Estimating seismometer orientations from teleseismic P-wave Particle Motion Analysis and Directional Statistics

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Abstract

The geographic orientation of three-component seismometers is an essential variable in modern seismological methods, such as earthquake source investigations, receiver functions, body and surface wave tomography, seismic anisotropy and polarization studies. For all these methods, it is routine to perform rotational transformations of the horizontal components. The most commonly used tool to align seismometers is the magnetic compass, which demands specific declination correction based mainly on the International Geomagnetic Reference Field (IGRF). Excluding the presence of magnetic rocks nearby the station or other local site effects, errors can be introduced when declination adjustment is not made, when this adjustment is made in the wrong sense or the declination of another location is applied. In order to verify the orientation of seismometers installed on XC-USP (Pantanal, Chaco and Paraná Structural Studies Network) and OS-UnB (Seismological Observatory Network) networks, we used P-wave Particle Motion Analysis combined with Directional Statistics. The event selection was based on three criteria: epicentral distance equal or larger than 30º and equal or less than 95º; magnitudes equal or larger than 6.0; and incidence angle of the P-waves, in relation to the normal direction, equal or larger than 10º. We analyzed a total of 1,062 teleseismic events, 691 recorded by OS-UnB and 371 recorded by XC-USP. The latter network had no station with mean orientation error less than ±10º. The OS-UnB network had 4 stations with mean orientation error larger than ±10º: FUN1 (-10.14º), SIM2 (-11.93º), SAMU (-19.59º) and SSV2 (-27.16º). It is not possible to claim that FUN1 and SIM2 are misoriented because the uncertainty, at the moment of seismometer installation, is approximately ±1.5º. The stations SAMU and SSV2 are possibly misoriented and the probable cause is the incorrect declination of the magnetic compass used to align the seismometers. The SAMU station was oriented with a compass declined with the right angle, but in the wrong sense and, in the case of the SSV2 station, the compass was not declined.