Presentation on -

Analysis using dielectric variation based hybrid-pol three-component model-based method

By

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Hybrid-pol Three-component Model-based (HTM) Technique

Most of the conventional **hybrid-pol analytical techniques do not produce the actual decomposition results that they are capable of**, due to the following two reasons:

- ✓ The hybrid-pol datasets synthesized from full-pol data does not produce accurate results.
- ✓ The decomposition techniques used for full-pol data analysis provide a more realistic representation of the natural surfaces due to the implementation of scattering models with dielectric surfaces, whereas, the hybrid-pol techniques do not consider such scattering models.

"To overcome these disadvantages, an unsupervised Hybrid-pol Three-component Model-based (HTM) is established. The performance of HTM (a dielectric properties based method) is compared with the previously reported m-δ, m-α, and modified m-χ"

Establishment of HTM technique:

- ✓ The proposed approach develops a hybrid-pol version of Freeman-Durden full-pol model.
- ✓ Freeman-Durden introduces three covariance matrices corresponding to three basic scattering mechanisms.

These matrices along with Stokes vector are expressed as follows:

Surface

$$C_{3S} = f_s \begin{bmatrix} |\beta|^2 & 0 & \beta \\ 0 & 0 & 0 \\ \beta^* & 0 & 1 \end{bmatrix} \hat{=} G_{3S} = f_s \begin{bmatrix} 0.5(|\beta|^2+1) \\ 0.5(|\beta|^2-1) \\ \Im(\beta) \\ \Re(\beta) \end{bmatrix}$$

Dihedral

$$C_{3D} = f_d \begin{bmatrix} |\alpha|^2 & 0 & \alpha \\ 0 & 0 & 0 \\ \alpha^* & 0 & 1 \end{bmatrix} \hat{=} G_{3D} = f_d \begin{bmatrix} 0.5(|\alpha|^2+1) \\ 0.5(|\alpha|^2-1) \\ \Im(\alpha) \\ \Re(\alpha) \end{bmatrix}$$

Volume

$$C_{3V} = \frac{f_v}{8} \begin{bmatrix} 3 & 0 & 1 \\ 0 & 2 & 0 \\ 1 & 0 & 3 \end{bmatrix} \hat{=} G_{3V} = f_v \begin{bmatrix} 0.5 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Continue. . .

Based on the conventional approach of m-δ, m-α, and m-χ, the total partially polarized backscattered wave can be expressed as the sum of completely polarized and completely depolarized terms:

$$\underbrace{\begin{bmatrix} G_0 \\ G_1 \\ G_2 \\ G_3 \end{bmatrix}}_{\text{Partially Polarized Backscattering}} = f_m \underbrace{\begin{bmatrix} 0.5(|\gamma|^2+1) \\ 0.5(|\gamma|^2-1) \\ \Im(\gamma) \\ \Re(\gamma) \end{bmatrix}}_{\text{Completely Polarized Part}} + f_v \underbrace{\begin{bmatrix} 0.5 \\ 0 \\ 0 \\ 0 \end{bmatrix}}_{\text{Completely Depolarized Part}}.$$

Completely Polarized Part can be separated in dihedral and surface scattering contributions

$$f_m \underbrace{\begin{bmatrix} 0.5(|\gamma|^2+1) \\ 0.5(|\gamma|^2-1) \\ \Im(\gamma) \\ \Re(\gamma) \end{bmatrix}}_{\text{Completely Polarized Part}} = f_s \underbrace{\begin{bmatrix} 0.5(|\beta|^2+1) \\ 0.5(|\beta|^2-1) \\ \Im(\beta) \\ \Re(\beta) \end{bmatrix}}_{\text{Surface Scattering}} + f_d \underbrace{\begin{bmatrix} 0.5(|\alpha|^2+1) \\ 0.5(|\alpha|^2-1) \\ \Im(\alpha) \\ \Re(\alpha) \end{bmatrix}}_{\text{Dihedral Scattering}} = \begin{bmatrix} G_{0'} \\ G_{1'} \\ G_{2'} \\ G_{3'} \end{bmatrix}$$

"By Solving these Equations, HTM method is derived. HTM is a hybrid-pol version of full-pol three-component scattering model"

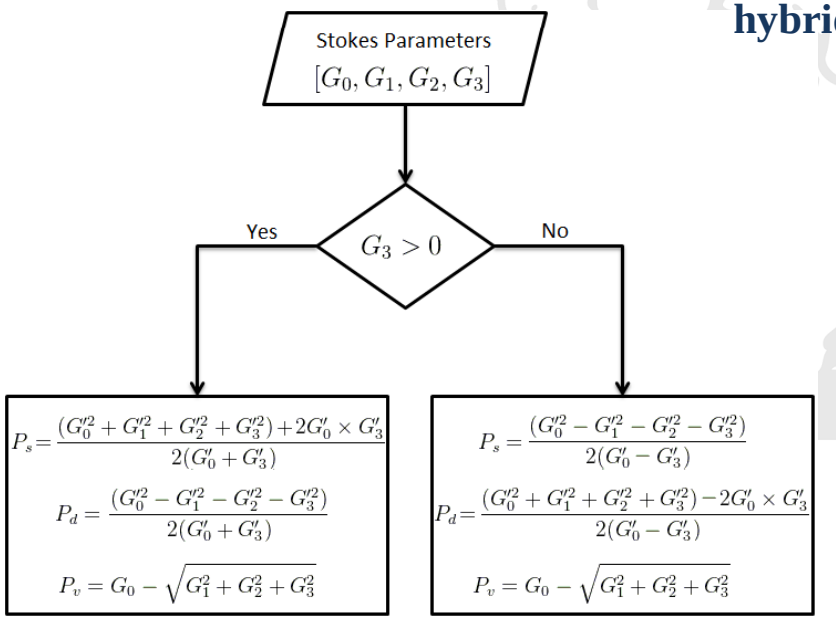


Fig. I. HTM techniques basic scattering contributions

Further the parameter, degree of circular polarization (μ) is used to modify HTM as,

$$P_{s'} = P_s; \quad P_{d'} = \mu P_d; \quad P_{v'} = P_v$$

Study Area and Dataset

For performance-evaluation, the original hybrid-pol data of RISAT-1 satellite, acquired over Mumbai city (India) is implemented.

Google Earth optical image of Mumbai (India) region . Urban regions contain buildings and mangrove region is a densely packed uniform patch of *Avincennia marina* species with an average height of 4m (dense canopy).

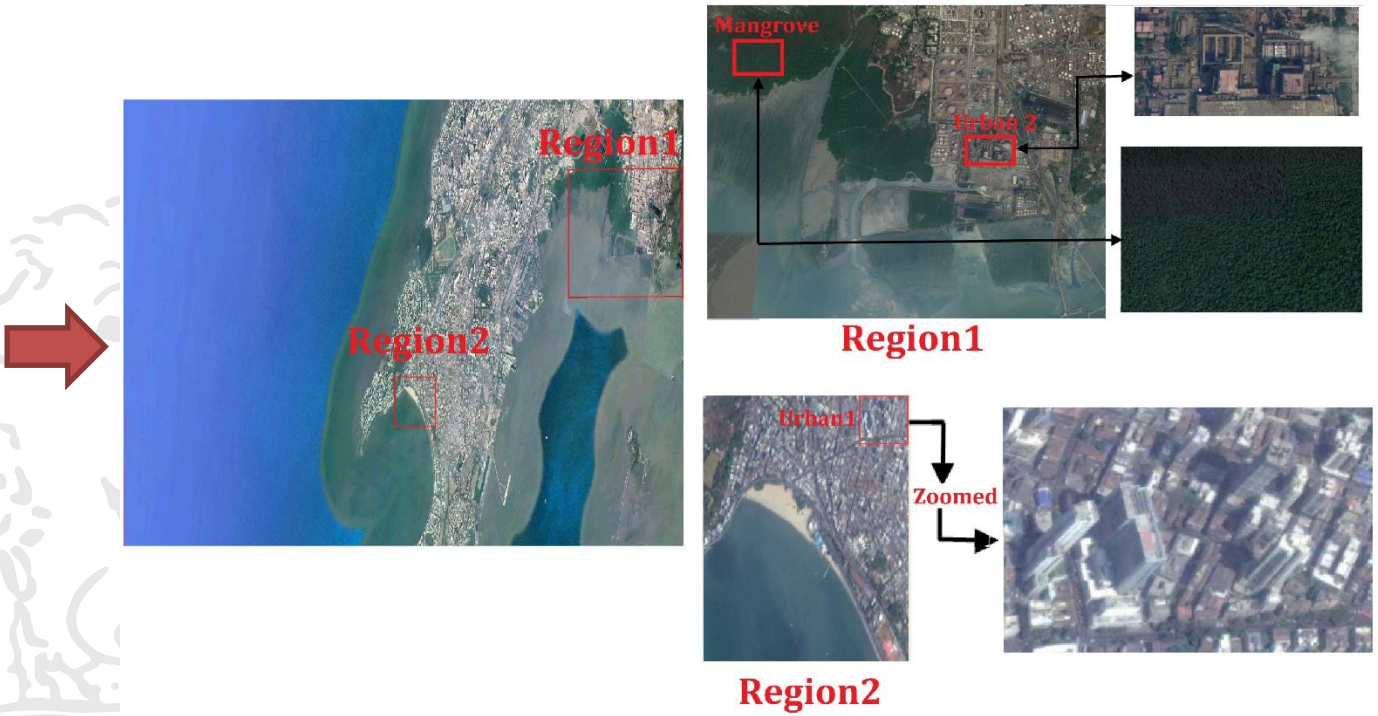


Fig. II. Google Earth optical image of the Study area

Table 1: The detailed description of true hybrid-pol dataset implemented in this work.

Sensor	Location	Acquisition Mode	Incidence Angle	Single Look Resolution (in m^2)	Date of Acquisition
RISAT-1 (C-band: 5.35 GHz)	Mumbai (India)	cFRS-1 (RH+RV)	12^0 - 55^0	4.19 × 2.08	22-July-2012

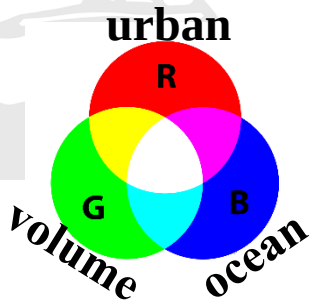
RISAT-1 Data Analysis: Decomposition Results

✓**Observation Points**

✓RGB color composition for pixel indicating dominance of specific scattering mechanism is more clear in dielectric variation based modified HTM decomposed image.

✓In the decomposition result obtained using modified HTM, the ocean, urban, and mangrove regions have clearer exhibition of blue, red and green colors, respectively, in comparison with m-δ, m-α, and modified m-χ.

✓For further validation, various small rectangular areas of different scattering types, indicated by white rectangles over Fig. III, are analyzed in the upcoming slides.



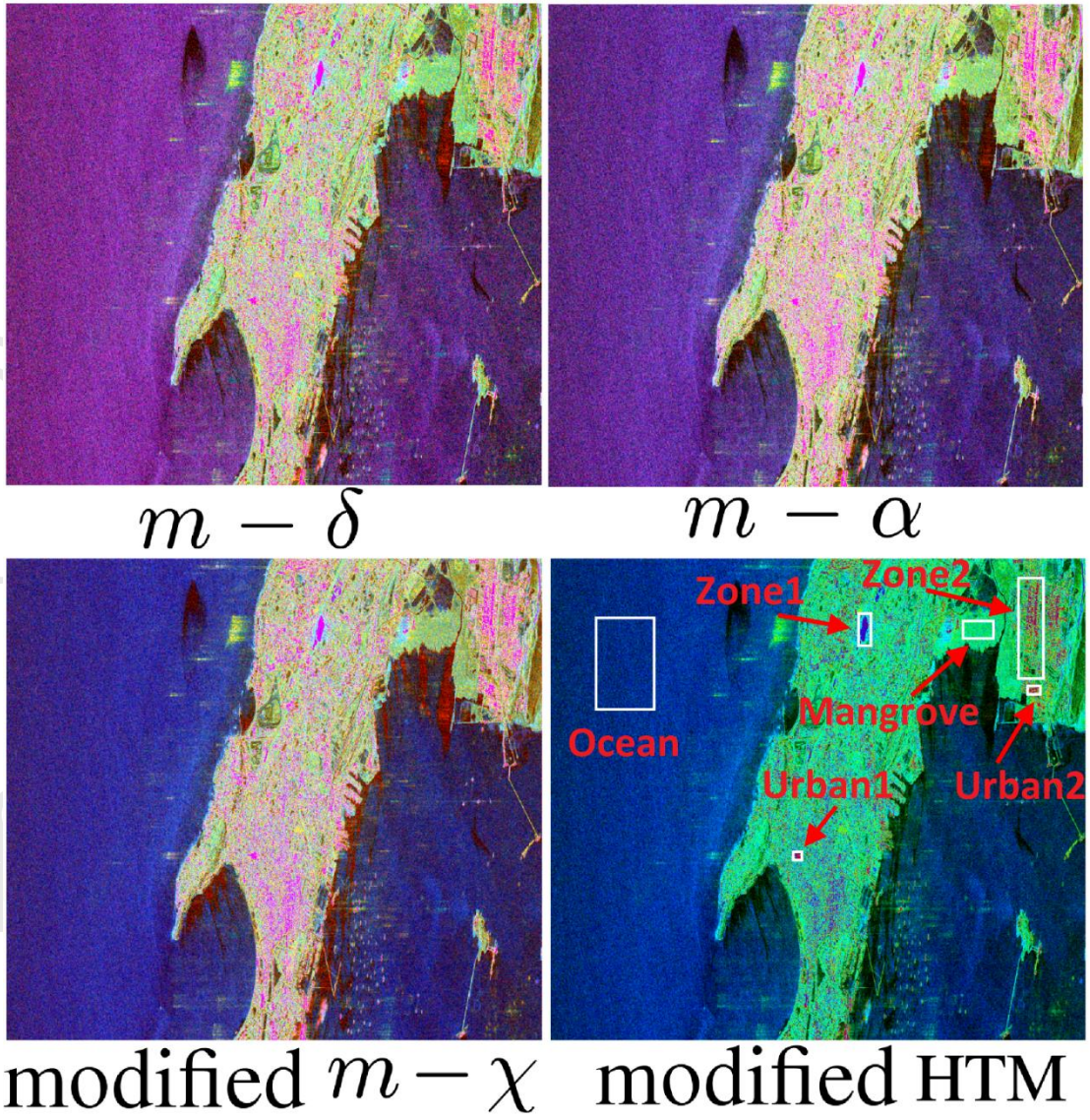
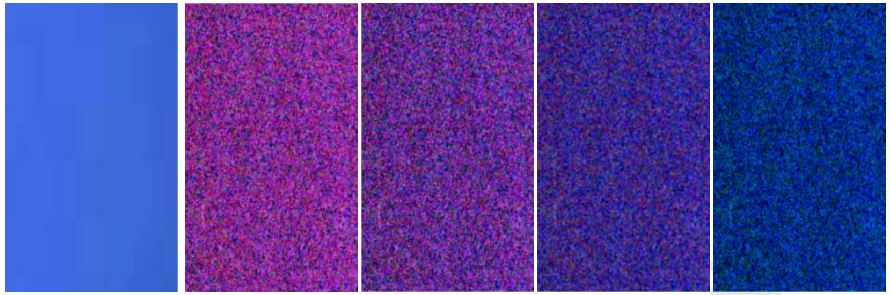


Fig. III. RGB decomposed image of RISAT-1 data.

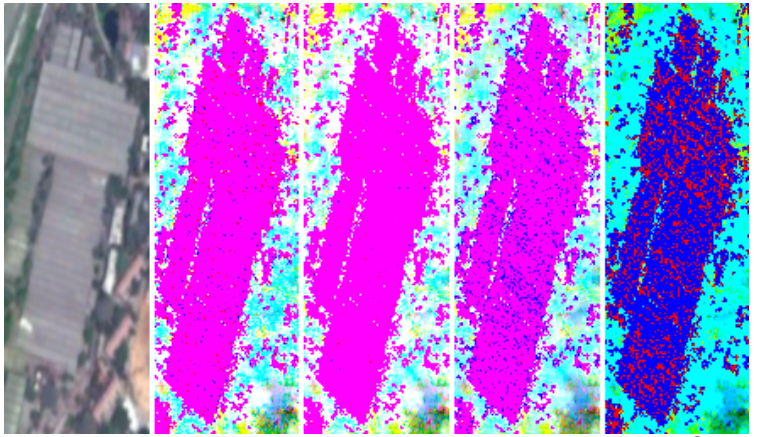
Analysis over selected regions containing surface and dihedral types

Selected Ocean Area



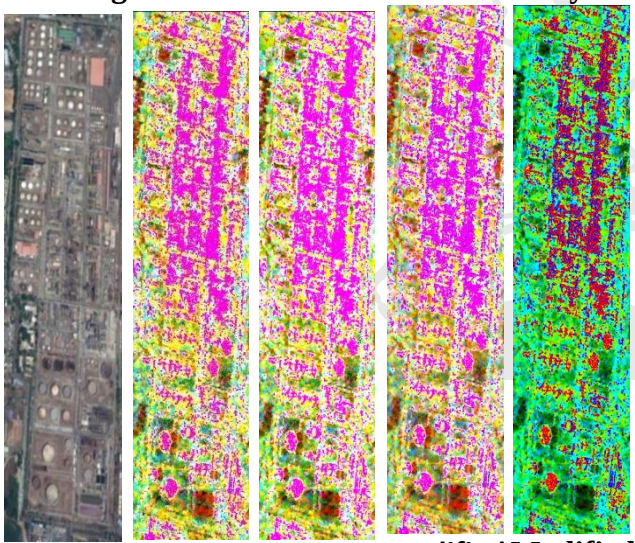
Google Earth Image | *m-δ* | *m-α* | Modified *m-χ* | Modified HTM

Zone 1: Railway-station's shed (mostly covers surface-scattering)



Google Earth Image | *m-δ* | *m-α* | Modified *m-χ* | Modified HTM

Zone 2: Region of Bharat Petroleum Refinery Buildings



Google Earth Image | *m-δ* | *m-α* | Modified *m-χ* | Modified HTM

Observation Points

- ✓The decomposed RGB image of selected ocean region, obtained using proposed HTM method contains majority of pixels with pure blue color. Whereas, these pixels in the decomposed RGB images obtained using other techniques, indicate the existence of small contribution of red color along with blue color.
- ✓The decomposed RGB images of **Zone 1** containing railway-station's shed (mostly covers surface-scattering type pixels) and **Zone 2** containing double-bounce scattering type buildings, have majority of pixels with same color (pink) in the decomposed result of **m-δ, m-α, and modified m-χ.**
- ✓On the other hand, the railway-station's shed in **Zone1** and buildings in **Zone 2** mostly consists of blue and red color pixels, respectively, in the decomposed RGB images obtained using proposed HTM technique.

Analysis over selected Mangrove region

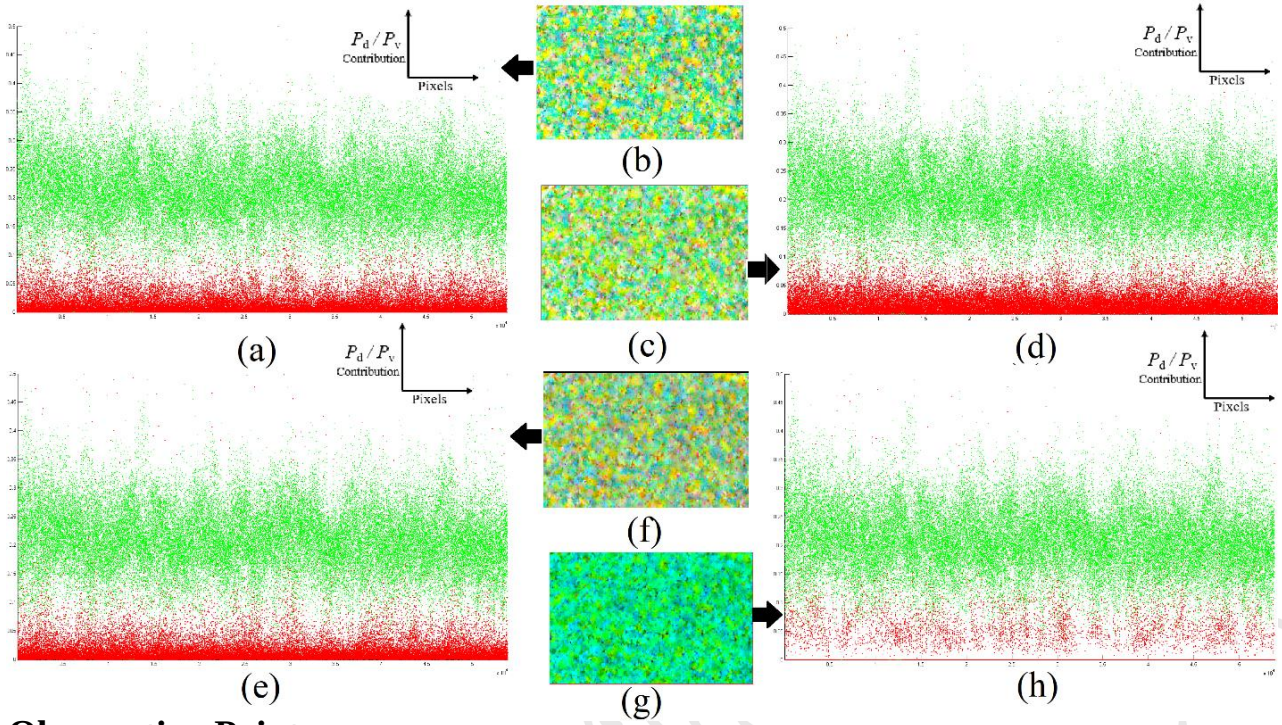


Fig. 5: Mangrove region results:
(a) P_v & P_d contributions using m-δ
(b) RGB decomposed result using m-δ
(c) RGB decomposed using m-α
(d) P_v & P_d contribution using m-α
(e) P_v & P_d contribution using modified m-χ
(f) RGB decomposed result using modified m-χ
(g) RGB decomposed result using modified HTM
(h) P_v & P_d contributions using proposed HTM.

Observation Points

- ✓ The decomposition images of mangrove region, as shown in Fig. 5 (b), (c), and (f), obtained using m-δ, m-α, and modified m-χ, respectively, contain yellowish and reddish pixels along with the green. Whereas, the proposed HTM decomposed image of mangrove region, as shown in 5(g), contains mostly green pixels. The reason of this is explained using P_d & P_v plots analysis in the next point.
- ✓ For the mangrove region pixels, the undesirable double-bounce contribution can be clearly observed in the case of m-δ, m-α, and modified m-χ. Contrarily, the double-bounce contribution, i.e. P_d is much lesser than P_v in the case of proposed HTM. Due to this reason, the reddishness is not there in the mangrove decomposition result obtained using HTM. Consequently, the clearer interpretation of dominant scattering type can be seen in HTM decomposition result.

Conclusion

- ✓In case of "dielectric-variation based hybrid-pol decomposition method", i.e. HTM, the dominant scattering types of single-bounce, double-bounce, and volume scattering mechanisms are more clearly exhibited by blue, red, and green colors, respectively.
- ✓The reason behind better decomposition results of HTM method has been explained in this paper by plotting the power contribution values of dominant as well as non-dominant scattering mechanisms.
- ✓As shown in the results of the paper, the contribution of non-dominating scattering mechanisms is very less in HTM, in comparison with other reported methods, such as m-δ, m-α, & modified m-χ.
- ✓The results obtained in the paper indicates that the utilization of surface dielectric variations in hybrid-pol decomposition methods provide more clear and realistic representation of Earth's surface.

THANK YOU FOR YOUR KIND ATTENTION !

Questions & Suggestions on:
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