07 May 2020, EGU

INTERANNUAL TO DECADAL VARIABILITY IN SUBTROPICAL CIRCULATION TRANSPORT IN THE SOUTH INDIAN OCEAN

JGR Oceans, under Minor Revision

MOTOKI NAGURA

(JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY)

INTRODUCTION

- Previous studies about decadal variability in the Indian Ocean mostly focused on the tropical region, which is about north of 15°S.
- There are only three studies that examined temporal variability in the subtropical circulation in the south Indian Ocean, i.e., Lee (2004), Lee and McPhaden (2008) and Zhuang et al. (2013).
- All of them used zonal difference of satellite sea surface height (SSH) as the index to the magnitude of subtropical gyre transport.

PURPOSE OF THIS STUDY

- Examine vertical structure of meridional velocity variability, which has never been done before.
- Discuss what variability zonal difference of satellite SSH represents and what it misses.

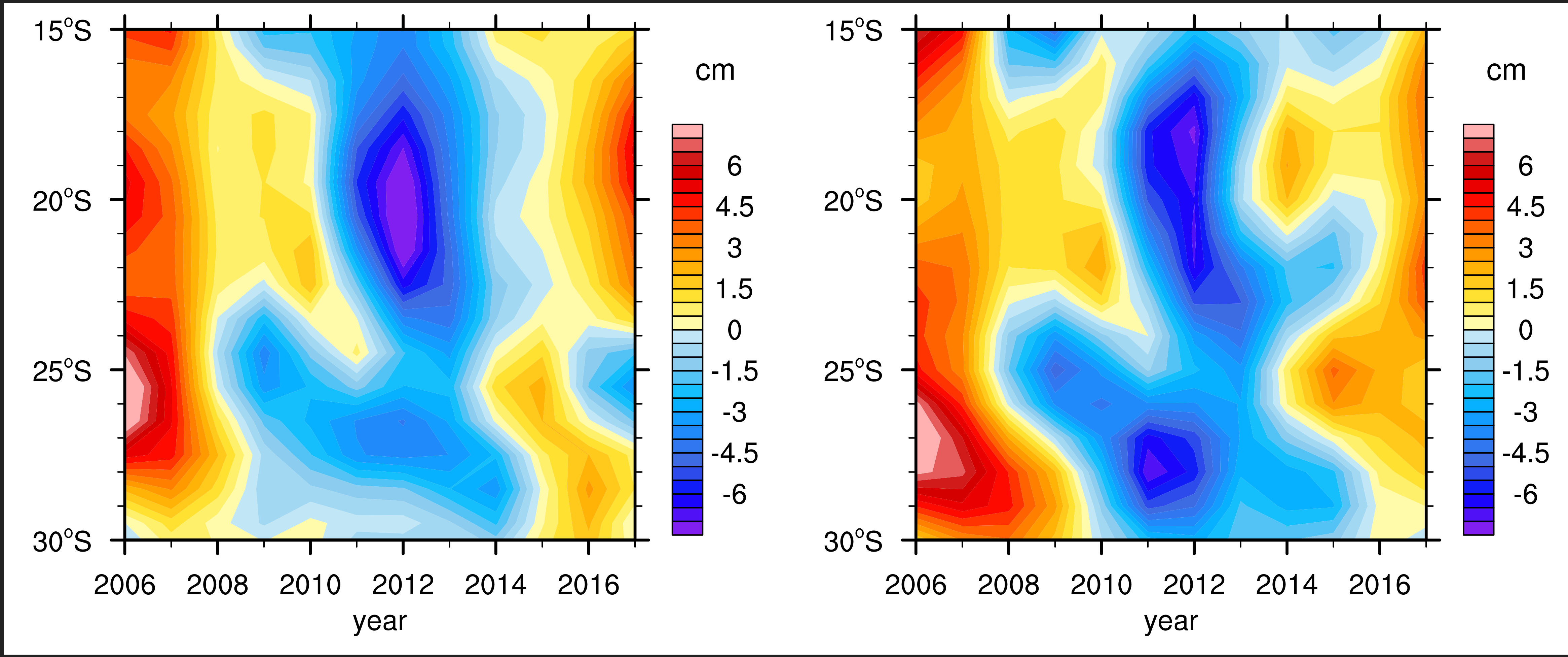
DATA AND METHODS

- In-situ hydrographic observations obtained from the World Ocean Database. They were objectively mapped onto a 1° x 1° grid at 35 depth levels. Steric height anomalies were computed from gridded temperature and salinity.
- Satellite SSH obtained from CMEMS (formerly provided by AVISO)
- Ocean reanalysis data obtained from MOVE-g2i and ORA-S4.
- The analysis period is from 2006 to 2017, during which in-situ observations are abundant. All data are averaged in each year.
- Estimates obtained in this study represent interior transport and do not include boundary currents.

Δh = Zonal difference (50°-60°E minus 100°-110°E)

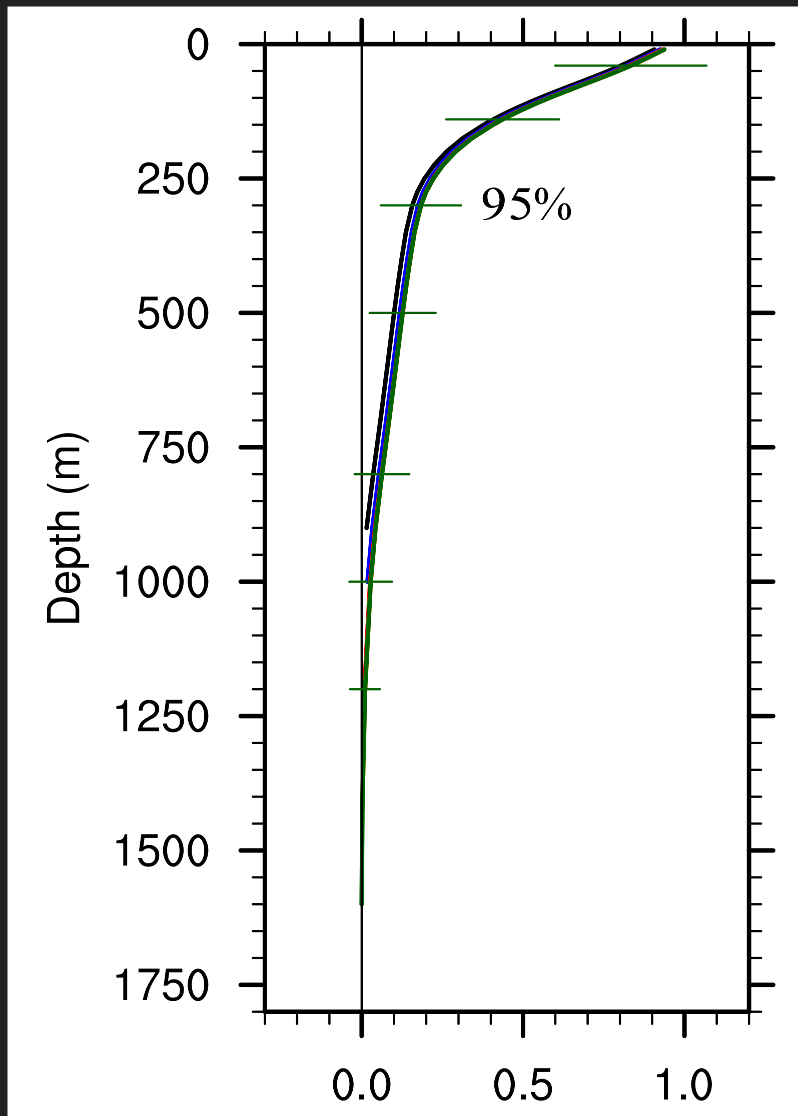
Δh obtained from Satellite measurements

Δh obtained from surface steric height anomalies



Previous studies used Δh obtained from satellite SSH (left panel) as an index to subtropical gyre variability.

Results obtained from in-situ observations (right panel) reliably estimate surface Δh.



Regression Slope

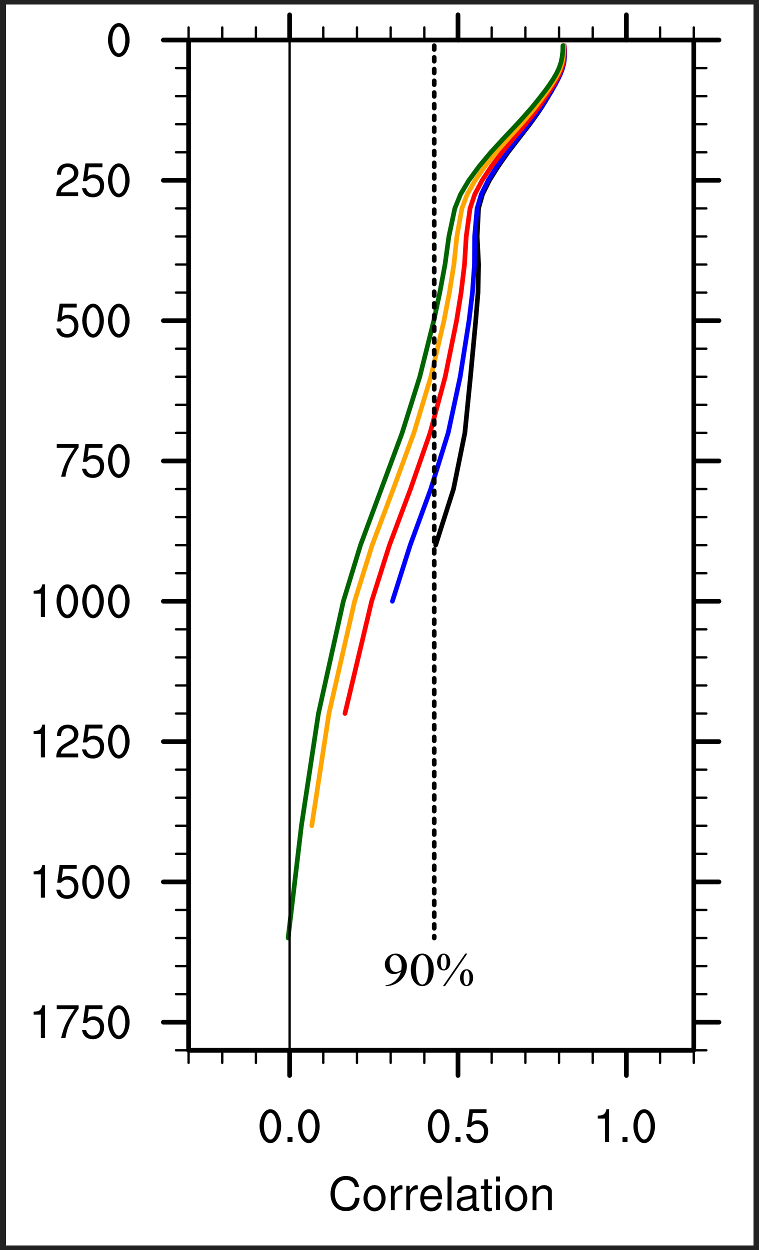
Vertical structure related to surface Δh is estimated using regression analysis.

$$y_k = a_k\, x + b_k$$

x	Δh obtained from satellite SSH
y_k	Δh obtained from steric height anomalies at k-th level
a_k	Regression slope for k-th level
b_k	Intercept for k-th level (negligible)

Δh of satellite SSH represents a surface-intensified pattern of velocity variability.

Essentially the same results were obtained if steric height anomalies are computed relative to 1000, 1200, 1400, 1600 and 1800 m depths (shown by black, blue, red, orange and green lines, respectively, but cannot distinguish in the figure).



However, correlation between x and y_k depends on the reference depth for steric height computation.

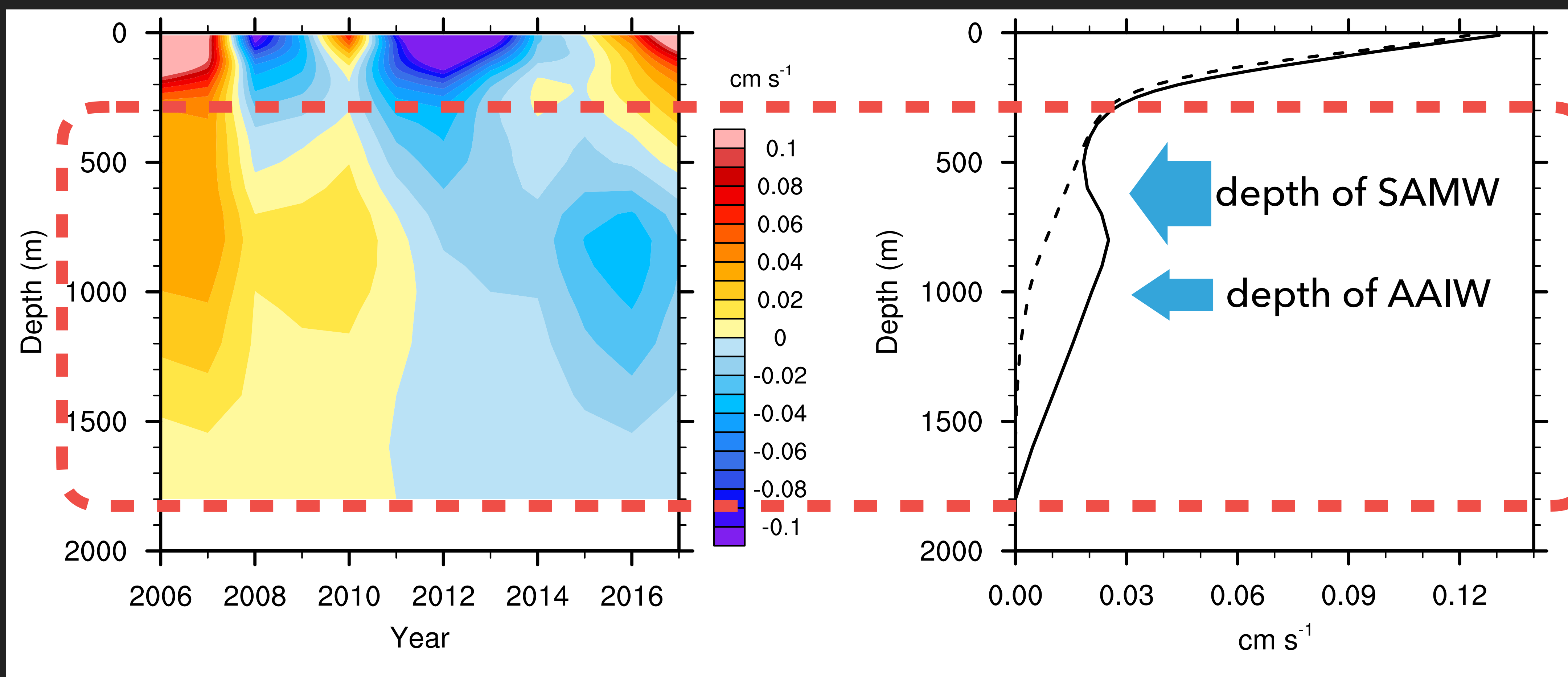
Correlation is lower if steric height anomalies are computed relative to a deeper depth level.

This suggests a presence of velocity variability at subsurface, which is not correlated with surface Δh.

Correlation coefficients between Δh obtained from satellite SSH and steric height anomalies obtained from in-situ observations

Steric height anomalies are computed relative to 1000 m, 1200 m, 1400 m, 1600 m, 1800 m depth

- There is a velocity variability below 300 m depth, which peaks at about 800 m depth in magnitude.
- It shows a monotonic decrease for the analysis period and is not correlated with surface Δh (compare with slide #4).
- It can affect transport of SubAntarctic Mode Water and AntArctic Intermediate Water.



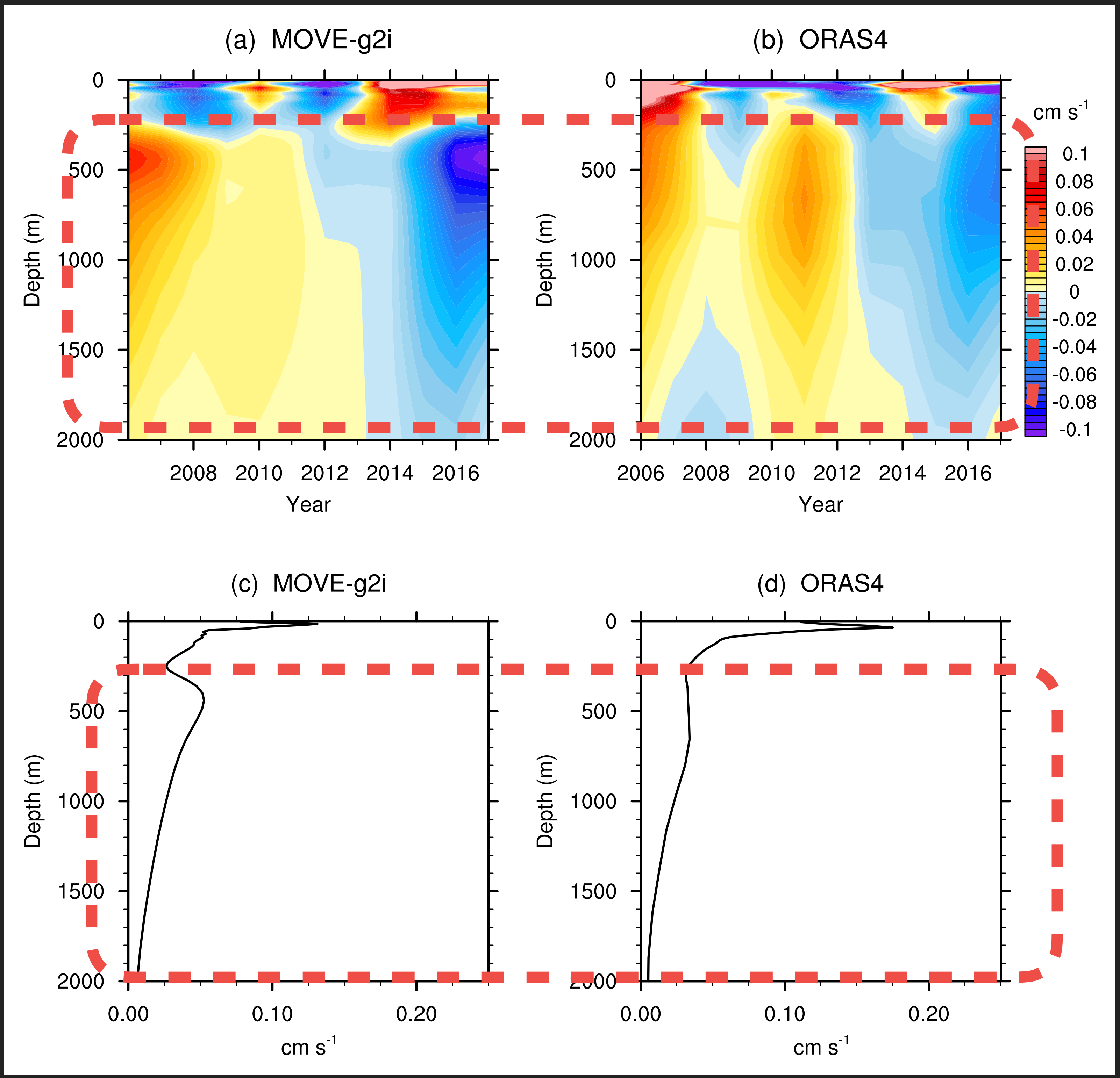
Meridional velocity along 22°S

(obtained from in-situ observations; zonally averaged over 55°-110°E; temporal mean subtracted)

—— Standard deviations of anomalies in the left panel

- - - - Profile of regression slope to surface Δh

Ocean reanalysis shows a consistent variability at subsurface.

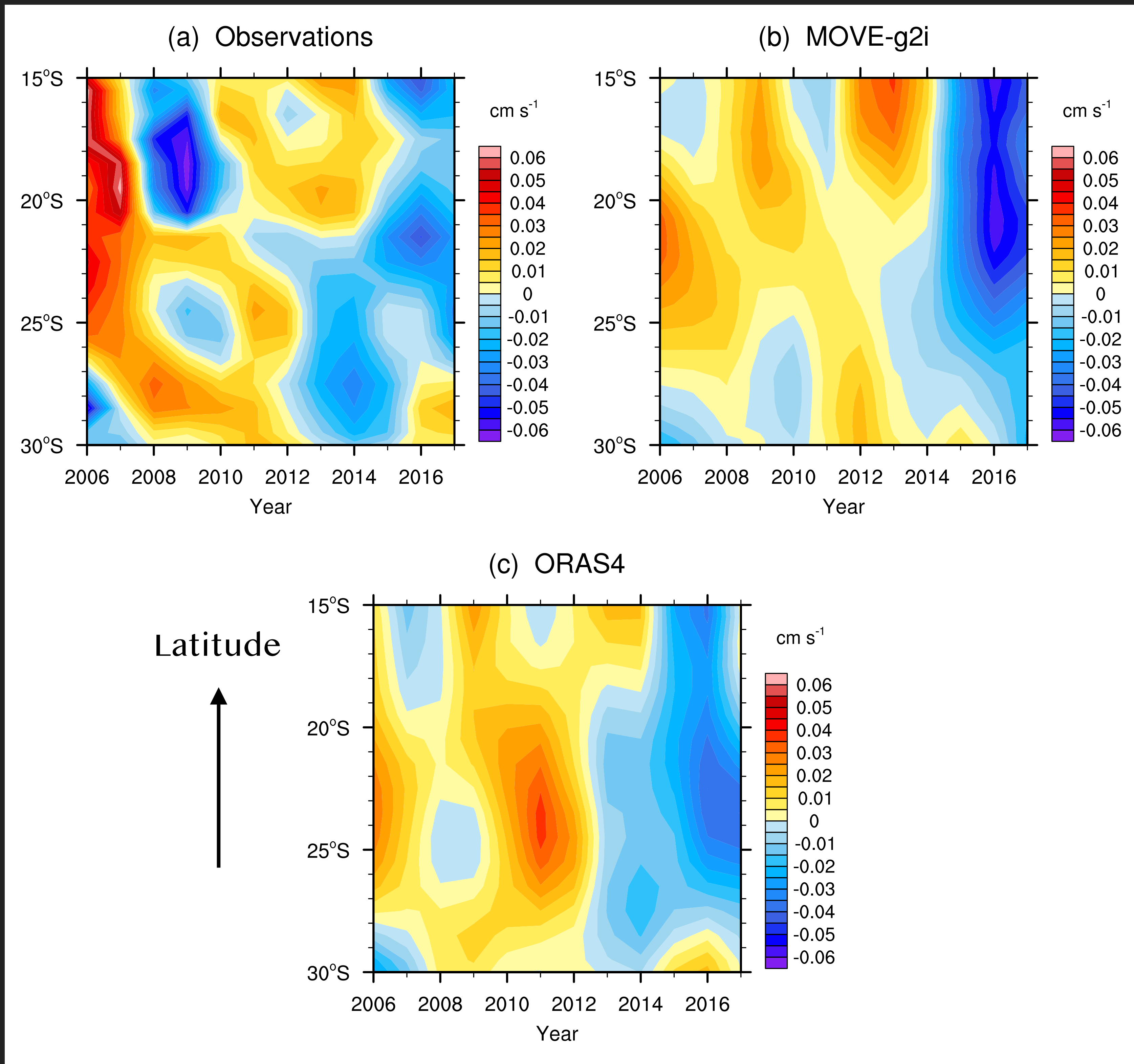


Meridional velocity along 22°S obtained from reanalysis datasets

(zonally averaged over 55°-110°E; temporal mean subtracted)

Standard deviations

Monotonic decrease in meridional velocity anomalies is observed between 15° and 30°S.



Time

Zonally averaged meridional velocity at 1000 m depth

SUMMARY

- This study estimates variability in meridional velocity in the interior of the south Indian Ocean using in-situ hydrographic observations and two reanalysis products for the period from 2006 to 2017.
- Results show that zonal SSH difference represents a surface trapped variability in meridional velocity, the amplitude of which is large in the upper 250 m and decreases to zero at about 1250 m depth. This variability is likely driven by winds.
- Results also show subsurface variability in meridional velocity, which peaks in magnitude at about 800 m depth. This variability is not correlated with zonal SSH difference and represents decadal weakening of northward transport of the subtropical circulation for the analysis period.
- Subsurface variability can contribute to interannual variability in transport of SAMW and AAIW, but its detailed forcing mechanism is not known and warrants a further study.