Integrated Hazard evaluation in Valparaiso: the MAR VASTO Project

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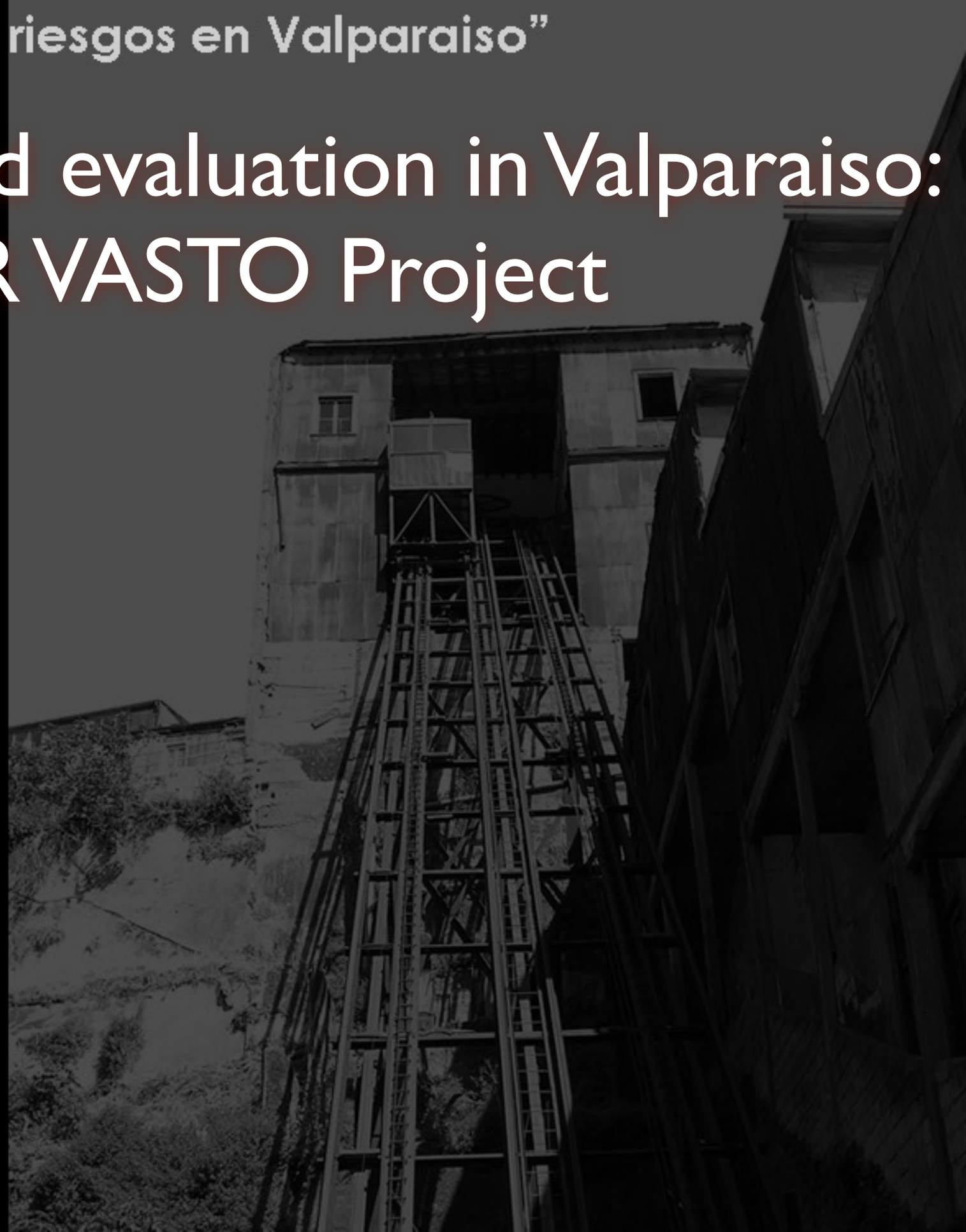


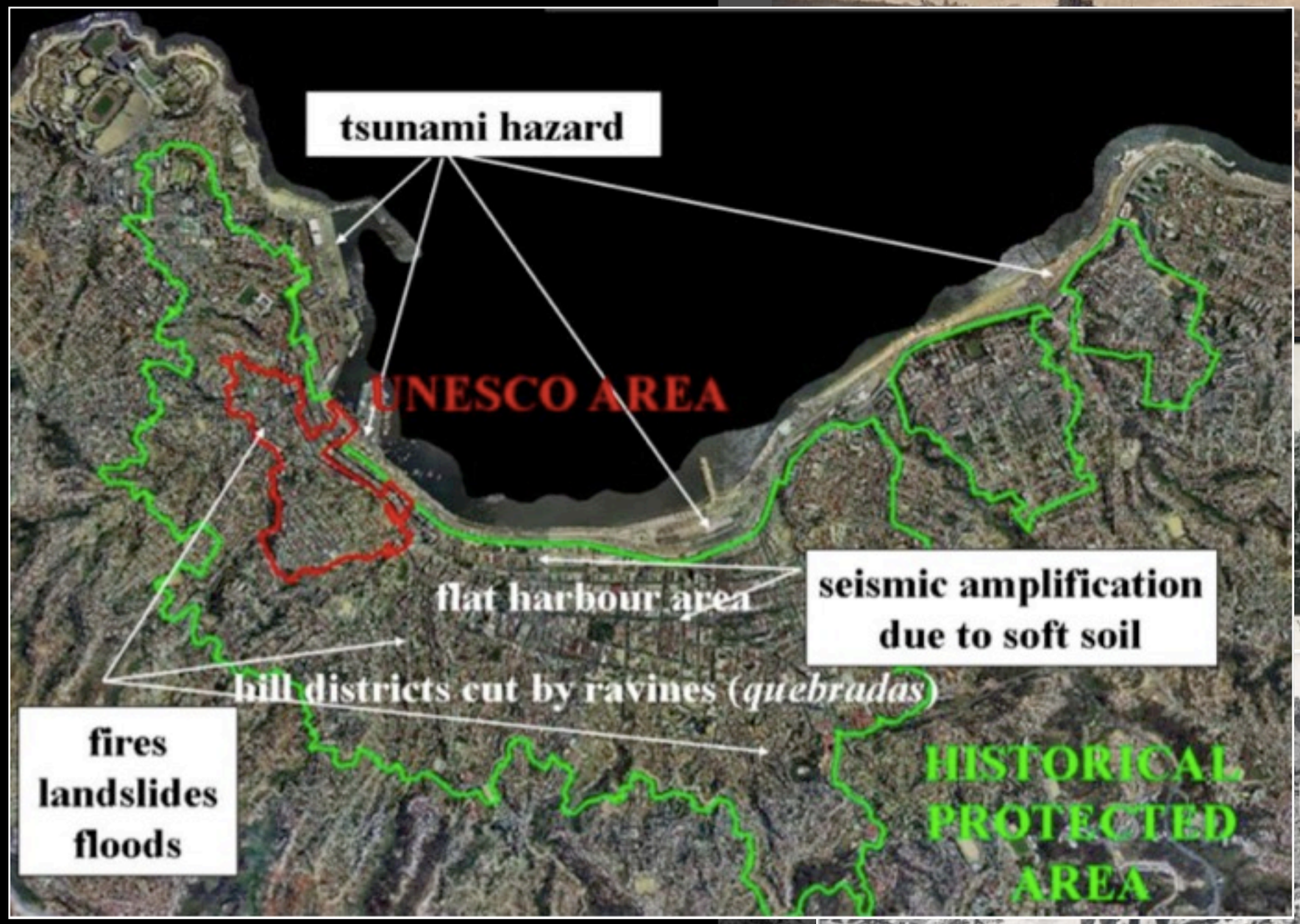
“MAR VASTO” - “Manejo de riesgos en Valparaiso”

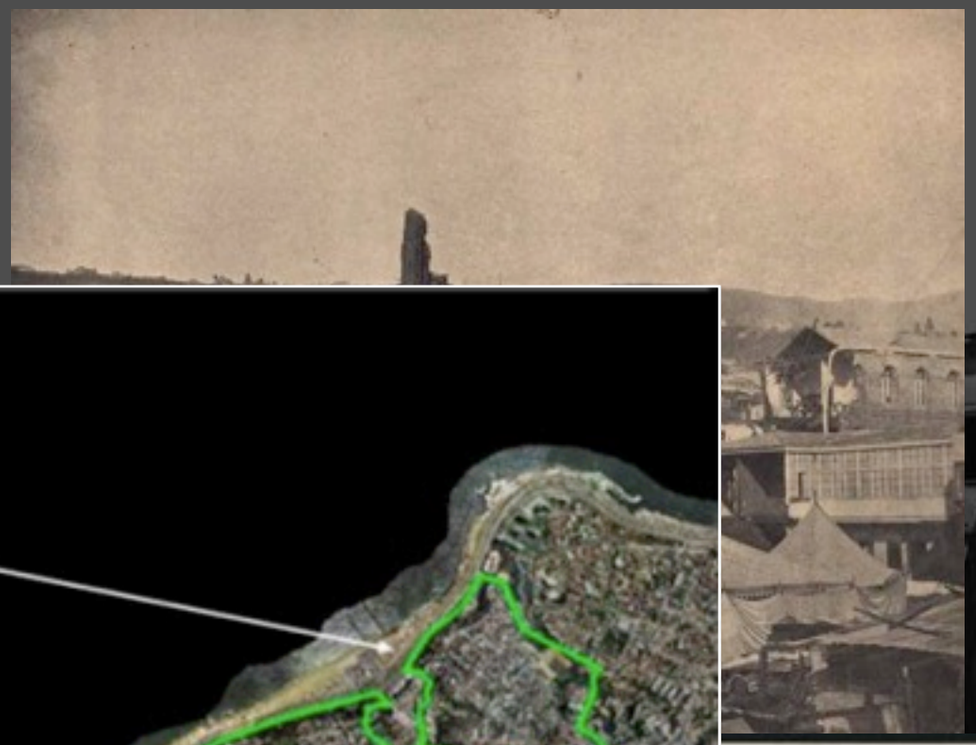
2003 - UNESCO Word Heritage List
of protected sites

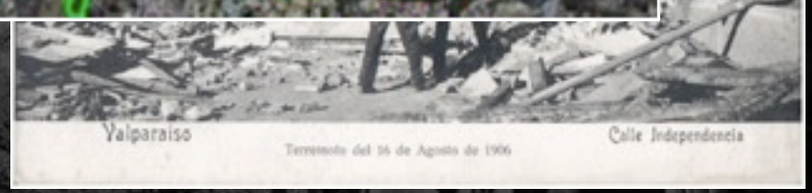
Growth of Valparaiso on reclaimed lands

“MAR VASTO” - “Manejo de riesgos en Valparaiso”

HAZARD







“MAR VASTO” - Manejo de riesgos en Valparaiso

CONTRACT BID-ENEA n. ATN/II-9816-CH

PARTNERSHIP

ENEA, Ente per le Nuove tecnologie, l’Energia e l’Ambiente

UNIFE, Università di Ferrara, Dip. di Architettura e Ingegneria

ICTP, Abdus Salam International Centre for Theoretical Physics, Trieste

UNIPD, Università di Padova, Facoltà di Ingegneria, Dipartimento di Costruzioni e Trasporti

USM, Universidad Tecnica Federico Santa Maria, Departamento de Obras Civiles

UC, Universidad de Chile, División Estructuras Construcción Geotecnia, Departamento de Ingeniería Civil, Facultad de Ciencias Físicas y Matemáticas

PARTNERSHIP

OGP, Ilustre Municipalidad de Valparaíso, Oficina de Gestion Patrimonial

VALPOMIO, Programa de Recuperación y Desarrollo Urbano de Valparaíso

“MAR VASTO” - “Manejo de riesgos en Valparaiso”

DISASTER HAZARD MAPS
(earthquakes, tsunami, landslides, fires)

SURVEYS
(photos, GPS, geology, laser scanner 3D)

VULNERABILITY ANALYSIS
(synthetic sheets, structural calculations)

GIS
(geo-referenced database for risk management)

MULTIMEDIA ACTIVITIES
(movies, workshops, publications)

FINAL PROPOSALS
(guidelines for future interventions)

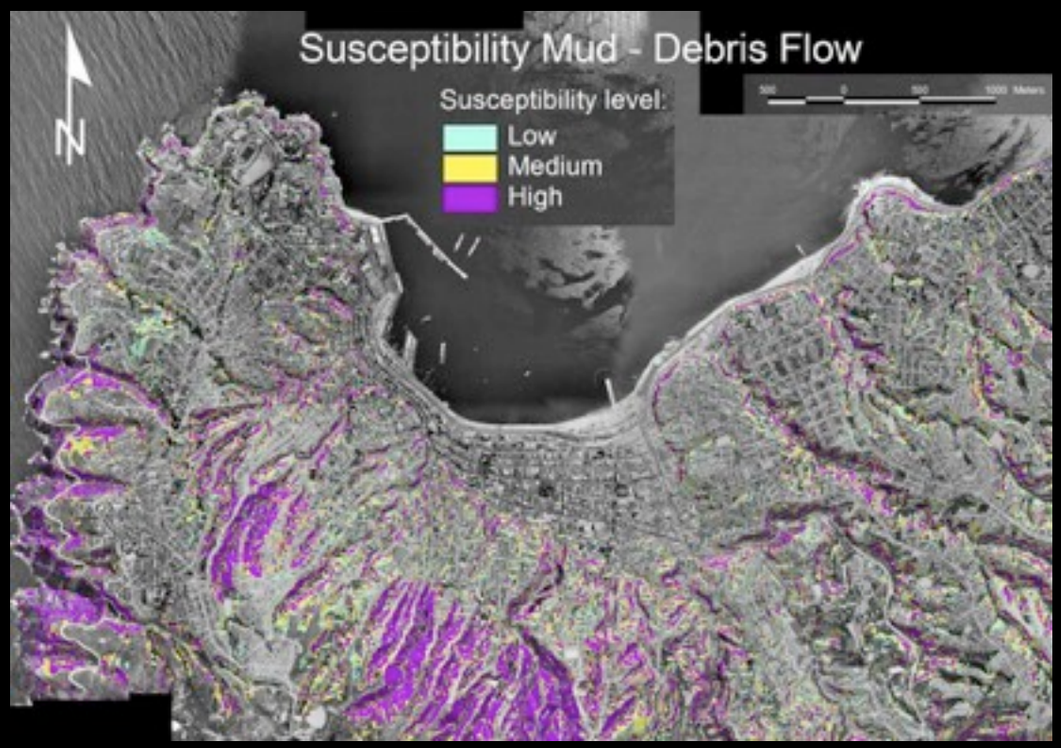
INVESTIGATION ON THREE HISTORICAL CHURCHES
(San Francisco, La Matriz, Las Hermanas de La Providencia)

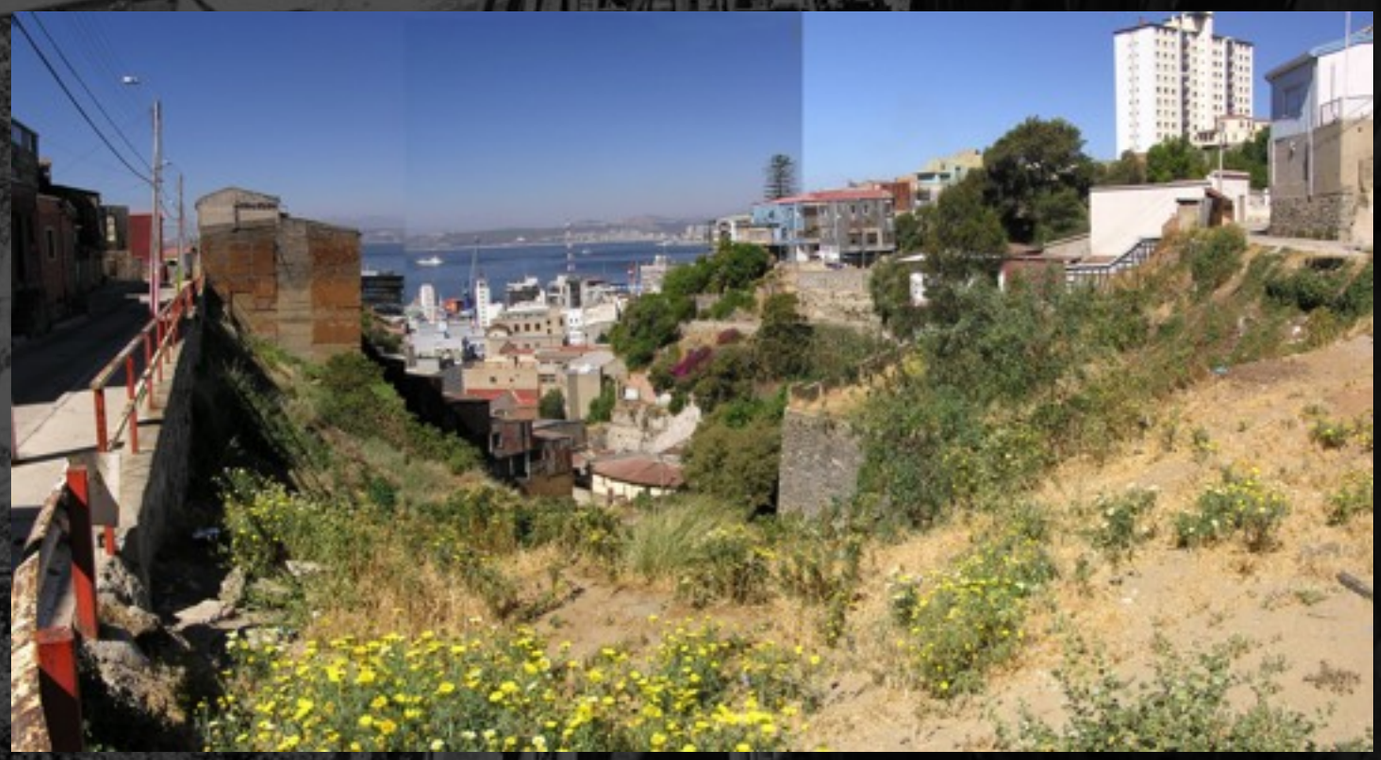
INVESTIGATION ON A PILOT BUILDING STOCK
(Cerro Cordillera)

“MAR VASTO” - “Manejo de riesgos en Valparaiso”

LANDSLIDE HAZARD

Cooperation with UC,
USM, OGP
cartography
quebradas Cerro Cordillera





“MAR VASTO” - “Manejo de riesgos en Valparaiso”

FIRE HAZARD

Cooperation with UC, USM, OGP,OREMI, CORPO DEI POMPIERI

cartography

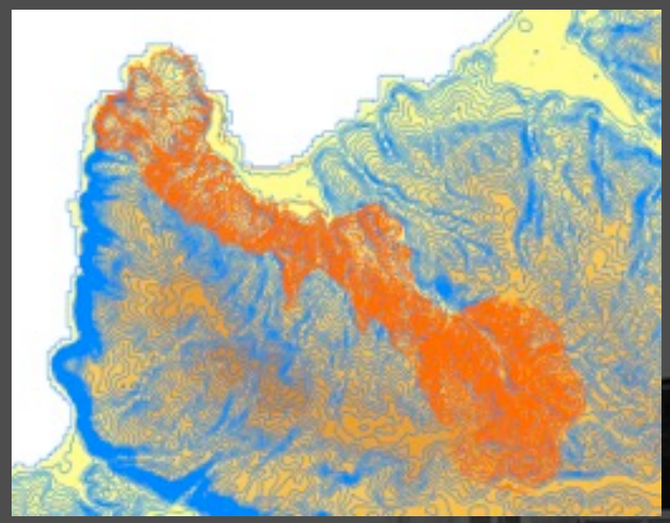
churches protection

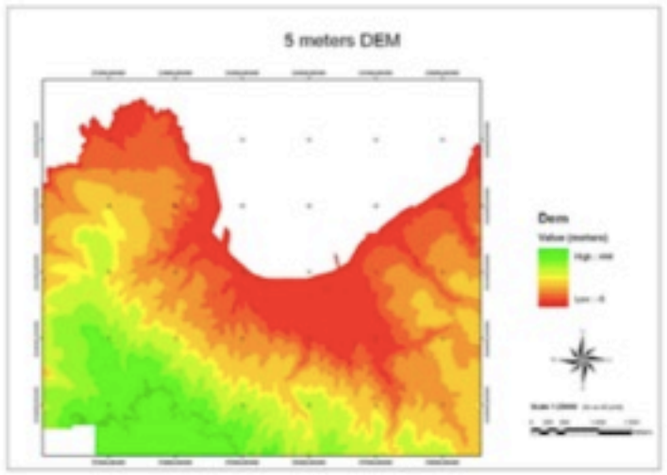
pilot study Cerro Cordillera

“MAR VASTO” - “Manejo de riesgos en Valparaiso”

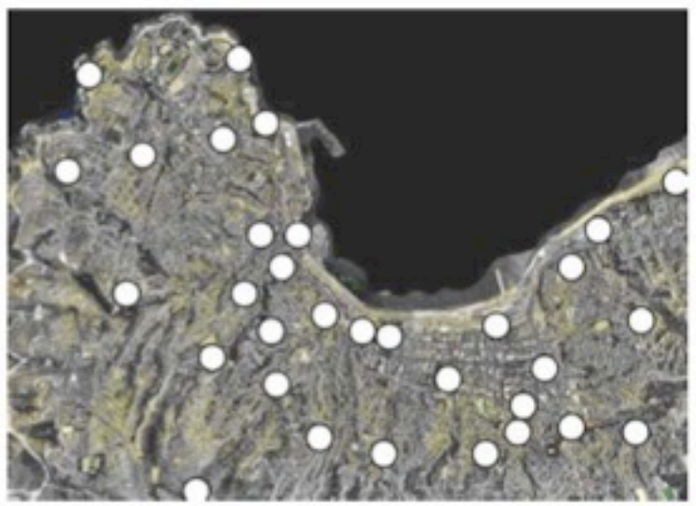
GIS DATABASE

cooperation with
OGP,OREMI, SHOA,
FIREMEN CORP
cartography
aerial photos
vulnerability analysis

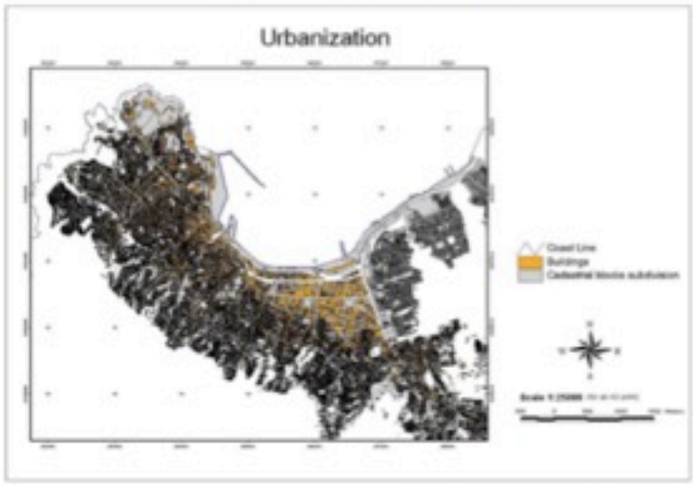


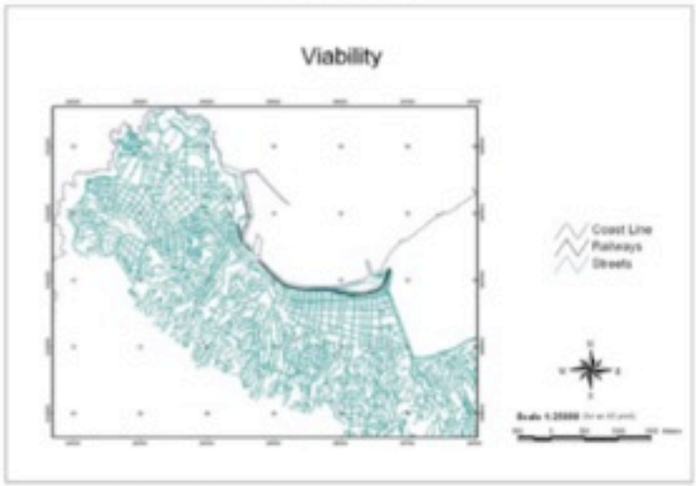


Digital Elevation Model



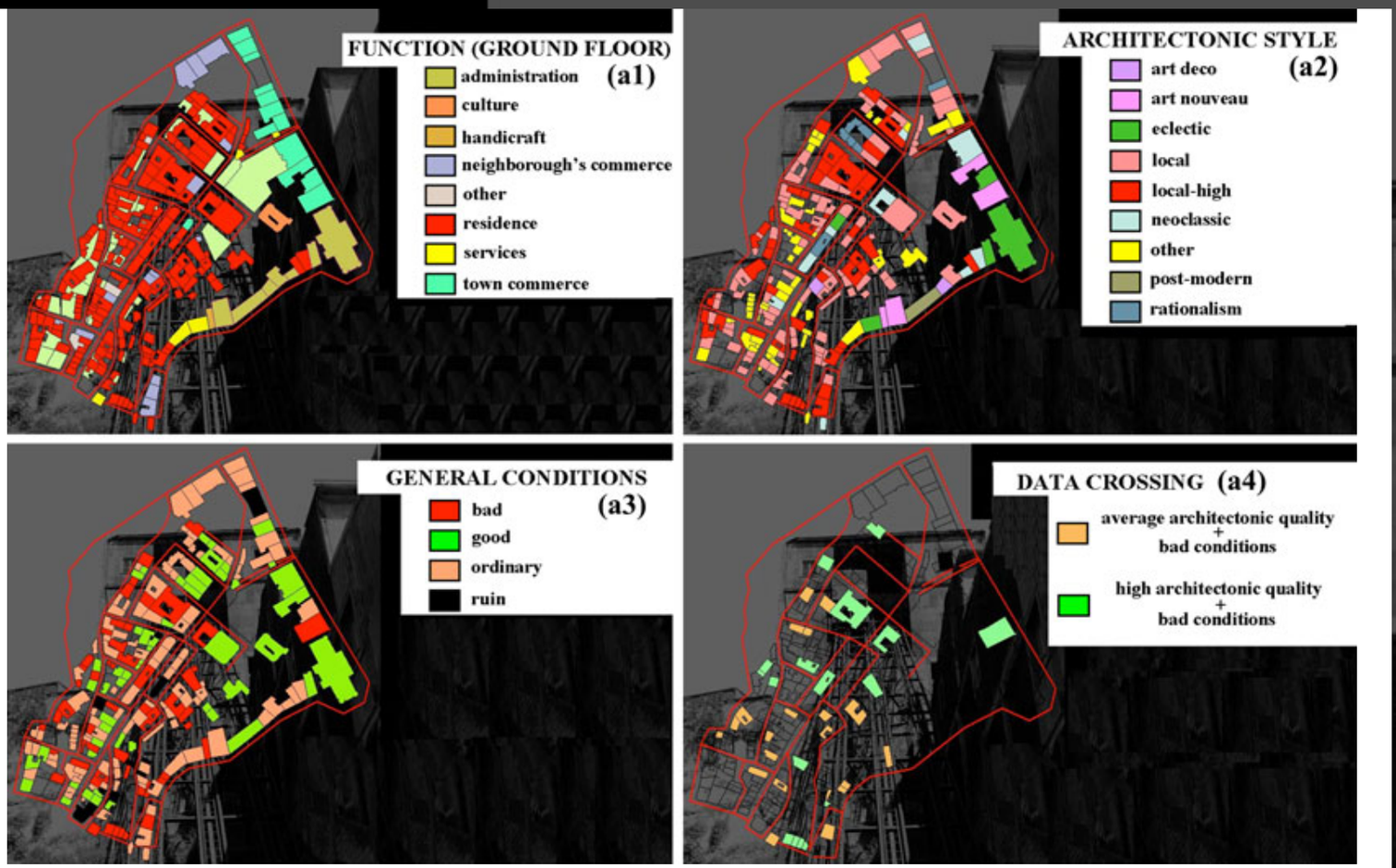
DGPS survey

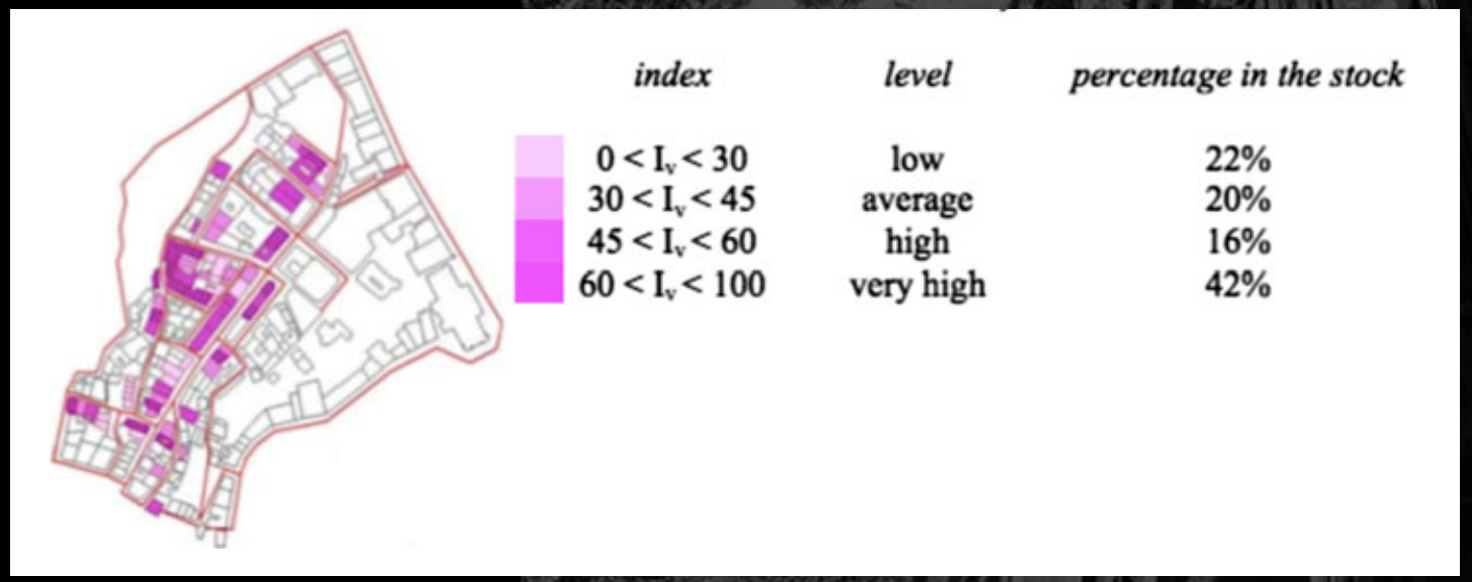




digital cartography (examples: urbanization and viability)

VULNERABILITY

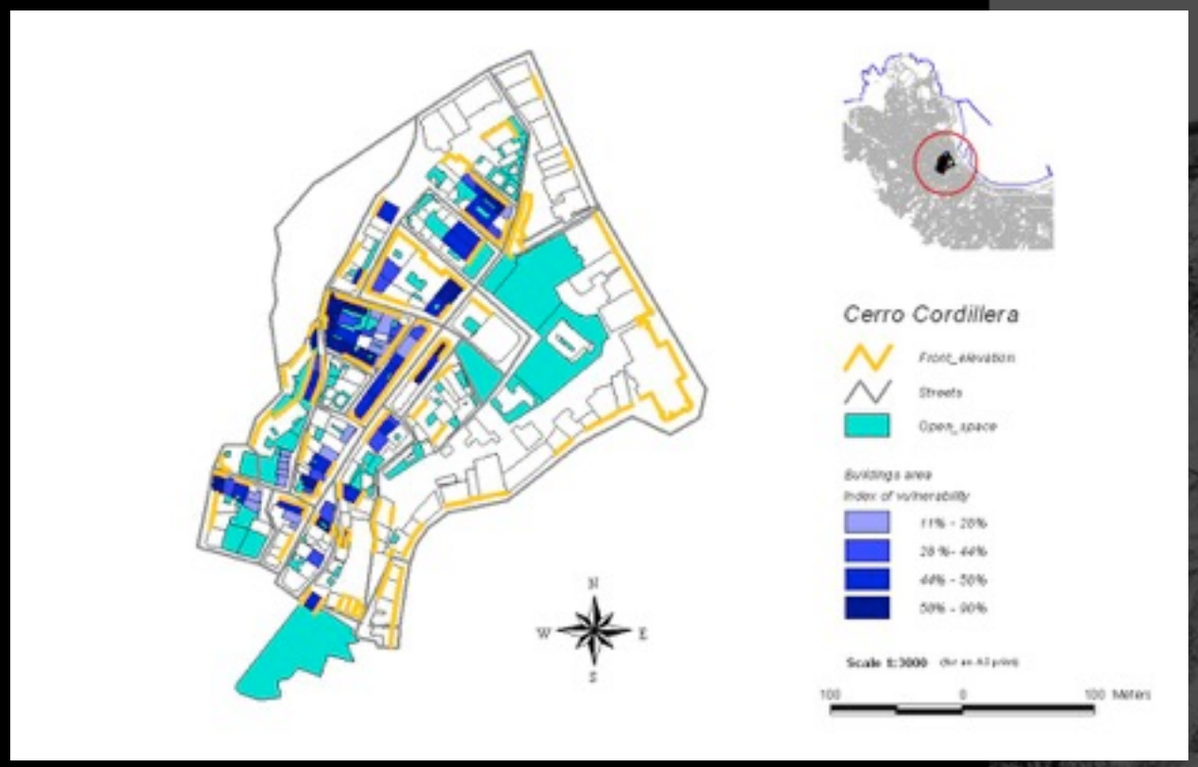




URBAN PLANNING

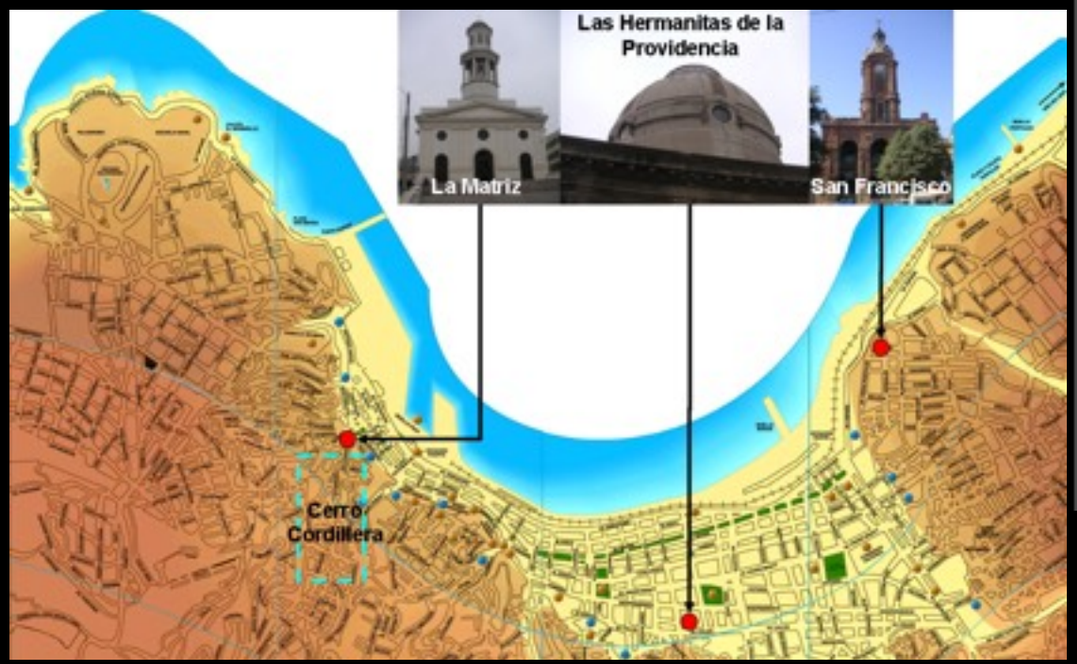
Cerro Cordillera pilot area

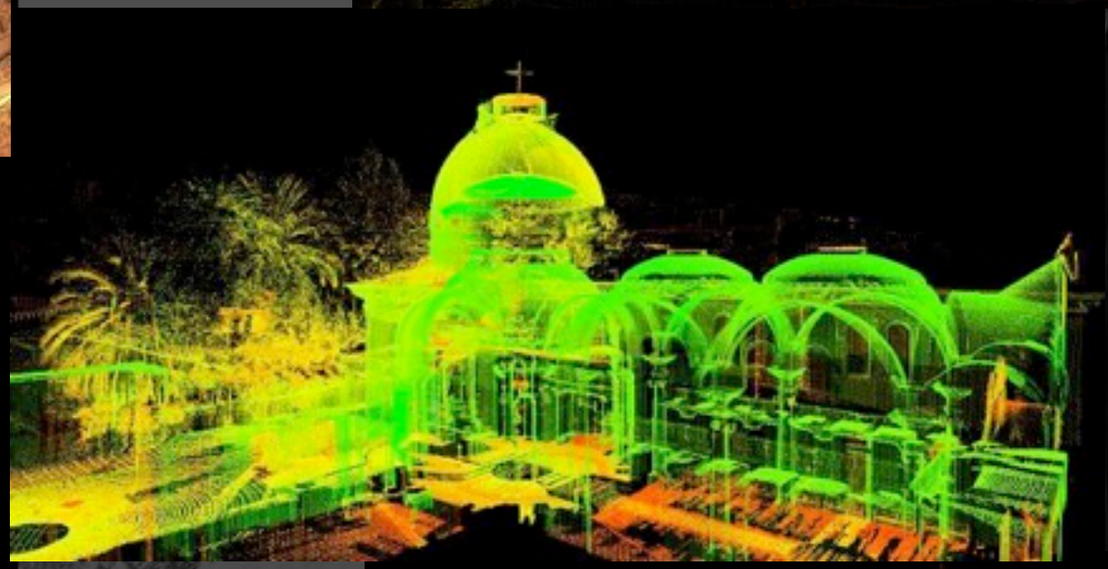
In situ vulnerability
investigation
restoration proposals

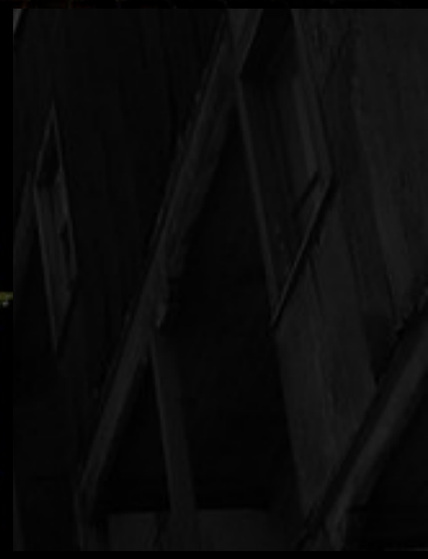


“MAR VASTO” - “Manejo de riesgos en Valparaiso”

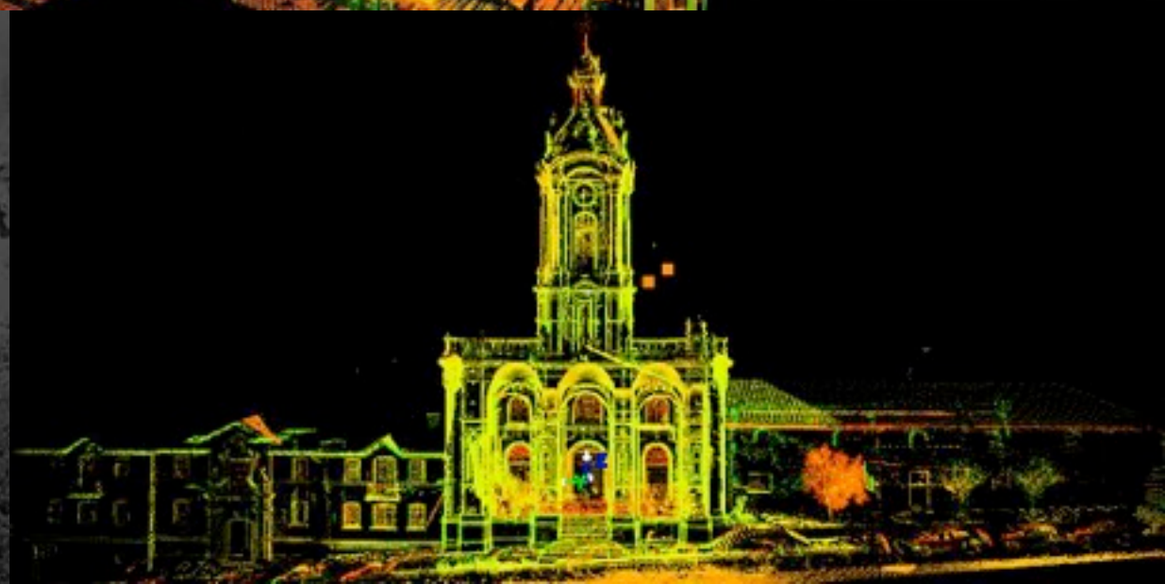
LASER SCANNER 3D







cooperation with
GEOCOM, OGP, FIREMEN CORP
La Matriz
San Francisco
Hermanas de la Providencia



“MAR VASTO” - “Manejo de riesgos en Valparaiso”

IGLESIA SAN FRANCISCO DEL BARON

La chiesa necessita di un restauro sulla torre campanaria per il consolidamento statico e dinamico possibile con interventi poco invasivi.

IGLESIA DEL SALVADOR, MATRIZ DE VALPARAISO

La chiesa risulta in buone condizioni statiche con la necessità, però, di un’intervento di recupero per il degrado dei materiali e di prevenzione per l’incendio.

CAPILLA DE LA PROVIDENCIA

La chiesa necessita di un restauro diffuso su tutta la chiesa per il consolidamento statico e dinamico.

SEISMIC HAZARD

Objectives:

- Hazard at a regional scale
- Scenario parametric tests

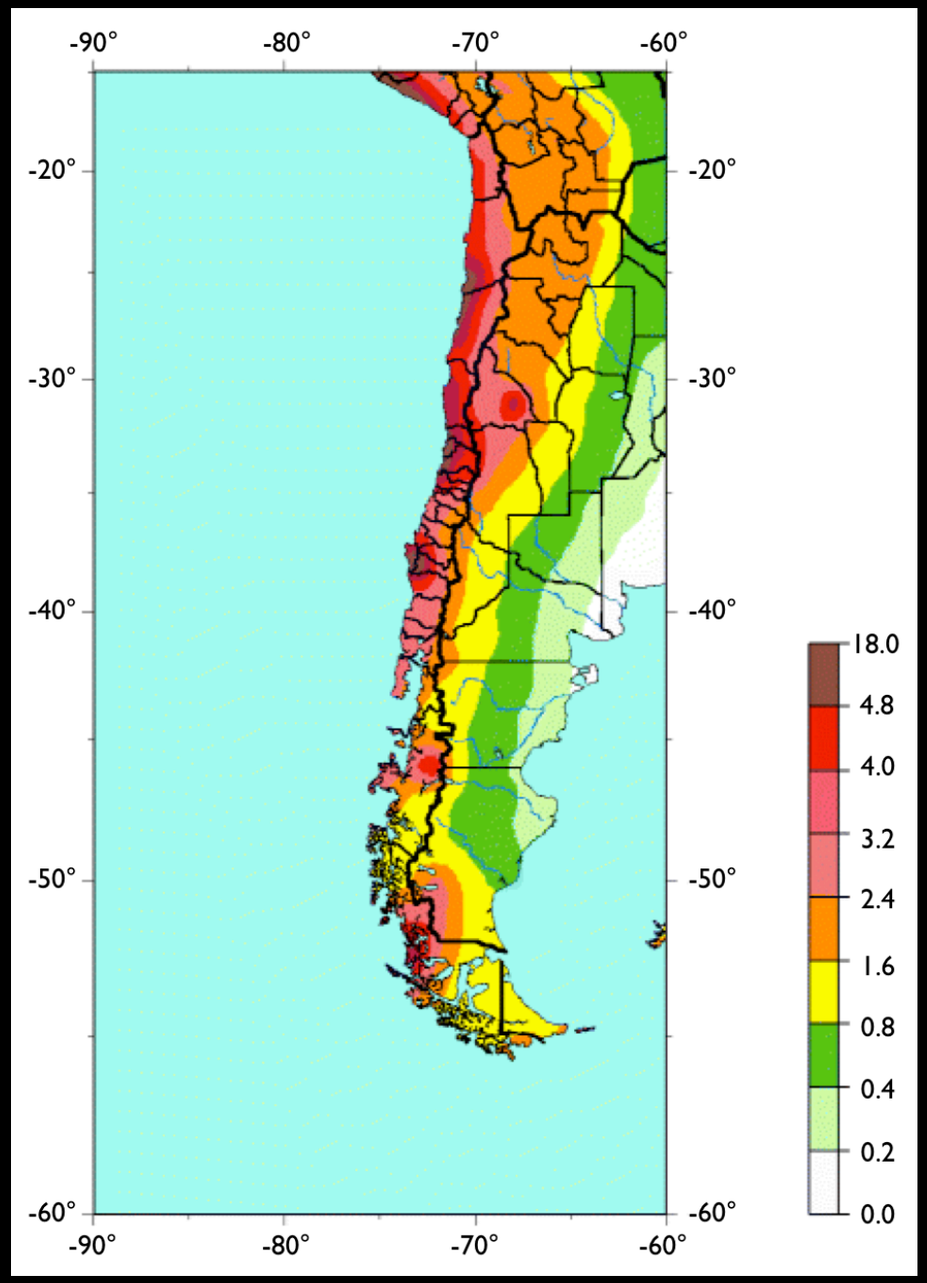
  Validation with experimental data
- Seismic input at urban scale

  3 selected churches

  Selected profiles with site effects

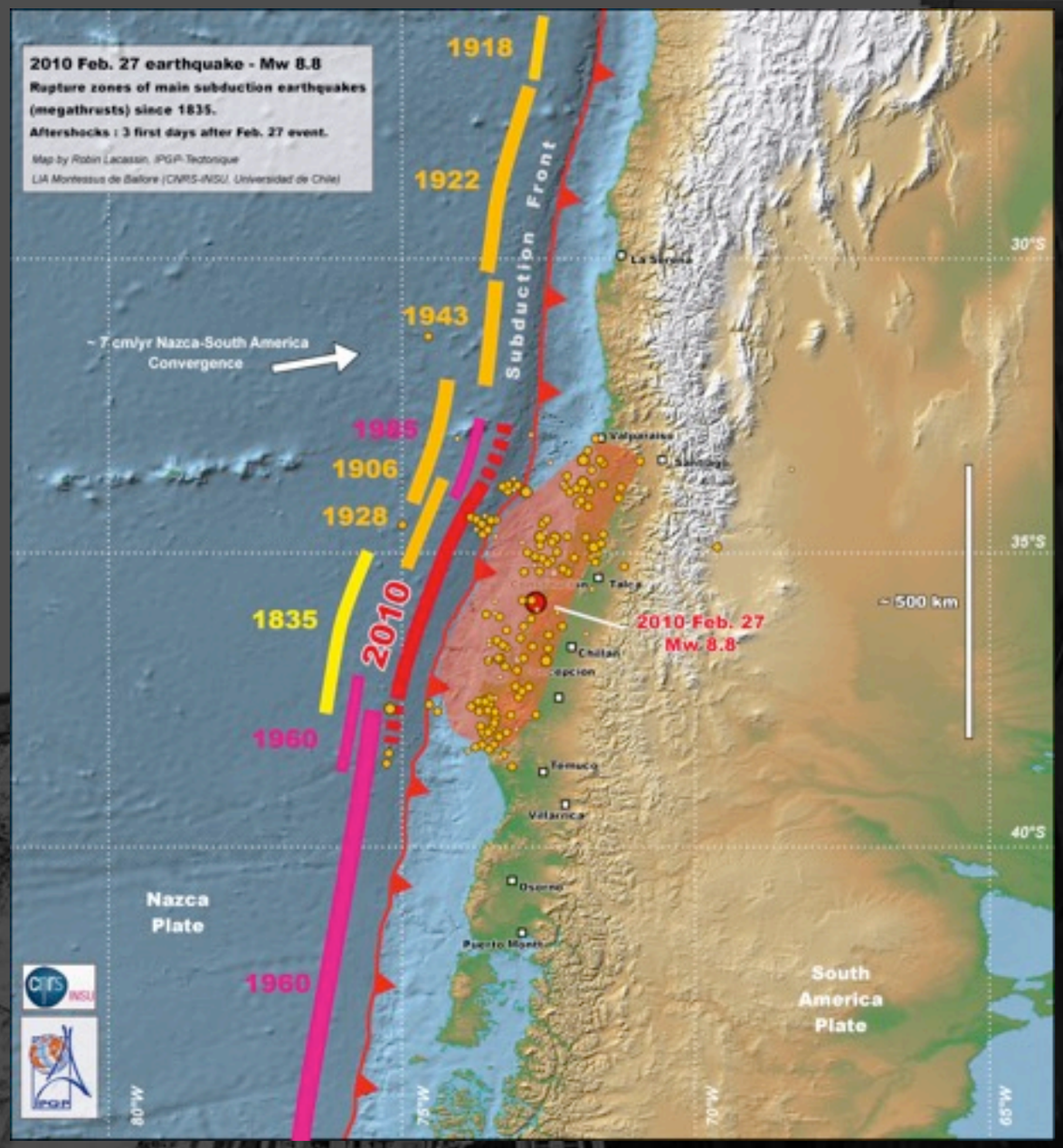
“MAR VASTO” - “Manejo de riesgos en Valparaiso”

SEISMIC HAZARD



Seismic hazard map (PGA in m/s^2 with 10% probability of exceedence in 50 years) of Chile using the probabilistic approach (see http://www.seismo.ethz.ch/gshap/)

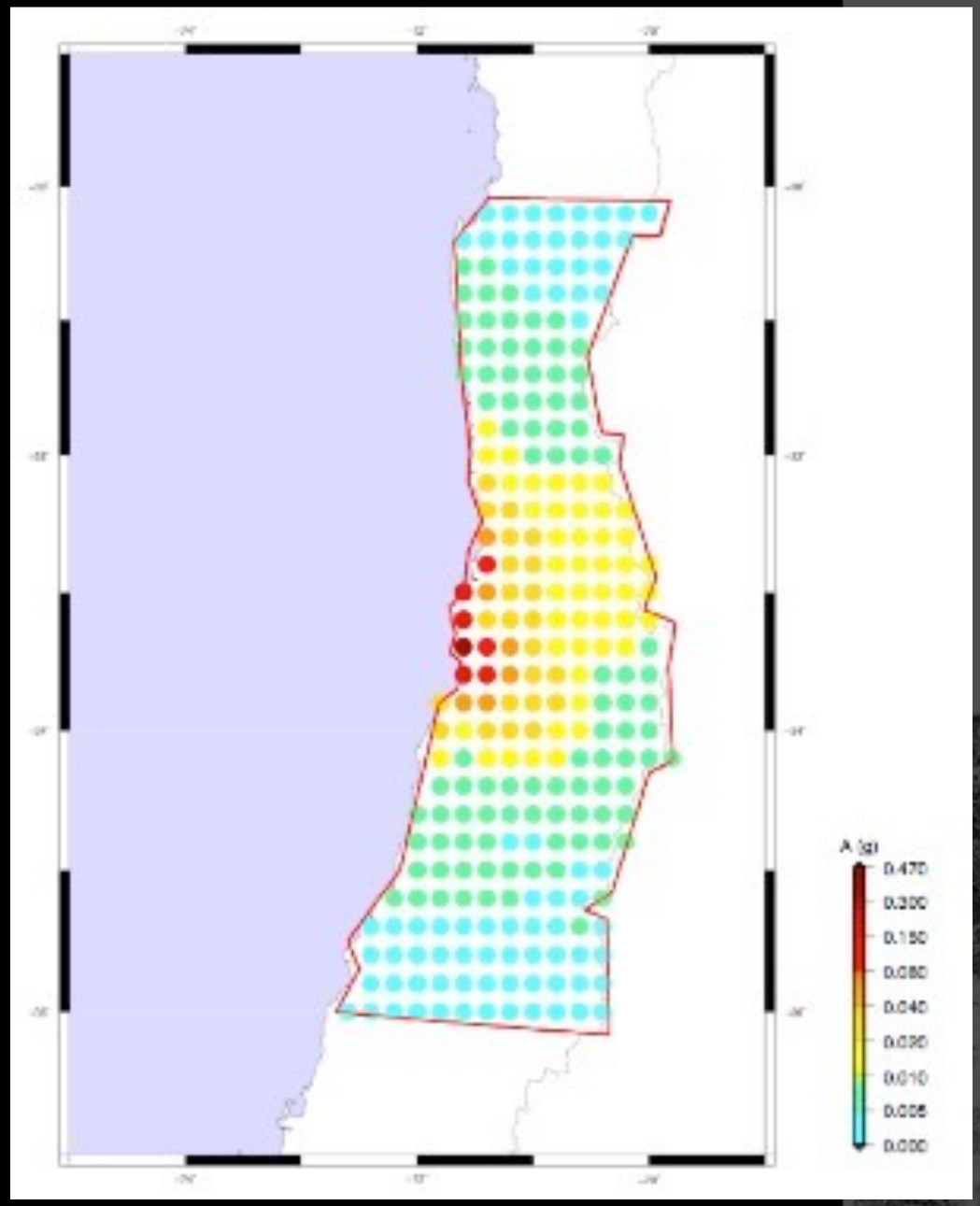
National scale

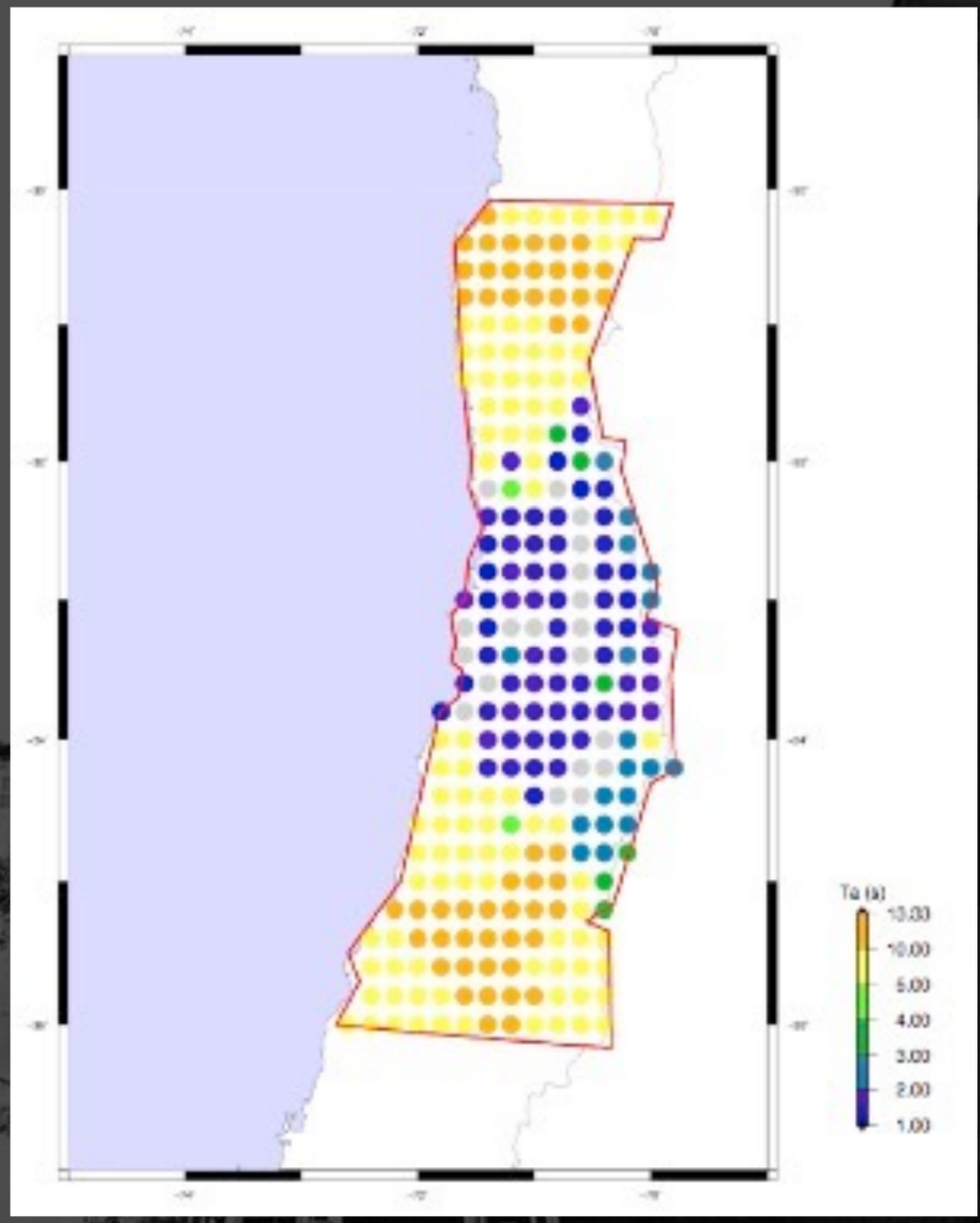


Map by LIA Montessus de Ballore (CNRS-INSU and Univ. de Chile) and IPGP tectonics lab (R. Lacassin) showing the 2010 event in the context of historical seismicity

SEISMIC HAZARD

Regional scale





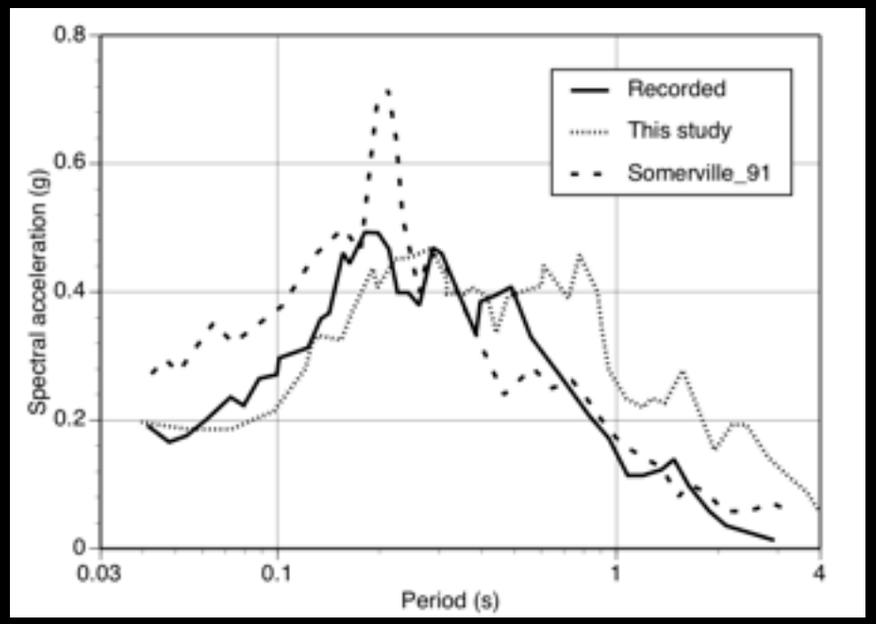
Horizontal PGA distribution and Period in seconds of its maximum after hazard deaggregation of the 1906 and 1985 events

SEISMIC HAZARD

El Almendral station: acceleration, velocity and displacement for the 1985 event.

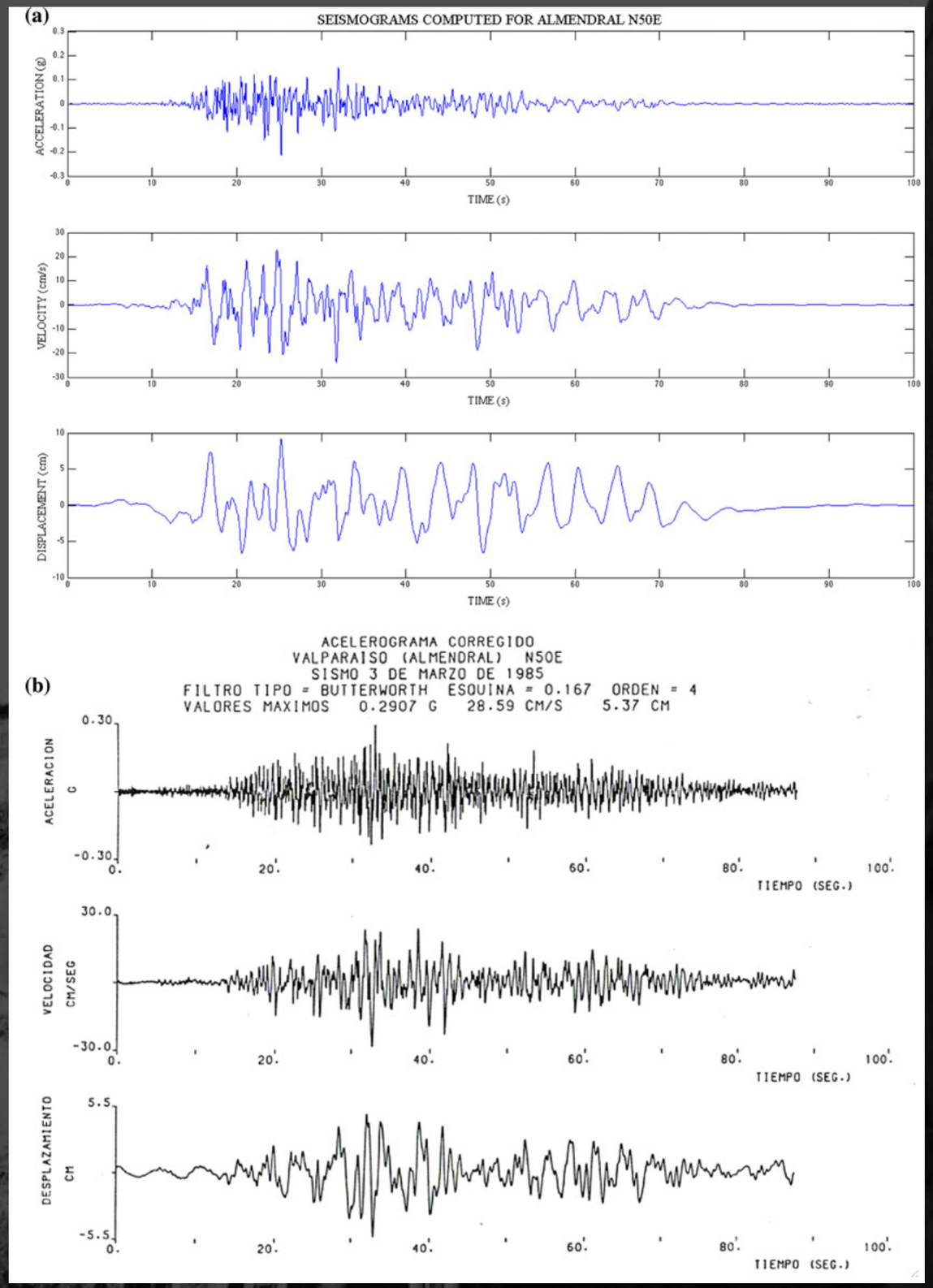
a) computed (unilateral rupture)

b) recorded.



Comparison of response spectra at UTSFM site: recorded, this study and the one simulated by Somerville et al., 1991.

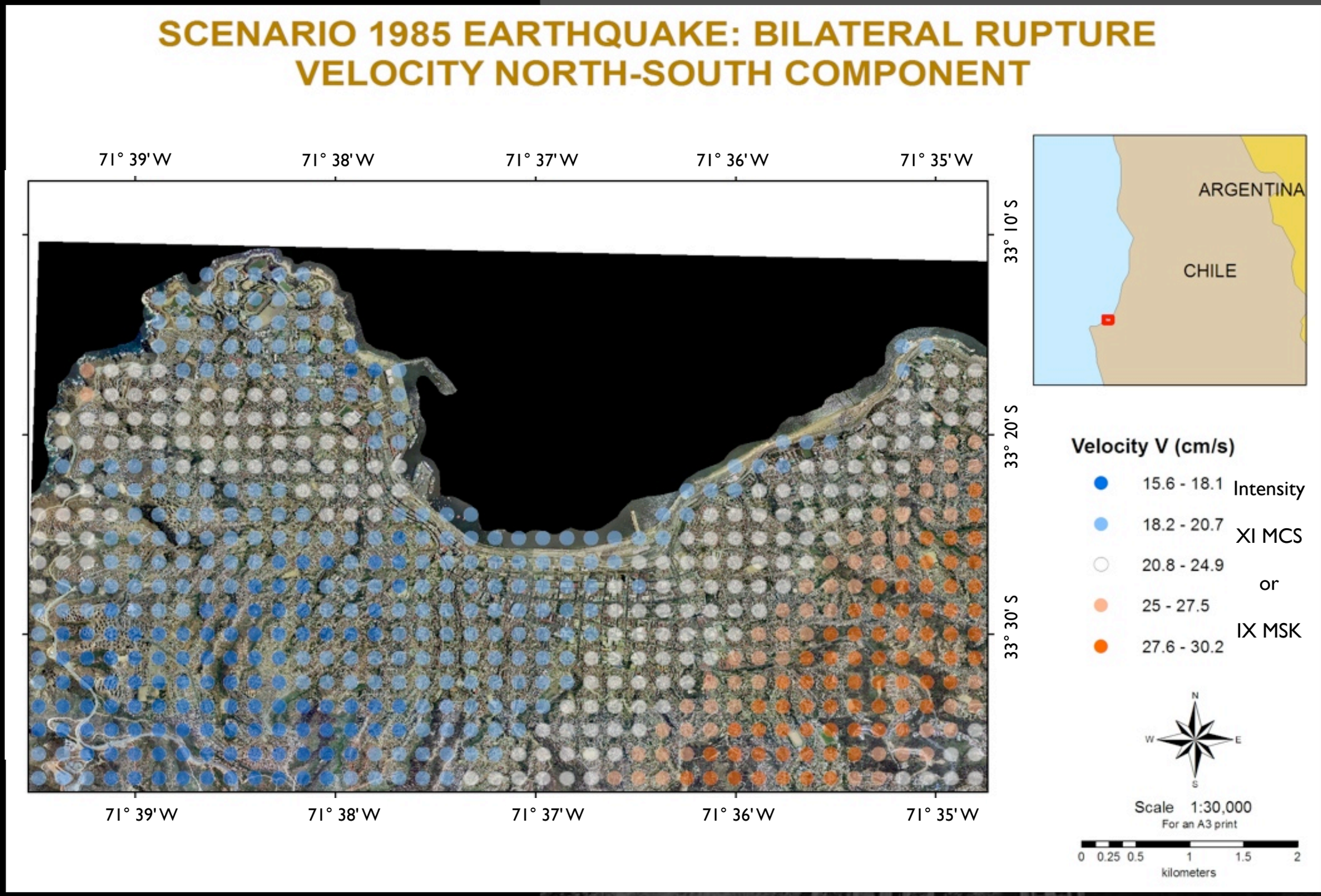
Validation



“MAR VASTO” - “Manejo de riesgos en Valparaiso”

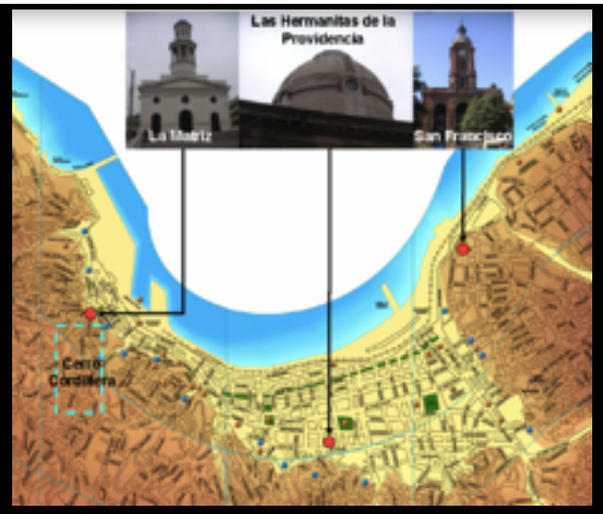
SEISMIC HAZARD

Urban scale

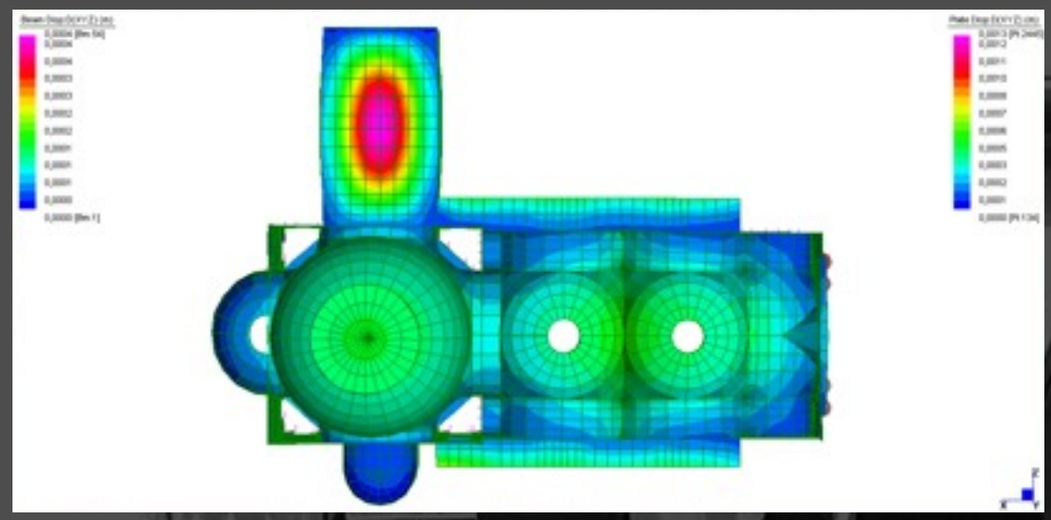


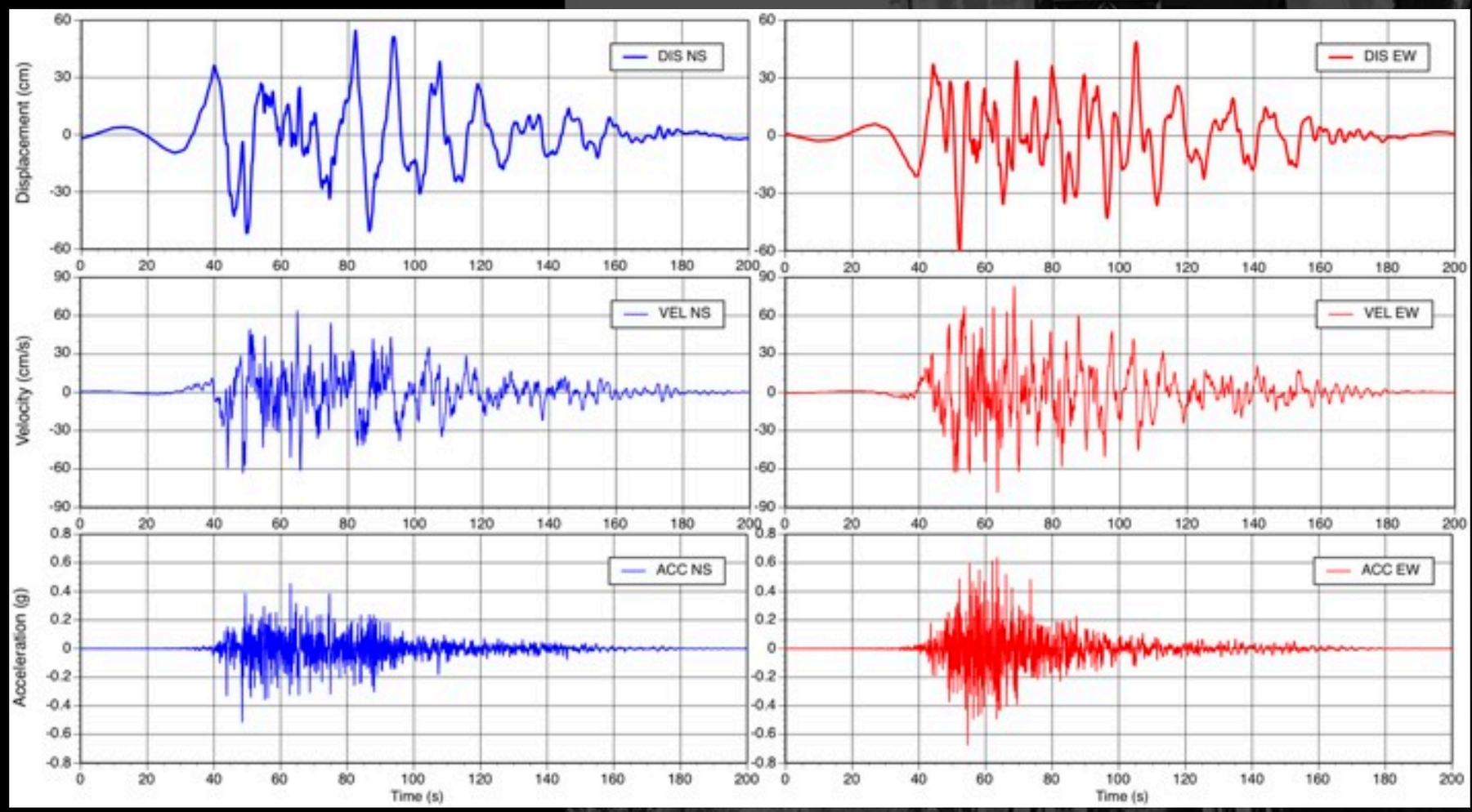
Groundshaking scenario in the Valparaiso urban area for the 1985 event.
NS component of velocities for bilateral rupture.

SEISMIC HAZARD



Seismic input for 3 selected churches

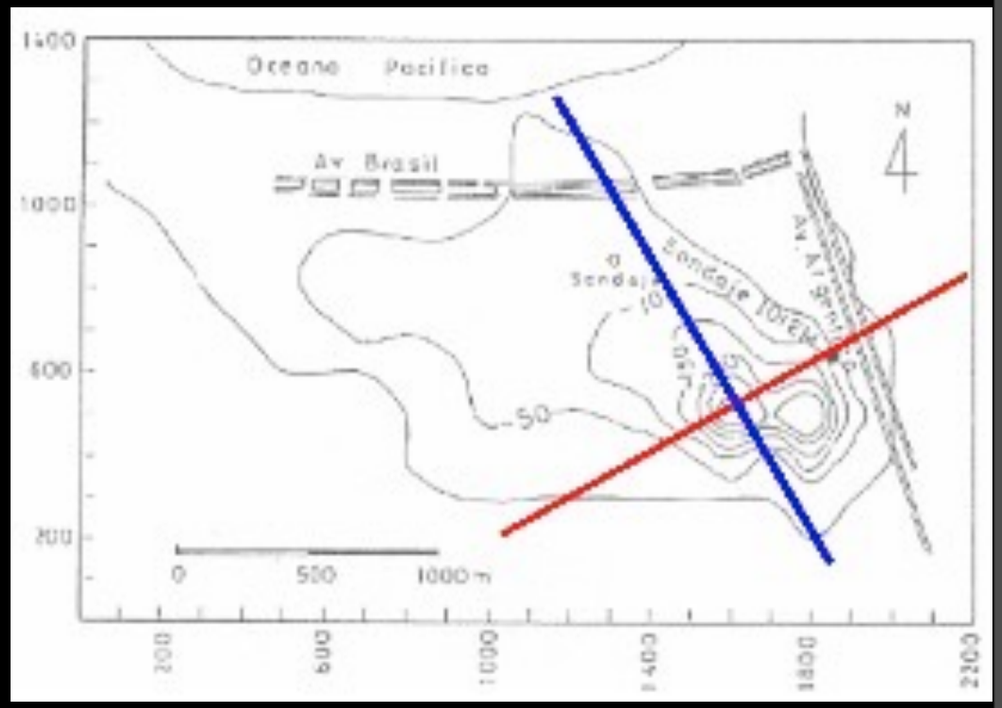




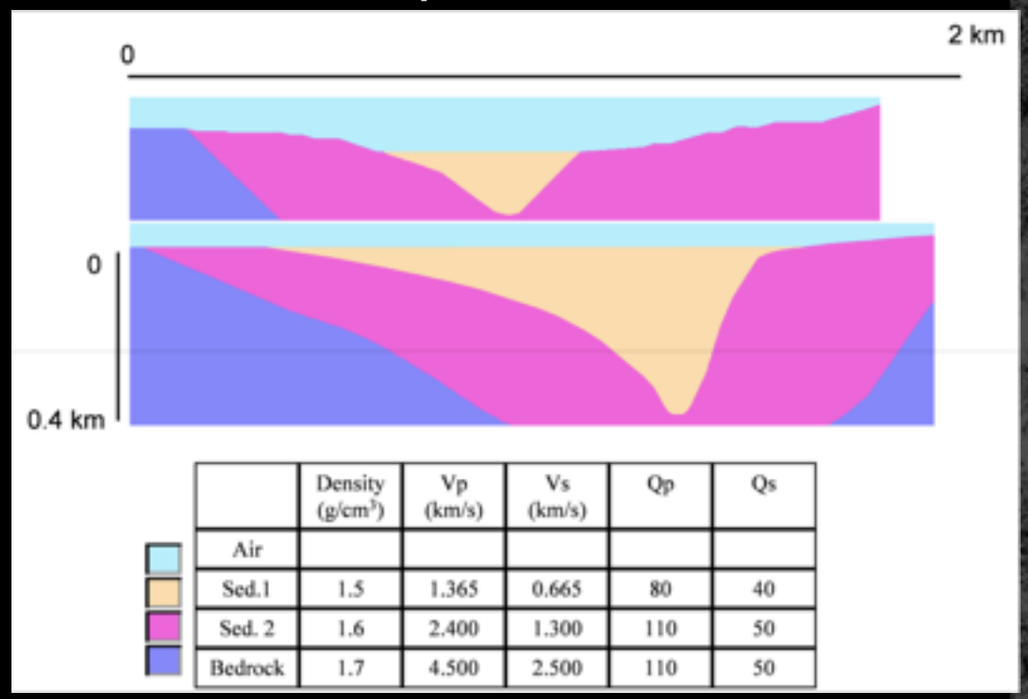
Example of seismic input computed at the La Matriz church: 1906 scenario, unilateral rupture. Displacements, velocities and accelerations for the two horizontal (North–South, NS, and East–West, EW) components of motion

“MAR VASTO” - “Manejo de riesgos en Valparaiso”

SEISMIC HAZARD

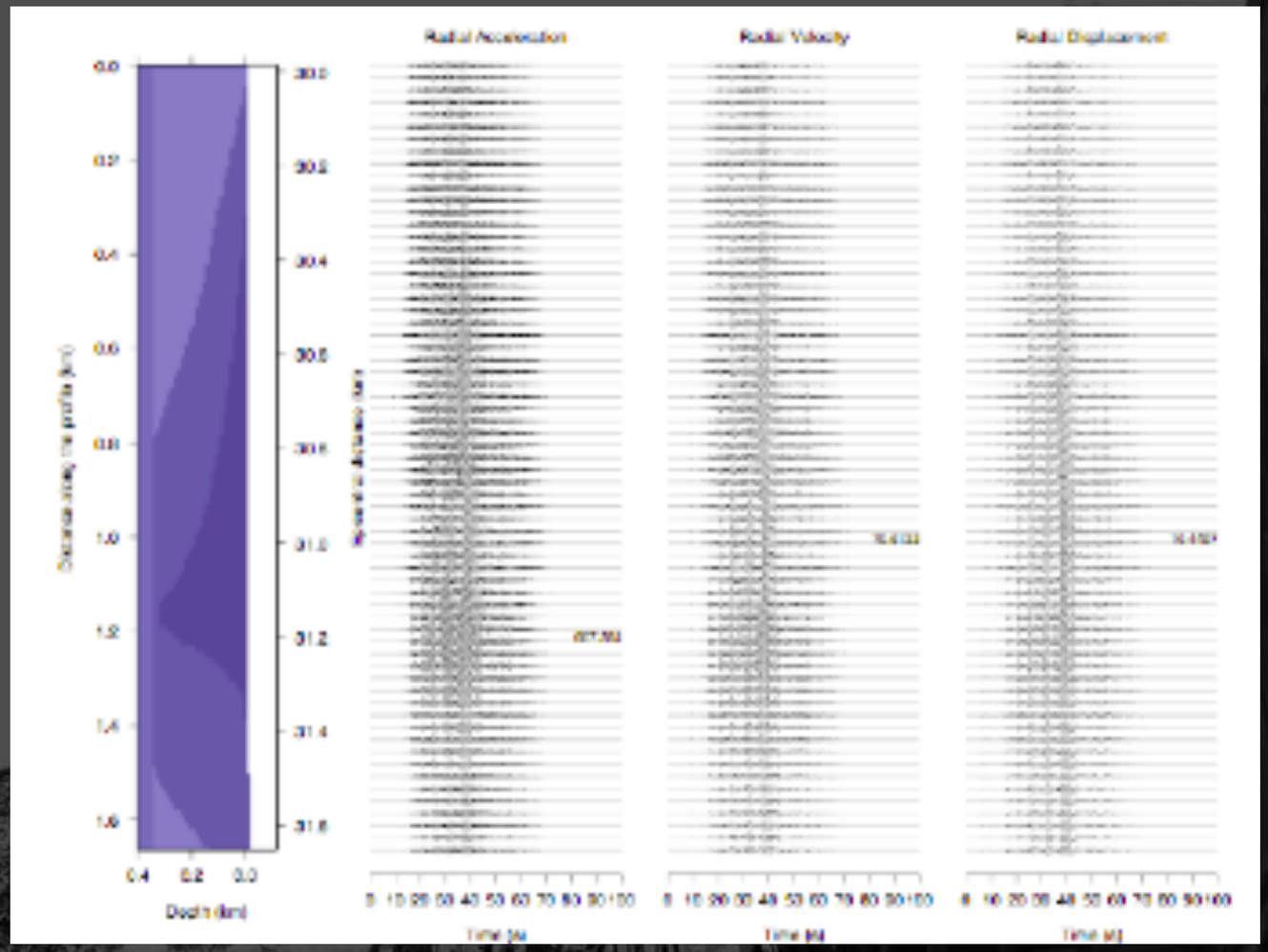


Bedrock model (depth) at El Almendral and the position of the two profiles with their parameters.



	Density (g/cm^3)	Vp (km/s)	Vs (km/s)	Qp	Qs
Air					
Sed.1	1.5	1.365	0.665	80	40
Sed. 2	1.6	2.400	1.300	110	50
Bedrock	1.7	4.500	2.500	110	50

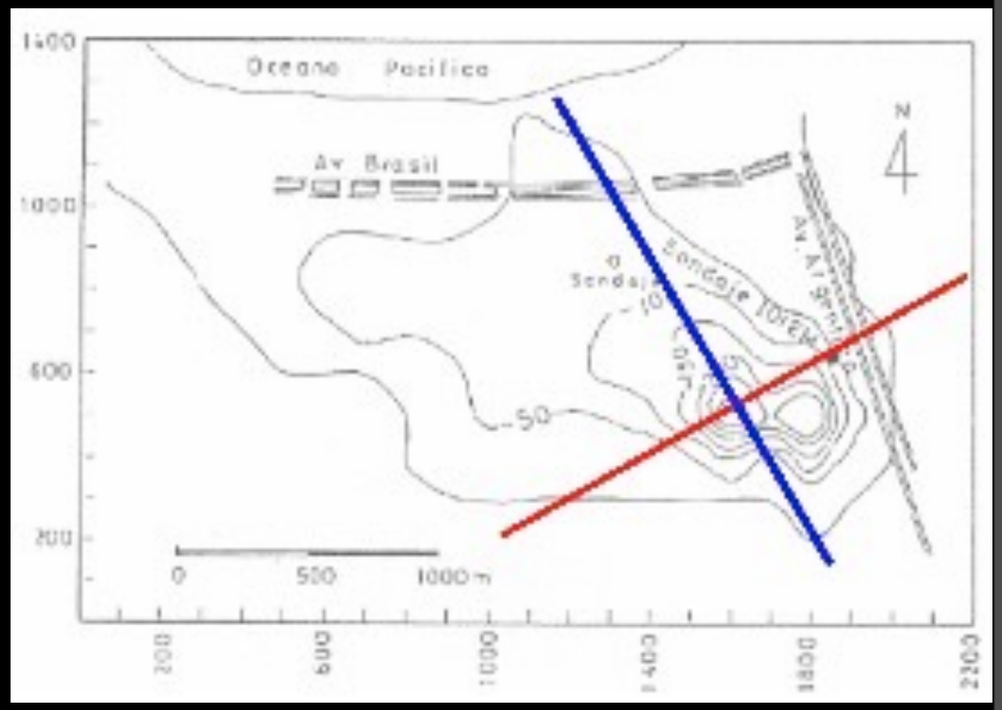
Profiles & site effects

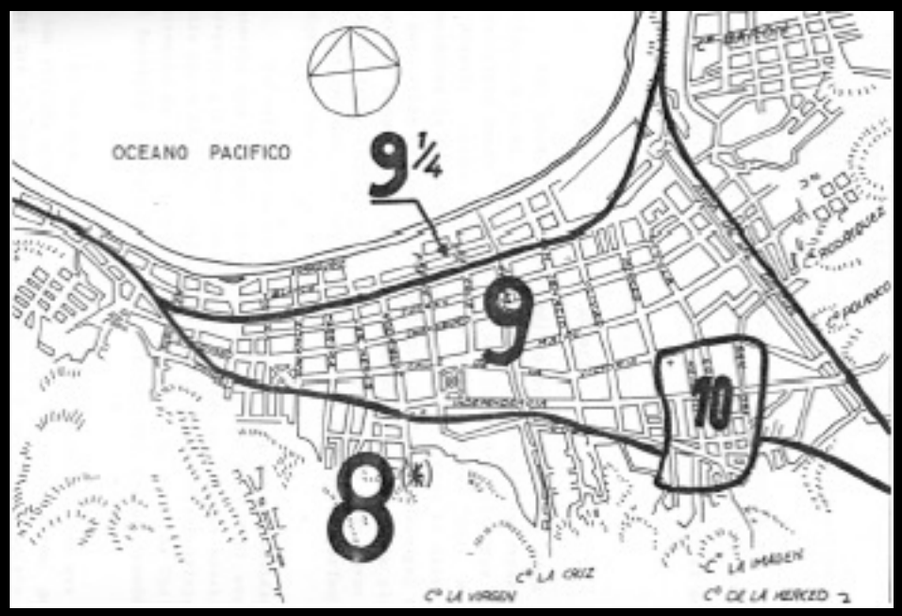


Radial component of motion along profile 2.
1906 scenario

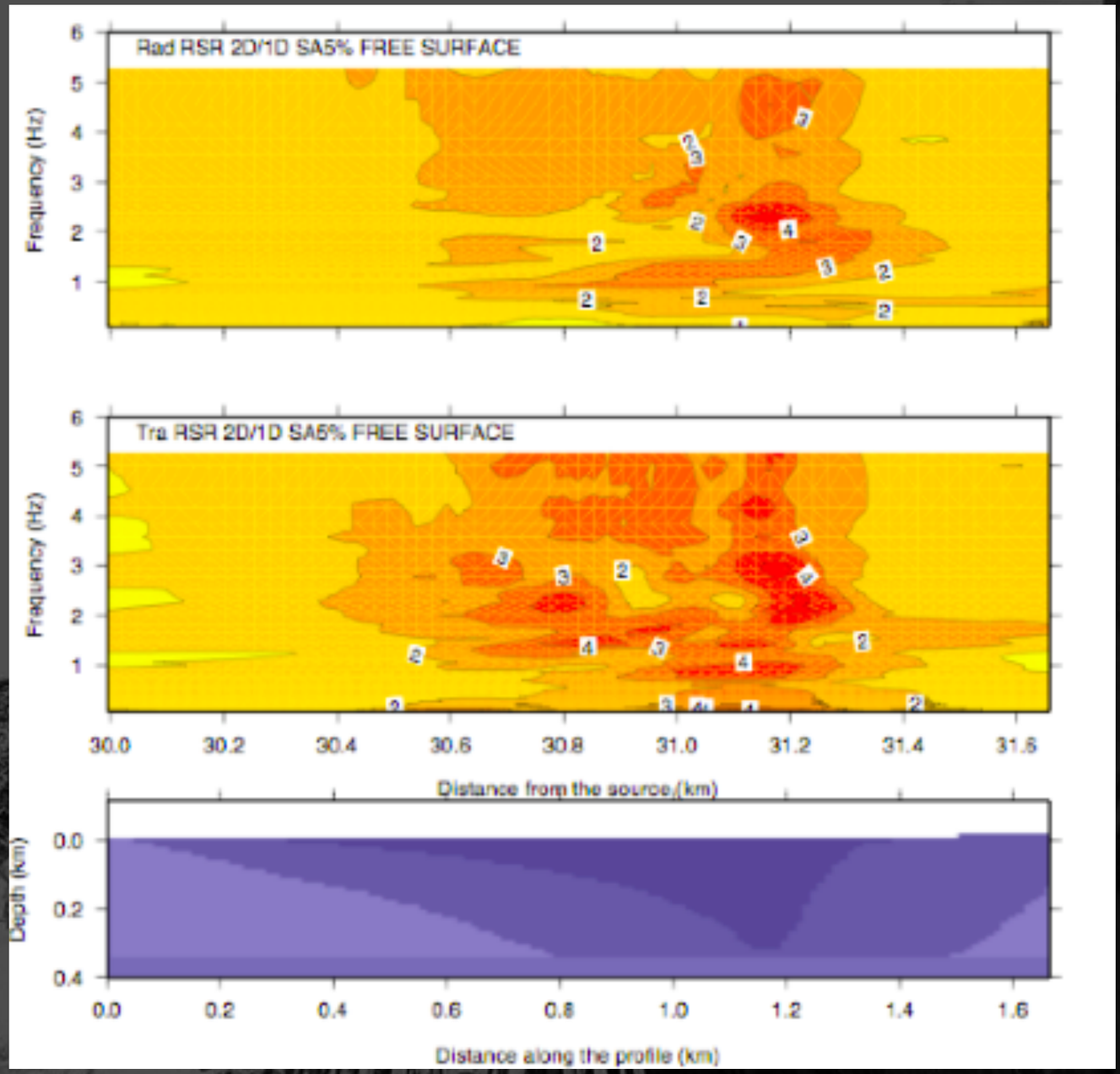
“MAR VASTO” - “Manejo de riesgos en Valparaiso”

SEISMIC HAZARD





Profiles & site effects

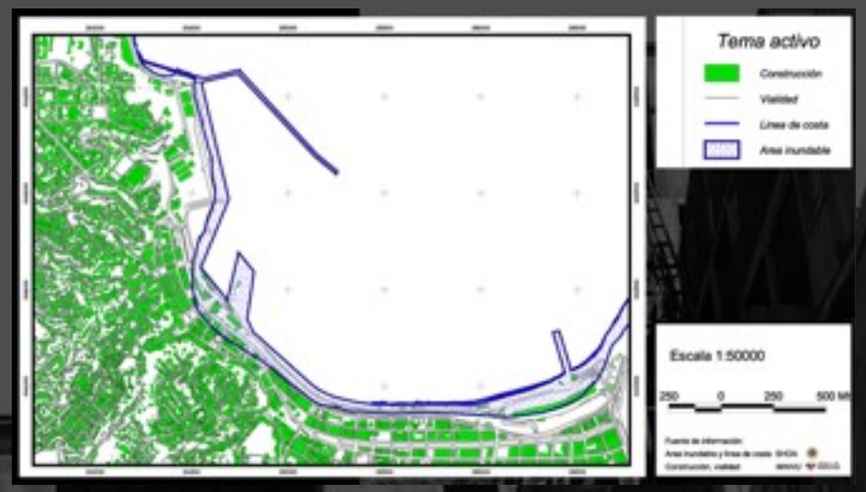


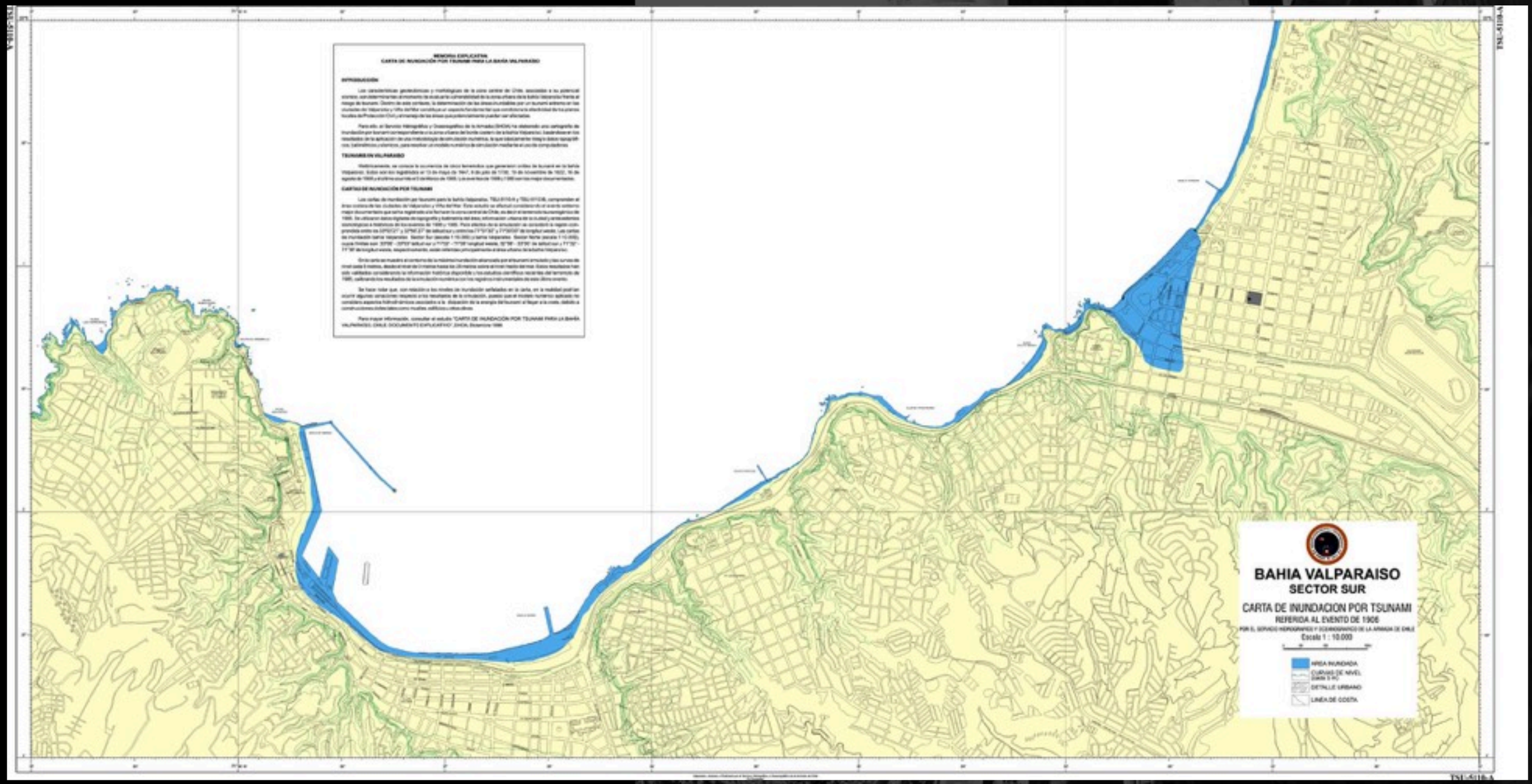
Spectral amplifications obtained along profile 2.
From top to bottom: radial and transverse component.

“MAR VASTO” - “Manejo de riesgos en Valparaiso”

TSUNAMI HAZARD

SHOA Inundation maps





TSUNAMI HAZARD

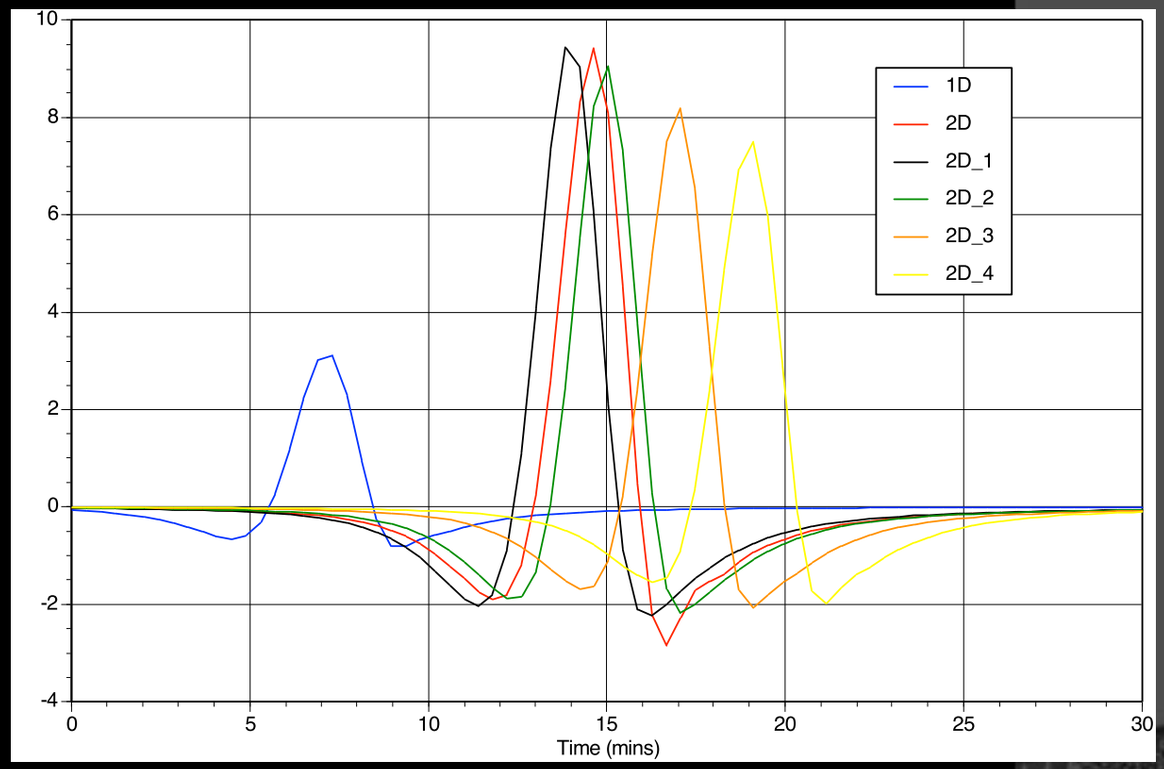
Earthquake Scenarios

We generate a set of tsunami scenarios at the site of Valparaiso, associated to different "scenario" earthquakes that can be classified, according to their different:
a) magnitude,
b) occurrence period, Tm, to be intended solely for an engineering analysis, and
c) risk level:

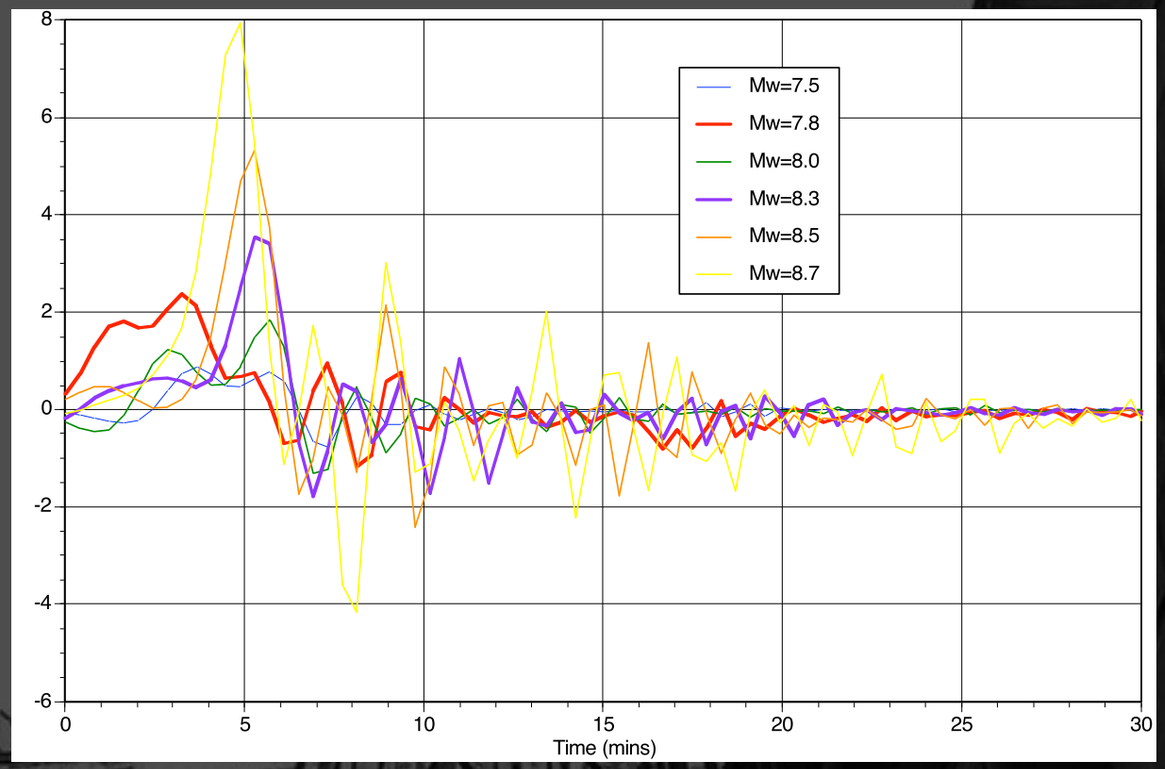
Magnitude 7.0	Frequent	(Tm≈70-80 years)
Magnitude 7.5	Occasional	(Tm≈120-140 years, Strong)
Magnitude 7.8 (1985)	Sporadic	(Tm≈200-250 years, Very Strong)
Magnitude 8.3 (1906)	Rare	(Tm≈500 years, Disastrous)
Magnitude 8.5	Exceptional	(Tm≈1000 years, Catastrophic)

TSUNAMI HAZARD

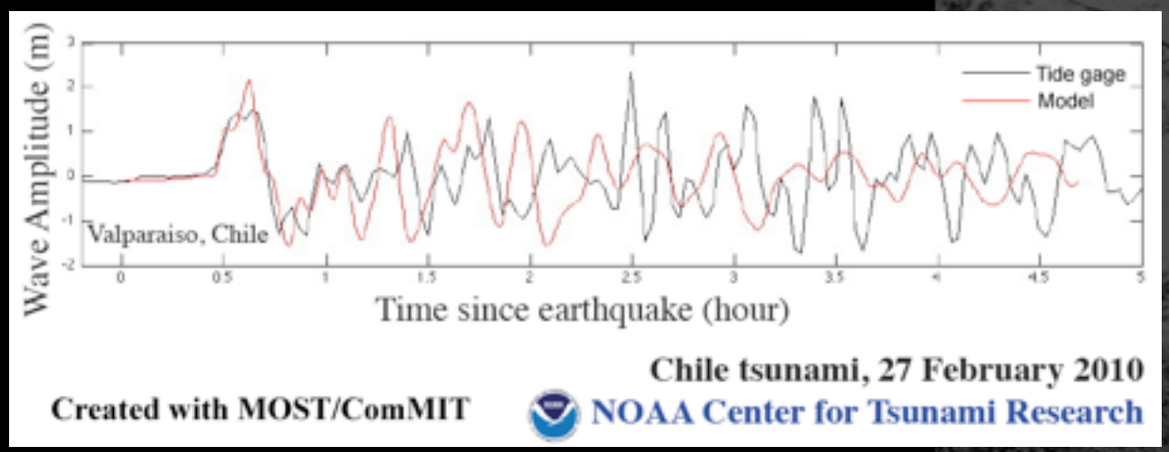
Laterally heterogeneous models & Extended sources



Tsunami signals for the reference case (1D) and different laterally heterogeneous models (2D).



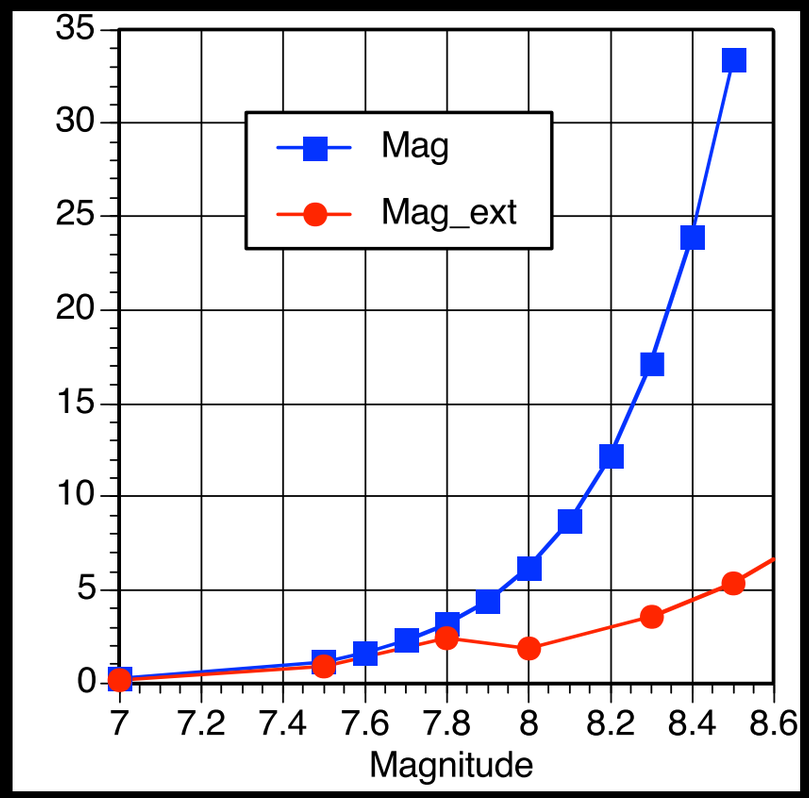
Tsunami signals computed at Valparaiso site (about 50 km) for different magnitudes (from 7.5 to 8.7) considering extended source models.

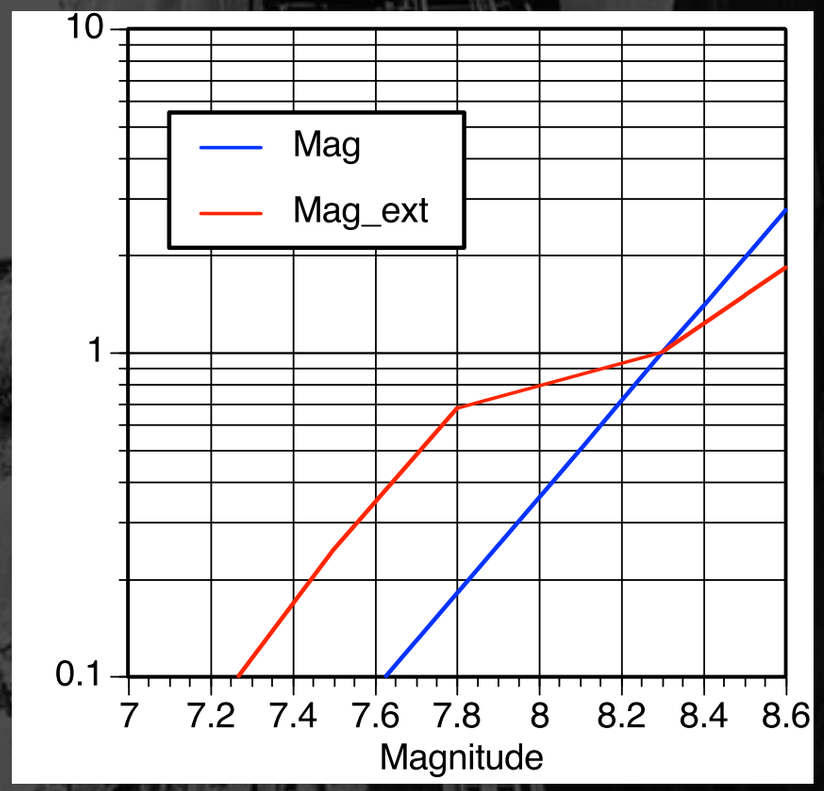


see the NOAA website for real-time modelling of the February 27, 2010 Chile event
http://nctr.pmel.noaa.gov/chile20100227/chile20100227-valparaiso.html

TSUNAMI HAZARD

Using as a base of knowledge the inundation map provided by SHOA (1999) associated to the 1906 event, an upper bound of the multiplication factor for the tsunami hazard associated to be used for the different scenarios can be read in Figure: the tsunami heights, computed with a scaled and an extended source, are plotted versus magnitude and the associated amplifications (using as reference the 1906 level) are shown:





a) Maximum height (for point and extended sources)
b) amplification compared to the reference event (1906 earthquake) for the scenario earthquakes considered.

THE END ?

The project showed importance and effectiveness of GIS databases in studying historic centers, important for their patrimonial value, prone to natural/anthropic disasters. At the present the methodology has been sufficiently defined in case of earthquake (hazard mapping; building inventory; architectonic/urban planning, structural vulnerability analyses; intervention pro- posals; etc.).

It originated important initiatives and further cooperation between Chile and Italy, now in progress, regarding heritage protection.

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Pure and Applied Geophysics

http://www.marvasto.bologna.enea.it/

Hazard Evaluation in Valparaíso: the MAR VASTO Project

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Building a culture of prevention is not easy. While the costs of prevention have to be paid in the present, its benefits lie in a distant future. Moreover, the benefits are not tangible; they are the disasters that did NOT happen.

Kofi Annan, 1999 (document A/54/1)