A focus on estimated coseismic displacements using IGS weekly station positions

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Introduction A

Nine analysis centers (ACs) compute operational solutions based on different networks of stations. Their solutions are then combined to form a single set of products, the official IGS solution.

Code	Description	Software
COD	Center for Orbit Determination in Europe, Switzerland	BERNESE
EMR	Natural Resources Canada, Canada	GIPSY/OASIS II
ESA	European Space Operations Center, Germany	NAPEOS
GFZ	GeoForschungsZentrum, Germany	EPOS.P.V2
GRG	GRGS-CNES/CLS, France	GINS/DYNAMO
JPL	Jet Propulsion Laboratory, USA	GIPSY/OASIS II
MIT	Massachusetts Institute of Technology, USA	GAMIT/GLOBK
NGS	NOAA / NGS, USA	PAGES/GPSCOM
SIO	Scripps Institution of Oceanography, USA	GAMIT/GLOBK

Tab.1 IGS Analysis Centers (ACs).

Are there differences between coseismic offsets estimated by different ACs ?

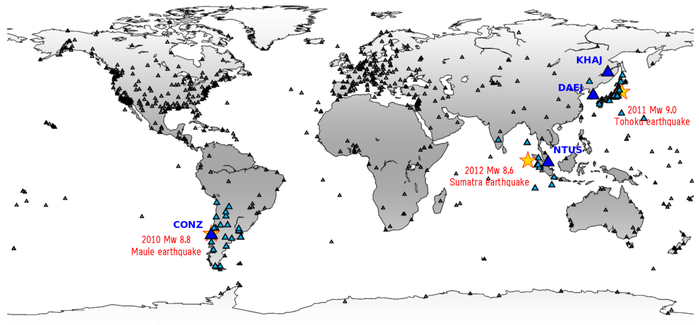

Fig.1 IGS stations (black triangle) and stations studied here (blue triangle) around 3 last great earthquakes.

Positions calculated by ACs B

The IGS analysis centers choose for every station the weekdays for which data are used to produce their weekly solution. When an earthquake affects a station, ACs may reject GPS observations. Three classes of coordinates can be derived :

① AC keeps **weekdays before the earthquake**. The weekly coordinates reflect the **pre-seismic deformation**,

② AC keeps **all weekdays**. The weekly coordinates are an **average position**,

③ AC keeps **weekdays after the earthquake**. The weekly coordinates are a **position resulting from coseismic and first days postseismic deformations**.

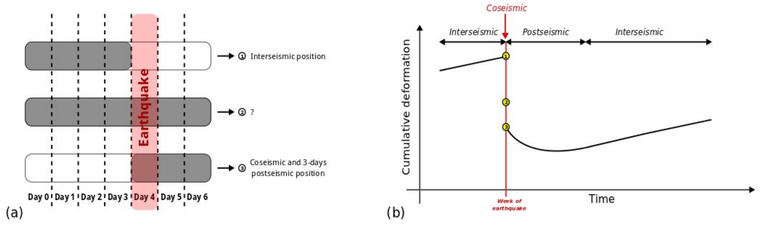

Fig.2 Interpretation of a weekly position according to weekdays used. (a) Choice of weekdays (in gray) to compute a weekly coordinate of a station in case of an earthquake on day 4. (b) Position of this solution in the seismic cycle [1].

Residuals of ACs weekly solutions w.r.t IGS combined solution C

In average, the AC solutions agree currently with IGS combination at levels of 1 to 3 mm in horizontal components and 2 to 6 mm in vertical [2]. But it is frequent to observe **differences which can reach 1 cm** the week of an earthquake or the week after. They are mostly explained by the different selection of weekdays used by each AC. The weekdays used are reported in the analysis summaries of all ACs, except NGS.

	1572	1573
AC	0123456	0123456
COD	XXXXXXX	
EMR	XXXXXX	XXXX
ESA	XXXXXX	XXXXX
GFZ	XXXXXX	XXXXXXX
GRG	XXXXXX	X XXXX
JPL	XXXX	
MIT	XXXXXX	XXXXXX
SIO	XXXXXX	XXXXX

↑ *earthquake*

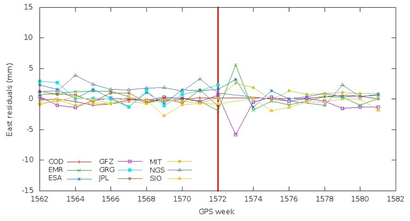

Fig.3 Station in Concepcion (CONZ) / 2010 Mw 8.8 Maule earthquake (1572:6).

	1626	1627
AC	0123456	0123456
COD	XXXXXX	XXXXXXX
EMR	XXXXXXX	XXXXXXX
GFZ	XXXXXXX	XXXXXXX
JPL	XXXXX	X XXX
MIT	XXXXXXX	XXXXXXX
SIO	XXXXXXX	XXXXXXX

↑ *earthquake*

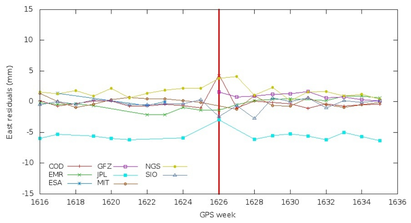

Fig.4 Station in Daejeon (DAEJ) / 2011 Mw 9.0 Tohoku earthquake (1626:5).

	1683	1684
AC	0123456	0123456
COD	X	XXXXX
EMR	XXXX	X XX
ESA	XXXXXXX	XXXXXXX
GFZ	XXXXXXX	XXXXXXX
GRG	XXXXXXX	XXXXXXX
MIT	XXXXXXX	XXXXXXX
SIO	XXXXXXX	XXXXXXX

↑ *earthquake*

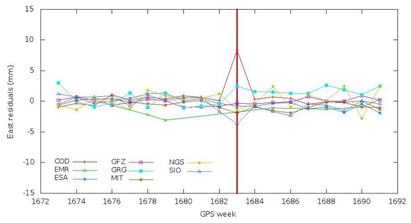

Fig.5 Station in Singapore (NTUS) / 2012 Mw 8.6 Sumatra earthquake (1683:3).

A significant **residual coseismic offset** has also been observed for KHAJ, even if all weekdays were used by all ACs on week 1626. This may indicate a software-dependent sensitivity to abrupt position changes.

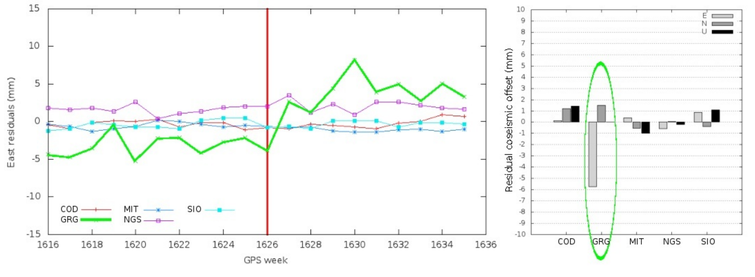

Fig.6 Station in Khabarovsk (KHAJ) / 2011 Mw 9.0 Tohoku earthquake (1626:5).

Global effects D

• For each station and each AC, we compute the difference between residual at the week of the earthquake and the mean residual over 20 weeks (except the week of the earthquake).

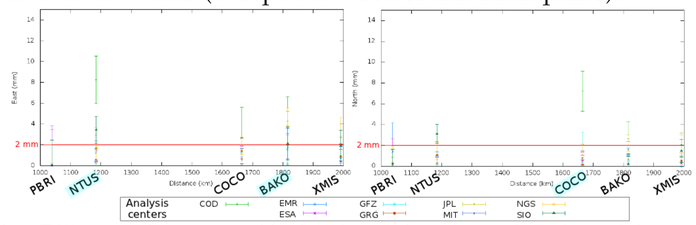

Fig.7 Differences between residual at the week of the earthquake and the mean residual for stations affected by the Sumatra earthquake and processed by ACs.

Global results :

Number of **stations studied**	**63**
Number of stations for which we have a solution over 20 weeks around the earthquake	30
Number of **stations processed by 5 ACs at least**	**18**
... and for which $\max_{\{E,N\}}(res(t_{eqk}) - \overline{res}) > 2$ mm	10
Number of **stations clearly disturbed by an earthquake**	**10**

• When an earthquake occurs, many stations near the epicenter are also removed during the combination or during the final stacking .

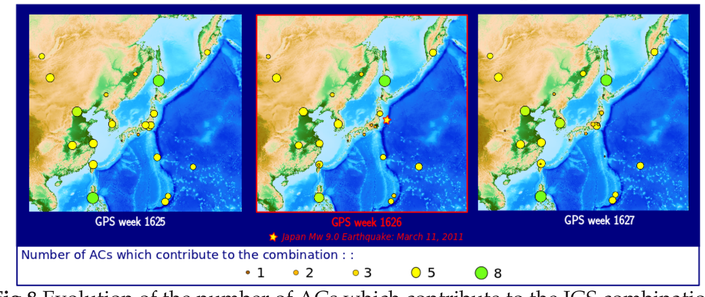

Fig.8 Evolution of the number of ACs which contribute to the IGS combination.

Conclusion E

With the switch to daily IGS solutions in September 2012, this problem will remain, but at the level of one day. Improvements of the IGS combined solutions could still be obtained by:

• **verifying the ACs' epoch-block solutions before combination**,

• **defining common AC processing strategies**.The major difficulty is to identify the stations affected by an earthquake because this step must be made in quasi real time by ACs. One alternative could be **to develop a warning system** which lists stations probably affected when an earthquake is detected by USGS.

References F

[1] Feigl K. L. and Thatcher W. Geodetic observations of post-seismic transients in the context of the earthquake deformation cycle In *C. R. Geoscience (2006)*.

[2] Rebischung P. and Garayt B. Recent results from the IGS terrestrial frame combinations, In *Proceedings of the IAG Symposium (2011)*. REFAG2010.