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Engineering

Determination of Tsukuba VLBI station post-Tohoku earthquake coordinates using VieVS

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Overview

- Goals and strategy
- Analysis with VieVS
- Results and conclusions
- Further development

Goals

- Determination of initial and post-seismic displacement of Tsukuba VLBI station using VieVS
  - Displacement and coordinates for TSUKUB32
- Create an efficient tool to inspect coordinate time series to be used with VieVS result files
  - Possibility for future VieVS GUI implementation
- Find out possible ways improve VieVS in the process

Strategy

- Select an adequate number of 24-hour R1 sessions before and after the 11 March 2011 earthquake
  - Tsukuba included in R1 sessions
- Identify and deal with problematic sessions
- Try out different parametrizations

Analysis conditions and procedure

- Done with VieVS 1d
- A total of 32 R1 sessions from 2011-01-03 to 2011-09-12
- Modeling options

TRF	VTRF2008
CRF	ICRF2
Ephemerides	JPL421
EOP	C04 08
Precession/Nutation	IAU2006/IAU2000
Tidal ocean loading	FES2004
Mapping function	VM1

Analysis conditions and procedure

- TSUKUB32 and TIGO removed from VTRF2008.mat
  - exclude TSUKUB32 and TIGO from NNR/NNT conditions for all epochs
  - excluded also before the earthquake for consistency
  - TIGO had noisy data -> removing TIGO in OPT-files decreased the std error of mean unit weight
  - Estimated parameters
    - Station position
    - clock parameter 60 min, relative constraint 0.5 ps^2
    - ZWD, 20 min interval, relative constraint 0.7 ps^2
    - Atmosphere gradient, 6h interval, relative constraints, 2mm/day

Analysis conditions and procedure

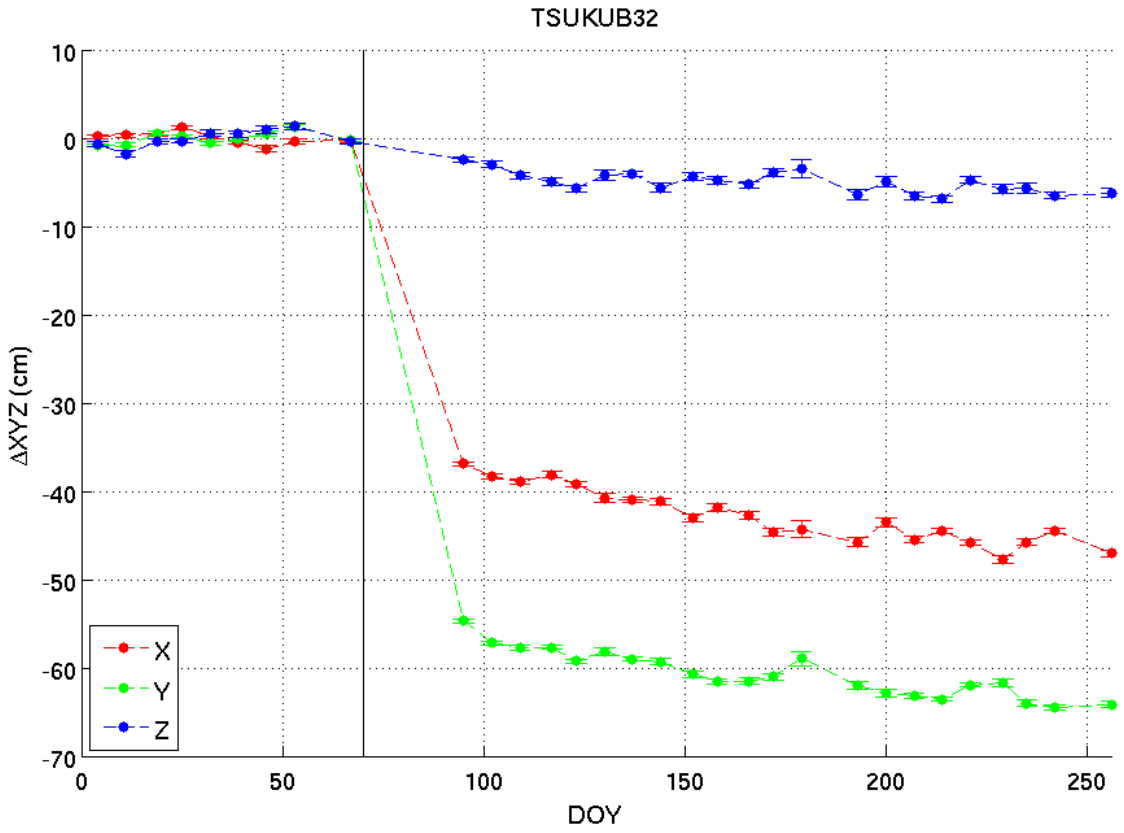
- Each session was first analyzed stationwise without main solution to remove clock breaks, bad baselines and other sources of error e.g. problems with a station
- OPT-files were created for each session. Example (11JAN18XA.OPT):

  CLOCK REFERENCE:
  WETTZELL
  STATIONS TO BE EXCLUDED: 1
  TIGOCONC
  CLOCK BREAKS: 2
  HOBART12 55580.265
  BADARY 55580.386
- One removed due to a crashing issue
  - 11SEP06XA_N004 -> index out of bounds error in Lagrange interpolation
- Main solution applied twice to every session to remove outliers
- - simple outlier test (5*mo)
- - 229 outliers removed

Visualization

- To visualize the resulting time series a Matlab tool was written
- Data initialization and collection (stationwise)
- Generates coordinate time series from the input of VieVS result directory and 8-letter IVS station name
  - e.g. timeseries('resultsdir','TSUKUB32')
  - Time series in ECEF and ENU coordinates
  - Corresponding series of standard error of mean unit weight for session
  - Possibility to divide data/timeseries to inspect a select interval(s)

TSUKUB32 ECEF



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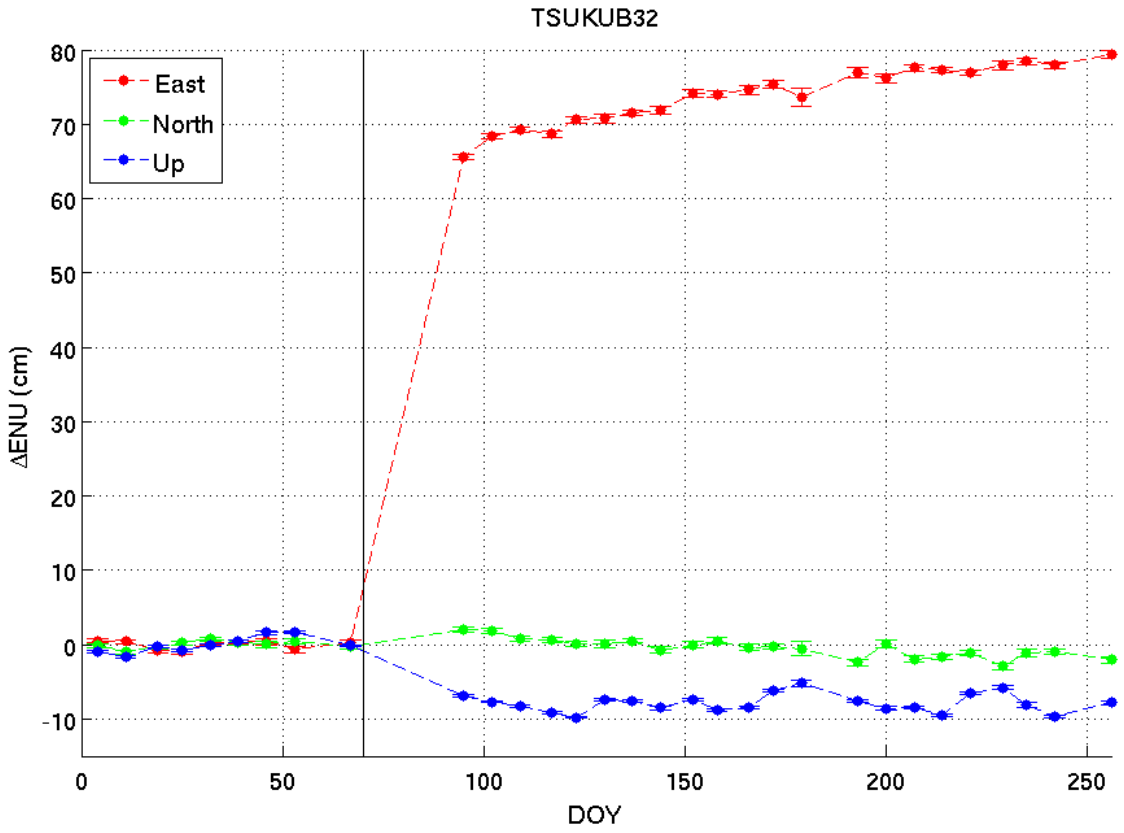
TSUKUB32 ENU



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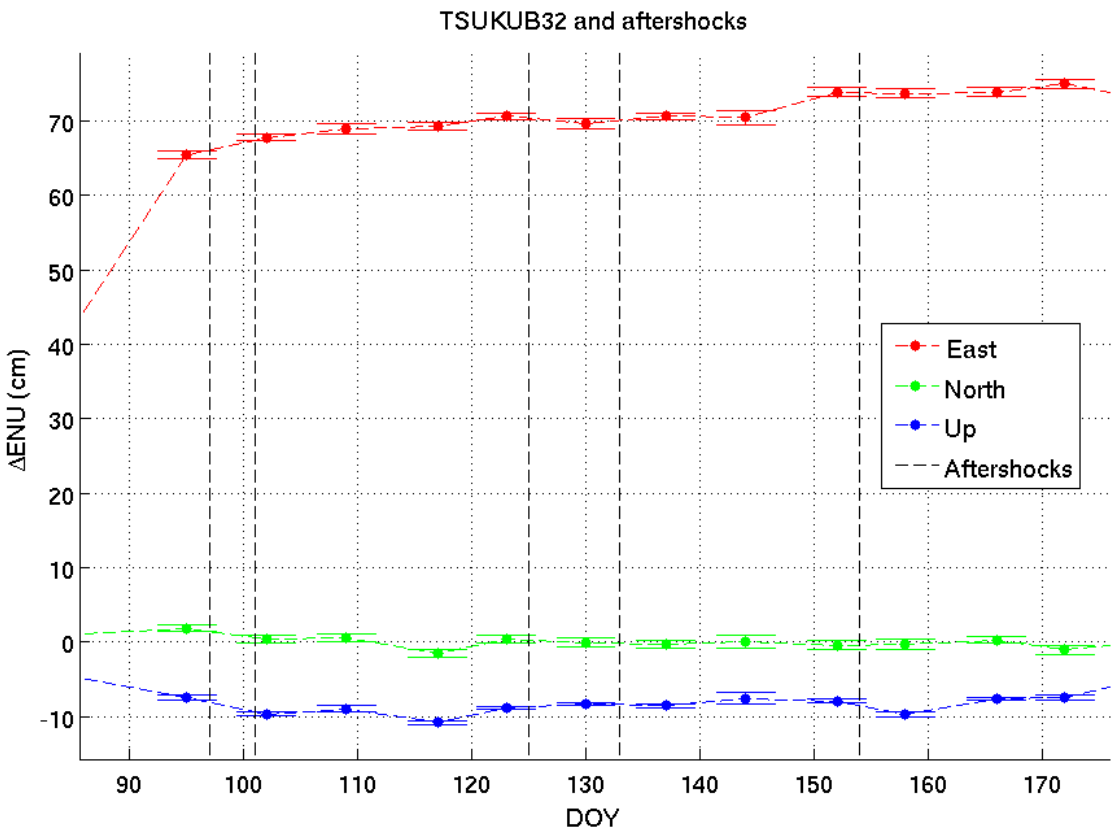
Results and conclusions

- Five of the biggest aftershocks between 2011-04-07 and 2011-06-30 were pictured in the graphs
- From 6.1 to 7.1 Mb (body wave magnitude)
- They do not seem to correspond to any major changes in the solution

Aftershocks



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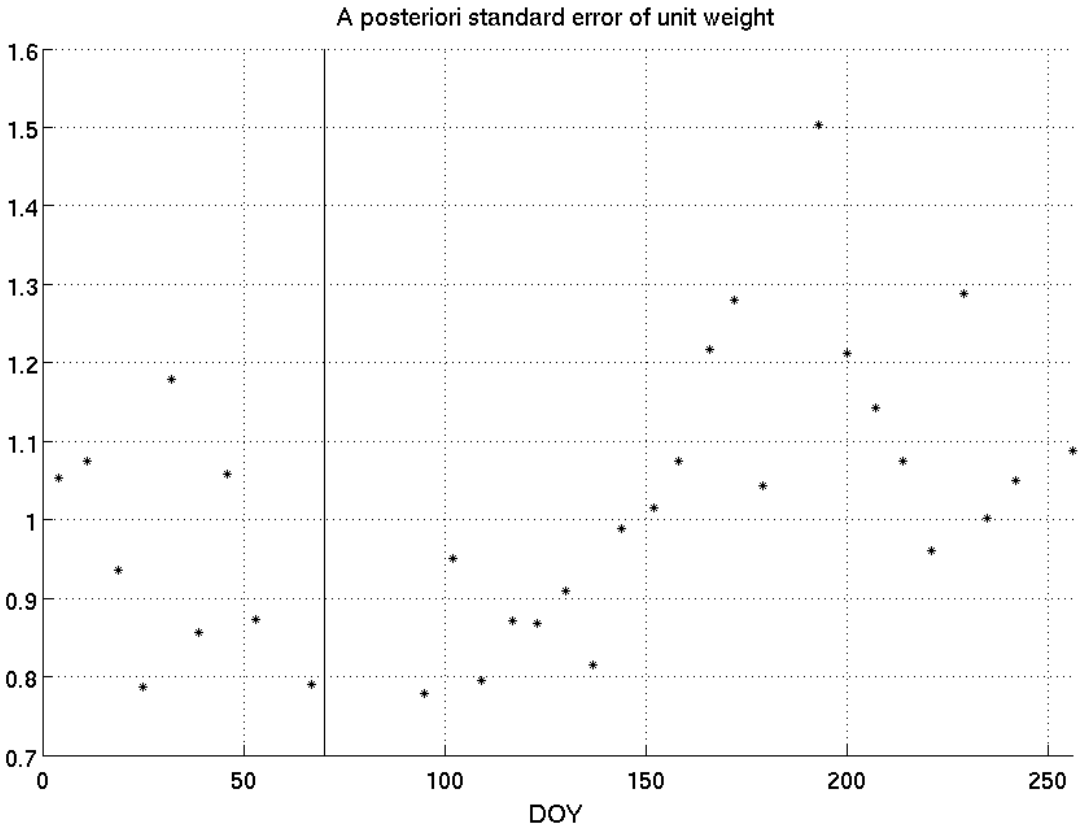
Standard error of unit weight



Results and conclusions

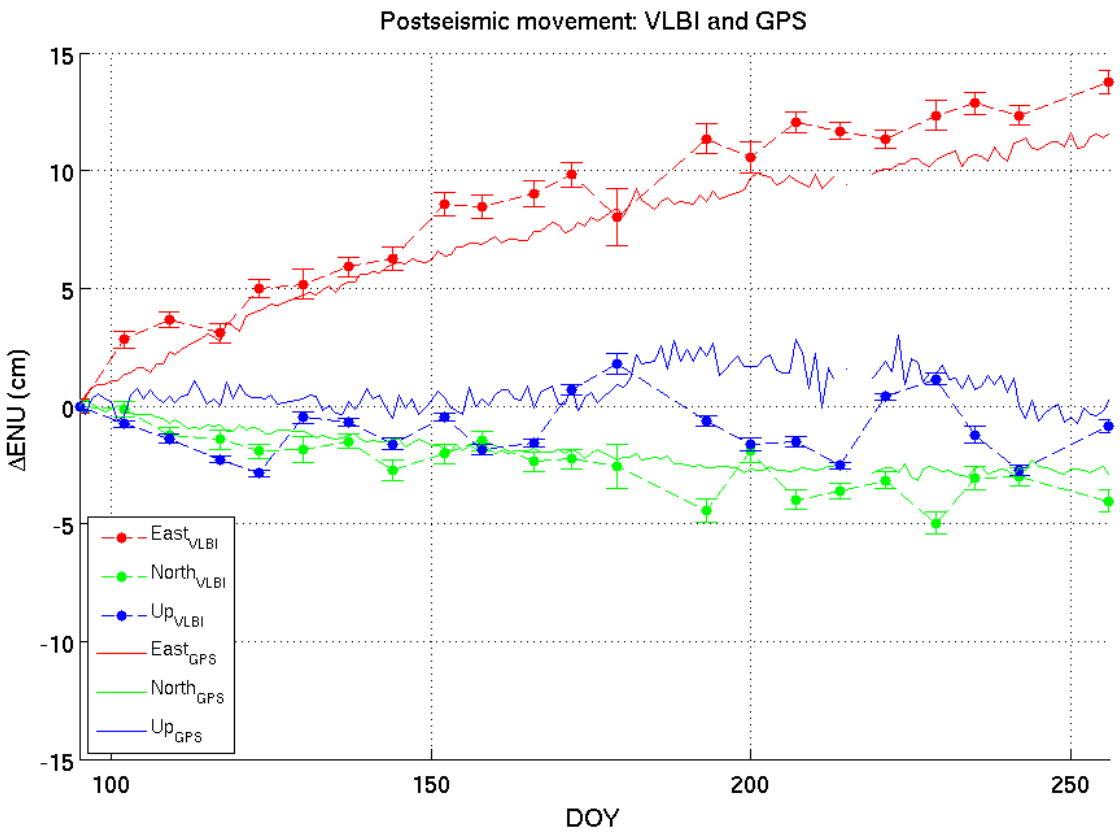
- Based on the analysis of 31 sessions, the initial displacement of Tsukuba VLBI station was

ΔX(cm)	ΔY(cm)	ΔZ(cm)	ΔE(cm)	ΔN(cm)	ΔU(cm)
-36.9	-54.7	-2.4	65.6	2.0	-6.9

- A priori coordinates + initial change

X (m)	Y (m)	Z (m)
-3957409.121	3310228.820	3737494.765

Postseismic movement



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Results and conclusions

- Results agreed relatively well with analyses of displacement of Tsukuba in other publications
- East and north components seem to have more stabile movement
- There was a clear postseismic movement in the coordinates
  - Motion was most prominent in to the East, to the direction of coseismic slip, in the region of 10-15cm over a period of 161 days
  - Some posteismic movement to the South, under 5cm
  - Relatively large variation of Up-component makes interpretation more difficult

Further development

- Further study to improve the estimates, especially the Up-component and some of the more problematic sessions
- Incorporate the time series tool created in the process to VieVS
- Create a more general visualization tool for plotting time series of all the geodetic parameters estimated by VieVS
- Develop the visualization tool to a standalone version with a more versatile language to get more flexibility and functionality
- Python + matplotlib + NumPy + SciPy

Thank you!

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