



Supplement of

Climatology and trends of observed daily and hourly extreme precipitation in the French Alps

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Sect. S1 Number of neighbours for each station in the neighbourhood approach

[section 3.2.2]

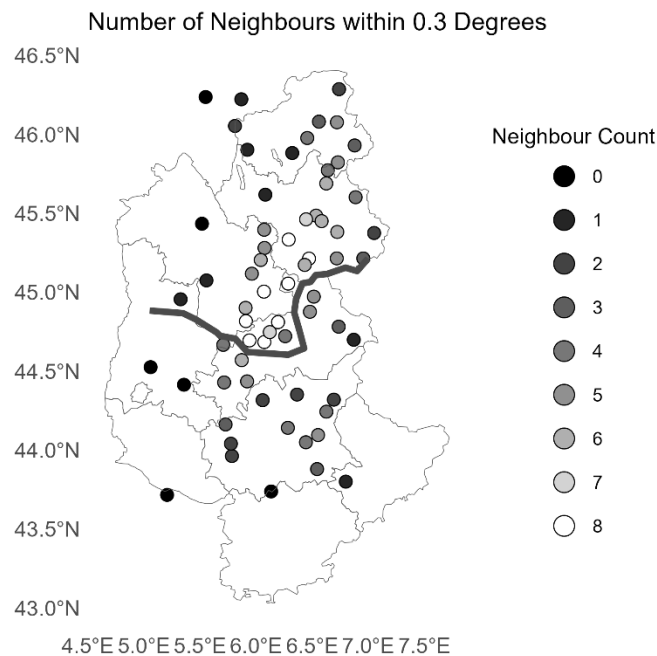


Figure S1: Number of other stations in each station's neighbourhood (0.3° radius). Only EDF stations are shown, as only these were used for the non-stationary analysis.

Sect. S2 Relative influence of WPs on hourly annual maxima

[section 4.1.2]

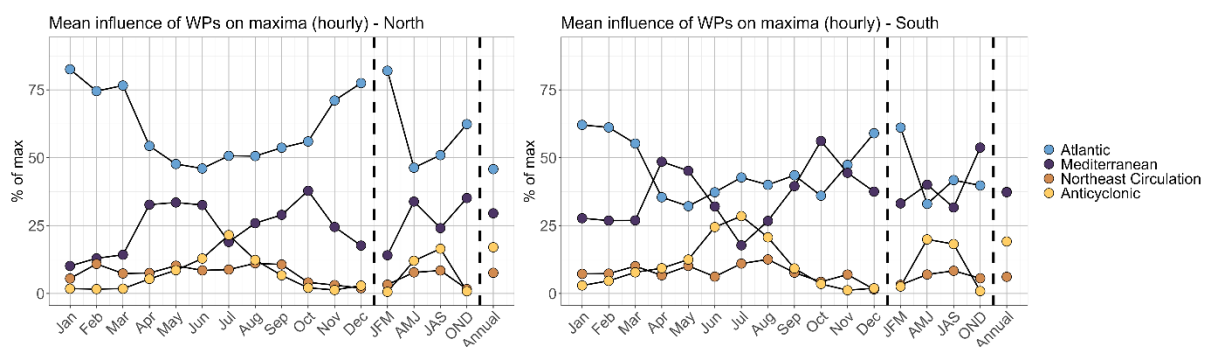


Figure S2: Same as Fig. 6, but for hourly annual maxima. Relative influence of the four weather patterns on monthly/seasonal/annual maxima of hourly precipitation intensity in the study region, grouped by stations north (left) and south (right) of the climatological divide.

Sect. S3 Non-stationary 20-year return levels in 1990 and 2020

[section 4.2]

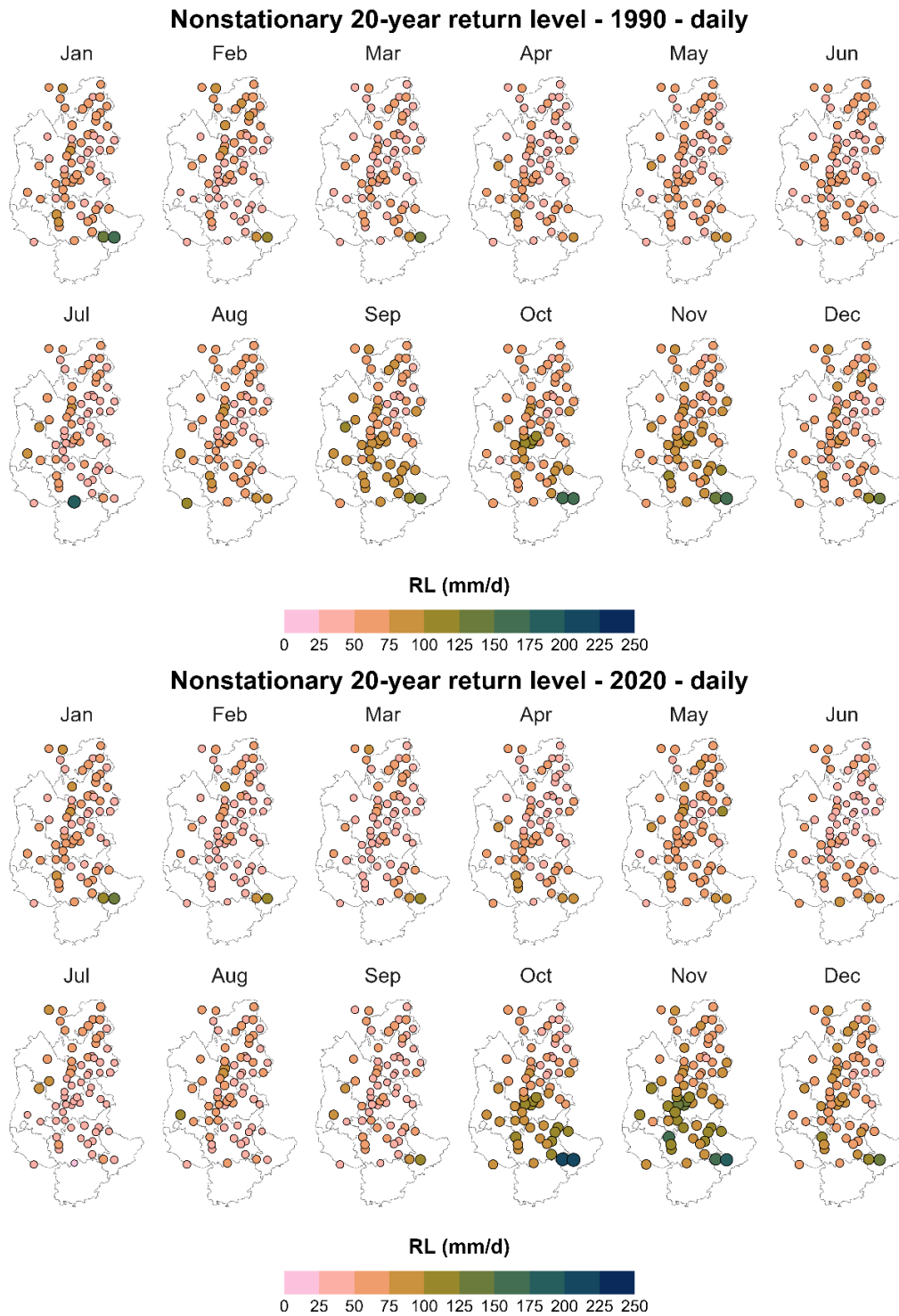


Figure S3: 20-year return level of daily precipitation intensity in years 1990 (top) and 2020 (bottom) in the non-stationary framework (same data subset and method as in Fig. 8). Note that the colourbar is different from Fig. 4.

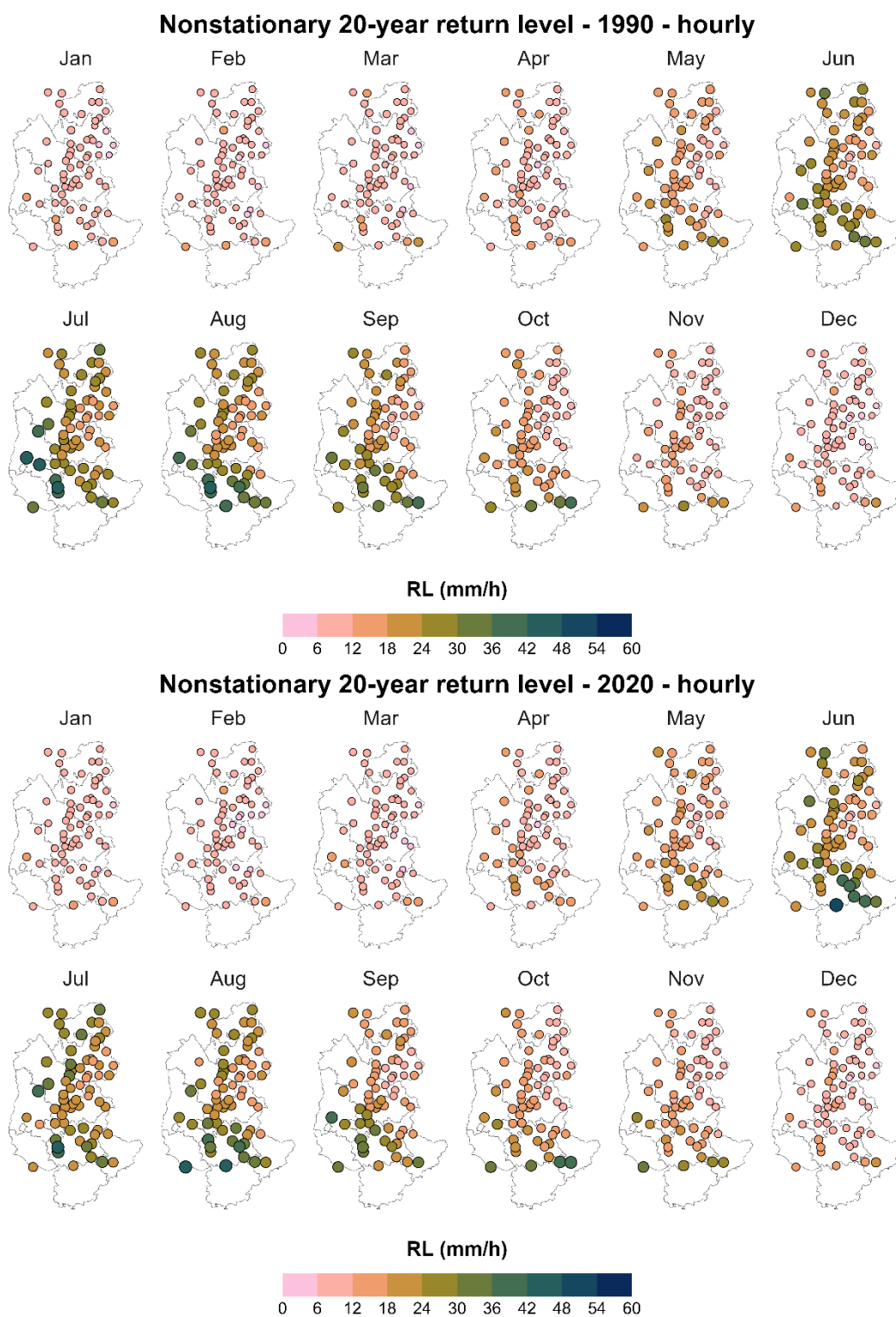


Figure S4: 20-year return level of hourly precipitation intensity in years 1990 (top) and 2020 (bottom) in the non-stationary framework (same data subset and method as in Fig. 10). Note that the colourbar is different from Fig. 7.

Sect. S4 Comparison of methods for computing seasonal and annual return levels

[section 5.1.3]

The following figures are in support of the section 5.1.3 of the Discussion. We compare two different methods for estimating seasonal and annual return levels: method 1 consists of fitting the GEV directly to seasonal / annual maxima, whereas method 2 consists of analytically deriving seasonal and annual return levels from the monthly fits.

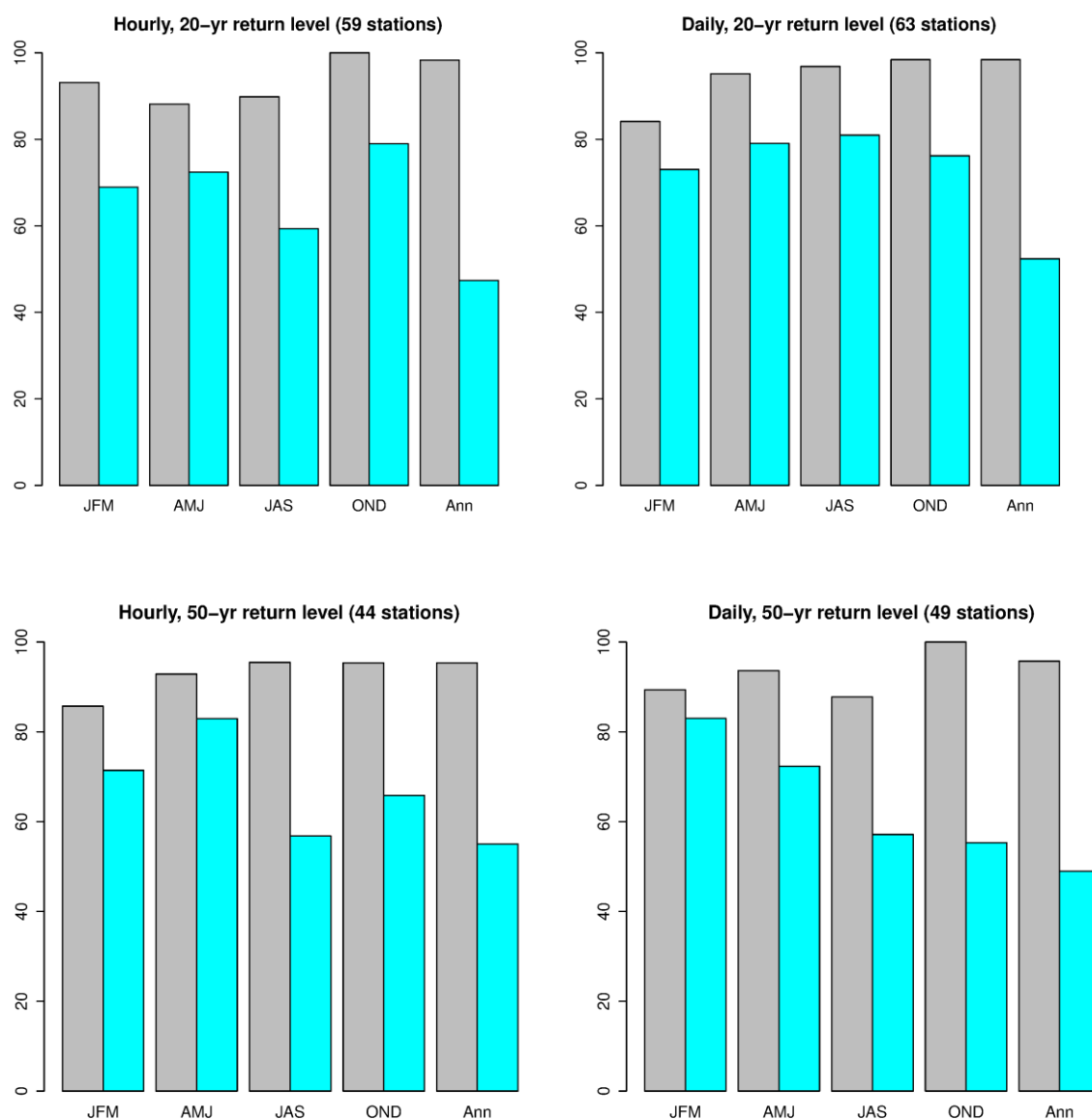


Figure S5: Percentage of stations where the N-year return level (top: $N=20$, bottom: $N=50$) is within the 90% confidence interval of the estimated CDF, at hourly (left) and daily (right) scale. Gray: method 1. Cyan: method 2. In each case ($n=20$ or $N=50$), only the stations whose neighborhood samples contain at least $3 \cdot N$ years are considered, in order to get reliable estimates of empirical return levels. Only the long EDF time series are used for producing this figure.

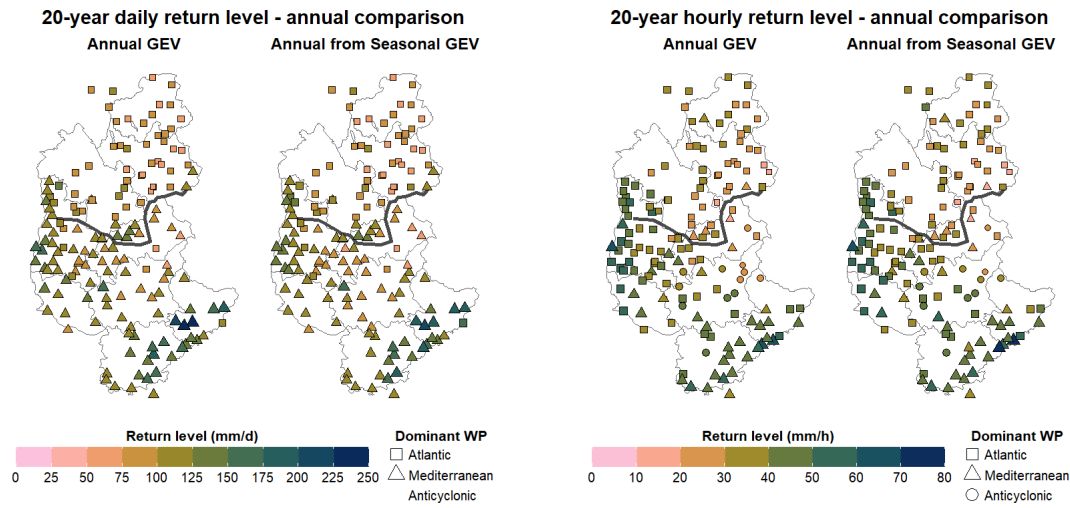


Figure S6: comparison of the two methods for daily (left) and hourly (right) estimates of stationary annual 20-year return levels. All available data in 1980-2023 with >25 years of observations is shown here.

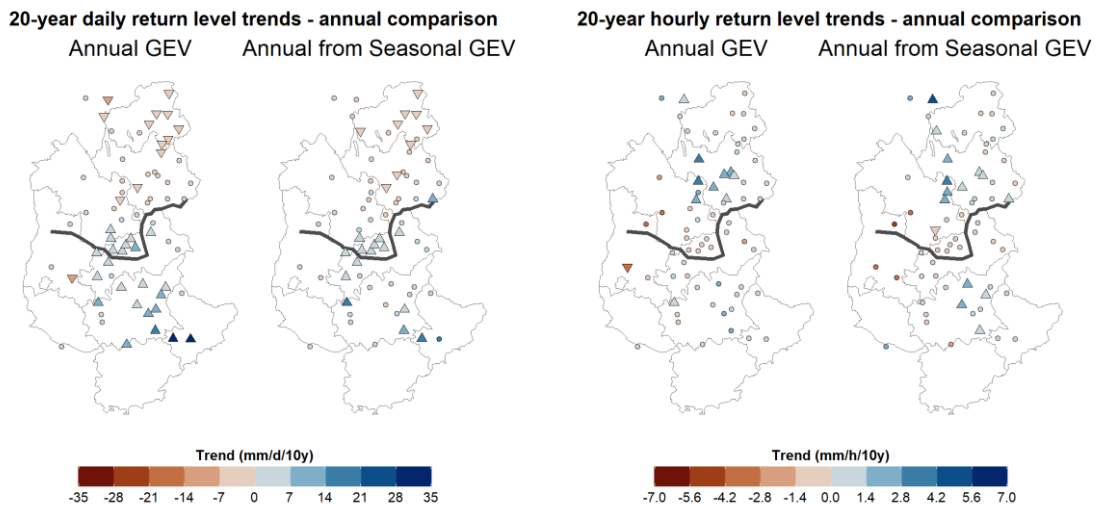


Figure S7: comparison of the two methods for daily (left) and hourly (right) estimates of trends in annual 20-year return levels in the non-stationary analysis. Only EDF stations with long time series are shown here.

Sect. S5 Station metadata

Station codes, names, locations, and first and last year of observations used in the study. For stationary analysis, only observations from 1980 or later are used. For non-stationary analysis, only the observations by EDF are used.

Provider	Code	Name	Lat (°)	Lon (°)	Altitude (M)	First Year Daily	Last Year Daily	First Year Hourly	Last Year Hourly
EDF-DTG	1252	Izernore Tra- blettes	46.24	5.55	430	1958	2022	1958	2022
EDF-DTG	1272	Chezery	46.22	5.87	580	1960	2022	1960	2022
EDF-DTG	1280	Génissiat Injoux	46.05	5.81	335	1978	2022	1978	2022
EDF-DTG	1316	Abondance Froggy	46.29	6.74	1000	1960	2022	1960	2022
EDF-DTG	1344	Chamonix	45.93	6.88	1035	1959	2022	1959	2022
EDF-DTG	1350	Les Contamines	45.82	6.73	1181	1980	2022	1987	2022
EDF-DTG	1365	Cluses Pressy	46.08	6.56	475	1969	2022	1969	2022
EDF-DTG	1371	Le Grand Bornand	45.98	6.46	1300	1980	2022		
EDF-DTG	1380	Samoens	46.08	6.72	695	1985	2022	1986	2022
EDF-DTG	1406	Thones	45.88	6.32	625	1959	2022	1959	2022
EDF-DTG	1422	Aillon Le Jeune	45.62	6.08	900	1960	2022	1960	2022
EDF-DTG	1432	Valliä `` Res	45.90	5.92	310	1961	2022	1961	2022
EDF-DTG	1510	Ste-Foy Le Miroir	45.60	6.89	1225	1980	2022	1986	2022
EDF-DTG	1524	Moutiers	45.48	6.53	480	1980	2022	1987	2022
EDF-DTG	1525	Valmorel	45.46	6.45	1400	1989	2022	1989	2022
EDF-DTG	1540	Pralognan	45.38	6.72	1420	1980	2022	1987	2022
EDF-DTG	1548	Vignotan	45.45	6.58	600	1959	2022	1959	2022
EDF-DTG	1571	Roselend Beau- fort	45.69	6.63	1580	1980	2022	1985	2022
EDF-DTG	1580	Belleville Hauteluze	45.77	6.64	1215	1960	2022	1960	2022
EDF-DTG	1604	Grand Scala	45.21	6.96	1720	1975	2022	1975	2022
EDF-DTG	1610	Bonneval Tralenta	45.37	7.05	1830	1984	2022	1984	2022
EDF-DTG	1624	Avrieux Villarodin	45.21	6.72	1100	1959	2022	1959	2022
EDF-DTG	1633	Le Chatelard	45.21	6.47	740	1980	2022	1983	2022
EDF-DTG	1638	Valloire	45.17	6.43	1435	1980	2022	1986	2022
EDF-DTG	1664	Le Glandon Ste Marie	45.33	6.29	545	1959	2022	1959	2022
EDF-DTG	1702	Fond De France	45.28	6.07	1085	1980	2022	1984	2022
EDF-DTG	1706	Allevard	45.40	6.07	495	1980	2022	1980	2022
EDF-DTG	1732	Grave	45.05	6.29	1798	1956	2022	1956	2022
EDF-DTG	1750	Allemont Le Rivier	45.20	6.04	1270	1980	2022	1986	2022
EDF-DTG	1753	Livet	45.12	5.96	703	1989	2022	1989	2022
EDF-DTG	1778	Pont Escoffier	45.00	6.07	766	1980	2022	1989	2022
EDF-DTG	1804	Champoleon Les Borels	44.72	6.26	1270	1959	2022	1959	2022
EDF-DTG	1812	St Bonnet	44.68	6.07	1020	1980	2022	1984	2022
EDF-DTG	1814	Molines	44.75	6.12	1240	1952	2022	1952	2022
EDF-DTG	1820	La Chapelle Val- gaudemar	44.81	6.20	1265	1980	2022	1988	2022
EDF-DTG	1832	St Etienne En Dévoluy	44.69	5.94	1265	1958	2022	1958	2022
EDF-DTG	1844	Pellafol Le Sautet	44.82	5.91	800	1963	2022	1963	2022

EDF-DTG	1857	Valbonnais	44.90	5.91	790	1963	2022	1963	2022
EDF-DTG	1911	Charavines Les Vannes	45.43	5.52	510	1961	2022	1961	2022
EDF-DTG	1940	Villard De Lans	45.07	5.56	1040	1960	2022	1960	2022
EDF-DTG	1954	Bouvante Forêt Lente	44.96	5.33	1080	1980	2022	1985	2022
EDF-DTG	2121	Rémuzat	44.41	5.36	450	1987	2022	1987	2022
EDF-DTG	2122	Dieulefit	44.52	5.06	380	1980	2022	1987	2022
EDF-DTG	2412	Monetier Les Bains	44.97	6.51	1460	1986	2022	1987	2022
EDF-DTG	2420	Pelvoux Les Claux	44.88	6.48	1250	1980	2022	1981	2022
EDF-DTG	2432	St Véran	44.70	6.87	2010	1980	2022	1984	2022
EDF-DTG	2436	Arvieux	44.78	6.74	1550	1980	2022	1984	2022
EDF-DTG	2474	Fours St Laurent	44.32	6.69	1660	1980	2022	1984	2022
EDF-DTG	2500	Seyne Les Alpes	44.35	6.36	1210	1980	2022	1983	2022
EDF-DTG	2514	Barillonnette	44.43	5.92	850	1980	2022	1990	2022
EDF-DTG	2520	Lus La Croix Haute	44.67	5.71	1035	1962	2022	1962	2022
EDF-DTG	2523	Montmaur	44.57	5.87	900	1980	2022	1980	2022
EDF-DTG	2526	Serres	44.43	5.71	670	1962	2022	1962	2022
EDF-DTG	2531	Clamensane	44.32	6.06	700	1986	2022	1986	2022
EDF-DTG	2539	Chateauneuf-Miravail	44.16	5.73	670	1980	2022	1981	2022
EDF-DTG	2558	Forcalquier	43.96	5.78	535	1980	2022	1981	2022
EDF-DTG	2560	St-Etienne-Les-Orgues	44.04	5.77	690	1962	2022	1962	2022
EDF-DTG	2575	Mallemort	43.72	5.21	150	1972	2022	1972	2022
EDF-DTG	2582	Marcoux St Martin	44.14	6.28	700	1978	2022	1978	2022
EDF-DTG	2602	Allos	44.24	6.63	1445	1980	2022	1980	2022
EDF-DTG	2608	Thorame	44.09	6.55	1160	1982	2022	1983	2022
EDF-DTG	2620	Lambruisse	44.05	6.44	1125	1980	2022	1980	2022
EDF-DTG	2626	Castillon De-mandolx	43.88	6.54	900	1968	2022	1968	2022
EDF-DTG	2651	Ste Croix	43.74	6.13	500	1980	2022	1987	2022
EDF-DTG	2814	Bas Thorenc Andon	43.80	6.80	1170	1980	2022	1980	2022
EDF-DTG	2816	Coursegoules	43.79	7.05	1000	1952	2022	1952	2022
EDF-DTG	2822	St Etienne De Tinée	44.26	6.93	1140	1960	2022	1960	2022
Météo-France	26035001	Beaufort-S-Gerv	44.78	5.14	379	1950	2023	1994	2023
Météo-France	26047001	Bellegarde-En-Diois	44.54	5.45	1017	1961	2023	1994	2023
Météo-France	26050001	Besignan	44.32	5.32	556	1990	2023	1994	2023
Météo-France	26056001	Bourdeaux	44.58	5.14	432	1961	2023	1995	2023
Météo-France	26063002	Buis -Baronnies	44.28	5.27	390	1989	2021	1994	2020
Météo-France	26064001	Valence-Chabeui	44.91	4.97	163	1974	2023	1998	2023
Météo-France	26074001	Chapelle-En-Vercors	44.96	5.42	879	1994	2023	1995	2023
Météo-France	26100001	Combovin	44.83	5.09	820	1991	2021		
Météo-	26113003	Die	44.77	5.34	384	1990	2023	1994	2023

France									
Météo-France	26115001	Divajeu	44.73	4.99	175	1987	2019	1994	2018
Météo-France	26116002	Donzere	44.43	4.73	66	1992	2023	1994	2023
Météo-France	26124001	Etoile	44.82	4.89	145	1987	2023	1995	2023
Météo-France	26142001	Glandage	44.67	5.62	1007	1967	2023	1995	2023
Météo-France	26168001	Lus L Croix Hte	44.67	5.71	1059	1950	2023	1993	2023
Météo-France	26176001	Marsanne	44.64	4.87	280	1957	2021	1993	2020
Météo-France	26177001	Marsaz	45.11	4.94	213	1971	2021	1994	2020
Météo-France	26179001	Mercuriol	45.06	4.88	153	1993	2023	1994	2023
Météo-France	26188001	Mollans-S-Ouvèze	44.23	5.18	280	1974	2021	1994	2020
Météo-France	26191001	Montboucher-S-Jabron	44.55	4.82	136	1981	2021	1994	2020
Météo-France	26198001	Montelimar	44.58	4.73	73	1950	2023	1991	2023
Météo-France	26211001	Montsegur-S-Lauzon	44.36	4.86	146	1950	2023	1993	2023
Météo-France	26258001	Puy-St-Martin	44.62	4.98	211	1970	2023	1993	2023
Météo-France	26264002	Remuzat	44.43	5.37	475	1992	2021	1993	2020
Météo-France	26281001	Romans	45.05	5.00	156	1990	2023	1994	2023
Météo-France	26295001	St-Barthelemy-Vals	45.17	4.90	203	1959	2023	1993	2023
Météo-France	26298001	St-Christophe-Laris	45.23	5.07	452	1990	2023	1993	2023
Météo-France	26307001	St-Jean-En-Royans	45.01	5.29	308	1950	2023	1995	2023
Météo-France	26313001	St-Marcel-Les-Valence	44.98	4.93	190	1965	2023	1993	2023
Météo-France	26321003	St-Nazaire-Le-Désert	44.55	5.28	607	1991	2022	1995	2021
Météo-France	26330001	St-Sorlin-En-Valloire	45.27	4.93	237	1950	2023	1993	2023
Météo-France	26340001	Sedron	44.20	5.54	804	1964	2023	1995	2023
Météo-France	26348001	Taulignan	44.43	4.99	257	1993	2020	1994	2019
Météo-France	26361001	Valdrome	44.51	5.58	786	1965	2023	1995	2023
Météo-France	26377003	Vinsobres	44.34	5.06	346	1990	2023	1994	2023
Météo-France	38095001	Chatte	45.14	5.31	272	1987	2023	1997	2023
Météo-France	38384001	Grenoble-St-Geoirs	45.36	5.31	384	1950	2023	1993	2023
Météo-France	38548001	Villard-De-Lans	45.08	5.56	1027	1959	2023	1995	2023
Météo-France	4019001	Barcelonnette	44.39	6.67	1155	1950	2023	1999	2023
Météo-France	4049001	St Auban	44.06	5.99	458	1954	2023	1993	2023
Météo-France	4230001	Valensole	43.84	6.00	600	1995	2023	1996	2023

Météo-France	5046001	Embrun	44.57	6.51	873	1950	2023	1993	2023
Météo-France	5055001	La Faurie	44.57	5.75	825	1997	2023	1998	2023
Météo-France	5070003	Laragne Monteglin	44.32	5.79	565	1992	2023	1993	2023
Météo-France	5126001	Rosans	44.39	5.46	625	1971	2023	1993	2023
Météo-France	5170001	Tallard	44.45	6.03	593	1964	2023	1994	2023
Météo-France	6004009	Antibes	43.60	7.11	32	1988	2023	1993	2023
Météo-France	6005001	Ascros	43.92	7.01	1173	1987	2023	1993	2023
Météo-France	6023004	Breil Sur Roya	43.94	7.51	305	1987	2023	1994	2023
Météo-France	6029001	Cannes	43.56	6.95	2	1950	2023	1993	2023
Météo-France	6037002	Caussols	43.75	6.92	1268	1987	2023	1993	2023
Météo-France	6077006	Peira Cava	43.93	7.36	1443	1989	2023	1993	2023
Météo-France	6079002	Mandelieu La Napoule	43.52	6.90	104	1988	2023	1993	2023
Météo-France	6083005	Menton	43.79	7.49	216	1988	2023	1993	2023
Météo-France	6088001	Nice	43.65	7.21	2	1950	2023	1993	2023
Météo-France	6152002	Valbonne-Sophia	43.62	7.03	238	1987	2023	1993	2023
Météo-France	73011004	Albertville JO	45.66	6.37	332	1992	2020	1994	2019
Météo-France	73054001	Bourg St Maurice	45.61	6.76	865	1950	2023	1994	2023
Météo-France	73098003	Feclaz	45.65	5.98	1328	1993	2023	1994	2023
Météo-France	73132003	Col-Des-Saisies	45.76	6.54	1614	1992	2023		
Météo-France	73255003	Ste Marie Cuines	45.34	6.31	460	1997	2023	1998	2023
Météo-France	73261003	St Michel Maurienne	45.22	6.46	698	1997	2023	1998	2023
Météo-France	73304005	Val D'isere Jos	45.44	6.98	1850	1992	2023	1994	2023
Météo-France	73329001	Chambery-Aix	45.64	5.88	235	1973	2023	1992	2023
Météo-France	74056001	Chamonix	45.93	6.88	1042	1950	2023	1997	2023
Météo-France	74182001	Meythet	45.93	6.09	455	1970	2023	1993	2023
Météo-France	74281001	Thonon	46.37	6.46	376	1950	2023	1995	2023
Météo-France	83004004	Les Arcs	43.45	6.47	55	1997	2023	1998	2023
Météo-France	83007004	Aups	43.64	6.19	497	1993	2023	1995	2023
Météo-France	83019002	Bormes Les Mimosas	43.20	6.38	88	1973	2023	1993	2023
Météo-France	83031001	Le Luc	43.38	6.39	80	1950	2023	1993	2023
Météo-France	83035001	Le Castellet	43.25	5.78	417	1969	2023	1993	2023
Météo-France	83035002	Le Castellet_Sapc	43.18	5.77	66	1997	2023	1998	2023

France									
Météo-France	83042001	Cogolin	43.26	6.51	31	1997	2023	1998	2023
Météo-France	83043005	Collobrieres	43.23	6.26	128	1991	2023	1995	2023
Météo-France	83050007	Draguignan	43.53	6.45	173	1996	2023	1997	2023
Météo-France	83061001	Frejus	43.42	6.74	7	1950	2023	1995	2023
Météo-France	83069001	Hyerres	43.09	6.15	2	1959	2023	1996	2023
Météo-France	83069003	Ile Du Levant	43.03	6.47	118	1968	2023	1996	2023
Météo-France	83083001	Montfort-Sur-Argens	43.47	6.13	141	1980	2023	1994	2023
Météo-France	83102005	Regusse	43.67	6.11	561	1997	2023	1998	2023
Météo-France	83124002	Seillans	43.58	6.62	278	1997	2023	1998	2023
Météo-France	83137001	Toulon	43.12	5.90	3	1950	2023	1994	2023
Météo-France	84007005	Avignon	43.91	4.90	34	1994	2023	1997	2023
Météo-France	84009002	La Bastide Des Jourdans	43.79	5.62	381	1988	2023	1993	2023
Météo-France	84025001	Cabrieres D'avi-gnon	43.88	5.16	142	1985	2023	1993	2023
Météo-France	84031001	Carpentras	44.08	5.06	98	1963	2023	1993	2023
Météo-France	84087001	Orange	44.14	4.86	57	1950	2023	1995	2023
Météo-France	84107002	St Christol	44.04	5.49	836	1970	2023	1996	2023
Météo-France	84150001	Visan	44.34	4.91	141	1988	2023	1995	2023