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SAR Image Enhancement: Combining Image Filtering and Segmentation

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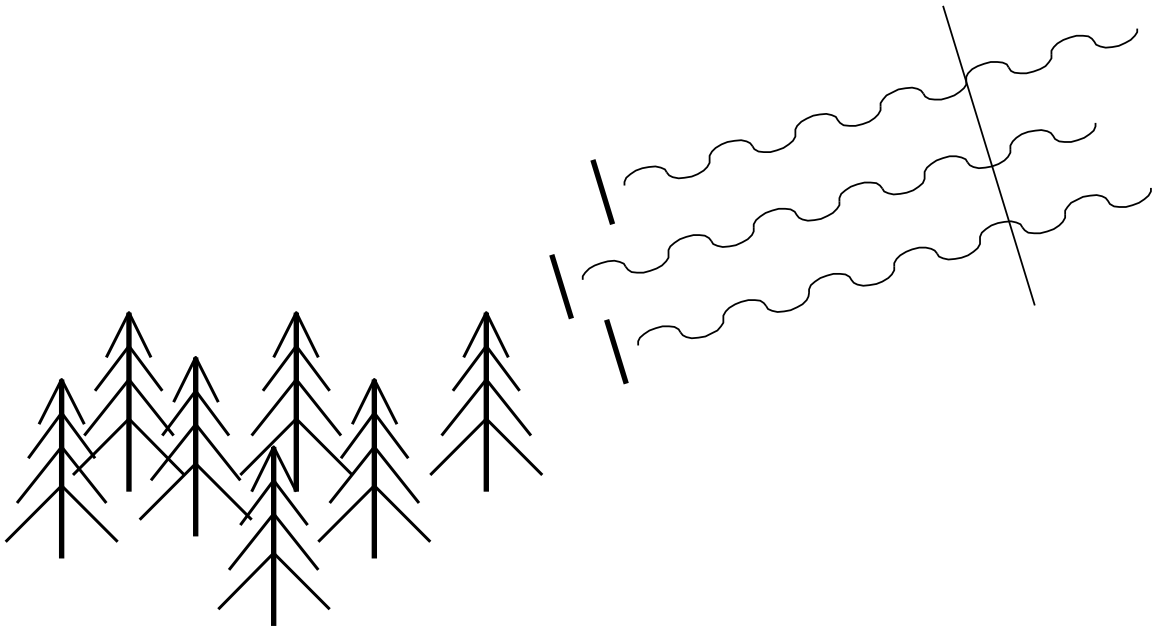
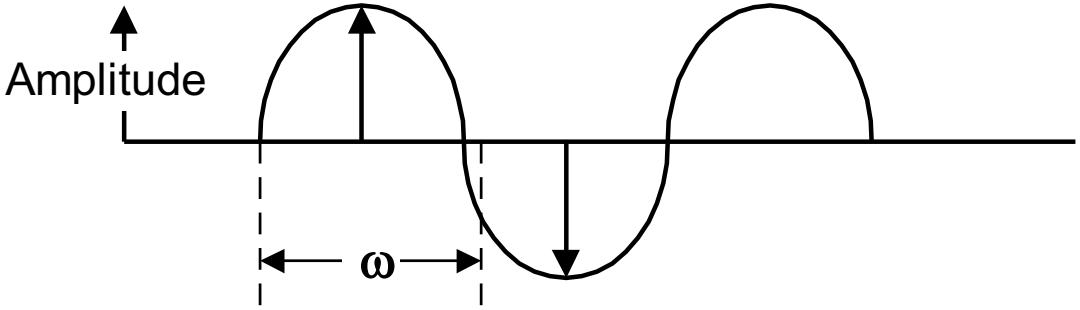
SAR IMAGE → COHERENT SIGNAL

→ INTERFERENCE PATTERN



RETURNED SIGNAL HAS **AMPLITUDE** AND **PHASE**

THE NOISE IS PROPORTIONAL TO THE AMPLITUDE



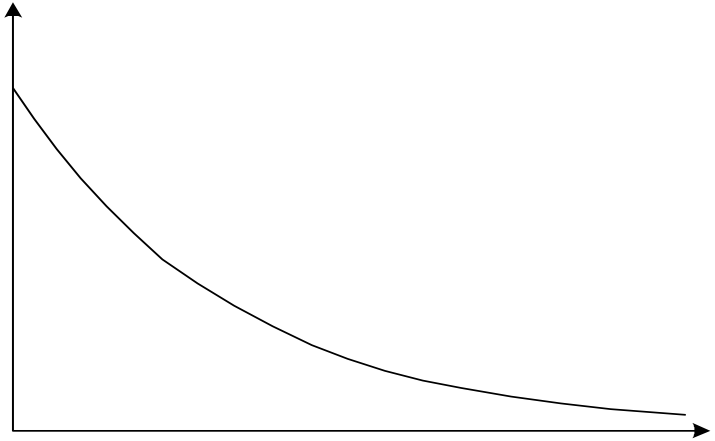
SIGNAL DISTRIBUTION

POWER OR **INTENSITY**

EXPONENTIAL DISTRIBUTION

$$p(I) = \frac{1}{\lambda} \; Exp\left\{\frac{-I}{\lambda}\right\}$$

$$where \;\; \sigma_I = E(I) = \lambda$$



MULTI-LOOK IMAGE

L = NUMBER OF LOOKS

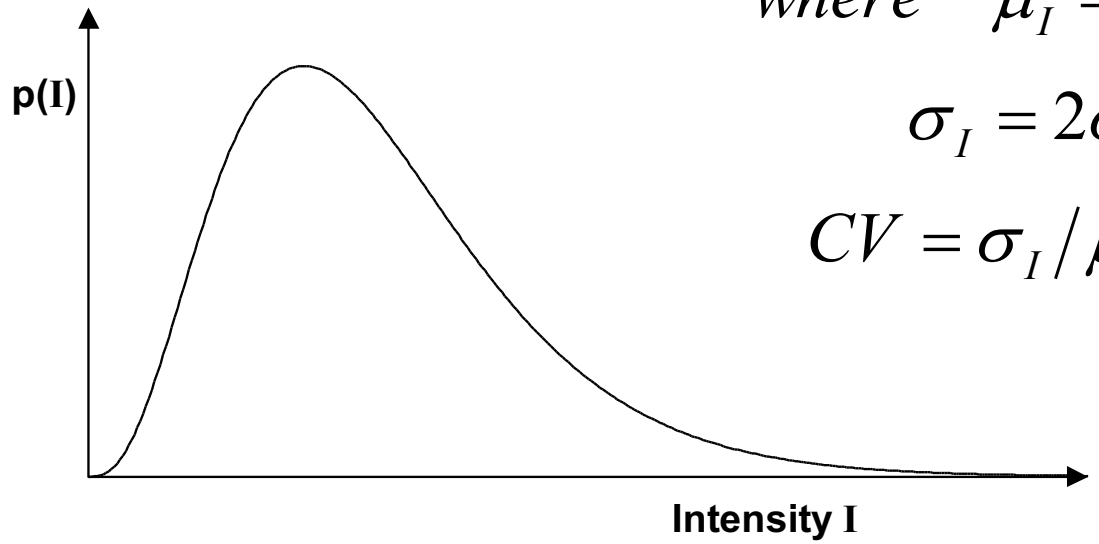
INTENSITY FOLLOWS A **GAMMA** DISTRIBUTION

$$p(I) = \left(\frac{L}{2\sigma^2}\right)^L \frac{I^{L-1}}{\Gamma(L)} Exp\left\{\frac{-L\,I}{2\sigma^2}\right\}$$

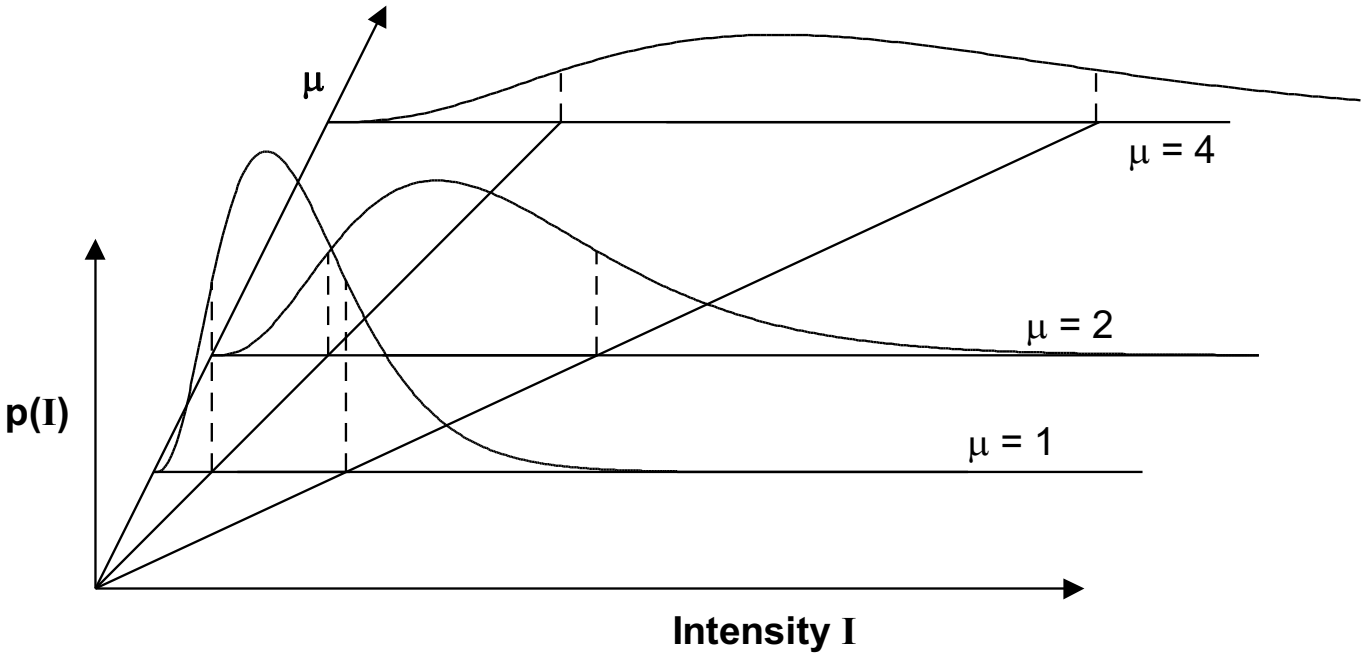
$$where \quad \mu_I = E(I) = 2\sigma^2$$

$$\sigma_I = 2\sigma^2 / \sqrt{L}$$

$$CV = \sigma_I / \mu_I = 1/\sqrt{L}$$

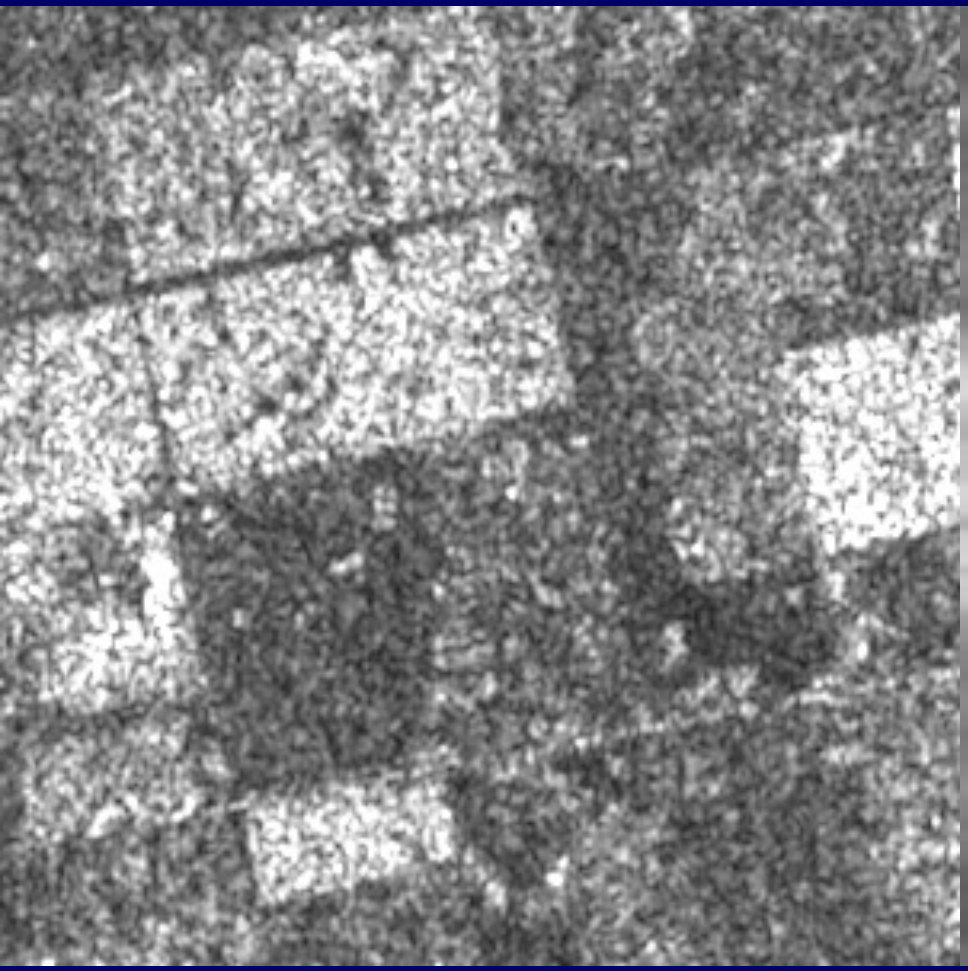


MULTIPLICATIVE NOISE

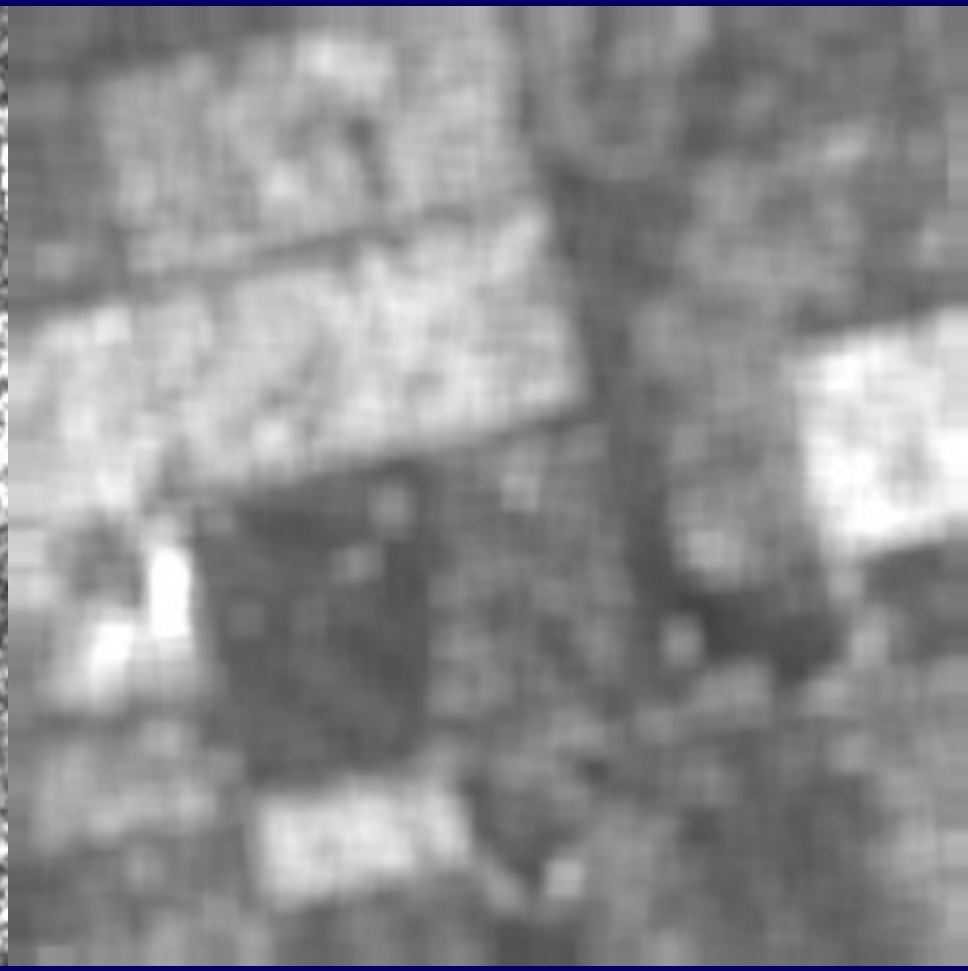


NOISE IS PROPORTIONAL TO INTENSITY

SAR Image



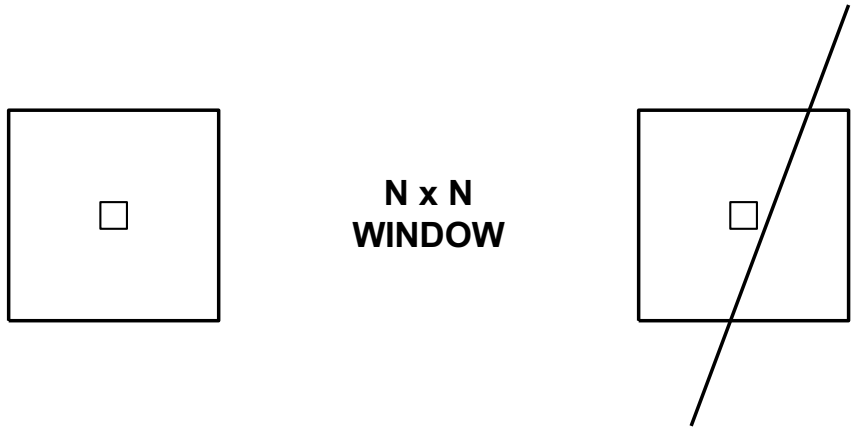
Box Filter



ADAPTIVE FILTERING

$$\hat{I} = \beta I + (1-\beta)\bar{I}_{N\times N}$$

- EVALUATE THE REGION HOMOGENEITY
- FROM THE VARIATION COEFFICIENT σ / μ



Signal model $I = R \times U$

Filtering $=$ *Estimation of* R

$$\hat{R} = \beta\ I + (1-\beta)\ \bar{I}_{N\times N}$$

Lee Filter $$\beta = 1 - \frac{C_U^2}{C_I^2}$$

Kuan Filter $$\beta = \frac{1 - C_U^2 / C_I^2}{1 + C_U^2}$$

where $$\bar{I}_{N\times N} = Mean_{N\times N}(I)$$

$$C_I = \sqrt{Var_{N\times N}(I)} \Big/ \bar{I}_{N\times N}$$

$$C_U = \sigma_U / \mu_U = 1/\sqrt{L}\ ;\ \mu_U = 1$$

Gamma Filter

$$\hat{R} = \begin{cases} \bar{I}_N & si \quad C_I < C_U \\ \dfrac{b\,\bar{I}_N + \sqrt{b^2\,\bar{I}_N^2 + 4\,a\,L\,I\,\bar{I}_N}}{2\,a} & si \quad C_U \le C_I \le C_{MAX} \\ I & si \quad C_I > C_{MAX} \end{cases}$$

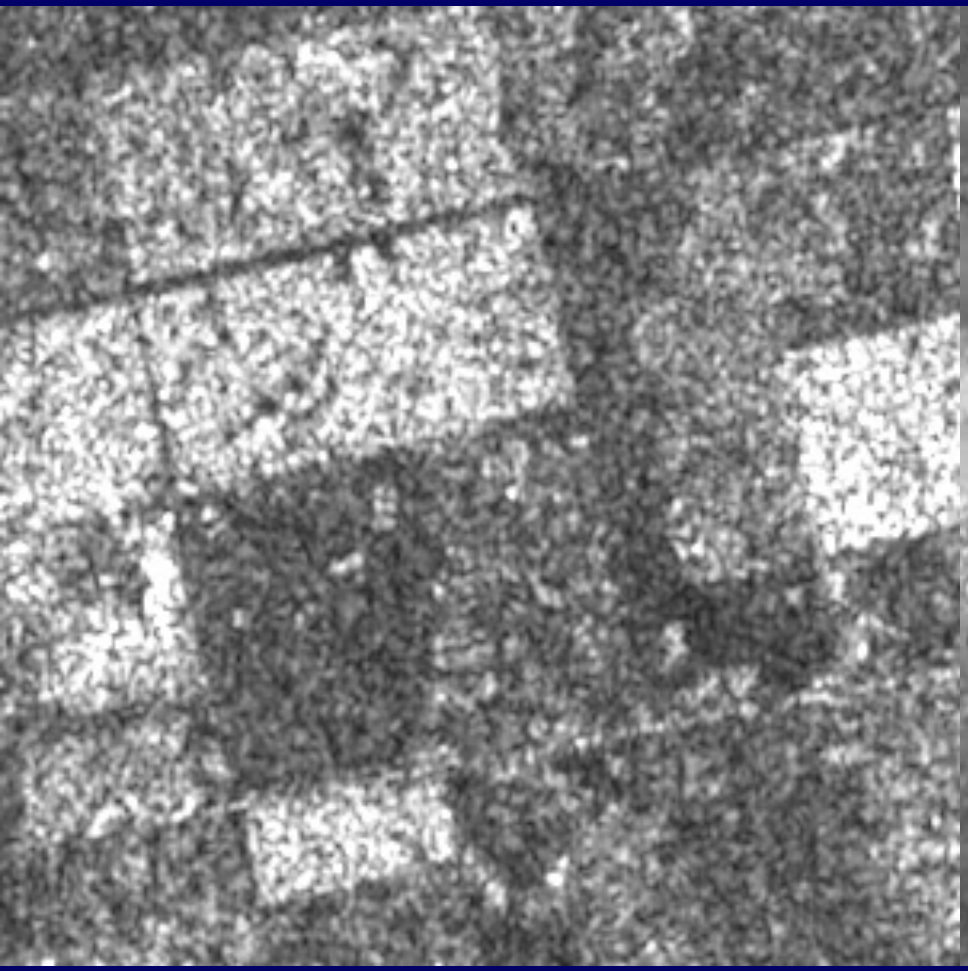
where $a = (1 + C_U^2) \,/\, (C_I^2 - C_U^2)$

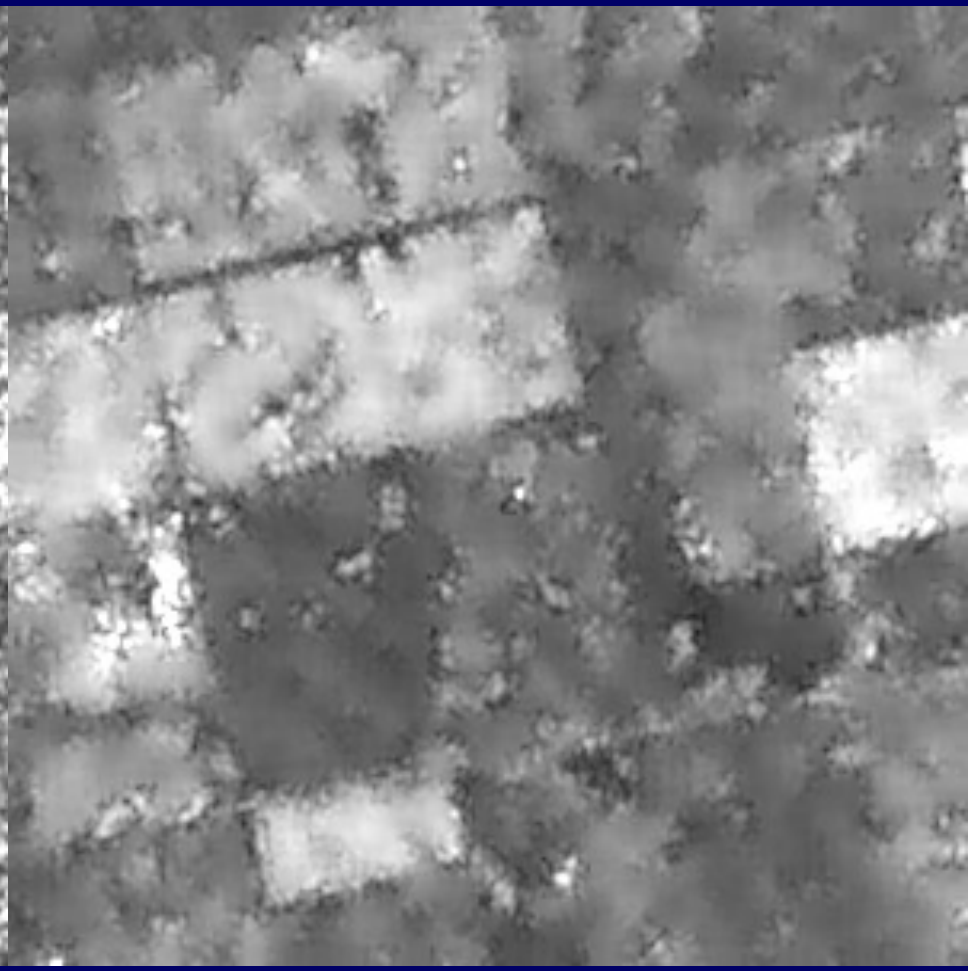
$b = a - L - 1$

$C_{MAX} = \sqrt{1 + 2/L}$

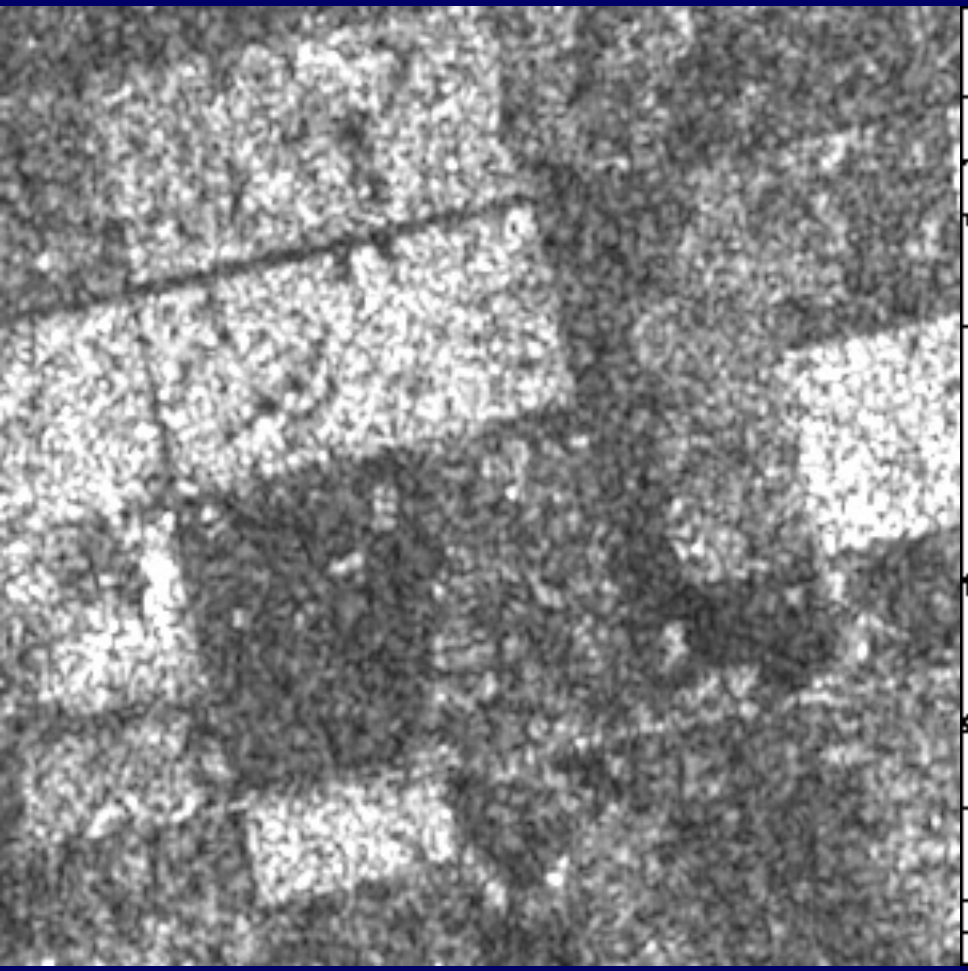
SAR Image

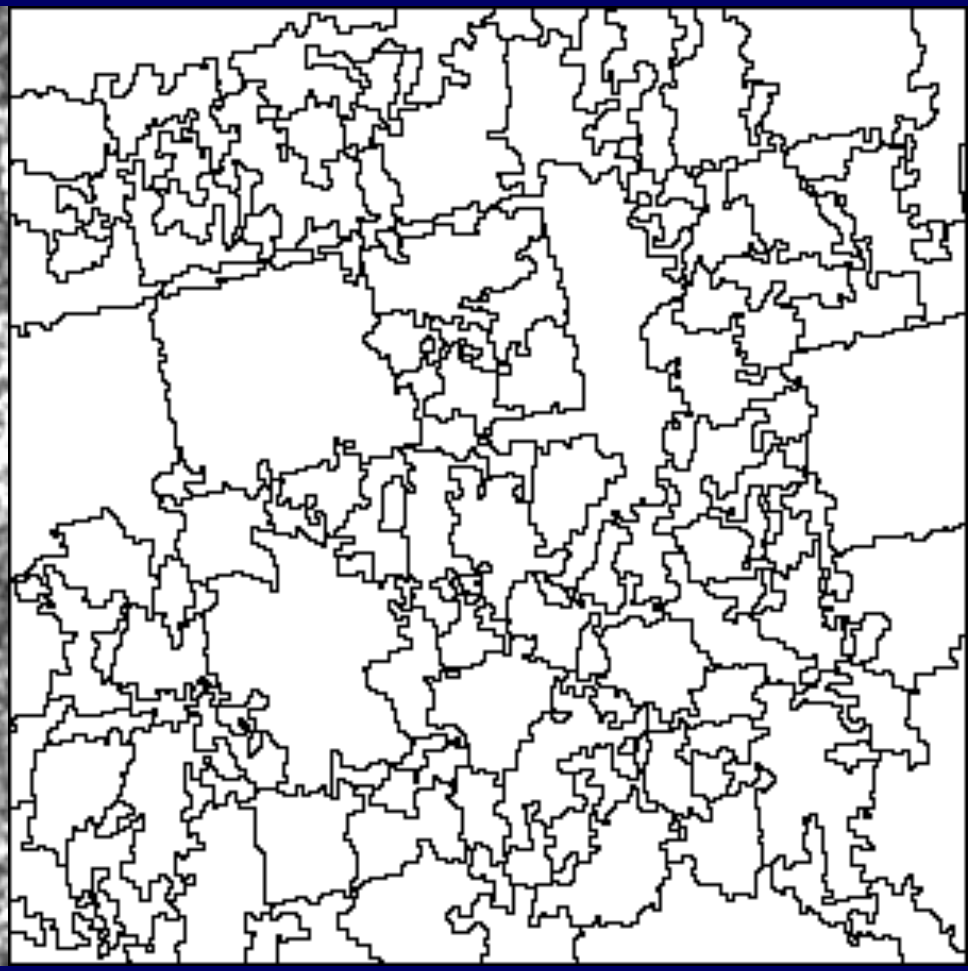
Gamma Filter





SAR Image Segmentation





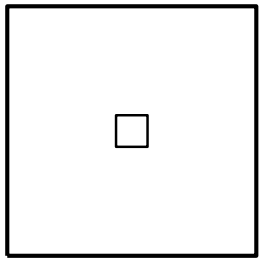
⇨ Segmentation and filtering of SAR images are difficult.

⇨ Filtering → could be used as a first step to segmentation

⇨ Segmentation → could be used to improve filtering

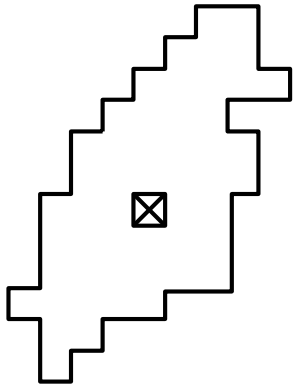
Spatial Information

⇨ Filtering → uses fixed windows



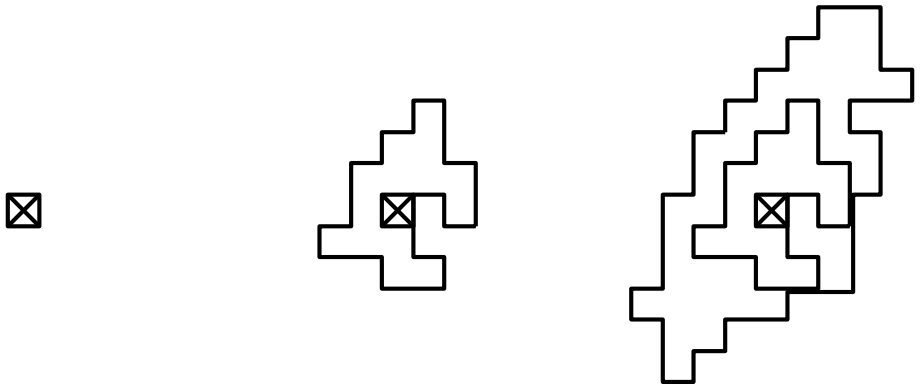
⇨ Segmentation →

- similar pixels are grouped
- homogeneous regions
- data driven



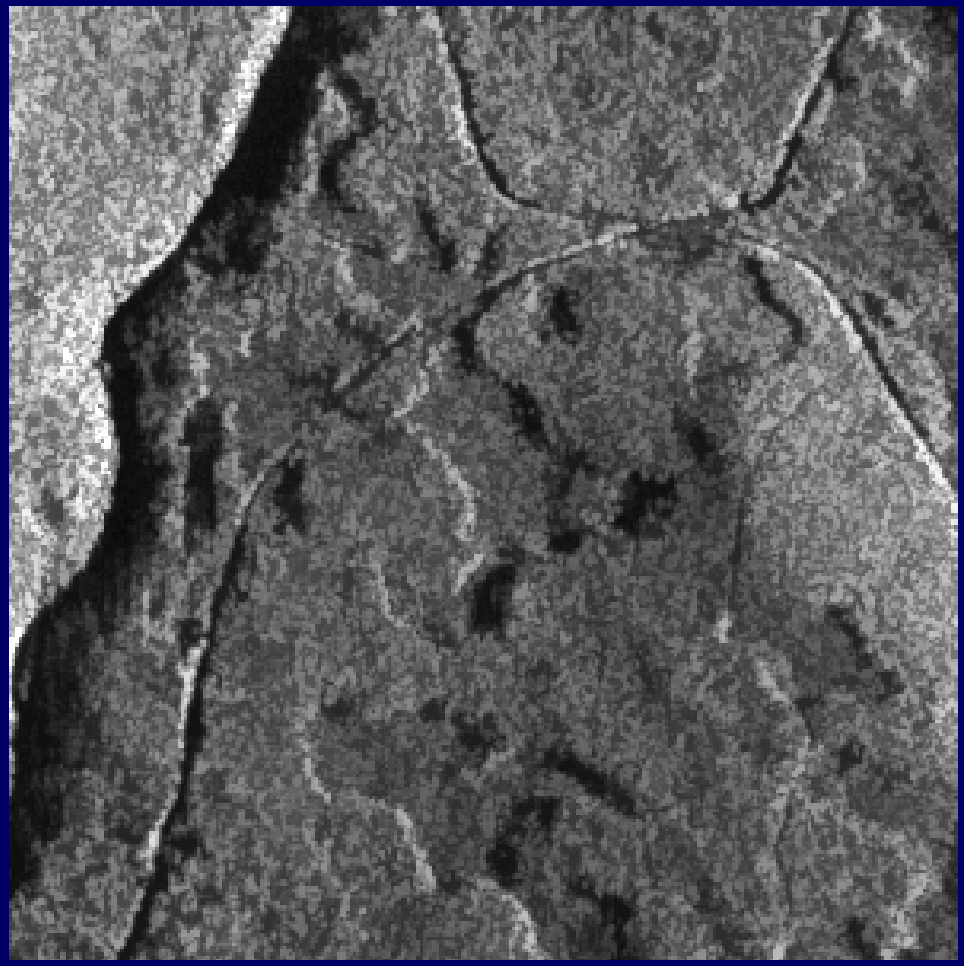
Region growing “filter”

- Selection of a pixel set for averaging
- Grow a region from a central pixel
- Use a region size limit



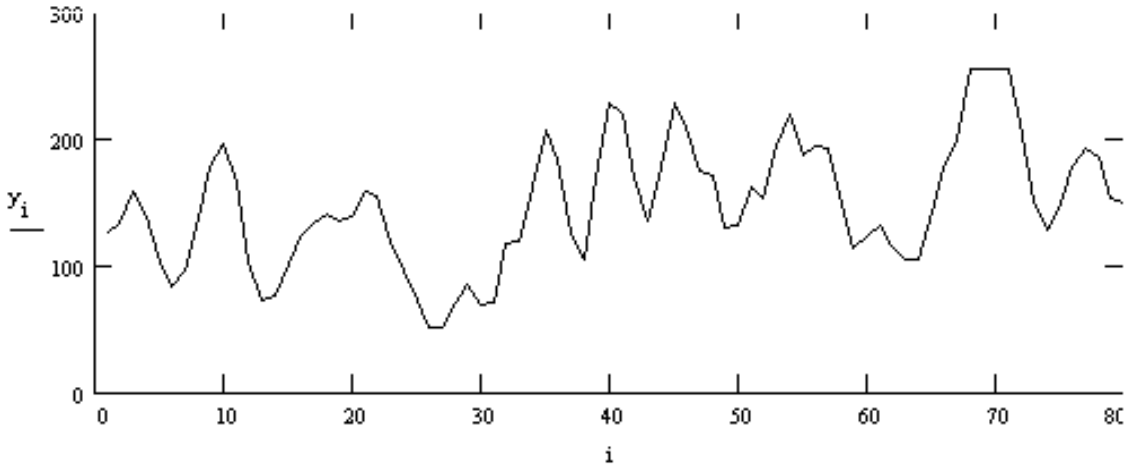
SAR Image

Region growing "filter"



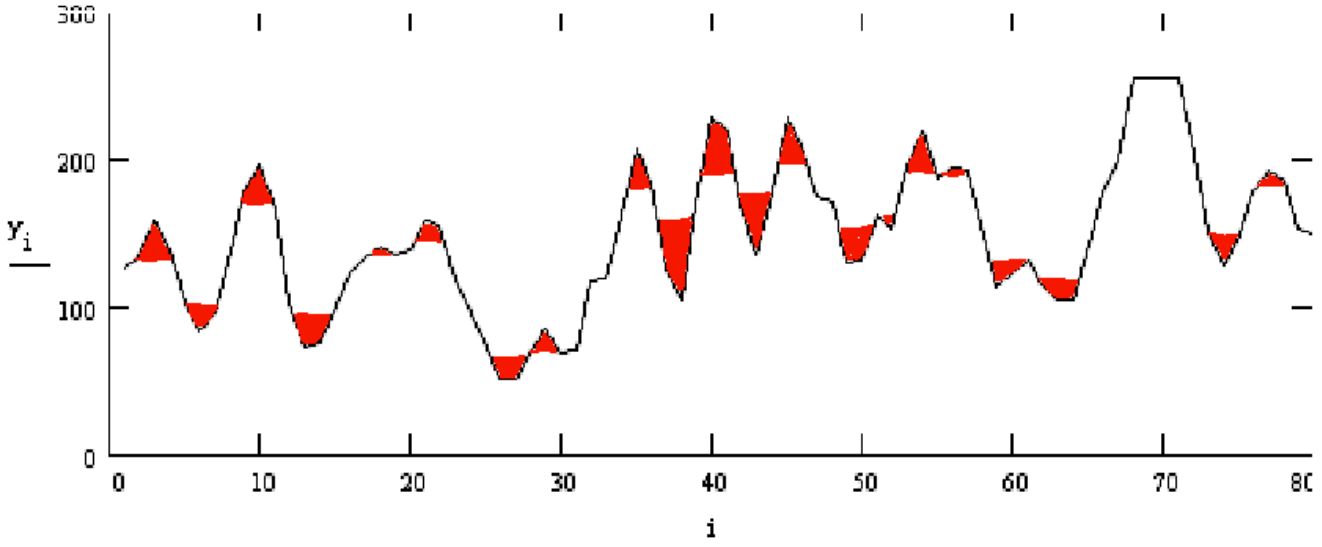
Extremum Reduction

- Speckle noise has a large range of values
- Reduce range by
  - cutting peaks
  - filling valleys



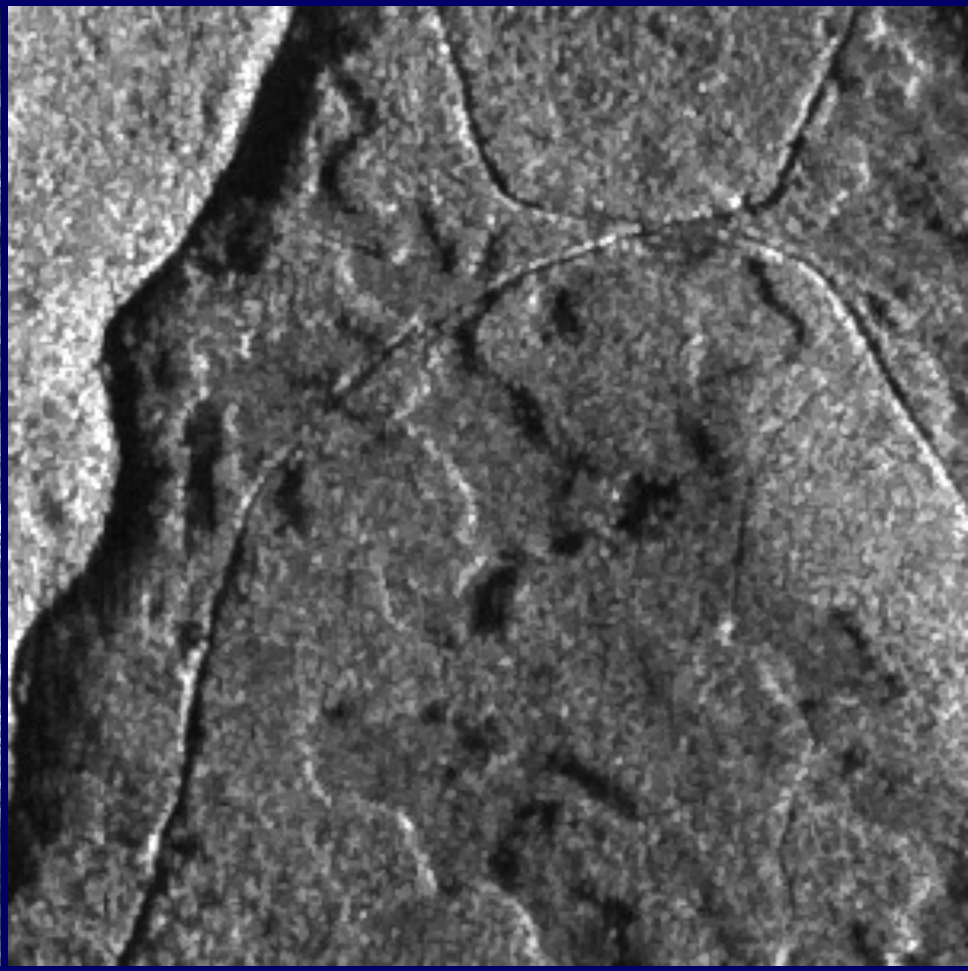
Extremum Reduction

- Start from local maximum (minimum) values
- Merge with the higher (lower) neighbour
- Stop after N merges
- Replace inside values by the lowest (highest)



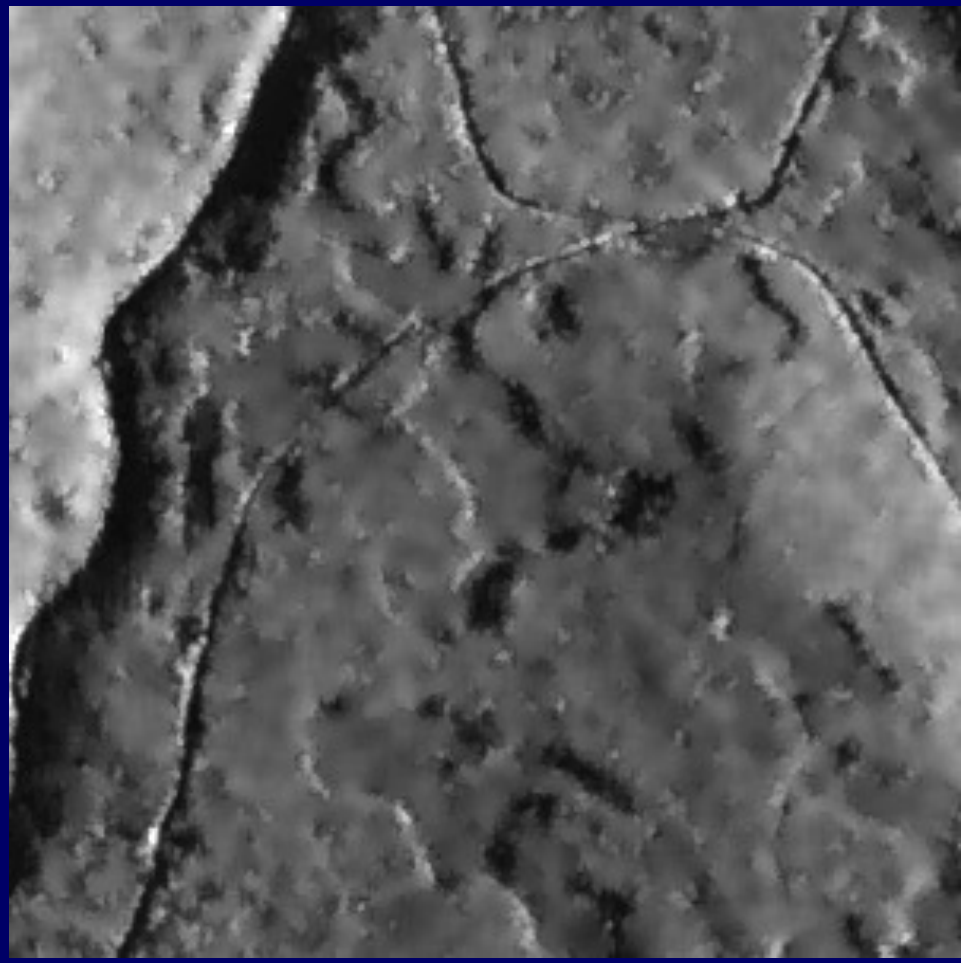
SAR Image

Extremum reduction result



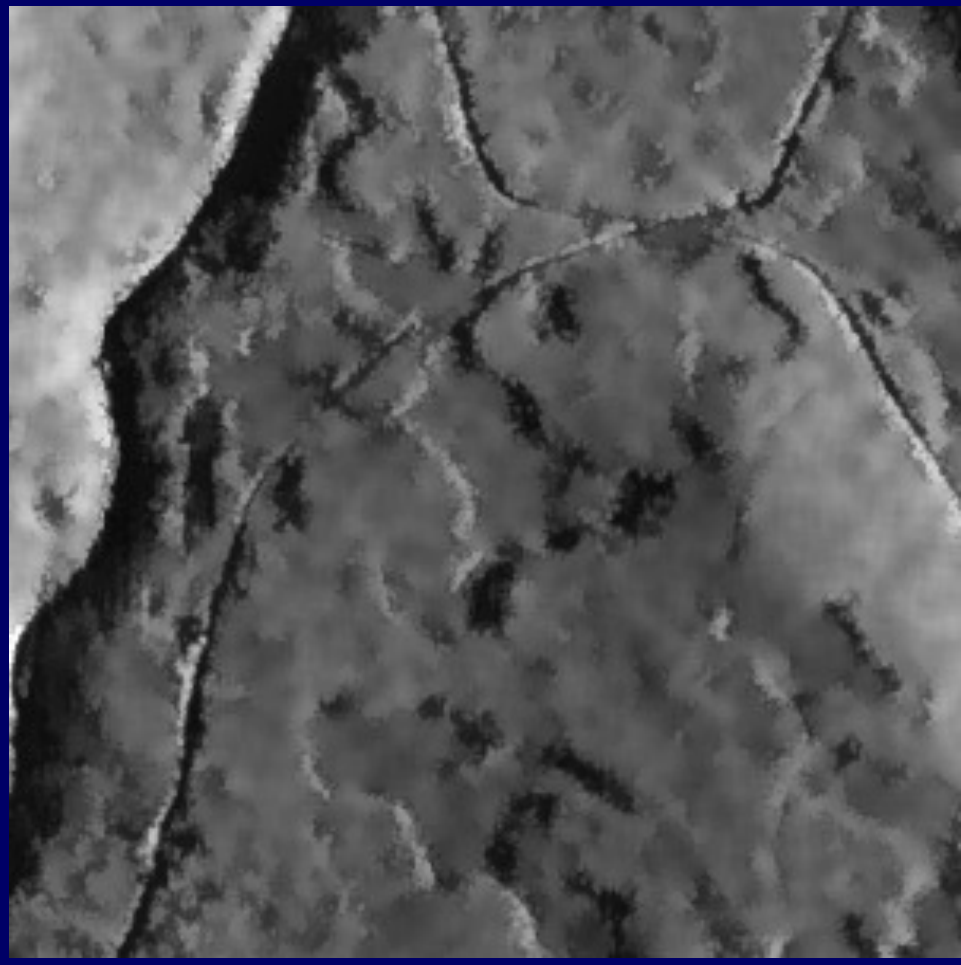
Gamma filter

Extremum reduction and Gamma filter

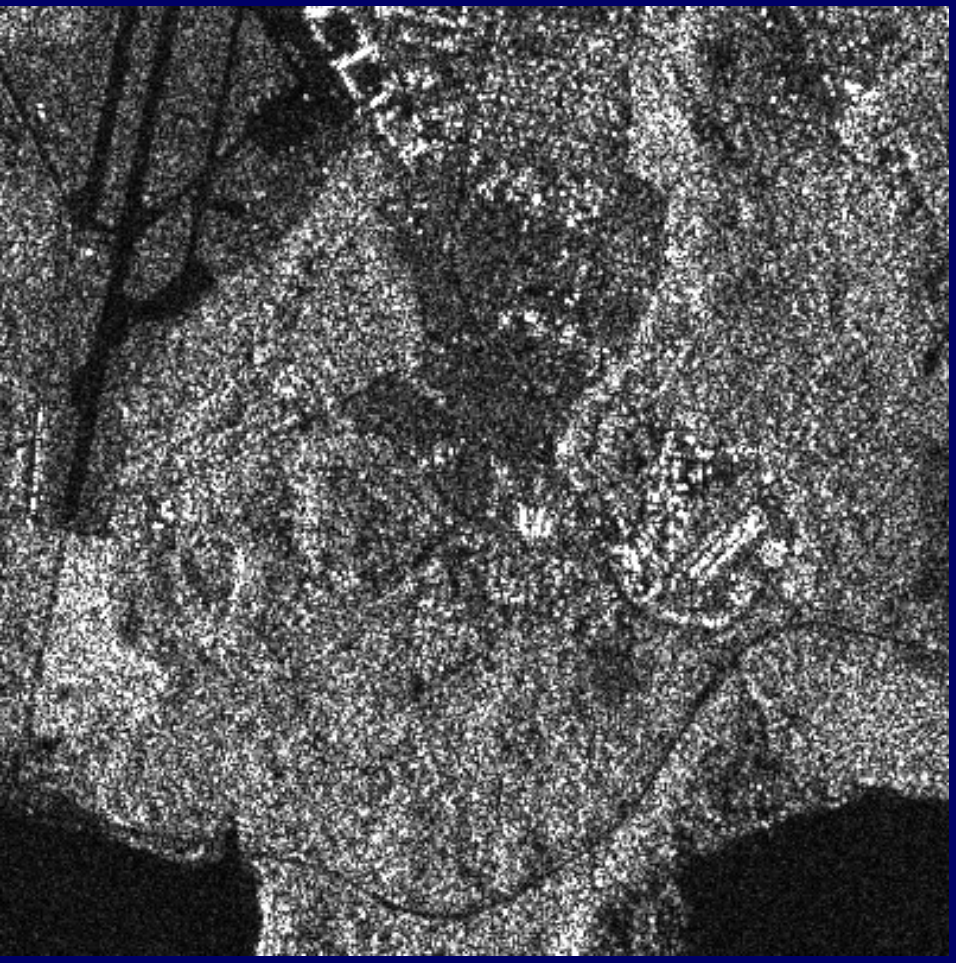


Gamma filter

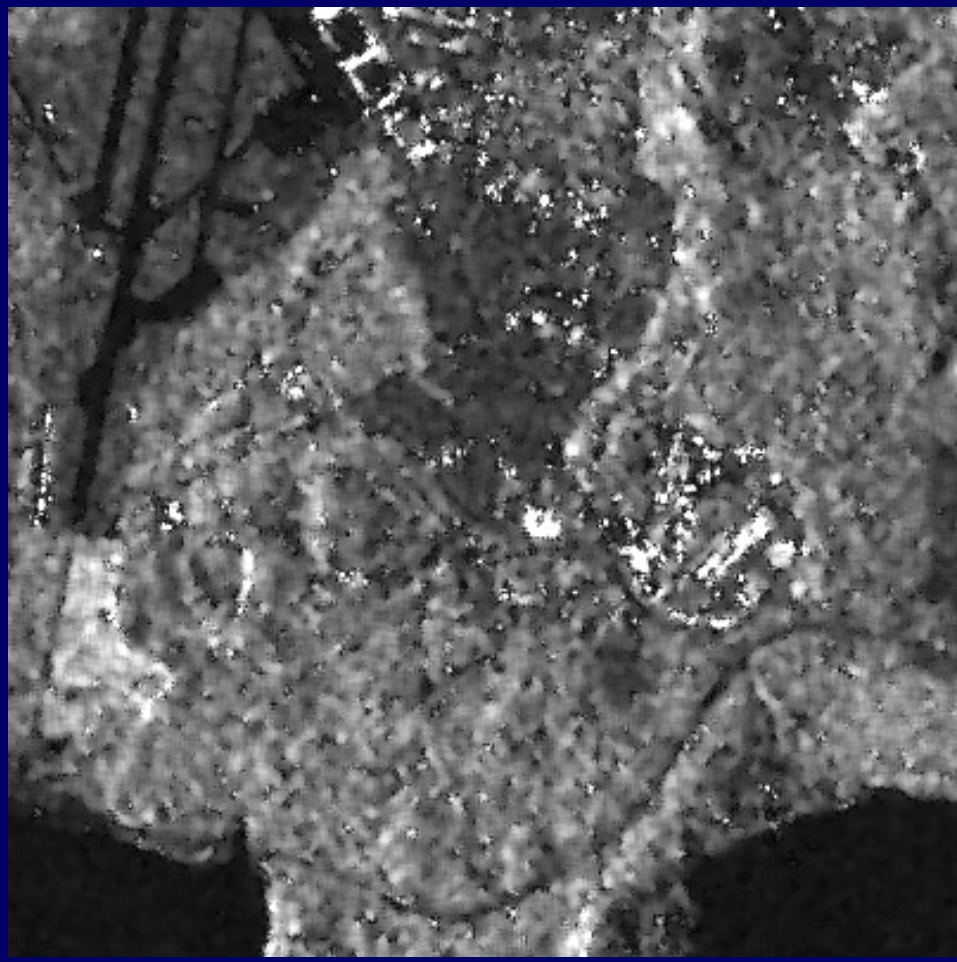
Region growing and Gamma filter



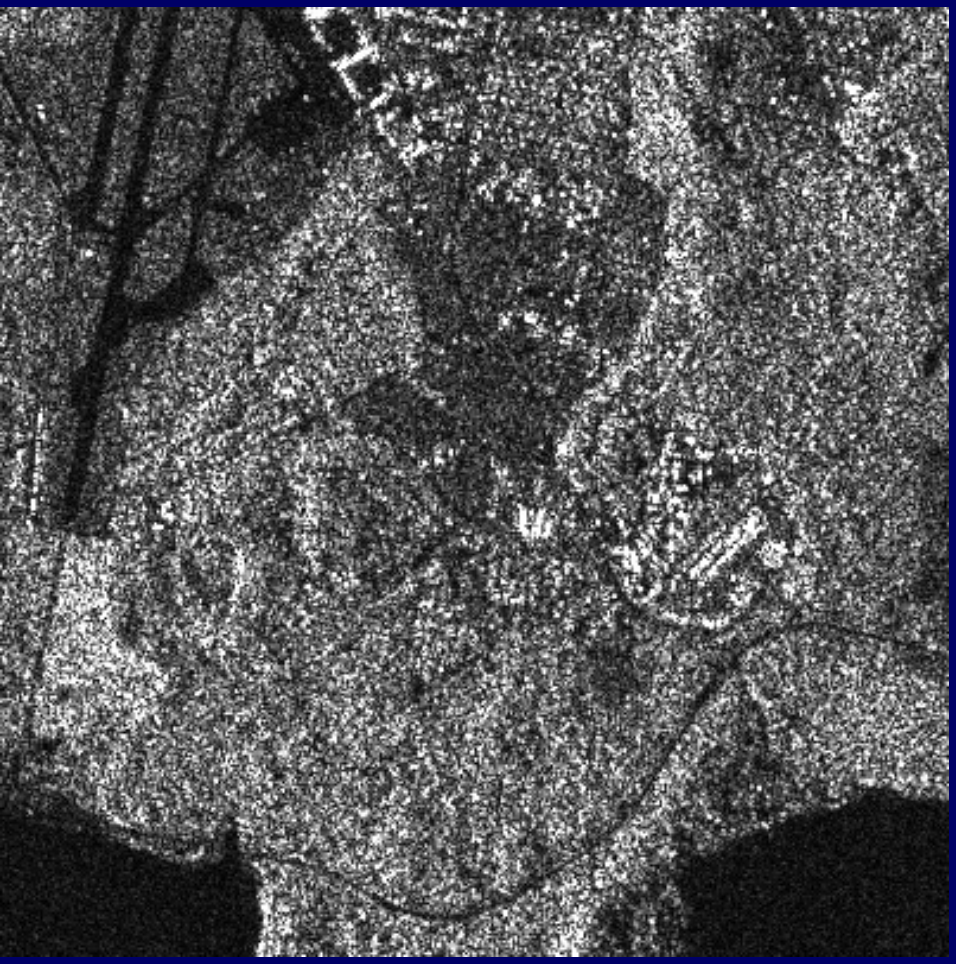
SAR Image (1-look)



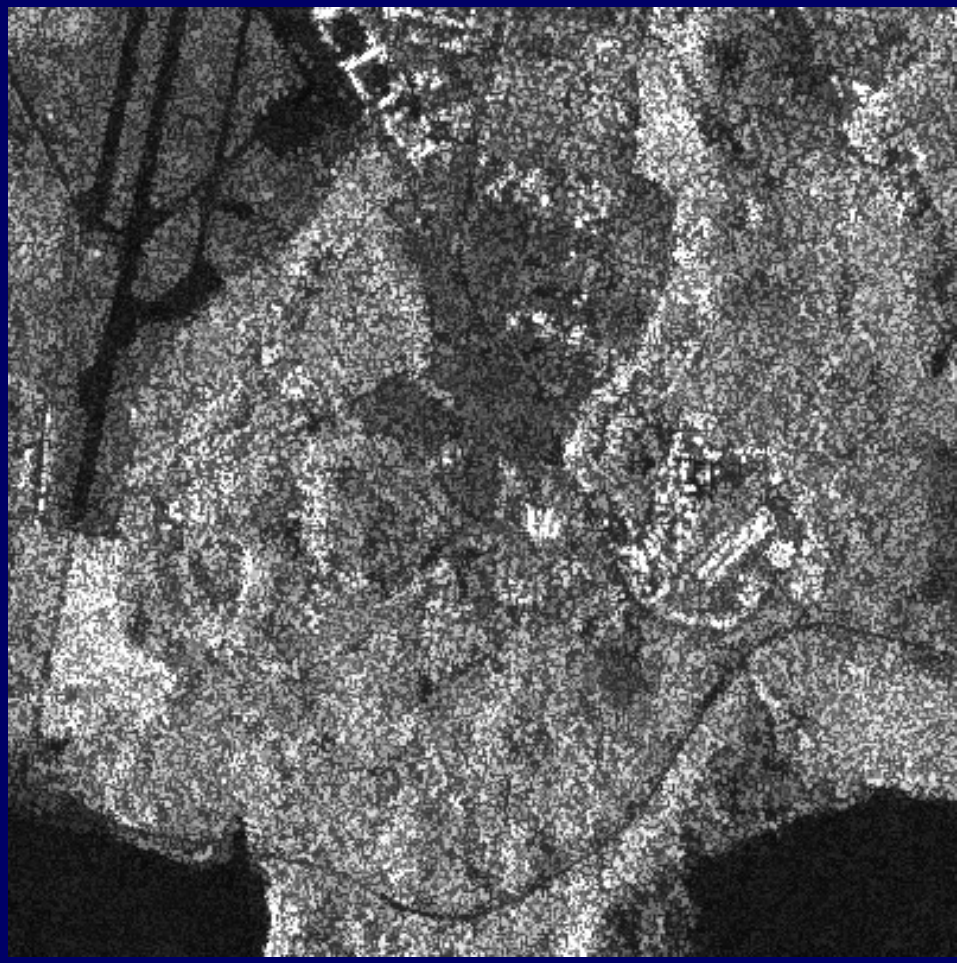
Gamma Filter



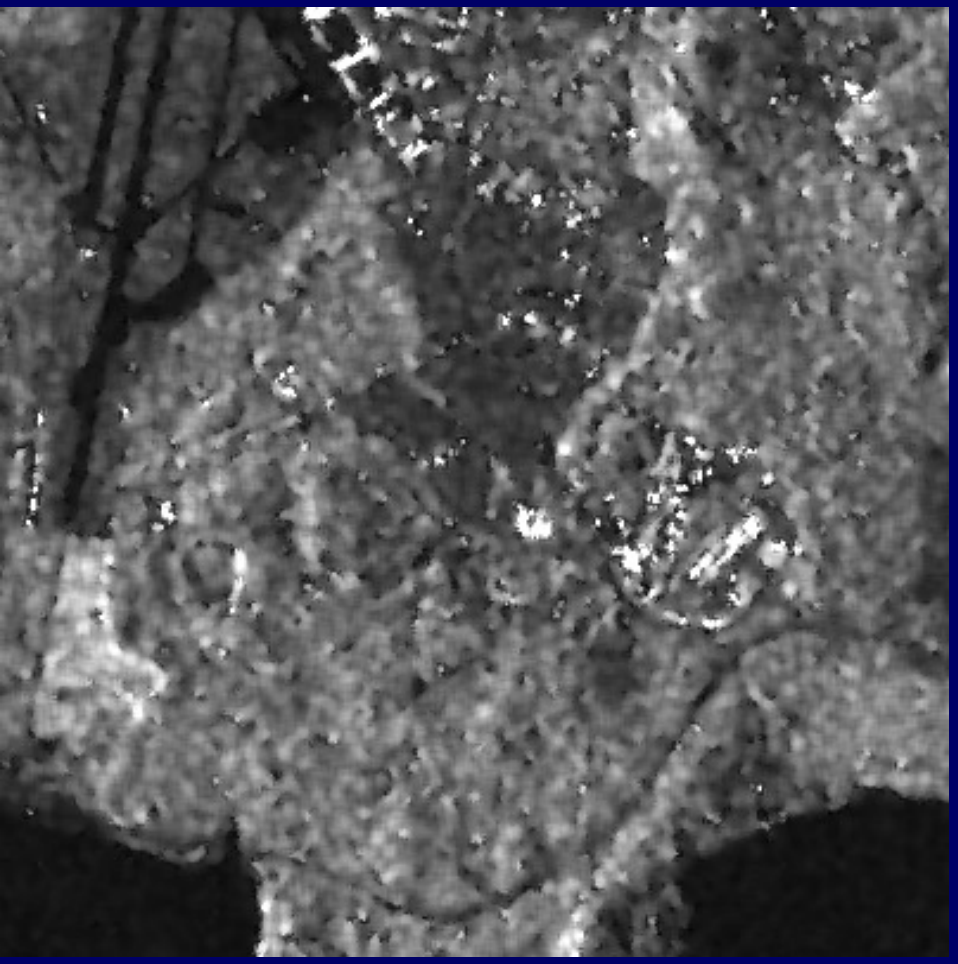
SAR Image



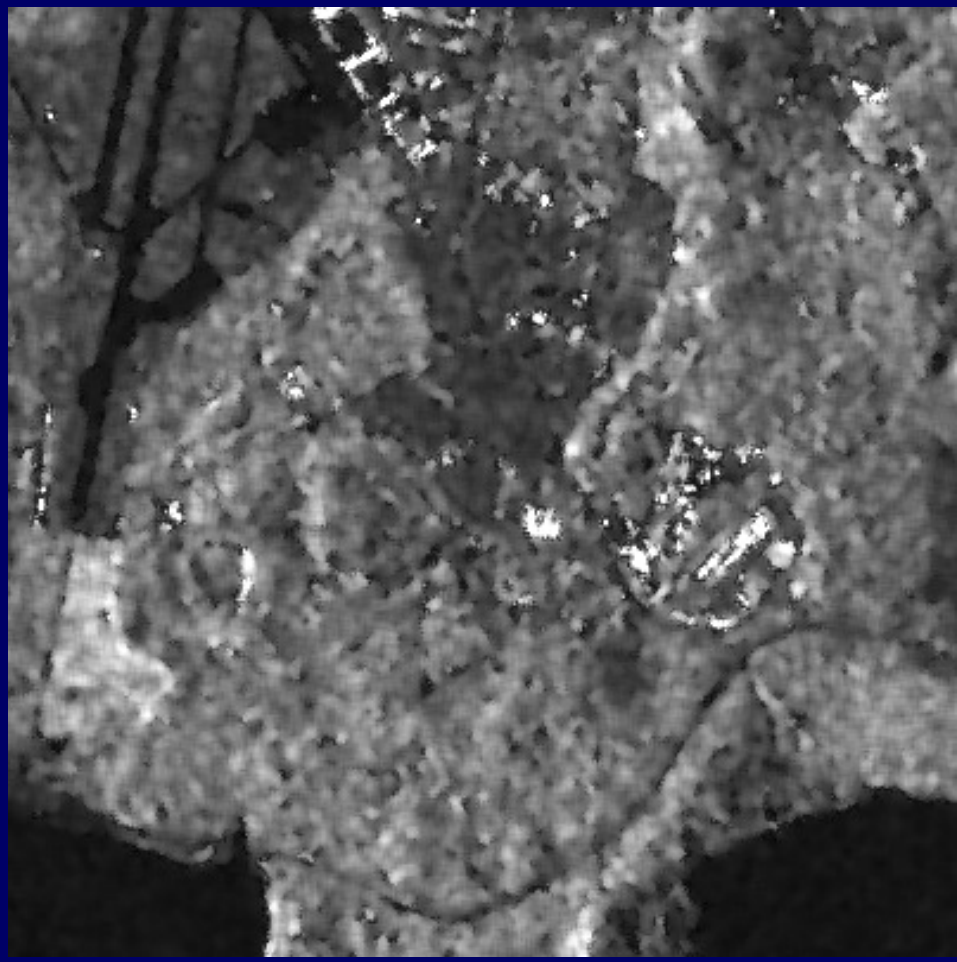
Region growing "filter"

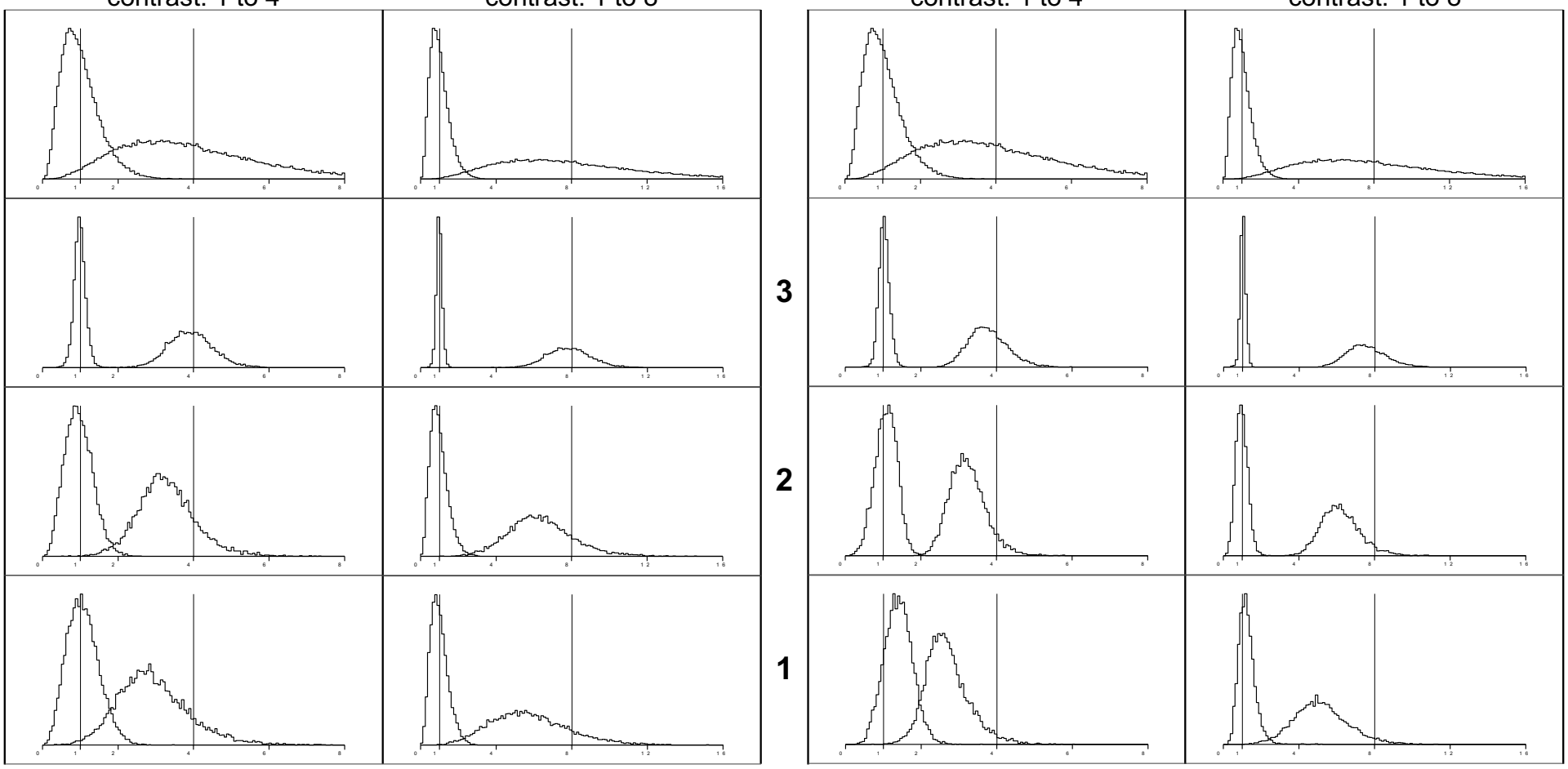


Extremum reduction and Gamma filter



Region growing and Gamma filter




GAMMA FILTER
contrast: 1 to 4
contrast: 1 to 8
PRE-PROCESSING & GAMMA FILTER
contrast: 1 to 4
contrast: 1 to 8
3
2
1

Conclusion

- Segmentation techniques could be useful for SAR image filtering
- Use progressive SAR image enhancement