

Development of Comprehensive High Resolution Probabilistic Tsunami Design Zone Maps for the Island of O`ahu

Kick-off Meeting – Dec. 7, 2018

Dr. Ian N. Robertson – Project Manager

Dr. Yong Wei, University of Washington (UW)

Development of Tsunami Source Scenarios

Dr. Kwok Fai Cheung, Applied Research International (ARI)

Tsunami Inundation modeling and mapping

Dr. Patrick Lynett – Independent Technical Review

Project Outline

- Development of Comprehensive High Resolution Probabilistic Design Zone Maps Compatible with ASCE 7-16 for the Island of O`ahu, State of Hawai`i.
- Project managed by Department of Business, Economic Development and Tourism (DBET), Office of Planning, Coastal Zone Management Program, State of Hawai`i
- Funding provided by National Oceanic and Atmospheric Administration (NOAA)
- Project timeline shortened from two years to one year, ending September 30, 2019.

Team Members



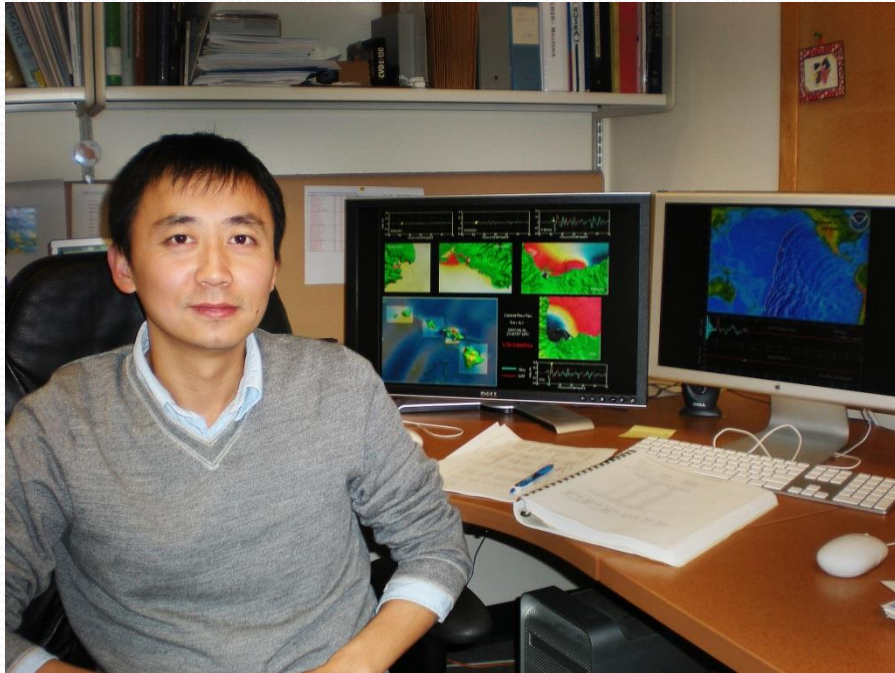
Ian N. Robertson, Ph.D., S.E.

- Project Responsibilities
 - Project management
 - Prepare work plan
 - Prepare progress reports
 - Organize and lead technical meetings
 - Organize and lead informational meetings
 - Project administration

- Vice-chair ASCE 7 Tsunami Loads and Effects Subcommittee
- Principal author of FEMA P-646 Third Edition – Vertical Evacuation
- Final edits of “Guide to the Tsunami Design Provisions of ASCE 7-16”.



Team Members



- Project Responsibilities
 - Develop tsunami source scenarios consistent with ASCE 7-16 offshore data
 - Participate remotely in technical and informational meetings
 - Assist with progress reports and final products

Yong Wei, Ph.D., University of Washington

- Member of ASCE 7 Tsunami Loads and Effects Subcommittee
- Generated tsunami sources and performed inundation modeling for the ASCE 7-16 Tsunami Design Zone maps.
- Developed the High-Resolution Benchmark TDZ maps for Honolulu and Hale'iwa



Team Members



- Project Responsibilities
 - Verify the bathymetry and topography to be used for the tsunami inundation modeling
 - Perform high-resolution inundation modeling based on the tsunami source scenarios
 - Prepare final map products
 - Participate in technical and informational meetings
 - Assist with progress reports and final products

Kwok Fai Cheung, Ph.D., Applied Research International, LLC

- Has performed all tsunami inundation mapping for generation of State of Hawai`i Tsunami Evacuation Maps.
- Has performed tsunami studies for ports and harbors and coastal areas throughout Hawai`i and around the Pacific Basin

Team Members



- Project Responsibilities
 - Assist Dr. Cheung with DEM verification, tsunami inundation modeling, and generation of mapping products.

Yoshiaki Yamazaki, Ph.D., Applied Research International, LLC

- Developed tsunami modeling program NEOWAVE with Kwok Fai Cheung.
- Has performed tsunami studies for numerous areas throughout Hawai`i and around the Pacific Basin

Team Members



- Project Responsibilities
 - Serves as the Independent Technical Reviewer for the project.
 - Will provide technical review of all products produced by the project team.

Patrick Lynett, Ph.D., Patrick Lynett LLC.

- Member of ASCE 7 Tsunami Loads and Effects Subcommittee
- Has performed numerous tsunami modeling studies of coastal regions and ports and harbors, with particular emphasis on flow velocities and eddy development.

Project Contracts

- Prime contract between Hawai'i State DBET's Office of Planning and Ian N. Robertson, Ph.D. (INR) effective Oct. 3, 2018
- Subcontracts established between INR and:
 - University of Washington (UW) on Nov. 29, 2018
 - Applied Research International, LLC (ARI) on Nov. 16, 2018
 - Patrick Lynett, LLC on Nov. 15, 2018

Project Objective

- Phase 1, “Year 1”
 - Develop high-resolution (10m horizontal grid) probabilistic tsunami design zone maps consistent with the requirements of ASCE 7-16 for Honolulu Urban Core and Hale`iwa.
 - Validate these maps relative to benchmark high-resolution maps generated under a prior project.
 - Produce mapping products as specified in the Prime Contract.
- Phase 1, “Year 2”
 - Develop high-resolution (10m) probabilistic tsunami design zone maps consistent with ASCE 7-16 for the rest of O`ahu.
 - Produce mapping products as specified in the Prime Contract.
 - Develop code language for inclusion of these maps in the Honolulu City & County Building Code.

Project Schedule – “Year 1”

Task	Week																						
	2018							2019															
	Nov. 9	Nov. 16	Nov. 23	Nov. 30	Dec. 7	Dec. 14	Dec. 21	Dec. 28	Jan. 4	Jan. 11	Jan. 18	Jan. 25	Feb. 1	Feb. 8	Feb. 15	Feb. 22	Mar. 1	Mar. 8	Mar. 15	Mar. 22	Mar. 29	Apr. 5	
4.1 Develop and submit detailed work plan for Phase I/ “Years 1 and 2”	Robertson	Robertson	Robertson																				
4.2a Develop source scenarios for Honolulu Urban Core mapping		U of Wash	U of Wash	U of Wash	U of Wash	U of Wash																	
4.2b Develop source scenarios for Hale’iwa mapping					U of Wash	U of Wash	U of Wash	U of Wash	U of Wash														
4.3a Verify bathymetric and topographic DEM for Honolulu Urban Core mapping		ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC																	
4.3b Verify bathymetric and topographic DEM for Hale’iwa mapping					ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC													
4.4a Perform high resolution inundation modeling for Honolulu Urban Core					ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC								
4.4b Perform high resolution inundation modeling for Hale’iwa								ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC			
4.5 Convene first technical meeting													Robertson	Robertson									
4.7a Conduct independent technical review of Honolulu Urban Core modeling													Lynett	Lynett									
4.6a Develop required map products for Honolulu Urban Core													ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC			
4.6b Develop required map products for Hale’iwa														ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC	ARI LLC			
4.7b Conduct independent technical review of Hale’iwa modeling and map products for Honolulu Urban Core and Hale’iwa																	Robertson	Robertson	Robertson	Robertson			
4.8 Prepare proposed language for Honolulu C&C code adoption																	Robertson	Robertson	Robertson	Robertson			
4.9 Convene second technical meeting																		Robertson	Robertson	Robertson			
4.18a Informational Meeting 1																							Robertson
4.10 Prepare and submit “Year 1” products to STATE																							All
4.19 Submit written Progress Reports every 4 (was 6) weeks				Robertson				Robertson				Robertson			Robertson							Robertson	

Legend: Responsible Personnel ■ Robertson ■ U of Wash ■ ARI LLC ■ Lynett ■ All * Light colors indicate flexibility in target date

Project Schedule – “Year 2”

Task	2018 Week Ending																									
	Apr. 12	Apr. 19	Apr. 26	May 3	May 10	May 17	May 24	May 31	June 7	June 14	June 21	June 28	July 5	July 12	July 19	July 26	Aug 2	Aug 9	Aug 16	Aug 23	Aug 30	Sept 6	Sept 13	Sept 20	Sept 27	
4.11a Develop scenarios for the remainder of Honolulu C&C: South Shore	█	█	█																							
4.11b Develop scenarios for the remainder of Honolulu C&C: West Shore			█	█	█																					
4.11c Develop scenarios for the remainder of Honolulu C&C: North Shore					█	█	█	█																		
4.11d Develop scenarios for the remainder of Honolulu C&C: East Shore							█	█	█	█																
4.12a Verify bathymetric and topographic DEM for HC&C: South Shore	█	█	█	█																						
4.12b Verify bathymetric and topographic DEM for HC&C: West Shore			█	█	█																					
4.12c Verify bathymetric and topographic DEM for HC&C: North Shore					█	█	█	█																		
4.12d Verify bathymetric and topographic DEM for HC&C: East Shore							█	█	█	█	█															
4.13a Perform high res inundation modeling rest of Honolulu C&C: S. Shore			█	█	█	█																				
4.13b Perform high res inundation modeling rest of Honolulu C&C: W. Shore							█	█	█	█	█															
4.16a Conduct independent technical review of S and W shore mapping											█	█														
4.18b Informational Meeting 2											█	█														
4.13c Perform high res inundation modeling for rest of Honolulu C&C: N. Shore											█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
4.13d Perform high res inundation modeling for rest of Honolulu C&C: E. Shore																█	█	█	█	█	█	█	█	█	█	█
4.15a Develop required map products for remainder of HC&C: South Shore																										
4.15b Develop required map products for remainder of HC&C: West Shore																	█	█	█	█	█	█	█	█	█	█
4.15c Develop required map products for remainder of HC&C: North Shore																										
4.15d Develop required map products for remainder of HC&C: East Shore																										
4.14 Convene third technical meeting																							█	█	█	█
4.16b Conduct independent technical review of N and E shore mapping products																							█	█	█	█
4.17 Prepare proposed language for Honolulu C&C code adoption																										
4.18c Informational Meeting 3																										
4.19 Submit written Progress Reports every month				█					█				█				█									
4.20 Prepare and submit final written report																										
4.21 Submit final map products for the remainder of Honolulu C&C																										

Legend: Responsible Personnel █ Robertson █ U of Wash █ ARI LLC █ Lynett █ All * Light colors indicate flexibility in target date

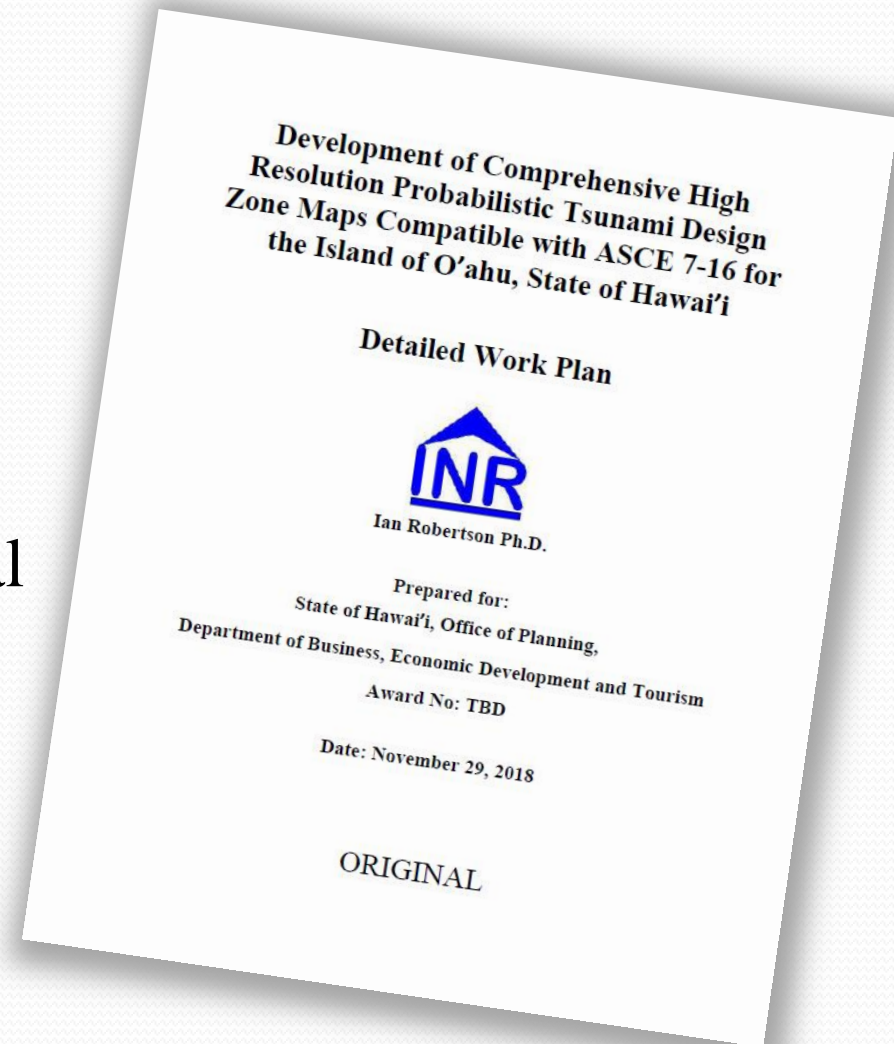
Project Schedule – “Year 1”

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	2018							2019															
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4.1 Develop and submit detailed work plan for Phase I / “Years 1 and 2”	█	█	█		Submitted to State																		
4.2a Develop source scenarios for Honolulu Urban Core mapping		█	█	█	█	█				In Progress													
4.2b Develop source scenarios for Hale’iwa mapping					█	█	█	█	█	In Progress													
4.3a Verify bathymetric and topographic DEM for Honolulu Urban Core mapping		█	█	█						In Progress													
4.3b Verify bathymetric and topographic DEM for Hale’iwa mapping					█	█	█	█	█	In Progress													
4.4a Perform high resolution inundation modeling for Honolulu Urban Core					█	█	█	█	█	█	█	█	█	█	█	█							
4.4b Perform high resolution inundation modeling for Hale’iwa									█	█	█	█	█	█	█	█	█	█	█				
4.5 Convene first technical meeting													█	█									
4.7a Conduct independent technical review of Honolulu Urban Core modeling													█	█									
4.6a Develop required map products for Honolulu Urban Core													█	█	█	█	█	█	█				
4.6b Develop required map products for Hale’iwa															█	█	█	█	█	█	█		
4.7b Conduct independent technical review of Hale’iwa modeling and map products for Honolulu Urban Core and Hale’iwa																	█	█	█	█			
4.8 Prepare proposed language for Honolulu C&C code adoption																	█	█	█	█			
4.9 Convene second technical meeting																			█	█			
4.18a Informational Meeting 1																						█	
4.10 Prepare and submit “Year 1” products to STATE																					█	█	
4.19 Submit written Progress Reports every 4 (was 6) weeks				█					█			█			█						█		

Legend: Responsible Personnel █ Robertson █ U of Wash █ ARI LLC █ Lynett █ All █ * Light colors indicate flexibility in target date

Task 4.1 – Detailed Work Plan

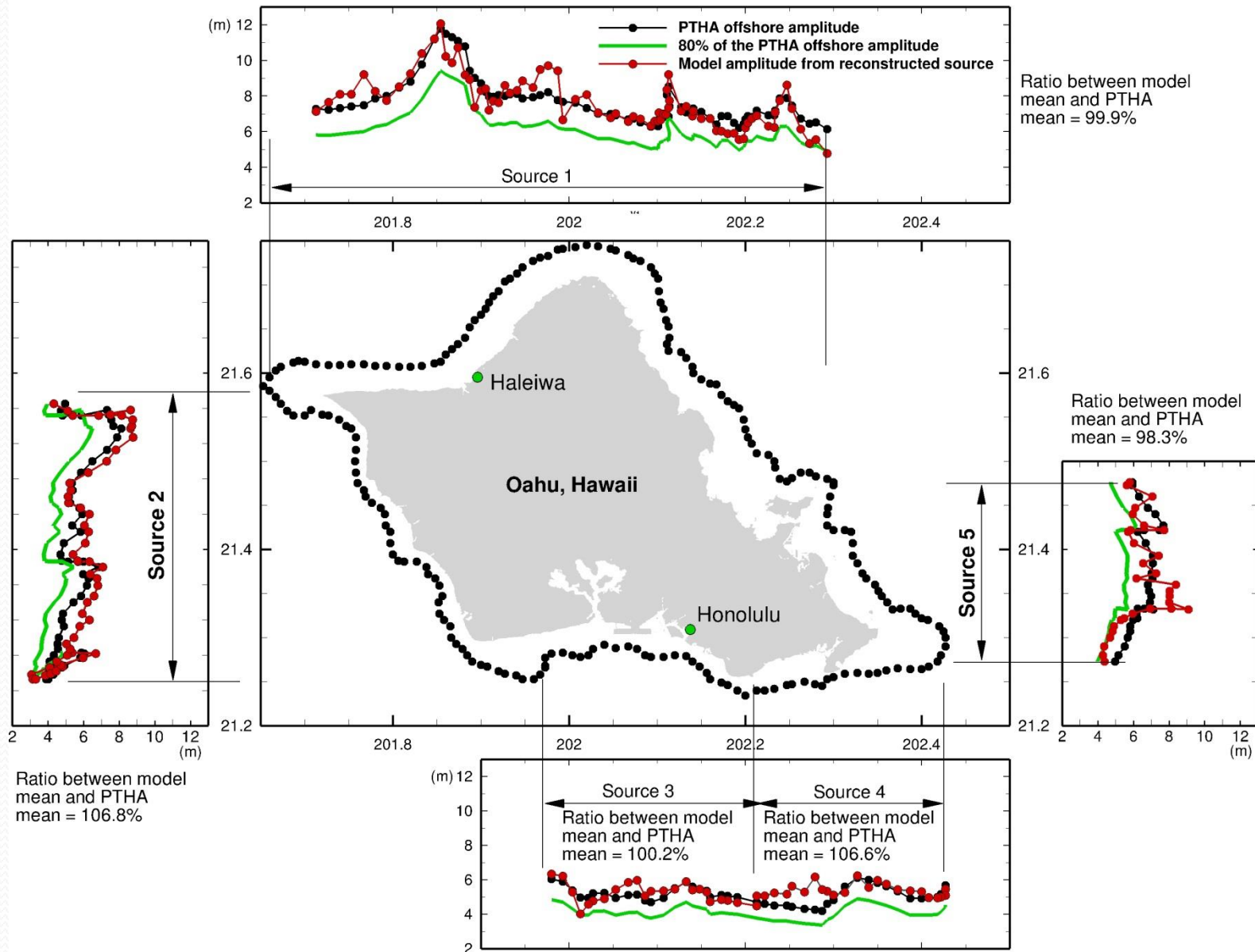
- Draft detailed work plan for Phase 1, “Years 1 and 2” was submitted to Office of Planning on Nov. 16, 2018.
- Review comments received Nov. 21, 2018.
- Comments addressed and final detailed work plan submitted on Nov. 29, 2018.



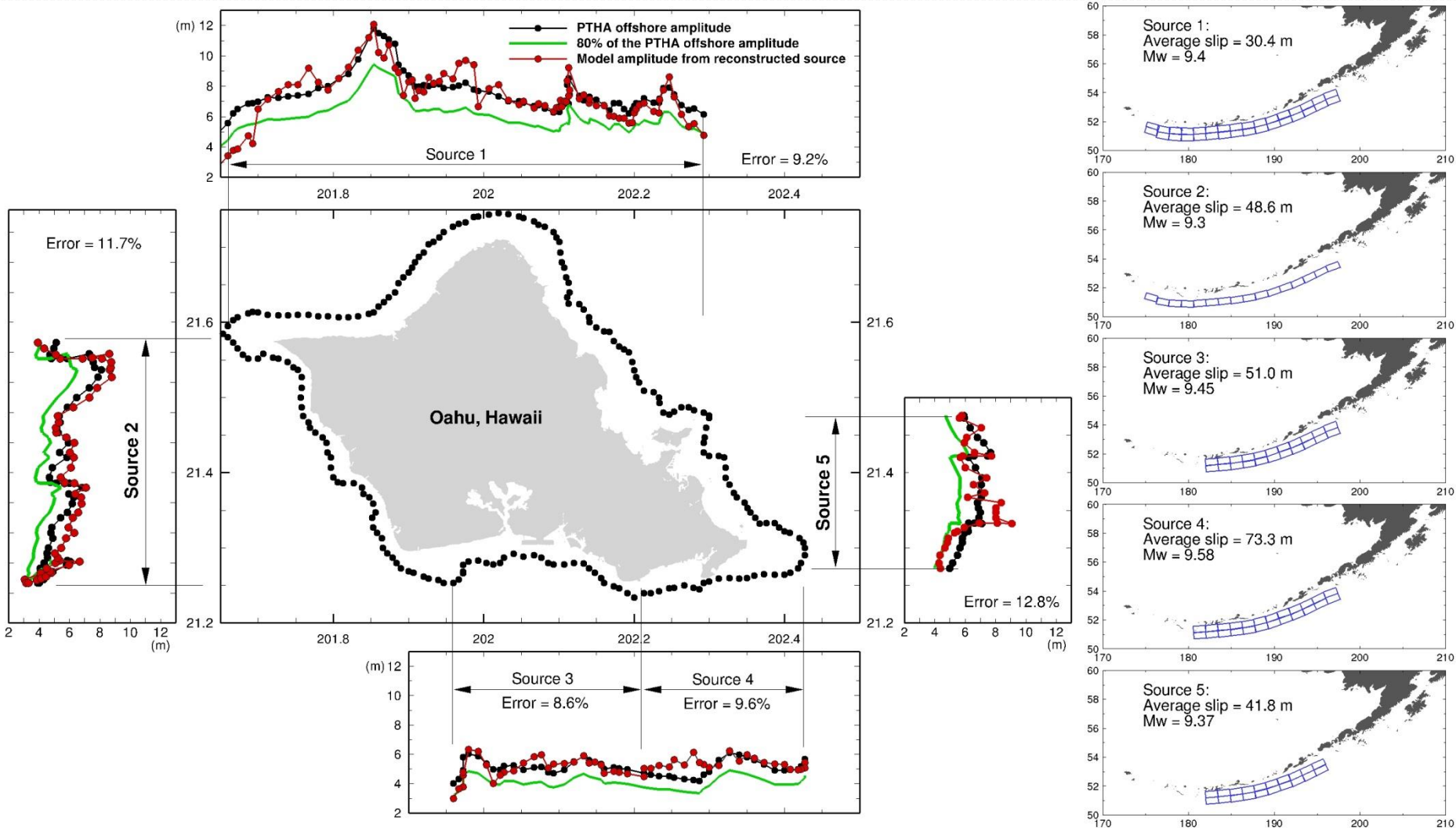
Task 4.2 – Develop Source Scenarios

- Tsunami Source Scenarios must produce offshore wave heights that agree with the ASCE 7-16 Offshore Wave Heights listed in the ASCE Tsunami Geodatabase.
- ASCE 7-16 only requires that for site specific PTHA, no point be less than 80% of the Geodatabase value.

Task 4.2 – Develop Source Scenarios



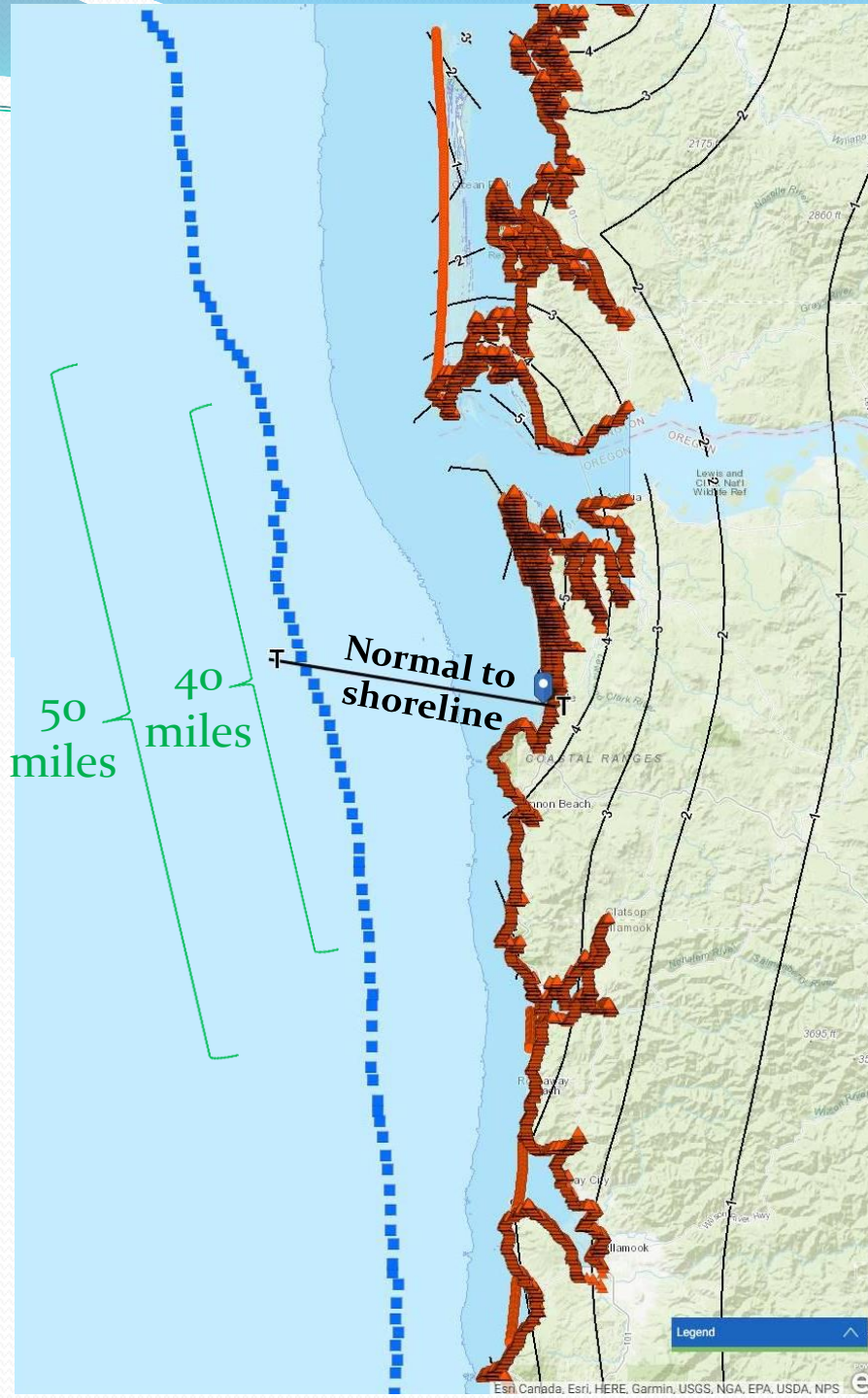
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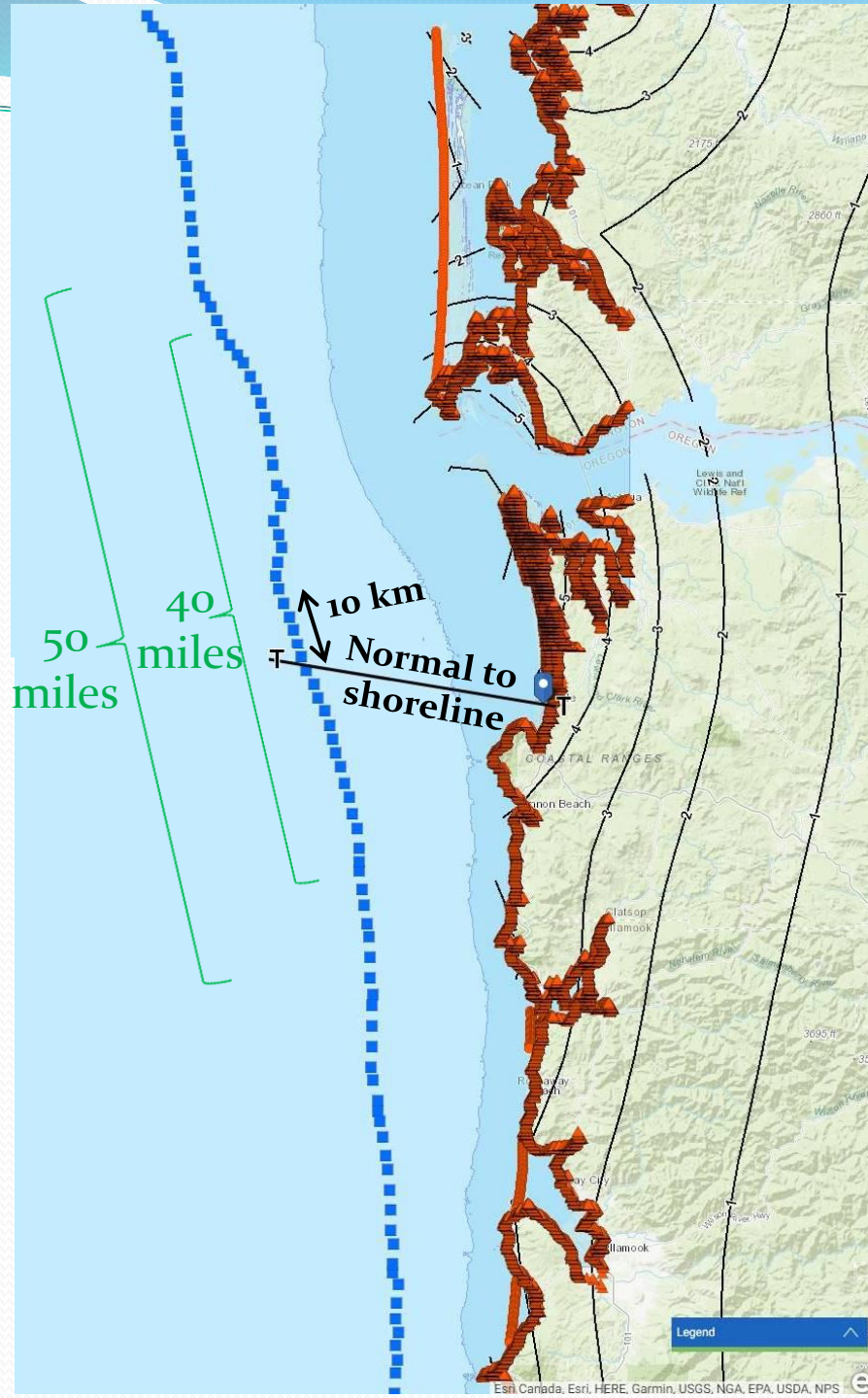
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- ASCE 7-16 only requires that for site specific PTHA, no point be less than 80% of the Geodatabase value.
- New requirements have been approved for ASCE 7-22 which require 100% average match over a 40-50 mile length, with no point falling below 80%.

Example: Seaside, OR



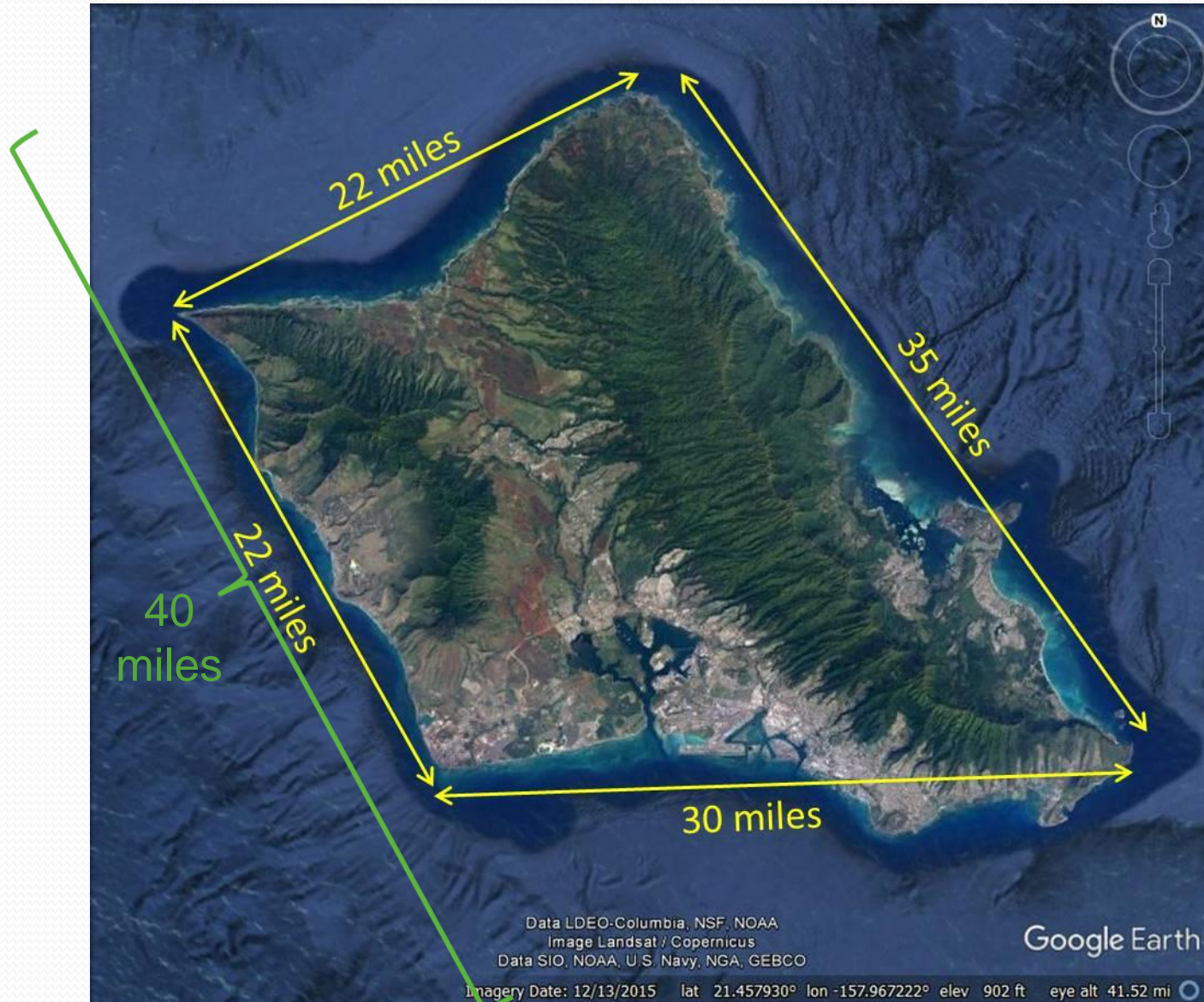
Example: Seaside, OR



Example: Seaside, OR



Application to Island of O'ahu



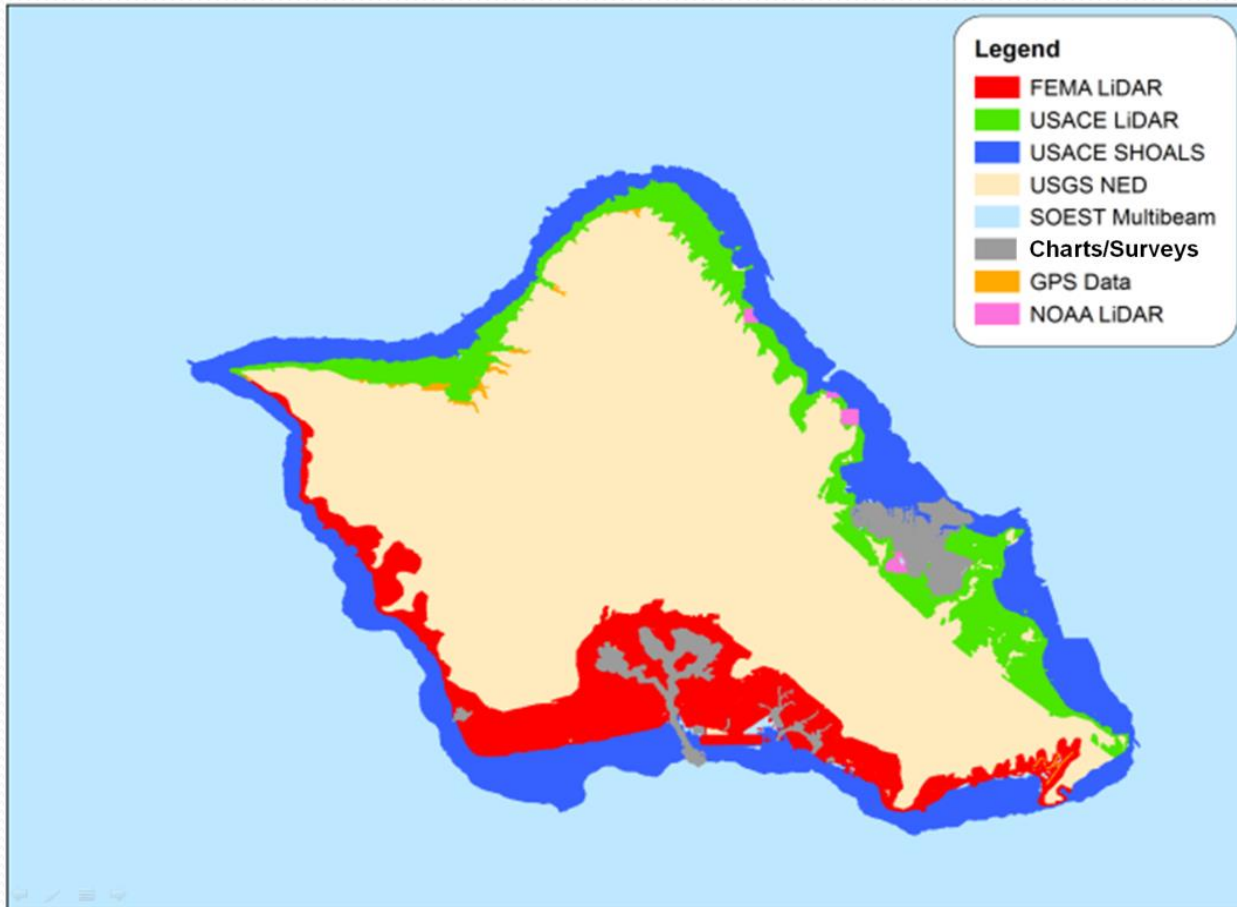
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- ASCE 7-16 only requires that for site specific PTHA, no point be less than 80% of the Geodatabase value.
- New requirements have been approved for ASCE 7-22 which require 100% average match over a 40-50 mile length, with no point falling below 80%.
- We plan to comply with the spirit of this new requirement even though it does not apply strictly to TDZ mapping.
- This new requirement may also not apply directly to islands, based on the size of the island.
- We propose to determine source scenarios for each “face” of the island of O`ahu, meeting the 100% and 80% criteria.

Task 4.3 – Verify DEM

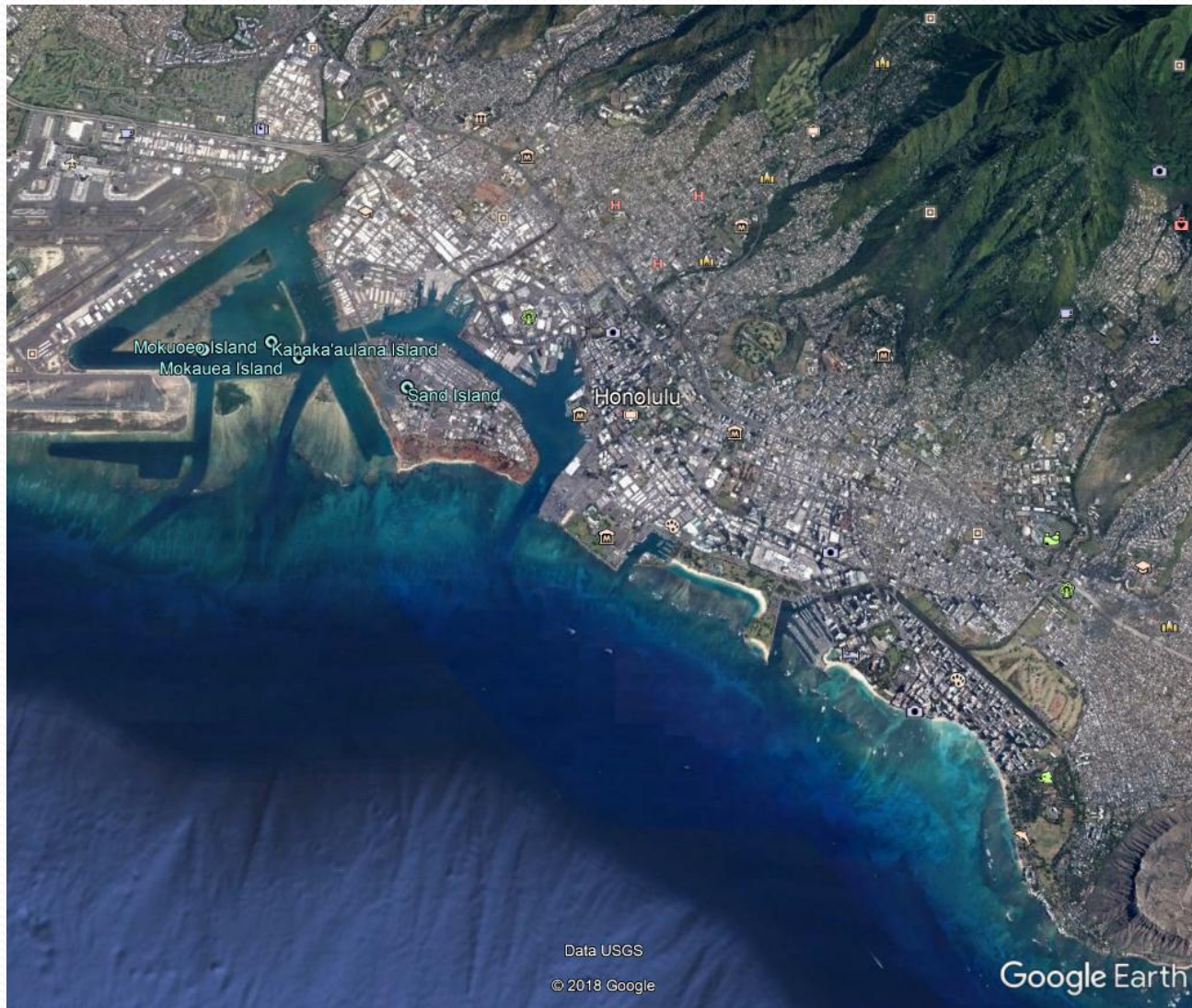
- For more than a decade, ARI has compiled high-resolution bathymetry and topography from a number of sources to generate their Digital Elevation Model (DEM) of O`ahu.
- This DEM has been used for prior tsunami inundation and harbor current studies on O`ahu.
- It is being verified by comparison with the 2013 USACE aerial LiDAR dataset for nearshore and coastal areas.

Task 4.3 – DEM for O`ahu

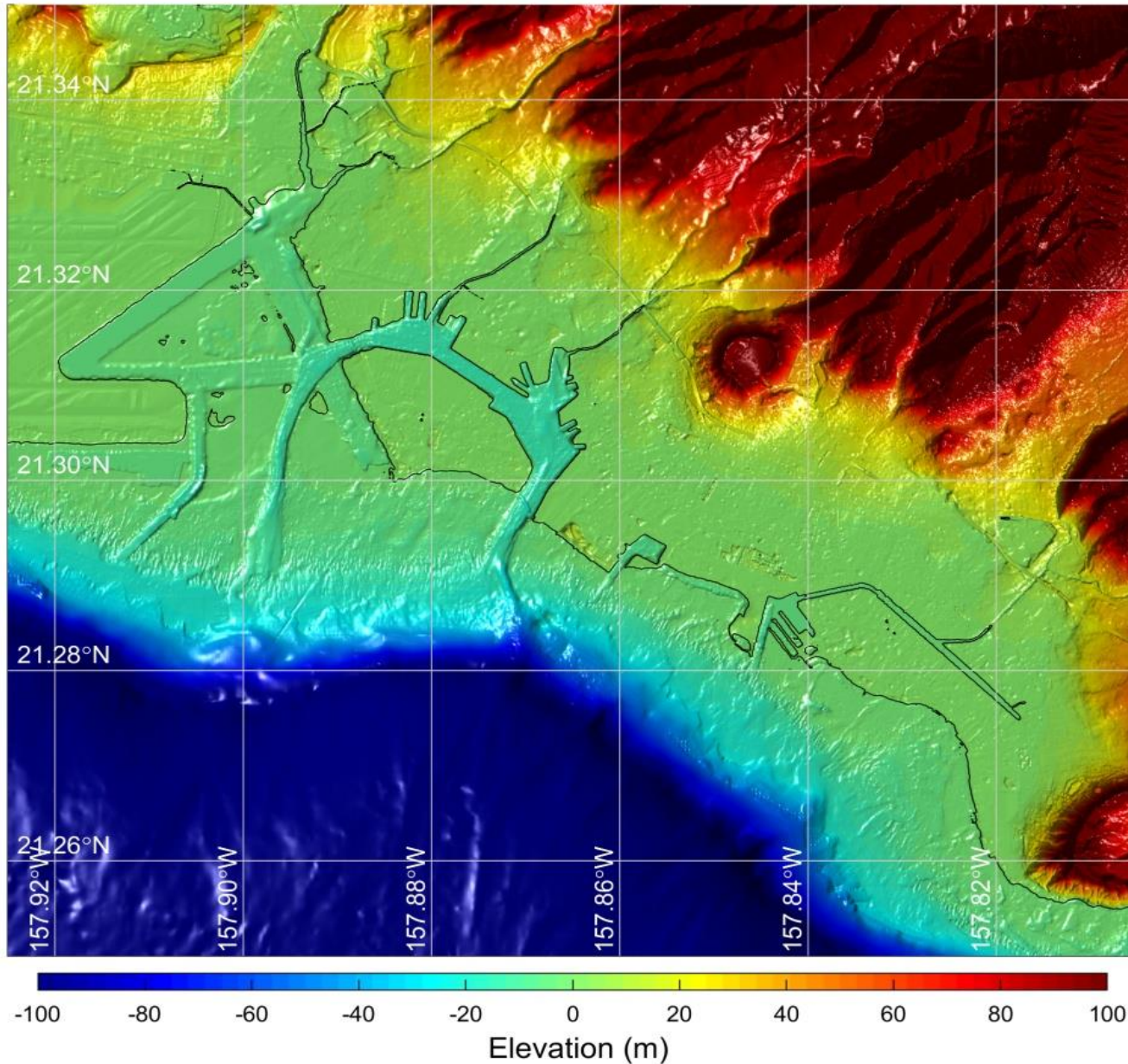


Sources used to compile ARI DEM for the Island of O`ahu
(1999 to 2009)

Task 4.3a – Honolulu Urban Core DEM

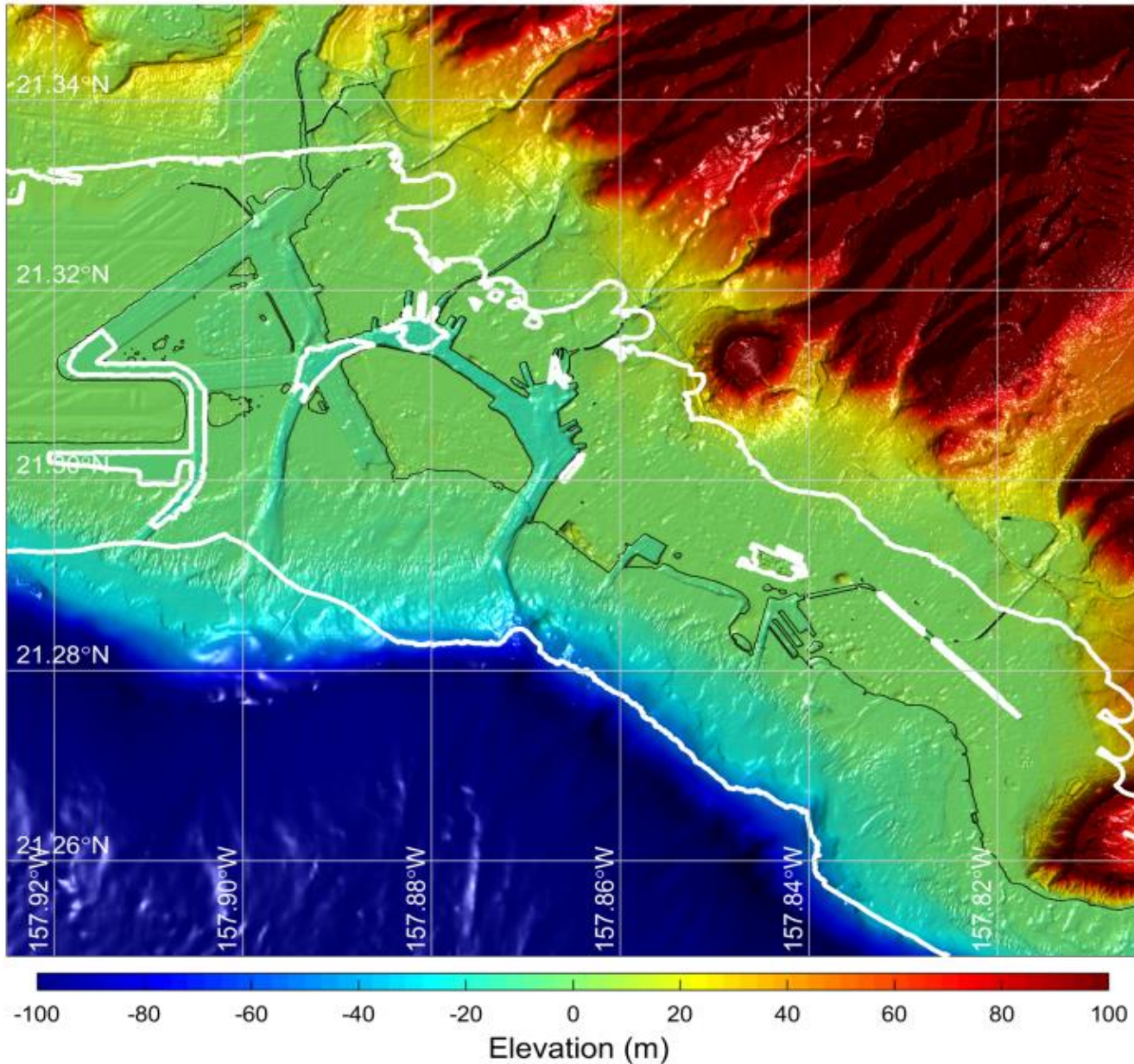


Task 4.3a – Honolulu Urban Core DEM



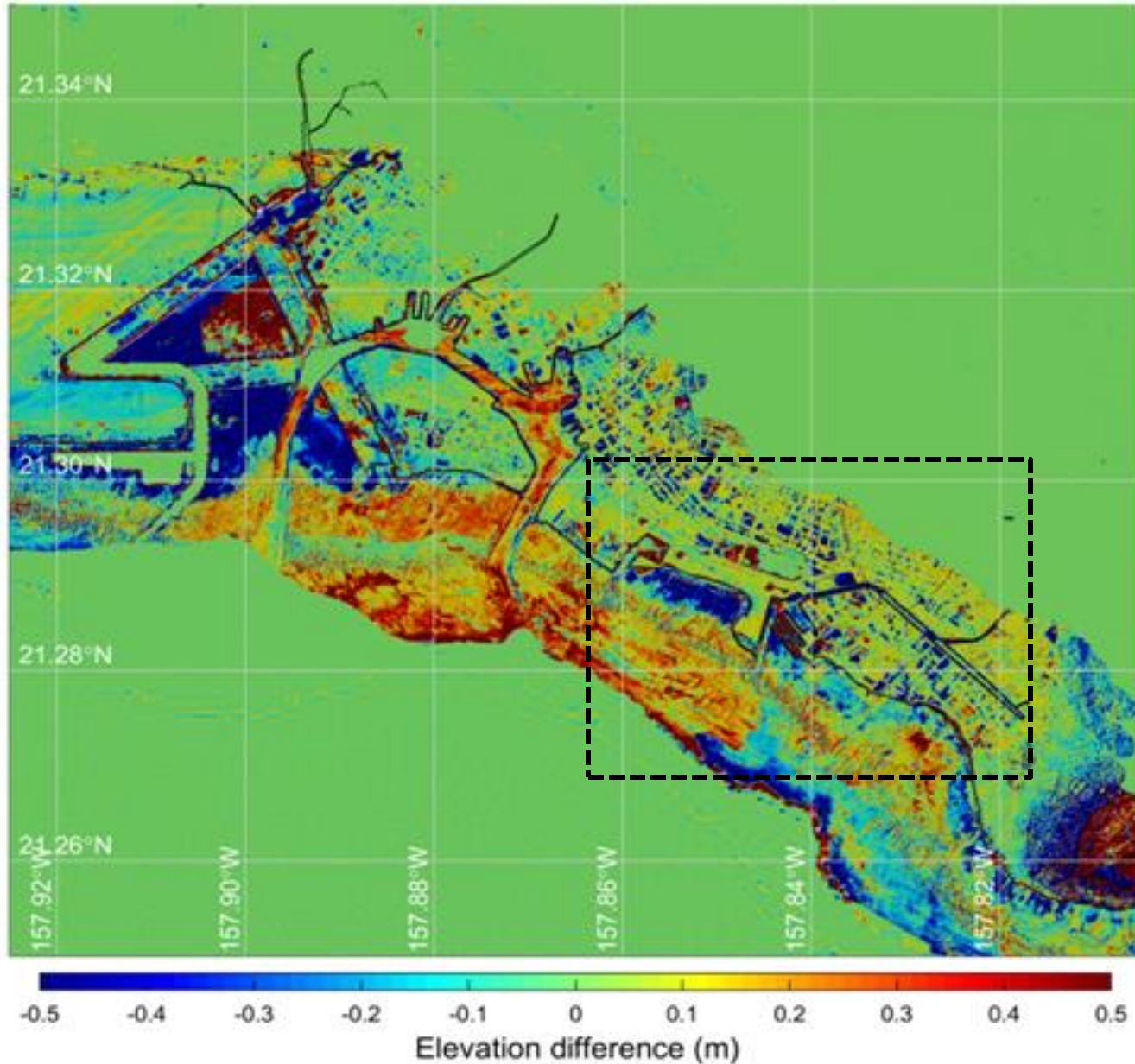
Task 4.3a – Honolulu Urban Core DEM

2013
USACE
LiDAR
boundaries



Task 4.3a – Honolulu Urban Core DEM

Difference
between
ARI DEM
and
2013
USACE
LiDAR

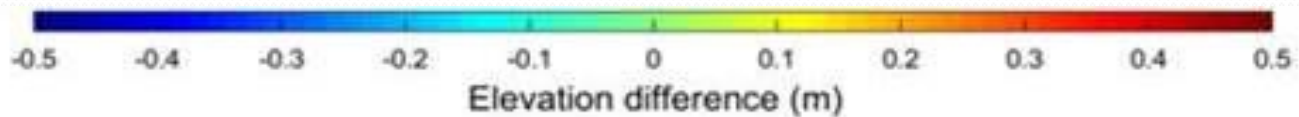
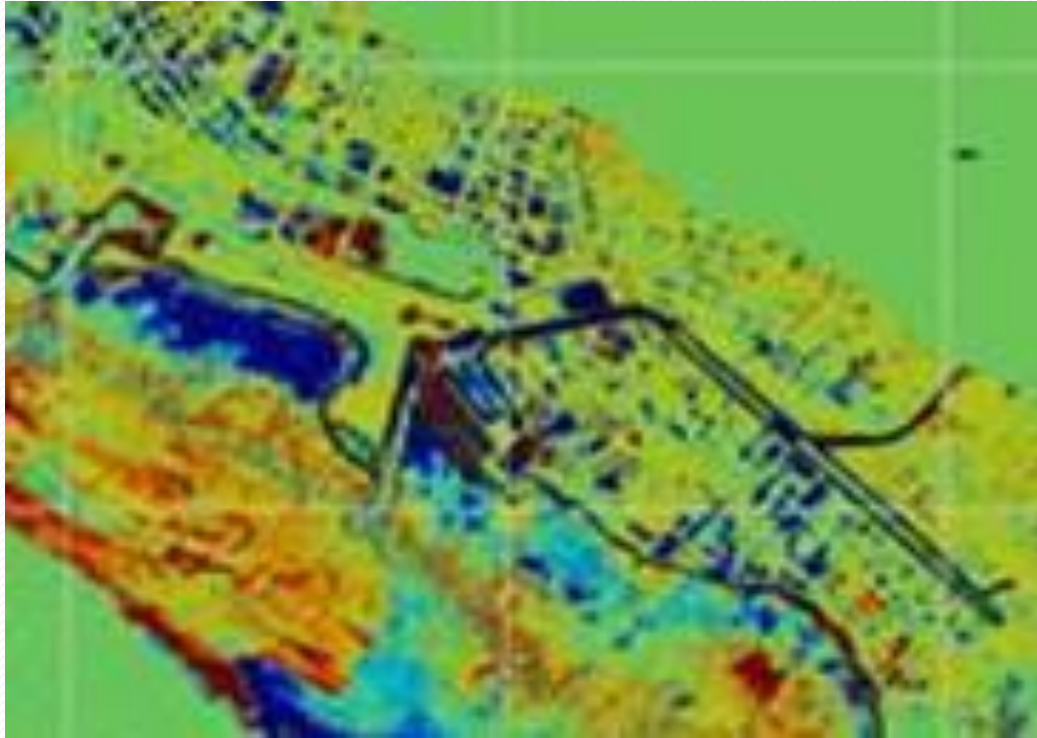


Task 4.3a – Honolulu Urban Core DEM

Difference
between
ARI DEM

and

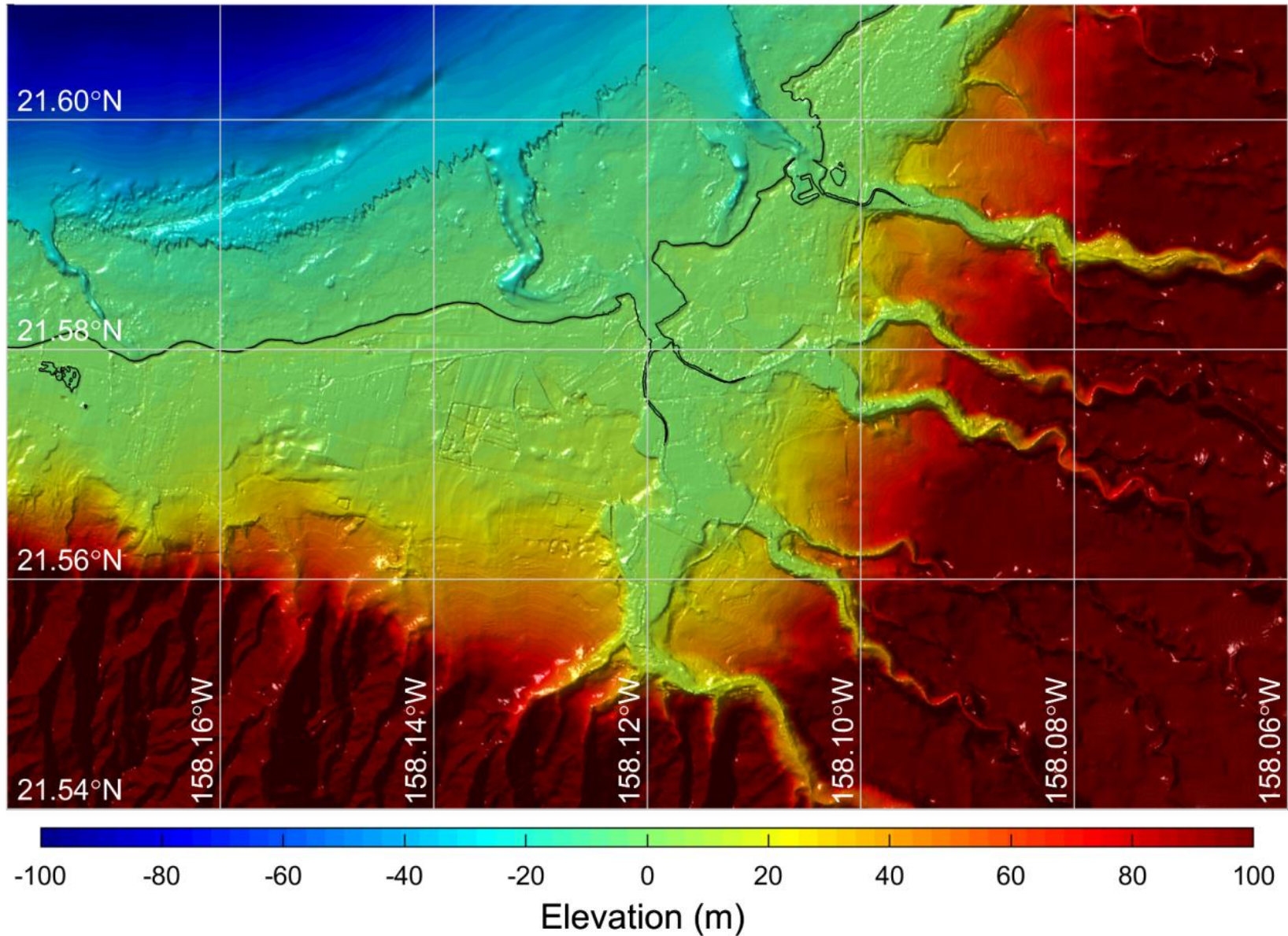
2013
USACE
LiDAR



Task 4.3b – Hale`iwa DEM

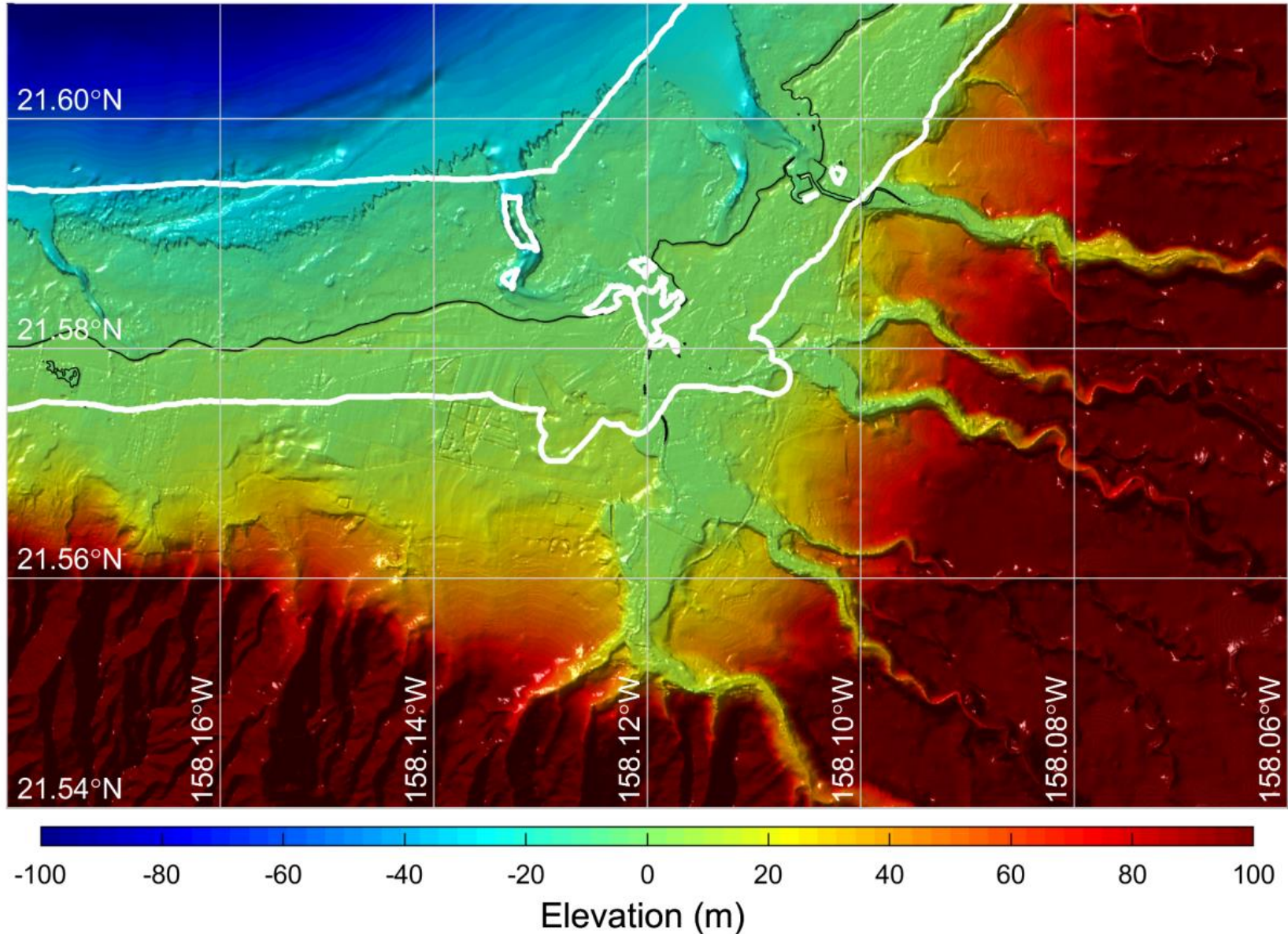


Task 4.3b – Hale`iwa DEM



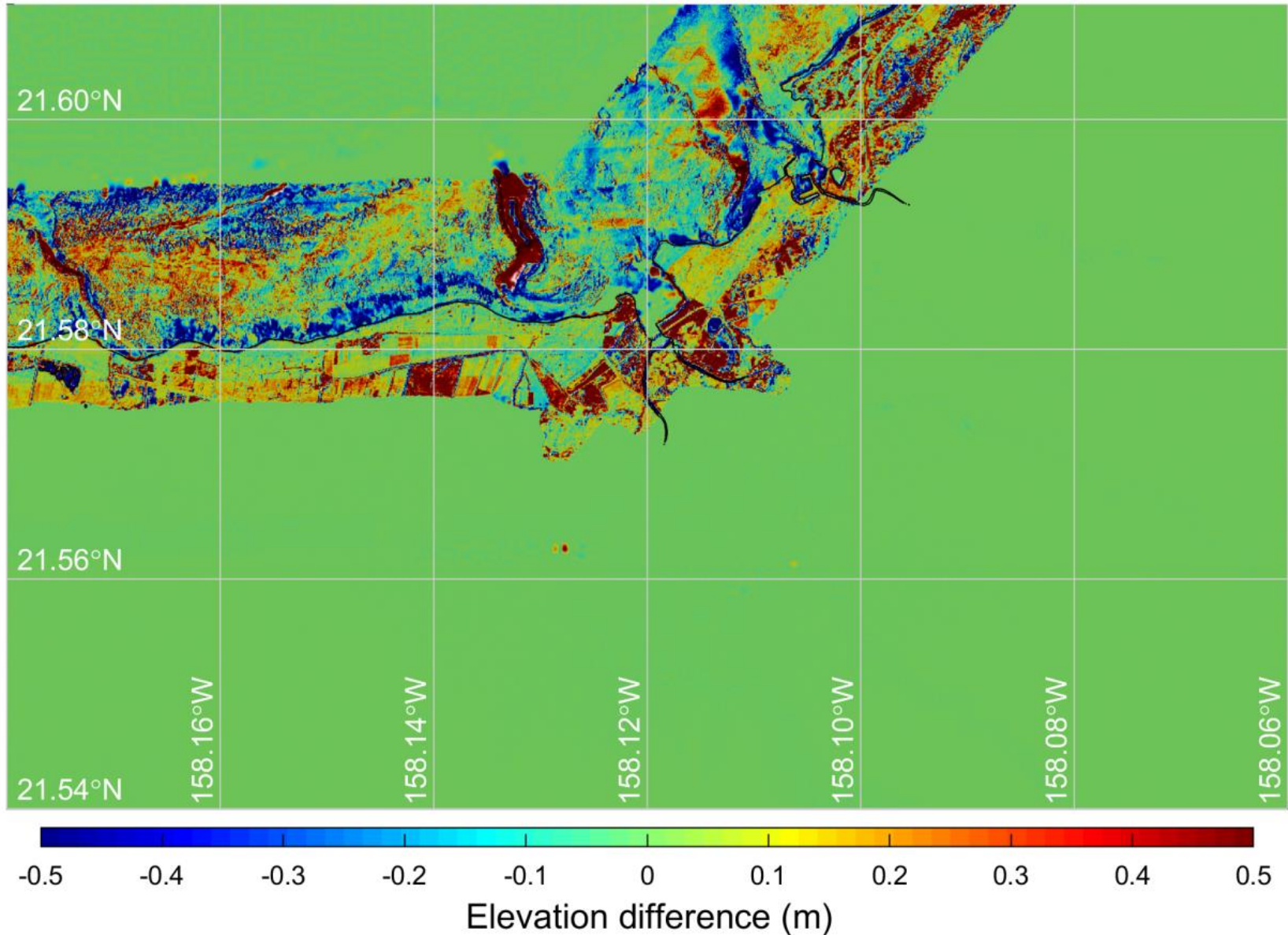
Task 4.3b – Hale`iwa DEM

2013 USACE LiDAR boundaries



Task 4.3b – Hale`iwa DEM

Difference between ARI DEM and 2013 USACE LiDAR



Task 4.3 – DEM Verification

- The ARI DEM has been verified against the 2013 USACE LiDAR data.
- We plan to proceed with inundation modeling using the ARI DEM based on this verification.
- A report documenting this DEM verification process will be submitted by the end of December.

Future Tasks

- Task 4.2 – Tsunami Source Scenarios
 - Will be completed by the end of December for Hale`iwa and Honolulu Urban Core.
 - A report documenting the scenario development will be submitted soon thereafter.
- Task 4.3 – DEM verification for Hale`iwa and Honolulu
 - Report documenting DEM verification will be submitted by the end of December.
- Task 4.4 – Perform high resolution inundation modeling for Hale`iwa and Honolulu Urban Core
 - Will start as soon as source scenarios are ready.

Thank-you

Any Questions?