Low cost GPS-wavelet-based methodologies to advertise climate and environmental extreme events

Eniuce Menezes de Souza*
Statistical Department, Maringa State University (UEM), Maringa, Parana, Brazil – emsouza@uem.br

Tamiris Trevisan Negri
Eletrical Engeneering Graduate Program, São Paulo University (USP), São Carlos, SP, Brazil – tamirisnegri@gmail.com

Luiz F. Sapucci
National Institute for Space Research (INPE), Center for Weather Forecast and Climatic Studies (CPTEC), Cachoeira Paulista, São Paulo, Brazil – luiz.sapucci@cptec.inpe.br

Viníssius B. Felix
Statistical Undergraduate Course, UEM, Maringa, Parana, Brazil - vinicius.estats@gmail.com

Nowadays the continuous monitoring of movement in large structures and of severe tempests is more than ever indispensable mainly due to the increasing occurrence of nature extreme events that can cause irreparable social and economic tragedies. This presentation will discuss about the first prospects towards the possibility of low cost monitoring of structure movements and forecasting tempests by GPS (Global Positioning System) satellite signals.

In case of structural movement monitoring, GPS has been extensively used. In general, large structures have two or more GPS receivers besides others sensors installed on them. However, no always installing a GPS receiver in the structure itself is possible even when the involved high costs can be afforded. This occurs in case of volcanoes, dams or hills at collapse risk, for example. Our propose is to perform the monitoring without the need of installing a GPS receiver directly in the structure, only in its vicinity to receive reflected signals, known as multipath signals. If the environment being monitored remains unchanged, the multipath effect repeats during consecutive days. Thus, instead of trying to estimate the receiver position, usual task where the non-stationary multipath effect is a great problem that deteriorates the estimative quality, we proposed the repeatability analysis of the multipath signals. If the multipath effect can be detected, it is possible to obtain time series that repeat daily if the environment remains unchanged. As the multipath effect is highly dependent on the distance between the structure and the receiver, once a change is detected in these time series at a significance level, a displacement at a monitored structure could be indicated and the appropriated providences could be taken. Consequently, human and material costs and risks can be drastically reduced. This could be reached by a multiscale non-decimated wavelet spectrum analysis and comparison of time series of multipath effect due to GPS signal reflections. The statistical aspects to obtain an unbiased and consistent wavelet spectrum as well as the results of an experiment simulating a structure movement, carried out with real GPS data, will be presented. The simulated movement could be correctly detected for all time series considering a 5% significance level.

The other GPS-wavelet-based methodology is related to wavelet cross correlation (WCC) between GPS integrated water vapor and precipitation time series for forecasting tempests. The WCC, obtained from the non-decimated wavelet transform, allows identifying the correlations in different lags in time, scale by scale. From one-minute temporal resolution time series it was possible to identify statistically significant WCC in scales of about 30 min showing tempests could be advertised analyzing specific oscillations in GPS integrated water vapor time series. Precipitation events of different intensity and spatial dimension in Brazil were investigated. The results and challenges of the proposed GPS-wavelet-based methodologies will be discussed.

Keywords: Multicale Analysis; Non-Decimated Wavelet Transform; Structure Monitoring; Tempest Forecasting.