Geophysical Research Abstracts
Vol. 14, EGU2012-7830, 2012
EGU General Assembly 2012

Kurtosis based automated P-S phase picking procedure for hypocenter determination: Vanuatu region case study

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Abstract

Automatic P and S phase picking is indispensable for seismologists dealing with large amounts of data. Robust algorithms, based on short term and long term average ratio comparison (Allen, 1982), are now commonly used for event detection, but further improvements can be made in phase picking and identification. We present a picking scheme using consecutively Kurtosis-derived Characteristic Functions (CF) and Eigenvalue decompositions on 3-component seismic data. When computed over a sliding window of the signal, a sudden increase in the CF reveals a transition from a gaussian to a non-gaussian distribution, characterizing the phase onset (Saragiotis, 2002). One strong point is that it requires much fewer adjustable parameters than competing methods.
We modified the Kurtosis CF to improve pick precision, computing the CF over several frequency bandwidths, window sizes and smoothing parameters. Once phases were picked, we determined onset type (P or S) using polarization parameters such as rectilinearity, azimuth and dip resulting from Eigenvalue decompositions of the covariance matrix (Cichowicz, 1993). Finally, we removed bad picks using a clustering procedure and a signal-to-noise ratio (SNR). The pick quality index was also assigned based on this SNR value.
We applied this procedure to data from a network of 30 wideband seismometers (including 10 oceanic bottom seismometers) in Vanuatu. Events were extracted from 10 months of continuous data using STA/LTA algorithm, then picked using our method. We estimated the reliability of our picking procedure by comparing 4301 manual and automatic picks. We found a mean difference of 0.07 ± 0.24 s overall; for high quality picks (quality index 0) the difference is 0.03 ± 0.13s. After inversion with HYPOCENTER, more than 30% of earthquakes have a RMS ≤ 0.7 s and localization uncertainty ≤ 20 km before velocity model improvement. The method demonstrates good performance to independently pick S and P waves with only a few parameters to adjust.