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On the use of tiltmeters for a better determination of fault strain at depth

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Geodetic tools like GPS and INSAR provide accurate and dense measurements of geodetic strain around active faults. However, these measurements do not allow to precisely infer the strain distribution at depth. For example, the classical arctangent shape observed on many strike-slip faults during interseismic loading can be equally well interpreted like the result of localized fault slip at depth (Savage et Burford, 1973) or resulting from the strain of a variable rigidity plate (Chéry 2008). Yet for each kind of model, the uniqueness of inversion is not guaranteed due to the uncertainty associated to data measurements. A way to reduce this equifinality problem is to add a different kind of data to the interseismic motion measurements. Here we study how a network of vertical tiltmeters can provide valuable information to infer the strain pattern associated the deep motion of a strike slip fault.
Many kinds of tiltmeters have been developed so far (Agnew, 1986). Among them, horizontal tiltmeters are based on water tube level measurements are both accurate and stable due to their large baseline. On the other hand, compact vertical tiltmeters allow to detect a small rotation of the gravity vector associated to mass displacement or strain. Even if horizontal and vertical tiltmeters measure similar kind of strain (a rotation), they do not detect the same strain component. Indeed, a horizontal tiltmeter detects the derivative of horizontal displacement with respect to horizontal direction. By contrast a vertical tiltmeter is sensitive to the derivative of horizontal displacement with respect to the vertical direction.
Using different models of interseismic strain for a vertical strike-slip fault, we study how measurements provided by vertical tiltmeters together with GPS measurements allow to restrict the model space and their associated parameters. We also show how a tiltmeter network can be used to detect episodic slip events at depth. We compare the capability of detection provided by tiltmeters with to the one associated to a GPS network.