To meet the needs of a growing population and to provide us with a higher quality of life, increasing pressures are being placed on our environment through the development of agriculture, industry, and infrastructures. Soil erosion, groundwater depletion, salinization, and pollution have been recognized for decades as major threats to ecosystems and human health. More recently, the progressive substitution of fossil fuels by biofuels for energy production and climate change have been recognized as potential threats to our water resources and sustained agricultural productivity.

The vadose zone mediates many of the processes that govern water resources and quality, such as the partition of precipitation into infiltration and runoff, groundwater recharge, contaminant transport, plant growth, and energy exchanges between the Earth's surface and its atmosphere. It also determines soil organic carbon sequestration and carbon-cycle feedbacks, which could substantially impact climate change. The vadose zone's inherent spatial variability and inaccessibility precludes direct observation of the important subsurface processes. Where the development of sustainable and optimal environmental management strategies has become a priority, there is a strong prerequisite for the development of noninvasive characterization and monitoring techniques of the vadose zone. In particular, hydrogeophysical approaches applied at relevant scales are required to appraise dynamic subsurface phenomena and to develop optimal sustainability, exploitation, and remediation strategies.

Among existing geophysical techniques, ground penetrating radar (GPR) technology is of particular interest for providing high-resolution subsurface images and specifically addressing water-related questions. Ground penetrating radar is based on the transmission and reception of VHF-UHF (30–3000 MHz) electromagnetic waves into the ground, whose propagation is determined by the soil electromagnetic properties and their spatial distribution. The dielectric permittivity of water overwhelms the permittivity of other soil components, the dielectric permittivity of water, therefore, the soil principally governs GPR wave propagation. Therefore, GPR-derived dielectric permittivity is usually used as surrogate measure for soil water content. In the areas of unsaturated zone hydrology and water resources, GPR has been used to identify soil stratigraphy, to locate water tables, to follow wetting front movement, to estimate soil water content, to assist in subsurface hydraulic parameter identification, to assess soil salinity, and to support the monitoring of contaminants.

The purpose of this special section of the Vadose Zone Journal is to present recent research advances and applications of GPR in hydrogeophysics, with a particular emphasis on vadose zone investigations. It includes contributions presented at the European Geosciences Union General Assembly 2006 (Vienna, Austria) and the 11th International Conference on Ground Penetrating Radar (GPR 2006, Columbus, OH). The studies presented here deal with a wide range of surface and borehole GPR applications, including sensitivity to contaminant plumes, new methods for soil water content determination, threedimensional imaging of the subsurface, time-lapse monitoring of hydrodynamic events and inversion techniques for soil hydraulic parameter estimation, and joint interpretation of GPR and electric resistivity tomography (ERT) data.

The first part of this special section deals with surface-based GPR applications. Because surface datasets can typically be acquired quite rapidly, they are attractive for providing information about subsurface variability.