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Ground-penetrating radar research in Belgium: from developments to applications

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Ground-penetrating radar research in Belgium spans a series of developments and applications, including mainly ultra wideband radar antenna design and optimization, non-destructive testing for the characterization of the electrical properties of soils and materials, and high-resolution subsurface imaging in agricultural engineering, archeology and transport infrastructures (e.g., road inspection and pipe detection). Security applications have also been the topic of active research for several years (i.e. landmine detection) and developments in forestry have recently been initiated (i.e. for root zone and tree trunk imaging and characterization). In particular, longstanding research has been devoted to the intrinsic modeling of antenna-medium systems for full-wave inversion, thereby providing an effective way for retrieving the electrical properties of soils and materials. Full-wave modeling is a prerequisite for benefiting from the full information contained in the radar data and is necessary to provide robust and accurate estimates of the properties of interest. Nevertheless, this has remained a major challenge in geophysics and electromagnetics for many years, mainly due to the complex interactions between the antennas and the media as well as to the significant computing resources that are usually required. Efforts have also been dedicated to the development of specific inversion strategies to cope with the complexity of the inverse problems usually dealt with as well as ill-posedness issues that arise from a lack of information in the radar data. To circumvent this last limitation, antenna arrays have been developed and modeled in order to provide additional information. Moreover, data fusion ways have been investigated, by mainly combining GPR data with electromagnetic induction complementary information in joint interpretation analyses and inversion procedures. Finally, inversions have been regularized by combining electromagnetics models together with soil hydrodynamic models in mechanistic data assimilation frameworks, assuming process knowledge as information as well.

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