Impacts of Sea Level Rise on Hypoxia—progress report

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Overview

We are investigating the impacts of sea level rise (SLR) on hypoxia using different models of the bay.

The experiments assume realistic conditions for the period **1991–1995** and use the same riverine forcing (Phase-6 CXXBASE).
We consider four scenarios:

1. No SLR: base run / control
2. SL raised by 0.17 m at the oceanic model boundary (2025)
3. SL +0.50 m (2050)
4. SL +1.00 m (2100)

Experiments completed / ongoing

Model ChesROMS-ECB:

- Control 1991–2000
- +0.17 m 1991–2000
- +0.50 m 1991–1995 (**ongoing**)
- +1.00 m 1991–1995 (**new**)

Model UMCES-ROMS (physics) + RCA (biology):

- Control 1991–1995 (physics)
- Control 1991–1995 (biology)
- +0.17 m 1991–1995 (physics)
- +0.17 m 1991–1995 (biology)
- +1.00 m 1991–1995 (physics) (**new**)
- +1.00 m 1991–1995 (biology) (**new**)

Model SCHISM:

- Control 1991–1995 (physics)
- Control 1991–1995 (biology) (need to ask Joseph)
- +0.17 m 1991–1995 (physics) (need to ask Joseph)

Response to ΔSL = +0.17m and +1.00m

Slides 5,6 show the response to an increase in sea level of +0.17 m or +1.00 m during the month of maximum hypoxia (July). A few things to notice:

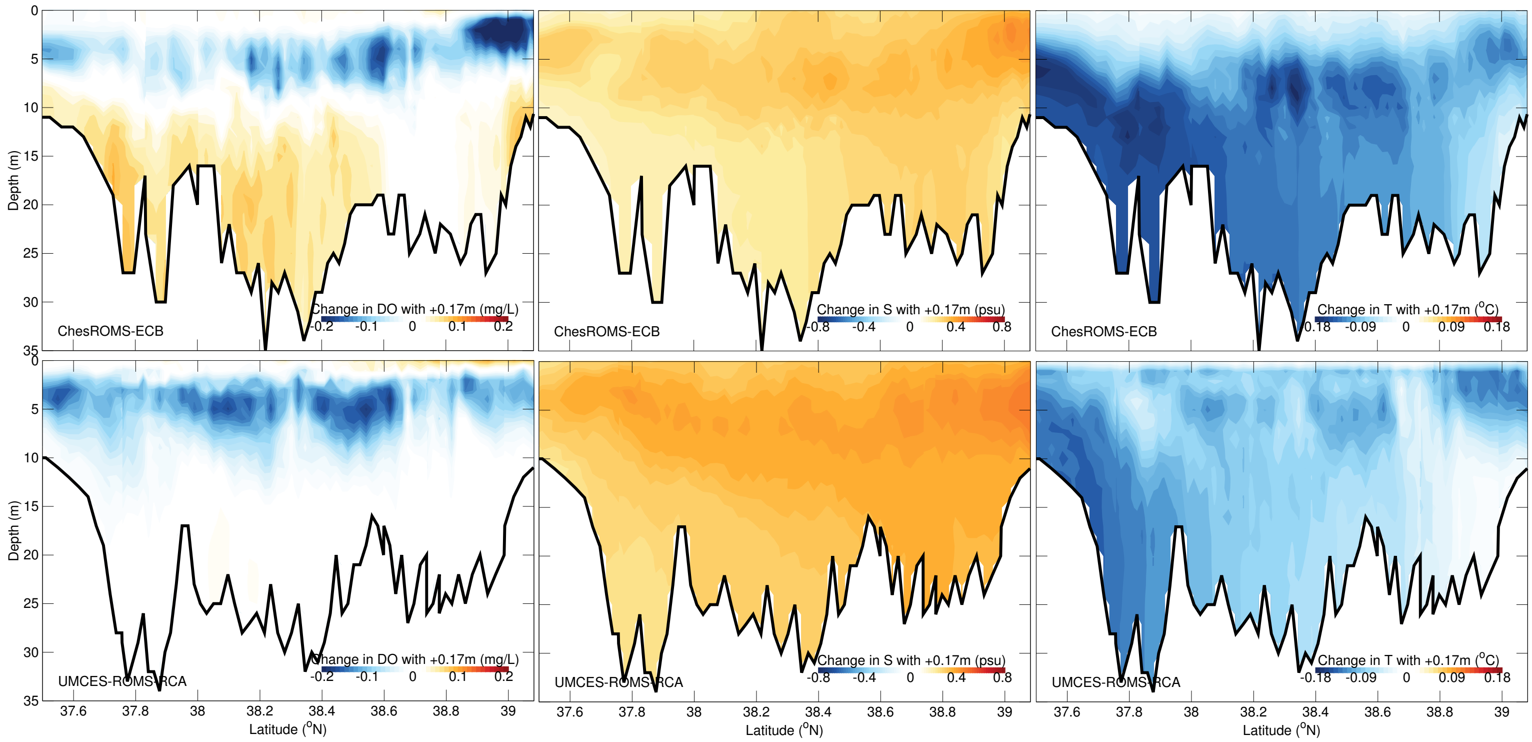
1. Both models show an upward displacement of the pycnocline, causing a band of ΔDO < 0 and $\Delta S > 0$ around $\sim$ 5 m depth.

2. Both models predict enhanced landward intrusion of seawater. **This pattern is the same in both scenarios** but amplified in the case +1.00 m (note change in scales).
   $\Delta\mathrm{SL} = +0.17\,\mathrm{m} \Rightarrow \Delta S \sim 0.35\,\mathrm{psu}$,
   $\Delta\mathrm{SL} = +1.00\,\mathrm{m} \Rightarrow \Delta S \sim 1.50\,\mathrm{psu}$ (both values similar to Hong & Shen 2012).

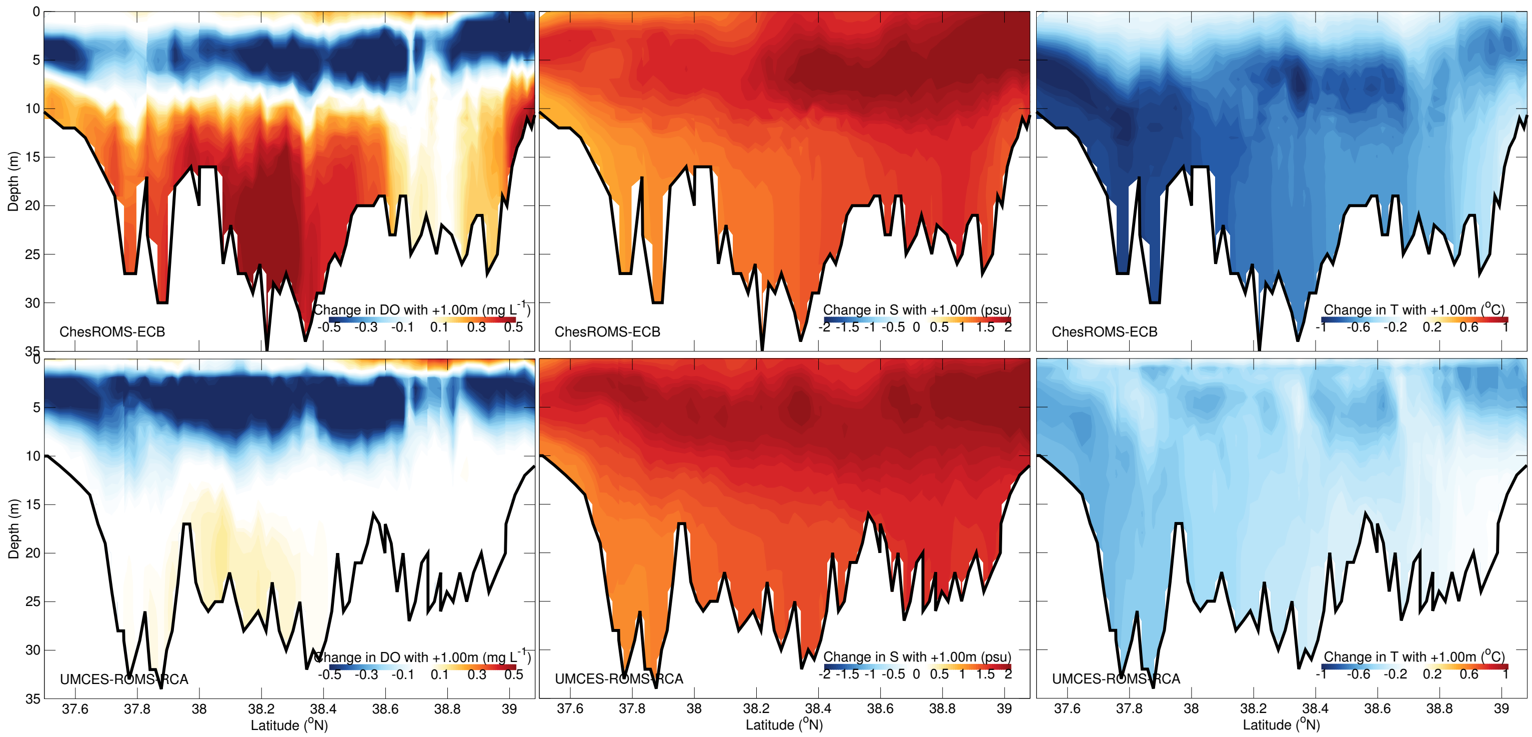
3. ChesROMS-ECB suggests a stronger cooling than UMCES-ROMS-RCA.

4. ChesROMS-ECB suggests a substantial improvement in bottom DO (both scenarios).
   UMCES-ROMS-RCA suggests no clear improvement for +0.17 m
   and a slight improvement for +1.00 m.

Response to ΔSL = +0.17m (July 1991–1995)



Response to ΔSL = +1.00m (July 1991–1995)



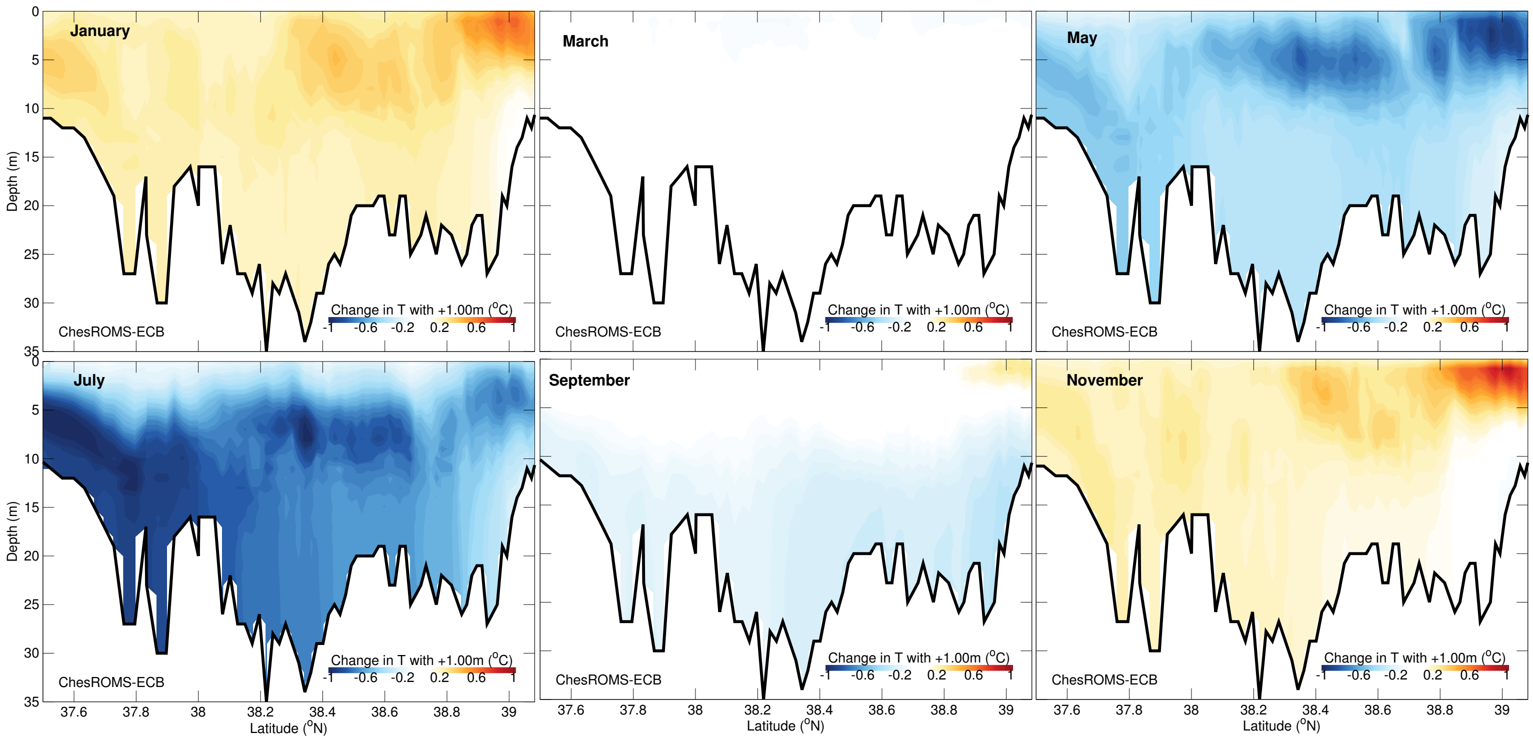
Response to ΔSL = +0.17m and +1.00m

While the increase in salinity (ΔS) is fairly constant throughout the year,
the change in temperature (ΔT) is not. T is strongly influenced by surface fluxes, and ΔSL appears to **delay** the impact of those surface fluxes on the deep layers.

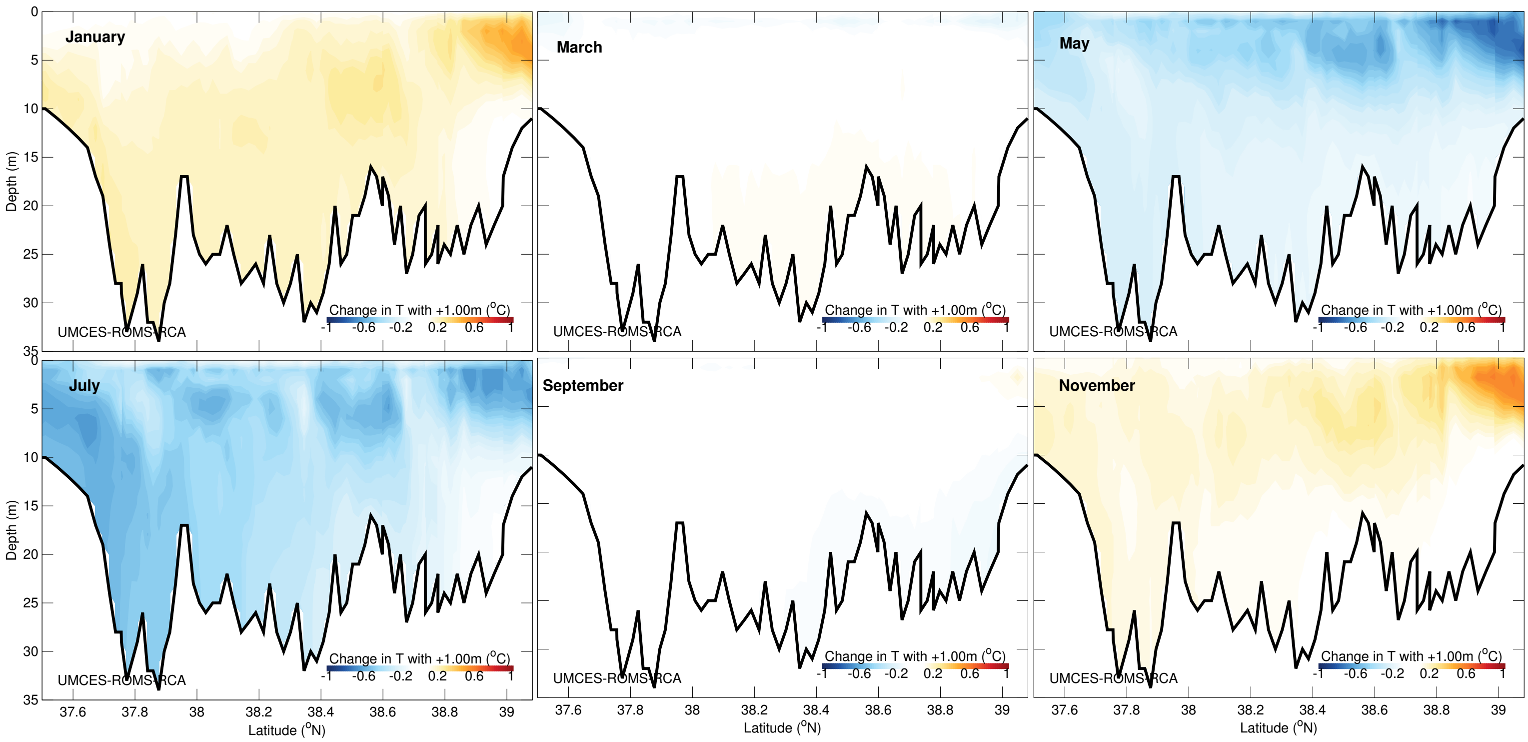
Slides 8,9 show the seasonal cycle of ΔT for both models (case $\Delta \text{SL} = +1.00\,\text{m}$):

- In fall/winter (surface cooling), ΔSL makes the water column warmer ($\Delta T = +0.2°\text{C}$).
- During the summer period (surface heating), ΔSL makes the water column cooler.
- In March or September, $\partial T/\partial z \sim 0$ and $\Delta T \sim 0$.
- Qualitatively, the two models show the same seasonal anomalies (ΔT).
  Quantitatively, the ΔT are larger in ChesROMS-ECB.
- Note that such ΔT can have a substantial effect on the rate of biological processes.
  For a $Q_{10} = 2.1$, $\Delta T = -0.6°\text{C} \Rightarrow \approx 5\%$ slower respiration (as Richard said in last call).

Change in *T* due to ΔSL = +1.00m, ChesROMS-ECB



Change in *T* due to ΔSL = +1.00m, UMCES-ROMS-RCA



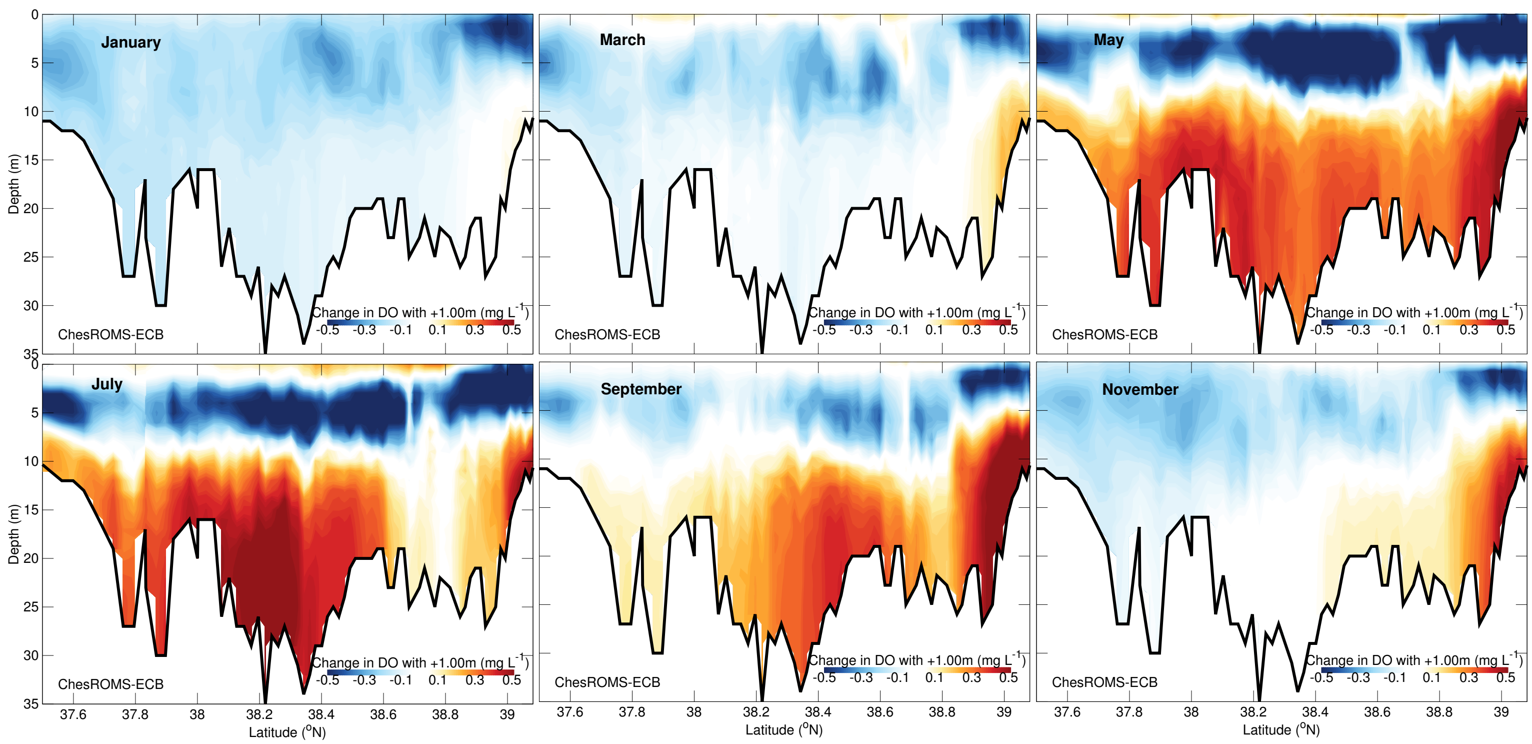
Response to $\triangle$SL = +0.17m and +1.00m

The change in DO also exhibits a seasonal cycle.

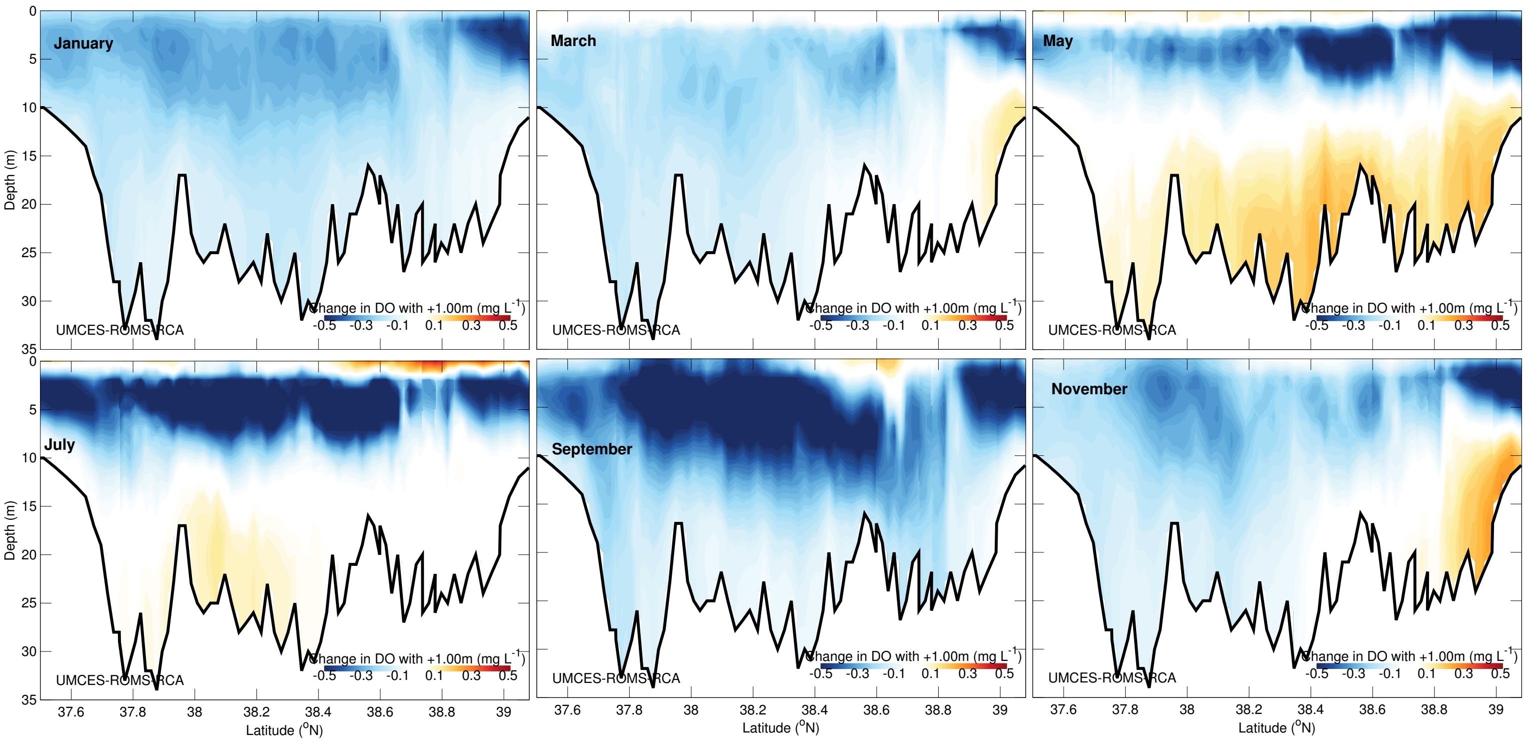
Slides 11,12 show the seasonal cycle of ΔDO for both models (case ΔSL $= +1.00\,$m).
A few things to notice:

- The seasonal cycle of the two models have a lot in common.
  Both models show slightly negative ΔDO in Jan–March,
  positive ΔDO in May–July, and mixed response in November.
- However, the magnitude and duration of the positive DO anomaly differ.
  It is more pronounced and lasts longer in ChesROMS-ECB than in UMCES-ROMS-RCA.
- Overall, this suggests that the same mechanisms are at play but that their intensity differs.

Change in DO due to ∆SL = +1.00m, ChesROMS-ECB



Change in DO due to △SL = +1.00m, UMCES-ROMS-RCA



DO budgets for the models

In the last conference call we presented a DO budget for ChesROMS-ECB. The goals were to illustrate the important terms, quantify each process and quantify how they change with SLR.

We are working with Wenfei Ni (UMCES, graduate student of Ming Li) to create a similar budget from UMCES-ROMS-RCA. Over the last month, it became apparent that some of the diagnostic fields necessary for the budget were not available. Wenfei kindly re-computed the three existing model runs (control run, +0.17 m, +1.00 m) to fill in the gap. The new outputs became available early this week and we will continue working with them to complete the budget.

Next steps

- Complete the DO budget of UMCES-ROMS-RCA.
  Use the budgets to quantify the effects of SLR on the DO balance.
- We submitted an abstract with Ming Li and Wenfei Ni for the upcoming CERF conference (Nov. 3–7):
  Impacts of sea level rise on Chesapeake Bay and its seasonal hypoxia
- Coming soon: Case with $\Delta SL = +0.50$ m; investigate linearity of response.
- SCHISM: Follow-up with Joseph's team about the status of their runs.