Postseismic deformation for the 1999 Izmit and Düzce earthquakes from satellite geodesy

Ekbal Hussain*[1], T. J. Wright[1], G. A. Houseman[1], R. J. Walters[1]

*eeehu@leeds.ac.uk,[1] School of Earth and Environment, University of Leeds

INSTITUTE OF GEOPHYSICS AND TECTONICS

UNIVERSITY OF LEEDS

1. INTRODUCTION

The 1999 Izmit and Düzce earthquakes (Mw7.4 and Mw7.2 respectively) occured on the ~1300km long North Anatolian Fault (NAF) which runs across northern Turkey. The fault slips at a rate of ~25mm/yr [1] in a dominant right-lateral sense.

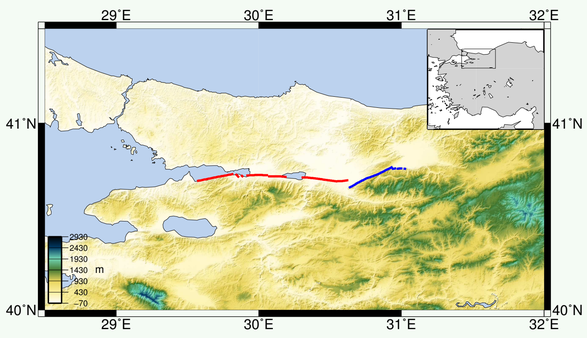

Fig1.1: Mapped surface ruptures of the 1999 Izmit (red) and Düzce (blue) earthquakes.

Abundant geodetic measurements from satellite radar and GPS allow us to investigate the postseismic response of the lithosphere due to these earthquakes.

We present here preliminary results of our InSAR data analysis of Envisat descending track 293 which covers the surface rupture locations for these two earthquakes.

2. METHOD AND DATA ANALYSIS

The Stanford Method for Persistent Scatterers (StaMPS) small baseline[2] approach was used to create a velocity map and displacement time series.

We created a connected network of acquisition dates using intererograms with small temporal and perpendicular baselines.

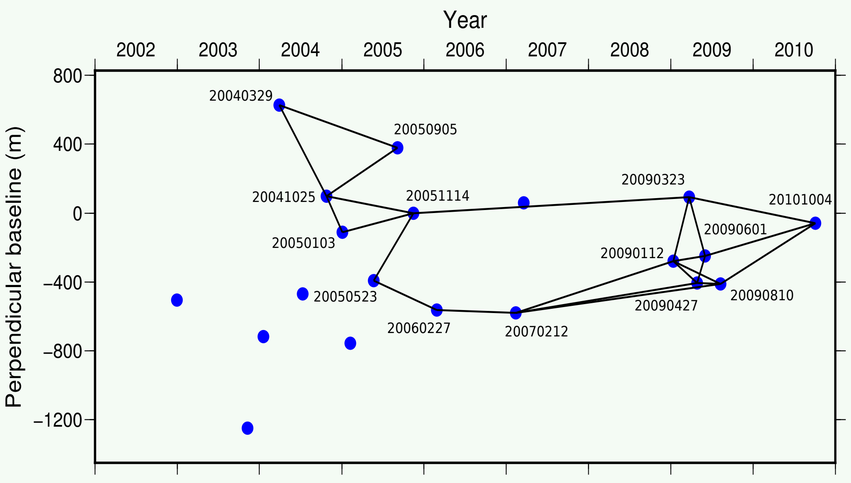

Fig2.1: The interferogram network for Envisat descending track 293 used in our time series analysis. Acquisiton dates not connected to the network had to be discarded due to unwrapping errors.

The interferograms were corrected for orbital and DEM errors, stacked and smoothed to produce a displacement time series and velocity map.

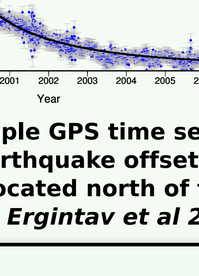

Fig2.2: The interferograms are stacked and smoothed in time to produce a time series of deformation.

3. VELOCITY MAP

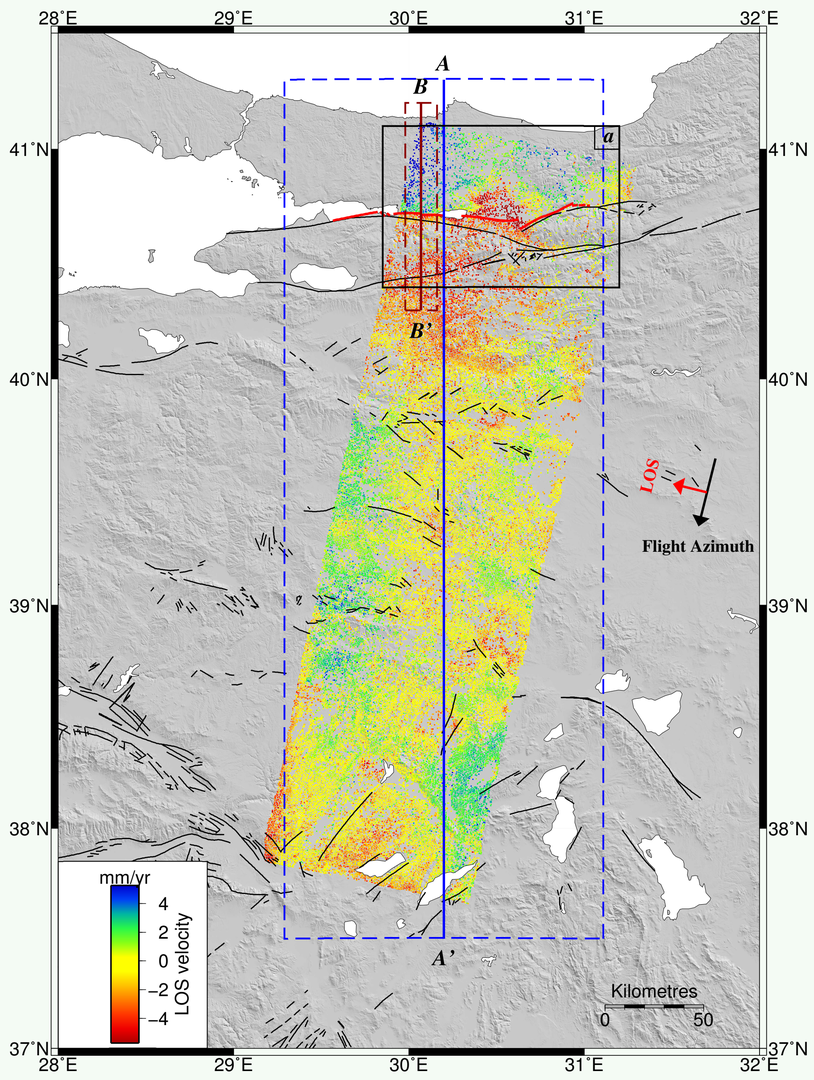

Fig3.1: Velocity map created from the interferogram network shown in Fig2.1. Velocities are with respect to the satellite Line of Sight (LOS) direction and referenced to southern Turkey. Blue colours indicate a decrease in the LOS range and red an increase. The 1999 Izmit and Düzce ruptures are shown in red.

In general the region north of the fault shows a positive velocity in the Line of Sight (LOS) direction indicating motion towards the satellite. The region to the south shows a negative LOS velocity implying motion away from the satellite. This is as expected from a right-lateral strike-slip fault.

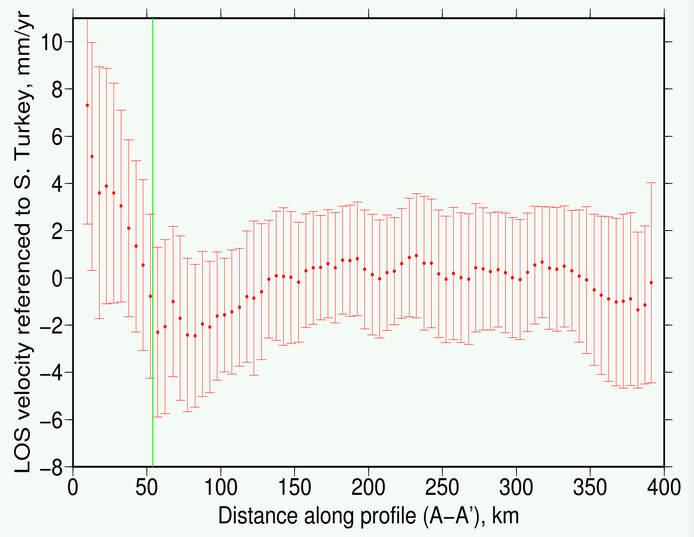

Fig3.2: Profile of velocities projected onto the line A-A' line in Fig3.1. Width of projection: +/- 100km (shown by the blue dashed box), bin width: 5km. Green line indicates location of the 1999 Izmit rupture. Error bars are one sigma.

The magnitude of change across the fault is about 9mm/yr in the LOS, equivalent to ~23mm/yr horizontal motion which matches published fault slip rates [1]. The postseismic signal is evident from the negative velocity increase just south of the fault.

4. CREEP AND SUBSIDENCE

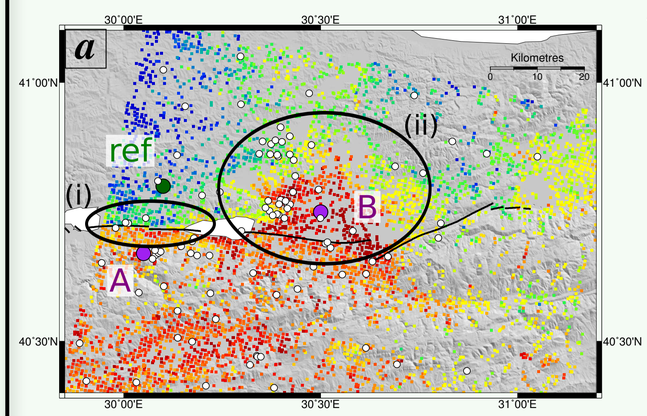

Fig4.1: Blow up of the region labelled *a* in Fig3.1. with the creeping section of the fault indicated by the black ellipse labelled (i). Ellipse (ii) shows an area of LOS range increase. White circles are local micro-seismic earthquakes measured between May 2012 and November 2012 by the DANA seismic deployment installed as part of the FaultLab project [4] *(data from David Thompson)*.

The ellipse labelled (ii) in Fig4.1 indicates a region of anomalous range increase. This can be interpreted to be susidence. And could potentially be due to water pumping within the basin.

A spatial discontinuity in LOS velocities at the exact location of the 1999 Izmit surface rupture indicates a region of shallow creep.

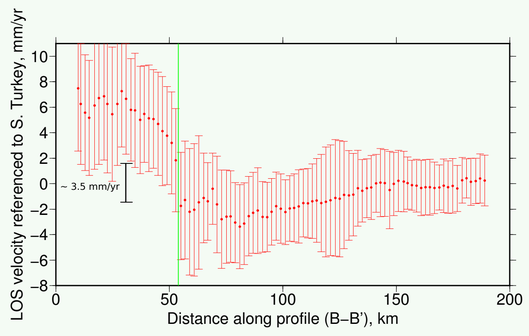

Fig4.2: Profile of LOS velocities projected onto line B-B' crossing the creeping segement shown in Fig3.1. Projection width: +/- 10km (shown by the dark red dashed box), bin width: 2km.

A LOS jump of ~3.5mm/yr across the fault implies a creep rate of ~9mm/yr.

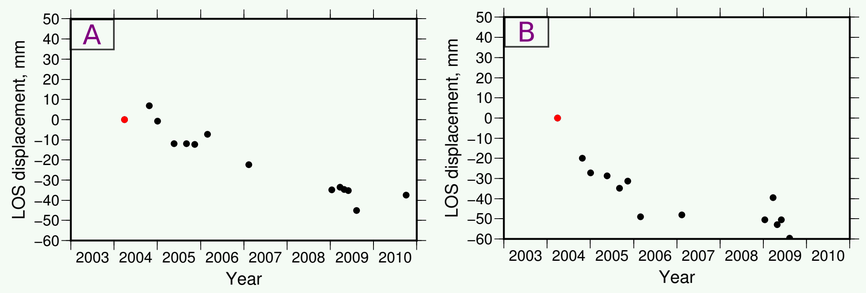

Fig5.1: Displacement time series for the purple points labelled A and B with respect to the green point labelled ref in Fig 4.1.

5. GPS TIME SERIES AND FURTHER WORK

A series of CGPS stations installed before and after the earthquakes provide a time series of displacements.

We will reference our InSAR results to the GPS and extend the time series to 2010.

We will confirm observed signals with more tracks.

We plan to model observed signals using a similar approach to *Yamasaki, Wright & Houseman (2013)* (In Revision) which incorporates a lower crustal weak zone.

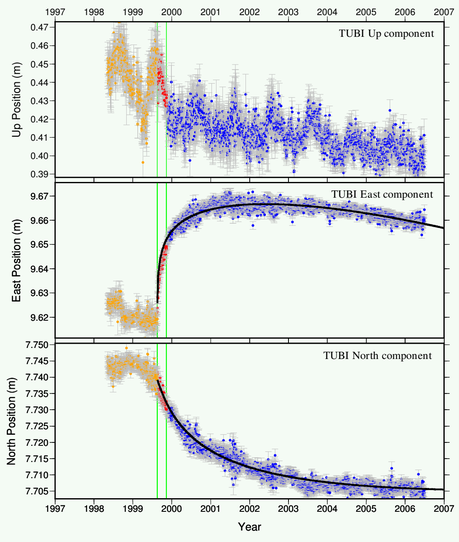

Fig7.1: An example GPS time series corrected for earthquake offsets from a station located north of the fault. Data from *Ergintav et al 2009*.

6. CONCLUSIONS

Preliminary analysis of Envisat descending track 293 produces a fault slip rate of ~23mm/yr which matches previously published geodetic slip rates.

The postseismic signal is superimposed over the interseismic signal and is observed as a decrease in LOS velocity just south of the fault.

The segment of the fault east of Lake Sapanca appears to be undergoing shallow creep. This is observed as a step in the velocity profile. A step of 3.5 mm/yr in the LOS corresponds to a creep rate of ~9mm/yr.

A region of anomalous LOS range increase is observed north of the fault. This could potentially be due to water pumping within the basin or be related to a pull apart basin between the two rupture segments.

7. REFERENCES

[1] McClusky S. et al. *Global Positioning System constraints on plate kinematics and dynamics in the eastern Mediterranean and Caucasus,* JGR, 2000, 105, 5695-5719

[2] Hooper, A. *A multi-temporal InSAR method incorporating both persistent scatterer and small baseline approaches,* GRL, 2008, 35, 16302

[3] Erintav S. et al. *Seven years of postseismic deformation following the 1999, M = 7.4 and M = 7.2, Izmit-Düzce, Turkey earthquake sequence*, JGR (Solid Earth), 2009, 114, 7403

[4]http://www.see.leeds.ac.uk/faultlab

8. ACKNOWLEDGEMENTS

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