Validation of Estuarine Water Temperature Simulation

Richard Tian and Modeling Team
UMCES/CBPO

Modeling Quarterly Review
Oct. 9, 2019
Annapolis

Context
Climate Change Document 2019

5. Estuarine Water Quality and Sediment Transport Model Results

5.3. Validation of model response

5.3.2. Reasonable Response to Temperature Change

Outline

- **Temperature simulation under climate change conditions**

  Estimating estuarine water column temperature is a key consideration for simulating Chesapeake hypoxia under climate change conditions and includes estuarine water column temperature from watershed boundary forcing, air boundary forcing, and ocean boundary forcing (considered previously in July Quarterly Review).

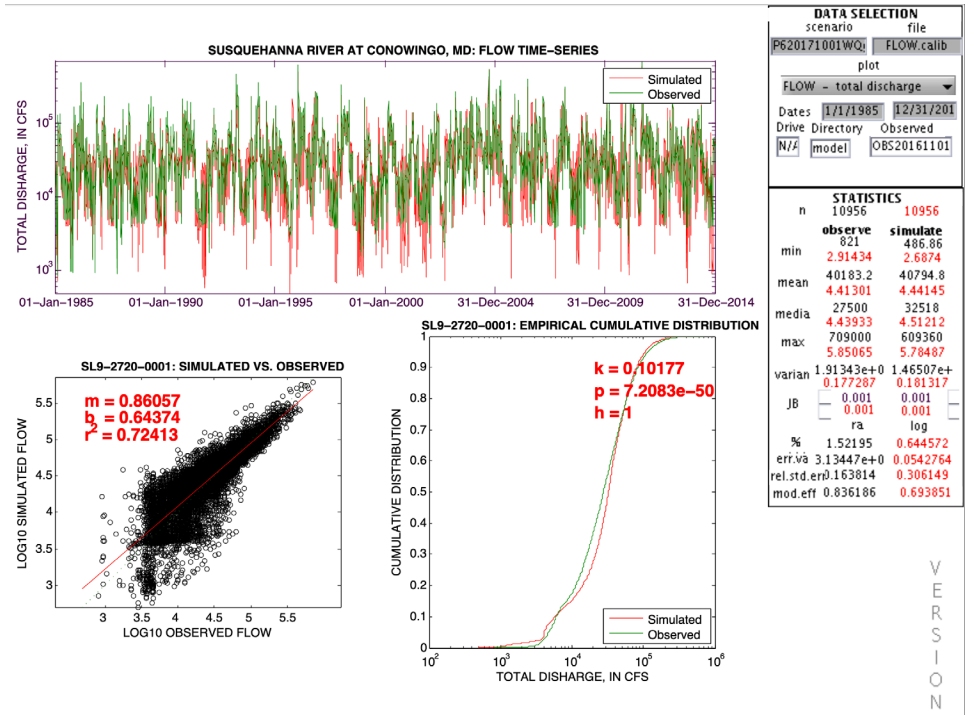
- **Comparison with data and literature**
- **Simulated pattern**
- **Request of approval**

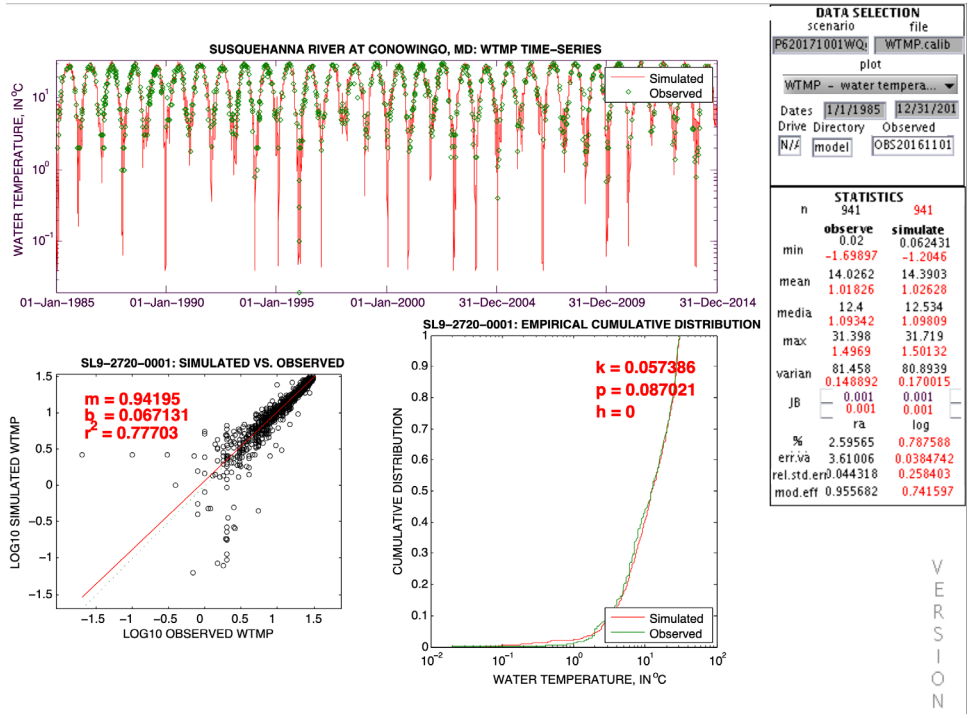
Watershed Boundary Forcing

Watershed Inputs

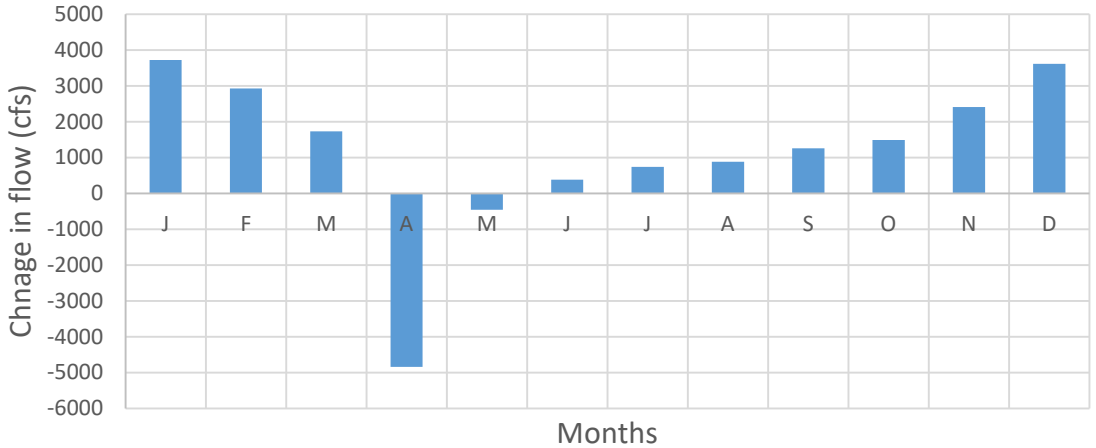
Susquehanna River at Conowingo, MD

From Gopal Bhatt

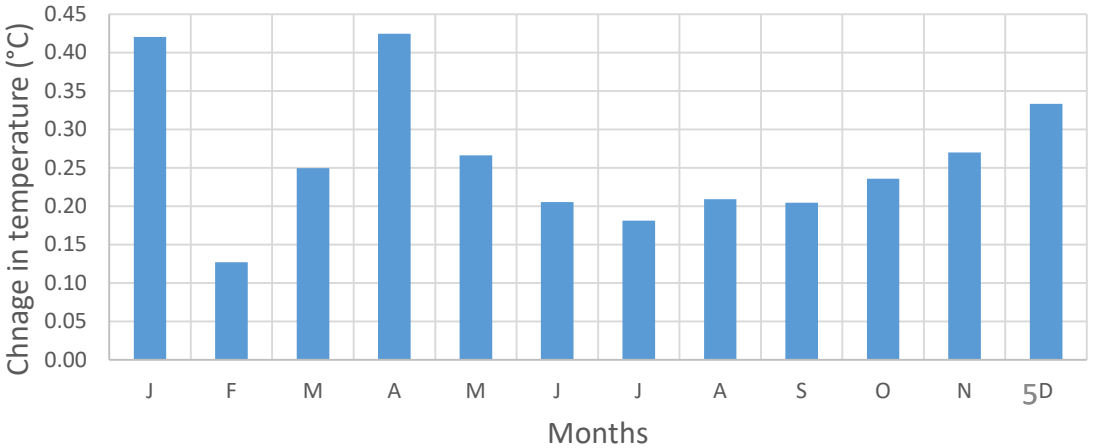




Average Monthly Change in Flow

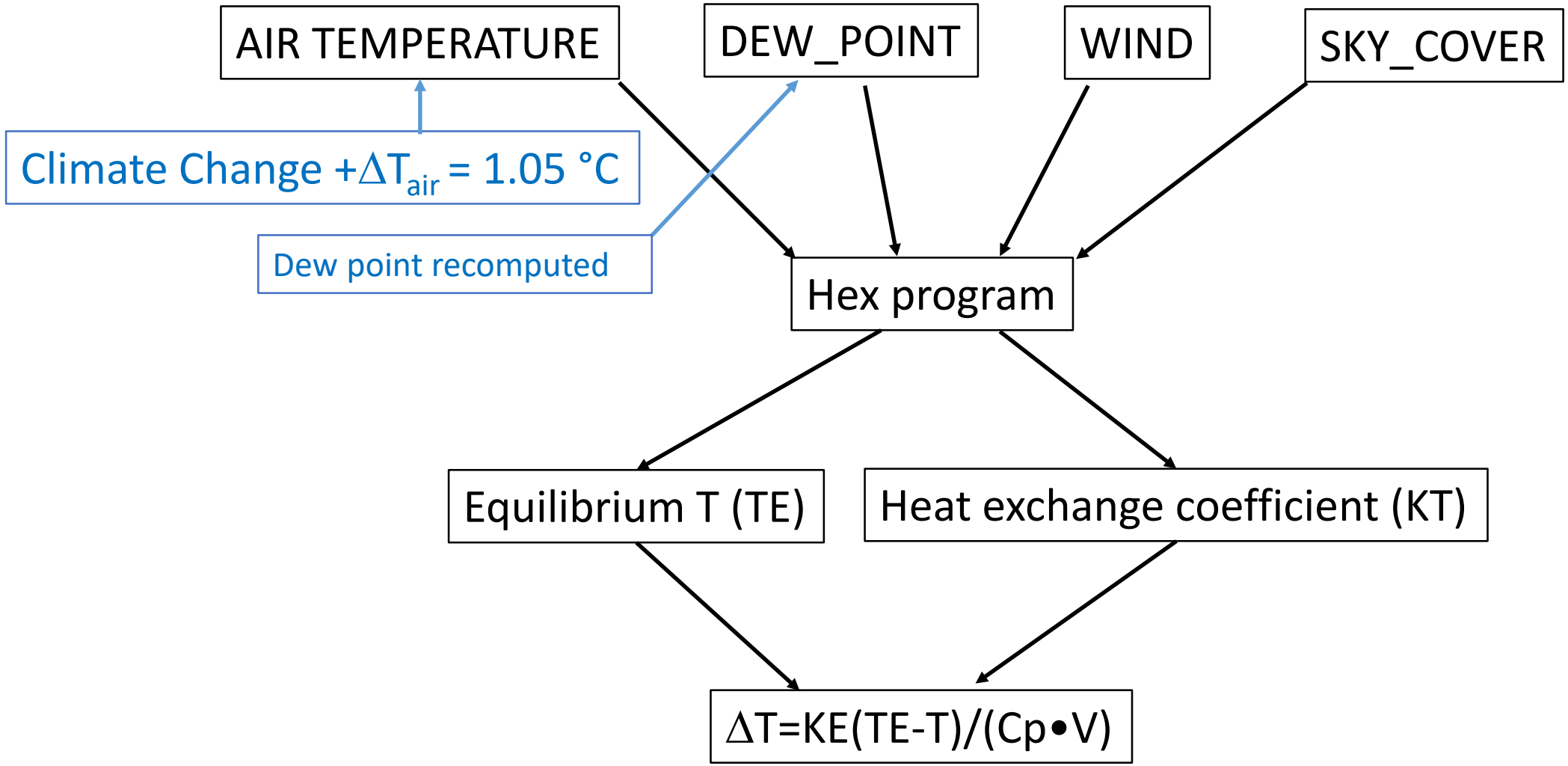


Average Monthly Change in Water Temperature

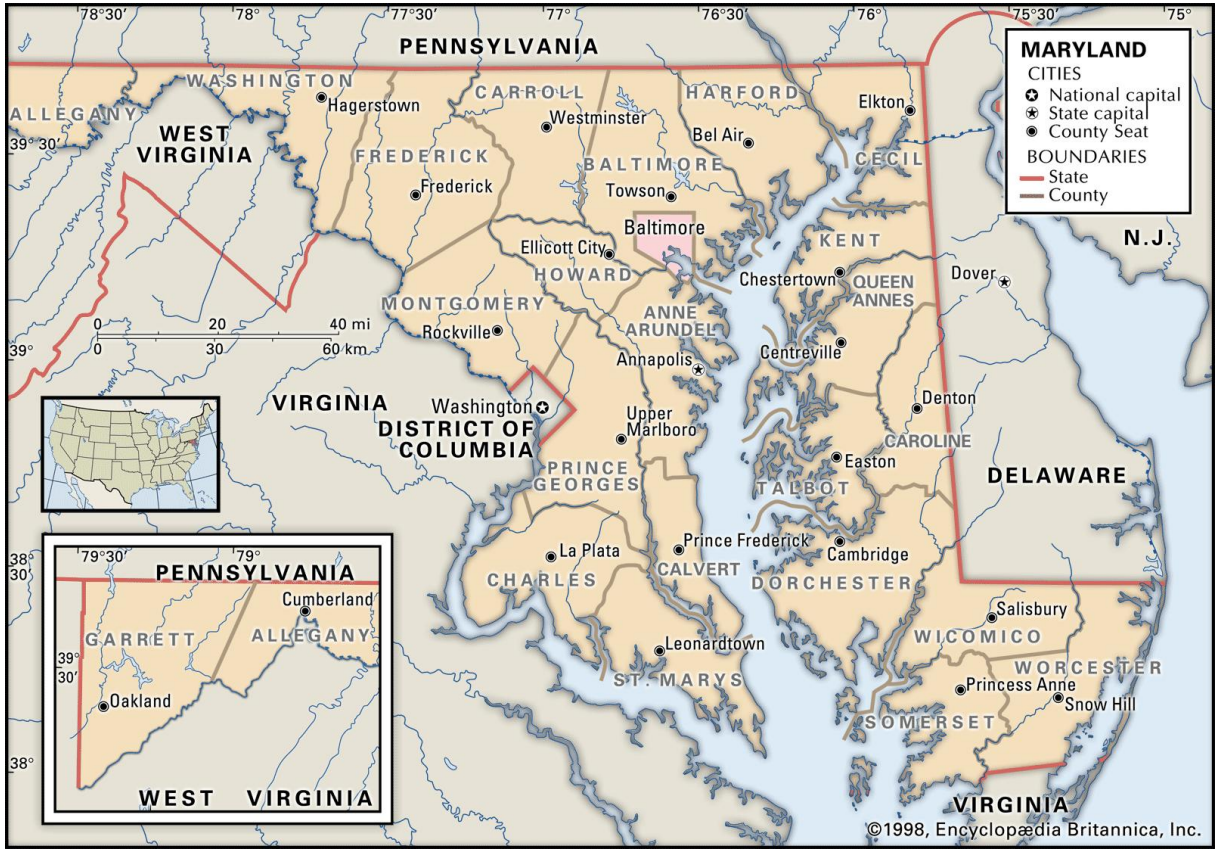


Air Boundary Forcing

ICM meteorological forcing



Atmospheric forcing data from the Patuxent Naval Air Station located at the Patuxent River mouth between Calvert and St. Mary's counties.

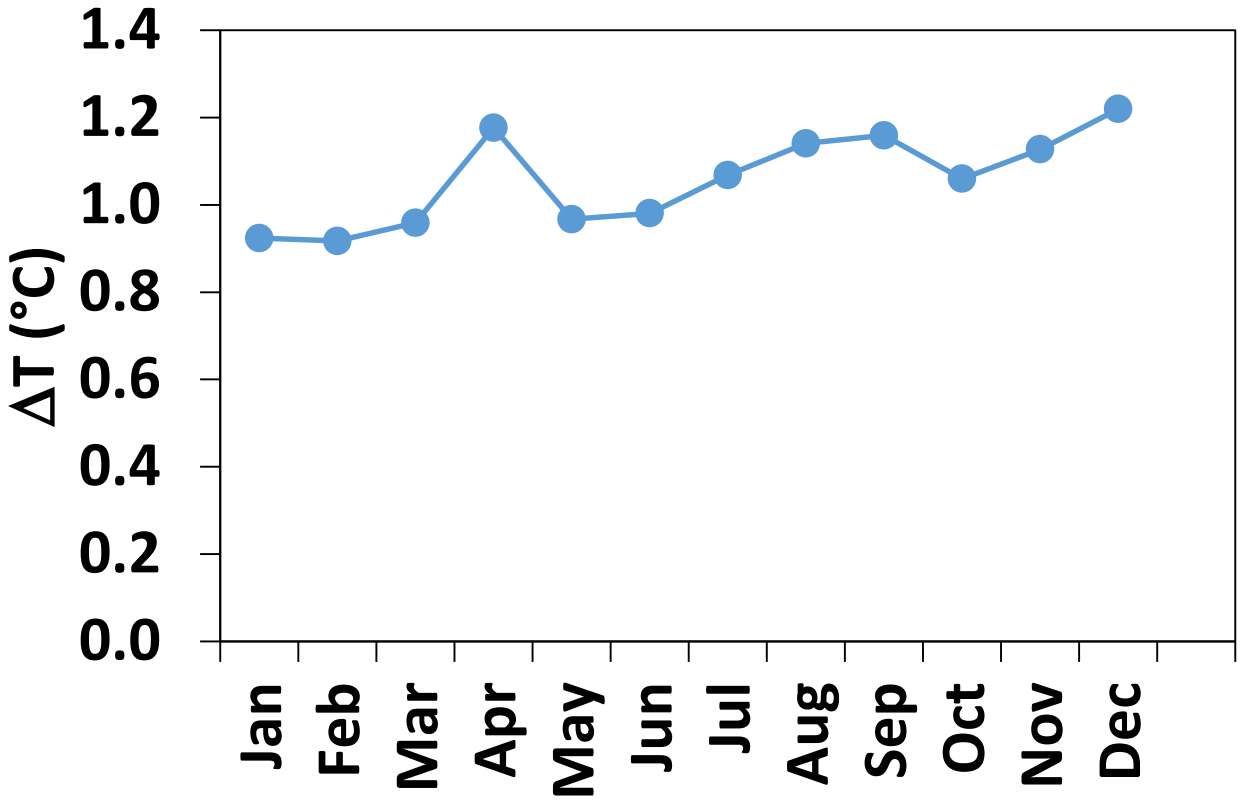


Atmospheric forcing data for climate change are from downscaling analysis of 31 GCMs to county (land-segment) level.

Model Name	Model Country	Model Agency	Atmosphere Resolution(Lon x Lat)	Ensemble Used
bcc-csm1-1	China	Beijing Climate Center, China Meteorological Administration	2.8 deg x 2.8 deg	r1i1p1
bcc-csm1-1-m	China	Beijing Climate Center, China Meteorological Administration	1.12 deg x 1.12 deg	r1i1p1
BNU-ESM	China	College of Global Change and Earth System Science, Beijing Normal University, China	2.8 deg x 2.8 deg	r1i1p1
CanESM2	Canada	Canadian Centre for Climate Modeling and Analysis	2.8 deg x 2.8 deg	r1i1p1
CCSM4	USA	National Center of Atmospheric Research, USA	1.25 deg x 0.94 deg	r6i1p1
CNRM-CM5	France	National Centre of Meteorological Research, France	1.4 deg x 1.4 deg	r1i1p1
CSIRO-Mk3-6-0	Australia	Commonwealth Scientific and Industrial Research Organization/Queensland Climate Change Centre of Excellence, Australia	1.8 deg x 1.8 deg	r1i1p1
GFDL-ESM2M	USA	NOAA Geophysical Fluid Dynamics Laboratory, USA	2.5 deg x 2.0 deg	r1i1p1
GFDL-ESM2G	USA	NOAA Geophysical Fluid Dynamics Laboratory, USA	2.5 deg x 2.0 deg	r1i1p1
HadGEM2-ES	United Kingdom	Met Office Hadley Center, UK	1.88 deg x 1.25 deg	r1i1p1
HadGEM2-CC	United Kingdom	Met Office Hadley Center, UK	1.88 deg x 1.25 deg	r1i1p1
inmcm4	Russia	Institute for Numerical Mathematics, Russia	2.0 deg x 1.5 deg	r1i1p1
IPSL-CM5A-LR	France	Institut Pierre Simon Laplace, France	3.75 deg x 1.8 deg	r1i1p1
IPSL-CM5A-MR	France	Institut Pierre Simon Laplace, France	2.5 deg x 1.25 deg	r1i1p1
IPSL-CM5B-LR	France	Institut Pierre Simon Laplace, France	2.75 deg x 1.8 deg	r1i1p1
MIROC5	Japan	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies,and Japan Agency for Marine-Earth Science and Technology	1.4 deg x 1.4 deg	r1i1p1
MIROC-ESM	Japan	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	2.8 deg x 2.8 deg	r1i1p1
MIROC-ESM-CHEM	Japan	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	2.8 deg x 2.8 deg	r1i1p1
MRI-CGCM3	Japan	Meteorological Research Institute, Japan	1.1 deg x 1.1 deg	r1i1p1
NorESM1-M	Norway	Norwegian Climate Center, Norway	2.5 deg x 1.9 deg	r1i1p1

Monthly air temperature change by 2025 averaged between Calvert and St. Mary's counties

Annual average: 1.058 °C



From Gopal Bhatt

Water temperature change in the water column at the open boundary from 1995 to 2025

$$\Delta T_{water} = 0.9 \bullet \Delta T_{air} \bullet T_{water} / T_{surface}$$

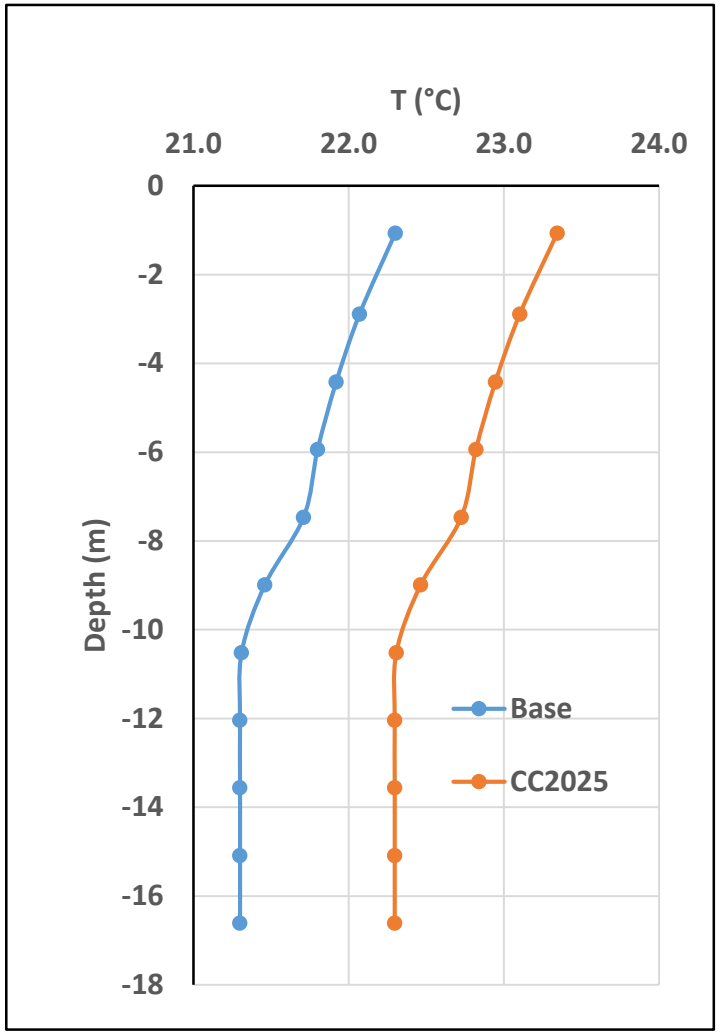
where

T_{water} = water temperature.

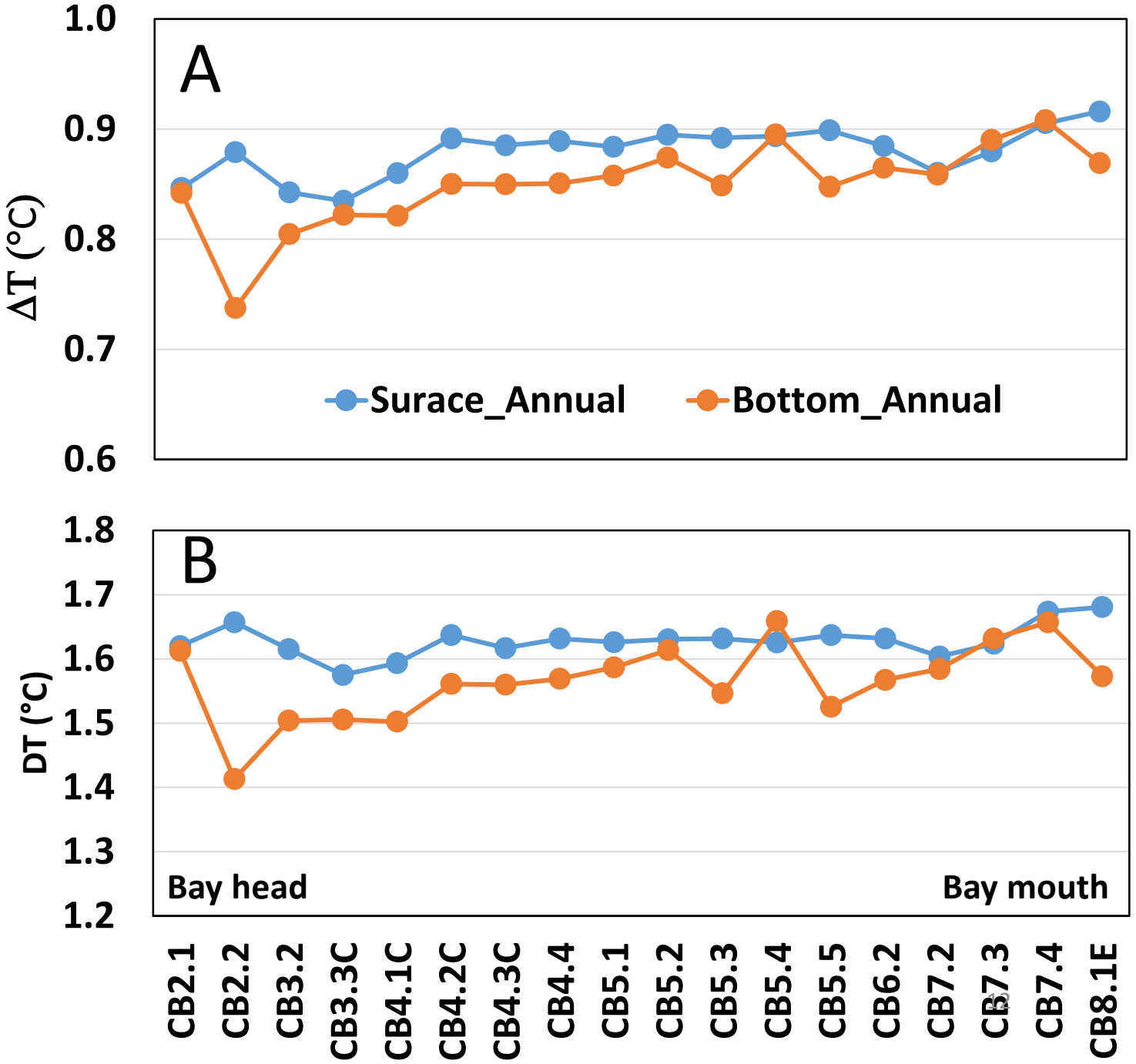
$T_{surface}$ = surface water temperature.

ΔT_{air} = air temperature change under climate change condition from downscaling GCMs ensemble projection.

The factor 0.9 will be applied to other periods 2035, 2045, and 2055 with acceleration included in the GCMs.

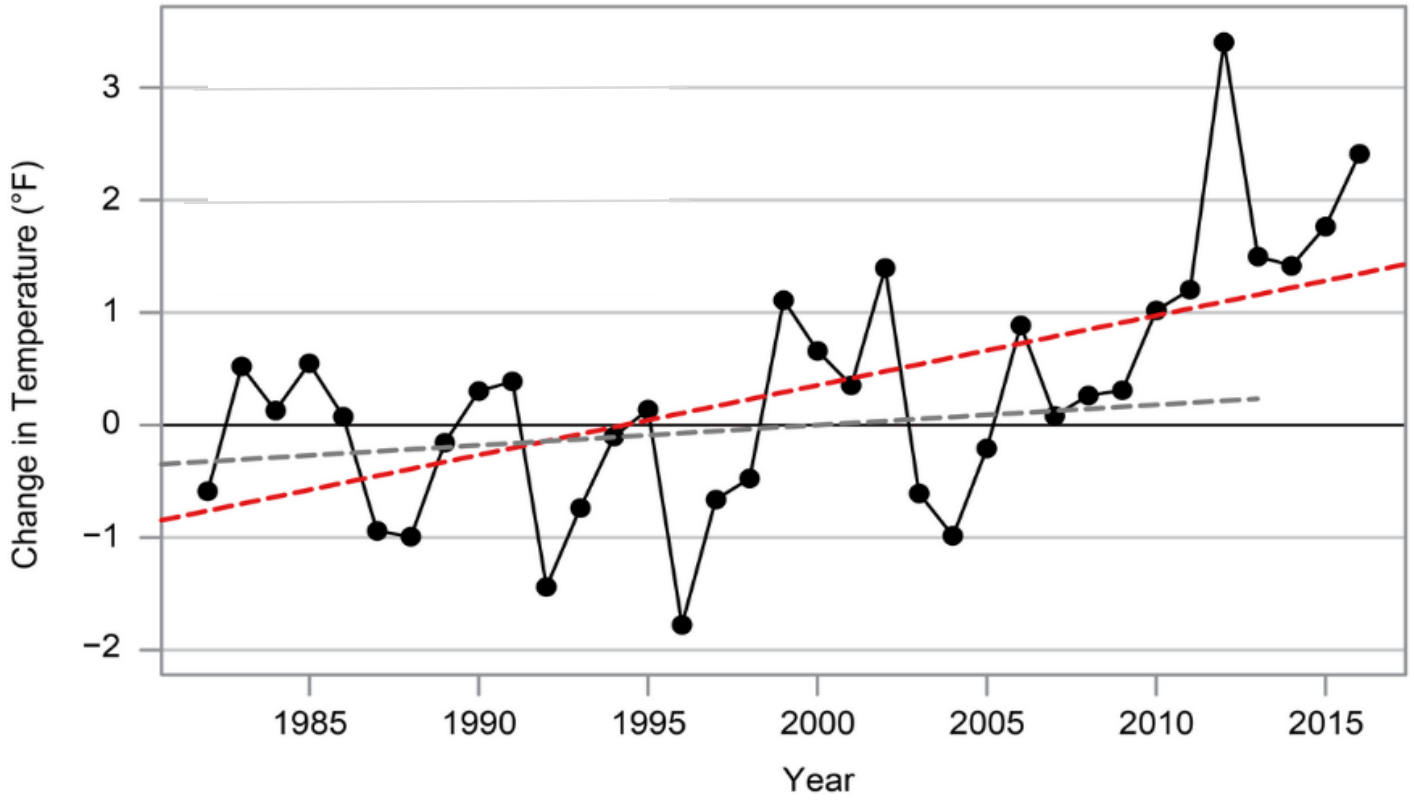


Summer water temperature change under 2025 (A) and 2055 CC (B) conditions (average 1991-2000)



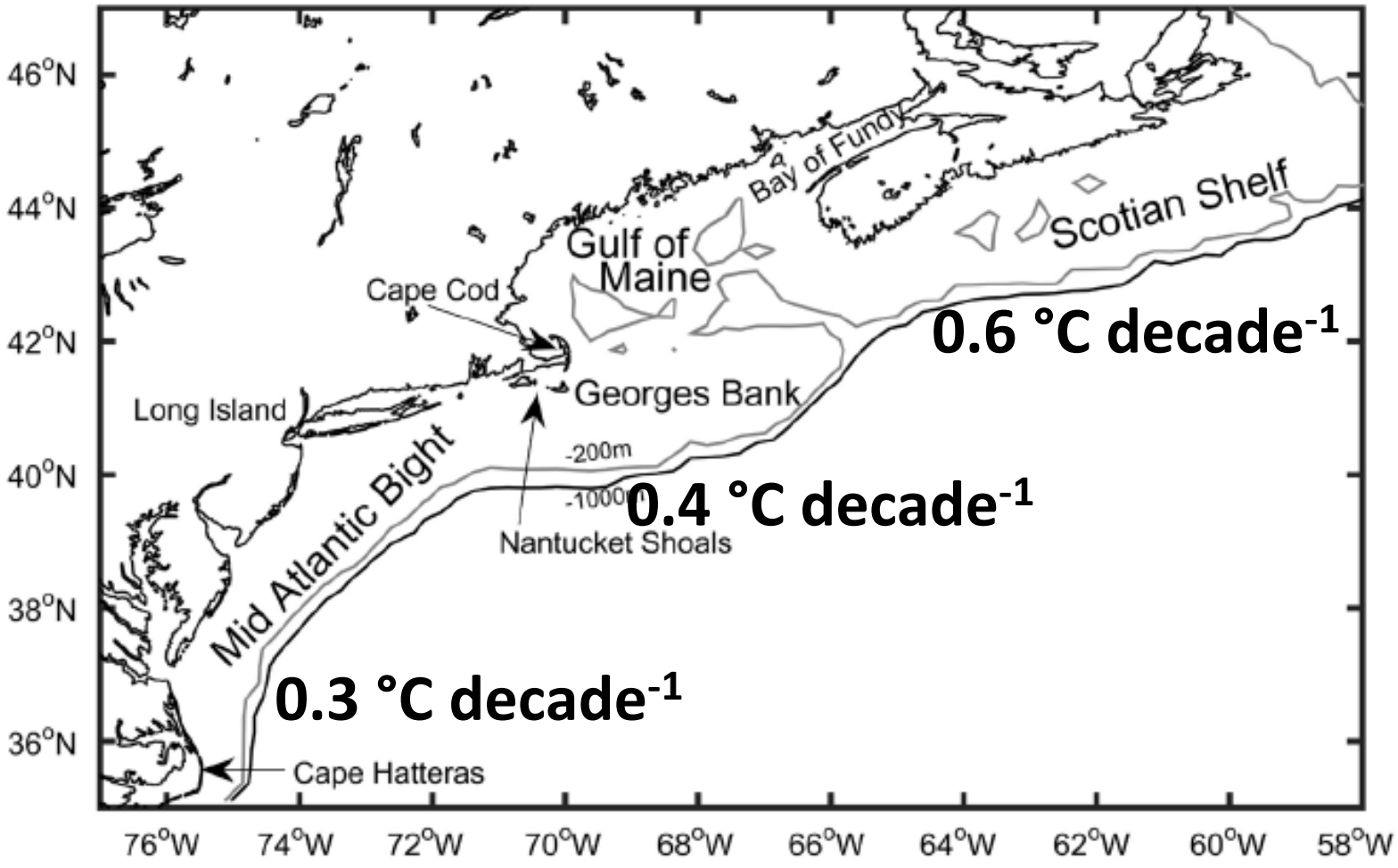
Comparison with Data and Literature

Sea Surface Temperature (SST) Trend On the Northeast Continental Shelf of USA (Maine – Maryland)



SST increased 0.33 °C per decade from 1982 to 2016 (NOAA, Dupigny-Giroux et al., 2018).

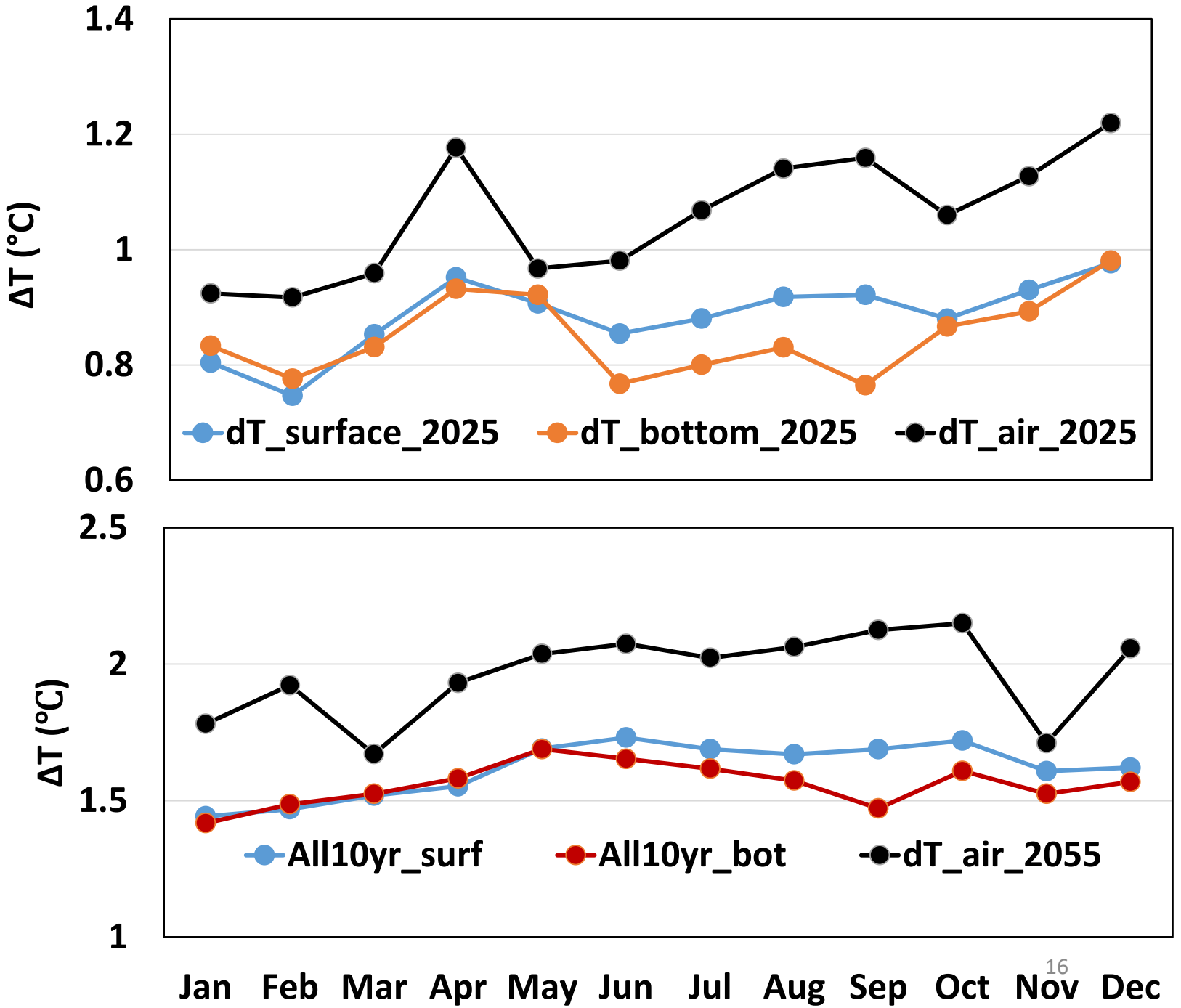
SST increase region by region



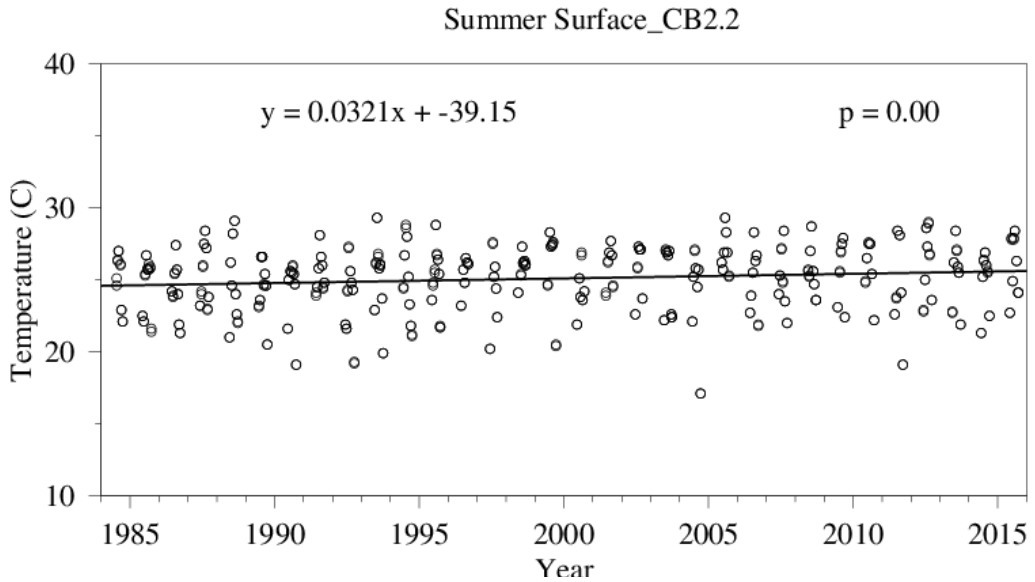
Data from 1982-2014; Thomas et al., 2017

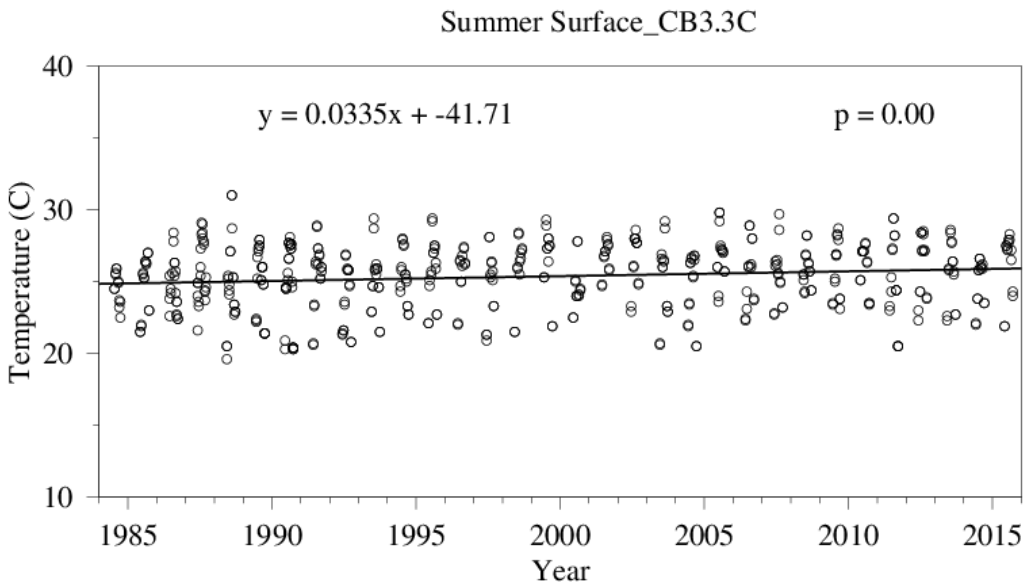
Monthly air T change and water T simulation at CB4.3C by 2025 (upper) and 2055 (lower panel)

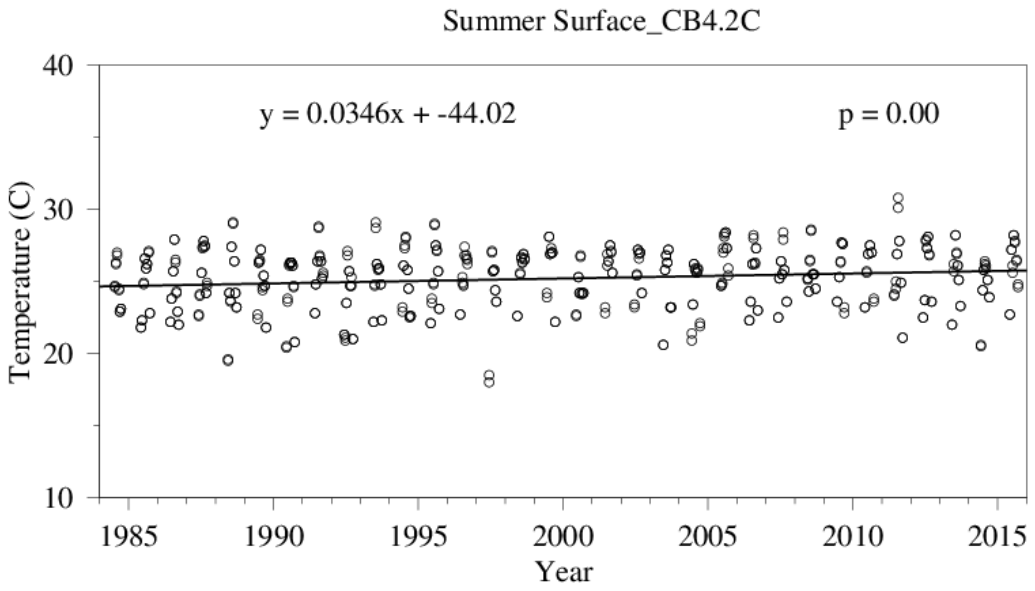
(Irby et al., 2018: deltaT=1.75 ℃ by 2050

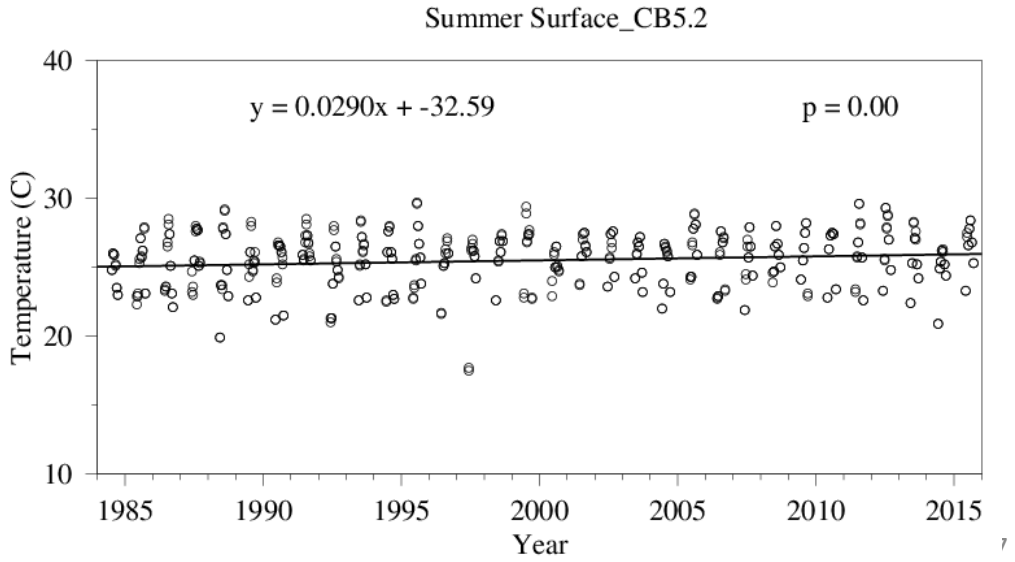


Surface water temperature in the main stem



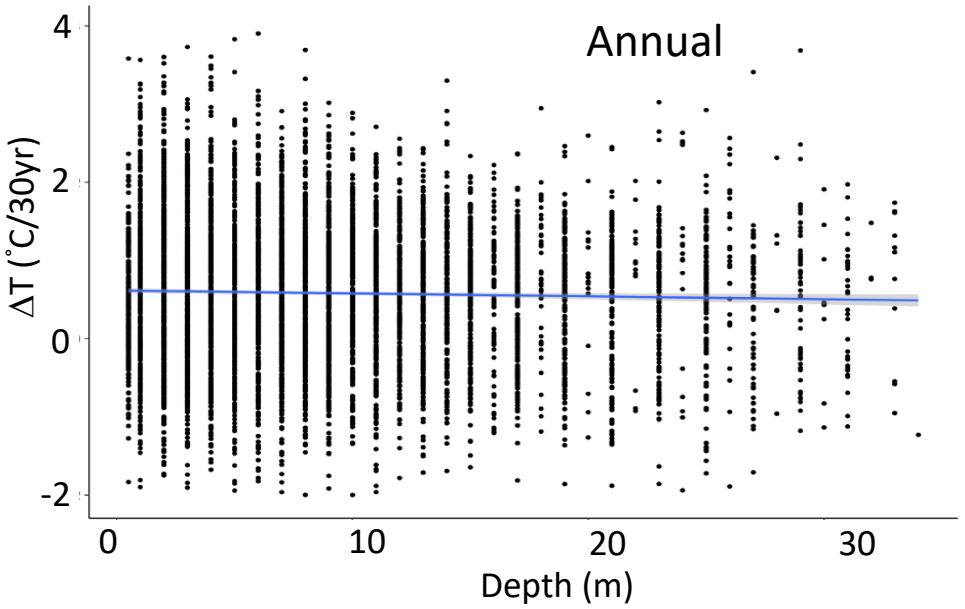




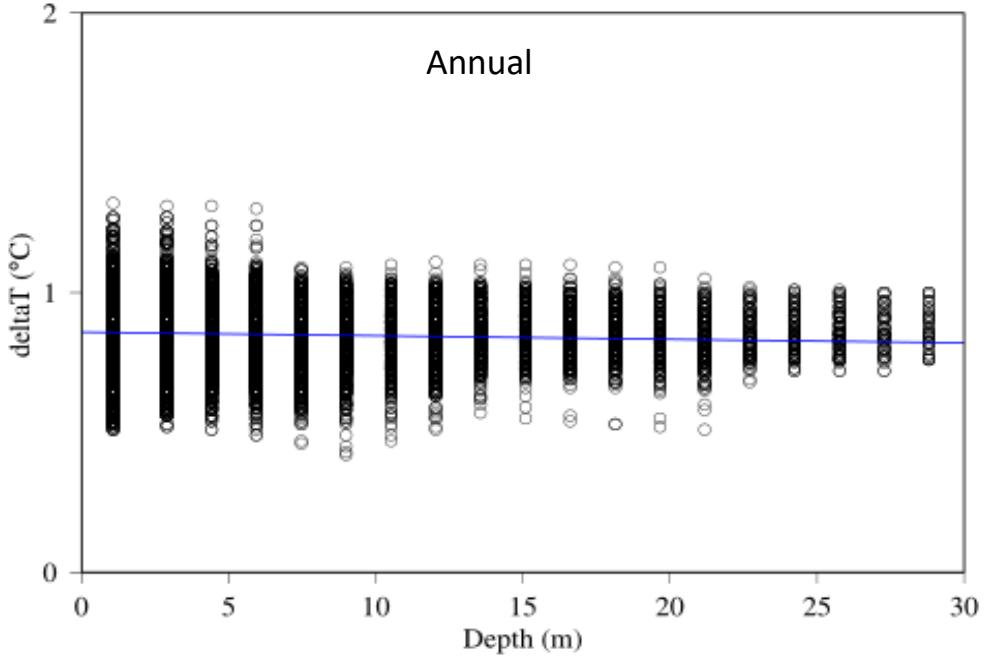


Observation (upper) and simulation (lower) of Temperature change over 30 years (Andrew Sommerlot)

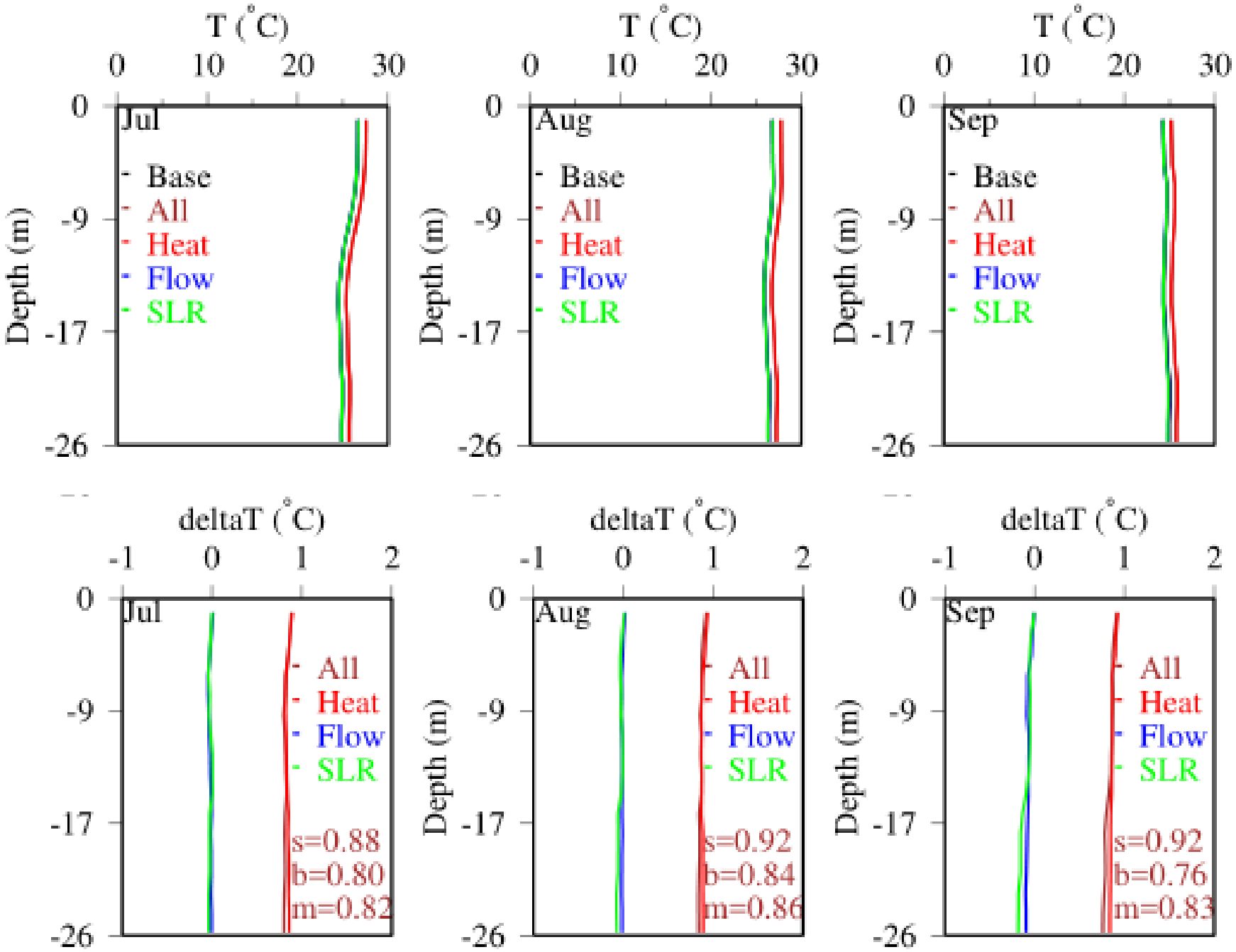
Data



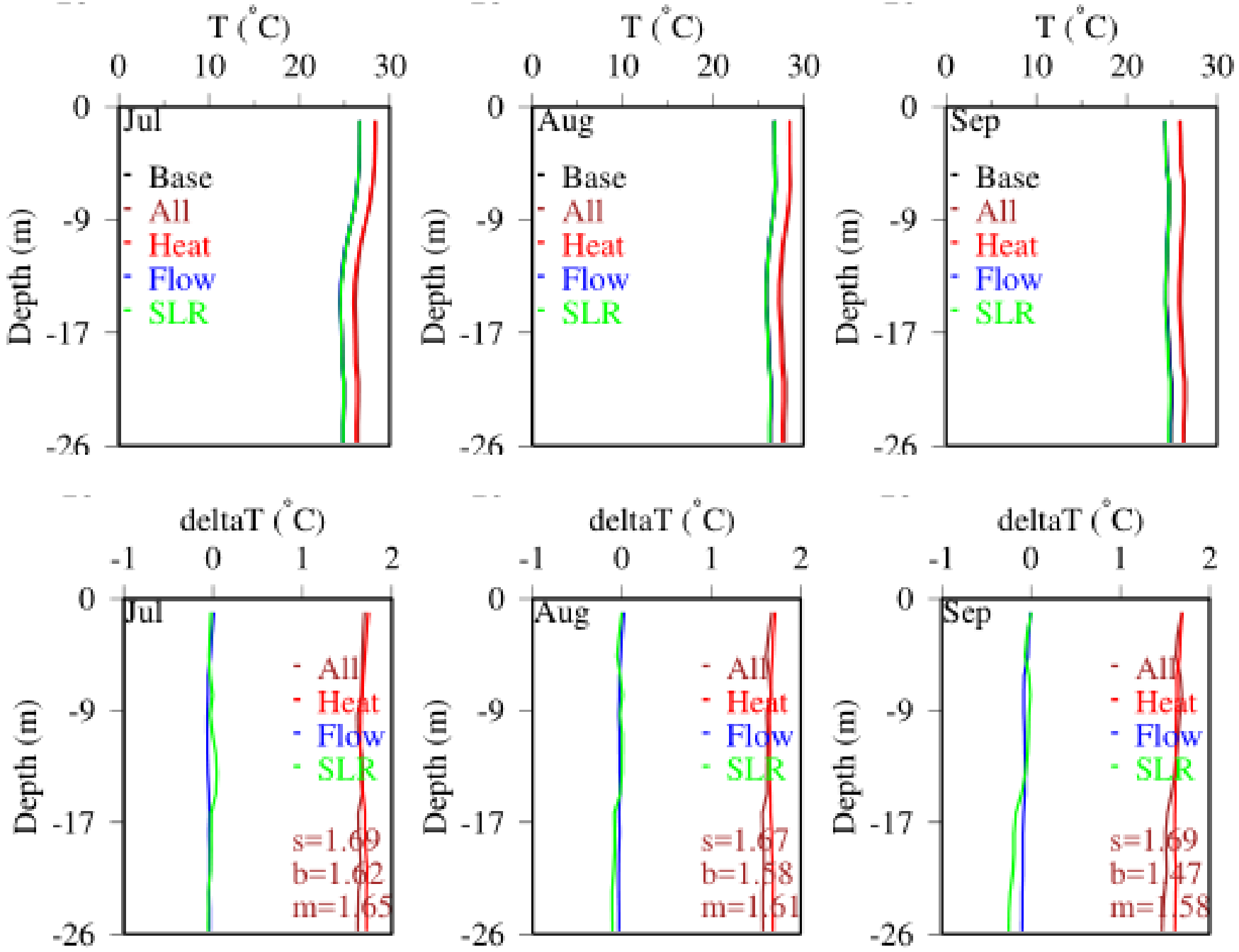
Model



Projected 2025 T profile at CB4.2C



Projected 2055 T profile at CB4.2C



Summary and request of approval

Overall, the model predictions of water temperature change under climate change conditions are in reasonable agreement with the literature and observations. Although it is inevitable that discrepancies occur between simulation and observation, partly due to the large variation in the data, the model predictions are comparable with the data in terms of magnitude and vertical patterns of temperature change under climate change conditions.