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DORIS TIME SERIES ANALYSIS AND FORECASTING

IDS Workshop

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ABSTRACT. IDS community has been generating weekly station state solutions for more than 50 DORIS network stations worldwide. Generally, permanent station time series include various types of signals, as both real and apparent causes (such as miss-modeled errors, effects of observational environments, random noise or any other effects produced by analysis software and settings of a prior stochastic models. Data analysis to the station time series aims to extract useful signals, such as crustal deformation, seasonal variations of station dynamics etc. The purposes of this study are: (a) identifying the nature of the phenomenon represented by the sequence of observations, and (b) forecasting (predicting future values of the time series variable). Additive model is applied to modeling and forecasting future values the time series of position changes of 4 DORIS sites (lca11wd02 weekly solution) time series from 2006 to 2013: ARFB, LICB, HBMB and KIUB. Regression analysis of irregular part of the height component with troposphere parameters (pressure and temperature) is also considered.

DATA N (North), E (East) and U (Up) coordinates (lca11wd02 weekly solution) components of considered stations from IDS data base cover the period for ARFB station from 8/2006, for LICB station from 12/2005, for HBMB station from 3/2007, for KIUB station from 1/2006 to 12/2013.

METHOD. In a classical model, time serial has four components:

- Trend (Tt) - long term movements in the mean
- Cyclical (Ct) – cyclical fluctuations related to the calendar
- Seasonal (St) – other cyclical fluctuations (such as business cycles)
- Irregular (Et) – other random or systematic fluctuations

Decomposition procedures are used in time series to describe the trend and seasonal factors in a time series. More extensive decompositions might also include long-run cycles, day of week effects and so on. Here, we'll only consider trend, seasonal and irregular decompositions. These components may be combined in different ways. It is usually assumed that they are multiplied or added. Assuming that the seasonal component is relatively constant over time in this research we applied additive model:

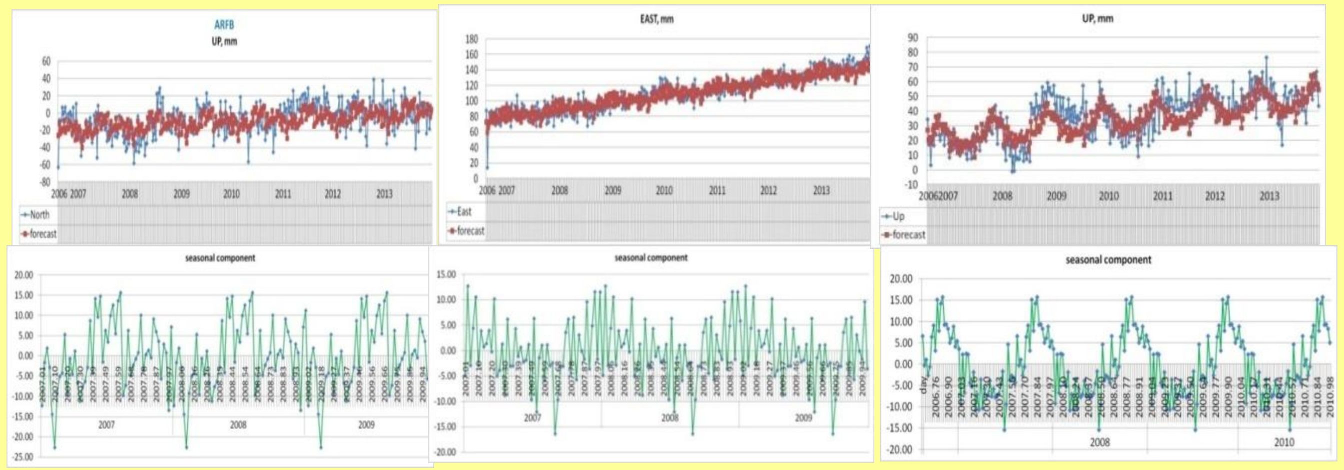
$$Y_t = T_t + S_t + E_t$$

A classical decomposition can be carried out using the following steps:

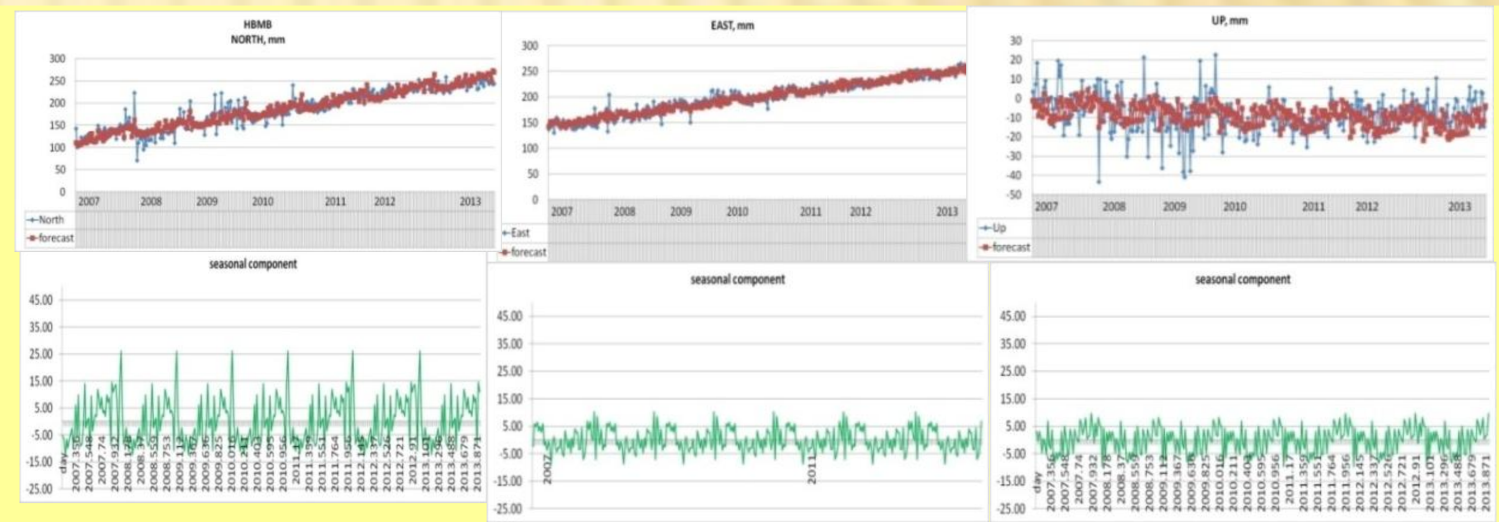
1: The trend cycle is computed using a centered MA of order k.
2: The de-trended series is computed by subtracting the trend-cycle component from the data
3: In classical decomposition we assume the seasonal component is constant from year to year. So we the average of the de-trended value for a given month (for monthly data) and given quarter (for quarterly data) will be the seasonal index for the corresponding month or quarter.
4: the irregular series E_t is computed by simply subtracting the estimated seasonality, and trend-cycle component from the original data.

Results

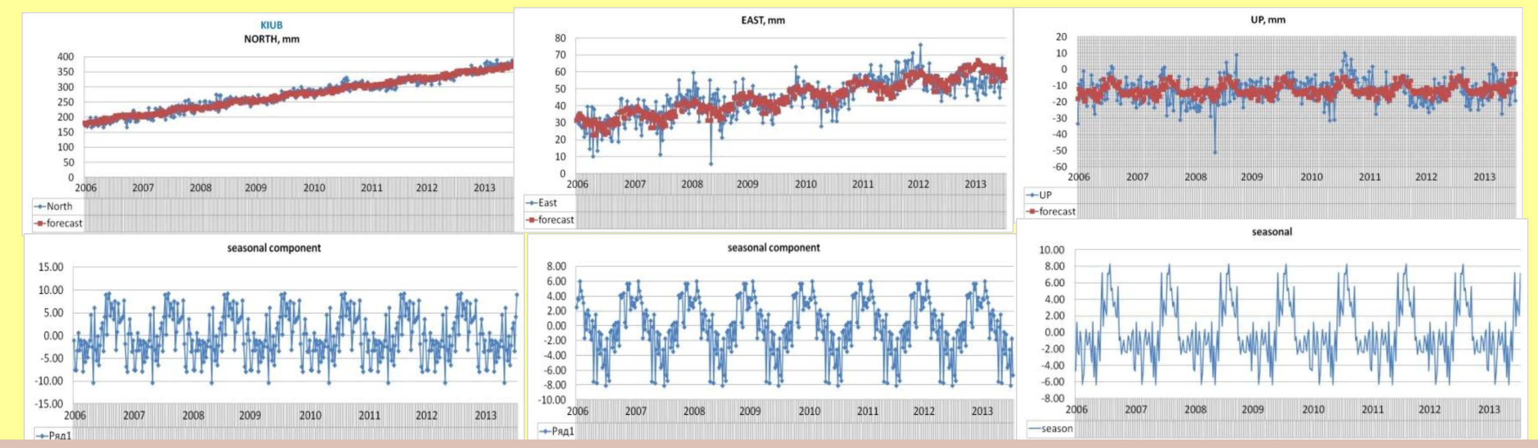
ARFB



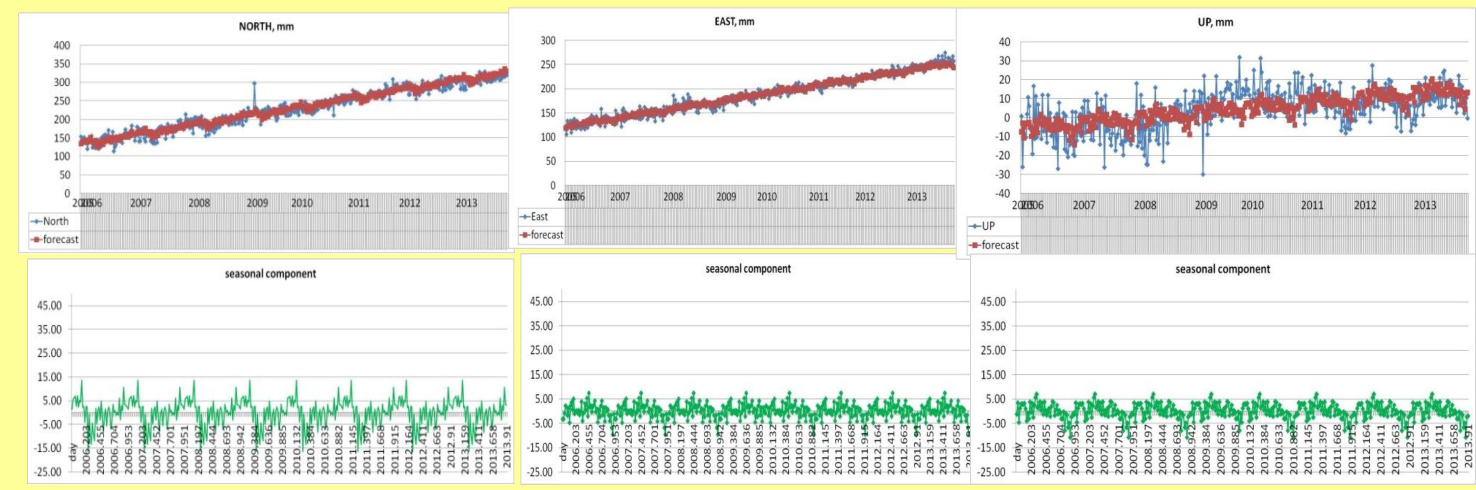
HBMB



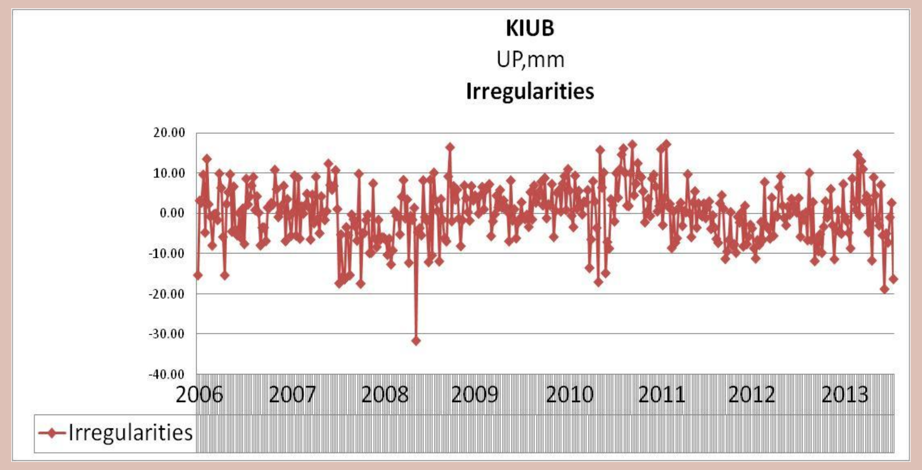
KIUB



LICB

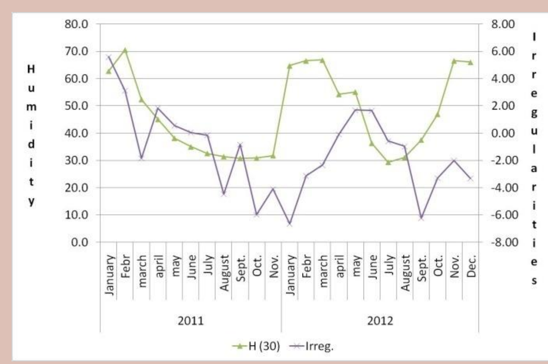


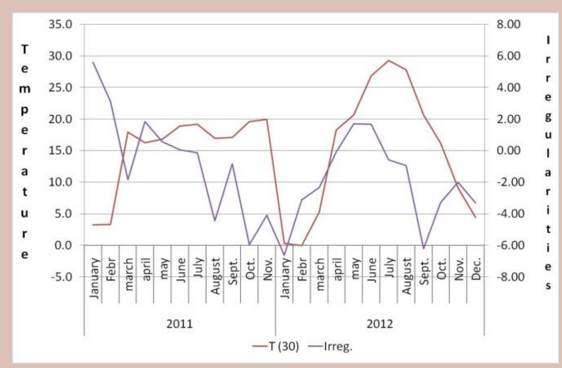
The random component could be analyzed for relationship with temperature and pressure. Irregular constitutes of UP component (E_t)for KIUB station were calculated by removing from original time series values (Y_t) Trend (T_t) and Seasonal (S_t) components. Meteo data for KIT3 /IGS station from ftp://cddis.gsfc.nasa.gov/gps/data/daily were used for analysis for investigation of correlations Irregularities with troposphere parameters (temperature T, pressure P and humidity H). Monthly values of T,P,H were calculated on basis daily data.

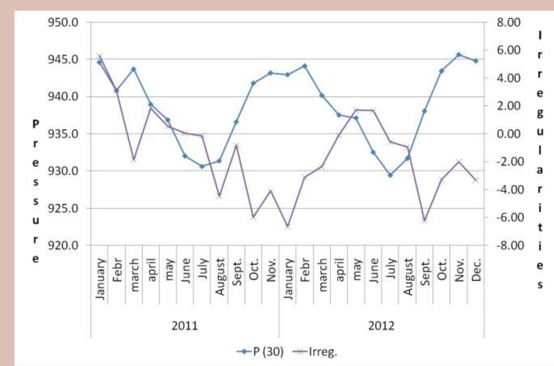


Coefficient of corelation

P	T	H
-0.55	0.57	-0.29







For estimation quality and validity of additive models for DORIS time series the **coefficient of determination, R^2**, was estimated. It is a number that indicates the proportion of the variance in the dependent variable that is predictable from the independent variable. It provides a measure of how well observed outcomes are replicated by the model, based on the proportion of total variation of outcomes explained by the model.

$$R^2 = 1 - \frac{\sum E_t^2}{\sum (y_t - \bar{y})^2}$$

Values of coefficient of determination, R^2

	N	E	U
KIUB	0.96	0.66	0.19
ARFB	0.24	0.85	0.52
LICB	0.93	0.95	0.24
HBMB	0.88	0.94	0.16

Conclusions. The main purpose of this work is to apply the additive model in order to obtain time series decomposition and forecast future values. North, East and Up components of DORIS stations' coordinates up to 2013 are used, trend and seasonal effects are modeled and extracted from time series. According constructed pattern of time series future values of Trend an Seasonal component were calculated and forecast of time series for 2013 was constructed and compared with real data. Additive model explain about 80% for plain coordinates of time series and only about 25% of vertical component Because series lcawd1102 used for the investigation includes some artifacts in vertical (see Soudarin, L., et al. Activity of the CNES/CLS Analysis Center for the IDS contribution to ITRF2014. Adv.Space Res. (2016), http://dx.doi.org/10.1016/j.asr.2016.08.006). Relation Irregularities (error) of Up component for 2 years period of KIUB station data with temperature, pressure and humidity was investigated also. Correlation between temperature (57%, direct) and pressure (55%,back) were found.