"International Remediation" - Development of an online-based course for German and American students

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The Department of Hydromechanics and Modeling of Hydrosystems has developed a course on the topic "Multiphase Flow and Transport in the Subsurface" for students in Stuttgart. It will be offered in fall 2004 as an online seminar at the same time for German students in Stuttgart and American students at universities participating in the INRA network ('Inland Northwest Research Alliance'). The course material will be distributed via a groupware in the Internet, where we also plan to establish topic-related discussion groups. To encourage active student participation, e.g. interactive elements as numerical simulations and virtual face-to-face meetings via video conference are envisaged.

1. INTRODUCTION

The Institute of Hydraulic Engineering at the University of Stuttgart has a long tradition in offering courses on the broad topic "Multiphase Flow". Integrated into the European Engineering Graduate School Environment Water of the International Association of Hydraulic Research (IAHR-EGW) the first courses were held in 1994. Over the years they developed into one-week short-courses which increasingly introduced collaborations between Stuttgart (Department of Hydromechanics and Modeling of Hydrosystems of the Institute of Hydraulic Engineering) and international researchers. In the last couple of years it became customary that next to lecturers from Stuttgart also guest speakers from other countries are invited.

As a regular guest, Prof. Al Cunningham joined the short-courses as lecturer. In cooperation between the authors of this paper, a short-course with the title "Multiphase Flow, Transport and Bioremediation in the Subsurface" was established [3]. The course is conducted as a course for further education and is not only accepted well by researchers and professionals from all over the world, but also increasingly by students.

In Stuttgart, the topics of this course taught by Prof. Helmig have now additionally flown into a new lecture called "Model concepts and simulation methods for single-phase and multi-phase flow (MSM)". This lecture is held in English and it is integrated into the main study period for civil engineers, environmental engineers and students of the international masters-program WAREM (Water Resources Engineering and Management)

as a mandatory course in the study field 'Modeling of Hydrosystems'.

After a first run of this lecture in the fall semester of 2003/2004, it is now planned to offer this lecture also to American Students. As Prof. Cunningham is member in the Inland Northwest Research Alliance (INRA) [1] the idea is to offer the Stuttgart course inside this network.

The following universities have so far joined the INRA Network:

- Boise State University, Boise, Idaho
- Idaho State University, Pocatello, Idaho
- Montana State University, Bozeman, Montana
- University of Alaska Fairbanks, Fairbanks, Alaska
- University of Idaho, Moscow, Idaho
- University of Montana, Missoula, Montana
- Utah State University, Logan, Utah
- Washington State University, Pullman, Washington

This means that the students participating in the online seminar are not only in two different countries, but also distributed over different cities. Therefore, the lecture is planned as an online seminar for both countries to encourage and strengthen communication and exchange between German and American students. A first run is envisaged for the fall semester 2004/2005.

2. TOPICS OF THE COURSE

The course MSM provides an introduction to the physics of multiphase flow and transport processes in porous media (see Fig. 1). Here, the focus lies on different aspects. On the one hand, the mathematical background is discussed. The governing flow and transport equations are derived, and their numerical solution by means of finite element as well as the finite volume method is presented. On the other hand, an insight is given as to which parameters are important for a numerical simulation. The constitutive relationships of relative permeability and capillary pressure are discussed in detail, focusing on their influence on the behavior of multiphase flow systems.

In order to strengthen the understanding for the underlying processes, a number of illustrative sample problems can be solved with a special software (MUFTE-UG, developed in cooperation between the Department for Hydromechanics and Modeling of Hydrosystems, Institute of Hydraulic Engineering, University of Stuttgart and the Interdisciplinary Center for Scientific Computing at the University of Heidelberg). The students are encouraged to try different parameter combinations. The results are then discussed in class.

So the concept of the course is to provide the students with the necessary mathematical knowledge of multiphase flow and transport processes and at the same time enable them to visualize the effects of different parameters on representative problems. This concept we now plan to apply to the online seminar.

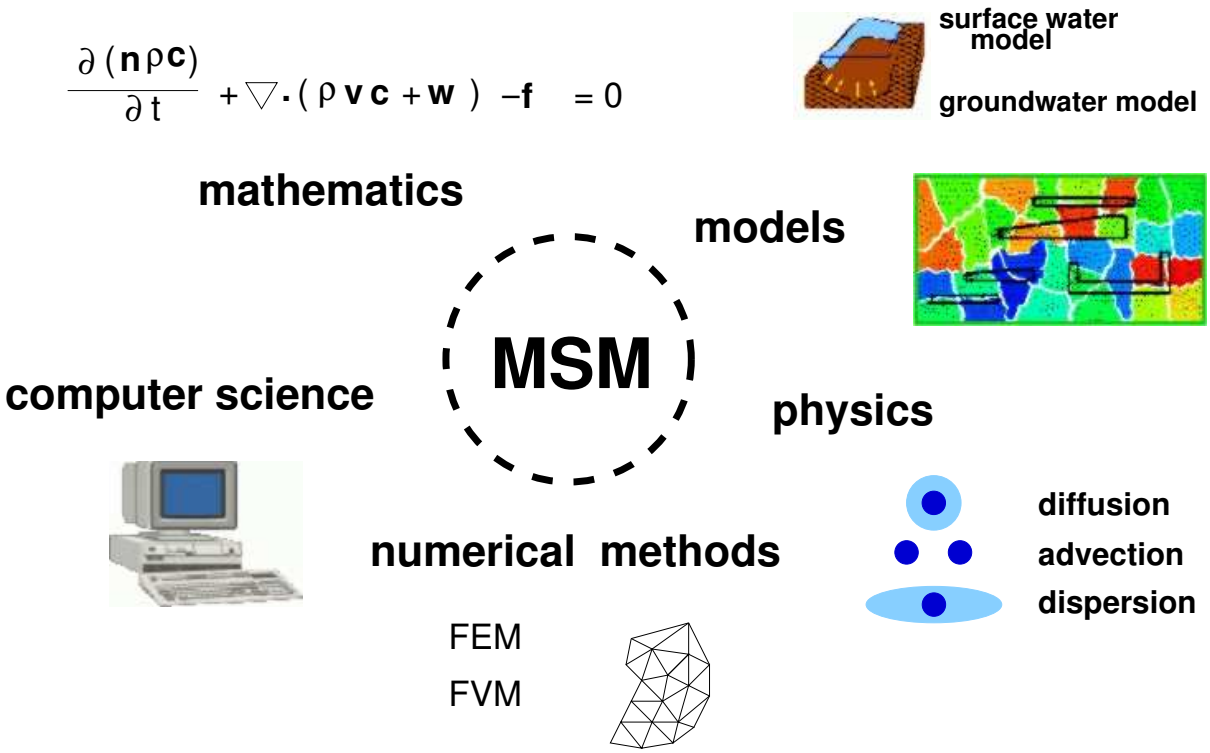

Figure 1. Overview of the topics taught in the course "Model concepts and simulation methods for single-phase and multi-phase flow (MSM)"

3. UNDERLYING CONCEPT

A pure online course makes large demands on the students self-discipline as the student him- or herself is responsible for keeping up with the lecture in time.

In order to help the students with this responsibility and to reduce the drop-out rate, some supporting structures are planned, which will be presented in the following.

3.1. Methodical scheme

For every course it is important to have a transparency of the course structure so that the students know what is expected and what the course will cover.

For an online course, this information is even more important. As the students may – and have to – plan their own time schedule, it is vital to know from the beginning what is expected when. Therefore, a detailed course description will be handed out. It will contain a course summary where the topics and the goals of the course are stated. This will help the students beforehand to decide whether this course fits into their study plan or not. For the German students this is ensured, as the course is anchored in their study program. For the American students, which can choose this course as an auxiliary credit, it is very important to make sure that the content is conform to their own studies.

However, as the course topics are closely related to the one-week short course "Multiphase Flow, Transport and Bioremediation in the Subsurface" held by the authors of this paper, it is ensured that it can serve as a basis for further courses covering these research areas in the INRA network.

Another important thing which has to be made transparent is the recommended prerequisites. This is important for both German and American students, as it not only concerns the knowledge the course is based on, but also the technical requirements. It has to be made sure that all aspects of the online seminar can be accessed. Therefore a detailed description is given as to which operating system, software, browser or programs are necessary.

As the course is held as an online seminar, all materials will be distributed and provided via the Internet utilizing a groupware. For the students this has the advantage that the materials are freely accessible and they are not restricted to a certain computer or to carry a CD with them. For the tutors it has the advantage that the materials can easily be changed, expanded, and kept up to date

As we plan to encourage discussions to certain topics or problem statements, the groupware we plan to use offers the possibility to attach discussion forums to documents or folders (see below). This can only be done if the materials and forums are stored centrally in the Internet.

We plan to provide the following materials:

lecture notes These are texts which have to be read and prepared by the students. The structure is planned in such a way that it corresponds to the time-table of the course. The lecture notes are either pdf-documents or specific references to recommended books (e.g. [4]).

pdf-presentations Here the material of the presentations are provided as they would be used by the lecturer in a normal classroom situation. The main issues are briefly summarized which gives the students the possibility to review the topics for themselves and see whether they can fill the pictures with "content" or not.

problems It is planned to provide two types of problem statements. One the one hand, small questions are asked at the end of each chapter, where the students can test for themselves if they have understood the material. On the other hand, also larger assignments are given, where a solution must be delivered to a tutor.

interactive elements We plan to give the students the possibility to access numerical simulation programs online. Here, they have the opportunity to freely test out parameter combinations and develop a feeling for the behavior of the system.

3.2. Didactical scheme

Together with a didactical professional we planned the following set-up:

At first we will provide the students with a time table as when to do what. This makes it easier for the students to have an insight into the required workload. Additionally, this gives those who cannot keep up for a certain period of time the possibility to have an orientation about the status of the rest of the group and to join in later at certain dates.

For an online seminar it is important that every participant is familiar with the technological surrounding. Therefore the first task for the students in the **introductory phase** will be to get acquainted to the system. Here, small assignments will be given so that they will use and explore the system with purpose. As a document-management system, the groupware BSCW ('Basic Support for Cooperative Work') will be used (see below).

In the next step the participants should get to know each other. As we plan to encourage discussions among the students it is important to recognize the other participants as individuals and not as an anonymous group. Here, again, the used groupware is specifically integrated into the task (create an own profile) so that another possibility is given to get used to the technical side.

In the last part of the introductory phase, a video conference will take place. The theme of this virtual face-to-face meeting will already be the first topics of the course, so that the lead-in to the actual lecture material is given. Another purpose of this video conference is to make cooperation and communication easier by actually seeing and getting to know all participants.

The next phase (**content phase**) of the course focuses on the self-study of the provided materials. According to the course schedule certain sections have to be read and prepared. Small questions which are integrated into the course material give the students the opportunity to test their understanding. Larger assignments are separately put into the systems at certain points in time. As these documents are sequentially handed out, they serve as a continuing impulse to access the system and to bring oneself up-to-date with the discussions going on.

The solutions to the larger assignments are looked over by a tutor so that an individual feedback is possible. In order to make this task easier for the tutors, only a certain answer period is allowed. Students who do not send in their solutions during this time will not get any feedback.

Another didactical aspect, next to self-study periods, small checkpoints, and feedback to solutions, is to give the students the opportunity to develop an own understanding of the topics. For this, we plan to integrate numerical simulations. With an access via the Internet, where all the students need is a simple browser, calculations of certain example problems can be carried out. Besides trying to work on the assignment, which gives the students the direction into which to look, they can also freely experiments with parameter combinations and explore the possibilities. With this, the students can make connections for themselves between the theoretical, mathematical knowledge and the 'physical' results.

And last but not least, at certain intervals again video conferences are planned. The didactical purpose is here on the one hand to further bind the students to the course, and on the other hand to give an opportunity to ask questions personally, clarify certain

terms and thus avoid misunderstandings of the matter. We also hope that with the help of virtual meetings a better team spirit can develop and the German and American students do not see themselves as separate groups.

3.3. Communication scheme

As the American students do not have the possibility to make personal contact with the lecturer and responsible persons, a well devised communication scheme is important. However, as we plan to encourage peer-to-peer communications, the tutors stay mainly in the background.

A basic communication tool will be e-mail. This tool is by now common practice and well known to all participants. Via e-mail, students can ask specific questions to tutors. This has the disadvantage that this communication is hidden from the other students, which may have the same questions. Our goal is to bring questions from the 'private' e-mail to a public forum. In order to do this, we plan to use an Internet-based groupware called BSCW ('Basic Support for Cooperative Work' [2]).

BSCW is a document-management groupware which has the advantage that only a browser is needed and documents of any format can be submitted. Figure 2 shows a snapshot of the interface. One can see that just like in a normal file-system, folders and documents can be created (small icons on the left). A short description of the items helps to keep the orientation inside the system. Next to documents and folders, also discussion forums can be integrated. They are indicated by a symbol showing a pinned note and can either be attached to a file or folder, or exist on their own in the system. The advantage is here that with the location of the discussion, also the topic is specified. This makes the maintenance of those discussions easier and additionally helps to find relevant entries.

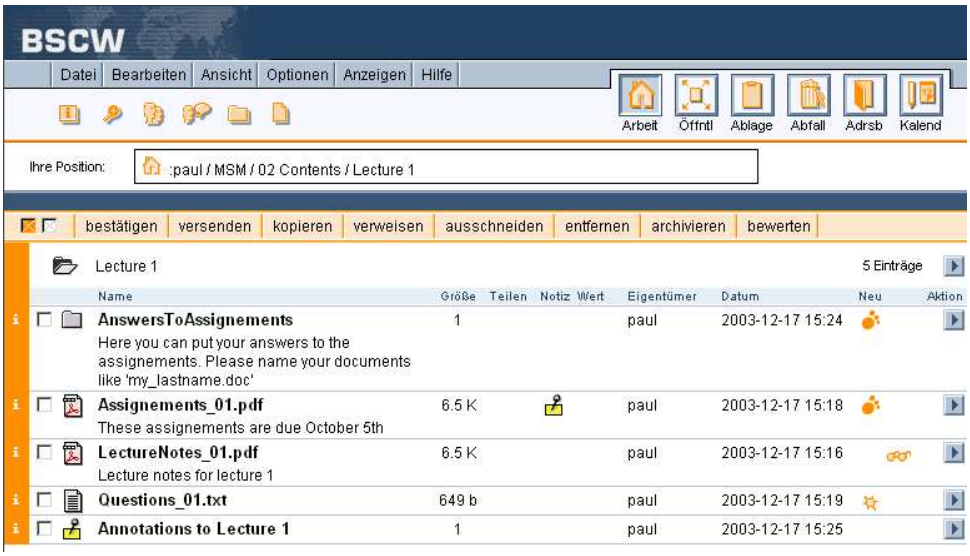

Figure 2. Snapshot of the BSCW interface

To help all users to keep an overview in the system, small icons indicate if certain actions have happened. For example one can see at one glance whether a new element has been put in (indicated by a star, see 'Questions_01.txt' in Fig. 2) or whether changes have taken place (indicated by a paw). An additional icon is a good help for the tutor: a small symbol of glasses indicates, who has read or accessed a certain element. With this it can be monitored whether all students have yet had a look at the material or not. For example it may be important to know whether all students noticed a new announcement concerning a changed date for submitting an exercise.

We plan to encourage the students to ask their questions in discussions inside the BSCW-system, so that also answers from other students are possible. Of course, e-mail questions are still answered, but we will try to put 'frequently asked questions' into the discussions, where we have the possibility to make them anonymous, if the student wishes.

As already mentioned above, also video conferences are envisaged as a communication tool. Here, we can reach back to a large experience with video conferences: we already conducted work-group meetings within a project, short talks (e.g. with Prof. Mary Wheeler, Director of the Center for Subsurface Modeling, Institute for Computational Engineering and Sciences, University of Texas at Austin), and even whole lectures were transmitted (e.g. by Prof. David Stephenson, University of the Witwatersrand, School of Civil and Environmental Engineering, Southafrika). We have the advantage, that a whole seminar room is supplied with a video conferencing system consisting of two room-cameras with automatic tracking of the speaking person, and a room-microphone [5]. This enables us to hold the video conference in our online seminar in a normal classroom-atmosphere, where the German students and the lecturer are present and the American students join in. This makes it easier for the lecturer to conduct the class, as real persons sit in front of him he can talk to. Our experiences have shown that it is very difficult for a lecturer to give a good presentation when all listeners are only virtually present.

4. NUMERICAL SIMULATION / INTERACTIVE ELEMENTS

As already explained, the planned online course deals with multiphase flow and transport processes. In the lecture notes those topics are treated theoretically. As experiences in teaching these subjects have shown that it is very helpful for students to have a practical application, we plan to use numerical simulations. For certain basic cases, problem files are set up, where the students can freely change parameters and thus develop a feeling for the behavior of the system and the interrelation between different variables.

For the German students, a computer exercise in the lab of the Department of Hydromechanics and Modeling of Hydrosystems is possible. For the American students, another possibility has to be found. Here, we plan to set up an interface in the Internet to use the numerical simulator MUFTE-UG. First steps were taken by bringing a small program online for the computation of steady-state groundwater flow. Figure 3 shows the input form for the program. It is HTML-based so that only a standard browser is needed. The simulation program runs on the web-server and the output is then given on another HTML-page (Fig. 4).

Opposed to the already implemented groundwater flow problem, MUFTE-UG is a very complex program for computation of multi-phase and multi-component flow and transport. Here, we are faced with the difficulty to install this on a web-server and enable a remote and multiple access. We plan to create new input forms for certain multiphase problems, as for example the Buckley-Leverett problem (Fig. 5). As shown in the figure, the students can try out different discretization lengths and investigate the influence on the solutions. Next to developing input forms and PERL-script to organize the actual computation, a major focus has to lie on intensive error-checking of the filled-in values in order to fulfill security standards.

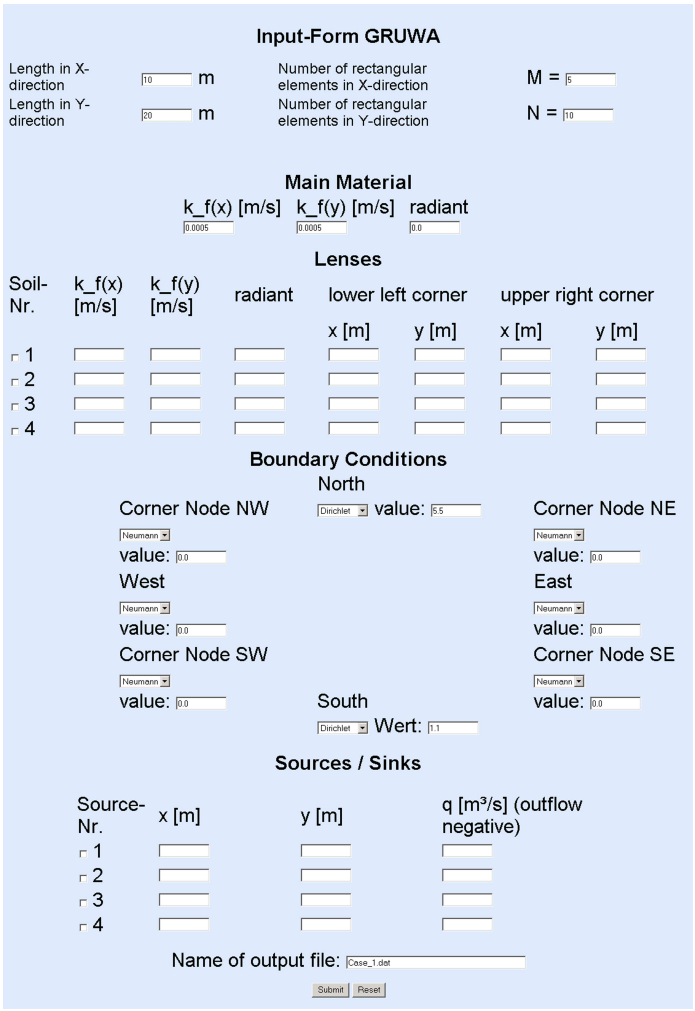

Figure 3. HTML input-form

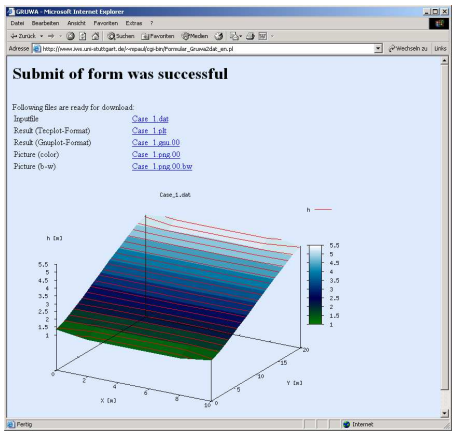

Figure 4. Result of simulation

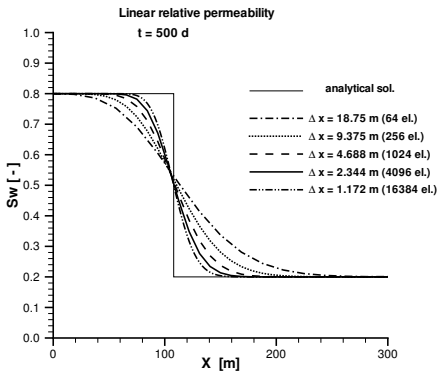

Figure 5. Influence of different discretization lengths on the Buckley-Leverett problem

So far, we are only able to present results of steady-state computations (one output file). A new challenge is to provide the students with results of transient computations, which produce a large number of resulting files. Often it is important to see the development of a process in the system, therefore we plan to find a possibility to bring movement into the results. As we cannot presume that the same software is installed on the computers of the students, we still have to find a way - either doing a server-based conversion, providing an open-source tool or to require a certain software - to enable a visualization of transient processes.

5. SUMMARY AND OUTLOOK

The Department of Hydromechanics and Modeling of Hydrosystems of the Institute of Hydraulic Engineering in Stuttgart, Germany, has developed a course on the topic of "Multiphase Flow and Transport", which is taught as a regular class for German students in Stuttgart in the study field of 'Modeling of Hydrosystems'. This course will be now offered as an online course to German and American students. The materials will be provided via the groupware BSCW in the Internet. Questions and assignments, which have to be sent in, are planned to keep the students in the course. Furthermore, video conferences are planned to strengthen the stronghold between German and American students, lecturers and tutors. Next to the mathematical and physical background of multiphase flow, also an understanding of the underlying processes should be developed by the students. For this, it is envisaged to use numerical simulations which can be accesses via the Internet. Based on our experience with a steady-state groundwater flow simulation, we hope to realize the web-based interactive simulation of multiphase flow until the start of the course in fall 2004.

REFERENCES

1. http://www.inra.com
2. http://www.bscw.de/index_en.html
3. http://www.iws.uni-stuttgart.de/weiterbildung/kurse/programm_09_2003.html
4. R. Helmig, Multiphase Flow and Transport Processes in the Subsurface, Springer, Heidelberg, 1997
5. http://www.iws.uni-stuttgart.de/Sonstiges/Teleraum/ (in German)