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Extent of gross underestimation of precipitation in India

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Supplement

The following is an overview of the supplementary material.

- S1: PBCOR dataset
- S2: Data Files (tables and GIS data) & Summary Watershed Characteristics
- S3: Precipitation
  - Average annual precipitation, WY 2007-2014
    - Maps of gridded average annual precipitation for each product
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  - Select Flooding Events
    - Assam flooding, June 2012
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- S6: Estimates of Annual ΔTWS
- S7: Spatial Averaging
- S8: Case Study on Potential Contribution of Inter-watershed Groundwater Flow (IGF)
- S9: Effect of different heuristics on Scenario II
- S10: Time series charts
  - Time series of hydrometeorological data for each of the 73 imbalanced watersheds identified in this study using the IMD-APHRO dataset.
  - Both annual (Jun-May) and seasonal (Jun-Sep) time series charts are presented.
- References

S1 PBCOR dataset

A bias-correction factor (CF) is defined the ratio of actual P to observed P. The PBCOR dataset (Beck et al., 2020) provides average annual and monthly estimates of bias-corrected P at a resolution of 0.05 deg. Estimates from PBCOR are specific to one of three reference climatology datasets used within its development - CHELSA V1.2, CHPclim V1 and WorldClim V2. The time period corresponding to each of these reference climatologies is as follows: for CHELSA V1.2 it is 1979-2013, for CHPclim V1 it is 1980-2009, and for WorldClim V2 it is 1970-2000. PBCOR was aggregated from its native 0.05 deg resolution to the IMD resolution of 0.25 deg by appropriately accounting for spatial overlap between the 0.05 deg and 0.25 deg grid meshes. Next, the long-term average monthly P was estimated for the IMD grids, for each of the above time periods corresponding to each climatology. The ratio of aggregated PBCOR data at 0.25 deg and IMD data, as shown in Eq S1.1 - S1.3, is the estimated CF and is shown in Figure S1.1.

$$CF^{CHELSA} = \frac{\overline{P}^{CHELSA}}{\overline{P}^{IMD}_{1979-2013}} \tag{S1.1}$$

$$CF^{CHPclim} = \frac{\overline{P}^{CHPclim}}{\overline{P}^{IMD}_{1980-2009}} \tag{S1.2}$$

$$CF^{WorldClim} = \frac{\overline{P}^{WorldClim}}{\overline{P}^{IMD}_{1970-2000}} \tag{S1.3}$$

If PBCOR's estimates were to be considered reasonable, then the ratio of PBCOR to IMD's observed data represents the CF associated with IMD data. Figure S1.2 shows the annual average precipitation from IMD and the CFs derived using CHPclim (Eq. S1.2).

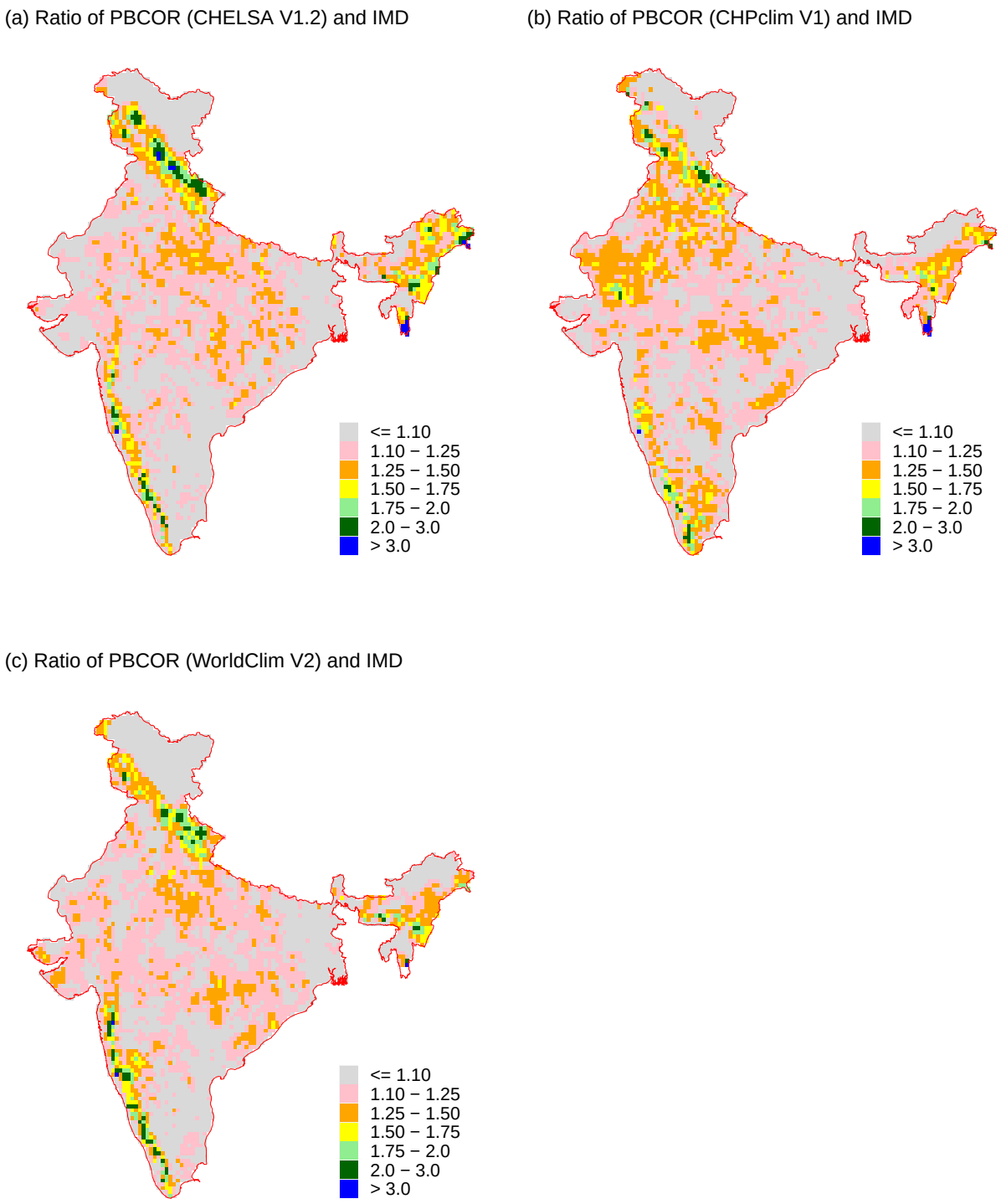


Figure S1.1: Ratio of bias-corrected annual P from PBCOR and annual P from IMD.

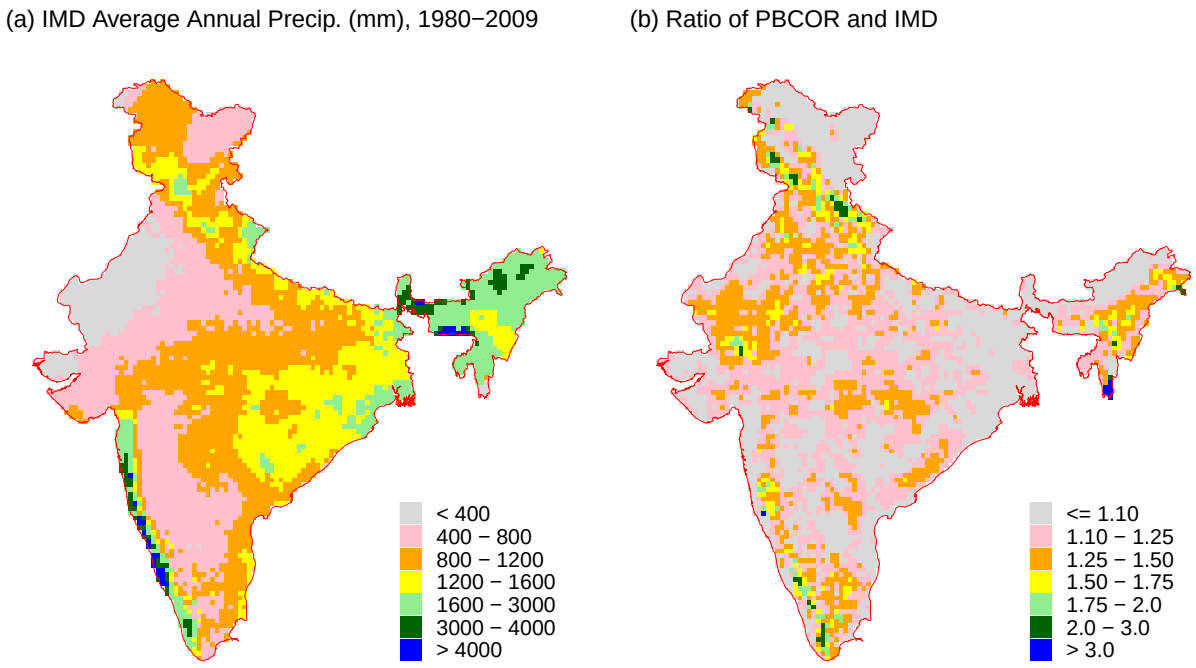


Figure S1.2: (a) Average annual P (mm) from IMD for 1980-2009. (b) Ratio of bias-corrected annual precipitation from PBCOR and annual precipitation from IMD.

S2 Data Files & Summary Watershed Characteristics

The following **tabular data** are included within the supplementary material.

- List of 242 streamflow gauging stations used in this study (CSV file, 'stations_all.txt'); attributes include:
  - ghi_stn_id : Unique station ID, 10 characters long, similar to GHI
  - disp_basin : Complete name of the River Basin
  - st : State associated with the station, CWC
  - site_name : Name of the station, CWC
  - riv_name : River/tributary, CWC
  - drai_area : Catchment area (sq km), CWC
  - shpArea_wgs : Catchment area (sq km), estimated in this study, similar to GHI
  - stn_lat : Latitude of the station (decimal degrees), CWC
  - stn_lon : Longitude of the station (decimal degrees), CWC
  - hydro_lat : Latitude of the relocated station (decimal degrees), similar to GHI
  - hydro_lon : Longitude of the relocated station (decimal degrees), similar to GHI
- List of 73 imbalanced watersheds identified in this study using the IMD-APHRO dataset (CSV file, 'stations_73.txt'); attributes same as 'stations_all.txt'
- Annual (WY-based) watershed-averaged hydrometeorological time series (CSV file, 'hydromet_annual.txt'); for WY 1980-2019, whenever data is available, for all 242 stations; attributes include:
  - ghi_stn_id : Unique station ID, 10 characters long, similar to GHI
  - wyr: water year
  - dname: P dataset name (referred to by the 'Alias' in Table 1 of the paper)
  - prec_mcm : P corresponding to each dataset, in mcm
  - evap_gleam_mcm, ET from GLEAM, in mcm
  - flow_mcm_obs, observed R, in mcm
  - cgros: annual cumulative maximum gross storage capacity, in mcm
  - clive: annual cumulative maximum live storage capacity, in mcm

The following **GIS data** are included within the supplementary material.

- GIS data on catchment boundaries of the 242 gauging stations (zip file, 'gis_watersheds.zip')
- GIS data on catchment boundaries of major river basins (zip file, 'basin_bounds.zip')

Table S2.1: Summary information on streamflow stations used in this study. Frequency of streamflow observations and the source of the data is also mentioned.

Region	Basin	Stations	Frequency	Source
Northern India	Barak	8	Annual	CWC-19
Northern India	Brahmaputra	2	Annual	CWC-19
Northern India	Ganga	18	Annual	CWC-19
Northern India	Indus	1	Annual	CWC-19
Peninsular India	Brahmani-Baitarani	7	Daily	GHI
Peninsular India	Cauvery	20	Daily	GHI
Peninsular India	EFR North	5	Daily	GHI
Peninsular India	EFR South	12	Daily	GHI
Peninsular India	Godavari	40	Daily	GHI
Peninsular India	Krishna	42	Daily	GHI
Peninsular India	Mahanadi	19	Daily	GHI
Peninsular India	Mahi	6	Daily	GHI
Peninsular India	Narmada	18	Daily	GHI
Peninsular India	Pennar	6	Daily	GHI
Peninsular India	Sabarmati	2	Daily	GHI
Peninsular India	Subernarekha	4	Daily	GHI
Peninsular India	Tapi	4	Daily	GHI
Peninsular India	WFR North	4	Daily	GHI
Peninsular India	WFR South	24	Daily	GHI

Table S2.2: Select characteristics of the 242 catchments analyzed in this study. 'Area' is catchment drainage are in sq. km; 'Elev' is elevation in meters and presented as median (maximum); percentage of catchment covered by cropland and forests (grassland, shrub, tree/forest); annual average precipitation and ET (WY 1985-2014) in mm/year.

Study ID	Site	Basin	Region	Area	Elev	%Crop	%Forest	P (mm)	ET (mm)
gbmx_annap	Anna Purna Ghat	Barak	N.India	19235	727(2912)	3	96	1780	1081
gbmx_badar	Badar Pur Ghat	Barak	N.India	25629	589(2912)	4	94	1898	1076
gbmx_baghm	Baghmara	Barak	N.India	2310	408(1333)	2	98	4949	1050
gbmx_fuler	Fulertal	Barak	N.India	15249	847(2912)	1	98	1695	1086
gbmx_kaila	Kailashahar	Barak	N.India	2188	105(883)	5	92	2093	1014
gbmx_matij	Matijuri	Barak	N.India	4630	351(1545)	3	96	2547	1105
gbmx_ranik	Ranikor	Barak	N.India	2510	1042(1876)	10	89	5795	1070
gbmx_tular	Tulargram	Barak	N.India	3182	351(1814)	4	94	2610	1081
gbmx_domoh	Domohani	Brahmaputra	N.India	9648	2526(8038)	4	75	2772	631
gbmx_panch	Pancharatna	Brahmaputra	N.India	458992	4306(7057)	4	69	925	490
gbmx_banda	Banda	Ganga	N.India	25447	376(715)	57	40	1065	476
gbmx_chhat	Chhatnag Allahabad	Ganga	N.India	440125	312(6872)	63	30	853	492
gbmx_chopa	Chopan	Ganga	N.India	47098	463(1207)	39	56	1135	571
gbmx_cs97a	C.S-97 A,Farakka	Ganga	N.India	927899	305(8454)	53	37	917	529
gbmx_dabri	Dabri	Ganga	N.India	24606	219(3043)	56	40	1066	689
gbmx_galet	Galeta	Ganga	N.India	4614	251(823)	63	30	949	614
gbmx_hathi	Hathidah	Ganga	N.India	780608	313(7584)	56	36	877	527
gbmx_jamal	Jamalpur	Ganga	N.India	21907	324(1285)	46	46	1295	614
gbmx_koelw	Koelwar	Ganga	N.India	68304	439(1207)	39	57	1112	578
gbmx_maigh	Maighat	Ganga	N.India	30055	120(210)	81	15	866	523
gbmx_mohan	Mohanpur	Ganga	N.India	5790	193(608)	51	44	1510	656
gbmx_palix	Pali	Ganga	N.India	76812	436(813)	68	26	885	458
gbmx_rishi	Rishikesh	Ganga	N.India	21897	2830(6872)	6	63	1303	531
gbmx_seond	Seondha	Ganga	N.India	16507	333(539)	68	28	810	454
gbmx_shahj	Shahjina	Ganga	N.India	44144	391(666)	70	26	981	473
gbmx_turti	Turtipar	Ganga	N.India	123606	981(7425)	34	52	1096	617
gbmx_udixx	Udi	Ganga	N.India	135935	414(1222)	64	31	779	433
gbmx_varan	Varanasi	Ganga	N.India	461772	309(6872)	63	30	858	492
indu_akhno	Akhnoor	Indus	N.India	22691	3822(6381)	4	52	1241	358
brba_altum	Altuma	Brah.-Bait.	P.India	937	147(941)	20	78	1577	751

Continued on next page

Table S2.2 – continued from previous page

GHI ID	Site	Basin	Region	Area	Elev	%Crop	%Forest	P (mm)	ET (mm)
brba_anand	Anandpur	Brah.-Bait.	P.India	8655	425(1143)	32	66	1538	727
brba_champ	Champua	Brah.-Bait.	P.India	1829	573(1093)	21	77	1417	705
brba_gomla	Gomlai	Brah.-Bait.	P.India	21758	505(1101)	34	62	1351	654
brba_jarai	Jaraikela	Brah.-Bait.	P.India	10541	565(1072)	37	60	1314	650
brba_jenap	Jenapur	Brah.-Bait.	P.India	36131	358(1137)	33	64	1426	687
brba_tilga	Tilga	Brah.-Bait.	P.India	3223	745(1101)	33	64	1302	634
cauv_akkih	Akkihebbal	Cauvery	P.India	5154	938(1735)	25	68	1001	762
cauv_bilig	Biligundulu	Cauvery	P.India	37505	818(1920)	29	64	931	731
cauv_chunc	Chunchunkatte	Cauvery	P.India	2816	903(1587)	15	81	1375	912
cauv_elunu	Elunuthimangalam	Cauvery	P.India	3501	351(1796)	43	38	751	636
cauv_hogen	Hogenakkal	Cauvery	P.India	1593	787(1316)	28	68	868	699
cauv_kmvad	K.M.Vadi	Cauvery	P.India	1464	855(1461)	16	81	1039	863
cauv_kodum	Kodumudi	Cauvery	P.India	52774	794(2577)	29	65	936	734
cauv_kudig	Kudige	Cauvery	P.India	1743	929(1587)	3	94	1710	1032
cauv_musir	Musiri	Cauvery	P.India	69632	732(2577)	33	60	911	717
cauv_mutha	Muthankera	Cauvery	P.India	1235	773(1920)	2	95	1780	1161
cauv_nall1	Nallamaranpatty	Cauvery	P.India	8725	314(2499)	46	49	898	658
cauv_nelli	Nellithurai	Cauvery	P.India	1499	912(2555)	6	92	1121	973
cauv_sakle	Sakleshpur	Cauvery	P.India	616	957(1345)	5	92	1793	995
cauv_savan	Savandapur	Cauvery	P.India	5656	744(2577)	18	77	1112	786
cauv_then1	Thengumarahada	Cauvery	P.India	1360	1004(2556)	6	91	1250	810
cauv_thevu	Thevur	Cauvery	P.India	1208	299(1605)	45	48	1077	775
cauv_thimm	Thimmanahalli	Cauvery	P.India	975	1010(1735)	20	74	864	822
cauv_thopp	Thoppur	Cauvery	P.India	356	490(1576)	28	70	877	749
cauv_tkhal	T.K.Halli	Cauvery	P.India	8158	798(1212)	42	50	812	628
cauv_urach	Urachikottai	Cauvery	P.India	44896	803(1920)	29	65	925	732
efrn_anaka	Anakapalle	EFR North	P.India	2118	146(1577)	22	76	1153	796
efrn_gudar	Gudari	EFR North	P.India	3147	432(1432)	12	88	1384	802
efrn_kutra	Kutragada	EFR North	P.India	1080	428(1432)	24	75	1382	763
efrn_purus	Purushottampur	EFR North	P.India	7055	154(1274)	26	72	1341	763
efrn_srika	Srikakulam	EFR North	P.India	9119	334(1530)	27	71	1257	780
efrs_ambas	Ambasamudram	EFR South	P.India	716	565(1860)	18	79	1178	817
efrs_avara	Avarankuppam	EFR South	P.India	3207	823(1214)	44	47	782	602
efrs_cheng	Chengalpet	EFR South	P.India	16403	430(1269)	41	52	950	688
efrs_gumma	Gummanur	EFR South	P.India	5138	882(1365)	37	45	780	640
efrs_irruk	Irrukkankudi	EFR South	P.India	3902	133(1902)	53	40	944	730
efrs_kudal	Kudalaiyathur	EFR South	P.India	7216	151(1352)	52	44	944	757
efrs_murap	Murappanadu	EFR South	P.India	4735	119(1745)	46	46	836	771
efrs_naidu	Naidupet	EFR South	P.India	2427	192(1103)	31	63	1129	671
efrs_param	Paramakudi	EFR South	P.India	5820	333(2602)	34	60	1005	796
efrs_theni	Theni	EFR South	P.India	1364	461(2602)	24	71	999	921
efrs_vazha	Vazhavachanur	EFR South	P.India	11656	636(1584)	41	49	813	697
efrs_villu	Villupuram	EFR South	P.India	13455	525(1584)	43	47	840	702
goda_ambab	Ambabal	Godavari	P.India	1932	624(750)	37	61	1373	626
goda_ashti	Ashti	Godavari	P.India	51469	337(1168)	46	51	1255	573
goda_bamni	Bamni	Godavari	P.India	46334	343(913)	63	33	995	550
goda_betmo	Betmogrra	Godavari	P.India	2117	498(663)	65	31	871	545
goda_bhatp	Bhatpalli	Godavari	P.India	3182	381(629)	39	59	1191	564
goda_cherr	Cherribeda	Godavari	P.India	1026	637(837)	34	64	1326	607
goda_chind	Chindnar	Godavari	P.India	17996	616(1342)	33	64	1441	656
goda_deglo	Degloor	Godavari	P.India	1923	502(684)	64	33	851	559
goda_dhale	Dhalegaon	Godavari	P.India	30771	552(1453)	63	31	723	521
goda_ghugu	Ghugus	Godavari	P.India	19925	309(913)	64	32	987	550
goda_grbri	G.R.Bridge	Godavari	P.India	33497	546(1453)	64	31	734	521
goda_hivra	Hivra	Godavari	P.India	10293	365(913)	63	33	907	540
goda_jagda	Jagdalpur	Godavari	P.India	7340	621(1342)	35	61	1503	671
goda_kanha	Kanhargaon	Godavari	P.India	3519	550(728)	76	21	884	529
goda_keola	Keolari	Godavari	P.India	3059	604(954)	58	38	1140	530
goda_koida	Koida	Godavari	P.India	304629	424(1605)	50	47	1119	592
goda_konta	Konta	Godavari	P.India	20334	555(1605)	20	78	1460	727
goda_kumha	Kumhari	Godavari	P.India	8432	532(954)	47	50	1206	550
goda_manch	Mancherial	Godavari	P.India	101456	521(1453)	65	30	846	543
goda_mangr	Mangrul	Godavari	P.India	2187	390(567)	68	28	886	548
goda_nandg	Nandgaon	Godavari	P.India	4586	287(574)	60	36	1062	569
goda_nowra	Nowrangpur	Godavari	P.India	3661	820(1342)	20	75	1488	720
goda_patha	Pathagudem	Godavari	P.India	38980	555(1342)	24	75	1462	687
goda_pauni	Pauni	Godavari	P.India	35992	439(1168)	48	48	1191	561
goda_perur	Perur	Godavari	P.India	267340	435(1453)	53	43	1077	575
goda_polav	Polavaram	Godavari	P.India	306684	424(1605)	49	47	1120	594
goda_potte	Potteru (Seasonal)	Godavari	P.India	1175	203(962)	31	67	1487	729
goda_rajeg	Rajegaon	Godavari	P.India	5403	367(805)	37	60	1333	618
goda_rajol	Rajoli	Godavari	P.India	1899	239(453)	50	47	1263	565
goda_ramak	Ramakona	Godavari	P.India	2520	720(1135)	40	57	1095	531
goda_sakmu	Sakmur	Godavari	P.India	47708	339(913)	63	34	1005	550
goda_saleb	Salebardi	Godavari	P.India	1780	277(698)	42	55	1354	632
goda_sarad	Saradaput	Godavari	P.India	5098	610(1548)	24	73	1530	693
goda_satra	Satrapur	Godavari	P.India	11201	599(1168)	47	50	1077	548
goda_soman	Somanpally (Seasonal)	Godavari	P.India	12928	328(641)	66	28	952	570
goda_sonar	Sonarpal	Godavari	P.India	1481	600(843)	36	62	1512	633
goda_tekra	Tekra	Godavari	P.India	107798	330(1168)	53	44	1151	563
goda_tumna	Tumnar	Godavari	P.India	1874	525(1218)	23	75	1489	640
goda_waira	Wairagarh	Godavari	P.India	1765	277(607)	25	73	1430	651
goda_yelli	Yelli	Godavari	P.India	53688	529(1453)	66	29	764	520
kris_arjun	Arjunwad (Seasonal)	Krishna	P.India	12280	690(1422)	43	50	933	585
kris_bawap	Bawapuram	Krishna	P.India	66893	596(1830)	47	46	774	598
kris_byala	Byaladahalli	Krishna	P.India	2508	650(1016)	47	48	788	570
kris_chola	Cholachugudda	Krishna	P.India	9939	632(1000)	54	40	694	607
kris_damer	Dameracherla	Krishna	P.India	11312	458(720)	63	27	802	567
kris_daund	Daund	Krishna	P.India	11439	640(1434)	42	47	1117	542

Continued on next page

Table S2.2 – continued from previous page

GHI ID	Site	Basin	Region	Area	Elev	%Crop	%Forest	P (mm)	ET (mm)
kris_deosu	Deosugur	Krishna	P.India	126250	575(1434)	58	36	758	554
kris_halia	Halia	Krishna	P.India	3284	293(689)	63	34	777	553
kris_haral	Haralahalli	Krishna	P.India	14654	653(1814)	28	67	1292	775
kris_holeh	Holehonnur	Krishna	P.India	3443	786(1814)	8	88	1578	950
kris_huvin	Huvinhedigi	Krishna	P.India	54166	611(1422)	52	41	770	602
kris_jeewa	Jeewangi	Krishna	P.India	1943	545(720)	63	33	828	571
kris_kagra	K. Agraharam	Krishna	P.India	129542	572(1434)	58	36	755	554
kris_karad	Karad	Krishna	P.India	5432	737(1422)	33	59	1138	618
kris_keesa	Keesara	Krishna	P.India	10545	177(732)	60	36	1048	634
kris_kello	Kellodu	Krishna	P.India	4297	798(1830)	41	53	643	593
kris_kokan	Kokangaon	Krishna	P.India	1483	572(752)	62	31	507	517
kris_kuppe	Kuppellur	Krishna	P.India	2062	640(974)	35	61	1037	711
kris_kurun	Kurundwad	Krishna	P.India	15265	670(1422)	42	50	1007	599
kris_madhi	Madhira	Krishna	P.India	1685	111(640)	59	38	1072	654
kris_malkh	Malkhed	Krishna	P.India	8380	540(720)	66	31	772	565
kris_mantr	Mantralayam	Krishna	P.India	64701	601(1830)	46	47	777	601
kris_marol	Marol	Krishna	P.India	5183	587(791)	40	55	1085	711
kris_mudho	Mudhol	Krishna	P.India	6773	679(1040)	47	47	878	679
kris_narsi	Narsingpur	Krishna	P.India	22326	609(1434)	48	43	933	531
kris_naval	Navalagund	Krishna	P.India	3079	634(836)	57	37	623	593
kris_oolle	Oollenur	Krishna	P.India	32961	607(1814)	40	54	973	685
kris_paler	Paleru Bridge	Krishna	P.India	2489	189(414)	73	23	950	611
kris_phulg	Phulgaon (Seasonal)	Krishna	P.India	2142	659(1198)	34	54	1517	577
kris_sadal	Sadalga (Seasonal)	Krishna	P.India	2285	605(1020)	38	56	958	692
kris_samdo	Samdoli (Seasonal)	Krishna	P.India	2010	618(1102)	36	58	1084	632
kris_sarat	Sarati	Krishna	P.India	6807	615(1364)	51	42	832	510
kris_shimo	Shimoga	Krishna	P.India	2761	672(1431)	5	92	2304	1020
kris_shird	Shirdhon	Krishna	P.India	611	533(700)	60	32	544	509
kris_takli	Takli	Krishna	P.India	33532	587(1434)	53	39	813	524
kris_talik	Talikot	Krishna	P.India	2434	599(744)	77	20	558	537
kris_terwa	Terwad (Seasonal)	Krishna	P.India	2444	598(1002)	31	59	1469	673
kris_trama	T. Ramapuram (Seasonal)	Krishna	P.India	23527	646(1830)	49	43	566	516
kris_wadak	Wadakbal	Krishna	P.India	12094	556(958)	66	29	681	475
kris_waden	Wadenapally	Krishna	P.India	240055	561(1830)	54	39	762	570
kris_warun	Warunjli	Krishna	P.India	1909	745(1396)	19	74	1435	676
kris_yadgi	Yadgir	Krishna	P.India	69779	547(1434)	61	33	752	519
maha_andhi	Andhiyarkhore	Mahanadi	P.India	2229	365(958)	52	45	1100	610
maha_bamni	Bamnidhi	Mahanadi	P.India	9860	477(1107)	35	60	1320	624
maha_baron	Baronda	Mahanadi	P.India	3238	439(916)	16	82	1239	656
maha_basan	Basantpur	Mahanadi	P.India	59091	333(1131)	49	46	1204	590
maha_ghato	Ghatora	Mahanadi	P.India	2965	377(1131)	36	61	1277	637
maha_jondh	Jondhra	Mahanadi	P.India	29822	314(1131)	57	38	1161	576
maha_kanta	Kantamal	Mahanadi	P.India	20374	298(1280)	36	62	1411	645
maha_kesin	Kesinga	Mahanadi	P.India	11956	296(1076)	41	56	1391	629
maha_kotni	Kotni	Mahanadi	P.India	7098	341(746)	54	40	1212	580
maha_kurub	Kurubhata	Mahanadi	P.India	4781	391(1138)	38	60	1332	610
maha_manen	Manendragarh	Mahanadi	P.India	1026	681(1018)	29	68	1268	648
maha_patha	Patharidih	Mahanadi	P.India	2484	306(445)	69	22	1164	543
maha_rajim	Rajim	Mahanadi	P.India	8511	419(916)	30	66	1251	631
maha_rampu	Rampur	Mahanadi	P.India	3451	320(808)	48	49	1187	570
maha_saleb	Salebhata	Mahanadi	P.India	4672	249(996)	54	43	1357	564
maha_seori	Seorinarayan	Mahanadi	P.India	48030	321(1131)	52	44	1180	583
maha_simga	Simga	Mahanadi	P.India	16903	317(852)	59	35	1162	560
maha_sunde	Sundergarh	Mahanadi	P.India	5937	479(1129)	43	55	1370	605
maha_tikar	Tikarapara	Mahanadi	P.India	126896	309(1280)	45	51	1310	615
mahi_chaka	Chakaliya	Mahi	P.India	3608	356(562)	50	46	872	404
mahi_dhari	Dhariawad	Mahi	P.India	1272	458(578)	48	50	760	423
mahi_khanp	Khanpur	Mahi	P.India	33306	300(972)	50	46	831	418
mahi_mataj	Mataji	Mahi	P.India	3769	459(581)	60	34	950	427
mahi_pader	Paderdibadi	Mahi	P.India	16472	399(972)	48	48	795	420
mahi_range	Rangeli	Mahi	P.India	8586	384(972)	43	54	678	412
narm_bamni	Bamni	Narmada	P.India	2579	581(883)	30	68	1232	601
narm_barma	Barmanghat	Narmada	P.India	26298	555(1128)	42	55	1226	562
narm_belkh	Belkheri	Narmada	P.India	1490	582(884)	46	52	1137	498
narm_chhid	Chhidgaon	Narmada	P.India	1765	512(789)	34	65	1205	521
narm_dhuls	Dhulsar	Narmada	P.India	787	316(565)	52	46	790	449
narm_dindo	Dindori	Narmada	P.India	2327	804(1128)	37	60	1242	613
narm_gadar	Gadarwara	Narmada	P.India	2232	634(1077)	33	64	1123	519
narm_garud	Garudeshwar	Narmada	P.India	87739	396(1286)	49	47	1069	517
narm_handi	Handia	Narmada	P.India	52734	470(1286)	46	51	1212	542
narm_hosha	Hoshangabad	Narmada	P.India	45142	490(1286)	44	53	1218	548
narm_kogao	Kogaon	Narmada	P.India	3934	325(928)	60	37	798	465
narm_mand2	Mandleshwar	Narmada	P.India	72673	416(1286)	49	47	1129	529
narm_manot	Manot	Narmada	P.India	4943	760(1128)	37	60	1228	604
narm_mohga	Mohgaoan	Narmada	P.India	3998	677(996)	28	70	1230	616
narm_morta	Mortakka	Narmada	P.India	66679	428(1286)	48	49	1158	534
narm_patan	Patan	Narmada	P.India	4088	408(732)	58	38	1197	501
narm_patix	Pati	Narmada	P.India	1668	437(966)	47	48	733	441
narm_sandi	Sandia	Narmada	P.India	32918	531(1184)	44	53	1209	550
penn_allad	Alladupalli	Pennar	P.India	8395	246(884)	48	46	759	581
penn_chenn	Chennur	Pennar	P.India	37721	431(1320)	46	46	660	538
penn_kamal	Kamalapuram	Pennar	P.India	7157	566(1241)	42	50	676	531
penn_nandi	Nandipalli	Pennar	P.India	2461	263(839)	33	62	815	617
penn_singa	Singavaram	Pennar	P.India	5960	540(1150)	44	47	619	529
penn_tadap	Tadapatri	Pennar	P.India	12473	543(1320)	48	43	583	515
saba_derol	Derol Bridge	Sabarmati	P.India	6396	392(1096)	39	58	706	436
saba_vauth	Vautha	Sabarmati	P.India	18325	163(1096)	52	43	780	412
sube_adity	Adityapur	Subernarekha	P.India	6350	281(913)	39	57	1398	649
sube_ghats	Ghatsila	Subernarekha	P.India	14291	286(980)	38	57	1308	649

Continued on next page

Table S2.2 – continued from previous page

GHI ID	Site	Basin	Region	Area	Elev	%Crop	%Forest	P (mm)	ET (mm)
sube_govin	Govindapur	Subernarekha	P.India	4450	100(1125)	31	67	1682	760
sube_jams1	Jamshedpur	Subernarekha	P.India	12785	299(980)	39	57	1293	650
tapi_burha	Burhanpur	Tapi	P.India	9070	489(1145)	39	60	1065	530
tapi_gopal	Gopalkheda	Tapi	P.India	8182	341(1144)	66	30	852	527
tapi_saran	Sarangkheda	Tapi	P.India	55842	349(1439)	59	37	806	509
tapi_yerli	Yerli	Tapi	P.India	15996	334(1144)	66	30	847	523
wfrn_durve	Durvesh	WFR North	P.India	2040	162(1036)	34	61	2609	589
wfrn_mahuw	Mahuwa	WFR North	P.India	1750	294(1295)	35	63	1277	549
wfrn_nanip	Nanipalson	WFR North	P.India	763	420(807)	34	62	1909	552
wfrn_ozerk	Ozerkheda	WFR North	P.India	678	386(1057)	33	64	2100	554
wfrs_addoo	Addoor	WFR South	P.India	719	103(1834)	4	94	3966	1207
wfrs_ambar	Ambarampalayam	WFR South	P.India	950	383(2450)	14	82	967	886
wfrs_arang	Arangaly	WFR South	P.India	1342	698(2253)	1	96	2382	1150
wfrs_avers	Avershe	WFR South	P.India	300	160(1104)	2	97	3903	1201
wfrs_ayila	Ayilam	WFR South	P.India	556	112(1443)	1	96	1564	1329
wfrs_bantw	Bantwal	WFR South	P.India	3295	161(1611)	2	96	3030	1176
wfrs_erinj	Erinjipuzha	WFR South	P.India	912	190(1374)	1	98	3735	1198
wfrs_halad	Halady	WFR South	P.India	566	251(865)	3	92	4075	1146
wfrs_kalam	Kalampur	WFR South	P.India	386	71(1038)	1	96	3017	1251
wfrs_kallo	Kallooppara	WFR South	P.India	733	104(1339)	1	96	3098	1234
wfrs_karat	Karathodu	WFR South	P.India	794	67(1241)	4	93	2266	1123
wfrs_kidan	Kidangoor	WFR South	P.India	618	83(1131)	2	95	3089	1226
wfrs_kumbi	Kumbidi	WFR South	P.India	5867	144(2450)	15	79	1508	982
wfrs_kuniy	Kuniyil	WFR South	P.India	2038	375(2516)	2	97	2108	1155
wfrs_kuzhi	Kuzhithurai	WFR South	P.India	739	134(1735)	2	94	1244	1164
wfrs_malak	Malakkara	WFR South	P.India	1650	412(1838)	1	97	1887	1229
wfrs_neele	Neeleswaram	WFR South	P.India	4150	933(2558)	1	96	1987	1156
wfrs_patta	Pattazhy	WFR South	P.India	1221	159(1711)	1	95	1862	1230
wfrs_perum	Perumannu	WFR South	P.India	1069	414(1546)	1	97	1974	1199
wfrs_pulam	Pulamanthole	WFR South	P.India	923	88(2294)	4	93	1749	1118
wfrs_ramam	Ramamangalam	WFR South	P.India	1482	56(1041)	3	92	3081	1270
wfrs_thump	Thumpamon	WFR South	P.India	839	172(1728)	1	97	1789	1276
wfrs_vandi	Vandiperiyar	WFR South	P.India	712	1088(1860)	1	96	1187	1069
wfrs_yenne	Yennehole	WFR South	P.India	357	101(1174)	1	97	3724	1247

S3 Precipitation

Graphics and tables on P datasets presented here include:

- maps of average annual P for WY 2007-2014;
- table showing basin-scale ratio of P from each product against IMD for WY 2007-2014;
- maps of monthly total P corresponding to three flooding events - Assam flooding of June 2012, Jammu and Kashmir flooding of September 2014 and Kerala flooding of August 2018; and
- time series of basin-averaged P for each product compared against IMD, and trends associated with such time series.

S3.1 Average Annual Precipitation, WY 2007-2014

For each of the 12 P products analyzed in this study, annual average P for the common eight year period of WY 2007-2014 is presented in Figures S3.1 to S3.12. It can be seen that all of the products have the broad spatial pattern of relatively wet Western Coast, Northeastern India and Northernmost India. The relatively dry regions of Northwestern India and interior Peninsular India are also evident in these maps.

The ratio of basin-averaged annual P between each product and IMD is presented in Table S3.1. The same common data period of WY 2007-2014 is used for estimating these ratios. A ratio greater (smaller) than 1.0 indicates that P from the particular product is higher (lower) than IMD. Across the whole of India, ERA5 and IMDAA have the highest ratios (1.15 and 1.31, respectively), while APHRO and GSMAP have the lowest ratios (0.91 and 0.90, respectively). In general, ERA5 and IMDAA have values greater than 1.0 for most river basins in India.

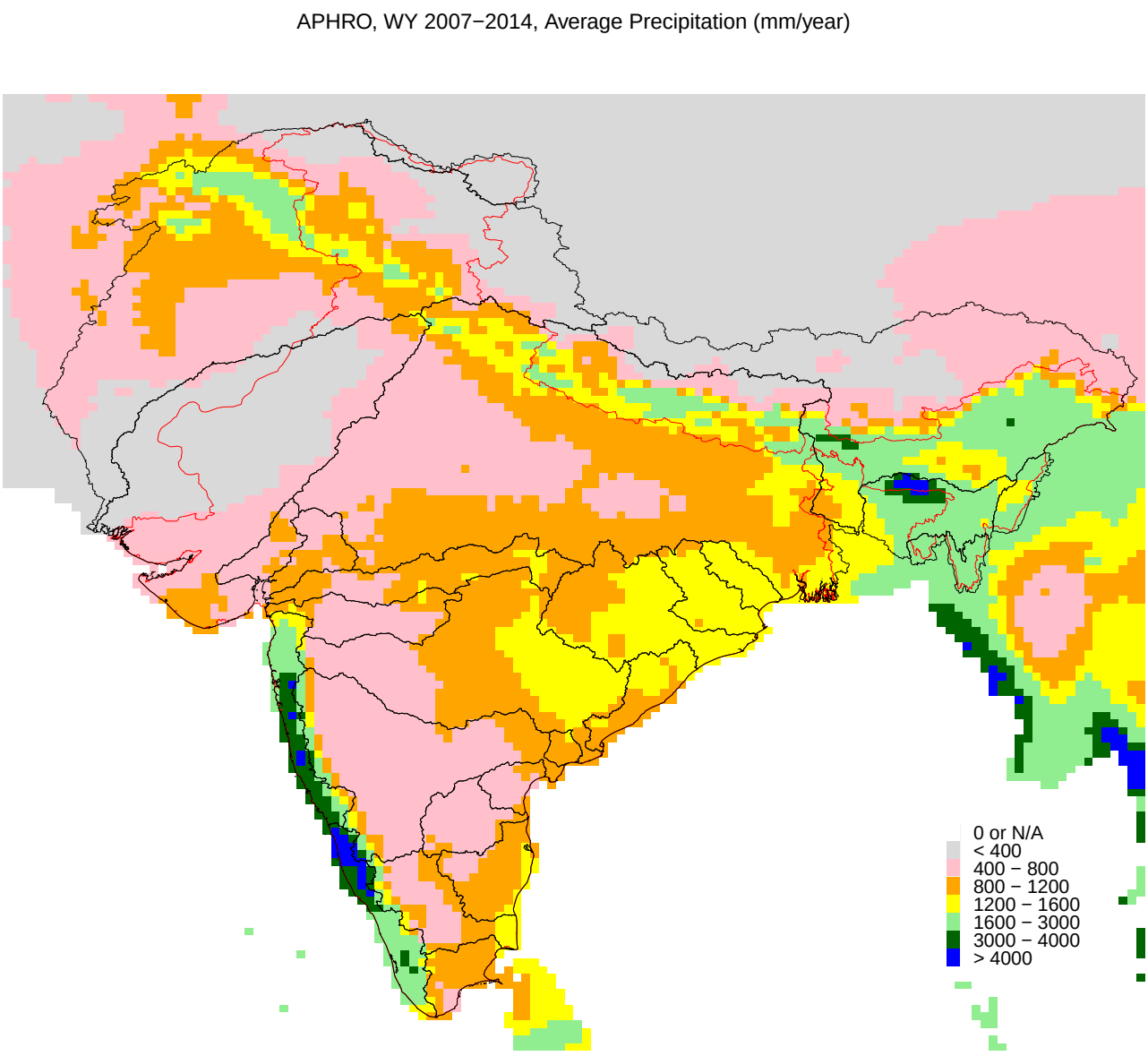


Figure S3.1: Annual average precipitation from APHRO.

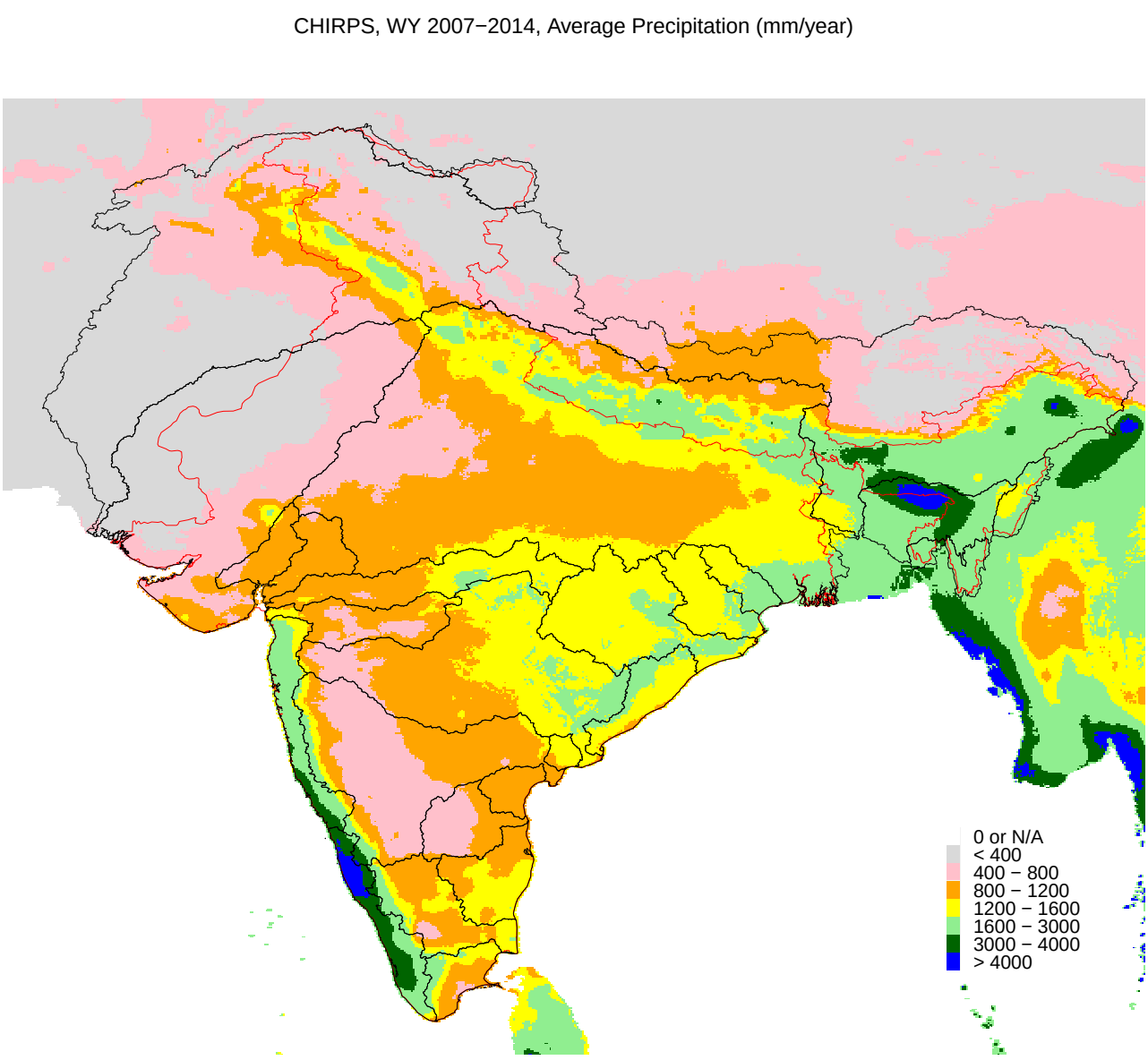


Figure S3.2: Annual average precipitation from CHIRPS.

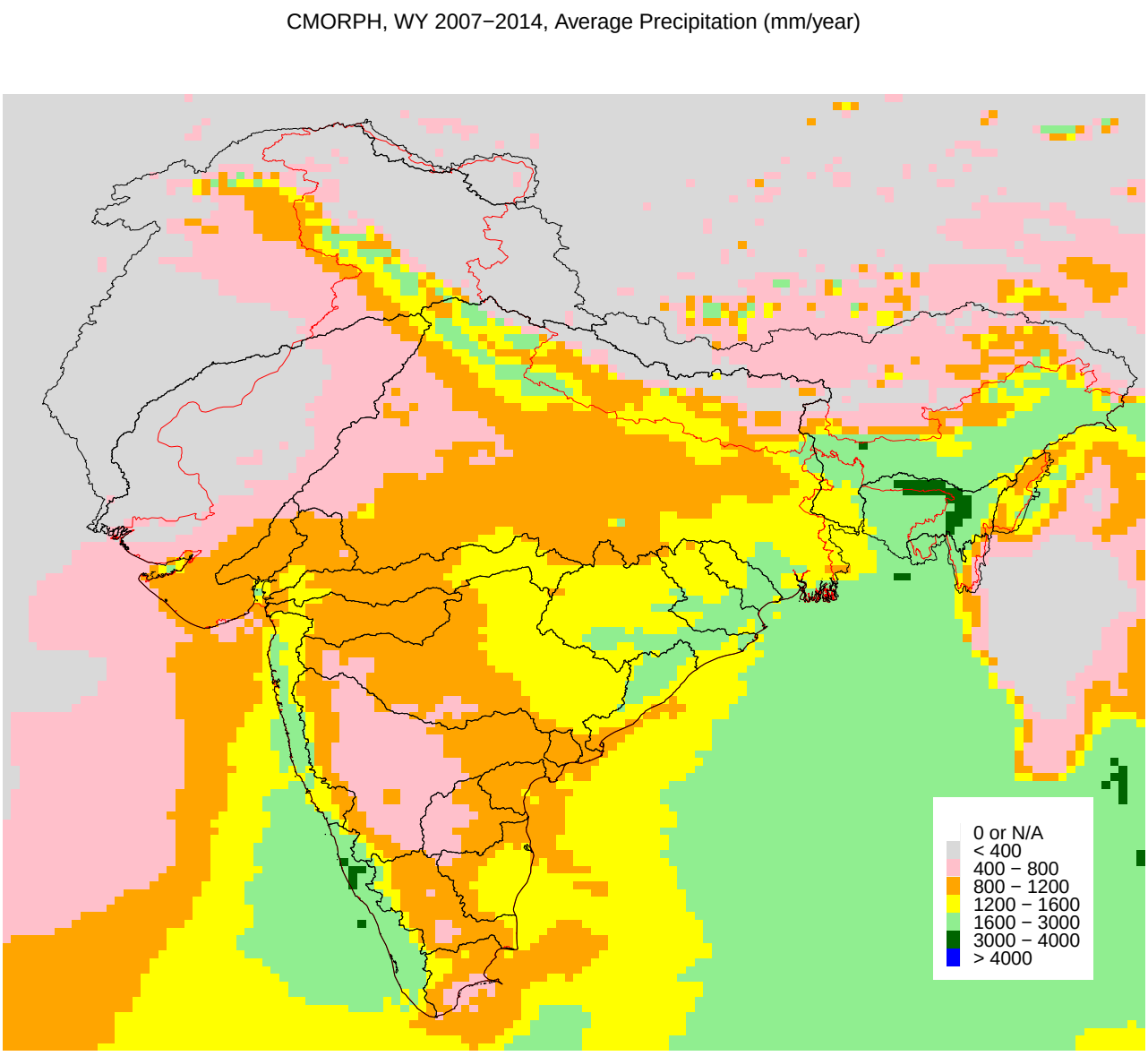


Figure S3.3: Annual average precipitation from CMORPH.

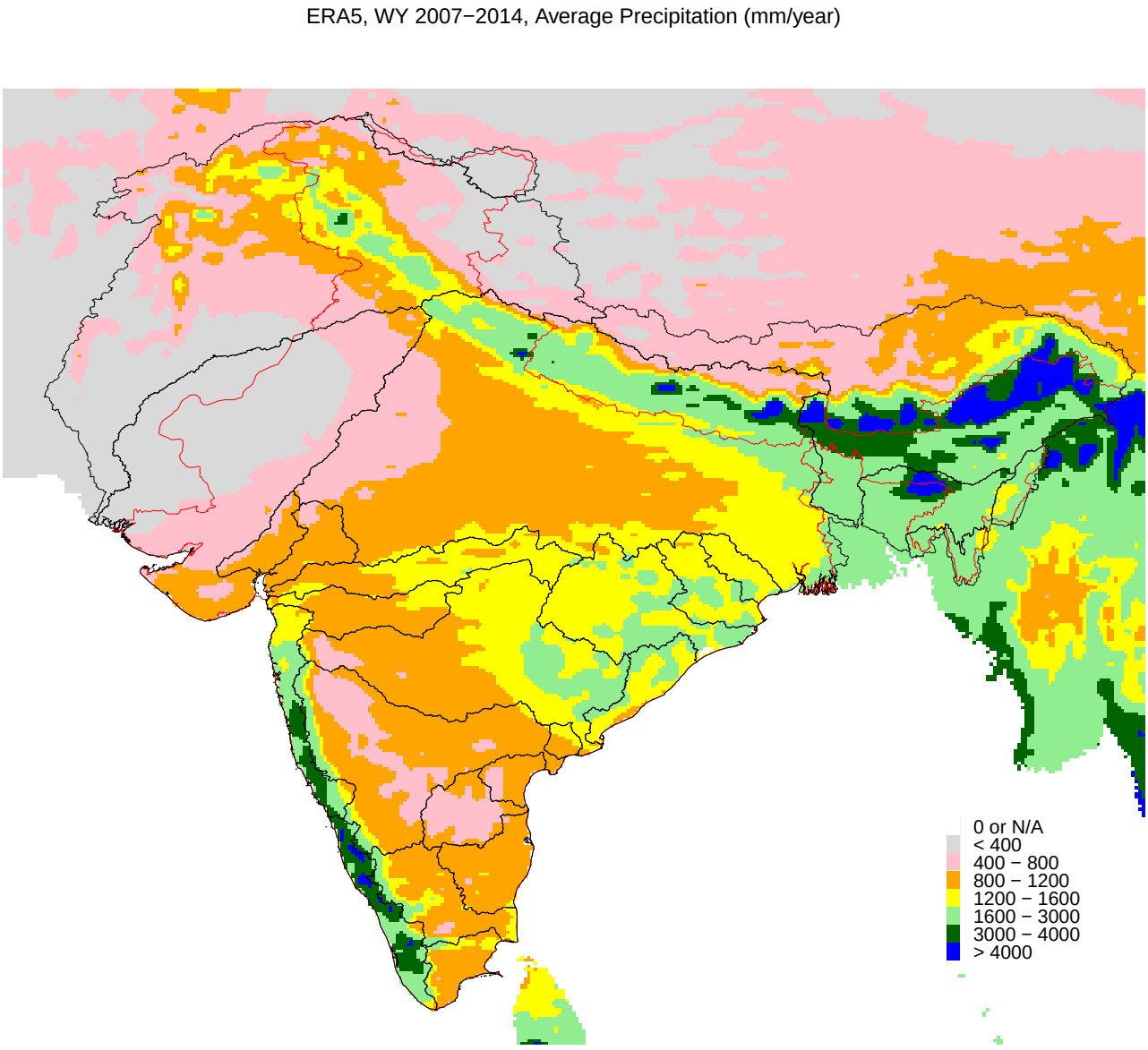


Figure S3.4: Annual average precipitation from ERA5.

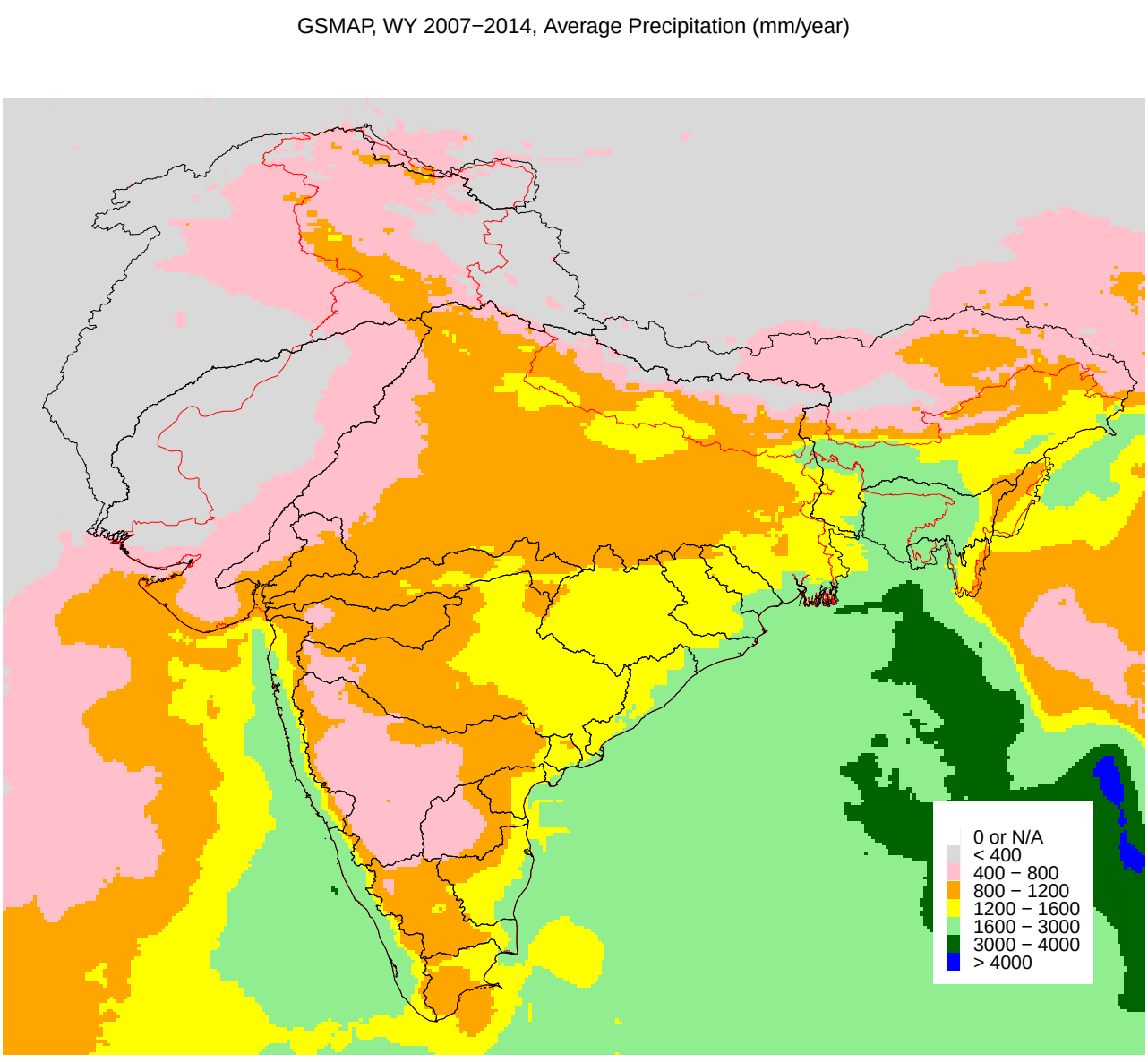


Figure S3.5: Annual average precipitation from GSMAP.

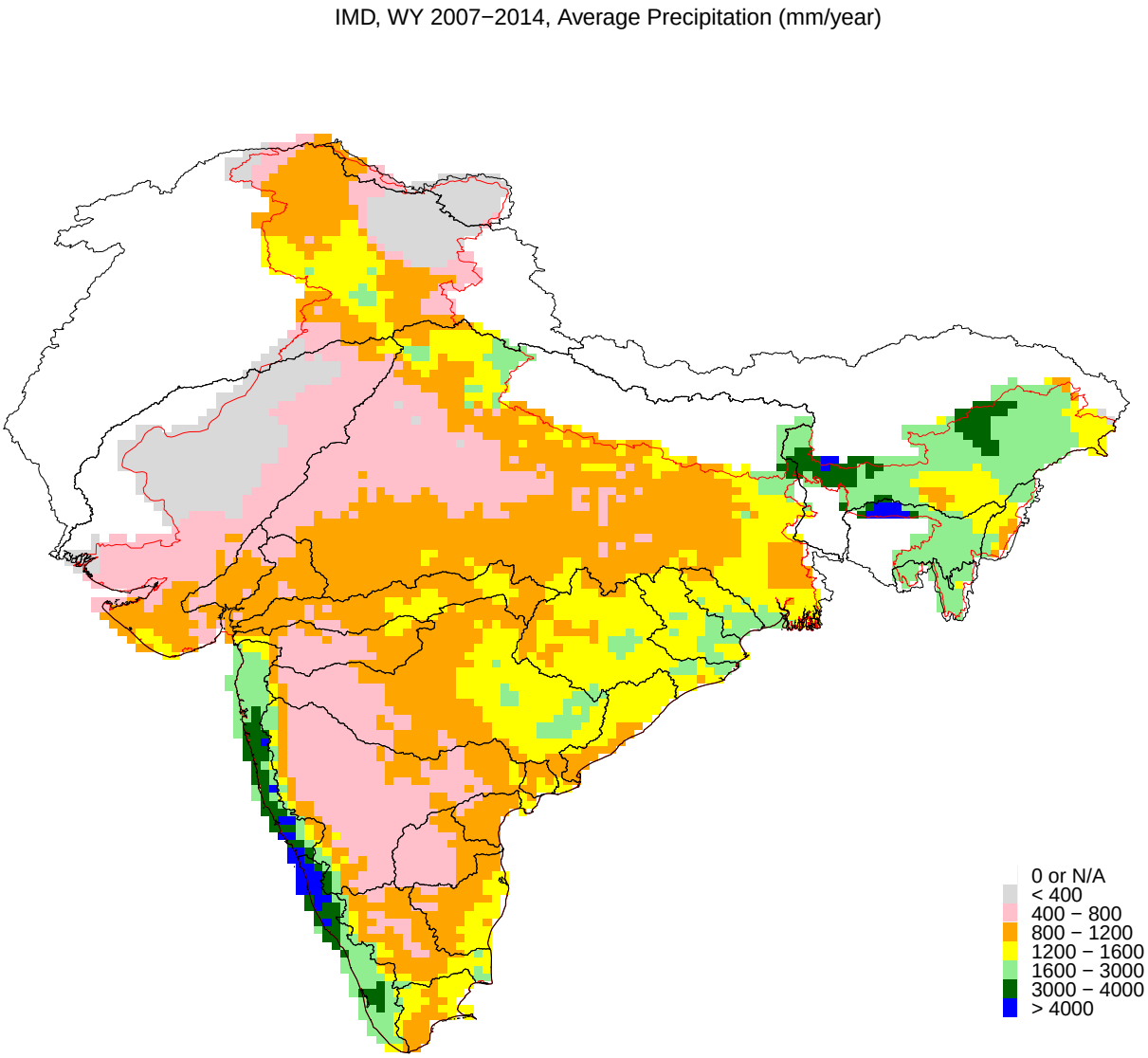


Figure S3.6: Annual average precipitation from IMD.

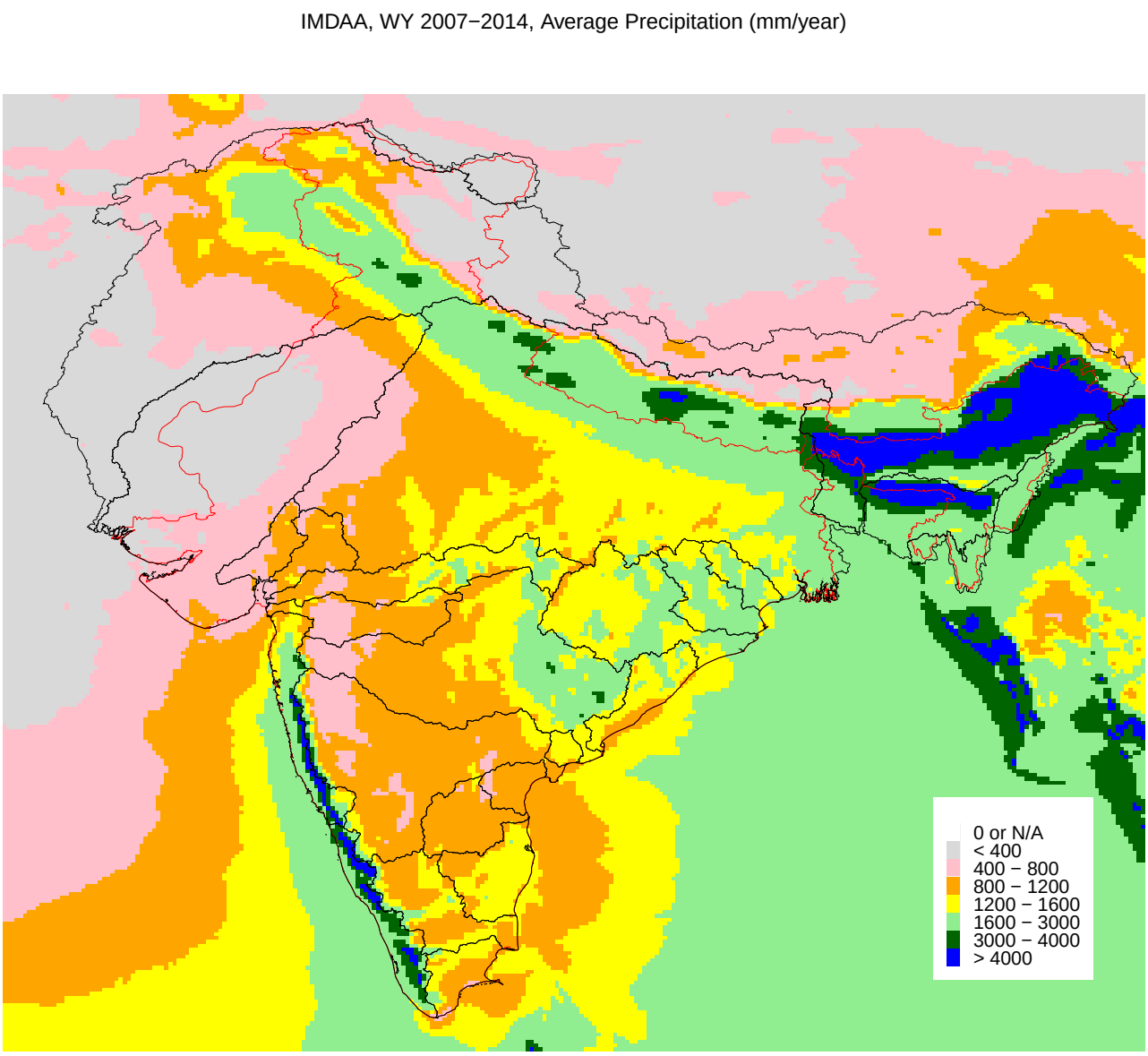


Figure S3.7: Annual average precipitation from IMDAA.

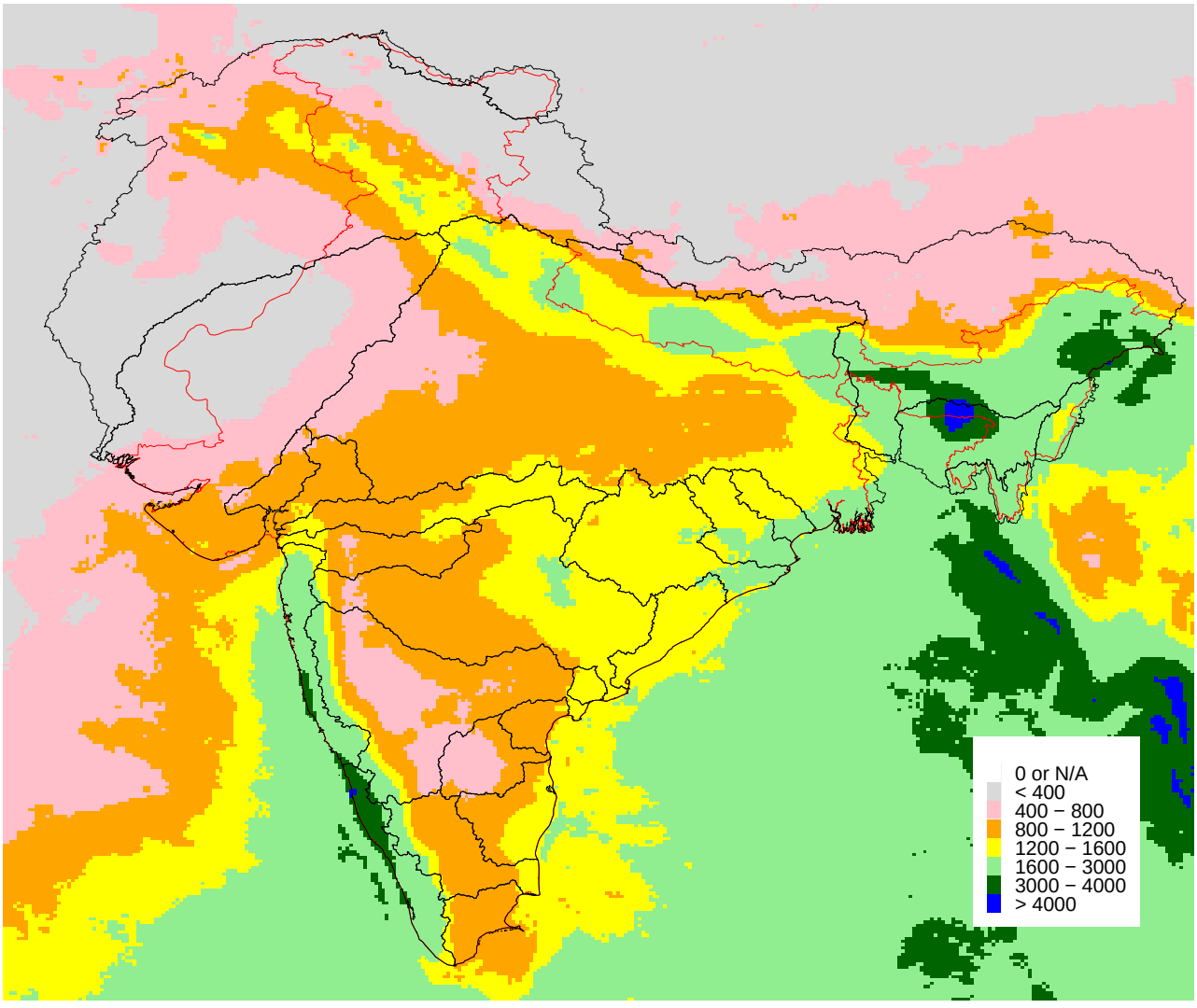


Figure S3.8: Annual average precipitation from IMERG.

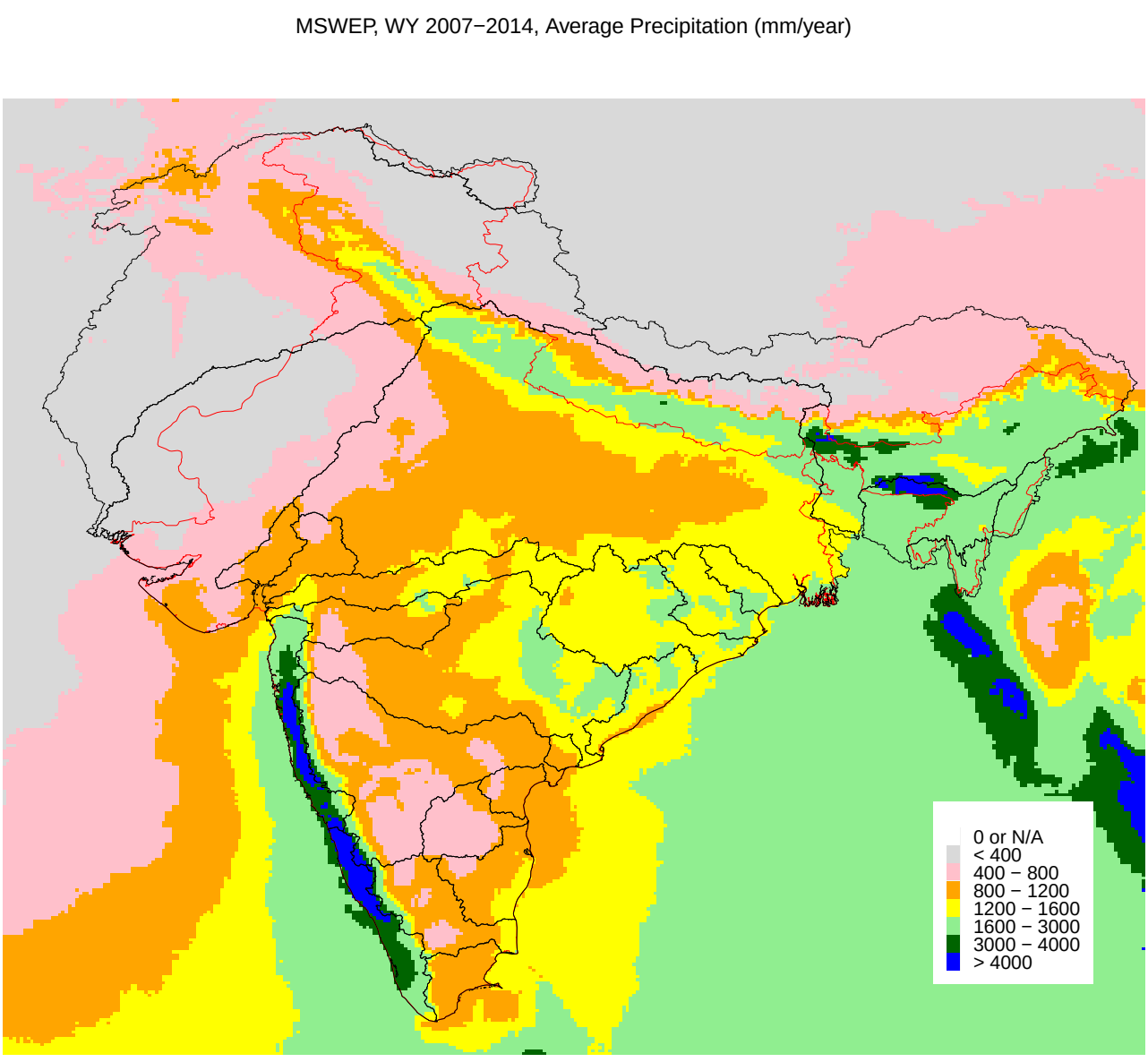


Figure S3.9: Annual average precipitation from MSWEP.

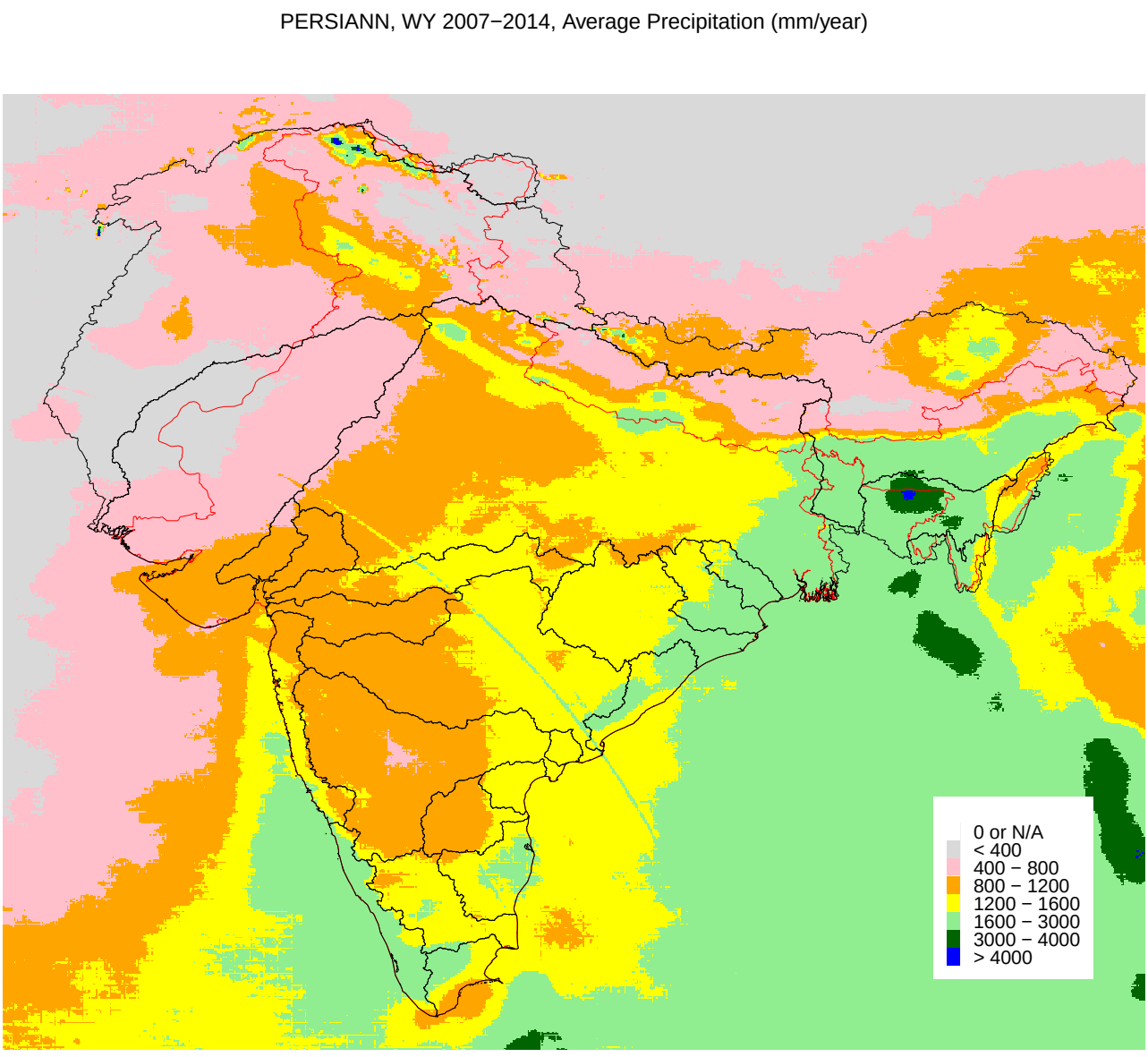


Figure S3.10: Annual average precipitation from PERSIANN.

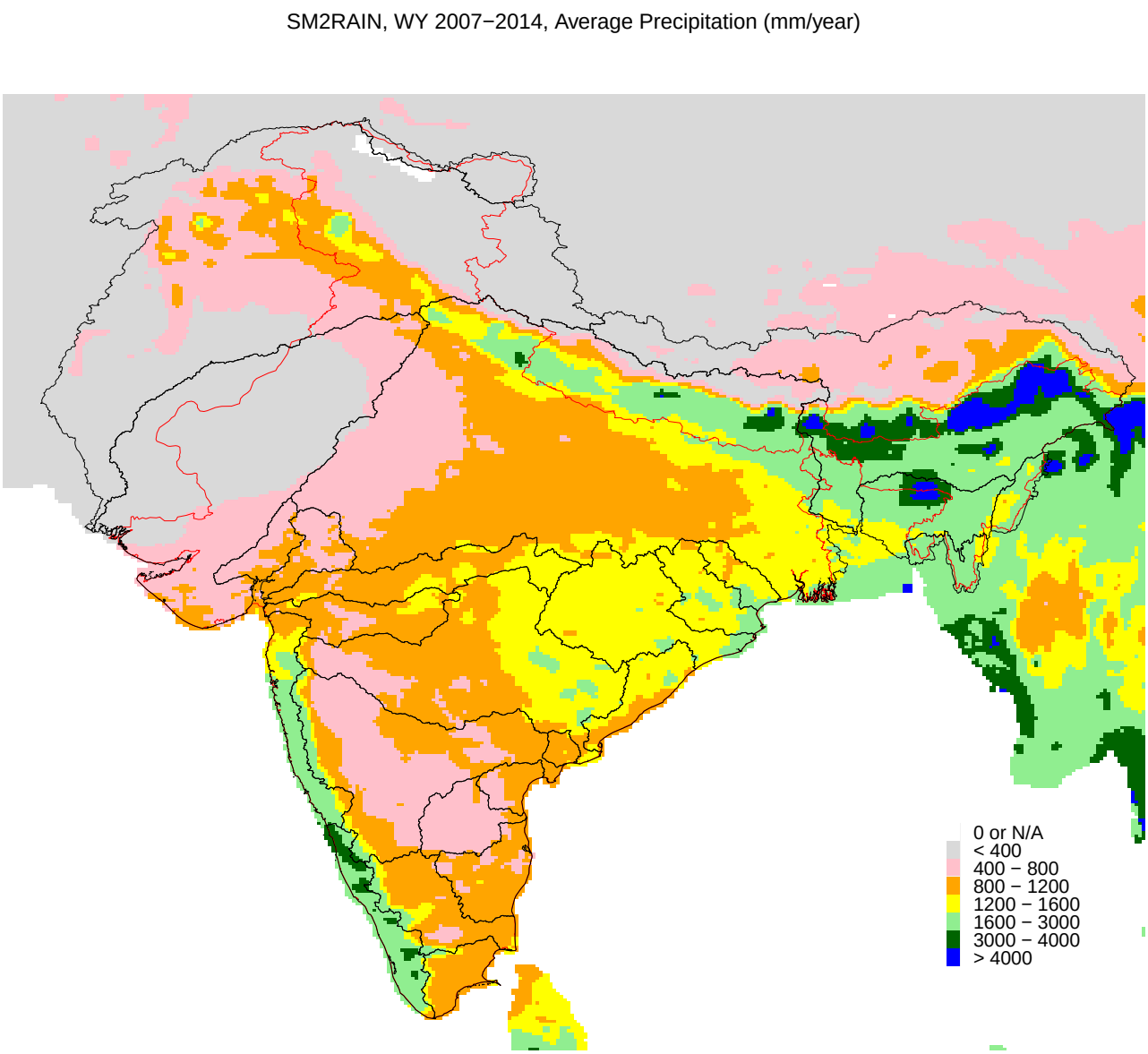


Figure S3.11: Annual average precipitation from SM2RAIN.

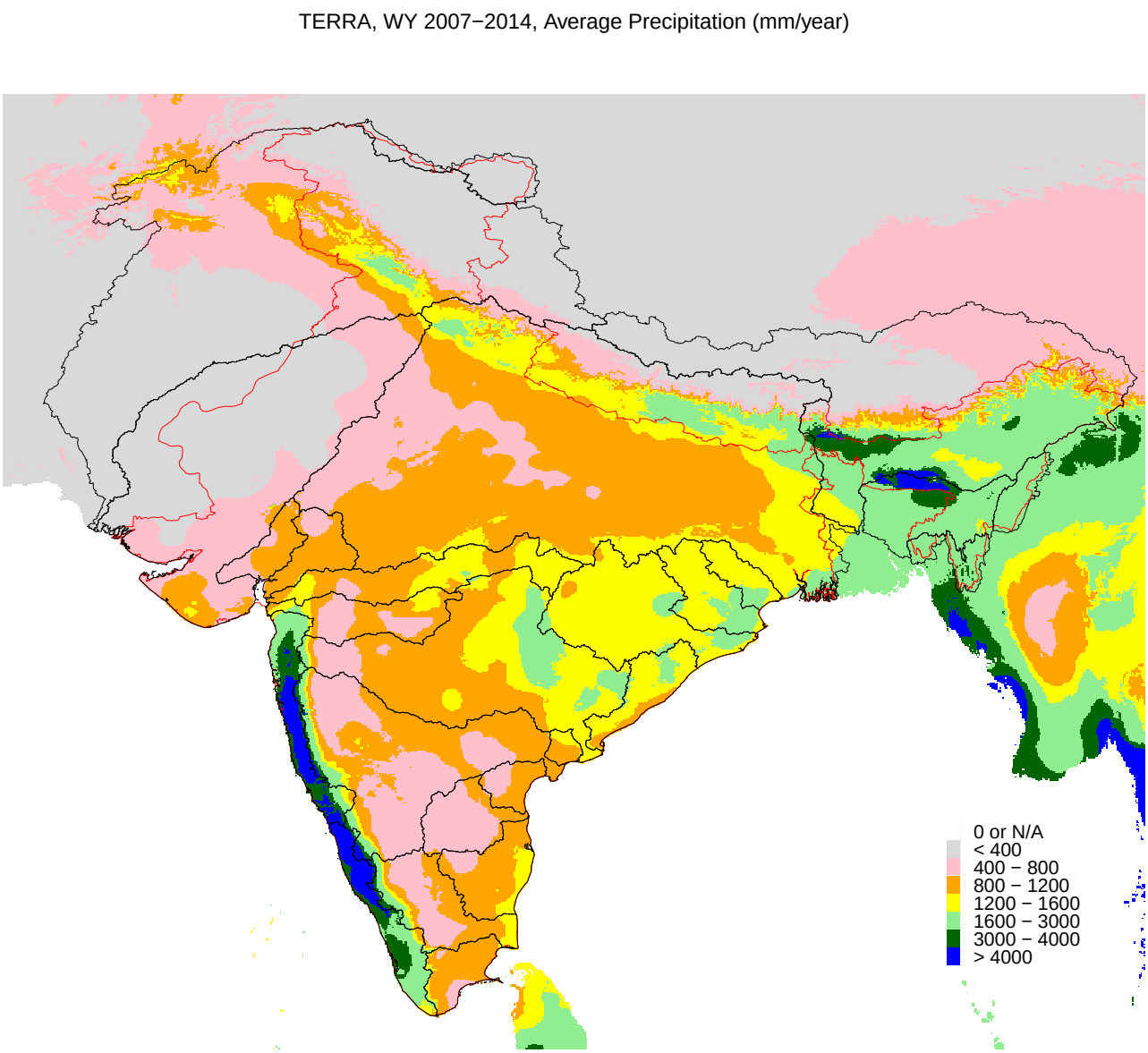


Figure S3.12: Annual average precipitation from TERRA.

Table S3.1: Annual P (mm/year) from IMD for WY 2007-2014, and the ratio of P from each dataset to P from IMD. Data is presented for each of the major river basins. The spatial domain is limited to the political boundaries of India where IMD data is available. Basin-scale aggregation of gridded P was performed only using the grids falling within India's boundaries.

Basin	IMD (mm)	APHRO	CHIRPS	CMORPH	ERA5	GSMAP	IMDAA	IMERG	MSWEP	PERSIANN	SM2RAIN	TERRA
All India	1,114	0.91	1.05	0.96	1.15	0.90	1.31	1.07	1.07	1.07	1.00	1.02
Barak	2,661	0.89	1.10	0.94	0.91	0.71	1.29	1.03	1.01	0.92	0.88	1.08
Brahmaputra	2,193	0.83	0.97	0.80	1.62	0.62	1.96	1.10	0.96	0.69	1.43	0.94
Ganga	983	0.91	1.14	1.09	1.18	1.03	1.44	1.16	1.16	1.24	1.06	1.03
Indus	886	0.82	0.71	0.60	1.07	0.67	1.33	0.76	0.68	0.90	0.53	0.59
Minor	1,681	1.10	1.23	0.84	1.13	0.81	1.32	1.23	1.33	1.00	1.09	1.38
North Ladakh	424	0.63	0.39	0.28	0.73	0.88	0.48	0.12	0.40	1.03	0.18	0.07
WFR Kutch	514	0.89	0.99	1.03	0.92	0.87	0.97	1.09	0.93	1.20	0.81	0.89
Brahmani-Baitarani	1,482	0.90	1.02	1.05	1.03	0.95	1.15	1.03	1.05	1.10	0.99	1.03
Cauvery	1,086	0.91	1.19	0.97	1.16	0.97	1.19	1.08	1.06	1.26	1.03	0.99
EFR North	1,127	0.93	1.15	1.18	1.13	1.26	1.13	1.14	1.14	1.39	1.02	1.08
EFR South	1,110	0.89	1.11	1.02	0.94	1.15	1.14	1.00	0.96	1.36	0.87	0.92
Godavari	1,116	0.91	1.12	1.02	1.13	1.02	1.23	1.09	1.12	1.11	1.01	1.11
Krishna	857	0.94	1.05	1.00	1.16	0.94	1.20	1.19	1.18	1.24	1.03	1.16
Mahanadi	1,343	0.93	1.12	1.10	1.13	1.04	1.16	1.09	1.11	1.12	1.06	1.08
Mahi	865	0.91	1.14	1.11	1.10	0.99	1.11	1.14	1.09	1.17	0.92	1.07
Narmada	1,079	0.92	1.15	1.09	1.15	1.01	1.16	1.10	1.14	1.15	1.04	1.08
Pennar	757	0.90	1.01	1.09	1.04	1.05	1.28	1.07	0.98	1.44	0.93	0.94
Sabarmati	837	0.91	1.15	1.19	1.00	0.91	0.97	1.09	1.03	1.13	0.93	0.99
Subernarekha	1,473	0.92	1.10	1.08	0.99	1.00	1.12	1.02	1.03	1.26	0.96	0.99
Tapi	856	0.91	1.08	1.20	1.27	1.10	1.07	1.20	1.18	1.25	1.14	1.08
WFR North	2,671	1.00	0.87	0.58	0.81	0.53	0.88	0.88	1.19	0.46	0.71	1.29
WFR South	2,906	0.99	1.07	0.76	1.01	0.59	1.06	0.91	1.23	0.68	0.87	1.16

S3.2 Select Flooding Events

Spatial maps of monthly gridded P from the various datasets for select major flooding events from the recent past are presented here. The events discussed here occurred in regions with mountainous terrain within the past 10 years and were identified from the Dartmouth Flood Observatory's global archive of major flood events (Brakenridge, 2023). These events include the flooding in the State of Assam (Northeastern India) in June 2012, flooding in the State of Jammu and Kashmir (Northernmost India) in September 2014, and flooding in the State of Kerala (Southwestern India) in August 2018.

For the Assam floods of 2012 (Figure S3.13), the heavy P cluster of greater than 1500 $mm/month$ present in IMD is also present in ERA5 and IMDAA. While the rest of the datasets have such a cluster to a smaller extent, CHIRPS and GSMAP do not have such a cluster. For the Jammu and Kashmir floods of 2014 (Figure S3.14), the heavy P cluster of 400-800 or greater than 800 $mm/month$ present in IMD is also present in several of the datasets. In some datasets, such as CHIRPS, IMERG and TERRA, the cluster is larger and contains P of higher magnitude than IMD. GSMAP, PERSIANN and SM2RAIN do not have such a cluster. For the Kerala floods of 2018 (Figure S3.15), the heavy P cluster of 1000-1500 or greater than 1500 $mm/month$ present in IMD is present only to a limited extent in IMDAA but absent in the rest of the datasets. While these maps correspond to unusually wet events, it is evident that there are substantial differences between the different datasets for such events.

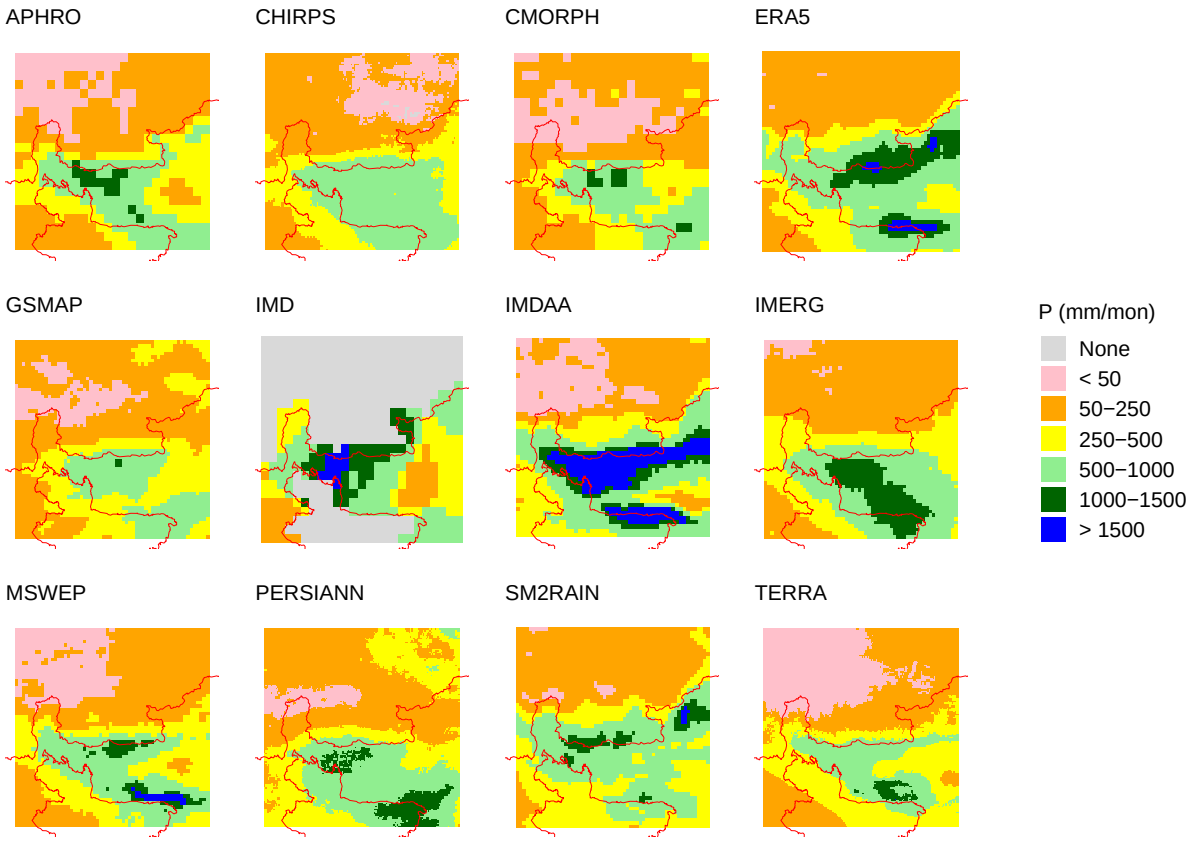


Figure S3.13: Total monthly P from various data sources for June 2012. Flooding in the state of Assam (Northeastern India) is the event of interest.

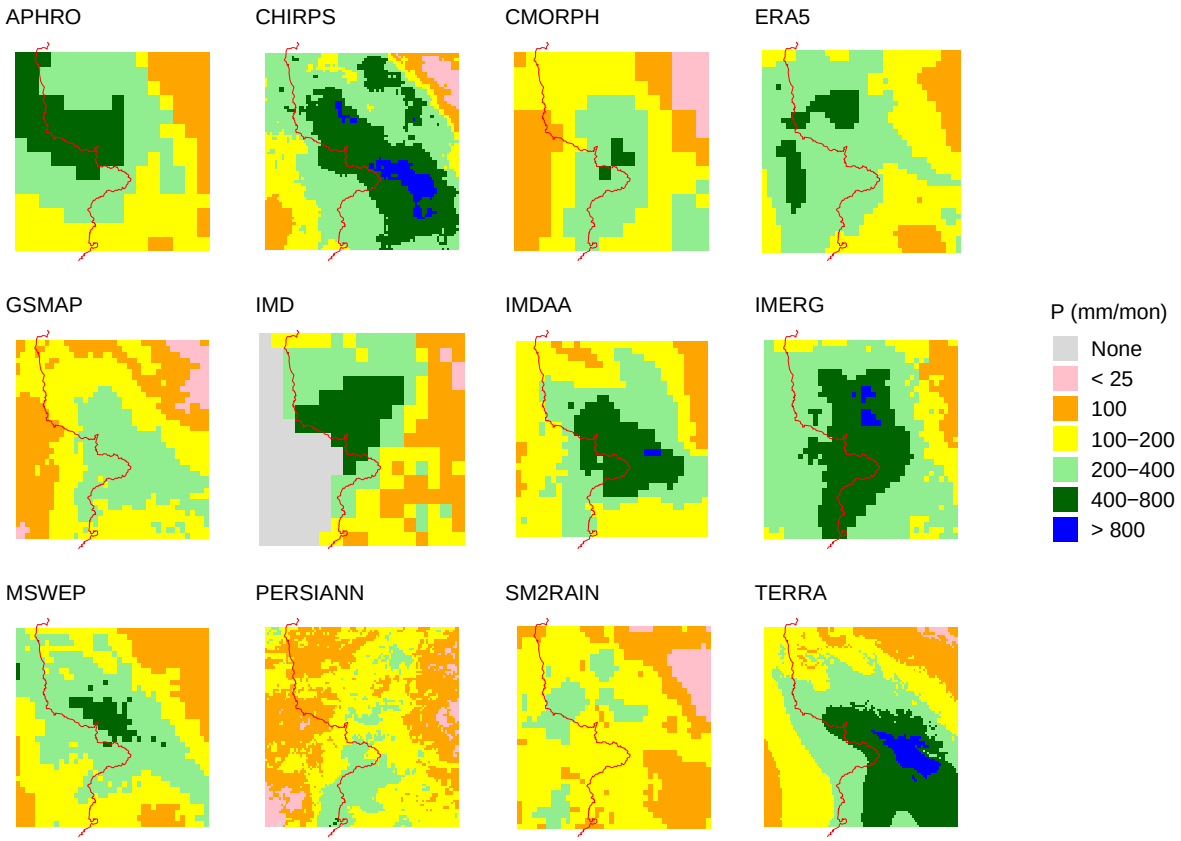


Figure S3.14: Total monthly P from various data sources for September 2014. Flooding in the state of Jammu and Kashmir (Northernmost India) is the event of interest.

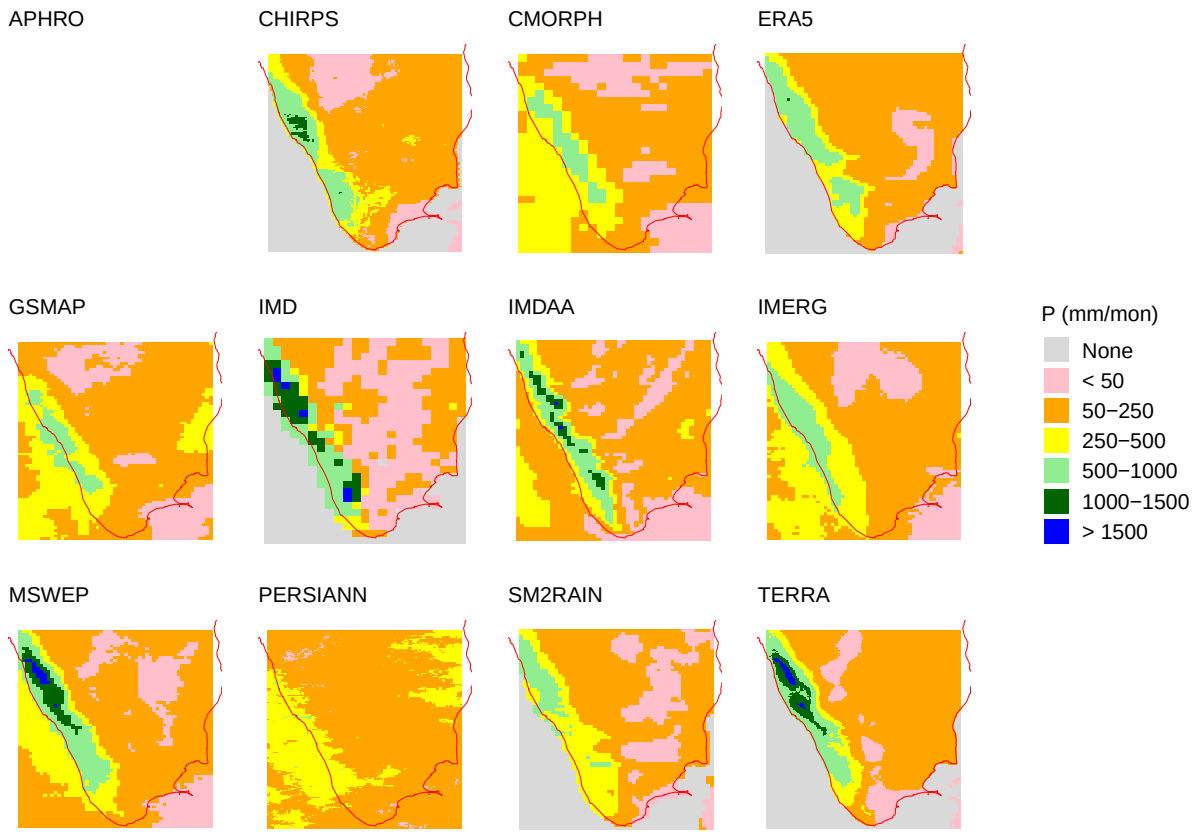


Figure S3.15: Total monthly P from various data sources for August 2018. Flooding in the state of Kerala (Southwestern India) is the event of interest. Data from APHRODITE is not available for WY 2018.

S3.3 Trends in Precipitation

Time series of area-averaged annual P from IMD is compared with the corresponding time series from other datasets in Figures S3.16 to S3.38. For the purposes of this comparison, all datasets were limited to the boundaries of India since IMD is limited to such boundaries (i.e., IMD-APHRO is not used here). Basin-scale aggregation of gridded P was performed only using the grids falling within India's boundaries. The 9-year running average is also shown for each of the datasets to highlight the temporal trends in each of the datasets. The trends presented are based only on the period WY 1985-2014, if data was available.

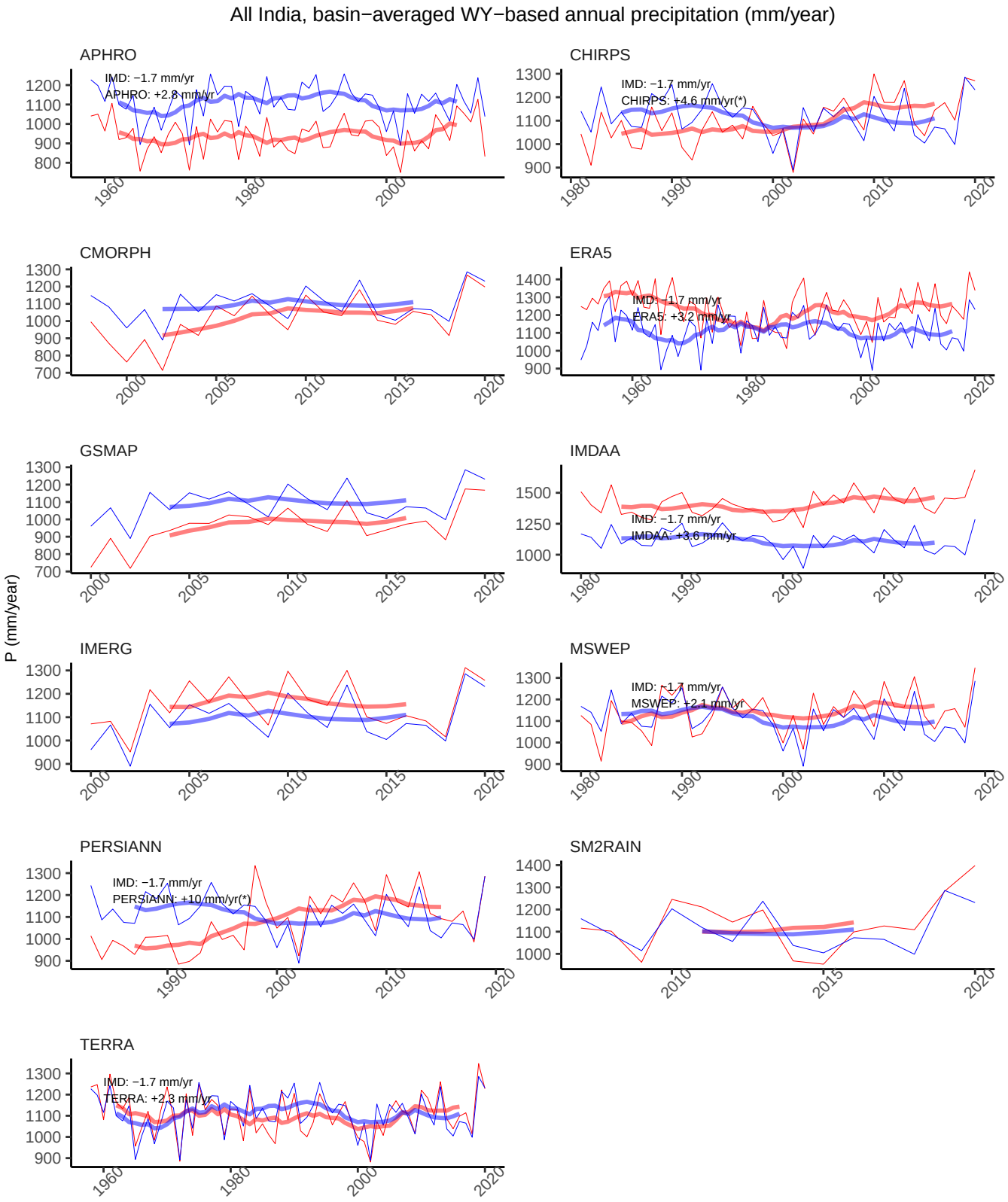


Figure S3.16: Annual P across India from IMD (blue) and other datasets (red). 9-year moving average values shown by the thick line. Theil-Sen slope for the period WY 1985-2014 is presented in units of mm/year, with statistically significant values indicated by '(*)'.

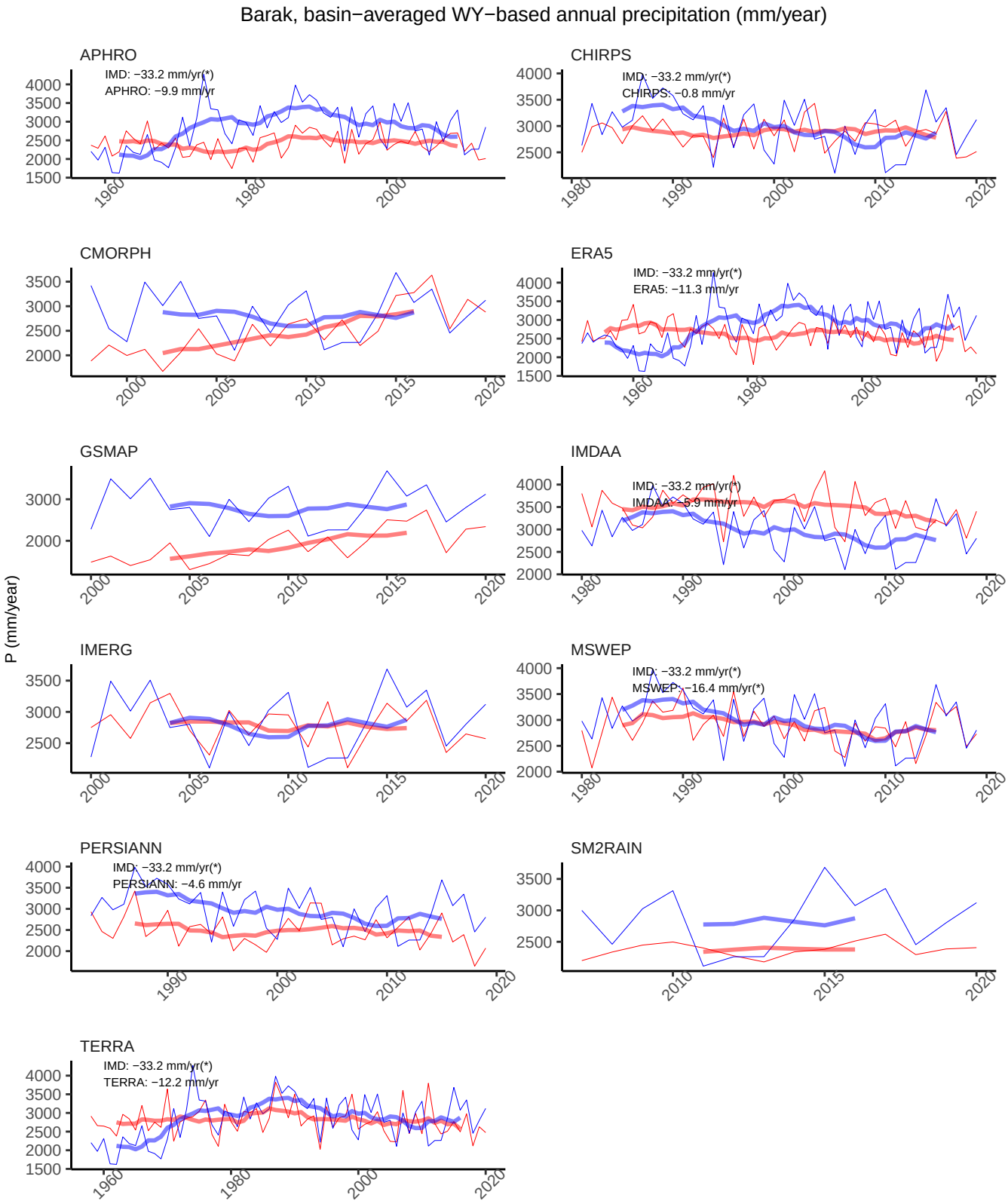


Figure S3.17: Same as Figure S3.16, except for the Barak Basin.

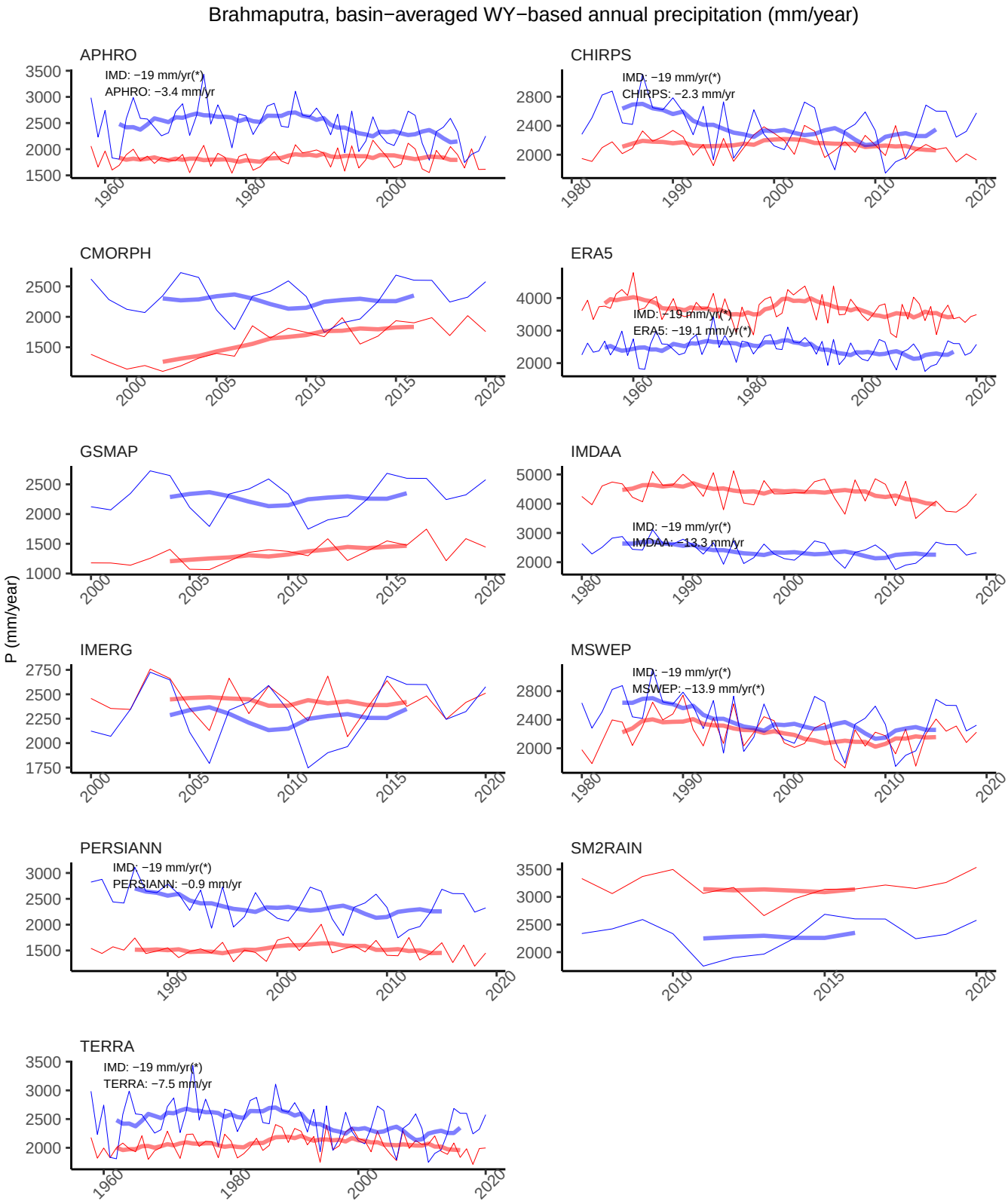


Figure S3.18: Same as Figure S3.16, except for the Brahmaputra Basin.

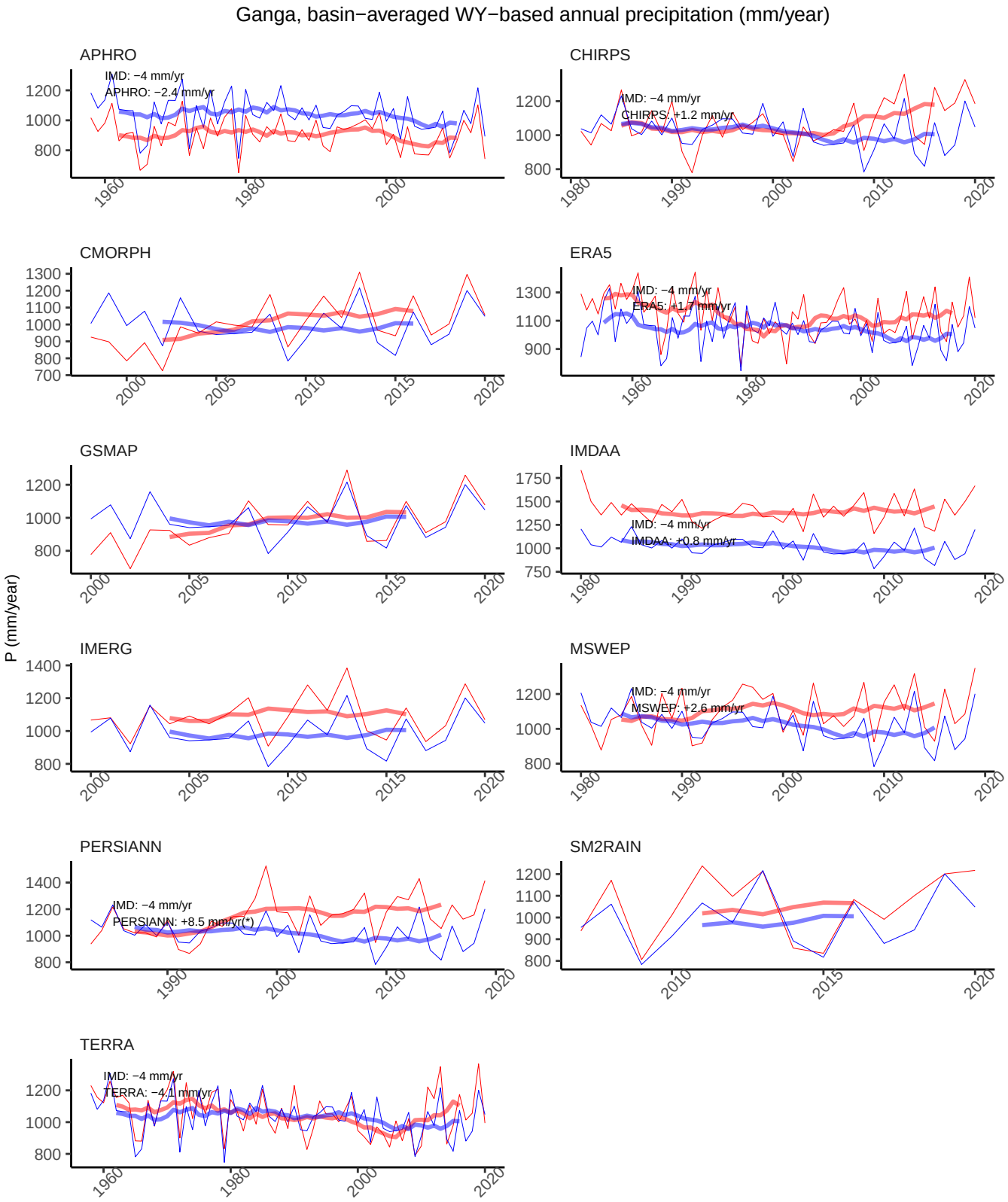


Figure S3.19: Same as Figure S3.16, except for the Ganga Basin.

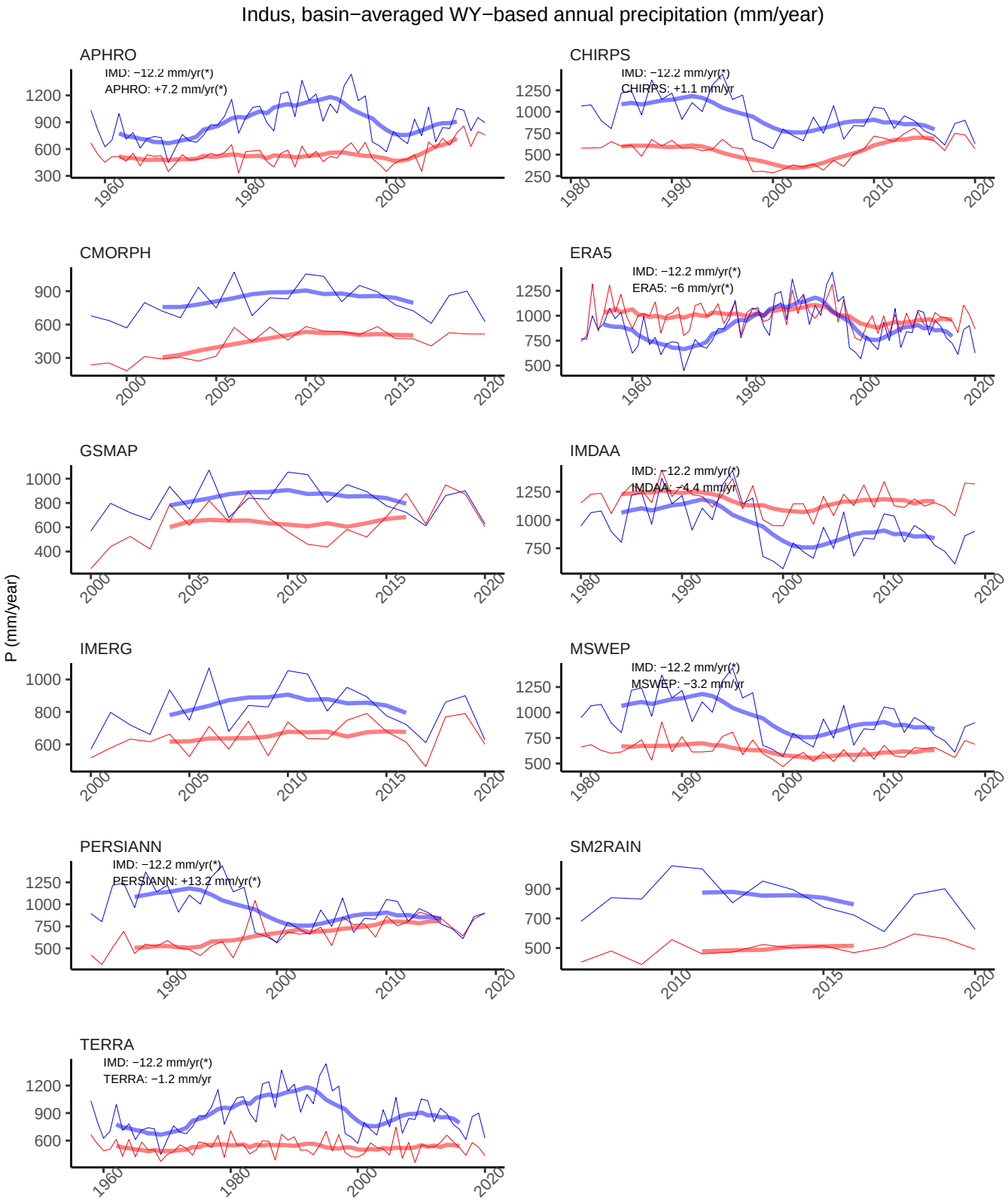


Figure S3.20: Same as Figure S3.16, except for the Indus Basin.

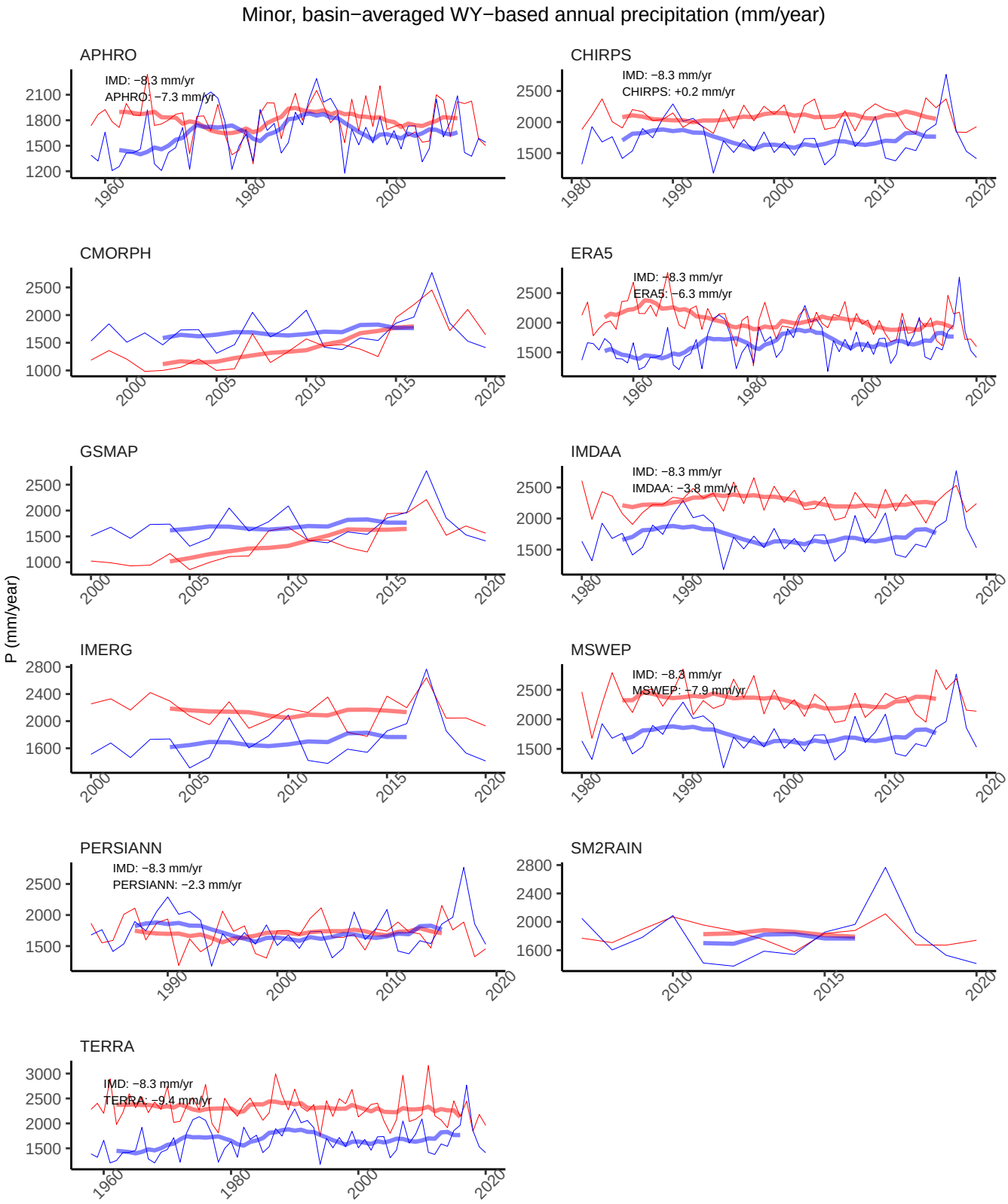


Figure S3.21: Same as Figure S3.16, except for the Minor Basin.

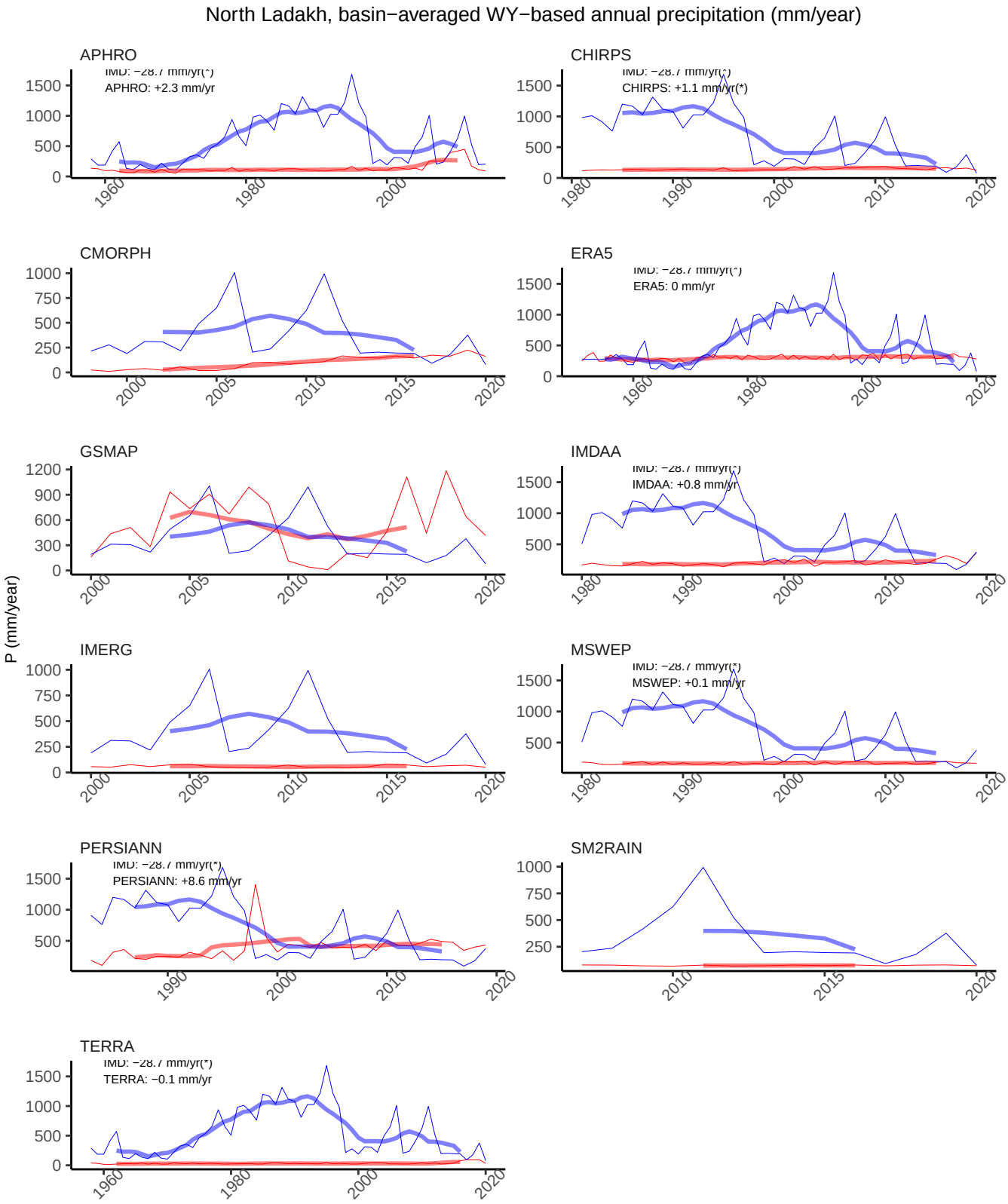


Figure S3.22: Same as Figure S3.16, except for the North Ladakh Basin.

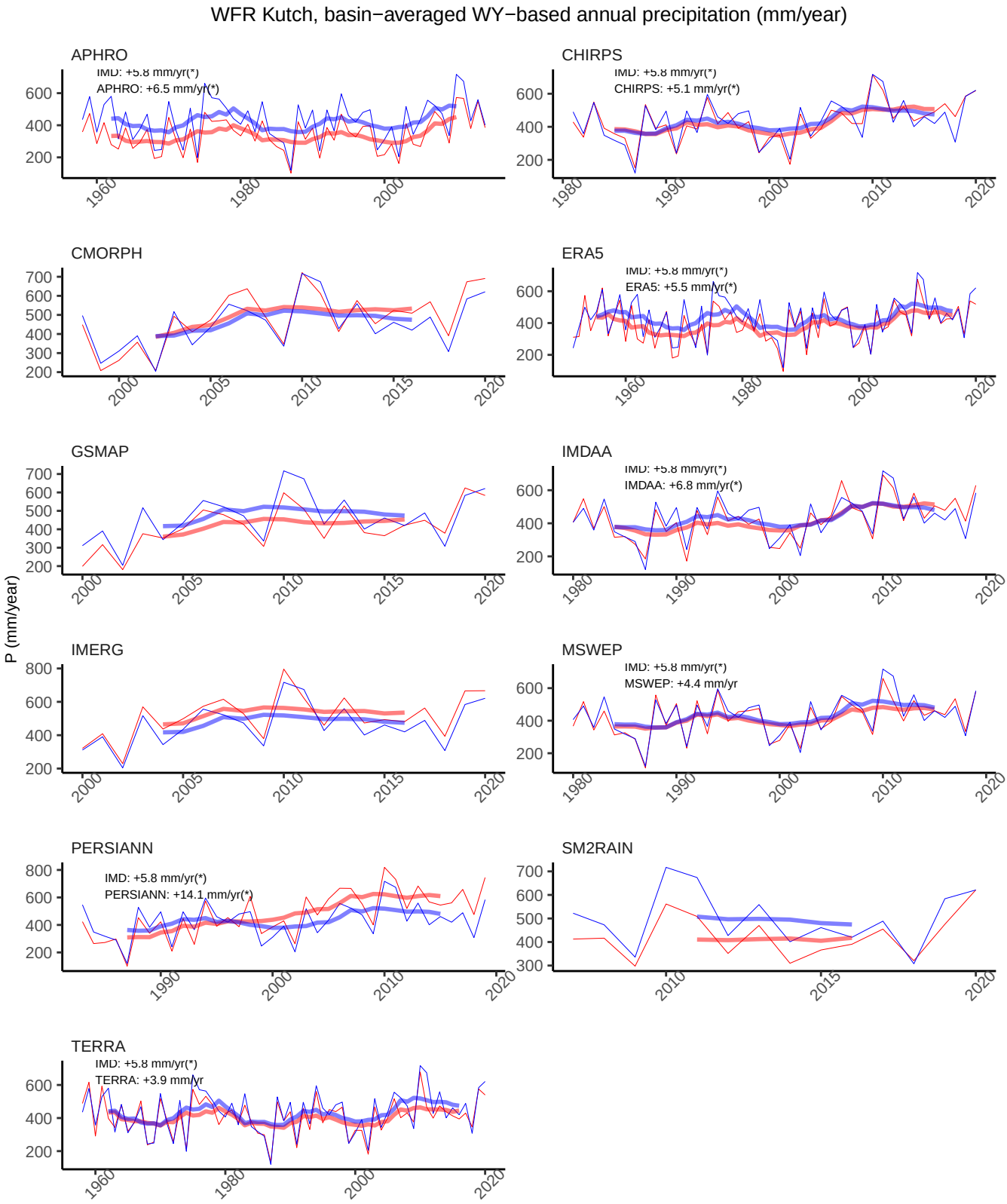


Figure S3.23: Same as Figure S3.16, except for the WFR Kutch Basin.

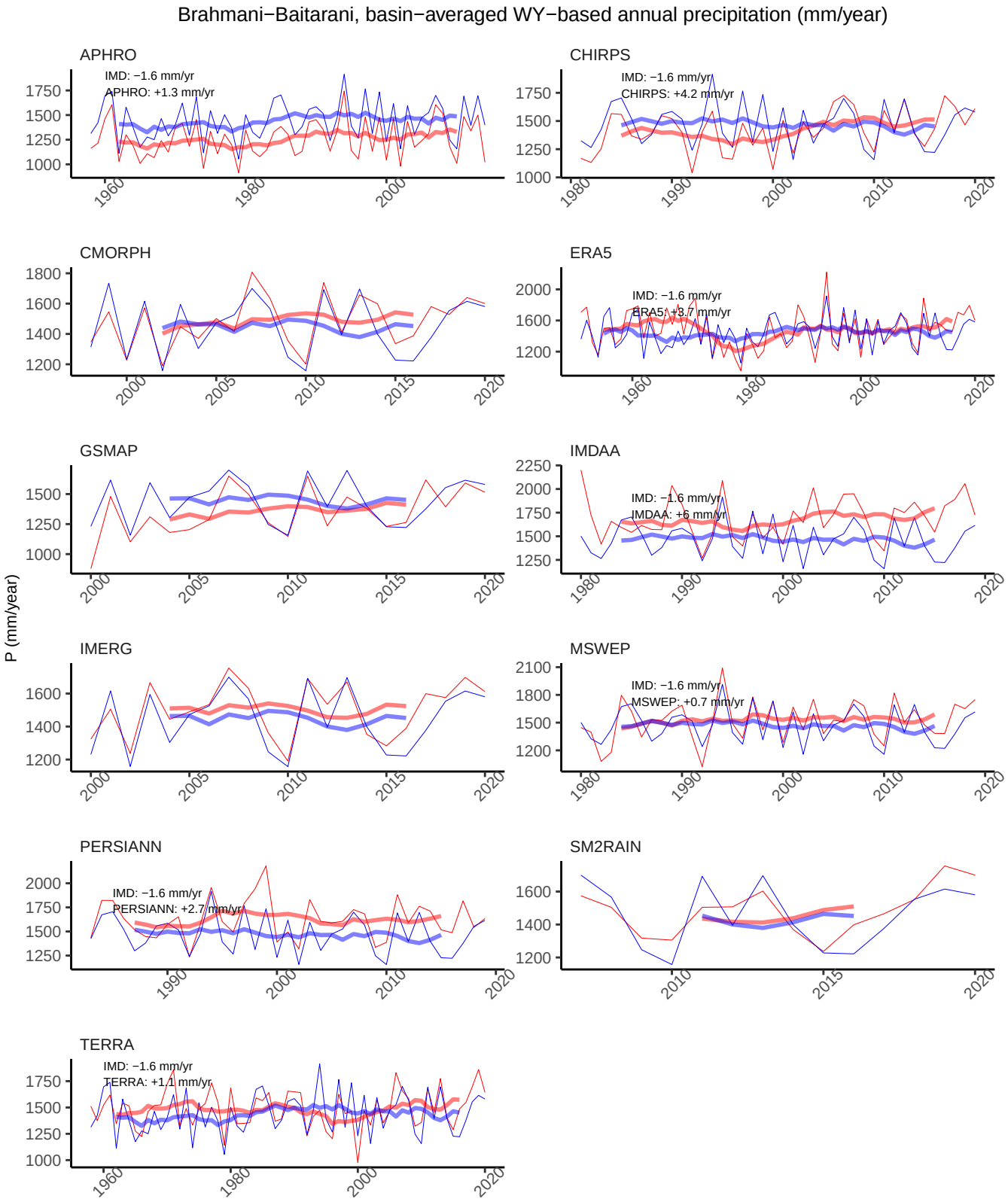


Figure S3.24: Same as Figure S3.16, except for the Brahmani-Baitarani Basin.

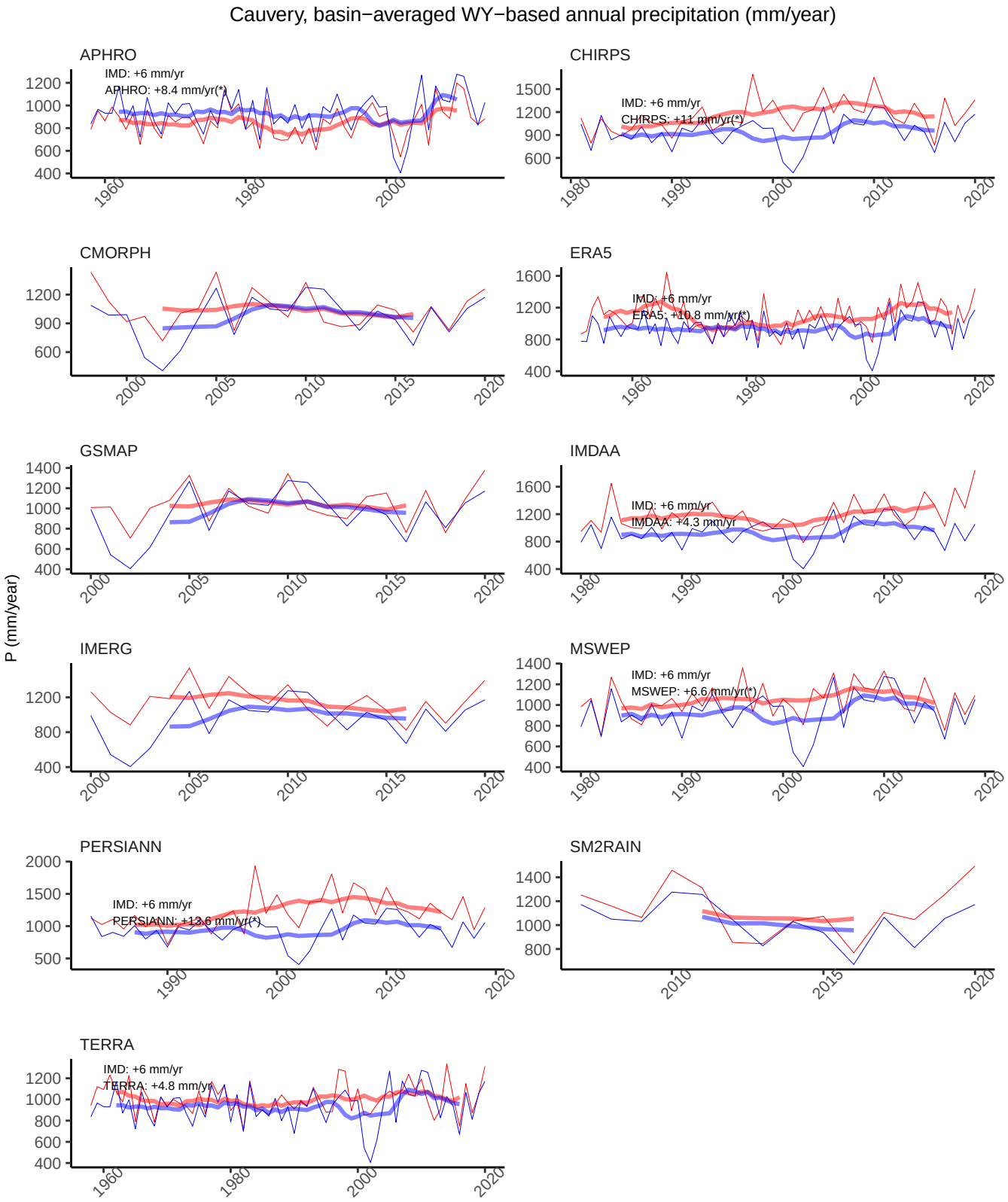


Figure S3.25: Same as Figure S3.16, except for the Cauvery Basin.

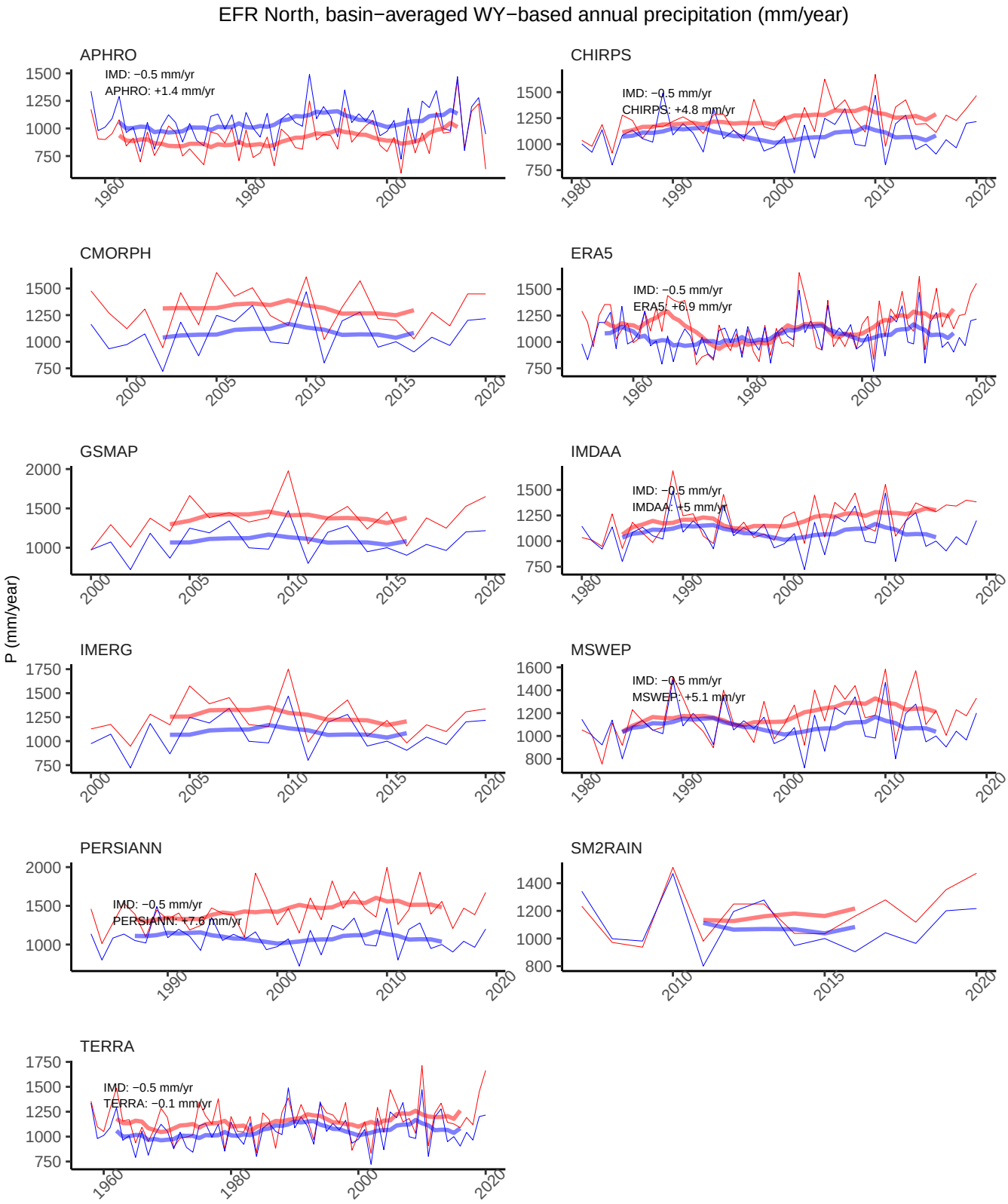


Figure S3.26: Same as Figure S3.16, except for the EFR North Basin.

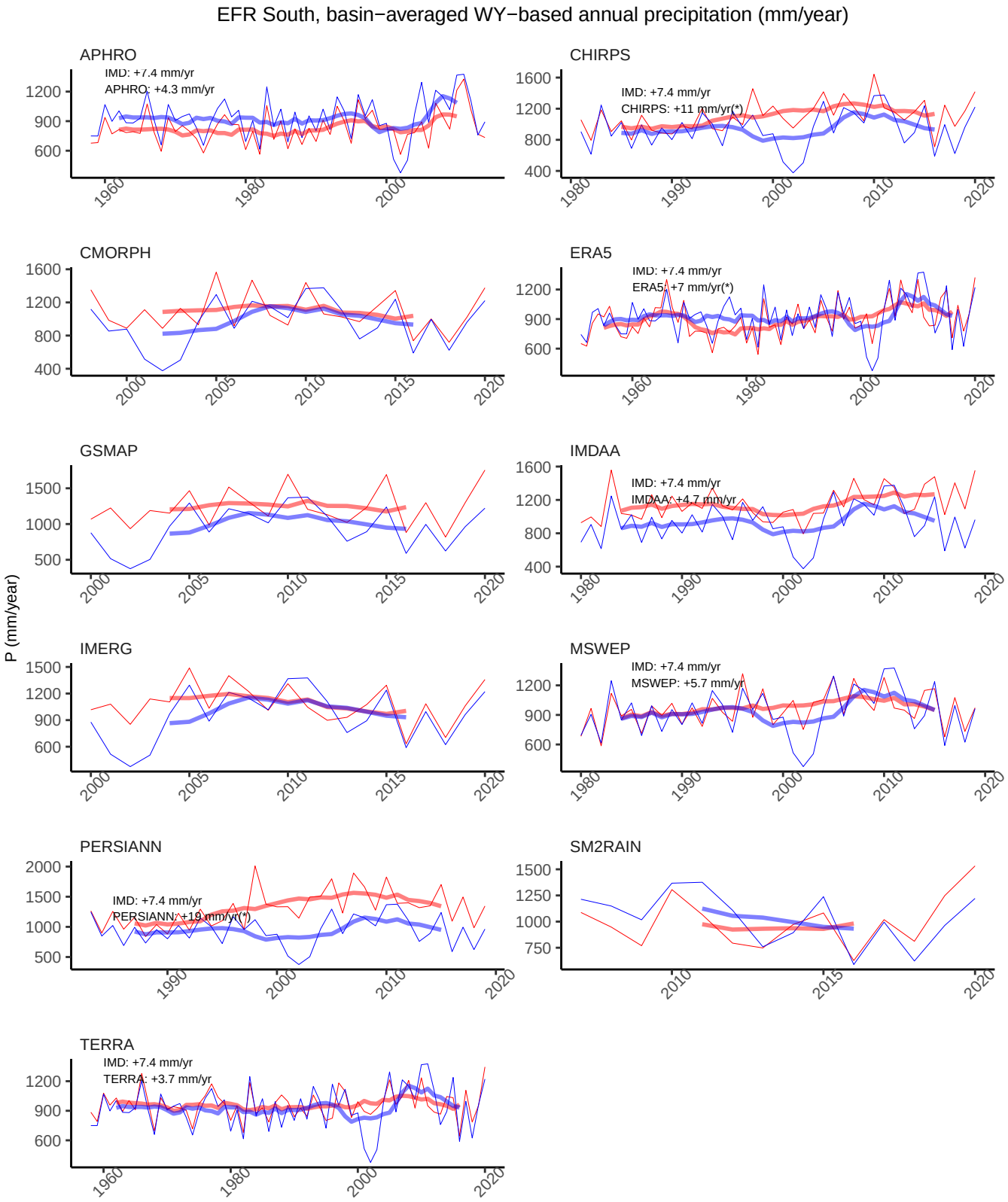


Figure S3.27: Same as Figure S3.16, except for the EFR South Basin.

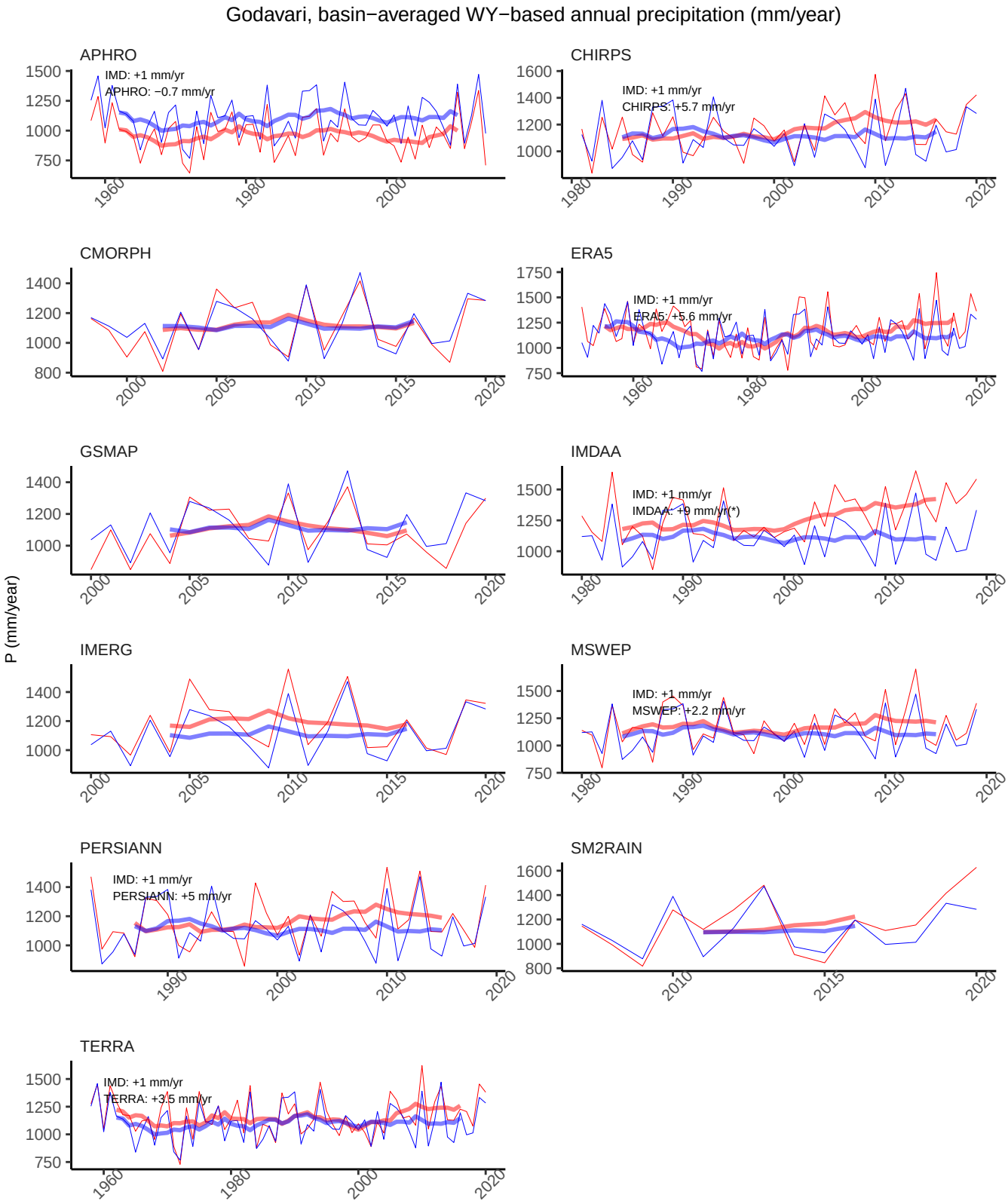


Figure S3.28: Same as Figure S3.16, except for the Godavari Basin.

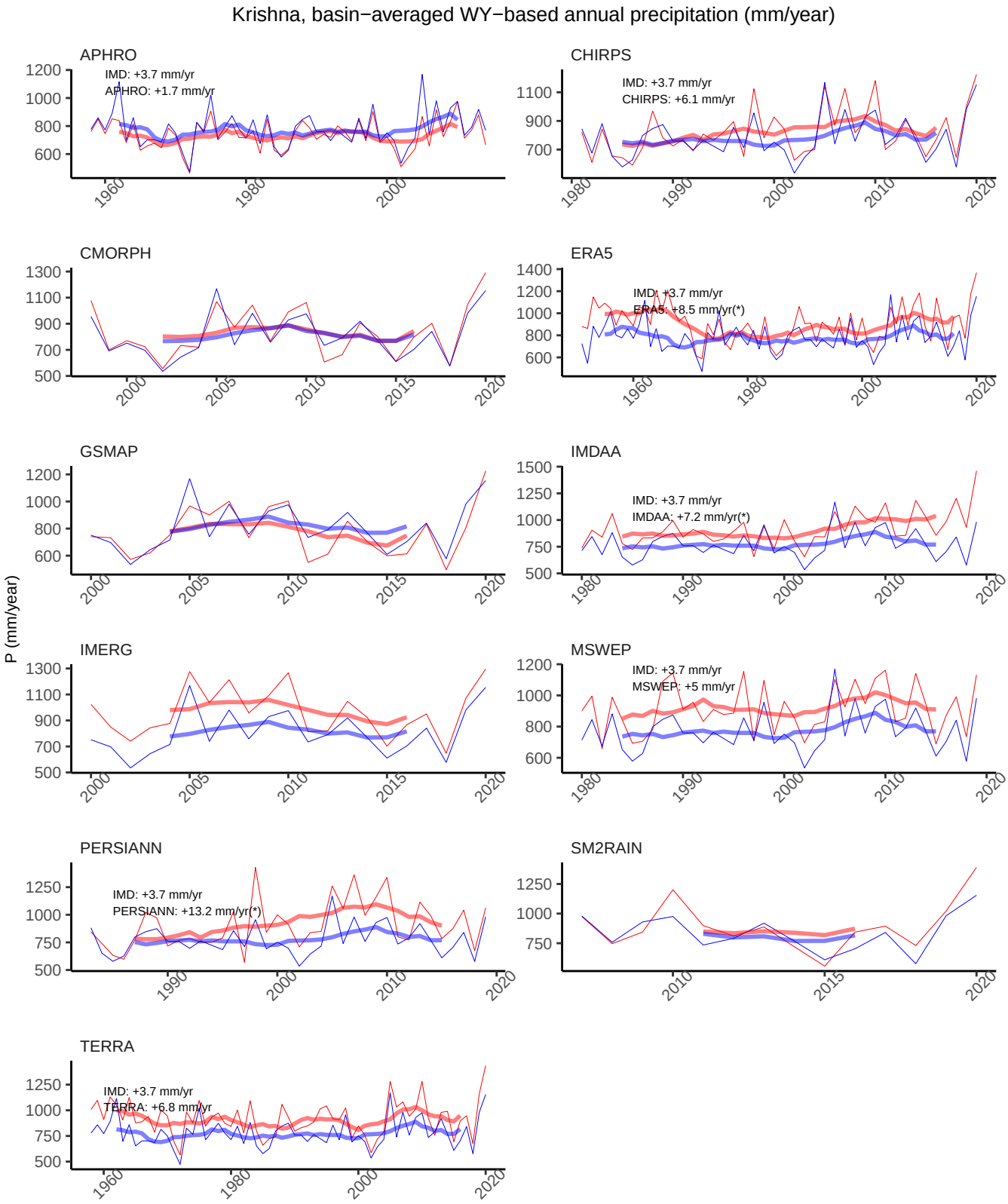


Figure S3.29: Same as Figure S3.16, except for the Krishna Basin.

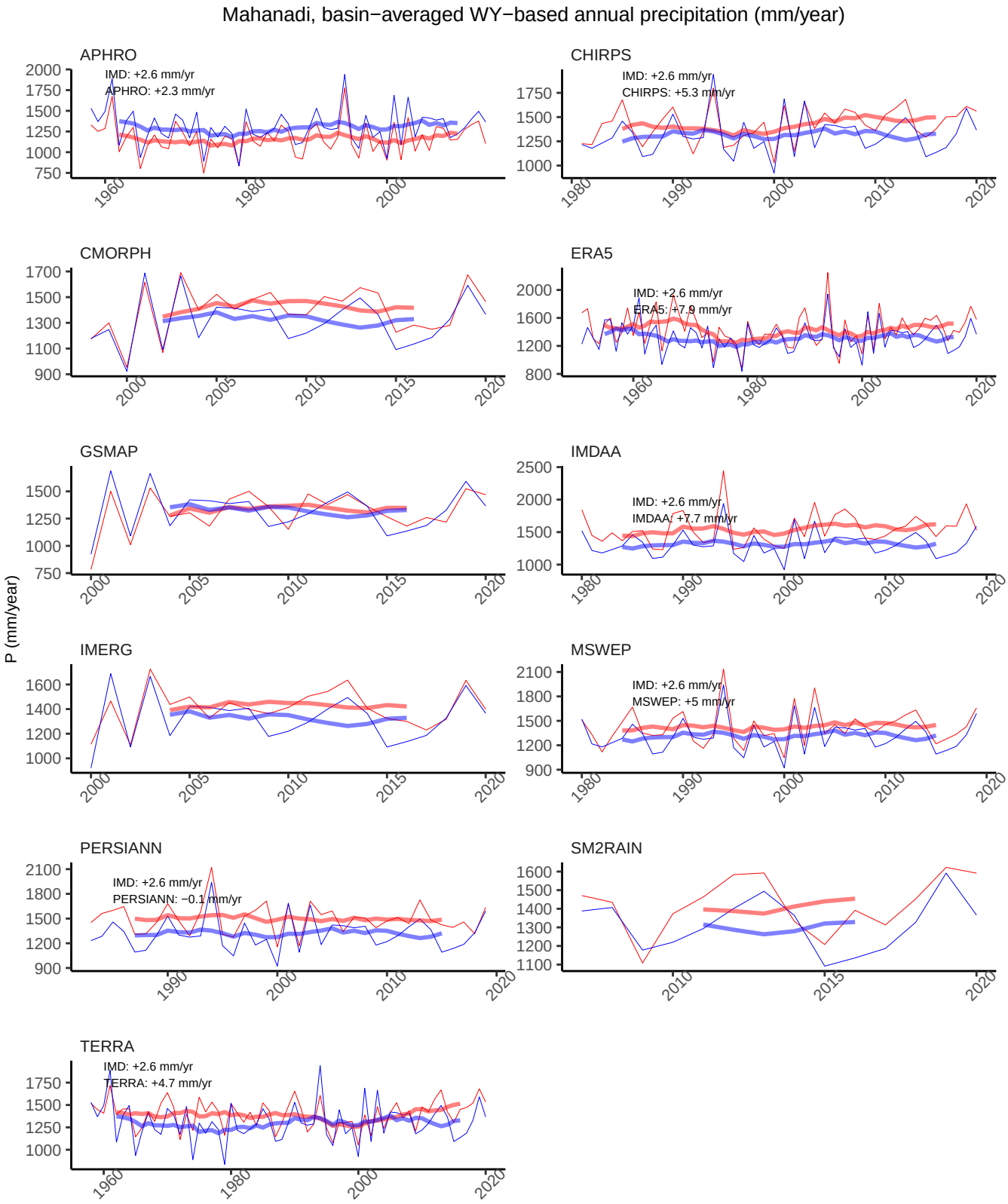


Figure S3.30: Same as Figure S3.16, except for the Mahanadi Basin.

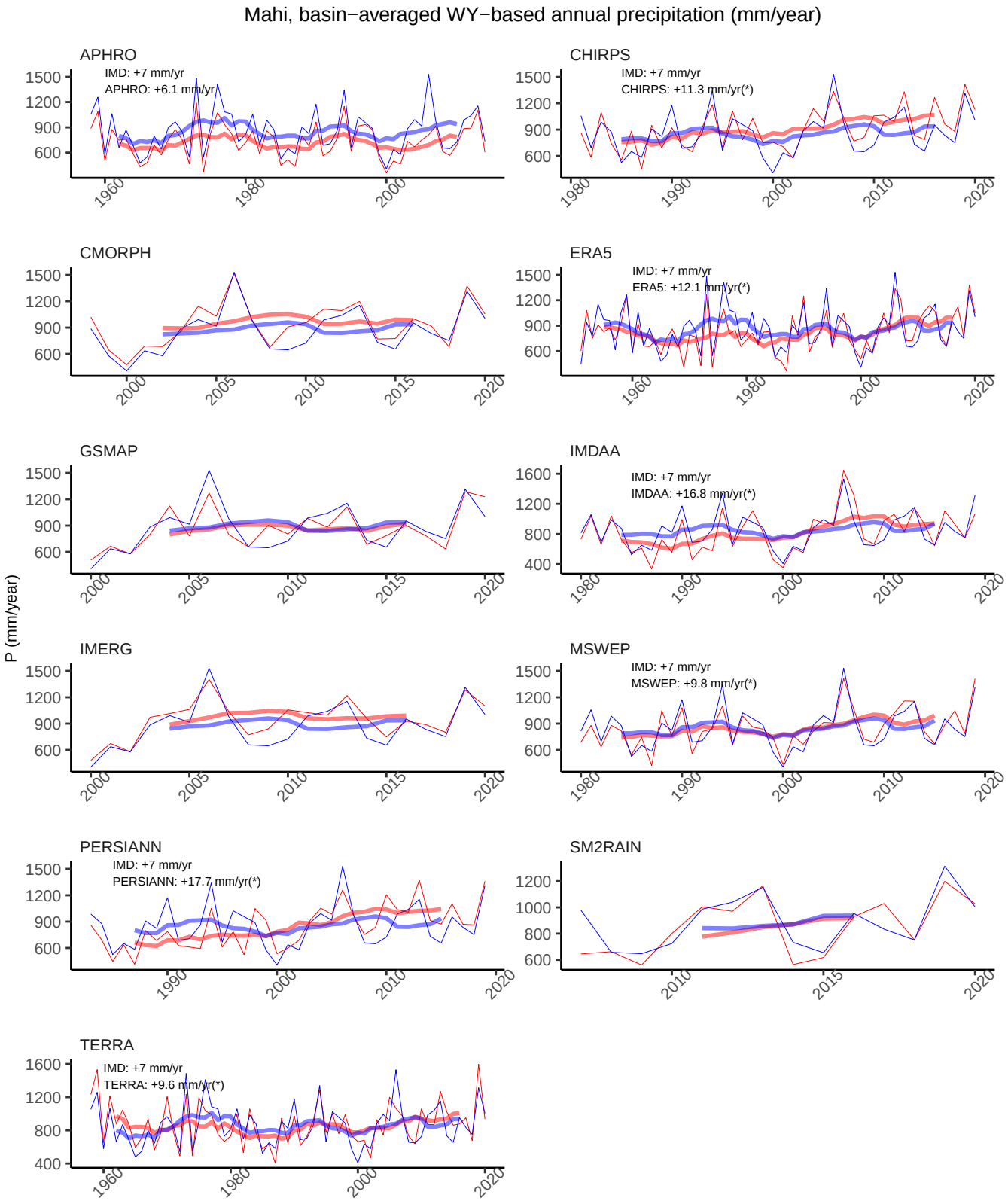


Figure S3.31: Same as Figure S3.16, except for the Mahi Basin.

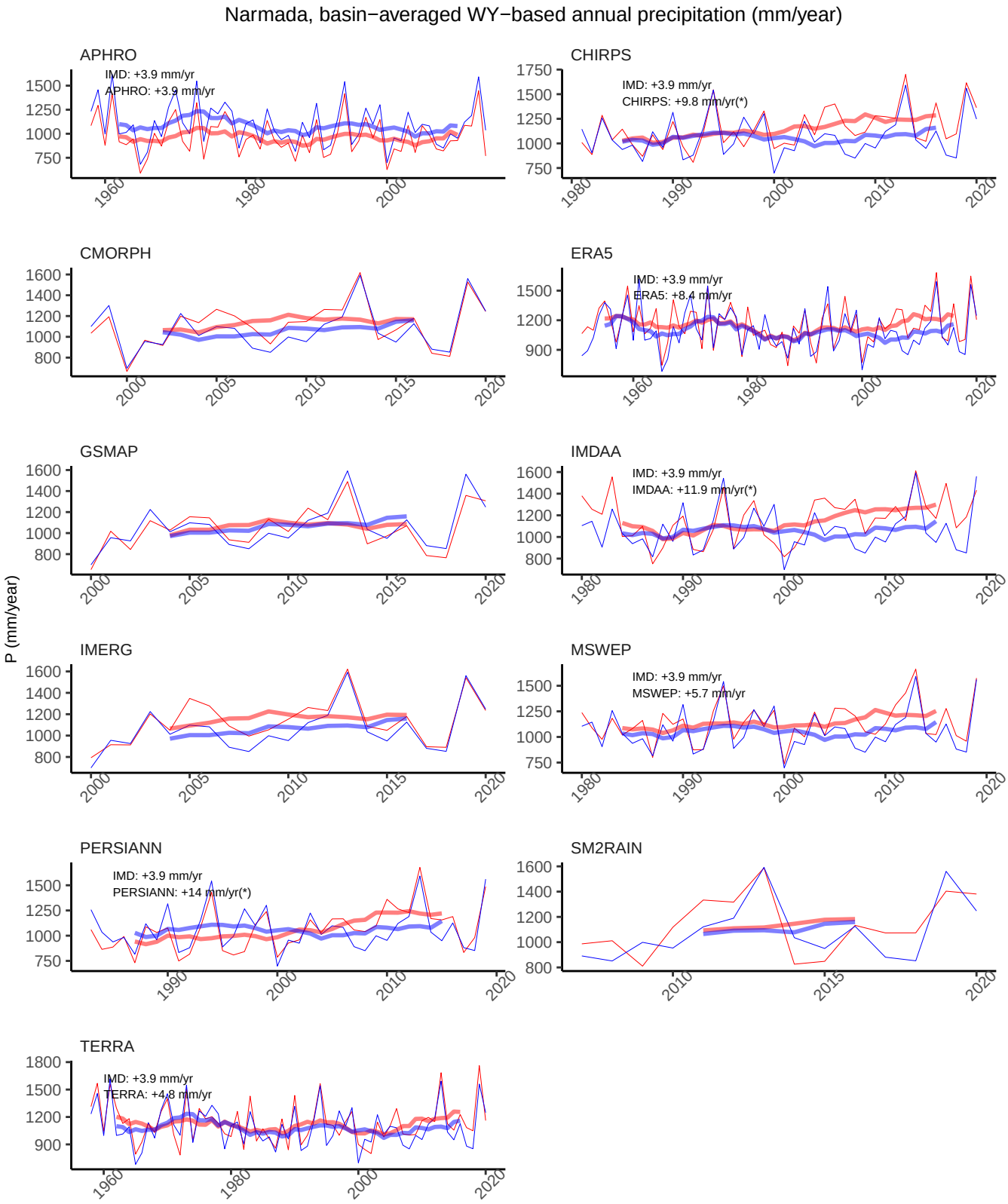


Figure S3.32: Same as Figure S3.16, except for the Narmada Basin.

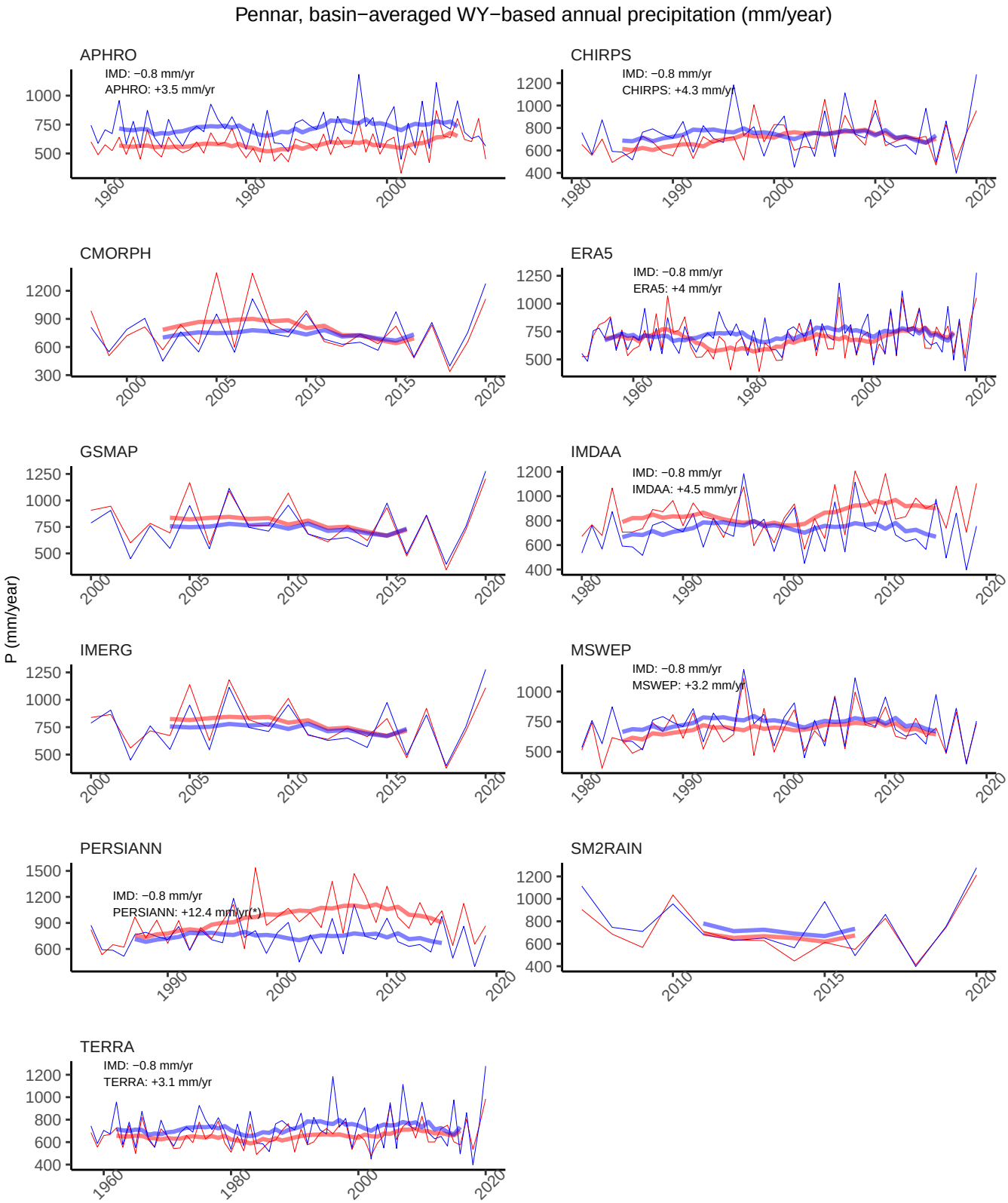


Figure S3.33: Same as Figure S3.16, except for the Pennar Basin.

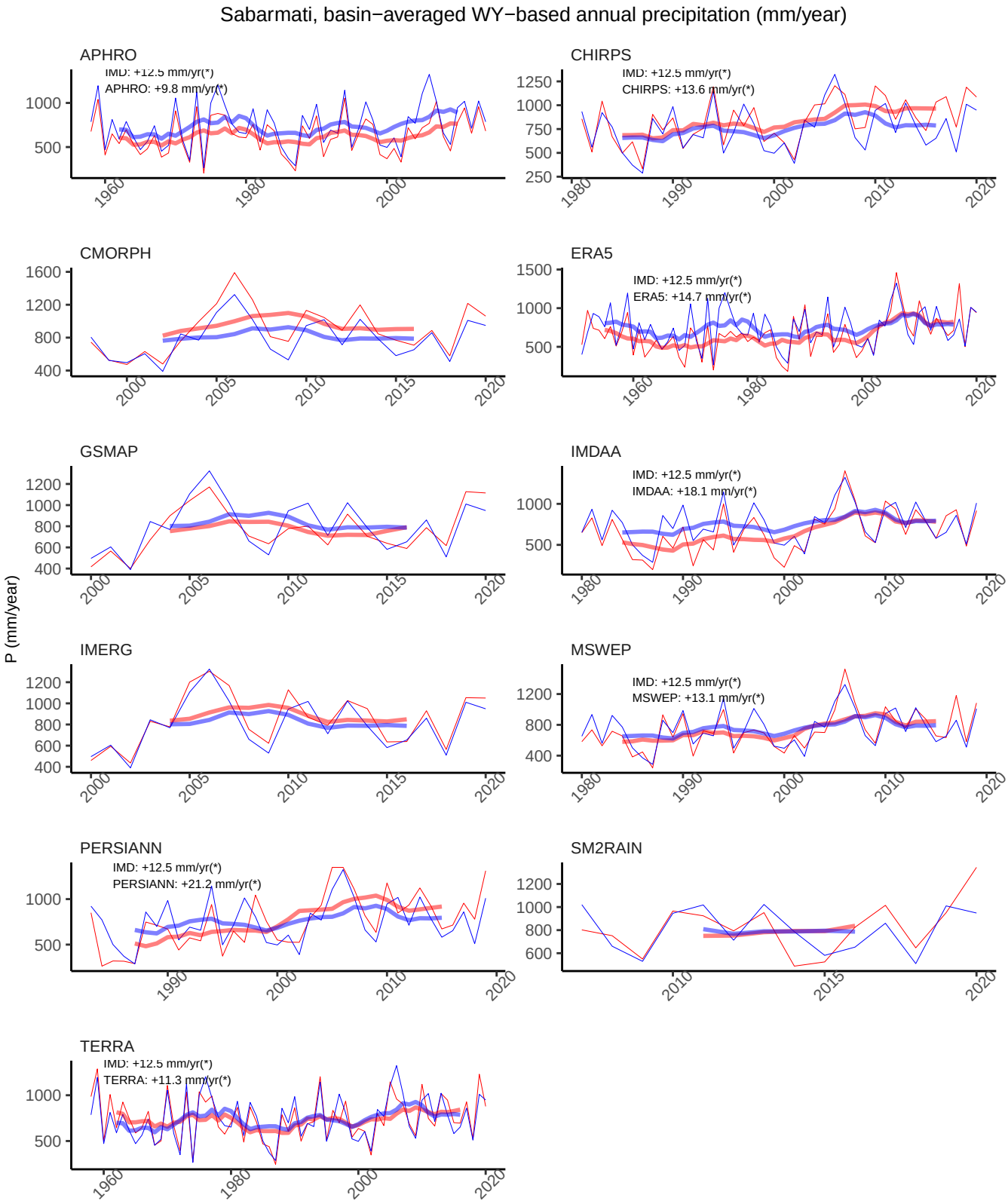


Figure S3.34: Same as Figure S3.16, except for the Sabarmati Basin.

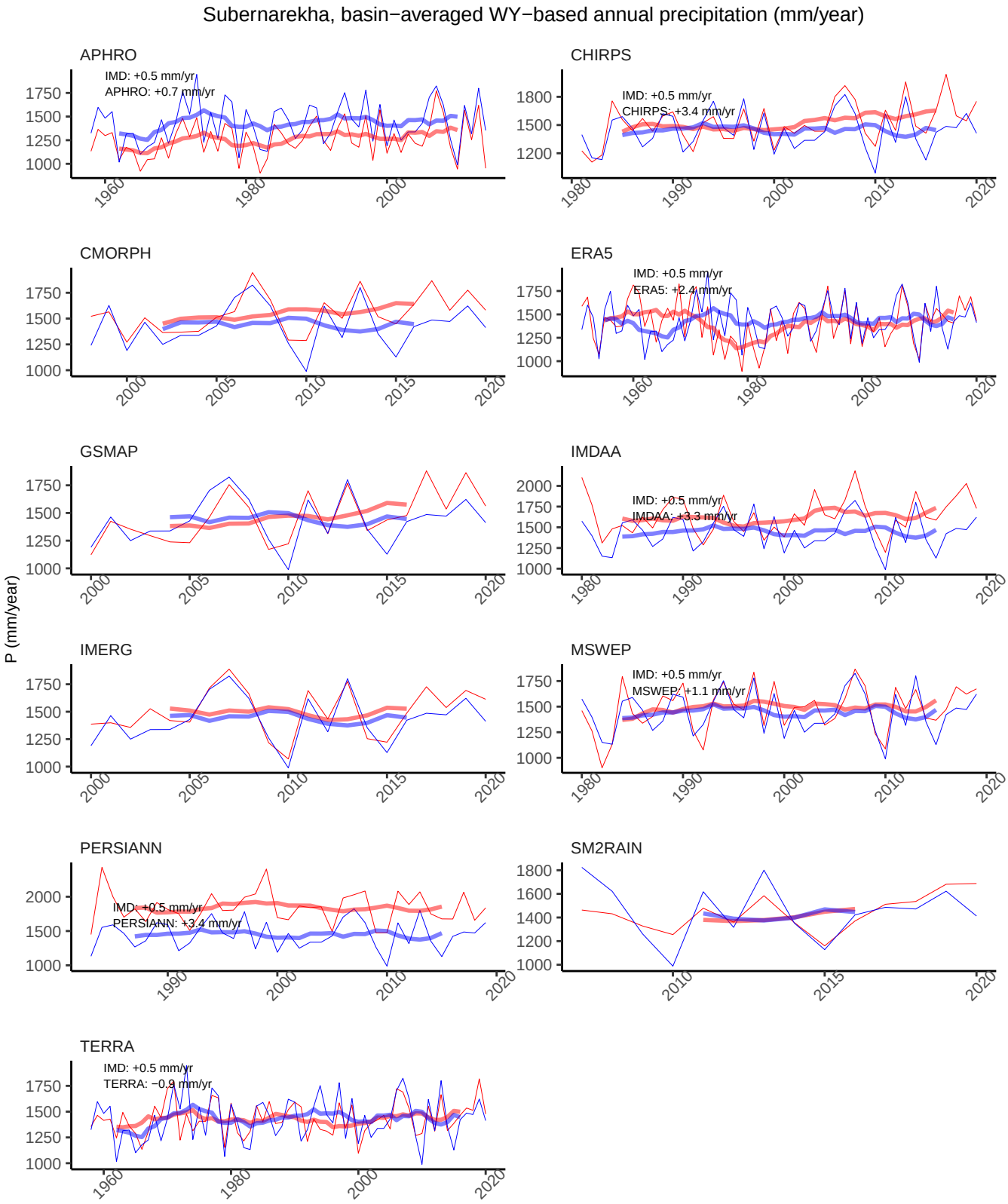


Figure S3.35: Same as Figure S3.16, except for the Subernarekha Basin.

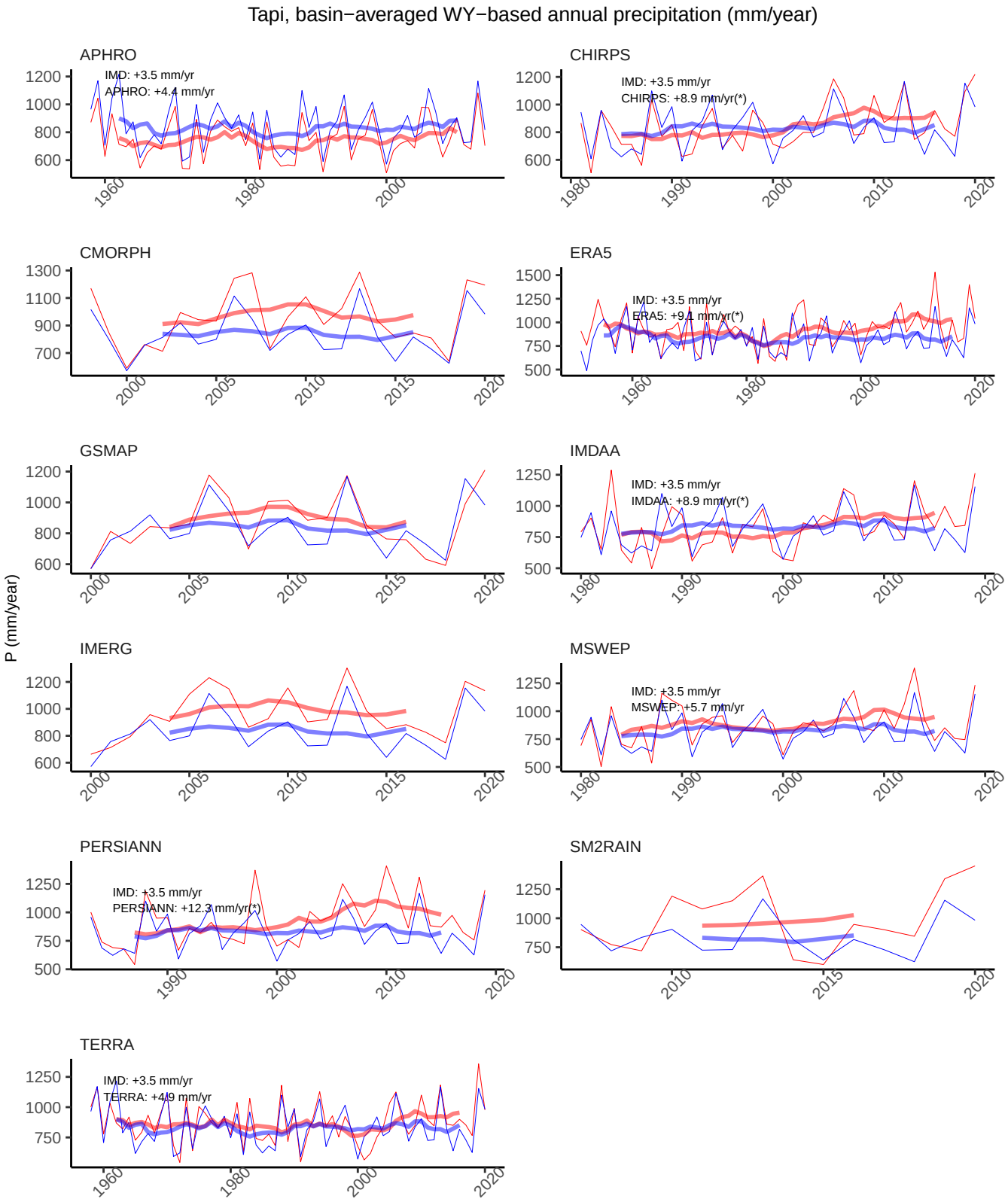


Figure S3.36: Same as Figure S3.16, except for the Tapi Basin.

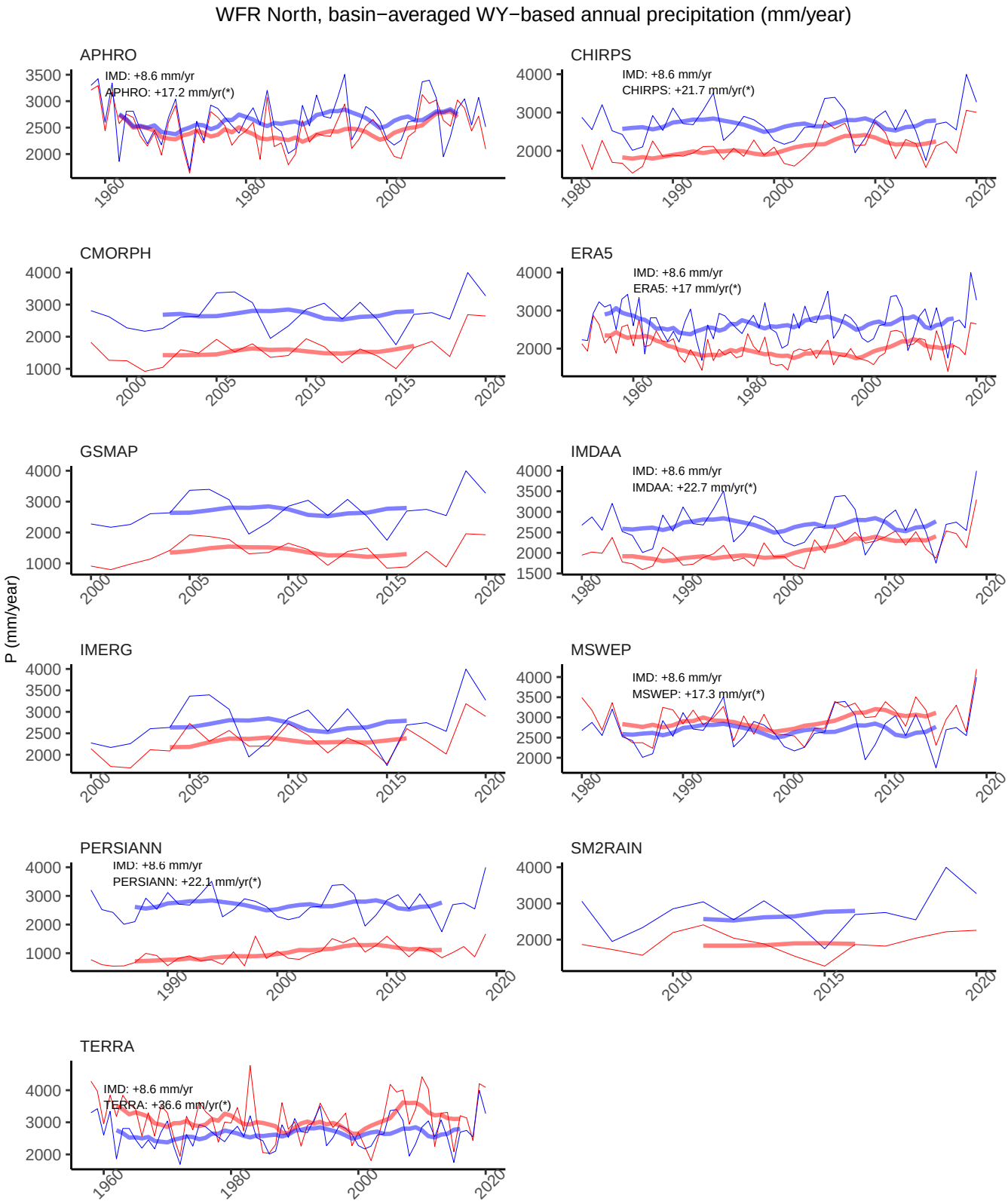


Figure S3.37: Same as Figure S3.16, except for the WFR North Basin.

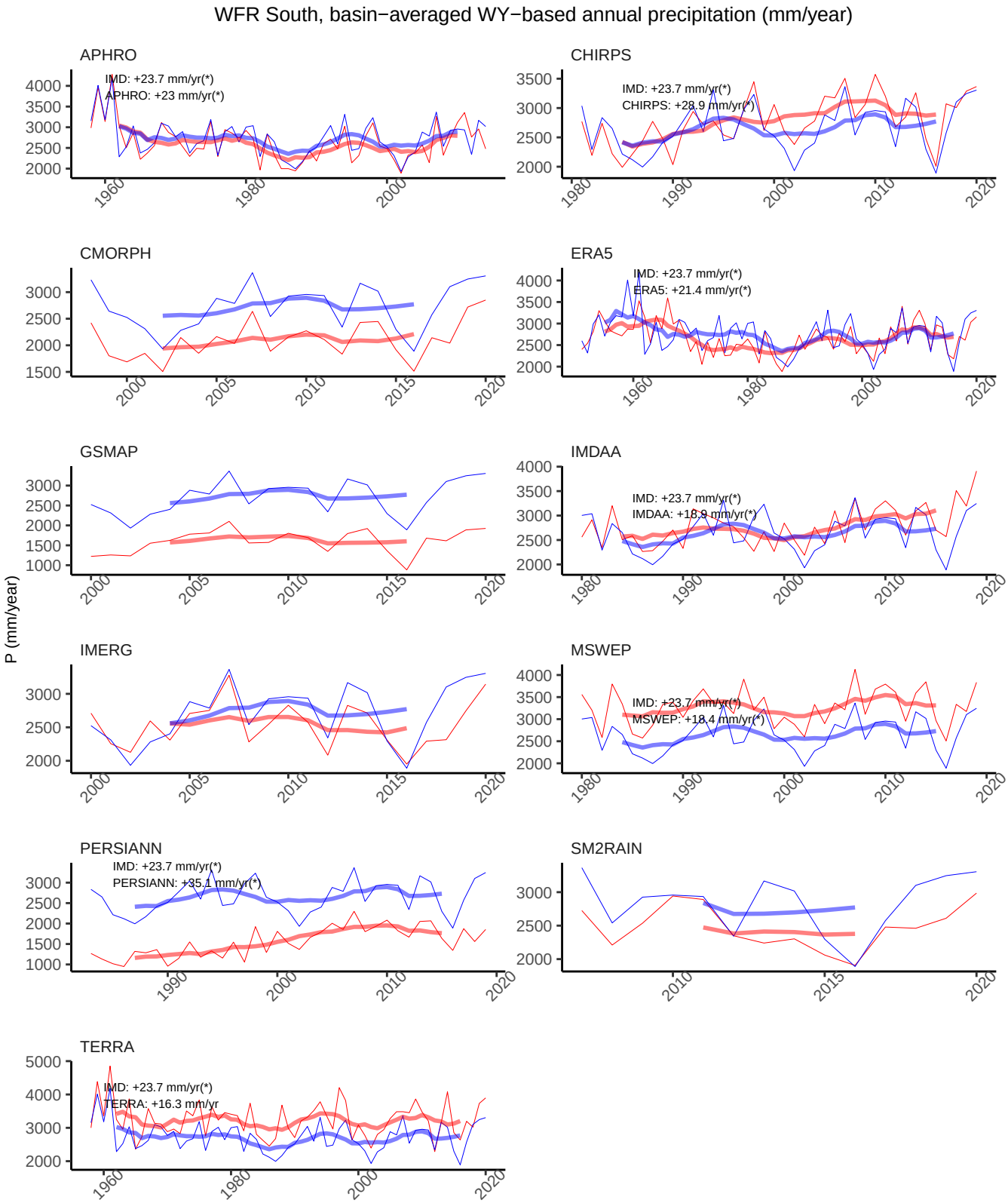


Figure S3.38: Same as Figure S3.16, except for the WFR South Basin.

S3.4 IMD versus Other Products

Table S3.2: Trend in annual basin-aggregated P (mm/year) for WY 1985-2014 for select datasets. Statistically significant values are indicated by '(*)'. All datasets were limited to the boundaries of India since IMD is limited to such boundaries (i.e., IMD-APHRO is not used here).

Basin	IMD	APHRO	CHIRPS	ERA5	IMDAA	MSWEP	PERSIANN	TERRA
All India	-1.7	+2.8	+4.6(*)	+3.2	+3.6	+2.1	+10(*)	+2.3
Barak	-33.2(*)	-9.9	-0.8	-11.3	-5.9	-16.4(*)	-4.6	-12.2
Brahmaputra	-19(*)	-3.4	-2.3	-19.1(*)	-13.3	-13.9(*)	-0.9	-7.5
Ganga	-4	-2.4	+1.2	+1.7	+0.8	+2.6	+8.5(*)	-4.1
Indus	-12.2(*)	+7.2(*)	+1.1	-6(*)	-4.4	-3.2	+13.2(*)	-1.2
Minor	-8.3	-7.3	+0.2	-6.3	-3.8	-7.9	-2.3	-9.4
North Ladakh	-28.7(*)	+2.3	+1.1(*)	0	+0.8	+0.1	+8.6	-0.1
WFR Kutch	+5.8(*)	+6.5(*)	+5.1(*)	+5.5(*)	+6.8(*)	+4.4	+14.1(*)	+3.9
Brahmani-Baitarani	-1.6	+1.3	+4.2	+3.7	+6	+0.7	+2.7	+1.1
Cauvery	+6	+8.4(*)	+11(*)	+10.8(*)	+4.3	+6.6(*)	+13.6(*)	+4.8
EFR North	-0.5	+1.4	+4.8	+6.9	+5	+5.1	+7.6	-0.1
EFR South	+7.4	+4.3	+11(*)	+7(*)	+4.7	+5.7	+19(*)	+3.7
Godavari	+1	-0.7	+5.7	+5.6	+9(*)	+2.2	+5	+3.5
Krishna	+3.7	+1.7	+6.1	+8.5(*)	+7.2(*)	+5	+13.2(*)	+6.8
Mahanadi	+2.6	+2.3	+5.3	+7.9	+7.7	+5	-0.1	+4.7
Mahi	+7	+6.1	+11.3(*)	+12.1(*)	+16.8(*)	+9.8(*)	+17.7(*)	+9.6(*)
Narmada	+3.9	+3.9	+9.8(*)	+8.4	+11.9(*)	+5.7	+14(*)	+4.8
Pennar	-0.8	+3.5	+4.3	+4	+4.5	+3.2	+12.4(*)	+3.1
Sabarmati	+12.5(*)	+9.8(*)	+13.6(*)	+14.7(*)	+18.1(*)	+13.1(*)	+21.2(*)	+11.3(*)
Subernarekha	+0.5	+0.7	+3.4	+2.4	+3.3	+1.1	+3.4	-0.9
Tapi	+3.5	+4.4	+8.9(*)	+9.1(*)	+8.9(*)	+5.7	+12.3(*)	+4.9
WFR North	+8.6	+17.2(*)	+21.7(*)	+17(*)	+22.7(*)	+17.3(*)	+22.1(*)	+36.6(*)
WFR South	+23.7(*)	+23(*)	+28.9(*)	+21.4(*)	+18.9(*)	+18.4(*)	+35.1(*)	+16.3

S4 ET, GLEAM vs NTSG

The *ET* datasets GLEAM and NTSG were considered for this analysis, but GLEAM was used because of the longer time span of this dataset and its availability to the present time. *ET* from the Numerical Terradynamic Simulation Group (NTSG) at the University of Montana (Zhang et al., 2010) provides estimates of monthly *ET*. Goroshi et al. (2017) compared NTSG estimates with lysimeter-based *ET* observations across many locations in India, and found that while there is reasonable agreement between them at seasonal and annual timescales, NTSG was found to underestimate observed *ET* during the monsoon (June-August) and post-monsoon (September-November) seasons. Goteti (2022) noted a similar issue with GLEAM in Godavari and Krishna basins of Peninsular India.

A comparison of GLEAM and NTSG, for the overlap period of WY 1982-2012 is presented here for the basins of Northern India (Figure S4.1) and Peninsular India (Figure S4.2). The basin-aggregated average *ET* for the major basins is shown. For ease of visualization, the extreme values - the lowest and highest annual values within each basin, corresponding to the NTSG dataset were excluded. In general, there is a reasonable correlation between GLEAM and NTSG across many basins. GLEAM values are also lower than NTSG for many basins, as indicated by the negative values of percent bias ('pbias'). Given NTSG's low bias, this indicates an even larger low bias with GLEAM's *ET*.

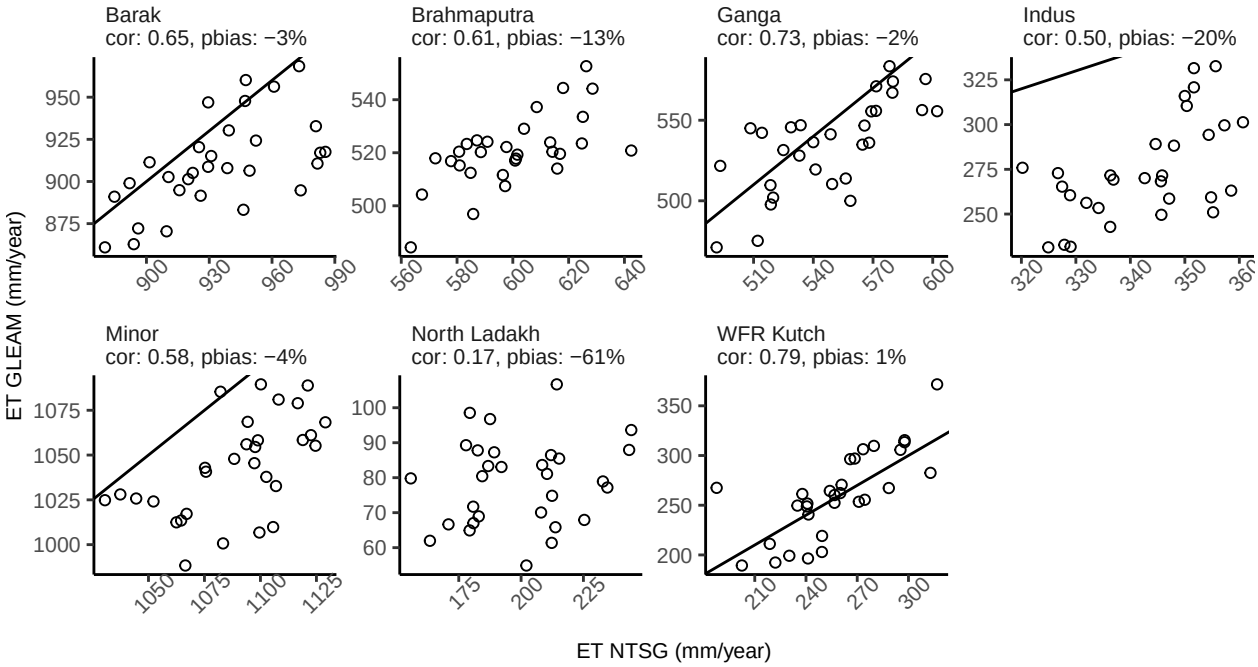


Figure S4.1: Basin-averaged annual ET from NTSG and GLEAM for the major river basins of Northern India, for the overlap period of WY 1982-2012. The solid line shows the 1:1 correspondence line. 'cor' indicates the Spearman rank correlation, while 'pbias' is the percent bias (GLEAM relative to NTSG).

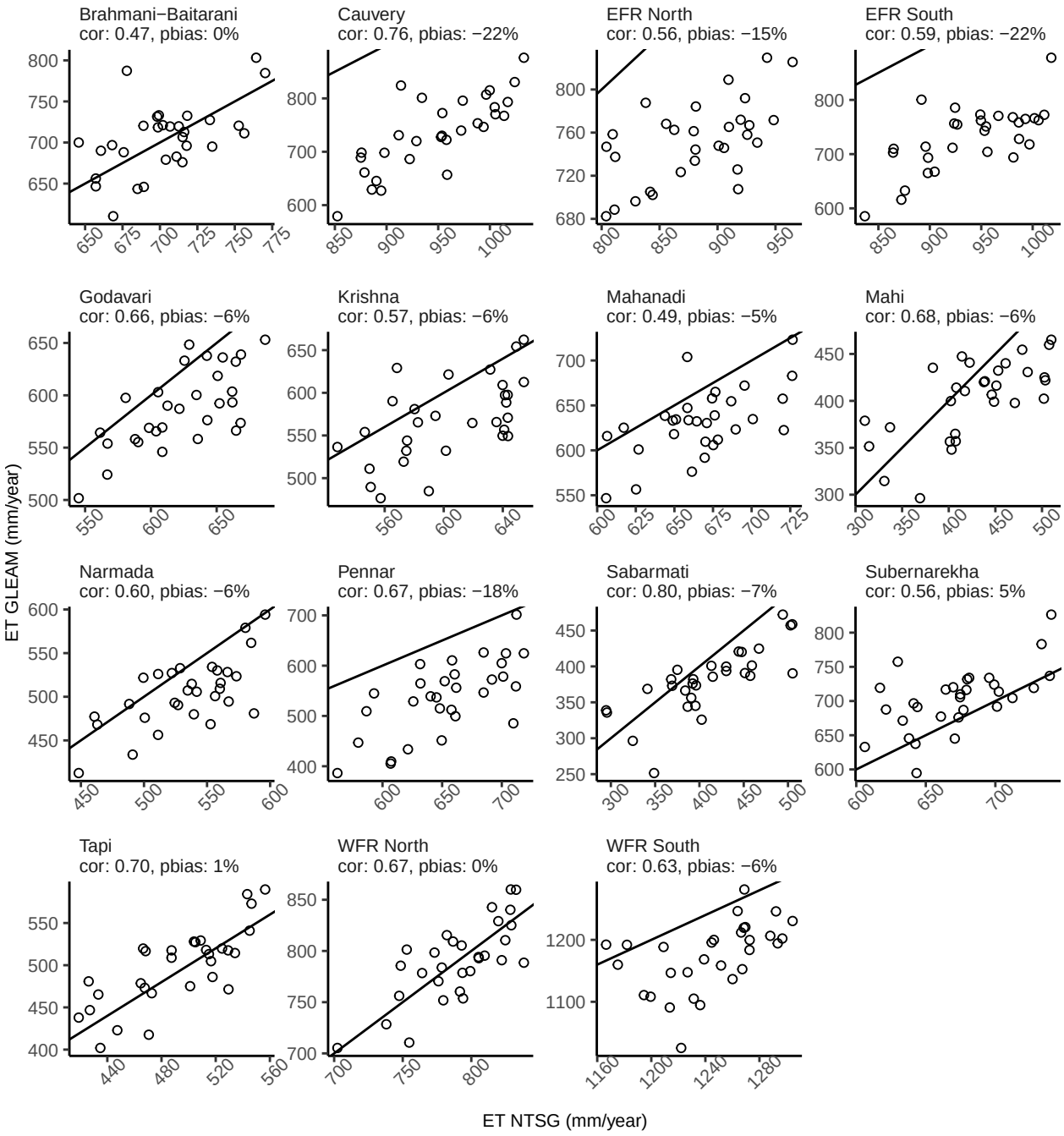


Figure S4.2: Same as Figure S4.1 but for Peninsular India

S5 Water Management

S5.1 Groundwater Extraction

Groundwater extraction and recharge estimates are available from India's Central Ground Water Board (CGWB, http://cgwb.gov.in/) for select years (https://ingres.iith.ac.in/). These estimates are available at the administrative district resolution. Districts in India are the third administrative tier, following national and state tiers. However, official GIS data on district boundaries is not readily available from Indian agencies. Moreover, administrative boundaries, including district and state boundaries, have been subject to change in the recent past (e.g., the states of Andhra Pradesh and Telangana). Available GIS data on district boundaries from geoBoundaries (Runfola et al., 2020) was compiled so that the names of the districts and their areas closely matched those from CGWB. The estimates from two recent years, WY 2019-20 and WY 2021-22 are used here. In order to have reliable district boundaries and also retain as much information as possible, the data for the State of Andhra Pradesh was taken from WY 2019-20 and data for the remaining states was from WY 2021-22.

Total groundwater extracted was estimated by CGWB for three different categories: command (or irrigated) - 'C', non-command (or non irrigated) - 'NC', and poor quality - 'PQ'. Consistent with CGWB, only the 'C' and 'NC' categories were used here to estimate the total volume of groundwater extracted. Annual P is also available from CGWB, and it was converted to a volume using the area of each district estimated by CGWB. Finally, the district-wise extent of annual groundwater extraction is quantified as a fraction of the annual P and is presented in Figure 3 of the paper.

S5.2 Imports and Exports

CWC-19 (2019) estimated the water resources availability for the major river basins of India and their sub-basins for WY 1985-2014, and during this process quantified the various inputs and outputs to these basins, including both natural and human-caused factors (Annexures A-S). The variables quantified by CWC-19 include volume of basin-aggregated P, imports to the basin, and exports from the basin. Both imports and exports are expressed as a fraction of annual P, and the maximum value of such estimates is presented in Figure 3 of the paper.

S5.3 Dams and Reservoirs

Information on large dams in India was obtained from the National Registry of Large Dams (NRLD, 2019). Raw data from NRLD for 5,745 large dams was available as a Portable Document Format (PDF) file. This data was first compiled into a spreadsheet and then imported into a GIS software to perform basic quality checks. Locations of dams with missing latitude or longitude, or those falling in the ocean or outside of India's political boundaries, were deemed spurious and discarded. Thus, a total of 5,629 dams were considered for this analysis. The specific purpose of the dam - such as storage, irrigation or hydro power, was not considered. For ease of illustration, the locations of the dams were mapped to a 25 km grid and the number of dams per each such grid is displayed in Figure 3 of the paper. It

is evident that the density of dams is the largest in the arid Western India. The density of dams is low along the Western Coast of India, in the Gangetic Plains and the mountainous portions of Northern India.

Other than the coordinates of the dam, the attributes of interest for each dam are the year of construction of the dam, the maximum live storage capacity and the total storage capacity of the dam. While a vast majority of the dams had such information available, some dams had this information missing. If the year of construction of a dam was missing, it was assumed to be 1950 - the earliest year of analysis. If live storage capacity was missing, it was assumed to be 0.9 times (or 90%) of the total storage capacity. The factor of 0.9 used here was based on the median ratio of such a factor where information was available. Once all the relevant information on dams was compiled, the river basin and watershed associated within each dam was identified using a GIS analysis. Thus, for a given streamflow gauging station, all the dams present in the upstream catchment area were identified. The annual cumulative live storage capacity for each gauging station, and for each year, was estimated as the sum total of all such upstream dams, taking into account the year of construction of the dam. In Figure 3 of the paper, cumulative live storage capacity in WY 2019 (the latest year for which data is available from NRLD) is expressed as a fraction of average annual P.

S6 Estimates of Annual ΔTWS

Temporal changes in the Earth's gravity field measured by the Gravity Recovery and Climate Experiment (GRACE) satellite mission (Tapley et al., 2004) have been used to infer changes in total terrestrial water storage (TWS) (Rodell et al., 2009). TWS includes groundwater, soil moisture, surface water (rivers, lakes, wetlands and reservoirs), snow and ice (including glaciers), canopy interception, and water within vegetation.

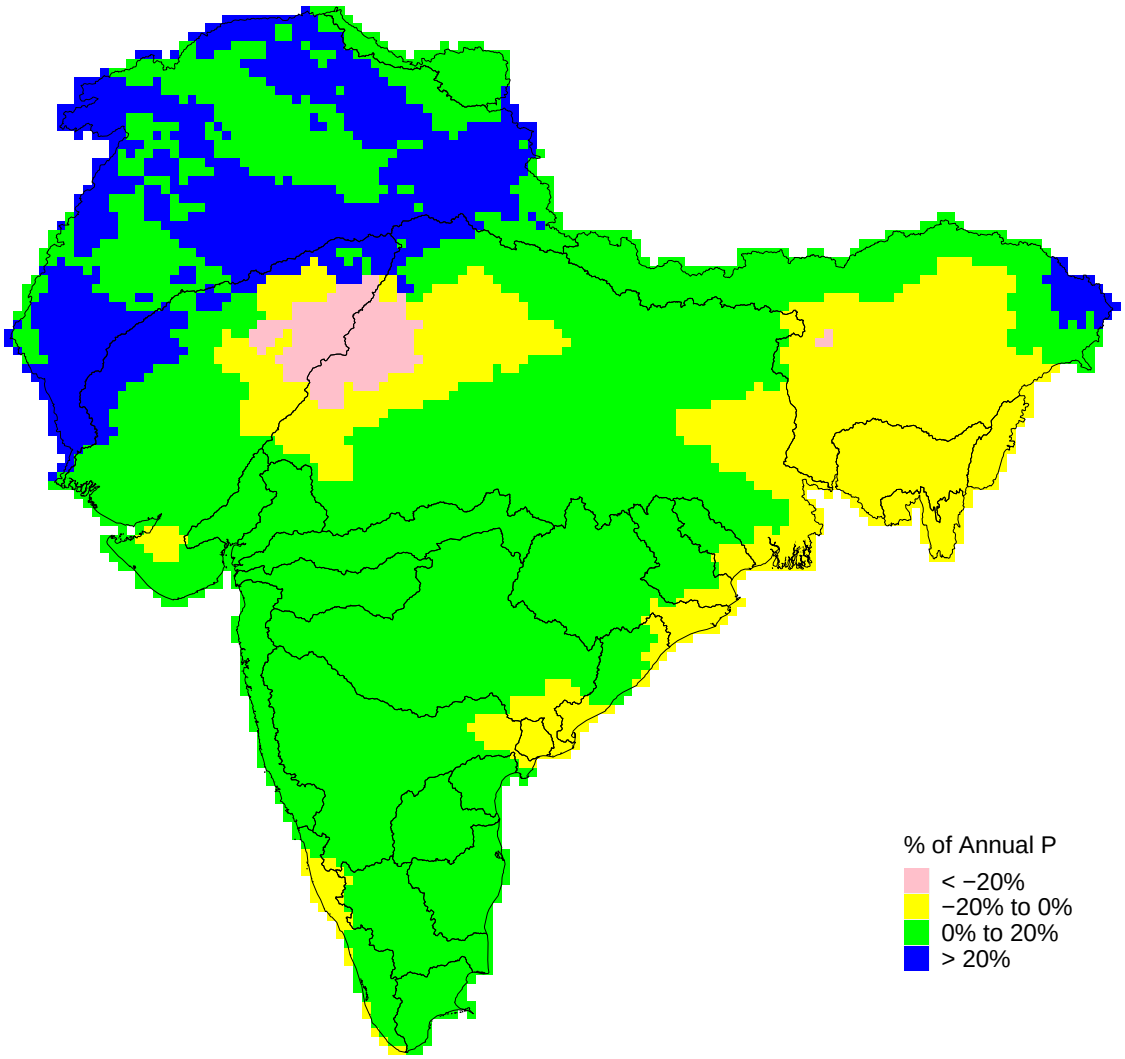
GRACE does not provide the total amount of TWS nor its long-term average ($\overline{TWS}$), but instead provides estimates of TWS anomalies (i.e., $TWSA = TWS - \overline{TWS}$) (Humphrey et al., 2023). Raw data from GRACE can be processed using several mathematical techniques to generate useful end products, and there are many such products currently available (Humphrey et al., 2023). This study uses the often-used 0.25 deg (∼25 km) resolution anomalies from the Center for Space Research (Save et al., 2016; Save, 2020).

The difference between the anomalies at two different times gives an estimate of the change in TWS (or ΔTWS) over that time period. Change in annual TWS (or ΔTWS) is of primary interest for the purposes of this analysis. Considering the definition of WY used in this study (period of June through May), ΔTWS was estimated using an equation similar to Eq. S6.1. As discussed by Humphrey et al. (2023), equations Eq. S6.1 is an approximation since GRACE monthly anomalies do not correspond to exact calendar months.

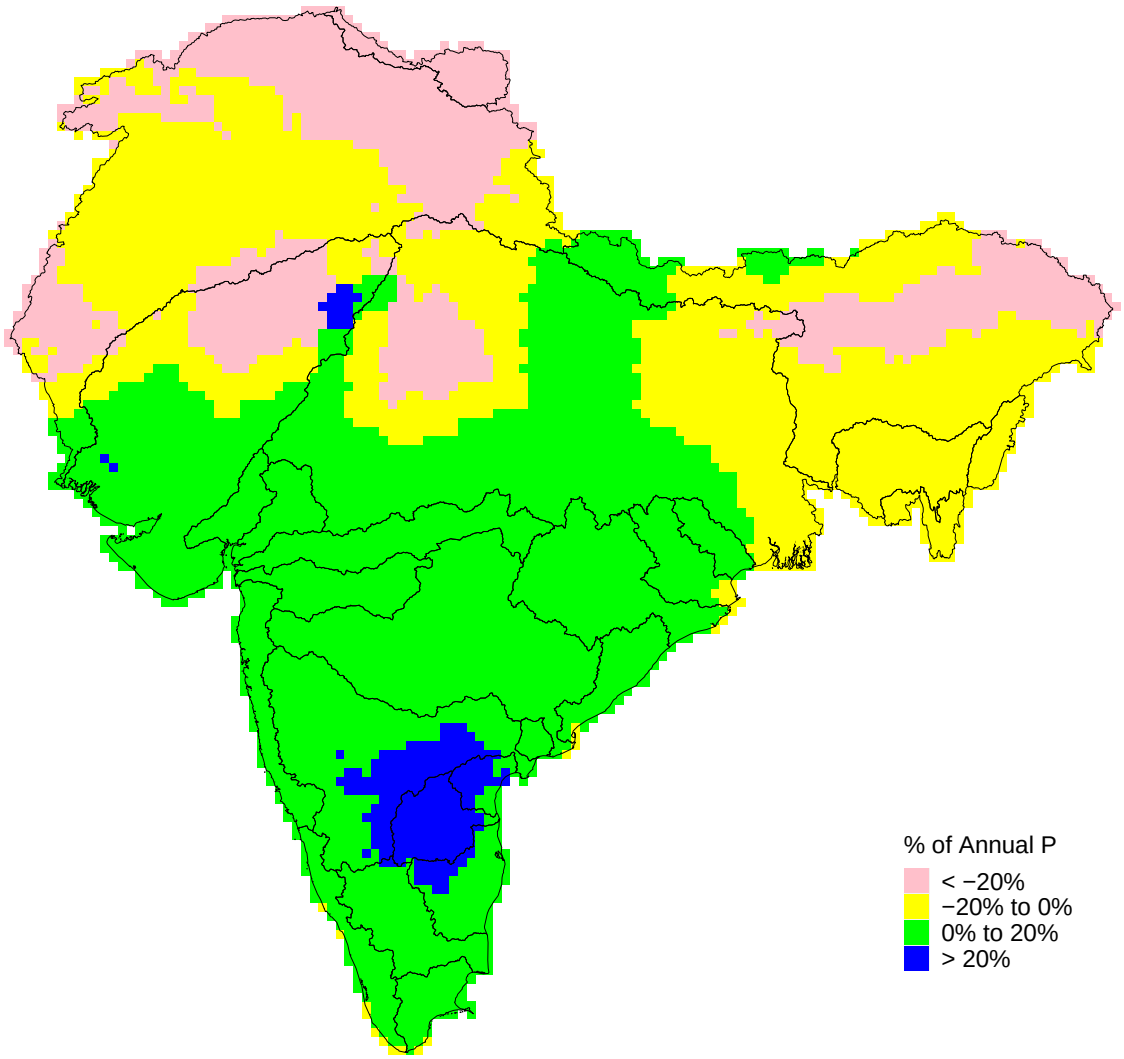
$$\Delta TWS_{WY\ 2010} = TWSA_{May\ 2011} - TWSA_{June\ 2010} \tag{S6.1}$$

Consistent with the other analyses of this study where hydrological variables were represented as a fraction of annual P, ΔTWS was also estimated as a fraction of annual P, using P from the IMD-APHRO dataset. The annual maps of ΔTWS are shown in the following graphics, for years when GRACE data is available for the months of May and June (starting WY 2002), and for years for which the IMD-APHRO dataset is available (up to WY 2014). Overall, there are 10 WYs during WY 2002-2014 for which such maps could be created. Figure 4 of the paper shows the grid-wise maximum and minimum ΔTWS across all such WYs.

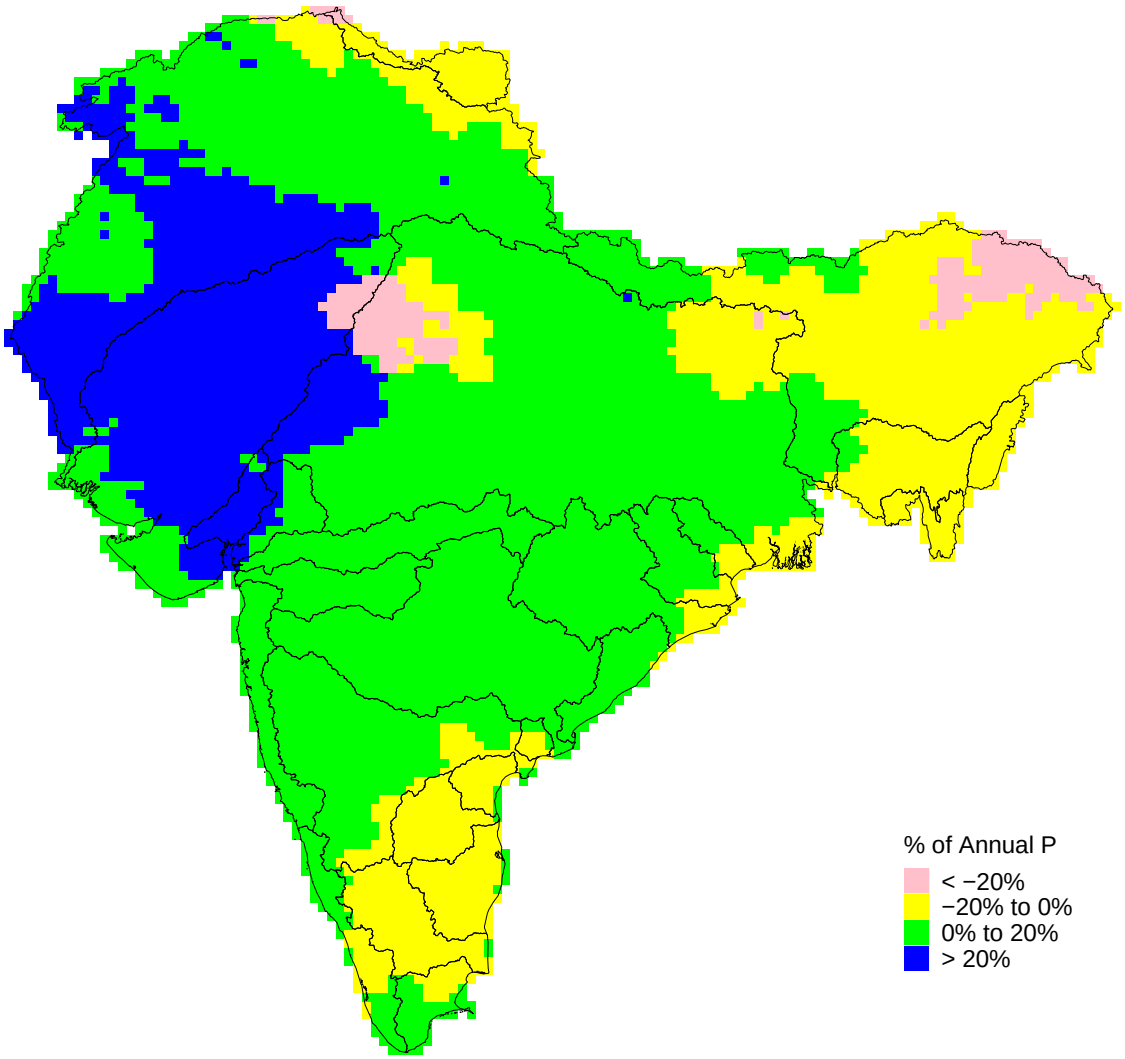
Delta TWS, WY 2004



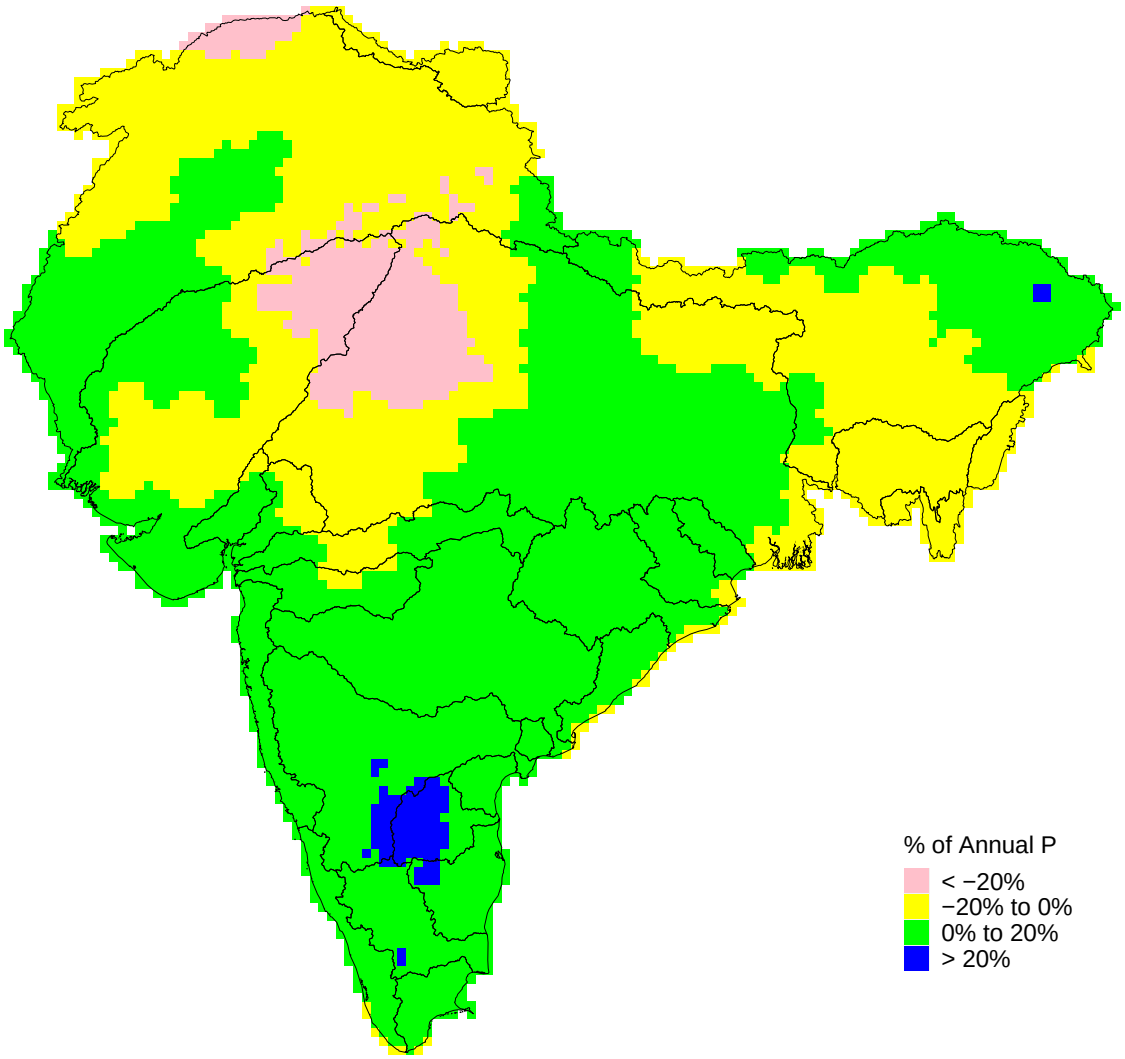
Delta TWS, WY 2005



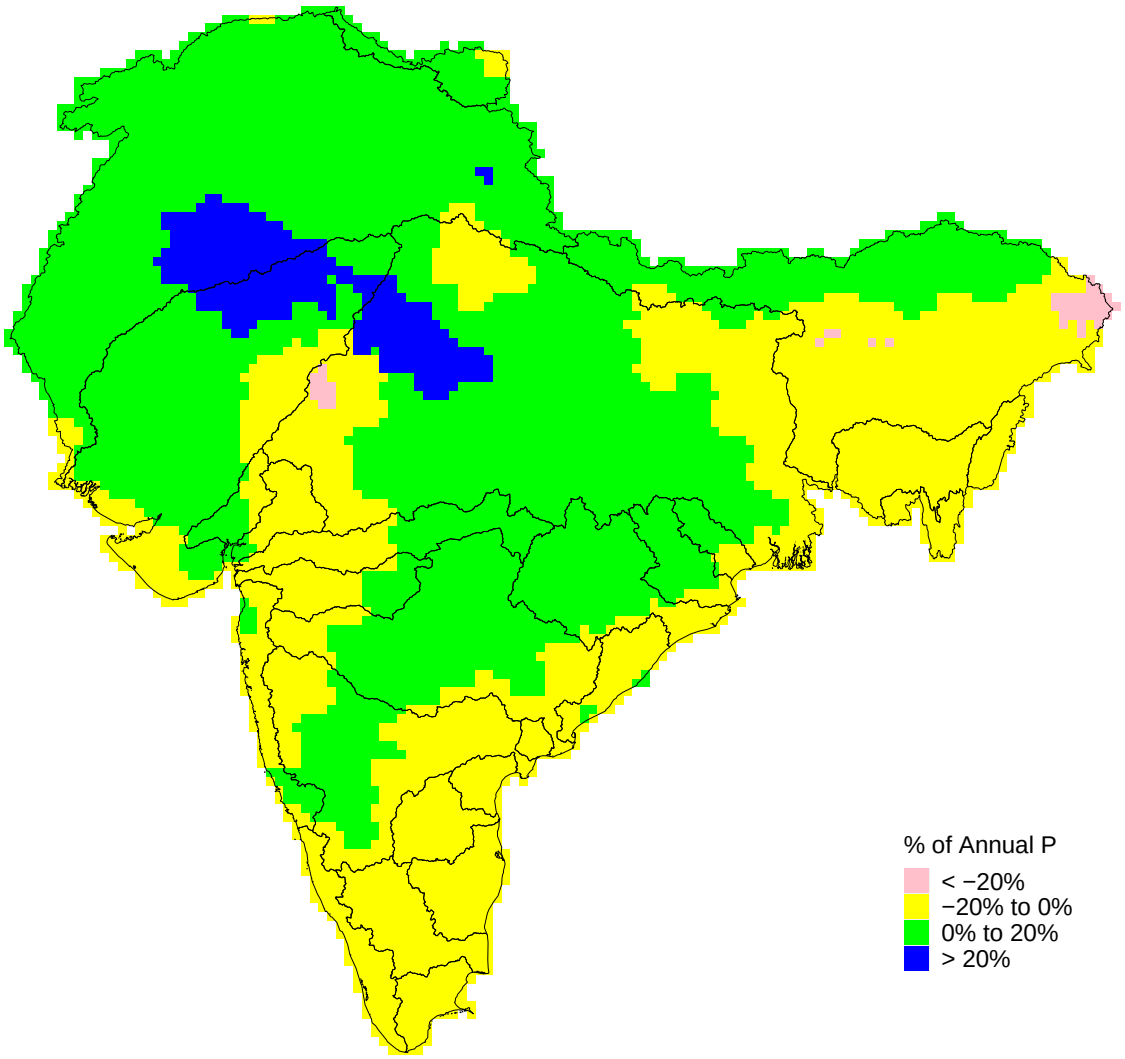
Delta TWS, WY 2006



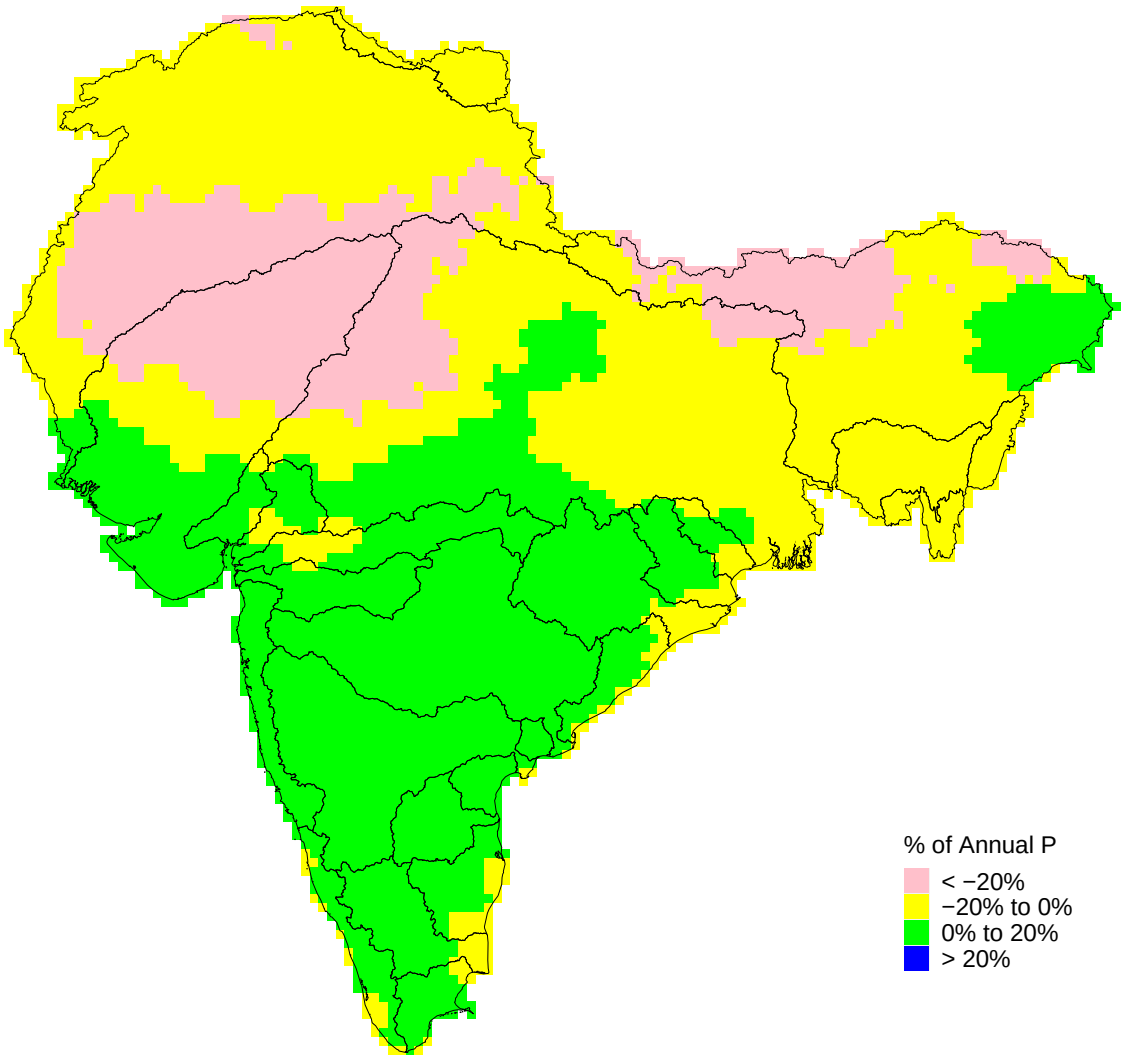
Delta TWS, WY 2007



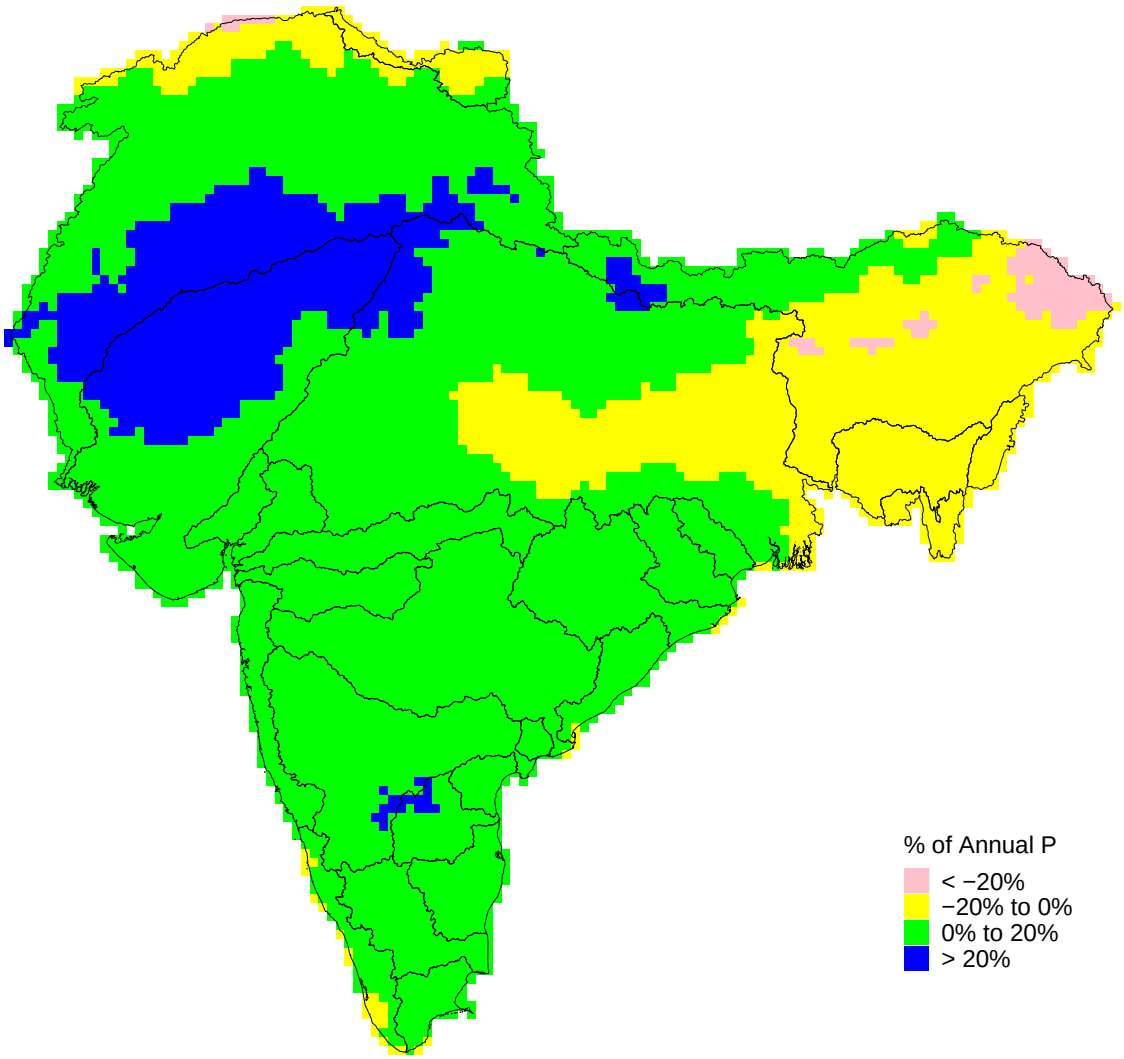
Delta TWS, WY 2008



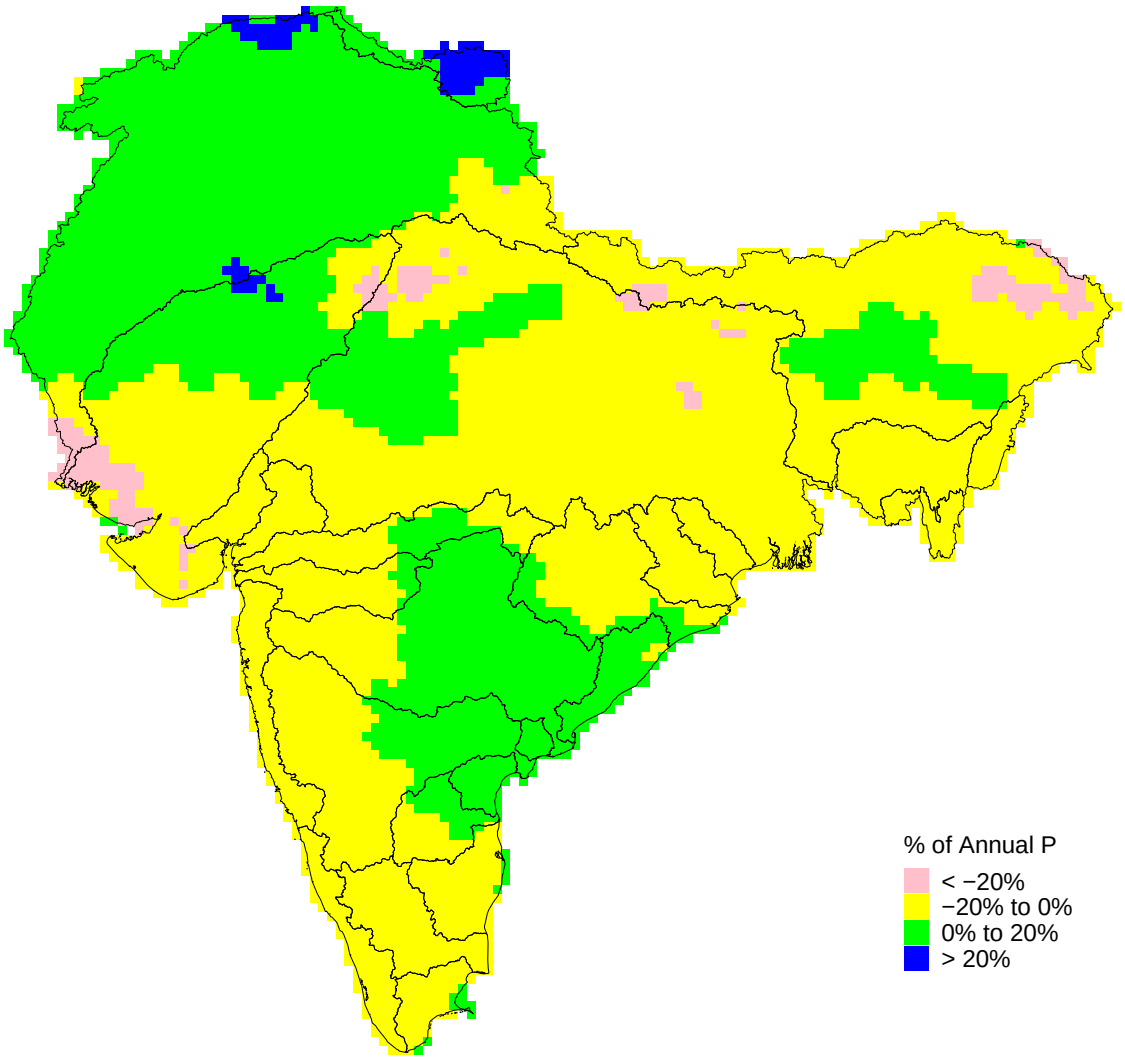
Delta TWS, WY 2009



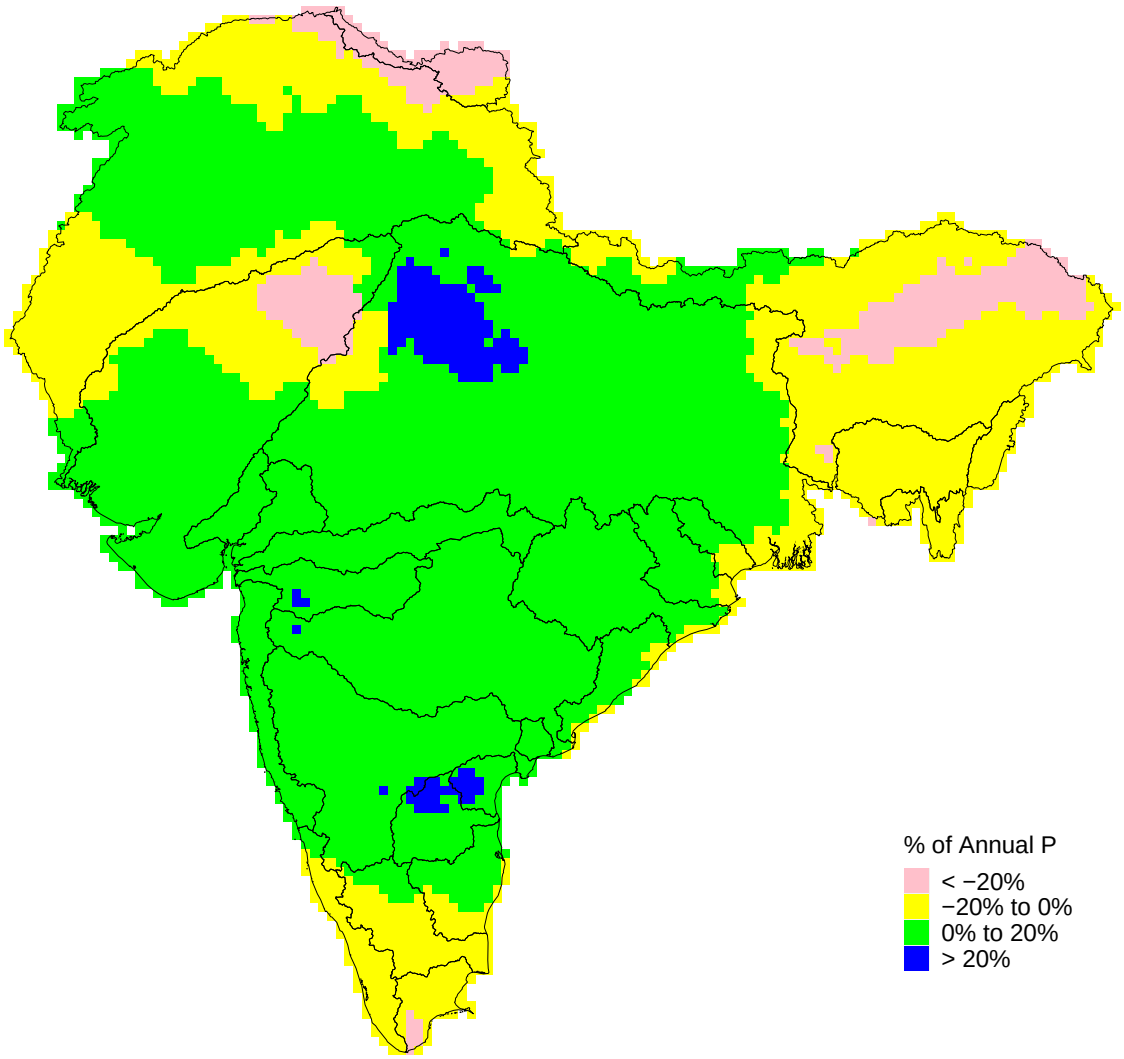
Delta TWS, WY 2010



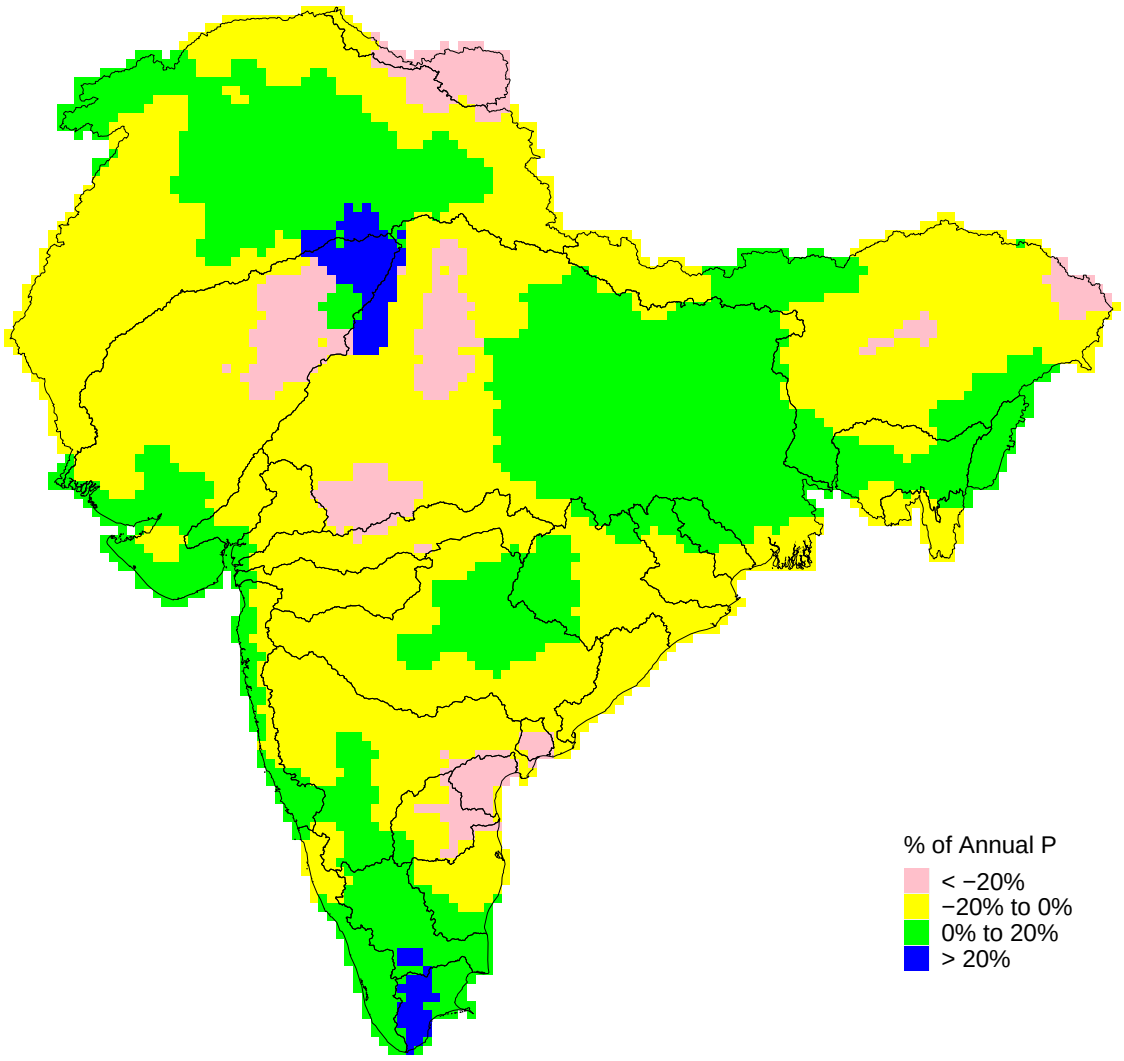
Delta TWS, WY 2012



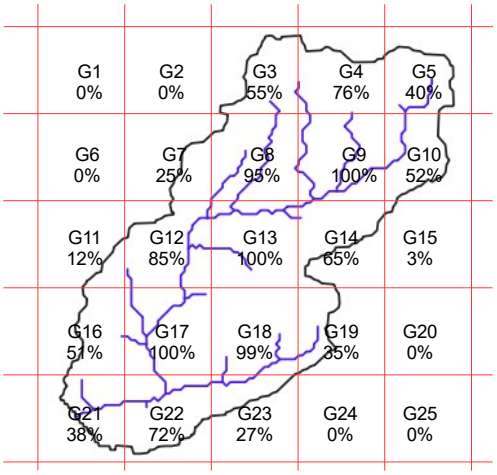
Delta TWS, WY 2013



Delta TWS, WY 2014



S7 Spatial Averaging



$$\textit{area-weighted watershed average} = \frac{\sum_{g=1}^{g=25} Variable \times Area_g \times Fraction_g}{\sum_{g=1}^{g=25} Area_g \times Fraction_g}$$

Figure S7.1: Schematic illustrating the area-weighted averaging procedure used to obtain watershed-aggregated variables from gridded products. The watershed is shown in black, the river network in blue, and the grid mesh in red. Grids are numbered G1 through G25.

S8 Case Study on Potential Contribution of Inter-watershed Groundwater Flow (IGF)

In order to demonstrate that inter-watershed groundwater flow (IGF) does not always explain the observed water budget imbalance, a case study is presented here. Annual and monthly water balance of nine select watersheds in Southwestern India are examined (Fig. S8.1). WY 2007 is chosen as an example, and it is one the many years where watershed imbalances were observed. The selected watersheds have been identified in this study to be experiencing UoP using the IMD-APHRO dataset. These watersheds are part of three major basins (Cauvery, Krishna and WFR South) and their catchment areas range from about 300 to 3,300 km^2 (Table S8.1). The combined area of these watersheds is about 11,270 km^2. These watersheds are adjacent to each other, and relative to the surrounding terrain they are located at a higher elevation (Fig. S8.1(c)).

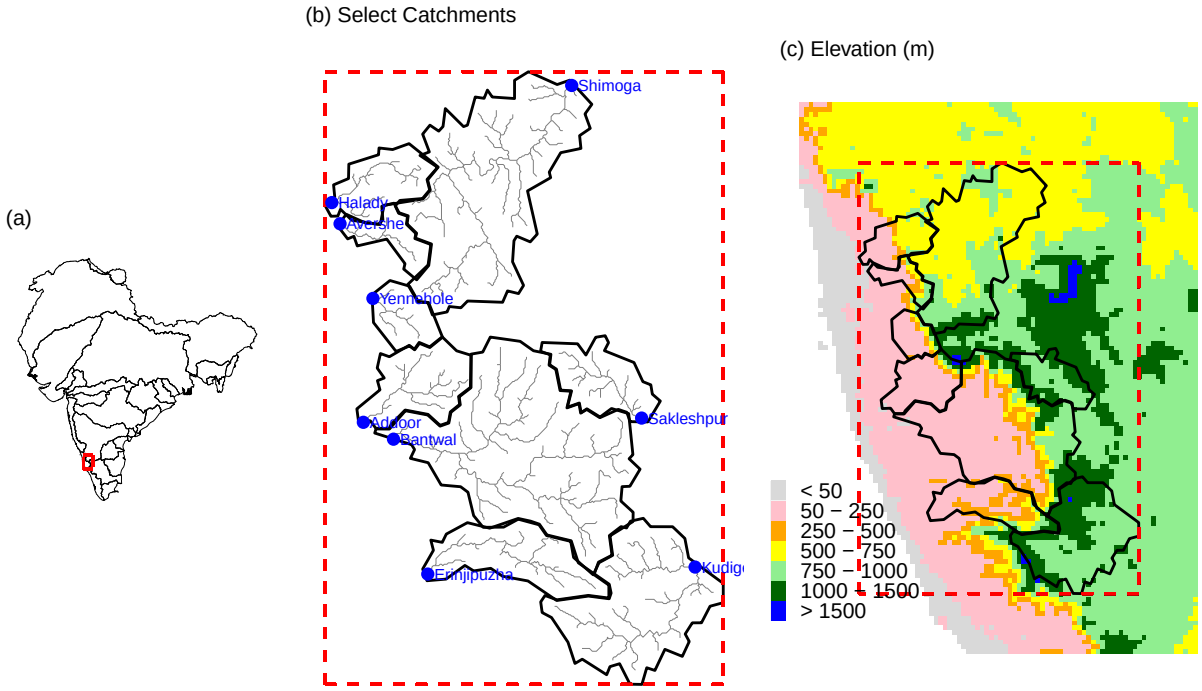


Figure S8.1: Select watersheds analyzed in this case study. (a) Red box shows the location of the nine watersheds within the study domain; (b) streamflow gauging stations (blue dots) at the outlets of the watersheds (black lines) and the river network (grey lines); (c) topography of the select watersheds and the surrounding region.

Table S8.1 shows the annual P, R and ET for WY 2007 for the nine watersheds. It is evident that the annual runoff coefficient (R/P) is at least 0.81, and exceeds 1.0 for five of the nine watersheds. The ratio of $(R + ET)/P$ ranges from 1.13 to 1.72. Monthly values of P, R and ET for the monsoon season (June to September) during WY 2007 are shown in Figure S8.2. Except for the smaller watershed of Halady, R exceeds P for multiple months

Table S8.1: Annual P, R and ET (in MCM) for WY 2007 for the watersheds in Fig. S8.1.

Basin	Site	Area (km^2)	P (IMD)	R	ET	R / P	(R + ET) / P
Cauvery	Kudige	1,742.8	3,794	3,932	1,962	1.04	1.55
Cauvery	Sakleshpur	615.6	1,572	2,018	681	1.28	1.72
Krishna	Shimoga	2,761.3	8,197	7,303	3,078	0.89	1.27
WFR South	Addoor	718.7	3,217	2,612	1,017	0.81	1.13
WFR South	Avershe	299.6	1,033	1,381	398	1.34	1.72
WFR South	Bantwal	3,295.4	13,058	14,952	4,432	1.15	1.48
WFR South	Erinjipuzha	912.0	3,389	3,031	1,244	0.89	1.26
WFR South	Halady	566.4	2,646	2,410	726	0.91	1.19
WFR South	Yennehole	356.9	1,527	1,535	510	1.01	1.34

during the monsoon season. Thus, these watersheds are simultaneously experiencing the water imbalance scenarios of $P \leq R$ or $P << R + ET$. The temporal pattern of P and R is generally similar across the watersheds - with July being the month of largest P and R.

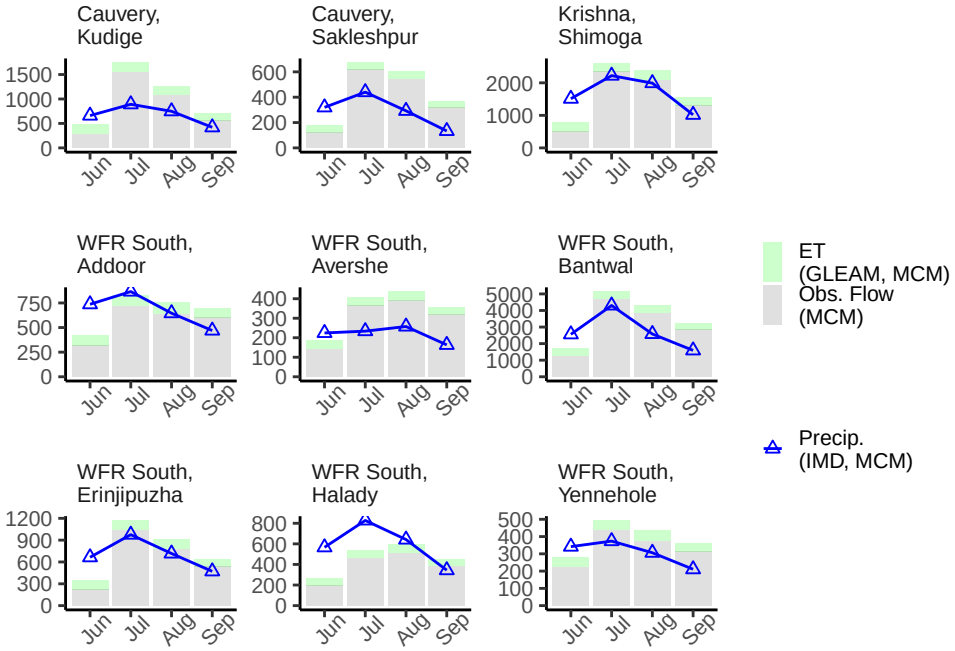


Figure S8.2: Monthly P, ET and R (in MCM) for WY 2007 for the watersheds in Fig. S8.1. Only the months of the monsoon season, June-September, are shown.

It is not known if, and to what extent, IGF is present within these watersheds. The possibility of IGF causing the observed spuriously high runoff coefficients is examined here. If IGF is present in this region, groundwater can flow between these watersheds and (or) can flow into these watersheds from the adjacent terrain.

In case of flow between the watersheds, some of them would be losing streamflow, while the others would be gaining streamflow. Under such circumstances, some watersheds would have lower runoff coefficients while others would have higher coefficients. One would not see

the simultaneous occurrence of monthly runoff coefficients greater than 1.0 across most of the watersheds, such as those during the months of July and August (Figure S8.2). This simultaneous occurrence of high monthly runoff coefficients also happens in other years (but is not shown here). Thus, it appears that IGF between the watersheds is unlikely the cause of observed watershed imbalance.

IGF from the surrounding terrain into these watersheds is unlikely since these watersheds are at a relatively higher elevation (Fig. S8.1(c)). Groundwater from lower elevations would have to flow against gravity in order to reach these watersheds at higher elevations. Thus, it appears that IGF from the surrounding terrain is unlikely the cause of observed watershed imbalance.

Based on the above discussion, it is reasonable to say that IGF is not the predominant cause of the observed water imbalance in the above watersheds. However, the reader should note that IGF can still be present. Only field data can truly reveal the pattern of groundwater flow occurring under these watersheds and the extent of its contribution to streamflow. The above analysis was not performed in other parts of the study domain because of data limitations - inadequate monthly streamflow and the non-contiguous nature of imbalanced watersheds.

S9 Effect of different heuristics on Scenario II

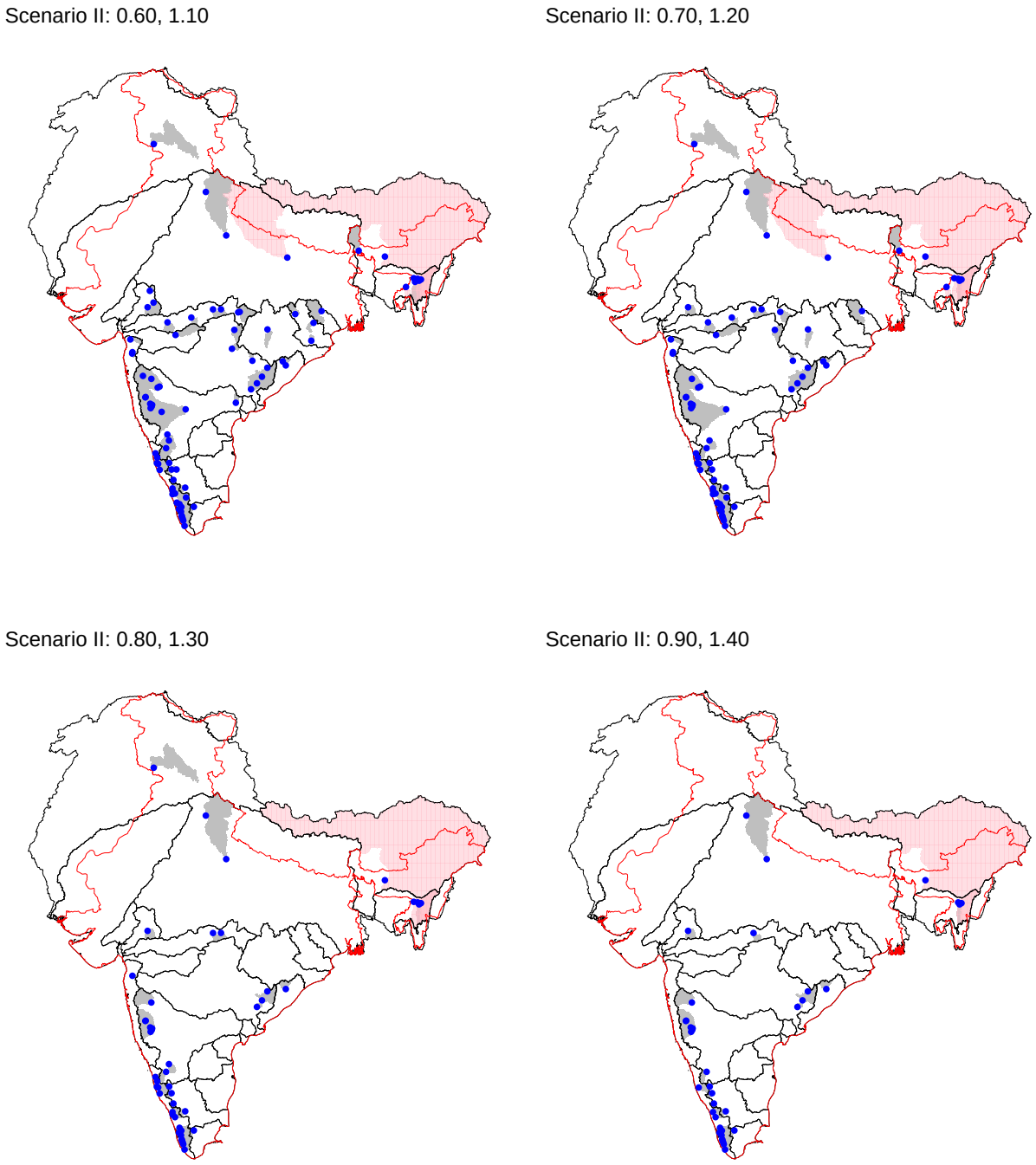


Figure S9.1: Watersheds where Scenario II is realized when using different sets of heuristics.

Table S9.1: Same as Table 3 in the paper, except for heuristics of 0.60 and 1.10 in Scenario II.

	North India				Peninsular India			
Product	Total	Scenario I	Scenario II	% Imbalanced	Total	Scenario I	Scenario II	% Imbalanced
APHRO	782	92	112	26.1%	5,788	349	624	16.8%
CHIRPS	782	76	62	17.6%	6,036	306	515	13.6%
CMORPH	436	61	63	28.4%	3,493	315	281	17.1%
ERA5	782	7	91	12.5%	6,153	245	489	11.9%
GSMAP	382	76	52	33.5%	3,132	441	222	21.2%
IMD-APHRO	782	32	104	17.4%	6,153	414	542	15.5%
IMDAA	782	8	24	4.1%	6,153	179	434	10.0%
IMERG	382	19	39	15.2%	3,132	169	264	13.8%
MSWEP	782	60	95	19.8%	6,153	122	361	7.8%
PERSIANN	782	89	93	23.3%	5,796	767	407	20.3%
SM2RAIN	195	9	24	16.9%	1,784	116	132	13.9%
TERRA	782	75	98	22.1%	6,153	153	451	9.8%

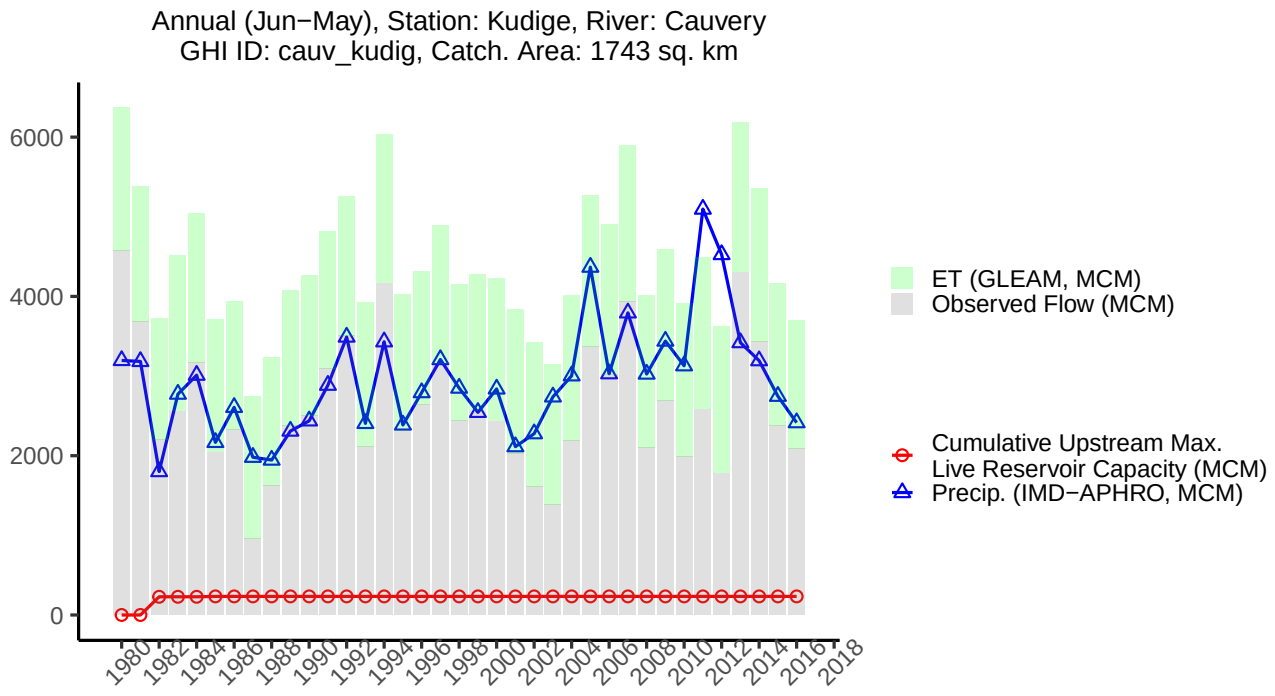
Table S9.2: Same as Table 3 in the paper, except for heuristics of 0.80 and 1.30 in Scenario II.

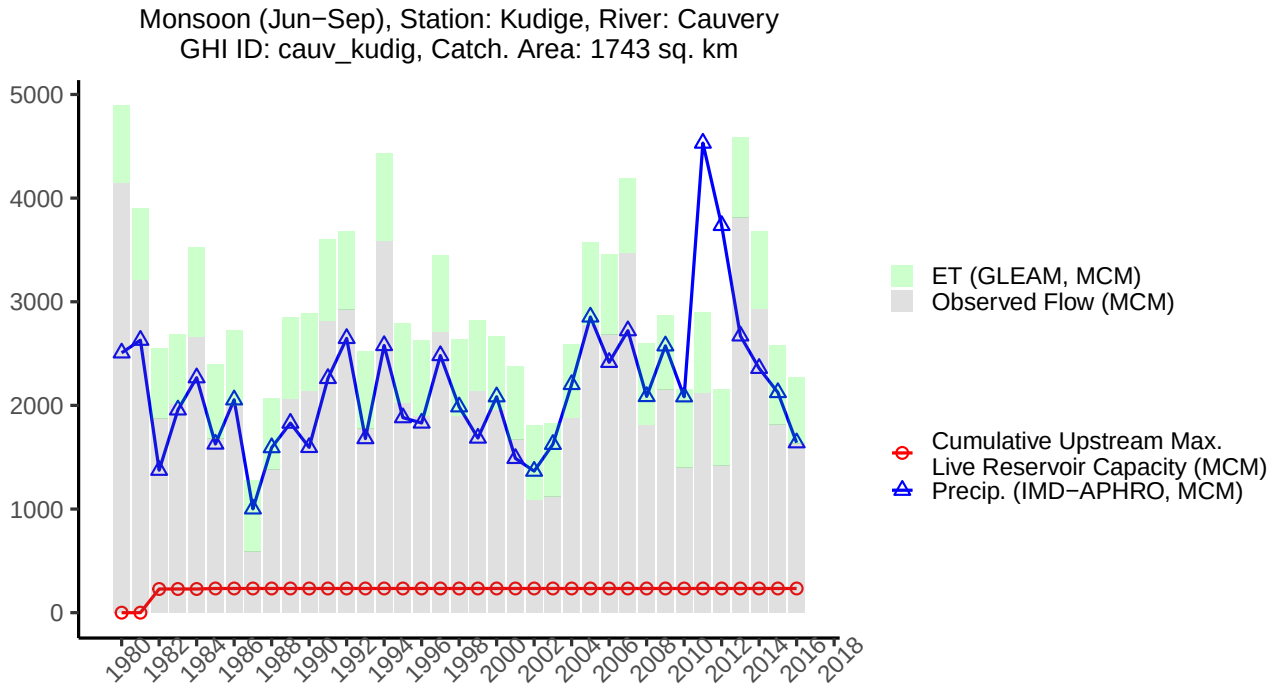
	North India				Peninsular India			
Product	Total	Scenario I	Scenario II	% Imbalanced	Total	Scenario I	Scenario II	% Imbalanced
APHRO	782	92	40	16.9%	5,788	349	203	9.5%
CHIRPS	782	76	25	12.9%	6,036	306	150	7.5%
CMORPH	436	61	18	18.1%	3,493	315	113	12.2%
ERA5	782	7	16	2.9%	6,153	245	139	6.2%
GSMAP	382	76	27	27.0%	3,132	441	84	16.8%
IMD-APHRO	782	32	28	7.7%	6,153	414	206	10.1%
IMDAA	782	8	4	1.5%	6,153	179	102	4.6%
IMERG	382	19	7	6.8%	3,132	169	83	8.1%
MSWEP	782	60	23	10.6%	6,153	122	89	3.4%
PERSIANN	782	89	43	16.9%	5,796	767	157	15.9%
SM2RAIN	195	9	7	8.2%	1,784	116	39	8.7%
TERRA	782	75	29	13.3%	6,153	153	102	4.1%

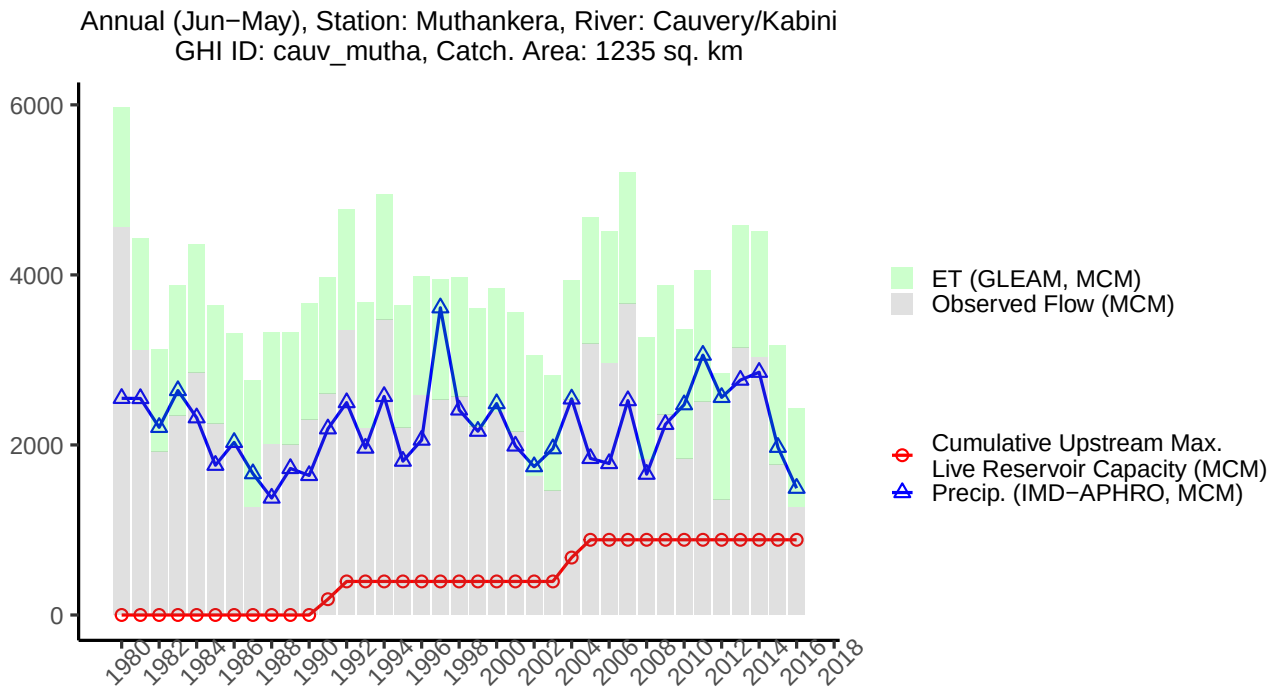
Table S9.3: Same as Table 3 in the paper, except for heuristics of 0.90 and 1.40 in Scenario II.

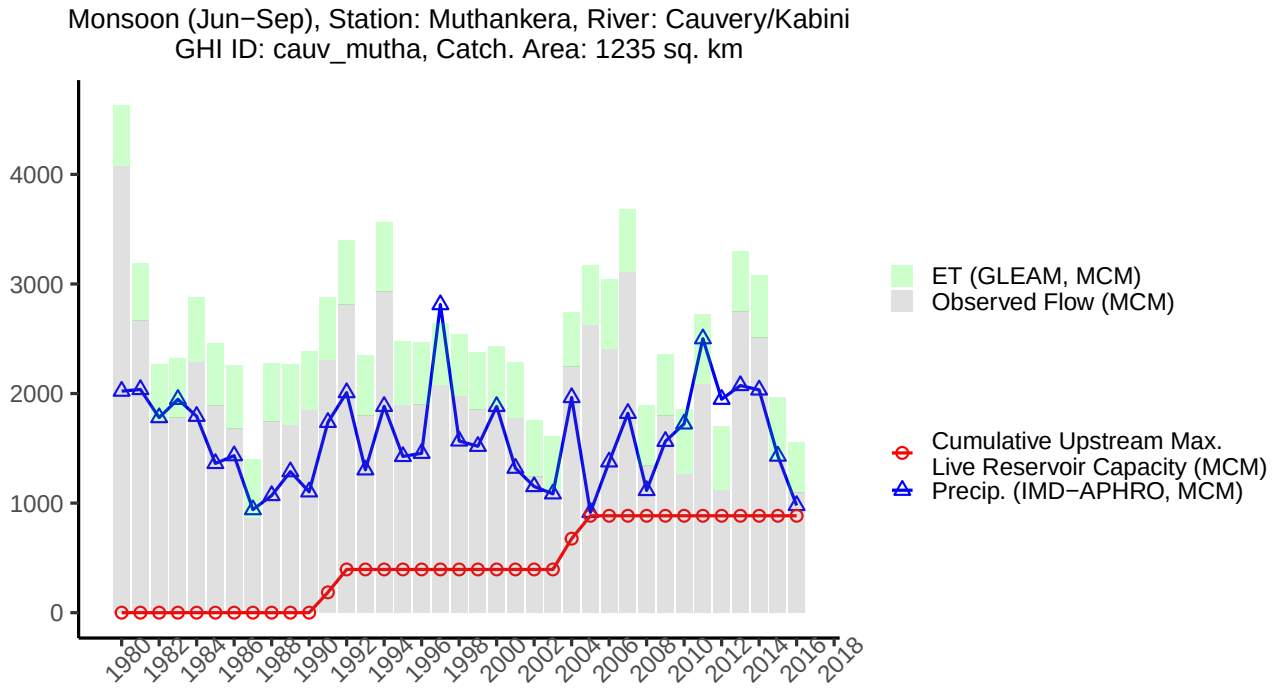
	North India				Peninsular India			
Product	Total	Scenario I	Scenario II	% Imbalanced	Total	Scenario I	Scenario II	% Imbalanced
APHRO	782	92	15	13.7%	5,788	349	79	7.4%
CHIRPS	782	76	9	10.9%	6,036	306	44	5.8%
CMORPH	436	61	6	15.4%	3,493	315	46	10.3%
ERA5	782	7	2	1.1%	6,153	245	35	4.5%
GSMAP	382	76	14	23.6%	3,132	441	37	15.3%
IMD-APHRO	782	32	11	5.5%	6,153	414	80	8.0%
IMDAA	782	8	1	1.1%	6,153	179	30	3.4%
IMERG	382	19	1	5.2%	3,132	169	34	6.5%
MSWEP	782	60	10	8.9%	6,153	122	33	2.5%
PERSIANN	782	89	17	13.6%	5,796	767	64	14.3%
SM2RAIN	195	9	1	5.1%	1,784	116	19	7.6%
TERRA	782	75	13	11.2%	6,153	153	32	3.0%

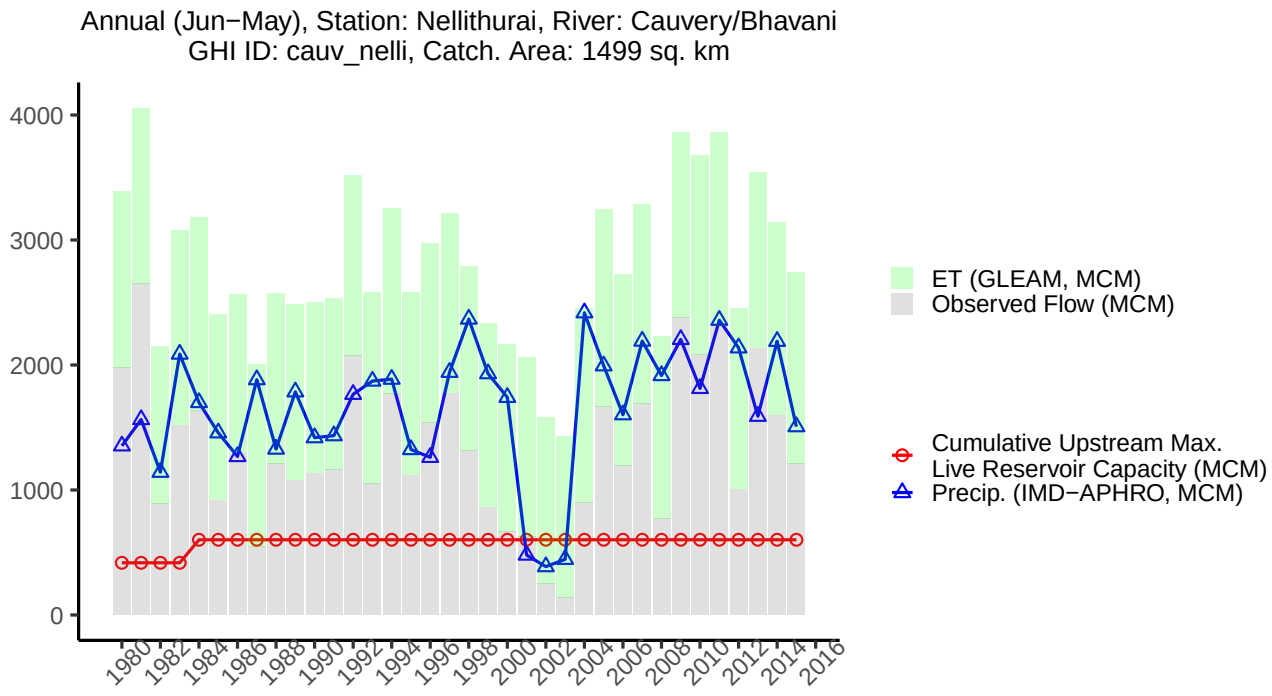
S10 Time series charts

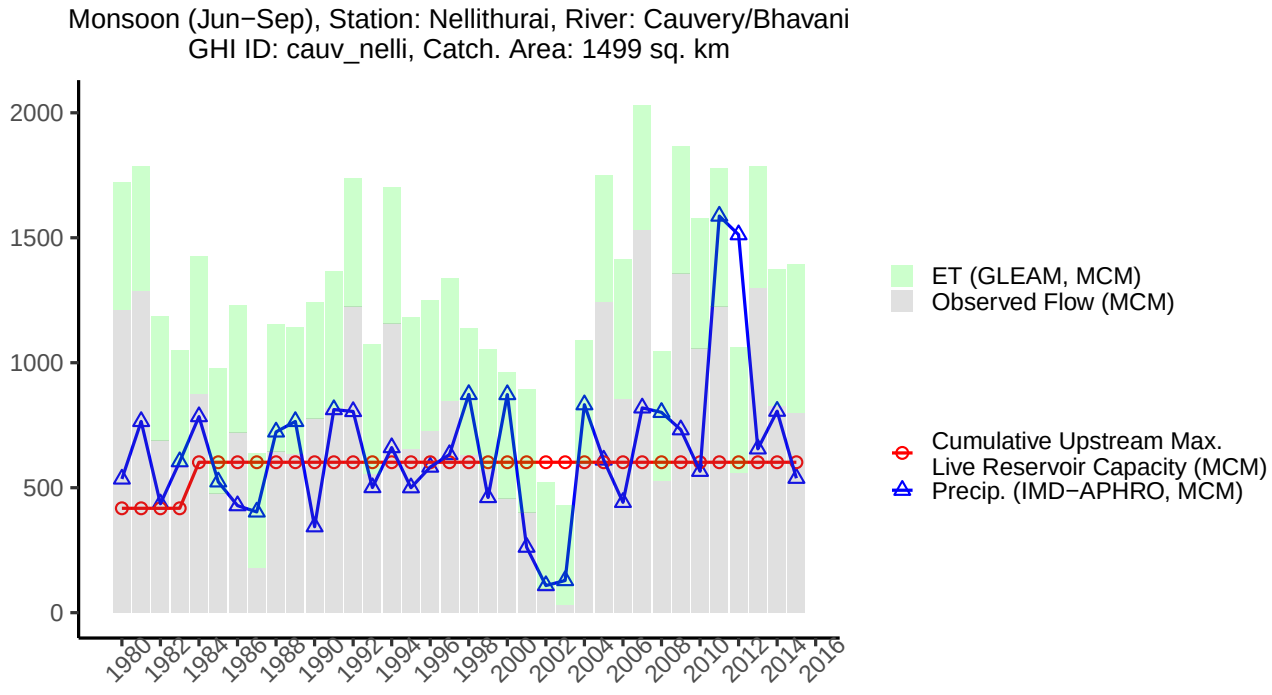




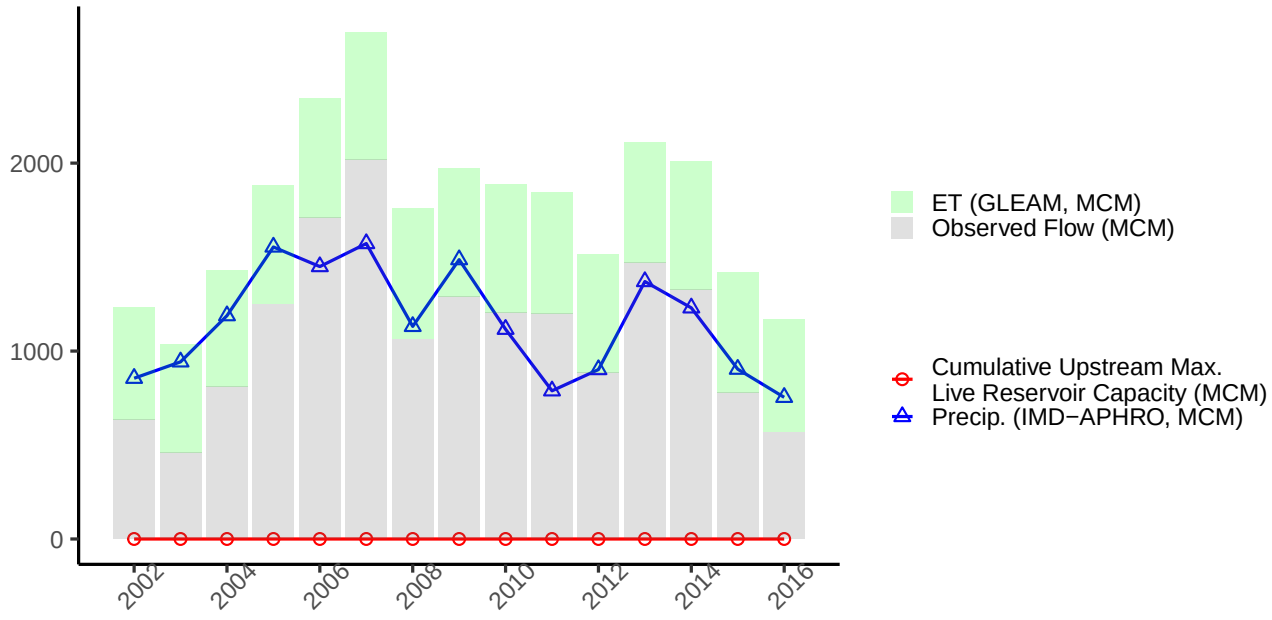

Annual (Jun−May), Station: Muthankera, River: Cauvery/Kabini
GHI ID: cauv_mutha, Catch. Area: 1235 sq. km
6000
4000
2000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Muthankera, River: Cauvery/Kabini
GHI ID: cauv_mutha, Catch. Area: 1235 sq. km
4000
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

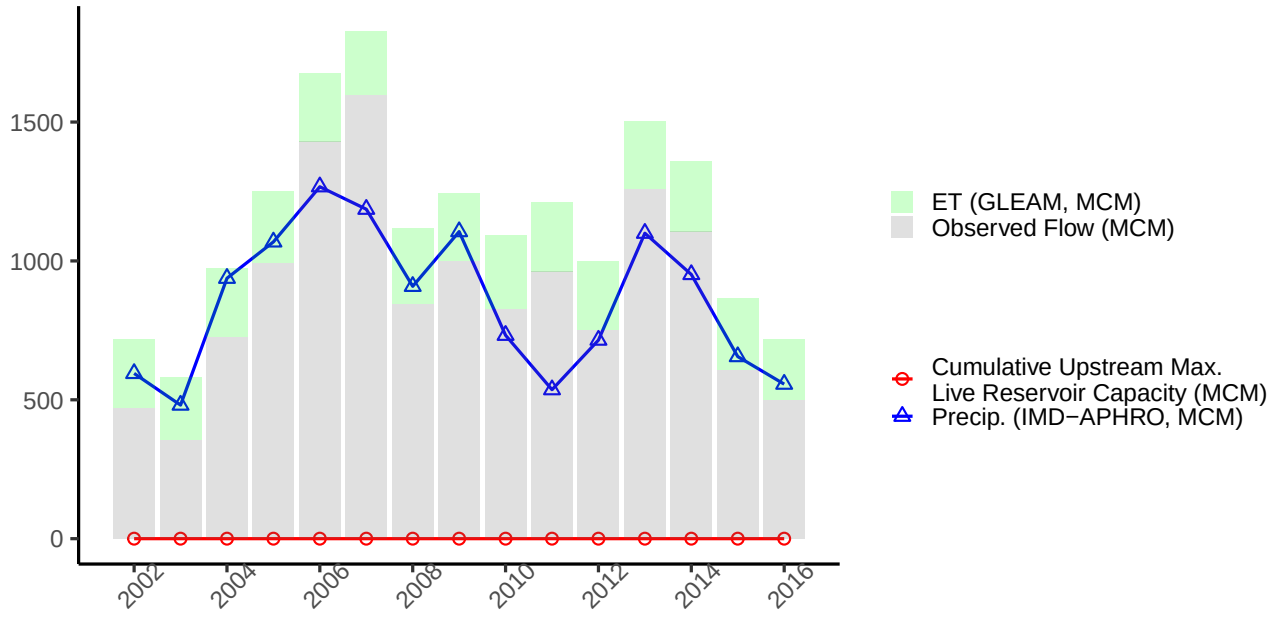

Annual (Jun−May), Station: Nellithurai, River: Cauvery/Bhavani
GHI ID: cauv_nelli, Catch. Area: 1499 sq. km
4000
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

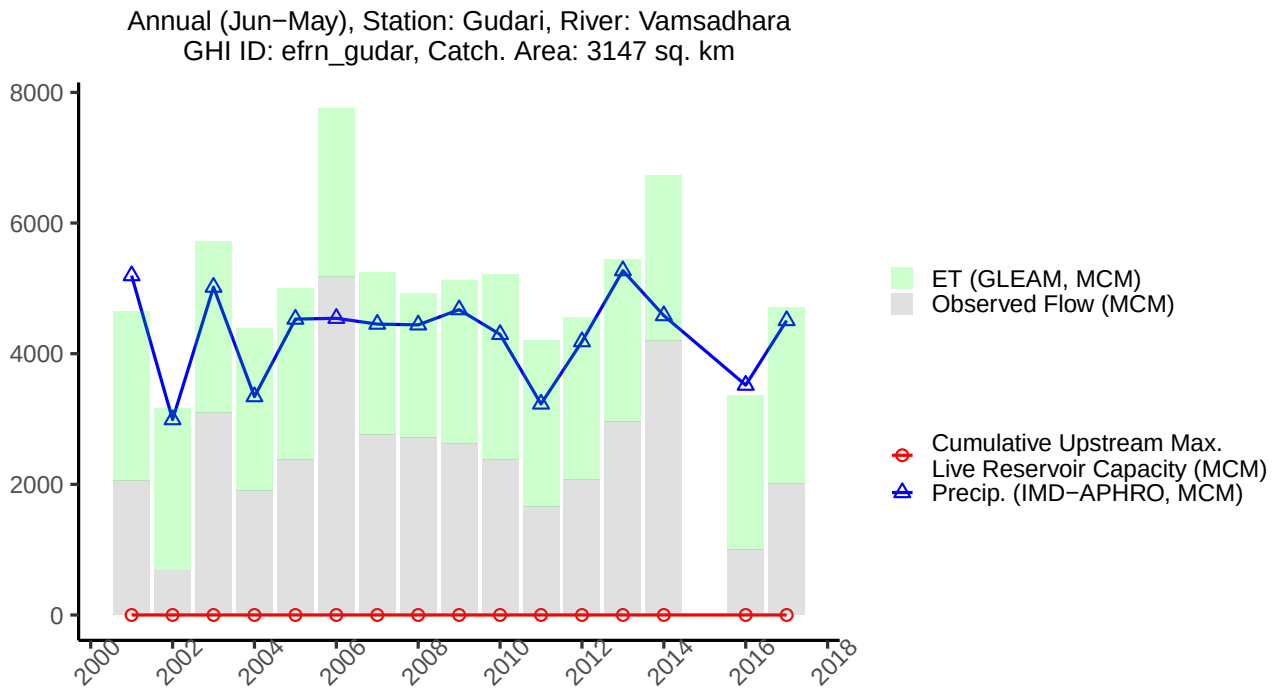

Monsoon (Jun−Sep), Station: Nellithurai, River: Cauvery/Bhavani
GHI ID: cauv_nelli, Catch. Area: 1499 sq. km
2000
1500
1000
500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

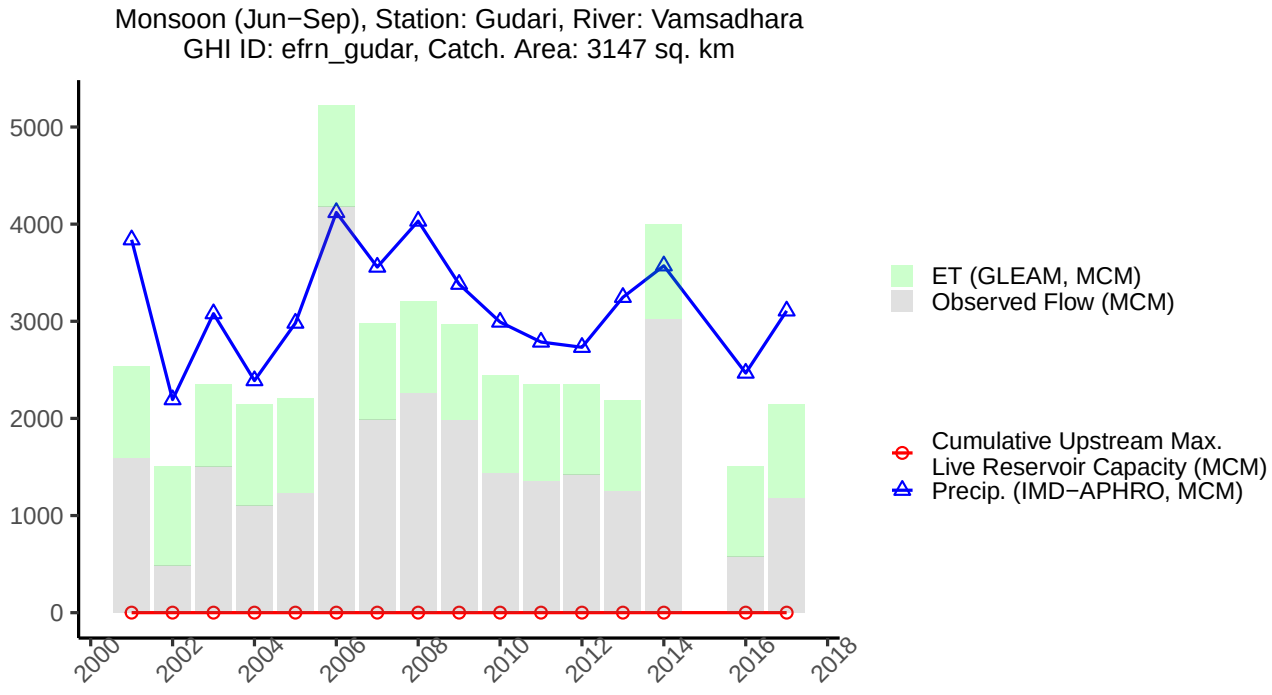
Annual (Jun−May), Station: Sakleshpur, River: Cauvery/Hemavati
GHI ID: cauv_sakle, Catch. Area: 616 sq. km

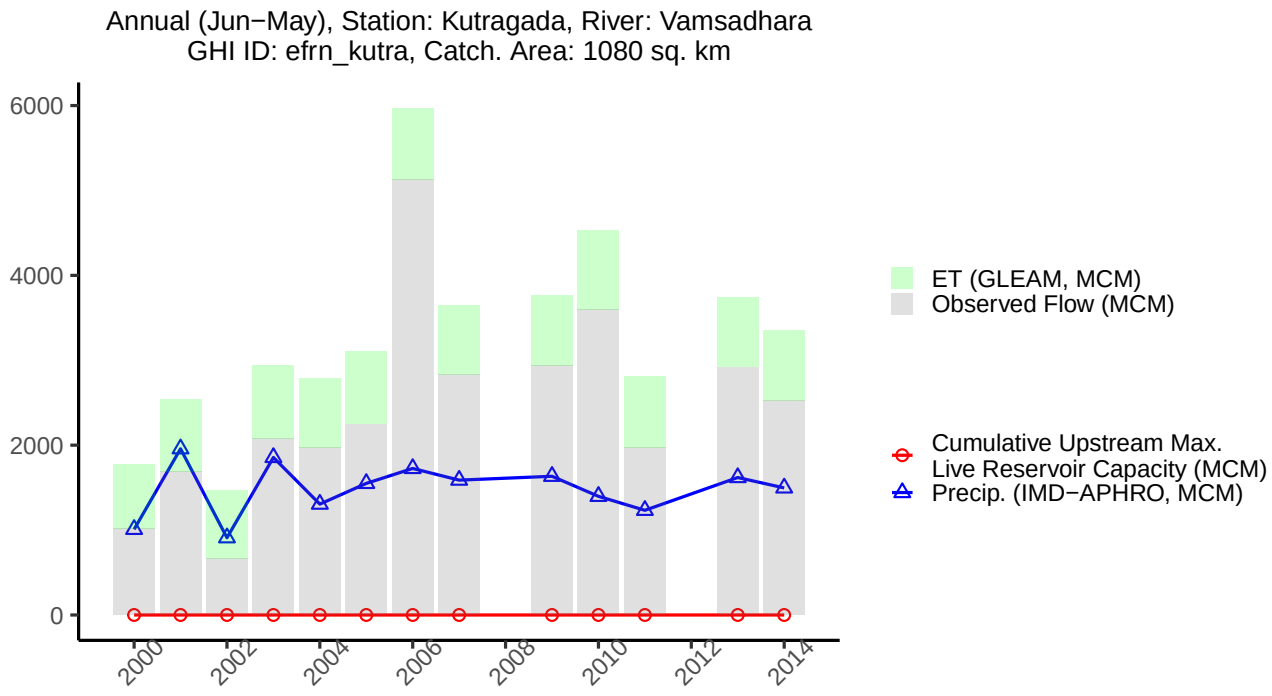


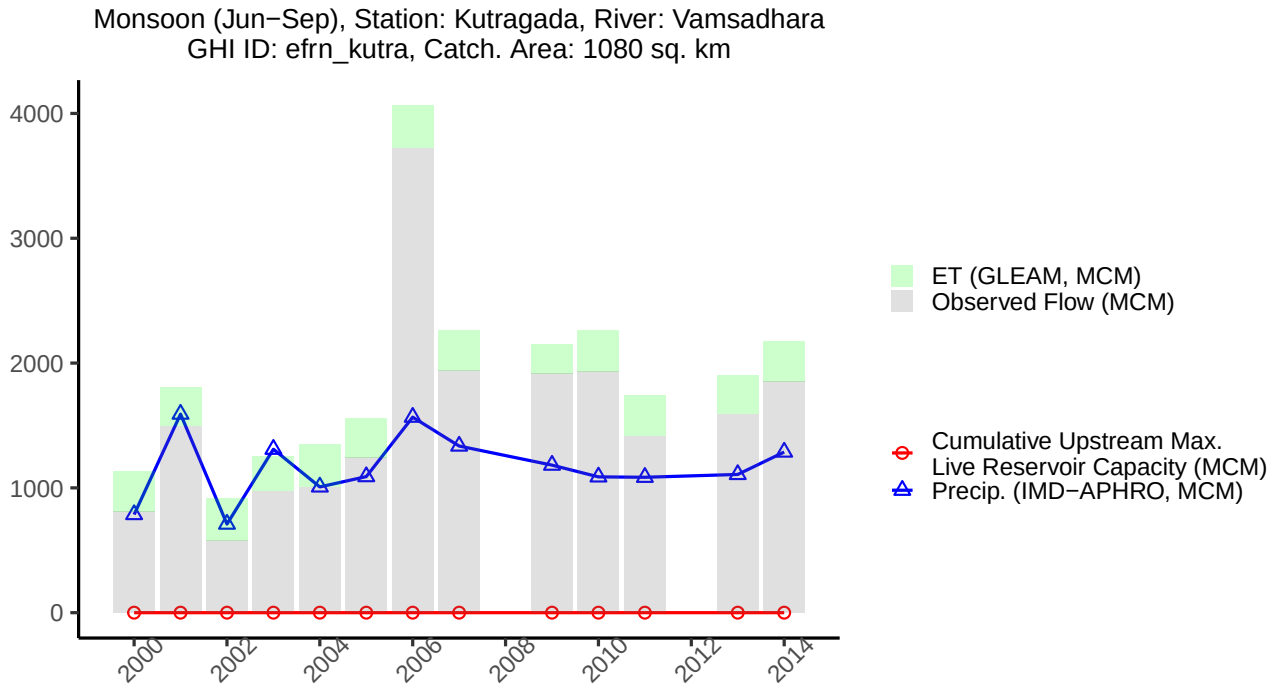
Monsoon (Jun−Sep), Station: Sakleshpur, River: Cauvery/Hemavati
GHI ID: cauv_sakle, Catch. Area: 616 sq. km

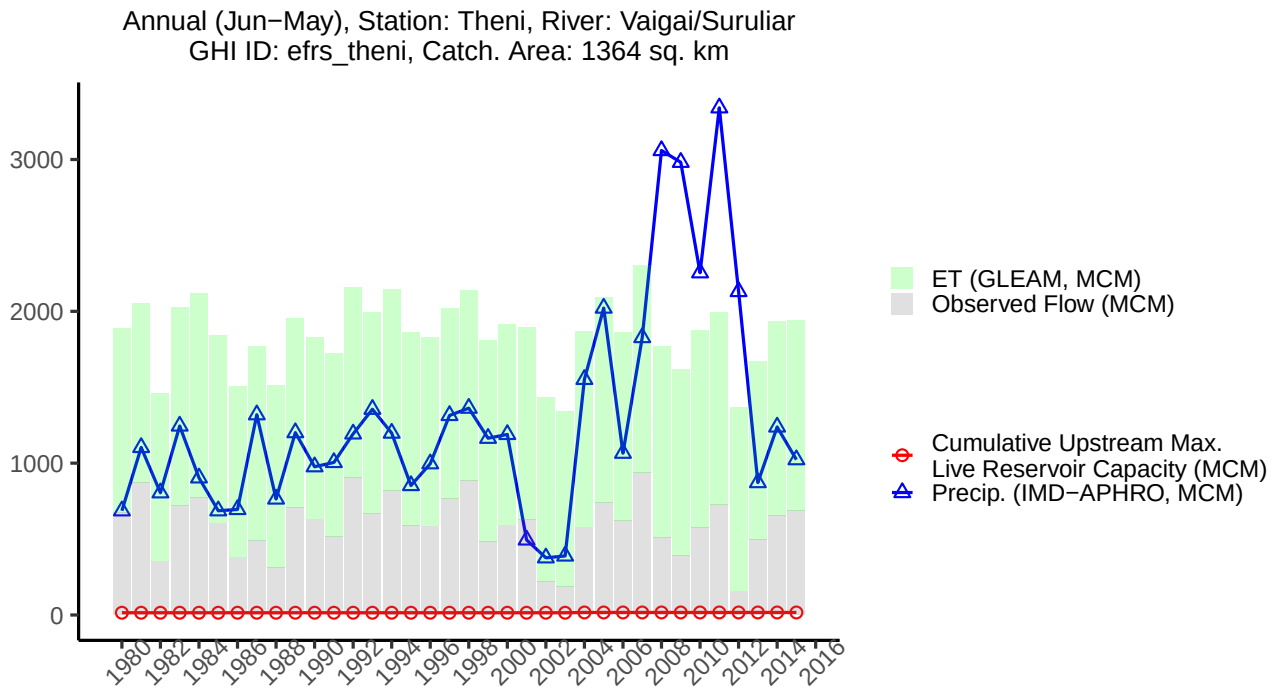


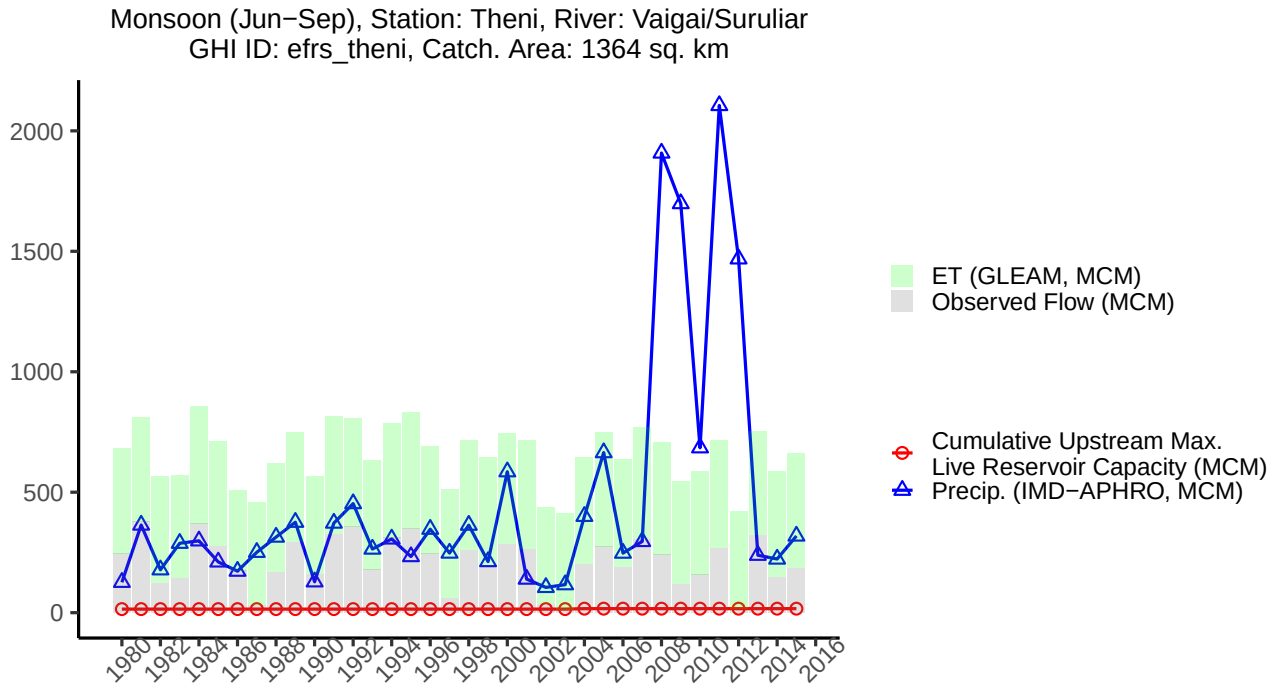

Annual (Jun−May), Station: Gudari, River: Vamsadhara
GHI ID: efrn_gudar, Catch. Area: 3147 sq. km
8000
6000
4000
2000
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

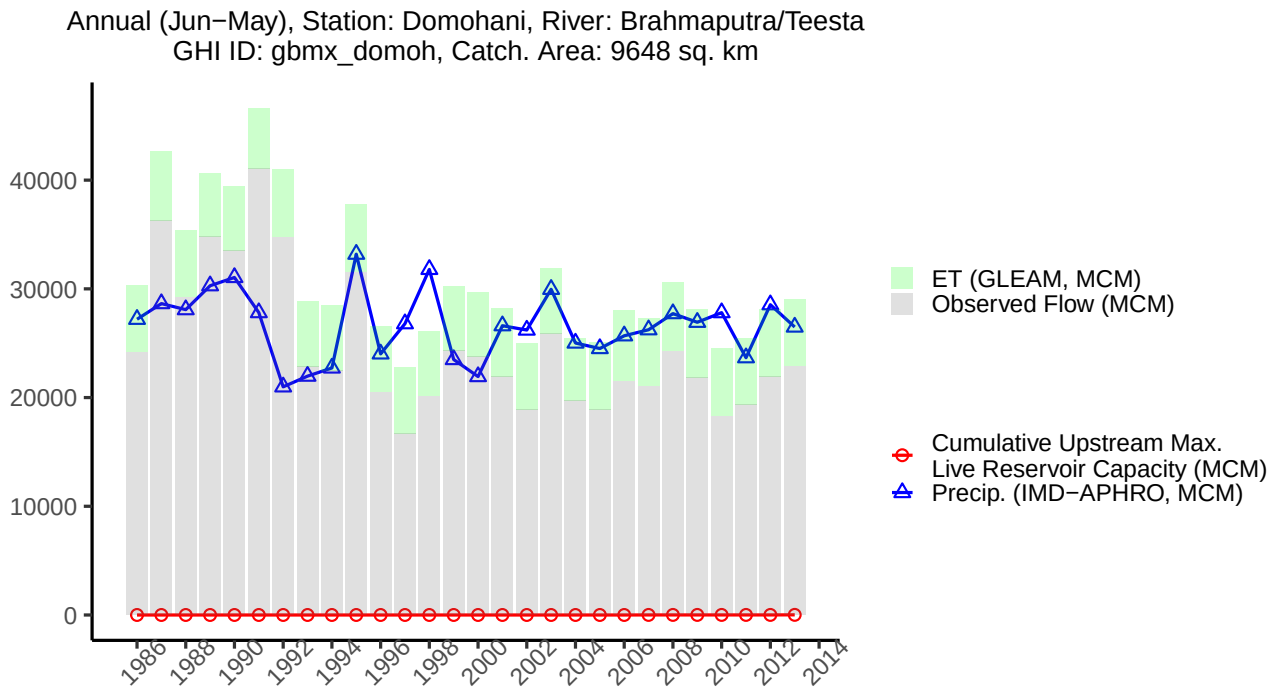

Monsoon (Jun−Sep), Station: Gudari, River: Vamsadhara
GHI ID: efrn_gudar, Catch. Area: 3147 sq. km
5000
4000
3000
2000
1000
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

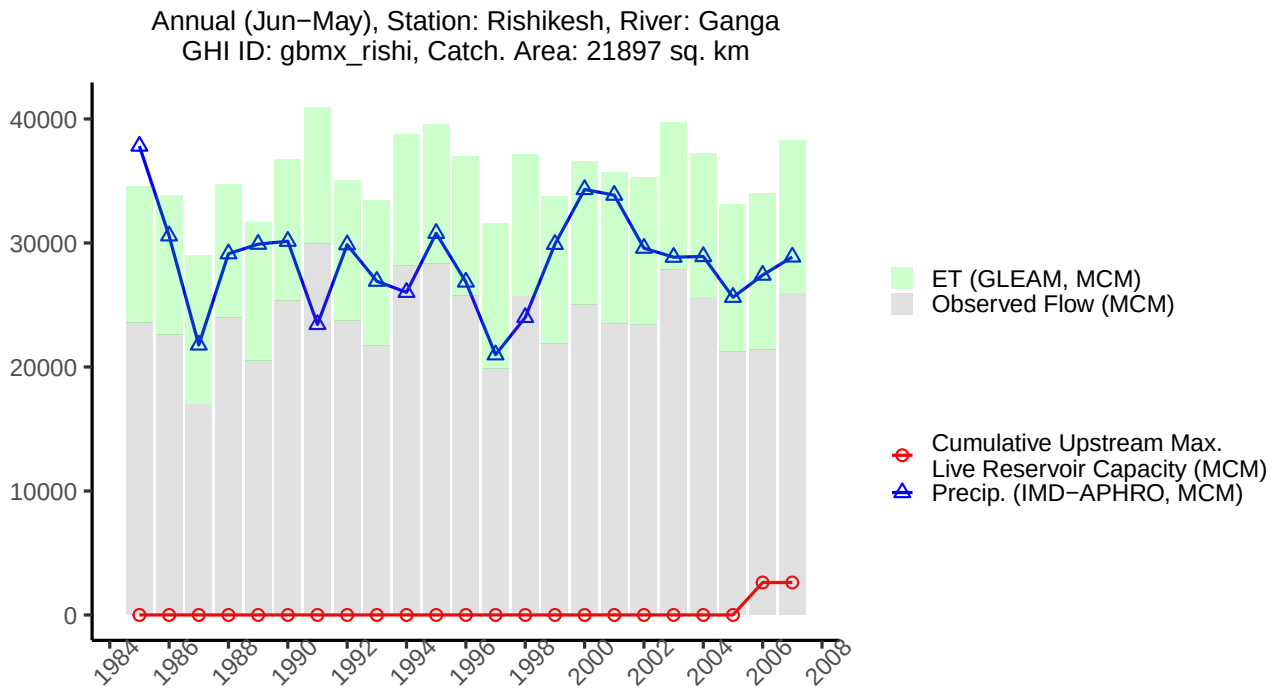

Annual (Jun−May), Station: Kutragada, River: Vamsadhara
GHI ID: efrn_kutra, Catch. Area: 1080 sq. km
6000
4000
2000
0
2000
2002
2004
2006
2008
2010
2012
2014
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Kutragada, River: Vamsadhara
GHI ID: efrn_kutra, Catch. Area: 1080 sq. km
4000
3000
2000
1000
0
2000
2002
2004
2006
2008
2010
2012
2014
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

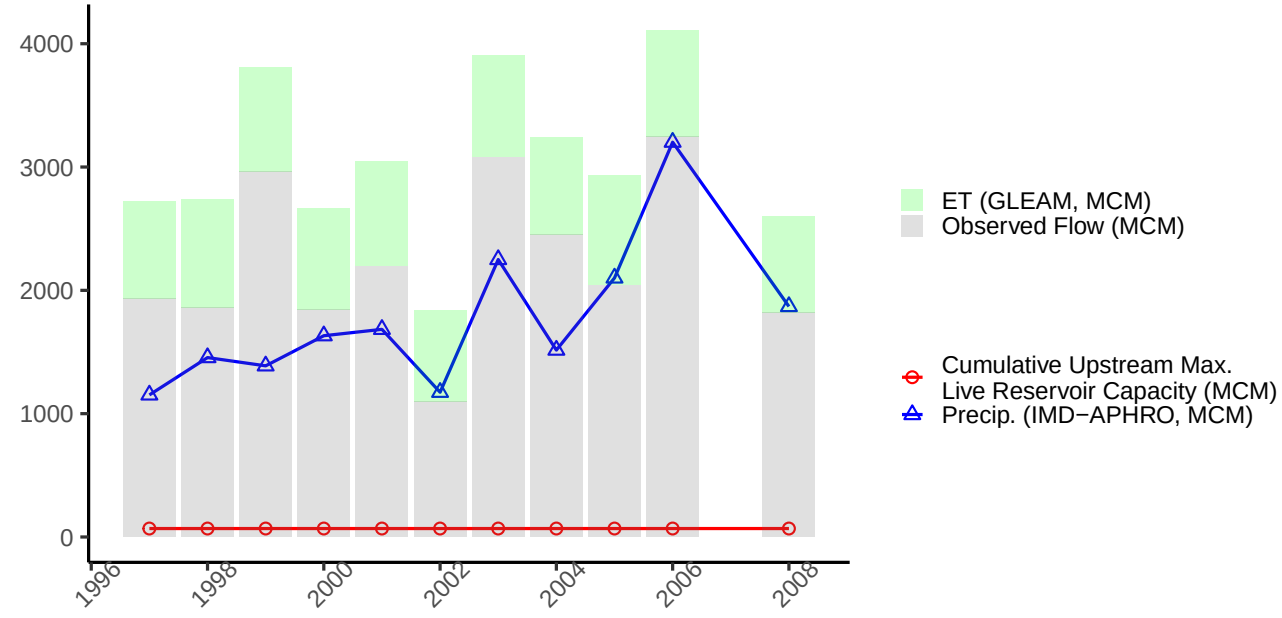

Annual (Jun−May), Station: Theni, River: Vaigai/Suruliar
GHI ID: efrs_theni, Catch. Area: 1364 sq. km
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Theni, River: Vaigai/Suruliar
GHI ID: efrs_theni, Catch. Area: 1364 sq. km
2000
1500
1000
500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

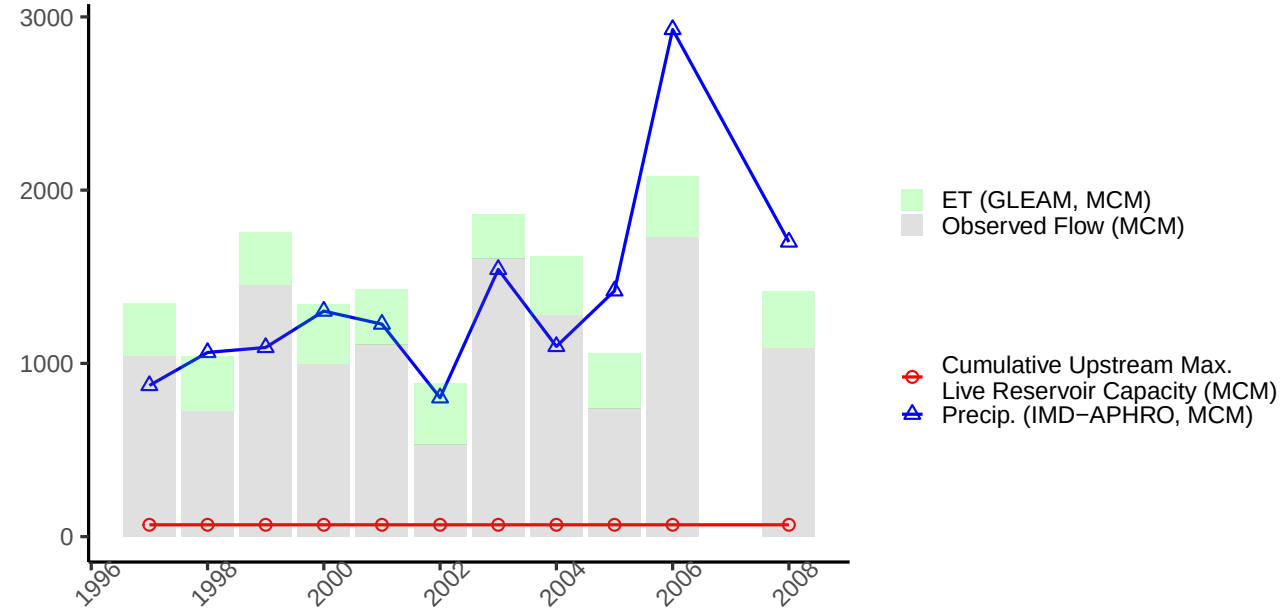

Annual (Jun−May), Station: Domohani, River: Brahmaputra/Teesta
GHI ID: gbmx_domoh, Catch. Area: 9648 sq. km
40000
30000
20000
10000
0
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

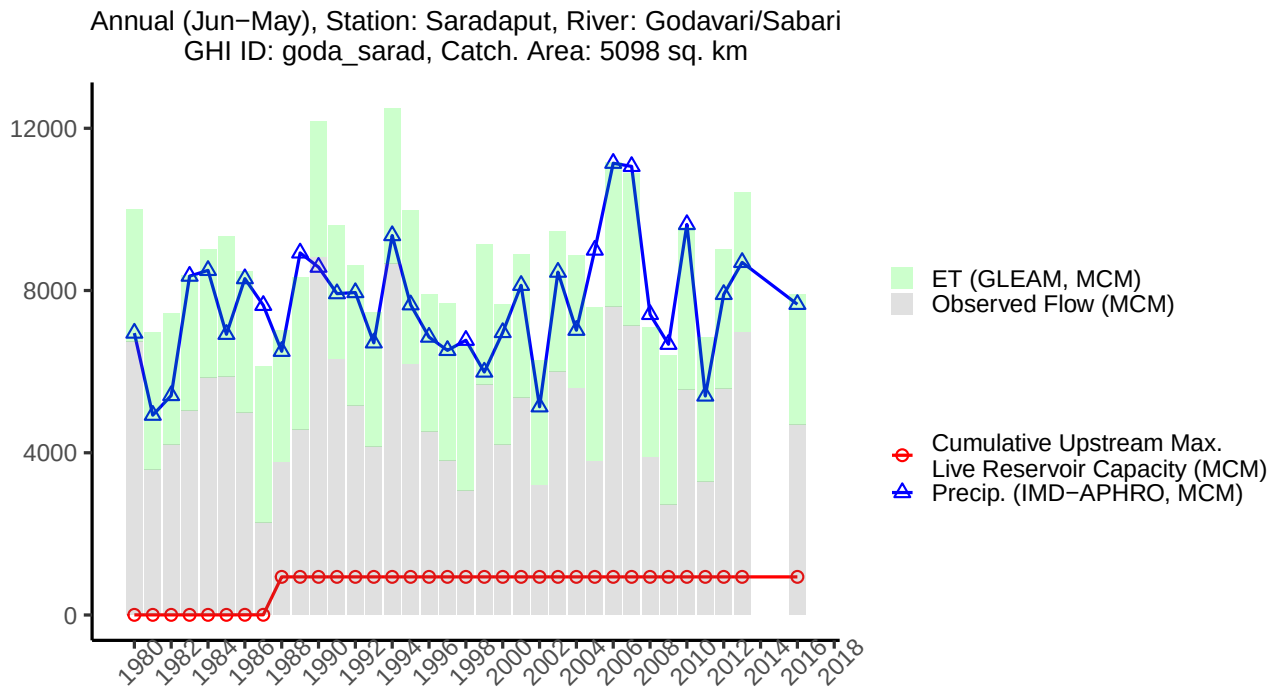

Annual (Jun−May), Station: Rishikesh, River: Ganga
GHI ID: gbmx_rishi, Catch. Area: 21897 sq. km
40000
30000
20000
10000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

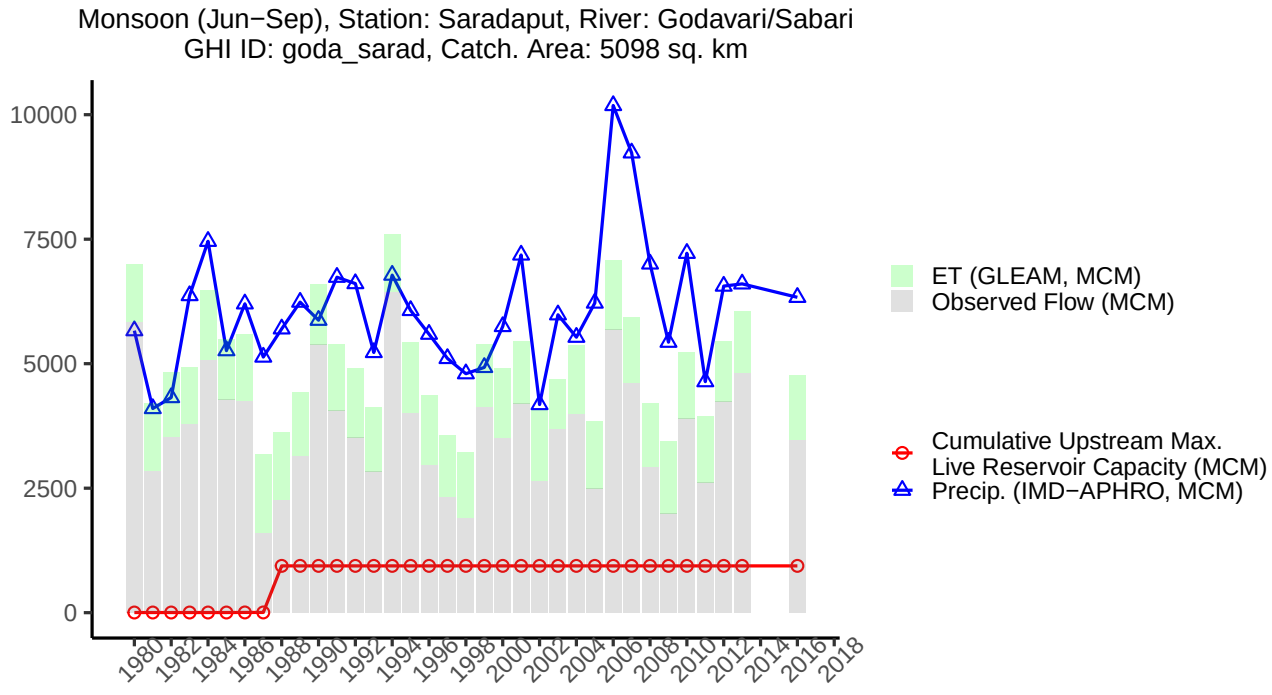
ıual (Jun−May), Station: Potteru (Seasonal), River: Godavari/Sabari/Potteru Vagu
GHI ID: goda_potte, Catch. Area: 1175 sq. km

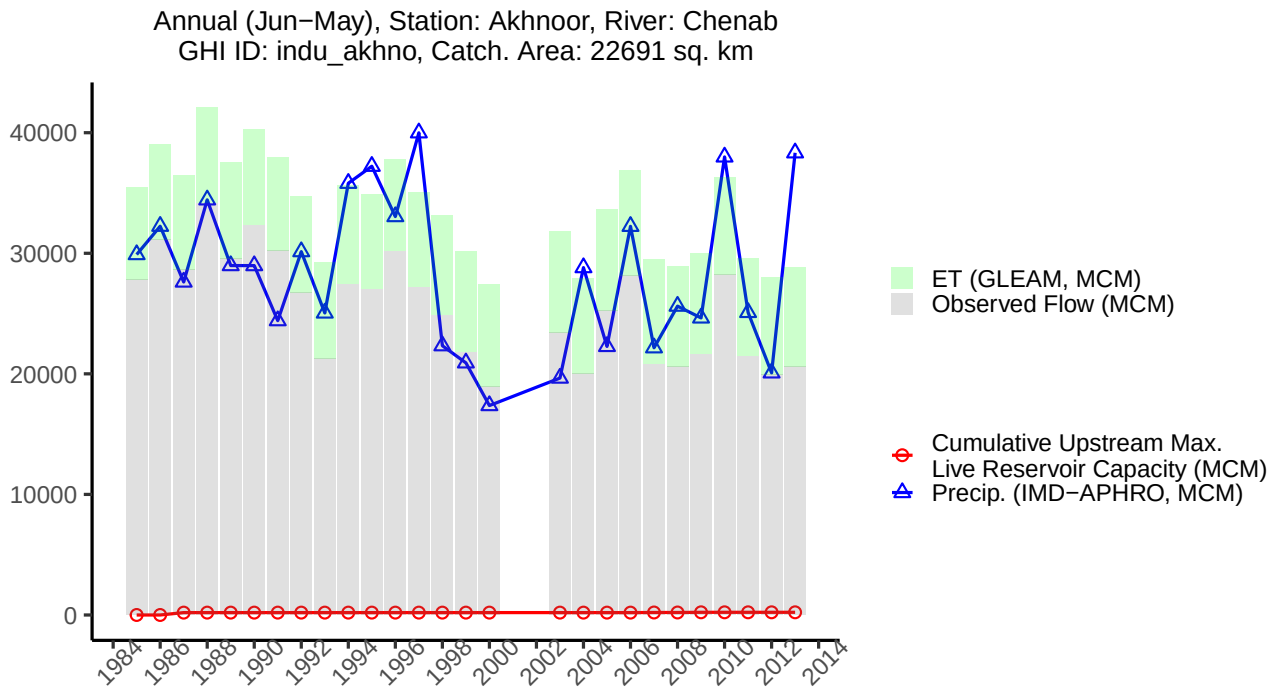


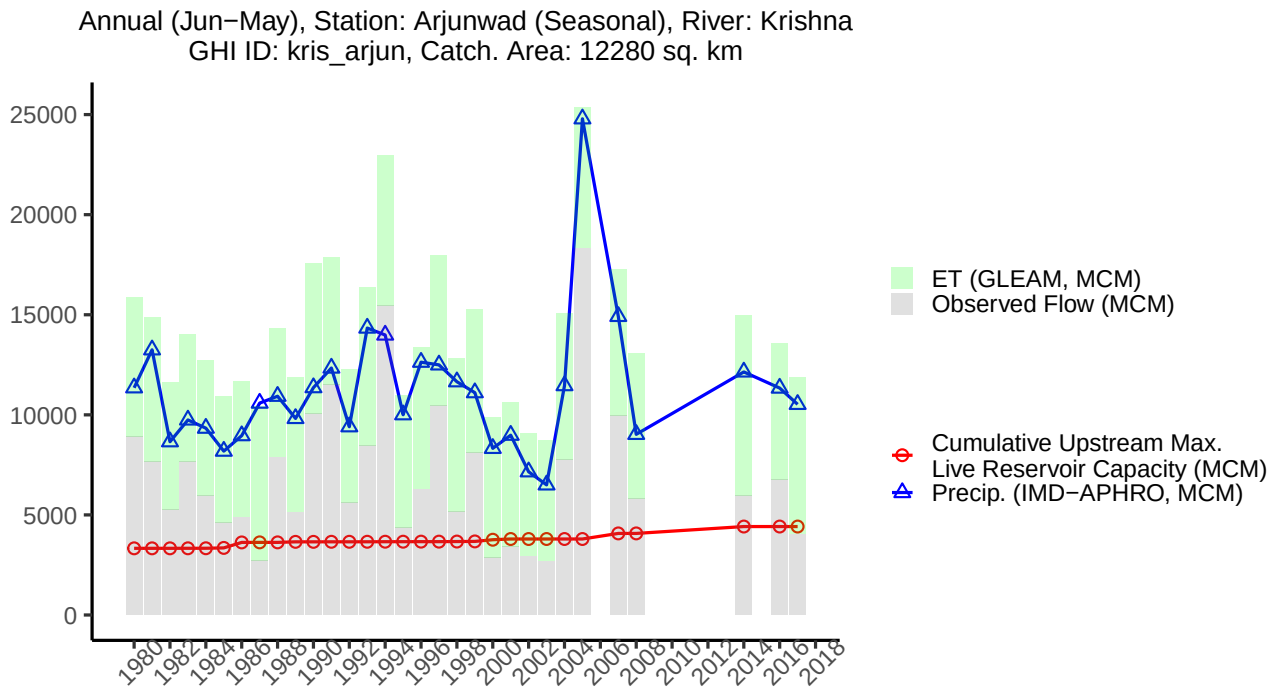
soon (Jun−Sep), Station: Potteru (Seasonal), River: Godavari/Sabari/Potteru Vagu
GHI ID: goda_potte, Catch. Area: 1175 sq. km

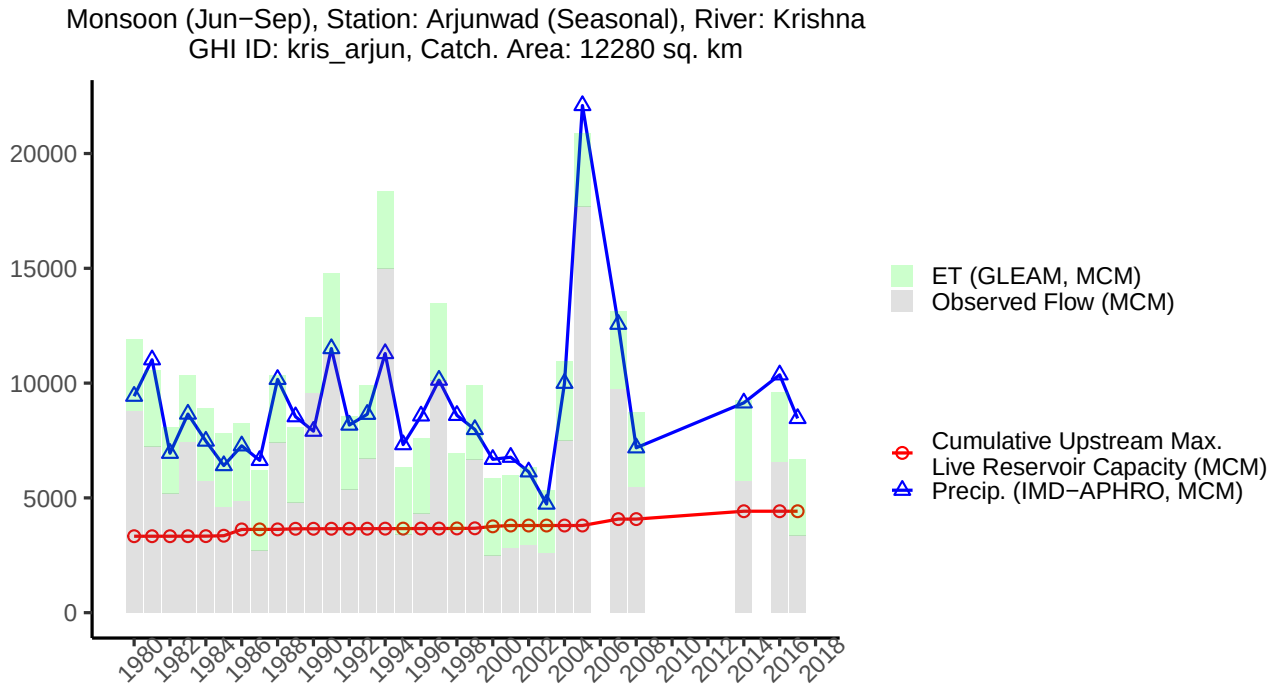


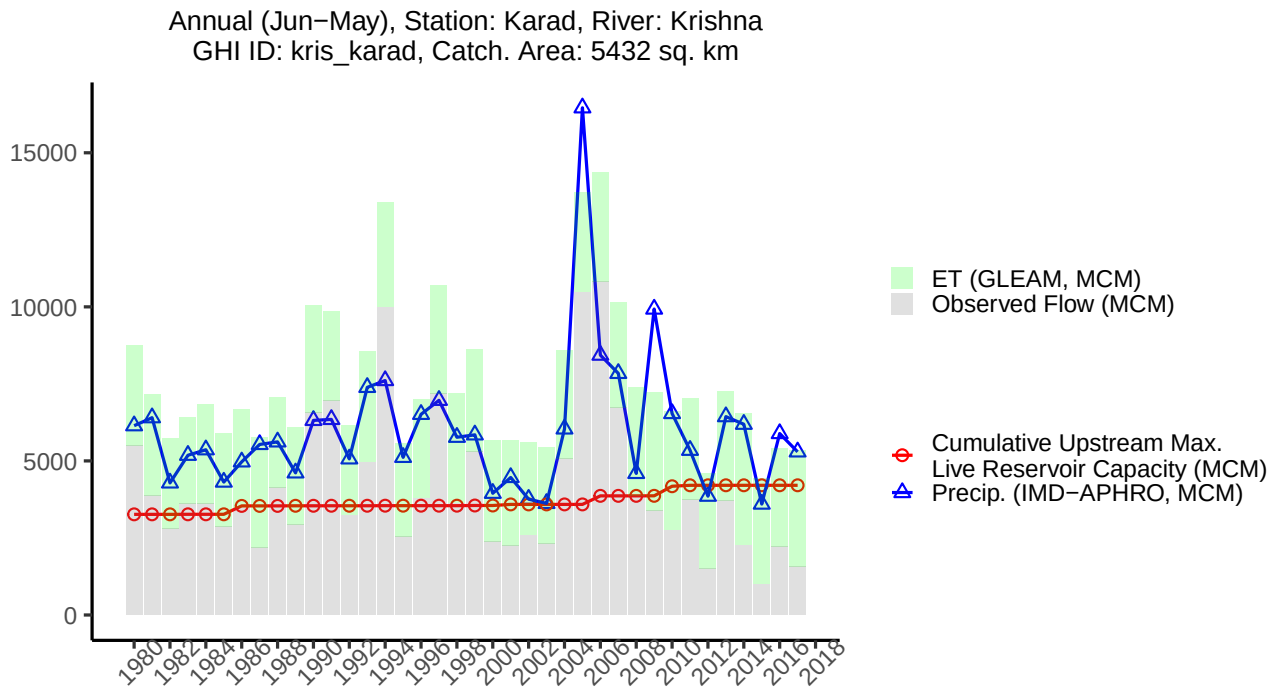

Annual (Jun−May), Station: Saradaput, River: Godavari/Sabari
GHI ID: goda_sarad, Catch. Area: 5098 sq. km
12000
8000
4000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

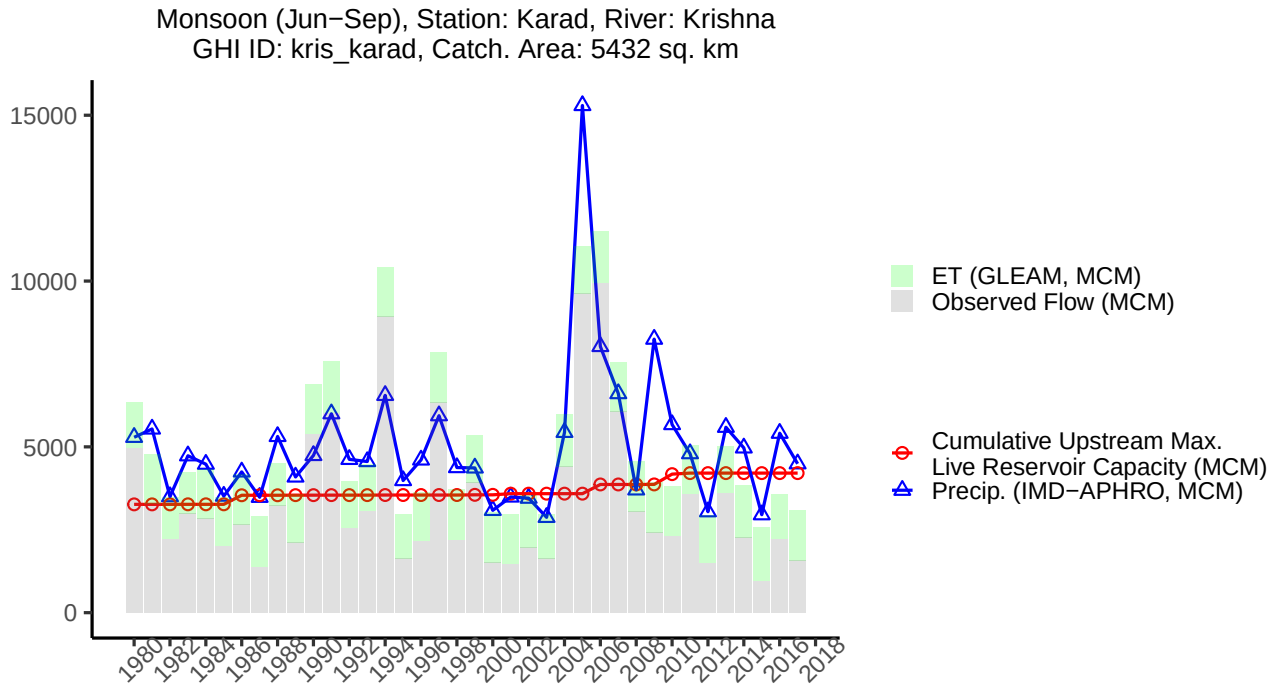

Monsoon (Jun−Sep), Station: Saradaput, River: Godavari/Sabari
GHI ID: goda_sarad, Catch. Area: 5098 sq. km
10000
7500
5000
2500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

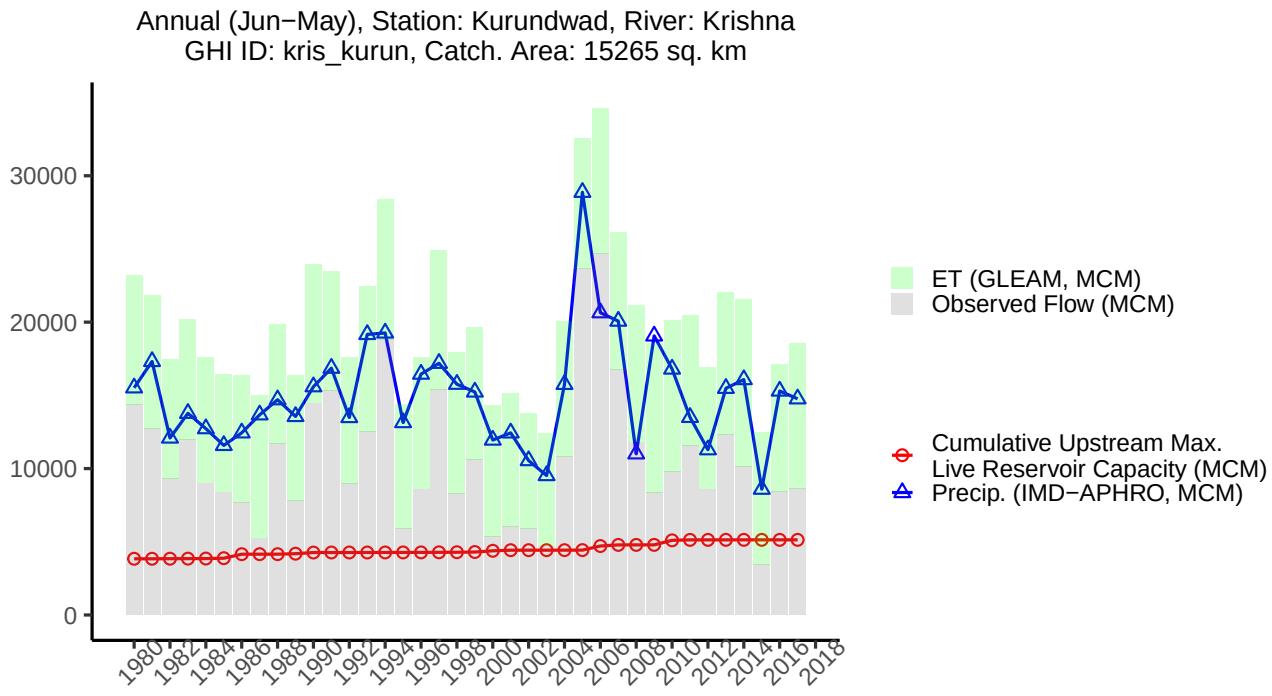

Annual (Jun−May), Station: Akhnoor, River: Chenab
GHI ID: indu_akhno, Catch. Area: 22691 sq. km
40000
30000
20000
10000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

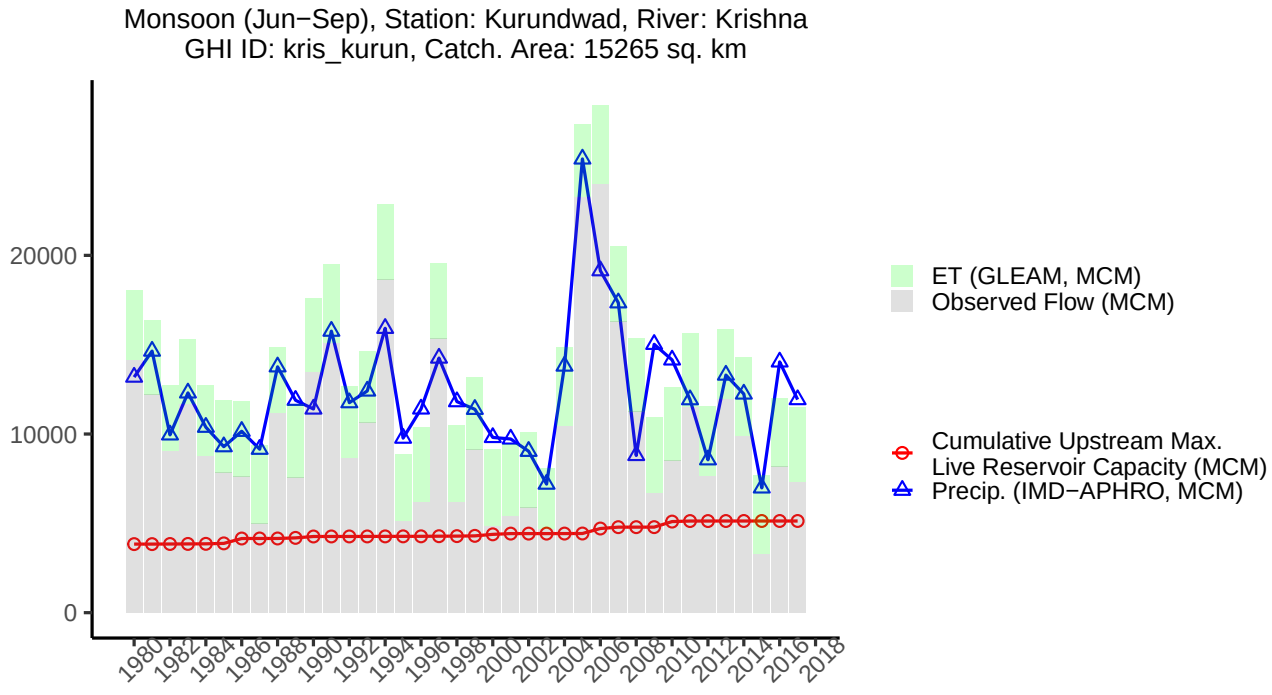

Annual (Jun−May), Station: Arjunwad (Seasonal), River: Krishna
GHI ID: kris_arjun, Catch. Area: 12280 sq. km
25000
20000
15000
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Arjunwad (Seasonal), River: Krishna
GHI ID: kris_arjun, Catch. Area: 12280 sq. km
20000
15000
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

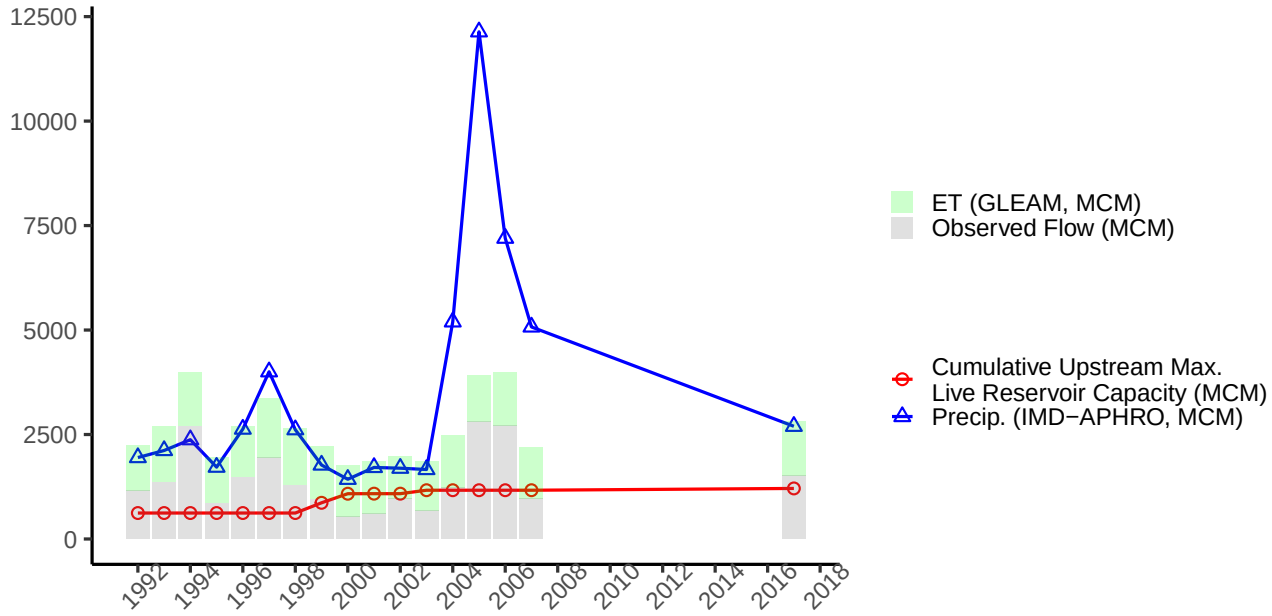

Annual (Jun−May), Station: Karad, River: Krishna
GHI ID: kris_karad, Catch. Area: 5432 sq. km
15000
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Karad, River: Krishna
GHI ID: kris_karad, Catch. Area: 5432 sq. km
15000
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

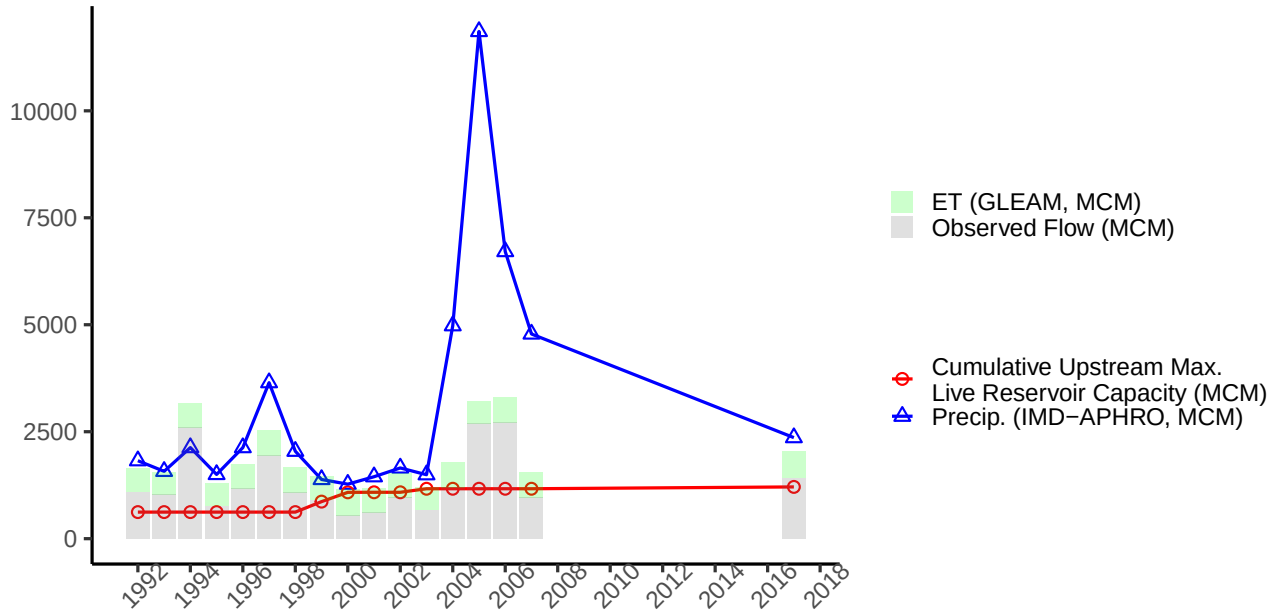

Annual (Jun−May), Station: Kurundwad, River: Krishna
GHI ID: kris_kurun, Catch. Area: 15265 sq. km
30000
20000
10000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Kurundwad, River: Krishna
GHI ID: kris_kurun, Catch. Area: 15265 sq. km
20000
10000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

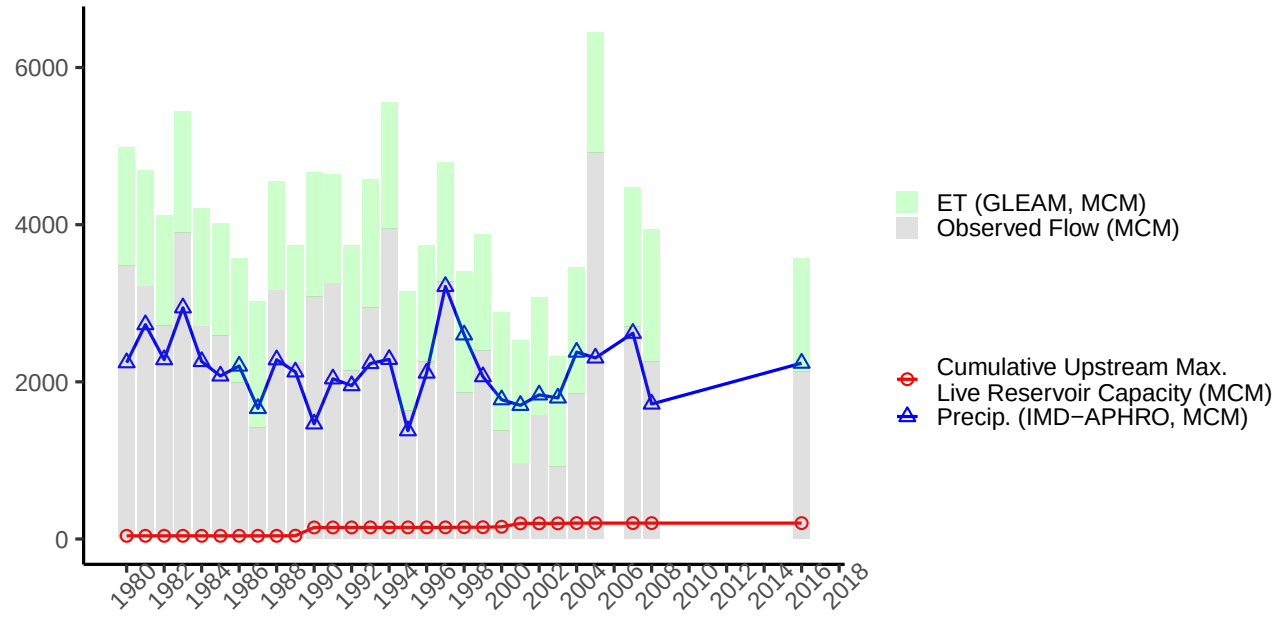
Annual (Jun−May), Station: Phulgaon (Seasonal), River: Krishna/Bhima
GHI ID: kris_phulg, Catch. Area: 2142 sq. km



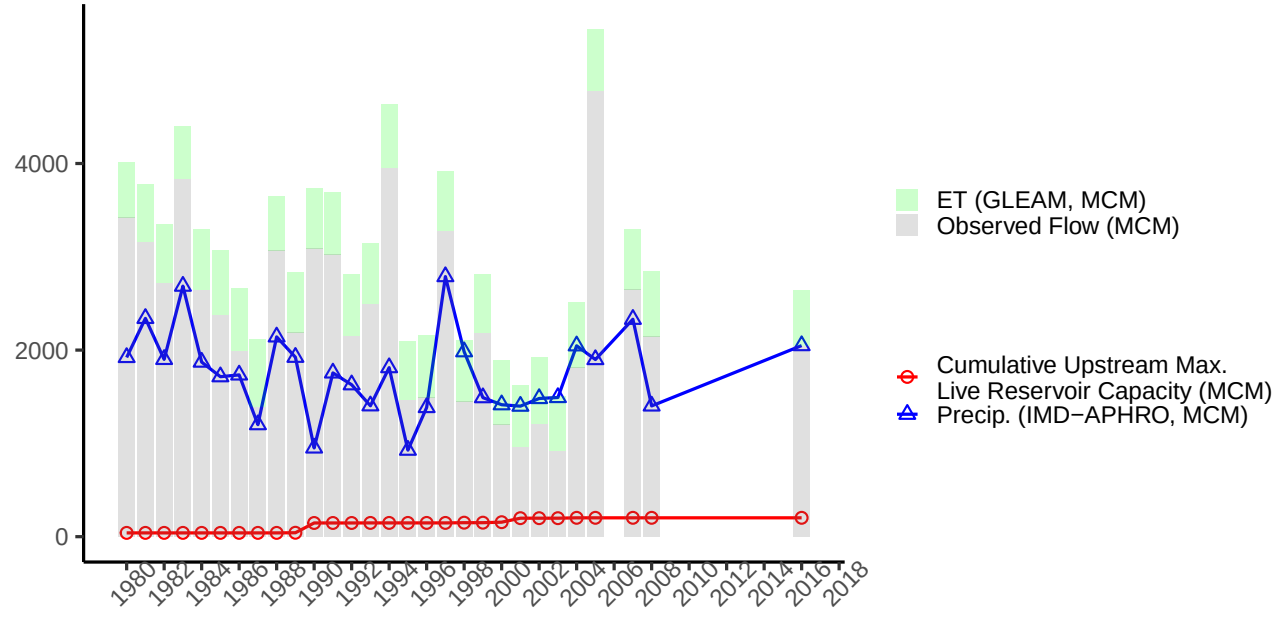
Monsoon (Jun−Sep), Station: Phulgaon (Seasonal), River: Krishna/Bhima
GHI ID: kris_phulg, Catch. Area: 2142 sq. km



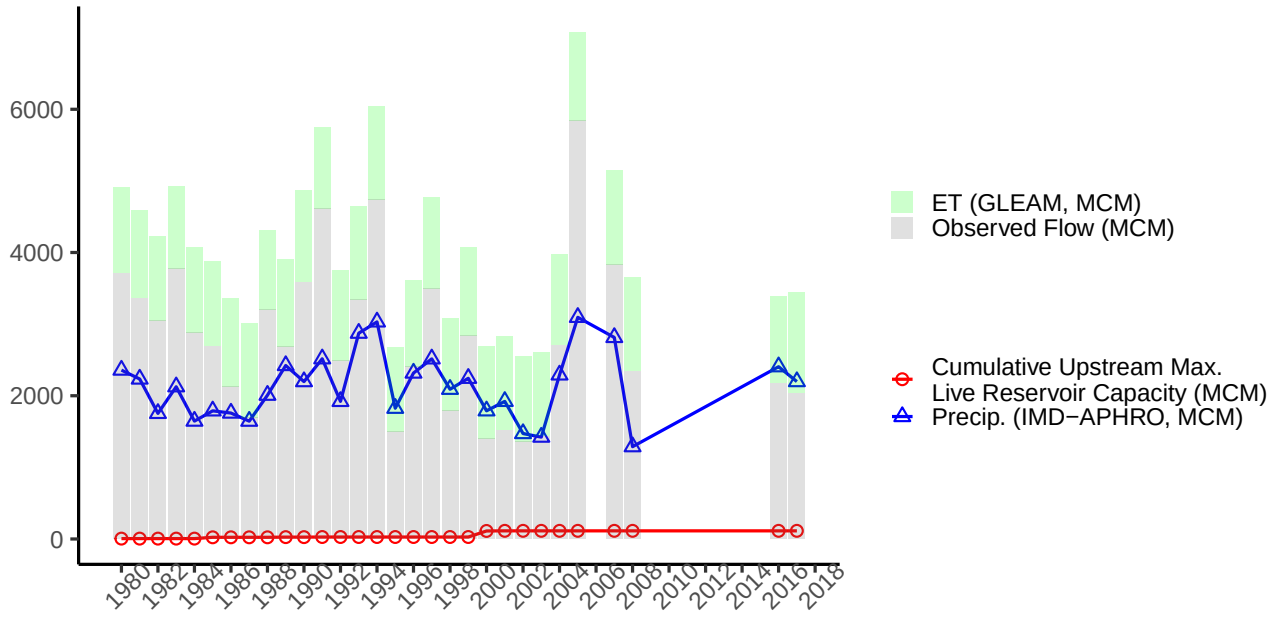
Annual (Jun−May), Station: Sadalga (Seasonal), River: Krishna/Dudhganga
GHI ID: kris_sadal, Catch. Area: 2285 sq. km



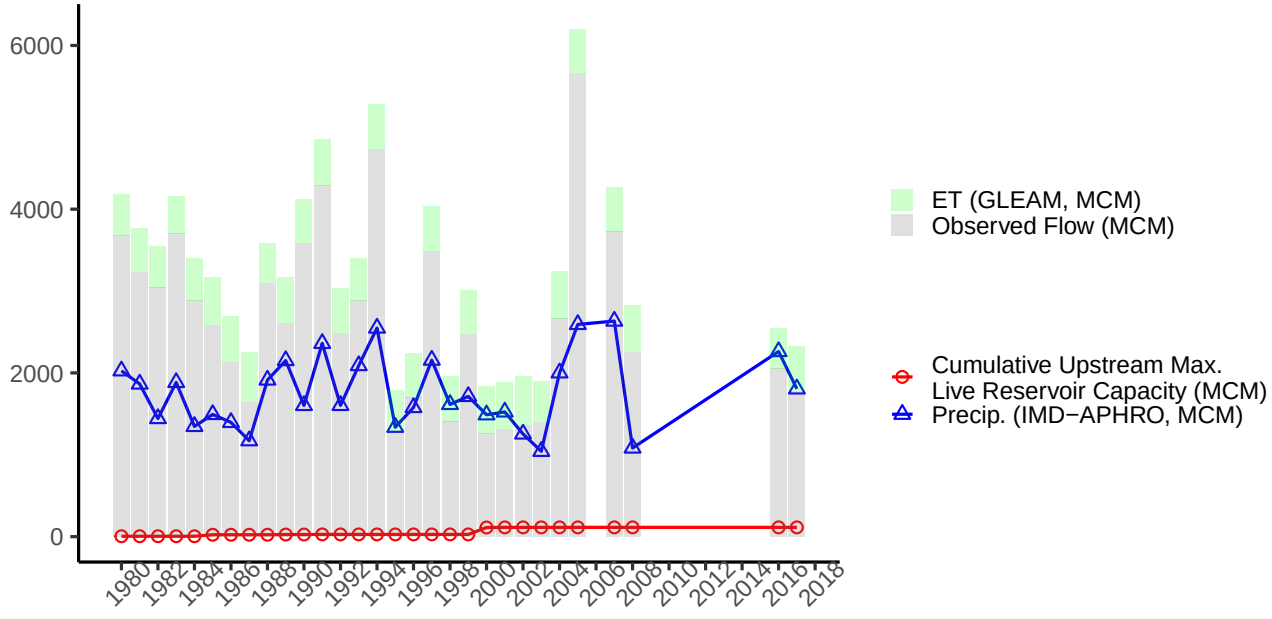
Monsoon (Jun−Sep), Station: Sadalga (Seasonal), River: Krishna/Dudhganga
GHI ID: kris_sadal, Catch. Area: 2285 sq. km

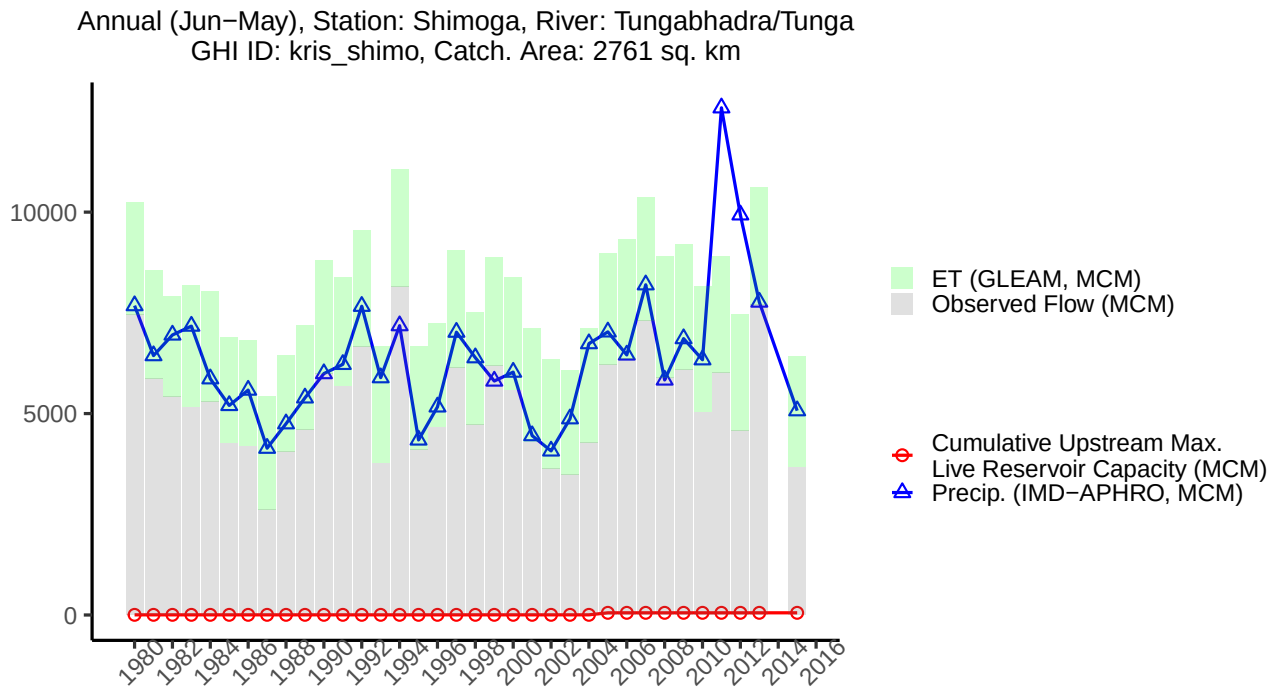


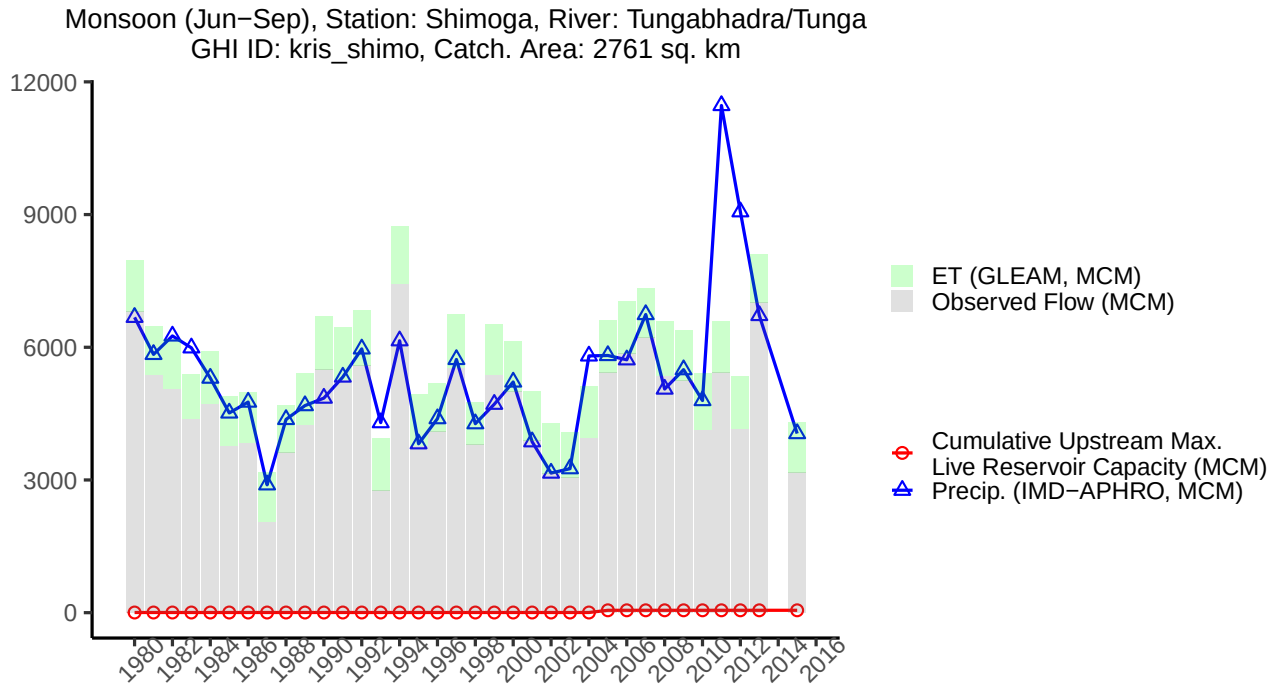
Annual (Jun−May), Station: Samdoli (Seasonal), River: Krishna/Varna
GHI ID: kris_samdo, Catch. Area: 2010 sq. km



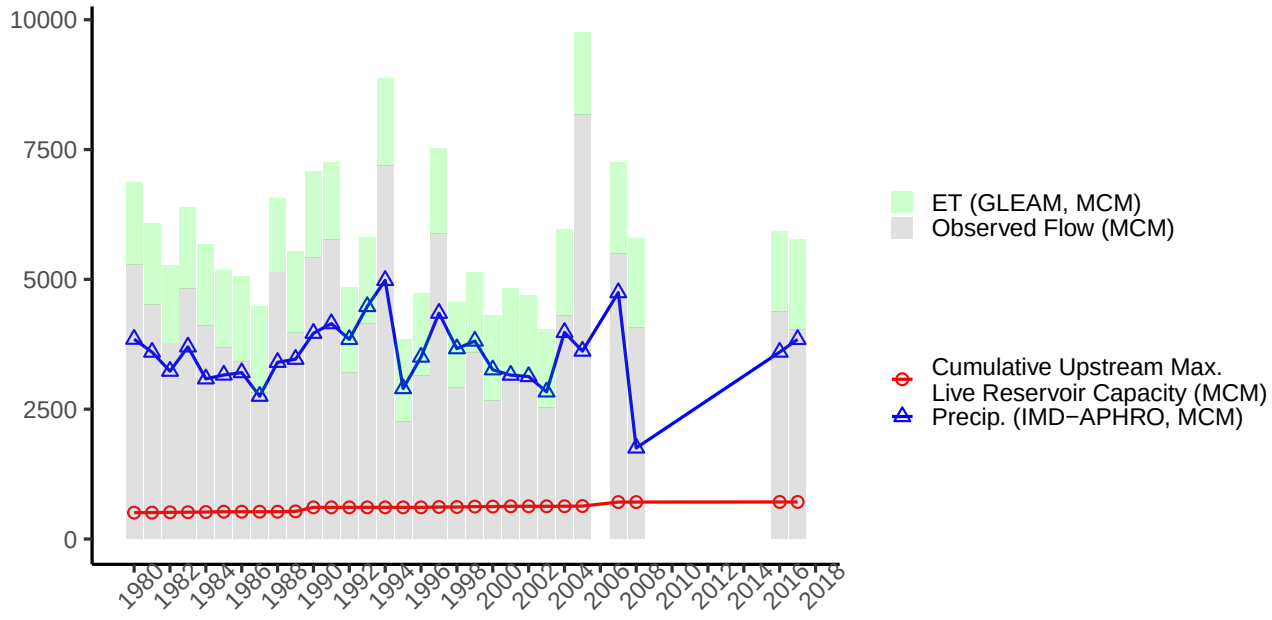
Monsoon (Jun−Sep), Station: Samdoli (Seasonal), River: Krishna/Varna
GHI ID: kris_samdo, Catch. Area: 2010 sq. km



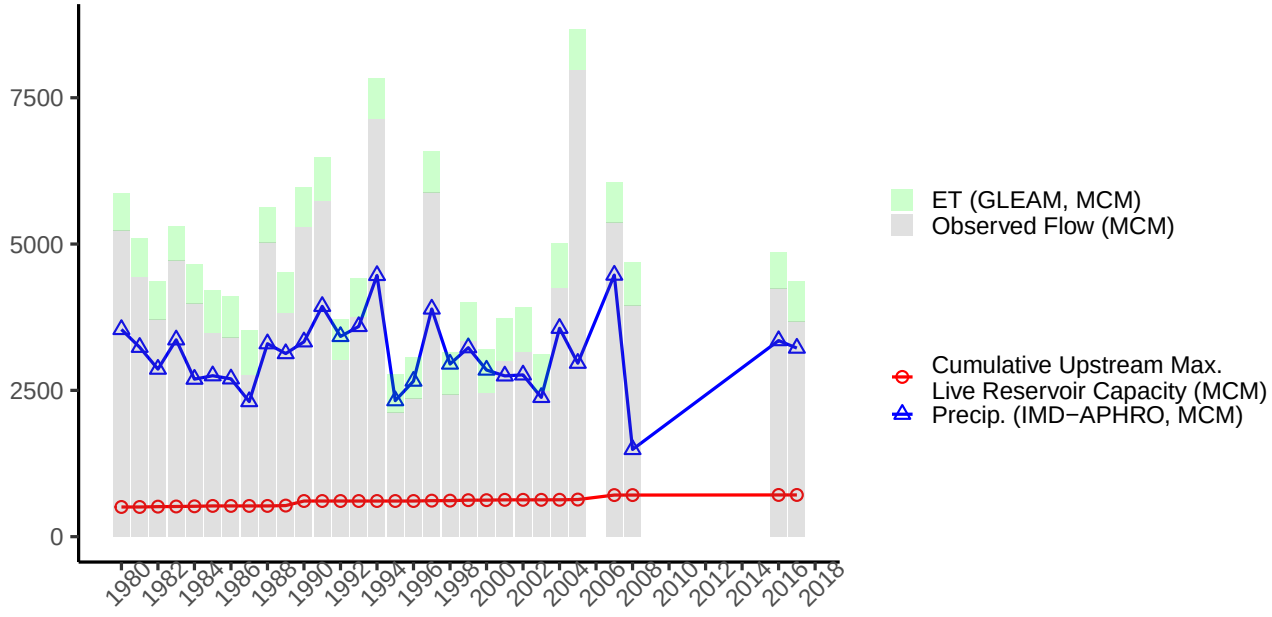

Annual (Jun−May), Station: Shimoga, River: Tungabhadra/Tunga
GHI ID: kris_shimo, Catch. Area: 2761 sq. km
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

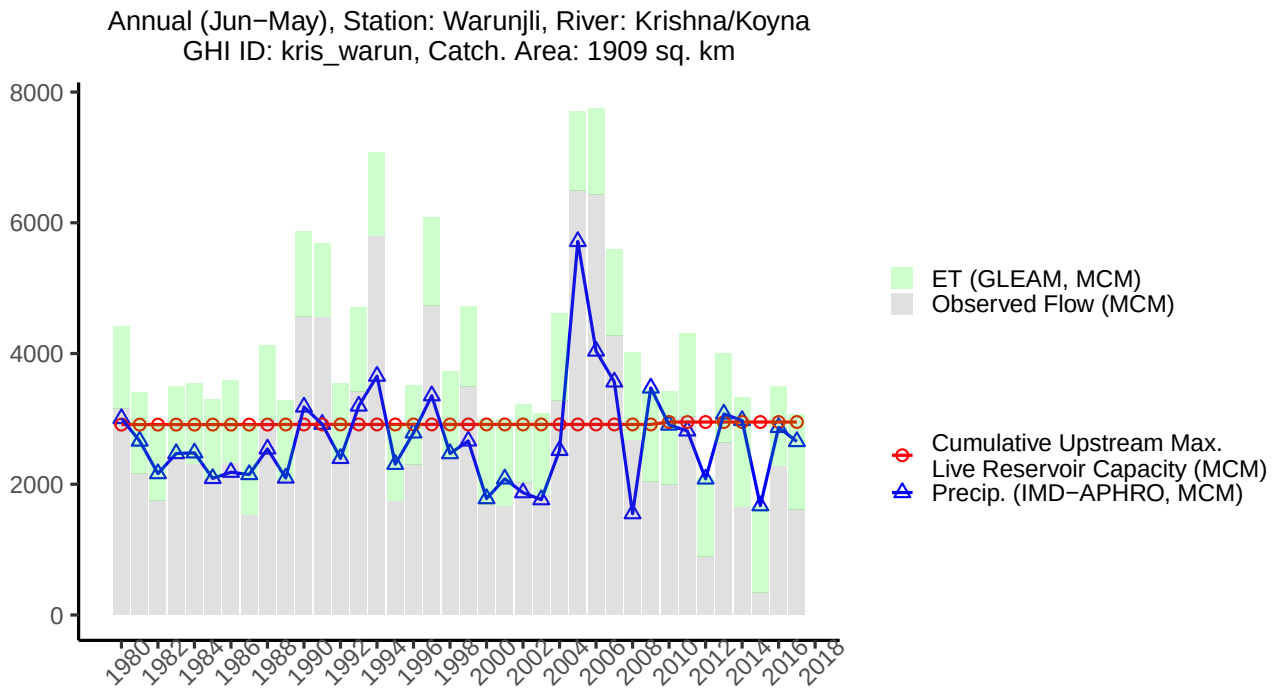

Monsoon (Jun−Sep), Station: Shimoga, River: Tungabhadra/Tunga
GHI ID: kris_shimo, Catch. Area: 2761 sq. km
12000
9000
6000
3000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

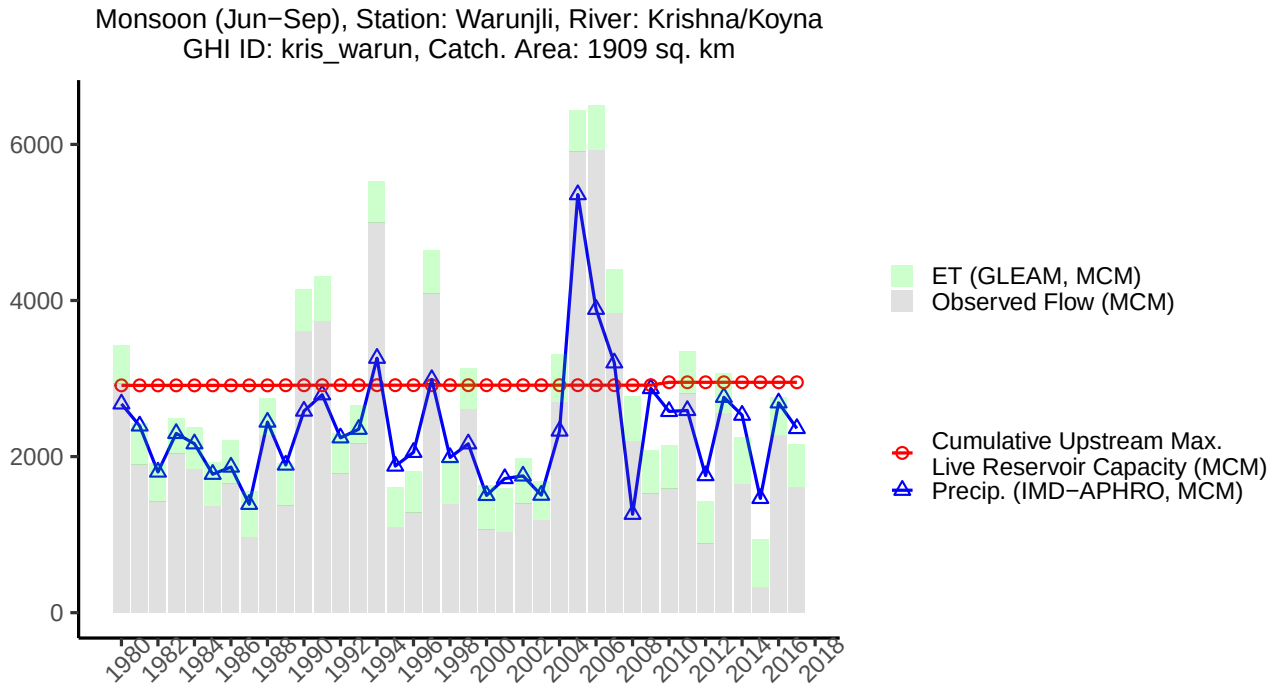
Annual (Jun−May), Station: Terwad (Seasonal), River: Krishna/Panchganga
GHI ID: kris_terwa, Catch. Area: 2444 sq. km

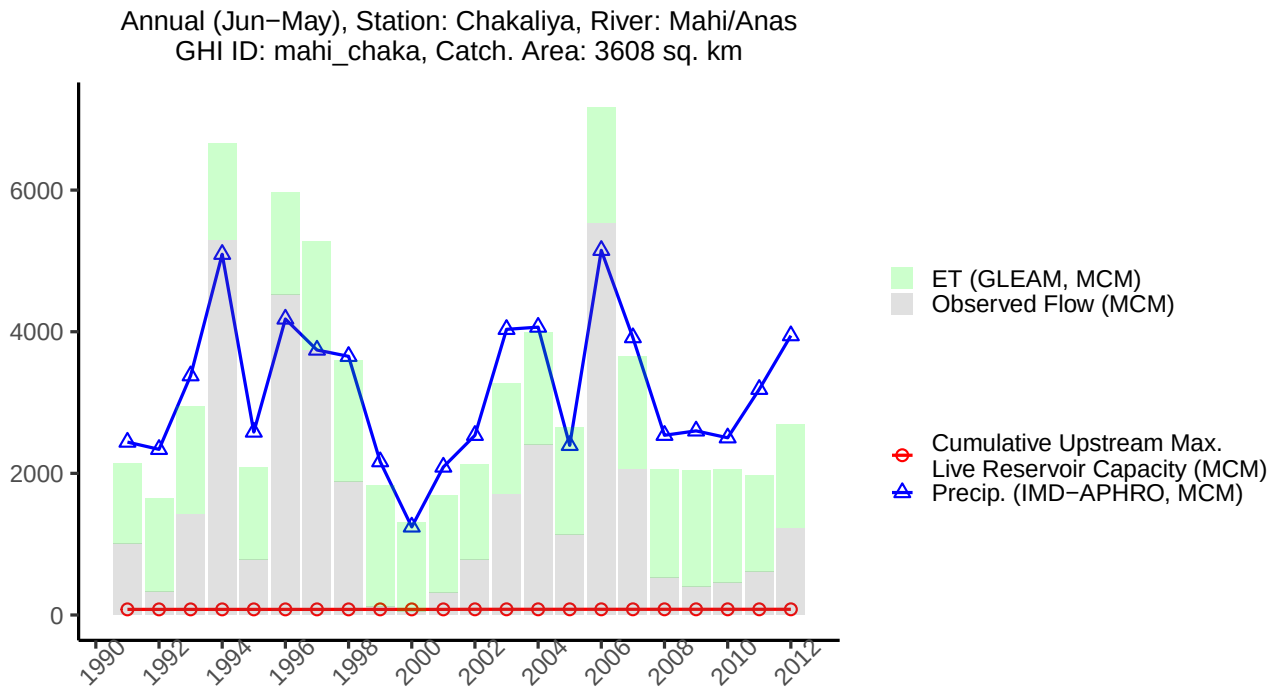


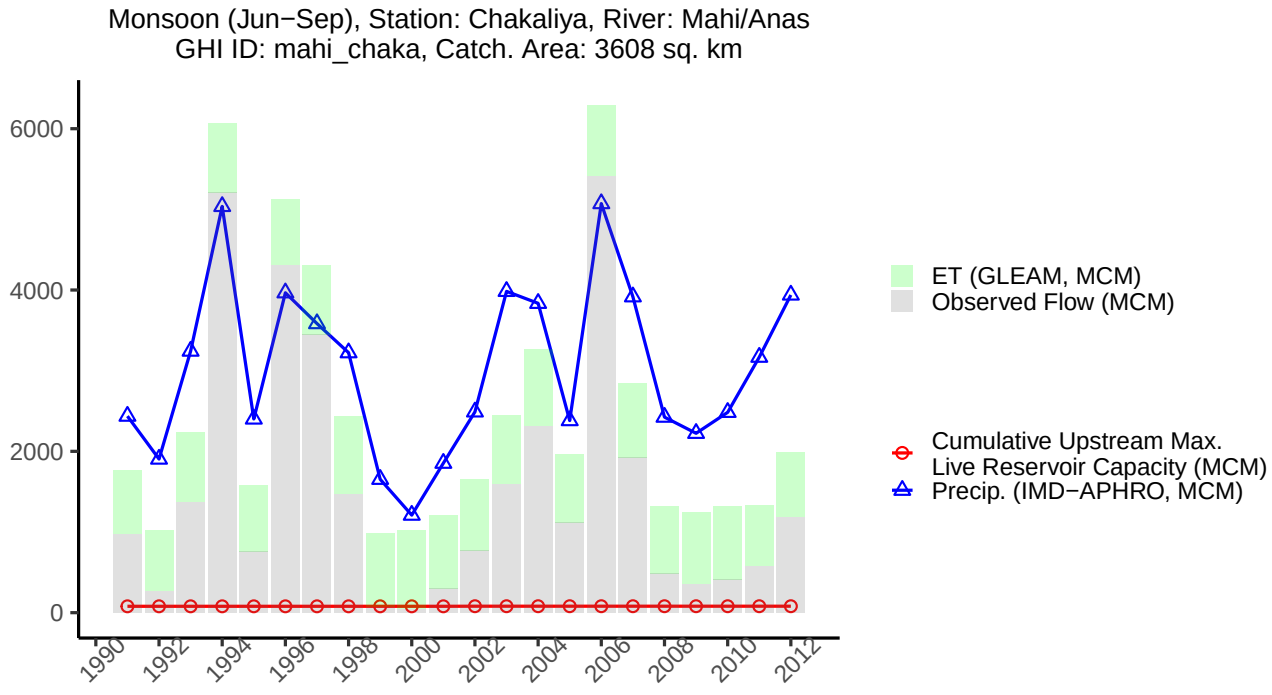
Monsoon (Jun−Sep), Station: Terwad (Seasonal), River: Krishna/Panchganga
GHI ID: kris_terwa, Catch. Area: 2444 sq. km

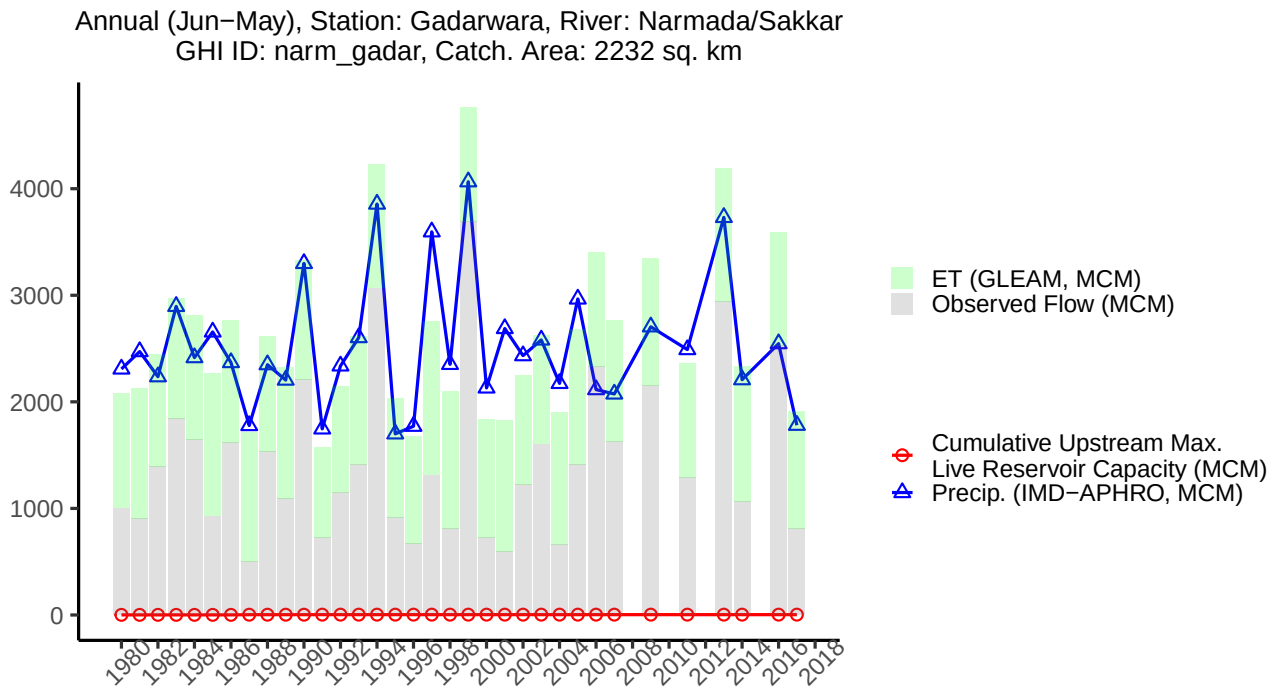


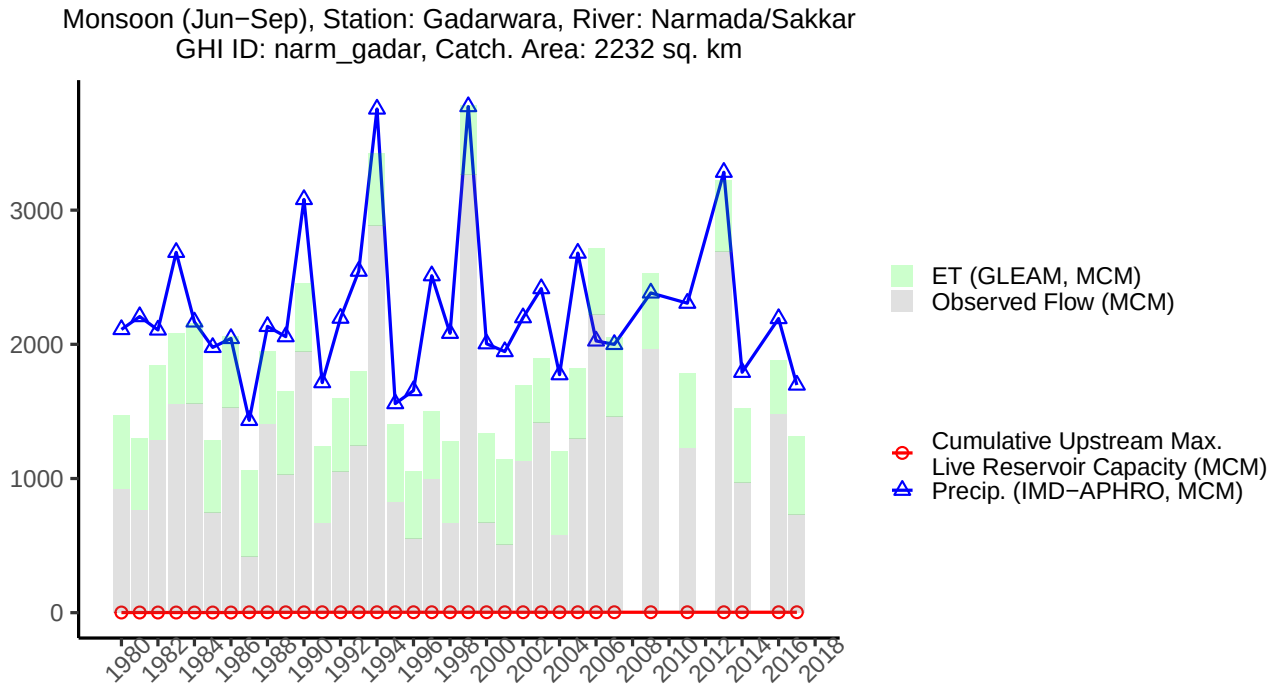

Annual (Jun−May), Station: Warunjli, River: Krishna/Koyna
GHI ID: kris_warun, Catch. Area: 1909 sq. km
8000
6000
4000
2000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

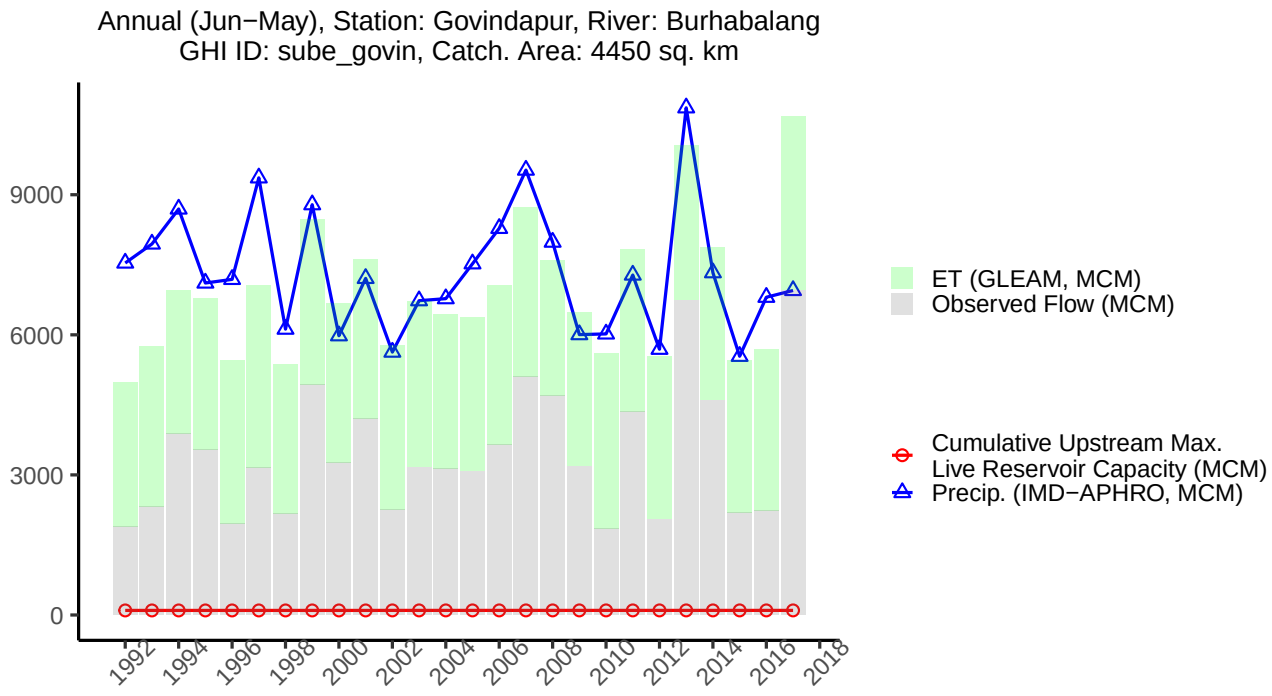

Monsoon (Jun−Sep), Station: Warunjli, River: Krishna/Koyna
GHI ID: kris_warun, Catch. Area: 1909 sq. km
6000
4000
2000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

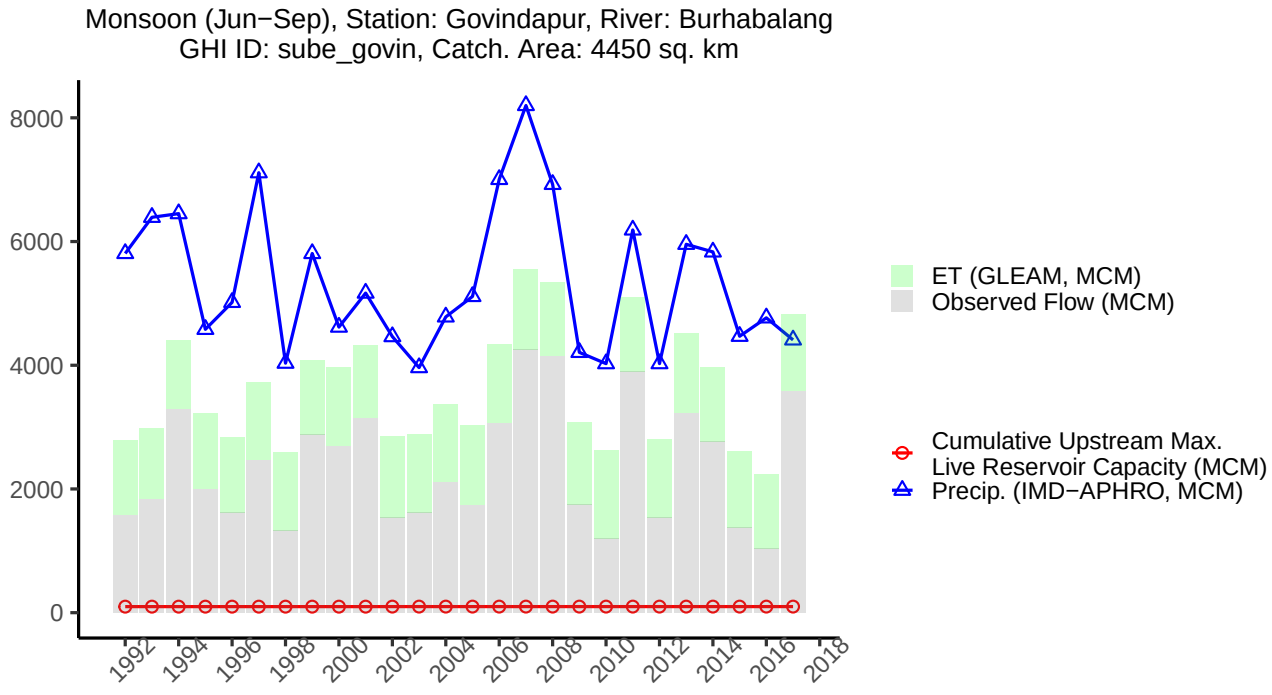

Annual (Jun−May), Station: Chakaliya, River: Mahi/Anas
GHI ID: mahi_chaka, Catch. Area: 3608 sq. km
6000
4000
2000
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

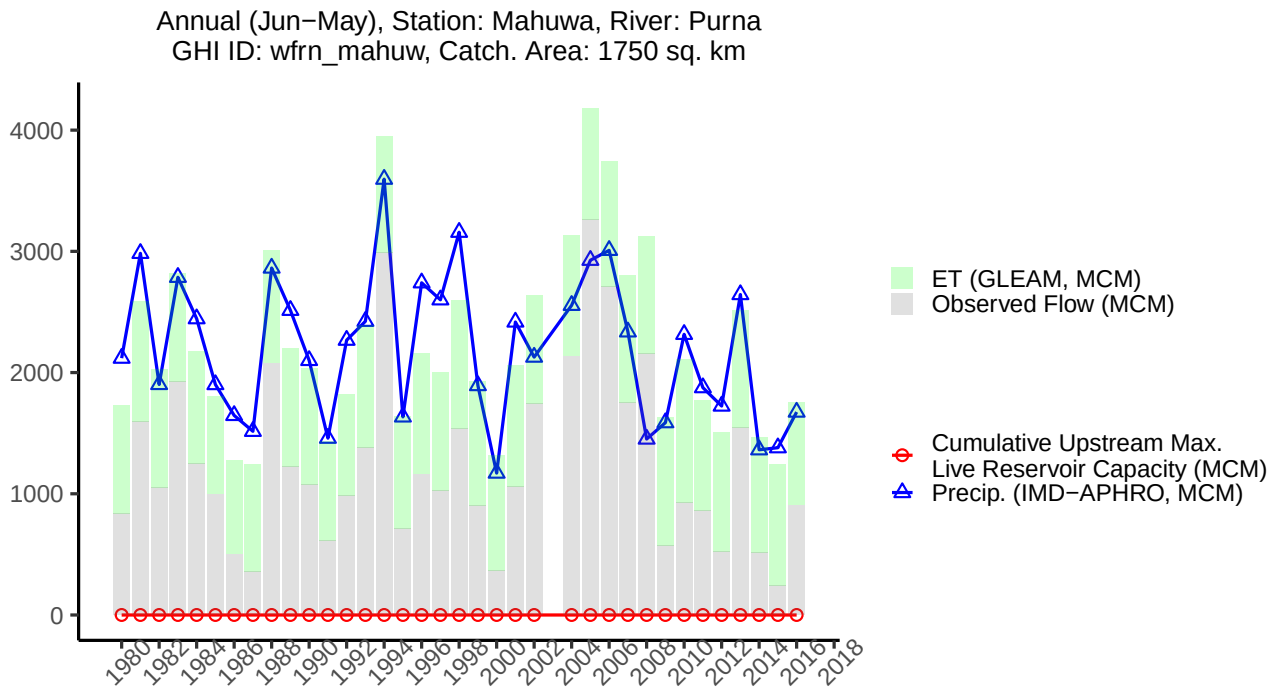

Monsoon (Jun−Sep), Station: Chakaliya, River: Mahi/Anas
GHI ID: mahi_chaka, Catch. Area: 3608 sq. km
6000
4000
2000
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

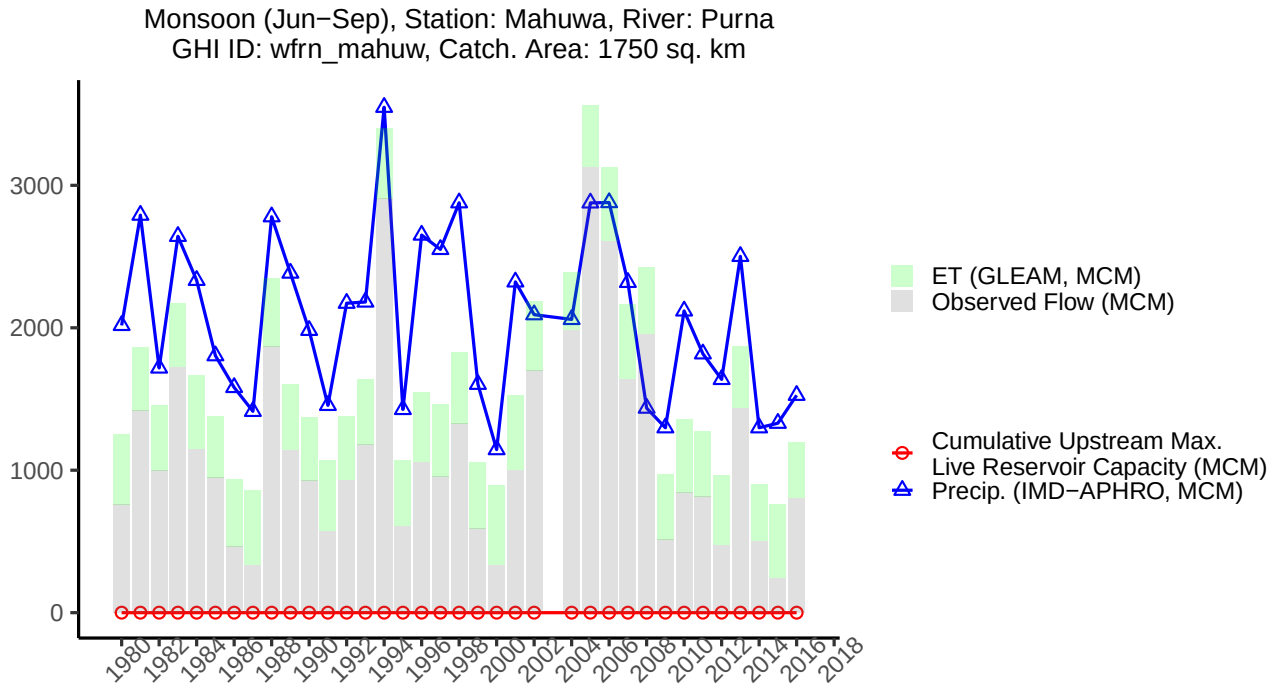

Annual (Jun−May), Station: Gadarwara, River: Narmada/Sakkar
GHI ID: narm_gadar, Catch. Area: 2232 sq. km
4000
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

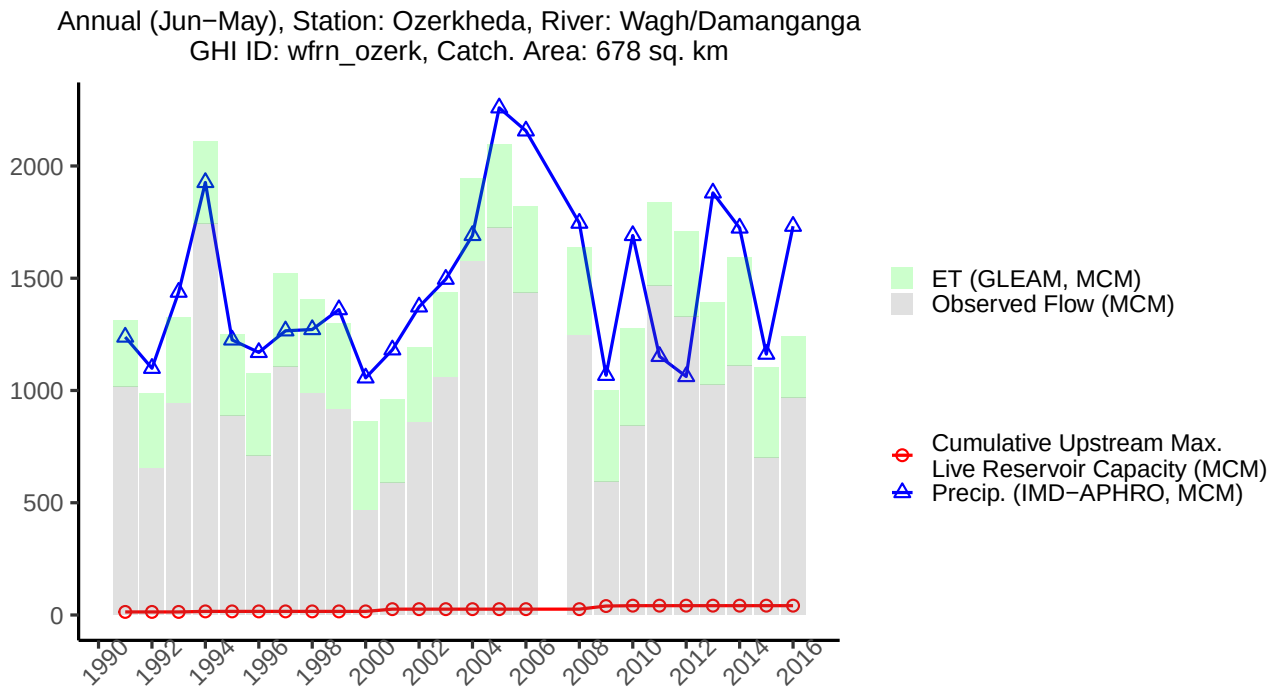

Monsoon (Jun−Sep), Station: Gadarwara, River: Narmada/Sakkar
GHI ID: narm_gadar, Catch. Area: 2232 sq. km
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

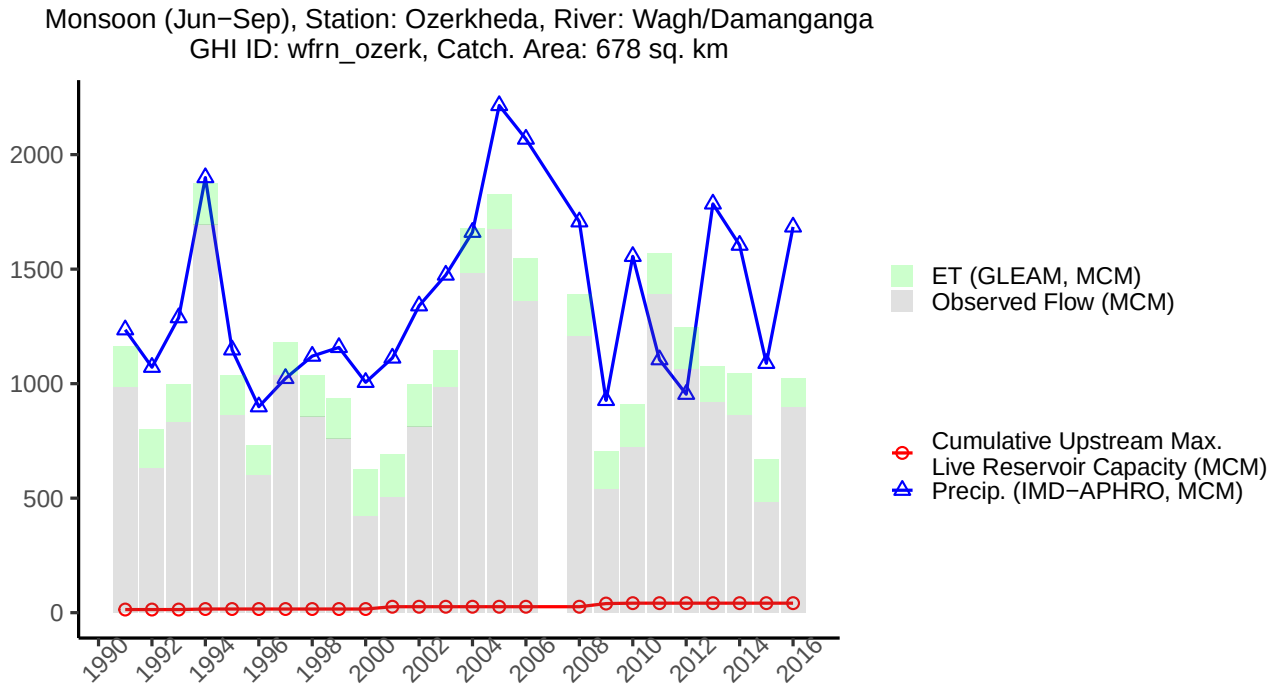

Annual (Jun−May), Station: Govindapur, River: Burhabalang
GHI ID: sube_govin, Catch. Area: 4450 sq. km
9000
6000
3000
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Govindapur, River: Burhabalang
GHI ID: sube_govin, Catch. Area: 4450 sq. km
8000
6000
4000
2000
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

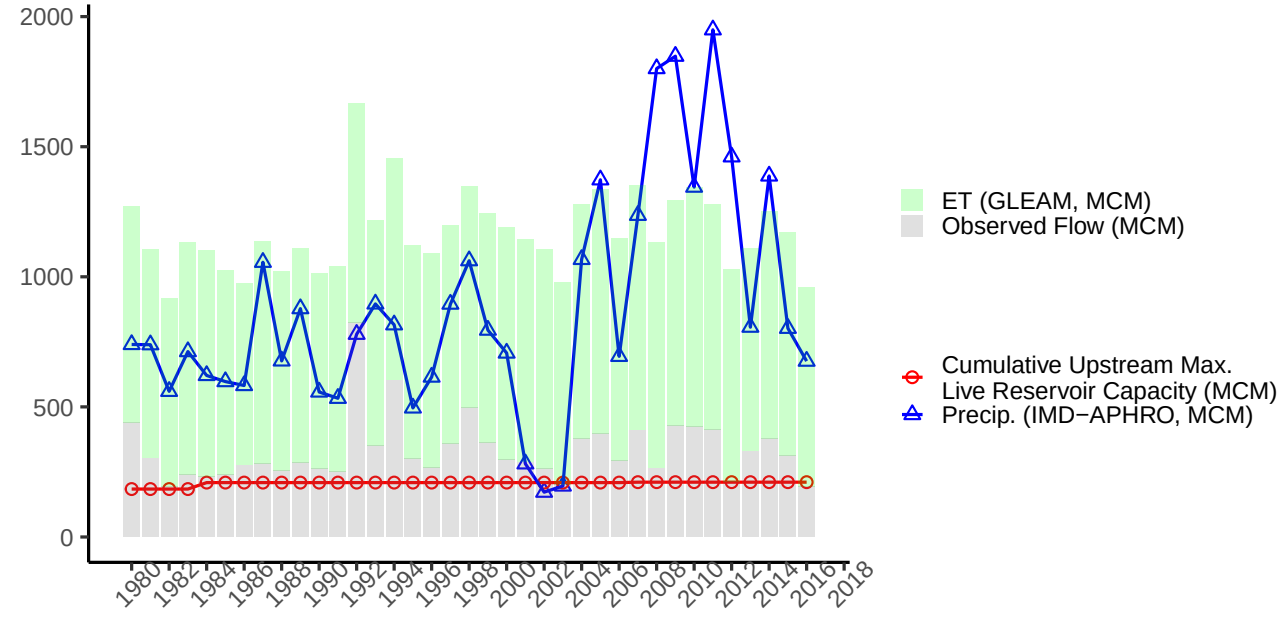

Annual (Jun−May), Station: Mahuwa, River: Purna
GHI ID: wfrn_mahuw, Catch. Area: 1750 sq. km
4000
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Mahuwa, River: Purna
GHI ID: wfrn_mahuw, Catch. Area: 1750 sq. km
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

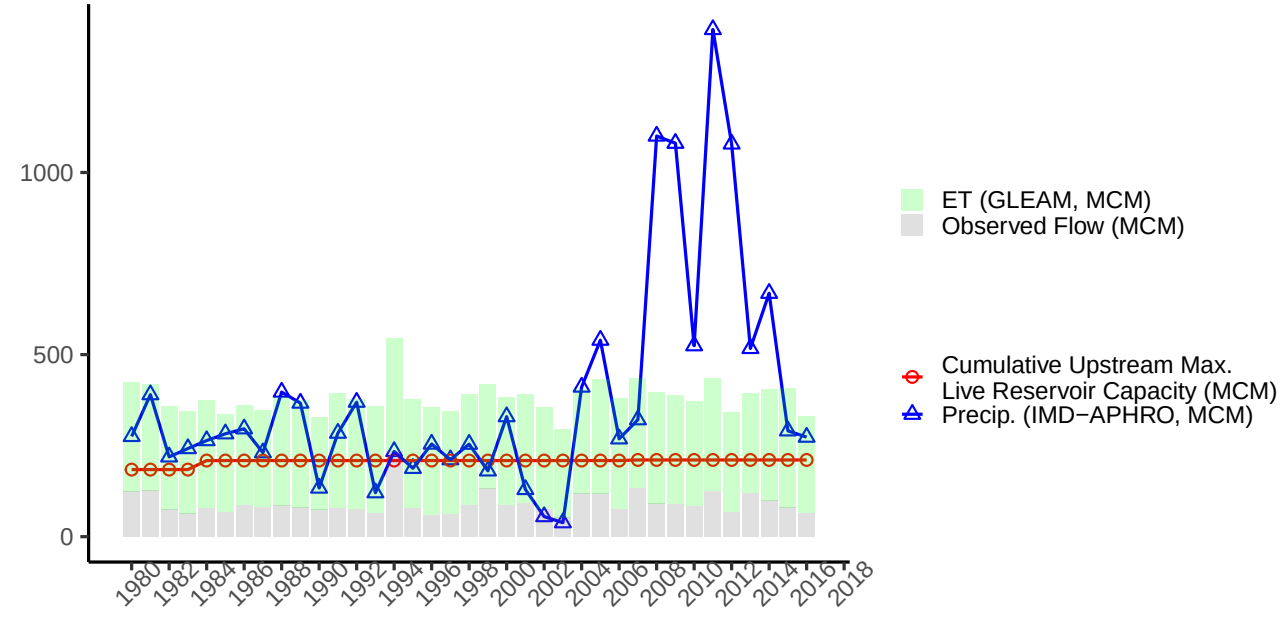

Annual (Jun−May), Station: Ozerkheda, River: Wagh/Damanganga
GHI ID: wfrn_ozerk, Catch. Area: 678 sq. km
2000
1500
1000
500
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

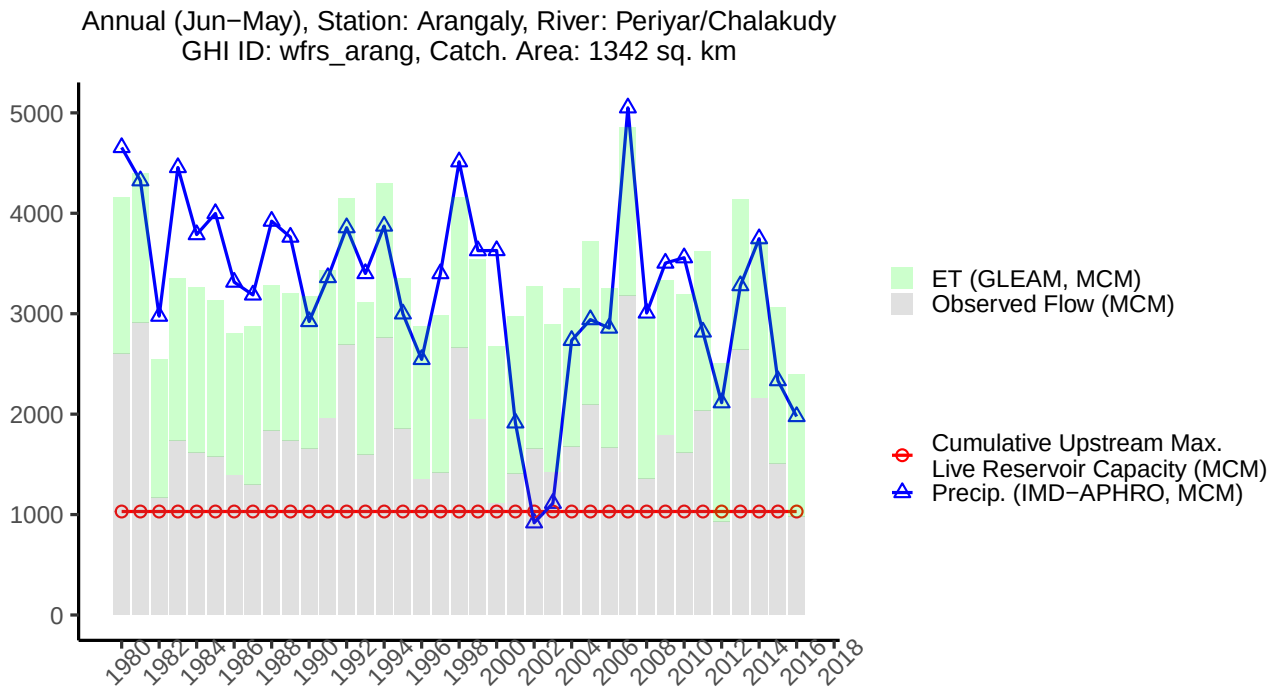

Monsoon (Jun−Sep), Station: Ozerkheda, River: Wagh/Damanganga
GHI ID: wfrn_ozerk, Catch. Area: 678 sq. km
2000
1500
1000
500
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

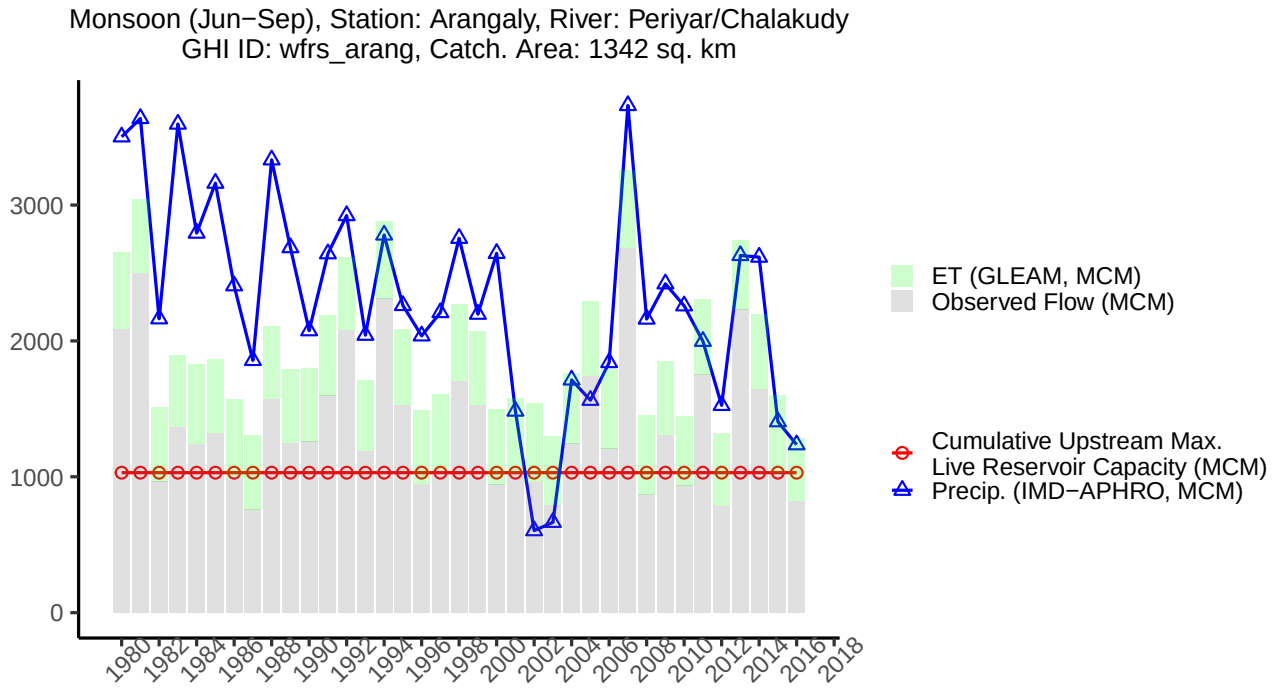
l (Jun−May), Station: Ambarampalayam, River: Bharathapuzha/Kannadipuzha/Aliyar
GHI ID: wfrs_ambar, Catch. Area: 950 sq. km

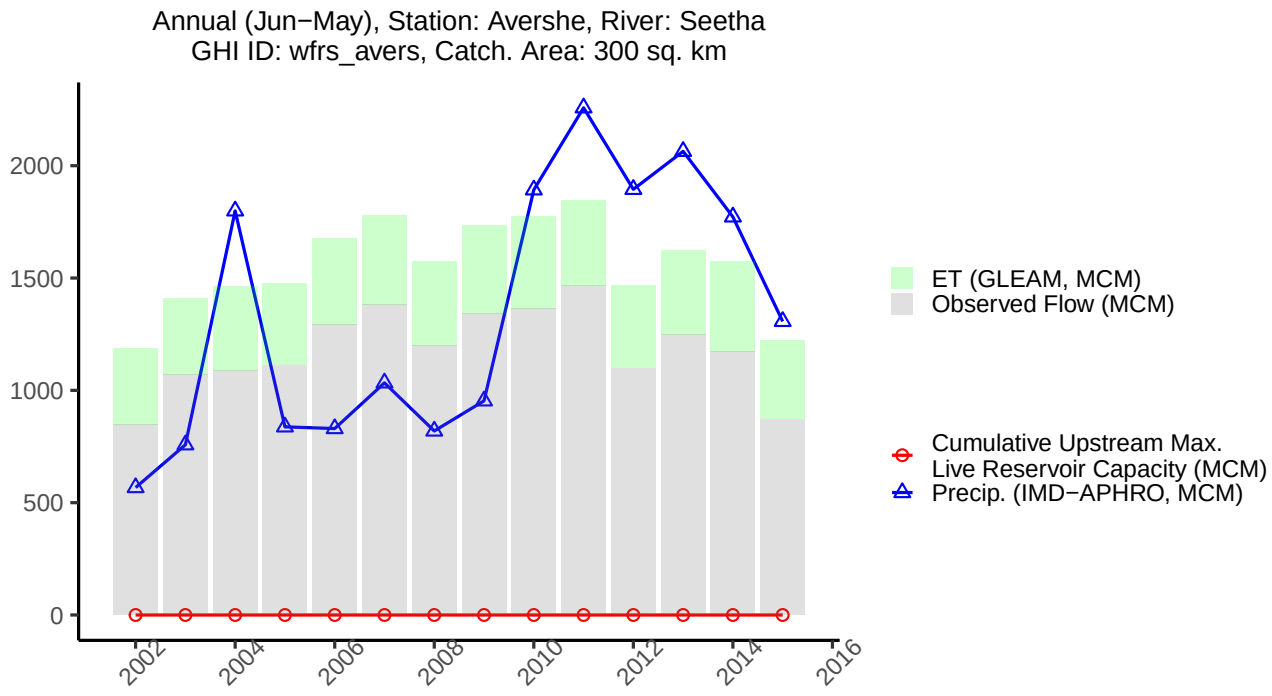


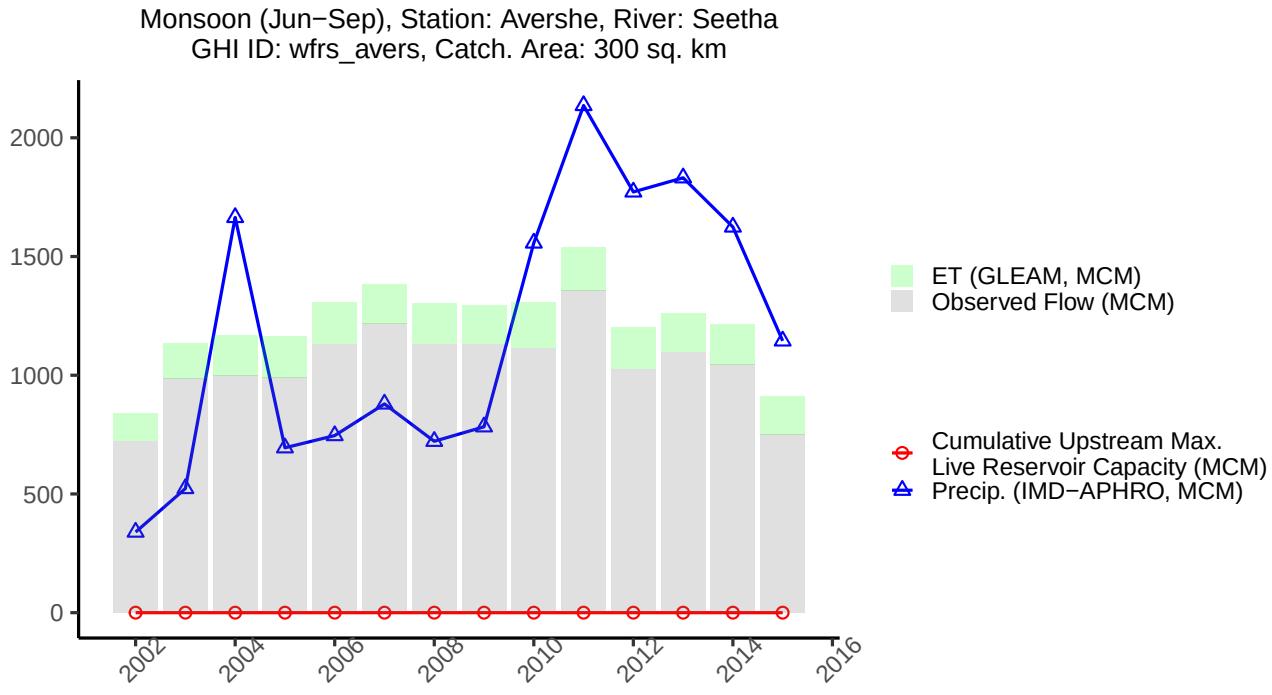
ɔn (Jun−Sep), Station: Ambarampalayam, River: Bharathapuzha/Kannadipuzha/Aliyar
GHI ID: wfrs_ambar, Catch. Area: 950 sq. km

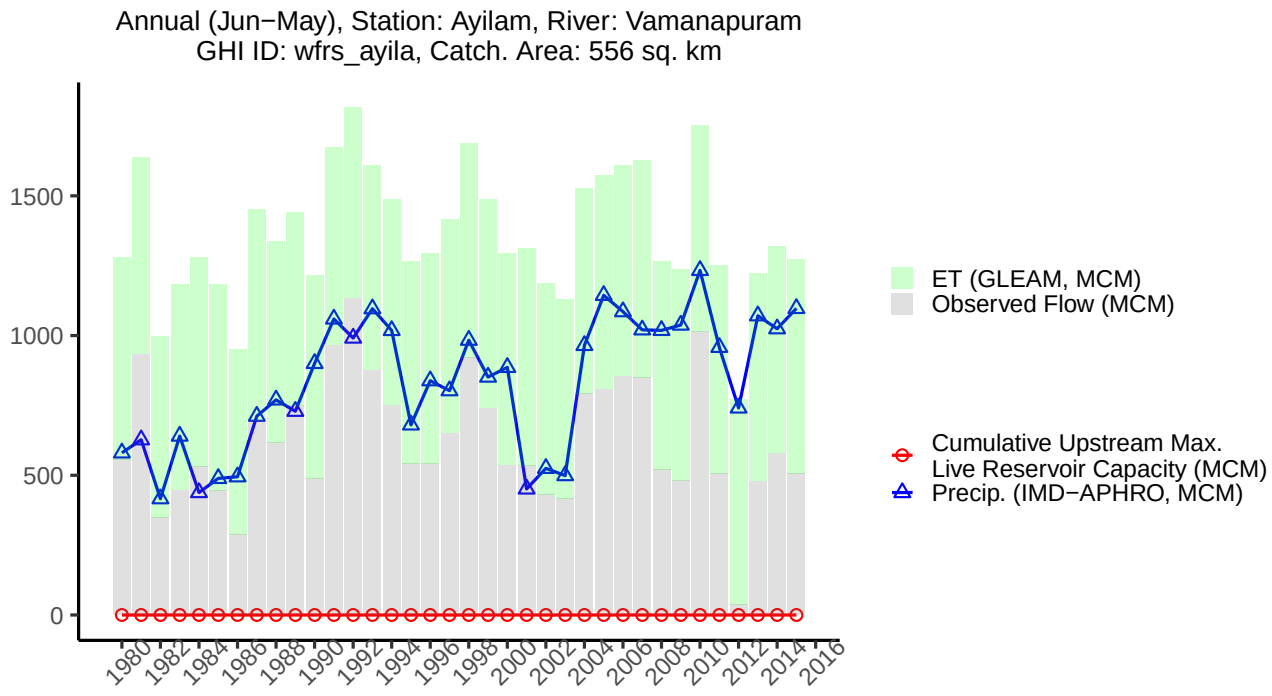


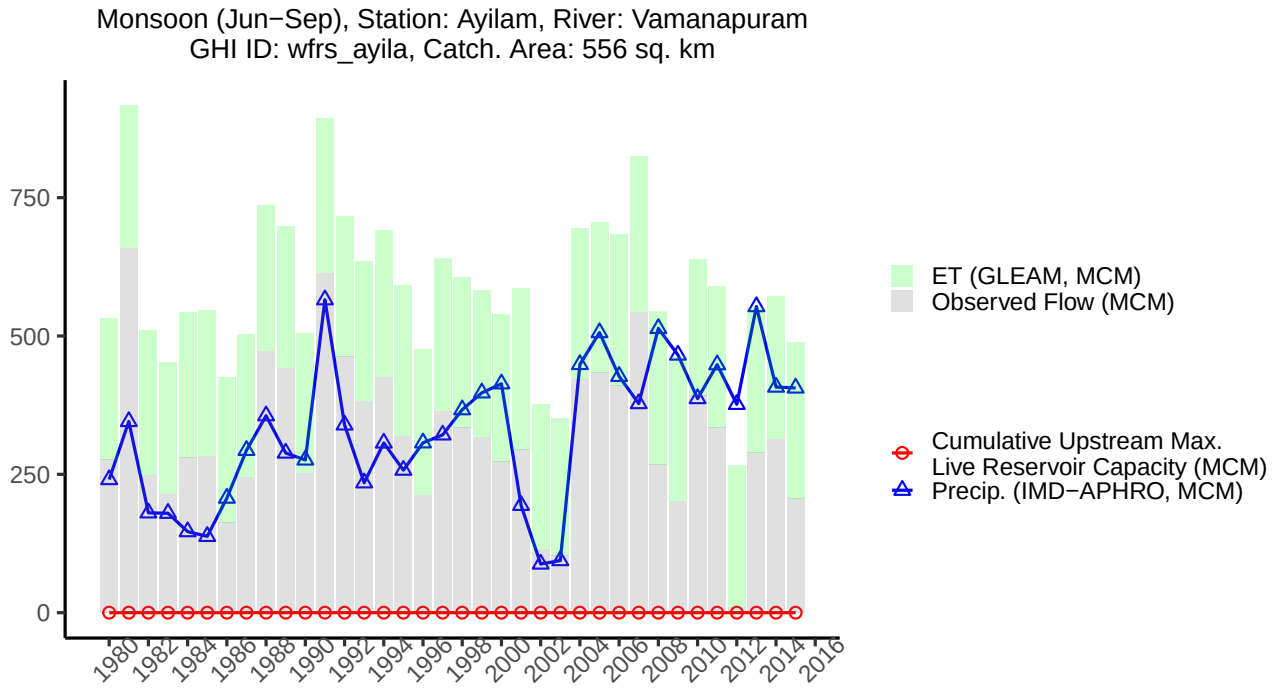

Annual (Jun−May), Station: Arangaly, River: Periyar/Chalakudy
GHI ID: wfrs_arang, Catch. Area: 1342 sq. km
5000
4000
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

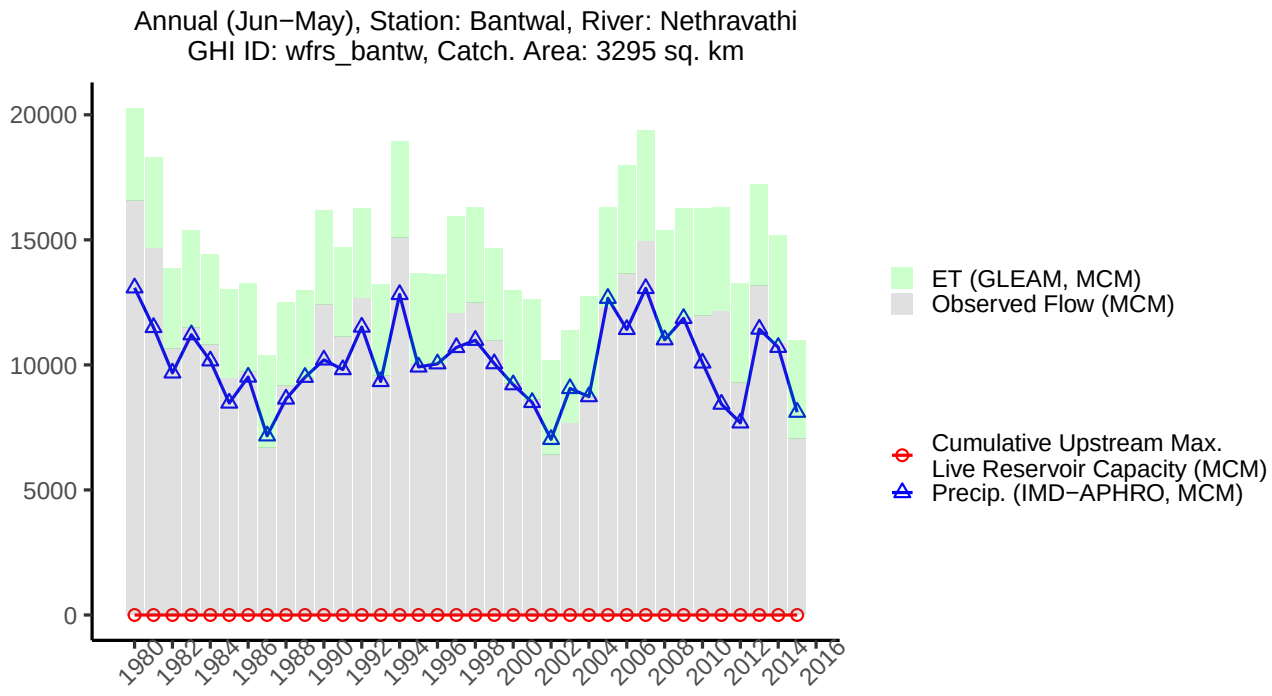

Monsoon (Jun−Sep), Station: Arangaly, River: Periyar/Chalakudy
GHI ID: wfrs_arang, Catch. Area: 1342 sq. km
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

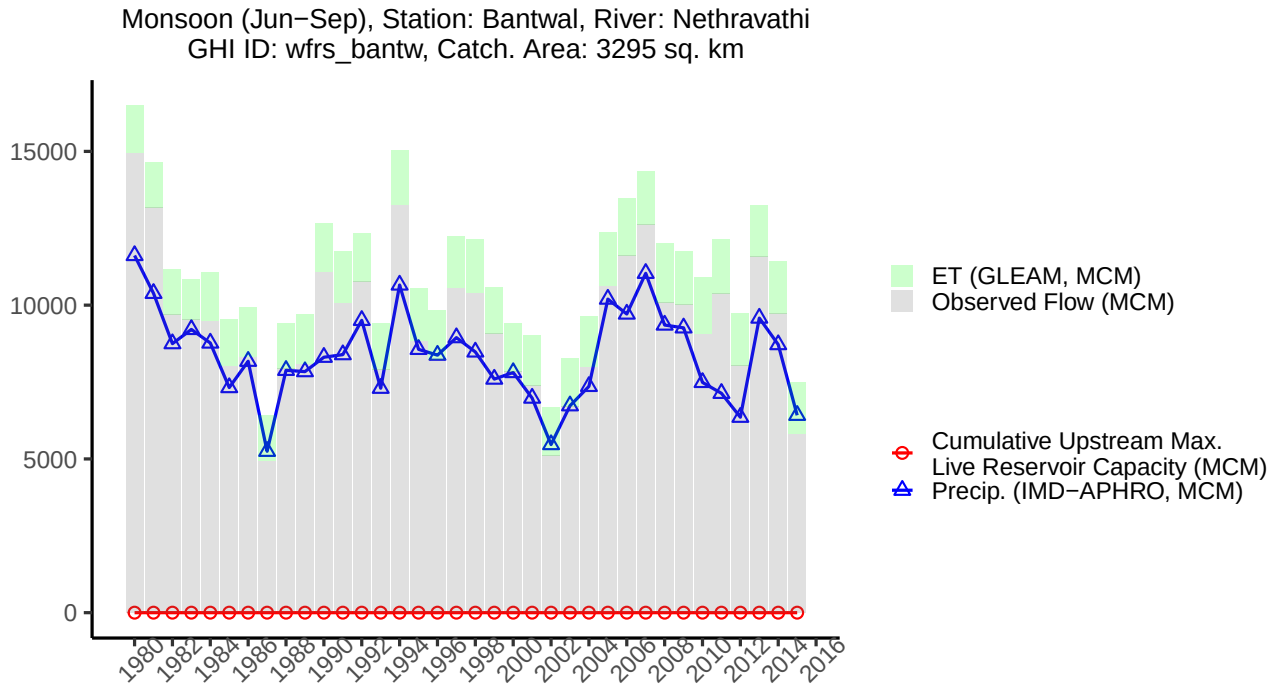

Annual (Jun−May), Station: Avershe, River: Seetha
GHI ID: wfrs_avers, Catch. Area: 300 sq. km
2000
1500
1000
500
0
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

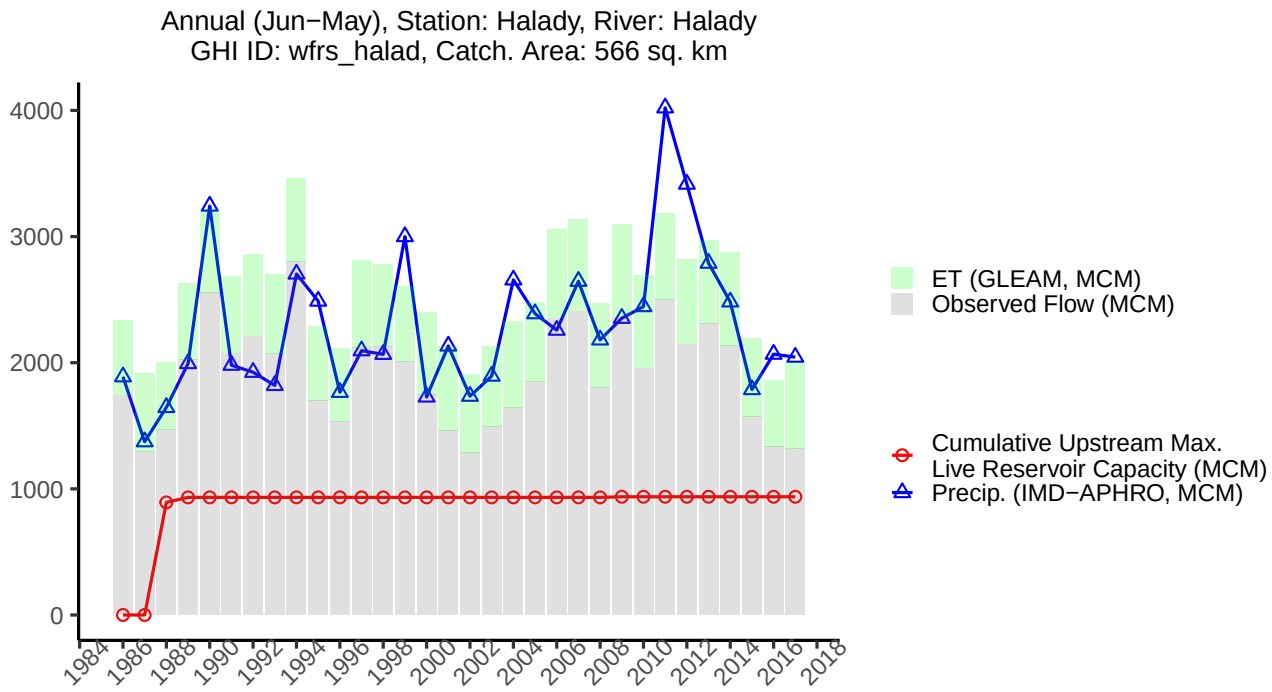

Monsoon (Jun−Sep), Station: Avershe, River: Seetha
GHI ID: wfrs_avers, Catch. Area: 300 sq. km
2000
1500
1000
500
0
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

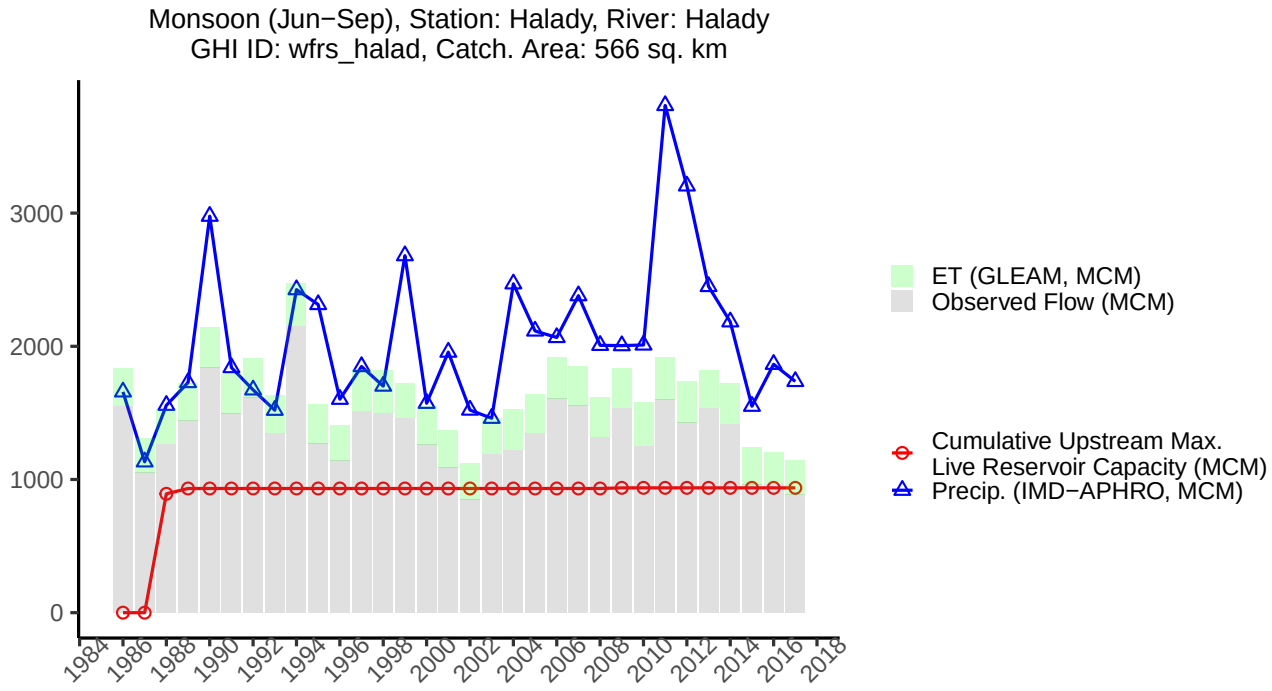

Annual (Jun−May), Station: Ayilam, River: Vamanapuram
GHI ID: wfrs_ayila, Catch. Area: 556 sq. km
1500
1000
500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Ayilam, River: Vamanapuram
GHI ID: wfrs_ayila, Catch. Area: 556 sq. km
750
500
250
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

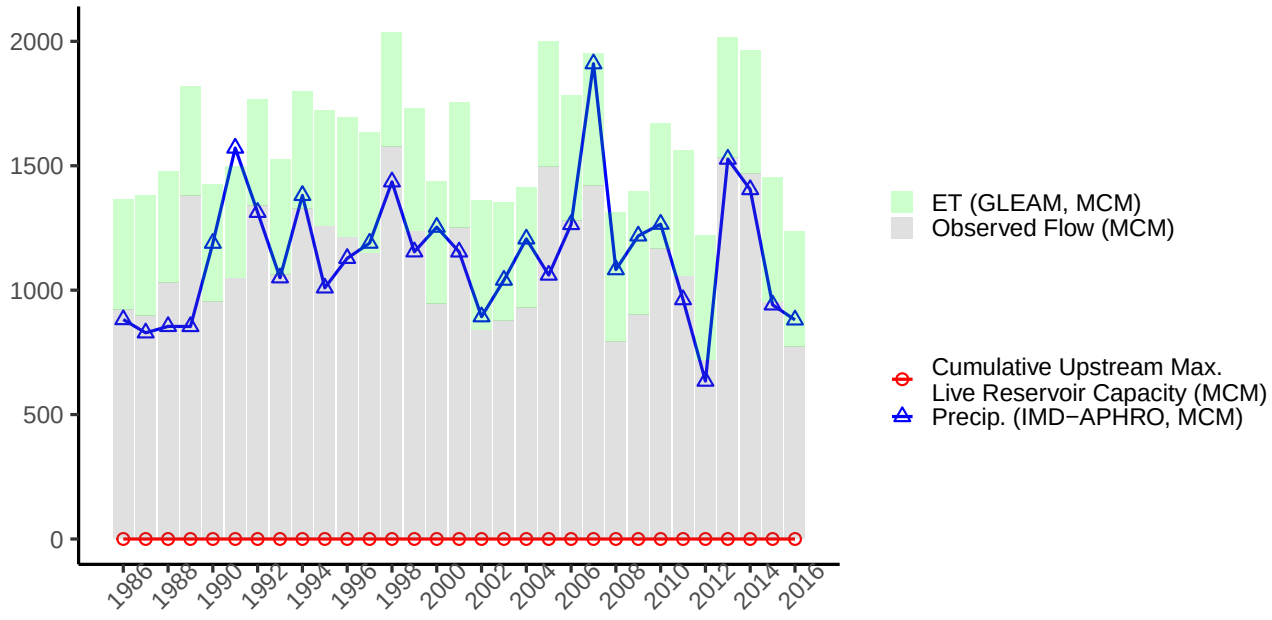

Annual (Jun−May), Station: Bantwal, River: Nethravathi
GHI ID: wfrs_bantw, Catch. Area: 3295 sq. km
20000
15000
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Bantwal, River: Nethravathi
GHI ID: wfrs_bantw, Catch. Area: 3295 sq. km
15000
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

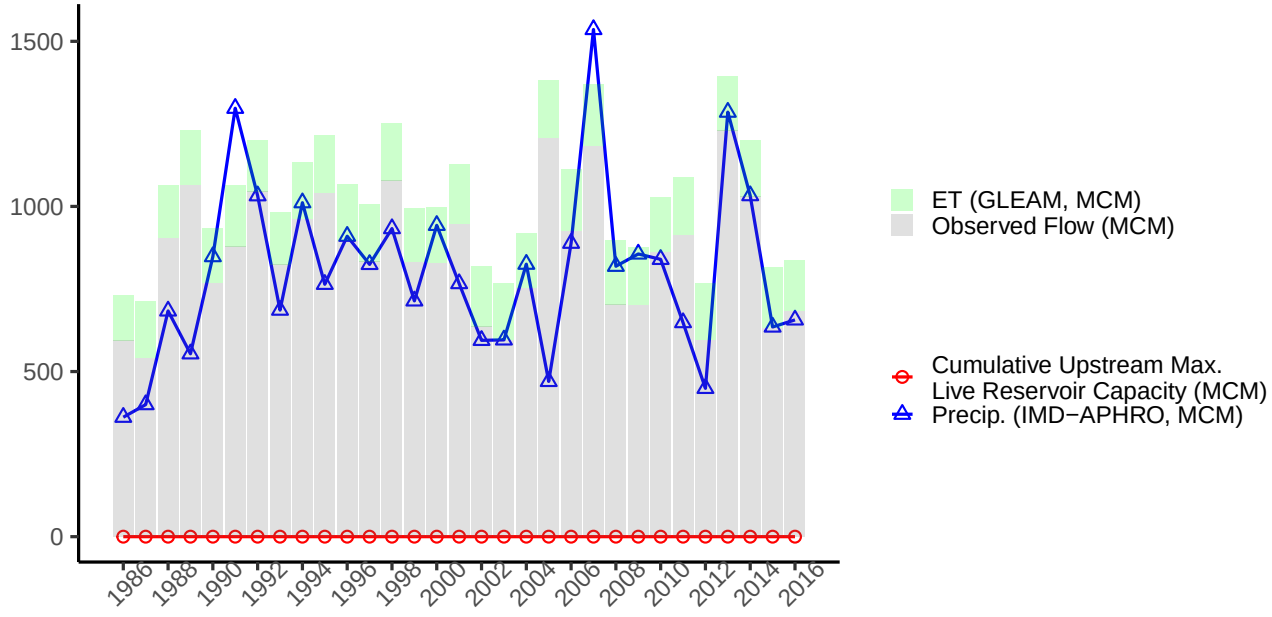

Annual (Jun−May), Station: Halady, River: Halady
GHI ID: wfrs_halad, Catch. Area: 566 sq. km
4000
3000
2000
1000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

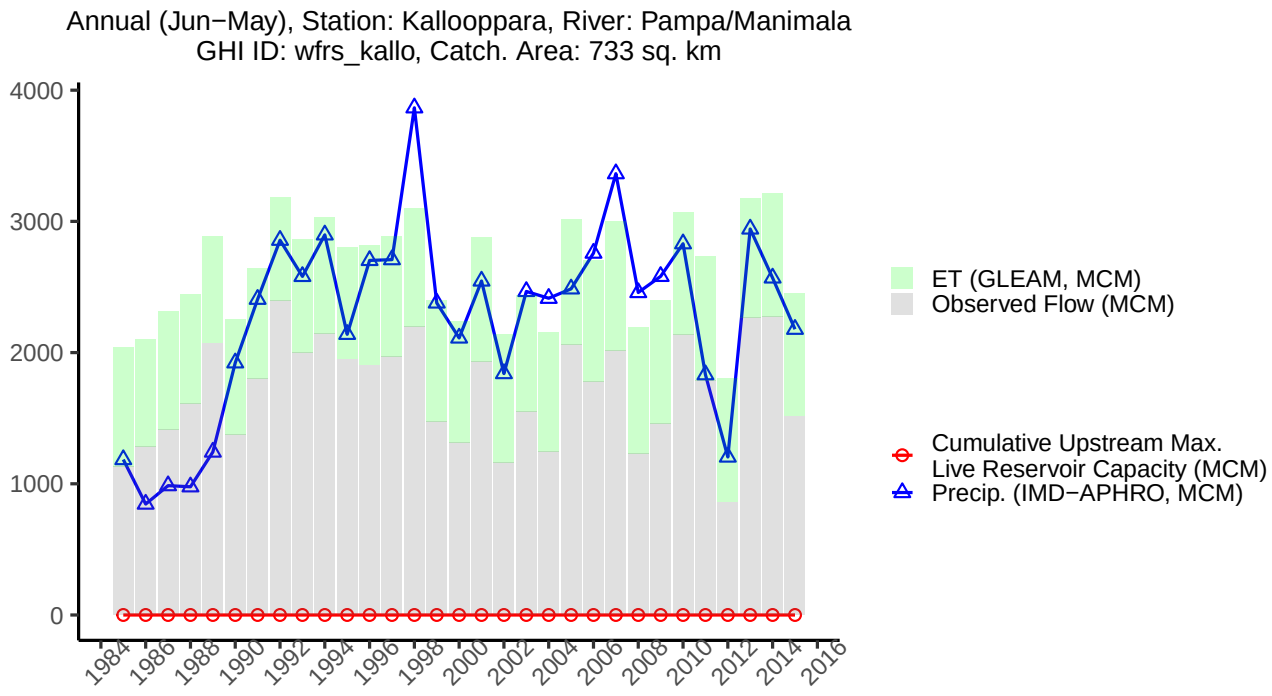

Monsoon (Jun−Sep), Station: Halady, River: Halady
GHI ID: wfrs_halad, Catch. Area: 566 sq. km
3000
2000
1000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

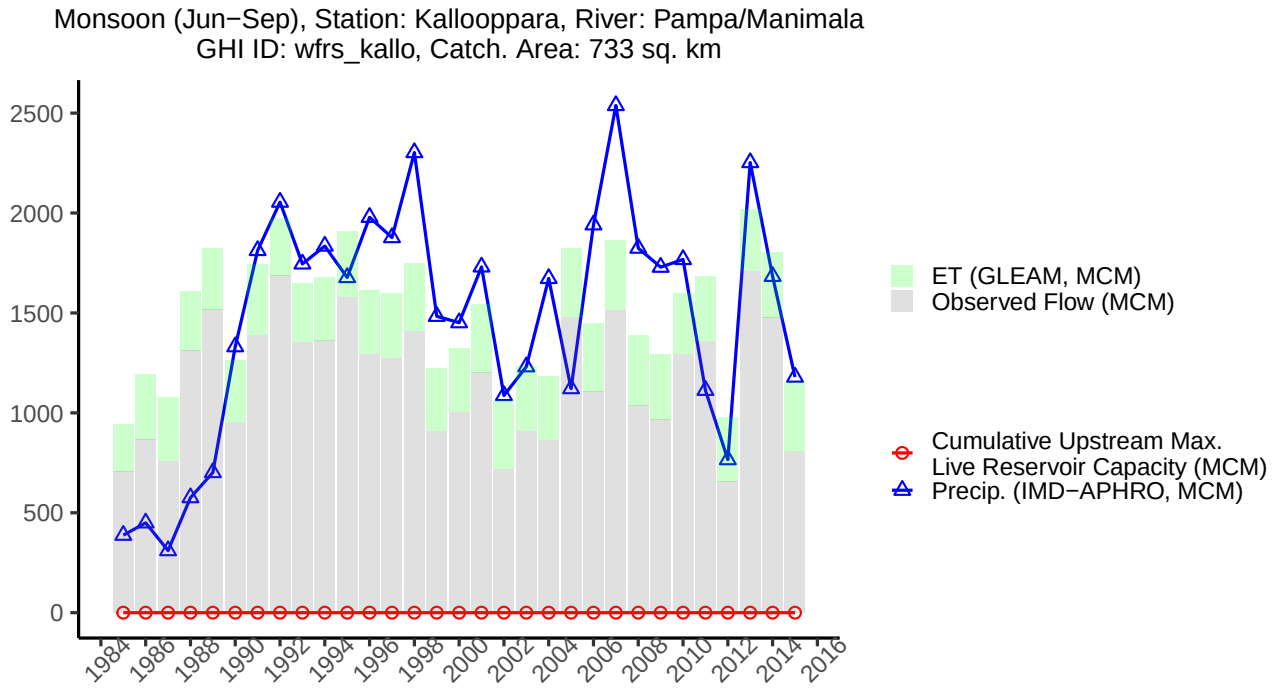
Annual (Jun−May), Station: Kalampur, River: Muvattupuzha/Kaliyar
GHI ID: wfrs_kalam, Catch. Area: 386 sq. km

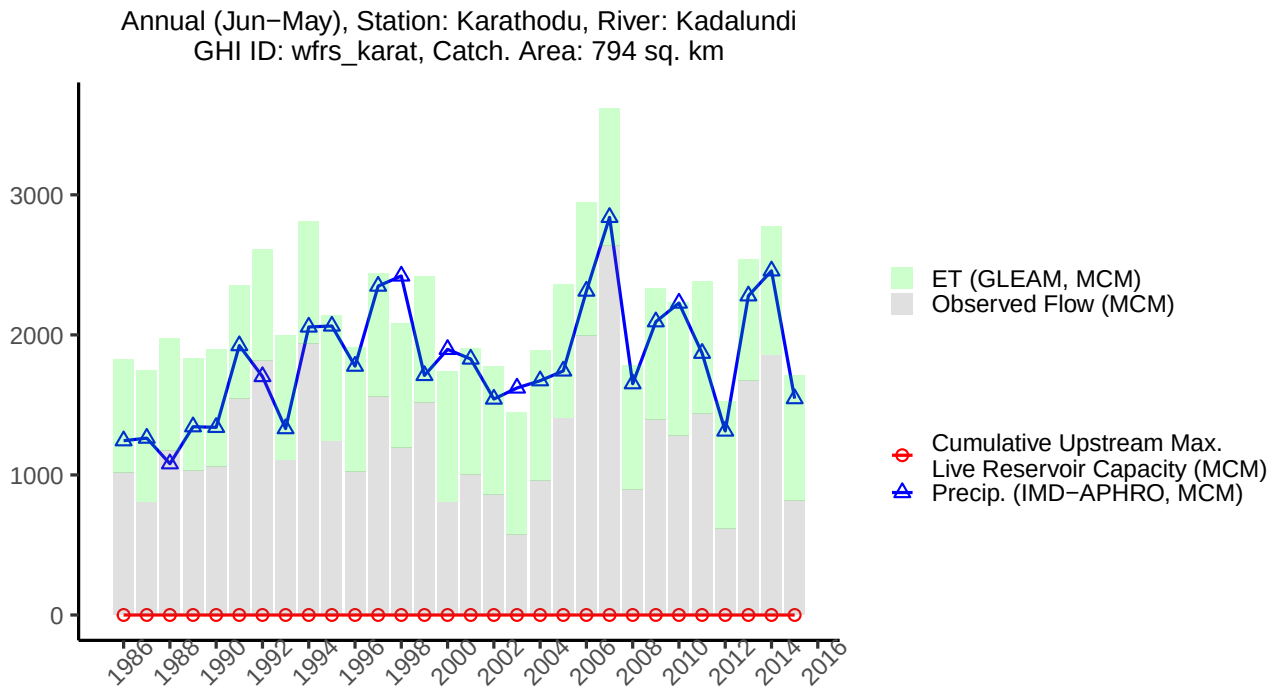


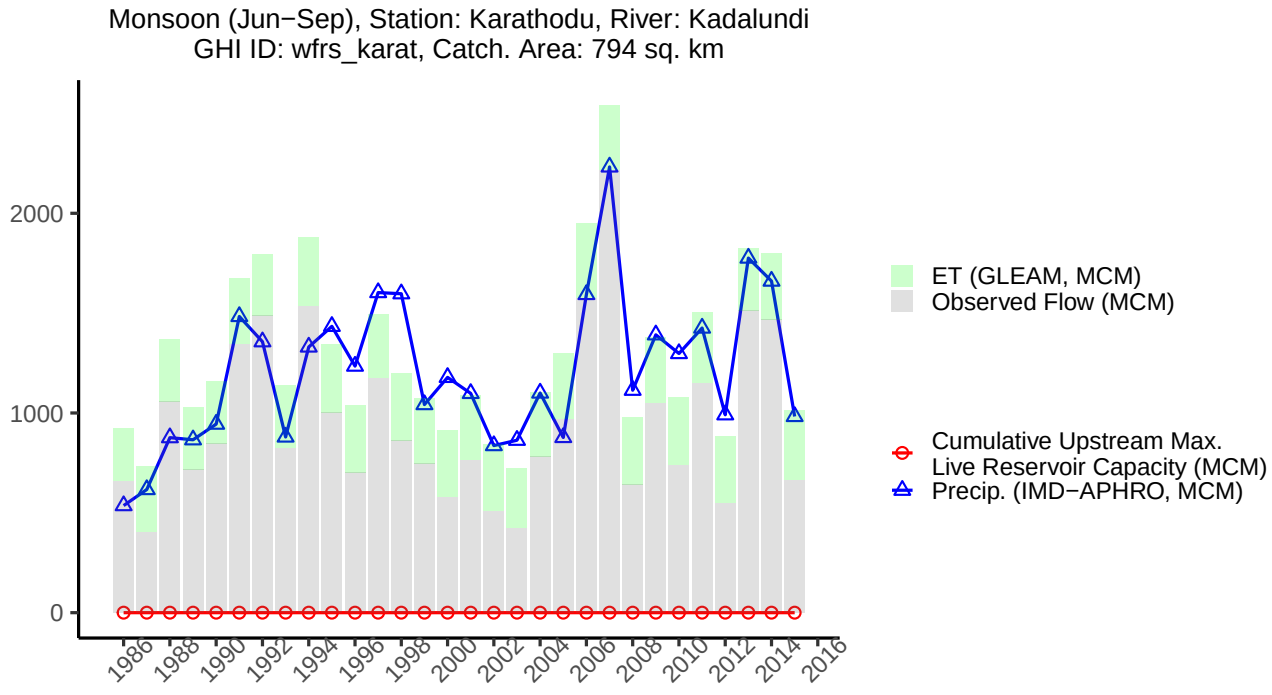
Monsoon (Jun−Sep), Station: Kalampur, River: Muvattupuzha/Kaliyar
GHI ID: wfrs_kalam, Catch. Area: 386 sq. km

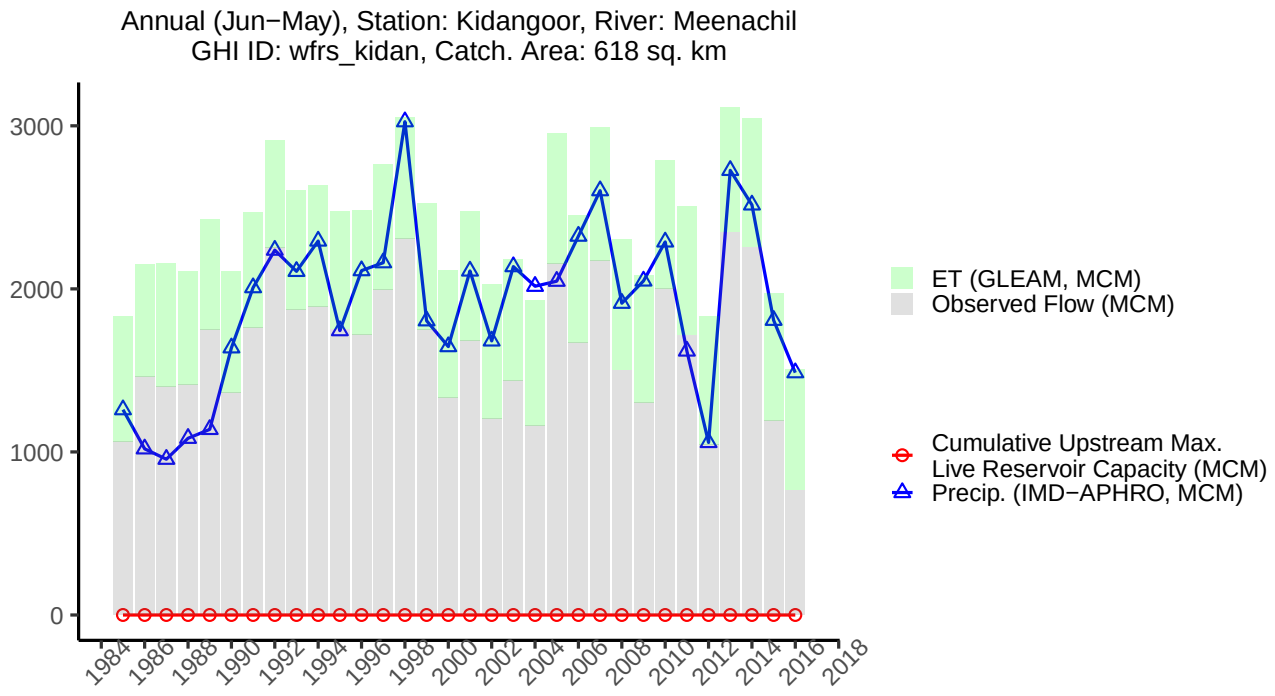


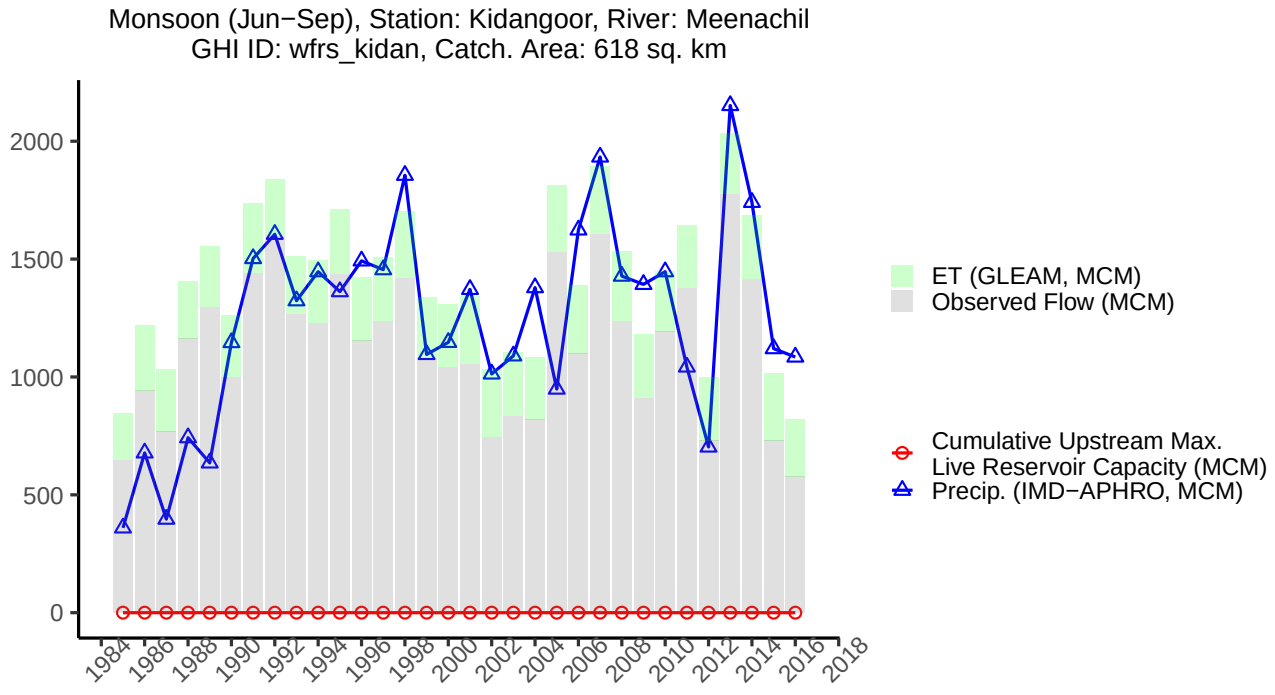

Annual (Jun−May), Station: Kallooppara, River: Pampa/Manimala
GHI ID: wfrs_kallo, Catch. Area: 733 sq. km
4000
3000
2000
1000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

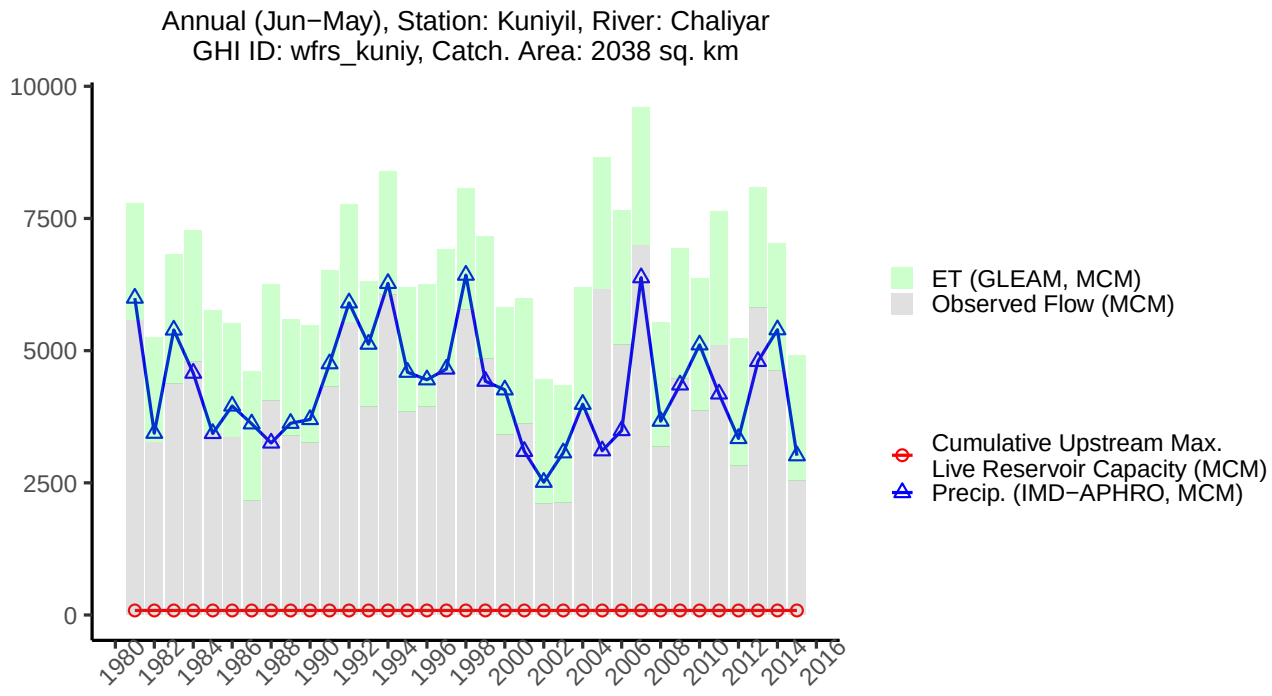

Monsoon (Jun−Sep), Station: Kallooppara, River: Pampa/Manimala
GHI ID: wfrs_kallo, Catch. Area: 733 sq. km
2500
2000
1500
1000
500
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

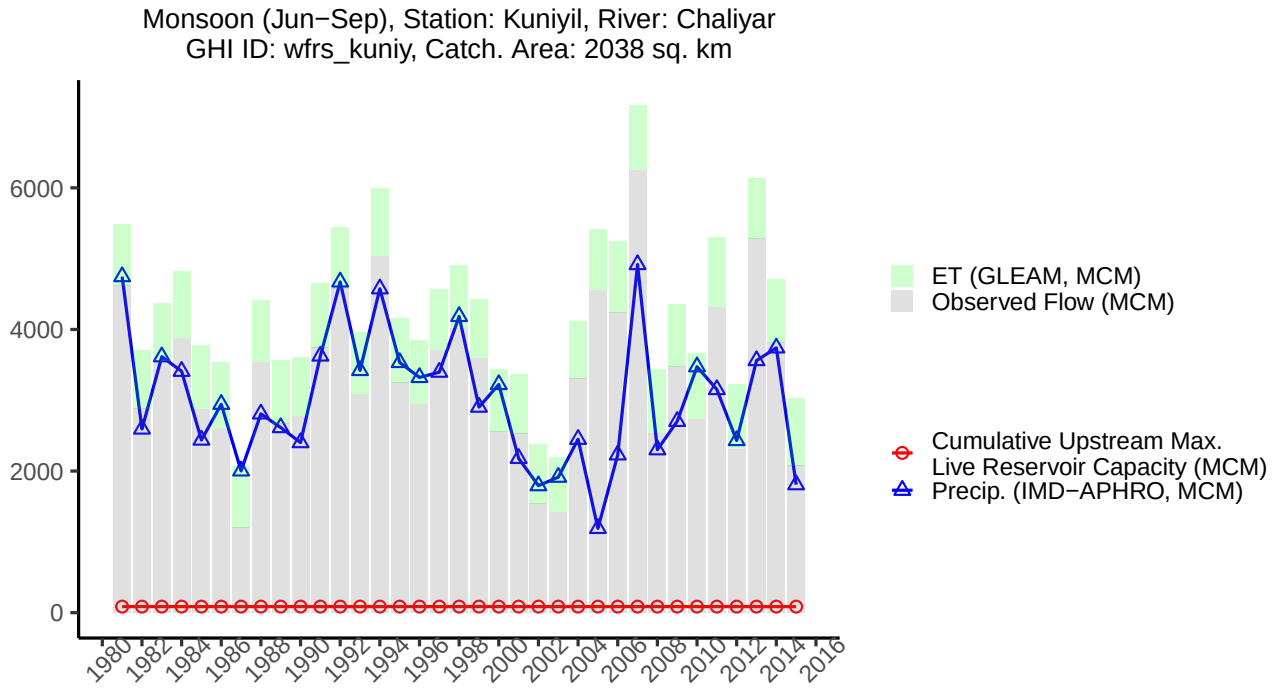

Annual (Jun−May), Station: Karathodu, River: Kadalundi
GHI ID: wfrs_karat, Catch. Area: 794 sq. km
3000
2000
1000
0
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

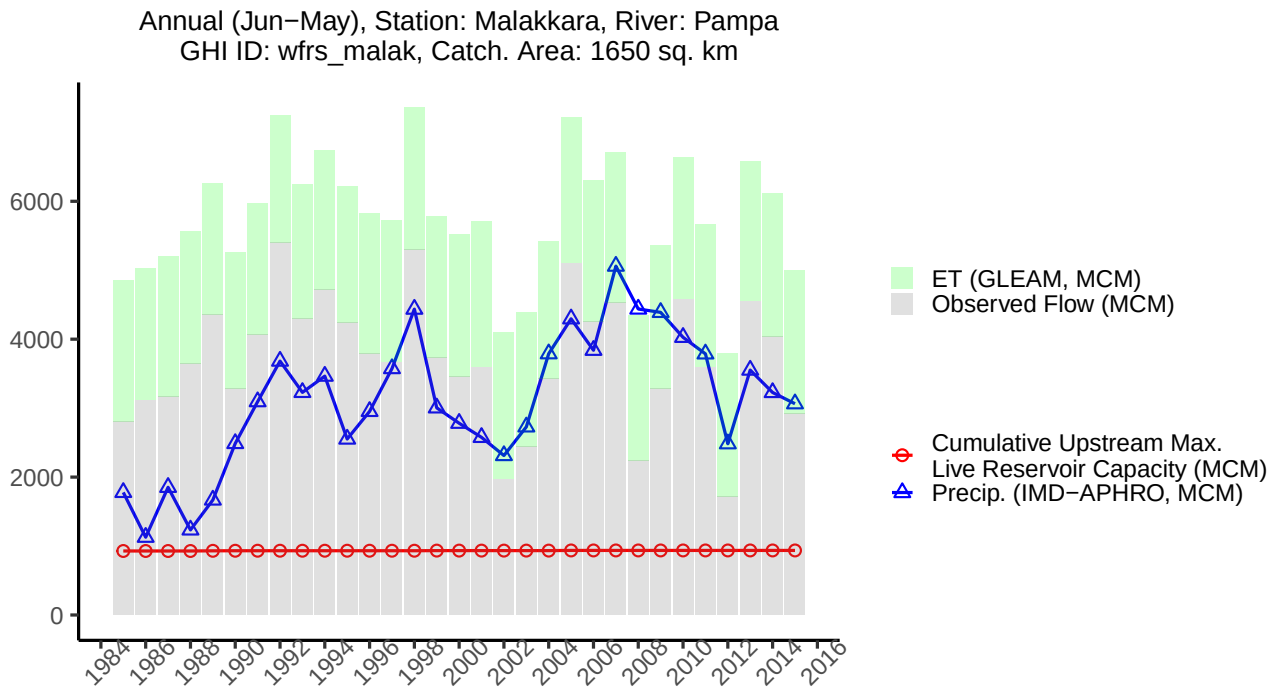

Monsoon (Jun−Sep), Station: Karathodu, River: Kadalundi
GHI ID: wfrs_karat, Catch. Area: 794 sq. km
2000
1000
0
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

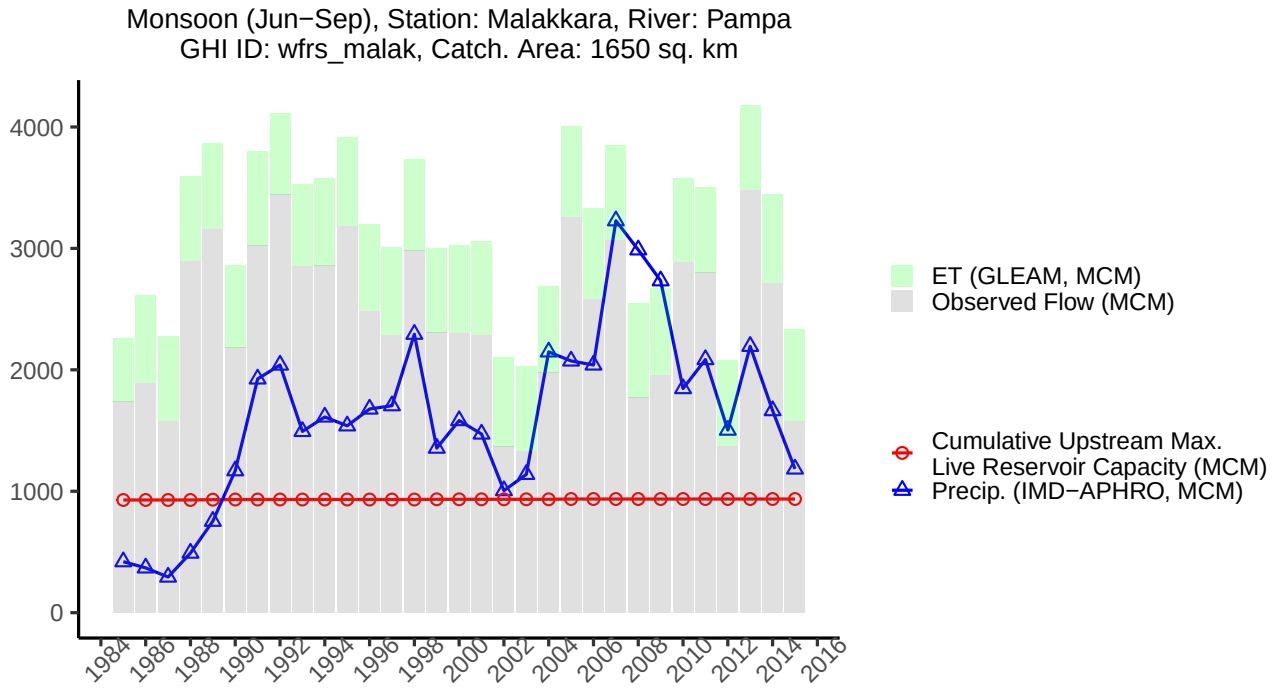

Annual (Jun−May), Station: Kidangoor, River: Meenachil
GHI ID: wfrs_kidan, Catch. Area: 618 sq. km
3000
2000
1000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

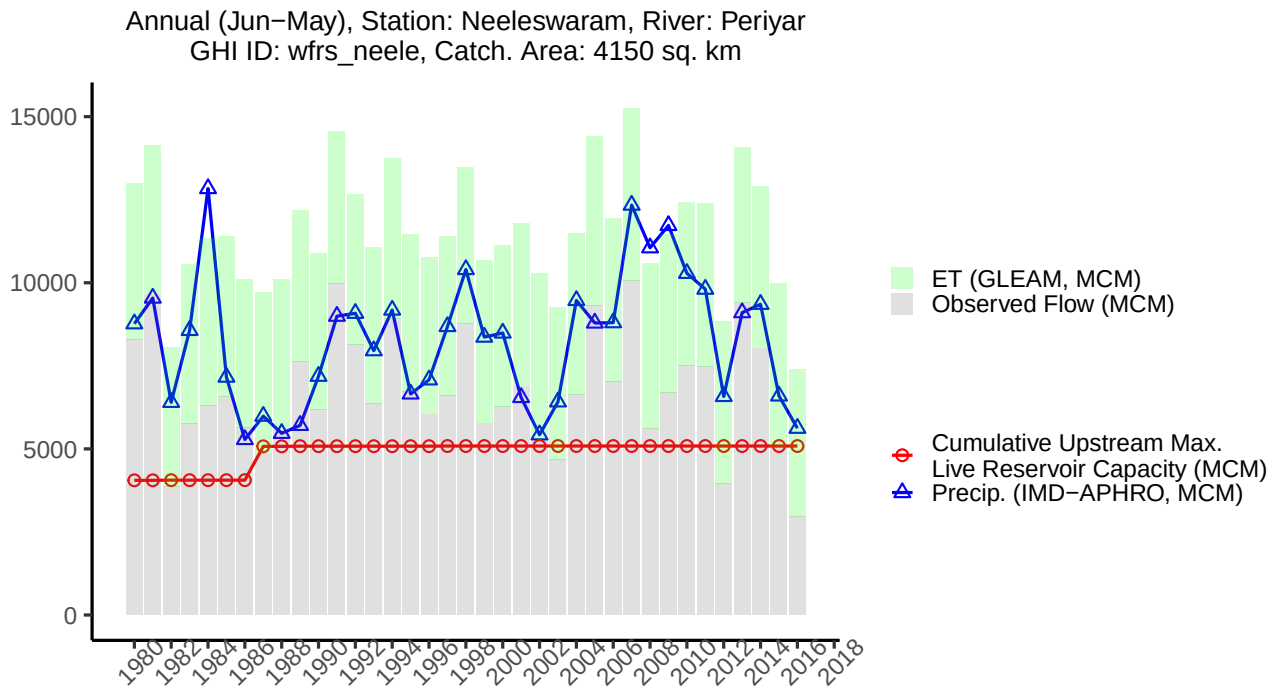

Monsoon (Jun−Sep), Station: Kidangoor, River: Meenachil
GHI ID: wfrs_kidan, Catch. Area: 618 sq. km
2000
1500
1000
500
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

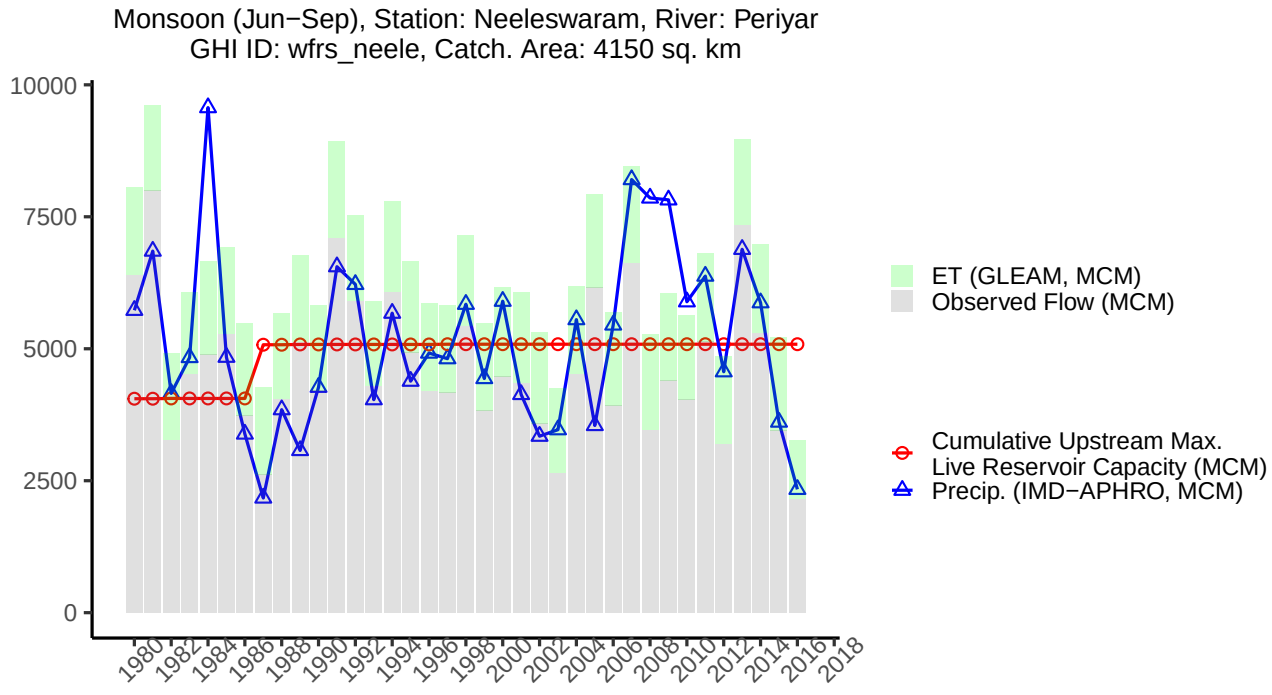

Annual (Jun−May), Station: Kuniyil, River: Chaliyar
GHI ID: wfrs_kuniy, Catch. Area: 2038 sq. km
10000
7500
5000
2500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

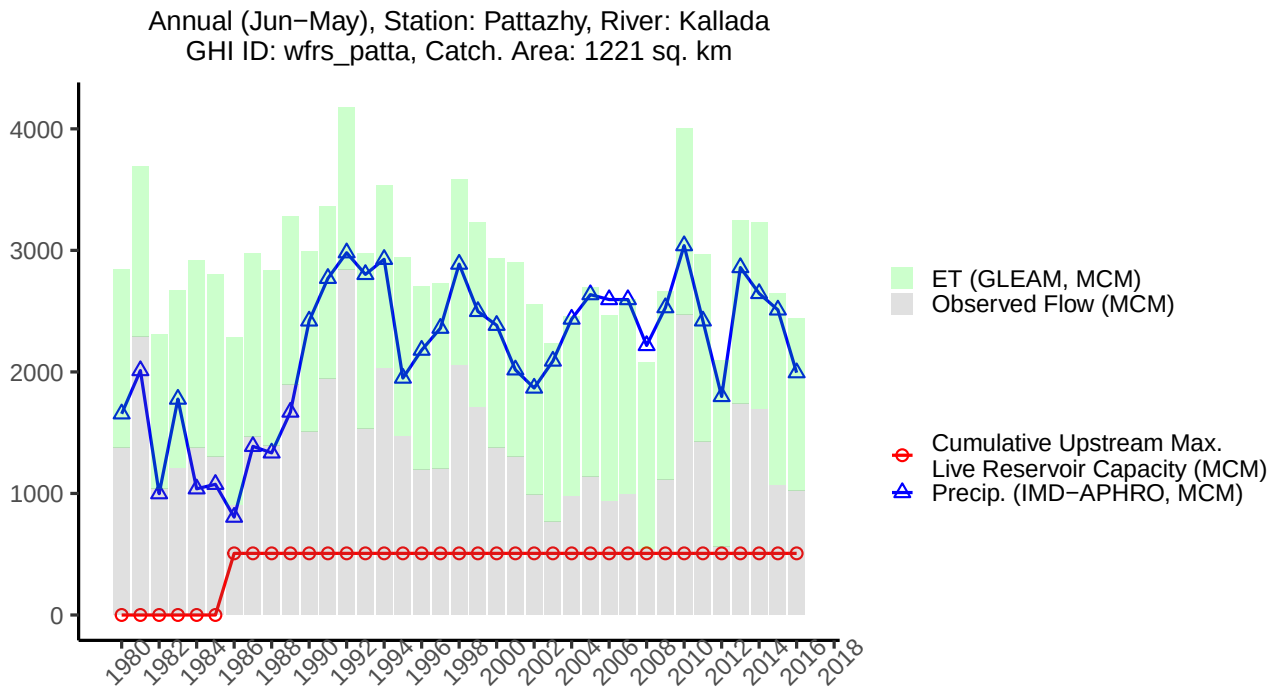

Monsoon (Jun−Sep), Station: Kuniyil, River: Chaliyar
GHI ID: wfrs_kuniy, Catch. Area: 2038 sq. km
6000
4000
2000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

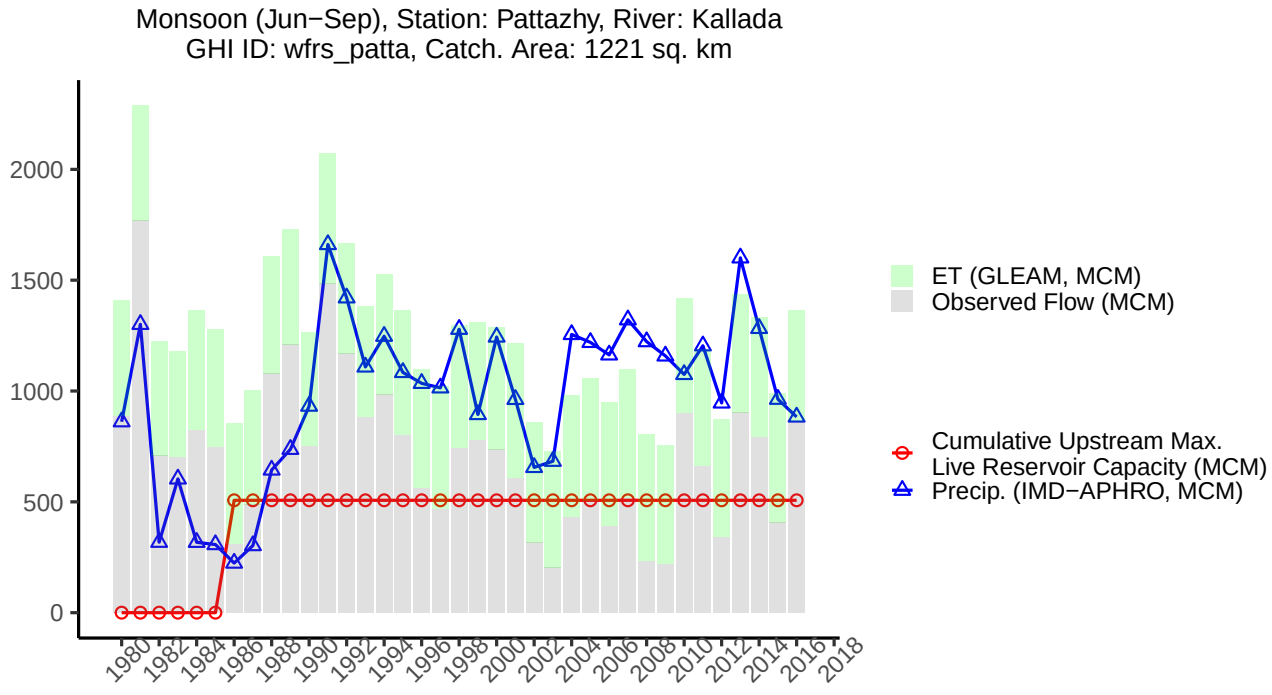

Annual (Jun−May), Station: Malakkara, River: Pampa
GHI ID: wfrs_malak, Catch. Area: 1650 sq. km
6000
4000
2000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

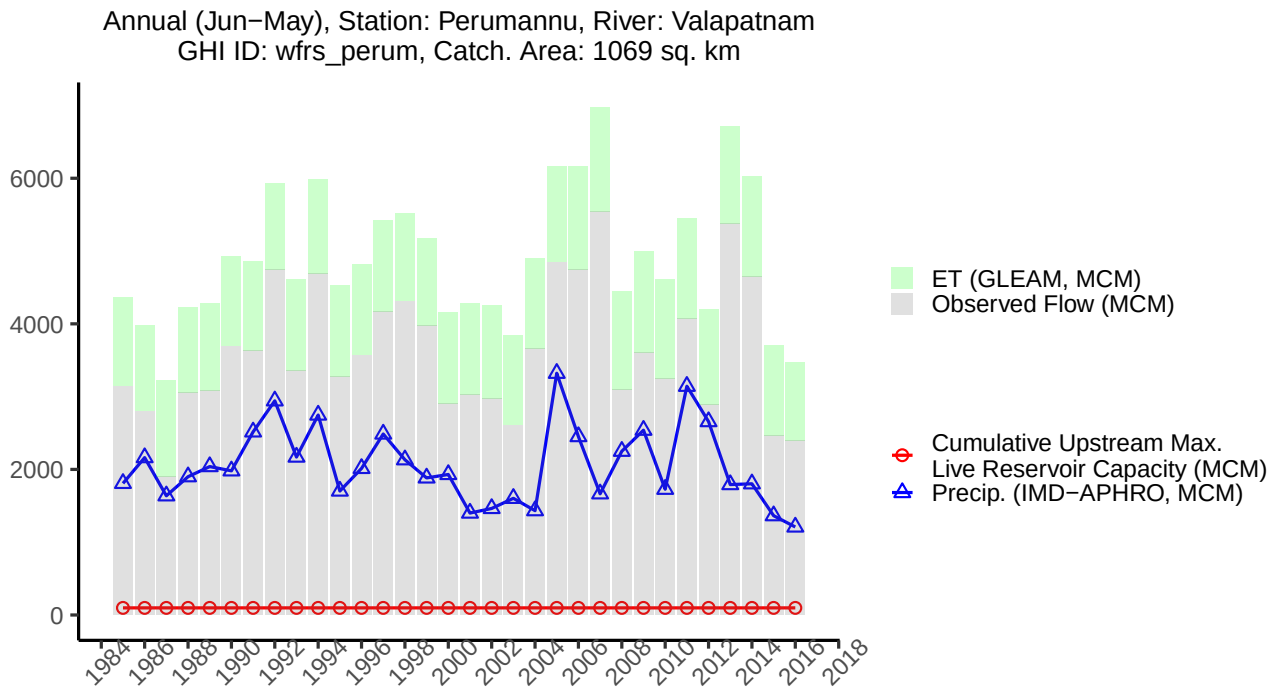

Monsoon (Jun−Sep), Station: Malakkara, River: Pampa
GHI ID: wfrs_malak, Catch. Area: 1650 sq. km
4000
3000
2000
1000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

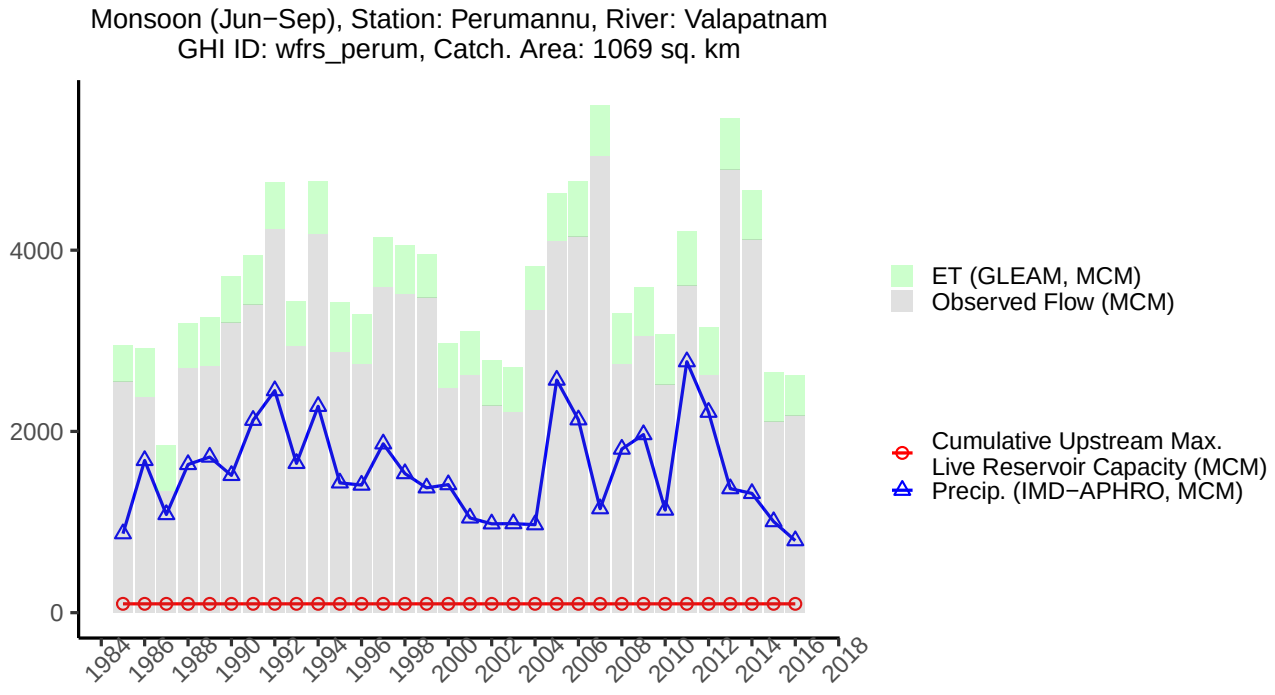

Annual (Jun−May), Station: Neeleswaram, River: Periyar
GHI ID: wfrs_neele, Catch. Area: 4150 sq. km
15000
10000
5000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Neeleswaram, River: Periyar
GHI ID: wfrs_neele, Catch. Area: 4150 sq. km
10000
7500
5000
2500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

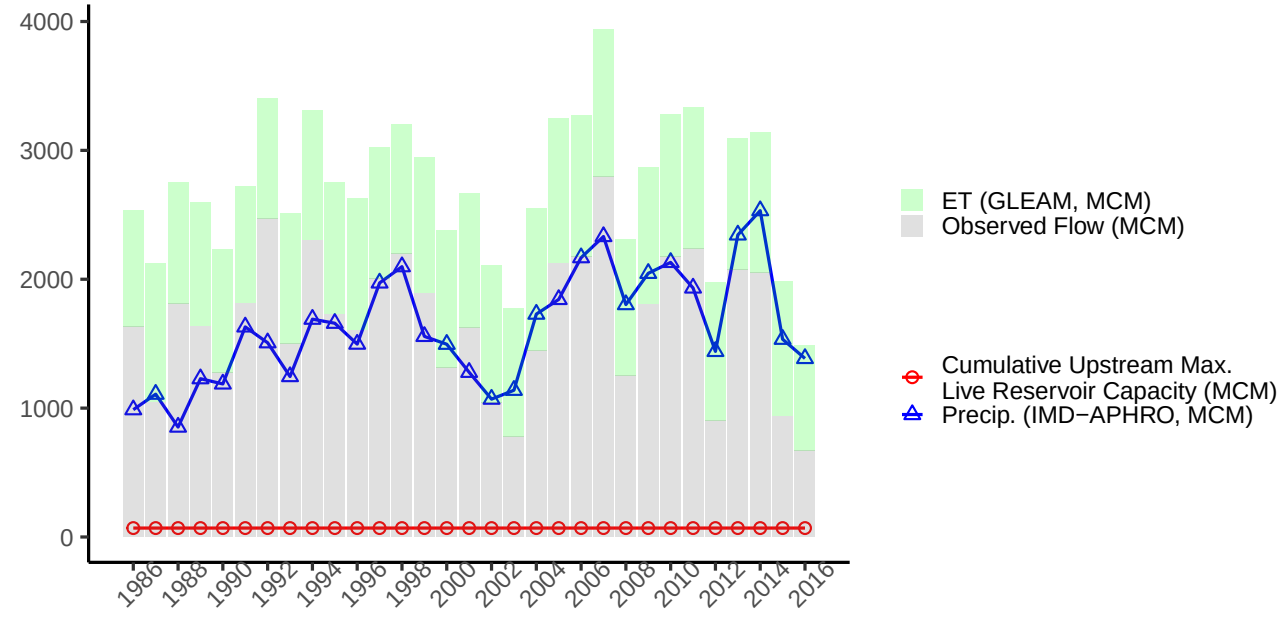

Annual (Jun−May), Station: Pattazhy, River: Kallada
GHI ID: wfrs_patta, Catch. Area: 1221 sq. km
4000
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Pattazhy, River: Kallada
GHI ID: wfrs_patta, Catch. Area: 1221 sq. km
2000
1500
1000
500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

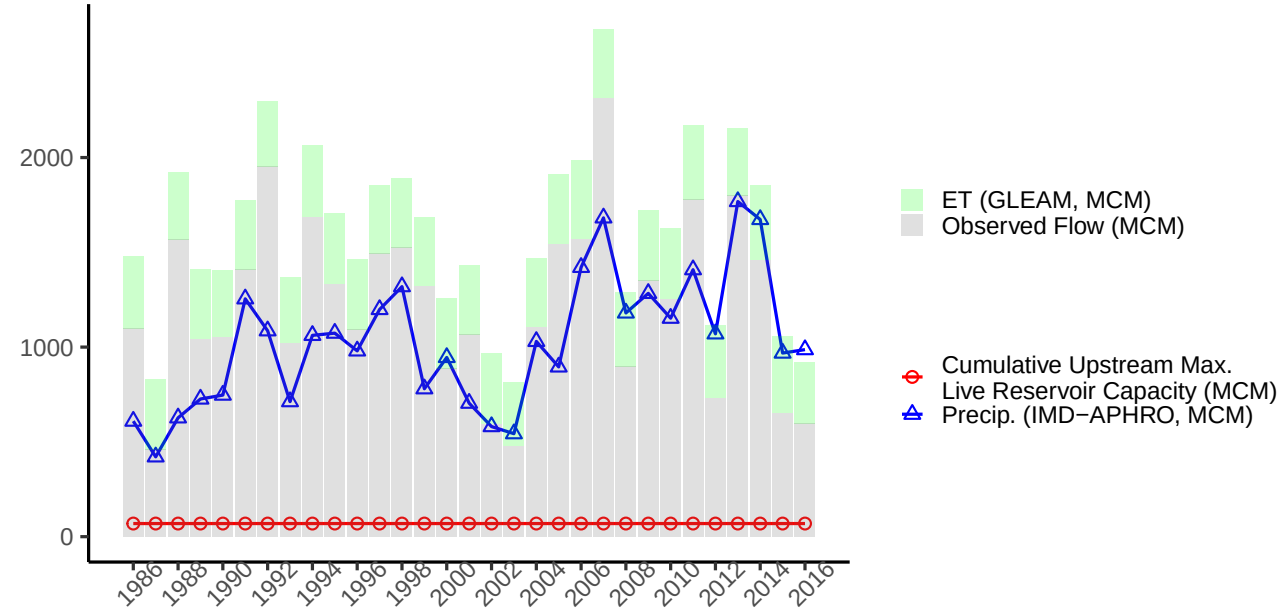

Annual (Jun−May), Station: Perumannu, River: Valapatnam
GHI ID: wfrs_perum, Catch. Area: 1069 sq. km
6000
4000
2000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

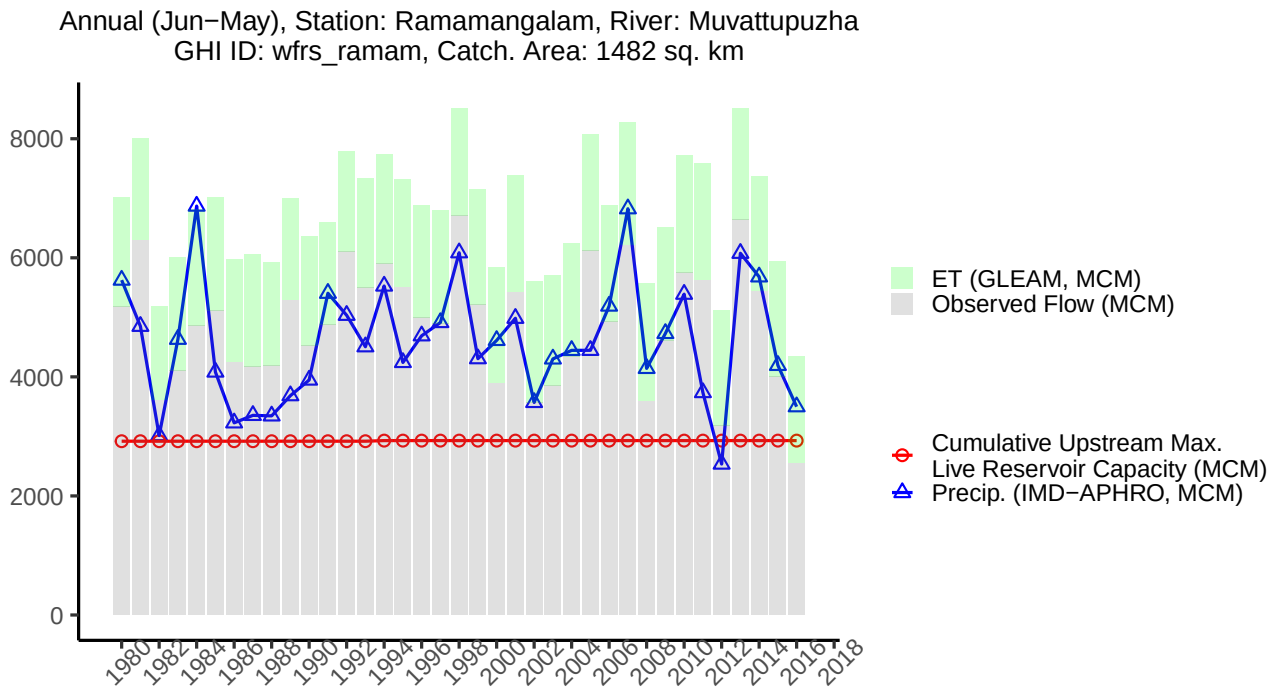

Monsoon (Jun−Sep), Station: Perumannu, River: Valapatnam
GHI ID: wfrs_perum, Catch. Area: 1069 sq. km
4000
2000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

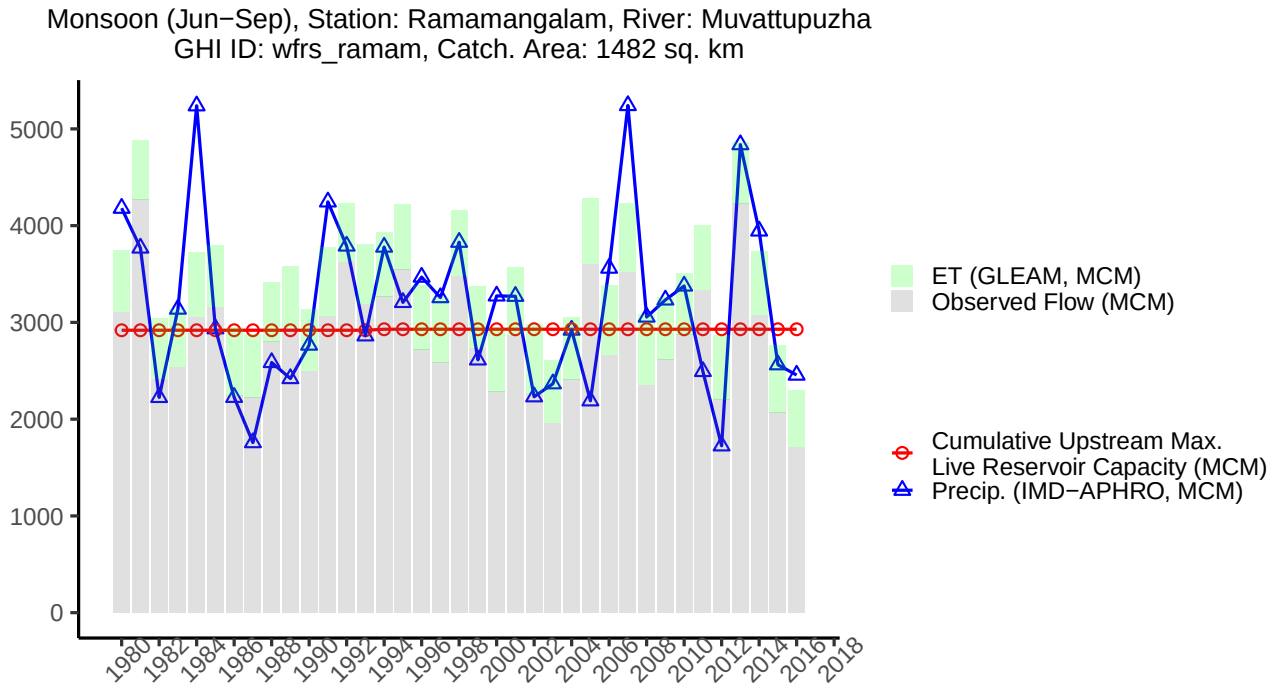
Annual (Jun−May), Station: Pulamanthole, River: Bharathapuzha/Pulanthodu
GHI ID: wfrs_pulam, Catch. Area: 923 sq. km

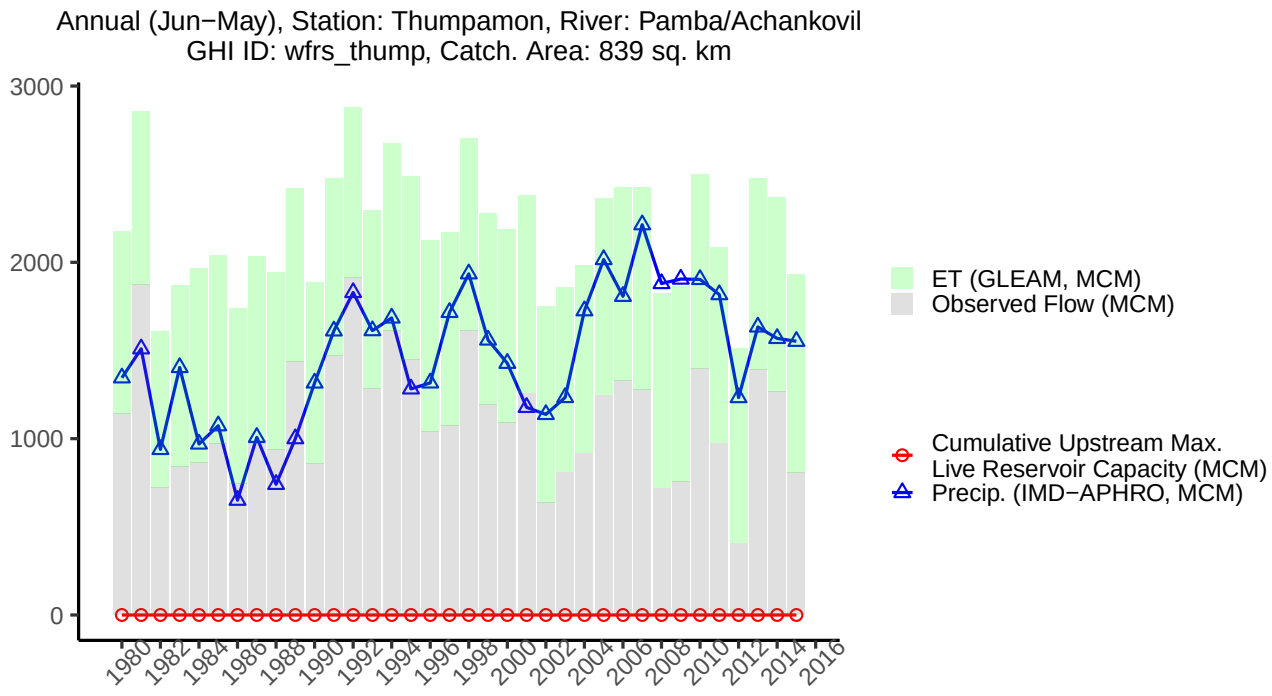


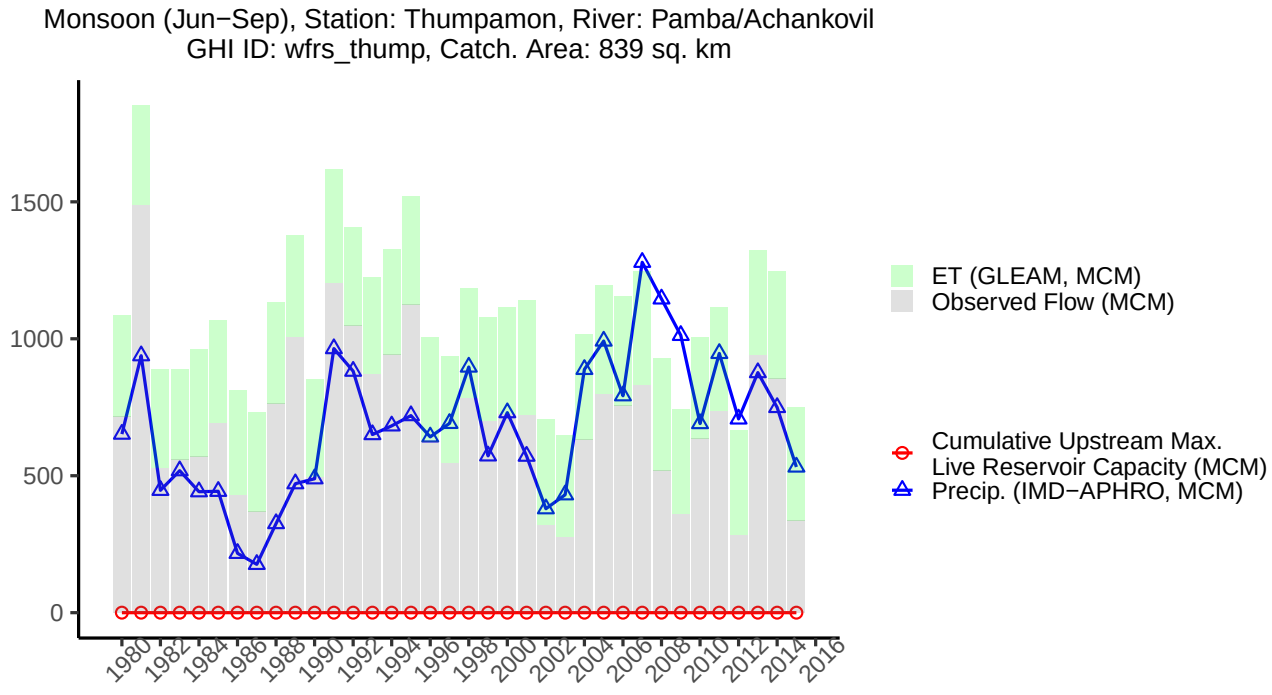
Monsoon (Jun−Sep), Station: Pulamanthole, River: Bharathapuzha/Pulanthodu
GHI ID: wfrs_pulam, Catch. Area: 923 sq. km

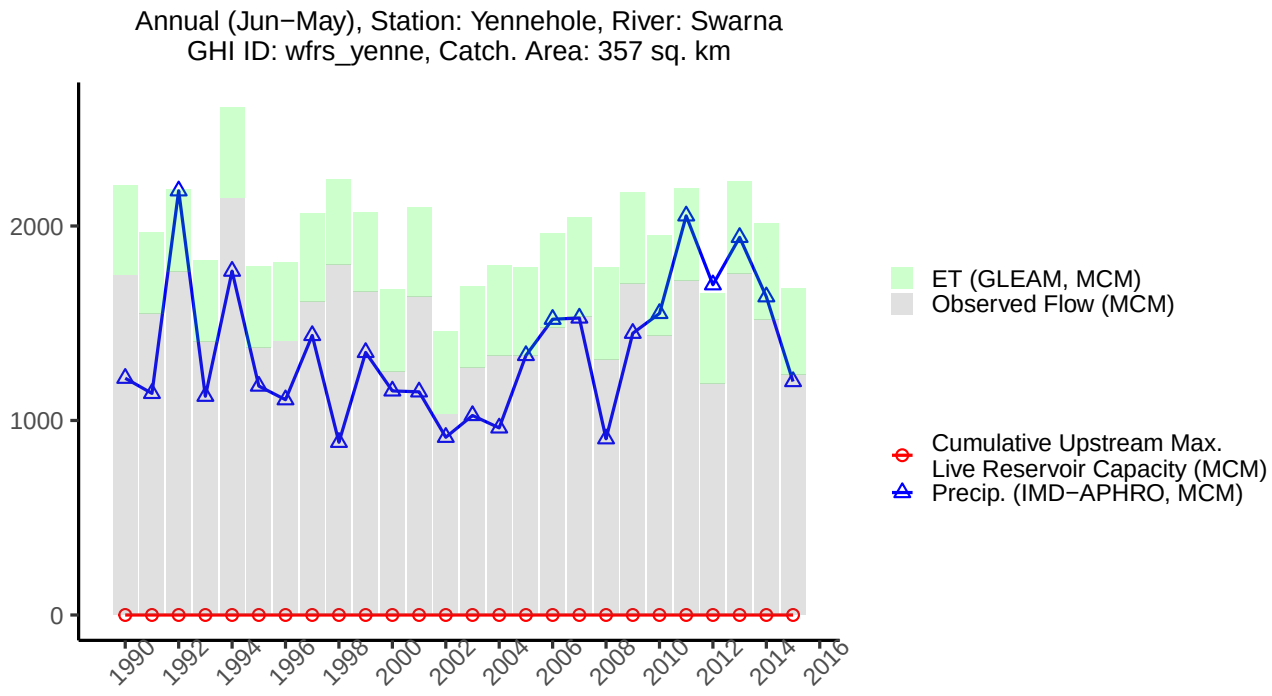


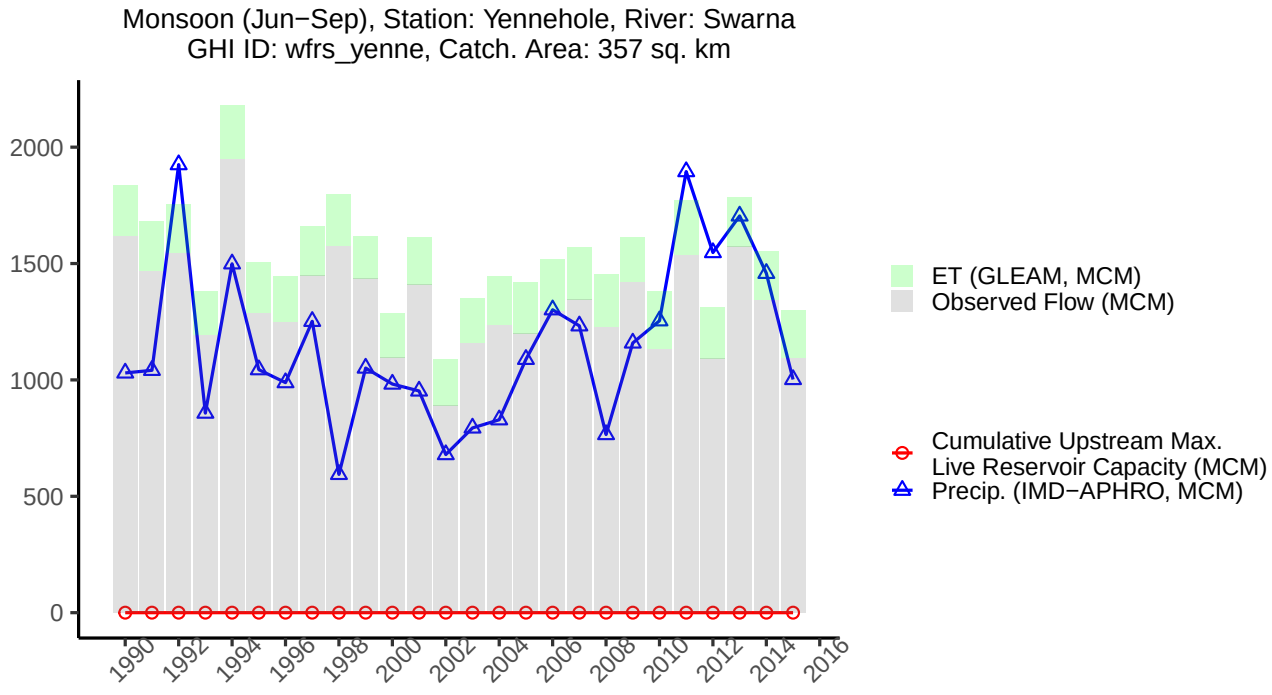

Annual (Jun−May), Station: Ramamangalam, River: Muvattupuzha
GHI ID: wfrs_ramam, Catch. Area: 1482 sq. km
8000
6000
4000
2000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

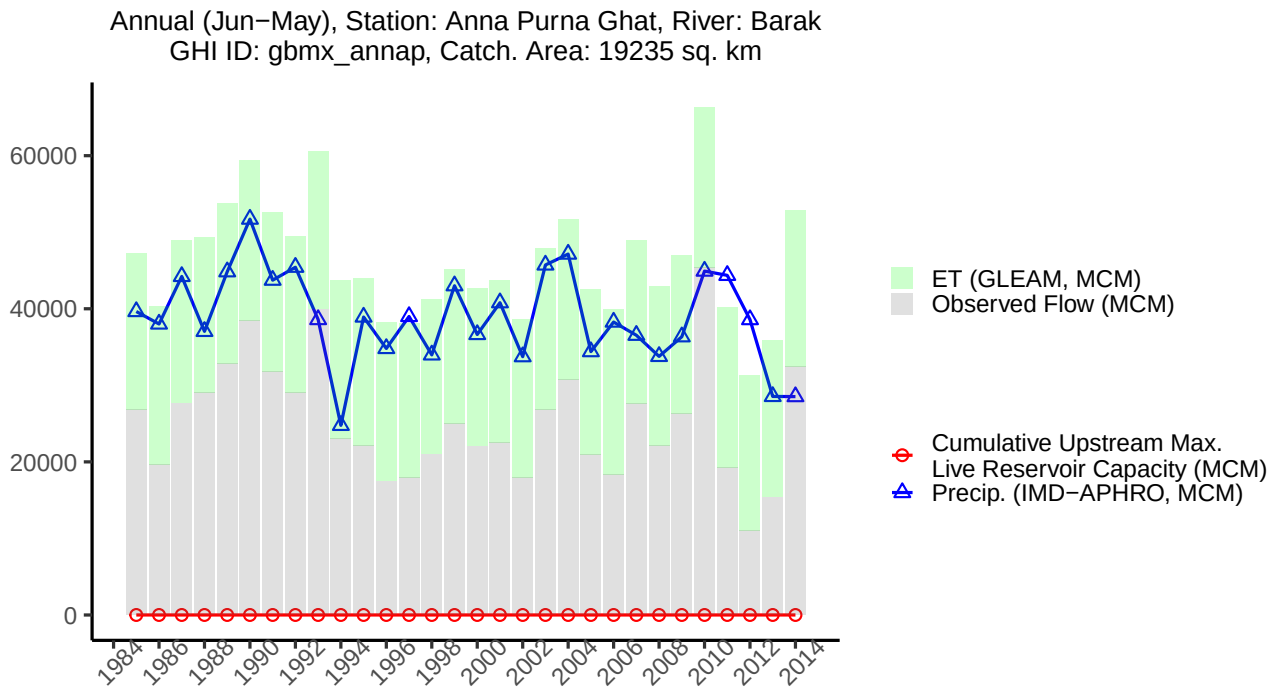

Monsoon (Jun−Sep), Station: Ramamangalam, River: Muvattupuzha
GHI ID: wfrs_ramam, Catch. Area: 1482 sq. km
5000
4000
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

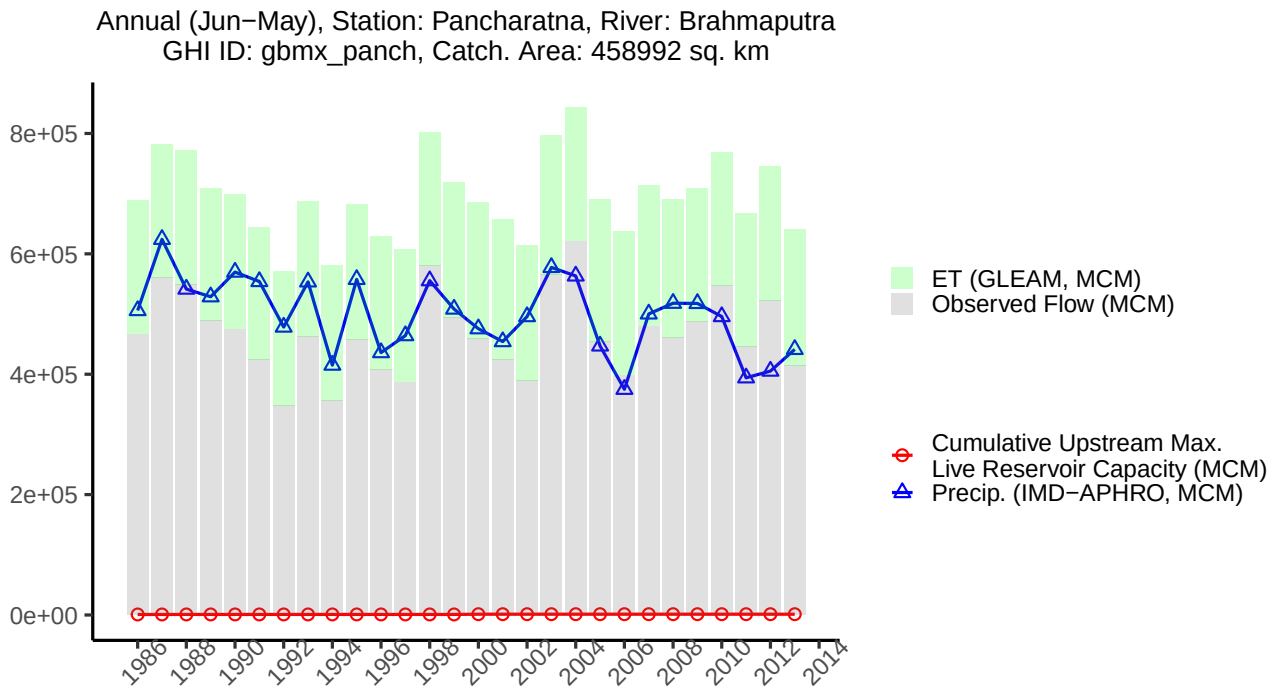

Annual (Jun−May), Station: Thumpamon, River: Pamba/Achankovil
GHI ID: wfrs_thump, Catch. Area: 839 sq. km
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

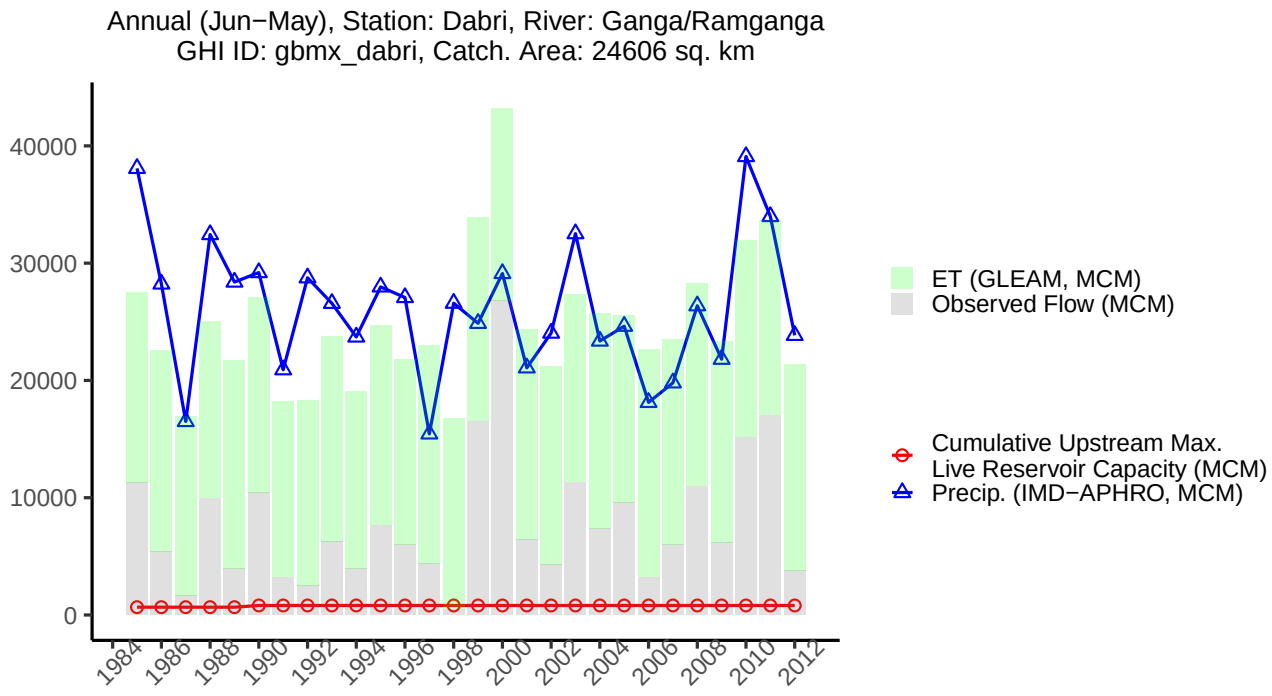

Monsoon (Jun−Sep), Station: Thumpamon, River: Pamba/Achankovil
GHI ID: wfrs_thump, Catch. Area: 839 sq. km
1500
1000
500
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

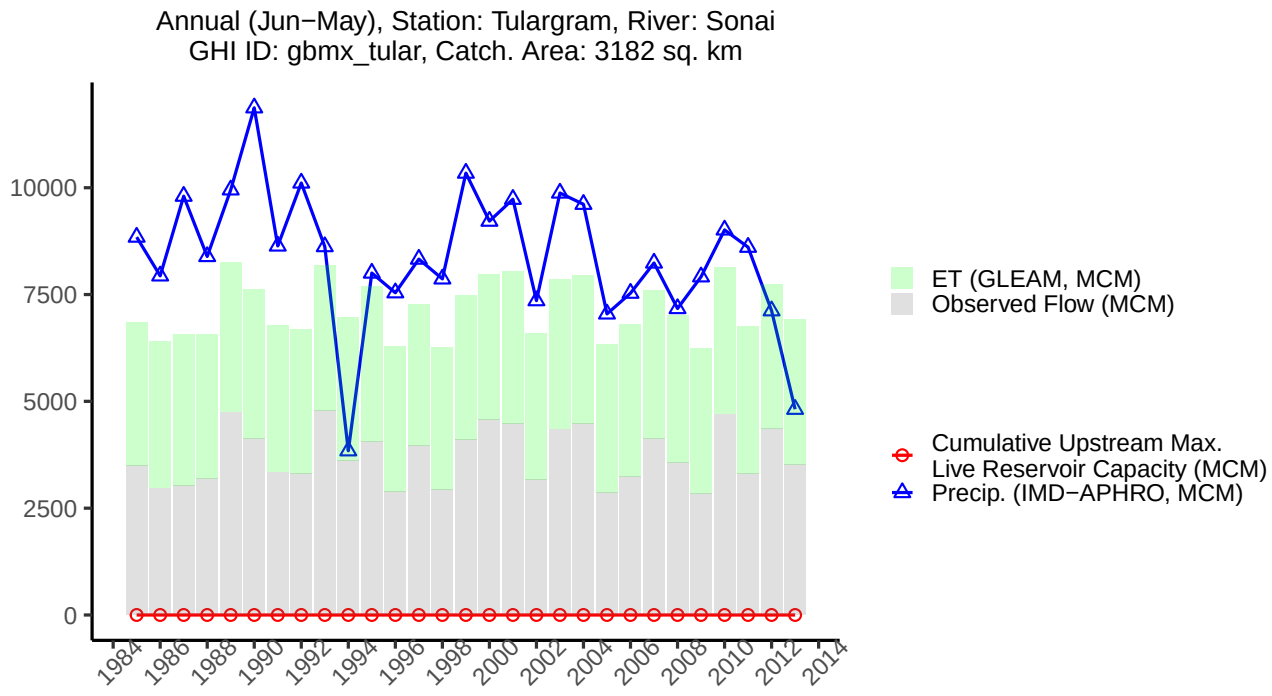

Annual (Jun−May), Station: Yennehole, River: Swarna
GHI ID: wfrs_yenne, Catch. Area: 357 sq. km
2000
1000
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Yennehole, River: Swarna
GHI ID: wfrs_yenne, Catch. Area: 357 sq. km
2000
1500
1000
500
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

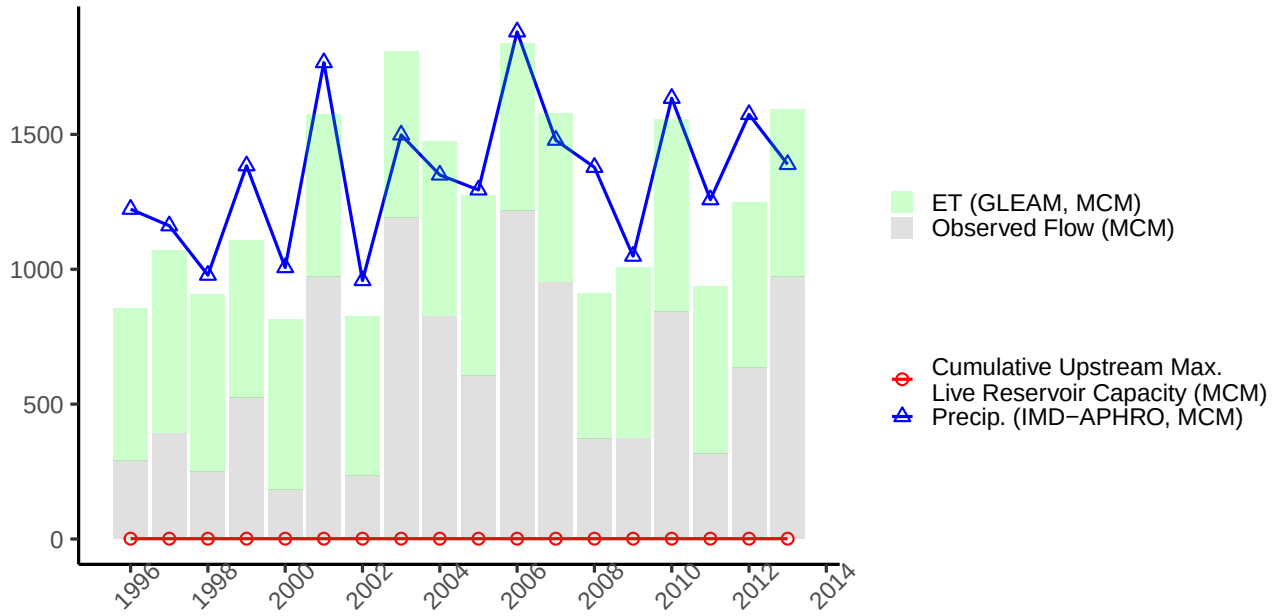

Annual (Jun−May), Station: Anna Purna Ghat, River: Barak
GHI ID: gbmx_annap, Catch. Area: 19235 sq. km
60000
40000
20000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Pancharatna, River: Brahmaputra
GHI ID: gbmx_panch, Catch. Area: 458992 sq. km
8e+05
6e+05
4e+05
2e+05
0e+00
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

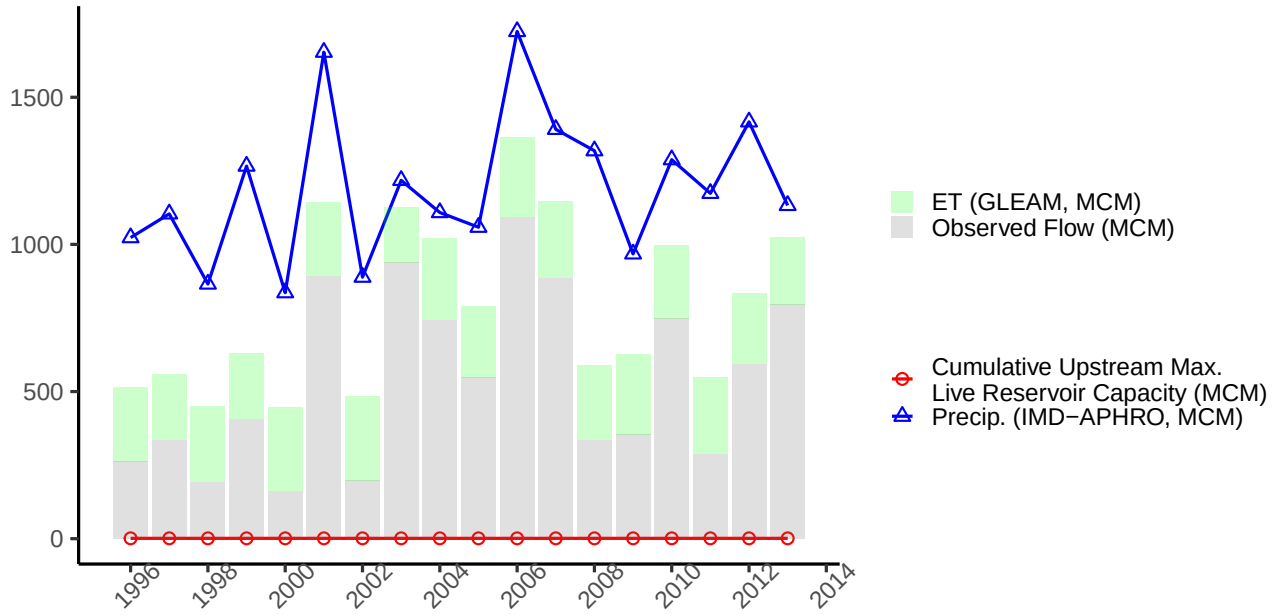

Annual (Jun−May), Station: Dabri, River: Ganga/Ramganga
GHI ID: gbmx_dabri, Catch. Area: 24606 sq. km
40000
30000
20000
10000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

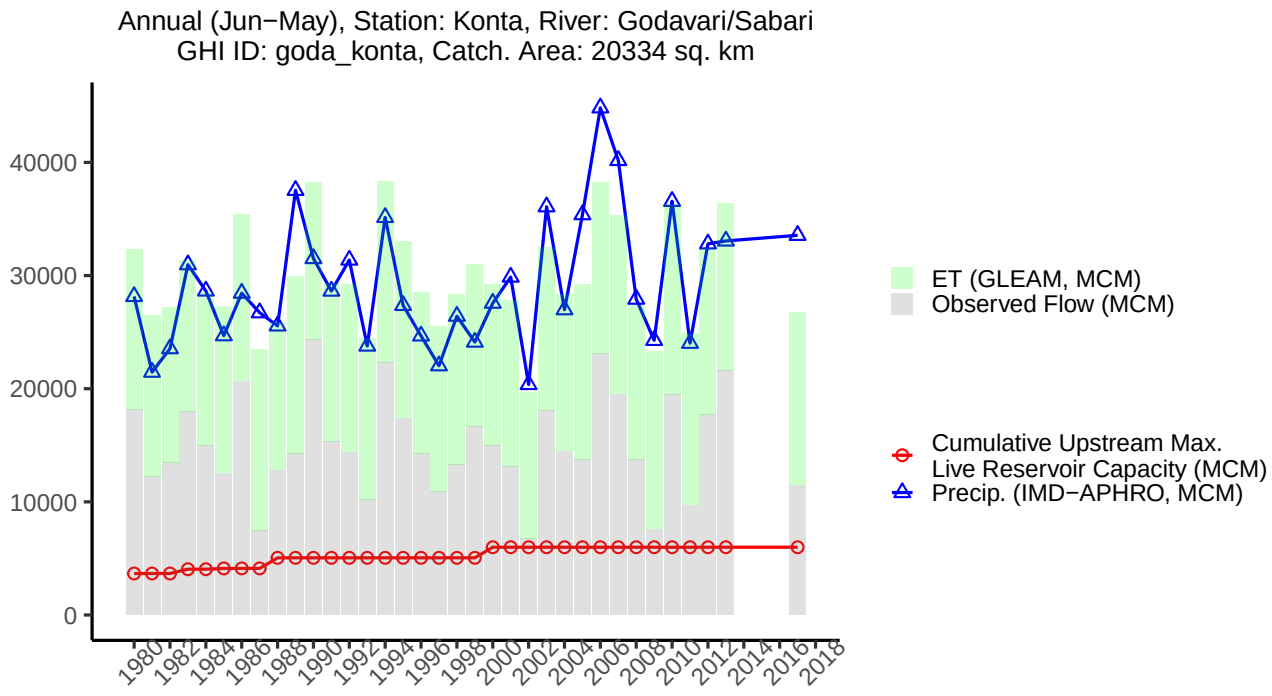

Annual (Jun−May), Station: Tulargram, River: Sonai
GHI ID: gbmx_tular, Catch. Area: 3182 sq. km
10000
7500
5000
2500
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

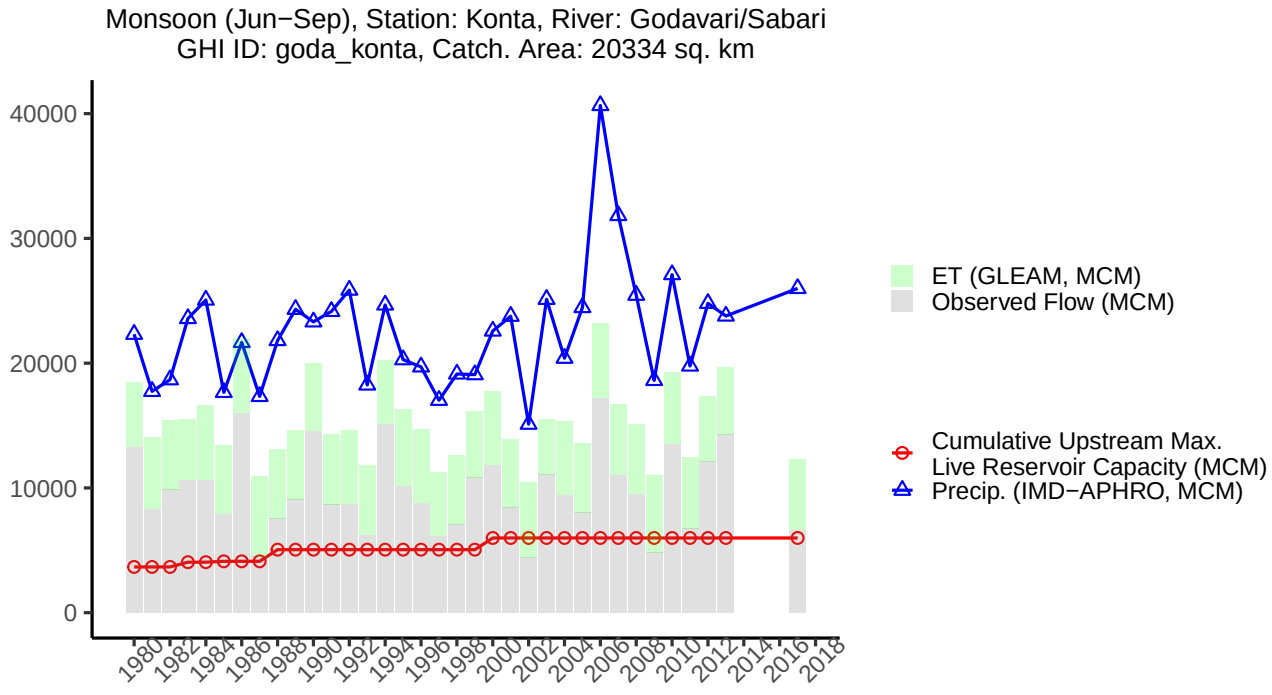
Annual (Jun−May), Station: Cherribeda, River: Godavari/Indravati/Bardha
GHI ID: goda_cherr, Catch. Area: 1026 sq. km



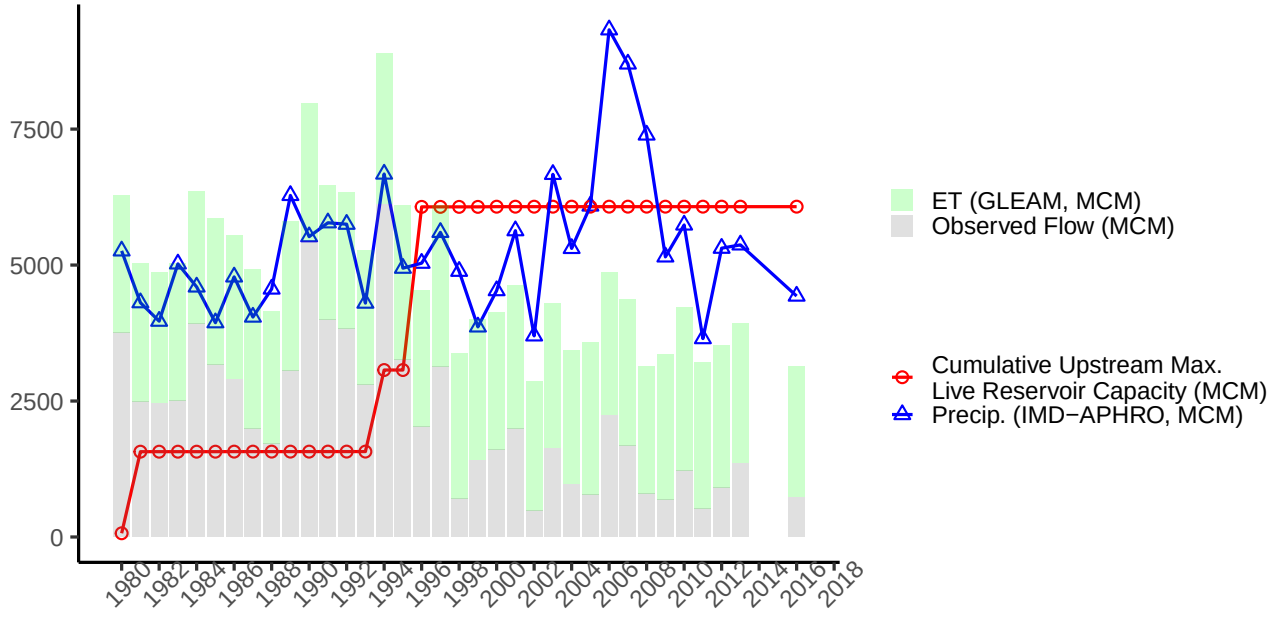
Monsoon (Jun−Sep), Station: Cherribeda, River: Godavari/Indravati/Bardha
GHI ID: goda_cherr, Catch. Area: 1026 sq. km



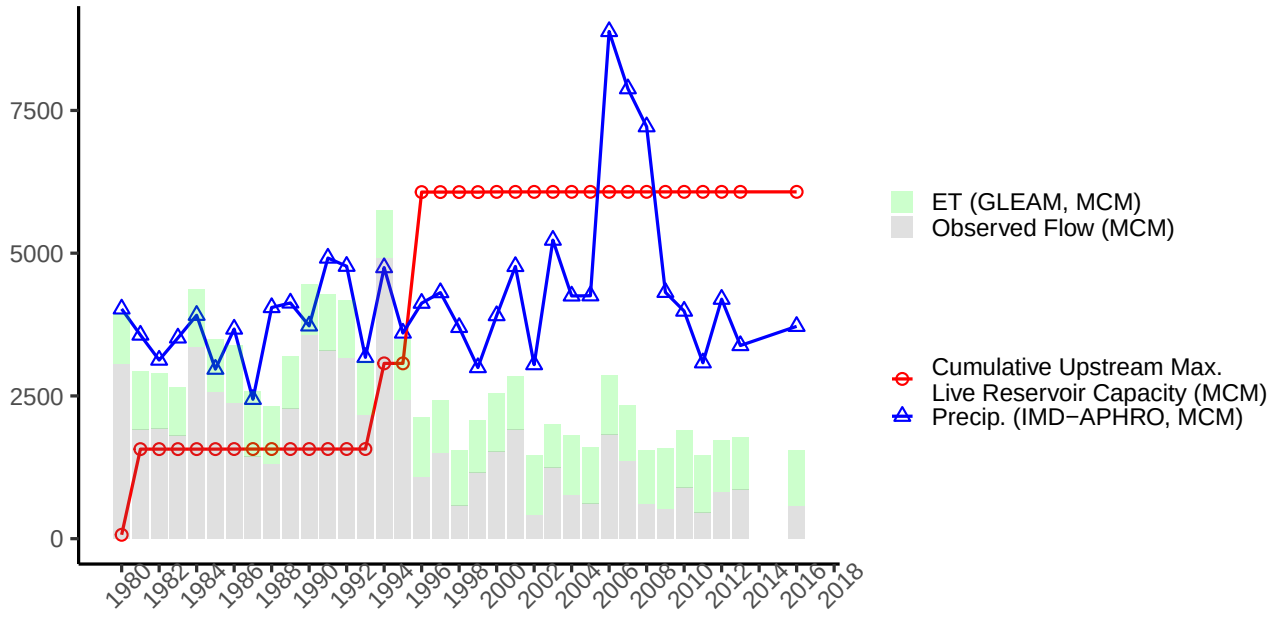

Annual (Jun−May), Station: Konta, River: Godavari/Sabari
GHI ID: goda_konta, Catch. Area: 20334 sq. km
40000
30000
20000
10000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Konta, River: Godavari/Sabari
GHI ID: goda_konta, Catch. Area: 20334 sq. km
40000
30000
20000
10000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

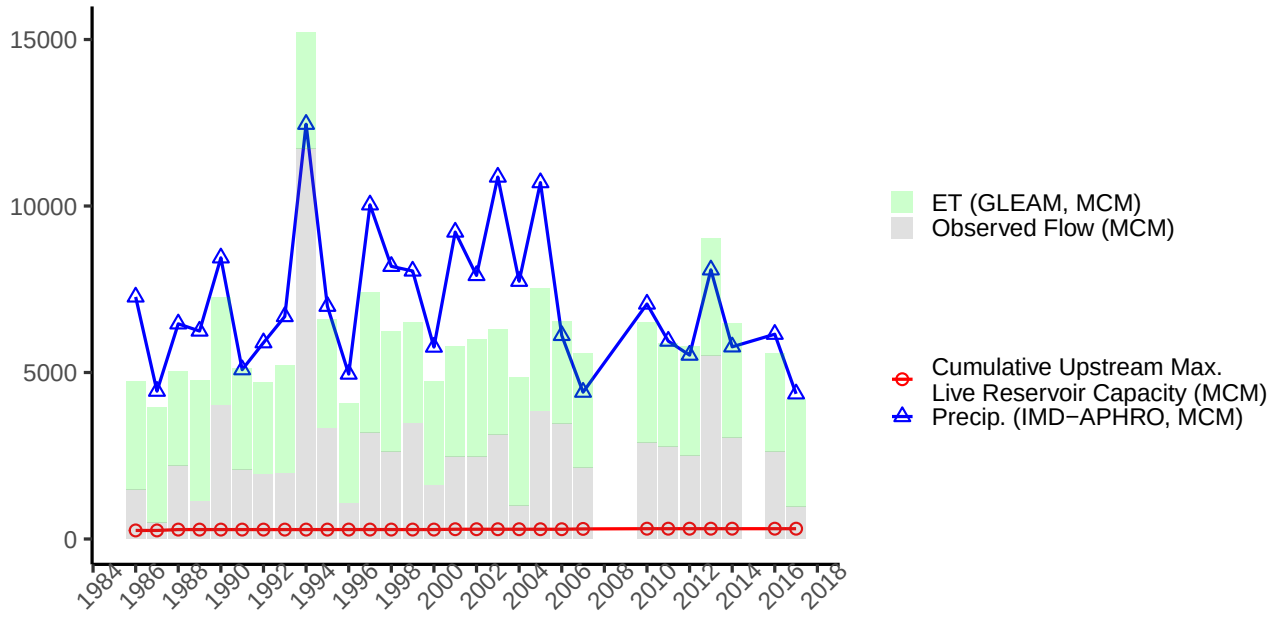
Annual (Jun−May), Station: Nowrangpur, River: Godavari/Indravati
GHI ID: goda_nowra, Catch. Area: 3661 sq. km



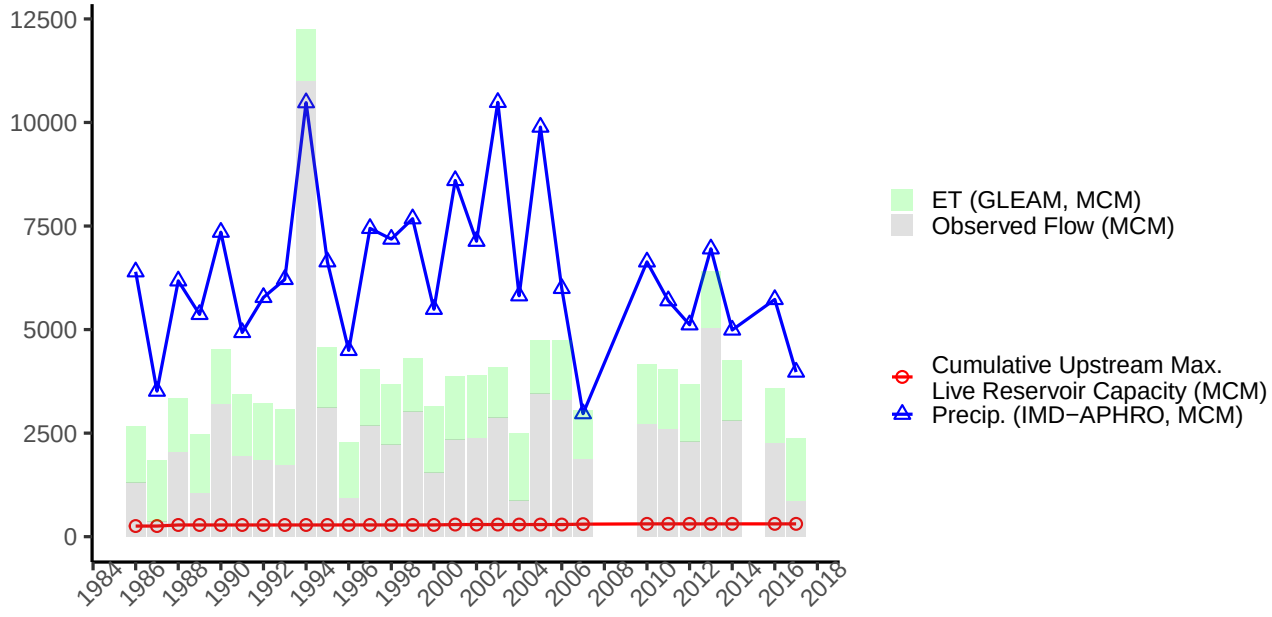
Monsoon (Jun−Sep), Station: Nowrangpur, River: Godavari/Indravati
GHI ID: goda_nowra, Catch. Area: 3661 sq. km



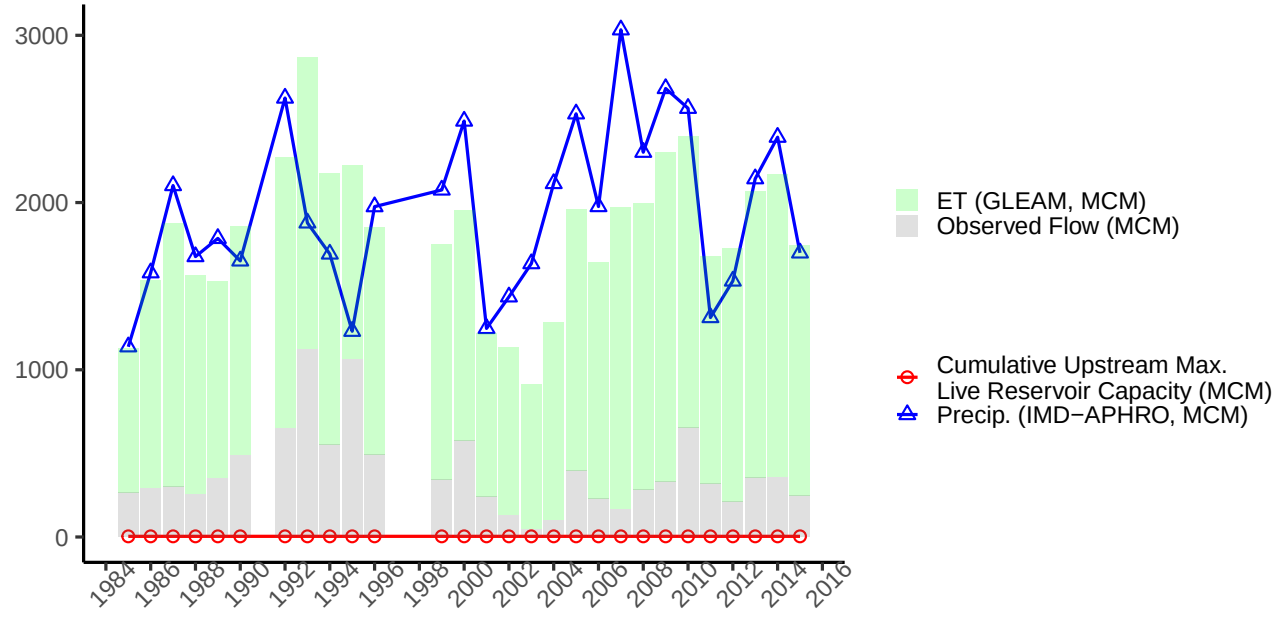
Annual (Jun−May), Station: Rajegaon, River: Godavari/Pranhita/Bagh
GHI ID: goda_rajeg, Catch. Area: 5403 sq. km



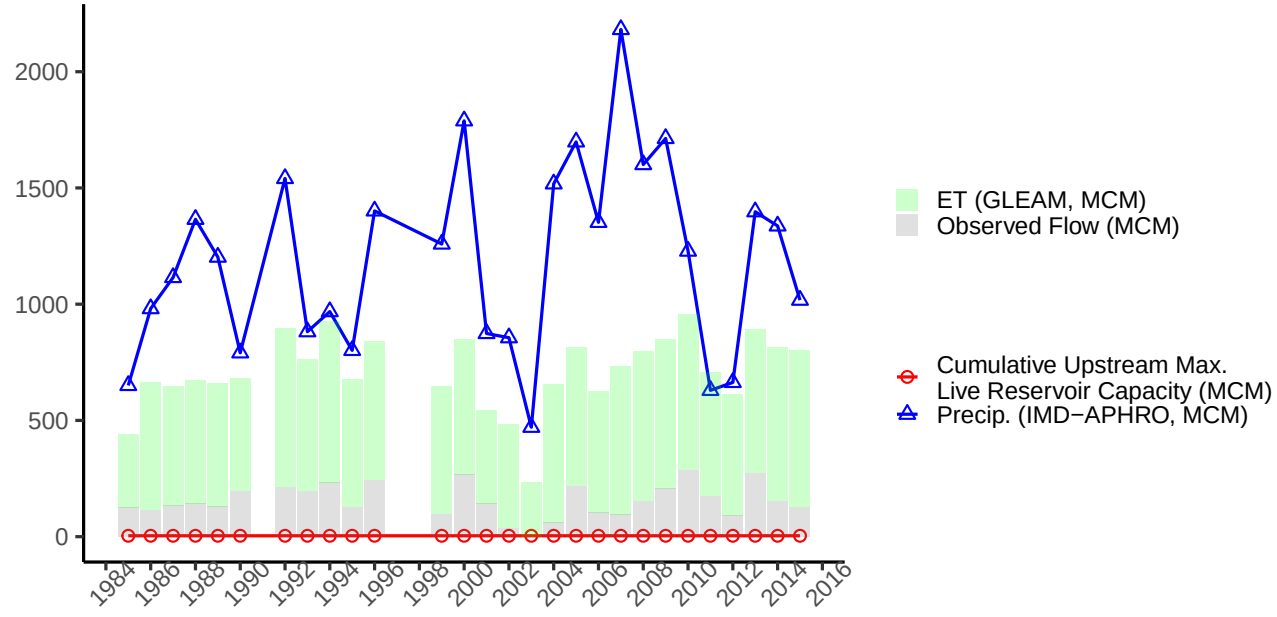
Monsoon (Jun−Sep), Station: Rajegaon, River: Godavari/Pranhita/Bagh
GHI ID: goda_rajeg, Catch. Area: 5403 sq. km

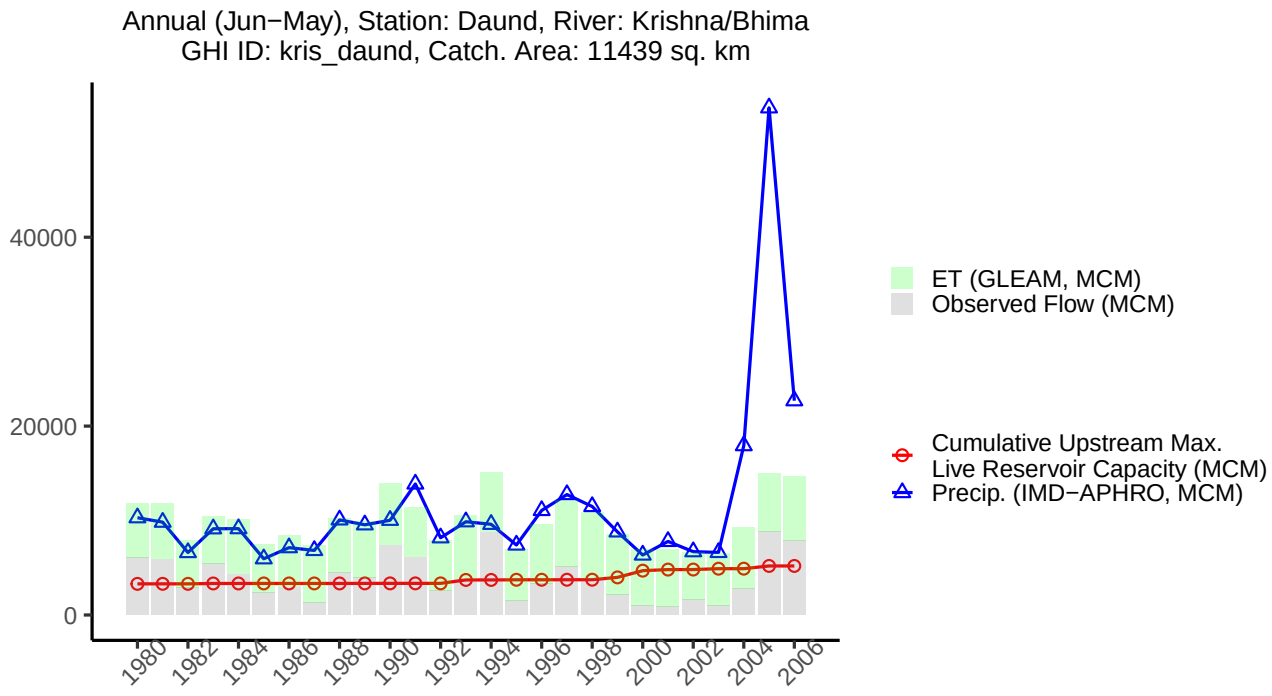


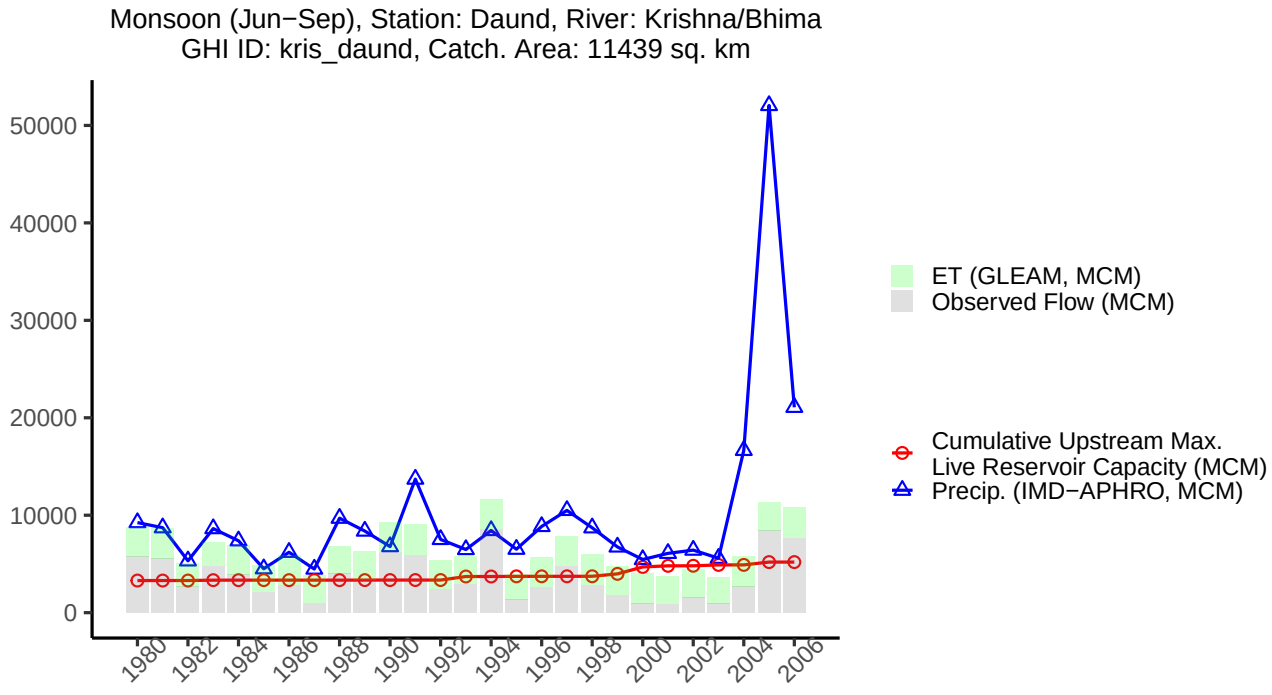
Annual (Jun−May), Station: Byaladahalli, River: Krishna/Tungabhadra/Tunga
GHI ID: kris_byala, Catch. Area: 2508 sq. km

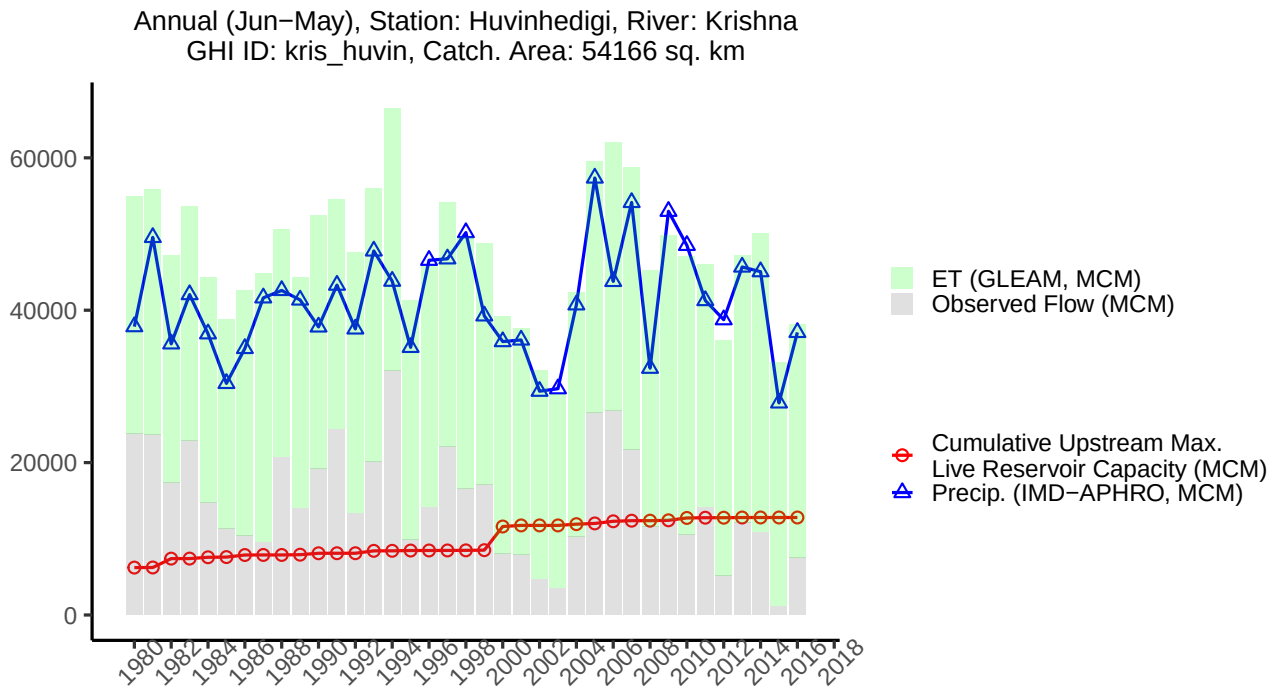


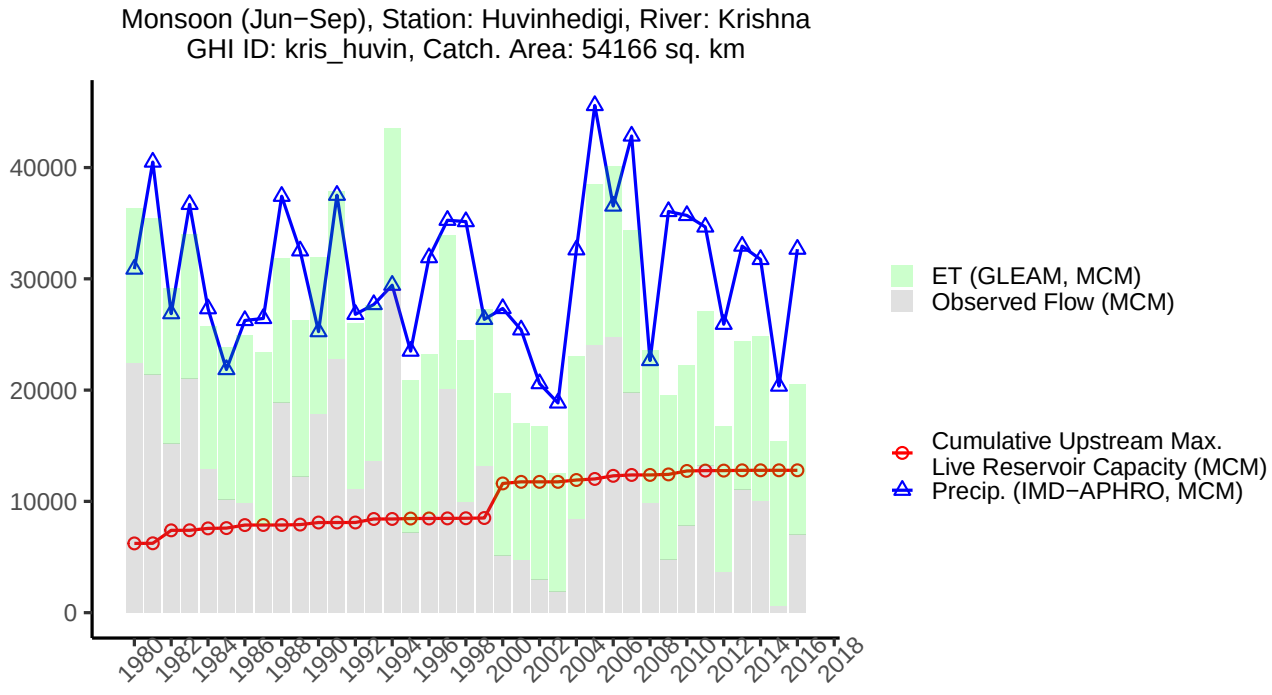
Monsoon (Jun−Sep), Station: Byaladahalli, River: Krishna/Tungabhadra/Tunga
GHI ID: kris_byala, Catch. Area: 2508 sq. km

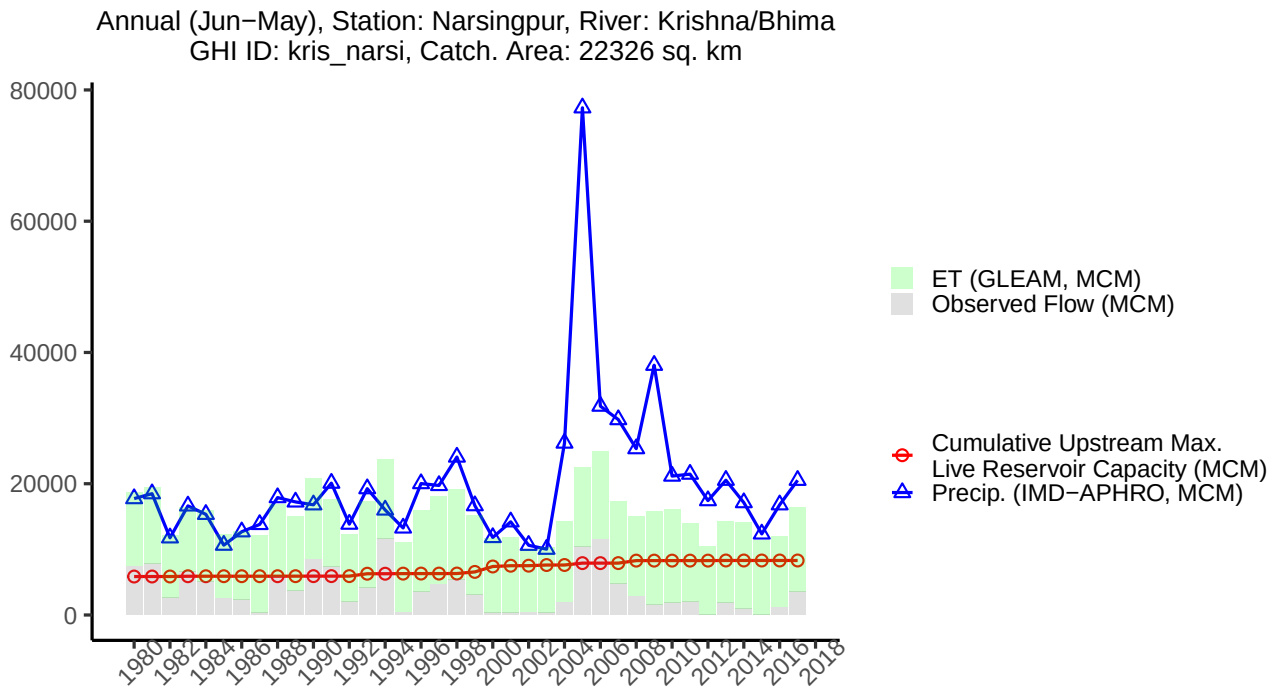


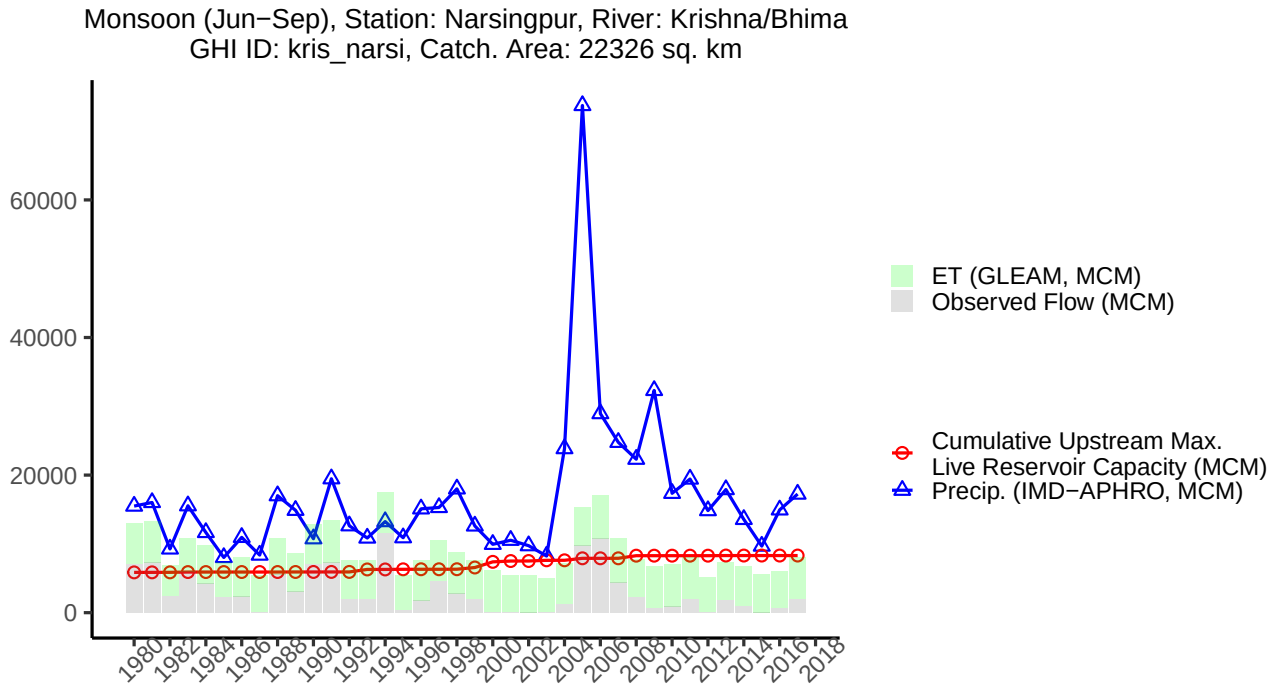

Annual (Jun−May), Station: Daund, River: Krishna/Bhima
GHI ID: kris_daund, Catch. Area: 11439 sq. km
40000
20000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

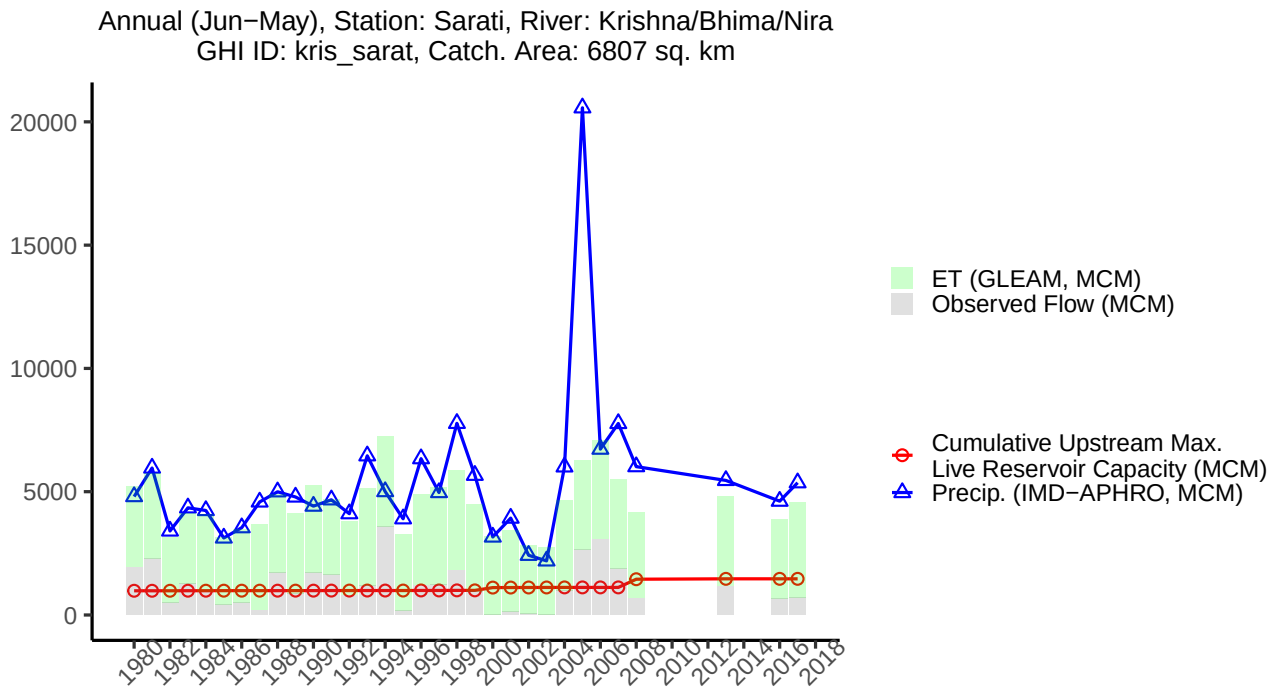

Monsoon (Jun−Sep), Station: Daund, River: Krishna/Bhima
GHI ID: kris_daund, Catch. Area: 11439 sq. km
50000
40000
30000
20000
10000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Huvinhedigi, River: Krishna
GHI ID: kris_huvin, Catch. Area: 54166 sq. km
60000
40000
20000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Huvinhedigi, River: Krishna
GHI ID: kris_huvin, Catch. Area: 54166 sq. km
40000
30000
20000
10000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Narsingpur, River: Krishna/Bhima
GHI ID: kris_narsi, Catch. Area: 22326 sq. km
80000
60000
40000
20000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Narsingpur, River: Krishna/Bhima
GHI ID: kris_narsi, Catch. Area: 22326 sq. km
60000
40000
20000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Sarati, River: Krishna/Bhima/Nira
GHI ID: kris_sarat, Catch. Area: 6807 sq. km
20000
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10000
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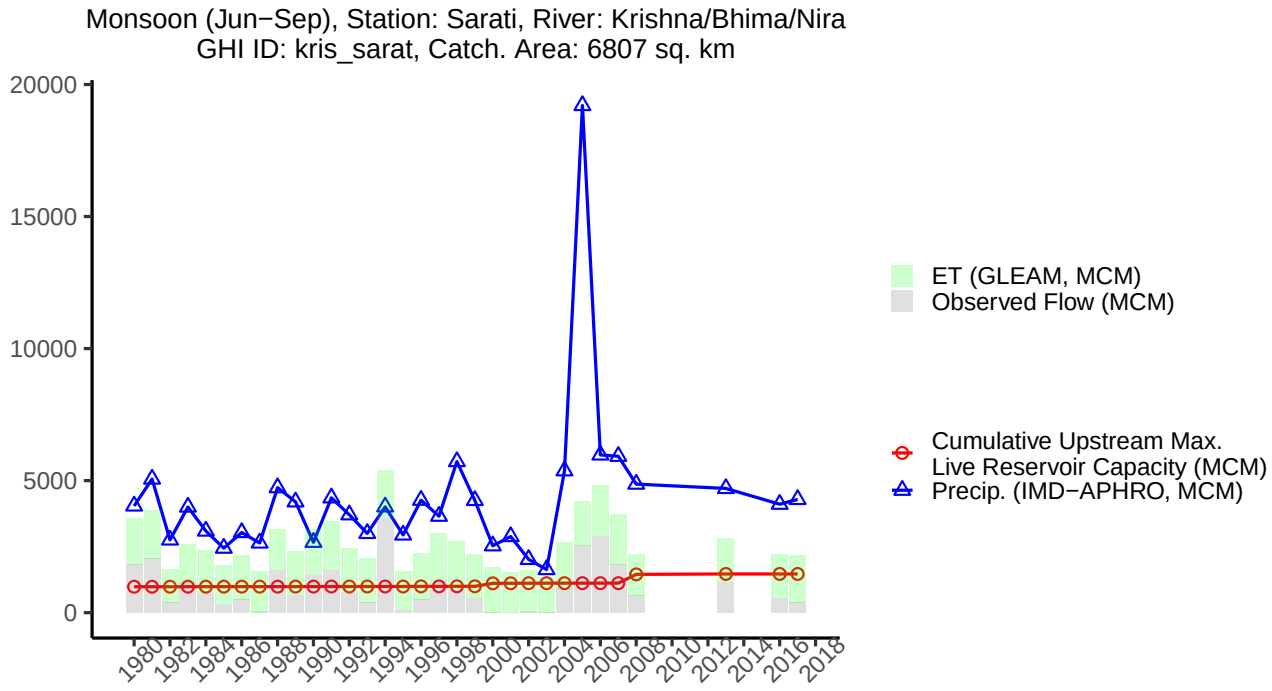
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Sarati, River: Krishna/Bhima/Nira
GHI ID: kris_sarat, Catch. Area: 6807 sq. km
20000
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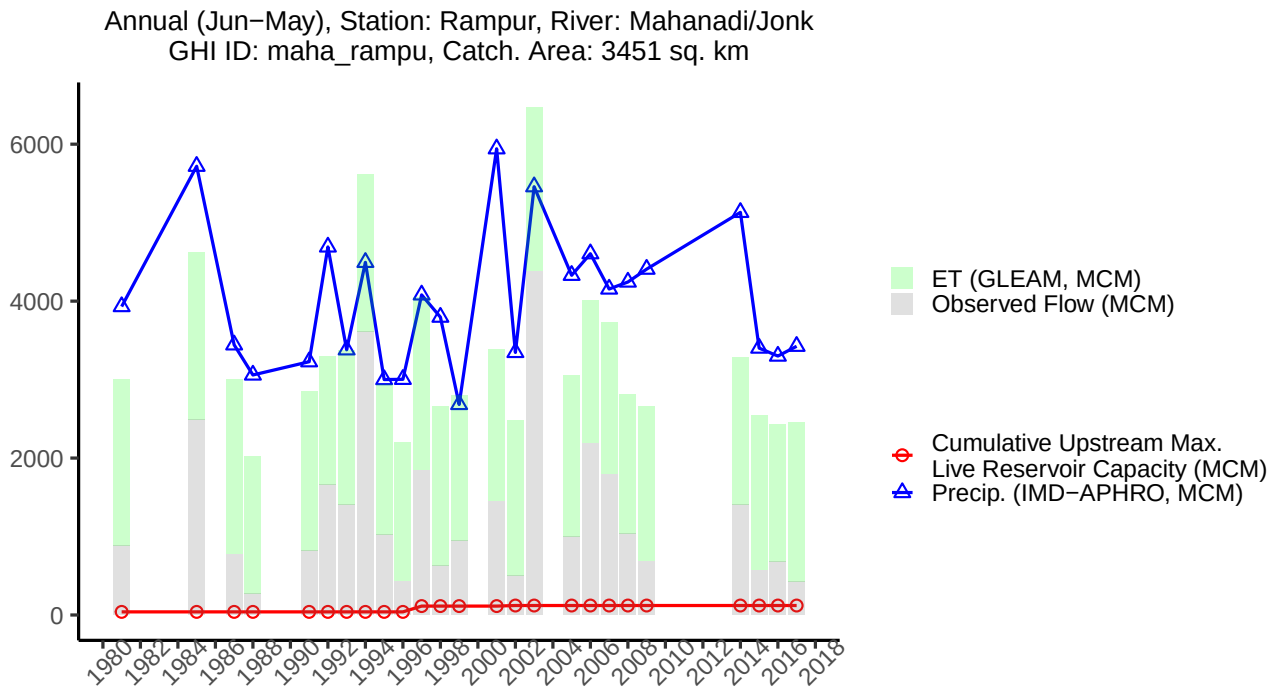
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Rampur, River: Mahanadi/Jonk
GHI ID: maha_rampu, Catch. Area: 3451 sq. km
6000
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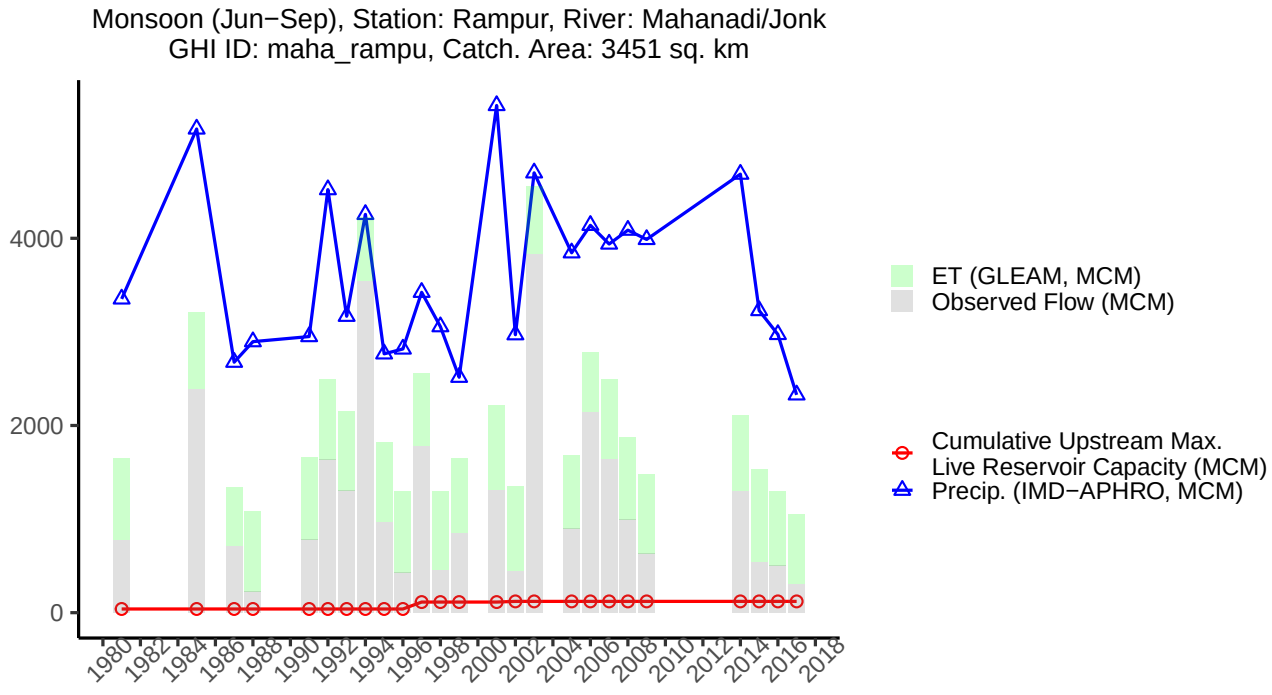
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Rampur, River: Mahanadi/Jonk
GHI ID: maha_rampu, Catch. Area: 3451 sq. km
4000
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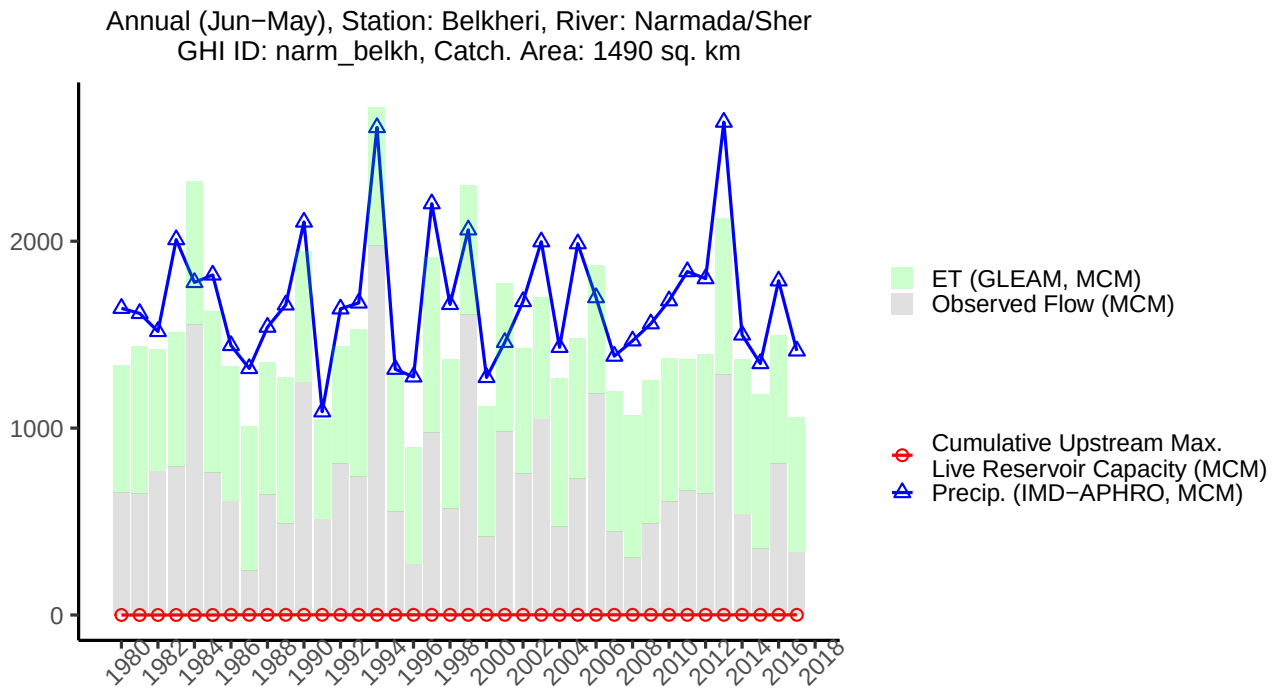
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Belkheri, River: Narmada/Sher
GHI ID: narm_belkh, Catch. Area: 1490 sq. km
2000
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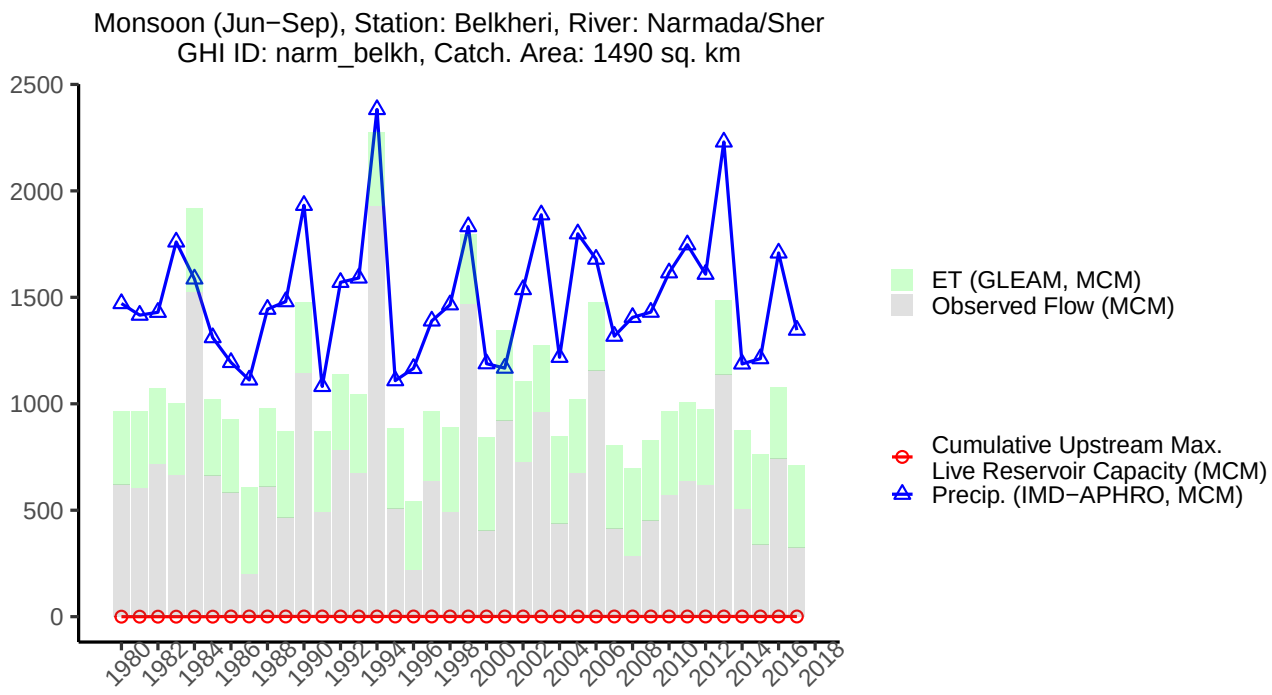
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Belkheri, River: Narmada/Sher
GHI ID: narm_belkh, Catch. Area: 1490 sq. km
2500
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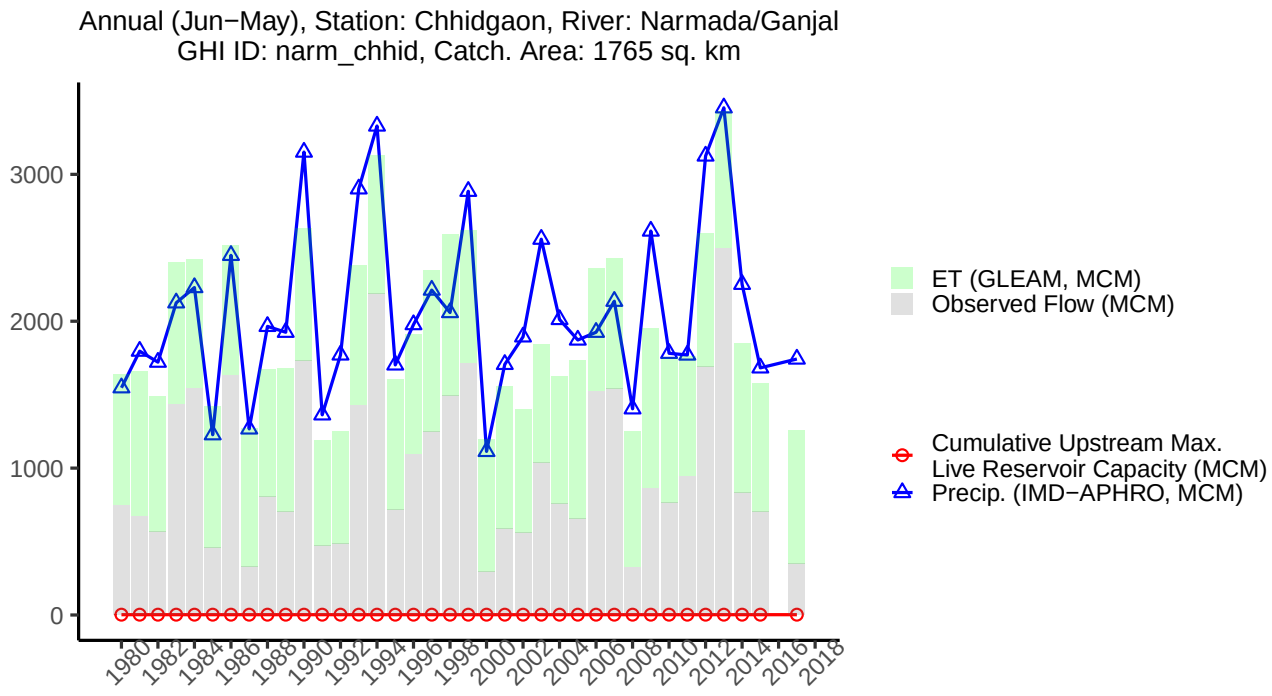
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Chhidgaon, River: Narmada/Ganjal
GHI ID: narm_chhid, Catch. Area: 1765 sq. km
3000
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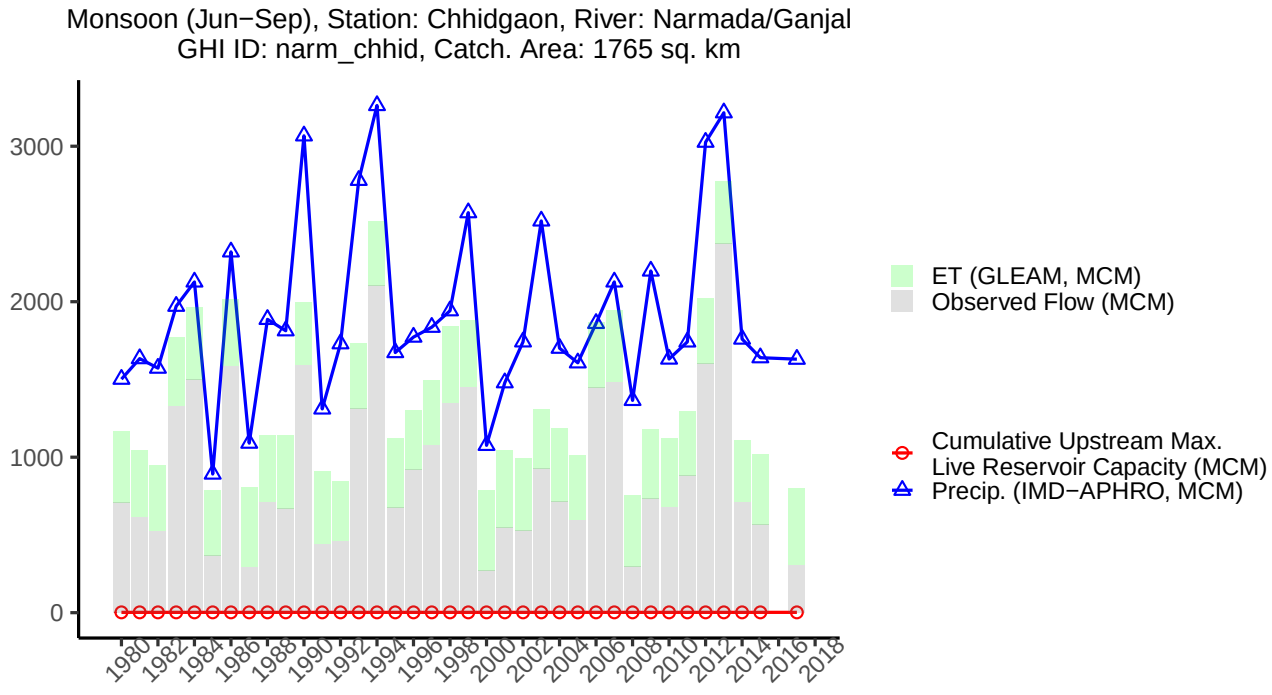
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Chhidgaon, River: Narmada/Ganjal
GHI ID: narm_chhid, Catch. Area: 1765 sq. km
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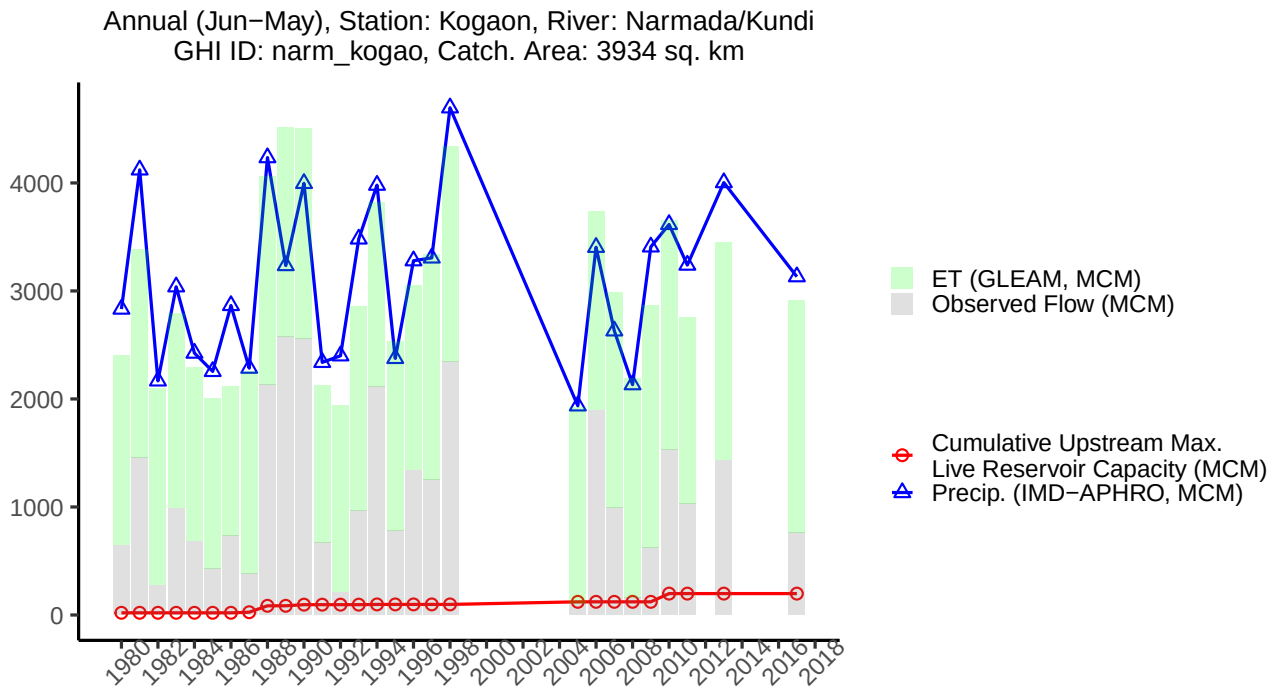
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Kogaon, River: Narmada/Kundi
GHI ID: narm_kogao, Catch. Area: 3934 sq. km
4000
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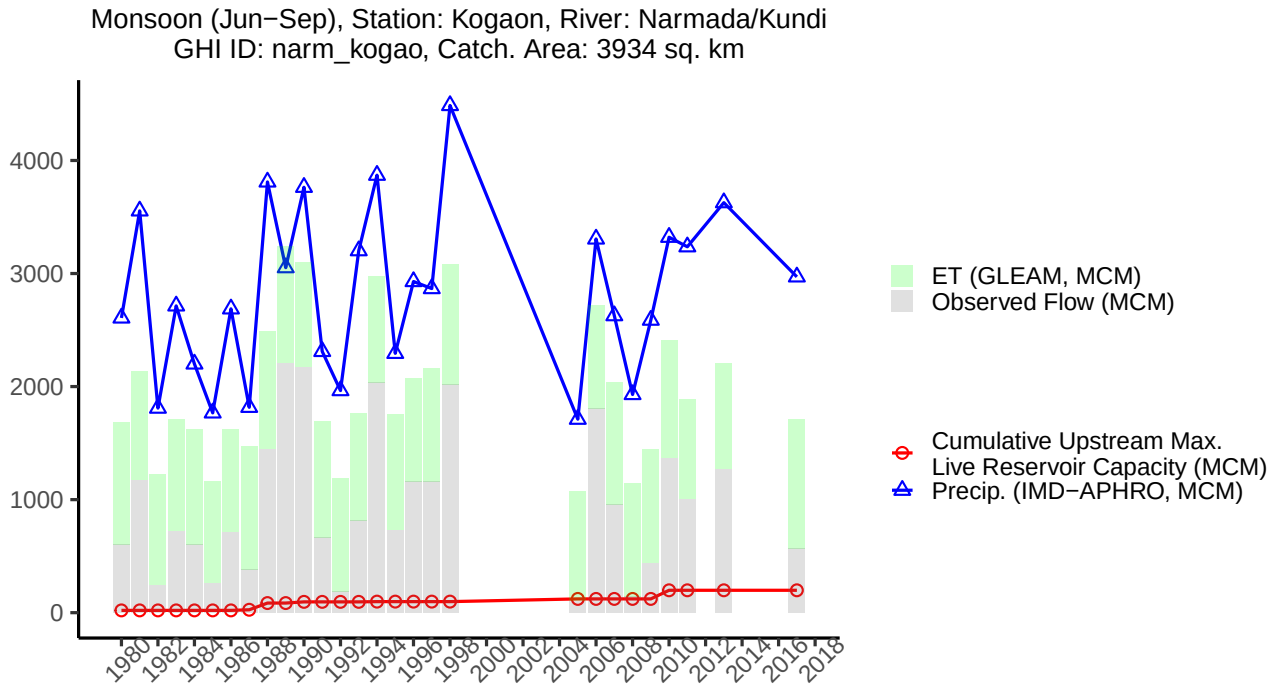
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Kogaon, River: Narmada/Kundi
GHI ID: narm_kogao, Catch. Area: 3934 sq. km
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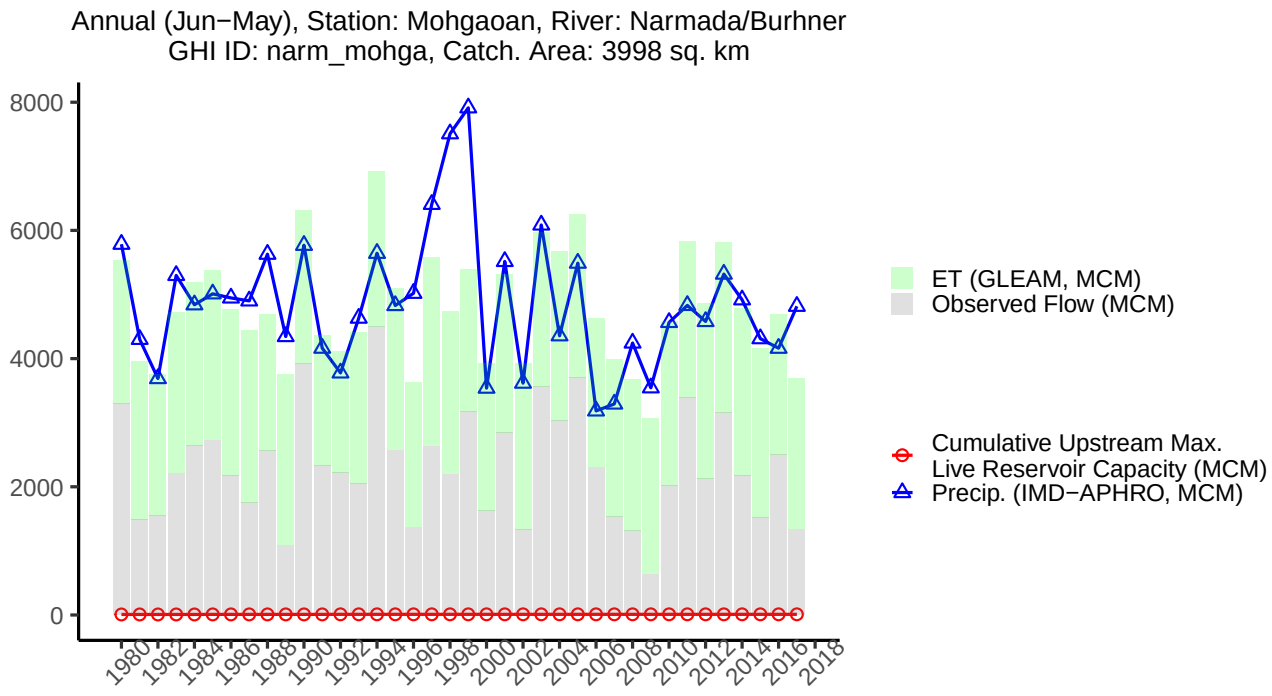
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Mohgaoan, River: Narmada/Burhner
GHI ID: narm_mohga, Catch. Area: 3998 sq. km
8000
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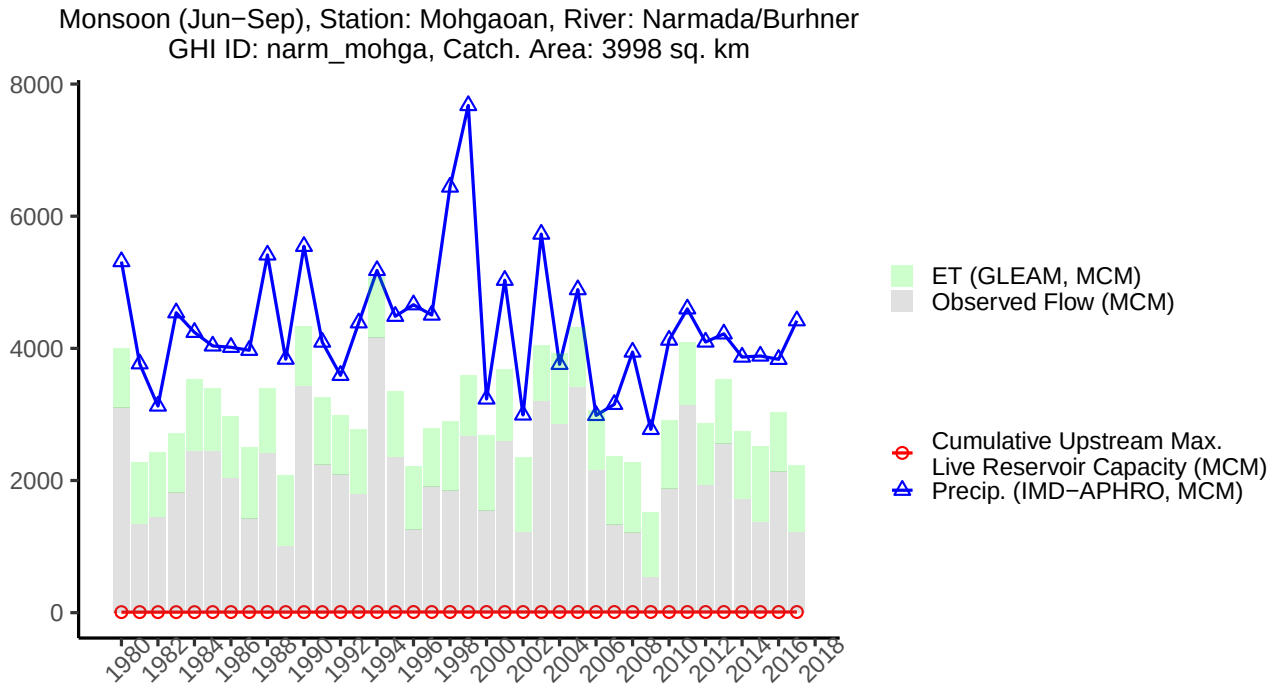
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Mohgaoan, River: Narmada/Burhner
GHI ID: narm_mohga, Catch. Area: 3998 sq. km
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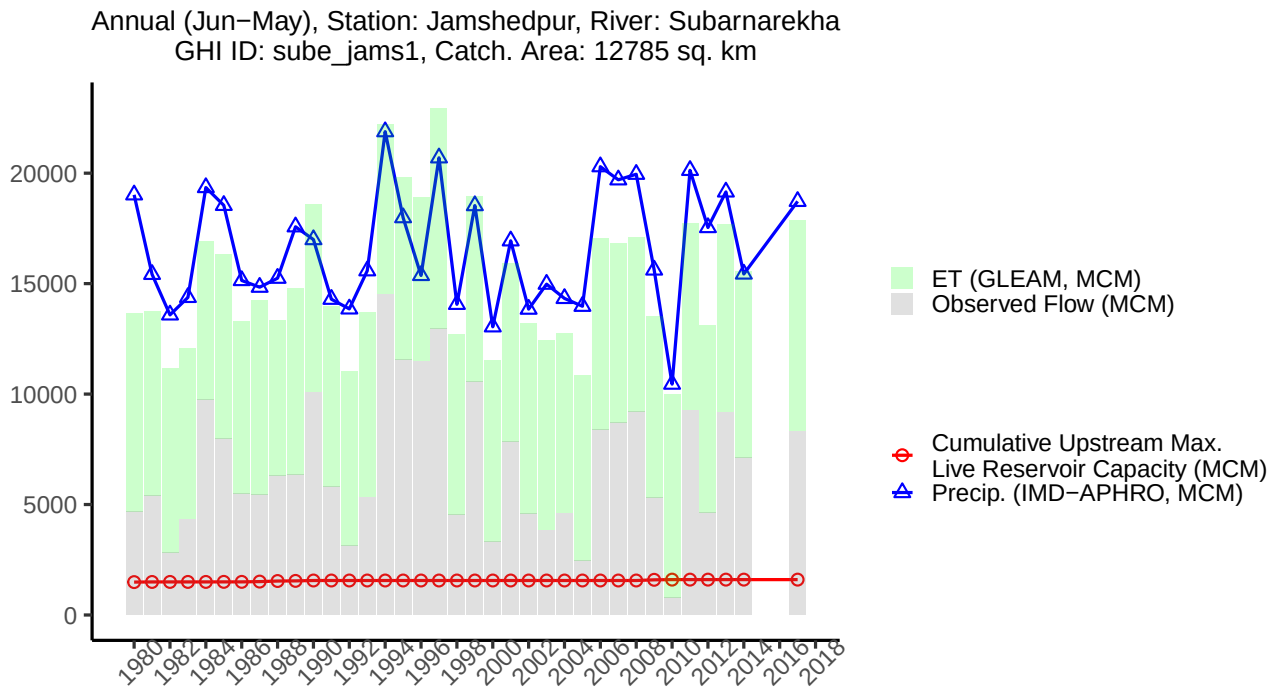
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Jamshedpur, River: Subarnarekha
GHI ID: sube_jams1, Catch. Area: 12785 sq. km
20000
15000
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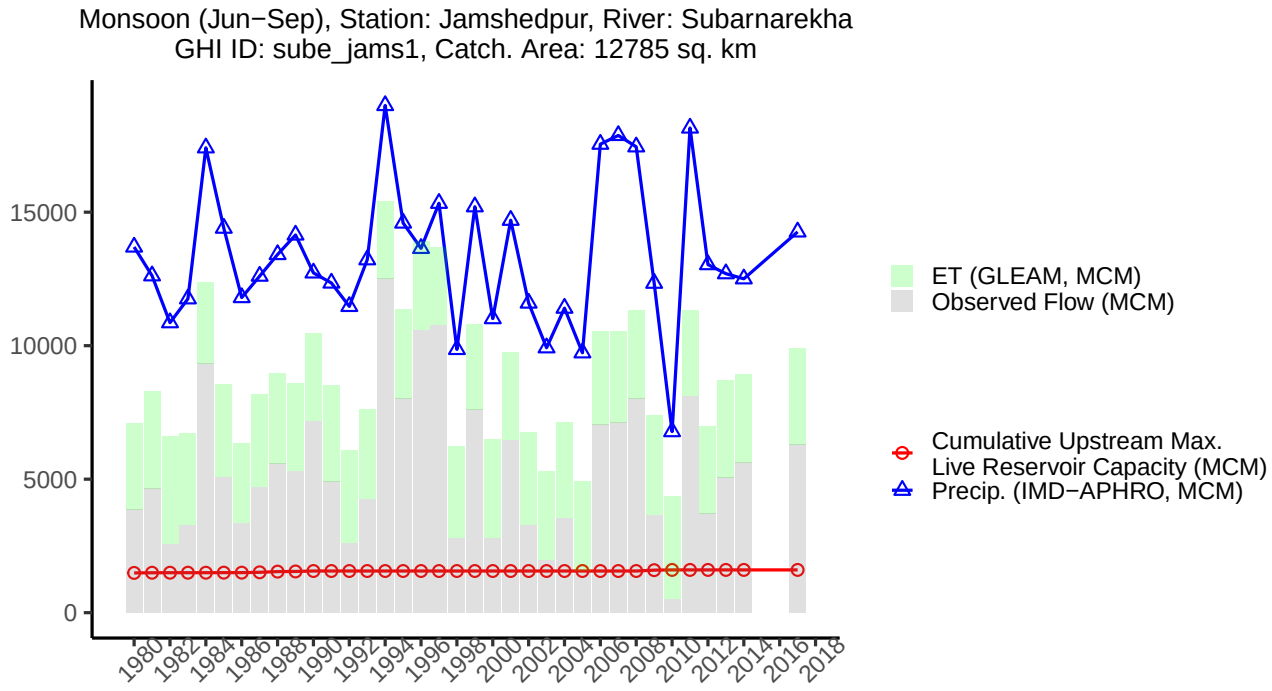
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Jamshedpur, River: Subarnarekha
GHI ID: sube_jams1, Catch. Area: 12785 sq. km
15000
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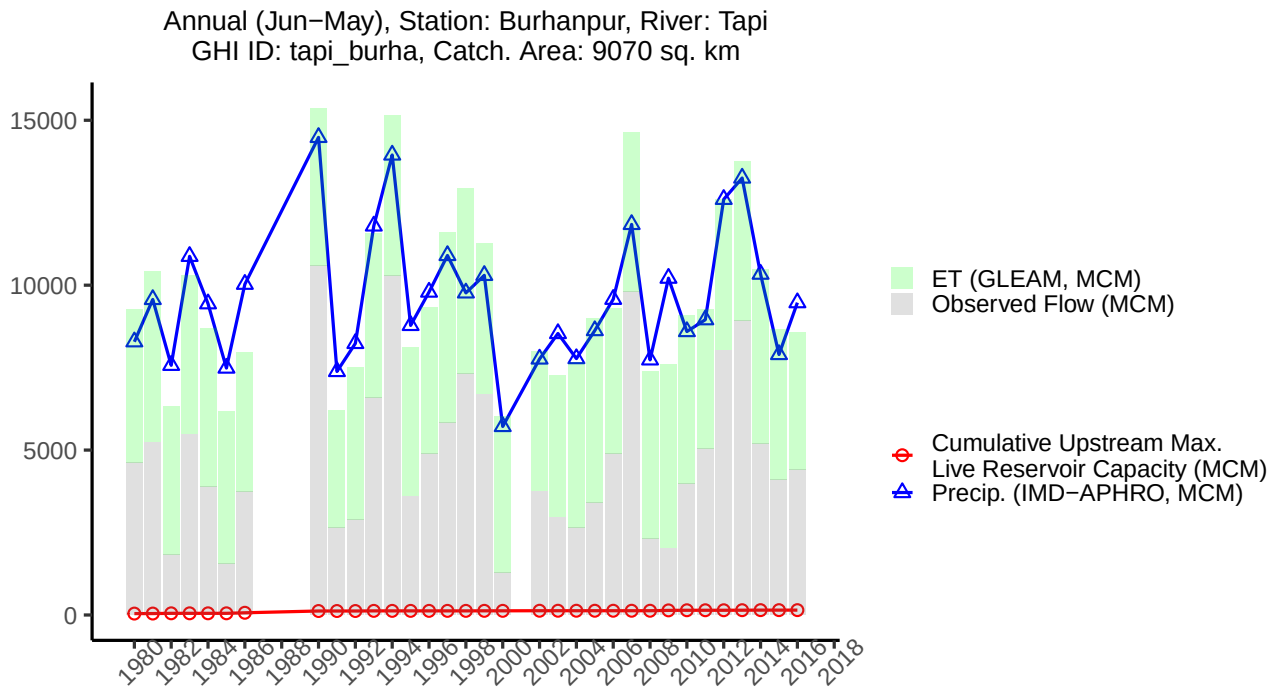
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Burhanpur, River: Tapi
GHI ID: tapi_burha, Catch. Area: 9070 sq. km
15000
10000
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1982
1984
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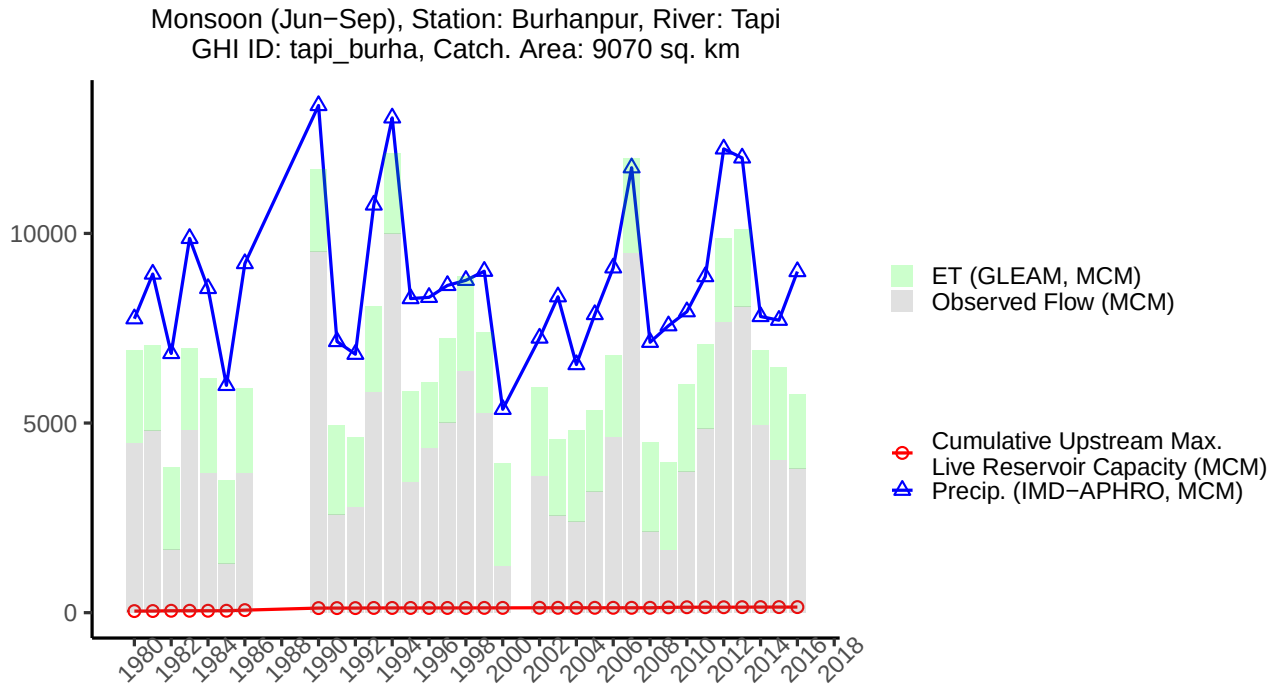
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Burhanpur, River: Tapi
GHI ID: tapi_burha, Catch. Area: 9070 sq. km
10000
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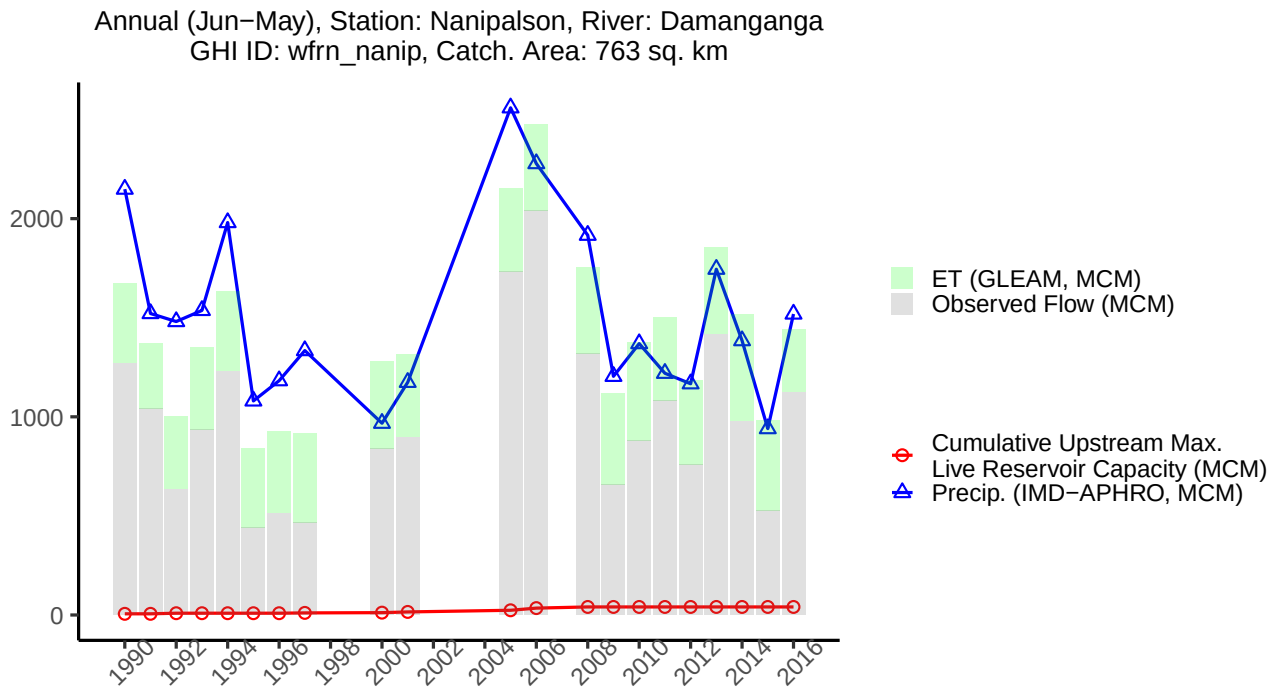
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Nanipalson, River: Damanganga
GHI ID: wfrn_nanip, Catch. Area: 763 sq. km
2000
1000
0
1990
1992
1994
1996
1998
2000
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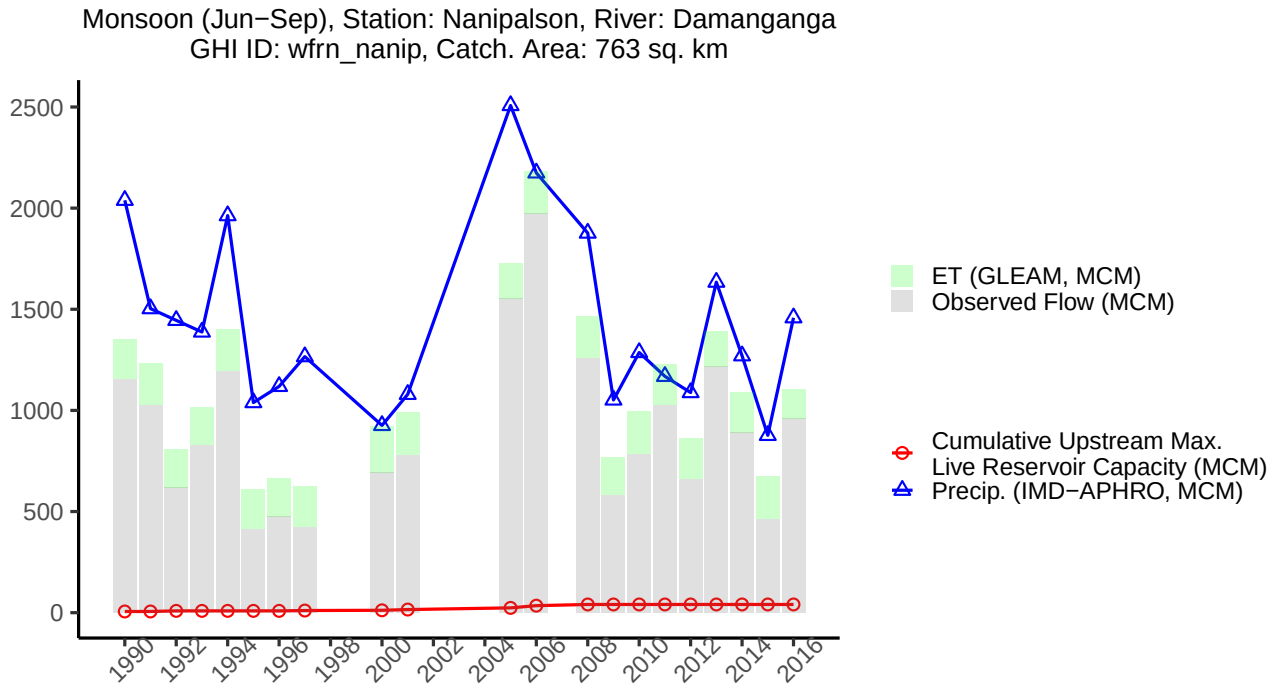
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Nanipalson, River: Damanganga
GHI ID: wfrn_nanip, Catch. Area: 763 sq. km
2500
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1500
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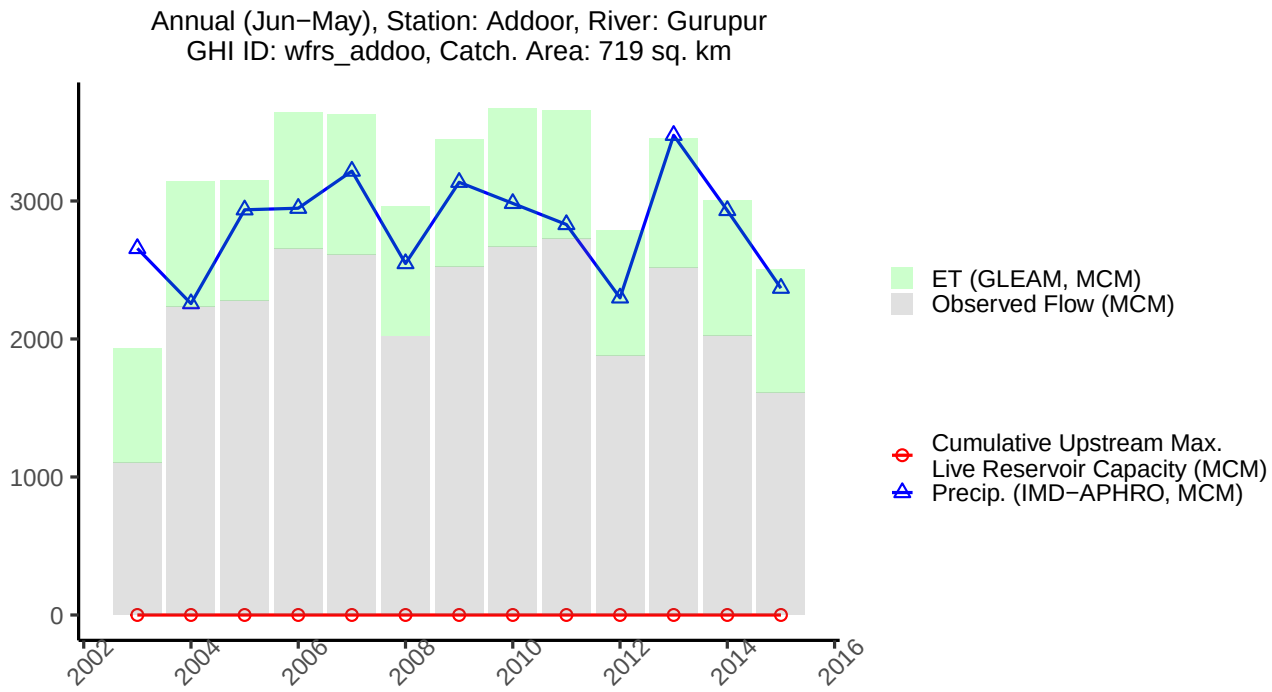
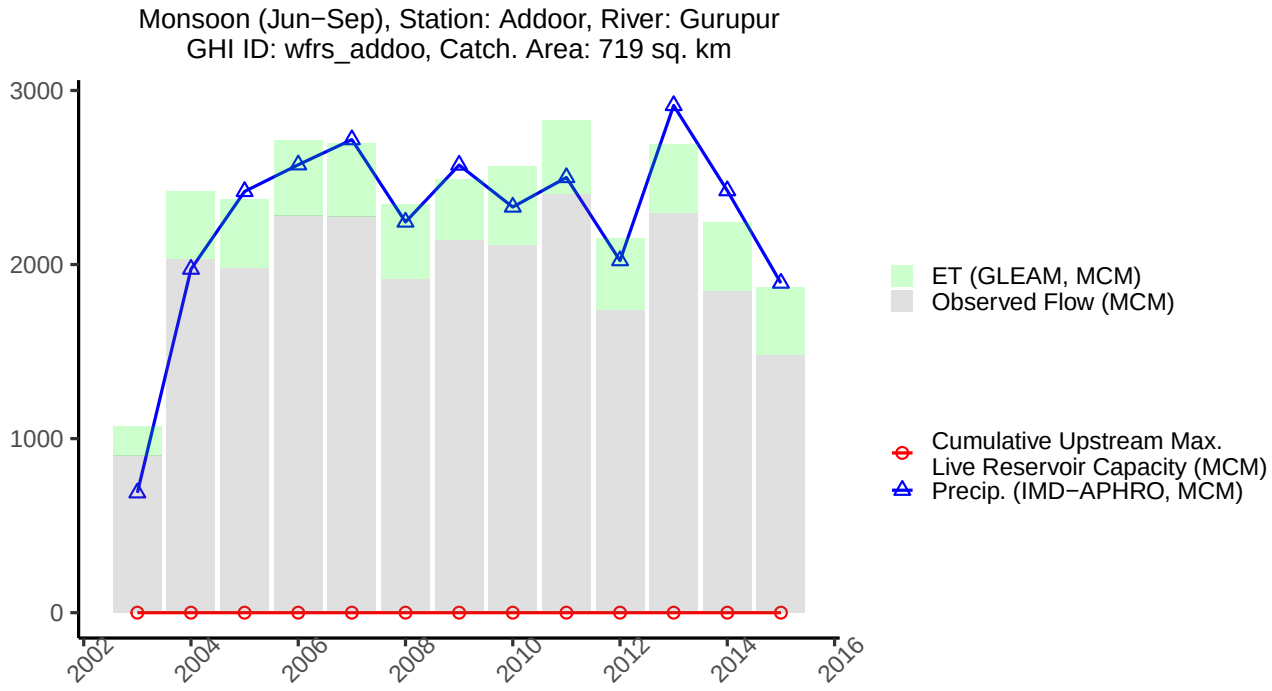
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Addoor, River: Gurupur
GHI ID: wfrs_addoo, Catch. Area: 719 sq. km
3000
2000
1000
0
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Addoor, River: Gurupur
GHI ID: wfrs_addoo, Catch. Area: 719 sq. km
3000
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1000
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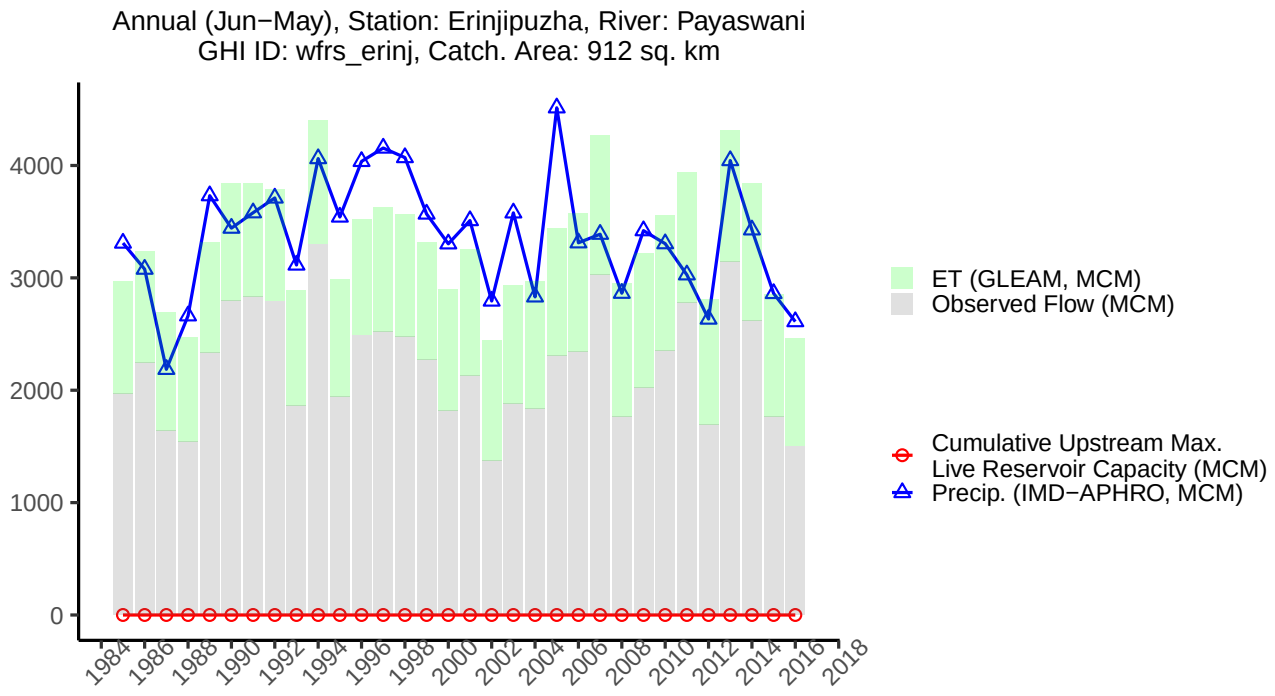
2002
2004
2006
2008
2010
2012
2014
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Erinjipuzha, River: Payaswani
GHI ID: wfrs_erinj, Catch. Area: 912 sq. km
4000
3000
2000
1000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
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2004
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2008
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2012
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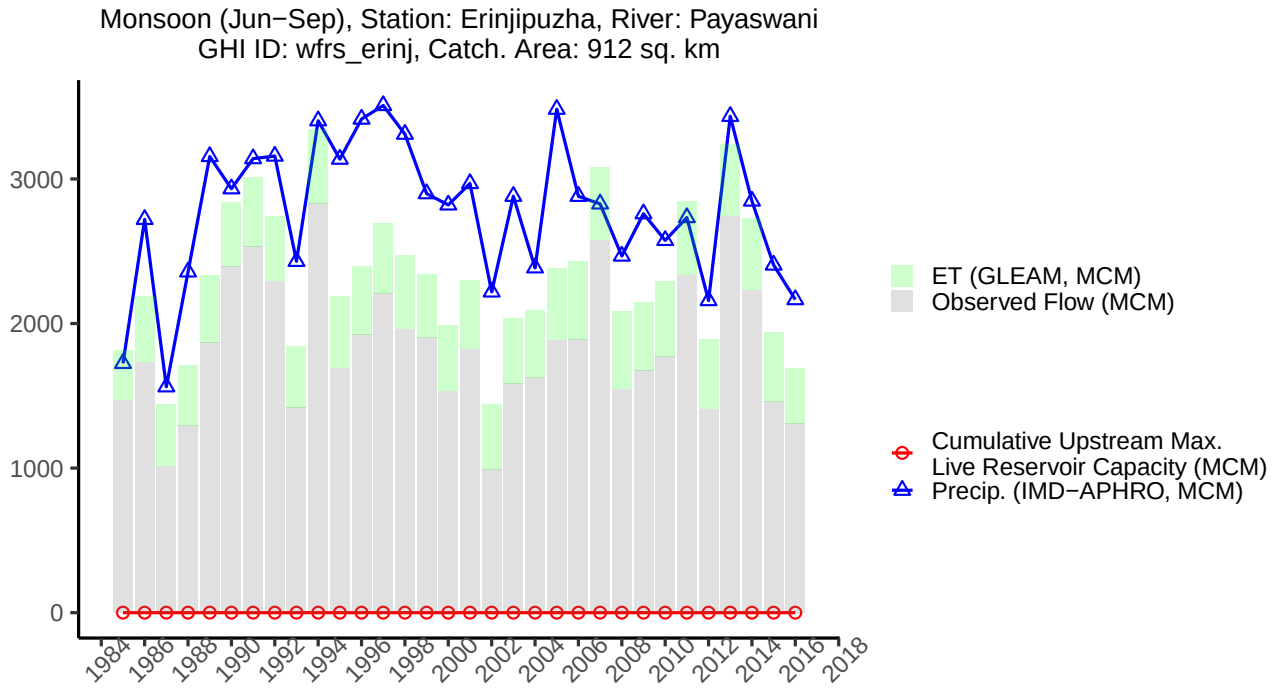
2016
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Erinjipuzha, River: Payaswani
GHI ID: wfrs_erinj, Catch. Area: 912 sq. km
3000
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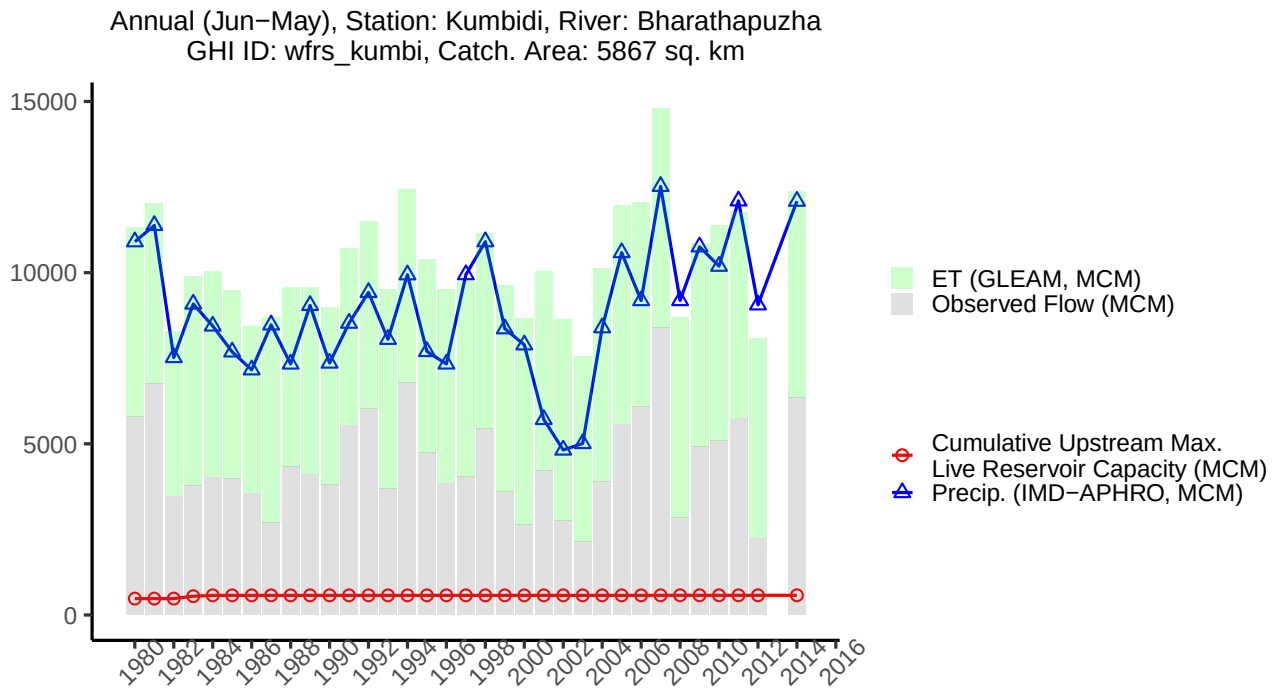
2018
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Kumbidi, River: Bharathapuzha
GHI ID: wfrs_kumbi, Catch. Area: 5867 sq. km
15000
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1980
1982
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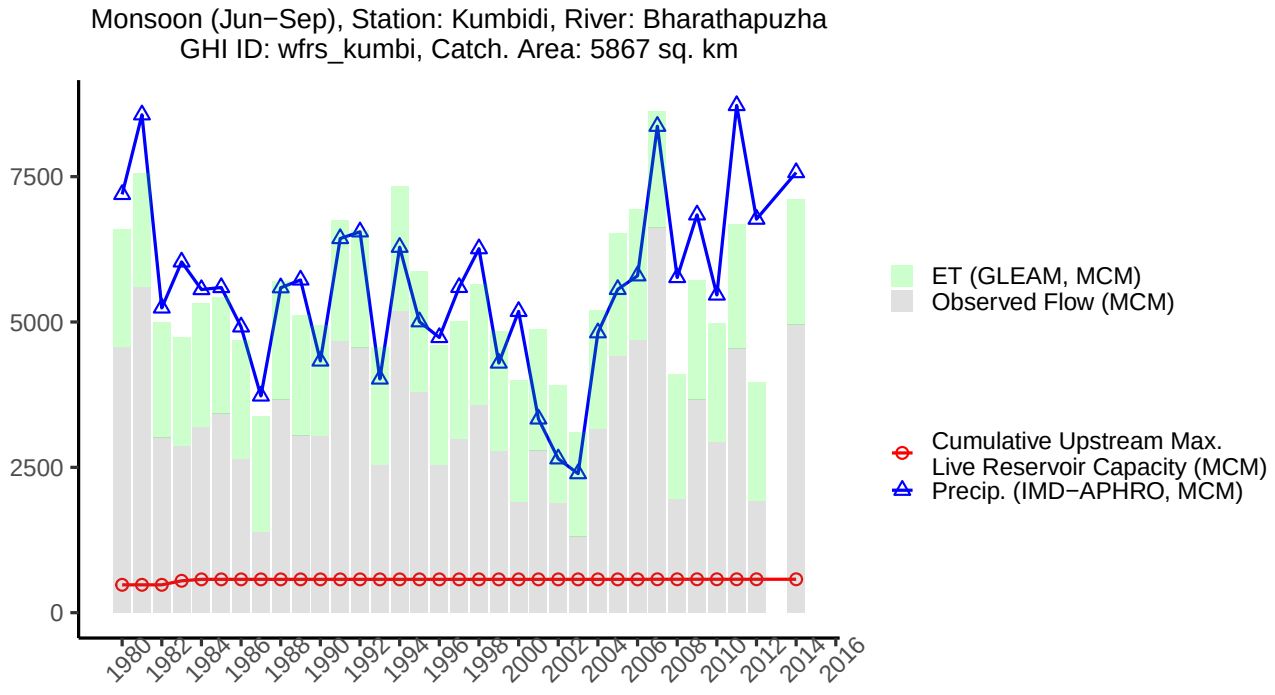
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Monsoon (Jun−Sep), Station: Kumbidi, River: Bharathapuzha
GHI ID: wfrs_kumbi, Catch. Area: 5867 sq. km
7500
5000
2500
0
1980
1982
1984
1986
1988
1990
1992
1994
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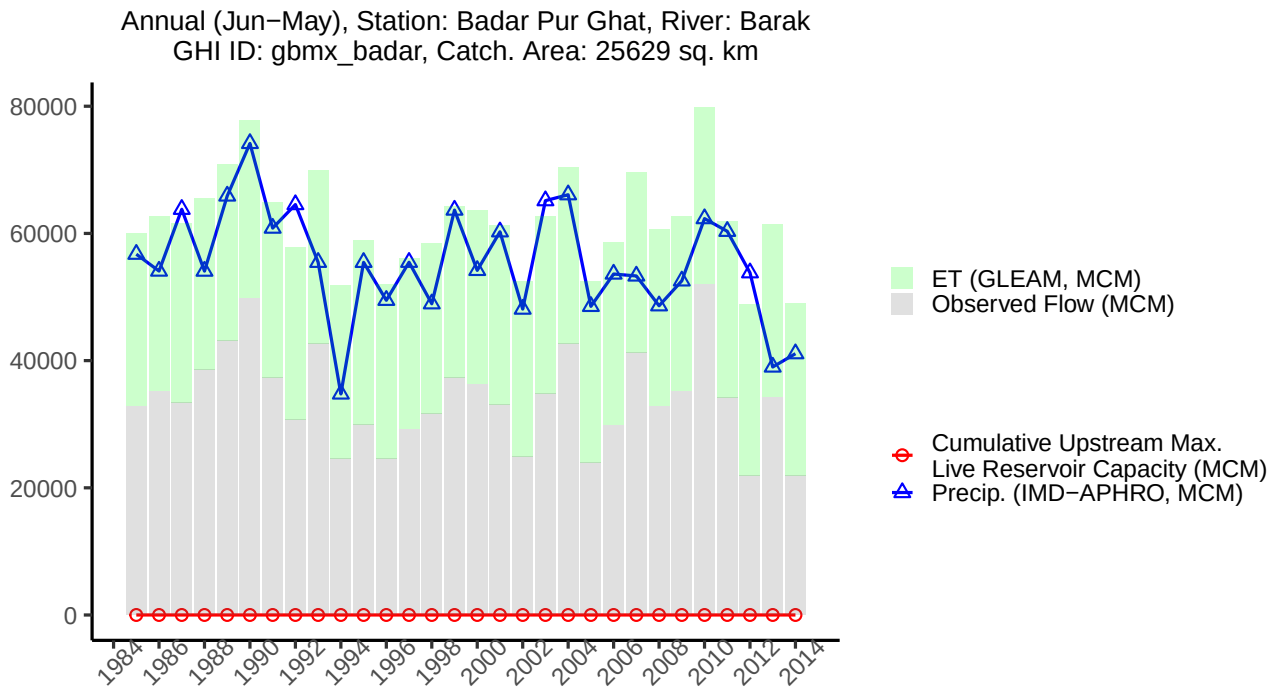
2016
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Badar Pur Ghat, River: Barak
GHI ID: gbmx_badar, Catch. Area: 25629 sq. km
80000
60000
40000
20000
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1984
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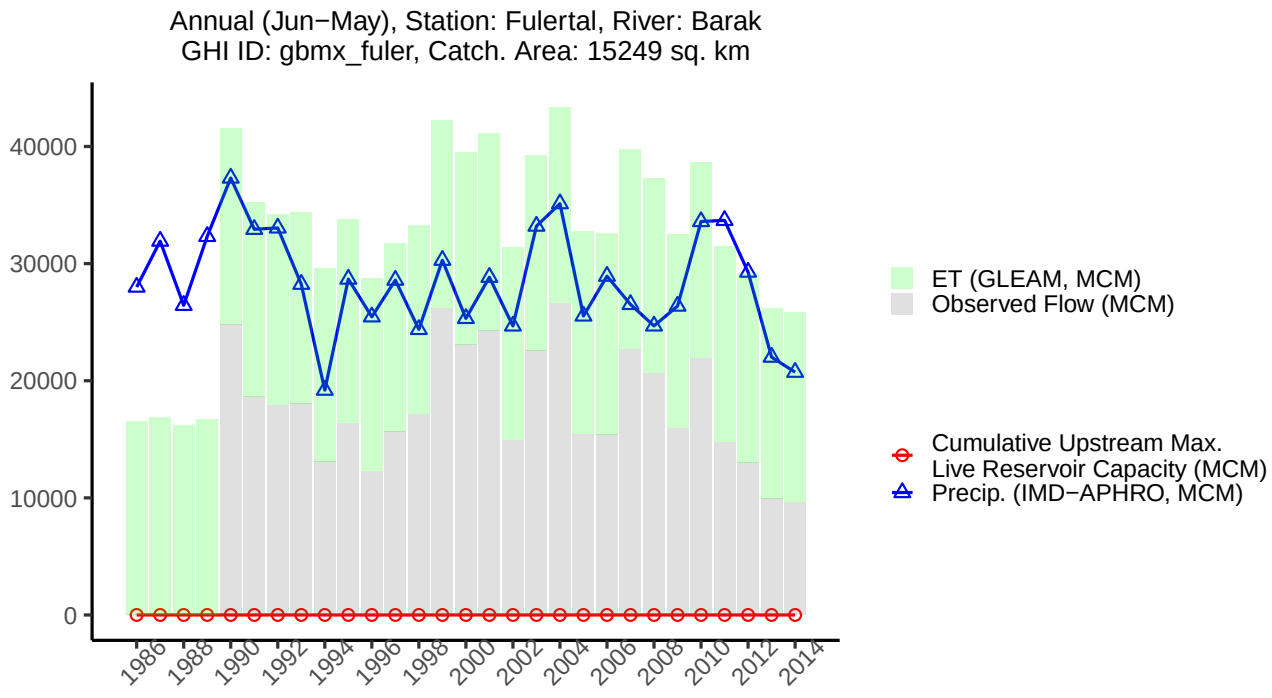
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Fulertal, River: Barak
GHI ID: gbmx_fuler, Catch. Area: 15249 sq. km
40000
30000
20000
10000
0
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
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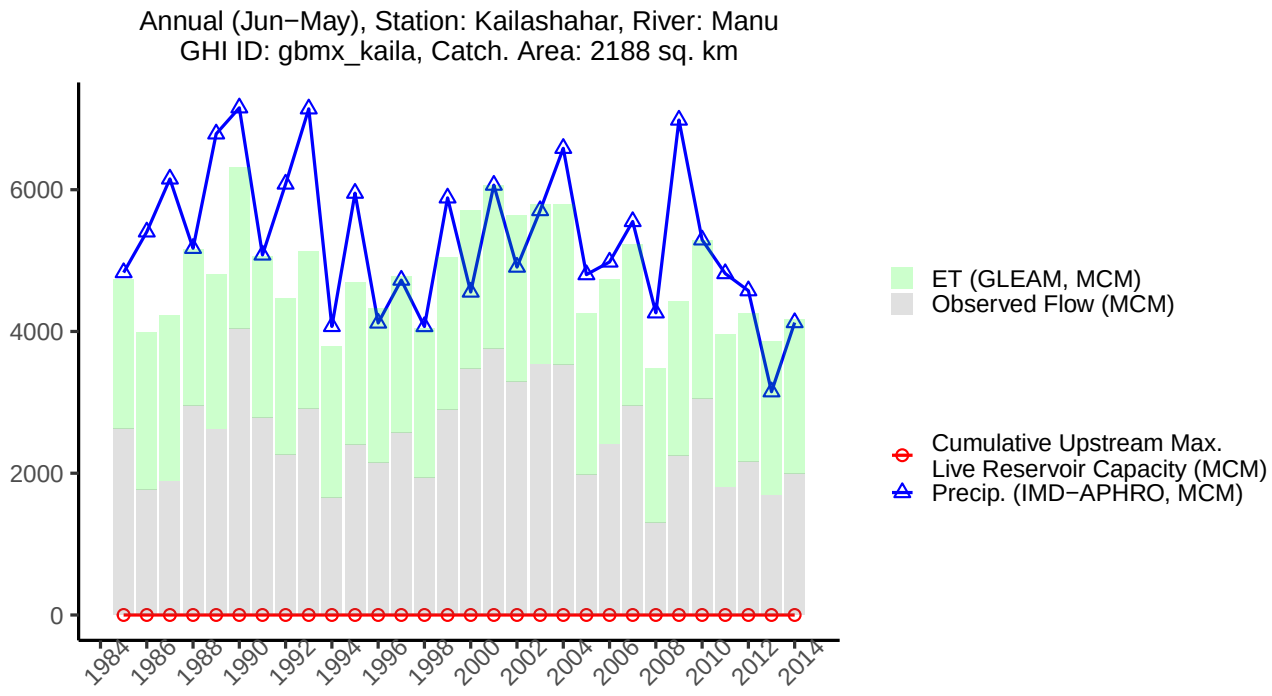
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)


Annual (Jun−May), Station: Kailashahar, River: Manu
GHI ID: gbmx_kaila, Catch. Area: 2188 sq. km
6000
4000
2000
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1984
1986
1988
1990
1992
1994
1996
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2002
2004
2006
2008
2010
2012
2014
ET (GLEAM, MCM)
Observed Flow (MCM)
Cumulative Upstream Max.
Live Reservoir Capacity (MCM)
Precip. (IMD−APHRO, MCM)

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