ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS

December 18, 2002

Scott Shewbridge
El Dorado Irrigation District
2890 Mosquito Rd.
Placerville, Ca 95667

Re: FERC Project 184, Water Temperature Modeling

As part of the relicensing of the El Dorado Hydroelectric Project, FERC 184-065 (Project 184), the El Dorado Irrigation District (EID) has contracted with ECORP Consulting, Inc. (ECORP) to complete a set of study elements as listed in the original scope of work. ECORP subcontracted the Water Temperature Modeling task to ENTRIX, who prepared the attached Temperature Model Development and Calibration report. This study addresses Section 6.0 of the Scope of Work dated September 24, 2001, and amended on October 19, 2001.

Please find enclosed the Temperature Model Development and Calibration for El Dorado Hydroelectric Project, FERC 184-065 (Project 184). If you have any questions, please call me at (916) 782-9100.

Sincerely,

Tom Keegan, B.S.
Senior Fisheries Scientist / Project Manager

CC: Richard Floch / Richard Floch and Associates

Attachment

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DRAFT REPORT FOR EL DORADO IRRIGATION DISTRICT TEMPERATURE MODEL DEVELOPMENT AND CALIBRATION

Prepared for:

EL DORADO IRRIGATION DISTRICT
Placerville, CA

Prepared by:

ENTRIX, INC.
Walnut Creek, CA

Project No. 327501

October 16, 2002

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Prepared for:

EL DORADO IRRIGATION DISTRICT
2890 Mosquito Road
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1.0 INTRODUCTION

This report describes the results of the development of a stream temperature model for evaluating the effects of the El Dorado Hydroelectric Project (FERC Project 184) operations on water temperatures in the South Fork American River and its tributaries.

The model is configured to simulate stream temperatures from the Project reservoirs to the confluence with the outfall from El Dorado Powerhouse. Specifically, the following streams are included in the model:

- South Fork American River (SFAR), from inflow of Echo Conduit to upstream of outfall from El Dorado Powerhouse;
- Pyramid Creek from Aloha Lakes to the confluence with SFAR;
- Silver Fork American River (SilFAR), from the junction of Silver Creek and Caples Creek to the confluence with SFAR;
- Silver Creek from Silver Lake to the junction with Caples Creek;
- Caples Creek from Caples Lake to the junction with Silver Creek;
- Carpenter Creek from just upstream of diversion to the confluence with SFAR;
- No Name Creek from just upstream of diversion to the confluence with SFAR;
- Alder Creek from just upstream of diversion to the confluence with SFAR;
- Mill Creek from just upstream of canal crossing to the confluence with SFAR;
- Bull Creek from just upstream of diversion to the confluence with SFAR;
- Ogilby Creek from just upstream of diversion to the confluence with SFAR;
- Esmeralda Creek from just upstream of diversion to the confluence with SFAR;

This report discusses the results of the calibration and validation of the stream temperature model and briefly presents the conditions that will be simulated with this validated model. The linkage to the flow operations model developed by HydroLogics, Inc. is also briefly discussed.

2.1 SIMULATION MODEL

The SNTEMP model developed by the U.S. Fish and Wildlife Service (Theurer *et al.* 1983) was selected to represent the project streams. This model can account for inflows, shading, and different meteorological and hydrological conditions. SNTEMP predicts mean daily temperatures throughout the simulated stream network for each of the selected time periods. Maximum daily water temperatures may also be simulated in the model.

2.1.1 TWO DAY TIME PERIOD

Water traveling through the streams within the Project area is estimated to have a travel time from less than a day to less than two days, depending on the rate of flow. The SNTEMP model assumes steady flow during a simulated time period. For this reason, we have selected a two-day averaging period for the temperature simulations.

2.2 CALIBRATION AND VALIDATION

The model being applied, SNTEMP, is generally calibrated to improve its ability to simulate downstream temperatures. Calibration involves adjusting model coefficients and parameters in such a way as to increase the accuracy and precision of downstream temperature predictions.

The stream temperature model was calibrated to data that EID collected during 2001. These data include stream temperatures, flow, and certain meteorological variables. The flow data during this period was filled and smoothed by HydroLogics, Inc. using methods developed during their Phase I model development (HydroLogics, Inc. 2001).

The calibration effort was validated to data collected in 2000. Model validation provides an estimate of how well the model can simulate downstream conditions.

Data collected from two temperature data sites (recorder 40 and recorder 5) were not used for calibration/validation resulting from too many missing values.

2.3 SIMULATIONS

Once calibrated and validated, the stream temperature can be used to simulate conditions not represented by observed (downstream temperature) data. These simulations, also called synthetic simulations to differentiate from calibration and validation simulations, will include the following operations conditions:

- Current Project (with-reservoirs) operations; and

- Pre-project (no-reservoirs) conditions.

To be able to simulate the “no-reservoirs” condition, additional stream temperature model segments (upstream of the proposed model) will have to be developed to supply starting temperatures to the stream temperature model proposed in this document. Additionally, the stream temperature model will be able to simulate any additional proposed Project operations that can be represented with the current flow operations model.

2.3.1 Integration of Stream Temperature simulations with Flow Operations Model

A flow operations model has been developed to provide flow estimates throughout the Project area subject to alternate operations (HydroLogics, 2001). As part of the stream temperature model development, we have developed a prototype interface to directly use the flows provided by the HydroLogics’ flow operations model to drive the stream temperature (synthetic) simulations. This interface was used to read the calibration/validation flow data set provided by HydroLogics.

In future simulations, HydroLogics will generate a database file (very similar to the one provided for stream temperature model calibration/validation) that contains the daily flows at the operations model node points for the time periods and conditions being simulated. The ENTRIX interface will filter these flows for the specific conditions to be simulated and will convert flows from the HydroLogics nodes to the flows that the stream temperature model requires. Currently, part of this filtering will be to select a normal and extreme year type (see below) from the HydroLogics supplied file.

The flow operations model uses the concept of flow nodes where flows are tracked at specific locations within the Project extents. The stream temperature model requires more detail than the flow nodes previously identified (HydroLogics, 2001). According to HydroLogics (Meyer, H. 2002), this additional information can be retrieved from the flow operations model runs.

2.3.2 Conditions to be Simulated

2.3.2.1 Hydrology and Operations

Specific flows to be used in future simulations have not yet been determined.

2.3.2.2 Meteorological Conditions

Normal and warmer-than-normal meteorological conditions will be developed for the temperature simulations.

Warmer than normal meteorology, as used here, includes conditions associated with 10 percent exceedance air temperatures. Regulated and unregulated stream flows will be simulated using the HydroLogics model (HydroLogics 2001). Warm water temperatures are generally a concern during the warmer months of the spring, summer, and fall. These months are generally April through October.

3.1 MEAN DAILY TEMPERATURE CALIBRATION - VALIDATION RESULTS

The SNTEMP model of the Project streams was calibrated to June through September 2001 observed temperatures and validated to June through October 2000 observed temperatures. A temperature model such as SNTEMP requires that conditions such as flows and meteorology be approximately constant for the period being analyzed. Constant conditions are simulated by assuming average conditions for the period of time it would take the stream to flow from the top to bottom of the system of interest. We used a two-day averaging period in our temperature simulations to account for this water travel-time.

Data values were averaged using a two-day moving mean to produce 117 two-day averages for the calibration set and 131 two-day averages for the validation set. The model was calibrated by adjusting the stream structure definitions to minimize observed systematic bias. After calibrating to the 2001 data, the validation run with 2000 data produced the following results for mean daily water temperatures:

Mean bias, Overall = 0.34 °C
Standard deviation of bias (SD) = 1.26°C
Number of points (131 simulation periods * 24 locations) = 3144

These statistics were calculated for each simulated stream and are summarized in Table 3-1.

Below, we discuss the validation by Project stream (for those streams that had validation recorders). In the following discussion, all distances are relative to the El Dorado Powerhouse outflow to the SFAR. Distances are in kilometers (1 km = 0.62 mi). On those streams that had more than one validation recorder (SFAR, SilFAR, and Caples Creek), we present time-series plots of selected recorders, skipping a discussion of recorders near to or otherwise similar to the selected recorders.

3.1.1 SOUTH FORK AMERICAN RIVER (SFAR)

A plot of the simulated temperature profiles compared to observed values for SFAR is shown in Figure 3-1 for 7/20/2000 of the validation data set. The simulation starts at the inflow from Echo Conduit and ends just upstream of the Powerhouse inflow. This day was chosen for display only because we were monitoring this simulation during our calibration and this day was already plotted.

Table 3-1. Mean Daily Validation Statistics by Stream.

Stream	Bias (°C)	SD (°C)	Minimum Bias (°C)	Maximum Bias (°C)	n
Bull	+0.24	0.93	-2.19	1.70	131
Caples	+0.88	1.23	-4.02	4.37	393
Esmerelda	-0.12	0.52	-1.53	0.98	131
Mill	-0.33	3.02	-8.03	3.41	131
Ogilby	+0.12	0.78	-1.45	2.16	131
Oyster	-0.05	0.76	-1.45	2.32	131
Pyramid	+0.51	0.16	+0.08	0.89	131
SFAR	+0.61	1.01	-4.07	4.26	917
SilFAR[1]	+0.11	1.26	-5.29	3.51	1048

In this plot the solid line represents the simulated temperature and the points represent temperatures recorded for 7/20/00. Downstream travel is from left to right. The fit is generally good starting from Echo Conduit (km 66, the first point upstream). The simulated temperature gradually increases to slightly overpredict the observed temperature just upstream of Pyramid Creek (the lower point near km 57). The jump in temperature at this location represents the temperature of the combined SFAR and Pyramid waters. At this point and at the next downstream validation point (Strawberry Creek, km 53), we slightly overpredict observed temperatures. Silver Fork American River combines with SFAR near km 37. Temperature gradually increases from here and increases at a more rapid rate after Canal withdrawal (the validation point near km 36 is recorder 20 just downstream of the El Dorado Dam). Simulated temperature continues to increase past 21 ºC and slightly overpredicts temperature (about 1 ºC) recorded at site 4 at km 4 (20.8 ºC recorded on 7/20/00). Tributary inflows from Alder Creek, Mill Creek, Bull Creek, etc. are responsible for the jaggedness of the simulated temperature profile in this area. The simulation for 7/20/00 was a relatively good fit. To demonstrate the validation fit over time we will display time-series plots at selected locations.

Figure 3-2[2] presents the time-series comparing simulated mean daily temperatures to observed values at the location upstream of Pyramid Creek This plot suggests that the simulation generally follows the observed trend at this location with a slight tendency to overpredict temperatures. Observed and simulated temperatures exceed 15 ºC in late July.

[1] Includes Silver Creek from Silver Lake to the junction with Caples Creek.

[2] In all mean daily validation time-series figures, "Tvnn" (where nn is a number) represents the mean daily temperature simulated at the validation recorder nn. "TvnnOBS" represents the mean daily temperatures observed at recorder nn.

Figure 3-3 presents the time-series comparing simulated mean daily temperatures to observed values at the location upstream of the confluence with Silver Fork American River (SilFAR). This plot suggests that the simulation generally follows the observed data at this location with a slight tendency to overpredict temperatures. Observed and simulated temperatures approach but do not exceed 20 ºC in late July, early August.

Figure 3-4 presents the time-series comparing simulated mean daily temperatures to observed values at the location upstream of the El Dorado Powerhouse inflow. This plot suggests that the simulation generally follows the observed data at this location with a slight tendency to overpredict temperatures (1 to 2 ºC) especially June through August. Observed and simulated temperatures exceed 20 ºC at various times in this June-August period.

3.1.2 SILVER FORK AMERICAN RIVER/SILVER CREEK (SILFAR)

The model of Silver Fork American River/Silver Creek begins on Silver Creek downstream of Silver Lake at km 70. A longitudinal profile of the SilFAR simulation for 7/20/00 is presented as Figure 3-5. On this day, the model overpredicts temperature (approximately 1 ºC) between the start and where SilFAR is joined by Oyster Creek (1 km downstream). In the combined Silver Creek/Oyster Creek simulation temperature gradually increases to the confluence with Caples Creek (km 63). The Caples Creek inflow results in a drop in temperature (both simulated and observed) followed by a gradual increase in temperature. The simulated temperature closely approximates the observed value at km 44 (recorder 37 upstream of Long Canyon and recorder 35 downstream of Long Canyon).

Figure 3-6 presents the time-series of the validation data set and simulation for recorder 46 representing SilFAR just upstream of the Oyster Creek confluence. The simulated values closely approximate the observed values, due in part from the fact that the validation point is only approximately 1.5 km downstream of the start of the (SilFAR) simulation.

Figure 3-7 presents the time-series of the validation data set and simulation for recorder 42 representing SilFAR just upstream of the Caples Creek confluence. At this location, simulated values follow the trend of the observed values but slightly overpredict (up to 2 ºC) the observed temperatures.

Traveling downstream, Figure 3-8 presents the time-series of the validation data set and simulation for recorder 22. This presents SilFAR temperatures just upstream of the South Fork American River confluence. Simulated temperatures follow the trend of the observed values, generally slightly underpredicting the observed values.

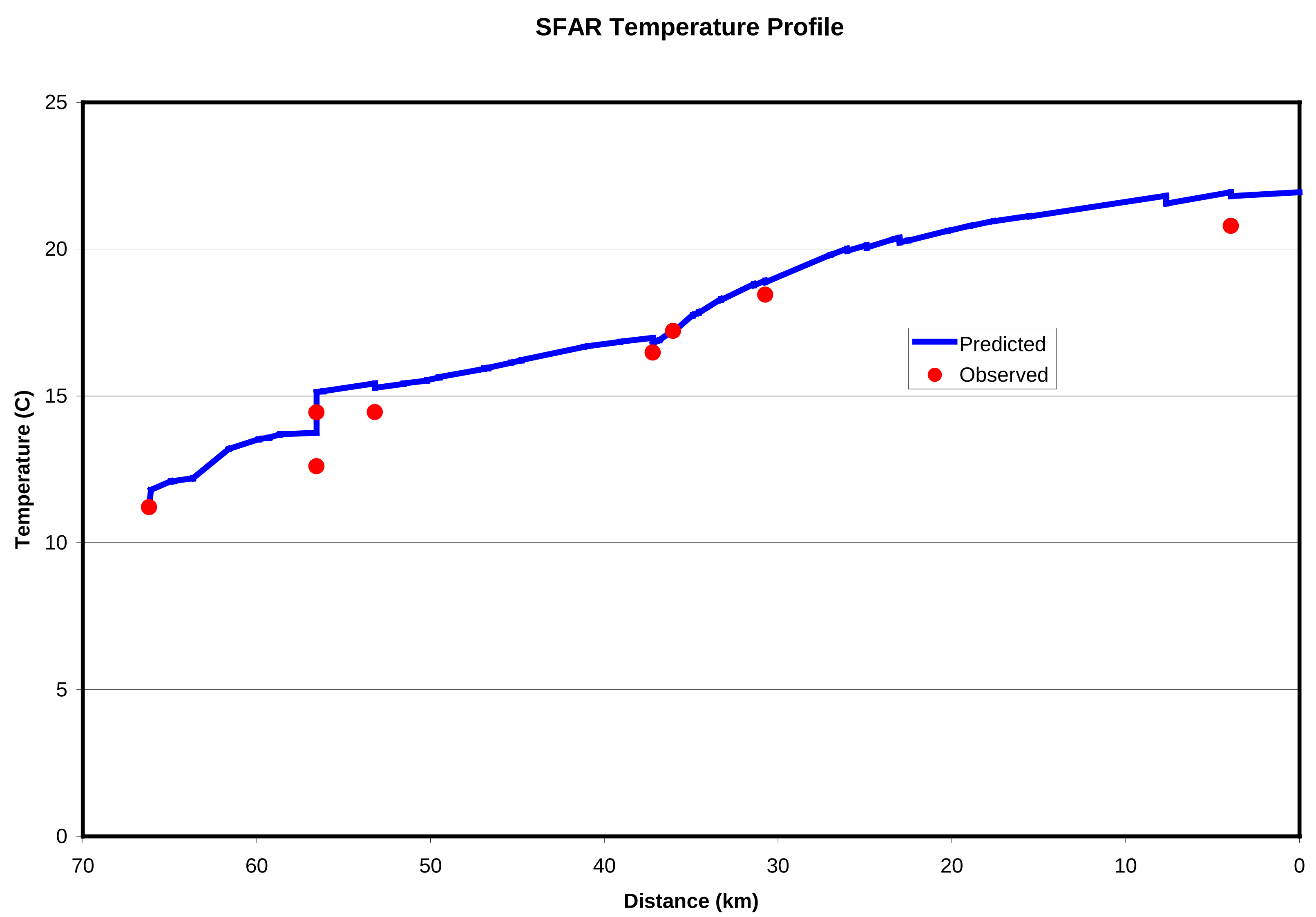

Figure 3-1. SFAR mean daily temperature longitudinal profile, 7/20/00.

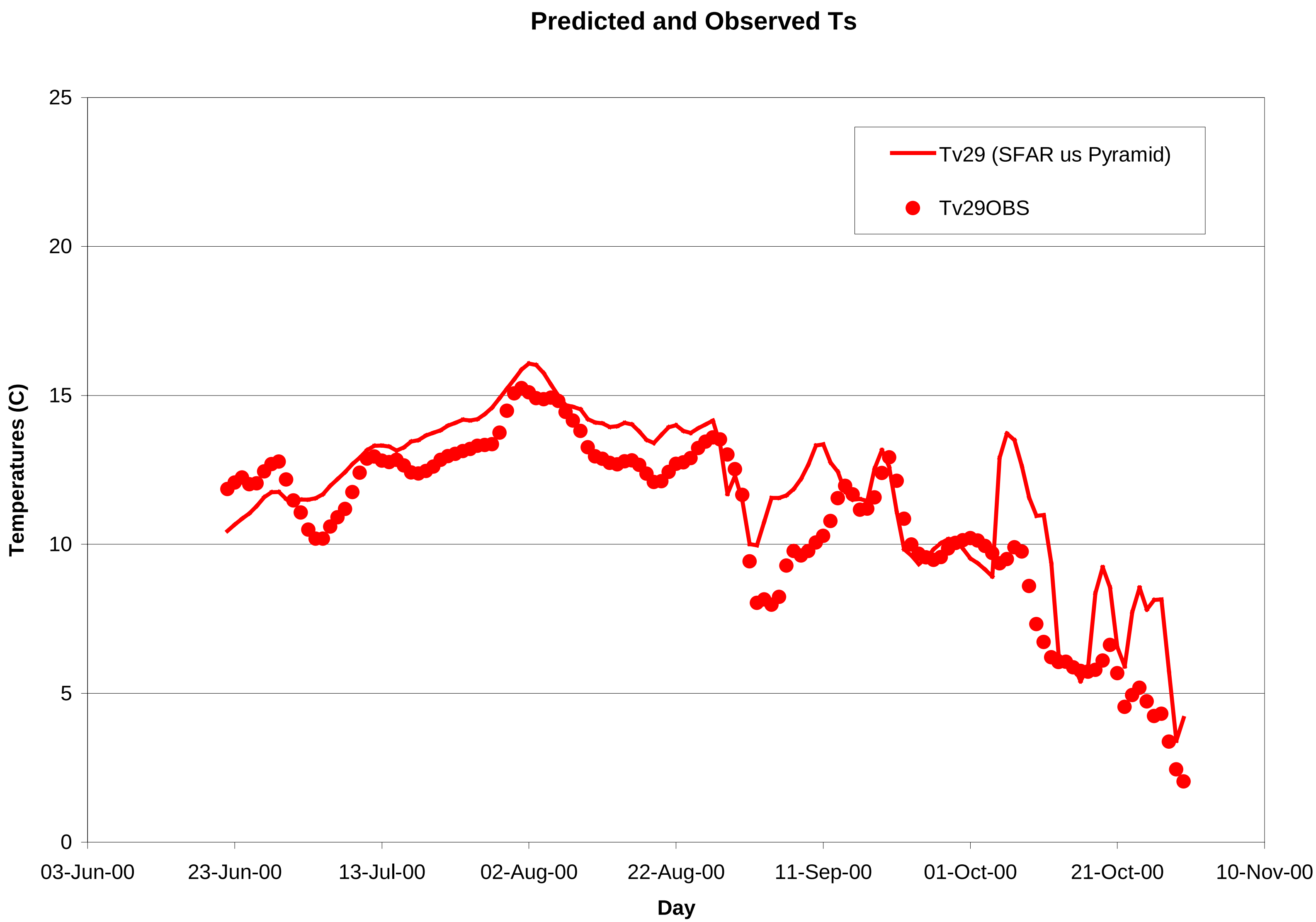

Figure 3-2. SFAR mean daily validation time-series, upstream of Pyramid Creek (recorder 29).

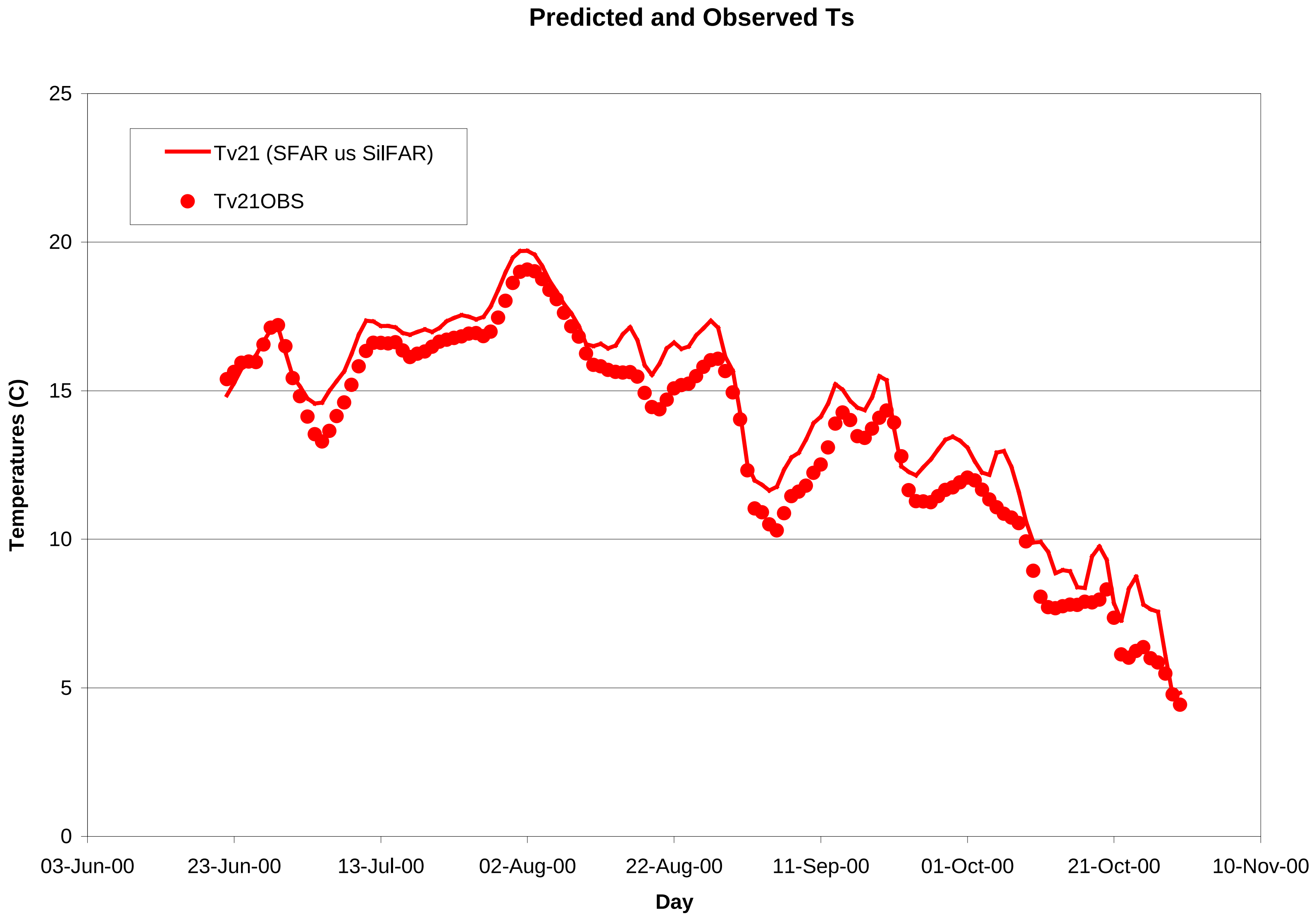

Figure 3-3. SFAR mean daily validation time-series, upstream of SilFAR (recorder 21).

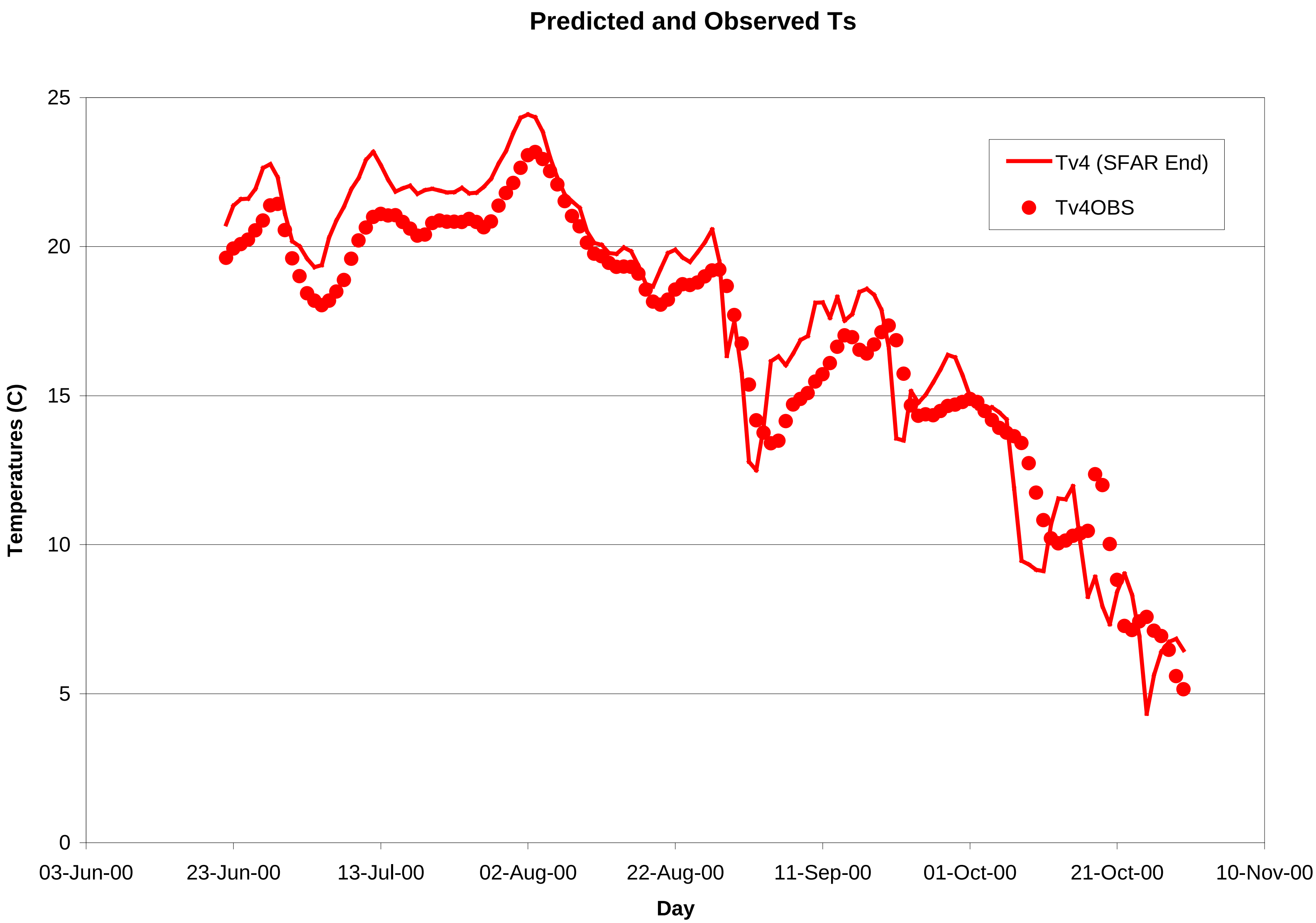

Figure 3-4. SFAR mean daily validation time-series, upstream of El Dorado Powerhouse Inflow (recorder 4).

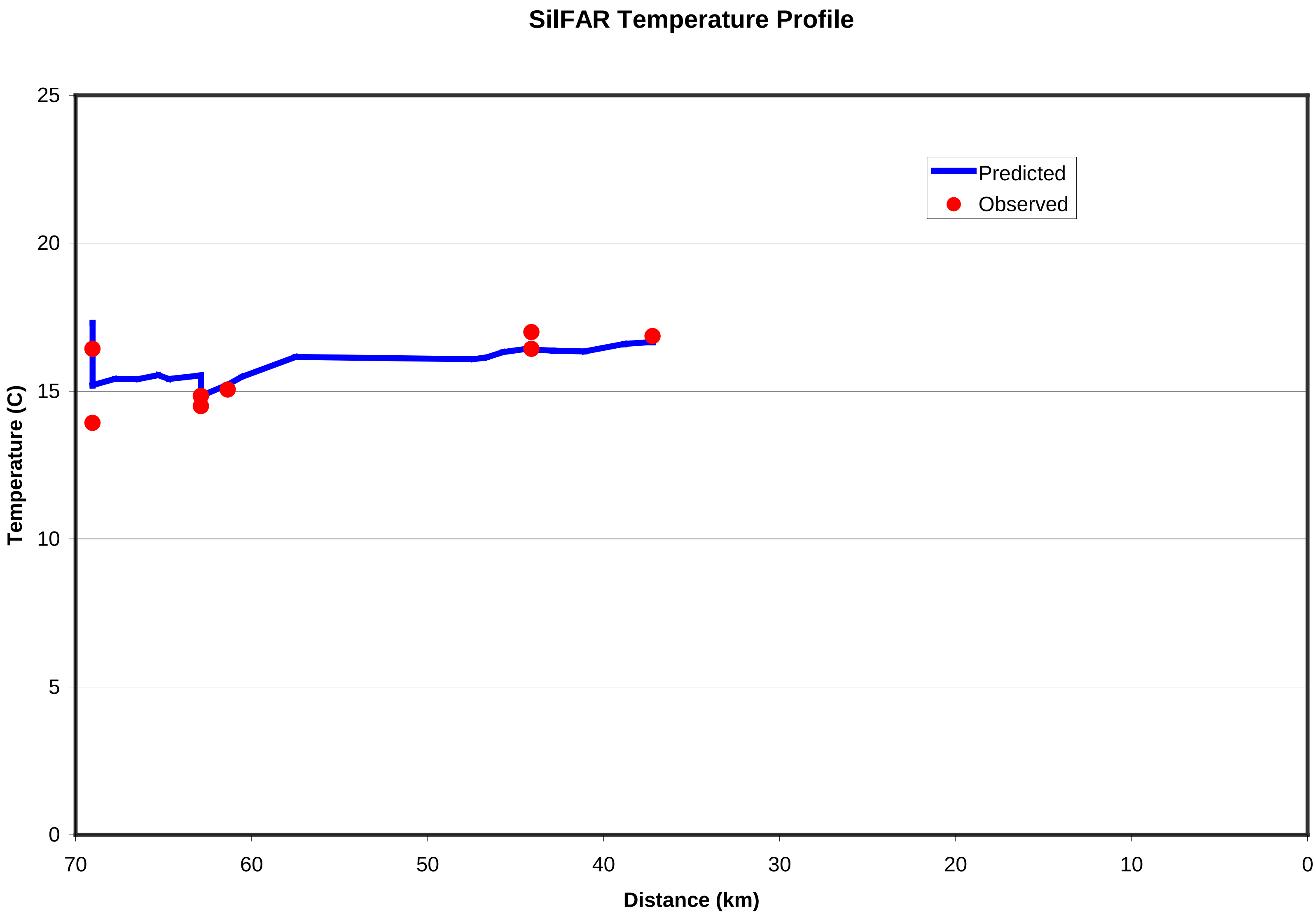

Figure 3-5. **SilFAR longitudinal profile, 7/20/00.**

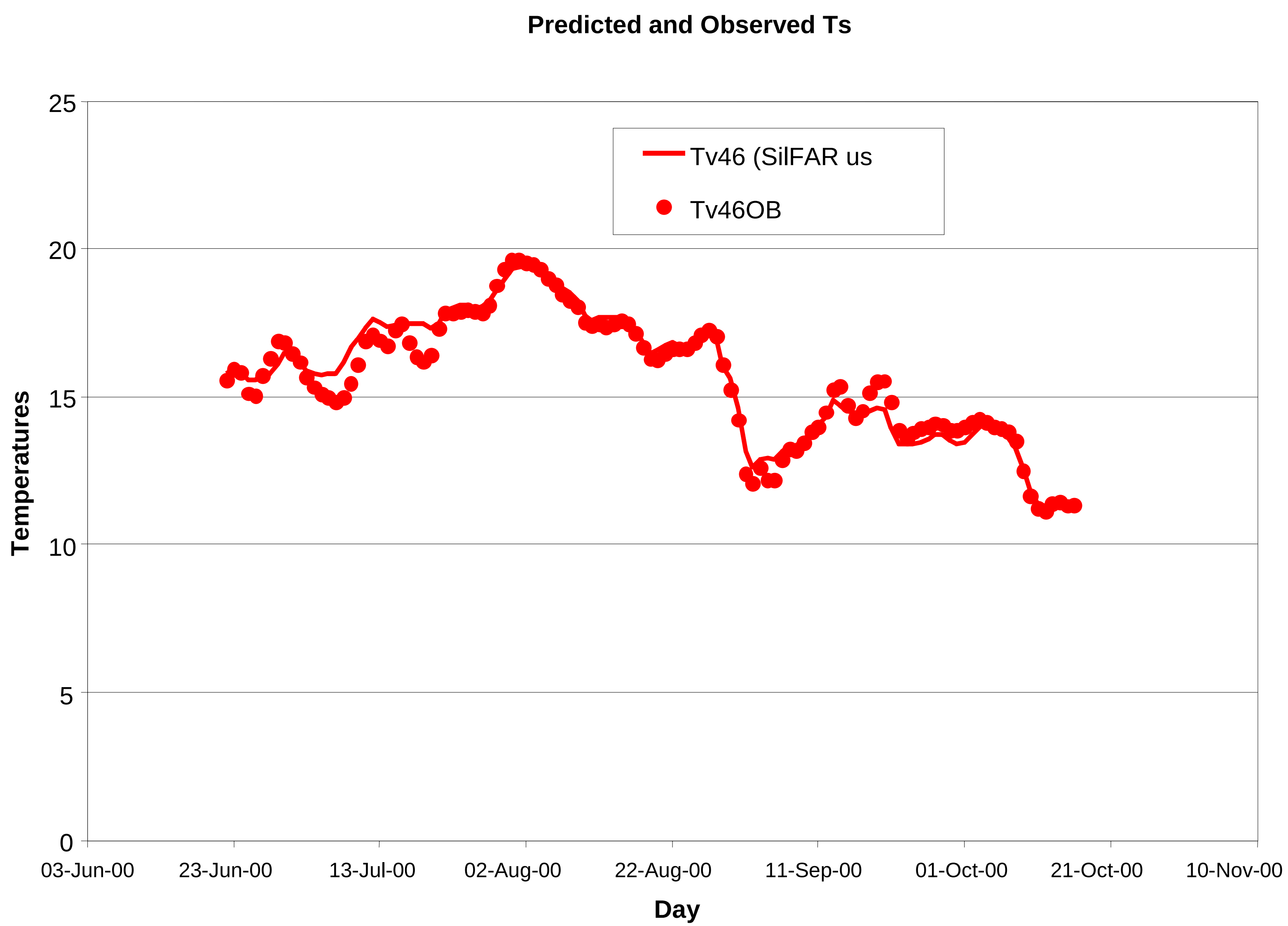

Figure 3-6. SilFAR mean daily validation time-series, upstream of Oyster Creek (recorder 46).

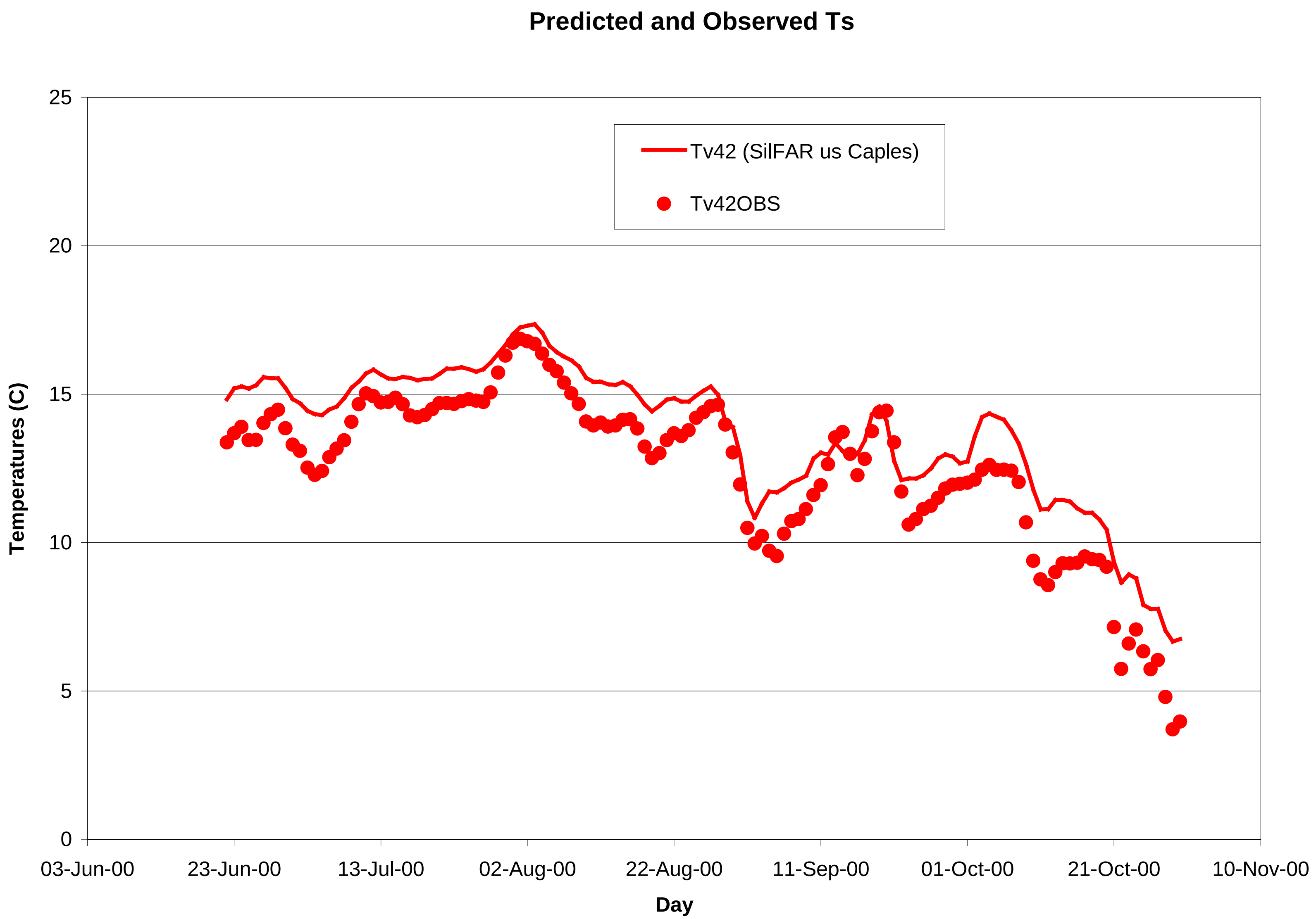

Figure 3-7. SilFAR mean daily validation time-series, upstream of Caples Creek (recorder 42).

3.1.3 CAPLES CREEK

Caples Creek was the most difficult stream to simulate. Those familiar with this Project stream indicated that the seasonal development of beaver dams could be influencing the stream temperatures by increasing widths and increasing travel time. This information was useful in the calibration; we were able to improve the fit to recorded data by assuming the stream was very wide with significant shade.

Figure 3-9 presents the validation time-series for recorder 50 that represents Caples temperatures immediately upstream of the Caples/North Fork Caples Creek confluence. At the start of the simulation (late June 2000) the model overpredicts (up to 3 ºC) but, thereafter, gradually approaches observed temperatures.

Figure 3-10 presents the validation time-series for recorder 48 that represents Caples temperatures immediately upstream of the Caples/Silver Creek confluence. At the start of the simulation (late June 2000) the model overpredicts, gradually approaches, and then slightly underpredicts observed temperatures.

The change from overprediction toward underprediction observed at these two Caples sites could result from a seasonally increasing volume of water behind beaver dams that would not be accounted for by the static width defined in the model.

3.1.4 PYRAMID CREEK

Figure 3-11 presents the validation time-series for recorder 27 on Pyramid Creek. This figure represents Pyramid Creek temperatures immediately upstream of the Pyramid/SFAR confluence. The simulated values are a very good approximation of the observed with only a slight tendency to overpredict. Bias ranged from 0.08 ºC to 0.89 ºC.

3.1.5 MILL CREEK

The Mill Creek simulation is the worst representation of observed mean daily values. Bias ranged from -8.0 ºC to +3.4 ºC. Figure 3-12 presents the validation time-series at recorder 12, upstream of the Mill Creek/SFAR confluence. At the start of the simulation in late June, the model overpredicts temperatures by almost 4 ºC. As the season progresses, simulated values approach the actual values and then significantly underpredict values starting in September. Stream width was increased in the model to account for the possibility of damming by beavers.

3.1.6 BULL CREEK

Figure 3-13 presents the validation time-series at recorder 10, upstream of the Bull Creek/SFAR confluence. In general this simulation is a good representation of observed values.

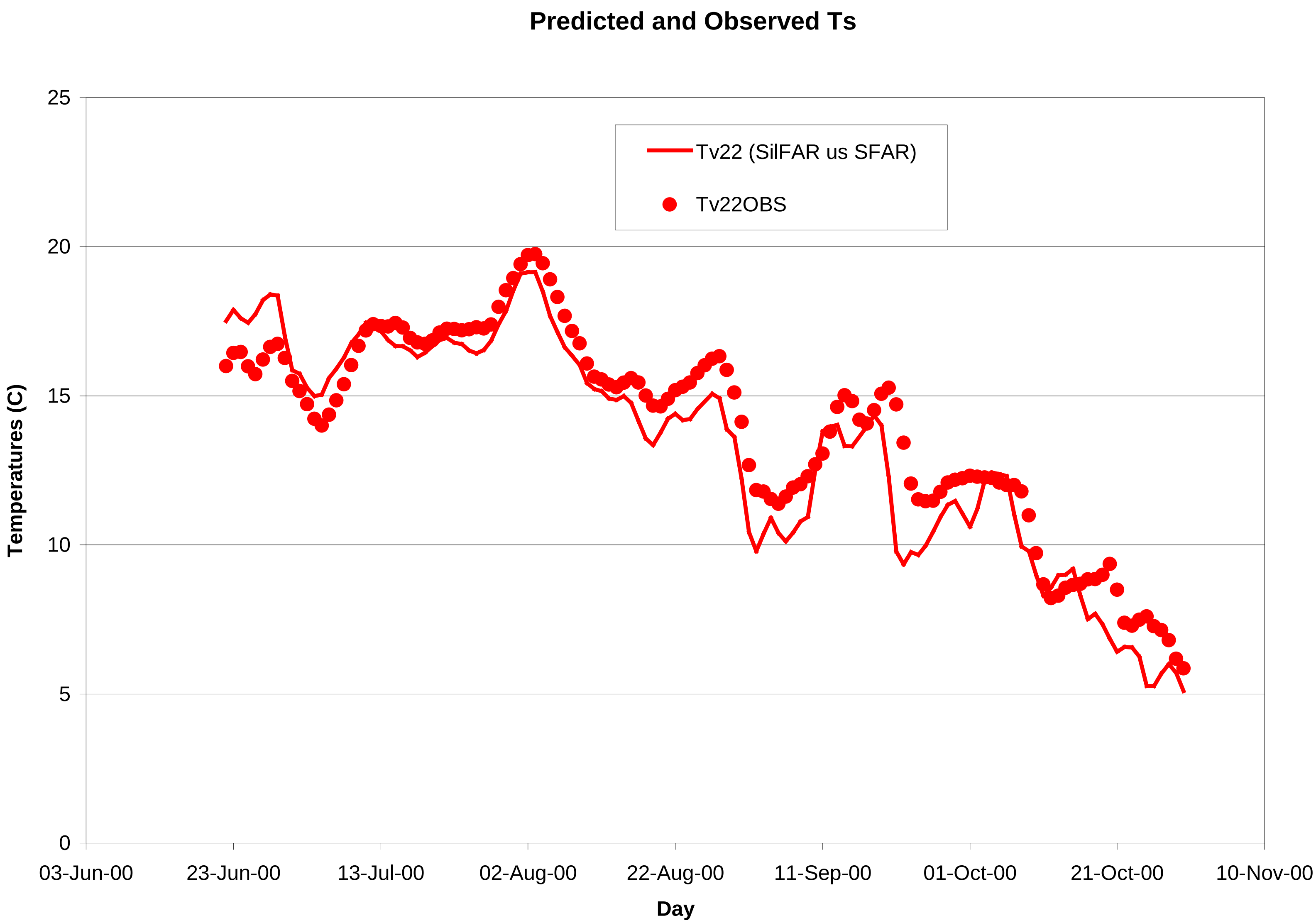

Figure 3-8. SilFAR mean daily validation time-series, upstream of SFAR (recorder 22).

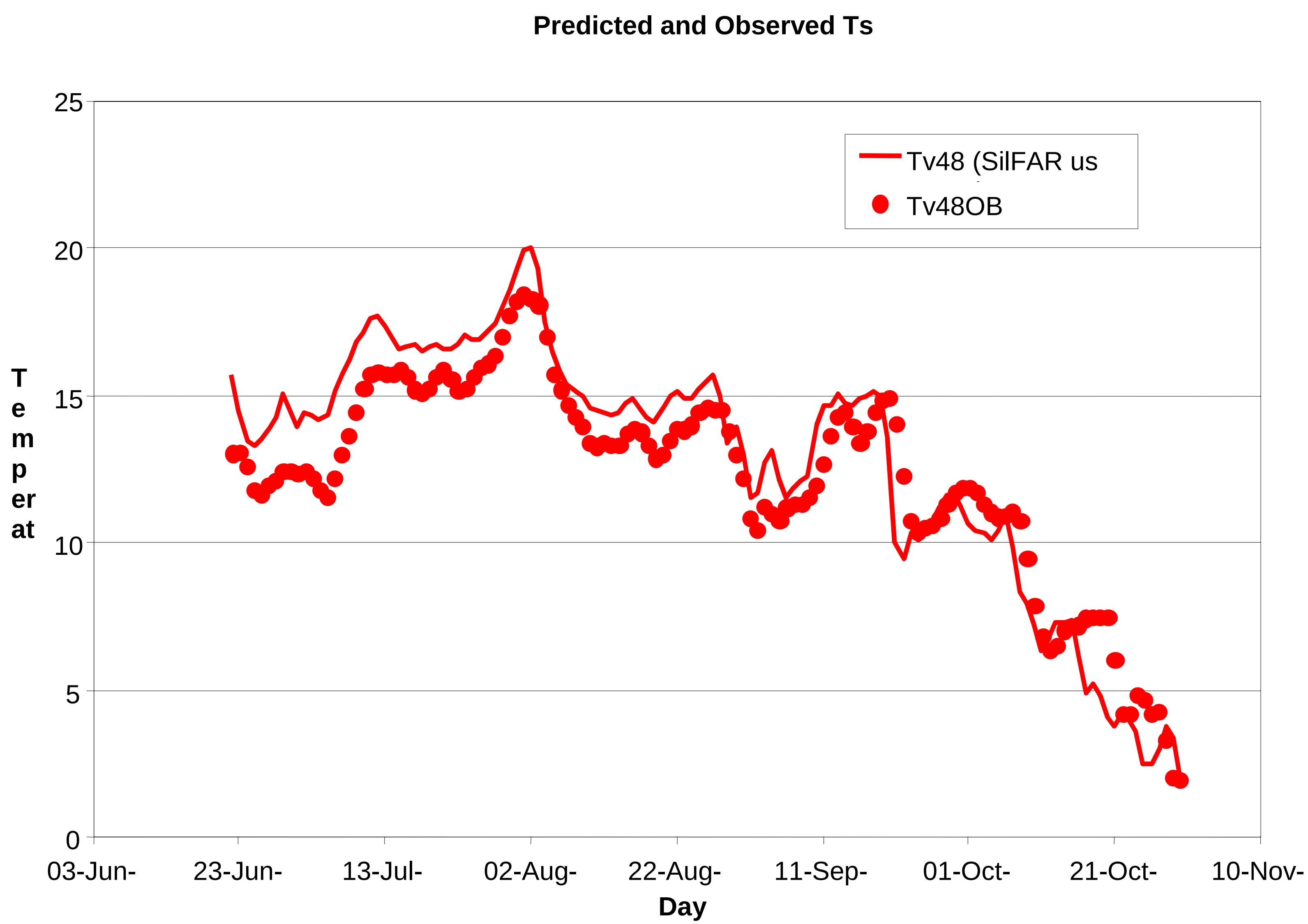

Figure 3-9. Caples Creek mean daily validation time-series, upstream of North Caples Creek (recorder 50).

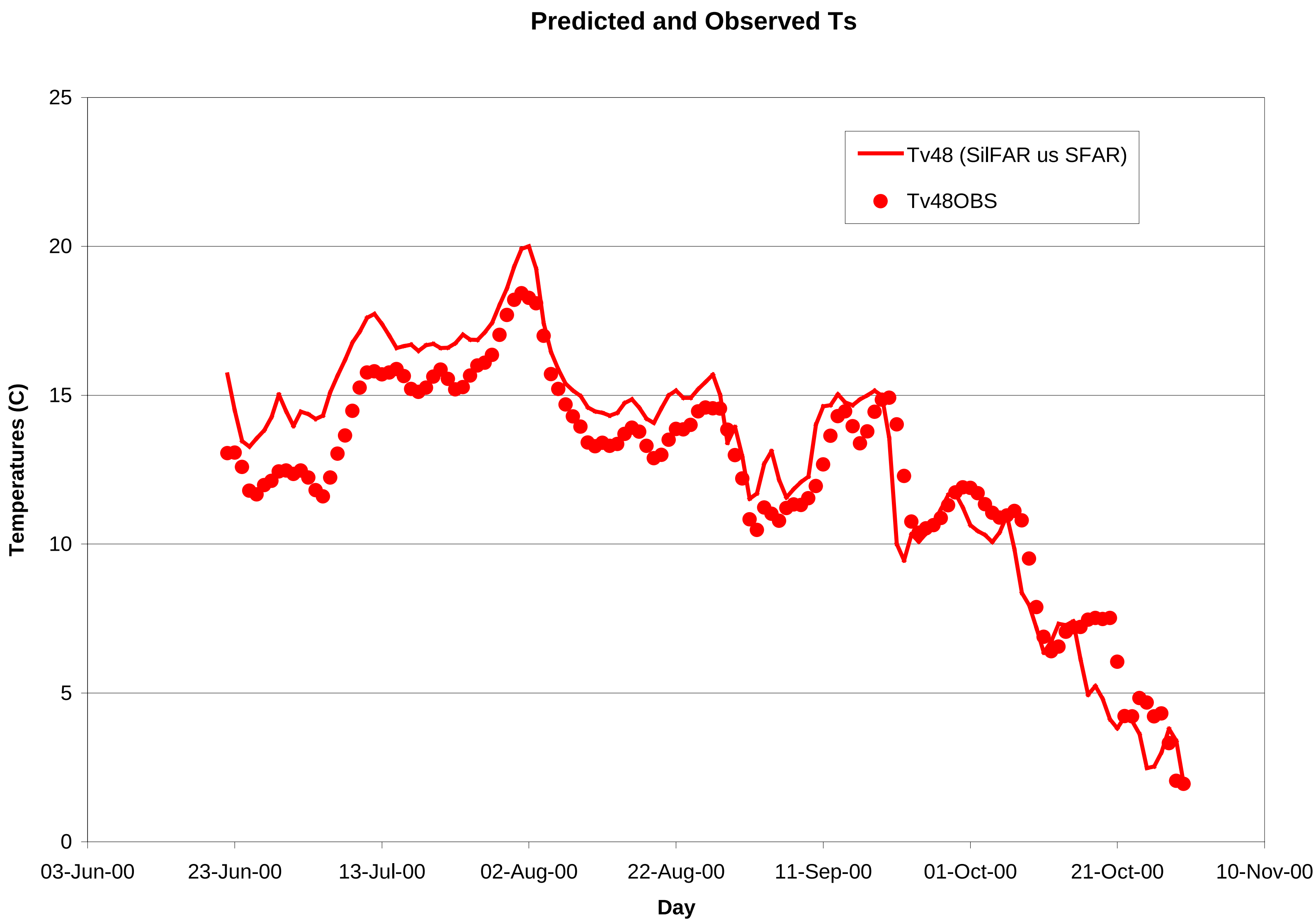

Figure 3-10. Caples Creek mean daily validation time-series, upstream of Silver Creek (recorder 48).

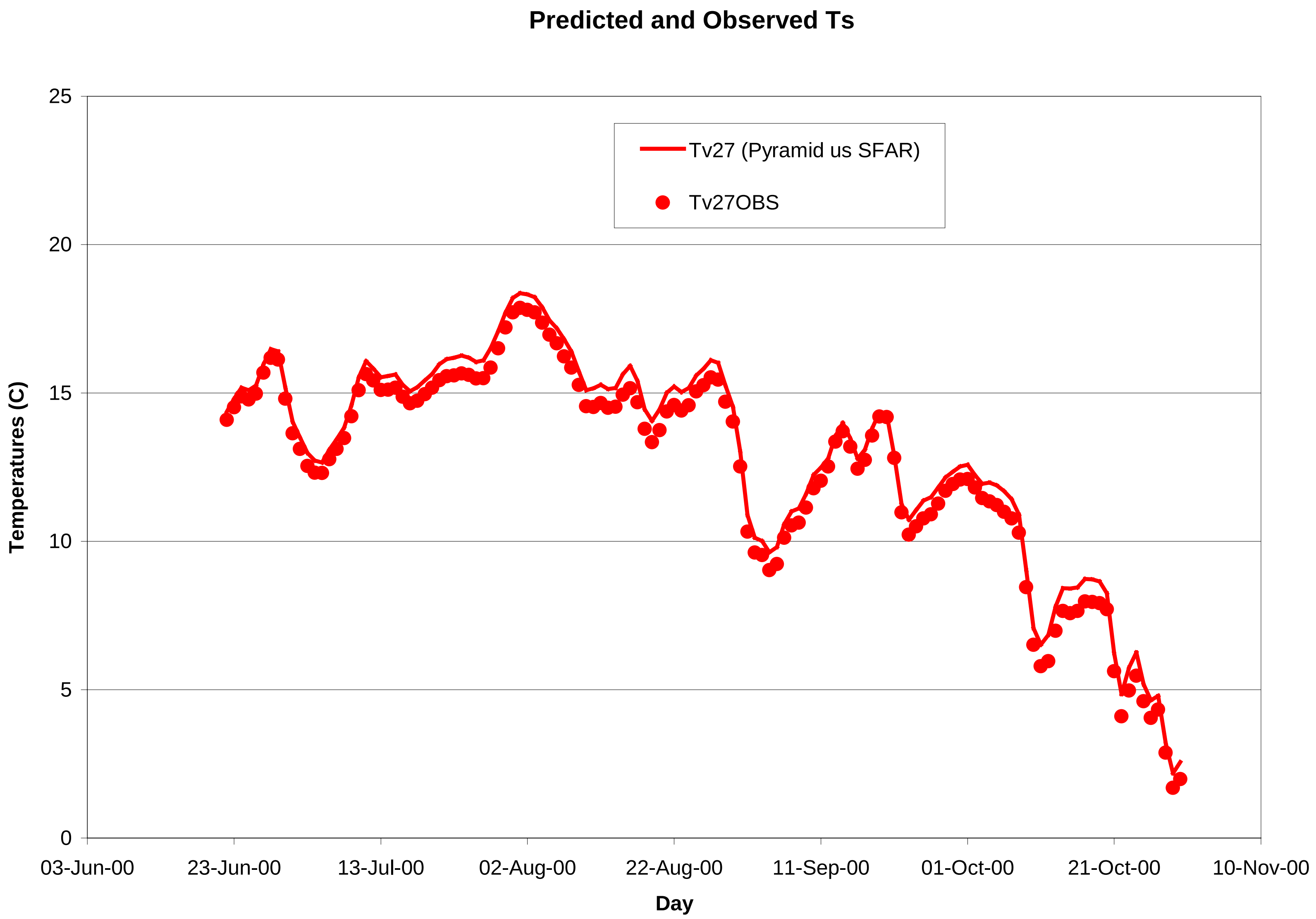

Figure 3-11. Pyramid Creek mean daily validation time-series, upstream of SFAR (recorder 27).

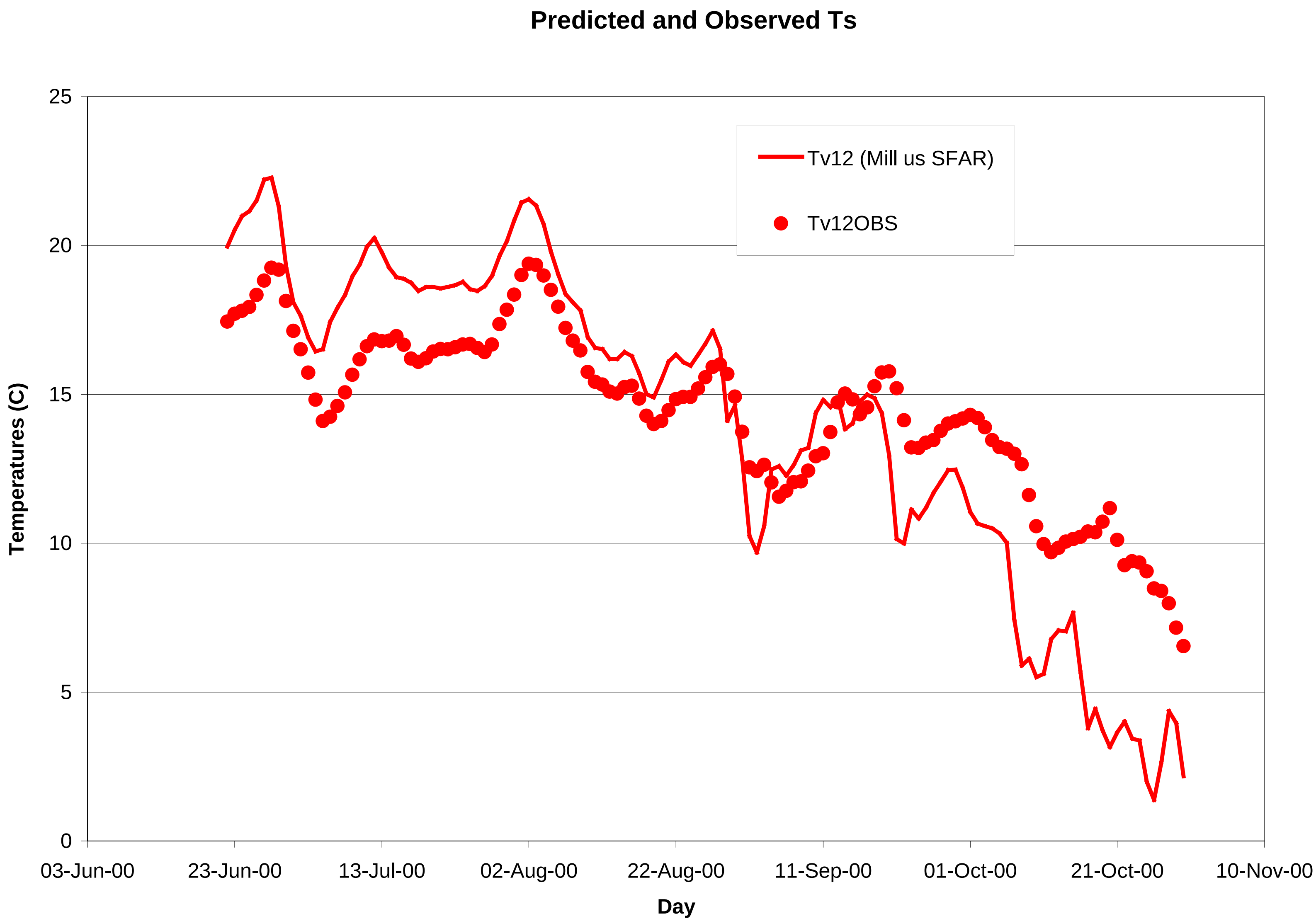

Figure 3-12. Mill Creek mean daily validation time-series, upstream of SFAR (recorder 12).

3.1.7 Ogilby Creek

Figure 3-14 presents the validation time-series at recorder 8, upstream of the Ogilby Creek/SFAR confluence. In general this simulation is a good representation of observed values with the model being somewhat more environmentally sensitive than it should be (resulting in simulated values occilating about the observed trends).

3.1.8 Esmerelda Creek

Figure 3-15 presents the validation time-series at recorder 6, upstream of the Esmerelda Creek/SFAR confluence. In general this simulation is a good representation of observed values with the model being somewhat less environmentally sensitive than it should be (resulting in simulated values not reaching the peaks of the observed trends).

3.1.9 Mean Daily Temperature Validation Summary

If we define an excellent stream temperature model as one that produces a bias of less than +/- 0.5 ºC and a standard deviation of the bias (SD) less than 1.0 ºC, four streams qualify: Bull Creek, Esmerelda Creek, Ogilby Creek, and Oyster Creek. If we define a good model as one that produces a bias less than +/- 1.0 ºC and an SD of less than 2 ºC, four additional streams qualify: Caples Creek, Pyramid Creek, SFAR, and SilFAR. Mill Creek simulations were, on the average, quite representative but did tend to fluctuate from observed values. Overall, the simulations of the mean daily water temperature provided a good to excellent fit to the observed validation data set.

3.2 Maximum Daily Temperature Calibration - Validation Results

When applying the SNTEMP model to a simple stream system, it is possible to calibrate mean daily temperatures and maximum daily temperatures at the same time. The EID system is so complex, however, that, due to data management issues, looking at mean daily and maximum daily simulations at the same time was overwhelming. We decided, therefore, to calibrate the maximum daily temperatures after we had completed mean daily calibration.

As currently designed, SNTEMP calculates maximum daily temperatures by assuming that the stream structure at the simulation point applies upstream. A mean daily temperature (calculated from the local structure definition) is hindcasted to an upstream location that is a day-light-hours travel time upstream. The maximum daily temperature at the simulation point is calculated from this hindcasted mean daily temperature by subjecting the traveling water to a maximum day-time air temperature that is calculated from meteorological conditions and user-supplied calibration coefficients. The major flaw in this approach is that this hindcasted mean-daily temperature has little association with what was predicted at this same upstream location by the mean daily temperature model. Another flaw in this maximum temperature algorithm is that the calculated maximum daytime air temperatures can be quite arbitrary with little relation to the actual maximum daytime air temperature.

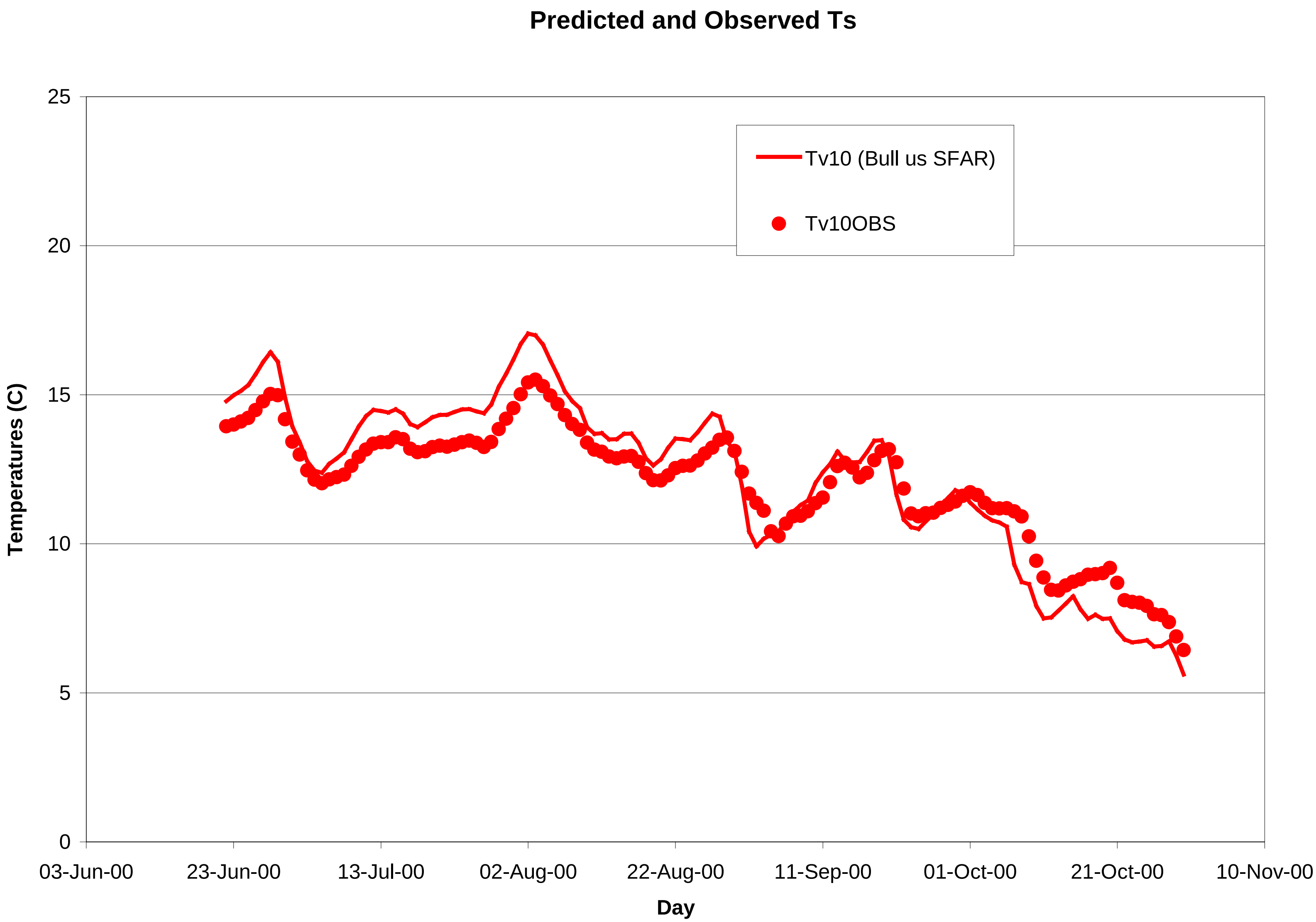

Figure 3-13. Bull Creek mean daily validation time-series, upstream of SFAR (recorder 10).

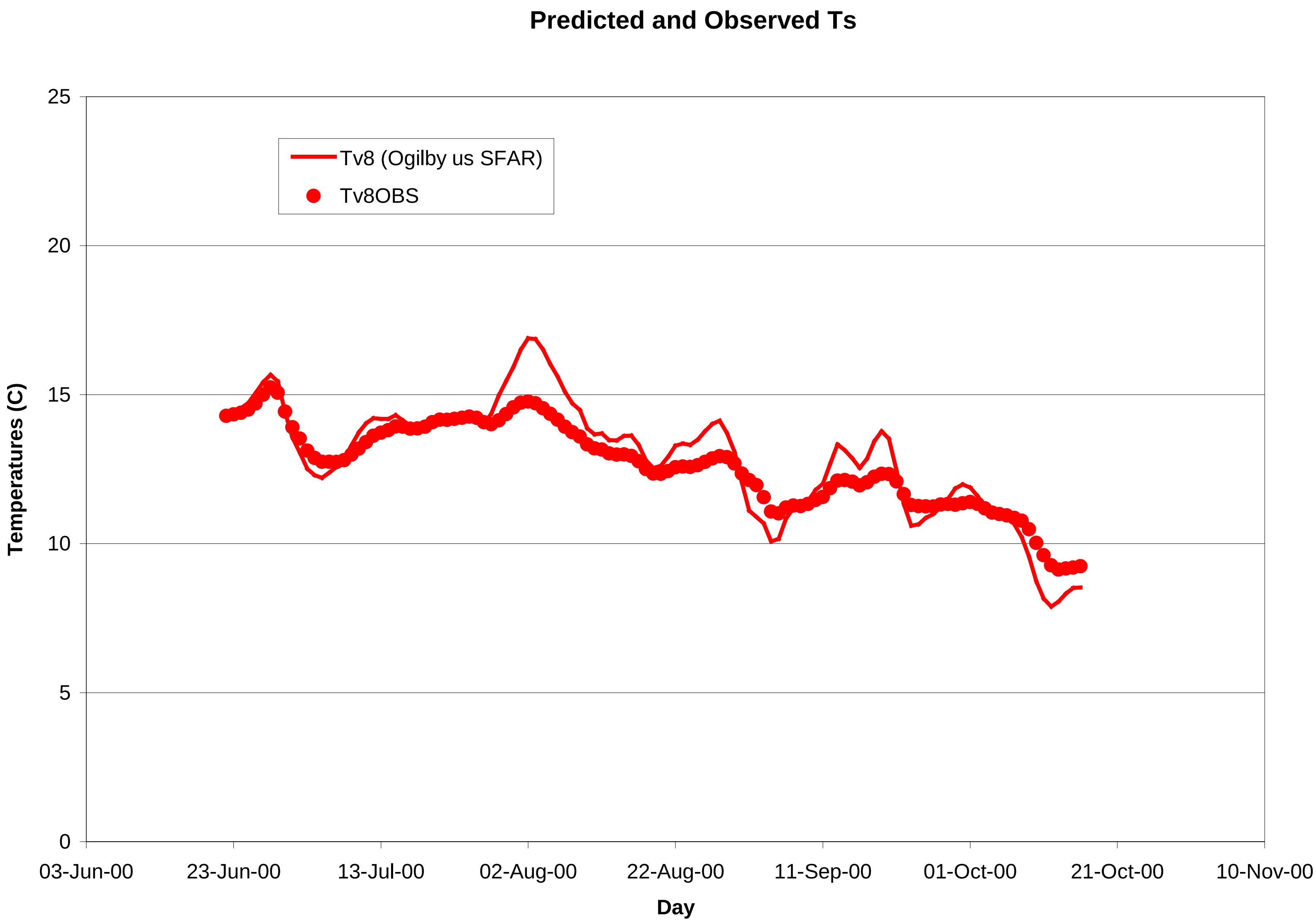

Figure 3-14. Ogilby Creek mean daily validation time-series, upstream of SFAR (recorder 8).

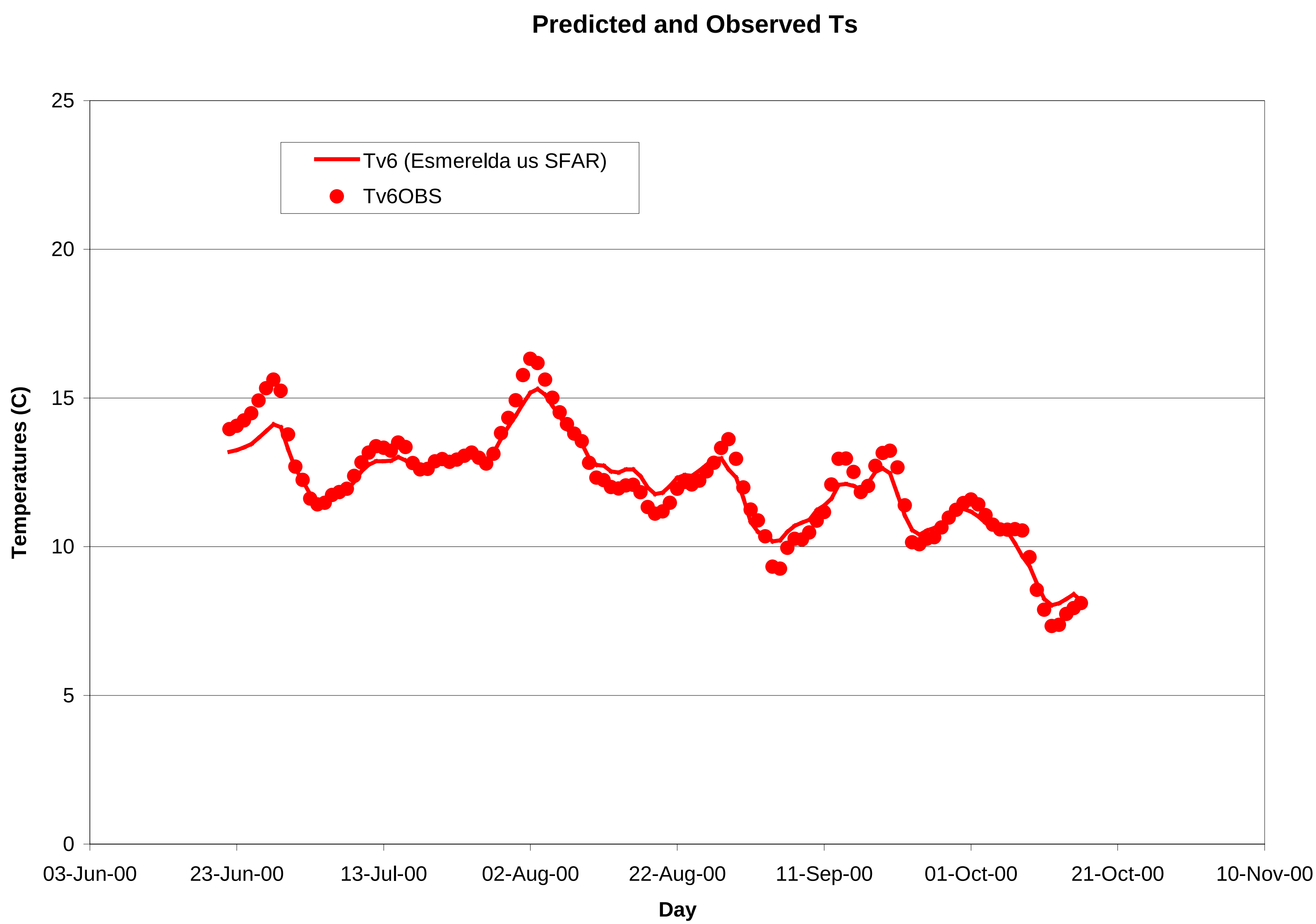

Figure 3-15. Esmerelda Creek mean daily validation time-series, upstream of SFAR (recorder 6).

Observed maximum daily temperature values were averaged using a two-day moving mean to produce 117 two-day averages for the calibration data set and 131 two-day averages for the validation data set. The models were calibrated by adjusting maximum daily stream temperature parameters to reduce observed systematic bias. After calibrating to the 2001 data the validation run with 2000 data produced the following results in simulation of daily maximum temperatures:

Mean bias, Overall = 1.93 °C
Standard deviation of bias (SD) = 3.25 °C
Number of points (131 simulation periods * 24 locations) = 3144

These statistics were calculated for each simulated stream and are summarized in Table 3-2.

Table 3-2. Maximum Daily Validation Statistics by Stream.

Stream	**Bias (°C)**	**SD (°C)**	**Minimum Bias (°C)**	**Maximum Bias (°C)**	**n**
Bull	+0.97	1.21	-2.03	2.46	131
Caples	+5.03	2.37	-1.97	10.74	393
Esmerelda	+0.40	0.68	-1.19	1.66	131
Mill	+2.67	2.55	-6.90	6.08	131
Ogilby	+1.47	1.06	-1.15	3.53	131
Oyster	+2.29	1.39	-1.91	6.71	131
Pyramid	+0.09	0.36	-0.89	1.11	131
SFAR	+2.85	1.98	-3.74	9.03	917
SilFAR[1]	+0.42	4.15	-18.48	6.44	1048

The maximum temperature model generally overpredicts what was observed in 2000 (and 2001). On average, this overprediction ranges from less than 0.5 ºC to over 5 ºC. A discussion of the simulations by stream follows.

3.2.1 South Fork American River (SFAR)

Figure 3-16 presents a longitudinal profile plot of the SFAR maximum daily temperature simulation (compare to Figure 3-1, the mean daily simulation). The solid line represents the simulated temperature; the observed data are presented as points. As this figure illustrates, the model overpredicts maximum daily temperatures at all locations on SFAR for this day. Overpredictions range from 1 to 4 ºC.

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[1] Includes Silver Creek from Silver Lake to the junction with Caples Creek.

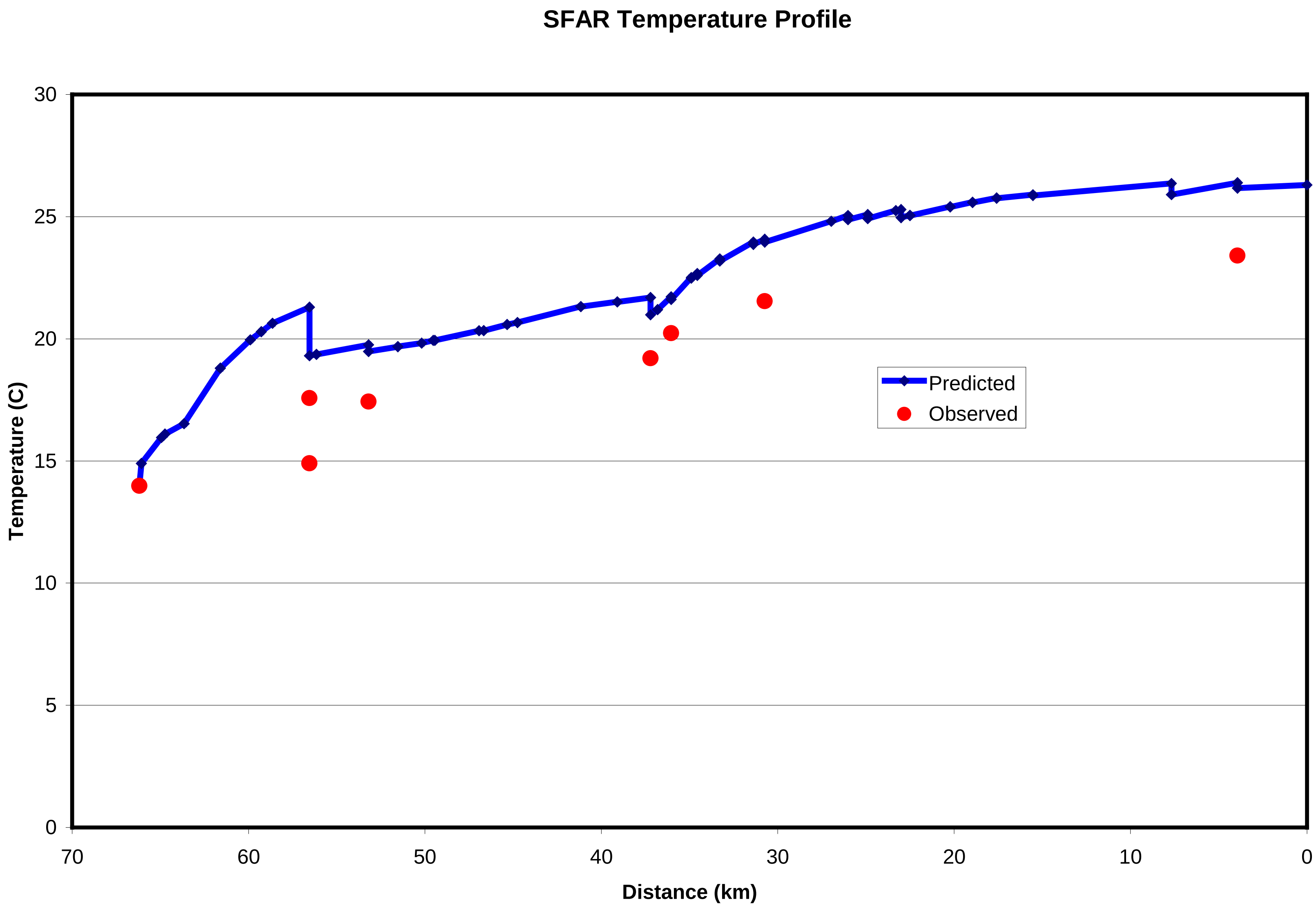

Figure 3-16. SFAR maximum daily temperature longitudinal profile, 7/20/00.

Figure 3-17[1] represents the validation simulation on SFAR upstream of Pyramid Creek. The model consistently overpredicted the observed values at this location, occasionally overpredicting by as much as 8 ºC (August 2000). This overprediction diminishes downstream.

Figure 3-18 presents the validation simulation on SFAR upstream of the SilFAR confluence. The simulated values follow the same pattern as the observed temperatures but are generally 3-4 ºC higher than observed.

Figure 3-19 presents the validation simulation on SFAR upstream of the El Dorado Powerhouse return flow. The simulated values follow the same pattern as the observed but temperature are generally 3.3 ºC higher than observed.

3.2.2 Silver Fork American River/Silver Creek (SilFAR)

A longitudinal profile of the SilFAR maximum daily temperature simulation for 7/20/00 is presented in Figure 3-20. On this day, the model overpredicts temperature (approximately 3 ºC) between where SilFAR is joined by Oyster Creek (1 km downstream of simulation start point) and where SilFAR is joined by Caples Creek (km 63). Between the Caples Creek confluence and Long Creek confluence (km 44) the amount of overprediction gradually decreases until a close approximation of the temperatures is observed upstream and downstream of Long Creek. The simulated temperature overpredicts the observed value by approximately 1.5 ºC at km 37 (recorder 22 upstream of the SFAR confluence).

Figure 3-21 presents the SilFAR maximum daily validation time-series, upstream of Oyster Creek at recorder 46. This represents a good approximation of observed values. Further downstream, Figure 3-22 presents the validation simulation on SilFAR upstream of Caples Creek (recorder 42). At this site, the model overpredicts observed daily maximum temperatures by about 5 ºC in June through August. By September and October, the simulation overpredicts observed temperatures by 1 to 2 ºC.

Figure 3-23 presents the SilFAR maximum daily validation time-series, upstream of SFAR confluence (recorder 22). This represents a good approximation of observed values with significant overprediction throughout July (up to 5 ºC).

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[1] In all maximum daily validation time-series figures, "Tvnnmax" (where nn is a number) represents the maximum daily temperature simulated at the validation recorder nn. "TvnnOBSmax" represents the maximum daily temperatures observed at recorder nn.

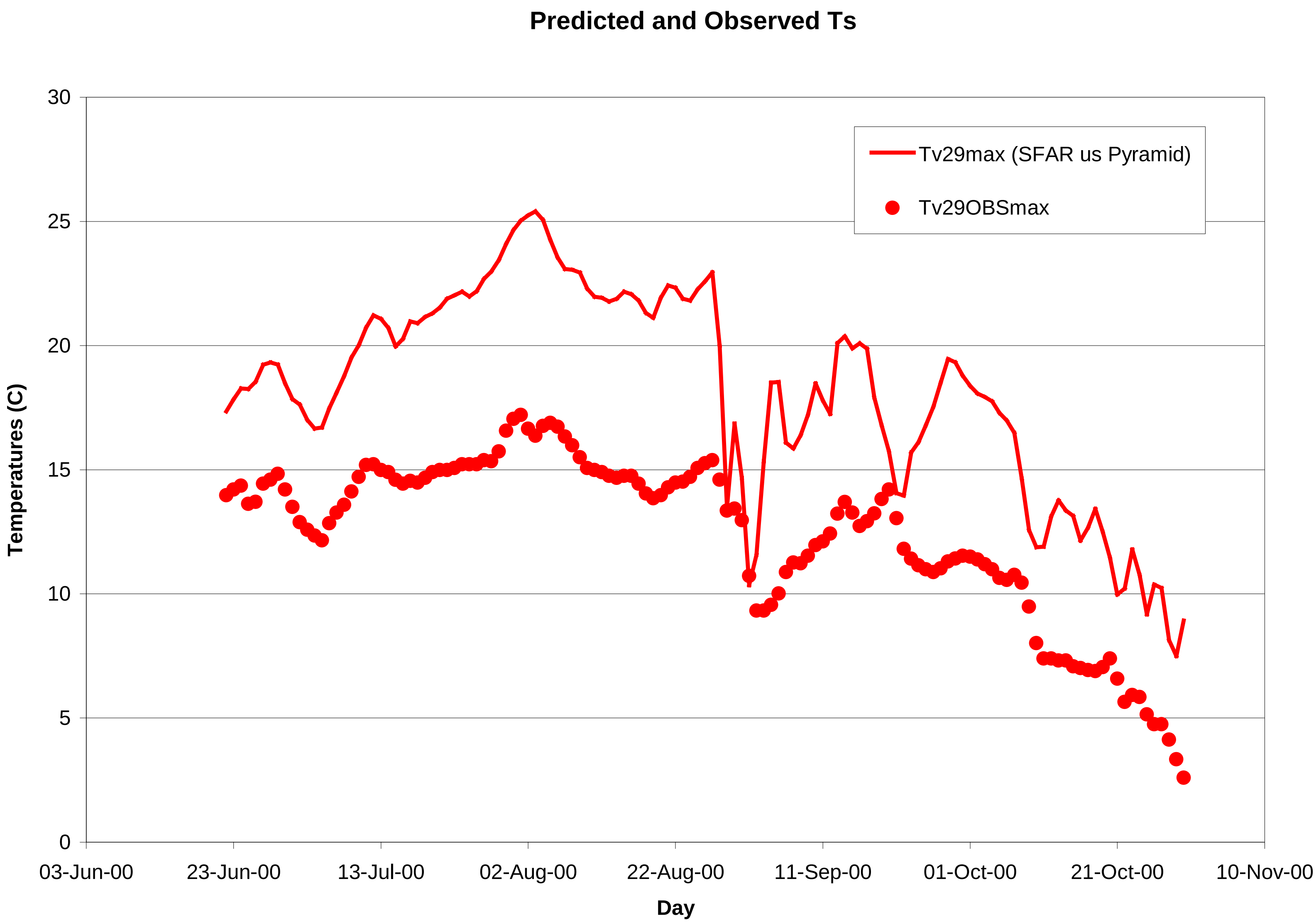

Figure 3-17. SFAR maximum daily validation time-series, upstream of Pyramid Creek (recorder 29).

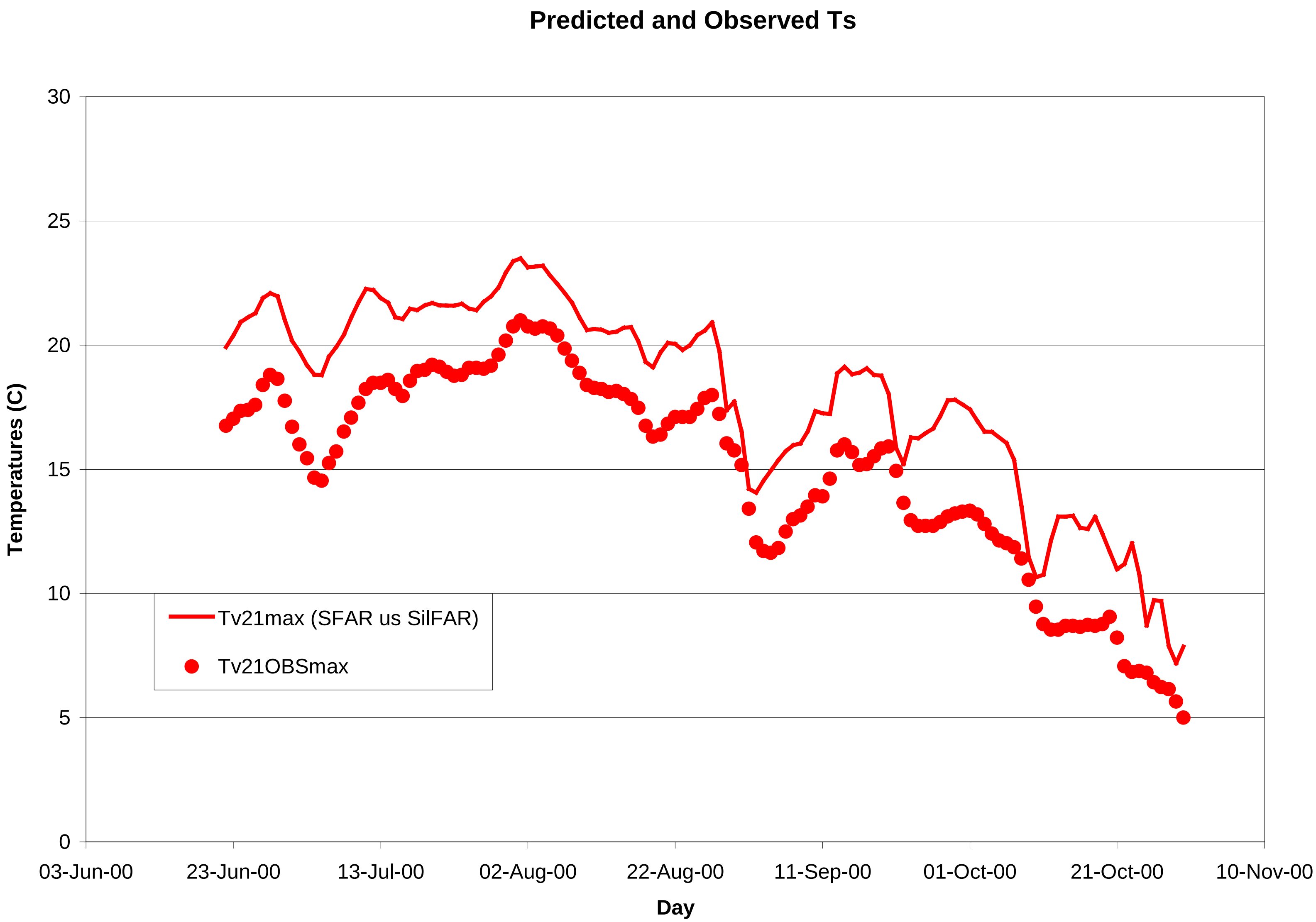

Figure 3-18. SFAR maximum daily validation time-series, upstream of SilFAR (recorder 21).

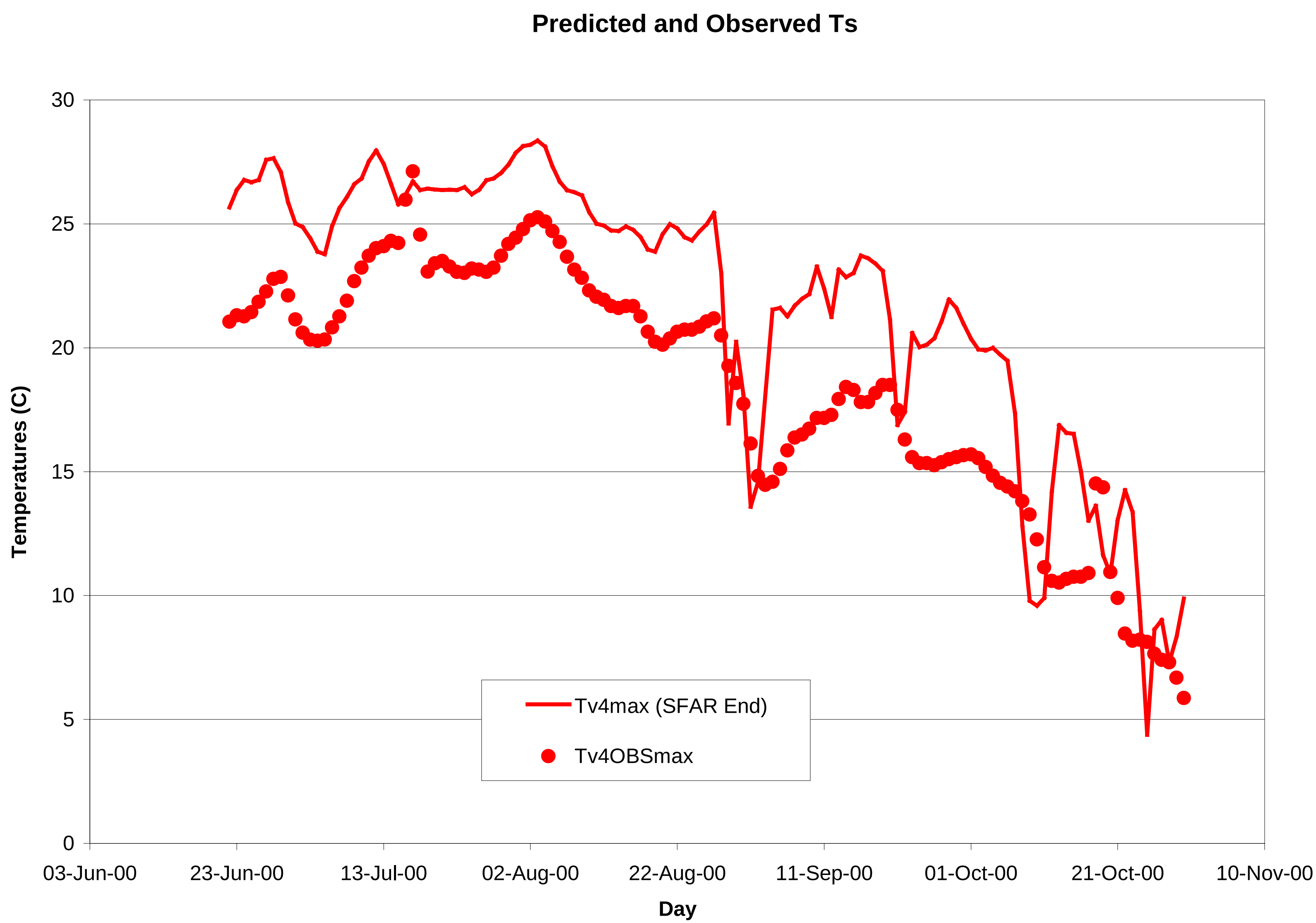

Figure 3-19. SFAR maximum daily validation time-series, upstream of El Dorado Powerhouse Inflow (recorder 4).

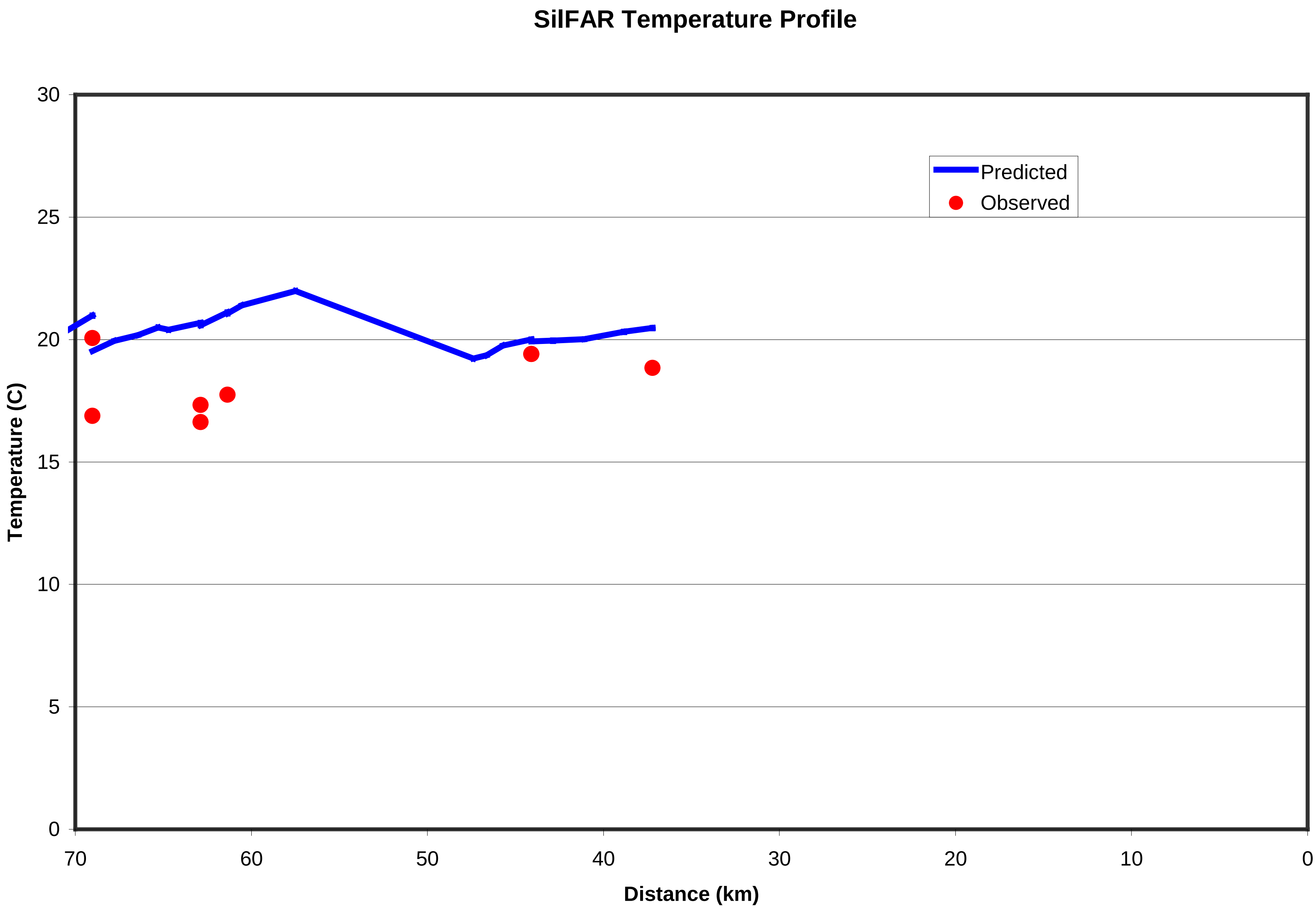

Figure 3-20. SilFAR maximum daily temperature longitudinal profile, 7/20/00.

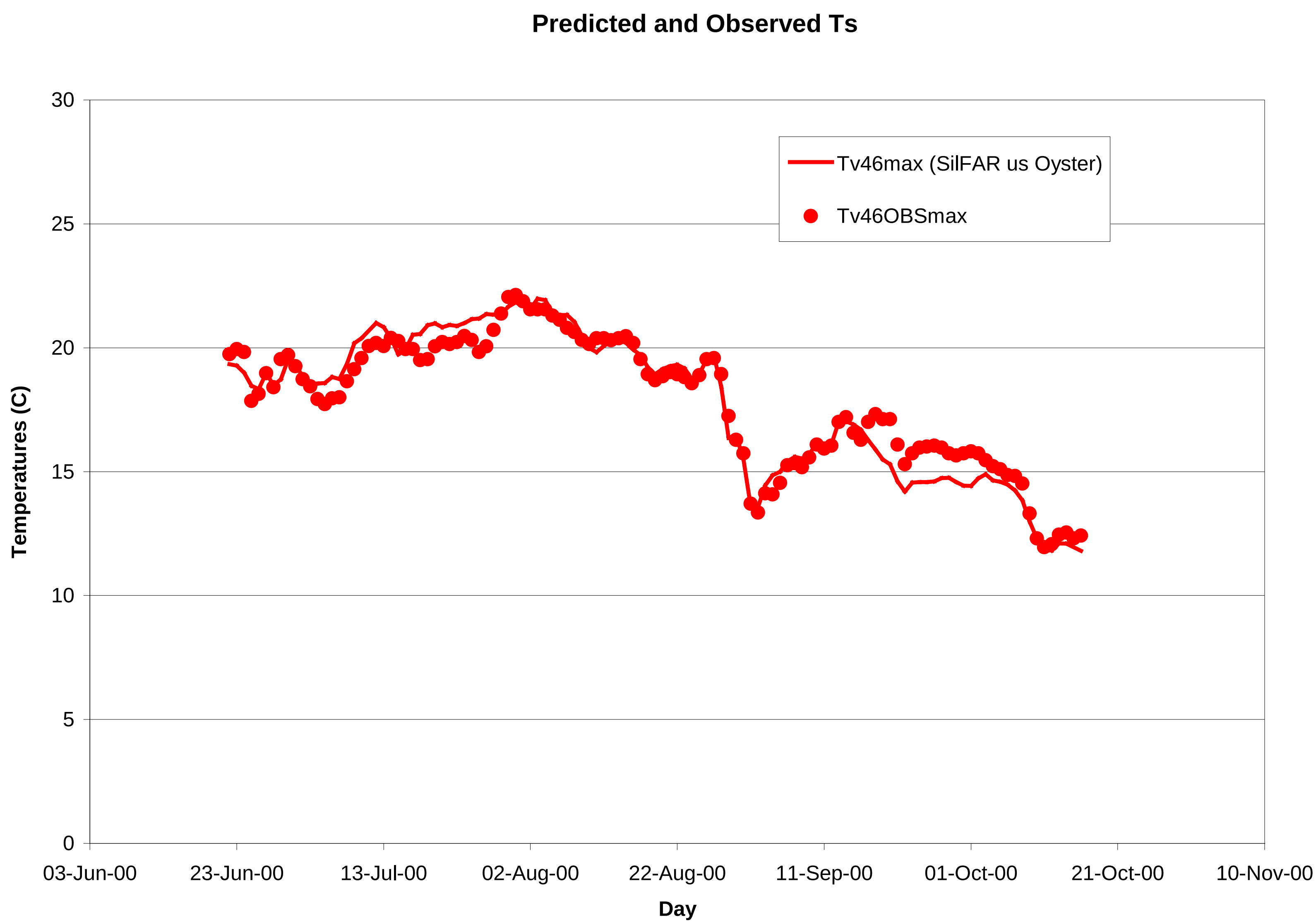

Figure 3-21. SilFAR maximum daily validation time-series, upstream of Oyster Creek (recorder 46).

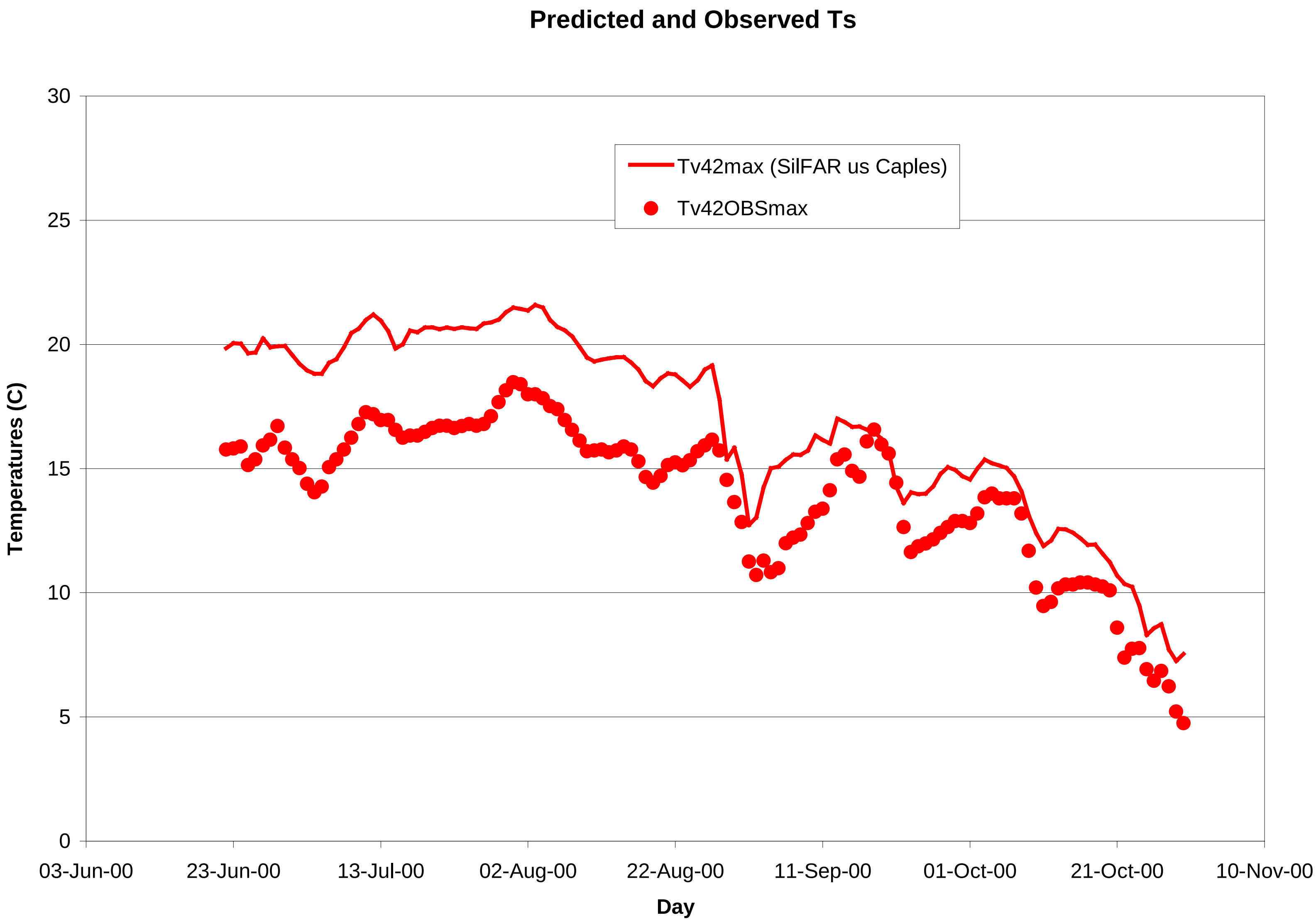

Figure 3-22. SilFAR maximum daily validation time-series, upstream of Caples Creek (recorder 42).

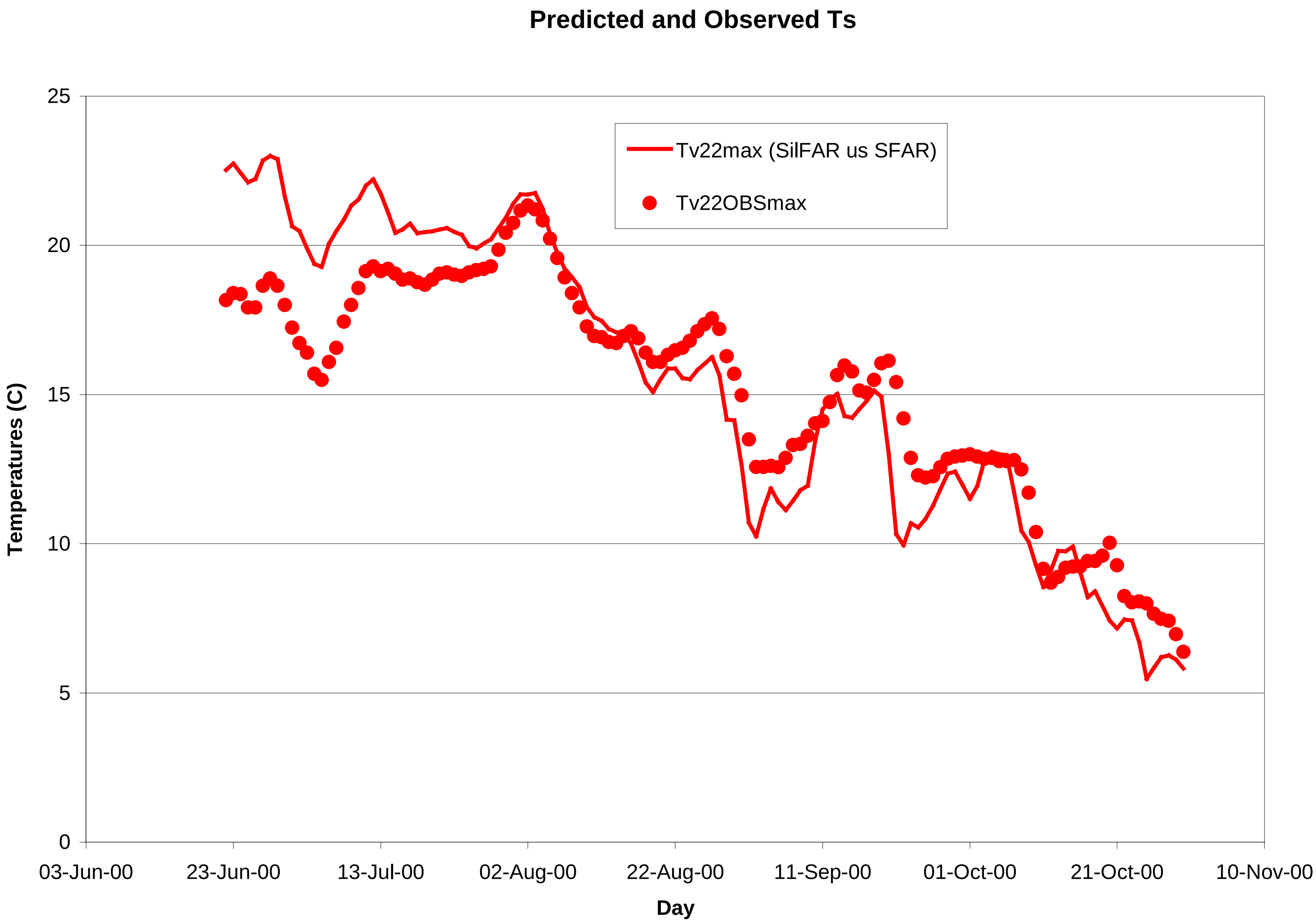

Figure 3-23. SilFAR maximum daily validation time-series, upstream of SFAR (recorder 22).

3.2.3 CAPLES CREEK

Figure 3-24 presents the validation time-series for recorder 50 that represents Caples Creek water temperatures immediately upstream of the Caples/North Fork Caples Creek confluence. Figure 3-25 presents the validation time-series for recorder 48 that represents Caples Creek water temperatures immediately upstream of the Caples/Silver Creek confluence. Both of plots indicate that Caples is poorly simulated. The model overpredicts observed temperatures by an average of 4.8 ºC at recorder 50 and by an average of 5.6 ºC at recorder 48.

3.2.4 PYRAMID CREEK

Figure 3-26 presents the validation time-series for recorder 27 on Pyramid Creek. This figure represents Pyramid Creek maximum daily temperatures immediately upstream of the Pyramid/SFAR confluence. The simulated maximum temperatures are a close approximation of the observed temperatures with an average bias of +0.09 ºC

3.2.5 MILL CREEK

Figure 3-27 presents the maximum temperature validation time-series at recorder 12, upstream of the Mill Creek/SFAR confluence. Simulated maximum temperatures overpredict observed values by 4 to 5 ºC from June through most of August. Starting in September simulated values more closely approximate observed temperatures but are considerably more variable than observed.

3.2.6 BULL CREEK

Figure 3-28 presents the maximum daily temperature validation time-series at recorder 10, upstream of the Bull Creek/SFAR confluence. In general this simulation is a fair representation of observed values. Simulated values overpredict observed values by 1 to 2 ºC from June through August. Starting in September simulated values more closely approximate observed values although tending to slightly underpredict.

3.2.7 OGILBY CREEK

Figure 3-29 presents the validation time-series at recorder 8, upstream of the Ogilby Creek/SFAR confluence. In general this simulation is a fair representation of observed values with the model having a tendency to overpredict observed values by about 1.5 ºC.

3.2.8 ESMERELDA CREEK

Figure 3-30 presents the validation time-series at recorder 6, upstream of the Esmerelda Creek/SFAR confluence. In general this simulation is a good representation of observed values.

3.2.9 MAXIMUM DAILY TEMPERATURE VALIDATION SUMMARY

We will classify the maximum temperature simulation models for each stream using the previously defined criteria for model goodness-of-fit:

- Excellent: bias of less than +/- 0.5 ºC and a standard deviation of the bias (SD) less than 1.0 ºC;

- Good: bias less than +/- 1.0 ºC and a SD of less than 2 ºC;

Additionally, if we define the following new categories:

- Fair: bias less than +/- 2.0 ºC and a SD of less than 4 ºC;

- Poor: worse than fair.

Two streams had an excellent representation of maximum daily water temperatures in the model: Esmerelda Creek and Pyramid Creek. Bull Creek has a good model representation. The representation of maximum daily water temperature by the model for Ogilby Creek is fair. The remaining five streams, including all of the larger Project streams, are poorly represented by the maximum temperature model.

The accuracy of the maximum temperature predictions by subtracting the validation bias (see Table 3-2) from future simulated maximum daily temperatures. With this simulation bias removed, only one stream (SilFAR) could be considered a poor representation as a result of poor precision (e.g. a large uncertainty will remain in the simulated values).

We should keep in mind, however, that this bias correction will not be that effective the farther simulated conditions deviate from those observed during calibration and validation.

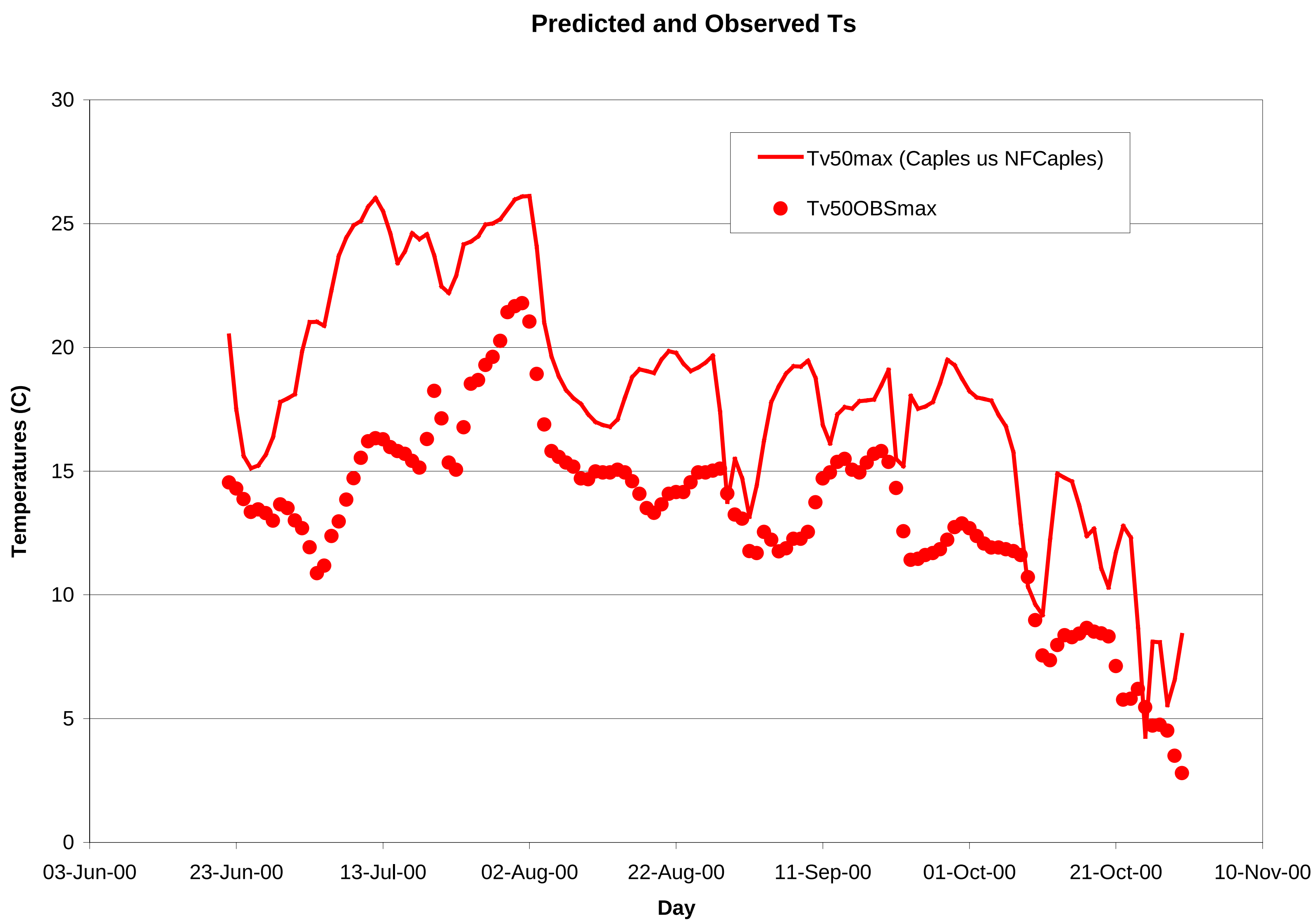

Figure 3-24. Caples Creek maximum daily validation time-series, upstream of North Caples Creek (recorder 50).

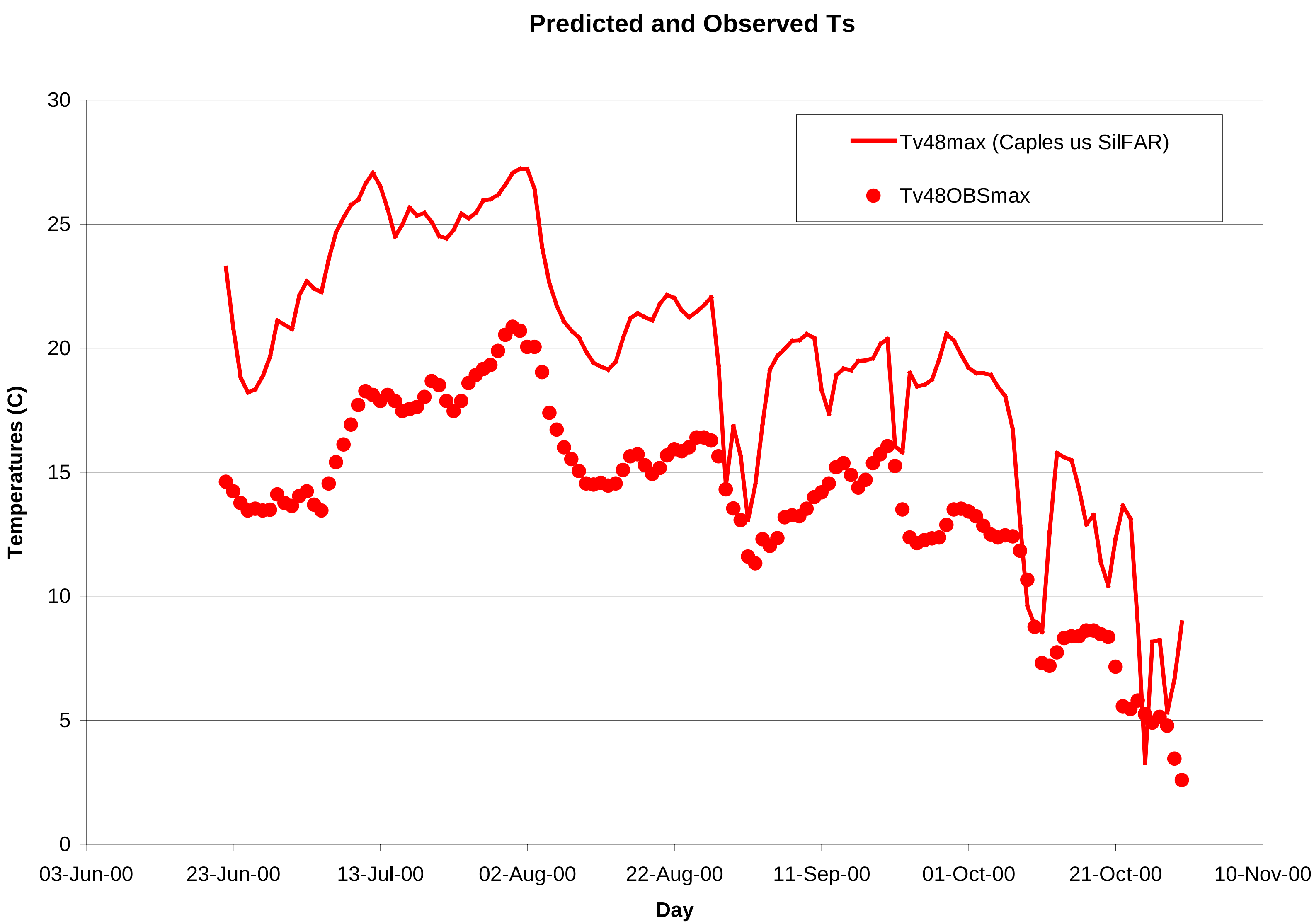

Figure 3-25. Caples Creek maximum daily validation time-series, upstream of Silver Creek (recorder 48).

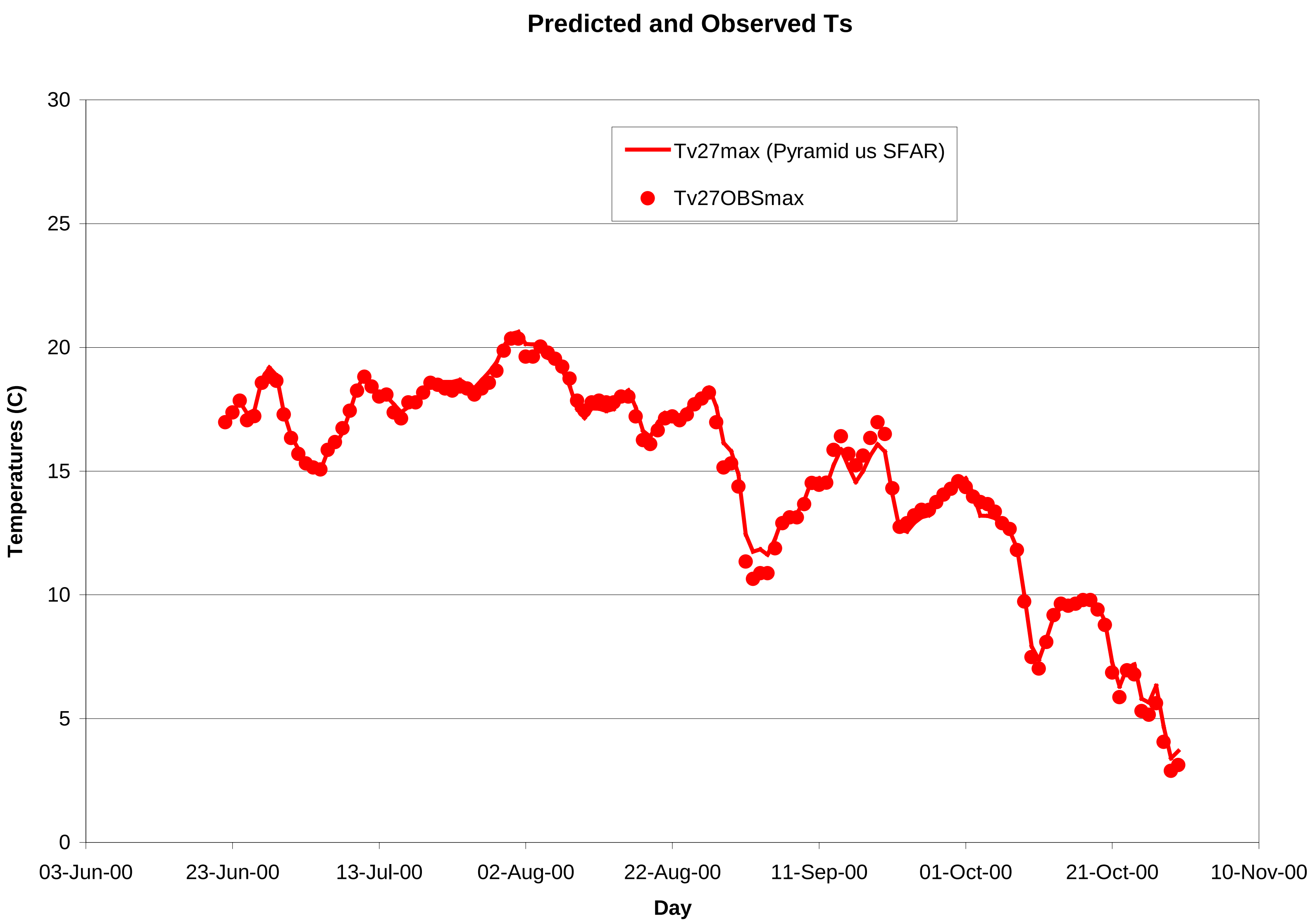

Figure 3-26. Pyramid Creek maximum daily validation time-series, upstream of SFAR (recorder 27).

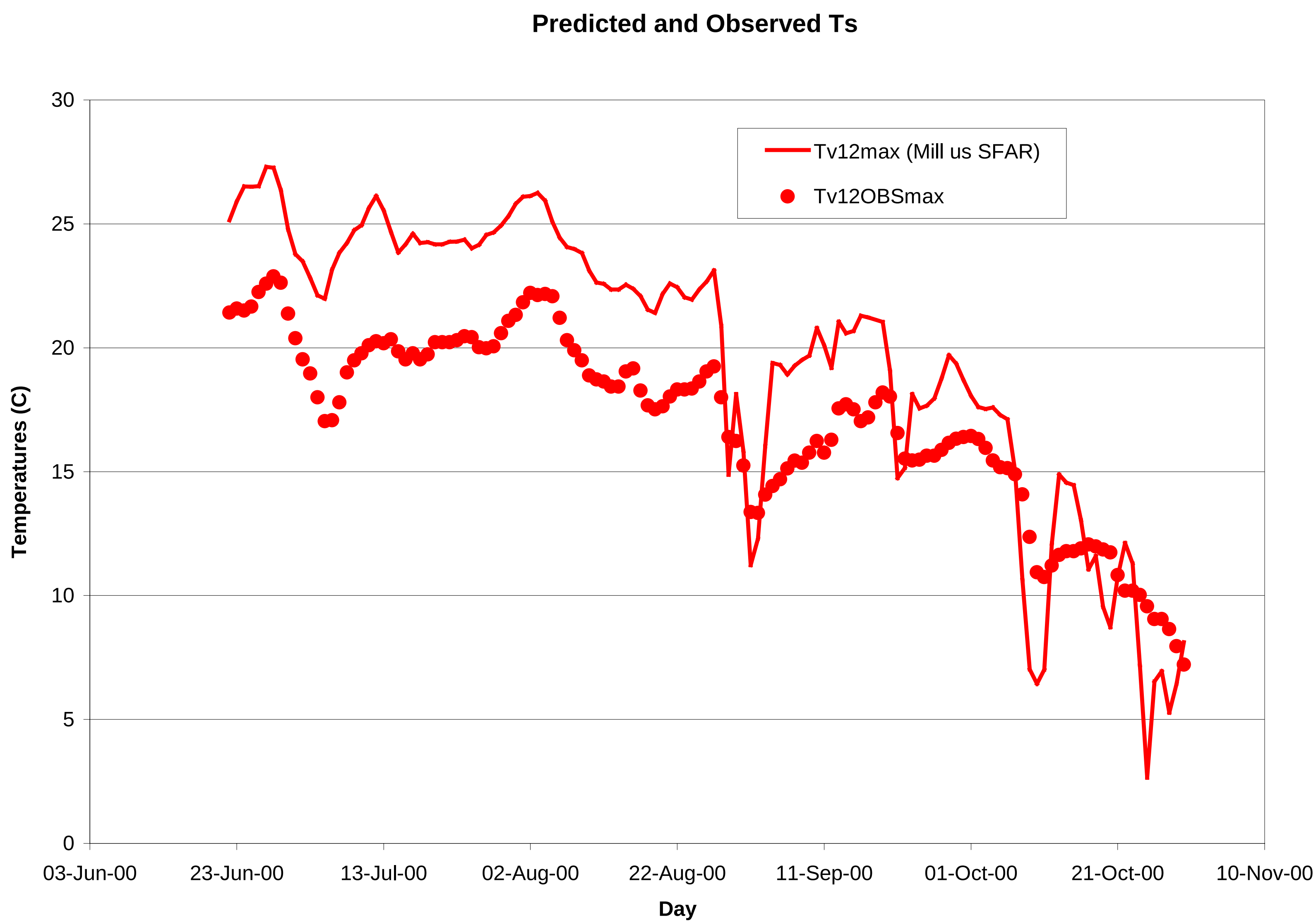

Figure 3-27. Mill Creek maximum daily validation time-series, upstream of SFAR (recorder 12).

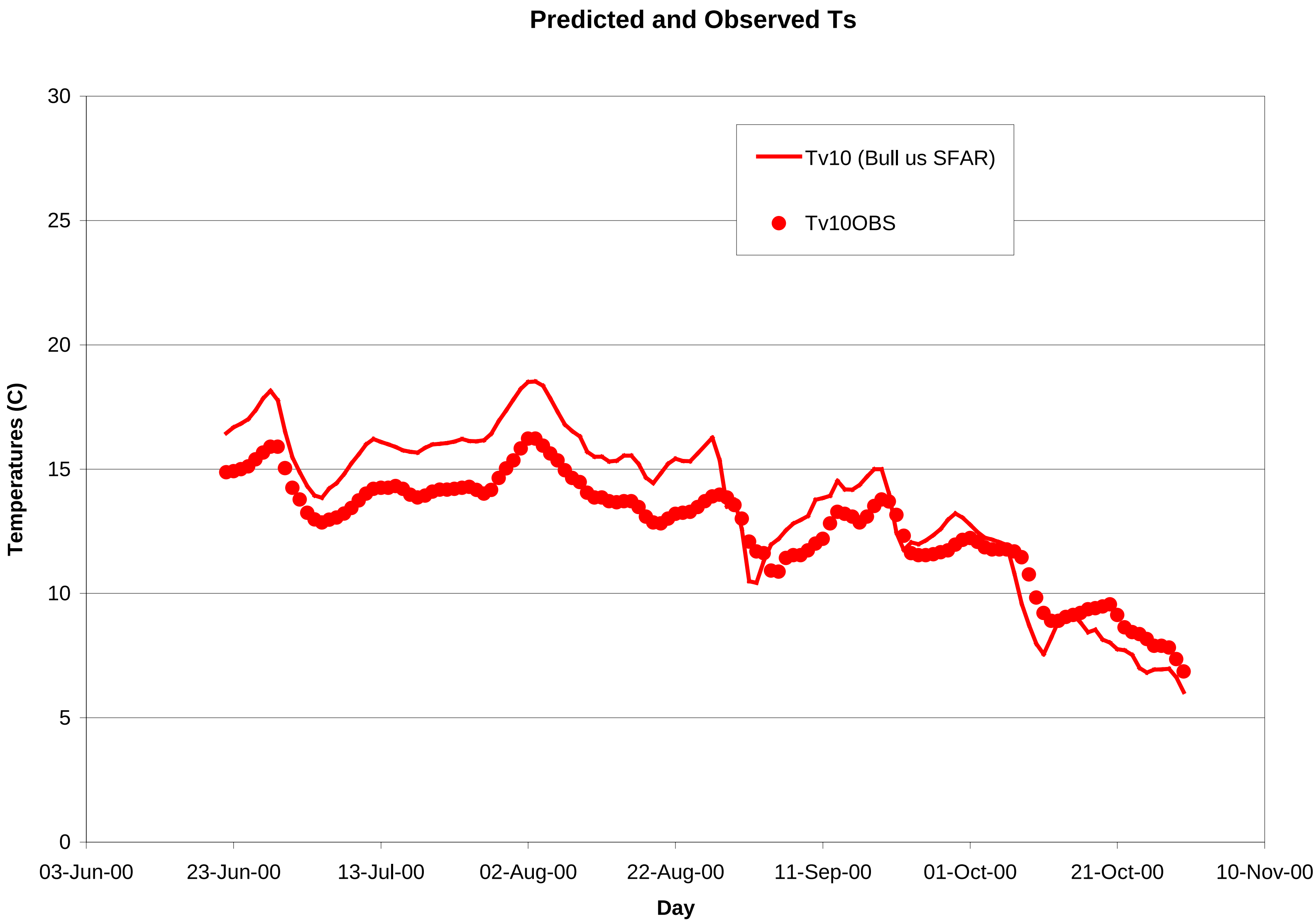

Figure 3-28. Bull Creek maximum daily validation time-series, upstream of SFAR (recorder 10).

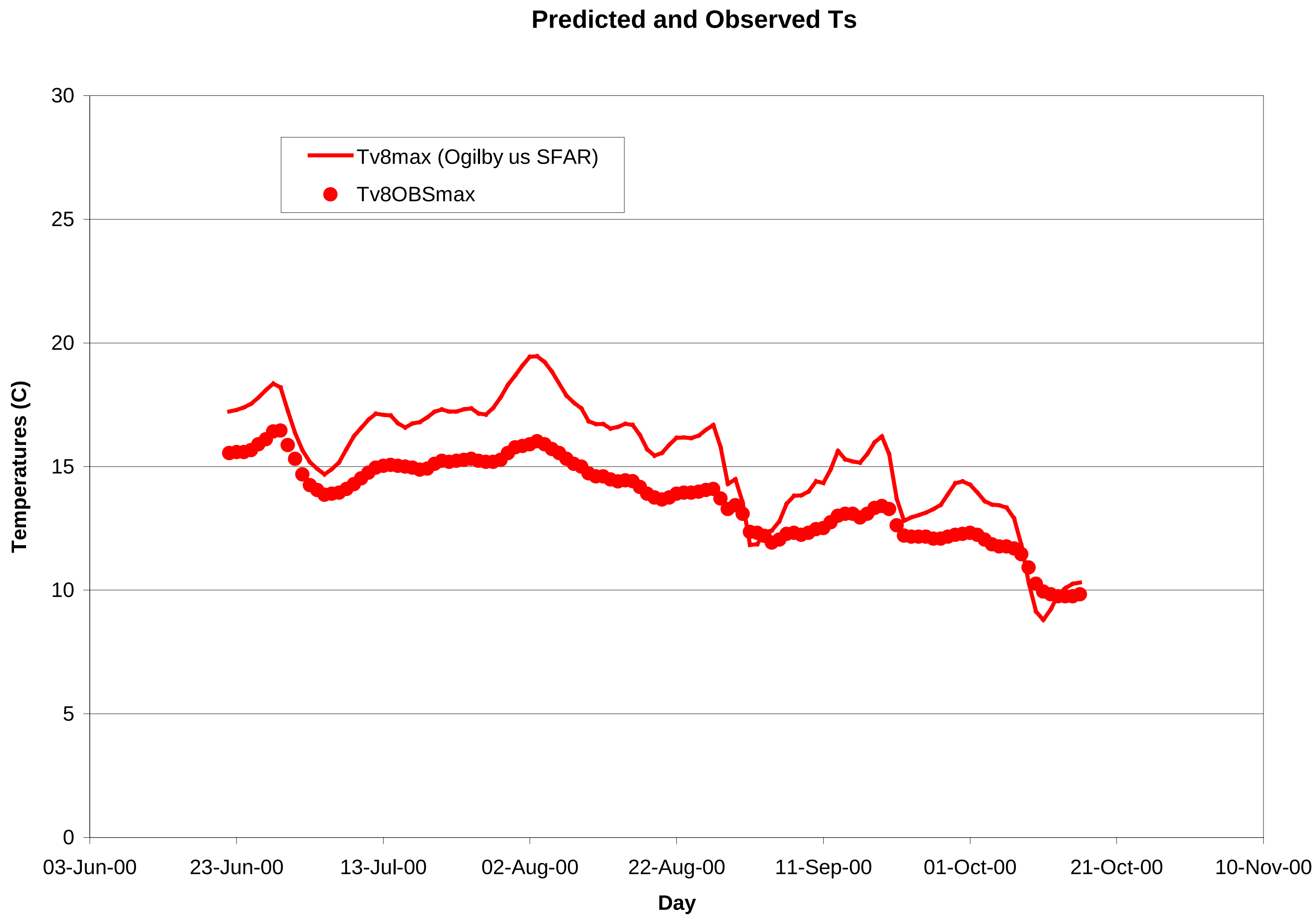

Figure 3-29. Ogilby Creek maximum daily temperature validation time-series, upstream of SFAR (recorder 8).

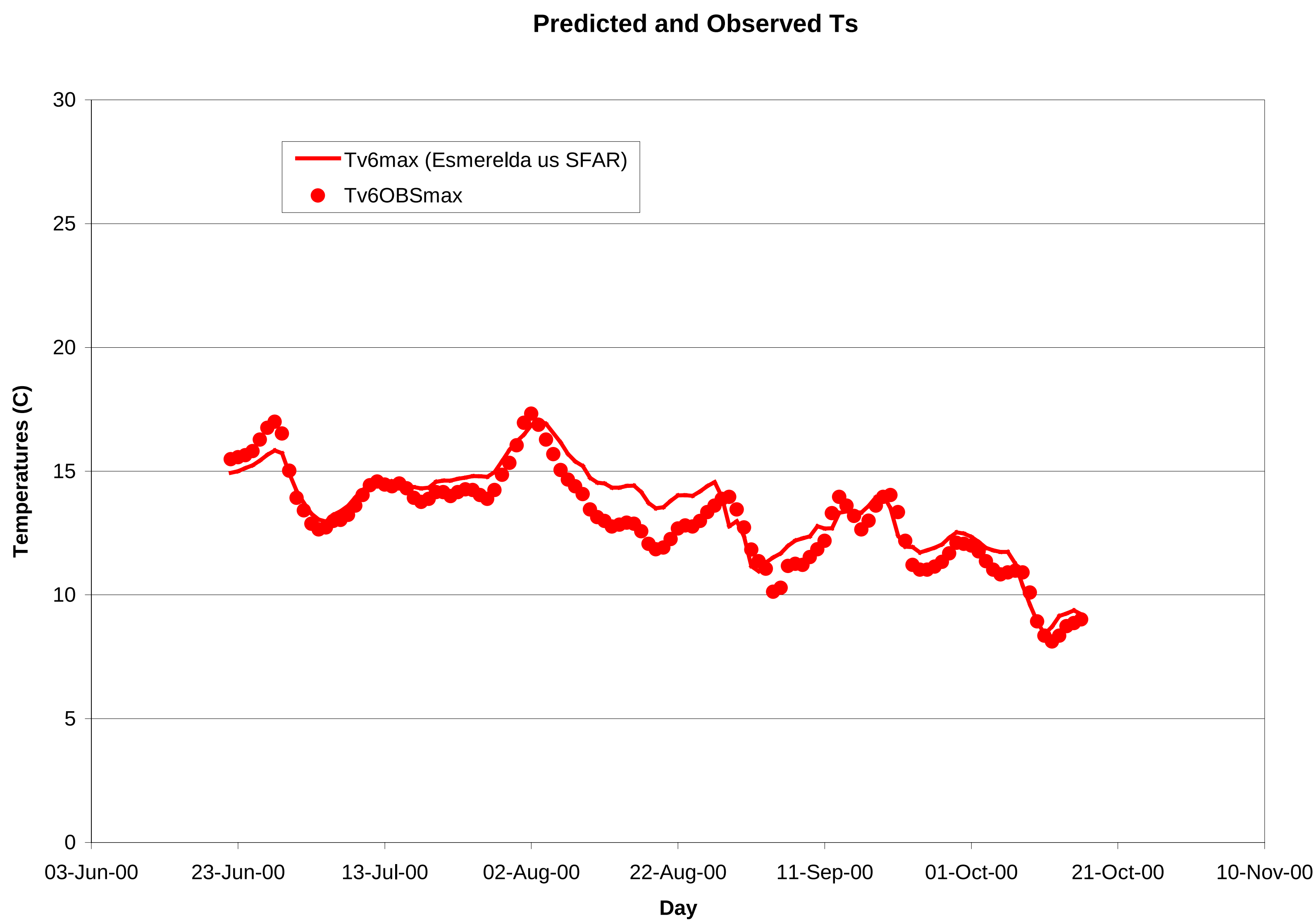

Figure 3-30. Esmerelda Creek maximum daily temperature validation time-series, upstream of SFAR (recorder 6).

The link between the temperature model and HydroLogics flow model has been developed and will need only minor adjustments (to account for flows at locations other than encountered in calibration/validation) to apply to forecasted simulations of alternate flows for the " with-reservoirs" set of simulations.

The mean daily temperature prediction model does a good to excellent job of predicting observed mean daily temperatures. This model can be considered ready to apply to forecasted simulations of alternate flows with no further modifications necessary.

The maximum daily temperature prediction model generally does a poor job of predicting observed maximum daily temperatures. This results from the limited nature of the maximum temperature algorithm in SNTEMP and also from the particular conditions within the EID Project area.

The only way to improve the maximum daily temperature predictions would be to recalibrate the mean-daily calibration and the maximum-daily calibration at the same time. We recommend, however, that the existing maximum daily model be used as is, except that the reported mean bias should be subtracted from the predicted values to provide an improved estimate of actual maximum daily temperatures. This should be done on a stream-by-stream basis.

HydroLogics, Inc. 2001. Phase I Model Development. Internet document. http://www.project184.org/doc_lib/doc_lib.html

Meyer, H. 2002. Pers. Comm. 6/17/02.

Theurer, D., K. A. Voos, and W. J. Miller, 1984. Instream Water Temperature Model. Instream Flow Information Paper 16 Cooperative Instream Flow and Aquatic System Group, U.S. Fish and Wildlife Service. Fort Collins, Colorado