Supporting Information for "Signature of magmatic processes in ground deformation signals from Campi Flegrei (Italy)"

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Introduction This information includes a summary of the fluid modeling results; details on the processing and some in-depth analysis of the strainmeters data; full results of the comparative analysis at all stations.

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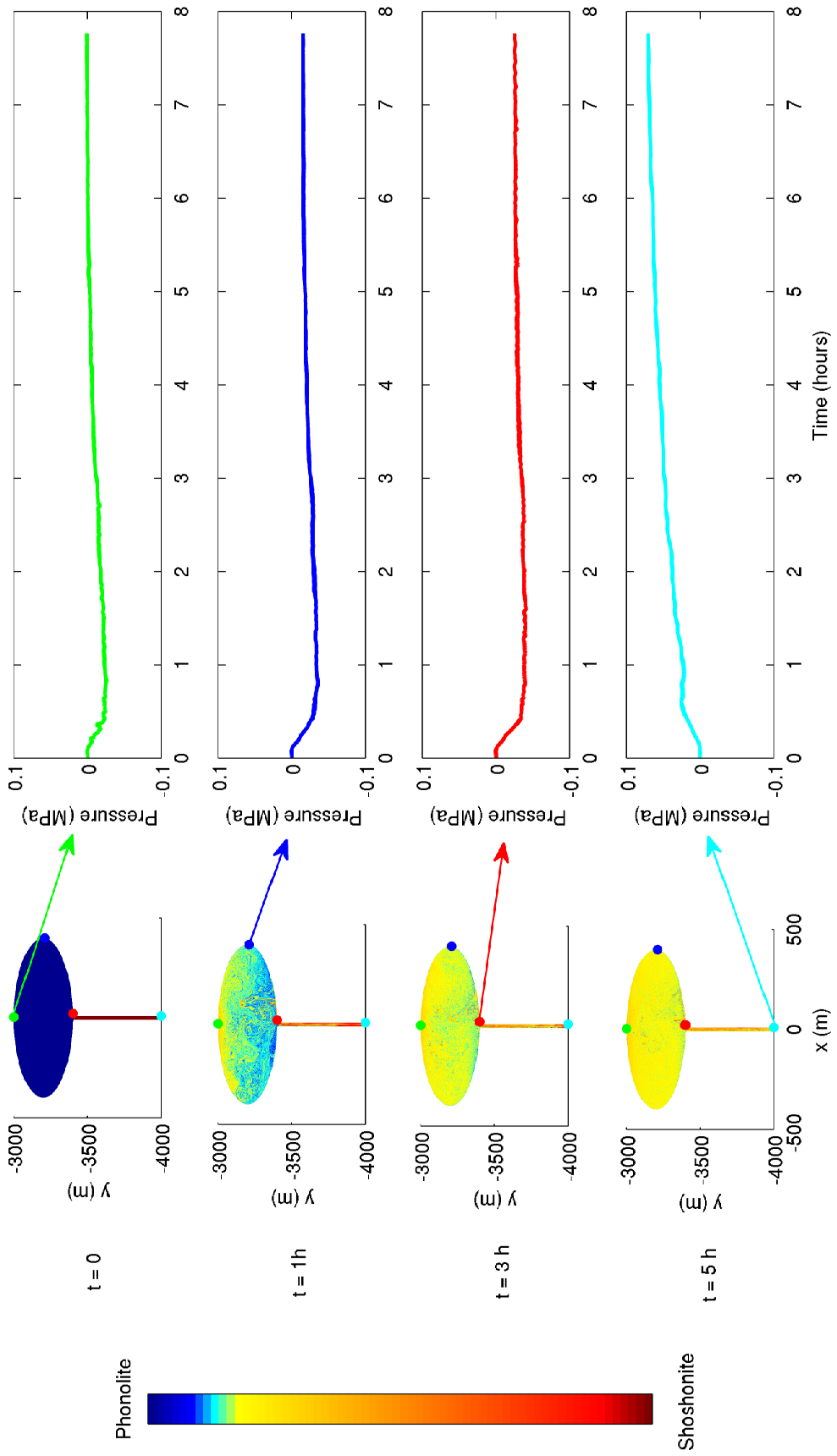
Pressure (MPa)
0.1
0
-0.1
0 1 2 3 4 5 6 7 8
Time (hours)
y (m)
-3000
-3500
-4000
x (m)
-500 0 500
t = 0
t = 1h
t = 3 h
t = 5 h
Phonolite
Shoshonite

Figure S1. (Previous page) Summary of the magma chamber dynamics. On the left, composition in the upper part of the domain at four different simulated times. On the right, pressure evolution in time for four different points on the fluid domain boundary. Line colors correspond to the colored points in the left panels.

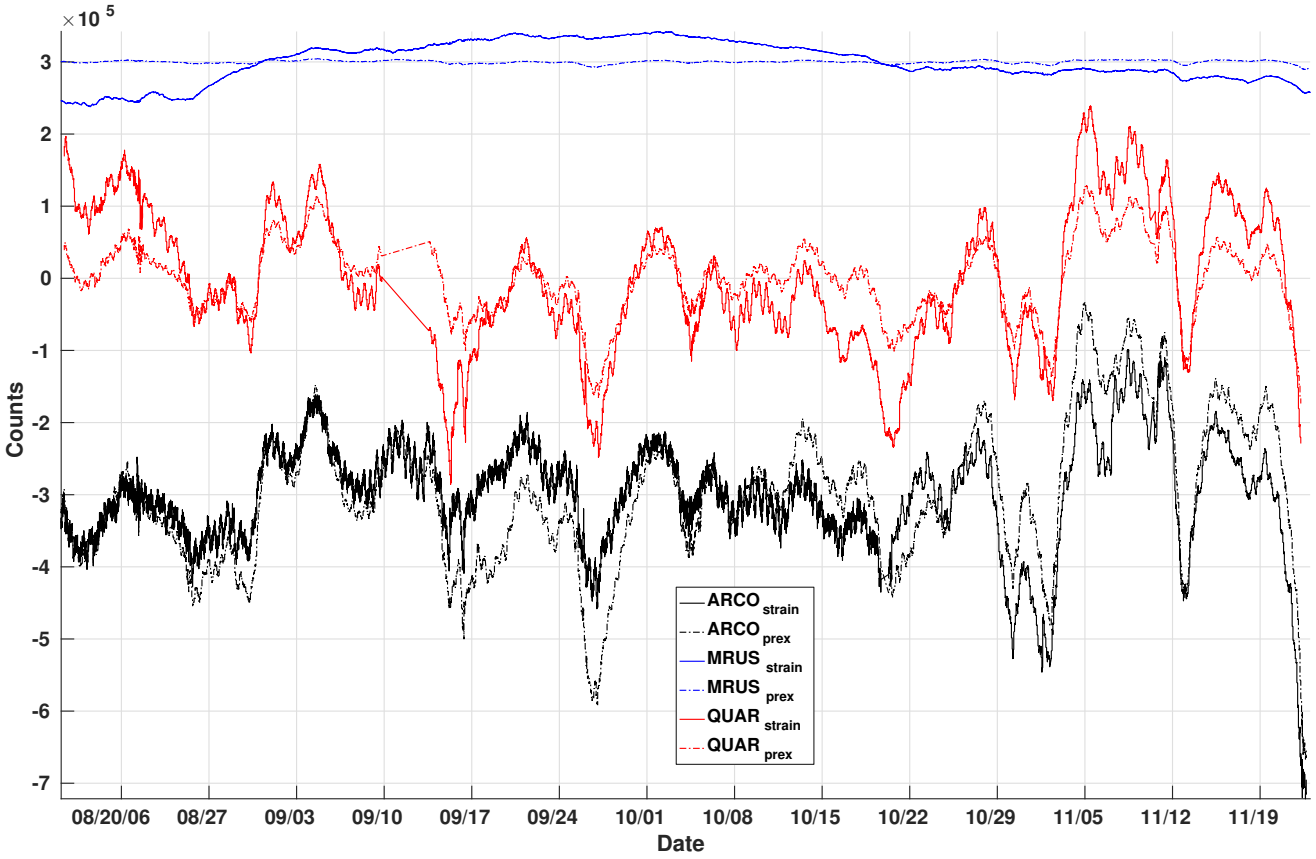

Figure S2. Raw strainmeters data (continuous) at the three stations ARCO (Arco - Rione Troiano), QUAR (Quarto) and MRUS (Monterusciello). Calibration of the instruments is beyond the scope of this work, as the amplitude of the strain transients has not been analyzed. Therefore, these data are shown in the raw unit counts [*Amoruso et al.,* 2015]. Atmospheric pressure time series (dash-dotted, suffix prex) are also shown.

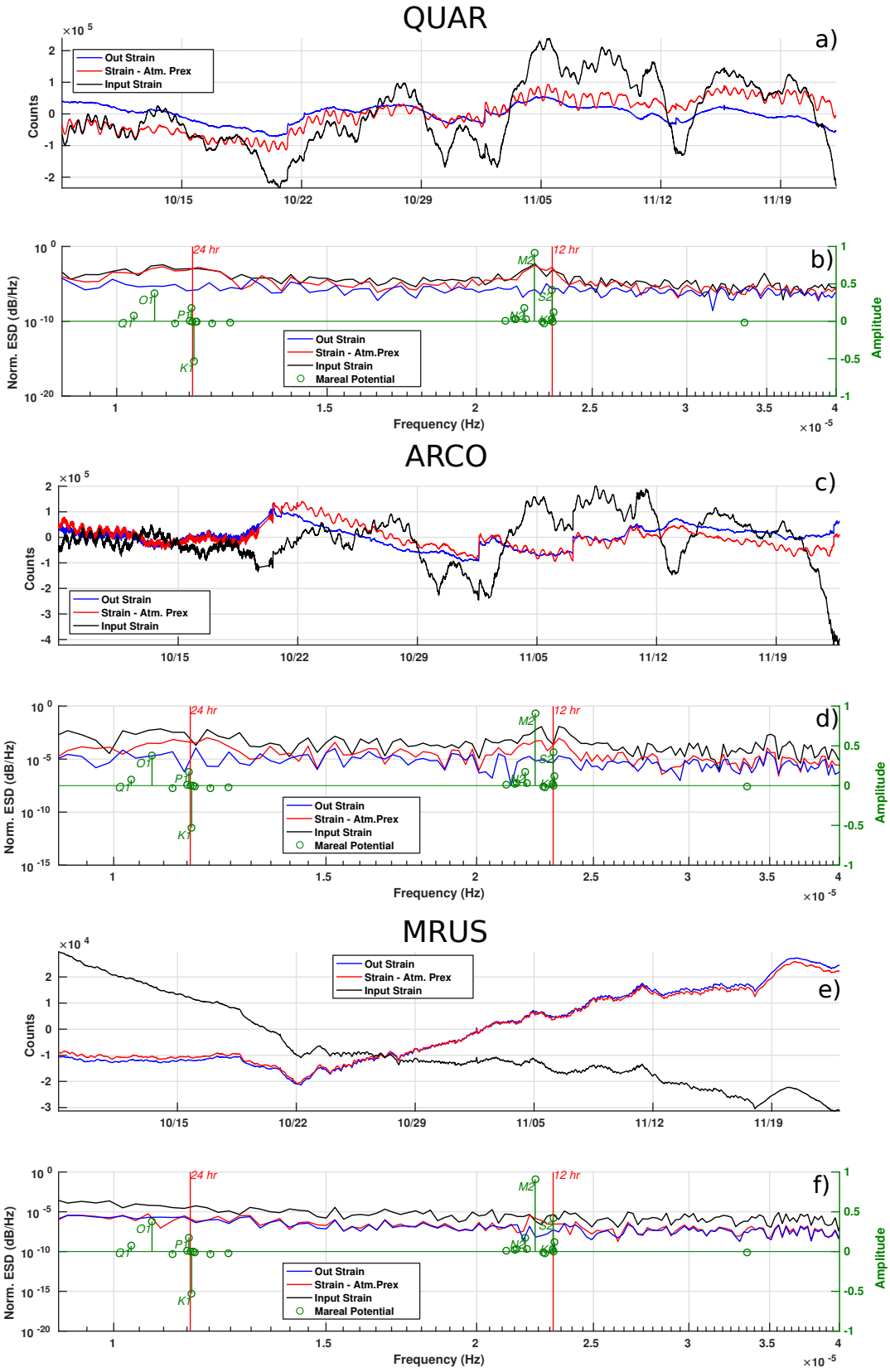
QUAR
a)
Out Strain
Strain - Atm. Prex
Input Strain
Counts
10/15
10/22
10/29
11/05
11/12
11/19
b)
24 hr
12 hr
M2
S2
O1
P1
K1
Out Strain
Strain - Atm.Prex
Input Strain
Mareal Potential
Norm. ESD (dB/Hz)
Amplitude
Frequency (Hz)
ARCO
c)
d)
MRUS
e)
f)

Figure S3. (Previous page) Raw and processed strainmeter data from the three stations. a), c), e) Raw data (black lines); atmospheric pressure removal (red lines); atmospheric pressure and tidal effects removal (blue lines). Daily (24 hours) and half-daily (12 hours) periodicities emerge as the atmospheric pressure effects are removed. b), d), f) Amplitude Fourier spectra for the raw (black lines), atmospheric pressure corrected (red lines) and fully processed (atmospheric pressure + tides, blue lines) strain time series. The most important tidal constituents (O1, K1, Q1, M2 and M3) are also indicated with their frequency (green dots), which have a much smaller component in the fully-proccessed time series. Red vertical lines indicate diurnal and semi-diurnal periodicities.

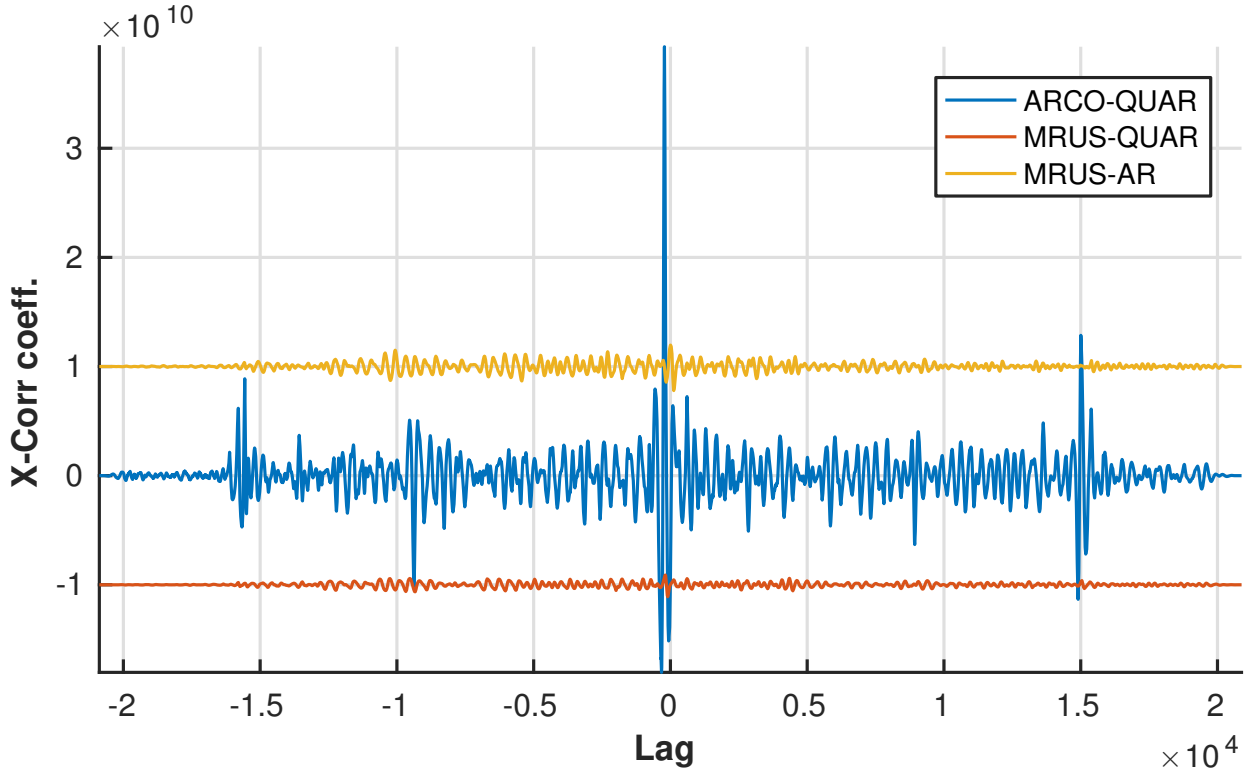

Figure S4. Cross correlation of the strainmeter data between stations for the time window analyzed (October 21 - November 5, 2006). The highest correlation is reached between ARCO and QUAR stations at time lag 0 (see also Figure S2); and the two peaks at lags $-1.5 \cdot 10^4$ and $1.5 \cdot 10^4$ represent the two transient events investigated.

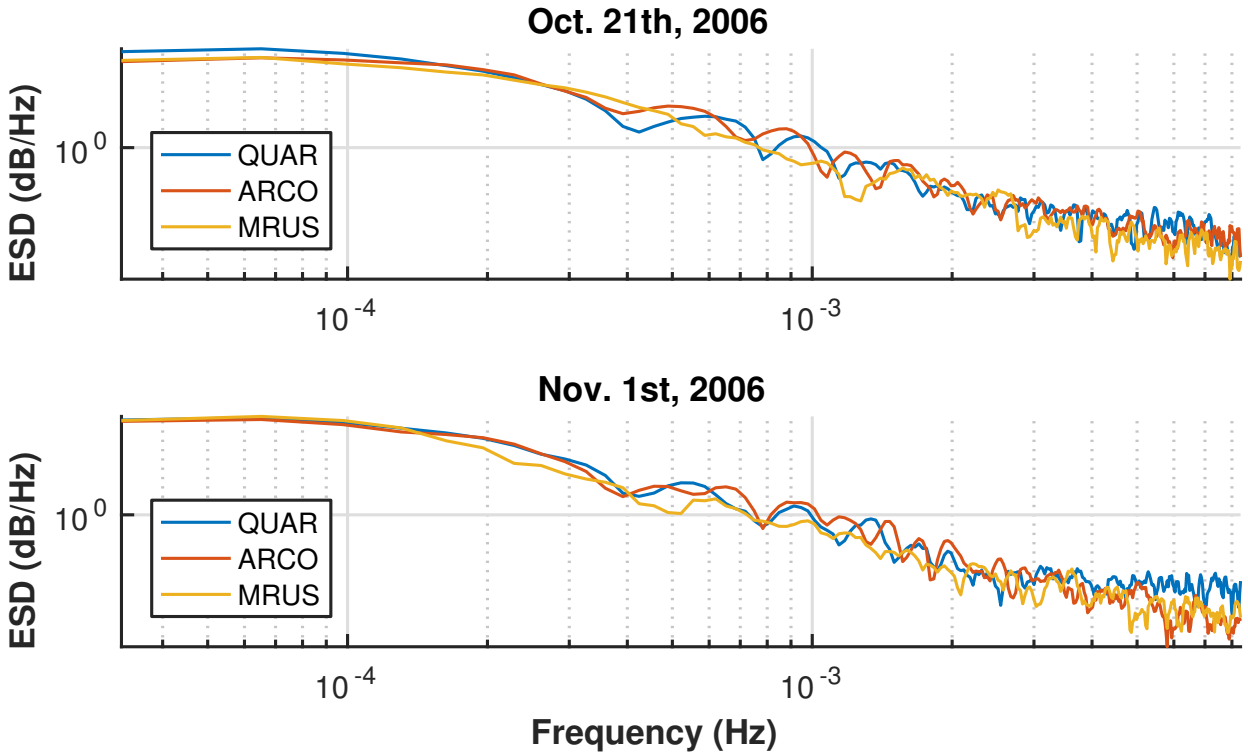

Figure S5. Energy Spectral Density for the strainmeter records during the two events recorded.

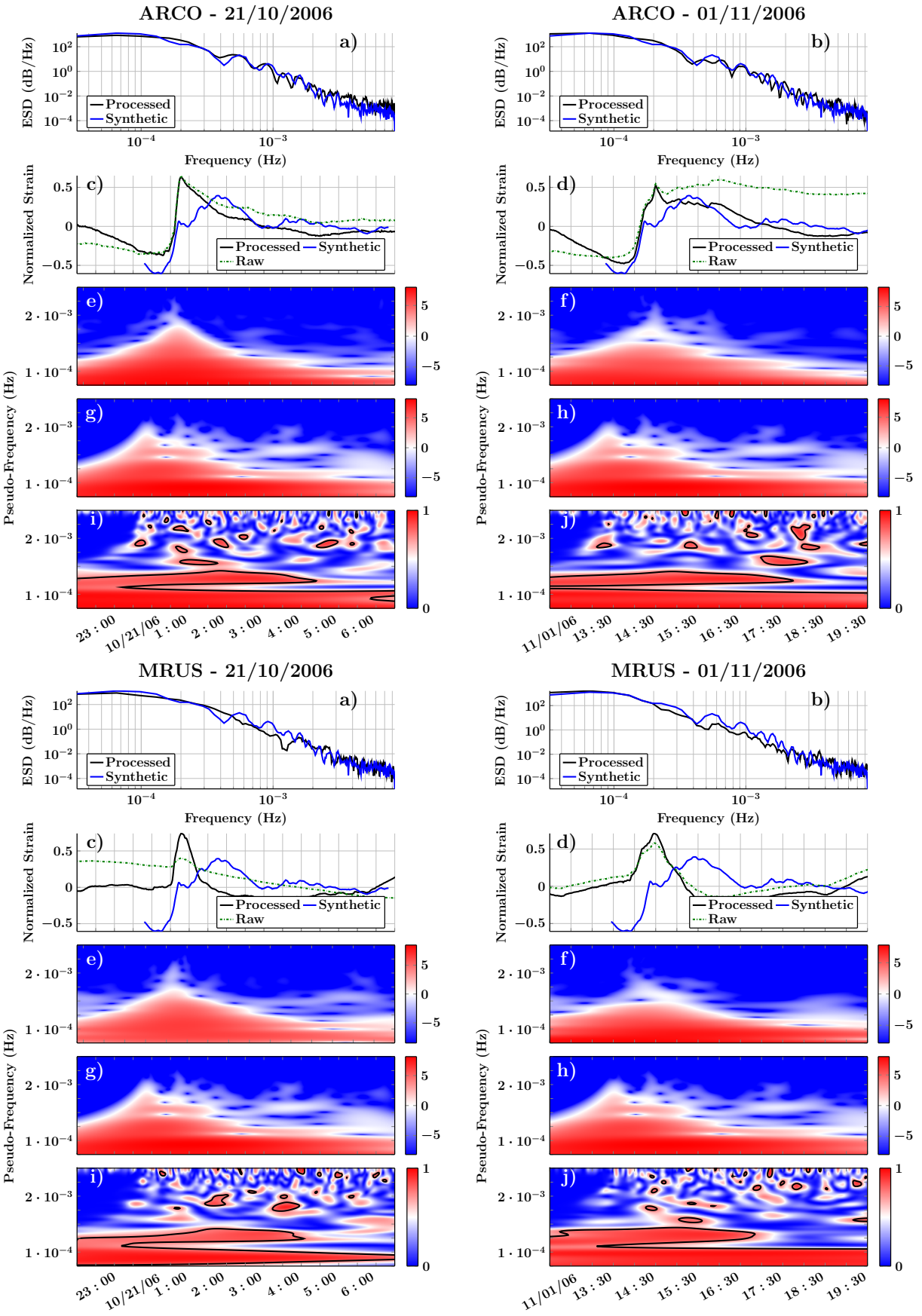
ARCO - 21/10/2006
ARCO - 01/11/2006
MRUS - 21/10/2006
MRUS - 01/11/2006
a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
ESD (dB/Hz)
Frequency (Hz)
Normalized Strain
Pseudo-Frequency (Hz)
Processed
Synthetic
Raw
10/21/06
11/01/06

Figure S6. (Previous page) Comparison in time and frequency domains between the transient signals on 21 October and 1 November 2006 recorded at ARCO and MRUS stations, and the synthetic template from the numerical simulations. The left columns refers to the 21 October event, the right columns to the 1 November event. a), b) Fourier spectra of synthetic (blue) and real (black) traces; c), d) synthetic template superimposed on the raw and processed strain time series; e), f) continuous wavelet transform spectrogram of the monitoring data; g), h) continuous wavelet transform spectrogram of the synthetic data; i), j) wavelet coherence between the two time-series. In the bottom panels, red color corresponds to high coherence. The 5% significance level against red noise is shown as a thick black contour line. This Figure corresponds to Figure 6 in the main manuscript, where the same results for the QUAR station are shown.