Ships and Iceberg detection

- WP6100

Scientific background and Purpose

• Icebergs are a key component of the Southern Ocean circulation and climate.

•They represent half of the mass loss of the Antarctic Ice cap.

•They can transfer fresh water far away from the coast into the ocean interior

• Large Iceberg transport the major part of ice while small icebergs are the main component of fresh water flux through melting

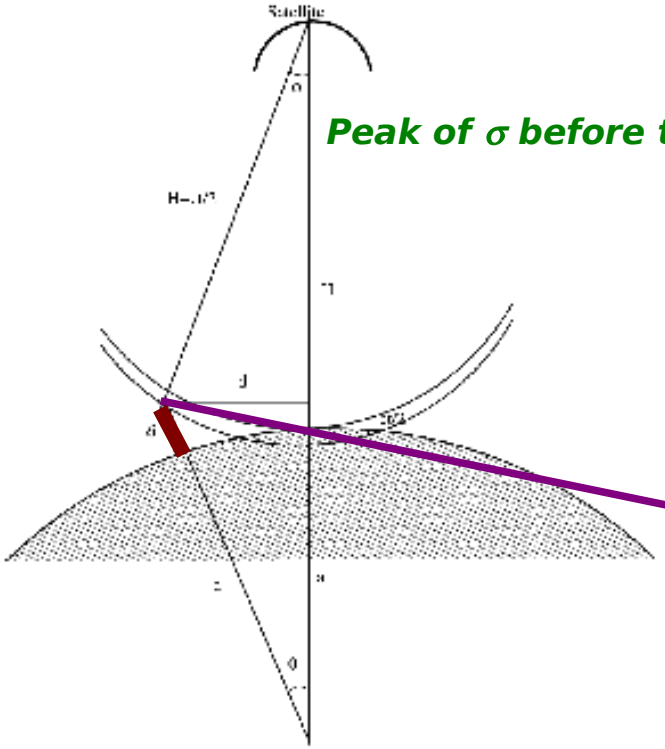
2

•Previous studies have shown that classical pulse limited altimeters are powerful tools to detect and characterize small (<3km in length) icebergs .

• The WP6100 main purpose is to demonstrate the capacities of SAR altimetry to detect icebergs and to determine the best L1A processor configuration.

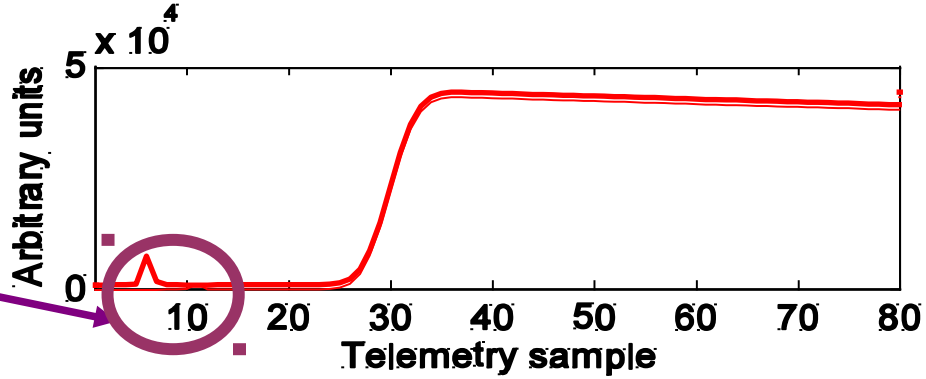
Icebergs detection using Pulse Limited Altimeter (LRM data)

- Targets emerging from the sea (iceberg, ships, lighthouse) : detectable signature in the noise part of Altimeter WF [*Tournadre et al , 2008, 2012*].
- In the waveform space the signature is a parabola determined by the orbital parameters.
- Detection algorithm: detection of parabola in the WF ***thermal noise part*** (TNP). Works only in open water



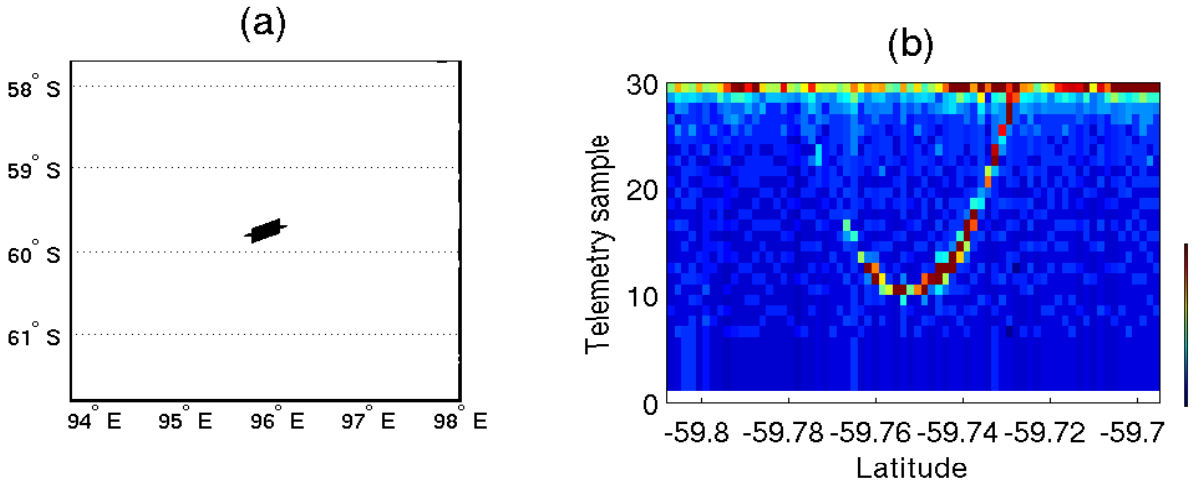
Peak of σ before the mean sea level

EX. signature of single iceberg (Jason WF)



Example of iceberg signature in WF TNP

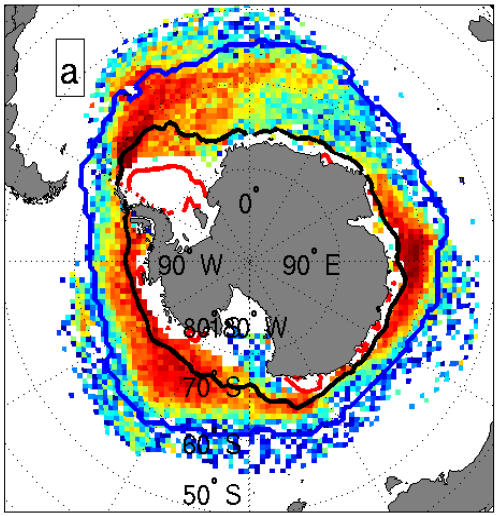
•In the waveform space the signature is purely deterministic and depends on the orbital parameters.



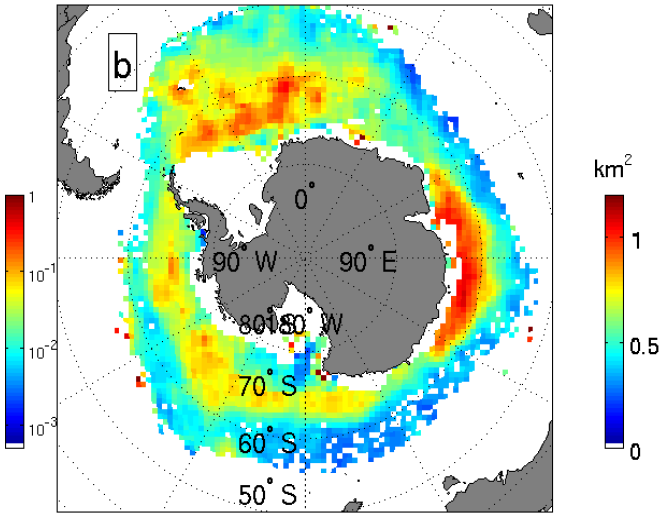
ALTIBERG Small iceberg Data base

- A small iceberg data base from 1992 to present. Nine pulse limited altimeters used .
- Climatology of iceberg area and Volume of ice

Mean Ice volume (km^3)



Mean Iceberg area (km^2)



WP6100 detection of iceberg in SAR echoes

• The case study concerns two Cryosat-2 orbits in SAR mode for which icebergs were detected.

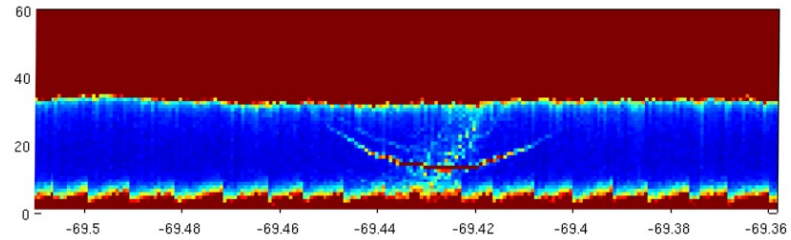
•These two orbits were converted to Sentinel-3 like data and are used to test the iceberg detection algorithm and the method to estimate the iceberg characteristics.

•As the detection sensitivity strongly depends on the number of samples in the waveform TNP (i.e. above sea level) and on the TNP noise level different processor configurations are tested to determine the best one.

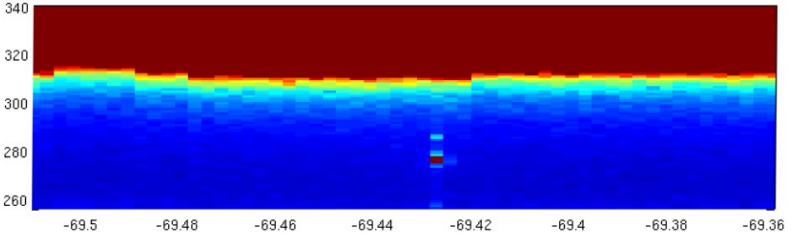
Iceberg signature in SAR echoes

- range alignment including slant, tracker and Doppler range corrections , stacking and incoherent summation of stacks of co-located Doppler beams are used to produce L1B echoes.
- The parabolic signature in LRM reduces to a bright spot in SAR echoes
- Several image processing algorithms have been developed to detect bright spots in imagery (especially for medical applications)

RDSAR -LRM



SAR

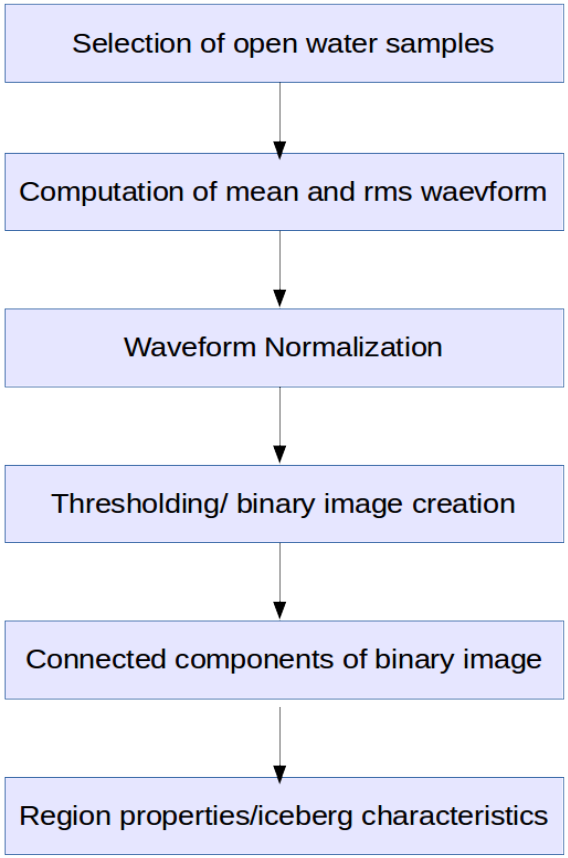


Configurations tested

- Four configurations are used to test mainly the impact of zero padding and hamming filtering on the noise level of the TNP of waveforms
  - *Default*
  - *Default, no zero padding*
  - *Default zero padding, hamming filtering*
  - *Default, no zero padding, hamming filtering*

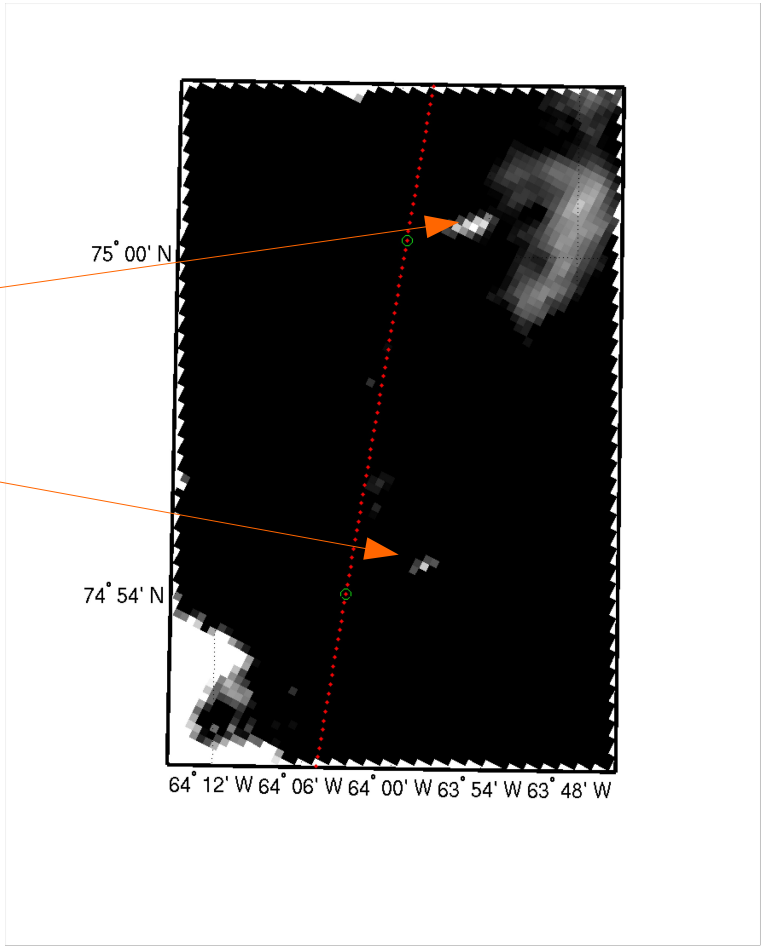
Post-processing: iceberg/ship detection algorithm

- Select only open water samples
- Compute mean and rms of waveforms
- Normalized WF $$WF'(i,j) = \frac{\left(WF(i,j) - \overline{WF}(j)\right)}{\sigma_{WF}(j)}$$
- Compute binary image, by thresholding normalized WF at 4
- Compute connected components (CC) of binary image
- Compute region properties of CC



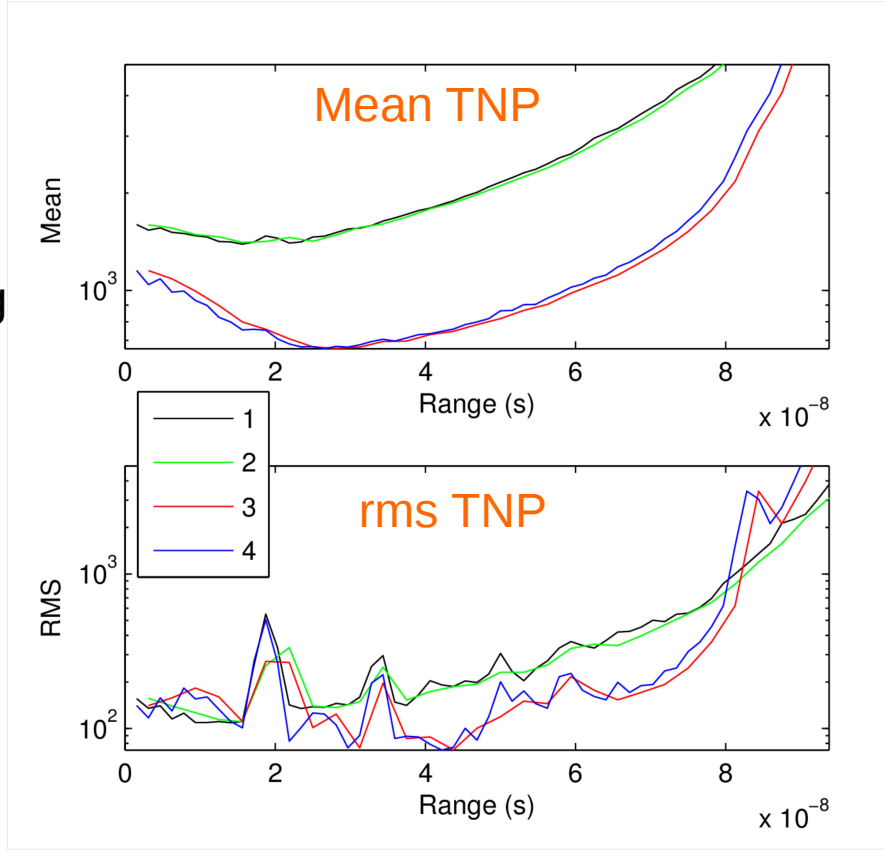
Case study 1 Icebergs near Greenland

- Modis image July 10th 2015 17:40 UT
- Cryosat-2 pass 6 hours latter
- Two icebergs
- Detection algorithm applied to the 4 configurations
- Analysis of the detection results



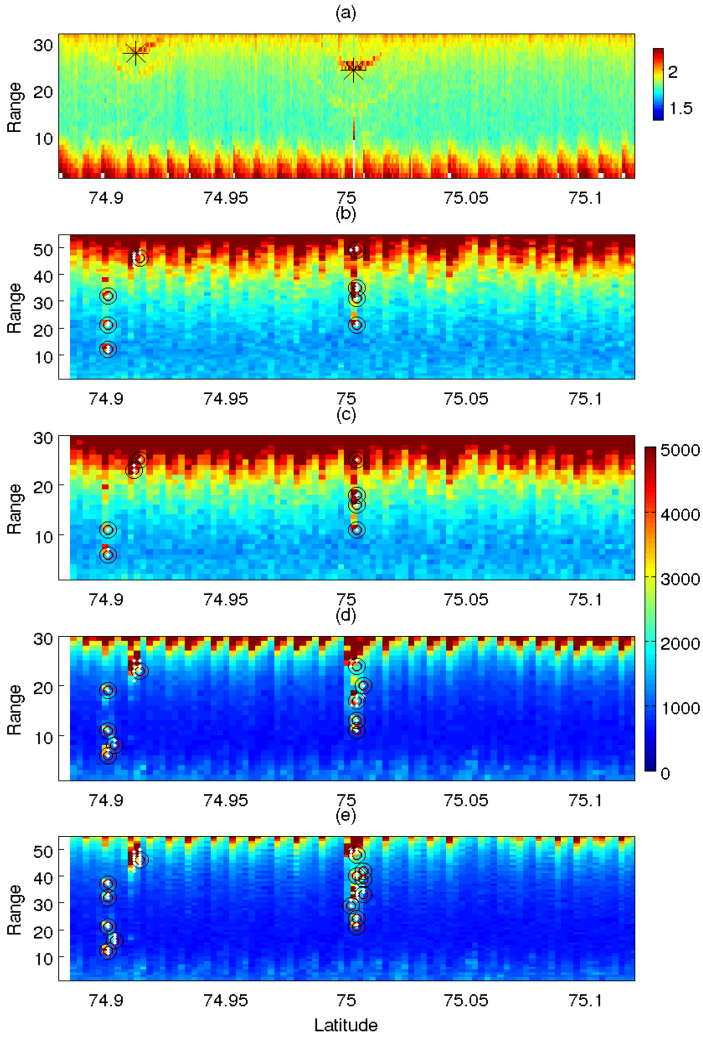
Noise level of the waveforms Thermal noise part

- The detection performance depends on the noise level
- Comparison of TNP noise level for the 4 configurations.
  - **1-2** *zero* and *no zero padding* no filtering
  - **3-4** *zero* and *no zero padding*, filtering
  - Large noise reduction by filtering
  - More samples available for detection if zero padding



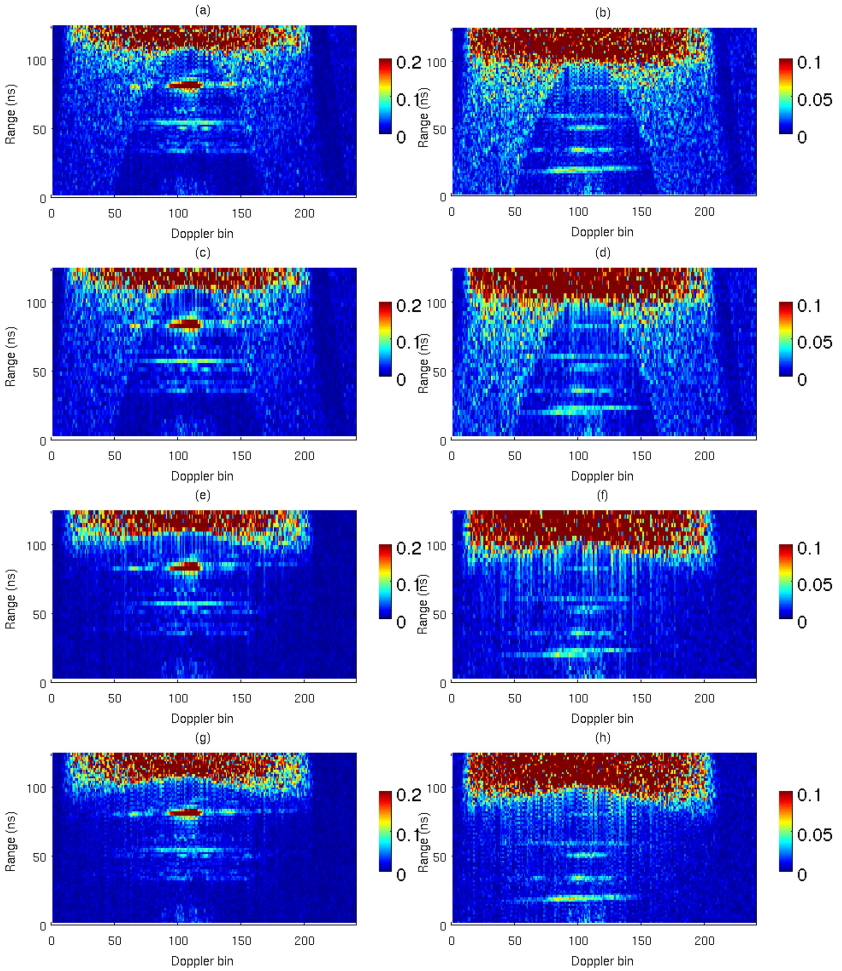
Comparison of Detection

- The two icebergs are detected in all config
- **RDSAR/LRM** algorithm detects only the two main parabolas (*black* *)
- **SAR** detect several bright spots associated to different elevation/part of the same iceberg (*black o*)
- Detect a small iceberg not detected in RDSAR
  - Zero padding increase the size of bright spot, easier detection
  - Noise reduction by filtering better detection especially ner leading edge.



Iceberg signatures in L1BS (stacked) data

- Signature of the larger iceberg (near 75°N and the smaller one near 74.9°N Iceberg near. Configurations 1 (top) to 4 (bottom)
- In stacked data signature should be a *straight line of constant backscatter*
- High specularity of ice reduces the signature to lower incidence
  - Clear signature of the different elevation within the iceberg
  - Filtering clearly reduces the noise at higher incidences



Comparison of size estimate

- **RDSAR** : area infer from range and backscatter (Tournadre et al 2012)
- **MODIS** number of pixels
- **SAR**: The length in range, *ly* from minimum to maximum range value of all signature at the same along-track location, width, w_y, along-track width at a 300 m resolution. Area : $A_i = w_y\,dx\,l_y\,dy$ *dx, dy* along and across-track resolutions.
- Size estimates closer to RDSAR and MODIS using configuration

Iceberg's area estimate in km²						
	Conf 1	**Conf 2**	**Conf 3**	**Conf4**	**RDSAR**	**MODIS**
Iceberg 1	0.5-0.8	0.3-0.4	0.6-0.8	0.9-1.3	1.1	0.6-1.0
Iceberg2	0.2-0.3	0.1-0.15	0.3-0.4	0.3-0.4	0.3	0.3-0.4
Iceberg3	0.1-0.2	0.1-0.2	0.25-0.36	0.17-0.24	-	-

Conclusions

•Sentinel-3 L1B data are powerful tools to detect icebergs and ships.

• Comparison with RDSAR, [i.e. ~ classical pulse limited altimeter) data shows that SAR processing improves the detection;

•Comparison of the different DeDop processor configurations show:

- zero padding improves detection by increasing the relative size of signature (more samples)
- Hamming filtering improves detection by reducing the noise level of the waveforms TNP.

• Detection could be further improved by extending the analysis window during the stacking process. The swath over which icebergs can be detected could thus be doubled.

Thank You!