Supplementary Material
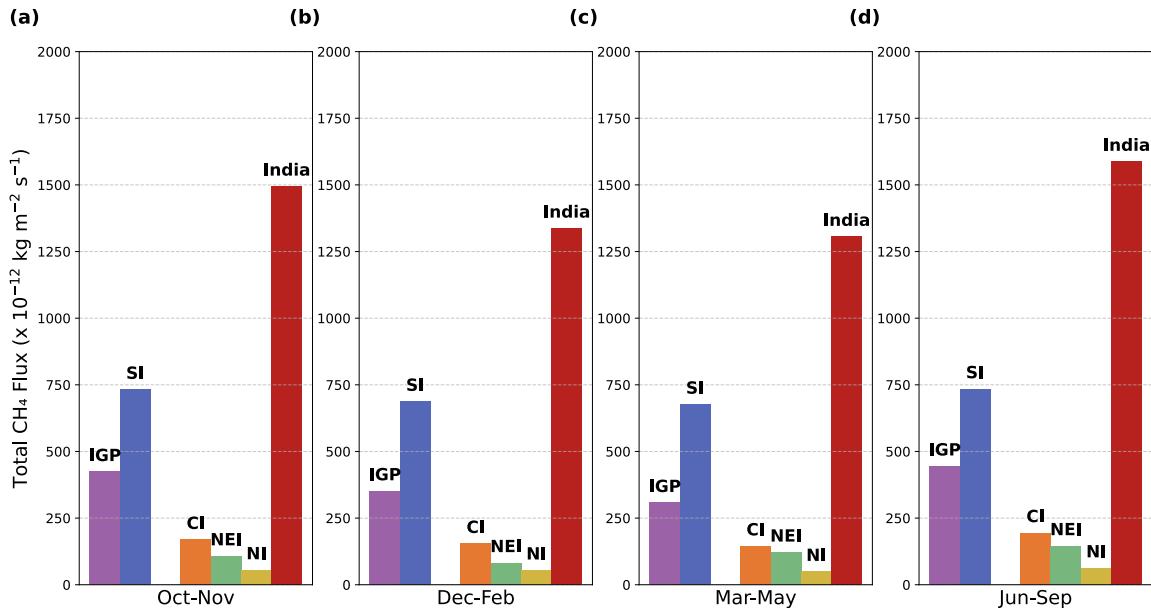
Figure S1. Total of wetland, biomass burning and anthropogenic seasonal fluxes from bottom-up inventory data.

Table S1. The observed and modeled monthly mean XCH$_4$ and their difference (in ppb) over the entire study domain for 2018 and 2019.

2018			
Month	**Tropomi (Mean $\pm$ Std Dev)**	**WRF (Mean $\pm$ Std Dev)**	**Diff (Mean $\pm$ Std Dev)**
January	1840.13 $\pm$ 36.65	1853.17 $\pm$ 34.51	-13.03 $\pm$ 28.47
February	1840.36 $\pm$ 36.06	1867.55 $\pm$ 39.89	-27.19 $\pm$ 36.68
March	1843.38 $\pm$ 32.54	1847.02 $\pm$ 49.70	-3.64 $\pm$ 40.90
April	1842.35 $\pm$ 29.73	1845.95 $\pm$ 36.25	-3.60 $\pm$ 35.33
May	1845.25 $\pm$ 29.71	1842.90 $\pm$ 25.10	2.35 $\pm$ 27.08
October	1870.58 $\pm$ 36.64	1819.10 $\pm$ 62.17	51.48 $\pm$ 64.00
November	1862.90 $\pm$ 31.60	1883.23 $\pm$ 41.55	-20.33 $\pm$ 29.53
2019			
Month	**Tropomi (Mean $\pm$ Std Dev)**	**WRF (Mean $\pm$ Std Dev)**	**Diff (Mean $\pm$ Std Dev)**
January	1847.95 $\pm$ 36.20	1876.88 $\pm$ 31.89	-28.93 $\pm$ 24.07
February	1848.04 $\pm$ 35.55	1864.56 $\pm$ 39.45	-16.53 $\pm$ 41.86
March	1851.30 $\pm$ 29.22	1858.26 $\pm$ 43.92	-6.96 $\pm$ 43.19
April	1849.99 $\pm$ 29.41	1850.17 $\pm$ 46.89	-0.18 $\pm$ 43.62
May	1852.43 $\pm$ 27.48	1857.51 $\pm$ 20.12	-5.08 $\pm$ 24.73
October	1883.78 $\pm$ 37.68	1862.82 $\pm$ 54.45	20.97 $\pm$ 46.29
November	1876.14 $\pm$ 31.91	1873.91 $\pm$ 52.02	2.23 $\pm$ 46.68
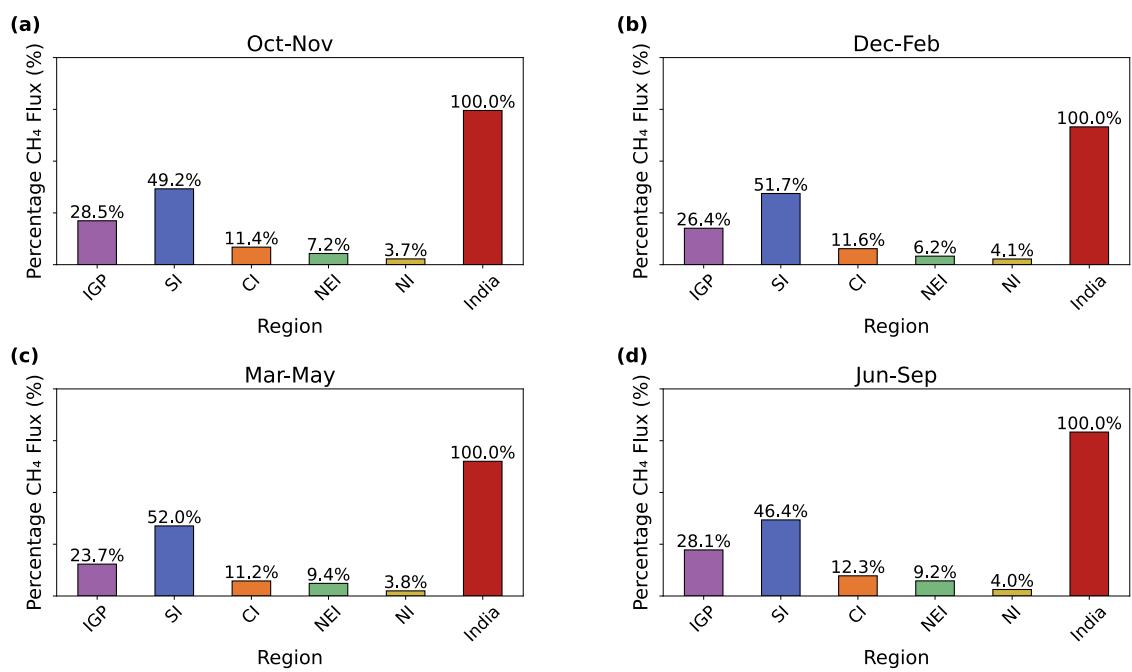
Figure S2. Percentage contribution of seasonal fluxes from bottom-up inventory data.
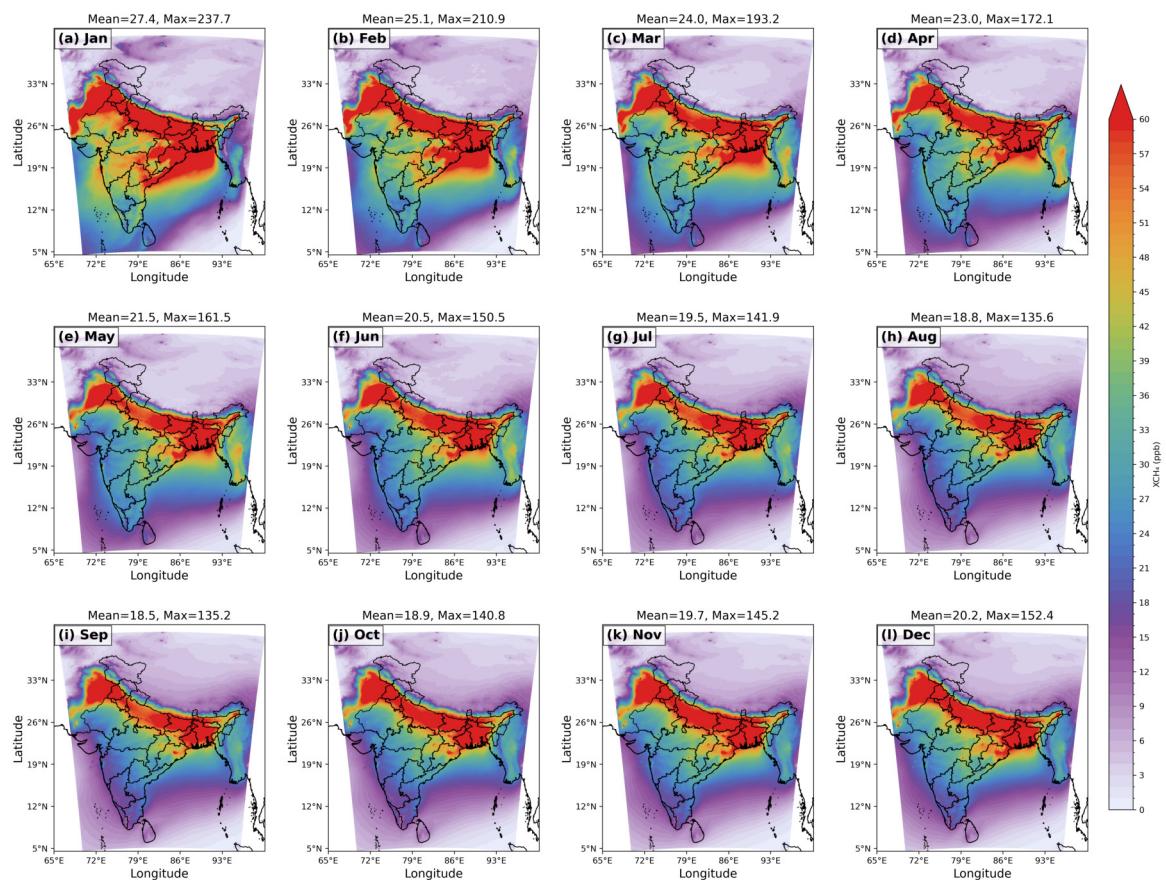
Figure S3. Spatial distribution of WRF anthropogenic mixing ratio enhancement (including biomass burning) for different months of 2019 (a)-(l).
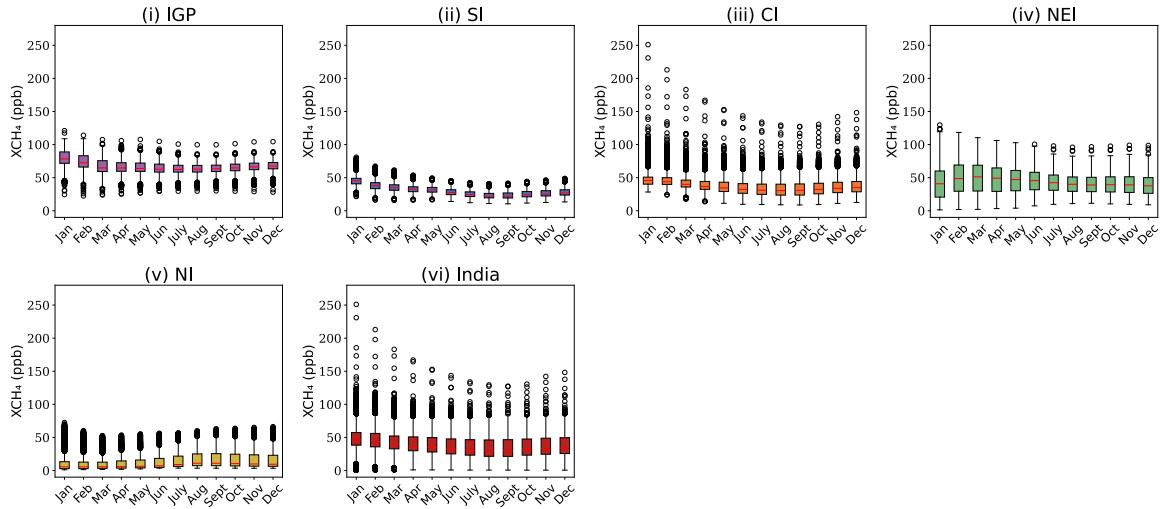
Figure S4. (a) Region-specific analysis of simulated mixing ration enhancement for 2018, over (i) IGP (ii) SI (iii) CI (iv) NEI (v) NI and (vi) India.
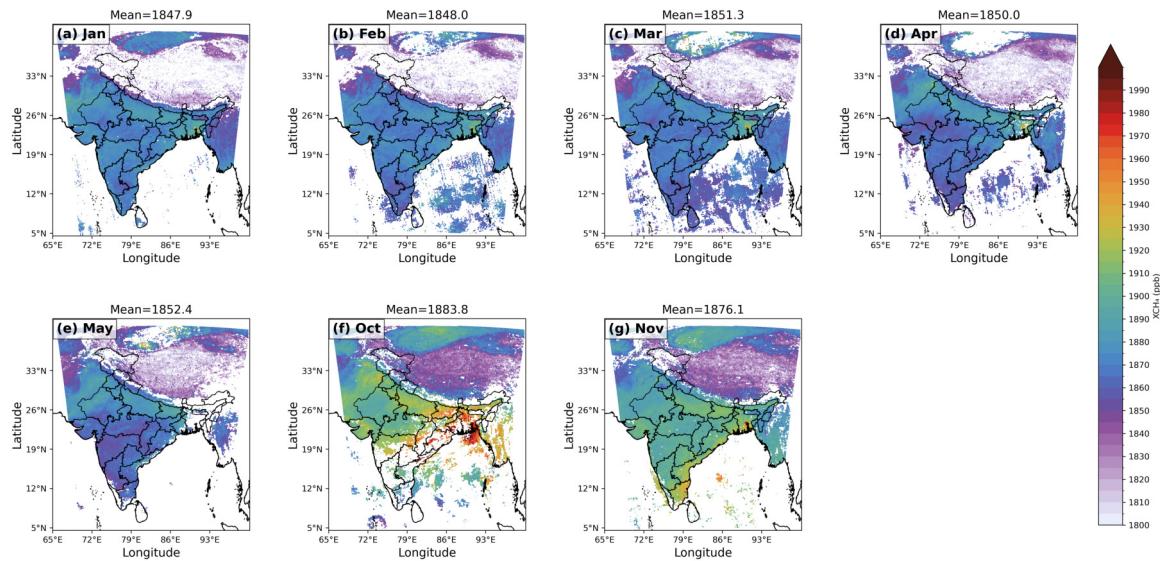
Figure S5. Spatial distribution of the TROPOMI Sentinel-5P retrievals of CH$_4$ for different months of 2019 (a-h). Some months are omitted due to filtering based on cloud pixels.
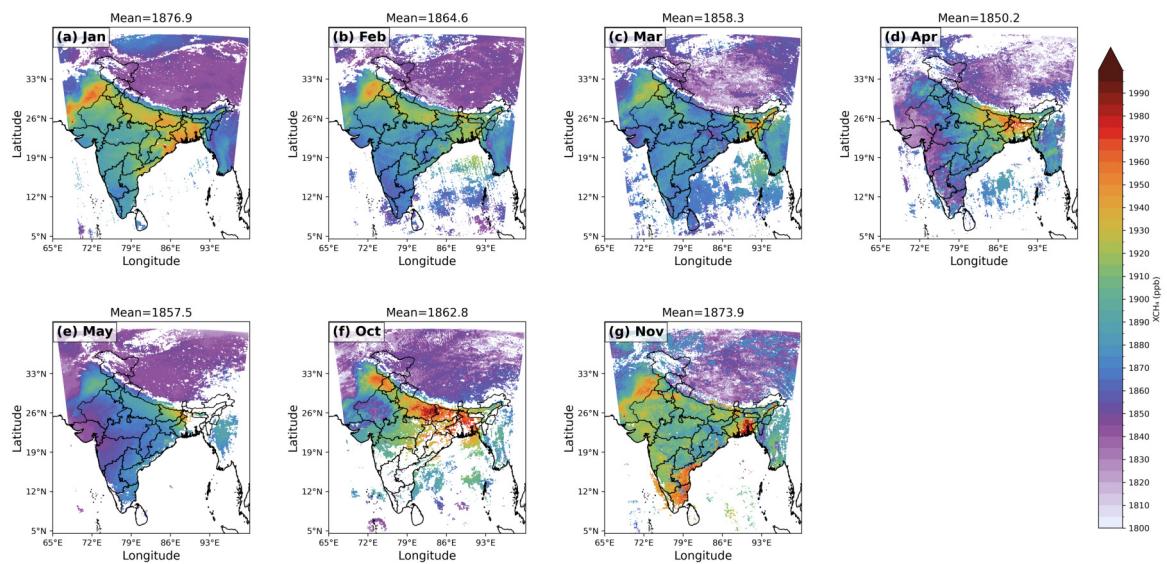
Figure S6. Spatial distribution of the WRF simulations for different months of 2019 (a-h). The months that are omitted in Fig. S5 are removed here also.
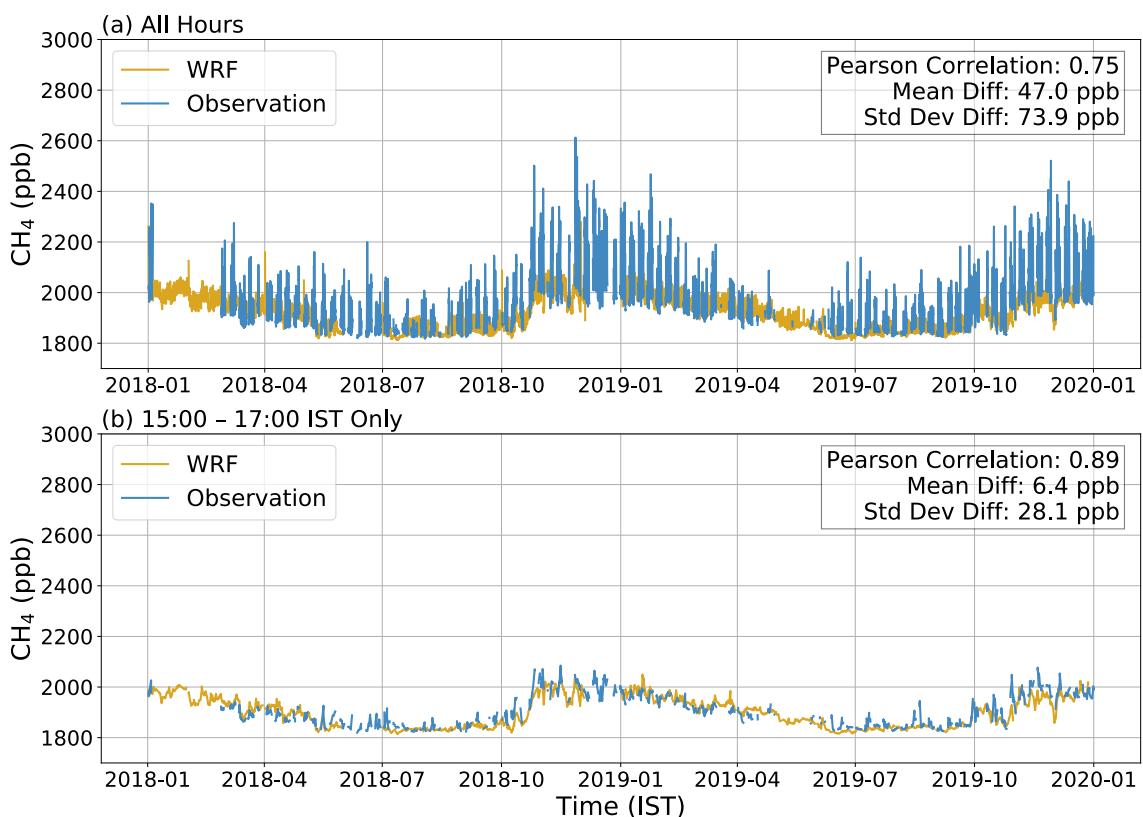
Figure S7. Comparison of the temporal distribution of observed and WRF-GHG simulated CH$_4$ at Thumba (see the site location as denoted in Fig. 1) for (a) all hours and (b) 15:00 -17:00 IST only