Judge's Commentary: The Polar Melt Problem Papers

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Introduction

The 2008 Polar Melt Problem presented teams with the challenge to model the effects over the next 50 years on the coast of Florida from melting of the North Polar ice cap due to the predicted increases in global temperatures. Teams were to pay particular attention to large metropolitan areas and propose appropriate responses to the effects predicted by their models. Teams were also encouraged to present a careful discussion of the data used.

From the judges' perspectives, this problem was especially interesting but at the same time somewhat challenging to judge, because of the wide variety in points of focus that the teams could choose to take: the physics of the model and the physical impacts of rising sea levels on coastal areas; indirect effects such as increases in the frequency and severity of hurricanes; and environmental, societal, and/or economic impacts. Regardless of the choice of focus selected by a team, in the final analysis it was good modeling that allowed the judges to discern the outstanding papers.

Judging

Judging of the entries occurs in three stages. The first stage is Triage, where a judge spends approximately 10 min on each paper. In Triage, a complete and concise Executive Summary is critically important because this is what the triage judges primarily use to pass first judgment on an entry. In reviewing the Executive Summary, judges look to see indications that the paper directly responds to the problem statement, that it uses good modeling practice, and

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that the mathematics is sound. Because of the limited time that the triage judges spend on each paper, it is very likely that some potentially good papers get cut from advancing in the competition because of poor Executive Summaries. The importance of a good Executive Summary cannot be overstated.

For those papers that make it past triage, the remaining two stages of judging are the Preliminary Rounds and the Final Judging. In the Preliminary Rounds, the judges read the body of the paper more carefully. The overriding question on the mind of most judges is whether or not the paper addresses the problem and whether it answers all of the specific questions. Papers that rate highly are those that directly respond to the problem statement and specific questions, clearly and concisely show the modeling process, and give concrete results with some analysis of their validity and reliability.

In the Final Judging, the judges give very careful consideration of the methods and results presented. The features that judges look for in an Outstanding Paper are:

- a summary of results and their ramifications;
- a complete and comprehensive description of the model, including assumptions and the refinements that were made during development;
- a mathematical critique of the model, including sensitivity analysis and a description of its strengths and weaknesses; and
- recommendations for possible further work to improve the model.

The judges select as Outstanding the papers best in including and presenting each of these features.

The Papers: The Good

Specifically for the "Take a Bath" problem, the judges identified a number of positive characteristics in the submitted papers. While many teams used regressions on historical sea-level data to predict future sea levels, the papers that were viewed more favorably were those that modeled the melting of the ice and its effects. Some even included thermal expansion of the water due to rising temperatures, and many recognized that melting of the floating portions of the North Polar ice cap would have much less impact than the melting of the ice supported by land in Greenland. While there was a wide range in the sea-level increases predicted by the models, many teams bounded their results using estimates of the total rise in sea levels worldwide if all the ice on Greenland were to melt. This estimate is widely available in the literature, and it enabled many of the teams to make judgments about what increases in sea levels might be reasonable (or unreasonable) to expect over the next 50 years.

The judges also favored papers that adequately addressed the impacts on Florida, especially in the metropolitan areas. Some of these papers predicted

large increases in sea levels and showed how the major cities would be impacted, whether it was only on structures near the coasts or in widespread flooding of the urban area. Others predicted small increases in sea levels, in which case the impacts were often limited to increased beach erosion and/or salt water intrusion into fresh water in the ground and on the surface. Good papers also proposed appropriate responses to the effects, whether they were great or small. Other important considerations that some teams investigated were the potential impact of larger and more frequent hurricanes and the impact of rising sea levels on the natural environment in Florida, particularly on the Everglades.

The Papers: The Bad

In some of the submitted papers, the judges also identified negative characteristics that should generally be avoided in good mathematical modeling and reporting. These items can detract from a paper that might otherwise be a good paper, and they may even result in removal of a potentially good paper from further contention:

- Some teams used regression and curve-fitting to develop a model from existing data, and then used the model to extrapolate over the next 50 years. The functions chosen for regression often had no rational basis for fitting the data. As one judge pointed out, "sixth degree polynomials rarely occur in nature." Extrapolation beyond the domain of the regression data must always be used with extreme caution, especially when there is no physical or other rational justification for the regression function in the context of the problem.
- While many of the teams did a good literature search to support their work, others used sources that were questionable. Before they are considered for use in a project, sources of information and data should always be critically judged as to their veracity, validity, and reliability.
- Some teams presented results to a degree of precision that is not appropriate. For example, one paper reported the predicted rise in sea level to a precision of eight significant digits. Modelers must always be cognizant of what degree of precision is appropriate for a given situation.
- Finally, some teams were not careful with units. Units should always be included and should be checked for correctness.

How a team addresses details like those listed here can make a big difference in how a judge rates a paper. Paying proper attention to such details in a team's report can help ensure that an otherwise worthy paper advances in the competition.

Conclusion

By and large, the judges were pleased with the overall quality of the papers submitted for the Polar Melt Problem in the 2008 MCM. Selecting the final Outstanding papers was especially difficult this year because so many of the papers were of high quality and they were competitive. As always, the judges are excited when they see papers that bring new ideas to a problem and go beyond looking up and applying models that are available in the literature. This year the judges had much to be excited about.

About the Author

John L. Scharf is the Robert-Nix Professor of Engineering and Mathematics at Carroll College in Helena, MT. He earned a Ph.D. in structural engineering from the University of Notre Dame, an M.S. degree in structural engineering from Columbia University, and a B.A. in mathematics from Carroll College. He has been on the Carroll College faculty since 1976 and served as Chair of the Department of Mathematics, Engineering, and Computer Science from 1999 to 2005. He also served as Interim Vice President for Academic Affairs during the 2005–06 academic year. He has served as an MCM judge in every year but one since 1996.