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Geospatial and geophysical information for earthquake hazard assessment in Vrancea area, Romania

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Vrancea area at the sharp bend of the Southeast Carpathians in Romania is one of the highest seismogenic zones in Europe, the present-day tectonic activity in this region being characterized by a small zone of intense shallow- to intermediate-depth seismicity that is often interpreted as reflecting the late stage of intra-continental collision. Efforts to advance understanding of earthquake physics and assessing of earthquake hazard in Vrancea seismic area require detailed observations of all phases of the earthquake cycle (pre-, co-, and post-seismic), across multiple fault systems and tectonic environment. Earthquake prediction has two potentially compatible but distinctly different objectives: (a) phenomena that provide information about the future earthquake hazard useful to those who live in earthquake-prone regions and (b) phenomena causally related to the physical processes governing failure on a fault that will improve our understanding of those processes.
Remote sensing and geospatial information tools and techniques, including numerical modeling, have advanced considerably in recent years, enabling a greater understanding of the Earth as a complex system of geophysical phenomena. Space-based geodetic measurements using the Global Positioning System in synergy with ground-based seismological measurements, interferometric synthetic aperture radar data, high-resolution digital elevation models as well imaging spectroscopy (e.g. using ASTER, MODIS and Hyperion data) are contributing significantly to seismic hazard and risk assessment. Space-time anomalies of Earth's emitted radiation (radon in underground water and soil and surface air , thermal infrared in spectral range measured from satellite months to weeks before the occurrence of earthquakes etc.), ionospheric and electromagnetic anomalies have been interpreted, by several authors, as pre-seismic signals. For seismic hazard analysis in Vrancea area, Romania have been selected the earthquake precursors detectable from space which can also be observed by ground-based monitoring experiments: surface deformation provided by GPS and SAR imaging, land surface temperature changes as possible precursors provided by ASTER, Landsat TM and ETM, electromagnetic and ionospheric anomalies, radon gas emissions in the faults areas prior to earthquakes, as well as seismicity. Multispectral and multitemporal satellite images (LANDSAT TM, ETM , ASTER, MODIS) over 1989-2009 period have been analyzed for recognizing the continuity and regional relationships of active faults as well as for geologic and seismic hazard mapping. In spite of providing the best constraints on the rate of strain accumulation on active faults (coseismic, postseismic, and interseismic deformation; plate motion and crustal deformation at plate boundaries), GPS measurements have a low spatial resolution, and deformation in the vertical direction can not be determined very accurately. As Vrancea area has a significant regional tectonic activity in Romania and Europe, the joint analysis of geospatial and in-situ geophysical information is revealing new insights in the field of hazard assessment. For Vrancea region, observations of surface kinematics with data provided by Global Positioning System (GPS) network constitute a new and independent data source. In combination with geologic and geophysical information, surface motions may help to unravel the intriguing tectonics of the region. GPS Romanian network stations data revealed a displacement of about few millimeters (5-6 mm) per year in horizontal direction relative motion, and a (2-3 mm) per year in vertical direction. As Vrancea area is characterized by a significant regional tectonic activity, evidenced by neotectonic deformation and seismicity, future use of long-term interferometric data will be a useful tool in active tectonic investigation for this region. The joint analysis of geodetic, seismological and geological information on the spatial distribution of crustal deformations as well as the analysis of some earthquake precursors is revealing new insights in the field of hazard and risk approach for Vrancea area.