Earth Tides

Contents

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 △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:

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

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

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

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:

$$\varepsilon_{zz} = \varepsilon_{rr} = \frac{-\lambda}{\lambda + 2\mu}\left(\varepsilon_{xx} + \varepsilon_{yy}\right)$$

$$= -\frac{1}{3}\left(\varepsilon_{xx} + \varepsilon_{yy}\right) \ (\nu = 0.25) \quad (4)$$

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.

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

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

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

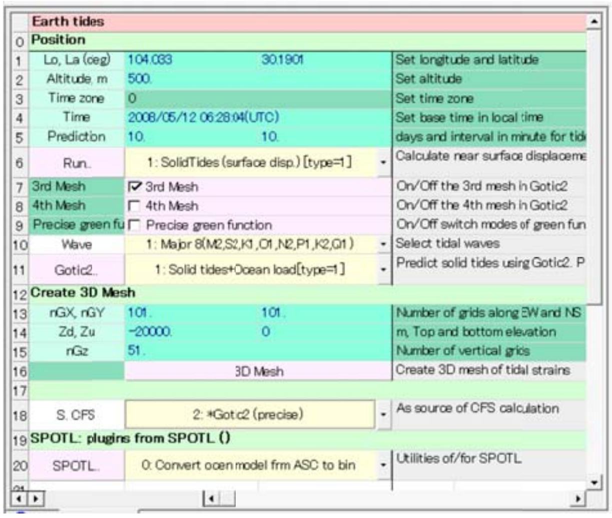
1.2 Gotic2

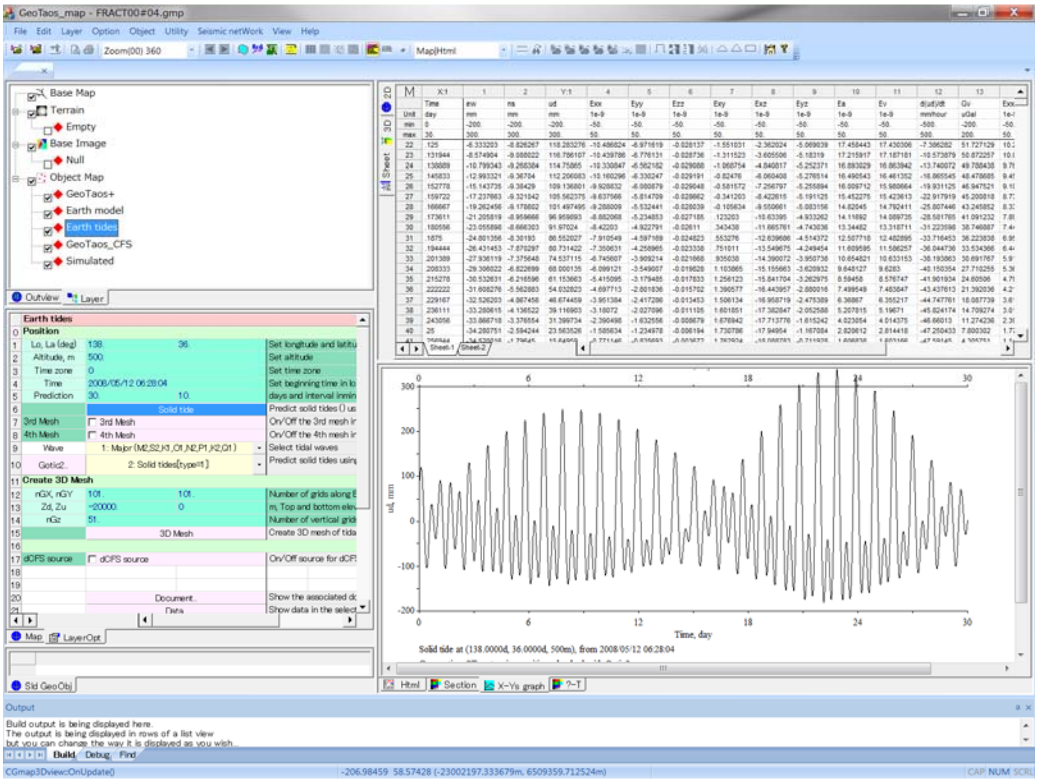
Gotic2 is a program developed by Matsumoto et al. for prediction theoretical solid tides and ocean loading effects

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

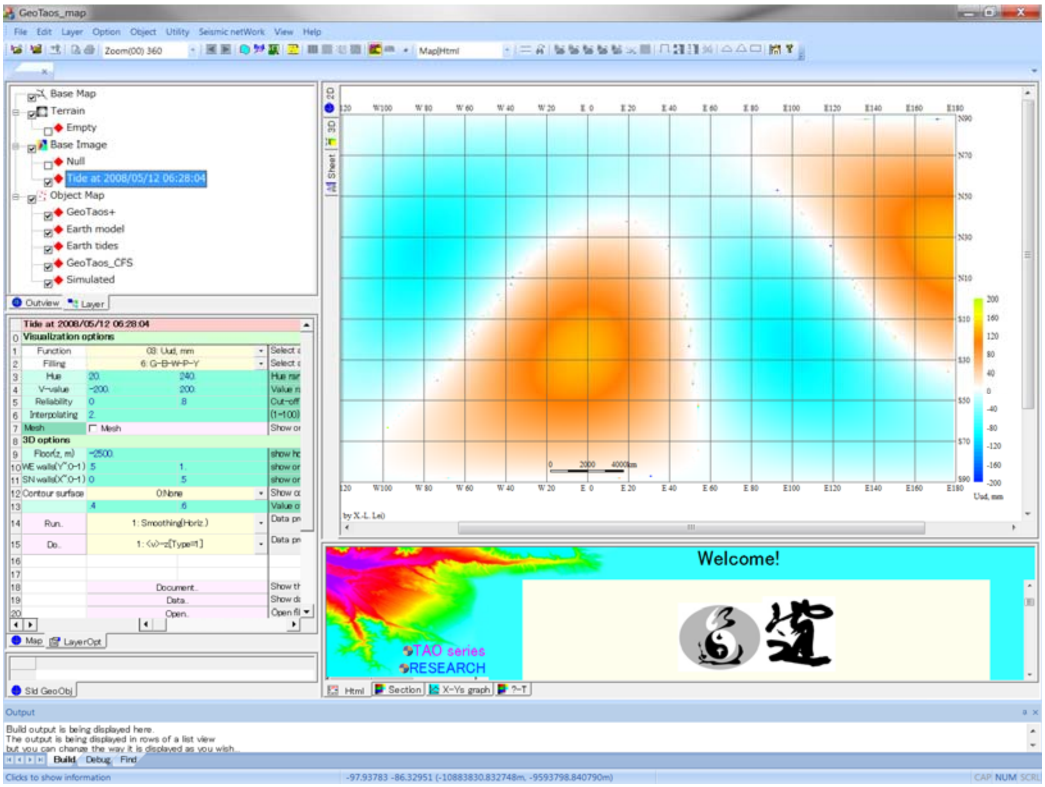
2. "Earth tides" layer in GeoTaos_map

2.1 Time series of tidal deformation

	[1] Define longitude and latitude in degree. [2] Give altitude in meter [3] Time zone [4] Time or start time of a period [5] Days of the period and interval in minute [6] Click [Run] to calculate the time series.
	[7]-[9] Options for ocean load [11] Click [Run] to calculate the time series using Gotic2.
	[13] Number of grids in EW and NS directions [14] Z range in meter [15] Grid number in vertical direction [16] Click [3D Mesh] to calculate tidal deformation at 3D Meshes. The results are stored in 3D mesh map and will be added to the "Base image" group.
	[18] Selection for including tidal stress in dCFS calculation



Tidal deformation calculated at a given position for a period



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.