

Carolyn Sumners*
Houston Museum of Natural Science
Patricia Reiff
Rice University

*"The same forces that create a cool breeze in spring or warm sunshine on the beach can sometimes converge into events of great scope and destructive power. Energy in our world constantly flows through natural cycles where heat, pressure, and radiation bring gradual changes in the environment. These changes periodically transform into catastrophic events. For the most powerful we reserve the title, **Force Five.**"*

Thus begins a unique full-dome digital theater production called *Force 5*. For 20 minutes audiences are immersed in the most deadly storms in our world: the hurricane, tornado, and coronal mass ejection. Each section introduces audiences to a different storm and explains what happens when the storm reaches "Force 5" in terms of energy stored and released. Each section ends with a full-dome rendered Force 5 storm complete with appropriate sights and sounds. The familiar hurricane and tornado provide an appropriate introduction to the less familiar CME.



The "Hurricanes" section begins... "Hurricanes are heat engines collecting energy from the warm, humid air over the tropical oceans and releasing this heat through the condensation of water vapor into water droplets in thunderstorms of the eyewall and rainbands. The energy in a hurricane can also be thought of as the kinetic energy generated in maintaining the strong swirling winds." Images and Edison's movie from the Galveston 1900 storm place the devastation of a hurricane into human terms. Then the full dome gives a flavor of the experience.

Corresponding author address: Carolyn Sumners
Houston Museum of Natural Science,
Houston TX 77005, csumners@hmns.org

The "Tornadoes" section begins ... "Between the Rocky and Appalachian Mountains, from Iowa to the Gulf of Mexico, thunderstorms develop. These turbulent giants are created when warm humid air from the Gulf collides with cool dry air from the Rockies. But thunderstorms themselves don't constitute a force five event. As a thunderstorm grows, the condensed moisture forms a thunderhead cloud that can rise 50,000 feet into the sky. Within the thunderhead a region of spinning air forms and stretches vertically. When this area of rotation lowers below the base of the storm, it becomes a wall cloud. From this wall cloud, nature's most violent and unpredictable storm descends to touch the ground... the tornado." Images of the aftermath of the Oklahoma City Force 5 tornado bring that force level to human terms. Then the full dome experience starts with a green sky and a few marble-sized hail stones whizzing by, and then the cloud descends.... The force of the sound shakes the seats of the theater.



The CME section begins.... "As we leave the Earth to live on the moon and on other worlds in our solar system, we trade our dangerous hurricanes and tornadoes for a more violent and deadly foe: the Solar Storm. Energy from the sun's core travels outwards to its atmosphere where it escapes as radiation and rising columns of gas. The transfer of energy to the boiling surface distorts the lines of a magnetic field around the sun. This distortion of the field stores energy and builds in intensity. When released, a solar flare occurs, often accompanied by a coronal mass ejection, spewing out over a million tons of solar particles toward Earth. These solar events occur at a magnitude of violent force and energy that equals the power of a billion hydrogen bombs." The solar storm animation shows the IMAGE spacecraft monitoring the Earth when an angry sun spews out a coronal mass ejection. Field lines from an LFM MHD model or a real storm shudder with the impact of the shock wave, and auroral movies from IMAGE's FUV detector give a taste of a solar storm to viewers who are unaware of what our magnetic field and atmosphere protects us from.

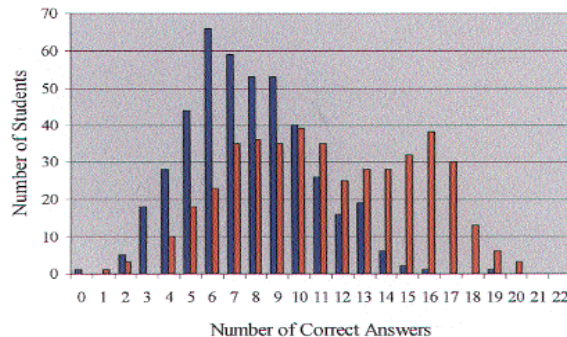


The show *Force 5* required 200,000 hours of computer time to render and composite, and has played to many tens of thousands of visitors since its release. It is especially popular during hurricane season in the summers and during recent solar events. It has played as a public and school program in the Burke Baker Planetarium and is now available to large-format theaters through Evans and Sutherland. A lower-resolution version is also available for smaller domes.

The accompanying curriculum materials use activities with hurricanes and tornadoes to familiarize students with concepts ranging from energy conservation to geographic coordinates. These activities prepare students to study the less familiar CMEs, focusing on concepts from energy

conservation and flow to geographic location of solar disturbances over the Earth.

Pre/post testing of a random sample of 4th and 7th grade student visitors to various venues in the museum [Summers and Weber, 2001] show significant gains of 3-dimensional concepts when presented in an immersive theater.



A post-hoc assessment of the pre and post test questions showed the following improvements among a randomly sampled set of 4th grade students (438 students from 8 classes):

Questions about concepts presented visually or with still images:

Pretest: 43.07% posttest 54.6% gain 11.53%

Questions about concepts presented with moving images:

Pretest: 31.28% posttest 49.02% gain 17.74%

Questions about concepts presented with immersive experiences:

Pretest: 33.22% posttest 57.21% gain 23.99%

In this group, which was over 90% nonwhite and 80% free lunch, a significant gain in the number who wanted to be scientists (39.5% from 28.3%) or wanted to read about science (31.3 from 12.8%) was also documented as a result of the experience..

Excerpts from *Force 5* and sample activities will be shown.

For more info: <http://earth.rice.edu>

Reference:

Sumners, C and Weber, W., "Quantification of Student Learning in the museum, Planetarium, and Imax", IPS conference proceedings, 2001.

This show was supported by NASA's office of Earth Science under the ESIP Federation program (NASA NCC5-311) and the Office of Space Science as an outreach project under the IMAGE mission (AO-95-OSS-02).