

Broad consistency between observed and simulated trends in SST patterns*

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Take-home messages

1| Observed and simulated multi-decadal SST trends are consistent in at least 90% of the global ocean area.

2| Individual ensemble members simulate trends in SST patterns that resemble the observed patterns.

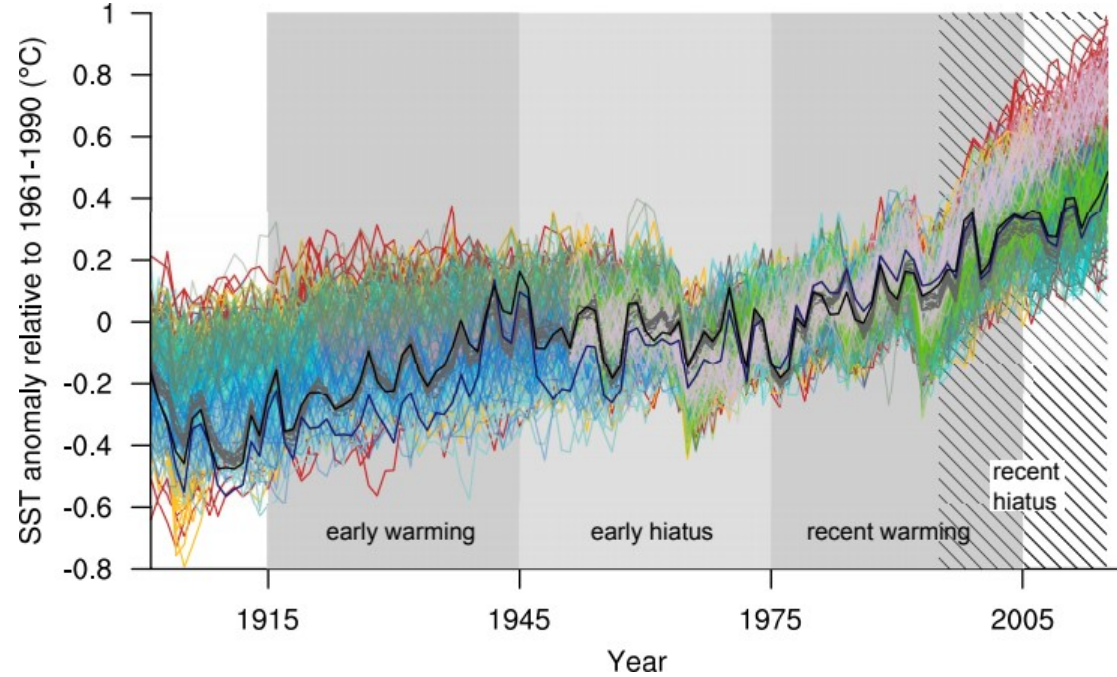
3| The large internal variability influences the existing range of SST trends more strongly than differences in the model formulation or in the observational data set.

4| The consistency obtains over larger areas in CMIP6 models than in CMIP5 models.

5| No region is robustly inconsistent with the observations across multiple model ensembles. Observed regional trends that lie at the edge of the distribution of internal variability are likely an unusual realization of the Earth's possible behavior.



Historical evolution of global mean SST



Models

- CMIP5 (116), $r = 0.72$
- CMIP6 (148), $r = 0.76$
- CanESM2 (50), $r = 0.84$
- CESM1-LE (41), $r = 0.69$
- CSIRO-Mk3-6-0 (30), $r = 0.54$
- GFDL-ESM2M (30), $r = 0.78$
- IPSL-CM6A-LR (32), $r = 0.78$
- MIROC6 (50), $r = 0.65$
- MPI-GE (100), $r = 0.74$

Observational data sets

- COBE-SST2
- HadISST2 (10)
- ERSSTv5

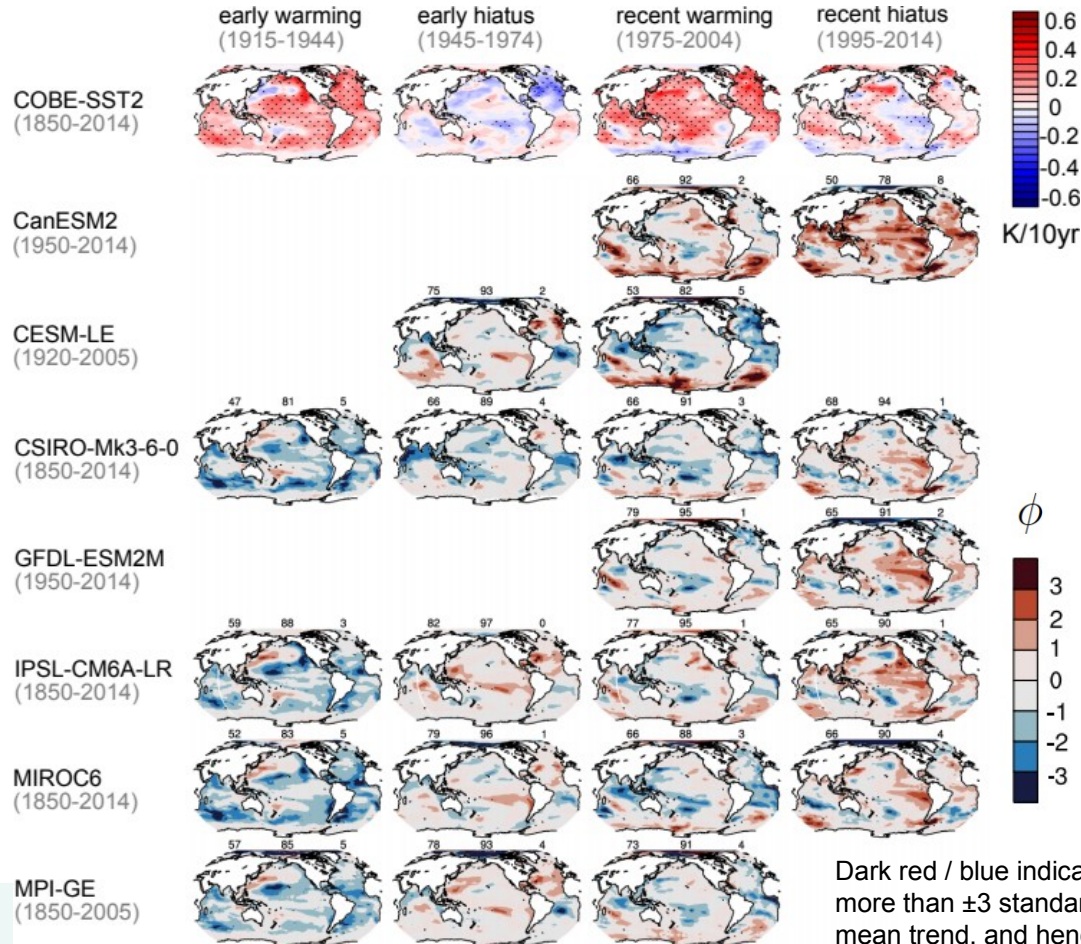
r : average correlation between each ensemble member of a model ensemble and each observational data set for the historical period

% ensemble members with a SST trend larger than the observed COBE-SST2 trend

Model ensemble	1915-1944	1945-1974	1975-2004	1995-2014
CMIP5	0	90	0	-
CMIP6	0	41	39	96
CanESM2	-	-	94	100
CESM-LE	-	39	2	-
CSIRO-Mk3-6-0	0	3	13	96
GFDL-ESM2M	-	-	26	93
IPSL-CM6A-LR	0	67	54	96
MIROC6	0	34	2	90
MPI-GE	0	79	24	-



Observed and simulated SST pattern changes are consistent



Measure of consistency

$$\phi = \frac{t_{mean} - t_{obs}}{\sigma}$$

t_{mean} : Ensemble-mean trend
(forced signal)

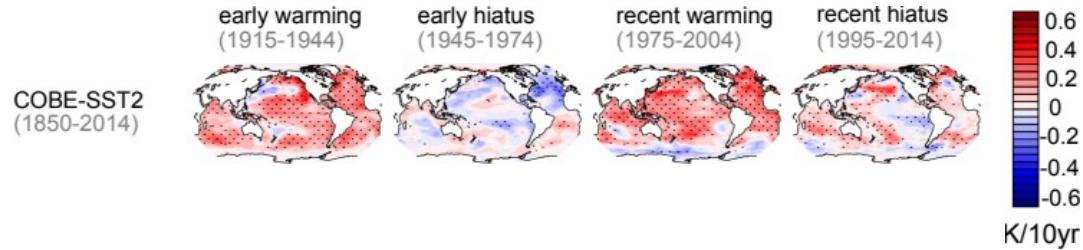
t_{obs} : observed trend (top row)

σ : Ensemble standard deviation
(internal variability)

Numbers on top: Percentage fraction of the ocean area in which the observed trend is within 1 (left), within 2 (center), and outside 3 standard deviations (right) of the simulated ensemble-mean trend

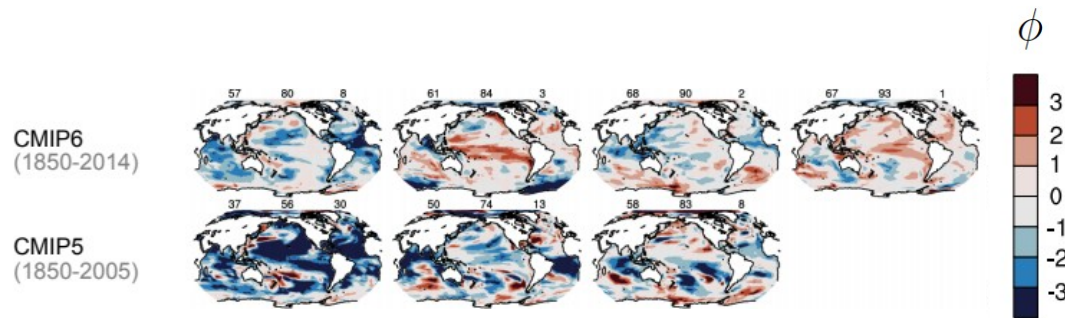
Dark red / blue indicates that the observed trend lies more than ± 3 standard deviations from the ensemble-mean trend, and hence outside the simulated range.

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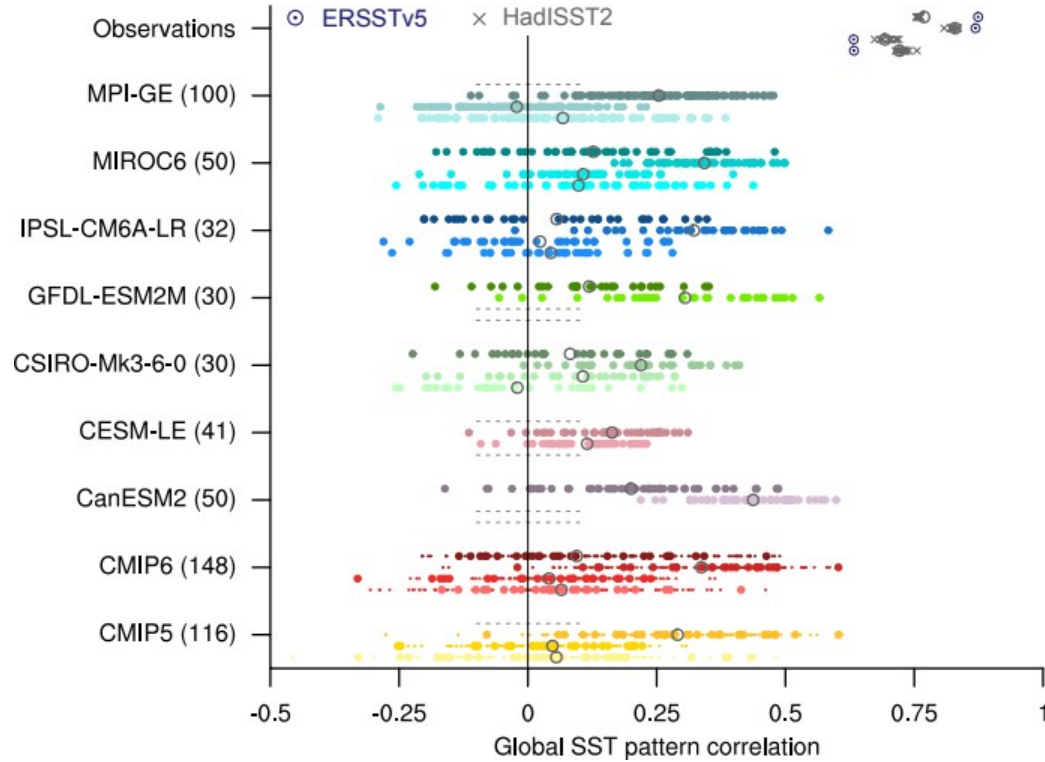
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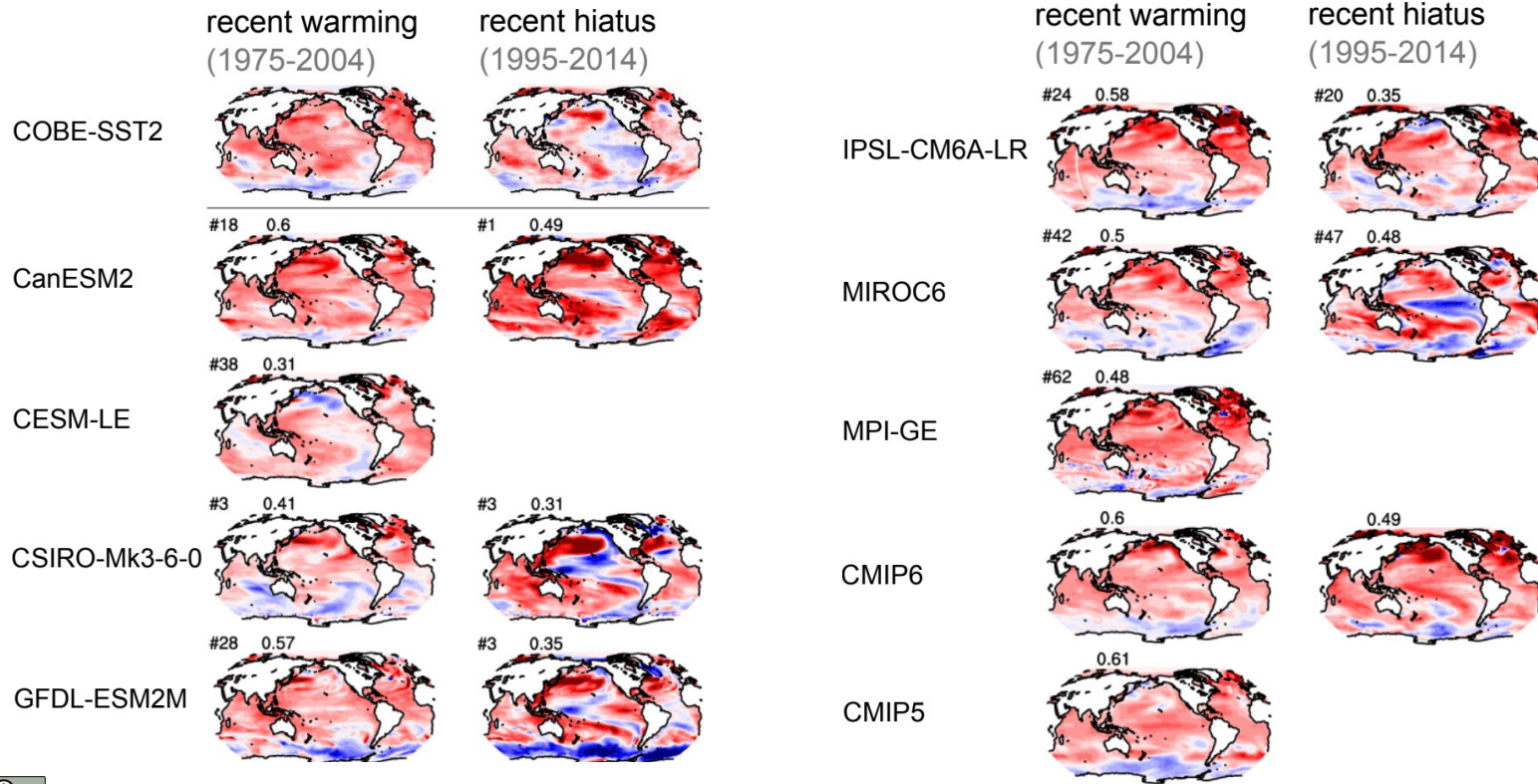
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Wide range of global pattern correlations to observations (COBE-SST2)



Ensemble members with the highest pattern correlation to COBE-SST2



Observed trends in the tropical Pacific SST gradient and the Southern Ocean SST are within the simulated range

