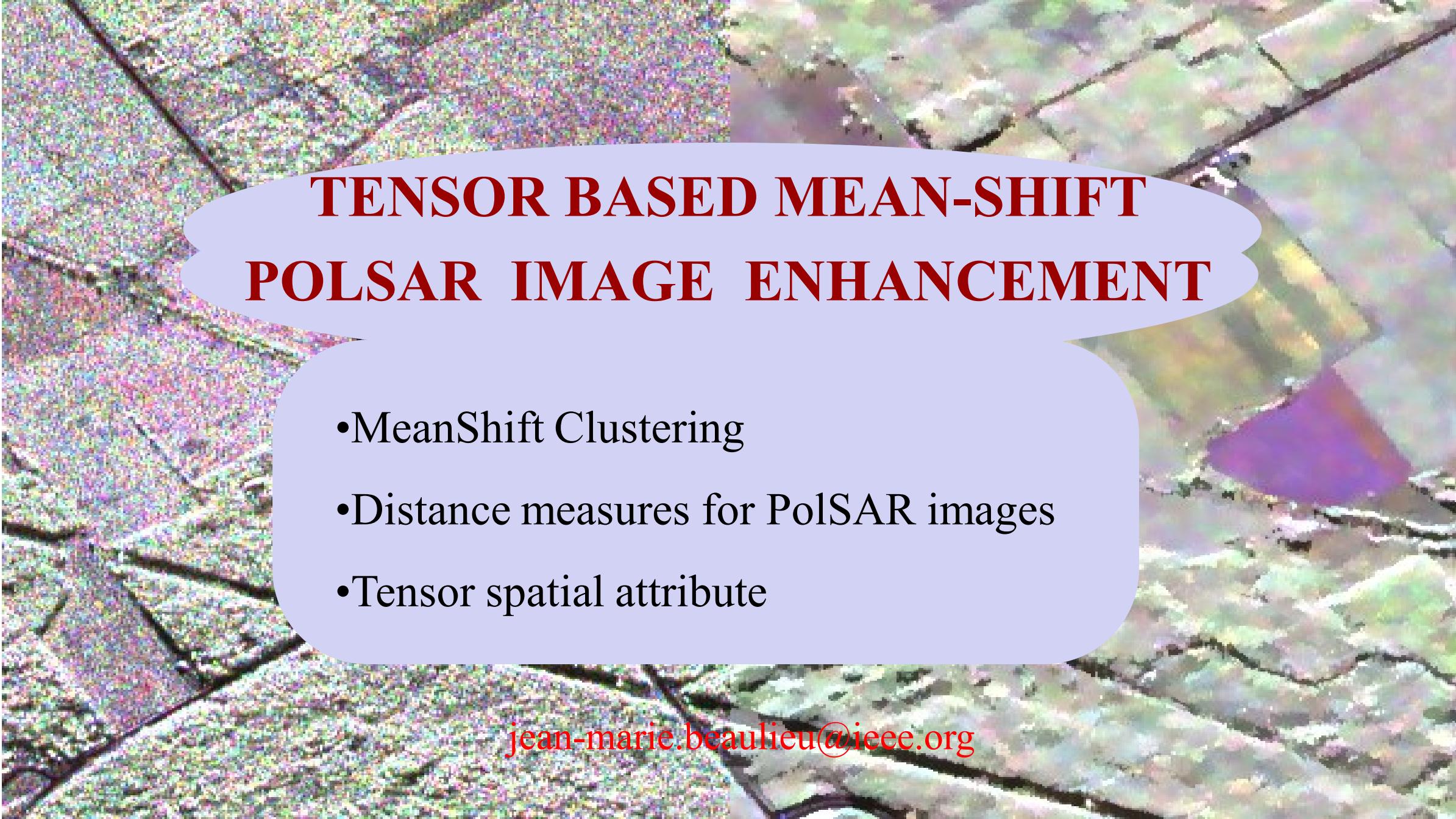


FILTRAGE D'IMAGE POLSAR
PAR MEAN-SHIFT AVEC TENSEUR

TENSOR BASED MEAN-SHIFT
POL SAR IMAGE ENHANCEMENT

Jean-Marie Beaulieu

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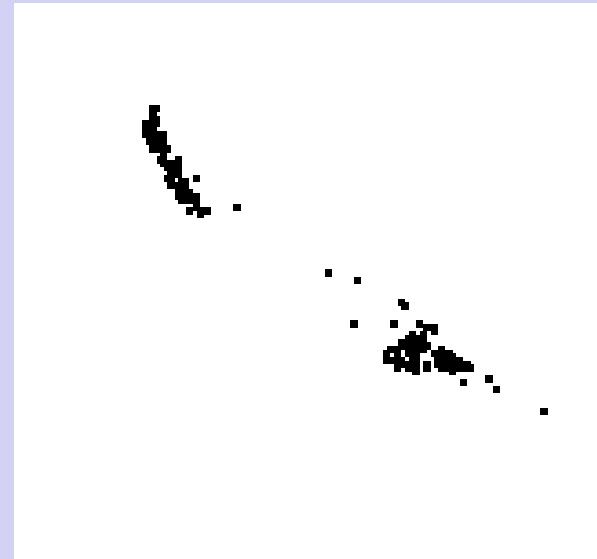
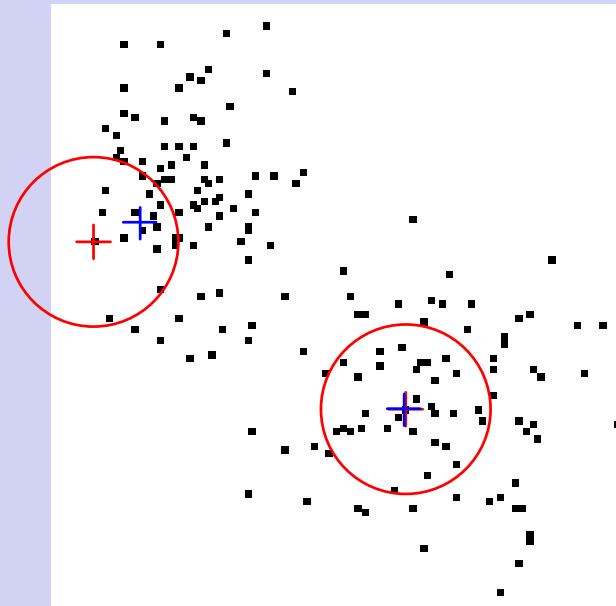


TENSOR BASED MEAN-SHIFT POLsar IMAGE ENHANCEMENT

- MeanShift Clustering
- Distance measures for PolSAR images
- Tensor spatial attribute

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- Mean-Shift clustering move every data points toward higher probability density zones (modes)
- Density → point count over a window (histogram)
- Direction toward higher density
→ position of weighted mean (window)



Radiometric

MEAN-SHIFT

$$\hookrightarrow D_{rad} = D(Z_i, Z_j)^{1/2} / F_{rad}$$

Distance

$$\hookrightarrow D_{spatial} = \text{Distance between pixels} / F_{spatial}$$

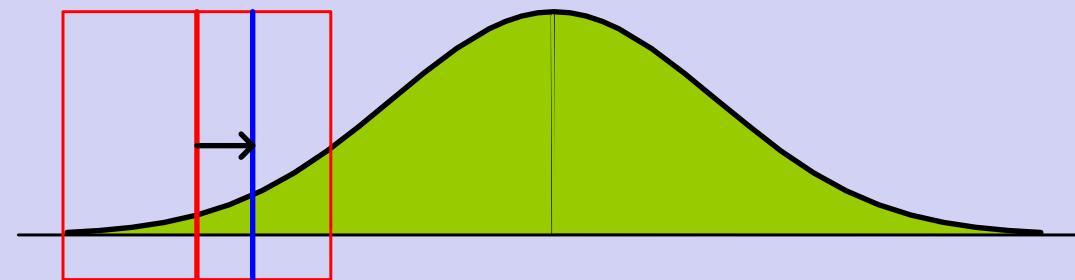
$$\text{Weight} = \text{EXP} [- (D_{rad}^2 + D_{spatial}^2)]$$

Mean = weighted pixel mean

$$\text{Shift}_R = \alpha \text{ value}_R + (1-\alpha) \text{ Mean}_R \quad (\text{radiometric value})$$

New

Old



- Radiometric distance $D(Z_i, Z_j)$ for PolSar images
- Z_k is pixel covariance matrix
- Non textured PolSar image
- Z_k follows a complex Wishart distribution

$$p(Z_k | \Sigma) = \frac{L^{3L} |Z_k|^{L-3}}{\pi^3 \Gamma(L)\Gamma(L-1)\Gamma(L-2)} \exp\left\{-L \operatorname{tr}\left(\Sigma^{-1} Z_k\right)\right\}$$

- Log of the likelihood ratio statistic is

$$D(Z_i, Z_j) = 2 \ln \left| \frac{1}{2} (Z_i + Z_j) \right| - \ln |Z_i| - \ln |Z_j|$$

- Distance between pixels → Euclidian distance

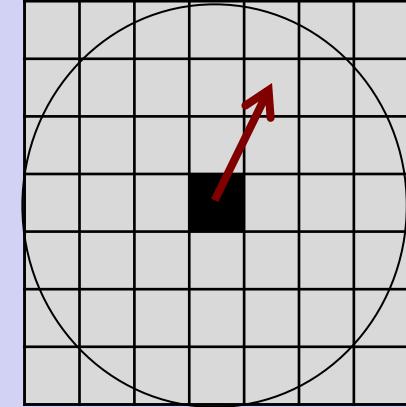
Gaussian like weight ($F_{spatial} = \sigma$)

$$\text{Weight} = \text{EXP} [- (D_{rad}^2 + D_{spatial}^2)]$$

Limited to a window (11x11)

$$\text{Shift}_R = \alpha \text{ value}_R + (1-\alpha) \text{ Mean}_R$$

New
 Old
 Radiometric



- Shifting the pixel position

$$\text{Shift}_p = \alpha \text{ value}_p + (1-\alpha) \text{ Mean}_p \quad \text{Position} \leftarrow (\text{pixel position } (x,y))$$

Distances between pixels will change

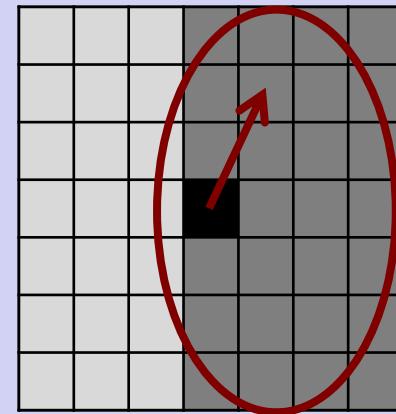
- Integrating other distances (texture, shape)
- Using weight to define a new attribute

$p_i = (x_i, y_i) \rightarrow$ pixel position

$V_i =$ position covariance or tensor

$$V_i = \sum_j w_{i,j} (p_j - p_i)(p_j - p_i)^t$$

$i \rightarrow$ center
 $j \rightarrow$ neighbour



Use V_i ellipse shape (orientation, elongation)

Shape indicate edge orientation

- **Using V_i in weight calculation**

Use S1 measure of Garcia to calculate the difference between V_i and V_j

(BMC Evolutionary Biology 2012, 12:222)

$$D_V = S1(V_i, V_j)^{1/2} / F_V$$

$$\text{Weight} = \text{EXP}[-(D_{rad}^2 + D_{spa}^2 + D_V^2)]$$

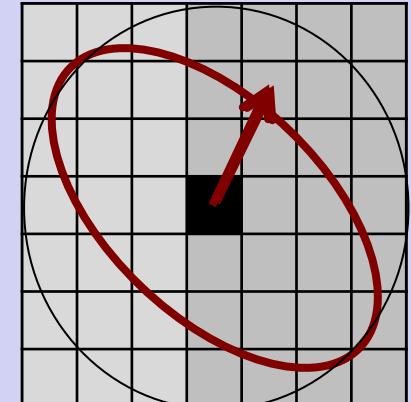
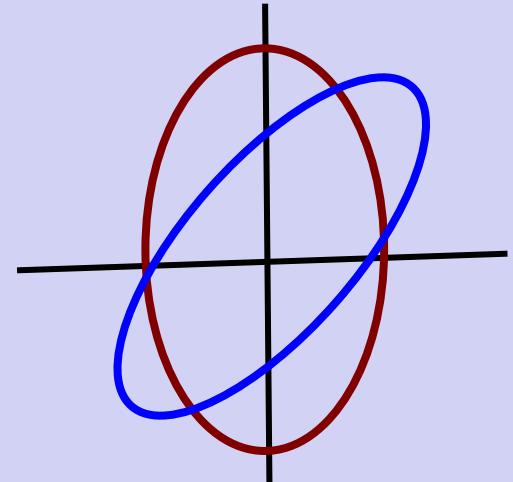
- **Shifting the value of V_i**

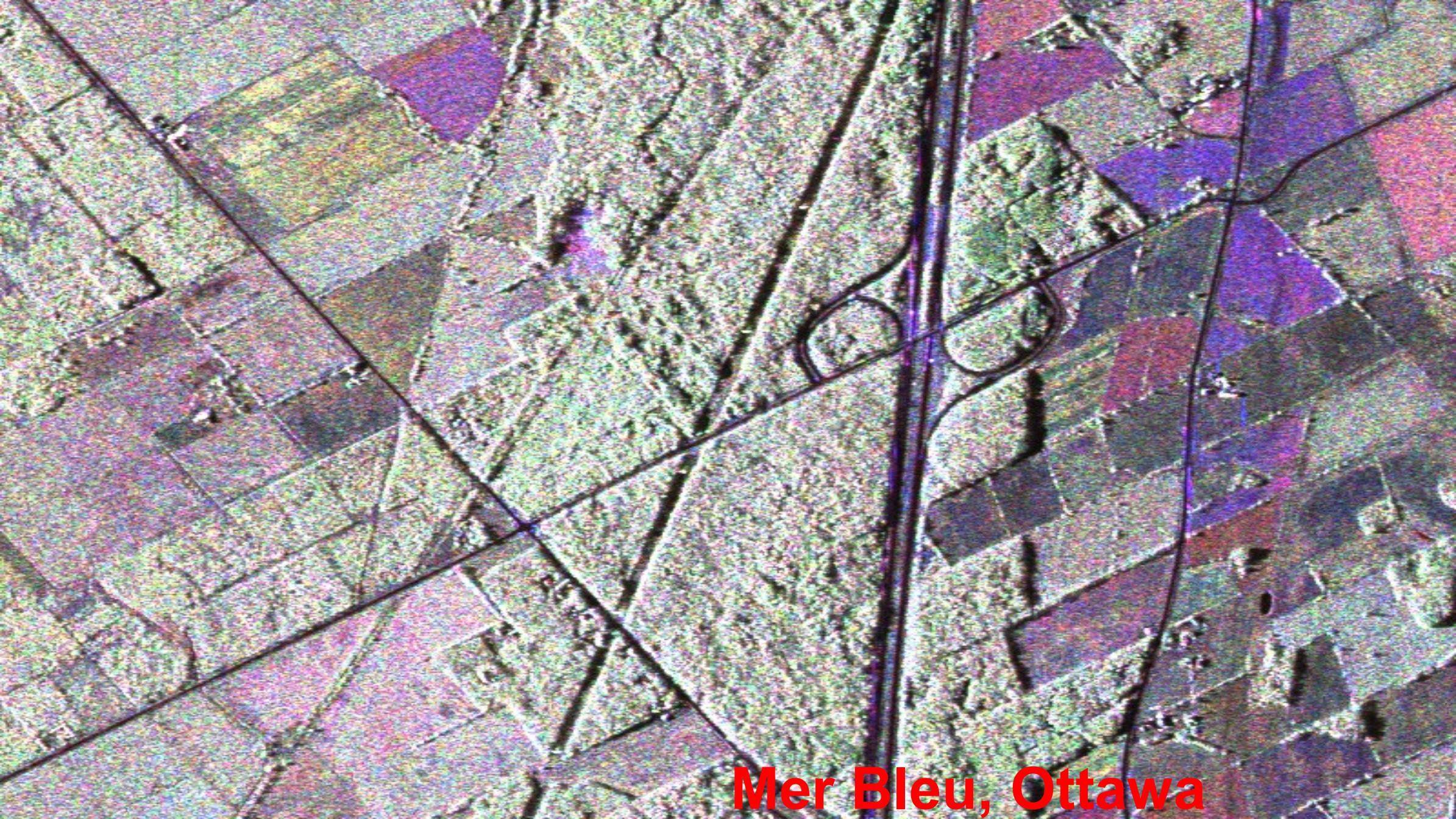
$$\text{Shift}_V = \alpha \text{ value}_V + (1-\alpha) \text{ Mean}_V$$

Tensor

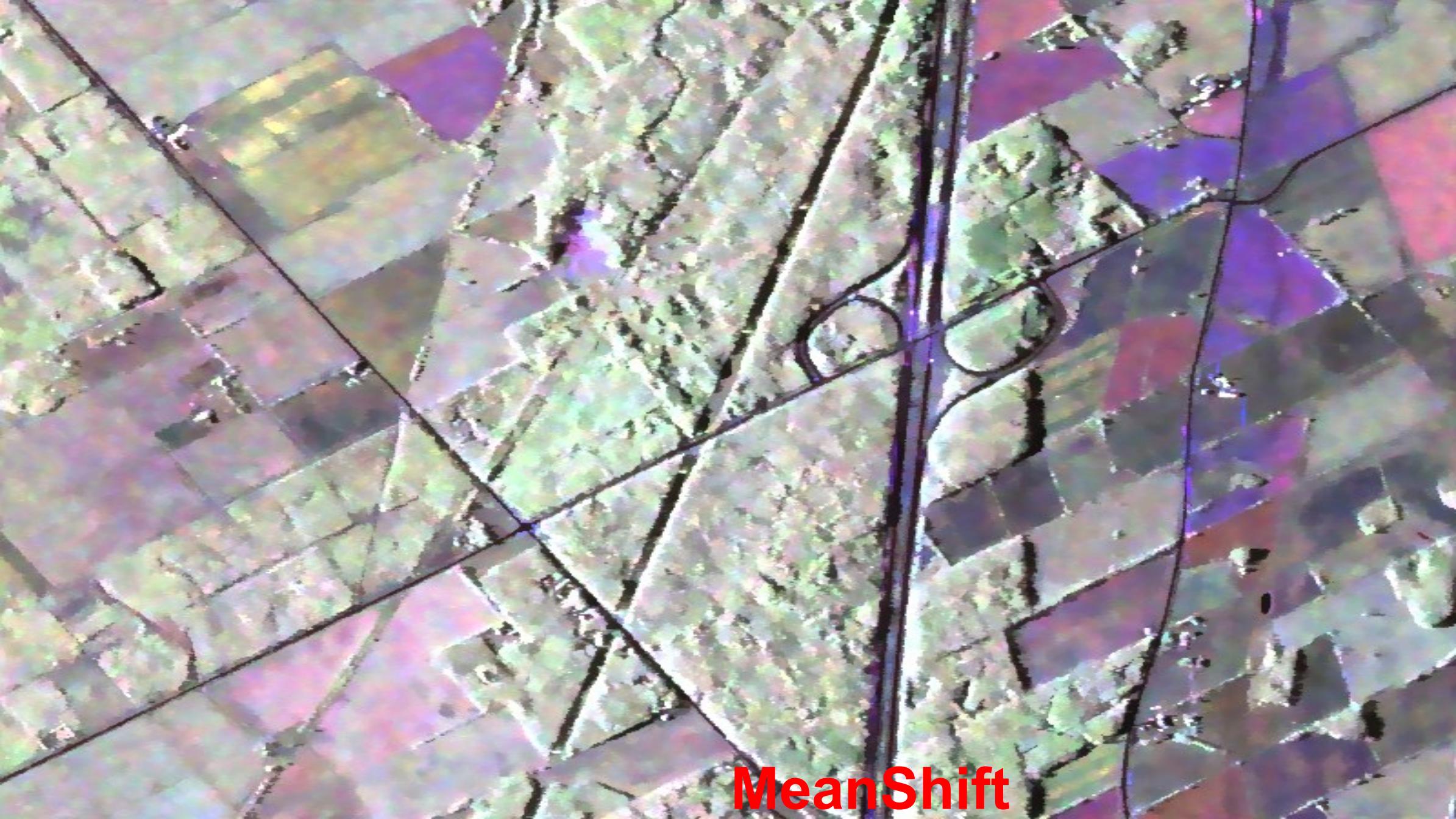
- **Mahalanobis pixel distance**

Use V_i to calculate Mahalanobis pixel distances

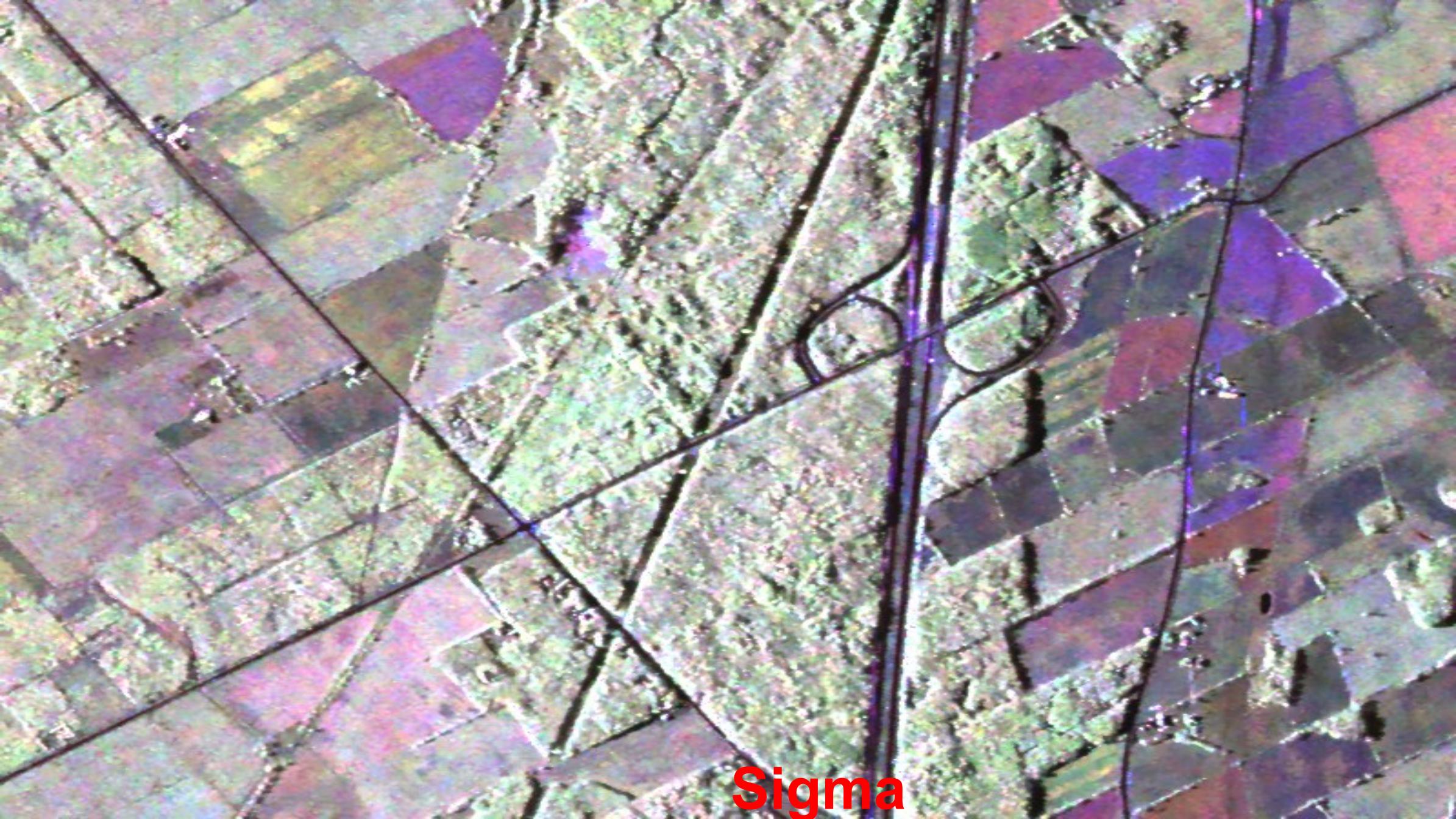




Mer Bleu, Ottawa



MeanShift

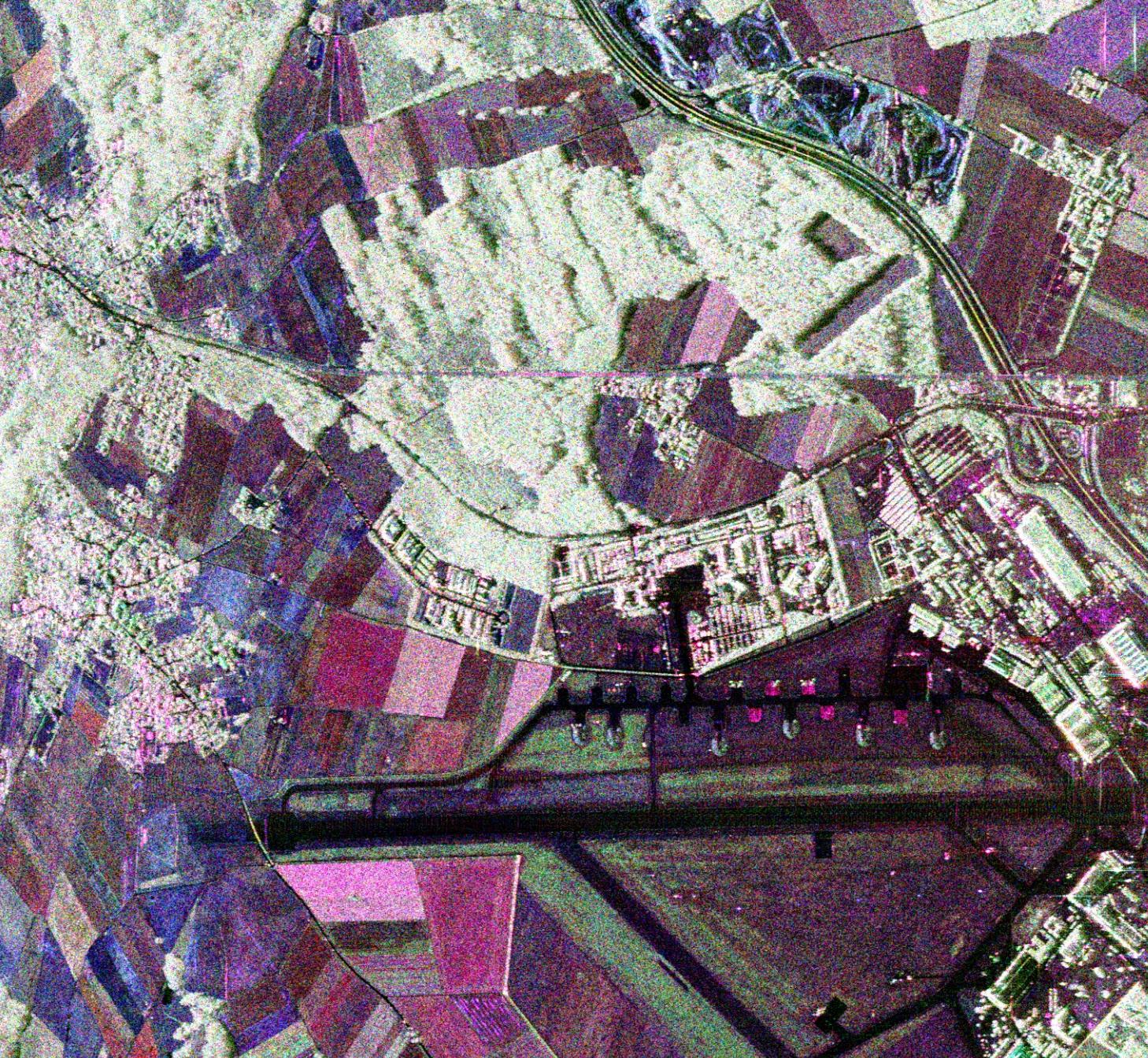


Sigma



IDAN

Oberaffenhofen



MeanShift



Sigma



original

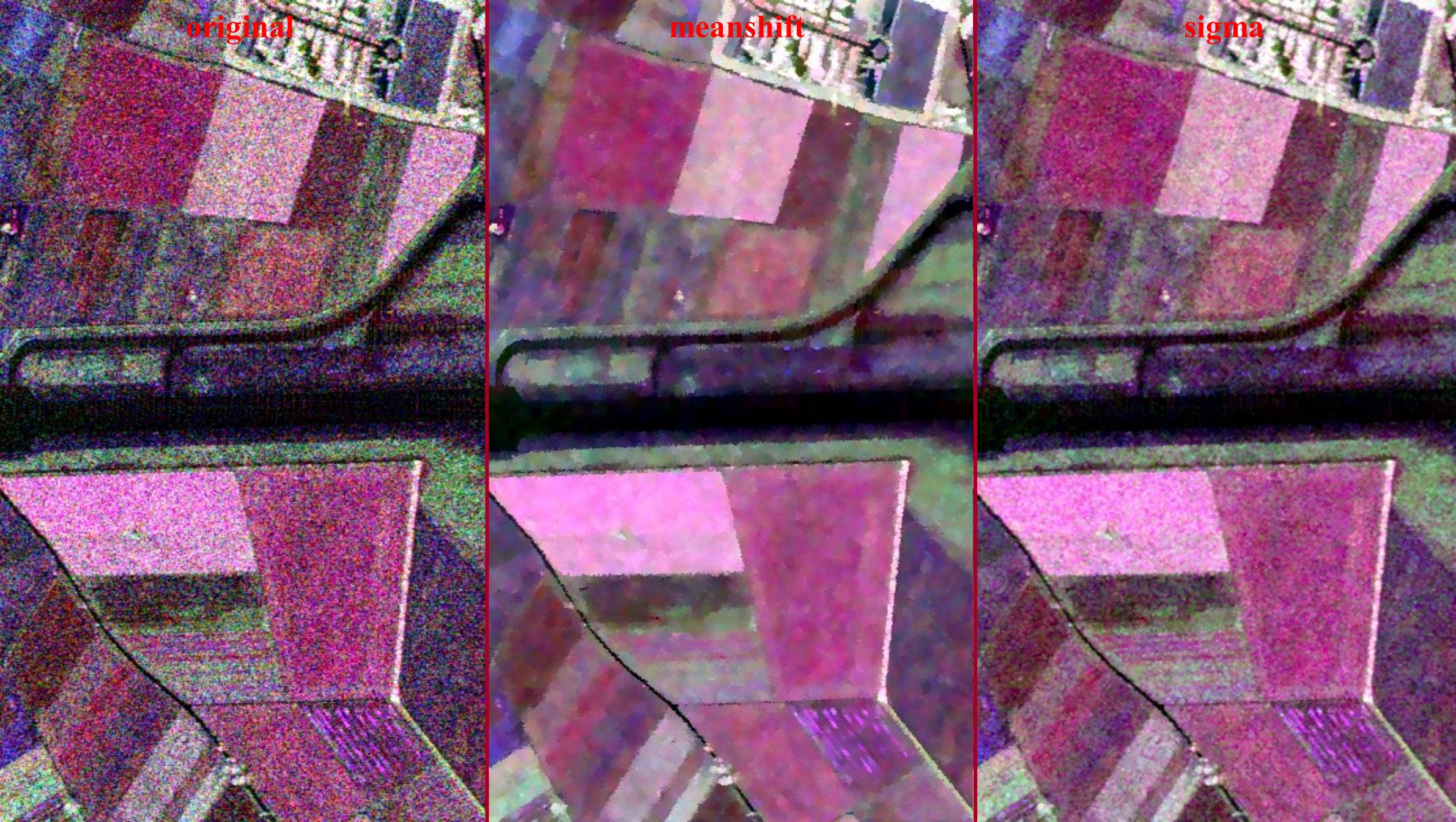


meanshift



sigma

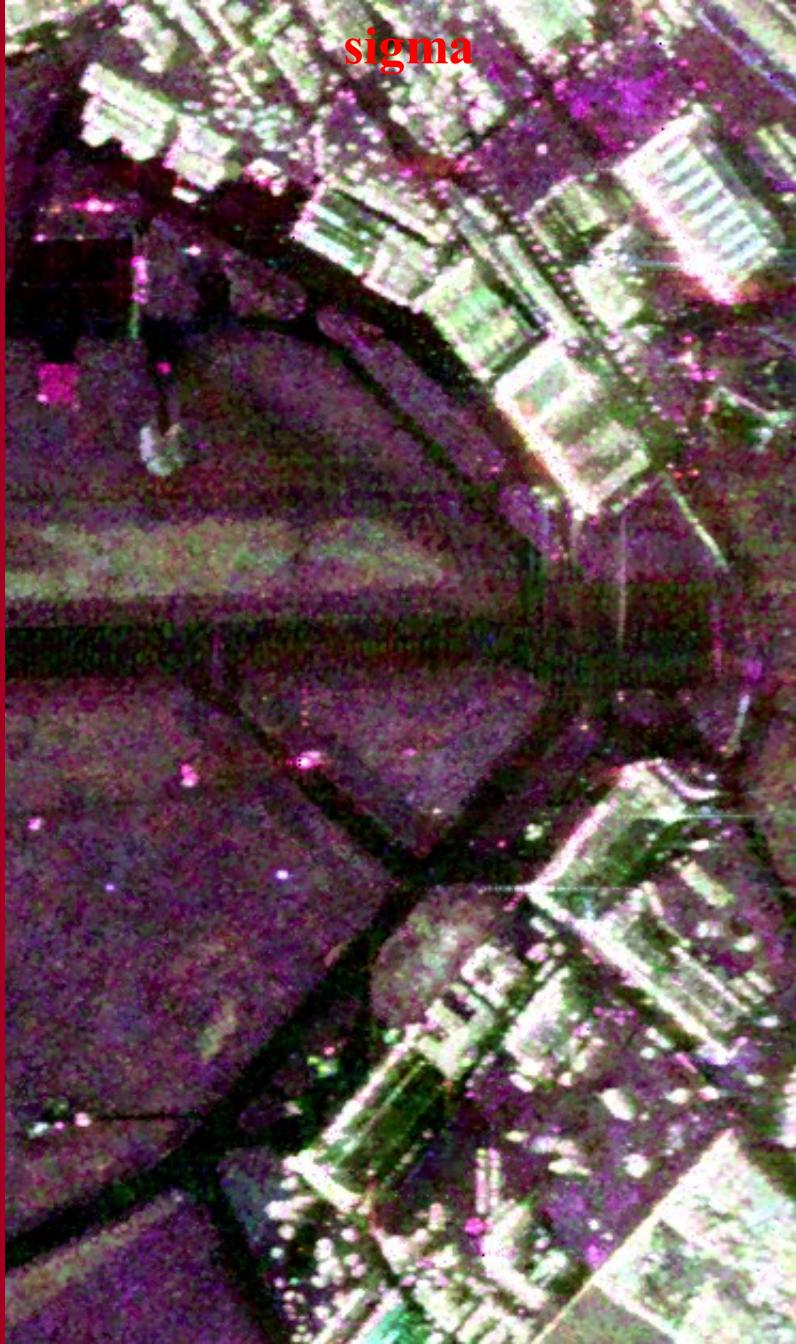
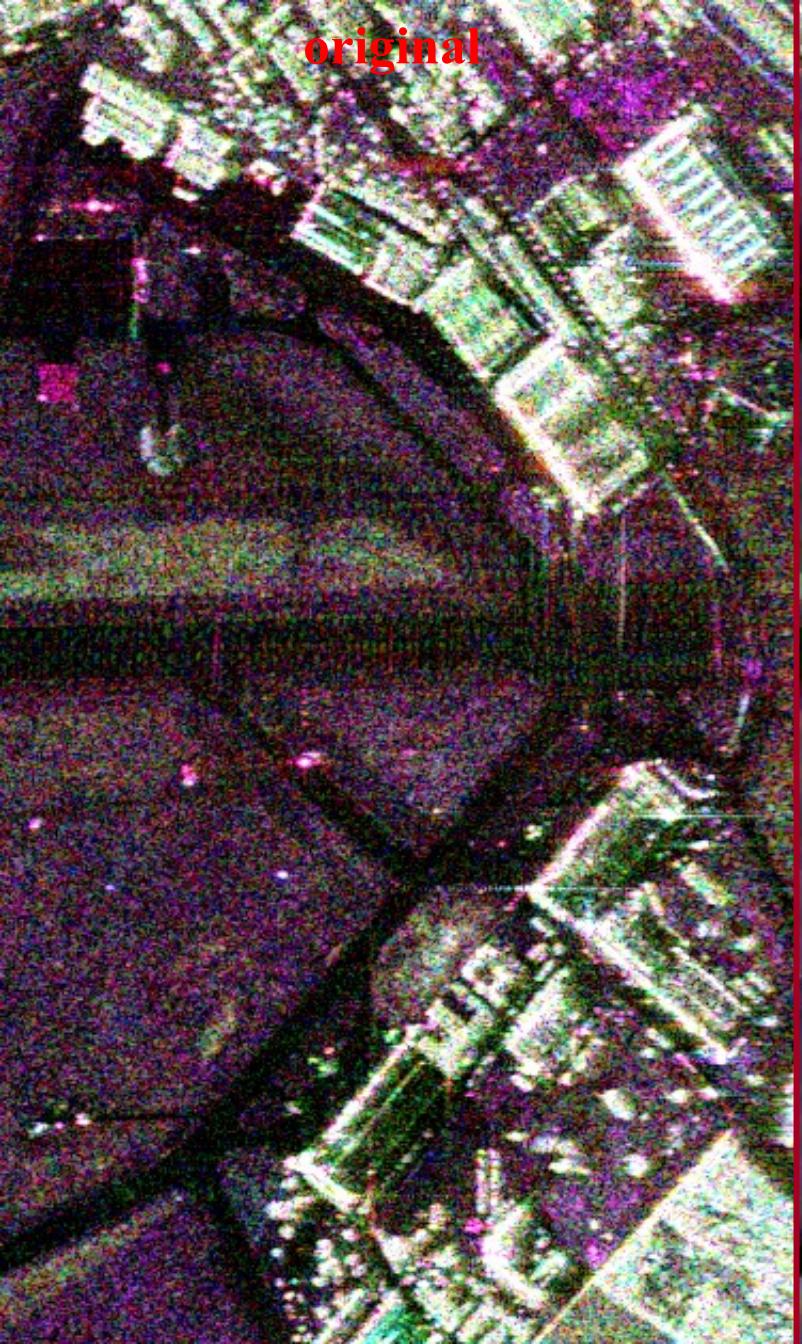




original

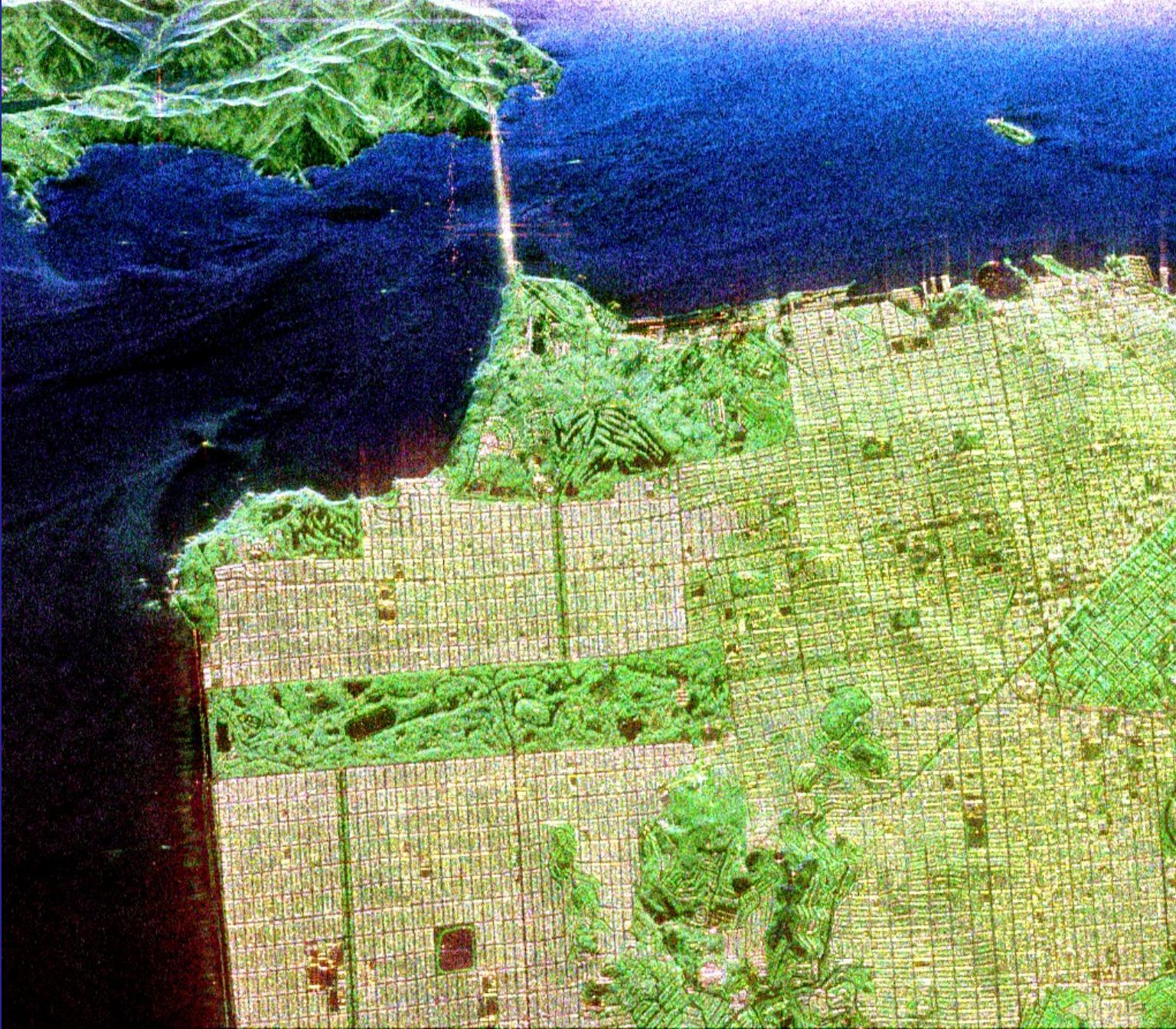
meanshift

sigma





San Francisco



MeanShift



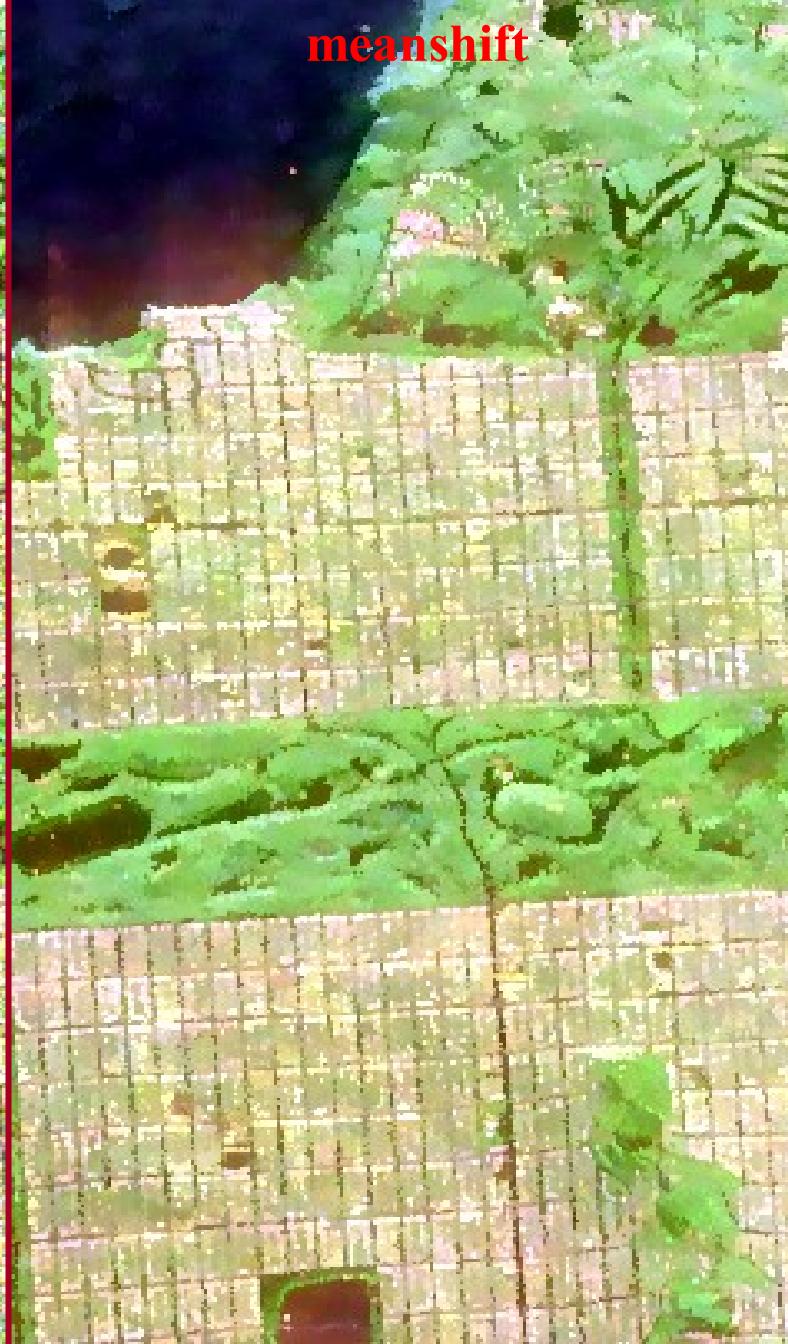
Sigma



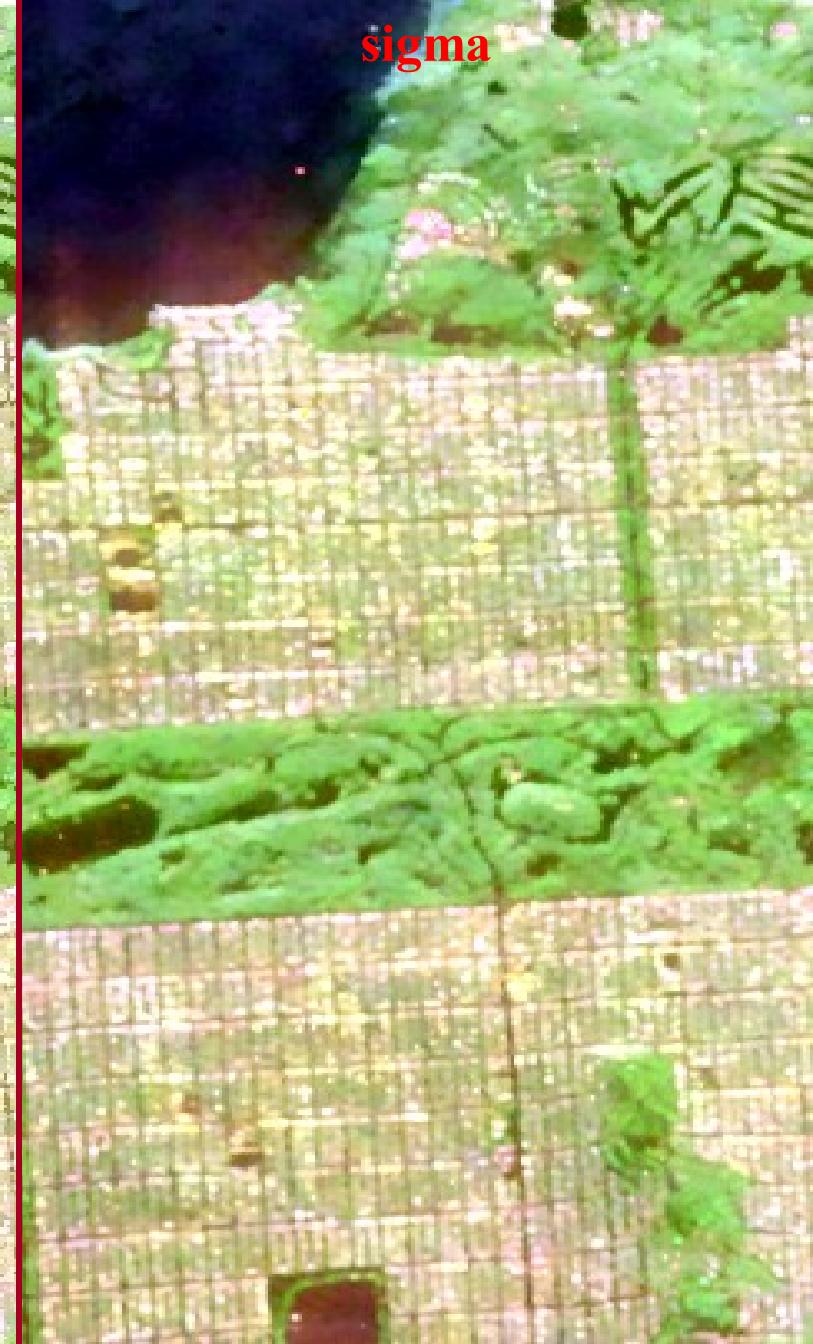
original



meanshift



sigma



CONCLUSION

- MeanShift can perform good image filtering.
- Position covariance tensor can provide a good textural attribute (ellipse orientation and elongation).
- Spatial attribute can be used in MeanShift to preserve edges.

