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A two-phase Neural Model for CMIP6 bias correction

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The Coupled Model Intercomparison Project, now in its sixth phase (CMIP6), is a global effort to project future climate scenarios on following certain shared socioeconomic pathways (SSP). For the period 1950-2014, CMIP6 provides a historical model output. From 2015 future projections with four different SSP scenarios, viz. SSP126, 245, 370 and 585 are available. From 2015-2023, we also have reanalysis of the actual ocean and atmosphere variables in these years. From this data, it is observed that CMIP6 future projections of ocean variables have a root mean square error (RMSE) of 1.22 psu in sea surface salinity, 1.24 °C in sea surface temperature, 2.23 m/s in the zonal ocean velocity component, 1.34 m/s in the meridional ocean velocity component. Similarly, the atmospheric variables have a RMSE of 1.34 °C in temperature at 2-meter height, 2.12 m/s in the zonal, and 1.321 m/s meridional wind component. Our goal is to develop an accurate method to correct this bias and provide updated future projections for scientific analysis. To this end, we developed a two phase deep neural network model that accepts monthly fields from the CMIP6 projections (all four SSP scenarios), and outputs a bias corrected field. In the first phase, a deep neural model, which we call as Atmospheric-Ocean Network 1 (AONet1) is used to obtain bias corrected fields for each of the four SSP separately. The AONet1 is trained and validated using the historical CMIP6 data (1950-2014) as input and ORAS5 and ERA5 data as the output (the bias corrected field). In the second phase, the four bias-corrected SSP fields are fed to AONet2 and the final bias corrected single field is produced. The AONet2 is trained and validated using future projection data from 2015-2021 as input and ORAS5 and ERA5 from the same period as output. The testing of the two phase model is performed for years 2022 and 2023, before bias corrected future fields are produced. Results are compared to the statistical EDCDF method using different Image Quality Assessment metrics such as Data structural similarity index measure (DSSIM), Multi-Scale SSIM, and Visual information fidelity. On test data, the RMSE after bias reduction using the two phase AONet model is 40% lower. Image assessment metric values surpassed the EDCDF approach as well.

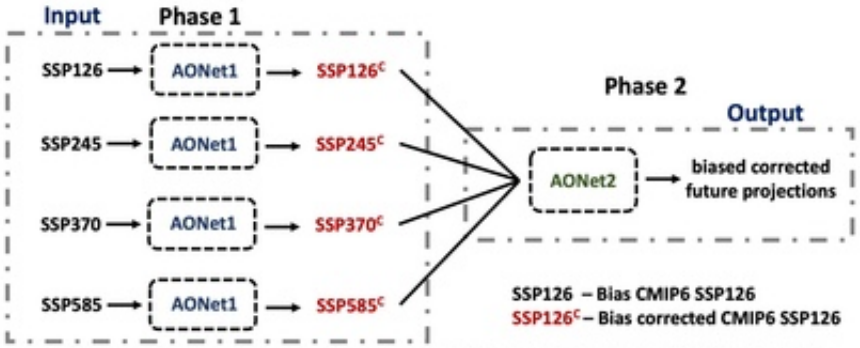

Figure 1: A schematic of data flow in the AONet architecture for CMIP6 correction.

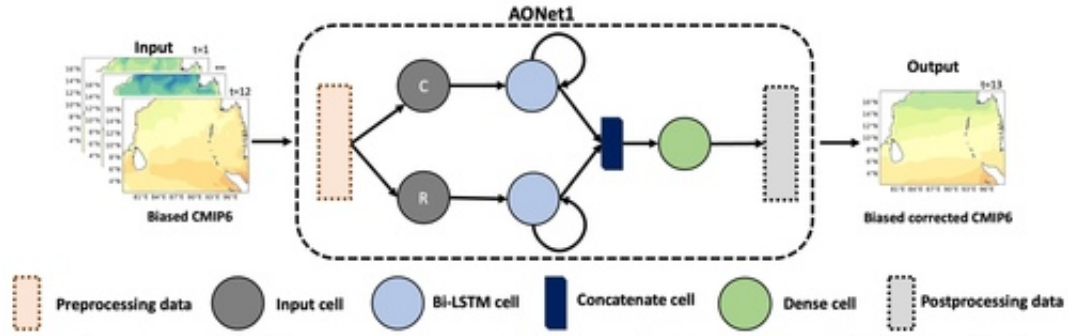

Figure 2: A schematic of AONet1 deep-learning model architecture for bias correction of CMIP6 using ORAS5.