EasyChair Preprint

№ 2585

# Statistical Analysis of Gaussian Filter of SAR Dataset of Radarsat-2 Satellite for Speckle Noise Reduction

Pornima Jagtap and Shafiyoddin Sayyed



February 6, 2020

# Statistical Analysis of Gaussian Filter of SAR Dataset of Radarsat-2 Satellite for Speckle Noise Reduction


## Abstract:

Reduction of speckle noise is one of the most important processes to increase the quality of SAR dataset. Image filtering is very important field in SAR imaging. Image variances or speckle noise that inherently exists in and degrades the quality of the active radar and SAR images. Microwave radiation back scatted the earth surface, generates a multiplicative speckle noise that corrupts SAR images. Gaussian filtering widely used for reduction of the speckle noises present in SAR datasets. The results have been presented by filtered images, statistical tables and diagrams.


**Keywords:** Synthetic Aperture Radar (SAR), speckle noise, Gaussian filter.


## Introduction:

The objective of these works is to reducing Speckle noise SAR images using the Gaussian filter & analyzed the filtered image on the basis of statistical parameters. The statistical parameters Viz., Mean, Standard Deviation, Coefficient Variance and ENL. This paper will provide Gaussian filter information and simulation model result of filter using Pol-SAR-Pro Ver. 5.0 and NEST Ver. 5.0.16 software.

## Methodology:

Image data set is required to be applied in the implemented approach. There are many approaches deal with the image analysis such as histogram analysis, feature extraction, image understanding and statistical approach. Here we used statistical approach. This approach is concentrated on five parameters of statistical measures that are mean, median, standard deviation, coefficient variation (C.V.) and equivalent number of looks (E.N.L.) value of image which reflect the speckle noise reduction in an image.

The proposed approach is divided into four main steps:

•The first step (Input images): In this step, images are collected from satellite to capture RADARSAT-2 SAR image. The acquisition of SAR image is raw or zero level image.

• The second step (Pre-processing): In this step, process the zero level/raw RADARSAT-2 SAR image using polsar-pro and NEST software. Images are resizing and filtering to reduce noise and redundancies as possible. This is an important stage to prepare an image that is ready for the processing stage.

• The third step (Statistical measures): In this step, input or zero level image (band-1, band-2, band-3), Gaussian image (T11, T22, T33) and speckle filter image (band-1, band-2, band-3) the mean, standard deviation values and correlation are calculated of grey and color images.

• The fourth step (Compare the results): In which compare the input/raw data (band-1,band-2,band-3) images, Gaussian images(T11, T22, T33) and speckle noise reduction resultant images (band-1,band-2,band-3). Calculated results of mean, median, standard deviation, coefficient

variation(C.V.) and equivalent number of looks (E.N.L.) values. This stage is realizing the difference in values between input and output images.

**Experimental Analysis:**

**Speckle Filtering:**
Speckle filtering consists of moving a kernel over each pixel in the image, using the pixel values under the kernel and replacing the central pixel with the calculated value by applying a mathematical calculation. The kernel is moved along the image one pixel at a time until the entire image has been covered. The visual appearance of the speckle is reduced by applying the filter a smoothing effect is achieved.

**Gaussian Filter:**
Gaussian filtering is more effective at smoothing images and it used to blur images and remove noise and detail. In one dimension, the Gaussian function is: $(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}}$. It is a non-uniform low pass filter. It might not preserve image brightness. When working with images, need to use the two dimensional Gaussian function. $G(x, y) = \frac{1}{\sqrt{2\pi}\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$. Where, σ indicates the standard deviation of the distribution. It is a symmetric function. The Standard deviation (σ) of the Gaussian function plays paramount role in its behavior.

**Standard Deviation (SD):** Standard deviation is denoted by σ, it is used to measure quantify the amount of variation/ dispersion of a set of data values and also used in statistical conclusions. A low standard deviation means that the data points close to the mean or also called the expected value of the set and high means the data points spread out over a wide range of values.

$$S = \sqrt{\sum(x - x')2/n - 1}$$

**Coefficient of Variation (CV):** This is also called as Standard deviation to mean ratio (SD/M) which is well known quantitative measure for evaluating the level of smoothing in homogenous area. Lower value of CV represents good speckle noise reduction.

$$C.V. = \sqrt{[x]/[x']}$$

**Mean Square Error (MSE):** Mean Square Error is defined as (x, x') = E [(x - x') $^2$]. Where x and x' represents original and filtered images respectively, [·] denotes statistical mean. The highest value of MSE represents original and filtered images are not similar and lowest value represents better image quality of the filtered image. MSE based measurements are useful to obtain a global performance assessment on the whole image, but usually they yields little information about the preservation of specific features, for which other indexes can be used.

**Equivalent Number of Looks (ENL):** The equivalent number of looks (ENL) was applied to measure the degree of suppression, which was defined as the square ratio of the mean to the standard deviation values in a homogeneous region. The larger the ENL was, the better the quality of the speckle reduction was. The ENL is another good indicator to show speckle noise reduction. The ENL for intensity image is defined as $1/\beta^2$ and for amplitude image is defined as ENL (A) = $(0.522/ \beta^2)$.

**Result and Discussion**

Band-1 Band-2 Band-3

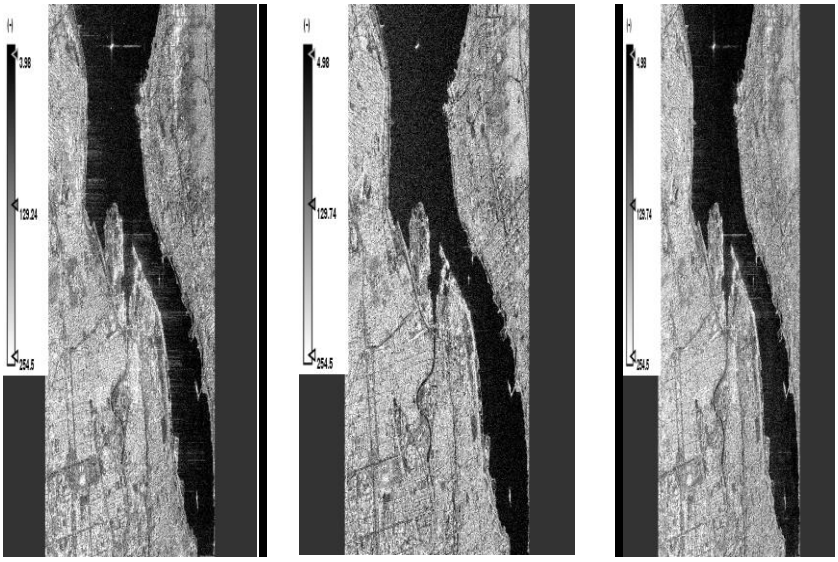

Figure 1: Radarsat-2 SAR data input image of Band-1, Band-2 and Band-3

T-11 T-22 T-33

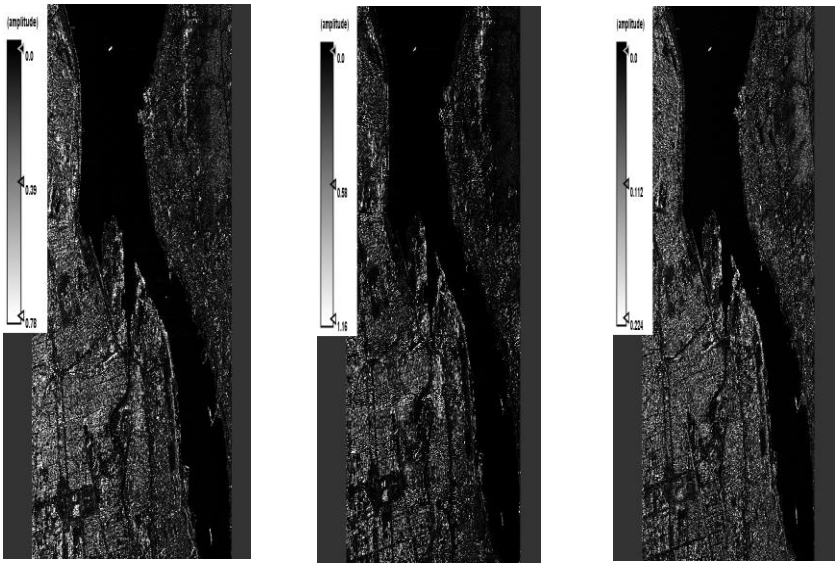

Figure 2: Radarsat-2 SAR data Gaussian filtered image of T-11, T-22 and T-33

Band-1 Band-2 Band-3

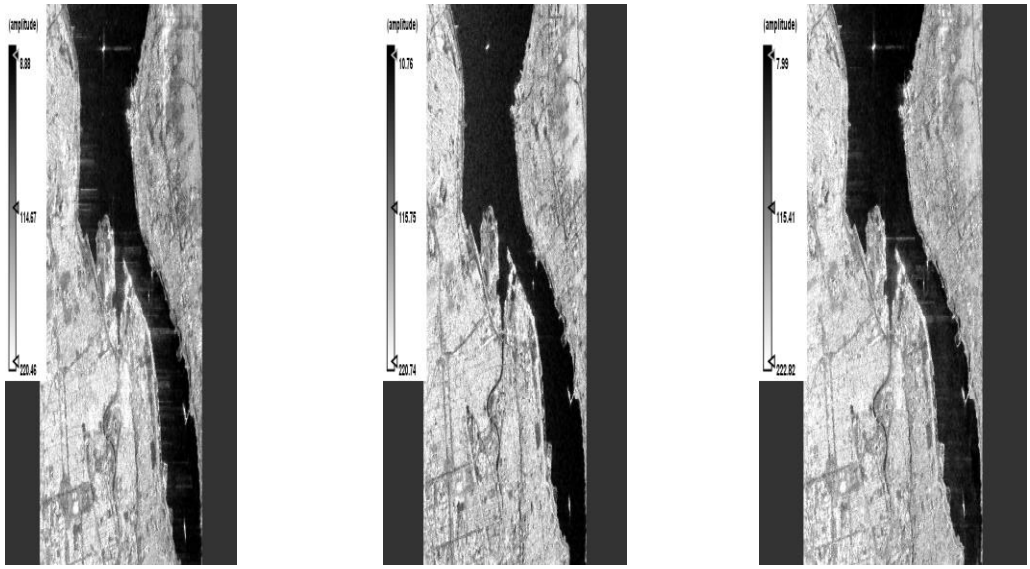

Figure 3: Speckle reduction in Gaussian filter image: Band-1, Band-2, Band-3

**Table: 1**

| Filter\ statistics | Mean | Median | Slandered Deviation | C. V. | E N L |
|---|---|---|---|---|---|
| Radar input Band-1 | 125.2179 | 131.000 | 75.8094 | 0.9111 | 1.2046 |
| Band-2 | 129.3824 | 137.000 | 78.3646 | 0.8916 | 1.2580 |
| Band-3 | 132.0548 | 143.000 | 77.1469 | 0.8524 | 1.3763 |
| Gaussian T11 | 0.0947 | 0.1259 | 1.7792 | 165.8353 | 0.0000 |
| T22 | 0.1259 | 0.0000 | 2.1341 | 119.8184 | 0.0001 |
| T33 | 0.0174 | 0.0000 | 0.3189 | 196.5268 | 0.0000 |
| Speckle reduction Image Band-1 | 125.3373 | 141.1715 | 66.1148 | 0.7572 | 1.7440 |
| Speckle reduction Image Band-2 | 129.6790 | 148.4180 | 67.2502 | 0.7372 | 1.8402 |
| Speckle reduction Image Band-3 | 132.2075 | 152.3933 | 67.8272 | **0.7126** | **1.9692** |

Radarsat-2 SAR raw image is collected. This image has band-1, band-2 and band-3 data input images shown in figure 2. The speckle noise reduction using Gaussian filter implemented

on Radatsat-2 Pol-SAR dataset using PolSAR-pro software, Gaussian filtered image of T-11, T-22 and T-33 shown in figure 2 and the resultant speckle reduction in Gaussian filter image of band-1, band-2 and band-3. The Gaussian filter of resultant images are analyzed using statistical parameters it includes Mean, Median, Standard Deviation, Coefficient Variance (C.V.) and Equivalence Number of Looks (ENL). Analyzed the performance of Gaussian filtered images, compare and analyze the statistical value from Table:1, the Band-1, Band-2 and Band-3 of Radatsat-2 SAR input data image from figure 1. figure 2 & 3 shows the result of Gaussian filtered and its Gaussian Speckle filtered images resp. of Band-1 for T11, Band-2 for T22 and Band-3 for T33. Ideally, mean should be close to unity and standard deviation should be as low as possible, Lower value of CV represents good speckle noise reduction and the higher value for ENL represents good noise reduction technique for a well performing filter. Here using the table conclude that speckle Gaussian filtered image is better than input and filtered image. Lower Coefficient Variance (0.7126) of Band-3 and higher value ENL (1.9692) of Band-3 image, then conclude that the speckle filter images (Band-3) is better.

## Conclusion

In this paper, study the statistical analysis of Gaussian filter to remove speckle noise in SAR dataset of Radatsat-2 SAR data image is used and resultant band-3 image is better.

## References


1. Jensen R.J. (2014). Remote Sensing of the Environment an Earth Resource Perspective (2nd ed.) Pearson.
2. Gaussian Filterring_1up.pdf, University of Auckland, New Zealand, 25/05/2010.
3. P. R. Jagtap1 , P. W. Khirade2 , S. B. Sayyad3, Comparative Study of Gaussian and Box-car Filter of L-Band SIR-C Data Image using Pol-SAR for Speckle Noise Reduction, International Journal of Universal Print ISSN: 2454-7263 ID: ACTRA 2018 023 Published Mar. 2018 Volume No. 04, Issue No.03.
4. R. C. Gonzalez and R. E. Wood, "Digital Image Processing", Third Edition, Prentice Hall, Person Education International, New Jersey, 2009.
5. Nupursaxena and Neha Rathore, A Review on Speckle Noise Filtering Techniques for SAR Images,International Journal of Advanced Research in Computer Science and Electronics Engineering (IJARCSEE) Volume 2, Issue 2, February 2013 ISSN: 2277 – 9043.
6. G. James, D. Witten, T. Hastie, R. Tibshirani, "An Introduction to Statistical Learning: with Applications in R", Springer, New York, Heidelberg, London, First Edition 2013.
7. T. Hastie, R. Tibshirani, J. Friedman, "The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Springer, New York, Heidelberg, London, Second Edition, 2009.

**8.** Muzhir Shaban Al-Ani, Khattab M. Ali Alheeti, Precision Statistical Analysis of Images Based on Brightness Distribution, Advances in Science, Technology and Engineering Systems Journal (ASTESJ) Vol.2, No. 4, 99-104(2017),ISSN:2415-6698.

**9.** S. Medasan and G. Umamaheswara, *Analysis and Evaluation of Speckle Filters forPolarimetric Synthetic Aperture Radar (PolSAR) Data* Reddy International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 15 (2017) pp.4916-4927 © Research India Publications. http://www.ripublication.com 4916.

**10.** Mirmajid Mousav,Jalal Amini, Yaser Maghsoudi and Saeed Arab, *PolSAR SpeckleFiltering Techniques and Their Effects On classification,*ASPRS Annual Conference, Tampa, Florida May 4-8 2015 , IGTF 2015.