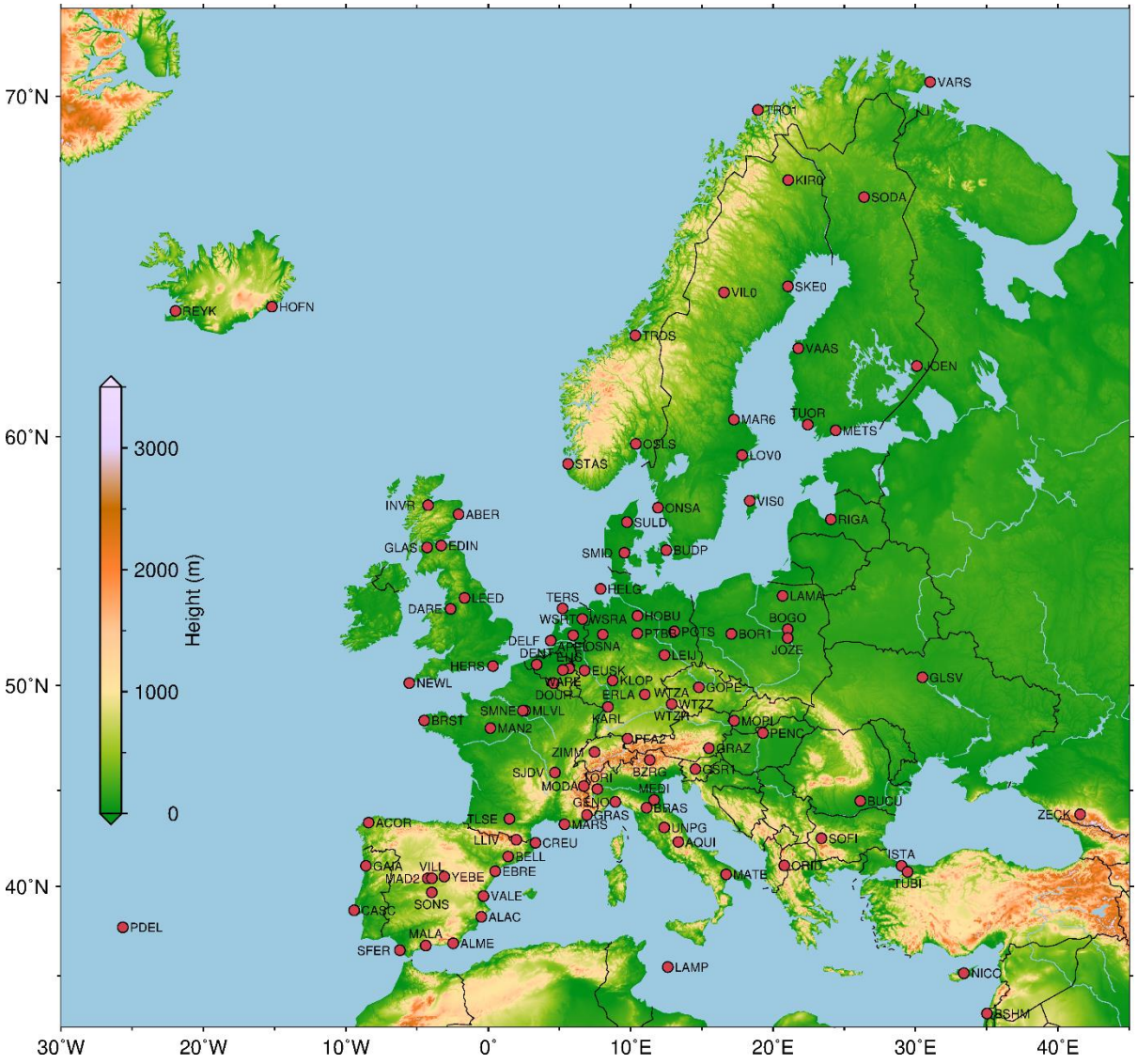

Figure S1. Geographical distribution of the 108 GPS stations. This is an amplified version of Fig. 1 with station names labelled.

Table S1. Time period, number of years (Num. of Y.), number of daily observations (Num. of O.), and integration rate (I-rate) of the GPS IWV time series. The Alt denotes altitude in orthometric height.

Station	Lat. (°)	Lon. (°)	Alt. (m)	Begin date	End date	Num. of Y.	Num. of O.	I-rate (%)
ABER	57.14	-2.08	3.1	1998-09-18	2018-12-31	20.3	6415	86.6
ACOR	43.36	-8.40	11.9	2003-11-14	2018-12-31	15.1	5291	95.7
ALAC	38.34	-0.48	9.9	1998-03-07	2018-12-31	20.8	7165	94.2
ALME	36.85	-2.46	77.1	1999-12-04	2018-12-31	19.1	6682	95.9
APEL	52.21	5.96	72.4	2000-10-24	2018-12-31	18.2	6477	97.5
AQUI	42.37	13.35	664.1	1999-06-15	2018-12-31	19.5	6710	94.0
BELL	41.60	1.40	802.9	1998-12-16	2018-12-31	20.0	7118	97.2
BOGO	52.48	21.04	118.8	1996-07-01	2018-12-29	22.5	7749	94.3
BOR1	52.28	17.07	88.8	1994-09-28	2018-12-31	24.3	8642	97.5
BRAS	44.12	11.11	857.5	2000-05-27	2018-12-31	18.6	6545	96.3
BRST	48.38	-4.50	14.3	1998-11-01	2018-12-31	20.2	6506	88.3
BSHM	32.78	35.02	204.3	1998-09-02	2018-12-29	20.3	6722	90.5
BUCU	44.46	26.13	107.7	1999-02-09	2018-12-31	19.9	7062	97.2
BUDP	55.74	12.50	57.7	2001-01-01	2018-12-31	18.0	6406	97.4
BZRG	46.50	11.34	279.0	2002-07-12	2018-12-31	16.5	5853	97.3
CASC	38.69	-9.42	22.2	1999-09-28	2018-12-31	19.3	6706	95.3
CREU	42.32	3.32	83.6	2003-07-31	2018-12-31	15.4	5465	97.0
DARE	53.34	-2.64	36.2	2000-07-09	2018-12-31	18.5	6236	92.4
DELF	51.99	4.39	30.7	1996-08-08	2018-12-31	22.4	8012	97.9
DENT	50.93	3.40	19.2	1996-01-02	2018-12-31	23.0	8077	96.2
DOUR	50.09	4.60	236.4	1996-01-02	2018-12-31	23.0	8052	95.9
EBRE	40.82	0.49	57.6	1997-04-16	2018-12-31	21.7	7588	95.7
EDIN	55.92	-3.29	65.8	2000-04-10	2018-12-31	18.7	6357	92.9
EIJS	50.76	5.68	57.6	1996-08-30	2018-12-31	22.3	7925	97.1
ERLA	49.59	11.00	291.0	1997-08-03	2018-12-31	21.4	7484	95.7
EUSK	50.67	6.76	198.1	1998-04-04	2018-12-31	20.7	7351	97.0
GAIA	41.11	-8.59	232.1	2000-01-02	2018-12-31	19.0	6435	92.7
GENO	44.42	8.92	110.0	1998-07-23	2018-12-31	20.4	7044	94.3
GLAS	55.85	-4.30	16.9	2000-03-16	2018-12-31	18.8	6467	94.2
GLSV	50.36	30.50	200.8	1997-12-09	2018-12-31	21.1	7464	97.0
GOPE	49.91	14.79	547.6	2001-12-22	2018-12-31	17.0	6058	97.4
GRAS	43.75	6.92	1268.2	1995-02-22	2018-12-31	23.9	8013	92.0
GRAZ	47.07	15.49	490.8	1994-01-02	2018-12-31	25.0	8678	95.0
GSR1	46.05	14.54	304.8	2001-12-23	2018-12-31	17.0	5958	95.8
HELG	54.17	7.89	9.0	1999-11-09	2018-12-31	19.1	6747	96.5

HERS	50.87	0.34	31.4	2001-09-14	2018-12-31	17.3	6170	97.7
HOBU	53.05	10.48	111.3	2002-06-21	2018-12-31	16.5	5828	96.5
HOFN	64.27	-15.20	17.4	1997-06-29	2018-12-31	21.5	7413	94.4
INVR	57.49	-4.22	12.8	2000-01-02	2018-05-08	18.3	6099	91.0
ISTA	41.10	29.02	109.9	1999-12-11	2018-12-31	19.1	6325	90.9
JOEN	62.39	30.10	96.4	1996-10-26	2018-12-31	22.2	7593	93.7
JOZE	52.10	21.03	110.0	1995-02-07	2018-12-31	23.9	8359	95.8
KARL	49.01	8.41	134.7	1997-06-29	2018-12-31	21.5	7469	95.1
KIR0	67.88	21.06	469.3	1996-11-05	2018-12-31	22.2	7794	96.3
KLOP	50.22	8.73	174.4	1997-06-30	2018-12-31	21.5	7461	95.0
LAMA	53.89	20.67	157.6	1994-12-22	2018-12-30	24.0	8180	93.2
LAMP	35.50	12.61	19.6	1999-03-26	2018-12-31	19.8	6341	87.8
LEED	53.80	-1.66	165.3	2000-01-02	2018-12-31	19.0	6482	93.4
LEIJ	51.35	12.37	134.2	1997-06-30	2018-12-31	21.5	7414	94.4
LLIV	42.48	1.97	1414.3	1999-05-14	2018-12-31	19.6	6917	96.4
LOV0	59.34	17.83	56.1	1995-08-01	2018-12-31	23.4	8156	95.3
MAD2	40.43	-4.25	776.4	1997-07-07	2018-12-31	21.5	7355	93.7
MALA	36.73	-4.39	71.2	2000-05-05	2018-12-31	18.7	6652	97.6
MAN2	48.02	0.16	120.9	1998-04-05	2018-12-31	20.7	7126	94.1
MAR6	60.60	17.26	50.6	1996-10-26	2018-12-31	22.2	7926	97.8
MARS	43.28	5.35	12.2	1998-07-17	2018-12-31	20.5	7030	94.1
MATE	40.65	16.70	490.2	1994-01-02	2018-12-31	25.0	8788	96.3
MEDI	44.52	11.65	10.2	1995-07-28	2018-12-31	23.4	8005	93.5
METS	60.22	24.40	75.7	1994-01-02	2018-12-31	25.0	8361	91.6
MLVL	48.84	2.59	115.9	1998-03-20	2018-12-31	20.8	7047	92.8
MODA	45.21	6.71	1127.9	1998-10-17	2018-12-31	20.2	6412	86.9
MOPI	48.37	17.27	535.3	1998-05-27	2018-12-31	20.6	6923	92.0
NEWL	50.10	-5.54	11.0	1998-09-30	2018-12-10	20.2	6685	90.6
NICO	35.14	33.40	161.9	1997-05-15	2018-12-31	21.6	6745	85.4
ONSA	57.40	11.93	8.9	1994-01-02	2018-12-31	25.0	8699	95.3
ORID	41.13	20.79	730.8	2000-07-13	2018-12-31	18.5	6262	92.8
OSLS	59.74	10.37	181.5	2000-10-30	2018-12-31	18.2	6430	96.9
OSNA	52.25	8.05	105.5	2000-01-01	2018-12-31	19.0	6528	94.1
PDEL	37.75	-25.66	53.5	2000-02-01	2018-12-31	18.9	6433	93.1
PENC	47.79	19.28	248.3	1996-03-03	2018-12-31	22.8	8033	96.3
PFA2	47.52	9.78	1042.9	1997-04-12	2018-12-31	21.7	7543	95.1
POTS	52.38	13.07	104.0	1995-10-04	2018-12-31	23.2	8135	95.8
PTBB	52.30	10.46	87.2	2000-03-30	2018-12-31	18.8	6629	96.8
REYK	64.14	-21.96	26.6	1996-01-02	2018-12-31	23.0	7813	93.0

RIGA	56.95	24.06	13.6	1996-10-26	2018-12-31	22.2	7649	94.4
SFER	36.46	-6.21	39.2	1998-06-03	2018-12-28	20.6	7007	93.3
SJDV	45.88	4.68	382.1	1999-03-12	2018-12-31	19.8	6320	87.4
SKE0	64.88	21.05	59.0	1996-11-02	2018-12-31	22.2	7912	97.7
SMID	55.64	9.56	82.5	2001-01-01	2018-12-31	18.0	6396	97.3
SMNE	48.84	2.43	81.6	2000-10-30	2018-12-31	18.2	6414	96.6
SODA	67.42	26.39	279.0	1996-10-26	2018-12-31	22.2	7192	88.8
SOFI	42.56	23.39	1074.5	1997-06-04	2018-12-31	21.6	7227	91.7
SONS	39.68	-3.96	755.3	2000-11-25	2018-12-31	18.1	6460	97.7
STAS	59.02	5.60	60.8	2000-10-30	2018-12-31	18.2	6340	95.5
SULD	56.84	9.74	82.0	2001-01-01	2018-12-31	18.0	6386	97.1
TERS	53.36	5.22	14.4	1996-10-31	2018-12-31	22.2	7924	97.9
TLSE	43.56	1.48	157.7	2001-01-06	2018-12-31	18.0	6391	97.3
TORI	45.06	7.66	261.2	1998-07-15	2018-12-31	20.5	6917	92.5
TRDS	63.37	10.32	277.7	2000-10-30	2018-12-31	18.2	6380	96.1
TRO1	69.66	18.94	106.6	2000-06-19	2018-12-31	18.5	6518	96.3
TUBI	40.79	29.45	184.3	2002-01-01	2018-12-31	17.0	6020	97.0
TUOR	60.42	22.44	41.0	1997-01-01	2016-11-05	19.8	6911	95.3
UNPG	43.12	12.36	303.5	1997-10-15	2018-11-20	21.1	6976	90.5
VAAS	62.96	21.77	40.1	1996-10-26	2018-12-31	22.2	7623	94.1
VALE	39.48	-0.34	27.0	2000-01-10	2018-12-31	19.0	6425	92.7
VARS	70.34	31.03	156.1	2000-10-30	2018-12-31	18.2	6343	95.6
VIL0	64.70	16.56	420.1	1996-10-29	2018-12-31	22.2	7853	97.0
VILL	40.44	-3.95	595.4	1994-11-29	2018-12-31	24.1	8327	94.6
VIS0	57.65	18.37	54.7	1996-11-05	2018-12-31	22.2	7855	97.1
WARE	50.69	5.25	141.6	1996-01-02	2018-12-31	23.0	7924	94.3
WSRA	52.91	6.60	40.5	1997-05-17	2018-12-31	21.6	7709	97.6
WSRT	52.91	6.60	40.5	1997-06-26	2018-12-31	21.5	7653	97.4
WTZA	49.14	12.88	619.1	1997-11-26	2018-12-31	21.1	7301	94.7
WTZR	49.14	12.88	619.2	1995-12-31	2018-12-31	23.0	8217	97.8
WTZZ	49.14	12.88	619.1	1999-02-05	2018-12-31	19.9	7015	96.5
YEBE	40.52	-3.09	920.3	1999-05-19	2018-12-31	19.6	6829	95.3
ZECK	43.79	41.57	1143.4	1997-07-06	2018-12-31	21.5	7092	90.4
ZIMM	46.88	7.47	906.7	1994-01-02	2018-12-31	25.0	8781	96.2

Table S2. Properties of the 108 GPS stations with their altitudes (Alt.), distance-to-sea (SeaDist), and climate zones shown with Code and Type. The climate of each station was classified according to Köppen Climate Classification (Beck et al., 2018) with a spatial resolution of about 1 km.

Station	Lat. (°)	Lon. (°)	Alt. (m)	SeaDist (km)	Code	Type
ABER	57.14	-2.08	3.1	0.4	Cfb	Temperate, no dry season, warm summer
ACOR	43.36	-8.40	11.9	0.3	Csb	Temperate, dry summer, warm summer
ALAC	38.34	-0.48	9.9	0.2	BWh	Arid, desert, hot
ALME	36.85	-2.46	77.1	2.2	BWh	Arid, desert, hot
APEL	52.21	5.96	72.4	42.2	Cfb	Temperate, no dry season, warm summer
AQUI	42.37	13.35	664.1	64.0	Cfa	Temperate, no dry season, hot summer
BELL	41.60	1.40	802.9	47.7	Csb	Temperate, dry summer, warm summer
BOGO	52.48	21.04	118.8	223.1	Dfb	Cold, no dry season, warm summer
BOR1	52.28	17.07	88.8	222.1	Dfb	Cold, no dry season, warm summer
BRAS	44.12	11.11	857.5	74.4	Dfb	Cold, no dry season, warm summer
BRST	48.38	-4.50	14.3	0.1	NaN	Sea
BSHM	32.78	35.02	204.3	3.4	Csa	Temperate, dry summer, hot summer
BUCU	44.46	26.13	107.7	199.0	Dfa	Cold, no dry season, hot summer
BUDP	55.74	12.50	57.7	5.3	Dfb	Cold, no dry season, warm summer
BZRG	46.50	11.34	279.0	134.4	Cfa	Temperate, no dry season, hot summer
CASC	38.69	-9.42	22.2	0.5	Csb	Temperate, dry summer, warm summer
CREU	42.32	3.32	83.6	0.4	BSk	Arid, steppe, cold
DARE	53.34	-2.64	36.2	2.9	Cfb	Temperate, no dry season, warm summer
DELF	51.99	4.39	30.7	16.0	Cfb	Temperate, no dry season, warm summer
DENT	50.93	3.40	19.2	46.5	Cfb	Temperate, no dry season, warm summer
DOUR	50.09	4.60	236.4	141.9	Cfb	Temperate, no dry season, warm summer
EBRE	40.82	0.49	57.6	17.7	BSk	Arid, steppe, cold
EDIN	55.92	-3.29	65.8	5.9	Cfb	Temperate, no dry season, warm summer
EIJS	50.76	5.68	57.6	120.0	Cfb	Temperate, no dry season, warm summer
ERLA	49.59	11.00	291.0	446.2	Dfb	Cold, no dry season, warm summer
EUSK	50.67	6.76	198.1	187.4	Cfb	Temperate, no dry season, warm summer
GAIA	41.11	-8.59	232.1	5.2	Csb	Temperate, dry summer, warm summer
GENO	44.42	8.92	110.0	0.6	Csa	Temperate, dry summer, hot summer
GLAS	55.85	-4.30	16.9	9.7	Cfb	Temperate, no dry season, warm summer
GLSV	50.36	30.50	200.8	399.9	Dfb	Cold, no dry season, warm summer
GOPE	49.91	14.79	547.6	410.3	Dfb	Cold, no dry season, warm summer
GRAS	43.75	6.92	1268.2	21.7	Csb	Temperate, dry summer, warm summer
GRAZ	47.07	15.49	490.8	203.3	Dfb	Cold, no dry season, warm summer
GSR1	46.05	14.54	304.8	73.9	Dfb	Cold, no dry season, warm summer

HELG	54.17	7.89	9.0	0.2	NaN	Sea
HERS	50.87	0.34	31.4	6.2	Cfb	Temperate, no dry season, warm summer
HOBU	53.05	10.48	111.3	68.8	Cfb	Temperate, no dry season, warm summer
HOFN	64.27	-15.20	17.4	0.4	ET	Polar, tundra
INVR	57.49	-4.22	12.8	0.9	Cfb	Temperate, no dry season, warm summer
ISTA	41.10	29.02	109.9	3.0	Csa	Temperate, dry summer, hot summer
JOEN	62.39	30.10	96.4	198.2	Dfc	Cold, no dry season, cold summer
JOZE	52.10	21.03	110.0	260.7	Dfb	Cold, no dry season, warm summer
KARL	49.01	8.41	134.7	394.3	Cfb	Temperate, no dry season, warm summer
KIR0	67.88	21.06	469.3	143.6	Dfc	Cold, no dry season, cold summer
KLOP	50.22	8.73	174.4	330.4	Cfb	Temperate, no dry season, warm summer
LAMA	53.89	20.67	157.6	82.3	Dfb	Cold, no dry season, warm summer
LAMP	35.50	12.61	19.6	0.5	BSh	Arid, steppe, hot
LEED	53.80	-1.66	165.3	59.2	Cfb	Temperate, no dry season, warm summer
LEIJ	51.35	12.37	134.2	289.2	Cfb	Temperate, no dry season, warm summer
LLIV	42.48	1.97	1414.3	88.0	Cfb	Temperate, no dry season, warm summer
LOV0	59.34	17.83	56.1	13.5	Dfb	Cold, no dry season, warm summer
MAD2	40.43	-4.25	776.4	328.0	BSk	Arid, steppe, cold
MALA	36.73	-4.39	71.2	0.5	Csa	Temperate, dry summer, hot summer
MAN2	48.02	0.16	120.9	131.1	Cfb	Temperate, no dry season, warm summer
MAR6	60.60	17.26	50.6	7.5	Dfb	Cold, no dry season, warm summer
MARS	43.28	5.35	12.2	0.8	BSk	Arid, steppe, cold
MATE	40.65	16.70	490.2	28.7	Csa	Temperate, dry summer, hot summer
MEDI	44.52	11.65	10.2	49.8	Cfa	Temperate, no dry season, hot summer
METS	60.22	24.40	75.7	10.4	Dfb	Cold, no dry season, warm summer
MLVL	48.84	2.59	115.9	160.8	Cfb	Temperate, no dry season, warm summer
MODA	45.21	6.71	1127.9	171.2	Dfb	Cold, no dry season, warm summer
MOPI	48.37	17.27	535.3	399.5	Dfb	Cold, no dry season, warm summer
NEWL	50.10	-5.54	11.0	0.5	Cfb	Temperate, no dry season, warm summer
NICO	35.14	33.40	161.9	21.5	BSh	Arid, steppe, hot
ONSA	57.40	11.93	8.9	0.3	Dfb	Cold, no dry season, warm summer
ORID	41.13	20.79	730.8	107.5	Cfb	Temperate, no dry season, warm summer
OSLS	59.74	10.37	181.5	8.1	Dfb	Cold, no dry season, warm summer
OSNA	52.25	8.05	105.5	115.4	Cfb	Temperate, no dry season, warm summer
PDEL	37.75	-25.66	53.5	0.9	Csa	Temperate, dry summer, hot summer
PENC	47.79	19.28	248.3	451.5	Dfb	Cold, no dry season, warm summer
PFA2	47.52	9.78	1042.9	295.5	Dfb	Cold, no dry season, warm summer
POTS	52.38	13.07	104.0	165.9	Dfb	Cold, no dry season, warm summer
PTBB	52.30	10.46	87.2	143.8	Cfb	Temperate, no dry season, warm summer

REYK	64.14	-21.96	26.6	0.7	Dfc	Cold, no dry season, cold summer
RIGA	56.95	24.06	13.6	7.9	Dfb	Cold, no dry season, warm summer
SFER	36.46	-6.21	39.2	1.1	Csa	Temperate, dry summer, hot summer
SJDV	45.88	4.68	382.1	261.9	Cfb	Temperate, no dry season, warm summer
SKE0	64.88	21.05	59.0	1.4	Dfc	Cold, no dry season, cold summer
SMID	55.64	9.56	82.5	5.9	Dfb	Cold, no dry season, warm summer
SMNE	48.84	2.43	81.6	153.4	Cfb	Temperate, no dry season, warm summer
SODA	67.42	26.39	279.0	192.4	Dfc	Cold, no dry season, cold summer
SOFI	42.56	23.39	1074.5	198.7	Dfb	Cold, no dry season, warm summer
SONS	39.68	-3.96	755.3	311.8	BSk	Arid, steppe, cold
STAS	59.02	5.60	60.8	0.5	Cfb	Temperate, no dry season, warm summer
SULD	56.84	9.74	82.0	27.3	Dfb	Cold, no dry season, warm summer
TERS	53.36	5.22	14.4	0.4	NaN	Sea
TLSE	43.56	1.48	157.7	136.0	Cfa	Temperate, no dry season, hot summer
TORI	45.06	7.66	261.2	105.6	Cfa	Temperate, no dry season, hot summer
TRDS	63.37	10.32	277.7	4.6	Dfc	Cold, no dry season, cold summer
TRO1	69.66	18.94	106.6	1.1	Dfc	Cold, no dry season, cold summer
TUBI	40.79	29.45	184.3	1.9	Csa	Temperate, dry summer, hot summer
TUOR	60.42	22.44	41.0	0.9	Dfb	Cold, no dry season, warm summer
UNPG	43.12	12.36	303.5	96.3	Cfa	Temperate, no dry season, hot summer
VAAS	62.96	21.77	40.1	10.4	Dfc	Cold, no dry season, cold summer
VALE	39.48	-0.34	27.0	1.2	BSk	Arid, steppe, cold
VARS	70.34	31.03	156.1	0.9	ET	Polar, tundra
VIL0	64.70	16.56	420.1	182.4	Dfc	Cold, no dry season, cold summer
VILL	40.44	-3.95	595.4	326.2	BSk	Arid, steppe, cold
VIS0	57.65	18.37	54.7	2.5	Dfb	Cold, no dry season, warm summer
WARE	50.69	5.25	141.6	101.3	Cfb	Temperate, no dry season, warm summer
WSRA	52.91	6.60	40.5	50.3	Cfb	Temperate, no dry season, warm summer
WSRT	52.91	6.60	40.5	50.3	Cfb	Temperate, no dry season, warm summer
WTZA	49.14	12.88	619.1	375.3	Dfb	Cold, no dry season, warm summer
WTZR	49.14	12.88	619.2	375.3	Dfb	Cold, no dry season, warm summer
WTZZ	49.14	12.88	619.1	375.3	Dfb	Cold, no dry season, warm summer
YEBE	40.52	-3.09	920.3	261.0	BSk	Arid, steppe, cold
ZECK	43.79	41.57	1143.4	98.0	Dfb	Cold, no dry season, warm summer
ZIMM	46.88	7.47	906.7	290.1	Dfb	Cold, no dry season, warm summer

Table S3. The IWV trend estimates with realistic uncertainties at the 108 stations. The specific optimal noise model for each IWV time series is also given. For the GPS-reanalyses IWV trend comparison, the relative IWV trend (in % decade^{-1}) is calculated as the ratio between the IWV trend (in kg m^{-2} decade^{-1}) and the average monthly IWV of the specific IWV time series. Note that the Table S3 is provided as a single file named as ***Table S3_ ACP-2021-797.xlsx*** with eight sheets in the supplementary material.