# Preliminary estimate of climate change impact on water quality in Chesapeake Bay using CH3D-ICM

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**and CBPO modeling team**

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# Outline

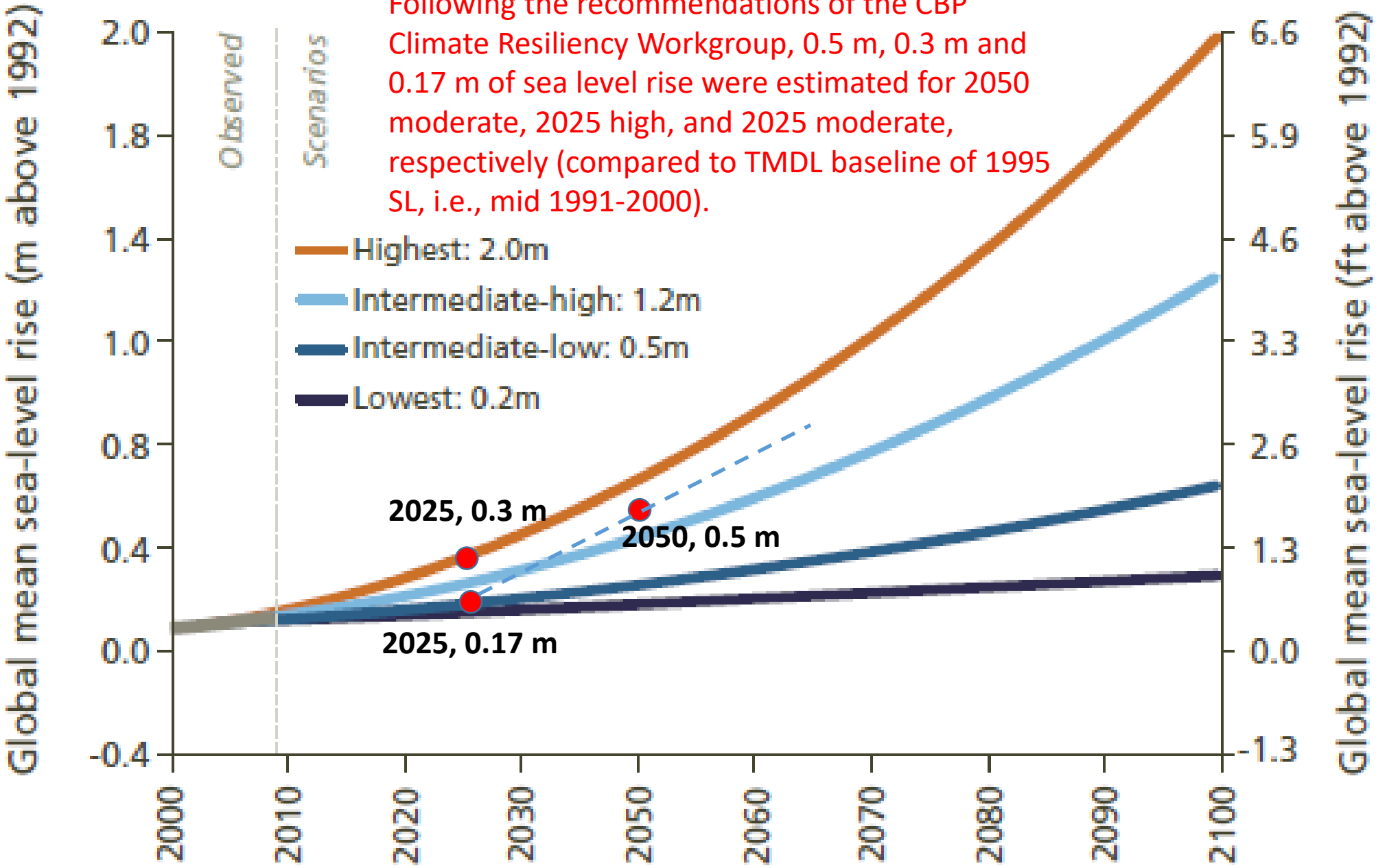
- Sea level rise
- Heat flux
- Nutrient loading
- Open ocean boundaries
- Preliminary results

# Sea level rise numbers

Following the recommendations of the CBP Climate Resiliency Workgroup, 0.5 m, 0.3 m and 0.17 m of sea level rise were estimated for 2050 moderate, 2025 high, and 2025 moderate, respectively (compared to TMDL baseline of 1995 SL, i.e., mid 1991-2000).

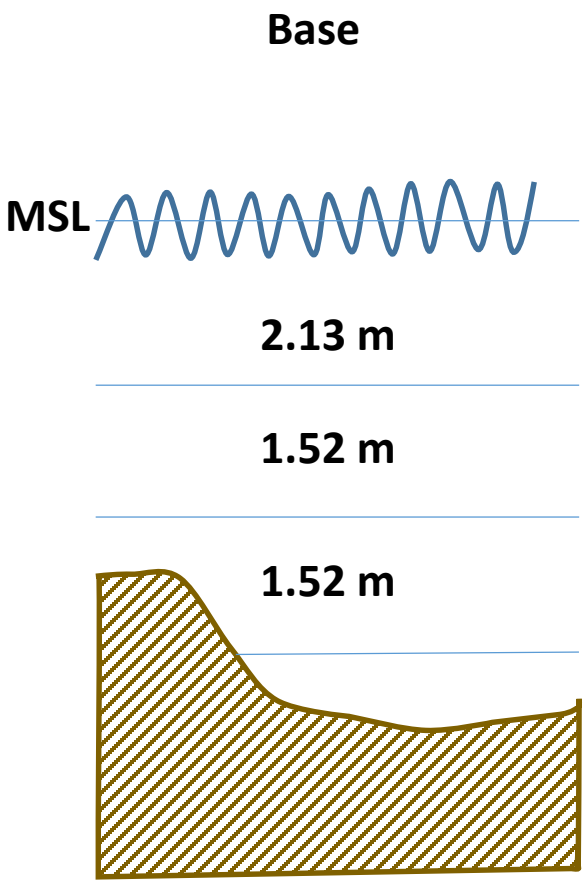
**Linear interpolation and extrapolation for 2035 (0.3 m), 2045 (0.43 m), 2055 (0.57 m) and 2065 (0.7 m).**

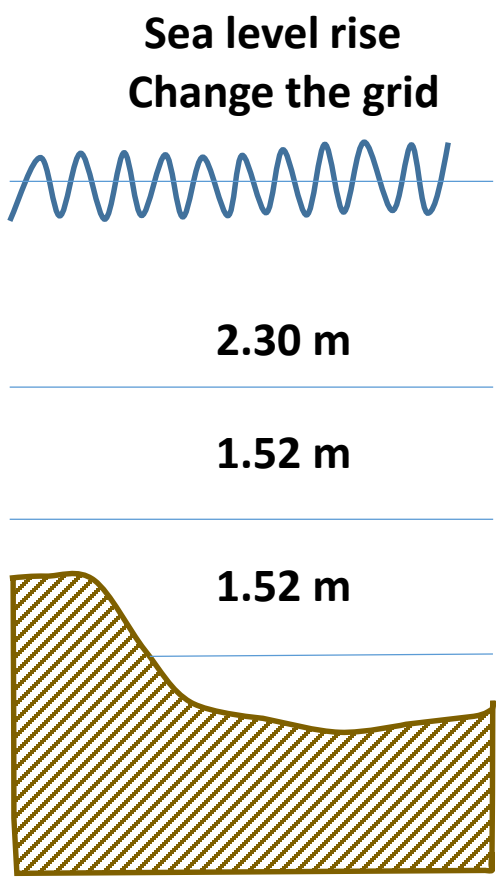
**Climate resiliency group will revise these numbers**

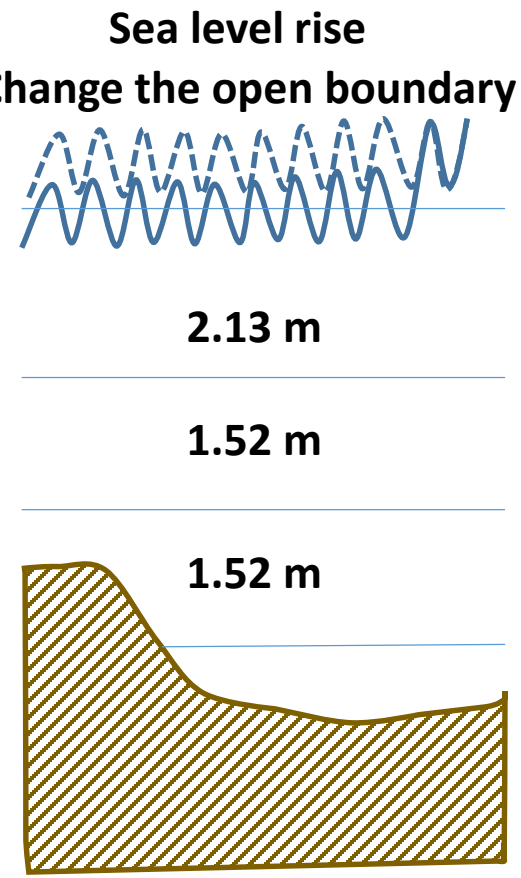


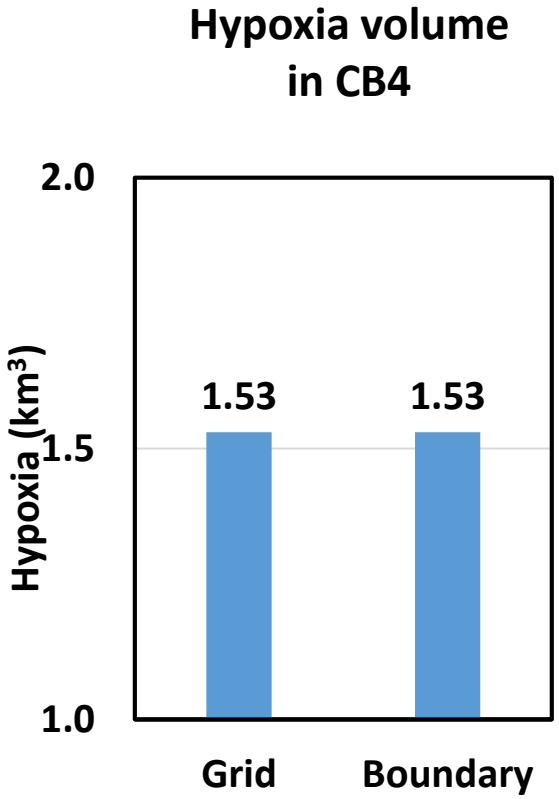

From Parris et al. (2012). *Global Sea Level Rise Scenarios for the United States National Climate Assessment. NOAA Technical Report OAR CPO-1. (1992 used as the starting year)*

# Sea level rise simulation

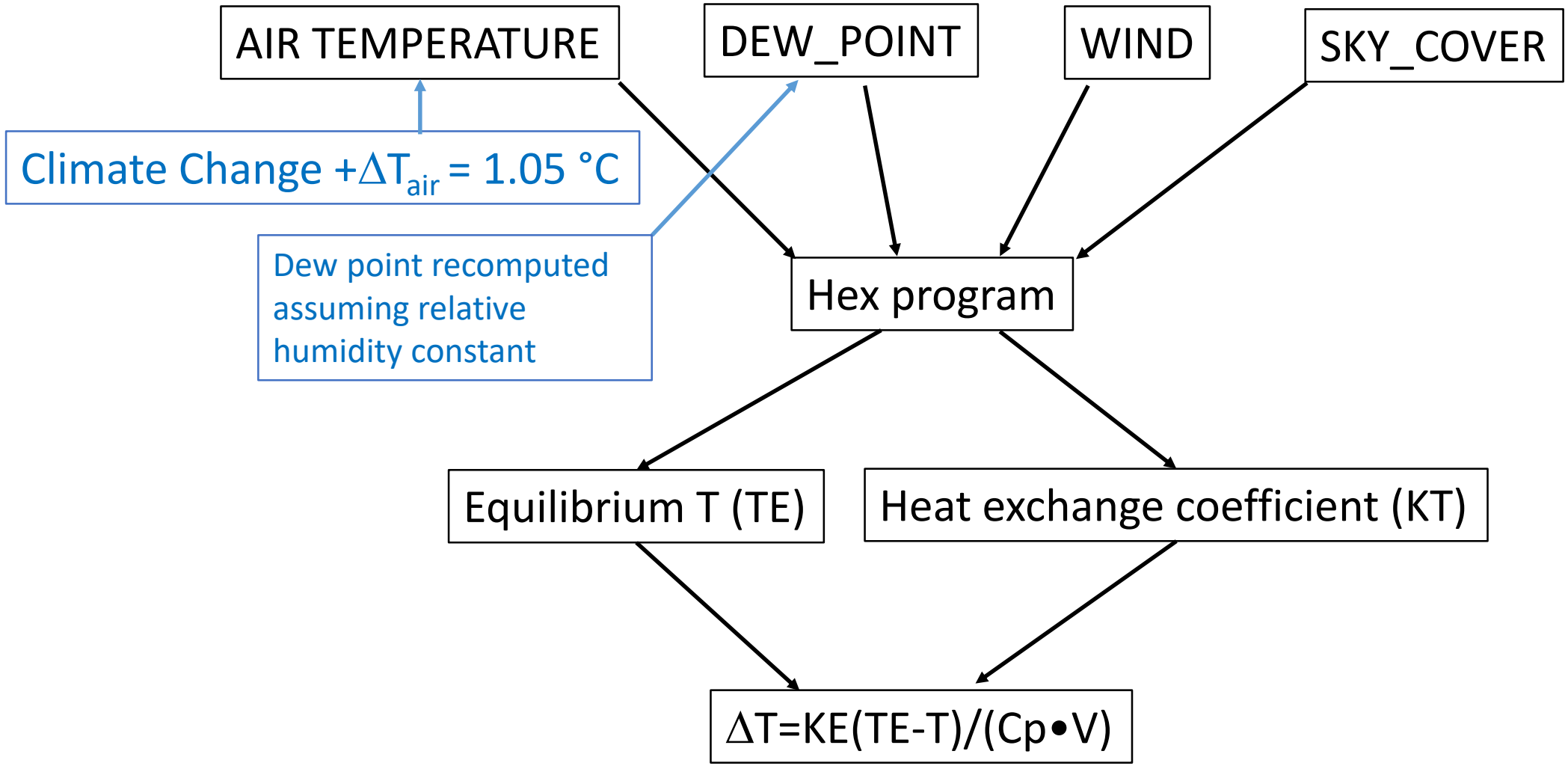


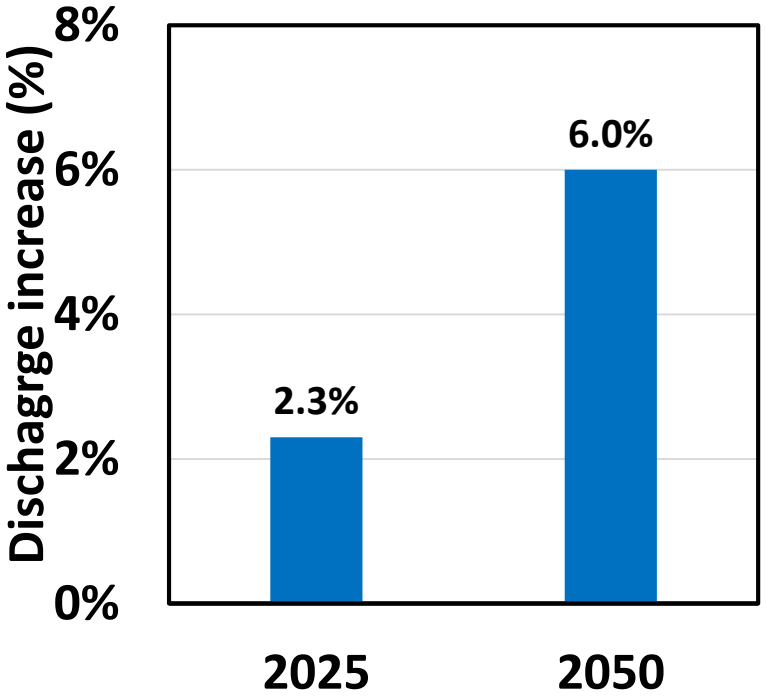



# ICM meteorological forcing

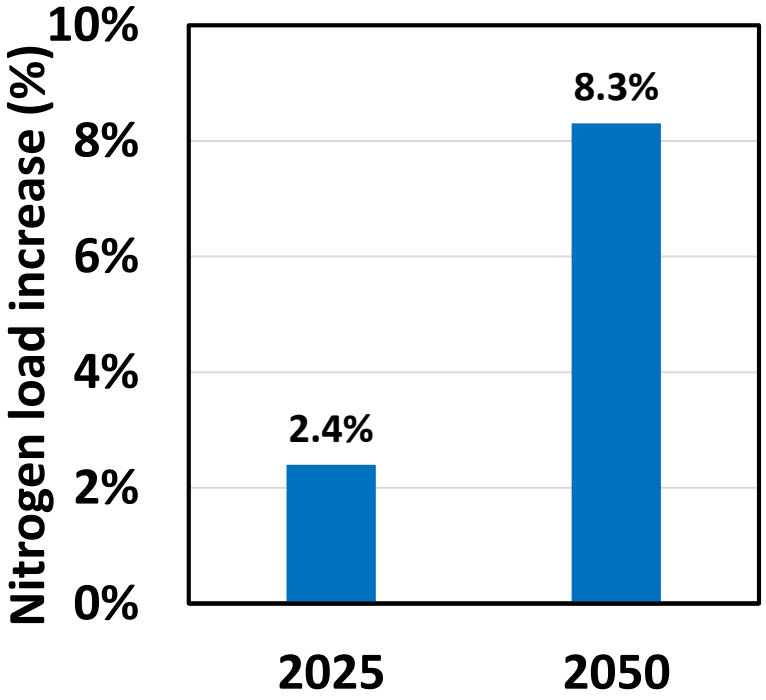


# Changes in river discharge and nutrient loading in the 2025 and 2050 climate change scenarios

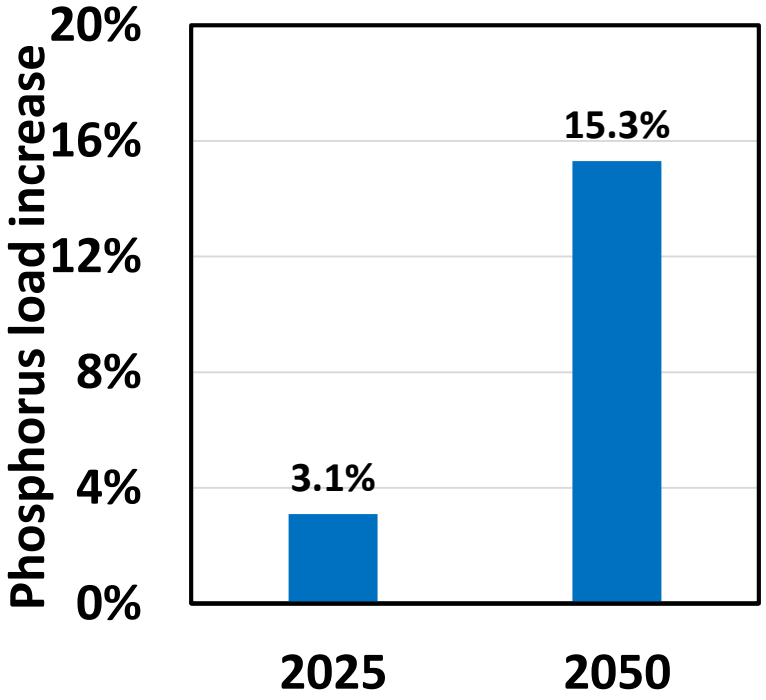
River discharge




Nitrogen loading



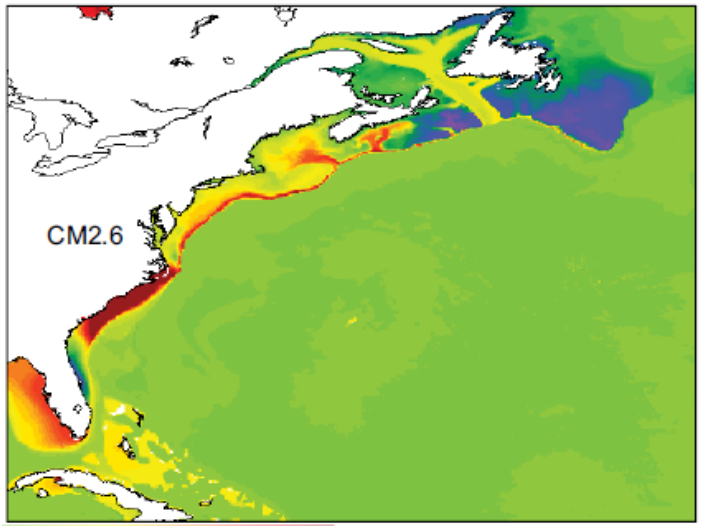

Phosphorus loading

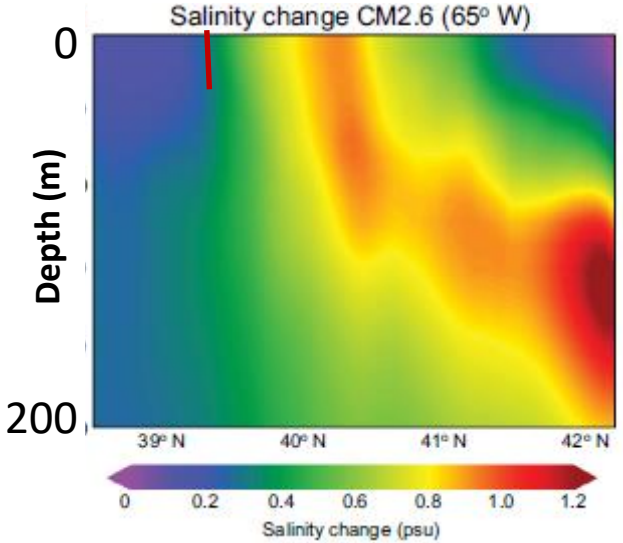



From Gopal Bhatt

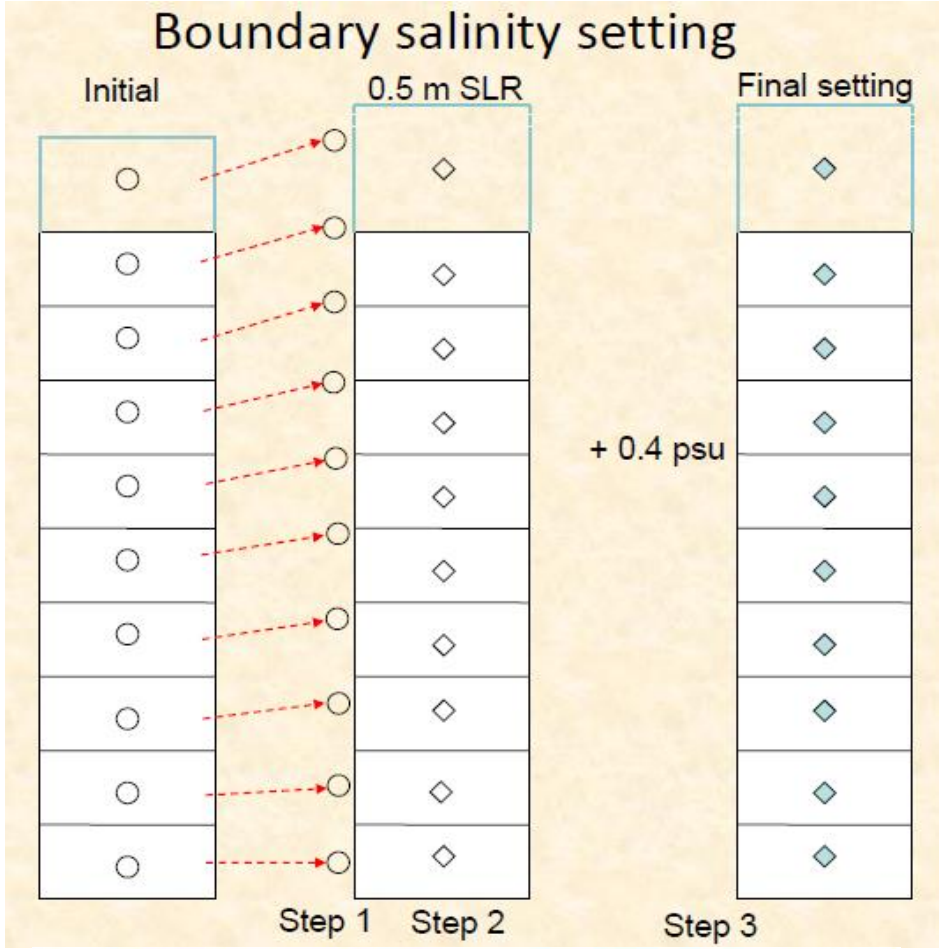
# 2050 salinity adjustment at the the ocean open boundary

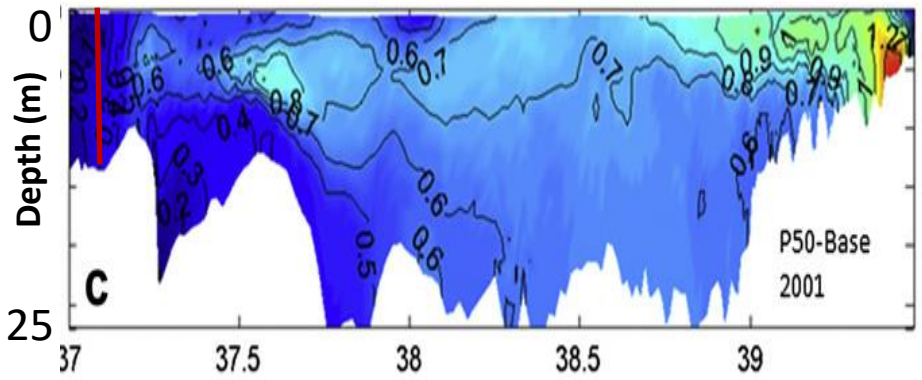
- +0.4 psu based on Hong and Shen, 2012, supported by Seba et al., 2016;
- 2025 + 0.14 psu (=0.4x0.17/0.5)



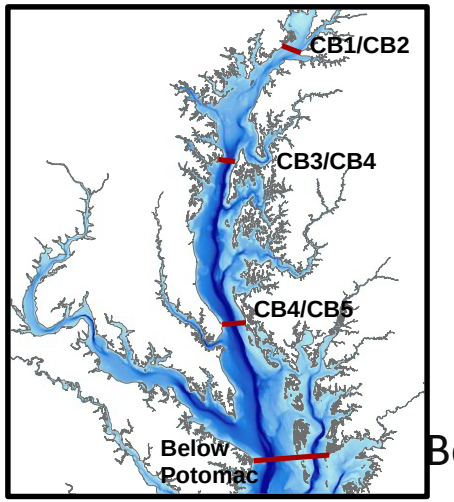

Seba et al. 2016

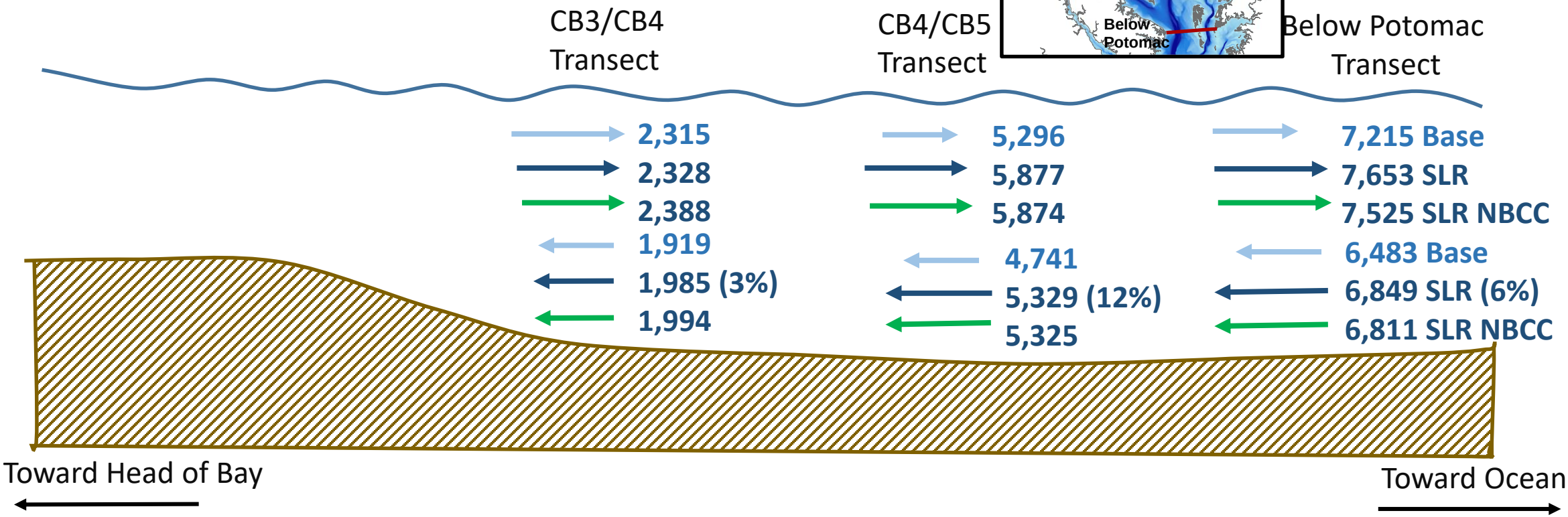



Hong & Shen 2012

# Cross-transect water fluxes (m3/s)
# Base case versus sea level rise (0.5m)
# Summer 1993-1995




Base = Beta 4 TMDL SLR = 0.5m Sea Level Rise Scenario representing relative Chesapeake sea level rise from 1995 to 2050. Units in mean kg DO per second ($m^3/s$) for summer ()Jun-Sept) 1993 to 1995; NBCC: No Boundary Change.

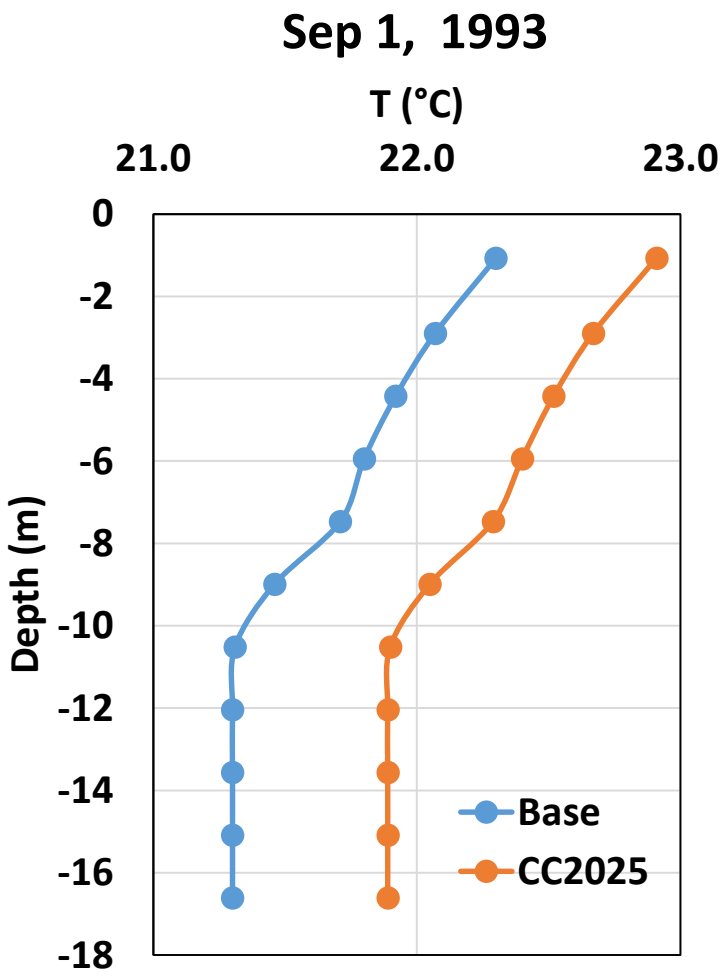
# Temperature adjustment at the the open boundary, including rivers

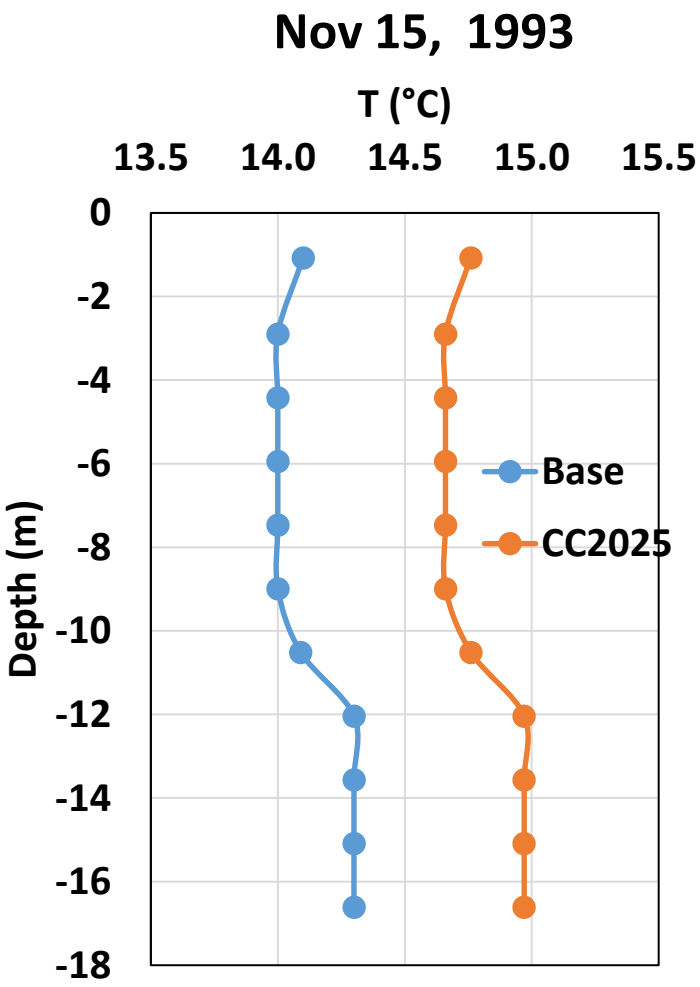
$$\Delta T_{water}=1.0 \bullet \Delta T_{air} \bullet T_{water}/T_{surface}$$

$$\Delta T_{water}=0.6 \bullet \Delta T_{air} \bullet T_{water}/T_{surface}$$

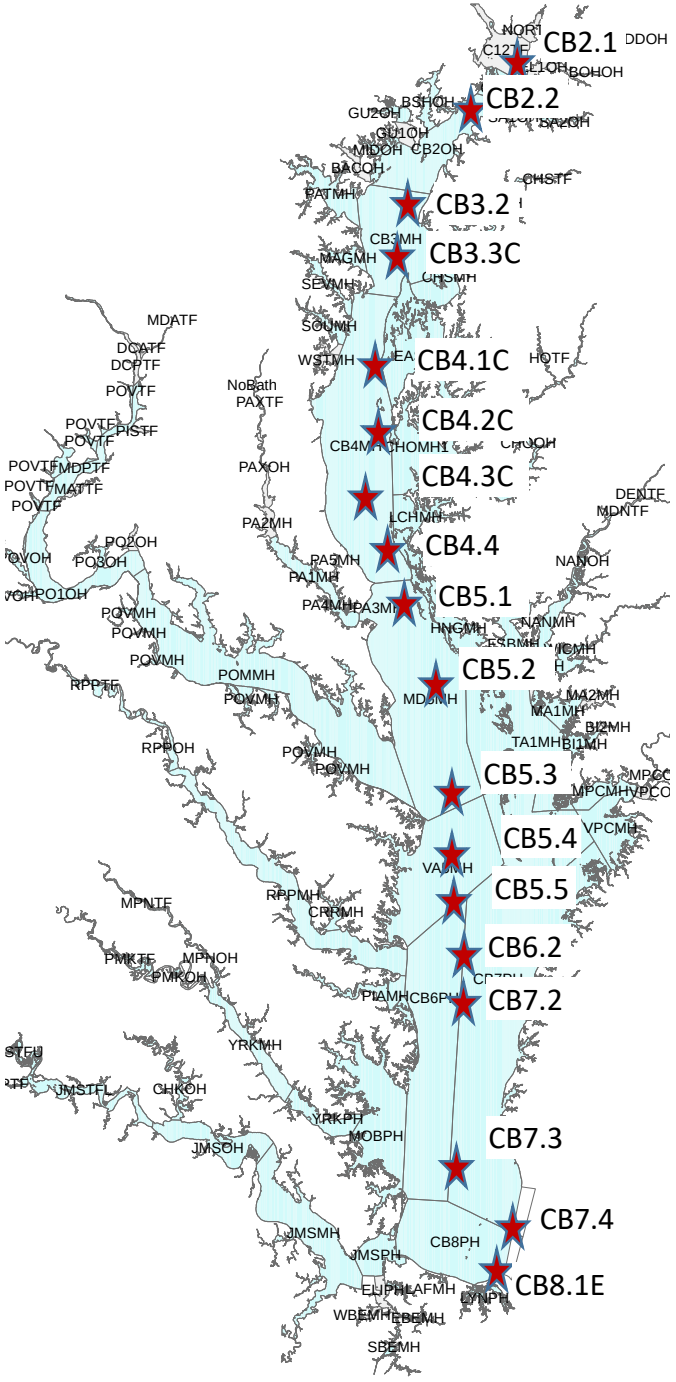
Morrill et al 2014:

- An increase in water temperature of about 0.6-1.0°C for every 1°C increase in air temperature,
- Lateral distributed flow assigned to equilibrium temperature

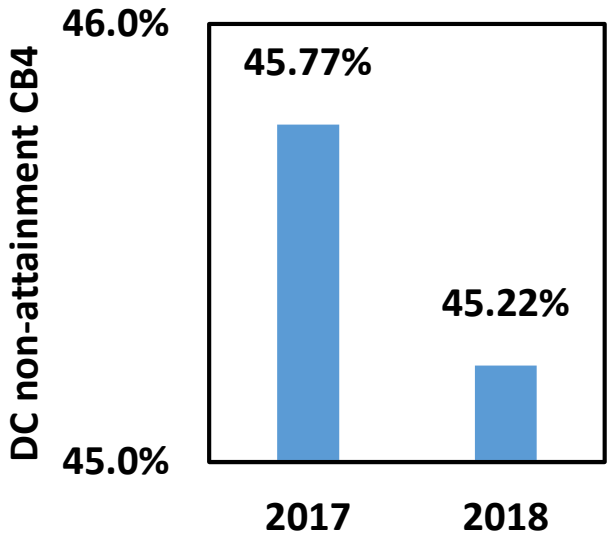


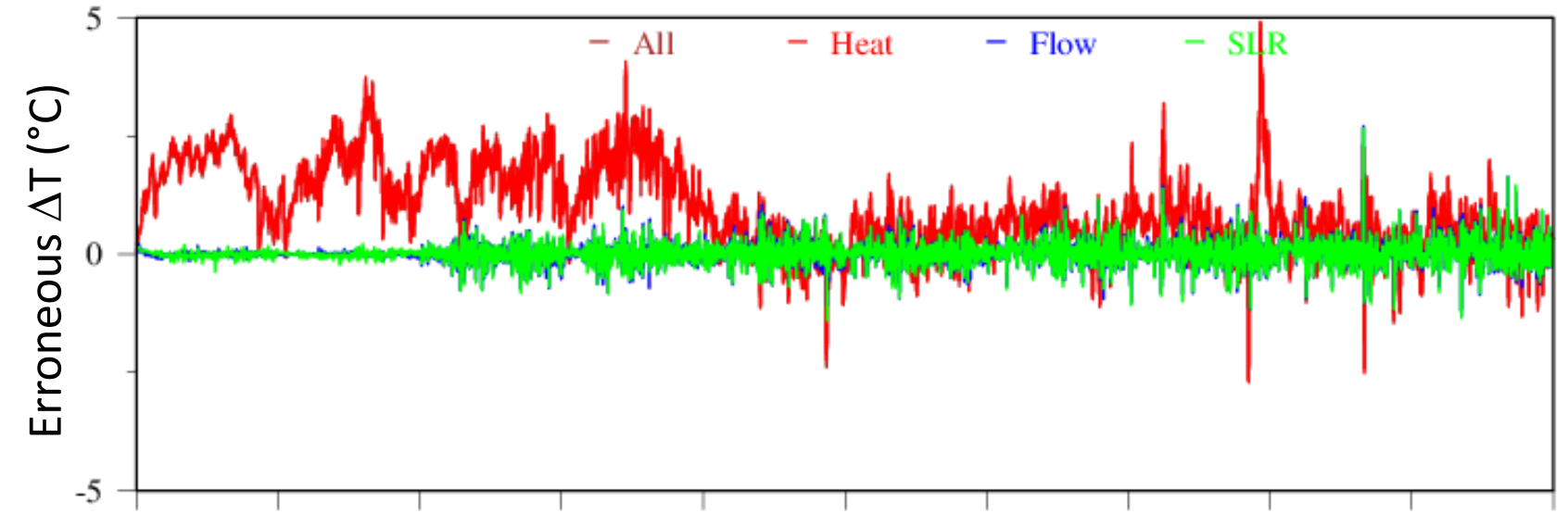



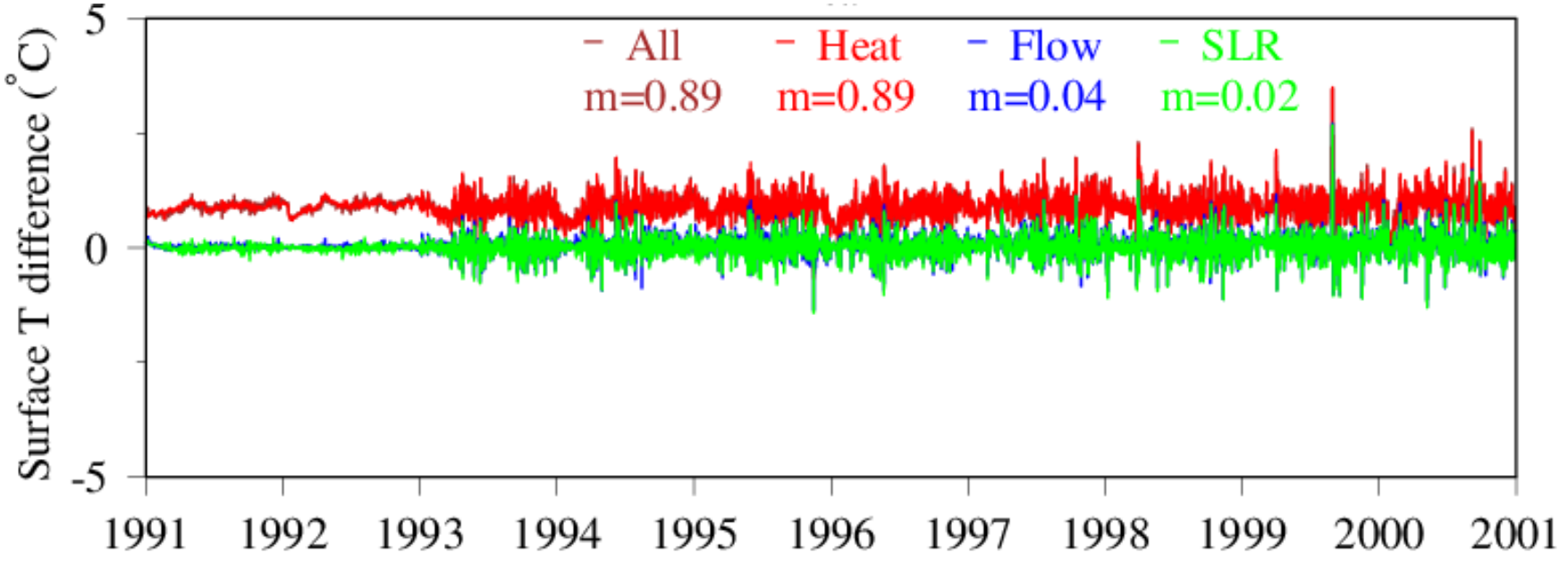
# 18 stations along the main stem were analyzed



# Surface temperature difference between climate change scenarios and the base case, Station CB4.3C.



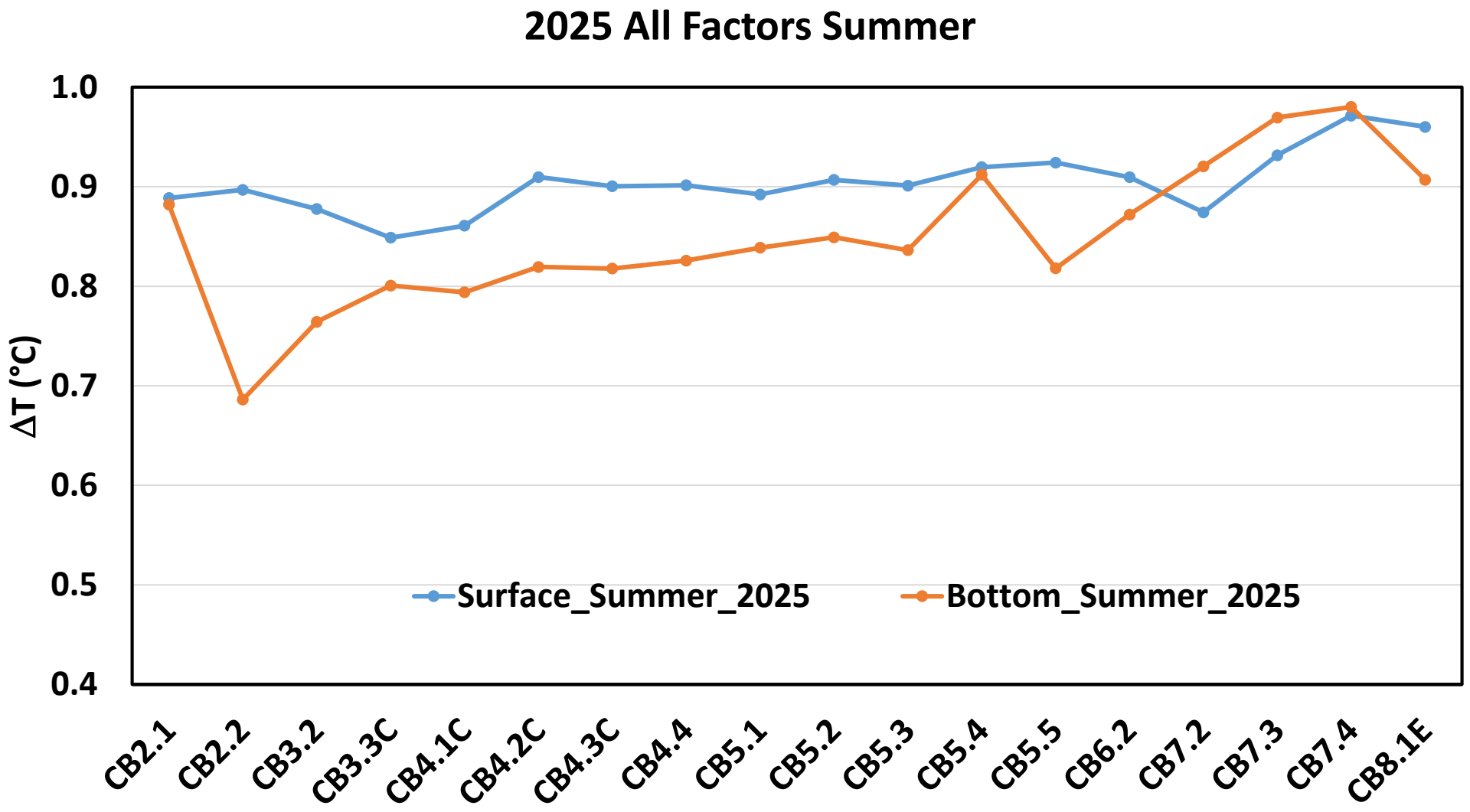

m: average over 10 years

Year

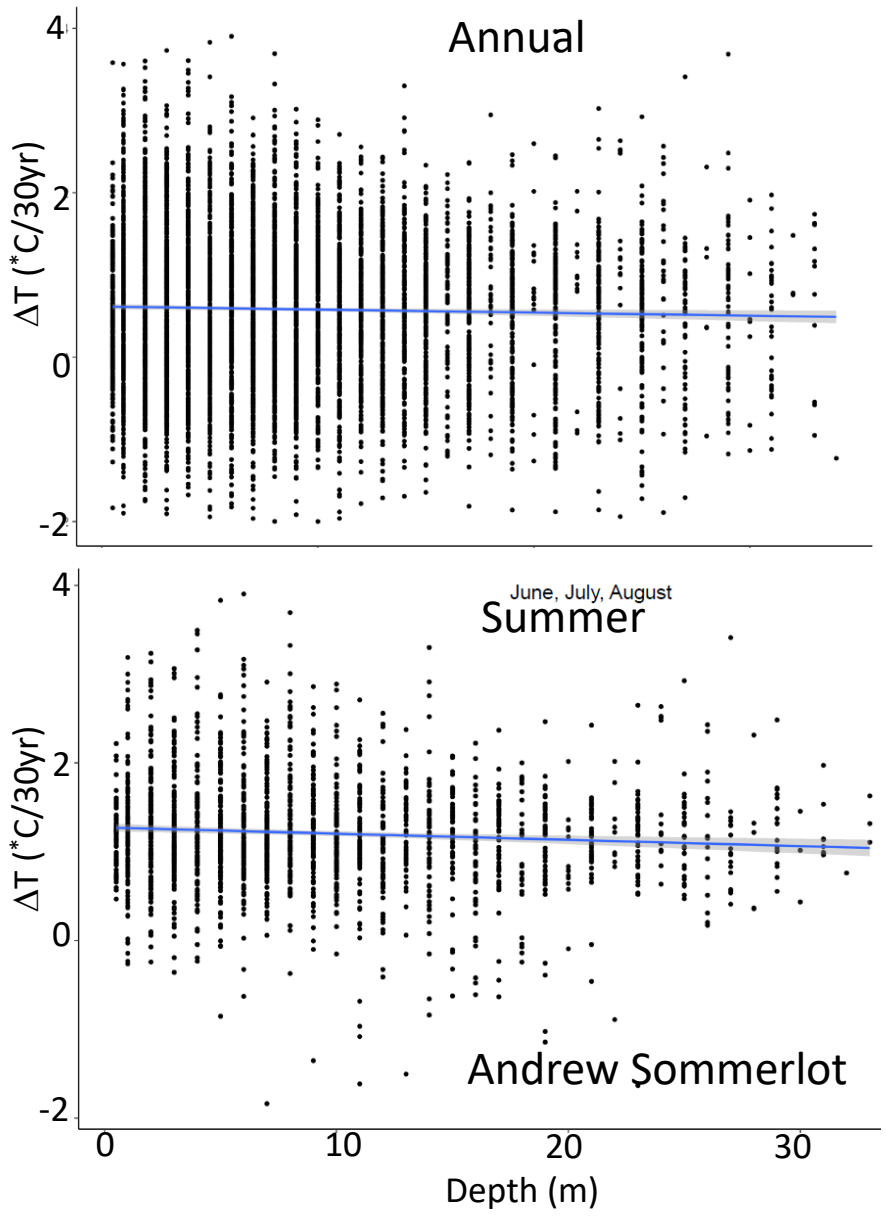
# Summer T change in the 2025 Climate Change scenario vs the base case

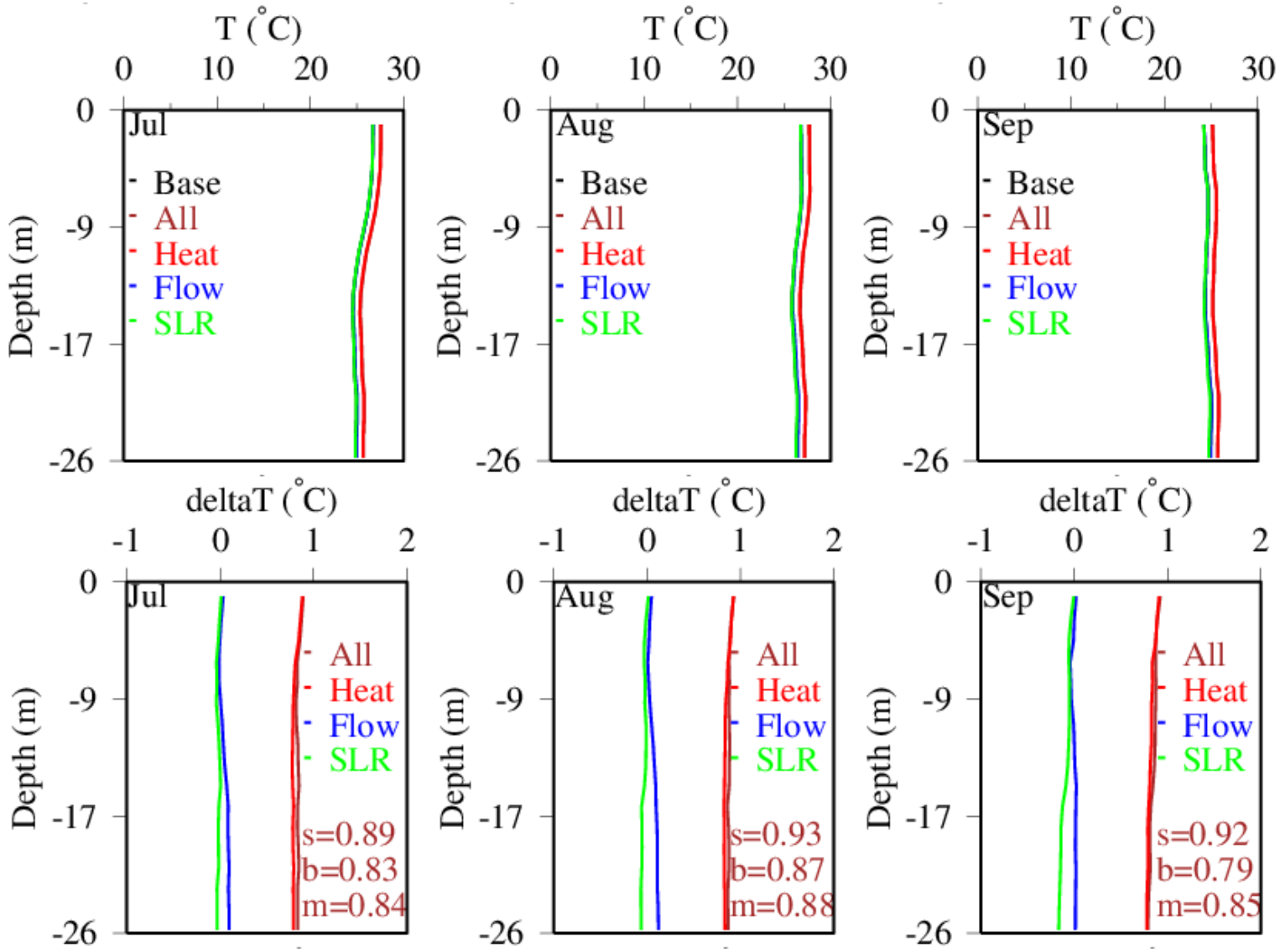
**Thomas et al 2017: data 1982-2014, 0.3 °C per decade;**

**Preston 2004: Data 1949-2002: 0.185 °C per decade;**



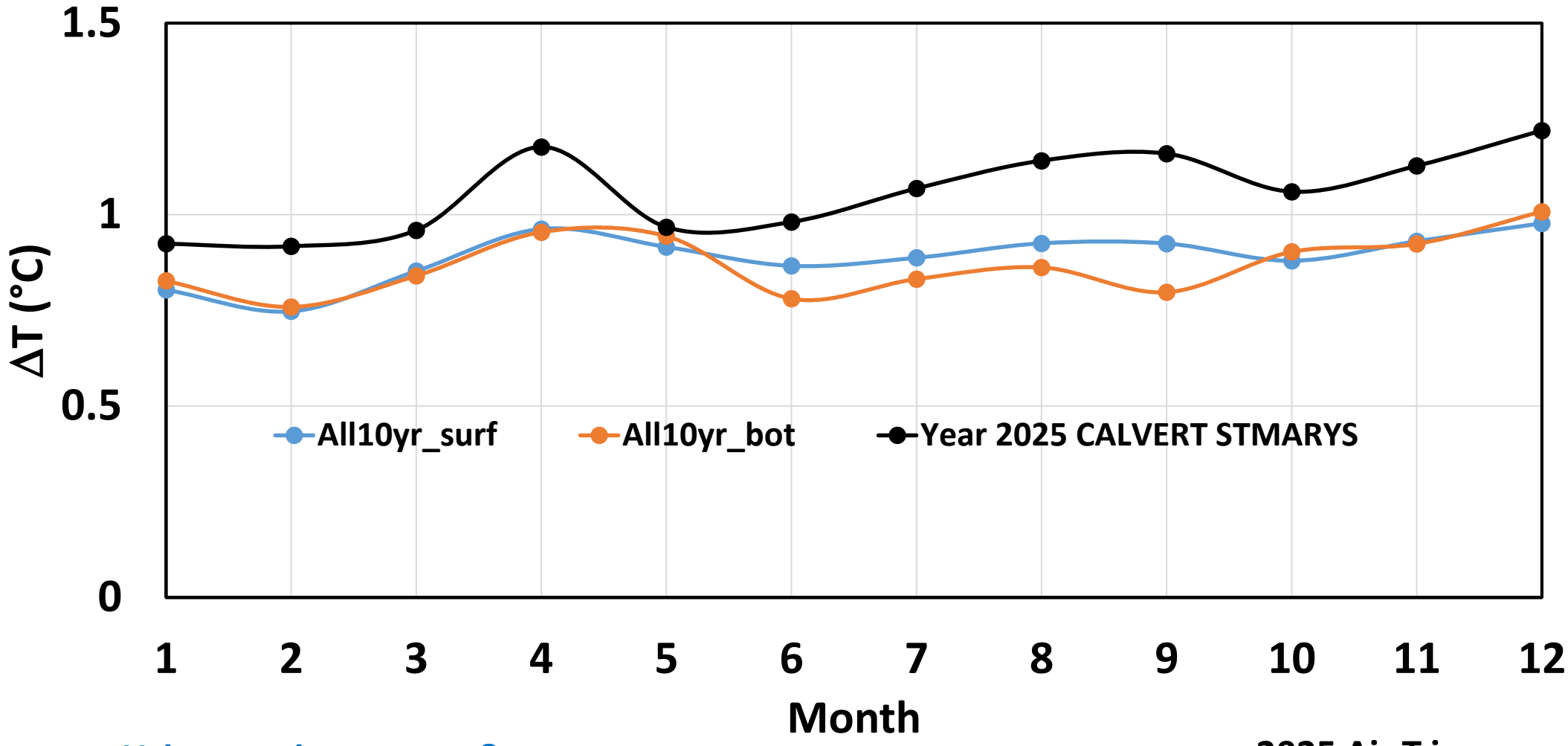
# T and ΔT profile at CB4.3C under 2025 CCC




**S: surface; b: bottom; m: vertical average over 10 years.**

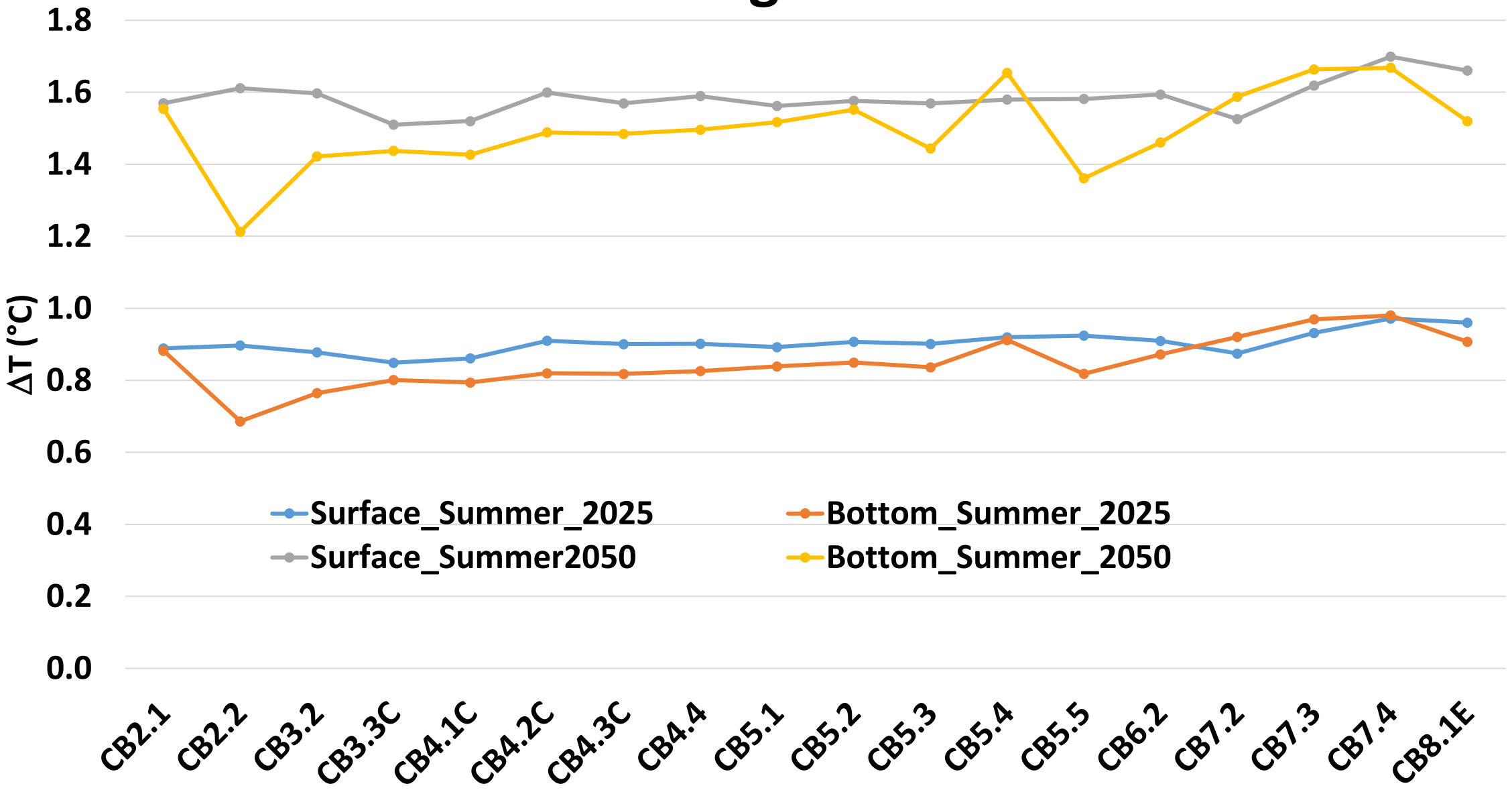
# Monthly air T change and surface T simulation at CB4.3C



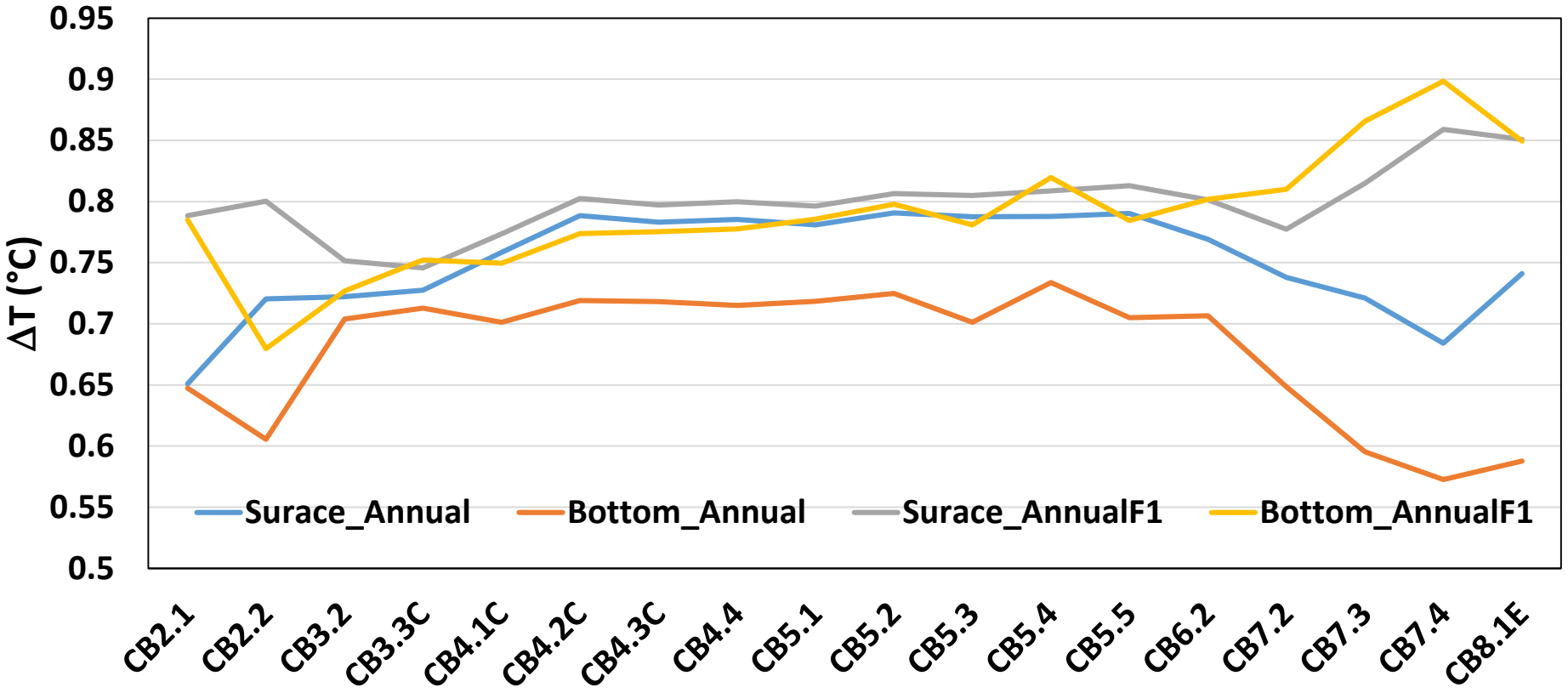

Using moving average?

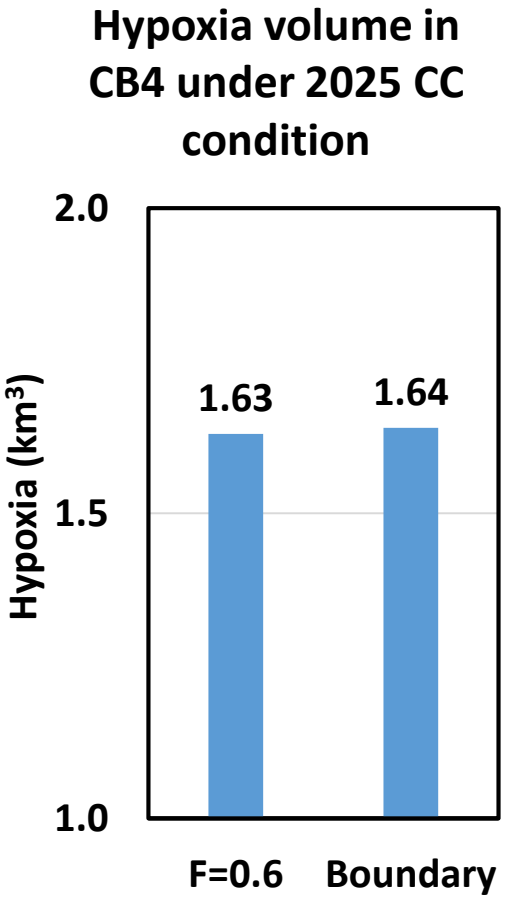
2025 Air T increase 1.05
2050 Air T increase 1.85

# Surface water T change 2025CC vs 2050CC



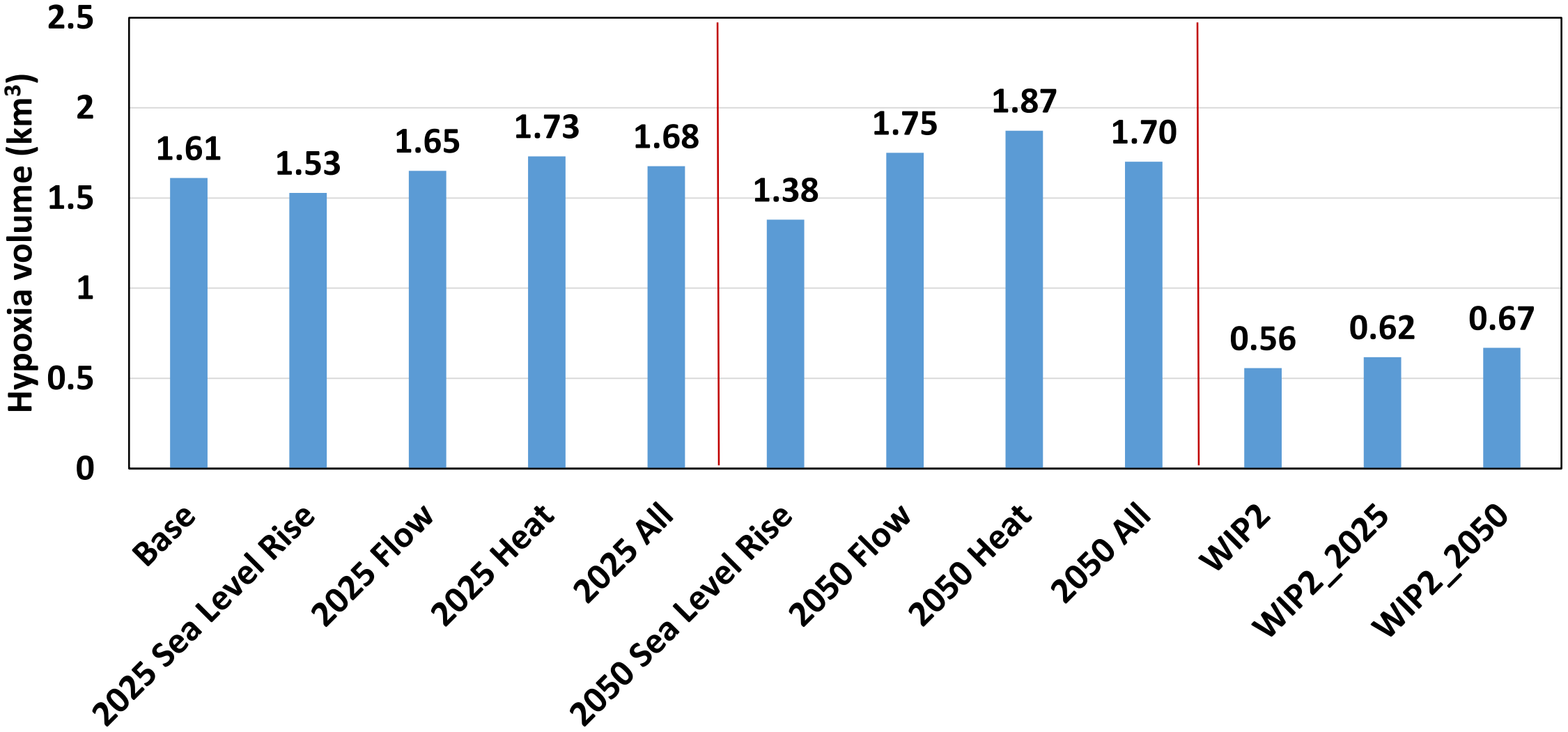
# Changes in surface T simulation by alter open boundary from 0.6 to 1 times of $\Delta T_{air}$




Open boundary has more influence in deeper layer than in the surface

# Summer (Jun-Sep) Hypoxia Volume (<1 mg/l) in CB4MH, 1991-2000



# Estimate on water quality attainment in the Deep Channel Designated Use

| Scenario | name | Base | 2025SLR_17cm | 2025Flow | 2025Heat | 2025All | 2050SLR_50cm | 2050Flow | 2050Heat | 2050All | WIP2 | WIP2_2025 | WIP2_2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen | loading | 325TN | 325TN | 333TN | 325TN | 333TN | 325TN | 352TN | 325TN | 352TN | 195TN | 200TN | 211TN |
| Phosph | loading | 21.9TP | 21.9TP | 22.6TP | 21.9TP | 22.6TP | 21.9TP | 25.3TP | 21.9TP | 25.3TP | 13.7TP | 14.1TP | 15.8TP |
| | | | | | | | | | | | | | |
| CB3MH | MD | 7.02% | 6.50% | 7.56% | 9.00% | 8.41% | 4.41% | 8.58% | 10.91% | 9.20% | 0.00% | 0.00% | 0.00% |
| CB4MH | MD | 44.76% | 42.07% | 45.51% | 47.66% | 46.44% | 36.45% | 48.27% | 51.11% | 47.71% | 5.02% | 6.80% | 9.61% |
| CB5MH_ | MD | 20.68% | 18.39% | 20.58% | 22.04% | 21.74% | 15.67% | 23.05% | 24.54% | 23.00% | 0.00% | 0.00% | 0.00% |
| CB5MH_ | VA | 4.03% | 2.65% | 4.63% | 6.16% | 5.39% | 0.48% | 7.66% | 8.74% | 6.97% | 0.00% | 0.00% | 0.00% |
| POTMH_ | MD | 15.47% | 13.56% | 15.68% | 17.21% | 17.06% | 10.32% | 17.16% | 19.39% | 18.77% | 0.00% | 0.00% | 0.00% |
| RPPMH | VA | 13.33% | 16.00% | 16.34% | 20.42% | 18.15% | 14.40% | 20.82% | 24.57% | 27.14% | 0.00% | 0.00% | 0.00% |
| ELIPH | VA | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| CHSMH | MD | 11.24% | 17.08% | 11.83% | 12.84% | 11.81% | 14.53% | 13.67% | 16.18% | 14.26% | 0.00% | 0.01% | 1.19% |
| EASMH | MD | 17.95% | 17.20% | 18.93% | 20.54% | 18.91% | 14.72% | 20.56% | 22.64% | 18.55% | 5.62% | 6.38% | 6.45% |

# Question

- **Which method for sea level rise, grid or open boundary?**
- **Sea level rise magnitude: 0.17 m in 2025 and 0.5 m in 2050 (linear interpolation: 2035: 0.3 m; 2045: 0.43 m; 2055: 0.57 m; 2065: 0.7 m; Waiting for final recommendation from Climate Change Resiliency WG)**
- **Factor for temperature adjustment at the open boundary (0.6 -1.0; 0.9)?**
- **Air temperature increase based on the Average of Calvert and St. Mary's counties, 3-year moving average?**

# ICPP AR5 2014

| AR5 global warming increase (°C) projections[7] | | |
|---|---|---|
| | 2046–2065 | 2081–2100 |
| Scenario | Mean and likely range | Mean and likely range |
| RCP2.6 | 1.0 (0.4 to 1.6) | 1.0 (0.3 to 1.7) |
| RCP4.5 | 1.4 (0.9 to 2.0) | 1.8 (1.1 to 2.6) |
| RCP6.0 | 1.3 (0.8 to 1.8) | 2.2 (1.4 to 3.1) |
| RCP8.5 | 2.0 (1.4 to 2.6) | 3.7 (2.6 to 4.8) |

| AR5 global mean sea level (m) increase projections[7] | | |
|---|---|---|
| | 2046–2065 | 2081–2100 |
| Scenario | Mean and likely range | Mean and likely range |
| RCP2.6 | 0.24 (0.17 to 0.32) | 0.40 (0.26 to 0.55) |
| RCP4.5 | 0.26 (0.19 to 0.33) | 0.47 (0.32 to 0.63) |
| RCP6.0 | 0.25 (0.18 to 0.32) | 0.48 (0.33 to 0.63) |
| RCP8.5 | 0.30 (0.22 to 0.38) | 0.63 (0.45 to 0.82) |