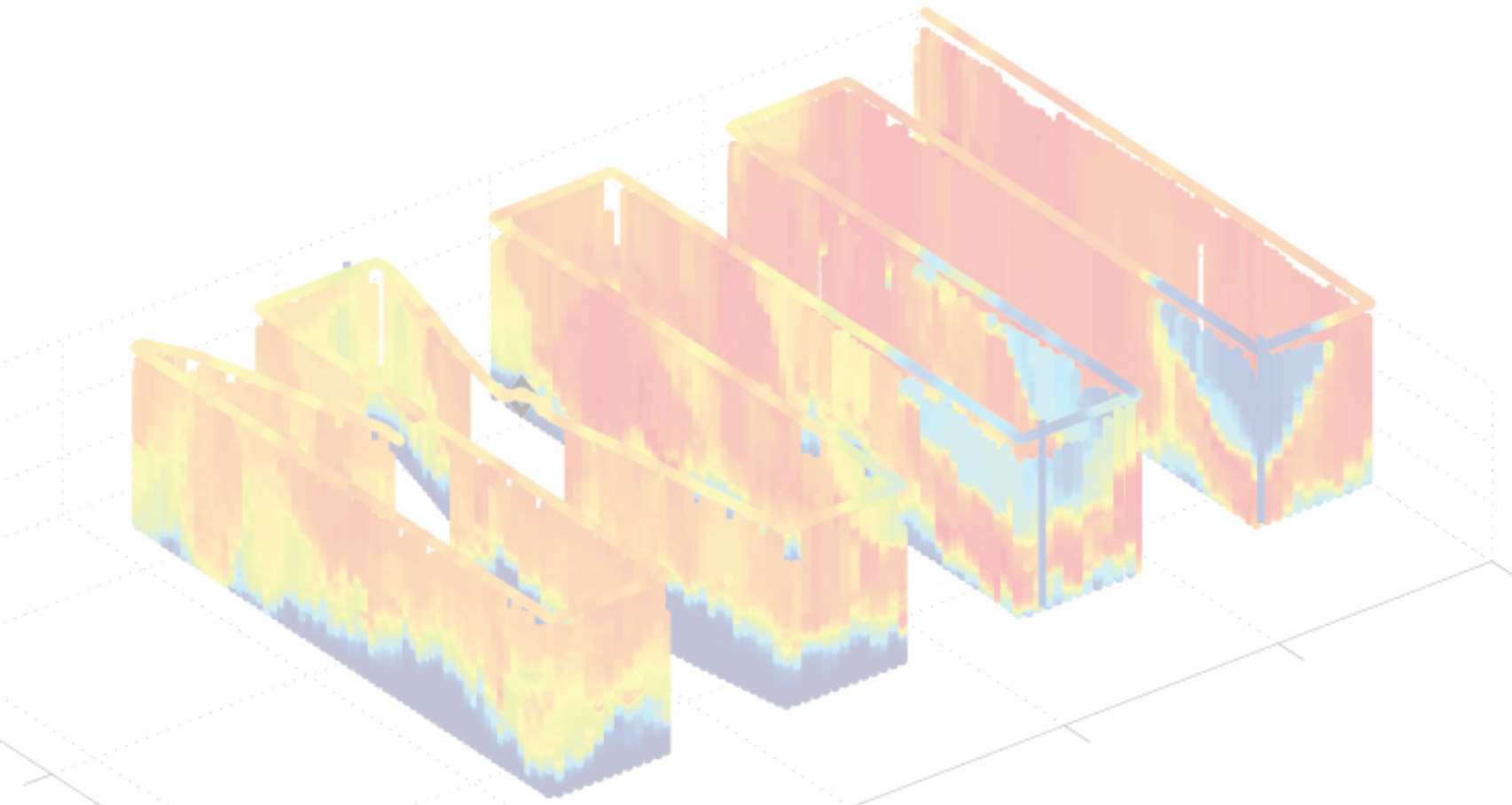
The North Atlantic surface layer and the shallow overturning circulation



Julius Busecke

Work presented here is in review at JGR: Oceans
Busecke, J., Gordon, A. L., Li, Z., Bingham, F., & Font, J.
Subtropical surface layer salinity budget and the role of mesoscale turbulence

EGU Assembly 2014, Vienna

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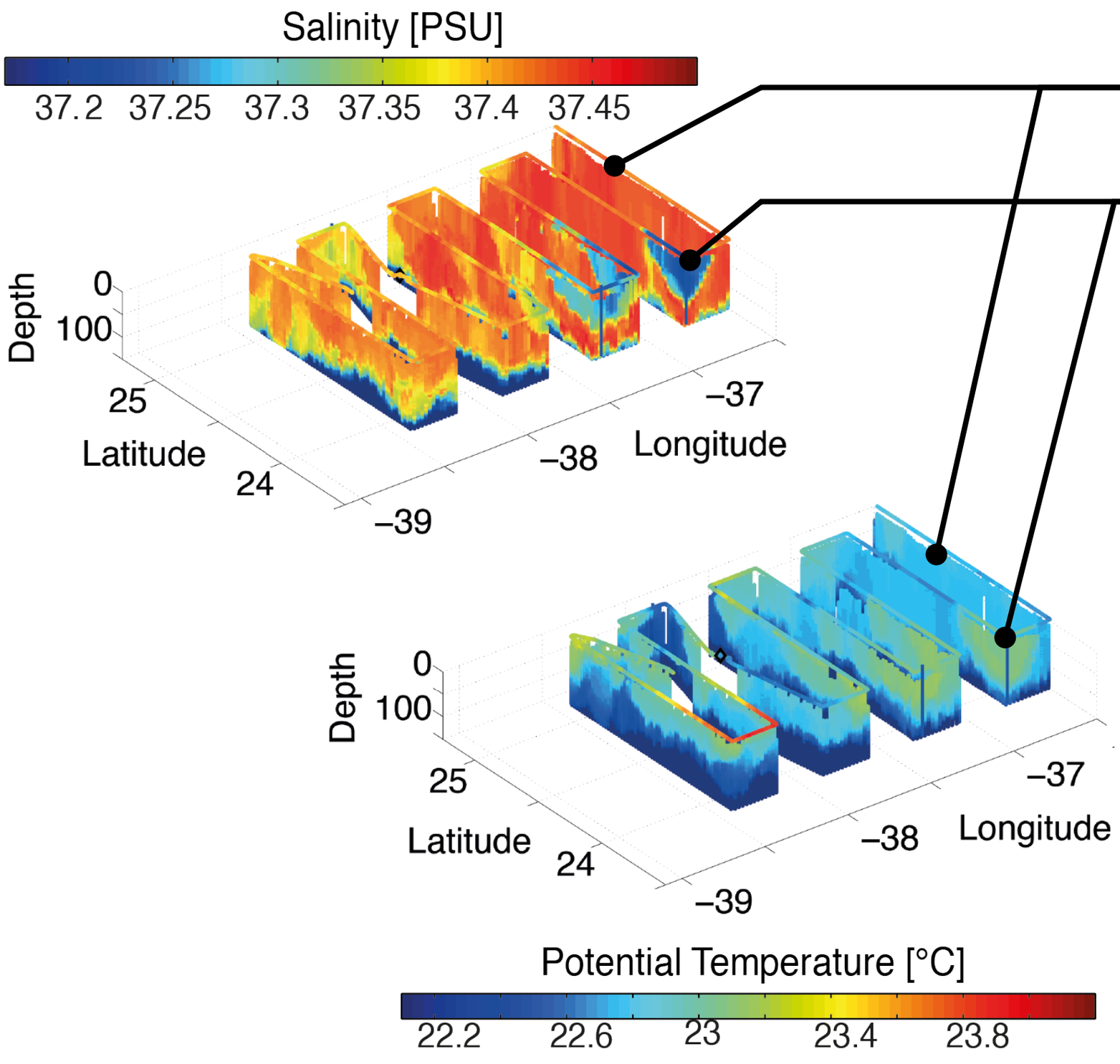
SeaSoar/TSG Survey



Prominent Features

- Deep salty mixed layers match climatology
- Fresh/warm features with strong surface fronts (>0.15 PSU/0.4 °C over less than 10 km)
- Northward migration, filamentation and weakening salinity/temperature contrast
  - **Fresh water is added to mixed layer in the domain**
- Movement associated with geostrophic velocity anomalies
  - **Mesoscale dynamics**

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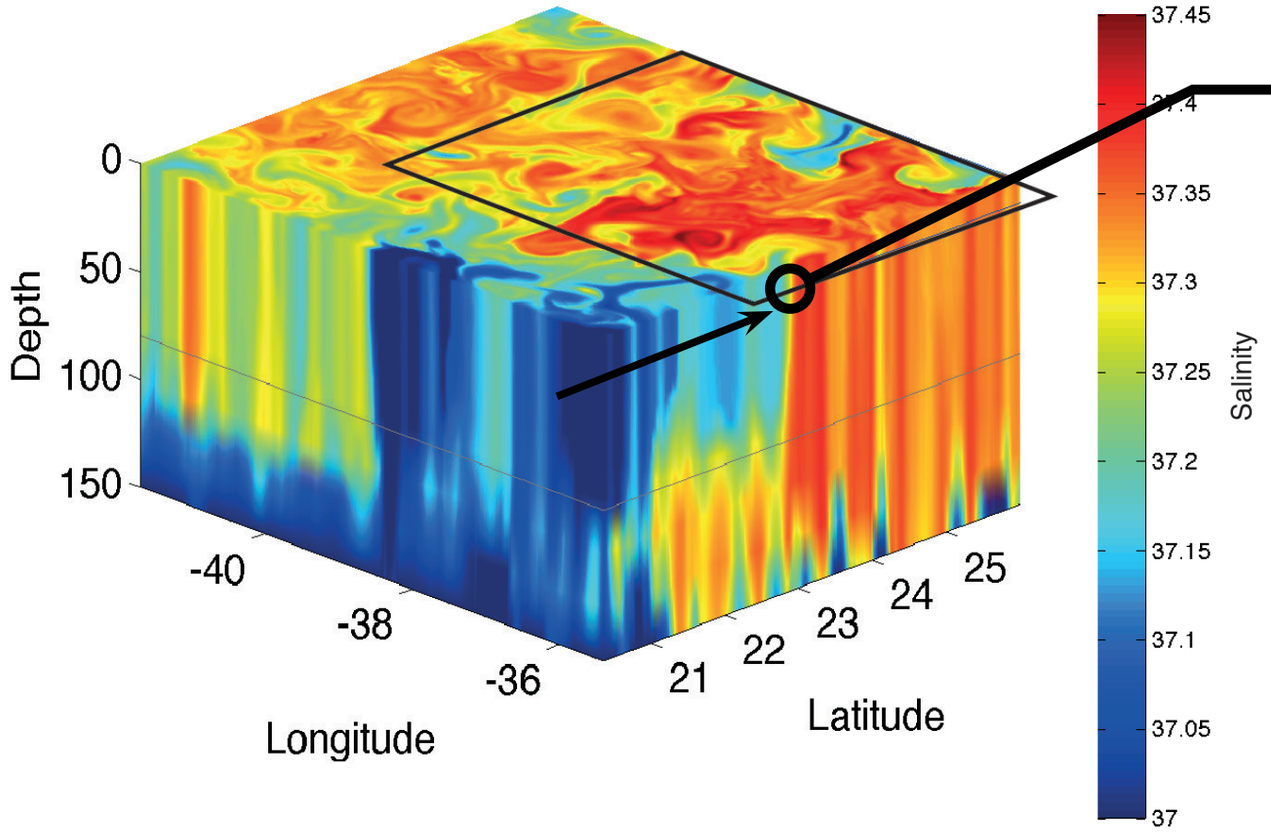
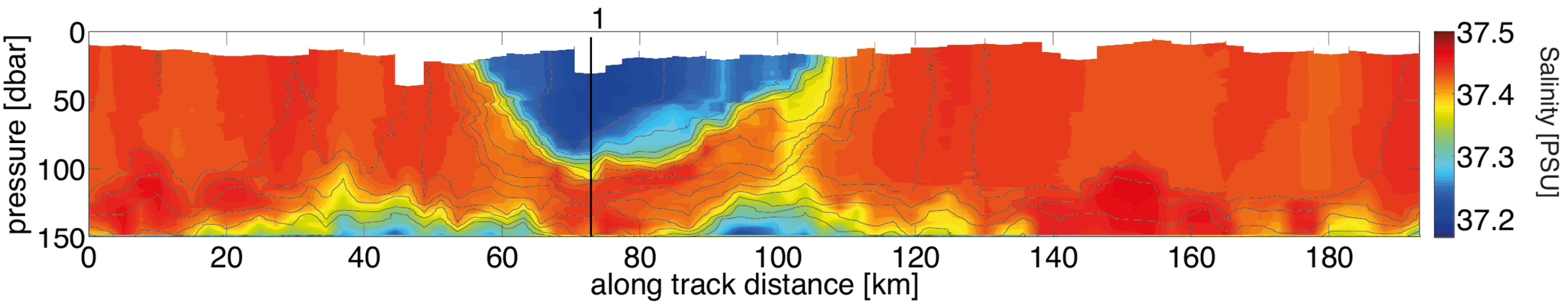
Regional model output

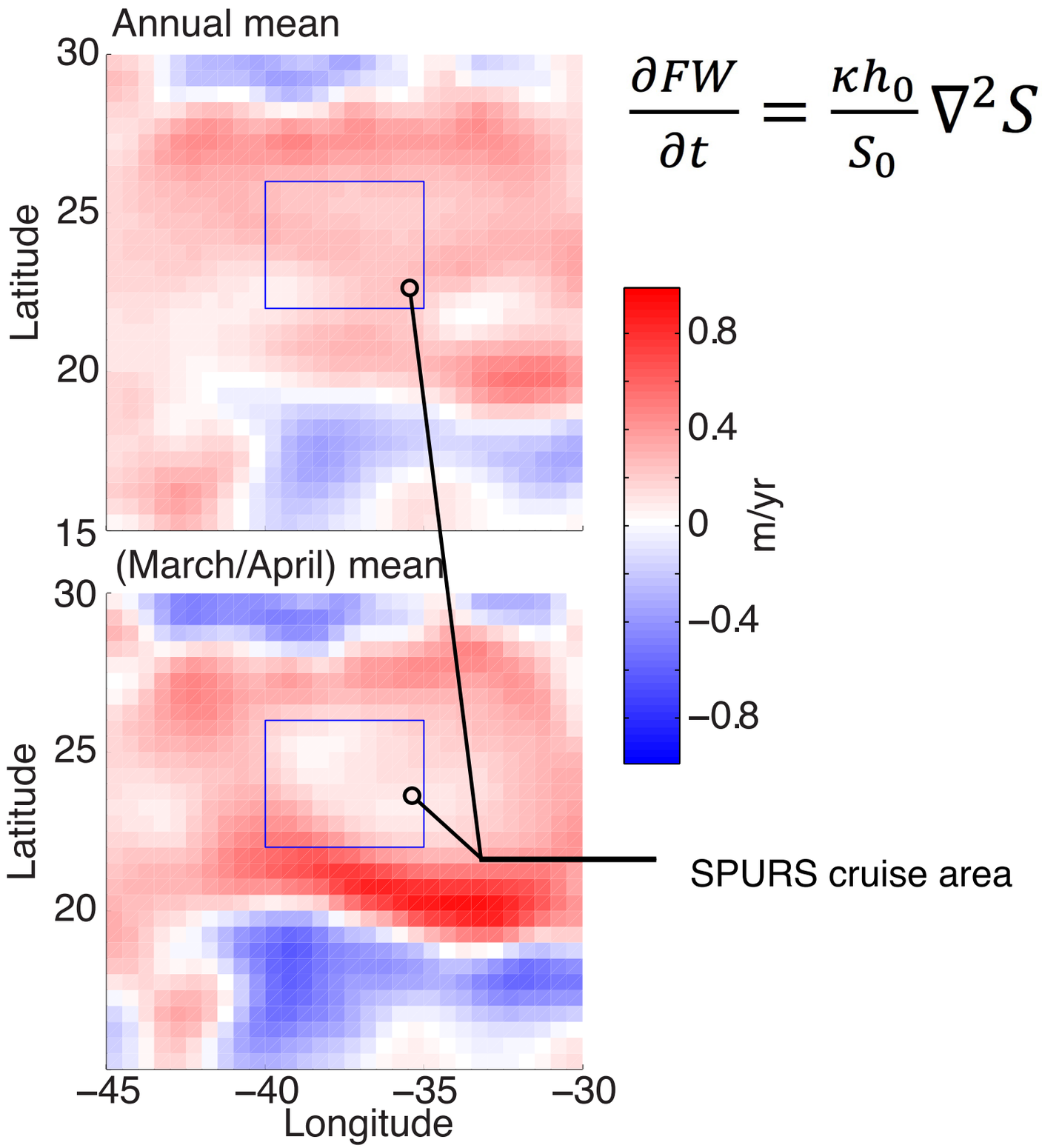


Comparison with survey data

- ROMS (2km resolution) reproduces an abundance of similar fresh features
- Lateral/vertical dimensions and surface characteristics are very similar to the in-situ data
- Northward advection from a fresh/warm body of water
- Fresh feature is dissipated on comparable time scale (~14-18 days)



Relevance for the SSS-max

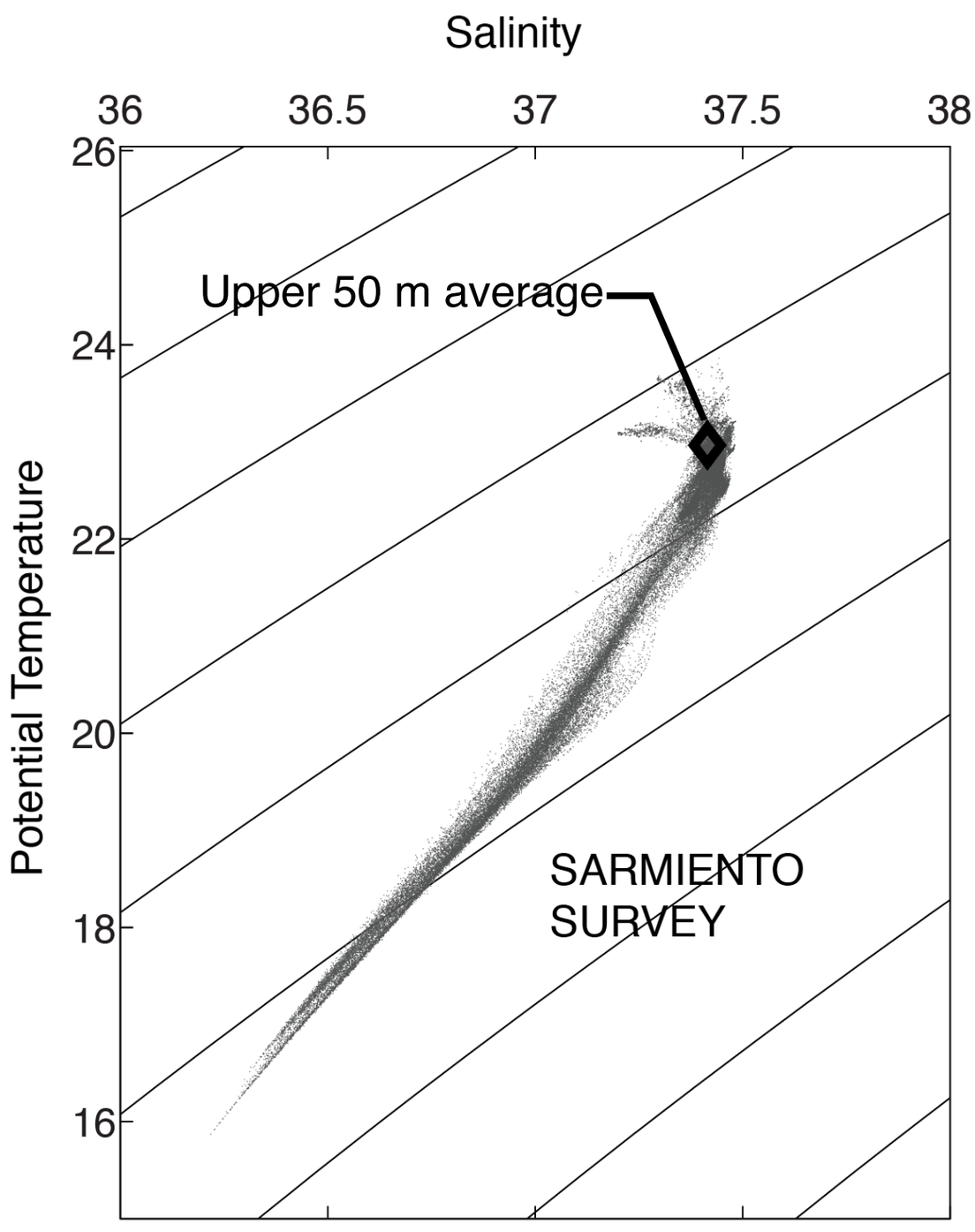


$$\frac{\partial FW}{\partial t} = \frac{\kappa h_0}{S_0} \nabla^2 S$$

Eddy diffusion estimate

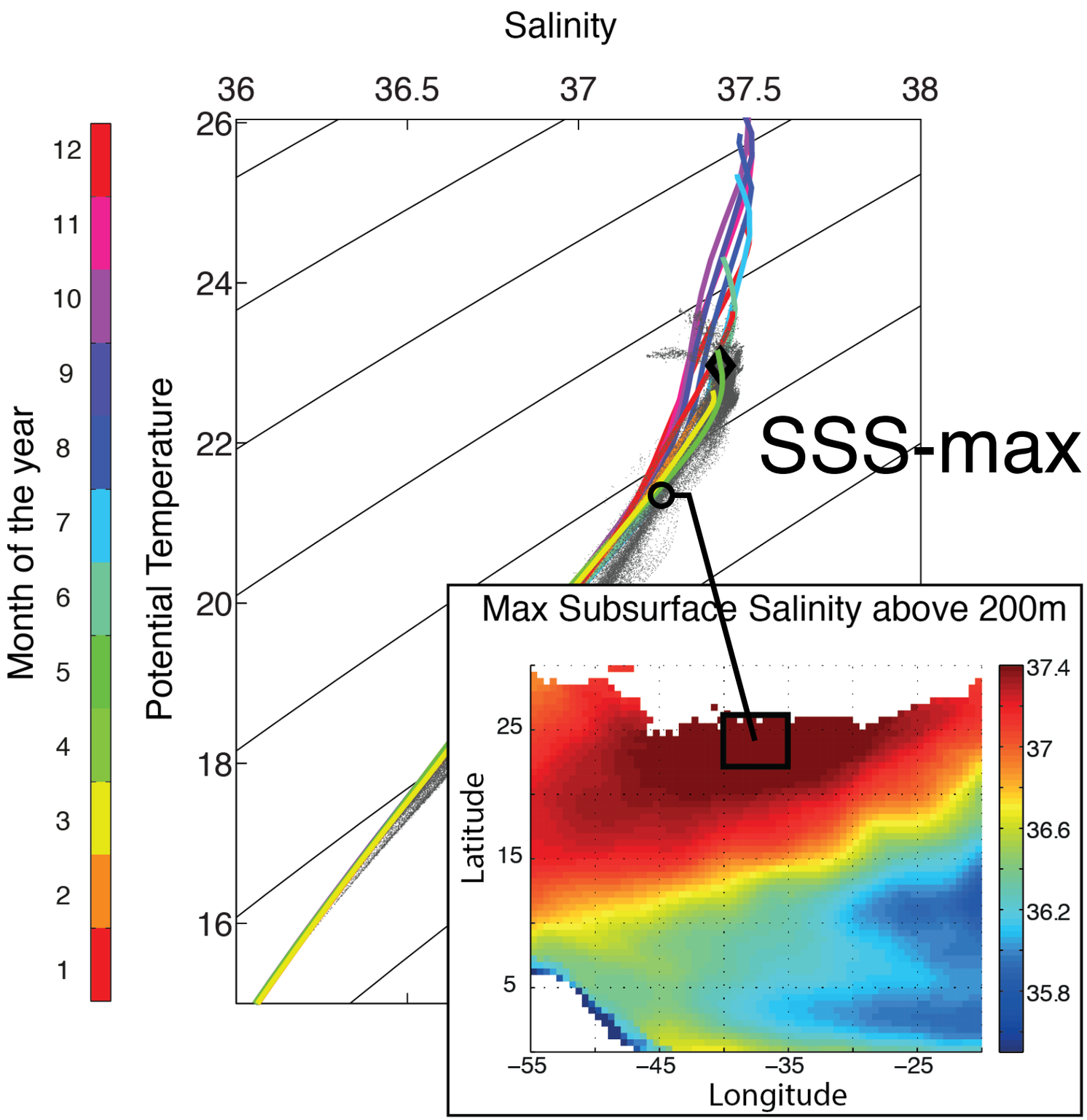
- 20-40% of the net evaporation can be balanced by eddy fluxes annually (mean E-P ~1 m/yr [Gordon and Giulivi, in review])
- Seasonally the influence seem even bigger
  - **The influence of this process is not negligible**

Connection to the subsurface salinity maximum



Comparison with MIMOC-Argo climatology

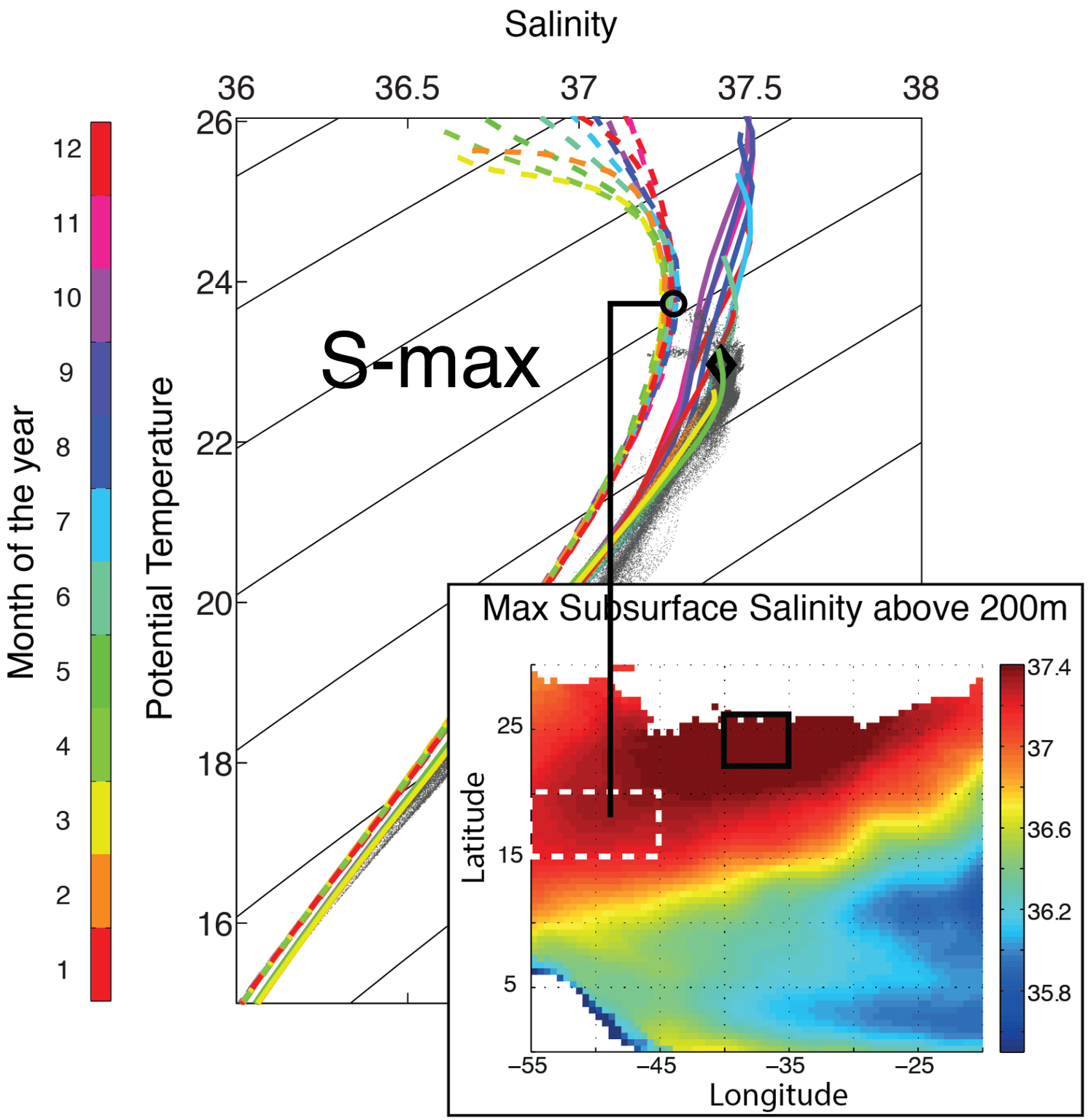
Connection to the subsurface salinity maximum



Comparison with MIMOC-Argo climatology

- Close match to the observed ‘salty and deep’ mixed layers
- Observed fresh features deviate strongly from the climatology

Connection to the subsurface salinity maximum



Comparison with MIMOC-Argo climatology

- Close match to the observed ‘salty and deep’ mixed layers
- Observed fresh features deviate strongly from the climatology
- SSS-max is too salty and cold to be exported as subsurface salinity maximum (S-max) via isopycnal pathways

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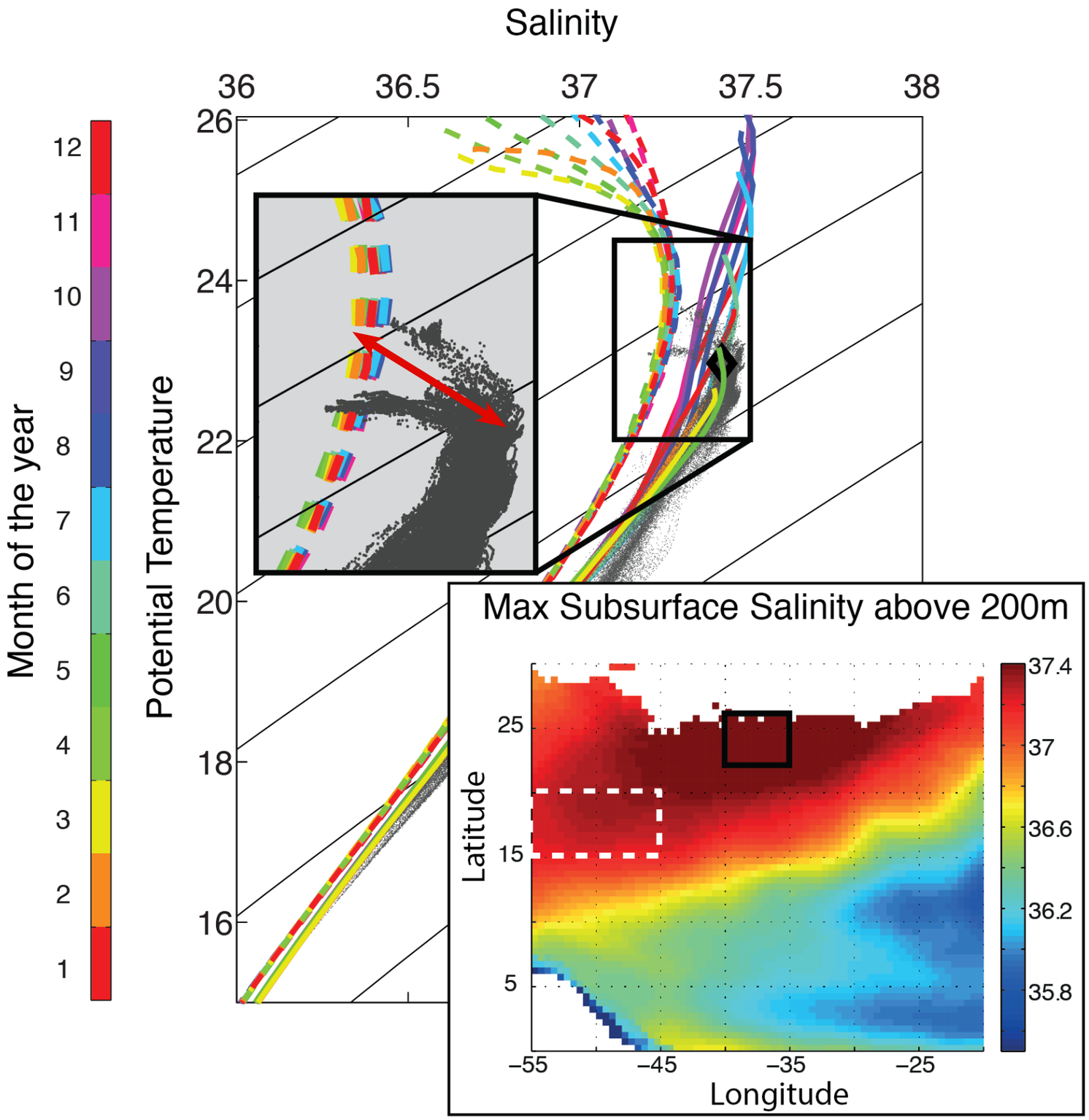
Connection to the subsurface salinity maximum



Relevance to the shallow overturning circulation:

- Fresh features connect SSS-max and S-max
  - **Mesoscale turbulence modifies the SSS and by that might change the properties of the water that gets subducted**

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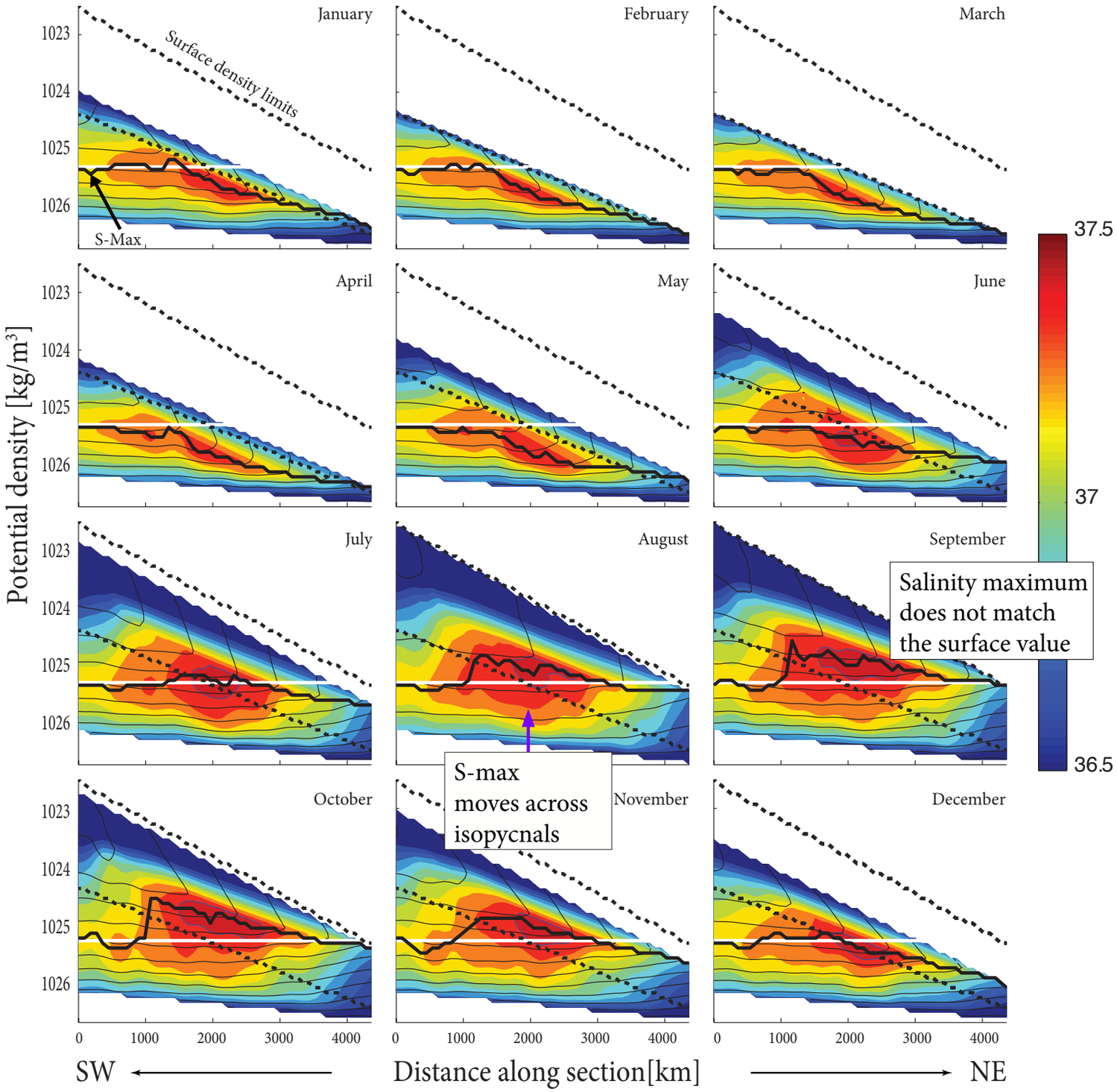
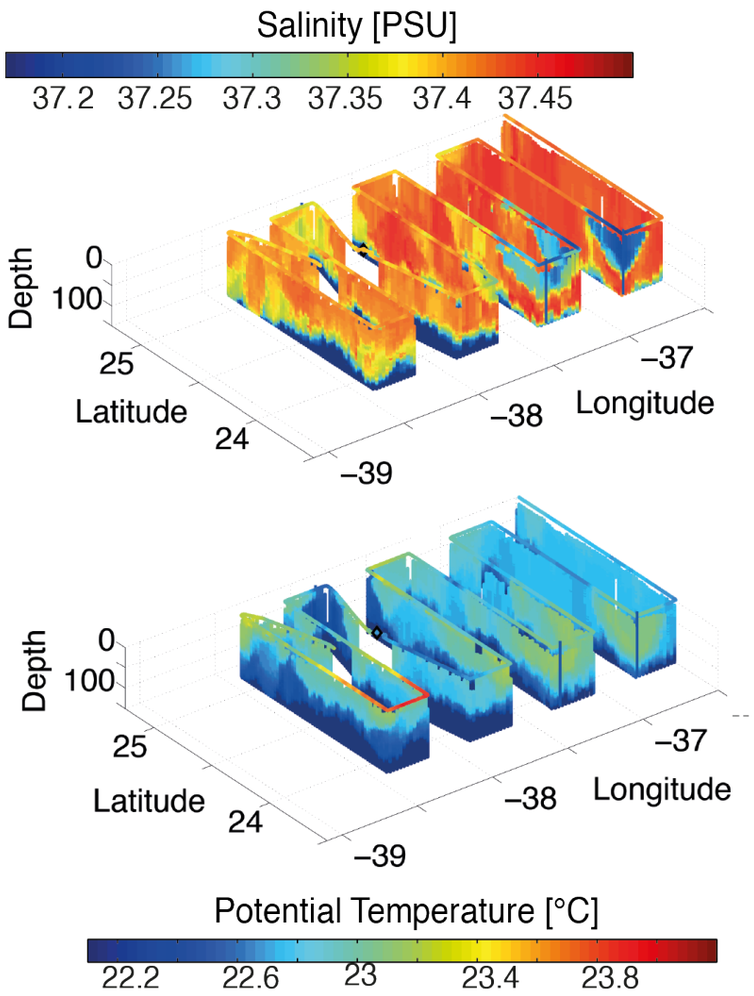
The export of salty water

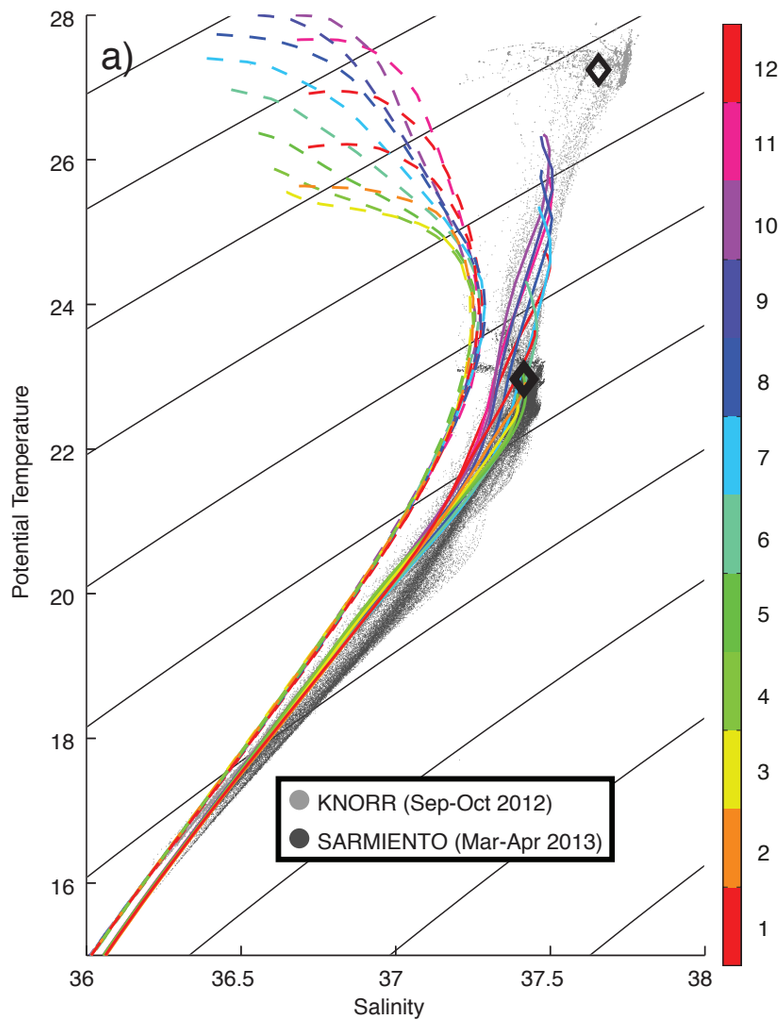


Relevance to the shallow overturning circulation:

- Density of high salinity water injected varies strongly over the annual cycle
- Resulting subtropical underwater shows less variability
  - **Diapycnal mixing! salt Fingers?**
  - **S-max charcteristics are set throughout the year**
- The climatology never shows the highest salinities at the surface

Connection to the surface





- Data collected during the SPURS cruises consistently shows a skewed surface salinity distribution
- The average will be influenced by the low outliers, caused by mesoscale turbulence.
- Fresh features appear to be shallower than the mixed layer
  - **Longterm average creates artificial ‘cap’**
- Water might in fact still be in contact with the atmosphere, even in regions where the climatology suggests the opposite

Conclusions

- **1. Highly variable surface salinity fields with pronounced fresh/warm features are documented**

- **2. The observed fresh/warm feature present a significant influx of freshwater and emphasize the importance of lateral freshwater flux by mesoscale turbulence to the region**

- **3. The S-max seems to be influenced by the surface salinity throughout the whole year**

- **4. Long term means might misrepresent the time/space where the water is in contact with the atmosphere**

Future Work

- **Investigate the upper limb of the shallow overturning circulation, specifically the role that mesoscale turbulence plays in the northward transport of fresh water and how this relates to wind, Ekman transport, regional E-P and SSS.**

- **Explore how the S-max behaves on interannual time scales and what water masses feed into the S-max**

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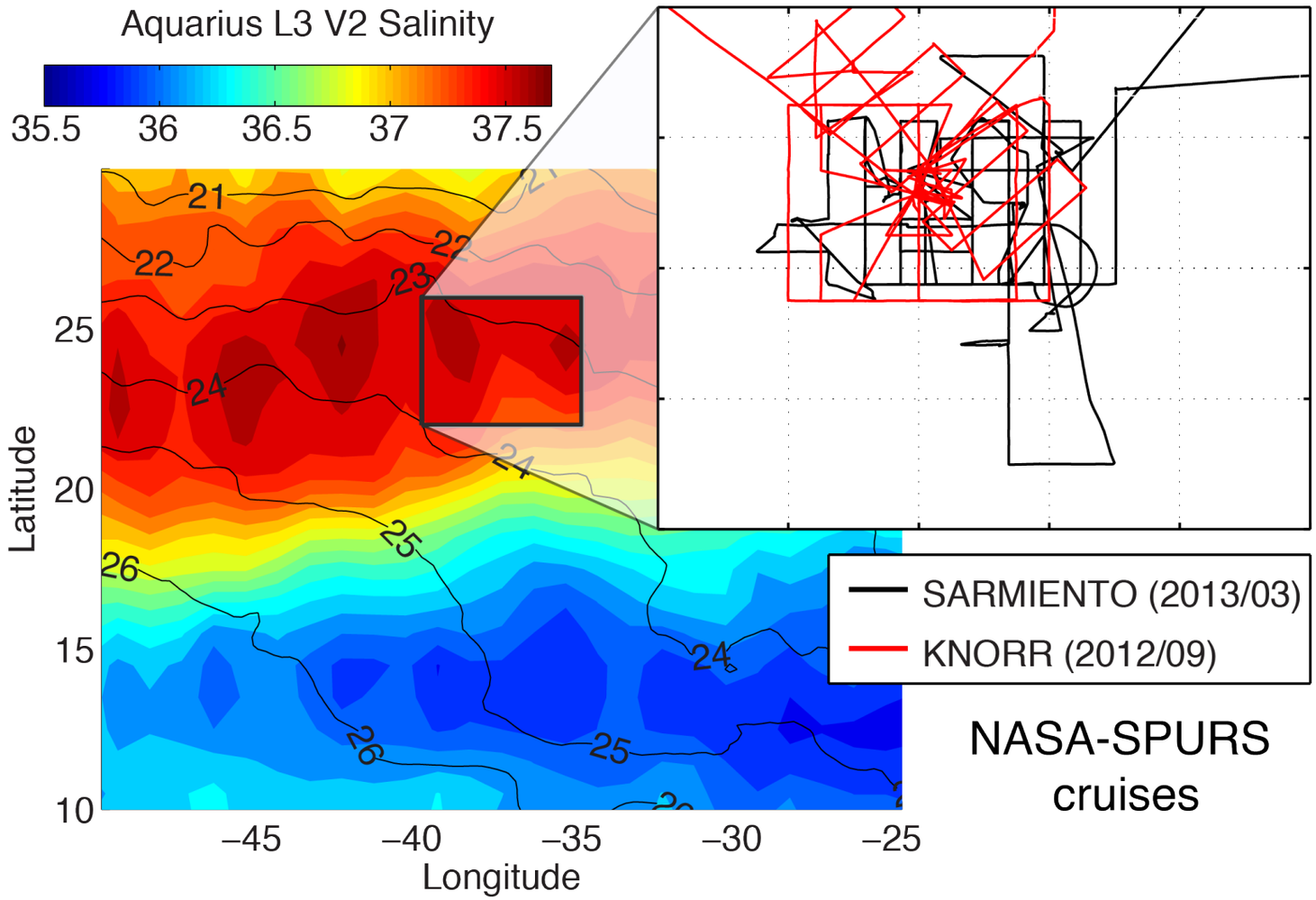
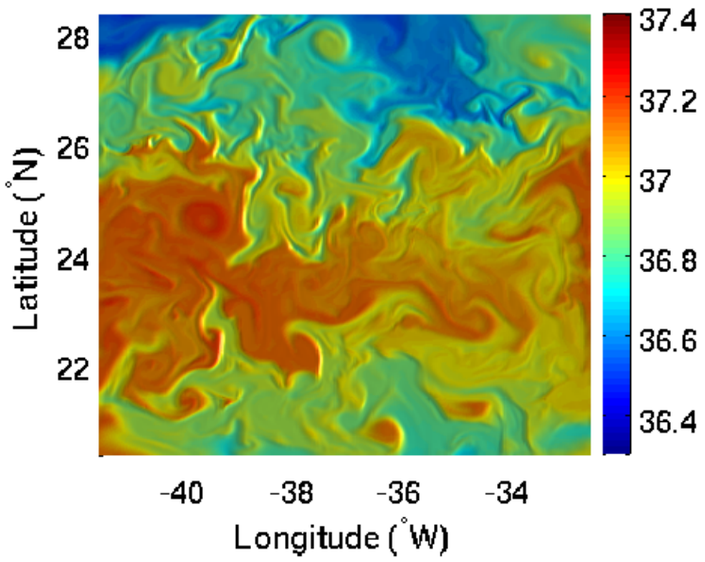
Introduction and Motivation



NASA-SPURS cruises



ROMS
Surface Salinity

The global freshwater cycle

- Sea surface salinity (SSS) as indicator for net evaporation
- Ocean processes are important to correctly interpret the freshwater cycle

The subtropical North Atlantic

- High variability in SSS
- Freshwater influx needed to balance net evaporation
- Which processes are significantly influencing the influx of freshwater? What shapes the variability in SSS?

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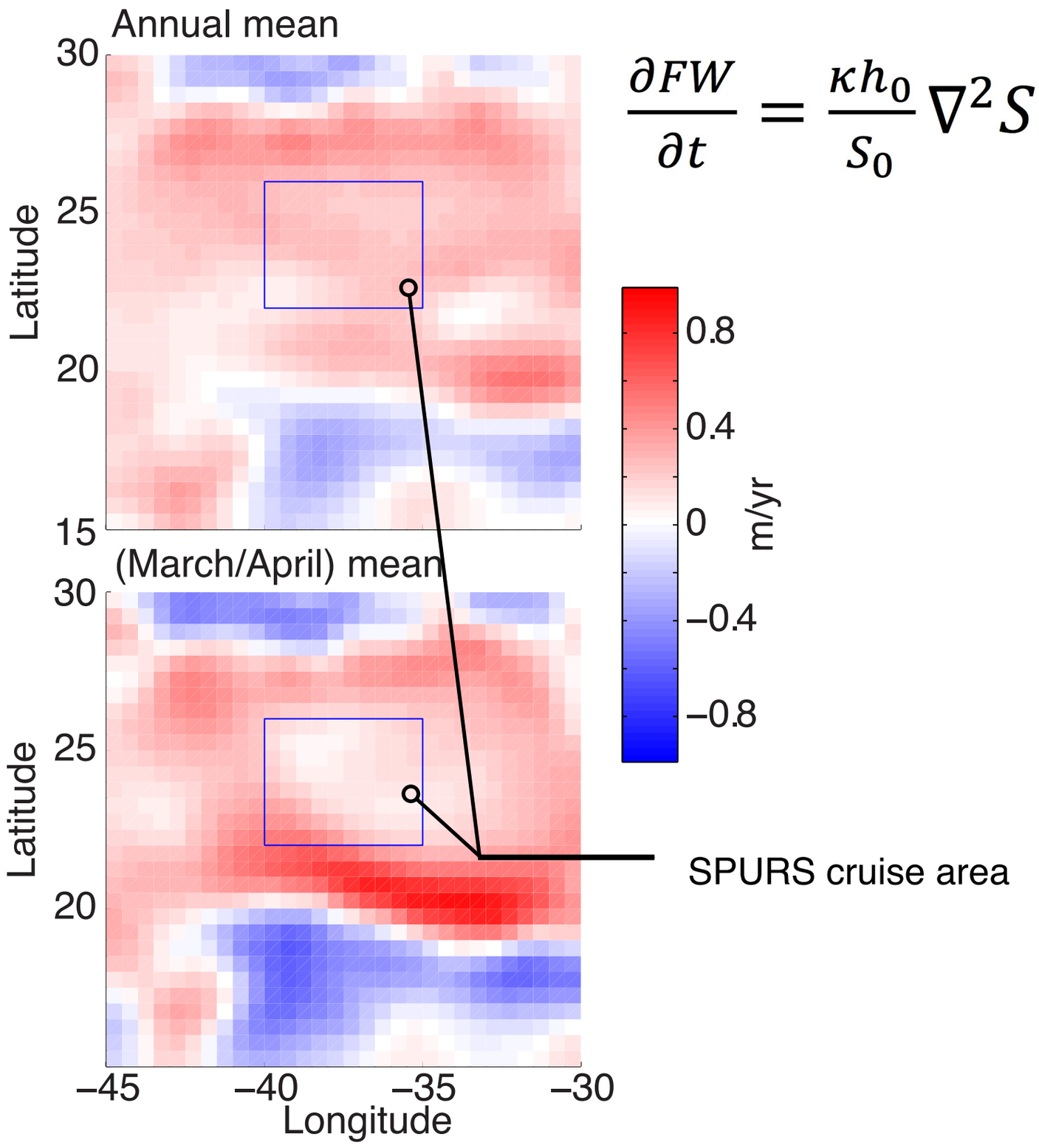
Relevance for the SSS-max

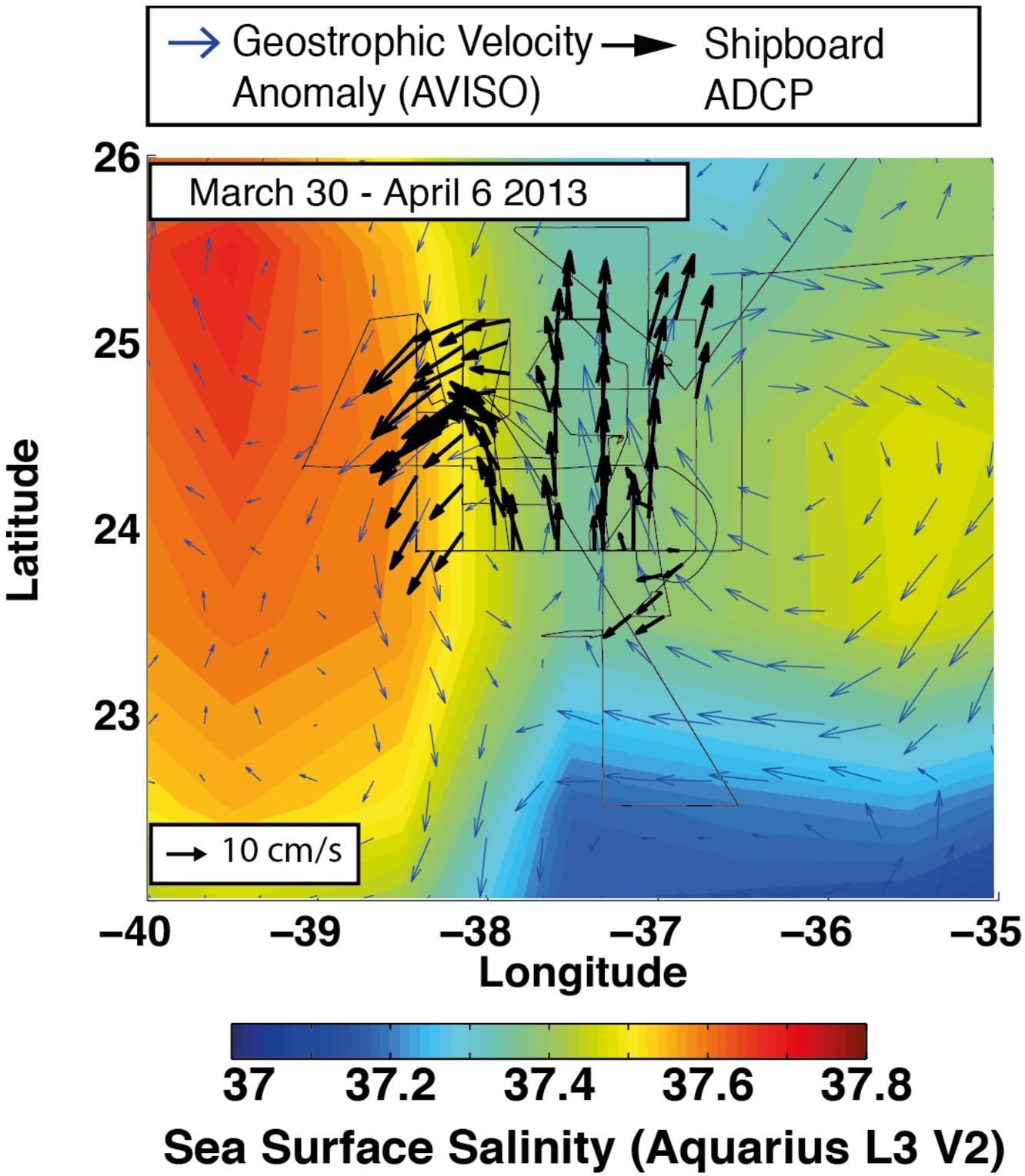


$$\frac{\partial FW}{\partial t} = \frac{\kappa h_0}{S_0} \nabla^2 S$$

Estimation of freshwater convergence by eddy diffusion

- Constant K=2000 m^2/s; [Abernathey and Marshall 2013])
- h_0 = 50 m (~ depth of fresh features)
- S_0 = 37.2 PSU
- S fields based on MIMOC Argo-Climatology

Origin of the fresh/warm feature



Satellite Data

- Not a local rain event (TRMM)
- Fresher water detected in the south
  - **Feature originates from a larger body of water to the south**
- Geostrophic velocities agree with shipboard velocities
- Horizontal scale ~ 1st baroclinic Rossby radius
- Two features in one month, suggesting regular occurrence
- Elevated EKE collocated with source region
  - **Mesoscale turbulence could be important for the total freshwater flux into the region**