Simulations and Analysis of Physical Environments in Delaware Bay: Past, Present and Future

Sensitivity Studies of Physical Environments in Delaware Bay to Climate Changes in near Future: Preliminary Results

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Outline

Scientific questions and methods

Numerical experiments conducted for climate sensitivity studies

Potential climate change in 100 years

sea level
air temperature and wind
river discharge

Experiment results and analysis

Summary

Acknowledgements

Scientific questions & methods

How will the salinity field respond to (e.g.) sea level rise & river flow alterations?

Will salinity become less sensitive to freshwater input with an increased water volume of the bay and intensified salt-intrusion?

How much warmer will the bay get in response to the higher surface air temperature associated with global warming?

Will stratification in the bay get stronger or weaker?

How will changes in the physical environment influence conditions for oysters?

Design climate sensitivity studies based upon observations and predictions

Apply a circulation model for Delaware Bay to conduct the climate sensitivity experiments

Use theoretical and analytical methods to summarize our experiment results

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Delaware Bay model (ROMS) is applied for this sensitive study

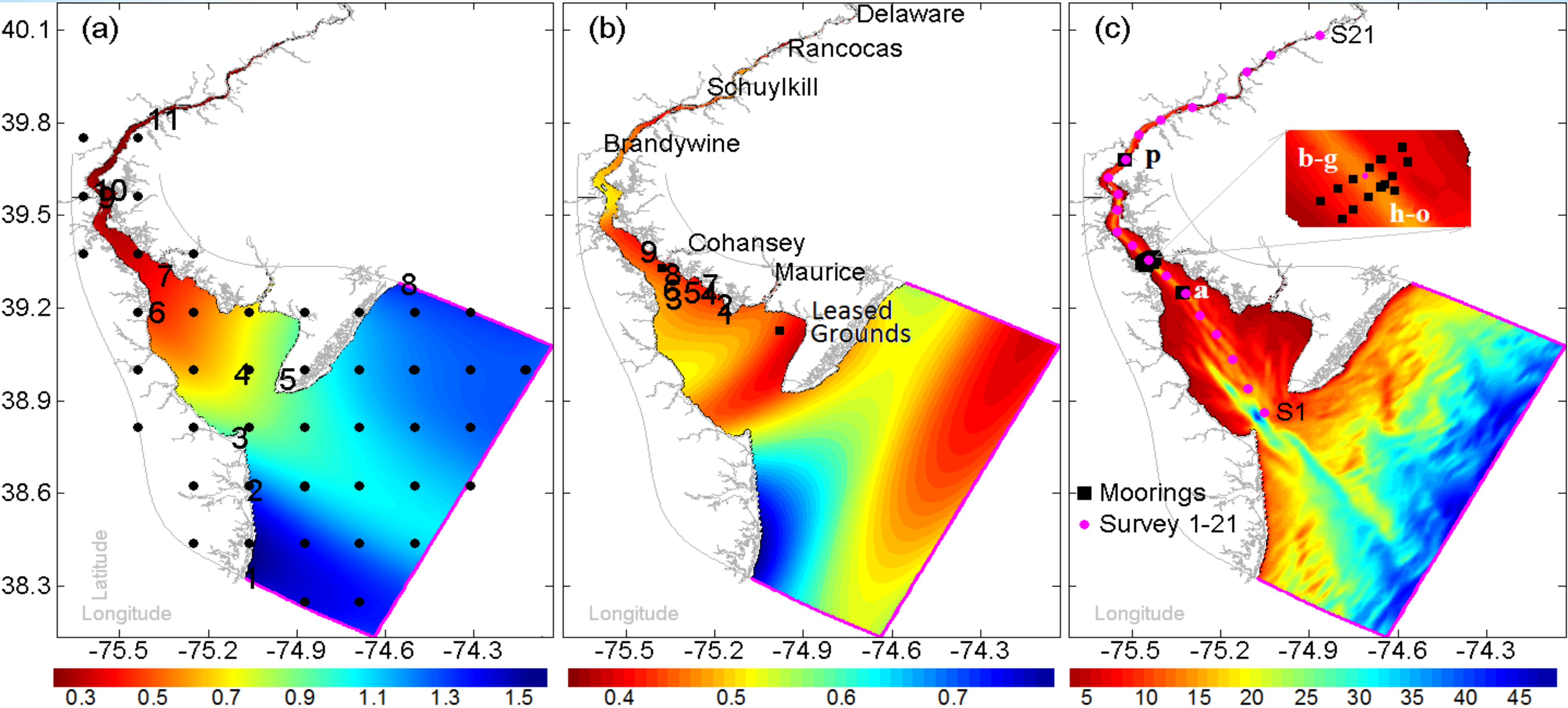
after its implementation, validation and application for studying the present bay

High resolution: 20 levels, 0.25-1.5km spacing, 1-min step

Multi-forcing: tidal (M2, N2, S2, K1, O1, M4, M6), daily riverine, hourly atmospheric inputs

Radiation open boundary: zero-gradient tracers; extrapolation for outward propagating u, v, ubar, vbar; ADCIRC tidal database for tidal elevation & inward propagating u, v, ubar, vbar

Multiple data resources: VERSA, DBMDP, USGS, NARR, DEOS, ECMWF, NWLP, MSXP, etc.



Numerical experiments conducted for climate sensitivity studies

Case	Definition	Object
Norm	Normal conditions in 2000-2002	for comparison with other cases
SLR1	1 m sea level rise (SLR)	effects from extreme SLR
SLR2	0.5 m sea level rise	effects from medium SLR
SLR3	1 m sea level rise without costal line change	effect from SLR & fixed costal line
Warm	Surface air warmer by 5^{o}C	warm effects
HC1	Predicted river flow	effects from predicted hydrology
HC2	March-May rain & river flow increased by 50%	effects from higher spring river flow
HC3	March-May rain & river flow decreased by 50%	effects from lower spring river flow
Wind1	Bay-cross/along wind increase/decrease by 30%	effects from enhanced zonal wind
Wind2	Bay-cross/along wind decrease/increase by 30%	effects from enhanced meridional wind
Comb1	SLR1+Warm+HC1	combined effect of SLR1+Warm+HC1
Comb2	SLR3+Warm+HC1	combined effect of SLR3+Warm+HC1

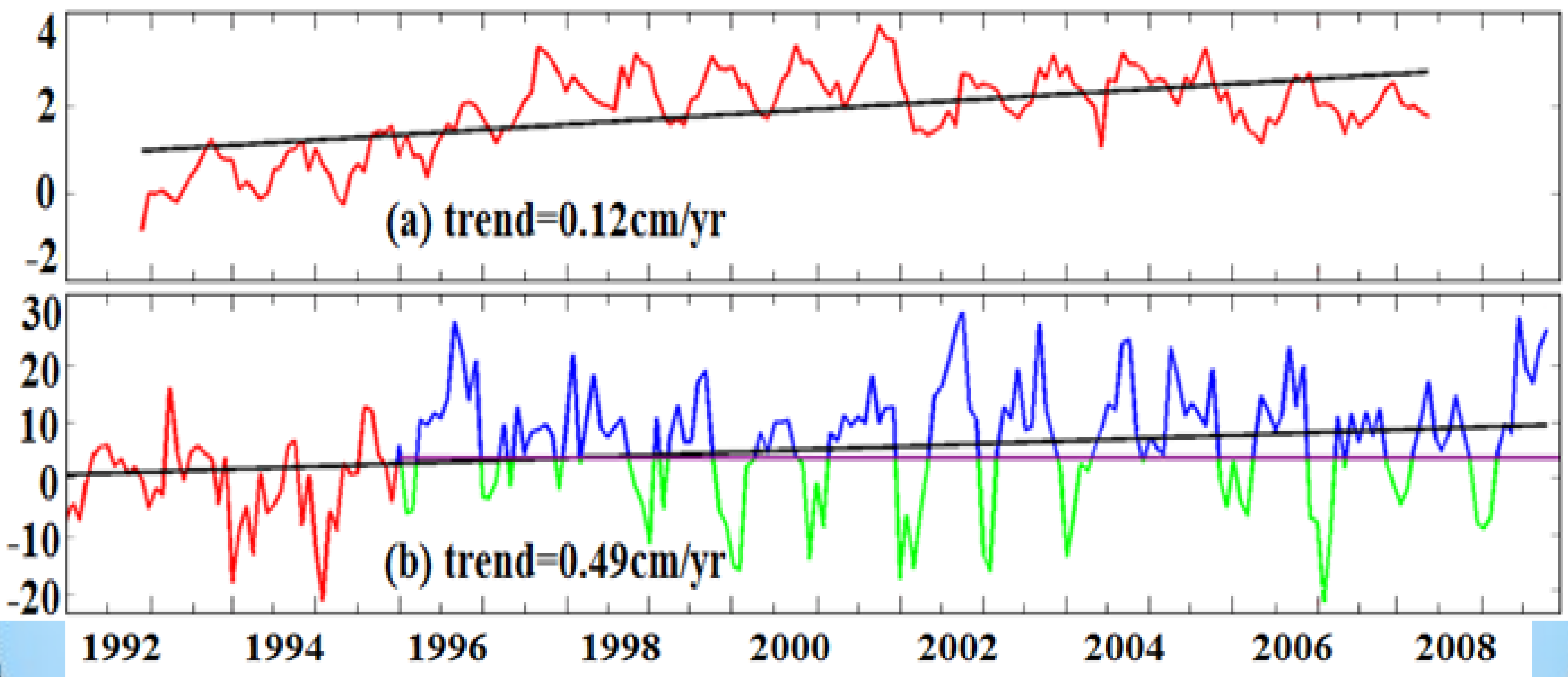
Predicted climate changes in ~100 years

Sea level rise:

20th century SLR in U.S. Atlantic coast: 1.8 ± 0.2mm/yr

SLR: 40~65cm in DB by 2100 according to modeling studies

Recently (1992-2009), SLR in DB: +4.92mm/yr, Atlantic: 1.2mm/yr



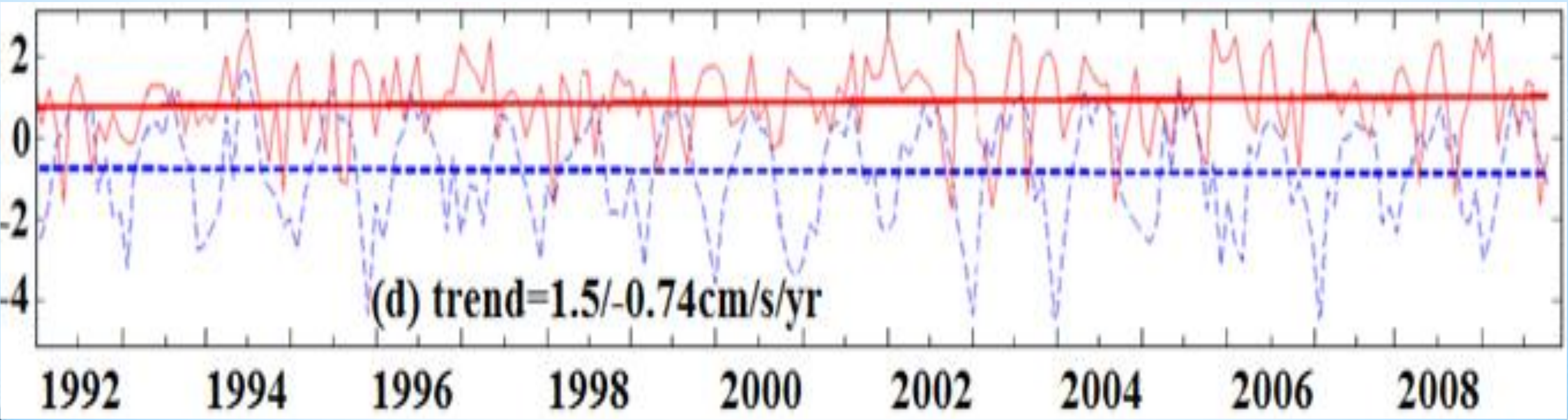
Sensitivity studies to climate changes in near future: **Predicted climate changes in ~100 years**

Air temperature and winds:

Global surface air temperature has risen by 0.07° C±0.02° C/10yr over the last 100 years, nearly double in the last 50 years

4.9° C±1.8° C increment over DB predicted by 7 global climate models by 2070-2099 with a CO_2 level of about 850 ppm for a medium-high emission.

Cross-/along bay wind increased with a trend of 0.15/-0.074 m/s/10yr, or by ~30%/-15% by 2100.



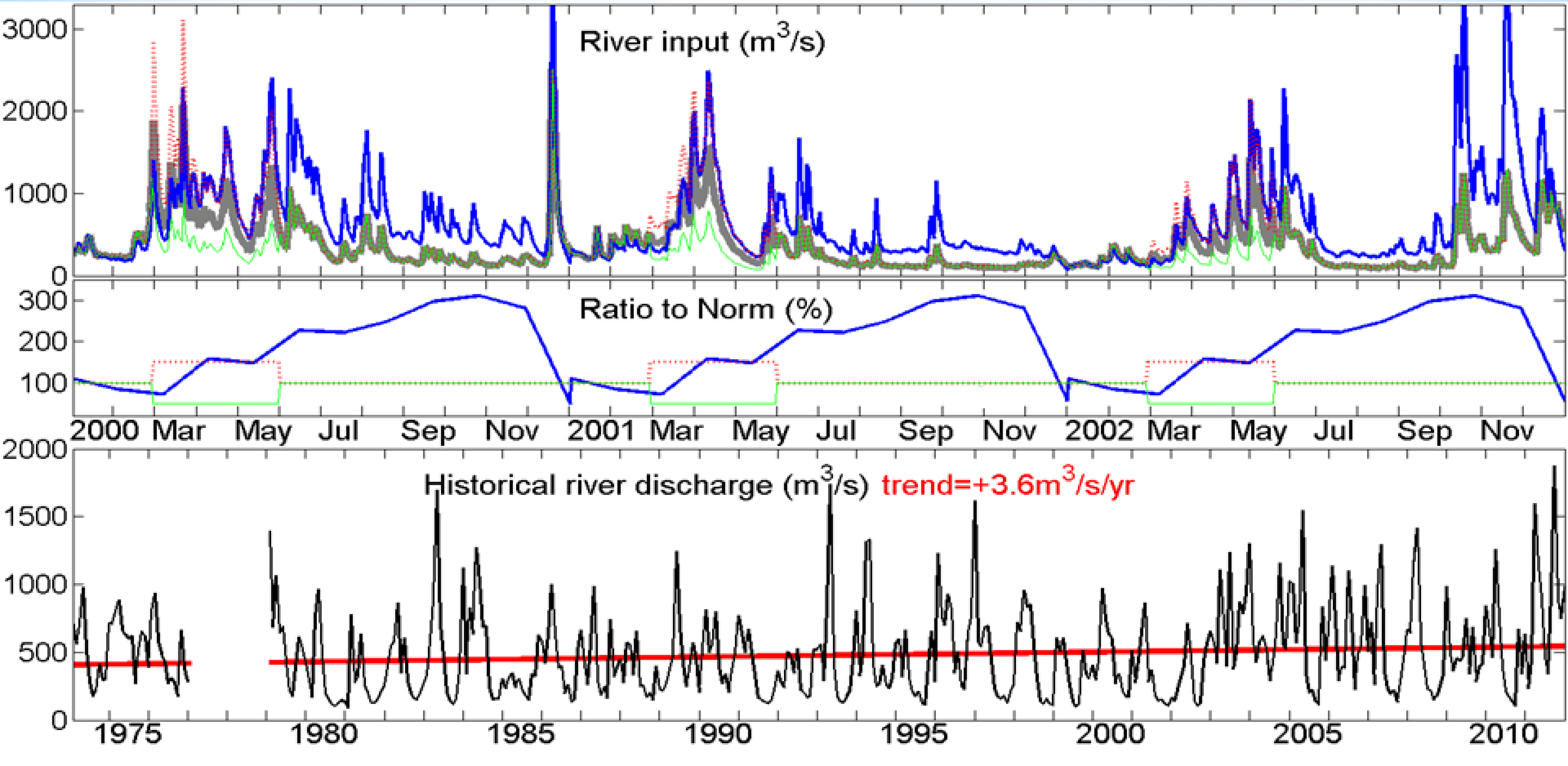
Sensitivity studies to climate changes in near future: Predicted climate changes in ~100 years

River discharge:

Changes with precipitation & sea ice extent (+~ 2.7±0.6%/10yr since 1978)

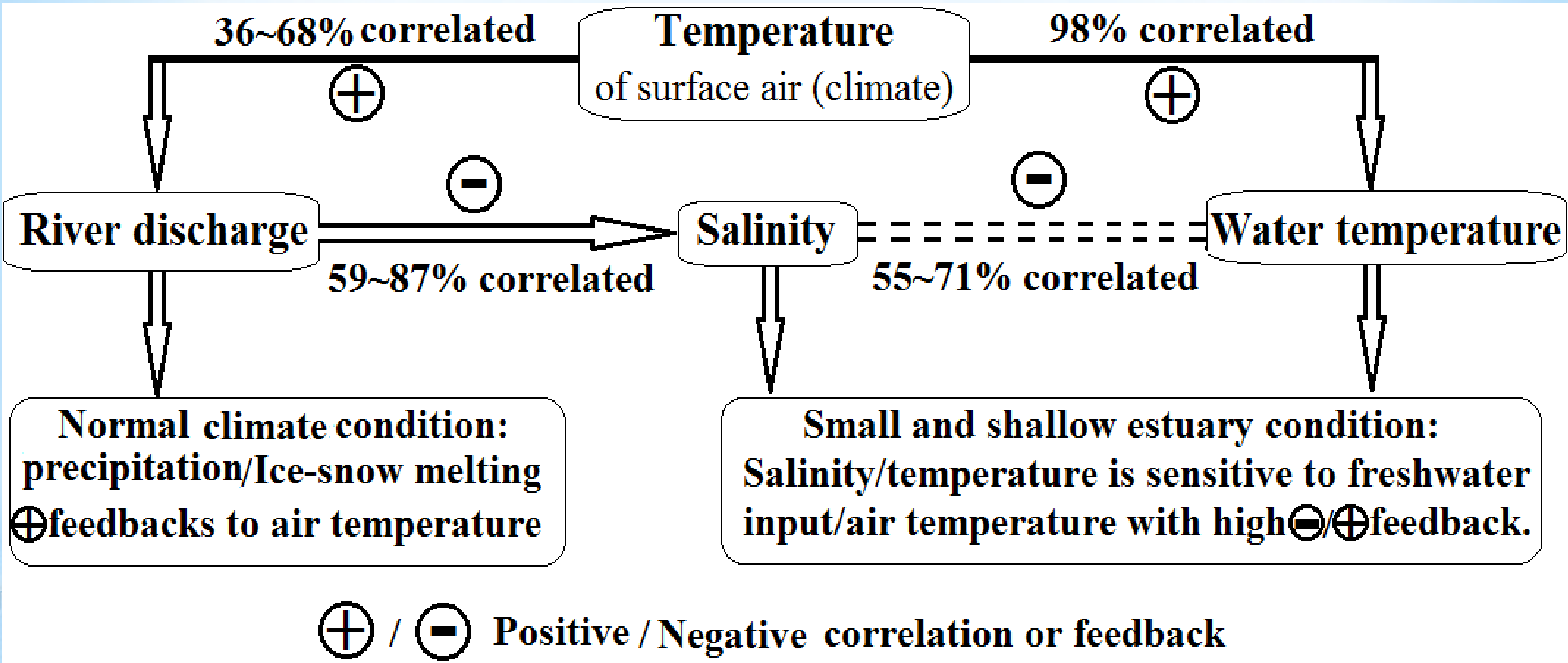
+3.6m3/s/yr into Delaware Bay since 1974

A 4%±7% increment of precipitation over DB has been predicted by 7 global climate models by 2070-2099, even more by Pollard.



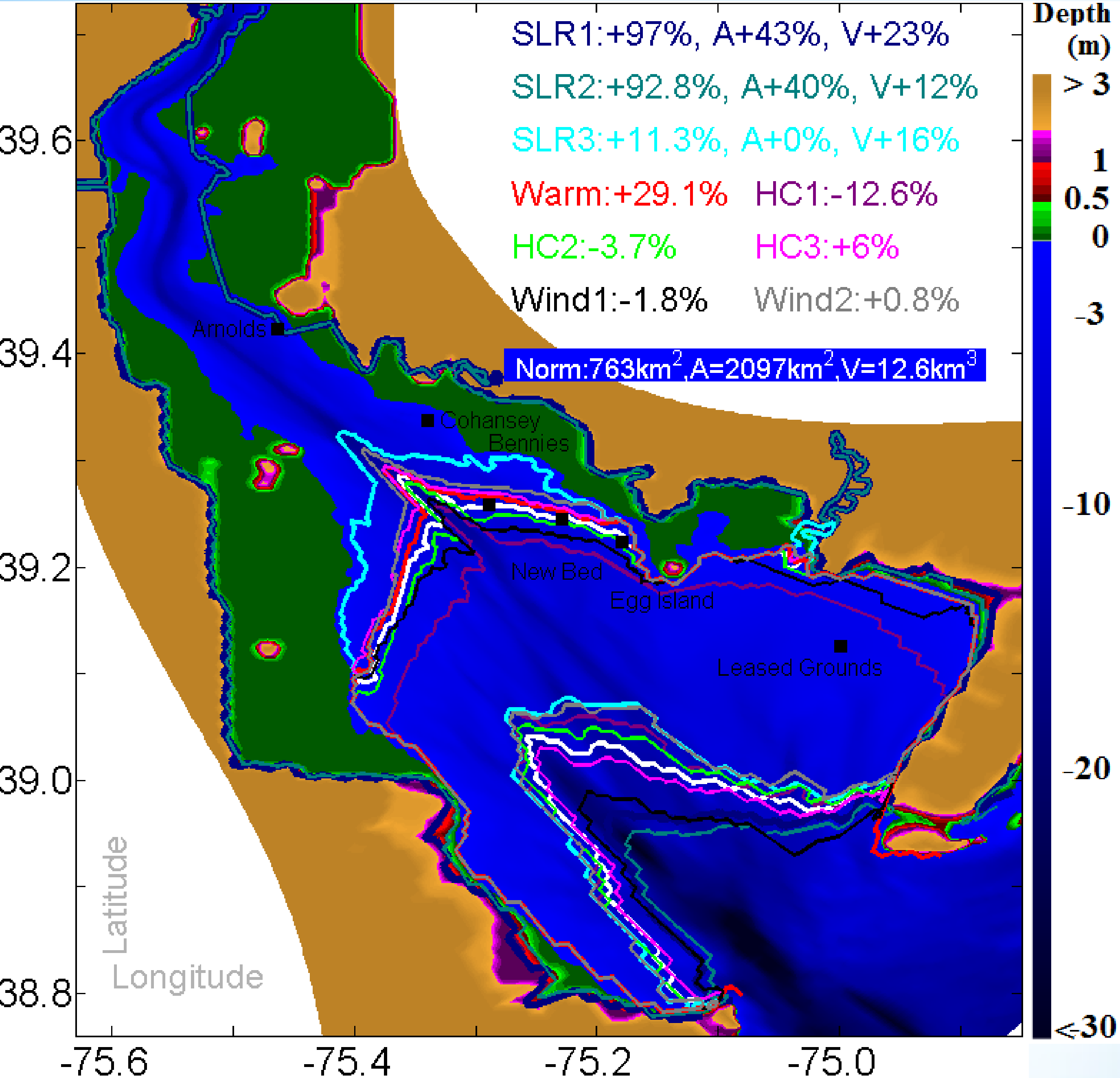
Experiment results and analysis

Feedback of salinity, temperature and river flow in present Delaware Bay



Negative S-T correlation keeps the bay being rarely both salty and warm with smaller SWA (salty-warm water area), helping limit MSX prevalence.

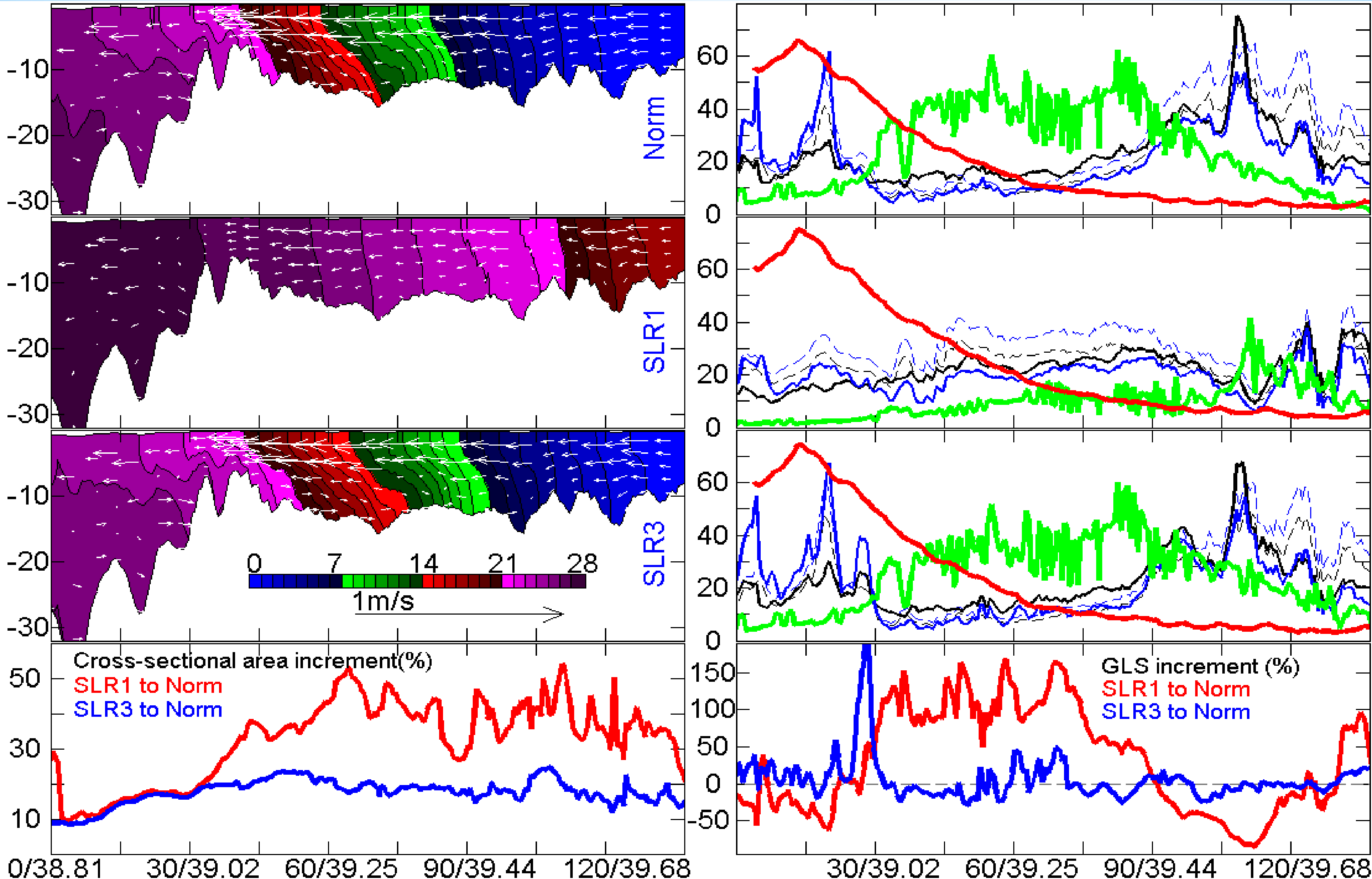
Sensitivity studies to climate changes in near future: Experiment results and analysis



SWA Bathymetry Beds

Sensitivity studies to climate changes in near future: Experiment results and analysis

Intensified salt-intrusion and mixing



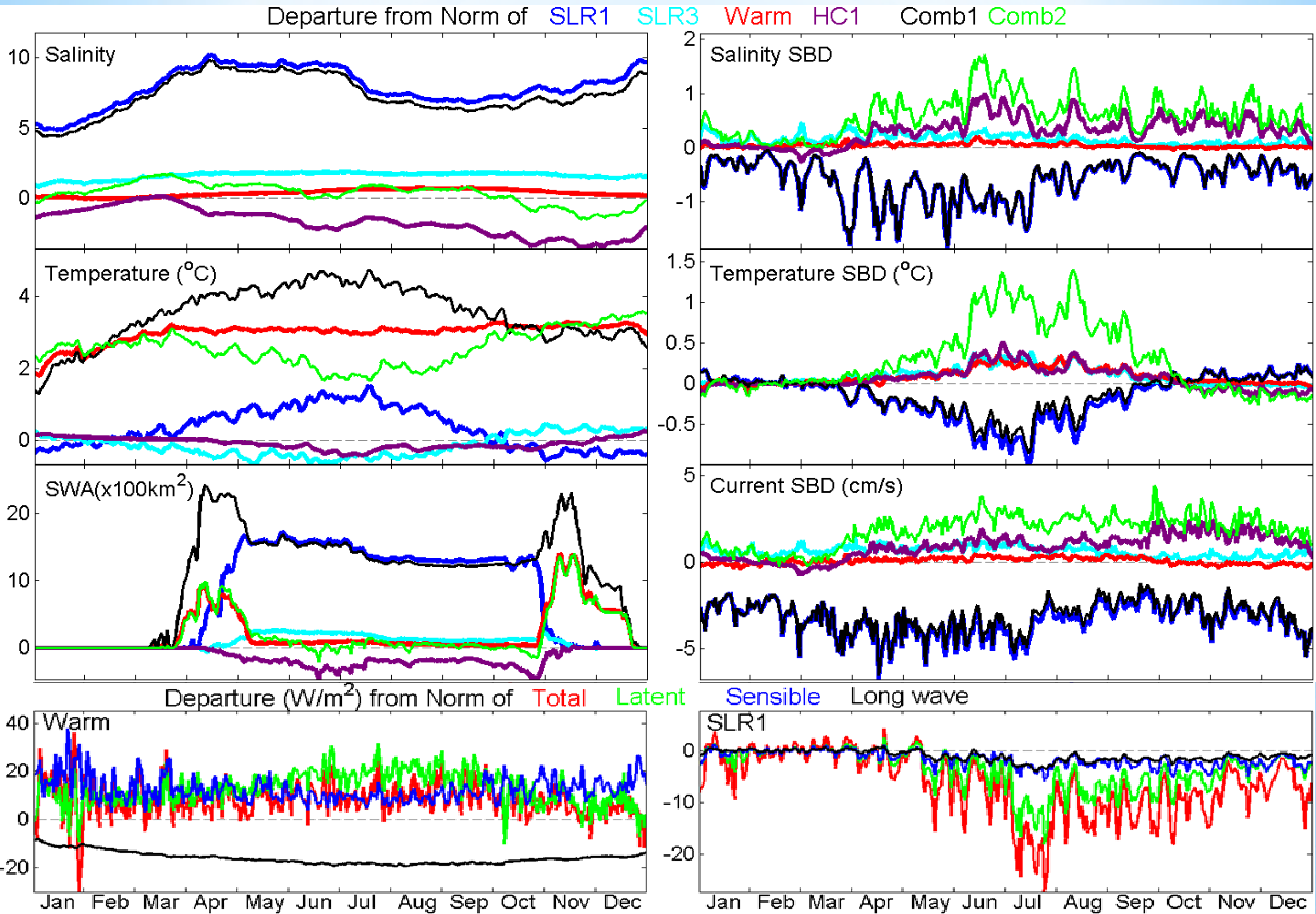
Estuary salinization and warming

Departures of SWA, ESI and SFI as well as salinity, temperature, current & their SBD

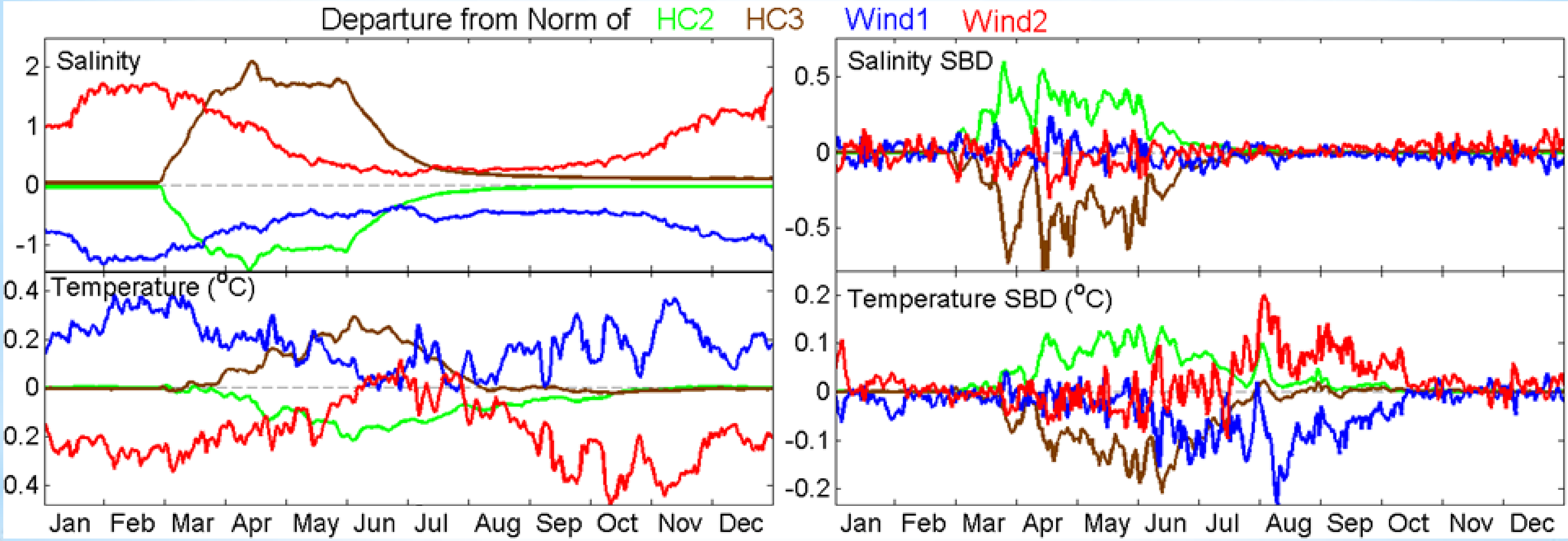
$ESI = 100 \times \frac{\Delta A_S - \Delta A}{A}$, estuary salinization index (%); $SFI = 100 \times \frac{\Delta C_r}{2Cr}$, S sensitivity to R (%)

	SWA	ESI	SFI	Salinity		Temperature		Current	
				bottom	SBD	bottom	SBD	surface	SBD
Norm	763	0	0	17.5	0.68	13.4	0.28	9.2	6.05
SLR1	+740	+21 (24)	-34	+7.60	-0.60	+0.41	-0.17	-4.08	-3.34
SLR2	+708	+21 (23)	-34	+7.40	-0.60	+0.45	-0.18	-4.22	-3.44
SLR3	+86	+8	0	+1.67	+0.15	-0.19	+0.08	+0.72	+0.62
Warm	+222	+2	+3	+0.35	+0.03	+2.95	+0.08	+0.05	+0.07
HC1	-96	-8	+5	-1.58	+0.31	-0.12	+0.06	+1.27	+0.89
HC2	-28	-2	+2	-0.29	+0.09	-0.07	+0.03	+0.33	+0.23
HC3	+46	+3	-7	+0.49	-0.11	+0.07	-0.03	-0.40	-0.29
Wind1	-14	-4	+2	-0.70	-0.01	+0.20	-0.04	-0.22	-0.16
Wind2	+6	+3	-8	+0.78	-0.01	-0.20	+0.02	+0.38	+0.18
Comb1	+1052	+18 (23)	-33	+7.03	-0.57	+3.58	-0.13	-3.90	-3.16
Comb2	+251	+4	+3	+0.62	+0.59	+2.43	+0.28	+2.28	+1.84

Sensitivity studies to climate changes in near future: Experiment results and analysis



Sensitivity studies to climate changes in near future: Experiment results and analysis



Summary of Preliminary Results

- Tracers and circulations of Delaware Bay would be changed by the predicted climate changes with e.g., an intensified salt-intrusion and an elevated temperature.
- 0.5-1m sea level rise with intensified salt-intrusion and mixing would seriously salinize the bay and weaken gradients tracers. Most of the newly water area would become saltier and warmer. Freshwater area in the upper bay retreats.
- A 5^{o}C warmer surface air, warming the bay, would largely increase the SWA.
- Higher MSX prevalence might be induced due to large SWA preferred by MSX and enhanced up-bay MSX transport likely from the intensified salt-intrusion.
- The predicted intensified hydrology cannot cancel the SLR1-induced salinization because it reduce salinity only by 1-2. It enhances salinity stratification, instead.
- A 50% higher/lower spring river flow would reduce/increase salinity by 1-2 and slightly enhance/weaken salinity stratification in spring and summer.
- The effects from an enhanced or a weakened zonal wind would be minor.
- The fixed coastal line would mitigate the salinization induced by sea level rise, but intensify the stratifications of salinity, temperature, and current mainly in the lower bay.

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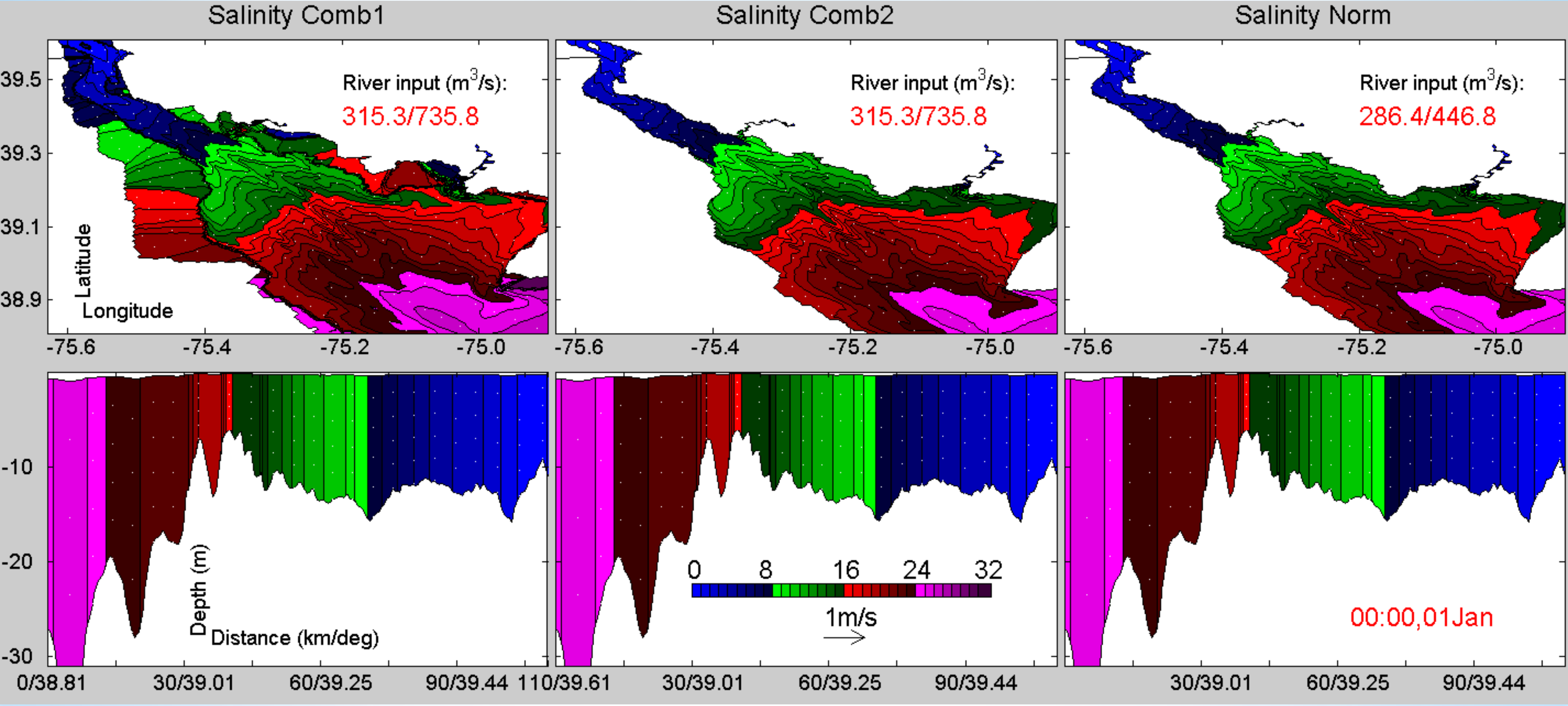
Salinity Comb1
Salinity Comb2
Salinity Norm
River input (m3/s):
315.3/735.8
River input (m3/s):
315.3/735.8
River input (m3/s):
286.4/446.8
39.5
39.3
39.1
38.9
Latitude
Longitude
-75.6
-75.4
-75.2
-75.0
-10
-20
-30
Depth (m)
Distance (km/deg)
0/38.81
30/39.01
60/39.25
90/39.44
110/39.61
0
8
16
24
32
1m/s
00:00,01Jan

Thanks 多谢 !!!