14 YEARS OF GPS TROPOSPHERIC DELAYS IN THE FRENCH-ITALIAN BORDER REGION: A DATA BASE FOR METEOROLOGICAL AND CLIMATOLOGICAL ANALYSES

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ABSTRACT:

GPS data from 181 permanent stations extracted from different networks covering France and the Italian part of the Alps are used to estimate a homogeneous set of tropospheric parameters over 14 years (from January 1998 to May 2012). The tropospheric zenith delay (ZTD) quantified in the GPS data analysis is closely related to the value of integrated water vapor above each GPS station. GPS ZTD is already successfully used for operational weather prediction and meteorological analyses, providing valuable data to improve our comprehension of the tropospheric water cycle and in particular to improve the prediction of precipitations. Moreover, GPS tropospheric measurements are intrinsically stable, so that long term observations represent a significant contribution to climatological studies.
The results of a homogeneous reanalysis of up to 14 years of data with MIT's GAMIT/GLOBK software version 10.4 are presented. The estimated tropospheric parameters are 1 ZTD every 2 hours and one couple of horizontal tropospheric gradients (NS and EW) every 3 hours for each of the 181 stations, simultaneously with a daily positioning solution. A quality check of the tropospheric parameter time series identifies offsets, for example due to instrument changes at individual sites.
The resulting verified time series can further be used for meteorological and climatological studies that go beyond the geodetic work presented here. Thanks to the length of the data set in time, a regional climatological approach could permit identifying specific patterns of ZTD variation that are related to severe weather events. The regional GPS stations could then contribute to an early warning system.

1. INTRODUCTION

Some 20 years ago, the first permanent GPS stations have been installed in Europe by different organizations such as French CNES and Italian ASI (stations MATE: 1992, GRAS: 1994, MEDI: 1995; TORI: 1996, TOUL: 1996, …). Today, a high number of permanent GPS stations exist in Europe that have been running over the long term and provide now a data set covering more than 10 years. GPS microwave signals are delayed by the atmosphere (Askne and Nordius, 1987; Solheim et al., 1999) and a precise measurement of the Zenith Total Delay (ZTD) can be achieve during GPS data processing. ZTD is function of atmospheric pressure, temperature and humidity along the signal travel path (Saastamoinen, 1972). GPS tropospheric measurements are intrinsically stable (e.g. Bevis et al., 1992), so that long term observations represent a significant contribution to climatological studies (Bock et al., 2008; Bouma and Stoew, 2001; Jin et al., 2009). One condition for exploiting GPS data for climatology is, however, the use of a homogeneous data analysis strategy over the total observation span (the problem of data homogeneity is discussed e.g. in Vey et al., 2009).
The aim of our work is to re-analyze data from GPS stations installed for long term measurements in France and Italy with an up-to-date GPS data analysis strategy. This analysis will provide a coherent set of ZTD for each station. The ZTD quantified in the GPS data analysis being closely related to the value of integrated water vapor above each GPS station (Bevis et al., 1992, 1994), GPS ZTD is already successfully used for operational weather prediction (e.g. the recent work from Bennitt and Jupp, 2012). It is shown to provide valuable data to improve our comprehension of the tropospheric water cycle and in particular to improve the prediction of precipitations (e.g. Boniface et al., 2009; De Pondeca and Zou, 2001; Yan et al., 2009) even in a very short time perspective (De Haan, 2013). In the current study, we want to test if our analysis of GPS data over up to 14 years can provide first constraints on the climatology of tropospheric water vapor.
This data re-analysis is done in particular as a contribution to the HyMeX project (HYdrological cycle in the Mediterranean EXperiment). This international project implying 15 countries and running from 2010 to 2020, aims at a better understanding and quantification of the hydrological cycle and related processes in the Mediterranean, with emphasis on high-impact weather events, inter-annual to decadal variability of the Mediterranean coupled system, and associated trends in the context of global change (www.hymex.org). Moreover, tropospheric water vapor observations in our regionally densified network (Mediterranean, Alps, Fig. 1, section 2) permits also to provide some constraints on regional climatologies. In these regional frameworks, the length of the observation span could make the data interesting for statistical approaches, for example trying to identify specific patterns of ZTD evolution that are related to intense precipitation events. The regional GPS stations analyzed in our study could then contribute to early warning systems.

2. GPS NETWORK

The GPS network of our analysis is particularly dense in the south-eastern part of France and the north-western part of Italy, therefore covering a significant area of the western Alps (Fig.1). The 181 identified Permanent Stations (PS) belong to different types of networks like the global IGS Tracking Network (International GNSS Service) and the EUREF Permanent Network (International Association of Geodesy Reference Frame Sub-Commission for Europe), the national networks RENAG (http://webrenag.unice.fr), RGP (http://rgp.ign.fr), AGNES (http://www.swisstopo.admin.ch), GEODAF (http://geodaf.mt.asi.it) and RING (http://ring.gm.ingv.it), transnational networks like GAIN (http://www.alpine-space.org/alps-gpsquakenet.html), and the regional networks of Italian Piemonte and Liguria. 15 old permanent stations (13 IGS and 2 EUREF stations) have been included in the analysis (red circles in Fig. 1) to obtain a stable Reference Frame for the entire time span. As one particularity of the RENAG network is site stability over the long term, the total of its present stations is included in the analysis. We also analyzed all stations made available by the Liguria and Piemonte regions. Then, the network coverage was completed in the Alpine and Mediterranean regions by subsets of stations from RGP, AGNES, GEODAF, RING and GAIN. The 181 station names and their coordinates can be found in the Appendix.
The data analysis covers the time interval from January 1998 to May 2012, representing more than 14 years of observations. From the 181 stations, 50 stations provide more than 10 years of data and 57 stations between 5 and 10 years of data. The 74 remaining stations have less than 5 years of available data.

3. GPS DATA ANALYSIS

The software used for the GPS data analysis is GAMIT/GLOBK ver. 10.4 (Herring et al., 2010) developed at the Department of Earth Atmospheric and Planetary Sciences, MIT (Robert W. King - rwk@chandler.mit.edu). The estimated tropospheric parameters are 1 ZTD every 2 hours and one couple of horizontal tropospheric gradients (NS and EW) every 3 hours for each of the 181 stations, simultaneously with a daily positioning solution. The troposphere is modeled using the empirical GMF mapping function (Boehm et al., 2006b) for its homogeneity over the study time span. It is in particular independent from weather models, unlike the VMF1 mapping function (Boehm et al., 2004, 2006a), constraint by 6 hourly ECMWF analysis results and nowadays widely used. Moreover, we use the GPT model (Boehm et al., 2007) for a priori information on station pressure and temperature. Furthermore, the absolute antenna phase center model IGS_08 is implemented (Schmid et al., 2007), as well as ocean loading (FES2004, Lyard et al., 2006) and atmospheric loading following Tregoning and van Dam (2005). IGS final orbits are readjusted in the analysis and coherent Earth orientation parameters are used.
Due to computational limits, the 181 station network has been split in three sub-networks. A stable, common reference frame is achieved by including in each sub-network an identical set of 15 IGS and EUREF stations (Fig. 1). Each sub-network comprises about 55 other, local PSs. We decided to configure the three sub-networks according to the age of the stations, to obtain network geometries that are as stable as possible in time. Sub-network 1 is composed of the oldest 54 stations (12 stations were already available in January 1998, the youngest net1 station started in June 2004), sub-network 2 of the 56 medium ones (starting before June 2008), and sub-network 3 includes the 56 youngest stations that have started after July 2008.
The a priori coordinates used for the stations are from ITRF2008 (Altamimi et al., 2011) when available. The coordinates are extrapolated to the daily position using their ITRF2008 velocity. For regional stations without ITRF2008 solution we calculated a precise coordinate solution over a few days in 2012 with respect to ITRF2008.

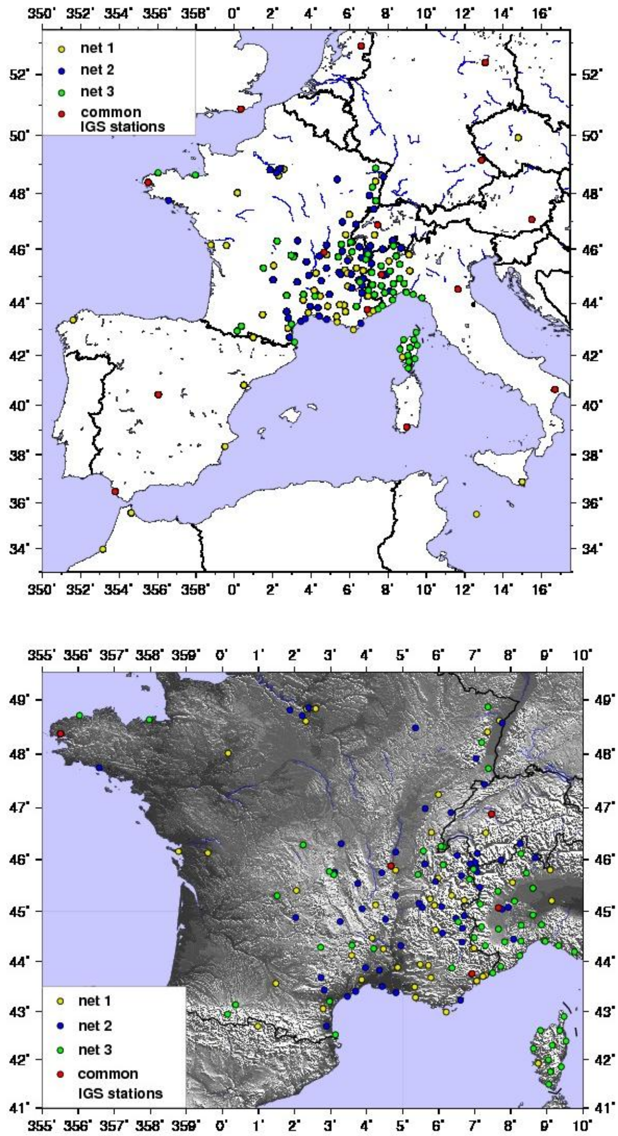

Figure 1. GPS station locations.
Upper graph: the total network extent.
Lower graph: zoom on the densification zone covering the French-Italian Mediterranean coast and the western Alps.
Red circles highlight the 15 common IGS and EUREF stations included in each of the three sub-networks
net1 (yellow circles), net2 (blue circles) and net3 (green circles) composed according to decreasing station age.
For station names and coordinates refer to the Appendix.

For a consistent tropospheric parameter estimation, the ITRF2008 a priori coordinates were only loosely constraint (c.f. Brenot et al., 2006). We estimated for each station 12 ZTDs and 8 pairs of tropospheric horizontal gradients (NS and EW direction) per 24 hour session. The parameters presented hereafter are extracted from the ambiguity free solution. Ambiguity resolution usually increases horizontal coordinate

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repeatability while degrading vertical coordinate repeatability by projecting unmodeled measurement errors on the more weakly constrained vertical component. This could introduce biases in the tropospheric parameter estimation, tropospheric zenith delay being correlated with the vertical positioning.
Our network conception insures also that ZTD is estimated to its total amount and not only in a relative way between the different stations, by including IGS stations at large distances from the local network in each analysis (> 1500 km, according to Tregoning et al., 1998).

4. QUALITY CONTROL

Apart from the homogeneous analysis and the intrinsic stability of GPS tropospheric delay measurements, the GPS station itself has to be stable throughout time to be able to interpret any tendency in its tropospheric parameters in terms of climatology. Obviously, the physical benchmark should also remain unchanged; the position of the station should be stable. The tropospheric delay varies in particular with height. A vertical offset of the measurement point creates an offset in ZTD that is however downscaled. A scale factor of about 3 has been quantified already by Santerre (1991) from simulations. The order of magnitude was confirmed in real measurements, for example by Vey et al. (2002) and Walpersdorf et al. (2007) with a factor of 4.4 for French Brittany and ≥ 3 for African stations, respectively.
To estimate the maximum vertical offset that does not significantly affect the evaluation of a long term trend of PWV above a GPS station, we are using a conservative estimate of a scale factor of 3 between ZTD and vertical position, and a relation of ZTD/PWV of about 6.5 (relation quantified by the mean temperature of the atmosphere above the GPS station, see Bevis et al., 1992). Observed PWV trends of the order of 0.3 mm PWV/decade (e.g. Morland et al., 2009) correspond to a ZTD trend of 2 mm/decade and imply that a single offset in the vertical time series should be smaller than 6 mm to be able to resolve a realistic PWV trend. We therefore consider that 6 mm is the maximum acceptable vertical offset for constraining significant PWV trends without correcting this offset. Looking for offsets in the position time series is more efficient than examining ZTD or even PWV time series directly because the signal to noise ratio is clearly more favorable in the positioning time series (related to the scale factors). Sites with significant offsets are still usable but have to be corrected (e.g. the offset estimated together with the slope, leading to lower constraints on the slope).
Effectively, a majority of long term GPS stations undergo modifications: change of GPS antenna and/or receiver, related to technical failures or modernization of the station, modifications in the antenna environment like constructions creating masks. Receiver and antenna changes are documented in the site log sheets and any related position offset can be modeled in the data analysis to a major part. However, some residuals can persist, related probably to the individual site installation and environment. Modifications in the surroundings of the antenna are generally not monitored and not modeled. A quality check of the position time series has therefore to be performed, to identify residual offsets related to an equipment change, or offsets due to undocumented modifications of the sites, or to undocumented measurement failures. The resulting verified time series highlight those stations providing tropospheric parameter time series that can further be used for meteorological and climatological studies. Developing these applications goes beyond the geodetic work presented here; however, our validated ZTD and gradient time series are made available to other researchers for further studies (section 5).
We summarize in Table 1 some parameters characterizing the quality of the individual stations for long term climatological studies. The parameters indicated are total measurement span, number of daily solutions, normalized root mean square dispersion (nrms) and weighted root mean square dispersion (wrms) of the vertical position time series and an empirical station quality index, established by visual inspection of the position time series. This visual inspection evaluates the presence of visible jumps (in particular on the vertical component), data gaps, linearity of the time series, and the level of noise. We attribute station by station a quality index of 1 for good stations, 2 if the time series is usable under certain conditions (removing noisy parts, correcting for jumps), and 3 if the time series is too bad to provide any constraints on ZTD climatology.
In this paper, we show these parameters for net 1, the full characterization will be available with the publication of the ZTD time series. In particular, out of the 69 stations in net 1 (including the 15 common stations), 54 PSs are assigned index 1, 14 PSs an index 2, and 1 PS has obtained an index 3 (BURE). Effectively, in the time series of index 2, discontinuities are present that are related to known but imperfectly modeled equipment changes, and to undocumented modifications at the stations. Some examples of time series for index 1, 2 and 3 stations are shown in Figure 2.
The noise level of the position time series of the vertical component is evaluated to an average of 1.4 nrms and 4.3 mm wrms for index 1 stations, to 1.8 nrms and 5.8 mm wrms for index 2 stations, and the index 3 station BURE has nrms and wrms of 2.1 and 5.6 mm, respectively.

Site	obser. span [yr]	# sol	wrms [mm]	nrms	index
ACOR	12.7	4333	4.1	1.3	2
AIGL	9.0	2500	6.8	2.1	2
AJAC	12.3	3859	3.8	1.5	2
ALAC	12.7	4484	4.4	1.5	1
AXPV	9.6	3043	5.1	1.7	2
BANN	8.8	2843	3.1	1.4	1
BIEL	6.8	1991	7.7	2.0	2
BRET	7.9	2283	3.9	1.2	1
BRST*	13.3	4081	6.3	2.0	2
BSCN	10.5	3545	3.8	1.3	1
BURE	5.2	1050	5.6	2.1	3
CAGL*	14.3	5038	3.7	1.3	1
CHAM	8.4	2637	4.1	1.4	1
CHIZ	11.3	3997	10.4	3.2	2
CHRN	11.5	3058	2.7	1.1	1
CHTL	13.0	3538	3.7	1.4	1
CLAP	9.1	2683	6.2	1.2	1
COMO	10.0	3564	3.7	1.2	1
EBRE	14.3	5064	4.2	1.4	1
EGLT	10.5	3665	4.3	1.3	1
ESCO	12.7	3657	4.3	1.5	1
FCLZ	13.6	4425	5.7	1.4	2
FJCP	10.0	3145	4.5	1.3	1
GENO	13.8	4809	3.8	1.0	1
GINA	10.9	3848	4.2	1.4	1
GOPE	14.3	5164	6.3	1.9	1
GRAS*	14.3	4890	3.3	1.1	1
GRAZ*	14.3	5074	4.6	1.8	1

HERS*	14.3	4906	6.3	2.5	2
JOUX	11.9	3278	3.3	1.4	1
LAMP	13.1	4228	3.3	1.1	1
LROC	10.4	3668	2.9	0.9	1
MANS	9.9	3311	4.4	1.4	1
MARS	13.8	4749	4.3	1.3	1
MART	3.8	1384	6.2	1.9	1
MATE*	14.3	5175	3.2	1.1	1
MDOR	9.6	3387	9.3	2.8	1
MEDI*	14.3	5080	4.3	1.2	2
MICH	13.8	4018	3.4	1.3	1
MLVL	14.1	4649	5.8	2.0	2
MODA	13.5	4384	4.4	1.5	1
MTPL	13.0	4361	3.2	1.1	1
NICA	9.4	3020	2.8	0.9	1
NICE	11.4	3873	2.9	1.0	1
NOT1	11.6	4156	3.5	1.2	1
NOVA	11.3	2804	3.0	0.9	1
OPMT	10.3	3651	3.3	0.8	2
PAVI	10.8	3746	9.4	3.3	1
POTS*	14.3	5144	4.7	1.8	1
PQRL	8.6	2845	4.3	1.2	1
RABT	11.9	4195	3.5	1.1	1
RSTL	9.8	2784	2.8	1.2	1
SAAN	3.8	1343	5.1	1.5	1
SAUV	8.5	2484	3.2	1.2	1
SFER*	14.3	5104	3.2	1.1	1
SJDV*	14.3	4705	3.1	1.3	1
SMNE	11.4	4073	5.9	2.1	2
SOPH	11.3	3973	2.9	1.0	1
STEY	8.9	2566	4.0	1.6	1
STJ9	12.5	4422	2.8	1.2	1
TENC	7.9	2291	10.8	3.9	1
TETN	11.9	3187	5.9	1.3	2
TLSE	11.3	4076	3.0	0.9	1
TORI*	14.3	4963	9.5	2.3	1
VILL*	14.3	5072	3.7	1.0	1
WELS	8.9	3110	5.4	1.2	1
WSRT*	14.3	5142	3.5	1.6	1
WTZR*	14.3	5185	3.3	1.2	1
ZIMM*	14.3	5178	3.4	1.3	1
Average	*11.5*	*3796*	*4.6*	*1.5*	*54 with 1* *14 with 2* *1 with 3*

Table 1. Four character codes of the GPS sites of net1 (stars indicate the 15 common stations), length of the observation span in years, number of daily solutions, wrms [mm], nrms and quality index (1-3: good to unusable).

The resulting homogeneous and quality checked time series of ZTD can now be used to establish the long term ZTD trend that should be closely related to the quantity of tropospheric water vapor present above each station. Time series of horizontal gradients could monitor the evolution of systematic anisotropies of the water vapor distribution in the vicinity of each site. Water vapor being a key variable in climate, these trend evaluations could therefore help characterizing regional climatologies.

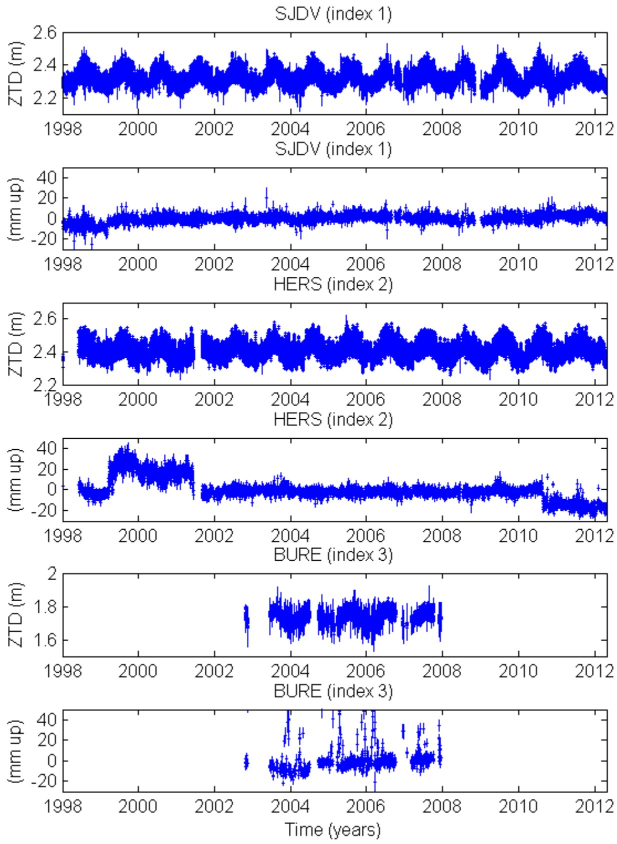

Figure 2. ZTD and vertical position time series for stations of index 1, 2, and 3 (SJDV, HERS and BURE).

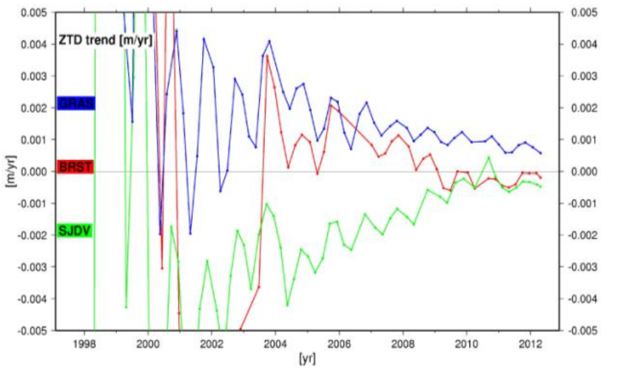

Figure 3. ZTD trend in m/yr for stations BRST, GRAS and SJDV from a simple linear fit through the unfiltered ZTD evaluations.

Figure 3 presents a quick test of the possible impact of our long term ZTD evaluations by calculating the ZTD trend at 3 ancient stations available already in the beginning of 1998 (BRST, GRAS and SJDV). This trend is calculated over successively increasing time spans to obtain an idea of the degree of convergence of the ZTD trend to its final value (and the uncertainty of the evaluation over the total analyzed measurement span). Even though the calculations consist in the simple estimation of a linear trend through the ZTD time series, without removing the annual signal but taking into account the uncertainties of the ZTD evaluations, ZTD trends converge to values of the order of 0.5 mm/yr ZTD for the three stations. This corresponds to the order of magnitude of Precipitable

Water Vapor (PWV) trends evaluated elsewhere (0.5 mm/yr ZTD ~ 0.075 mm/yr PWV), however with a quite large variability with respect to site location and data processing. The prevailing annual signal is due to our basic trend estimation technique that is known to be limited. The trend estimation can be done more precisely by more sophisticated approaches (Steigenberger et al., 2007; Nilsson and Elgered, 2008; Morland et al., 2009; Sohn and Cho, 2010; Haas et al., 2011), but in the scope of this paper, this simple test shows that our re-analysis will certainly provide new constraints on water vapor climatology.

5. ZTD DATA BASE

The data that we will make available in the HyMeX data base on www.hymex.org are: full lists of station coordinates, station characteristics according to Table 1, ZTD time series with formal errors, NS and EW gradient time series with their formal errors. We chose to provide high quality geodetic information with the homogeneously calculated time series using an up-to-date data analysis strategy, including a quality control. This information is ready and available for highly precise exploitation. Dependent on the application, users can chose their algorithm for ZTD/gradient trend estimation, conversion from ZTD to PWV using pressure and temperature from synoptic networks or weather models, etc.

6. CONCLUSIONS

GPS data from 181 permanent stations extracted from different networks covering France and the Italian part of the Alps are used to estimate a homogeneous set of tropospheric parameters over 14 years (from January 1998 to May 2012). The quality checked data base of ZTD and gradient values will be published in the framework of the international HyMeX project (www.hymex.org). The tropospheric parameters are obtained in a GPS network that is particularly dense in the Mediterranean region and over the French-Italian Alps. Both are interesting test areas for meteorological and climatological analyses, so that our ZTD/gradient data base will constitute a significant contribution to such studies. Thanks to the length of the data set in time, a regional climatological approach could permit identifying specific patterns of ZTD variation that are related to severe weather events. The regional GPS stations could then contribute to an early warning system.

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APPENDIX

Station names and coordinates in WGS84, as well as corresponding sub-network.

Site	lat [°N]	lon [°E]	alt [m]	net
ACCE	44.476	6.988	1321.7	3
ACOR	43.364	-8.399	66.9	1
AGDE	43.296	3.466	65.8	2
AGNE	45.468	7.140	2354.6	2
AIGE	46.248	6.128	473.7	3
AIGL	44.121	3.581	1618.8	1
AJAC	41.927	8.763	98.8	1
ALAC	38.339	-0.481	60.3	1
ALPE	45.087	6.084	1892.2	2
ALSN	44.923	8.616	146.7	3
AMB2	45.541	3.750	617.6	2
ANCY	45.901	6.123	528.8	3
ARAN	45.715	5.425	289.2	3
ARGR	45.947	7.005	2834.8	2
AUBU	48.217	7.197	1151.8	3
AXPV	43.491	5.333	229.4	1
BACT	44.388	6.650	1205.2	2

BAJA	43.904	7.719	921.8	3
BANN	44.369	4.156	357.6	1
BAST	42.001	9.049	855.1	3
BAUB	43.877	3.967	211.0	2
BEA2	42.515	3.137	108.2	3
BEVE	44.194	9.769	144.7	3
BIEL	45.561	8.048	480.5	1
BLGN	46.172	5.574	544.7	3
BLIX	43.874	6.367	1077.1	3
BOUS	46.288	2.236	558.5	3
BRET	48.610	2.315	140.3	1
BRST	48.380	-4.497	65.8	1/2/3
BSCN	47.247	5.989	359.6	1
BUAN	48.486	5.354	416.3	2
BURE	44.633	5.911	2614.6	1
BUSL	45.137	7.152	496.2	3
CAGL	39.136	8.973	238.4	1/2/3
CAMN	44.405	8.281	390.1	3
CANL	44.722	8.293	205.5	3
CARZ	46.042	8.680	1165.3	2
CBRY	45.581	5.909	324.7	2
CERN	46.257	6.061	525.9	3
CHAM	45.111	5.881	1874.6	1
CHIV	44.320	9.324	70.7	3
CHIZ	46.133	-0.408	113.2	1
CHMX	45.926	6.873	1120.8	2
CHRN	43.881	4.862	103.0	1
CHTL	45.304	6.359	850.3	1
CLAP	44.248	6.927	1369.9	1
CLFD	45.761	3.111	473.6	2
COMO	45.802	9.096	292.3	1
CORT	42.299	9.153	499.4	3
CRAL	43.128	0.367	658.3	3
CRSN	45.192	8.106	211.7	3
CUOR	45.388	7.648	483.1	3
DEMN	44.316	7.293	862.7	3
DEVE	46.314	8.261	1679.4	2
DOMS	46.119	8.286	365.6	3
EBRE	40.821	0.492	107.8	1
EGLT	45.403	2.052	667.0	1
EOST	48.580	7.763	213.3	2
ERCK	48.873	7.364	296.1	3
ESAB	45.307	4.798	207.7	2
ESCO	42.694	0.976	2508.4	1
EZEV	43.774	7.497	76.7	3
FCLZ	45.643	5.986	1358.3	1
FERR	45.867	7.028	2400.3	2
FJCP	43.048	2.795	322.7	1
FLRC	44.325	3.595	607.9	3
FOND	45.820	6.964	1505.3	3
GENO	44.419	8.921	155.5	1
GENU	44.403	8.959	127.4	3
GINA	43.676	5.787	382.0	1
GLRA	44.839	4.524	814.0	2
GOPE	49.914	14.786	592.6	1
GOZZ	45.747	8.433	416.6	3
GRAS	43.755	6.921	1319.3	1/2/3
GRAZ	47.067	15.493	538.3	1/2/3
GRJF	45.303	1.514	458.6	3
GUIL	44.662	6.662	1171.1	2
HERS	50.867	0.336	76.5	1/2/3
JANU	44.910	6.710	2583.9	2
JOUX	46.529	5.796	845.5	1
LACA	43.681	2.728	1315.5	2

LAMP	35.500	12.606	57.8	1
LEBE	45.916	5.625	940.6	2
LFAZ	45.117	5.399	1071.2	2
LOAN	44.119	8.250	70.8	3
LROC	46.159	-1.219	57.9	1
LUCE	47.438	7.268	741.6	2
LUCI	42.386	9.531	63.7	3
LUMI	42.603	8.827	57.0	3
LURI	42.888	9.476	54.2	3
MAKS	47.923	7.032	1237.2	2
MANS	48.019	0.155	168.1	1
MAR2	46.122	7.071	644.1	2
MARG	46.084	6.511	524.2	2
MARS	43.279	5.354	61.8	1
MART	46.122	7.071	644.7	1
MATE	40.649	16.704	535.7	1/2/3
MDOR	45.799	4.809	330.6	1
MEDI	44.520	11.647	50.0	1/2/3
MICH	43.924	5.717	628.2	1
MLVL	48.841	2.587	160.5	1
MODA	45.214	6.710	1182.3	1
MOGN	46.148	4.803	233.0	2
MONC	45.074	7.927	464.5	2
MONV	44.390	7.829	637.7	3
MRGE	45.770	7.061	1722.8	2
MTPL	43.637	3.865	120.3	1
NARB	43.198	2.973	72.8	3
NICA	43.703	7.227	256.5	1
NICE	43.725	7.300	427.3	1
NIME	43.829	4.357	106.2	2
NOT1	36.876	14.990	126.3	1
NOVA	45.447	8.614	218.6	1
NOVR	45.447	8.614	218.6	3
OATO	45.042	7.765	658.8	2
OGAG	44.788	6.540	1356.5	3
OPME	45.713	3.090	708.0	3
OPMT	48.836	2.335	122.6	1
OSTA	44.692	7.188	1309.4	3
PALI	43.376	4.811	60.4	2
PANA	48.855	2.394	120.6	2
PARD	43.431	2.824	622.8	2
PARO	44.446	8.081	849.8	2
PAVI	45.203	9.136	143.7	1
PDOM	45.772	2.948	1466.8	3
PERP	42.689	2.882	96.0	2
PIAA	42.235	8.629	543.4	3
PIAN	41.495	9.056	153.1	3
PIMI	42.936	0.143	2923.4	3
PLOE	47.746	-3.427	73.9	2
POTS	52.379	13.066	144.4	1/2/3
PQRL	42.983	6.206	112.3	1
PRNY	46.905	6.338	883.6	2
PUYA	44.858	6.479	1690.3	2
PUYV	45.044	3.879	710.3	2
RABT	33.998	-6.854	90.1	1
RIXH	47.733	7.378	366.8	3
ROSD	45.691	6.628	1694.5	2
ROSI	45.625	6.856	1880.0	3
ROTG	48.718	-3.966	56.1	3
RSTL	43.941	5.484	1069.8	1
SAAN	46.516	7.301	1419.5	1
SARI	41.858	9.403	57.2	3
SAUV	44.255	4.467	367.4	1
SAVI	44.648	7.661	380.4	3

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SCDA	44.795	3.268	1115.4	2
SCLP	45.750	4.426	703.8	2
SCOP	41.754	9.101	928.0	3
SERR	44.731	8.853	251.2	3
SETE	43.398	3.699	53.9	2
SFER	36.464	-6.206	84.2	1/2/3
SIRT	48.712	2.209	217.5	2
SJDV	45.879	4.677	432.4	1/2/3
SLVT	43.920	3.268	811.8	2
SMNE	48.844	2.425	126.3	1
SMTG	48.641	-2.028	57.8	3
SOPH	43.611	7.054	178.8	1
SOUS	44.875	2.027	597.7	2
STBX	44.259	4.197	219.3	3
STEY	45.235	5.762	1394.9	1
STJ9	48.622	7.684	237.2	1
STMR	43.449	4.422	56.1	2
STPS	46.308	3.294	299.7	2
STV2	44.567	6.106	814.7	2
TENC	45.125	4.288	936.5	1
TETN	35.562	-5.363	63.7	1
TLSE	43.561	1.481	207.2	1
TORI	45.063	7.661	310.8	1/2/3
TRMO	44.285	2.725	810.9	3
TROP	43.219	6.601	369.3	2
TUDA	42.604	9.362	457.7	3
VAUD	46.981	5.627	271.5	2
VILL	40.444	-3.952	647.4	1/2/3
VILR	45.073	5.552	1076.7	2
VISN	44.320	4.949	245.7	2
VSFR	48.815	1.870	124.1	2
WELS	48.415	7.351	819.1	1
WSRT	52.915	6.605	82.3	1/2/3
WTZR	49.144	12.879	666.0	1/2/3
ZERM	46.001	7.732	1931.2	2
ZIMM	46.877	7.465	956.3	1/2/3

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