Physical Geodesy Lab3: Gravity and Coriolis accelerations

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Task1: Gravity, gravitation, and centrifugal accelerations

1.

1.1 Gravitational potential V

$$V = \frac{GM}{R} = \frac{G \cdot 4/3\pi\rho R^3}{R} = \frac{4}{3}\pi G\rho R^2 = 6.256 \times 10^7\ m^2/s^2$$

1.2 Centrifugal potential V_c

$$V_c = \int \boldsymbol{a_c} = \frac{1}{2}w^2R^2(\cos\varphi)^2 = 9.530 \times 10^4\ m^2/s^2$$

1.3 Gravity potential W

$$W = V + V_c = \frac{4}{3}\pi G\rho R^2 + \frac{1}{2}w^2R^2(\cos\varphi)^2 = 6.266 \times 10^7\ m^2/s^2$$

1.4 Gravitational attraction a

$$\boldsymbol{a} = -\frac{GM}{R^3} \cdot \begin{pmatrix} x \\ y \\ z \end{pmatrix} = -\frac{GM}{R^3} \cdot \begin{pmatrix} Rcos\varphi cos\lambda \\ Rcos\varphi sin\lambda \\ Rsin\varphi \end{pmatrix}$$

$$a = |\boldsymbol{a}| = \frac{GM}{R^2} = 9.8197\ m/s^2$$

1.5 Gravity attraction g

Centrifugal attraction

$$\boldsymbol{a_c} = -\boldsymbol{\omega} \times (\boldsymbol{\omega} \times \boldsymbol{r_e}) = \omega^2 \cdot \begin{pmatrix} x \\ y \\ 0 \end{pmatrix} = \omega^2 \cdot \begin{pmatrix} Rcos\varphi cos\lambda \\ Rcos\varphi sin\lambda \\ 0 \end{pmatrix}$$

Gravity attraction $\boldsymbol{g}$

$$\boldsymbol{g} = \boldsymbol{a} + \boldsymbol{a_c}$$

$$g = |\boldsymbol{g}| = 9.7898\ m/s^2$$

1.6 Disturbance of the direction ξ

$$\xi = \arccos\left(\frac{\boldsymbol{a} \cdot \boldsymbol{g}}{|\boldsymbol{a}||\boldsymbol{g}|}\right) = 0.0633°$$

1.7 Disturbance of the attraction δ_g

$$\delta_g = g - a = -0.0299\ m/s^2$$

2.

2.1 Disturbance of the direction ξ

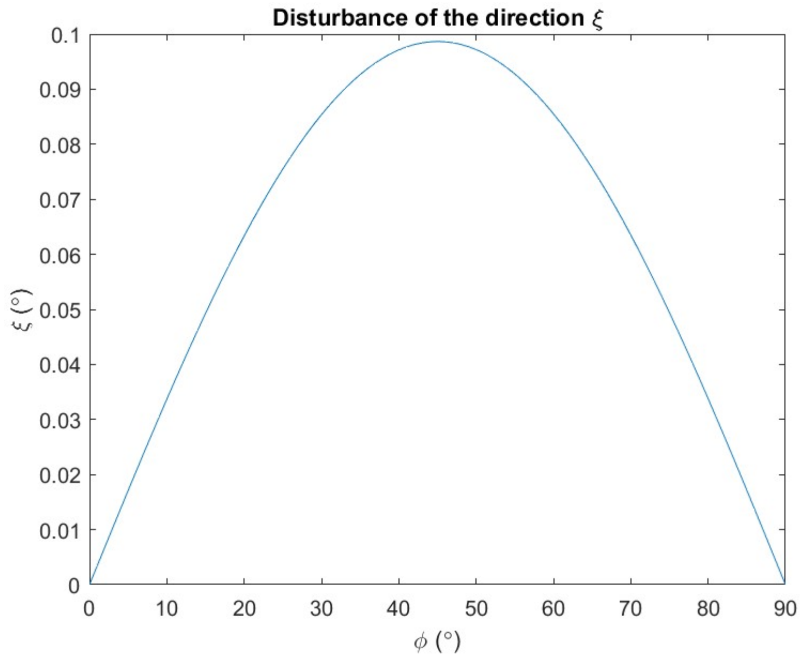

Fig 2.1

2.2 Disturbance of the attraction δ_g

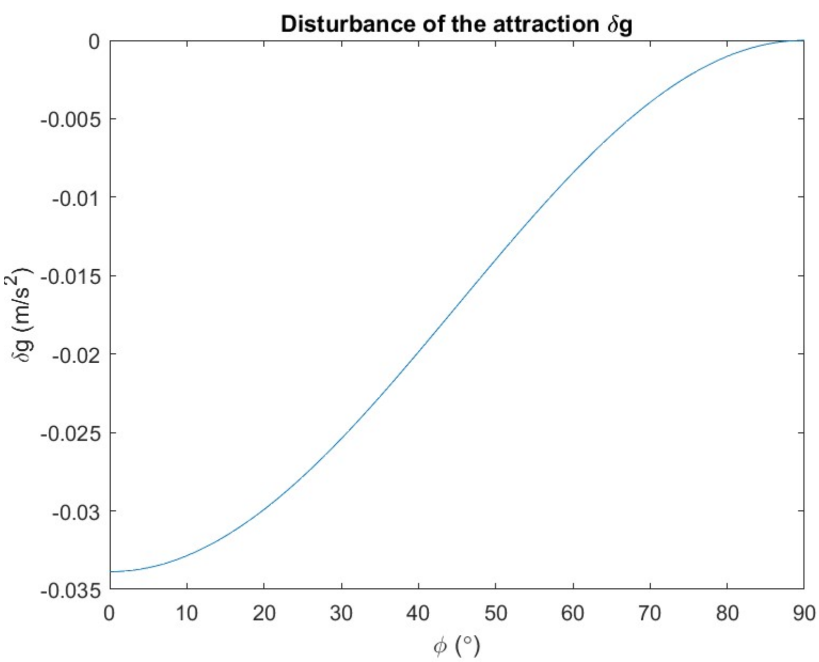

Fig 2.2

2.3 Centrifugal potential V_c

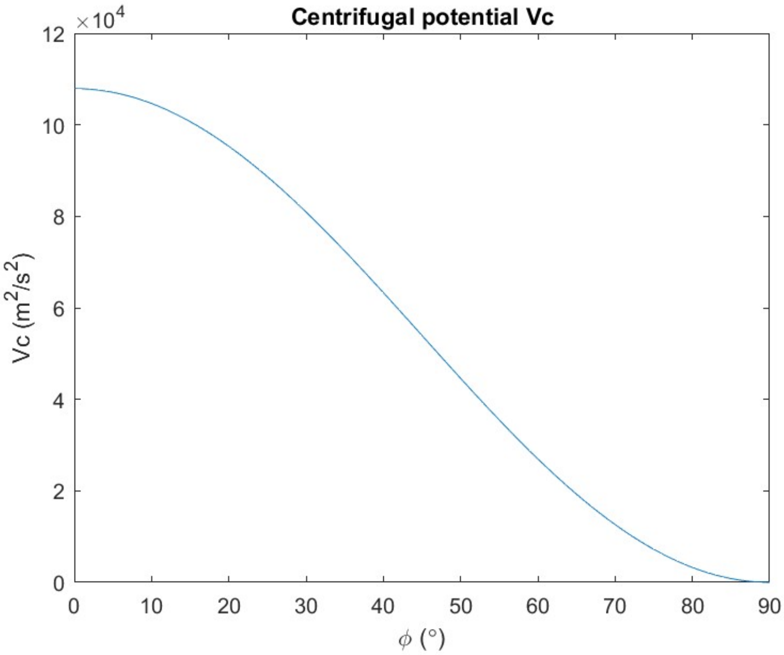

Fig 2.3

Task 2: Eotvos correction

3.1 Coriolis acceleration

$$\boldsymbol{a_{cor,e}} = -\boldsymbol{2} \cdot \boldsymbol{\omega} \times \dot{\boldsymbol{r}}_{\boldsymbol{e}} = 2\omega \cdot \begin{pmatrix} \dot{y} \\ -\dot{x} \\ 0 \end{pmatrix} = 2\omega \cdot \begin{pmatrix} -sin\varphi cos\lambda \cdot v_N - sin\lambda \cdot v_E \\ -sin\varphi sin\lambda \cdot v_N + cos\lambda \cdot v_E \\ cos\varphi \cdot v_N \end{pmatrix}$$

East-West:

$$\boldsymbol{a_{cor,e}} = 2\omega \cdot \begin{pmatrix} -sin\lambda \cdot v_E \\ cos\lambda \cdot v_E \\ 0 \end{pmatrix} = \begin{pmatrix} -0.0028 \\ 0.0160 \\ 0 \end{pmatrix}$$

$$a_{cor,e} = 0.0162 \ \ m/s^2$$

North-South:

$$\boldsymbol{a_{cor,e}} = 2\omega \cdot \begin{pmatrix} -sin\varphi cos\lambda \cdot v_N \\ -sin\varphi sin\lambda \cdot v_N \\ cos\varphi \cdot v_N \end{pmatrix} = \begin{pmatrix} -0.0107 \\ -0.0019 \\ 0.0120 \end{pmatrix}$$

$$a_{cor,e} = 0.0162 \ \ m/s^2$$

3.2 Eotvos correction

$$\boldsymbol{a_{cor,t}} = S_1 \cdot R(\varphi) \cdot R(\lambda) \cdot \boldsymbol{a_{cor,e}} = 2\omega \cdot \begin{pmatrix} -sin\varphi \cdot v_E \\ sin\varphi \cdot v_N \\ cos\varphi \cdot v_E \end{pmatrix}$$

$$a_{cor,t} = 2\omega \cdot \sqrt{v_E^2 + (sin\varphi)^2 \cdot v_N^2}$$

East-West:

$$\boldsymbol{a_{cor,t}} = 2\omega \cdot \begin{pmatrix} -sin\varphi \cdot v_E \\ 0 \\ cos\varphi \cdot v_E \end{pmatrix} = \begin{pmatrix} -0.0108 \\ 0 \\ 0.0120 \end{pmatrix}$$

$$a_{cor,t} = 0.0162 \ m/s^2$$

$$da = 2\omega \cdot dv_E$$

$$\sigma_v = \frac{\sigma_a}{2\omega} = 0.0686 \ m/s$$

North-South:

$$\boldsymbol{a_{cor,t}} = 2\omega \cdot \begin{pmatrix} 0 \\ sin\varphi \cdot v_N \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0.0108 \\ 0 \end{pmatrix}$$

$$a_{cor,t} = 0.0108 \ m/s^2$$

$$da = 2\omega \cdot sin\varphi \cdot dv_N$$

$$\sigma_v = \frac{\sigma_a}{2\omega \cdot sin\varphi} = 0.1025 \ m/s$$