MARBL-DART: An Ensemble System for Biogeochemical Data Assimilation

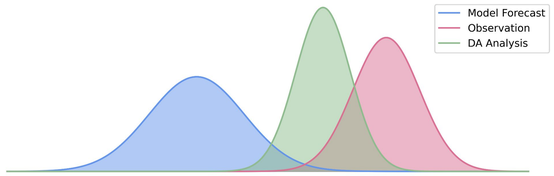
Robin Armstrong, Moha Gharamti, Dan Amrhein, Kristen Krumhardt, Mike Levy, Helen Kershaw

CISL Computational & Information Systems Lab

NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

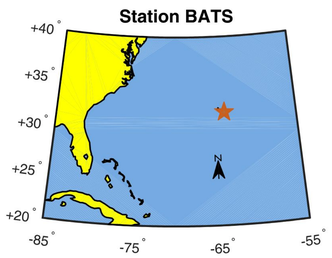
BACKGROUND

Geoscientists rely on numerical models and empirical data to learn about the Earth system, but data are sparse and have errors, while models are biased and sensitive to inputs. **Ensemble data assimilation algorithms** allow us to **combine models with data** to obtain more accurate and complete information **while quantifying uncertainty**.



OBJECTIVES

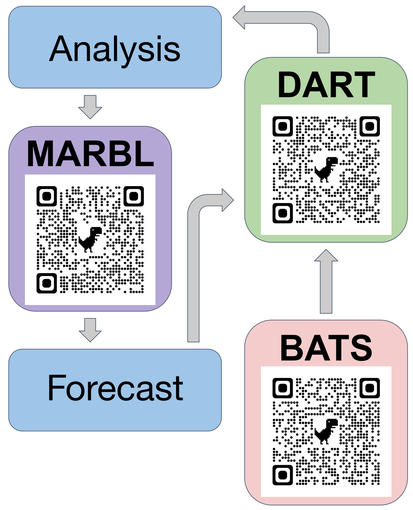
This project builds an interface that links **DART** (Data Assimilation Research Testbed) [1] to **MARBL** (Marine Biogeochemistry Library) [3], enabling **improved biogeochemistry forecasting** for a **single-column ocean model**.



The location of our simulated ocean column. This is also the location of the Bermuda Atlantic Time-Series Study, our source for in-situ biogeochemical data. Image source: [2].

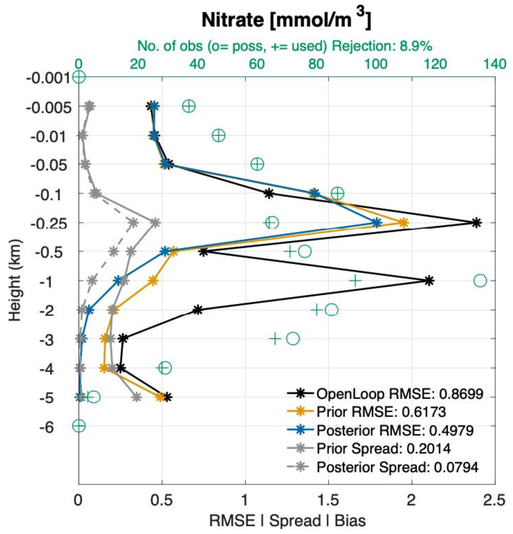
METHODS

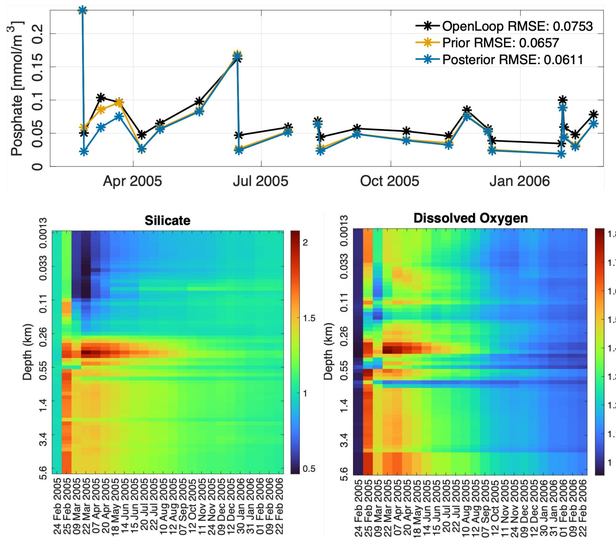
- **MARBL** creates an ensemble of biogeochemical forecasts.
- **In-situ data** is gathered from **BATS** (Bermuda Atlantic Time-Series Study)
- **DART** combines forecasts with data using an **ensemble adjustment Kalman filter**.
- **Custom-built Fortran interface functions** allow MARBL-DART data transfer.
- **Top-level script** coordinates execution between DART binaries and MARBL binaries.



RESULTS

- MARBL-DART tests used **80 ensemble members** and data from **February 2005 to February 2006**.
- Broadly, forecasts of MARBL-DART are **more accurate than those of MARBL by itself**.
- Some issues remain; e.g., **MARBL-DART produces worse alkalinity forecasts than MARBL alone**.





CONCLUSIONS

- MARBL-DART provides the capability for **improved ocean biogeochemistry forecasting** via ensemble data assimilation of in-situ biogeochemical data.
- More work is needed to explain MARBL-DART's **anomalous alkalinity forecasts**.
- Future work will build upon MARBL-DART to produce a **parameter estimation system**, wherein data assimilation is used to **optimize the underlying biogeochemical model**.
- We will also **assimilate satellite data**, e.g. chlorophyll-A, which may improve alkalinity forecasts.

REFERENCES

[1] Anderson et al, "The Data Assimilation Research Testbed: A Community Facility," *American Meteorological Society* (2009).
[2] Gharamti et al, "Ensemble Data Assimilation for Ocean Biogeochemical State and Parameter Estimation at Different Sites," *Ocean Modeling* (2017).
[3] Long et al, "Simulations With the Marine Biogeochemistry Library," *Journal of Advances in Modeling Earth Systems* (2021).