Using Dry Erasable Globes in Earth and Space Science Classes

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Abstract

Geoscience classes often involve illustrating spatial relations among surface features on Earth and other planetary bodies. Plate boundaries, crater distributions, volcanism, seismicity, etc. may have distinct patterns when plotted on a map. Of course, the basic problem with all maps is that they are merely 2-dimensional representations of 3-dimensional worlds, and as such necessarily distort the very patterns being illustrated. Dry-erasable globes provide a solution to this problem. Presented here are practical classroom applications of two such globes – one of Venus, showing topographic and geomorphic features, and another showing a simple grid.

The Venus globe is large (30" diameter), and thus visible in an average-sized classroom and, when mounted on its stand, rotates easily. Topography is shown by color variations, and geomorphic features by shading. Magellan radar data were used for both topography and geomorphology. In the classroom, the globe can be used to demonstrate orbital dynamics. Spinning the globe one can then illustrate how a polar orbit is best used for mapping missions (tracing vertical lines on the surface as the globe spins), or how geostationary orbits must be over the equator (contrary to what Star Trek typically portrays). Interactive exercises can include having students identify various features (impact craters, rifts, coronae, etc.) and then describe their distributions.

The gridded globe (and accompanying measuring ring and inserts) can be very useful in introducing spherical coordinates and measurements, and relating two-dimensional representations (i.e., stereonets) to three-dimensional reality, specifically in the case of earthquake focal mechanism plots. The grid allows for easy plotting of points such as seismic recording stations, and the ring allows for easy measurement of azimuth and distance. Using actual earthquake arrival data and plotting first arrivals as compressions or dilatations, then helps the student visual the compression and dilatation quadrants. The measuring ring can be used to draw the appropriate mutually-perpendicular great circles that divide the quadrants. P- and T-axes, and slip vectors can then be derived. Removing the upper portion of the globe reveals the stereonet insert, thus allowing the conversion from 3D to 2D.

Venus Globe Demonstrations

We can use the Venus globe to determine global distributions of features such as impact craters and major rifts, and to illustrate orbital dynamics. The large size (30" diameter) allows for its use in larger classrooms.

Global Distributions

1a) Carrie is outlining impact craters. Many of Venus' 940 craters are readily visible on this globe. One exercise is to have the students outline as many as possible. Other than a sampling bias (few students like bending down to get craters in the far southern latitudes) the exercise reveals that the craters have an apparent random distribution. The sampling bias can also serve as a starting point for a data-collection error discussion.

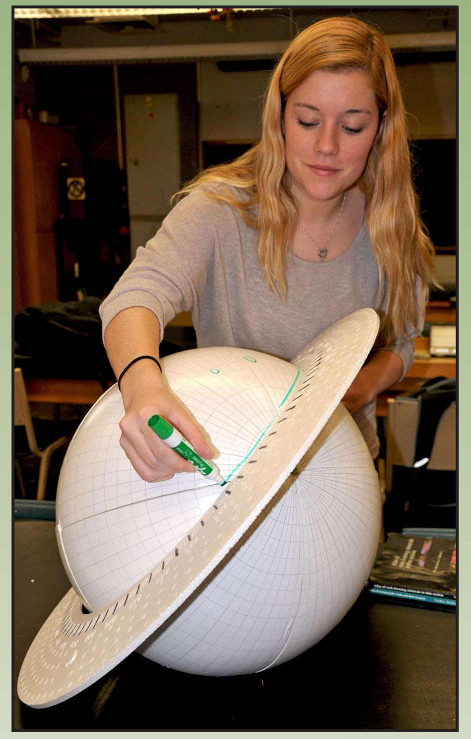
1b) Carrie is identifying rift features on Venus. These rifts form a global system, somewhat similar to Earth's mid-ocean ridges.

The globe allows for a truer sense of the distribution of features, as there is none of the scale distortion inevitably introduced by 2D maps. One suggestion for improved displays would be to use a fainter color scheme for the globe, so that the dry-erase markings stand out better.

Constructing a Focal Mechanism Solution

We use earthquake arrival data from the International Seismological Centre (ISC) Bulletin to create focal mechanism ("first motion") solutions on the gridded globe.

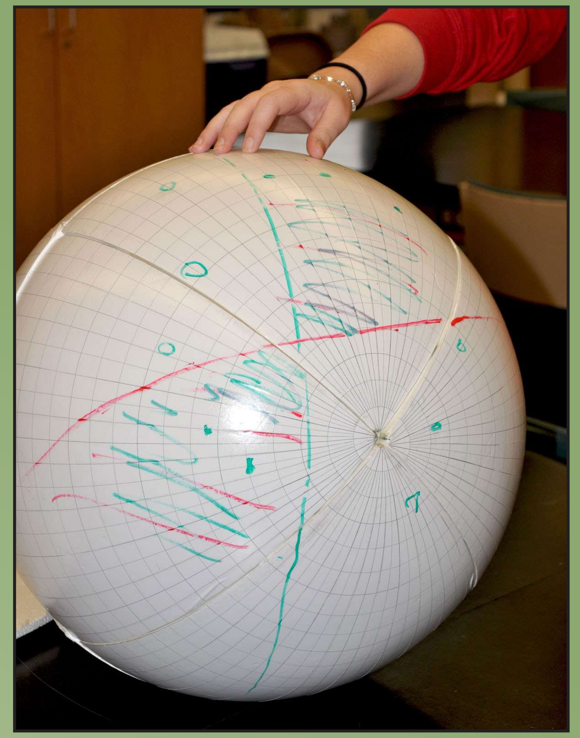
1) Carrie plots arrival data at globe locations corresponding to the latitude and longitude of seismic stations. Closed circles indicate first motion "up;" open circles indicate first motion "down."



2) After plotting the arrival data, Carrie uses the measuring ring to trace a great circle separating regions of open circles from regions of closed circles.

3) Stacy (with a helping hand) uses the accompanying protractor to mark a perpendicular to Carrie's great circle.

4) Using the measuring ring, Stacy draws the great circle through her marks, and finishes delineating the open-circle and closed-circle quadrants.

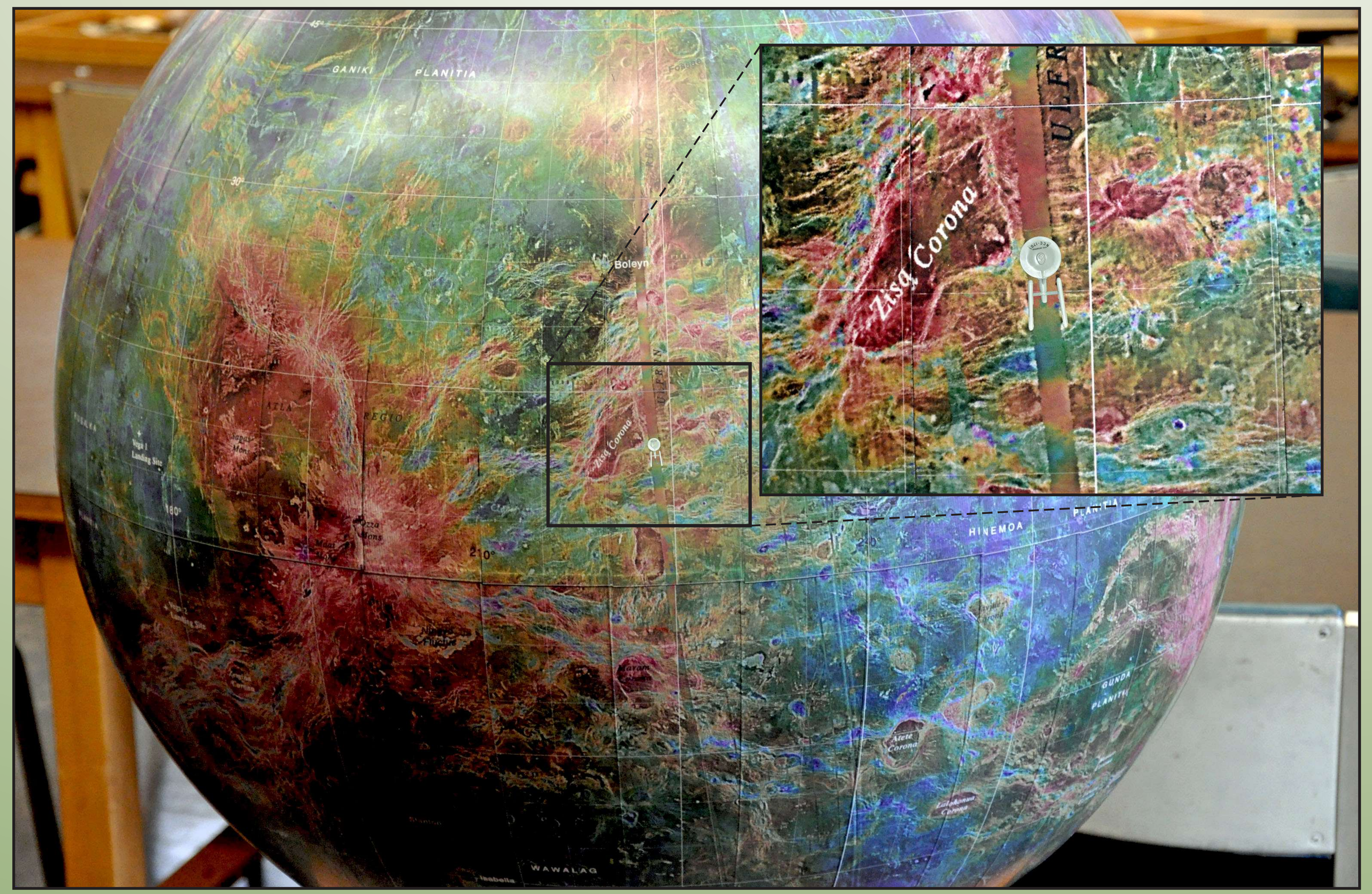


5) The finished focal mechanism solution, showing compressional (shaded, closed-circle) quadrants and dilatational quadrants.

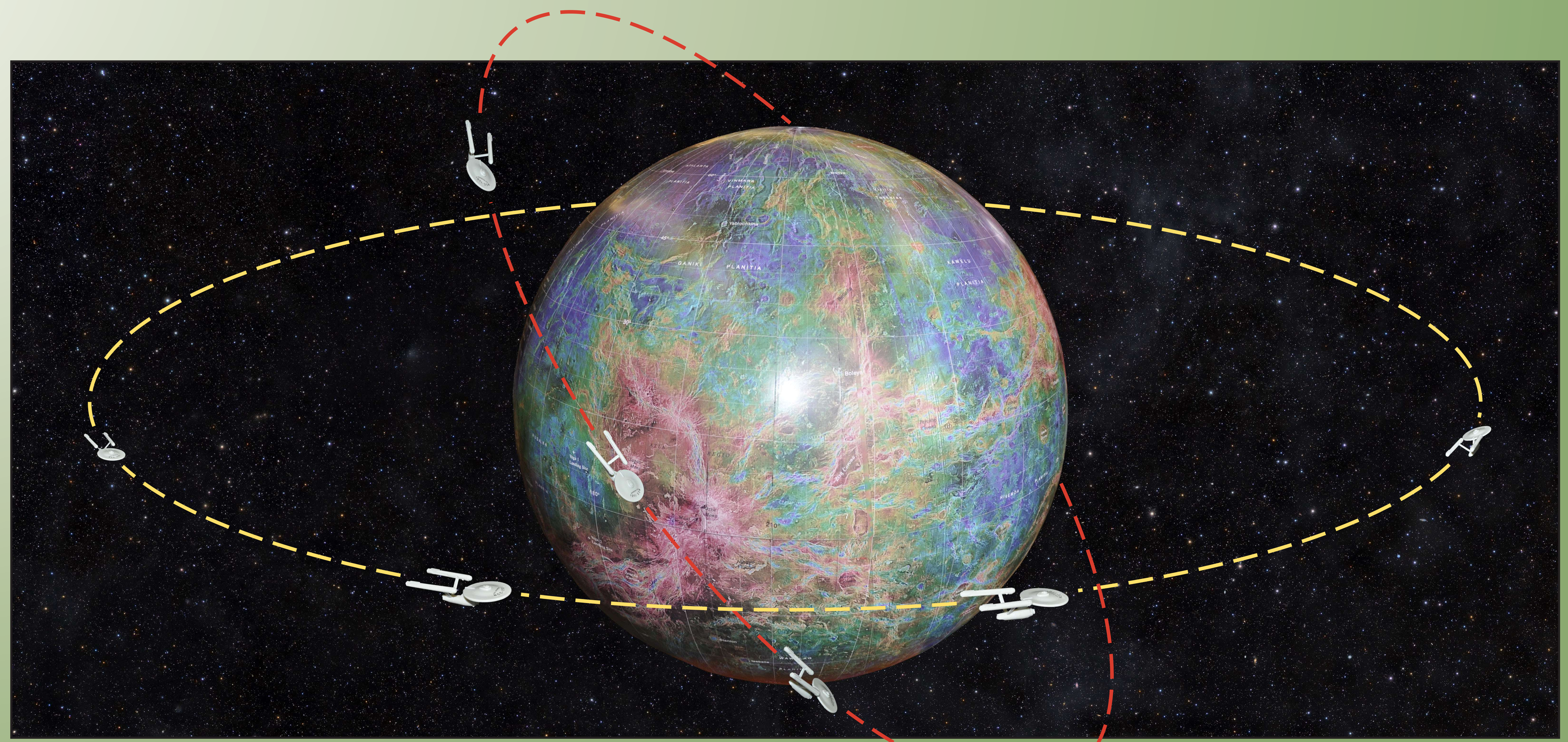
Once finished, the global focal mechanism allows for a clearer visual presentation. Reorienting the globe shows how traditional 2D "beachball" pictures of different focal mechanisms (normal, reverse, strike-slip, oblique slip) are actually all the same, but just oriented differently. Spatial relations between nodal planes, P- and T-axes, and slip vectors are much easier to demonstrate in three dimensions.

Orbital Dynamics

A model of the Magellan spacecraft not being available, we use *Star Trek*'s USS Enterprise to illustrate orbital motions.



2a) North-south trending strips of low-resolution data indicate satellite tracks. These strips are actually Pioneer data, collected in the 1980s, used to fill in gaps in the Magellan data set. The gaps arise from radar downtime (which occurred when the spacecraft was communicating with Earth, or when there was a software/hardware glitch), and thus follow the satellite's path over the surface of Venus. We demonstrate a typical "mapping" orbit by flying the Enterprise in an orbit over the poles while Venus spins underneath. This way, the Enterprise can map virtually the entire surface with its sensors.



2b) Geostationary Orbits. In *Star Trek*, the Enterprise typically assumes what the writers call a "standard orbit." From the graphics, we are led to believe this is an orbit which allows the Enterprise to remain over wherever the landing party is to beam down, and is always in the mid-latitude regions of the planet's northern hemisphere. A true geostationary orbit must actually parallel the planet's equator as all orbits must be centered around the planet's center of mass, which will generally coincide with the planet's center of figure. To illustrate, we (gently!) spin the globe, and walk the Enterprise around the globe (in its equatorial plane, yellow line in the figure), matching the globe's spin rate. If the Enterprise were to actually pass over the landing party's beam-down point, its orbit (red line) would carry the ship far from Kirk and Spock (not good if Klingons are nearby!).