
# Projection of Sea Surface Salinity using Ensemble of Selected CMIP6 GCMs of Bay-of-Bengal


**Mahiuddin Alamgir[1] *, Mazlan Hashim[1,2,] * and Shamsuddin Shahid[3]**

[1]Geoscience and Digital Earth Centre (INSTeG), Research Institute of Sustainable Environment (RISE), Universiti Teknologi Malaysia (UTM), Johor Bahru 81310, Malaysia.

[2]Faculty of Built Environment & Surveying, Universiti Teknologi Malaysia (UTM), Johor Bahru 81310, Malaysia.

[3]Department of Water & Environmental Engineering, Faculty of Civil Engineering, Universiti Teknologi Malaysia (UTM), 81310 Skudai, Johor, Malaysia


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# Introduction

1. Changing ocean properties threaten coastal communities and marine ecosystems global.
2. Climate change, primarily driven by anthropogenic activities, contributes to changes in global sea surface characteristics like sea surface salinity.
3. A few of studies have used **Coupled Model Intercomparison Project Phase 6 (CMIP6)** models to estimate sea surface salinity in the Bay of Bengal and sorrunding seas (Bhattacharya et al 2022; Sein et al 2024) .
4. The global mean sea surface salinity (SSS) typically ranges around 35 PSU (Practical Salinity Units), where the Bay of Bengal ranges from 30 to 33 PSU.

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# Introduction

5. Salinity levels can vary depending on geographical location, climate, and ocean currents, with higher salinity observed in subtropical regions due to high evaporation rates and lower salinity in polar and equatorial regions where there is more precipitation and freshwater input.

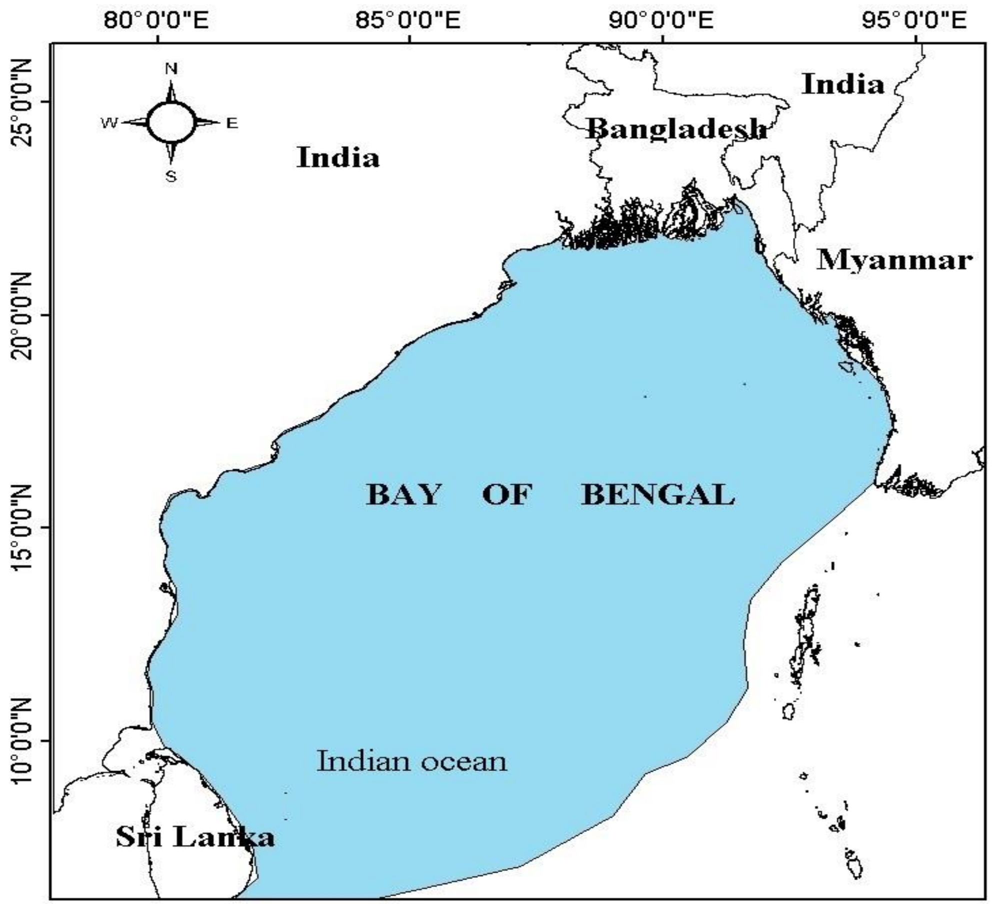
6. Future change of sea surface salinity using seventeen **Global Climate Models (GCMs)** models. We found that four out of the seventeen GCMs were best suited to replicate the **Ocean Reanalysis System 5 (ORAS5)** data.

# Objective

- Future potential changes in **Sea Surface Salinity (SSS)** over the Bay of Bengal

# Location map of the study area

The Bay of Bengal (BOB) primarily extend in the south of **Bangladesh-to-southeast India-south west Myanmar** across between 10° to 23°N latitude and 80° to 97°E longitude.



# Methodology

The list of the General Circulation Models (GCMs) evaluated in this study

## *Dataset*

| No | Model name | Institution | Country | Resolution |
|---|---|---|---|---|
| 1. | ACCESS-CM2 | Australian Community Climate and Earth System Simulator coupled model | Australia | 1.2°×1.8° |
| 2. | ACCESS-ESM1-5 | Australian Community Climate and Earth System Simulator (ACCESS) and Earth System Model (ESM) | Australia | 1.2°×1.8° |
| 3. | CanESM5 | Canadian Earth System Model version 5 | Canada | 2.8°×2.8° |
| 4. | CanESM5-1 | Canadian Earth System Model version 5 | Canada | 2.8°×2.8° |
| 5. | CESM2-WACCM | Community Earth System Model version 2 with the Whole Atmosphere Community Climate Model | USA | 1.9° × 2.5° |
| 6. | CMCC-CM2-SR5 | Euro-Mediterranean Centre on Climate Change coupled climate model (standard configuration) | Europe | 1°×1° |
| 7. | CMCC-ESM2 | Fondazione Euro-Mediterranean Center on Climate Change | Italy | 0.9°×0.9° |
| 8. | EC-Earth3 | EC-Earth consortium | Europe | 0.7°×0.7° |
| 9. | EC-Earth3-Veg | EC-Earth consortium | Europe | 0.7°×0.7° |
| 10. | EC-Earth3-Veg-LR | EC-Earth consortium | Europe | 0.7°×0.7° |
| 11. | INM-CM4-8 | Institute for Numerical Mathematics | Russia | 1.5°×2.0° |
| 12. | INM-CM5-0 | Institute for Numerical Mathematics | Russia | 1.5°×2.0° |
| 13. | MIROC6 | Model for Interdisciplinary Research on Climate Version 6 | Japan | 1.4°×1.4° |
| 14. | MPI-ESM1-2-LR | Max Planck Institute Earth System Model | Germany | 1.875°×1.86° |
| 15. | MRI-ESM2-0 | Meteorological Research Institute Earth System Model Version 2.0 | Japan | 1.125°×1.125° |
| 16. | NorESM2-LM | The Norwegian Earth System Model | Norway | 2.5° × 1.89° |
| 17. | NorESM2-MM | The Norwegian Earth System Model | Norway | 2.5° × 1.89° |

# Methodology

***Procedure***

- Every GCMs were interpolated to align with ORAS5 grid points using bilinear interpolation at a spatial resolution of 0.25° × 0.25°.
- Bias in the re-gridded GCMs' SSS data for the period 1970 to 2014 was corrected using the Quantile Mapping (QM) method.
- A Multimodel Ensemble (MME) was constructed using the top four GCMs identified during the ranking procedure.
- The MME of the selected GCMs was used to project changes in sea surface salinity under four **Shared Socioeconomic Pathways (SSPs)** for the **near future (2020–2059)** and the **far future (2060–2099).**
- Upper and lower band uncertainties were established by calculating the 95th percentile, mean, and 5th percentile of all GCMs across all SSPs.
- The procedure was repeated for SSS projections using the top-ranked four GCMs' models.

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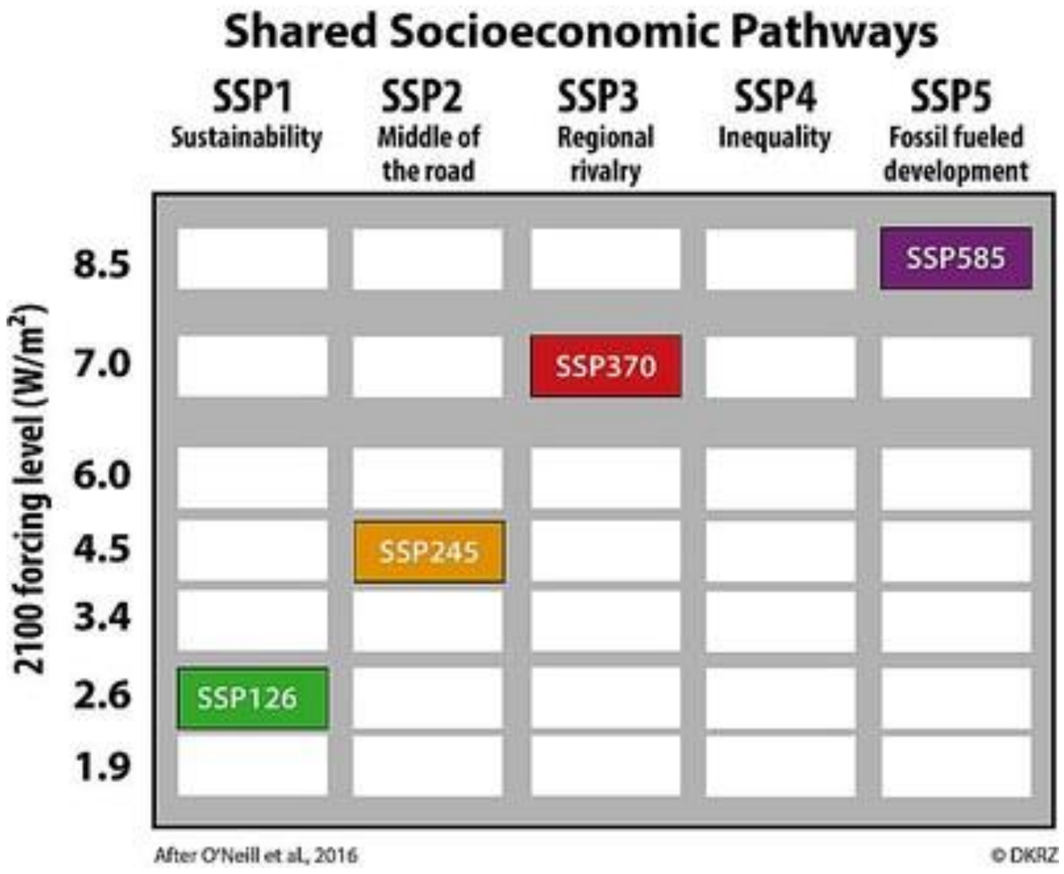
# SSP – shared socio-economic pathways used in climate modelling

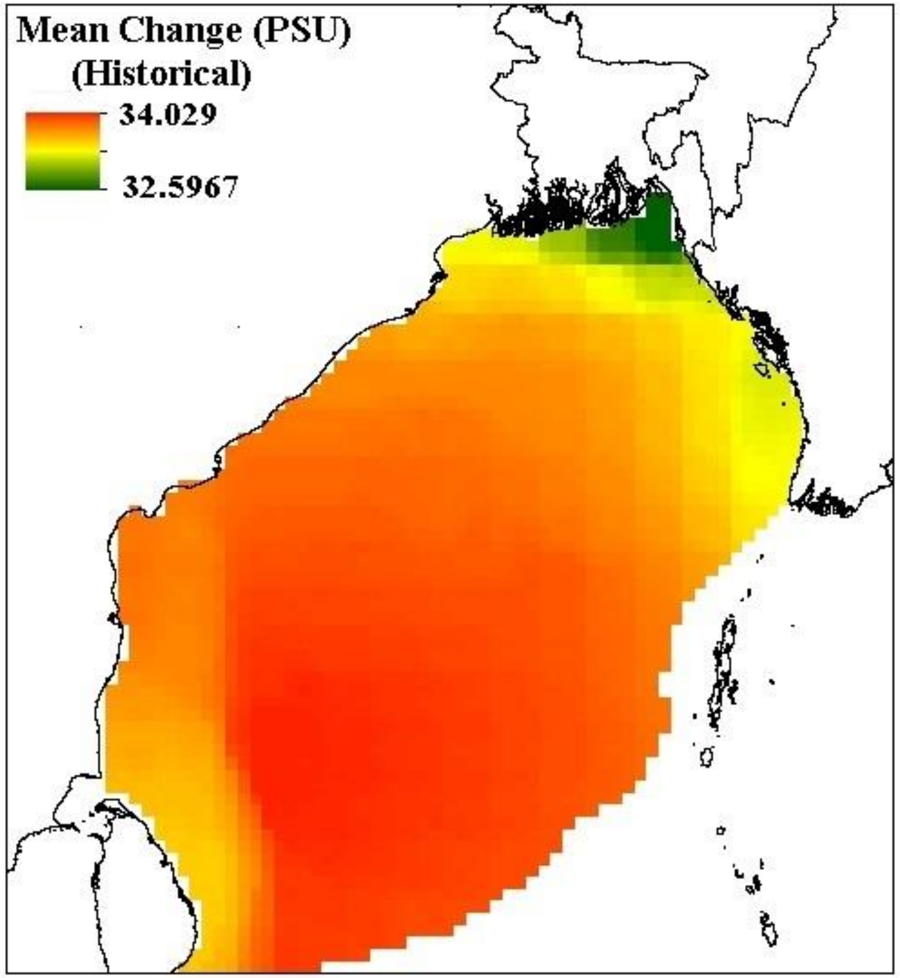
- **SSP370** is used in conjunction with climate models to assess impacts on temperature, precipitation, and other climate variables.
- **SSP245** reflects a future where some climate policies are implemented, but not as aggressively as in more ambitious scenarios. It considers a balance between socioeconomic development and environmental concerns, resulting in a world that faces significant climate challenges but also has pathways for adaptation and mitigation.
- **SSP585** envisions a future with rapid economic growth, high energy demand, and limited efforts toward climate mitigation. It reflects a scenario where societal and technological advancements do not prioritize sustainability, resulting in substantial climate impacts, such as extreme weather events and sea-level rise.
- **SSP126**: This scenario with 2.6 W/m² by the year 2100 is a remake of the optimistic scenario RCP2.6 and was designed with the aim of simulating a development that is compatible with the 2°C target. This scenario, too, assumes climate protection measures being taken.



# Results

## Observed, raw and bias-corrected SSS

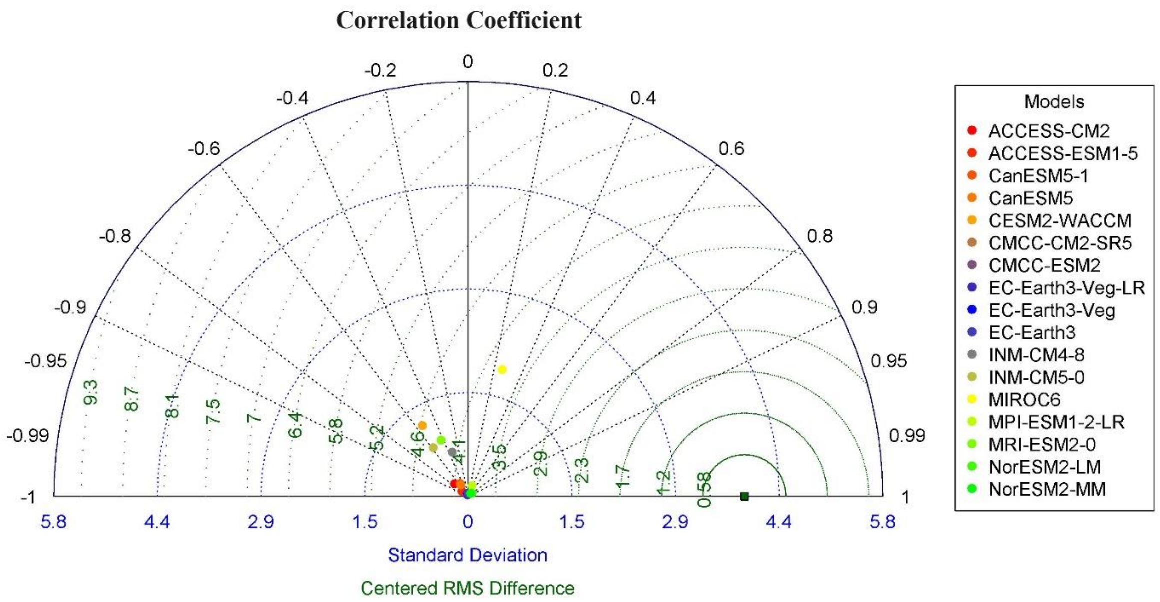
- The each grid point was averaged over the period from 1970 to 2014.
- The spatial distribution of sea surface salinity (SSS) for observed ORAS5 data, the top-ranked raw GCM outputs, and the bias-corrected subset of GCMs using the QM algorithm.



# Results

## Valuation of the Simulation Skill of SSS by the CMIP6 Models

- Taylor Diagram of simulated annual mean sea surface salinity (SSS) in BOB in the CMIP6 models.
- The blue color indicates the **normalized spatial standard deviation.**
- The green color indicates the centered **RMS difference,** and
- black solid color **correlation coefficient.**

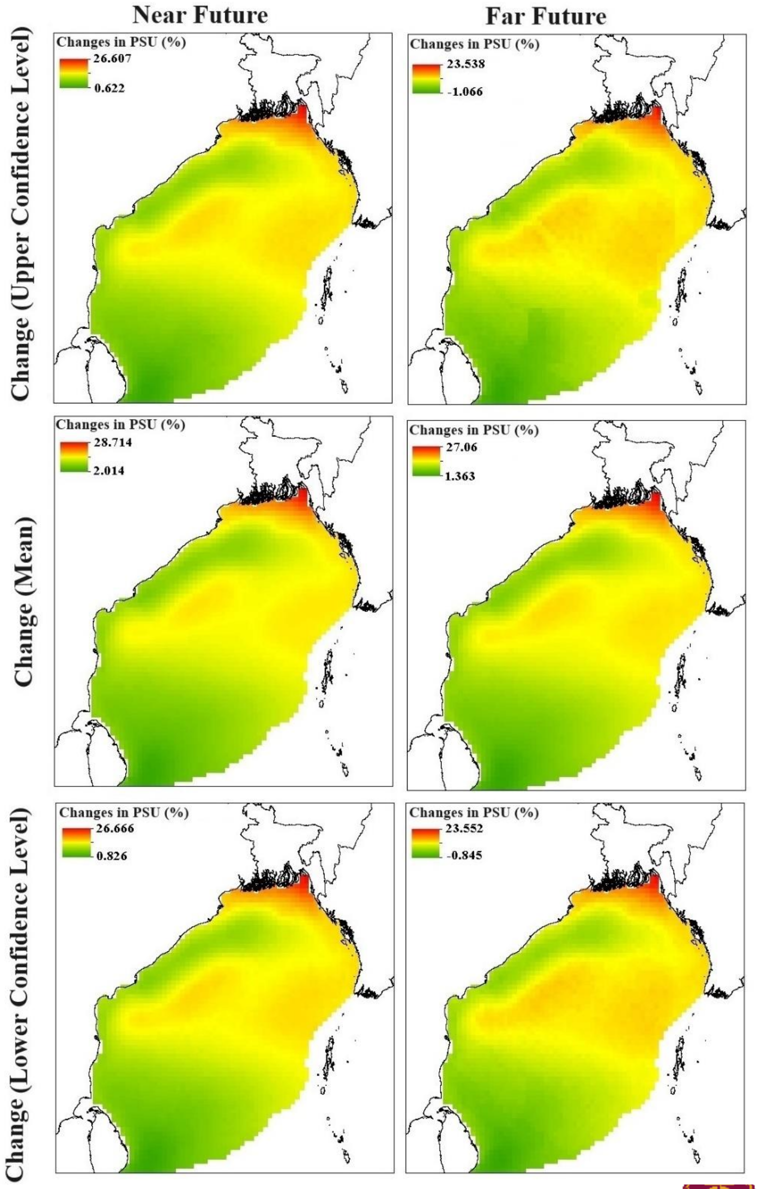


# Results

## % changes of SSS compared to base period under SSP370 scenario

- The SSP370 results indicate that near-future (2020-2059) changes range **from -6.22 to 26.60 PSU** at the upper confidence level and -0.82 to 26.66 PSU at the lower confidence level.

- In contrast, far-future (2066-2099) changes range from -1.06 to 23.53 PSU at the upper confidence level and **-8.45 to 23.55 PSU** at the lower confidence level.

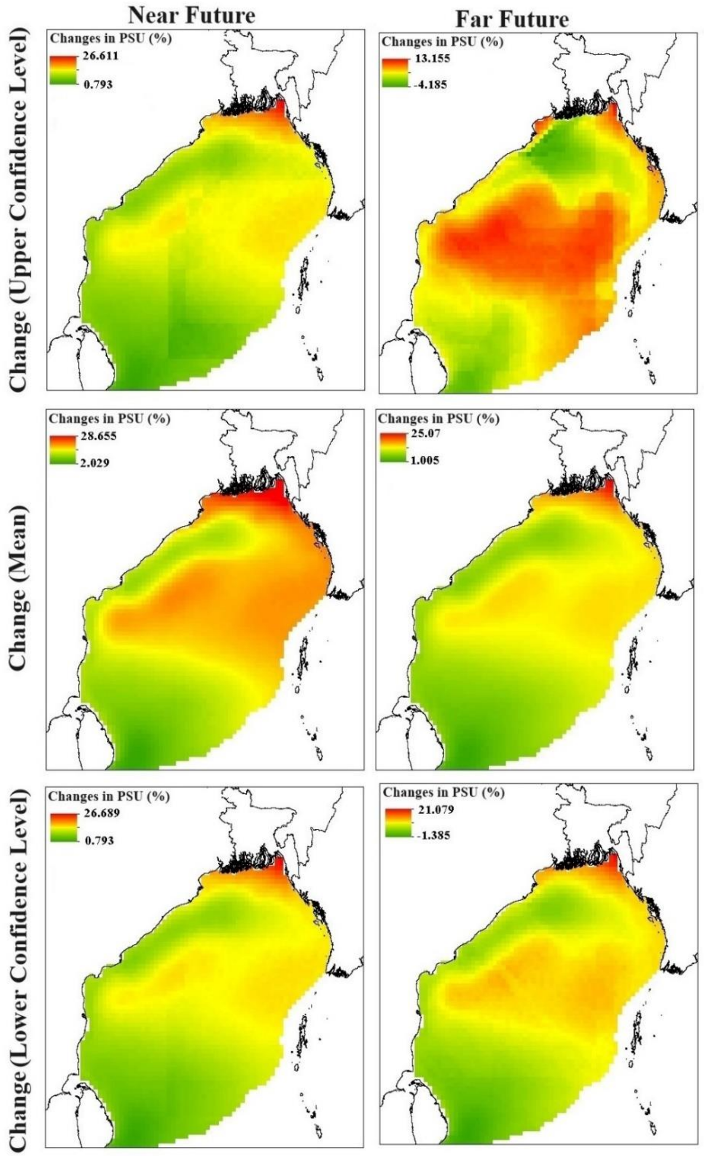


# Results

## % changes of SSS compared to base period under SSP585 scenario

- SSP585 results show that near-future changes range from **0.79 to 26.61 PSU** at the upper confidence level and **0.79 to 26.69 PSU** at the lower confidence level.

- In contrast, far-future changes range from **-4.18 to 13.15 PSU** at the upper confidence level and **-1.38 to 21.07 PSU** at the lower confidence level.

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# Results

- SSP126 scenario, sea surface salinity (SSS) changes range from **-29.01 to 16.51 PSU** in the near future and from **-28.56 to 15.50 PSU** in the far future.

- In the SSP245 scenario, SSS changes range from **0.59 to 26.24 PSU** in the near future and from **0.14 to 25.34 PSU** in the far future.

- For the SSP370 scenario, SSS changes range from **-6.22 to 26.60 PSU** in the near future and from **-1.06 to 23.53 PSU** in the far future.

- Finally, in the SSP585 scenario, SSS changes range from **0.79 to 26.61 PSU** in the near future and from **-4.18 to 13.15 PSU** in the far future, all with a 95% confidence interval.

# Conclusions

- The projected to experience the **highest changes** south and south east of **Bangladesh, south west of Myanmar, north and east coast of Sri Lanka and some part of India.**
- The projected change in sea surface salinity (SSS) in the Bay of Bengal, which could significantly impact fisheries, wet land ecosystems, and marine biodiversity.
- Future work could address this by utilizing a broader range of observational data, including tidal gauge measurements, to further validate the accuracy of GCMs.
- **Integrating tidal gauge data together with existing satellite-based measurements and reanalysis data would provide a more comprehensive validation approach.**
- These findings focus on robust adaptation planning to protect coastal communities and marine ecosystems from the complex challenges of climate change.

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