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Geodetic Observatory TIGO and the Chilean Mw 8.8 Earthquake



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www.tigo.cl

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Chile


North
Santiago
8.8
Concepción
South American Plate
Nazca Plate
Pacific Ocean
South

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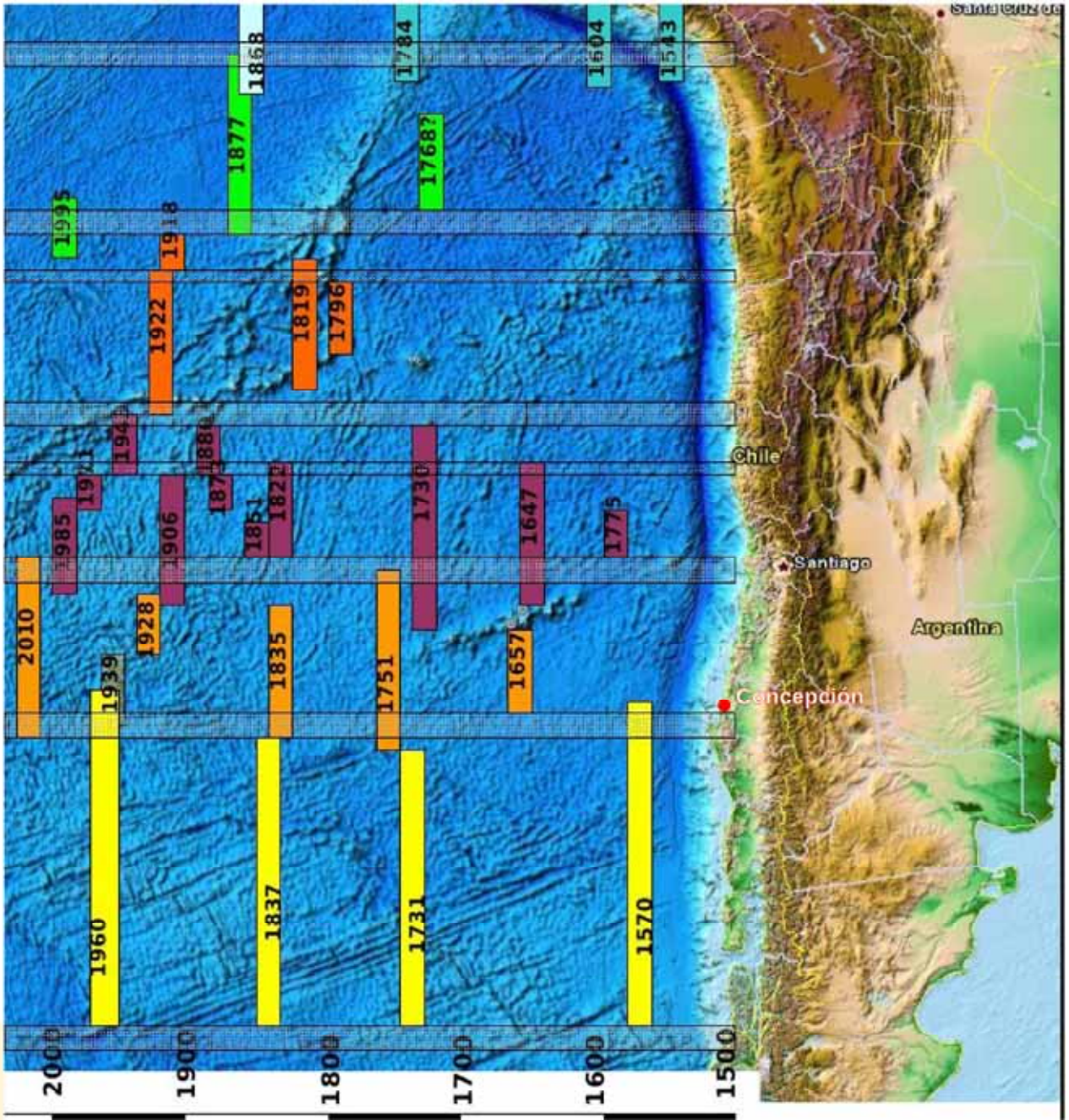
Segmentation of the Subductionzone

Earthquake was expected.

~100 years of seismic silence



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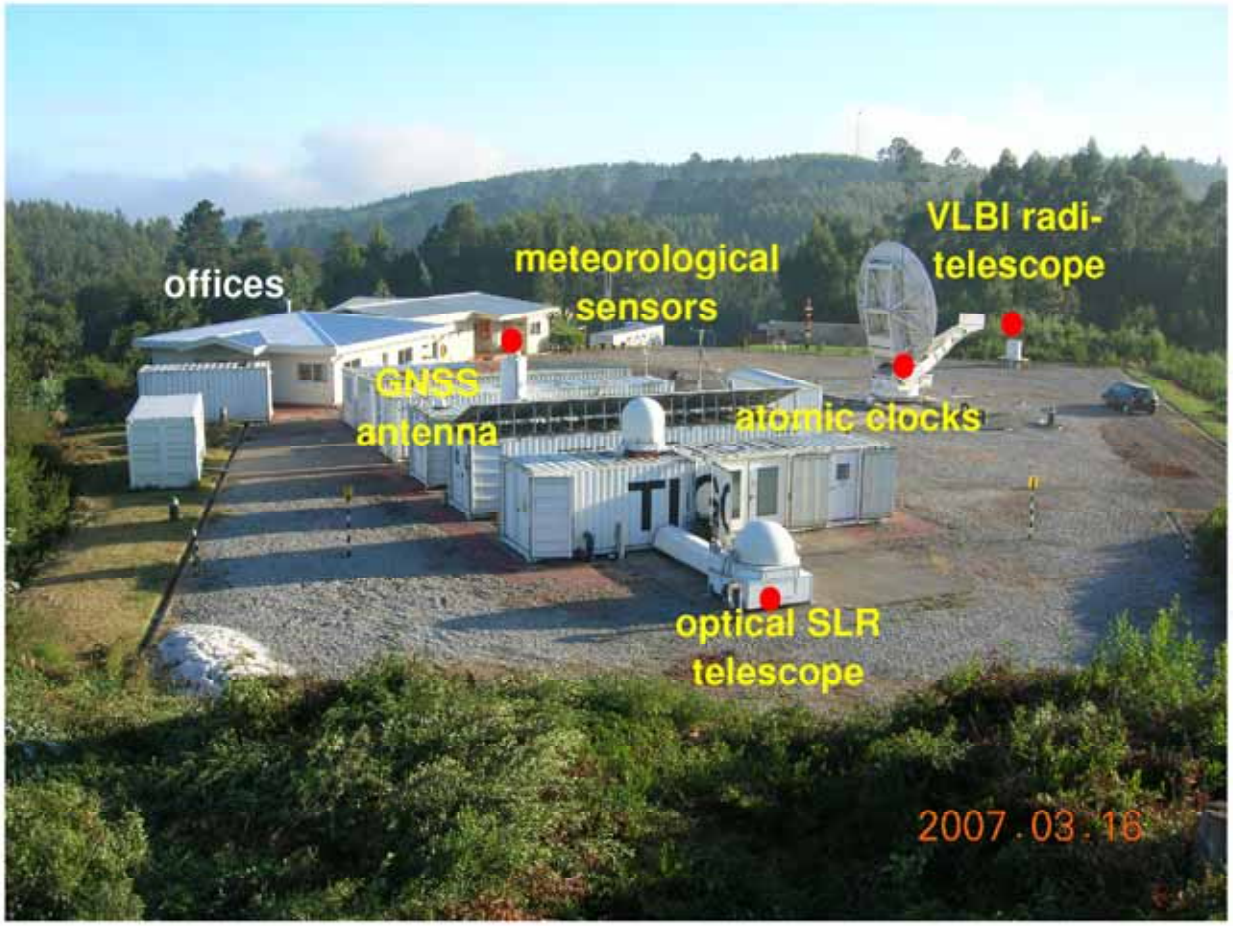
Mission of TIGO

regional GPS
netzwork and
tide gauge

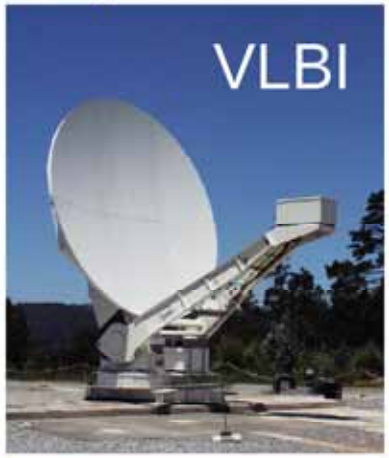


gravimeter
seismometer

The realization of terrestial reference points in the domain of
space and *time* and in the *gravitational field* of Earth
is the mission of TIGO.

Instrumentation of the Geodetic Observatory TIGO

Space



radio telescope

optical telescope

meteorological sensors

Time

H-maser

Cs standards

Gravitation

seismometer

absolute gravity meter

superconducting gravity meter

GNSS

GPS+tide gauge

International Services

TIGO is supplies geodetic observational data to six international services:

- **IERS**, International Earth Rotation and Reference System Service
- **IVS**, International VLBI Service for Geodesy and Astrometry
- **ILRS**, International Laser Ranging Service
- **IGS**, International GNSS Service
- **BIPM-UT**, Universal Time Service
- **IGFS**, International Gravity Field Service

TIGO is the only observatory of its type in Latin America.

The errors in global reference systems double without contributions of TIGO (Earth orientation parameters, center of mass).

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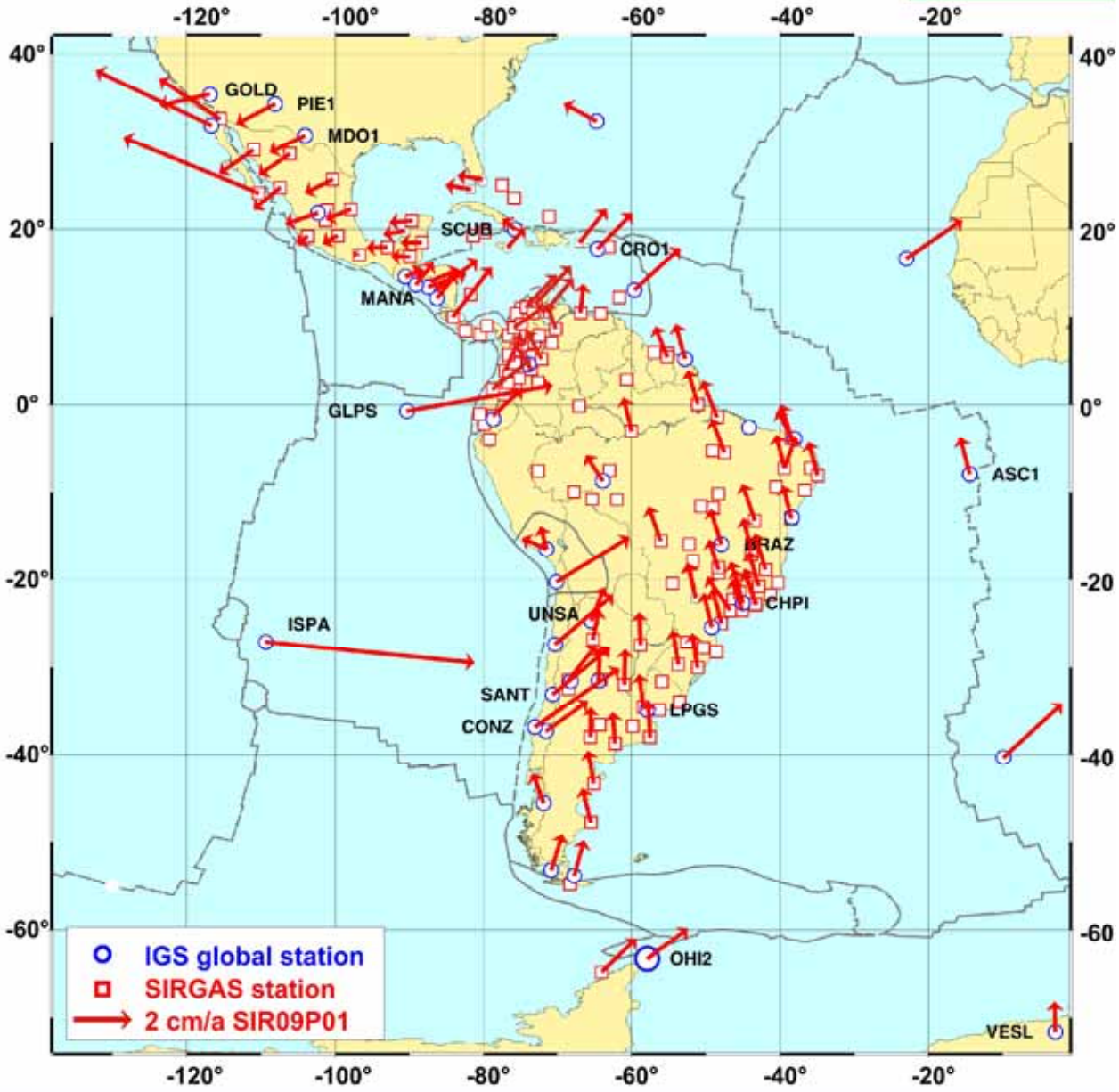
Plate Tectonics before the Earthquake

Argentina, Brazil
1-2cm north

Chile
3-4cm north-east



L. Sanchez et al.

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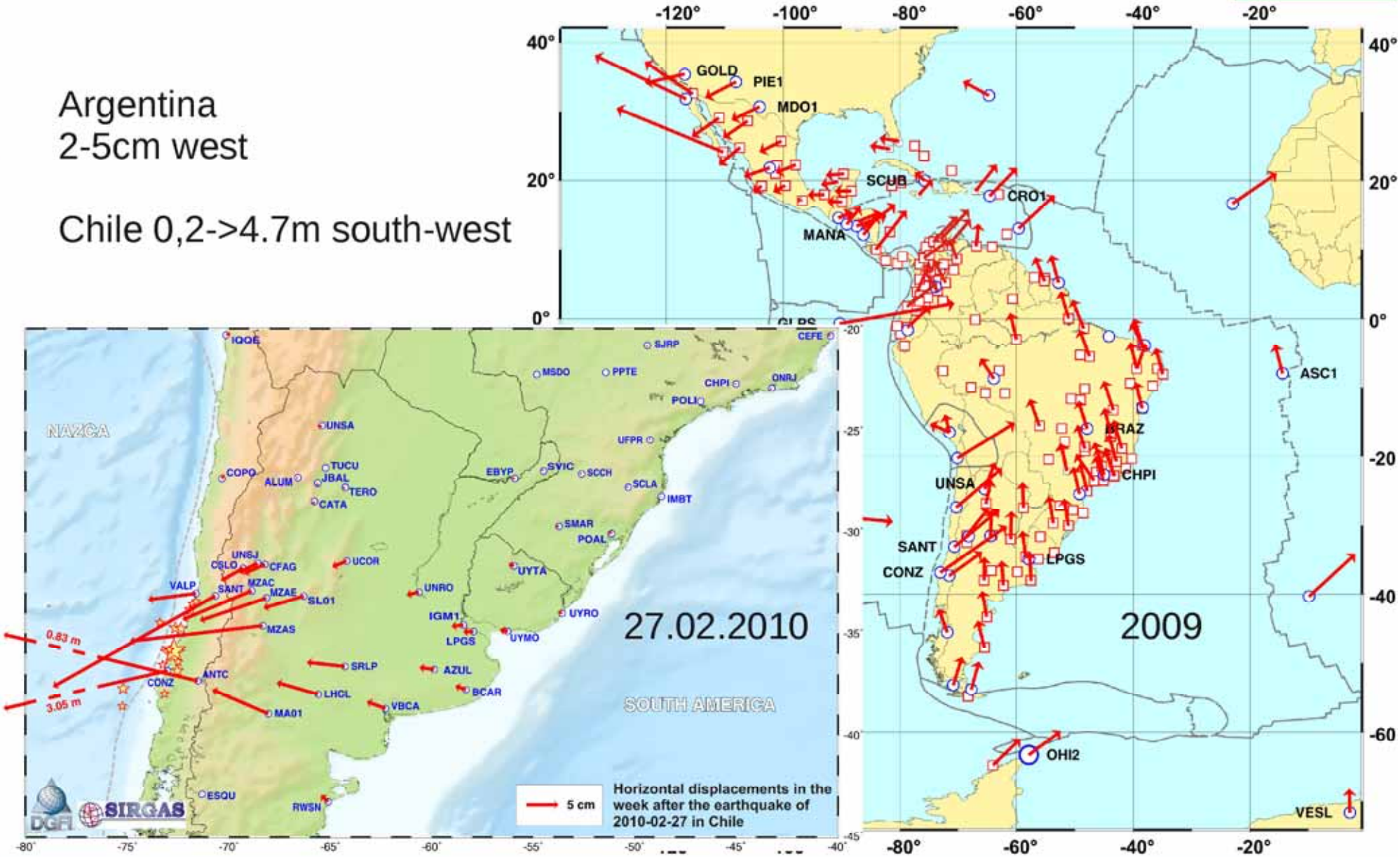
Plate Tectonics during the Earthquake

Argentina
2-5cm west

Chile 0,2->4.7m south-west



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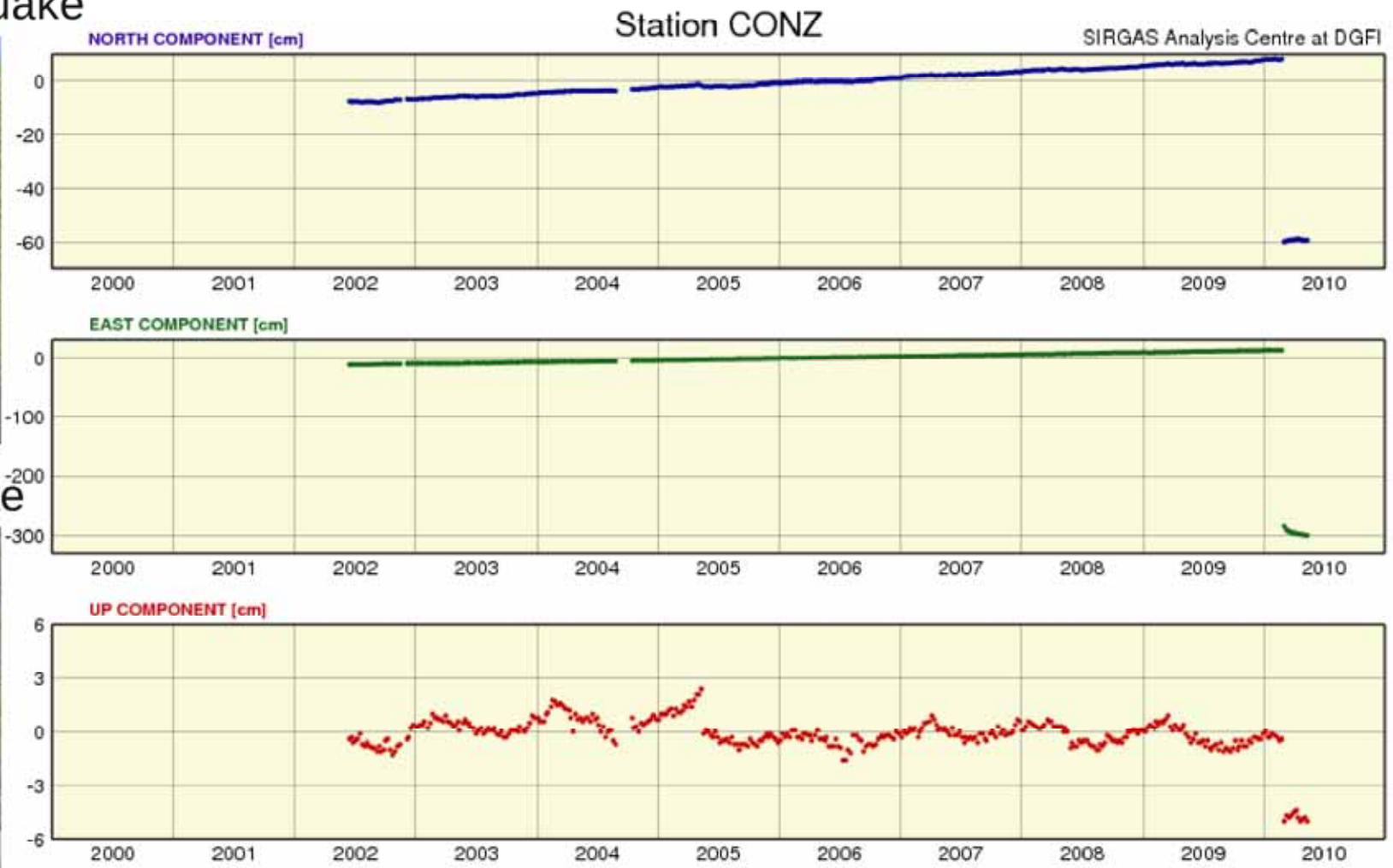
Time Series 2002-2010, IGS-Station CONZ

before earthquake

after earthquake



GPS/Glonass station CONZ

Monument 300 of the Geodetic Observatory TIGO after february 27, 2010

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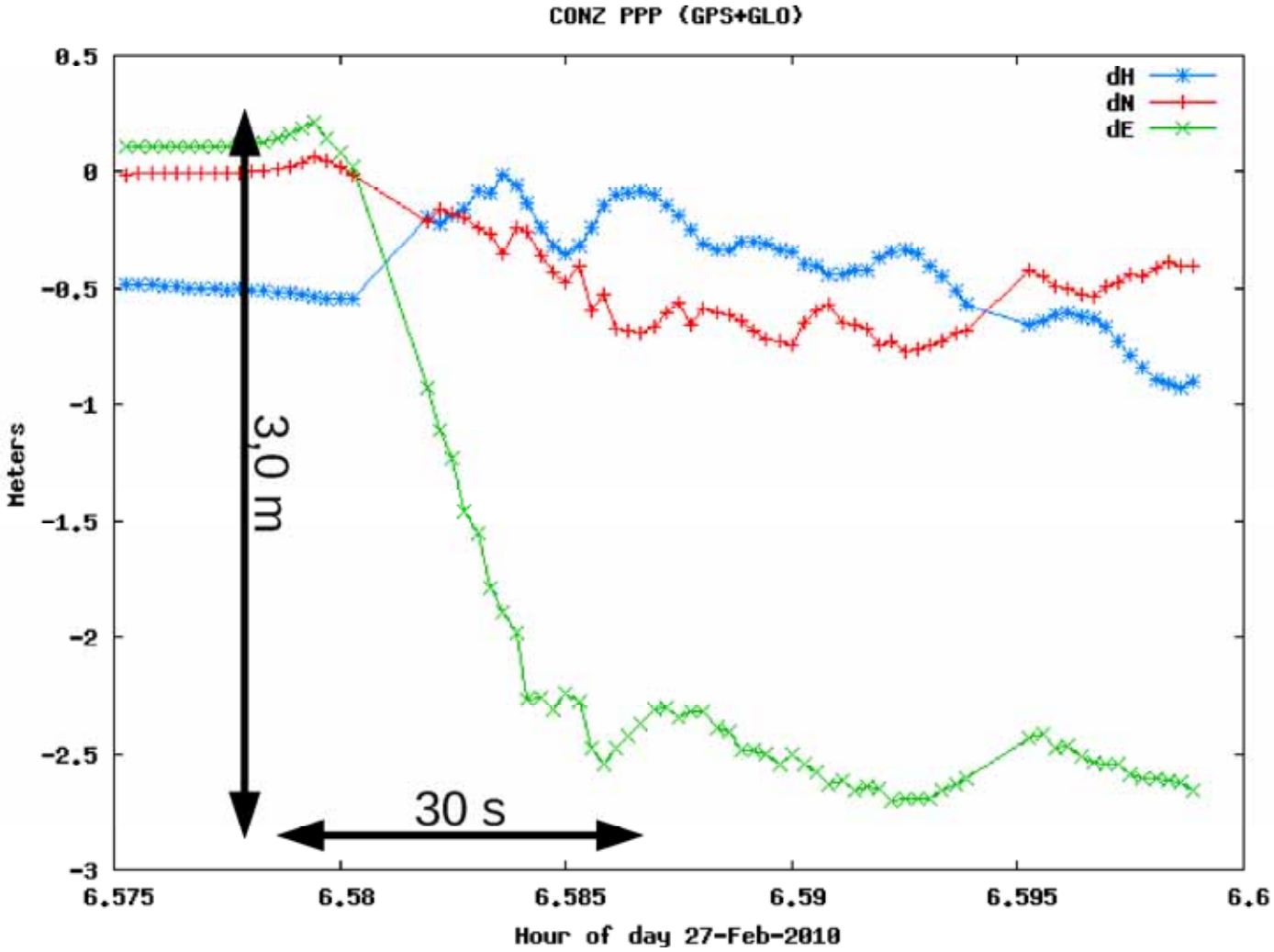
CONZ Time Series PPP-Mode during Earthquake

1. 2. 3.



1. Earthquake began with north-east motion.

2. Displacement of 3m towards south-west during first 30s of earthquake.

3. Seismic waves with amplitudes up to 50cm.

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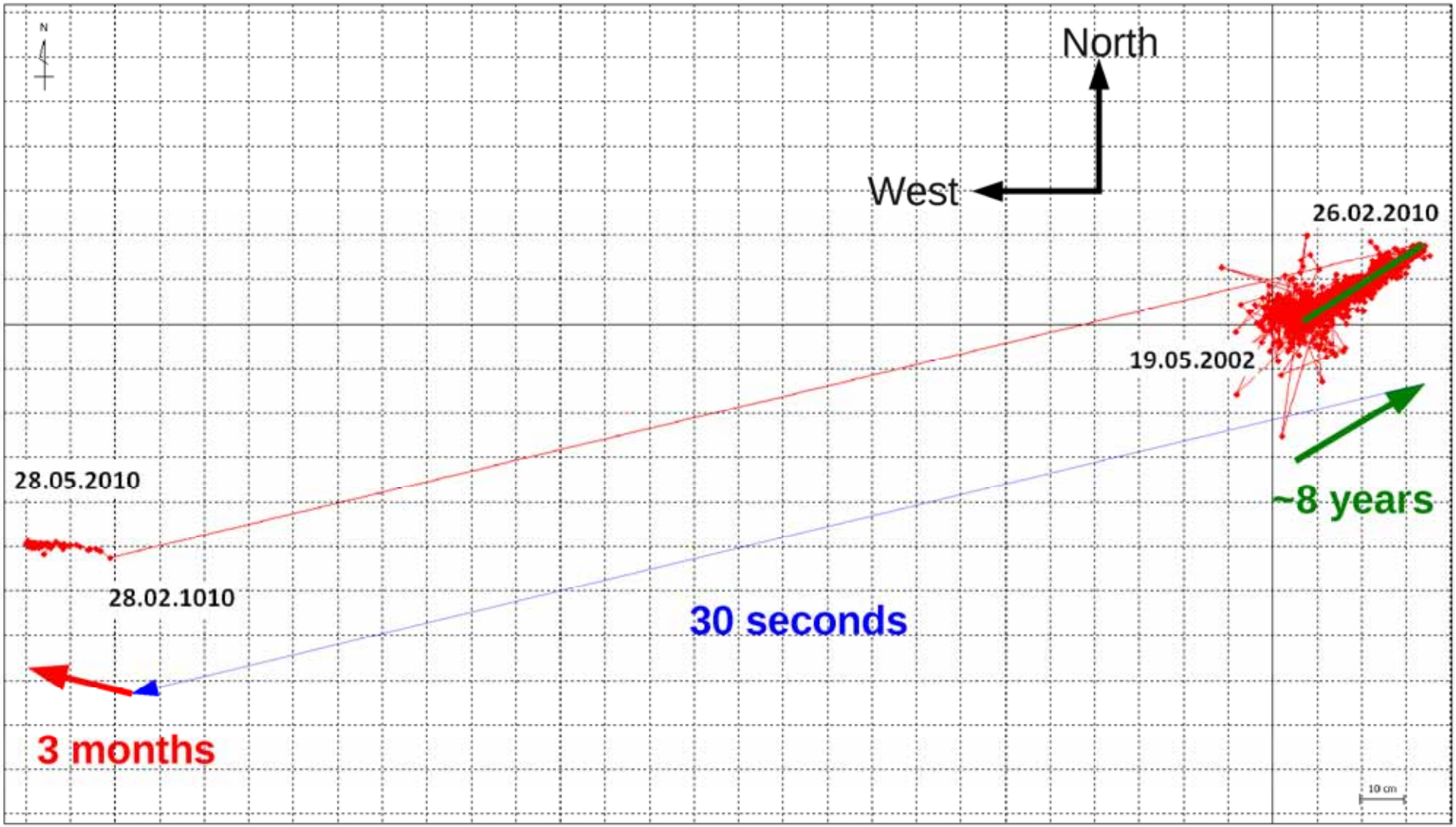
Tracking Map of CONZ 2002-2010



P. Neumaier

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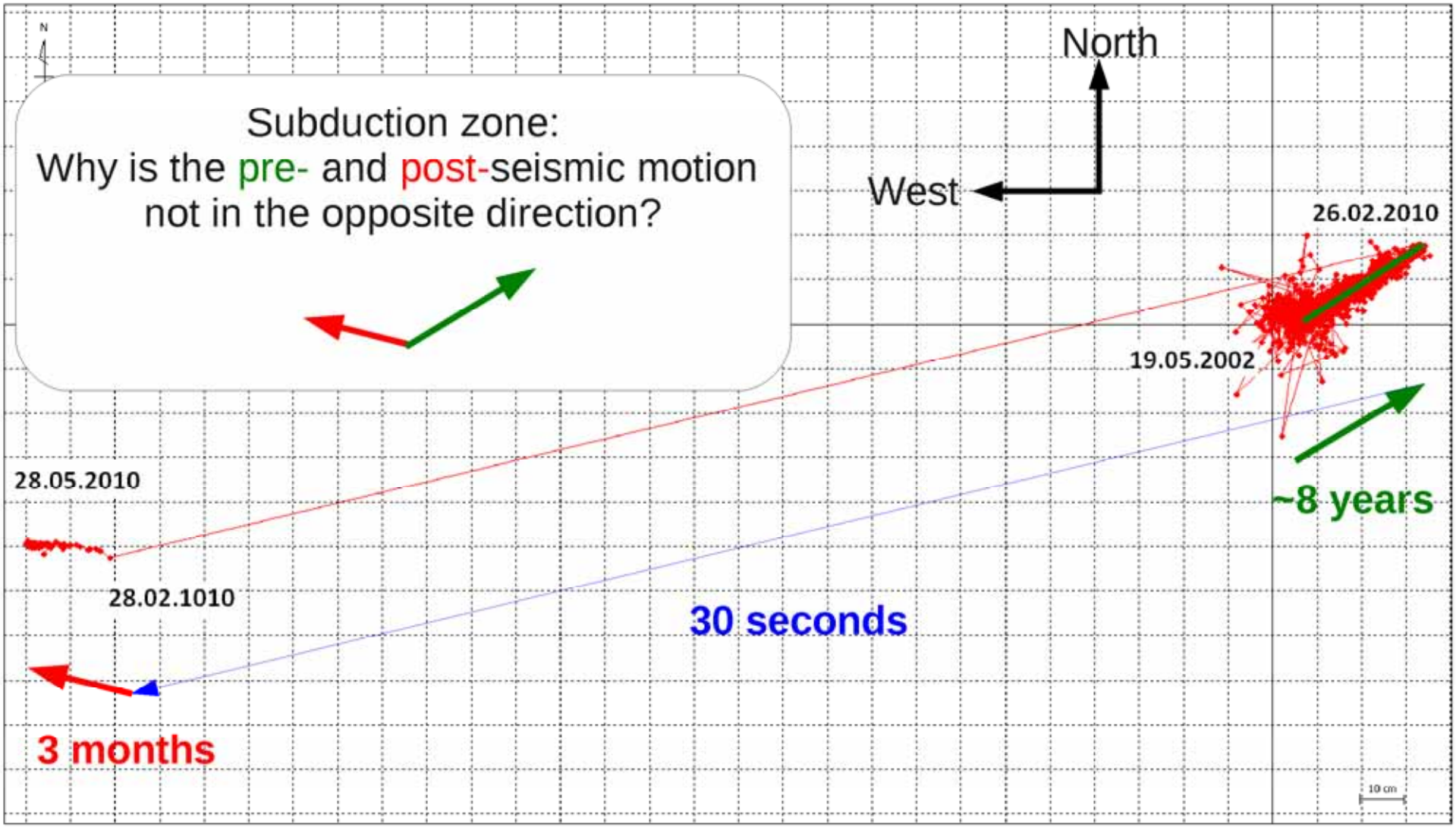
Tracking Map of CONZ 2002-2010



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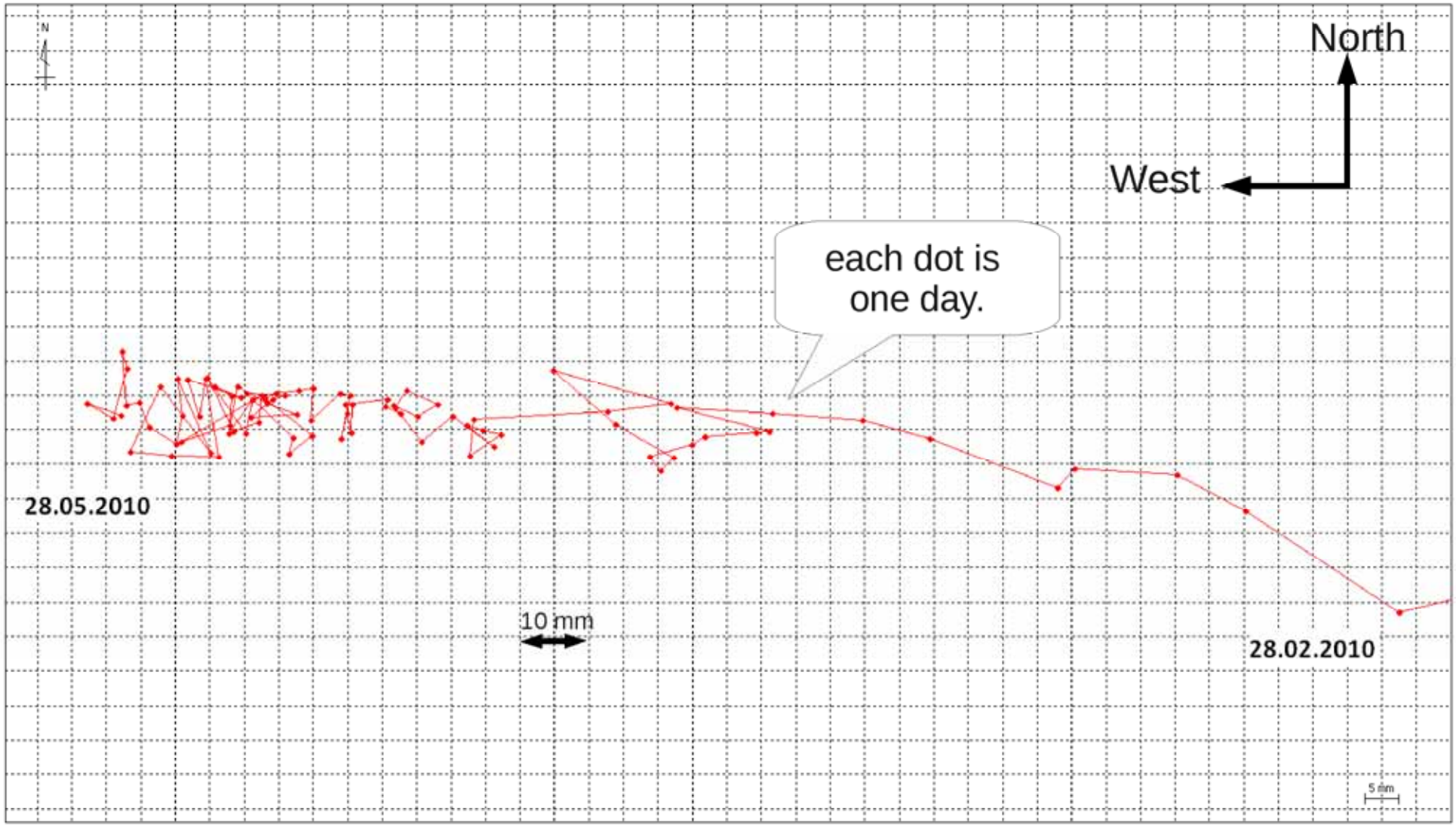
Tracking Map of CONZ 28.02.-28.05.2010



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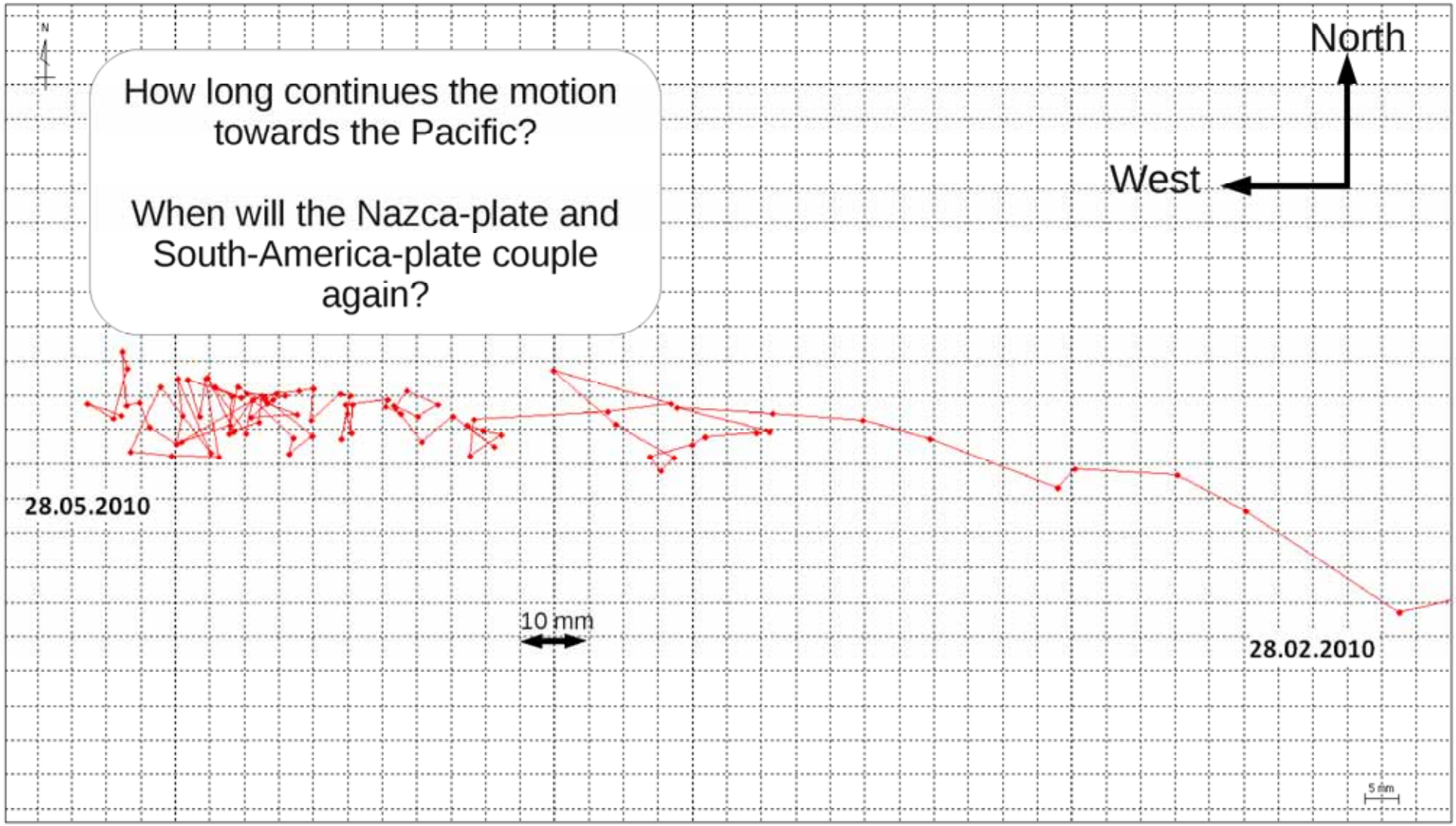
Tracking Map of CONZ 28.02.-28.05.2010



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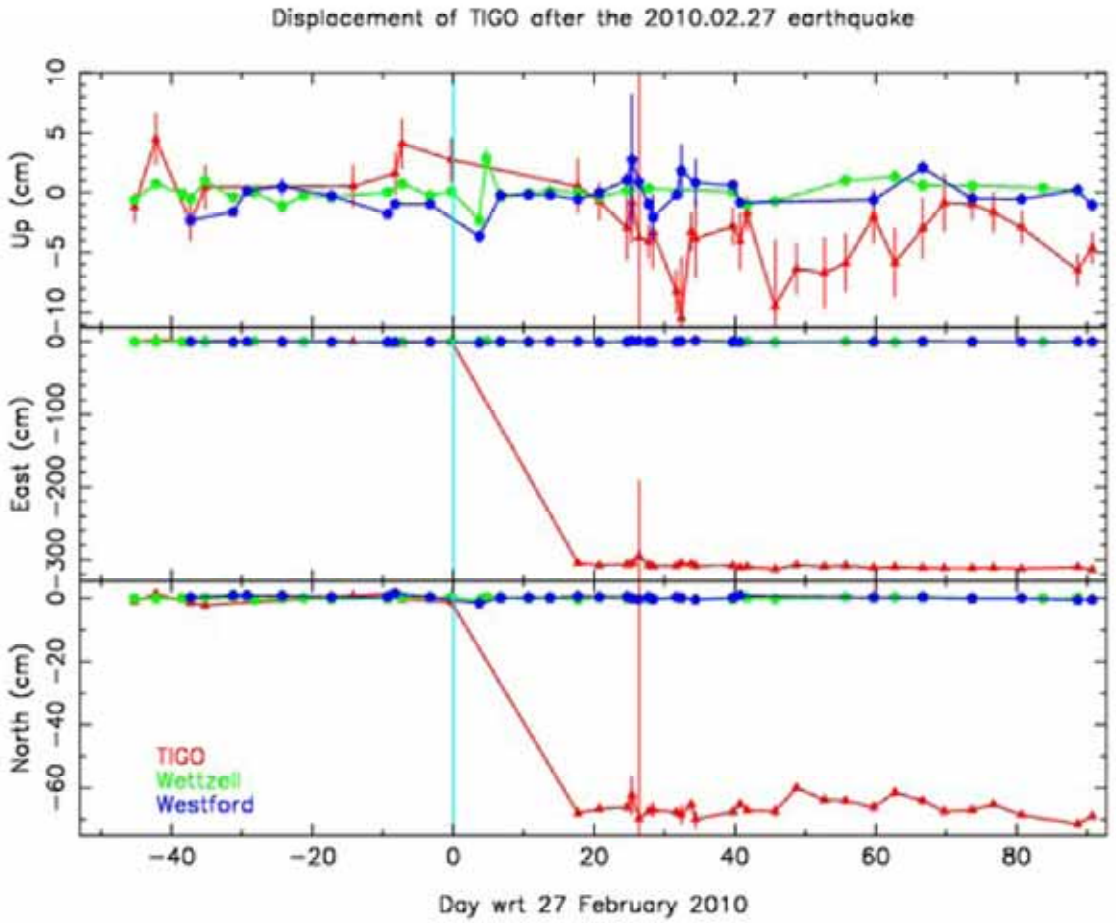
Time Series of VLBI 2010

TIGO
Wettzell
Westford



Height

East

North

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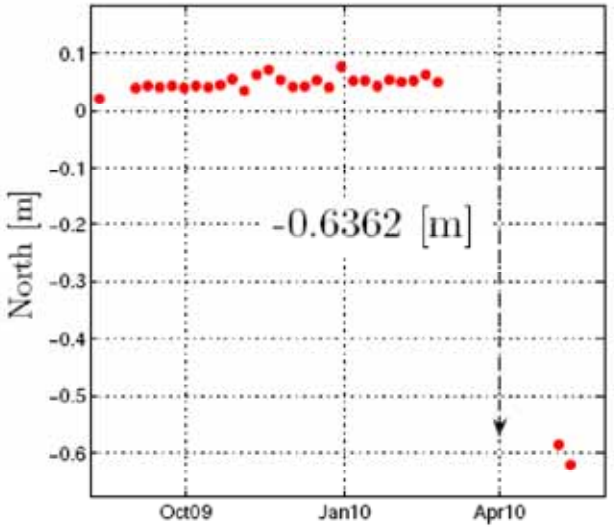
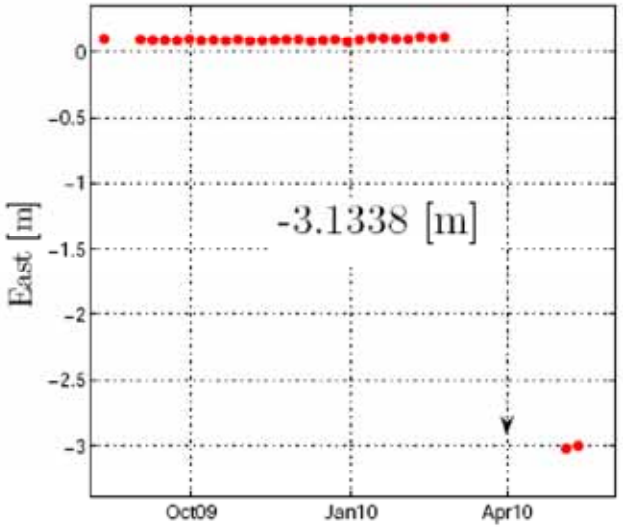
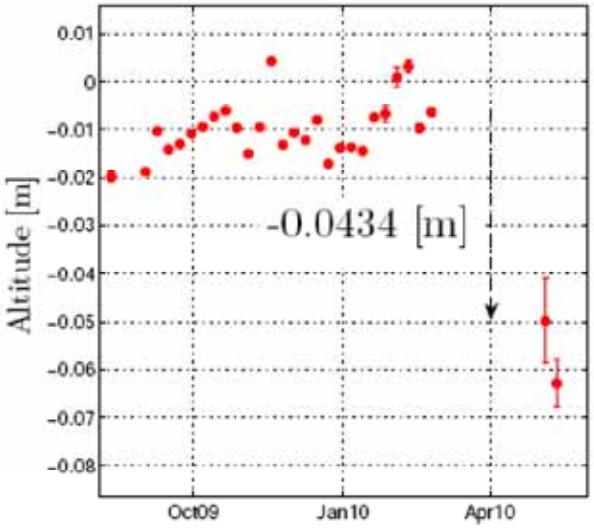
SLR Zeitreihe 2010



(a)



(b)



(c)

TIGO Gravimeter Equipment

Superconducting Gravimeter RSG038:

- first remote controlled instrument

Absolute Gravimeter FG5-227:

- with remote control option,
- since May 2006 at TIGO:
  - one observation period / week: 24 sets/150 drops
  - maintenance at Micro-g: Oct 2007 – Oct 2008; delayed due to complicated customs procedure

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FG5-227 after Earthquake

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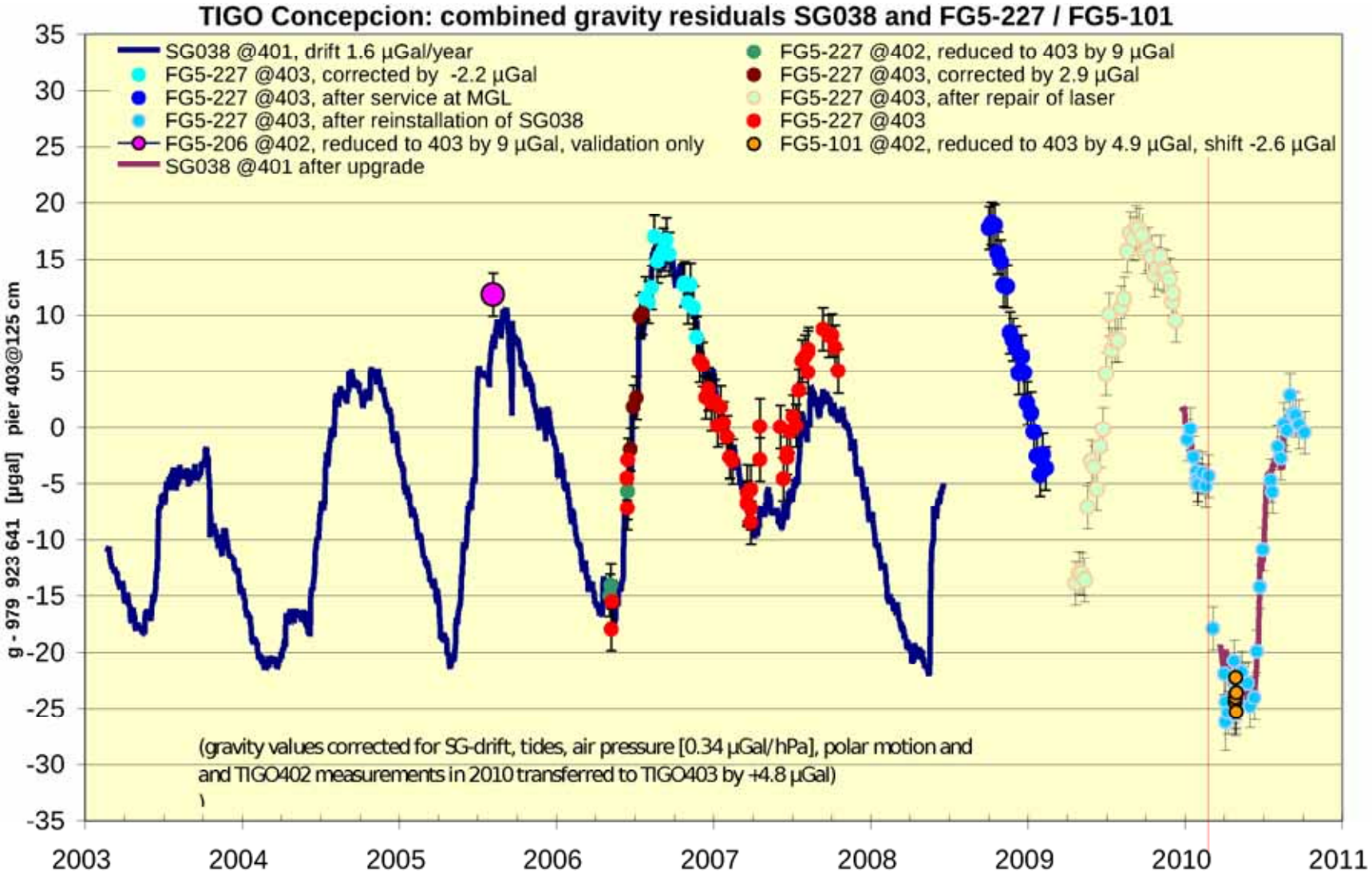
Time Series Gravimetry 2003-2010



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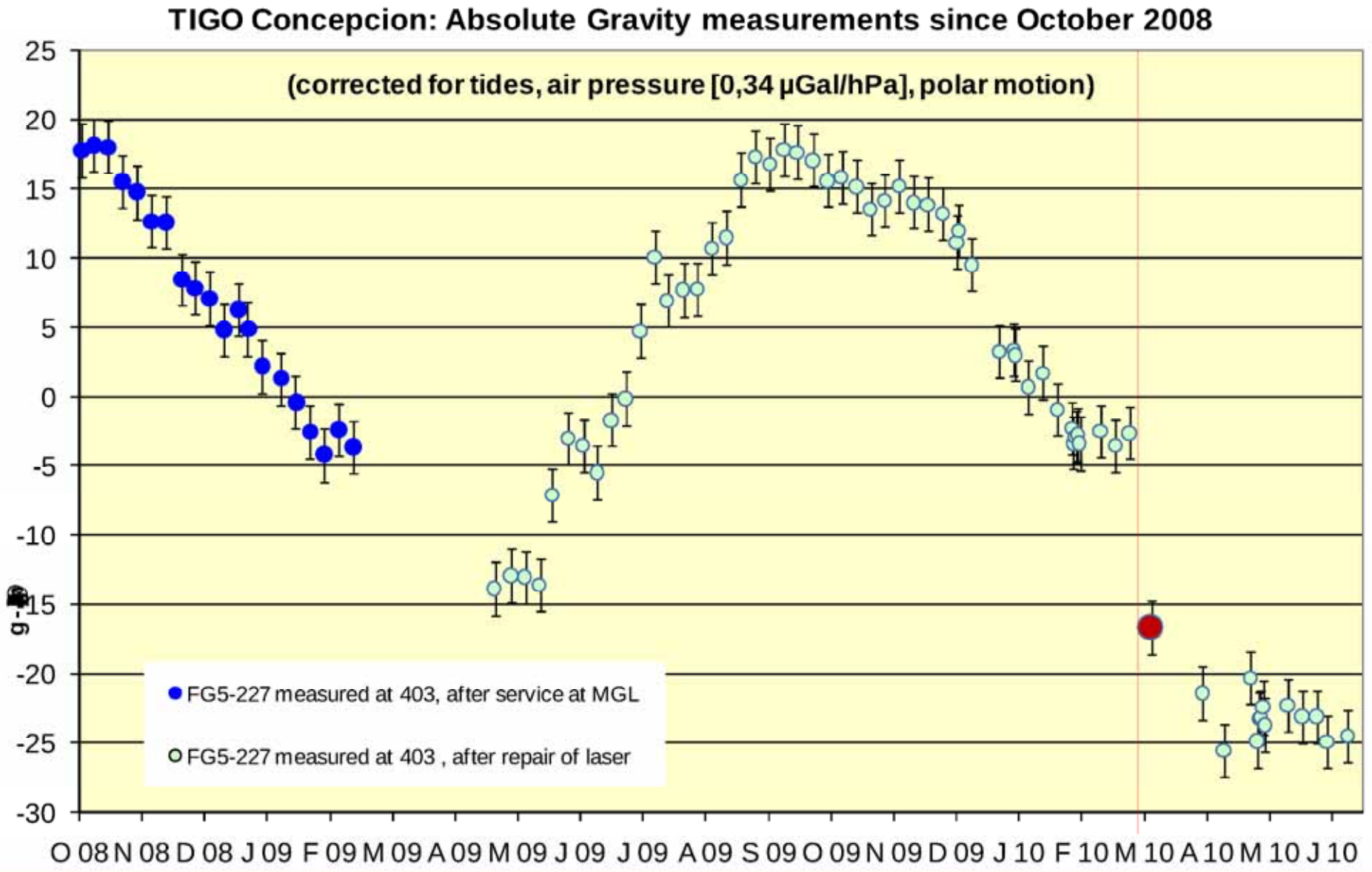
Time Series Absolute Gravimetry
Oct. 2008-2010



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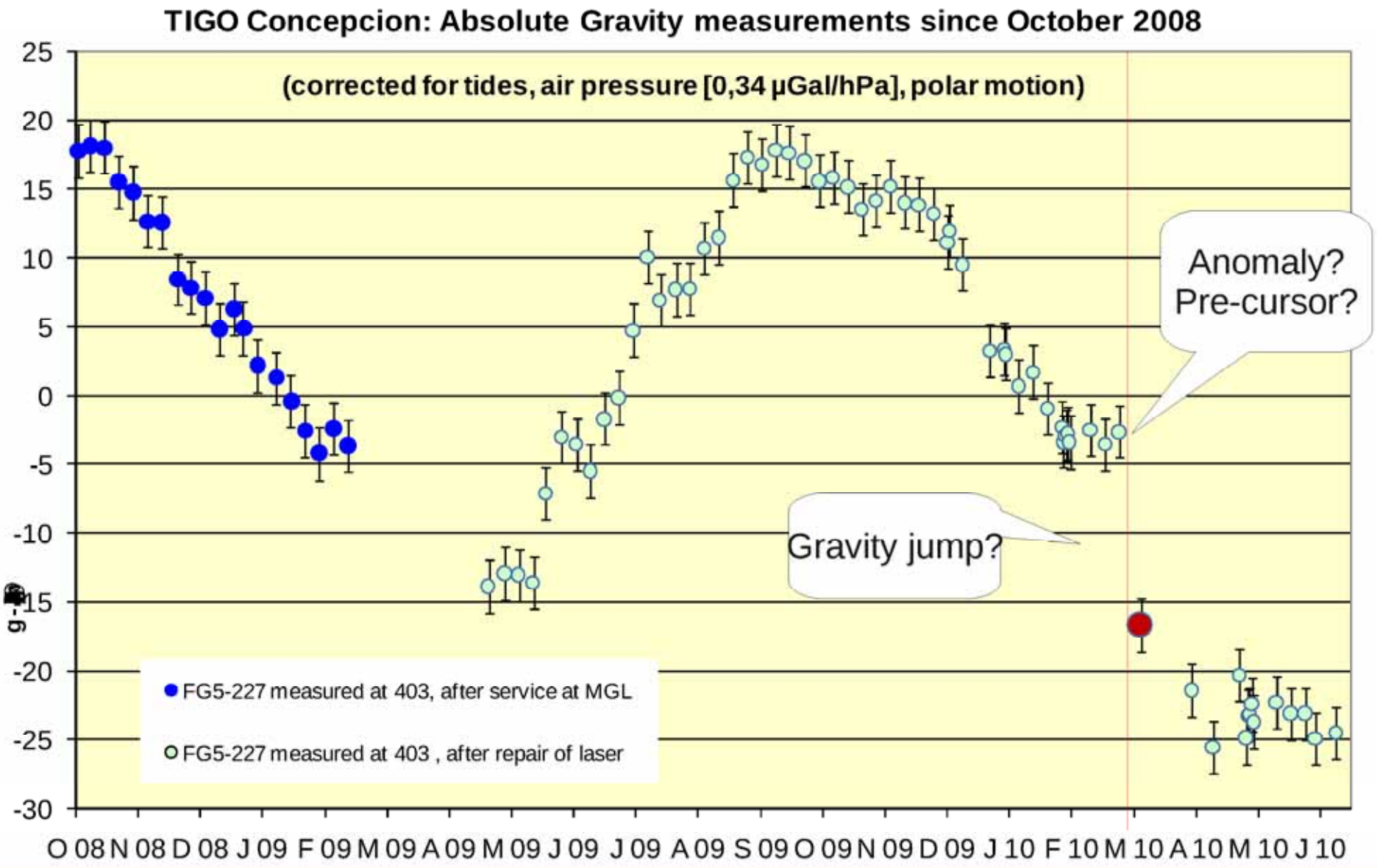
Time Series Absolute Gravimetry
Oct. 2008-2010



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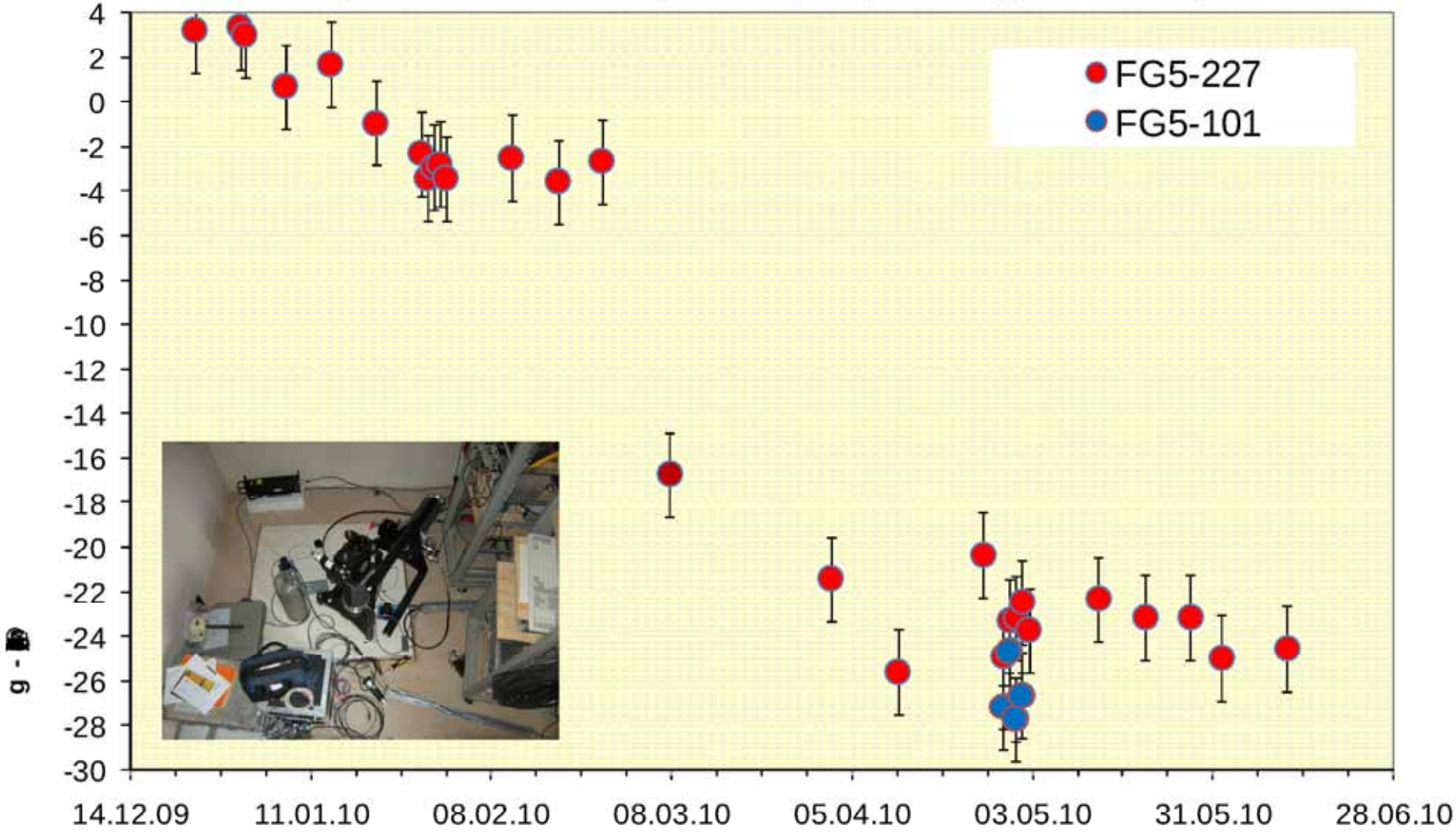
Time Series Absolute Gravimetry
Dec. 2009 - Jun. 2010

TIGO Concepcion
Absolute Gravity measurements (24 h mean) since reinstallation of SC38
(corrected for tides, air pressure [0,34 µGal/hPa], polar motion)



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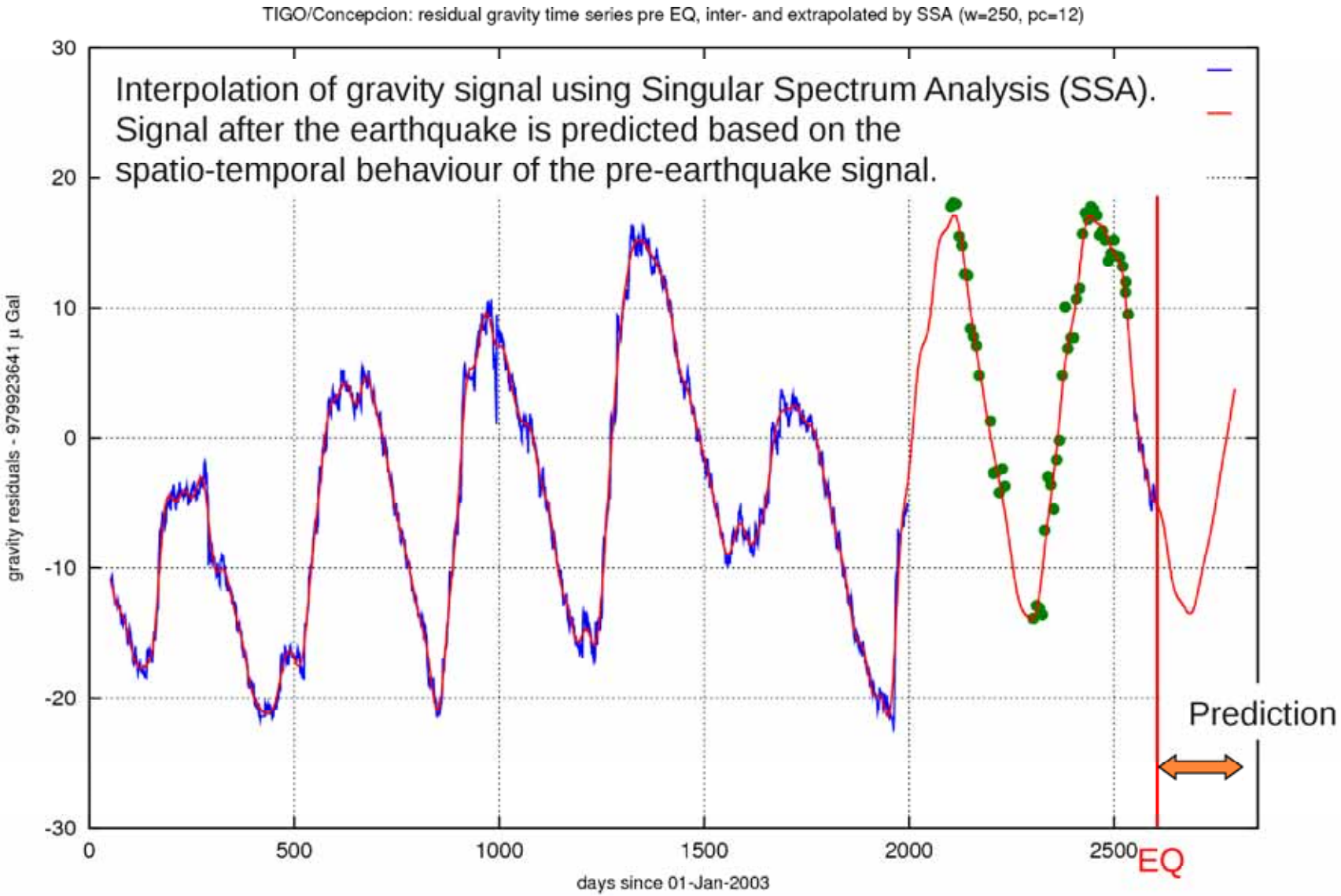
Seasonal Variations inter- and extrapolated by Singular Spectrum Analysis (SSA)



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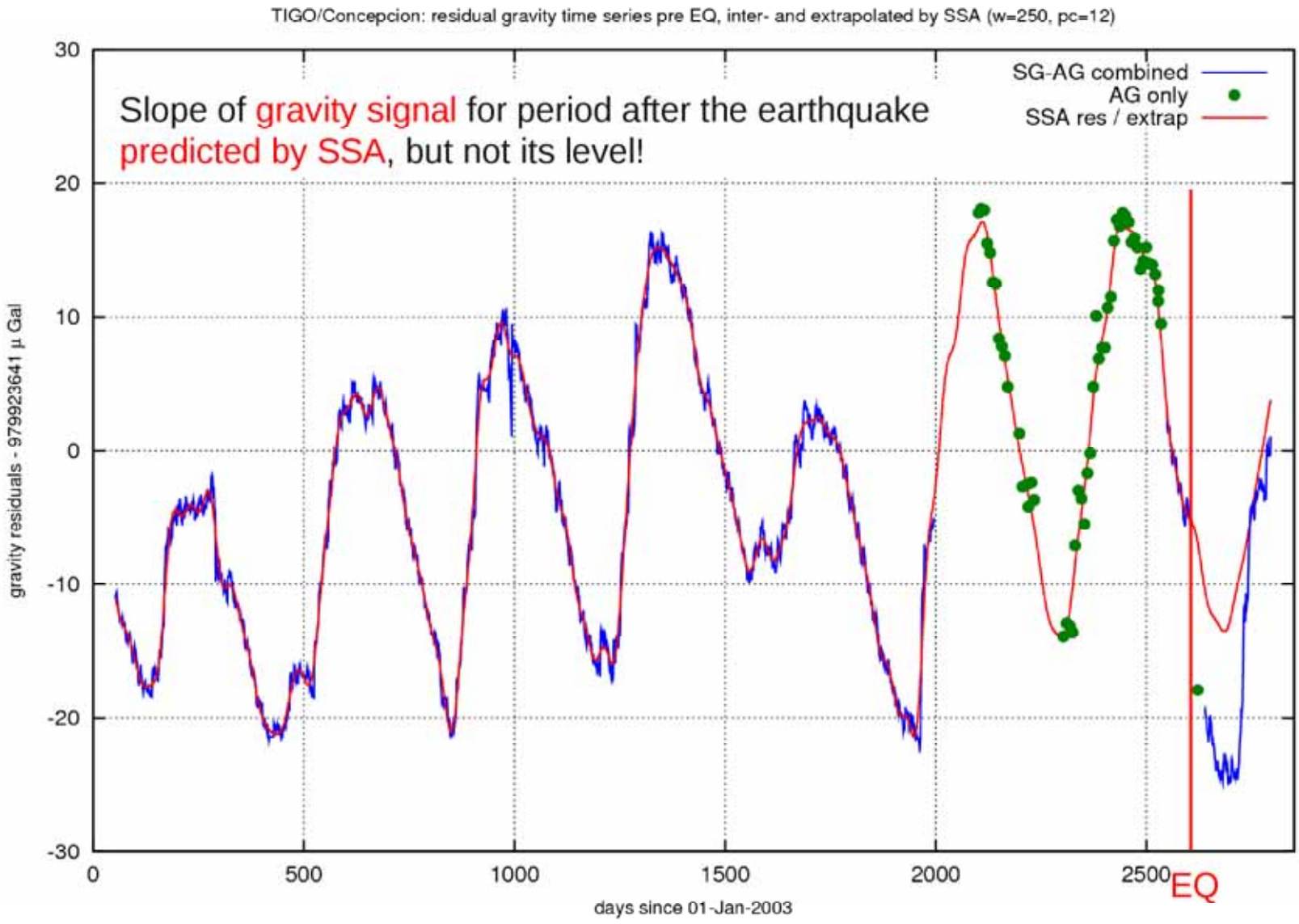
Seasonal Variations
Inter- and exptrapolated by SSA



offset shows evidence of true jump in gravity!

real data points

Conclusions

- World's first to obtain successfully observational data with a fundamental station for geodesy (TIGO) almost at the epicenter of a Mw 8.8 earthquake (about 80km distance).
- GPS/GLONASS 1s data samples of CONZ and CONT before, during and after the earthquake are an unique resource to understand the kinematics in a subduction zone.
- Historical and future geodetic data from TIGO will help to understand the complete seismic cycle. This is needed for basic research for earthquake prediction.
- A unique gravity data series was obtained. It documents the mass changes (gravity jump) due to compression and relaxation by an earthquake in a subduction zone.
- No evidence for pre-cursor so far. Hydrological impact must be investigated further.
- TIGO became quickly operational again, thanks to the extraordinary dedication of its staff to recuperate from damages of the instruments.

Personal Conclusions

- Reference frames in seismic active zones require more frequent updates to model the point kinematics correctly.
- Linear interpolations between epochs must be replaced by non-linear models.
- SIRGAS weekly production of a reference frame helped me a lot. Thank you.
- The anticipated accuracy of GGOS for global reference frames (1mm position, 0.1mm/yr velocity) will show non-linear motion outside seismic active areas as well.
- Real-time geodetic networks are upcoming.
- Future concepts of reference frames must serve both interests: long-term stability vs. immediate availability of high-precision reference frame.

Earthquake history of Concepción

1570-02-08, town destroyed by earthquake, 20 years after foundation

87

1657-03-15, town destroyed by earthquake and tsunami

73

1730-07-08, town destroyed by earthquake and tsunami

21

1751-05-25, town destroyed by earthquake and tsunami, decision of relocation of town (Concepción of today)

84

1835-02-20, 60% destruction of town, tsunami along the coast 30°-43°S, testified by Charles Darwin

33

1868-08-13, coastal zone destroyed by tsunami, epicenter 2000km north

71

1939-01-24, town destroyed, earthquake Mw 8-9

21

1960-05-21/22, town destroyed, earthquake Mw 9.5+8, tsunami

49

2010-02-27, town destroyed, earthquake Mw 8.8, tsunami

Each day without earthquake is one day less until the next!