

Configuring Large Language Models for Regional Ocean Model Development

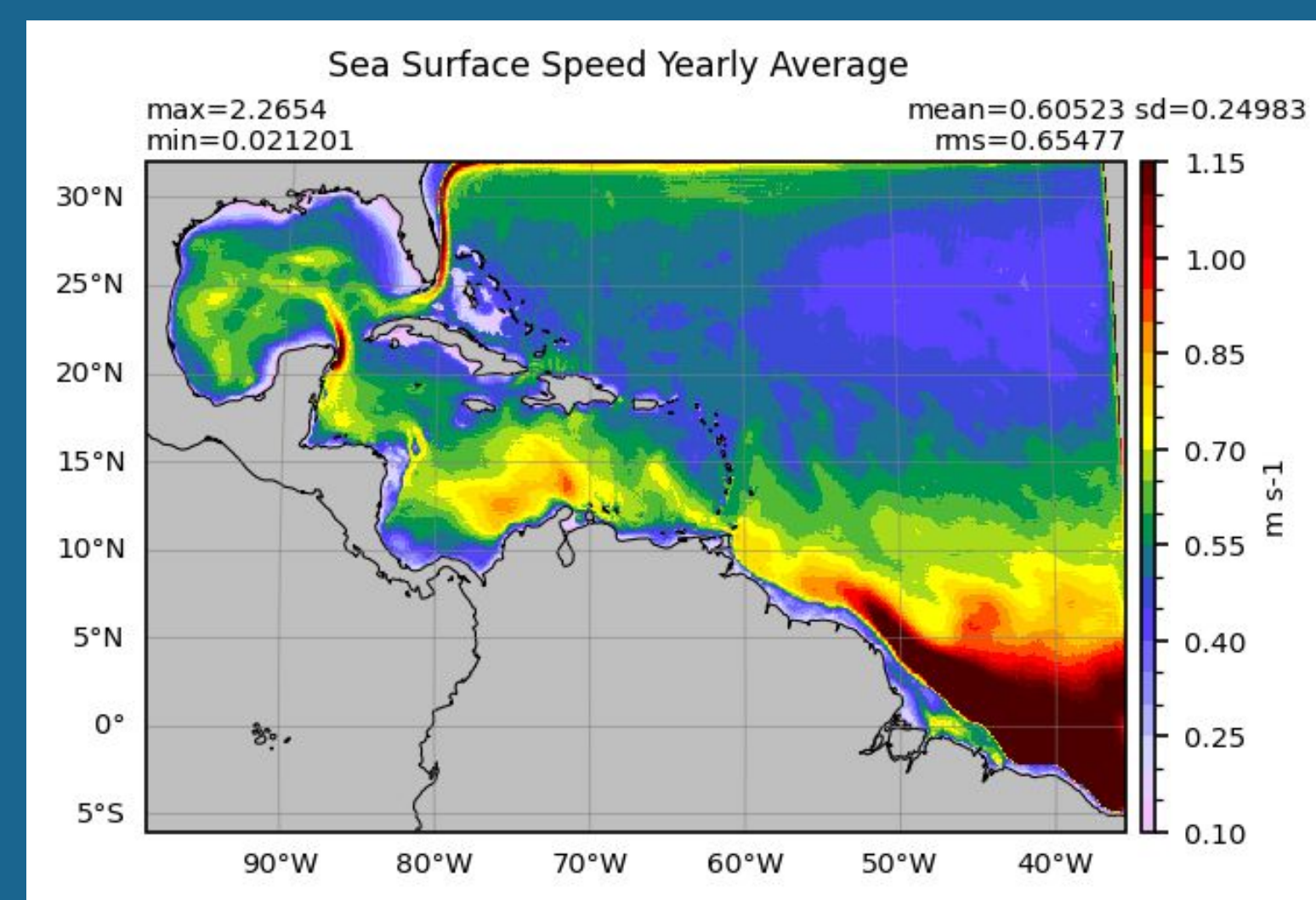
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BACKGROUND & OBJECTIVES

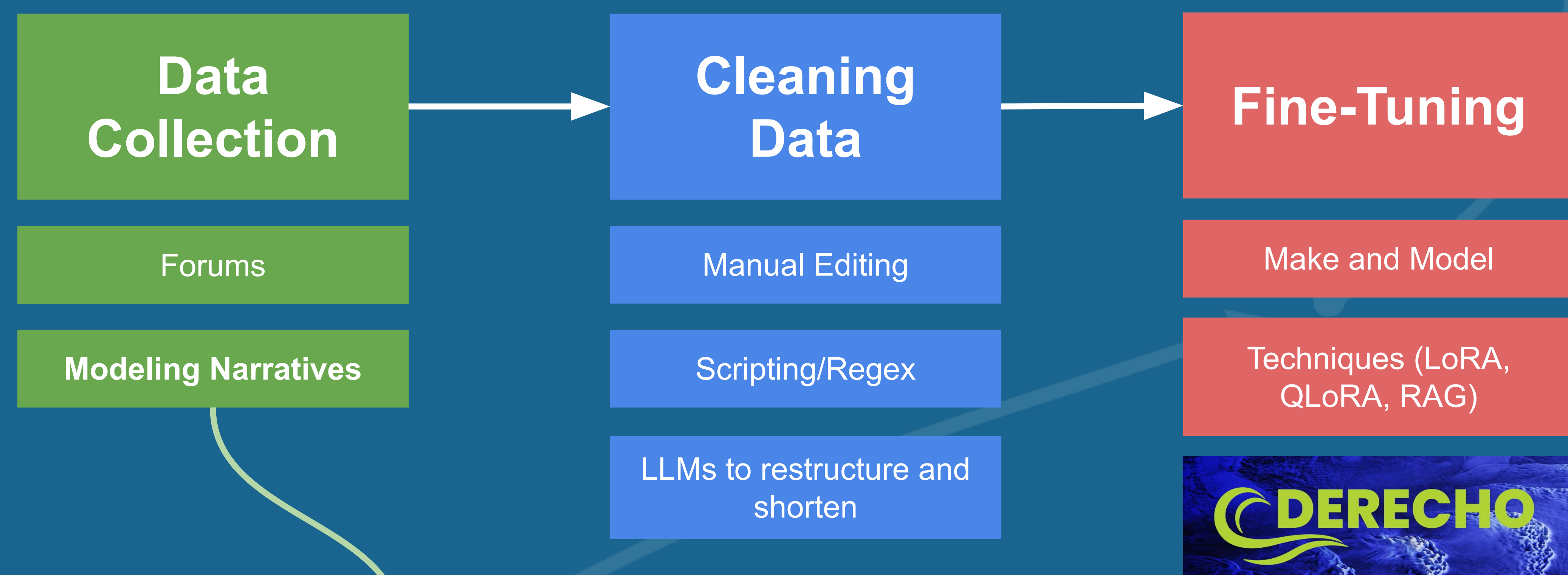
- How do we provide resources for tuning ocean models?
- Large language models (LLMs) are powerful natural language processors that can be tailored to a use case.
- Many tools, techniques, parameters → all need DATA

Objective: Fine-tune an LLM with a small dataset of interviews from ocean modeling experts.



Be Careful: Language Model vs Ocean Model

METHODS



How do we record lived experience? Interview the experts

1. Modeling Background

When did you start modeling?
What models have you used?
What questions are you interested in?

2. Specific Experience

Tell us about a time when you had to develop or refine a regional ocean model configuration to make it better suited to a particular science question.

3. Speculative Modeling

Please pick a region where you think there are interesting open questions about variability and process representation that can be studied by developing a new model.

4. Summarize life's work

What guidance would you give someone who is brand new to modeling in just a few sentences?

“Open boundary conditions are a black art”
Modeling Expert

Evaluate for yourself!

RESULTS

LLM Prompt: The transport through the Windward passage in my model of the Caribbean is way too big, what can I try changing?

GPT-4o

- If transport through the Windward Passage is too high, try the following:
1. **Bathymetry:** Check depth and width—make sure it's ~1,700–1,800 m deep and ~80 km wide. Refine resolution or **manually edit bathymetry**.
 2. **Wind Forcing:** Reduce wind stress if it's overdriving the Caribbean flow.
 3. **Boundary Conditions:** Limit inflow from the Atlantic; check if boundary SSH or velocity is too high.
 4. **Mixing/Viscosity:** Increase horizontal viscosity or bottom friction to reduce unrealistic jetting.
 5. **SSH Gradient:** Check for steep sea surface slopes across the passage—they drive barotropic flow.

Let me know your model (e.g., ROMS, MITgcm) for more specific tweaks.

Practical Sequence to Try:

- ✓ Start with **bathymetry edits** (adjust sill depth, narrow the cross-section slightly).
- ✓ Then adjust **viscosity/bottom drag**—but don't push values too far from physically reasonable ranges.
- ✓ Finally, **review boundary forcing**—you might be inheriting too-strong transport from your parent model.

Would you like me to pull observational estimates of transport through the Windward Passage (to give you a target value) and provide a quick bathymetry check using ETOPO or GEBCO data for that region?

Base Llama-3.2-3B-Instruct

To reduce excessive water transport through the windward passage in your model:

- * **Narrow the passage**
- * Add obstacles or hills to disrupt flow
- * Change the shape of the passage (e.g., add a bend)
- * Increase coastally-roughed elements (e.g., reefs, bays, headlands)
- * Adjust current strengths or directions

Try one change at a time to see what works best for your model.

One thing to consider would be the bathymetry along narrow passages. It's possible **adjusting some of the topographic features could help control flow behavior**.

Another option would be to revisit how atmospheric forcing is being applied, especially in those channels. Sometimes even **small changes in wind or current forcing** can have a big impact on model flow—particularly in narrow passages where there is limited room for error.

“There are also seasonal or diurnal variations in bathymetry”

Custom GPT-4o (RAG)

Fine-Tuned Llama-3.2-3B-Instruct

CONCLUSION & NEXT STEPS

- **Proof of concept for using expert interviews as training data**
- Fine-tuning results: **linguistic change or content improvement**
 - Is good advice always accurate? Catch-all vs. pointing one direction
- Can we use LLMs to **map the space of ocean model development/tuning?** What about Earth System Models?
- Bigger models, plenty of parameters, mixing LLM tools

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Notes and References

