

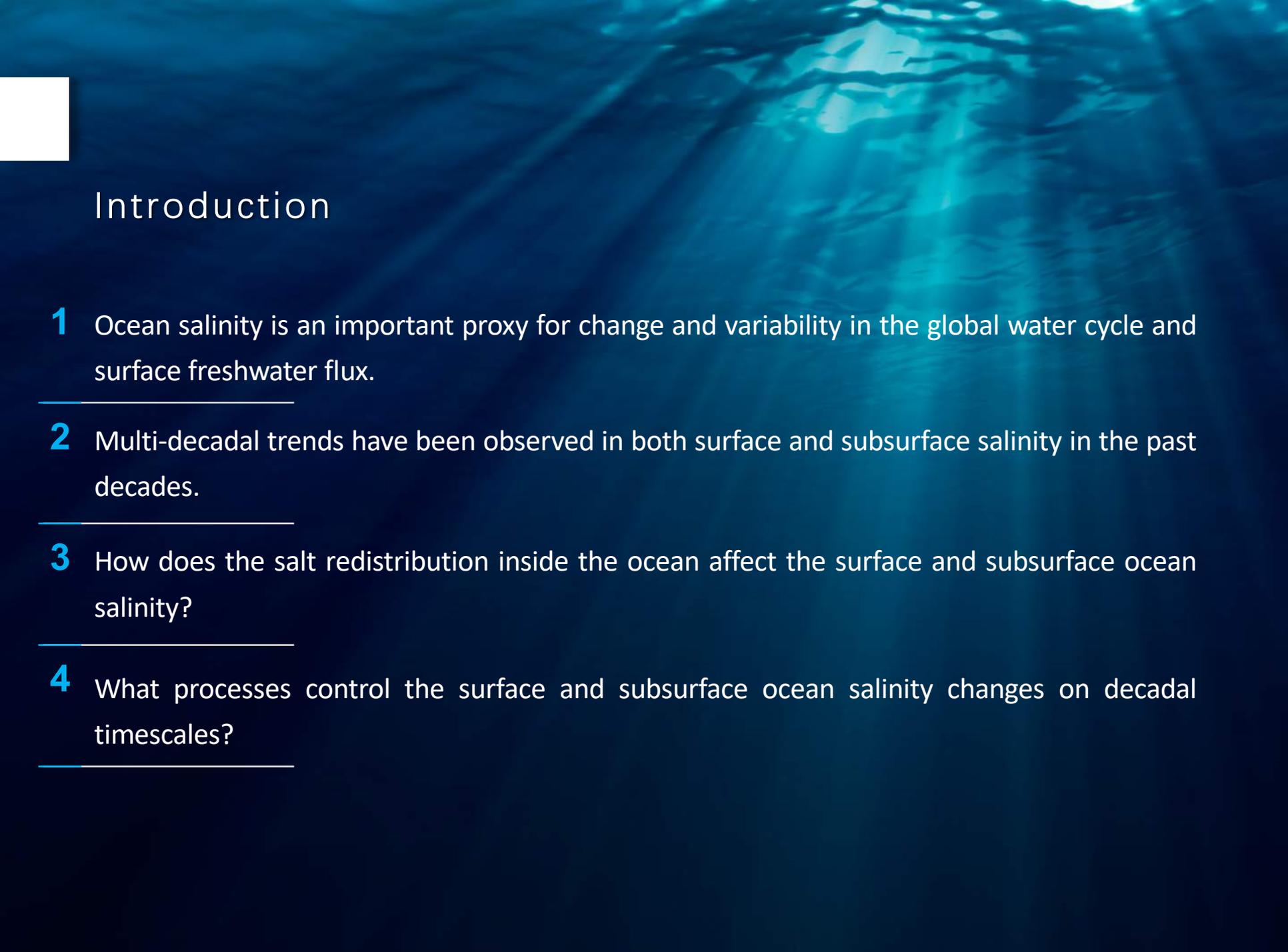
# Vertical Redistribution of Global Ocean Salt Content

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Chao Liu<sup>1</sup>, Xinfeng Liang<sup>1\*</sup>, Rui M. Ponte<sup>2</sup>, Nadya Vinogradova-Shiffer<sup>3,4</sup>, Ou Wang<sup>5</sup>

with acknowledgement to Christopher G  
Piecuch<sup>2</sup>

1. University of South Florida, College of Marine Science, St Petersburg, FL
2. Atmospheric and Environmental Research, Lexington, MA
3. NASA Headquarters, Science Mission Directorate, Washington, DC
4. Cambridge Climate Institute, Boston, MA
5. Jet Propulsion Laboratory, Pasadena, CA



# Introduction

- 1** Ocean salinity is an important proxy for change and variability in the global water cycle and surface freshwater flux.

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- 2** Multi-decadal trends have been observed in both surface and subsurface salinity in the past decades.

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- 3** How does the salt redistribution inside the ocean affect the surface and subsurface ocean salinity?

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- 4** What processes control the surface and subsurface ocean salinity changes on decadal timescales?

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## Data

### ◎ The ECCO (version 4 release 3): Estimating the Circulation & Climate of the Ocean

- ✓ A 24-year dynamically consistent and data-constrained ocean state estimate, assimilates nearly all modern global-scale observations with a time-evolving general ocean circulation model (MITgcm).
- ✓ No unknown physical increment; using real freshwater flux boundary condition, nonlinear free surface approximation, which produce consistent and closed budgets of ocean properties and tracers.
- ✓ All the variables and dynamical diagnostics satisfy the control equations and are close to the available observations, hence they're at least physically reasonable, even for those without available corresponding observations.

# Results

Changes in Globally Averaged Salinity

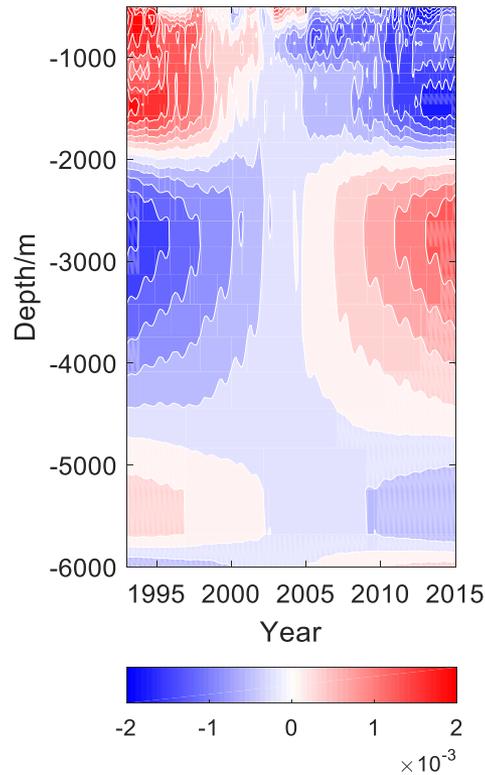
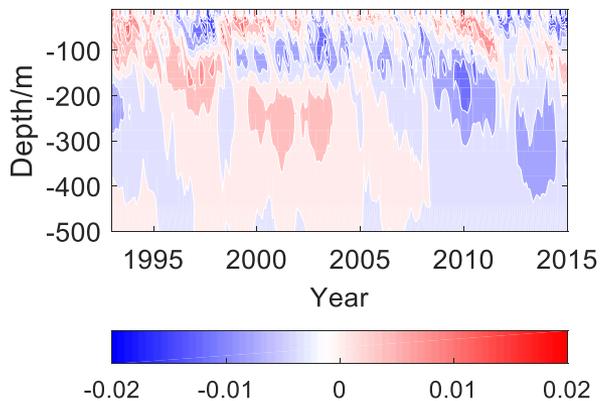


Figure 1: Temporal variation of the global ocean salinity from ECCO v4r3.

- ▶ Strong temporal variation appears near the surface, along with a freshening tendency since 2000 between 200-500 m.
- ▶ A layered structure appears in the long-term changes of the globally averaged salinity, with freshening in both upper and abyssal oceans but salinification between them.

# Results

Regional Changes of Layer-averaged Salinity

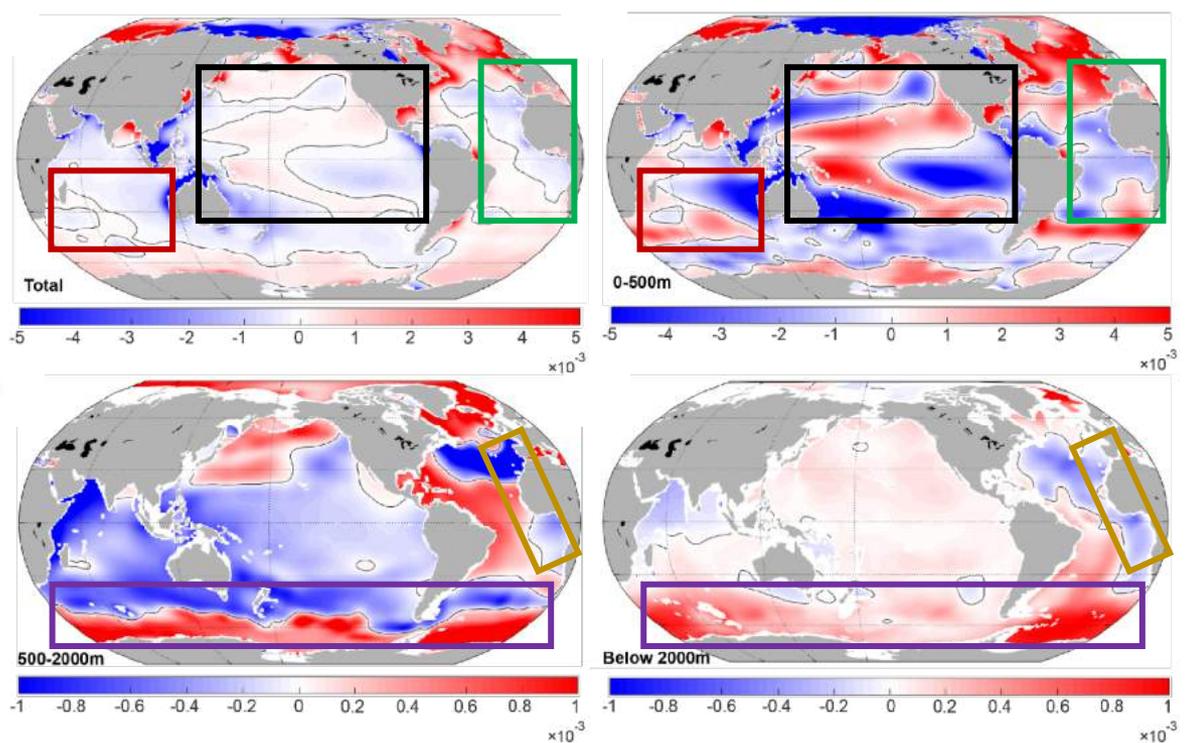


Figure 2: Spatial distribution of the bidecadal changes of ocean salinity in sampled layers (psu/yr).

- ▶ The upper 0-500 m ocean contributes the most to the changes of the whole water column.
- ▶ The long-term changes from the layered structure comes from the Pacific and Indian Ocean.

# Results

From Salinity Changes to Salt Fluxes



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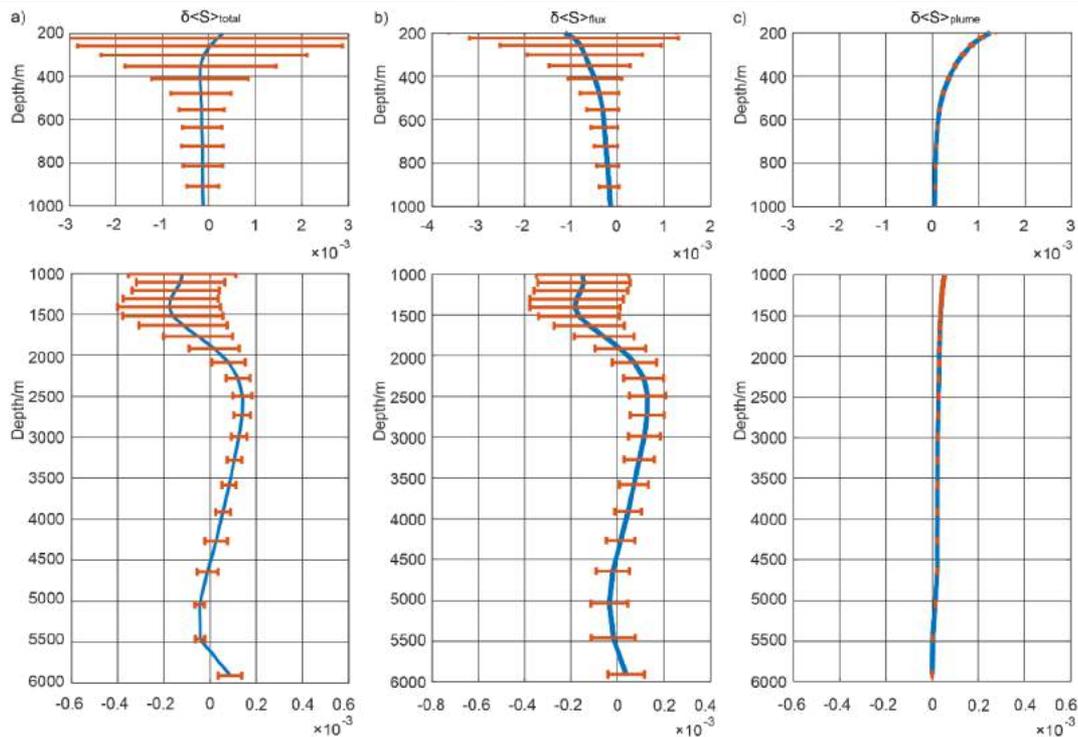


Figure 3: 22-year horizontally averaged total salt tendency based on salinity profile (a,  $\delta\langle S \rangle_{\text{total}}$ ), the net vertical salt flux (b,  $\delta\langle S \rangle_{\text{flux}}$ ) and the salt plume (c,  $\delta\langle S \rangle_{\text{plume}}$ ). The unit is  $\text{psu year}^{-1}$ .

- ▶ The bi-decadal change on the salinity for the ocean below 500 m can almost be solely attributed to the net vertical salt flux, while the upper counterpart is also strongly influenced by the salt plume.

# Results

## Surface Freshwater Flux and Subsurface Salt Flux

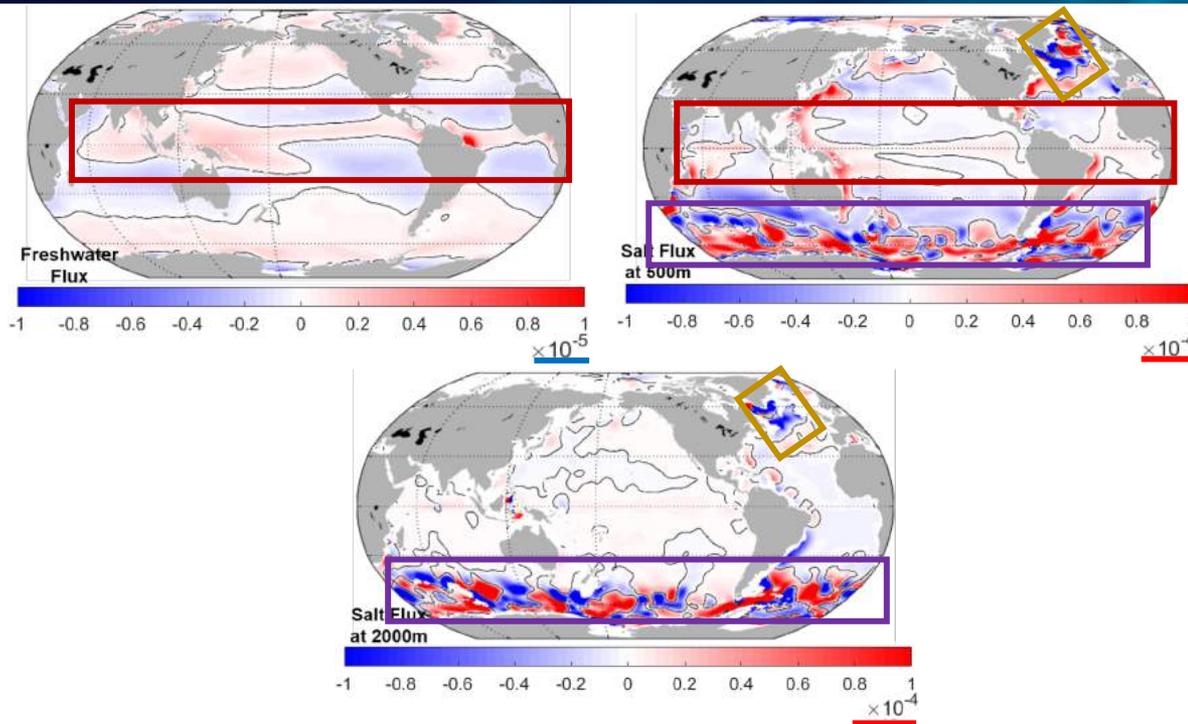


Figure 4: Temporal means of surface freshwater flux (converted to  $\text{psu m s}^{-1}$ ) and net vertical salt fluxes at 500m and 2000 m ( $\text{psu m s}^{-1}$ ).

- ▶ Globally averaged surface freshwater flux:  
 $-2.10 \pm 1.16 \times 10^{-8} \text{ psu m s}^{-1}$
- ▶ Globally averaged vertical salt flux at 200m:  
 $0.90 \pm 1.71 \times 10^{-8} \text{ psu m s}^{-1}$

# Results

## Global Means of Salt Fluxes

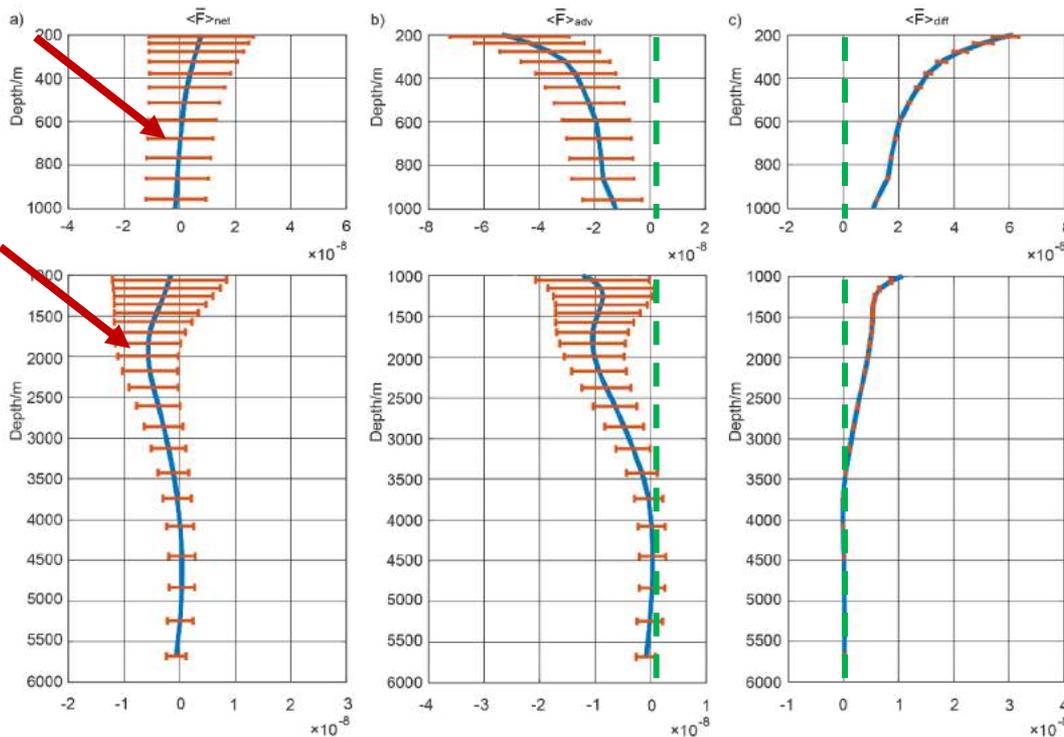


Figure 5: Global and temporal averages of the net, advective and diffusive vertical salt fluxes,  $\langle \bar{F} \rangle_{\text{net}}$ ,  $\langle \bar{F} \rangle_{\text{adv}}$  and  $\langle \bar{F} \rangle_{\text{diff}}$ . Here,  $F_{\text{net}}$  is the sum of  $F_{\text{adv}}$  and  $F_{\text{diff}}$ . The unit is  $\text{psu m s}^{-1}$ .

- ▶ While the relatively large uncertainties indicate strong temporal variabilities, the horizontally averaged vertical salt flux,  $\langle S_v \rangle$ , shows a net upward salt transport that decreases with depth in the upper 700 m over the examined period.

# Results

Advective & Diffusive Components

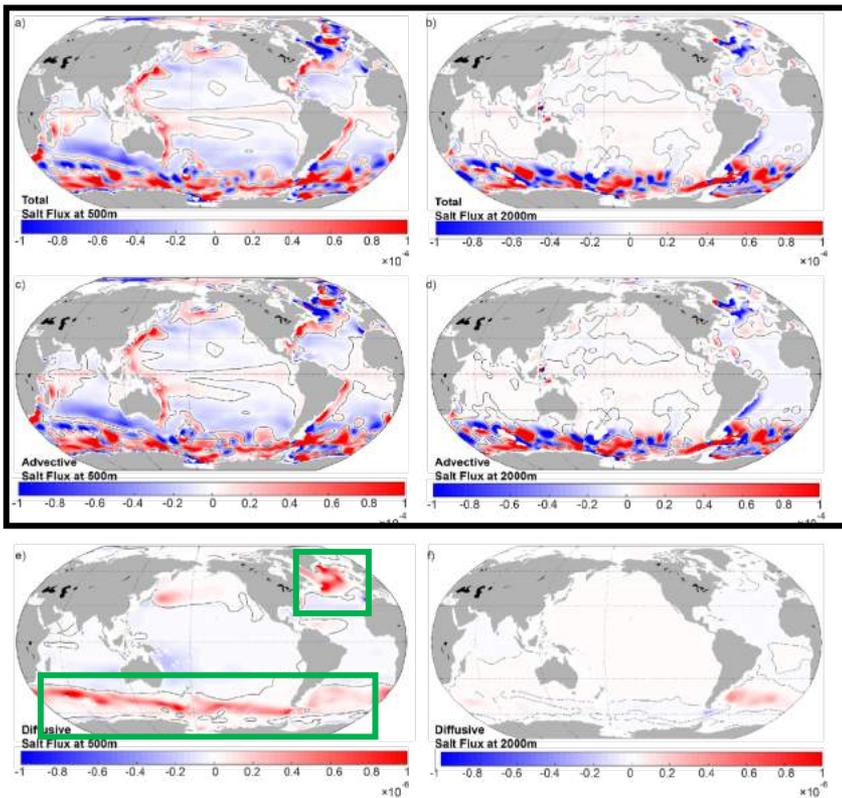
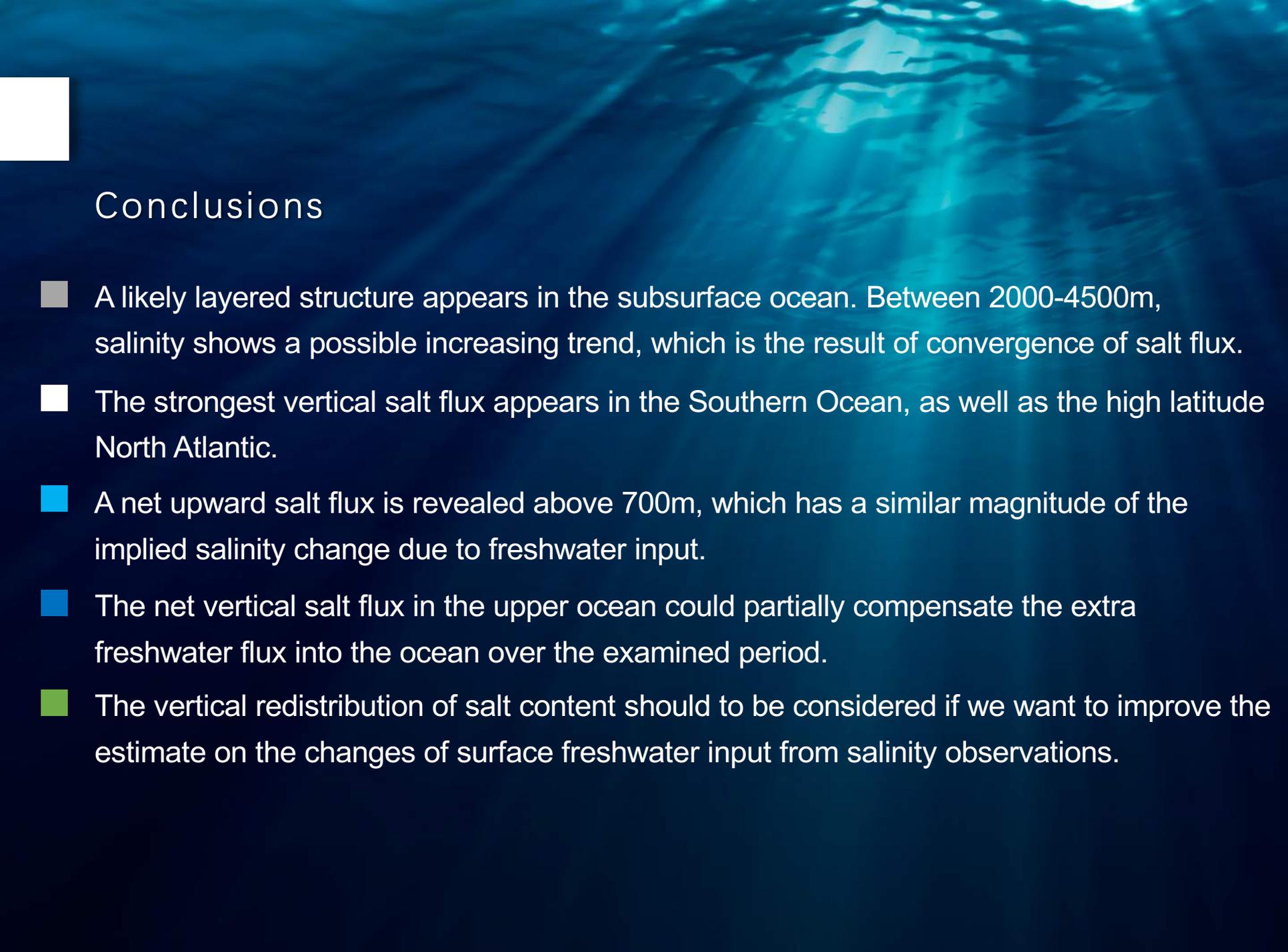


Figure 6: 22-year means of net, advective and diffusive vertical fluxes of salt at 500 m and 2000 m. The unit is  $\text{psu m s}^{-1}$ .

- ▶ The advective component plays a dominant role in the spatial variations of the vertical salinity transport.
- ▶ The diffusive terms are of similar magnitudes in the Southern Ocean and the North Atlantic, but much smaller in other regions.

An underwater photograph showing a diver's legs and fins, viewed from below. The water is clear and blue, with light filtering through from above. The diver's legs are in a kicking motion, and the fins are visible. The background shows the water surface and some light reflections.

## Conclusions

- A likely layered structure appears in the subsurface ocean. Between 2000-4500m, salinity shows a possible increasing trend, which is the result of convergence of salt flux.
- The strongest vertical salt flux appears in the Southern Ocean, as well as the high latitude North Atlantic.
- A net upward salt flux is revealed above 700m, which has a similar magnitude of the implied salinity change due to freshwater input.
- The net vertical salt flux in the upper ocean could partially compensate the extra freshwater flux into the ocean over the examined period.
- The vertical redistribution of salt content should to be considered if we want to improve the estimate on the changes of surface freshwater input from salinity observations.

An underwater photograph showing sunlight rays filtering through the water surface, creating a serene and ethereal atmosphere. The water is a deep blue, and the light rays are bright and distinct, creating a sense of depth and tranquility.

Thank you !