To the Graduate Council:

I am submitting herewith a thesis written by SallyRose Anderson entitled "Wind River Range Snowpack Reconstruction Using Dendochronology and Sea Surface Temperatures." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Environmental Engineering.

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Wind River Range Snowpack Reconstruction
Using Dendochronology and Sea Surface Temperatures

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ABSTRACT

Multiple reconstructions of April 1st snow water equivalent (SWE) are generated for the Wind River Range (WRR), located in west-central Wyoming, to determine the most accurate predictors. Predictors included climate signal data (Southern Oscillation Index), traditional predictors (tree-ring chronologies), and non-spatially biased Pacific Ocean sea surface temperatures (SSTs). Incorporation of Pacific Ocean SSTs as a whole provides a more comprehensive representation of oceanic-atmospheric variability. Rotated principal component analysis (PCA) was used to regionalize April 1st snowpack data (1961 – 1999) from snow telemetry stations (SNOTEL stations). Tree-ring chronologies that were stable across the period of overlapping records (1961 – 1999) and that were positively correlated with regional snowpack at 99% confidence levels or higher were retained. Singular value decomposition (SVD) was performed on Pacific Ocean SSTs and regional snowpack data to identify coupled regions of climate (SSTs) and hydrology (SWE). Stepwise regressions were performed across the calibration period to identify the best predictor combinations. When data from the instrumental based SST regions identified by SVD were included in the pool of predictors, an increase in reconstruction skill was observed. Further regressions were performed using tree based and coral based SST data. Reconstruction equations were obtained from these regressions and regional April 1st snowpack was reconstructed for the WRR for all three types of SST data. A higher degree of snowpack variance is explained by reconstructions utilizing tree based, coral based, and instrumental based data for the Pacific Ocean SST region identified by SVD than is possible utilizing only tree-ring and SOI data, indicating that non-spatially biased SSTs are excellent predictors for snowpack reconstruction in the WRR.

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1.0 INTRODUCTION

1.1 Introduction and Literature Review

Snowfall in the western United States accounts for 50 to 70% of the total precipitation in the area (Clark et al., 2001). The resulting snowpack serves as a natural reservoir, storing water during the winter and releasing it during the spring and summer snowmelt season, comprising 50 to 80% of the annual stream flow [Natural Resources Conservation Service (NRCS), 2010]. The snowmelt period is defined as April 1st through September 30th with the majority of stream flow in the Colorado River basin resulting from melting of mountain snowpack during April through July (Kuhn, 2005).

Since snowpack is a major source of surface water supply it is important to understand snowpack characteristics, including the natural variability of seasonal snowpack and the range of extremes that can be expected (Woodhouse, 2003). The Colorado River provides water to seven states and Mexico, and serves an estimated 25 million people (Southern Nevada Water Authority). This study examines the Wind River Range. Runoff from the Wind River Range snowpack flows into the Green River, the largest tributary to the Colorado River and a key component of the Upper Colorado River Basin.

Snowpack measurements exist for the Wind River Range, but only date back to the mid 1900s. This limited data is inadequate for assessing long-term variation in annual snowpack and resulting water supply. Snow water equivalent (SWE) is the amount of water contained within the snowpack (NRCS, 2010). A longer record of historical snowpack is necessary to draw any conclusions about regional snowpack and potential future SWE variability in a long-term perspective (Timilsena and Piechota, 2007).

In the western United States, the compounding effects of atmospheric variability and increased population have resulted in concerns regarding the availability of water. Understanding the historical variation in snowpack accumulation would provide a basis for more accurate projections for future snowpack accumulation and resulting SWE.

To increase understanding of snowpack variability, it is necessary to look at other climate data. There are several studies that have successfully used tree-ring chronologies as a predictor to reconstruct precipitation, drought, temperature, and stream flow records (Stahle and Cleaveland 1988, Loaiciga et al. 1993, Biondi et al., 1999, Cook et al. 1999, Cleaveland, 2000, Gray et al., 2004, Watson et al., 2009, Barnett et al., 2010). Alternatively, only a few studies have been done using tree-rings to reconstruct snowpack (Woodhouse, 2003, Larocque and Smith, 2005, Timilsena and Piechota, 2007).

Reconstructions have likely not been generated primarily because of the short overlap between snow measurements and available tree-ring chronologies (Woodhouse, 2003). The majority of snowpack records in the Wind River Range date back to 1961. Recent tree-ring chronology collections have resulted in a dataset of chronologies that are current through 1999. This allows for a 39-year period of overlap.

Atmospheric variability occurs on interannual and interdecadal time scales in the form of the El Niño Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), the Atlantic Multidecadal Oscillation (AMO), and the North Atlantic Oscillation (NAO). Since the current snowpack record for the Wind River Range only dates back approximately 50 years, it is an insufficient period to fully understand the impacts of interannual and interdecadal atmospheric variability. Several potential relationships between historic climatic variability and western United States stream flow and precipitation levels have been identified when reviewing data for the past hundred years (Cayan et al, 1992, Enfield et al, 2001, Graumlich et al., 2003, McCabe et al, 2004). Reconstructing the Wind River Range would provide valuable information necessary for the investigation of long-term oceanic and atmospheric influences on the stream flow in the Upper Colorado River Basin.

The goal of this study is to reconstruct regional snowpack for April 1st for the Wind River Range. The snowpack data available on April 1st is a good indicator of the water content in the maximum seasonal snowpack and the resulting water supply following the summer snowmelt season (Cayan, 1996). In addition to incorporating tree-ring chronology data and climate variability (ENSO), this study also incorporates Pacific Ocean Sea Surface Temperatures (SSTs) to improve the statistical skill of the reconstruction. The combining of biological (tree-ring) proxy records with climate (Pacific Ocean SST) variability will result in a more statistically skillful reconstruction of snowpack in the Wind River Range. In turn, this will provide information necessary for in-depth analysis of interdecadal and interannual climate fluctuations, which may reveal linkages that will result in improved drought prediction, planning, and response to climate change.

2.0 REGION OF STUDY

The Wind River Range (WRR) is located in west-central Wyoming, as shown in Figure 1. This remote mountain range is approximately 160 kilometers (100 miles) in length and encompasses over 9,100 square kilometers (2.25 million acres). The mountain range is tall and narrow, with eight summits exceeding 4,110 meters (13,500 feet) (Peakware, 2010). At 4,207 meters (13,804 feet), Gannett Peak is the highest peak in the range and the highest point in the state. There are 63 glaciers in this range, including seven of the 10 largest glaciers in the Rocky Mountains (Bonney, 1987).

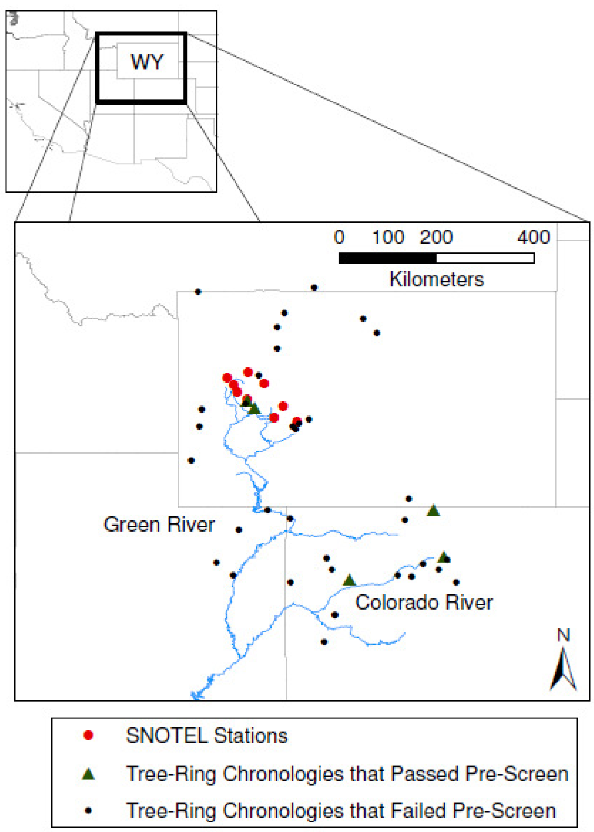

Figure 1: Map of SNOTEL stations and tree-ring chronologies

The WRR is located on the crest of the Continental Divide. Runoff from the eastern slope of the WRR contributes to the Missouri River Basin. Runoff from the western slope of the WRR contributes to the Colorado River Basin. The WRR is the northern boundary for the Upper Green River Basin (UGRB). This basin is approximately 22,600 square miles (Barnett et al., 2010). The UGRB flows directly into the Upper Colorado River Basin (UCRB), which is approximately 279720 square kilometers (108,000 square miles) (Timilsena and Piechota, 2007). Stream flow in the UGRB is driven by snowpack and glacial runoff. Water generated in the UGRB is managed by the federal and state governments (Follum et al., 2009).

The Green River originates at the base of the WRR and is the largest tributary to the Colorado River. The Green River is 1,170 kilometers (730 miles) long and traverses across parts of Wyoming, Utah, and Colorado. The Wyoming portion of the Green River Basin covers nearly 25,000 sq miles and covers parts of Sweetwater, Sublette, Carbon, Lincoln, Uinta, Fremonth, and Teton counties (Wyoming State Water Plan, 2001).

The UGRB is a vital water supply for states involved in the Colorado River Compact of 1922. The Colorado River Compact addresses appropriate usages and equitable division of water contained in the Colorado River and its tributaries (called the “Colorado River System”) (Colorado River Compact, 1922). The recent drought conditions coupled with the rapid development in the southwestern United States (namely Las Vegas and Phoenix) has greatly stressed the available water in the Colorado River System (Bellamy et al., 2009). Given the importance of this water system, and the number of people dependent upon it, it is important to fully understand the factors that contribute to water availability in this basin. The Green River, which is fed primarily by snowpack in the WRR, is the largest tributary to the Colorado River.

Prior to this study snowpack in the WRR has never been reconstructed. The closest areas with snowpack reconstructions are in Western Colorado (Woodhouse, 2003) and in the Upper Colorado River Basin (Timilsena and Piechota, 2007). While stream flow and precipitation have been reconstructed in this region (Barnett et al., 2010, Follum et al., 2009, Watson et al., 2009), snowpack reconstructions would be beneficial in increasing the understanding of the linkages between oceanic and atmospheric influences on SWE in this critical region.

3.0 DATA

The datasets used to reconstruct snowpack include data from Snowpack Telemetry stations (SNOTEL stations), tree-ring chronologies, the Southern Oscillation Index (SOI), and Pacific Ocean Sea Surface Temperatures (Pacific SSTs). Further information regarding these datasets is shown in Appendix 1.

3.1 SNOTEL Stations

SNOTEL stations are operated by the Natural Resources Conservation Service (NRCS). These stations are automated systems that collect snowpack data and related climatic data. SNOTEL stations were first introduced in the mid-1930s as a response to a NRCS Congressional mandate to assist with forecasting water supply. Until the 1980s, data was collected manually. Now, SNOTEL stations have a pressure sensing pillow to measure snowpack and utilize meteor burst communication technology to gather data and transmit measurements via radio signals to the SNOTEL central computer (NRCS).

There are currently 780 active SNOTEL stations in the western United States (NCRS). There are 13 SNOTEL stations in the Wind River Range. Of these 13 stations, nine stations have complete records of early April SWE from 1961 – present. The SWE data on or nearest to April 1st is used as the April 1st SWE for this study. These nine stations were selected for this study and are shown in Figure 1. Latitudes, longitudes, and periods of record are provided for these nine stations in Table 1.

Table 1
Description of SNOTEL sites

SNOTEL Site	Latitude	Longitude	Elevation	Reporting Period
Gros Venture Summit	43.38	-110.13	2667.00	1948 - 2009
Little Warm	43.50	-109.75	2855.98	1949 - 2009
Cold Springs	43.28	-109.45	2935.22	1949 - 2009
Hobbs Park	42.87	-109.10	3078.48	1949 - 2009
South Pass	42.57	-108.85	2755.39	1940 - 2009
Big Sandy Opening	42.65	-109.27	2767.58	1961 - 2009
Elkhart Park	43.00	-109.77	2865.12	1961 - 2009
New Fork Lake	43.12	-109.95	2542.03	1961 - 2009
Kendall RS	43.25	-110.02	2359.15	1936 - 2009

3.2 Tree-Ring Chronologies

Tree-ring chronologies were obtained from three sources: 25 chronologies were obtained from the International Tree Ring Data Bank (ITRDB), nine chronologies were obtained from recent paleohydrologic studies in the UGRB (Gray et al., 2004a; Gray et al., 2004b; Gray et al., 2007), and six chronologies were obtained from recent tree-ring collections within the UGRB (Watson et al., 2009, Barnett et al., 2010). These chronologies were constructed with data from four species of trees. A total of 40 tree-ring chronologies were considered for use in this study. Of these 40 chronologies, 16 were Douglas fir (*Pseudotsuga menziesii*, PSME), 13 were piñon pine (*Pinus edulis*, PIED), 10 were limber pine (*Pinus flexilis*, PIFL), and one was ponderosa pine (*Pinus ponderosa*, PIPO). These four species have been found to be moisture sensitive (Fritts, 1976). Residual chronologies were selected since the autocorrelation between annual ring widths is removed (Timilsena and Piechota, 2007). These 40 chronologies are shown in Figure 1. Information regarding these chronologies is available in Table 2.

Table 2
Description of tree-ring chronologies

	Code	Site Name	Latitude	Longitude	Elevation	Species
	ARE	Anderson Ridge East	42.45	-108.87	2525	PIFL
	ARR	Anderson Ridge Rim	42.49	-108.93	2615	PSME
	BEAR	Bear Canyon	45.07	-108.52	2100	PIFL
*	BLE	Boulder Lake East	42.85	-109.63	2260	PSME
	CARTE	Carter Mountain	44.32	-109.21	2500	PIFL
	CFY	Clarks Fork Yellowstone	44.58	-109.08	1474	PSME
	COL	Collins Gulch	39.83	-108.2	2050	PIED
	COOK	Cooks Canyon	44.22	-107.37	2100	PIPO
	DIL	Dillon	39.6	-105.9	2880	PSME
	DOU	Douglas Pass	39.6	-108.96	2590	PSME
	Dutch	Dutch John Mountain	40.95	-109.38	2200	PIED
	ENC	Encampment	41.15	-106.78	2500	PSME
	FBN	Fossil Butte NM	41.87	-110.8	2225	PIFL
*	FMT	Fremont Lake	42.96	-109.77	2420	PSME
	FSE	Fremont Lake Southeast	42.92	-109.8	2390	PIFL
	GMR	Green Mountain Reservoir	39.85	-106.23	2515	PSME
*	HOT	Hot Sulphur Springs	40.07	-106.13	2500	PSME
	LAN	Land's End	39	-108.15	2987	PSME
	LBC	LaBarge Creek	42.5	-110.65	2743	PIFL
	LLR	Lewis Lake Road	42.55	-108.81	2733	PIFL
	MDP	McDougal Pass	42.8	-110.6	2743	PIFL
	MEV	Mount Everts	44.98	-110.67	2150	PSME
*	NPU	North Park Update	40.95	-106.33	2450	PSME
	NUTTE	Nutter's Ridge	39.97	-110.33	2250	PIED
	PIC	Piceance	40.05	-108.3	1900	PIED
	PLU	Plug Hat Butte	40.78	-108.97	2130	PIED
	PUM	Pump House	39.95	-106.52	2195	PIED
	RCU	Red Canyon Upper	42.63	-108.62	2000	PIFL
	RED	Red Canyon	39.7	-106.73	2165	PIED
*	RIF	Rifle	39.67	-107.88	2073	PIED
	RPC	Red Pine Canyon	40.57	-109.92	2325	PIED
	SEE	Seedhouse Road	40.75	-106.85	2380	PSME
	TRAPP	Trapper Canyon	44.48	-107.62	2100	PSME
	TRG	Trail Gulch	39.72	-106.98	2210	PIED
	UNA	Unaweep Canyon	38.5	-108.34	2225	PIED

Table 2 (continued)
Description of tree-ring chronologies

Code	Site Name	Latitude	Longitude	Elevation	Species
VAS	Vasquez Mountain	40.03	-106.07	2865	PSME
WELLS	Well's Draw	39.73	-110.02	2150	PIED
WIL	Wild Rose	39.01	-108.14	2636	PIED
WOOD	Wood River Canyon	43.94	-109.21	2400	PIFL
WSK	Whiskey Mountain	43.43	-109.55	2695	PSME

* Indicates the chronology was retained following the process described in section 4.1.2

3.3 Southern Oscillation Index (SOI)

The Southern Oscillation Index (SOI) measures air pressure fluctuations across the tropical Pacific. These air pressure fluctuations are more pronounced during El Niño and La Niña events (Climate Prediction Center). Air pressure measurements from Tahiti are collected and compared with air pressure measurements from Darwin, Australia. Below-normal air pressure at Tahiti and above-normal air pressure at Darwin, Australia indicates warmer than normal ocean water temperatures associated with El Niño events (Climate Prediction Center). This occurs during the negative phase of the SOI. Above-normal air pressure at Tahiti and below-normal air pressure at Darwin, Australia indicates colder than normal ocean water temperatures associated with La Niña events (NOAA, Climate Prediction Center).

The most commonly associated index of climatic variability in the western Wyoming region is the El Niño Southern Oscillation (Cayan, 1994, Graumlich et al., 2003). In 1998, the SOI was reconstructed for a winter season from 1706 – 1977 (Stahle et al., 1998). The availability of this reconstructed data allows us to incorporate SOI into our model (Graumlich et al., 2003). Data for SOI prior to 1977 is obtained from the National Weather Service Climate Prediction Center. This data is available monthly. Given the reconstructed data (Stahle et al., 1998) is for a winter season (December, January, February), the data from the National Weather Service was averaged to obtain winter SOI index data for a DJF period for the years subsequent to 1977.

3.4 Sea Surface Temperatures (SSTs)

Several studies have identified variations in Pacific Ocean SSTs as significant driving forces of atmospheric circulation in the western United States (Mantua et al. 1997, McCabe and

Dettinger, 1999, Clark et al. 2001, McCabe and Dettinger, 2002, Tootle and Piechota, 2006, Aziz et al., 2010). Pacific Ocean SST data were obtained from the National Climatic Data Center website. These data consist of monthly average values for 2° by 2° grid cells from 60°S to 65°N latitude and 110°E to 65°W longitude, based on instrumental records back to 1856 (Kaplan et al., 1998, Evans et al., 2002). This results in 2792 SST cells. Reconstructed Pacific Ocean SST data are available from the NOAA World Data Center for Paleoclimatology. Evans et al. (2002) utilized this data to create proxy-based Pacific Ocean SST reconstructions. Tree-ring based reconstructions date back to 1590, coral based reconstructions date back to 1800, and instrumental based reconstructions date back to 1856 (Evans et al., 2002).

4.0 Reconstruction Methodology

4.1 Concentration of Data

Several steps were undertaken to ensure the strongest datasets were being analyzed. The process undertaken for each dataset is explained below.

4.1.1 Principal Component Analysis for SNOTEL Station Data

Data from the nine selected SNOTEL stations was analyzed using a varimax rotated principal component analysis to determine specific snowpack regions in the Wind River Range (Woodhouse, 2003, Timilsena and Piechota, 2007). This spatial regionalization technique was employed to reduce the size of the dataset, while retaining critical information (Richman 1986, Knapp et al., 2002). Utilization of an Eigen value cutoff of 1.0 resulted in all nine stations being identified in the first component. This was the only component retained. This single component explained 82% of the total variance in April 1st SWE for the SNOTEL stations involved, indicating all nine stations were statistically similar on an annual basis. This result was expected because all nine stations were correlated at a confidence level of 99%. Data from these stations was averaged together to produce a composite April 1st SWE dataset for the Wind River Range (Woodhouse, 2003).

4.1.2 Correlation for Tree-Ring Chronologies

The composite April 1st SWE dataset was correlated with each of the 40 tree-ring chronologies using Pearson's correlation method. Several of the chronologies ended in 1999, so the period of 1961 – 1999 was used. This period encompasses 39 years (n=39). With an n-value of 39, 99% confidence is obtained with a critical value (r-value) in excess of 0.41. Chronologies that were positively correlated with the composite April 1st SWE at or above a 99% confidence level were retained (Barnett et al., 2010). These retained chronologies were then examined for stability. Of the 40 chronologies tested, five were found to be positively correlated with greater than 99% confidence and stable for the period of overlap with SWE data. These five chronologies were retained while the other 35 chronologies were rejected. Of the 5 chronologies retained, four were Douglas fir (*Pseudotsuga menziesii*) and one was a piñon pine (*Pinus edulis*). These five chronologies are denoted in Figure 1 and specific information is detailed in Table 2.

4.1.3 Range Selection for SOI and SST data

Composite SOI data was constructed by averaging December, January, and February data to form a winter SOI index. Data from December 1960 was averaged with data from January 1961 and February 1961.

SST data was constructed as an annual average. Averaged SST data from 1960 explains SWE data from 1961. This is done to account for oceanic lag time.

4.2 Singular Value Decomposition (SVD)

Singular Value Decomposition (SVD) is a statistical tool used for identification of coupled relationships between two spatial-temporal fields (Tootle et al., 2008). Studies have been conducted to determine that SVD is a simple method that effectively isolates important modes of variability when attempting to identify relationships between datasets involving grid point arrays (station arrays) and time series (Bretherton et al., 1992, Wallace et al., 1992). SVD of the cross-covariance matrix identifies, from two data fields, pairs of spatial patterns that explain as much as possible of the mean-squared temporal covariance between the two fields

(Bretherton et al., 1992). This study uses SVD to establish a relationship and determine coupled regions between Pacific Ocean SSTs and WRR April 1st SWE.

SVD has been used in the fields of social sciences for many years (Tucker, 1958, Cliff 1966), but was first used in the field of atmospheric sciences by Prohaska (1976) and Lanzante (1984). Prohaska (1976) successfully used SVD to document the simultaneous relationship between monthly mean surface air temperatures over the United States and hemispheric sea level pressure patterns. Lanzante (1984) successfully used SVD to determine relationships between circulation patterns at 700 mb heights and Pacific and Atlantic SSTs. Subsequent studies have continued to use SVD to identify coupled relationships between established climatic factors and SSTs (Hsu, 1994, Lau and Nath, 1994, Uvo et al., 1998, Wang and Ting, 2000, Tootle and Piechota, 2006, Tootle et al., 2008, Aziz et al., 2010).

In this study, SVD will eliminate any bias caused by selection of predefined SST regions (i.e., ENSO through the use of the SOI). This approach will allow identification of a new region of influence that may or may not be represented in the classic climate indices (ex. Niño 3.4, SOI, Pacific Decadal Oscillation). Historically, other studies have identified relationships between classic climate indices and SWE as it relates to snowpack. McCabe and Dettinger (2002) and Hunter et al. (2006) defined relationships between April 1st SWE and PDO and April 1st SWE and ENSO. Additionally, Graumlich (2003) identified the existence of a relationship between the SOI in western-Wyoming and regional stream flow. This study will build on the existence of this relationship and translate it to test applicability of SOI data to WRR April 1st SWE. It will also consider the relationship between Pacific Ocean SSTs as a whole and WRR April 1st SWE.

Before SVD can be performed it is necessary to standardize the anomalies of SSTs and SWE. The time dimension of each matrix must be equivalent, while the spatial component can vary in dimension. In this study, the time dimension is defined by the period of overlap between SWE data and available SST data (lagged one year previous to the SWE data). The spatial component varies. For SVD, the SWE dataset was comprised of nine individual SNOTEL stations and the SST dataset consisted of 2792 cells. The next step is to create a covariance matrix. This is computed for the two spatial-temporal matrices, providing physical information to determine the relationship between SST cells and regional SWE.

SVD of the covariance matrix results in two matrices of singular vectors (left and right) and one matrix of singular values. The singular values are ordered in decreasing order with the first value being greatest and the final value being smallest. The two singular vector matrices are examined. The left matrix contains SST data and the right matrix contains SWE data. The first column of the SST matrix is projected onto the standardized SST anomalies matrix, generating the first temporal expansion series for SST data. The first column of the SWE matrix is projected onto the standardized SWE anomalies matrix, generating the first temporal expansion series for SWE data. These first temporal expansion series are correlated with the opposing data (SST with SWE and SWE with SST), resulting in heterogeneous correlation values. For our study, correlation of the SWE first temporal expansion series with the SST matrix reveals the regional SST data specific to the WRR SWE. Correlation of the SST first temporal expansion series with the SWE matrix reveals the strength of the response between individual SWE data points (SNOTEL stations) and the resultant SST anomaly data.

While SVD allows simultaneous interaction between two spatial-temporal matrices, limitations do exist. There are some instances where application of SVD does not provide any additional value to the datasets. If the leading temporal expansion series (1^{st}, 2^{nd}, and 3^{rd}) explain a significant amount of the variance between the two fields, application of SVD will be able to successfully determine the strength of the coupled variability existing in the two datasets (Newman and Sardeshmukh, 1995). However, when using SVD to examine two fields, the examiner must exhibit caution when attempting to explain the physical cause of the results (Newman and Sardeshmukh, 1995).

4.2.1 Application of SVD

SVD was applied to instrumental Pacific Ocean SSTs and the April 1^{st} WRR snowpack. The squared covariance fraction for the first mode indicated that 94% of variance was explained, indicating a linear relationship between Pacific Ocean SSTs and the WRR snowpack. The second and third modes explained 3% and 1.5%, respectively. For this reason the first mode was selected.

Two distinct regions were identified as significant with regards to WRR SWE. These regions are shown graphically in Figure 2. The red region is defined, approximately, as 15°S to 5°N latitude and 137°W to 87°W longitude. The blue region is defined, approximately, as 10°S to 15°N latitude and 130°E to 155°E (230°W to 205°W) longitude.

The red region indicates a negative relationship between SSTs and the composite WRR SWE. Increases in SSTs in the red region result in decreased SWE in the WRR. The blue region indicates a positive relationship between SSTs and the composite WRR SWE. Increased SSTs in the blue region will result in increased SWE in the WRR. Closer examination revealed the red region located in the equatorial Pacific Ocean is closely aligned with the ENSO related Niño 3.4 region, a region in the central equatorial Pacific Ocean that is bounded by 5°N to 5°S latitude and 170°W to 120°W longitude (NCAR).

Pacific Ocean SST indices were created for these two regions. This was accomplished by identifying all SST cells expressing greater than 95% confidence with the WRR regional SWE. Annual data for significant SST cells in the red region were averaged to form the SST1 dataset. Annual data for significant SST cells in the blue region were averaged to form the SST2 dataset.

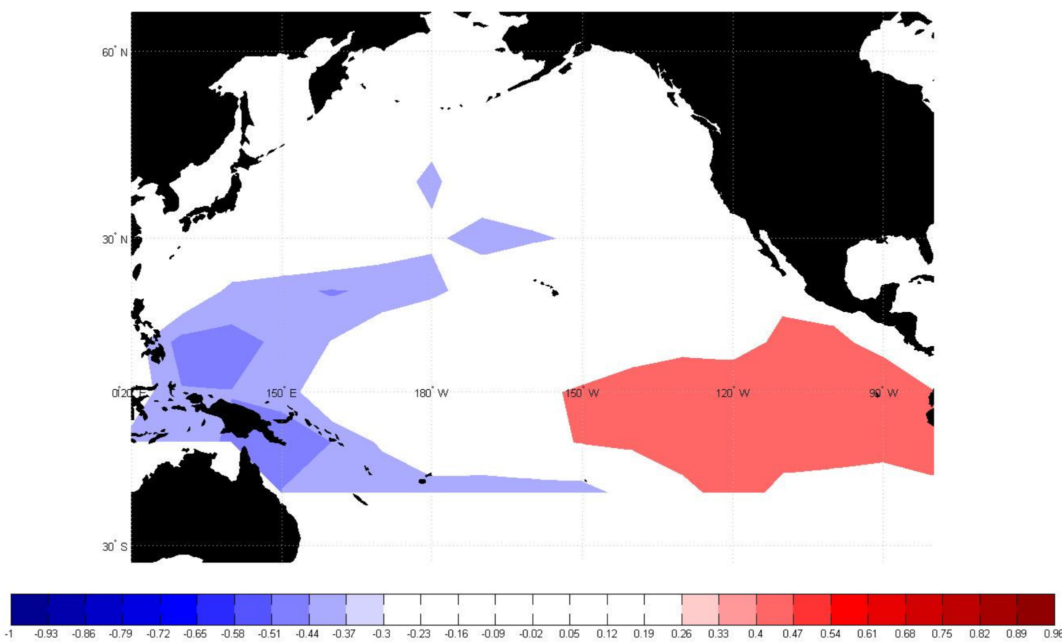

Figure 2: Map of Pacific SST Regions

4.3 Stepwise Regression

Multiple linear regression is a common approach for reconstructing hydrologic variables utilizing tree-ring chronologies (Touchan et al., 1999, Diaz et al., 2001, Woodhouse, 2001, Gray et al., 2004a). The five tree-ring chronologies that passed pre-screening were selected as predictor variables for the WRR regional April 1st SWE in a stepwise regression process (Woodhouse, 2003) and were entered into MiniTab (MiniTab, Version 15, 2007). The SOI data and instrumental based Pacific Ocean SST indices (SST1 and SST2) were also included as potential predictor variables for the stepwise regression. Tolerances for entry into the model and removal from the model were set. Appropriate tolerances prevent the entry of a variable into the model that is highly correlated with an independent variable that has already been selected. Alpha-to-enter and alpha-to-remove values were set at 0.05 and 0.10 respectively (Girardin et al., 2008).

Stepwise regression was performed for three key sets of predictor variables. The first iteration contained the five tree-ring chronologies (TRCs). This regression retained one chronology. The second iteration contained the five tree-ring chronologies and the SOI data. This regression retained one chronology and the SOI data. The third iteration contained the five tree-ring chronologies and instrumental based PAC SST data. This regression retained two chronologies and the PAC SST data from region 1. These three iterations were run to provide regression data for various model combinations to determine what degree of skill is added to a model with the addition of climate indices (SOI data) and instrumental based regional SST data. Results from these iterations are summarized in Table 3. Retained tree-ring chronologies are shown graphically in Figure 3.

Table 3
Predictors retained by stepwise regression

Predictors	Retained	Specifics
TRC	TRC (1)	BLE
TRC, SOI	TRC (1), SOI	BLE, SOI
TRC, SOI, SST – Instrumental	TRC (2), SST 1 - Inst	SST 1 – Inst, RIF, NPU

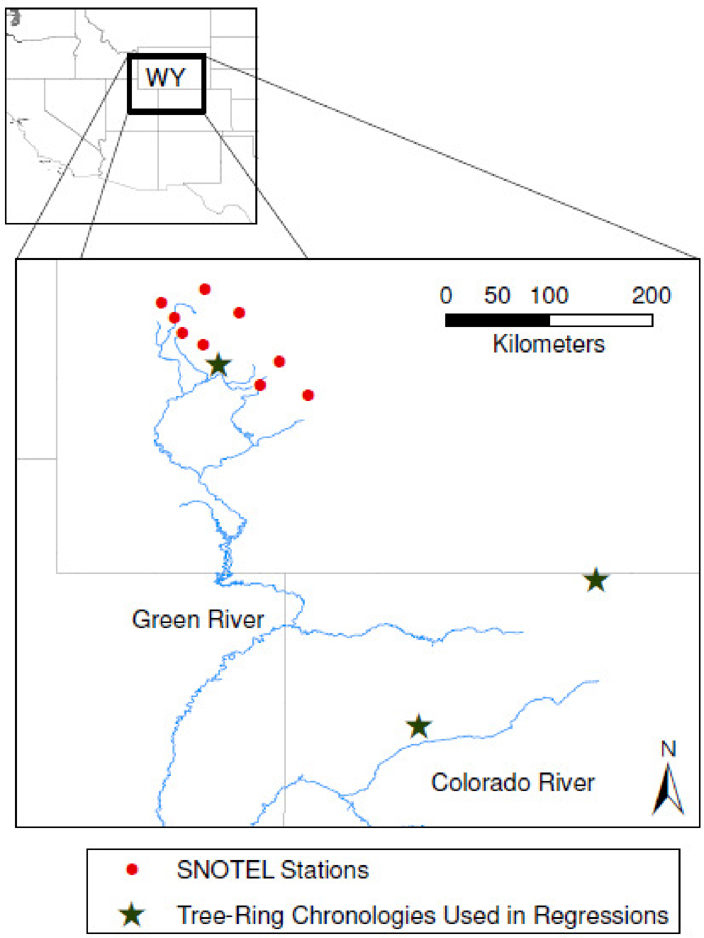

Figure 3: Map of SNOTEL stations and retained tree-ring chronologies

4.4 Regression Analysis

Given the predictor variables retained by stepwise regression, a standard regression was run for each iteration. Statistical analysis was performed and the Standard Error (s), R^2, Adjusted R^2, and Predicted R^2 values were obtained. Coefficients for the regression equations were recorded and model fits and residuals were stored. Fits are the values the model obtains for the response variable (snowpack) using the equation generated by the predictors. Residuals are the difference between the fits and the observed data.

4.4.1 Autocorrelation

Residuals from the regression were analyzed for signs of low order autocorrelation, trending over time, or significant relation to predictor variables. The Durbin-Watson statistic was also calculated to further check for autocorrelation. No low order autocorrelation was detected for the regressions performed in the calibration period.

5.0 Fit Statistics for Calibration Period

Multiple statistics were calculated to determine the skill and validity of the regression models generated, including the standard error of the regression (S), the Durbin-Watson statistic, R^2, adjusted R^2, and predicted R^2. Table 4 shows the statistics obtained from regressions performed in the calibration period.

5.1 Standard Error of the Regression (S)

The standard error of the regression (S) is used to measure the accuracy with which the model fits the existing data. Lower S-values indicate a model with higher accuracy. The S-value is calculated by measuring the distance between each data point and the regression line (the standard deviation of the residual) and averaging the absolute value of the results.

In this study the regression involving only tree-ring chronologies as predictors has a higher S-value than the other regressions. This is understandable because the addition of diverse predictors (SOI and SSTs) allows the model to select predictors that explain SWE variation not accounted for by tree-ring chronologies. The S-values for the other regressions decrease as more accurate predictors are introduced to the model.

Table 4
Regression statistics

Predictors	S	Durbin-Watson	R^2	R^2 adjusted	R^2 predicted
TRC	8.50	2.11	0.26	0.24	0.17
TRC, SOI	7.87	1.75	0.39	0.35	0.27
TRC, SOI, SST – Instrumental	5.91	1.58	0.67	0.63	0.58

5.2 Durbin-Watson Statistic

The Durbin-Watson statistic tests for autocorrelation among residuals generated by a regression model. Autocorrelation is an indicator that adjacent terms in a regression are correlated with each other. The Durbin-Watson statistic is based on the assumption that datasets are provided in a temporally logical order. Error terms are calculated for each data point and the correlation between adjacent error terms is examined. Upper and lower bounds are established for significance of autocorrelation of 5% or less. A Durbin-Watson statistic in excess of the upper bound indicates no correlation, while a value in deficit of the lower bound indicates positive correlation. Values between the two bounds are inconclusive. The Durbin-Watson statistic is calculated from these error statistics. The value is always between 0 and 4. A value of 2.0 indicates no correlation. Values above 2.0 indicate negative correlation and values below 2.0 indicate positive correlation.

As shown in Table 4, Durbin-Watson statistics for the regressions fall within approximately 0.5 of 2.0. This indicates there is little to no correlation across the error statistics from the regressions. Autocorrelation was also evaluated graphically and no autocorrelation was detected.

5.3 R^2

R^2 is the coefficient of determination for a regression. The R^2 value explains the percent of response variable variation that is explained by the regression equation. The higher the R^2 value, the more variation is explained by the generated model. Theoretically, a model with an R^2 value of 1.0 would explain 100% of the response variable variation and the predicted values would equal the observed values.

As more predictors were added to the model, the R^2 value increased. The addition of SOI data and regional SST data greatly increased the R^2 value for these regressions. The highest amount of variation is explained in the model utilizing instrumental based SST data.

5.4 Adjusted R^2

An adjusted value of R^2 takes into account the number of predictors used in the model. Models that retain more predictors generally have a higher R^2 value. While sometimes the addition of new predictors does increase the accuracy of the model, often this increase in R^2 is due to chance alone. Adjusted R^2 eliminates this increase in percent of response variable variation explained. The adjusted R^2 value increases only if the addition of a new predictor increases explained variation by more than would be expected by chance. Additionally, adjusted R^2 will decrease if the new predictor increases the explained variation by less than expected by chance.

The adjusted R^2 value for these three regressions is lower than the regular R^2 value by 2 – 4%. This indicates that increasing the number of predictors through the addition of SOI data and SST data did not diminish the relative accuracy of the data to a greater degree than the regression involving only tree-ring chronologies.

5.5 Predicted R^2

Predicted R^2 is an indicator of how well the model predicts future responses for new observations. Predicted R^2 can prevent overfitting of the model. Predicted R^2 is calculated using observations not included in the estimation of the model. Predicted R^2 is calculated by removing one observation from the dataset and using the remaining observations and predictors to estimate the removed observation. This process is repeated for each observation. When the predicted R^2

value is drastically less than the R^2 value, this indicates that the regression model generated will not predict future responses based on new observations as well as it fits the existing data.

The predicted R^2 is 9 – 11% lower than the regular R^2 value for the three regressions. This indicates that all three regressions see a similar decrease in variability explained by the regression model outside of the calibration period. However, the regression involving climate index data (SOI) explains 10% more variation than the regression using only tree-ring chronologies, and the regressions involving instrumental base SST data explains 41% more variation than the regression using only tree-ring chronologies, indicating that the addition of these other predictors enhances the accuracy of the model.

6.0 Results

Regression equations were generated for models constructed using: (1) tree-ring chronologies as predictors; (2) using tree-ring chronologies and SOI data as predictors; and (3) using tree-ring chronologies, SOI data, and instrumental based SSTs as predictors. These regression equations are displayed graphically over the calibration period alongside the observed regional SWE in Figure 4.

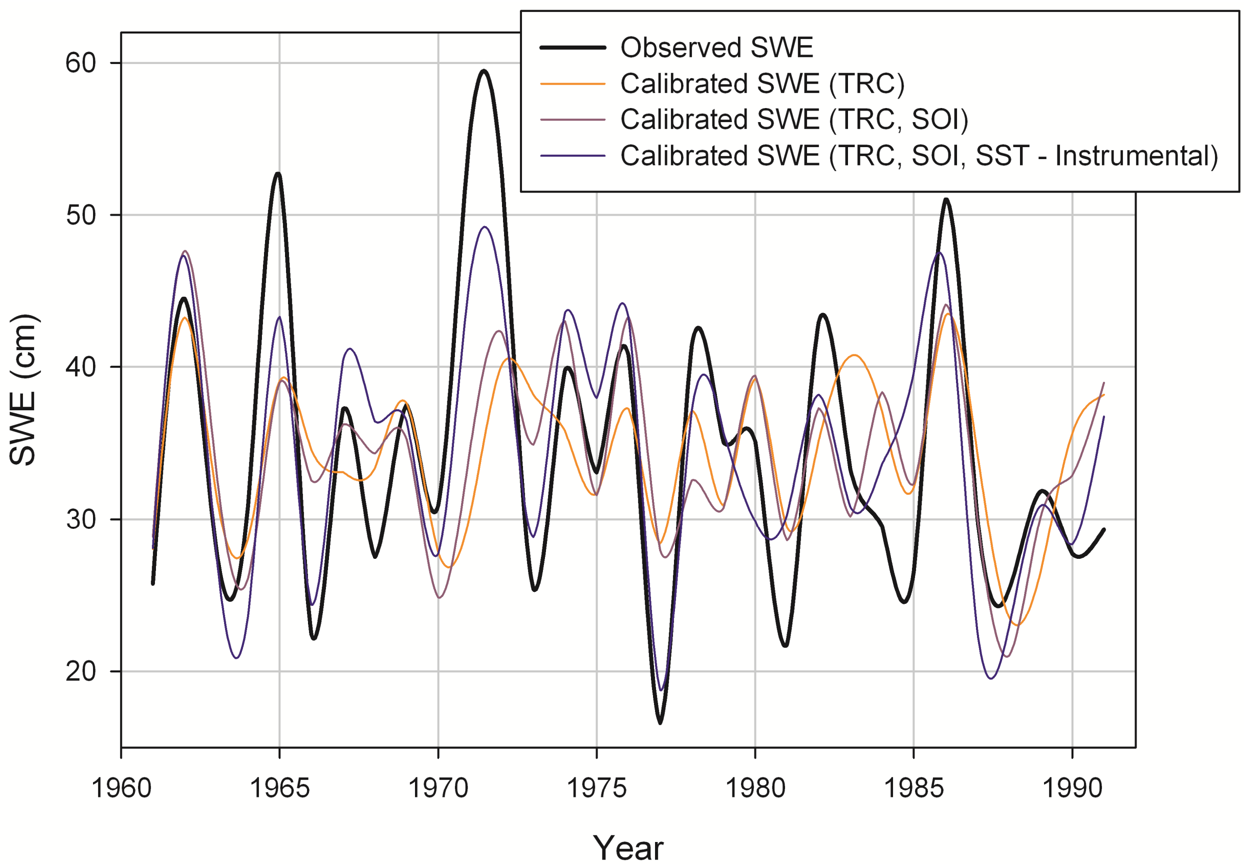

Figure 4: Observed and calibrated SWE

The calibrated SWE with tree-ring chronologies, SOI data, and instrumental SST data is the closest fit to the observed snowpack. Interestingly, Table 3 shows that when this regression was run in stepwise, the SOI dataset was rejected in favor of the instrumental SST data set as determined with SVD. Next, two regressions were run that included SST 1 and SST 2 data individually. In both cases the SST data was retained and the SOI data was rejected. This indicates that SST data that is not spatially biased is a better predictor variable for SWE calculations in the WRR than SOI data.

Based on these results, additional stepwise regressions were performed using additional types of SST data. SST data is available as tree based reconstructions, coral based reconstructions, and instrumental based reconstructions (Evans et al., 2002). Following the analysis that revealed SST to be a key predictor for snowpack reconstruction, the three different types of SST data were analyzed individually. The process followed the method described above. Stepwise regression was run using the five tree-ring correlations and each specific type of SST data individually with the first regression using tree based data, the second using coral based data, and the third repeating the regression using instrumental based data. The retained predictors were then used in a standard regression and descriptive statistics were obtained. Tables showing retained predictors and descriptive statistics for these regressions are show below in Table 5 and Table 6, respectively.

Table 5
Predictors retained by stepwise regression for SST specific data

Predictors	Retained	Specifics
TRC, SST – Tree	TRC (2), SST 1 - Tree	BLE, SST 1 - Tree, RIF
TRC, SST – Coral	TRC (2), SST 1 - Coral	SST 1 - Coral, RIF, BLE
TRC, SST - Instrumental	TRC (2), SST 1 - Inst	SST 1 - Inst, RIF, NPU

Table 6
Statistics from standard regression for SST specific data

Predictors	S	Durbin-Watson	R^2	R^2 adjusted	R^2 predicted
TRC, SST – Tree	7.42	1.91	0.48	0.42	0.31
TRC, SST – Coral	6.37	1.45	0.62	0.57	0.48
TRC, SST - Instrumental	5.91	1.58	0.67	0.63	0.58

The resulting statistics for these models were similar to those found with the first set of regressions. The S-values are relatively low, with the tree based regression slightly higher and the instrumental based regression slightly lower. The Durbin-Watson values are within acceptable limits and close to 2.0. Graphically representation of the autocorrelation statistics did not indicate any significant low order autocorrelation for these three regressions. The adjusted R^2 values are slightly lower (4 – 6%) than the regular R^2 values. The predicted R^2 value for the tree based SST data regression is 17% lower than the regular R^2 value. This indicates that the data may not predict SWE data based on new observations as well as it is able to represent the calibration period. The difference between the predicted R^2 value and the regular R^2 value for the coral based SST1 data is 14% and the difference for the SST1 instrumental data is 9%. This, coupled with the fact that these two regressions have higher R^2 values, suggests the coral based and instrumental based SST1 datasets are more likely to accurately predict regional SWE based on new observations.

Regression equations were generated for these three predictor sets. These regression equations are displayed graphically over the calibration period alongside the observed regional SWE in Figure 5.

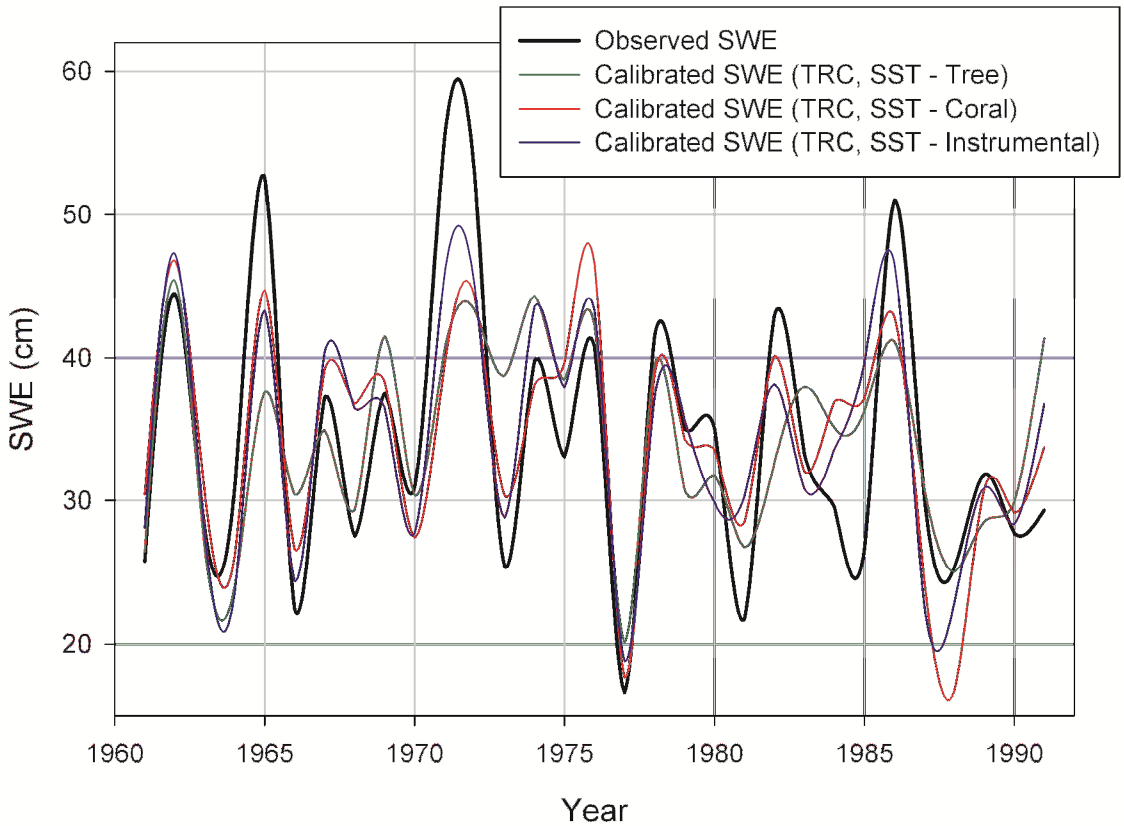

Figure 5: Observed and calibrated SWE for SST specific data

As previously stated, tree based SST data extends back to 1590, coral based SST data extends back to 1800, and instrumental based SST data extends back to 1856. All of the tree-ring chronologies date back to prior to 1590, which means the SST datasets will be the limiting factor for the reconstructions. Using the equations generated through MiniTab regressions, regional April 1st SWE for the WRR was reconstructed using each of the three types of SST1 data. Five-year and twenty-year filters were applied to the reconstructions. These results are shown in Figure 6.

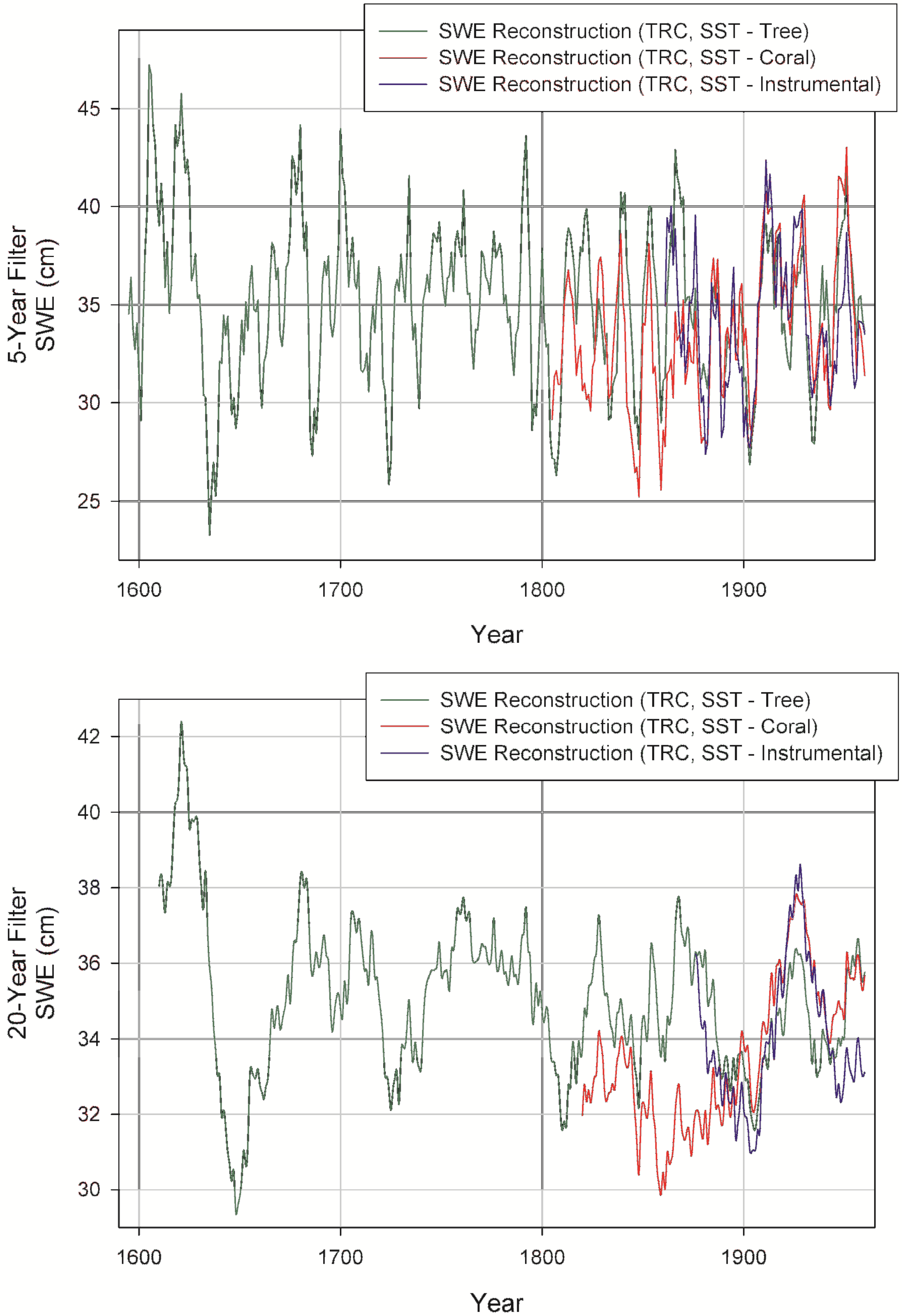

Figure 6: Reconstructed April 1st SWE for the Wind River Range

7.0 Conclusion and Future Work

The elimination of spatial bias with SSTs yielded more accurate regression models with a higher level of variance explained for subsequent predictions. The regional SST indices were shown to be a larger component of change in regional April 1st SWE than the SOI data. By utilizing global SSTs as predictor variables, datasets can be reconstructed with a higher level of accuracy and precision. This methodology is transferable to other regional and is applicable for other hydrologic variables (stream flow, precipitation).

Further research should examine the impact of Atlantic Ocean SSTs on regional reconstructions for a complete representation of oceanic-atmospheric variability. Subsequent research may also incorporate North Atlantic Oscillation data and Atlantic Multidecadal Oscillation data. Inclusion of Atlantic Ocean oscillations and non-spatially biased Atlantic SSTs may result in increased reconstruction skill.

Research could be conducted to examine the relationship between regional SWE on March 1st and May 1st to possibly obtain regressions with higher skill value. Additionally, reconstruction of snowpack for a single SNOTEL station could yield different results based on the period of record for individual stations.

Investigation into past climatic and hydrologic variability can provide important insights into future water availability given climate change. As previously discussed, the Colorado River is a critical water source that provides water to over 25 million people and several vital agricultural regions. The WRR snowpack, located in the UCRB, contributes directly to the Green River, the largest tributary of the Colorado River. By accurately reconstructing WRR snowpack and developing a greater understand of the linkages between non-spatially biased

SSTs and regional climatic change, this study provides heightened understanding of past hydrological variability in the UCRB will provide insight into future adaptation and sustainability of the basin.

8.0 Acknowledgements

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Appendices

Appendix 1: Data Source Summary

Data	Source
Snow Water Equivalent (SWE)	**National Resources Conservation Service** **Website:** http://www.wcc.nrcs.usda.gov/snow/
Tree-Ring Chronologies	**International Tree Ring Data Bank** **Website:** http://www.ncdc.noaa.gov/paleo/treering.html **Recent Paleohydrologic Studies** **Recent Tree-Ring Collections**
Southern Oscillation Index (SOI)	**National Weather Service: Climate Prediction Center** **Website:** http://www.cpc.noaa.gov/data/indices/soi
Pacific Ocean SSTs	**National Climate Data Center** **Website:** http://www.cdc.noaa.gov/cdc/data.noaa.ersst.html

Appendix 2: Principal Components Analysis Report

Principal Components Report

Page/Date/Time 1 5/28/2010 11:37:28 AM
Database

Descriptive Statistics Section

Variables	**Count**	**Mean**	**Standard Deviation**	**Communality**
Gros_Venture_Summit	37	14.82432	4.676146	0.816648
Little_Warm	37	11.62703	3.622281	0.875303
Cold_Springs	37	9.132432	2.957951	0.764522
Hobbs_Park	37	15.03514	3.663879	0.659234
South_Pass	37	16.56216	4.237357	0.707331
Big_Sandy_Opening	37	14.59459	4.596493	0.837654
Elkhart_Park	37	13.74595	4.121326	0.877445
North_Fork_Lake	37	11.1973	3.529202	0.888972
Kendall_RS	37	14.45676	6.014314	0.948903

Eigenvalues after Varimax Rotation

No.	**Eigenvalue**	**Individual Percent**	**Cumulative Percent**	**Scree Plot**
1	7.376012	81.96	81.96	|||||||||||||||||
2	0.596861	6.63	88.59	||
3	0.362371	4.03	92.61	|
4	0.239084	2.66	95.27	|
5	0.161587	1.80	97.07	|
6	0.101590	1.13	98.19	|
7	0.073232	0.81	99.01	|
8	0.053328	0.59	99.60	|
9	0.035935	0.40	100.00	|

Eigenvectors after Varimax Rotation

Variables	**Factors Factor1**
Gros_Venture_Summit	-0.332741
Little_Warm	-0.344484
Cold_Springs	-0.321947
Hobbs_Park	-0.298957
South_Pass	-0.309671
Big_Sandy_Opening	-0.336993
Elkhart_Park	-0.344905
North_Fork_Lake	-0.347163
Kendall_RS	-0.358674

Appendix 3: MiniTab Output for Model Calibration

General Models: Stepwise Regression, Regression, Autocorrelation

```
Welcome to Minitab, press F1 for help.
Executing from file: C:\Program Files\Minitab 15\English\Macros\Startup.mac

 This Software was purchased for academic use only.
 Commercial use of the Software is prohibited.
```

Stepwise Regression: Average Snowpack versus BLE, FMT, HOT, RIF, NPU

```
  Alpha-to-Enter: 0.05  Alpha-to-Remove: 0.1


Response is Average Snowpack (cm) on 5 predictors, with N = 31


Step              1
Constant      10.53

BLE            24.0
T-Value        3.22
P-Value       0.003

S              8.50
R-Sq          26.30
R-Sq(adj)     23.75
Mallows Cp      2.7
PRESS       2371.21
R-Sq(pred)    16.68
```

Regression Analysis: Average Snowpack (cm) versus BLE

The regression equation is
Average Snowpack (cm) = 10.5 + 24.0 BLE

Predictor	Coef	SE Coef	T	P	VIF
Constant	10.529	7.539	1.40	0.173	
BLE	23.967	7.451	3.22	0.003	1.000

S = 8.50458   R-Sq = 26.3%   R-Sq(adj) = 23.8%

PRESS = 2371.21   R-Sq(pred) = 16.68%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	748.33	748.33	10.35	0.003
Residual Error	29	2097.51	72.33		
Total	30	2845.84			

Unusual Observations

Obs	BLE	Average Snowpack (cm)	Fit	SE Fit	Residual	St Resid
11	0.82	55.32	30.28	1.97	25.04	3.03R

R denotes an observation with a large standardized residual.

Durbin-Watson statistic = 2.10807

Autocorrelation Function: RESI1

Lag	ACF	T	LBQ
1	-0.074010	-0.41	0.19
2	-0.186115	-1.03	1.41
3	-0.012273	-0.07	1.41
4	0.171989	0.92	2.53
5	-0.244979	-1.28	4.90
6	-0.032700	-0.16	4.94
7	0.376216	1.86	10.97
8	-0.046760	-0.21	11.07

Autocorrelation for RESI1

Stepwise Regression: Average Snow versus BLE, FMT, HOT, RIF, NPU, SOI

```
  Alpha-to-Enter: 0.05  Alpha-to-Remove: 0.1


Response is Average Snowpack (cm) on 6 predictors, with N = 31


Step              1        2
Constant     10.529    8.389

BLE            24.0     26.5
T-Value        3.22     3.80
P-Value       0.003    0.001

SOI                      3.0
T-Value                 2.43
P-Value                0.022

S              8.50     7.87
R-Sq          26.30    39.10
R-Sq(adj)     23.75    34.75
Mallows Cp      8.6      4.4
PRESS       2371.21  2076.49
R-Sq(pred)    16.68    27.03
```

Regression Analysis: Average Snowpack (cm) versus BLE, SOI

The regression equation is
Average Snowpack (cm) = 8.39 + 26.5 BLE + 2.98 SOI

Predictor	Coef	SE Coef	T	P	VIF
Constant	8.389	7.029	1.19	0.243	
BLE	26.499	6.971	3.80	0.001	1.023
SOI	2.982	1.229	2.43	0.022	1.023

S = 7.86723   R-Sq = 39.1%   R-Sq(adj) = 34.8%

PRESS = 2076.49   R-Sq(pred) = 27.03%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	1112.83	556.41	8.99	0.001
Residual Error	28	1733.01	61.89		
Total	30	2845.84			

Source	DF	Seq SS
BLE	1	748.33
SOI	1	364.50

Unusual Observations

Obs	BLE	Average Snowpack (cm)	Fit	SE Fit	Residual	St Resid
11	0.82	55.32	34.50	2.52	20.82	2.79R
23	1.26	33.30	30.20	4.90	3.11	0.51 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Durbin-Watson statistic = 1.75028

Autocorrelation Function: RESI2

Lag	ACF	T	LBQ
1	0.095265	0.53	0.31
2	-0.312057	-1.72	3.74
3	-0.162354	-0.82	4.71
4	0.060912	0.30	4.85
5	-0.215627	-1.06	6.68
6	-0.011307	-0.05	6.68
7	0.378152	1.80	12.78
8	0.013857	0.06	12.79

Autocorrelation for RESI2

Stepwise Regression: Average Snowpack (cm) versus BLE, FMT, ...

```
  Alpha-to-Enter: 0.05  Alpha-to-Remove: 0.1


Response is Average Snowpack (cm) on 8 predictors, with N = 31


Step              1        2        3
Constant      35.25    17.84    10.91

1 - Inst       -8.7     -8.9     -9.1
T-Value       -3.59    -4.64    -5.24
P-Value       0.001    0.000    0.000

RIF                     17.0     13.4
T-Value                 4.29     3.49
P-Value                0.000    0.002

NPU                              10.1
T-Value                          2.65
P-Value                         0.013

S              8.24     6.51     5.91
R-Sq          30.78    58.24    66.85
R-Sq(adj)     28.39    55.26    63.17
Mallows Cp     28.3      8.4      3.5
PRESS       2285.90  1402.22  1187.38
R-Sq(pred)    19.68    50.73    58.28
```

Regression Analysis: Average Snowpack (cm) versus 1 - Inst, RIF, NPU

The regression equation is
Average Snowpack (cm) = 10.9 - 9.10 1 - Inst + 13.4 RIF + 10.1 NPU

Predictor	Coef	SE Coef	T	P	VIF
Constant	10.910	4.645	2.35	0.026	
1 - Inst	-9.099	1.737	-5.24	0.000	1.003
RIF	13.390	3.831	3.49	0.002	1.142
NPU	10.057	3.798	2.65	0.013	1.145

S = 5.91112   R-Sq = 66.8%   R-Sq(adj) = 63.2%

PRESS = 1187.38   R-Sq(pred) = 58.28%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	1902.42	634.14	18.15	0.000
Residual Error	27	943.42	34.94		
Total	30	2845.84			

Source	DF	Seq SS
1 - Inst	1	875.82
RIF	1	781.57
NPU	1	245.03

Unusual Observations

Obs	1 - Inst	Average Snowpack (cm)	Fit	SE Fit	Residual	St Resid
25	-0.05	26.59	39.65	1.51	-13.07	-2.29R

R denotes an observation with a large standardized residual.

Durbin-Watson statistic = 1.57964

Autocorrelation Function: RESI5

Lag	ACF	T	LBQ
1	0.178005	0.99	1.08
2	-0.216495	-1.17	2.73
3	-0.491262	-2.54	11.55
4	-0.203318	-0.88	13.12
5	-0.137339	-0.58	13.86
6	0.257714	1.08	16.58
7	0.249140	1.01	19.22
8	0.150154	0.59	20.23

Autocorrelation for RESI5

Specific SST Models: Stepwise Regression, Regression, Autocorrelation

Stepwise Regression: Average Snowpack (cm) versus BLE, FMT, ...

```
  Alpha-to-Enter: 0.05  Alpha-to-Remove: 0.1


Response is Average Snowpack (cm) on 7 predictors, with N = 31


Step              1        2        3
Constant     10.529    9.019    6.036

BLE            24.0     26.0     16.7
T-Value        3.22     3.72     2.15
P-Value       0.003    0.001    0.041

1 - Tree                -9.9    -10.6
T-Value                -2.36    -2.68
P-Value                0.025    0.012

RIF                              11.8
T-Value                          2.19
P-Value                         0.037

S              8.50     7.90     7.42
R-Sq          26.30    38.54    47.82
R-Sq(adj)     23.75    34.15    42.03
PRESS       2371.21  2216.64  1956.83
R-Sq(pred)    16.68    22.11    31.24
```

Regression Analysis: Average Snowpack (cm) versus BLE, 1 - Tree, RIF

The regression equation is
Average Snowpack (cm) = 6.04 + 16.7 BLE - 10.6 1 - Tree + 11.8 RIF

Predictor	Coef	SE Coef	T	P	VIF
Constant	6.036	6.740	0.90	0.378	
BLE	16.745	7.783	2.15	0.041	1.435
1 - Tree	-10.623	3.958	-2.68	0.012	1.022
RIF	11.829	5.396	2.19	0.037	1.439

S = 7.41582   R-Sq = 47.8%   R-Sq(adj) = 42.0%

PRESS = 1956.83   R-Sq(pred) = 31.24%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	1360.99	453.66	8.25	0.000
Residual Error	27	1484.85	54.99		
Total	30	2845.84			

Source	DF	Seq SS
BLE	1	748.33
1 - Tree	1	348.35
RIF	1	264.31

Unusual Observations

Obs	BLE	Average Snowpack (cm)	Fit	SE Fit	Residual	St Resid
5	1.19	52.61	37.60	2.04	15.00	2.10R
11	0.82	55.32	40.55	3.56	14.77	2.27R

R denotes an observation with a large standardized residual.

Durbin-Watson statistic = 1.91297

Autocorrelation Function: RESI3

Lag	ACF	T	LBQ
1	-0.005427	-0.03	0.00
2	-0.184957	-1.03	1.21
3	-0.175949	-0.95	2.34
4	0.007641	0.04	2.34
5	-0.310509	-1.63	6.13
6	0.111296	0.54	6.64
7	0.342946	1.64	11.65
8	0.098505	0.44	12.09

Autocorrelation for RESI3

Stepwise Regression: Average Snowpack (cm) versus BLE, FMT, ...

```
  Alpha-to-Enter: 0.05  Alpha-to-Remove: 0.1


Response is Average Snowpack (cm) on 7 predictors, with N = 31


Step              1        2        3
Constant     34.871   18.543    9.908

1 - Coral     -12.3    -11.9    -11.6
T-Value       -3.61    -4.23    -4.41
P-Value       0.001    0.000    0.000

RIF                     15.9     10.4
T-Value                 3.86     2.26
P-Value                0.001    0.032

BLE                              14.3
T-Value                          2.15
P-Value                         0.041

S              8.23     6.76     6.37
R-Sq          30.98    54.98    61.55
R-Sq(adj)     28.60    51.76    57.27
Mallows Cp     19.5      5.3      2.9
PRESS       2241.35  1514.44  1476.69
R-Sq(pred)    21.24    46.78    48.11
```

Regression Analysis: Average Snowpack (cm) versus 1 - Coral, RIF, BLE

The regression equation is
Average Snowpack (cm) = 9.91 - 11.6 1 - Coral + 10.4 RIF + 14.3 BLE

Predictor	Coef	SE Coef	T	P	VIF
Constant	9.908	5.771	1.72	0.097	
1 - Coral	-11.631	2.640	-4.41	0.000	1.003
RIF	10.435	4.618	2.26	0.032	1.430
BLE	14.337	6.675	2.15	0.041	1.432

S = 6.36642   R-Sq = 61.5%   R-Sq(adj) = 57.3%

PRESS = 1476.69   R-Sq(pred) = 48.11%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	1751.50	583.83	14.40	0.000
Residual Error	27	1094.35	40.53		
Total	30	2845.84			

Source	DF	Seq SS
1 - Coral	1	881.55
RIF	1	682.97
BLE	1	186.98

Unusual Observations

Obs	1 - Coral	Average Snowpack (cm)	Fit	SE Fit	Residual	St Resid
11	-0.490	55.32	39.49	2.40	15.82	2.68R

R denotes an observation with a large standardized residual.

Durbin-Watson statistic = 1.44864

Autocorrelation Function: RESI4

Lag	ACF	T	LBQ
1	0.256921	1.43	2.25
2	-0.164646	-0.86	3.21
3	-0.427765	-2.19	9.89
4	-0.320408	-1.43	13.78
5	-0.139092	-0.58	14.54
6	0.162584	0.68	15.63
7	0.210731	0.86	17.52
8	0.144341	0.58	18.44

Autocorrelation for RESI4

Stepwise Regression: Average Snowpack (cm) versus BLE, FMT, ...

```
  Alpha-to-Enter: 0.05  Alpha-to-Remove: 0.1


Response is Average Snowpack (cm) on 7 predictors, with N = 31


Step                1        2        3
Constant        35.25    17.84    10.91

1 - Inst         -8.7     -8.9     -9.1
T-Value         -3.59    -4.64    -5.24
P-Value         0.001    0.000    0.000

RIF                       17.0     13.4
T-Value                   4.29     3.49
P-Value                  0.000    0.002

NPU                                10.1
T-Value                            2.65
P-Value                           0.013

S                8.24     6.51     5.91
R-Sq            30.78    58.24    66.85
R-Sq(adj)       28.39    55.26    63.17
Mallows Cp       27.4      7.8      3.0
PRESS         2285.90  1402.22  1187.38
R-Sq(pred)      19.68    50.73    58.28
```

Regression Analysis: Average Snowpack (cm) versus 1 - Inst, RIF, NPU

The regression equation is
Average Snowpack (cm) = 10.9 - 9.10 1 - Inst + 13.4 RIF + 10.1 NPU

Predictor	Coef	SE Coef	T	P	VIF
Constant	10.910	4.645	2.35	0.026	
1 - Inst	-9.099	1.737	-5.24	0.000	1.003
RIF	13.390	3.831	3.49	0.002	1.142
NPU	10.057	3.798	2.65	0.013	1.145

S = 5.91112   R-Sq = 66.8%   R-Sq(adj) = 63.2%

PRESS = 1187.38   R-Sq(pred) = 58.28%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	1902.42	634.14	18.15	0.000
Residual Error	27	943.42	34.94		
Total	30	2845.84			

Source	DF	Seq SS
1 - Inst	1	875.82
RIF	1	781.57
NPU	1	245.03

Unusual Observations

Obs	1 - Inst	Average Snowpack (cm)	Fit	SE Fit	Residual	St Resid
25	-0.05	26.59	39.65	1.51	-13.07	-2.29R

R denotes an observation with a large standardized residual.

Durbin-Watson statistic = 1.57964

Autocorrelation Function: RESI5

Lag	ACF	T	LBQ
1	0.178005	0.99	1.08
2	-0.216495	-1.17	2.73
3	-0.491262	-2.54	11.55
4	-0.203318	-0.88	13.12
5	-0.137339	-0.58	13.86
6	0.257714	1.08	16.58
7	0.249140	1.01	19.22
8	0.150154	0.59	20.23

Autocorrelation for RESI5

Appendix 4: Model Calibration Fits

General Models

Year	Fits - TRC	Fits - TRC, SOI	Fits - TRC, SOI, SST - Inst
1961	28.04922	28.85367	28.09716
1962	43.24446	47.64211	47.29356
1963	31.66828	33.25264	27.87633
1964	28.7203	26.11675	23.61789
1965	39.09813	38.98246	43.29643
1966	34.54435	32.55605	24.37647
1967	33.10631	36.23415	40.40275
1968	33.34599	34.3124	36.43855
1969	37.63612	35.27867	36.4817
1970	27.85748	24.86458	27.74177
1971	30.27818	34.49881	45.80717
1972	40.10475	42.28217	45.06364
1973	38.18737	34.89418	28.82988
1974	35.81461	43.00565	43.57174
1975	31.69224	31.58938	37.97424
1976	37.25265	43.30344	43.26376
1977	28.40873	27.95899	18.77883
1978	37.15678	32.56195	37.16975
1979	30.92529	30.74141	35.70335
1980	39.21796	39.41315	29.89257
1981	29.46329	28.62797	30.30421
1982	35.14353	37.29382	38.18599
1983	40.67997	30.19531	30.82906
1984	37.08488	38.34688	33.64443
1985	32.09969	32.33806	39.65034
1986	43.3643	44.09691	46.63358
1987	34.42451	30.23682	22.71623
1988	23.56734	21.0158	22.8674
1989	26.53928	30.16614	30.89358
1990	35.64684	32.88044	28.35005
1991	38.18737	38.96946	36.75778

Specific SST Models

Year	Fits - TRC, SST - Tree	Fits - TRC, SST - Coral	Fits - TRC, SST - Inst
1961	26.43456	30.399132	28.097159
1962	45.42228	46.789701	47.293559
1963	26.7124	30.607675	27.876334
1964	24.04993	26.181294	23.617894
1965	37.60181	44.75257	43.296433
1966	30.4177	26.603289	24.37647
1967	34.94954	39.183612	40.402754
1968	29.35805	36.782236	36.438547
1969	41.50604	38.333746	36.481698
1970	30.39046	27.446139	27.741775
1971	40.54583	39.493852	45.80717
1972	43.33156	44.253389	45.063645
1973	38.78276	30.349047	28.829883
1974	44.3565	38.119893	43.571742
1975	38.50581	39.658946	37.974238
1976	42.25814	46.563877	43.263764
1977	20.12048	17.656148	18.778835
1978	39.52586	38.795129	37.169751
1979	30.79791	34.359461	35.70335
1980	31.79684	33.556949	29.892574
1981	26.7559	28.499406	30.304209
1982	32.63205	40.139909	38.18599
1983	37.9901	32.046065	30.82906
1984	35.11794	36.93638	33.644431
1985	36.28251	37.174558	39.650335
1986	41.16751	42.890297	46.633584
1987	30.87584	24.491138	22.716234
1988	25.04672	16.723054	22.867398
1989	28.52335	30.807628	30.893584
1990	29.89391	29.166014	28.350047
1991	41.35994	33.749686	36.757776

Appendix 5: Regression Equations for Reconstructions

TRC

Variables: BLE

Equation: 10.52915 + 23.96726 * BLE

TRC, SOI

Variables: BLE, SOI

Equation: 8.389381 + 26.4992 * BLE + 2.981916 * SOI

TRC, SOI, SST Instrumental

Variables: SST 1 Inst, RIF, NPU

Equation: 10.90955 – 9.09906 * SST 1 Inst + 13.38973 * RIF + 10.0567 * NPU

TRC, SST Tree

Variables: BLE, SST 1 Tree, RIF

Equation: 6.035585 + 16.74497 * BLE – 10.6229 * SST 1 Tree + 11.82903 * RIF

TRC, SST Coral

Variables: SST 1 Coral, RIF, BLE

Equation: 9.90813 – 11.6312 * SST 1 Coral + 10.43538 * RIF + 14.33691 * BLE

TRC, SST Instrumental

Variables: SST 1 Inst, RIF, NPU

Equation: 10.90955 – 9.09906 * SST 1 Inst + 13.38973 * RIF + 10.0567 * NPU

Appendix 6: Chronology Data Used in Reconstructions

BLE

Year	**BLE**	**1611**	1.204	**1647**	1.108	**1683**	1.351
1576	0.780	**1612**	0.657	**1648**	0.463	**1684**	0.985
1577	0.945	**1613**	0.291	**1649**	0.952	**1685**	0.679
1578	1.063	**1614**	1.410	**1650**	1.229	**1686**	1.216
1579	0.467	**1615**	0.758	**1651**	1.095	**1687**	1.377
1580	0.631	**1616**	1.216	**1652**	0.957	**1688**	0.970
1581	0.447	**1617**	1.506	**1653**	1.287	**1689**	1.006
1582	1.318	**1618**	1.476	**1654**	1.164	**1690**	0.623
1583	0.945	**1619**	1.280	**1655**	1.486	**1691**	1.281
1584	0.672	**1620**	1.227	**1656**	1.163	**1692**	1.711
1585	0.525	**1621**	1.767	**1657**	0.234	**1693**	0.940
1586	0.500	**1622**	1.092	**1658**	0.827	**1694**	1.468
1587	0.846	**1623**	1.079	**1659**	0.646	**1695**	0.218
1588	0.754	**1624**	1.423	**1660**	0.661	**1696**	1.055
1589	1.391	**1625**	0.617	**1661**	0.821	**1697**	1.255
1590	2.231	**1626**	0.512	**1662**	0.756	**1698**	0.833
1591	0.776	**1627**	0.718	**1663**	1.122	**1699**	1.353
1592	1.228	**1628**	1.080	**1664**	0.975	**1700**	1.385
1593	0.899	**1629**	0.989	**1665**	1.097	**1701**	0.841
1594	0.845	**1630**	0.837	**1666**	0.922	**1702**	1.404
1595	1.112	**1631**	0.530	**1667**	0.617	**1703**	0.533
1596	1.262	**1632**	0.475	**1668**	0.650	**1704**	0.788
1597	0.245	**1633**	1.367	**1669**	1.002	**1705**	1.445
1598	0.971	**1634**	0.876	**1670**	0.920	**1706**	0.857
1599	1.034	**1635**	0.593	**1671**	0.940	**1707**	0.589
1600	0.796	**1636**	0.915	**1672**	0.903	**1708**	0.599
1601	0.318	**1637**	0.529	**1673**	1.206	**1709**	1.206
1602	1.352	**1638**	0.908	**1674**	1.069	**1710**	0.652
1603	1.147	**1639**	0.586	**1675**	1.145	**1711**	1.052
1604	1.356	**1640**	1.202	**1676**	1.829	**1712**	0.980
1605	2.333	**1641**	1.253	**1677**	0.787	**1713**	1.092
1606	0.124	**1642**	1.357	**1678**	0.358	**1714**	1.105
1607	1.165	**1643**	0.927	**1679**	1.363	**1715**	0.803
1608	1.390	**1644**	0.821	**1680**	1.033	**1716**	0.958
1609	1.230	**1645**	0.538	**1681**	0.735	**1717**	0.388
1610	2.038	**1646**	0.407	**1682**	0.672	**1718**	1.181

1719	1.224	**1760**	0.703	**1801**	0.653	**1842**	0.489
1720	0.913	**1761**	1.338	**1802**	1.049	**1843**	1.361
1721	0.534	**1762**	0.931	**1803**	0.555	**1844**	0.933
1722	1.109	**1763**	1.232	**1804**	0.744	**1845**	0.592
1723	1.184	**1764**	1.136	**1805**	0.674	**1846**	0.757
1724	0.681	**1765**	0.799	**1806**	0.740	**1847**	0.988
1725	0.874	**1766**	1.491	**1807**	0.895	**1848**	0.655
1726	1.426	**1767**	1.576	**1808**	0.702	**1849**	1.331
1727	1.078	**1768**	0.753	**1809**	0.848	**1850**	0.893
1728	1.088	**1769**	0.958	**1810**	1.232	**1851**	0.842
1729	0.215	**1770**	0.963	**1811**	1.120	**1852**	0.966
1730	1.525	**1771**	1.142	**1812**	1.126	**1853**	1.359
1731	0.946	**1772**	0.949	**1813**	0.836	**1854**	1.679
1732	0.887	**1773**	0.960	**1814**	0.768	**1855**	0.412
1733	1.388	**1774**	0.816	**1815**	0.926	**1856**	0.725
1734	1.186	**1775**	1.197	**1816**	1.030	**1857**	0.875
1735	0.442	**1776**	1.531	**1817**	0.644	**1858**	0.934
1736	0.799	**1777**	0.609	**1818**	0.971	**1859**	0.800
1737	1.355	**1778**	0.985	**1819**	0.698	**1860**	0.764
1738	0.821	**1779**	1.006	**1820**	0.866	**1861**	0.789
1739	0.703	**1780**	1.353	**1821**	1.364	**1862**	1.093
1740	0.951	**1781**	0.828	**1822**	0.608	**1863**	0.959
1741	0.922	**1782**	0.646	**1823**	1.057	**1864**	0.940
1742	1.021	**1783**	0.834	**1824**	0.753	**1865**	0.773
1743	0.825	**1784**	1.018	**1825**	0.807	**1866**	1.604
1744	0.967	**1785**	0.875	**1826**	1.151	**1867**	1.072
1745	1.330	**1786**	1.048	**1827**	1.269	**1868**	1.231
1746	1.648	**1787**	1.140	**1828**	1.568	**1869**	1.266
1747	1.026	**1788**	0.968	**1829**	0.918	**1870**	1.004
1748	1.187	**1789**	1.354	**1830**	0.618	**1871**	0.452
1749	0.782	**1790**	1.075	**1831**	0.841	**1872**	1.021
1750	1.113	**1791**	1.077	**1832**	1.092	**1873**	1.270
1751	1.442	**1792**	1.725	**1833**	1.105	**1874**	0.836
1752	1.000	**1793**	0.454	**1834**	0.630	**1875**	1.137
1753	1.030	**1794**	1.106	**1835**	0.960	**1876**	1.061
1754	0.979	**1795**	0.144	**1836**	0.967	**1877**	0.823
1755	0.867	**1796**	1.821	**1837**	1.524	**1878**	0.967
1756	0.475	**1797**	0.946	**1838**	1.382	**1879**	0.951
1757	1.205	**1798**	0.687	**1839**	1.598	**1880**	0.750
1758	1.138	**1799**	1.356	**1840**	0.456	**1881**	1.116
1759	0.798	**1800**	0.604	**1841**	1.117	**1882**	0.661

1883	1.099	**1912**	1.174	**1941**	1.306	**1970**	0.723
1884	1.325	**1913**	1.437	**1942**	1.219	**1971**	0.824
1885	1.261	**1914**	1.377	**1943**	1.187	**1972**	1.234
1886	0.720	**1915**	0.825	**1944**	1.178	**1973**	1.154
1887	0.974	**1916**	1.467	**1945**	1.203	**1974**	1.055
1888	0.836	**1917**	1.186	**1946**	1.047	**1975**	0.883
1889	0.965	**1918**	1.239	**1947**	1.593	**1976**	1.115
1890	1.040	**1919**	0.549	**1948**	0.851	**1977**	0.746
1891	0.957	**1920**	0.565	**1949**	1.189	**1978**	1.111
1892	1.034	**1921**	1.087	**1950**	1.047	**1979**	0.851
1893	0.481	**1922**	0.864	**1951**	1.524	**1980**	1.197
1894	1.099	**1923**	1.155	**1952**	0.787	**1981**	0.790
1895	1.028	**1924**	0.759	**1953**	0.712	**1982**	1.027
1896	0.615	**1925**	1.221	**1954**	0.946	**1983**	1.258
1897	0.881	**1926**	0.896	**1955**	0.699	**1984**	1.108
1898	1.313	**1927**	1.141	**1956**	0.917	**1985**	0.900
1899	0.775	**1928**	1.280	**1957**	1.143	**1986**	1.370
1900	0.644	**1929**	1.015	**1958**	0.772	**1987**	0.997
1901	0.649	**1930**	1.432	**1959**	0.890	**1988**	0.544
1902	0.838	**1931**	0.465	**1960**	0.704	**1989**	0.668
1903	0.927	**1932**	0.686	**1961**	0.731	**1990**	1.048
1904	0.944	**1933**	0.787	**1962**	1.365	**1991**	1.154
1905	1.059	**1934**	0.528	**1963**	0.882	**1992**	0.657
1906	0.908	**1935**	0.962	**1964**	0.759	**1993**	1.225
1907	1.541	**1936**	0.877	**1965**	1.192	**1994**	0.897
1908	1.473	**1937**	1.304	**1966**	1.002	**1995**	1.156
1909	1.010	**1938**	1.123	**1967**	0.942	**1996**	1.155
1910	1.198	**1939**	1.168	**1968**	0.952	**1997**	0.913
1911	0.604	**1940**	0.416	**1969**	1.131		

NPU

Year	NPU
1486	0.917
1487	1.004
1488	1.017
1489	0.821
1490	0.992
1491	1.114
1492	1.15
1493	0.875
1494	1.178
1495	0.546
1496	1.022
1497	0.484
1498	1.63
1499	1.945
1500	0.319
1501	0.931
1502	0.632
1503	0.819
1504	1.087
1505	1.166
1506	0.708
1507	0.952
1508	1.005
1509	0.977
1510	0.712
1511	0.809
1512	0.975
1513	0.583
1514	0.875
1515	0.63
1516	0.968
1517	0.552
1518	1.116
1519	0.862
1520	0.784
1521	1.391
1522	0.382
1523	1.314
1524	1.271
1525	1.489
1526	0.845
1527	0.703
1528	0.411
1529	1.25
1530	1.104
1531	0.483
1532	0.645
1533	0.756
1534	0.899
1535	1.641
1536	1.55
1537	1.653
1538	0.538
1539	1.717
1540	1.351
1541	0.858
1542	0.246
1543	0.472
1544	1.019
1545	1.07
1546	1.227
1547	0.468
1548	0.753
1549	1.258
1550	1.139
1551	1.003
1552	1.196
1553	1.319
1554	1.197
1555	1.297
1556	1.452
1557	1.319
1558	0.684
1559	0.942
1560	1.552
1561	1.639
1562	0.443
1563	0.703
1564	1.633
1565	1.211
1566	0.5
1567	0.824
1568	0.624
1569	0.698
1570	1.133
1571	0.932
1572	0.69
1573	1.016
1574	0.936
1575	0.903
1576	0.843
1577	1.134
1578	1.186
1579	0.549
1580	0.633
1581	0.993
1582	1.426
1583	1.379
1584	0.483
1585	1.443
1586	1.317
1587	0.368
1588	0.755
1589	1.161
1590	0.612
1591	0.668
1592	0.559
1593	0.931
1594	1.278
1595	0.843
1596	1.224
1597	1.066
1598	0.975
1599	1.099
1600	0.393
1601	1.625
1602	1.056
1603	1.192
1604	1.759
1605	1.765
1606	0.821
1607	0.128
1608	0.764
1609	0.78
1610	0.816
1611	1.064
1612	0.562
1613	1.025
1614	1.201
1615	1.28
1616	0.79
1617	1.541
1618	1.071
1619	1.313
1620	0.942
1621	0.919
1622	0.329
1623	1.296
1624	1.213
1625	1.07
1626	1.149
1627	0.661
1628	0.709
1629	1.211
1630	0.5
1631	0.948
1632	1.024
1633	1.524
1634	1.508
1635	1.426
1636	0.77

1637	1.072	**1678**	1.637	**1719**	1.294	**1760**	1.003
1638	0.95	**1679**	1.12	**1720**	1.394	**1761**	1.064
1639	1.366	**1680**	1.44	**1721**	1.126	**1762**	1.197
1640	0.468	**1681**	0.562	**1722**	0.587	**1763**	0.747
1641	0.723	**1682**	0.627	**1723**	0.944	**1764**	1.369
1642	1.111	**1683**	1.391	**1724**	0.985	**1765**	0.977
1643	0.243	**1684**	0.812	**1725**	1.048	**1766**	1.079
1644	1.168	**1685**	0.333	**1726**	1.785	**1767**	0.878
1645	0.874	**1686**	0.718	**1727**	0.683	**1768**	1.71
1646	1.266	**1687**	1.065	**1728**	0.995	**1769**	1.172
1647	0.955	**1688**	1.029	**1729**	1.252	**1770**	0.867
1648	0.916	**1689**	0.931	**1730**	0.739	**1771**	1.23
1649	1.118	**1690**	0.758	**1731**	1.172	**1772**	0.994
1650	0.96	**1691**	1.016	**1732**	0.704	**1773**	0.819
1651	1.124	**1692**	1.508	**1733**	1.119	**1774**	0.752
1652	0.565	**1693**	0.462	**1734**	1.211	**1775**	1.016
1653	0.501	**1694**	1.301	**1735**	0.708	**1776**	0.748
1654	0.493	**1695**	0.714	**1736**	0.5	**1777**	0.696
1655	1.566	**1696**	0.874	**1737**	1.15	**1778**	1.041
1656	0.984	**1697**	0.989	**1738**	0.876	**1779**	0.614
1657	0.869	**1698**	0.891	**1739**	1.273	**1780**	0.862
1658	0.674	**1699**	1.244	**1740**	1.223	**1781**	1.142
1659	1.221	**1700**	0.83	**1741**	1.112	**1782**	0.769
1660	0.837	**1701**	1.734	**1742**	0.598	**1783**	1.091
1661	1.291	**1702**	1.253	**1743**	0.803	**1784**	0.946
1662	1.124	**1703**	1.289	**1744**	0.785	**1785**	1.079
1663	1.56	**1704**	0.501	**1745**	1.041	**1786**	0.755
1664	1.474	**1705**	0.912	**1746**	1.368	**1787**	1.369
1665	0.443	**1706**	0.407	**1747**	1.376	**1788**	0.787
1666	0.735	**1707**	1.231	**1748**	1.242	**1789**	0.365
1667	0.937	**1708**	0.669	**1749**	0.901	**1790**	1.728
1668	0.32	**1709**	0.781	**1750**	1.116	**1791**	0.945
1669	1.055	**1710**	0.812	**1751**	0.781	**1792**	1.618
1670	0.617	**1711**	0.424	**1752**	1.431	**1793**	0.742
1671	0.972	**1712**	1.228	**1753**	1.419	**1794**	1.556
1672	1.069	**1713**	0.771	**1754**	1.018	**1795**	0.743
1673	1.398	**1714**	0.588	**1755**	0.887	**1796**	1.419
1674	1.112	**1715**	0.608	**1756**	0.701	**1797**	1.237
1675	0.944	**1716**	0.903	**1757**	0.788	**1798**	0.677
1676	1.593	**1717**	0.868	**1758**	0.911	**1799**	1.415
1677	0.972	**1718**	1.003	**1759**	0.632	**1800**	0.788

1801	0.869	**1842**	0.418	**1883**	0.912	**1924**	1.021
1802	1.123	**1843**	2.238	**1884**	0.993	**1925**	1.288
1803	1.016	**1844**	0.91	**1885**	0.885	**1926**	1.791
1804	0.895	**1845**	0.049	**1886**	0.777	**1927**	0.915
1805	0.668	**1846**	0.906	**1887**	0.654	**1928**	1.915
1806	1.077	**1847**	0.553	**1888**	0.614	**1929**	0.614
1807	0.539	**1848**	0.605	**1889**	0.711	**1930**	0.804
1808	0.973	**1849**	1.357	**1890**	0.708	**1931**	1.31
1809	0.388	**1850**	1.048	**1891**	1.224	**1932**	0.952
1810	0.957	**1851**	0.559	**1892**	0.998	**1933**	0.872
1811	1.295	**1852**	1.076	**1893**	0.536	**1934**	0.615
1812	1.304	**1853**	1.233	**1894**	0.939	**1935**	0.612
1813	1.137	**1854**	0.843	**1895**	1.273	**1936**	0.723
1814	0.974	**1855**	0.281	**1896**	0.665	**1937**	1.374
1815	0.971	**1856**	1.083	**1897**	1.13	**1938**	0.882
1816	0.833	**1857**	0.929	**1898**	0.771	**1939**	0.746
1817	0.851	**1858**	1.183	**1899**	0.707	**1940**	0.724
1818	0.998	**1859**	0.935	**1900**	1.188	**1941**	0.943
1819	0.879	**1860**	1.227	**1901**	0.726	**1942**	1.072
1820	0.724	**1861**	0.945	**1902**	0.665	**1943**	0.633
1821	1.365	**1862**	1.308	**1903**	0.877	**1944**	1.004
1822	1.067	**1863**	0.669	**1904**	0.977	**1945**	1.117
1823	0.93	**1864**	1.225	**1905**	0.933	**1946**	0.69
1824	0.611	**1865**	0.869	**1906**	0.9	**1947**	1.343
1825	1.137	**1866**	1.486	**1907**	1.261	**1948**	0.946
1826	1.035	**1867**	1.523	**1908**	0.539	**1949**	0.939
1827	0.697	**1868**	0.69	**1909**	1.36	**1950**	1.194
1828	1.364	**1869**	1.45	**1910**	0.879	**1951**	1.128
1829	0.718	**1870**	0.757	**1911**	1.393	**1952**	0.904
1830	0.827	**1871**	0.257	**1912**	0.853	**1953**	0.639
1831	1.378	**1872**	1.05	**1913**	1.056	**1954**	0.554
1832	1.349	**1873**	0.963	**1914**	0.996	**1955**	0.435
1833	0.709	**1874**	0.374	**1915**	0.936	**1956**	1.206
1834	0.617	**1875**	1.327	**1916**	1.097	**1957**	1.355
1835	0.864	**1876**	1.345	**1917**	1.472	**1958**	1.04
1836	1.253	**1877**	0.734	**1918**	0.981	**1959**	0.722
1837	1.592	**1878**	1.175	**1919**	0.795	**1960**	0.835
1838	1.581	**1879**	0.888	**1920**	0.849	**1961**	1.004
1839	1.676	**1880**	1.151	**1921**	1.421	**1962**	1.527
1840	1.259	**1881**	0.97	**1922**	0.746	**1963**	0.633
1841	1.188	**1882**	0.695	**1923**	1.096	**1964**	0.62

1965	1.031	**1975**	0.85	**1985**	1.078	**1995**	1.199
1966	0.933	**1976**	0.924	**1986**	1.721	**1996**	1.127
1967	1.229	**1977**	1.107	**1987**	0.61	**1997**	0.869
1968	0.881	**1978**	0.912	**1988**	1.091	**1998**	1.081
1969	1.153	**1979**	0.843	**1989**	0.452	**1999**	1.368
1970	0.957	**1980**	0.94	**1990**	1.081	**2000**	0.784
1971	1.138	**1981**	0.682	**1991**	1.132	**2001**	0.834
1972	1.504	**1982**	1.105	**1992**	0.943		
1973	1.17	**1983**	1.536	**1993**	1.159		
1974	1.533	**1984**	1.385	**1994**	0.641		

RIF

Year	RIF						
1352	0.881	**1387**	0.757	**1423**	0.646	**1459**	0.730
1353	0.809	**1388**	0.767	**1424**	0.926	**1460**	0.704
1354	0.937	**1389**	0.588	**1425**	0.554	**1461**	0.983
1355	0.882	**1390**	0.807	**1426**	1.180	**1462**	1.665
1356	1.237	**1391**	1.072	**1427**	0.971	**1463**	1.302
1357	1.261	**1392**	1.109	**1428**	0.805	**1464**	0.952
1358	1.310	**1393**	1.060	**1429**	0.918	**1465**	1.001
1359	1.179	**1394**	1.241	**1430**	1.280	**1466**	1.192
1360	0.629	**1395**	0.922	**1431**	1.205	**1467**	1.261
1361	0.941	**1396**	1.107	**1432**	0.798	**1468**	0.991
1362	0.654	**1397**	0.611	**1433**	0.863	**1469**	0.807
1363	1.037	**1398**	0.915	**1434**	0.924	**1470**	0.782
1364	0.729	**1399**	0.404	**1435**	0.876	**1471**	0.890
1365	0.934	**1400**	0.743	**1436**	1.333	**1472**	0.960
1366	1.086	**1401**	1.541	**1437**	0.944	**1473**	1.227
1367	0.667	**1402**	1.116	**1438**	1.054	**1474**	0.964
1368	0.785	**1403**	1.120	**1439**	0.771	**1475**	0.512
1369	0.753	**1404**	1.380	**1440**	1.287	**1476**	1.117
1370	1.028	**1405**	1.110	**1441**	1.070	**1477**	1.174
1371	1.050	**1406**	1.294	**1442**	0.598	**1478**	0.933
1372	1.068	**1407**	0.907	**1443**	0.865	**1479**	0.942
1373	0.874	**1408**	1.158	**1444**	0.777	**1480**	0.922
1374	0.952	**1409**	1.069	**1445**	0.793	**1481**	0.808
1375	1.183	**1410**	0.731	**1446**	0.837	**1482**	1.365
1376	0.955	**1411**	1.073	**1447**	1.055	**1483**	0.917
1377	1.295	**1412**	0.770	**1448**	1.075	**1484**	1.619
1378	1.300	**1413**	0.643	**1449**	1.146	**1485**	0.756
1379	1.009	**1414**	1.294	**1450**	1.191	**1486**	0.966
1380	0.864	**1415**	0.842	**1451**	1.477	**1487**	1.037
1381	1.250	**1416**	0.500	**1452**	0.872	**1488**	1.025
1382	1.047	**1417**	0.977	**1453**	0.901	**1489**	1.292
1383	1.048	**1418**	1.268	**1454**	0.838	**1490**	1.052
1384	1.071	**1419**	1.098	**1455**	0.873	**1491**	1.167
1385	0.941	**1420**	0.992	**1456**	0.789	**1492**	1.068
1386	0.971	**1421**	0.737	**1457**	1.114	**1493**	0.945
		1422	1.004	**1458**	1.076	**1494**	1.144

1495	0.428	**1536**	1.328	**1577**	1.500	**1618**	1.297
1496	0.671	**1537**	0.980	**1578**	1.179	**1619**	1.075
1497	1.136	**1538**	0.748	**1579**	0.857	**1620**	0.968
1498	1.286	**1539**	0.900	**1580**	0.415	**1621**	1.445
1499	0.722	**1540**	1.338	**1581**	0.937	**1622**	0.530
1500	0.494	**1541**	1.211	**1582**	0.892	**1623**	0.830
1501	1.005	**1542**	0.530	**1583**	0.608	**1624**	0.915
1502	1.039	**1543**	0.783	**1584**	0.462	**1625**	0.878
1503	0.962	**1544**	1.189	**1585**	0.520	**1626**	0.829
1504	1.318	**1545**	0.835	**1586**	0.995	**1627**	1.094
1505	0.679	**1546**	1.358	**1587**	0.839	**1628**	1.104
1506	0.166	**1547**	1.019	**1588**	1.061	**1629**	0.879
1507	1.181	**1548**	1.076	**1589**	1.205	**1630**	1.273
1508	1.137	**1549**	1.626	**1590**	0.440	**1631**	0.578
1509	1.482	**1550**	1.132	**1591**	0.928	**1632**	0.571
1510	0.621	**1551**	0.772	**1592**	0.734	**1633**	1.561
1511	0.920	**1552**	0.860	**1593**	1.138	**1634**	0.436
1512	1.265	**1553**	1.237	**1594**	1.133	**1635**	0.564
1513	1.083	**1554**	0.997	**1595**	1.249	**1636**	1.288
1514	1.299	**1555**	1.088	**1596**	1.088	**1637**	0.900
1515	1.072	**1556**	1.128	**1597**	1.031	**1638**	1.062
1516	0.930	**1557**	1.236	**1598**	0.582	**1639**	0.921
1517	1.102	**1558**	0.480	**1599**	1.225	**1640**	1.178
1518	0.831	**1559**	1.237	**1600**	0.332	**1641**	0.920
1519	1.055	**1560**	0.945	**1601**	1.066	**1642**	1.094
1520	0.971	**1561**	0.882	**1602**	1.273	**1643**	0.788
1521	1.427	**1562**	1.091	**1603**	1.319	**1644**	0.990
1522	0.654	**1563**	1.177	**1604**	1.343	**1645**	0.623
1523	1.468	**1564**	1.298	**1605**	1.001	**1646**	0.549
1524	1.399	**1565**	1.472	**1606**	1.018	**1647**	1.252
1525	1.431	**1566**	1.030	**1607**	0.623	**1648**	0.658
1526	1.184	**1567**	0.702	**1608**	1.003	**1649**	1.130
1527	0.887	**1568**	1.076	**1609**	0.997	**1650**	1.295
1528	0.955	**1569**	1.026	**1610**	1.242	**1651**	1.026
1529	1.022	**1570**	1.135	**1611**	1.083	**1652**	1.352
1530	0.966	**1571**	1.150	**1612**	1.010	**1653**	0.658
1531	0.951	**1572**	1.046	**1613**	0.754	**1654**	0.232
1532	0.140	**1573**	0.932	**1614**	1.377	**1655**	1.629
1533	0.816	**1574**	0.530	**1615**	1.367	**1656**	0.779
1534	1.002	**1575**	0.968	**1616**	1.370	**1657**	0.935
1535	1.435	**1576**	1.102	**1617**	1.089	**1658**	1.140

1659	1.083	**1700**	0.998	**1741**	1.329	**1782**	0.617
1660	0.963	**1701**	1.158	**1742**	0.889	**1783**	0.970
1661	0.652	**1702**	1.045	**1743**	1.248	**1784**	1.608
1662	1.097	**1703**	0.648	**1744**	0.720	**1785**	0.958
1663	0.806	**1704**	0.704	**1745**	1.034	**1786**	0.489
1664	0.844	**1705**	1.130	**1746**	1.377	**1787**	1.299
1665	0.935	**1706**	0.860	**1747**	1.232	**1788**	0.709
1666	0.782	**1707**	0.815	**1748**	0.453	**1789**	1.031
1667	0.910	**1708**	0.809	**1749**	1.411	**1790**	1.811
1668	0.730	**1709**	1.022	**1750**	0.630	**1791**	1.233
1669	1.449	**1710**	0.703	**1751**	1.047	**1792**	1.249
1670	0.554	**1711**	1.023	**1752**	0.654	**1793**	0.541
1671	0.928	**1712**	1.099	**1753**	1.218	**1794**	0.803
1672	1.448	**1713**	0.864	**1754**	0.719	**1795**	0.840
1673	1.326	**1714**	0.540	**1755**	0.750	**1796**	1.190
1674	1.452	**1715**	0.967	**1756**	0.632	**1797**	1.699
1675	0.859	**1716**	1.109	**1757**	0.926	**1798**	0.435
1676	1.424	**1717**	0.711	**1758**	1.362	**1799**	1.383
1677	1.021	**1718**	1.206	**1759**	0.943	**1800**	1.101
1678	1.426	**1719**	1.169	**1760**	1.067	**1801**	0.870
1679	0.942	**1720**	1.359	**1761**	1.203	**1802**	1.147
1680	1.801	**1721**	0.659	**1762**	0.852	**1803**	0.780
1681	1.006	**1722**	0.396	**1763**	0.686	**1804**	0.514
1682	0.601	**1723**	0.823	**1764**	0.973	**1805**	0.840
1683	1.472	**1724**	1.070	**1765**	0.446	**1806**	1.073
1684	0.609	**1725**	1.283	**1766**	1.123	**1807**	0.996
1685	0.179	**1726**	1.501	**1767**	0.759	**1808**	0.907
1686	0.613	**1727**	1.212	**1768**	1.414	**1809**	0.796
1687	1.187	**1728**	0.517	**1769**	1.245	**1810**	1.072
1688	1.330	**1729**	0.996	**1770**	1.003	**1811**	1.576
1689	1.224	**1730**	0.886	**1771**	1.076	**1812**	1.175
1690	1.112	**1731**	0.825	**1772**	0.796	**1813**	0.850
1691	1.130	**1732**	0.803	**1773**	0.612	**1814**	0.470
1692	0.798	**1733**	0.990	**1774**	0.763	**1815**	1.121
1693	0.995	**1734**	1.664	**1775**	1.278	**1816**	1.264
1694	1.032	**1735**	0.175	**1776**	1.080	**1817**	1.056
1695	0.650	**1736**	0.786	**1777**	0.652	**1818**	1.177
1696	1.047	**1737**	0.812	**1778**	0.917	**1819**	0.907
1697	0.982	**1738**	1.282	**1779**	1.036	**1820**	0.401
1698	1.052	**1739**	1.176	**1780**	0.793	**1821**	1.476
1699	1.135	**1740**	0.600	**1781**	1.120	**1822**	0.938

1823	1.010	**1864**	1.066	**1905**	1.276	**1946**	0.639
1824	0.323	**1865**	0.866	**1906**	1.387	**1947**	1.253
1825	0.953	**1866**	1.469	**1907**	1.382	**1948**	0.934
1826	1.257	**1867**	1.384	**1908**	0.793	**1949**	1.100
1827	1.104	**1868**	0.927	**1909**	1.251	**1950**	0.919
1828	1.609	**1869**	0.857	**1910**	0.970	**1951**	0.888
1829	0.355	**1870**	0.865	**1911**	1.276	**1952**	1.040
1830	1.102	**1871**	0.572	**1912**	1.200	**1953**	0.753
1831	0.880	**1872**	1.447	**1913**	1.177	**1954**	0.800
1832	1.469	**1873**	0.836	**1914**	1.496	**1955**	0.878
1833	0.634	**1874**	0.668	**1915**	0.899	**1956**	0.752
1834	0.553	**1875**	0.587	**1916**	1.382	**1957**	1.137
1835	1.020	**1876**	0.977	**1917**	1.101	**1958**	0.911
1836	0.954	**1877**	0.480	**1918**	0.976	**1959**	0.584
1837	1.355	**1878**	0.924	**1919**	0.682	**1960**	0.928
1838	1.530	**1879**	0.286	**1920**	1.350	**1961**	0.515
1839	1.206	**1880**	1.147	**1921**	1.463	**1962**	1.413
1840	1.308	**1881**	0.731	**1922**	1.094	**1963**	0.564
1841	1.126	**1882**	0.720	**1923**	0.925	**1964**	0.717
1842	0.708	**1883**	1.245	**1924**	1.068	**1965**	1.243
1843	1.230	**1884**	1.351	**1925**	1.123	**1966**	0.858
1844	1.047	**1885**	1.239	**1926**	1.475	**1967**	1.154
1845	0.112	**1886**	0.787	**1927**	1.440	**1968**	0.792
1846	0.685	**1887**	0.863	**1928**	0.882	**1969**	1.170
1847	0.258	**1888**	0.905	**1929**	1.133	**1970**	0.995
1848	1.417	**1889**	0.461	**1930**	0.886	**1971**	1.157
1849	1.953	**1890**	1.123	**1931**	0.762	**1972**	1.105
1850	1.350	**1891**	0.966	**1932**	1.322	**1973**	1.278
1851	0.371	**1892**	1.009	**1933**	1.078	**1974**	0.829
1852	1.114	**1893**	0.576	**1934**	0.571	**1975**	1.226
1853	1.446	**1894**	0.365	**1935**	1.212	**1976**	1.239
1854	1.013	**1895**	1.336	**1936**	0.537	**1977**	0.189
1855	0.759	**1896**	0.269	**1937**	1.187	**1978**	1.402
1856	0.771	**1897**	1.410	**1938**	1.328	**1979**	1.142
1857	0.669	**1898**	0.833	**1939**	0.577	**1980**	1.029
1858	0.953	**1899**	0.967	**1940**	1.059	**1981**	0.991
1859	0.766	**1900**	0.886	**1941**	1.397	**1982**	1.203
1860	1.209	**1901**	0.961	**1942**	1.085	**1983**	1.381
1861	0.246	**1902**	0.467	**1943**	0.713	**1984**	1.384
1862	1.805	**1903**	1.126	**1944**	1.098	**1985**	1.306
1863	1.066	**1904**	1.019	**1945**	1.037	**1986**	1.167

1987	0.883	**1990**	0.508	**1993**	1.343	**1996**	1.012
1988	0.867	**1991**	1.251	**1994**	0.748	**1997**	1.273
1989	0.907	**1992**	1.123	**1995**	1.650		

Appendix 7: Reconstructed SST Data

Tree: SST 1

1590	-0.07589	**1626**	-0.39643	**1662**	-0.12963
1591	-0.10292	**1627**	-0.54705	**1663**	-0.52976
1592	0.033158	**1628**	-0.1779	**1664**	-0.97012
1593	-0.01331	**1629**	0.046441	**1665**	-0.73181
1594	0.167681	**1630**	-0.0049	**1666**	-0.42091
1595	-0.00172	**1631**	0.297676	**1667**	-0.20074
1596	-0.10805	**1632**	0.457396	**1668**	-0.08225
1597	0.043373	**1633**	0.64799	**1669**	-0.07195
1598	-0.25454	**1634**	0.684201	**1670**	-0.25809
1599	-0.07418	**1635**	0.291555	**1671**	0.04335
1600	-0.43767	**1636**	0.105118	**1672**	0.035378
1601	-0.46413	**1637**	-0.02089	**1673**	-0.09494
1602	-0.51422	**1638**	-0.16627	**1674**	-0.12576
1603	-0.58567	**1639**	-0.00451	**1675**	-0.11794
1604	-0.43362	**1640**	0.463701	**1676**	-0.42361
1605	-0.58304	**1641**	0.469355	**1677**	-0.43997
1606	-0.27558	**1642**	0.192239	**1678**	-0.63522
1607	0.01592	**1643**	-0.18023	**1679**	-0.49708
1608	0.15926	**1644**	-0.39635	**1680**	-0.31493
1609	-0.02738	**1645**	-0.19356	**1681**	-0.05162
1610	0.159701	**1646**	-0.15259	**1682**	0.491888
1611	0.145632	**1647**	0.04923	**1683**	0.519553
1612	-0.28097	**1648**	-0.18293	**1684**	0.148084
1613	-0.23529	**1649**	0.197948	**1685**	0.485207
1614	-0.19386	**1650**	0.426046	**1686**	0.574097
1615	-0.12866	**1651**	0.549281	**1687**	0.332449
1616	-0.09948	**1652**	0.089057	**1688**	0.317103
1617	-0.02229	**1653**	-0.15098	**1689**	-0.05762
1618	-0.25674	**1654**	-0.16191	**1690**	-0.3974
1619	-0.15106	**1655**	-0.15999	**1691**	0.193336
1620	-0.19133	**1656**	-0.00813	**1692**	0.220332
1621	-0.25003	**1657**	-0.05481	**1693**	0.367705
1622	-0.38521	**1658**	-0.29313	**1694**	0.423609
1623	-0.53169	**1659**	-0.26296	**1695**	-0.53316
1624	-0.65819	**1660**	-0.19169	**1696**	-0.67809
1625	-0.51128	**1661**	-0.11538	**1697**	-0.84151

1698	-0.61766	**1739**	-0.35883	**1780**	-0.17714
1699	-0.09874	**1740**	-0.2425	**1781**	-0.44194
1700	0.40266	**1741**	-0.57795	**1782**	0.19234
1701	-0.17064	**1742**	-0.10252	**1783**	0.390863
1702	-0.65304	**1743**	0.054337	**1784**	0.058662
1703	-0.67434	**1744**	-0.08211	**1785**	-0.01201
1704	-0.52428	**1745**	0.348136	**1786**	0.131874
1705	-0.42556	**1746**	-0.08675	**1787**	-0.03577
1706	-0.62758	**1747**	-0.3094	**1788**	-0.71557
1707	-0.21766	**1748**	0.049802	**1789**	-0.52278
1708	-0.32033	**1749**	0.094334	**1790**	-0.18693
1709	0.34508	**1750**	0.318865	**1791**	0.273877
1710	0.127851	**1751**	-0.38271	**1792**	0.731235
1711	0.208549	**1752**	-0.35931	**1793**	0.339357
1712	0.262678	**1753**	-0.47213	**1794**	0.52148
1713	-0.08189	**1754**	-0.73959	**1795**	0.312902
1714	-0.5535	**1755**	-0.71889	**1796**	-0.1783
1715	-0.54471	**1756**	-0.94949	**1797**	-0.13994
1716	-0.52479	**1757**	-0.29225	**1798**	0.061203
1717	-0.12342	**1758**	-0.10213	**1799**	-0.04797
1718	0.144011	**1759**	-0.42515	**1800**	-0.23147
1719	0.452018	**1760**	-0.33355	**1801**	0.085364
1720	0.55978	**1761**	0.267832	**1802**	-0.02725
1721	0.540826	**1762**	-0.11811	**1803**	0.326158
1722	0.643306	**1763**	0.441618	**1804**	0.310517
1723	0.243914	**1764**	0.21439	**1805**	0.16584
1724	-0.26643	**1765**	0.448368	**1806**	0.06254
1725	0.154395	**1766**	0.243676	**1807**	-0.19548
1726	0.029099	**1767**	-0.04952	**1808**	-0.09502
1727	-0.05938	**1768**	-0.08799	**1809**	-0.05714
1728	-0.31253	**1769**	-0.25695	**1810**	-0.24564
1729	-0.56297	**1770**	-0.01204	**1811**	-0.44159
1730	-0.68233	**1771**	-0.21784	**1812**	-0.40889
1731	-0.25393	**1772**	-0.50656	**1813**	-0.44667
1732	-0.20251	**1773**	-0.54693	**1814**	-0.07288
1733	0.076496	**1774**	-0.24543	**1815**	-0.26395
1734	-0.05291	**1775**	-0.24717	**1816**	-0.041
1735	-0.02642	**1776**	-0.27226	**1817**	-0.93054
1736	0.100394	**1777**	-0.29361	**1818**	-0.83773
1737	0.300525	**1778**	-0.12513	**1819**	-0.85366
1738	-0.26056	**1779**	-0.24292	**1820**	-0.30121

1821	-0.44775	**1862**	-0.5762	**1903**	-0.26963
1822	-0.35872	**1863**	-0.58939	**1904**	0.623256
1823	-0.09142	**1864**	-0.20466	**1905**	0.768141
1824	0.200163	**1865**	-0.15051	**1906**	0.499694
1825	0.144041	**1866**	-0.25294	**1907**	0.298878
1826	0.337134	**1867**	-0.07997	**1908**	-0.16555
1827	0.226678	**1868**	0.223433	**1909**	-0.65495
1828	0.602674	**1869**	-0.09407	**1910**	-0.05993
1829	0.583466	**1870**	-0.44096	**1911**	0.421464
1830	-0.12055	**1871**	-0.37205	**1912**	0.215972
1831	-0.26706	**1872**	-0.15365	**1913**	0.536905
1832	0.489751	**1873**	-0.12018	**1914**	0.612653
1833	0.318662	**1874**	0.053015	**1915**	0.084428
1834	0.253831	**1875**	-0.00958	**1916**	-0.09742
1835	-0.02489	**1876**	-0.12201	**1917**	-0.08926
1836	0.159309	**1877**	-0.07437	**1918**	0.477584
1837	-0.13105	**1878**	-0.30162	**1919**	0.435626
1838	0.302632	**1879**	-0.2873	**1920**	0.155975
1839	0.299128	**1880**	0.10473	**1921**	-0.25442
1840	-0.09266	**1881**	0.182119	**1922**	-0.09392
1841	-0.40998	**1882**	-0.21957	**1923**	0.248118
1842	-0.07839	**1883**	-0.00477	**1924**	-0.27574
1843	-0.01935	**1884**	0.373086	**1925**	0.375379
1844	0.067244	**1885**	-0.09515	**1926**	0.205598
1845	0.37547	**1886**	0.030779	**1927**	0.081813
1846	-0.30151	**1887**	0.162488	**1928**	0.063263
1847	-0.18744	**1888**	0.059854	**1929**	0.266537
1848	0.028414	**1889**	-0.06611	**1930**	0.48158
1849	-0.18647	**1890**	0.026438	**1931**	0.341941
1850	-0.44629	**1891**	-0.52606	**1932**	0.221163
1851	0.042762	**1892**	-0.38827	**1933**	-0.37348
1852	0.011532	**1893**	-0.39503	**1934**	-0.06273
1853	-0.45115	**1894**	-0.47954	**1935**	-0.03979
1854	-0.43674	**1895**	-0.35492	**1936**	0.082366
1855	0.262279	**1896**	-0.16636	**1937**	-0.19717
1856	0.009303	**1897**	0.201339	**1938**	-0.38774
1857	0.116864	**1898**	0.066023	**1939**	0.186701
1858	-0.48828	**1899**	-0.02716	**1940**	0.668084
1859	-0.39566	**1900**	0.367444	**1941**	0.770961
1860	-0.27069	**1901**	0.131075	**1942**	0.332948
1861	-0.38212	**1902**	0.61859	**1943**	0.149656

1944	-0.00236	**1960**	-0.19453	**1976**	0.060486
1945	-0.4197	**1961**	0.017378	**1977**	0.159814
1946	-0.0882	**1962**	0.071903	**1978**	0.282069
1947	-0.17673	**1963**	0.299024	**1979**	0.607606
1948	-0.13094	**1964**	0.291565	**1980**	0.398269
1949	-0.45801	**1965**	0.239638	**1981**	0.454767
1950	-0.46092	**1966**	0.048057	**1982**	0.512718
1951	-0.22978	**1967**	0.18708	**1983**	0.549986
1952	-0.1032	**1968**	-0.25341	**1984**	0.02563
1953	-0.33455	**1969**	-0.04503	**1985**	0.151857
1954	-0.31966	**1970**	-0.66142	**1986**	0.216467
1955	-0.67894	**1971**	-0.33528	**1987**	0.033314
1956	-0.55569	**1972**	0.159468	**1988**	-0.05396
1957	0.083409	**1973**	-1.02125	**1989**	-0.02828
1958	-0.08033	**1974**	-0.29954	**1990**	-0.1132
1959	0.025414	**1975**	-0.27259		

Tree: SST 2

1590	0.00878	**1628**	0.020582	**1666**	0.048697
1591	0.011907	**1629**	-0.00537	**1667**	0.023225
1592	-0.00384	**1630**	0.000567	**1668**	0.009516
1593	0.00154	**1631**	-0.03444	**1669**	0.008324
1594	-0.0194	**1632**	-0.05292	**1670**	0.029859
1595	0.000199	**1633**	-0.07497	**1671**	-0.00502
1596	0.012501	**1634**	-0.07916	**1672**	-0.00409
1597	-0.00502	**1635**	-0.03373	**1673**	0.010984
1598	0.029449	**1636**	-0.01216	**1674**	0.01455
1599	0.008582	**1637**	0.002417	**1675**	0.013644
1600	0.050635	**1638**	0.019237	**1676**	0.049009
1601	0.053697	**1639**	0.000522	**1677**	0.050902
1602	0.059492	**1640**	-0.05365	**1678**	0.073491
1603	0.067758	**1641**	-0.0543	**1679**	0.057509
1604	0.050167	**1642**	-0.02224	**1680**	0.036435
1605	0.067454	**1643**	0.020851	**1681**	0.005972
1606	0.031883	**1644**	0.045855	**1682**	-0.05691
1607	-0.00184	**1645**	0.022393	**1683**	-0.06011
1608	-0.01843	**1646**	0.017654	**1684**	-0.01713
1609	0.003168	**1647**	-0.0057	**1685**	-0.05614
1610	-0.01848	**1648**	0.021164	**1686**	-0.06642
1611	-0.01685	**1649**	-0.0229	**1687**	-0.03846
1612	0.032506	**1650**	-0.04929	**1688**	-0.03669
1613	0.027222	**1651**	-0.06355	**1689**	0.006666
1614	0.022428	**1652**	-0.0103	**1690**	0.045977
1615	0.014885	**1653**	0.017468	**1691**	-0.02237
1616	0.011509	**1654**	0.018732	**1692**	-0.02549
1617	0.002579	**1655**	0.018509	**1693**	-0.04254
1618	0.029703	**1656**	0.000941	**1694**	-0.04901
1619	0.017477	**1657**	0.006341	**1695**	0.061684
1620	0.022136	**1658**	0.033913	**1696**	0.078451
1621	0.028927	**1659**	0.030423	**1697**	0.097357
1622	0.044567	**1660**	0.022178	**1698**	0.07146
1623	0.061514	**1661**	0.013348	**1699**	0.011424
1624	0.076148	**1662**	0.014998	**1700**	-0.04659
1625	0.059152	**1663**	0.06129	**1701**	0.019742
1626	0.045865	**1664**	0.112237	**1702**	0.075553
1627	0.063291	**1665**	0.084665	**1703**	0.078016

1704	0.060656	**1745**	-0.04028	**1786**	-0.01526
1705	0.049235	**1746**	0.010036	**1787**	0.004138
1706	0.072608	**1747**	0.035796	**1788**	0.082787
1707	0.025182	**1748**	-0.00576	**1789**	0.060482
1708	0.03706	**1749**	-0.01091	**1790**	0.021627
1709	-0.03992	**1750**	-0.03689	**1791**	-0.03169
1710	-0.01479	**1751**	0.044278	**1792**	-0.0846
1711	-0.02413	**1752**	0.04157	**1793**	-0.03926
1712	-0.03039	**1753**	0.054623	**1794**	-0.06033
1713	0.009474	**1754**	0.085566	**1795**	-0.0362
1714	0.064037	**1755**	0.083171	**1796**	0.020628
1715	0.063019	**1756**	0.10985	**1797**	0.016191
1716	0.060715	**1757**	0.033812	**1798**	-0.00708
1717	0.014279	**1758**	0.011816	**1799**	0.005549
1718	-0.01666	**1759**	0.049187	**1800**	0.02678
1719	-0.0523	**1760**	0.03859	**1801**	-0.00988
1720	-0.06476	**1761**	-0.03099	**1802**	0.003153
1721	-0.06257	**1762**	0.013665	**1803**	-0.03773
1722	-0.07443	**1763**	-0.05109	**1804**	-0.03592
1723	-0.02822	**1764**	-0.0248	**1805**	-0.01919
1724	0.030824	**1765**	-0.05187	**1806**	-0.00724
1725	-0.01786	**1766**	-0.02819	**1807**	0.022615
1726	-0.00337	**1767**	0.005729	**1808**	0.010993
1727	0.006869	**1768**	0.01018	**1809**	0.006611
1728	0.036158	**1769**	0.029727	**1810**	0.028419
1729	0.065132	**1770**	0.001393	**1811**	0.05109
1730	0.078942	**1771**	0.025202	**1812**	0.047306
1731	0.029378	**1772**	0.058606	**1813**	0.051676
1732	0.023429	**1773**	0.063276	**1814**	0.008432
1733	-0.00885	**1774**	0.028394	**1815**	0.030537
1734	0.006122	**1775**	0.028596	**1816**	0.004743
1735	0.003057	**1776**	0.031499	**1817**	0.107657
1736	-0.01161	**1777**	0.033969	**1818**	0.09692
1737	-0.03477	**1778**	0.014477	**1819**	0.098763
1738	0.030145	**1779**	0.028104	**1820**	0.034848
1739	0.041514	**1780**	0.020495	**1821**	0.051802
1740	0.028056	**1781**	0.051129	**1822**	0.041502
1741	0.066865	**1782**	-0.02225	**1823**	0.010577
1742	0.011861	**1783**	-0.04522	**1824**	-0.02316
1743	-0.00629	**1784**	-0.00679	**1825**	-0.01666
1744	0.009499	**1785**	0.001389	**1826**	-0.039

1827	-0.02623	**1868**	-0.02585	**1909**	0.075774
1828	-0.06973	**1869**	0.010884	**1910**	0.006933
1829	-0.0675	**1870**	0.051017	**1911**	-0.04876
1830	0.013947	**1871**	0.043044	**1912**	-0.02499
1831	0.030898	**1872**	0.017776	**1913**	-0.06212
1832	-0.05666	**1873**	0.013904	**1914**	-0.07088
1833	-0.03687	**1874**	-0.00613	**1915**	-0.00977
1834	-0.02937	**1875**	0.001108	**1916**	0.011271
1835	0.002879	**1876**	0.014116	**1917**	0.010327
1836	-0.01843	**1877**	0.008604	**1918**	-0.05525
1837	0.015162	**1878**	0.034895	**1919**	-0.0504
1838	-0.03501	**1879**	0.033239	**1920**	-0.01805
1839	-0.03461	**1880**	-0.01212	**1921**	0.029435
1840	0.01072	**1881**	-0.02107	**1922**	0.010866
1841	0.047432	**1882**	0.025403	**1923**	-0.02871
1842	0.00907	**1883**	0.000552	**1924**	0.031901
1843	0.002238	**1884**	-0.04316	**1925**	-0.04343
1844	-0.00778	**1885**	0.011008	**1926**	-0.02379
1845	-0.04344	**1886**	-0.00356	**1927**	-0.00947
1846	0.034882	**1887**	-0.0188	**1928**	-0.00732
1847	0.021686	**1888**	-0.00692	**1929**	-0.03084
1848	-0.00329	**1889**	0.007648	**1930**	-0.05572
1849	0.021574	**1890**	-0.00306	**1931**	-0.03956
1850	0.051633	**1891**	0.060862	**1932**	-0.02559
1851	-0.00495	**1892**	0.04492	**1933**	0.043209
1852	-0.00133	**1893**	0.045703	**1934**	0.007257
1853	0.052195	**1894**	0.05548	**1935**	0.004603
1854	0.050529	**1895**	0.041062	**1936**	-0.00953
1855	-0.03034	**1896**	0.019247	**1937**	0.022811
1856	-0.00108	**1897**	-0.02329	**1938**	0.044859
1857	-0.01352	**1898**	-0.00764	**1939**	-0.0216
1858	0.056491	**1899**	0.003143	**1940**	-0.07729
1859	0.045775	**1900**	-0.04251	**1941**	-0.0892
1860	0.031317	**1901**	-0.01516	**1942**	-0.03852
1861	0.044209	**1902**	-0.07157	**1943**	-0.01731
1862	0.066662	**1903**	0.031194	**1944**	0.000273
1863	0.068189	**1904**	-0.07211	**1945**	0.048557
1864	0.023678	**1905**	-0.08887	**1946**	0.010204
1865	0.017413	**1906**	-0.05781	**1947**	0.020447
1866	0.029263	**1907**	-0.03458	**1948**	0.015149
1867	0.009251	**1908**	0.019154	**1949**	0.052989

1950	0.053326	**1964**	-0.03373	**1978**	-0.03263
1951	0.026584	**1965**	-0.02772	**1979**	-0.0703
1952	0.01194	**1966**	-0.00556	**1980**	-0.04608
1953	0.038706	**1967**	-0.02164	**1981**	-0.05261
1954	0.036982	**1968**	0.029318	**1982**	-0.05932
1955	0.078549	**1969**	0.00521	**1983**	-0.06363
1956	0.06429	**1970**	0.076522	**1984**	-0.00297
1957	-0.00965	**1971**	0.038789	**1985**	-0.01757
1958	0.009293	**1972**	-0.01845	**1986**	-0.02504
1959	-0.00294	**1973**	0.118153	**1987**	-0.00385
1960	0.022506	**1974**	0.034655	**1988**	0.006243
1961	-0.00201	**1975**	0.031537	**1989**	0.003272
1962	-0.00832	**1976**	-0.007	**1990**	0.013097
1963	-0.0346	**1977**	-0.01849		

Coral: SST 1

1800	0.406639	**1838**	0.905673	**1876**	0.175773
1801	0.117978	**1839**	0.691391	**1877**	0.457794
1802	-0.29235	**1840**	0.668068	**1878**	0.524907
1803	-0.27459	**1841**	0.176113	**1879**	-0.04372
1804	0.018351	**1842**	0.368565	**1880**	-0.03685
1805	-0.2379	**1843**	0.296296	**1881**	0.268327
1806	-0.34236	**1844**	0.19026	**1882**	-0.41474
1807	0.299144	**1845**	0.343017	**1883**	-0.36499
1808	0.109741	**1846**	0.275702	**1884**	0.220217
1809	0.116169	**1847**	0.305746	**1885**	0.401819
1810	-0.3039	**1848**	-0.25631	**1886**	-0.06466
1811	-0.32054	**1849**	-0.26928	**1887**	0.089284
1812	0.131768	**1850**	0.214222	**1888**	0.220239
1813	0.128259	**1851**	0.260186	**1889**	-0.09431
1814	-0.00564	**1852**	0.164397	**1890**	-0.4954
1815	-0.00519	**1853**	0.344499	**1891**	-0.0427
1816	-0.03838	**1854**	0.429421	**1892**	-0.19341
1817	0.15512	**1855**	0.279322	**1893**	-0.21325
1818	0.225241	**1856**	0.546286	**1894**	-0.36835
1819	0.265618	**1857**	0.149872	**1895**	-0.32515
1820	0.42497	**1858**	-0.00785	**1896**	0.120331
1821	0.166476	**1859**	-0.0378	**1897**	-0.39722
1822	0.008934	**1860**	0.238196	**1898**	-0.27477
1823	0.129128	**1861**	0.25163	**1899**	0.107015
1824	-0.27991	**1862**	0.202957	**1900**	-0.02199
1825	-0.17275	**1863**	0.193533	**1901**	0.039014
1826	-0.04382	**1864**	0.511081	**1902**	0.652339
1827	0.226872	**1865**	0.454192	**1903**	0.203107
1828	0.213928	**1866**	0.473453	**1904**	0.281384
1829	0.044368	**1867**	0.320062	**1905**	0.712333
1830	0.37472	**1868**	0.311383	**1906**	0.193791
1831	0.318662	**1869**	0.100876	**1907**	-0.18797
1832	-0.06857	**1870**	0.06218	**1908**	-0.41008
1833	-0.05921	**1871**	0.177292	**1909**	-0.38569
1834	-0.40374	**1872**	-0.32952	**1910**	-0.20878
1835	-0.10982	**1873**	0.031016	**1911**	0.072256
1836	0.152415	**1874**	0.051453	**1912**	0.008356
1837	0.479089	**1875**	0.034868	**1913**	0.22668

1914	0.451282	**1955**	-0.47627
1915	0.123278	**1956**	-0.21794
1916	-0.05954	**1957**	0.347706
1917	-0.54961	**1958**	0.37674
1918	0.104706	**1959**	0.05278
1919	0.183322	**1960**	-0.39862
1920	-0.12538	**1961**	-0.22066
1921	-0.01022	**1962**	-0.18647
1922	-0.13127	**1963**	0.17975
1923	0.082666	**1964**	-0.41128
1924	-0.11759	**1965**	0.569499
1925	0.101113	**1966**	-0.32049
1926	-0.04472	**1967**	-0.42648
1927	-0.1923	**1968**	-0.0001
1928	-0.41795	**1969**	0.276048
1929	-0.30291	**1970**	-0.48992
1930	0.422268	**1971**	-0.4404
1931	-0.01783	**1972**	0.811633
1932	-0.15481	**1973**	-0.38133
1933	-0.50535	**1974**	-0.36948
1934	0.066139	**1975**	-0.66551
1935	0.142263	**1976**	0.422965
1936	0.101198	**1977**	0.143726
1937	0.237145	**1978**	-0.02867
1938	0.106357	**1979**	0.365436
1939	0.503288	**1980**	0.26449
1940	0.893232	**1981**	-0.25397
1941	1.017343	**1982**	0.886334
1942	-0.14644	**1983**	0.283686
1943	-0.3126	**1984**	-0.06316
1944	-0.50442	**1985**	-0.09995
1945	-0.60576	**1986**	0.767359
1946	-0.12089	**1987**	0.86249
1947	-0.32806	**1988**	-0.1597
1948	-0.14885	**1989**	0.091854
1949	-0.57613	**1990**	0.495038
1950	-0.83948		
1951	0.372492		
1952	-0.0413		
1953	0.208643		
1954	-0.54499		

Coral: SST 1

1800	-0.02756
1801	0.112159
1802	0.093704
1803	0.058308
1804	0.033878
1805	0.099543
1806	0.218659
1807	0.022242
1808	-0.0322
1809	-0.0788
1810	0.015171
1811	0.047056
1812	0.042705
1813	-0.05667
1814	-0.17051
1815	-0.08906
1816	-0.11445
1817	-0.12852
1818	-0.14688
1819	-0.17985
1820	-0.10568
1821	-0.0785
1822	-0.07602
1823	-0.05251
1824	-0.03661
1825	-0.08593
1826	-0.11251
1827	-0.0491
1828	-0.05643
1829	0.02959
1830	0.001797
1831	0.000451
1832	-0.00217
1833	0.020974
1834	0.05774
1835	-0.05215
1836	-0.15472
1837	-0.21363
1838	-0.11237
1839	-0.11058
1840	-0.18764
1841	-0.00567
1842	-0.06398
1843	-0.08565
1844	0.062876
1845	-0.02577
1846	-0.00726
1847	-0.06313
1848	0.07434
1849	0.094698
1850	0.038648
1851	0.052279
1852	0.035339
1853	-0.00437
1854	-0.04597
1855	0.016923
1856	-0.04979
1857	-0.06376
1858	-0.00736
1859	0.0472
1860	0.010117
1861	0.004243
1862	0.067947
1863	0.053968
1864	-0.02374
1865	0.013099
1866	-0.0316
1867	-0.01718
1868	-0.06745
1869	-0.0551
1870	-0.1542
1871	-0.12762
1872	0.013673
1873	-0.08966
1874	-0.10295
1875	-0.11784
1876	-0.02706
1877	0.012541
1878	-0.0052
1879	0.053928
1880	-0.01023
1881	-0.10132
1882	0.023755
1883	-0.0449
1884	-0.20966
1885	-0.19366
1886	-0.09446
1887	0.007136
1888	-0.0638
1889	0.035039
1890	0.108231
1891	0.016567
1892	0.059647
1893	0.091525
1894	0.130286
1895	0.037109
1896	-0.04735
1897	-0.00013
1898	0.039413
1899	-0.06265
1900	-0.01684
1901	-0.1204
1902	-0.25291
1903	-0.17416
1904	-0.13896
1905	-0.22979
1906	-0.12665
1907	-0.15774

1908	0.056852
1909	-0.04827
1910	-0.04238
1911	-0.07299
1912	-0.05806
1913	-0.03545
1914	-0.10239
1915	0.006284
1916	-0.06855
1917	0.040767
1918	0.011756
1919	-0.00072
1920	-0.04283
1921	-0.1138
1922	-0.0118
1923	-0.11339
1924	-0.11523
1925	-0.08815
1926	-0.02439
1927	-0.01539
1928	0.002289
1929	0.040368
1930	-0.04381
1931	-0.04755
1932	-0.00256
1933	0.023149
1934	-0.01805
1935	-0.04046
1936	0.015897
1937	-0.01733
1938	0.005652
1939	0.000332
1940	-0.11749
1941	-0.1485
1942	0.047362
1943	0.123886
1944	0.149877
1945	0.173795
1946	0.149676
1947	0.136863
1948	0.123231
1949	0.205894
1950	0.183135
1951	0.050291
1952	0.202554
1953	0.089657
1954	0.204853
1955	0.137384
1956	0.168647
1957	0.071043
1958	0.03244
1959	0.061002
1960	0.147831
1961	0.121269
1962	0.132744
1963	0.124823
1964	0.152672
1965	-0.06357
1966	0.087104
1967	0.152501
1968	0.125667
1969	0.053385
1970	0.18088
1971	0.170207
1972	0.018351
1973	0.187874
1974	0.146028
1975	0.273554
1976	0.082368
1977	0.067008
1978	0.132354
1979	0.102094
1980	0.094069
1981	0.139579
1982	-0.01308
1983	0.057292
1984	0.071916
1985	0.116154
1986	0.049669
1987	-0.0226
1988	0.188448
1989	0.184983
1990	0.091146

Instrumental: SST 1

1856	-0.13483	**1893**	-0.81619	**1930**	1.031972
1857	-0.45607	**1894**	-0.36445	**1931**	0.20653
1858	-0.24944	**1895**	0.257833	**1932**	0.232212
1859	-0.34502	**1896**	0.959142	**1933**	-0.39706
1860	-0.60397	**1897**	0.097294	**1934**	-0.08831
1861	-0.49617	**1898**	-0.34503	**1935**	0.019157
1862	-0.46313	**1899**	0.83805	**1936**	0.108161
1863	-0.20768	**1900**	0.528081	**1937**	-0.22404
1864	0.401556	**1901**	0.002114	**1938**	-0.48946
1865	0.773243	**1902**	0.820049	**1939**	0.34072
1866	0.689107	**1903**	-0.52879	**1940**	1.102768
1867	0.487572	**1904**	0.337831	**1941**	0.97193
1868	0.608946	**1905**	0.957322	**1942**	-0.67038
1869	-0.60584	**1906**	-0.28675	**1943**	0.014577
1870	-0.58116	**1907**	-0.2069	**1944**	0.038918
1871	-0.36232	**1908**	-0.74304	**1945**	0.040375
1872	-0.70034	**1909**	-0.88705	**1946**	-0.25903
1873	-0.8212	**1910**	-0.80458	**1947**	-0.05287
1874	-0.80501	**1911**	0.307876	**1948**	-0.17647
1875	-0.82002	**1912**	0.001547	**1949**	-0.56113
1876	-0.07897	**1913**	0.213869	**1950**	-0.57982
1877	1.714809	**1914**	0.703138	**1951**	0.546717
1878	0.326549	**1915**	0.103425	**1952**	0.089304
1879	-0.36223	**1916**	-1.07519	**1953**	0.253498
1880	0.01889	**1917**	-0.53305	**1954**	-0.77189
1881	-0.08486	**1918**	0.919741	**1955**	-0.94809
1882	-0.45196	**1919**	0.603241	**1956**	-0.42255
1883	-0.11311	**1920**	-0.03581	**1957**	0.781769
1884	0.309067	**1921**	-0.2928	**1958**	0.182937
1885	0.057806	**1922**	-0.57731	**1959**	0.039094
1886	-0.62998	**1923**	0.311073	**1960**	-0.02143
1887	-0.05131	**1924**	-0.60562	**1961**	-0.23164
1888	1.070501	**1925**	0.701254	**1962**	-0.3351
1889	-0.34221	**1926**	0.320913	**1963**	0.343689
1890	-0.46217	**1927**	-0.0636	**1964**	-0.59072
1891	0.123107	**1928**	-0.14645	**1965**	0.813752
1892	-1.00596	**1929**	0.125208	**1966**	-0.18483

1967	-0.66648
1968	0.185647
1969	0.672028
1970	-0.87494
1971	-0.46523
1972	1.20431
1973	-0.67536
1974	-0.23087
1975	-0.71128
1976	0.636785
1977	0.185065
1978	-0.11264
1979	0.466896
1980	0.080584
1981	-0.00615
1982	1.540687
1983	1.068796
1984	-0.04535
1985	-0.30669
1986	0.676008
1987	1.167474
1988	-0.36201
1989	0.025583
1990	0.251292

Instrumental: SST 2

1856	-0.05506	**1894**	0.06209	**1932**	-0.07334
1857	-0.12352	**1895**	-0.0087	**1933**	0.214065
1858	-0.16886	**1896**	-0.12901	**1934**	0.104825
1859	-0.11882	**1897**	0.239339	**1935**	0.079935
1860	-0.44199	**1898**	-0.20486	**1936**	0.190496
1861	-0.12287	**1899**	-0.26112	**1937**	0.212918
1862	-0.09301	**1900**	0.099946	**1938**	0.25127
1863	-0.21746	**1901**	0.09322	**1939**	0.059875
1864	-0.24276	**1902**	-0.40092	**1940**	-0.10386
1865	-0.11252	**1903**	-0.11371	**1941**	-0.1365
1866	-0.17764	**1904**	-0.36203	**1942**	0.349597
1867	-0.17392	**1905**	-0.33059	**1943**	0.34819
1868	-0.06653	**1906**	-0.04217	**1944**	0.389255
1869	0.205434	**1907**	-0.05884	**1945**	0.42169
1870	-0.01926	**1908**	-0.04637	**1946**	-0.03621
1871	-0.06445	**1909**	0.030495	**1947**	0.021852
1872	0.139052	**1910**	0.047394	**1948**	-0.16637
1873	0.031185	**1911**	-0.40534	**1949**	-0.06884
1874	0.068547	**1912**	-0.18349	**1950**	0.022806
1875	0.061842	**1913**	-0.29636	**1951**	-0.01002
1876	0.026141	**1914**	-0.4357	**1952**	-0.00645
1877	0.06741	**1915**	-0.06194	**1953**	-0.15105
1878	0.155653	**1916**	0.04446	**1954**	-0.04794
1879	0.214259	**1917**	-0.07466	**1955**	0.069016
1880	-0.13072	**1918**	-0.45701	**1956**	0.11935
1881	-0.04859	**1919**	-0.33996	**1957**	-0.10353
1882	0.091369	**1920**	-0.12298	**1958**	-0.11639
1883	-0.0712	**1921**	-0.05615	**1959**	-0.04199
1884	-0.1032	**1922**	-0.09788	**1960**	0.046466
1885	-0.2221	**1923**	-0.41675	**1961**	0.005492
1886	0.185224	**1924**	-0.00504	**1962**	0.167253
1887	0.043648	**1925**	-0.31236	**1963**	0.06163
1888	-0.33532	**1926**	0.113676	**1964**	0.128919
1889	0.10796	**1927**	0.062206	**1965**	-0.38285
1890	0.043534	**1928**	-0.02531	**1966**	-0.0695
1891	-0.00663	**1929**	-0.23665	**1967**	-0.04658
1892	0.249615	**1930**	-0.18497	**1968**	0.180725
1893	0.202911	**1931**	0.116362	**1969**	0.252146

1970	0.400336
1971	0.091873
1972	-0.3151
1973	0.353288
1974	0.024019
1975	0.201287
1976	-0.06344
1977	-0.10834
1978	0.146381
1979	0.056996
1980	0.148462
1981	0.370065
1982	-0.02937
1983	0.171956
1984	0.274133
1985	0.363601
1986	0.287271
1987	0.143261
1988	0.666414
1989	0.429718
1990	0.235123

Appendix 8: Reconstruction Data

Tree Based

1591	30.81366	**1627**	35.21113	**1663**	35.73516
1592	36.37466	**1628**	42.99117	**1664**	37.97369
1593	34.19892	**1629**	34.88432	**1665**	45.77098
1594	33.72917	**1630**	34.61654	**1666**	38.49914
1595	37.64959	**1631**	21.80005	**1667**	31.60343
1596	40.05639	**1632**	17.58203	**1668**	27.68791
1597	23.48205	**1633**	42.53257	**1669**	40.82847
1598	28.71913	**1634**	18.97846	**1670**	28.75898
1599	40.54485	**1635**	15.36907	**1671**	35.49528
1600	24.08023	**1636**	33.49624	**1672**	37.82462
1601	28.61996	**1637**	24.42353	**1673**	41.5399
1602	48.66398	**1638**	34.02481	**1674**	42.12066
1603	46.30754	**1639**	28.50941	**1675**	36.7061
1604	50.85013	**1640**	40.14596	**1676**	54.75993
1605	61.54929	**1641**	32.97427	**1677**	35.79173
1606	26.34793	**1642**	36.71393	**1678**	33.57269
1607	35.8409	**1643**	28.83772	**1679**	46.75035
1608	41.00692	**1644**	33.40892	**1680**	49.91812
1609	36.73405	**1645**	26.62465	**1681**	33.58906
1610	55.14481	**1646**	21.40151	**1682**	24.94618
1611	37.31128	**1647**	41.02037	**1683**	40.84546
1612	27.43771	**1648**	21.04945	**1684**	24.21447
1613	22.81259	**1649**	37.28726	**1685**	17.95015
1614	48.4345	**1650**	39.83136	**1686**	28.49474
1615	36.95828	**1651**	31.98244	**1687**	37.03625
1616	43.97036	**1652**	32.21876	**1688**	34.47962
1617	45.1925	**1653**	34.42424	**1689**	33.99158
1618	46.33067	**1654**	29.87538	**1690**	30.23407
1619	42.91309	**1655**	51.9085	**1691**	45.07471
1620	39.63734	**1656**	36.42476	**1692**	42.07243
1621	54.74985	**1657**	21.10085	**1693**	31.20557
1622	33.24701	**1658**	33.9514	**1694**	38.91906
1623	38.01404	**1659**	32.77798	**1695**	12.87526
1624	46.33585	**1660**	31.28923	**1696**	41.75074
1625	33.74546	**1661**	29.53252	**1697**	45.87039
1626	29.84704	**1662**	32.89728	**1698**	41.36805

1699	48.67933	**1740**	32.86971	**1781**	35.03115
1700	42.08213	**1741**	39.77169	**1782**	28.84644
1701	29.53907	**1742**	39.78821	**1783**	29.43224
1702	43.72002	**1743**	35.70227	**1784**	37.95131
1703	29.56352	**1744**	30.16808	**1785**	31.39689
1704	34.72214	**1745**	41.41024	**1786**	29.49668
1705	49.16871	**1746**	46.22204	**1787**	39.09027
1706	35.08013	**1747**	38.71125	**1788**	31.01188
1707	32.20627	**1748**	34.55763	**1789**	48.50598
1708	27.94815	**1749**	35.29226	**1790**	51.01268
1709	41.72258	**1750**	31.12335	**1791**	40.64128
1710	21.60374	**1751**	39.17995	**1792**	46.78615
1711	34.39465	**1752**	34.58273	**1793**	12.26981
1712	33.23075	**1753**	41.50799	**1794**	30.44967
1713	31.75137	**1754**	35.94987	**1795**	12.84396
1714	31.79682	**1755**	37.2823	**1796**	47.2812
1715	36.80072	**1756**	29.10259	**1797**	43.86828
1716	40.9825	**1757**	47.25379	**1798**	24.17205
1717	26.51833	**1758**	44.30748	**1799**	44.45156
1718	41.38868	**1759**	31.6382	**1800**	29.68326
1719	38.83015	**1760**	34.9456	**1801**	29.72062
1720	32.59801	**1761**	46.21444	**1802**	36.26255
1721	16.8266	**1762**	28.85873	**1803**	24.84558
1722	23.5453	**1763**	36.03526	**1804**	21.10961
1723	28.76351	**1764**	31.87663	**1805**	23.95987
1724	27.50528	**1765**	22.41353	**1806**	29.3581
1725	38.67802	**1766**	39.52375	**1807**	32.1401
1726	46.02956	**1767**	38.81576	**1808**	30.59645
1727	38.11474	**1768**	35.89722	**1809**	30.66102
1728	31.00091	**1769**	37.73958	**1810**	39.95354
1729	24.7379	**1770**	36.75547	**1811**	46.04234
1730	48.03303	**1771**	38.0147	**1812**	43.48099
1731	38.88412	**1772**	33.65696	**1813**	34.43312
1732	33.08502	**1773**	34.73173	**1814**	29.20073
1733	43.14007	**1774**	34.53546	**1815**	35.57643
1734	44.76641	**1775**	43.80441	**1816**	41.0391
1735	16.06947	**1776**	47.07356	**1817**	29.74672
1736	28.99355	**1777**	26.83843	**1818**	46.10322
1737	37.26414	**1778**	36.49603	**1819**	37.35215
1738	31.75595	**1779**	36.46555	**1820**	34.34903
1739	34.48655	**1780**	40.65289	**1821**	49.53551

1822	32.069	**1863**	40.82511	**1904**	36.76131
1823	39.49343	**1864**	40.64715	**1905**	32.24191
1824	23.4369	**1865**	31.39792	**1906**	29.48732
1825	28.69592	**1866**	51.87061	**1907**	42.87947
1826	38.6484	**1867**	43.04492	**1908**	36.9068
1827	36.76324	**1868**	38.46405	**1909**	39.50522
1828	48.91702	**1869**	34.9991	**1910**	44.52819
1829	19.20499	**1870**	34.07939	**1911**	31.88038
1830	23.2218	**1871**	25.05528	**1912**	35.41222
1831	31.80865	**1872**	44.20151	**1913**	41.72703
1832	44.53536	**1873**	38.82337	**1914**	41.08651
1833	26.83619	**1874**	29.21326	**1915**	23.97668
1834	19.74164	**1875**	31.45551	**1916**	46.05171
1835	31.48034	**1876**	35.46116	**1917**	39.95421
1836	33.77766	**1877**	26.79116	**1918**	39.27635
1837	45.89134	**1878**	33.94846	**1919**	18.22301
1838	48.66816	**1879**	28.54768	**1920**	26.83842
1839	43.84543	**1880**	35.21459	**1921**	39.88672
1840	25.96642	**1881**	32.25788	**1922**	36.14731
1841	39.04397	**1882**	23.68667	**1923**	37.31602
1842	26.95445	**1883**	41.49833	**1924**	28.74307
1843	44.2084	**1884**	44.25483	**1925**	42.6948
1844	34.24958	**1885**	37.84428	**1926**	34.49964
1845	16.55955	**1886**	28.41261	**1927**	39.99174
1846	22.82622	**1887**	32.22709	**1928**	37.03368
1847	28.83484	**1888**	29.01395	**1929**	35.76239
1848	35.75688	**1889**	27.01227	**1930**	37.66391
1849	51.12379	**1890**	37.43705	**1931**	17.7203
1850	38.93935	**1891**	33.20692	**1932**	29.52857
1851	29.26477	**1892**	40.87412	**1933**	29.61656
1852	34.93492	**1893**	25.02844	**1934**	25.59915
1853	45.77468	**1894**	32.95277	**1935**	37.14782
1854	50.92615	**1895**	44.14754	**1936**	27.49623
1855	26.55269	**1896**	23.2865	**1937**	41.03753
1856	24.51009	**1897**	39.2345	**1938**	42.64407
1857	28.50265	**1898**	35.73692	**1939**	36.53841
1858	31.70742	**1899**	29.75065	**1940**	23.5455
1859	33.68003	**1900**	27.58884	**1941**	37.33303
1860	37.33352	**1901**	24.36781	**1942**	31.0927
1861	25.03323	**1902**	24.20005	**1943**	30.80949
1862	49.74893	**1903**	28.30679	**1944**	37.16005

1945	38.47202
1946	35.58521
1947	48.46944
1948	33.21173
1949	40.34873
1950	39.30431
1951	46.95589
1952	33.95746
1953	27.96198
1954	34.89393
1955	31.52232
1956	37.4989
1957	44.52825
1958	28.85331
1959	28.70051
1960	28.53182
1961	26.435
1962	45.42269
1963	26.71282
1964	24.05032
1965	37.60219
1966	30.41809
1967	34.94995
1968	29.35845
1969	41.50647
1970	30.39087
1971	40.5463
1972	43.332
1973	38.78316
1974	44.357
1975	38.50624
1976	42.25857
1977	20.12091
1978	39.52625
1979	30.79829
1980	31.79721
1981	26.75627
1982	32.63242
1983	37.99046
1984	35.1183
1985	36.28291
1986	41.16792
1987	30.87624
1988	25.04713
1989	28.52376
1990	29.89434
1991	41.36036

Coral Based

1801	23.61889	**1839**	34.86925	**1877**	24.67174
1802	35.54425	**1840**	22.05308	**1878**	28.08922
1803	29.40467	**1841**	29.90194	**1879**	20.42171
1804	29.1321	**1842**	22.25841	**1880**	33.13819
1805	28.1231	**1843**	37.96893	**1881**	33.96471
1806	34.48109	**1844**	30.76365	**1882**	23.77704
1807	37.11491	**1845**	17.35131	**1883**	43.47979
1808	25.95778	**1846**	23.91946	**1884**	47.24745
1809	29.09564	**1847**	23.55849	**1885**	38.35457
1810	37.40635	**1848**	30.52899	**1886**	23.76943
1811	45.94569	**1849**	52.35121	**1887**	33.62974
1812	42.04076	**1850**	39.93016	**1888**	30.29895
1813	29.23088	**1851**	23.35953	**1889**	25.99214
1814	24.33148	**1852**	32.35591	**1890**	37.63386
1815	34.94724	**1853**	42.5689	**1891**	39.47068
1816	37.92529	**1854**	40.54361	**1892**	35.75806
1817	30.60677	**1855**	18.74042	**1893**	25.06418
1818	34.30703	**1856**	25.09891	**1894**	31.95344
1819	26.76	**1857**	23.08004	**1895**	42.87186
1820	23.41887	**1858**	31.50015	**1896**	25.31406
1821	39.9229	**1859**	29.46208	**1897**	35.85267
1822	26.47664	**1860**	33.91703	**1898**	42.04495
1823	35.49765	**1861**	21.01644	**1899**	34.30569
1824	22.57238	**1862**	41.48681	**1900**	27.14175
1825	34.67812	**1863**	32.4203	**1901**	29.49649
1826	41.53593	**1864**	32.2575	**1902**	26.34178
1827	40.1316	**1865**	24.08283	**1903**	27.36085
1828	46.53958	**1866**	42.95085	**1904**	31.71305
1829	24.2856	**1867**	34.21257	**1905**	35.13316
1830	29.75159	**1868**	33.50746	**1906**	29.1142
1831	26.78985	**1869**	33.37974	**1907**	44.1685
1832	37.18666	**1870**	32.15534	**1908**	41.48767
1833	33.16376	**1871**	21.63393	**1909**	42.21215
1834	25.3995	**1872**	37.58344	**1910**	41.6916
1835	39.01107	**1873**	40.67232	**1911**	34.31088
1836	35.00424	**1874**	28.50357	**1912**	38.42123
1837	44.12428	**1875**	31.73607	**1913**	42.69508
1838	40.115	**1876**	34.909	**1914**	42.62429

1915	25.86823
1916	43.9277
1917	39.09317
1918	44.24859
1919	23.67785
1920	29.96344
1921	42.21704
1922	33.82987
1923	37.64639
1924	30.97288
1925	40.49965
1926	36.96953
1927	41.81307
1928	39.69962
1929	41.14403
1930	43.20709
1931	19.61477
1932	33.7456
1933	34.24075
1934	29.31406
1935	35.57815
1936	26.43048
1937	39.81276
1938	37.1079
1939	31.43757
1940	21.06911
1941	32.82063
1942	26.87406
1943	36.06944
1944	41.89046
1945	43.84343
1946	38.63239
1947	47.22802
1948	35.67077
1949	40.16442
1950	41.20962
1951	50.78786
1952	27.71116
1953	28.45388
1954	29.39207
1955	35.43028
1956	36.44161
1957	40.69464
1958	26.43828
1959	24.38011
1960	29.07105
1961	30.39878
1962	46.7891
1963	30.60736
1964	26.181
1965	44.75197
1966	26.60306
1967	39.18305
1968	36.78179
1969	38.33327
1970	27.44576
1971	39.49324
1972	44.25284
1973	30.34873
1974	38.11945
1975	39.65834
1976	46.56322
1977	17.65611
1978	38.7946
1979	34.35896
1980	33.55662
1981	28.49903
1982	40.13935
1983	32.04573
1984	36.93589
1985	37.174
1986	42.88982
1987	24.49094
1988	16.72285
1989	30.80717
1990	29.1658
1991	33.7493

Instrumental Based

1857	30.43769	**1896**	18.8538	**1935**	34.09711
1858	39.71789	**1897**	32.42707	**1936**	25.19733
1859	32.8397	**1898**	28.93254	**1937**	39.63809
1860	42.57775	**1899**	34.10783	**1938**	39.60073
1861	29.20332	**1900**	27.09584	**1939**	30.59215
1862	52.74816	**1901**	26.27416	**1940**	29.27106
1863	36.12586	**1902**	23.8318	**1941**	29.06549
1864	39.39323	**1903**	27.3455	**1942**	27.37567
1865	27.59151	**1904**	39.19158	**1943**	32.92291
1866	38.48888	**1905**	34.30489	**1944**	35.57681
1867	38.48839	**1906**	29.82256	**1945**	35.67499
1868	25.82544	**1907**	44.70604	**1946**	26.03817
1869	31.42708	**1908**	28.83161	**1947**	43.55117
1870	35.618	**1909**	48.09929	**1948**	33.41122
1871	26.44166	**1910**	40.80965	**1949**	36.68825
1872	44.14197	**1911**	49.32588	**1950**	40.32915
1873	38.16131	**1912**	32.75526	**1951**	39.42042
1874	31.08791	**1913**	37.27615	**1952**	28.95255
1875	39.44031	**1914**	39.01222	**1953**	26.60651
1876	44.98007	**1915**	25.96311	**1954**	24.887
1877	25.43757	**1916**	39.50645	**1955**	34.06463
1878	19.49629	**1917**	50.23949	**1956**	41.73468
1879	20.69889	**1918**	38.69478	**1957**	43.60645
1880	41.13985	**1919**	19.66857	**1958**	26.45426
1881	30.2815	**1920**	32.036	**1959**	24.32637
1882	28.31259	**1921**	45.11636	**1960**	31.3778
1883	40.86488	**1922**	35.7254	**1961**	28.09805
1884	40.0157	**1923**	39.57117	**1962**	47.29483
1885	33.58846	**1924**	32.64827	**1963**	27.8771
1886	28.73624	**1925**	44.41093	**1964**	23.61874
1887	34.77505	**1926**	42.29163	**1965**	43.29749
1888	29.66986	**1927**	36.47377	**1966**	24.37748
1889	14.49283	**1928**	42.55784	**1967**	40.40387
1890	36.18107	**1929**	33.58843	**1968**	36.43943
1891	40.35979	**1930**	29.7201	**1969**	36.48282
1892	33.33725	**1931**	24.89794	**1970**	27.74281
1893	33.16645	**1932**	36.30663	**1971**	45.80822
1894	32.66739	**1933**	32.00122	**1972**	45.06481
1895	44.91774	**1934**	28.35363	**1973**	28.83109

1974	43.57283	**1980**	29.89361	**1986**	46.63484
1975	37.97526	**1981**	30.30513	**1987**	22.71714
1976	43.26478	**1982**	38.18709	**1988**	22.86847
1977	18.7797	**1983**	30.83043	**1989**	30.89439
1978	37.17086	**1984**	33.64573	**1990**	28.35096
1979	35.70435	**1985**	39.65145	**1991**	36.75891

Vita

SallyRose Anderson was born in Eagle River, Alaska. Her parents are Tom and Beryl Anderson. She has one sibling, a younger brother named Casey. She attended Monroe Elementary School in Norman, Oklahoma for four years. She then returned to Eagle River, Alaska and attended Homestead Elementary School, Gruening Middle School, and Chugiak High School.

Following high school graduation, SallyRose traveled to Golden, Colorado and attended Colorado School of Mines. She completed a Bachelors of Science in Engineering with an environmental specialty. She also obtained a minor in Public Affairs. While pursuing her undergraduate degree, SallyRose had the opportunity to travel to China and Honduras to learn about engineering and public affairs in different nations.

After graduation, SallyRose worked as a consultant for the energy industry. Based out of Denver, she worked on projects in London, New York, and Los Angeles, and had over 60 clients located across the United States. SallyRose then pursued contract consulting work that took her to Rock Springs, Wyoming for a year and then to Austin, Texas.

Interested in pursuing an advanced degree, SallyRose and her boyfriend, Adam, moved to Tennessee in August 2009. Here she enrolled in a dual degree program. SallyRose is on track to obtain a Masters of Engineering in Water Resources and a Masters of Business Administration in December 2010.