ISSMGE FOUNDATION
REPORT ON CONFERENCE ATTENDANCE

Your Name: Kamal Nanda	***Your Organization:*** Indian Institute of Technology Kanpur India	***Date of report:*** April 04, 2023
Conference Title: Coupled Subsurface Dynamics 2023 (Winter School)	***Location of Conference:*** Myrkdalen Hotel, Vossestrand (Norway)	***Dates of Conference:*** March 13-17, 2023

What you learned:

Coupled subsurface winter school 2023 (5-days), organized by the "Center for Modeling of Coupled Subsurface Dynamics", University of Bergen (UiB) and provided a perfect atmosphere for knowledge dissemination and interactions with the eminent and active researchers in the field of carbon capture and sequestration (CCS). Following are the few takeaways lessons from the workshop:

- The formulation and development of the large-scale simulator for CO2 storage, GEOSX: An Open-source Multiphysics, Multilevel Simulator for Simulating CO2 Storage on HPC developed in collaboration with Stanford University and Lawrence Livermore National Laboratory.
- Hands-on training on the Python Simulation Tool for fluid flow in fractured and deformable porous media (PorePy) developed at the Department of Mathematics, UiB.
- Issues and plausibility of implementation of machine learning in underground storage projects.
- Development of iterative solvers for solving coupled partial differential equations (Thermo-Hydro-Chemo-Mechanical) during the flow and transport of CO2 in aquifers.
- The impact of natural and induced seismicity on large underground storage projects.
- Quantification and address of risk associated with underground storage projects.

Interactions with other participants and experts from around the world during winter school were both academically and culturally enriching.

People you met:

1. Prof. Hamdi Tchelepi (Energy Science and Engineering, Stanford University)
2. Prof. Rainer Helmig (IWS, University of Stuttgart)
3. Prof. Maarten V. de Hoop (Rice University)
4. Prof. Kundan Kumar (Department of Mathematics, University of Bergen)
5. Prof. Jan Martin Nordbotten (Department of Mathematics, University of Bergen)
6. Dr. Volker Oye (Applied seismology, NORSAR)
7. Dr. Eirik Keilegavlen (Researcher, University of Bergen)
8. Dr. Jakub Both (Researcher, University of Bergen)

Main features of the conference:

- Lecture series on the multiphase thermo-hydro-mechanical simulator by Prof.

Hamdi.

- Lecture series on risk assessment in carbon capture and sequestration projects by Prof. Rainer.
- Machine learning in carbon sequestration project by Prof. Hoop
- "FluidFlower": an interesting validating and forecasting case study, using the results of a large experimental model of carbon sequestration involving international research groups (the model is stored now at the Museum of Natural Sciences UiB) by Prof. Nordbotten.
- Case study on the induced seismicity due to CO2 storage in project sites by Volker Oye.
- Case study on the numerical predictions of Northern Lights CO2 storage site by Francois Hamon (TotalEnergies)
- Group project (among the participants) for advocating the pros and cons of CO2 storage proposal to different stakeholders of society (general public, local businessman, politicians).

Your comments on the conference:

The winter school has been an invaluable chance for early-stage researchers and Ph.D. candidates to learn from experts, and discuss issues and problems with them. Experts from many disciplines (applied mathematics, geology, geophysics, hydrogeology, and engineering) shared the common goal of carbon neutrality and addressed the issue, and discussed contributions from different research fields. The advanced technical lectures on multiphase flow with phase transfer in porous aquifers and fast iterative solvers for coupled physical problems are useful for geoscientists in enhancing the design and comprehension of subsurface storage systems. Case studies on induced seismicity and carbon storage project have been instrumental in highlighting the interdisciplinary nature of the problem, in which geologists, geophysicists, reservoir modelers, and earth scientists collaborate to address the impending challenge of carbon neutrality and energy sustainability. The winter school provided an excellent academic and cultural platform for interaction and learning with other researchers from around the world. I would like to express my gratitude to the winter school organizing committee for all of the logistics and an excellent setting for lectures and accommodations. In addition, I am grateful to the ISSMGE foundation for providing financial support for my attendance at this enriching event.

Please attach a short report (maximum 400 words) suitable for publication in the ISSMGE Bulletin:

Coupled subsurface winter school 2023, organized by the "Center for Modeling of Coupled Subsurface Dynamics", University of Bergen (UiB), from March 13–17, 2023, at Vossestrand (Norway). The prime objectives of this workshop were to disseminate computational and experimental techniques and address challenges in the storage of CO2 in the subsurface.

The instructors include Prof. Hamdi Tchelepi (Stanford University), Prof. Rainer Helmig (University of Stuttgart), Prof. Maarten V. de Hoop (Rice University), Prof. Jan Martin Nordbotten (University of Bergen), and Dr. Jakub (University of Bergen). The 5-day program covered a wide range of topics, from the social and economic effects to the use of high-performance computer simulations and machine learning in CO2 storage projects. Deliberations from the field and industry experts include Dr. Volker Oye (Applied Seismology, NORSAR), Dr. Sarah Gasda (Research Director, NORCE), and Dr. Francois Hamon (Senior Research Scientist, TotalEnergies) on the topics of induced seismicity, offshore CO2 storage, and a case study on the Northern Lights project. The participants include early-stage researchers and doctorate candidates from Imperial College London, the University of Stuttgart, the University of Bergen, Herriot Watt University, TU Delf, and Indian Institute of Technology Kanpur.

The fundamental goal of the winter school is to address the imminent and massive task of CO2 storage from geomechanics standpoint by employing multiphase and multiscale inclusive simulation techniques that account for gas flow hydrodynamics, subsurface mechanical deformation, and phase changes due to thermal gradients and chemical reactions as well. The focus is also on developing faster solvers to handle large-scale coupled boundary value problems while keeping computation time and resources under control. Sessions on scientific writing and policy-making group tasks on the CO2 storage project have given insights into the nuances anticipated for the project's acceptance and success in public and academic discourse.

The workshop provided a fertile environment for the exchange of ideas with academic and industry experts in both formal and informal discussions. Interactions among participants with diverse academic backgrounds (applied mathematics, reservoir engineering, earth sciences, and geotechnical engineering) aided in gaining a broader view of the multi-faceted nature of underground storage. The coupled subsurface winter school-2023 has succeeded in its vision of enriching young minds with technical knowledge while also sowing the seeds for future geoscience research toward the global goal of carbon neutrality. Winter school has also been an outstanding opportunity to learn about the cultural backgrounds of participants from all over the world.

Photographs from the Conference:

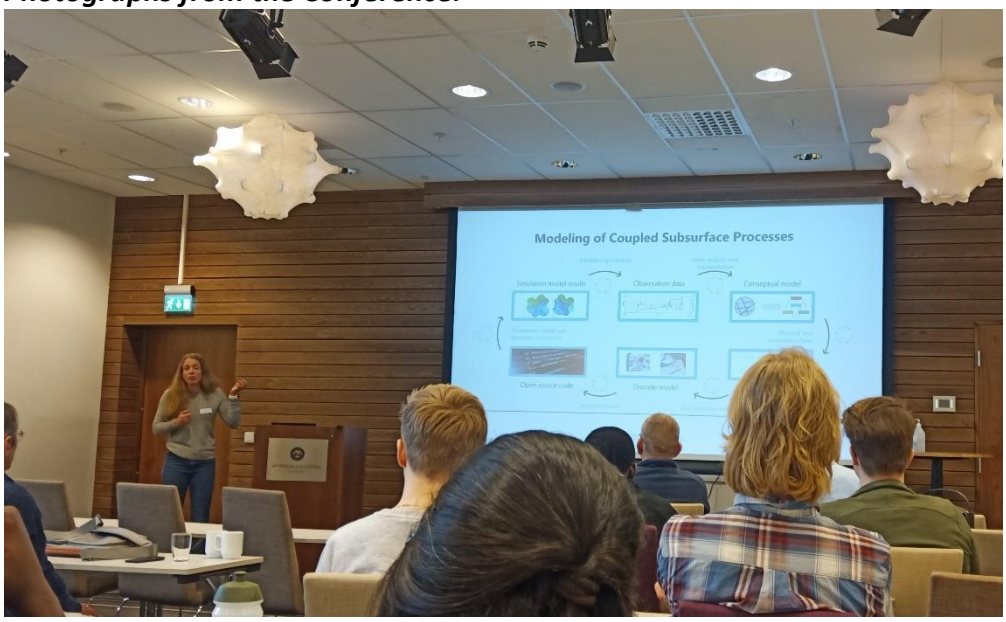

Figure 1 Welcome address by Professor Inga Berre Director of VISTA Center for Modeling of Coupled Subsurface Dynamics (UiB Norway)

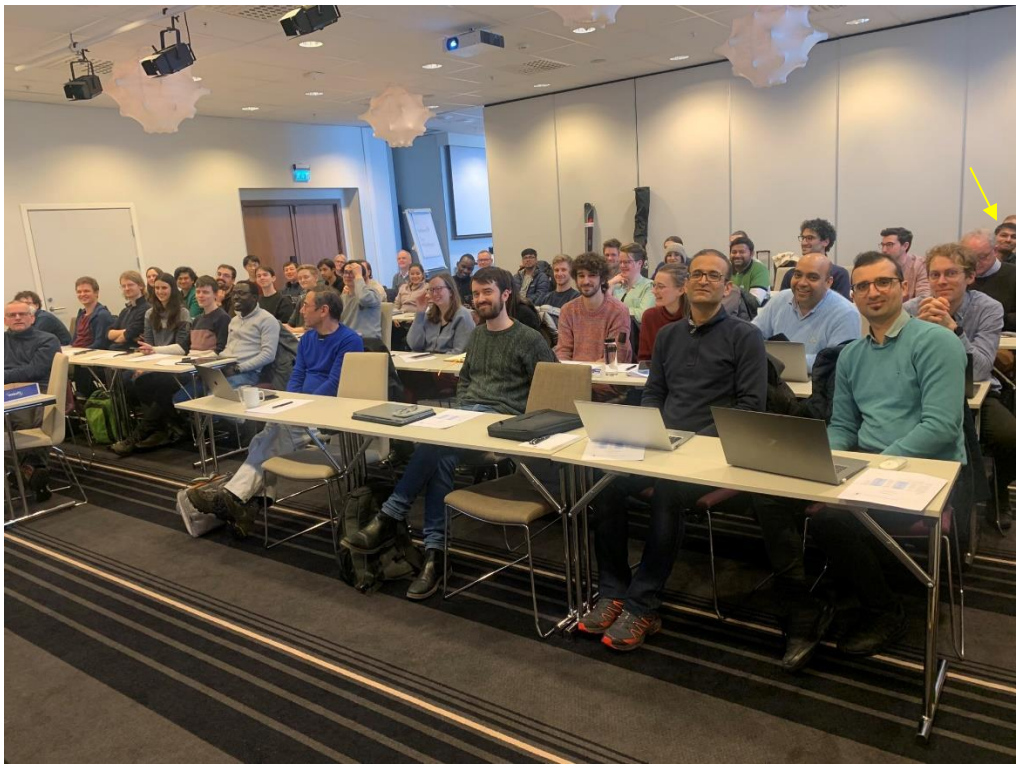

Figure 2 Attendees at coupled subsurface winter school 2023 at Norway (Kamal Nanda at the arrow)

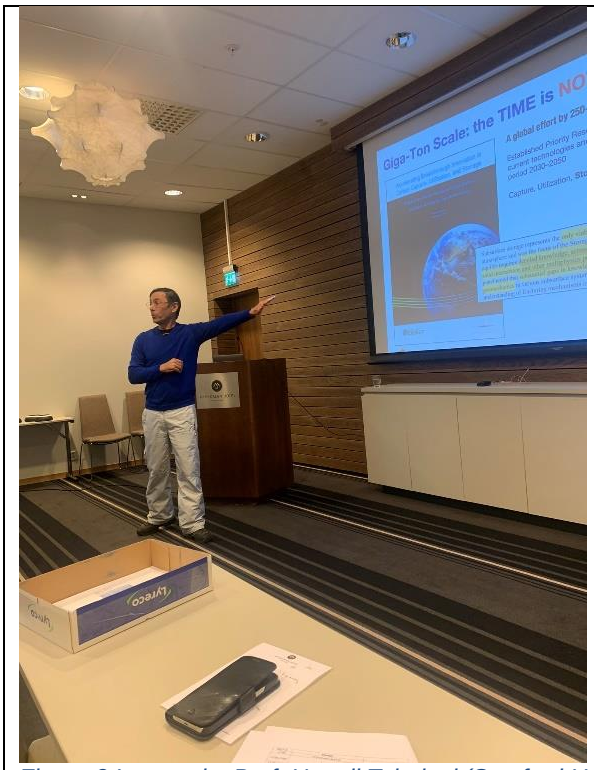

Figure 3 Lecture by Prof. Hamdi Tchelepi (Stanford University)

Figure 4 Meeting Prof. Rainer Helmig (IWS, University of Stuttgart)