TURKISH PERMANENT GPS NETWORK: INTRODUCTION

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Abstract

The establishment and the development of three-dimensional geodetic networks supported by continuous Global Positioning System (GPS) data are capable of yielding valuable data in order to enable regional realization of the International Terrestrial Reference Frame (ITRF) and monitor the deformation of the lithosphere. Providing 24-hour continuous data in connection with International GPS Service (IGS) global stations, the Turkish Permanent GPS Network (TPGN) has been being established since 1999. The basic goal of this network stations is to give adequate information for all GPS based survey activities and monitoring deformation throughout Turkey as well.

Introduction

The General Command of Mapping (GCM) has considered the requirement of continuously tracking GPS stations in Turkey for monitoring tectonic activity, given the outcomes obtained from its campaign based GPS projects held periodically since 1988. The basic motivation behind such a plan is very similar to those of world's existing permanent arrays considering the high rates of regional and local deformation caused by inter-plate deformation throughout Turkey.

Other requirements for establishing permanent stations are based on both off-line and real-time data availability, imposed by global, regional geodetic and local survey activities. Therefore, the aims for continuously operating stations may be specified as:

a. Data contribution for the global network of permanent stations (e.g. the International GPS Service, IGS; the Mediterranean Network), enabling the realization of reference systems in the International Terrestrial Reference Frame (ITRF).

b. Monitoring of local and regional crustal deformation, enabling earthquake prediction and hazard assessment.

c. Controlling the height system and monitoring sea-level changes by tide-gauge fixing between the Turkish National Fundamental GPS Network (TNFGN) and Turkish National Sea-level Monitoring System (TUSELS) stations.

d. Enabling the integration and connection to the European Reference Frame (EUREF) and the European Vertical Network (EUVN) with National Geodetic Control Networks.

e. Provision of raw and/or suitably formatted data for respective other Earth Science research, local cadastral surveys, and Geographic Information System (GIS) activities both in real and near real-time, including transmitting Differential GPS (DGPS) corrections through some specific stations with suitably equipped hardware.

Considering these aims, GCM, as the active mapping authority responsible for geodetic activities in Turkey, initiated the Turkish Permanent GPS Network (TPGN) project in 1999. The preliminary aim of the TPGN is to establish about 16 stations throughout Turkey. The ultimate goal is to install 50 stations, with emphasis on areas with high rate of crustal deformation.

The Present Status of the TPGN

The locations of the existing and planned TPGN stations are shown in Figure-1. Being the first permanent global station in Turkey under IGS, the Ankara Permanent GPS Station (ANKR) has been operating since 1991, serving as master station in all GPS based geodetic activities worldwide. This station has been operated by GCM with a receiver provided by Bundesamt Kartographie und Geodasie (BKG). The BKG has provided two receivers to İstanbul Technical University (İTU) and Karadeniz Technical University (Trabzon-KTU), which have been operational since 1999. The Marmara Region Continuous GPS Network (MAGNET), a relatively dense network around Marmara Sea, is operated by The Scientific and Technical Research Council of Turkey (TÜBİTAK), Marmara Research Center, Earth and Marine Sciences Research Institute (EMSRI), was established in 1998-99 (Figure-1). Gebze (TUBI) and Erdek (ERDT) stations of MAGNET are also incorporated into the TPGN. As part of collaboration between GCM, Massachusetts Institute of Technology (MIT), the University NAVSTAR Consortium (UNAVCO) and Dicle University, DYR2 (formerly DYAR) station has been operational in Diyarbakır since 1997. As part of the same cooperation, Erdemli (MERS) site has been operated since 2000 by Middle East Technical University, Institute of Marine Sciences and GCM. A list of the TPGN stations with their collaborators is given in Table-1.

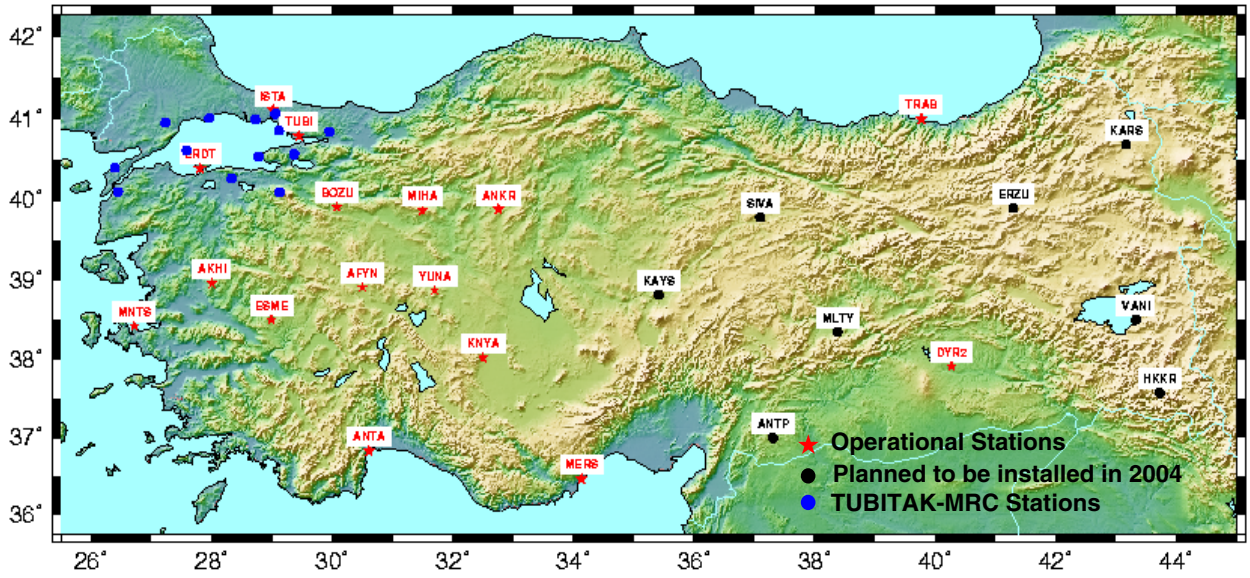

Figure-1: Distribution of TPGN stations (as of MAY 2004)

TPGN data are collected with various types of receivers. The summary of receiver and antenna information of TPGN is given in Table-2.

Beginning in late 1999, the data from these stations has been analyzed by GCM on a daily basis to fulfill some of the above requirements synchronized with IGS operations, their standards and specifications. All data transfers take place over the Internet and the national integrated communication system through GCM, and the data is archived in the existing GPS database. As an example, KNYA site is shown in Figure-2a and instruments used in KONYA (KNYA) site are shown in Figure-2b.

Table-1: List of the TPGN stations with their collaborators.

SITE	4 CH. NAME	ESTABLISHMENT DATE	LOCAL RESPONSIBLE AGENCY	COLLABORATOR AGENCY
ANKARA	ANKR	1991	GCM[1]	BKG[2]
DİYARBAKIR	DYR2	1997	GCM/DİCLE Uni.[3]	MIT[4]/UNAVCO[5]
GEBZE	TUBI	1998-1999	EMSRI[6]	EMSRI
İSTANBUL	ISTA	1999	ITU[7]	BKG
TRABZON	TRAB	1999	KTU[8]	BKG
MERSİN	MERS	2000	METU[9]/GCM	MIT/UNAVCO
ERDEK	ERDT	2002	GCM/EMSRI	GCM/EMSRI
KONYA	KNYA	2003	GCM	COMET[10]/Selçuk Uni.[11]
MİHALIÇÇIK	MIHA	2003	GCM	COMET
EŞME	ESME	2003	GCM	COMET
AKHİSAR	AKHI	2003	GCM	COMET
MENTEŞ	MNTS	2003	GCM	COMET
ANTALYA	ANTA	2003	GCM	COMET
YUNAK	YUNA	2003	GCM	COMET
BOZUYUK	BOZU	2003	GCM	COMET
AFYON	AFYN	2004	GCM	COMET

1: General Command of Mapping (GCM), 2: Bundesamt Kartographie und Geodasie (BKG),
3: Dicle University (DİCLE Uni.), 4: Massachusetts Institute of Technology (MIT),
5: University NAVSTAR Consortium (UNAVCO), 6: Earth and Marine Sciences Research Institute (EMSRI),
7: İstanbul Technical University (İTU), 8: Karadeniz Technical University (KTU), 9: Middle East Technical University (METU), 10: (COMET) Center for the Observation and Modelling of Earthquakes and Tectonics
11: Selçuk University (Sekçuk Uni.)

Table-2: Receiver and antenna information for TPGN sites.

RECEIVER TYPE	ANTENNA MODEL	TPGN SİTES
Turbo Rogue SNR 8000	AOA/Dorne Margolin T	ANKR, MERS, DYR2
Trimble 5700	Zephyr Geodetic with Radome	MIHA, ESME, AKHI, YUNA, BOZU, AFYN
	Zephyr Geodetic	MNTS
Ashtech Z-XII3	ASH700936D_M	ISTA, TRAB
Ashtech UZ-12 iCGRS	ASH701945E_M Snow	ANTA
Trimble 4000 SSI	TRIM29659.00 D_M	ERDT, TUBI, KNYA

2. Data Analyses

Data collected from these permanent GPS stations have been processed on a daily basis using the standard GAMIT/GLOBK GPS processing software (Herring, 2000; King and Bock, 1998). IGS final orbits and International Earth Rotation Service (IERS) Earth Orientation Parameters (EOP) Bulletin B values have been used, and a set of IGS stations covering the region are included in the analysis to establish a link between the regional and the global solutions. The regional station coordinates, satellite state vectors, and 12 tropospheric zenith delay parameters per site for each day are estimated, with the

Figure-2b: Instruments used in KONYA (KNYA) site.

Having finished the GAMIT stage, regional daily solutions have been combined with the global solutions performed by Scripps Orbit and Permanent Array Center (SOPAC). The reference frame is constrained for each day by minimizing the position and the velocity of a reliable set of IGS stations with respect to a no-net-rotation (NNR) frame of International Terrestrial Reference Frame (ITFR00) while estimating the translation, orientation and scale parameters for each day with the origin fixing module (GLORG) of GLOBK.

The time-series analyses of TPGN stations are performed at General Command of Mapping on daily basis. From daily time series, inter-seismic analysis, co-seismic analysis, post-seismic analysis and spectral analysis have been made. ANKR Site Time Series is shown in Figure-3.

The feasibility of TPGN for DGPS operations and a homogeneously distributed high-precision GPS network enable civilian end users to work at ease in variety of applications ranging from large-scale mapping, GIS and cadastral applications.

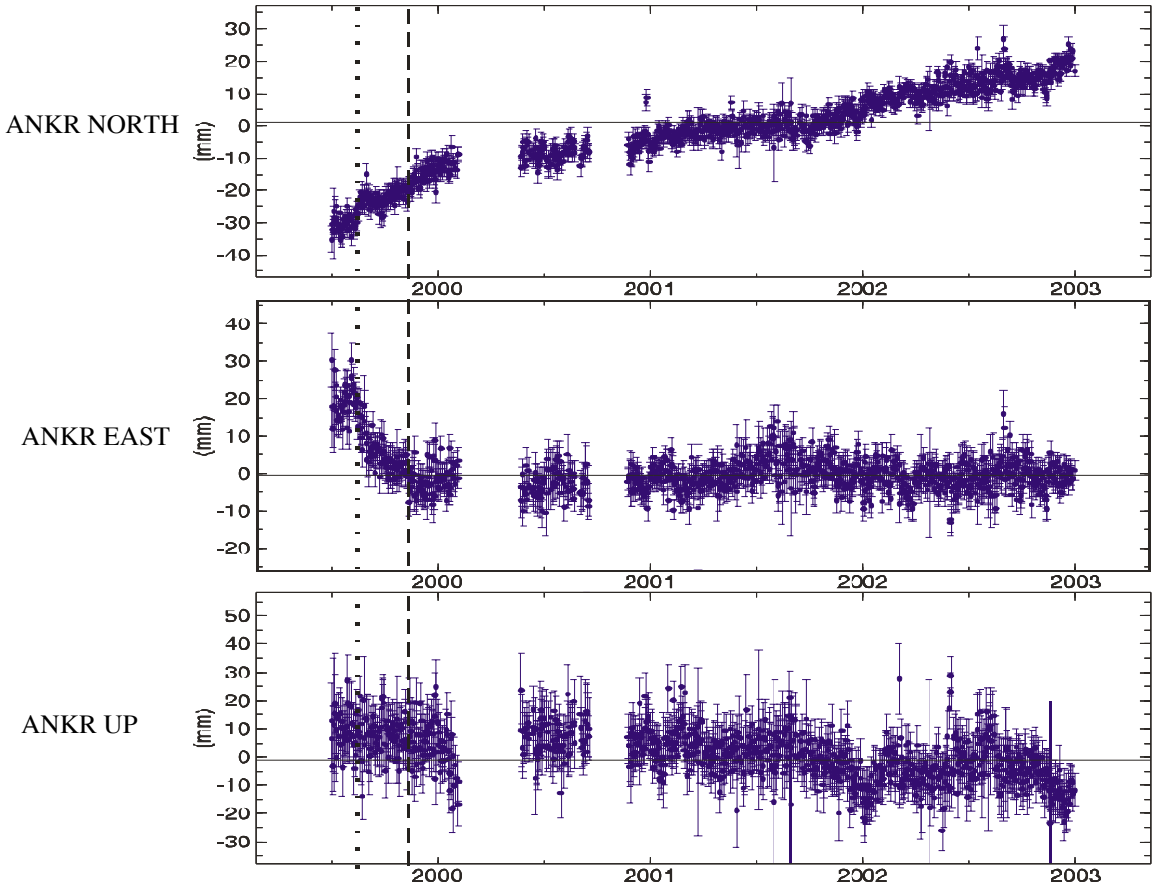

Figure-3: ANKR Time Series

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