1 **Supplementary information**

2 **Supplementary Table 1. Impact of different factors on June rainfall over India.**
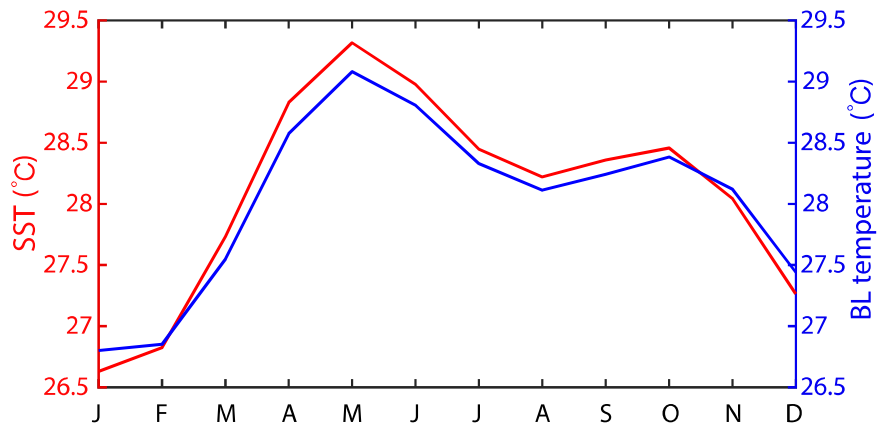
Region	Variable	Correlation coefficient	Removing IOD (SON)	Removing ENSO (DJF)	Removing BLT (DJF)
India	IOD	–0.12	–	–0.01	0.05
	ENSO	–0.21	–0.17	–	0.06
	BLT	**0.46***	**0.45***	**0.42***	–
CNE	IOD	–0.02	–	0.18	0.14
	ENSO	**–0.30***	**–0.35***	–	–0.12
	BLT	**0.40***	**0.42***	**0.29***	–
NE	IOD	0.05	–	0.11	0.12
	ENSO	–0.08	–0.13	–	0.10
	BLT	0.16	0.20	0.22	–
NW	IOD	–0.10	–	–0.10	–0.04
	ENSO	–0.03	0.03	–	0.01
	BLT	0.20	0.18	0.14	–
Island	IOD	–0.18	–	–0.25	–0.20
	ENSO	0.06	0.19	–	0.07
	BLT	–0.01	–0.08	0.03	–
WC	IOD	–0.12	–	–0.04	0.05
	ENSO	–0.16	–0.12	–	0.13
	BLT	**0.48***	**0.47***	**0.47***	–

Pearson's correlation coefficients and partial correlation coefficients between SON (0) IOD, DJF ENSO indices and DJF BLT and June (+1) ISM rainfall over different region of India.
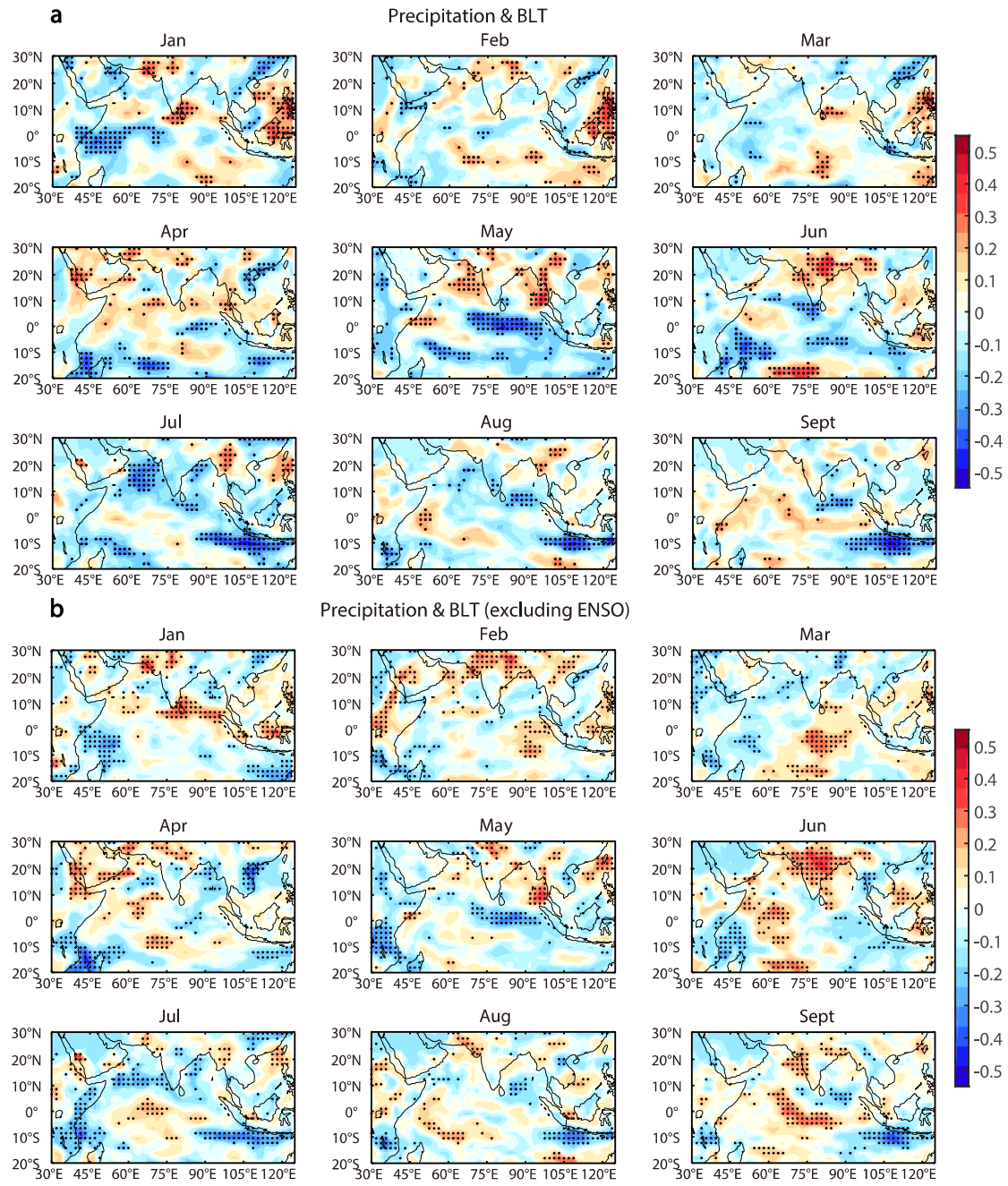
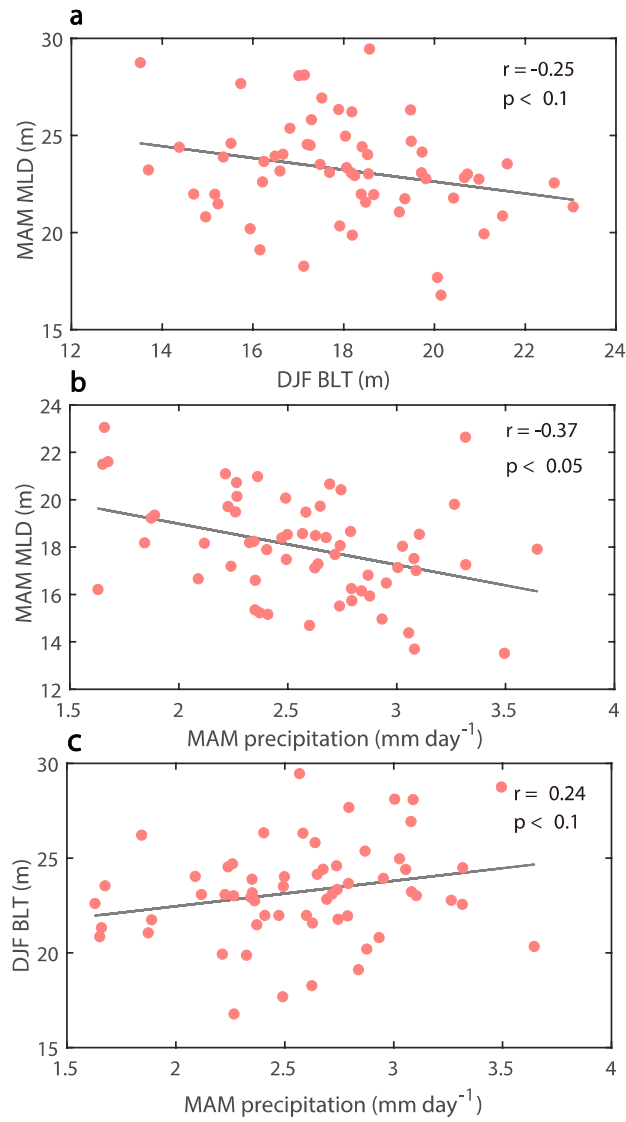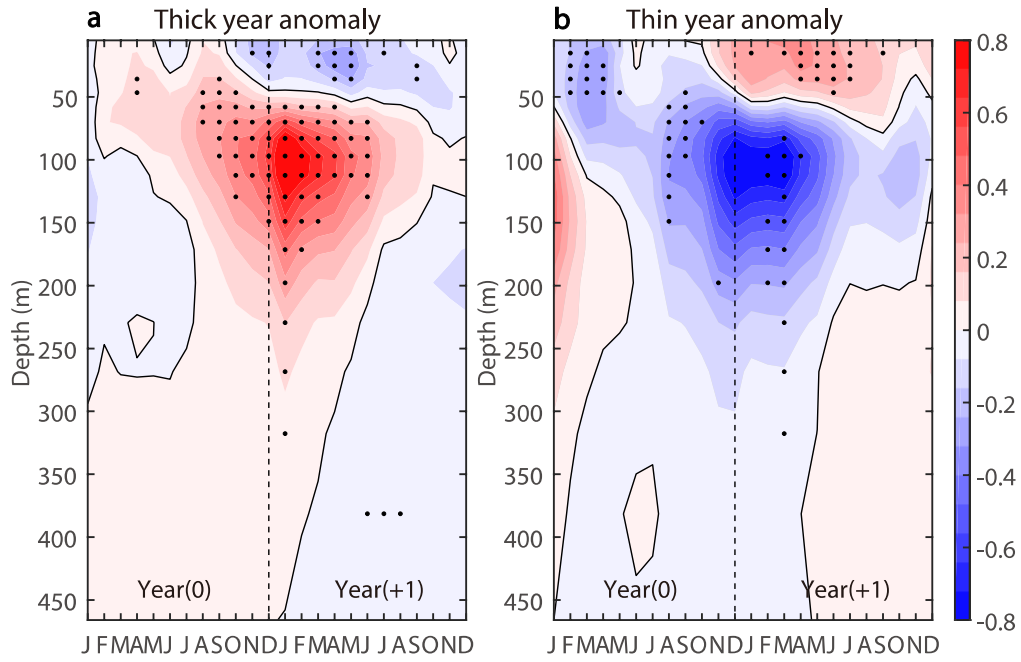*The asterisks indicate statistical significance at the 95% level using Student's *t* test.

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Supplementary Fig. 1 Monthly climatological mean of temperature. Seasonal evolution of SST (red line) and averaged temperature in BL (blue line) for the period of 1951–2010, averaged over BoB (75˚–95˚E, 5˚–25˚N).
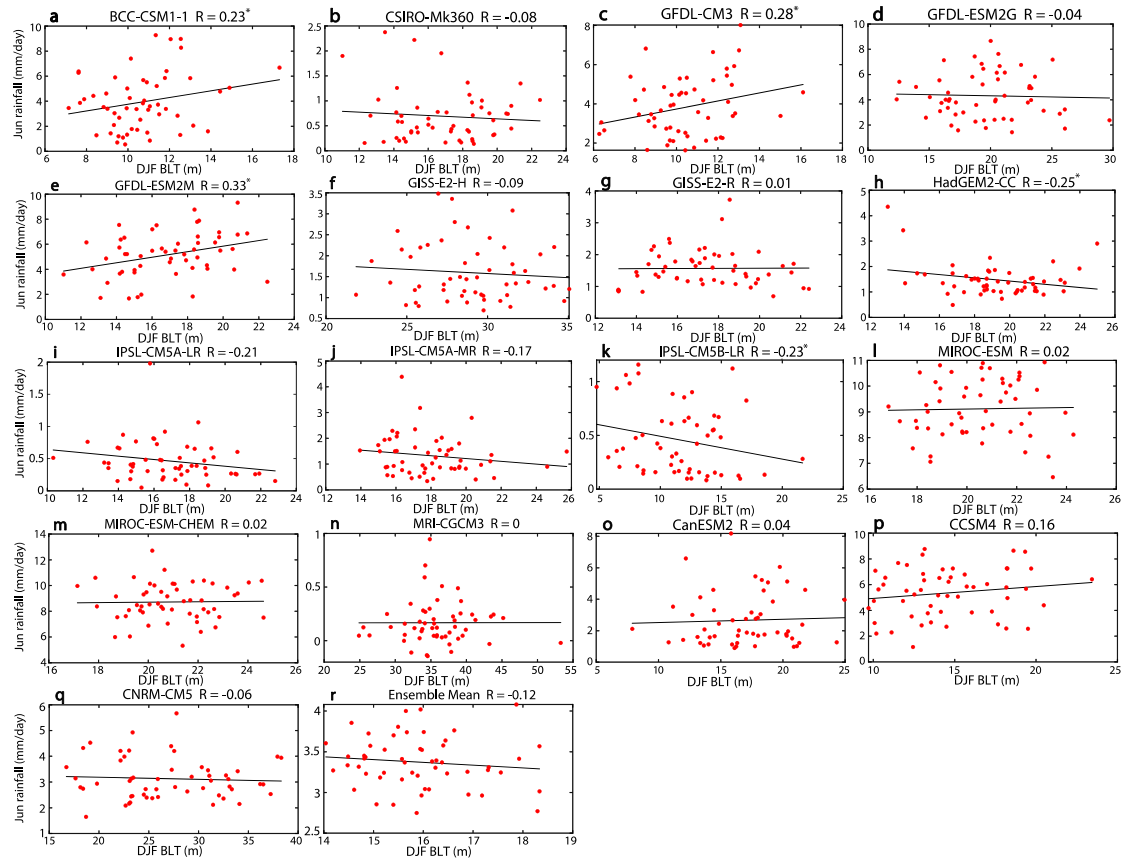
Supplementary Fig. 2 Distribution of precipitation. (**a**) Pearson's correlation coefficients between DJF BLT and precipitation from January (+1) to September (+1). (**b**) Partial correlation coefficients between DJF BLT and precipitation from January (+1) to September (+1) after excluding the effect of DJF Niño 3.4.
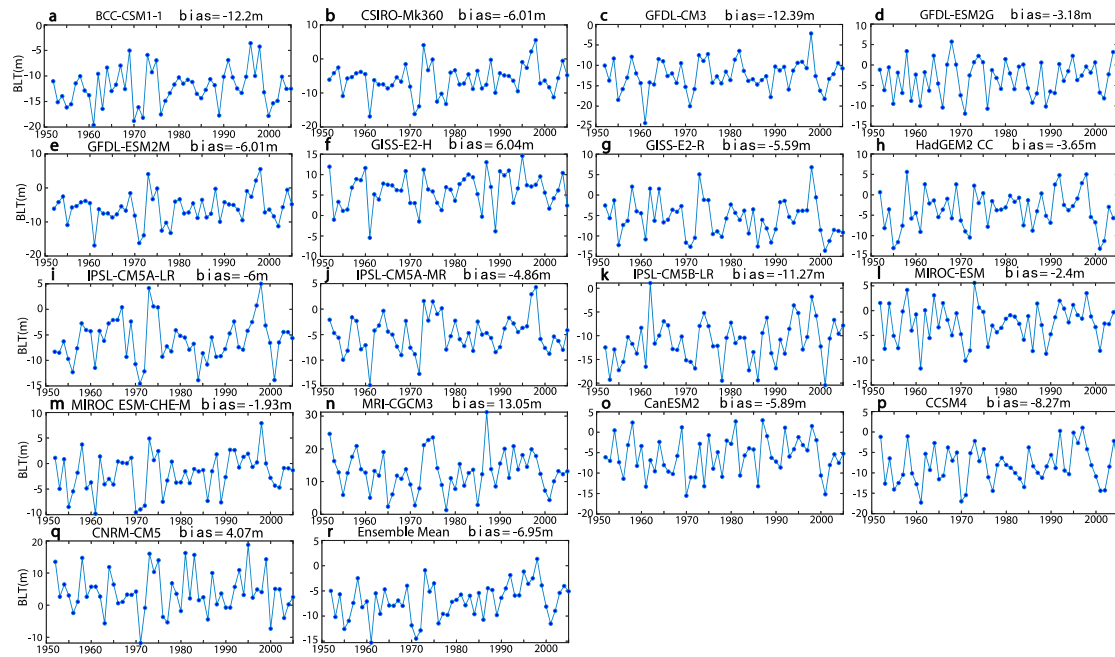
Supplementary Fig. 3 Linear correlation analysis among BLT, MLD, and precipitation. Scatterplots (**a**) between DJF BLT (m) and MAM (+1) MLD (m), and (**b**) between MAM (+1) precipitation rate (mm day^{-1}) and MAM (+1) MLD, and (**c**) DJF BLT, averaged over BoB. The gray lines indicate the least–squared fits.

Supplementary Fig. 4 Seasonal evolution of vertical temperature. Anomalous evolution of temperature (°C) averaged over BoB from January (0) to December (+1), for prior winter (**a**) thick BL years and (**b**) thin BL years. The black lines denote the zero contour. The black spots denote statistical significance at the 90% confidence level by two–tailed Student's *t* test.
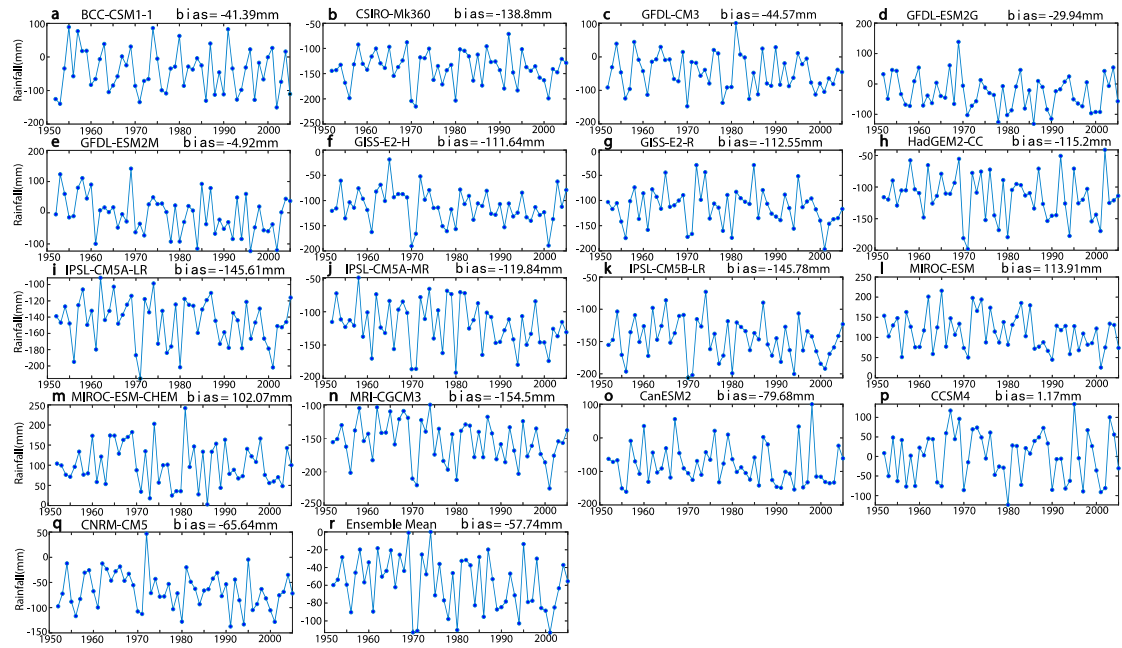
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Supplementary Fig. 5 Linear correlation analysis between precipitation and BLT in different coupled models. (a–r) Scatterplots between June (+1) rainfall (mm) over India and DJF BLT (m) in the BoB based on the outputs of 55–year historical runs by the 17 CMIP5 models. The black dots denote original data. The last scatterplot is the result of ensemble means. The black lines indicate the least–squared fits. The asterisks (*) indicate statistical significance at the 95% level using Student's *t* test.

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Supplementary Fig. 6 Biases of BLT simulated by different coupled models. (a–r)

Differences in averaged BoB DJF BLT (m) between the outputs of 55–year historical

runs by the 17 CMIP5 models and SODA data (CMIP5 minus SODA). The black dots

denote original data. The last plot is the difference between the ensemble mean of

models and SODA. The "bias" indicates the biases in climatology of DJF BLT for years

1951 to 2005.

Supplementary Fig. 7 Biases of rainfall simulated by different coupled models. (a–r) Differences in averaged India June rainfall (mm) between the outputs of 55–year historical runs by the 17 CMIP5 models and IITM (see "Methods") observed data (CMIP5 minus IITM). The black dots denote original data. The last plot is the difference between the ensemble means of 17 CMIP5 models and IITM. The "bias" indicates the biases in climatology of June rainfall for years 1951 to 2005.