

The Detection of Offsets in GPS Experiment (DOGEx): Call for Participation

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Introduction

The accuracy of Global Positioning System (GPS) time series is degraded by the presence of offsets. If these are not detected and adjusted correctly they bias velocities, and hence geophysical estimates, and degrade the terrestrial reference frame. They also alter apparent time series noise characteristics as undetected offsets resemble a random walk process. As such, offsets are now a substantial problem in geodesy. A number of automated offset detection algorithms have been developed across a range of fields, and some of these are now being tested in geodetic time series

Here, we announce a community experiment in detecting offsets in GPS time series (DOGEx) and demonstrate the performance of a few of the offset detection approaches on a variant of the publicly released data set

Methods

◆ We have produced simulated 3-d GPS coordinate time series for 50 "sites". The simulated series contain realistic (and perfectly known) GPS signal, noise, offset frequencies and data gaps (e.g., **Figure 1**). Noise characteristics are modelled on that present in state-of-the-art GPS reprocessing solutions using a "white plus flicker" noise model, although the noise is not necessarily time-constant at each site

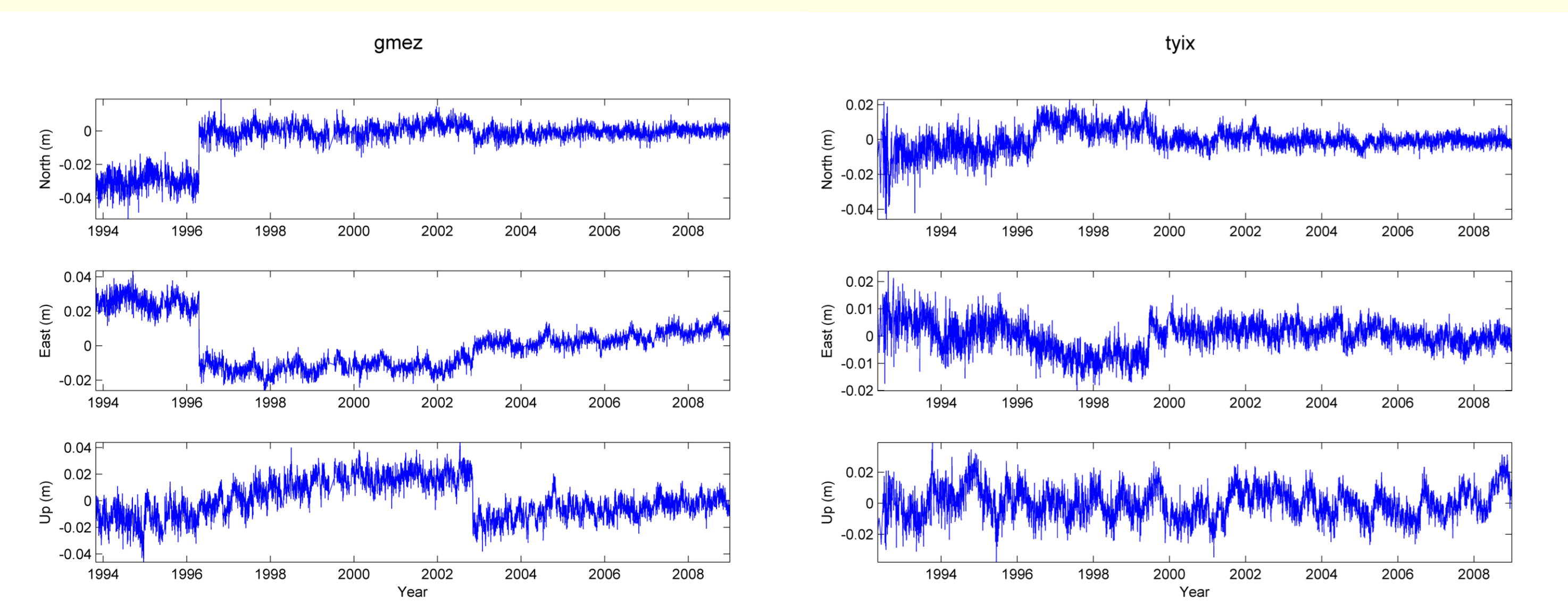


Figure 1 Example DOGEx time series

Experiment Details

- ◆ The DOGEx time series may be downloaded from <http://www.cost-es0701.gcparks.com/working-groups/wg>
- ◆ The true offset times and site velocities will *not* be provided to the community
- ◆ At regular intervals (IGS workshops, EGU, AGU) we will update the community on the best approaches and the effects of undetected or mis-detected offsets on GPS time series, velocities and apparent noise

Some initial results (variant of DOGEx data set)

We have attempted to adopt data homogenisation/segmentation strategies used in the climate, hydrological and bio-medicine time series. Here we present results from 1) a maximum likelihood approach (Picard et al, 2005; **PIC**) with the number of segments chosen using one of two penalising functions (Lavielle, 2005; **LAV**, and Lebarbier, 2005; **LEB**) each considering **HOM**oscedastic and **HET**eroscedastic time series; and 2) a shifting means hidden markov model approach (Kehagias and Fortin, 2006; **K&F**).

Many of the offsets are reliably detected, although over-segmentation frequently occurs (**Figure 2, Table 1**). Errors in site velocities due to offset mis-identification (**Figure 3, Table 1**) are occasionally very large, but generally $\pm 0.5\text{mm/yr}$

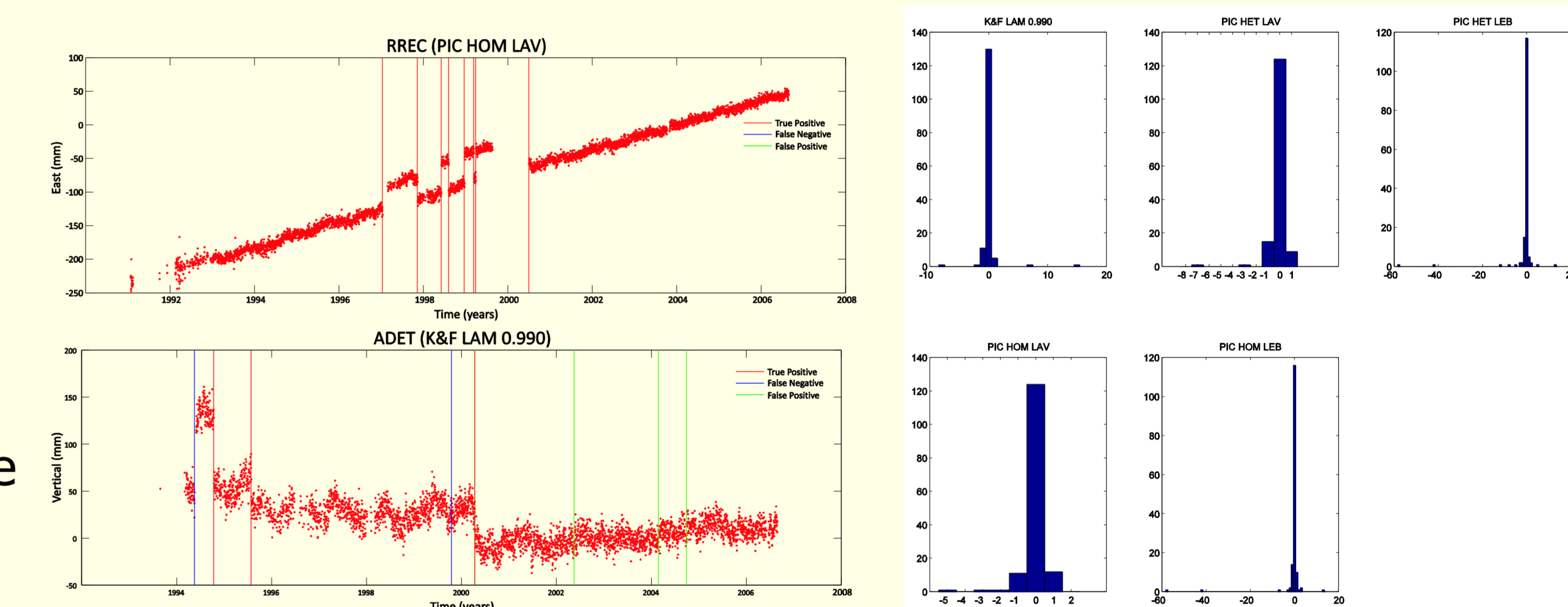


Figure 2 Examples of two sites showing success/failure using the (top) Picard (PIC) approach with HOMoscedastic assumption and the LAVielle (2005) penalty function and (bottom) the Kehagias and Fortin (K&F) with a scaling parameter set to 0.99

Figure 3 Histograms of the rate difference (from truth) when we use the estimated offsets and the true model (without noise), in mm/yr

	Noff	N	E	U	TP	FP	FN	RMS1	IQR	RMS2	% outliers	MAX
K&F_LAM_0.990	811	320	237	254	121	690	185	1.5	0.15	0.18	12	14.7
PIC_HET_LAV	407	142	124	141	104	303	191	0.7	0.15	0.29	4	7.1
PIC_HET_LEB	330	132	102	96	88	242	213	6.1	0.24	0.27	14	58.1
PIC_HOM_LAV	441	144	145	152	120	321	172	0.6	0.15	0.27	6	4.8
PIC_HOM_LEB	294	94	106	94	87	207	208	6	0.19	0.25	15	58.1

Table 1 Number of offsets detected in total (Noff) and by NEU components, and number of true positives (TP), false positives (FP) and false negatives (FN). Actual number of offsets is 306 (102 per component). Also shown are the velocity errors (mm/yr) after estimating rates from the pure model + estimated offset positions in terms of RMS1 (no outlier sites removed), Inter-Quartile Range (IQR), RMS2 (outlier sites removed), % outliers (3-sigma criterion) and maximum velocity error (MAX)

Conclusions

Further work is required in order to accurately determine offsets in GPS time series.

Over-segmentation and mis-identification of offsets near the ends of time series remain problematic. It is likely that techniques developed in other fields will not provide an optimal solution for GPS, at least without modification. We encourage individuals and groups to download the DOGEx dataset and provide solutions to us for assessment

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