

## Abstract and conclusions

- The study suggests how India's terrestrial biosphere sequestered CO<sub>2</sub> in the recent past, and how it is going to change in the future under high emission scenario.
- Gross Primary Productivity (GPP) is an indicator of primary productivity, hence, carbon sequestration by the biosphere. ~ 30% of the CO<sub>2</sub> released by human activities is sequestered by terrestrial biosphere as primary productivity.
- Using Coupled Model Intercomparison Project (CMIP6) climate model simulations, we assess both past and future trends in GPP across India.
- The Indian biosphere's ability to sequester CO<sub>2</sub> has been increasing recently, with regional variation. Historically, India's GPP has grown by 2.37 gCm<sup>-2</sup>y<sup>-1</sup>, and future projections suggest it could increase to 6 gCm<sup>-2</sup>y<sup>-1</sup> under SSP-585 high-emission scenarios with regional variations.
- Land-use land cover (LULC) changes, like deforestation and farming expansion etc., have implications for regional carbon sequestration. We noticed the decrease in observed green cover of the Northeast region in the recent past.
- Climate models projections suggest that increased rainfall in models could be influencing the GPP trends.

## Figures

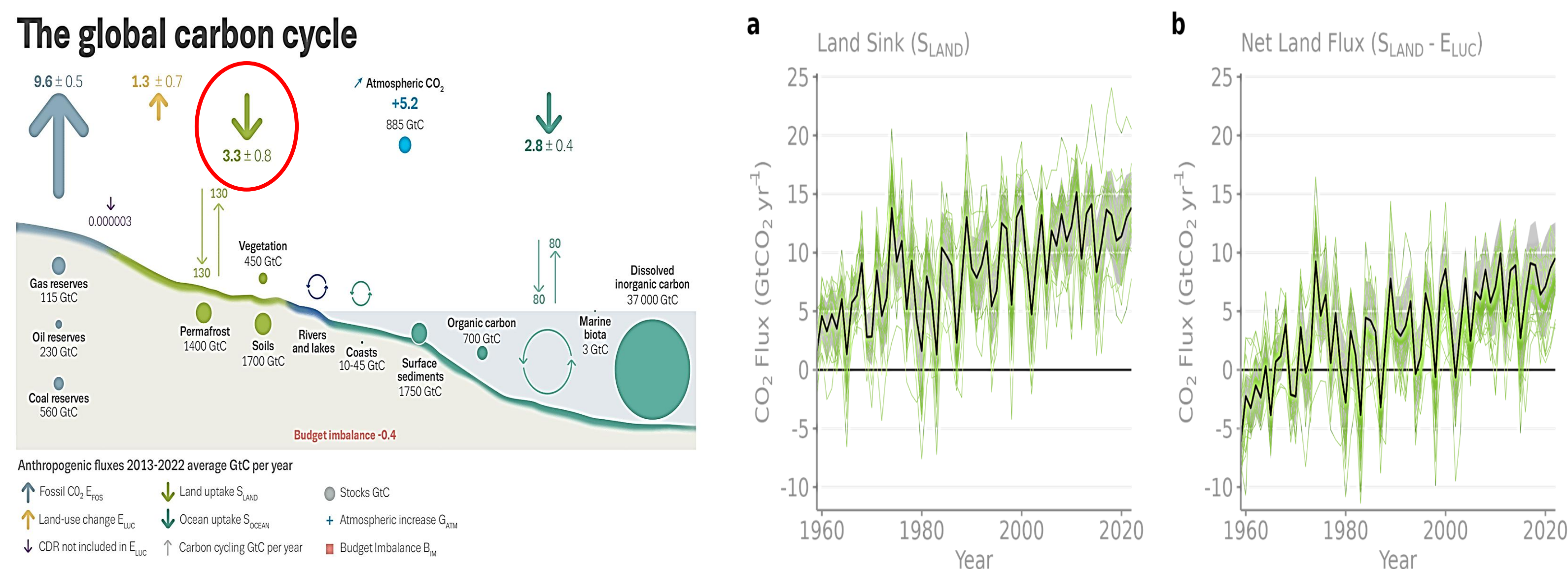


Figure 1: The Global Carbon Budget (Friedlingstein et al. 2023, Global Carbon Project) & Global Carbon Sinks estimate : Fluxes are in gigatonnes of carbon per year (Gt C yr<sup>-1</sup>)

### CMIP6 models: Historical and future period trends in GPP

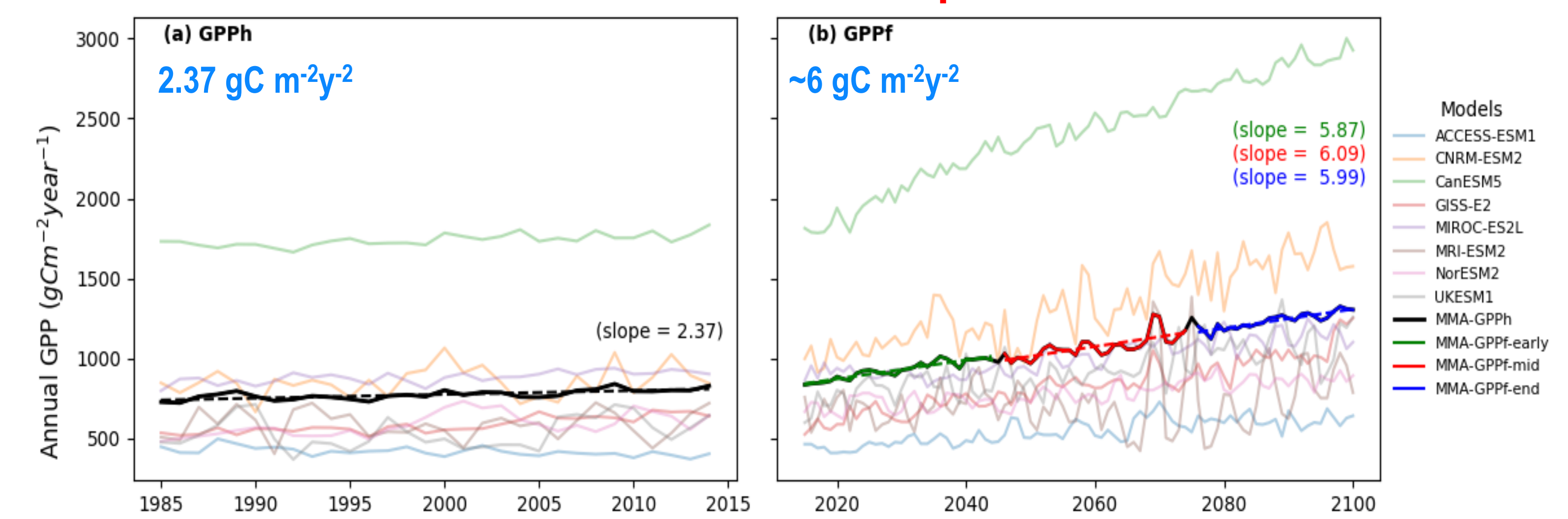


Figure 2: Annual GPP from CMIP6 models, (a) Historical period: GPPh (1985-2014) (b) Future period- (experiment- esm-ssp585): GPPf (2015-2100). Multimodel average (MMA) for early (2015-2044), middle (2045-2074), and end-century (2075-2100) period.

### CMIP5 and CMIP6: Future projections of annual GPP

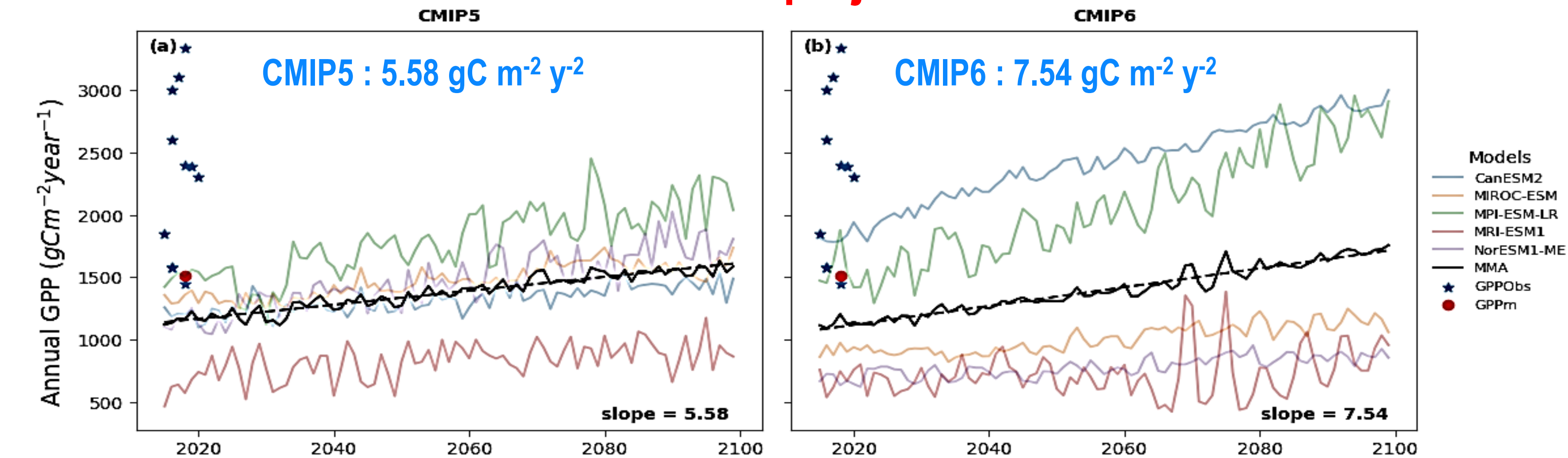


Figure 3: Comparison of GPPf between (a) CMIP5 (experiment: esm-rcp85) and (b) CMIP6 (experiment: esm-ssp585), five common models in r11p1 initialization (color coded), their MMA (black thick line), and regression line (black dash line, p~0.000)

## Model description

Table 1						Table 2								
S. No.	Model Name	Institute	Atmosphere resolution	N2 cycle	Land Carbon and BGC	Reference	S. No.	Institute	Model Name	Corresponding	Atmosphere resolution	Land Carbon and BGC	N <sub>2</sub> cycle	Reference
1	ACCESS-ESM1-5	CSIRO	1.25 x 1.875	Yes	CABLE2.4 with CASA CNP	Ziehn et al. (2020)	1	CCCma	CanESM2	CanESM5	2.81 x 2.81	CLASS2.7+CTE M1	No	Arora and Boer, 2010
2	CNRM-ESM2-1	CNRM	1.4 x 1.4	No	ISBA-CTRIP	S'ef'erian et al. (2019)	2	MIROC	MIROC-ESM	MIROCS	2.81 x 2.81	MATSIRO+SEIB-DGVM	No	Watanabe et al.
3	CanESM5	CCCma	2.81 x 2.81	No	CLASS-CTEM	Swart et al. (2019)	3	MPI	MPI-ESM-LR	MPI-ESM1-2-LR	1.88 x 1.88	JSBACH	No	Reick et al. 2013
4	GISS-E2-1-G-CC	NASA GISS	2 x 2.5	No	CLM5	Kelley et al. (2020)	4	MRI	MRI-ESM1	MRI-ESM2-0	3.2 x 1.6	LPJDGVM at ecosystem level	No	Adachi et al. 2013
5	MIROC-ES2L	JAMSTEC	2.81 x 2.81	Yes	MATSIRO VISIT-e	Hajima et al. (2019)	5	NorESM	NorESM1-ME	NorESM2-MM	1.88 x 2.50	CLM4	Yes	Tijpstra et al. 2013
6	MRI-ESM2-0	MRI	1.00 x 0.50	No	HAL	Yukimoto et al (2019)								
7	NorESM2-LM	NCC	1.9 x 2.5	Yes	CLM5	Seland et al. (2020)								
8	UKESM1-0-LL	UK	1.875 x 1.25	Yes	JULES-ES-1.0	Sellar et al., (2019)								

Table 1: Eight CMIP6 Models: C4MIP experiment, BGC models (esm-historical, future: esm-ssp585 (Eyring et al., 2016) all initializations

Table 2: Five common CMIP5 & CMIP6 Models: BGC models (future: esmrcp585 & esm-ssp585) first initializations

## Results

Historical and future SSP585 projections suggest increase in annual GPP, consistent with the observed forest and crop cover increase in the past.

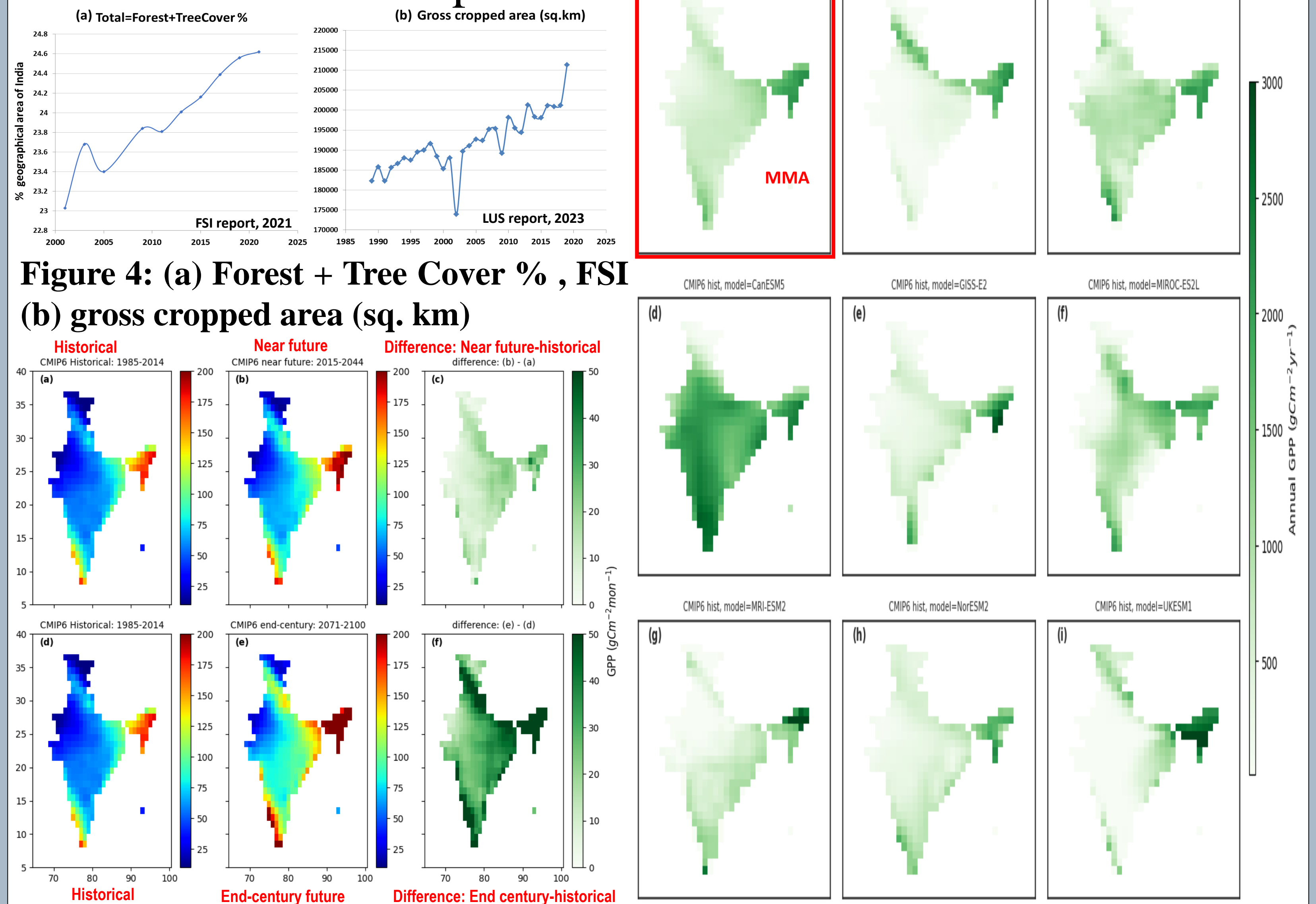


Figure 4: (a) Forest + Tree Cover % , FSI report, 2021 (b) gross cropped area (sq. km) Figure 5: Spatial distribution of historical annual GPP from 1985-2014: (a) Average of all eight models (MMA), and (b-i) Average annual GPP of individual eight models

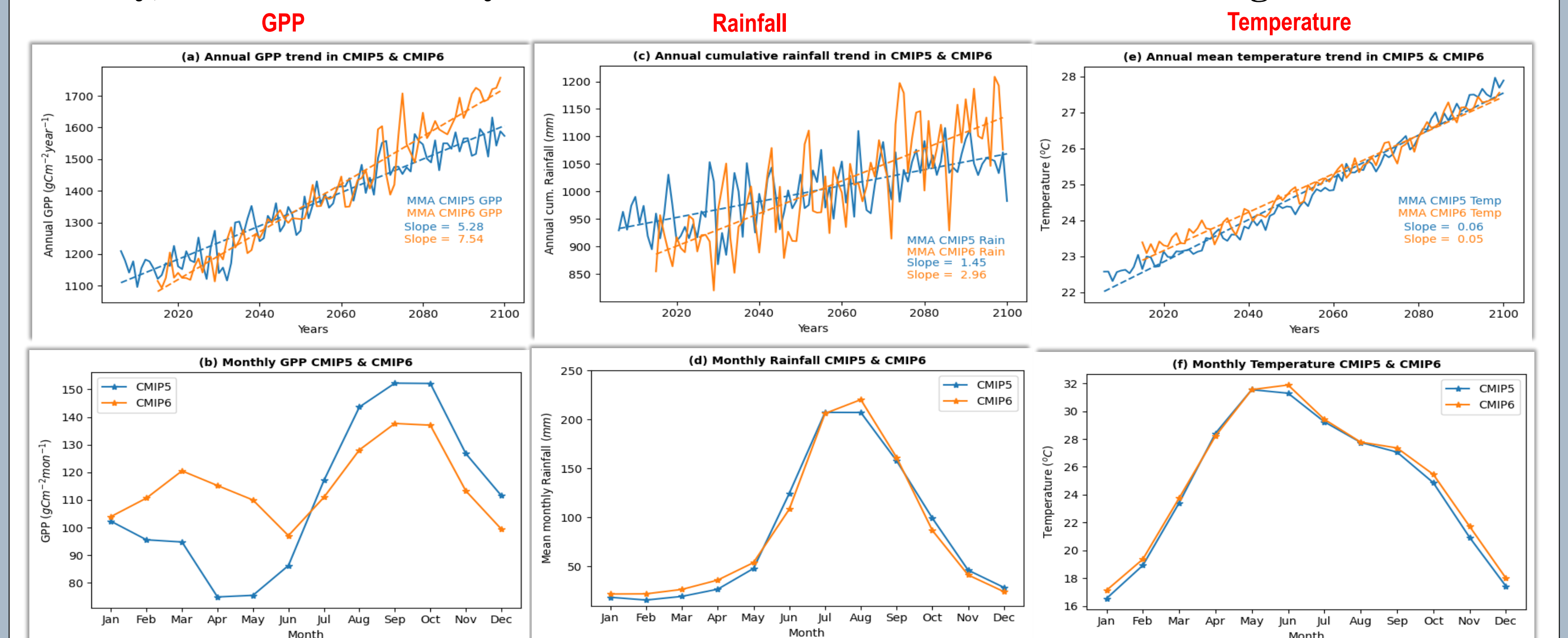


Figure 7: Comparison between common CMIP5 & CMIP6 (a) Annual GPP trend, (b) Mean monthly GPP, (c) Annual total rainfall, (d) Mean monthly rainfall, (e) Annual mean temperature, and (f) Mean monthly temperature

## Acknowledgements and References

### Acknowledgments:

- Director, IITM, Pune; Director, IESD, BHU; ESRL (<https://psl.noaa.gov/data/gridded/>)
- FSI report 2021 (<https://fsi.nic.in/forest-report-2021>); LUS report (Department of Economic Survey, MAFW, GOI, ([https://eands.dacnet.nic.in/LUS\\_latest\\_year.htm](https://eands.dacnet.nic.in/LUS_latest_year.htm)))

### References:

- Eyring, V., Bony, S., Meehl, ..., and Taylor, K. E.: Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9, 1937–1958, <https://doi.org/10.5194/gmd-9-1937-2016>, 2016.
- Friedlingstein, P., O'Sullivan, M., Jones... and Zheng, B.: Global Carbon Budget 2023, Earth Syst. Sci. Data, 15, 5301–5369, <https://doi.org/10.5194/essd-15-5301-2023>, 2023.