

# Precipitation Processing

## Introduction

A sketch of the current *philosophy* of precipitation processing is as follows: Use two independent methods to determine annual totals; the first method uses the original GUI program and requires that any erroneous events or periods are corrected, then the same input to the GUI program is used in Automated Precipitation Correction Program (APCP). If the two annual totals are close enough then we believe that any anomalous events have been corrected (that the different methods have found the same errors and corrected them similarly). The GUI method would be a better overall record for precipitation but its full use is too time consuming so only an annual total is used; the APCP method is very easy but is *black-box* since it is not possible to see what it is doing. So the GUI is *ultimately better* but APCP is *much faster* so if the two provide the same annual total we gain confidence in the APCP results since it is corroborated by the GUI results. When all of the gages have been processed comparisons are made between shielded and unshielded gages and across sites to look for any anomalies.

## Preliminaries

Here is a detailed chronological presentation of the steps and methods used to process raw precipitation records to create reduced annual series. Some of these steps are collective and some will be done for each site. It should be clear when the step is to be done “for each”.

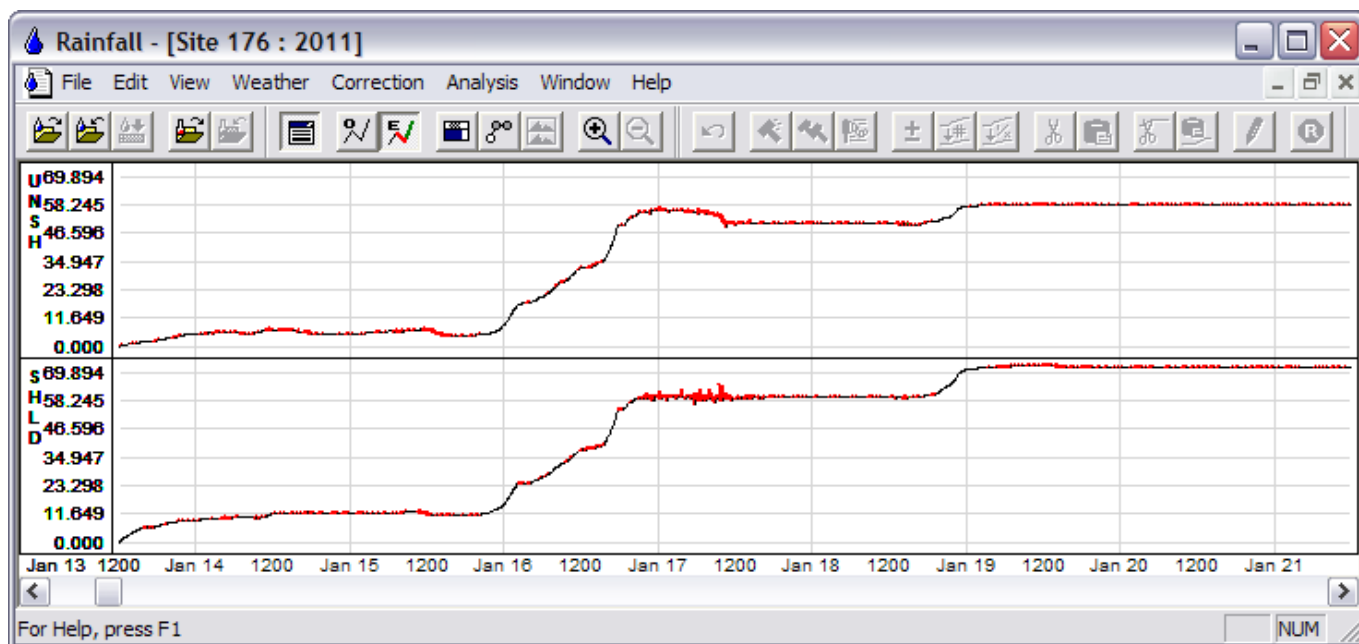
- Check to see if there was an event over the New Year. If one occurred you will need to edit several of the scripts to follow to include records past the end of year sufficient to capture the entire year-end event.
- Create a new \yyyy-totalmass\ folder in \database\precipitation\gui-rainfall-correction-program\
- Run \database\precipitation\sas-programs\processing\write-raw-rfp-input-files.sas. The script will need minor edits for year and period to write if there was a year end event. Check at the bottom of the script to see what suite of sites to write. The files will be named for the site and year as *site.year.rfp*. Currently using 5 minute step input although most 1997–2006 processing was done using a 15 minute step input.

```
/* 5-minute (300 seconds) or 15-min steps (900 seconds) */
%let step=300;

%include sascode(set-filename-suffixes);
%macro writeRFP(site,year);
%let outpath=C:\database\precipitation\processing-steps\raw-input-2-apcp\;
%*let outpath=c:\database\precipitation\gui-rainfall-correction-
program\2011-totalmass\;
%directoryExists(&outpath);
```

- Open site's .rfp file written above using the GUI based reduction program rainfall.exe. The goal here is to carefully examine the record to look for any signal that is not precipitation or normal noise that will be corrected by APCP. Scroll through the record and correct using the GUI tools anything that appears anomalous; note the reason and period for any corrections that are not

obvious like bucket recharges or site calibrations.



- Look for any gaps in the record that may need to be filled in. These periods will appear as grey lines in the GUI program. There is also the script check-for-gaps.sas that may be helpful.
- review field notes for any guidance in necessary corrections to precipitation signal
- Take notes of any periods that need to be corrected. Any corrections in the record made in the GUI program that are not likely to be automatically detected and corrected in APCP will have to be applied to the raw data when writing input files to APCP. I cannot stress this enough; if a period is flattened using the GUI tool then it also needs to be modified some way in write-raw-rfp-files.sas before sending to APCP. Most of the hard to find discrepancies were when I failed to do this - once done then the two matched much, much better. Even though it appears that APCP has taken care of the period removed in the GUI program, there being no precipitation for that period, APCP distributes errors throughout other periods so need to really squash the periods that one wants to remove. Each year presents it own challenges but here is an [example of the correction notes](#) that were done in 2011.
- Deal with any extra-special weirdness like [those at Reynolds Mountain Snow Pillow & Ridge raingages](#).
- When the corrections are completed in the GUI program select the entire year (right click the mouse and drag from the beginning to the end of the year) and record the GUI totals in \database\precipitation\metadata & documentation\processing\gui-total-mass-comparisons.xls.
- Make the needed modifications to the raw records using code added to \database\precipitation\sas-programs\processing\write-raw-rfp-input-files.sas and re-write .rfp files but this time direct the output files to \database\precipitation\processing-steps\raw-input-2-apcp. Here are some examples of modifications to the record. In some cases if the repairs are extensive enough an entire stand-alone script may be called for.
- Missing data is not an option in either the GUI correction program or APCP so the modifications need to create some value from another value.

```
if "&site"='138l21' & '28jul2010:08:20'dt<=datetime<='28jul2010:21:00'dt
then ppts=pptu*1.05;
if "&site"='138l21' & datetime>='28jul2010:08:20'dt & &year=2010 then
ppts=ppts+50;
```

```

if "&site"='147' & datetime>='5dec2010:08:55'dt & &year=2010 then do;
  ppts=ppts+50;
  pptu=pptu+50;
end;

/* shielded gages outer casing bolts had come loose */
if "&site"='166b' & '26aug2010:00:0'dt<=datetime<='2sep2010:23:55'dt then
ppts=pptu+50;
if "&site"='166b' & '25oct2010:00:0'dt<=datetime<='27oct2010:23:55'dt then
ppts=pptu*1.08+50;
if "&site"='166b' & '15nov2010:00:0'dt<=datetime<='16nov2010:23:55'dt then
ppts=pptu*1.06+50;
if "&site"='166b' & '18nov2010:00:0'dt<=datetime<='30nov2010:23:55'dt then
ppts=pptu*1.06+50;
if "&site"='166b' & '1dec010:00:0'dt<=datetime<='31dec2010:23:55'dt then
ppts=pptu*1.14+100;

```

## Running APCP

- Automated Precipitation Correction Program [precipcorrection.exe latest version dated 2008-03-04 12:22 PM] is run for each site-year using the default parameters for bucket decanting and recharge limits, noise limits and daily trace limits. A fixed hourly output time step is used. Output files are written to database\precipitation\processing-steps\from-apcp\.

**Precipitation Correction**

Year  Input File

Site Name  Output File

**Bucket Decanting Limits**

Shielded Gauge	Unshielded Gauge
6.25	6.25

**Bucket Recharge Limits**

Shielded Gauge	Unshielded Gauge
25.0	25.0

**Noise Limits**

Shielded Gauge	Unshielded Gauge
2.5	2.5

**Out of Range Value**

**Daily Trace Limit**

Minimum Daily Precipitation

**Reference Gauge**

☒ Shielded ☐ Unshielded

**Output File Time Interval**

☒ Same as Input File ☐ Fixed Interval (min)

- The resulting .rfc output is a running cumulative precipitation so the last record is the total annual precipitation. Record this value in \database\precipitation\metadata & documentation\processing\gui-total-mass-comparisons.xls. If you get strange results from APCP check that there aren't any blank lines at end of yearly files and that the input start with an even increment of the interpolation step, to get hourly output the input file must start on a whole hour.
- If the percent error  $[100 * (\text{abs}(y-x) / \text{abs}(x))]$  is less 2% then you are done; if it's between 2%-5%

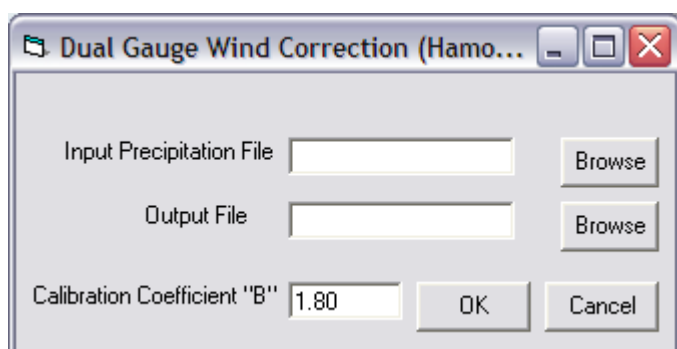
you may or not be able to find the discrepancy so best come back to this later; over 5% you should be able to find the discrepancy and correct it as needed. Since the comparison is between the GUI annual total and the APCP annual total it is possible that one or the other may be the source of the discrepancy.

```
absolute error == abs(y-x)
relative error == abs(y-x)/(abs(x)+abs(y))/2
percent error == 100*(abs(y-x)/abs(x))
```

- Run diagnostic scripts like \database\precipitation\sas-programs\xplore\xplore-apcp-corrected.sas or compare-2-rfc-files.sas to look for the periods that have noticeable differences between the GUI and APCP results. Significant differences between shielded and unshielded gage totals may also indicate where to look to resolve discrepancies.
- It's time to iterate. Rerun any and all of the steps above steps until the percent error between the GUI and APCP results is reduced as much as possible. It may also be necessary to modify APCP limits and settings. If these are changed then make note of the values used for APCP in gui-total-mass-comparisons.xls.
- It may also be helpful to compare daily totals across all sites.
- When finished make sure all of the final .rfc files are written to database\precipitation\processing-steps\from-apcp\.

## Wind Correction

- Run wind correction program [windcorrection.exe 2008-03-04 1:03 PM] for each dual gage site using the .rfc files from APCP as inputs.



## Updating SAS database

The steps outlined below re-read all processed data files; since the reads are fast enough it is more methodical and safer to just start over each time. If you are certain that nothing has changed with the historical breakpoint records (pre 1996 records) then you can start at step 6 below. When processing sites as additional errors may be detected it is possible in some of these programs to just run a single site. 'Write' is used when both creating SAS datasets and when writing ASCII files.

Creating the corrected precipitation records:

1. sas-programs/processing/read-corrected-precipitation-thru-1996.sas writes  
/database/precipitation/sas-datafiles/scratch bkpt96\_&site\_precipitation

2. breakpoint-2-hourly/write-bkpt-precip-inputs.sas
3. execute breakpoint-2-hourly/bkpt\_TMP.bat
4. breakpoint-2-hourly/read-BptPrec-output.sas *writes* /database/precipitation/sas-datafiles/scratch/hr1996\_&site\_precipitation [move breakpoint-2-hourly ascii files to /saved-input & saved-output]
5. sas-programs/processing/read-year-end-patches.sas *writes* /database/precipitation/sas-datafiles/scratch/yearend\_&site\_precipitation
6. sas-programs/processing/**read-wind-corrected-results.sas** *writes* /database/precipitation/sas-datafiles/scratch/wind\_&site\_precipitation
7. sas-programs/processing/**read-apcp-results.sas** *writes* /database/precipitation/sas-datafiles/scratch/apcp\_&site\_precipitation
8. sas-programs/processing/**merge-all-parts.sas** *writes* /database/precipitation/sas-datafiles/hourly\_&site\_precipitation
9. sas-programs/processing/**repair-year-end-events.sas** *corrects* hourly files with missing first hour for year end events (*only used for the 2003-2004 event; later year-end events are handled during processing*)
10. sas-programs/processing/**set-gaps-missing.sas** *corrects* /database/precipitation/sas-datafiles/hourly\_&site\_precipitation with enforced missing periods when gages were inactive
11. sas-programs/processing/**set-precipitation-daily-etc-summaries.sas** *writes* /database/precipitation/sas-datafiles/corrected-csv-format/[daily\_, \_monthly & \_annual]

Run export-daily-totals.sas and review results to look for additional needed corrections.

Writing the corrected datasets to ASCII formats:

1. sas-programs/**write-precipitation-hourly.sas** writes generic ASCII hourly datafiles to /corrected-data; **run hourly, daily, monthly, annual, and water-year scripts**; unless otherwise indicated these will be the primary source for shared precipitation datafiles and will be posted to the public FTP site and shared with cooperators.
2. run sas-programs/wiki-specific/**zipper.sas** to create zipped formats for hourly files
3. run sas-programs/**update-sites-folders.sas** to, well, update the /sites folders

For a simple annual update start with step 6. Any gaps set missing in set-gaps-missing have to be propagated into write-precipitation-daily-etc-summaries.

## Site Example

- 057.dat - raw, telemetered data → read by read057.sas → which writes q057precip.sas7bdat
- write-raw-ftp-input-files.sas → writes 057.2012.rfp → which is opened in rainfall.exe (GUI program) → actionable correction periods are identified → return to start of step and edit write-raw-ftp-input-files.sas or create independent correction scripts if actions needed are extensive enough to warrant
- calculate annual total using rainfall.exe and precipcorrection.exe → compare annual totals and daily and hourly values if needed → return to prior steps of totals are too different → write final 057.2012.rfc
- run windcorrection.exe using 057.2012.rfc as input to create 057.2012.rfw as output
- run read-wind-corrected-results.sas → writes pscratch.wind\_057\_precipitation (will be combined with any repair datafiles or year end patches)
- merge-all-parts.sas → writes precip.hourly\_057\_precipitation
- write-precipitation-public-datafiles.sas → writes hourly-057-precipitation.csv

- write-precipitation-daily-etc-summaries.sas → writes precip.annual\_057\_precipitation, precip.monthly\_057\_precipitation and precip.daily\_057\_precipitation

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