Modeling and Validation of Vertical Surface Deformation in Subduction Zones Using Locking Maps and Slip Models

project subtitle

Department: Earth Sciences
Research group: Tectonics
Supervisors: Ylona van Dinther & Ehsan Kosari
Email address: y.vandinther@uu.nl e.kosari@uu.nl

Project description

Subduction zones, where one tectonic plate slides beneath another, produce Earth's largest earthquakes (e.g., the 2004 Sumatra and 2011 Japan events, both magnitude 9.1). These dynamic plate boundaries, where strain accumulation and release control patterns of uplift and subsidence, influence both seismic hazard and long-term landscape evolution. This project aims to compile and synthesize existing fault (interseismic) locking models and (coseismic) earthquake slip distributions from global subduction zones, focusing on the physical mechanisms driving vertical surface deformation.

The primary objective is to map predicted uplift and subsidence zones along selected subduction margins and to compare these model results with existing geodetic and geomorphological observations. The student will validate modeled vertical motions against GNSS vertical velocities, InSAR-derived deformation rates, and longer-term geomorphological indicators such as marine terraces. This comparison will enable an assessment of how well elastic (half-space) models reproduce real-world deformation signals, and will help identify regions where deviations may indicate complex rheology or other non-elastic processes.

By integrating geodetic, seismic, and geomorphological data, the project will provide insights into the reliability of elastic models for predicting vertical motions in subduction settings. The results will help refine our understanding of how interplate locking translates into observable surface deformation, highlight discrepancies between models and observations, and discuss their potential causes. The outcomes will contribute to a broader group effort to improve the representation of subduction processes in geodynamic and seismic hazard frameworks.

Through this work, the student will gain experience in synthesizing geophysical data, computational modeling, and interpreting earthquake cycle deformation processes. The student will compile and analyze published datasets of subduction zone locking and earthquake slip distributions, implement forward models to compute deformation fields, and compare these results with geodetic and geomorphological observations. This will involve working with real earthquake and geodetic data, learning to use modeling and visualization tools (e.g., MATLAB or Python), and interpreting deformation in a tectonic context.

Job requirements

- High motivation in forward modeling and researching earthquake topics.
- Ability in searching and reading relevant literature (e.g., papers) and combining available data.
- Good/very good Python/MATLAB programming skills.
- Experience with, or highly interested in, forward and/or inverse modelling.
- Good oral (for discussion and presentation) and written English skills are required.