



Kristel Chanard

RESEARCH SCIENTIST · IPGP & IGN · GEODESY

35, rue Hélène Brion, 75013 Paris, France

☎ (+33) 7-68-54-49-98 | ✉ chanard@ipgp.fr | 🏠 kristelchanard.weebly.com | 🐦 @KChanard

Research Interests

Understanding how the Earth's shape, gravity field and rotation change in response to shifting hydrological, atmospheric and oceanic mass loads is at the core of my research. Answering this question offers interesting scientific and societal perspectives, including monitoring climate variables, especially water resources, and deepening our understanding of the seismic cycle. However, *hydrogeodesy* comes with scientific and technological challenges that are intimately related, and require hand-in-hand improvements in observing techniques and understanding of the interplay between hydrology and the solid Earth. My research is interdisciplinary, drawing inspiration from various fields such as geodesy, hydrology and seismology. Additionally, I use a wide range of research techniques, including theoretical studies, numerical modeling, as well as field and laboratory observations.

Positions

Research Scientist , INSTITUT DE PHYSIQUE DU GLOBE DE PARIS (IPGP) & INSTITUT NATIONAL DE L'INFORMATION GÉOGRAPHIQUE ET FORESTIÈRE (IGN), Paris, France	2017 - Present
Associate Research Scientist , ÉCOLE NORMALE SUPÉRIEURE, Paris, France	2020 - Present
Postdoctoral Research Fellow , UNIVERSITY OF LAUSANNE, Switzerland	2016-2017
PhD Candidate , ÉCOLE NORMALE SUPÉRIEURE, Paris	2011-2015
Geodesy Field Engineer (Nepal) , CALIFORNIA INSTITUTE OF TECHNOLOGY, Pasadena, USA	2009-2010

Award

EUROPEAN GEOSCIENCES UNION Geodesy division Outstanding Early Career Award	2022
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Education

Ph.D. in Geophysics, with honors	2015
ÉCOLE NORMALE SUPÉRIEURE AND CALIFORNIA INSTITUTE OF TECHNOLOGY	Paris, France
Diploma of the École Normale Supérieure, with honors	2012
ÉCOLE NORMALE SUPÉRIEURE	Paris, France
M.S., Geophysics, with honors	2011
INSTITUT DE PHYSIQUE DU GLOBE DE PARIS & ÉCOLE NORMALE SUPÉRIEURE	Paris, France
B.S., Physics, with honors	2008
UNIVERSITÉ PIERRE ET MARIE CURIE & ÉCOLE NORMALE SUPÉRIEURE	Paris, France

Academic Service

Earthscope consortium	2023-Present
ELECTED MEMBER OF THE BOARD OF DIRECTORS	
International Terrestrial Reference System Combination Centre	2017-Present
ACTIVE STAFF MEMBER	
International Association of Geodesy	2020-Present
<ul style="list-style-type: none">• Chair of the Working Group on Geocenter Motion• Member of the Working Group on Glacial Isostatic Adjustment modelling• Member of the Working Group on Assessing impacts of loading on Reference Frame realizations	
Institut de Physique du Globe de Paris	2020-Present
MEMBER OF THE SCIENTIFIC COUNCIL	
Institut de Physique du Globe de Paris	2022-Present
CO-CHAIR OF THE EQUALITY, DIVERSITY AND INCLUSION DISCUSSION COMMITTEE	
Solid Earth committee of the French National Centre for Scientific Research	2022-Present
IGN REPRESENTATIVE	

National service of satellite imagery observation (ISDeform)

MEMBER OF THE SCIENTIFIC COUNCIL

2022-Present

Scientific Committee on Antarctic Research

FRANCE REPRESENTATIVE OF ANTARCTIC GEOGRAPHIC INFORMATION

2022-Present

Reviewer for scientific journals

JGR, GRL, NATURE COMMUNICATIONS, PAGEOPH, EPSL, JOG, ASR, NATURE GEOSCIENCES, SCIENCE, GJI

On occasion

Nominated Associate Editor

JOURNAL OF GEODESY EDITORIAL BOARD

2023-

Reviewer for scientific proposals

CNES, CNRS

On occasion

Organisation of Conferences and Seminars

- SAGE/GAGE science community workshop, Pasadena (~300 persons) 2023
- RhEIA: Rheology of Earth's Interior Across scales, Paris (~100 persons) 2022
- National satellite gravity workshop, Marseille, (~50 persons) 2022
- Equality, Diversity and Inclusion seminars series (IPGP) 2022-present
- IGS Workshop Paris 2017
- Unified Analysis Workshop Paris 2017
- Geodesy seminars series (IPGP) 2020-2021
- AGU and EGU sessions 2017-Present

Memberships

- American Geophysical Union 2011-Present
- European Geosciences Union 2011-Present
- International Association of Geodesy 2017-Present

Teaching

Graduate Level Courses

- When climate loads the Earth: rheology from Geodesy, Ecole de Physique des Houches, Doctoral Training: Solid Earth 2022
- Satellite Geodesy, IPGP 2019-Present
- Geodesy for Geophysical Applications, ENSG 2019-Present
- Viscoelastic deformation and Rotation of the Earth induced by climatic forcing, IPGP 2018-Present

Undergraduate Level Courses

- Geoid and altitude references, ENSG 2018-2020
- Mathematics for Geodesy, ENSG 2018-2020

Field Experience

Geophysics field missions

GNSS AND GRAVITY MEASUREMENTS

On occasion

IGN, IPGP

Field engineer in Geodesy

MAINTENANCE AND IMPROVEMENT OF THE NEPAL GNSS NETWORK

2009-2010

Caltech, USA

Invited Lectures

- Upcoming: UNIVERSITY OF OXFORD, Earth Sciences Department Seminar 2023
- EUROPEAN GEOSCIENCES UNION, Geodesy Early Career Award Talk 2022
- AMERICAN GEOPHYSICAL UNION, Geodesy Division Seminar 2021
- MICHIGAN STATE UNIVERSITY, Geosciences Division Seminar 2021
- LAMONT-DOHERTY EARTH OBSERVATORY, Marine Geology and Geophysics & Seismology Geology and Tectonophysics Seminar Series 2021
- CAMBRIDGE UNIVERSITY, Bullard Seminar Series 2021
- CALIFORNIA INSTITUTE OF TECHNOLOGY, Geology and Planetary Sciences Division Seminar 2021
- BROWN UNIVERSITY, Brown DEEPS Colloquium 2020
- SCEC, Scientific Council, *Perspectives on geodetic transient detection* 2020
- SAGE/GAGE WORKSHOP, Plenary Speaker on Earth Rheology and Structure: New Approaches, Applications & Implications for Dynamics 2019
- RESIF, Scientific Council, *Perspectives on environmental geodesy* 2019
- LABORATOIRE DE GÉOLOGIE DE LYON, TERRE, PLANÈTES, ENVIRONNEMENT, Division Seminar 2019
- ISTERRE, GRENOBLE, Geodesy Seminar 2015

Awarded Grants

As lead PI

- FRENCH NATIONAL RESEARCH AGENCY (ANR): ICe Evolution: Bridging Elevation change and Radar with GRACE in review
- FRENCH NATIONAL SPACE AGENCY (CNES): Hydrogeodesy 2022-present
- FRENCH NATIONAL CENTRE FOR SCIENTIFIC RESEARCH SPACE PROGRAM (PNTS): Geocenter Motion 2020-present
- CNES: Spatio-temporal variations of the Earth gravity field measured by GRACE/GRACE-Follow On: 2020-present
- SATELLITE IMAGING PROJECTS (FLATSIM): Hydrogeodesy, Ozark, USA 2020
- CNES: (Visco-)elastic response of the Earth to surface loading 2015-2019

As co-PI

- ANR SSDYN: Identifying slow slop dynamics combining seismic and geodetic data 2022-present
- EC2CO: Impact of earthquakes on aquifers in La Martinique 2021-present
- ANR S5: Synchronous Slow Slip & Seismic Swarm 2020-present
- CNES: International Terrestrial Reference Frame Realization 2017-present
- CNES: Separating recent and past ice melting signals in space geodetic observations 2017-present

As collaborator

- NSF-FRONTIER RESEARCH IN EARTH SCIENCES 2022-present
Collaborative Research: Towards a new framework for interpreting mantle deformation: integrating theory, experiments, and observations spanning seismic to convective timescales

Advised and co-advised students

Graduate students

- LAETITIA PANTOBE (IPGP), Periodic modulation of volcanic seismicity, example of La Soufrière de Guadeloupe 2020-Present
- MARTIN COLLEDGE (ENS), Periodic modulation of microseismicity, from the laboratory to the natural case 2020-Present
- LOUIS-MARIE GAUER (IPGP), Contribution of space gravity and radar interferometry to ice mass balance 2020-Present
- ANA SANCHEZ (IPGP), Separating contributions of past and recent ice reeat on the Earth's deformation and gravity field 2017-2022
- STACY LAROCHELLE (Caltech), Separating and modeling sources of seasonal deformation in GNSS time series 2017-2022
- PAOLINE PREVOST (ENS), Extracting the spatio-temporal variations in the GRACE gravity field: methods & geophysical applications 2016-2019

Undergraduate students

- SOFIA CHARISSIS (Montpellier University), Measuring ice melting in Patagonia using space gravimetry 2023
- LAURA SOUEIDAN (ENS), Validating GRACE/-FO hydrological mass balance of the Caspian sea using altimetry measurements 2022
- NELLY-WANGUE MOUSSISSA (IPGP), Hydrological mass balance of Lake Victoria: GRACE/-FO versus altimetry measurements 2022
- ELIE-ALBAN LESOUC (ENSG), Global comparison of hydrological loading models with GNSS time series 2020

Engineering student

- JULIEN BARNÉOUD (IGN), Building a Load-Induced Earth Deformation Online Computation Service 2022-2023

Publications

Published

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– IN PEER-REVIEWED JOURNALS

- Pétrélis, F., **Chanard, K.**, Schubnel, A., & Hatano, T., 2023 Earthquake magnitude distribution and aftershocks: a statistical geometry explanation. *Physical Review E*. [Preprint] at arXiv:2302.10981.
- * Larochelle, S., **Chanard, K.**, Fleitout, L., Fortin, J., Gualandi, A., Longuevergne, L., Rebischung, P., Violette, S. and Avouac, J. P., 2022. Understanding the geodetic signature of large aquifer systems: Example of the Ozark Plateaus in Central United States. *Journal of Geophysical Research: Solid Earth*
- Van Camp, M., de Viron, O., Dassargues, A., Delobbe, L., **Chanard, K.**, and Gobron, K., 2022. Extreme hydrometeorological events, a challenge for gravimetric and seismology networks. *Earth's Future*, 10(4), e2022EF002737.
- Adhikari LB., Bollinger L., Vergne J., Lambotte S., **Chanard, K.**, Laporte M., Grace L., Koirala B., Bhattarai M., Bishwokarma TN., Wendling Vazquez N., Girault F. and Perrier F. Orogenic collapse and stress adjustments revealed by an intense seismic swarm following the 2015 Gorkha earthquake in Nepal, *Frontiers in Earth Science*, 524.
- Hetenyi, G., **Chanard, K.**, Baumgardner, L., Herman, F., Metamorphic transformation rate over large spatial and temporal scales constrained by geophysical data and coupled modeling, accepted to *Journal of Metamorphic Geology*
- Pétrélis, F., **Chanard, K.**, Schubnel, A. and Hatano, T., 2021. Earthquake sensitivity to tides and seasons: theoretical studies. *Journal of Statistical Mechanics: Theory and Experiment*, 2021(2), p.023404.
- Couhert, A., Bizouard, C., Mercier, F., **Chanard, K.**, Greff, M. and Exertier, P., 2020. Self-consistent determination of the Earth's GM, geocenter motion and figure axis orientation. *Journal of Geodesy*, 94(12), pp.1-16
- **Chanard, K.**, Métois, M., Rebischung, P. and Avouac, J.P., 2020. A warning against over-interpretation of seasonal signals measured by the Global Navigation Satellite System. *Nature communications*, 11(1), pp.1-4
- Benoist, C., Collilieux, X., Rebischung, P., Altamimi, Z., Jamet, O., Métivier, L., **Chanard, K.** and Bel, L., 2020. Accounting for spatiotemporal correlations of GNSS coordinate time series to estimate station velocities. *Journal of Geodynamics*, p.101693
- * Prevost, P., **Chanard, K.**, Fleitout, L., Calais, E., Walwer, D., van Dam, T. and Ghil, M., 2019. Data-adaptive spatio-temporal filtering of GRACE data. *Geophysical Journal International*, 219(3), pp.2034-2055

- **Chanard, K.**, Nicolas, A., Hatano, T., Petrelis, F., Latour, S., Vinciguerra, S. and Schubnel, A., 2019. Sensitivity of acoustic emission triggering to small pore pressure cycling perturbations during brittle creep. *Geophysical Research Letters*, 46(13), pp.7414-7423
 - * Larochelle, S., Gualandi, A., **Chanard, K.**, Avouac, J-P., 2018. Identification and extraction of seasonal geodetic signals due to surface load variations, *Journal of Geophysical Research: Solid Earth*, , 123(12), pp.11-031
 - **Chanard, K.**, Fleitout, L., Calais, E., Rebischung, P. and Avouac, J.P., 2018. Toward a global horizontal and vertical elastic load deformation model derived from GRACE and GNSS station position time series. *Journal of Geophysical Research: Solid Earth*, 123(4), pp.3225-3237
 - **Chanard, K.**, Fleitout, L., Calais, E., Barbot, S. and Avouac, J.P., 2018. Constraints on transient viscoelastic rheology of the asthenosphere from seasonal deformation. *Geophysical Research Letters*, 45(5), pp.2328-2338
 - Craig, T.J., **Chanard, K.** and Calais, E., 2017. Hydrologically-driven crustal stresses and seismicity in the New Madrid Seismic Zone. *Nature communications*, 8(1), pp.1-11
 - **Chanard, K.**, J. P. Avouac, G. Ramillien, and J. Genrich, 2014. Modeling deformation induced by seasonal variations of continental water in the Himalaya region: Sensitivity to Earth elastic structure, *J. Geophys. Res. Solid Earth*, 119, 5097–5113, doi:10.1002/2013JB010451
 - Ader, T., J. P. Avouac, J. Liu-Zeng, H. Lyon-Caen, L. Bollinger, J. Galetzka, J. Genrich, M. Thomas, **Chanard, K.**, S. N. Sapkota, S. Rajaure, P. Shrestha, L. Ding, and M. Flouzat, 2012. Convergence rate across the Nepal Himalaya and interseismic coupling on the Main Himalayan Thrust: Implications for seismic hazard, *J. Geophys. Res.*, 117, B04403, doi:10.1029/2011JB009071
- BOOK CHAPTER
- Altamimi Z., Rebischung P., Collilieux X., Métivier L., **Chanard, K.**, 2019. Review of Reference Frame Representations for a Deformable Earth. *International Association of Geodesy Symposia*. Springer, Berlin, Heidelberg

In Review

– IN PEER-REVIEWED JOURNALS

- * Larochelle, S., **Chanard, K.**, Dalaison, M., Fleitout, L., Fortin, J., Longuevergne, L., Jolivet, R., Avouac, J.P., Imaging the abrupt collapse of the Sacramento Valley aquifer over the 2021-2022 California drought, *Science*
- * Gauer, L.M., **Chanard, K.**, Fleitout, L., 2022. Data-driven gap filling and spatio-temporal filtering of the GRACE/GRACE-FO records, *Journal of Geophysical Research*. [Preprint] at <https://doi.org/10.1002/essoar.10512455.1>
- * Colledge, M., Aubry, J., **Chanard, K.**, Pétrélis, F., Duverger, C., Bollinger, L., Schubnel, A., 2022. Susceptibility of microseismic triggering to small sinusoidal stress perturbations at the laboratory scale, *Journal of Geophysical Research*. [Preprint] at <https://doi.org/10.1002/essoar.10512456.1>
- * Pantobe, L., Burtin, A., **Chanard, K.**, Komorowski, J.C., Seasonal shallow seismicity at la Soufrière de Guadeloupe following the Mw 4.1 2018 earthquake, *EPSL*
- Altamimi, Z., Rebischung, P., Collilieux, X., Métivier, L., **Chanard, K.**. ITRF2020: An augmented reference frame refining the modeling of nonlinear station motions, *Journal of Geodesy*

– BOOK CHAPTER

- Burgmann, R., **Chanard, K.**, Fu, Y., Climate-Driven Solid-Earth Deformation and Seismicity, for “Monitoring of the Terrestrial Environment: Earthquakes, Volcanoes, and Climate Changes”. *Elsevier*

In preparation

– FOR PEER-REVIEWED JOURNALS

- Fleitout, L., **Chanard, K.**, Thermoelastic deformation of a spherical elastic Earth with realistic mechanical properties
- **Chanard, K.**, Fleitout, L., Constraining the kinetics of mantle mineralogical phase transformation using the Earth’s response to surface mass redistribution
- * Larochelle, S., **Chanard, K.**, Dalaison, M., Fleitout, L., Fortin, J., Longuevergne, L., Jolivet, R., Avouac, J.P., Modeling of aquifer deformation: an example from the Sacramento Valley (California)
- * Sanchez, A., Metivier, L., Fleitout, L., **Chanard, K.**, Greff, M. Comparing Greenland Surface-Mass-Balance and Firn-Densification Data Using ICESat and CryoSAT-2 Altimetry and GRACE data
- * Gauer, L-M., **Chanard, K.**, Fleitout, L., A comparison of GRACE/-FO and altimetry derived regional hydrological mass balance: example of the Caspian Sea
- * Gauer, L-M., Grandin, R., **Chanard, K.**, Fleitout, L., Constraining ice mass loss from the Kerguelen islands: new insights from InSAR-measured crustal uplift

Recent Conferences Presentations

- **Chanard, K.**, Larochelle, S., Dalaison, M., Fleitout, L., Fortin, J., Longuevergne, L., Jolivet, R., Avouac, J.P., 2022, Geodetic signature of aquifer systems, G2 & MDIS
- **Chanard, K.** (2022). Geodesy: a sensor for hydrology (No. EGU22-12642). Copernicus Meetings.
- Baden, C., Wang, L., **Chanard, K.**, Burgmann, R., 2022, Modeling Proposed Deep Slab-Deformation Processes Behind Potential Precursory Signals Preceding Large Subduction Zone Earthquakes Using Finite Elements, AGU Fall Meeting
- Baden, C., Rousset, B., **Chanard, K.**, Fleitout, L., Burgmann, R. 2022, Seasonal hydrologic loading and surface deformation reveal the rheology of the lithosphere in CA, GSA
- Altamimi, Z., Rebischung, P., Collilieux, X., Métivier, L., **Chanard, K.**, 2022. ITRF2020: main results and key performance indicators (No. EGU22-3958). Copernicus Meetings.
- Argus, D., Martens, H., Borsa, A., Wiese, D., Knappe, E., Larochelle, S., Anderson, M., Peidou, A., Khatiwada, A., Lau, N., White, A., Hoylman, Z., Swarr, M., Cao, Q., Pan, M. **Chanard, K.**, Avouac JP., Payton, G. and Landerer F., 2022. Intensifying hydrologic drought in California (No. EGU22-6800). Copernicus Meetings.
- Colledge, M., Aubry, J., **Chanard, K.**, Pétrélis, F., Duverger, C., Bollinger, L., Schubnel, A., 2022. Susceptibility of microseismic triggering to small sinusoidal stress perturbations at the laboratory scale (No. EGU22-6034). Copernicus Meetings.
- Gauer, L-M., **Chanard, K.**, Fleitout, L., 2022. Data-driven gap filling and spatio-temporal filtering of the GRACE-GRACE-FO records (No. EGU22-12024). Copernicus Meetings.

- Van Camp, M., de Viron, O., Dassargues, A., Delobbe, L., **Chanard, K.**, 2022a. Extreme hydrometeorological events, a challenge for geodesy and seismology networks. In EGU General Assembly 2022.
- Altamimi, Z., Rebischung, P., Collilieux, X., Metivier, L., **Chanard, K.**, 2021a. ITRF2020: From Data Analysis to Results. Presented at the AGU Fall Meeting Abstracts, pp. G53A-08.
- Argus, D., Martens, H., Wiese, D., Borsa, A., Knappe, E., Larochelle, S., Avouac, J.-P., **Chanard, K.**, Anderson, M., Peidou, A., 2021. Loss of water in the ground in the southwest US during drought in 2020 and 2021. Presented at the AGU Fall Meeting Abstracts, pp. G13A-02.
- Altamimi, Z., Rebischung, P., Metivier, L., Collilieux, X., **Chanard, K.**, Teyssendier-de-la-Serve, M., 2021b. Preparatory analysis and development for the ITRF2020. Presented at the EGU General Assembly Conference Abstracts, pp. EGU21-2056.
- **Chanard, K.**, Pétrelis, F., Hatano, T., Schubnel, A., Colledge, M., 2021. Earthquake sensitivity to seasons: field observations, laboratory experiments and theoretical considerations. Presented at the AGU Fall Meeting 2021, AGU.
- Larochelle, S., **Chanard, K.**, Fleitout, L., Fortin, J., Argus, D., Longuevergne, L., Avouac, J.-P., 2021. Extracting and separating different sources of hydrology-induced deformation in geodetic datasets. Presented at the AGU Fall Meeting Abstracts, pp. G51A-01.
- Rebischung, P., Collilieux, X., Metivier, L., Altamimi, Z., **Chanard, K.**, 2021. Analysis of IGS repro3 Station Position Time Series. Presented at the AGU Fall Meeting 2021, AGU.
- Sanchez, A., Metivier, L., Fleitout, L., **Chanard, K.**, Greff-Lefftz, M., Berthier, E., Hugonnet, R., 2021a. Evolution of the Greenland ice sheet: a multi-technique geodetic approach. Presented at the AGU Fall Meeting Abstracts, pp. G32A-02.
- Sanchez, A., Métivier, L., Fleitout, L., **Chanard, K.**, Marianne, G., 2021b. Spatio-temporal evolution of the Greenland ice sheet and associated deformation of the Earth: a multi-technic geodetic approach. Presented at the EGU General Assembly Conference Abstracts, pp. EGU21-7341.
- **Chanard, K.** and Fleitout, L. Constraining the kinetics of mantle mineralogical phase transformation using the Earth's response to surface mass redistribution, In AGU Fall Meeting 2020. AGU.
- Zhou, B., Zaliapin, I., Johnson, C. W., Fu, Y., **Chanard, K.**, & Ben-Zion, Y. (2020). Environmental triggering of seismicity in California. In AGU Fall Meeting 2020. AGU.
- Larochelle S., **Chanard, K.**, Fleitout L., Gualandi A, Fortin J, Rebischung P, Violette S, and Avouac JP. Understanding the geodetic signature of large aquifer systems: example of the Ozark Plateaus Aquifer in central United States. In AGU Fall Meeting 2020. AGU.
- Radiguet, M., Kazachkina, E., Maubant, L., Cotte, N., Kostoglodov, V., Gualandi, A. and **Chanard, K.**, Systematic characterization of slow slip events along the Mexican subduction zone over 20 years. In AGU Fall Meeting 2020. AGU.
- Zhou, B., Zaliapin, I., Johnson, C., Fu, Y., **Chanard, K.**, & Ben-Zion, Y (2020). Environmental triggering of seismicity in California . Poster Presentation at 2020 SCEC Annual Meeting
- Couhert, A., Bizouard, C., Mercier, F., **Chanard, K.**, Greff, M., and Exertier, P.: Constraints on the Rheology of the Earth's Deep Mantle from Decadal Observations of the Earth's Figure Axis and Rotation Pole, EGU General Assembly 2020, Online, 4–8 May 2020, EGU2020-18545
- Radiguet, M., Kazachkina, E., Maubant, L., Cotte, N., Kostoglodov, V., Gualandi, A., and **Chanard, K.**: Systematic characterization of slow slip events along the Mexican subduction zone from 2000 to 2019, EGU General Assembly 2020, Online, 4–8 May 2020, EGU2020-17441

Outreach Activities

- Press interview for national newspaper Libération on Earth rotation and climate change 2023
- TV Documentary on Earth's gravity field (C'est toujours pas sorcier: la gravité, la force invisible) 2022
- IGS Community Spotlight, The Newsletter of the International GNSS Service, Issue 5 2022
- Interview for L'esprit Sorcier 2022
- Kristel Chanard: Trekking and tracking mountains. Wheeling, K. (2021), *Eos*, 102 2021
- Press interviews on Earth rotation variations 2021
- Geosciences outreach interventions in primary and middle schools 2016-present
- TV and Radio Interviews following the 2015 Gorkha Earthquake 2015
- TV Documentary La valse des continents: L'Asie d'aujourd'hui, Arte 2012
- Earthquake awareness in Nepal 2010-2015
- Member of the Caltech Tectonics Observatory outreach program 2010-2012
- Animation of the India-Asia collision 2010