Sea-level Budget of Indian Ocean vis-à-vis Global Ocean

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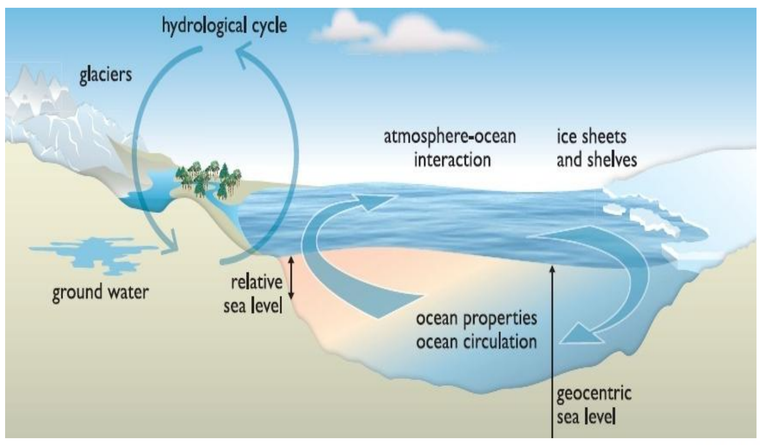
Introduction

▪Change in sea-level is a major concern for coastal populations and society at large, and occurs over a wide range of temporal and spatial scales – with many contributing factors making it an integral measure of climate change ;

▪ The IPCC 5th assessment report (AR5) revealed an increased confidence in projections of global mean sea-level, owing to improved physical understanding of components of sea-level, improved agreement of process-based models with observations, and the inclusion of ice-sheet dynamical changes

Global sea-level

Drivers and relevance of sea-level change

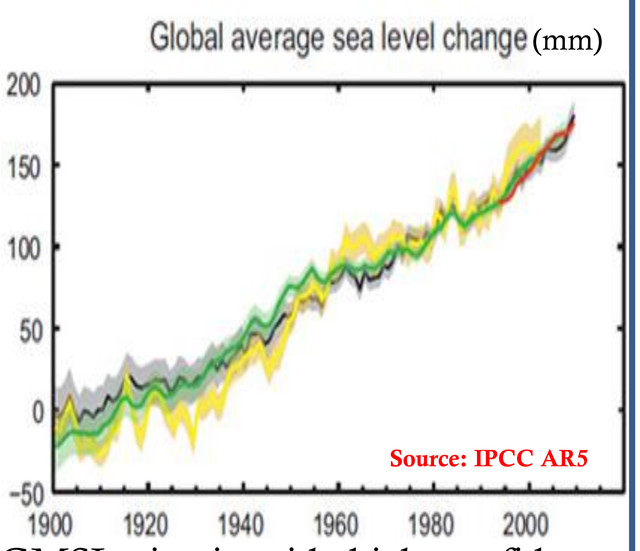


Source: AR5, IPCC 2013

▪ Importance of sea-level rise for coastal systems and low-lying areas: storm surge, coastal flooding, coastal erosion, salinization.

▪ The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia (high confidence).

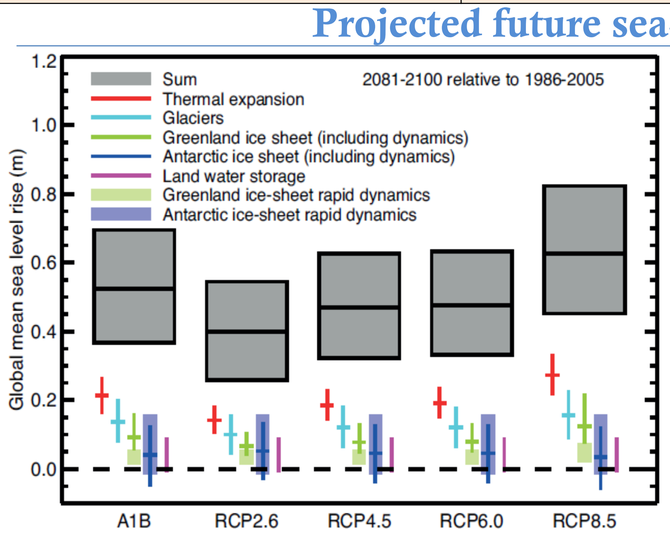
▪ Since the early 1970s, glacier mass loss and ocean thermal expansion from warming together explain about 75 % of the observed global mean sea level rise (high confidence) ;



▪ Over the period 1993 to 2010, GMSL rise is with high confidence consistent with the sum of the observed contributions from ocean thermal expansion, changes in glaciers, Greenland ice sheet, Antarctic ice sheet and land water storage with maximum contribution from land ice melting.

Source	1901-1990	1971-2010	1993-2010
Observed contribution to global mean sea level (GMSL) rise			
Thermal Expansion	---	0.8 [0.5 to 1.1]	1.1 [0.8 to 1.4]
Glaciers except in Greenland and Antarctica	0.54 [0.47 to 0.61]	0.62 [0.25 to 0.99]	0.76 [0.339 to 1.13]
Glaciers in Greenland	0.15 [0.10 to 0.19]	0.06 [0.03 to 0.09]	0.10 [0.07 to 0.13]
Greenland ice sheet	---	---	0.33 [0.25 to 0.41]
Antarctica ice sheet	---	---	0.27 [0.16 to 0.38]
Land water storage	-0.11[-0.16 to -0.06]	0.12[0.03 to 0.22]	0.38 [0.26 to 0.49]
Total of contributions	---	---	2.8 [2.33 to 3.4]
Observed GMSL rise	1.5 [1.3 to 1.7]	2.0 [1.7 to 2.3]	3.2 [2.8 to 3.6]

Projected future sea-level change

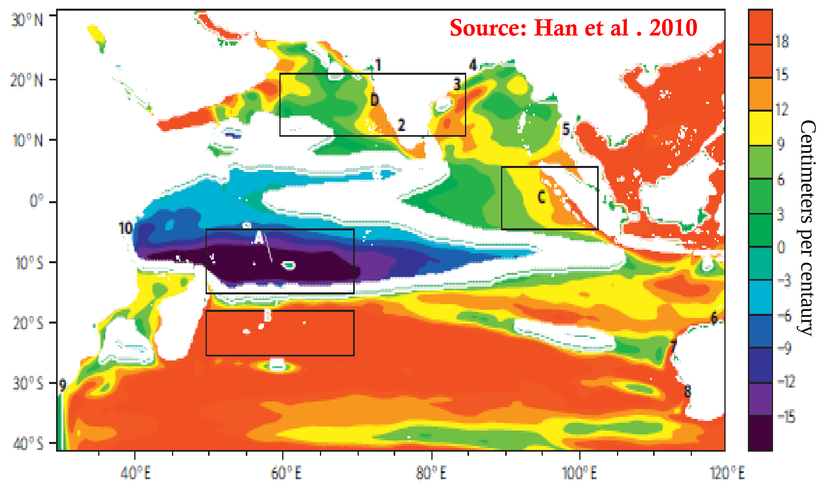


▪ GMSL will continue to rise during the 21st century and beyond. Under all RCP scenarios, the rate of GMSL rise will very likely exceed that observed during 1971-2010, due to increased ocean warming and increased loss of mass from glaciers and ice sheets ;

▪ The Global sea-level is dominated by melting of land ice and accounts for about 56% for recent two decades.

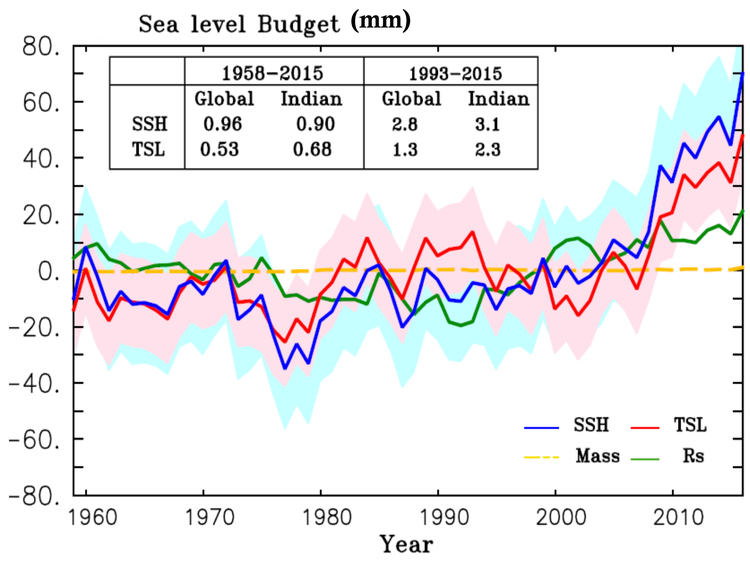
Indian Ocean sea-level

Patterns of Indian Ocean sea-level change



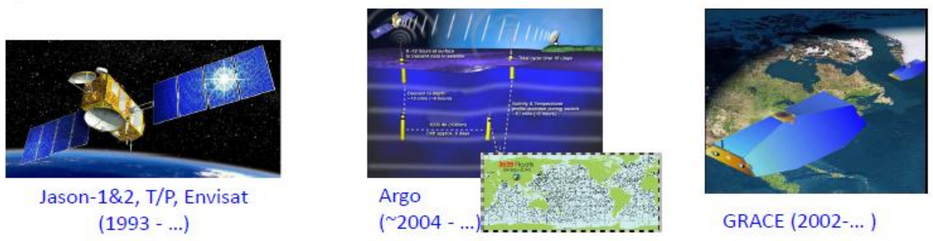
▪ Sea level has decreased substantially in the south tropical Indian ocean and has increased Elsewhere. This pattern is driven by changing surface winds.

▪ Unlike the global mean sea-level, which is dominated by ocean mass changes in the recent decades (Church et al. 2013), regional sea level variability in the north Indian Ocean is dominated by thermosteric component (TSL). The TSL has shown considerable increase during last few decades.



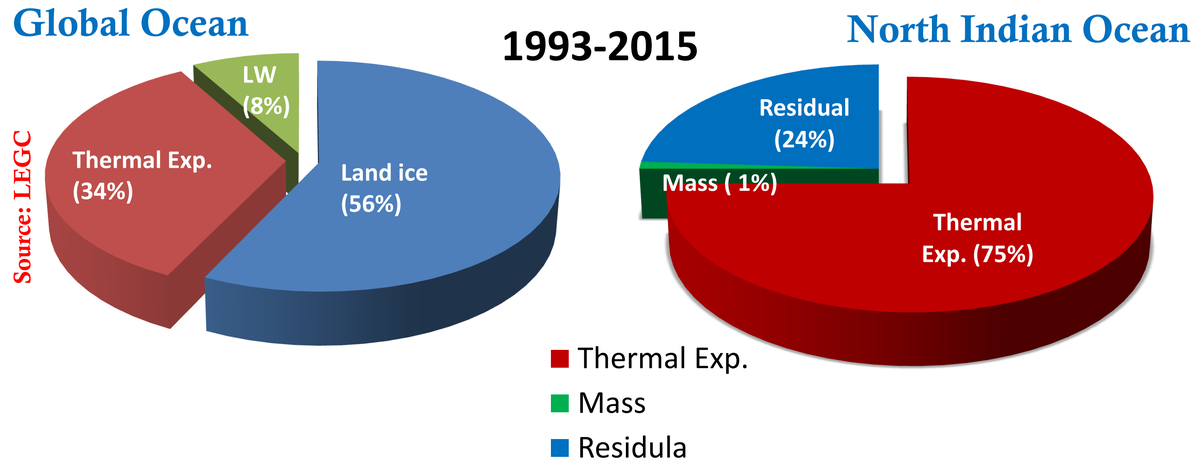
Sea-level budget

$$\Delta SLR_{total} = \Delta SLR_{steric} + \Delta SLR_{mass}$$



$$\Delta SLR_{total} = \Delta SLR_{steric(0\text{-}2000m)} + \Delta SLR_{mass}$$

$$+ \text{Residual } (\Delta SLR_{steric(<2000m)})$$



Conclusions

- Sea-level rise is highly non-uniform. Regional sea-level patters differ significantly from GMSL rise.
- Regional departures of sea-level from global-mean rise needs better understanding of regional sea-level budget
- Sea-level rise in the north Indian Ocean is dominated by thermosteric component (~75%), while mass addition due to land ice melt (~56%) dominates the GMSL.
- The thermosteric sea-level rise in the north Indian Ocean is driven by the weakening of monsoon circulation.

References

▪ Church, J.A. et al. (2013): Sea Level Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report t of the IPCC. Cambridge University Press, United Kingdom and New York, NY, USA.
▪ Swapna et al., (2017). Multidecadal weakening of Indian summer monsoon circulation induces an increasing northern Indian Ocean sea level. GRL,44. https://doi.org/10.1002/2017GL074706