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GEP Application – Satellite Differential Interferometry (DInSAR) for ground deformation monitoring.

SAPIENZA
UNIVERSITÀ DI ROMA

Felipe Orellana - PhD Student

Concepcion, Chile
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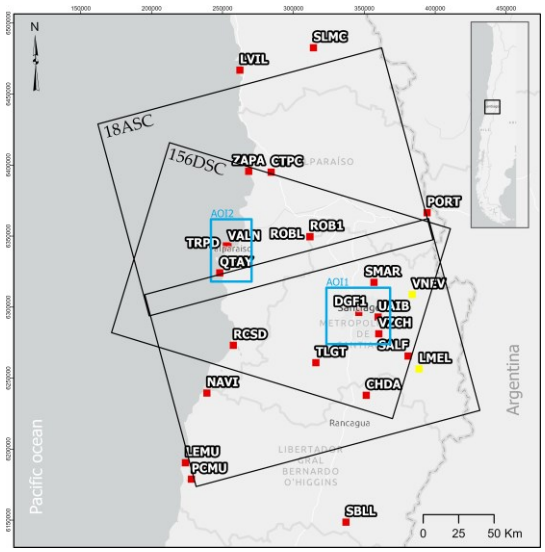
Introduction:

This work is based on the P-SBAS service of the GEP application, mainly of DInSAR differential interferometry applied to Land displacement, identifying the most relevant subsidence zones in infrastructures and comparing them with geological, geotechnical and hydrogeological data

In particular, the analysis presented is based on a large-scale analysis where subsidence areas are identified for cities in Central Chile, where soil displacement can be caused by tectonic activity, hydrogeological processes or variations in the water table. A more detailed analysis is presented for each city, where sub-areas with greater displacements are identified, and analyzing the time series obtained from the DInSAR.

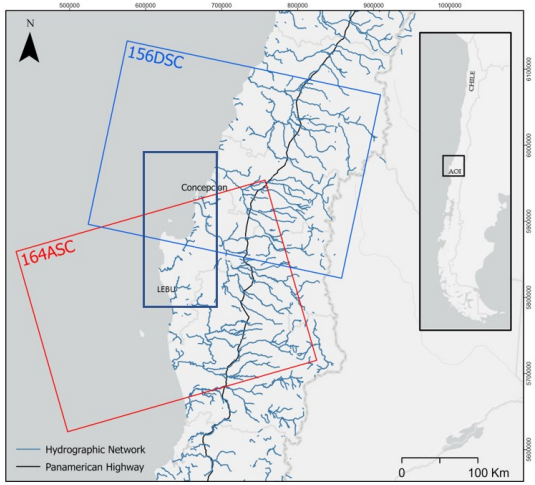
Data set :

Hundreds of C-band SAR Sentinel-1 images were used, covering the period 3 to 4 years, using ascending and descending geometries. We limit our analysis to Sentinel-1 data only (12-day repeat cycle) (Table 1-2), which is considered sufficient given the expected magnitude of ground displacements and the availability and coverage of the images over the area of interest.



Sensor	First image	Last image	Band	Pol	Orbit	N° acquisitions
Sentinel 1B	2018/02/05	2021/05/26	C	VV	18ASC	112
Sentinel 1B	2018/02/05	2021/05/26	C	VV	18ASC	112
Sentinel 1B	2018/01/10	2021/05/30	C	VV	156DSC	96

*In the case of the metropolitan area of Concepcion, no data is available before 2019.



Sensor	First image	Last image	Band	Pol	Orbit	SAR Image
Sentinel 1B	2018/01/18	2021/05/05	C	VV	156 ASC	62
Sentinel 1B	2018/02/06	2021/05/05	C	VV	164 DSC	60

General Methods :

The proposed method is based mainly on the analysis of long-scale of Land displacement, of the most important metropolitan cities of Chile, the location and geomorphological characteristics, allow us to show the different phenomena that cause soil deformation.

For the validation we intend to work with instrumentation in situ, and complement the results of GEP, with other studies carried out previously.

STEP1:Land displacement Overview

(large-scale)

1.definition of the study area -AOI.

2.data collection and processing.

4.Identify subsidence area and post-processing

STEP2:Displacement area analysis

(local-scale)

1.PSI maps classification

2. Time-series analysis

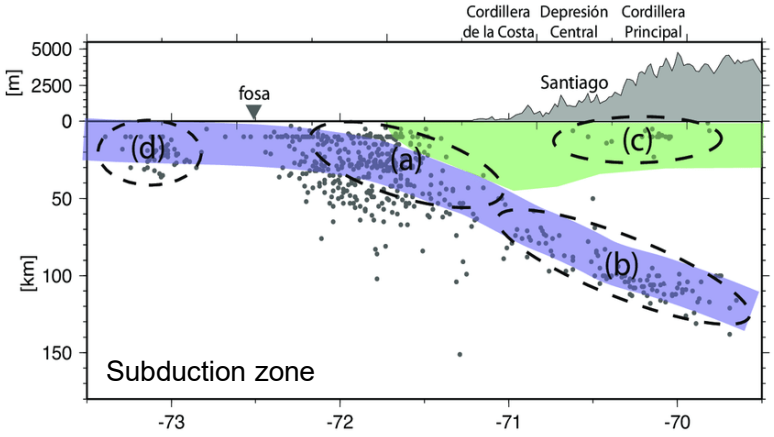
STEP3: results validation

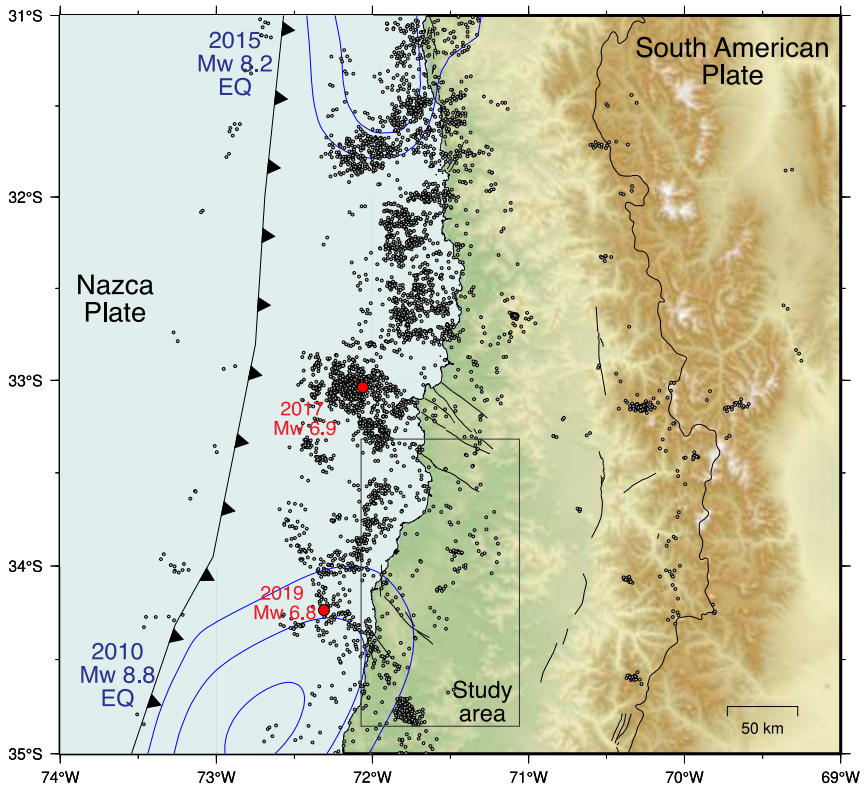
1 Geotechnical interpretation

2. In situ instrumentation

Results: Chile case studies

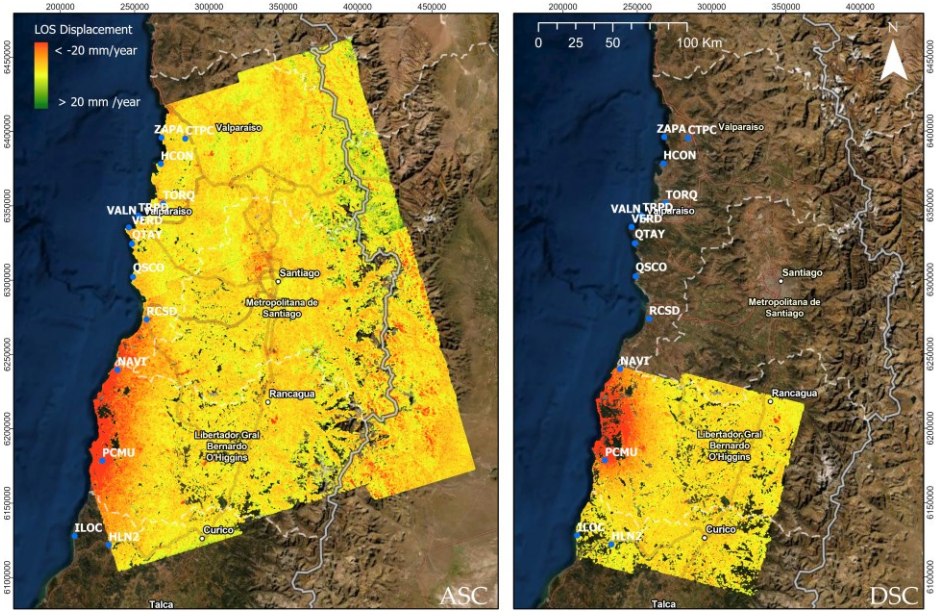
- Seismic area
- Earthquake Mw 6,8
  2019 (Pichilemu)



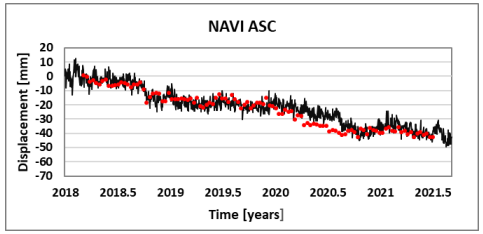


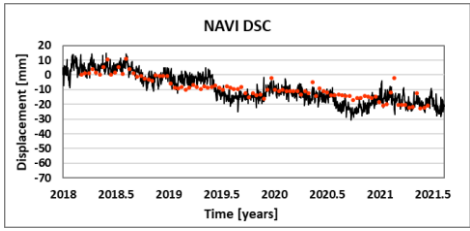
Regional deformation of Chile Central

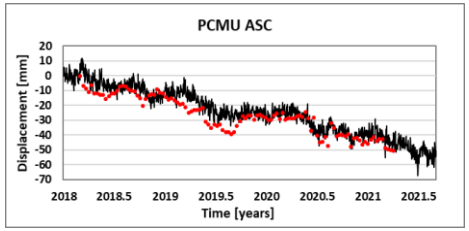
- Regional deformation overview
- Time series LOS SAR (red dots) and GPS (black dots)

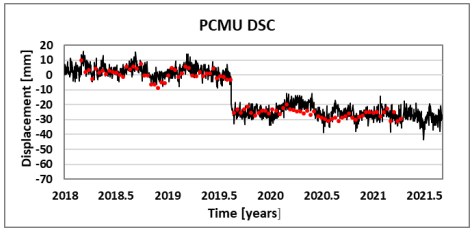


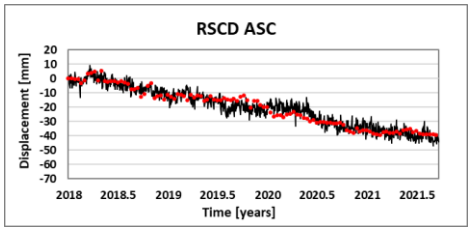
From 2018 to 2021

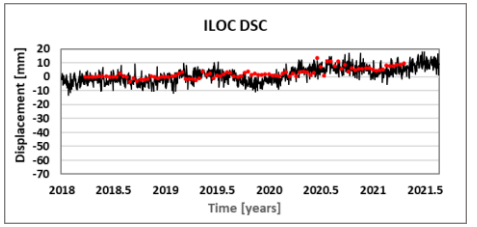




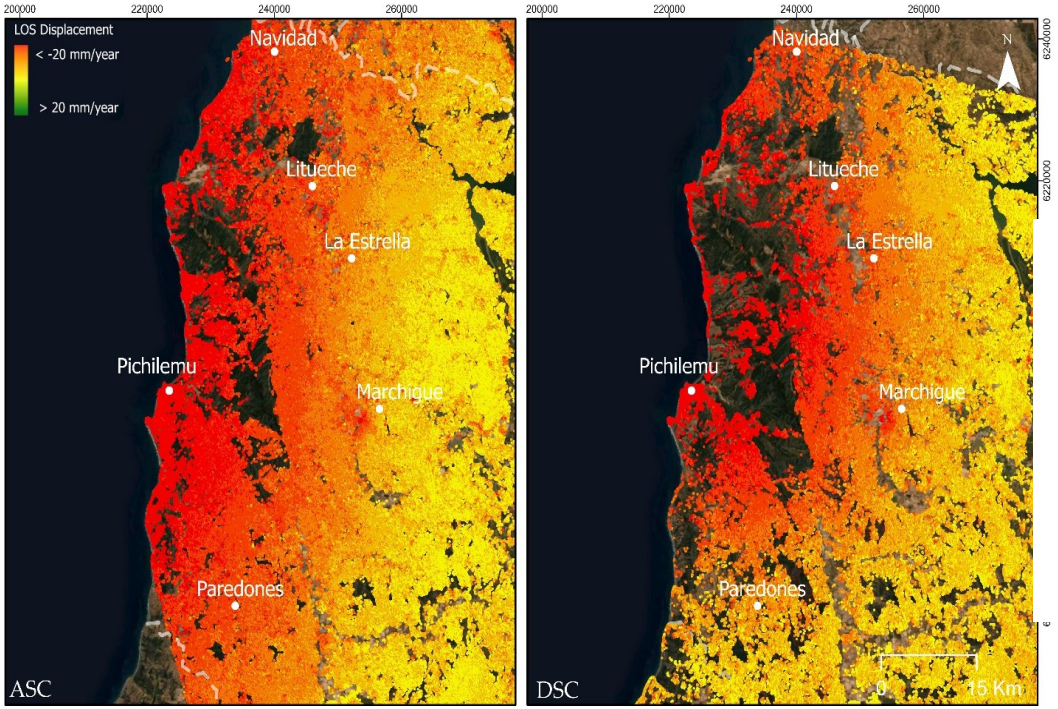








Subsidence area Chile Central



$$V_{ui} = \frac{E_{Di} * V_{Ai} - E_{Ai} * V_{Di}}{E_{Di} * U_{Ai} - E_{Ai} * U_{Di}}$$

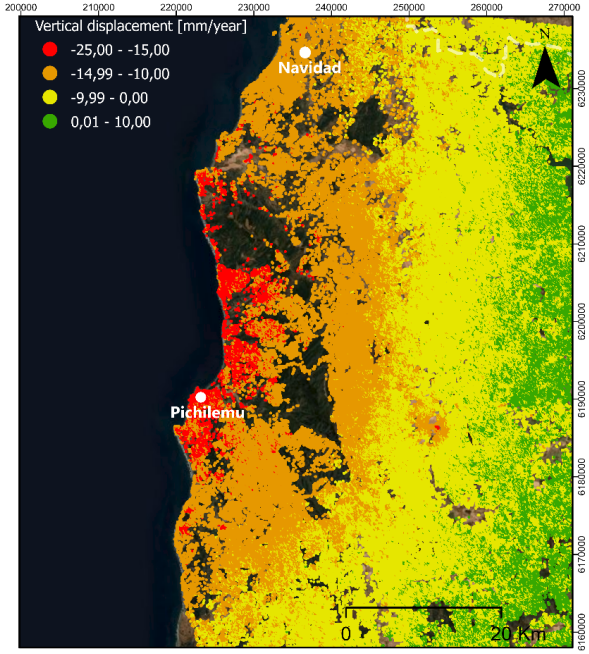
$$V_{Ei} = \frac{U_{Di} * V_{Di} - U_{Di} * V_{Ai}}{E_{Di} * U_{Ai} - E_{Ai} * U_{Di}}$$

(Cigna et al., 2021)

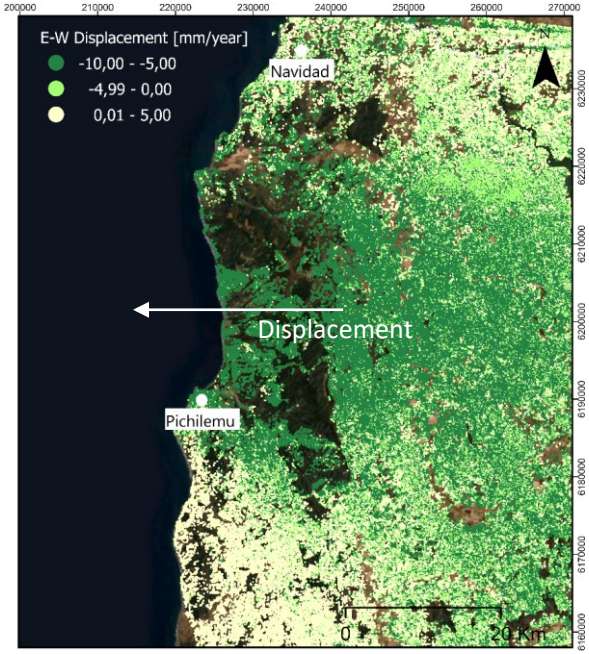
- Ascending and Descending orbits
- Foreshortening effect

Estimation vertical and EW components

- Estimation vertical and EW components



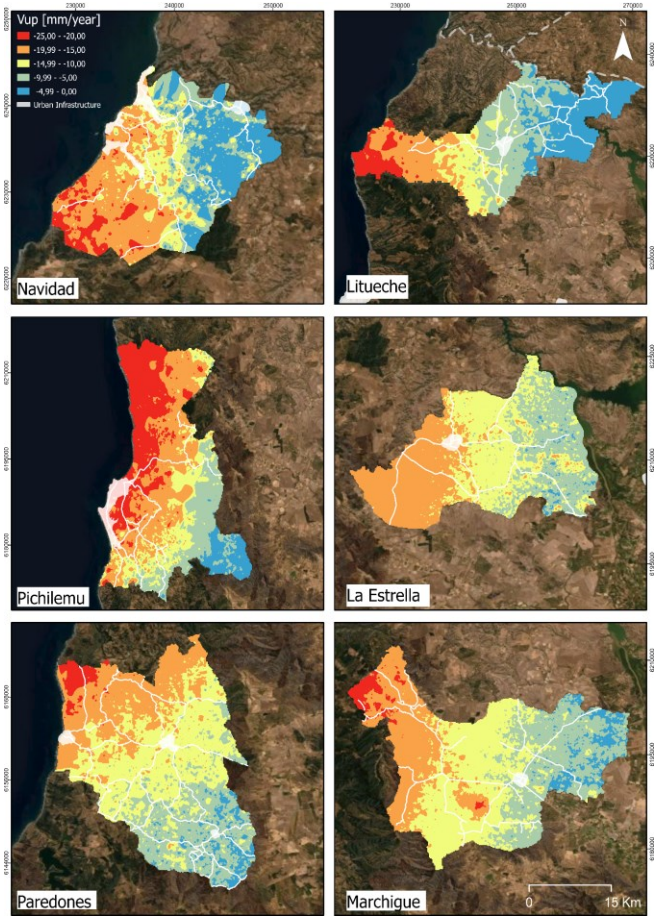
- Vertical components map (mm/year)



- E-W components map (mm/year)

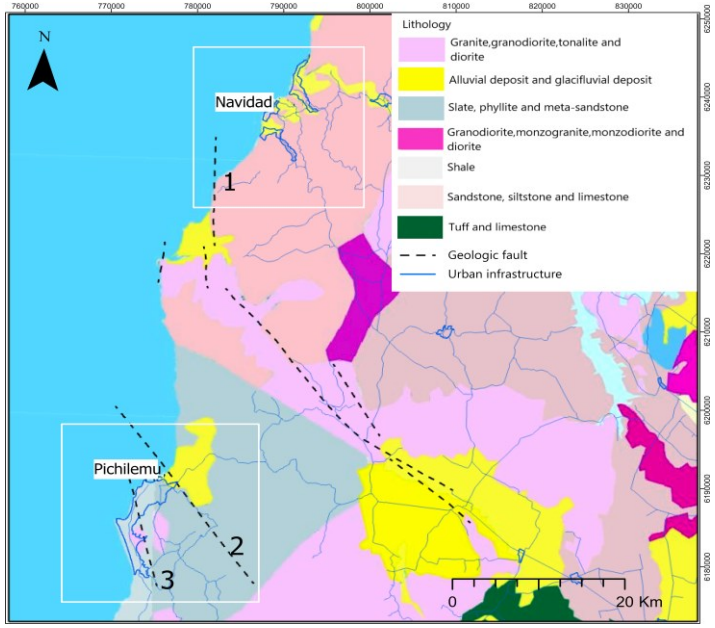
Subsidence Urban areas

- Deformation maps for urban areas
- Pichilemu 231 km2 di subsidence

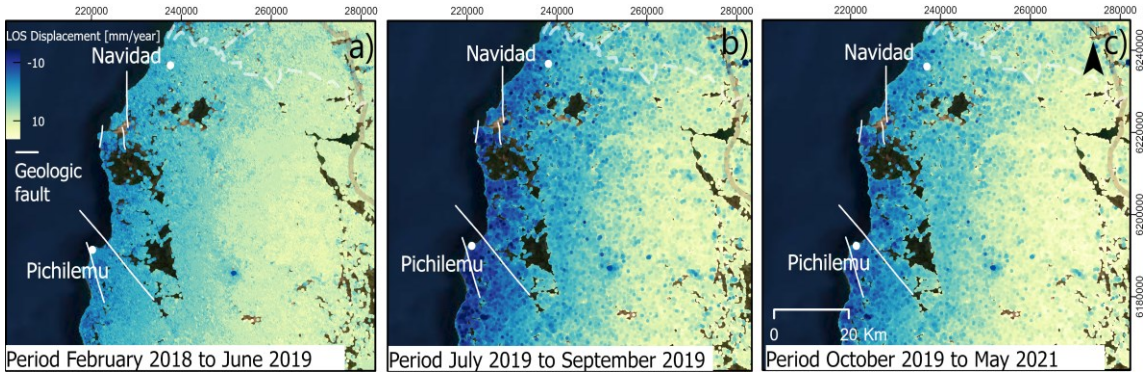


Municipalities	Count PSI	Min	Max	Mean	Standard Deviation	Subsidence Area km²	R^2
Navidad	52,659	−2.70	0.68	−0.65	0.62	44.13	0,89
Litueche	60,676	−3.42	0.58	−1.09	0.72	58.35	0.85
Pichilemu	50,250	−3,28	−0.23	−2.00	0.50	231.07	0.77
La Estrella	45,827	−1,92	0.56	−0.33	0.39	0.00	0.00
Paredones	48,077	−2,84	0,18	−0.83	0.42	17.04	0.95
Marchigue	58,816	−2,70	−0.24	−1.43	0.37	16.93	0.90

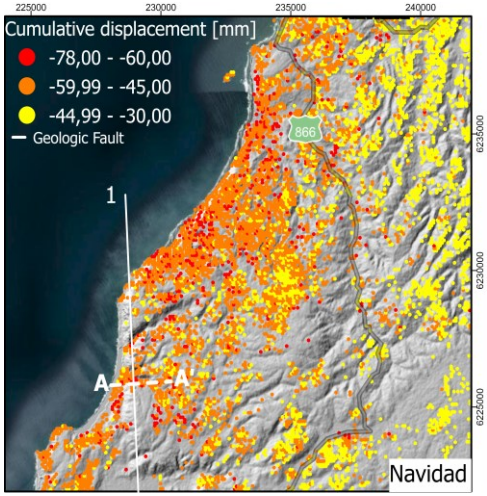
Navidad y Pichilemu Geologic faults

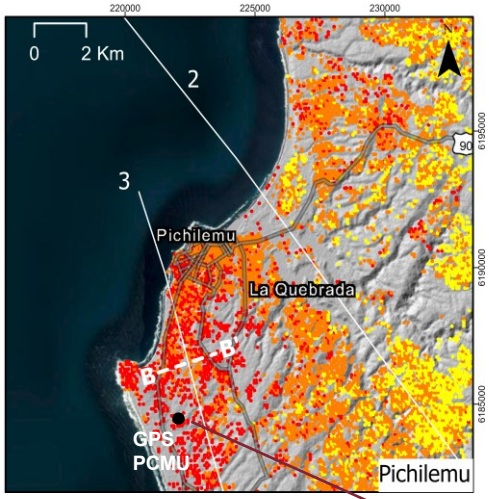


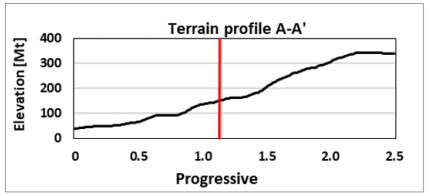
PRE-EVENT EVENT POST-EVENT



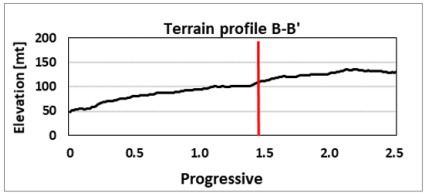
Navidad y Pichilemu geologic faults



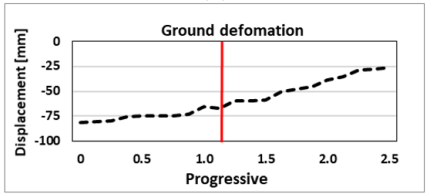




(A)



(B)



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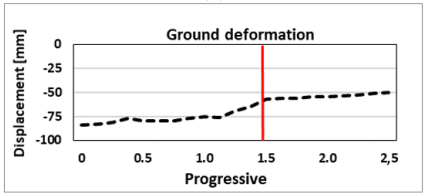
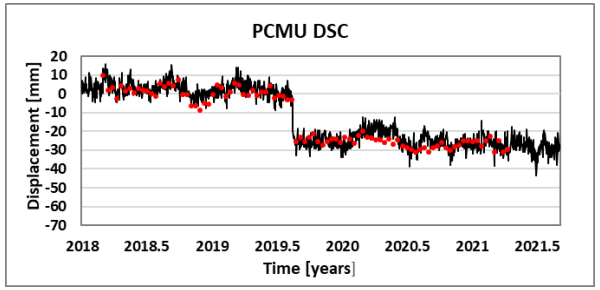


(D)

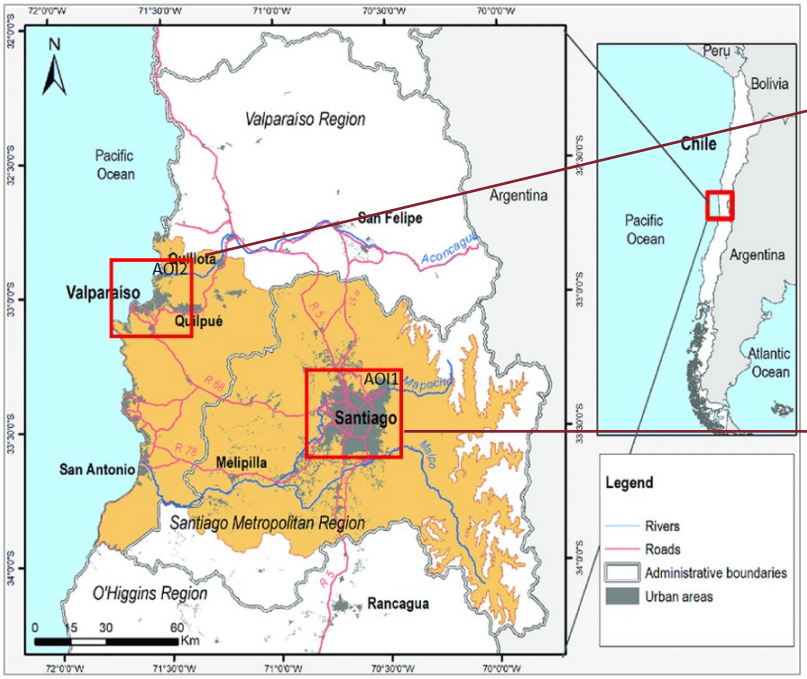


- Navidad y Pichilemu
- Fault 3
- Seismic cycle 2010 8,8 Mw (6,8 Mw and 6,9 Mw)

FULL PAPER:

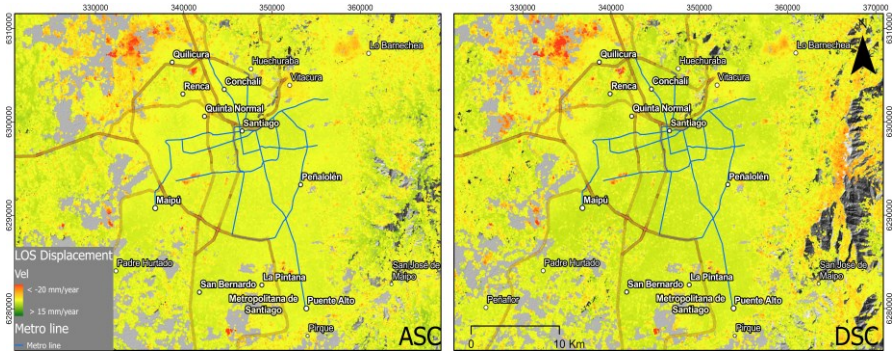
Orellana, F., Hormazábal, J., Montalva, G., & Moreno, M. (2022). **Measuring Coastal Subsidence after Recent Earthquakes in Chile Central Using SAR Interferometry and GNSS Data.** *Remote Sensing*, *14*(7), 1611. https://doi.org/10.3390/rs14071611

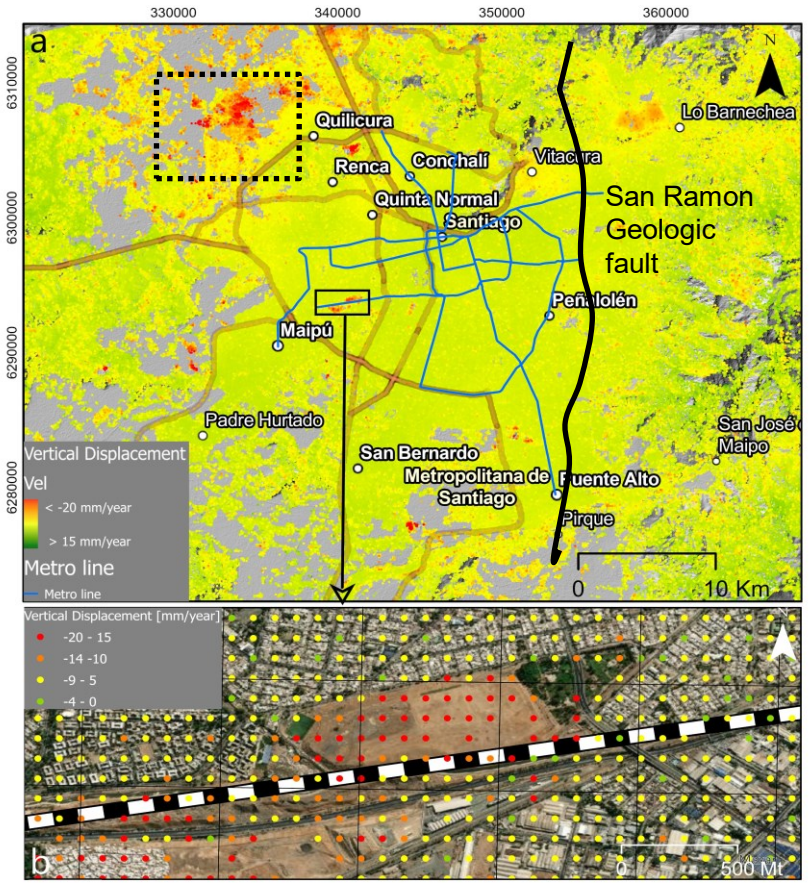
Chilean metropolitan areas



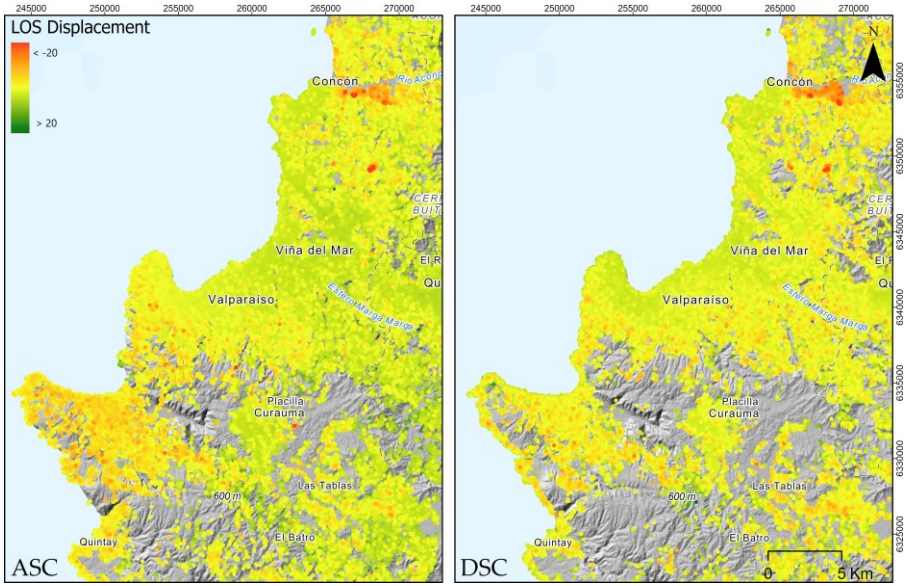
Chilean Metropolitan areas (Santiago)

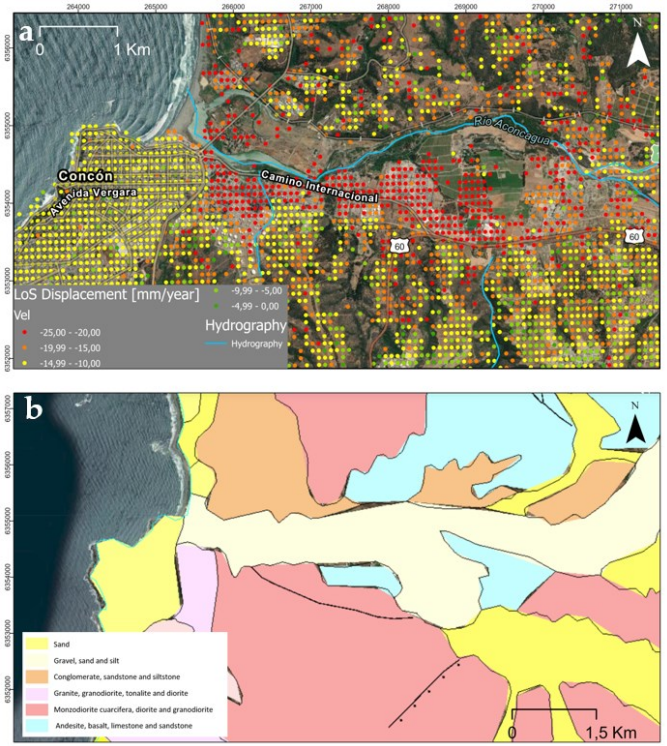
- P-SBAS
- From 2018 to 2021
- Vertical components estimation (mm/year) > -20 mm/year





Chilean Metropolitan areas (Valparaiso)





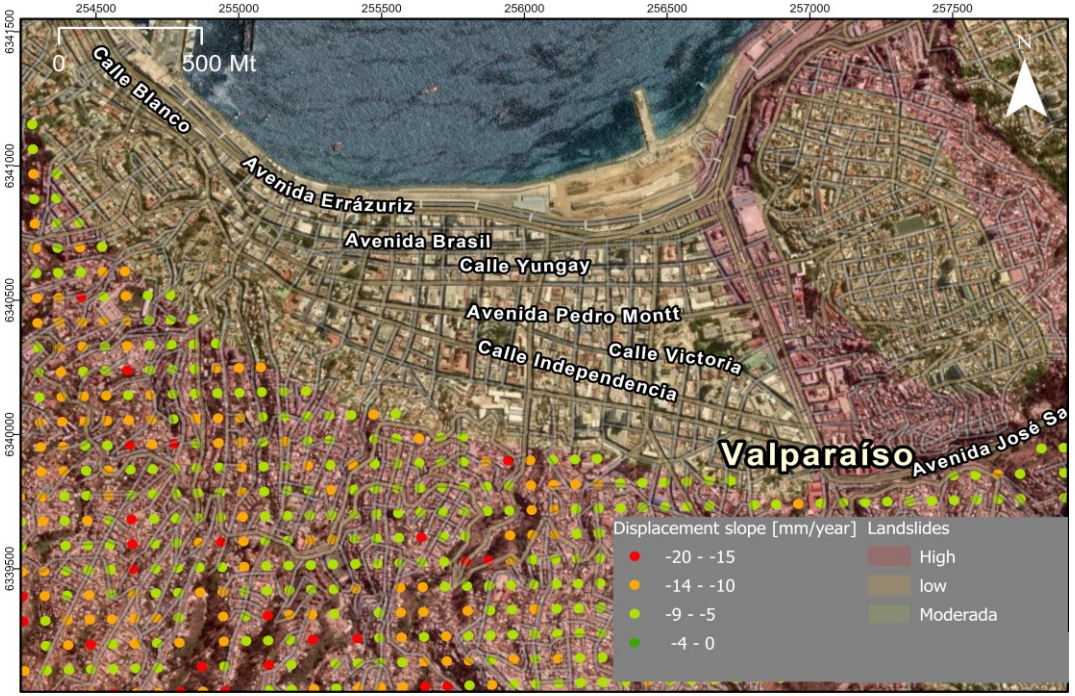
- Valparaiso river delta
- Deformation velocity > -20 mm/year

Chilean Metropolitan areas (Valparaiso)

- Deformation on the steepest slope
- Landslides risk (red PSI: -20 - -15 mm/year)

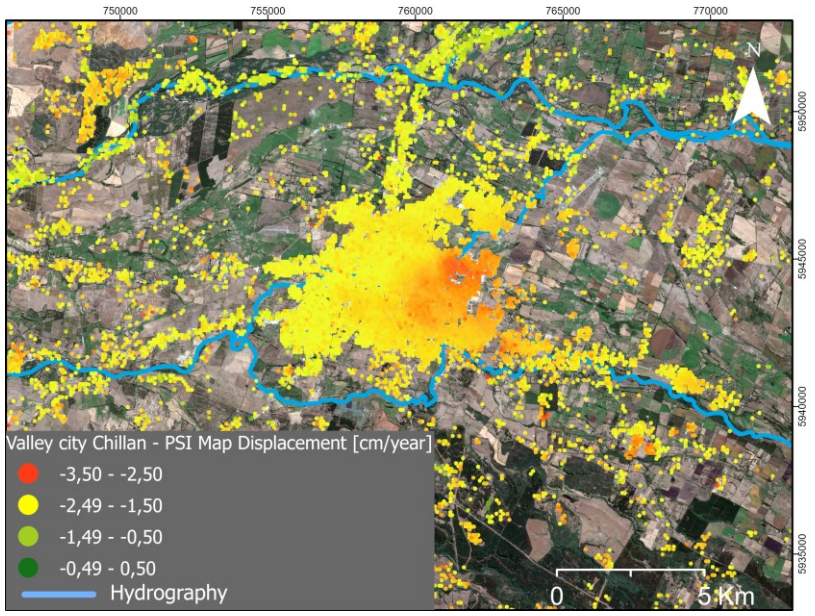
$$V_{Si} = \frac{V_{LOSi}}{E_{LOSi} * E_{Si} + N_{LOSi} * N_{Si} + U_{LOSi} * U_{Si}}$$

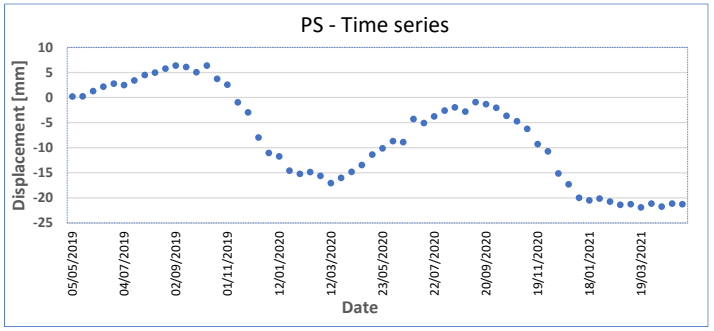
(Cigna et al., 2021)

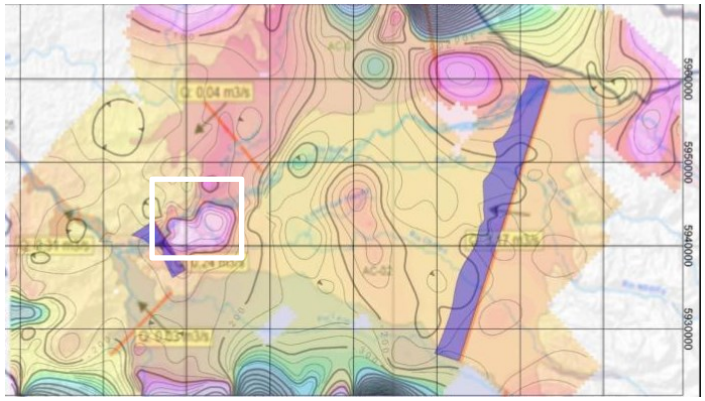


Results: Land Displacement and water table.

Some cities in Chile, with high demands for drinking water and for agricultural use, located in the intermediate depression, show sub-incidence due to the variation of the water table, this hypothesis must be deepened with hydrogeological studies.

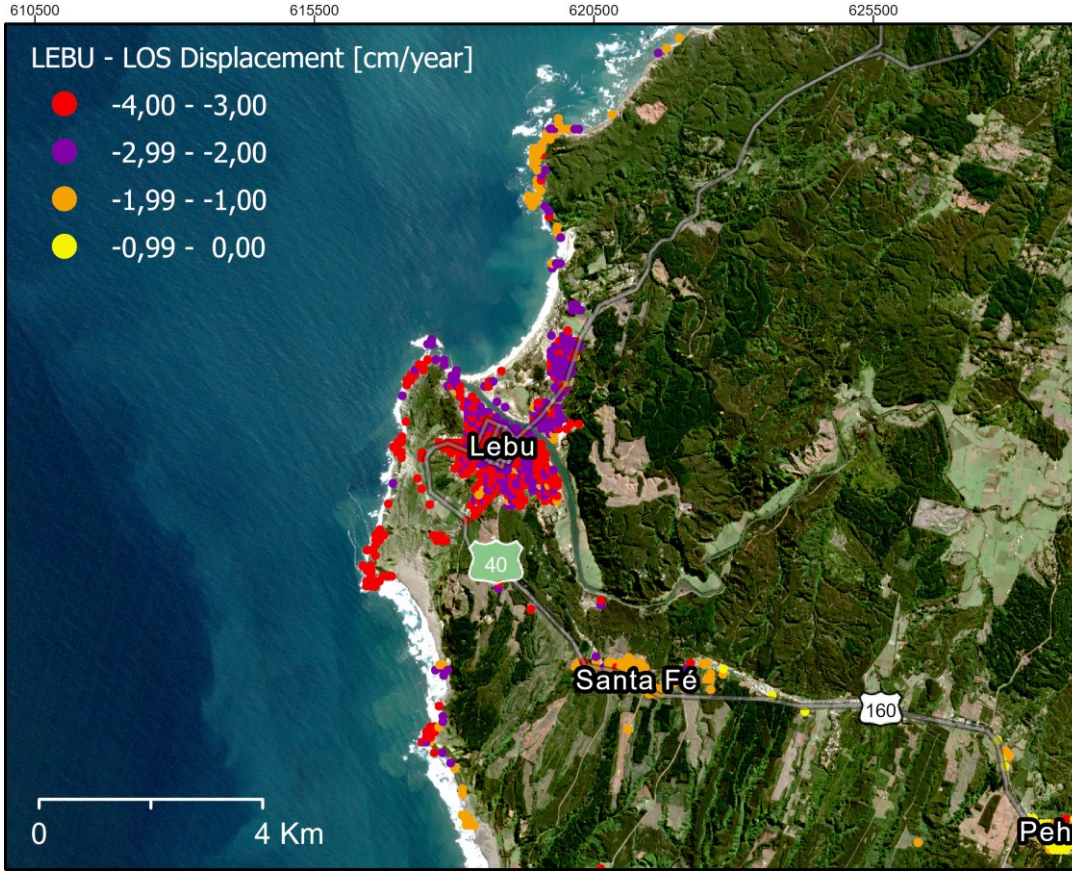


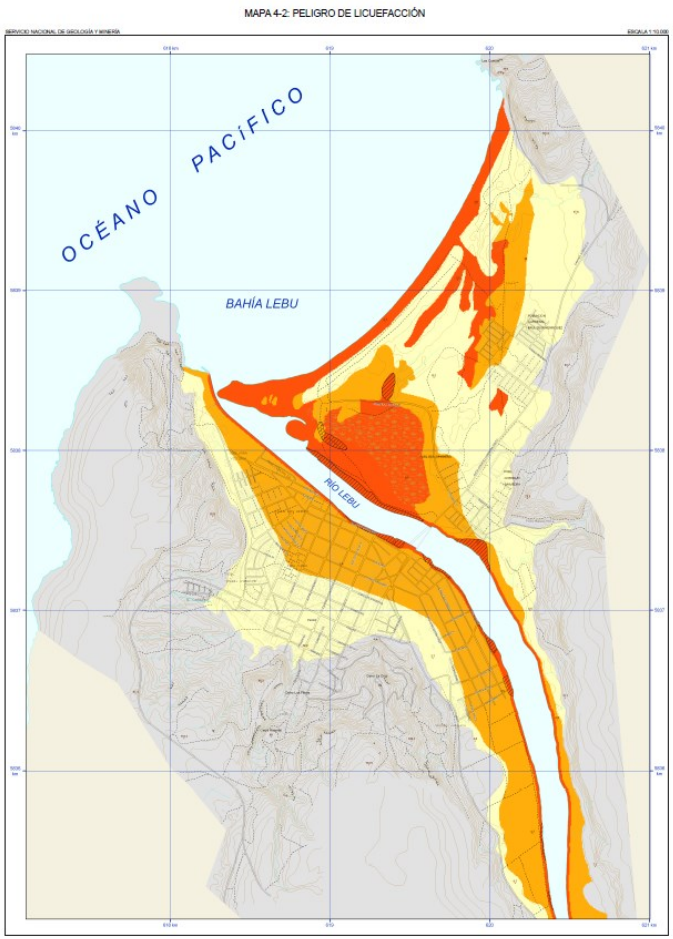




Results: Land Displacement local – scale

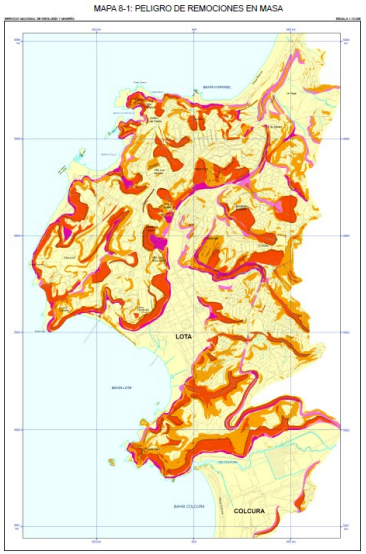
Small coastal cities have shown great subsidence, this can be caused by tectonic activity and amplified by the type of soil, mainly recent alluvial deposits.

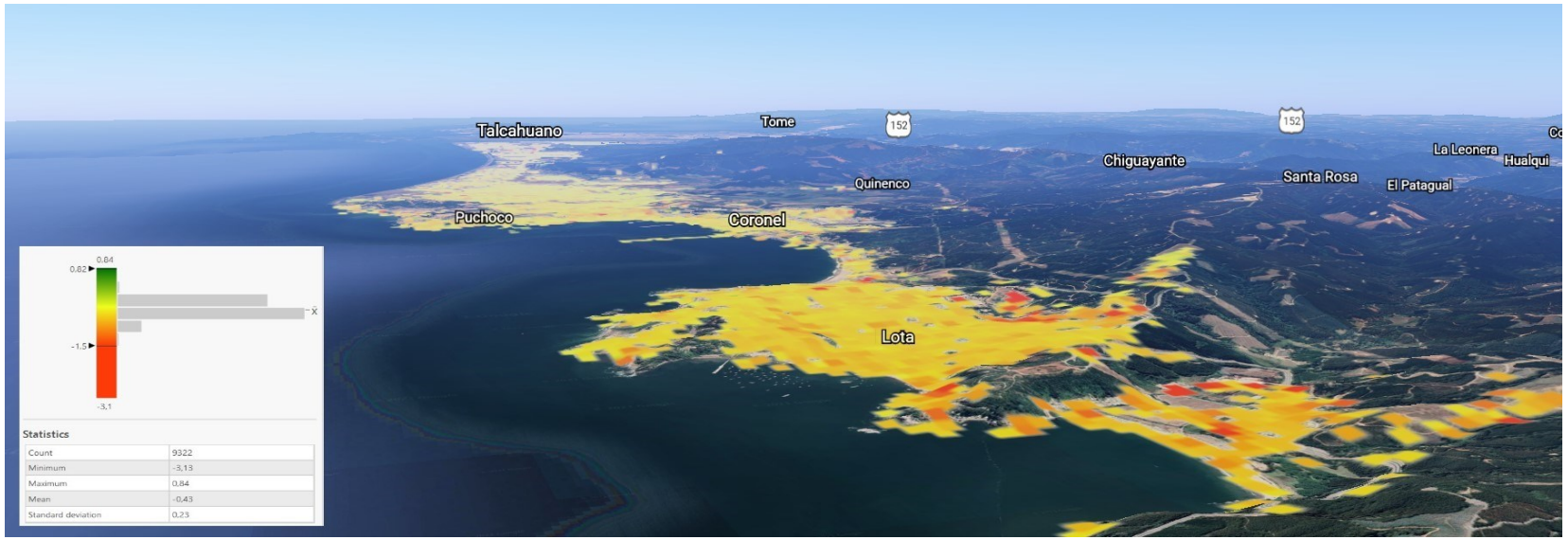




Results: Land Displacement Coastline

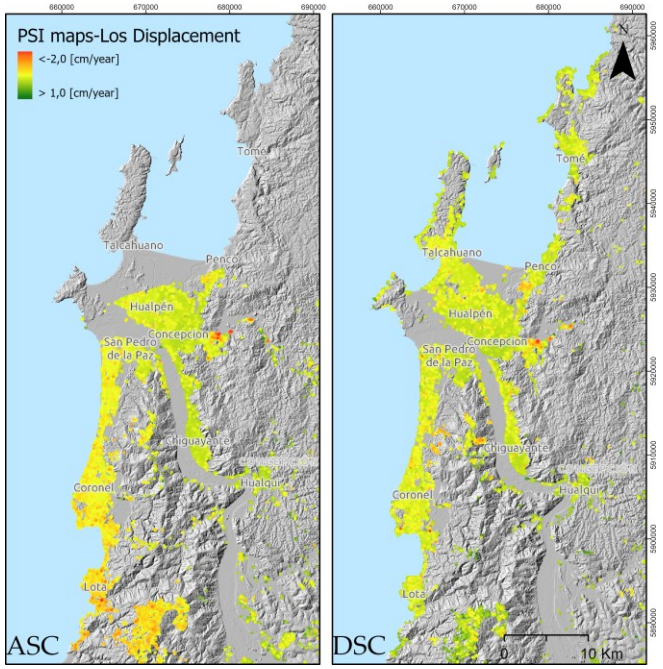
Chile's coastline is very long, its geomorphology is defined by the coastal mountain range, urban areas, ports, also tourist areas, they are of great importance for economic development. With Sentinel 1 we were able to cover coastal areas and identify deformed areas, prone to landslides (this requires further study).

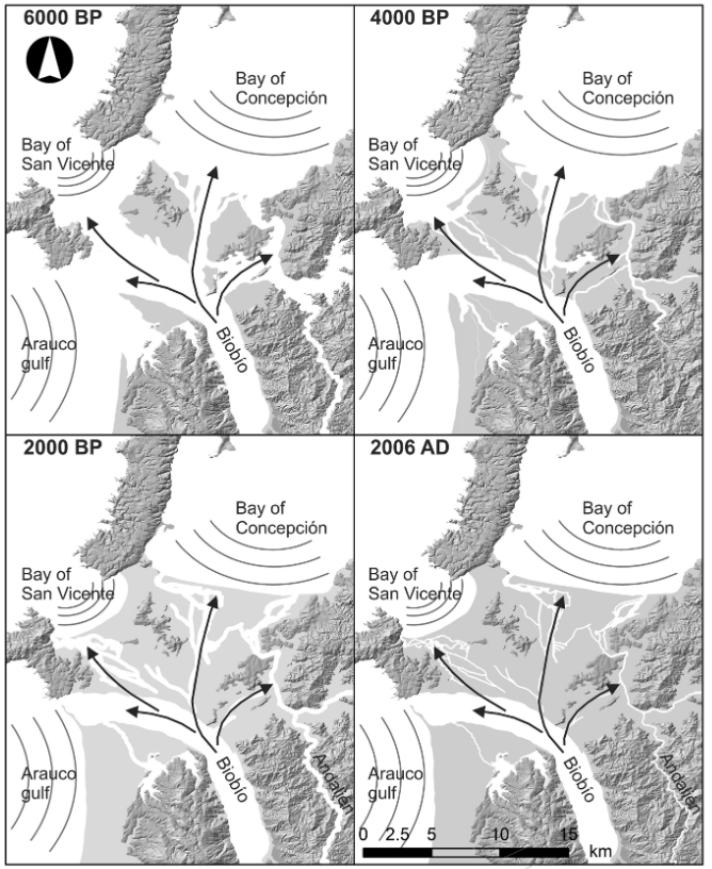




Results: INSAR and Paleo-Hydro-Geomorphologic

The data obtained with DInSAR together with the geography defined by the great rivers of Chile, and some studies carried out at the University of Concepcion, Chile, allow to show some areas prone to subsidence, due to hydrogeological processes, in this case InSAR can be complementary, to the study and some areas at risk of flooding.





Acknowledgment

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Universidad de Concepción

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