National Report to the XVIII Session of the Group of Experts for the Global Sea Level Observing System (GLOSS)

Status of the Cuban National Sea Level Network and Sea Level Research

Introduction

The general objective of the National Tide Gauge Network, since its creation to date, has been to guarantee permanent and temporary sea level measurements and their primary processing. This has allowed the fulfillment of various activities in Cuban institutions and companies, such as establishing geodetic references for diverse uses, calculating and forecasting tides on Cuban coasts, annual edition of Tide Tables to provide safety to navigation; characterizing, simulating and forecasting sea level variations on the entire time scale (tsunamis, astronomical tides, storm surge and storm tides, monthly sea level anomalies, annual mean cycle, sea level trend and sea level projection), and coastal flooding of diverse origin; establishing the protocols for the early warning systems and the issuance of alert reports by the National Civil Defense Staff; and contributing hourly sea level height data series to the implementation of different multidisciplinary scientific research projects and commercial services.

Geographic distribution of Cuban tide gauges

National Tide Gauge Network			
1	Los Morros de Piedra	21°54,0´	84°54,4´
2	Mariel (Boca)	23°01,2´	82°45,4´
3	Siboney	23°05,6´	82°28,2´
4	Habana	23°08,9´	82°21,2´
5	La Isabela	22°56,4’	80°00,8’
6	Playa Victoria	22°22’58”	79°12’05”
7	Bufadero	21°33,6´	77°14,2´
8	Punta de Prácticos	21°36,2´	77°05,9´
9	Puerto Padre	21°12,1´	76°36,0´
10	Gibara	21°06.5´	76°07,5´
11	Baracoa	20°21,1	74°30,1
12	Maisí	20°14,8	74°08,7
12	Baitiquirí	20°01’35”	74°51’32”
13	Santiago de Cuba	19°59,1´	75°52,5´
14	Manzanillo	20°20,4´	77°08,8´
15	Cabo Cruz	19°50,4´	77°43,7´
16	Santa Cruz del Sur	20°42,0´	77°58,6´
17	Casilda	21°45,2´	79°59,5´
18	Cayo Loco	22°09,1´	80°27,3´
19	La Coloma	22°14,2’	83°34,3’

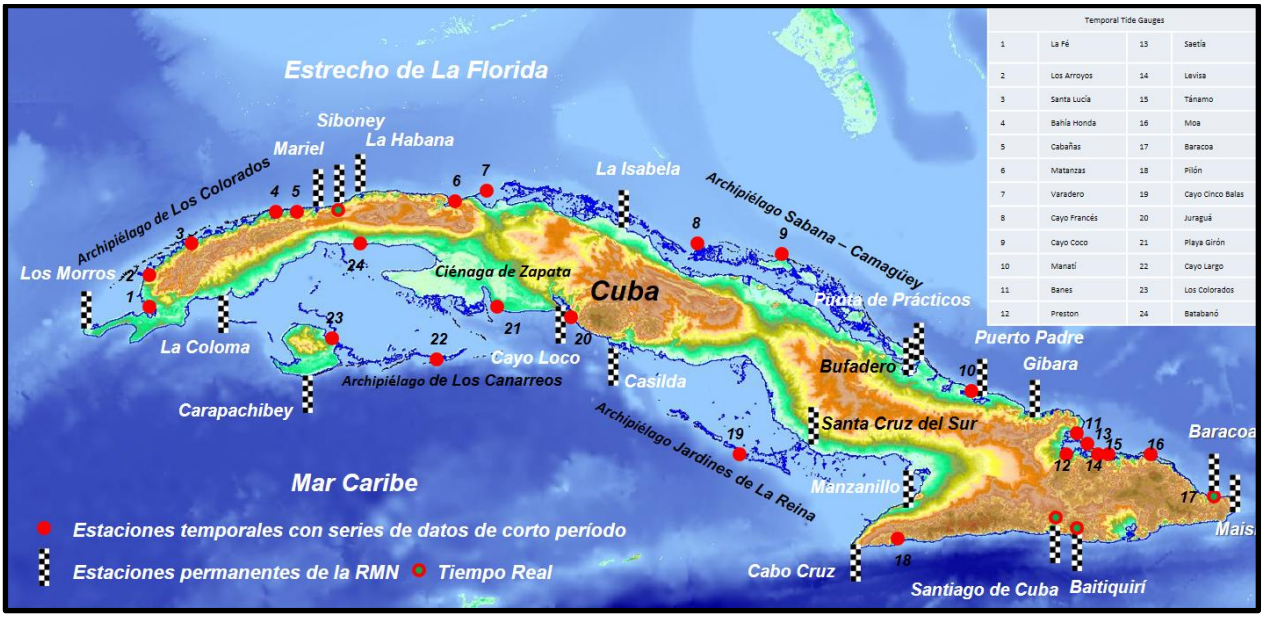


Figure1. Permanent and temporary sea level tide gauge network.

Main research and activities supported by the National Tide Gauge Network

1. **Sea level variability and long-term trend**

Authors: Hernández – González, M.[(1)], Ríos – Ortega, Y.[(2)], Marzo – Lobaina, O. y Benítez -Rodríguez, L., [(1)].

[(1)] Institute of Meteorology (Cuba)

[(2)] Empresa de Soluciones Geodésicas y Ambientales Geodesa del Grupo Empresarial Geocuba.

The long-term trend of relative mean sea level in the Cuban archipelago has accelerated since 2004, mainly in northwestern Cuba according to the Siboney (Havana) tide gauge data series, where the maximum annual mean value of 30.85 cm was recorded, being about 28.71 cm higher than the 2.14 cm logged in 1966. The accelerated rise in the relative mean sea level in Siboney is part of a regional process.

2. **Statistical calculation of annual relative sea level extreme values and synoptic meteorological conditions that generated them**

Authors: Hernández – González, M. [(1)], Ríos – Ortega, Y.,[(1)], Marzo – Lobaina, O.[(1)], Fernández – González, G.L., [(1)], Pérez – Osorio, P. J. [(1)], Labastida – Ramos, L. [(1)],

Mosqueda – Borges, N. [(1)], Espalter – Berto, O. D. [(1)], Corrales – Pino, J. de la C. [(1)], Labrada - Hernández A. E., Herreiz – Báez, D. [(2)].

[(1)] Institute of Meteorology.

[(2)] Empresa de Soluciones Geodésicas y Ambientales Geodesa del Grupo Empresarial Geocuba.

Análisis Estadístico de Valores Extremos
Función de Gumbel (Método de Gumbel)

Estación: Cabo San Antonio — 6/16/2011 3:51:31 PM

Tipo de Estación: Mareográfica

Período analizado: 1971 - 2010

Parámetros de los Datos de Entrada

Valor medio de X:	34.45	**Asimetría:**	2,8476
Desviación Estándar:	6.1767	**Curtosis:**	10,2491

Parámetros de la Variable Reducida Y		**Coeficientes de Ajuste**	
Valor medio de Y:	0.5436	**Pendiente:**	5.3438
Desviación Estándar:	1.1559	**Ordenada al Origen:**	31.545
		Coeficiente de Correlación:	0.8606

Tabla No.5.1. Resumen del Análisis Estadístico

T	P	Y	Lím Sup95	Lím Sup68	X	Lím Inf68	Lím Inf95	Max Val Med Anual	Alt Max NM
1.01	0.99	-1.529	39.778	29.464	23.372	17.281	6.967	14	43.466
1.1	0.909	-0.875	43.277	32.963	26.871	20.779	10.466	14	46.961
1.58	0.633	-0.002	47.939	37.625	31.534	25.442	15.128	14	51.626
2	0.5	0.367	49.909	39.596	33.504	27.412	17.098	14	53.598
5	0.2	1.5	55.966	45.652	39.56	33.468	23.155	14	59.653
10	0.1	2.25	59.976	49.662	43.571	37.479	27.165	14	63.661
20	0.05	2.97	63.823	53.509	47.417	41.325	31.012	14	67.508
50	0.02	3.902	68.802	58.488	52.396	46.304	35.991	14	72.489
100	0.01	4.6	72.533	62.219	56.127	50.035	39.722	14	76.219
200	0.005	5.296	76.25	65.937	59.845	53.753	43.439	14	79.938
500	0.002	6.214	81.155	70.841	64.749	58.657	48.344	14	84.843
1000	0.001	6.907	84.862	74.548	68.456	62.364	52.051	14	88.547

Análisis Estadístico de Valores Extremos
Función de Gumbel (Ajuste de Kaczmarek)

Estación: Cabo San Antonio — 16/06/2011 15:51:56

Tipo de Estación: Mareográfica

Período analizado: 1971 - 2010

Parámetros de los Datos de Entrada

Valor medio de X:	34,45	**Asimetría:**	2,8476
Desviación Estándar:	6,1767	**Curtosis:**	10,2491

Parámetros de la Variable Reducida Y		**Coeficientes de Ajuste**	
Valor medio de Y:	0,5436	**Pendiente:**	5,3438
Desviación Estándar:	1,1559	**Ordenada al Origen:**	31,545
		Coeficiente de Correlación:	0,8606

Tabla No.5.3. Resumen del Análisis Estadístico

T	P	Y	Lím Sup95	Lím Sup68	X	Lím Inf68	Lím Inf95	Max Val Med Anual
1.01	0.99	-1.529	23.374	23.374	23.374	23.374	23.374	14
1.1	0.909	-0.875	26.869	26.869	26.869	26.869	26.869	14
1.58	0.633	-0.002	31.534	31.534	31.534	31.534	31.534	14
2	0.5	0.367	33.506	33.506	33.506	33.506	33.506	14
5	0.2	1.5	39.561	39.561	39.561	39.561	39.561	14
10	0.1	2.25	47.174	45.046	43.569	42.091	39.964	14
20	0.05	2.97	52.006	49.297	47.416	45.536	42.826	14
50	0.02	3.902	58.294	54.813	52.397	49.98	46.499	14
100	0.01	4.6	63.015	58.949	56.127	53.304	49.238	14
200	0.005	5.296	67.863	63.131	59.846	56.561	51.829	14
500	0.002	6.214	74.107	68.585	64.751	60.918	55.396	14
1000	0.001	6.907	78.825	72.704	68.455	64.206	58.084	14

Figure 2. Extreme sea level calculation.

The abovementioned scientific research results were obtained within the framework of the project “Hazard and vulnerability scenarios of the Cuban coastal zone, associated

with mean sea level rise for 2050 and 2100". As part of said project, the result "Updating the annual mean values, trend, monthly anomalies, extreme values and synoptic meteorological conditions from the National Tide Gauge Network data" has been developed since 2009, under the auspices of the Scientific Program "Integrated Disaster Risk Reduction in Cuba", with the participation of specialists from the Institute of Meteorology and Empresa de Soluciones Geodésicas y Ambientales Geodesa del Grupo Empresarial Geocuba.

Tsunamis

Scientific reports and articles

Authors: Claudia Cáceres – Rodríguez [(1)], C., Calzadilla – Pérez, J. A.[(1)], Valdés – Lorenzo, O.[(3)], Daniela Pérez del Rey, D.[(1)], Hernández – González, M.[(1)] y Harig, S.[(2)].,

TSUNAMI HAZARD CALCULATION FOR BARACOA (CUBA) USING THE HIGH RESOLUTION TSUNAWI MODEL (article under review)

[(1)] Institute of Meteorology (Cuba)

[(2)] Alfred Wegener Institute (Germany)

[(3)] Institute of Geophysics and Astronomy (Cuba)

The earthquake and subsequent tsunami of January 12, 2010 in Haiti has sparked the interest of the scientific community in the Caribbean area, due to the increase in coastal communities exposed to this hazard, despite tsunamis being rare in this region. In the specific case of Cuba, the coastal area that comprises Baracoa municipality, located in the easternmost part of the country, is one of the areas that can be seriously affected by the impact of a tsunami, as it is located close to the tsunamigenic source that occupies the North Hispaniola fault (Arango, 2015). Therefore, it is proposed to calculate the tsunami hazard for Baracoa, the first town founded by Diego Velázquez in Cuba, by implementing the high-resolution numerical model TsunAWI, adopting the worst-case scenario approach. In this sense, the propagation of the waves was simulated with the highest possible resolution according to the available bathymetric information. Hazard maps were drawn up with a zoning of the study area showing three hazard levels: high, medium and low.

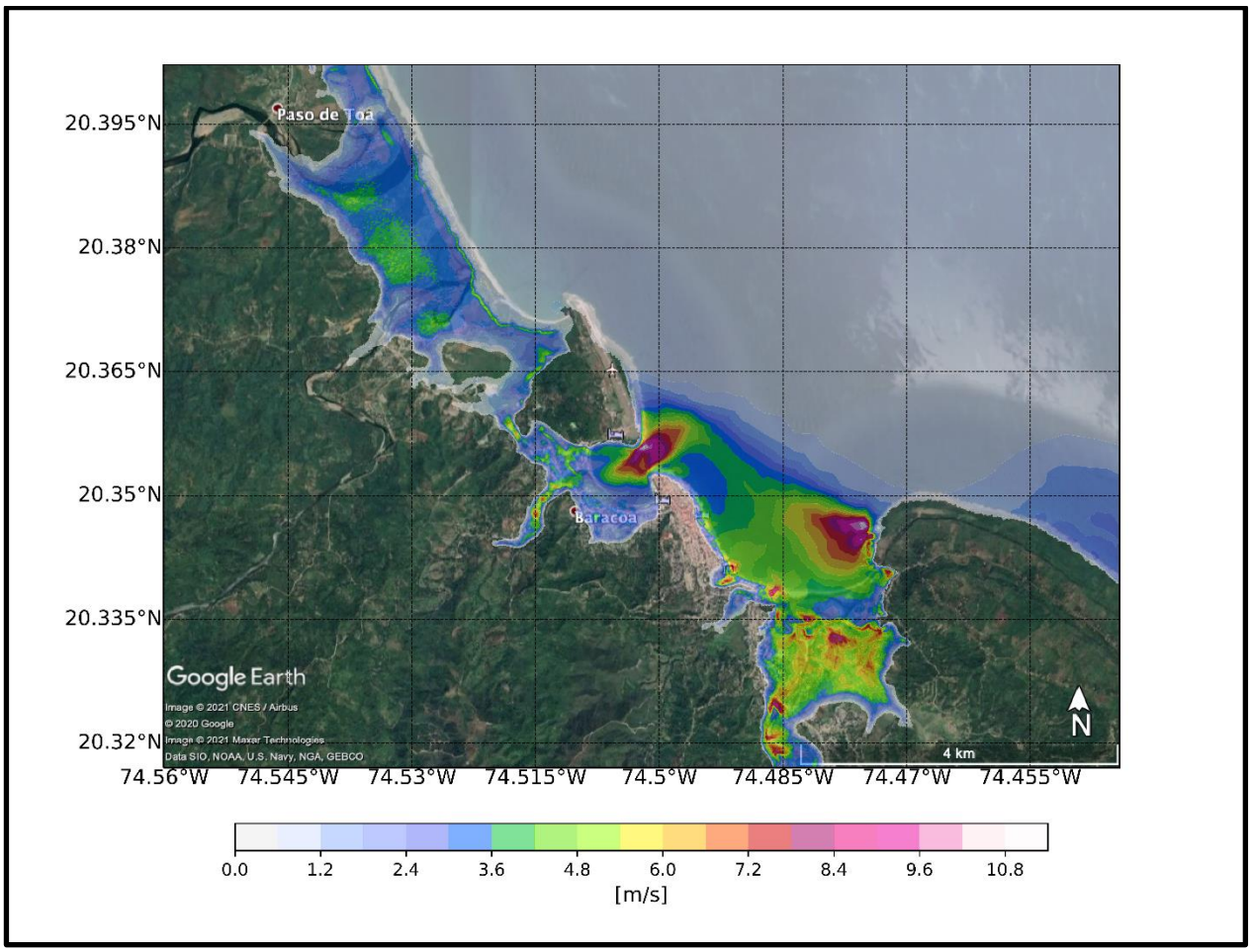


Figure 3. Maximum current flow speed induced by a tsunami.

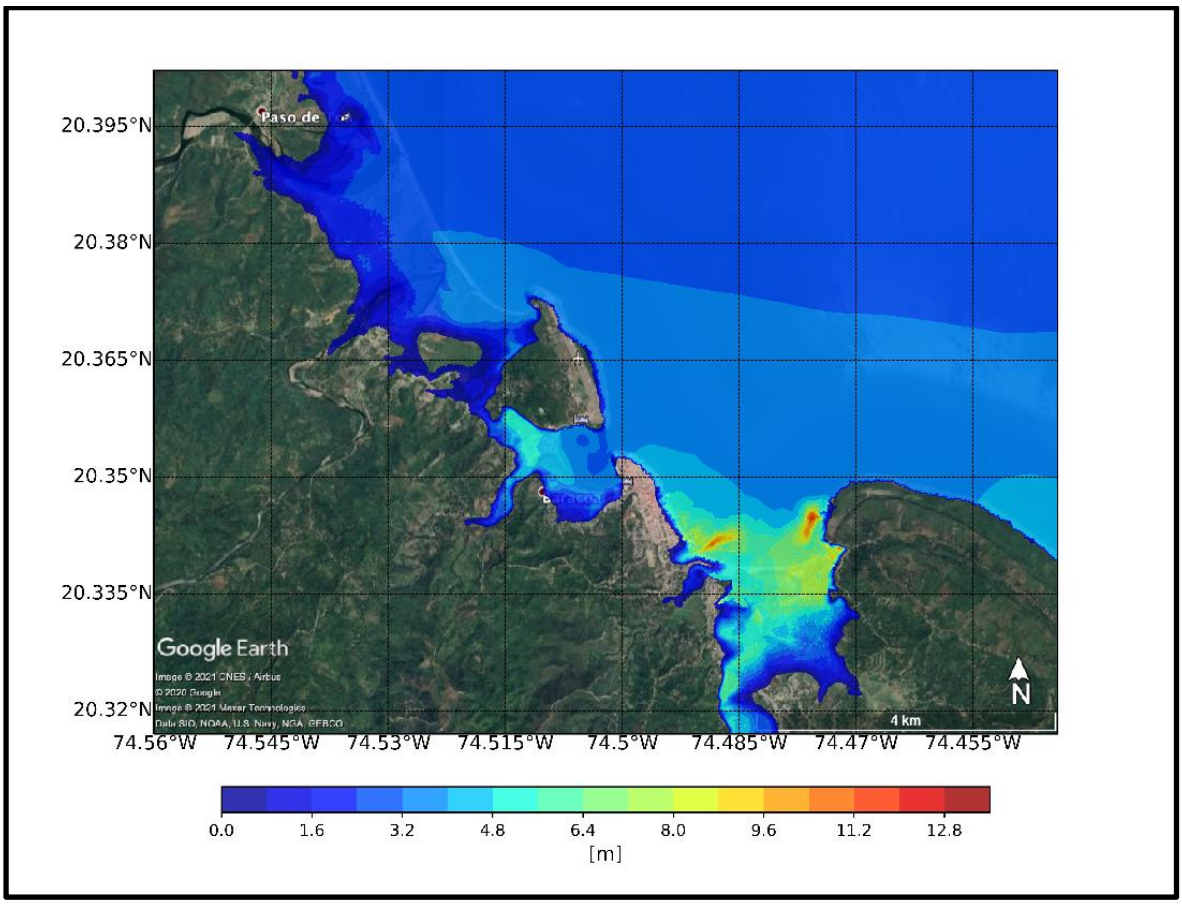
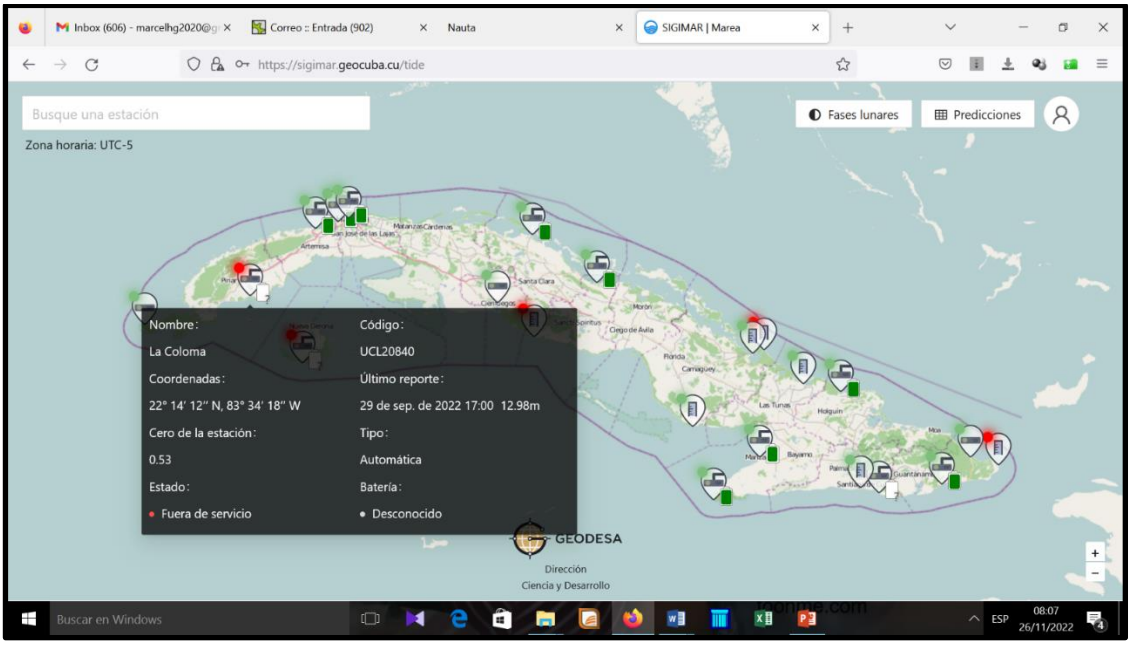


Figure 4. Maximum wave height.

Warning Systems

Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions



The SIGIMAR platform is currently under development, although it is still limited for national institutions due to the work being done on its improvement, with the aim of making it available internationally again, once the technical modifications underway are completed.

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