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Effects of Climate Change on Water Quality in the Yaquina Estuary, Oregon

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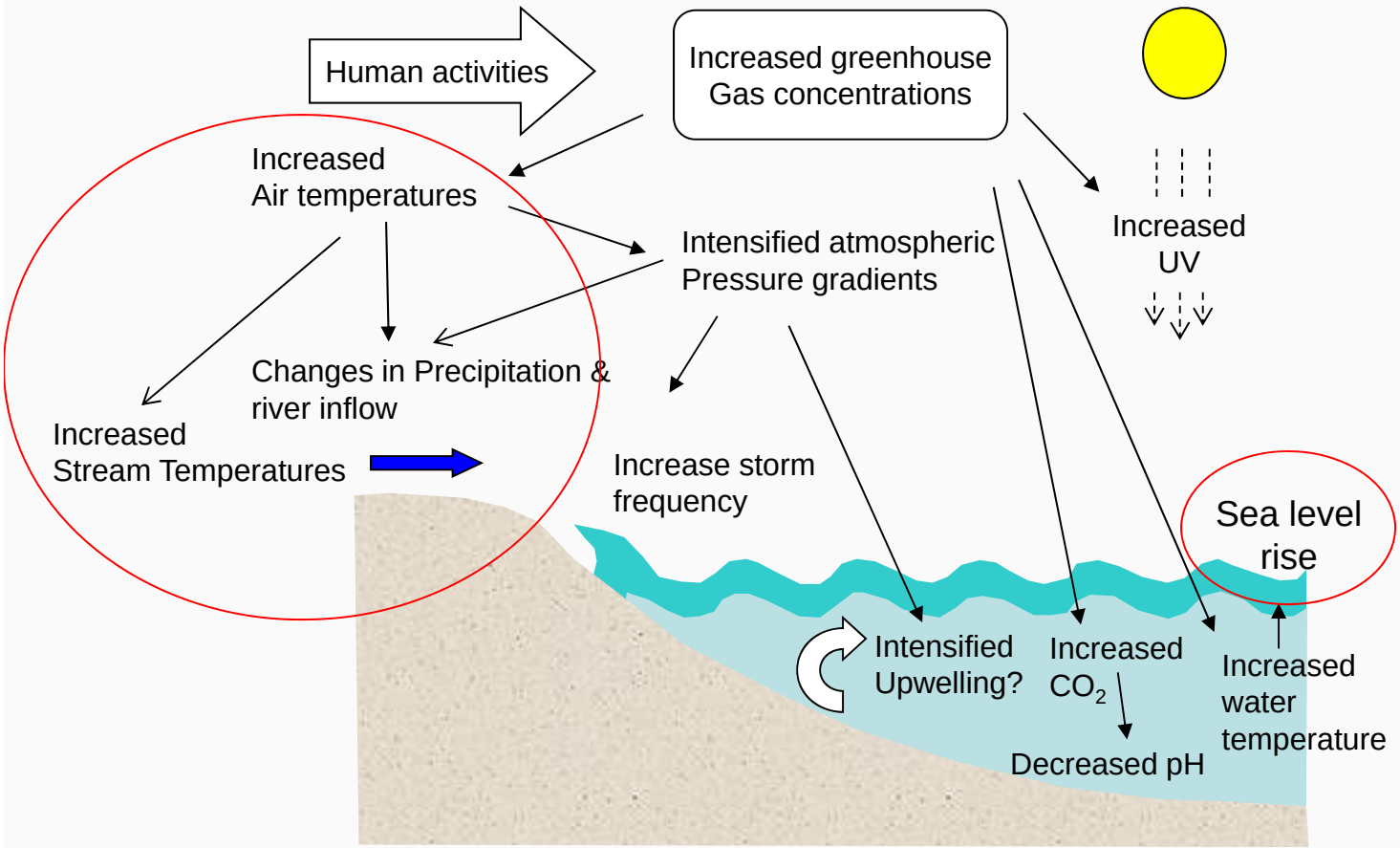
[3]Portland State University

Study Background

Predicting CC threats to key estuarine habitats & ecosystem services.

US EPA, USGS, USDA, USFS, USFWS, Oregon DSL
Nature Conservancy, OCCRI, OIMB, PSU



Modified from Harley et al. (2006)

Climate Change Impacts Are Expected to Vary With Estuary Type

Marine — Riverine

Netarts

Yaquina

Coquille

Methods

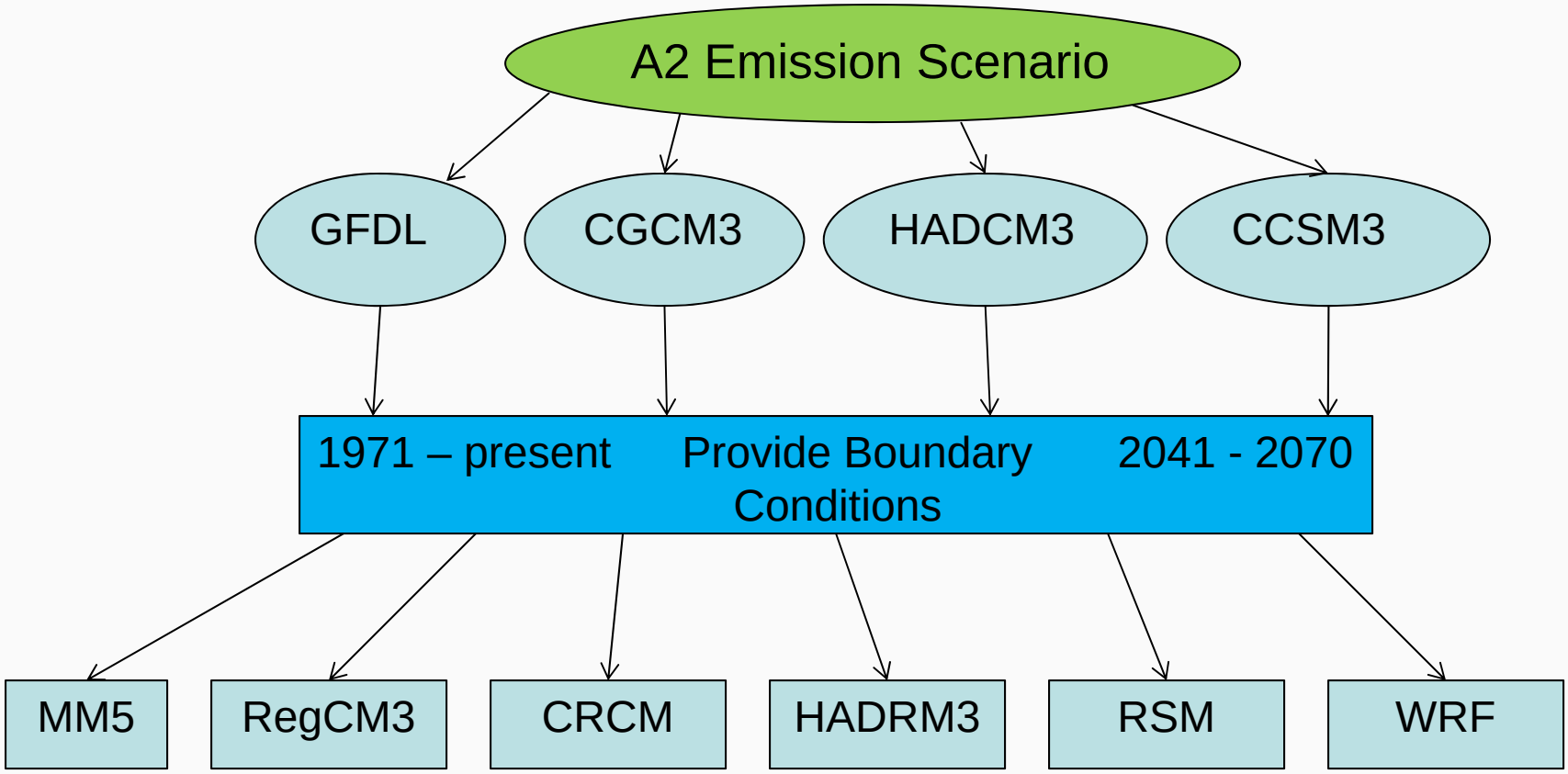
Downscaled Scenarios from NARCCAP

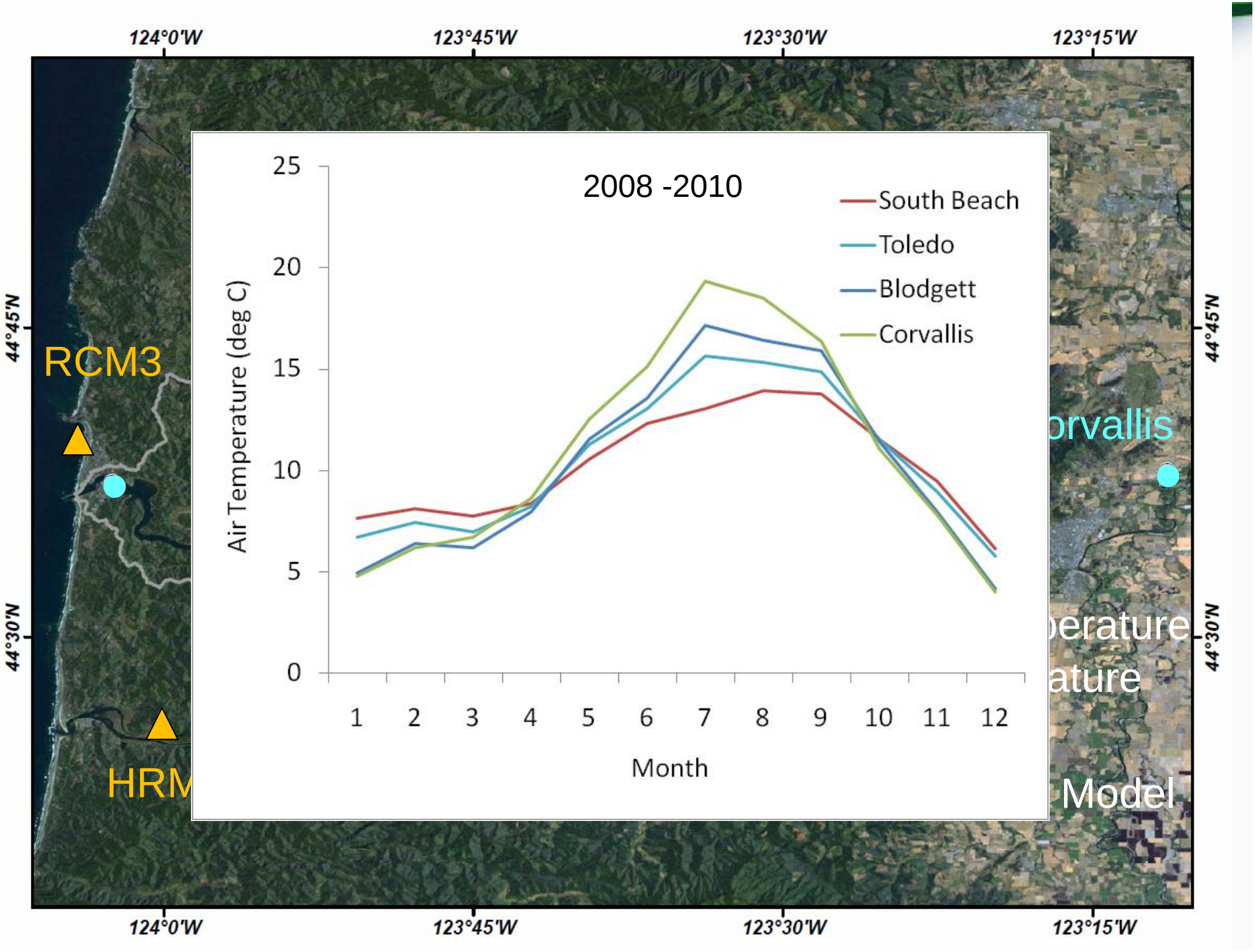
Freshwater Inflow Model

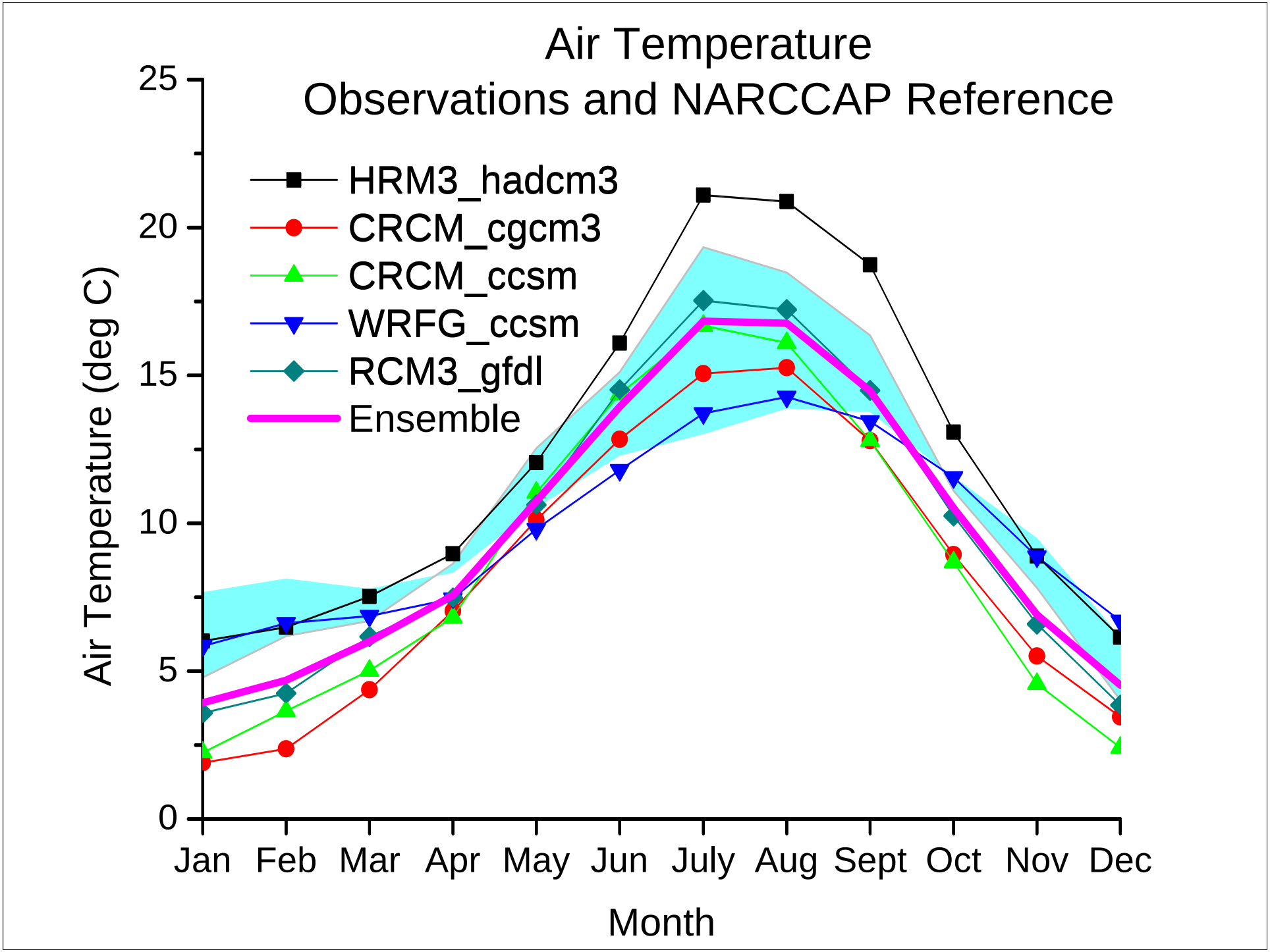
Estuary Hydrodynamic Model

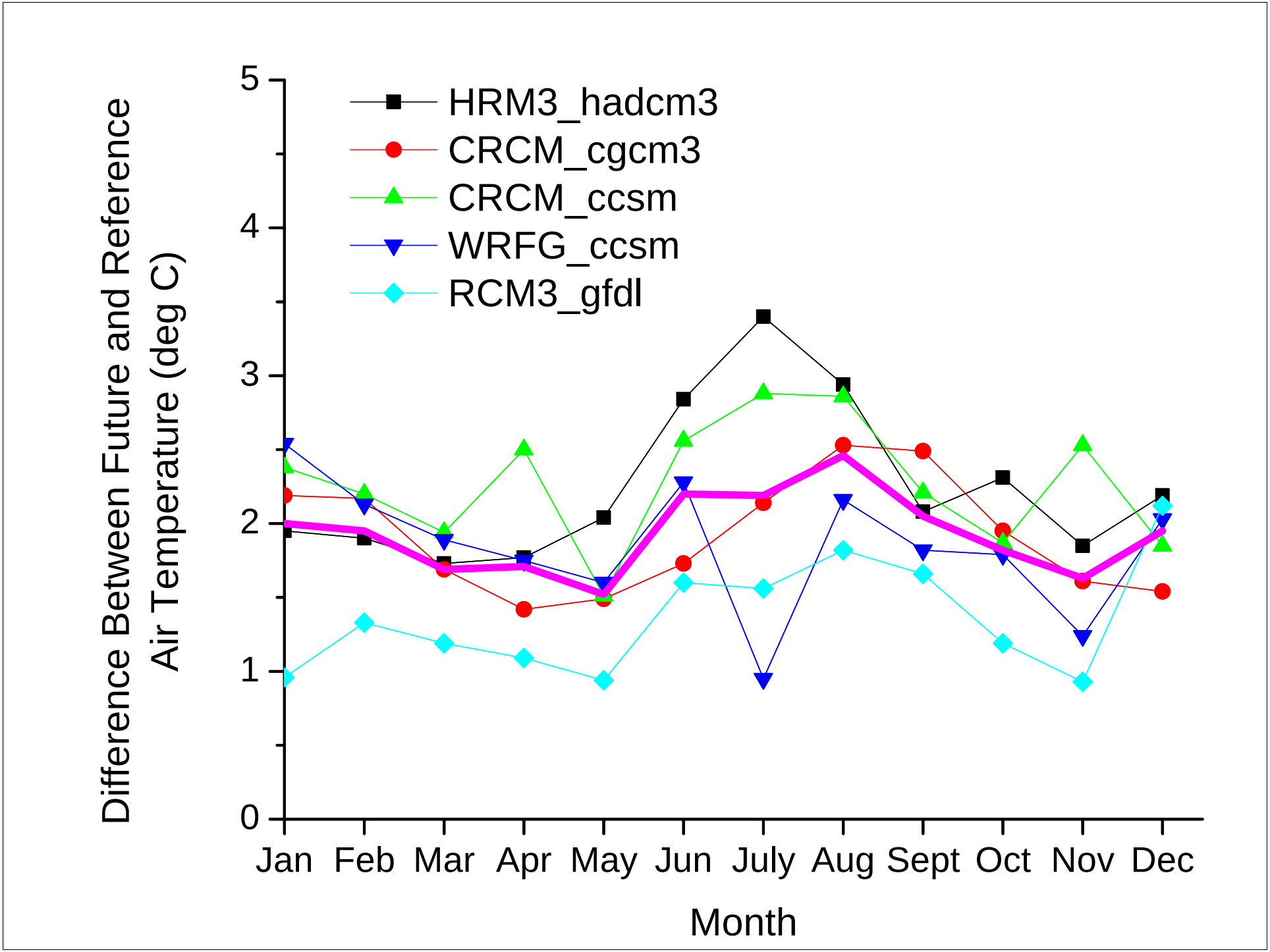
- Steady freshwater inflow cases for sea level ranging from present conditions to 1.5 m rise
- Simulations of annual cycle (2004) with increase in air temperature and stream temperature + sea level rise

NARCCAP Projections

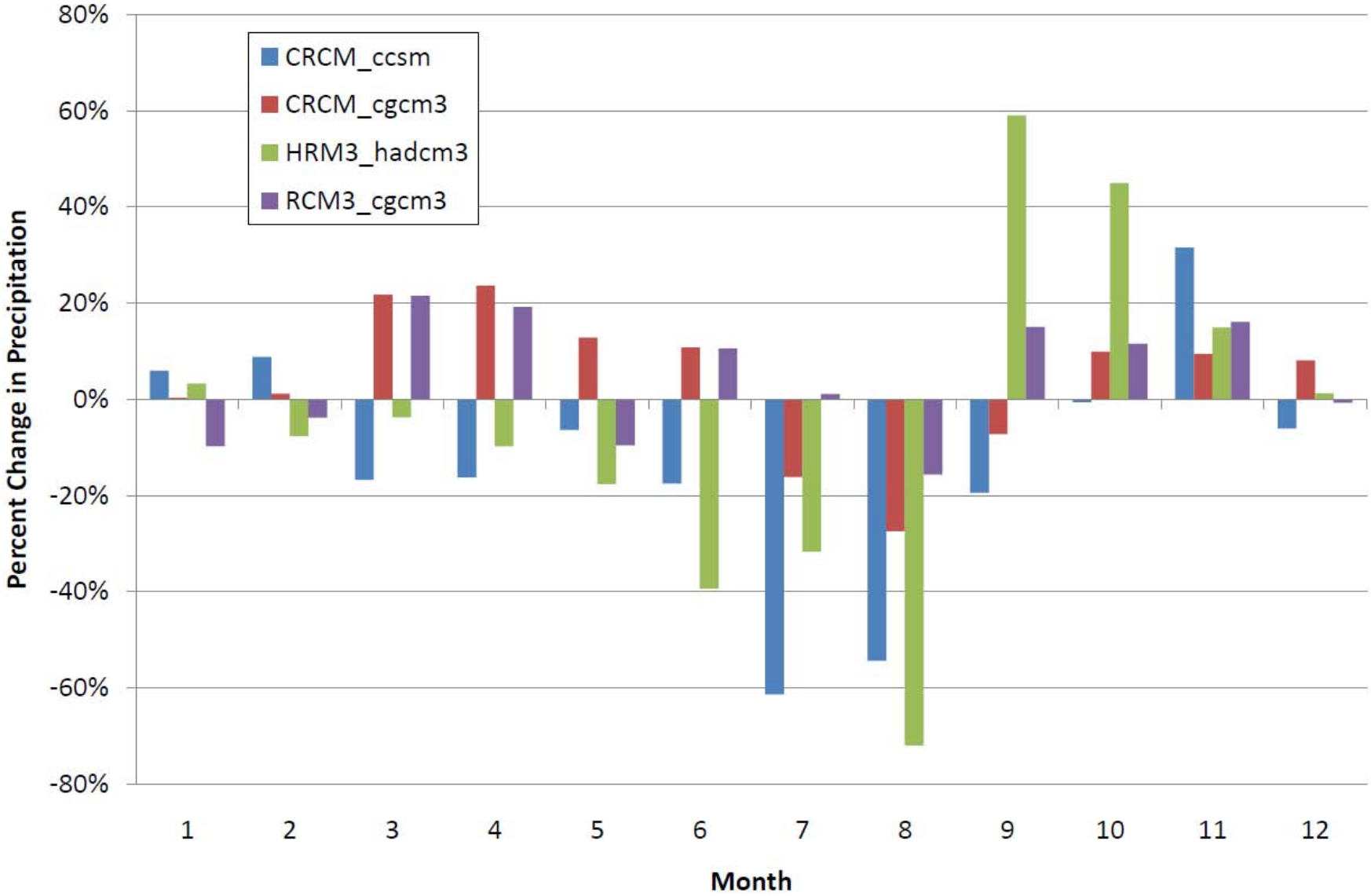



124°0'W
123°45'W
123°30'W
123°15'W
44°45'N
44°30'N
RCM3
HRM
orvallis
perature
ature
Model
2008 -2010
South Beach
Toledo
Blodgett
Corvallis
Air Temperature (deg C)
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
Month


Air Temperature
Observations and NARCCAP Reference
HRM3_hadcm3
CRCM_cgcm3
CRCM_ccsm
WRFG_ccsm
RCM3_gfdl
Ensemble
Air Temperature (deg C)
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sept
Oct
Nov
Dec
Month

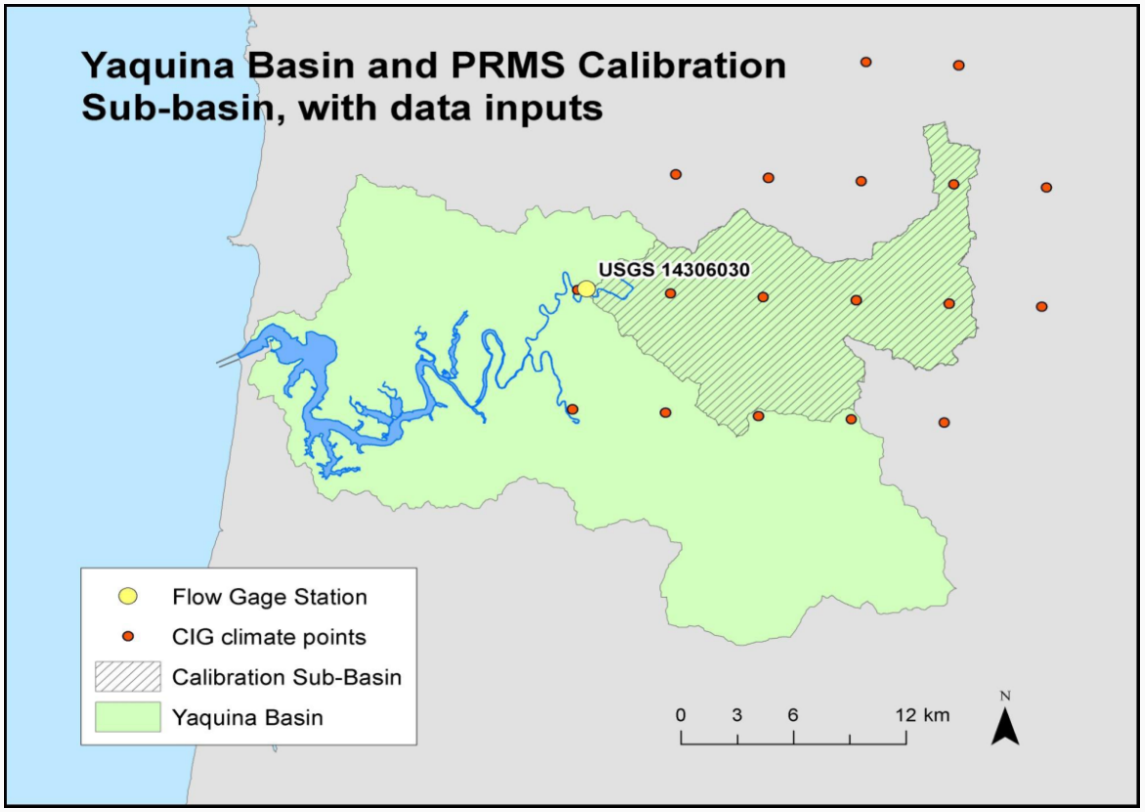

HRM3_hadcm3
CRCM_cgcm3
CRCM_ccsm
WRFG_ccsm
RCM3_gfdl
Difference Between Future and Reference
Air Temperature (deg C)
0
1
2
3
4
5
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sept
Oct
Nov
Dec
Month

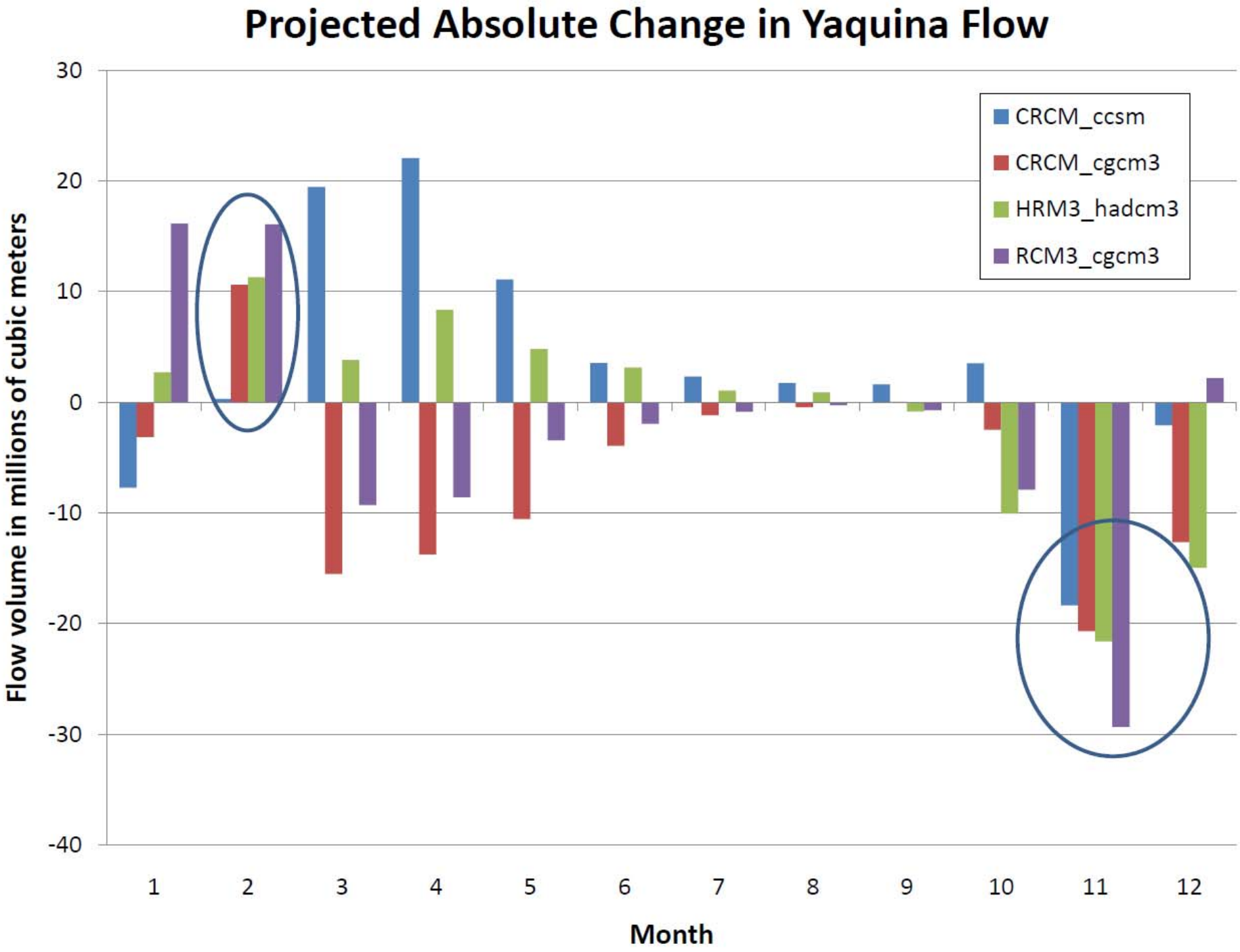
Percent change in precip. from reference to future period, Yaquina

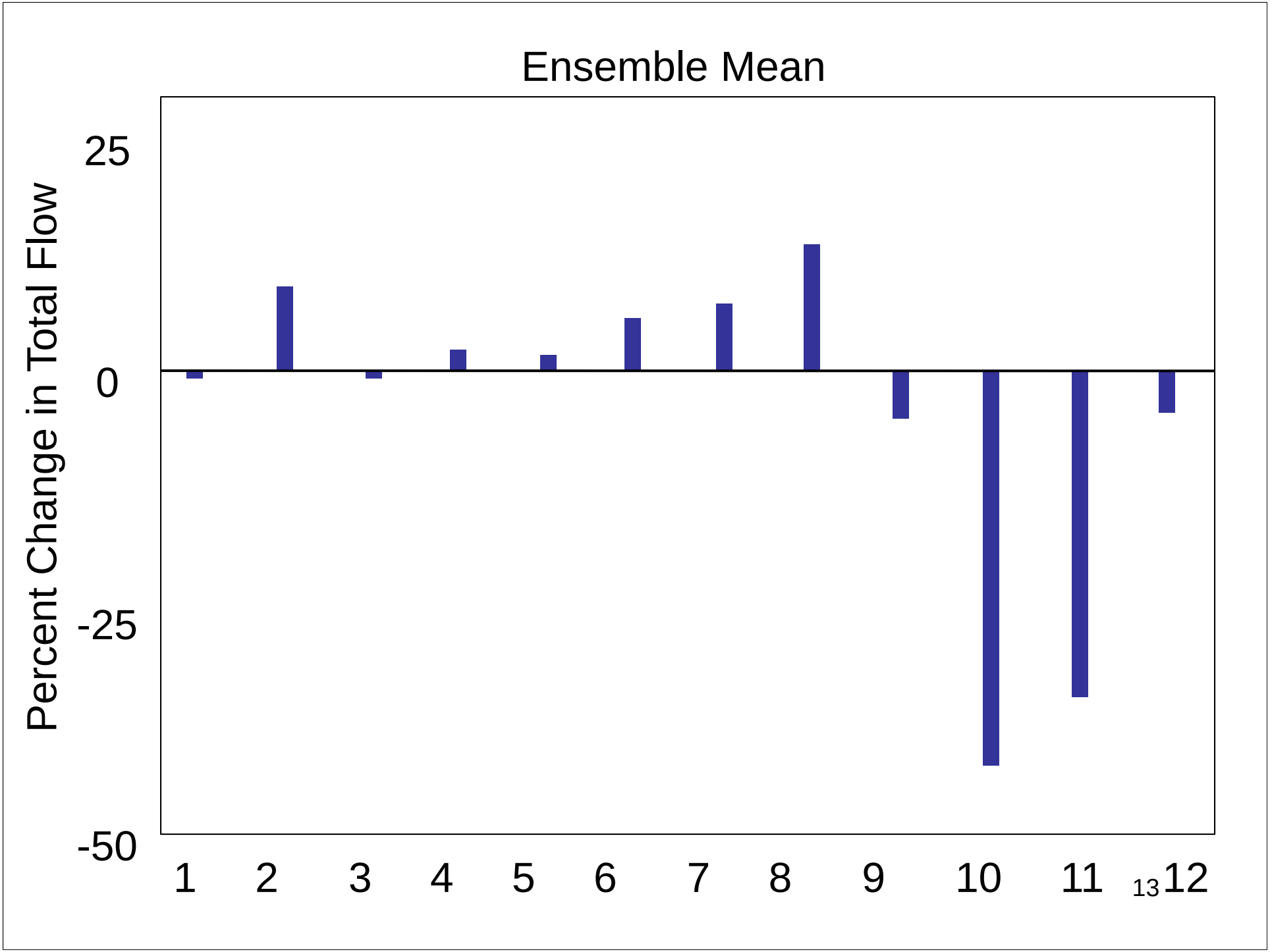


Freshwater Inflow

- Precipitation Runoff Modeling System (PRMS; Leavesley et al. 1983)




Projected Absolute Change in Yaquina Flow
Flow volume in millions of cubic meters
30
20
10
0
-10
-20
-30
-40
1
2
3
4
5
6
7
8
9
10
11
12
Month
CRCM_ccsm
CRCM_cgcm3
HRM3_hadcm3
RCM3_cgcm3


Ensemble Mean
Percent Change in Total Flow
25
0
-25
-50
1
2
3
4
5
6
7
8
9
10
11
12
13

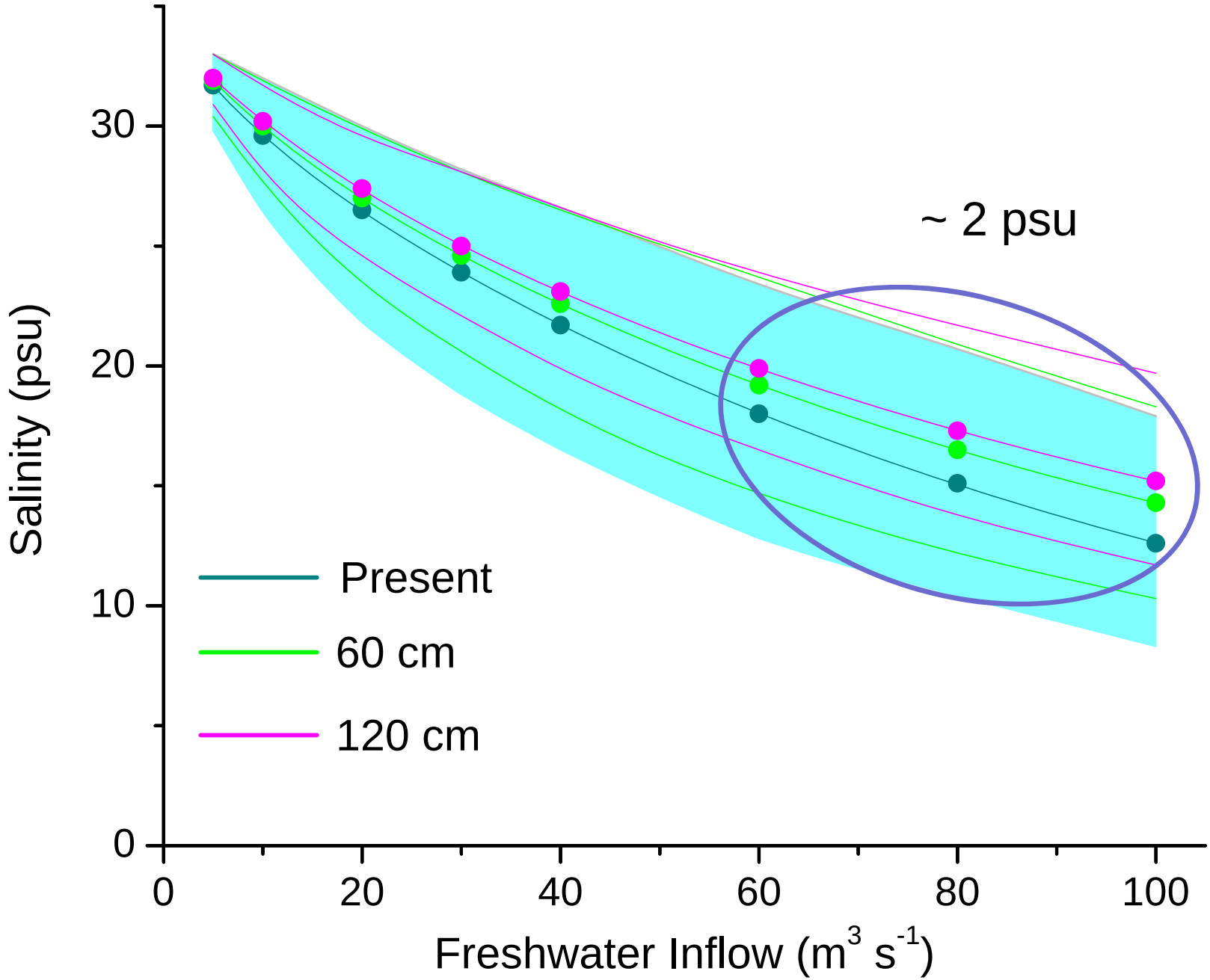
Estuarine Modeling

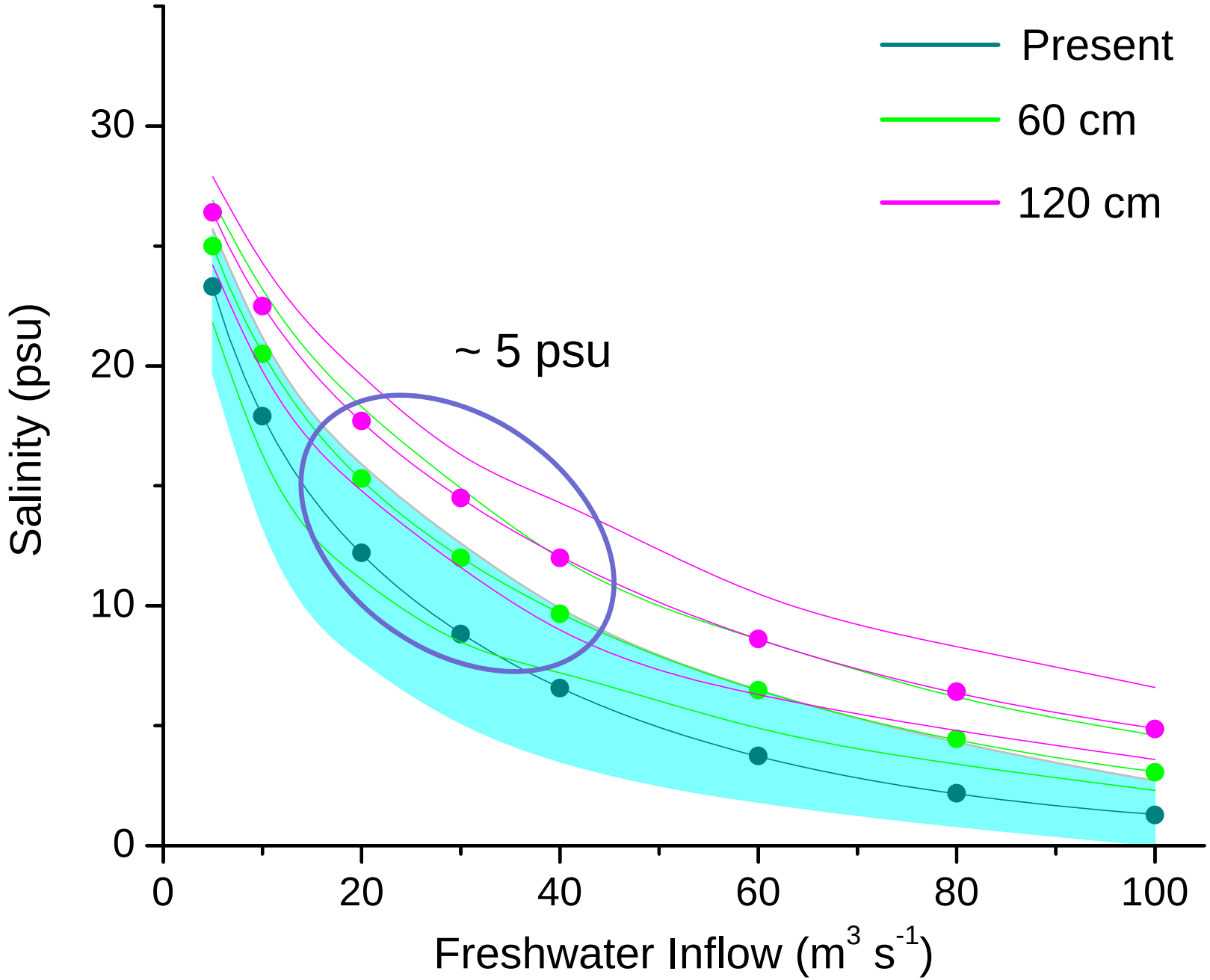
Response Variables: Salinity & Temperature

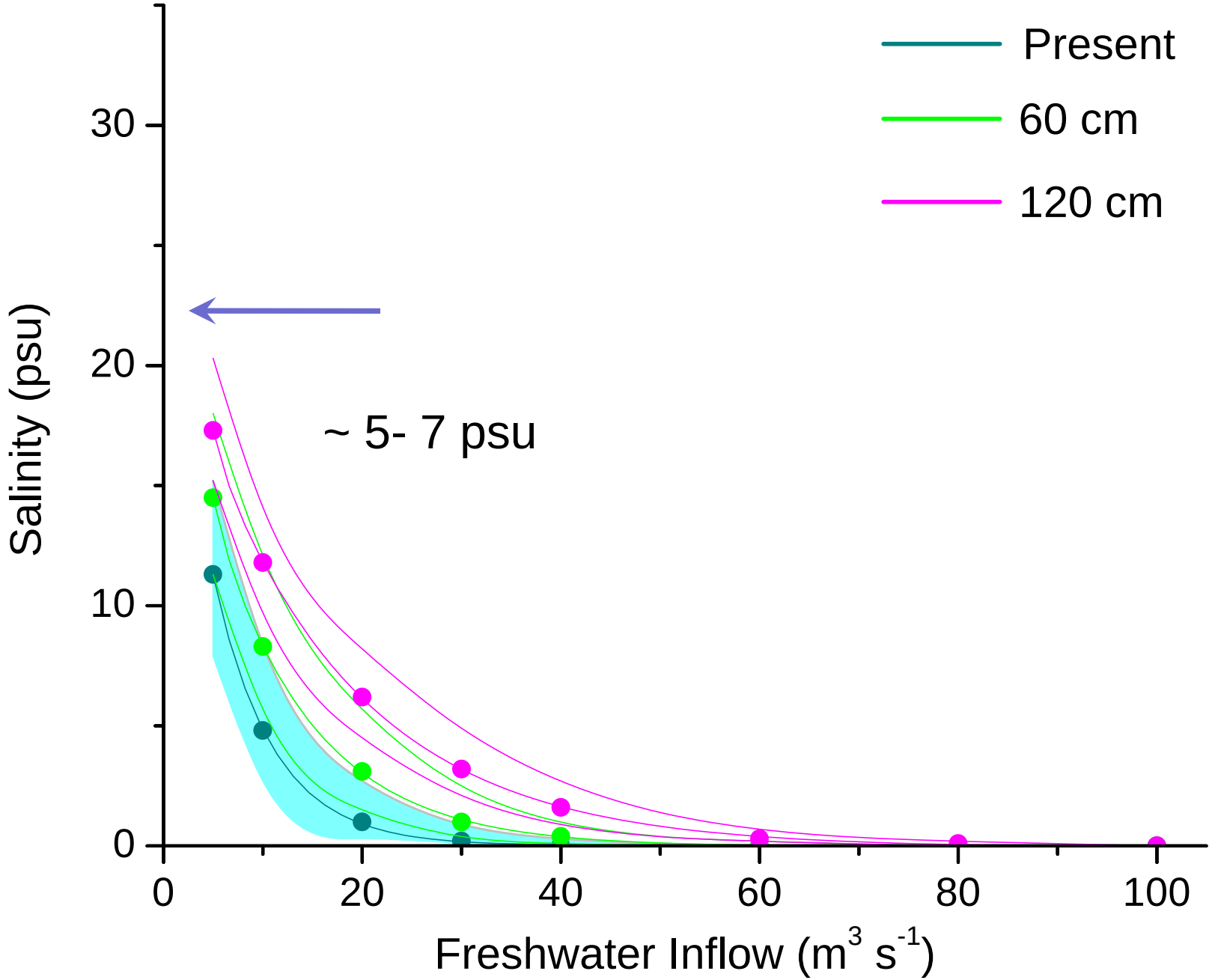
Steady Discharge Simulations

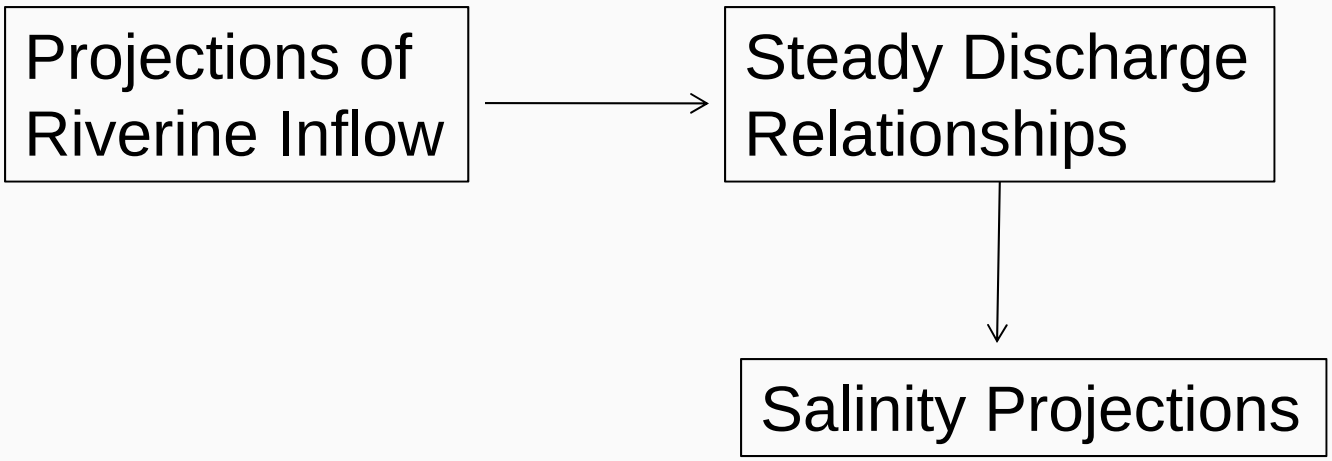
- Includes freshwater inflow & tidal forcing
- Annual average used to impose temperature gradients.
- Sea level varied from present to +1.5 m

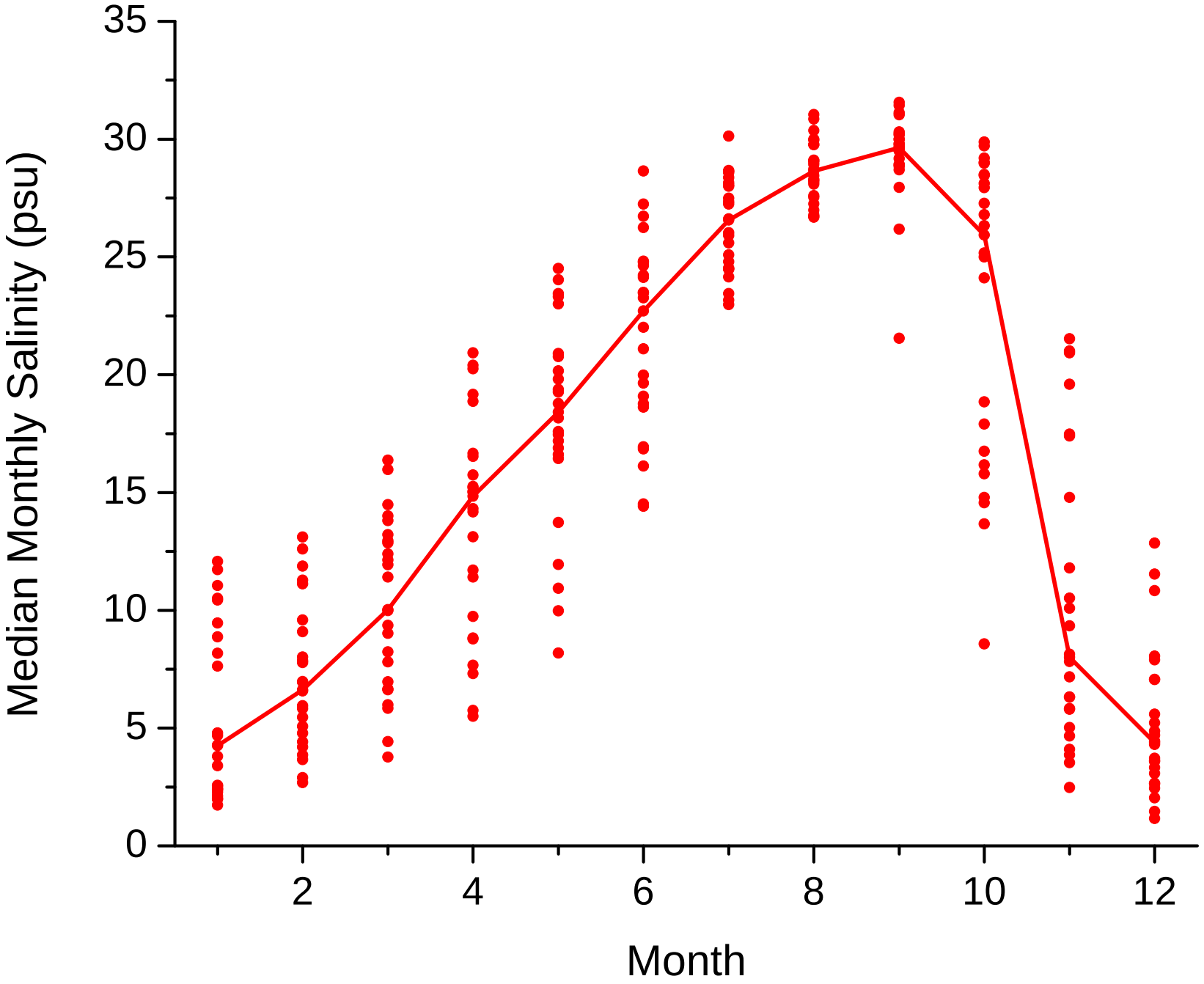
Simulations of the effect of increased air temperature and sea level rise.

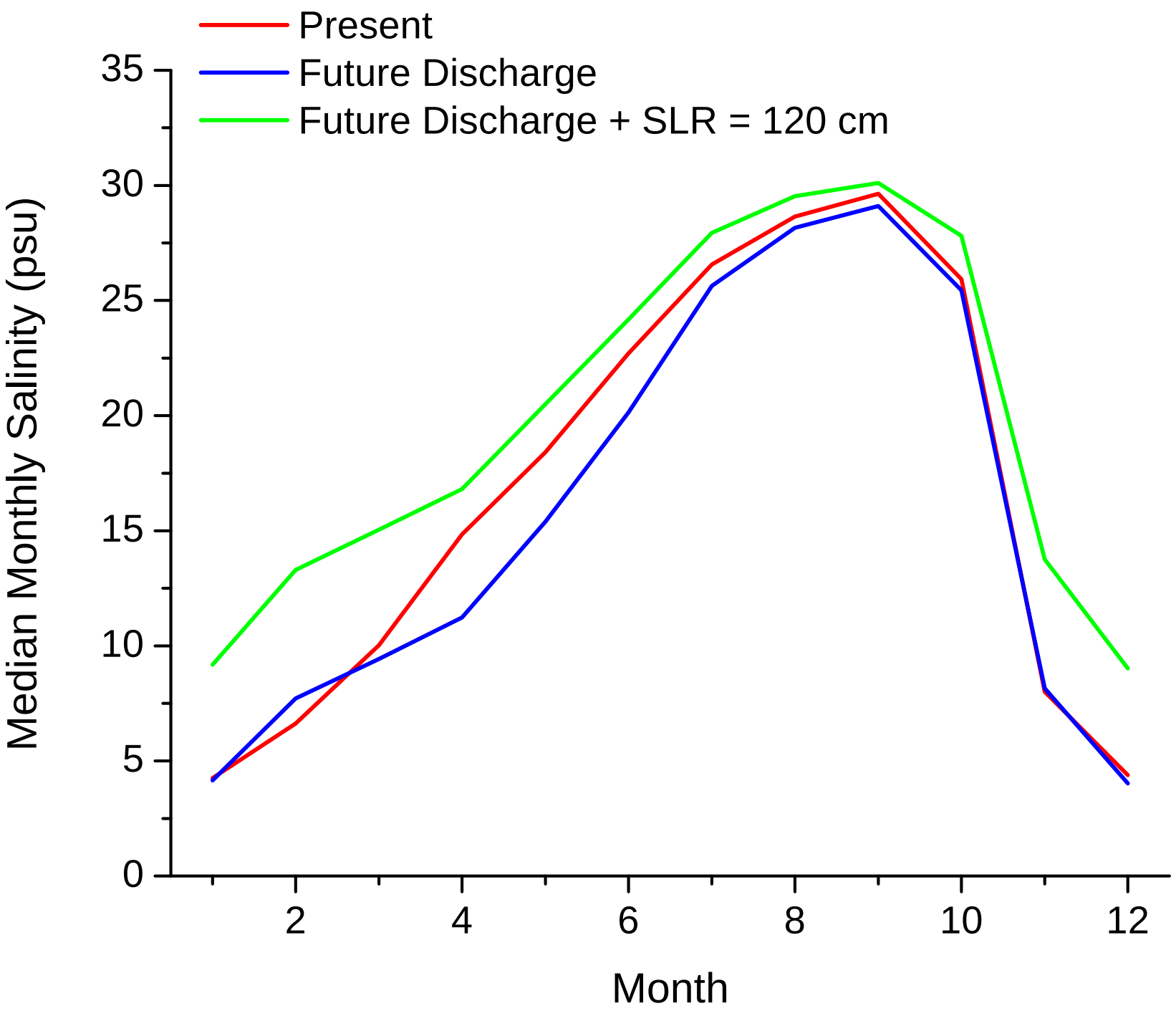

~ 2 psu
Present
60 cm
120 cm
Salinity (psu)
0
10
20
30
0
20
40
60
80
100
Freshwater Inflow (m3 s-1)


Present
60 cm
120 cm
~ 5 psu
Salinity (psu)
0
10
20
30
0
20
40
60
80
100
Freshwater Inflow (m3 s-1)


Present
60 cm
120 cm
~ 5- 7 psu
Salinity (psu)
0
10
20
30
0
20
40
60
80
100
Freshwater Inflow (m3 s-1)


Projections of Riverine Inflow
Steady Discharge Relationships
Salinity Projections

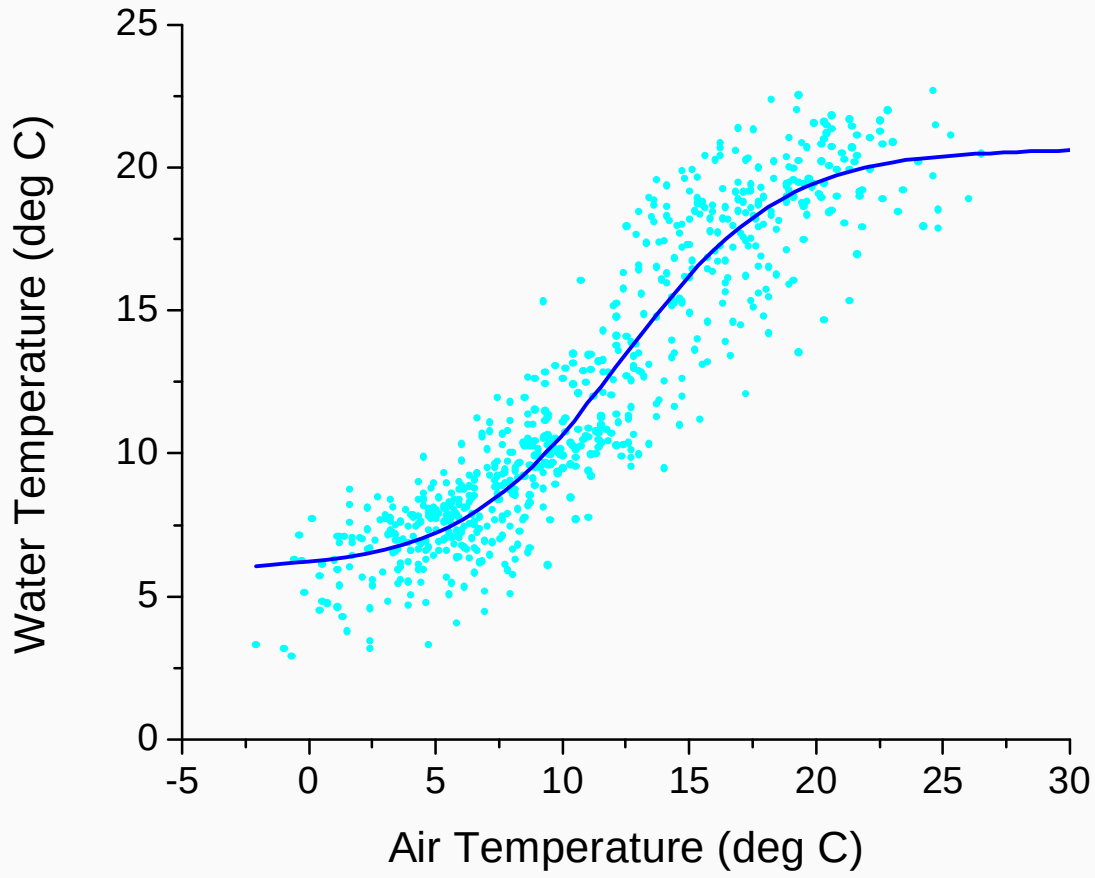

Median Monthly Salinity (psu)
35
30
25
20
15
10
5
0
2
4
6
8
10
12
Month


Present
Future Discharge
Future Discharge + SLR = 120 cm
Median Monthly Salinity (psu)
0
5
10
15
20
25
30
35
2
4
6
8
10
12
Month

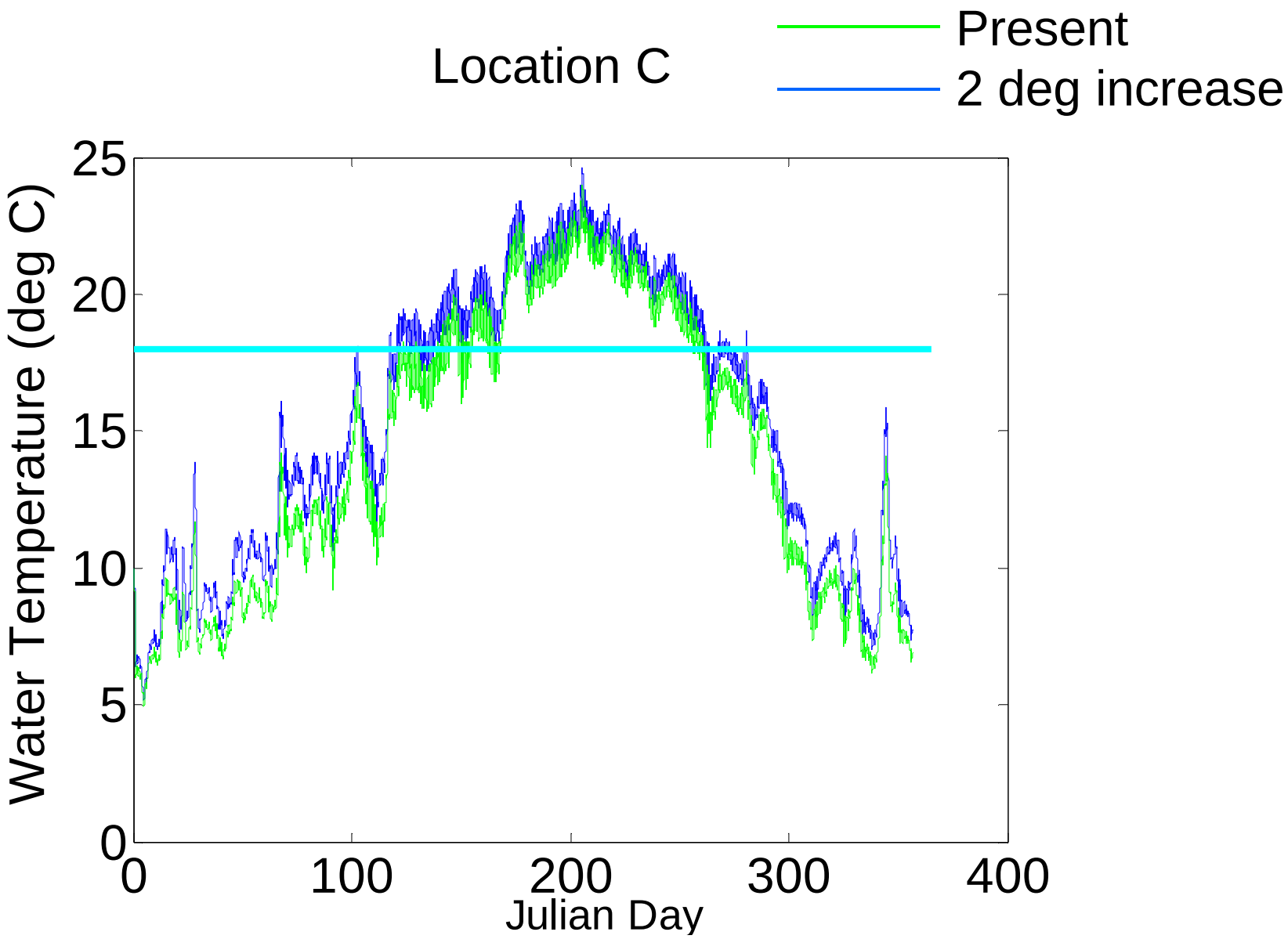
Climate Change Impacts on Estuarine Water Temperature

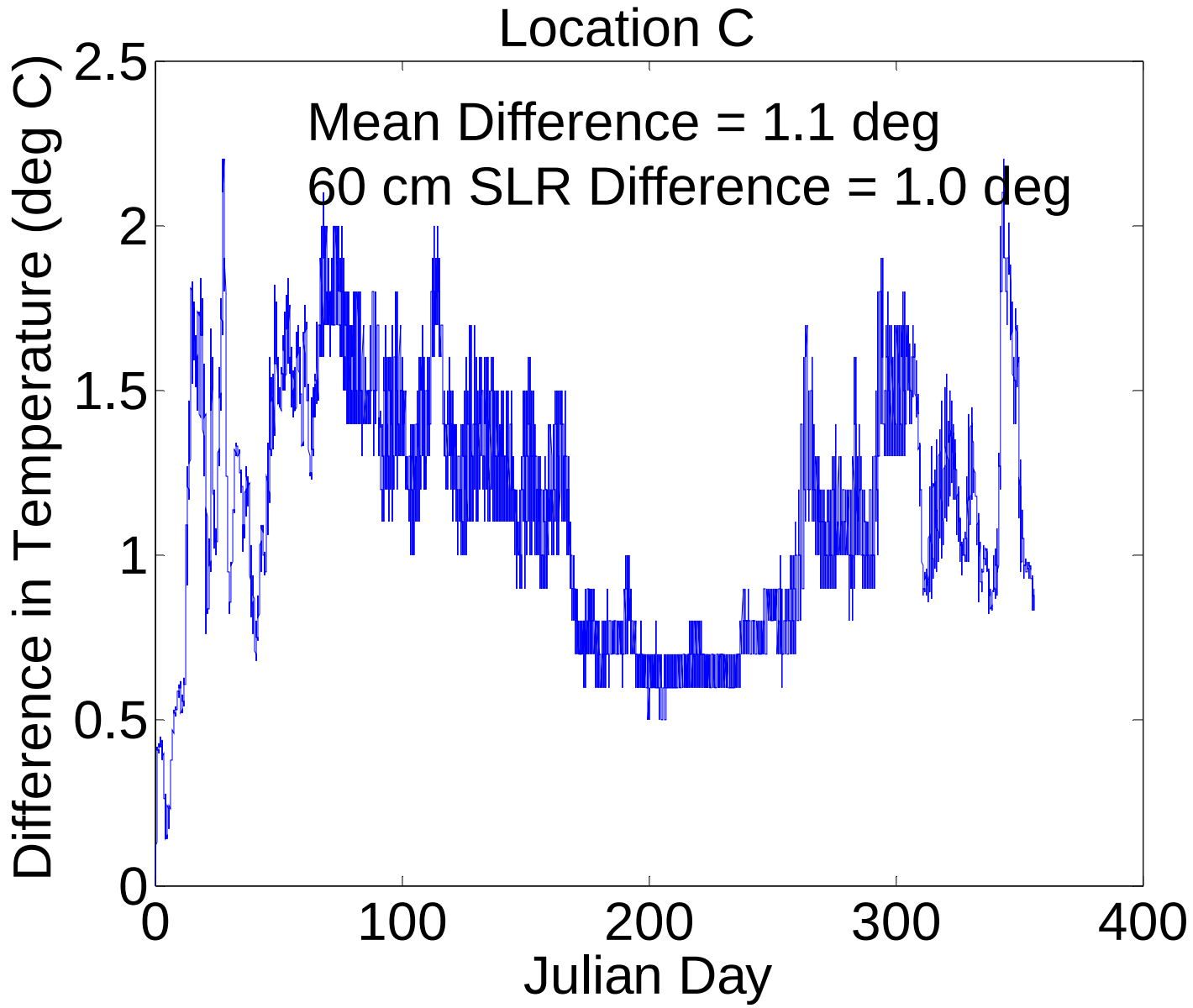
- Base Case of 2004
- Includes tidal forcing and river discharge
- Compared to 2004 observations
- Projected increase in air temperature and river temperature at Elk City

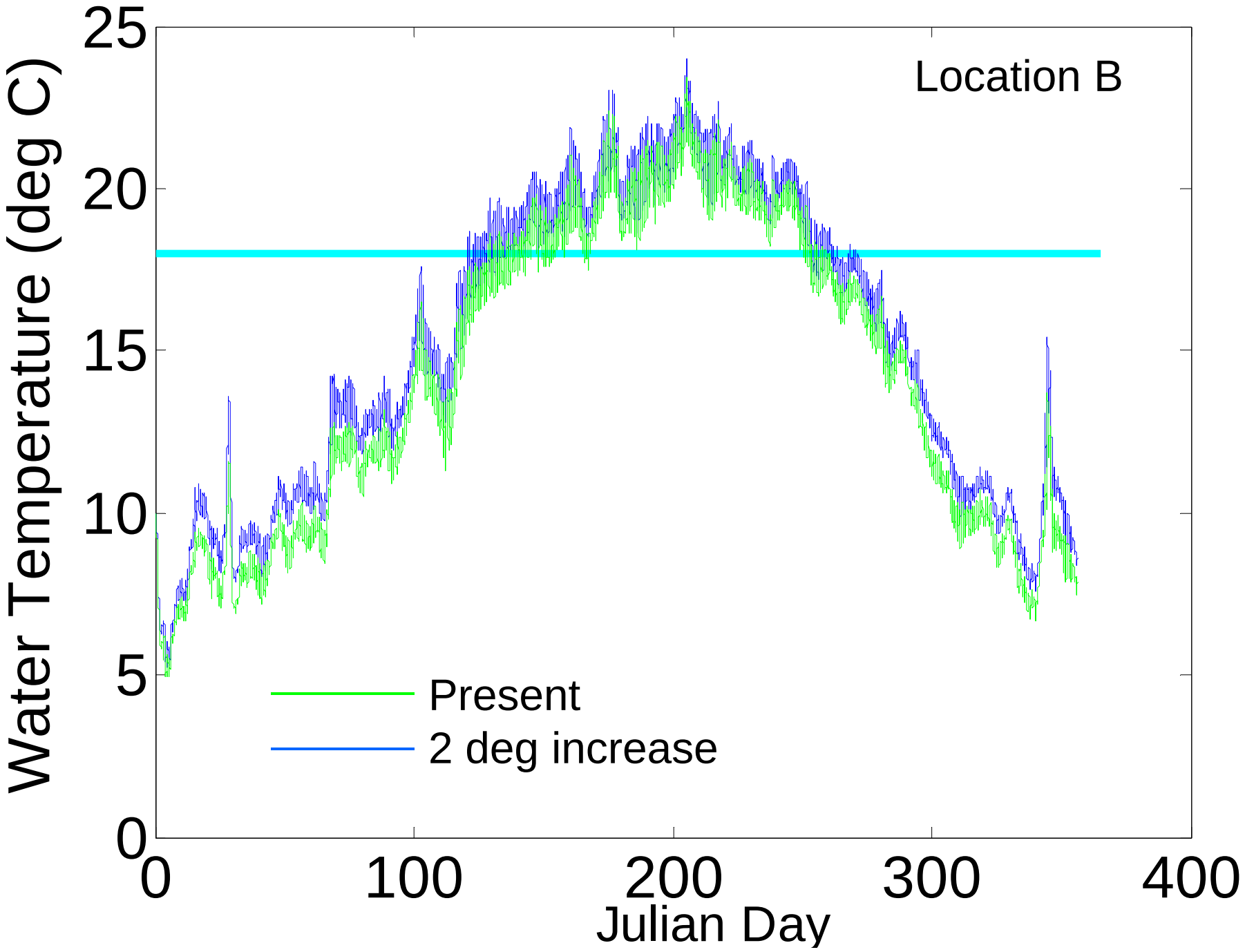
Water Temperature of Freshwater Inflow



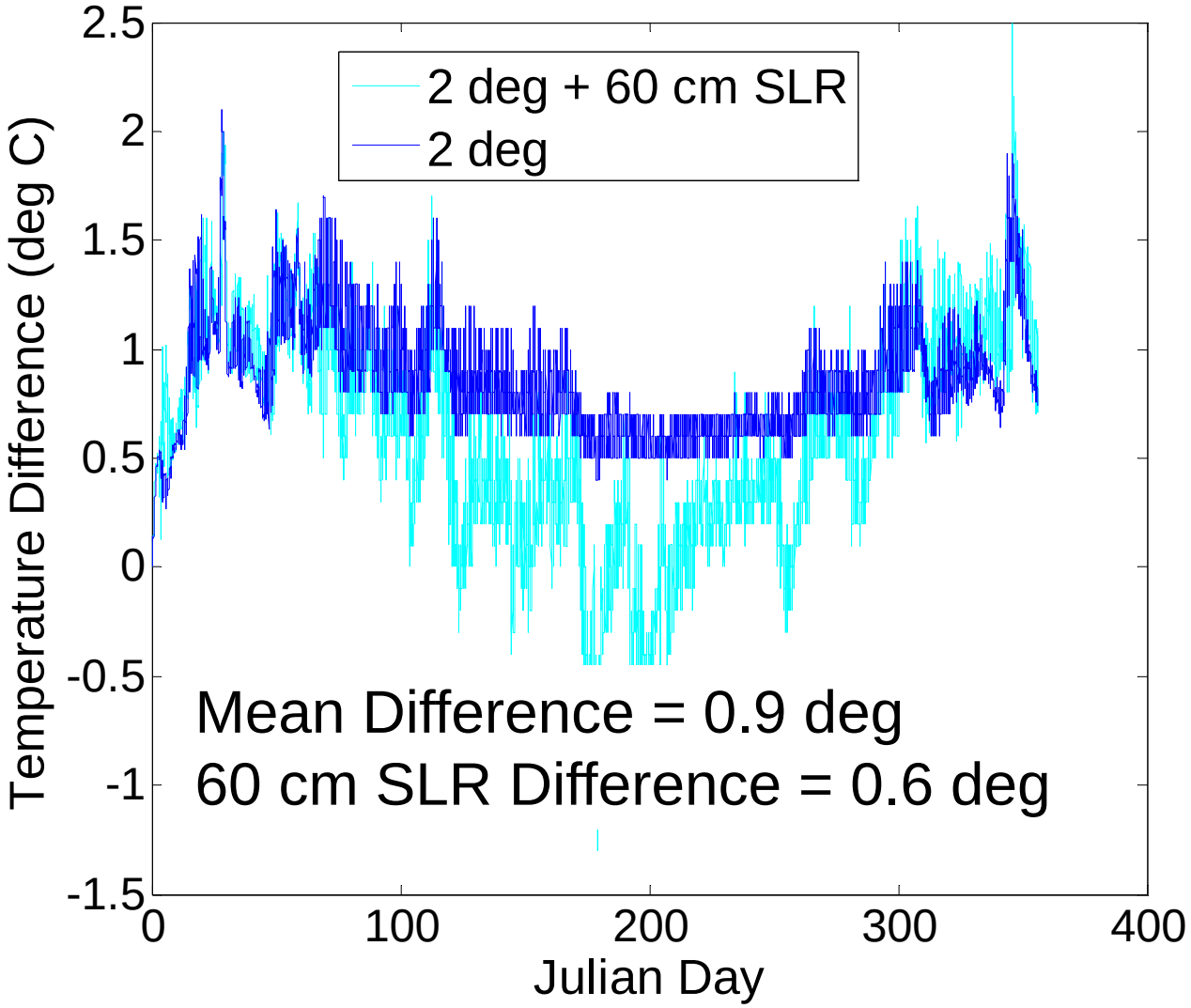

44°40'N
44°35'N
124°5'W
124°0'W
123°55'W
A
B
C

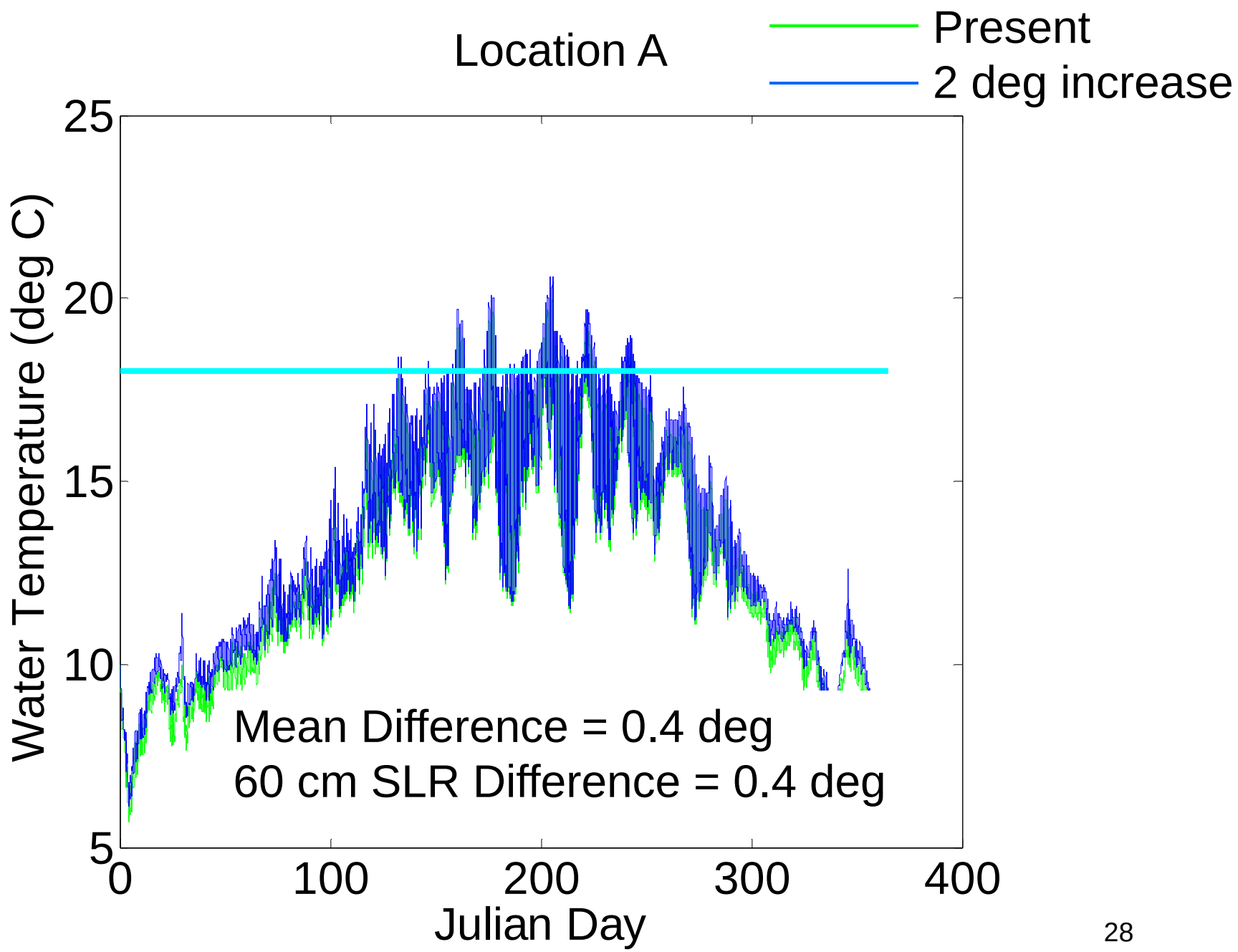

Location C
Present
2 deg increase
Water Temperature (deg C)
0
5
10
15
20
25
0
100
200
300
400
Julian Day


Location C
Mean Difference = 1.1 deg
60 cm SLR Difference = 1.0 deg
Difference in Temperature (deg C)
Julian Day
0
0.5
1
1.5
2
2.5
0
100
200
300
400


Location B
Water Temperature (deg C)
Julian Day
Present
2 deg increase
0
5
10
15
20
25
0
100
200
300
400

Location B


2 deg + 60 cm SLR
2 deg
Mean Difference = 0.9 deg
60 cm SLR Difference = 0.6 deg
Temperature Difference (deg C)
Julian Day
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0
100
200
300
400


Location A
Present
2 deg increase
Water Temperature (deg C)
25
20
15
10
5
0
100
200
300
400
Julian Day
Mean Difference = 0.4 deg
60 cm SLR Difference = 0.4 deg

Conclusions

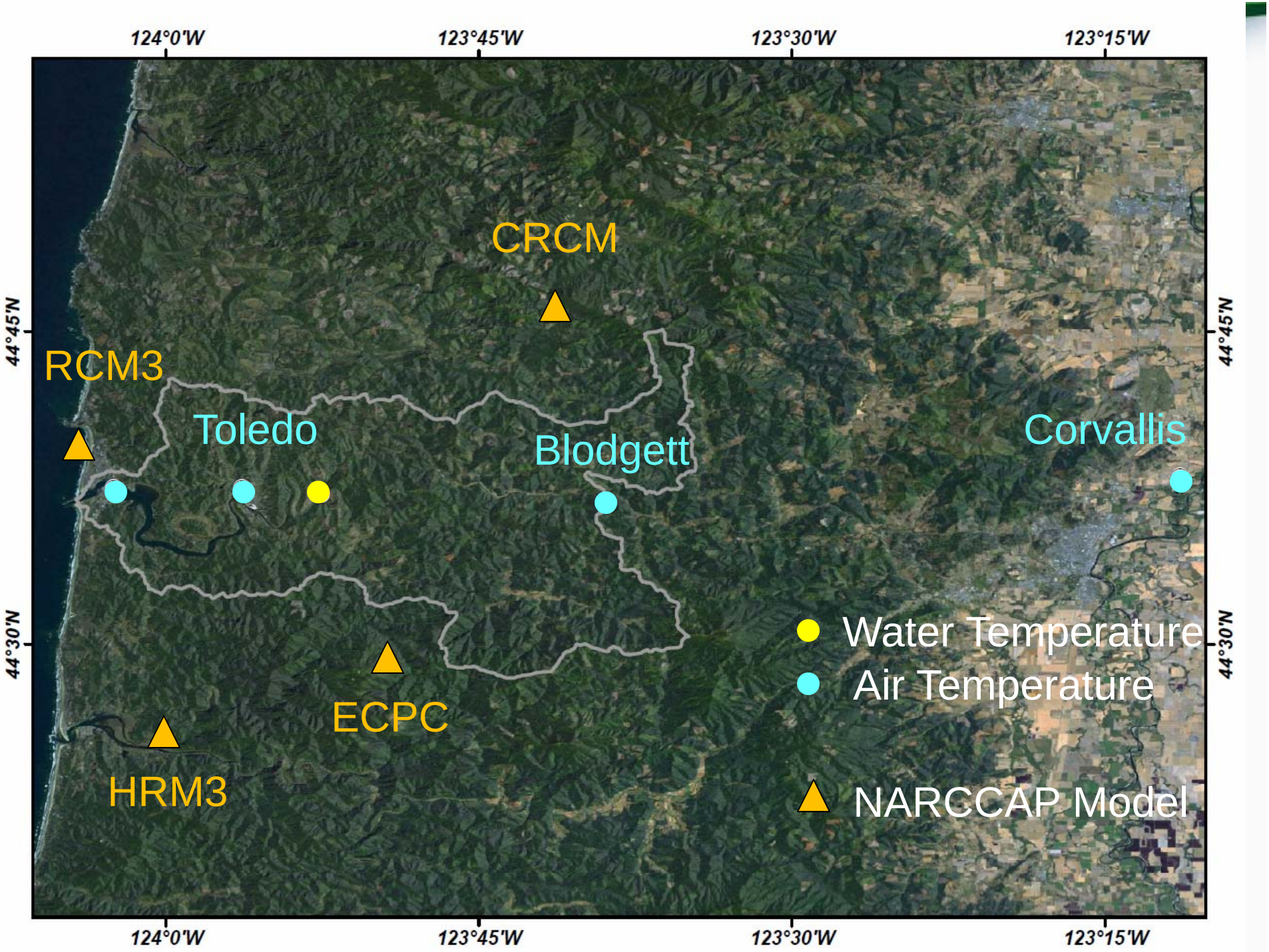
- High degree of uncertainty in future projections
- Need to present results in a manner that remain useful as projections evolve.
- Steady discharge simulations are a useful way to determine which portions of the estuary exhibit strongest response.
- Months with largest change in discharge may not translate to largest change in salinity.

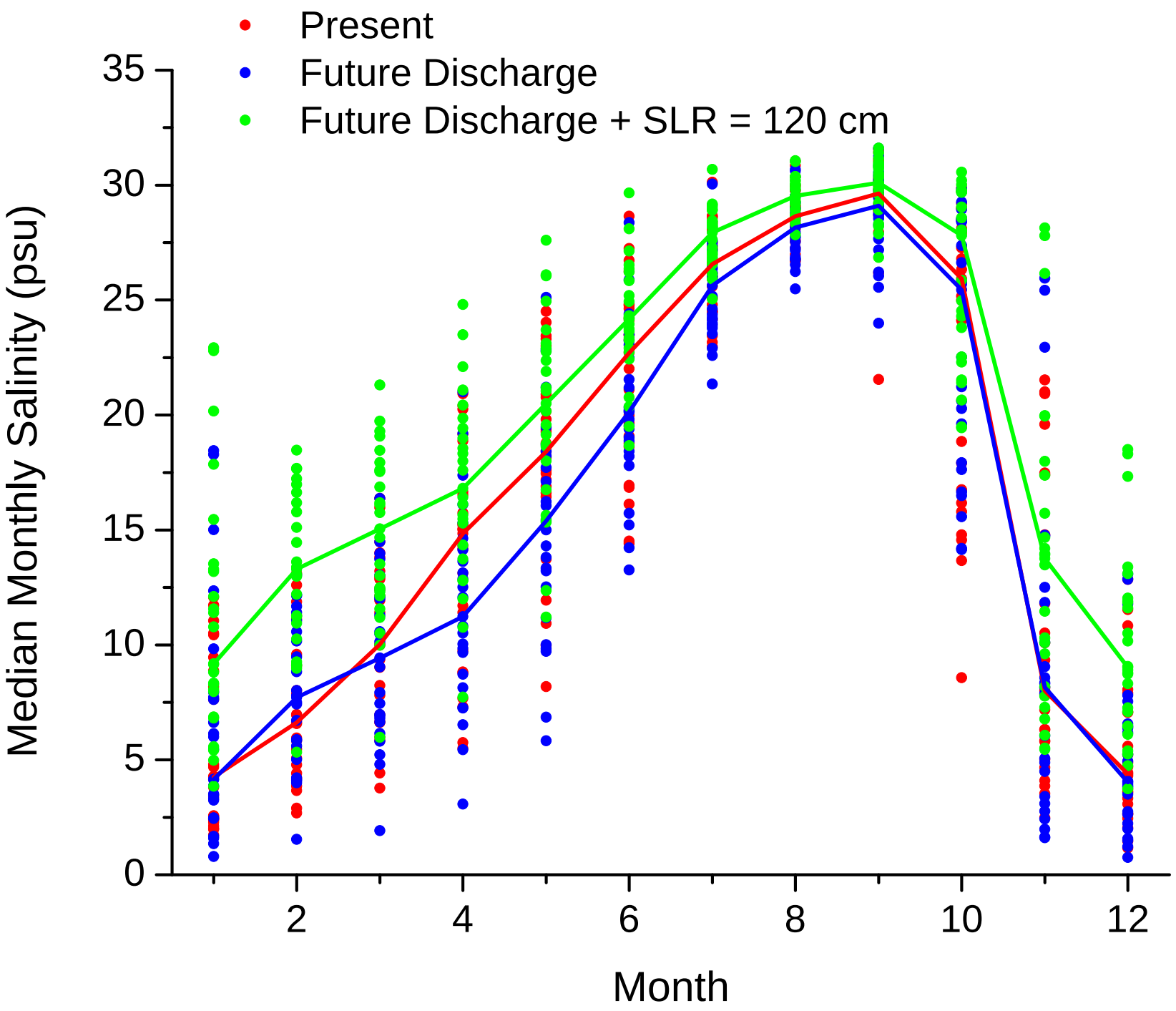
Future Research Directions

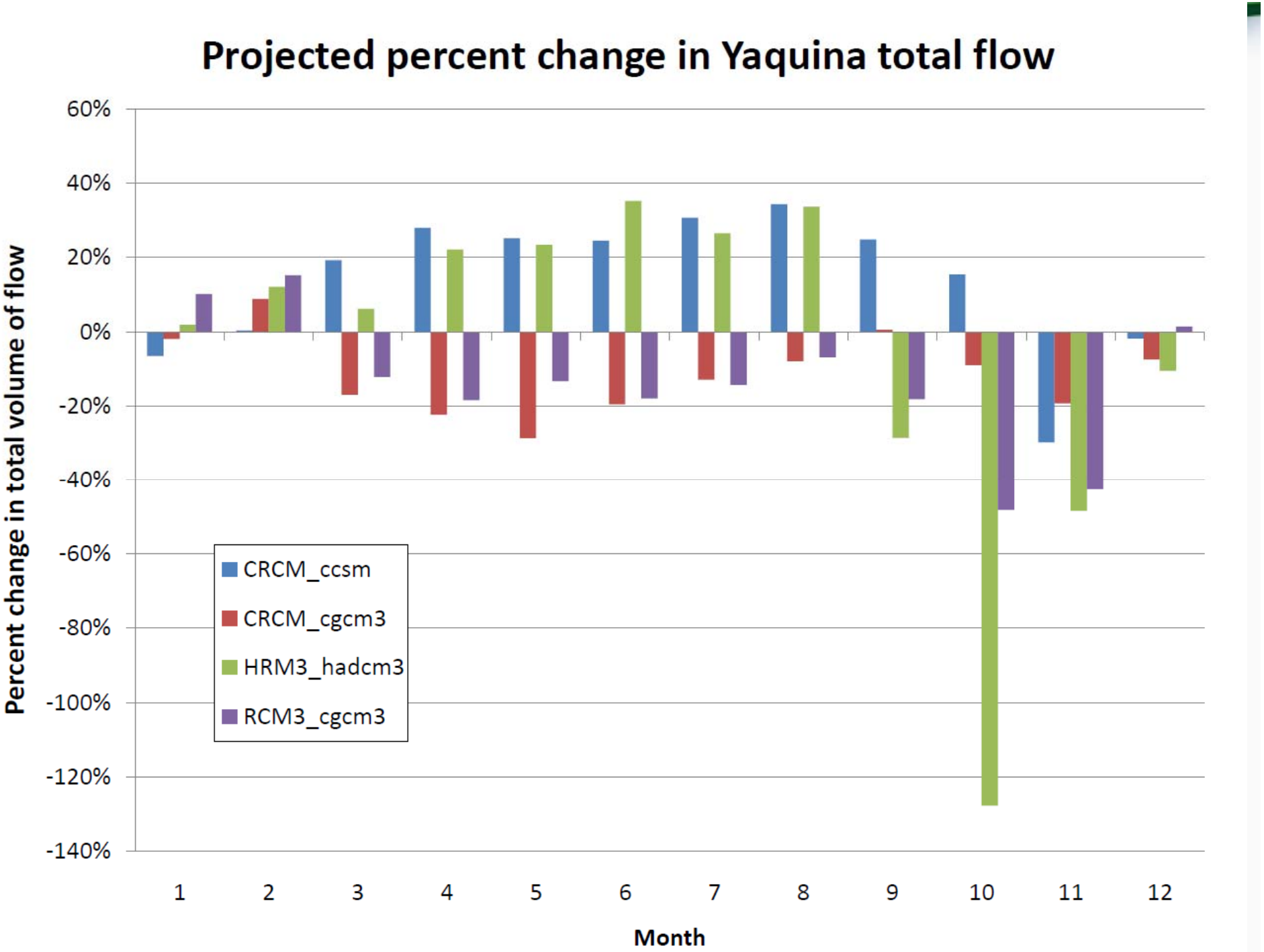
- Other metrics – salt delivery to wetlands
- Other types of estuaries
- More modeling of water quality
- Upwelling
- Link to biologic end points
- Incorporate water withdrawls

Acknowledgements

This research was funded by the U.S. Environmental Protection Agency and the U.S. Geological Survey.


124°0'W
123°45'W
123°30'W
123°15'W
44°45'N
44°30'N
CRCM
RCM3
Toledo
Blodgett
Corvallis
ECPC
HRM3
Water Temperature
Air Temperature
NARCCAP Model


Present
Future Discharge
Future Discharge + SLR = 120 cm
Median Monthly Salinity (psu)
0
5
10
15
20
25
30
35
2
4
6
8
10
12
Month


Projected percent change in Yaquina total flow
Percent change in total volume of flow
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
-120%
-140%
1
2
3
4
5
6
7
8
9
10
11
12
Month
CRCM_ccsm
CRCM_cgcm3
HRM3_hadcm3
RCM3_cgcm3