National Data Stewardship Team Rounding Advice

Three major types of rounding have been used for climate data analysis and product development in recent years: “round half up asymmetric” or “round up”, “round half up symmetric” or “round away from zero”, and “round half even” or “banker’s rounding”.

WMO and NWS currently require “round half up asymmetric” for most METAR fields, but historically many other approaches have been commonly used by NCDC or NWS and their predecessors. NDST recommends “round half up asymmetric”.

Three choices past the initial rounding method decision that will impact the outcome of climate analyses and product development in combination with rounding: precision, computational algorithms, and computational environment.

Binary floating point environments can lead to a variety of results when rounding due to small residuals left by the approximation. The combination of computer, operating system, and computer language/program can produce subtle difference in results. Where possible, Base 10 math (BigDecimal class in Java, for example) should be used, and binary floating point avoided if feasible.

If the program is rounding up, but some results are inconsistent, the addition of a very small number that is not significant climatically (e.g., 10-7) could resolve a binary floating point problem, as long as the number of values or calculations involved would not lead to the small number become significant.

A dataset specifically designed to test the function of rounding in any computational environment should be rounded in the programming language intended for use to identify the type and sensitivity of rounding being used.

SPECIFIC STRATEGIES:

NDST suggests that the “round half up asymmetric” or “round up” method be adopted for use in analyzing temperature and precipitation data and in constructing temperature and precipitation products.

Do not round intermediate data states or calculation results, round only at the end of the calculation for final presentation of the result.

If unit conversion is required prior to the end result, apply the rule above, and do not round the data following unit conversions taking place before the final result.

If unit conversion takes place prior to storage of data, sufficient precision must be stored so that if these data are returned to their native units, the value remains the same as observed.

When employing the “round up” method, it is necessary to carry an additional decimal place of precision beyond conventional significant digits in order to minimize any positive bias caused by this rounding.

Temperatures used in calculating departures from normal, degree days, monthly means, etc., should carry one decimal place in final form, and should not be rounded at all prior to the last step in a calculation
Daily Mean = (MaxT + MinT)/2 = XX.0 or XX.5 for any stations observing in integers
Daily Mean = (MaxT.x + MinT.x)/2 = XX.xxx … (no rounding of intermediate value)
For final form, round Daily Mean to one place: XX.x

Rounding degree days to whole numbers, while a practice of great tradition, is not necessary in the current age of computer processing.
Daily DD = Daily Mean.x – Base = XX.0 or XX.5, or 0 if Daily Mean < Base for cooling and growing DD, and
Daily DD = Base – Daily Mean.x = XX.0 or XX.5, or 0 if Daily Mean > Base for heating and chilling DD

Monthly Temperature Averages - Ideally, though, it would be better to go back to the original daily maximum and minimum observations and perform the calculations without rounding at intermediate steps, and this is the recommendation here for cases when the original daily maximum and minimum data are available.

Monthly MaxT = ∑Daily MaxT/# of Days = XX.xxx… (no rounding of intermediate value)
Monthly MinT = ∑Daily MinT/# of Days = XX.xxx… (no rounding of intermediate value)
Monthly MeanT = (Monthly MaxT.xxx… + Monthly MinT.xxx…)/2 = XX.x
For final form, also round Monthly MaxT and MinT to one place: XX.x

Multi-month averages, such as seasonal, annual, or long term averages, should also avoid rounding intermediate values before completing a final average calculation:

Seasonal MeanT = (Seasonal MaxT.xxx… + Seasonal MinT.xxx…)/2 = XX.x
Annual MeanT = (Annual MaxT.xxx… + Annual MinT.xxx…)/2 = XX.x
For final form, also round Seasonal or Annual MaxT and MinT to one place: XX.x

Any degree day summation is improved in accuracy by carrying an extra decimal place, as was demonstrated earlier. The final result can be left as a decimal, or rounded up to the nearest integer if required.
Monthly DD = ∑Daily DD.x = XX.x