

Land and ocean temperature discrepancies do not compensate each other

Shreya Dhame¹ | Maria Rugenstein² | Dirk Olonscheck¹

Contact: shreya.dhame@mpimet.mpg.de

1 Max Planck Institute for Meteorology, Hamburg, Germany
2 Colorado State University, Fort Collins, United States

[in /shreyadhame](https://www.linkedin.com/in/shreyadhame)

1 Motivation - Coupled Model Intercomparison Project (CMIP) models do not reproduce the anomalous cooling pattern of sea surface temperatures in the tropical Pacific & Southern Ocean since the late 1970s (e.g., Willis et al., 2022; Rugenstein et al. 2023). The global mean surface temperature change is within the uncertainty of observations for most models (Fig 1).

Q1 Do models underestimate the global mean sea surface temperature change and overestimate the global mean land surface temperature during this period?

Q2 Is there a systematic land pattern discrepancy in climate models?

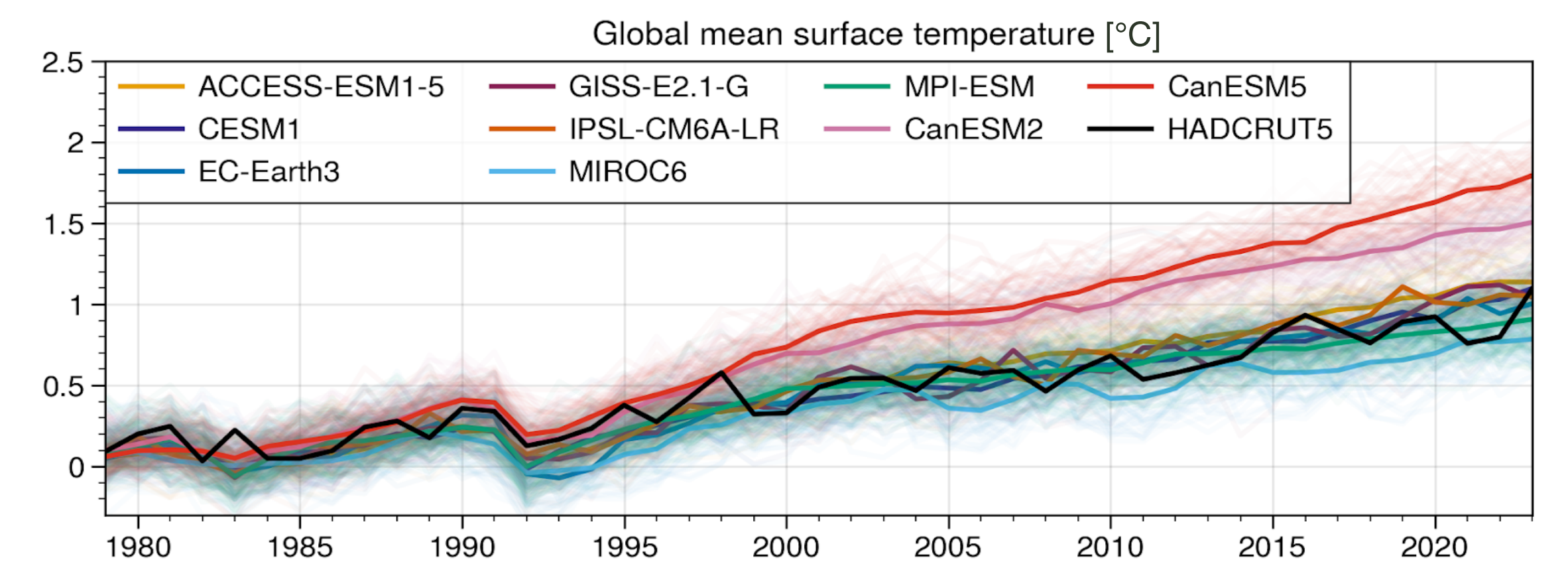


Fig 1: Global mean surface temperature from 1979 to 2023 in observations and CMIP large ensembles

2 Method - Consistency between each model ensemble and observations is defined as:-

$$\phi = (T_{mm} - T_{obs}) / \sigma$$

where T_{mm} is the model ensemble mean trend, T_{obs} is the trend from observations (HADCRUT5), and σ is the standard deviation of trends calculated across each model ensemble (assumed to capture internal variability/inherent uncertainty in the climate system; Olonscheck & Notz, 2017).

4 Pattern discrepancy (ϕ) of surface temperature trends (1979 - 2023)

(a) Median ϕ across models

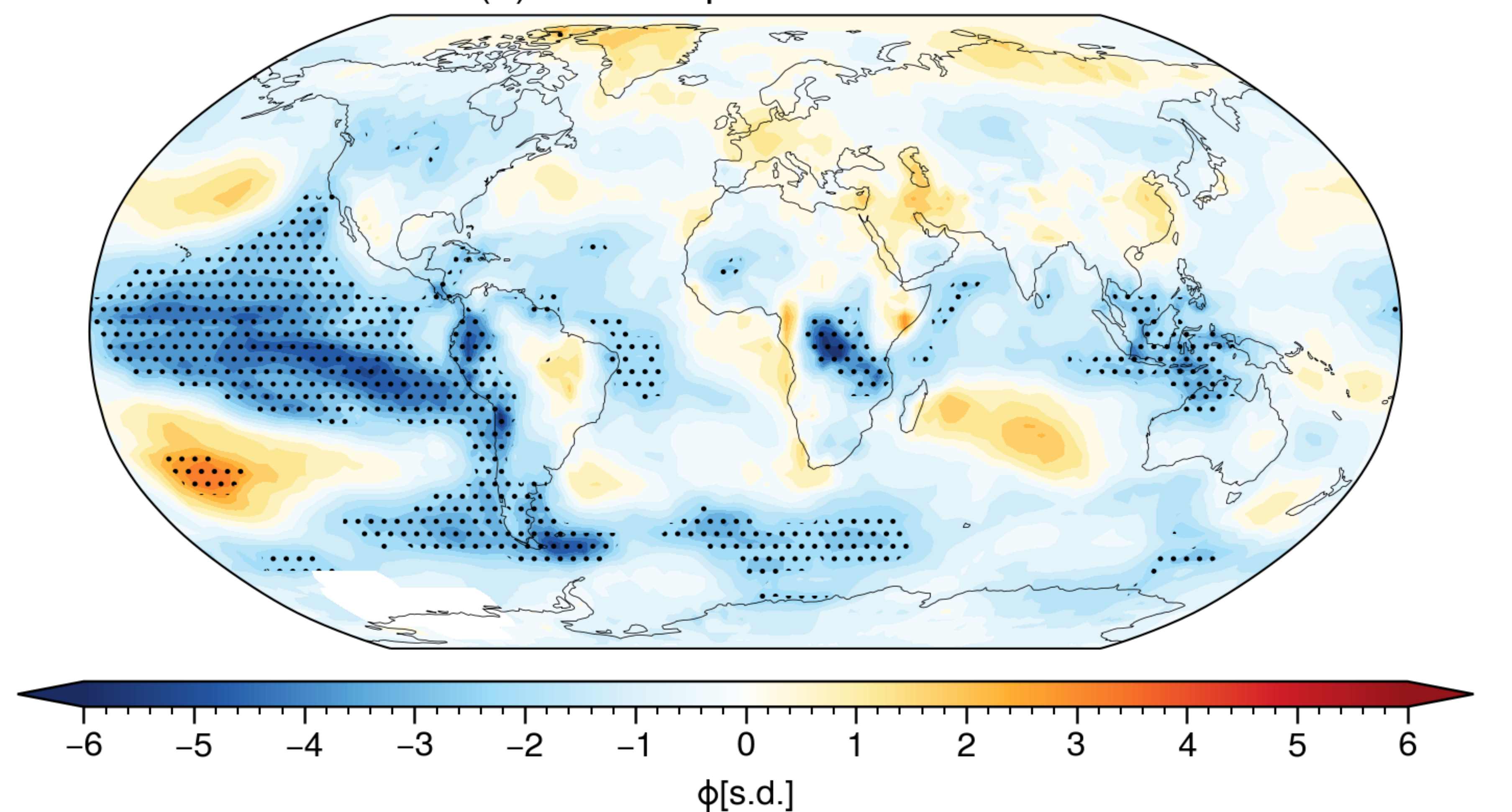


Fig 3: (a) Pattern discrepancy (ϕ) of surface temperature trends from 1979 to 2023 between observations and multi-model mean of climate model large ensembles. Stippling indicates regions for which the observations fall outside ± 2 standard deviations of the model mean for at least 5 out of 9 large ensemble climate models used here: ACCESS-ESM1-5, CESM1, EC-Earth3, GISS-E2.1-G, IPSL-CM6A-LR, MIROC6, MPI-ESM, CanESM2, CanESM5 (b) Standard deviation of the pattern discrepancy (ϕ) across models.

3 Global means

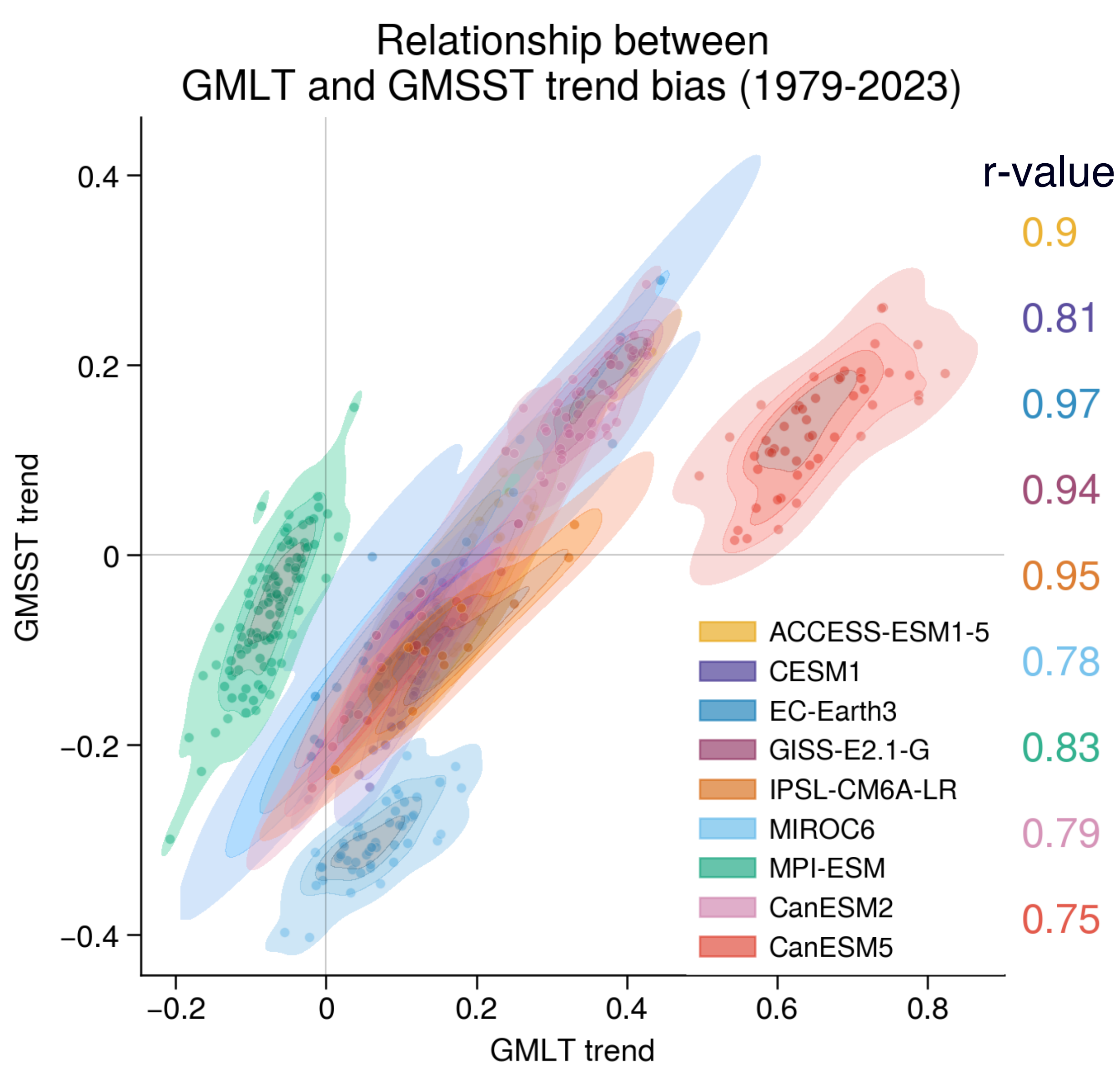
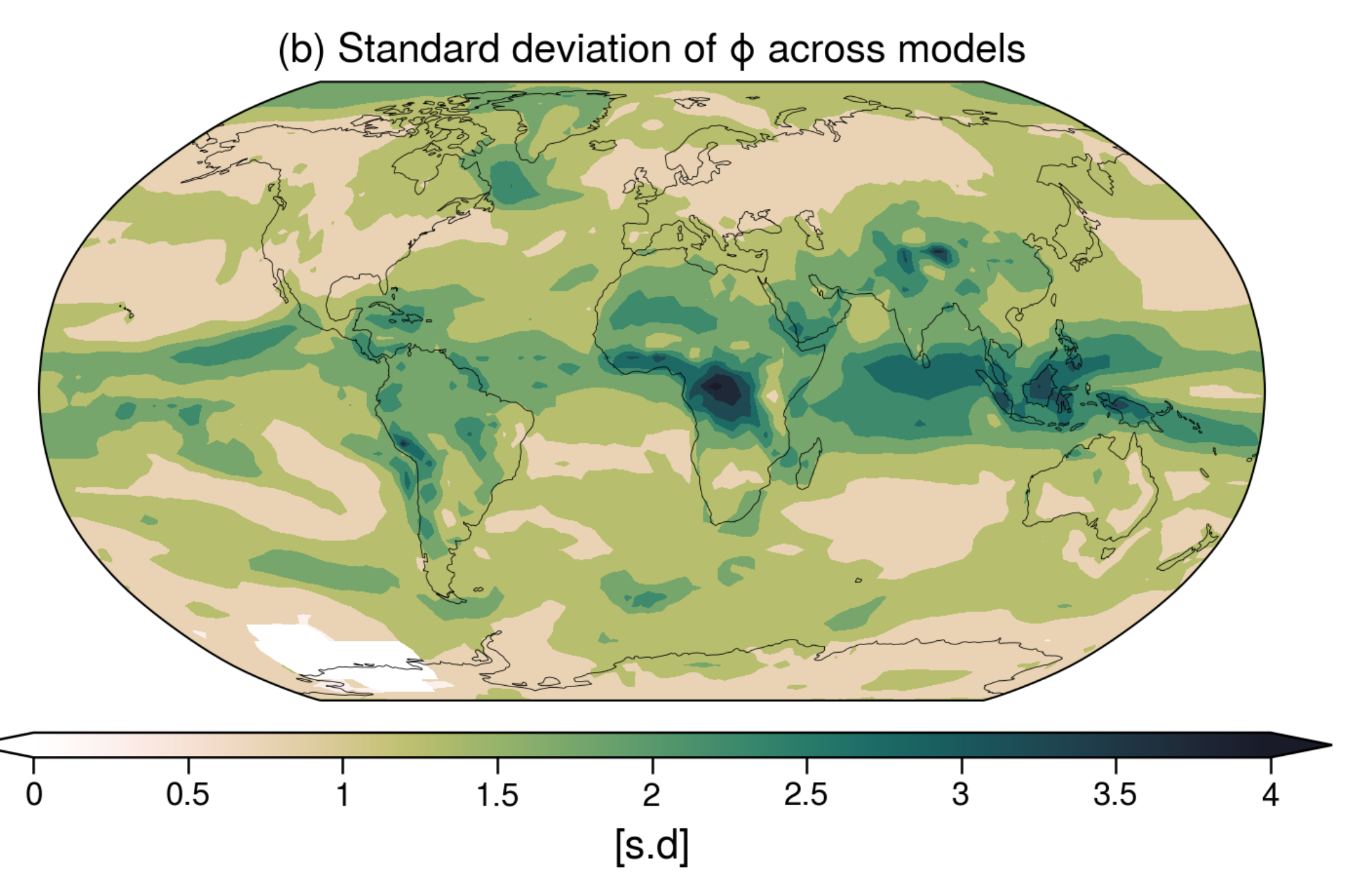


Fig 2: Correlation between global mean land temperature and global mean sea surface temperature trend bias [$^{\circ}\text{C}/44$ years] from 1979 to 2023 for 9 climate model large ensembles. Numbers indicate Pearson correlation coefficient.

A1 Result - Many model simulations (except CanESM) underestimate global mean sea surface temperature trend. Models (except MPI-ESM) overestimate global mean land surface temperature trend during the 1979-2023 period (Fig 2).



A2 Result - Models systematically overestimate warming over North America, West, Central (Congo basin) and East Africa, Maritime continent (Fig 3a). The pattern discrepancy across models varies the most in the tropical land regions (Fig 3b).

5 Conclusion - Models have regionally compensating errors in surface temperature trends. There is no systematic land surface temperature pattern discrepancy to compensate for the sea surface temperature pattern discrepancy.

Open question: What causes the land surface temperature pattern discrepancy in models?

