New Insights into the San Andreas Fault System from Space Geodesy and the next Generation of Crustal Deformation Models

Roland Bürgmann, UC Berkeley, with Matt d’Alessio, Alessandro Ferretti, Eric Fielding, George Hilley, Ingrid Johanson, Ling Lei, Dave Manaker, Fabrizio Novali, Fred Pollitz, Isabelle Ryder, David Schmidt
Motivation: Illuminate and Quantify Active Deformation Processes and Hazard

Space geodetic deformation data (Aseismology) reveals:

• Elastic strain and geodetic fault slip rates for earthquake probabilities

• Earthquake potential along locked and creeping Hayward fault

• Post Loma Prieta Transient deformation and lithosphere rheology for time dependent hazard estimates

• Various non-tectonic deformation processes relevant for hazard
GPS Geodesy
GPS Geodesy

Shen, King and Agnew, 2006 (unpublished)
Block Tectonics and Deep Slip Rates

d’Alessio et al., JGR, 2005
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Creep And Earthquakes on Hayward Fault

1868 M = 7 Earthquake

Downtown Hayward, 1868

SF at Bush & Market

1974

1993

Long Term Rate: 10 mm/yr
GPS Creep Rate: 4 mm/yr

STAB
STAC
STAD
STAA

Hayward fault

10 mm yr⁻¹
100 m

www.mcs.csuhayward.edu/~shirschf/tour-4.html

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InSAR & PS-InSAR Geodesy
(Permanent Scatterer Interferometric Synthetic Aperture RADAR (Radio Detection And Ranging))
From Surface Deformation to Fault Slip

Input: Surface Deformation Measurements

Computer Model
Equations relate fault slip to surface deformation based on elasticity

Output: Fault Behavior
(Where creeping, where locked)
Details of background image

Mechanical models of fault creep

NW SE

Moment deficit rate $M_w 6.8/100yr$

Last earthquake: $1868 M \approx 6.8 - 7.0$

Earthquake hazard: high

ERS Descending

Funning et al., 2009 in prep.
Model residuals indicate anomalous subsidence and contraction near Loma Prieta.
Models favor a high-viscosity lower crust and low-viscosity upper mantle (5 x 10^{18} Pas)
Pollitz & Schwarz (2008):
“The probability of rupture of the S Hayward fault over the next 30 years is 40% - 75% ”
Non-tectonic Deformation from InSAR
Treasure Island


RADARSAT track 038 (1998-2006)

9.85±0.96
1.18±1.69

LOS vel. (mm/yr)
Deep Seated Landslides

RADARSAT-1 ascending beam-3 =>
Solve for the horizontal and vertical velocities (mm/yr)

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