Icebergs: Improving methods for automatic detection using Synthetic Aperture Radar images

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Icebergs can be a hazard for navigation in Polar Regions, but they are also **important in our understanding of how global warming impacts our planet** today. By applying automatic detection algorithms to Synthetic Aperture Radar (SAR) images we can obtain a huge amount of information regarding location of icebergs, their size and distribution. We can also evaluate how these factors changed over the decades.

A **good algorithm** should…

- Be fast
- Have a low false alarm rate
- Detect all icebergs

Sentinel-1 Data → Calibrate → Apply HV-DePolRAD-filter → Calculate pdf for a m x n background-area for each pixel → Calculate threshold from a chosen PFA → Detect icebergs!

HV-DePolRAD – filter

$$\langle I \rangle = |HV|^2{}_{test} \cdot \frac{|HV|^2{}_{test} - |HV|^2{}_{train}}{|HH|^2{}_{train}}$$

HV and HH are polarizations, train and test are two different windows where the background is calculated.

A comparison between the K-, Generalized Gamma-, and Exponential distribution

The K-distribution

$$f(x) = \frac{2}{x}\left(\frac{L\upsilon x}{\mu}\right)^{\frac{L+\upsilon}{2}} \frac{1}{\Gamma(L)\Gamma(\upsilon)} K_{\upsilon-L}\left[2\left(\frac{L\upsilon x}{\mu}\right)^{\frac{1}{2}}\right]$$

The Generalized Gamma distribution

$$f(x) = \frac{|\upsilon|}{\Gamma(k)} x^{\upsilon k-1} e^{x^{\upsilon}}$$

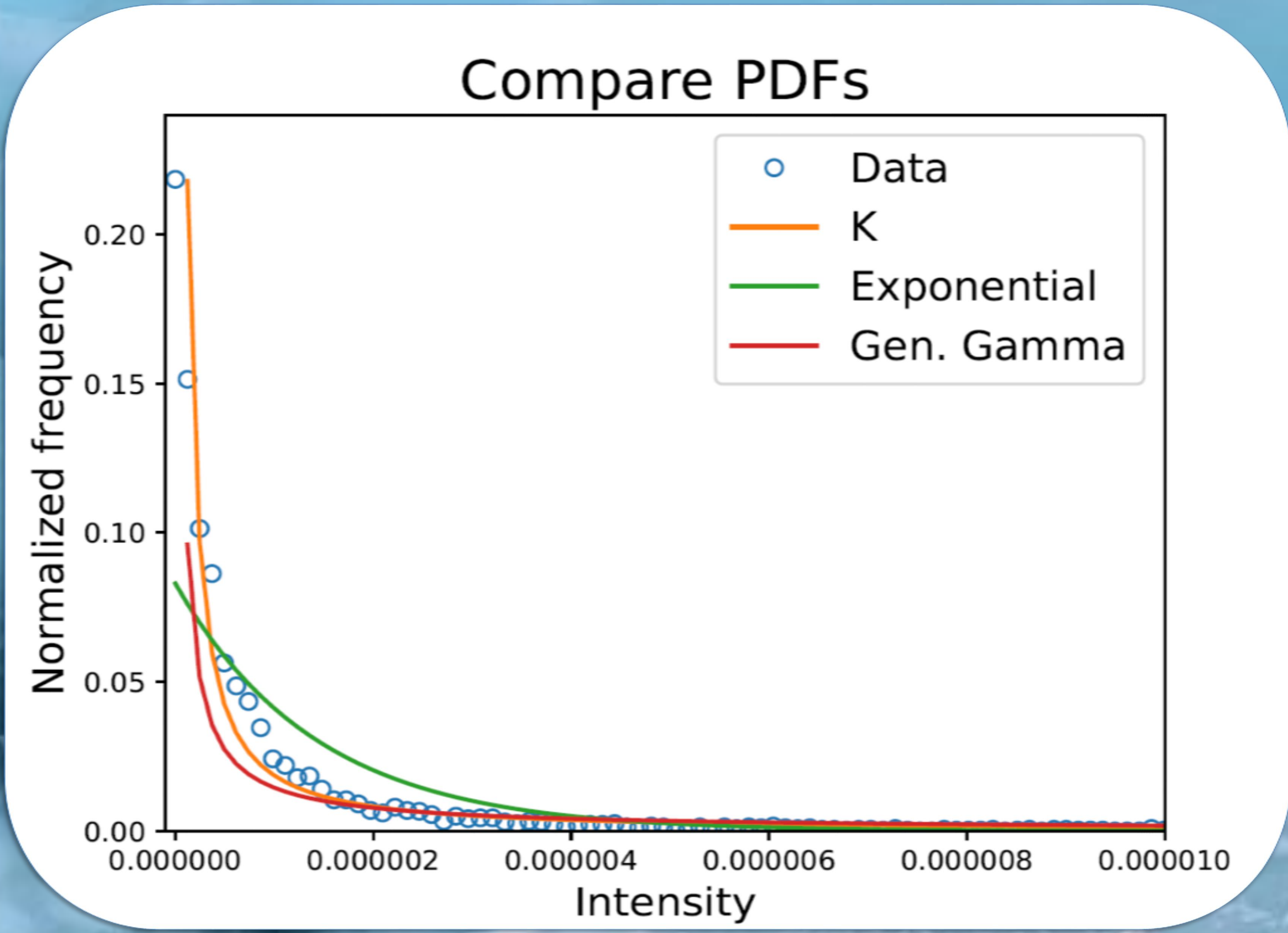
The exponential distribution

$$f(x) = \lambda e^{-\lambda x}$$

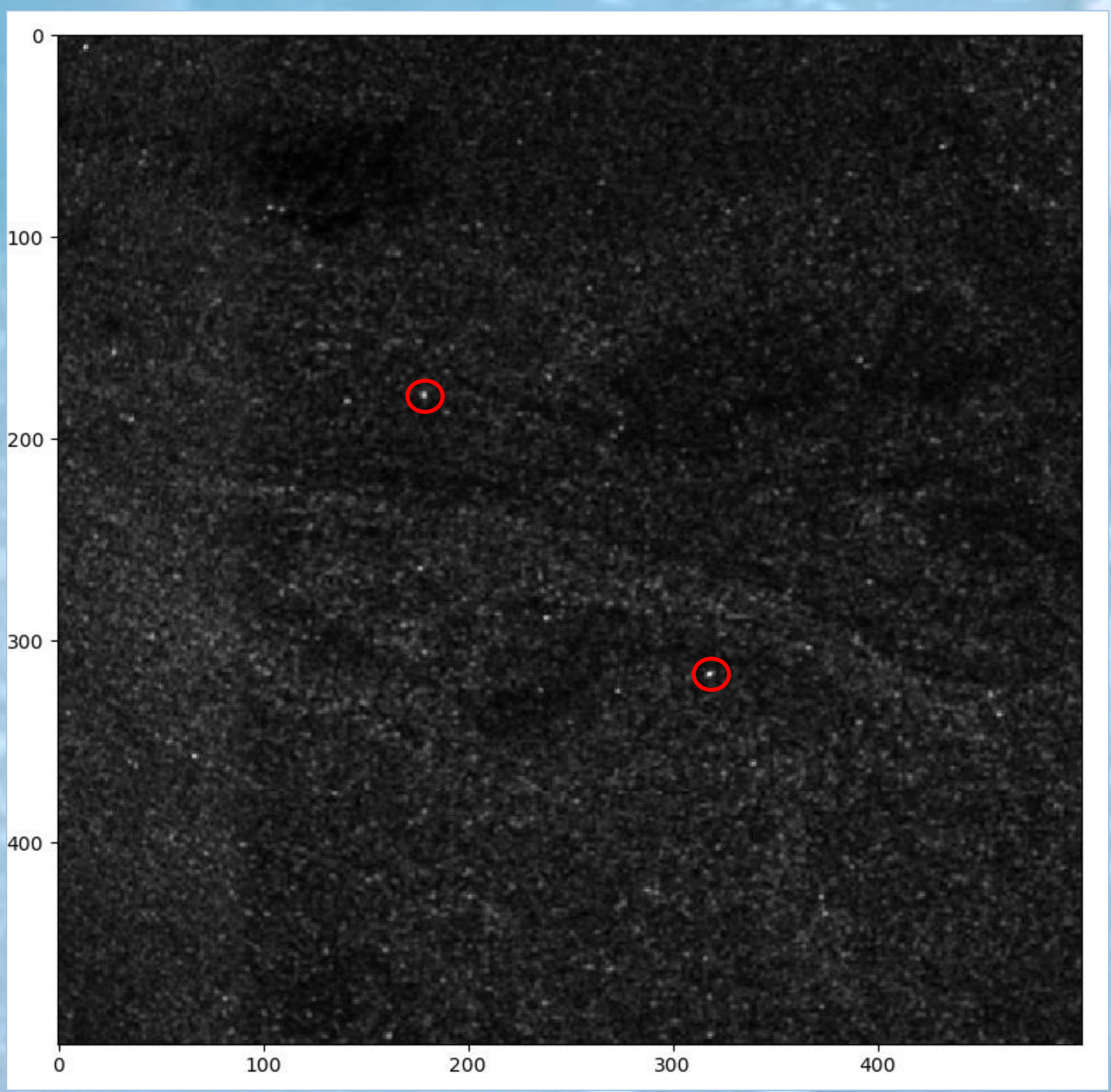
The threshold, T, is calculated from a given probability of false alarm, P_f, such that

$$P_f = \int_T^{\infty} f(x)dx = 1 - F(T) = 1 - \int_0^T f(x)dx$$

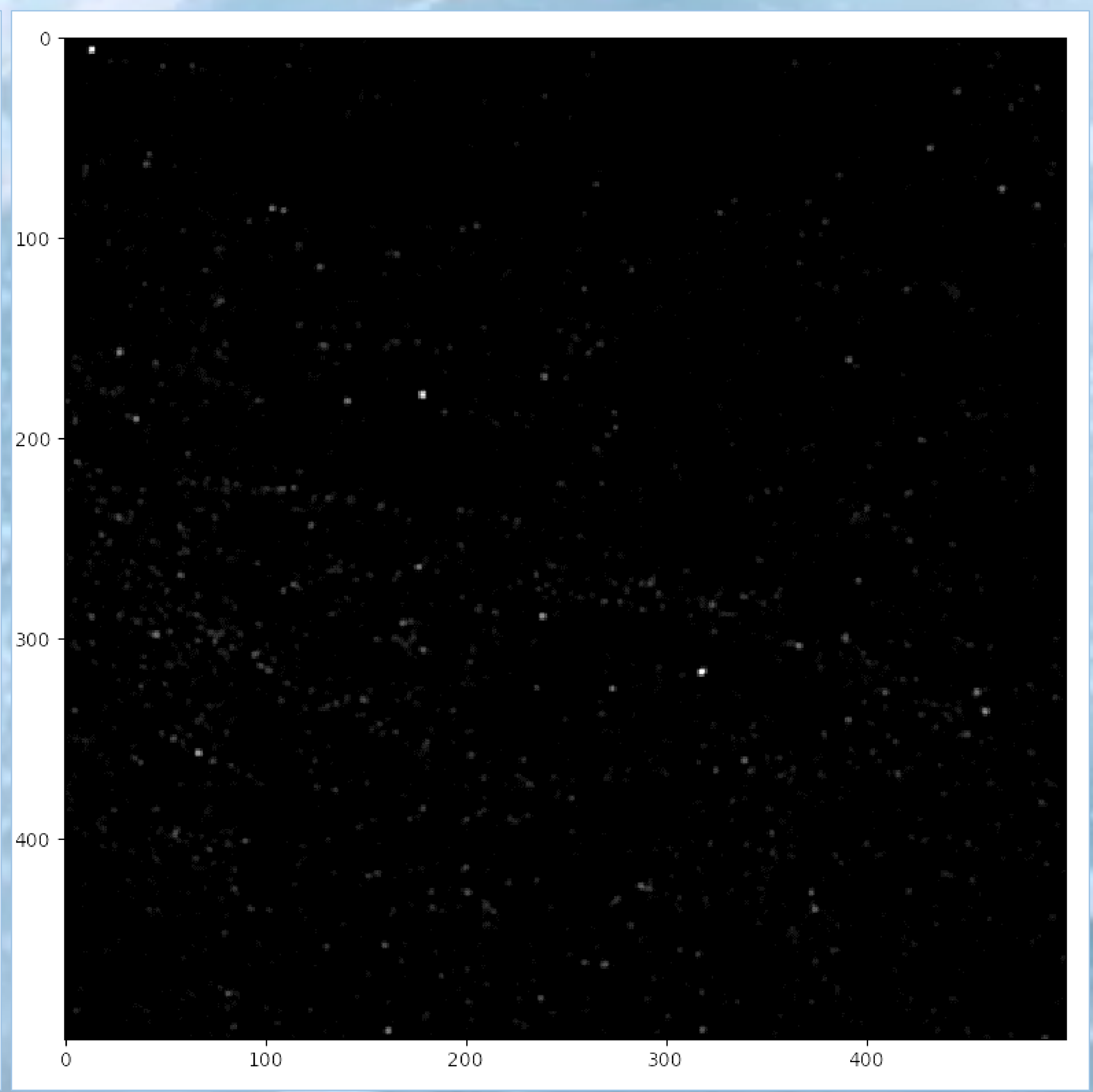
For further explanations about the symbols, please ask me.



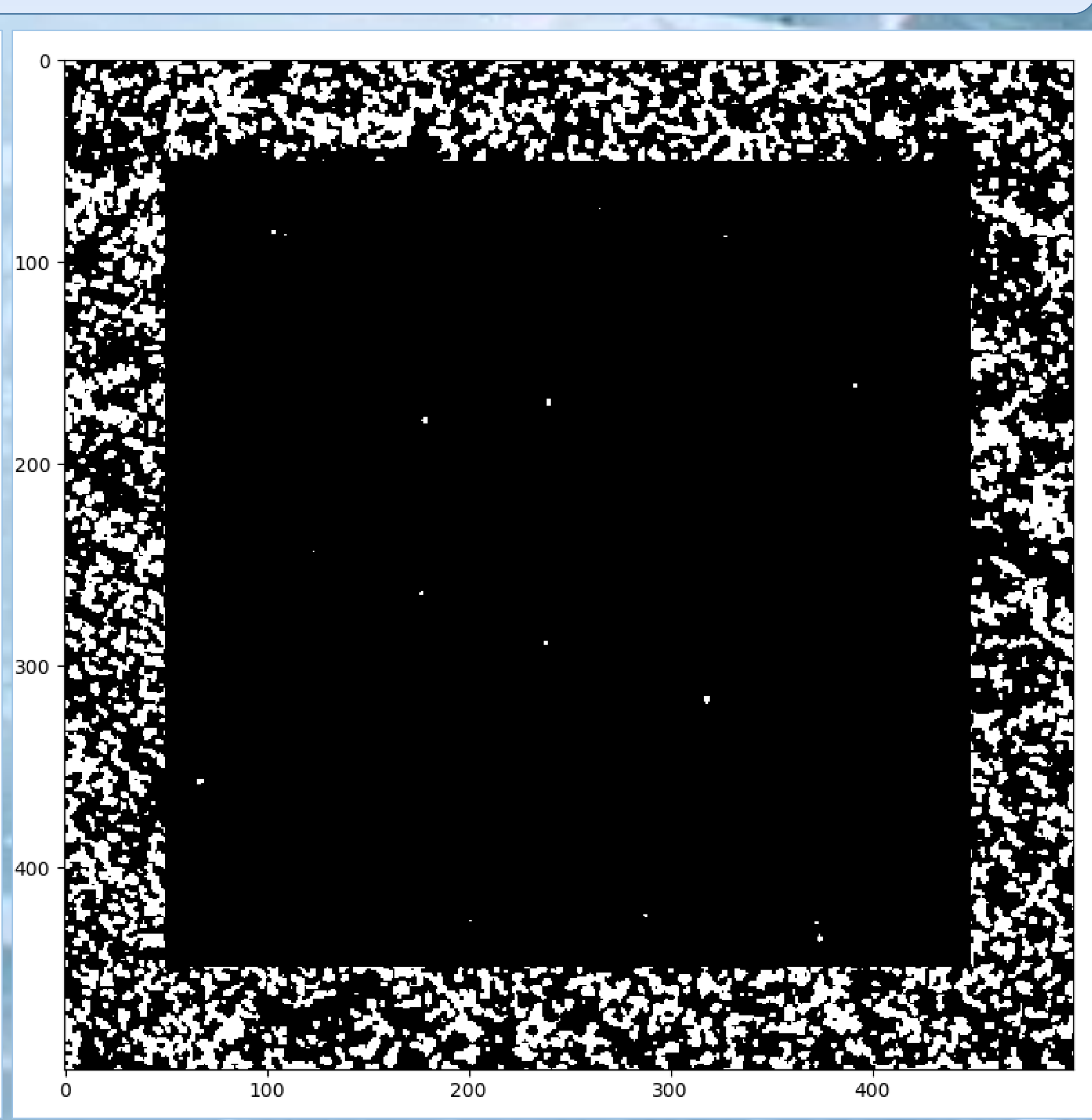
From the graph it can be assumed that the K-distribution fits the real data the best. However, we would have to verify this result by applying statistical tests, such as the Kolmogorov-Smirnov or Chi-Squared Goodness of Fit tests, before drawing any conclusions. Regarding computation time the exponential distribution is the fastest, but due to a high rate of false alarms other distributions may be better.



The original HV-polarized image, only being calibrated using the ESA SNAP-toolbox. This is an area covered with sea ice, with some potential icebergs appearing as bright pixels (marked with a red circle).



The same area after applying the HV-DePolRAD filter. We can now see that the background clutter is reduced and the icebergs appear brighter and more distinguishable.



The final detection using a PFA = 10^{-4} after assuming the data is approximately K-distributed. The two "assumed-to-be" icebergs are detected, but so are several presumably false alarms.

Background photo by Ian Mackenzie, 2008, "The ice highway"