Georeferencing Calculator Manual

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Cover image

Western bobcat (*Lynx rufus* subsp. *fasciatus*), Sonoma County, California, United States. Photo 2019 Sonoma Ecology Center–Research Department via iNaturalist research-grade observations, licensed under CC BY-NC 4.0.

1. Introduction

The Georeferencing Calculator (Wieczorek & Wieczorek 2020) described in this document is a tool created to aid in the georeferencing of descriptive localities such as those found in museum-based natural history collections. It was originally designed for the Mammal Networked Information System (MaNIS) and has been widely adopted in other large-scale collaborative georeferencing projects to supplement semi-automated georeferencing tools. The application makes calculations using the theory given in Georeferencing Best Practices (Chapman & Wieczorek 2020), derived from the earlier MaNIS/HerpNET/ORNIS Georeferencing Guidelines (Wieczorek 2001), and The point-radius method for georeferencing locality descriptions and calculating associated uncertainty

(Wieczorek et al. 2004). Specific methods for calculating a wide variety of examples of the distinct locality types are given in Georeferencing Quick Reference Guide (Zermoglio et al. 2020).

Underlined terms throughout this document (e.g. accuracy) link to definitions in the Glossary (the same glossary of terms used in Georeferencing Best Practices, while terms in italics (e.g. *Input Latitude*) refer to fields and/or labels in the Calculator. Darwin Core terms are displayed in monospace (e.g. `georeferenceRemarks`) in all GBIF digital documentation and link to the definitions maintained by Biodiversity Information Standards (TDWG) in the approved List of Darwin Core terms.

2. Running the Calculator

The Georeferencing Calculator uses JavaScript and runs in a browser. The latest version can be initiated here, or it can be downloaded in a .zip or .tar.gz archive from the releases page of the Calculator GitHub repository, unzipped to a convenient location and run in a browser by opening the file gc.html. Problems encountered with the Calculator should be entered as issues in the GitHub repository issue tracker and should include the version identifier, which can be found in the lower right-hand corner of the Calculator (see Figure 1). When the Calculator is opened it should appear as shown in Figure 1.

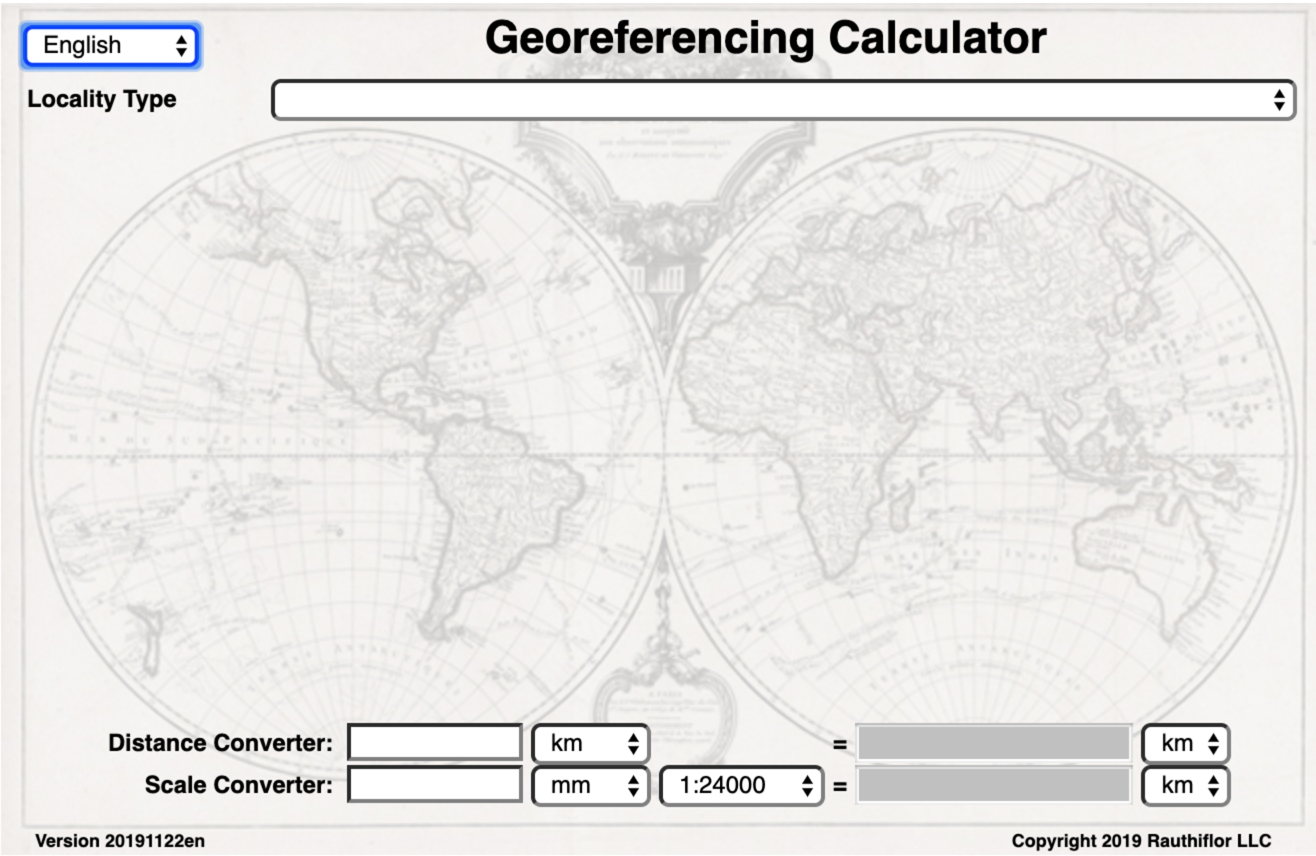

Figure 1. Screen image of the Georeferencing Calculator when it first opens, showing the language selection drop-down, the Locality Type *drop-down box to initiate a georeference calculation, the Distance Converter, and the Scale Converter.*

3. Basic Workflow

The Georeferencing Calculator (Wieczorek & Wieczorek 2020) is designed to prompt the user only for what is needed to georeference based on the Locality Type selected. The steps in the basic workflow are:

1. Choose the language for the Calculator.
2. Select the locality type that best matches the descriptive locality for the georeference. The interface will add all of the fields necessary to calculate the georeference.
3. Make selections and fill in all of the parameters shown. Refer to the Glossary and Georeferencing Concepts in the Georeferencing Quick Reference Guide (Zermoglio et al. 2020) to get a description of what each parameter means.
4. Click on the Calculate button to calculate the results.
5. Enter the metadata for the person who is georeferencing and the **protocol** being used.
6. Click on the *Copy* button to put the results on the system clipboard.
7. Paste the results where the georeference will be stored.
8. Repeat for the next calculation. Note that the values for parameters chosen in one calculation will remain in the text and drop-down boxes and thus carry over to the next calculation whenever possible.

4. Citation and Documentation

Any time the Georeferencing Calculator (Wieczorek & Wieczorek 2020) is used, the georeferencer should record its use.

If the Darwin Core standard is used to record Calculator output, the Calculator version and the date of use should be recorded in the field `georeferenceSources`. The following format should be used:

> Wieczorek C & J Wieczorek (yyyy). Georeferencing Calculator, version [yyyymmdd(language)]. Available: http://georeferencing.org/georefcalculator/gc.html. Accessed [yyyy-mm-dd].

For example

> Wieczorek C & J Wieczorek (2020) Georeferencing Calculator, version 20191217en. Available: http://georeferencing.org/georefcalculator/gc.html. Accessed 2020-01-28.

The version and language of the Calculator can be found in the lower left-hand corner of the calculator.

If the Darwin Core standard is not used to record calculator output, the georeferencer should record this citation in a suitable field in the database of choice and in any written documentation or notes for future georeferencing efforts.

5. Detailed Workflow

Step 1: Choose a Language

Click on the drop-down in the upper left-hand corner of the Calculator to choose the language for the interface. When the list is expanded, the application should appear as in Figure 2.

The number format always uses the full stop '.' as the decimal indicator (e.g. 2.5 for the number halfway between 2 and 3), regardless of the selected language.

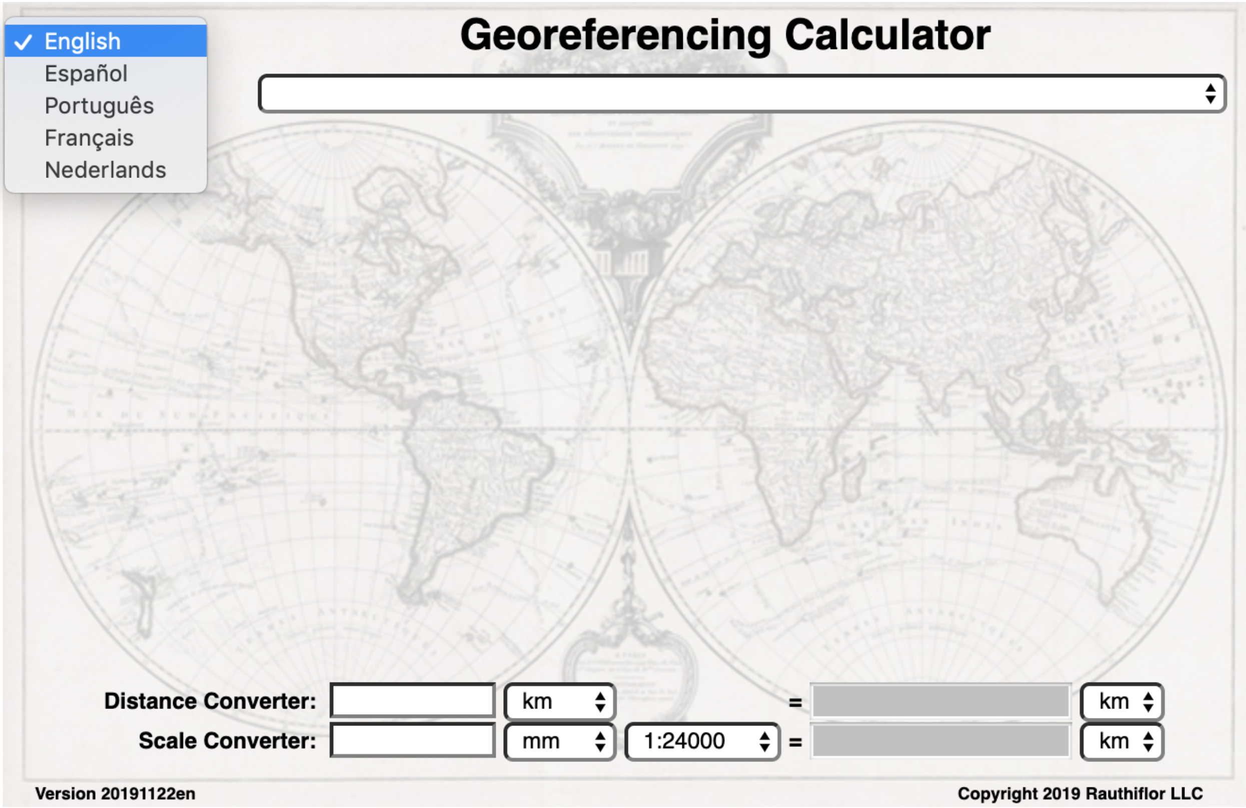

Figure 2. Step 1: Choose a language. The Calculator with the five language options showing after opening the Language drop-down list.

Step 2: Choose a Locality Type

Click on the Locality Type drop-down to expand the list. When the list is expanded, the application should appear as in Figure 3.

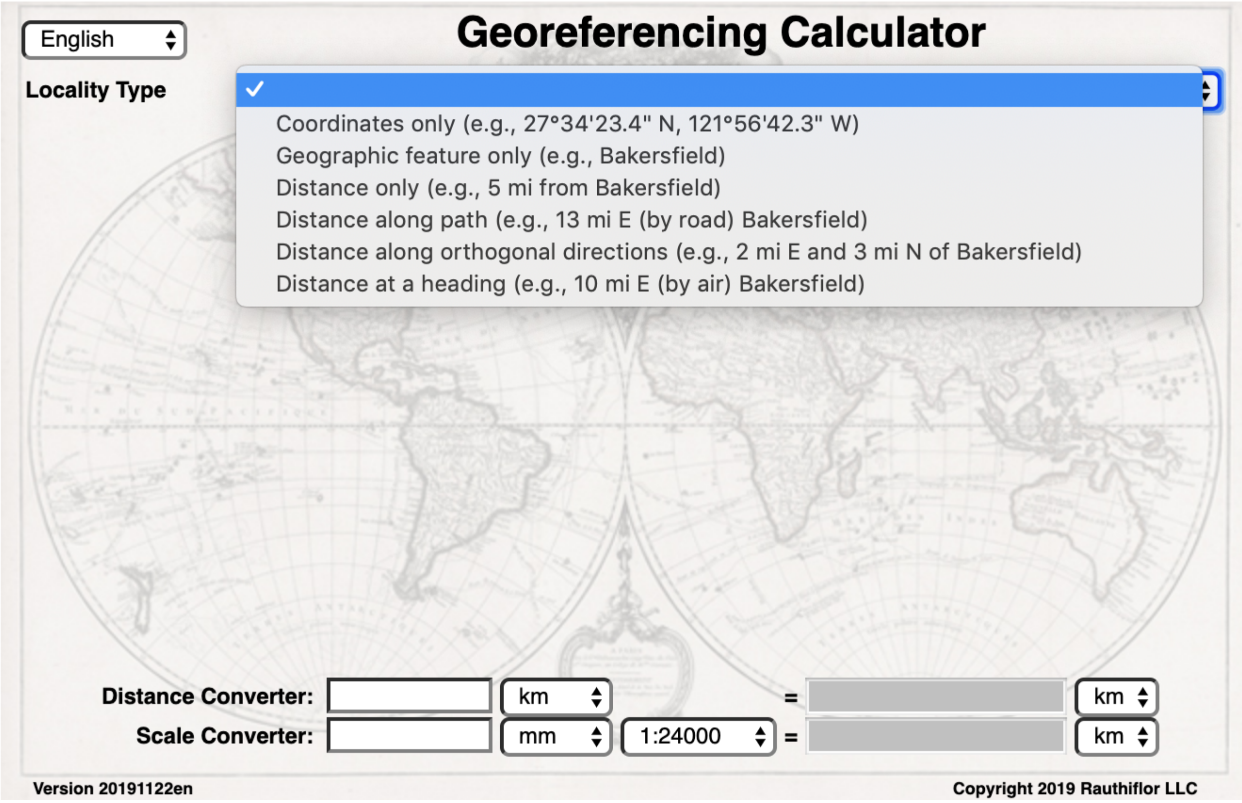

Figure 3. Step 2: Choose a locality type. The Calculator with the six basic locality types showing after opening the Locality Type drop-down list.

Select the Locality Type that best matches the characteristics of the locality to be georeferenced. Each Locality Type in the drop-down list shows an example to try to help match the locality to a locality type using the pattern shown. Locality types with more examples are described in the Georeferencing Quick Reference Guide (Zermoglio et al. 2020).

Step 3: Enter Parameters

After selecting the Locality Type, a variety of text boxes, drop-down boxes, and buttons will appear on the Calculator (Figure 4). These text and drop-down boxes need to be filled and/or values selected to make the calculation of the selected Locality Type. If no parameters are entered, then the default values will be used automatically.

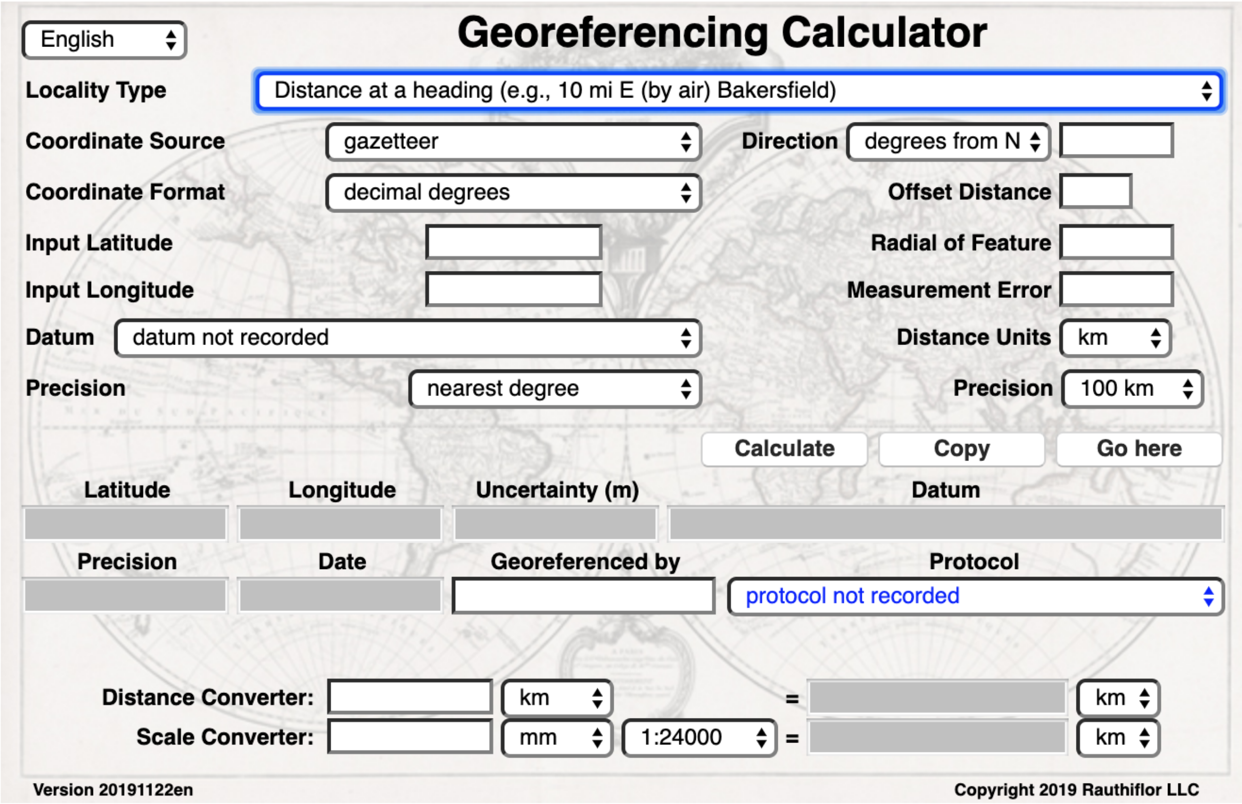

Figure 4. Step 3: Enter parameters. The Calculator after selecting the "Distance at a heading" Locality Type*, with all of the relevant text and drop-down boxes needed to be filled in or selected correctly in order to do a georeference calculation.*

Step 4: Calculate

The Calculate button appears after a Locality Type is selected. After all the parameters are correctly chosen or entered, click the Calculate button. The calculated results will fill the text boxes with grey backgrounds in the middle of the Calculator, below the buttons and above the converters.

Example 1. Calculation Example

Suppose the locality to be georeferenced is "10 mi E (by air) Bakersfield", as shown in the example in selection box for the "*Distance at a heading*" Locality Type (for details about this type of locality see Offset – Distance at a Heading in Georeferencing Quick Reference Guide (Zermoglio et al. 2020)). Next, suppose the coordinates for Bakersfield (35° 22′ 24″ N, 119° 1′ 4″ W) were obtained by determining the centre of town to the nearest second using a USGS Gosford 1:24,000 Quad map.

To begin, select "*USGS map: 1:24,000*" from the Coordinate Source drop-down. Next, select "*degrees minutes seconds*" from the Coordinate Format drop-down. Next, enter the coordinates for Bakersfield in the Input Latitude and Input Longitude boxes that appear after selecting the *Coordinate Format*. Make certain to select the correct hemisphere from the drop-downs to the right of each coordinate field.

For this example, the Coordinate Format "*degrees minutes seconds*" was selected because the USGS map showed coordinates in degrees minutes seconds, thus the coordinates determined for the centre of Bakersfield were described in the same way. In some cases, coordinates on a map, or other resource, may be represented in degrees decimal minutes (e.g. 35° 22′ N, 119° 0′ W or 35° 22.4′ N, 119° 1.066667′ W) or as decimal degrees (e.g. 35.3733333, −119.0177778). The Coordinate Format selected in the Calculator MUST reflect the coordinate format used on the map or other resource.

The Gosford Quad map uses the North American 1927 horizontal datum, so select "*North American Datum 1927*" from the Datum drop-down list. In most cases the datum can be found printed on the map, although sometimes an ellipsoid is listed instead. The Calculator also includes ellipsoids in the *Datum* drop-down list. If a resource, such as a map with a datum, is not listed in the Calculator, try to find the ellipsoid for that datum using online resources such as epsg.io and then select the appropriate ellipsoid in the *Datum* drop-down list.

The coordinates in this example have been specified to the nearest second, so select "*nearest second*" from the Coordinate Precision drop-down list. The direction given in the locality description is E (east), so select "*E*" in the Direction drop-down list. The offset distance is 10 mi (miles), so type "*10*" into the *Offset Distance* text box and select "*miles*" from the Distance Units drop-down list.

Bakersfield is a large place, and we don't know if the original locality means 10 miles from the center of town, 10 miles from the city limits, or something else entirely. Given that it is 3 miles from the specified coordinates to the furthest edge of town (as measured on the USGS map), the Radial of Feature should be 3 miles (see Feature – with an Obvious Spatial Extent in the Georeferencing Quick Reference Guide). Enter "*3*" into the Radial of Feature text field, since the units of the radial must be in the same units as the offset.

If this distance had been measured in kilometres the value should be converted to miles using the *Distance Converter* at the bottom of the Calculator. The converted number should then be entered into the appropriate field (see Coordinate, Distance, and Scale Converters to learn how to use the converters). All distance measurements MUST be in the same units as the locality description for the Calculator to return proper results.

The determination of the coordinates for Bakersfield is only as accurate as the tools that are used; the map, the size of the units on the measurement tool, and the georeferencer's ability to place a marker relative to items on the map. Any error associated with the map itself is accounted for in the Coordinate Source selection. Error associated with the georeferencer's ability to measure on the map is accounted for in the Measurement Error field.

To complete the Measurement Error field, the smallest distance that can be measured on the map reliably and repeatedly must be determined. Generally, features or locations can be distinguished on a map to within about one (1) millimetre, given a ruler with millimetre divisions. If a ruler with English units is used, it may be possible to distinguish to 1/16th of an inch. The quality of the measuring tool, eyesight, and technique may alter these suggested values.

Once the smallest distance that can be measured consistently and reliably has been determined, enter that value and its units into the *Scale Converter* at the bottom of the Calculator, select the scale of the map used for the measurement, and then select the unit of measure into which the conversion should be made. For example, if a digital measuring tool was used to measure to the nearest 0.1 mm on a 1:24000 map and this needs to be converted to miles, enter "*0.1*" into the Radial of Feature, then select "*mm*" from the units drop-down list. Next, choose the "*1:24000*" scale option in the map scale drop-down list. Finally, select "*mi*" in the second drop-down list. The value of 0.1 mm at 1:24000 converted into miles will be displayed in blue ("*0.00149 mi*") within the grey text box on the right side of the *Scale Converter*. Type "*0.00149*" into the Measurement Error field, or move it from the *Scale Converter* using copy and paste keyboard combinations.

Next, make certain that "*mi*" is selected in the Distance Units drop-down, since the locality is described in miles ("10 mi E…"). The offset component in this locality is 10 mi, which is precise to the nearest 10 miles (see the discussion on this topic in the section Uncertainty Related to Offset Precision in Georeferencing Best Practices (Chapman & Wieczorek 2020). Select "*10 mi*" in the distance *Precision* drop-down.

Next, click the Calculate button. The calculated coordinates (always presented in decimal degrees) for the locality "10 mi E (by air) Bakersfield" and the Uncertainty for the calculation (always in meters) will be given in the controls just above the *Distance Converter* at the lower part of the Calculator, as shown in Figure 5.

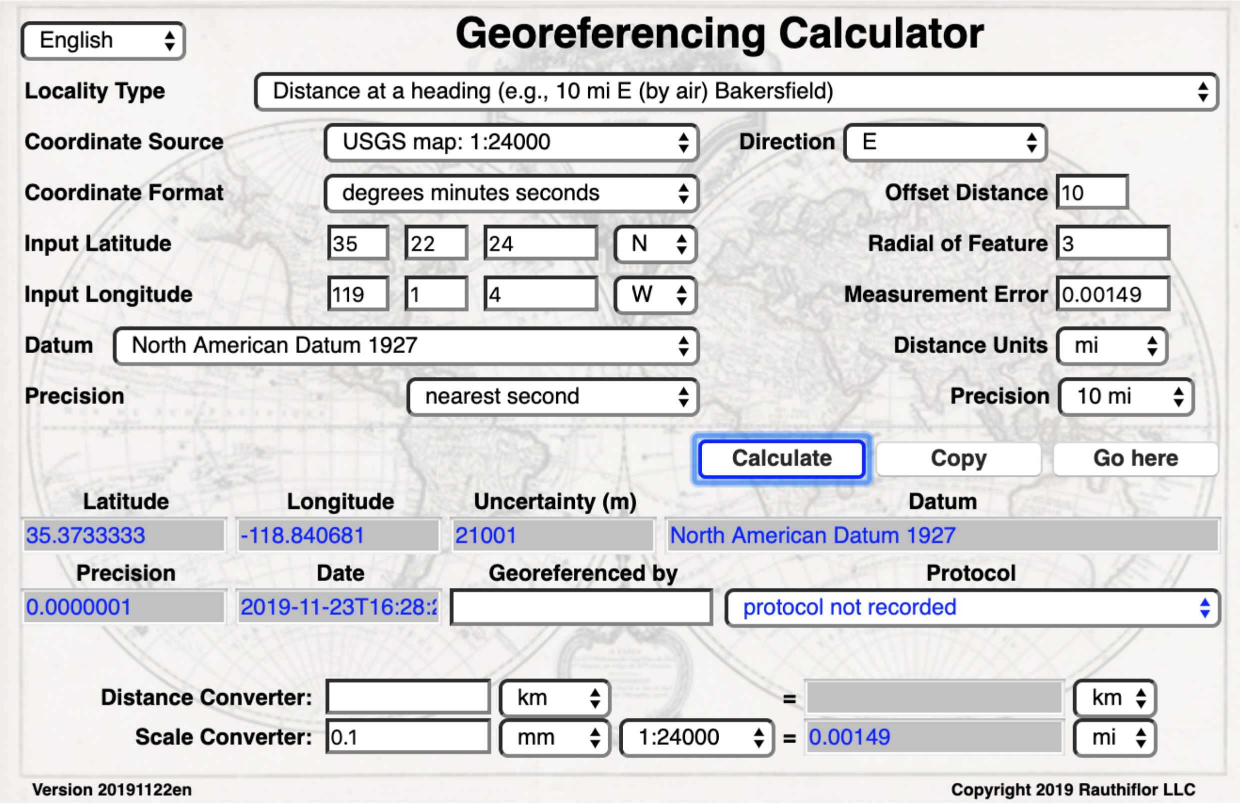

Figure 5. Step 4: Calculate. The Calculator after clicking on the Calculate button, with all of the relevant text and drop-down boxes filled in or selected for an example of locality type "Distance at a heading". Results appear written in blue in the grey text boxes in the middle section of the Calculator below the Calculate button.

Step 5: Enter Metadata

After the results of the calculation have been presented, add the name of the georeferencer in the *Georeferenced by* text box. If there is more than one person, separate the names in the list by ' | '. Finally, select the appropriate georeferencing *Protocol*. We recommend the Georeferencing Quick Referencing Guide (Zermoglio et al. 2020) as the georeferencing protocol to follow and select. Do not use this option if the protocol was altered in any way. Rather, make a citable document available and reference that. People will rely on strict application of the georeferencing protocol in order to be able to reproduce a georeference given the same input parameters. If an undocumented protocol is followed, select "*protocol not recorded*". The example georeference from Figure 5, with the metadata filled in, is shown in Figure 6.

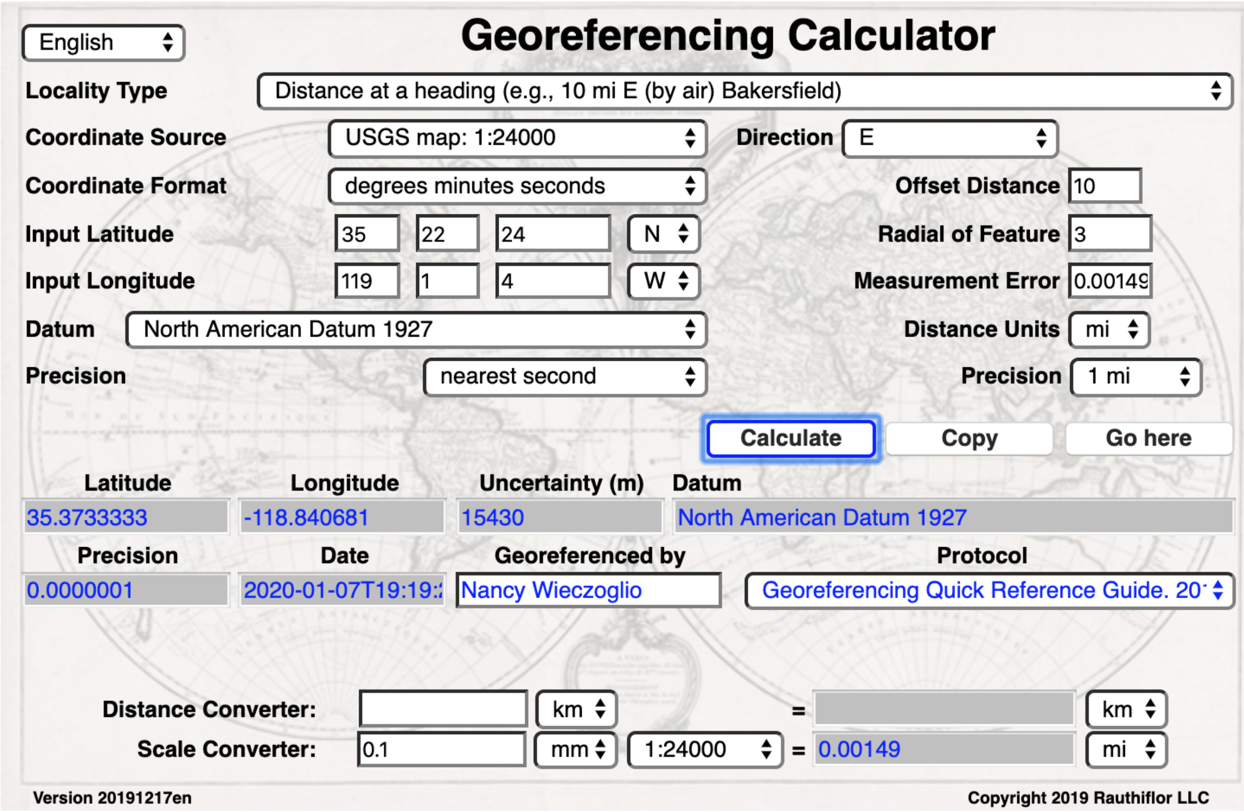

Figure 6. Step 5: Enter Metadata. The Calculator after entering an example of georeference metadata for the georeferencer and the georeferencing Protocol used.

Step 6: Copy Results

The results (in blue in the middle section of the Calculator after clicking on the Calculate button), including the metadata, can be copied onto the system clipboard by clicking on the *Copy* button, after which a dialog box will appear displaying the content that has been copied, as shown in Figure 7.

This dialog box does not get translated based on the language chosen for the Calculator interface. To close the box, click the *OK* button. Once copied, the content can be transferred and pasted to a spreadsheet, database or text file as a tab-delimited record of the data for the current calculation.

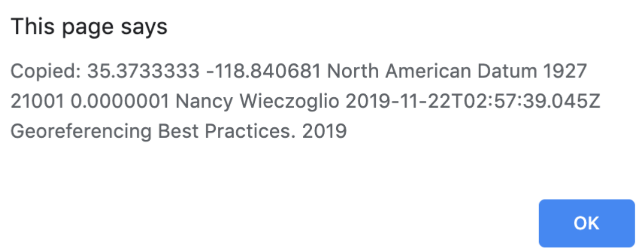

Figure 7. Step 6: Copy Results. Pop-up dialog box after clicking on the Copy button, showing the tab-delimited results of the example georeference that have been copied to the system clipboard.

Step 7: Paste Results

The content on the system clipboard after clicking on the *Copy* button is tab-delimited. It can be pasted into a series of columns of a spreadsheet directly (this works in Excel as well as Google Sheets). It can also be pasted into a tab-delimited text file. When pasting the results, be certain that the order of the fields in the destination document matches the order of the fields in the results. Using Darwin Core standard term names (see also Wieczorek et al. 2012), the order of the result fields is:

- `decimalLatitude`
- `decimalLongitude`
- `geodeticDatum`
- `coordinateUncertaintyInMeters`
- `coordinatePrecision`
- `georeferencedBy`
- `georeferencedDate`
- `georeferenceProtocol`

Note that only the values are copied and can be pasted, and not the corresponding headers. Figure 8 shows the results after being pasted into a cell in a Google Sheet.

	A	B	C	D	E	F	G	H	I
1	decimalLatitude	decimalLongitude	geodeticDatum	coordinateUncerta	coordinatePre	georeferencedBy	georeferencedDa	georeferenceProtocol	
2	35.3733333	-118.840681	North American [	21001	0.0000001	Nancy Wieczoglio	2019-11-22T03:1	Georeferencing Best Practices. 2019	

Figure 8. Step 7: Paste Results. Part of a Google Sheet into which the results have been pasted. The column names reflecting Darwin Core terms were already in row 1 when the results were pasted into the cell A2.

Step 8: Start a New Calculation

A new calculation can be started simply by entering new parameter values and selecting new drop-down list values pertinent to the next calculation. If the Locality Type for the next calculation is different from the previous one, make a new selection on the Locality Type drop-down list. New parameters will appear that are relevant to the new Locality Type calculation. Previously entered and chosen values will remain in the text and drop-down boxes and thus carry over to the next calculation whenever possible. This can increase the efficiency of calculations if locality descriptions that include the same feature are georeferenced one after another.

Always check that all parameter values and choices are correct before accepting the results of a calculation. Figure 9 shows the Calculator after selecting the Locality Type: *Geographic feature only* for a new georeference following the georeference calculation shown in Figure 6. Without doing anything further, the Calculator would be ready to calculate the georeference for the locality "Bakersfield" based on the previous entries. Note that the *Date* value will change automatically when the Calculate button is clicked.

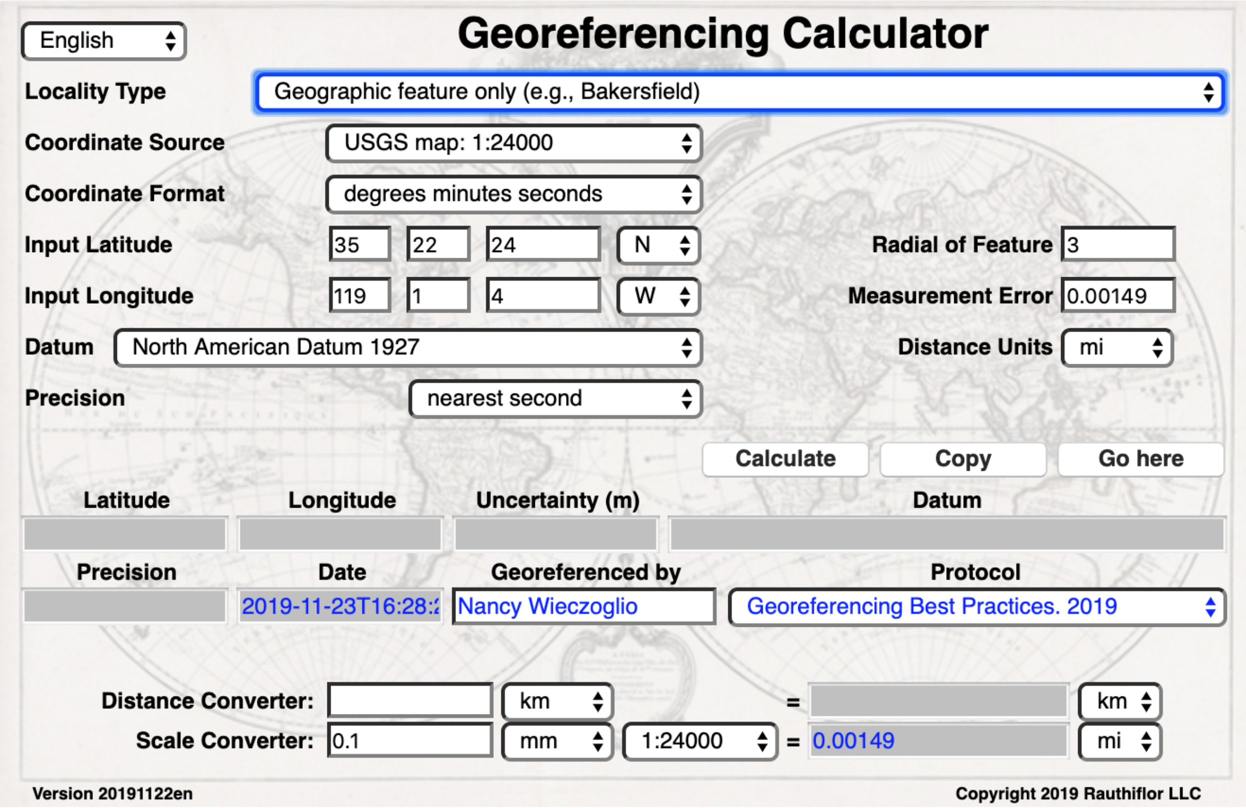

Figure 9. Step 8: Start a New Calculation. The Calculator after selecting a new Locality Type to start a new georeference calculation following the calculation from Figure 6*. Note that there are fewer parameters to enter for this Locality Type, and that the relevant parameter values that were in the previous calculation are preserved for this calculation.*

6. Calculating Coordinates from a Map

Georeferences for every locality type require coordinates. For all of the locality types except "*Coordinates only*" and "*Distance along path*", the coordinates of the corrected center of the reference feature are needed. In many cases these can be determined directly from a gazetteer or from an online tool such as Google Maps. If the coordinates of a feature need to be determined from other reference points that have coordinates on a map (such as the corners), there is a nice little trick that can be done with the Georeferencing Calculator to determine the coordinates of the feature easily. For example, to georeference the locality "10 mi E (by air) Bakersfield", first determine the coordinates for "Bakersfield". Suppose the Coordinate Source is the USGS Gosford 1:24,000 Quad map. Once the corrected centre of Bakersfield has been determined on the map, find a convenient spot on the map having known coordinates, such as the corner nearest to the feature. In this case, the northeast corner of the map is closest and marked with the coordinates 35° 22′ 30″ N, 119° 00′ W.

To begin the calculation, select the Locality Type "*Distance along orthogonal directions*" (because the measurement is due south and due west from the northeast corner of the map to the corrected centre of Bakersfield). Next, select "*degrees minutes seconds*" as the Coordinate Format. Enter the coordinates of the known point (the northeast corner of the map, in this example) into the Input Latitude and Input Longitude fields (35° 22′ 30″ N, 119° 0′ 0′ W – don't neglect the hemisphere indicators). Select "*North American Datum 1927*" as the Datum used by the map.

Now use a measuring tool (e.g. a ruler) to measure a) the distance between the northeast corner of the map and the line of latitude of the corrected center of Bakersfield where it meets the east edge of the map, and b) the distance between the northeast corner of the map and the line of longitude of the corrected center of Bakersfield where it meets the north edge of the map. These are the orthogonal distances to the S and W of the known point, the northeast corner of the map.

Convert all measurements made on the maps (mm, cm, or inches) into the distance unit provided in the locality (miles, in this example). Use the *Scale Converter* at the bottom of the Calculator, to do this calculation (see Coordinate, Distance, and Scale Converters).

The point we have determined to be the corrected center of Bakersfield is 8 mm south of the 35° N line of latitude and 67 mm west of the 119° W line of longitude. After the *Scale Converter* has been used to convert millimetres to miles, cut and paste the values for miles into the *Offset Distance* text boxes on the right side of the Calculator: 0.1193 should be pasted or typed into the *North or South Offset Distance* field, and the cardinal direction drop-down should be set to "*S*" (south); 0.99916 should be pasted or typed into the *East or West Offset Distance* field, and the cardinal direction drop-down should be set to "*W*" (west). The Distance Units drop-down should display "*mi*" (miles), since that is the unit described in the locality. The Calculator now has all of the parameters necessary to complete the calculation and should appear as in Figure 10.

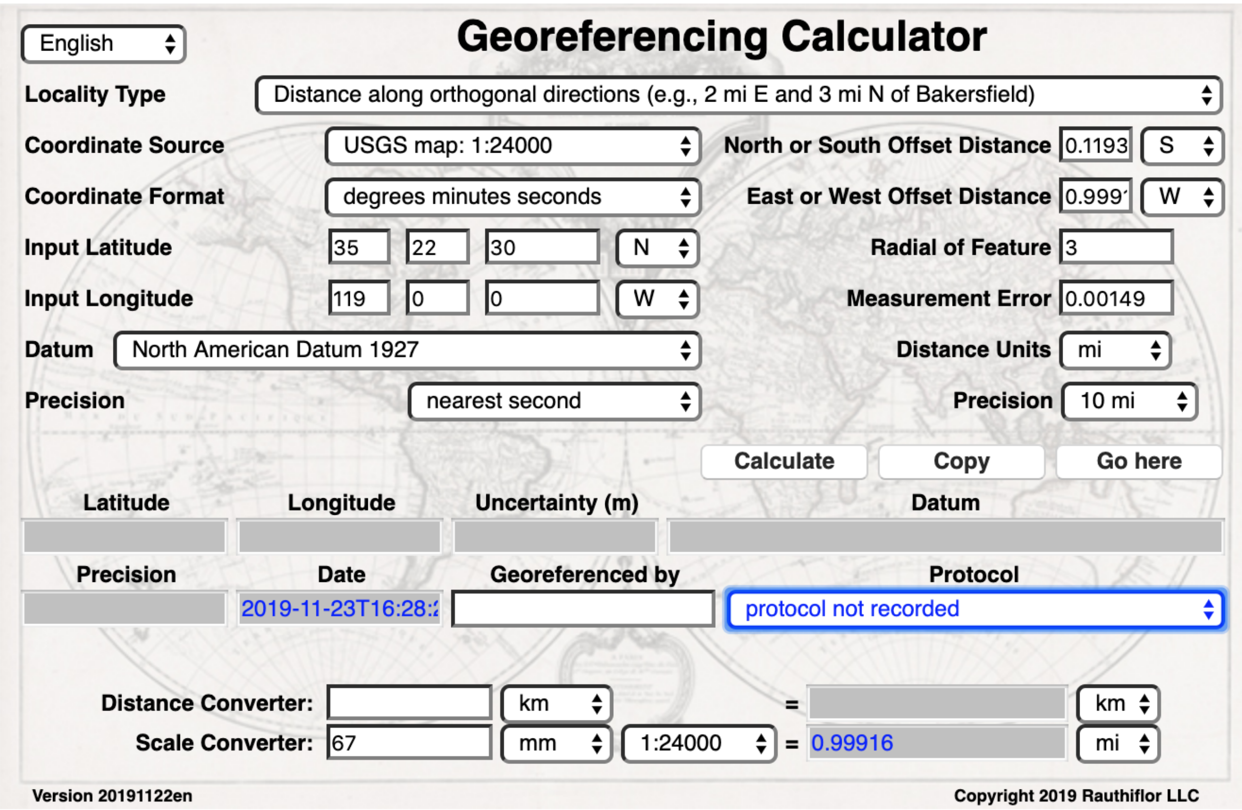

Figure 10. Calculating coordinates from a map: The Calculator after setting the parameters needed to calculate the coordinates of the corrected center of Bakersfield by using measured offsets south and west of the northeast corner of a 1:24000 map, converted to miles.

Next, click the Calculate button. The calculated coordinates (always in decimal degrees) for the corrected center of Bakersfield are displayed in blue in the Output Latitude and Output Longitude fields in the results section of the Calculator, as shown in Figure 11.

This calculation was only to determine a new set of coordinates based on offsets from a known set of coordinates. The parameters Coordinate Precision, Radial of Feature, Measurement Error, and Distance Precision were irrelevant to this calculation.

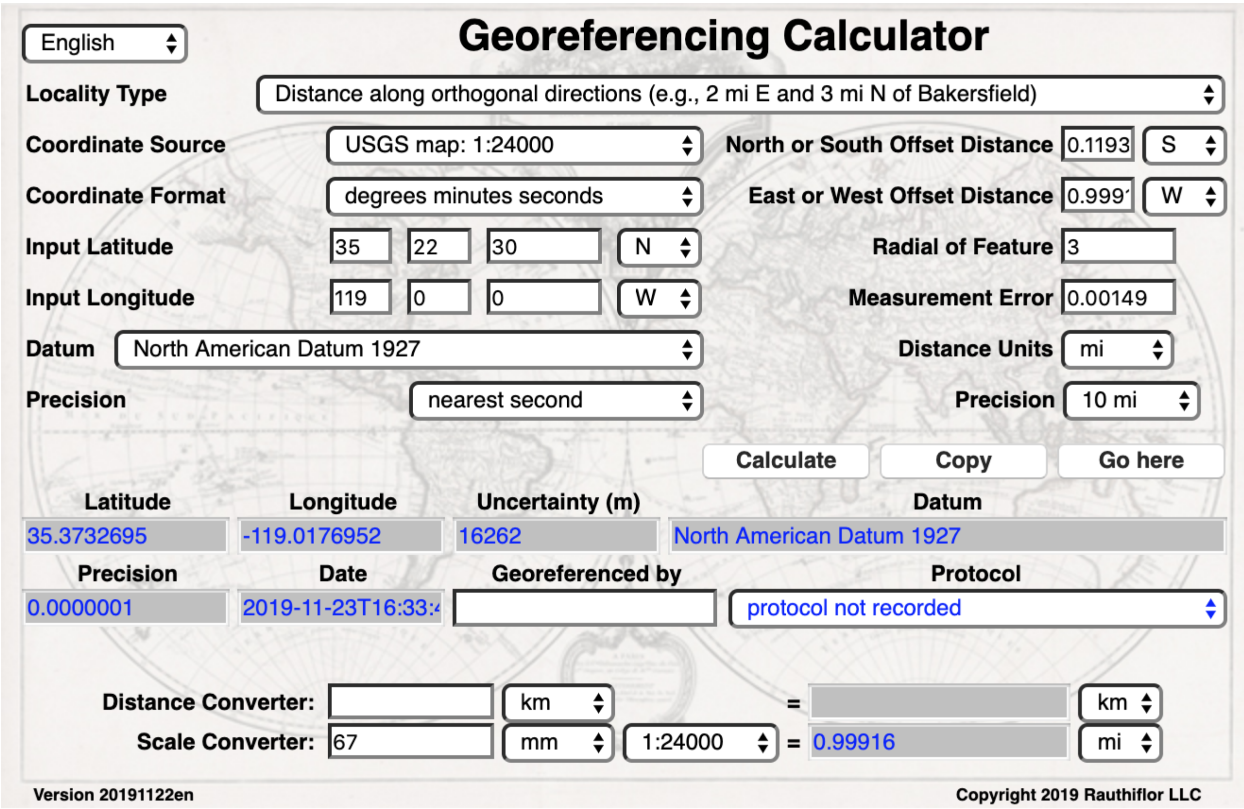

Figure 11. Calculated coordinates from a map. The Calculator after clicking on the Calculate button to determine the coordinates of Bakersfield by using measured offsets south and west of the northeast corner of a 1:24000 map, converted to miles.

7. "Going to" Calculated Coordinates

Now that the starting coordinates for the corrected center of Bakersfield have been calculated after measuring offsets on a map, use those coordinates to georeference subsequent locality descriptions that reference Bakersfield. Rather than copying and pasting (and possibly also converting) the coordinates into the Input Latitude and Input Longitude fields, click the Go here button to copy and convert the previous Input Latitude and Input Longitude from the results into the Input Latitude and Input Longitude fields in the Coordinate Format currently in use (degrees minutes seconds in this example), as shown in Figure 12.

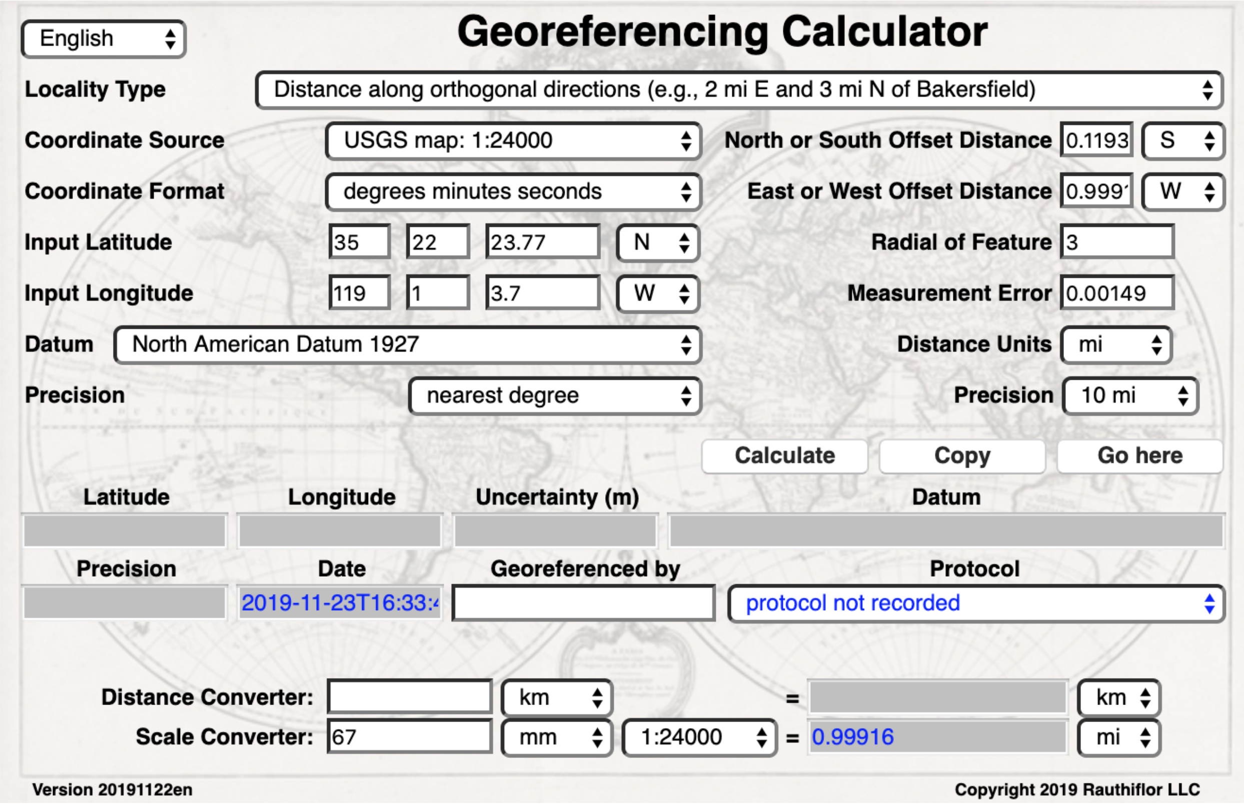

Figure 12. Calculated coordinates pushed to input coordinates. The Calculator after clicking on the Copy button to move the coordinates in a previous result to the starting coordinates for a new calculation.

To complete a georeference using the new coordinates, follow the Basic Workflow starting with Step 2: Choose a Locality Type.

8. Coordinate, Distance, and Scale Converters

The Calculator has three converters built in to eliminate the need for additional tools during the georeferencing process. Built into the parameters section of the Calculator is a converter to change the format of coordinates between three geographic coordinate options: decimal degrees, degrees decimal minutes, and degrees minutes seconds.

To convert between coordinate formats, simply select the desired format from the Coordinate Format drop-down list. The text and drop-down boxes for the Input Latitude and Input Longitude will change and be populated with the values in the new format. For coordinate systems other than geographic coordinates (e.g. Universal Transverse Mercator (UTM)), a coordinate transformation into geographic coordinates will have to be done to use the Georeferencing Calculator.

Below the Calculate section of the Calculator is a *Distance Converter*. To convert a distance from one unit to another, put the value and units in the text and drop-down boxes in the *Distance Converter*, to the left of the "=". The value in the units of the drop-down box will appear in blue in the text box with the grey background on the right side of the "=". For example, to convert 10 miles into kilometres, enter "*10*" in the first field of the *Distance Converter*, select "*mi*" from the left-hand unit drop-down list, and select "*km*" from the right-hand unit drop-down list. The result, "*16.09344*", automatically appears in the right-hand text box. This value can be copied and placed into a distance field in the input area of the Calculator or elsewhere (see Figure 13).

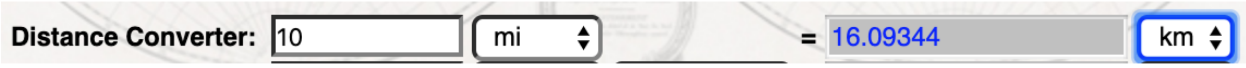

Figure 13. Distance Conversion. The Distance Converter section of the Calculator showing a conversion of 10 miles into kilometres.

Below the *Distance Converter* is a *Scale Converter* designed to convert a measurement on a map of a given scale to a real-world distance in another unit. To convert a distance measured on a map with a known scale into a distance on the ground, put the distance value, distance units, and map scale in the text and drop-down boxes in the *Scale Converter*, to the left of the "=". The value in the units of the drop-down box to the right of the "=" will appear in blue in the text box with the grey background on the right side of the "=". For example, to convert a map measurement of 8 centimetres on a 1:50000 map into miles on the ground, enter "*8*" in the first field of the *Scale Converter*, select "*cm*" from the left-hand unit drop-down list, select "*1:50000*" in the second drop-down list, containing scales, and select "*mi*" from the right-hand unit drop-down list. The result, "*2.48548*", automatically appears in the right-hand text box. This value can be copied and placed into a distance field in the input area of the Calculator or elsewhere (see Figure 14).

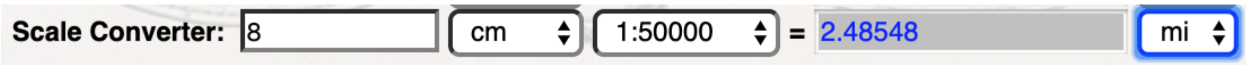

Figure 14. Map Measurement Distance Conversion. The Scale Converter section of the Calculator showing a conversion of 8 centimetres on a map of 1:50000 scale to miles on the ground.

9. Understanding uncertainty contributions

The Georeferencing Calculator is an excellent tool for investigating the contributions to uncertainty from distinct sources. For any given Locality Type, one can nullify all but one source of uncertainty to see what the contribution to overall uncertainty is from that source. For example, to see what the contribution to overall uncertainty is from an unknown datum at a given location, choose the "Coordinate only" Locality Type, set the Input Latitude and Input Longitude to the place that needs to be checked, set the Coordinate Source to "gazetteer" or "locality description" (because neither of these choices contributes an uncertainty to the calculation), select "datum not recorded" from the Datum drop-down list, select "exact" from the Coordinate Precision drop-down list, set the Measurement Error to "0". With these settings, the only source of uncertainty is the unknown datum. At the coordinate 0,0, the calculated uncertainty is 5030m, as shown in Figure 15. This large uncertainty reflects the maximum distance between the point 0,0 in any geographic coordinate reference system and the point 0,0 in the coordinate reference system WGS84. See Coordinate Reference System in Georeferencing Best Practices (Chapman & Wieczorek 2020) for further discussion on the subject.

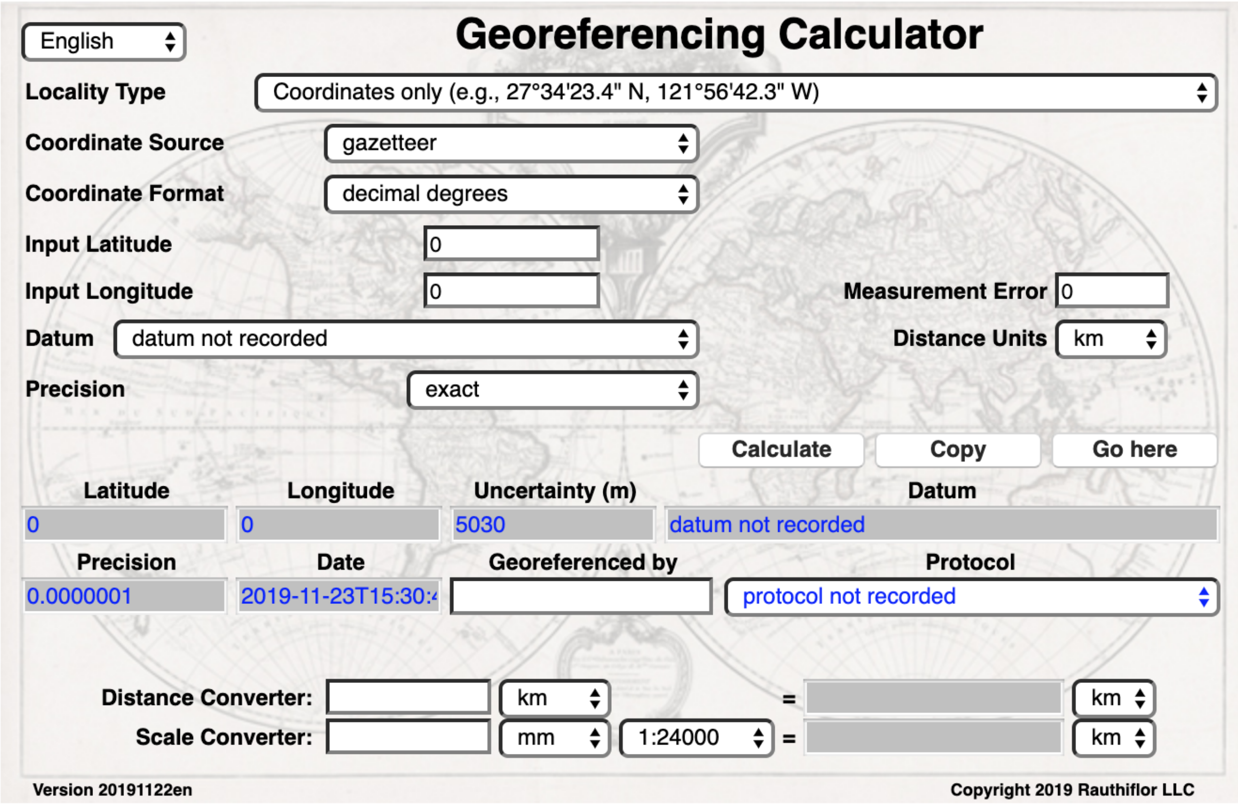

Figure 15. Isolating uncertainty from an unknown datum. The Calculator showing parameter settings that reveal the uncertainty due to an unknown datum at the coordinate 0,0. The choices of all other parameters nullify all other contributions to overall uncertainty.

Appendix A: UI components and how they relate to calculations

Calculate

Button used to calculate coordinates and uncertainty using the point-radius method (Wieczorek et al. 2004), based on the values of parameters pertinent to the selected Locality Type. Clicking on the Calculate button fills in the results section of the Calculator formatted as Darwin Core fields that need to be recorded for a georeference that follows the Georeferencing Best Practices (Chapman & Wieczorek 2020) (i.e. `decimalLatitude`, `decimalLongitude`, `geodeticDatum`, `coordinateUncertaintyInMeters`, `coordinatePrecision`, `georeferencedBy`, `georeferencedDate`, and `georeferenceProtocol`). The calculation combines the sources of uncertainty using an algorithm appropriate to the locality type (see Calculating Uncertainties in Georeferencing Best Practices). The calculations account for uncertainties due to coordinate precision, unknown datum, data source, GPS error, measurement error, feature geographic radial, distance precision, and heading precision.

Coordinate Format

Defines the original geographic coordinate format (decimal degrees, degrees minutes seconds, degrees decimal minutes) of the coordinate source. Equivalent to the Darwin Core term `verbatimCoordinateSystem`. Selecting the original Coordinate Format allows the coordinates to be entered in their native format and forces the Calculator to present appropriate options for Coordinate Precision. Note that changing the Coordinate Format will reset the Coordinate Precision value to "nearest degree". Be sure to correct this for the actual coordinate precision.

Behind the scenes, the Calculator stores coordinates in decimal degrees to seven decimal places. This is to preserve the correct coordinates in all formats regardless of how many transformations are done.

Coordinate Precision (input)

Labelled as *Precision* in the first column of input parameters, this drop-down list is populated with levels of precision in keeping with the Coordinate Format chosen for the verbatim original coordinates. This is similar to, but **NOT** the same as the Darwin Core term `coordinatePrecision`, which applies to the output coordinates. A value of "*exact*" is any level of precision higher than the otherwise highest **precision** given on the list.

Example

> For 35° 22′ 24″, the Coordinate Precision would be "nearest second".

Coordinate Precision (output)

Labelled as *Precision* in the results, this text box is populated with precision of the output coordinates, and as such is equivalent to the Darwin Core term `coordinatePrecision`. The precision of the output in the Calculator is always "0.0000001", no matter how many digits appear to the right of the decimal indicator in the Output Latitude and Output Longitude.

Coordinate Source

The resources (map, GPS, gazetteer, locality description) from which the Input Latitude and Input Longitude were derived. Related to, but **NOT** the same as the Darwin Core term `georeferenceSources`, which requires the specific resources used rather than their characteristics. Note that the uncertainties from the two sources "*gazetteer*" and "*locality description*" can not be anticipated universally, and therefore do not contribute to the uncertainty in the calculations. If the error characteristics of the specific sources of this type are known, they can be added in the Measurement Error before calculating. If the source "*GPS*" is selected, the label for Measurement Error will change to GPS Accuracy, which is where accuracy distance of the GPS at the time the coordinates were taken should be entered. For details on GPS Accuracy see Using a GPS in Georeferencing Best Practices (Chapman & Wieczorek 2020).

Datum

Defines the position of the origin and orientation of an ellipsoid upon which the coordinates are based for the given Coordinate Source. Equivalent to the Darwin Core term `geodeticDatum`. The Calculator includes ellipsoids on the Datum drop-down list, as sometimes that is all that coordinate source shows. The choice of Datum has two important effects. The first is the contribution to uncertainty if the datum of the source coordinates is not known. If the datum and ellipsoid are not known, choose the option "*datum not recorded*". *Uncertainty* due to an unknown datum can be severe and varies geographically in a complex way, with a worst-case contribution of 5359 m (see Coordinate Reference System in Georeferencing Best Practices (Chapman & Wieczorek 2020). The second important effect of the Datum selection is to provide the characteristics of the ellipsoid model of the earth, which the distance calculations depend on.

Direction

The heading given in the locality description, either as a standard compass point (see Boxing the compass) or as a number of degrees in the clockwise direction from north. If "*degrees from N*" is selected, there will appear a text box to the right of it in which to enter the degree heading.

> Some marine locality descriptions reference a direction to a landmark (azimuth) rather than a heading from the current location, for example, "327° to Nubble Lighthouse". To make an offset at a heading calculation for such a locality description, use the compass point 180 degrees from the one given in the locality description (147° in the example above) as the Direction.

Distance Precision

Labelled as *Precision* in the second column of input parameters. Refers to the precision with which a distance was described in a locality (see Uncertainty Related to Offset Precision in Georeferencing Best Practices (Chapman & Wieczorek 2020). This drop-down list is populated in keeping with the *Distance Units* chosen and contains powers of ten and simple fractions to indicate the precision demonstrated in the verbatim original offset.

Examples

select "*1 mi*" for "6 mi NE of Davis," select "*1/10 km*" for "3.2 km SE of Lisbon".

Distance Units

Denotes the real world units used in the locality description. It is important to select the original units as given in the description, because this is needed to properly incorporate the uncertainty from distance precision.

Examples

select "*mi*" for "10 mi E (by air) Bakersfield,"
select "*km*" for "3.2 km SE of Lisbon".

Go here

Button used to copy and potentially convert the calculated coordinates from the Output Latitude and Output Longitude into the Input Latitude and Input Longitude fields in preparation for a new calculation based on the previous results, eliminating the need to copy manually or to use cut and paste keyboard combinations.

GPS Accuracy

When "*GPS*" is selected from the Coordinate Source drop-down list, the label for the Measurement Error text box changes to GPS Accuracy. Enter the value given by the GPS at the time the coordinates were captured. If not known, enter 100 m for standard hand-held GPS coordinates taken before 1 May 2000 when Selective Availability was discontinued. After that, use 30 m as a default value.

Language

The Calculator may be used in English, Spanish, Portuguese, French, or Dutch. The language can be changed using the *Language* drop-down in the upper left-hand corner of the Calculator. Regardless of the language chosen, the Calculator always uses a period ('.') as the decimal separator. If you would like to contribute labels for another language, please submit an issue to the Calculator GitHub repository.

Input Latitude

The geographic coordinate north or south of the Equator (where latitude is 0) for the point of reference for the calculation, which is determined by the specific locality type. Latitudes north of the Equator are positive by convention, while latitudes to the south are negative. The minus sign ("−") should be included as appropriate. The Calculator supports degree-based geographic coordinate formats for latitude and longitude: decimal degrees (e.g. 35.3733333), degrees decimal minutes (e.g. 35° 22.4′ N) and degrees-minutes-seconds (e.g. 35° 22′ 24″ N).

Output Latitude

The resulting latitude for a given calculation, in decimal degrees. Equivalent to the Darwin Core term `decimalLatitude`. See also, Input Latitude.

Locality Type

The pattern of the most specific part of a locality description to be georeferenced. The Calculator can compute georeferences for six basic locality types: *Coordinates only*, *Geographic feature only*, *Distance only*, *Distance along a path*, *Distance along orthogonal directions*, and *Distance at a heading*. Selecting a Locality Type will configure the Calculator to show all of the parameters that need to be set or chosen in order to do the georeference calculation. The Georeferencing Quick Reference Guide (Zermoglio et al. 2020) gives specific instructions for how to set the parameters for different examples of each of the locality types.

Input Longitude

The geographic coordinate east or west of the prime meridian (an arc between the north and south poles where longitude is 0) for the point of reference for the calculation, which is determined by the specific locality type. Longitudes east of the prime meridian are positive by convention, while longitudes to the west are negative. The minus sign ("−") should be included as appropriate. The Calculator supports degree-based geographic coordinate formats for latitude and longitude: decimal degrees (−105.3733333), degrees decimal minutes (105° 22.4′ W), and degrees minutes seconds (105° 22′ 24″ W), .

Output Longitude

The resulting longitude for a given calculation in decimal degrees. Equivalent to the Darwin Core term `decimalLongitude`. See also, Input Longitude.

Measurement Error

Accounts for error associated with the ability to distinguish one point from another using any measuring tool, such as rulers on paper maps or the measuring tools on Google Maps or Google Earth. The units of the measurement must be the same as those for the locality description. The *Distance Converter* at the bottom of the Calculator is provided to aid in changing a measurement to the locality description units.

> If more than one measurement is made in the course of a georeference determination, enter the sum of all the measurement errors.

Offset Distance

The linear distance from a point of origin. Offsets are used for the *Locality Types* "*Distance at a heading*" and "*Distance only*". If the Locality Type "*Distance in orthogonal directions*" is selected, there are two distinct offsets:

North or South Offset Distance

The distance to the north or south of the Input Latitude.

East or West Offset Distance

The distance to the east or west of the Input Longitude.

Radial of Feature

The feature is the place in the locality description that corresponds to the Input Latitude and Input Longitude. Types of features vary widely and include, for example, populated places, street addresses, junctions, crossings, lakes, mountains, parks, islands, etc. The geographic radial of the feature is the distance from the corrected center of the feature to the furthest point on the geographic boundary of that feature (see Extent of a Location in Georeferencing Best Practices (Chapman & Wieczorek 2020) and Radial of Feature in Georeferencing Quick Reference Guide (Zermoglio et al. 2020)).

Uncertainty (m)

The resulting combination of all sources of uncertainty (coordinate precision, unknown datum, data source, GPS accuracy, measurement error, feature geographic radial, distance precision, and heading precision) expressed as a linear distance – the radius in the point-radius method (Wieczorek et al. 2004). Along with the Output Latitude, Output Longitude, and Datum, the radius defines a smallest enclosing circle containing all of the possible places a locality description could mean.

Version

Displayed in the bottom left-hand corner of the Calculator in the format yyyymmddll, where ll is the two-letter language code of the interface.

Glossary

accuracy

The closeness of an estimated value (for example, measured or computed) to a standard or accepted ("true") value. Antonym: inaccuracy. Compare error, bias, precision, false precision and uncertainty.

> "The true value is not known, but only estimated, the accuracy of the measured quantity is also unknown. Therefore, accuracy of coordinate information can only be estimated." (Geodetic Survey Division 1996, FGDC 1998).

altitude

A measurement of the vertical distance above a vertical datum, usually mean sea level or geoid. For points on the surface of the earth, altitude is synonymous with elevation.

antimeridian

The meridian of longitude opposite a given meridian. A meridian and its antimeridian form a continuous ring around the Earth. The "Antimeridian" is the specific meridian of longitude opposite the prime meridian and is used as the rough basis of the International Date Line.

bathymetry

1. The measure of depth of water in oceans, seas and lakes.
2. The shapes of underwater terrains, including underwater topography and sea floor mapping.

bias

The difference between the average value of a set of measurements and the accepted true value. Bias is equivalent to the average systematic error in a set of measurements and a correction to negate the systematic error can be made by adjusting for the bias. Compare accuracy, error, precision, false precision and uncertainty.

boundary

The spatial divide between what is inside a location and what is outside of it.

bounding box

An area defined by the coordinates of two diagonally opposite corners of a polygon, where those two corners define the north-south and east-west extremes of the area contained within.

clause

see locality clause.

coordinate format

The format in which coordinates are encoded, such as "decimal degrees", "degrees minutes seconds", "degrees decimal minutes", or Universal Transverse Mercator (UTM).

coordinate precision

The fraction of a degree corresponding to the number of significant digits in the source coordinates. For example, if the coordinates are reported to the nearest minute, the precision is 1/3600th (0.00027778) of a degree; if a decimal degree is reported to two decimal places, the precision is 0.01 of a degree.

coordinate reference system

(also spatial reference system) A coordinate system defined in relation to a standard reference or datum.

coordinate system

A geometric system that defines the nature and relationship of the coordinates it uses to uniquely define positions. Examples include the geographic coordinate system and the Universal Transverse Mercator (UTM) coordinate system.

coordinate uncertainty

A measure of the minimum distance on the surface from a coordinate within which a locality might be interpreted to be.

coordinates

A set of values that define a position within a coordinate system. Coordinates are used to represent locations in space relative to other locations.

coordinateUncertaintyInMeters

The Darwin Core term corresponding to the maximum uncertainty distance when given in meters.

corrected center

The point within a location, or on its boundary, that minimizes the geographic radial of the location. This point is obtained by making the smallest enclosing circle that contains the entire feature, and then taking the center of that circle. If that center does not fall inside the boundaries of the feature, make the smallest enclosing circle that has its center on the boundary of the feature. Note that in the second case, the new circle, and hence the radial, will always be larger than the uncorrected one (see Polygons (Chapman & Wieczorek 2020)).

Darwin Core

A standard for exchanging information about biological diversity (see Darwin Core).

data quality

'Fitness for use' of data (Juran 1964, Juran 1995, Chrisman 1991, Chapman 2005a). As the collector of the original data, you may have an intended use for the data you collect but data have the potential to be used in unforeseen ways; therefore, the value of your data is directly related to the fitness of those data for a variety of uses. As data become more accessible, many more uses become apparent (Chapman 2005c).

datum

A set of one or more parameters that serve as a reference or basis for the calculation of other parameters ISO 19111. A datum defines the position of the origin, the scale, and the orientation of the axes of a coordinate system. For georeferencing purposes, a datum may be a geodetic datum or a vertical datum.

decimal degrees

Degrees expressed as a single real number (e.g. −22.343456). Note that latitudes south of the equator are negative, as are longitudes west of the prime meridian to −180 degrees. See also decimal latitude and decimal longitude.

decimal latitude

Latitude expressed in decimal degrees. The limits of decimal latitude are −90 to 90, inclusive.

decimal longitude

Longitude expressed in decimal degrees. The limits of decimal longitude are −180 to 180, inclusive.

declination

see magnetic declination.

DEM

see digital elevation model.

depth

A measurement of the vertical distance below a vertical datum. In this document, we try to modify the term to signify the medium in which the measurement is made. Thus, "water depth" is the vertical distance below an air-water interface in a waterbody (ocean, lake, river, sinkhole, etc.). Compare distance above surface. Depth is always a non-negative number.

digital elevation model (DEM)

A digital representation of the elevation of locations on the surface of the earth, usually represented in the form of a rectangular grid (raster) that stores the elevation relative to mean sea level or some other known vertical datum. The term Digital Terrain Model (DTM) is sometimes used interchangeably with DEM, although it is usually restricted to models representing landscapes. A DTM usually contains additional surface information such as peaks and breaks in slope.

direction

see heading.

distance above surface

In addition to elevation and depth, a measurement of the vertical distance above a reference point, with a minimum and a maximum distance to cover a range. For surface terrestrial locations, the reference point should be the elevation at ground level. Over a body of water (ocean, sea, lake, river, glacier, etc.), the reference point for aerial locations should be the elevation of the air-water interface, while the reference point for sub-surface benthic locations should be the interface between the water and the substrate. Locations within a water body should use depth rather than a negative distance above surface. Distances above a reference point should be expressed as positive numbers, while those below should be negative. The maximum distance above a surface will always be a number greater than or equal to the minimum distance above the surface. Since distances below a surface are negative numbers, the maximum distance will always be a number less than or equal to the minimum distance. Compare altitude.

DMS

Degrees, minutes and seconds – one of the most common formats for expressing geographic coordinates on maps. A degree is divided into 60 minutes of arc and each minute is divided into 60 seconds of arc. Degrees, minutes and seconds are denoted by the symbols °, ′, ″. Degrees of latitude are integers between 0 and 90, and should be followed by an indicator for the hemisphere (e.g. N or S). Degrees of longitude are integers between 0 and 180, and should be followed by an indicator for the hemisphere (e.g. E or W).

easting

Within a coordinate reference system (e.g. as provided by a GPS or a map grid reference system), the line representing eastward distance from a reference meridian on a map.

elevation

A measurement of the vertical distance of a land or water surface above a vertical datum. On maps, the reference datum is generally some interpretation of mean sea level or the geoid, while in devices using GPS/GNSS, the reference datum is the ellipsoid of the geodetic datum to which the GPS unit is configured, though the device may make corrections to report the elevation above mean sea level or the geoid. Elevations that are above a reference point should be expressed as positive numbers, while those below should be negative. Compare depth, distance above surface, and altitude.

ellipsoid

A three-dimensional, closed geometric shape, all planar sections of which are ellipses or circles. An ellipsoid has three independent axes. If an ellipsoid is made by rotating an ellipse about one of its axes, then two axes of the ellipsoid are the same, and it is called an ellipsoid of revolution. When used to represent a model of the earth, the ellipsoid is an oblate ellipsoid of revolution made by rotating an ellipse about its minor axis.

entry point

The entry point on the surface of the ocean or lake where a diver enters the water and from which all activities are measured. See Three-Dimensional Shapes (Chapman & Wieczorek 2020).

EPSG

EPSG codes are defined by the International Association of Oil and Gas Producers, using a spatial reference identifier (SRID) to reference spatial reference systems. The EPSG Geodetic Parameter Dataset (IOPG 2019) is a collection of definitions of coordinate reference systems (including datums) and coordinate transformations which may be global, regional, national or local in application.

error

The difference between a computed, estimated, or measured value and the accepted true, specified, or theoretically correct value. It encompasses both the imprecision of a measurement and its inaccuracies. Error can be either random or systematic. If the error is systematic, it is called "bias". Compare accuracy, bias, precision, false precision and uncertainty.

event

A process occurring at a particular location during a period of time. Used generically to cover various kinds of collecting events, sampling events, and observations.

extent

The entire space within the boundary a location actually represents. The extent can be a volume, an area, or a distance.

false precision

An artefact of recording data with a greater number of decimal places than implied by the original data. This often occurs following transformations from one unit or coordinate system to another, for example from feet to meters, or from degrees-minutes-and-seconds to decimal degrees. In general, precision cannot be conserved across metric transformations; however, in practice it is often recorded as such. For example, a record of 10°20′ stored in a database in decimal degrees is ~10.3°. When exported from some databases, it will result in a value of 10.3333333333 with a precision of 10 decimal places in degrees rather than the original precision of 1-minute. Misinterpreting the precision of the coordinate representation as a precision in distance on the ground, 10^{-10} degrees corresponds to about 0.002 mm at the equator, while the precision of 1-minute corresponds to about 2.6 km. This is not a true precision as it relates to the original data, but a false precision as reported from a combination of the coordinate conversion and the representation of resulting fraction in the export from a database. Compare with precision and accuracy.

feature

An object of observation, measurement, or reference that can be represented spatially. Often categorized into "feature types" (e.g. mountain, road, populated place, etc.) and given names for specific instances (e.g. "Mount Everest", "Ruta 40", "Istanbul"), which are also sometimes referred to as "named places", "place names" or "toponyms".

footprint

See shape. Note that "footprint" was used in some earlier georeferencing documents and in the Darwin Core term names `footprintWKT` and `footprintSpatialFit`.

gazetteer

An index of geographical features and their locations, often with geographic coordinates.

generalization

In geographic terms, refers to the conversion of a geographic representation to one with less resolution and less information content; traditionally associated with a change in scale. Also referred to as: *fuzzying*, *dummying-up*, etc. (Chapman 2020).

geocode

The process (verb) or product (noun) of determining the coordinates for a street address. It is also sometimes used as a synonym for georeference.

geodetic coordinate reference system

A coordinate reference system based on a geodetic datum, used to describe positions on the surface of the earth.

geodetic datum

A mathematical model that uses a reference ellipsoid to describe the size and shape of the surface of the earth and adds to it the information needed for the origin and orientation of coordinate systems on that surface.

geographic boundary

The representation in geographic coordinates of a vertical projection of a boundary onto a model of the surface of the earth.

geographic center

The midpoint of the extremes of latitude and longitude of a feature. Geographic centers are relatively easy to determine, but they generally do not correspond to the center obtained by a least circumscribing circle. For that reason it is not recommended to use a geographic center for any application in georeferencing. Compare corrected center.

geographic component

The part of a description of a location that consists of geographic coordinates and associated uncertainty. Non-geographic components of a location description include elevation, depth, and distance above surface.

geographic coordinate system

A coordinate system that uses geographic coordinates.

geographic coordinate reference system

A geodetic coordinate reference system that uses geographic coordinates.

geographic coordinates

A measurement of a location on the earth’s surface expressed as latitude and longitude.

geographic extent

The entire space within the geographic boundary of a location. The geographic extent can be an area or a distance.

geographic information system (GIS)

A set of computer-based tools designed to capture, store, manipulate, analyse, map, manage, and present all types of geographical data and information in the form of maps.

geographic radial

The distance from the corrected center of a location to the furthest point on the geographic boundary of that location. The geographical radial is what contributes to calculations of the maximum uncertainty distance using the point-radius georeferencing method. The term geographic radial, as defined here, replaces its equivalent "extent" used in the early versions of these Best Practices and related documents, including the Georeferencing Quick Reference Guide (Wieczorek et al. 2012a) and versions of the Georeferencing Calculator (Wieczorek & Wieczorek 2018) and its Manual for the Georeferencing Calculator (Wieczorek & Bloom 2015) before 2019, while the new definition of extent as found in this document remains more in keeping with common usage and understanding and has also been updated in the latest versions of the Georeferencing Quick Reference Guide (Zermoglio et al. 2020) and in this Manual.

geoid

A global equipotential surface that approximates mean sea level. This surface is everywhere perpendicular to the force of gravity (Loweth 1997).

geometry

The measures and properties of points, lines, and surfaces. Geometry is used to represent the geographic component of locations.

georeference

The process (verb) or product (noun) of interpreting a locality description into a spatially mappable representation using a georeferencing method. Compare with geocode. The usage here is distinct from the concept of georeferencing satellite and other imagery (known as georectification).

georeferencing method

The type of spatial representation produced as the output of a georeferencing protocol. In this document we discuss three particular methods of representation in detail, the shape method, the bounding box method, and the point-radius method.

georeferencing protocol

The documented specific steps to apply to a locality, based on the locality type, to produce a particular type of spatial representation.

GIS

see geographic information system.

Globally Unique Identifier (GUID)

Globally Unique Identifier, a 128-bit string of characters applied to one and only one physical or digital entity so that the string uniquely identifies the entity and can be used to refer to the entity. See also persistent identifier (PID).

GNSS

Global Navigation Satellite System, the generic term for satellite navigation systems that provide global autonomous geo-spatial positioning. This term encompasses GPS, GLONASS, Galileo, BeiDou and other regional systems.

GPS

Global Positioning System, a satellite-based system used for determining positions on or near the earth. Orbiting satellites transmit radio signals that allow a receiver to calculate its own location as coordinates and elevation, sometimes with accuracy estimates. A GPS or GNSS Receiver (including those in smartphones and cameras) is the instrument that receives the radio signals and translates them into geographic coordinates. See also GNSS of which GPS is one example.

GPS (receiver)

The colloquial term used to refer to both GPS and GNSS receivers. A GPS or GNSS receiver is an instrument which, in combination with an inbuilt or separate antenna, is able to receive and interpret signals from GNSS satellites.

grid

a network or array of evenly spaced orthogonal lines used to organize space into partitions. Often these are superimposed on a map and used for reference, such as Universal Transverse Mercator (UTM) grid.

ground zero

the location on the land surface directly above a radiolocation point in a cave where the magnetic radiation lines are vertical. See Elevation (Chapman & Wieczorek 2020).

GUID

see Globally Unique Identifier.

heading

Compass direction such as east or northwest, or sometimes given as degrees clockwise from north. Usually used in conjunction with offset to give a distance and direction from a feature.

height datum

see vertical datum.

latitude

The angular distance of a point north or south of the equator.

locality

The verbal representation of a location, also sometimes called "locality description".

locality clause

A part of a locality description that can be categorized into one of the locality types, to which a specific georeferencing method can be applied.

locality type

A category applied to a locality clause that determines the specific georeferencing method that should be applied.

location

A physical space that can be positioned and oriented relative to a reference point, and potentially described in a natural language locality description. In georeferencing, a location can have distinct representations based on distinct rules of interpretation, each of which is embodied in a georeferencing method.

longitude

The angular distance of a point east or west of a prime meridian at a given latitude.

magnetic declination

The angle on the horizontal plane between magnetic north (the direction the north end of a magnetized compass needle points, corresponding to the direction of the Earth's magnetic field lines) and true north (the direction along a meridian towards the geographic North Pole). This angle varies depending on the position on the Earth's surface and changes over time.

maximum uncertainty distance

The radius in a point-radius representation of a location, that is a numerical value that defines the upper limit of the horizontal distance from the position of the given geographic coordinate to a point on the outer extremity of the geographic area within which the whole of a location lies. When given in meters, it corresponds to the Darwin Core term `coordinateUncertaintyInMeters`.

mean sea level (MSL)

A vertical datum from which heights such as elevation are usually measured. Mean sea levels were traditionally determined locally by measuring the midpoint between a mean low and mean high tide at a particular location averaged over a 19-year period covering a complete tidal cycle. More recently, MSL is best described by a geoid.

meridian

A line on the surface of the earth where all of the locations have the same longitude. Compare antimeridian and prime meridian.

named place

see feature. Note that "named place" was used in some earlier georeferencing documents.

northing

Within a coordinate reference system (e.g. as provided by a GPS or a map grid reference system), the line representing northward distance from a reference latitude.

offset

A displacement from a reference location. Usually used in conjunction with heading to give a distance and direction from a feature.

path

A route or track between one place and another. In some cases the path may cross itself.

persistent identifier (PID)

A long-lasting reference to a document, file, web page, or other object. The term "persistent identifier" is usually used in the context of digital objects accessible over the Internet. There are many options for PIDs, such as Globally Unique Identifiers (GUIDs), Digital Object Identifiers (DOIs), and Universal Unique Identifiers (UUIDs).

point-radius

A representation of the geographic component of a location as a geographic coordinate and a maximum uncertainty distance. The point-radius georeferencing method produces georeferences that include geographic coordinates, a coordinate reference system, and a maximum uncertainty distance that encompasses all of the possible geographic coordinates where a locality might be interpreted to be. This representation encompasses all of the geographical uncertainties within a circle. The point-radius method uses ranges to represent the non-geographic descriptors of the location (elevation, depth, distance above surface).

precision

1. The closeness of a repeated set of observations of the same quantity to one another – a measure of control over random error.
2. With values, it describes the finest unit of measurement used to express that value (e.g. if a record is reported to the nearest second, the precision is 1/3600th of a degree; if a decimal degree is reported to two decimal places, the precision is 0.01 of a degree).

Antonym: imprecision. Compare accuracy, error, bias, false precision, and uncertainty.

prime meridian

The set of locations with longitude designated as 0 degrees east and west, to which all other longitudes are referenced. The Greenwich meridian is internationally recognized as the prime meridian for many popular and official purposes.

projection

A series of transformations that convert the locations of points in a coordinate reference system on a curved surface (the reference surface or datum) to the locations of corresponding points in a coordinate reference system on a flat plane. The datum is an integral part of the projection, as projected coordinate systems are based on geographic coordinates, which are in turn referenced to a geodetic datum. It is possible, and even common for datasets to be in the same projection, but referenced to distinct geodetic datums, and therefore have different coordinate values.

quality

see data quality.

radial

The distance from a center point (e.g. the corrected or geographic center) within a location to the furthest point on the outermost boundary of that location. See also geographic radial.

repatriate, repatriation

The process of returning something to the source from which it was extracted. In the georeferencing sense, this refers to the process of adding the results of georeferencing to the original data, especially when georeferencing was done by a third party.

rules of interpretation

A documented set of steps to take in order to produce a standardized representation of source information.

Satellite Based Augmentation System (SBAS)

A civil aviation safety-critical system that supports wide-area or regional augmentation through the use of geostationary (GEO) satellites that broadcast the augmentation information (see discussion in Satellite Based Augmentation System (Chapman & Wieczorek 2020)).

shape

Synonym of footprint. A representation of the geographic component of a location as a geometry. The result of a shape georeferencing method includes a shape as the geographic component of the georeference, which contains the set of all possible geographic coordinates where a location might be interpreted to be. This representation encompasses all of the geographical uncertainties within the geometry given. The shape method uses ranges to represent the non-geographic descriptors of the location (elevation, depth, distance above surface).

smallest enclosing circle

a circle with the smallest radius (radial) that contains all of a given set of points (or a given shape) on a surface (see Smallest-circle problem). This is seldom the same as the geographic center, nor the midpoint between two most distant geographic coordinates of a location.

spatial fit

a measure of how well one geometric representation matches another geometric representation as a ratio of the area of the larger of the two to the area of the smaller one. (See Determining Spatial Fit (Chapman & Wieczorek 2020)).

spatial reference system

see coordinate reference system.

stratigraphic section

A local outcrop or series of adjacent outcrops that display a vertical sequence of strata in the order they were deposited.

transect

A path along which observations, measurements, or samples are made. Transects are often recorded as a starting location and a terminating location.

trig point

A surveyed reference point, often on high points of elevation (mountain tops, etc.) and usually designated with a fixed marker on a small pyramidal structure or a pillar. The exact location is determined by survey triangulation and hence the alternative names "trigonometrical point", "triangulation point" or "benchmark".

uncertainty

A measure of the incompleteness of one's knowledge or information about an unknown quantity whose true value could be established if complete knowledge and a perfect measuring device were available (Cullen & Frey 1999). Georeferencing methods codify how to incorporate uncertainties from a variety of sources (including accuracy and precision) in the interpretation of a location. Compare accuracy, error, bias, precision, and false precision.

Universal Transverse Mercator (UTM)

A standardized coordinate system based on a metric rectangular grid system and a division of the earth into sixty 6-degree longitudinal zones. The scope of UTM covers from 84° N to 80° S. (See Universal Transverse Mercator (UTM) Coordinates (Chapman & Wieczorek 2020)).

vertical datum

A reference surface for vertical positions, such as elevation. Vertical datums fall into several categories, including: tidal, based on sea level; gravimetric, based on a geoid; geodetic, based on ellipsoid models of the Earth; or local, based on a local reference surface. Also known as height datum.

Wide Area Augmentation System (WAAS)

An air navigation aid developed by the US Federal Aviation Administration to augment the Global Positioning System (GPS), with the goal of improving its accuracy, integrity, and availability. See also SBAS, of which WAAS is one example.

WGS84

World Geodetic System 1984, a popular globally-used horizontal geodetic coordinate reference system (EPSG:4326) upon which raw GPS measurements are based (though a GPS receiver is capable of delivering coordinates in other reference systems). The term is also commonly used for the geodetic datum used by that system and for the ellipsoid (EPSG:7030) upon which that datum (EPSG:6326) is based.

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