INTEGRATING LEAD RESEARCH IN EDUCATION

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Abstract

Linked Environments for Atmospheric Discovery (LEAD) is making meteorological data, forecast models, and analysis and visualization tools available to anyone who wants to interactively explore the weather as it evolves. The LEAD education and outreach initiative is aimed at bringing new capabilities into classroom from the middle school level to graduate education and beyond. One of the principal goals of LEAD is to democratize the availability of advanced weather technologies for research and education. The degree of democratization is tied to the growth of student knowledge and skills, and is correlated with education level. This is necessary to accommodate not only differences in knowledge and skills, but to assure that the “teachable moment” is not lost. Undergraduates will have the opportunity to query observation data and model output, explore and discover relationships through concept mapping using an ontology service, select domains of interest based on current weather, and employ an experiment builder within the LEAD portal as an interface to configure, launch the WRF model, monitor the workflow, and visualize results using Unidata’s Integrated Data Viewer (IDV), whether it be on a local server or across the TeraGrid. Such a robust and comprehensive suite of tools and services can create new paradigms for embedding students in an authentic, contextualized environment where the knowledge domain is an extension, yet integral supplement, to the classroom experience. The presentation will focus on the development and refinement of LEAD-to-LEARN modules, collaborative efforts between LEAD Education and Outreach thrust and National Center for Supercomputing Applications Cybereducation group including the development of a basic version of IDV.

Index Terms

Integrated test beds, ITB, Learning modules, TeraGrid, WRF model, Education, Forecasting, Dynamic adaptivity, LEAD, ontology service, Integrated Data Viewer, IDV, LEAD-to-LEARN modules, workflow, LEAD portal, CAPS, MyLEAD

1. INTRODUCTION

Linked Environments for Atmospheric Discovery (LEAD) is making meteorological data, forecast models, and analysis and visualization tools available to anyone who wants to interactively explore the weather as it evolves. LEAD evolves through the development and beta-deployment of Integrated Test Beds (ITBs), which are technology build-outs that are the fruition of collaborative IT and meteorological research. As the ITBs mature, opportunities emerge for the integration of this new technological capability into education.

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The LEAD Education and Outreach (E&O) initiative is aimed at bringing new capabilities into classroom from the middle school level to graduate education and beyond. One of the principal goals of LEAD is to democratize the availability of advanced weather technologies for research and education. The degree of democratization is tied to the growth of student knowledge and skills, and is correlated with education level (though not for every student in the same way). The average high school student may experience LEAD through an environment that is more controlled by the instructor than an undergraduate student. This is necessary to accommodate not only differences in knowledge and skills, but to assure that the “teachable moment” is not lost.
Undergraduates will have the opportunity to query observation data and model output, explore and discover relationships through concept mapping using an ontology service, select domains of interest based on current weather, and employ an experiment builder within the LEAD portal as an interface to configure, launch the WRF model, monitor the workflow, and visualize results using Unidata’s Integrated Data Viewer (IDV), whether it be on a local server or across the TeraGrid. Such a robust and comprehensive suite of tools and services can create new paradigms for embedding students in an authentic, contextualized environment where the knowledge domain is an extension, yet integral supplement, to the classroom experience.

This presentation provides an overview of the efforts towards these goals involving undergraduate students at Millersville University and the collaborative efforts with the undergraduate students at the National Center for Supercomputing Applications (NCSA) Cybereducation group. The collaborative work has had four main areas of focus: 1) review, analysis, and accessibility of LEAD-to-LEARN modules initially developed by undergraduates at Millersville; 2) development of a basic version of the Integrated Data Viewer (IDV) for pre-college use; 3) design and compilation of a menu-driven module for pre-college use; 4) use-cases for integrating LEAD technology into undergraduate subject material. The use-cases (4) are embedded in learning modules (LEAD-to-LEARN) designed to have students explore a particular weather phenomenon (e.g., a frontal boundary, jet streak, or lake effect snow event) through self-guided inquiry, and are intended as a supplement to classroom instruction.

2. USE CASES FOR UNDERGRADUATES

LEAD-to-LEARN modules were created by undergraduate students at Millersville University specifically to build conceptual knowledge of the phenomenon, adjoin germane terminology, explore relationships between concepts and similar phenomena using the LEAD ontology, and guide them through the experiment builder and workflow orchestration process in order to establish a high-resolution WRF run over a region that exhibits the characteristics of the phenomenon they wish to study. Several learning modules have been developed around case studies that focus on a set of atmospheric phenomena. The current modules were extensively reviewed and tested by the NCSA Cybereducation Undergraduate students. The NCSA group was able to provide valuable feedback on the clarity, organization, usability of bundles and embedded data sets in the modules in addition to technical help with pop-up definitions feature. This interaction between the undergraduate students at the two institutions provided a unique venue for interaction, conversation and collaborative work integrating research and education. The learning modules are pedagogically structured, complete with learning objectives, content within the context of the phenomenon, a glossary with pop-up definitions, and tools for self-assessment. So far the LEAD team has developed nine modules that can be accessed via the LEAD portal > Education > LEAD-to-LEARN (http://portal.leadproject.org). Figure 1 provides a screen shot of the modules page. The student is guided through the module through a sequence of descriptions and visualizations of the meteorological conditions that would be associated with the particular weather event.

Some modules contain the partial differential equations that serve as the mathematical underpinning for an in-depth treatment of the subject, and were designed for use in junior and senior undergraduate meteorology courses. For example, the module on “Understanding the Quasi-Geostrophic Height Tendency Equation” comes with a full mathematic description of the equation and its individual terms, and content and visualizations that illustrate how each term plays a role in influencing the Q-G height tendency (Figs. 2 and 3).

Other modules use a more descriptive approach. For instance, the module on “Exploring Lake Effect Snow” events was designed with discussions and visualizations of observational data and model output to explore the atmospheric conditions leading to
lake-effect snowfall. The module is suitable as a lake-effect snow primer or for meteorology students enrolled in their first course in the major sequence.

The modules also contain links to archived data sets that the student can download in Unidata’s 3-D Integrated Data Viewer (IDV) by importing XML bundles that have pointers to the data, and can either explore the data volume using the module’s approach to guided inquiry, or discover for themselves or with guidance from their instructor, the features related to the phenomenon.

At Millersville, course instructors incorporating these modules to supplement their instruction either in class or given as an assignment have found them to be useful, and students have commented that they gain a better understanding of the phenomenon by having the content and visual materials in the form of guided inquiry.

However, LEAD technologies allow the learning process to be much more than one of guided inquiry; they enable the student in an authentic way that exposes the same process of investigation, and many of the same tools, that are used by researchers to study a phenomenon. Moreover, this comes at a time when undergraduates are no longer satisfied to only look at model products. Students want to investigate the model itself, understand the physical core, parameterizations, boundary conditions, and data assimilation techniques. They want to create the workflow themselves, launch a high-resolution WRF run over a domain of their
choosing, and have their own space to store, retrieve, visualize, analyze, and interpret the atmospheric features characteristic of their investigation. And this is exactly what the LEAD developers have been challenged to create – an integrated, scalable framework for identifying, accessing, decoding, assimilating, predicting, managing, analyzing, mining, and visualizing a broad array of meteorological data and model output, independent of format and physical location in a democratized environment that is friendly and intuitive to the end-user.

3. ENHANCED USE CASES

The LEAD project is now at a period of development when some of the fundamental IT research challenges have been met and are ready for testing and integration into other LEAD thrusts. The first effort involved the LEAD E&O thrust is to build into the learning modules use-cases that enable the student to query real-time observations and model output for atmospheric signatures that are similar to those described in the module about a particular phenomenon. The concept is simple but powerful. Once the student has been introduced to lake-effect snowfall events (for instance) and the atmospheric conditions and features that favor those events, they will begin to formulate additional questions, such as “Can I use the LEAD data query service to investigate in real-time similar conditions playing out across the U.S? Can I use the experiment builder to define a domain over the region of interest (Fig. 4), compose an automated workflow (i.e. a sequencing of steps or programs that go into the realization of a meteorological analysis or experimentation) that includes choosing the model’s physical core, boundary layer parameterization, initialization field for the assimilation service, launch a high-resolution WRF run (Fig. 5), and store the output in the student’s MyLEAD workspace for visualization and analysis (Fig. 6)?” The student becomes the researcher in an authentic scientific investigation. As functional components of this technology become hardened and available from the LEAD development team, they are being incorporated as features in the learning modules for students use.

To-date, a few of the learning modules allow students to position a domain over a region of interest, select the model resolution, acquire NAM or ADAS (CAPS atmospheric data assimilation system) initialization fields, choose from a few workflow templates, launch a WRF model run using external resources, and store the data in MyLEAD workspace, which can be imported to IDV for analysis and visualization. The student can enter the experiment builder from the learning module or by going directly to the experiment builder through the LEAD portal.
4. COLLABORATIVE EFFORTS

The collaborative efforts between LEAD E&O and NCSA Cybereducation have been very fruitful and continue to aid in the process of developing and refining undergraduate learning materials in addition to tools and features for the pre-college education. As stated earlier, IDV is the main visualization tool for LEAD. Although IDV is a powerful and unique visualization tool, it is also at the same time complicated for use in the pre-college environment. Since LEAD is committed to making LEAD data and tools available to a large educational audience (grades 6-12, undergraduate, and graduate), it is essential that the tools including IDV can be utilized in the pre-college environment. In collaboration with Millersville undergraduate students and LEAD teacher partners, NCSA computer science students are in the process of developing a basic version of IDV which contains a reduced parameter list, and allows for a methodical selection of variables based on the phenomenon of interest.

The features of this basic version of IDV were presented at a LEAD educator workshop sponsored and hosted by NCSA in December of 2006. The workshop participants provided valuable feedback that is guiding this continued effort. Furthermore, an additional feature is being developed by NCSA students to enable the user to select a particular phenomena of interest (e.g., tornadoes), and then be presented with all the parameters and data sets available at the time selected to study and analyze the event. Undergraduate meteorology students at Millersville are involved in compiling these lists to be used in the compilation of this routine and eventually a menu-driven module. A preview of this feature will be included in the presentation in addition to a preliminary version of IDV Basic.

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