# Measured Impulse responses

Trevor J. Cox, Bruno M. Fazenda, Susan E. Greaney, Using Scale Modelling to Assess the Prehistoric Acoustics of Stonehenge, Journal of Archaeological Science

## Folders

* "2200BC model" is for the complete 2,200 BC model with 157 stones
* “configurations” is for the measurement with only parts of the 2,200BC model (see Table 2 from paper)
  + The subfolders indicate the parts present e.g. “InnerTrilithonHorseshoe+OuterSarsenCircleUprights+OuterSarsenCircleLintels+OuterBluestoneCircle+InnerBluestoneOval” is the same as the 2,200 BC model
* “calibration” is a free field on-axis measurement for the source
* Each sub-folder name is the source and receiver measured (see Figure 2 of paper for plan)

## Code

Process\_impulse\_responses.m shows how to apply gains to the octave-band impulse responses because wav files have been normalised to give an abs(maximum value) of 1.

## Within each measurement folder are:

* 6 wav files IR\_xxxx for the impulse responses in the octave bands as indicated by the filename (full scale equivalents)
* gains.txt

See Process\_impulse\_responses.m for how to apply the gains to the impulse responses

## Processing of the impulse responses

A logarithmic sine sweep was used sweeping from 800 Hz to 96,000 Hz in 1s with a 0.01s fade in. This was followed by 1s silence. The impulse response was calculated via deconvolution using an inverse signal generated with Kirkeby regularization (using Aurora plug-in). Analysis was carried out in octave bands (3rd order bandpass Butterworth filters used, applied with MATLAB function filter()). A loop-back measurement was made to allow the time of flight to be removed, so the direct sound is at the start of the impulse response file.

Each octave band had at least 45 dB decay. The portion of the decay that fell below the background noise has been replaced with exponentially decaying gaussian noise to ensure that parameters calculated from the impulse response were not affected by the truncation. The process was as follows. The time, , where the measurement meets the background noise and the time, , at which the direct sound arrived were identified by eye. The decay rate was estimated by a linear regression between and . The impulse response was then truncated at ., Gaussian noise was added from to continue the decay with the same rate as the earlier decay from to . The standard deviation of the added Gaussian noise was set to match that in the early part of the decay (calculated with the linear decay removed). This process is equivalent to correction C in Equation (3) in ISO 3382.

The loss of energy as sound waves goes through the air was compensated for, so the impulse responses had a loss that is the same as would be expected in a full-scale measurement. A correction curve was applied to the impulse responses in each octave band. Relative humidity and temperature were taken for each measurement to allow the correction curve to be calculated from air absorption per metre formulations.