

Geodesy and plate tectonics

Addressed topics

- Geodesy and Earth remote sensing : general introduction
- Global properties of the Earth : Topography, gravity and Geoïd, Global surface deformation, plate tectonics and plates deformation
- Measuring the Earth deformation : terrestrial and spatial geodesy : a review of present day tools (leveling, triangulation, SLR, VLBI, DORIS, GPS, Insar, etc...)
- GPS : How and what for ? Technical and detailed explanations on this tool : basics of the theory and from network design to data acquisition, processing and modeling
- Measuring plate tectonics, monitoring faults, and surveying earthquakes with GPS
- Practical training sessions: GPS data acquisition, overview of GPS data acquisition, simple modeling (rigid rotation pole, strain rate tensors, elastic deformation around fault zones)

Detailed structure of lessons

1. Introduction to Geodesy

- Terrestrial geodesy
- Physical geodesy: Gravity field and Geoïd. definition of altitude
- Measurement of the Geoïd and Earth gravity field (Satellite Laser Ranging, satellite gravimetry and altimetry)
- physical processes associated to gravity

2. Monitoring the Earth Surface from space

- Picture of the surface from optical Imagery, i.e. obtained by telescopes or cameras operating in visual bandwidth.
- Shape of the surface from radar imagery
- Surface deformation from space/satellite geodesy : SLR, VLBI, DORIS, GPS, INSAR

3. Basics of GPS measurements: uncertainties/precision/errors

- what kind of noise/errors/uncertainties/un-modeled things affect the GPS precision : AS, SA, orbits, clocks, ionosphere, troposphere, antenna phase centers, centering (tribrachs), etc...
- how do we evaluate GPS uncertainties ? (difference between formal and a posteriori) can we trust them ?
- difference between precision and accuracy (internal consistency like repeatability is assertion of precision, comparison with other method affected by different biases is accuracy)
- reference frames : how do we map ? with what precision ? What influence on results ?
- Elements of GPS data processing, using GAMIT software

4. Introduction to rigid plate tectonics

- Plate definition
- Plate motion : Euler pole
- Geological model : Nuvel-1A
- Geodetic model : ITRF
- Rigid plate rotations
- Plate deformation : strain and rotation tensors

5. Deformation patterns in elastic crust

- Stress and force in 2D
- Strain : normal and shear

- Elastic medium equations
- Vertical fault in elastic medium => arctangent
- General elastic dislocation (Okada's formulas)
- Fault examples

6. Earthquakes and Seismic cycle on faults

- Elastic accumulation and rupture on a fault. Example on a Strike-slip fault and a Subduction fault
- Size of an earthquake
- Time dependent station motion and earthquake cycle : READ and Wallace models
- Pre-seismic, co-seismic and post-seismic motions
- Triggering of earthquake
- Precursors ?
- Famous examples : Sumatra, Aysen, Tocopilla....

Exercises: (usage of Fortran codes and Linux Shell scripts on work station)

- Exercise 1 : Computing Strain and Rotation rates in a GPS network
- Exercise 2 : Finding and applying a rigid rotation pole to a velocity field
- Exercise 3 : Inverting a velocity field around a strike-slip fault
- Exercise 4 : Surface deformation generated by an elastic dislocation buried at a depth

Training session:

Installation of GPS receivers, receiver programming, acquisition of GPS data,...

Text books and related literature

- Applications of continuum physics to geological problems, **D.L. Turcotte and G. Schubert**, *John Wiley & sons Inc.*, 1982. ISBN 0-471-06018-6
- Plate Tectonics: How it Works, **A. Cox and R.B. Hart**, *Blackwell scientific publications*, 1986. ISBN 0-86542-313-X
- Inside the Earth, **B.A. Bolt**, *W.H. Freeman and company*, 1982. ISBN 0-7167-1359-4
- Geophysical geodesy, **K. Lambeck**, *Oxford University Press*, 1988. ISBN 0-19-854438-3
- Geodesy : the concepts, **P. Vanicek and E. Krakiwsky**, *Elsevier Science Publisher*, 1982. ISBN 0-444-87777-0
- GPS for Geodesy, **A. Kleusber and P.J.G. Teunissen** Editors, *Springer-Verlag*, 1996. ISBN 3-540-60785-4