Temperature trends over the PIRATA moored buoy array: an overview from observations and CMIP5 and CMIP6 climate change scenarios

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1. Introduction

Global warming is having a particularly large impact on the ocean: current systems are changing, sea-level rise is increasing, and biological processes are altering, all of which are strongly governed by ocean temperature.

The ocean warming has been a direct consequence of increasing atmospheric temperature due to the "greenhouse effect". This warming affects the exchange of gases between the ocean surface and the atmosphere, and their transport and storage in deeper waters (Turley et al., 2013). As the major water, heat, and carbon reservoirs of the world, the ocean plays an especially crucial role in climate regulation. This analysis focuses on superficial and subsuperficial ocean temperature measurements and numerical simulations required for climate assessment, with an emphasis on temperature trends obtained from PIRATA moored buoys, ocean reanalyses, and CMIP model outputs.

2. Data and diagnostic methodology

PIRATA ocean temperature moored buoys data, as well as WOA18, GLORYS, SODA v.3 and ERSST v.5 datasets are used to evaluate the performance of numerical simulations in terms of climatological representations of SST and Tropical Water Mass (TW) over the PIRATA buoy sites for the present climate. Then, we contrast temperature trends predicted by CMIP5 and CMIP6 scenarios to observed trends inferred from the PIRATA over the Tropical Atlantic Ocean for global mean warming levels of 1.5°C, 2°C, and 3.0°C relative to preindustrial global mean air temperature.

3. Results
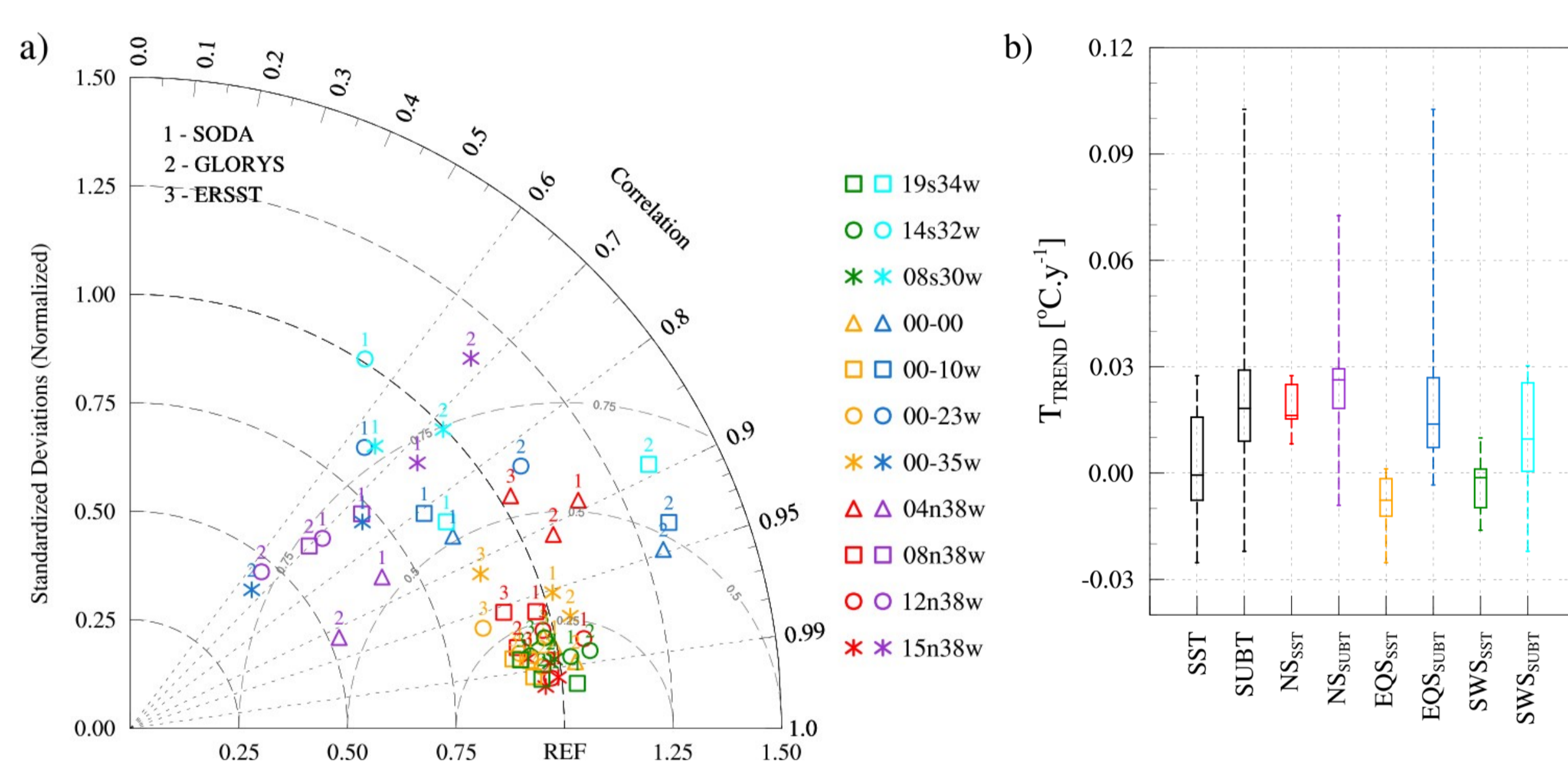
3.1. Pirata Analyses

Figure 1: (a) Taylor diagram: Sea Surface (SST: red, yellow, green) and Subsurface (SUBT: purple, blue, light blue) Temperatures with reference the PIRATA buoys. (b) SST and SUBT trend (°C.year⁻¹) from 1998 to 2015.
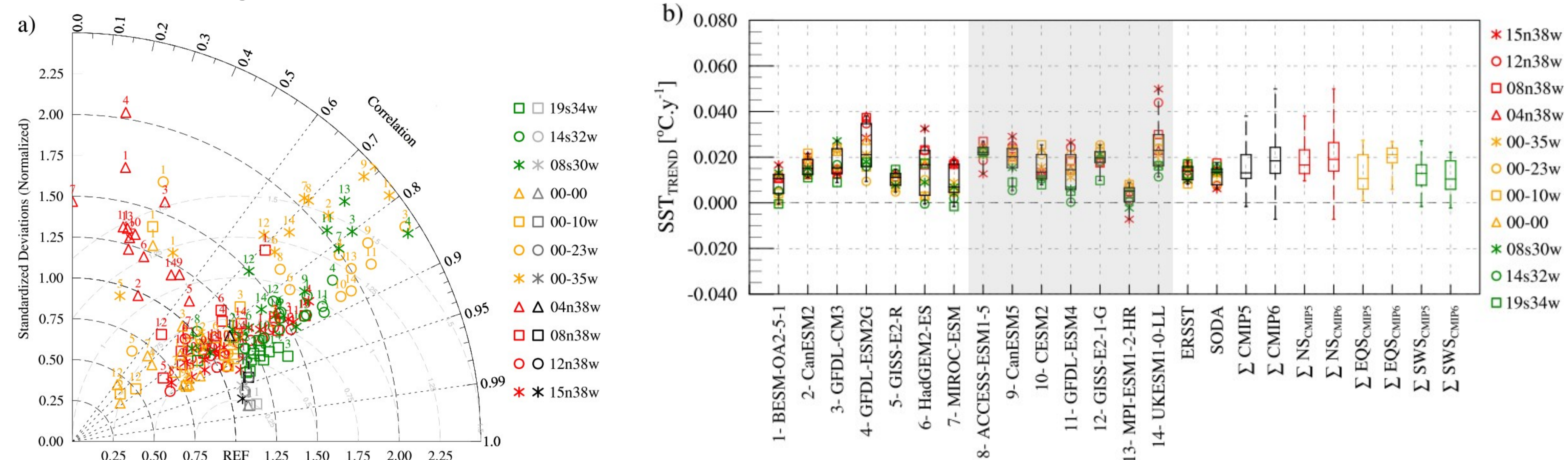
3.2. CMIP Analyses

Figure 2: (a) SST Taylor diagram. Each number represents a model and ERSST as the reference. Southwest (SWS: green), Equatorial (EQS: yellow) and North (NS: red) sectors data distributions in which the grey scale represents the SODA dataset. (b) SST trend (°C.year⁻¹) from 1980 to 2005.
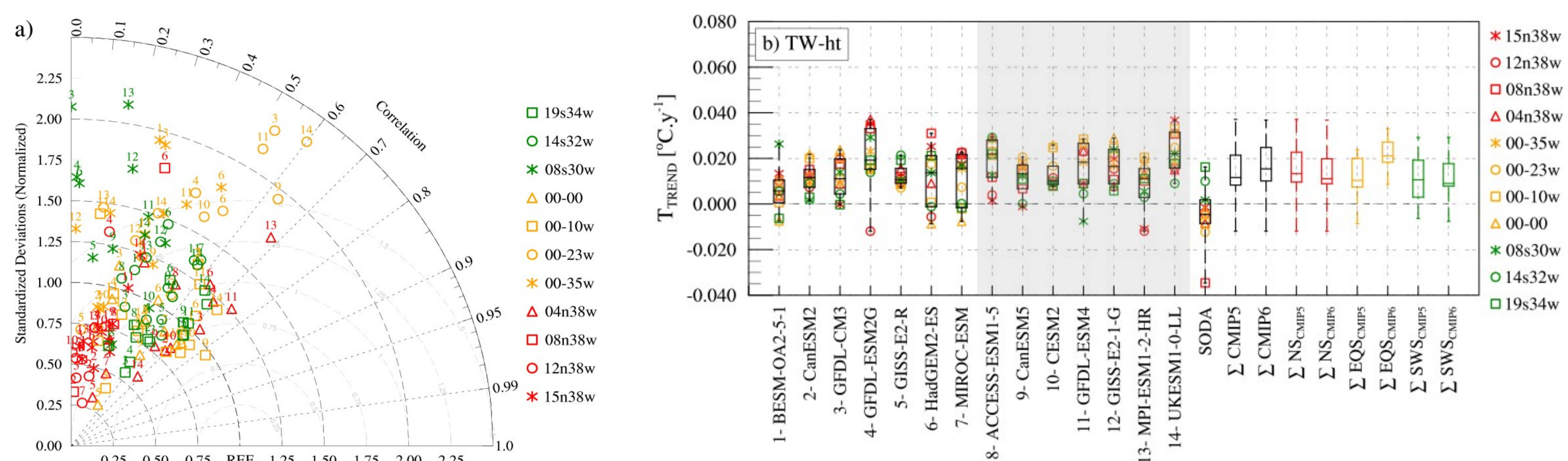

Figure 3: (a) TW Taylor diagram. Each number represents a model and SODA as the reference. SWS (green), EQS (yellow) and NS (red) sectors data distributions, from 1980 to 2005. (b) TW temperature trend (°C.year⁻¹).

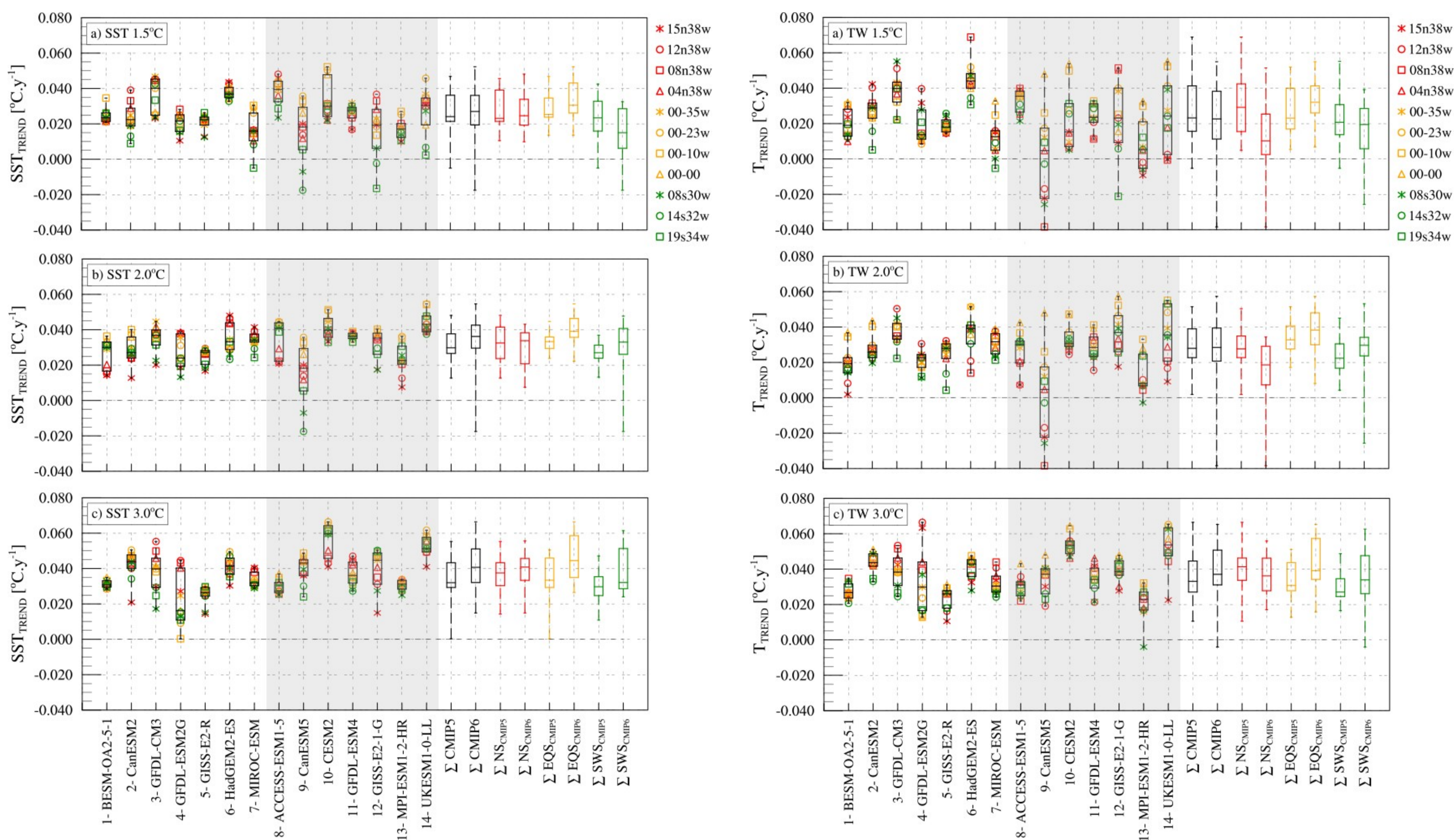Figure 4: SST trend (°C.year⁻¹) predicted by CMIP5 and CMIP6 scenarios for particular global warming levels: (a) 1.5°C, (b) 2°C and (c) 3.0°C).

Figure 5: TW trend (°C.year⁻¹) predicted by CMIP5 and CMIP6 scenarios for particular global warming levels: (a) 1.5°C, (b) 2°C and (c) 3.0°C).

4. Conclusions

- SST analyses converge to the observed PIRATA buoys values, but less so at 04n38w;
- Observed EQS and SWS SST showed a cooling trend while SUBT showed a warming trend on the three sectors, and SUBT data indicated a warming greater than the SST;
- Reanalyses products showed significant errors in the SUBT representation, indicating possible impact on lesser volume of assimilated data at subsurface;
- The numeric simulations presented difficulty in representing the temporal variability, particularly in the SST 04n38w buoy;
- All simulations showed a warming trend in all sectors;
- The simulations showed a linearity between the increase ocean temperature in relation to the increase in global temperature.