Earth Tides

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1. Introduction

GeoTaos_Map has a built in map layer named as "Earth tides" which provides utilities estimating deformation and stress caused by the tidal forces. Tidal response at any given point on the earth for any given time or period can be theoretically calculated. There are two build-in or plug-in calculators in GeoTaos::Earth tides. The 1st one is "Solid tides" which calculates solid tides at near surface region. The 2nd one is Gotic2 program which has several options for the calculation of solid tides and ocean loading. At a location close to any of the oceans, where ocean tides are important, the Gotic2 program should be used. It is also possible to include tidal loading to the calculation of $\triangle CFS$ for given faults.

1.1 Solid tides

"Solid tides" is a fast calculator of synthetic solid tides. The tidal corrections of surface displacements caused by lunar and solar gravitational attraction are calculated using the nominal second degree and the third degree love numbers and Shida numbers (h20 = 0.6078, l20 = 0.0847, h3 = 0.292, l3 = 0.015).

Strain tensor can be computed by:

$$\varepsilon_{xx} = \varepsilon_{\lambda\lambda} = \frac{1}{r * \cos(\varphi)} \frac{\partial u_{\lambda}}{\partial \lambda} - \frac{\tan(\varphi)}{r} u_{\varphi} + \frac{u_r}{r}$$
(1)

$$\varepsilon_{yy} = \varepsilon_{\varphi\varphi} = \frac{1}{r} \frac{\partial u_{\varphi}}{\partial \varphi} + \frac{u_r}{R}$$
(2)

$$2\varepsilon_{xy} = 2\varepsilon_{\lambda\varphi} = \frac{1}{r * \cos(\varphi)} \frac{\partial u_{\lambda}}{\partial \lambda} + \frac{\tan(\varphi)}{r} u_{\lambda} + \frac{\partial u_{\lambda}}{\partial \varphi}$$
(3)

where z (r, radial, upward), x(eastward), y(northward), λ , ϕ are longitude and latitude, respectively. Near the earth's surface, where the boundary is stress-free, the vertical strain can be estimated by:

$$\varepsilon_{zz} = \varepsilon_{rr} = \frac{-\lambda}{\lambda + 2\mu} (\varepsilon_{xx} + \varepsilon_{yy})$$
$$= -\frac{1}{3} (\varepsilon_{xx} + \varepsilon_{yy}) \quad (\nu = 0.25) \tag{4}$$

From (4), the ratio of volumetric strain to area strain in the near surface region is about 2/3. Following approximation works quite well and thus can be used to estimate shear strain components on vertical planes from tilt.

$$\varepsilon_{xz} \approx -1.8T_e$$
 (5)

$$\varepsilon_{yz} \approx 0.375 T_n$$
 (5)

where Te (positive for upward-east) and Tn(positive for upward-north) are titles along north direction and east direction, respectively.

1.2 Gotic2

Gotic2 is a program developed by Matsumoto et al. for prediction theoretical solid tides and ocean loading effects

[Matsumoto et al., 2001; Matsumoto et al., 2000].

2. "Earth tides" layer in GeoTaos_map

2.1 Time series of tidal deformation

-				[1] Define lengthede and letitude in demos	
	Earth tides		<u>*</u>	[1] Define longitude and latitude in degree.	
0	Position		and the second	[2] Give altitude in meter	
1	Lo, La (ceg)	104.033 30.1901	Set longitude and latitude		
2	Altitude m	500.	Set altitude	[3] Time zone	
3	Time zone	0	Set time zone	[1] Time or start time of a period	
4	Time	2008/05/12 06:28:04(UTC)	Set base time in local time	[4] TIME OF STALL TIME OF a PELLOU	
5	Prediction	10. 10.	days and interval in mnute for tick	[5] Days of the period and interval in minute	
6	Run.	1: SolidTides (surface disp.) [type=1] •	Calculate near surface displaceme	[6] Click [Run] to calculate the time series.	
7	Brd Mesh	Srd Mesh	On/Off the 3rd mesh in Gotic2	[0] CITCK [Kan] to carcatate the time beries.	
8	Ith Mesh	T 4th Mesh	On/Off the 4th mesh in Gotic2	[7]-[9] Ontions for ocean load	
9	Precise green fu	Precise green function	On/Off switch modes of green fun		
10	Wave	1: Major 8(M2,S2,K1,O1,N2,P1,K2,Q1)	Select tidal waves	[11] Click [Run] to calculate the time series	
11	Gotic2	1: Solid tides+Ocean load[type=1] •	Predict solid tides using Gotic2. P	using Gotic2.	
12	12 Create 3D Mesh				
13	nGX, nGY	101. 101.	Number of grids along EW and NS	[13] Number of grids in EW and NS directions	
14	Zd, Zu	-20000. 0	m, Top and bottom elevation		
15	nGz	51.	Number of vertical grics	[14] Z range in meter	
16		3D Mesh	Create 3D mesh of tidal strains	[15] Grid number in vertical direction	
17					
18	S. CFS	2: *Gotic2 (precise) ·	As source of CFS calculation	[16] Click [3D Mesh] to calculate tidal	
19	19 SPOTL pluges from SPOTL () deformation at 3D Meshes. The results a				
20	SPOTL	0: Convert ocen model frm ASC to bin .	Utilities of/for SPOTL	stored in 3D mesh map and will be added to the	
24	1	Let 1		stored in 50 mesh map and will be added to the	
	<u> </u>			"Base image" group.	
Dabo imogo Group.					
				[18] Selection for including tidal stress in dCFS	
				calculation	
				•	







Tidal deformation calculated on 2D/3D meshes

References

Matsumoto, K., T. Sato, T. Takanezawa, and M. Ooe (2001), GOTIC2: A Program for Computation of Oceanic Tidal Loading Effect, 測地学会誌, 47(1), 243-248.

Matsumoto, K., T. Takanezawa, and M. Ooe (2000), Ocean tide models developed by assimilating TOPEX/POSEIDON altimeter data into hydrodynamical model: a global model and a regional model around Japan, *Journal of Oceanography*, *56*(5), 567-581.