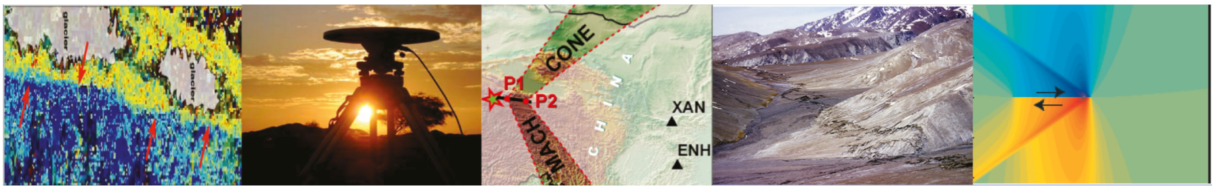

Deform2015 thematic school
February, 7-13, 2015, Barcelonnette, France

Syllabus of lectures

Requirements

Several courses plan to include exercise on laptops.
The students are asked to bring a laptop, with Matlab installed, if possible.

Geodesy

GPS
Teachers : J. Freymueller (Univ. Fairbanks, USA), J.-M. Nocquet (Geoazur, Nice, France)

- Introduction to geodesy for tectonics & earthquake cycle
- principle of GPS: orbits, signal, propagation, positioning concepts, observation equations and coordinates estimation
- reference frame
- kinematics positioning: principle, application to seismology
- See floor geodesy
- GPS time series: properties, non tectonic contributions, velocity estimation and related uncertainties
- Analysis of GPS velocity fields: rigid block modeling, estimating strain rates from GPS
- Examples & Case studies

InSAR
Teacher: C. Lasserre (ISTerre, Grenoble, France)

- radar satellite systems: some generalities; Synthetic Aperture Radar; amplitude and phase characteristics of radar images
- SAR interferometry : principle; phase difference components (main equations)
- InSAR applications and associated specificities in processing : coseismic ; post seismic and interseismic (time series analysis of interferograms, improvement of signal to noise ratio) deformation ; more on interseismic : from averaged velocity

maps to space and time variations of the deformation ; main challenges for the next years

Photogrammetry for earth scientist
Teacher: Marc Pierrot Deseilligny (IGN Paris, France)

- fundamentals of photogrammetry
- "modern" fully automatic photogrammetric pipeline for 3D modelization of a rigid scene
- application of photogrammetry
- photogrammetry for computing deformation, basic theory of image correlation
- photogrammetry for monitoring dynamic object (glacier, landslide ...)
- existing software, with emphasis on MicMac

Kinematic Modeling of Geodetic Results
Teachers : J. Freymueller (Univ. Fairbanks, USA), J.-M. Nocquet (Geoazur, Nice, France), C. Lasserre (ISTerre, Grenoble, France)

- the elastic rebound & earthquake cycle
- Basics of inverse problems
- modeling co-seismic slip distribution
- Modeling of the interseismic deformation
- elastic block modeling
- Modeling (kinematically) the time dependent deformation

Earthquake Seismology

Teachers : M. Vallée (IPG Paris, France), H. S. Bhat, (IPG Paris) & F. Renard (UJF, Grenoble)

Illustrating how seismology provides information on the fault activity during earthquakes (M. Vallée)

In a first part, the fundamental relations relating a force/moment acting in the Earth to the displacements observed at the surface will be presented. These initial relations will be used to show how seismologists are able to quantitatively determine the mechanism, magnitude, depth and moment rate functions of earthquakes. We will show how these determinations provide information on some generic earthquake characteristics. Going beyond these global characterizations of the earthquake process, the following part of the course will concentrate on the spatio-temporal characteristics of the earthquake process. Different methods able to give insights on these aspects (such as Deterministic and Empirical Green Function approaches; line source versus bidimensional analyses) will be detailed, before showing examples of application, including a focus on the determination of the rupture velocity. The implications in terms of rupture and fault mechanics will be discussed.

Theoretical and Experimental approaches towards understanding Earthquake Ruptures (H. S. Bhat)

1. Basic Modes of Fracture
2. Some Examples of Analytical Models of Steady State Ruptures

3. Earthquakes through Complex Fault Systems
4. Supershear Earthquakes
5. Laboratory Earthquakes (Bi-Material, Damage effects on Rupture)

Variety of fault slip processes: what do we learn from laboratory experiments? (F. Renard)

1. Introduction
   - The origin of friction: Amontons (1699), to Coulomb (1821), and Bowden&Tabor (1939)
   - The rate&state friction law (Dietrich, 1979)
2. Friction at low velocity
   - Parameters of the r&s friction law
3. Dynamic rupture and related friction & damage
   - Rupture velocity: from super slow to supershear
   - Damage related to propagating rupture
   - Evolution of friction with sliding
4. Postseismic slip and creep
   - Mechanisms of creep deformation
   - Evolution of the gouge
5. Conclusion: what are the open questions and which experiments will solve them ?
   - Range of velocities of dynamic ruptures
   - Seismic vs. aseismic sliding
   - Predictability of a rupture

Geomorphology, Dating Technics, Fault Geometry, Paleoseismology

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Teachers : Y. Klinger (IGP Paris), J. Van der Woerd (EOST, France)

Part I : long-term geomorphology
1) Geomorphic offsets
- surface fault traces : in the field, in satellite or air-borne images
- geomorphic features : what kind ?
- tectonic/geomorphology relations (i.e., top/base of riser, fill/cut/strath terraces)

2) Dating geomorphic offset
- methods (14C, OSL, 10Be, U-Th, …)
- 10Be cosmogenic method : particularity/problems

3) Examples : description and problems

4) Practical exercise : from the image interpretation to the tectonic quantification

Part II : short-term seismic deformation
1) Measurements of coseismic offsets
- recent events, older events;
- HR imagery; HR topography

2) Slip function

- significance of along-strike variations

3) Paleoseismology
- trenching (strike-slip faults, thrusts ?)
- subduction paleoseismology
- recurrence time of earthquakes (slip models)

Seismic cycle experimental modeling
Teacher : Stéphane Dominguez (Géosciences Montpellier, France)

- Kinematic and mechanic evolution of earthquake cycles at the scale of tens of seismic cycles.

Rheology and friction, Earthquake cycle modeling

Viscoelastic models of the earthquake cycle
Teacher : Luce Fleitout (ENS Paris, France)

- Viscoelastic rheologies: Equations for elastic, viscous and viscoelastic (Maxwell and Burger) rheologies. What we know and what we don't know about mantle viscosities for various time-scales. Mechanisms involved at a microscopic scale.

- Deformations during the seismic cycle associated with subduction megaearthquakes: Constraints brought by the analysis of the postseismic data after Aceh, Maule and Tohoku earthquakes Spectral methods versus finite element methods Elastic versus viscoelastic backslip and the seismic cycle

Earthquake cycle in the context of geodesy modeling.
Teacher : Sylvain Barbot (EOS, Singapore)

- rate and state equations,
- critical nucleation size,
- simulations of slow-slip events and seismic ruptures.
- Examples of afterslip modeling with matlab.

Earthquakes, scaling laws and fault systems
Teacher : B. Shaw (Lamont Observatory, USA)

- Surface slip observations and earthquake scaling
- Fault system and earthquakes

Seismic Hazards Analysis

Teacher : S. Baize (IRSN, Fontenay-aux-Roses, France)

This section of the DEFORM2015 School will give an overview of the main geoscience data, hypotheses, tools and outcomes that are involved in the Seismic Hazard Analyses. In this course, I will focus on SHA that aims at providing the probability of occurrence of a given ground motion amplitude at a site or in a region. I will develop the level of detail necessary to integrate geological data in SHA and show the key role of propagating data uncertainties in the analysis. Seismological and geodetic datasets will also be discussed. These topics will be illustrated through case examples. The required level of knowledge is a basic background in earthquake geology, seismology and geodesy.

One-day Field Trip

Geomorphology and tectonic structures
Lead by JC Hippolyte (CEREGE, France) & S. Baize (IRSN, France)