

2001 and 2003 from two seafloor precision transponder arrays at 12S off the coast of Peru. The geodetic positioning technique uses two reference points located 20 km and 50 km upslope from the Peru-Chile trench to characterize the updip limit of locking between the downgoing Nazca plate and the South America plate. Stick slip behavior is thought to cause the majority of interseismic activity between the convergent plates. Absolute and relative horizontal deformation was determined with 1-cm uncertainty and may help in understanding the cause and location of stick slip behavior between the plates. Combined with land based geodetic stations, this study presents the first observations of convergent plate motion above the entire subduction thrust zone. We will report preliminary results and their implications for models of thrust fault behavior.

## G21C CC: 220 C-E Tuesday 0830h Toward a Stable North America-Fixed Reference Frame II Posters (joint with S, T)

**Presiding:** G Blewitt, University of Nevada, Reno; M Craymer, Natural Resources Canada; W E Holt, State University of New York at Stony Brook

### G21C-01 0830h POSTER

#### First Report of the Stable North America Reference Frame (SNARF) Working Group

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We report on the first SNARF Workshop funded by NSF EarthScope, held on Jan 27, 2004. The initial SNARF Working Group membership was approved by the UNAVCO Board and is charged with producing a standard reference frame (for studies in North America) and specifying standard procedures to realize such a frame to meet the needs of EarthScope and the UNAVCO community. SNARF is an official IAG working group under the North America Reference Frame (NAREF) sub-commission. There is also a public service element to these activities in that one objective is for SNARF to become part of the definition of the legal reference frame used in the USA and Canada (NAD83), a natural spin-off demanded by society's increasingly sophisticated needs following on the heels of scientific progress. Through the first workshop, the SNARF WG has already begun to address the pressing needs for a North America-fixed reference frame that is stable at the sub-millimeter level, and what is involved in defining a frame with such stability. Velocity solutions from GPS networks covering the North America-Pacific plate boundary (including the Plate Boundary Observatory under construction) are most naturally expressed with respect to the stable interiors of either the North America or Pacific plates. As well as providing a common

frame by which to compare results from different analysis groups, such a system makes it easier to interpret the data in terms of where the total budget of relative plate motion is accommodated, and how deep plate boundary dynamics penetrate into the plate interior. Defining a stable frame at the sub-millimeter level requires adequate characterization of kinematics at that level across a sufficiently broad expanse of what may be termed the "plate interior," which deforms due to GIA and other mantle processes, coupled with lithospheric heterogeneity. A dynamically defined velocity datum (as opposed to a purely kinematic choice) is preferable to add interpretive value to site velocities. We summarize initial findings of the workshop that begin to address these issues, and present a roadmap of what is required to realize a reference frame for stable North America.

### G21C-02 0830h POSTER

#### The NAREF Perspective on a New Plate-Fixed Reference Frame for North America

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In collaboration with the IAG community, its service organizations and the national geodetic organizations of North America, the IAG's Sub-Commission 1.3a on Regional Reference Frames for North America (NAREF) provides international focus, cooperation and coordination for issues involving the geodetic reference frames and control networks of North America. Some of these issues include the maintenance and future evolution of reference frames for North America and the setting of standards and guidelines. To this end, NAREF has coordinated the densification of the ITRF reference frame in North America and has been providing regular weekly coordinate solutions for most of the permanent GPS receivers on the continent since 2001. Work is now progressing on providing regular cumulative solutions with velocities estimates for all stations. More recently, a new initiative has begun, underwritten by UNAVCO, Inc. in support of the EarthScope project, to establish a stable, plate-fixed reference frame for North America that would serve the broad scientific and geomatics communities. The goal is to provide a consistent reference system, including velocity models, procedures and transformations, tied to a "stable" North America in which scientific and geomatics results (e.g., positions in tectonically active areas) can be produced and compared. This paper focuses on the requirements that such a reference frame would need to satisfy from the perspective of NAREF. We also make some suggestions for how such a new reference frame could be implemented for the benefit of the general public and discuss some pitfalls learned from the ITRF densification work.

URL: <http://www.naref.org>

### G21C-03 0830h POSTER

#### Test of a Center of Lateral Figure (CL) reference frame for a global GPS network

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Seasonal degree-one deformation related to loading effects are a source of significant misfit between observed site coordinates and assumed positions that are based on a linear center of surface figure (CF) reference frame. This discrepancy is partly absorbed by apparent annual variations in the GPS "scale" parameter which, in turn, spreads annual deformation artifacts to sites elsewhere on the Earth's surface. In the presence of degree-one deformation, a suitable reference frame model should allow for non-linear site motion. The Center of Lateral Figure (CL) reference frame is one possible solution. With the CL model, station motions are constrained to move with constant horizontal velocities, and the vertical velocities are unconstrained. This confines degree-one deformation to the unconstrained vertical component. A CL reference frame model is demonstrated here using the results of a GIPSY/OASIS II fiducial-free analysis of over 100 globally distributed GPS sites. The reference frame model utilizes only the horizontal component of site positions and the GPS "scale" parameter is neglected in the initial solution. Preliminary results show that seasonal deformation is placed in the vertical component, as expected, and that the geographical distribution of seasonal signals is consistent with degree-one loading models. An additional finding from this test is that the

WRMS scatter in daily horizontal site positions is reduced. This is likely due to reliance on the precise horizontal component, and omission of the noisier vertical component. The result is that the horizontal scatter for stations in a global solution approaches the quality of a regionally-filtered solution. For analysis on a plate-wide to global scale, as is the case for SNARF, use of a CL frame with the vertical component unconstrained may be useful. With the vertical component unconstrained, horizontal positions are not biased by seasonal vertical motion and noisy vertical motion at sites located 90 degrees around the side of the earth. In turn, a precise datum for the local vertical component is realized using horizontal data from the same sites a quarter turn around the Earth.

### G21C-04 0830h POSTER

#### New Constraints on Crustal Deformation in the New Madrid Seismic Zone From Continuous GPS Geodesy.

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Preliminary results from the first determination of crustal velocities in the area of the New Madrid seismic zone based on two years of continuous GPS geodetic measurements indicate that velocities with respect to stable North America are small (less than 3mm/yr) and not significantly different than zero. Our results are significantly stronger than previous campaign results, which while also not statistically different from zero, yielded velocities with respect to stable North America from near zero to several cm/yr. They also rule out velocities determined by campaign measurements that are "statistically significant" with magnitudes larger than a few mm/yr. The continuous GPS results are also the first to suggest tectonically reasonable deformations, in terms of both rates and geologically and seismologically defined structures in the New Madrid seismic zone. The relatively undurated pile of Mississippi Embayment sediments, may also act as a filter to displacements at its base, which may be significantly larger than those observed at the surface. Our results strengthen the argument against models based on conventional, plate boundary style dynamics for the generation of large earthquakes in the New Madrid seismic zone. With respect to the development of new models for New Madrid tectonics, we stress both the preliminary nature of our results and the sparse sampling provided by the continuous network. Our results can clearly be used to reject models that do not produce small or no surface deformation but are currently less useful to additionally constrain or distinguish among competing tectonic models that meet the stringent limitations placed on surface deformation. The upper bound, of a few mm/yr, on the velocity of our stations with respect to a stable North America shows the importance, timeliness and necessity of improving the definition of stable North America to further our understanding of intraplate earthquakes.

## G21D CC: 516 B Tuesday 0830h Toward a Stable North America-Fixed Reference Frame I (joint with S, T)

**Presiding:** G Blewitt, University of Nevada, Reno; M Craymer, Natural Resources Canada; W Holt, State University of New York at Stony Brook

### G21D-01 0830h INVITED

#### Evolving from NAD 83

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