**Draft Script: Collins et al presentation at GSA 2018**

***Includes 2 demonstrations that will require 3 highly trained student helpers.***

Title Slide. Thanks to the conveners for letting us talk about our work.

Slide 2. Several years ago, a group of amiable nerds from UNAVCO and its member institutions created a curricular module about crustal strain.

We want to teach geoscience students how to use GPS-velocity data to measure present-day crustal strain within a triangle of GPS sites.

That module is part of the GETSI project, and you can learn more about it at the website listed here.

This URL will be repeated on slides throughout this presentation, so you can jot it down when you have a chance.

Slide 3. Undergraduate or graduate students learn how to select sites within the Plate Boundary Observatory through a Google-Maps-style network map...

Slide 4. ...and access summary data on the overview page associated with each site.

These data are continually updated, and expressed relative to common reference frames.

Slide 5. Here, we will look at three sites astride the Cajon Pass area of southern California.

These PBO sites are on the order of 20 to 30 km apart.

Slide 6. Site velocity data indicate that they are all in motion at between 22 and 31 millimeters per year, relative to the stable cratonic interior of North America.

Note that the scale of the velocity vectors is quite different than the map scale between the PBO sites -- millimeters versus kilometers.

Slide 7. The black arrow extending from the center of the triangle is the translation vector, indicating that the entire array is moving almost 27 millimeters per year toward the northwest.

Slide 8. We subtract the translation vector from the individual site vectors to obtain the instantaneous horizontal motion of each site relative to the center of the array.

Slide 9. We can imagine how the present-day triangle defined by the three PBO sites must deform as a result of these different velocities.

Slide 10. If we imagine a circle in the middle of the unstrained triangle, it would change to an ellipse in the *strained* triangle.

We can express this instantaneous or infinitesimal change in shape using a strain ellipse.

*This* strain ellipse is exaggerated so we can actually *see* the ellipse in this image, reflecting a million years of continuous strain at current rates.

We also notice that the dashed triangle is rotated clockwise relative to its initial position.

Slide 11. We convert information from the strain ellipse into a common set of map symbols used for this kind of analysis...

Slide 12. ...and refer back to the map area.

The crustal-strain analysis, based on GPS-velocity data, indicates that this area is *shortening* in a (nearly) north-south direction and *stretching* nearly east-west.

This area is also *rotating* clockwise.

Slide 13. This makes sense in the structural context of active faults in the Cajon Pass area.

Calculators in Excel, Matlab, and Mathematica have been created for students to use in performing this analysis.

But before they start slinging data and code, ...

Slide 14. ...students explore various crustal-strain scenarios using a simple physical model -- a triangle of stretchy cloth.

The raw cloth is widely available at fabric stores, usually in either white or black, and is made with spandex to make it elastic.

We use cloth marketed as "swimsuit liner," and you can acquire a lifetime supply of this stuff for a few dollars.

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***DEMONSTRATION 1 :*** Three students grab corners of the cloth and simulate translation, ... <<wait>>

...rotation, ... <<wait>>

...and various types of distortion <<wait>>

...by pulling on the three corners and watching the circle drawn on the cloth as it changes shape.

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As useful and fun as this experience with stretchy cloth has been, students tend to notice that the circle on the cloth doesn't *really* become an ellipse during distortion, as they were *told* it would.

Rather, it becomes some irregular blobby shape.

The reason is that the distortion is not *homogeneous*, because the edges of the cloth triangle do not remain straight as the corners are pulled.

That was a problem, and here is the solution.

Slide 15. In this particular model, we cut the cloth to have the same shape as the triangle between the three PBO sites near Cajon Pass.

That's so we can have a physical-model experiment that relates directly to a part of the crust on which people actually live -- people whose wellbeing *should* be of concern to us.

The fabric is cut with an inch-wide seam allowance all the way around.

A circular arc with an inch-and-a-half radius is cut around the apices.

Slide 16. A rod-pocket seam is sewn with a simple zig-zag stitch that is able to expand as the fabric is stretched.

Slide 17. We use steel rods that are 3 feet long and a quarter of an inch in diameter, and fit a wooden handle to the end.

A groove with about the same radius as the rod is cut or filed into the handle.

So the rod and handle form a "T".

Slide 18. The rods are slipped into the rod-pocket seams so that there is one handle at each of the apices of the triangle.

The adjacent rod passes along the groove in the handle, and is free to slide along the groove.

Slide 19. We carefully draw a circle on the cloth triangle when its geometry is the same as the initial geometry of the Cajon Pass array.

Then we can distort the triangle in a homogeneous manner to simulate the observed crustal strain, exaggerated by perhaps a million times.

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***DEMONSTRATION 2 :*** So we start with a triangle with a circle drawn around its center, ... <<wait>>

...we shorten or lengthen the various sides as required to duplicate the strain-analysis results, ...

<<wait>>

Slide 20. ...and we end-up with an ellipse that resembles the strain ellipse for this area.

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Much more information about the use of GPS velocities to determine present-day crustal strain is available from the GETSI and UNAVCO websites -- both accessible from the URL shown here.

Slide 21. The use of a rigid adjustable framework for our elastic-cloth model has made it possible for us to simulate homogeneous strain in a way that is direct, intuitive, and very clearly reproduces the results of a crustal-strain analysis