Corrections to Gravity Survey Data

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2017-03-09

https://www.google.ca/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwj2qbOhn8rSAhVB8WMKHRHmA6sQjRwIBw&url=http%3A%2F%2Fwww.loe.org%2Fshows%2Fsegments.html%3FprogramID%3D13-P13-00042%26segmentID%3D6&bvm=bv.149093890,d.cGc&psig=AFQjCNFusElWMwhMOVhXaahUEVgnFvI1WQ&ust=1489177120180518

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Background and Theory

- Absolute Gravity:

$$g_i = g_{abs,0} + \Delta g_i$$

- Normal gravity:

$$\Delta g_{norm} = g_t(\theta)$$

IGF: $g_t(\theta) = 9.780327[1 + 0.0053024\sin^2(\theta) - 0.0000058\sin^2(2\theta)]$

- Tide correction:

$$\Delta g_{tide,i} = \Delta g_{tide,ref}(\theta, \varphi, t_i)$$

- Instrument drift: (linear relationship)

$$\Delta g_{drift,i} = \frac{g_{ref,2} - g_{ref,1}}{t_{ref,2} - t_{ref,1}}(t_i - t_{ref,1})$$

(Measurements at base station at both beginning and end of the loop)

Background and Theory

- Free air correction:

$$\Delta g_{FA,i} = -\frac{2GM_e\Delta Z_i}{{R_e}^3} \approx -0.3086\mathrm{mGal/m}$$

- Bouguer plate correction:

Surface: $\Delta g_{BP,i} = 2\pi G\rho_B\Delta Z_i \approx 0.04193\rho_B\mathrm{mGal/m}$

Underground: $\Delta g_{BP,i} = 4\pi G\rho_B\Delta Z_i \approx 0.08387\rho_B\mathrm{mGal/m}$

- terrain correction:

$$\Delta g_{terr,i} = -\sum_m \frac{GM_m|Z_{im}-Z_{datum}|}{{r_{im}}^3}$$

$$\Delta g_{B,i} = g_{abs,0} + \Delta g_i - \Delta g_{norm} - \Delta g_{tide,i} - \Delta g_{drift,i} - \Delta g_{FA,i} - \Delta g_{BP,i} - \Delta g_{terr,i}$$

Algorithm Implementation – Gravity Corrections

- Quickly going over questions 1 – 7
  - Loading data and performing fairly simple operations to produce figures
  - Sorting into unique lists, creating columns

Algorithm Implementation – Gravity Corrections

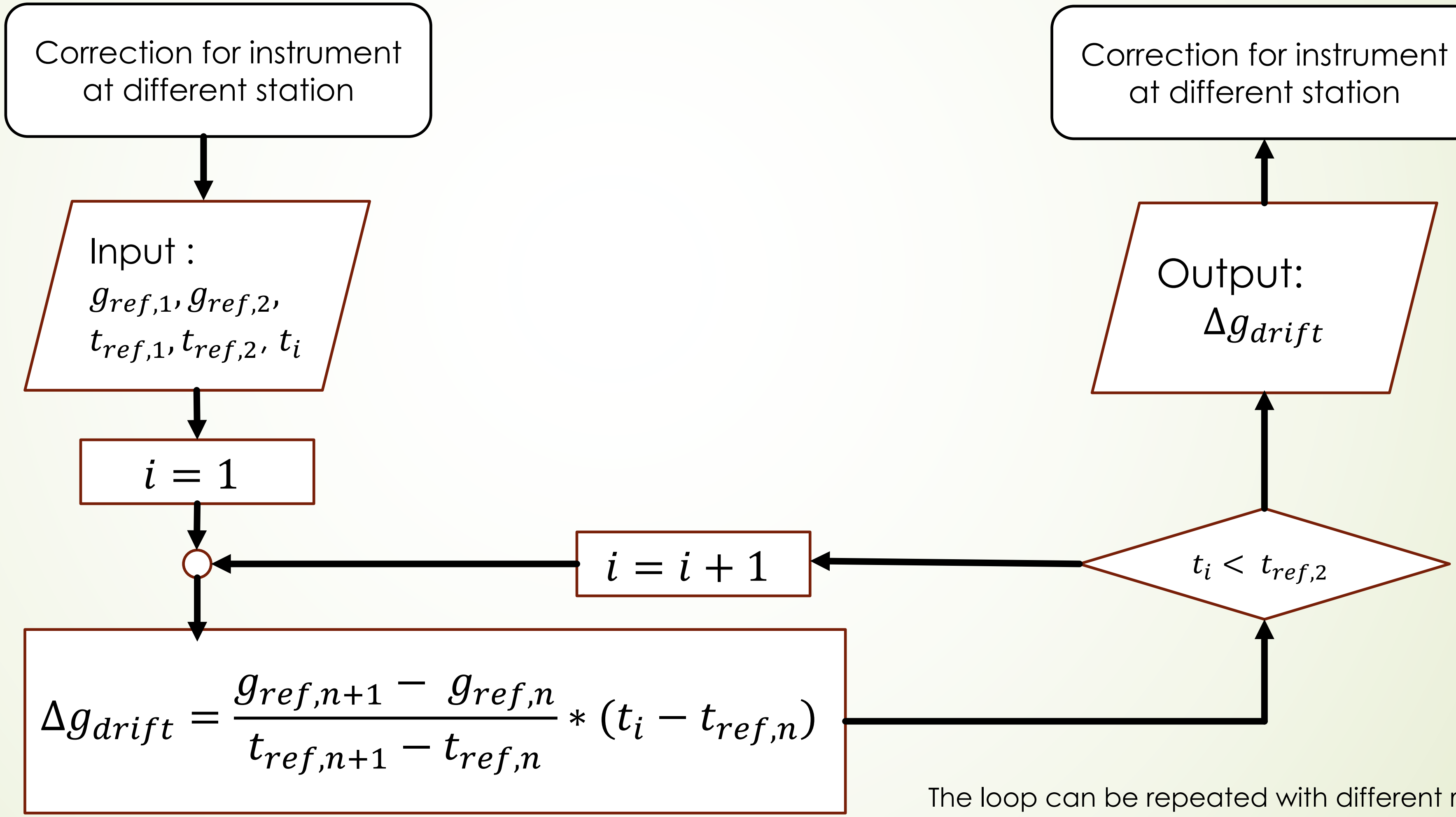
- Question 8 – 9 implementation
  - Q8: Using **IGF** from background and theory and applying it to obtain normal gravity
  - Q9: create variable 'l' to use in 'for' loop to execute the number of times to add gnorm points to all other points
  - Sort the unique data to compose grid for normal gravity corrected data, which is later plotted

```
% Q9
g_norm=g_corr;
g_norm(1)=g_corr(1);
l=length(g_norm);
for i=2:l
    g_norm(i)= g_norm(1)+g_norm(i);
end
g_norm=g_norm(ind_sort);% Extracting the sorted data
g_norm=g_norm(ind_uniq);% Extracting the unique data
g_norm=reshape(g_norm,[Nx Ny]);% Turning the data into a grid
```

Algorithm Implementation – Elevation Corrections

- Question 8 – 9 implementation
  - Q8: Using **IGF** from background and theory and applying it to obtain normal gravity
  - Q9: create variable 'I' to use in 'for' loop to execute the number of times to add gnorm points to all other points
  - Sort the unique data to compose grid for normal gravity corrected data, which is later plotted

Drift Correction



The loop can be repeated with different reference point to make the data more accurate

Algorithm Implementation – Elevation Corrections

- Question 15/16 – Free Air Corrections
  - Creating variable del_Z which is the difference from the mean elevation to survey point
  - Applying formula to calculate free air correction and then adding it to our previous g_corr, then creating new variable to store value
  - Finally getting min max for later plots

$$\Delta g_{FA} = -\frac{GM_e \Delta Z_i}{R_e^3} \approx -0.3086 \text{ mGal/m}$$

```
del_Z = Zg - z_datum; % m
dg_FA = (-0.3086*del_Z); % Calculates free air correction in units mGal
dg_FA = dg_FA * 1000; % Convert mGal to microGal
g_corr = g_corr + dg_FA; % Apply free air correction

g_FA = g_corr;

maxGFA =  max(max(g_FA)); % Max and min of free air corrected gravity
minGFA = min(min(g_FA));
```

Algorithm Implementation – Elevation Corrections

- Question 17/18 – Bougeur Plate Corrections
  - Very similar to previous implementation
  - Using previously created variable del_Z, and multiplying it with our given density (**2.65gcm^-3**), Bougeur Plate correction is found, then converted to appropriate units and added to our g_corr
  - Storing g_corr as g_elev, finding min and max which are then like before are used to plot figures

$$\Delta g_{BP} = 2\pi G \rho_B \Delta Z \approx 0.04193 \rho_B \ \text{mGal/m}$$

```
rho_b = 2.650; % Density in units g/cm^3
dg_BP = 0.04193*rho_b*del_Z; % Calculates the Bouguer Plate correction in units mGal
dg_BP = dg_BP * 10^3; % Converts mGal to microGal
g_corr = g_corr + dg_BP; % Applies Bouguer plate correction

g_elev = g_corr;

maxGelev = max(max(g_elev)); % Max and min of Bouguer corrected gravity
minGelev = min(min(g_elev));
```

Concluding Remarks

- Raw gravity data can be inaccurate at face value
- Must apply corrections;
  - Normal gravity
  - Tidal drift, instrument drift
  - Elevation
  - Terrain

References

- [1,2]Karchewski, B. (2017). GOPH 547 - Gravity and magnetics. Retrieved from https://d2l.ucalgary.ca/d2l/le/content/169330/viewContent/2346958/View
- W.M. Telford, L.P. Geldart and R.E. Sheriff. (1990). *Applied Geophysics, Second Edition*. Cambridge University Press.