GlobalReservoirModel V1.0 A new global reservoir modeling database

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Introduction

Population growth and increasing demand for energy are driving the recent surge in global dam construction. Research on dams and reservoirs, including water quality, biogeochemical cycling, sediment trapping, greenhouse gas emissions, and implications for dam operation and maintenance, have therefore become interdisciplinary scientific hotspots[4,7]. While existing global databases provide information on dam and reservoir attributes, there is a lack of user-friendly databases that can generate input files for reservoir water quality models. Here, we introduce a new 2D global reservoir model-usable database called GRM V1.0, which integrates data from the following existing global databases: Global Reservoir and Dam database (GRanD)[3], Reservoir Storage-Area-Depth dataset (ReGeom)[6], WaterGAP V2.2D[5], FutureStreams[1], and ERA5 reanalysis databases[2].

Objectives

- Integrate existing datasets and develop the software to extract model usable time series data files for hydrological and meteorological variables;
- Build a 2-D reservoir typology database equipped with intelligent multithreading tools to accelerate comparative studies of reservoir biogeochemistry.

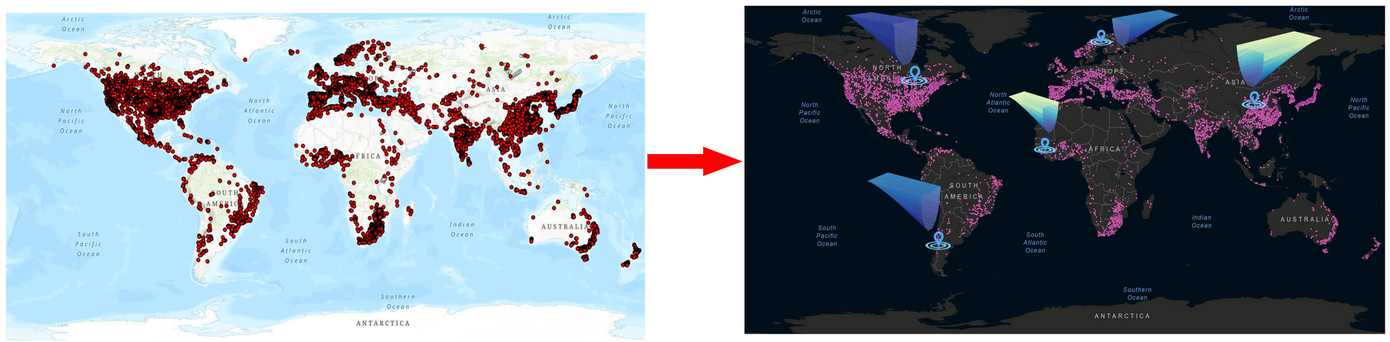

Figure 1. Global major reservoirs [3] with GRM reservoir typology.

Methods

GRM V1.0 Flow Chart and algorithms

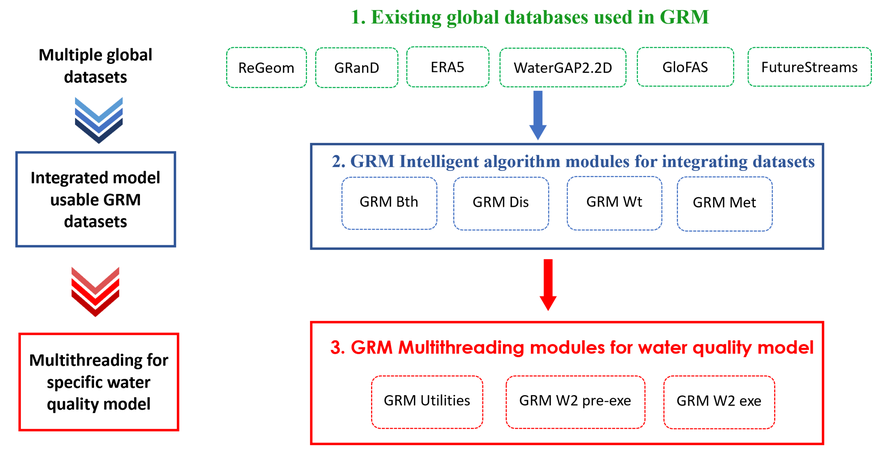

Figure 2. GRM V1.0 Flow chart

- $\textbf{\textit{Layer height}}\ (LH) = \frac{MD}{N}$
- $\textbf{\textit{Segment Lengh}}\ (SL) = \frac{TL}{N}$
- $\textbf{\textit{Width of each segment}}\ (WS) = \frac{V_{n+1} - V_n}{LH \times (n+1)SL}$
- $\textbf{\textit{Wind speed}} = \sqrt{u^2 + v^2}$
- $\textbf{\textit{Angle between vectors}} = arctan\frac{u}{v}$

Data Records & Interpretation

Example of GRM model domain discretization

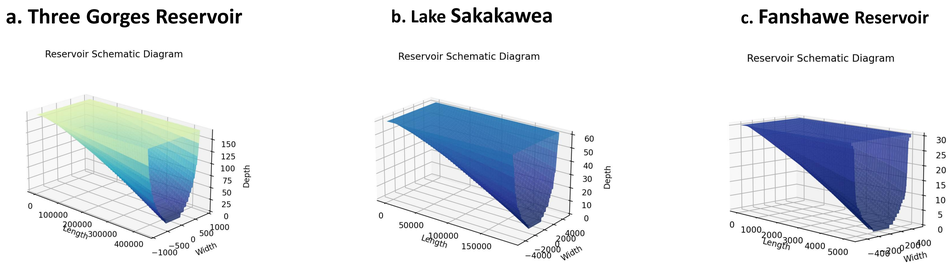

Figure 3. Conceptual reservoir model for 30 layers: (a) Three Gorge Reservoir; (b) Lake Sakakawea; (c) Fanshawe Reservoir.

GRM V1.0 Outputs applications- CE-QUAL-W2 surface water quality model

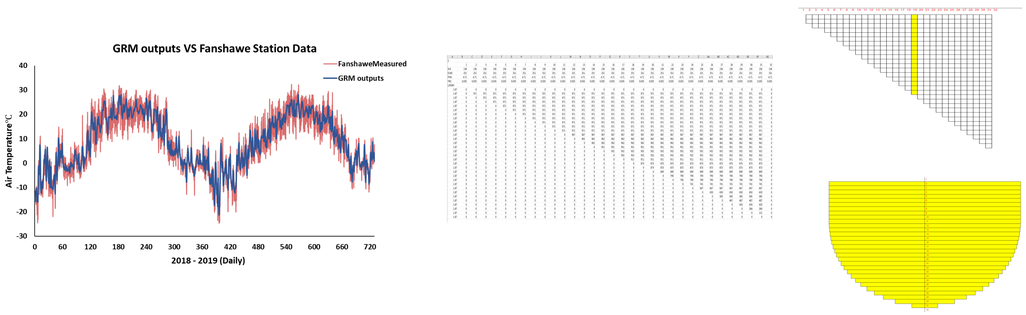

Figure 4. GRM V1.0 Output: Meteorological data and reservoir shape typology conceptual diagrams.

GRM v1.0 Multithreading examples – CE-QUAL-W2

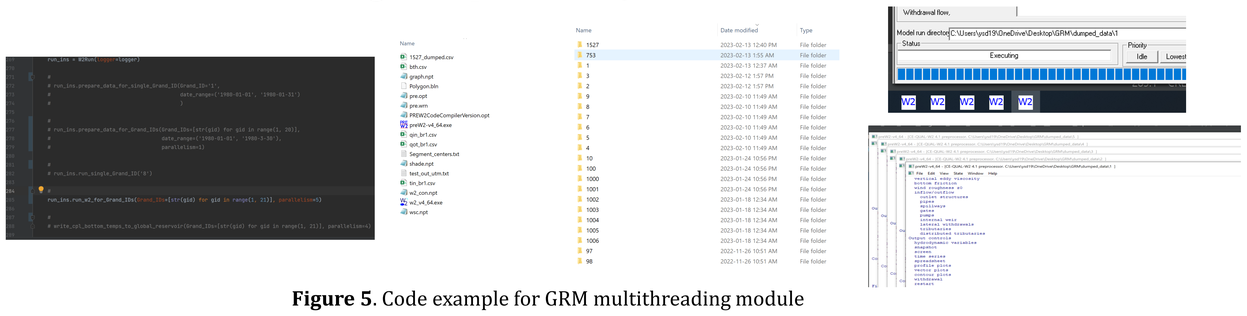

Figure 5. Code example for GRM multithreading module

Reservoir Brunt Vaisala Frequency (N) and Anoxic Factor applications – ID 753 and ID 1527

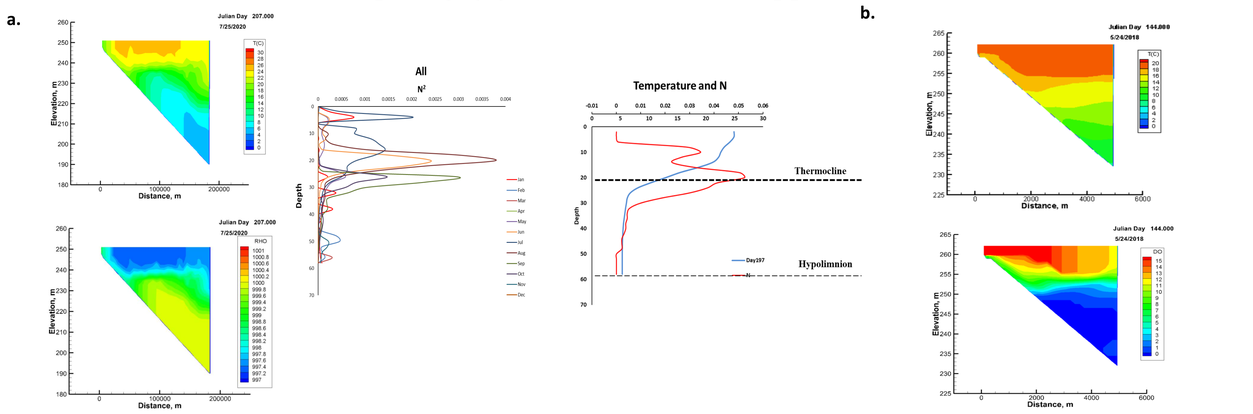

Figure 6. Brunt Vaisala Frequency and Anoxic Factor modeling applications: (a) ID 753 – Lake Sakakawea; (b) ID 1527 – Fanshawe Reservoir

Conclusions & Perspectives

Conclusions

- GRM V1.0 provides a global-scale modeling database with multithreading tools for reservoirs and dams;
- GRM contains 6824 simplified reservoir bathymetry files together with long-term water discharge (1901-2019), air temperature (1979 - 2005), and daily meteorological (1959 - 2022) data;
- As a first application of GRM V1.0 we assess the vulnerability of stratification of reservoirs and predict the daily to annual average bottom temperature.

Perspectives

- Existing process-based water quality models (1D to 3D model) will be linked with the current GRM intelligent multithreading module;
- Machine learning modeling will be incorporated in the next version of GRM to account for dam operation and the impacts on reservoir water quality.

References & Acknowledgements

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Data repository : https://github.com/SYubaby/GRM

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