A geodetic matched-filter search for slow slip with application to the Mexico subduction zone

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Series of Mw 7.6 Slow Slip Events in the Guerrero Area with ~ 3 years recurrence intervals.
Low Frequency Earthquakes in Mexico

LFEs detected along the MASE profile clustered in two spots:
- the **sweet spot**
- the **transient zone**
Inter-SSE bursts of LFEs

Bursts of LFEs during the inter-SSE period, on the transitional zone

From Frank et al., EPSL, 2014
Average short-term SSE

From Frank et al., GRL, 2015
1. Raw data processed with Gamit / Globk

2. Removal of interseismic signal, linear term, co-seismic step and post-seismic signals

3. Removal of slow-slip periods and linear inter-SSE trends

4. Take the temporal derivative
The synthetic templates

Processed GPS Time Series

Library of synthetic signals

Parameters:
- Location
- Amplitude of slip
- Sliping area
- Duration

From Rousset et al., JGR., 2017
Synthetic tests

Processing of the GPS time series

Library of synthetic signals

Synthetic time series
White and coloured noise + transient events
Weighted correlation function

(1) Computation of the cross correlation for each individual GPS time series

(2) Sum all the correlation functions, weighted by the amplitude of the synthetic template
Processing of the GPS time series

Library of synthetic signals

Detection: Weighted Correlation

Weighted correlation function, stacked over the East and North time series, and weighted by the amplitude of the synthetic template

From Rousset et al., JGR., 2017
The diagram illustrates the processing of GPS time series data. It includes the following steps:

1. **Processing of the GPS time series**
2. **Library of synthetic signals**
3. **Detection: Weighted Correlation**
4. **Stack of displacement GPS time series**

The chart shows a comparison between a **Raw Stack** and a **Weighted Stack** of GPS time series. The Weighted Stack is represented by a red line, while the Raw Stack is shown in black. The graph indicates the displacement in millimeters over time in days. The chart is a visual representation from Rousset et al., JGR, 2017.
Estimation of the events duration

Processing of the GPS time series

Library of synthetic signals

Detection: Weighted Correlation

Sum on stations and components

Extraction of the magnitude and the duration

Graph showing time (Days) on the x-axis and displacement (mm) on the y-axis. Another graph in the inset shows template duration (Days) on the x-axis and residuals (mm) on the y-axis.
Estimation of the events magnitude

Processing of the GPS time series

Library of synthetic signals

Detection: Weighted Correlation

Sum on stations and components

Extraction of the magnitude and the duration

Weighted Correlation

Graph showing time series with displacement and residuals over magnitude.
Application to the Guerrero GPS data

Detection of 28 events from 2005 to 2013

From Rouset et al., JGR., 2017
Example of stack an transient event

From Rousset et al., JGR., 2017
Locations of the detected events

From Rousset et al., JGR., 2017
Conclusion

We developed a method:
(1) to detect short-term transient aseismic events
(2) to characterise their location, duration and magnitude

Compare to other methods, like the NIF:
- The detection threshold of the geodetic matched filter is lower, because it takes into account the redundancy of information in a network of stations.
- It is particularly suited for short-term transients.
- It doesn’t allow neither to characterise the spatial extent of slow slips, nor any propagation.

Applied to the Mexico subduction:
- We have detected 28 new transients events (Mw 6.3 to Mw 7.1) from 2005 - 2014.
- They are located at the down-dip edge of the large slow-slip events.