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Title: EM waves and GPR method; Processing, topographic migration and 1D Modeling

Abstract:
According to Maxwell's equations, a time-varying electric field (***E***) generates a time-varying magnetic field (***H***) and vice versa. Therefore an EM wave corresponds to a simultaneous propagation of the electric and magnetic field. The magnetic and electric fields of an EM wave are perpendicular to each other and the vector product ***E*** x ***H*** indicates the direction of propagation of the wave or the direction of the wave number vector (***k***). Light, for example, is an EM wave that has a propagation velocity ***c*** = 300 000 km/s (or 0.3 m/ns). EM waves can travel in a vacuum (free space), air, and solid objects, making them very useful for many technologies.
The ground penetrating radar (GPR) method is a geophysical method, based on the propagation, reflection/diffraction of high frequency EM waves within the Earth. The frequencies used are on the range between 10 MHz and 2.5 GHz (wave length λ = 10 m and 4 cm, for a velocity of V = 0.1 m/ns). The GPR method works for medium with low *electrical conductivity* $\sigma < 1$ mS/m.
GPR data processing is carried out with Radlab software written in Matlab and developed in our laboratory. The sequence of the processing is as follows: Time-zero correction, DC (or running average over time) filter, amplification (AGC or Envelope), flat reflection (or running average over x) filter. After the last filter, we can also apply a frequency band-pass filter and continue the velocity analysis and finally topographic migration. Topographic migration is based on the Kirchhoff migration method and is necessary when the variation in topography is comparable to the depth of investigation. When the topography is almost flat, a classic migration method without topography works well. We show some processed GPR profiles (from Ecuador and Chad) obtained with a 250/500 MHz antenna.
The *dielectric constant* ($\kappa = \varepsilon/\varepsilon_0$) for moist soils increases with increasing water content and lies in the range 6 to 30. This is because the dielectric constant of water (κ_w = 81) is much larger than that of dry soils (between 3 and 5). This implies a decrease in the propagation speed of GPR waves as humidity increases. Thus, by performing GPR measurements at different periods at the same location, we show an example of soil moisture monitoring. Finally, the last example presented here is the modeling of GPR signals from data obtained with a 2.5 GHz antenna on a mural in Mexico. The objective is to study the cracks/fissures on the wall paint using the GPR method.

Biography:
Maksim Bano received the Master Degree in Physics from Ecole Normale Supérieure of Tirana University (1980), the Master Degree in Geophysics (1985) and the PhD doctorate in Applied Geophysics (1989) from Louis Pasteur University of Strasbourg, France. In 2000, he received the state doctoral thesis diploma (Habilitation à Diriger des Recherches: HDR) from the Strasbourg University. The title of the latter was: '*Imaging the interior of the Earth using GPR waves*'. Maksim Bano is a member of European Association of Geoscientists & Engineers (EAGE) since 1996, Society of Exploration Geophysicists (SEG) since 1998, and is Associated Editor of 'Geophysics' journal since 2004. He co-organized (with Professor Sato, Tohoku University, Japan) the Workshop on "GPR measurements of active faults and tsunami sediments", Tokyo from 2nd to 8th October 2017. He is the main supervisor of six PhD's thesis, ten projects of Master degrees since 2002 and 60 engineer diplomas in geophysics since 1995. He is author of more than 60 papers in international journals with reading committee.