Using Neural Network Ensembles to Differentiate Biology and Physics in Earth System Models

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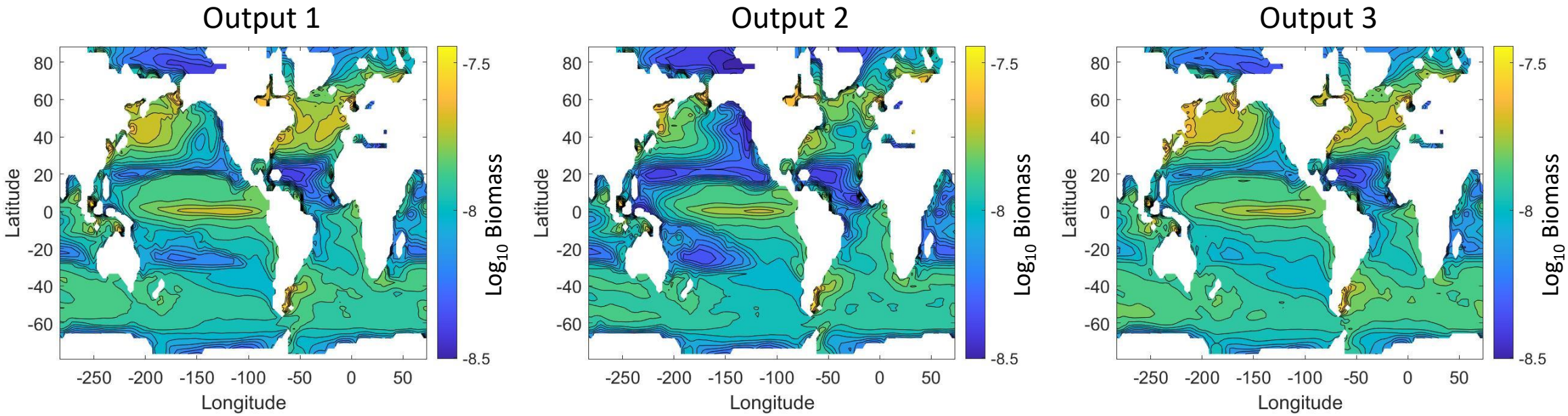
October 2020
2020 E3SM Conference

Motivation and Background

- Earth System Models can produce differences in their outputs
- It can be difficult to understand why these differences are occurring

What is causing the differences in these outputs?



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Motivation and Background

- Differences in Earth System Model output are usually due to:
  - Different formulations for modelling biology
  - Different physical forcings
  - Different physical forcings **and** biology

Research Question

Can we use Neural Network Ensembles (NNEs) to find the main causes of differences in Earth System Model outputs?

Methods

- Trained NNEs on output from ESMs and used sensitivity analyses to view the relationships found by the NNEs

- Predictors were macronutrient, micronutrient, light, and temperature
- Target variable was phytoplankton biomass for small and large phytoplankton (separately)

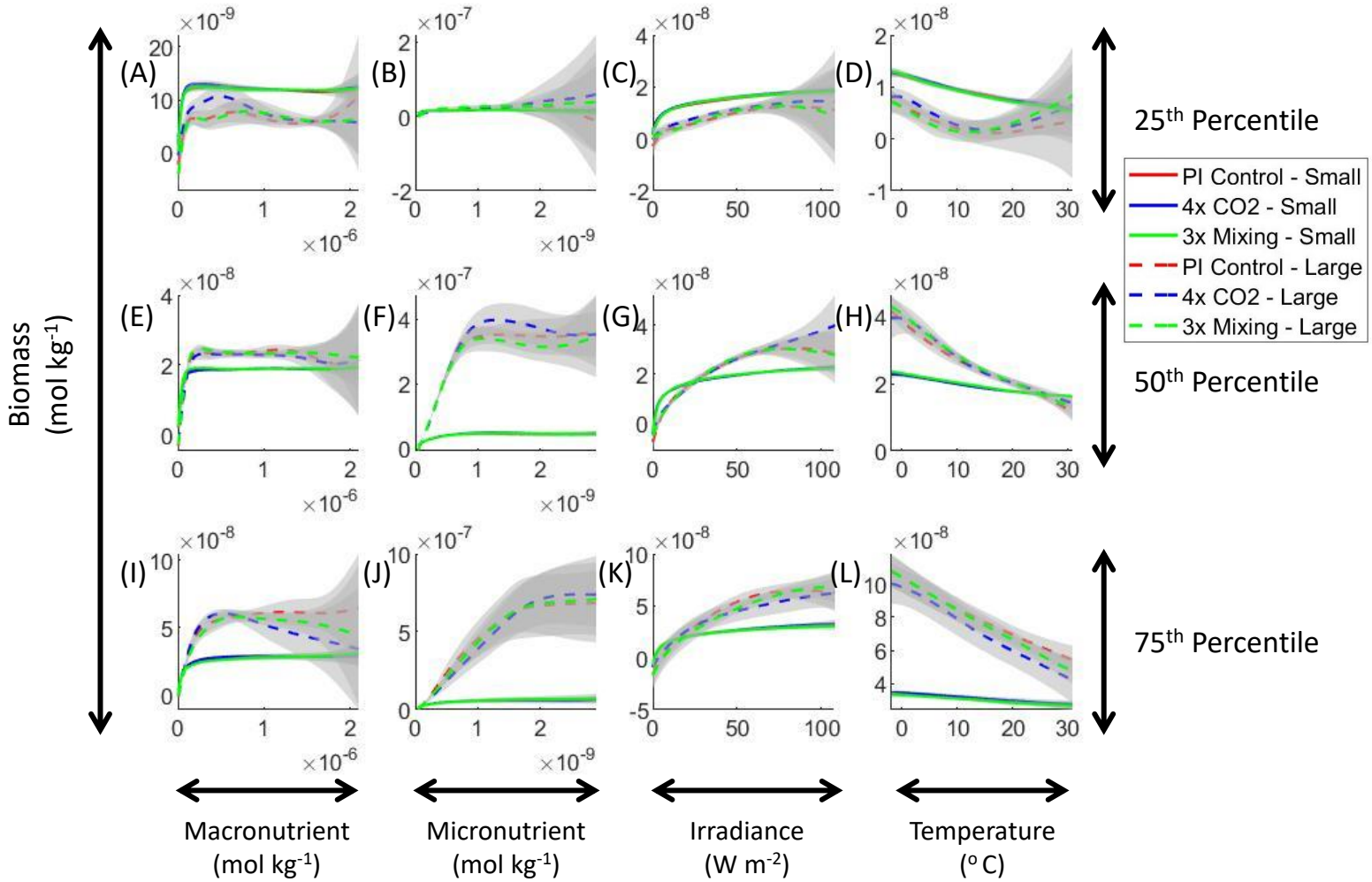
- Looked at two cases:
  - Case 1: Used three model runs from same ESM where the biological equations between them were the same, but they each had different physical forcings

  - Case 2: Used model runs from the same ESM where the biological equations between them were different, but the physical forcings between them were the same

Results and Discussion – Case 1

- When the biology was the same between model runs and the physical forcings were different, NNEs found the same biological relationships in each run

- This suggests that the different physical forcings were simply shuffling the nutrients and light around, but not necessarily creating new states of biology



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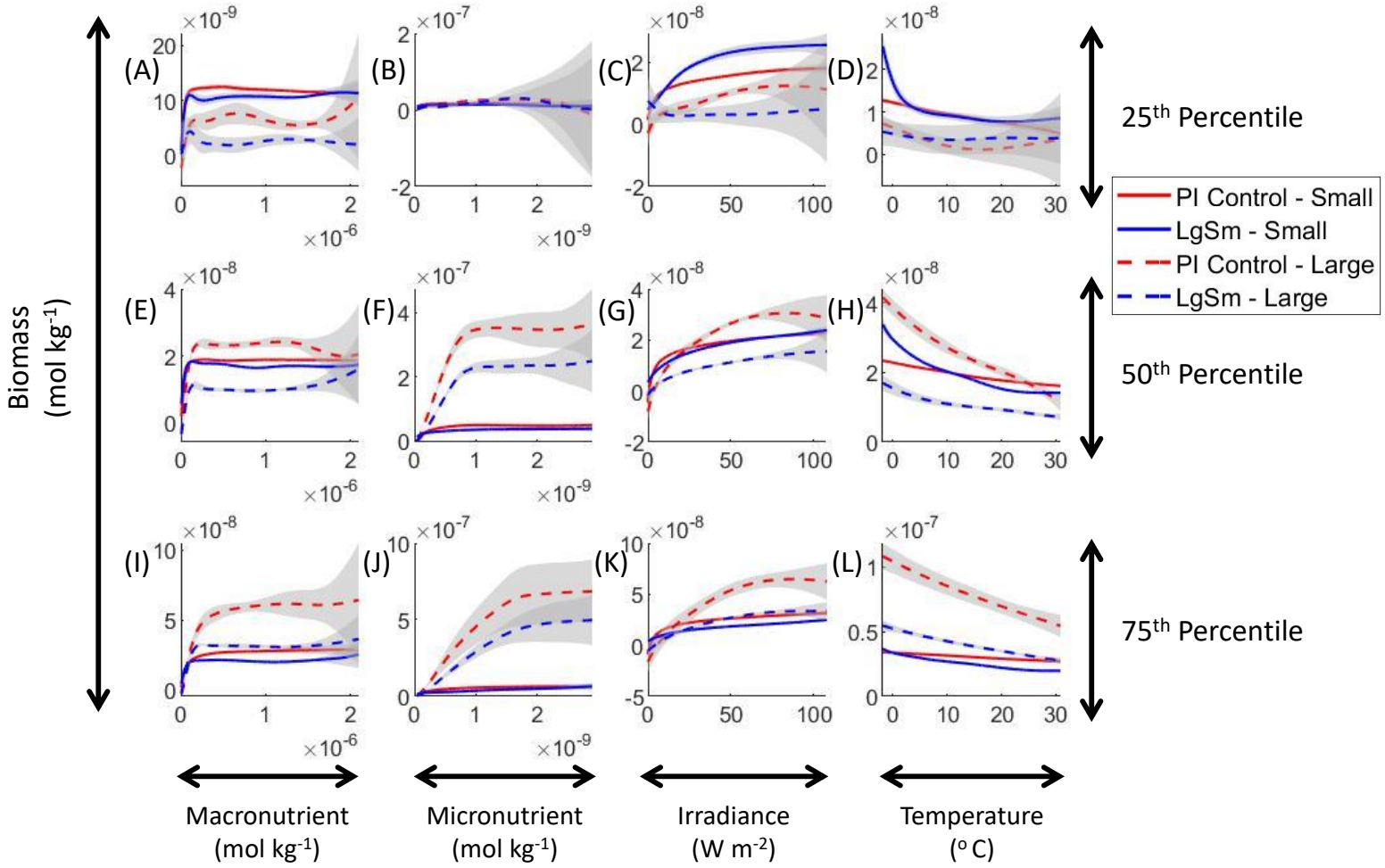
Results and Discussion – Case 2

- When the biological relationships were different between model runs and the physical forcings were identical, NNEs found different relationships in each run and the extent of those differences

- Implies that the biological relationships programmed into the model produced differences in the relationships found by the NNEs



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Main Conclusions and Future Work

- We may be able to use NNEs to understand why ESMs differ in their output

- Work in progress and future work:
  - Determine if NNEs can detect differences between ESMs when both the biology and the physics differ and understand how to back out their respective contribution to the differences
  - Use observations to develop relationships against which models can be compared


Questions?
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