GPH 642

Global Seismology (3+0+0) 3

Course Description

This graduate level course presents a study of the Earth Structure inferred from seismological observations. It introduces techniques necessary for understanding of the physical and chemical conditions of rocks and minerals that contitute the interior of the Earth. Most of the modern techniques that have been developped in the last two decades are introduced in depth, with emphasis both to their theoretical and practical aspects.

Prerequisites:

GPH 520 - Plate Tectonics and Crustal Dynamcs
GPH 540 - Wave Propogation I ,
GPH 542 - Theory of Earthquake Source I

Technical Requirements

The student is expected to be familiar with various concepts of wave propagation, inversion theory, and plate tectonics. Knowledge of basic digital signal processing tools (Fourrier Transform, Digital Signal Processing) are required and MATLAB® and/or SAC will be used intensively troughout the course.

Staff

Instructor:
Prof. Dr. Mustafa AKTAR

Syllabus (as appears in the BU COURSE CATALOG)

Global distribution of seismic sources. Large scale structure of the Earth. Crustal and upper mantle propagation. Mantle and core phases. Receiver Function. Global tomography. S-wave spilitting and upper mantle anisotropy. Free oscillations of the Earth. Program Surface waves on spherical earth. Normal modes. Centroid moment tensor.

Program

week 1 **Introduction**
Global Processes
Overview of Thermal, Seismic, Mineral Properties of the Globe

week 2 **Crustal Structure (Flat Earth)**
Ray Theory, Local/Regional Phases: Crust and Uppermost Mantle
Why we use rays instead of wavefields: Eikonal Equation
Seismic arrivals at Crustal Distance: (Flat layer assumption)
Nomenclature for crustal phases
Formulae for Direct arrival, reflection, refraction
Properties of Continental Crust: Cratons, Shields, Orogenes, Margins
Reading:
Thone and Lay Chapter 3.1, 3.2 , 3.4
Meissner, The Crust, Chapter IV

week 3 **General model for the Earth (Spherical Earth)**
Upper Mantle
Vertical Properties of Upper Mantle:
- Seismic Lid
- Low velocity zone
- Transition Zone

Lateral Properties of Upper Mantle:
- Slabs
- Craton roots
- Anisotropy (Upper Mantle)
- Attenuation

Reading:
Physical, Chemical and Chronological Characteristics of Continental Mantle
Carlson, Pearson, James, Reviews of Geophysics, vol 43, N 1, 2005
International Handbook of Earthquake Eng. Seismology, Chapter Vı, Section 51,
Thorne Lay, The Earth's Interior, 2002

week 4 **Lithosphere, Aestonosphere**
Geological features at Lithospheric dimension
Extensional Tectonics and Rifting
Compressional Tectonics and Orogeny
Strike-slip Tectonics
Seismological Investigation: Receiver Function Method
Reading:
Isostacy and Flexture of the Lithosphere, A.B. Watts, Chapter 7
http://eqseis.geosc.psu.edu/~cammon/HTML/RftnDocs/rftn01.html

week 5 **Lower Mantle and Core**
Introduction

Lower Mantle: D''
Properties of Core
Seismological Investigation: Nomenclature for Earth phases
Reading:
International Handbook of Earthquake Eng. Seismology, Chapter Vı, Section 51,
Thorne Lay, The Earth's Interior, 2002

week 6 **Earth Structure Inversion: Seismic Tomography**
General definition of tomographic problem
generalized inverse solution
Mantle structure inferred from global tomography
Reading:
Thone and Lay, Global Seismology Chapter 7.1
Menke, Geophysical Data Analysis, Chapter3, 4, 7, 11.4

week 7 **Mid-Term**

week 8 **Anisotropy: Shear-Wave Splitting**
What is anisotropy, and how it is observed
The concept of polarisation of seismic wave (P, SV, SH)
Representation of Particle motion
Seismological Investigation: Shear-wave Splitting Method

week 9 **Relation between anisotropy and Deformation**
Diffusion creep: isotropic
 solid state diffusion between grain boundaries:, low stress, small grain
Dislocation creep: anisotropic
 motion of criystalline dislocation within grain:, high stress, large grain
What are Olivine a, b and c axis? orthorhombic
 a-axis are within the foliation plane
 parallel to lineation direction
 parallel to horizontal flow or extension direction in the mantle
 b- and c- axis are randomly interchanged
Factors effecting Anisotropy
Where along the path does anisotropy occur (Sherical Symetric Distribution) In which regions does anisotropy occur (Lateral Distribution)
Readings:
M.K. Savage Seismic Anisotropy and mantle deformation: what we have learned from shear wave splitting, Reviews of Geophysics, 37, 1, pp 65-106, February 1999,
E. Sandvol et al, Shear-wave splitting in a youg continent collision: An exemple from Eastern Turkey, Geophys. Res. Letters, Vol 30, No: 24, 8041, 2003

week 10 **Surface Waves**
Free-Surface interactions:
 plane-wave potentials at the surface,
 P-SV interaction
 Evanescent wave
Rayleigh Wave
 Rayleigh denominator

Rayleigh wave velocity
Particle motion
Readings:
Thone and Lay Chapter 4.1, 4.2

week 11 **Surface Waves (suite)**
Love Wave
Dispersion
Group velocity, Phase velocity
Readings:
Thone and Lay Chapter 4.3, 4.4

week 12 **Free Oscillations of the Earth**
Spherical Harmonics
Readings:
Thone and Lay Chapter 4.6