INVESTIGATING EFFECTS IN GPS TIME SERIES AND CASE STUDY ON TROPOSPHERIC EFFECTS

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INTRODUCTION

- Time series are a set of values and observed measurements over a period of time, For example, a weekly amount of product exported from the factory, a highway accidents that occur annually, seasonal sea-level height, a fixed point is an example of an annual time series of coordinate changes. The use of time series can be expressed in the form of reporting results of the forward predictive with established by the mathematical models or in unknown time intervals in any way before the temporal data obtained from measurements made at regular intervals or with expected to occur in the future situation.

INTRODUCTION

- Time series analysis is of great importance in the field of engineering. We consider that a very high cost and labor-intensive seen in their realization of the plan-project phases and steps of structures such as dams, bridges, towers and to ensure the continuation of engineering structures. These structures show a different behavior in life expectancy under different loads, such as deformation and displacement. The necessary measures will be provided in time with continuous monitoring of behavior and with this pre-determination of the possible accidents that may occur.

TIME SERIES

- At the periodic points of time, collecting data through observation of a response variable is called a time series (Sincich 1996). Time series appear while saving sequential values of variable in clear time space. Free variable can change content of study topic in time series. It can appear as in Geodesy science changes of coordinate components, in economy science this wholesale price index yearly, exporting of one product yearly for any firm. Data recording space is usually acceptable equal. However, in the practice usually come upon with no equal time series. This situation creates problems in analysis step.

TIME SERIES

- Time series analysis produces summarization properties of a series and outstanding of a series structure. This process can handle in frequency dimension like the time dimension. In other words, while frequency dimension periodic moves can consider, in the time dimension is given point to appearance of between different observations on time's different points. Both of the dimension analysis has properties vitals and same knowledge gives different ideas about a time series' qualitative in different ways.

TIME SERIES

- In statistics, signal processing, econometrics and mathematical finance, a time series is a sequence of data points, measured typically at successive time instants spaced at uniform time intervals. Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the use of a model to predict future values based on previously observed values. Time series are very frequently plotted via line charts.

TIME SERIES

- In a classical model, time serial has a four component (Mann 1995).
- ✓ Long-term common trend, T
- ✓ Conjecture wave, C
- ✓ Seasonal wave, S
- ✓ Variation and irregular randomly motions, I

Y=T.C.S.I

Time series aim for statically is investigation of mentioned above each of four components how much effective take value on the event.

TIME SERIES

- **Trend** is naming which a time series shows a clear route tendency. If trend components find in time series, conforming of line or curve equation with LSM could obtain for separation of this component from series.
- Few method's using for calculate of Trend.
  - The graphical method
  - Moving averages method
  - Principle of least squares method

TYPES OF TIME SERIES

- Autocorrelation function
- Partial autocorrelation function
- The moving average (Moving Average, MA) series
- Autoregressive (auto regressive, R) series
- Difference equations
- Autoregressive moving average (ARMA) series
- Holt-Winters exponential smoothing forecasting model
- The Fourier technique and seasonal time series.

IN PERMANENT GNSS STATIONS FACTORS AFFECTING TIME SERIES

- The effect of satellites,
- The long-term multipath effects,
- Atmospheric effects,
- Hardware effects,
- Seasonal effect (ocean loading, streams of ocean, tidal effect, glacial effects, ocean stream,
- Tropospheric effects (temperature and pressure),
- Earthquake effect (postsismic, co-sismic and inrtersismic effect), fault movements
- Global plate movements etc.

NUMERICAL APPLICATION

- Time series raw data of IGNSS stations in Turkey
- ✓ ANKR (20805M002),
- ✓ TUBI (20806M001),
- ✓ ISTA (20807M001),
- ✓ TRAB (20808M001),

NUMERICAL APPLICATION

GNSS station used in time series analysis

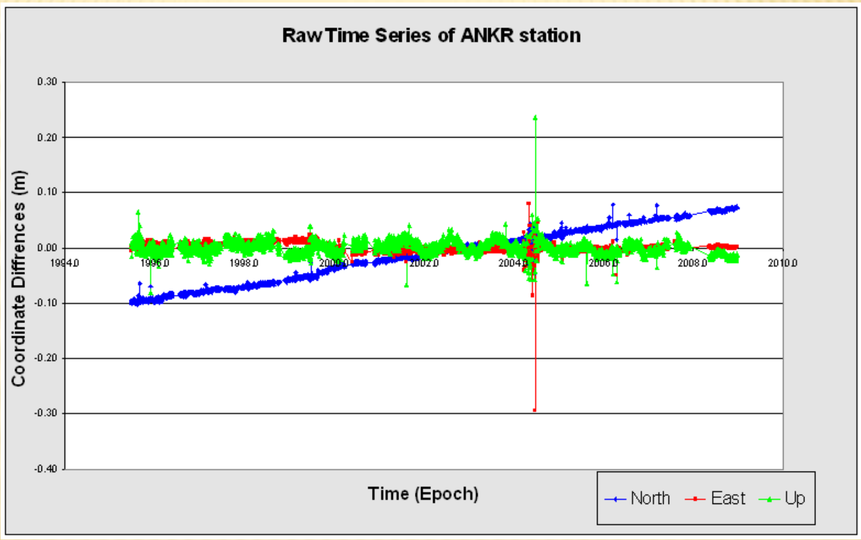
NUMERICAL APPLICATION

- The raw data of N (North), E (East) ve U (Up) local coordinates components of these stations from the Scripps Orbit and Permanent Array Center (SOPAC) GPS archive (web-1, 2009).

NUMERICAL APPLICATION

- Dates of the data cover
  - ✓ the period from 26/06/1995 to 12/21/2008 in ANKR station,
  - ✓ the period from 21/12/1995 to 08/05/1998 in TUBI station,
  - ✓ the period from 26/12/1999 to 12/21/2008 in ISTA station,
  - ✓ the period from 26/12/1999 to 28/11/2007 in TRAB station.

NUMERICAL APPLICATION



NUMERICAL APPLICATION

- Up component of four stations' coordinate time series is similar to the periodic due to seasonal effects and it appears to have been seen to act. In addition, the unusual changes were noticed in up component and these changes that changes caused by earthquakes are assumed. Firstly, the data interruptions of stations and gaps in time series were examined. For these gaps and interruptions, time series were analyzed. The long-term discontinuities in the stations were analyzed separately for different ranges of epochs.

- Then V-test was performed to determine outliers. Thus the outliers were eliminated from time series. Then, in height component of time series, periodic changes or seasonal effects were detected. So covering the years 1995 and 2008 daily average temperature and pressure values of four stations were obtained from General Directorate of State Meteorology Affairs. Regression analysis of height component was performed with according to the average pressure and average temperatures.

NUMERICAL APPLICATION

- In the measures made for sample the elements x1, x2, ..., xn, V-statistics is used to examine the values showing the greatest difference whether belonging to the same set or not.
- For the implementation of this test

$$S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

S root mean square of value must be calculated.

- Here V;

$$V = \frac{\left|X_E - \bar{X}\right|}{S}$$

NUMERICAL APPLICATION

- V - Statistics were performed separately for every period of application because of big range of data. The purpose of this test, one can understand whether the series are stationary or not when one investigate the long periodic time series. As a result, values not outlying must stay in the own time series.
- According to V-statistics, outliers were extracted from time series of four station .In table 1 outliers of ISTA station are seen. There is much outlier in the other stations. But in this paper other outlier tables are not presented because of big tables.

NUMERICAL APPLICATION

Table 1. Outliers of ISTA station time series

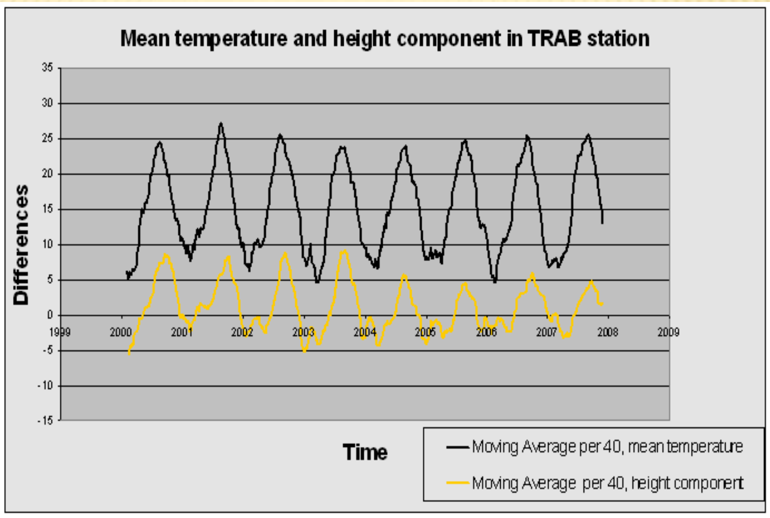
Epoch	Year-Doy	N(m)	E(m)	U (m)
2001.223	2001 082	-0.0284	-0.0817	0.0198
2001.330	2001 121	-0.0211	-0.0851	0.0110
2002.484	2002 177	-0.0109	-0.0444	0.0054
2002.580	2002 212	-0.0218	-0.0266	0.0115
2002.596	2002 218	-0.0213	-0.0349	0.0393
2003.604	2003 221	-0.0168	-0.0185	0.0394
2004.062	2004 023	-0.0041	-0.0026	0.0169
2004.684	2004 251	0.0082	0.0086	0.0041
2005.722	2005 264	0.0051	0.0384	0.0231
2008.575	2008 211	0.0453	0.1026	0.0111
2008.578	2008 212	0.0509	0.1039	0.0107
2008.742	2008 272	0.0496	0.1128	-0.0089

NUMERICAL APPLICATION

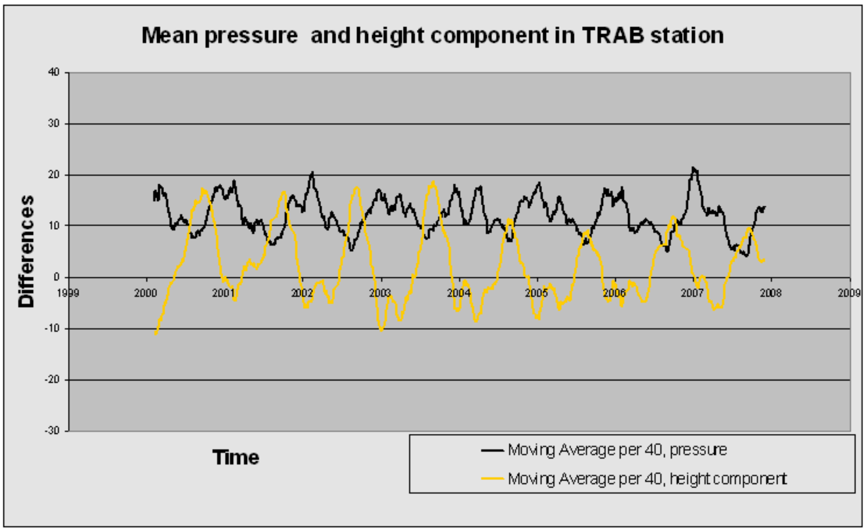
- Regression Analysis of height components in ANKR, TUBI, ISTA ant TRAB GNSS Stations with average temperature and pressure

- Each station's average temperature and pressure values with height components are shown in the graphics e.g. in Figure 3 and Figure 4 TRAB station height components with temperature and pressure values. In these graphics y column is no unit. Two variables multiplied by specific coefficients for better understanding of the visual. Then, regression analysis of height component was performed with according to the average pressure and average temperatures

NUMERICAL APPLICATION



NUMERICAL APPLICATION



NUMERICAL APPLICATION

- Regression Analysis in ANKR Station
- ✓ ANKARA station data was divided into three parts because of long term gaps and regression analysis was made separately for the three sections. The first part of ANKR station, the dates cover the period from 13.08.1999 to 26.06.1995. The second part, the dates cover the period from 17.03.2004 to 25.11.2000. The third part, dates cover the period from 30.11.2007 to 20.07.2004. In table 2, regression analysis coefficients and correlation coefficient with temperature are seen as y=ax+b regression equation. In table 3, regression analysis coefficients and correlation coefficient with pressure are seen as y=ax+b

NUMERICAL APPLICATION

Table 2. Regression Analysis of height components in ANKR Station with average temperature

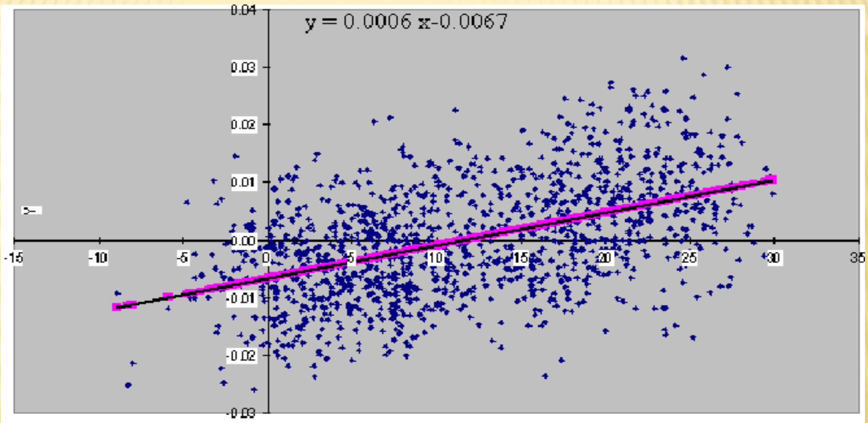
Part number	a	b	Correlation coefficient, R
1	0.0006	-0.0067	0.4874
2	0.0008	- 0.0094	0.7575
3	0.0006	- 0.0081	0.6451

NUMERICAL APPLICATION

Table 3. Regression Analysis of height components in ANKR Station with average pressure

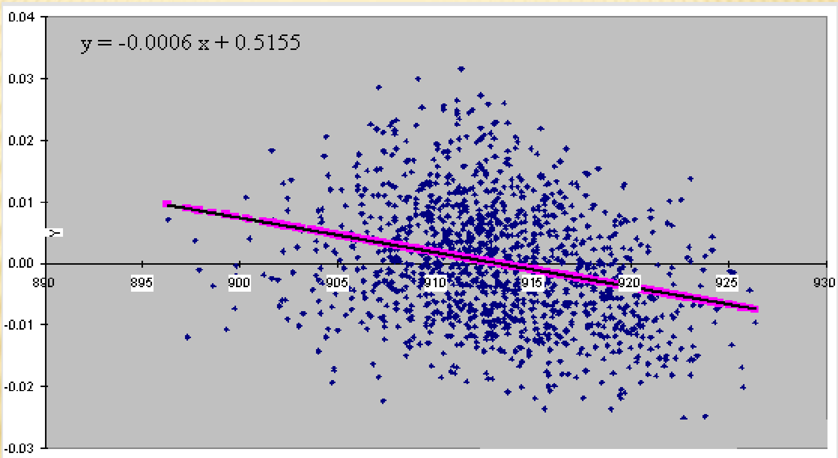
Part number	a	b	Correlation coefficient, R
1	-0.0006	0.5155	-0.2761
2	-0.0006	0.5404	-0.3029
3	-0.0007	0.6150	-0.3772

NUMERICAL APPLICATION



First part of ANKR Station regression line of height components with average temperature

NUMERICAL APPLICATION



First part of ANKR Station regression line of height components with average pressure

NUMERICAL APPLICATION

- Regression Analysis in Other Stations

Table 4. Regression Analysis of height components in other stations with average temperature

Part number	a	b	Correlation coefficient, R
ISTA	0.0011	- 0.0162	0.7876
TRAB	0.0009	- 0.0134	0.6897
TUBI	0.0007	-0.0101	0.6370

Table 5. Regression Analysis of height components in other stations with average pressure

Part number	a	b	Correlation coefficient, R
ISTA	-0.0005	0.5047	-0.3124
TRAB	-0.0007	0.7063	-0.4691
TUBI	-0.0006	0.5924	-0.4605

CONCLUSIONS

- One of the non secular behaviors often observed in GPS time series is the periodic variations with an annual period. The most obvious environmental factors with such period are temperature and pressure. Non-uniform temperature distributions and pressure of Earth surface due to solar radiation and tropospheric layer can cause thermal stress, expansion, subsidence and hence change in displacements and instability at the geodetic sites.

CONCLUSIONS

- In this study, we analyzed time series of GPS stations with temperature and pressure variations in a longer period of time. The GPS time series of stations lead us to assume that the displacement change of the GNSS station due to temperature and pressure. Also there is a linear correlation between height component of station coordinates and temperature. On the other hand inverse correlation between height component of station coordinates and pressure has been seen.

- Thank you for listening