Chile National Net: Geodetic Overview

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Outline

CSN
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- What we want to observe with C-GNSS?
- Status of all of GNSS network in Chile
  - First stations
  - Scientific networks
  - CSN, current status
  - Monumentation
- Network design for EW
- Schedule of CSN solutions
- Results
- Final remarks

What we want to observe with C-GNSS?

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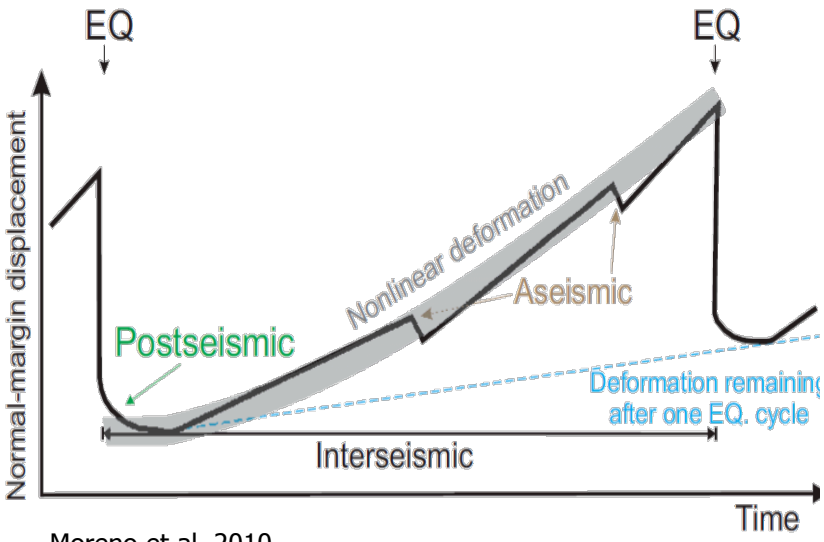
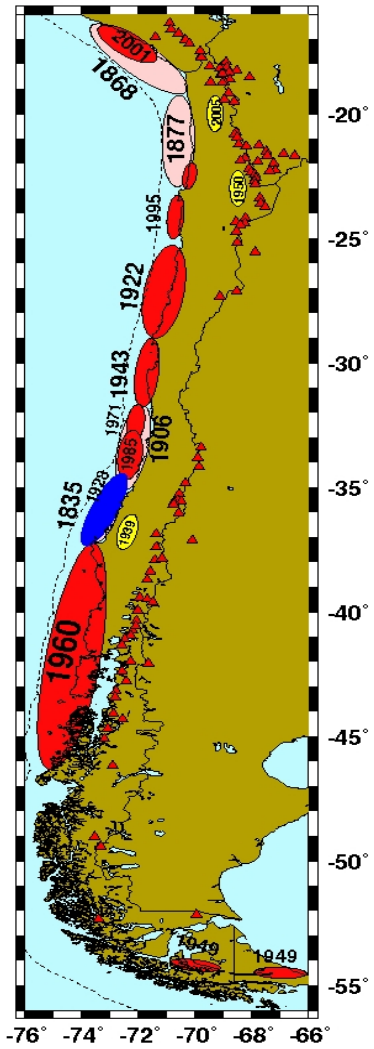
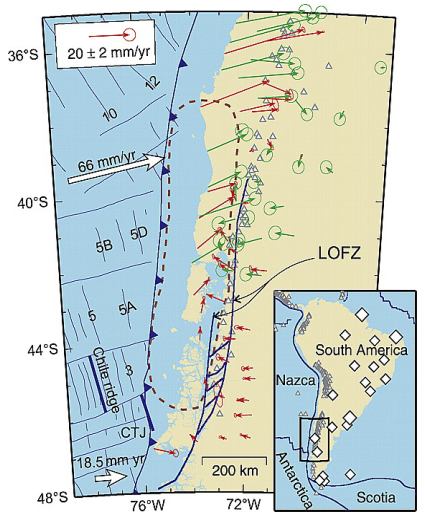
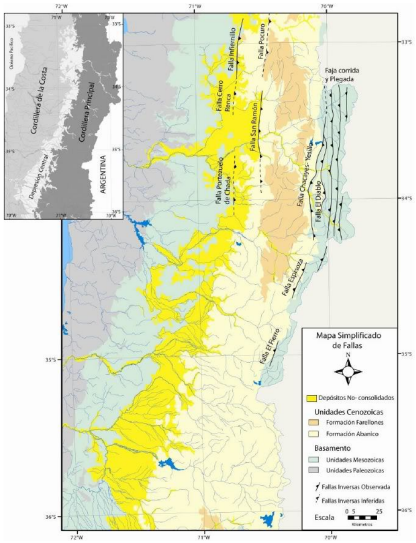


Moreno et al, 2010





Wang et al, 2007



GNSS observation for:

- Seismic cycle
- Intra plate
- Fault systems
- Volcanoes (SERNAGEOMIN)
- Early warning

Status of all GNSS networks in Chile

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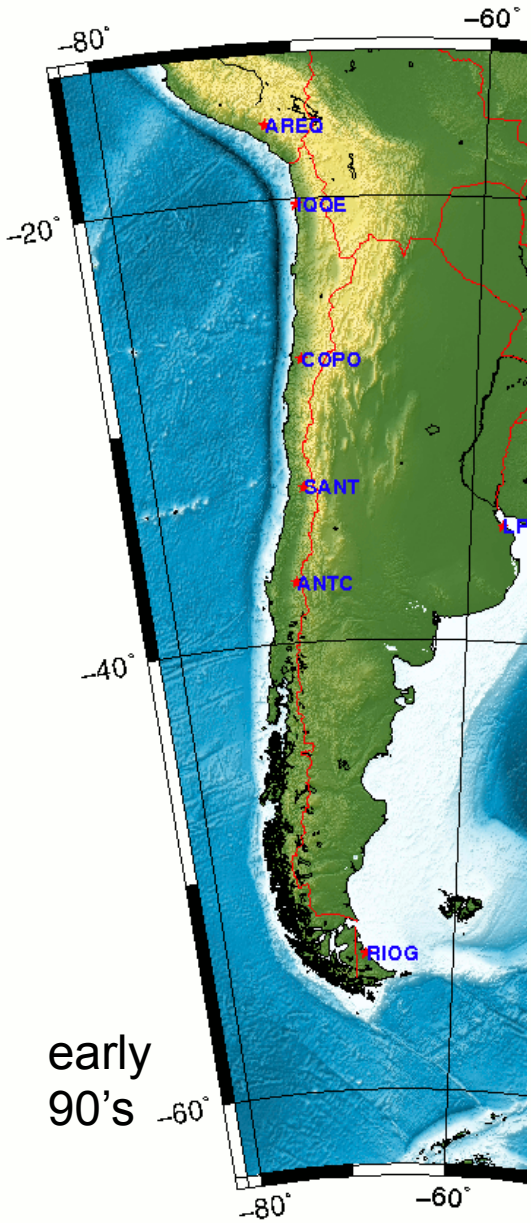
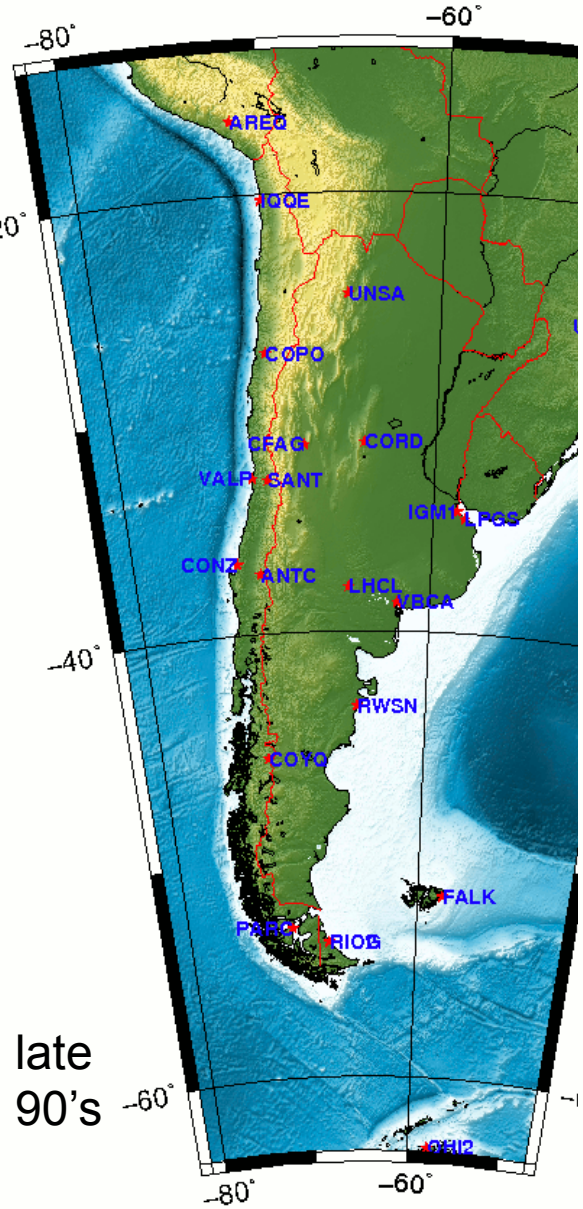
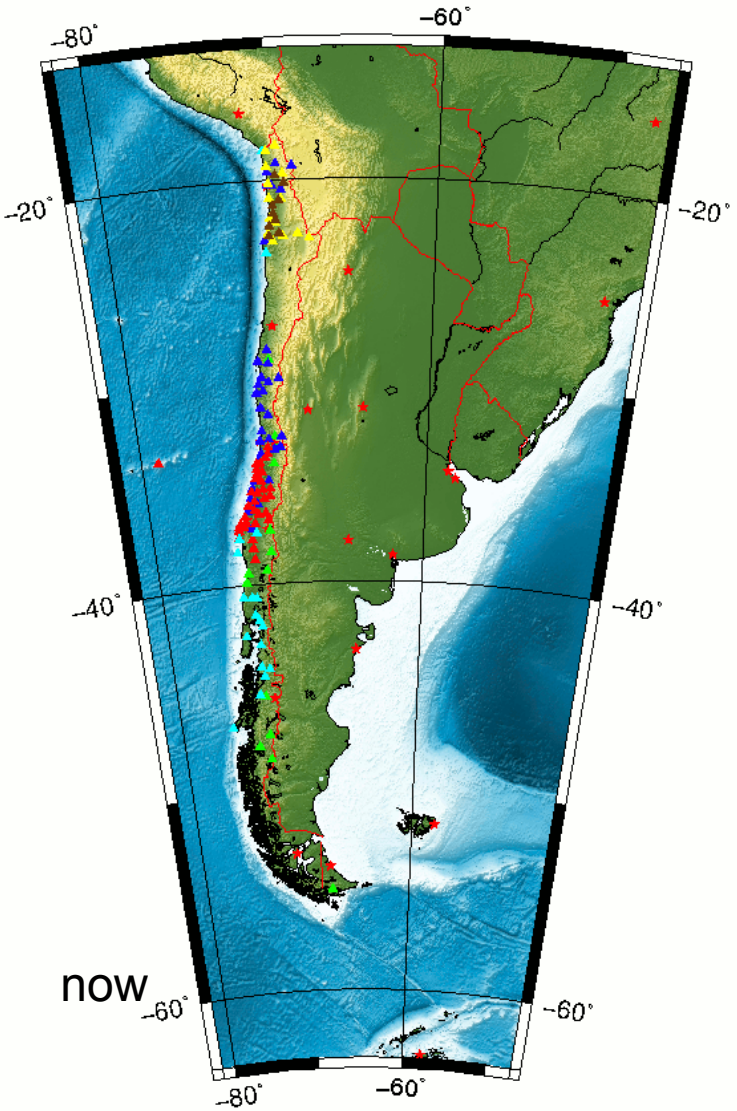


early 90's

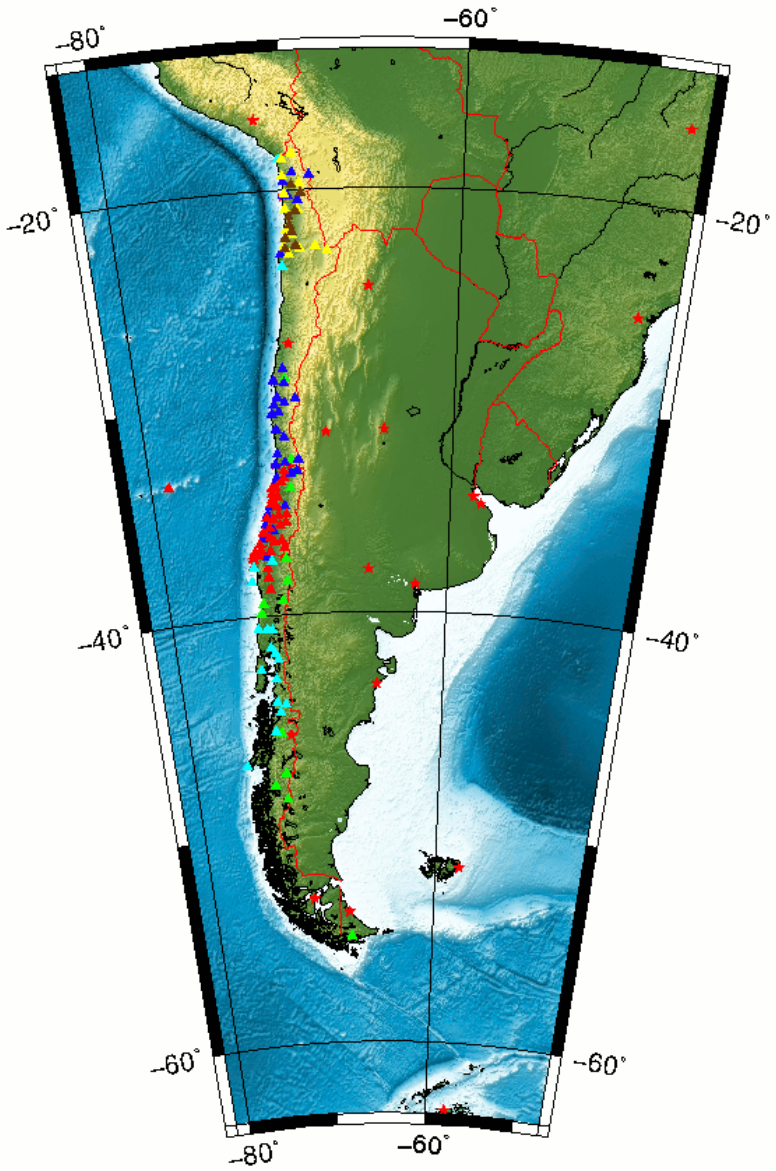


late 90's



now

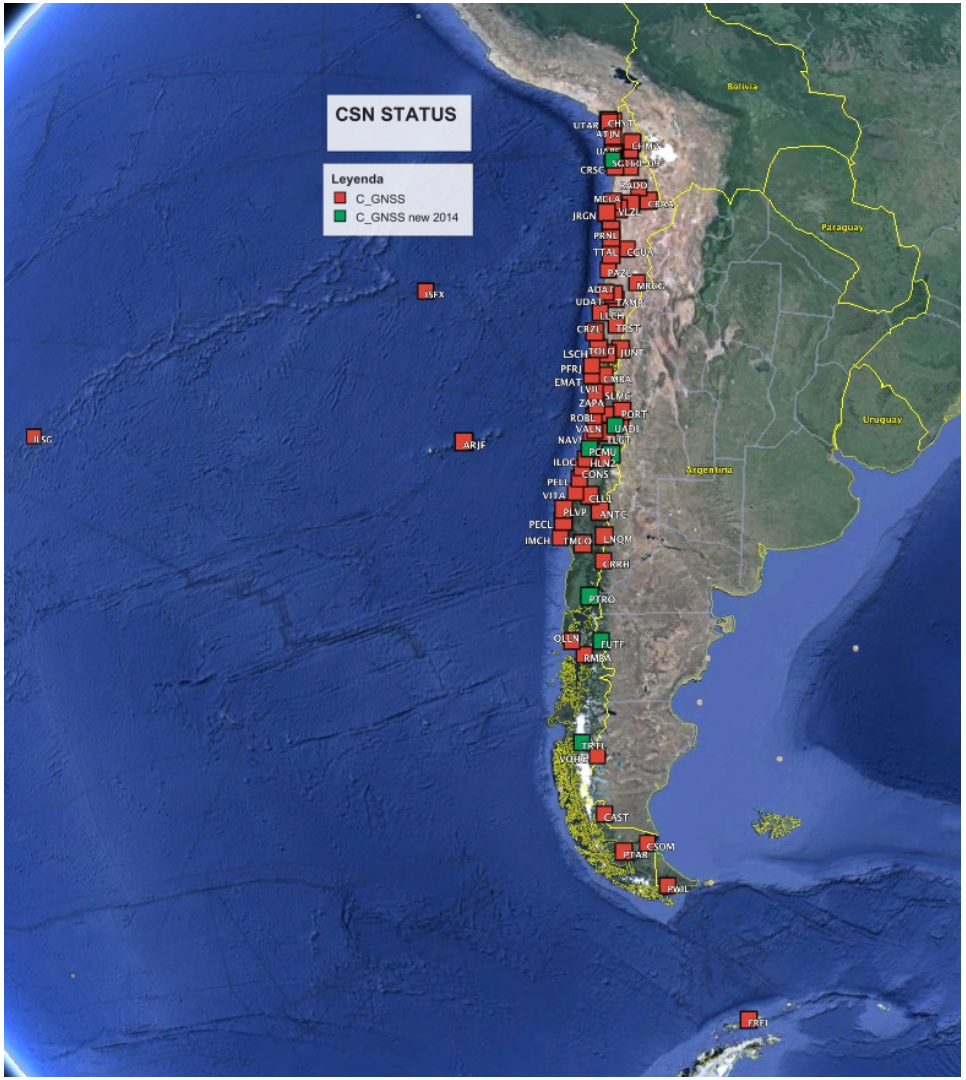
Status of all GNSS networks in Chile



CAP/IGM/UDEC stations
UDEC/GFZ/IGM stations
IPGP/DFG stations
CALTECH stations
GFZ/IPGP/DGF stations

More than 151 C-GNSS

CSN current status



- 76 stations ready installed
- 54 remaining stations
- 130 in total for this project
- 40 with RTX capabilities
- 4 stations was vandalized
- Not all of them with good communications at the moment
- 92% are stations replaced from IPGP/CALTECH/CAP/FENIX (UNAVCO et al)
- 21 stations will be in a multi-parametric sites (velocities, acceleration and displacement)

- We have a open data policy!!!

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CSN current status

```
jcbaez@jcbaez:~> sftp gpsext@200.9.100.121
gpsext@200.9.100.121's password:
Connected to 200.9.100.121.
sftp> ls RINEX/2015/146/*.Z
RINEX/2015/146/aeda1460.15d.Z                RINEX/2015/146/antc1460.15d.Z                RINEX/2015/146/cbaa1460.15d.Z
RINEX/2015/146/chyt1460.15d.Z                RINEX/2015/146/cmba1460.15d.Z                RINEX/2015/146/crsc1460.15d.Z
RINEX/2015/146/dgf11460.15d.Z                RINEX/2015/146/futf1460.15d.Z                RINEX/2015/146/imch1460.15d.Z
RINEX/2015/146/mrcg1460.15d.Z                RINEX/2015/146/navi1460.15d.Z                RINEX/2015/146/pazu1460.15d.Z
RINEX/2015/146/pcmu1460.15d.Z                RINEX/2015/146/pell1460.15d.Z                RINEX/2015/146/ptar1460.15d.Z
RINEX/2015/146/ptro1460.15d.Z                RINEX/2015/146/qlln1460.15d.Z                RINEX/2015/146/rado1460.15d.Z
RINEX/2015/146/rcsd1460.15d.Z                RINEX/2015/146/sbll1460.15d.Z                RINEX/2015/146/srgd1460.15d.Z
RINEX/2015/146/tlgt1460.15d.Z                RINEX/2015/146/utar1460.15d.Z                RINEX/2015/146/valn1460.15d.Z
sftp> ls incoming/????20150526*
incoming/VALN201505260000s.T02               incoming/AEDA201505260000s.T02               incoming/ANTC201505260000s.T02
incoming/PTRO201505260000s.T02               incoming/RADO201505260000s.T02               incoming/PCMU201505260000s.T02
incoming/CMBA201505260000s.T02               incoming/FUTF201505260000s.T02               incoming/SRGD201505260000s.T02
incoming/PELL201505260000s.T02               incoming/PAZU201505260000s.T02               incoming/CRSC201505260000s.T02
incoming/CBAA201505260000s.T02               incoming/DGF1201505260000s.T02               incoming/QLLN201505260000s.T02
incoming/PTAR201505260000s.T02               incoming/MRCG201505260000s.T02               incoming/IMCH201505260000S.T02
incoming/NAVI201505260000s.T02               incoming/RCSD201505260000s.T02               incoming/CHYT201505260000s.T02
incoming/TLGT201505260000s.T02               incoming/SBLL201505260000s.T02               incoming/UTAR201505260000S.T02
incoming/SANT201505260000s.T02
sftp>
```

```
     2.11           OBSERVATION DATA    G (GPS)             RINEX VERSION / TYPE
teqc  2013Mar15     Juan Carlos Baez    20150527 12:53:44UTCPGM / RUN BY / DATE
Linux 2.4.21-27.ELsmp|Opteron|gcc|Linux x86_64|=+           COMMENT
teqc  2013Mar15     CSN/UCHILE          20150527 12:49:36UTCCOMMENT
BIT 2 OF LLI FLAGS DATA COLLECTED UNDER A/S CONDITION       COMMENT
UTAR                                                        MARKER NAME
0000                                                        MARKER NUMBER
-Unknown-           Centro Sismologico Nacional             OBSERVER / AGENCY
5229K50867          TRIMBLE NETR9       4.85                REC # / TYPE / VERS
5000112786          TRM57971.00     NONE                    ANT # / TYPE
  2040107.6400 -5696703.5800 -2009987.7400                  APPROX POSITION XYZ
        0.0000        0.0000        0.0000                  ANTENNA: DELTA H/E/N
     1     1                                                WAVELENGTH FACT L1/2
     7    L1    L2    C1    P1    P2    S1    S2           # / TYPES OF OBSERV
    15.0000                                                 INTERVAL
    16                                                      LEAP SECONDS
                                                            COMMENT
  Centro Sismologico Nacional                               COMMENT
      Universidad de Chile                                  COMMENT
       Unidad de Geodesia                                   COMMENT
                                                            COMMENT
      gps@csn.uchile.cl                                     COMMENT
 SNR is mapped to RINEX snr flag value [0-9]                COMMENT
  L1 & L2: min(max(int(snr_dBHz/6), 0), 9)                  COMMENT
Forced Modulo Decimation to 15 seconds                      COMMENT
  2015     5    26     0     0    0.0000000     GPS         TIME OF FIRST OBS
                                                            END OF HEADER
 15  5 26  0  0  0.0000000  0 10G30G02G09G03G07G23G05G28G06G10
 108046535.07948  84192226.64547  20560543.0864                  20560550.7234
       50.5004         42.9004
 122126686.67147  95163726.09245  23239946.2274                  23239951.5784
```

- RAW data available in 1hz
- RINEX data available in 15 sec

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Status of C-GNSS stations under CSN

CSN
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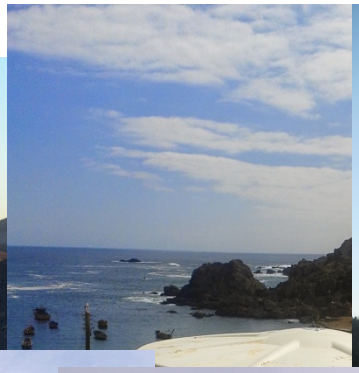
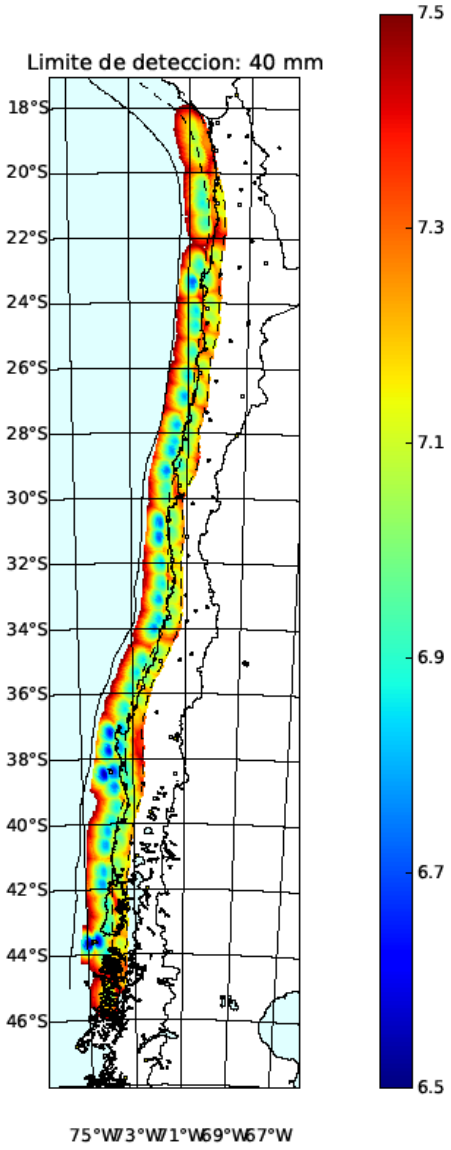
Monumentation



Network design for EW



Detectability threshold of actual CSN network. (Thanks Francisco del Campo)

The scale of colors displays the minimum moment magnitude (Mw) to observe a 40 mm horizontal displacement due to an inter-plate earthquake.

- It is clear that coast-stations are more sensitive;
- For great earthquakes (>8.0) coast-stations still have better response, but inland stations become of increasing importance;
- We will increase the number of stations near to coast, to have one every 40 km

Schedule of CSN solutions

1 hz observation

Storage in mem

Dif. Positioning

RTX reading

NMEA streaming

Time, X, δ

RTCM streaming

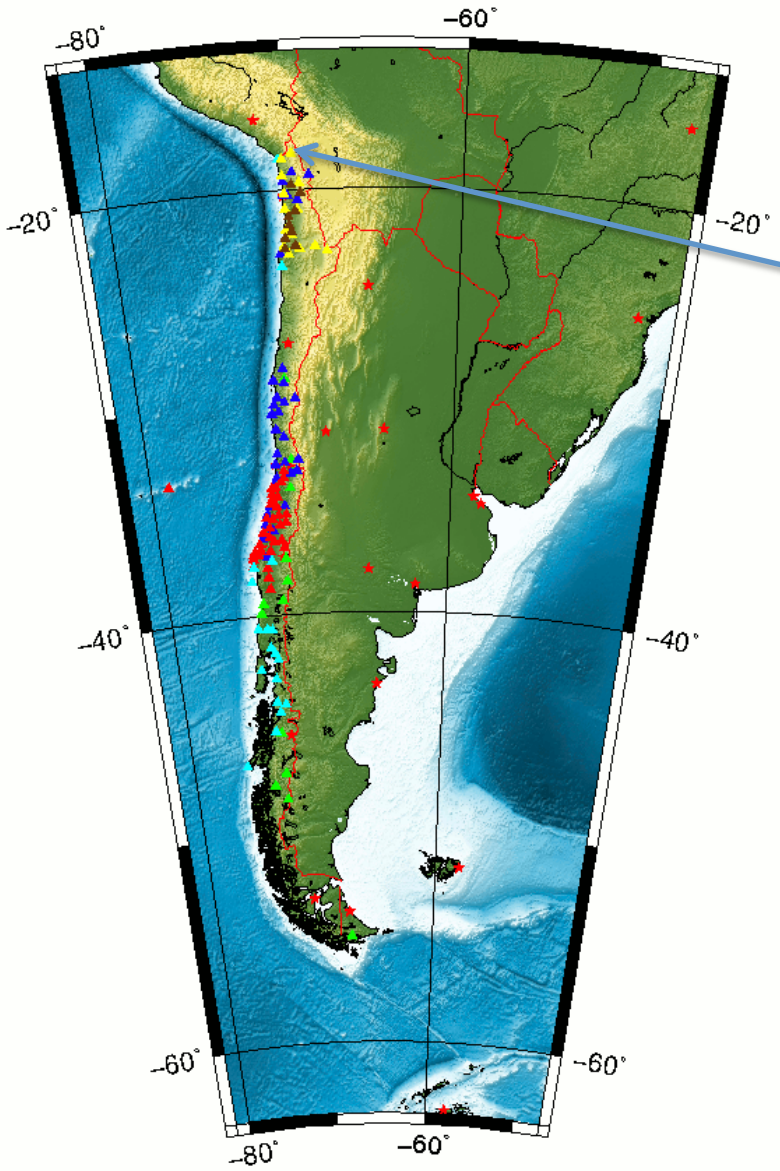
NTRIP

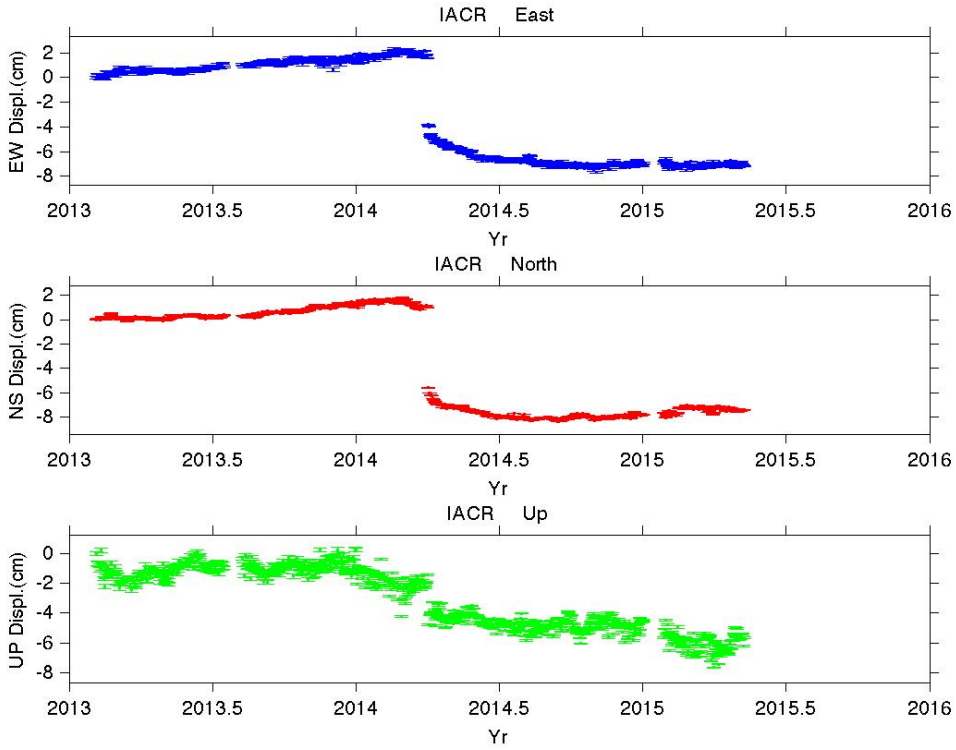
PPP

Input for EW

Data Storage and publishing

Results from Pisagua EQ 2014





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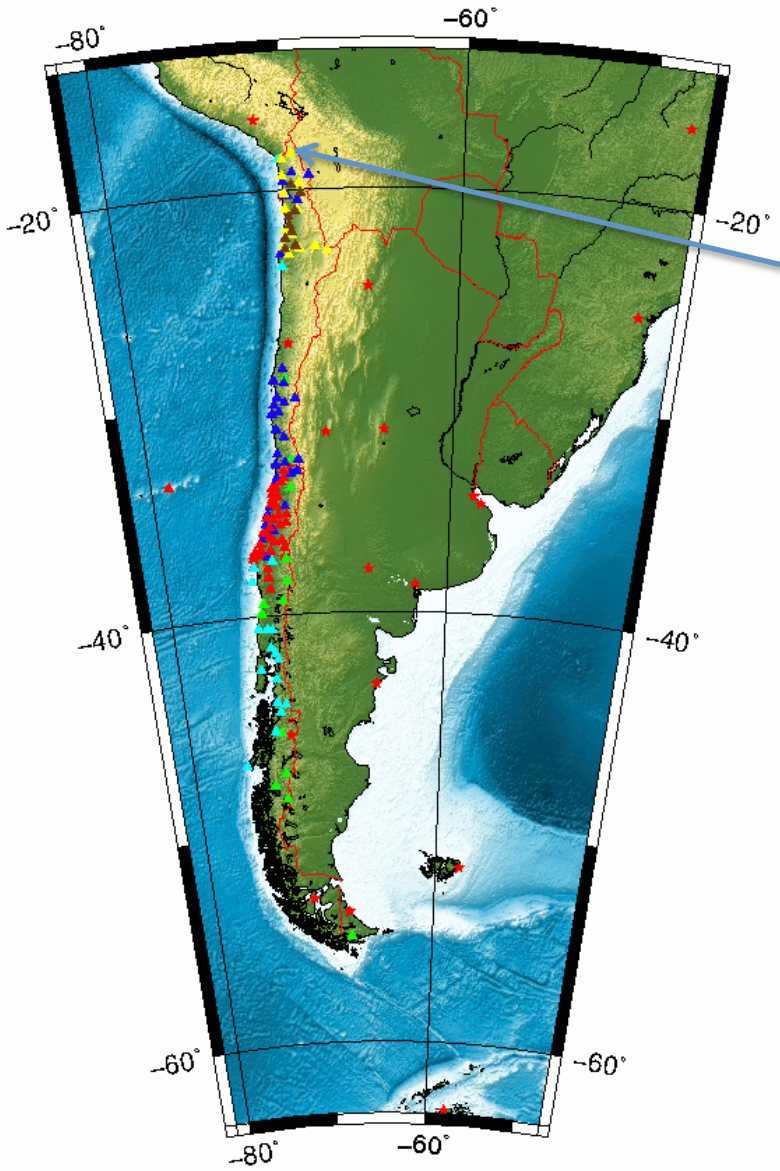

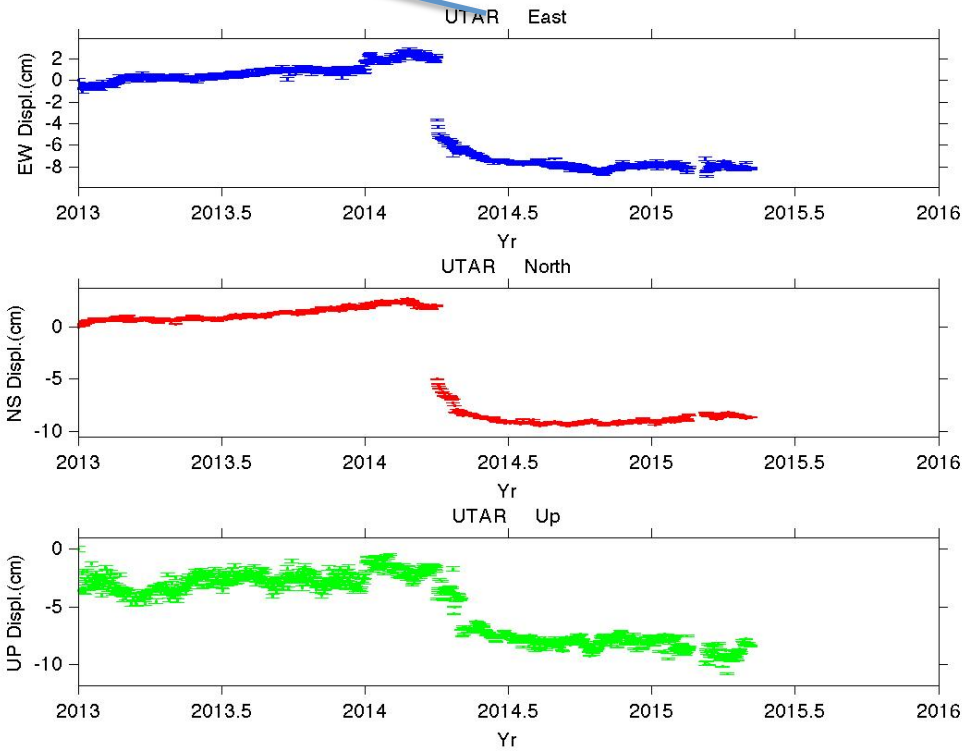

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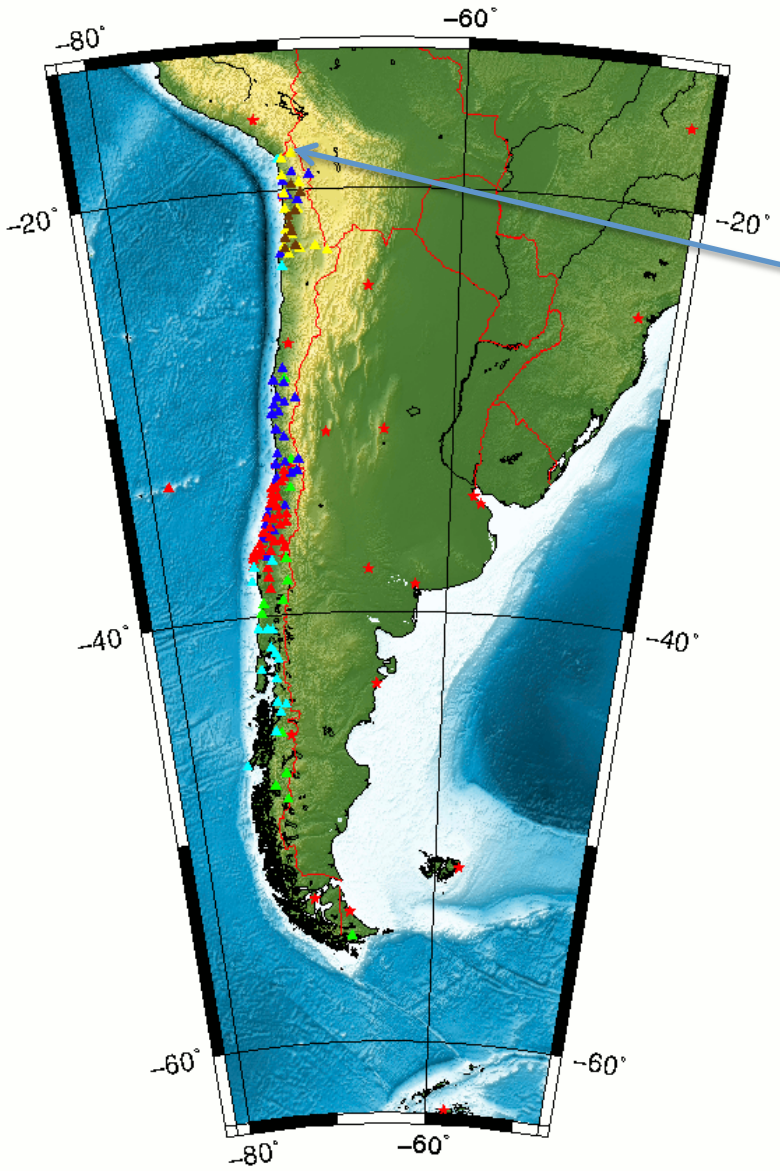

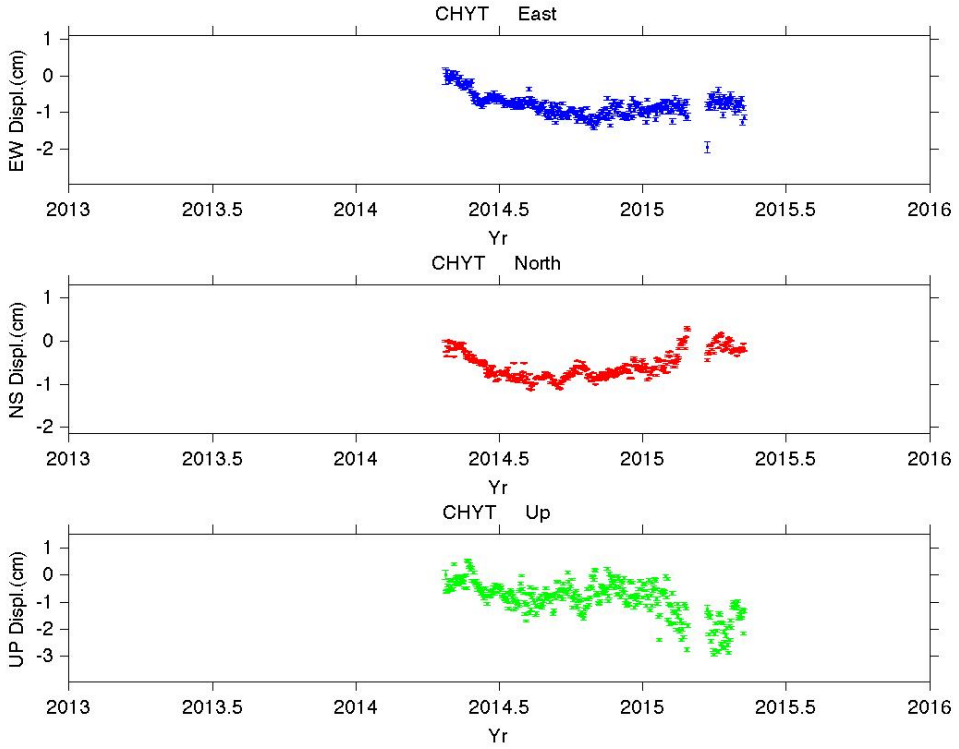

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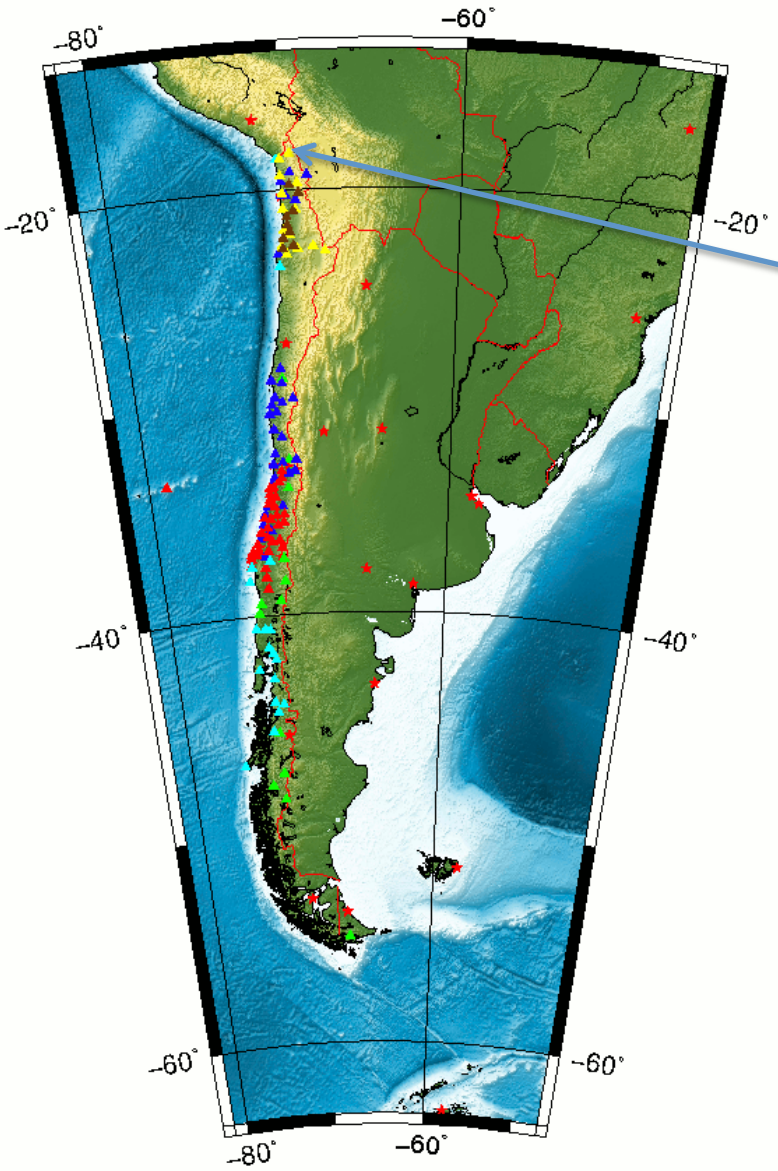

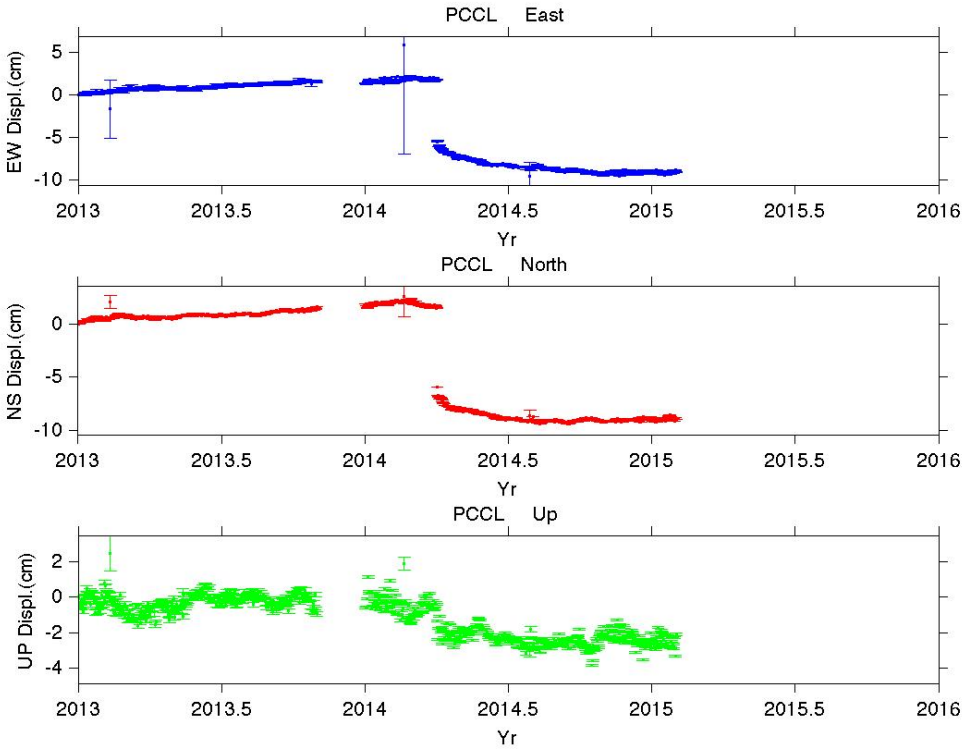

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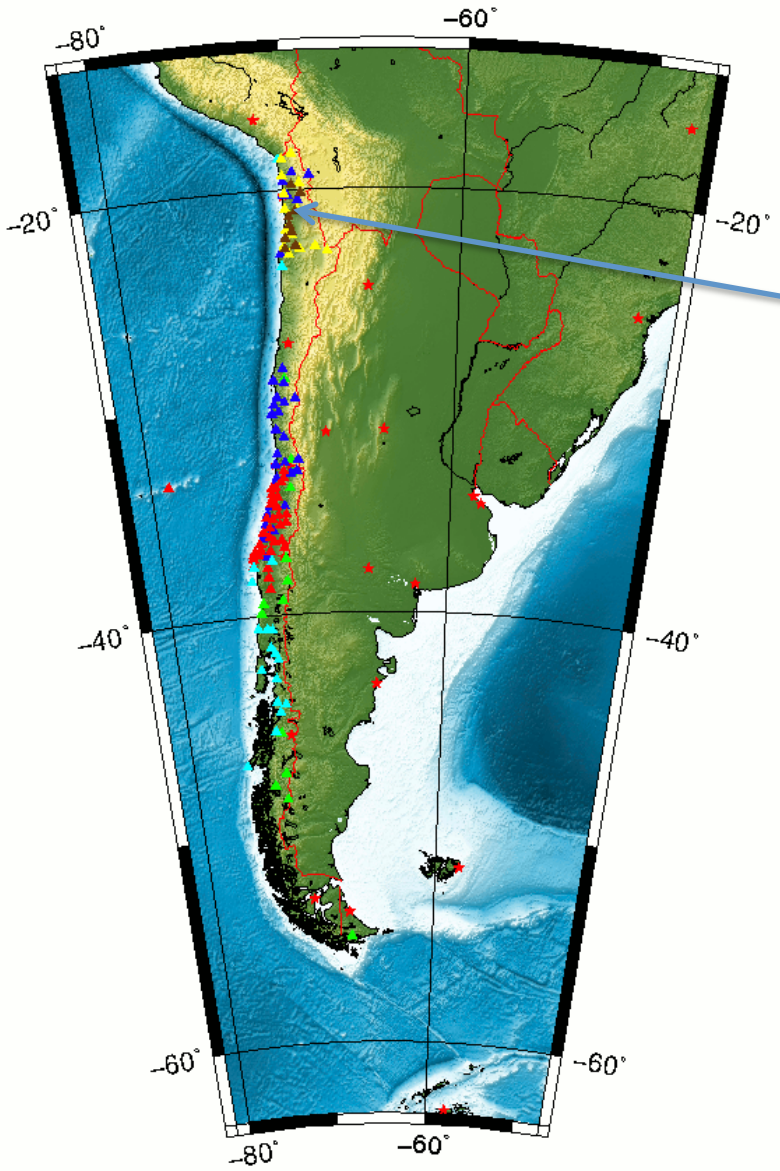

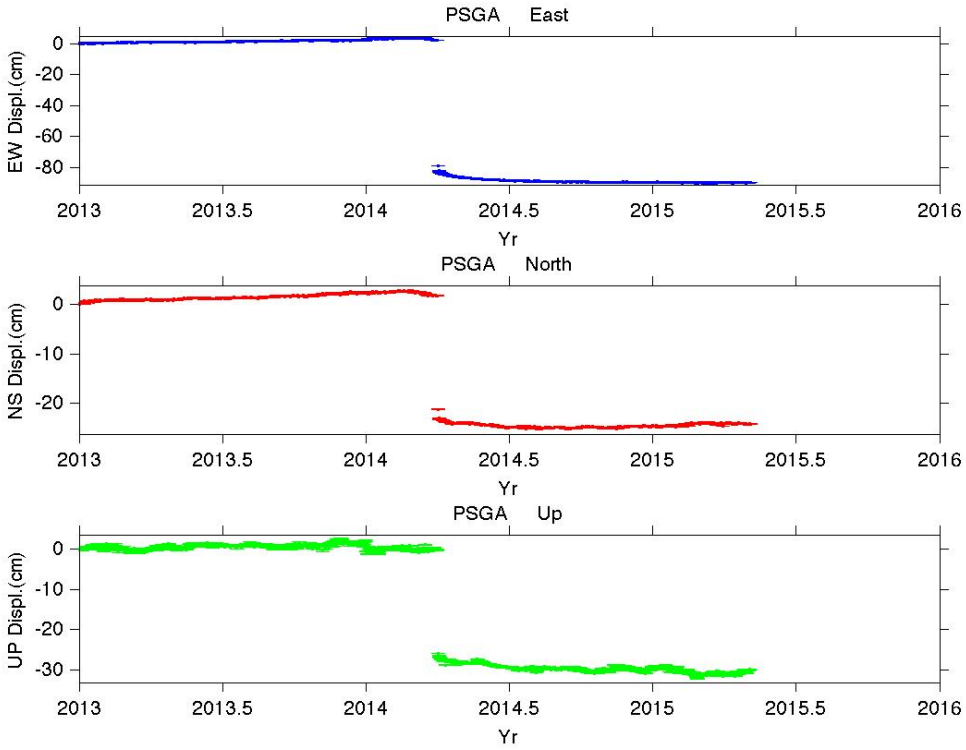

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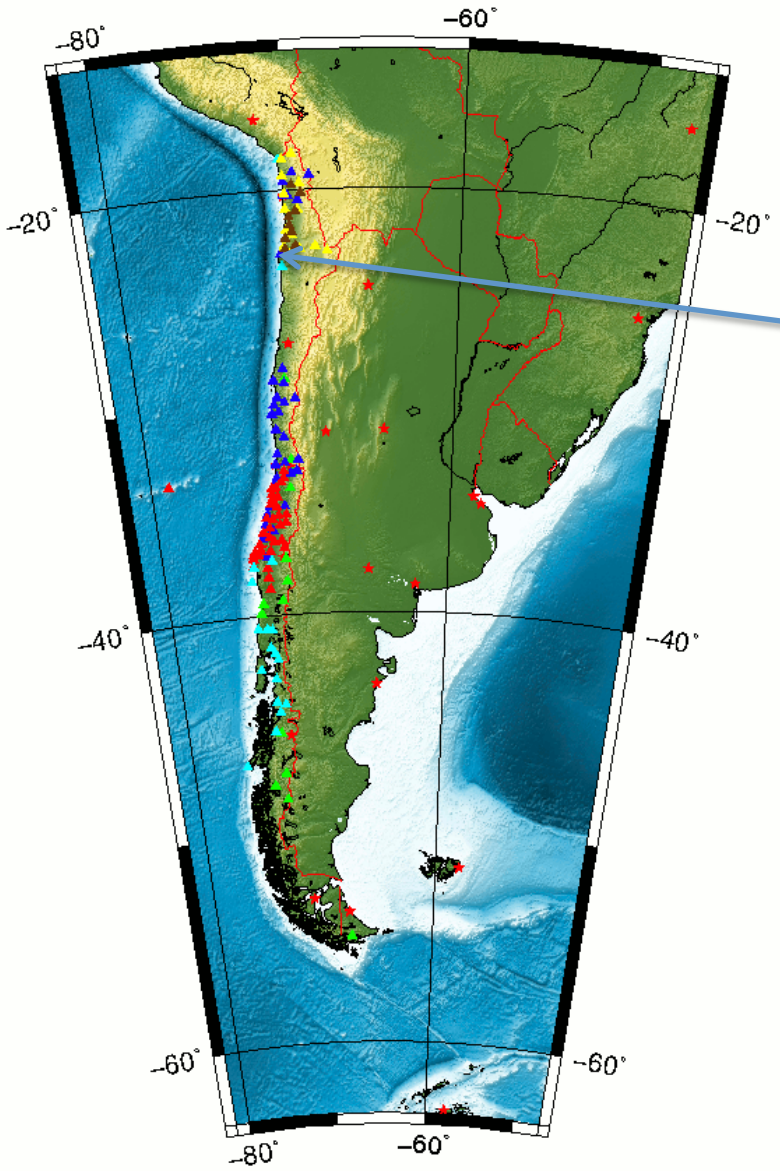

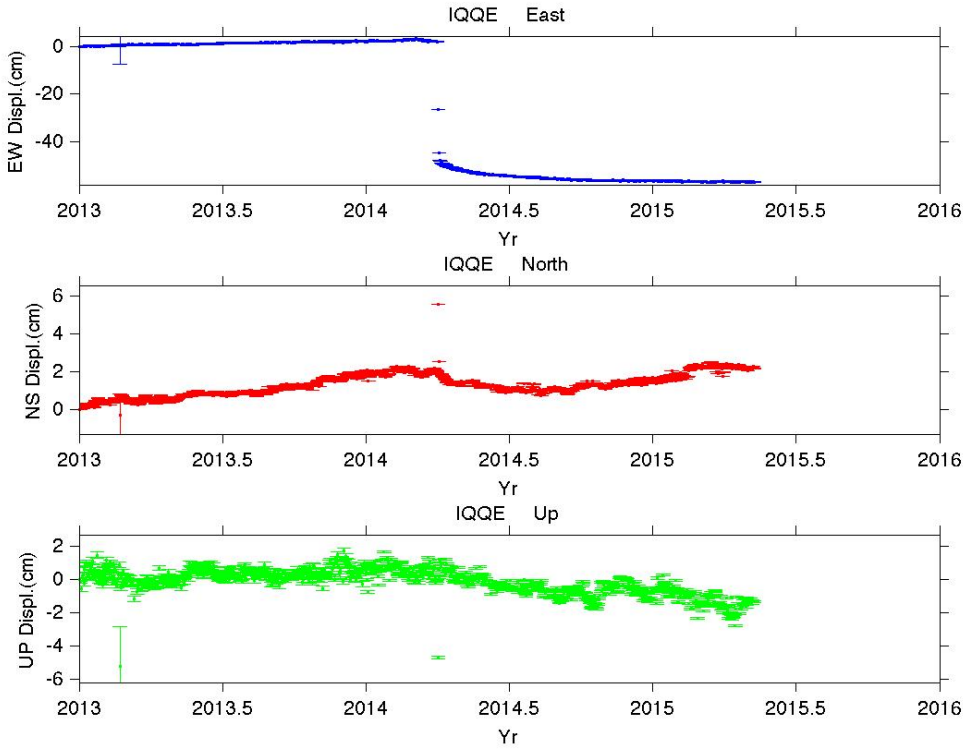

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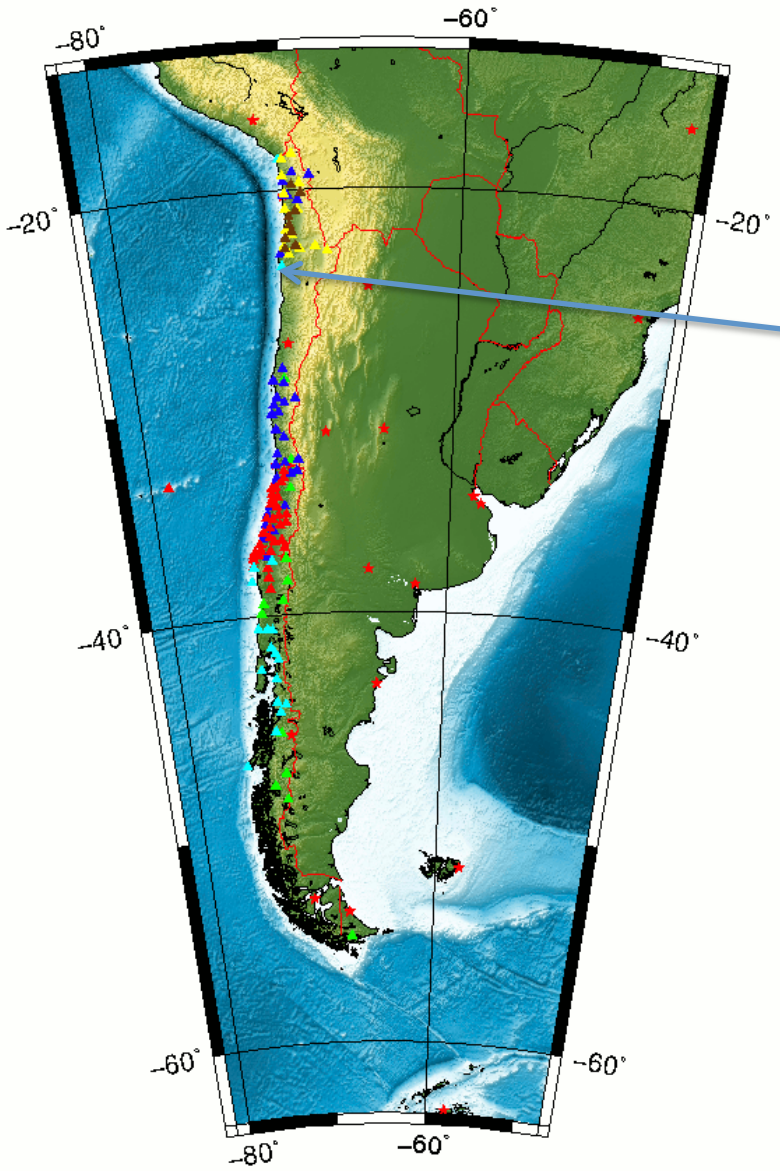

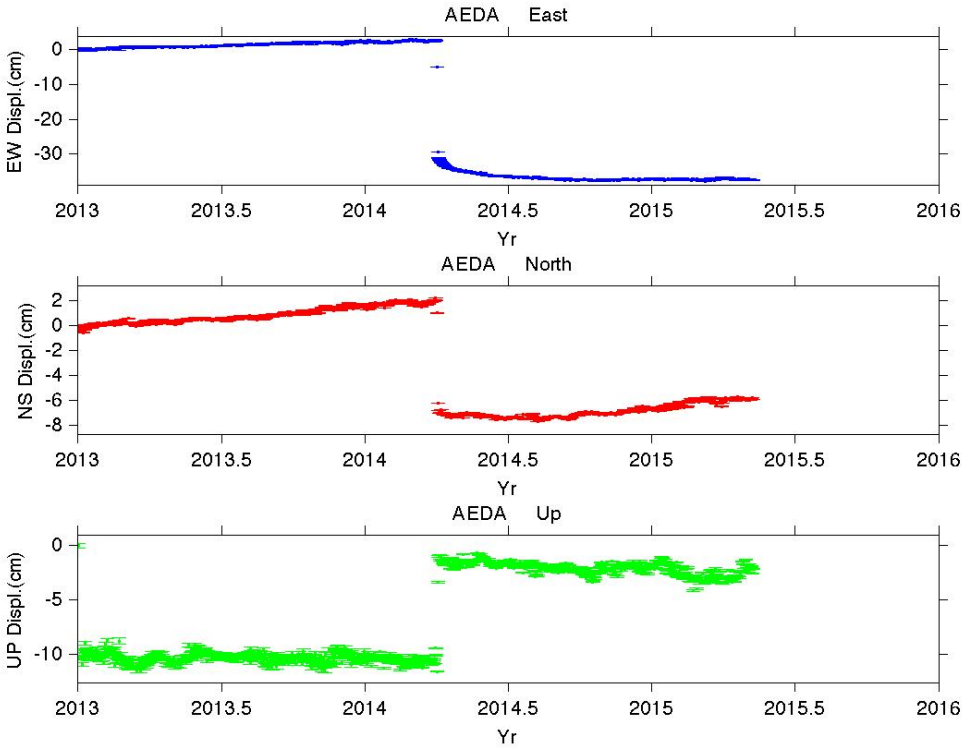

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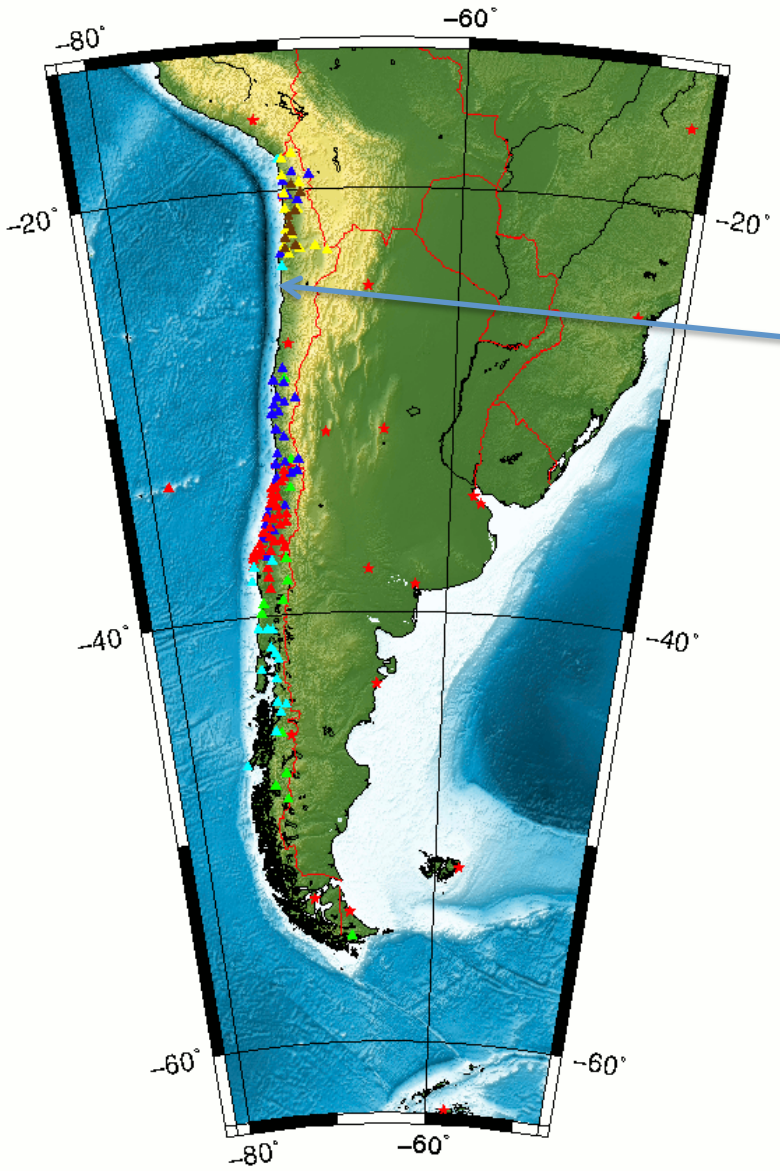
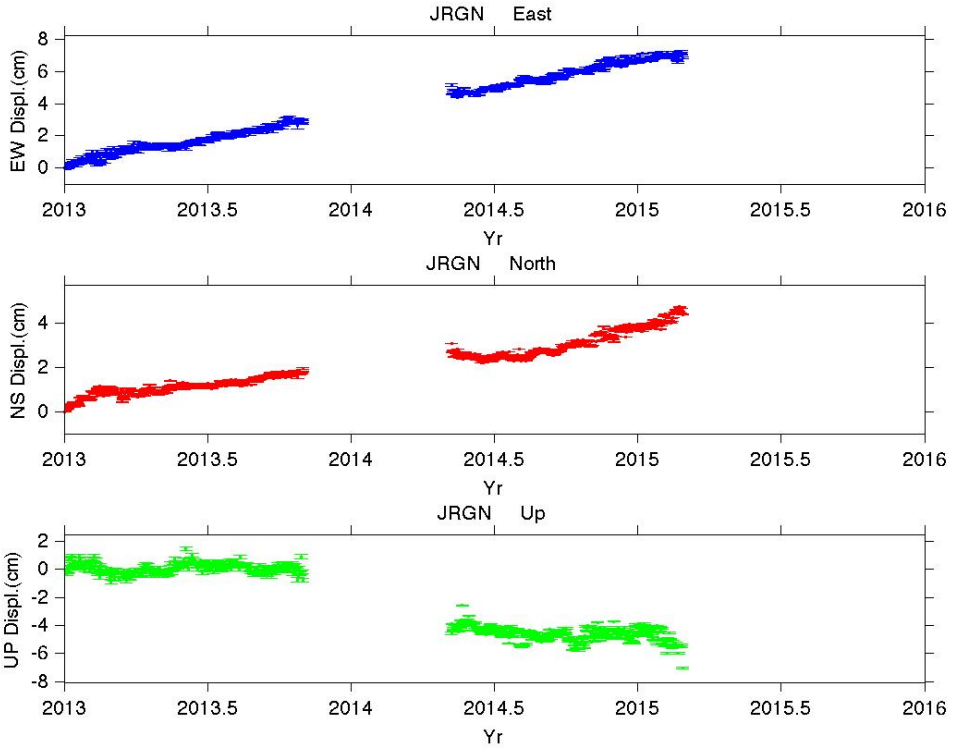
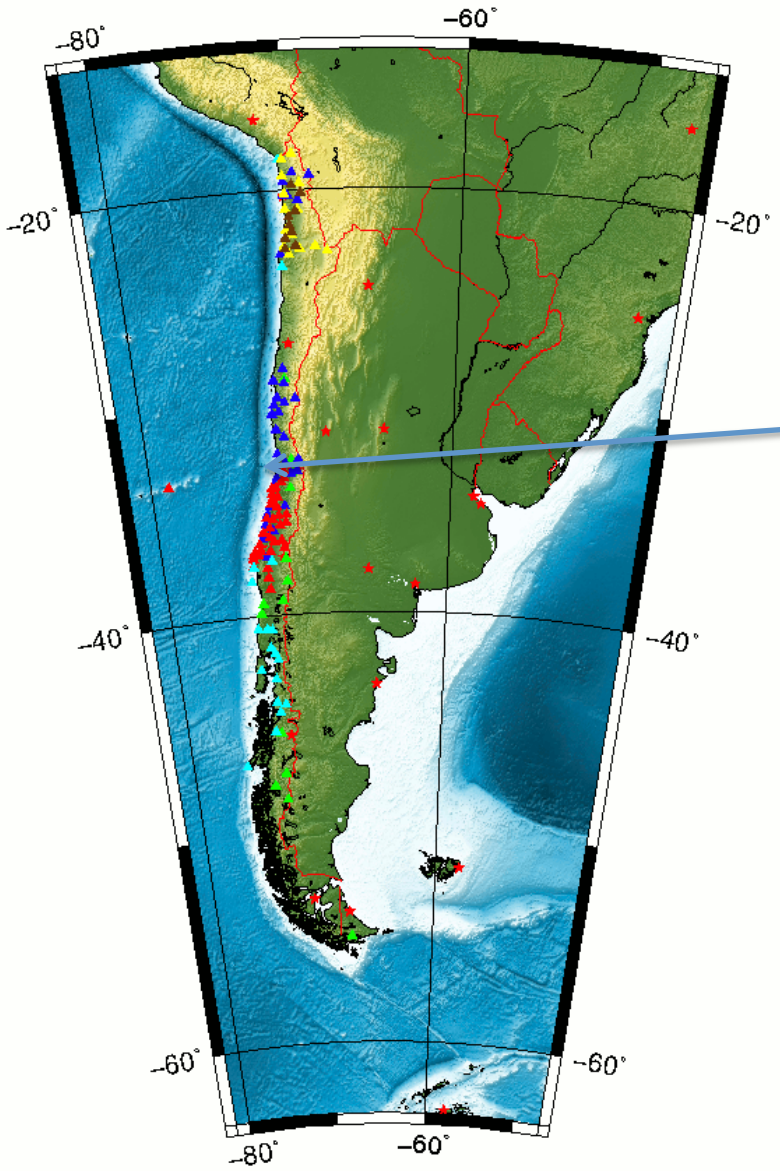
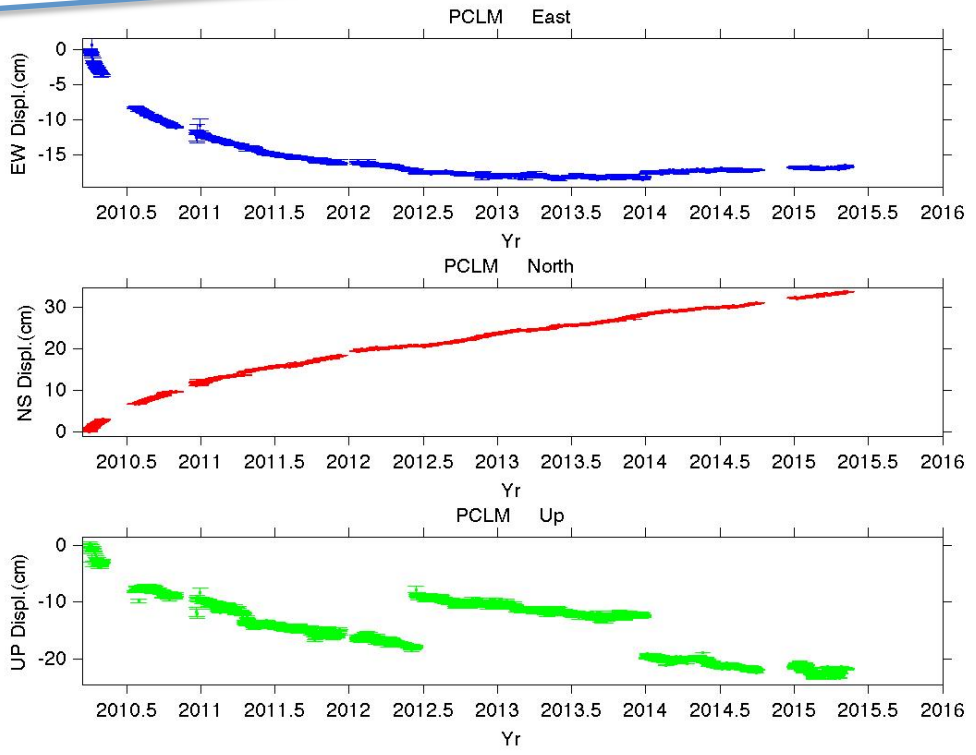




Results from Maule EQ 2010





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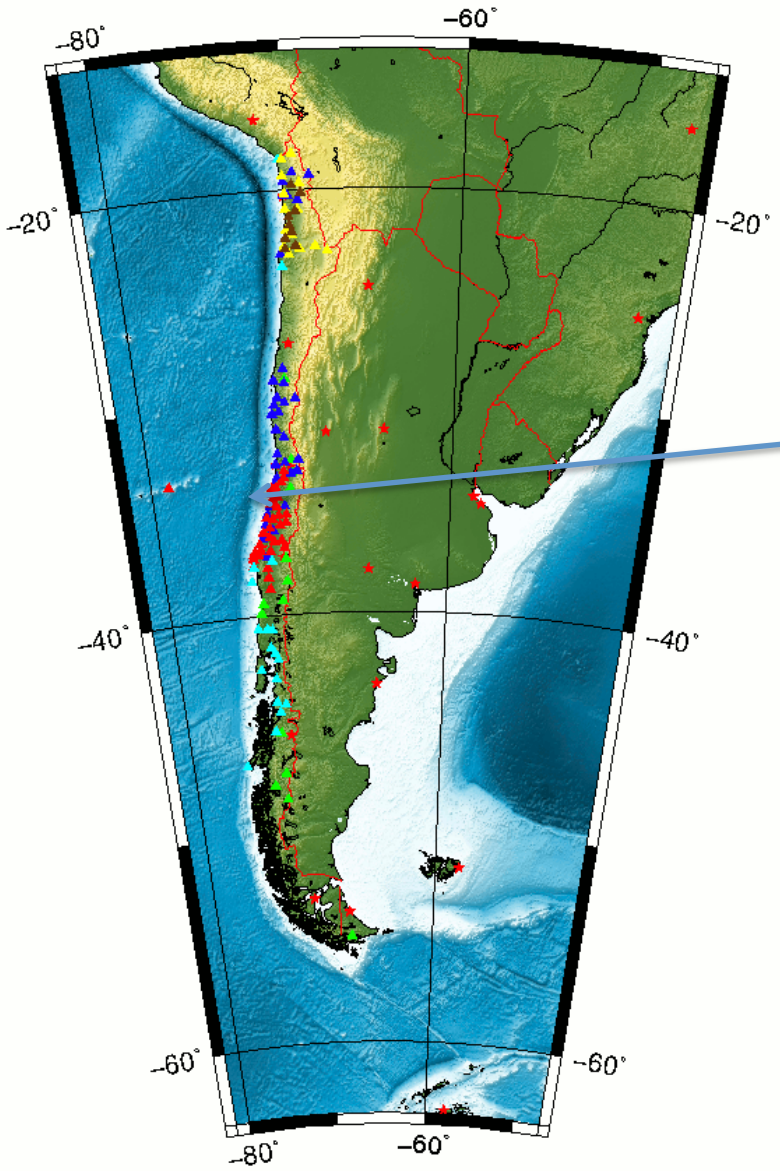

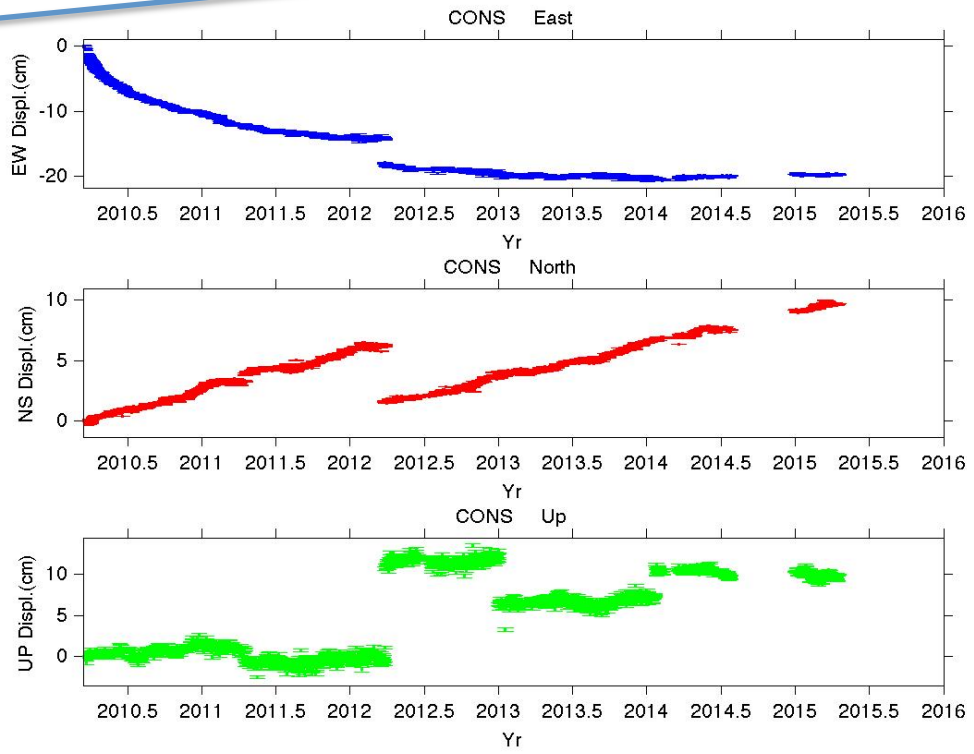

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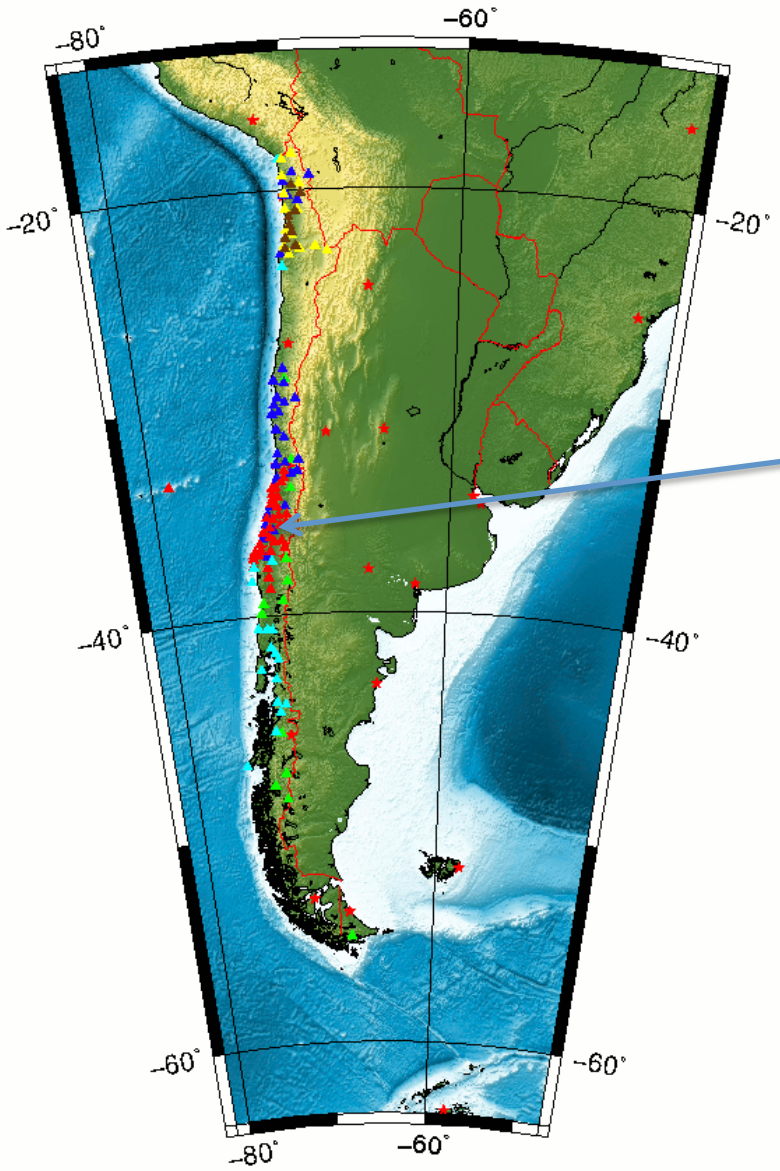

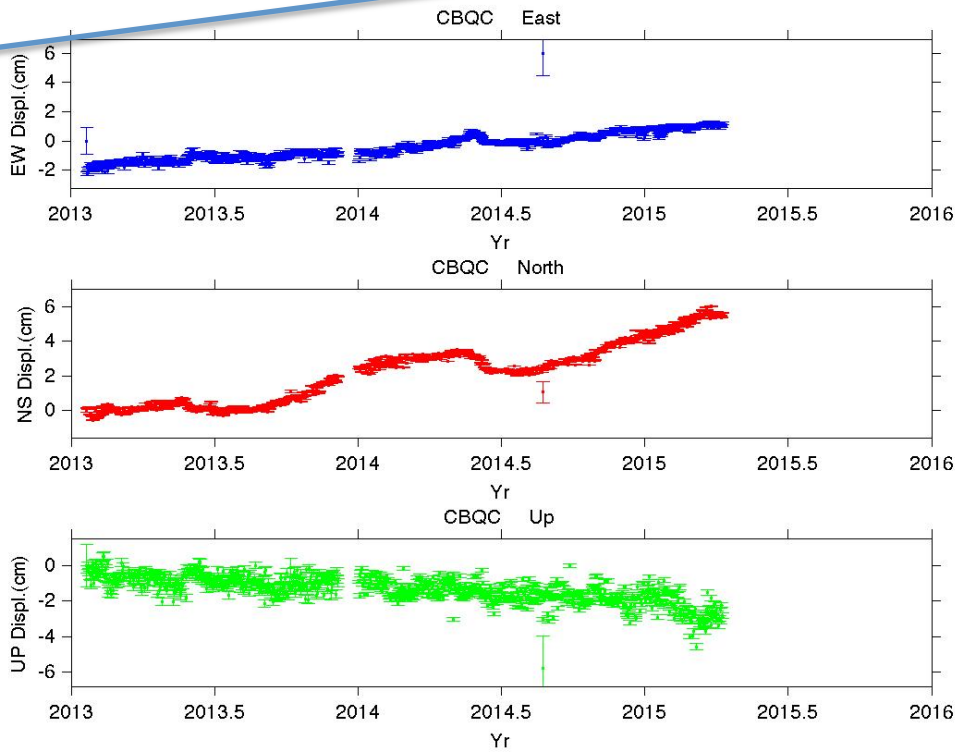

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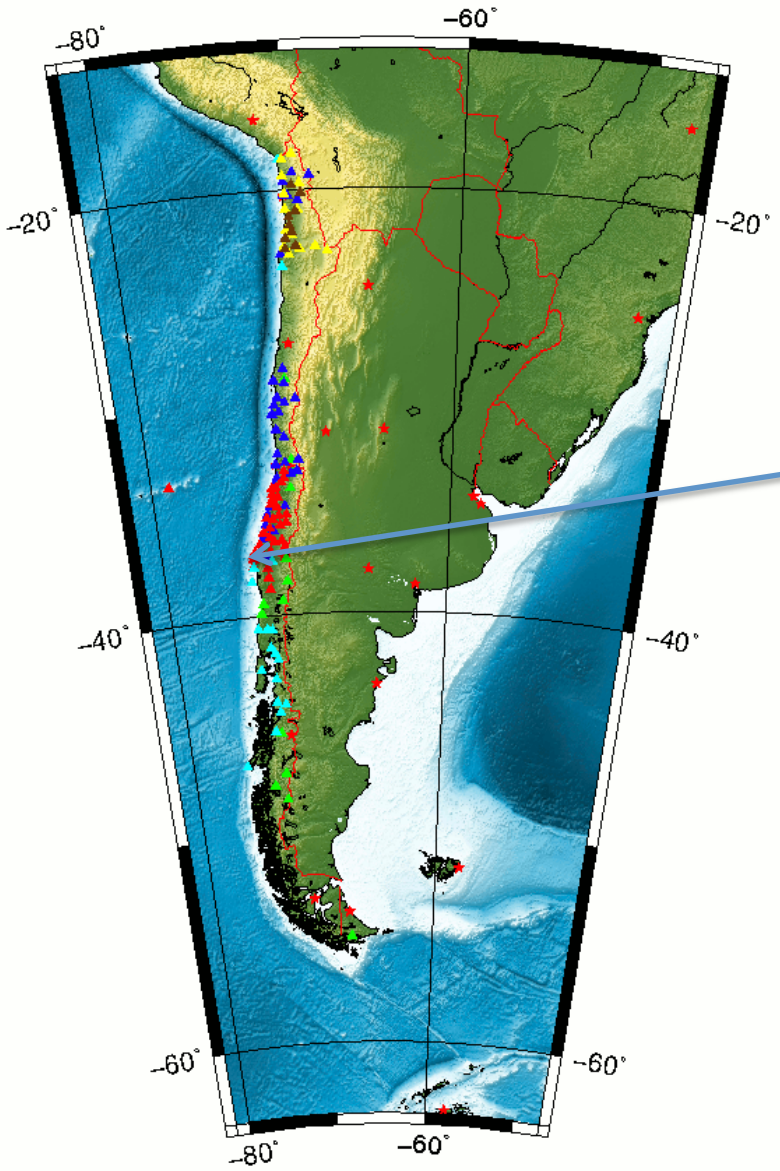

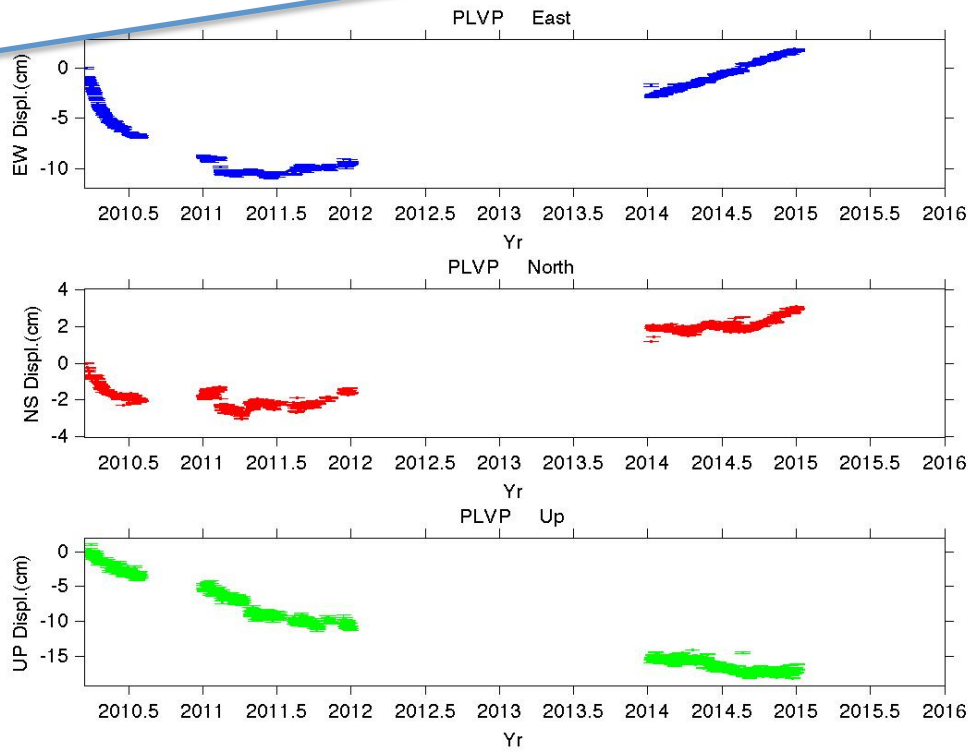

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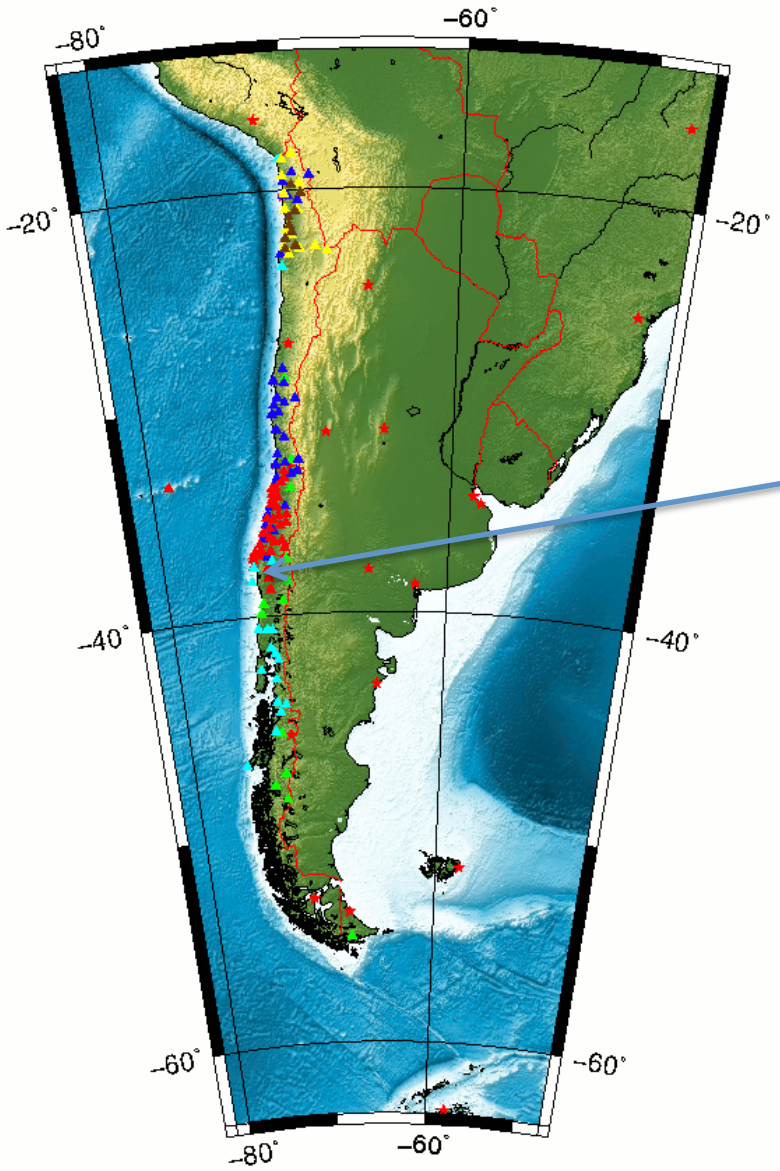
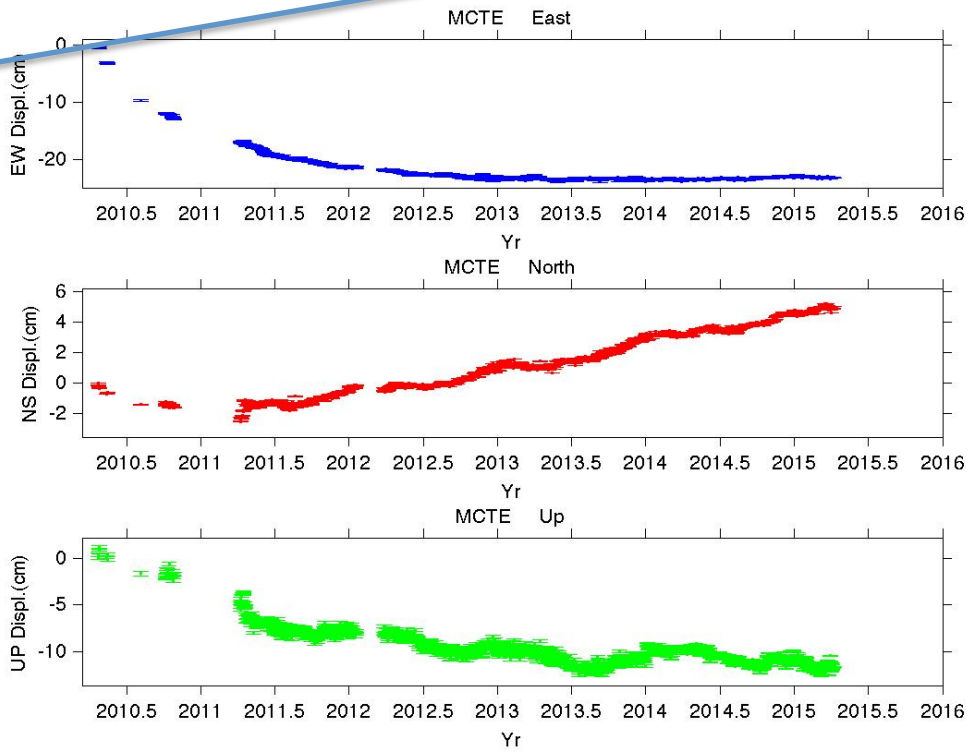
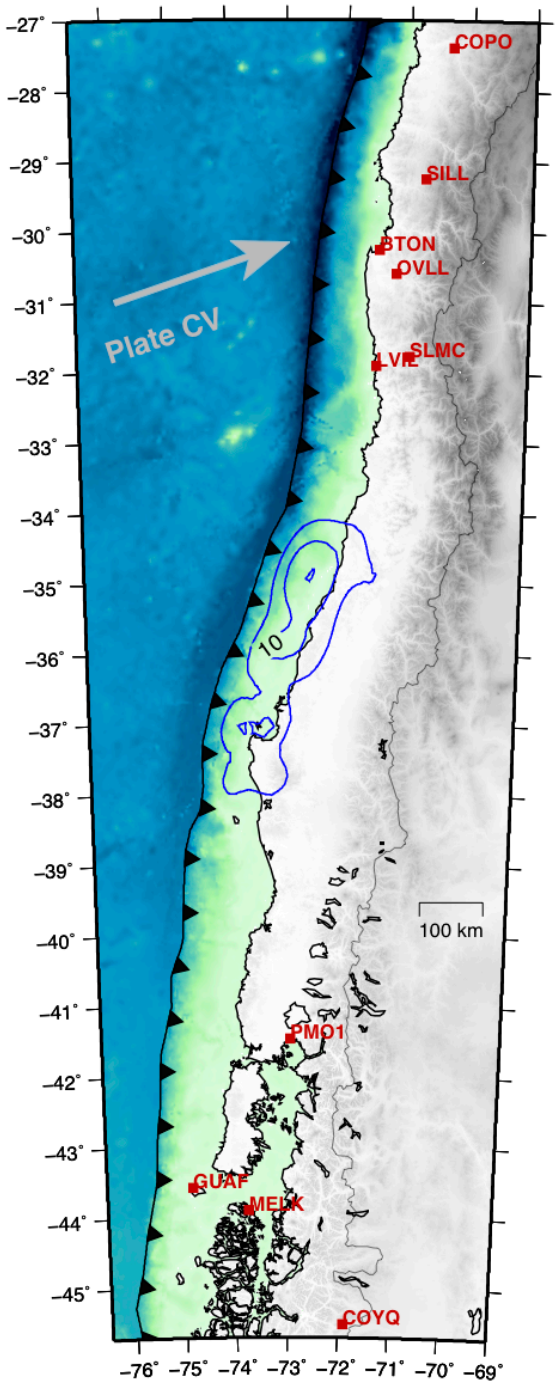


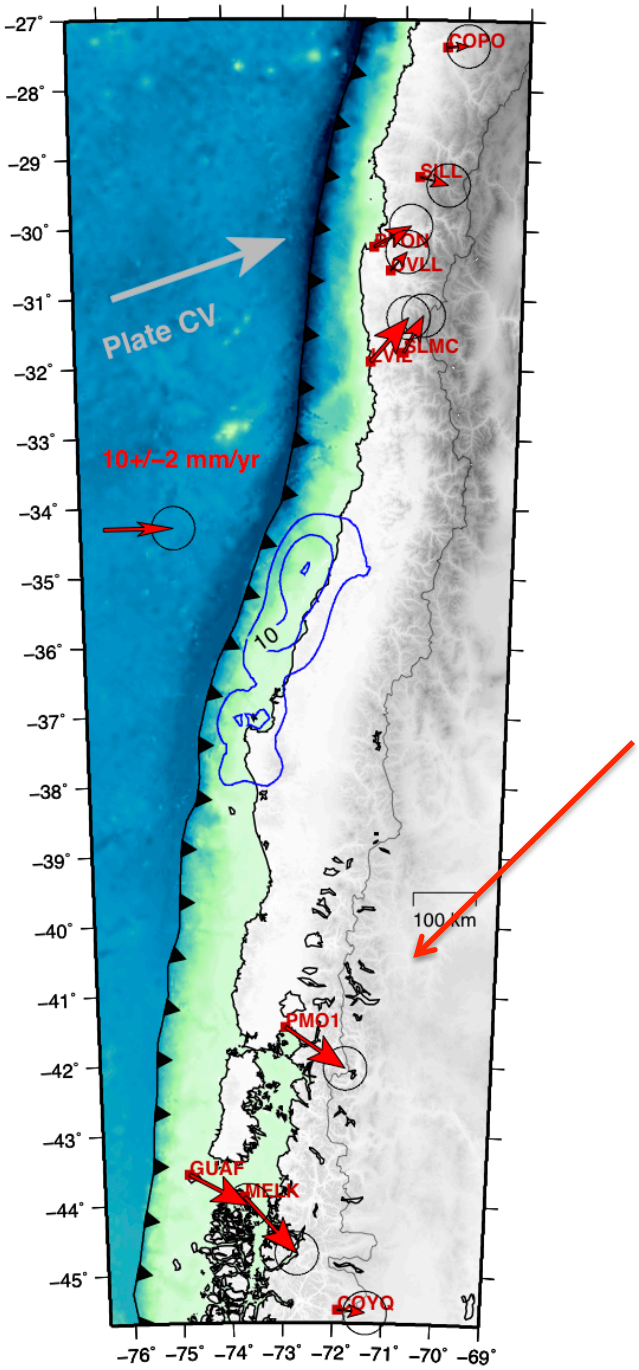


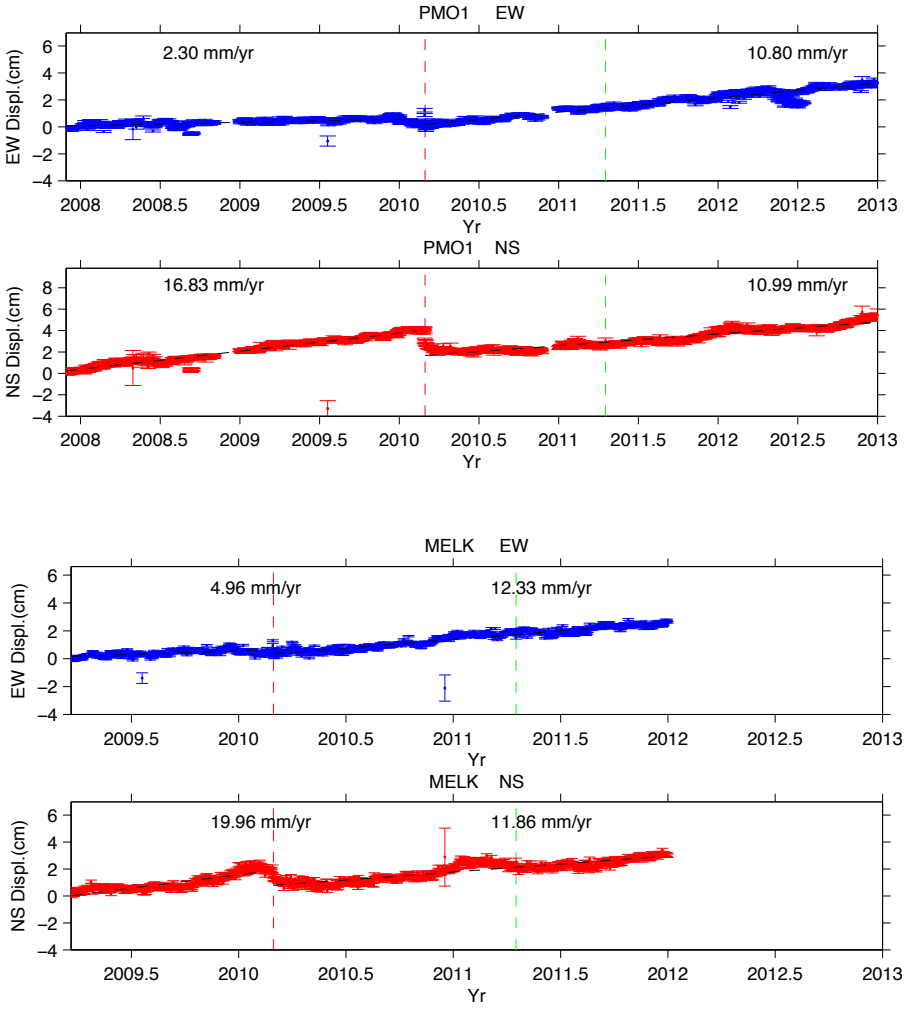


Time-series outside the Maule rupture zone

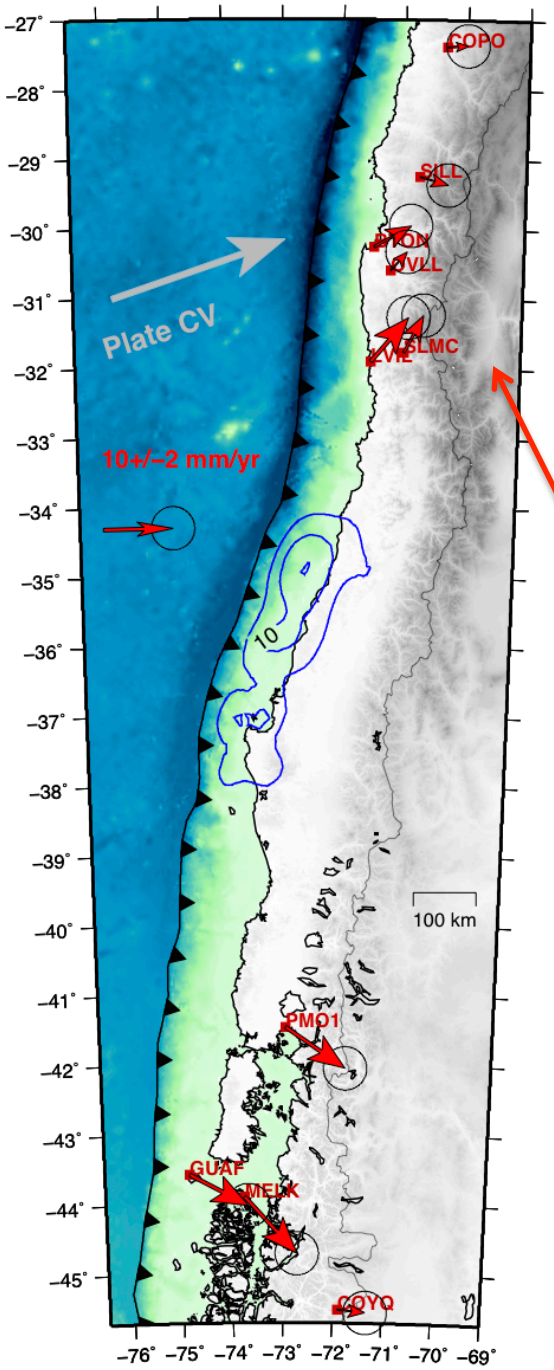
cGPS stations +700 km from Maule rupture zone

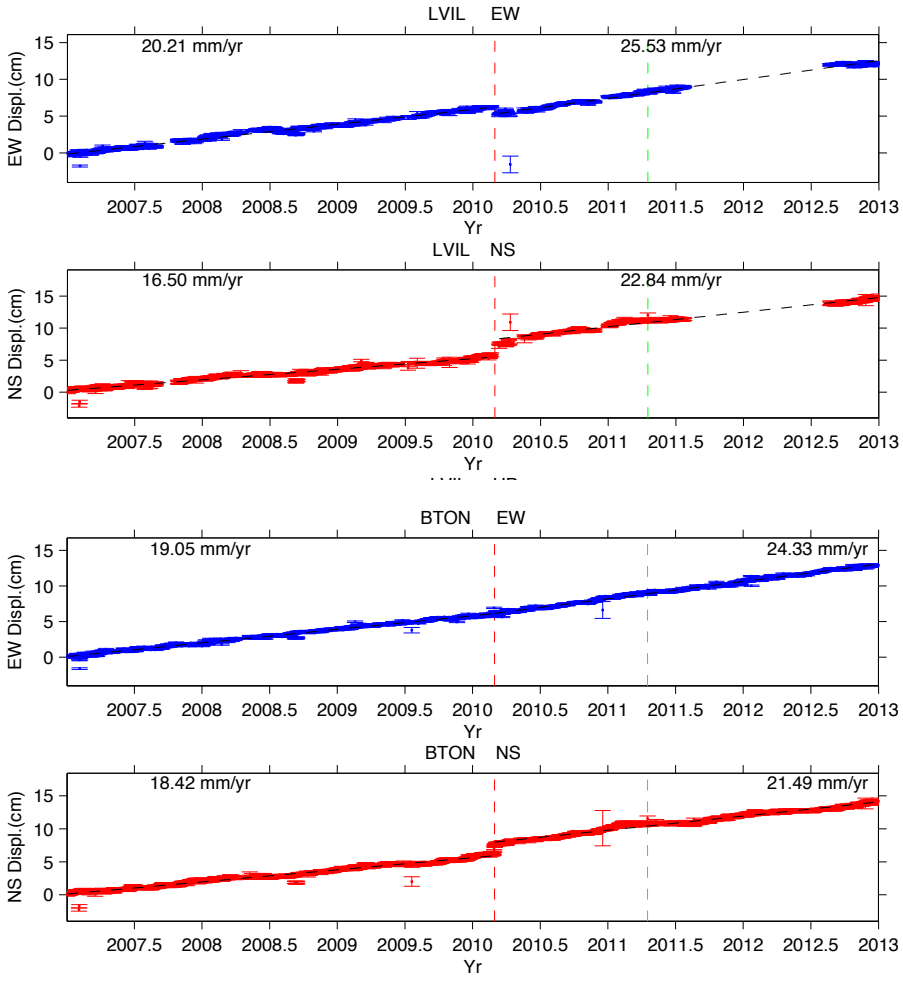
Difference before & after the Maule EQ.

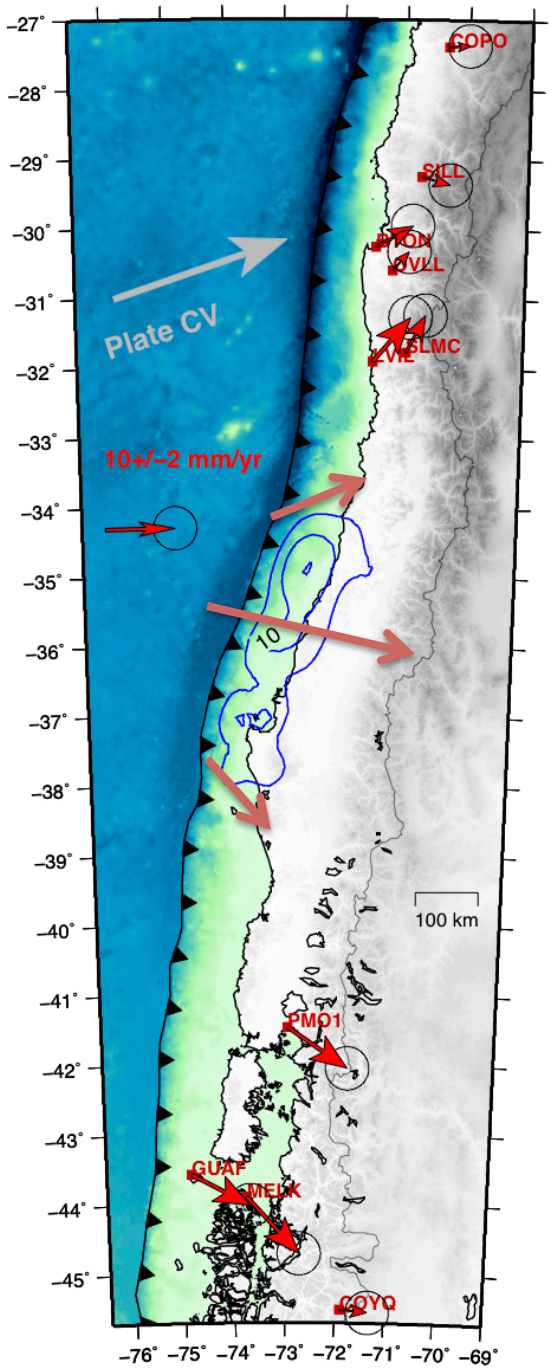




Difference before & after the Maule EQ.







Difference before & after the Maule EQ.

Increase of inter-seismic velocities outside rupture area

Acceleration in the slab velocity after the Maule EQ?

Increase in locking degree at the adjacent segments?

NRT solutions

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Results

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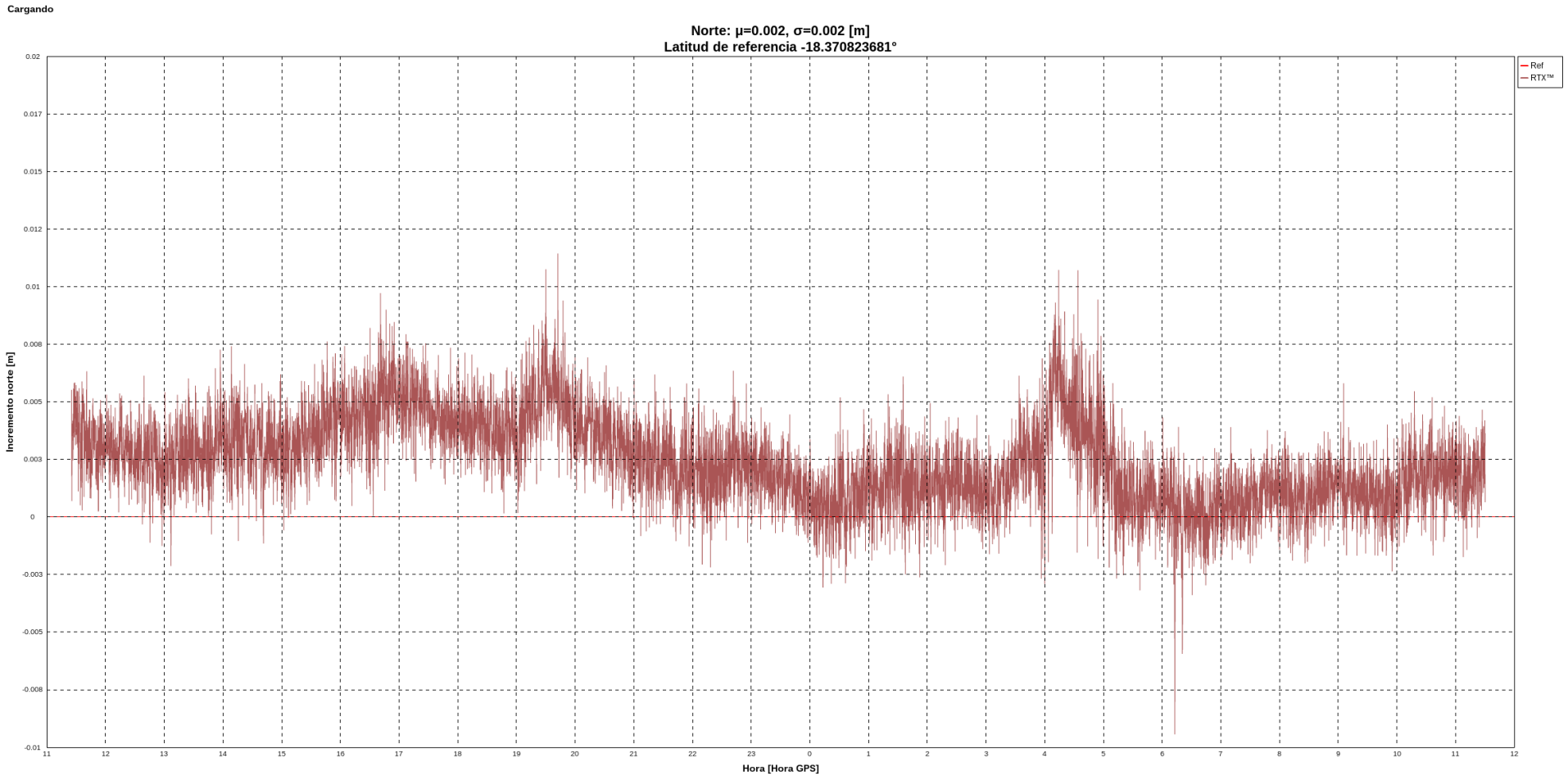
NRT RTX-NMEA streaming



Results

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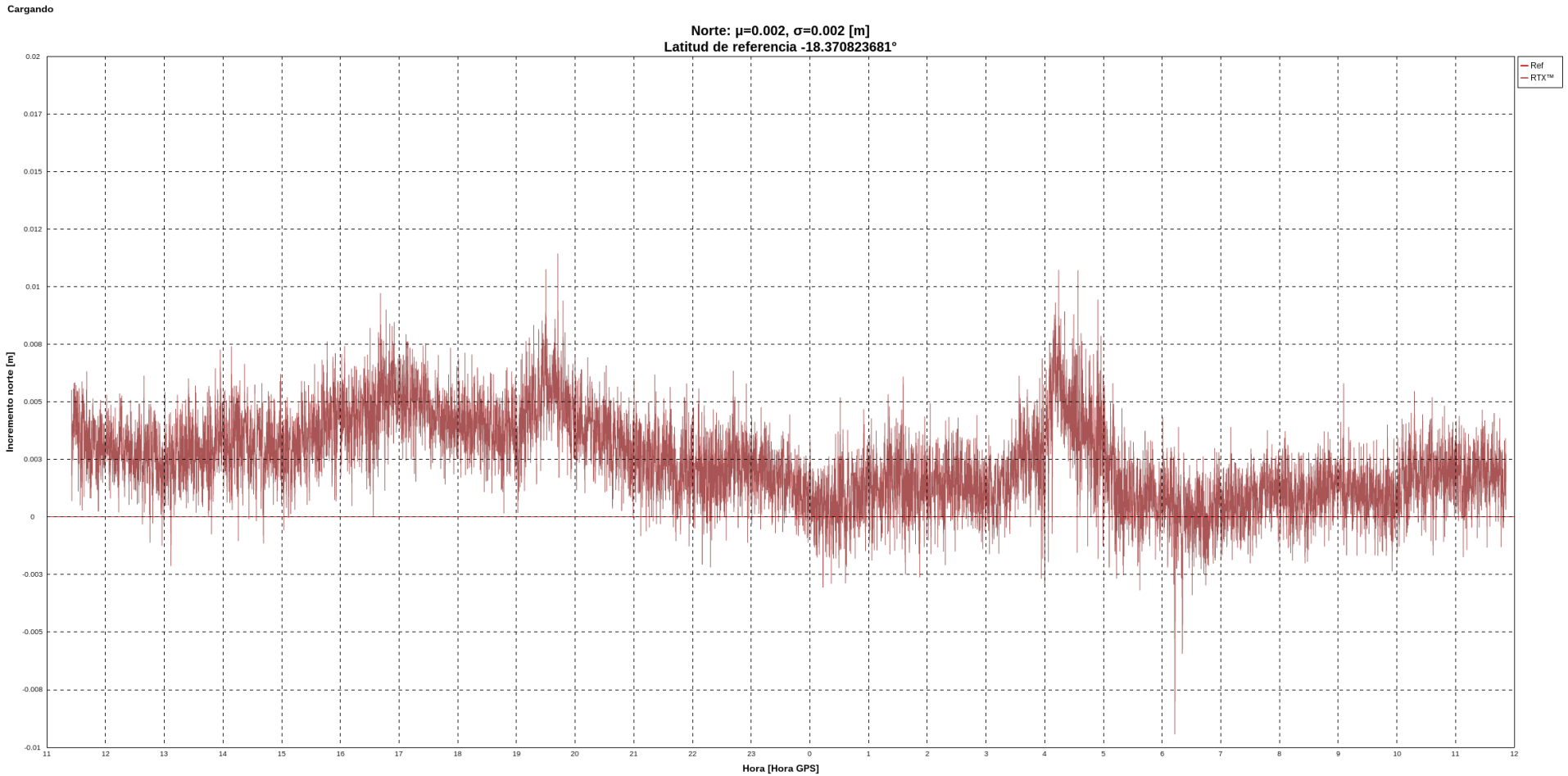
NRT RTX-NMEA streaming



Results (5)

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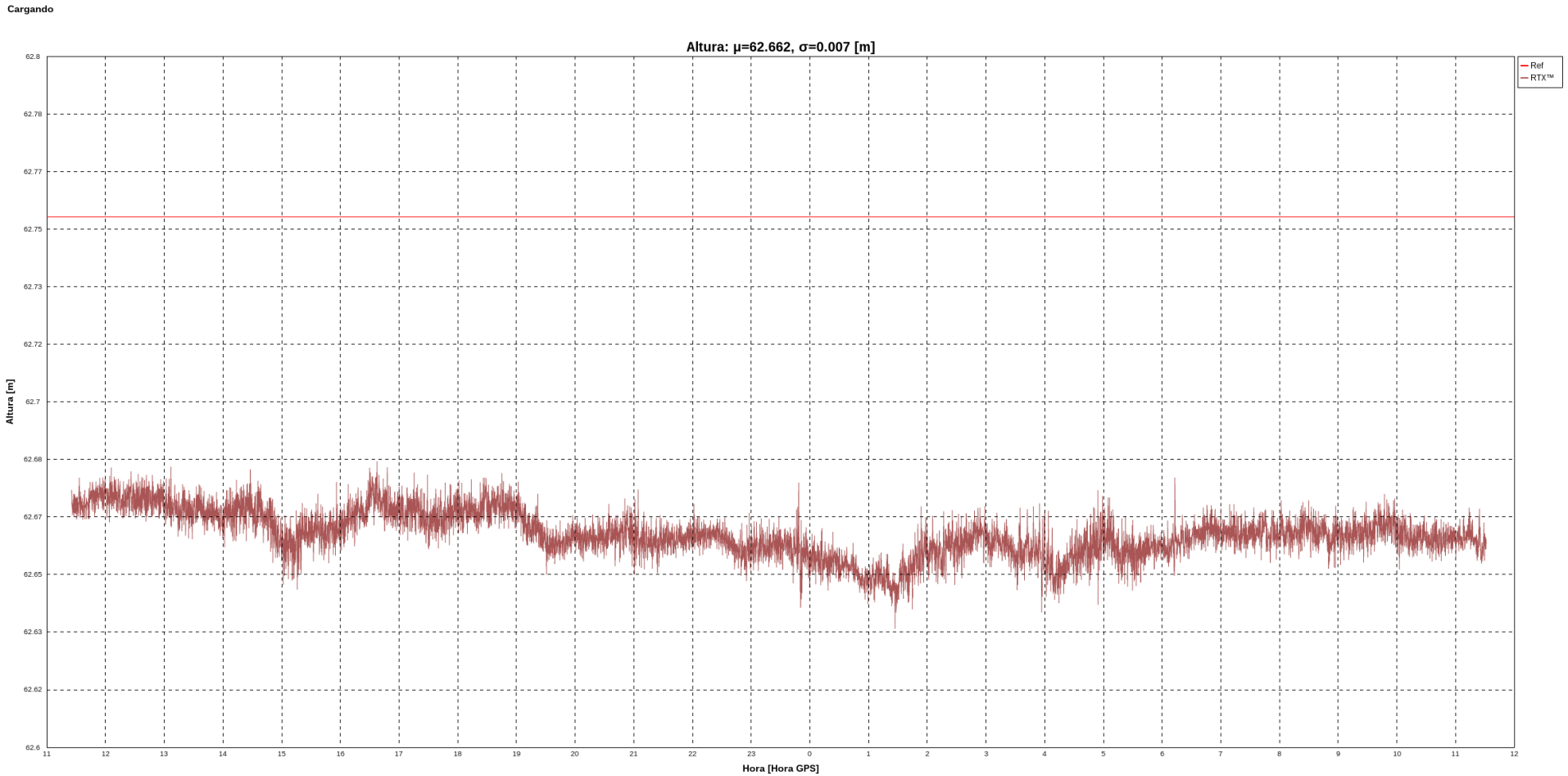
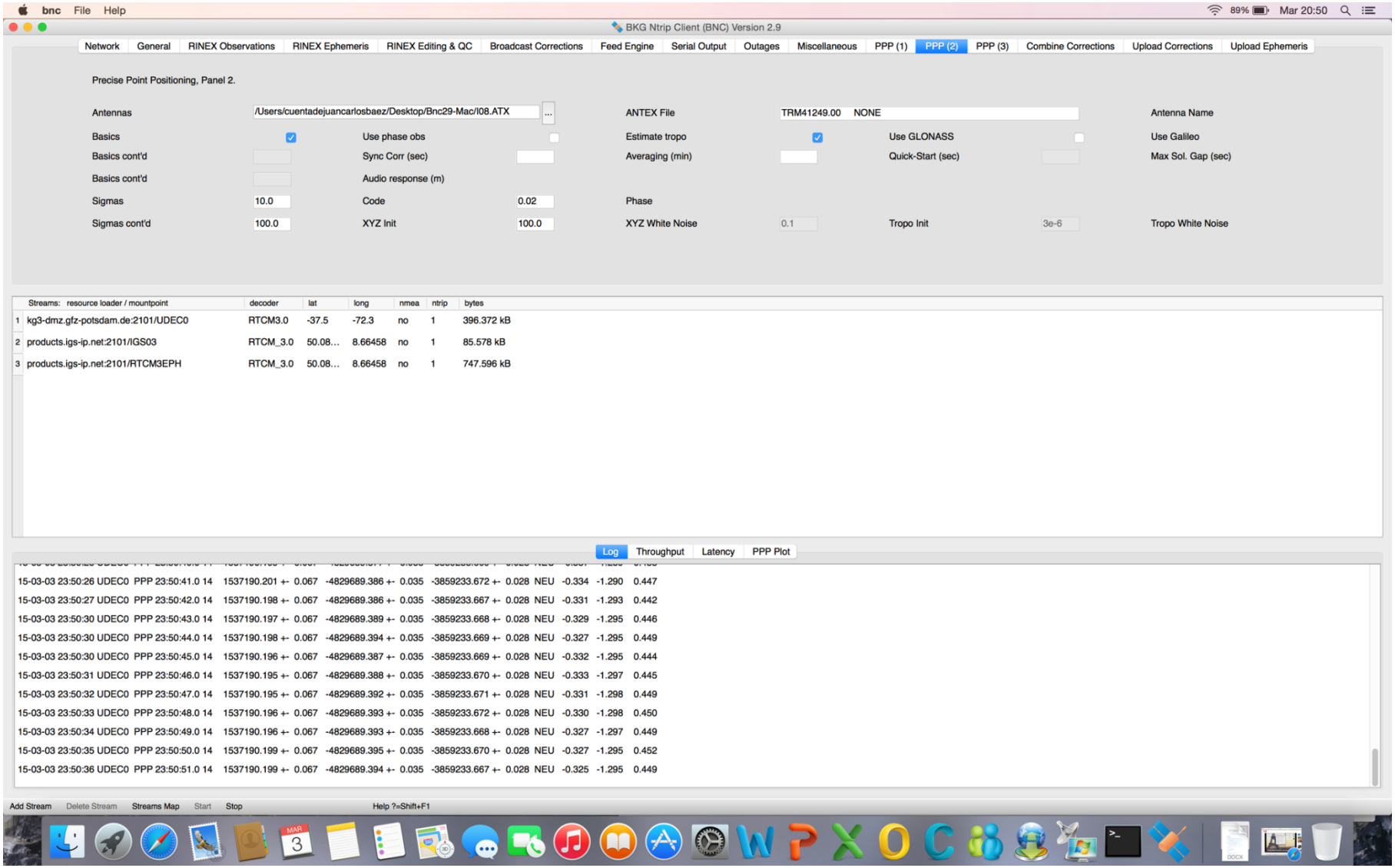
NRT RTX-NMEA
streaming



Results

NRT PPP



Results

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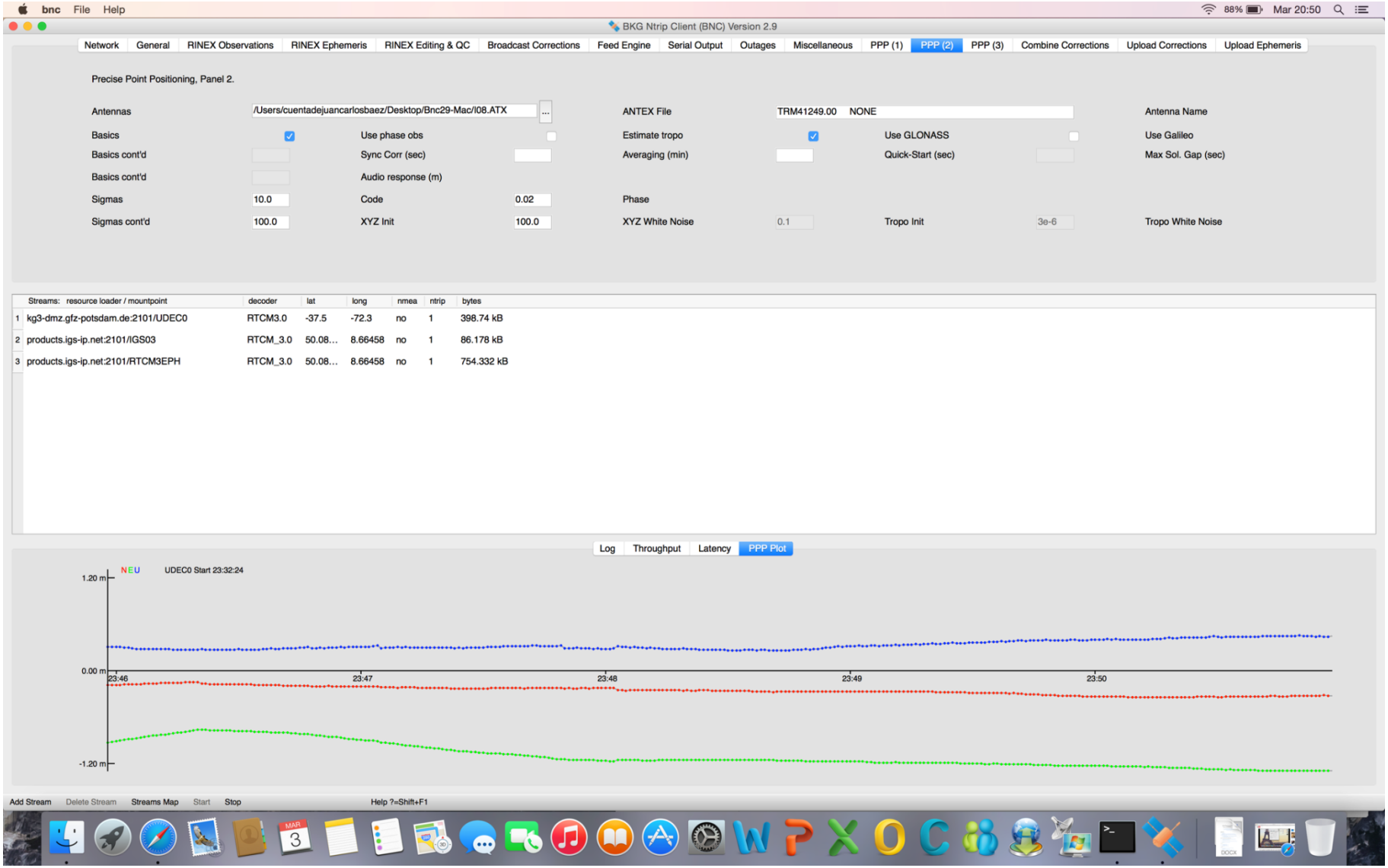
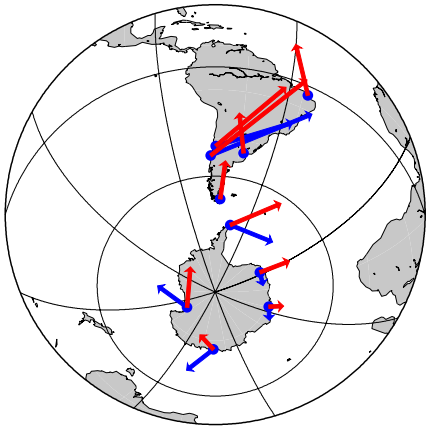
NRT PPP

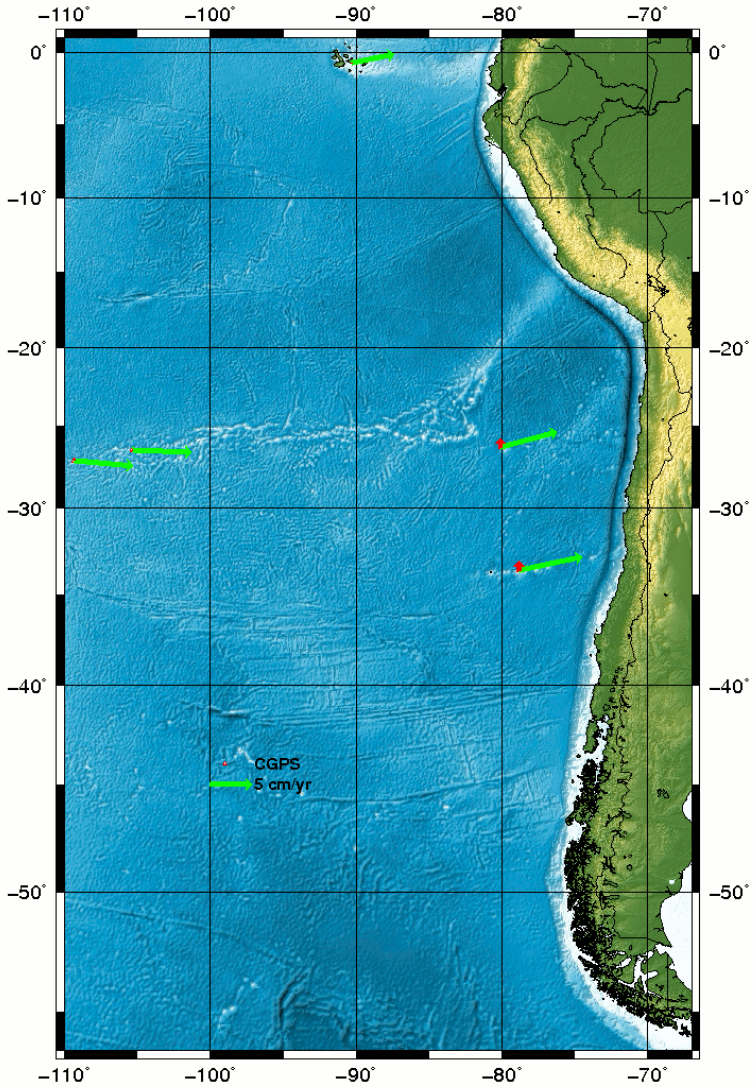


Results

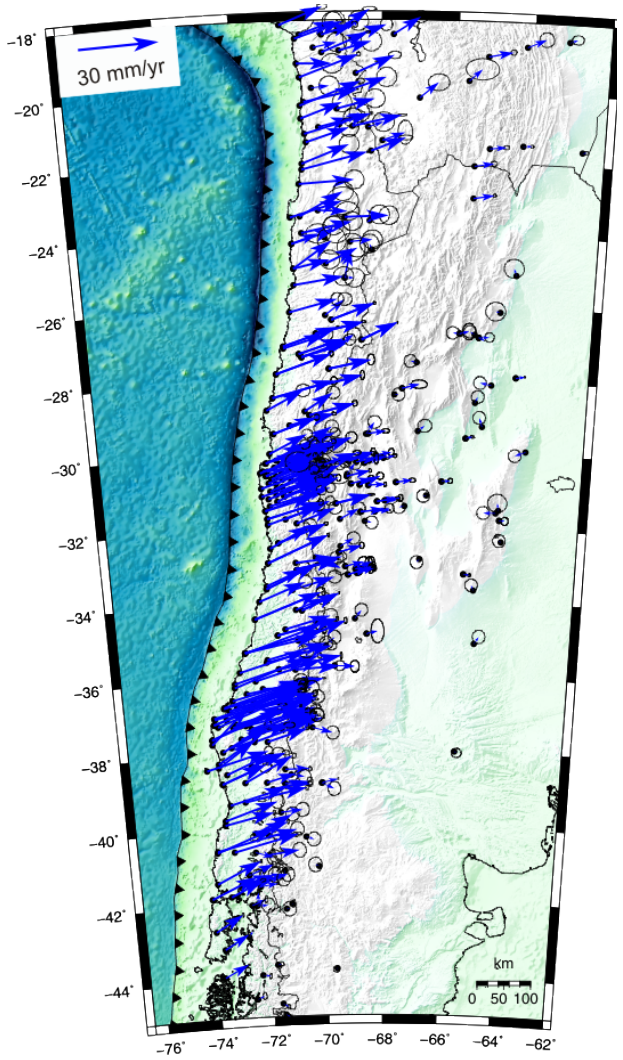
Velocities field of Nazca plate locking rate deficiency



Báez & Bataille 2006

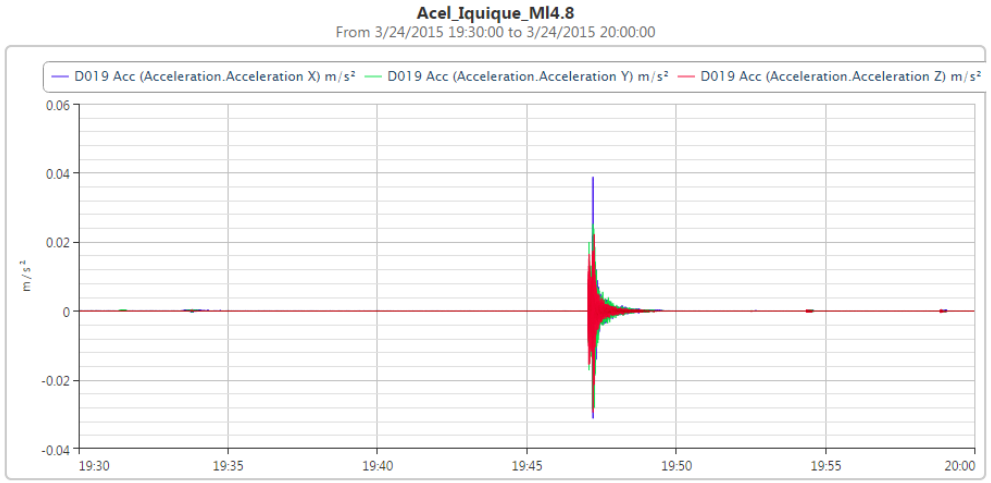


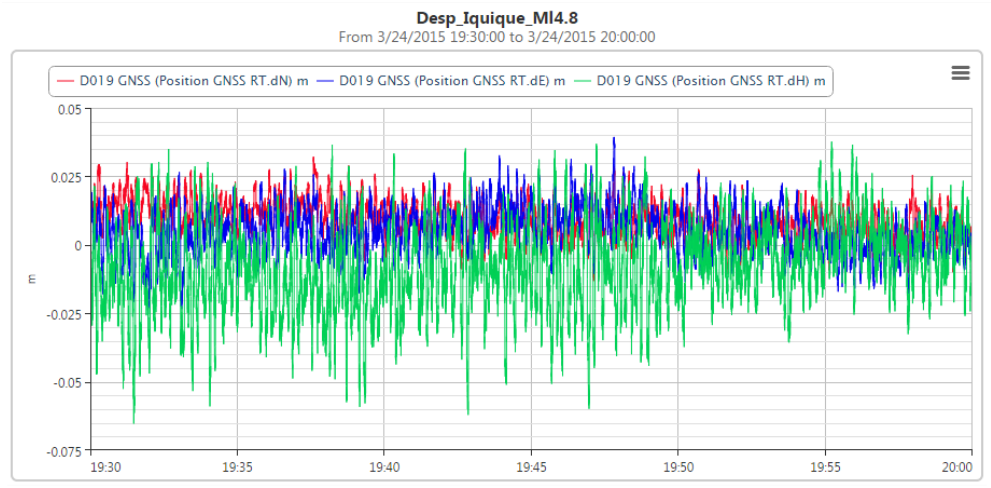
Baez et al 2015 (in preparation)



Results

Acceleration v/s displacement





We have displacement from GNSS and we integrate acceleration to correct displacement measurements Appling Kalman Filtering

(data from Trimble SG160-09)

Final Remarks

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- Network need to be re-designed for EW
- Good communications are still the key of the system
- Redundancy of the system for NRT are strongly necessary (RTX – PPP)
- Filter applications is necessary for false-positive detections
- We need to implement our own software application to eliminate external dependencies
- Integrations of multi-sensor observations are our next step

Thanks to

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Thanks you!!!!

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Chile National Net: Geodetic Overview

Juan Carlos Báez - et al.
Centro Sismológico Nacional
Universidad de Chile

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