A new dataset of Wood-Anderson magnitude from the Trieste (Italy) seismic station

D. Sandron, G. F. Gentile, S. Gentili, A. Rebez, M. Santulini, D. Slejko

ABSTRACT

The standard torsion Wood-Anderson (WA) seismograph owes its fame to the fact that historically it has been used for the definition of the magnitude of an earthquake (Richter, 1935). With the progress of the technology, digital broadband (BB) seismographs replaced it. However, for historical consistency and homogeneity with the old seismic catalogues, it is still important continuing to use the so-called Wood Anderson magnitude. In order to evaluate WA magnitude, the synthetic seismograms WA equivalent are simulated convolving the waveforms recorded by a BB instrument with a suitable transfer function. The value of static magnification that should be applied in order to simulate correctly the WA instrument is debated. The original WA instrument in Trieste operated from 1972 to 1992 and the WA magnitude (MAW) estimates were regularly reported in the seismic station bulletins. The calculation of the local magnitude was performed following Richter’s formula (Richter, 1935), using the table of corrections factor unmodified from those calibrated for California and adjusted for a local environment. The calculation applied to the WA magnitude was adopted as vector sum rather than arithmetic average of the horizontal components, resulting in a systematic overestimation of approximately 0.25, depending on the azimuth. In this work, we have retrieved the E-W and NS components of the original recordings and re-computed MAW according to the original Richter (1935) formula. In 1992, the WA recording were stopped, due to the long time required for the daily development of the photographic paper, the costs of the photographic paper and the progress of the technology. After a decade of interruption, the WA was recovered and modernized by replacing the recording on photographic paper with an electronic device and it continues presently to record earthquakes. The E-W and NS components records were memorized, but not published till now. Since 2004, next to the WA (few decimeters apart), a Guruli 40-T BB seismometer was installed, with a proper period extended to 60 s. Aim of the present work is twofold: from one side to recover the whole data set of MAW values recorded from 1972 until now, with the correct estimate of magnitude, and from the other side to verify the WA static magnification, comparing the real WA data with the ones simulated from broadband seismometer recordings.

RESULTS

The motion generated when the WA was shaken by an earthquake caused the rotation of a small, copper, cylindrical inertial mass (C) affixed to a thin wire under high tension (T). Damping of the torsional motion was accomplished using magnets (M). A mirror (m) attached to the mass reflected incident light, generated by an external bulb lamp, on a fixed cylindrical mirror, fixed on the instrument frame (not shown). The mirror reflected back the light on m which reflected it on a photosensitive paper (not shown).

THE DIGITAL WOOD ANDERSON SEISMOGRAPH

The WA was modernized by:

• Removing the bulb lamp and the fixed cylindrical mirror with its support and creating a small side window;
• Adding a laser (Flexpoint model FP-05/S-AE-AW-SDS-GL47, 650 nm wavelength, Power S with). Through the new window the red laser visible beam hits the moving mirror m;
• Adding a Strob Light position-sensing detector (PSD), a few centimetres far from the instrument on which the laser beam is reflected.

By removing the cylindrical mirror the ray undergoes a single reflection changing the optical leverage from 4 to 2 times. The PSD is a 1D semiconductor radiation sensitive to visible radiation. The sensor has a two nodes (Y3 and Y2) and a cathode (X) and an anode (Z) which generates an electrical signal proportional to the brightness of its surface (20x3 mm of active area). It offers high resolution and linearity: it is enough to stay inside the 80% of its surface to preserve a 0.1% of linearity.

THE WOOD ANDERSON SEISMOGRAPH

In order to simulate a WA on a BB seismometer it is necessary to know the transfer function. In particular the magnification.

- Anderson and Wood (1925): magnification 2000
- Uffhammer and Collins (1990) and Uffhammer et al. (1999): magnification 2080.

According to Uffhammer and Collins (1990), the difference derives from the wrong assumption by Anderson and Wood (1925) that the wire stretched in suspension used in the sensor WA does not deviate from a straight line. The deformation is actually sufficient to influence the measure and not simply reduce the static magnification.

We found that the magnification depends on the signal amplitude.

WA MAGNIFICATION

\[ G_k = \frac{A}{a + (A+\alpha)/g(\Theta/2)} \]

Where we are in a range of 2-3, \(A\), is the amplitude, \(\alpha\) is the expansion coefficient, \(g\) the maximum of the signal, and \(\Theta\) the angle.

FIRST METHOD: Wood and Anderson (1925).

We tilted the instrument of a known angle \(b\) and we measured the output voltage of the PSD, which is proportional to \(A\).

SECOND METHOD: The ratio of the maximum amplitudes (peak to peak) of the simulated and the real WA were calculated. Each \(G_k\) value corresponds to the weighted average of a set of 75 similar amplitude points and the corresponding amplitude value to its mean amplitude. The difference in magnitude between the corresponding ratios between a simulated \((G_k=2800)\) and a range between \((0.02\text{ and }0.13)\) depending on the signal amplitude.