

## **Tidal gravity factors Interpolated on a 0.5°x0.5° grid.**

Three main tidal gravity prediction programs are available through the ICET WEB site:  
PREDICT from ETERNA 3.4,  
MT80W,  
T-soft.

The characteristics of these programs are discussed in Ducarme B., 2006

Comparison of some tidal prediction programs and accuracy assessment of tidal gravity predictions.

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The input format of the three programs is really different, so that we must provide here 3 different sets of input parameters.

We provide values of the tidal parameters on the 0.5°x0.5° template used by Zahran et al., 2005. The ocean tides loading vector is computed according to the longitude, latitude and elevation of the nodes of the grid. It is then added to a body tides model to provide modeled tidal parameters as explained in the following section.

We propose here two different approaches:

- Zhou J.C. (2007) used the CSR3 ocean tides model together with a purely elastic Earth model. Ocean load vectors have been computed using the Agnew (1996, 1997) software.
- The NAO99 model was used at ICET with the Melchior et al. (1980) software. The computed load vectors were associated to a non hydrostatic/inelastic Earth model (Dehant et al., 1999) to compute modeled tidal parameters.

### **1. Tidal gravity prediction on the real Earth**

The main problem for tidal gravity prediction is that the Earth tides are strongly perturbed by the influence of the oceanic tides which modify the tidal parameters distribution at the surface of the Earth. The oceanic tides produce a direct attraction due to the moving water masses, a flexure of the crust and an additional change of the potential due to the mass redistribution. The effect can reach up to 10% of the Earth body tides, but is generally at the level of a few percent. The uncertainties and contradictions between different ocean tides models are such that the dispersion of the corresponding modeled tidal parameters  $\delta_m$ ,  $\alpha_m$  is generally at the level of a few tenths of a per cent. In coastal areas it can easily exceed 1%.

We use hereafter the general definition of the amplitude factor  $\delta$  as the ratio  $A/A_{th}$  of the tidal amplitude with respect to the astronomical tidal amplitude  $A_{th}$  (Melchior, 1978). For the main tidal waves, we build the modeled tidal factors based on the body tide amplitude  $\mathbf{R}(A_{th}, \delta_{model}, 0)$ , where  $\delta_{model}$  is the amplitude factor computed using a model of the response of the Earth to the tidal force, and the ocean load vector  $\mathbf{L}(L, \lambda)$ , computed from different ocean tides models. The modelled vector  $\mathbf{A}_m(A_m, \alpha_m)$  is given as

$$\mathbf{A}_m = \mathbf{R} + \mathbf{L} \quad (1)$$

The modelled amplitude factor  $\delta_m$  is simply given by the ratio  $A_m/A_{th}$ .

The  $\mathbf{R}$  vector depends on the choice of the body tides model describing the response of the Earth to the tidal forces. Dehant et al., 1999 proposed two different models the elastic

one and the non-hydrostatic/inelastic one. The discrepancy between the elastic and inelastic models is at the level of 0.15%. In such a way the modeled tidal factors are defined as

$$\mathbf{A}_m(\delta_m \cdot A_{th}, \alpha_m) = \mathbf{R}(\delta_{model} A_{th}, 0) + \mathbf{L}(L, \lambda) \quad (2)$$

We computed modeled tidal factors using 2 different ocean tides models: CSR3 and NAO99. The tidal loading vector  $\mathbf{L}$  was evaluated by performing a convolution integral between the ocean tide models and the load Green's function computed by Farrell (1972). The Green's functions are tabulated according to the angular distance between the station and the load. The water mass is condensed at the centre of each cell and the Green's function is interpolated according to the angular distance. This computation is rather delicate for coastal stations and models computed on a coarse grid, as the station can be located very close to the centre of the cell. The numerical effect can be largely overestimated. To avoid this problem the ICET tidal loading computation checks the position of the station with respect to the centre of the grid. If the station is located inside the cell, this cell is eliminated from the integration and the result is considered as not reliable (Melchior et al., 1980).

As the selected ocean tide models do not provide the smaller tidal constituents J1, OO1, M3, M4 we provide only the theoretical amplitude factors of the corresponding groups. As there is no long period tidal constituent associated with CSR3 we use also the theoretical body tides value for Mf. For the annual and semi-annual solar waves Sa and Ssa the tidal loading is not the main perturbation. The contributions from meteorological and hydrological sources are preponderant. Tidal gravity analyses Superconducting Gravimeters data determined observed tidal factor larger than 2 for Sa (Ducarme et al, 2006), while global models are required for effective pressure corrections (Neumeyer et al., 2004). Continental water storage fluctuations induce strong seasonal effects (Peter et al, 1995; Neumeyer et al, 2006). As these very long period tidal waves are only important for absolute gravity measurements and deserve a special treatment we use also the body tides model values for tidal predictions. The constant tidal effect called MOS0 should be treated with a special care in order to follow the resolutions of the International Association of Geodesy (IAG). In gravimetry one has to follow the "zero tide" correction principle i.e. one should remove only the astronomical part of the MOS0 tide and not the constant deformation. Clearly speaking the amplitude factor of MOS0 should be put equal to one.

## 2. Interpolation software

The proposed software is an update of the WPAREX program developed by H. G. Wenzel for a bilinear interpolation inside the grid. If the input coordinates are not surrounded by 4 grid points error message is issued and the values at the closest point are selected..

If one of the grid points is too close from one cell of the ocean tides model a warning is issued, as the load vector computation is probably not accurate at this point.

### Input files:

The CSR3G.dat and NAO99G.dat files should be stored in a subdirectory “modified”. This location can be changed by replacing the variable “direct” in the source code.

Three input files are required:

Eterna.ini: list of the tidal waves

Wparex.dat: coordinates of the point to be interpolated FORMAT(I4,A21,F8.4,F9.4,F4.0)

Col 1-4: station number

Col 5-25: station name

Col 26-33: latitude (N+)

Col 34-42: longitude (E+)

Col 43-46: altitude (m)

FILIN (CSR3G.dat or NAO99.dat according to selection): tidal parameters on the 0.5°x0.5° template of Zahran(2005), 3 records for each grid point

Record 1: coordinates of the grid point FORMAT (3F10.2,I10,1x,A1)

Col 1-10: longitude

Col 11-20: latitude

Col 21-20: altitude (m)

Col 22: \* indicates that the corresponding point was too close from a cell of the ocean tides model.

Record 2: amplitude factor for 9 tidal waves (Mf, Q1, O1, P1, K1, N2, M2, S2, K2) FORMAT(9f10.4)

Record 3: phase difference for 9 tidal waves (Mf, Q1, O1, P1, K1, N2, M2, S2, K2) FORMAT(9f10.4)

### Interactive execution

Choice of tidal potential (MT80w output only)

'POTENTIAL: 1=CTE505, 2=tam1200'

Choice of the ocean tides model

'choice of map: 1=CSR3, 2=NAO99 '

### Output

The available output parameters are different for the three tidal prediction programs: PREDICT, MT80w or T-soft:

- For predict you can directly use the output “predict.out” as \*.ini file. To run a prediction you have only to fill:

```
SAMPLERATE=                #data sampling in seconds(integer)
INITIALEPO= xxxx   xx   xx #initial epoch in year, month, day
PREDICSPAN=                #time span in hours(integer)
```

according to ETERNA manual.

- For MT80w the output “mt80w.out” can be used directly as STATION file
- For T-soft the output “tsoft.out” should be manually inserted in the LOCAT.TSD data base before computing a tidal gravity prediction using Tides/Synthetic\_tides/Open\_location\_data\_base.

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