Arequipa's Contribution to the ILRS Network

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Conventional SLR applications include reference frame and Earth orientation definition, as well as accurate satellite orbit determination to support altimeter and gravity missions.

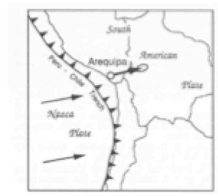
The application of any SLR Observatory to tasks expected from members of the Global Network is affected by its location.

Arequipa's proximity to the Nazca/South America (or Nazca/Altiplano) Plate boundary yields a sensitivity to earthquake events there.

The benefits of this sensitivity to improvement in our knowledge of Earth behavior need not compromise the use of Arequipa data for conventional SLR applications.

This goal would be attained if an accurate geophysical model can be developed which can match the rigid plate motion assumptions at other SLR Observatories.

"Tectonic Motion and Deformation from Satellite Laser Ranging to LAGEOS", Smith, D.E. et al. (JGR 1990)

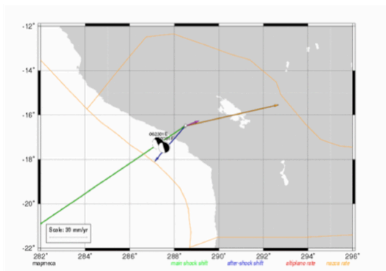


It was shown that stations in boundary zones do not move according to the 15 plate NNR-NUVEL1 model.

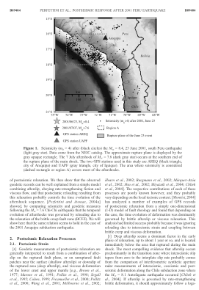
"An updated digital model of plate boundaries", Bird, P. (GGG 2003)

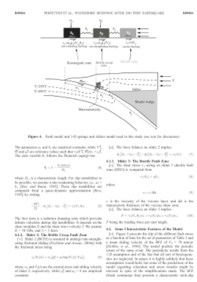
The 52 plates of model PB2002 are shown with contrasting colors
The Altiplano plate is pink

Displacements and plate motion vectors at Arequipa in 2001



The focal mechanisms describe 2 large shocks of magnitude 8.4 and 7.6 in June 2001.
The earthquakes shifted Arequipa trenchward,
This compensates for stress accumulation from the Nazca plate motion not accommodated by the Altiplano plate motion.
This plot shows eastward velocities: Nazca plate at 70 mm/year and Altiplano plate 20 mm/yr (NNR-NUVEL-1 reference)
The westward displacements amount to 50 cm (main shock: green) and 4 cm (after-shock: blue).





Perfettini et al. provide expressions for the effect on Arequipa of three fault zones: Seismogenic, Brittle Creep and Ductile.

Perfettini et al's One Dimensional Model can be expressed as:

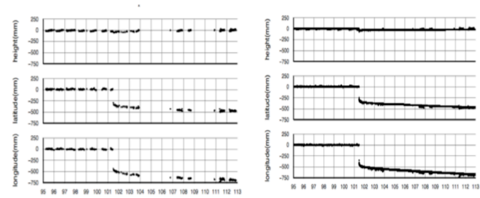
If t is time in years, time of quake tq = 2001.477, speed cf. NUVEL before tq v- = -22 mm/yr, direction N 235 E t > tq, (direction N 237 E t < tq for SLR)

Quake shift c0 = -420 mm, bcfz speed v2 = -5.1 mm/yr, dfz speed v3 = -13 mm/yr

Then, displacement before quake in mm: d-= v- * (tq - t)
and displacement after quake in mm: d+ = d- + c0 + dbcfz + ddfz
in which ddfz = v3 * (t-tq)
and dbcfz= v2 * N
where cumulative shock count N= (rnt - rn0) / r0
and shock rate after quake rnt = r0+tr * log(1 + r+ / r0+tr) * t * 365
In which r0+tr = 37 events/day and r+ = 800 events/day
Note:
P. et al's N can be improved with rnt = rnt + rnta
where shock rate after aftershock rnta= r0 + tr * log(1 + r+ / r0+tra) * (t - 13) * 365
and r0+tra = 10 events/day

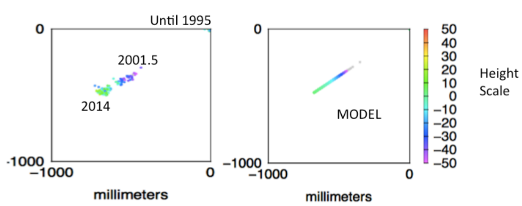
Furthermore, a credible height model is dh = dbcfz * h/d – hdrop
where h/d = -.4 and hdrop = 100 mm

Arequipa SLR with Perfettini model (Altiplano)



Arequipa's motion can be approximated by a preliminary implementation of Perfettini's model

Bird's Eye View



Arequipa's displacement relative to the Altiplano plate is N235E.
The green point at top right shows the stationary period before the earthquake.
The SW motion shows the height rebounding.
A side-by-side comparison supports the Perfettini model (refined to include height variation)

Conclusions

The motion of the Arequipa station is seen to be uniform during aseismic periods, when it can be modeled as well as any station located far from a fault zone.

Perfettini et al. provide a model of co-seismic and post-seismic motion which could approach the quality of the uniform plate assumptions applied in stable locations.

Our preliminary analysis provides encouraging results from a simple implementation of this geophysical model at the station.

It is driven by seismicity observations in the Andes region, and provides an improvement to the observed horizontal motion of the station, compared with purely empirical models.

Refinement of this technique, enhanced by improved definition of the vertical component of motion in the region, will allow Arequipa to fully contribute to the goals of the SGP.