STUDY OF EASTERN CANADIAN COASTAL SITE DISPLACEMENT DUE TO OCEAN TIDE LOADING USING A GPS NETWORK IN ATLANTIC CANADA

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Ocean Tide Loading :

The surface loading of the Earth due the weight of the ocean tides causes a time varying deformation of the solid Earth, which is called ocean tide loading. This deformation has a vertical component and also a horizontal component, which is typically smaller then the vertical component. The eastern Canadian provinces experiences considerable ocean tidal loading in the coastal zones because of the generation of high tides in the adjacent sea. The initial investigations in the area have revealed that some of the areas around Bay of Fundy are experiencing ocean tidal loading, with predicted ocean tidal loading showing M_2 as the dominant tidal constituent in the area. In this context the question of whether different tide loading constituents, and therefore loading corrections, in the area are derivable by differential GPS needs further data analysis.

Basic concepts, principles and definitions:

Ocean Tides:

Tides can be defined as periodic movements which are directly related in amplitude and phase to some periodic geophysical force. The dominant geophysical force, which cause gravitational tides, is the gravitational attraction of moon and sun on the surface of the earth. The meteorological forces also produce smaller tides called meteorological tides. Any measurement of sea-level have tidal and non-tidal component. The non-tidal component which remains after analysis has removed the regular tides is called the residual or meteorological residual.

Ocean Tidal Loading:

As the ocean tides move about they periodically load and unload the earth causing displacement, tilt and gravity changes in and around region where loading is occurring (see Figure 1). This is the **ocean tidal loading (OTL)** displacement. Crustal deformations caused by surface load due to ocean tides are strongly dependent on the surface load closest to the observing site. In order to correctly model this ocean loading effect near irregular coastal areas, a high-resolution coastline is required.

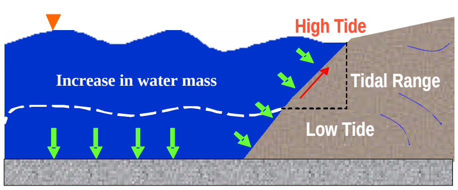

Figure 1. The mechanism of Ocean Tide Loading

For high accuracy GPS applications, when millimeter level accuracies are required, the OTL induced site displacements can have significant effect on the geodetic parameters estimated. Such applications include the monitoring of crustal dynamics and GPS meteorology. The geodetic parameters, in addition to latitude and longitude, may also include parameters like tropospheric delays.

Ocean tide models have been broadly classified as empirical, hydrodynamic and combination models. These models agree well with each other and with observations over most of the open oceans except in some near coastal areas and shallow seas.

To evaluate the effect of ocean tide loading on the geodetic quantities of interest, such as deformations, gravity and tilt, also called displacements, the usual procedure of convolution of appropriate Green's functions (this is important) with an ocean tide model can be followed. A separate Green function for each geodetic quantity is required. These Green's functions incorporate the response of the earth to loading and depend among other variables on the properties of the earth. The properties of the earth enter into the Green's functions through some dimensionless quantities called Load deformation coefficients (called Love numbers or Load numbers), computed according to the given earth models. Green's functions give the effects of the response of the Earth Model on a single point.

$$L(r) = r_w \iint G(|\underline{r} - \underline{r}'|) x(r') dA \qquad (1)$$

The GPS approach can also be used to estimate the vertical OTL parameters for major semi-diurnal and diurnal constituents

Ocean Tidal Loading in Eastern Canadian Atlantic Region

In the present research a network of five continuous GPS stations are being used for investigations in the sphere of crustal dynamics and real time kinematics positioning. The location of the stations can be seen in Figure 4. It is evident that four stations are located in the periphery of Bay of Fundy, while IGS station HLFX lies directly on the open Atlantic coast.

Through comprehensive and critical GPS data analysis OTL signal (effects) would be extracted from the GPS baseline solutions. A comparative analysis shall be made among the solutions obtained from different OTL models and GPS observations. OTL displacements in Atlantic region in height using GOT99.2 Ocean tide model Dec 3, 2003

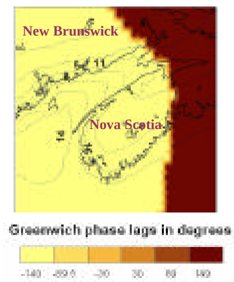

Figure 2. Radial amplitude (mm) and phase for M_2 constituent using GOT99.2 Ocean tide model

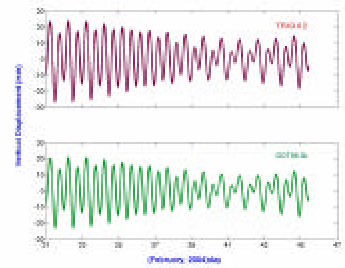

Figure 3. Computed displacement, at CGSJ using two different Ocean tide model

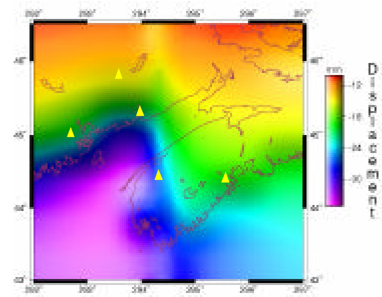

Figure 4. Vertical displacement in Atlantic region using GOT99.2 OTL model at noon Feb 18 2004

Conclusions

1. Coastal areas in Atlantic region are experiencing loading effect with M_2 being the major tidal loading constituent.
2. The TPXO.6.2. is giving slightly higher vertical displacement for GPS station CGSJ in the project area.
3. Since the current research is being carried out in area close to the Bay of Fundy, known for its turbulent and high tides, it is expected that the geodetic measurements of the ground motion in the area may yield some useful constraints for improving the modeling of ocean loading in the area.
4. GPS data will be used for further inference.

Acknowledgments

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