Capability of Jason-2 subwaveform retrackers for Significant Wave Height in the calm semi-enclosed Celebes Sea

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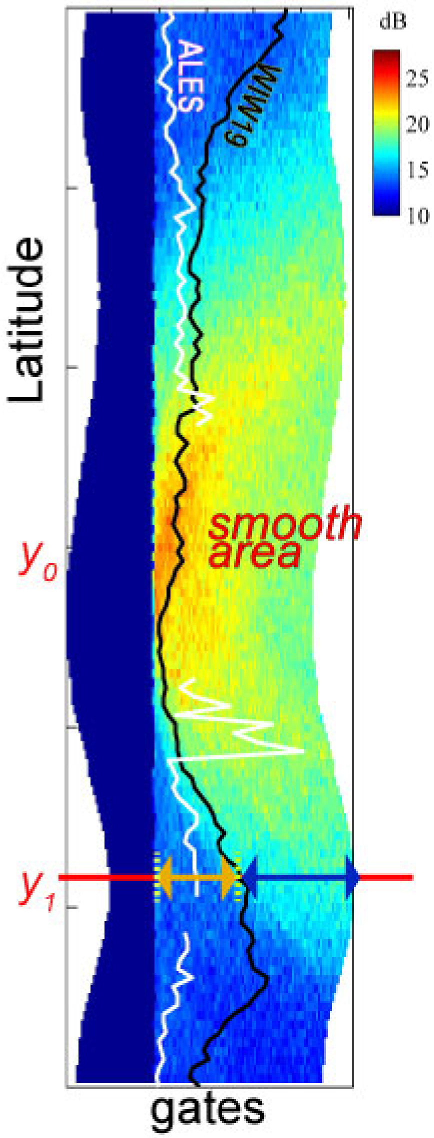
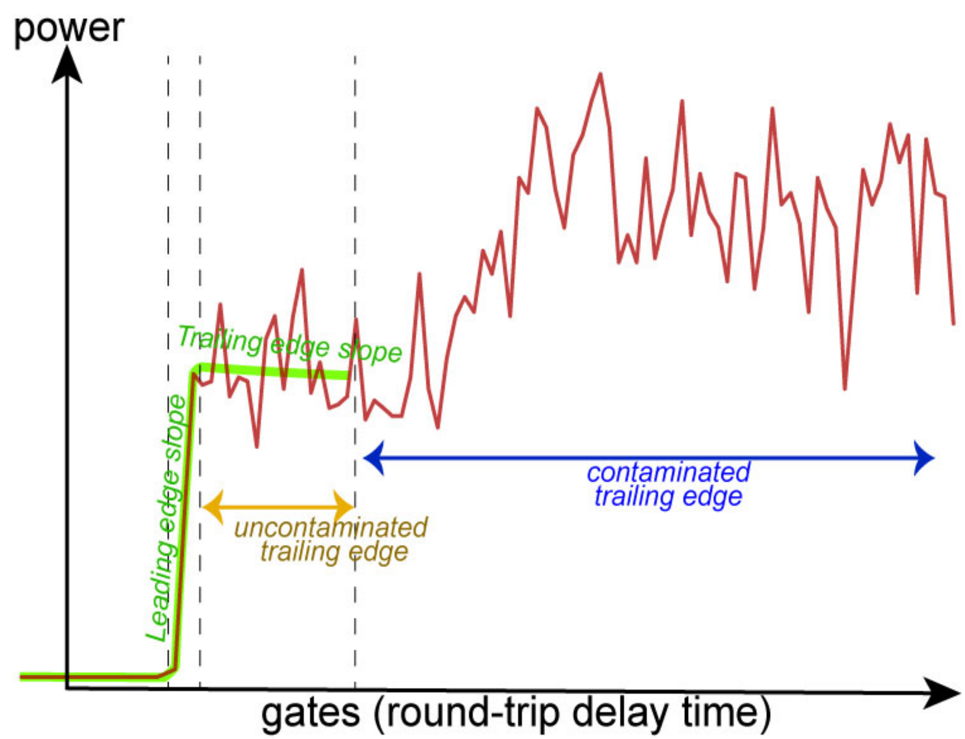
altimetry SWH measurements

- Significant wave height (SWH) can be measured by conventional altimeters as the leading edge rise time of a waveform
  - Since reflections from wave crests returns earlier than ones from wave troughs
- SWH measurements have been reported quite accurate in open oceans, but they have not been fully discussed in areas near lands.
  - Unreliable altimeters observations in coastal area
  - Larger spatial gradients of wave fields

Radargram and Waveform



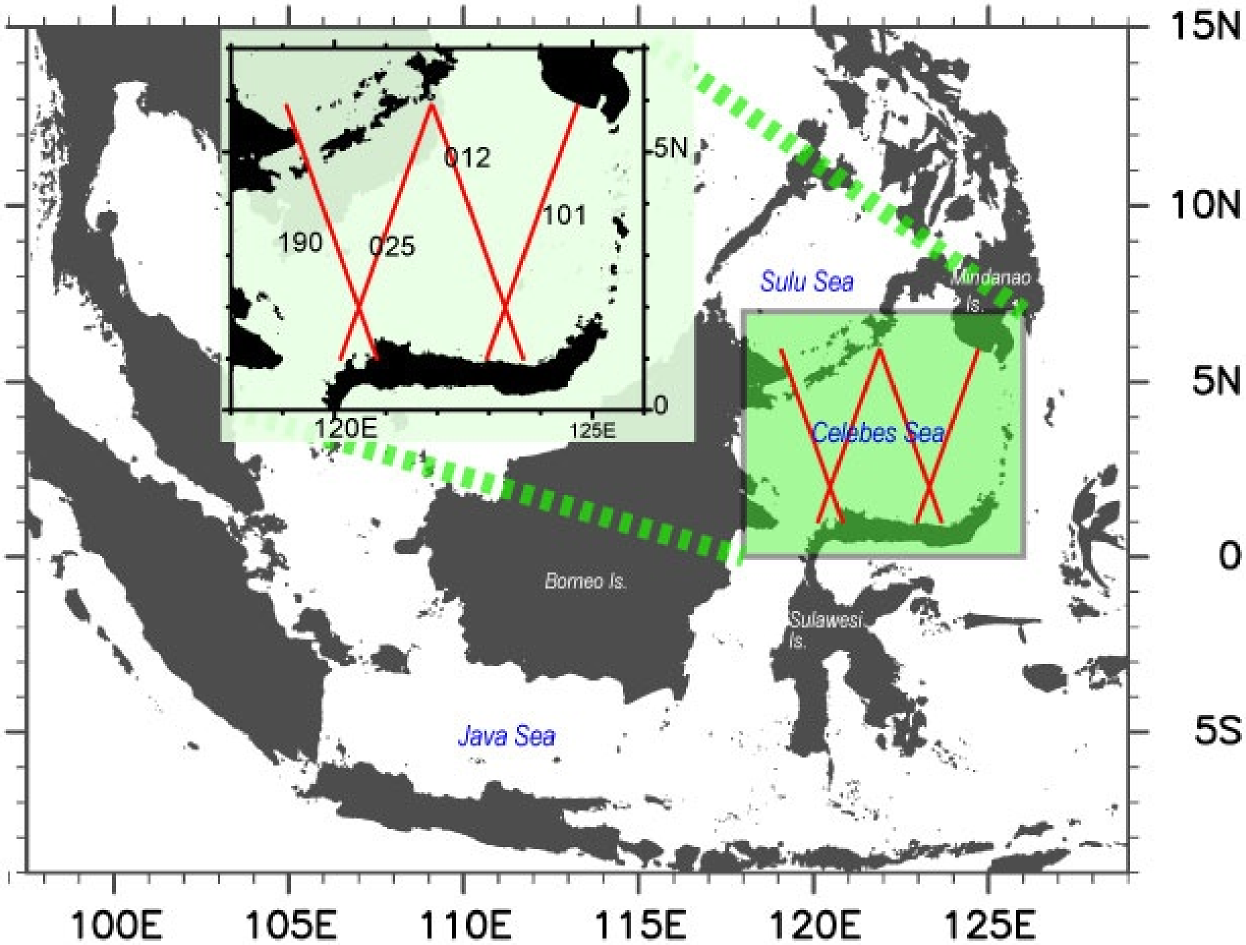


Schematic waveform (right) at a latitude y_1 and radargram (left) affected by an area of smooth sea surface.

Waveforms in the radargram are aligned with respect to the gate of the leading edge bottom.

After [Wang, Ichikawa and Wei (2019)](); WIW19

calm semi-enclosed Celebes Sea



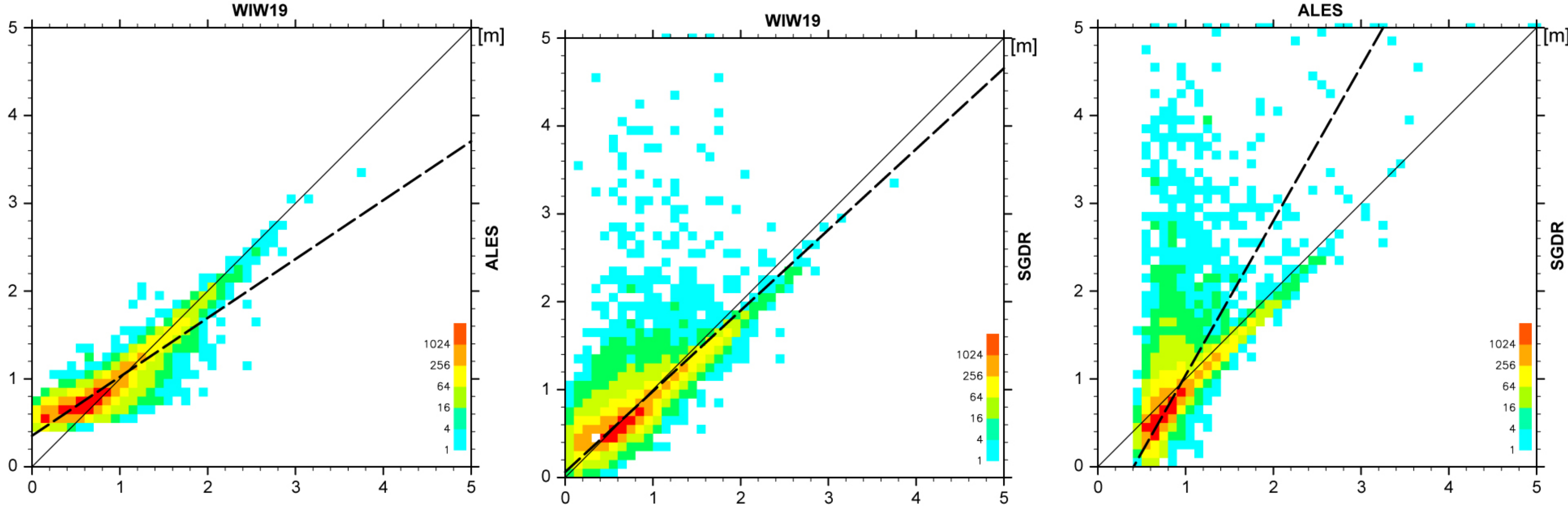
Location of the Indonesian Seas. The Celebes Sea, or the study area of Jason-2 altimeter data, is highlighted as the green inner box. Four Jason-2 tracks are present in the Celebes Sea.

Data

- Jason-2 20 Hz SGDR (ver d)
    - From 2008/07 to 2015/04
  - 20 Hz data are filtered based on Product Handbook
    - except that SWH=0 data are not used in this study
  - Averaged over 18 km along tracks (51 points)
    - Median Absolute Deviation (MAD) filter is applied

- nested WW3 models (1/2° outer box, 1/12° inner box) are used for comparisons
    - From 2014/01 to 2014/05

Intercomparison of Jason-2 SWHs

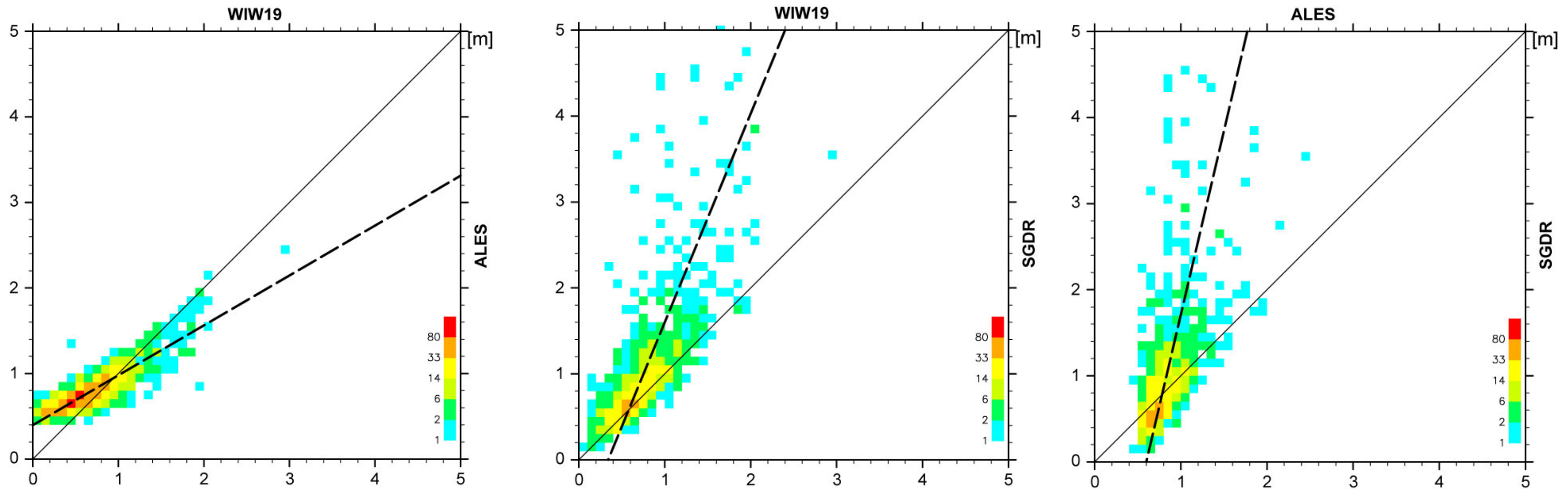


Scatter density plots of Jason-2 SWH values between WIW19 and ALES datasets (left), WIW19 and SGDR datasets (middle), and ALES and SGDR datasets (right). Orthogonal regression lines are indicated by bold broken lines. Reference equivalence lines are also indicated by thin lines.

Distance from contamination sources

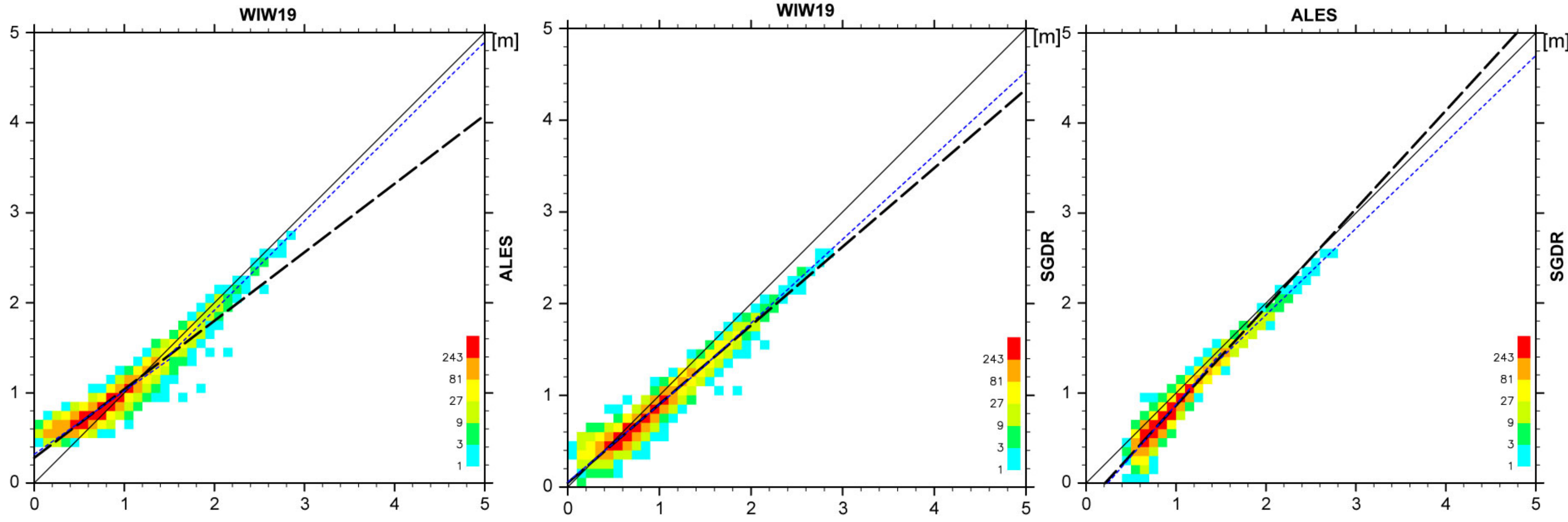
- Discrepancies of three algorithms would mainly depend on the estimation window size
- Distance from contamination sources (i.e. slicks or lands) can be identified as the length of uncontaminated trailing edge (UTE) in WIW19
  - Separate observations by the UTE length
    - small UTE (close to contamination sources)
      - full-length SGDR should be affected by contamination
    - large UTE (far from contamination sources)
      - estimation window size in WIW19 is as long as full-length SGDR , although it is a “subwaveform” retracker

For contaminated observations



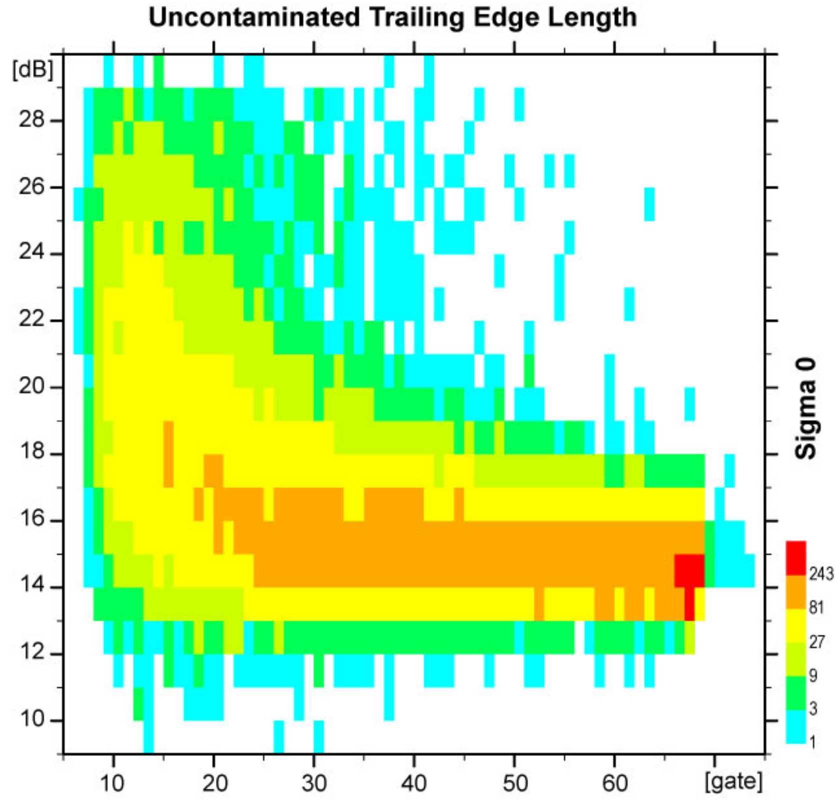
- Observations near contamination sources (4.5km)
- WIW19 vs ALES (left), WIW19 vs SGDR (mid), ALES vs SGDR (right)

For uncontaminated observations



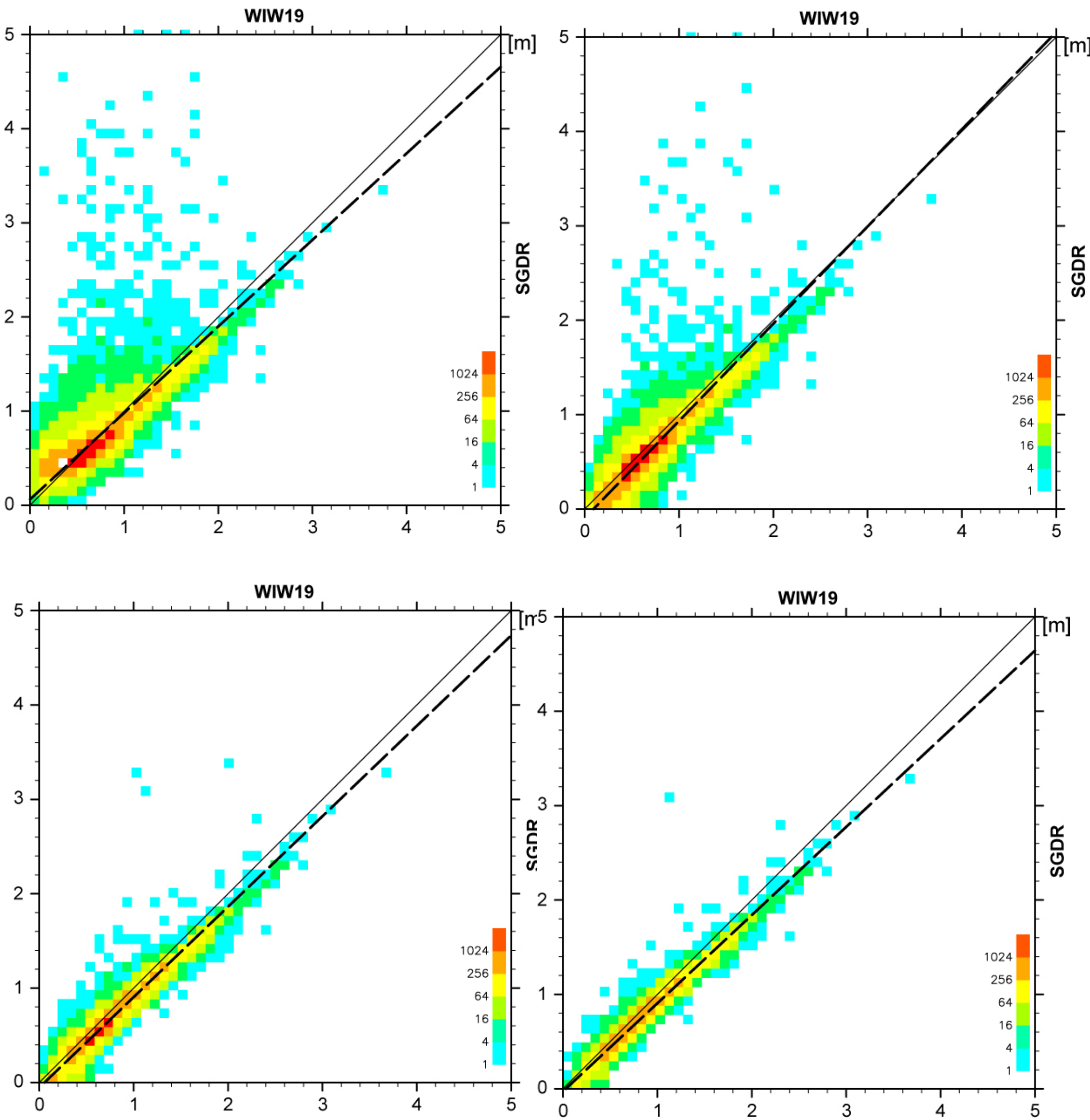
- Observations with no contamination sources within a footprint (9 km).
- WIW19 vs ALES (left), WIW19 vs SGDR (mid), ALES vs SGDR (right)
- Dotted blue lines are orthogonal regression lines separately calculated for x>1.5m and x<1.5m.

Filtering sigma0 blooms in SGDR



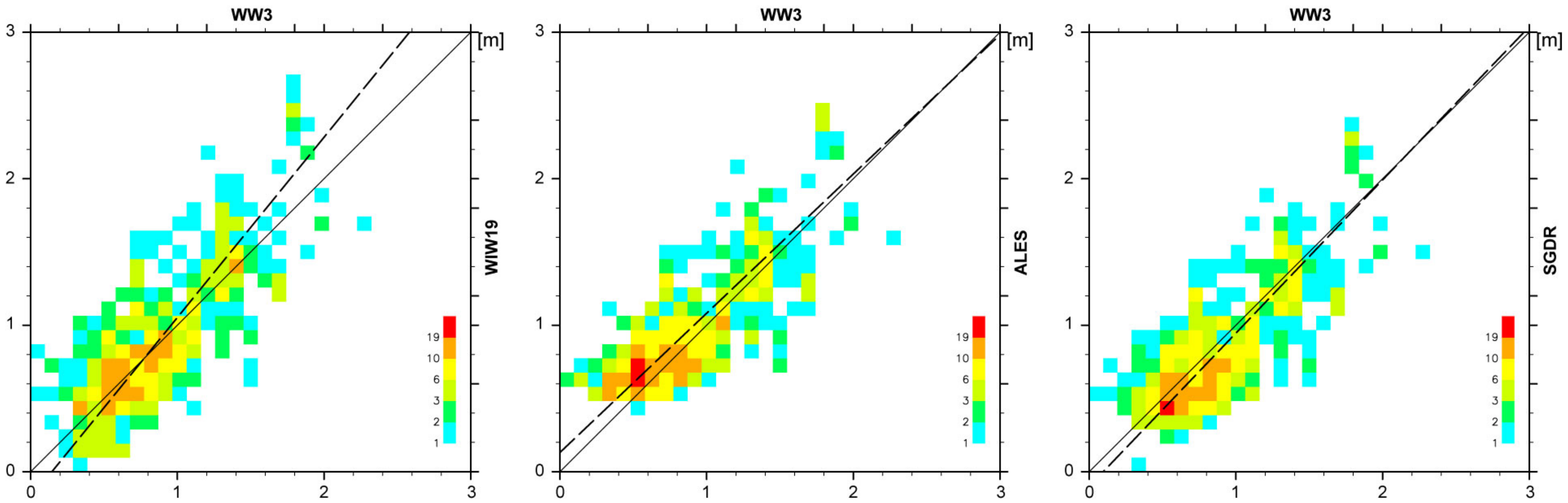
Scatter density plot between the UTE lengths and sigma0 values of 18-km averaged SGDR data.

Examples of sigma0 filters to SGDR



Scatter density plots between WIW19 and SGDR, but data are excluded when SGDR sigam0 is larger than 30 dB (top left), 22 dB (top middle), 19 dB (top right), 16 dB (bottom left), and 15 dB (bottom middle)

Comparison with WW3 model(uncontaminated obs)



- Scatter density plots against WW3 model; WIW19 (left), ALES (middle) and SGDR (right) for observations with UTE length larger than 60 gates.

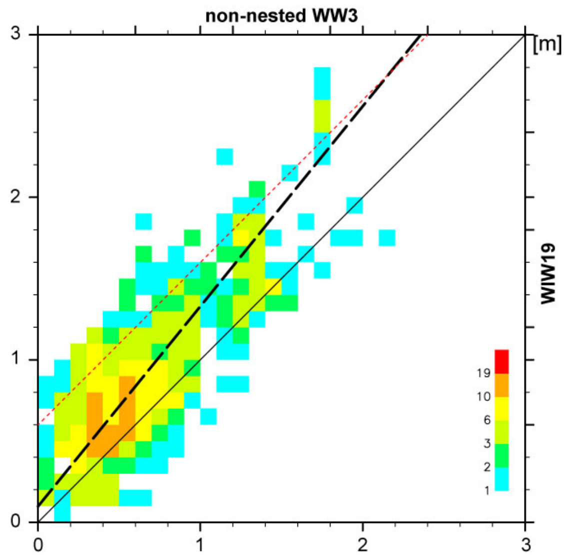
Statistics of agreement with WW3 model

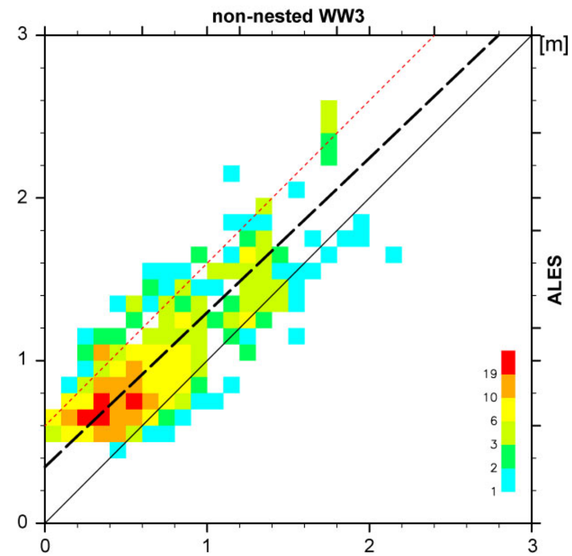
Statistics	WIW19	ALES	SGDR
Number of data	2010	2125	2018
RMS Diff.	0.30 m	0.30 m	0.40 m
Slope of reg. line	1.23	0.87	1.30
Intercept of reg. line	−0.17 m	0.22 m	−0.20 m
Pearson Corr. Coef.	0.76	0.74	0.55

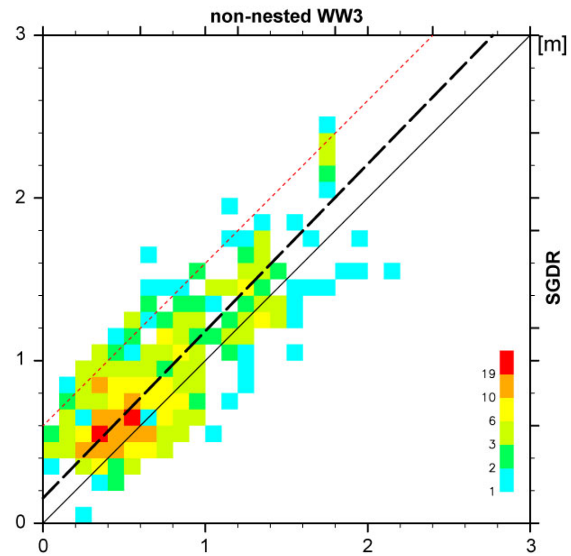
Whole data (top)
and
with UTE filter >60 (bottom)

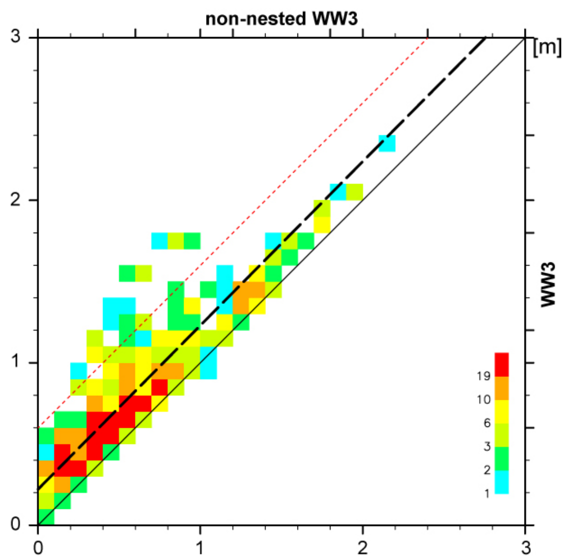
Statistics	WIW19	ALES	SGDR
Number of data	583	580	537
RMS Diff.	0.30 m	0.27 m	0.28 m
Slope of reg. line	1.23	0.95	1.05
Intercept of reg. line	−0.18 m	0.13 m	−0.10 m
Pearson Corr. Coef.	0.78	0.79	0.77

non-nested WW3 vs nested WW3





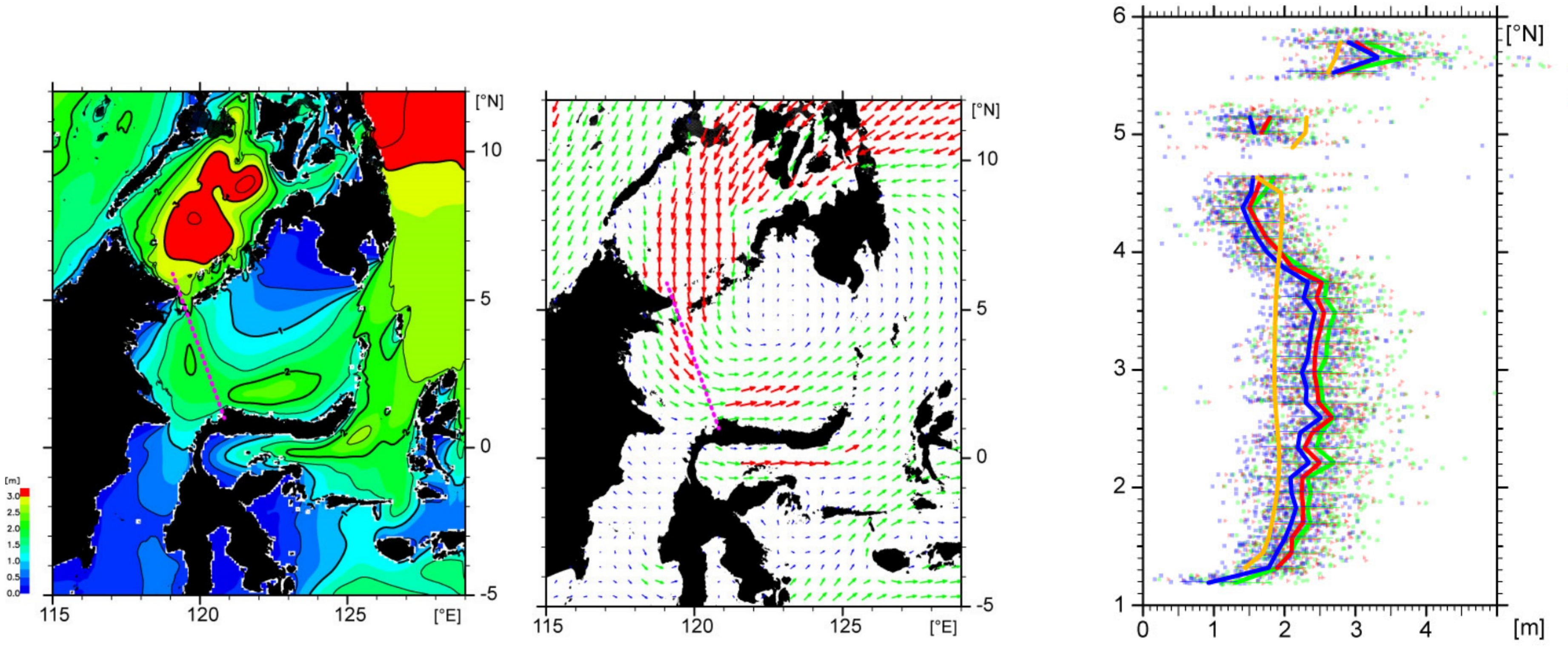




Scatter density plots for non-nested WW3 model vs uncontaminated observations of WIW19 (top left), ALES (top middle), SGDR (top right) and nested WW3 model (bottom).

The reference equivalence lines for 0.6-m swell are plotted by red dotted lines for reference.

Example of localized SWH



The SWH field in the nested WW3 model (left) and the NCEP wind field (middle) at 10:00 on 2014/01/12. Jason-2 passed along Track 190 (shown by purple broken lines) six minutes before, as shown in the right panel; SWH values by WIW19 (green), ALES (red), and SGDR (blue) are plotted together with WW3 model value (orange).

Conclusions

- Two subwaveform retrackers (ALES and WIW19) are compared with SGDR data in the calm semi-enclosed Celebes Sea.

- Using radargrams, an optimal index can be obtained how Jason-2 observation points are close to contamination sources (e.g. slicks and lands)
  - When observations are close to these contamination sources,
    - SGDR occasionally estimates unrealistic SWH values due to contaminated echoes. They could be partly filtered by sigma0 criterion.
      - Strict sigma0 filtering certainly reduces SWH outliers and improves data quality, but unnecessarily removes uncontaminated observations at the same time.
    - Subwaveform retrackers successfully avoid to use contaminated echoes within the trailing edge of the waveforms
  - When uncontaminated full-length waveforms are available,
    - All algorithms are well correlated
    - Except that ALES retracker has a positive bias in a calm sea state (SWH < 1 m), whose state is not unusual in the calm semi-enclosed Celebes Sea.
      - Estimation window sizes of ALES could be too short in the calm sea states to properly fit the Brown model to a waveform with the steep leading edge.
        - » Improved algorithm WHALES could treat this low SWH problems.

Conclusions

- Agreement with WW3 model is good even in the Celebes Sea
  - Especially when limited to uncontaminated observations.
    - WIW19 retracker can achieve similar agreement with all available observations without strict limitation, providing better data availability
      - data availability would be especially important e.g., in assimilating fast-varying SWH field in coastal areas.
  - Agreement becomes worse if swells from the Pacific is excluded in the WW3 model
    - suggesting that the swells are almost always present in the Celebes Sea, in spite of its semi-enclosed nature.
  - Comparisons with individual Jason-2 data also reveal discrepancies that may be caused by insufficiency of the present WW3 model calculated from the NECEP wind fields
    - e.g., displacements of locally-confined SWH events with respect to Jason-2 tracks.

- Together with improved quality of the altimetry SWH data, better wave models with better wind field inputs would further improve wave fields descriptions in semi-enclosed coastal seas.