New Chilean Reference Frame, 3 years after Maule Earthquake

IGM
INSTITUTO GEOGRÁFICO MILITAR
Cartografía Oficial del Estado de Chile

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FIG XXV International FIG Congress
Kuala Lumpur, Malaysia, 16–21 June 2014

Military Geographic Institute

MISIÓN

- *Constitutes the official authority, on a permanent basis and representing the State, in all matters relating to geography, surveying and mapping of the Chilean territory.*

MISIÓN

- *Constitutes and provides a permanent technical information service concerning the Chilean geography, as required by State organisations for the development and security of the nation.*

VISIÓN

- *Constitutes the national point of reference where the creation of geo-spatial information starts.*

SOME FACTS: GENERAL DESCRIPTION OF CHILE

- Total Surface: 2,006,096 $Km^{2.}$
- Population: 2012 Census (INE): 16,634,630 inhabitants.
- Costal Line: 6435 kms. 4630 kms. North to south.

International boundaries:

- Peru: 180 kms.
- Bolivia: 850 kms.
- Argentina: 5,600 kms.

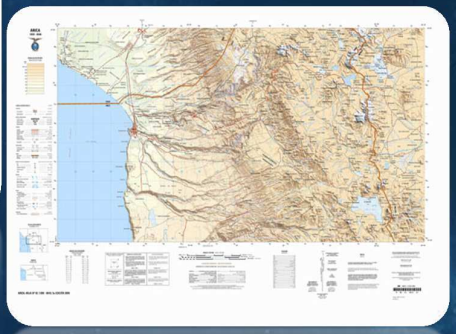
IGM PRODUCTS AND SERVICES

STANDARD BASE CARTOGRAPHY

1:500,000

22

1:250,000



80

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IGM PRODUCTS AND SERVICES

Atlases and Publications

Multimedia CDs

Maps of Chile

Continental and world maps

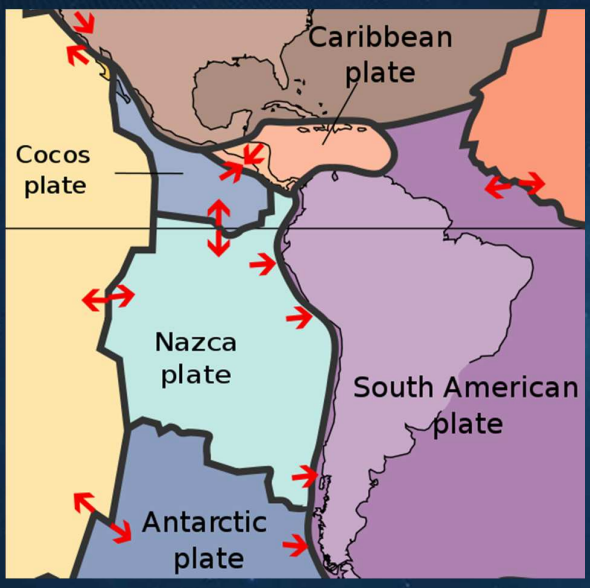
NATIONAL GEODESIC NETWORK

Official reference framework for the whole country, based on SIRGAS

Main applications

- Monitoring of deformations of the surface.
- Calculation of velocities.
- Network supporting differential measurements by GPS users.

Background: Chile, SIRGAS and the RGN up to 2010



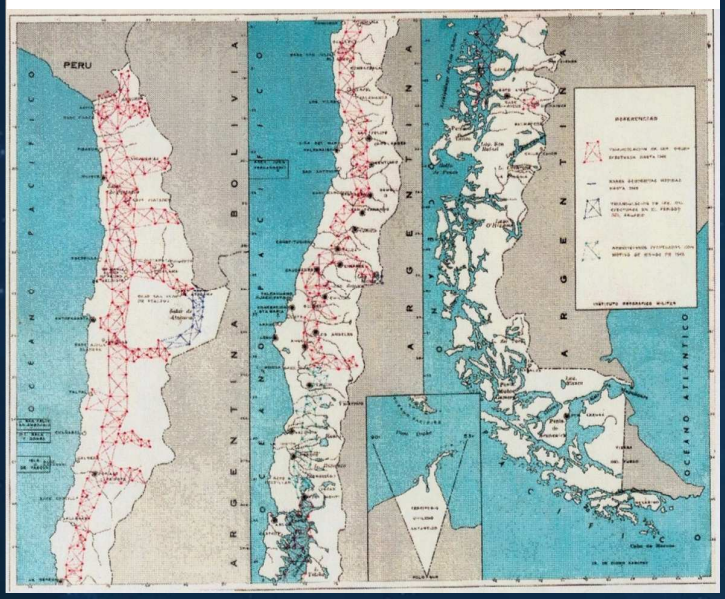
Valdivia, CHILE
22-May-1960

9.5 Mw
Richter scale.

Biggest Earthquake ever recorded in the world

Background: Chile, SIRGAS and the RGN up to 2010

Old National Geodesic Network of Chile



PSAD 56
- 17º 30 to 45º 30
- Canoa, Venezuela
- 1924 International Ellipsoid

SAD 69
- 45º 30 to south
- Chúa, Brasil
- 1969 Sudamerican Ellipsoid
- IPGH

PSAD 56 and SAD 69

WGS84

National Geodetic Network SIRGAS CHILE 2002.0

- RGN. SIRGAS-Chile.
- 14 Permanent Stations CGPS
- Adjusted 2002.0
- Based on ITRF 2000,
- 500 monumented passive points

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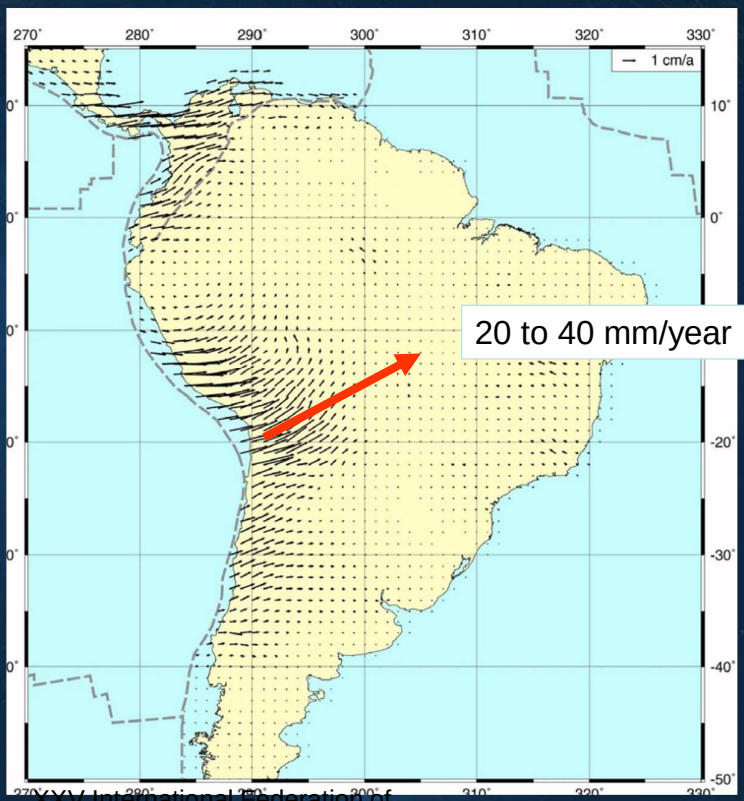
The objective of the CGPS Network is monitoring the velocities and deformations of the continent.

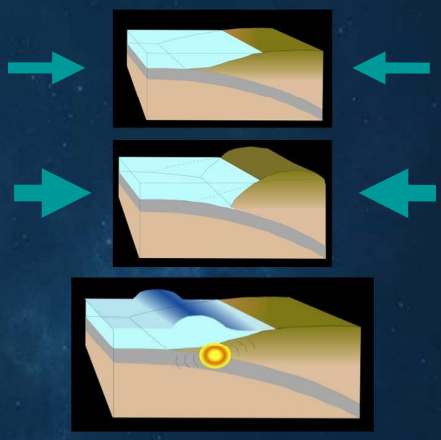


The Maule Earthquake

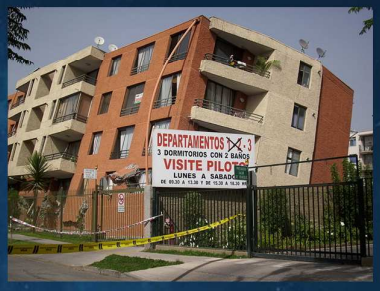
Saturday February 27, 2010 3:34 AM (local time)

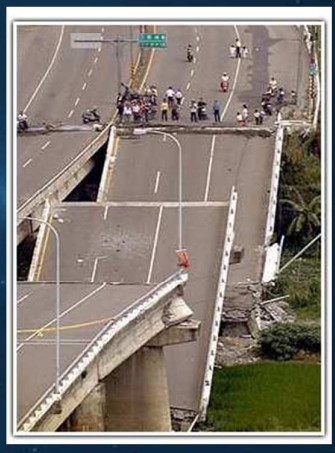
Moment magnitude 8.8 Mw

This is the fifth largest event in the history of instrumental seismology. (The Biggest ever occurred in 1960, immediately to the south of this event in VALDIVIA, CHILE).



- **521 fatal victims, 56 disappeared.**
- **Population affected: 12,880,000 (75% of the whole country).**





XXV International Federation of Surveyors Congress, Kuala Lumpur, Malaysia, 16 – 21 June

REBUILDING AND MEASURING THE MOVEMENTS

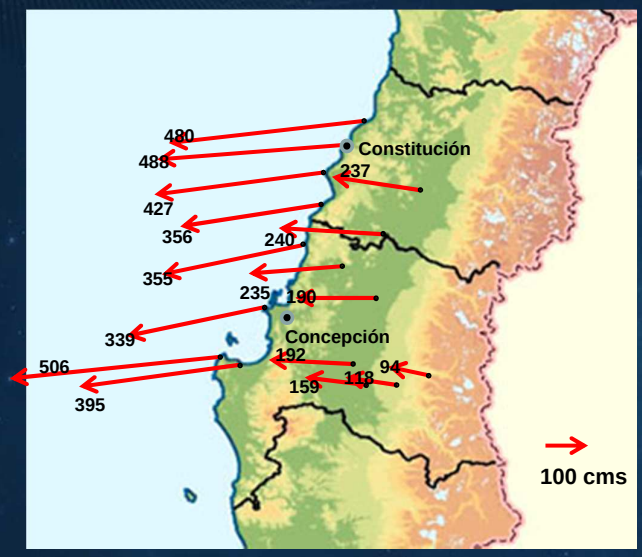
"PHOENIX PROJECT"

- *Objetive 1:*
  Deformation in the Geodetic National Network.
- *Objetive 2:*
  Monitoring of the postseismic deformations.
- *Objetive 3:*
  Scientific analysis of the EQ.

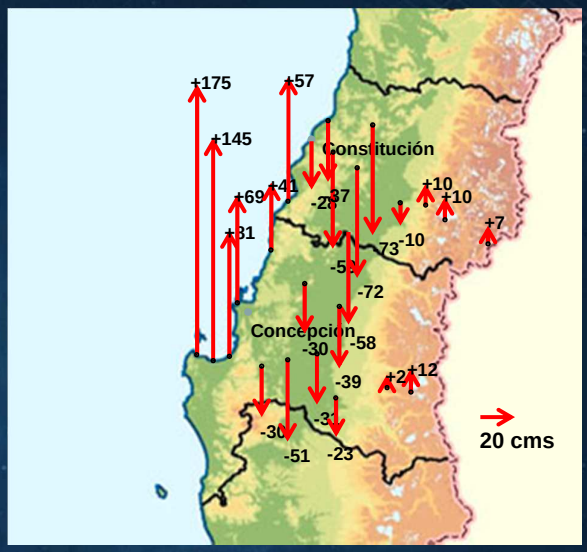
Instituto Geográfico Militar, IGM Chile
The Ohio State University, USA
Departamento de Geodesia, U. De Concepción, Chile

Departamento de Sismología de la Universidad de Chile
University of Hawaii
University of Memphis
UNAVCO
Caltech

Coseismic movement with the Maule earthquake.

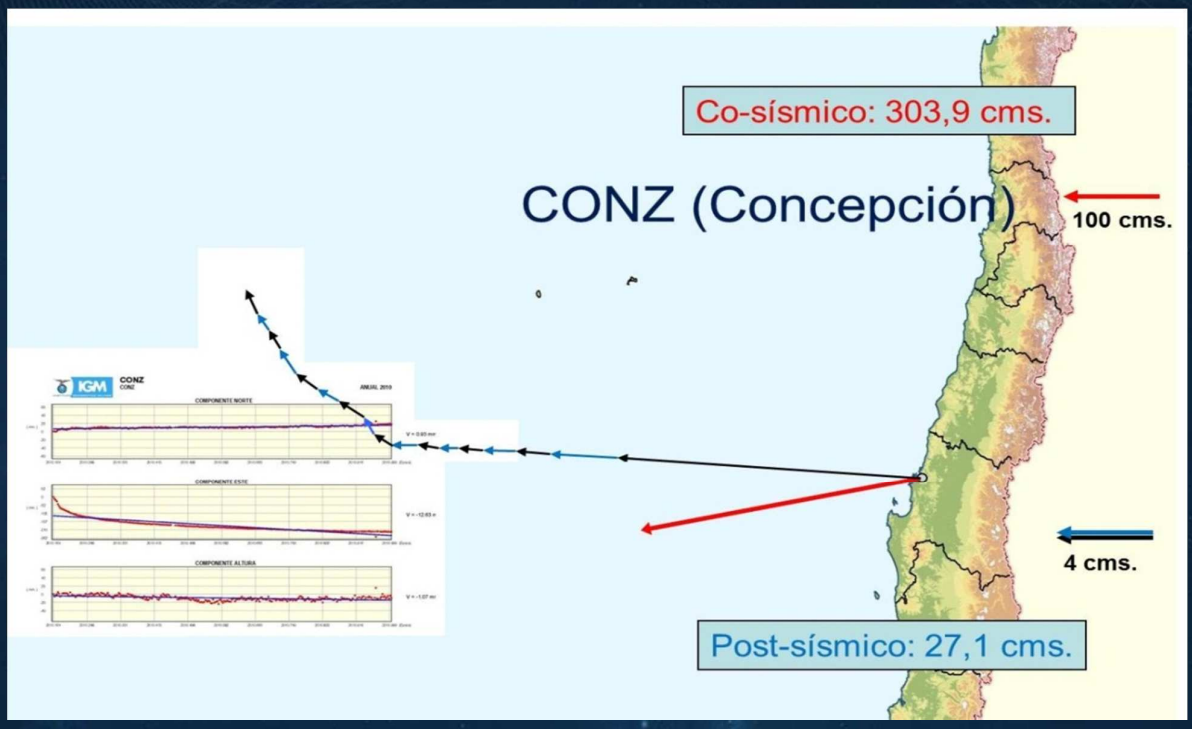


Horizontal Movement



Vertical Movement

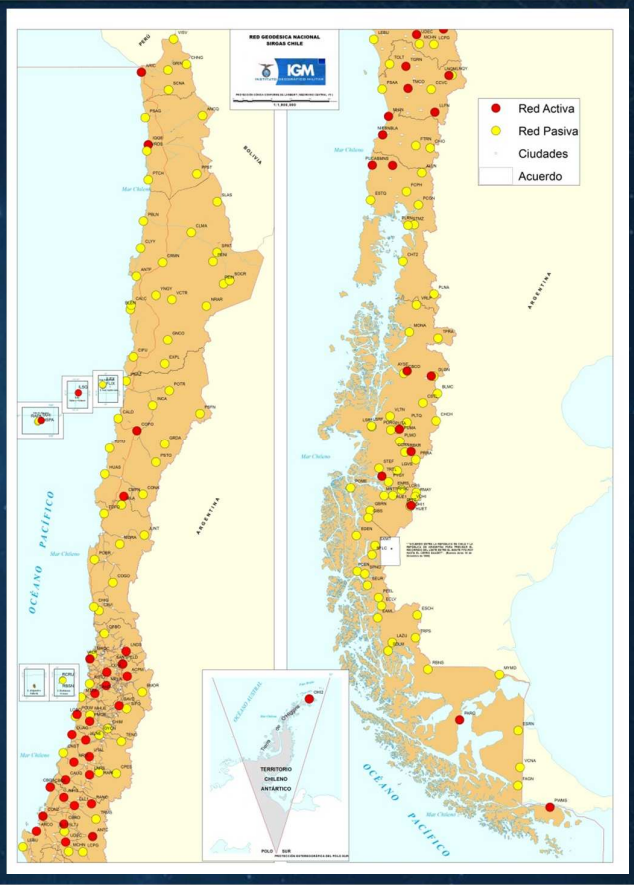
Post Seismic Movement of CONZ station



Post-seismic movement of CONZ station in Chile up to the year 2013

THE NEW RGN AND FUTURE DEVELOPMENTS

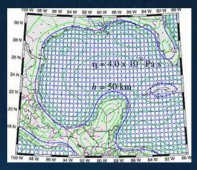
- Processing 130 passive points remeasured between 2011-2013.
- Processing of 60 continuous GPS stations
- New Framework SIRGAS Chile
- ITRF2008, epoch 2013.0
- Ellipsoid GRS80
- Adjust using 14 network stations SIRGAS-CON (continental network) (ITRF-2008)



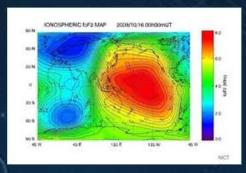
THE NEW RGN AND FUTURE DEVELOPMENTS

ACCURATE EPHEMERIDES

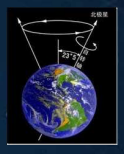
SIRGAS-CON STATION



OCEANIC CHARGES

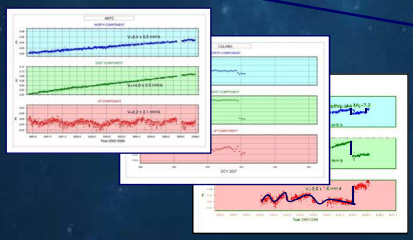


IONOSPHERIC MODEL

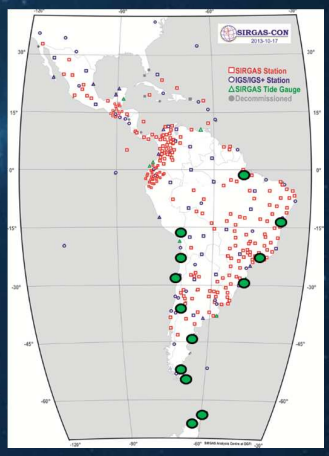


EARTH ROTATION PARAMETERS

ITRF STATIONS



BERNESE V5.0



Setting accuracy RGN

- - 3 mm Horizontal
- - 10 mm Vertically

Results

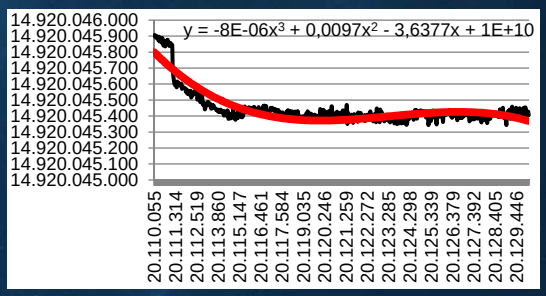
						Diferencias (metros)		
Ajuste FINAL	Coordenada					Norte	Este	Altura
COPO 1721 SIR	Geodésica	-27.3845255	-70.338235	479.0793				
	UTM	6970262.976	367674.360	19				
					COPO	0.002	0.003	-0.012
COPO 2013.0				479.0917				
	UTM	6970262.97	367674.357	19				
CONZ 1721 SIR	Geodésica	-36.8437657	-73.0255159	180.6203				
	UTM	5920639.600	676050.501	18				
					CONZ	0.002	-0.003	-0.007
CONZ 2013.0				180.6272				
	UTM	5920639.6	676050.504	18				
VALP 1721 SIR	Geodésica	-33.0272418	-71.6260911	31.1901				
		6342628.046	254721.804	19				
					VALP	0.002	0.002	-0.006
VALP 2013.0				31.1964				
	UTM	6342628.04	254721.802	19				

Future

RGN
Red Geodésica Nacional
SIRGAS – Chile 2013

National Geodetic Network

Velocity Model



CHILEAN REFERENCE FRAME SUMMARY

Much of the physical infrastructure of south and central Chile was damaged by the Maule earthquake, and will have to be repaired or rebuilt. The same was true of the spatial reference system in this region.

The national spatial reference system had to be rebuilt very quickly so as to be able to support the reconstruction effort. The only practical solution was to build large numbers of CGPS stations, quickly.

The scientific community played a leading role, because its interests were entirely parallel to those of Chile: quickly build as many CGPS stations as possible in order to record the postseismic ground motions in considerable detail.

Scientifically, this is likely to be the most important earthquake that has ever occurred.

We hope to recover the National Reference Frame during the 2014.

CONCLUSIONS

The Earth is a long way from being a rigid and static body. Far from trying to remove these effects in geodesic networks, we should learn from them, in order to be able to adapt these networks to the activity of the earth's crust.

It is fundamental to have available a large amount of reliable and accurate information, promptly, for the whole area being studied, in order that, through these means, the methodologies enabling this adaptability can be developed.

A non-linear velocity model is an essential element in the maintenance of a reference framework under these conditions, as it makes it possible to model the changes in velocity at the stations, which thus adapts even more to the reality of the movements of the earth's crust in zones affected by seismic events.

Thanks for your attention

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"Vertical Control" Geodetic Networks

a) Levelling Network

- 12,000 kilometers have been surveyed since 1948 to date.
- We have the altitude values for the whole network loaded into the relevant digital media.
- The geographic position has been determined in 90% of the monuments.
- Within the agreements made in the framework of the SIRGAS project, the IGM has made international connections of its survey lines with Argentina, Peru and Bolivia.
- The Official vertical Datum is Mean sea level

b) Gravity Network

OBJECTIVE

- Supply data to the geoidal models.
- Provide data to the International Gravity Bureau (IGB - France).

- Network made up of 59 absolute gravity points.

  - NGA (USA) 4 stations (2000)
  - IRD (France) 64 stations (2001 - 2010)

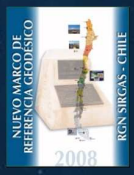
- Network made up of 71 relative gravity points

  - IBGE - USP (Brazil)

“Horizontal Control”
Geodetic Networks

a) Densification of the Network

- Name: National Geodesic Network SIRGAS-Chile.
- Geodesic Datum : ITRF 2000, epoch 2002.0
- Ellipsoid: GRS80
- Network made up of 650 points at monuments, measured 48 hours and processed with BERNESE.
- CD SIRGAS-Chile with information about the Network (monograph records) for users.
- Book RGN SIRGAS CHILE available to users with the history of the National Geodetic Network.
- Network made more dense, annually, by the IGM and by the “Joint Campaigns” in which we invite Chilean users to participate in the measurements of terrain in places chosen by them, following IGM measurement protocols. The IGM processes the data and sends certificates of the coordinates to the participants, without cost to them, thus ensuring that projects in Chile are geo-referenced in SIRGAS.



b) Continuous GPS Network

- Network of 64 CGPS stations operating at this date.
- 14 stations IGS and SIRGAS-CON.
- 22 CGPS stations managed by IGM with a daily download of data via Internet.
- Soon, a web page will be set up for placing at the disposal of users the daily data.
- The IGM, together with the Ohio State University, has established stations since 1996. Initially this was for purposes related only to geophysics, but over time these were added to the IGS network and then to SIRGAS-CON.

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