Supplemental Material:

Documentation of Data Analysis Steps and Model Development

Following provides details of data analysis steps, SAS code and model development discussed in main body of text.

Contents

Water Level and Hydroperiod Data

The summary water level and hydroperiod data are in text Table 2.

Observed hydrologic station data

The observed water level data can be found in Supplemental Table 1. Raw Everglades National Park (ENP) data were downloaded from South Florida Water Management District - https://www.sfwmd.gov/science-data/dbhydro. Raw observed data are in stage feet relative to NGVD29.

Steps:

1) Trim data to appropriate time-frame (P33 (1/1/1965 to 12/31/2000; NP206 1/1/1975 to 12/31/2000; EVER4 1/1/1994 to 12/31/2000)
2) These data are in NGVD29 FT so subtract elevation (P33 = 4.87 ft; NP206 = 5.99 ft; EVER4 = 1.81 feet)
3) Then delete any values of 0 or less. (Value of ≤ 0 means there is no above-ground water for those days.)
4) Calculate counts (number of days water above ground), mean, median. Compare count and mean from Excel files and SAS output to verify.
5) In Excel, calculate average hydroperiod (Supplemental Table 3) by taking only the above ground water days, sorting by date, counting the number of days in each calendar year water is above ground. Average for span of time to get average hydroperiod.

Observed SAS Runs

P33 Observed SAS Code: Converts data to cm, subtracts elevation, restricts dates, and removes any ≤ 0 water level values.

P33 obs 4-4-18 - Notepad

File Edit Format View Help

```
*this is observed;
*this converts observed stage to depth above ground in cm;
*since this is observed- use ground elevation to  get depth;
*P33 grnd elev = 4.87;
data P33_cm_depth; set mysaslib.Fullstagedata_updated_29;
P33_cm_depth = (P33_29 - 4.87) *30.48;
where date >= '01jan1965'd and date <='31dec2000'd;
keep date P33_cm_depth;
run;

data  P33_cm_abvgrnd; set  P33_cm_depth;
P33_cm_abvgrnd = P33_cm_depth;
where P33_cm_depth > 0.0;
keep date P33_cm_abvgrnd;
run;


proc means data = P33_cm_abvgrnd n mean max min range stderr P10 P25 P75 P90;
where date >='01jan1965'd and date <='31dec2000'd;
where P33_cm_abvgrnd NE .;
run;

quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

P33 obs out 4-4-18 - Notepad

File Edit Format View Help

```
                                 The SAS System        11:08 Wednesday, April 4, 2018   5

                                The MEANS Procedure

Variable            N          Mean       Maximum       Minimum         Range     Std Error
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
date            12236       8407.45      14975.00       1827.00      13148.00    34.3306838
P33_cm_abvgrnd  12236    38.1268033    97.8408000     0.3048000    97.5360000     0.1556778
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

        Variable           10th Pctl       25th Pctl       75th Pctl       90th Pctl
        ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
        date                 3203.00         5122.50        11714.50        13717.00
        P33_cm_abvgrnd    16.7640000      25.2984000      49.6824000      62.1792000
        ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

NP206 Observed SAS Code: Converts data to cm, subtracts elevation, restricts dates, and removes any ≤ 0 water level values.

NP206 obs 4-4-18 - Notepad

File Edit Format View Help

```
*this is observed;
*this converts observed stage to depth above ground in cm;
*since this is observed- use ground elevation to  get depth;
*NP206 grnd elev = 5.99;

data NP206_cm_depth; set mysaslib.Fullstagedata_updated_29;
NP206_cm_depth = (NP206_29 - 5.99) *30.48;
where date >= '01jan1975'd and date <='31dec2000'd;
keep date NP206_cm_depth;
run;

data  NP206_cm_abvgrnd; set  NP206_cm_depth;
NP206_cm_abvgrnd = NP206_cm_depth;
where NP206_cm_depth > 0.0;
keep date NP206_cm_abvgrnd;
run;

proc means data = NP206_cm_abvgrnd n mean max min range stderr P10 P25 P75 P90;
where date >='01jan1975'd and date <='31dec2000'd and NP206_cm_abvgrnd NE .;
run;

quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

NP206 obs out 4-4-18 - Notepad

File Edit Format View Help

```
                                        The SAS System         11:08 Wednesday, April 4, 2018   3

                                      The MEANS Procedure

Variable              N           Mean        Maximum        Minimum          Range      Std Error
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
date               3017       11486.42       14963.00        5997.00        8966.00     47.5606312
NP206_cm_abvgrnd   3017      9.6619680     43.2816000      0.3048000     42.9768000      0.1320494
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

         Variable               10th Pctl       25th Pctl       75th Pctl       90th Pctl
         ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
         date                     7977.00         8719.00        13795.00        14503.00
         NP206_cm_abvgrnd       1.8288000       3.6576000      14.0208000      20.1168000
         ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

EVER4 Observed SAS Code: Converts data to cm, subtracts elevation, restricts dates, and removes any ≤ 0 water level values.

EVER4 obs 4-4-18 - Notepad

File Edit Format View Help

```
*this is observed;
*this converts observed stage to depth above ground in cm;
*since this is observed- use ground elevation to  get depth;
*EVER4 grnd elev = 1.81;
data EVER4_cm_depth; set mysaslib.Fullstagedata_updated_29;
EVER4_cm_depth = (EVER4_29 - 1.81) *30.48;
where date >= '01jan1994'd and date <='31dec2000'd;
keep date EVER4_cm_depth;
run;

data  EVER4_cm_abvgrnd; set  EVER4_cm_depth;
EVER4_cm_abvgrnd = EVER4_cm_depth;
where EVER4_cm_depth > 0.0;
keep date EVER4_cm_abvgrnd;
run;

proc means data = EVER4_cm_abvgrnd n mean max min range stderr P10 P25 P75 P90;
run;


quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

EVER4 obs out 4-4-18 - Notepad

File Edit Format View Help

```
                                       The SAS System        11:08 Wednesday, April 4, 2018   1

                                     The MEANS Procedure

Variable               N            Mean         Maximum         Minimum           Range       Std Error
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
date                2085        13686.84        14975.00        12419.00         2556.00      16.5402341
EVER4_cm_abvgrnd    2085      15.2188029      53.6448000       0.3048000      53.3400000       0.1749168
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

          Variable               10th Pctl       25th Pctl       75th Pctl       90th Pctl
          ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
          date                    12649.00        12981.00        14287.00        14767.00
          EVER4_cm_abvgrnd       4.8768000       9.1440000      20.1168000      25.9080000
          ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

NSM 4.6.2 data

The NSM 4.6.2 water level data can be found in Supplemental Table 1.

Steps:

1) Trim data to appropriate time-frame (P33 (1/1/1965 to 12/31/2000; NP206 1/1/1975 to 12/31/2000; EVER4 1/1/1994 to 12/31/2000)
2) Raw NSM data are water depth in feet so data are converted to cm
3) Delete any values ≤ 0 (retains above-ground water levels only)
6) Summary stats are calculated on above-ground water levels. Compare count and mean from Excel files and SAS output to verify.
4) In Excel, calculate average hydroperiod (Supplemental Table 3) by taking only the above ground water days, sorting by date, counting the number of days in each calendar year water is above ground. Average for span of time to get average hydroperiod.

NSM 4.6.2 SAS Runs

P33 NSM SAS Code: Converts raw NSM to cm, restricts dates, and removes any ≤ 0 water level values.

P33 NSM water level 2-7-2019 - Notepad

File Edit Format View Help

```
*this is raw NSM;
*nsm_4_6_2 is feet of depth so output is feet of depth;

*converts to cm of depth and keeps above ground values;
data P33raw_cm; set  mysaslib.nsm_4_6_2;
P33raw_cm = ((P33_nsm)*30.48);
where date >='01jan1965'd and date <='31dec2000'd;
keep date P33raw_cm;
run;


data P33_raw_cm_abvgrnd;   set P33raw_cm;
P33raw_cm_abvgrnd= P33raw_cm;
where P33raw_cm > 0.0;
keep date P33raw_cm_abvgrnd;
run;

proc means data = P33_raw_cm_abvgrnd n mean max min range stderr P10 P25 P75 P90;
run;

*proc export data=P33raw_cm_abvgrnd_merge
outfile='C:\Users\User\Documents\
A All Current Projects\2016 USGS Manuscript\
new water level hydroperiod flow\Water level\
P33raw_cm_abvgrnd_merge 3-19-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;

quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

P33 NSM water level out 2-7-2019 - Notepad

File Edit Format View Help

```
                                           The SAS System        10:55 Monday, February 11, 2019   5

                                         The MEANS Procedure

  Variable                 N          Mean       Maximum       Minimum          Range      Std Error
  ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
  date                 12735       8400.41      14975.00       1827.00       13148.00     33.8372521
  P33raw_cm_abvgrnd    12735    42.6190818    81.3816000     0.3048000     81.0768000      0.1373158
  ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

          Variable              10th Pctl       25th Pctl       75th Pctl       90th Pctl
          ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
          date                    3100.00         5125.00        11792.00        13702.00
          P33raw_cm_abvgrnd    19.5072000      33.2232000      54.2544000      60.3504000
          ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

NP206 NSM SAS Code: Restricts dates, removes any ≤ 0 water level values, and converts raw NSM to cm.

NP206 NSM water level 4-3-18 - Notepad

File Edit Format View Help

```
*this is NSM;
*nsm_4_6_2 is feet of depth so output is feet of depth;
data NP206_nsm_ft; set mysaslib.nsm_4_6_2;
keep date NP206_nsm;
run;

*converts to cm of depth and keeps above ground values;
data NP206_nsm_cm; set  Np206_nsm_ft;
NP206_nsm_cm = ((NP206_nsm)*30.48);
where NP206_nsm > 0.0;
keep date NP206_nsm_cm;
run;

proc means data = NP206_nsm_cm n mean max min range stderr P10 P25 P75 P90;
where date >='01jan1975'd and date <='31dec2000'd;
run;

quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

NP206 NSM water level out 4-3-18 - Notepad

File Edit Format View Help

```
                                    The SAS System          17:25 Tuesday, April 3, 2018  13

                                  The MEANS Procedure

 Variable            N          Mean        Maximum        Minimum          Range      Std Error
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
 date             8100      10348.58       14975.00        5479.00        9496.00     31.5307518
 NP206_nsm_cm     8100    22.3082744     54.8640000      0.3048000     54.5592000      0.1041719
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

           Variable          10th Pctl       25th Pctl       75th Pctl       90th Pctl
           ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
           date                6519.50         7734.50        12950.50        14165.50
           NP206_nsm_cm      9.1440000      16.1544000      28.9560000      33.8328000
           ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

EVER4 NSM SAS Code: Restricts dates, removes any ≤ 0 water level values, and converts raw NSM to cm.

EVER4 NSM water level 4-5-18 - Notepad

File Edit Format View Help

```
data EVER4_NSM_raw_cm; set mysaslib.nsm_4_6_2;
EVER4_NSM_raw_cm = Ever4_nsm*30.48;
where EVER4_nsm > 0.0 and date >='01jan1994'd and date <='31dec2000'd;
keep date Ever4_nsm_raw_cm;
run;

proc means data = EVER4_NSM_raw_cm n mean max min range stderr P10 P25 P75 P90;
run;

*proc export data=EVER4paleo_cm_abvgrnd_merge
outfile='C:\Users\User\Documents\A All Current Projects\
2016 USGS Manuscript\AA  L and O 11-18-17 new start\
rev EVER4 paleo cm abv grnd 3-21-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;


quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

EVER4 NSM water level out 4-5-18 - Notepad

File Edit Format View Help

```
                                    The SAS System          10:47 Thursday, April 5, 2018   3

                                  The MEANS Procedure

Variable                N            Mean         Maximum         Minimum           Range       Std Error
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
date                 1903        13662.08        14975.00        12419.00         2556.00      16.6130681
EVER4_NSM_raw_cm     1903      14.0441846      42.3672000       0.3048000      42.0624000       0.1756228
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

        Variable                10th Pctl       25th Pctl       75th Pctl       90th Pctl
        ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
        date                     12742.00        13027.00        14256.00        14648.00
        EVER4_NSM_raw_cm        3.3528000       7.9248000      19.5072000      23.7744000
        ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

NSM 4.6.2 bias-adjusted data

The NSM 4.6.2 bias-adjusted water level data can be found in Supplemental Table 1.

Bias adjustments are values were calculated previously[1]. Model bias is the difference between the model output and the measured value of the parameter being estimated (water level in this case). For these runs, bias was removed by making a temporally-constant adjustment to the NSM data as follows:

Station	Adjustment in ft	Adjustment in cm
P33	+ 0.01	+ 0.30
NP206	- 0.13	- 3.96
EVER4	- 0.03	- 0.91

Steps:

1) Trim data to appropriate time-frame (P33 (1/1/1965 to 12/31/2000; NP206 1/1/1975 to 12/31/2000; EVER4 1/1/1994 to 12/31/2000)
2) Bias adjustment (in feet) is applied to raw NSM
3) Bias-adjusted raw NSM data are converted to cm
4) Delete any values ≤ 0 (retains above-ground water levels only)
5) Summary stats are calculated on above-ground water levels. Compare count and mean from Excel files and SAS output to verify.
6) In Excel, calculate average hydroperiod (Supplemental Table 3) by taking only the above ground water days, sorting by date, counting the number of days in each calendar year water is above ground. Average for span of time to get average hydroperiod.

[1] Bias in NSM predecessor South Florida Water Management Model (SFWMM), discussed in MacVicar et al., 1984 and South Florida Water Management District report in 2005. Bias adjustment calculated by Marshall (unpublished reports in 2014, 2015, 2016).

MacVicar, T., Van Lent, T., and Castro A. (1984). South Florida Water Management Model Documentation Report. South Florida Water Management District Technical Publication 84-3. https://palmm.digital.flvc.org/islandora/object/fiu%3A9791#page/FI05082907_018/mode/2up

South Florida Water Management District. (2005). Documentation for the South Florida Water Management model Version 5.5. https://www.sfwmd.gov/sites/default/files/documents/sfwmm_final_121605.pdf

NSM bias-Adjusted SAS Runs

P33 NSM Bias-Adjusted SAS Code: Code applies bias-adjustment of +0.01 ft (+0.30 cm) to raw NSM, converts to cm, removes any ≤ 0 water level values, and restricts dates.

P33 NSM bias-adj water level 4-4-18 - Notepad

File Edit Format View Help

```
*nsm_4_6_2 is feet of depth so output is feet;
*following applies bias adjustment of .01 ft (or .30 cm);
data P33nsm_adjustbias; set mysaslib.nsm_4_6_2;
P33nsm_adjustbias=P33_nsm +.01;
run;

*following converts to cm and restricts to above ground water level only;
data P33nsm_adjustbias_cm_abvgrnd; set  P33nsm_adjustbias;
P33nsm_adjustbias_cm = ((P33nsm_adjustbias)*30.48);
where P33nsm_adjustbias > 0.0;
keep date P33nsm_adjustbias_cm;
run;

proc means data = P33nsm_adjustbias_cm_abvgrnd n mean max min range stderr P10 P25 P75 P90;
where date >='01jan1965'd and date <='31dec2000'd;
run;

*proc export data=P33paleo_cm_abvgrnd_merge
outfile='C:\Users\User\Documents\
A All Current Projects\2016 USGS Manuscript\
new water level hydroperiod flow\water level\
P33paleo_cm_abvgrnd_merge 3-19-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;

quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

P33 NSM bias-adj water level out 4-4-18 - Notepad

File Edit Format View Help

```
                                  The SAS System        11:08 Wednesday, April 4, 2018   6

                                The MEANS Procedure

 Variable                 N          Mean        Maximum        Minimum          Range     Std Error
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
 date                 12740       8400.07       14975.00        1827.00       13148.00    33.8282252
 P33nsm_adjustbias_cm 12740    42.9071554     81.6864000      0.3048000     81.3816000     0.1374655
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

        Variable                 10th Pctl       25th Pctl       75th Pctl       90th Pctl
        ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
        date                       3100.50         5124.50        11790.50        13701.50
        P33nsm_adjustbias_cm    19.8120000      33.5280000      54.5592000      60.6552000
        ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

NP206 NSM Bias-Adjusted SAS Code: Code applies bias-adjustment of -0.13 ft (-3.96 cm) to raw NSM, converts to cm, removes any ≤ 0 water level values, and restricts dates.

NP206 NSM bias-adj water level 4-4-18 - Notepad

File Edit Format View Help

```
*The text below is bias adjustment;
*output values (below) values are ft of depth;
data NSM_adjustbias_depth; set mysaslib.nsm_4_6_2;
NP206nsm_adjustbias=NP206_nsm - 0.13;
keep date NP206nsm_adjustbias;
run;

*following converts to cm and restricts to above ground water level only;
data NSM_adjustbias_depth_cm; set NSM_adjustbias_depth;
NP206_adjustbias_cm_depth =  ((NP206nsm_adjustbias)*30.48);
where  NP206nsm_adjustbias > 0.0;
keep date NP206_adjustbias_cm_depth;
run;


proc means data = NSM_adjustbias_depth_cm n mean max min range stderr P10 P25 P75 P90;
where date >='01jan1975'd and date <='31dec2000'd;
run;

*proc export data=NP206paleo_cm_abvgrnd_merge
outfile='C:\Users\User\Documents\
A All Current Projects\2016 USGS Manuscript\
new water level hydroperiod flow\Water level\
rev 65-2000 NP206 paleo hydroperiod 2-18-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;
quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

NP206 NSM bias-adj water level out 4-4-18 - Notepad

File Edit Format View Help

```
                                     The SAS System         11:08 Wednesday, April 4, 2018   4

                                   The MEANS Procedure

 Variable                       N          Mean        Maximum        Minimum          Range
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
 date                        7836      10401.50       14975.00        5479.00        9496.00
 NP206_adjustbias_cm_depth   7836    19.0213715     50.9016000      0.3048000     50.5968000
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

  Variable                     Std Error     10th Pctl     25th Pctl     75th Pctl     90th Pctl
  ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
  date                        32.0894539       6581.00       7929.50      13012.50      14188.00
  NP206_adjustbias_cm_depth    0.0990113     6.4008000    13.1064000    24.9936000    29.8704000
  ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

EVER4 NSM Bias-Adjusted SAS Code: Code applies bias-adjustment of -0.03 ft (-0.91 cm) to raw NSM, restricts dates, converts to cm, and removes any ≤ 0 water level values.

EVER4 NSM bias-adj water level 4-3-18 - Notepad

File Edit Format View Help

```
*The text below is bias adjustment;
*output values (below) values are ft of depth;
data EVER4_NSM_adjustbias; set mysaslib.nsm_4_6_2;
Ever4nsm_adjustbias=Ever4_nsm - 0.03;
where date >= '01jan1994'd and date <='31dec2000'd;
keep date Ever4nsm_adjustbias;
run;

*following converts to cm and restricts to above ground water level only;
data EVER4_NSM_adjustbias_cm; set EVER4_NSM_adjustbias;
EVER4_NSM_adjustbias_cm = Ever4nsm_adjustbias*30.48;
where EVER4nsm_adjustbias > 0.0;
keep date Ever4_nsm_adjustbias_cm;
run;

proc means data = EVER4_NSM_adjustbias_cm n mean max min range stderr P10 P25 P75 P90;
run;

*proc export data=EVER4paleo_cm_abvgrnd_merge
outfile='C:\Users\User\Documents\A All Current Projects\
2016 USGS Manuscript\AA  L and O 11-18-17 new start\
rev EVER4 paleo cm abv grnd 3-21-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;


quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

EVER4 NSM bias-adj water level out 4-3-18 - Notepad

File Edit Format View Help

```
                                   The SAS System          17:25 Tuesday, April 3, 2018   2

                                 The MEANS Procedure

Variable                   N         Mean      Maximum       Minimum         Range     Std Error
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
date                    1861     13661.48     14975.00      12419.00       2556.00    16.6710704
EVER4_NSM_adjustbias_cm 1861   13.4329831   41.4528000     0.3048000    41.1480000     0.1732389
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

      Variable                  10th Pctl     25th Pctl     75th Pctl     90th Pctl
      ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
      date                       12753.00      13032.00      14250.00      14640.00
      EVER4_NSM_adjustbias_cm   3.0480000     7.3152000    18.5928000    22.8600000
      ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

Paleo-based NSM 4.6.2 data

The NSM 4.6.2 bias-adjusted water level data can be found in Supplemental Table 1.

Derivation of paleo-adjustments to NSM are described in detail in the text but are the paleoecologic-based estimate of water level at the beginning of the 20th century minus the median bias-adjusted NSM. Paleo-adjustments are as follows:

Station	Paleo-estimated annual water depth (cm)	Median bias-adjusted NSM (cm)	Paleo-adjustment (cm)
P33	67	45.42	+21.58
NP206	30	19.51	+10.49
EVER4	40-67*	14.33	+25.67

*Because EVER4 paleo-estimate is a range, decision was made to use the low end of the range (40 cm) for adjustment calculation as described in the text.

Steps:

1) Trim data to appropriate time-frame (P33 (1/1/1965 to 12/31/2000; NP206 1/1/1975 to 12/31/2000; EVER4 1/1/1994 to 12/31/2000)
2) Data from raw NSM are converted to cm
3) Bias-adjustment in cm is applied (as described in section above)
4) Paleo-adjustment in cm is applied
5) Delete any values ≤ 0 (retains above-ground water levels only)
6) Summary stats are calculated on above-ground water levels. Compare count and mean from Excel files and SAS output to verify.
7) In Excel, calculate average hydroperiod (Supplemental Table 3) by taking only the above ground water days, sorting by date, counting the number of days in each calendar year water is above ground. Average for span of time to get average hydroperiod.

Paleo-based, bias-adjusted NSM SAS Runs

SAS code for P33 Paleo-adjusted Water Level: Code brings in raw NSM data, converts to cm, applies bias-adjustment in cm (+0.30), applies paleo-adjustment (+21.58 cm), restricts dates, and removes any ≤ 0 water level values.

P33 paleo-adj water level 2-12-2019 - Notepad

File Edit Format View Help

```
*this is paleo;
*nsm_4_6_2 is feet of depth so this changes it to cm;
data P33nsm_cm; set mysaslib.nsm_4_6_2;
P33nsm_cm = P33_nsm * 30.48;
keep date P33nsm_cm;
run;

data NSM_adjustbias_cm; set P33nsm_cm;
P33nsm_adjustbias_cm=P33nsm_cm +0.30;
run;

*p33;
*this applies paleo adjustment (paleo est water depth minus median NSM bias-adj water depth);
*The P33  adjustment is + 21.58 cm;
data P33paleo_cm; set NSM_adjustbias_cm;
P33paleo_cm =  P33nsm_adjustbias_cm + 21.58;
where date >='01jan1965'd and date <='31dec2000'd;
keep date P33paleo_cm;
run;

data P33paleo_cm_abvgrnd; set  P33paleo_cm;
P33paleo_cm_abvgrnd = (P33paleo_cm);
where P33paleo_cm > 0.0;
keep date P33paleo_cm_abvgrnd;
run;

proc means data = P33paleo_cm_abvgrnd n mean median max min range stderr P10 P25 P75 P90;
run;

*proc export data=P33paleo_cm_abvgrnd_merge
outfile='C:\Users\User\Documents\
A All Current Projects\2016 USGS Manuscript\
new water level hydroperiod flow\water level\
P33paleo_cm_abvgrnd_merge 3-19-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;

quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

P33 paleo-adj water level out 2-12-2019 - Notepad

File Edit Format View Help

```
                                          The SAS System       15:04 Tuesday, February 12, 2019   1

                                        The MEANS Procedure

 Variable                      N          Mean        Median        Maximum        Minimum          Range
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
 date                      12989       8373.03       8328.00       14975.00        1827.00       13148.00
 P33paleo_cm_abvgrnd       12989    63.4690906    66.6856000    103.2616000      0.2392000    103.0224000
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ

 Variable                   Std Error      10th Pctl      25th Pctl      75th Pctl      90th Pctl
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
 date                      33.4096780        3125.00        5081.00       11728.00       13677.00
 P33paleo_cm_abvgrnd        0.1492575     38.6440000     54.1888000     76.1344000     82.2304000
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

SAS code for NP206 Paleo-adjusted Water Level: Code brings in raw NSM data, converts to cm, applies bias-adjustment in cm (-3.96), applies paleo-adjustment (+10.49 cm), restricts dates, and removes any ≤ 0 water level values.

NP206 paleo-adj water level 2-12-2019 - Notepad

File Edit Format View Help

```
*The text below applies bias adjustment and converts to cm;
data NP206nsm_cm; set mysaslib.nsm_4_6_2;
NP206nsm_cm = NP206_nsm * 30.48;
keep date NP206nsm_cm;
run;

data NP206nsm_adjustbias; set NP206nsm_cm;
NP206nsm_adjustbias_cm=NP206nsm_cm - 3.96;
where date >= '01jan1975'd and date <='31dec2000'd;
keep date  NP206nsm_adjustbias_cm;
run;

*this adjustment creates the NP206 freshwater paleo-based depth;
*Paleo adjustment based on difference between median bias-adj NSM water level and paleo-based water level;
*The 'simple' NP206  paleo adjustment is +10.49;
data NP206paleo; set NP206nsm_adjustbias;
NP206paleo =  NP206nsm_adjustbias_cm + 10.49;
where date >= '01jan1975'd and date <='31dec2000'd;
keep date NP206paleo;
run;

*this keeps only above ground values and changes to cm;
data NP206_paleo_cm_abvgrnd; set NP206paleo;
NP206paleo_abvgrnd = NP206paleo;
where NP206paleo > 0.0;
keep date NP206paleo_abvgrnd;
run;


proc means data = NP206_paleo_cm_abvgrnd n mean median stderr;
run;


quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

NP206 paleo-adj water level out 2-12-2019 - Notepad

File Edit Format View Help

```
                                The SAS System       15:04 Tuesday, February 12, 2019   2

                                The MEANS Procedure

          Variable                N            Mean          Median       Std Error
          ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
          date                 8261      10326.57      10102.00      31.1255104
          NP206paleo_abvgrnd   8261      28.3677522    29.3900000     0.1085781
          ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

SAS code for EVER4 Paleo Water Level: Code brings in raw NSM data, converts to cm, applies bias-adjustment in cm (-0.91), applies paleo-adjustment (+25.67 cm), removes any ≤ 0 water level values, and restricts dates.

EVER4 paleo-adj water level 2-12-2019 - Notepad

File Edit Format View Help

```
*The text below applies bias adjustment and converts to cm;
data EVER4nsm_cm; set mysaslib.nsm_4_6_2;
EVER4_NSM_cm = EVER4_nsm * 30.48;
keep date EVER4_NSM_cm;
run;

*this applies bias adjustment of -0.91 cm;
data EVER4nsm_adjustbias; set EVER4nsm_cm;
EVER4nsm_adjustbias_cm=EVER4_nsm_cm - 0.91;
where date >= '01jan1994'd and date <='31dec2000'd;
keep date  EVER4nsm_adjustbias_cm;
run;

*this applies paleo adjustment based on sediment core analysis results;
*For EVER4 use low end of Paleo range (40) instead of mid-pt for simple adjustment (Paleo - median bias-adj NSM);
*The EVER4  adjustment is + 25.67 cm;
data EVER4paleo_depth; set EVER4nsm_adjustbias;
EVER4paleo_depth =  EVER4nsm_adjustbias_cm + 25.67;
keep date EVER4paleo_depth;
run;

*this adjustment creates the EVER4 freshwater paleo-based depth (cm)
*and retains only above ground water level values;
data EVER4paleo_cm_abvgrnd; set EVER4paleo_depth;
EVER4paleo_cm_abvgrnd =  EVER4paleo_depth;
where EVER4paleo_depth > 0.0;
keep date EVER4paleo_cm_abvgrnd;
run;

data EVER4paleoabvgrnd942000; set EVER4paleo_cm_abvgrnd;
where date >= '01jan1994'd and date <='31dec2000'd;
keep date EVER4paleo_cm_abvgrnd;
run;

proc means data = EVER4paleoabvgrnd942000 n mean median stderr stDdev;
run;


quit;
quit;
```

Output from above: Count and mean data cross-checked to excel file for agreement.

EVER4 paleo-adj water level out 2-12-2019 - Notepad

File Edit Format View Help

```
                                The SAS System       15:04 Tuesday, February 12, 2019   3

                              The MEANS Procedure

   Variable                     N            Mean          Median       Std Error         Std Dev
   ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
   date                      2377      13659.39      13612.00      15.2359481      742.8208318
   EVER4paleo_cm_abvgrnd     2377     33.6006105     35.7328000       0.2646435       12.9025560
   ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
```

Development of Flow Models

The flow models are developed for Shark River Slough (SRS; multiple stations combined) and Taylor Slough (TSB, station at Taylor Slough Bridge) using the linear regression procedure in SAS (step 5 on text Figure 3).

Prior to selecting the final linear regression equations used in the analyses presented in the text, we experimented with the following:

1) Selection of dependent variable. As noted in the text, water level was the logical choice for the independent variable because stage (converted to water level in the models) is the output variable provided by the NSM (and other hydrologic models), and it is the variable estimated by the paleoecologic analyses. Our goal was to predict the circa 1900 flows from the paleo-water levels.
2) Choice of stations data to include. As explained in the text, P33 station data explains most of the variance in SRS. For the TSB models, NP206 contributed very little to the variance, so only EVER4 data were used for the TSB models.
3) Inclusion of ≤ 0 water levels and flows. In developing the models, we tested what happened when below ground water levels or zero flows were included. For SRS, because of the location of P33 in the main flow path of SRS and the persistence of some flow even in dry years, we were able to leave in all observed values. However, because Taylor Slough frequently has no flow and EVER4 has a large number of below ground values, we needed to set zero or less than zero values to missing to obtain improved model performance for TSB.
4) Use of multipliers. We experimented with squaring or cubing the water level term to reflect periods of peak flows. For SRS cubing the water level term produced the highest r^2 values, and plots of the model produced versus observed data showed that by cubing this term we were better matching the peak flows. Adjustments did not improve the model for TSB, so no multipliers were used.
5) Period of the observed record. The two time periods we tested fully were a) the full period of record available at the start of this study for the flow monitoring stations, and b) a truncated period of record beginning in 1995. Models that used the shorter time period (starting in 1995) gave higher r^2 values. Given the history of water management, this makes sense, because the 1960s through 1980s flow was significantly reduced and therefore very unlike the natural system. Beginning in 1990s, water management was trying to send more water into the southern part of the system. Since we are trying to model the natural system, using data beginning in the 1990s data was logical.

After experimenting with the above parameters, the final choice of models was based on two things: 1) selecting the model parameters that produced the best r^2 value and 2) comparing model output to observed output to examine how closely the model tracks the observed. This comparison of plots was particularly useful in determining whether the multipliers were useful in replicating peak flows.

Text Table 3 summarizes the data that were used in the final step of model development and compares the results of the two time periods ("full" period of record, and starting in 1990), with all other parameters being the same within each model.

Comparison of models developed using different time periods

Text Table 3 summarizes the data that were used in the final step of model development, reflecting decisions noted based on experimentation with items 1-4 above, and compares the results of the two time periods ("full" period of record, and starting in 1990), with all other parameters being the same within each model.

SRS "Full" Period of Record

SRS flow data used for these analyses represent a water balance based on the measured flows into Shark River Slough through six water control structures along Tamiami Trail: SRS = S12A + S12B + S12C + S12D + S333 - S334 (note, S334 is a subtraction, because its location on the eastern side of the park diverts water away from SRS). Flow data are from South Florida Water Management District; https://www.sfwmd.gov/science-data/dbhydro. P33 station water level data are used in SRS model development (discussed above, experimentation #2).

SAS steps in model development:

1) Adjust for P33 station elevation relative to NGVD29 (4.87 feet for P33)
2) Convert observed water level data at P33 station to meters
3) Cube water depth term (discussed above, experimentation #4)
4) Convert observed flow data from cubic feet per second (cfs) to cubic meters per second (cms)
5) For model, set flow as dependent variable, water level as independent
6) Set relevant dates (for "full" period of record 10/10/1978 to 9/30/2015)
7) No values are removed for SRS, i.e. includes all values <0, =0, >0 (discussed above, experimentation #3)

SAS code for SRS model development using “full” (10/10/1978 to 9/30/2015) period of record:

SRS model development 05-31-2019 full POR - Notepad

File Edit Format View Help

```
*P33 elevation = 4.87 ft NGVD29;
*P33 values are feet of stage - not depth;
*convert feet stage to meters of depth;
data P33_obs_depth_m; set mysaslib.fullstagedata_updated_29;
P33_m_depth = ((P33_29-4.87)*(0.3048));
keep date P33_m_depth;
run;

data P33_obs_depth_m_cu; set P33_obs_depth_m;
p33_m_depth_cu=(P33_m_depth*P33_m_depth*P33_m_depth);
keep date P33_m_depth_cu ;
run;

*SRS is cfs - convert to cubic meters per sec - cms;
data SRS_cms; set mysaslib.Srs_updated_dec2016;
srs_cms = srs*0.0283;
keep date srs_cms;
run;

data merge_srs_stuff;
merge SRS_cms P33_obs_depth_m_cu;
by date;
run;

proc reg data=merge_srs_stuff;
model srs_cms=
P33_m_depth_cu ;
output out=psrs_cms
p=psrs_cms;
where date >='10oct1978'd and date <='30sep2015'd;
run;

data merge_more_stuff;
merge
srs_cms
psrs_cms;
by date;
run;

data keep_stuff; set merge_more_stuff;
keep date SRS_cms psrs_cms;
run;

proc means data=keep_stuff N mean stddev stderr;
var SRS_cms psrs_cms;
where SRS_cms NE . and psrs_cms  NE .;
run;

*proc export data=keep_stuff
outfile='C:\Users\User\Documents\A All Current Projects\
2016 USGS Manuscript\new water level hydroperiod flow\
Flow Models\rev 6-27-18 New SRS model revised and runs
SRS from P33 cms after 95 6-27-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;

quit;
```

Output from above:

SRS model development 05-31-2019 out full POR - Notepad

File Edit Format View Help

```
                                The SAS System              13:25 Friday, May 31, 2019   7

                               The REG Procedure
                                 Model: MODEL1
                         Dependent Variable: srs_cms

                 Number of Observations Read                   13505
                 Number of Observations Used                   12533
                 Number of Observations with Missing Values      972

                              Analysis of Variance

                                      Sum of           Mean
      Source                 DF      Squares         Square    F Value    Pr > F

      Model                   1      8812181        8812181    28386.2    <.0001
      Error               12531      3890112      310.43910
      Corrected Total     12532     12702293

                 Root MSE            17.61928    R-Square     0.6937
                 Dependent Mean      28.71390    Adj R-Sq     0.6937
                 Coeff Var           61.36151

                              Parameter Estimates

                                    Parameter       Standard
         Variable          DF        Estimate          Error    t Value    Pr > |t|

         Intercept          1         3.05919        0.21899      13.97      <.0001
         p33_m_depth_cu     1       223.21059        1.32483     168.48      <.0001
                                The SAS System              13:25 Friday, May 31, 2019   8

                              The MEANS Procedure

 Variable    Label                              N            Mean         Std Dev       Std Error
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
 srs_cms                                    12533      28.7138995      31.8369074       0.2843828
 psrs_cms    Predicted Value of srs_cms     12533      28.7138995      26.5174347       0.2368667
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

<u>TSB "Full" Period of Record</u>

TSB flow data are from a single station at Taylor Slough Bridge. Flow data are from South Florida Water Management District; https://www.sfwmd.gov/science-data/dbhydro. EVER4 station water level data are used in TSB model development (discussed above, experimentation #2).

SAS steps do the following:

1) Adjust for EVER4 station elevation relative to NGVD29 (1.81 feet for EVER4)
2) Convert observed water level data at EVER4 station to meters
3) Set any below ground water levels (<0) to missing (discussed above, experimentation #3)
4) Convert observed flow data from cubic feet per second (cfs) to cubic meters per second (cms)
5) Set any flow values <0 to missing (discussed above, experimentation #3)
6) For model, set flow (cms) as dependent variable, water level as independent
7) Set relevant dates (for "full" period of record 10/1/1960 to 12/31/2008)

SAS code for TSB model development using “full” (10/1/1960 to 12/31/2008) period of record:

TSB model development 6-13-2019 full POR - Notepad

File Edit Format View Help

```
*This run tests EVER4 as the independent variable.  TSB flow is dependent;
*values are not squared. Values <0 changed to missing;

*convert exist stage to meters depth above ground;
data EVER4_obs_m_depth; set mysaslib.fullstagedata_updated_29;
EVER4_m_depth =((EVER4_29-1.81)*(0.3048));
if EVER4_m_depth < 0.0 then EVER4_m_depth = '.';
keep date EVER4_m_depth;
run;

*TSB is cfs - convert to cubic meters per sec - cms;
data TSB_cu_m_sec; set mysaslib.TSB;
TSB_cu_m_sec = TSB*0.02832;
if TSB_cu_m_sec < 0.0 then TSB_cu_m_sec = '.';
keep date TSB_cu_m_sec;
run;

data merge_EVER4_TSB;
merge EVER4_obs_m_depth TSB_cu_m_sec;
by date;
where date >='01oct1960'd and date <='31dec2008'd;
run;

ods preferences;

*Develop linear regression model - EVER4 is dependent;
*Dependent listed first in model run and TSB flow is independent;
proc reg data=merge_EVER4_TSB;
model TSB_cu_m_sec = EVER4_m_depth;
output out=ptsb
p=ptsb_ms;
run;

data merge_more_stuff;
merge
merge_EVER4_TSB
ptsb;
by date;
where date >='01oct1960'd and date <='31dec2008'd;
run;

proc means data=merge_more_stuff N mean stddev stderr;
run;

ods _all_ close;
ods listing;

proc export data=merge_more_stuff
outfile='C:\Users\Documents\A All Current Projects\
2016 USGS Manuscript\flow only\TSB EVER4 models\
redo 3 tsb from EVER4 only 2-4-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;

quit;
quit;


quit;
```

Output from above:

TSB model development 6-13-2019 full POR out - Notepad

File Edit Format View Help

```
                                The SAS System         11:57 Thursday, June 13, 2019   3

                               The REG Procedure
                                 Model: MODEL1
                        Dependent Variable: TSB_cu_m_sec

               Number of Observations Read                         17624
               Number of Observations Used                          4137
               Number of Observations with Missing Values          13487


                              Analysis of Variance

                                        Sum of           Mean
        Source                   DF    Squares         Square    F Value    Pr > F

        Model                     1      37156          37156    7162.81    <.0001
        Error                  4135      21450        5.18733
        Corrected Total        4136      58605


                     Root MSE              2.27757    R-Square     0.6340
                     Dependent Mean        3.34806    Adj R-Sq     0.6339
                     Coeff Var            68.02651


                              Parameter Estimates

                                    Parameter       Standard
           Variable         DF       Estimate          Error    t Value    Pr > |t|

           Intercept         1       -2.07058        0.07316     -28.30      <.0001
           EVER4_m_depth     1       37.85135        0.44724      84.63      <.0001
                                The SAS System         11:57 Thursday, June 13, 2019   4

                               The MEANS Procedure

  Variable       Label                             N          Mean        Std Dev      Std Error
  ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
  date                                         17624       9085.50        5087.75     38.3242743
  EVER4_m_depth                                 4137     0.1431558      0.0791848      0.0012311
  TSB_cu_m_sec                                 17624     1.5002476      2.7171857      0.0204676
  ptsb_ms        Predicted Value of TSB_cu_m_sec  4137     3.3480625      2.9972515      0.0465994
  ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

SRS Truncated Period of Record

SRS flow data used for these analyses represent a water balance based on the measured flows into Shark River Slough through six water control structures along Tamiami Trail: SRS = S12A + S12B + S12C + S12D + S333 - S334 (note, S334 is a subtraction, because its location on the eastern side of the park diverts water away from SRS). Flow data are from South Florida Water Management District; https://www.sfwmd.gov/science-data/dbhydro. P33 station water level data are used in SRS model development (discussed above, experimentation #2).

SAS steps in model development:

1) Adjust for P33 station elevation relative to NGVD29 (4.87 feet for P33)
2) Convert observed water level data at P33 station to meters
3) Cube water depth term (discussed above, experimentation #4)
4) Convert observed flow data from cubic feet per second (cfs) to cubic meters per second (cms)
5) For model, set flow as dependent variable, water level as independent
6) Set relevant dates (for truncated period of record 1/1/1995 to 9/30/2015)
7) No values are removed (i.e. includes all values <0, =0, >0)

SAS code for SRS model development using truncated (1/1/1995 to 9/30/2015) period of record:

SRS model develop 1995-2015 POR water level cubed 5-31-2019 - Notepad

File Edit Format View Help

```
*P33 elevation = 4.87 ft NGVD29;
*P33 values are feet of stage - not depth;
*convert feet stage to meters of depth;
data P33_obs_depth_m; set mysaslib.fullstagedata_updated_29;
P33_m_depth = ((P33_29-4.87)*(0.3048));
keep date P33_m_depth;
run;

data P33_obs_depth_m_cu; set P33_obs_depth_m;
p33_m_depth_cu=(P33_m_depth*P33_m_depth*P33_m_depth);
keep date P33_m_depth_cu ;
run;

*SRS is cfs - convert to cubic meters per sec - cms;
data SRS_cms; set mysaslib.Srs_updated_dec2016;
srs_cms = srs*0.0283;
keep date srs_cms;
run;

data merge_srs_stuff;
merge SRS_cms P33_obs_depth_m_cu;
by date;
run;

proc reg data=merge_srs_stuff;
model srs_cms=
P33_m_depth_cu ;
output out=psrs_cms
p=psrs_cms;
where date >='01jan1995'd and date <='30sep2015'd;
run;

data merge_more_stuff;
merge
srs_cms
psrs_cms;
by date;
run;

data keep_stuff; set merge_more_stuff;
keep date SRS_cms psrs_cms;
run;

proc means data=keep_stuff N mean stddev stderr;
var SRS_cms psrs_cms;
where SRS_cms NE . and psrs_cms  NE .;
run;

*proc export data=keep_stuff
outfile='C:\Users\User\Documents\A All Current Projects\
2016 USGS Manuscript\new water level hydroperiod flow\
Flow Models\rev 6-27-18 New SRS model revised and runs
SRS from P33 cms after 95 6-27-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;

quit;
```

Output from above:

```
SRS model develop 1995-2015 POR water level cubed out 5-31-2019 - Notepad
File  Edit  Format  View  Help
                                The SAS System          12:09 Monday, May 27, 2019   1

                               The REG Procedure
                                 Model: MODEL1
                          Dependent Variable: srs_cms

              Number of Observations Read                       7578
              Number of Observations Used                       7061
              Number of Observations with Missing Values         517

                             Analysis of Variance

                                         Sum of          Mean
      Source                 DF         Squares        Square    F Value    Pr > F

      Model                   1         6320509       6320509    24438.7    <.0001
      Error                7059         1825646     258.62677
      Corrected Total      7060         8146156

               Root MSE             16.08188    R-Square     0.7759
               Dependent Mean       31.51247    Adj R-Sq     0.7759
               Coeff Var            51.03338

                             Parameter Estimates

                                Parameter       Standard
        Variable        DF       Estimate          Error    t Value    Pr > |t|

        Intercept        1       -1.63582        0.28564      -5.73      <.0001
        p33_m_depth_cu   1      225.39848        1.44182     156.33      <.0001
                                The SAS System          12:09 Monday, May 27, 2019   2

                              The MEANS Procedure

 Variable    Label                            N           Mean        Std Dev       Std Error
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
 srs_cms                                   7061     31.5124693     33.9683145       0.4042415
 psrs_cms    Predicted Value of srs_cms    7061     31.5124693     29.9208331       0.3560743
 ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

Selection of final SRS model for use in analyses:

R^2 value for truncated period of record starting in 1995 was higher (0.78) than the "full" period of record (0.69), therefore, the model derived from the truncated period was used. Additionally, as stated above, using data from the 1990s forward reflected water management decisions to more closely emulate the natural system.

Model developed from the output above sets flow as the dependent and water level as the independent variables; SRS flow is predicted by water depth at the P33 station and water depth is cubed to simulate peak flows.

$$\text{SRS flow } (m^3\ s^{-1}) = (-1.64) + (225.4 * (\text{P33 water depth}(m)^3))$$

TSB Truncated Period

TSB flow data are from a single station at Taylor Slough Bridge. Flow data are from South Florida Water Management District; https://www.sfwmd.gov/science-data/dbhydro. EVER4 station water level data are used in TSB model development (discussed above, experimentation #2).

SAS steps in model development:

1) Adjust for EVER4 station elevation relative to NGVD29 (1.81 feet for EVER4)
2) Convert observed water level data at EVER4 station to meters
3) Set any below ground water levels (<0) to missing (discussed above, experimentation #3)
4) Convert observed flow data from cubic feet per second (cfs) to cubic meters per second (cms)
5) Set any flow values <0 to missing (discussed above, experimentation #)
6) For model, set flow (cms) as dependent variable, water level as independent
7) Set relevant dates (for truncated period of record 1/1/1995 to 12/31/2008)

SAS code for TSB model development using truncated (1/1/1995 to12/31/2008) period of record:

TSB model develop 1995-2008 POR 5-31-2019 - Notepad

File Edit Format View Help

```
*convert exist stage to meters depth above ground;
data EVER4_obs_m_depth; set mysaslib.fullstagedata_updated_29;
EVER4_m_depth =((EVER4_29-1.81)*(0.3048));
if EVER4_m_depth < 0.0 then EVER4_m_depth = '.';
keep date EVER4_m_depth;
run;

*TSB is cfs - convert to cubic m per sec;
data TSB_cu_m_sec; set mysaslib.TSB;
TSB_cu_m_sec = TSB*0.02832;
if TSB_cu_m_sec < 0.0 then TSB_cu_m_sec = '.';
keep date TSB_cu_m_sec;
run;

data merge_EVER4_TSB;
merge EVER4_obs_m_depth TSB_cu_m_sec;
by date;
where date >='01jan1995'd and date <='31dec2008'd;
run;

ods preferences;

proc reg data=merge_EVER4_TSB;
model TSB_cu_m_sec=
EVER4_m_depth;
output out=ptsb
p=ptsb_ms;
run;

data merge_more_stuff;
merge
merge_EVER4_TSB
Ptsb;
by date;
where date >='01jan1995'd and date <='31dec2008'd;
keep date TSB_cu_m_sec ptsb_ms
run;

proc means data = merge_more_stuff n mean stderr;
run;


ods _all_ close;
ods listing;

*proc export data=merge_more_stuff
outfile='C:\Users\Documents\A All Current Projects\
2016 USGS Manuscript\flow only\TSB EVER4 models\
redo 3 tsb from EVER4 only 2-4-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;

quit;
quit;


quit;
```

Output from above:

TSB model develop 1995-2008 POR out 5-31-2019 - Notepad

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```
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                                   The REG Procedure
                                     Model: MODEL1
                            Dependent Variable: TSB_cu_m_sec

                  Number of Observations Read                      5114
                  Number of Observations Used                      3740
                  Number of Observations with Missing Values       1374

                                  Analysis of Variance

                                           Sum of           Mean
         Source                   DF      Squares         Square    F Value    Pr > F

         Model                     1        34737          34737    6389.38    <.0001
         Error                  3738        20322        5.43673
         Corrected Total        3739        55060

                   Root MSE              2.33168    R-Square     0.6309
                   Dependent Mean        3.36058    Adj R-Sq     0.6308
                   Coeff Var            69.38321

                                  Parameter Estimates

                                 Parameter       Standard
            Variable       DF     Estimate          Error    t Value    Pr > |t|

            Intercept       1     -2.26274        0.08002     -28.28      <.0001
            EVER4_m_depth   1     38.95716        0.48737      79.93      <.0001
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                                  The MEANS Procedure

     Variable        Label                               N          Mean       Std Error
     ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
     date                                             5114    15340.50      20.6458228
     TSB_cu_m_sec                                     5114    2.5733304      0.0503565
     ptsb_ms         Predicted Value of TSB_cu_m_sec  3740    3.3605820      0.0498408
     ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

Selection of final SRS model for use in analyses:

R^2 value is the same for both the "full" and the truncated TSB models (r^2 = 0.63). The truncated model was selected, however, for consistency in comparison with the SRS model, with previous modeling work on south Florida's estuaries, and because, as stated above, water management adjustments in the 1990s suggest this time period more closely emulates the natural system.

Model developed from the output above sets flow as the dependent and water level as the independent variables; TSB flow is predicted by water depth at the EVER4 station. No multipliers were needed to simulate peak flows.

TSB flow (m^3 s^{-1}) = (-2.26) + (38.96 * EVER4 water depth (m))

Application of models to produce flow estimates circa 1900

Paleo-adjusted NSM mean flow estimates are derived by taking the equations developed above and applying the paleo-adjustments to the NSM bias-adjusted water levels at P33 station for SRS and at EVER4 station for TSB. By utilizing the paleo-adjusted water levels in the equations derived from modern flow we can estimate flow volumes around the beginning of the 20th century.

For both SRS and TSB two time periods within the NSM were analyzed:

1) The "full" period of overlap of the observed flow data (from South Florida Water Management District; https://www.sfwmd.gov/science-data/dbhydro) with the NSM 4.6.2 model (for SRS this is 10/10/1978 to 12/31/2000; for TSB this is 1/1/1965 to 12/31/2000).
2) A truncated period of overlap of the observed flow data with the NSM 4.6.2 model (for both TSB and SRS this is 1/1/1990 to 12/31/2000)

Paleo-adjusted NSM 4.6.2 flow SAS Runs for SRS

Steps in calculating SRS flow estimates:

1. Changes raw NSM water level data for P33 station to m
2. Applies bias-adjustment (in m) of 0.30 cm to NSM water level for P33
3. Applies the paleo-adjustment (in m) of 21.58 cm to the NSM bias adjusted water level data for P33
4. Restricts the dates (for "full" period of overlap = 10/10/1978 to 12/31/2000; for truncated period of overlap 1/1/1990 to 12/31/2000)
5. Cubes the bias-adjusted, paleo-adjusted NSM water level value for P33
6. Inserts the resulting values into the linear regression equation (derivation described in section above):
   SRS paleo-adjusted flow ($m^3\ s^{-1}$) = (-1.64) + (225.4 * (P33 paleo-adjusted water depth$(m)^3$))
7. Calculates summary statistics for the paleo-adjusted flow and the observed flow (presented in Text Table 5)

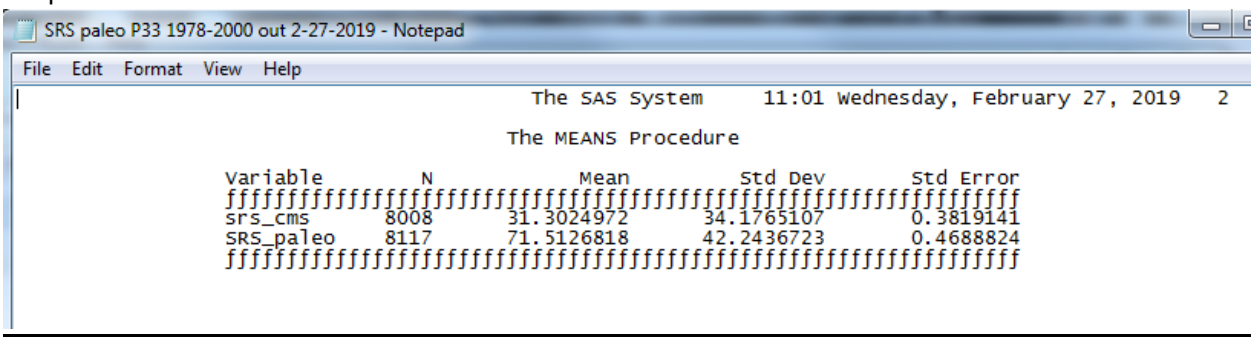
Paleo-adjusted SRS flow SAS code using “full” period of overlap (10/10/1978 to 12/31/2000):

SRS paleo P33 1978-2000 2-27-2019 - Notepad

File Edit Format View Help

```
*this is paleo;
*nsm_4_6_2 is feet of depth so this changes it to m;
data P33nsm_m; set mysaslib.nsm_4_6_2;
P33nsm_m = P33_nsm * .3048;
keep date P33nsm_m;
run;

*The text below is bias adjustment;
*bias adjustment = + 0.0030 m;
*output values are m depth;
data NSM_adjustbias_m; set P33nsm_m;
P33nsm_adjustbias_m=P33nsm_m +0.0030;
run;

*p33;
*this applies 2nd adjustment using difference between;
*paleo depth est and median bias-adj NSM water depth m;
*The P33  paleo adjustment is + 21.58 cm = 0.2158m;
data P33paleo_m_abvgrnd; set NSM_adjustbias_m;
P33paleo_m =  P33nsm_adjustbias_m + 0.2158;
where date >='12oct1978'd and date <='31dec2000'd;
keep date P33paleo_m;
run;

*Next step cubes bias-adj NSM paleo depth for the model equation;
data p33paleo_m_cubed; set p33paleo_m_abvgrnd;
p33paleo_m_cu=(P33paleo_m*P33paleo_m*P33paleo_m);
keep date P33paleo_m_cu;
run;

data  SRSpaleo_from_P33paleo_m; set p33paleo_m_cubed;
*This is model: SRS FLOW = -1.64 + 225.40(Stage at P33 cubed);
*The P33 water level value in the model development was cubed;
*Flow is dependent variable, water level at P33 is independent;
SRS_paleo = -1.64 + (225.4*P33paleo_m_cu);
keep date SRS_paleo;
run;

*SRS_obs is cfs - convert to cubic meters per sec - cms;
data SRS_cms; set mysaslib.Srs_updated_dec2016;
srs_cms = srs* 0.0283168;
keep date srs_cms;
run;

data merge_SRSpaleo_cms;
merge SRSpaleo_from_P33paleo_m
SRS_cms;
by date;
where date >='12oct1978'd and date <='31dec2000'd;
run;

proc means data=merge_SRSpaleo_cms N mean stddev stderr;
var srs_cms SRS_paleo;
run;

*proc export data=merge_P33paleo_SRS_cms
outfile='C:\Users\User\Dosqments\A All Current Projects\
2016 USGS Manuscript\new water level hydroperiod flow\
Flow Models\use this SRS model revised and runs\
rev SRS paleo run cms 6-27-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;
quit;
quit;
```

Output from above:


SRS paleo P33 1978-2000 out 2-27-2019 - Notepad

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The MEANS Procedure

Variable	N	Mean	Std Dev	Std Error
srs_cms	8008	31.3024972	34.1765107	0.3819141
SRS_paleo	8117	71.5126818	42.2436723	0.4688824

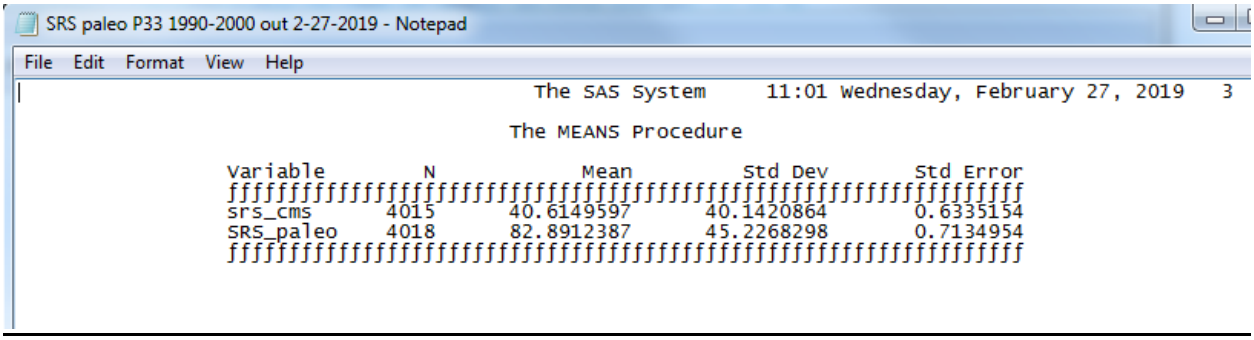
Paleo-adjusted SRS flow SAS code using truncated period of overlap (1/1/1990 to 12/31/2000):

SRS paleo P33 1990-2000 2-27-2019 - Notepad

File Edit Format View Help

```
*this is paleo;
*nsm_4_6_2 is feet of depth so this changes it to m;
data P33nsm_m; set mysaslib.nsm_4_6_2;
P33nsm_m = P33_nsm * .3048;
keep date P33nsm_m;
run;

*The text below is bias adjustment;
*bias adjustment = + 0.0030 m;
*output values are m depth;
data NSM_adjustbias_m; set P33nsm_m;
P33nsm_adjustbias_m=P33nsm_m +0.0030;
run;

*p33;
*this applies 2nd adjustment using difference between;
*paleo depth est and median bias-adj NSM water depth m;
*The P33  paleo adjustment is + 21.58 cm = 0.2158m;
data P33paleo_m_abvgrnd; set NSM_adjustbias_m;
P33paleo_m =  P33nsm_adjustbias_m + 0.2158;
where date >='01jan1990'd and date <='31dec2000'd;
keep date P33paleo_m;
run;

*Next step cubes bias-adj NSM paleo depth for the model equation;
data p33paleo_m_cubed; set p33paleo_m_abvgrnd;
p33paleo_m_cu=(P33paleo_m*P33paleo_m*P33paleo_m);
keep date P33paleo_m_cu;
run;

data  SRSpaleo_from_P33paleo_m; set p33paleo_m_cubed;
*This is model: SRS FLOW = -1.64 + 225.40(Stage at P33 cubed);
*The P33 water level value in the model development was cubed;
*Flow is dependent variable, water level at P33 is independent;
SRS_paleo = -1.64 + (225.4*P33paleo_m_cu);
keep date SRS_paleo;
run;

*SRS_obs is cfs - convert to cubic meters per sec - cms;
data SRS_cms; set mysaslib.Srs_updated_dec2016;
srs_cms = srs* 0.0283168;
keep date srs_cms;
run;

data merge_SRSpaleo_cms;
merge SRSpaleo_from_P33paleo_m
srs_cms;
by date;
where date >='01jan1990'd and date <='31dec2000'd;
run;

proc means data=merge_SRSpaleo_cms N mean stddev stderr;
var srs_cms SRS_paleo;
run;

*proc export data=merge_P33paleo_SRS_cms
outfile='C:\Users\User\Dosqments\A All Current Projects\
2016 USGS Manuscript\new water level hydroperiod flow\
Flow Models\use this SRS model revised and runs\
rev SRS paleo run cms 6-27-18.csv'
dbms=dlm
replace;
delimiter = ',' ;
run;
quit;
quit;
```

Output from above:


SRS paleo P33 1990-2000 out 2-27-2019 - Notepad

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The MEANS Procedure

Variable	N	Mean	Std Dev	Std Error
srs_cms	4015	40.6149597	40.1420864	0.6335154
SRS_paleo	4018	82.8912387	45.2268298	0.7134954

Paleo-adjusted NSM 4.6.2 flow SAS Runs for TSB

Steps in calculating TSB flow estimates:

1. Changes raw NSM water level data for EVER4 station to m
2. Applies bias-adjustment (in m) of -0.91 cm to NSM water level for EVER4
3. Applies the paleo-adjustment (in m) of 25.67 cm to the NSM bias adjusted water level data for EVER4
4. Inserts the resulting values into the linear regression equation (derivation described in section above):

   TSB paleo-adjusted flow ($m^3\ s^{-1}$) = (-2.26) + (38.96 * EVER4 paleo-adjusted water depth (m))

5. Restricts the dates (for "full" period of overlap = 1/1/1965 to 12/31/2000; for truncated period of overlap 1/1/1990 to 12/31/2000)
6. Calculates summary statistics for the paleo-adjusted flow and the observed flow (presented in Text Table 5)

Paleo-adjusted TSB flow SAS code using “full” period of overlap (1/1/1965 to 12/31/2000):

TSB paleo EVER4 1965-2000 2-27-2019 - Notepad

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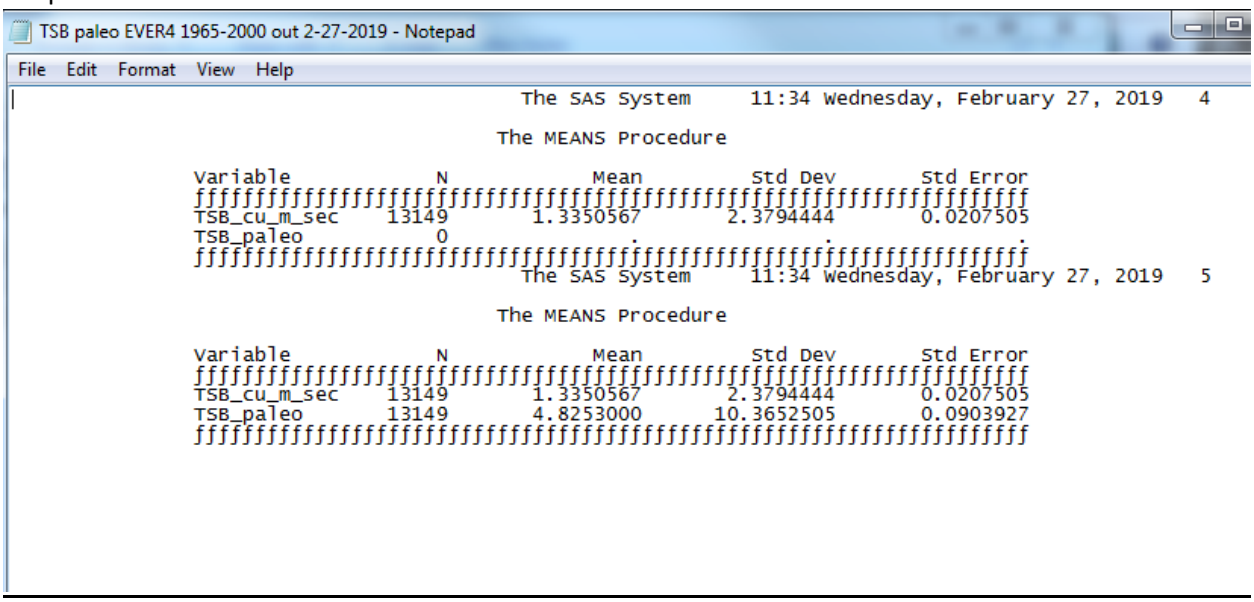
```
*nsm_4_6_2 is feet of depth so this changes it to m depth;
data EVER4nsm_m; set mysaslib.nsm_4_6_2;
EVER4nsm_m = EVER4_nsm * .3048;
keep date EVER4nsm_m;
run;

*The text below is bias adjustment;
*bias adjustment = - 0.0091 m;
*output values are m depth;
data EVER4nsm_adjustbias_m; set EVER4nsm_m;
Ever4nsm_adjustbias_m=Ever4nsm_m - 0.0091;
keep date Ever4nsm_adjustbias_m;
run;

*this adjustment creates the EVER4 freshwater paleo-based depth (m)
*by applying 2nd adjustment based on the sediment core analysis results and
*using the low estimate;
*The EVER4  adjustment is + 25.67 cm = 0.2567 m;
data EVER4paleo_depth_m; set EVER4nsm_adjustbias_m;
EVER4paleo_m =  EVER4nsm_adjustbias_m + 0.2567;
EVER4paleo_m_abvgrnd = EVER4paleo_m;
keep date EVER4paleo_m_abvgrnd;
run;

data TSB_paleo_cu_m_sec; set EVER4paleo_depth_m;
*This is model: TSB FLOw = -2.26 + 38.96(Stage at EVER4);
*Flow is dependent variable, water level at EVER4 is independent;
TSB_paleo = -2.26 + (38.96*EVER4paleo_m_abvgrnd);
where date >='01jan1965'd and date <='31dec2000'd;
keep date TSB_paleo;
run;

*TSB_obs is cfs - convert to cubic m per sec;
data TSB_cu_m_sec; set mysaslib.Tsb;
TSB_cu_m_sec = TSB*0.0283168;
where date >='01jan1965'd and date <='31dec2000'd;
keep date TSB_cu_m_sec;
run;

data merge_EVER4paleo_TSB;
merge TSB_cu_m_sec
TSB_paleo_cu_m_sec;
by date;
run;

proc means data=merge_EVER4paleo_TSB N mean stddev stderr;
var TSB_cu_m_sec TSB_paleo;
run;

quit;
quit;
```

Output from above:



TSB paleo EVER4 1965-2000 out 2-27-2019 - Notepad

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```
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                                  The MEANS Procedure

                Variable            N            Mean         Std Dev       Std Error
                ffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffff
                TSB_cu_m_sec    13149       1.3350567       2.3794444       0.0207505
                TSB_paleo           0                .               .               .
                ffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffff
                                    The SAS System     11:34 Wednesday, February 27, 2019   5

                                  The MEANS Procedure

                Variable            N            Mean         Std Dev       Std Error
                ffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffff
                TSB_cu_m_sec    13149       1.3350567       2.3794444       0.0207505
                TSB_paleo       13149       4.8253000      10.3652505       0.0903927
                ffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffff
```

Paleo-adjusted TSB flow SAS code using truncated period of overlap (1/1/1990 to 12/31/2000):

TSB paleo EVER4 1990-2000 2-27-2019 - Notepad

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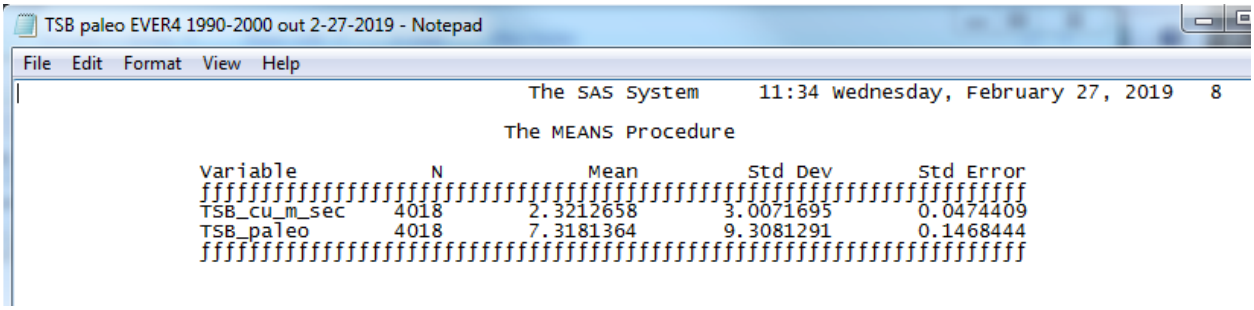
```
*nsm_4_6_2 is feet of depth so this changes it to m depth;
data EVER4nsm_m; set mysaslib.nsm_4_6_2;
EVER4nsm_m = EVER4_nsm * .3048;
keep date EVER4nsm_m;
run;

*The text below is bias adjustment;
*bias adjustment = - 0.0091 m;
*output values are m depth;
data EVER4nsm_adjustbias_m; set EVER4nsm_m;
Ever4nsm_adjustbias_m=Ever4nsm_m - 0.0091;
keep date Ever4nsm_adjustbias_m;
run;

*this adjustment creates the EVER4 freshwater paleo-based depth (m)
*by applying 2nd adjustment based on the sediment core analysis results and
*using the low estimate;
*The EVER4  adjustment is + 25.67 cm = 0.2567 m;
data EVER4paleo_depth_m; set EVER4nsm_adjustbias_m;
EVER4paleo_m =  EVER4nsm_adjustbias_m + 0.2567;
EVER4paleo_m_abvgrnd = EVER4paleo_m;
keep date EVER4paleo_m_abvgrnd;
run;

data TSB_paleo_cu_m_sec; set EVER4paleo_depth_m;
*This is model: TSB FLOW = -2.26 + 38.96(Stage at EVER4);
*Flow is dependent variable, water level at EVER4 is independent;
TSB_paleo = -2.26 + (38.96*EVER4paleo_m_abvgrnd);
where date >='01jan1990'd and date <='31dec2000'd;
keep date TSB_paleo;
run;

*TSB_obs is cfs - convert to cubic m per sec;
data TSB_cu_m_sec; set mysaslib.Tsb;
TSB_cu_m_sec = TSB*0.0283168;
where date >='01jan1990'd and date <='31dec2000'd;
keep date TSB_cu_m_sec;
run;

data merge_EVER4paleo_TSB;
merge TSB_cu_m_sec
TSB_paleo_cu_m_sec;
by date;
run;

proc means data=merge_EVER4paleo_TSB N mean stddev stderr;
var TSB_cu_m_sec TSB_paleo;
run;


quit;
quit;
```

Output from above:


TSB paleo EVER4 1990-2000 out 2-27-2019 - Notepad

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The MEANS Procedure

Variable	N	Mean	Std Dev	Std Error
TSB_cu_m_sec	4018	2.3212658	3.0071695	0.0474409
TSB_paleo	4018	7.3181364	9.3081291	0.1468444