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EDUCATION AND OUTREACH WITHIN THE MODELING ENVIRONMENT FOR ATMOSPHERIC DISCOVERY (MEAD) PROJECT

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1. INTRODUCTION

In 2002, researchers across the country began collaborating on the Modeling Environment for Atmospheric Discovery (MEAD) Expedition. The goal of the MEAD Expedition is the development and adaptation of Grid and TeraGrid-enabled cyberinfrastructure for enabling ensemble or very large domain model simulations coupled with data handling, analysis, data mining, and visualization services.

The specific applications chosen for MEAD are mesoscale storm and hurricane research and education. It is the efforts of the Education Group of the MEAD Expedition that will be discussed in this paper.

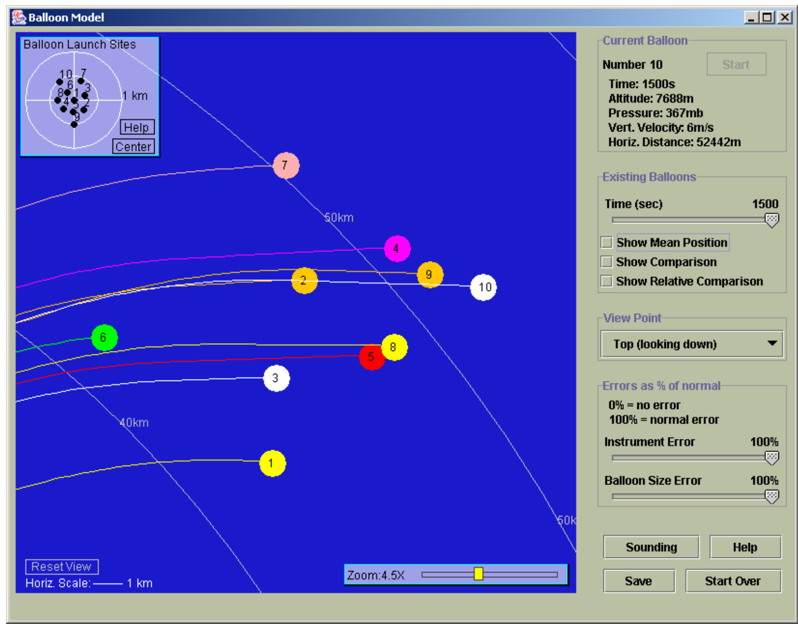

Fig. 1. Example screen of the Balloon Model (UIUC).

2. EDUCATIONAL COMPONENT

The MEAD Education Group is developing and providing curriculum and simple MEAD-related model, analysis, and visualization tools that will aid in understanding of model uncertainty in weather, including the prediction of hurricane strength, behavior, and human impact. The materials focus on inquiry-based learning with hands-on experimentation and bring K-12 and undergraduate students into the world of the scientific researcher and weather forecaster.

Students using these resources will have the opportunity to learn about:

- Nature of uncertainty
- Decision-making processes
- Interactive models and simulations
- Quantitative and qualitative contexts
- Ability to explore more rigorous analysis paths (e.g. transition from Algebra to Calculus classes)

This work is being done in collaboration with the investigators from the Education, Outreach, and Training (EOT) Division of the National Center for Supercomputing Applications (NCSA).

3. GROUP ORGANIZATION AND WORK

The Education Group is centered at NCSA under the leadership of Scott Lathrop, the division head of EOT-NCSA. MEAD-related models are being developed at four major institutions: The University of Illinois at Urbana-Champaign (UIUC – *Balloon Model*), the Ohio Supercomputing Center (OSC – *Hurricane Floyd Models*), the Shodor Foundation (*Physical-to-Computational Models*), and the Maryland Virtual High School (MVHS – *Hurricane Simulation*). Further, MVHS

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will coordinate the testing of these models in K-12 classrooms. Each institution's work will be discussed in greater detail below.

3.1 *UIUC: Balloon Model*

An interactive Java application has been created to serve as an example of the usefulness of ensemble weather prediction In the application, students launch weather balloons into the atmosphere and observe their trajectory as they rise and drift in the wind for a predetermined amount of time.

In Fig. 1, the screen view of the Balloon Model reveals ten separate balloons as viewed from above depicted by the colored circles. The lines leading to each circle represent the path each balloon took to get to where it was. Even though the background atmosphere was the same and each balloon flew for the exact same amount of time, there were subtle variations in the wind field from balloon to balloon. These variations mimic how the atmosphere might change if the balloons were released at a slightly different location or time. Also, a 'human error' in the amount of hydrogen gas that the balloon was filled with was inserted.

The differences in the balloons' location relative to the ground approximate differences between individual forecast tracks of storms or hurricanes obtained from an ensemble of simulations. Analysis of these differences helps students gain an appreciation for how small changes in the atmosphere can significantly affect the trajectory of the balloon. This knowledge can then be used to help them understand differences in tracks of meteorological phenomena (e.g., hurricanes) obtained from different simulations and also to provide the basis for learning about how different tracks can be used to estimate the observed track of these phenomena.

3.2 *OSC: Hurricane Floyd Models*

The OSC is leading an effort to make Hurricane Floyd data available for classroom analyses. Information collected will include flood stage data, rainfall and temperature data, and Landsat imagery. Three models are being developed with the following goals:

1. Relate flood occurrence to streamflow
2. Relate streamflow to predict flooding
3. Observe the impacts of flooding and model the property damage costs.

Students will be introduced to a number of techniques for fitting data and estimating models including curve fitting and regression analysis using the Excel spreadsheet program. They will also use freely available geographic information system software to observe the historical path of Hurricane Floyd and its impacts on flooding and property damage.

3.3 *Shodor: Connection Models*

Lessons used with middle school students in Shodor workshops introduce the concepts of computational science in the context of human-scale physical systems and experiments. Variations in the paths of foam 'shooter' discs help motivate the concepts surrounding uncertainty in the prediction of natural hurricane paths and preface the introduction of computational Stella models, building from simple examples to a multi-variable educational model and used in NCSA K-12 teacher training workshops.

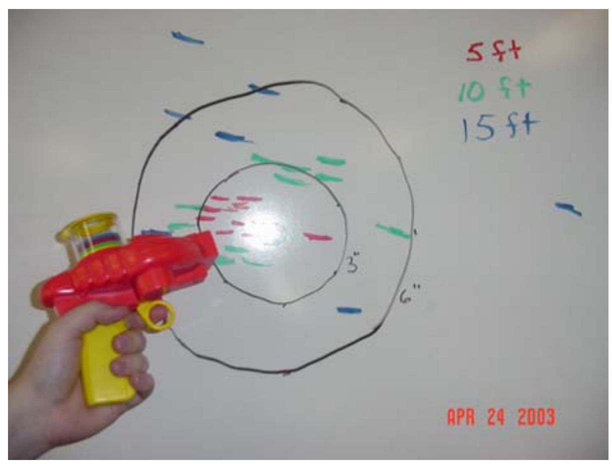

Fig. 2. Results of a foam 'shooter' disc experiment.

In Fig. 2, a photograph shows the uncertainty associated with foam discs fired from a gun. The operator aimed the disc gun at the center of a target from three different distances. The impact location was then marked with a specific color depending on how far the operator was from the target. In this case, red marks indicates shots taken from five feet, green from ten feet, and finally blue marks for shots taken from 15 feet.

The students can easily observe that the closer the gun was to the target, the less variability there was in the results – just as there would be less uncertainty in forecasting where a hurricane would be twelve hours from now as there would thirty-six hours from now.

3.4 *MVHS: STELLA Hurricane Modeling*

MVHS has developed materials for a hurricane simulation that creates possible hurricane paths from historical data (See Fig. 3). The classroom simulation allows students to investigate the roles of sea surface temperature, location of landfall region, and uncertainty in predicting a hurricane's strength upon making landfall.

Also, in the upcoming school year, MVHS will transform the hurricane model into a web-based simulation with an accompanying database in which teachers may pose questions and students may post answers.

4. TESTING

MVHS tested the materials with teachers this past summer and used them the during the fall hurricane season. Classroom testing of the Balloon Model, the Hurricane Floyd Models, and the Foam Disc Flight Pattern Exercises also occurred. As a result, the model developers have received valuable feedback that will help make the models more effective learning tools.

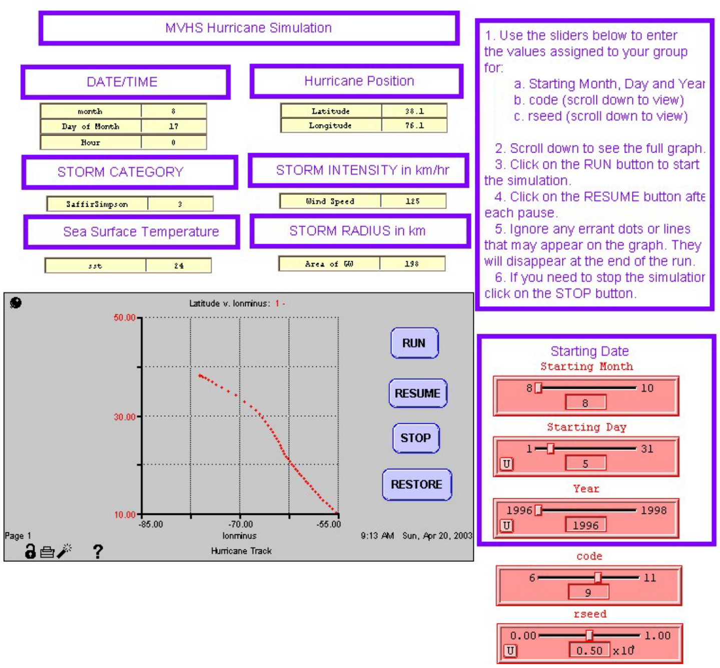

Fig. 3. Interface of MVHS Hurricane Simulation with example track graphed at bottom.

5. SUMMARY

Each of these MEAD-related models help the MEAD Expedition by providing either direct evidence of analogous reasoning for the need to understand the concept of uncertainty and how it pertains to the atmosphere – and more specifically hurricanes and thunderstorms.

It is a desired goal of the MEAD Expedition that non-scientists use the MEAD interface to make advanced model simulations for a class project. Without these educational tools, students might not be able to make the leap from no modeling experience to using advanced models. These models can serve as the stepping-stone between the two levels and allow students to become more familiar with modeling

6. WEB SITES

MEAD: www.ncsa.uiuc.edu/expeditions/MEAD
NCSA-EOT: www.ncsa.uiuc.edu/Divisions/eot/
EOT-PACI: www.eot.org
UIUC: www.atmos.uiuc.edu
OSC: www.osc.edu/education
Shodor: www.shodor.org
MVHS: mvhs.mbhs.edu

7. ACKNOWLEDGEMENTS

Funding for the MEAD Expedition is provided by the National Computational Science Alliance and funding for the Education Group also comes from the Education, Outreach, and Training Division of the National Center for Supercomputing Applications.

8. SEE ALSO

Wilhelmson, R., et al., 2003: Modeling Environment for Atmospheric Discovery. Proceedings of the 19th Conference on IIPS, Long Beach, CA, American Meteorological Society.

Wilhelmson, R., et al., 2004: MEAD (A Modeling Environment for Atmospheric Discovery). Proceedings of the 20th Conference on IIPS, Seattle, WA, American Meteorological Society.