Linking the Subtropical Surface and Subsurface Smax Observed by Satellite and Argo

- Understanding the physical characteristics of SSS Products

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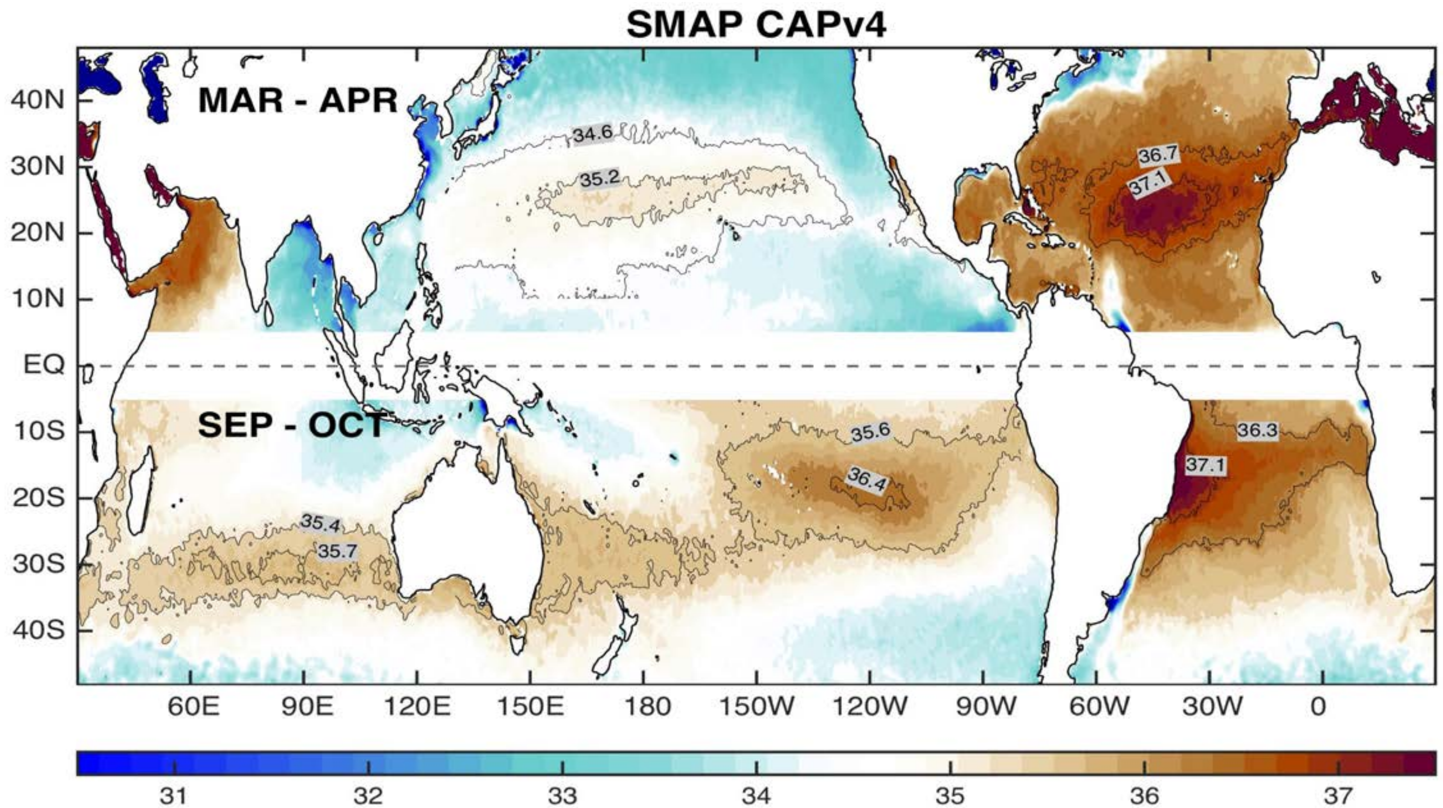
Products used in the study

- SMAP JPL CAP v4 monthly
- SMAP RSS v2 70 km monthly
- SMOS CADTv3, 9days -> monthly
- Argo RG Scripps monthly

NASA OSST meeting
Santa Rosa, California
Aug. 27-29 2018

The subtropical Sea-Surface Smax



Unique features of the subtropical Smax:

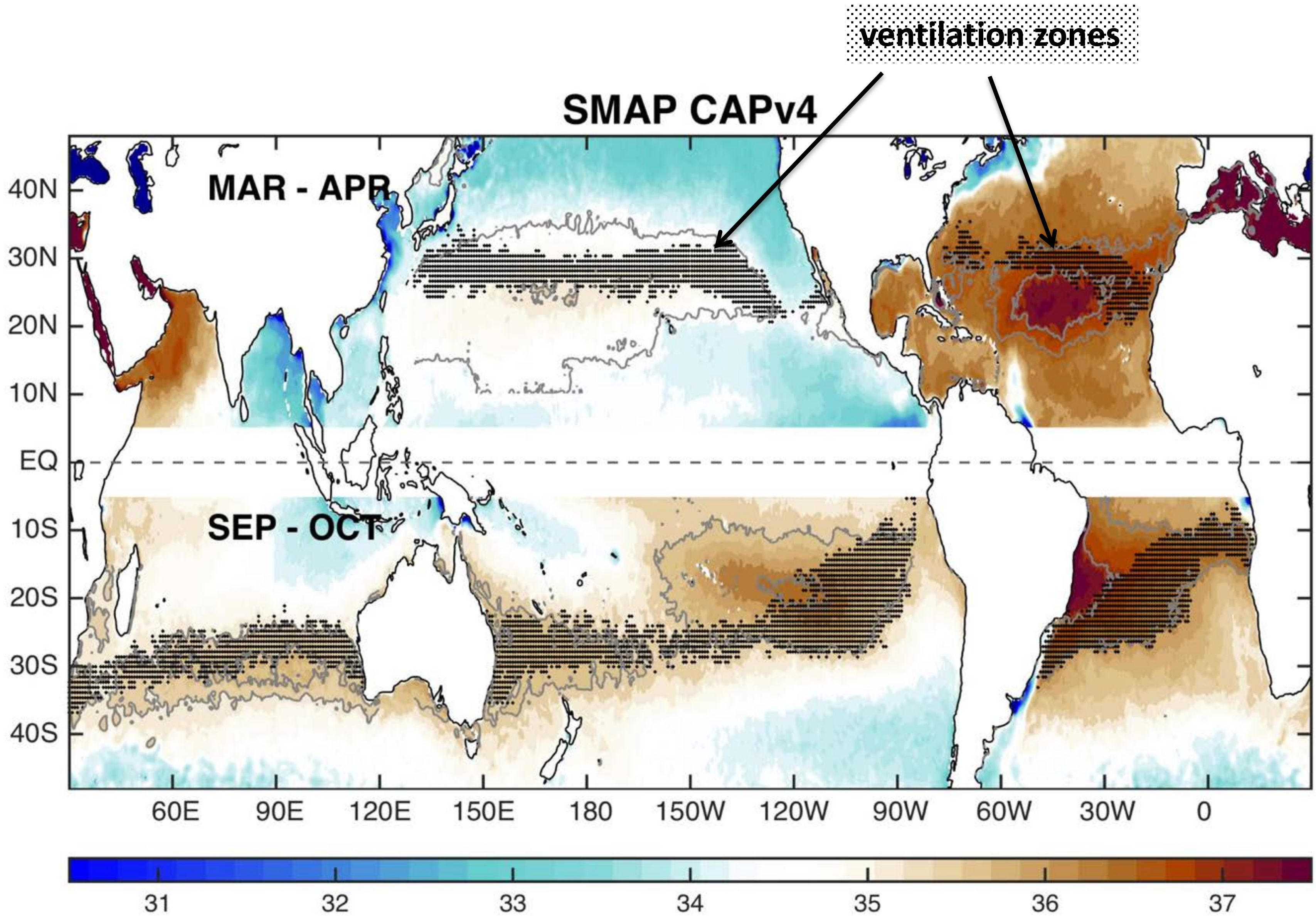
- N. Atl: the saltiest of the 5 SSS-max.
- S. Atl: located at the western sector of the basin.
- N. Pac: the freshest of the 5 SSS-max
- S. Pac: two SSS-max, primary and secondary
- S. Ind: the furthest from the equator

from Gordon et al. (2015), “Differences Among Subtropical Surface Salinity Patterns”

Role of Smax in ocean and climate:

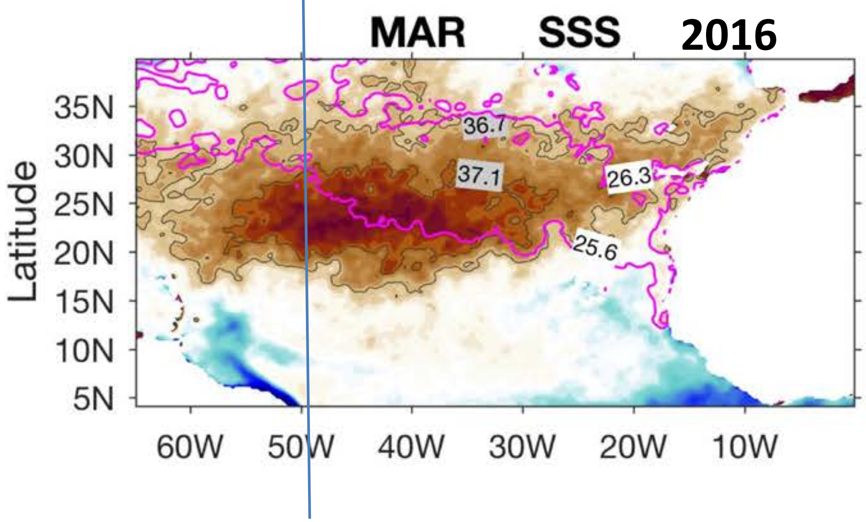
- Formed under net evaporation forcing and influenced by ocean Ekman transport
- Indicator of the change of the global hydrological cycle
- **Source waters of the subtropical underwater (STUW), a distinct Smax at the depth of 50-300m (O’Connor et al. 2005).**

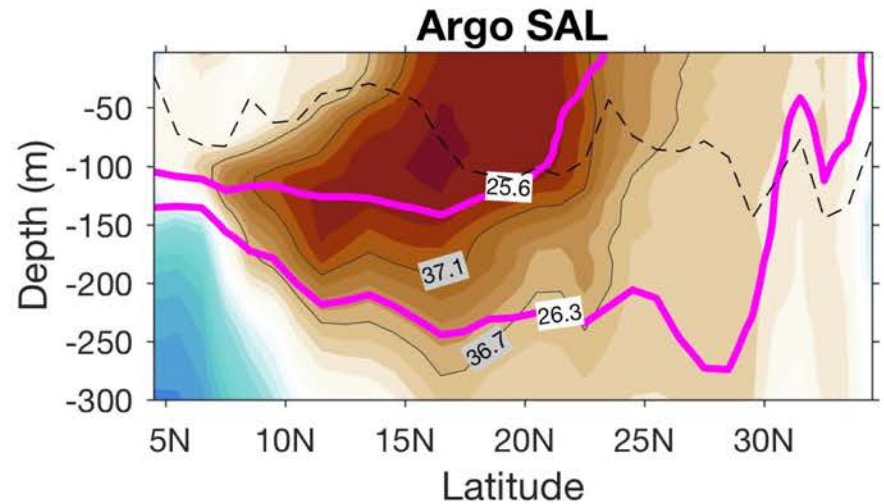
Ocean ventilation: injecting surface influence into the subsurface



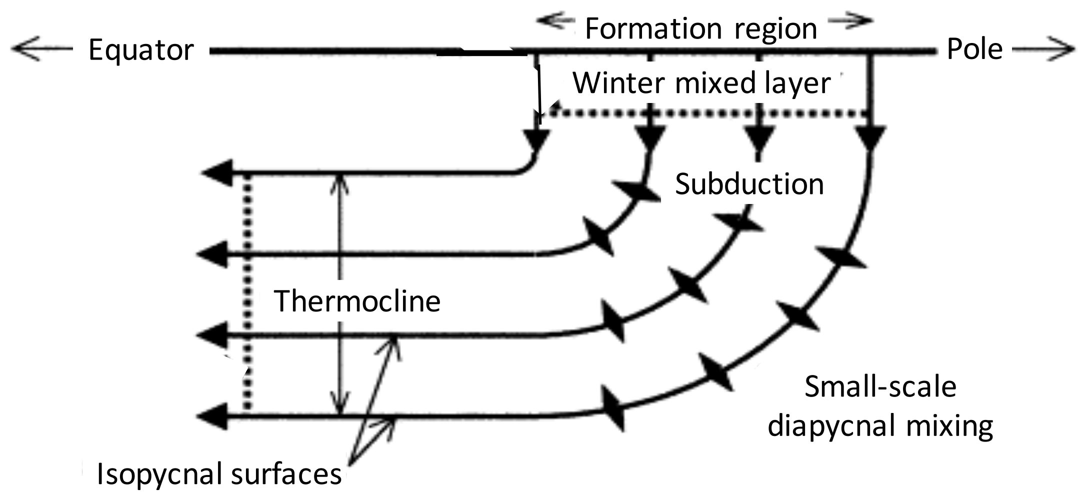
Ocean ventilation and STUW

STUW Range: Salinity [36.7 37.1]; Temperature [20.4 22.2]; Density [25.6 26.3]





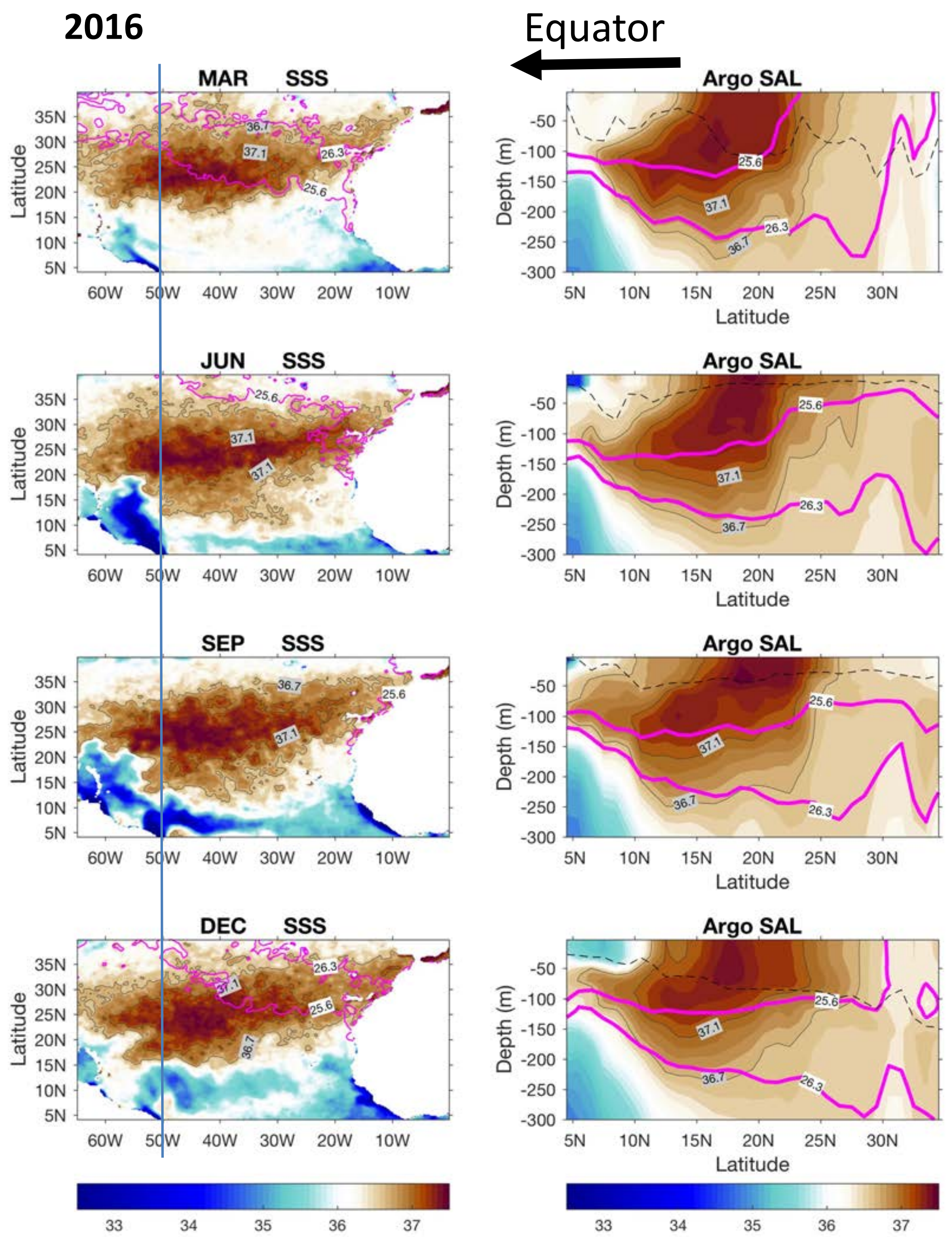
The winter mixed layer water subducted from formation regions moves along isopycnals into the thermocline.



(The schematic diagram adapted from Poole and Tomczak 1999)

Time window of ventilation:

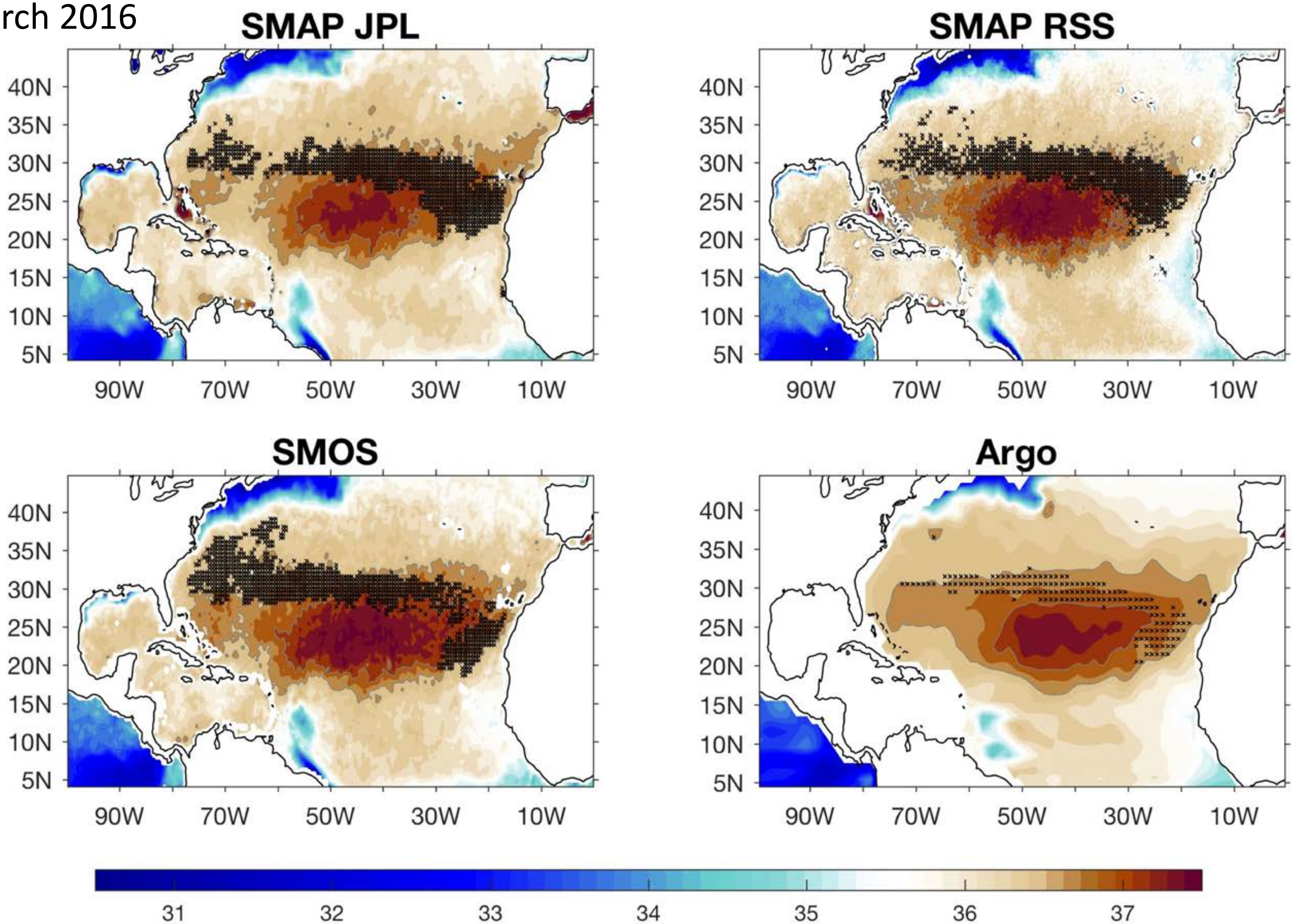
mostly Spring (March-April), when the mixed layer is deepest



Products differ in the size and location of the STUW formation region. Does it matter?

STUW Range: Salinity [36.7 37.1]; Temperature [20.4 22.2]; Density [25.6 26.3]

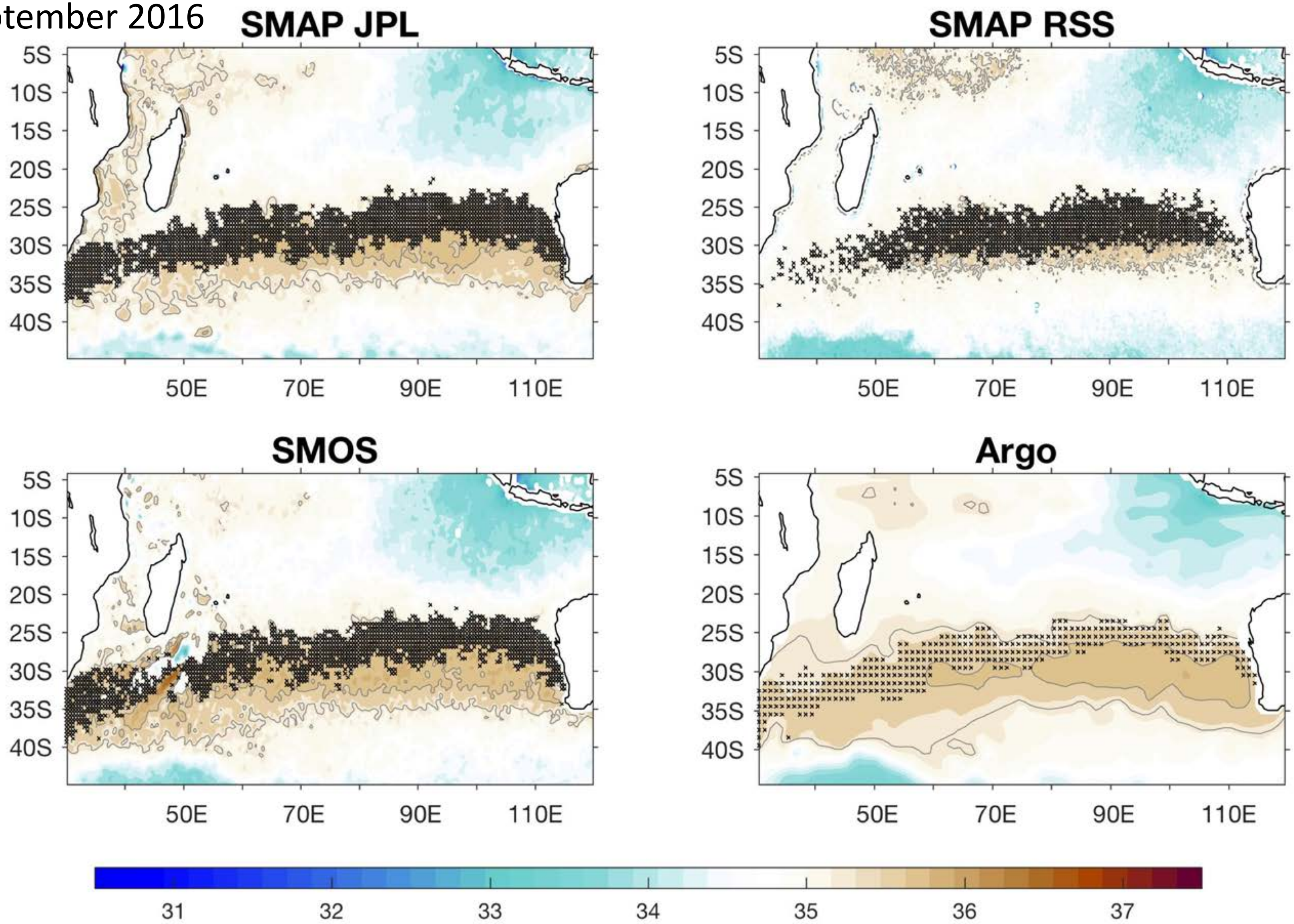
March 2016



STUW formation regime in the South Indian Ocean

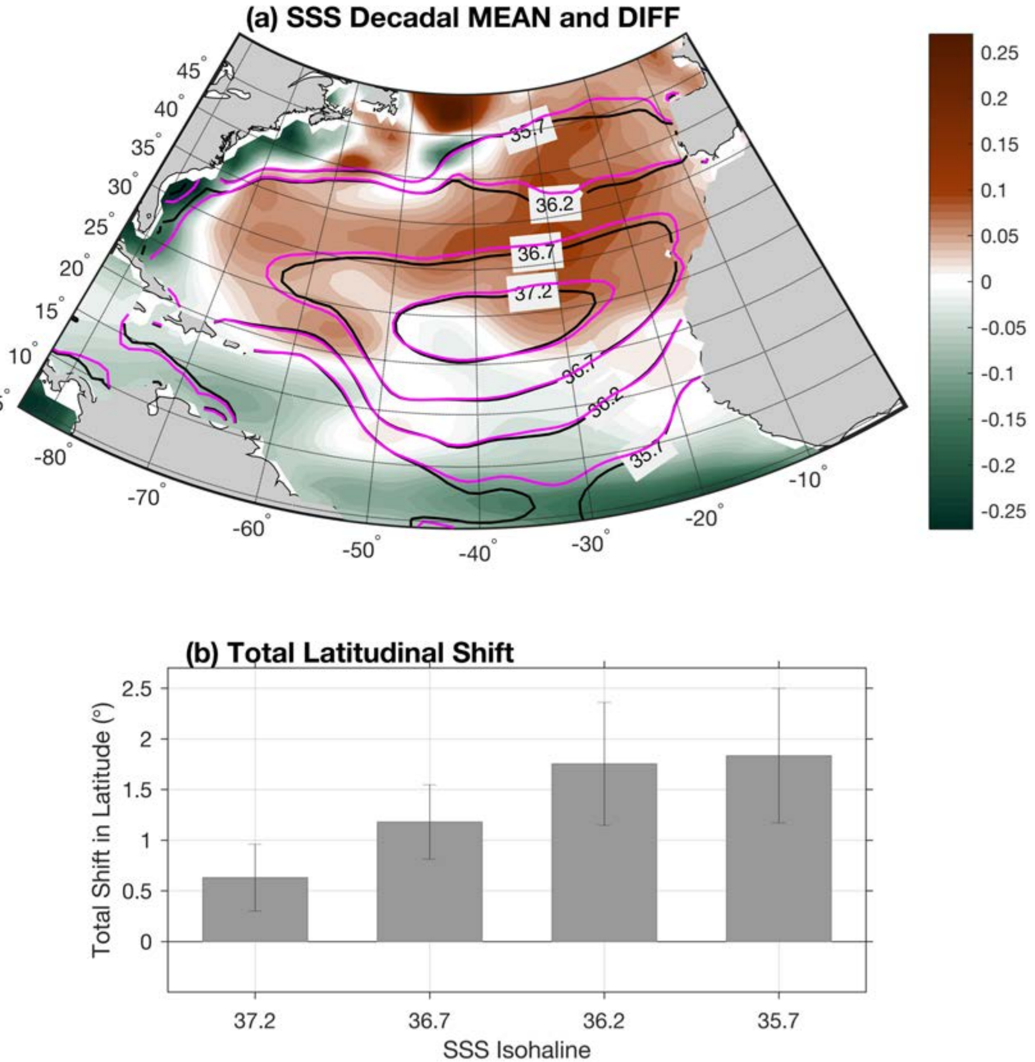
STUW Range: Salinity [35.4 25.7]; Temperature [18.2 21.1]; Density [24.7 26.3]

September 2016



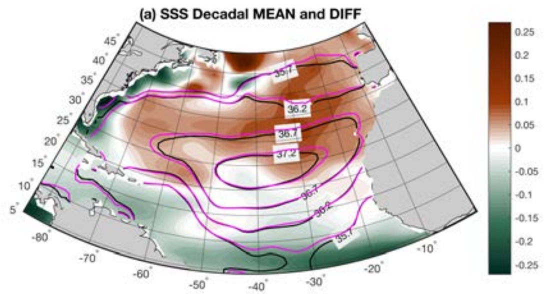
STUW is sensitive to the change of Smax location.

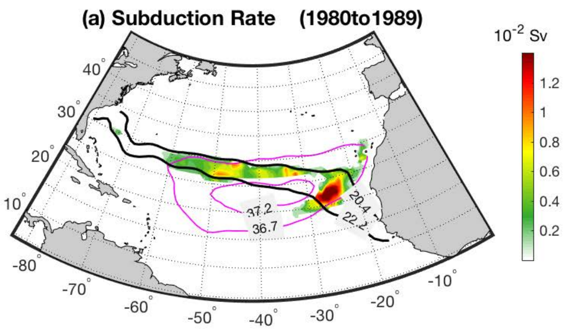
In past 30 years, the Smax center has expanded northward by ~1° latitude

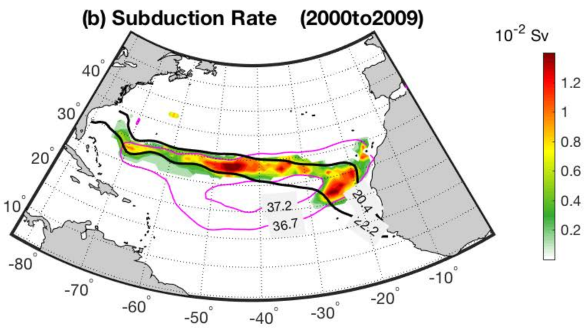


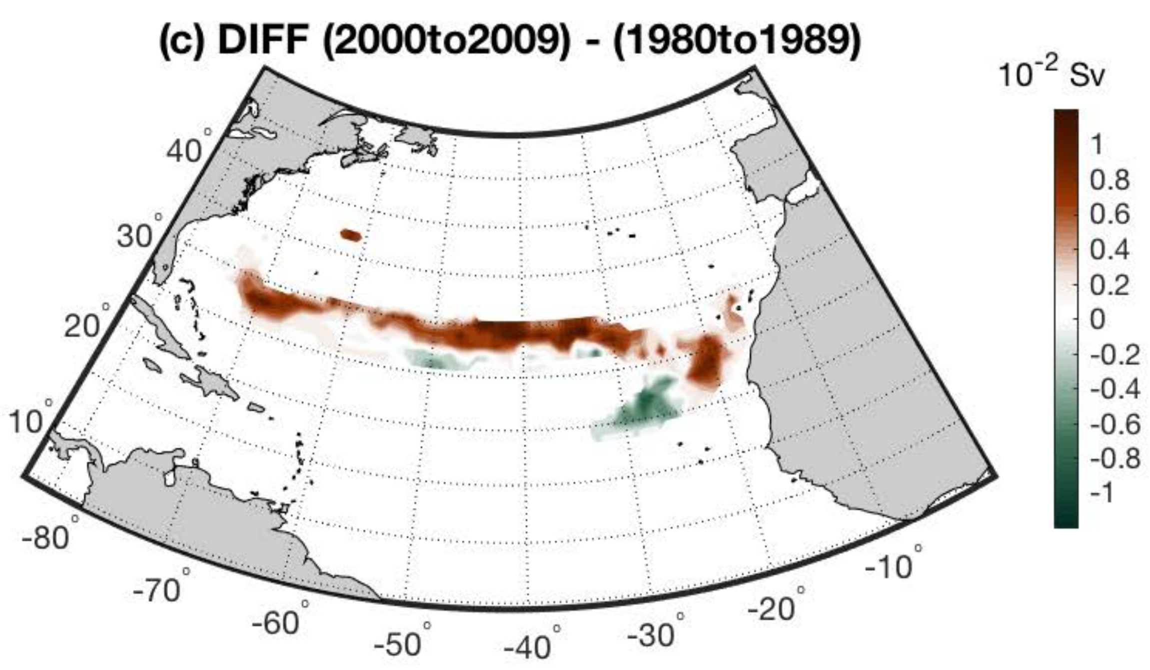
Yu, L., X. Jin, and H. Liu, 2018: Poleward Shift in Ventilation of the North Atlantic Subtropical Underwater. Geophys. Res. Lett., 45, DOI: 10.1002/2017GL075772

The expansion has pushed the ventilation zone northward and westward

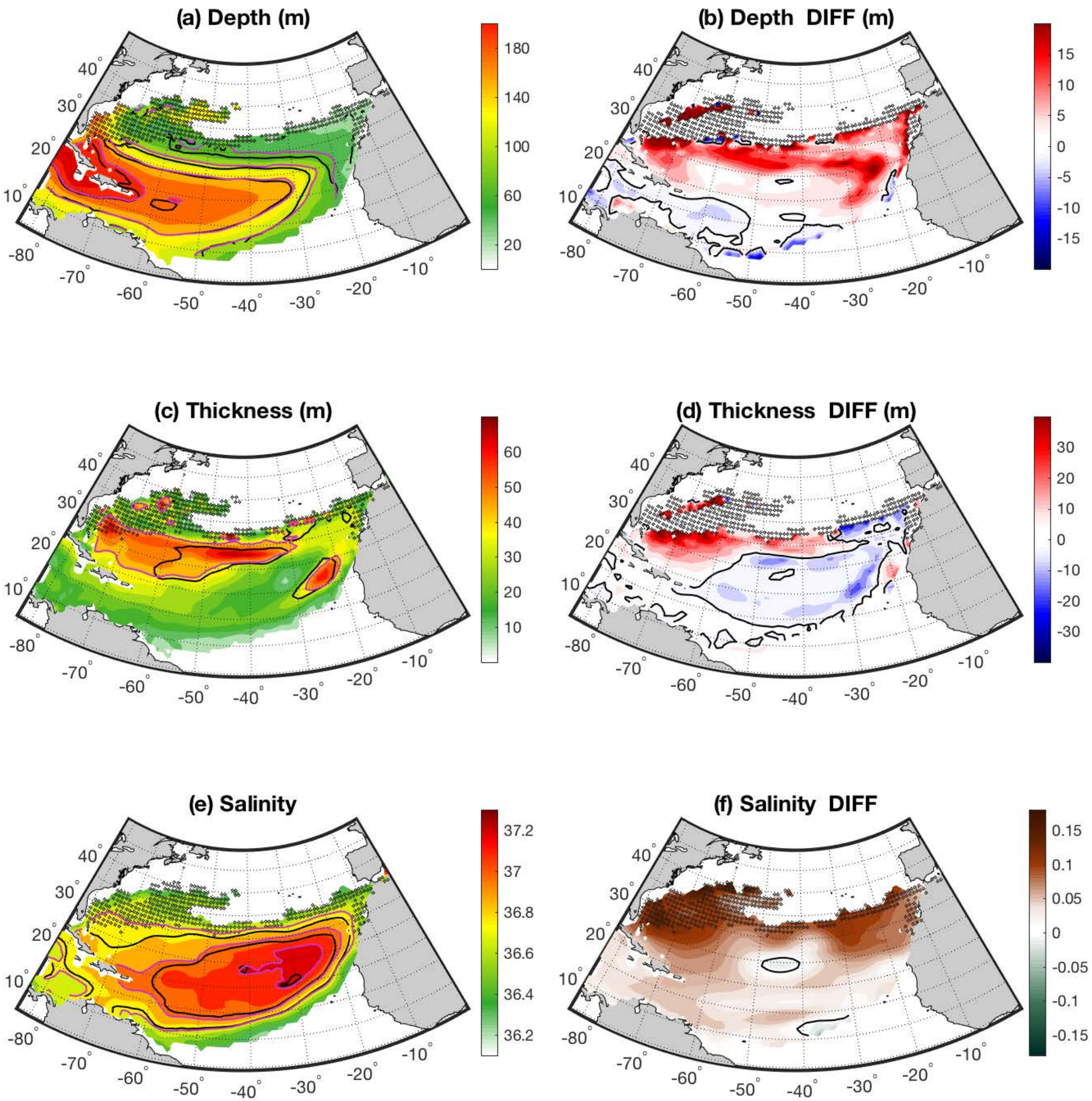








As a result of the poleward shift in subduction, the STUW has become deeper, broader, and saltier

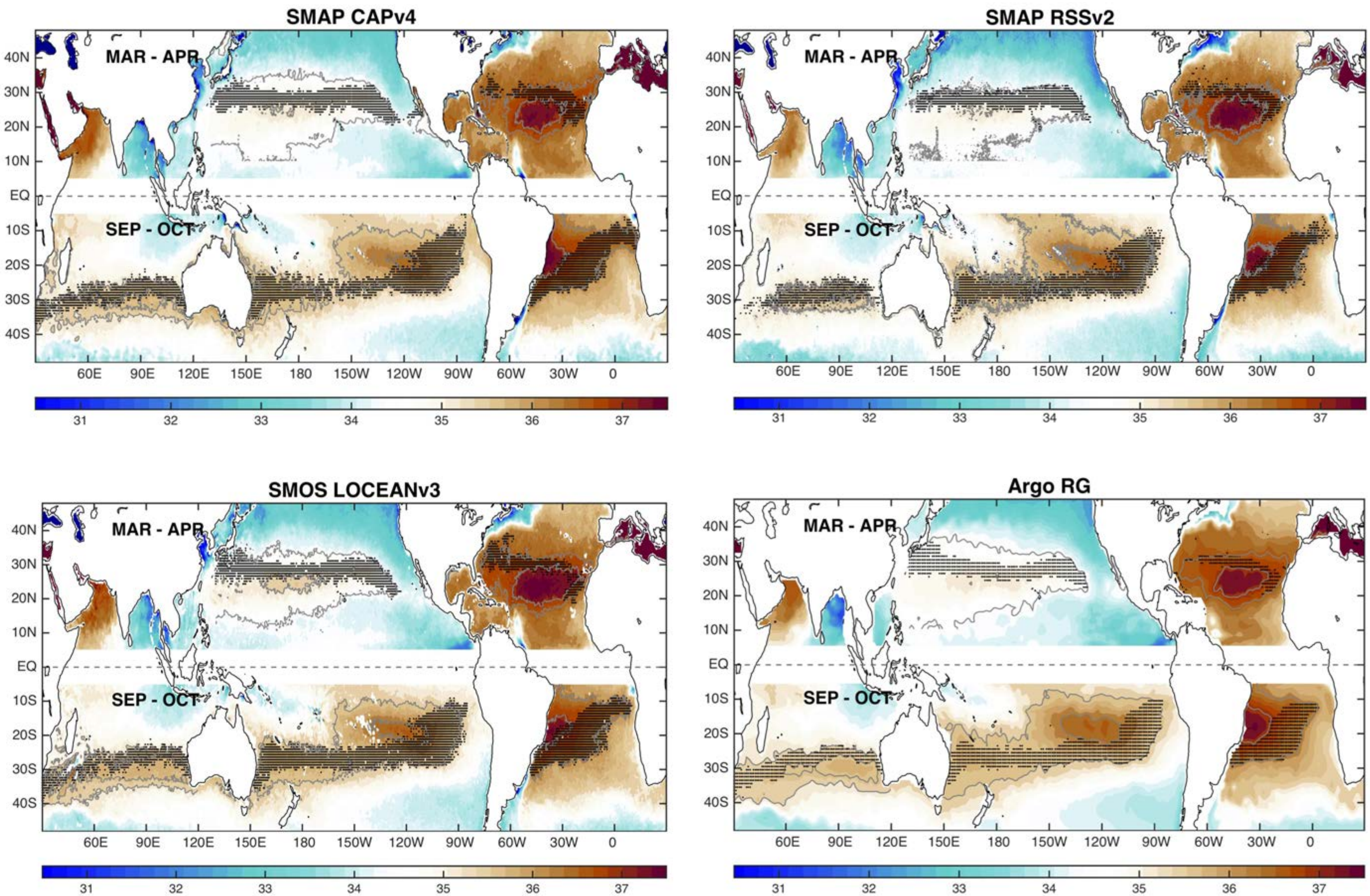


Red: deeper

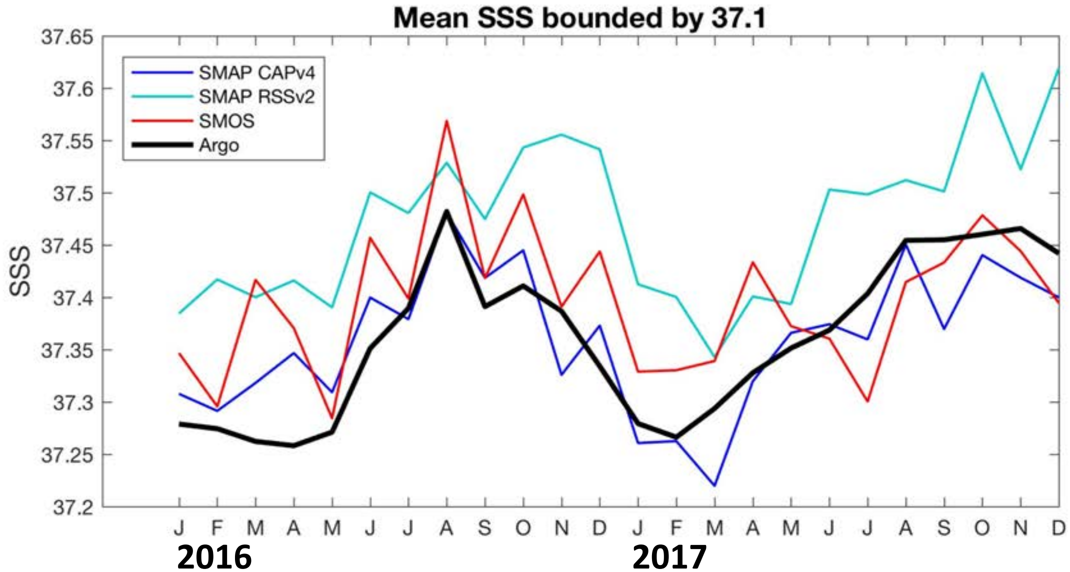
Red: thicker

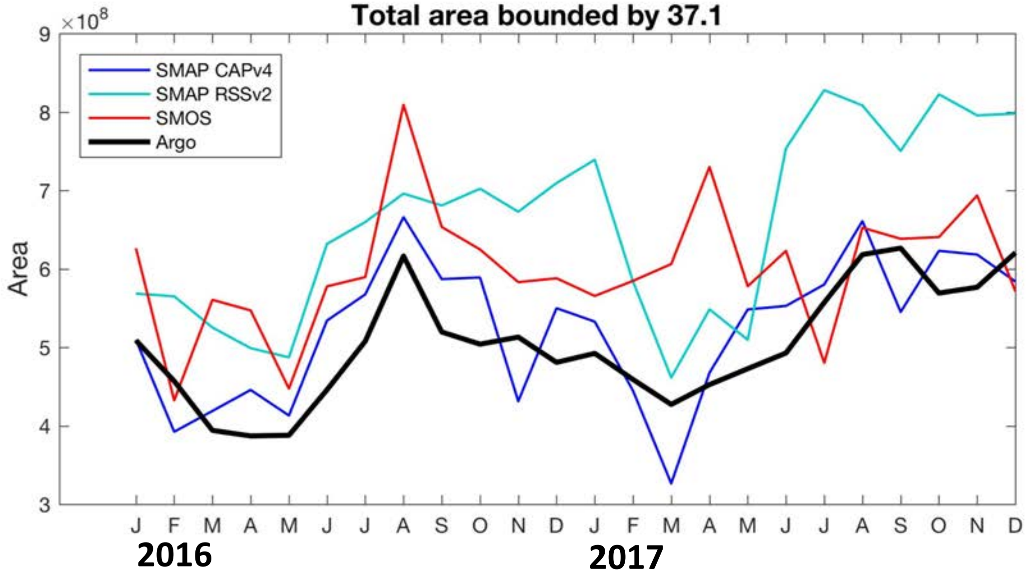
Brown: saltier

The size and location of the ventilation zone are important features for the STUW formation

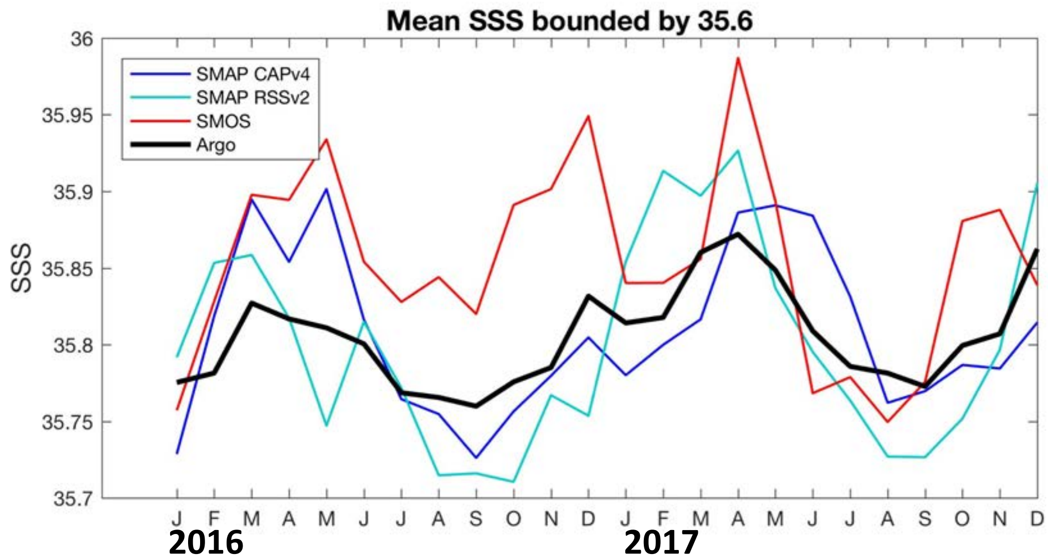


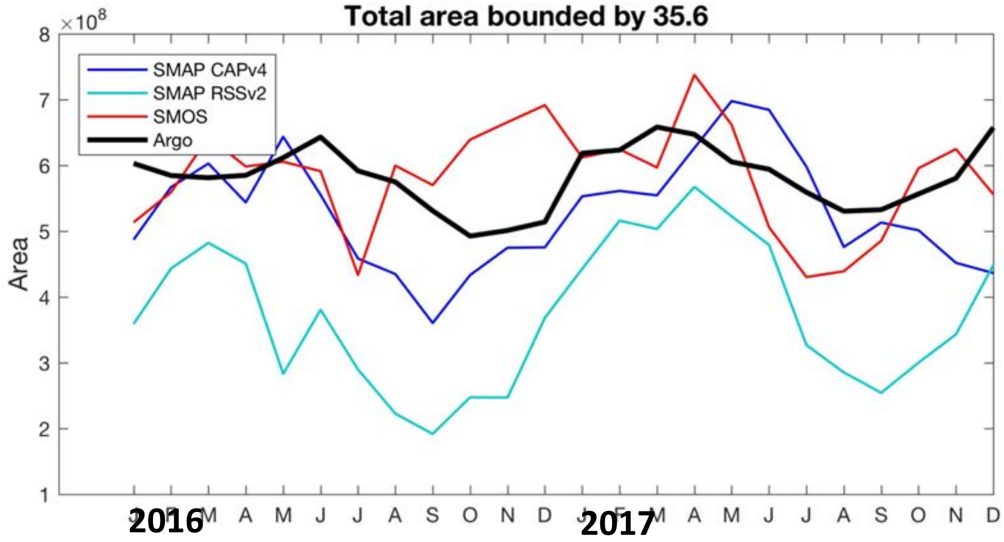
Seasonal change of the Smax Center in the North Atlantic





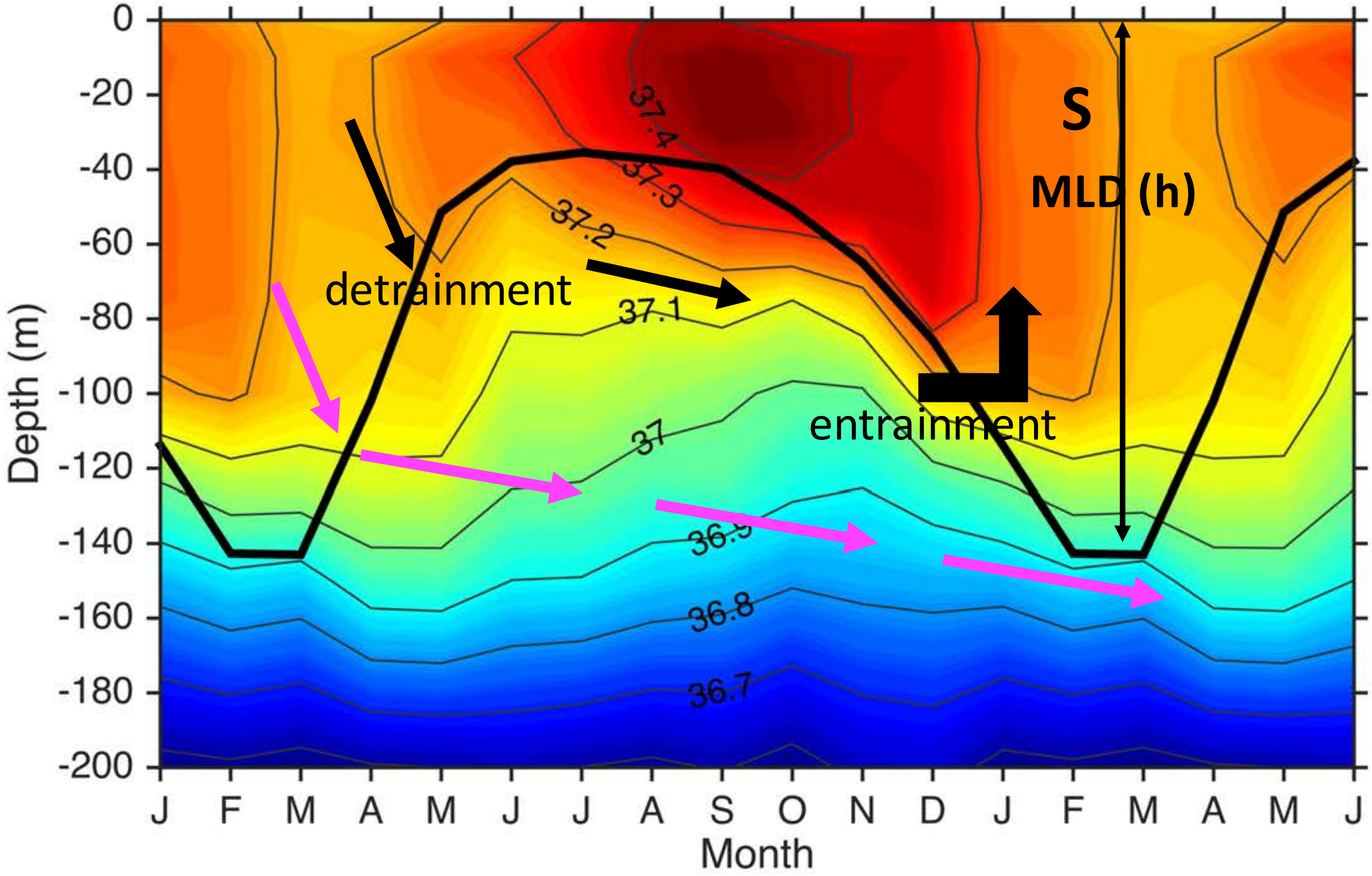
Seasonal change of the Smax Center in the South Indian Ocean



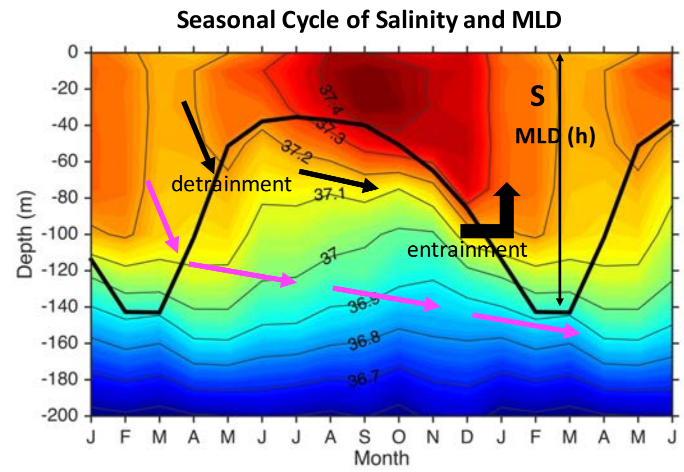


Possible to use Argo to check SSS products?

Seasonal Cycle of Salinity and MLD



Detrainment vs. subduction



Detrainment rate:

The instantaneous detrainment rate is defined as the volume flux of water per unit horizontal area (Cushman-Roisin, 1987)

$$D = -\left(w_{mb} + \vec{v}_{mb} \cdot \nabla h_m + \partial h_m / \partial t\right)$$

where $w_{mb} = w_e - \frac{\beta}{f}\int_{-h}^{0} v\,dz$ and $\vec{v}_{mb}$ are the vertical and horizontal velocity at the base of the mixed layer, and h_m is the mixed layer depth

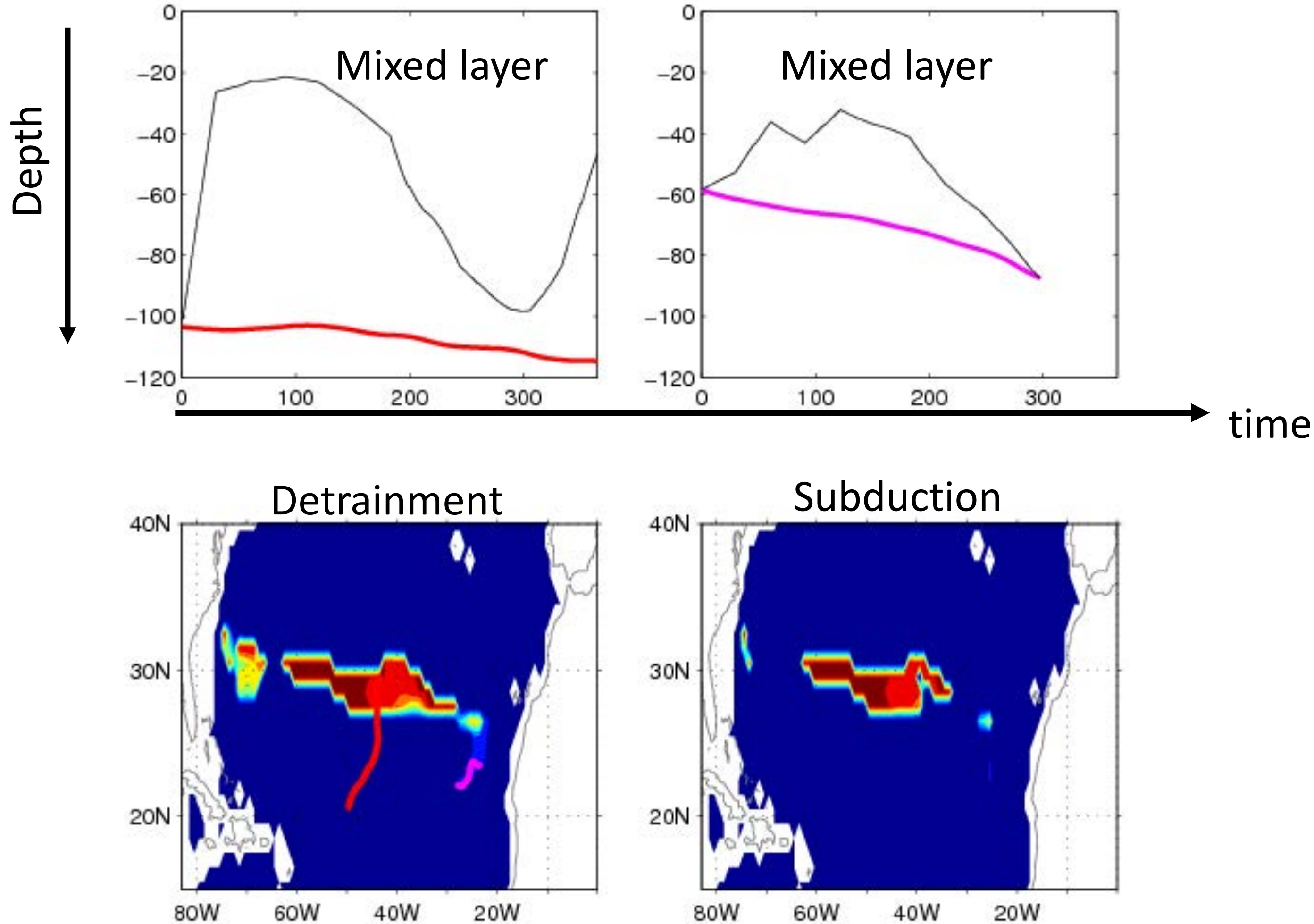
Subduction rate:

$$S_{ann} = -\frac{1}{T}\int_{T_1}^{T_2} D\,dt = -\frac{1}{T}\int_{T_1}^{T_2} w_{tr}\;dt - \frac{1}{T}\int_{T_1}^{T_2}\left(\mathbf{u}_{tr}\cdot\nabla h_m + \frac{\partial h_m}{\partial t}\right)dt$$

where w_{tr} and $\mathbf{u}_{tr}$ are the vertical and horizontal velocities along the trajectories. T is still one year, while T_1 and T_2 are the times when effective detrainment starts and ends (Qiu and Huang 1995).

Integration S_{ann} over the ventilation zone at the surface yields an annual subduction rate in unit of Sv (1 Sv = 10^6 m^3 s^{-1}).

Fates of the particles injected into the ocean interior: an example of two trajectories



Conducted by X. Jin

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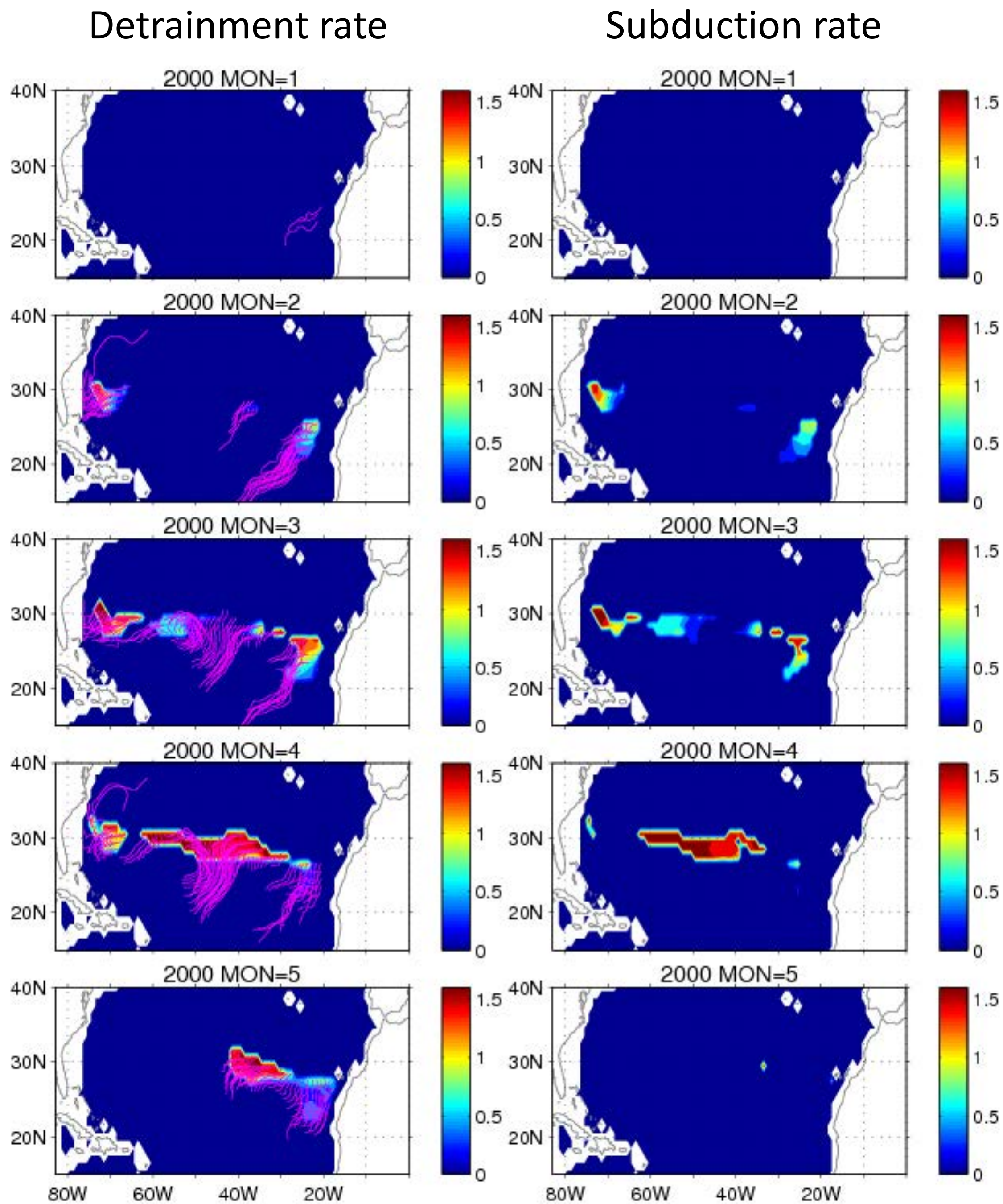
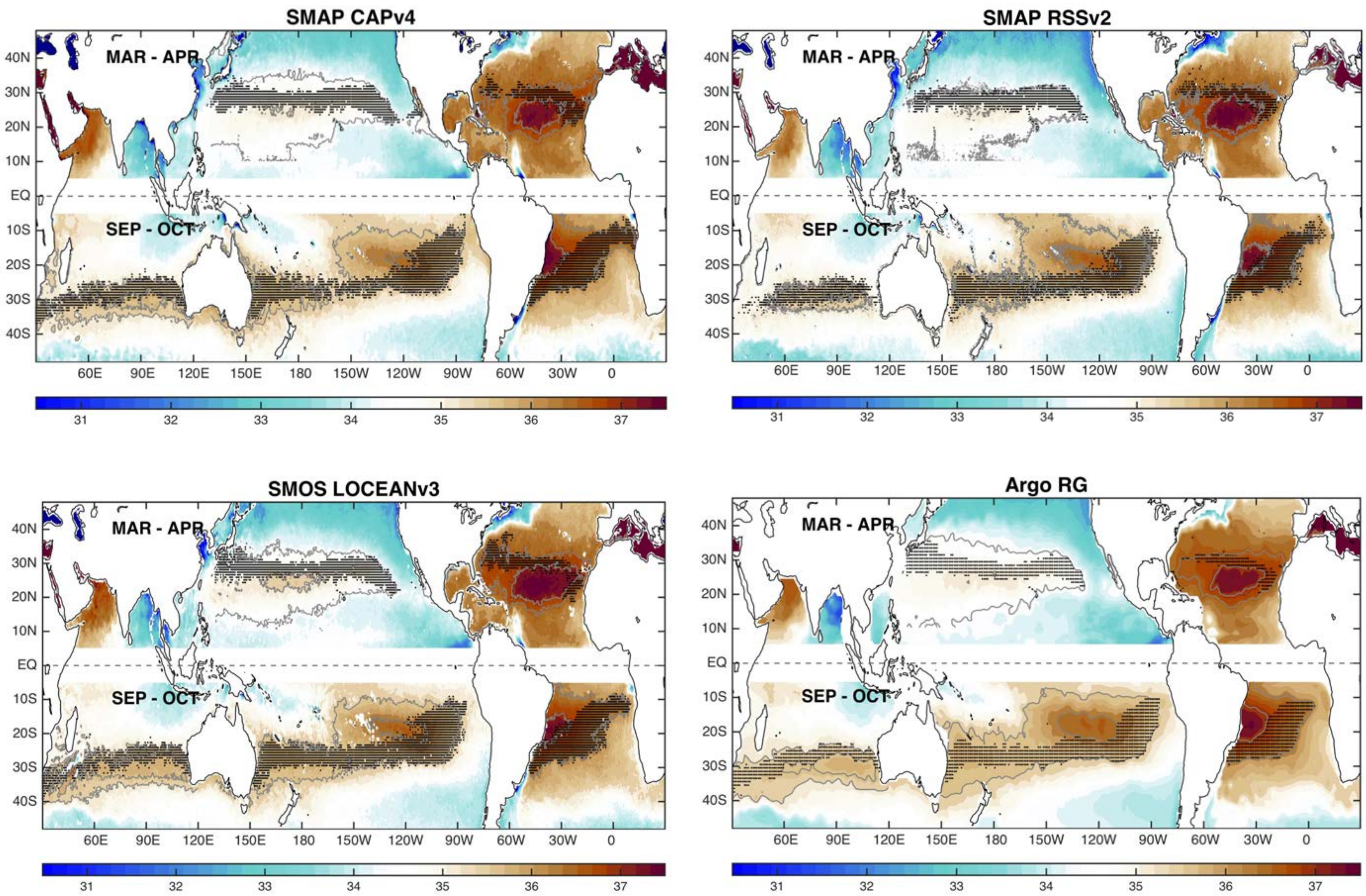
Detrainment vs Subduction



Conducted by X. Jin

An Argo-based framework to test the SSS products – work in progress



Summary

- Satellite SSS products provide excellent depiction of the global subtropical Smax centers. They agree well on large-scale structures.
- There are, however, some subtle differences in the depiction of some physical properties, such as the size of the Smax center and the formation area of the STUW.
- These Smax properties are important features for the STUW formation.
- We propose an Argo-based framework to test the sensitivity of the subduction rate to the differences in SSS products, with work ongoing.