# TOWARDS A NEW VELOCITY MODEL FOR ARGENTINA

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## ABSTRACT

Before the 2010 Chile Earthquake, for geometric network adjustments the VEMOS2009 Horizontal Velocity Field Model (Drewes, H., O. Heidbach, 2012) produced usable estimates of geodetic benchmark movements due to deformation associated with the South America-Nazca plate boundary. The Maule earthquake, however, produced significant co-seismic displacements and an ongoing post-seismic deformation in a large region associated with the rupture zone of the earthquake.

We use available continuous and campaign GPS data for co- and post-seismic time periods to develop a new time dependent spatial deformation field for estimating the effects of the earthquake on the Argentine Geodetic network. This poster presents the results of this work to date.

## INTRODUCTION

Before the Maule earthquake, the VEMOS2009 (Drewes, H., O. Heidbach, 2012) velocity model was a useful tool for estimation of benchmark and CORS velocities in Argentina. After February 27th, 2010, the ongoing post-seismic deformation present in the central region of the country introduced considerable differences between position estimations based on the model and current observations.

For geodetic networks based on space geodetic technology, it is therefore necessary when performing network adjustments to account for the displacements created by the post-seismic relaxation. Although post-earthquake measurements have been made in the affected region, not all the benchmarks of the Argentina Reference Network and the Central Andes Project (CAP) have had their post-seismic velocities estimated. In addition, because of the non-secular relaxation process occurring after such a large earthquake, linear interpolation of velocities between benchmarks to estimate position at a given time is not possible, or could possibly create considerable discrepancies between the estimates and observations.

Using data from the RAMSAC CORS Network and the continuous sites of the CAP Project IGN produced a time series of weekly positions. A geophysical model is being developed, for a simple 2-layer viscoelastic model, using the program Relax (Barbot et al., 2010) to model the motions observed.

In this poster, we present the results of this work to date and the future approaches to improve this velocity model.

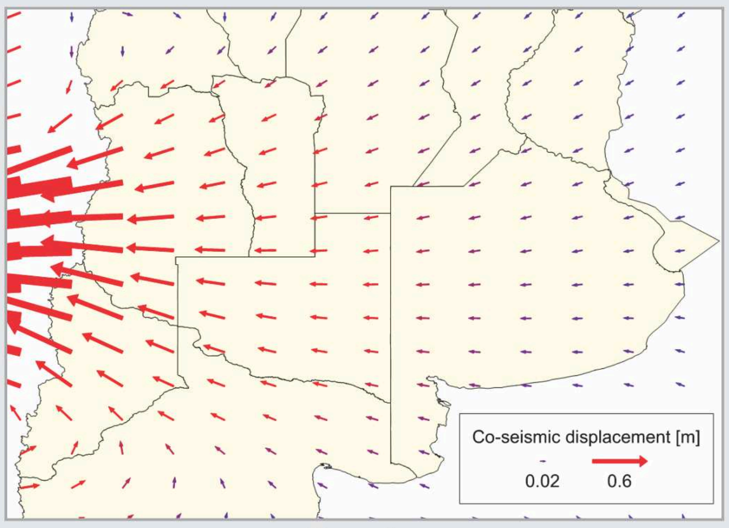


Figure 1

## ESTIMATION OF VELOCITY FIELD

For post-seismic relaxation modeling, a co-seismic slip model is required. Two alternative models were tested. A simple slab with uniform slip (USGS, 2010) and a grid (19.5 x 20 km) slip model by Tong, 2010 (Figure 2). The best results where obtained using the grid model.

Values between 30 and 70 GPa were tested for the elastic parameters at the top layer, with no significant differences in the obtained results. For the viscous layer, starting at the bottom edge of the fault (~70 km), a cubic power law viscous sub-lithosphere was assumed. To find the preferred viscosity, several relaxation times were tested by iterative runs of the model. By comparing the resulting model displacements with the CORS Network and campaign data, a good fit between observations and the model was found for a relaxation time of 0.04 years (14.6 days).

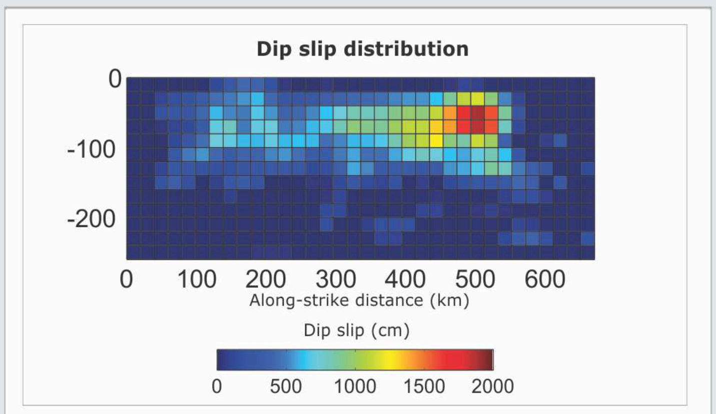


Figure 2
(Tong et al., 2010)

## COMBINATION OF POST-SEISMIC MODEL AND VEMOS2009

Relax uses a fixed reference frame to obtain displacement and velocity fields. As the IGN time series are adjusted to ITRF2005, it is necessary to add the velocities of the reference frame. This was realized by adding the VEMOS2009 velocity model to the post-seismic velocity field.

Since VEMOS2009 has the sum of the frame displacements (ITRF velocities + South American plate velocity) and the inter-seismic signal produced by the South American and Nazca plate boundary, adding these velocities to the post-seismic model transforms the fixed frame velocities of the post-seismic model into ITRF2005. This procedure, however, assumes that the inter-seismic signal modeled by VEMOS2009 is still present after the earthquake, which is still being discussed among scientists. Nevertheless, good results were obtained assuming an on-going inter-seismic signal after the event.

## RESULTING VELOCITY MODEL

The resulting velocity model has an overall good fit to the time series, where for most cases the model was within 1 cm of the observed data. Around the fracture zone, good fits were obtained for stations in western Argentina, with some outliers for station MZAU and MZAC (Mendoza Province). Stations in Chile, however, (SANT –Figure 3-, CONZ, CRRL) show major discrepancies, most likely due to the simplicity of the viscoelastic model.

Stations farther eastward in Argentina such as SUAR, UNRO, BCAR and PEJO (Figure 4) are in very good agreement with the model. In other cases, such as IGM1 and LHCL (Figure 5) a larger misfit of approximately 1.5 cm can be observed.

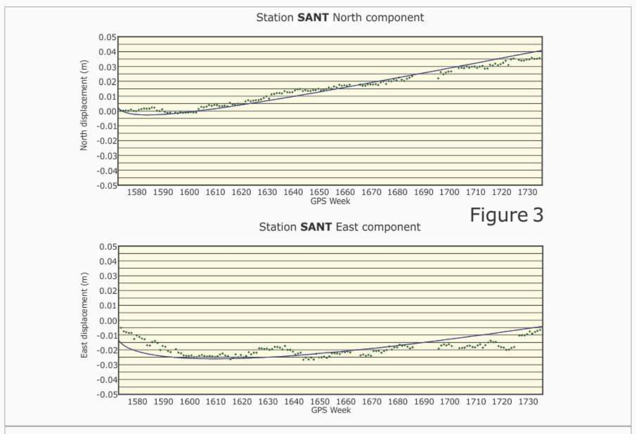


Figure 3

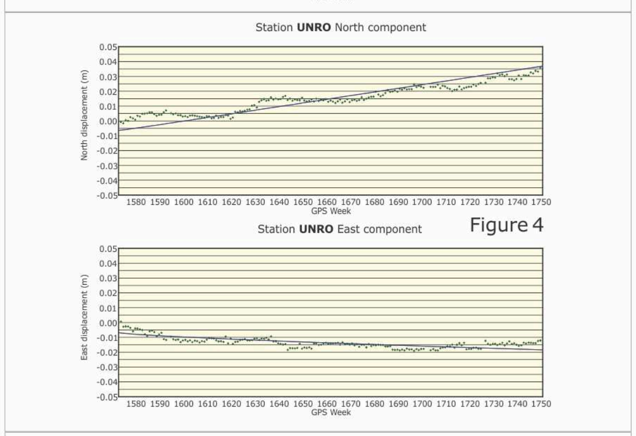


Figure 4

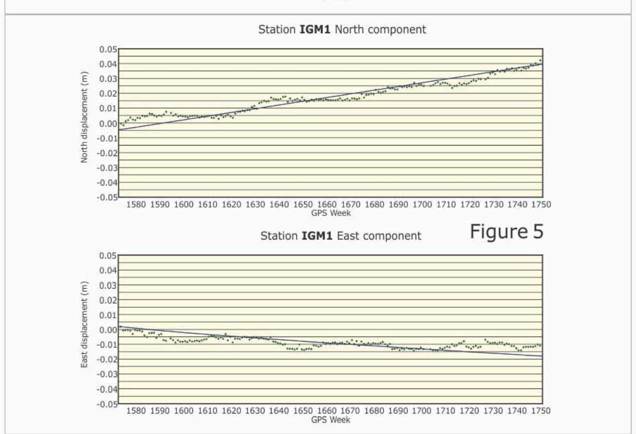


Figure 5

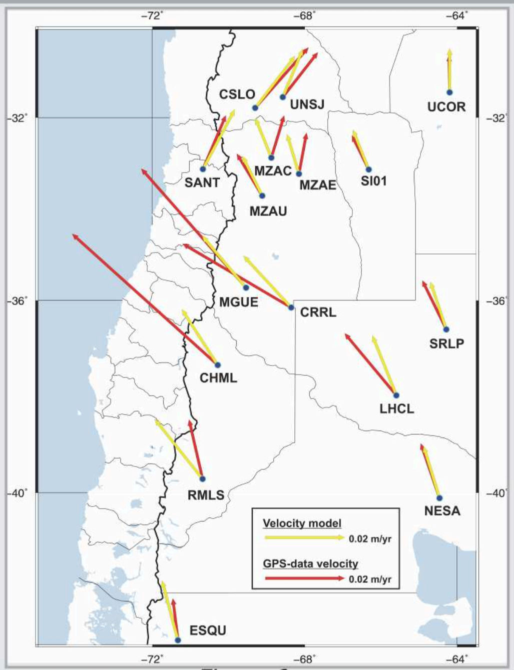


Figure 6

## DISCUSSION

The goal of this project was to obtain a usable tool to predict and obtain velocities for Argentine territory. We are not concentrating on the geophysical interpretation, nor looking for agreement with dynamic tectonic models. As a result, assumptions of a uniform lithosphere and sub-lithospheric layer could lead to erroneous modeling for areas where the lithospheric and sub-lithospheric properties are not uniform. This is the most probable explanation for misfits between the model and the data in the epicentral area in Chile. Nevertheless, this model is a good first approach towards a new velocity model for Argentina.

Another point is the application of the VEMOS velocity field to obtain the velocities of our model with respect to ITRF2005. Three years after the Maule earthquake, a post-seismic signal is still present in the observed data, and will probably continue for several more years. By taking a more detailed look at the time series of stations like MZAC, however, which are closest to the epicentral region, a partial recovery towards the inter-seismic signal can be observed.

## CONCLUSIONS

We report on the development of the first estimation of a velocity model for central Argentina that includes the observable post-seismic effects. This model permits calculation of the displacements directly in ITRF2005 without any further transformation. As VEMOS2009 was used for the interseismic plate boundary deformation, the velocities obtained using the new model are still valid even where no deformation is present due to the Maule earthquake.

It should also be noted that co-seismic displacements were not modeled during this project, and will be part of the follow up work. This will allow a user to also obtain the co-seismic displacement for geodetic measurements made after the Maule event. The combination of co-seismic and post-seismic models will allow estimation of benchmark locations without the need to re-measure the whole passive geodetic benchmark network, saving time and resources.

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