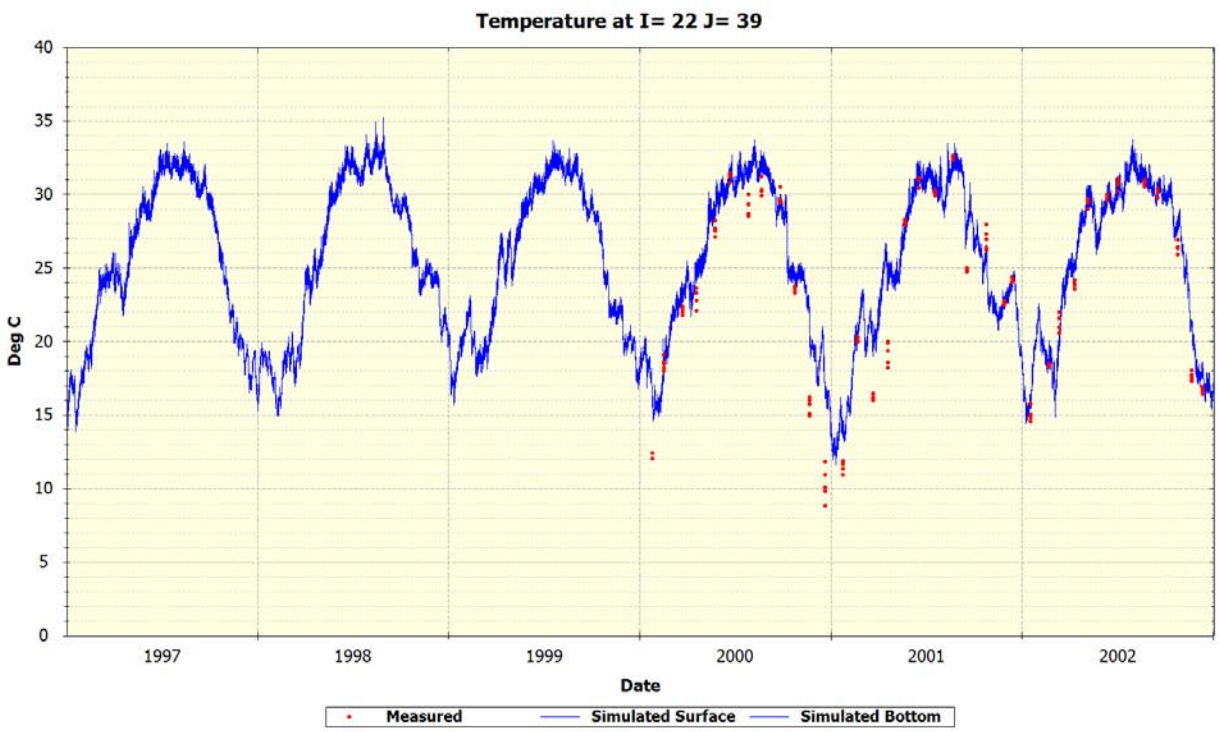

Figure 4.3.39 1997-2002 validation measured versus simulated temperature at I=22 J=39

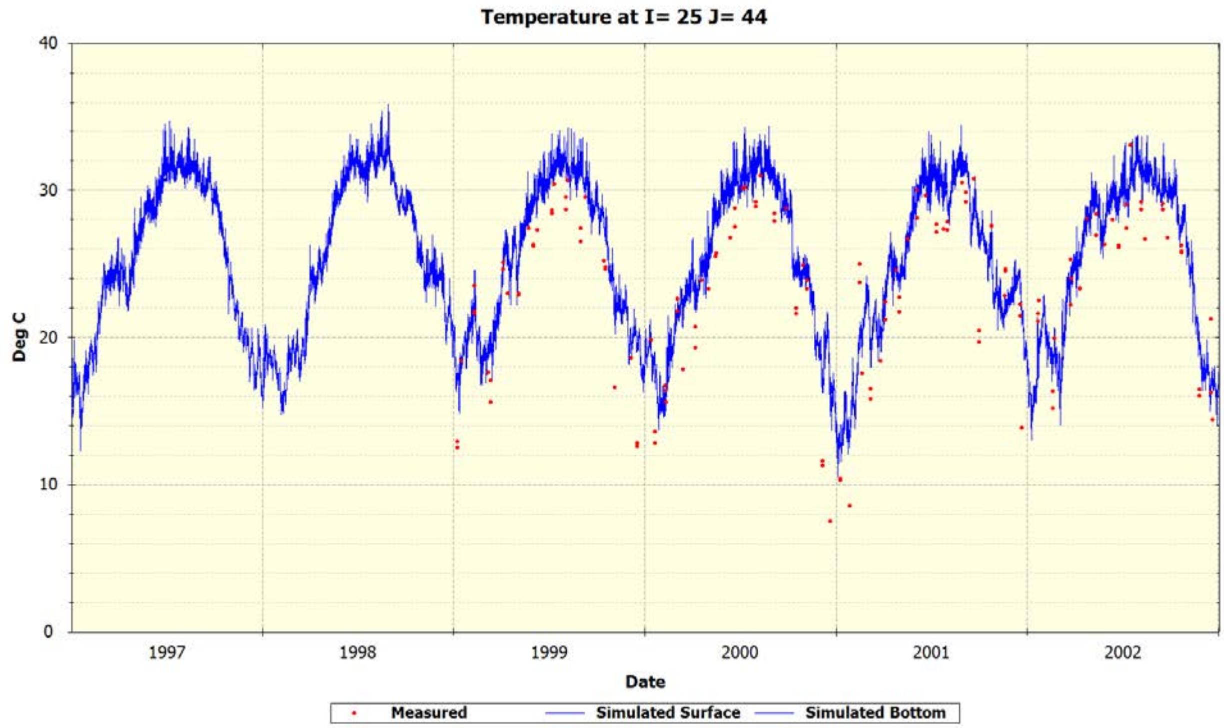

Figure 4.3.40 1997-2002 validation measured versus simulated temperature at I=25 J=44

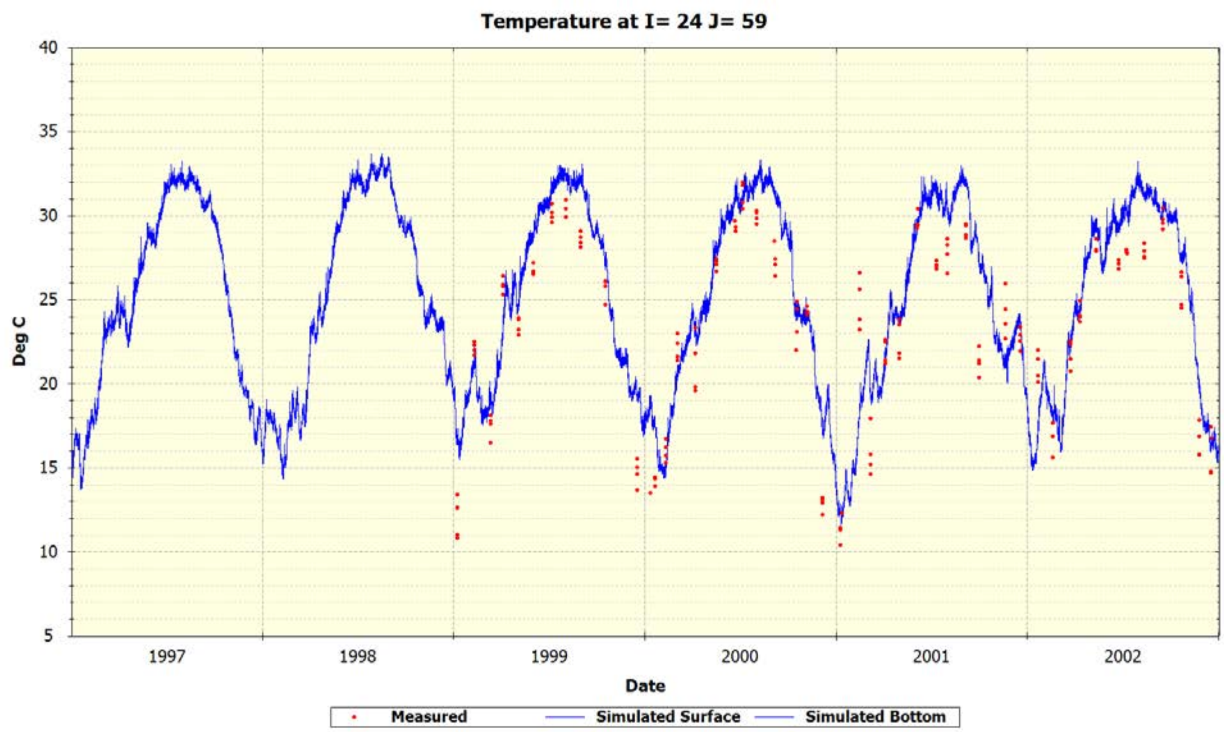

Figure 4.3.41 1997-2002 validation measured versus simulated temperature at I=24 J=59

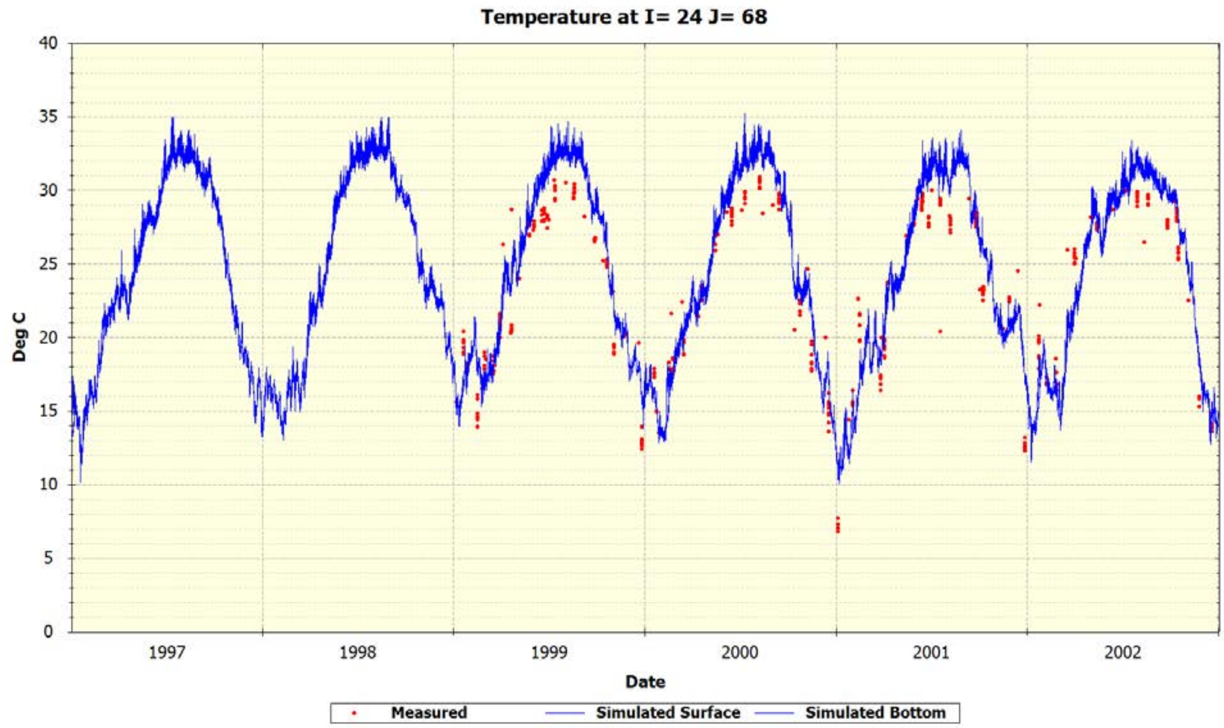

Figure 4.3.42 1997-2002 validation measured versus simulated temperature at I=24 J=68

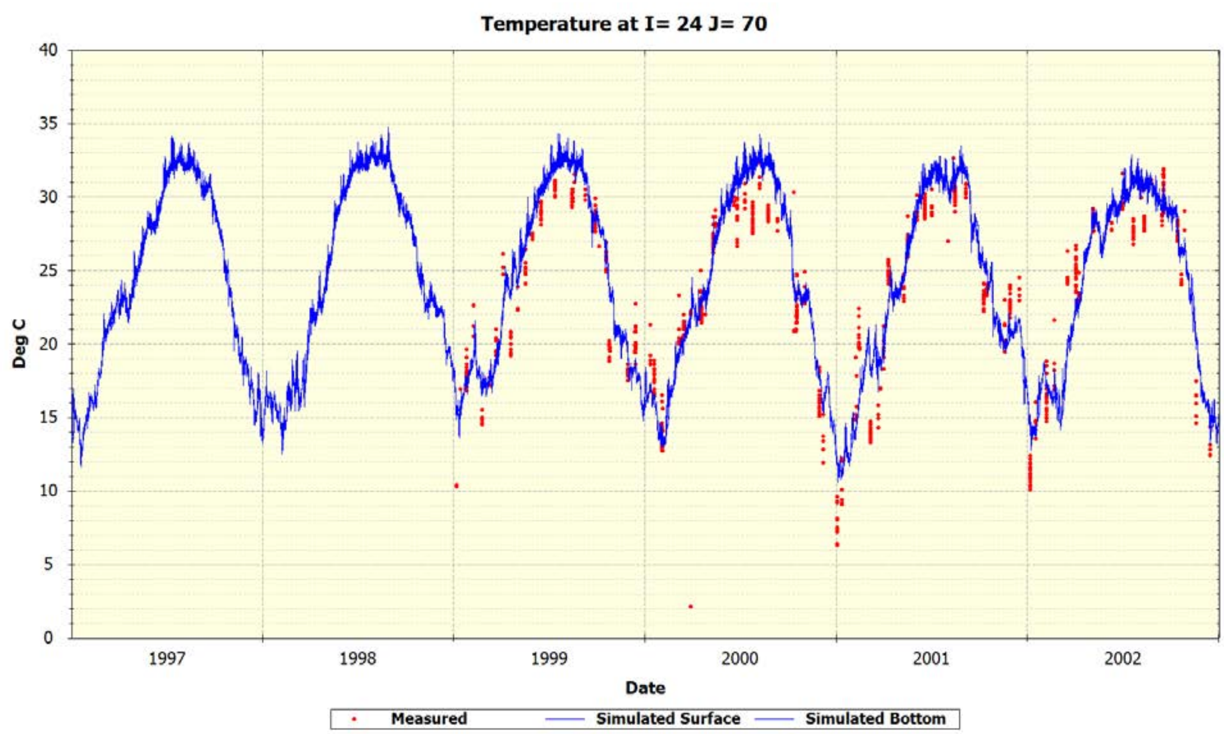

Figure 4.3.43 1997-2002 validation measured versus simulated temperature at I=24 J=70

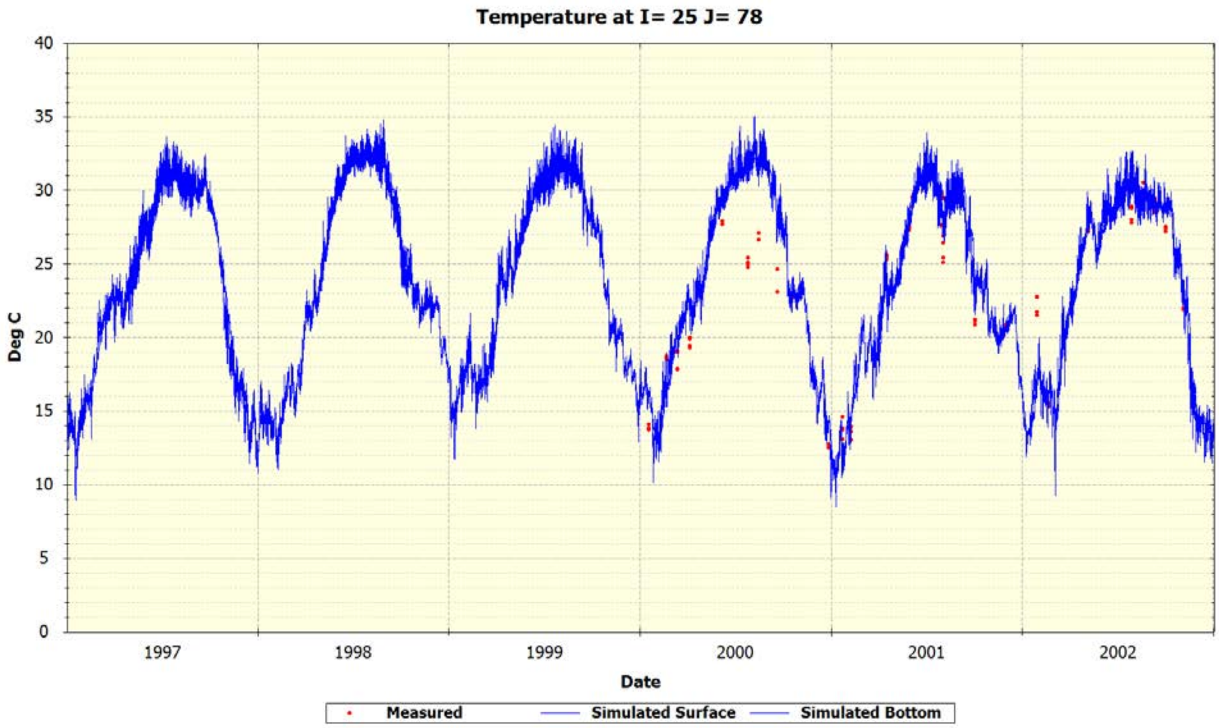

Figure 4.3.44 1997-2002 validation measured versus simulated temperature at I=25 J=78

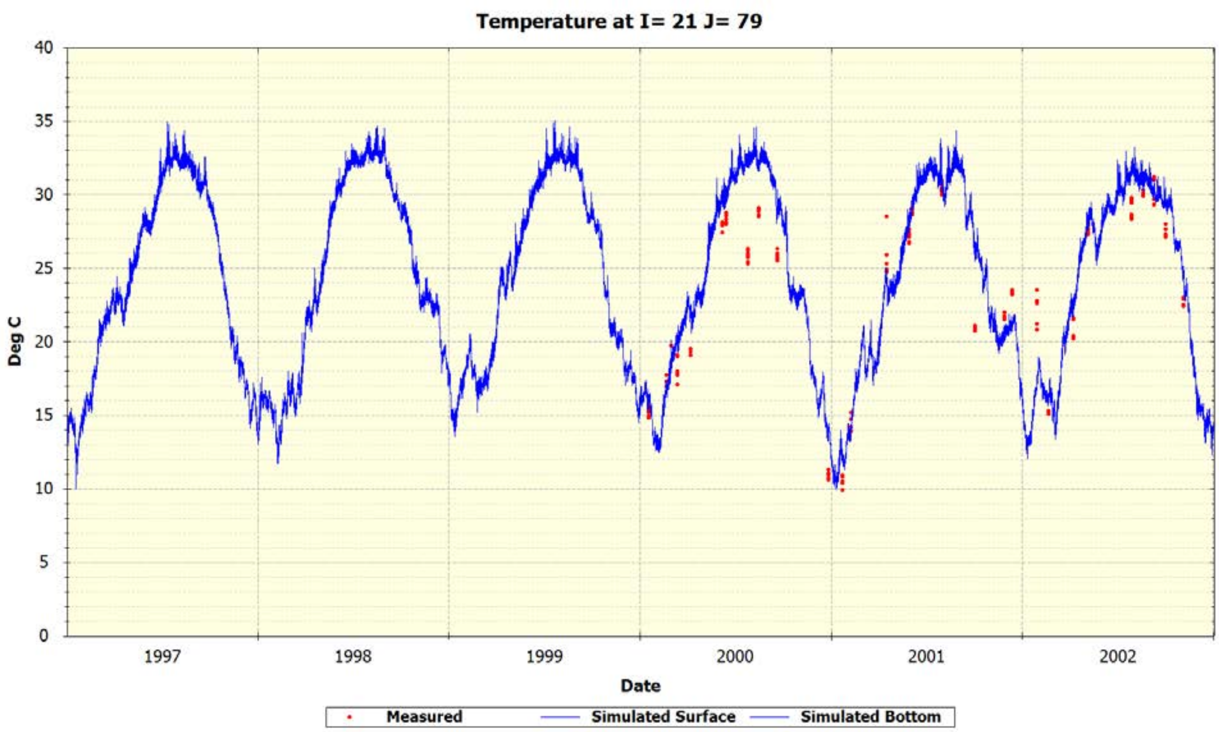

Figure 4.3.45 1997-2002 validation measured versus simulated temperature at I=21 J=79

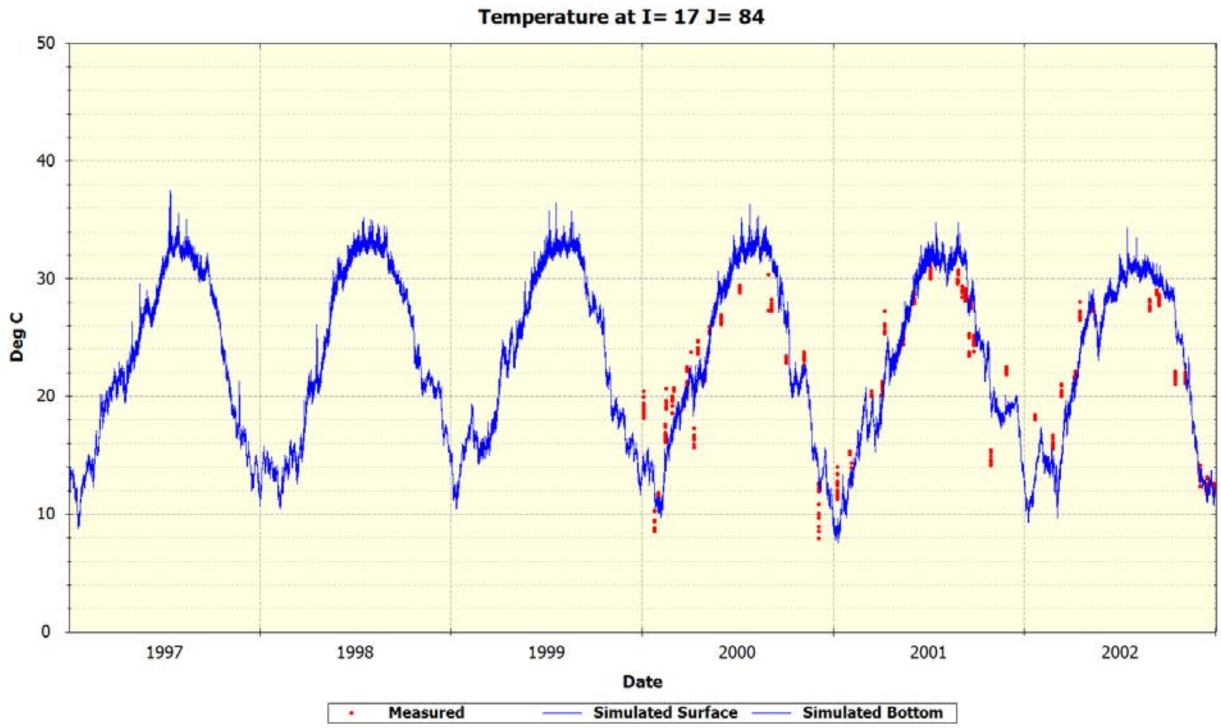

Figure 4.3.46 1997-2002 validation measured versus simulated temperature at I=17 J=84

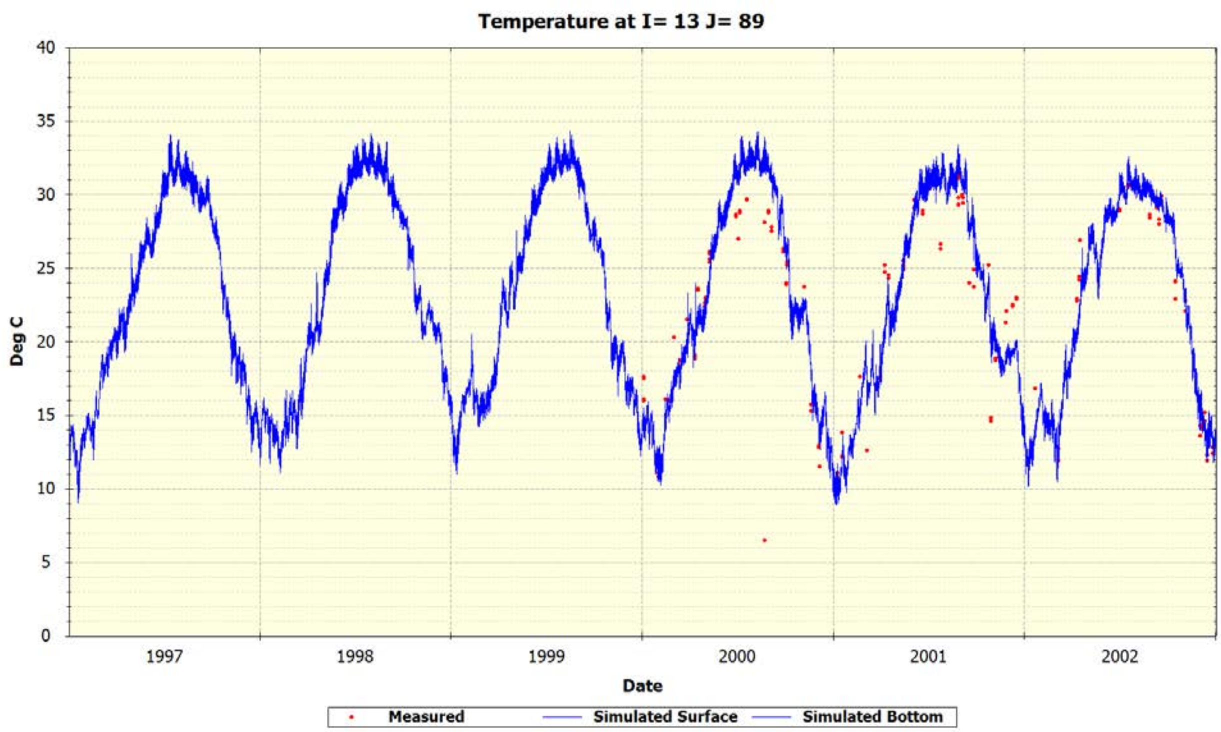

Figure 4.3.47 1997-2002 validation measured versus simulated temperature at I=13 J=89

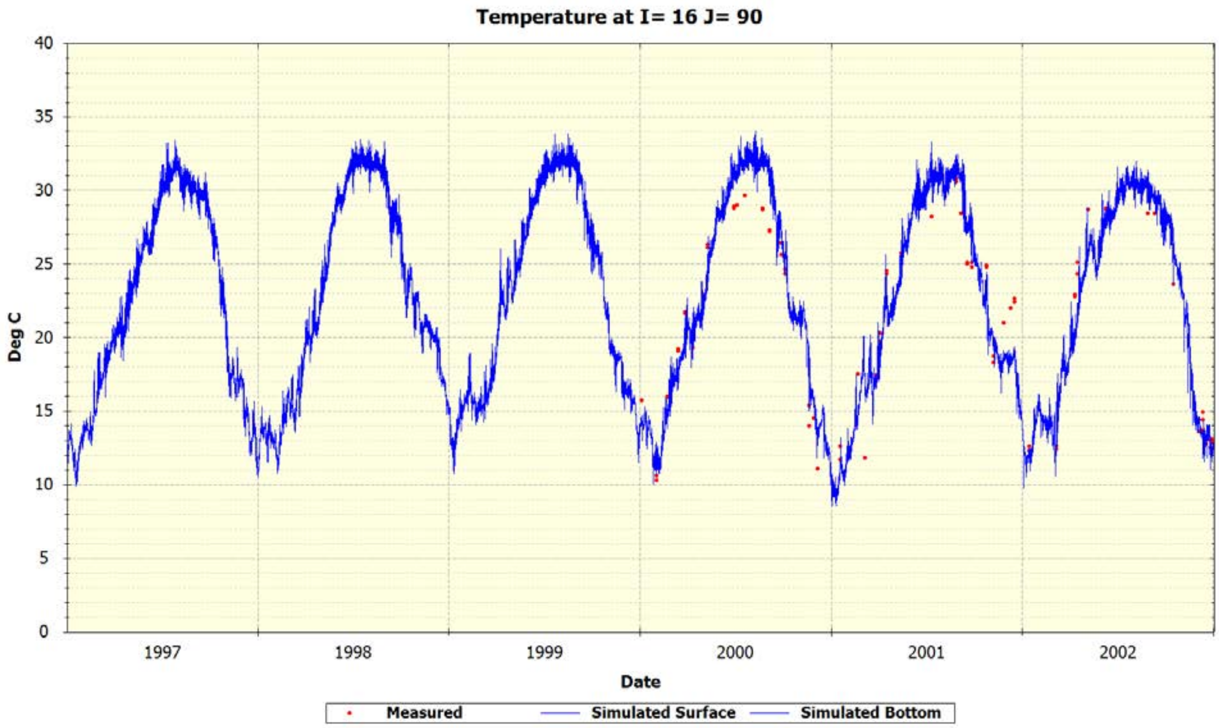

Figure 4.3.48 1997-2002 validation measured versus simulated temperature at I=16 J=90

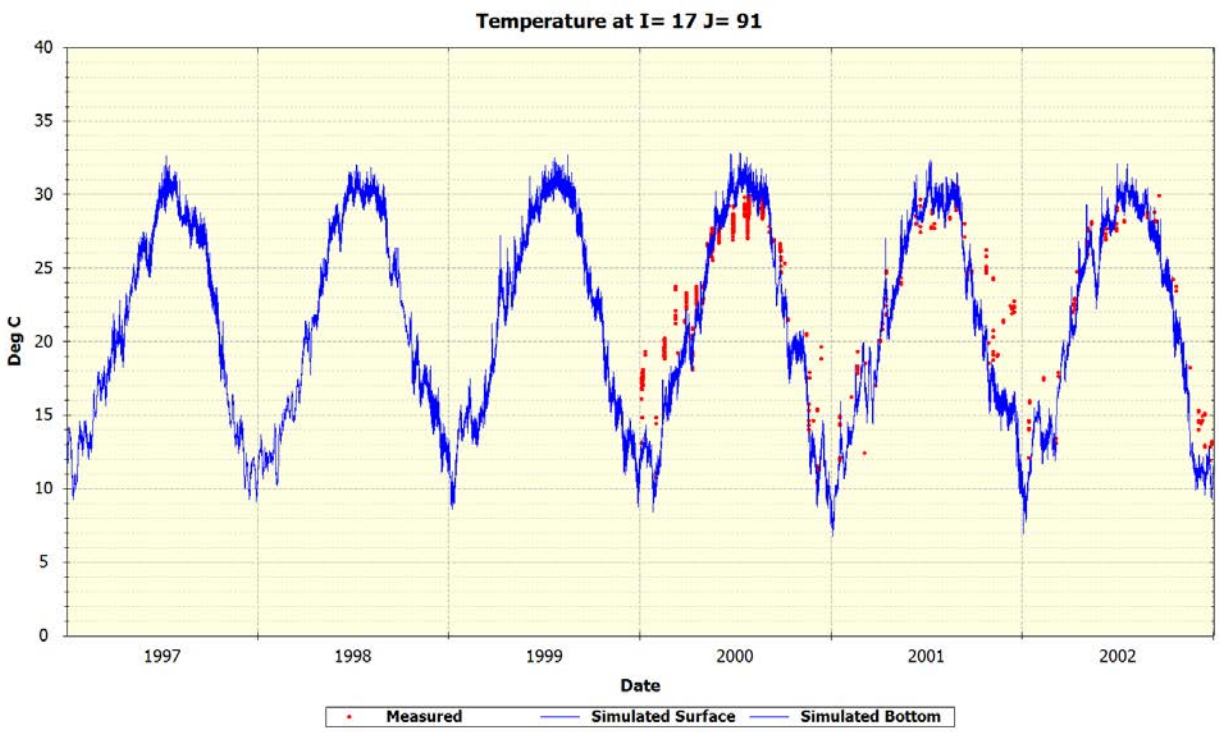

Figure 4.3.49 1997-2002 validation measured versus simulated temperature at I=17 J=91

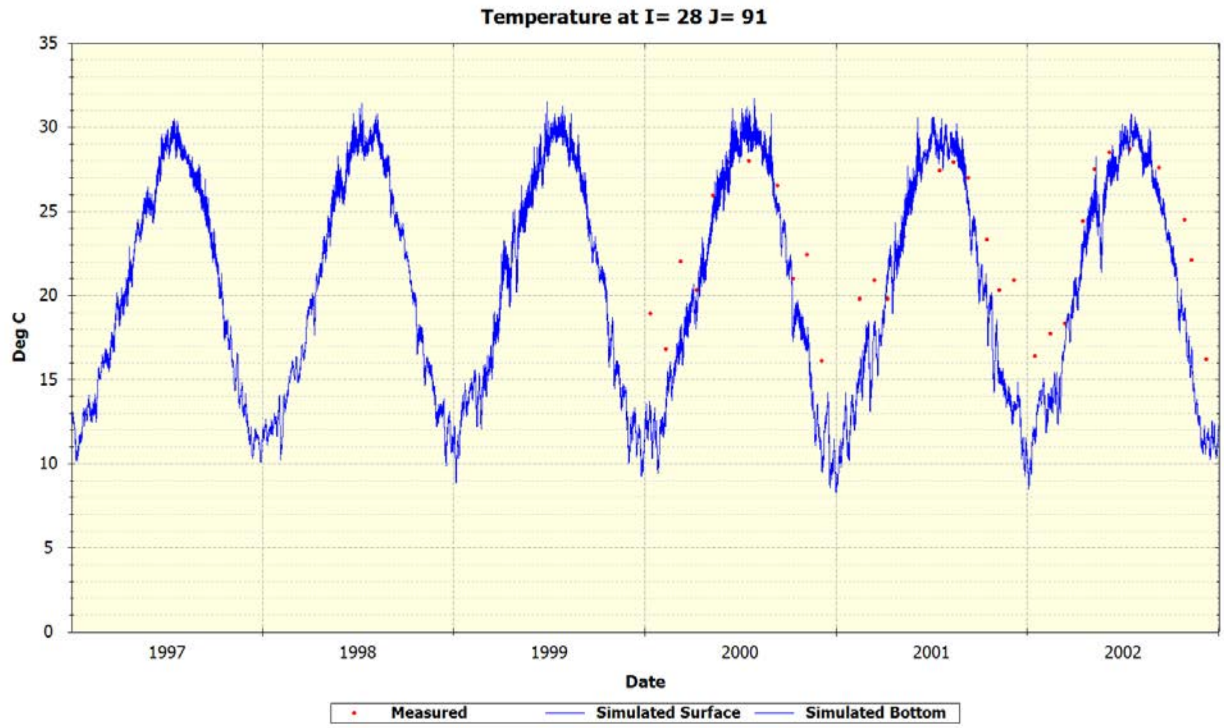

Figure 4.3.50 1997-2002 validation measured versus simulated temperature at I=28 J=91

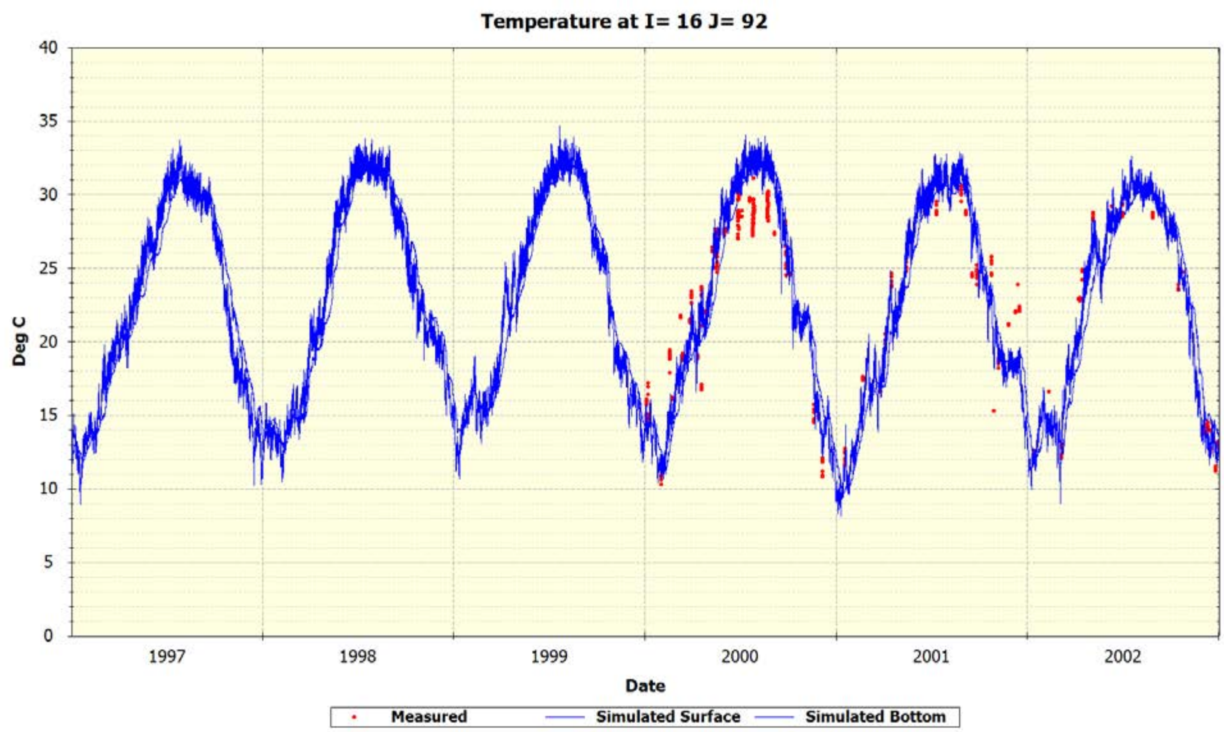

Figure 4.3.51 1997-2002 validation measured versus simulated temperature at I=16 J=92

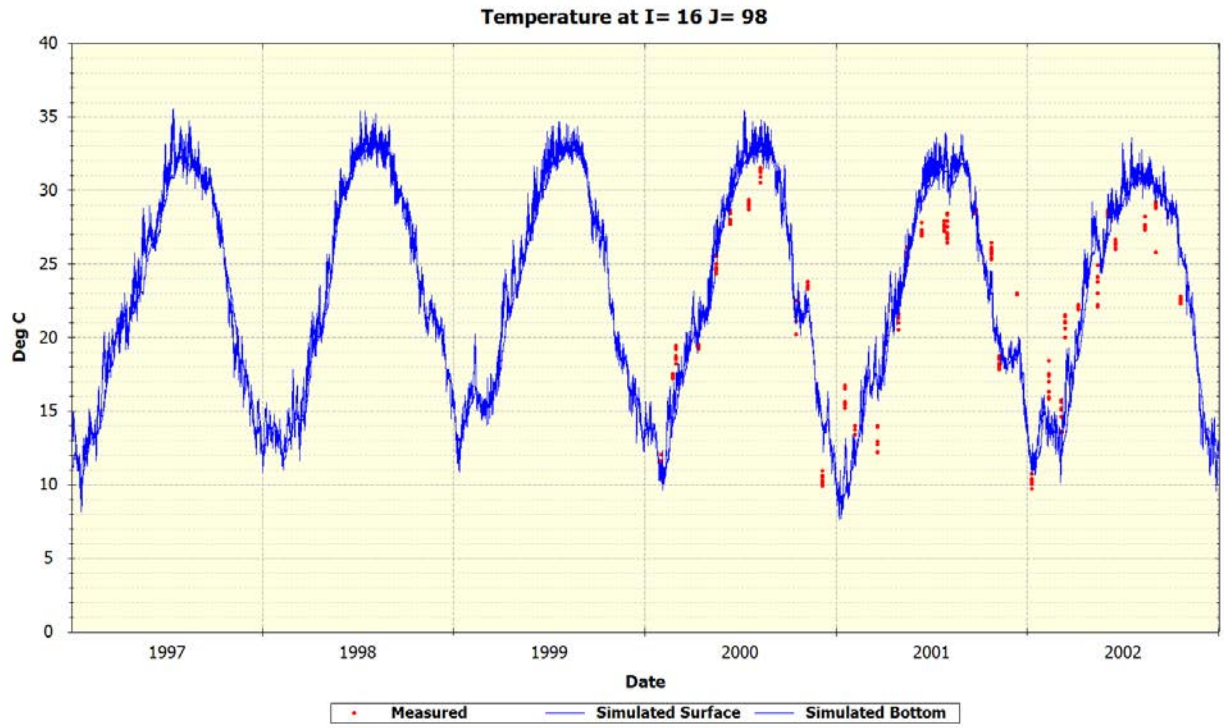

Figure 4.3.52 1997-2002 validation measured versus simulated temperature I=16 J=98

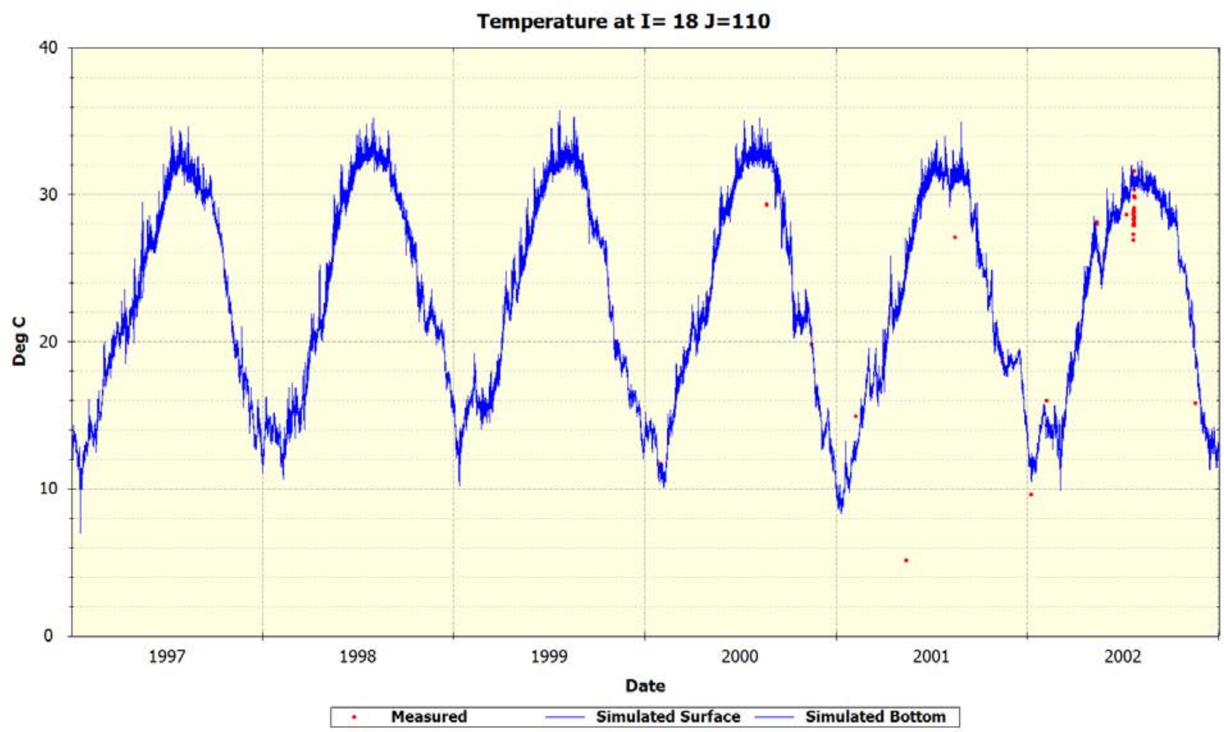

Figure 4.3.53 1997-2002 validation measured versus simulated temperature at I=18 J=110

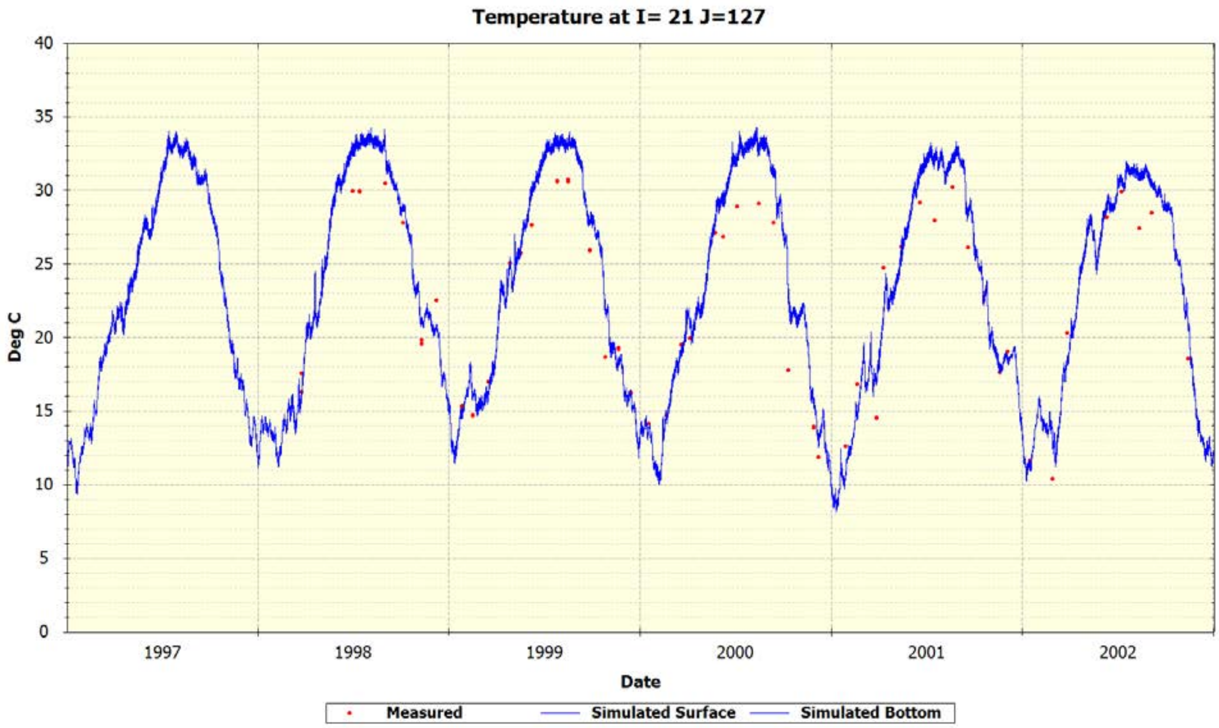

Figure 4.3.54 1997-2002 validation measured versus simulated temperature I=21 J=127

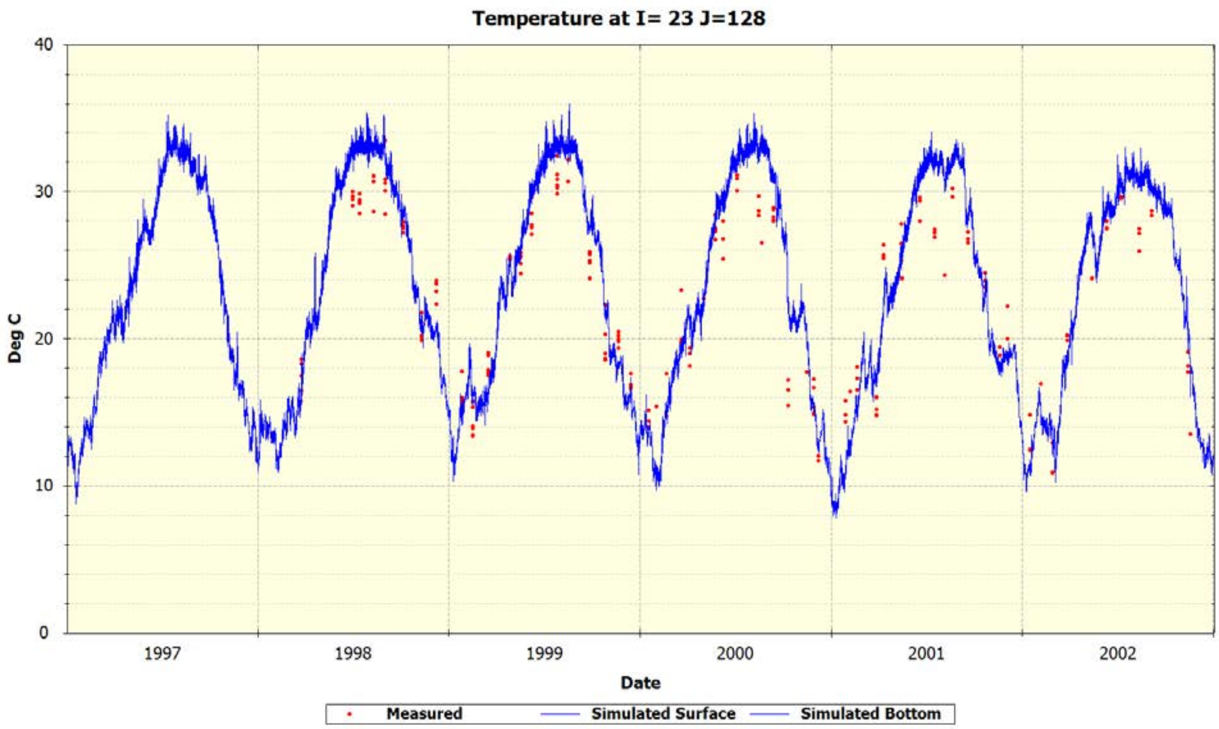

Figure 4.3.55 1997-2002 validation measured versus simulated temperature at I=23 J=128

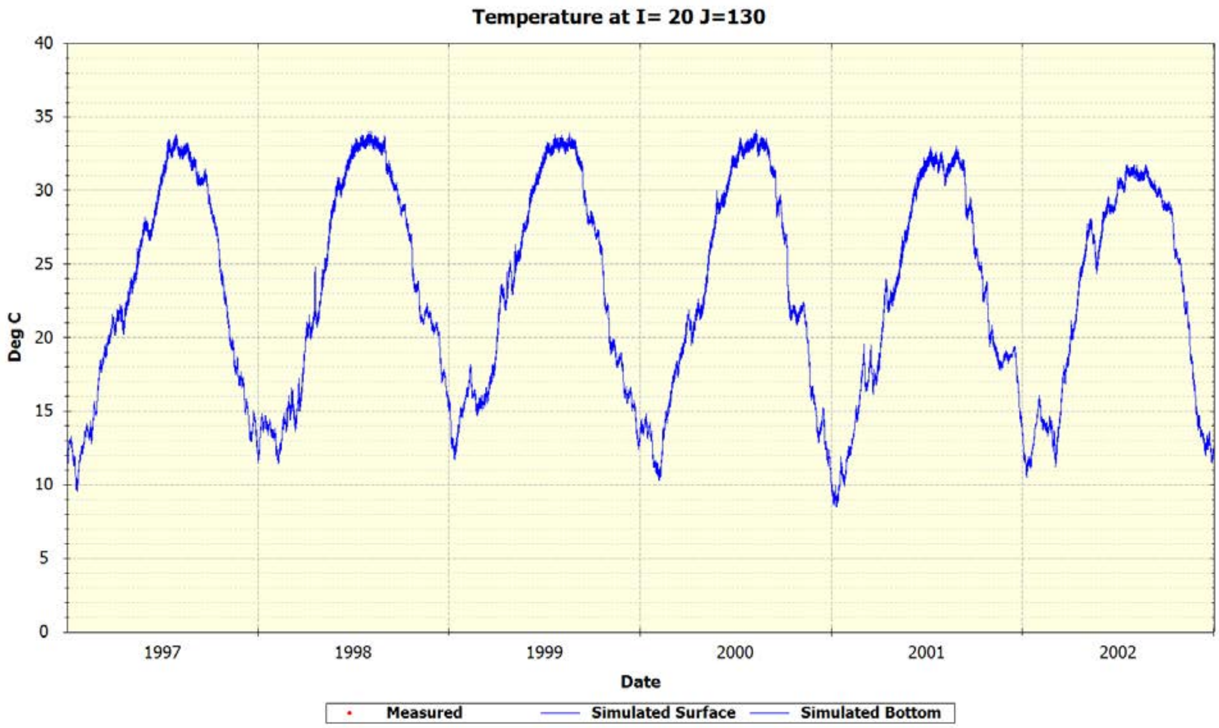

Figure 4.3.56 1997-2002 validation measured versus simulated temperature at I=20 J=130

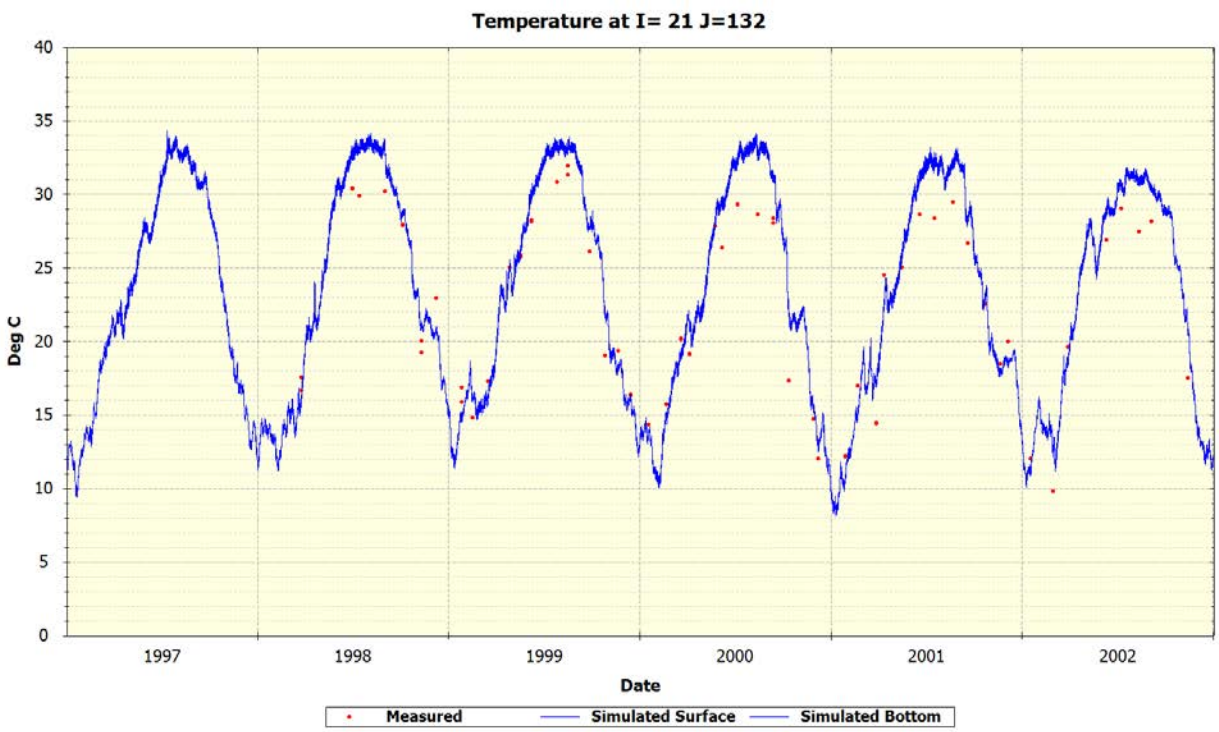

Figure 4.3.57 1997-2002 validation measured versus simulated temperature at I=21 J=132

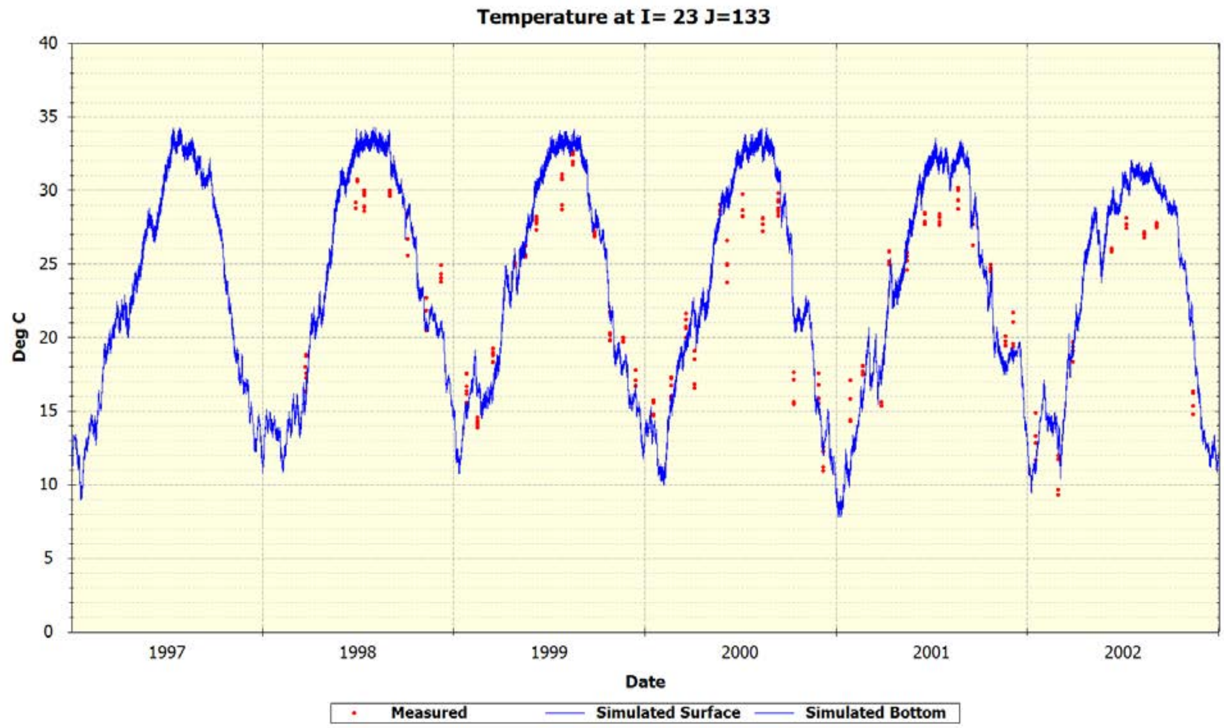

Figure 4.3.58 1997-2002 validation measured versus simulated temperature at I=23 J=133

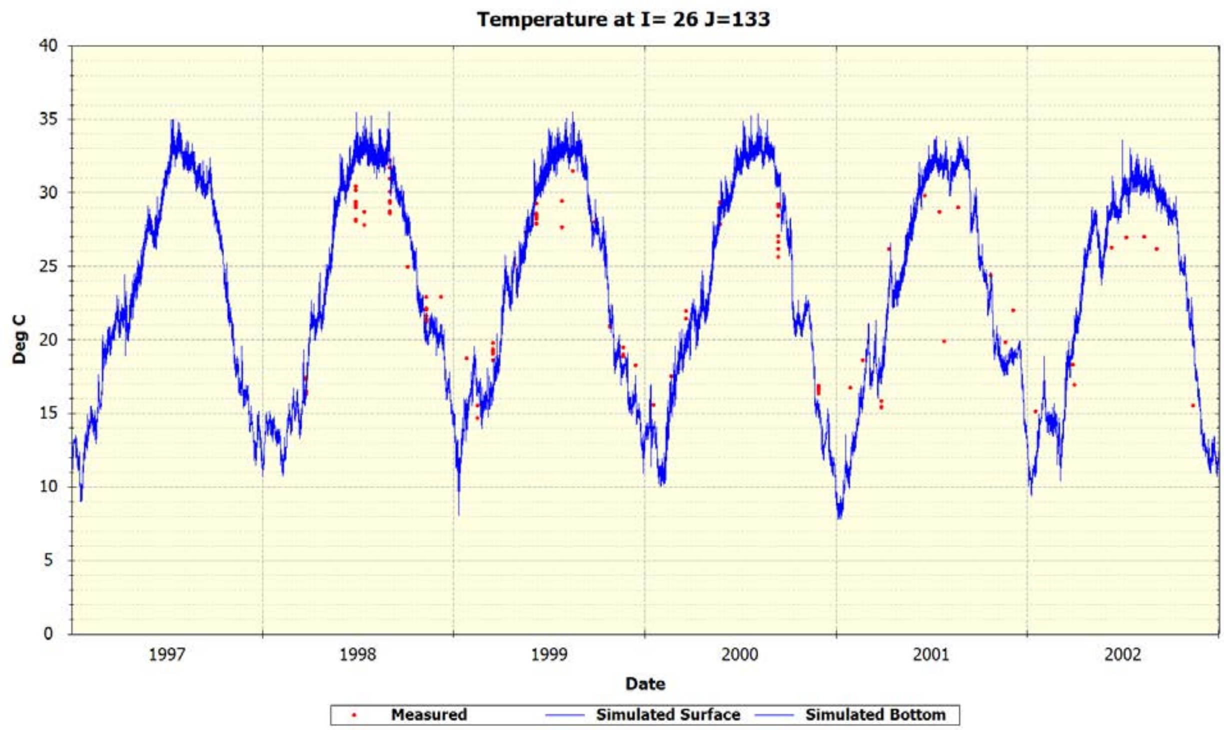

Figure 4.3.59 1997-2002 validation measured versus simulated temperature at I=26 J=133

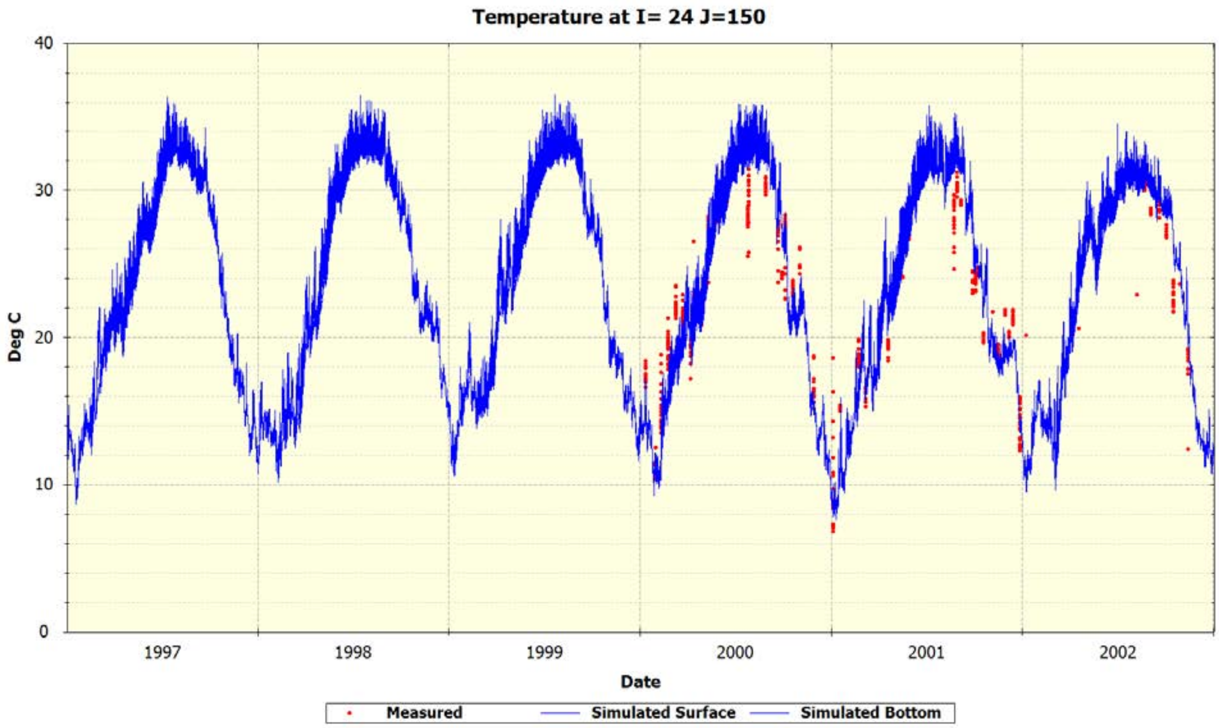

Figure 4.3.60 1997-2002 validation measured versus simulated temperature at I=24 J=150

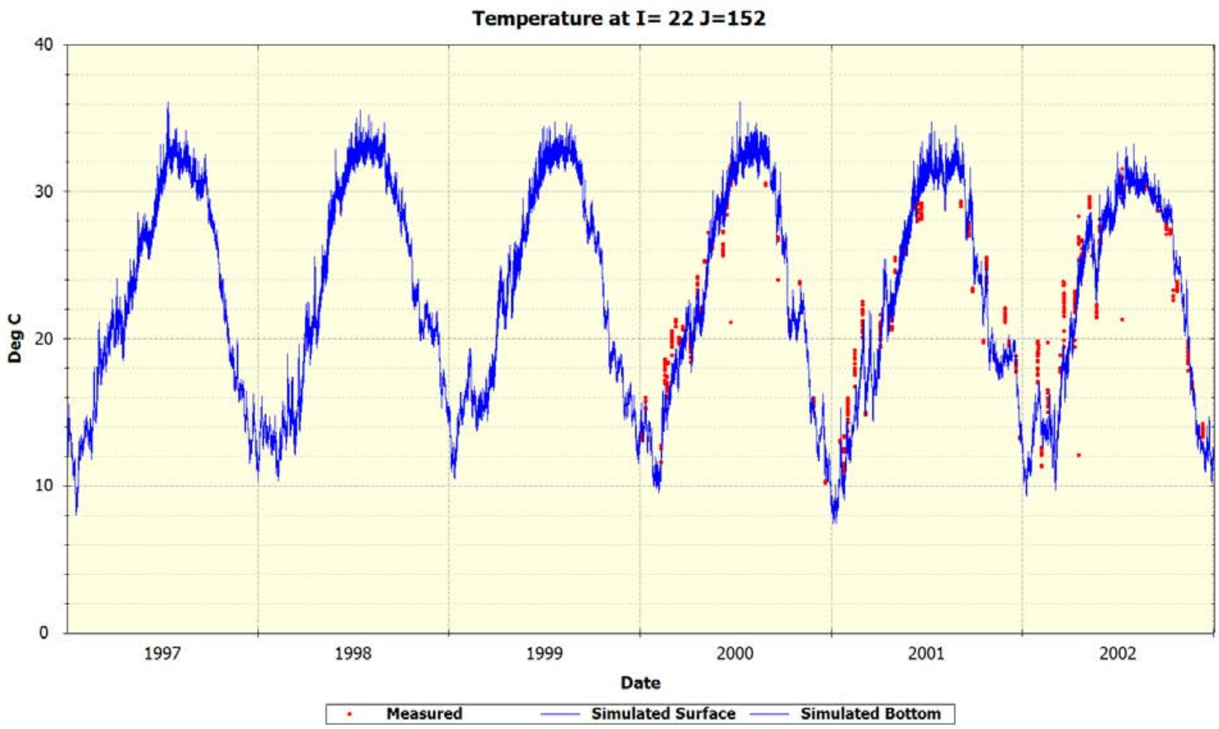

Figure 4.3.61 1997-2002 validation measured versus simulated temperature at I=22 J=152

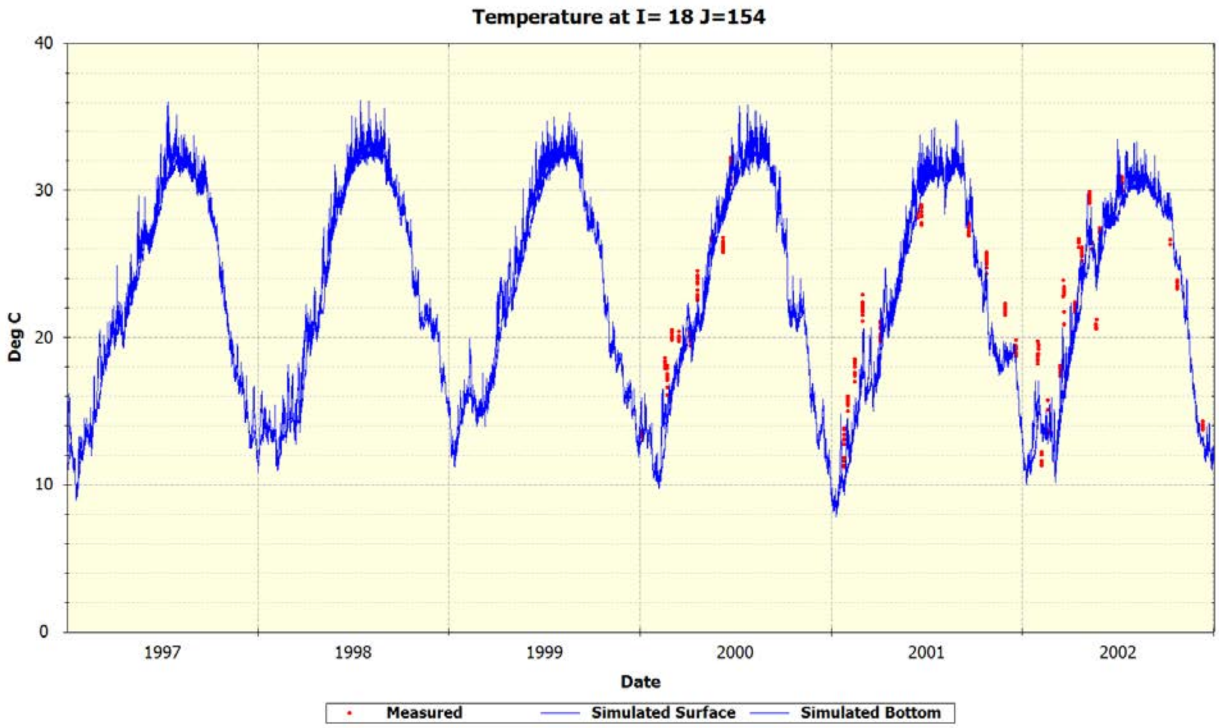

Figure 4.3.62 1997-2002 validation measured versus simulated temperature at I=18 J=154

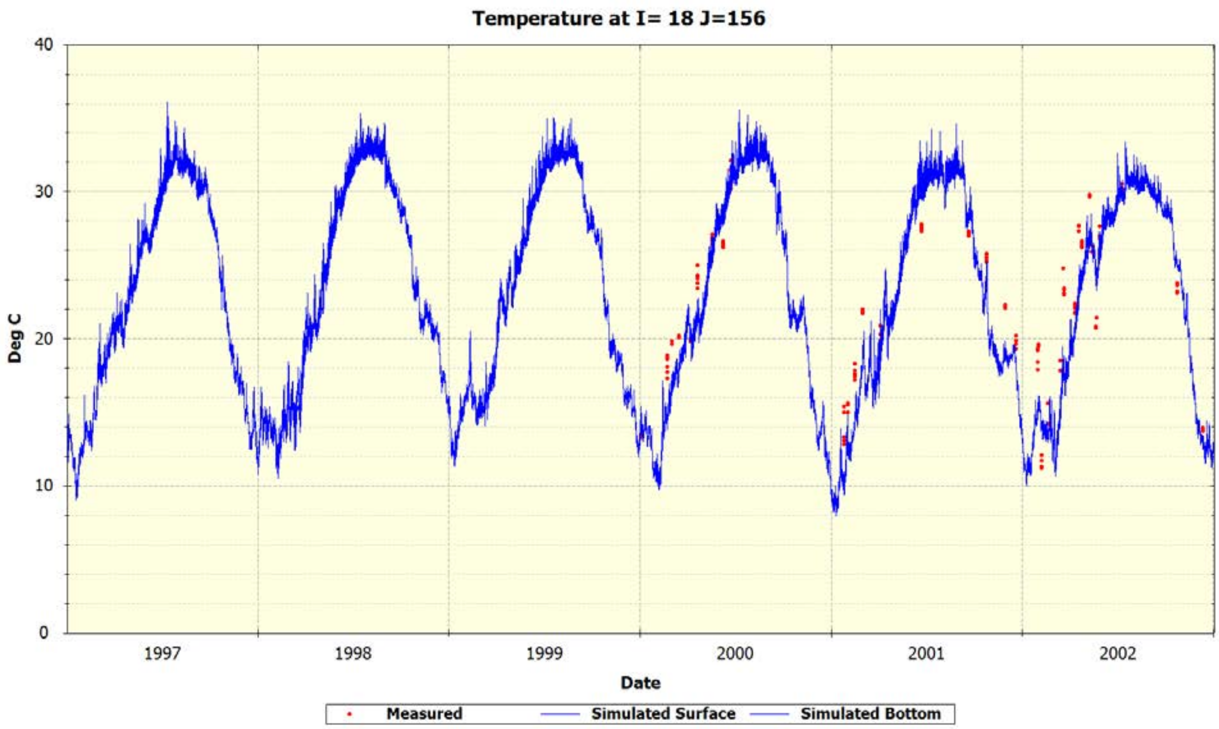

Figure 4.3.63 1997-2002 validation measured versus simulated temperature at I=18 J=156

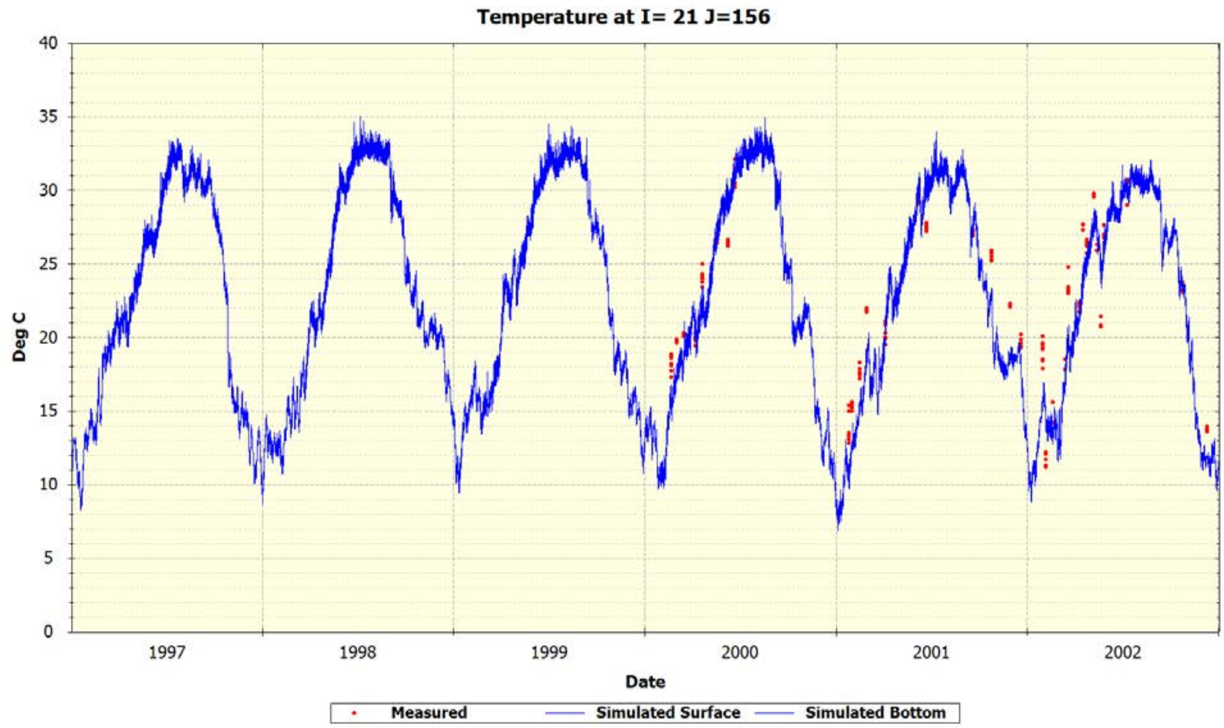

Figure 4.3.64 1997-2002 validation measured versus simulated temperature at I=21 J=156

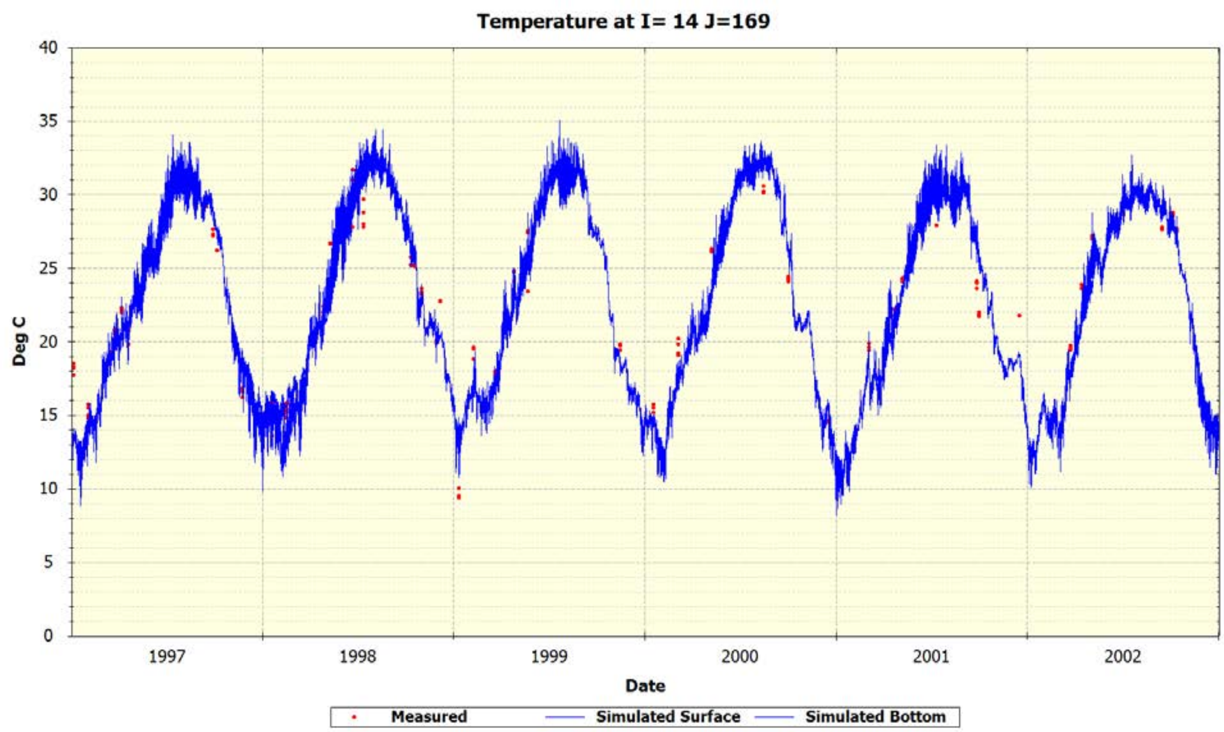

Figure 4.3.65 1997-2002 validation measured versus simulated temperature at I=14 J=169

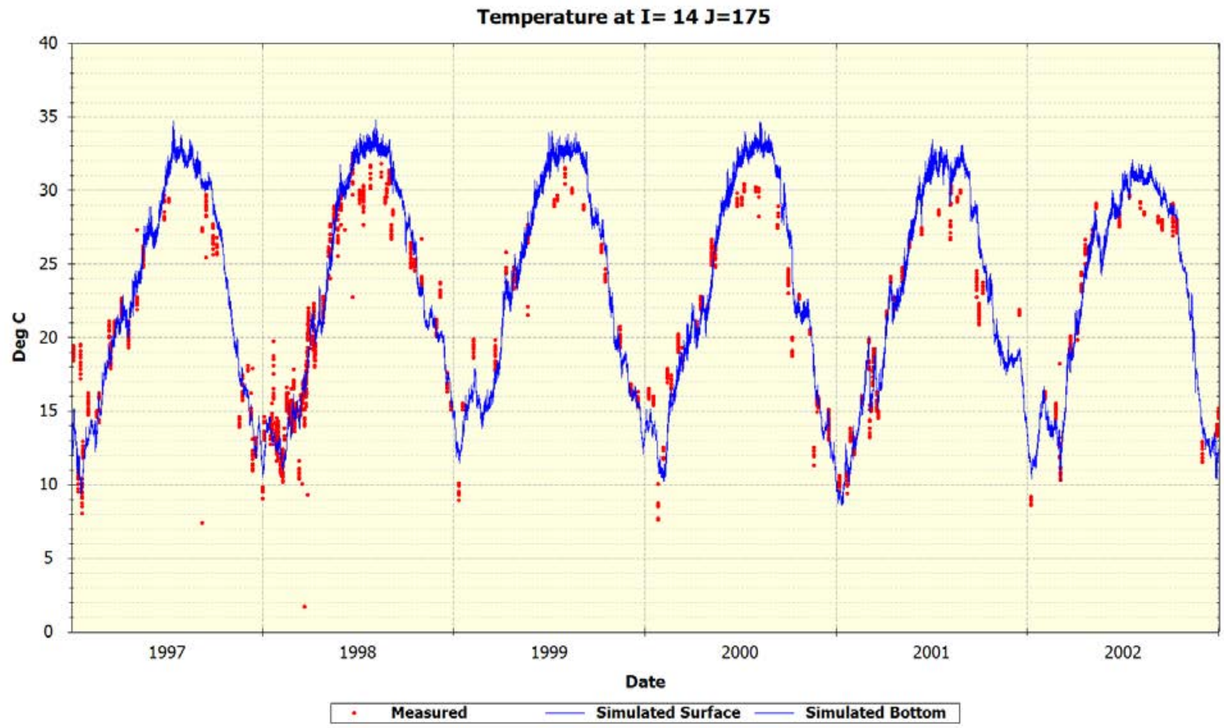

Figure 4.3.66 1997-2002 validation measured versus simulated temperature at I=14 J=175

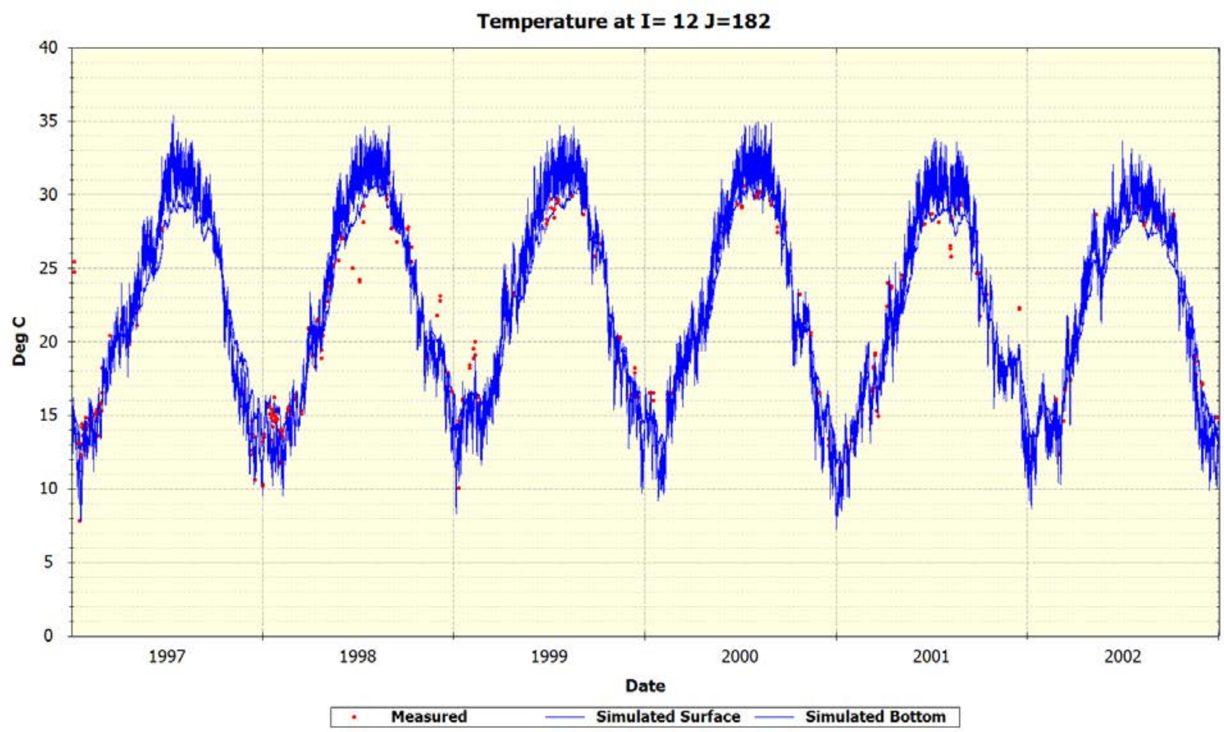

Figure 4.3.67 1997-2002 validation measured versus simulated temperature at I=12 J=182

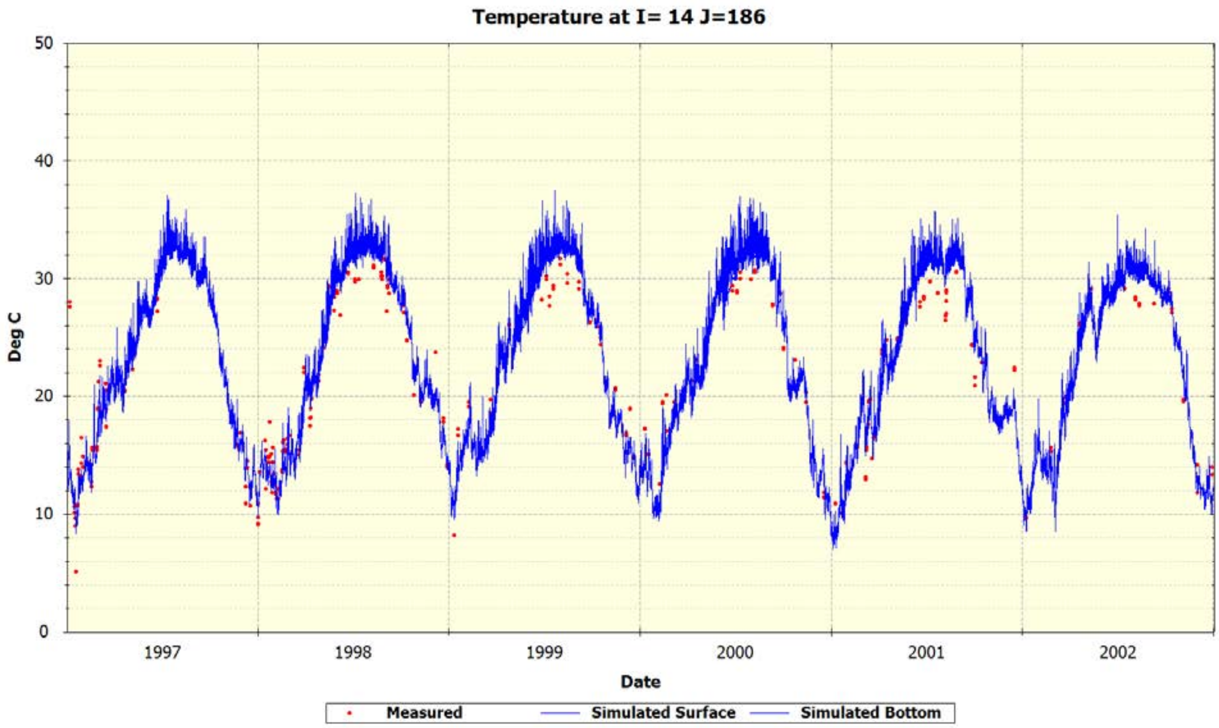

Figure 4.3.68 1997-2002 validation measured versus simulated temperature at I=14 J=186

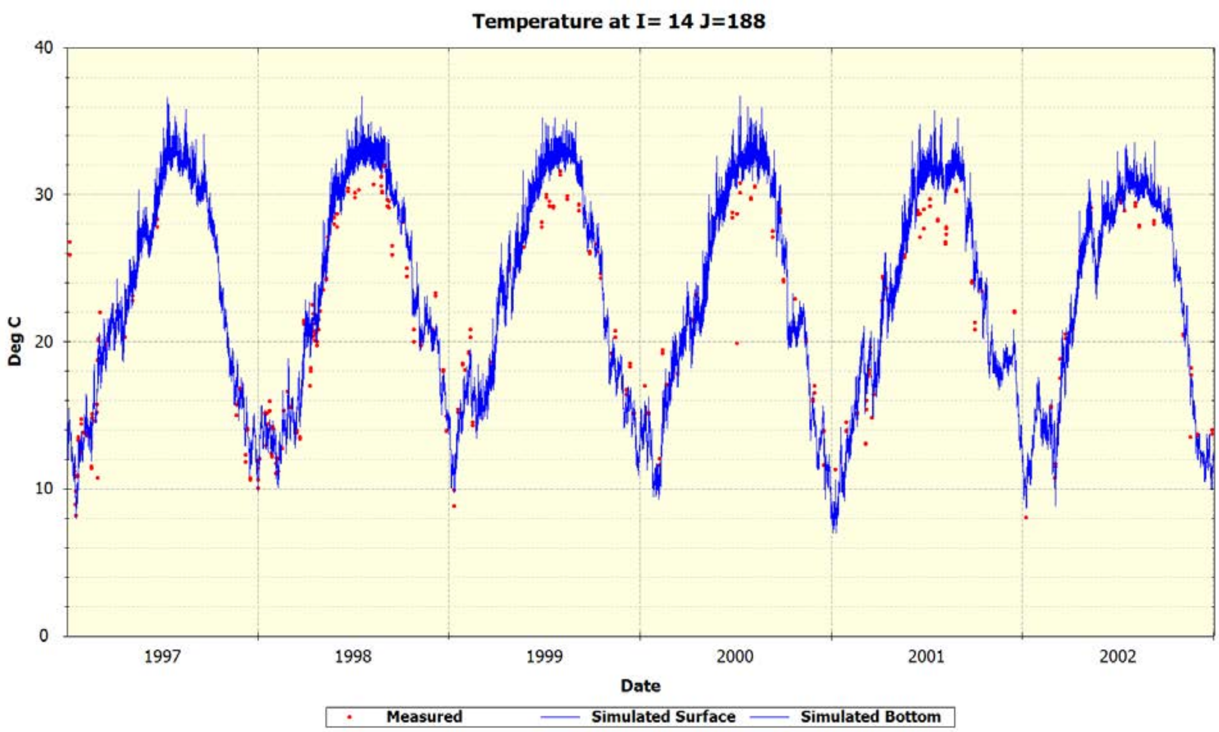

Figure 4.3.69 1997-2002 validation measured versus simulated temperature at I=14 J=188

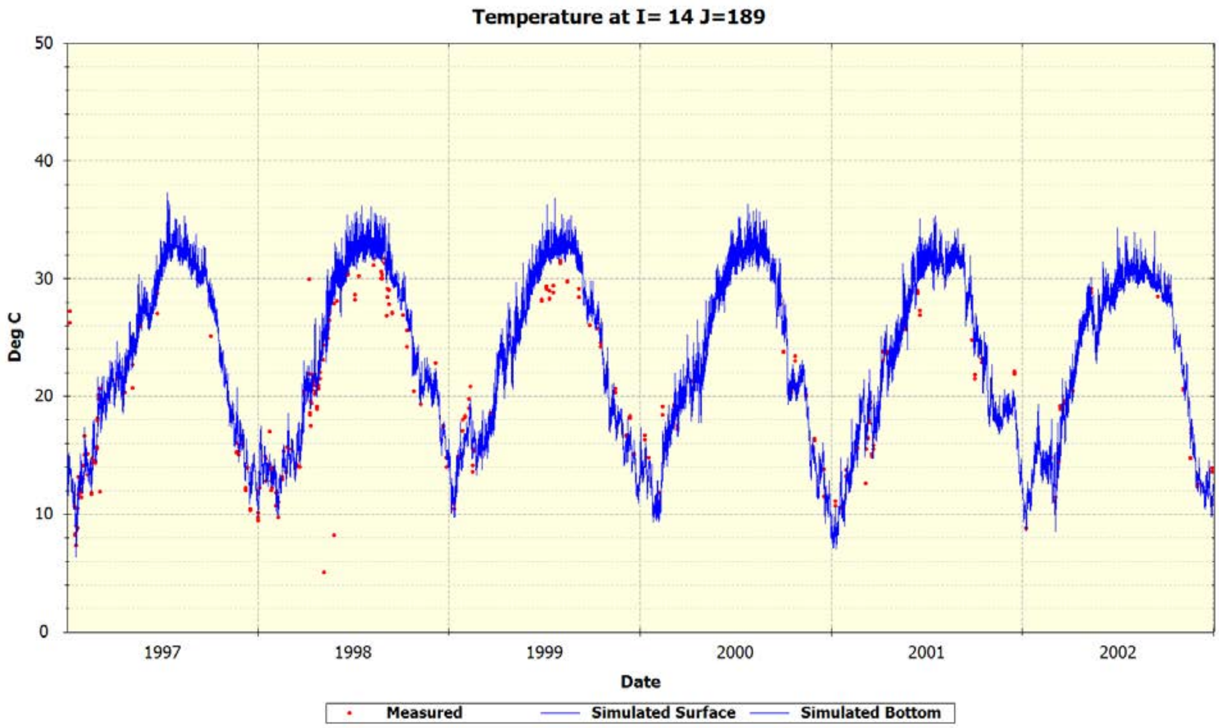

Figure 4.3.70 1997-2002 validation measured versus simulated temperature at I=14 J=189

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