Decadal reorganization of Subantarctic Mode Water

Ivana Cerovečki [1] and F. Alexander Haumann [2,3,4]

[1] Scripps Institution of Oceanography, University of California San Diego, USA

[2] Atmospheric and Oceanic Sciences Program, Princeton University, USA

[3]Alfred Wegener Institute, Germany

[4]Ludwig-Maximilians-University Munich, Germany

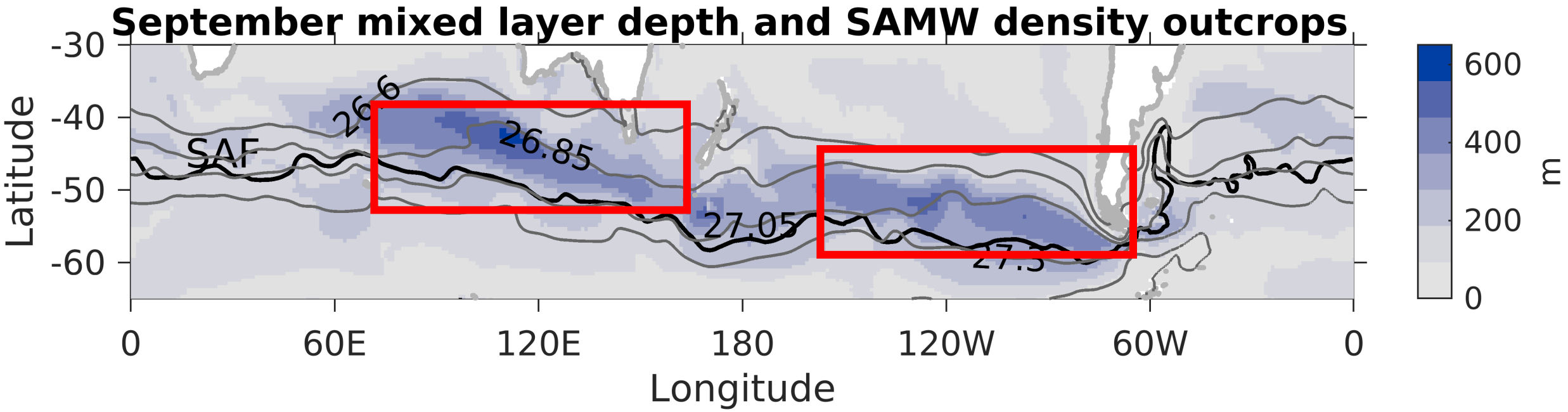
Motivation:

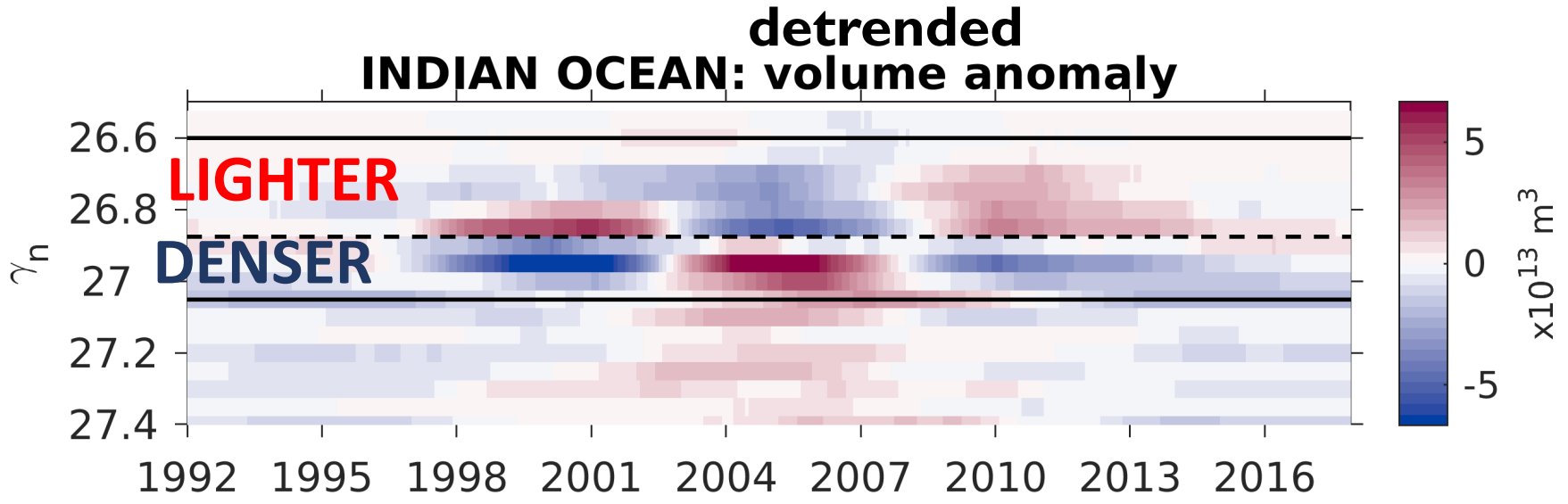
Much of the upper ocean warming in the southern hemisphere is in close association with SAMW, and most (84%) of the increase in SAMW heat content is the result of changes in SAMW thickness, while only the remaining 16% are caused by warming through an increased heat flux to the ocean (Gao et al., 2018; Meijers et al., 2019).

The goal:

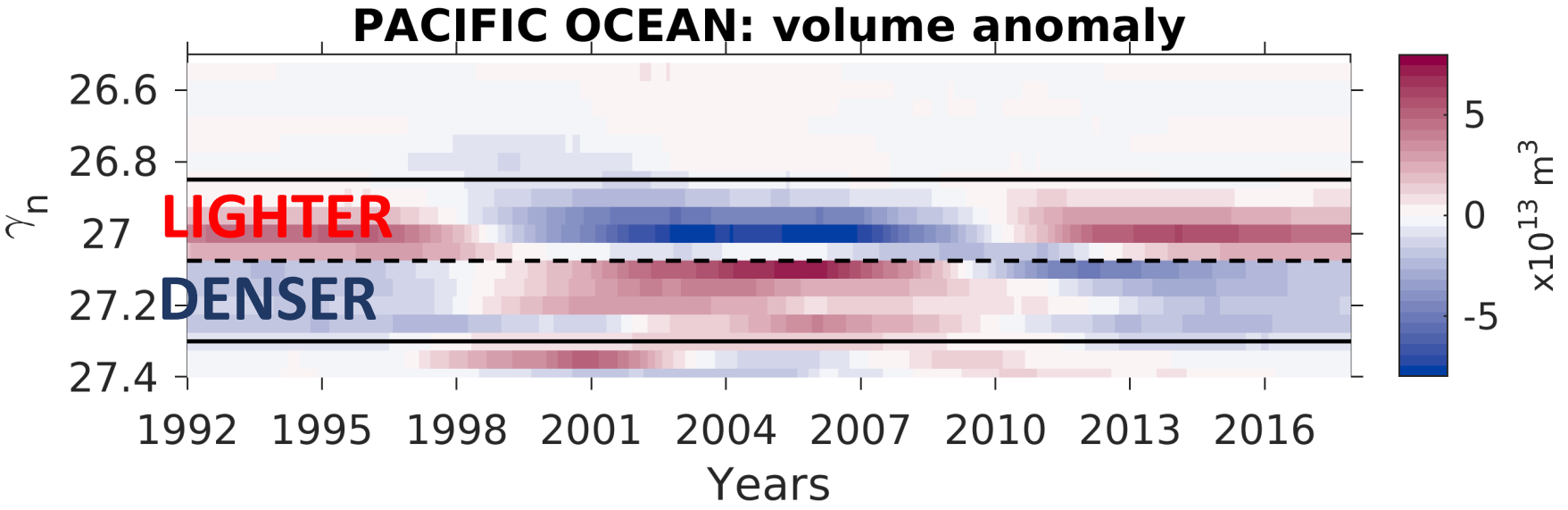
Understand better the mechanisms governing the long-term variability of SAMW volume.

ECCO4v4 state estimate: 1992-2017





Volume variability within the lighter and denser SAMW density ranges tend to oppose each other, indicating a reorganization between these layers.



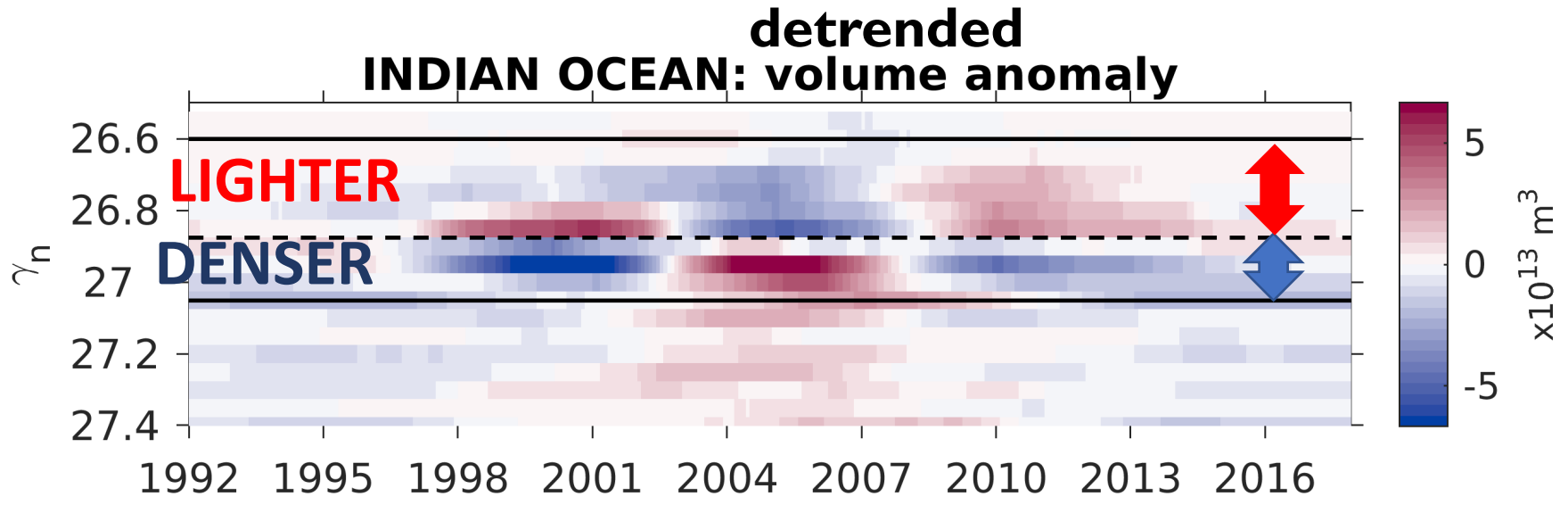
Volume trend

+ LIGHTER

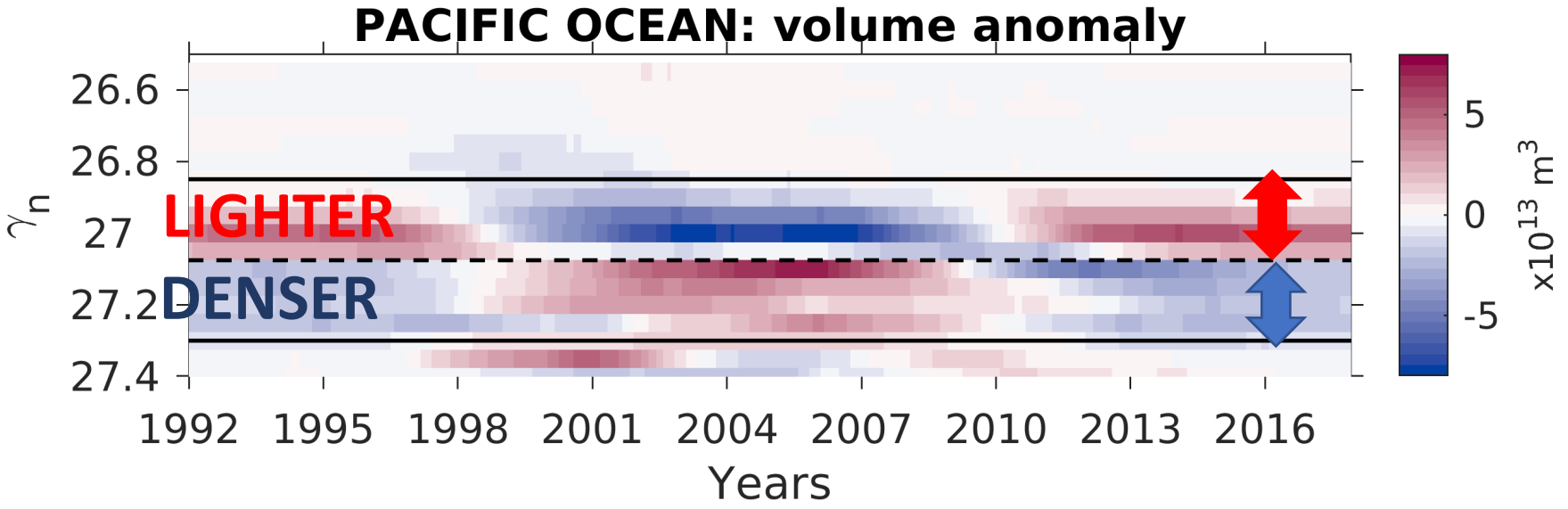
- DENSER

Kolodziejczyk et al. (2019)

Portella et al. (2020)



Volume variability within the lighter and denser SAMW density ranges tend to oppose each other, indicating a reorganization between these layers.



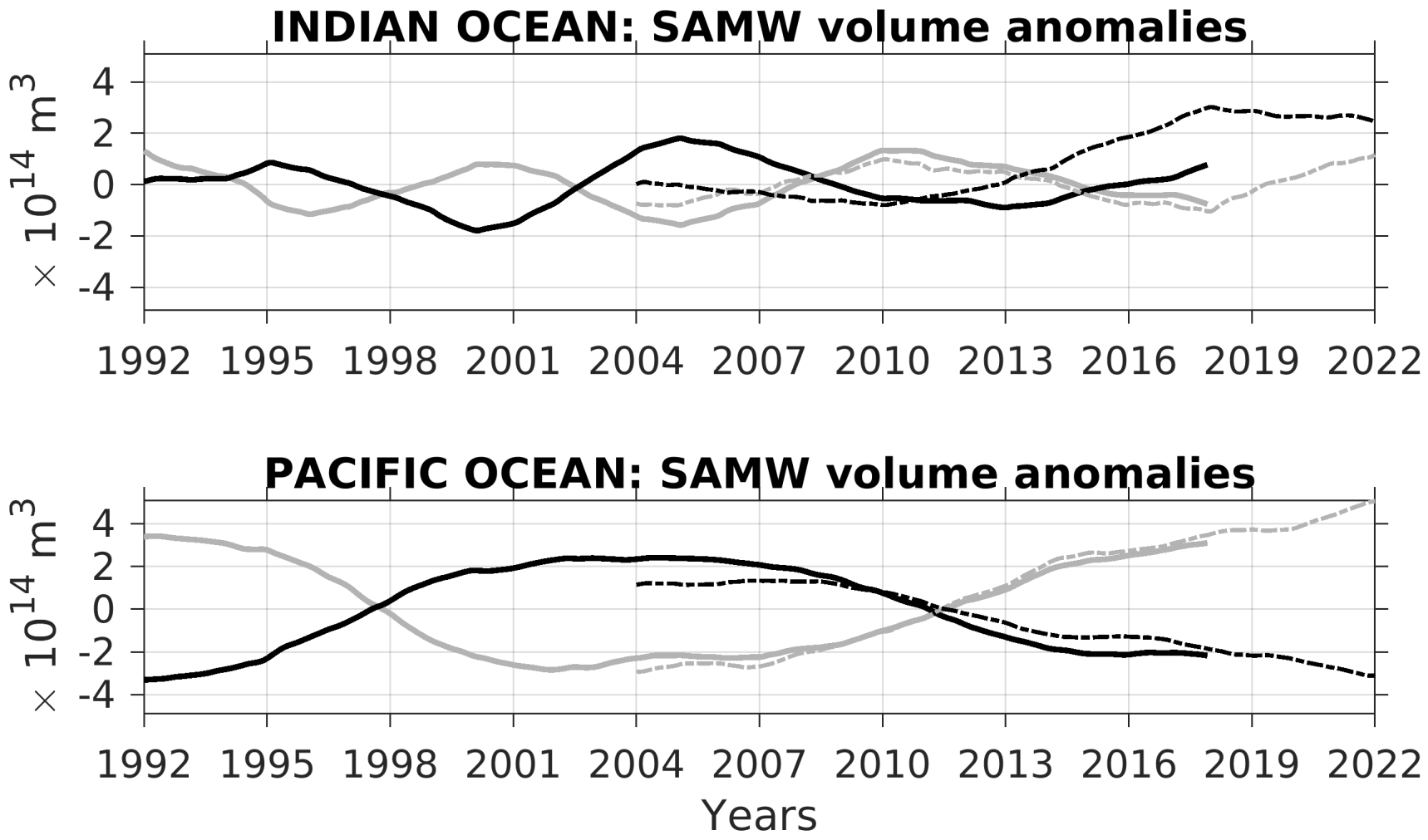
Volume trend

+ LIGHTER

- DENSER

Kolodziejczyk et al. (2019)

Portella et al. (2020)



gray: lighter SAMW

black: denser SAMW

solid: ECCO

dashed: Argo

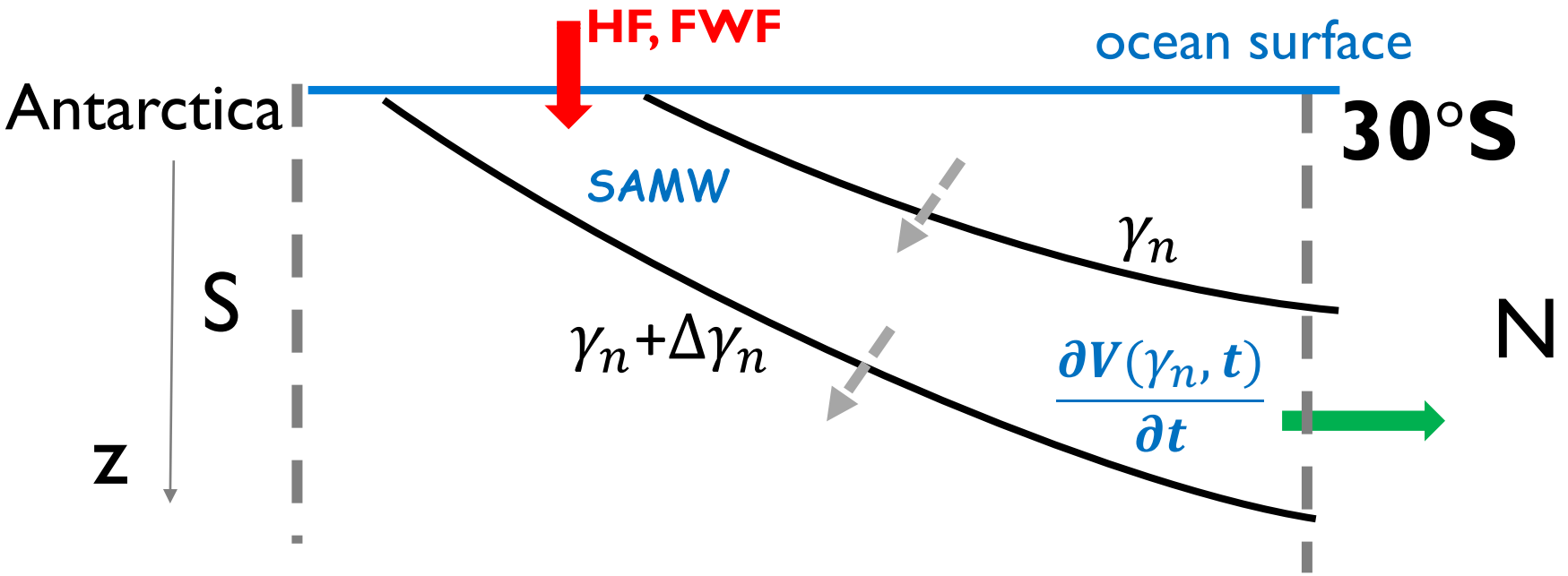
detrended by removing ECCO trend

Volume changes of lighter and denser SAMW are nearly compensating in both ocean sectors.

- Indian SAMW: quasi-decadal volume variability (magnitude comparable to the volume trend)
- Pacific SAMW: multi-decadal volume variability (magnitude larger than the volume trend)

Which processes drive the long term SAMW volume variability?

We consider isopycnal volume budgets from ECCO, integrated over density ranges of lighter and denser SAMW.

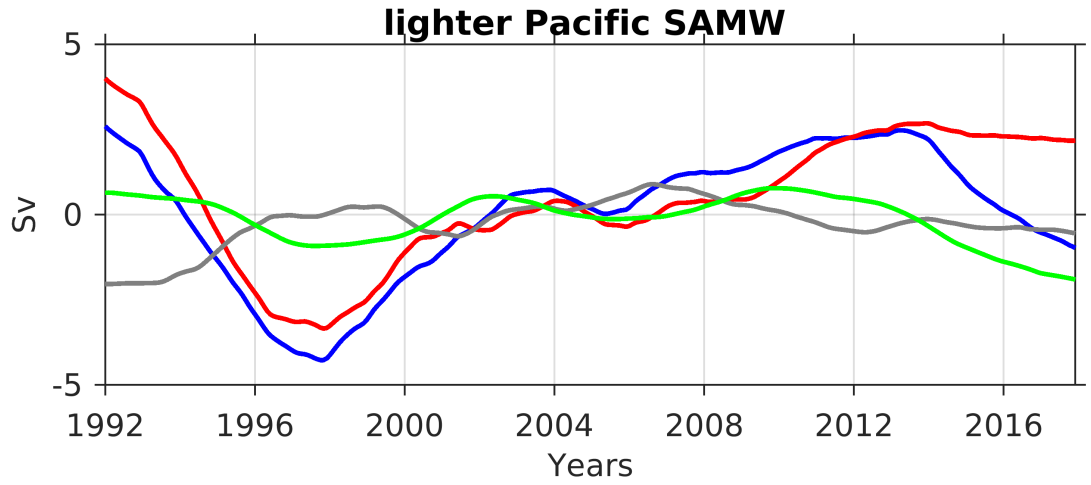


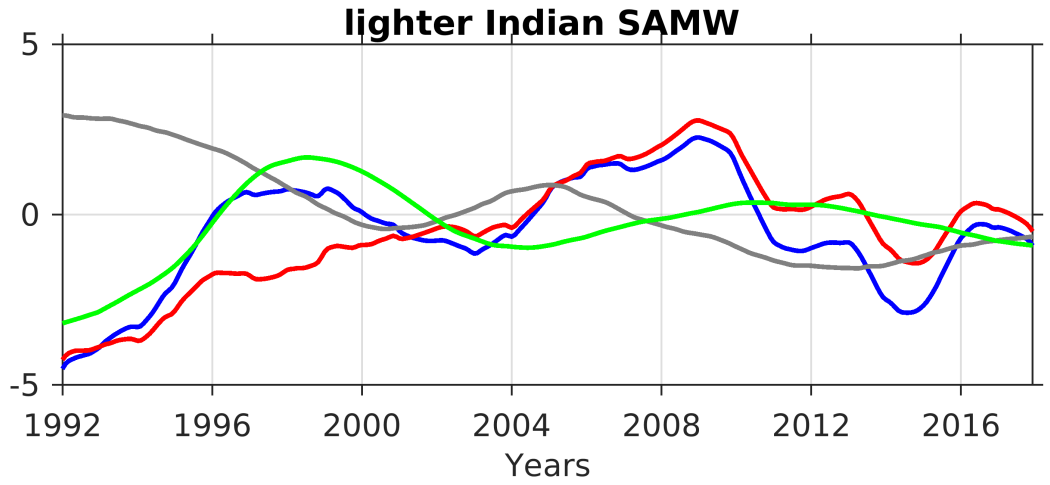
Volume Tendency
Surface Formation
Formation by Mixing
Advection

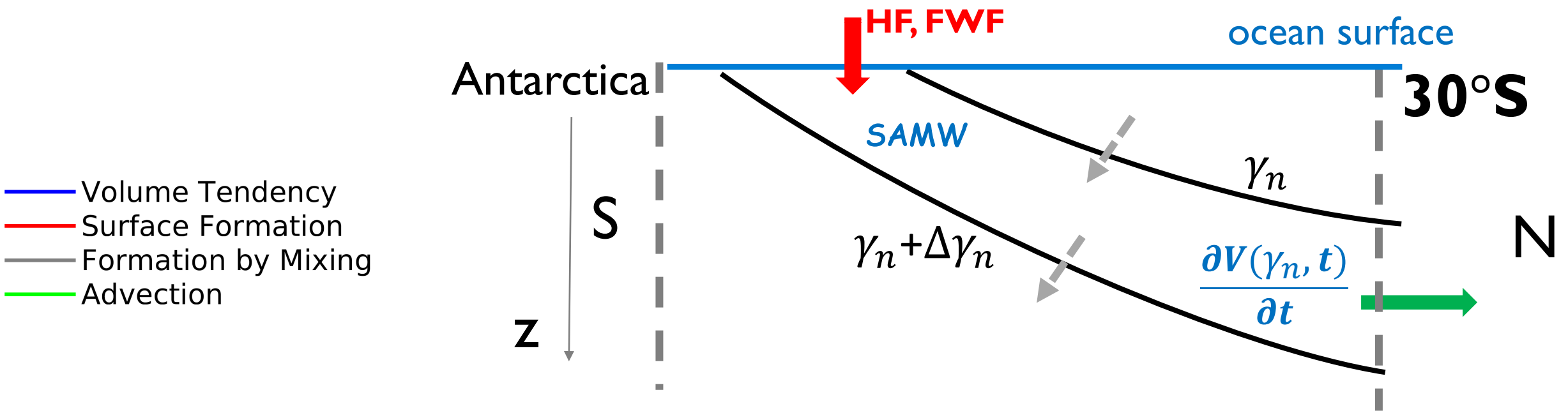
volume tendency=

advection+ water mass formation by **surface buoyancy fluxes** &
diapycnal ocean mixing

Volume tendency anomaly (Sv)



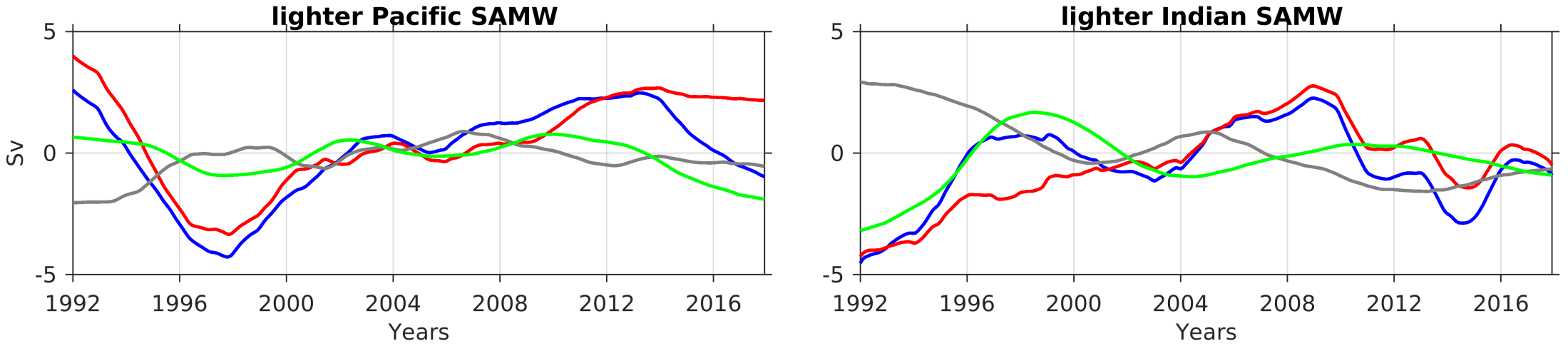


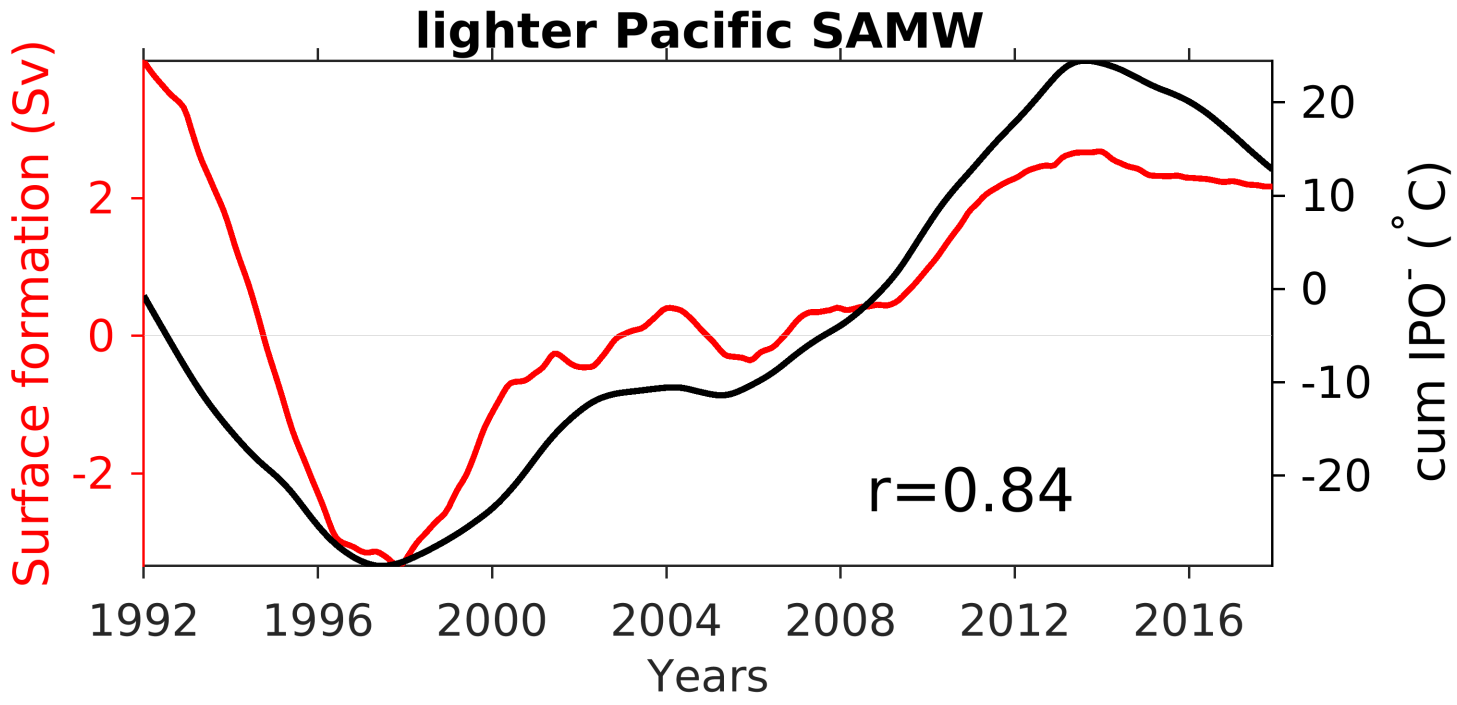


The long term reorganization of SAMW volume is predominantly driven by WMF by air-sea buoyancy fluxes.

Tropical teleconnections: Li and England (2020)

Volume tendency anomaly (Sv)





This indicates that the ocean is an integrator of the atmospheric forcing, having a memory of previous years.

Cumulative effects of the IPO govern the surface formation of lighter Pacific SAMW, which in turn dominates the multidecadal volume variability of this water mass.

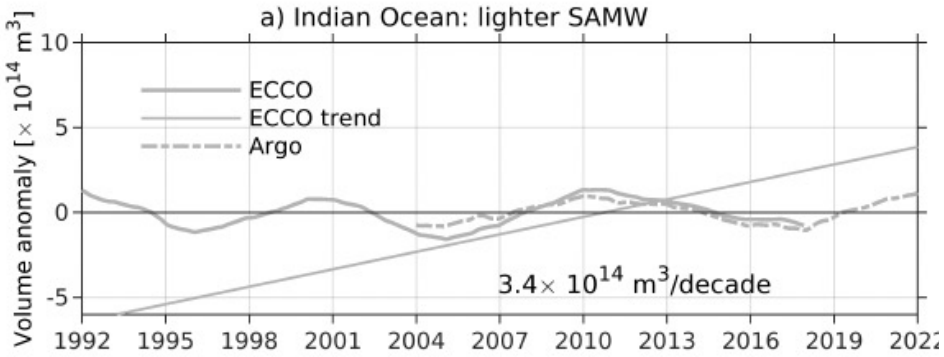
Conclusions:

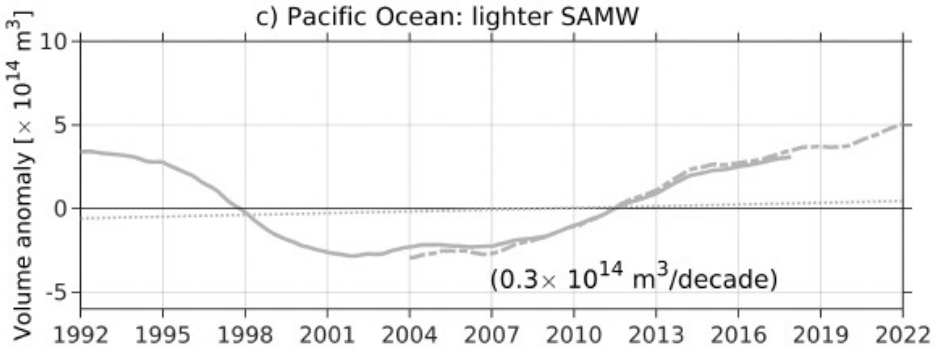
- Decadal to multidecadal variability of SAMW volume can regionally exceed long-term volume trends.
- The variability exhibits compensating volume changes of lighter and denser varieties of SAMW in both the Indian and Pacific sectors.
- This two-layer density reorganization is primarily driven by water mass formation by surface buoyancy flux, which is significantly impacted by the Interdecadal Pacific Oscillation.
- Tropical teleconnections play an essential role in driving multidecadal two-layer SAMW reorganization in both ocean sectors.

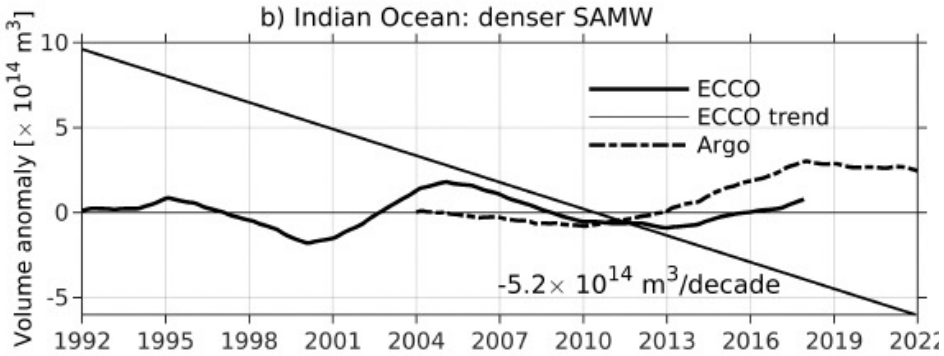
Conclusions:

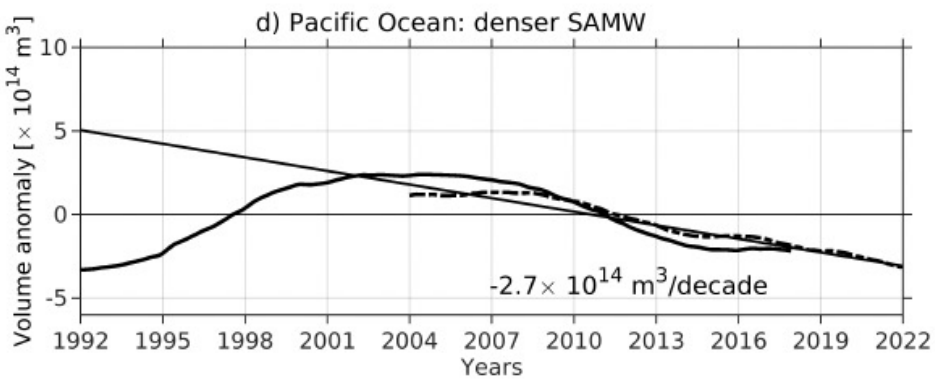
- Decadal to multidecadal variability of SAMW volume can regionally exceed long-term volume trends.
- The variability exhibits compensating volume changes of lighter and denser varieties of SAMW in both the Indian and Pacific sectors.
- This two-layer density reorganization is primarily driven by water mass formation by surface buoyancy flux, which is significantly impacted by the Interdecadal Pacific Oscillation.
- Tropical teleconnections play an essential role in driving multidecadal two-layer SAMW reorganization in both ocean sectors.

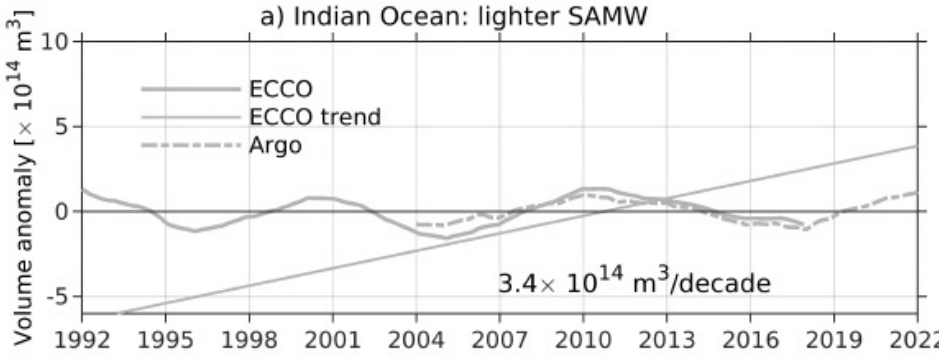
- Cerovečki, I., & Haumann, F. A. (2023). Decadal Reorganization of Subantarctic Mode Water. *Geophysical Research Letters*, *50*(14)

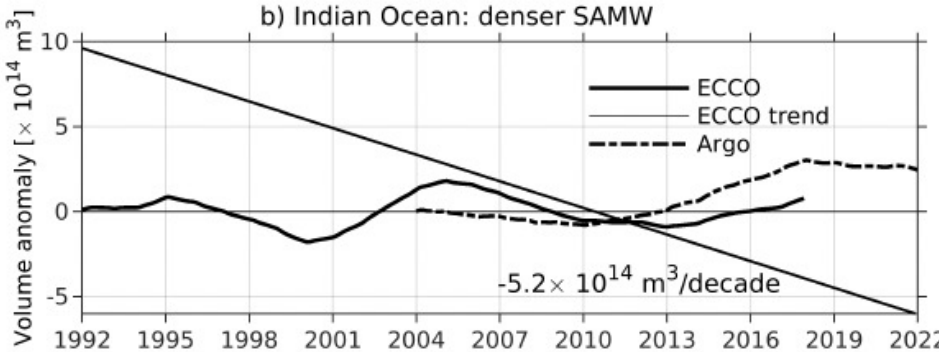

a) Indian Ocean: lighter SAMW
Volume anomaly [× 10^14 m^3]
ECCO
ECCO trend
Argo
3.4× 10^14 m^3/decade
10
5
0
-5
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022

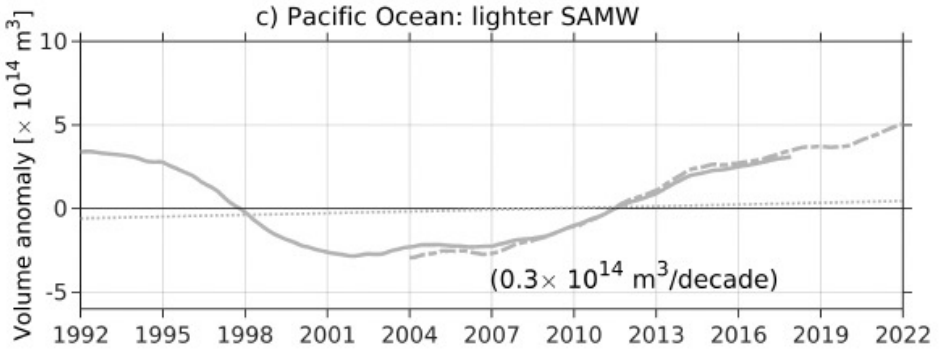

c) Pacific Ocean: lighter SAMW
Volume anomaly [× 10^14 m^3]
(0.3× 10^14 m^3/decade)
10
5
0
-5
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022

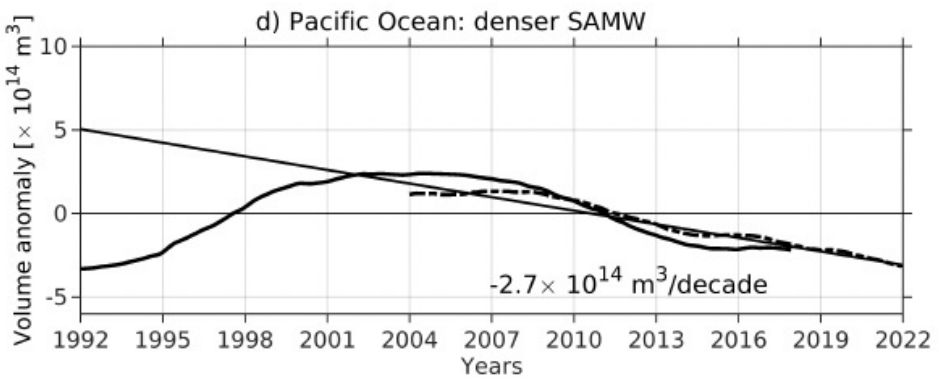

b) Indian Ocean: denser SAMW
Volume anomaly [× 10^14 m^3]
ECCO
ECCO trend
Argo
-5.2× 10^14 m^3/decade
10
5
0
-5
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022


d) Pacific Ocean: denser SAMW
Volume anomaly [× 10^14 m^3]
-2.7× 10^14 m^3/decade
10
5
0
-5
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022
Years

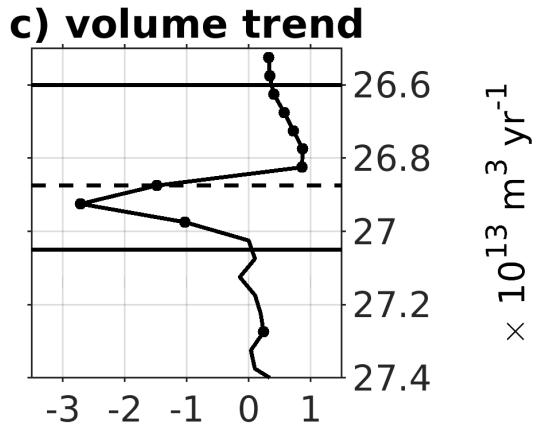




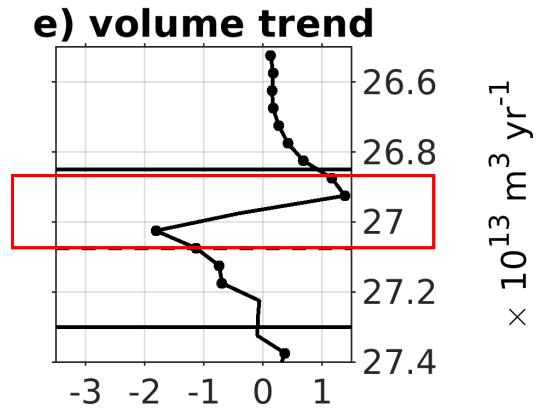




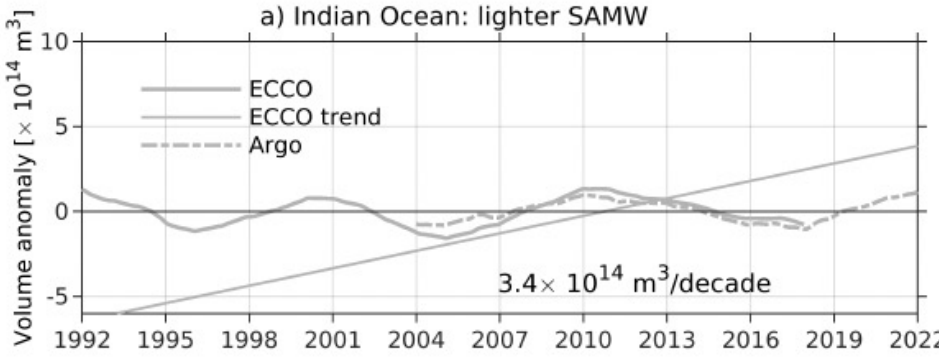
Indian

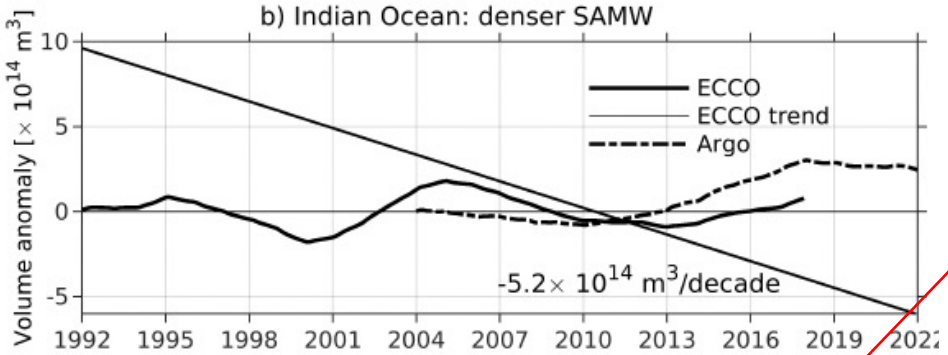


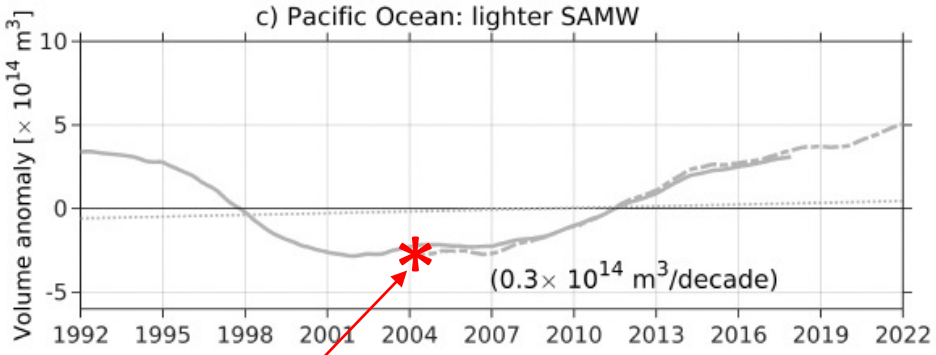
Pacific

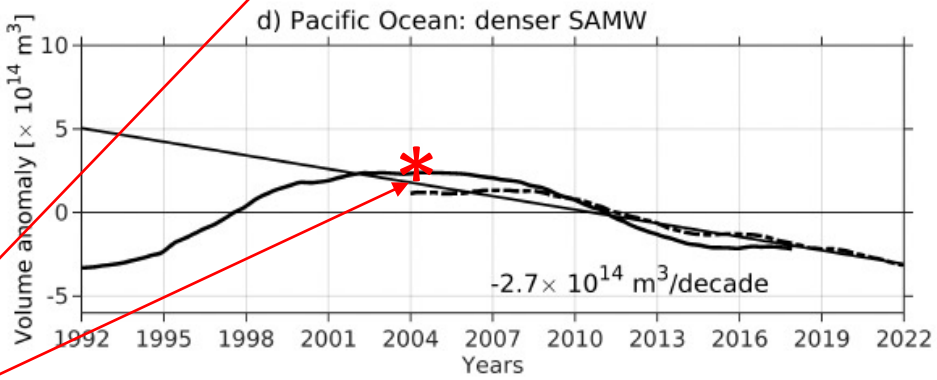


LIGHTER

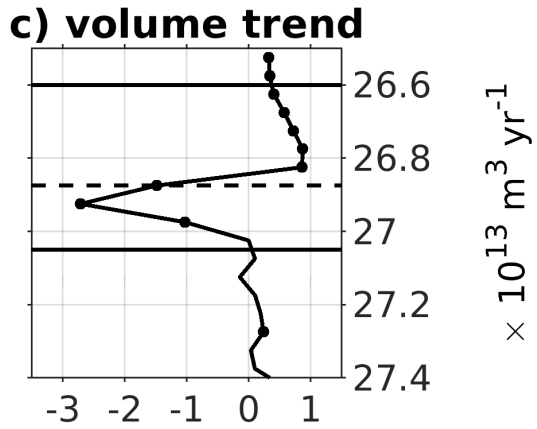




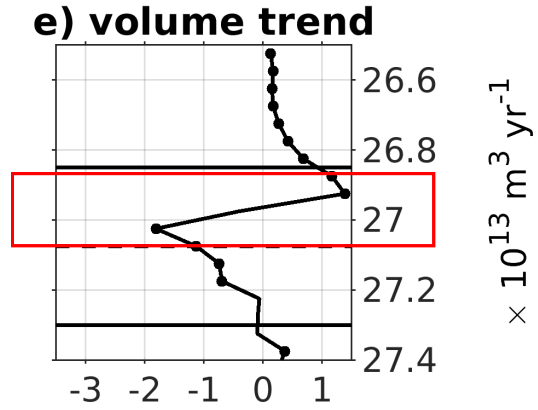




Indian

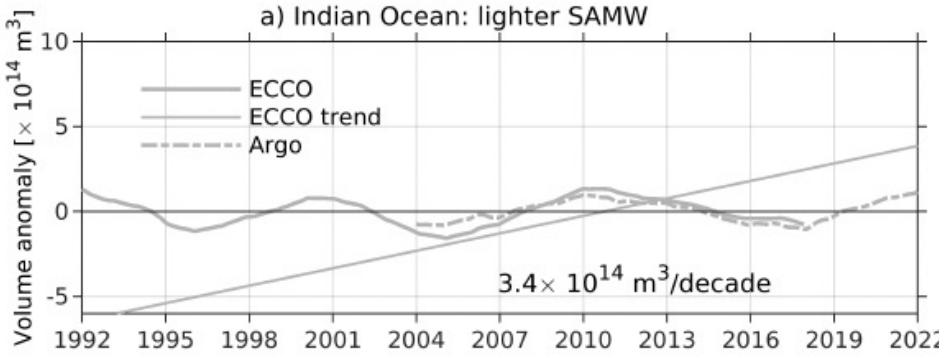


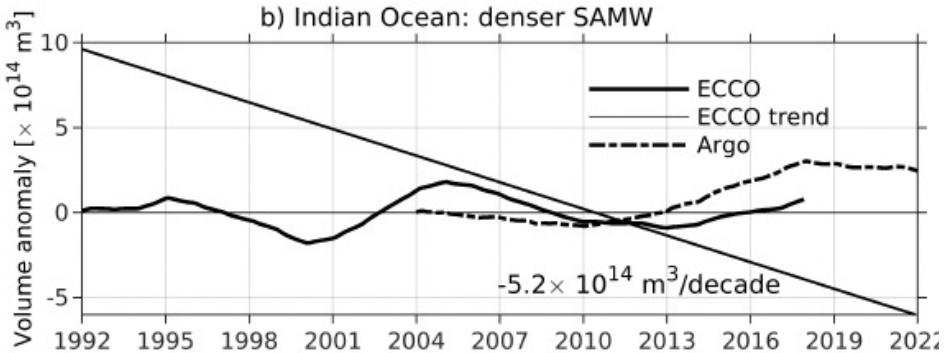
Pacific

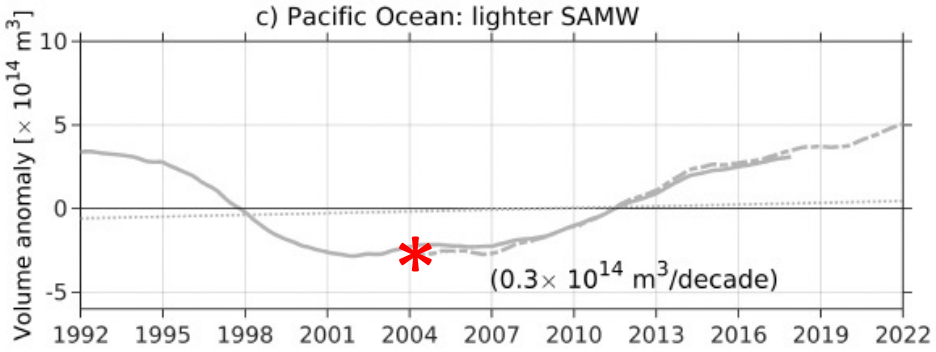


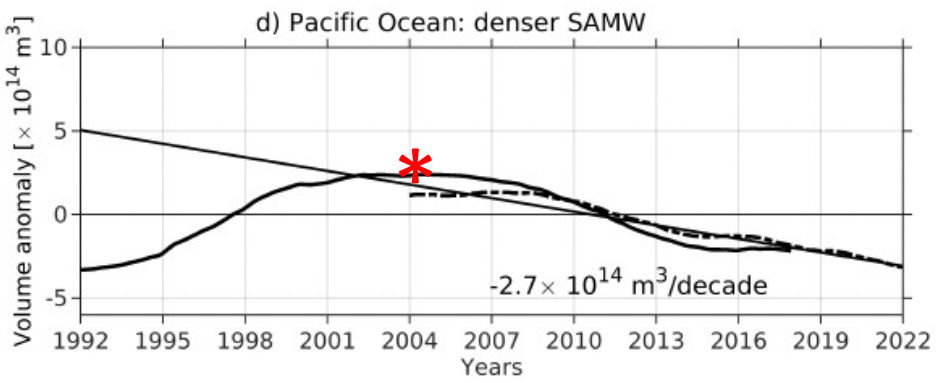
LIGHTER

Since the beginning of Argo period, volume change is part of the multidecadal variability

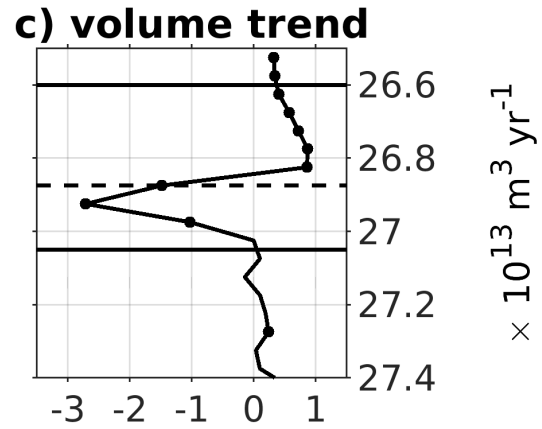




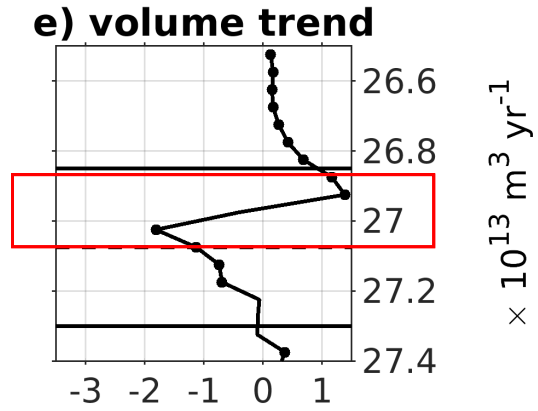




Indian



Pacific



LIGHTER

Which processes drive the long term SAMW volume variability?

We consider isopycnal volume budgets from ECCO, integrated over density ranges of lighter and denser SAMW.