Using Ambient Vibration Array Techniques for Site Characterization and Seismic Microzonation

Sunday, February 21st to Sunday, February 28th 2010
Thessaloniki, Greece

Course outline

	Sunday	
09:00-09:30	**Reception and welcome**	
09:30-10:30	• Technical issues and program overview **Physical background of ambient vibrations and their use for site microzonation** • State of the art about the nature of the ambient vibration wave field. • The linkage between subsurface structure and wave field propagation properties: relationships between site conditions, Rayleigh ellipticity, Airy phase of Love waves and S_H transfer function. • Review of world-wide studies using ambient vibrations.	Lecture
10:30-11:30	**Scientific issues regarding use of ambient noise for site characterization** • Results from an international benchmark performed within the last ESG2006 Symposium.	Lecture
11:30-11:45	Coffee break	
11:45-12:45	**Single station measurement, H/V** • Computation and interpretation of horizontal to vertical spectral ratio technique (H/V) • Effects of experimental conditions.	Lecture
12:45-13:30	**Introduction to sesarray package** • Sesarray software philosophy. • Introduction to general features (figures handling, on-line command tools, data management, etc ...) .	Exercises
13:30-15:00	Lunch break	
15:00-15:30	**Introduction to sesarray package (continued)** • Sesarray software philosophy. • Introduction to general features (figures handling, on-line command tools, data management, etc ...) .	Exercises
15:30-16:30	**Single station measurement, H/V** • Geopsy tools for H/V. • Field data examples.	Exercises
16:30-16:45	Coffee break	
16:45-18:00	**Single station measurement, H/V (continued)**	Exercises

- Geopsy tools for H/V.
- Field data examples.

Monday

9:00-11:00	**Basic array processing concepts (conventional and high-resolution frequency wavenumber, f-k)**	Lecture

- Overview array processing methods.
- The intuitive shift-and-sum technique in time domain and its transposition into the frequency wavenumber (f-k) domain.
- Discrete spatial sampling of the continuous seismic wave field (by small groups of seismic stations - arrays) : concepts of resolution and aliasing.
- Resolution and aliasing of simple linear array layouts and generalisation to bi-dimensional array settings.
- Relation between array geometry and resulting estimation capabilities: rules of thumb and the array response function.
- Background of a widely used method, the high resolution f-k method after Capon (1969).

11:00-11:15	Coffee break	
11:15-12:45	**Array geometry and f-k response**	Exercises

- Computation of array response with waran_gps software: optimum usage and functionalities.
- Building experience on how modifications in array layout affect the theoretical array performances.

12:45-13:30	**Conventional and high-resolution f-k processing**	Exercises

- Application of the conventional and high-resolution f-k algorithms to estimate the dispersion curves from noise synthetics.

13:30-15:00	Lunch break	
15:00-16:30	**Conventional and high-resolution f-k processing (continued)**	Exercises

- Application of the conventional and high-resolution f-k algorithms to estimate the dispersion curves from noise synthetics.

16:30-16:45	Coffee break	
16.45-18.00	**Conventional and high-resolution f-k processing (continued)**	Exercise

- Application of the conventional and high-resolution f-k algorithms to estimate the dispersion curves from noise synthetics.

Tuesday

9:00-10:30	**Spatial autocorrelation method (SPAC)**	Lecture

- Background of the spatial autocorrelation technique (SPAC) introduced by Aki (1957).

10:30-10:45	Coffee break	
10:45-13:30	**Spatial autocorrelation method (SPAC)**	Exercise

- Application of the method to the synthetic data set, previously mentioned.
- Comparison with FK estimates: advantages and limitations of each approach.

13:30-15:00	Lunch break	
15:00-17:00	**Active surface waves techniques (SASW, MASW) and passive linear array technique**	Lecture and exercise

- The SASW, MASW and passive linear array techniques: theory, acquisition,

processing and resolution limits.
- Application of MASW to real data set.

16:30-16:45 Coffee break

16:45-18:00 **Active surface waves techniques (SASW, MASW) and passive linear array technique** Exercise

- Application of MASW to real data set.

Wednesday

9:00-11:00 **Dispersion curve inversion** Lecture

- Short introduction to the fundamentals of inversion theory.
- Direct search methods based on a random sampling, and particularly the Neighbourhood algorithm.
- Specific issues solved for the inversion dispersion curves: robustness of the forward computation, non-uniqueness of the final solution.

11:00-11:15 Coffee break

11:15-13:30 **Dispersion curve inversion** Exercises

- Introduction to dinver software
- Inversion of theoretical dispersion curve in order to identify critical issues.
- Model parameterisation and parameter range (v_P, v_S), a natural way to introduce prior information and to reduce the non-uniqueness.

13:30-15:00 Lunch break

15:00-17:00 **Preparation of the field experiment** Tutorial

- Presentation of the WARAN (wireless array network) equipment.
- Presentation of the active seismic equipment.

Thursday

8:00-18:00 **Field experiment** Field

- Field experiment in Thessaloniki (noise array and MASW).

21:00-... Workshop Diner

Friday

9:00-11:00 **Dispersion (autocorrelation) curve inversion** Exercises

- Inversion of synthetic dispersion and autocorrelation curves.
- Influence of the frequency range used for inversion.
- Influence of prior information for reducing non-uniqueness.

11:00-11:15 Coffee break

11:15-13:30 **Dispersion (autocorrelation) curve inversion** Exercises
...

- Integrating to a single dispersion curve (autocorrelation curve) dispersion curves (autocorrelation curves) obtained through different processing.
- Handling shear-wave profiles: extraction of usefull engineering parameters (e.g. Vs30).

13:30-15:00 Lunch break

15:00-16:30 **Processing field data.** Exercises

- Analysis of the signals recorded on the field with f-k, high-resolution f-k, SPAC and MASW techniques.

16:30-16:45 Coffee break

16:45-18:00	**Processing field data.**	Exercises

- Analysis of the signals recorded on the field with f-k, high-resolution f-k, SPAC and MASW techniques.

Saturday

9:00-11:00	**Processing field data.**	Exercises

- Combining results of arrays dispersion/autocorrelation curves estimated by the different arrays.
- Comparison with dispersion/autocorrelation curves obtained in previous measurements .

11:00-11:15	Coffee break	
11:15-13:30	**Processing field data.**	Exercises

- Decision on the usable frequency range for the inversion target.
- Inversion of dispersion/autocorrelation curve in order to derive velocity model.

13:30-15:00	Lunch break	
15:00-16:45	**Processing field data**	Exercises

- Inversion of dispersion/autocorrelation curve in order to derive velocity model.

16:45-17:00	Coffee break	
17:00-18:30 ...	**Processing field data**	Exercises

- Extraction of velocity models and Vs30.

Sunday

9:00-11:00	**Discussion of results from data sets**	Moderated discussion

- Comparison of the individual results obtained during the inversion.
- General discussion of experience gained during this complete test.

11:00-11:15	Coffee break	
11:15-13:30	**Course summary**	Discussion

- Summary of the various steps involved for the task of ambient vibration array and MASW analysis and site characterisation by the inversion of one-dimensional earth models. Recall of the advantages and limitations of using ambient vibrations to site characterisation.

13:30-15:00	Lunch break	
15:00-...	**Departure of Participants**	Open discussion