Tournadre et al (2008) presented a method of detection of iceberg in HR (20Hz) altimeter waveforms. We present an improvement of the method that allows, assuming a constant iceberg freeboard elevation and constant ice backscatter coefficient, to estimate the iceberg area and the distribution of the volume of ice on a monthly basis. The complete Jason-1 archive (Versions: covering the 2002-2010 period was processed to produce a small iceberg (length<2km) data base for the southern ocean. It gives a description of the small iceberg distribution at unprecedented time and space resolutions. The iceberg sizes follow a log-normal distribution with a mean of 630 m. The strong seasonal cycle of iceberg sizes reflects the melting of icebergs during the austral summer (estimated at 1.5 m/day). The total volume of ice in the southern ocean has an annual mean value of about 400±120 Gt, i.e. ~35% of the volume of large icebergs. It can thus play a significant role in the injection of freshwater in the ocean. The distribution of the ice volume which has strong seasonal cycle presents a very contrasted in the three ocean basins (South Atlantic, Indian and Pacific oceans). The analysis of the relationship between small and tabular icebergs shows that a majority of small icebergs are directly associated with the tabular ones but that vast regions, such as the eastern branch of the Wedell Gyre, exists where the transport of ice is done only by the smaller ones.

Estimation of icebergs area
For climatology, ocean circulation modeling, impact on biology, the volume of ice is the key parameter. The method is improved to include an estimate of the iceberg surface.

Detection gives 2 parameters (range \( r \) and backscatter \( b \)) depending on distance from nadir \( r \) (iceberg area \( A \), iceberg freeboard elevation \( h \) and iceberg surface backscatter \( b \)). Two parameters, 4 unknowns, hypothesis necessary.

Freeboard fixed to 28 m, i.e. thickness of 250 m (Gladstone et al 2001).

Parameters, 4 unknowns, hypotheses

\[ h = f(r, A, b, \sigma) \]

Detection algorithm: detection of parabola in the noise part of the WF. Works only in open water.

Detection of small icebergs over 9 years, Estimation of icebergs area and of the volume of ice in the Southern Ocean. Unprecedented description of the time and space variability of icebergs distribution.

Small icebergs act as a diffusive process of ice from large tabular icebergs. They carry about 35% of the total volume of ice from icebergs. Estimation of fresh water flux from icebergs.

CONCLUSION & PERSPECTIVE
Detection of small icebergs act as a diffusive process of ice from large tabular icebergs. They carry about 35% of the total volume of ice from icebergs. Estimation of fresh water flux from icebergs. Extension to Topex/Poseidon, Jason2 Envisat archive in the near future.

Relation with giant tabular icebergs
Brigham Young University Antarctic iceberg database in 2008-2009. The red line indicates the C19a trajectory in sea ice and the black line in open water. The number of small icebergs calved from C19a varies from 2-3/10days to 20/10days.

Number of small icebergs detected along the trajectory of the C19a tabular iceberg from Brigham Young University Antarctic iceberg data base in 2008-2009.

Ratio of small detected icebergs closer than 200 km to a large one and mean distance
Two regimes:
1. ex Scotia Sea, along the Antarctic coast in the South Atlantic
2. no direct relationship between the small and large, mean distance >800 km. Transport of ice due solely to small icebergs drifting over very long distances.

Estimation of mean fresh water flux in the southern ocean from small icebergs

The difference between the maximum and minimum of the volume of ice observed during one year used as a proxy to the available fresh water. Similar patterns as the one obtained from numerical model, but higher values especially in the Eastern branch of the Wedell Gyre.