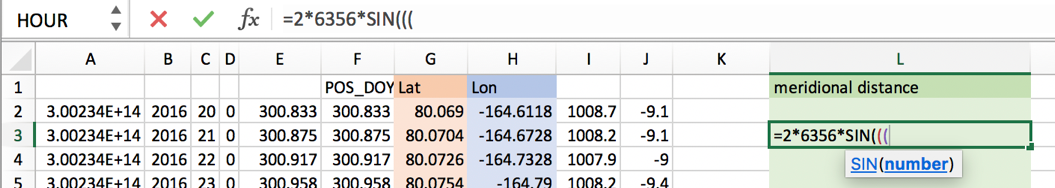
**(2.4) Extension: Distance and bearing along a trajectory**

*If you would like an extra challenge, you can use excel to calculate the distance traveled by a buoy at many points in time over many days. This lets us calculate the distance along a long winding buoy trajectory by breaking the trajectory into pieces.*

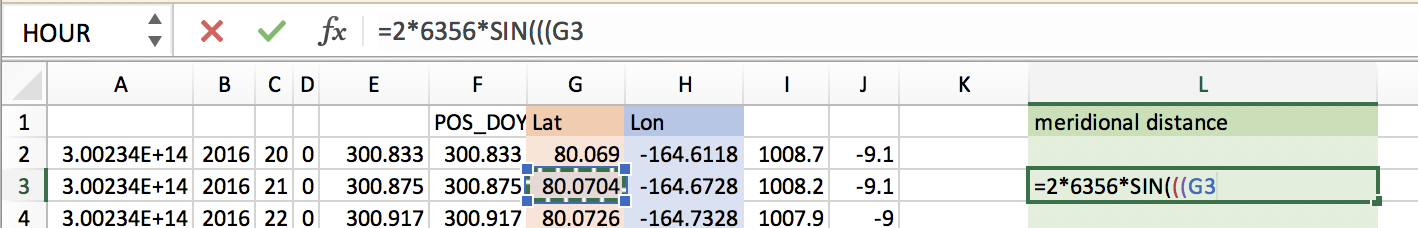
Piecewise linear approximation of the buoy trajectory:

We can do these calculations with excel. The following instructions will allow you to calculate distance travelled between each position reported by the buoy.

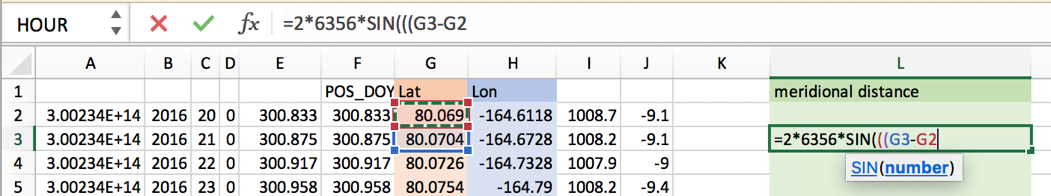
1. Open your excel notebook containing the buoy data
2. Find an empty column in the notebook. Title this column **Meridional Distance**. *This column will calculate the meridional distance traveled over each reported buoy position between its position at a given row of data and its position at the row before.*
   1. **Click** on the 2nd row of this column (or whichever row is aligned with the 2nd row of the buoy data) to begin the following equation:
   2. **Type ‘=’** to set the cell equal to an equation.
   3. Type ‘**2\*6356\*SIN(((**’ to begin the equation.



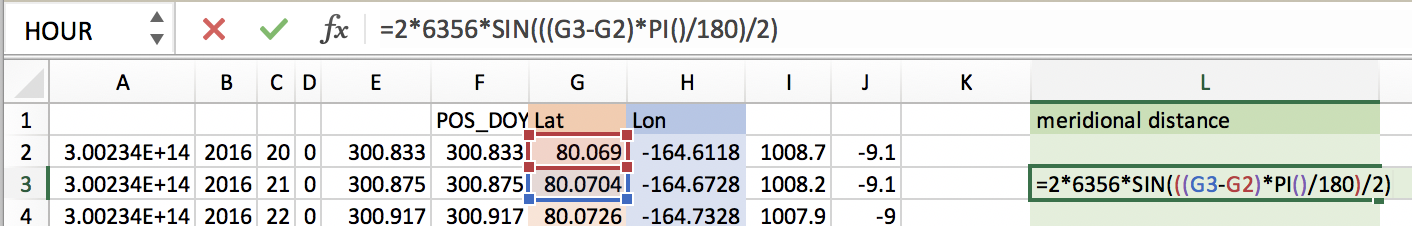
* 1. **Click** on the second row of data in the buoy’s Latitude List.



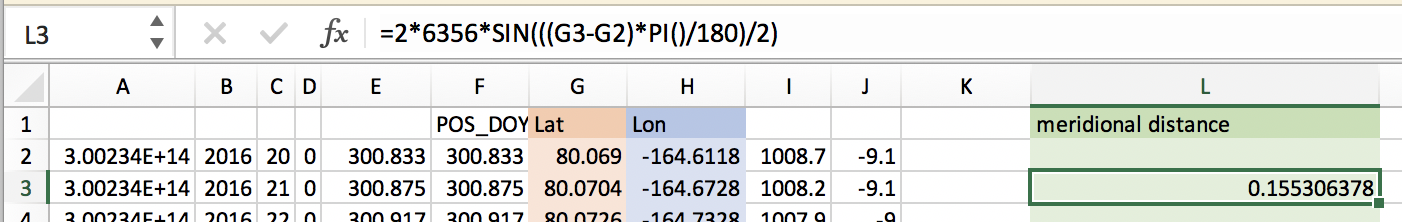
* 1. **Type ‘-’** and then **click** on the first row of data in the buoy’s Latitude List.



* 1. **Type ‘)\*PI()/180’** to convert from degrees to radians and then **type ‘)/2)**’ to finish the equation.

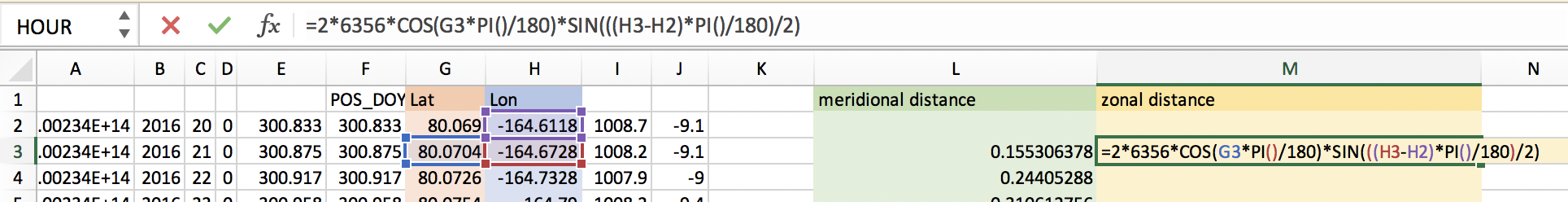


* 1. Press **enter**. A number will appear in the cell. Do the calculation by hand to check that it is accurate.
  2. **Click** on the cell. It will become outlined in green.



* 1. **Click** on the green square in the bottom right corner of the cell, and drag down to repeat this calculation for the whole latitude list (or for however long you would like to carry out the calculation)

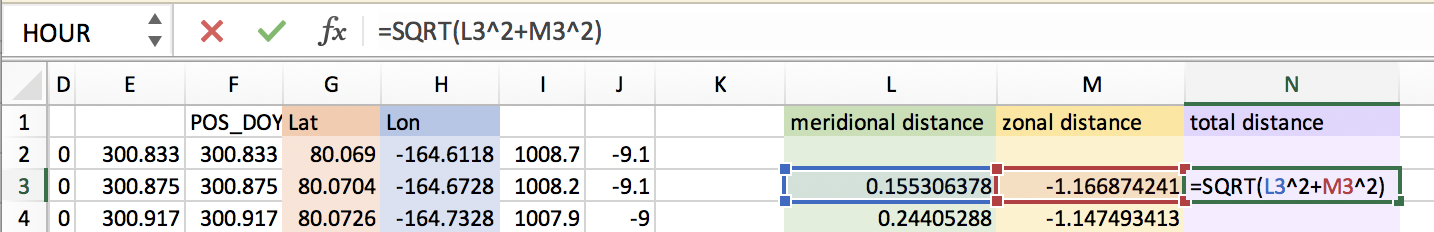
1. Find another empty column and title this column **Zonal Distance**. *This column will calculate the zonal distance traveled over each reported buoy position using the following equation:*
   1. See if you can set up this equation on your own. If you need assistance, you can check against the equation written below as a guide:



* 1. Repeat *steps 2i- 2j* to carry out the calculation for as many rows as you choose.

1. Find another empty column title it **Total Distance**. This is where you will calculate the distance traveled during each reported buoy position, using:
   1. See if you can carry out this calculation yourself. Again, you can reference the below example if needed.

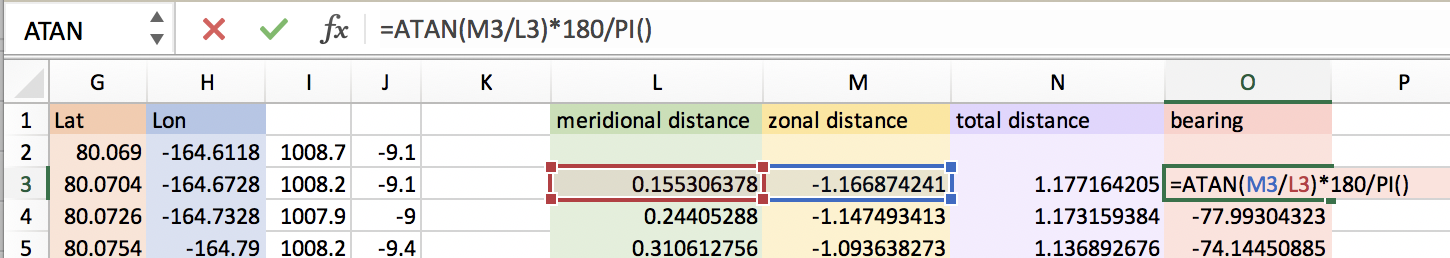
* To take the square root of something in excel, type ‘**SQRT(**’
* To square something in excel, type ‘**^2**’ after the value you want to square.



* 1. Repeat *steps 2i- 2j* to carry out the calculation for as many rows as you choose.

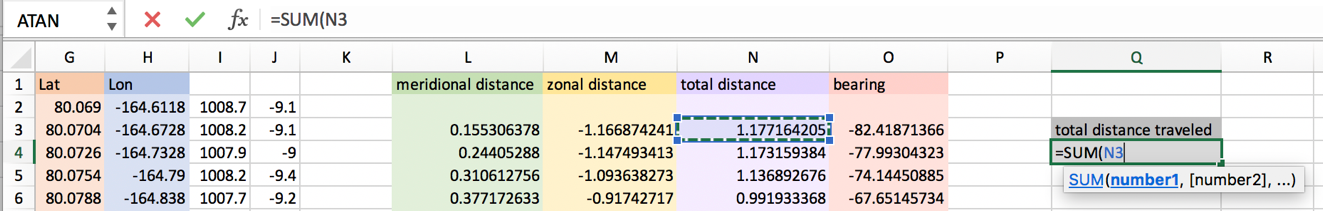
1. Find another empty column title it **Bearing**. This is where you will calculate the bearing of the buoy’s travel over each change in reported buoy position, using:
   1. See if you can carry out this calculation yourself. Again, you can reference the below example if needed.

* To take an arctangent in excel, use ‘**ATAN(**’
* To convert from radians to degrees, use **‘\*180/PI()’**

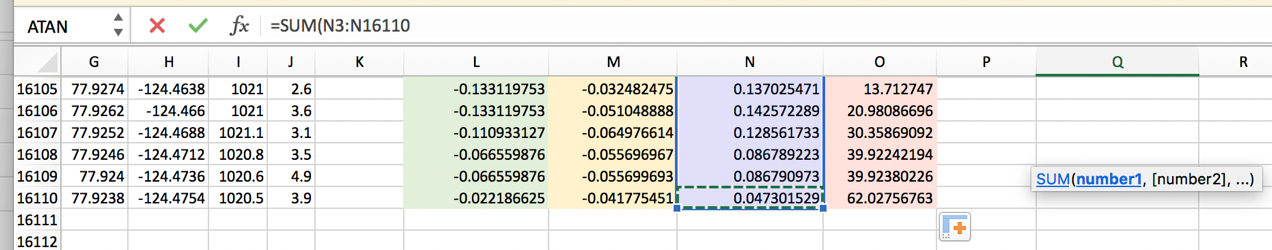


* 1. Repeat *steps 2i- 2j* to carry out the calculation for as many rows as you choose.

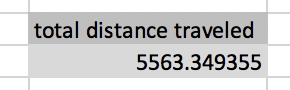
1. Find an empty cell and click on it. This is where you will calculate the total distance traveled over the entire time span of the buoy data.
   1. Type ‘**= SUM(**’ to begin a new equation.



* 1. **Click** on the first data value in the data column **Total Distance**.
  2. Type ‘**:**’ and then **click** on the last data value in **Total Distance**



* 1. **Type ‘)’** and press **enter** to finish the equation.



Equations written out in plain text:

2.a. = 2\*6356\*SIN(((latB-latA)\*PI()/180)/2)

3.a. = 2\*6356\*COS(latB\*PI()/180)\*SIN(((lonB-lonA)\*PI()/180)/2)

4.a. = SQRT(z^2 + m^2)

5.a. = ATAN(z/m)\*180/PI()