



36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018

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The State of the Art and Science of Coastal Engineering

ENGINEERING BASED ANALYSIS OF THE COAST OF CAMPECHE AS THE PATH TO SUSTAINABLE DECISION MAKING

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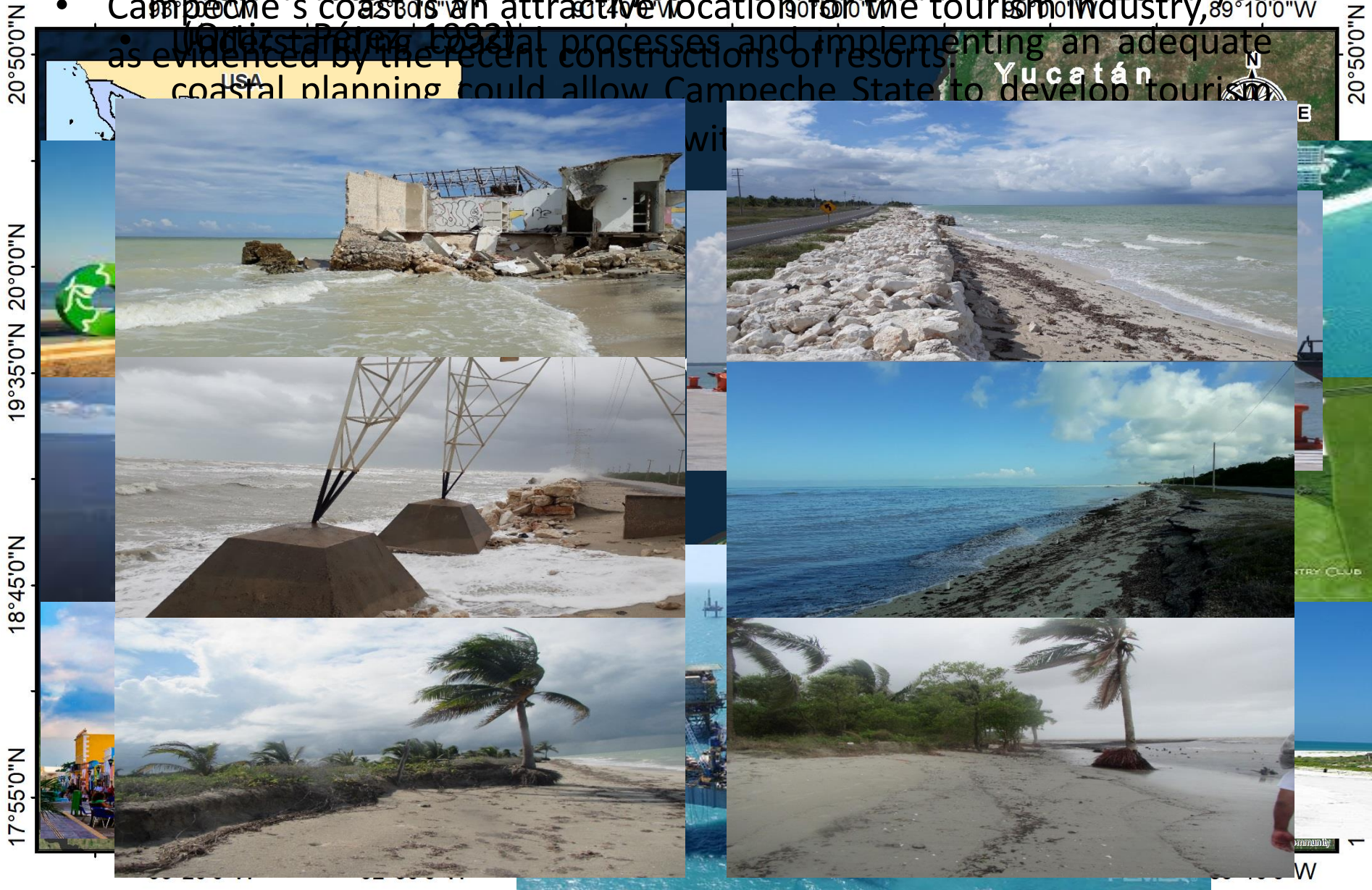
Outline

- Motivation
- Objectives
- Results
- Conclusions



Motivation

- Erosion rates of up to 7 m/year with maximum of up to 15 m/year
- Campeche's coast is an attractive location for the tourism industry, as evidenced by the recent constructions of resorts.
- Coastal planning could allow Campeche State to develop tourism



Objectives

Littoral cells
characterization

- Littoral cell

Provide a ranking for
coastal cities

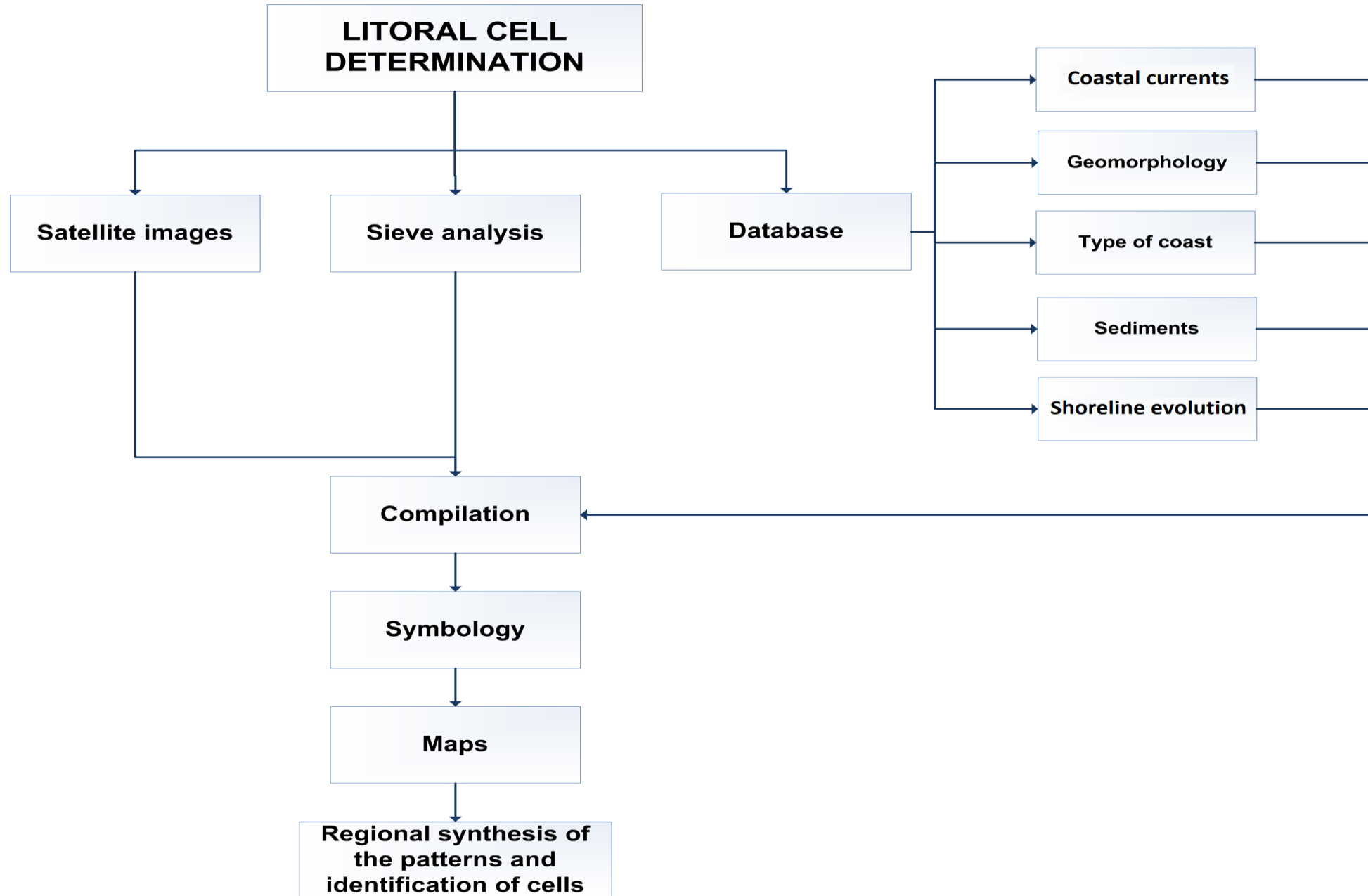
- Coastal Vulnerability Index
- Intervention index

Create decision support
tools based in coastal
dynamics and health

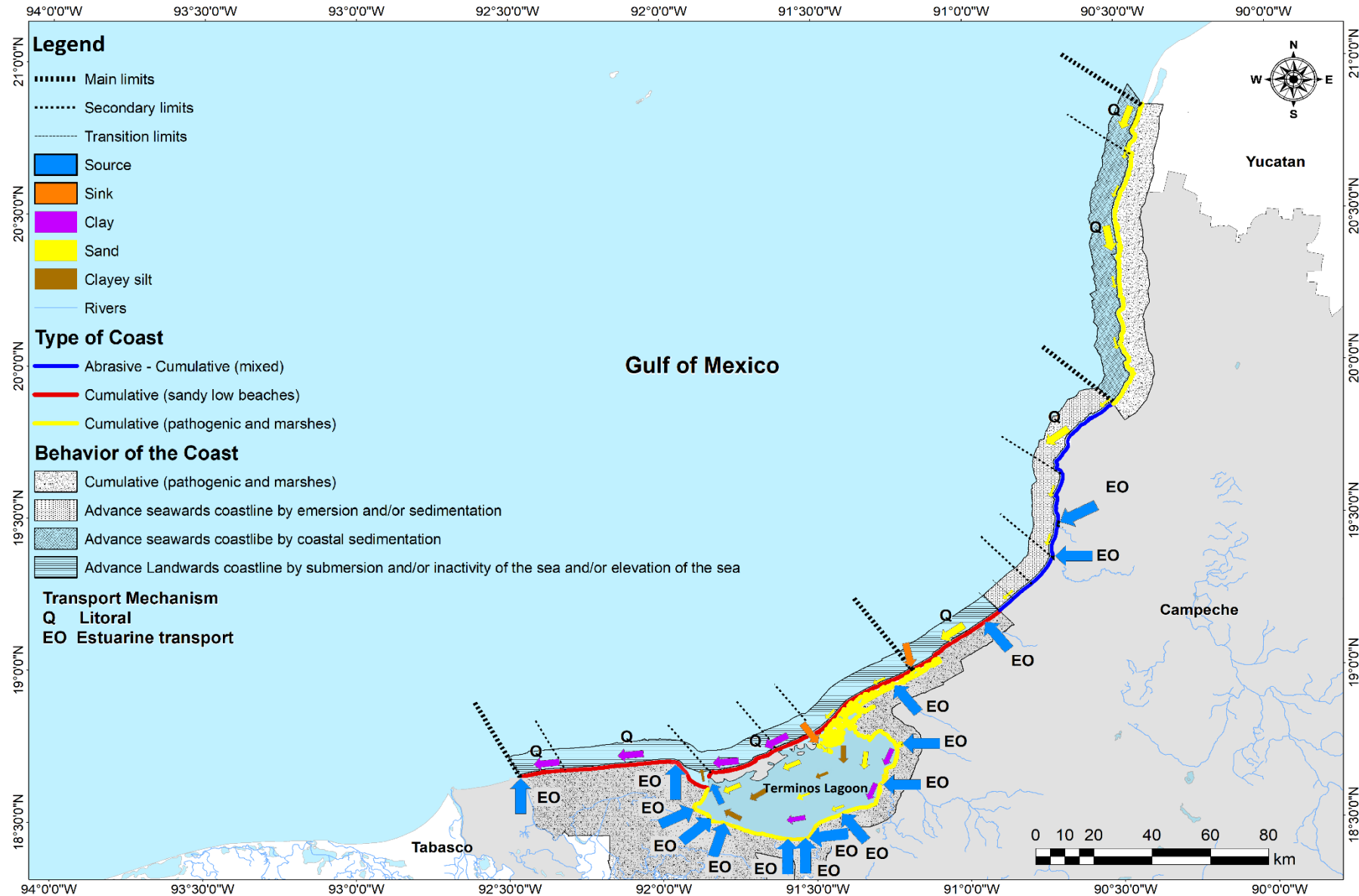
- Numerical model
application



Littoral Cell characterization



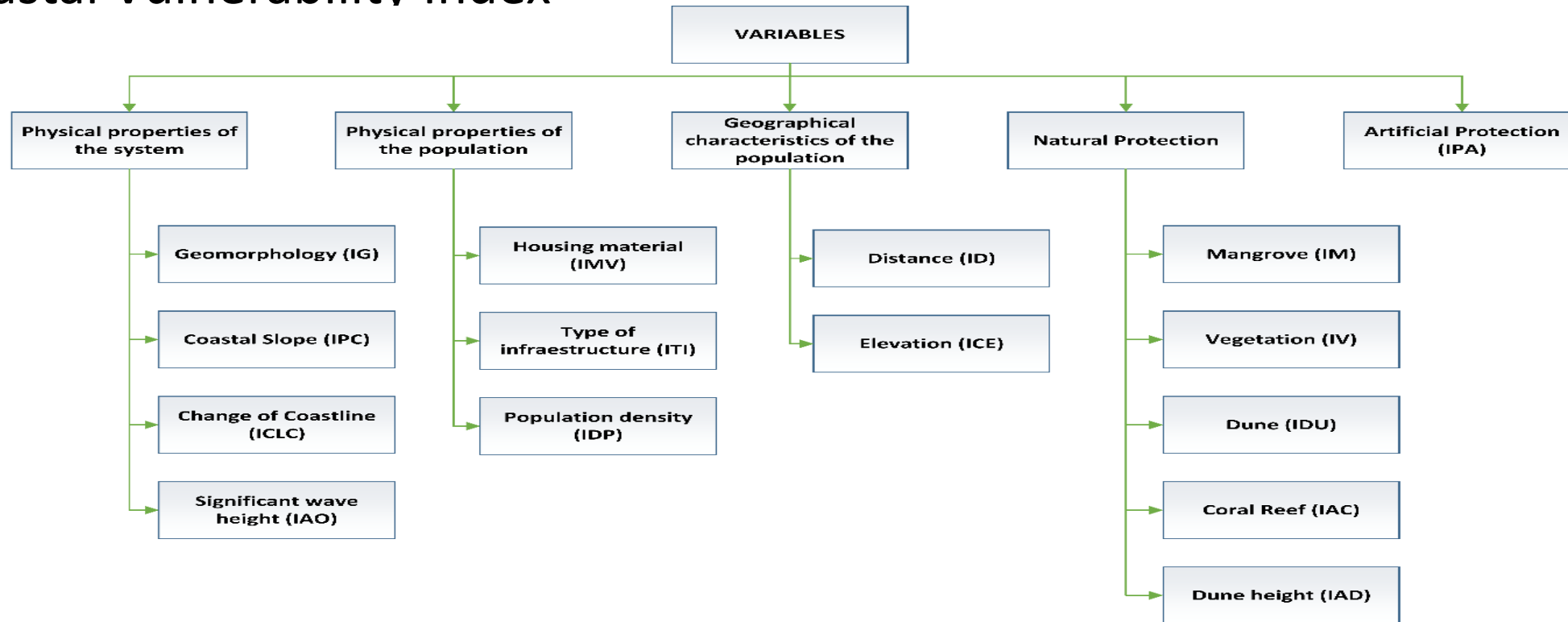
Results



Littoral Cells



Coastal Vulnerability Index



CVI

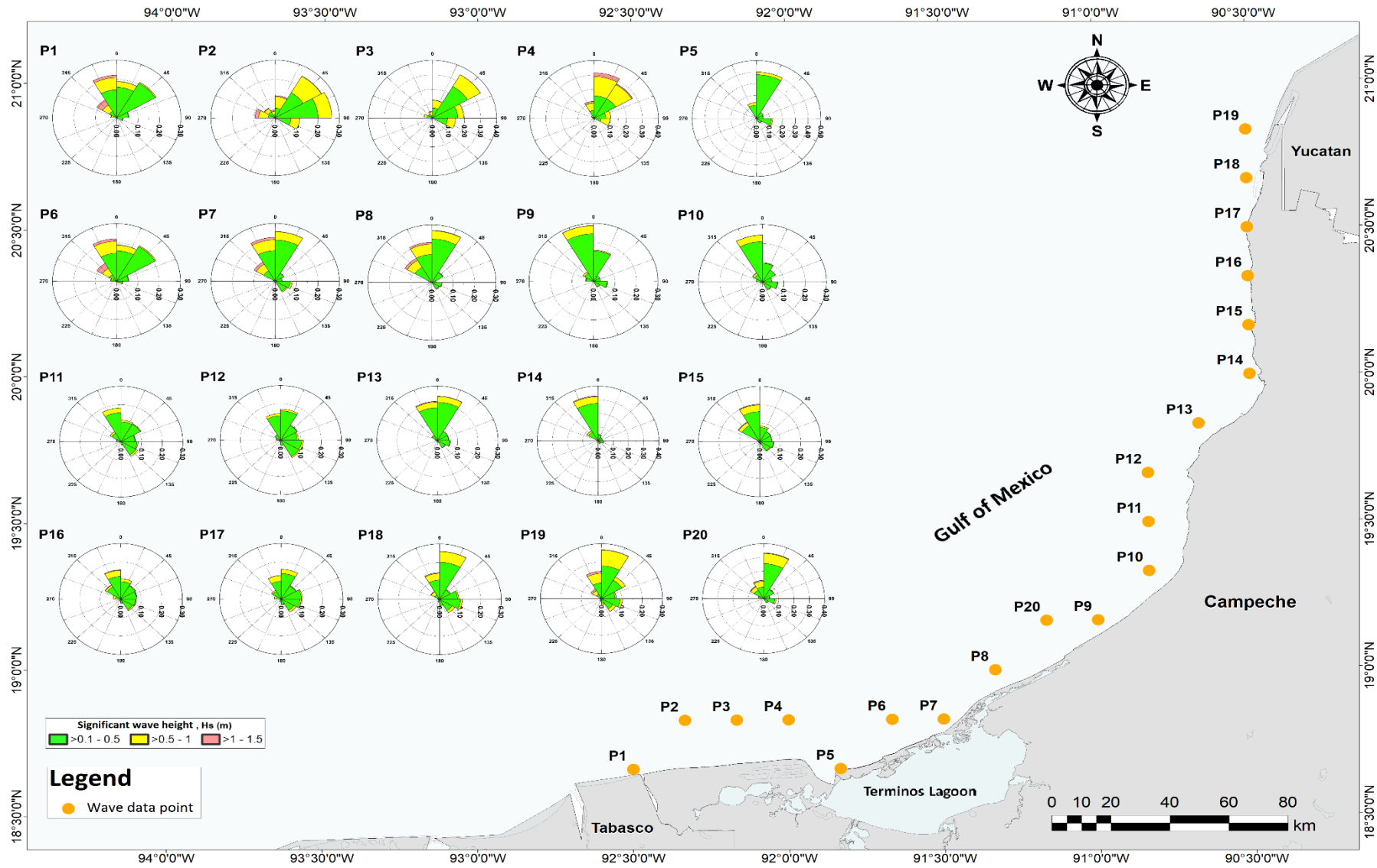
$$= 15 * ICE + 14 * ID + 13 * IPC + 12 * IAO + 11 * IDP + 10 * ITI + 9 * IMV + 8 * IAD + 7 * IDU + 6 * IG + 5 * ICLC + 4 * IPA + 3 * IM + 2 * IV + 1 * IAC$$

Value	Categories
10.45 – 30.45	Very low
30.46 – 50.45	Low
50.46 – 70.45	Moderate
70.46 – 90.45	High
90.46 – 110.45	Very high



Weight	Variables	Classification	Specific values	Weight	Variables	Classification	Specific values	
15	Elevation (ICE) (Praddep et al., 2014)	Greater than 10 m	0	8	Dune height (IAD)	Greater than 5 m	0	
		Greater than 4 m and less than or equal to 10 m	0.2			Greater than 2 m and less than or equal to 5 m	0.5	
		Greater than 1 m and less than or equal to 4 m	0.5			Less than or equal to 2 m	0.9	
		Less than or equal to 1 m	0.9					
14	Distance to coast (ID)	Greater than 4 km	0	7	Dune (IDU)	Dune with vegetation	0.2	
		Greater than 1 km and less than or equal to 4 km	0.5			With dune	0.5	
		Greater than 500 m and less than or equal to 1 km	0.7			Without dune	1	
		Less than or equal to 500 m	0.9	6	Geomopholy (type of coast) (IG) (Nageswara et al., 2008)	Cliff or rocky brach	0.2	
		Sandy or gravel beach	0.7					
13	Coastal slope (IPC) (Ashraful Islam et al., 2016)	> 1.0	0	5	Change of coastline (ICLC) (Nageswara et al., 2008)	Mud coast	0.9	
		0.50 – 1.0	0.2			> 2.0	0	
		0.10 – 0.50	0.5			1.0 to 2.0	0.2	
		0.10 – 0.05	0.7			-1.0 to 1.0	0.5	
		< 0.05	0.9			-2.0 to -1.0	0.7	
12	Significant wave height (IAO) (Nuñez et al., 2016)	< 0.55	0	4	Artificial protection (IPA)	With artificial protection	0.5	
		0.55 – 0.85	0.2			Without artificial protection	1	
		0.85 – 1.05	0.5		3	Mangrove (IM)	With mangrove	0.2
		1.05 – 1.25	0.7				Without mangrove	0.9
11	Population density (IDP) (Murali et al., 2013)	Scattered	0.2	2	Vegetation (without considering mangrove) (IV)	With vegetation	0.2	
		Concentrated	0.9			Without vegetation	0.9	
10	Type of infrastructure (ITI)	Urban	0.1	1	Coral reef (IAC)	With reef	0.2	
		Rural	1			Without reef	0.9	
9	Housing material (IMV)	Concrete	0.2					
		Wood and others	0.9					





Section 3 Shoreline evolution Significant wave height Section 4



Results (Example Chenkán)

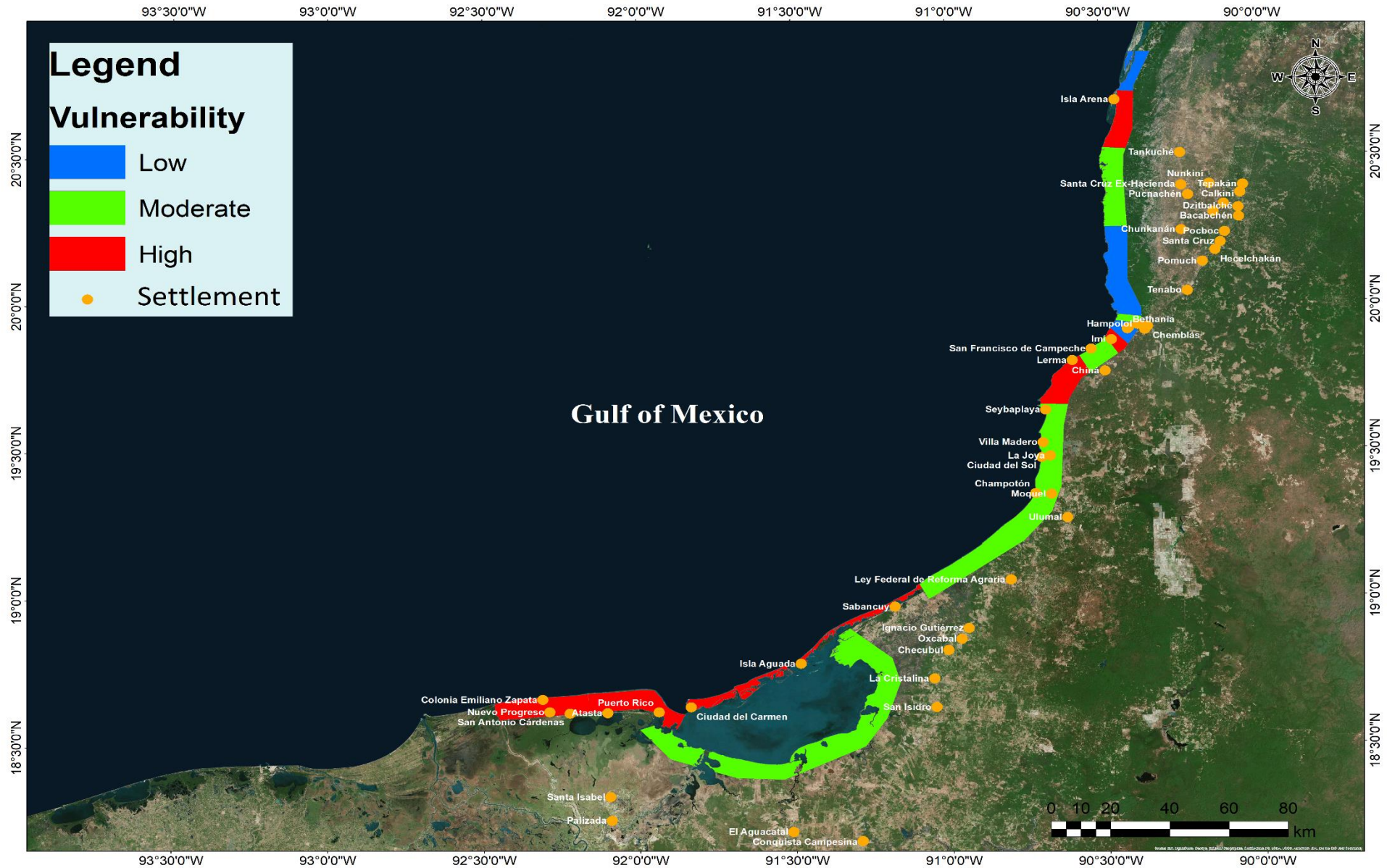
Weight	Variables	Classification	Specific values	Weight	Variables	Classification	Specific values
15	Elevation (ICE)	Greater than 1 m and less than or equal to 4 m	0.5	8	Dune height (IAD)	Greater than 2 m and less than or equal to 5 m	0.5
				7	Dune (IDU)	Dune with vegetation	0.2
14	Distance (ID)	Less than or equal to 500 m	0.9	6	Geomopholy (type of coast) (IG)	Sandy or gravel beach	0.7
13	Coastal slope (IPC)	0.10 – 0.05	0.7	5	Change of coastline (ICLC)	< -2.0	0.9
12	Significant wave height (IAO)	0.85 – 1.05	0.5	4	Artificial protection (IPA)	With artificial protection	0.5
				3	Mangrove (IM)	Without mangrove	0.9
				2	Vegetation (without considering mangrove) (IV)	With vegetation	0.2
11	Population density (IDP)	Scattered	0.2	1	Coral reef (IAC)	Without reef	0.9
10	Type of infrastructure (ITI)	Rural	1				
9	Housing material (IMV)	Concrete	0.2				

CVI = 69.1

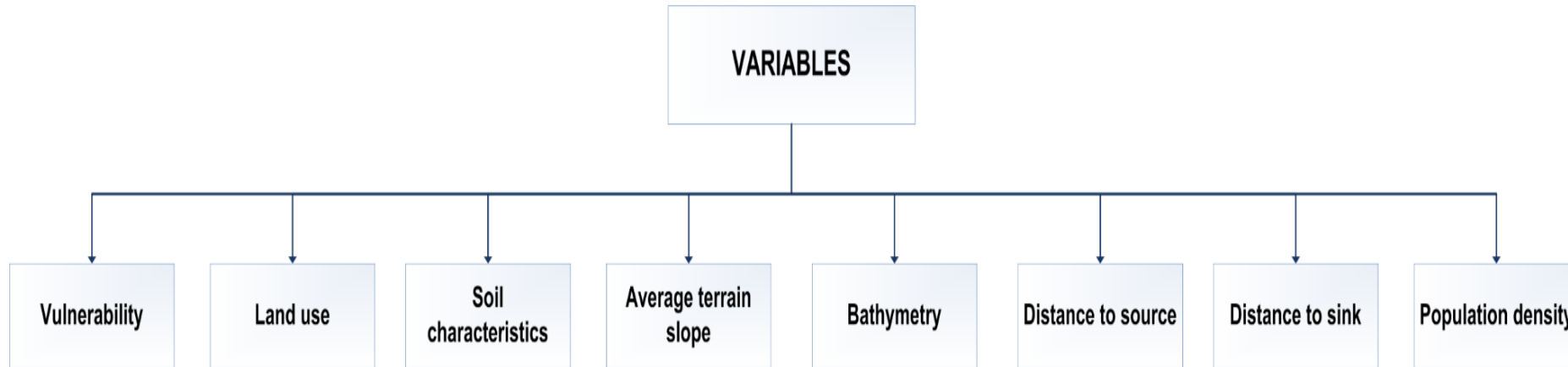
Moderate vulnerability



Results



Intervention Index



$$IU = V + US + CS + PMT + B + DF + DS + DP$$

Value	Categories
8 – 16.25	Low importance
16.25 – 24.5	Moderate importance
24.5 – 32.75	High importance
32.75 - 41	Very High importance



Variables	Classification	Specific values	Variables	Classification	Specific values
Vulnerability (V)	Very low	1	Distance to sink (DS)	>7.5 km	1
	Low	2		5 – 7.5 km	2
	Moderate	3		2.5 – 5 km	3
	High	4		1 – 2.5 km	4
	Very high	5		< 1 km	5
Land use (US)	Urban área	1	Population density (DP)	1.03 – 6.03	1
	Agricultural area	2		6.03 – 11.03	2
	Area without vegetation	3		11.03 – 16.03	3
	Pasture	4		16.03 – 21.03	4
	Jungle	5		> 21.03	5
	Mangrove	6			
Soil characteristics (CS)	Kars plain	1			
	Fluvial plain	2			
	Lacustrine plain	3			
	Palustre plain	4			
	Coastal beach ridges	5			
Average terrain slope (PMT)	>1.0	1			
	0.50 – 1.0	2			
	0.10 – 0.50	3			
	0.05 – 0.10	4			
	< 0.05	5			
Bathymetry (B)	> 5.0 m	1			
	5.0 – 4.0 m	2			
	4.0 – 3.0 m	3			
	3.0 – 2.0 m	4			
	< 2.0 m	5			
Distance to source (DF)	< 1 km	1			
	1 – 2.5 km	2			
	2.5 – 5 km	3			
	5 – 7.5 km	4			
	>7.5 km	5			



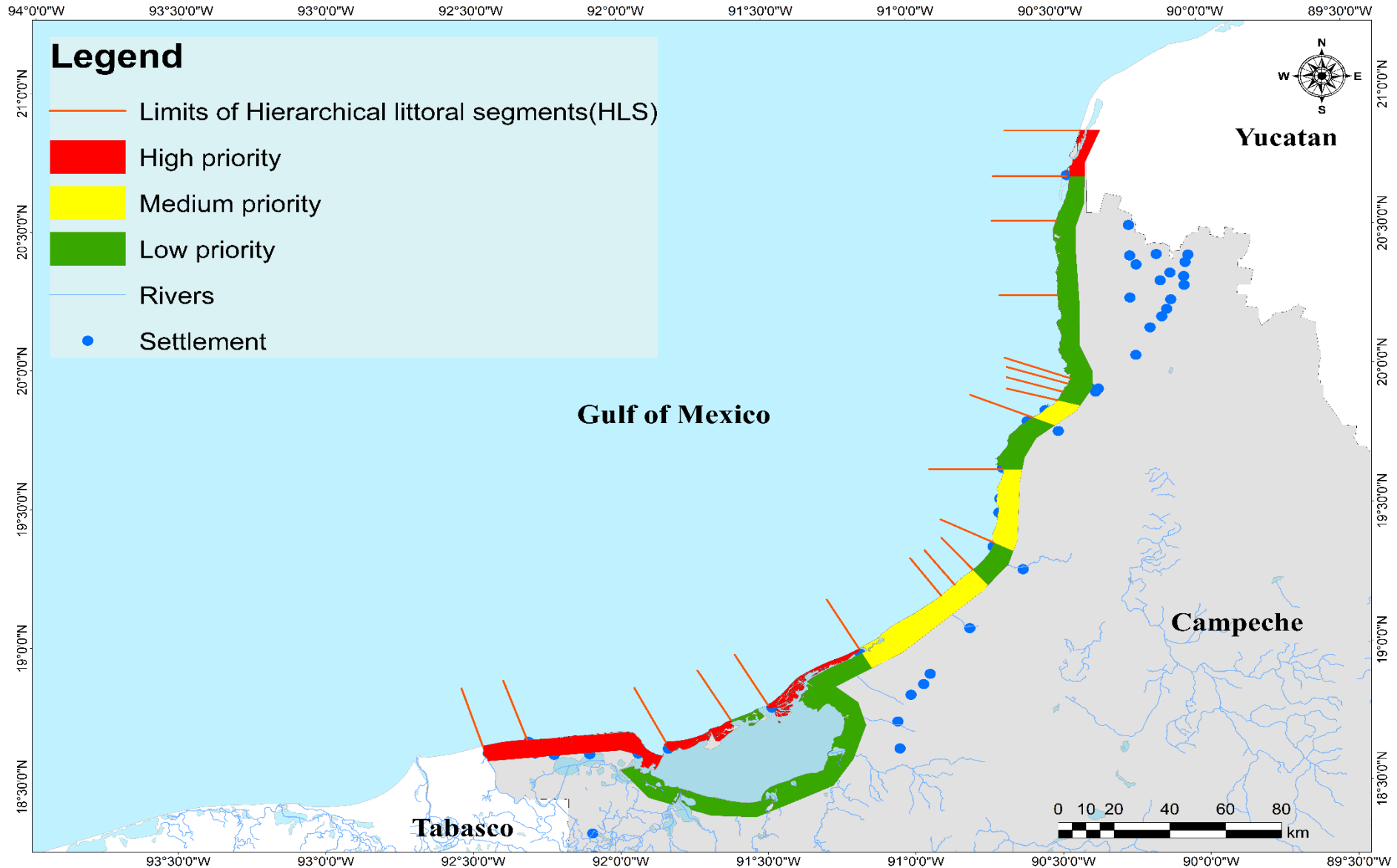
Results



Interventions



Results



Hierarchical littoral segments



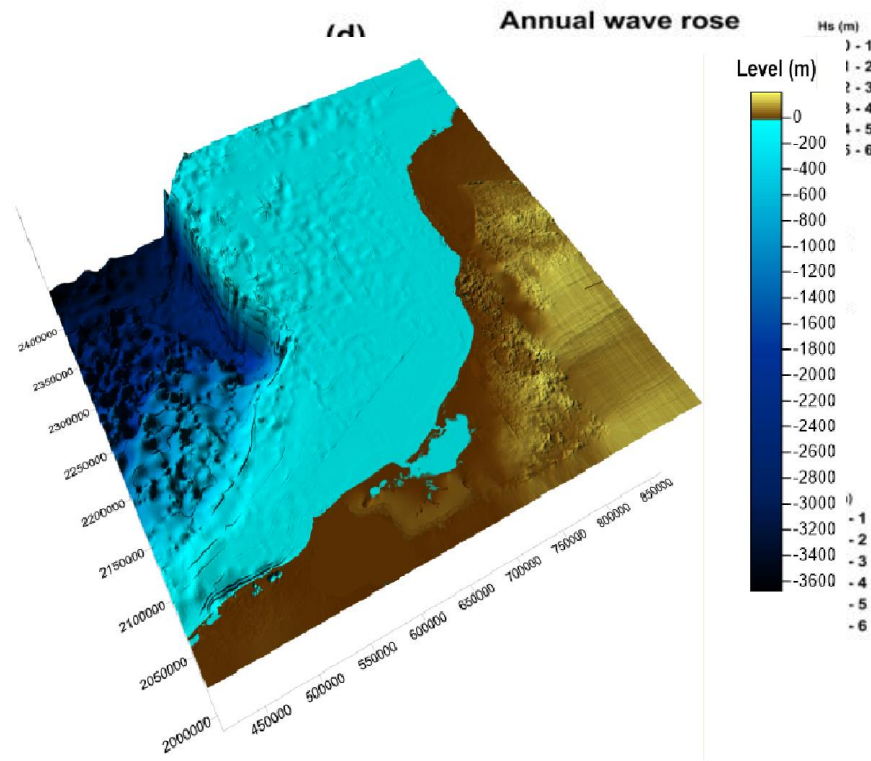
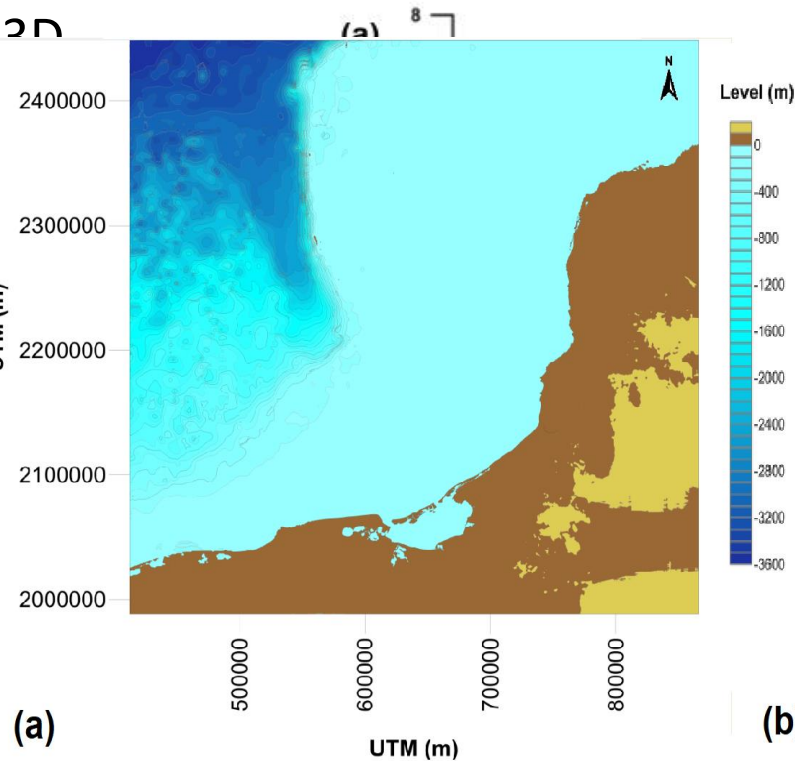
Numerical Model

- Delft 3D

- Tj

- Xbeach

- $St_{UTM}^{(m)}$

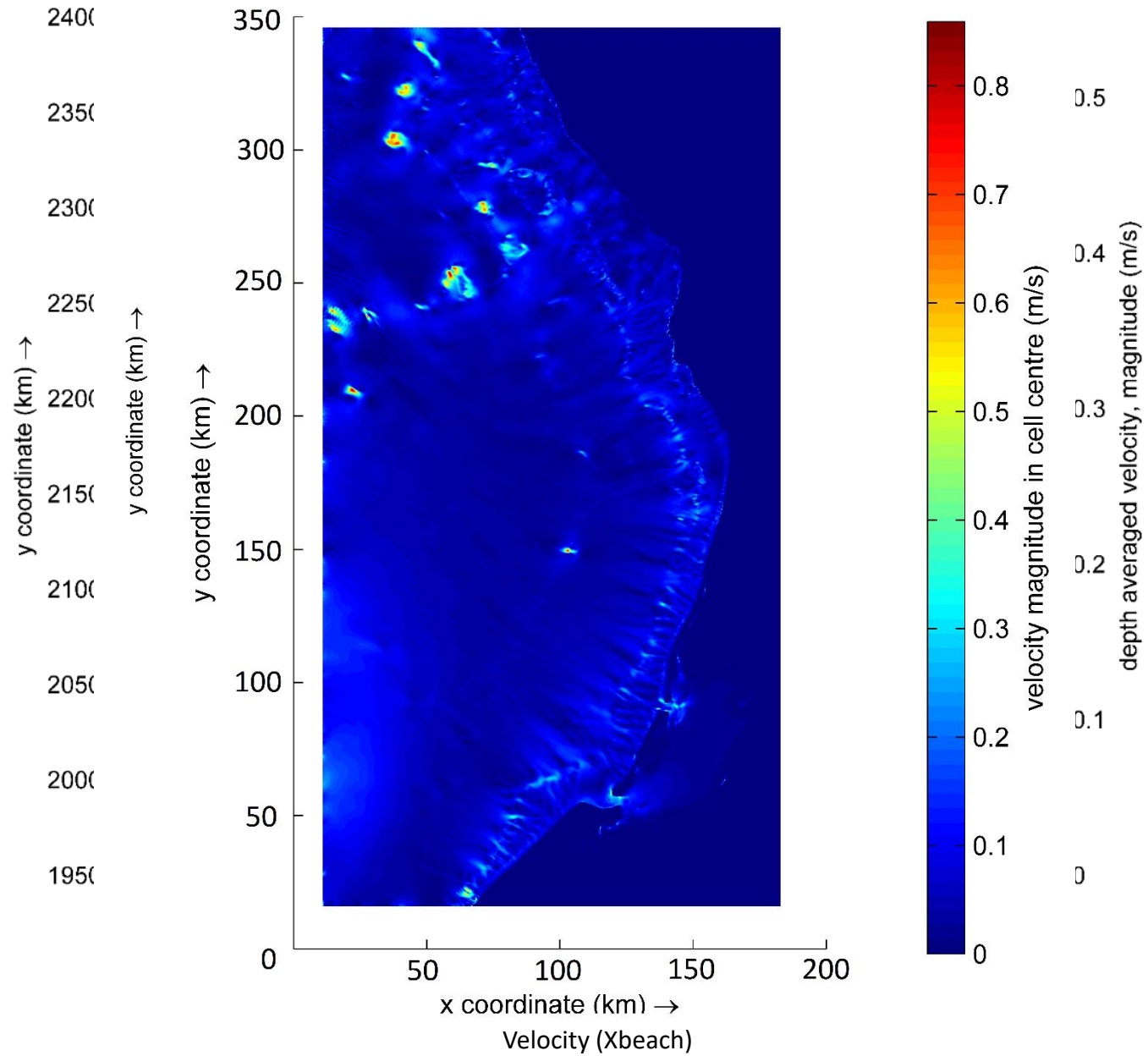


a) Topobathymetry data 2D, (b) Topobathymetry data 3D
 Date 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
 12 years of data

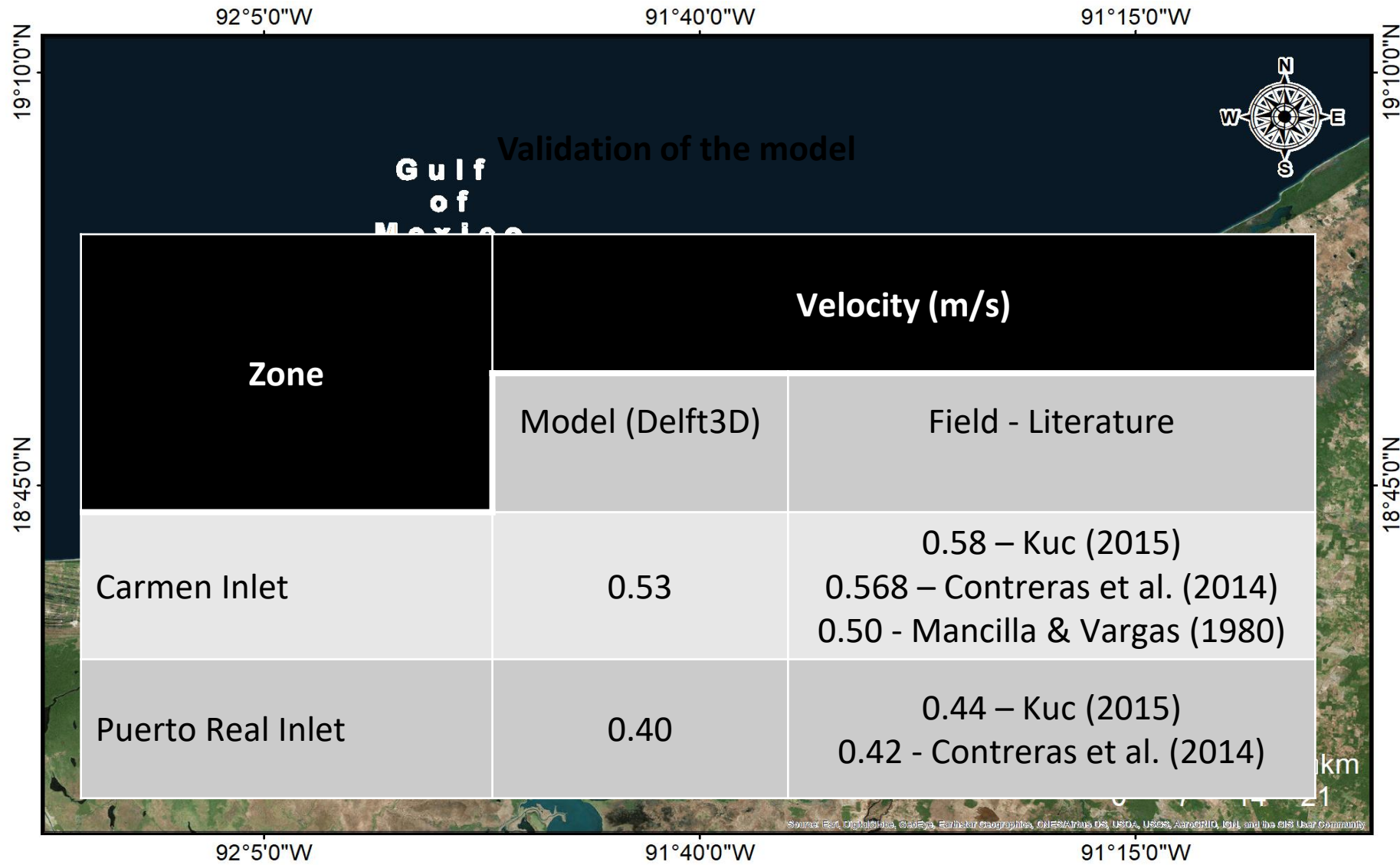
Wave data series. (a) Significant wave height; (b) peak period; (c) wave direction; (d) annual wave rose; (e) wave storm rose.



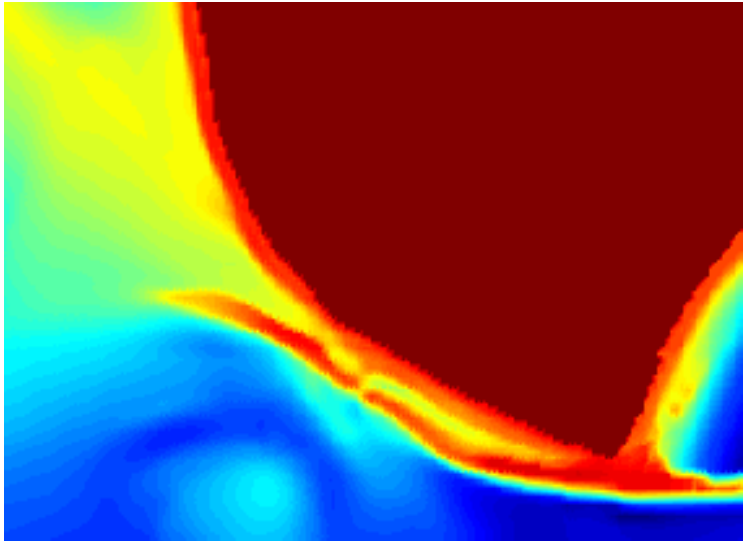
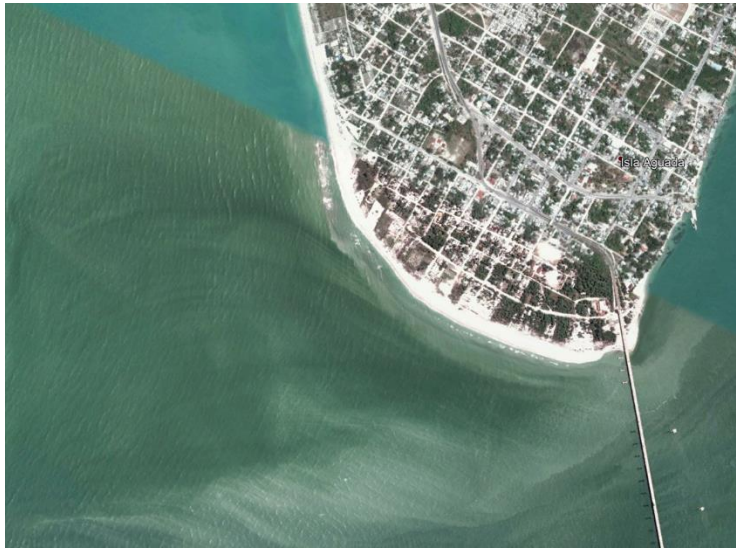
Results



Results



Validation of the model

Zone	Morphodynamic Patterns	
	Model (Xbeach)	Google Earth
Isla Aguada		



Conclusions

- The indices implemented in this work allow the characterization of coastal zones in such a way that financial resources are used efficiently.
- Three littoral cells were identified along the Campeche Coast: north (Peten zone), central (rocky and sand beach) and south (Lagoon system and sand beach).
- Shoreline changes along the Campeche coast for the 1994 – 2018 period were assessed. The south of the state presents higher rates of erosion.
- The southern part of Campeche has the highest vulnerability and the intervention priority is high.
- Littoral segments were identified that allow stakeholders to decide which area to start working on.



Thanks for your attention

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