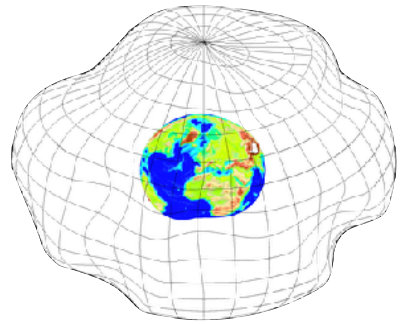
Remote Sensing of Tectonic and Volcanic Deformation

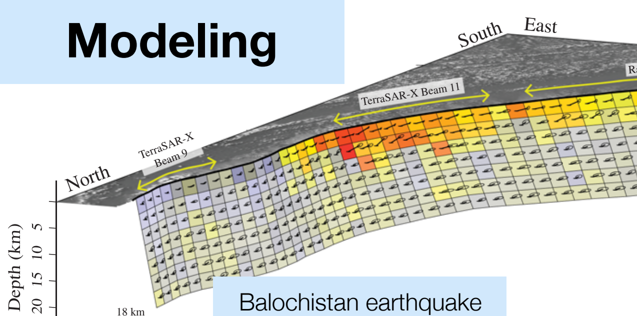
Introductory class

Physical geodesy

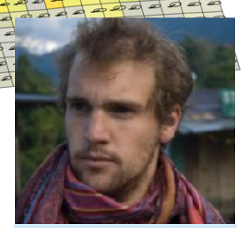


Application class

Modeling



Balochistan earthquake (2013, Pakistan)



Romain JOLIVET (ENS)

Tutorial class

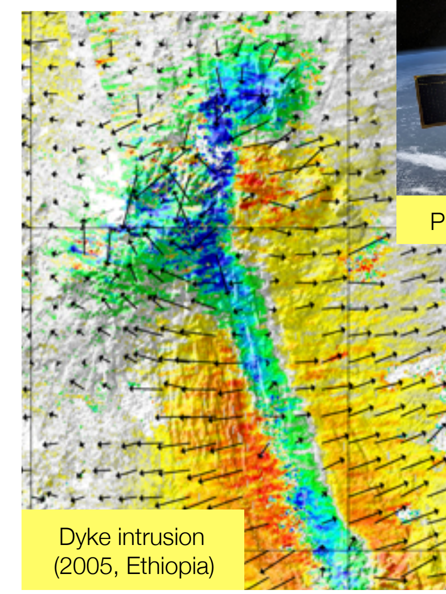
Reading a paper
Writing an abstract

Three techniques

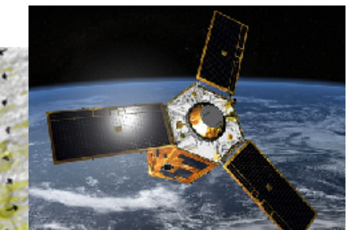
1. Theory (lecture)
2. Practice (lab)

Applications:
- seismology
- volcanology

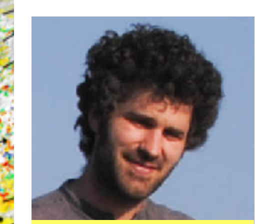
Optical imagery



Dyke intrusion (2005, Ethiopia)



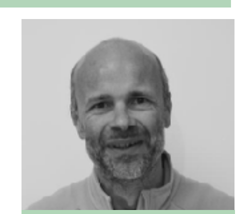
Pléiades satellite (CNES)



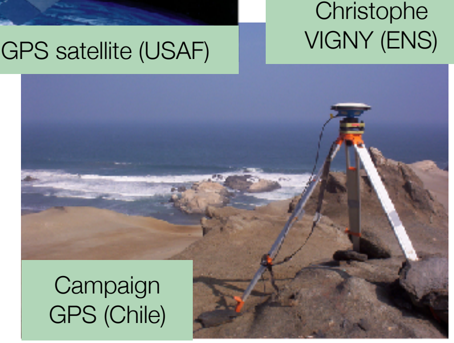
Arthur DELORME (IPGP)

Global Positioning System (GPS)

GPS satellite (USAF)



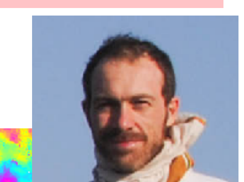
Christophe VIGNY (ENS)



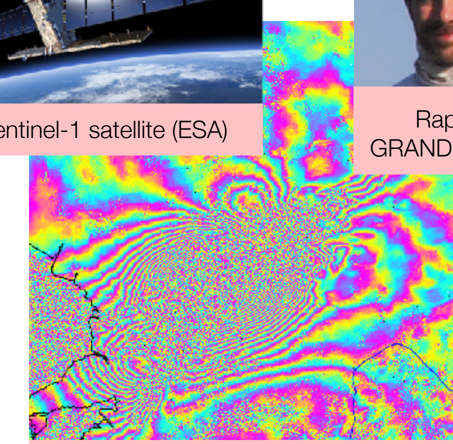
Campaign GPS (Chile)

Radar interferometry (InSAR)

Sentinel-1 satellite (ESA)



Raphaël GRANDIN (IPGP)



Kumamoto earthquakes (2016, Japan)

Raphaël Grandin (Tectonique) – grandin@ipgp.fr

Fiche UE **22_23**

Course title : **Satellite Geodesy and Geophysical Applications**

Teaching manager : Samuel Nahmani (nahmani@ipgp.fr)

Teaching team : Olivier Bock (bock@ipgp.fr), Kristel Chanard (chanard@ipgp.fr), Guillaume Lion (lion@ipgp.fr)

Academic cycle : M2 Fundamentals of Remote Sensing

Program Summary : This lecture aims to give a general culture on current utilization of the space geodetic techniques in many geophysical fields (non-tectonic deformations, meteorological and climate applications) and open up new perspectives on their future utilizations.

Outline

- **How to achieve a millimeter precision with space geodetic data?** (S. Nahmani)
  - GNSS Data processing (2h lecture)
  - Application with real GNSS data (~7h lecture / TD with Matlab)
- **Satellite Geodesy and non-tectonic applications** (Sea level rise, GIA and recent ice melting, loading effects, thermo and poroelastic effects) (K. Chanard)
  - Space Gravimetry, GNSS, Altimetry and combination of satellite geodetic techniques for non-tectonic solid Earth applications (3h lecture)
  - Physical models of non-tectonic solid Earth deformation (3h lecture + 3h TD)
- **Gravimetry and chronometric geodesy** (G. Lion) (6h lecture /TD)
- **Meteorological and climate applications** (O. Bock) (2h lecture)
  - From Zenithal Tropospheric Delay of GNSS to Integrated Water Vapor (IWV)
  - Analysis of global and regional variability of IWV using GNSS networks
- **Assessment** (~ 2 x 2h)
  - Scientific articles: read and comment

Targeted skills: General knowledge of the basics of geodesy and understanding of its current issues in geophysics and environmental science

Prerequisite: linear algebra, signal processing, optimization, basic programming in matlab or python

Nombre ECTS : 6

Volume horaire par étudiant

CM : 15 h CM/TD : 15 h
TD : 0 h TP/Terrain : 0 h

Total heure /étudiant : 30 h

Modalités de contrôle des connaissances

	1ère session					**2nde session**			
	Type de contrôle **C**ontrôle **C**ontinu (CC) / **E**xamen **T**erminal (ET)			Type d'épreuve si examen terminal (**O**ral/**E**crit)	**2nde chance intégrée** (licences) **(OUI/NON)** minimum 3CC qd scde chance intégée	**OUI/NON**	**Si OUI**		
	100% CC **(OUI/NON)**	%CC / %ET	100% ET **(OUI/NON)**				Type de contrôle **(CC /ET)**	Type d'épreuve (**O**ral/**E**crit)	Durée épreuve écrite
exemple	NON	CC+ET/66+34	NON	E	NON	OUI	ET	E	2h
à vous	NON	CC+ET / 50+50	NON	O	NON	NON			

Illustration

Remote Sensing of Planetary Surfaces
C. Ferrari

3 ECTS
10 x 3 h: 6 lessons + 4 labs
This lecture aims at giving a general culture on the exploration of the Solar System and describing the remote sensing methods commonly used to study the planets and small bodies without atmosphere in the Solar System.
The methodologic part is dedicated to implementing in Python language sensitivity analysis and an inversion method using Bayesian inversion.

Syllabus

1 – (1) The Golden Age of Solar System exploration: from light dots to new worlds. An history of space exploration. General questions on the origin and evolution of the Solar System. Beyond the Solar System: towards other point sources.
Surfaces scars as fingerprints of endogenic and exogenic evolution processes: bombardments, space weathering, topography, composition.

2 – (2) Multi-wavelengths remote sensing strategy: from radio to gamma photons. How to probe surfaces at various depths? Imaging and spectroscopy. Light-matter interactions and remote sensing instruments. Examples.

3 – (1) From observations to structure and composition: modelling planetary surfaces. More quantitative. Developing around particles scattering, surfaces scattering, energy balance

4 – (2) Introduction to methodology: sensitivity analysis, inversion and Python

5 – Methodology (after Python lectures, end of semester) with Python 3, Anaconda 3 and Notebooks
- (1) Photometric models of planetary surfaces
- (2) Sensitivity analysis of photometric models of planetary surfaces
- (3-4) Bayesian inversion of photometric phase curves,

Evaluation

Evaluation of lab work through notebooks.
Oral presentation on published articles dedicated to the remote sensing of planetary surfaces.

Energetics of the climate system

Hervé Le Treut

Géneral Organization of the Course

1. The Earth seen as a whole: global processes and history

2. Radiative Processes and Radiative-Convective Models

(vertical dimension of the problem)

3. Atmospheric and Oceanic Transport (horizontal dimension

of the problem)

4. Anthropogenic forcings and climate response: uncertainties and

feedbacks

5. The COPs: what is the role expected from science

Géneral Content of the Course

Part 1

Global processes and history

1. *The atmosphere and the ocean: generalities*
2. *A global view of radiative processes*
3. *Past climate history*
4. *A global idea of climate stability.*

Part 2

The vertical dimension. Radiative Processes and Radiative-Convective Models

1. *Radiative processes: generalities*
2. *Absorption and Greenhouse effect*
3. *The role of convection*
4. *Diffusion of Solar Radiation*

Part 3

The energy transfer

1. *Energy budget at the top of the atmosphere*
2. *Energy exchanges at the surface of the atmosphere*
3. *Transport by the atmosphere and the ocean*
4. *Vertical and horizontal transport*

Part 4

From science to decision: a few issues

1. *Anthropogenic forcing*
2. *Climate response at different scales*

Clouds, Aerosols and Precipitation

Hélène Chepfer
Jean-Christophe Raut
3 ECTS

Clouds constitute the visible part of the water cycle in the atmosphere. They regulate precipitations and atmospheric water vapour, they interact with the surface and with pollution (e.g. by producing smog), they are one of the main modulators of the Earth temperature through their interaction with solar and telluric radiations. Aerosol particles play a significant role on air quality but also on climate through their interaction with radiation and clouds. Without aerosol particles, cloud formation in the atmosphere would not occur at the temperatures and relative humidities at which clouds are observed to exist.

This course provides key elements of aerosol, cloud and precipitation physics, from the small scale (the particles composing clouds) to the regional scale (a cloud system) and up to the global scales. It includes:

- Origin and chemical composition of aerosols
- Spatial and vertical distributions of particles in the atmosphere
- Microphysics of aerosols: brownian motion, coagulation, condensation, deposition, cloud nucleation
- Optical properties of aerosols
- Aerosol radiative forcing: direct, semi-direct, indirect, impact on snow and ice surfaces
- Water in the atmosphere: thermodynamics of moist air
- Microphysics of warm clouds: formation and growth of cloud droplets
- Microphysics of cold clouds: formation and growth of ice crystals
- Precipitation processes : Rain and Snow
- Opical properties of clouds
- Effect of clouds on radiations
- Cloud feedbacks and link with climate sensitivity.

Hélène Chepfer is professor at Sorbonne Université and researcher at the Dynamic Meteorology Laboratory (LMD). Research interests: Clouds, Radiation, Remote sensing, Climate
http://www.lmd.polytechnique.fr/~chepfer/

Jean-Christophe Raut is associate professor at Sorbonne Université and researcher at LATMOS. Research interests: Aerosols (microphysics and radiation), Aerosol-cloud interactions, Mesoscale modelling, Arctic studies.
http://raut.page.latmos.ipsl.fr/

General outline

Lecture 1 : Cloud microphysics, H. Chepfer
Microphysical processes in warm/cold clouds (nucleation, vapor diffusion, collection, settling, phase mixing), cloud water (vapor, liquid, precipitating liquid, ice, precipitation ice).

Lecture 2 : Overview on atmospheric aerosols, JC Raut
Origin, chemical composition, vertical distribution, microphysical processes, size distribution.

Lecture 3 : Cloud optical properties, H. Chepfer
Radiation-cloud particles interactions, optical properties of cloud particles (liquid droplets and ice crystals).

Lecture 4 : Clouds and radiation, H. Chepfer
Equation of radiative transfer in the atmosphere containing clouds; cloud albedo effect (cooling) and cloud greenhouse effect (warming).

Lecture 5 : Dynamics of aerosol particles, JC Raut
Brownian displacement, aerosol thermodynamics, coagulation, condensation, dry and wet deposition, aerosol and cloud droplets nucleation.

Lecture 6 : Clouds and climate, H. Chepfer
Response of clouds to natural and anthropogenic forcings. Cloud feedbacks mechanisms and link with climate sensitivity. Role of clouds on uncertainties on future climate predictions

Lecture 7 : Optical properties of an aerosol population, JC Raut
Radiation-particles interactions, aerosol scattering, absorption, refractive index and mixing state.

Lecture 8 : Aerosol radiative impacts, JC Raut
Direct, indirect, semi-direct effects, deposition on snow and ice surfaces.

Physico-chemistry of the atmospheric and air quality

Solène Turquety
3 ECTS – MU5SCA33

This course presents the mechanisms that control the composition of the atmosphere in the lower atmosphere, in remote and polluted environments. A first part introduces the basics of chemical kinetics and photochemical equilibria in the troposphere. The equilibrium of the stratosphere and the evolution of the ozone layer are then studied. The rest of the course is devoted more specifically to the understanding of the oxidative capacity of the troposphere and the composition and properties of atmospheric aerosols. The main processes involved in the development of air pollution episodes at urban and regional scales, as well as the tools used by the scientific community and air quality management services for air quality monitoring and forecasting, are then described. The specific structure of the boundary layer and the associated chemical and dynamical processes are detailed, including emissions, deposition and chemical evolution.
All aspects are introduced theoretically before providing a specific description of the practical application in modeling platforms. These models are presented in the context of current air quality policies in Europe and key issues are presented to understand the realistic abatement choices discussed for improving air quality and limiting climate change. Various current applications are described such as extreme case analysis, scenario studies up to operational forecasting, health impact assessment, chemistry-climate analysis.

Implementation

Tuesdays, 13h30-16h30 (note: there will be 2 sessions until 17h30).
Each course will be divided into a lecture and an associated tutorial with applied examples. In addition, students will work in groups on two practical projects:

- Numerical modelling project to understand chemical regime controlling photo-oxidant pollution episodes (ozone) in the Paris area;
- Data analysis project using the air quality observation network in the Paris area, as well as the observations from the Qualair station in Jussieu. Key questions will be: what variability in surface pollutants? what complementarities between observing systems?

Lectures will be given in English if one or more master student does not understand French.

Evaluation

Two reports (30% of final mark), final written exam (70% of final mark).

Course outline

1) Introduction and basics of atmospheric chemistry

2) Stratospheric composition
- Understanding the ozone layer
- Ozone hole development and recent trends

3) Tropospheric composition
- Gaseous atmospheric chemistry

    - The radical cycle
    - Photochemical equilibrium
    - NOx and VOCs chemistry
- Chemical regimes

4) Introduction to aerosols
- Characteristics of a population of aerosol: chemical composition and size distribution;
- Formation of secondary aerosols.

3) Modelling emissions, deposition, chemistry and transport
- General concepts and modelling choices: from box models to 3D Earth system models;
- Example with a numerical application.

4) Polluted boundary layer and air quality management
- Meteorological characteristics of the boundary layer
- Development of pollution episodes

5) Interactions between air quality and climate

Solène Turquety is professor at Sorbonne Université, researcher at LATMOS
Contact: solene.Turquety@sorbonne-universite.fr