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Xiaopeng Tong, David T. Sandwell
Scripps Institution of Oceanography, University of California San Diego, La Jolla, California
Bridget Smith-Konter
Department of Geological Sciences, University of Texas at El Paso, El Paso, Texas

High Resolution Interseismic Crustal Velocity Model of the San Andreas Fault From GPS and InSAR

Abstract

We are recovering the interseismic deformation along the entire San Andreas Fault system (SAFs) at a spatial resolution of 300 m by combining InSAR and GPS observations using a dislocation model. An analysis of 17 strain-rate models for the SAFs shows that GPS-data alone cannot uniquely resolve the rapid velocity gradients near faults. Measuring near-fault strain rate is important for understanding along-strike variations in stress accumulation rate and thus earthquake hazard. We are integrating the GPS observations with InSAR observations, initially from ALOS, using a remove/restore approach. The integration uses a dislocation-based velocity model to interpolate the line-of-sight (LOS) velocity at the full resolution of the InSAR data in radar coordinates. The residual between the model and InSAR LOS velocity are stacked and high-pass filtered at 40 km wavelength, then added back to the model. The initial results show previously unknown details in along-strike variations in surface fault creep. Moreover, the high-resolution velocity field will resolve asperities in these "creeping" sections that are important for understanding moment accumulation and thus seismic hazard. We find much of the high-resolution velocity signal is related to non-tectonic processes (e.g., ground subsidence and uplift) sometimes very close to the fault zone. Future work includes refining InSAR data processing and improving interseismic crustal deformation models.

Mean LOS velocity (2006-2010) along ALOS ascending tracks
The positive value (red color) shows the ground moving toward the satellites, which are flying northwest and looking down (~37° from vertical) and northeast (~9° to the North from East). The shading highlights the gradient in the velocity field. The areas with low coherence (< 0.06) and large standard deviation (> 6mm/yr) are masked out to be transparent.

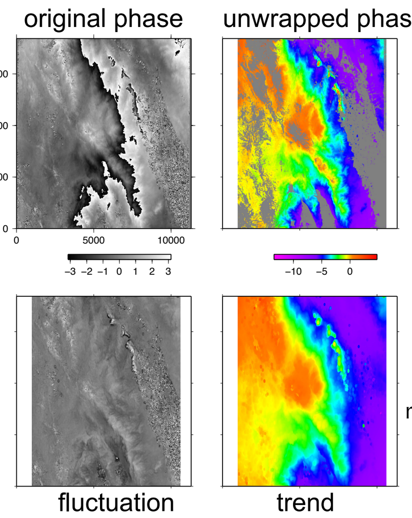
Flowchart of processing an interferogram

Goal: Unwrap phase without error without mask

raw data → GMTSAR → original phase → mask and snaphu → unwrapped phase → trending & low-pass & medium filter → trend → fluctuation → check ? +-π → yes → total phase = trend + fluctuation

(no → back to trending & low-pass & medium filter; remove: trend → original phase)

The two flowcharts show how the data are processed. The figure in the middle demonstrate the concept of unwrapping without error and without mask.



Recipe: Stacking/Remove/Filter/Restore

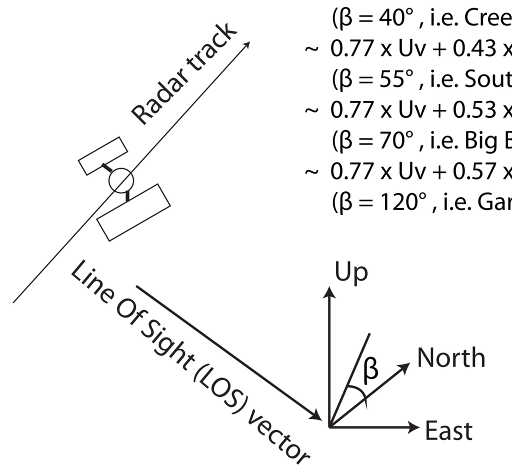
total phase → stack & mask → stack → remove a model → residual → low-pass filter at λ = 40km → low-pass residual → remove the low-pass filter → high-pass residual → restore the model → improved crustal motion model

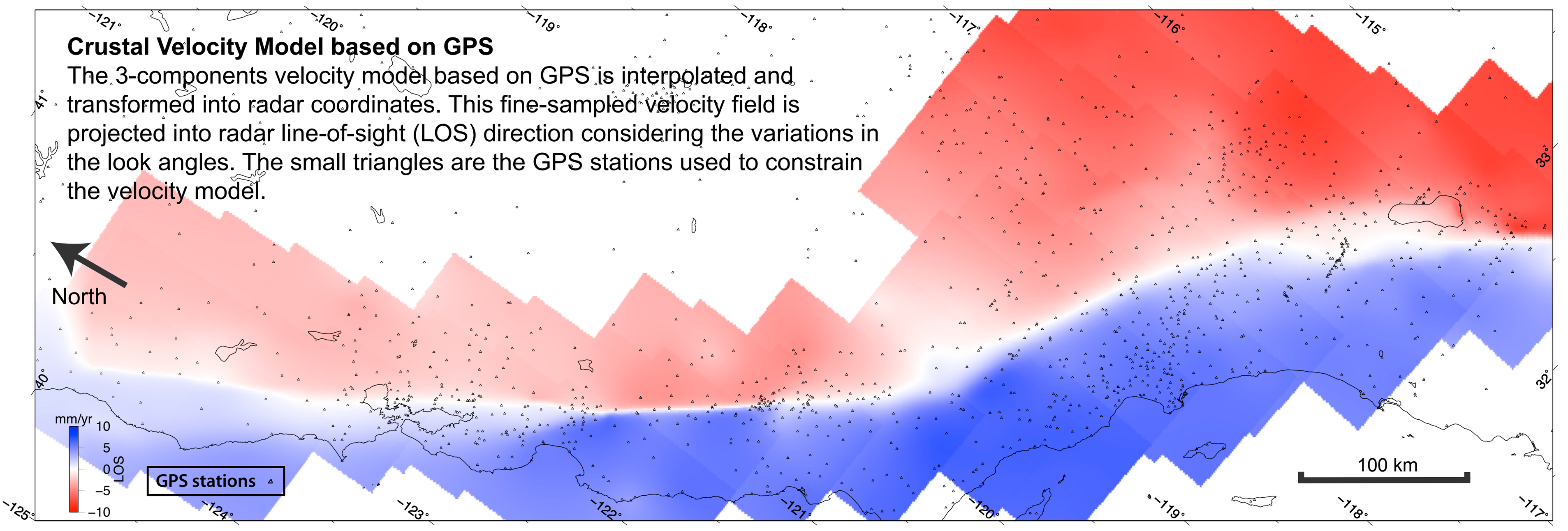
(crustal motion model — stack; crustal motion model — high-pass residual)

Ue ----- East velocity
Un ----- North velocity
Uv ----- Vertical velocity
Us ----- Along-fault-strike velocity
LOS ----- Line-of-sight velocity

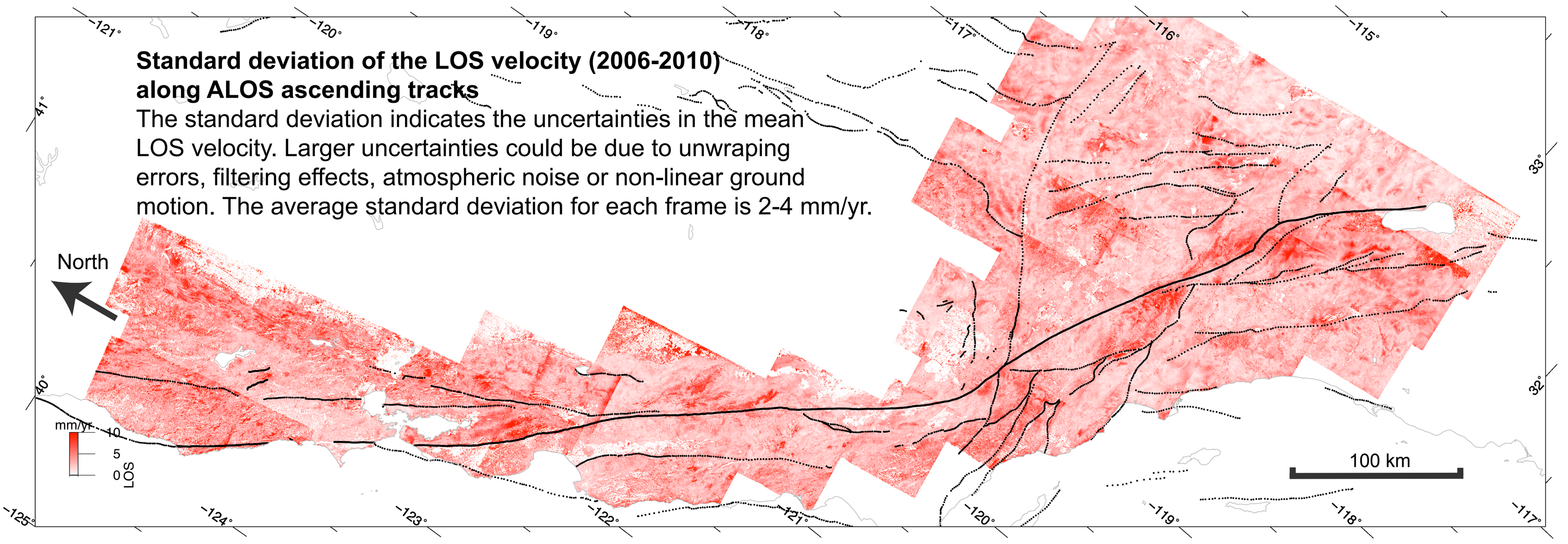
Ue = - Us x sin(β)
Un = Us x cos(β)

LOS ~ - 0.63 x Ue - 0.11 x Un + 0.77 x Uv
~ 0.77 x Uv + 0.32 x Us (β = 40° , i.e. Creeping section)
~ 0.77 x Uv + 0.43 x Us (β = 55° , i.e. South SAF)
~ 0.77 x Uv + 0.53 x Us (β = 70° , i.e. Big Bend)
~ 0.77 x Uv + 0.57 x Us (β = 120° , i.e. Garlock fault)





Crustal Velocity Model based on GPS
The 3-components velocity model based on GPS is interpolated and transformed into radar coordinates. This fine-sampled velocity field is projected into radar line-of-sight (LOS) direction considering the variations in the look angles. The small triangles are the GPS stations used to constrain the velocity model.



Standard deviation of the LOS velocity (2006-2010) along ALOS ascending tracks
The standard deviation indicates the uncertainties in the mean LOS velocity. Larger uncertainties could be due to unwraping errors, filtering effects, atmospheric noise or non-linear ground motion. The average standard deviation for each frame is 2-4 mm/yr.

References
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