The Coastal Waveform Retracking Using Fuzzy Expert System Approach

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Introduction

- A number of new/improved retrackers have been developed in the last few years to extract precise SSHs from corrupted waveforms
- Different retracking algorithms should be considered because no universal retracker that can deal with all waveform shapes
- However, this brings an issue of which retracker has performed the best and which retracker should be used under various conditions

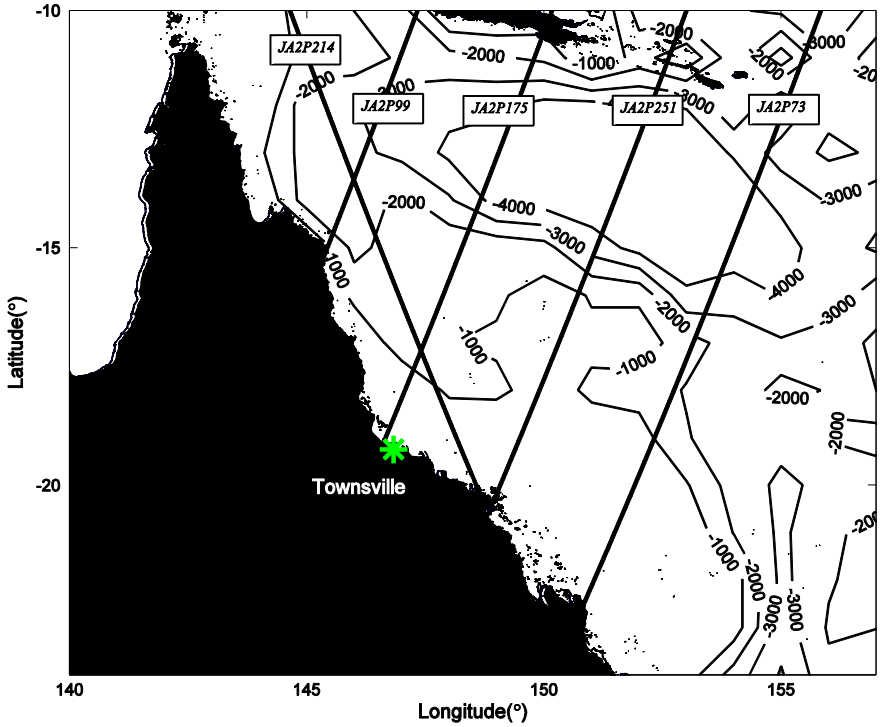
Objectives

- To improve SSHs near coast using a waveform retracking system
- To develop a method that selects the most appropriate/optimal retracker using a fuzzy expert system
- To validate the results with in-situ data

  -e.g. tide gauge and geoid height

Data and study area

- The world's most largest reef system composed of over 1000 individual reefs and 900 islands
- Altimeter footprints are contaminated thus producing high complexity of waveform patterns



The Great Barrier Reef, Australia. Background is the ocean bathymetry

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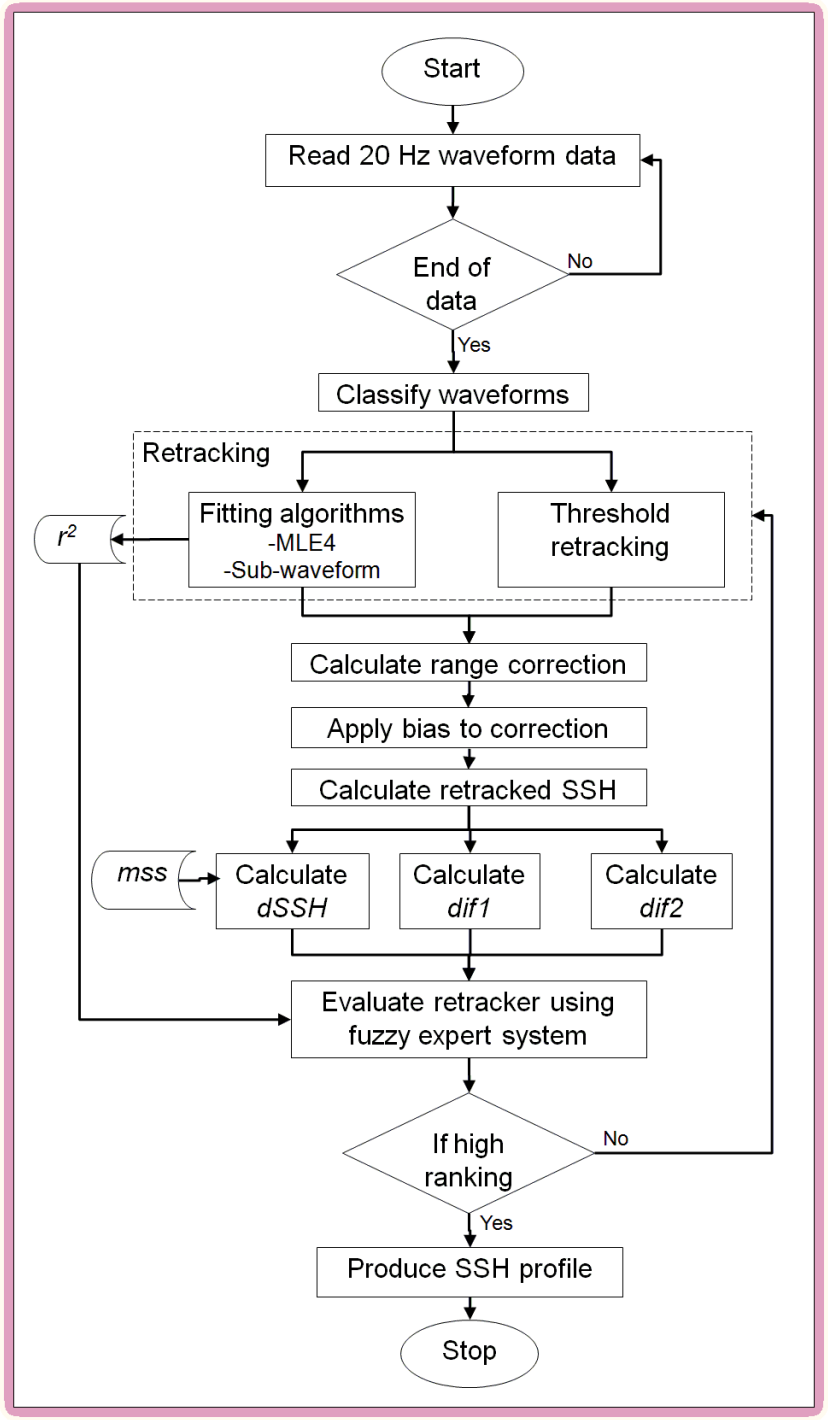
- Jason-2 SGDR 20 Hz waveforms from cycles 19 to 136 (January 2009 to April 2012) along

  - four ascending passes (73, 99, 175, and 251)

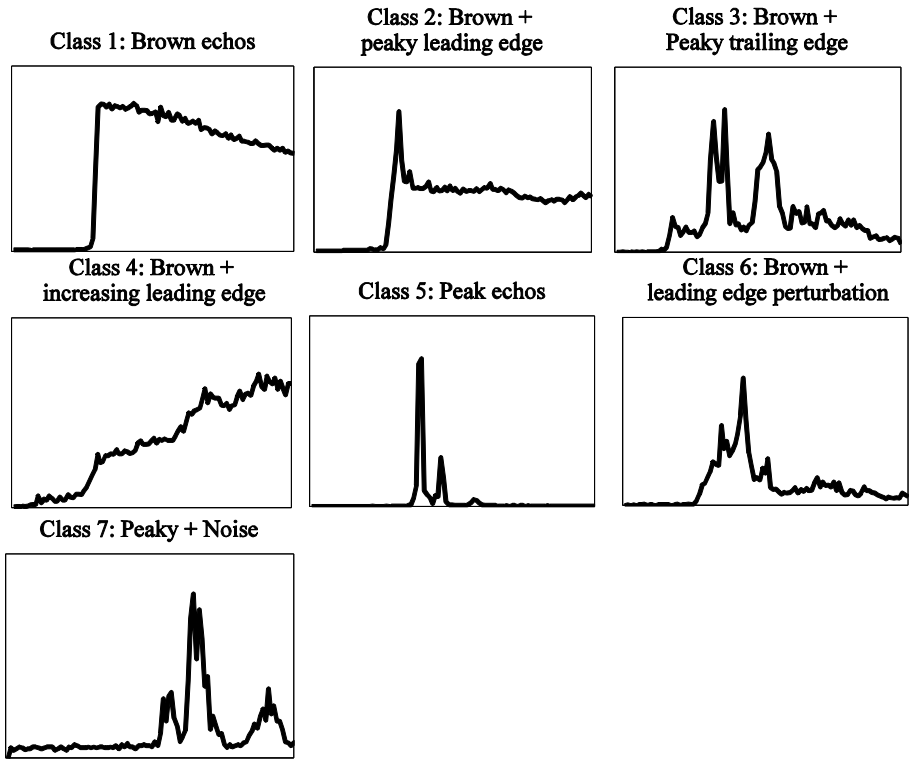
  - one descending pass (214)

Waveform retracking system



- A fuzzy retracking system is developed to select the optimal retracker
- Block diagram of coastal waveform retracking system

Waveform classification



- Waveforms were classified into 7 classes using a Bayesian classifier

Waveform retracking

- The classified waveform was then retracked using one of specific retrackers
  - MLE4
  - sub-waveform (Idris and Deng 2011)
  - threshold (10%, 20% and 30% level) (Lee et al, 2008)

Fuzzy expert system

- A fuzzy expert system was then used to evaluate the performance of each waveform retrackers
- When the fuzzy expert system considers a retracker as 'high ranking', the corresponding retracked SSH is used as the output of SSH profile

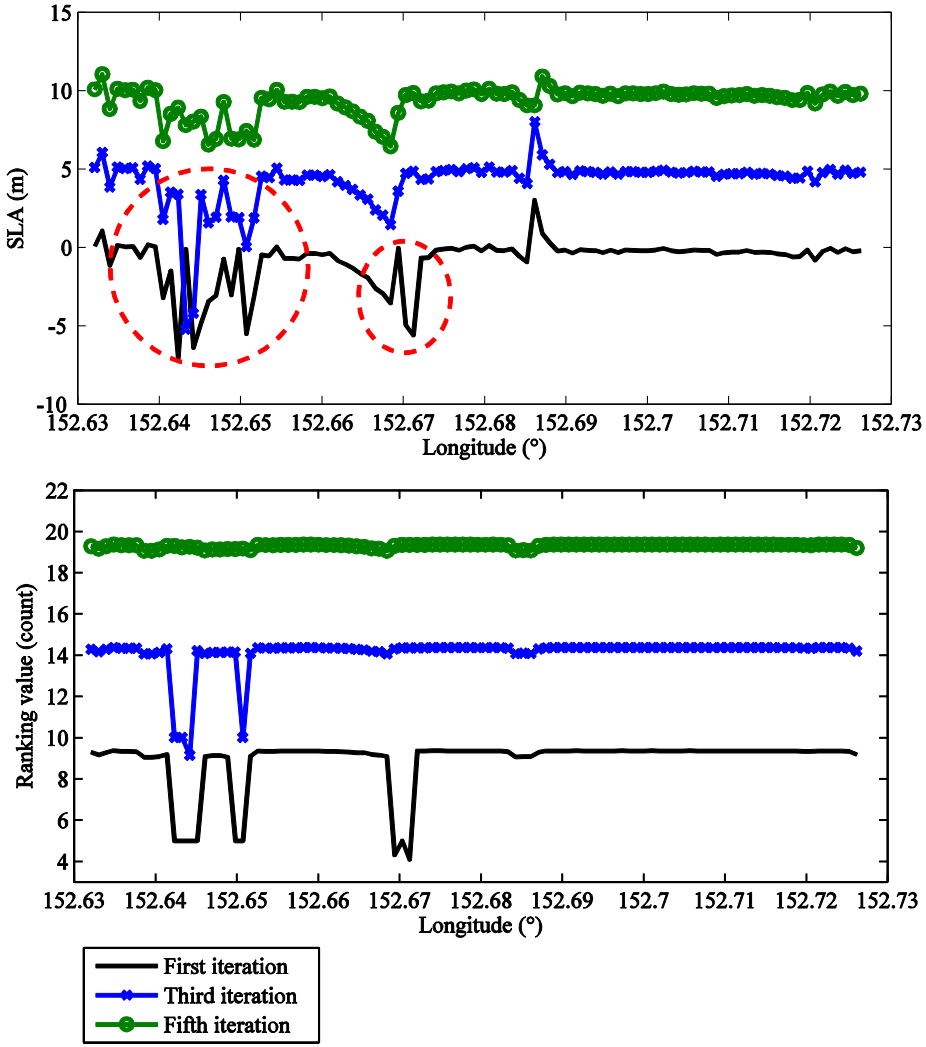
- In the case of 'low ranking', the waveform is retracked iteratively using the other retrackers, which is assigned base on specific rules, until a 'high ranking' retracker is found
- In a condition when 'high ranking' retracker is not found, the retracked SSH corresponding to the next highest ranking retracker is used as the output of SSH profile

- Advantages of the fuzzy expert system are:

  - capability of integrating data from various sources offers a benefit for analysing and interpreting the coastal waveform retracking results

  - the selection of optimal retracker is not only rely on the physical features of waveforms (waveform class) but also considering the statistical features of retracking results

Iterative retracking



- Standard deviation of SLA during the first iteration is 165.89 cm
- Standard deviation at the final iteration is reduced to 94.87 cm

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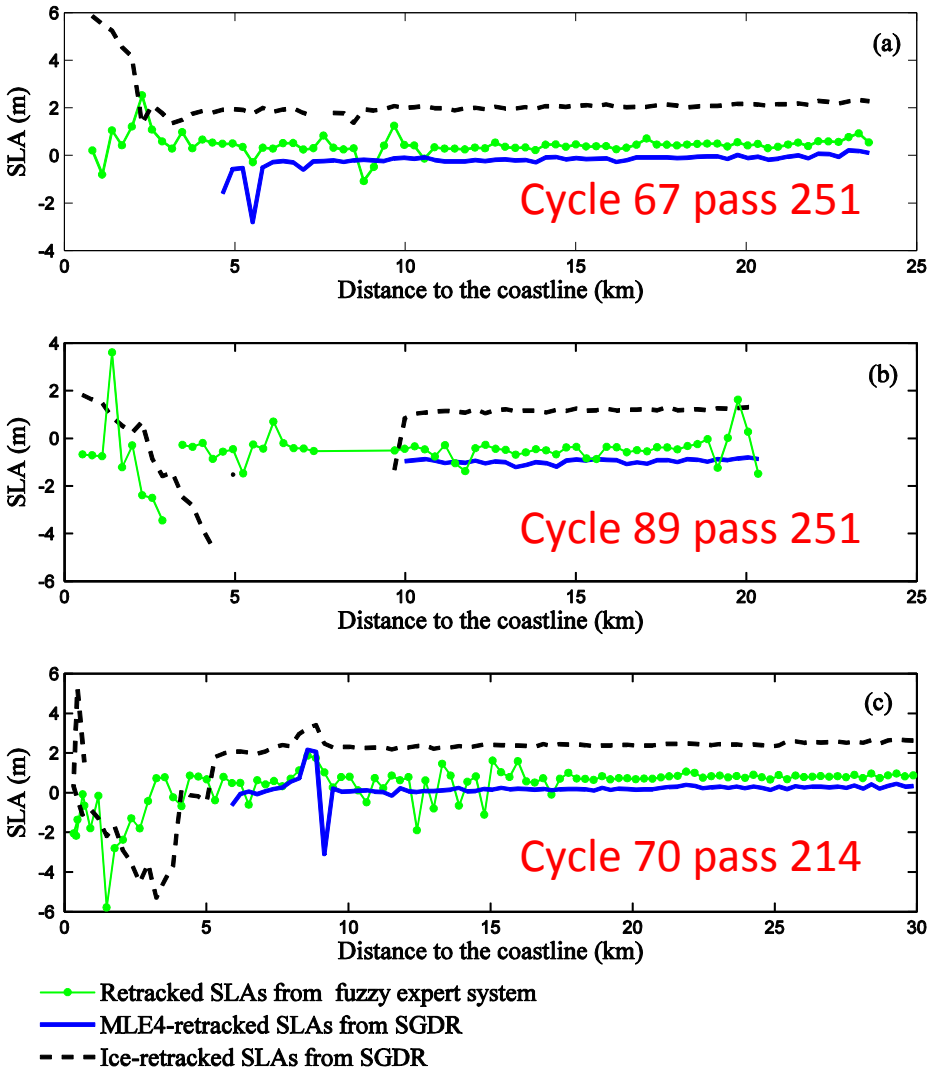
SLA profiles



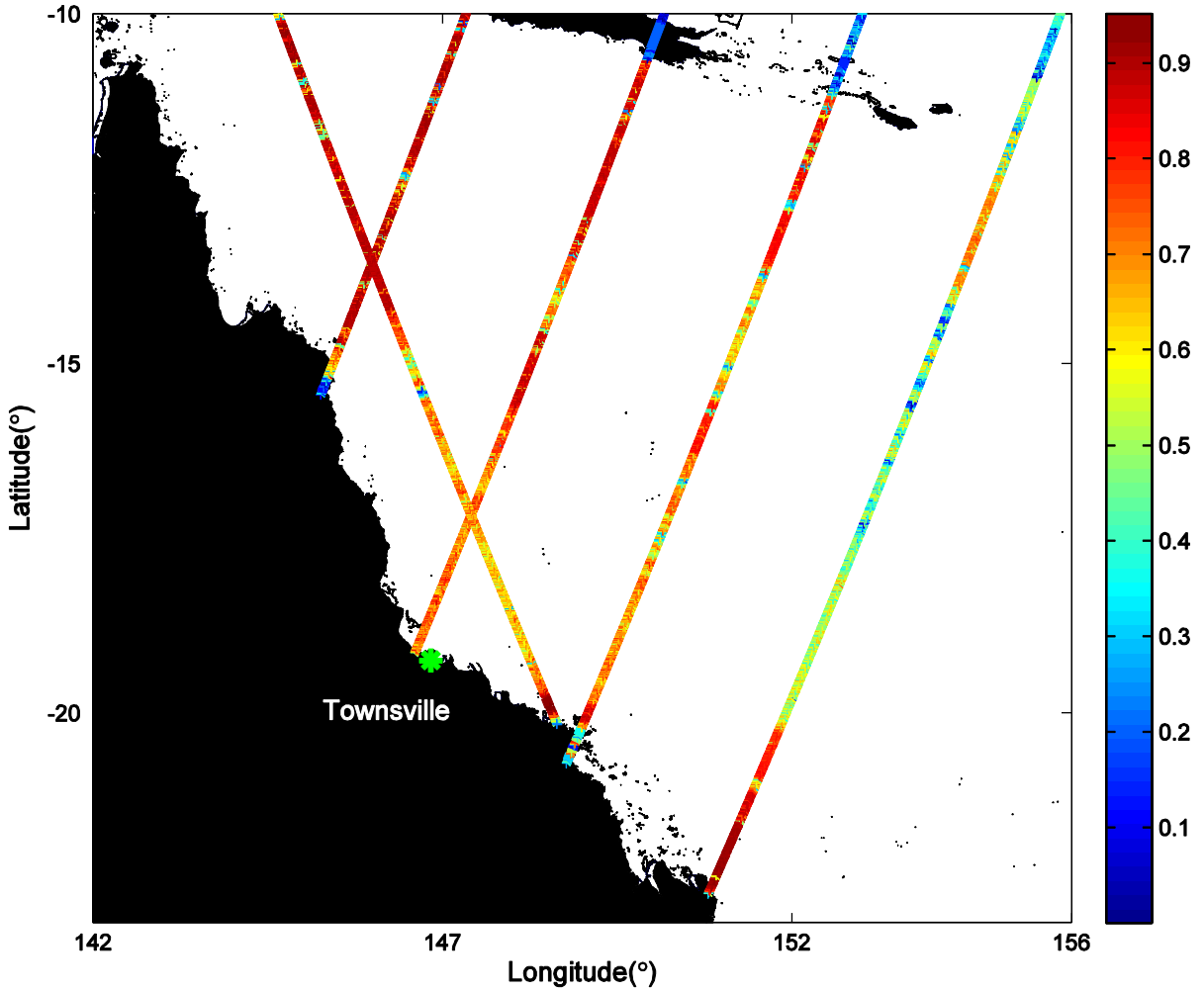
SLAs derived from the fuzzy expert system are precisely extended to the coastline when compared to the SLAs from SGDR

Statistics of retracked SSH

Pass	Raw SSH	Ice retracker		Fuzzy expert system		No. of points
	STD (cm)	STD (cm)	IMP (%)	STD (cm)	IMP (%)	
73	334.89	215.45	35.67	165.68	**59.29**	3540
99	443.68	230.89	47.96	183.60	**58.62**	5900
175	276.05	149.46	45.86	122.58	**55.60**	6018
214	254.24	173.33	31.82	136.95	**46.13**	5782
251	564.73	607.07	-7.50	188.46	**66.63**	2714

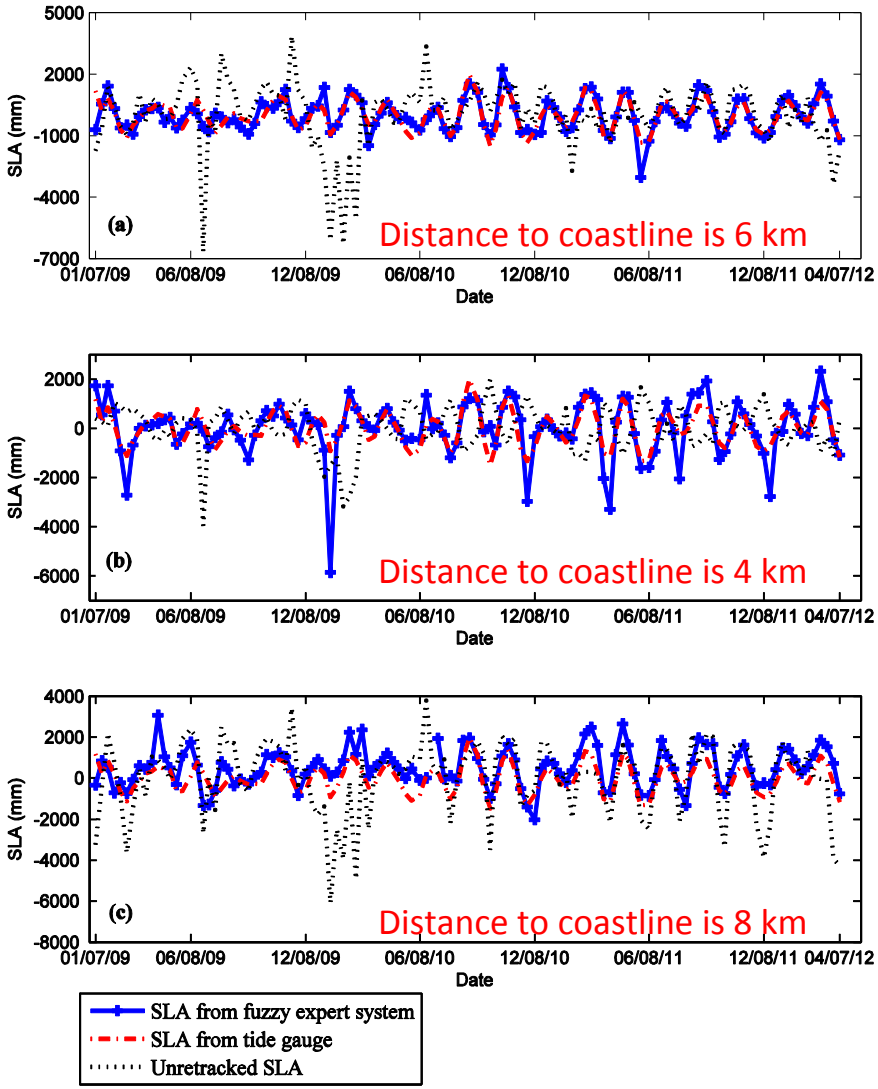
- The highest IMPs are indicated by bold numbers
- Fuzzy expert system has IMPs >50% in 4 of 5 cases

Validation using tide gauge



Max correlation=0.84; along track 175, where distance from the coastline is 6 km and distance to Townsville station is 45 km

SLA time series



- Within 10 km from the coastline, SLAs from the fuzzy system agree well with SLAs from the tide gauge

Conclusions

1. The fuzzy expert system is practical for selecting the optimal retracker, thus improving the precision of SSHs near coasts
2. Comparison with independent in-situ data has shown that there is also a satisfactory agreement between SLAs from the fuzzy expert system and the tide gauge

Future works

1. While combining retracking results from multiple retracker, bias among retrackers is found. Therefore research has to be conducted
2. Comparison with other independent data e.g. high frequency radar will be conducted to validate the results

Thank you

See poster at 20 Years Symposium of Progress in Radar Altimetry

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