Block Models of Walker Lane and Great Basin Tectonic Deformation, Slip Rates and Seismic Cycle Effects

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Abstract

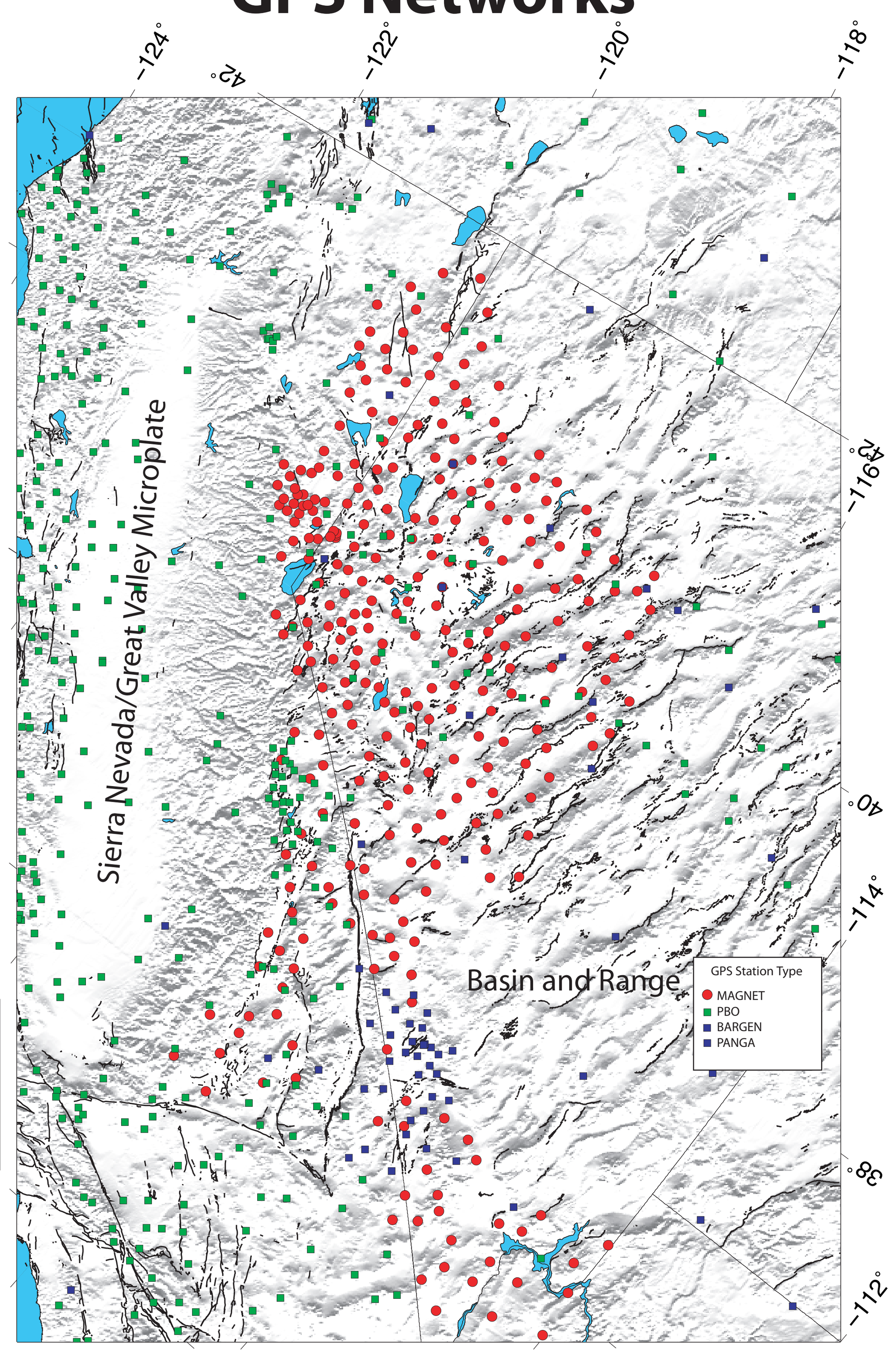
We have developed block models for the northern, central and southern Walker Lane and western Great Basin constrained by GPS from the regional continuous networks (e.g. EarthScope Plate Boundary Observatory) and our own semi-continuous GPS network, the Mobile Array of GPS for Nevada Transtension (MAGNET). These models combine data on the location of active faults and GPS velocity gradients to infer rates of slip on the faults. In this region numerous fault systems work to accommodate ~25% of the Pacific North/America relative motion through a complex pattern of dextral, normal and sinistral slip. The models portray the pattern of crustal deformation, but we find that because of the complexity of deformation there the final result depends significantly on the regularization of the inversion used to find the optimal slip rates. Additionally, postseismic relaxation from past historic earthquakes has a significant impact. We have used the VISCO1D software (Pollitz, 1997) to estimate the contribution from historic earthquakes in central Nevada, and southern California to the contemporary deformation field, and on the slip rates inferred in block models. In this presentation we compare and contrast the patterns of slip across different portions of the Walker Lane, and show the effect that our corrections for viscoelastic relaxation have on the final models.

Right) GPS sites of the EarthScope Plate Boundary observatory (PBO), nucleus networks (e.g. BARD, PANGA, BARGEN), and the Mobile Array of GPS for Nevada Transtension (MAGNET) which is operated by the University of Nevada, Reno. MAGNET coverage of the Walker Lane is nearly complete at 20 km spacing. A number of the sites, especially those in southern Nevada, have been established but not surveyed enough to estimate a velocity (above right). MAGNET sites are "semi-continuous" in most locations, and are surveyed multiple times per year, but for about 1/3 of the network are surveyed episodically (yearly or every other year) as funds and logistics allow.

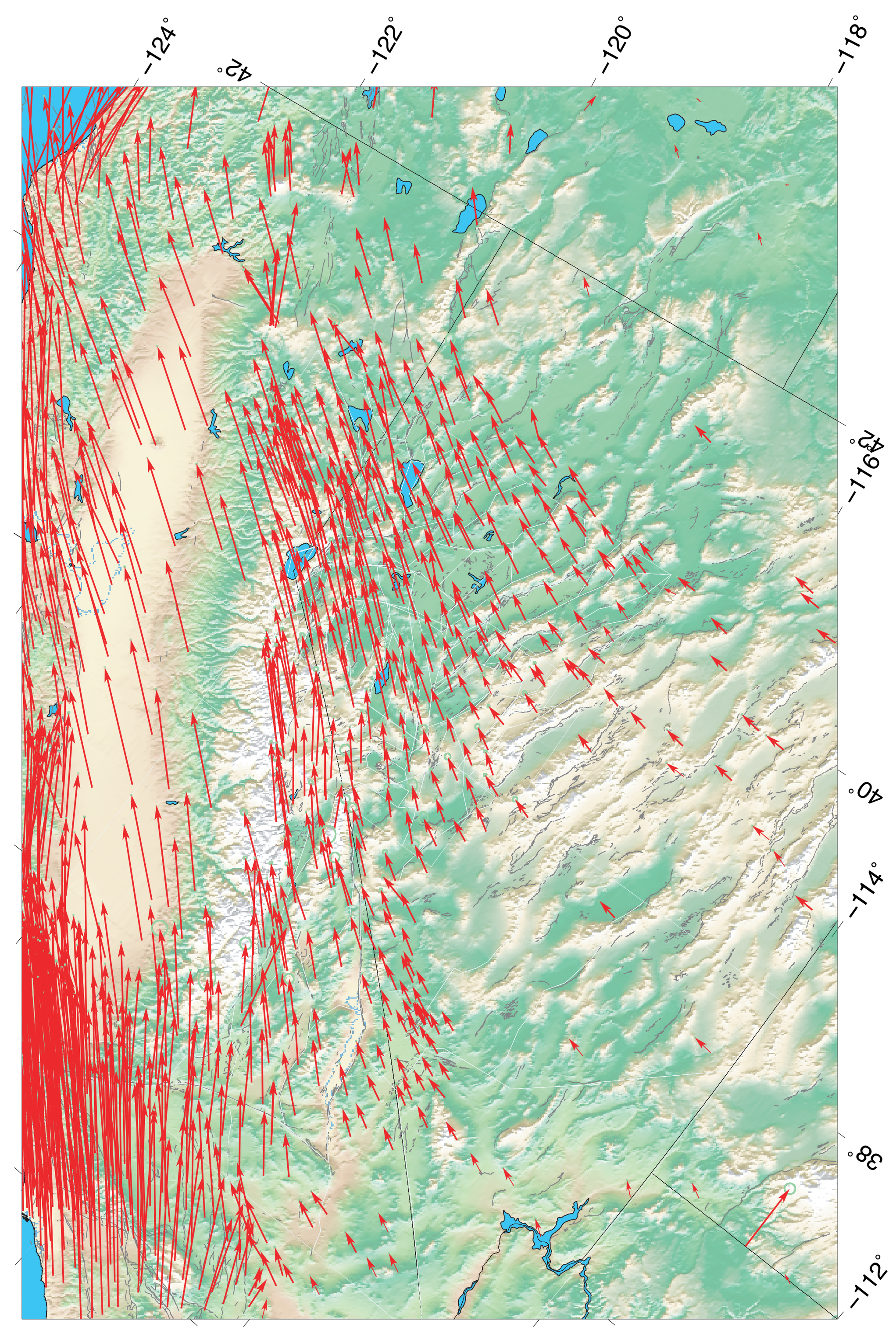
Far Right) GPS velocities in a North America fixed reference frame. Approximately 10 mm/yr of deformation is ongoing across the Walker Lane, but the width of the deformation zone varies from north to south. Most (but not all) of the sites in these network (above left) have been surveyed for 2.0 or more years, a point at which the velocity is relatively stable. Additional surveys will be necessary to achieve uncertainties of <0.3 mm/yr for all sites.

Far Far Right) Location and block geometries for three separate block modeling investigations that are ongoing in the Walker Lane. Overlap between study areas provides continuity of deformation so that each study area can be adequately constrainted at its boundary. Souther Walker Lake (blue), Central Walker Lane (red), and Northern Walker Lane (green).

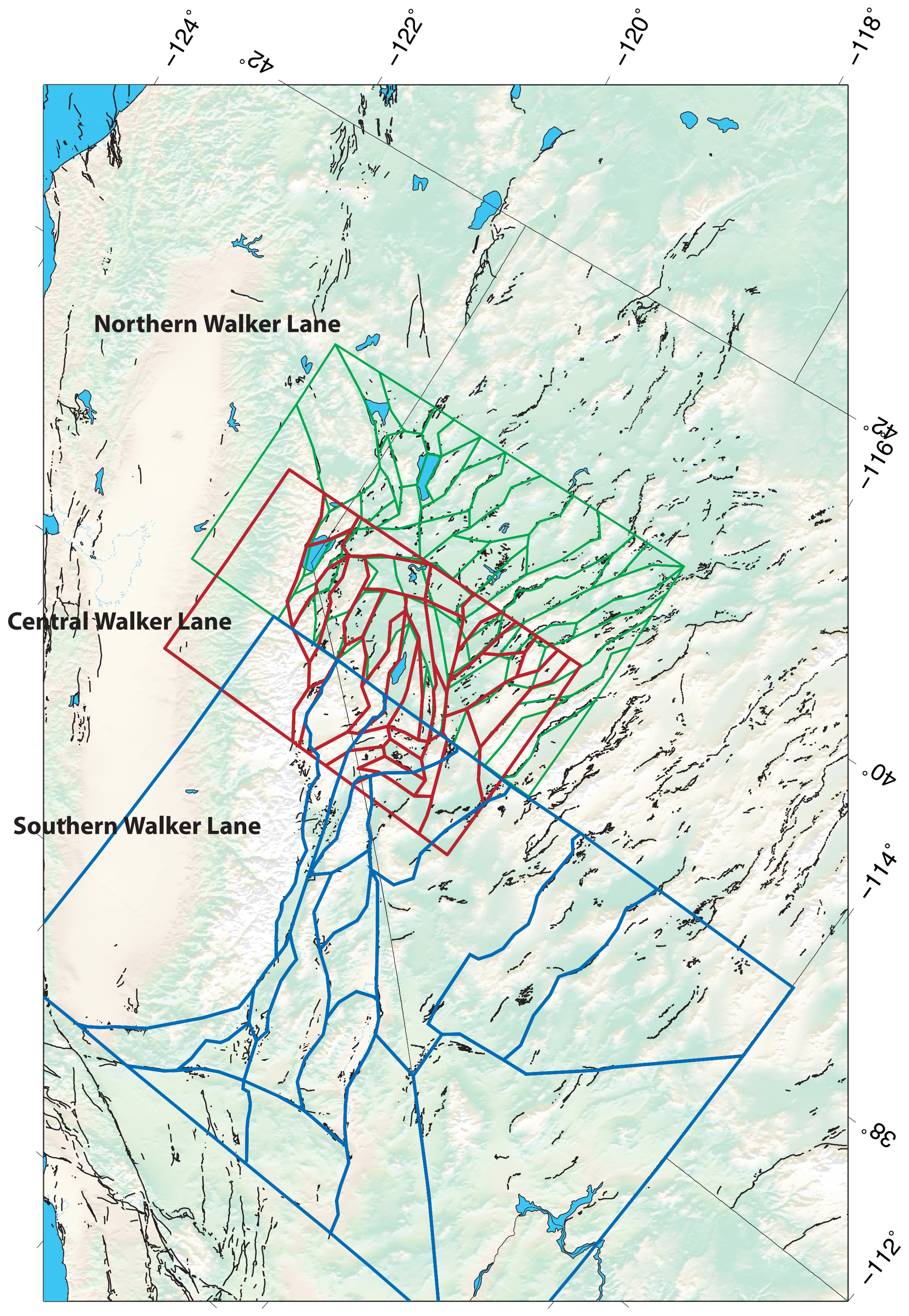
MAGNET and Continuous GPS Networks



GPS Velocities



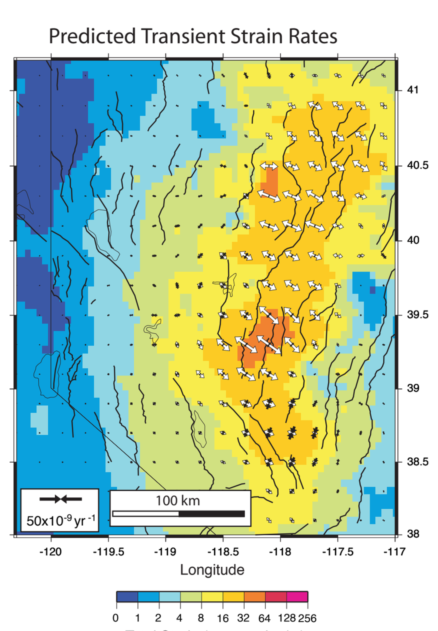
Block Models

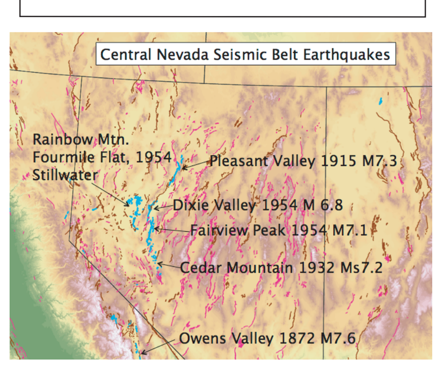


Models of Postseismic Viscoelastic Relaxation

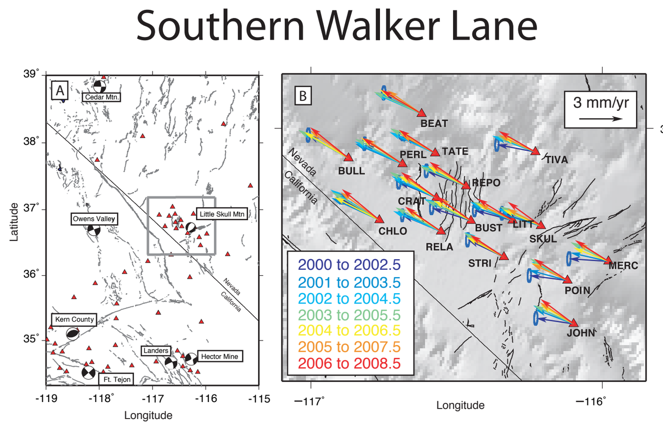
Northern and Central Walker Lane

Right) Deformation patternsn in the Northern Walker Lane are affected by viscoelastic postseismic relaxation following earthquakes in the Central Nevada Seismic Belt (CNSB - below). We developed a model of CNSB relaxation using VISCO1D (Pollitz, 1997). This model explains vertical motions observed across the CNSB with InSAR and GPS, the high rate of deformation observed around the CNSB, and a disagreement between geodetic and geologic estimates of slip rates across CNSB faults (Hammond et al., 2009). A strain map of the transient velocities (right) shows the predominantly northwest-southeast uniaxial extension and dextral shear in this field.

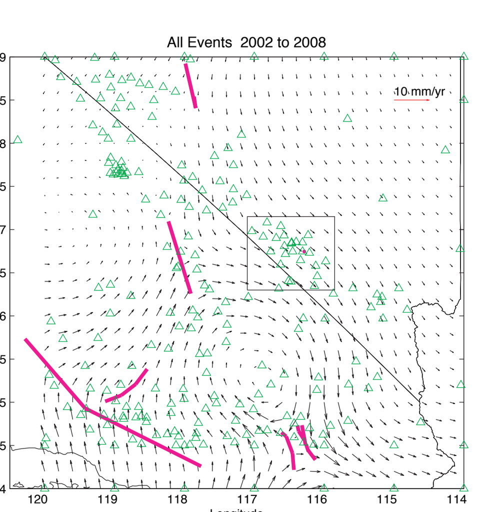




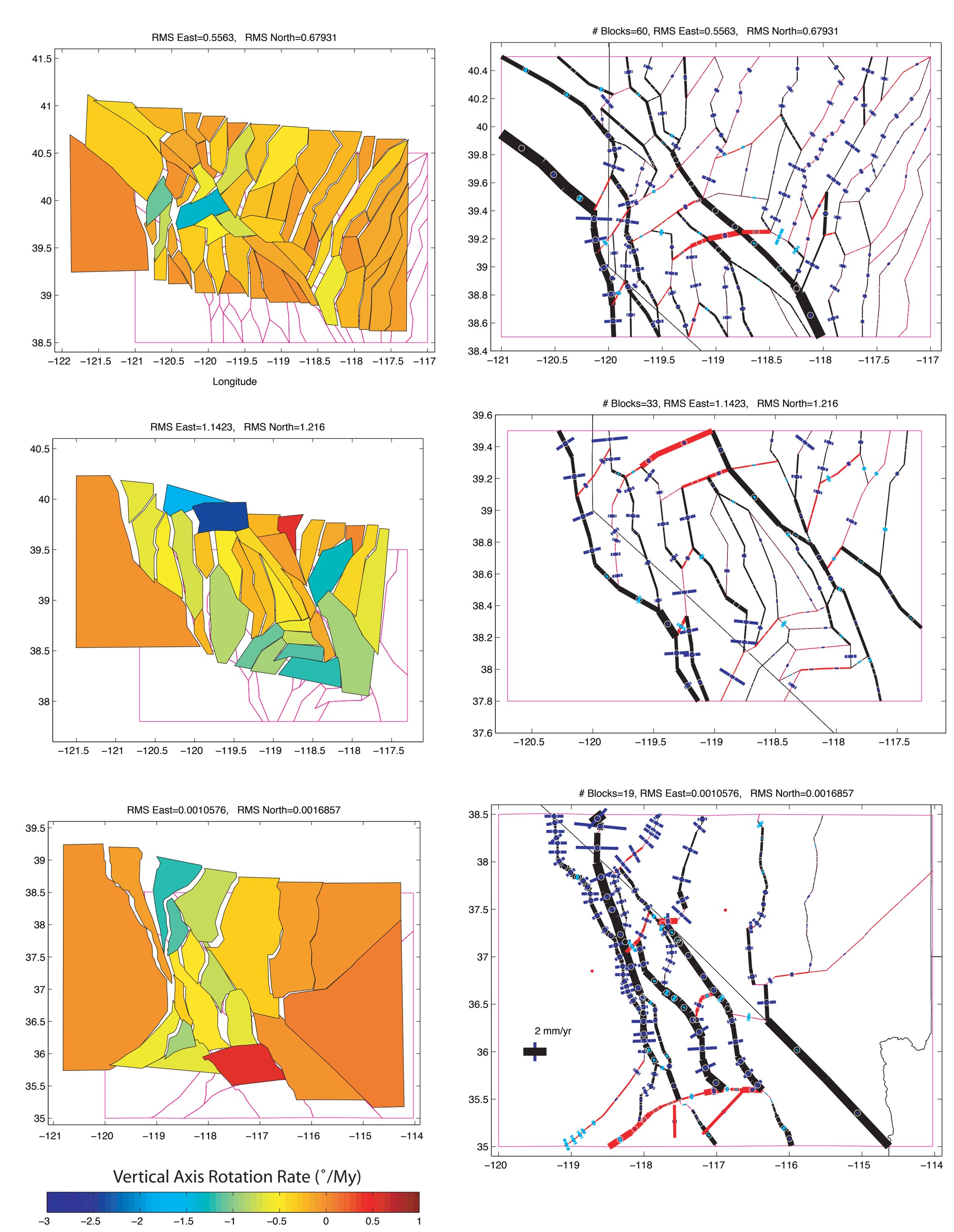
Southern Walker Lane



Right and Above Right) Deformation patterns in the Southern Walker Lane are affected by more recent earthquakes in the Mojave, as well as older and more distant events. The 1992 Landers and 1999 Hector Mine events cause significant transient deformations that also cause non-linearity in the GPS time series as far north as Yucca Mountain, NV. These can be seen as changes in GPS velocity over time (above right). Here we again use VISCO1D (Pollitz, 1997), but select the viscosity model that best straightens the GPS time series. As seismic sources we include the 1857 Ft. Tejon, 1872 Owen's Valley, 1932 Cedar Mountain, 1952 Kern County, 1986 Chalfant Valley, 1992 Little Skull Mountain, 1992 Landers, 1999 Hector Mine events (majgenta segments right). The model predicts a complex pattern of contemporary transient deformation (black vectors right).



Block Models No Postseismic Correction



Northern Walker Lane

Central Walker Lane

Southern Walker Lane

Block Models With Postseismic Correction

Red=Data, Green=Model, Black=Residual