PROCEDURE FOR ASSIGNING A VALUE FOR TRACE PRECIPITATION DATA WITHOUT CHANGING THE CLIMATIC HISTORY

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Abstract

Trace is the amount of precipitation that is less than 0.005" (AMS, 1959). Generally, it is not a measurable amount but just enough to wet the rain gauge that it is observed in. It is a global practice that "T" (indicating "Trace") is entered in daily precipitation records such as the National Weather Service form B-91 under the precipitation column. Although trace is not a quantitative value, it is valuable information to better assess the weather condition of the day. However, when the precipitation data are tabulated, most spreadsheet programs do not know how to deal with a character that is not a numerical value. We explain a procedure for including trace observations when evaluating precipitation behavior over a period of time or between multiple time periods. This procedure temporarily assigns a computationally insignificant value to trace observations in order to incorporate those observations into database calculations (e.g. number of precipitation days) as well as also greatly reduce the chance of ties in the precipitation rankings. Our procedure allowed us to separate individual precipitation events in perspective especially in ranking tables without changing accumulated monthly, seasonal or annual precipitation values, thus preserving the climate history of the location.

Background

There are many documented ties (data with identical magnitude) in the climatological records simply because of limited resolution in either measurements or recording of data in the historical records. This limitation makes ranking different periods (e.g., months, seasons, years, etc.) challenging. In temperature, this challenge can be removed by carrying all the decimal numbers into the next set of calculations, then truncating to the nearest acceptable resolution. In precipitation, the challenge is exacerbated by the occurrence of trace precipitation amounts (noted by a "T"). The reason trace precipitation in the data is problematic is twofold:

1. "T" is not a numeric value, precluding the direct calculation of monthly, seasonal and annual precipitation data.

2. Non-numerical values such as “T” do not automatically register in queries such as least snow or rain in a month at a given location. Instead, such queries may return several months for which the numeric precipitation quantities were tied, regardless of number of potentially tie-breaking trace precipitation observations in those periods.

We created a methodology in which we assigned a numerical value to “T” in our database that was small enough to avoid changing the total amount of precipitation observed for a respective day, month or year. By doing so, we gain more precision and reduce ties in climatological rankings of precipitation.

The climatic tie-breakers sub-committee made up of the authors of this paper is formed within the National Data Stewardship Team to identify issues that specifically exist in precipitation measurements. In the U.S., precipitation observations are recorded to the nearest 0.01”. If precipitation is observed but the amount falling into the gauge is less than half of the first graduated mark (0.01”), “T” or Trace is recorded for the precipitation quantity. However, monthly and annual precipitation totals are calculated by adding only daily precipitation amounts of 0.01” or greater for the respective period. Similarly, rankings such as months with most/least precipitation or greatest/fewest number of days with precipitation are calculated based on measurable precipitation, ignoring the number of traces in the respective time period. While this does not necessarily lead to inaccuracy in the aggregated total precipitation amounts, it often causes ties between months and/or years, especially for locations with a long climatological history (e.g. 100 years or longer). Those ties could be separated from each other if number of traces is evaluated properly (i.e. counted without altering total precipitation amounts). Logically, a trace of precipitation is a greater quantity than no precipitation. Thus when considered in the context of two periods with the same total measurable precipitation but one having an additional trace while the other does not, the period containing a trace has experienced the greater overall amount of precipitation. However, our goal is not to create an estimated value for a trace observation, which may vary between a single drop and 0.049 inch; rather it is to provide a consistent yet computationally insignificant amount to permit computer algorithms to appropriately utilize the observation. For example, a record-setting span of continuous rain days may go unrecognized if a day with trace precipitation were interpreted as a rain free day (i.e. zero accumulation). Assigning a temporary yet negligible non-zero value to the trace day would enable the processing system to recognize that day as having had some precipitation.

Furthermore, although all precipitation observations are subject to resolution limitations (e.g. 0.073 inch of rain may have fallen, but it is rounded to 0.07 in the observation), we assume that an equivalent number of observations are rounded up to the next hundredth of an inch as are rounded down, resulting in a zero net error over the period of record. Traces are more critical in that they represent a non-zero amount of fallen precipitation that is simply not enough to exceed the minimum sampling resolution. Their omission from calculations unnecessarily introduces bias into the results.

We developed a proper tie-breaker procedure:

1. to minimize climatic ties,
2. to properly identify an extreme precipitation event in a dataset where the record event may seem to be hidden among the other events sharing the same magnitude before the traces are properly evaluated, and
3. to ensure a consistent and objective approach to the inclusion of trace observations in precipitation related calculations.

One good example is the March 2010 extreme snowless event in Fargo, ND. Based on official data in the Applied Climate Information System (ACIS) (ACIS, 2011), March 2010 is one of 3 snowless Marches in history, tying the record with 1905 and 1961 (Table 1). However, a close look at all March months shows that there were 2, 6 and 10 days with a trace amount of snow that fell in 2010, 1905 and 1961, respectively (Table 2). As an effective climate service provider such as a climate focal point of the corresponding local weather service office or a state climatologist testifying the record to a local media, one will have to recognize that 2010 was indeed the March that had the least snow in the history of the location. But if the climate service provider did not manually look at the individual daily weather records, he/she would have concluded that March 2010 tied the record with 1905 and 1961 based on the official data even though the true record goes to March 2010 based on least number of days with a trace amount of snowfall.

Table 1. Extreme Lowest Monthly Total Snowfall Ranking for March in Fargo, ND (Records from 1881 through 2011 from ACIS)

Rank	*Value (in)*	*Year*
1	0.0	2010, 1961, 1905
4	0.1	1910

Table 2. Original Daily Precipitation Data for Fargo, ND in March 2010, March 1961 and March 1905

March 2010			March 1905			March 1961		
Day	*Pcpn*	*Snow*	*Day*	*Pcpn*	*Snow*	*Day*	*Pcpn*	*Snow*
1	0	0	1	0	0	1	T	0
2	0	0	2	0	0	2	0.01	0
3	0	0	3	0	0	3	0	0
4	0	0	4	0	0	4	T	T
5	0	0	5	0	0	5	T	T
6	0.03	0	6	T	T	6	0	0
7	0	0	7	T	T	7	0	0
8	0.01	0	8	0.02	0	8	T	T
9	0.04	0	9	T	T	9	0	0
10	0.65	0	10	T	T	10	0	0
11	0.51	0	11	0	0	11	0	0
12	0.07	0	12	0	0	12	0	0
13	0	0	13	0	0	13	0	0
14	0.02	0	14	0	0	14	0	0
15	0.08	0	15	T	0	15	0	0
16	0	0	16	0	0	16	0	0
17	0	0	17	0.04	0	17	T	0
18	0	0	18	0.04	0	18	0	0
19	T	T	19	0	0	19	0	0
20	0	0	20	0.02	T	20	0	0
21	0	0	21	T	T	21	0.01	T
22	0	0	22	0.06	0	22	T	T
23	0	0	23	T	0	23	0	0
24	T	0	24	T	0	24	0	0
25	0	0	25	0	0	25	0.02	0
26	0	0	26	0	0	26	0.34	T
27	T	T	27	0.3	0	27	T	T
28	0	0	28	0.02	0	28	T	T
29	0	0	29	0	0	29	T	T
30	0	0	30	0	0	30	0	0
31	0	0	31	0	0	31	T	T
Sum	**1.41**	**0**	**Sum**	**0.50**	**0**	**Sum**	**0.38**	**0**

Procedure of Replacing "T" with a Numerical Value without Changing Total Daily, Monthly and Annual Precipitation Totals

We recommend the following procedure so that your digital database would automatically rank precipitation events by taking into consideration "Trace" amounts in all precipitation events. The procedure does not change the precipitation amount in daily, monthly or even annual values when totaled.

Let "T" or trace have a dummy value that would only exist in resolution which would not appear in the 100^{th} of an inch. Since we only see the precipitation amounts in 0.01" increments, it would not change the total precipitation amount. It would however give the digital database enough precision to rank it properly. Annual accumulation of precipitation is the longest period we accumulate the precipitation data. Therefore, the designation of a value for T takes into an account that even if a location had 365 trace days, the magnitude of the accumulated trace precipitation would not change the annual total precipitation amount at the 100^{th} of an inch resolution.

There are 365 possible number of "T" days per year. In a worst case scenario, a location can have 365 Ts. Therefore we made sure that 365 stays to the right of 0.01. This way:

1. The computer would round the excess resolution to true precipitation amount.
2. Users would not even see the excess resolution, as it is there just for the processors to take into consideration (automation of manual interpretation).
3. When the records are ranked, it would return to fewer ties.
4. True records stand separate from false ties.

In Table 3 below we assigned 0.00001" ($1*10^{-5}$) to "T" in the same example given in Table 2. The summation is calculated by first substituting the non-numerical "T"s with their assigned numerical value (0.00001). Once the tied months were correctly ranked, the "T"s were reinstated to the data set to preserve the original information. Table 3 shows the precipitation amounts in full resolution without truncating any decimal points. The difference is in the 5^{th} digit after the decimal where trace events occurred. Since it is a global practice that we show the precipitation data to the nearest 100^{th} of an inch, we repopulated the table based on common practice and displayed the data to the nearest 100^{th} of an inch on Table 4. Note that the accumulated amounts are exactly the same as the original data on Table 2.

Conclusion

Using Table 4 gives us great advantage over the original data. It enables better ranking, taking into consideration number of "T" occurrences. It does not however change the absolute value of precipitation in the resolution that we use. The readers have to keep in mind that the authors are not suggesting any permanent changes to observed data. It is merely a way to allow a computer program to temporarily handle these non-numeric characters in a way that would allow multiple tied precipitation values to be ranked more appropriately. If ACIS, for example adopted our procedure, the ranking in Table 1 would have indicated that March 2010 for Fargo was in fact the most snowless March in the recorded history without requiring further analysis of the daily climate data. Table 5 is the comparison between the current ranking (the ranking that does not take into account for number of traces) and modified ranking as if the ACIS applied our procedure to take into account for the number of traces. We believe that Table 4 has an advantage and has more value to a user. Furthermore, it better reflects the true magnitude and duration of extreme events that took place historically. We understand that the procedure has some complexity in modifying the database. For example, user may want to see "T" in the database instead of 0.00001. However, ACIS system may be programmed to retain the "T" for display but treat it as a numerical value of 0.00001 for calculation purposes. Personal communication with Keith Eggleston (Eggleston, 2012), ACIS programmer, North Eastern Regional Climate Center, confirmed that this procedure is not only possible for implementation, but also useful in raking of precipitation, and also be useful in other products such as proper identification of number of days with precipitation greater than zero for a given period.

Our procedure is also applicable to observations that are recorded in metric (millimeters) by simply assigning "T" the same value of 0.00001mm. We believe that the gained advantage of the procedure is sizable and has great potential application in climate summary reports of a given location. Therefore, we recommend the adaptation of the procedure as standard in climate application. However, use of the procedure should be limited to aggregation periods having fewer than 500 trace values (e.g. this method may not be appropriate for comparing two decades of daily data), as a summation of 500 or more would add at least 0.005 inch (mm) to the period's total precipitation, potentially rounding it up by a hundredth of an inch (mm). For comparing periods of over 500 observations apiece, an appropriately smaller substitute value should be used.

Table 3. Modified Daily Precipitation Data for Fargo, ND in March 2010, March 1961 and March 1905 (Showing the Full Precision)

March 2010			March 1905			March 1961		
Day	*Pcpn*	*Snow*	*Day*	*Pcpn*	*Snow*	*Day*	*Pcpn*	*Snow*
1	0	0	1	0	0	1	0.00001	0
2	0	0	2	0	0	2	0.01	0
3	0	0	3	0	0	3	0	0
4	0	0	4	0	0	4	0.00001	0.00001
5	0	0	5	0	0	5	0.00001	0.00001
6	0.03	0	6	0.00001	0.00001	6	0	0
7	0	0	7	0.00001	0.00001	7	0	0
8	0.01	0	8	0.02	0	8	0.00001	0.00001
9	0.04	0	9	0.00001	0.00001	9	0	0
10	0.65	0	10	0.00001	0.00001	10	0	0
11	0.51	0	11	0	0	11	0	0
12	0.07	0	12	0	0	12	0	0
13	0	0	13	0	0	13	0	0
14	0.02	0	14	0	0	14	0	0
15	0.08	0	15	0.00001	0	15	0	0
16	0	0	16	0	0	16	0	0
17	0	0	17	0.04	0	17	0.00001	0
18	0	0	18	0.04	0	18	0	0
19	0.00001	0.00001	19	0	0	19	0	0
20	0	0	20	0.02	0.00001	20	0	0
21	0	0	21	0.00001	0.00001	21	0.01	0.00001
22	0	0	22	0.06	0	22	0.00001	0.00001
23	0	0	23	0.00001	0	23	0	0
24	0.00001	0	24	0.00001	0	24	0	0
25	0	0	25	0	0	25	0.02	0
26	0	0	26	0	0	26	0.34	0.00001
27	0.00001	0.00001	27	0.3	0	27	0.00001	0.00001
28	0	0	28	0.02	0	28	0.00001	0.00001
29	0	0	29	0	0	29	0.00001	0.00001
30	0	0	30	0	0	30	0	0
31	0	0	31	0	0	31	0.00001	0.00001
Sum	**1.41003**	**0.00002**	**Sum**	**0.50008**	**0.00006**	**Sum**	**0.3801**	**0.0001**

Table 4. Modified Daily Precipitation Data for Fargo, ND in March 2010, March 1961 and March 1905 (Showing only the Required Precision)

March 2010			March 1905			March 1961		
Day	*Pcpn*	*Snow*	*Day*	*Pcpn*	*Snow*	*Day*	*Pcpn*	*Snow*
1	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
2	0.00	0.00	2.00	0.00	0.00	2.00	0.01	0.00
3	0.00	0.00	3.00	0.00	0.00	3.00	0.00	0.00
4	0.00	0.00	4.00	0.00	0.00	4.00	0.00	0.00
5	0.00	0.00	5.00	0.00	0.00	5.00	0.00	0.00
6	0.03	0.00	6.00	0.00	0.00	6.00	0.00	0.00
7	0.00	0.00	7.00	0.00	0.00	7.00	0.00	0.00
8	0.01	0.00	8.00	0.02	0.00	8.00	0.00	0.00
9	0.04	0.00	9.00	0.00	0.00	9.00	0.00	0.00
10	0.65	0.00	10.00	0.00	0.00	10.00	0.00	0.00
11	0.51	0.00	11.00	0.00	0.00	11.00	0.00	0.00
12	0.07	0.00	12.00	0.00	0.00	12.00	0.00	0.00
13	0.00	0.00	13.00	0.00	0.00	13.00	0.00	0.00
14	0.02	0.00	14.00	0.00	0.00	14.00	0.00	0.00
15	0.08	0.00	15.00	0.00	0.00	15.00	0.00	0.00
16	0.00	0.00	16.00	0.00	0.00	16.00	0.00	0.00
17	0.00	0.00	17.00	0.04	0.00	17.00	0.00	0.00
18	0.00	0.00	18.00	0.04	0.00	18.00	0.00	0.00
19	0.00	0.00	19.00	0.00	0.00	19.00	0.00	0.00
20	0.00	0.00	20.00	0.02	0.00	20.00	0.00	0.00
21	0.00	0.00	21.00	0.00	0.00	21.00	0.01	0.00
22	0.00	0.00	22.00	0.06	0.00	22.00	0.00	0.00
23	0.00	0.00	23.00	0.00	0.00	23.00	0.00	0.00
24	0.00	0.00	24.00	0.00	0.00	24.00	0.00	0.00
25	0.00	0.00	25.00	0.00	0.00	25.00	0.02	0.00
26	0.00	0.00	26.00	0.00	0.00	26.00	0.34	0.00
27	0.00	0.00	27.00	0.30	0.00	27.00	0.00	0.00
28	0.00	0.00	28.00	0.02	0.00	28.00	0.00	0.00
29	0.00	0.00	29.00	0.00	0.00	29.00	0.00	0.00
30	0.00	0.00	30.00	0.00	0.00	30.00	0.00	0.00
31	0.00	0.00	31.00	0.00	0.00	31.00	0.00	0.00
Sum	**1.41**	**0.00**	**Sum**	**0.50**	**0.00**	**Sum**	**0.38**	**0.00**

Table 5. Original and Modified Extreme Lowest Monthly Total Snowfall Ranking for March in Fargo, ND (Records from 1881 through 2011)

Original ACIS Ranking		
Rank	Value (in)	Year
1	0.0	2010, 1961, 1905
4	0.1	1910

Modified Ranking*		
Rank	Value (in)	Year
1	0.0	2010
2	0.0	1905
3	0.0	1961
4	0.1	1910

*The modified ranking takes into account for number of trace-days in individual years with two trace-days in 2010, six trace-days in 1905, and 10 trace-days in 1910.

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