Sea Level CCI project

Phase II
1st annual review
Improvement of the sea level in Arctic: waveform classification

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Summary

- Introduction / General processing scheme
- Ocean/Sea Ice identification through a waveform classification
- Results of the Neural Network approach
- Introduction to the next step: the retracking
- Conclusion
The WP2220 aims at proposing a new sea level estimation in the Arctic ocean through the re-processing of the ENVISAT measurements.

- The first step consists in identifying measurements over the different surfaces: ocean, ice floe, leads, etc ...

Introduction
General processing scheme
Definition of the waveform classes

- After analyzing ENVISAT waveforms over all surfaces of interest, 12 classes are defined to describe the main observed waveforms.
- Knowing that the classification is performed on all ENVISAT measurements, it is important to define a class for all waveform shapes of interest but also for all other waveforms.
**Method:**

- Parameters describing the waveform shape are computed (peakiness, slope of the trailing edge, amplitude computed in different parts of the waveform, etc ...) and used as input of the 2 Neural Network algorithms.

- The priority is given to the neural network using retracking outputs to bring geophysical information when it is possible.

- Both NNet have learned on 2 specific learning base, each built with ~2000 waveforms selected over all surfaces.
Ocean measurements are identified by class 1.

Measurements affected by sea ice are mainly identified by classes 4, 6 (and a class 5 at borders). The different classes correspond to different types of surface backscattering.

Peaky echo (corresp. to leads) are identified by class 2.

The sea ice is easily detected and discriminated from ocean. Leads can be detected through RA-2 echoes with a peaky shape.
At transition between ocean and sea ice, all the different types of echo shapes are identified.

The waveform classification allows to precisely quantify the sea ice extent.
Seasonal variations

- The proportion of peaky waveforms strongly increases during the sea ice melting and decreases as the freeze-up begins.

- Sea ice extent is maximum in February/March, the minimum is in September/October.

Ocean waveforms (class 1)
Peaky waveforms / leads (class 2)
Sea ice waveforms (classes 4, 5 and 6)
Seasonal variations

- Percentage of ocean waveforms per grid boxes over 1 year (2008):
  - Ocean in magenta (100%)
  - Sea ice in blue (0%)
Evolution of sea ice types and leads with time

Class 4 ➔ sea ice waveforms with high backscattering

Class 2 ➔ leads / peaky waveforms
- Patterns of leads concentration logically evolve with sea ice melting. The maximum proportion of leads is reached in June/July when melting is maximum.

- Leads are always found in all seasons but not in all regions.

→ Issues to extend sea level estimates in certain regions/periods
A good classification is just the beginning …

- Next step to improve the Arctic sea level to better process the selected measurements.
- Improvement of the **retracking** on the selected measurements
- **Editing of** outliers and corrupted data: hooking phenomenon, wrong retracking estimates …
- **Accounting of penetration issues** in Ku-band (for freeboard estimation)
- **Applying of** the most adapted corrections and MSS
- **Filtering and averaging** of the data (AT or on grids)
- **Filling** of potential gaps

Not so simple

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Plot of along track SLA and CLS classification
ENVISAT Cycle 13 01-22-2003

SLA on this plot:
SEAICE retracking and MSS_DTU13
Next step: retracking

- A lot of retracking algorithms have been studied for years thanks to different projects: MLE4, MLE3, SEAICE, ICE1, ICE2, ICE3, ICE3Sup, BAGP, Red-3, etc.

- 2 solutions:
  - 2 algorithms, 1 for ocean and another for leads → manage bias between estimates
  - 1 algorithm for all measurements → A new adaptive algorithm is needed

- 1 solution currently under evaluation over sea ice: IceNew (L. Amarouche)
  - Performances already evaluated over ocean in the frame of the PEACHI project
  → Very good performances, similar to MLE4 (better $\sigma_0$)
  - New formulation of the Brown model allowing to account for the mean square slope of the surface

\[
S(t) = \frac{P_u}{2} \left[ 1 + \text{erf} \left( \frac{t - \tau - \frac{4c \sigma_e^2}{\Gamma h}}{\sqrt{2} \sigma_e} \right) \right] \exp \left[ -\frac{4c}{\Gamma h} \left( t - \tau - \frac{2c \sigma_e^2}{\Gamma h} \right) \right] + N,
\]

\[
\Gamma = \frac{4 \text{mss} \gamma}{4 \text{mss} + \gamma}
\]

with mss = mean square slope
A classification of the RA-2 waveforms based on a Neural Network approach has been developed and successfully performed over the entire ENVISAT period.

Sea ice is precisely detected/identified and different types of waveform shapes / surface backscattering / sea ice are observed.

The leads detection provides very good results as shown by the different animations and diagnoses presented.

The waveform classification allows to compute the Arctic sea ice coverage which is consistent with external data (OSI-SAF, NSIDC).

Many issues are currently under investigation to compute an improved Arctic sea level.

The “IceNew” retracking algorithm allowing to process both leads and ocean waveforms.

A similar processing is developed in parallel on AltiKa data in the frame of the PEACHI project with Ka-band advantages: lower microwave penetration, better precision, etc …
THANK YOU FOR YOUR ATTENTION!!