Representer-based observing system design in the New York Bight

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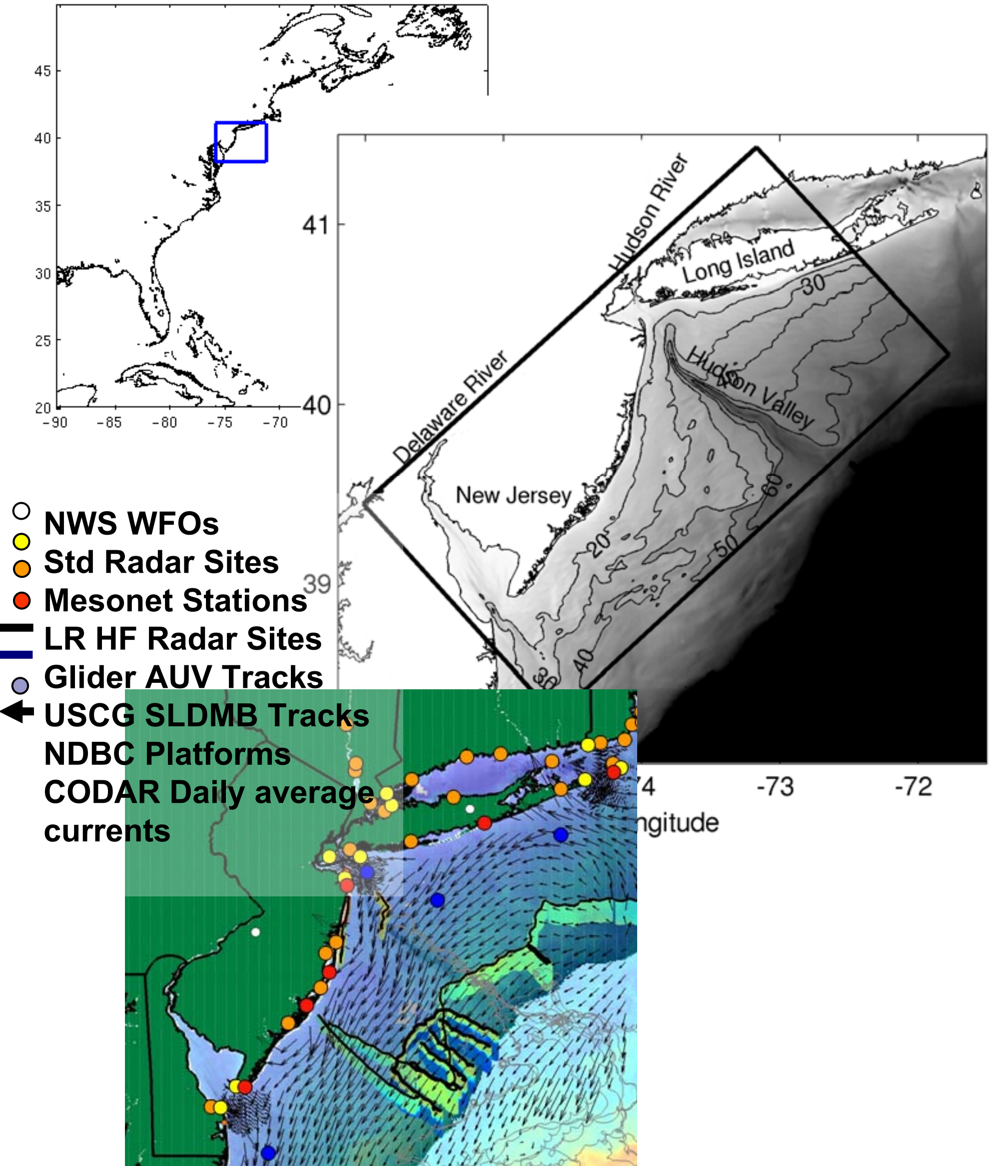
Outline of the presentation

1. Background and motivations
2. IS4DVAR Data assimilation result
3. Set-up of the representer system
4. Observing system design
5. Summary

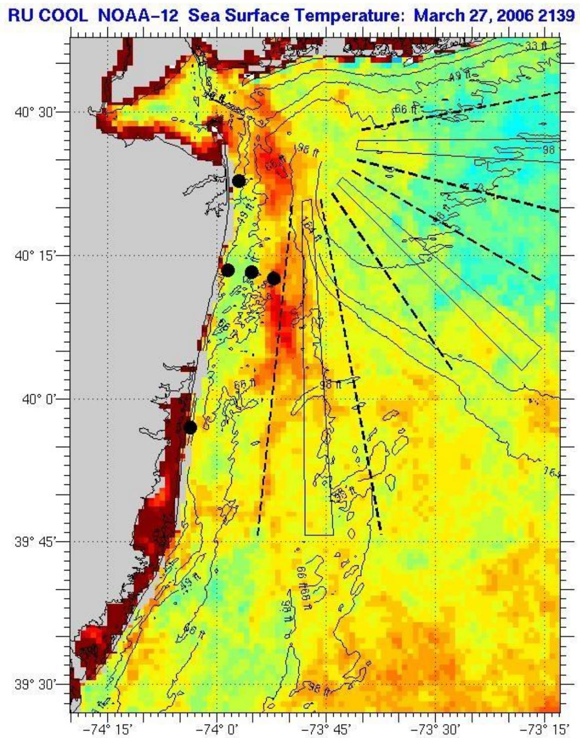
Background



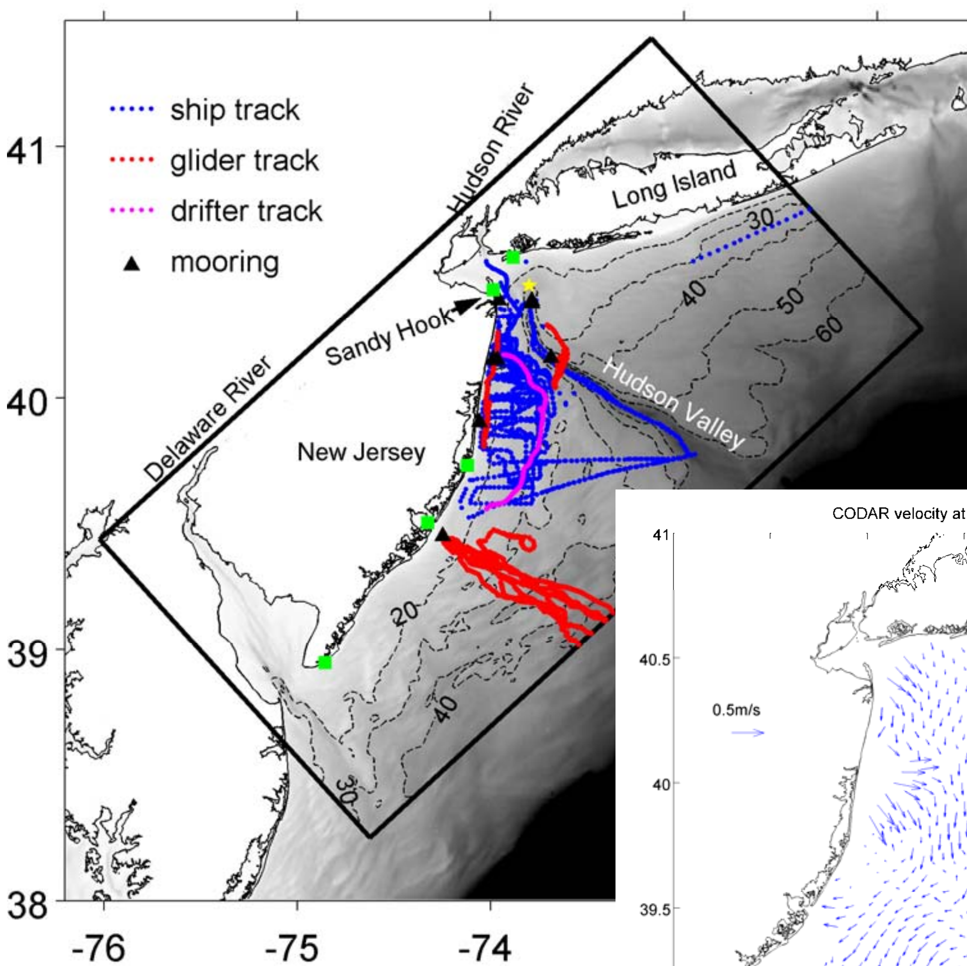
New York Bight:

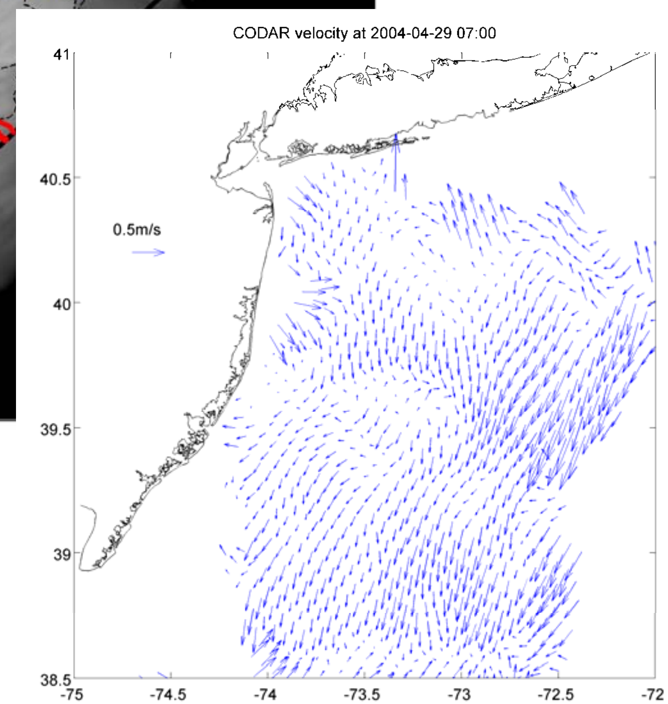
- biologically active
- complicated but interesting dynamics
- affected by both local forces (wind, river discharge, topography, etc.) and remote forces (large-scale circulation, tides, etc.)
- one of best observed coastal areas around the world

Observations: spring 2006



(from Rutgers COOL webpage)





Motivations

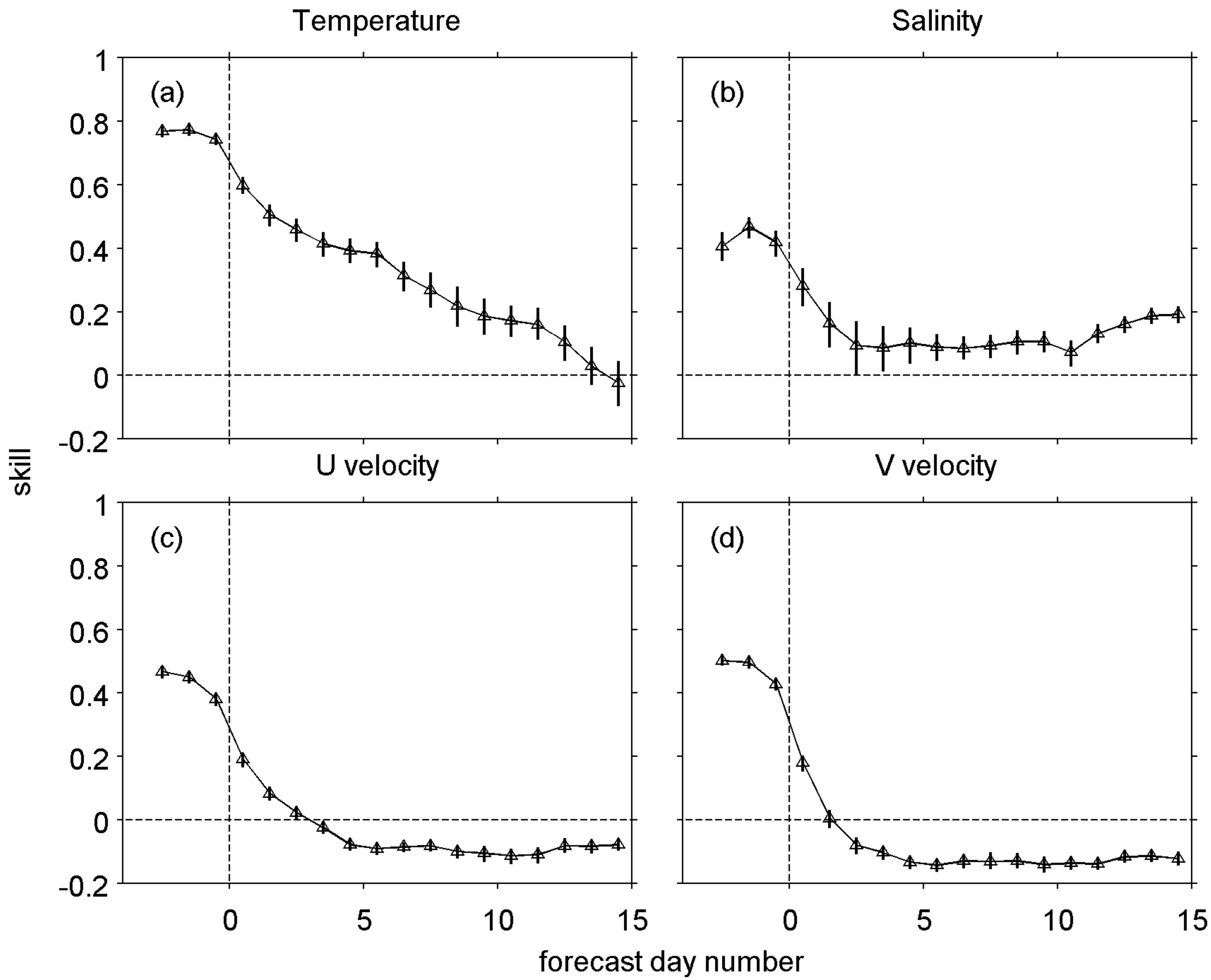
- To improve the estimation of the ocean state and prepare for real-time ocean forecast
- To evaluate existing observation pattern and help design targeted observations
- Towards building an integrated modeling and observation system

ROMS IS4DVAR result

– improvement of the analysis and forecast

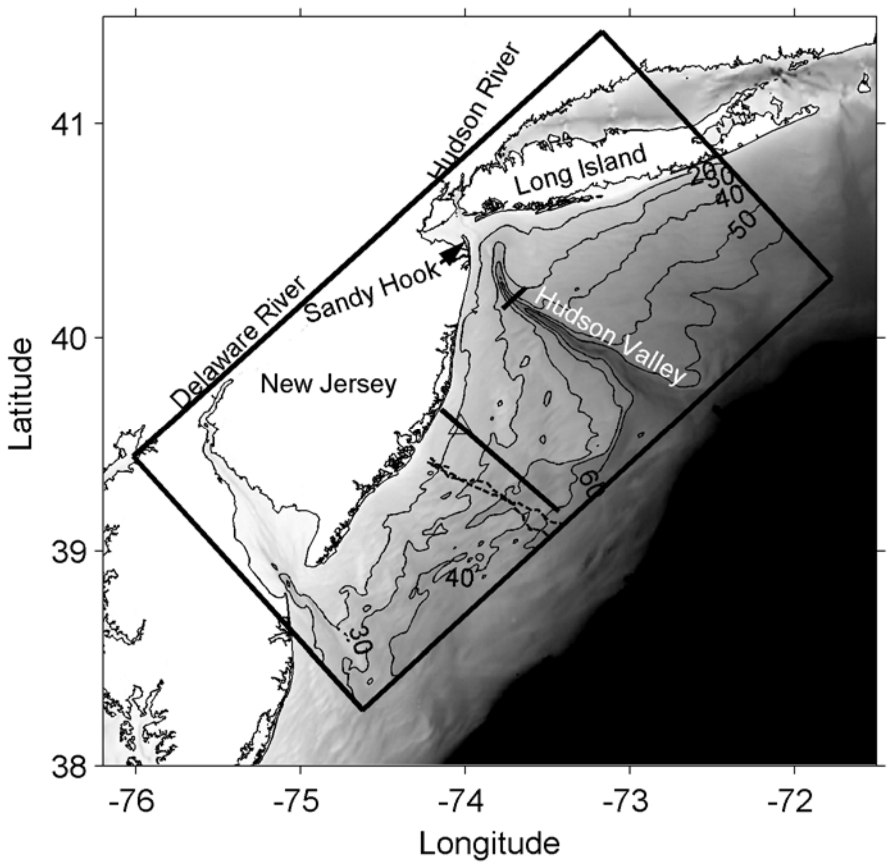
$$\text{skill} = 1 - \frac{\text{RMS}_{\text{afterDA}}}{\text{RMS}_{\text{beforeDA}}}$$

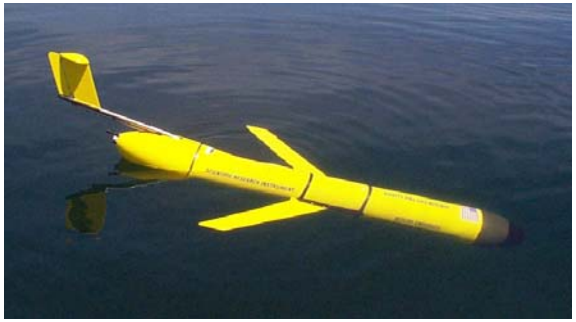
- substantial improvement of temperature and salinity forecast (~15 days)
- velocity forecast is improved for 2-3 days



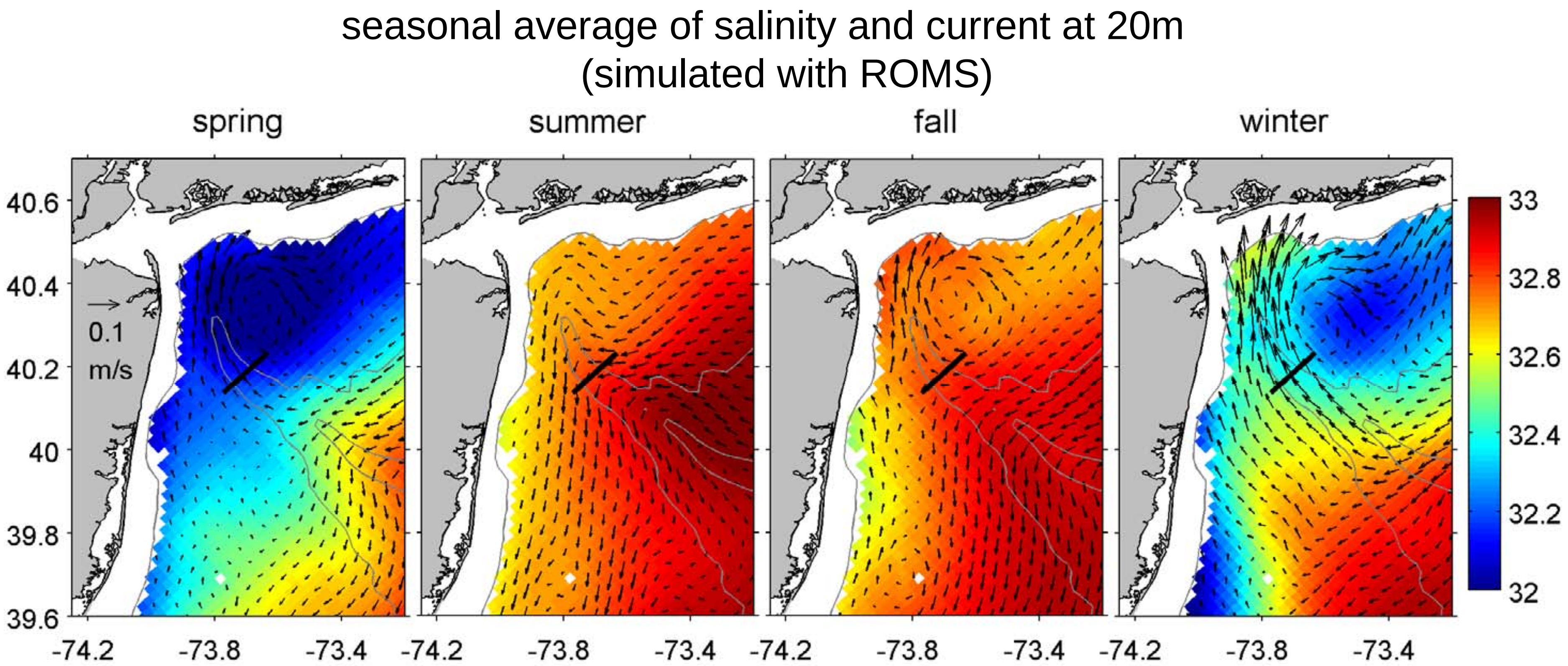
Representer-base observing system design

- Question: where should we deploy the gliders to better predict the salt flux with the Hudson Shelf Valley in 2 days



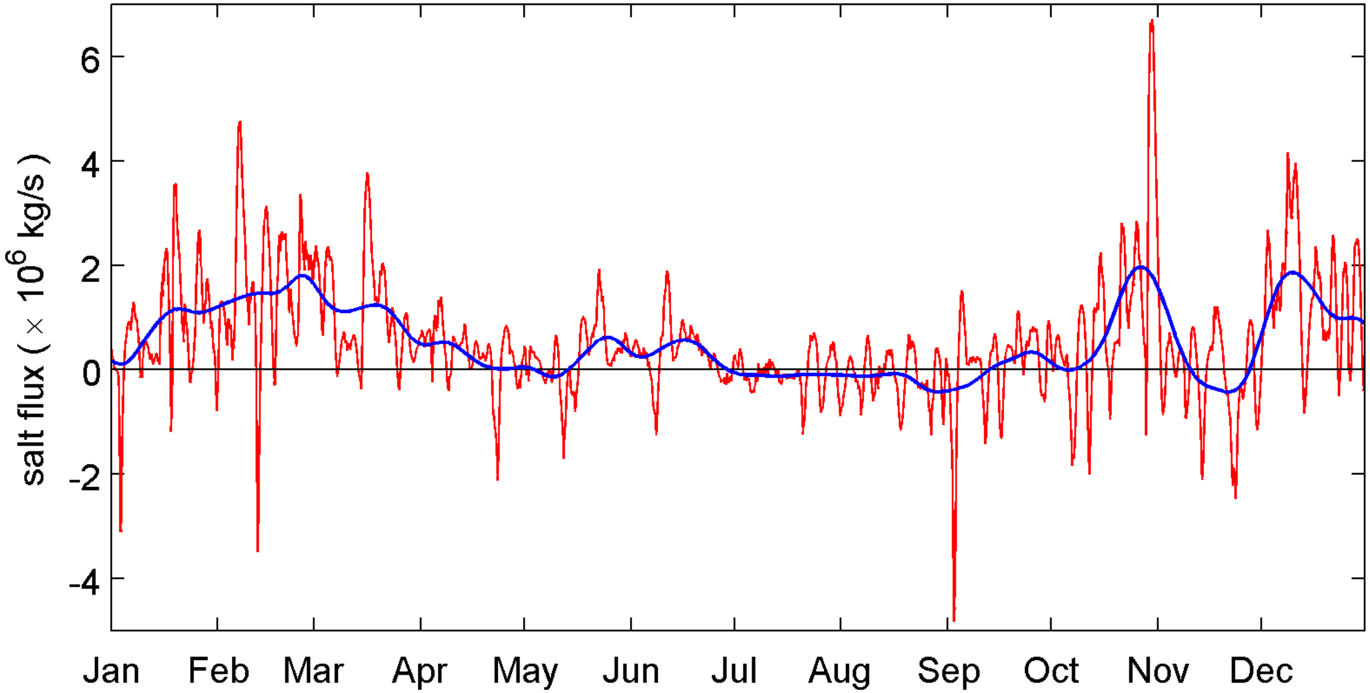


Observing system design ---- background



Observing system design ---- background

salt flux time series



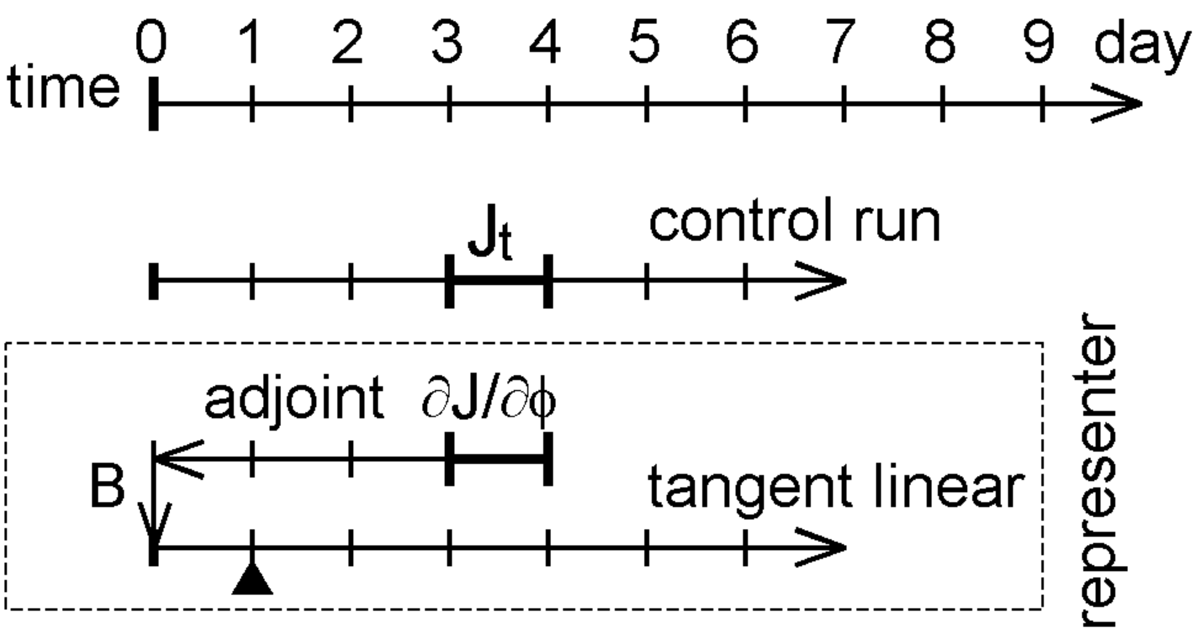
Salt flux in the Hudson Valley:

- strong shoreward intrusion in winter and spring
- little net flux in summer

the representer-based system

$$J = \frac{1}{\Delta t}\int_L \int_H \int_{\Delta t} \left[vS - \overline{vS} \right] dtdzdx$$

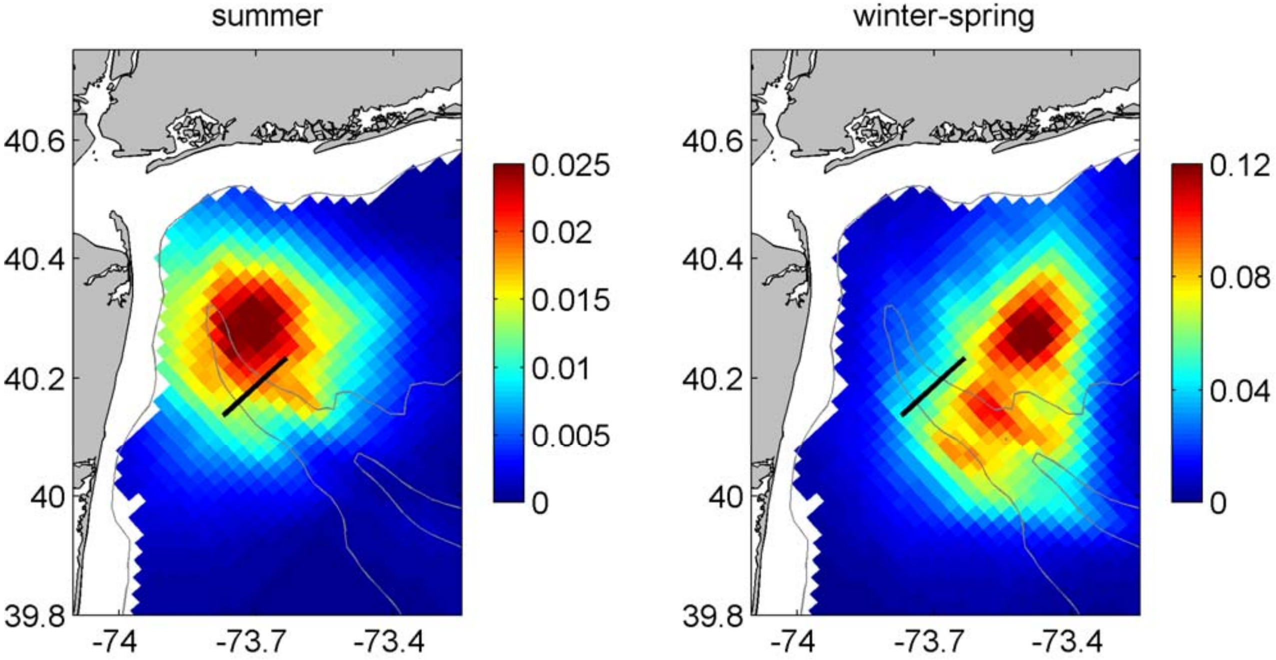
- The representer of y_i, $\mathbf{HRB}^{-1}\mathbf{R}^T \delta_{i,t_0} = \mathbf{HRB}^{-1}\mathbf{R}^T \frac{\partial \mathbf{\Phi}(\mathbf{x}_i, t_0)}{\partial \mathbf{\Phi}(\mathbf{x}, t_0)}$, tells the covariance between $\mathbf{\Phi}(\mathbf{x}_i, t_0)$ and $\mathbf{H\Phi}(\mathbf{x}, t)$
- $\mathbf{RB}^{-1}\mathbf{R}^T \frac{\partial J}{\partial \mathbf{\Phi}}$ gives the covariance between J and model state $\mathbf{\Phi}(\mathbf{x}, t)$
- Assuming no other observation available around the targeted area



Observing system design

$$J = \frac{1}{\Delta t}\int_L \int_H \int_{\Delta t} \left[vS - \overline{vS} \right] dt\,dz\,dx$$

RMS of the correlation of *J* with salinity at 20m



Observing system design

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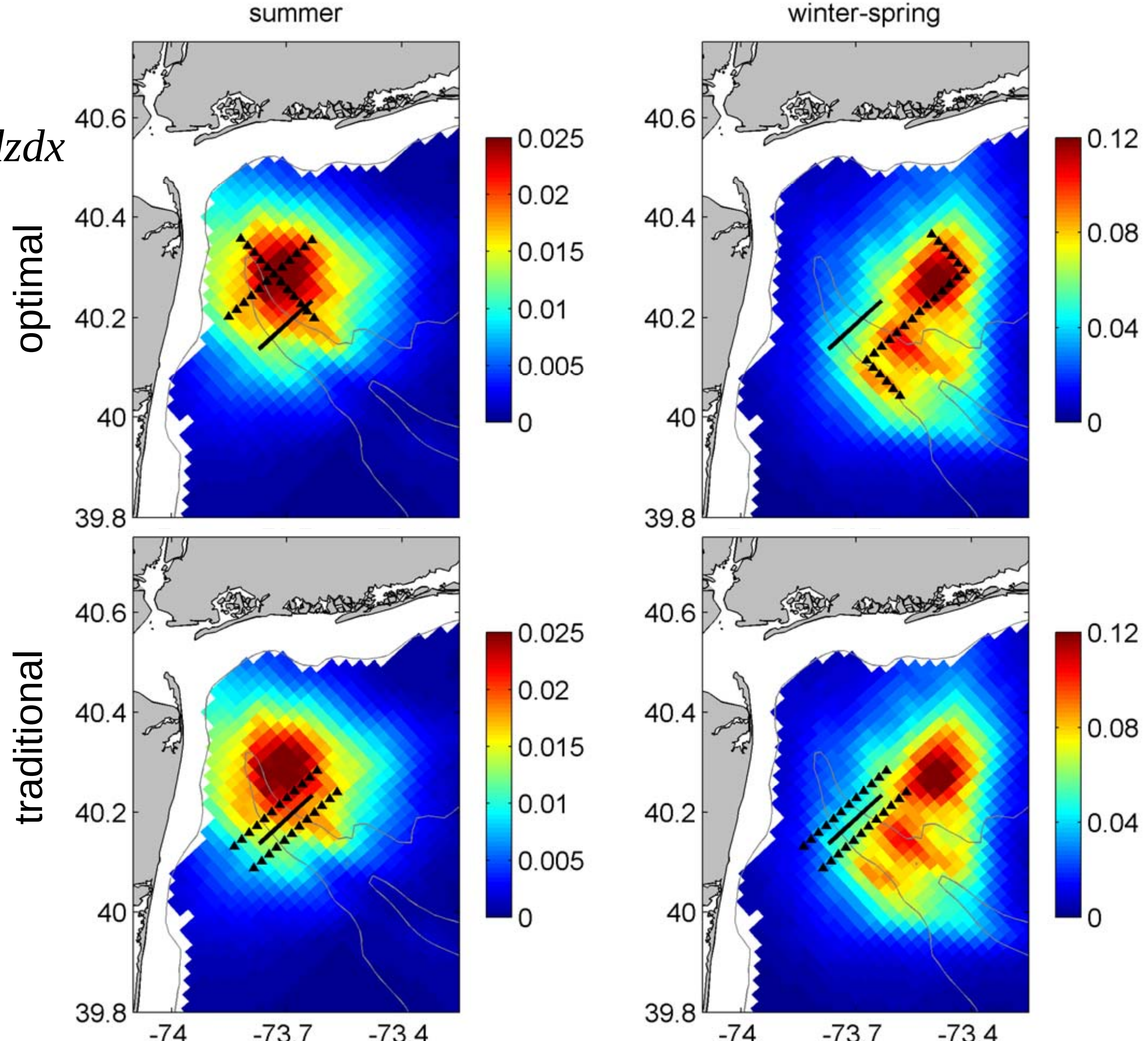
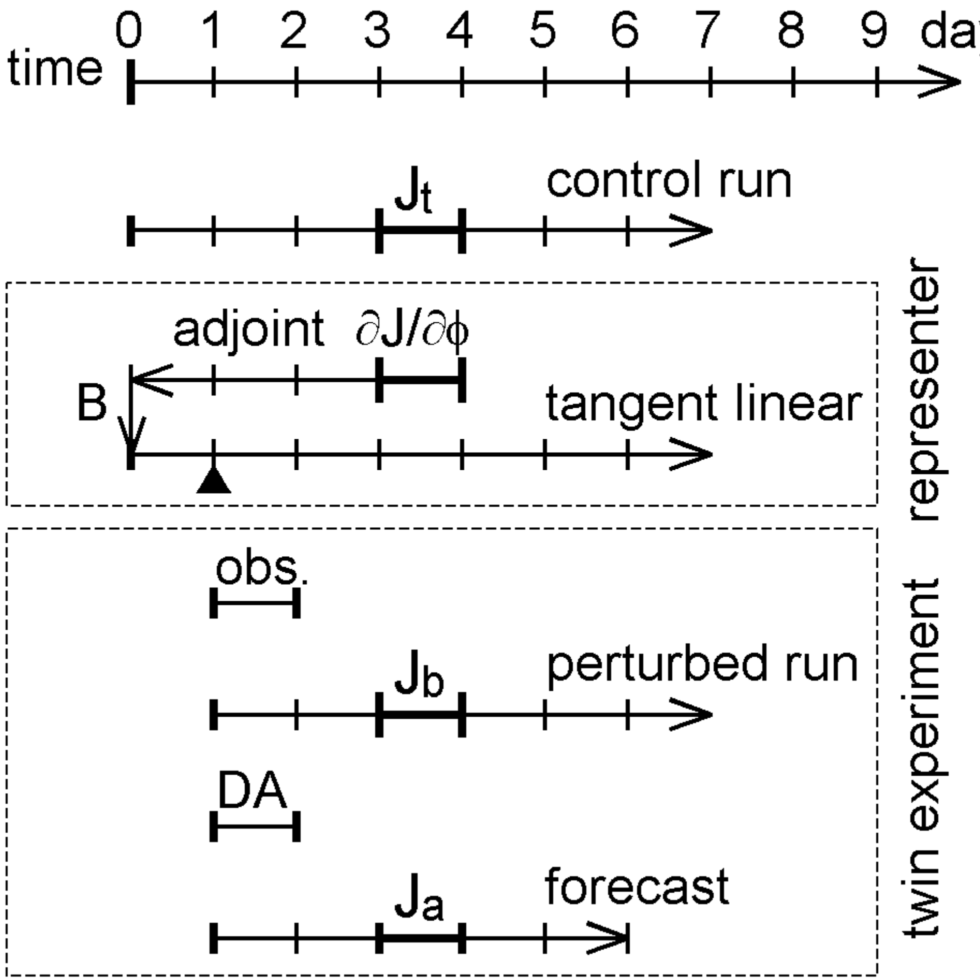
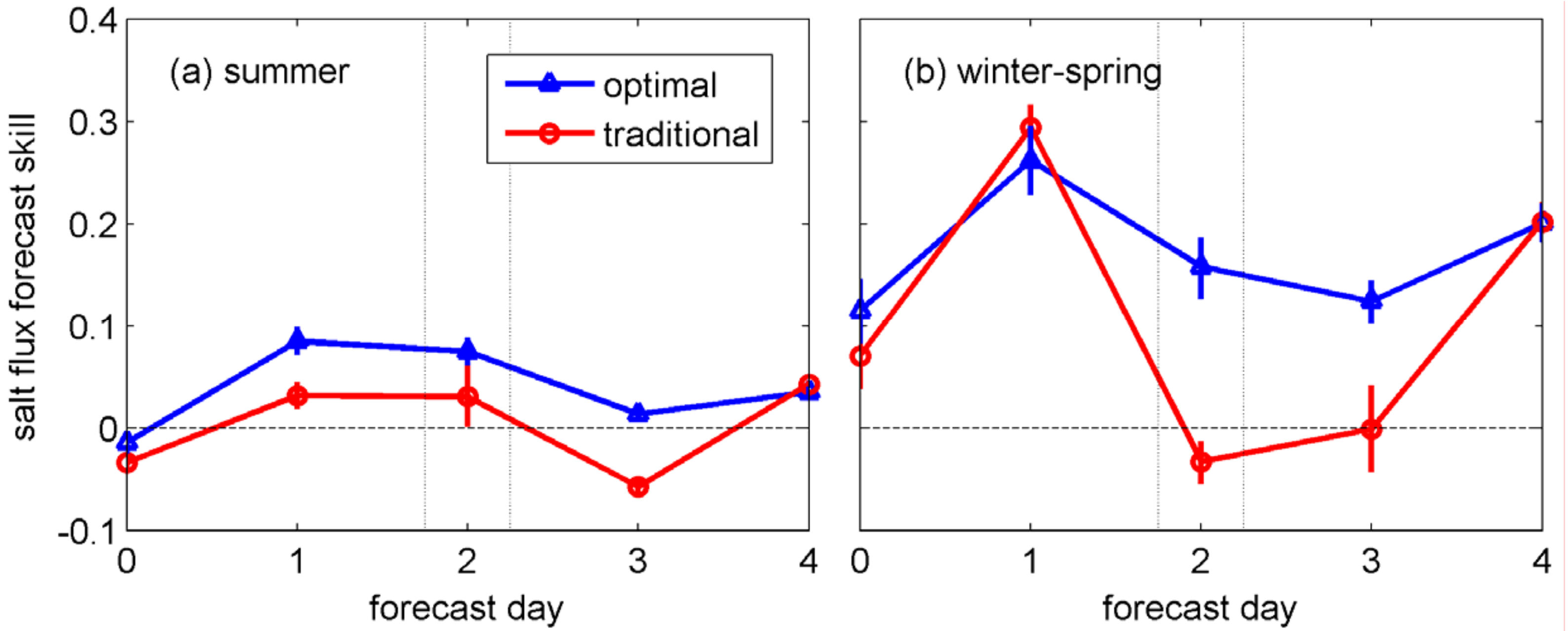


Set-up of the DA twin experiments



DA twin experiments

$$\text{skill} = 1 - \frac{\left| J_{\text{afterDA}} - J_{\text{true}} \right|}{\left| J_{\text{beforeDA}} - J_{\text{true}} \right|}$$

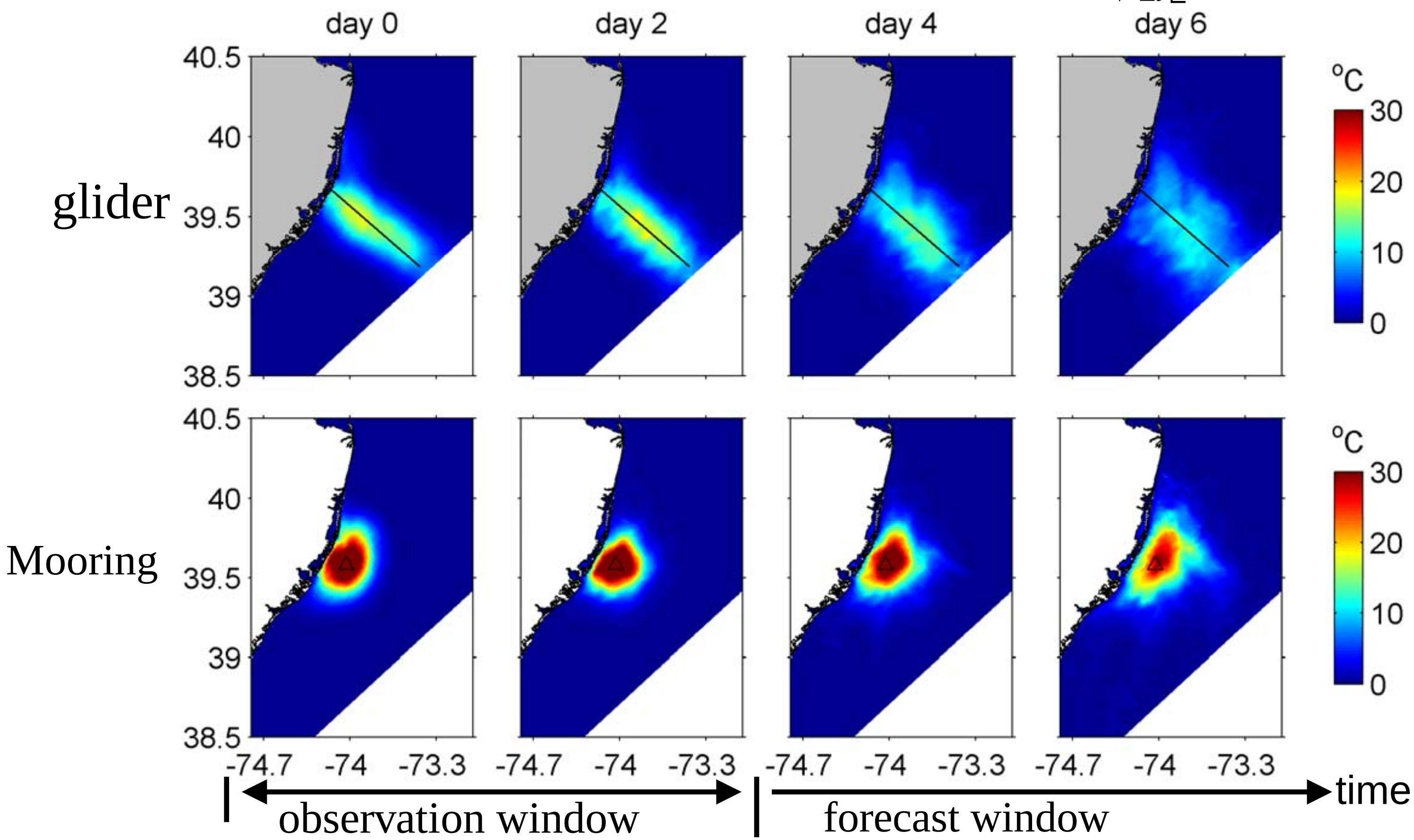


- For both seasons, the DA system assimilated data from optimally positioned gliders gives better 2nd-day prediction of *J*.
- The big improvement in winter-spring season is presumably caused by the strong landward intrusion in the valley and then clear identification of dynamical upstream.

Observation comparison – glider vs. mooring

Assuming: model error ~ ocean state anomaly

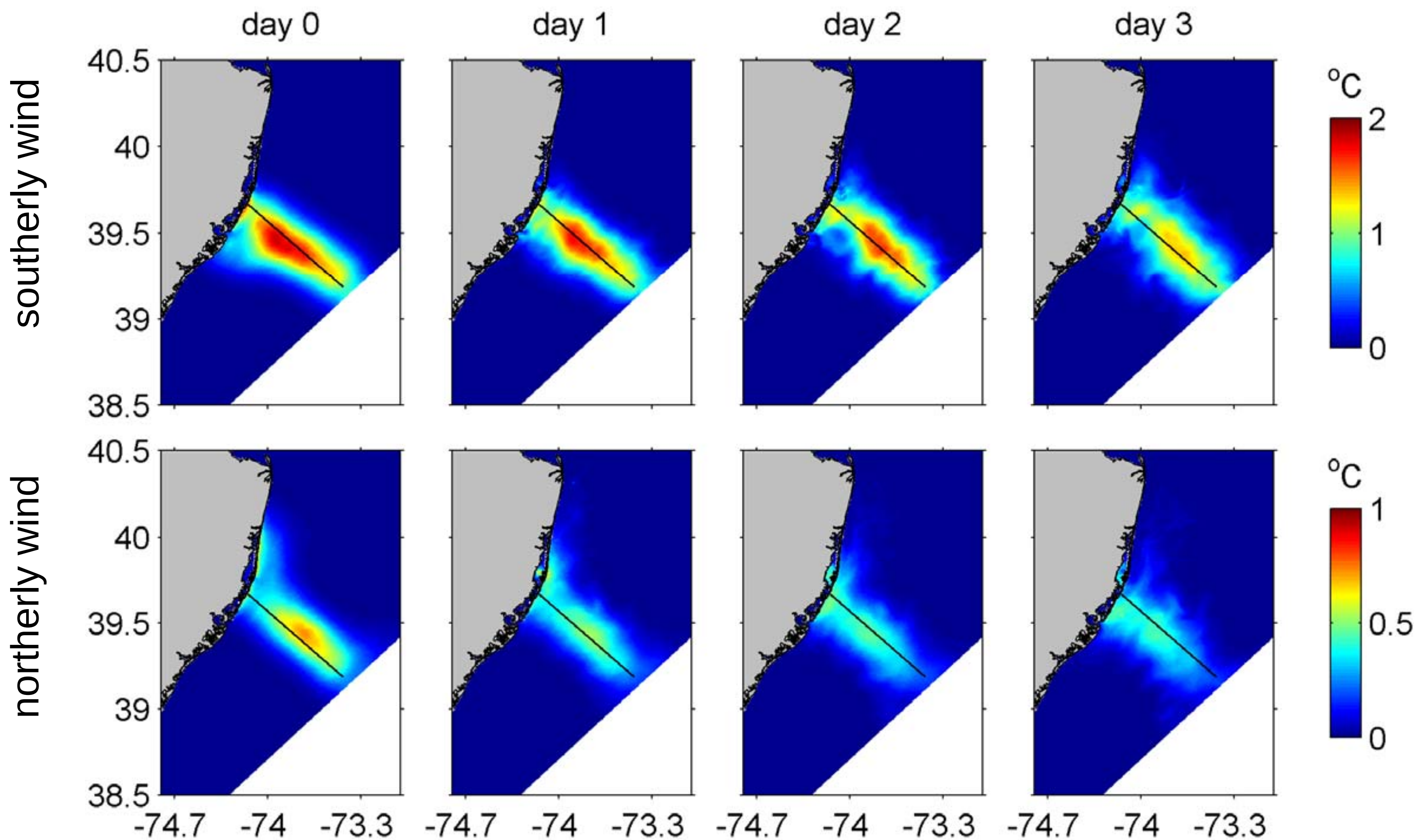
$$J = \frac{1}{V\Delta t}\int_V \int_{\Delta t} \left[\frac{(T-\bar{T})^2}{\mathbf{O}_T} + \frac{(S-\bar{S})^2}{\mathbf{O}_S} \right] dt dV$$



- a glider has broader influence area and a mooring has stronger influence around the observation location

Observing system design –- upwelling vs. downwelling

$$J = \frac{1}{V\Delta t}\int_V\int_{\Delta t}\left[\frac{(T-\bar{T})^2}{\mathbf{O}_T} + \frac{(S-\bar{S})^2}{\mathbf{O}_S}\right]dtdV$$



Summary and future work

- ROMS IS4DVAR has been applied in the NYB area and improved analysis and forecasts

- The representer system provides guidance on the design of targeted observation and has been used to compare different types observations and same observation in different dynamical regimes

- The newly developed observation sensitivity module in ROMS can be used to check the influences of observations in a data assimilation and forecast system.