2024 ICM
Problem D: Great Lakes Water Problem

Background

The Great Lakes of the United States and Canada are the largest group of freshwater lakes in the world. The five lakes and connecting waterways constitute a massive drainage basin that contains many large urban areas in these two countries, with varied climate and localized weather conditions.

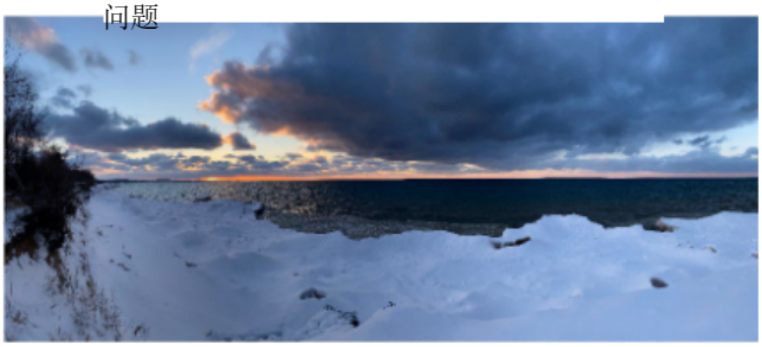
The lakes' water is used for many purposes (fishing, recreation, power generation, drinking, shipping, animal and fish habitat, construction, irrigation, etc.). Consequently, a vast variety of stakeholders have an interest in the management of the water that flows into and out of the lakes. In particular, if too little water is drained or evaporates from the lakes, then flooding may occur and homes and businesses along the shore suffer; if too much water is drained, then large ships cannot travel through the waterways to bring supplies and support the local economy. The main problem is regulating the water levels such that all stakeholders can benefit.

The water level in each lake is determined by how much water enters and leaves the lake. These levels are the result of complex interactions among temperature, wind, tides, precipitation, evaporation, bathymetry (the shape of the lake bottom), river flows and runoff, reservoir policies, seasonal cycles, and long-term climate changes. There are two primary control mechanisms within the flow of water in the Great Lakes system – Compensating Works of the Soo Locks at Sault Ste. Marie (three hydropower plants, five navigation locks, and a gated dam at the head of the rapids) and the Moses-Saunders Dam at Cornwall as indicated in the Addendum.

While the two control dams, many channels and canals, and the drainage basin reservoirs may be controlled by humans, the rates of rain, evaporation, erosion, ice jams, and other water-flow phenomena are beyond human manipulation. The policies of local jurisdictions may have different effects than expected, as can seasonal and environmental changes in the water basin. These changes in turn affect the ecosystem of the area, which impacts the health of the flora and fauna found in and around the lakes and the residents that live in the water basin. Even though the Great Lakes seem to have a regular annual pattern, a variance from normal of two to three feet of water level can dramatically affect some of the stakeholders.

This dynamic network flow problem is "wicked" – exceptionally challenging to solve because of interdependencies, complicated requirements, and inherent uncertainties. For the lake's problems, we have ever-changing dynamics and the conflicting interests of stakeholders.
See Problem D Addendum for Additional Information.

2024 ICM 问题 D：五大湖水问题



背景

美国和加拿大的五大湖是世界上最大的淡水湖群。五个湖泊和相连的水道构成了一个巨大的流域，其中包含这两个国家的许多大城市地区，气候和局部天气条件各不相同。

湖泊的水有多种用途（捕鱼、娱乐、发电、饮用、航运、动物和鱼类栖息地、建筑、灌溉等）。因此，各种各样的利益相关者都对流入和流出湖泊的水的管理感兴趣。特别是，如果从湖泊中排出的水太少或蒸发，则可能会发生洪水，沿岸的家庭和企业会受到影响;如果排干了太多的水，那么大型船只就无法通过水道运送物资并支持当地经济。主要问题是调节水位，使所有利益相关者都能受益。

每个湖泊的水位取决于进出湖泊的水量。这些水位是温度、风、潮汐、降水、蒸发、测深（湖底形状）、河流流量和径流、水库政策、季节性周期和长期气候变化之间复杂相互作用的结果。五大湖系统的水流有两种主要的控制机制——苏圣玛丽水闸的补偿工程（三座水电站、五座通航闸和急流源头的一座门控水坝）和康沃尔郡的摩西-桑德斯大坝，如附录所示。

虽然这两个控制大坝、许多渠道和运河以及流域水库可能由人类控制，但降雨、蒸发、侵蚀、冰塞和其他水流现象的速度超出了人类的控制范围。地方管辖区的政策可能产生与预期不同的影响，流域的季节性和环境变化也是如此。这些变化反过来又影响了该地区的生态系统，从而影响了湖泊及其周围动植物以及生活在流域中的居民的健康。尽管五大湖似乎有规律的年度模式，但与正常水位两到三英尺的差异可能会极大地影响一些利益相关者。

这种动态网络流问题是“邪恶的”——由于相互依赖性、复杂的需求和固有的不确定性，解决起来非常具有挑战性。对于湖泊的问题，我们有不断变化的动态和利益相关者的利益冲突。

有关其他信息，请参阅问题 D 附录。

Requirement

The International Joint Commission (IJC) requests support from your company, **I**nternational network **C**ontrol **M**odelers – **ICM**, to assist with management and models for the control mechanisms (the two dams – Compensating Works and Moses-Saunders Dam as indicated in the Addendum) that directly influence water levels in the Great Lakes flow network. Your ICM supervisor has given your team the lead in developing the model and a management plan to implement the model. Your supervisor indicates there are several considerations that may help to achieve this goal starting with the building of a network model for the Great Lakes and connecting river flows from Lake Superior to the Atlantic Ocean. Some other optional considerations or issues your supervisor mentioned were:

- Determination of the optimal water levels of the five Great Lakes at any time of the year, taking into account the various stakeholders' desires (the costs and benefits could be different for each stakeholder).
- Establishment of algorithms to maintain optimal water levels in the five lakes from inflow and outflow data for the lakes.
- Understanding of the sensitivity of your control algorithms for the outflow of the two control dams. Given the data for 2017, would your new controls result in satisfactory or better than the actual recorded water levels for the various stakeholders for that year?
- How sensitive is your algorithm to changes in environmental conditions (e.g., precipitation, winter snowpack, ice jams)?
- Focus your extensive analysis of ONLY the stakeholders and factors influencing Lake Ontario as there is more recent concern for the management of the water level for this lake.

The IJC is also interested in what historical data you use to inform your models and establish parameters, as they are curious to compare how your management and control strategies compare to previous models. Provide a one-page memo to IJC leadership communicating the key features of your model to convince them to select your model.

Your PDF solution of no more than 25 pages total should include:

- One-page summary sheet that clearly describes your approach to the problem and your most important conclusions from your analysis in the context of the problem.
- Table of Contents.
- Your complete solution.
- One-page memo.
- Reference List.
- AI Use Report (if used).

Note: There is no specific required minimum page length for a complete ICM submission. You may use up to 25 total pages for all your solution work and any additional information you want to include (for example: drawings, diagrams, calculations, tables). Partial solutions are accepted. We permit the careful use of AI such as ChatGPT, although it is not necessary to create a solution to this problem. If you choose to utilize a generative AI, you must follow the COMAP AI use policy. This will result in an additional AI use report that you must add to the end of your PDF solution file and does not count toward the 25 total page limit for your solution.

要求

国际联合委员会 （IJC） 请求贵公司 International network Control Modelers - ICM 提供支持，以协助对直接影响五大湖水网水位的控制机制（附录中指出的两座大坝 - 补偿工程和摩西-桑德斯大坝）进行管理和建模。您的ICM主管已让您的团队领导开发模型和实施该模型的管理计划。您的主管表示，有几个考虑因素可能有助于实现这一目标，首先是建立五大湖网络模型，并将从苏必利尔湖到大西洋的河流连接起来。您的主管提到的其他一些可选考虑因素或问题是：

- 确定五大湖在一年中任何时候的最佳水位，同时考虑到不同利益攸关方的愿望（每个利益攸关方的成本和收益可能不同）。
- 根据湖泊的流入和流出数据建立算法，以保持五个湖泊的最佳水位。
- 了解控制算法对两个控制大坝流出的敏感性。鉴于 2017 年的数据，您的新控制措施是否会使各利益相关者满意或优于当年实际记录的水位？
- 您的算法对环境条件变化（例如降水、冬季积雪、冰塞）的敏感度如何？
- 仅将您的广泛分析重点放在影响安大略湖的利益相关者和因素上，因为最近人们越来越关注该湖的水位管理。

IJC 还对您使用哪些历史数据来告知模型和建立参数感兴趣，因为他们很想知道您的管理和控制策略与以前的模型相比如何。向 IJC 领导层提供一页纸的备忘录，传达您的模型的关键特征，以说服他们选择您的模型。

总页数不超过 25 页的 PDF 解决方案应包括：

- 一页摘要表，清楚地描述了您解决问题的方法以及您在问题上下文中分析得出的最重要结论。
- 目录。
- 您的完整解决方案。
- 一页备忘录。
- 参考列表。
- AI 使用报告（如果使用）。

注意：完整的ICM提交没有具体的最小页面长度要求。您最多可以使用 25 页来完成所有解决方案工作以及要包含的任何其他信息（例如：图纸、图表、计算、表格）。接受部分解决方案。我们允许谨慎使用 ChatGPT 等 AI，尽管没有必要为此问题创建解决方案。如果您选择使用生成式 AI，则必须遵循 COMAP AI 使用策略。这将导致一个额外的 AI 使用报告，您必须将其添加到 PDF 解决方案文件的末尾，并且不计入解决方案的 25 页总页数限制。

Files provided:

- ***Problem D Addendum*** – Additional background information.
- ***Data Examples*** – These are possible sources for data. Some of which were used to populate the *Problem_D_Great_Lakes.xlsx* data set. These examples can be found on page 4 of the *Problem D Addendum*. Note: These examples are not required to successfully formulate a solution.
- ***Problem_D_Great_Lakes.xlsx*** – Data for the inflows, outflows, and water levels for the lakes.

References (in addition to the included background data file):

1. **Explanation of the IJC's Efforts to Manage the Great Lakes Basin:** National Research Council; The Royal Society of Canada. (2006). *Review of Lake Ontario-St. Lawrence River Studies.* Washington D.C.: National Research Council of the National Academies. Retrieved from https://nap.nationalacademies.org/catalog/11481/review-of-the-lake-ontario-st-lawrence-river-studies
2. **Description of the Great Lakes Navigation Systems:** *Great Lakes Seaway Navigation System*. (2023). Retrieved from American Great Lakes Ports Association: https://www.greatlakesports.org/industry-overview/the-great-lakes-seaway-navigation-system/#:~:text=Lake%20Erie%20drains%20into%20Lake,in%20elevation%20approximately%20600%20feet

提供的文件：

- 问题 D 附录 – 其他背景信息。
- 数据示例 – 这些是可能的数据源。其中一些用于填充Problem_D_Great_Lakes.xlsx数据集。这些示例可以在问题 D 附录的第 4 页找到。注意：这些示例不是成功制定解决方案所必需的。

- Problem_D_Great_Lakes.xlsx – 湖泊的流入、流出和水位数据。

参考资料（除随附的背景数据文件外）：

1. IJC管理大湖流域的努力说明：国家研究委员会;加拿大皇家学会。（2006）. 安大略湖-圣湖回顾劳伦斯河研究。华盛顿特区：美国国家科学院国家研究委员会。取自 https://nap.nationalacademies.org/catalog/11481/review-of the-lake-ontario-st-lawrence-river-studies
2. 五大湖导航系统的描述：五大湖航道导航系统。（2023）. 检索自美国五大湖港口协会：https://www.greatlakesports.org/industry-overview/the-great-lakes-seaway-navigationsystem/#:~:text=Lake%20Erie%20drains%20into%20Lake,in%20elevation%20approxim ately%20600%20feet

Use of Large Language Models and Generative AI Tools in COMAP Contests

This policy is motivated by the rise of large language models (LLMs) and generative AI assisted technologies. The policy aims to provide greater transparency and guidance to teams, advisors, and judges. This policy applies to all aspects of student work, from research and development of models (including code creation) to the written report. Since these emerging technologies are quickly evolving, COMAP will refine this policy as appropriate.

Teams must be open and honest about all their uses of AI tools. The more transparent a team and its submission are, the more likely it is that their work can be fully trusted, appreciated, and correctly used by others. These disclosures aid in understanding the development of intellectual work and in the proper acknowledgement of contributions. Without open and clear citations and references of the role of AI tools, it is more likely that questionable passages and work could be identified as plagiarism and disqualified.

Solving the problems does not require the use of AI tools, although their responsible use is permitted. COMAP recognizes the value of LLMs and generative AI as productivity tools that can help teams in preparing their submission; to generate initial ideas for a structure, for example, or when summarizing, paraphrasing, language polishing etc. There are many tasks in model development where human creativity and teamwork is essential, and where a reliance on AI tools introduces risks. Therefore, we advise caution when using these technologies for tasks such as model selection and building, assisting in the creation of code, interpreting data and results of models, and drawing scientific conclusions.

It is important to note that LLMs and generative AI have limitations and are unable to replace human creativity and critical thinking. COMAP advises teams to be aware of these risks if they choose to use LLMs:

- Objectivity: Previously published content containing racist, sexist, or other biases can arise in LLM-generated text, and some important viewpoints may not be represented.
- Accuracy: LLMs can ‘hallucinate’ i.e. generate false content, especially when used outside of their domain or when dealing with complex or ambiguous topics. They can generate content that is linguistically but not scientifically plausible, they can get facts wrong, and they have been shown to generate citations that don’t exist. Some LLMs are only trained on content published before a particular date and therefore present an incomplete picture.
- Contextual understanding: LLMs cannot apply human understanding to the context of a piece of text, especially when dealing with idiomatic expressions, sarcasm, humor, or metaphorical language. This can lead to errors or misinterpretations in the generated content.
- Training data: LLMs require a large amount of high-quality training data to achieve optimal performance. In some domains or languages, however, such data may not be readily available, thus limiting the usefulness of any output.

在COMAP竞赛中使用大型语言模型和生成式AI工具

这项政策的动机是大型语言模型（LLMs）和生成式人工智能辅助技术的兴起。该政策旨在为团队、顾问和评委提供更大的透明度和指导。本政策适用于学生工作的各个方面，从模型的研究和开发（包括代码创建）到书面报告。由于这些新兴技术正在迅速发展，COMAP将酌情完善这一政策。

团队必须对他们使用 AI 工具的所有情况开诚布公。一个团队及其提交越透明，他们的工作就越有可能被其他人完全信任、欣赏和正确使用。这些披露有助于理解智力工作的发展和对贡献的正确承认。如果没有对人工智能工具的作用进行公开和明确的引用和参考，有问题的段落和作品更有可能被认定为抄袭并被取消资格。

解决问题不需要使用人工智能工具，尽管允许负责任地使用它们。COMAP认识到生成式人工智能作为生产力工具的价值LLMs，可以帮助团队准备提交;例如，在总结、释义、语言润色等时，为结构产生初步想法。在模型开发中，有许多任务需要人类的创造力和团队合作，而依赖人工智能工具会带来风险。因此，我们建议在将这些技术用于模型选择和构建、协助创建代码、解释模型的数据和结果以及得出科学结论等任务时要谨慎。

需要注意的是，LLMs生成式人工智能有局限性，无法取代人类的创造力和批判性思维。COMAP建议团队在选择使用LLMs以下方法时注意这些风险：

- 客观性：以前发布的内容包含种族主义、性别歧视或其他偏见可能会出现在生成的文本中LLM，并且可能无法代表一些重要的观点。
- 准确性：LLMs可以“产生幻觉”，即产生虚假内容，尤其是在其领域之外使用或处理复杂或模棱两可的主题时。他们可以生成在语言上但在科学上不合理的内容，他们可能会弄错事实，并且它们已被证明可以生成不存在的引文。有些人LLMs只接受过特定日期之前发布的内容的培训，因此呈现出不完整的画面。

- 语境理解：LLMs不能将人类的理解应用于一段文本的上下文，尤其是在处理惯用语、讽刺、幽默或隐喻语言时。这可能会导致生成的内容出现错误或误解。

- 训练数据：LLMs需要大量高质量的训练数据才能达到最佳性能。然而，在某些领域或语言中，这些数据可能不容易获得，从而限制了任何输出的有用性。

Guidance for teams

Teams are required to:

1. **Clearly indicate the use of LLMs or other AI tools in their report,** including which model was used and for what purpose. Please use inline citations and the reference section. Also append the Report on Use of AI (described below) after your 25-page solution.
2. **Verify the accuracy, validity, and appropriateness** of the content and any citations generated by language models and correct any errors or inconsistencies.
3. **Provide citation and references, following guidance provided here.** Double-check citations to ensure they are accurate and are properly referenced.
4. **Be conscious of the potential for plagiarism** since LLMs may reproduce substantial text from other sources. Check the original sources to be sure you are not plagiarizing someone else's work.

COMAP will take appropriate action when we identify submissions likely prepared with undisclosed use of such tools.

Citation and Referencing Directions

Think carefully about how to document and reference whatever tools the team may choose to use. A variety of style guides are beginning to incorporate policies for the citation and referencing of AI tools. Use inline citations and list all AI tools used in the reference section of your 25-page solution.

Whether or not a team chooses to use AI tools, the main solution report is still limited to 25 pages. If a team chooses to utilize AI, following the end of your report, add a new section titled Report on Use of AI. This new section has no page limit and will not be counted as part of the 25-page solution.

Examples (this is *not* exhaustive – adapt these examples to your situation):

Report on Use of AI

1. OpenAI *ChatGPT* (Nov 5, 2023 version, ChatGPT-4)
   Query1: *<insert the exact wording you input into the AI tool>*
   Output: *<insert the complete output from the AI tool>*

2. OpenAI *Ernie* (Nov 5, 2023 version, Ernie 4.0)
   Query1: *<insert the exact wording of any subsequent input into the AI tool>*
   Output: *<insert the complete output from the second query>*

3. Github *CoPilot* (Feb 3, 2024 version)
   Query1: *<insert the exact wording you input into the AI tool>*
   Output: *<insert the complete output from the AI tool>*

4. Google *Bard* (Feb 2, 2024 version)
   Query: *<insert the exact wording of your query>*
   Output: *<insert the complete output from the AI tool>*

团队指南

团队必须：

1. 在报告中明确指出人工智能工具的使用LLMs或其他工具，包括：
   使用了模型以及用于什么目的。请使用内联引文和参考文献部分。此外，在 25 页的解决方案后附加 AI 使用报告（如下所述）。

2. 验证内容的准确性、有效性和适当性以及语言模型生成的任何引用，并纠正任何错误或不一致之处。
3. 按照此处提供的指导提供引文和参考文献。仔细检查引文，确保它们准确无误并被正确引用。
4. 请注意抄袭的可能性，因为LLMs可能会复制大量文本
   来自其他来源。检查原始来源以确保您没有剽窃他人的作品。

> 当我们发现可能使用此类工具未公开使用此类工具准备的提交内容时，COMAP将采取适当的行动。

引文和参考文献说明

仔细考虑如何记录和引用团队可能选择使用的任何工具。各种风格指南开始纳入引用和引用人工智能工具的政策。使用内联引文，并列出 25 页解决方案的参考部分中使用的所有 AI 工具。

无论团队是否选择使用 AI 工具，主要解决方案报告仍限制在 25 页以内。如果团队选择使用 AI，请在报告末尾添加标题为“AI 使用报告”的新部分。此新部分没有页数限制，不会计为 25 页解决方案的一部分。

示例（这并非详尽无遗 - 请根据您的情况调整这些示例）：

人工智能使用报告

1. OpenAI ChatGPT（2023年11月5日版，ChatGPT-4）
   Query1：<插入您在 AI 工具中输入的确切措辞>输出：<插入 AI 工具的完整输出>

2. OpenAI Ernie（2023 年 11 月 5 日版，Ernie 4.0）
   Query1：<将任何后续输入的确切措辞插入 AI 工具>输出：<插入第二个查询的完整输出>

3. Github CoPilot（2024 年 2 月 3 日版）
   Query1：<插入您在 AI 工具中输入的确切措辞>输出：<插入 AI 工具的完整输出>

4. Google Bard（2024年2月2日版）
   查询：<插入查询的确切措辞>输出：<插入 AI 工具的完整输出>