

Seeing Complex Systems as They Really Are and Should Be: Moving from 2-D to 3-D Viewing Perspectives For Teaching and Research

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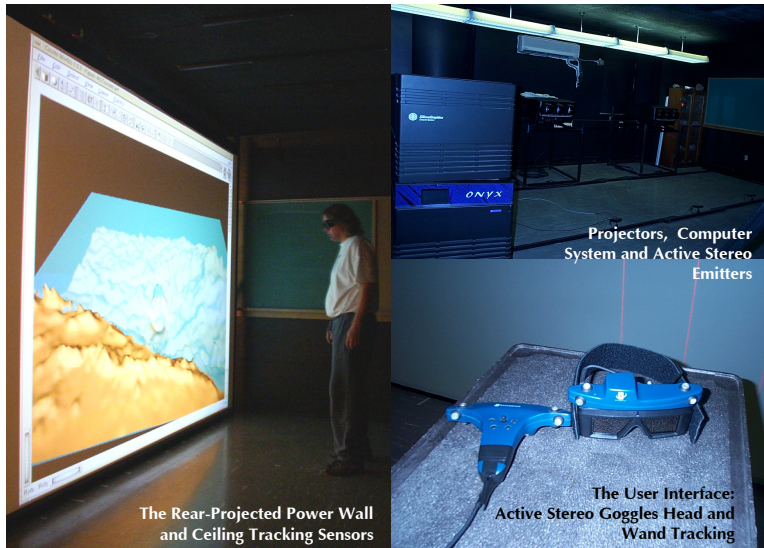
Introduction & Background

Advances in scientific visualization technology have opened countless doors in both quantitative and intuitive data analysis. One of the larger-scale technologies proliferating through the science and engineering communities is the use of *immersive* approaches, including Immersadesk™, Power Wall, and CAVE™ technologies.

These approaches involve complex computational 3-D graphics and human-machine tracking allowing users to “enter” their datasets. The data processing applications used to drive these environments, both general and discipline-specific, often include problem solving environments that not only allow users to be immersed in their data but also permit the ability to analyze their datasets. Other applications permit interaction between two users at two immersive facilities, or “teleimmersion,” opening new avenues for collaborative research.

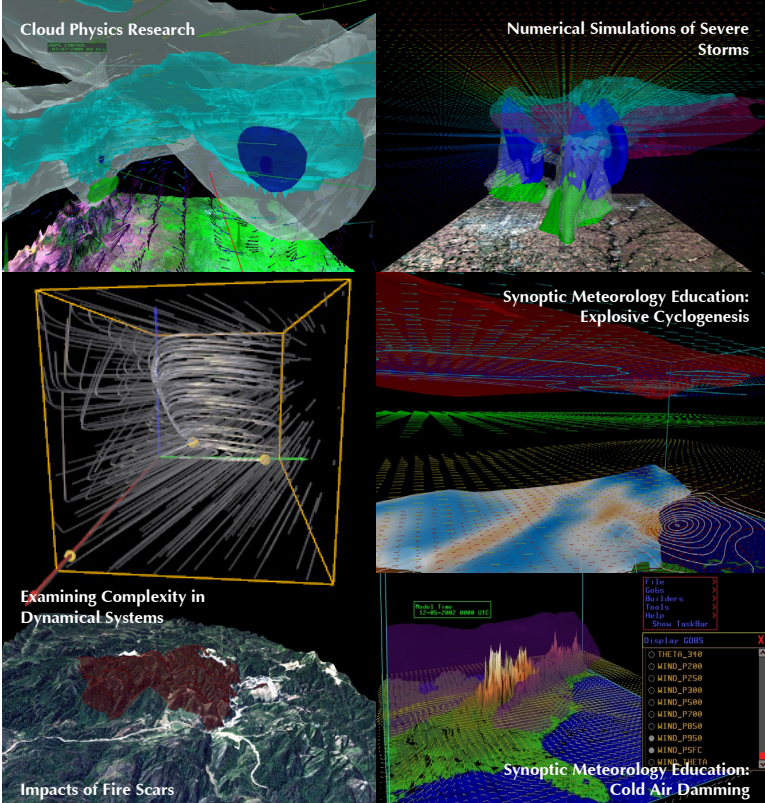
In education, this environment also allows the professor to create data landscapes that may be more intuitive for students to comprehend over more “traditional” flat or abstract viewing regimes. In communicating research results to non-specialists these environments can also provide a means by which abstract and complex information can be presented clearly thus better facilitating outreach.

Presented here are a set of examples used at SDSM&T by researchers in Meteorology, Materials Processing and Paleontology using the university's PowerWall facility, the Black Hills Advanced Visualization Laboratory.



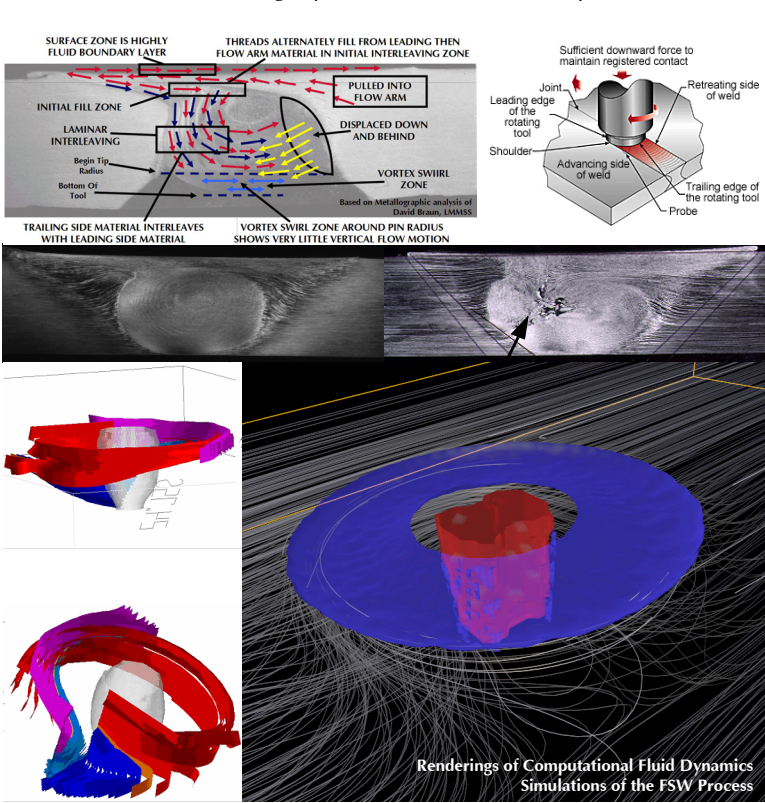
Meteorology Education

The Institute of Atmospheric Sciences (IAS) has made extensive use of the Wall environment for both research and education. Many of these applications have involved the rendering of complex geophysical fields, including hydro-geological systems, rendering severe storm environments, and viewing turbulence patterns within lake-effect snow storms. Traditional presentations of these complex 3-D fields are often limited to two-dimensional “slices” through a volume which do not quickly lend themselves to interpretation. In a 3-D immersive environment, such fields can be viewed in their entirety and in combination with other parameters, providing the viewers with the “full” picture of their problem domain. In research, this permits a scientist to quickly identify anomalies, errors, and emerging features that would otherwise require more painstaking analysis methods. This is also important in the education process where a student can now understand the full context of an emerging storm event from upper levels in the atmosphere to the surface in a single viewing.



Materials Processing

BHAVL’s most successful and productive collaboration to date has been with the SDSM&T Advanced Materials Processing (AMP) Center. Here, AMP investigators have examined computational fluid dynamics model output of the Friction Stir Welding (FSW) process using BHAVL equipment, personnel, and software. This collaboration also demonstrates an example of cross-fertilization between disciplines in that the original renderings of the FSW model output were produced using meteorologically-based software (University of Wisconsin’s *Vis5D* package) used within the Institute of Atmospheric Sciences. In these sessions, and those that followed, AMP investigators were able to see, for the first time, flows within the welding process that they had hypothesized and seen in the post-weld product, but now were able to see in the forming process through the immersive renderings. Since the original sessions between IAS and AMP, the BHAVL has acquired licenses for the TGS *Amira*VR problem solving environment, which has created an enhanced viewing experience for their data and problem domain.



Paleontology

Through the University of Texas, high-resolution X-ray CT (Computed Tomography) scans of three SDSM&T Museum of Geology fossil specimens have been obtained. With assistance from IAS and BHAVL, a high-resolution CT scan was imaged to allow *non-destructive examination* of the internal structure of bones and teeth, and to distinguish between fossil bone and sediment matrix. The tangible products of images, animations, or simulations, and rapid prototype models of these specimens, are immediately usable in the Museum’s core mission of education. Using these methods, the paleobiology and functional morphology of fossil organisms can be modeled and studied in virtual space. The ability to non-destructively examine the internal structure of bones and teeth provides important information on the age and development of fossil organisms, and extract the maximum scientific value from specimens without damage to them. Pending research includes a detailed analysis of the inner ear of *Nimravus bumphensis*. The AMP Center, the Museum of Geology, and BHAVL will eventually be producing physical models of the imaged objects using rapid prototyping technologies or other production methods.

